MANAUS 99

International Symposium
Hydrological and Geochemical Processes in Large Scale River Basins

November 15-19, 1999, Manaus, Brazil

PROGRAM and ABSTRACTS

Organized by HiBAm
Hydrology and Geochemistry of the Amazon Basin

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Manaus 99

Manaus'99

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SCIENTIFIC PROGRAM
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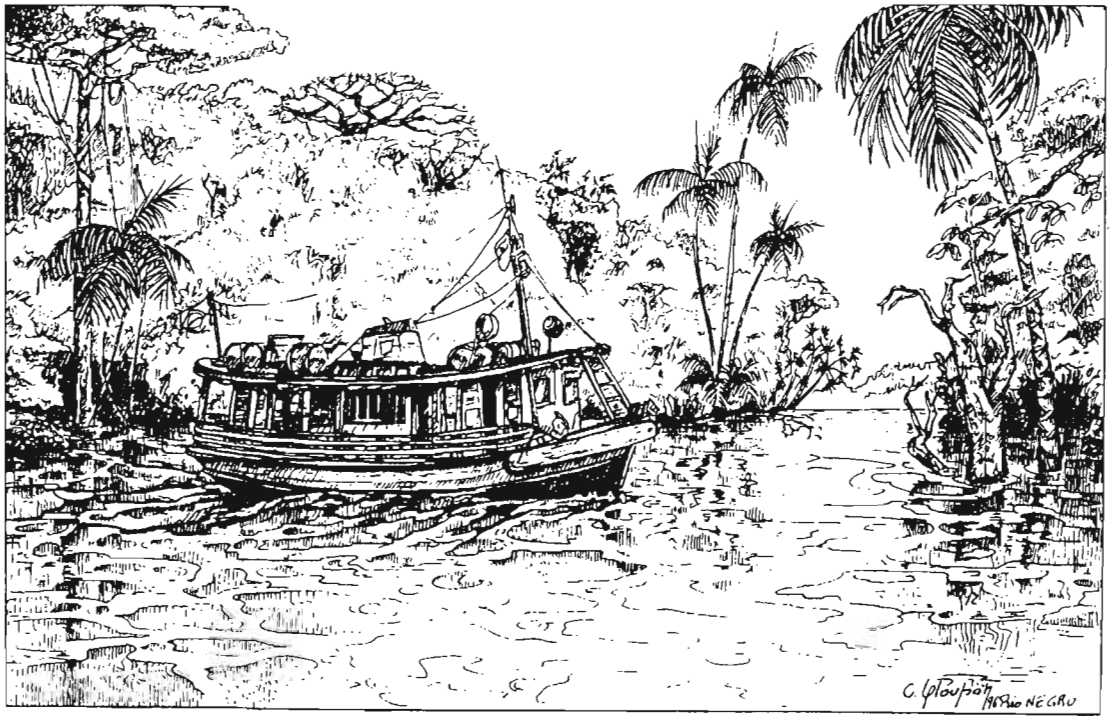


Monday / Segunda Feira / Lunes / Lundi 15/11/99 pm

Time Schedule for Topic 5 - Oral communications
Towards hydrological and biogeochemical models of large-scale basins

First Session / 14:15 - 16:00 / Chairman : Dr. Alfred Becker

14:15 - 14:30 : Güntner, A. and Bronstert, A. A large-scale hydrological model for the semi-arid tropics of north-eastern Brazil.

14:30 - 14:45 : Conway, D. and Mahé, G. River flow modelling in two large river basins: the Paraná (subtropical) and the Niger (tropical).

14:45 - 15:00 : Azevedo, J. R. G., Tanton, T. W., and Clarke, D. A hydrological model for assessing global warming effects on hydrological regimes of catchments with scarce data.

15:00 - 15:15 : Becker, A., Krysanova, V., and Wechsung, F. Integrated ecohydrological modelling in the Elbe river basin in Germany.

15:15 - 15:30 : Mayorga, E., Richey, J. E., and Aufdenkampe, A. K. Towards a mechanistic, remote-sensing driven model of organic matter cycling linking the land surface and river system in the Amazon basin.

15:30 - 15:45 : Hrissanthou, V. Erosion, transport and sedimentation in Nestos river basin.

15:45 - 16:00 : Santos, C. A. G., Suzuki, K., and Watanabe, M. Application of a physically-based erosion model for a large river basin in Japan.

Coffee break / 16:00 - 16:30

Second Session / 16:30 - 18:30 / Chairman : Dr. Tomas Dunne

16:30 - 16:45 : Hubert, P., Bendjoudi, H., Schertzer, D., and Lovejoy, S. Approche multifractale de la définition des régimes hydrologiques.

16:45 - 17:00 : Versiani, B. R., Souto, G. S., and Lebel, T. Étude de régionalisation de débits maxima en grands bassins : cas de la région du Alto São Francisco - Minas Gerais.

17:00 - 17:15 : Cappelaere, B., Lubes-Niel, H., Guyot, J. L., Molinier, M., Oliviera, E. et Rodrigues, M. S. Prévision des crues à Manaus.

17:15 - 17:30 : Grisales, C. L., Lozano, J. G., and Carvajal, Y. Análisis comparativo de modelos de pronóstico de caudal autorregresivos simples involucrando variables macroclimáticas en dos ríos interandinos de Colombia.

17:30 - 17:45 : Perrin, C., Michel, C., Melo, M. D., and Nascimento, N. O. Intercomparation of lumped and semi distributed watershed models on Brazilian river basins.

17:45 - 18:00 : Wittenberg, H. Discharge, recharge and evapotranspiration of groundwater determined by baseflow separation.

18:00 - 18:15 : Sambou, S. and Thirriot, C. Identification d'un modèle de régression linéaire pour la prévision des crues du Fleuve Sénégal.

18:15 - 18:30 : Mendiondo, E. M. and Clarke, R. T. Resiliência das bacias fluvias a partir de intervalos de variação de vazões máximas.

Tuesday / Terça Feira / Martes / Mardi 16/11/99 am

Time Schedule for Topic 1 - Oral communications
Hydrology of large-scale river basins

First Session / 08:00 - 10:00 / Chairman : Dr. Eurides de Oliveira

08:00 - 08:15 : Fontana, D. and Kruse, E. Aplicación de tecnicas de medición de caudales mediante perfilador de corriente por efecto Doppler en grandes rios de Argentina.

08:15 - 08:30 : Filizola, N. P., Guimarães, V. S., and Guyot, J. L. Medição de vazão em grandes rios Amazônicos com o uso do Perfilador Doppler-Acústico de Corrente.

08:30 - 08:45 : Rodrigues, M. S., Guimarães, V. S., Oliveira, E., Silva, J. J., Callède, J., and Oliveira, A. M. Aquisição automática de dados em hidrologia.

08:45 - 09:00 : Bourrel, L., Philipps, L., and Moreau, S. Estudio de la dinámica de las inundaciones en la cuenca Amazónica boliviana con un enfoque conjunto de la hidrología i de la percepción remota.

09:00 - 09:15 : Hamilton, S. K., Sippel, S. J., and Melack, J. M. Determination of inundation patterns in the major floodplains of South America from passive microwave remote sensing.

09:15 - 09:30 : Rosenqvist, A., Forsberg, B. R., Pimentel, T. P., Rauste, Y. A., and Richey, J. E. The Use of Spaceborne Radar Data for Inundation Modelling and Subsequent: Estimations of Trace Gas Emissions in Tropical Wetland Areas.

09:30 - 09:45 : Muller, F., Seyler, F., and Guyot, J. L. Utilisation d'imagerie radar ROS JERS-1 pour l'extraction de réseau de drainage. Exemple du Rio Negro (Amazonie).

09:45 - 10:00 : Seyler, F., Muller, F., Cochonneau, G., and Guyot, J. L. Délimitation de bassins versants à partir d'un modèle numérique de terrain. Comparaison de différentes méthodes pour le bassin du Rio Negro (Amazonie).

Coffee break / 10:00 - 10:30

Second Session / 10:30 - 12:30 / Chairman : Dr. Bernard Pouyaud

10:30 - 10:45 : Costa, M. H. and Foley, J. A. Water balance of the Amazon basin: potential effects of environmental change.

10:45 - 11:00 : Eid, N. J. and Campana, N. A. Estimativa da vazão média mensal em sub-bacia do Rio Negro com o apoio de sistema de informações geográficas.

11:00 - 11:15 : Guyot, J. L., Callède, J., Cochonneau, G., Filizola, N. P., Guimarães, V. S., Laraque, A., Molinier, M., Oliveira, E., and Seyler, F. Caractéristiques hydrologiques du bassin amazonien.

11:15 - 11:30 : Pombosa Loza, R., Heredia Calderón, E., Hoorelbeke, R. Perez, V., Roura, J. and Erazo, A. Balance Hídrico Superficial de la Cuenca del Río Napo, Pastana y Santiago.

11:30 - 11:45 : Olivry, J. C. Evaluation de l'écoulement inter-annuel des rivières sous forêt intertropicale humide à partir des précipitations.

11:45 - 12:00 : Mahé, G., Bamba, F., Soumaguel, A., Orange, D., and Olivry, J. C. Pertes en eau dans la cuvette lacustre du Niger: bilan hydrologique et surfaces inondées.

12:00 - 12:15 : Campos, J. N. B., Studart, T. M. C., Franco, S. R., and Luna, R. Liquid discharges from Jaguaribe river to Atlantic Ocean after large reservoir construction: Variability analysis.

12:15 - 12:30 : Grimaldi, M., Caron, X., Allard, V., Roselen, V., Lamotte, M., Fritsch, E., Boulet, R., and Magat, P. Dynamique de la nappe et régime hydrologique des rivières dans le haut bassin amazonien (Humaitá, Brésil).

Tuesday / Terça Feira / Martes / Mardi 16/11/99 pm

Time Schedule for Topic 1 - Oral communications
Hydrology of large-scale river basins

Third Session / 14:00 - 16:00 / Chairman : Dr. José Marengo

14:00 - 14:15 : Pouyaud, B., Ribstein, R., Gallaire, R., Chevallier, P., Caballero, Y., and Berthier, E. Régimes hydrologiques des hauts bassins nivo-glaciaires boliviens et variabilité pluviométrique des vallées andines en conditions El Niño et La Niña.

14:15 - 14:30 : Ronchail, J. Weakness of the relationship between rainfall and ENSO in the lowlands of Bolivia.

14:30 - 14.45 : Heredia Calderón, E. and Pombosa Loza, R. Influencia del ENSO sobre los caudales mensuales de las grandes cuencas septentrionales del Ecuador: ríos Napo y Esmeraldas.

14:45 - 15:00 : Rossel, F. and Cadier, E. ENSO et précipitations sur le bassin versant du Guayas (équateur).

15:00 - 15:15 : Ordoñez Galvez, J. J. Análisis y tendencia de los años de El Niño en la cuenca Amazónica Peruana.

15:15 - 15:30 : Molinier, M., Guyot, J. L., Cochonneau, G., Guimarães, V. S., and Oliveira, E. La variabilité hydrologique du bassin amazonien et la circulation atmosphérique océanique.

15:30 - 15:45 : Marengo, J. A. Interdecadal and long-term variability of the hydrometeorology of the Brazilian Amazon basin.

15:45 - 16:00 : Uvo, C. B. and Tölle, U. Comparison between linear and non-linear methods of forecasting discharge in the Amazon one season in advance.

Coffee break / 16:00 - 16:30

Fourth Session / 16:30 - 18:30 / Chairman : Dr. Carlos Tucci

16:30 - 16:45 : Seoane, R. and Obertello, I. Variación estacional de variables hidrológicas y su relación con eventos extremos del ENSO.

16:45 - 17:00 : Chavasse, D. I. and Seoane, R. Anomalías climáticas en una subcuenca del río Iguazú y predicción extendida de volúmenes.

17:00 - 17:15 : Flamenco, E. A Modelos de pronostico estacional en el Río Paraná (períodos Octubre-Marzo/Abril - Setiembre), basado en las temperaturas observadas de la superficie del Mar (TSM) y fenomeno ENOS (El Niño/Oscilación del Sur).

17:15 - 17:30 : Piovano, E. L., Depetris, P. J., and Probst, J. L. The hydrological signal of ENSO in the upper Paraná drainage basin.

17:30 - 17:45 : Paula, A. C. A Maré em ambientes estuarinos de interesse à navegação : caso Barra Norte do Rio Amazonas.

17:45 - 18:00 : Kosuth, P., Callède, J., Laraque, A., Filizola, N. P., Guyot, J L., and Seyler, P. Sea-tide effects on downstream Amazon River flows.

18:00 - 18:15 : Hida, N., Maia, J. G., Hiraoka, M., Shimmi, O., and Mizutani, N. River water level changes of the Amazon estuary at Breves, Caxiuanã and Abaetetuba.

18:15 - 18:30 : Kosuth, P., Blitzkow, D., Campos, I. O., Bueno, R. F., Correa y Castro, C. A., and Callède, J. Altimetric reference for Amazon area: first experiments.

Wednesday / Quarta Feira / Miercoles / Mercredi 17/11/99 am

Time Schedule for Topic 2 - Oral communications
Erosion, transport and sedimentation in large-scale river basins

First Session / 08:00 - 10:00 / Chairman : Dr. Robert Meade

08:00 - 08:15 : Walling, D. and Fang, D. Longer-term variability of sediment transport to the oceans .

08:15 - 08:30 : Aalto, R., Dunne, T., and Guyot, J. L. Geomorphic Controls on Andean Denudation Rates.

08:30 - 08:45 : Baby, P., Guyot, J. L., Deniaud, Y., Zubieta, D., Christophoul, F., Rivadeneira, M., and Jara, F. The High Amazonian Basin: tectonic control and mass balance.

08:45 - 09:00 : Filizola, N. P., Boaventura, G. R., and Guyot, J. L. Suspended Sediment Yield in The Brazilian Amazon Drainage Basin.

09:00 - 09:15 : Guyot, J. L., Filizola, N. P., Laraque, A., and Seyler, P. La variabilité saisonnière des flux sédimentaires dans le bassin de l'Amazone.

09:15 - 09:30 : Dunne, T., Mertes, L. A. K., Meade, R. H., Richey, J. E., and Forsberg, B. R. Sediment transport and floodplain storage along the Amazon River valley in Brazil.

09:30 - 09:45 : Irion, G., Müller, J., Keim, G., Mello, J. N., and Junk, W. J. The Late Quaternary river and lake Development in Central Amazonia.

09:45 - 10:00 : Keim, G., Irion, G., Behling, H., Junk, W. J., and Mello, J. N. The sediment deposits of Lago Calado, a Ria-lake in Central Amazonia (Brazil), as indicator for postglacial water level rise of the Amazon River.

Coffee break / 10:00 - 10:30

Second Session / 10:30 - 12:00 / Chairman : Dr. Jean Claude Olivry

10:30 - 10:45 : Laraque, A., Guyot, J. L., Filizola, N. P., and Seyler, P. Dynamique hydrologique et hydrochimique de la rencontre des eaux des rivières Solimões et Negro dans le bassin de l'Amazone.

10:45 - 11:00 : Vieira da Silva, R. C. and Goulart Pecly, J. O. Distribuição vertical de velocidades e concentrações de sedimentos no rio Solimões.

11:00 - 11:15 : Callède, J., Guyot, J. L., Kosuth, P., and Guimarães, V. S. Estimation de la vitesse de déplacement du fond de l'Amazone.

11:15 - 11:30 : Vieira da Silva, R. C., Moraes Novo, E. M. L., and Goulart Pecly, J. O. Potencialidades do uso de satélites para o monitoramento da concentração de sedimentos no rio Amazonas.

11:30 - 11:45 : Vinzon, S. B. An assessment of the Amazon Shelf sediment dynamics.

11:45 - 12:00 : Sidorchuk, A. The Hierarchical System Alluvial Relief of the Large Rivers.

Thursday / Quinta Feira / Jueves / Jeudi 18/11/99 am

Time Schedule for Topic 3 - Oral communications
Geochemistry of large-scale river basins

First Session / 08:00 - 10:00 / Chairman : Dr. Michel Meybeck

08:00 - 08:15 : Richey, J. E. and Victoria, R. L. Regional -scale biogeochemical cycles of the Amazon: A riverine perspective.

08:15 - 08:30 : Mounier, S., Benedetti, M., Benaim, J. Y., and Boulègue, J. Dissolved, colloidal and particulate organic carbon transport in the great Amazonian rivers: mixing and characterisation.

08:30 - 08:45 : Turcq, P. M., Seyler, P., Guyot, J. L., and Etcheber, H. Characterization of suspended particulates and dissolved adsorbed organic matter in Amazon river.

08:45 - 09:00 : Aufdenkampe, A. K., Hedges, J. I., Quay, P. D., Richey, J. E., and Krusche, A. V. Sorptive fractionation of organic matter in the Amazon basin: Consequences for nitrogen fluxes.

09:00 - 09:15 : Gadel, F., Serve, L., and Blazi, J. L. Biogeochemical characteristics of organic matter in waters of the Amazon river and its tributaries. Their evolution during the water mixing downstream Manaus.

09:15 - 09:30 : Patel, N., Mounier, S., Guyot, J. L., Benamou, C., and Benaim, J. Y. Behaviour of a little Solimões's tributary: the Purus.

09:30 - 09:45 : Fernandes, M. B., Elias, V. O., and Cardoso, J. N. Assessment on polar lipid levels and compositions on the Amazon shelf.

09:45 - 10:00 : Fernandes, M. B. and Sicre, M. A. n-Alkanes and PAHs discharged by the Ob and Yenisei Rivers into the Arctic Kara Sea shelf.

Coffee break / 10:00 - 10:30

Second Session / 10:30 - 12:30 / Chairman : Dr. Robert Stallard

10:30 - 10:45 : Gaillardet, J., Dupré, B., and Allègre, C. J. Chemical weathering mass budgets in the Amazon river Basin.

10:45 - 11:00 : Mortatti, J. and Probst, J. L. Chemical erosion of silicates in the Amazon basin.

11:00 - 11:15 : Brinkmann, W. L. F. Suspended sediment-bound trace consistuents of Rio Negro waters upstream Manaus-Amazonia.

11:15 - 11:30 : Seyler, P., Boaventura, G. R., Sondag, F., and Alves, V. P. Distribution and partition of trace elements in the Amazon mainsteam.

11:30 - 11:45 : Tao, F., Aucour, A. M., Sheppard, S., Benedetti, M., and Guyot, J. L. Mixing at the Rio Negro/Solimoes confluence: Isotopic constraints and major element redistribution.

11:45 - 12:00 : Gérard, M., Seyler, P., Sondag, F., Boaventura, G. R., and Benedetti, M. Rare Earth Elements in the Amazon Basin: Encontro das Aguas.

12:00 - 12.15 : Benedetti, M., Mounier, S., Benaim, J. Y., Boulègue, J., Seyler, P., and Filizola, N. P. Metal ions transport by colloids in the Amazon basin.

12:15 - 12:30 : Probst, J. L., Leleyter, L., Depetris, P. J., Haida, S., and Mortatti, J. Trace element and rare earth speciation in river sediments by new sequential extraction procedure. Implications for continental erosion and river transports into the oceans.

Thursday / Quinta Feira / Jueves / Jeudi 18/11/99 pm

Time Schedule for Topic 3 - Oral communications
Geochemistry of large-scale river basins

Third Session / 14:00 - 16:00 / Chairman : Dr. Pedro Depetris

14:00 - 14:15 : Meybeck, M., Vorosmarty, C., and Green, P. Towards typologies of major world river basins.

14:15 - 14:30 : Stallard, R. F. The Mississippi River Basin - An Examination of Major - Element, Nutrient, and Sedimentary Biogeochemistry as Related to the Global Carbon Cycle.

14:30 - 14:45 : Subramanian, V. Geochemical processes in the Ganges-Brahmaputra river system.

14:45 - 15:00 : Probst, J. L., Amiotte Suchet, P., Boeglin, J. L., Mortatti, J., and Ludwig, W. Silicate rock weathering and atmospheric/soil CO2 uptake estimated from river transports of alkalinity, cations and silica.

15:00 - 15:15 : Hieronymus, B., Godot, J. M., and Boulègue, J. Hydrochimie du fleuve Tocantins et de rivières côtières de l'est du Pará.

15:15 - 15:30 : Depetris, P. J. and Probst, J. L. The Geochemical Nature of the Paraná River Suspended Sediment Load.

15:30 - 15:45 : Ndam Ngoupayou, J. R., Sigha Nkamdjou, L., Braun, J. J., Meybeck, M., Dupré, B., Viers, J., Sighomnou, D., Lienou, G., Nia, P., and Molinier, M. Comparaison des transports de matières dans les écosystèmes tropicaux du Sud Cameroun: example des bassins des fleuves Nyong et Sanaga et de la rivière Dja-Ngoko.

15:45 - 16:00 : Torres, A. M. and Stattegger, K. Provenance of surface sediments of the Amazon mouth: interpretation from mineralogical and geochemical analyses.

Coffee break / 16:00 - 16:30

Fourth Session / 16:30 - 18:30 / Chairman : Dr. V. Subramanian

16:30 - 16:45 : Allard, T., Ponthieu, M., Filizola, N. P., Guyot, J. L., and Benedetti, M. Particulate and colloidal matter from the Rio Negro / Solimões mixing zone (Brazil) : insight from crystal chemistry.

16:45 - 17:00 : Delaune, M. Minéralogie des sédiments grossiers de l'Amazone : Origine et évolution en fonction des apports latéraux.

17:00 - 17:15 : Biggs, T. and Dunne, T. Stream chemistry and mesoscale land use change in the Amazon basin: Defining biogeochemical response units based on watershed properties.

17:15 - 17:30 : Forsberg, B. R., Rosenqvist, A., Richey, J. E., and Pimentel, T. P. Modeling spatial patterns of flooding and methane emission on the Jaú River floodplain using multitemporal JERS-1 SAR imagery.

17:30 - 17:45 : Glauber, A. J., Peralta, D. G., and Naiman, R. J. The Effects of Landslide Disturbance on Seasonal Cycles of Allochthonous Input to Peruvian Amazonian Headwaters Streams.

17:45 - 18:00 : Seyler, P. and Boaventura, G. R. How significant is the pollution of the Amazon basin by trace elements?

18:00 - 18:15 : Roulet, M. and Lucotte, M. Modern cycle of mercury in the Amazon.

18:15 - 18:30 : Maurice Bourgoin, L., Quemerais, B., Guyot, J. L., Laraque, A., and Seyler, P. Transport and behaviour of total mercury in the Amazon River at the confluence of black and white waters.

Friday / Sexta Feira / Viernes / Vendredi 19/11/99 am

Time Schedule for Topic 2 - Oral communications
Erosion, transport and sedimentation in large-scale river basins

Third Session / 08:00 - 10:00 / Chairman : Dr. Desmond Walling

08:00 - 08:15 : Meade, R. H. Large rivers and their floodplain as conveyors and storers of sediment. An overview.

08:15 - 08:30 : Laraque, A. and Olivry, J. C. Contribution des différentes unités physiographiques du bassin du Congo sur ses exportations de matières à l'Océan Atlantique.

08:30 - 08:45 : Alekseevskiy, N. and Sidorchuk, A. Total sediment yield of the Lena River, Eastern Siberia.

08:45 - 09:00 : Amsler, M. L. and Drago, E. C. A review of the suspended sediment budget at the confluence of the Paraná and Paraguay Rivers.

09:00 - 09:15 : Mortatti, J., Probst, J. L., Rodrigues, J. C., Milde, L. C. E., Ferraz, F. F. B., and Bortoletto, M. Erosion balance of the Piracicaba river basin (São Paulo, Brazil).

09:15 - 09:30 : Picouet, C., Hingray, B., and Olivry, J. C. Essai de modélisation du régime du transport particulaire sur les fleuves tropicaux d'Afrique : le Niger supérieur.

09:30 - 09:45 : Smith, L. C. and Sidorchuk, A. Hydrologic variability and floodplain sedimentation of major West Siberian Rivers.

09:45 - 10:00 : Sichingabula, H. M. Clastic sediment flux into the Indian and Pacific oceans by rivers in Central Southern Africa and Western Canada.

Coffee break / 10:00 - 10:30

Friday / Sexta Feira / Viernes / Vendredi 19/11/99 am

Time Schedule for Topic 4 - Oral communications
Ecohydrology of large river basins

First Session / 10:30 - 12:30 / Chairman : Dr. Jeffrey Richey

10:30 - 10:45 : Zalewski, M. Application of ecohydrological approach for restoration and sustainable management of river basin.

10:45 - 11:00 : Kreibich, H. and Kern, J. Studies on the Role of Nitrogen Fixation and Denitrification in the Floodplain Forest of the Várzea.

11:00 - 11:15 : Saxena, D. P. and Subramanian, V. Biogeochemical studies of the floodplain sediments of Yamuna river (tributary of Ganga) during recent past.

11:15 - 11:30 : Rosales, J., Bradley, C., Petts, G., and Gilvear, D. A conceptual model of hydrogeomorphological-vegetation interactions within confluence zones of large tropical rivers; Orinoco, Venezuela.

11:30 - 11:45 : Kosuth, P., Vauchel, P., Bader, J. C., and Lamagat, J. P. Respective effects of Climate Change and Anthropic Action on the modification of the annual extension of flooded areas along Senegal River Valley.

11:45 - 12:00 : McClain, M., Gomez Barrios, M., and Gonzales, M. Water Quality in the Peruvian Amazon: A Survey of Results from Environmental Impact Assessments.

12:00 - 12:15 : Wasson, J. G., Barrère, B., Guyot, J. L., Gourdin, F., and Binet, D. Hydro-écorégions et facteurs de contrôle physiques et chimiques des hydrosystèmes dans le bassin amazonien bolivien.

12:15 - 12:30 : Mendiondo, E. M. and Neiff, J. J. Ligaciones entre el régimen hidrológico y la productividad biológica en la planicie de inundación del Río Paraná.

Friday / Sexta Feira / Viernes / Vendredi 19/11/99 pm

Time Schedule for Topic 4 - Oral communications
Ecohydrology of large river basins

Second Session / 14:00 - 16:00 / Chairman : Dr. Maciej Zalewski

14:00 - 14:15 : Duchemin, E., Lucotte, M., Canuel, R., Almeida, D. C., Pereira, H. C., Dezincourt, J. D., and Queiroz, A. G. Reservoirs as an Anthropogenic Perturbation on the Carbon cycle.

14:15 - 14:30 : Rosa, L. P., Matvienko, B., Santos, M. A., Sikar, E. M., Lourenço, R. S. M., and Menezes, C. F. Biogenic gas production from major Amazon dams, Brazil.

14:30 - 14:45 : Maurice Bourgoin, L., Quiroga, I., Malm, O., and Courau, P. Total mercury distribution in the Bolivian tributaries of the Madeira River. Importance of the biomagnification process in the aquatic food-chain.

14:45 - 15:00 : Telmer, K., Costa, M., Araujo, E. S., Angélica, R. S., and Maurice, Y. Mercury in the Tapajós River Basin - The Significance of Suspended Sediments from Alluvial Gold Mining, Pará, Brazilian Amazon.

15:00 - 15:15 : Vink, R. J. Modelling human influence on heavy metal flow from source to river mouth: the Elbe.

15:15 - 15:30 : Viramontes, D., Descroix, L., Nouvelot, J. F., and Barrios, J. L. G. Variabilité des apports liquides et solides dans un grand bassin endoréique du Nord Mexique : le bassin Nazas-Aguanaval (92 000 km2).

15:30 - 15:45 : Haida, S. and Probst, J. L. Impact des barrages sur les transports dissous dans un bassin versant semi aride: Le Sebou (Maroc).

15:45 - 16:00 : Nasfi, F. H., Boujelben, A., and Ben n'Cir, H. Evolution Hydrologique du Bassin Versant de l'oued Zeroud.

Coffee break / 16:00 - 16:30

Third Session / 16:30 - 19:00 / Chairman : Dr. Newton de Carvalho

16:30 - 16:45 : Pouyaud, B., Diaz, C., Fraizy, P., and Maurice Bourgoin, L. Variabilité interannuelle des caractéristiques hydrologiques du rio Beni au site du projet de barrage de Angosto del Bala et conséquences prévisibles.

16:45 - 17:00 : Zahar, Y. and Albergel, J. Hydrodynamique fluviale de l'Oued Medjerdah à l'aval du barrage Sidi Salem. Evolution récente.

17:00 - 17:15 : Sanz Montero, M. E., Avendaño Salas, C., and Cobo Rayán, R. Influencia de los embalses en el transporte de sedimentos hasta el delta del río Ebro (España).

17:15 - 17:30 : Tucci, C. E. M. Potenciais impactos e o desenvolvimento do Pantanal.

17:30 - 17:45 : Silveira, A. L. L. Não-estacionaridade do escoamento do rio Jacuí/RS.

17:45 - 18:00 : Mwaura, F. Small Man-Made Reservoirs in Eastern Rift Valley, Kenya. Are they Valuable Common Property Resources or just a Source of Watershed Nuisance ?

18:00 - 18:15 : Maiga, H. A. and Gerbe, A. The Threat of Sand on the Niger River in Mali.

18:15 - 18:30 : Murty, K. S. Impact of major river valley projects: India.

18:30 - 18:45 : Ismagilov, H. A. Turbidity of Amudarya river in regulated conditions.

18:45 - 19:00 : Wei Wenshou and Hu Xunlun. Water Resources and Its Management in Tarim River Basin, China.

POSTERS

Tuesday / Terça Feira / Martes / Mardi 16/11/99

Topic 1 - Posters - 08:00 - 18:00
Hydrology of large-scale river basins

Alcázar, J., González, A., and Palau, A. A comparison of commonly used methodologies to determine minimum instream flow needs for rivers.

Asabina, E. Methodology for researching and exposing of significance of environmental factors in large river basins.

Bourges, J. and Carrasco, L. M. Los regímenes hidrológicos de la cuenca Amazónica de Bolivia.

Cordero, A., Severo, D. L., Terán, A. L., and Medeiros, P. A. Principais avanços no monitoramento da rede hidrológica da bacia do rio Itajai.

Diarra, B. Evolution de la pluviométrie et ses implications au Mali.

Eid, N. J. Balanço Hídrico Vertical Médio Mensal e Distribuído da Bacia Amazônica.

Fisch, G., Vendrame, I., and Albuquerque, V. F. Um modelo simples para estimativa de evapotranspiração horária aplicada em áreas de floresta e de pastagem na Amazônia.

Flamenco, E. A. and Kruse, E. Regimen hidrológico del Río Paraná (Argentina) y su relación con gases de efecto invernadero.

Galvani, E., Pereira, A. R., and Klosowski, E. S. Relações entre o Índice de Oscilação Sul (IOS) e o total mensal de chuva em Maringá-Pr.

Gamaro, P. E. M. ADCP Problemas ou Soluções.

Laraque, A., Guyot, J. L., and Cochonneau, G. La rencontre des eaux des rivières Solimões et Negro modèle en 3 dimensions.

Nelngar, Y. Variations des niveaux du Lac Tchad : les effets de la sécheresse dans le bassin du Chari.

Newton, B. E., Dunne, T., Elsenbeer, H., and Morais, J. M. The effects of land-use on runoff generation for hillslopes on deeply weathered Precambrian basement rocks in the state of Rondonia, Brazil.

Shermatov, E., Nurtayev, B. S., Yuldashev, T. U., and Raisov, B. O. Water resources variability of inland lakes at Central Asia.

Shumova, N. Volga river basin: generalize estimates of the evapotranspiration losses from agricultural fields.

Vivas, J. M., Escudero, H. M., and Carvajal, Y. Influencia de variables macroclimáticas asociadas al ENSO (El Niño Oscilación del Sur) en la hidroclimatologia del Municipio de Cali (Colombia).

Wednesday / Quarta Feira / Miercoles / Mercredi 17/11/99

Topic 2 - Posters - 08:00 - 18:00
Erosion, transport and sedimentation in large-scale river basins

Ferreira, C. A. B. and Carvalho, N. O. Análise da vida útil do empreendimento UHE Coaracy Nunes no Estado do Amapá.

Figueiredo, A. G. O transporte de sedimentos na bacia fluvial do Rio Aguapeí, afluente do Rio Paraná.

Grisales, C. L., Lozano, J. G., and Carvajal, Y. Análisis del efecto del Fenómeno ENSO en el transporte de sedimentos en dos ríos interandinos de Colombia (Cauca y Magdalena).

Orange, D., Laraque, A., and Olivry, J. C. Evolution des flux de matières le long de l'Oubangui et du fleuve Congo.

Soares, L. M. F., Jouanneau, J. M., Walling, D., Boaventura, G. R., and Guyot, J. L. Variabilidade das taxas de sedimentação na várzea de Óbidos.

Torra, R. Erosion velocity on the left margin of the Paraná river gullies'. Mesopotamia region. Northeastern Argentina.

Topic 5 - Posters - 08:00 - 18:00
Towards hydrological and biogeochemical models of large-scale basins

Miranda, G. Modelo matemático para pasar la información pluviométrica a información menor a 24 horas y su aplicación en caudales máximos en la cuenca del Río Uchusula Mizque.

Odiyo, J. O. and James, C. S. Modelling process driven sediment storage response in typical pool-rapid channel types.

Ordoñez Galvez, J. J. Modelo regional de simulación de niveles en rios amazónicos.

Peña, A., Ayuso, J. L., and Giráldez, J. V. Influencia de la topología de la red de desagüe en la respuesta hidrológica de una cuenca.

Puentes, A., Ayuso, J. L., Peña, A., and Giráldez, J. V. Caraterización de la respuesta unitaria de una cuenca tropical.

Swain, P. C. and Umamahesh, N. V. Artificial neural networks for streamflow forecasting.

Thursday / Quinta Feira / Jueves / Jeudi 18/11/99

Topic 3 - Posters - 08:00 - 18:00
Geochemistry of large-scale river basins

Dessert, C., Dupré, B., Oliva, P., Gaillardet, J., Bajpayee, S., and Chakrapani, G. J. Chemical weathering of Deccan traps determinated by river geochemistry. Impact on the CO2 cycle and the transport of material to the ocean.

Ibañez, M. S. R. and Aranha, F. J. Limnology of a pre-Amazonian river basin (Itapecuru, MA).

Llerena, C. A. and McClain, M. AARAM Perú - Hidrología y biogeoquímica de la cuenca andino-amazónica del río Pachitea.

Maurice Bourgoin, L., Seyler, P., Elbaz Poulichet, F., and Gasc, F. Trace elements distribution in the Andean sub-basins of the Madeira river : role of the weathering processes in the freshwaters geochemistry .

Pereira, S. B. and El-Robrini, M. Aspectos geoquímicos do material particulado da plataforma continental do Amazonas.

Quintanilla, J., Maurice Bourgoin, L., and Guyot, J. L. Evolución espacio temporal de la hidrogeoquímica de la cuenca amazónica de Bolivia.

Salomão, M. S. M. B., Molisani, M. M., Ovalle, A. R. C., Rezende, C. E., Lacerda, L. D., and Carvalho, C. E. V. Particulate heavy metal dynamic and mass balance in the lower Paraíba do Sul river watershed, Southeastern, Brazil.

Scribe, P., Briand, G., and Pèpe, C. Biogeochimistry of organic matter transfered from various soils to rivers in small tropical draining basins (Manaus, Brazil).

Friday / Sexta Feira / Viernes / Vendredi 19/11/99

Topic 4 - Posters - 08:00 - 18:00
Ecohydrology of large river basins

Almeida, D. C., Duchemin, E., Lucotte, M., Queiroz, A. G., Silva, H. C. P., Dias, J. D., Canuel, R., and Silva, E. C. R. Emissão de metano através do fluxo de bolhas do reservatório tropical de Curuá-Una, Estado do Pará, Brasil.

Bernal, N. A. H. Disponibilidad y distribución de agua para la generación de energía hidroeléctrica por grandes vertientes en México.

Cabo, L., Puig, A., Arreghini, S., Olguin, H. F., Seoane, R., and Obertello, I. Physicochemical parameters and plankton in the Lower Delta of the Paraná River in relation with flow.

Carvalho, N. O., Silva, J. T. N., and Palma, L. N. Avaliação do assoreamento do reservatório de Itá, no Rio Uruguai, e programa de monitoramento.

Chembarisov, E. I. Basin landscape geochemical method for calculating mineralization of water: example of the Syrdarya river.

Dollar, E. S. J. Fluvial geomorphology as an aid to river management and conservation in South Africa.

Domingues, T. F., Ometto, J. P. H. B., Martinelli, L. A., Krusche, A. V., Bernardes, M. C., Ballester, M. V., Camargo, P. B., and Victoria, R. L. Biogeochemistry of two southeastern Brazilian meso-scale watersheds under different anthropogenic influences.

Kambarov, B. F. Conservation soil and water resources.

Maco, J. G. Hidrología y contaminación de los rios de la Amazonía andina por las actividades antrópicas.

Magalhães, M. D., Figueiredo, A. M., and Laraque, A. Balbina, 10 anos depois...

Morais, S. S., Roulet, M., Sousa Passos, C. J., and Duchemin, E. Mercury contamination in fish of an old Amazonian reservoir (Curuá Una).

Palau, A. Evolución de la fisico-química del agua durante las operaciones de vaciado total del embalse de Barasona (Río Esera, Huesca).

Prasad, G. K. and Rajamani, V. Biogeochemistry of the Cauvery flood plain sediments, southern India: Implications to their origin and farming .

Rios, A. J. W., Tarapanoff, I., and Del'Arco, J. O. Diagnóstico ambiental da bacia do Rio Araguaia (Área Piloto) - Mapa de vulnerabilidade natural das terras.

Shirokova, Y., Forkutsa, I., and Stulina, G. The problems of the rivers pollution of Uzbekistan.

Sighomnou, D., Sigha Nkamdjou, L., and Molinier, M. Influence des prélèvements pour irrigation sur l'hydrosystème du Lac Tchad. Exemple de la SEMRY au Cameroun.

EXCURSIONS
EXCURSÕES
EXCURSIONES
EXCURSIONS

Wednesday / Quarta Feira / Miercoles / Mercredi 17/11/99 pm

EXCURSION FOR ALL PARTICIPANTS
EXCURSÃO PARA TODOS OS PARTICIPANTES
EXCURSIÓN PARA TODOS LOS PARTICIPANTES
EXCURSION POUR TOUS LES PARTICIPANTS

"Encontro das Águas"

Departure from the Manaus Tropical Hotel :	14:00
Return to the Manaus Tropical Hotel :	19:00

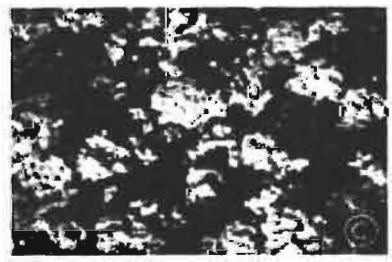
Saturday / Sábado / Sabado / Samedi 20/11/99

EXCURSION / EXCURSÃO / EXCURSIÓN / EXCURSION

1. ADCP Discharge Measurement at Manacapuru

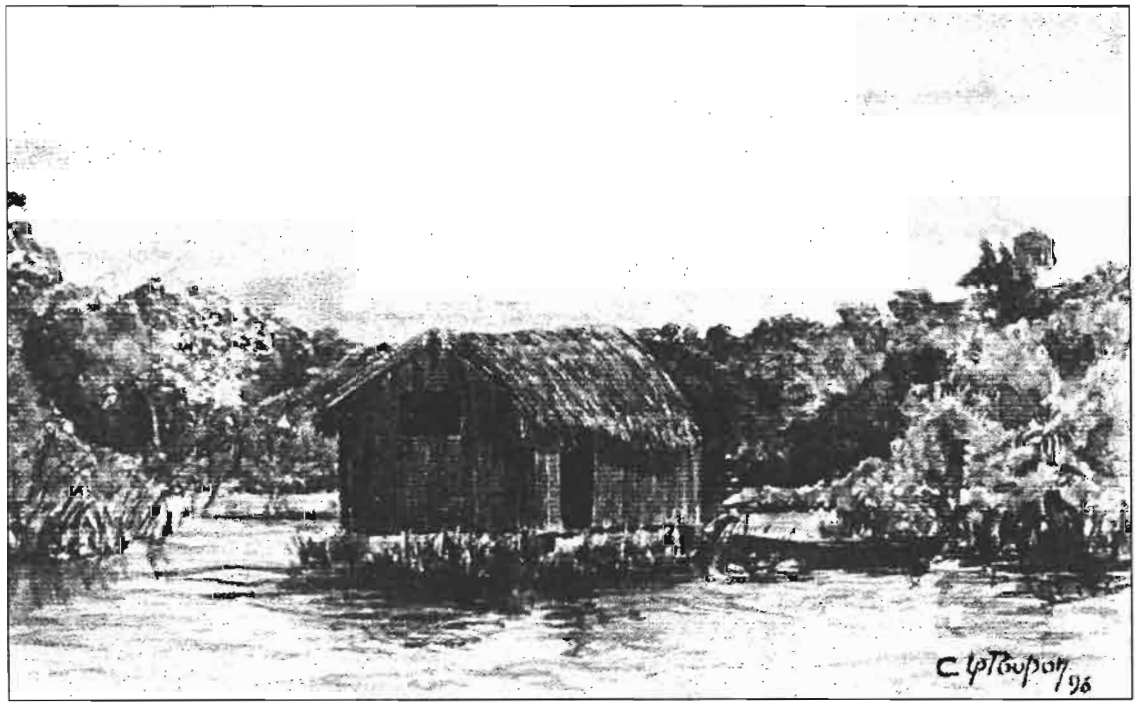
2. Rio Negro and Anavilhanas Islands

3. Floresta Tropical no Lago salvador



4. Technical Tour at Balbina Dam

ABSTRACTS
RESUMOS
RESUMENES
RÉSUMÉS



Geomorphic controls on Andean denudation rates

R. AALTO, T. DUNNE, J.L. GUYOT

While Andean rivers supply over 99% of the total sediment load for the Amazon basin, only a fraction of this material reaches gauged tributaries of the mainstem Amazon river; an unknown amount is deposited in large foreland basins along the range front. We present a regression analysis of sediment discharge for Bolivian basins which concludes that mean catchment hillslope and lithology account for up to 88% of the variance in yield. Unlike previous studies of fluvial denudation rates for large basins throughout the world, our analysis finds erosion rates uncorrelated to either basin area or elevation, both non-physical parameters that often show strong but spurious correlation when continental-scale basins are treated as geomorphically-homogeneous units. By identifying and separating zones of production (e.g., steep topography and weak lithology) from zones of storage and deposition (e.g., foreland basins and cratonal shields), mass flux sources can be isolated for a more rigorous standard of denudation analysis. For these erosional basins, runoff is not correlated with denudation, suggesting that river incision into bedrock may be driven more by bedload scour than by the stream power of water alone. Theoretical models of mass-wasting are tested to estimate cell-based yield from the individual hillslope pixels of a digital elevation model. The best-fit model (R^2 = 92%) predicts an annual Andean sediment flux to the Amazon Basin of 3.0 Gtonnes. Since ~ 1.3 Gtonnes/a of sediment reach the lower mainstem Amazon river, the intervening foreland basins intercept over half of the total mass flux out of the Andes.

We present a procedure for mass flux analysis in large, continental-scale basins. By separating the Amazon Basin into geomorphic process zones, we are able to focus our attention on appropriate process rates in the rapidly-eroding region that supplies most of the sediment: the Andes of Bolivia, Columbia, and Peru. After selecting erosional Bolivian basins that are demonstrably free from major sediment sinks and the non-physical scaling effects of basin area, we can test geomorphic models of mass wasting and determine which physical parameters best predict modern denudation rates: lithology and average hill slope. The statistical unimportance of runoff in determining erosion rates is both perplexing and complex, especially given the range of our runoff data (16-2700 mm/y); we explore this conundrum and the intriguing relationship between runoff and mean basin slope. We test various deterministic cell-based mass flux models to identify which best predicts present-day erosion rates for our study basins. Our model can easily be applied to estimate flux rates for similar ungauged basins elsewhere in the Andes.

This initial success is encouraging, suggesting that this approach to mass flux modeling is viable and may improve further as new high-resolution digital elevation data become available, such as the 25m NASA SRTM DEM, which would enable more appropriate modeling of hillslope mass wasting processes. We can refine our lithologic index with a comparison of field-measured rock strength (using a Schmidt hammer) to local rock type and observed rate and process of hillslope failure. An improved mass-flux model employing a globally-consistent data set could feasibly be applied outside of the relatively uniform climate and lithology of the Andes to predict denudation rates elsewhere in the world.

Finally, the strategy of breaking large, continental-scale basins into geomorphic process zones is now being applied farther downstream to study rates of sediment transport and deposition on a reach-scale characterized by homogenous processes and morphometry (e.g., valley slope, sinuosity, discharge, lateral migration rate, and channel and floodplain width). By quantifying first-order transport and trap efficiency of reach-scale segments of lowland fluvial systems, we may be able to better understand and model problems of intracratonal mass flux and sediment discharge to the oceans.

A comparison of commonly used methodologies to determine minimum instream flow needs for rivers

J. ALCÁZAR, A. GONZÁLEZ, A. PALAU

Three different approaches have been made to study instream flow needs for rivers, resulting in what we call hydrologic (historical discharge based methods), hydraulics (cross-section methods), and hydro-biological (habitat simulation methods) techniques. Hydro-biological techniques have gained increased recognition and are widely accepted currently. They are based on simulation techniques that describe physical river habitat for some species as a function of streamflow variables, such as depth and water velocity, and streambed materials. These variables are strongly related to streamflow regimes, and we can define them as dependent variables in equations where the only independent variable is the river flow.

In this paper, the Basic Flow methodology, as well as other commonly used methodologies including hydrologic, hydraulic, and hydro-biological techniques, are applied to 7 river reaches at the Ebro Watershed (north eastern Spain) to simulate physical habitat conditions created from the minimum flow proposed by each technique. The Basic Flow method, which is based on the application of the simple moving average forecasting model as the tool to get the information from hydrological series of daily mean flows, provided acceptable physical habitat conditions that meet standard requirements from literature. Furthermore, it has major advantages over other methodologies, such as objectivity, lack of arbitrariness, and it seems to have a biological meaning at least in the calculation process. Besides, it is easy to apply (it has been programmed in a PC), fast obtaining results, and cost-efficient, so it seems to be a good methodology to apply when determining instreamflow needs for rivers in regulated river management.

Total sediment yield of the Lena River, Eastern Siberia

N. ALEKSEEVSKIY, A. SIDORCHUK

Lena River is one of the largest on the globe. Its length is 4400 km (world 10th), basin area is 2490000 km^2 (world 8th), mean discharge is 17000 m^3/s (world 8-9th), maximum discharge is 178000 m^3/s (world 2nd). The area of alluvial delta of the Lena River in the Laptev Sea is about 20000 km^2 (world 5-9th), despite a very young age (about 4000 - 6000 years) of this sedimentary body. That shows a very high rate of sediment yield from the river mouth during the second part of the Holocene.

Suspended sediment yield is measured by Russian Hydrometrical Survey beginning 1967 at Kusur station (basin area is 2430000 km^2, or 97.6% of the whole). With the help of sediment concentration / discharge relationship the sequence of mean annual suspended sediment yield was calculated for the whole period of hydrometrical observation in Kusur from 1935. The calculated mean annual yield is 19 106 t, with the maximum 43 10^6 t in 1961 and minimum 5 10^6 t in 1952. For such river the suspended sediment yield to the ocean is very low, and can not explain the formation of a large river delta.

Bed load transport is very intensive at the Lena River. Bottom alluvial sediments at the lower reaches consist mainly of fine sand. It is transported in form of hierarchical system of alluvial features: ripples, dunes, bars and islands. Special measurements of ripple dynamics on the Lena River near Yakutsk (1700 km from the river mouth) showed bed load specific discharge 20-25 t/m per day. Original method to calculate sediment transport was worked out. Morphology and dynamics of the whole system of alluvial forms in the river is used for bed load calculations with this method. Calculated mean annual bottom sediment yield is about 20 10^6 t.

Total sediment yield at the lower reaches of the Lena River is about 40 10^6 t per annum, and 50% of this quantity is bed load. Relatively high transport of sandy sediment explains complicated alluvial relief of the Lena River channel and high rate of the river delta formation.

Particulate and colloidal matter from the Rio Negro/Solimões mixing zone (Amazonia, Brazil) : insight from structural chemistry

T. ALLARD, M. PONTHIEU, N. FILIZOLA, J.L. GUYOT, M. BENEDETTI

At the Earth's surface, elements are mobilized during alteration and erosion processes, and exported mainly via rivers towards oceans as particulate, colloidal and dissolved forms. A major contribution to these exportations at global scale originates from intertropical area, and the interpretation of mass balance requires the understanding of trapping and mobilization of elements as solid matter. This study focuses on particulate and colloidal matter in the mixing zone of Rio Negro and Solimões, which form Amazon river. Previous geochemical studies reported a non conservative partition of some elements including metals, resulting from mixing of waters with contrasting chemistries and suspended matter contents. Our objective is to understand the role of transported solids, in relation with redistribution of elements. This requires to determine the nature and proportion of solid phases in the particulate and colloidal fractions, together with their fate during mixing of waters.

Samples were collected in September 1997 during one of the cruise of the Hibam project in both Rio Negro and Solimões (end members) and at several km distances downstream. Tangential flow ultrafiltration was used to concentrate particulate (63µm-0.2µm) and colloidal (0.2 µm-5kD) fractions. Grids for Transmission Electron Microscopy (TEM) were prepared in the field by embedding aliquots of water in hydrophilic resin. Solid matter was further separated in the laboratory by ultracentrifugation and ultrafiltration of supernatents (5 kD cuttoff).

Owing to the nature of transported phases (crystalline, amorphous, mineral and organic), this study requires the combination of traditional tools (X-ray diffraction, TEM) and spectroscopies sensitive to local structural order and having low detection limits (Fourier transformed infrared spectroscopy, UV-visible spectroscopy, Electron Paramagnetic Resonance (EPR)). The nature of transported solids in the particular fractions is known to consist of phases inherited from soils (clays, quartz, iron oxy-hydroxides, organic matter...), in various proportions according to their origin. Impurities and defects can reveal several generations of the same mineral in materials from the Earth's surface (Muller et al., 1995). They provide probes for studying particle mixture in the studied zone. By comparison to the particulate fractions, the colloidal fractions are more organic in all samples, but still contain crystalline phases such as kaolinite or quartz. In addition to the nature of colloids, attention is paid specifically to speciation of ferric iron as determined through EPR spectroscopy. Indeed, using this methodology for suspended matter from organic-dominated streams (Cameroon), an important colloid-mediated transport of ferric iron as Fe3+-Organic matter complexes and amorphous oxides was recently quantitatively evidenced (Olivié-Lauquet et al., 1999). Results are coupled to geochemical analyses and discussed by reference to the degree of water mixing.

Emissão de metano através do fluxo de bolhas do reservatório tropical de Curuá-Una, Estado do Pará, Brasil

D. C. ALMEIDA, E. DUCHEMIN, M. LUCOTTE, A. G. QUEIROZ, H. C. P. DA SILVA, J.D. DIAS, R. CANUEL, E.C.R. SILVA

Reservatórios de hidrelétricas são responsáveis por causar a pertubação em grande escala da troca de carbono entre a biosfera - atmosfera. Medidas realizadas em alguns reservatórios tropicais demonstraram que eles são importantes fontes de gases do efeito estufa. O metano (CH4), considerado um dos principais gases do efeito estufa, têm como fontes ambientais importantes os lagos tropicais e ambientes inundados. O mecanismo crítico da emissão de metano por ambientes tropicais aquáticos acontece através de bolhas. O objetivo desse estudo foi avaliar os níveis de emissão de metano no reservatório da Usina Hidrelétrica de Curuá - Una, um reservatório com 21 anos de inundação localizado a 80 Km ao Sul de Santarém. As campanhas de amostragens foram realizadas em Fevereiro de 97 com nível de água no reservatório alto e, Maio e Setembro de 98 com o nível de água do reservatório considerado baixo. Bolhas evasivas foram medidas usando funis coletores de 1m de diâmetro. Os resultados mostram 65 mg/ m2/ dl (n=55) para Fevereiro de 97, 11 mg/ m2/ dl (n=15) para Maio de 98 e 95 mg/ m2/ dl (n=24) para Setembro de 98. Os primeiros resultados são considerados baixos em relação a dois outros reservatórios tropicais: Gatun Lake no Panamá e Petit Saut na Guiana Francesa onde foram feitos estudos com o CH4 através do fluxo de bolhas. Contudo não existe nenhuma relação entre emissão de metano e profundidade, porém descobriu-se uma relação entre a variação do nível de água e as emissões. O estudo das emissões do CH4 em reservatórios tropicais são importantes para se conhecer futuramente o aumento desse gás na atmosfera contribuindo para o efeito estufa, sendo o fluxo ebulitivo um importante mecanismo para a emissão desse gás.

A review of the suspended sediment budget at the confluence of the Paraná-Paraguay Rivers

M.L. AMSLER, E.C. DRAGO

Drago and Amsler (1988), computed the concentration charges of suspended sediment transported along the Paraguay-Paraná hydrosystem during its period of maximum solid discharges. They showed that the concentrations in the Paraná River downstream of the Paraguay River mouth, increased as much as 60 % due to the sedimentary load supplied by the Bermejo River to the Paraguay mainstem, 80 km upstream its confluence with the Paraná River.

This conclusion arised from a careful analysis of available concentrations data obtained during the 1970 decade at several cross-sections of the Bermejo, Paraguay and Paraná rivers. At that time, the large dams of Itaipú and Yaciretá were not still built on the Upper Paraná River, thus their influences on the sediment transport of this last river were not present in the computations of Drago and Amsler (1988).

In this paper the sediment budget reported by these authors is updated on the base of new suspended sediments concentrations data measured during the nineties, after the construction of the cited large dams at properly located cross-sections. With these data and under the assumption that the sediment loads supplied by the Bermejo and Paraguay rivers did not change (there were not built large dams on these rivers during the last thirty years), it was possible to know a decreasing of the suspended sediment transport in the Upper Paraná River owing to Itaipú and Yaciretá reservoirs. As a consequence of this result, it was computed the increased influence of the sediment load delivered by the Bermejo River on the solid discharges transported along the middle and lower reaches of the Paraná River.

Methodology for researching and exposing of significance of environmental factors in large river basins

E. ASABINA

This methodology was used for studying how environmental factors effect on hydrological regime in basins of Niger and rivers of coastal area of Cameroon.

There are two characteristics in generating conditions of hydrological regime in large watersheds:

1. Large rivers flow through different natural zones with unlike climatic conditions and have complex polyzonal regime. So the influence of several environmental factors is smoothed in large watersheds.

2. Total runoff from large watersheds consists of cumulative runoff of average and small rivers, i.e. the large basin may be considered as aggregate of smaller ones. Just within the boundaries of large river basin notation of local and transit runoff takes sense.

Climatic factors such as air temperature, evaporation, precipitation, etc., concern to number of zonal factors. Another group of geographical factors named azonal are caused by their different origin in the geological past. Azonality reflects in heterogeneity of relief, geological texture, stream network, soils, vegetation, etc. Zonality and azonality are opposite sides of common development process of geographical systems.

Zonal characteristics expose more distinct in hydrological regime of average rivers, which basins are representative for specific zone. The average rivers flow mainly in homogeneous location and have simple regime therefore. Azonal characteristics reflects in regime of small rivers and streams very much.

The simple technique to expose several environmental factors is supposed to understand and estimate their influence on runoff. It supposes to determine zonal parameters primarily, i.e. the runoff characteristics where influence of local (azonal) factors is excluded.

The methodology for researching of hydrological processes in large watersheds lets to account all of peculiarities of regime resulted from diversity of natural conditions. Its nucleus is in accounting of the circumstance that hydrological characteristics of studied smaller watersheds are typical for different landscapes. So the hydrological characteristics may be distributed on unstudied watersheds with similar landscape because ratios of elements of hydrological regime and water balance stay rather constant in homogeneous natural conditions and in many years duration. This state is very important because it excludes necessity to do hydrological observations in every individual streams.

Sorptive fractionation of organic matter in the Amazon Basin: Consequences for nitrogen fluxes

A.K. AUFDENKAMPE, J.I. HEDGES, P.D. QUAY, J.E. RICHEY, A.V. KRUSCHE

The significant role of sorption to mineral surfaces is one of the most important new insights in natural organic matter dynamics. Fine minerals in most soils, suspended river sediments and marine shelf sediments have uniform surface-associated organic coatings of 0.5-1.1 mg C m-2 that are largely protected from otherwise rapid degradation for as long as they remain sorbed (Hedges and Keil, 1995). Thus, understanding the processes that form and maintain this sorbed organic matter is important to cycles of bioactive elements at both regional and global scales.

In the Amazon and other major rivers of the world, about 90% of transported organic matter is either sorbed to fine minerals or has remained dissolved (Meybeck, 1982 & 1993; Keil et al., 1997), yet the compositions of these two fractions are quite different. Relative to co-existing dissolved organic matter (DOM), fine particulate organic matter (POM) consistently has lower carbon to nitrogen ratios, higher total amino acid concentrations and higher ratios of basic to acidic amino acids (Hedges et al., 1994). In addition, the stable carbon and nitrogen isotope composition are rarely alike at the same location, with fine POM depleted in both 13C and 15N relative to DOM for all lowland Amazon samples measured to date by our group (Quay et al., 1992). Despite the vastly different residence times of dissolved and particulate OM, nitrogen and amino acid patterns have been used to implicate preferential sorption of these components. On the other hand, isotopic observations have been interpreted solely as source indicators.

This study examines whether biochemical and isotopic fractionation of DOM components occurs during sorption to mineral surfaces, thus determining the OM compositional trends observed in the Amazon Basin and other river systems. To test this hypothesis, changes in DOM and POM compositions during sorption were directly measured in a set of nine laboratory experiments, in which natural suspended river sediments and organic-free kaolinite were mixed with various natural DOM samples from the Peruvian Amazon. Analyses of dissolved and particulate organic carbon, nitrogen, hydrolyzable amino acids, □13C and □15N were used to directly trace molecular-level fractionation.

In every case, nitrogen was preferentially taken into the POM fraction relative to the parent DOM, as were total hydrolyzable amino acids with respect to total organic carbon and total nitrogen. Particulate amino acid compositional patterns indicated preferential sorption of basic amino acids with positively charged nitrogen side chains and to a lesser extent those with hydrophobic side chains. In short, we have recreated in a beaker all the various organic nitrogen compositional patterns of the Amazon Basin. While conjectured from river samples, this is the first direct evidence for preferential uptake of naturally-occurring nitrogenous DOM by suspended riverine minerals.

Additional experiments are currently being conducted to determine the relative extents to which microbially-mediated processes versus purely abiotic sorptive processes contribute to the observed selective uptake of nitrogen into POM. Because incubations lasted 24 hours at 30□C, numerous generations of microbial colonies should have been able to leave behind biofilms and necromass. Whereas microbial biomass alone could not account for the concentrations seen, bacterial exopolymers and cell wall remains could be quantitatively and qualitatively important.

This study demonstrates that the fractionation effects of sorptive processes need to be taken into account when comparing differences in OM composition between phases, and highlights the need to understand the dynamics of exchange between phases in future conceptual and quantitative models.

A hydrological model for assessing global warming effects on hydrological regimes of catchments with scarce data

J.R.G AZEVEDO, T.W. TANTON, D. CLARKE

This paper describes a simulation model to evaluate the potential effects of global warming on the hydrological regime and the potential for irrigation and hydro power generation of the Sao Francisco River Basin in the Northeast of Brazil. This basin was chosen because of the vital importance of its water resources for energy generation and crop production for this part of Brazil. The Sao Francisco River basin has an area of 640 thousand km^2, equivalent to 7.5% of the Brazilian territory, a length of about 2700 km and a mean annual volume of 84 billion m3. Because of the scarcity of hydrological and climatological data in the Northeast of Brazil an empirical-statistical hydrological model relating river discharge to both temperature and precipitation was developed. The river basin was divided into twelve main sub-basins. Eight are large sub-basins drained by major tributaries and the remaining four reaches are on the main river, their length largely being dictated by the presence of dams. In the version of the model presented a hydrological simulation was developed for the 27442 km^2 Velhas River sub-catchment, using the Least Squares Method to calculate a multiple linear regression relationship between discharge and both temperature and precipitation The relationship when used in a whole catchment model with a +2 degree rise in temperature and precipitation varying between 80% and 100% of the current levels, suggests that there would be a decrease in discharge of between -33% and -19% percent and resulting in a loss of power generation of between -33% and -21%. A validation procedure was carried out and the model presented a reasonable level of agreement with other data sets. A sensitivity analysis was also carried out and the model results compared with those obtained from two different works, which employed conceptual hydrological models. The proposed hydrological model performed reasonably well and could be a good alternative for catchments with scarcity of data.

Le bassin d'avant pays des Andes amazoniennes Contrôle tectonique et bilans de masse

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Le bassin d'avant-pays andin a commencé à se développer il y a environ 27 Ma, mais le système de drainage transcontinental de l'Amazonie s'est mis en place il y a seulement 6 Ma à la suite d'une forte accélération de la surrection des Andes. Depuis cette époque, la paléogéographie a peu changé et le bassin d'avant-chaîne des Andes boliviennes, péruviennes et équatoriennes constitue la bordure ouest et l'alimentation du grand bassin amazonien. Le piégeage des sédiments continentaux dans cette partie du bassin amazonien est directement contrôlée par l'avancée du front orogénique andin et donc par les processus d'interactions tectonique-érosion-climat qui le dirigent.

L'étude géologique réalisée au pied des Andes à partir d'observations de terrain, d'analyses de forages pétroliers et de sismique réflexion, a permis de caractériser deux cas extrêmes (Nord-Bolivie et Equateur) dans le fonctionnement du bassin d'avant-pays amazonien. Les bilans de masse de sédiments piégés - dans ces 2 cas extrêmes - à l'échelle du million d'année sont corrélés aux bilans actuels obtenus à partir de l'étude hydrologique du grand bassin amazonien.

En Bolivie, durant les 6 derniers millions d'années, le front orogénique qui s'est déplacé vers l'est de 85 km en chevauchant la plaque brésilienne, a provoqué par sa surcharge une forte subsidence du bassin d'avant-pays et d'importants taux de sédimentation.

A l'opposé, le bassin d'avant-pays équatorien qui a été déformé par une tectonique en décrochement (transpressive), s'est soulevé et a été soumis à l'érosion, alimentant ainsi les zones subsidentes plus méridionales du grand bassin amazonien.

Integrated ecohydrological modelling in the Elbe river basin in Germany

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Global and regional water and biogeochemical cycles are not enough understood and need to be further investigated. This also concerns the terrestrial and fluvial parts of these cycles, i.e. water and associated fluxes of material and solutes in river catchments and fluvial systems at different space and time scales.

The model SWIM (Soil and Water Integrated Model) has been developed for this purpose. It represents a continuous-time semi-distributed model, which is capable of simulating hydrological processes, vegetation growth, erosion and nutrient dynamics (nitrogen, N and phosphorus, P) with a daily time step at river basin scales (mesoscale basins having drainage areas between about 100 and a few thousand km²). A three-level scheme is used for the areal discretisation of the land surface in modelling, namely into river basins - subbasins - hydrotopes, plus a vertical subdivision of the root zone into a maximum of 10 layers to be derived from available soil data bases. A hydrotope (or Hydrological Response Unit, HRU) is defined as a set of elementary areal units having the same land use and soil type. SWIM has an interface to the GRASS GIS, which represents a modification of the GRASS interface of the USDA model SWAT. This interface is used to initialize the model by using spatially distributed GIS-data of elevation, land use, soil, hydrogeology, climate, and the routing structure (related to the river network structure). All hydrological, geochemical, and relevant vegetation growth processes at and below the land surface, including essential component processes and systems, are taken into account in the modelling, some in rather detailed, distributed, process relevant form as, for instance, the hydrotope related dynamics of soil water and vegetation, others in a more simplified way. This combination of component models allows the SWIM model system to be classified as rather robust. It further facilitates the application in larger river basins and in particular the determination/estimation of model parameters.

SWIM has been applied for integrated hydrological, vegetation growth and water quality modelling in a number of tributary basins of the German part of the Elbe river basin (about 100 000 km²). Selected results of these applications will be presented and discussed to illustrate the performance capabilities of SWIM. In addition to examples of model validation, recent results of some impact analyses will also be presented. They use scenarios of climate change as expected for the coming fifty years in the region as model input. Finally some general conclusions concerning the large scale application of SWIM and the extrapolation of results will be drawn.

Metal ions transport by colloids in the Amazon basin

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Organic colloids play a very important role in the geochemistry of major and trace elements in surface and soil waters. They may change mineral sorbent properties by coating and they may affect the speciation of minor and trace elements in surface, lake, sea, and interstitial waters. Adsorption and chelation of trace metals by dissolved (DOC<0.45 μm) and colloidal organic carbon (5000 Dalton < DOC < 0.45μm) influence the bioavailability, toxicity and transport in rivers. Size fractionation by ultrafiltration coupled with the complexation capacity measurements is a powerful tool to gain knowledge about trace element speciation in aquatic systems. Here we report the distribution of DOC, which passed initially through a 0.20μm filter membrane. The distribution and the degree of association of major and trace elements with the discrete size fractions are presented. Samples were taken in brazil 1996-97-98 during various cruises on the Rio Negro and on the Amazon river from Manaus to Santarem. Surface water samples were taken and treated on board with sequential cross flow ultrafiltration (ultrasart from Sartorius). All samples were treated in the same way: 50 liters of water were filtered using clean ultrafiltration membranes with the molecular cutoffs of 0.2μm, 100kD and 5kD. All membranes were cleaned in the lab with 50 liters of MQ water. In the field the first 5 liters were systematically discarded to prevent sample contamination during the filtration. Total C and metal ion (Na, K, Ca, Mg, Al, Fe...) concentrations were measured in each concentrated fraction and as well as in the permeate. Metal ions were determined by ICP AES and GFAAS. Total organic carbon and dissolved organic carbon were determined with a Dohrman 80 analyser. Mass balance calculations indicate a good recovery of carbon and metal ions (>80%). Total metal complexing capacities (TMCC) were determined by fluorescence quenching at pH 5 using Copper as a quenching probe. The distributions of the C and the metal ions are expressed as the percentage of the sum of the different fractions (i.e.; particulate P <0.22μ, colloidal 5000D < C < 0.22μ, and dissolved D < 5000D). For the Rio Negro the colloidal fraction represents 30 to 10 % of the total organic carbon. Particulate and colloidal carbons account for at least 60% of the total organic carbon. In the Rio Solimões and the Amazon after Manaus the dissolved organic carbon represents more than 75 % of the total organic carbon. Thus carbon flux at Obidos once the mixing is completed is essentially due to dissolved organic carbon. The distributions of major and trace elements are also expressed as the percentage of the sum of the different fractions (P, C, and D). Three groups of elements can be distinguished. The group of Na and Si, both elements are found in the dissolved fraction. The group of Mg, Ca, K, for which 50 % of the total amount of each element is found in fraction D while 15% and 35 % are found in fractions C and P, respectively. The group of Al and Fe which are found in the particulate fraction at 99% for all river samples. Complexing properties of the different fractions (i.e. P, C, and D) vary from one river to an other. In black rivers 67% of the TMCC is due to the fraction C. For white rivers (Solimões, Madeira) it ranges from 24% to 0%. The fraction P accounts for 0 to 30% of the metal ion complexing capacity for all rivers. The fraction D accounts for most of the metal complexing capacity for white rivers. This conclusion is not confirmed by the distribution of Fe and Al in the fractions below 0 2μm. Ninety to 80 % of the concentration of both metal ions is located in the colloidal fraction (C1+C2) and not in the dissolved fraction (D). The strong affinity of Al and Fe for organic ligands is well known. Their distribution may confirm the presence of organic colloids with a specifically high affinity for metal ions. A similar result was previously obtained for small rivers where in the watershed podzolization processes were occurring. However, here in fraction C1 the high concentrations of Fe and Al could also be due to the presence of sub-micron sized Fe or Al oxy-hydroxides. Such minerals were observed by TEM in similar water samples. The association of positively charged oxides at the pH of the samples with negatively charged organic matter could explain the similar distribution of Fe, Al and C for those samples. We are currently undertaking proton titration of the same fractions to see if the overall binding capacity follows the same pattern. Such an information is important to understand the behaviour of the organic matter and the metal ions during the mixing between the Amazon fresh water and the Atlantic seawater.

Disponibilidad y distribución de agua para la generación de energía hidroeléctrica por grandes vertientes en México

N.A.H. BERNAL

La distribución del agua en México es muy desigual y por lo tanto su disponibilidad está determinada por las condiciones geográficas del territorio mexicano. El desarrollo de México está relacionado fuertemente al recurso agua, el cual por ser escaso ha definido los patrones de desarrollo demográfico y económico.

La mayor parte de las corrientes mexicanas se localizan en las vertientes exteriores. Se originan en las cordilleras y descienden hacia las costas del Océano Pacífico y del Golfo de México. En este punto se precisa señalar la importancia que tiene la línea divisoria continental, ya que es fundamental en la distribución de los volumenes de escurrimiento.

En México se ha tratado de aprovechar en gran medida los rios para la generación de energía eléctrica además de otros usos como son el riego agrícola, derivadoras o para servicios a la población. En este trabajo se ha hecho enfasis en el estudio de las 13 presas hidroeléctricas de mayor importancia en México, por su producción de energía y por el tamaño de la misma.

La distribución espacial de la disponibilidad de agua para la generación de energía eléctrica en México está intimamente relacionada con las características geográficas del país en general y en particular a las geomorfológicas, fluviales y de pluviosidad. Durante los últimos años, en México se han construido un número importante de presas para la generación de energía hidoreléctrica. A partir de la década de los años cuarenta a la fecha, este tipo de obras se han realizado en forma constante y sistemática, las cuales constituyen la base para el almacenamiento y disponibilidad de agua para la generación de energía.

Las presas estudiadas y su respectivo volumen de disponibilidad de agua se localizan -de una manera general- por vertientes. Siete grandes embalses se localizan a lo largo de la vertiente del Oceano Pacífico y las seis restantes en la parte meridional de la vertiente del Golfo de México. En estas presas se trabajó con datos referentes a volumenes de agua para cada una de ellas en lo referente al aporte de agua, almacenaje en la presa, extracción de agua para generación de energía y energía producida. Se analizaron los datos en conjunto por grandes vertientes para obtener una visión diferenciada de ambas vertientes, conocer la disponibilidad y distribución geográfica de agua existente en cada vertiente para la generación de energía hidroeléctrica.

Stream chemistry, solute fluxes and mesoscale land use change in the Amazonia

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Analyses of surface waters collected in both the wet and dry seasons in Rondonia, Brazil are used to define a chemical land use signal for 75 watersheds of varying soil type, size, and land use intensity. During the dry season (August 1998), forest catchments had consistently low concentrations of major cations, Cl, SO4, TDN, TDP, and H2SiO4, while concentrations of these dissolved species were significantly elevated in deforested catchments <5000 km2. In small watersheds with low alfisol frequency (<1000 km2, average 250 km2, <10% alfisols, n=9), total cations were 350% higher in deforested catchments (>40% deforested, from 1996 Landsat TM) than forested catchments (<20% deforested), dissolved Si 750%, TDN 40%, TDP 430%, Cl 840%, and SO4 125%. Catchments with higher alfisol occurrence (>50% alfisols, n=9, from GIS soils database) showed less dramatic changes. Wet season concentrations (January-March, 1999) were diluted compared to dry season concentrations for most streams below 5,000 km2. The largest watersheds (>10,000 km) showed no wet season dilution, suggesting that above that size, the streams become groundwater dominated.

The total flux of dissolved material was calculated for 11 watersheds with permanent discharge stations, ranging from 1000 km2 to 30,000 km2, allowing calculation of export rate per unit area. Assuming a uniform background export rate in forested regions, the mean export rate per unit area for deforested areas was calculated. Samples of rain water, deep groundwater wells (>45 m), saturated areas and weekly wet season soil water samples in forest and pasture were also collected to elucidate the observed stream concentrations.

The results suggest that a signal of enhanced solute yields resulting from deforestation in Rondonia is recognizable up to a drainage area of between 5000 and 10,000 km2. Beyond that size, streams appear to become groundwater dominated and buffered against changes in land use and hydrologic regime.

Los regímenes hidrológicos de la cuenca Amazónica de Bolivia

J. BOURGES, L.M. CARRASCO

Bolivia cuenta con aproximadamente 1'100.000 Km² de superficie, de la cual el 63% se encuentra ocupada por la Cuenca Amazónica. Gracias al aporte de sus cuatro grandes tributarios, principalmente procedentes de Bolivia, el Madera participa con cerca del 8% a los aportes del Amazonas al Océano

La distribución temporal de las lluvias mensuales en el año, presenta la misma forma sobre el conjunto de la cuenca amazónica. Las precipitaciones más fuertes caen durante el verano austral, de diciembre a marzo. Según las regiones, puede haber el resto del año una estación seca bien marcada o lluvias muy frecuentes. La distribución espacial de las lluvias aparece muy distinta según las regiones. Puede variar de 500 mm./año en la alta cuenca del río grande, a cerca de 6000 mm. en ciertas zonas de la cuenca del Chapare. En la llanura, la pluviometría decrece de Norte a Sur con promedios de 1800 mm. sobre las cuencas del Mamoré y del Beni, y más de 2000 mm. sobre el del Madre de Dios.

El conjunto de la cuenca Amazónica podemos subdividirla en: "Andinas", situadas en el costado amazónico de la Cordillera Oriental, con dos subgrupos: las del Beni y del Chapare más meridionales y más irrigadas, "Intra-Andinas" aquellas que encontrándose al interior del macizo andino, se hallan protegidas en parte por la influencia amazónica, "Ando-amazónicas", cuya parte superior se sitúa en la Cordillera, pero que reciben también en su parte inferior la contribución de aguas de la llanura y las de "Llanura" que no experimentan ninguna influencia andina.

Sobre el conjunto de las cuencas Andinas o Intra-andinas, el período de aguas altas dura aproximadamente tres meses, generalmente, de enero a marzo. Este periodo es idéntico en la llanura sobre los ríos Ando-Amazónicos hasta aproximadamente una distancia de 500 a 800 Km de pie de monte. Más allá de este límite y hasta la formación del madera, las aguas altas se desfasan progresivamente y pasan más bien de febrero a abril, lo que corresponde a las aguas altas observadas en las cuencas de llanura donde las velocidades de propagación son mucho más lentas. No obstante, en el curso inferior del Mamoré y del Itenez, aguas debajo de las llanuras de inundación que retrasan la crecida anual, se observa que el periodo de aguas altas se sitúa frecuentemente entre los meses de marzo y mayo.

La heterogeneidad física de la zona estudiada y la amplitud del relieve hacen que el régimen de las precipitaciones y la pluviometría anual sean muy variables de una región a otra, y muchas veces de una cuenca a otra. A fin de estudiar la relación precipitación-escurrimiento y de discernir eventualmente un carácter regional, se relacionan la precipitación media sobre una cuenca con el parámetro que mide el escurrimiento, y de la misma dimensión que la precipitación, la lámina escurrida.

Se evidencia un grupo de cuencas que reciben una altura de lluvia superior a 1200 mm por año y en el cual se puede considerar que existe poca relación entre precipitación y altura de escurrimienbto superficial.

Este grupo representa la llanura y las regiones Ando-Amazónicas y Andinas, con excepción del Beni, para el cual las alturas de lluvias son incoherentes con las alturas de escurrimiento superficial. Por debajo de 1200 mm., es decir: en las regiones "semi-áridas", la dispersión es tal que es difícil vislumbrar una relación válida. En todo caso, la imprecisión sobre la determinación de la precipitación media no permite evidenciar caracteres regionales ni establecer una relación correcta entre lluvia y escurrimiento.

Estudio de la dinámica de las inundaciones en la cuenca Amazónica boliviana con un enfoque conjunto de la hidrología i de la percepción remota

L. BOURREL, L. PHILLIPS, S. MOREAU

La Amazonia boliviana se caracteriza por una gran llanura central generalmente inundada mas de 4 meses al año. La superficie afectada puede abarcar 100 000 a 150 000 km2 según la variabilidad hidrometeorológica anual en las subcuencas andinas (cabeceras de los ríos Madre de Dios, Beni y Mamore que alimentan el Río Madeira) y en la llanura. Las inundaciones provocan generalmente perdidas considerables de millares de cabezas de ganado, en particular en el Departamento del Beni donde se produce 47% de los bovinos de Bolivia. Además, impiden la gestión sostenible de los recursos piscícolas de la región Amazónica y afectan a numerosas ciudades, pueblos y comunidades, siendo necesarias medidas de evacuación en ciertos casos.

En el año 1997, el ORSTOM (1) ha empezado, con sus socias bolivianas del SENAMHI (2), del SEMENA (3) y de la ABTEMA (4), un programa de investigaciones para estudiar la dinámica de las inundaciones en Amazonia boliviana.

En época de lluvias, esta región presenta una persistente cobertura nubosa y zonas vastas de difícil acceso : por esta razón, este estudio hidrológico se basa primero sobre la utilización de la percepción remota radar que permite de prender la distribución espacio-temporal de las inundaciones.

El principal objetivo de la parte teledetección de este programa es de identificar las zonas a riesgos con el objetivo final de monitorear el fenómeno de las inundaciones (orientar y optimizar las acciones de Defensa Civil, así como la gestión de los recursos piscícolas y ganaderos).

Por eso, hemos primero intentado valuar la utilización de los datos radar en banda C con polarizaciones HH (ERS) y VV (RADARSAT) por el objetivo específico de la identificación de las zonas inundadas de la Amazonia boliviana.

Este articulo presenta los primeros resultados obtenidos en los dos últimos años, en la llanura de inundación del río Mamore alrededor de la ciudad de Trinidad, con la utilización de imágenes ascendientes ERS-SAR y RADARSAT-SAR correspondientes a las épocas seca y inundada, de datos de terreno y de sobrevuelos adquiridos en el mismo tiempo que las imágenes radar i también de datos hidrometeorológicos como precipitaciones, temperaturas y niveles diarios de agua (en los ríos y en la llanura) obtenidos en estaciones ubicadas en la parte alta y en la parte baja de la cuenca del Mamore.

Después de la caracterización del ciclo hidrometeorológico anual de las inundaciones estudiadas, están primero presentadas compuestas color y clasificación de imágenes ópticas Landsat TM para mapear las principales unidades de vegetación en la área de estudio, y luego algunas SAR-TM compuestas color (cómo transformaciones RGB-IHS, cómo diferencias entre imágenes RADARSAT o ERS de épocas seca y inundada) están utilizadas para valuar las respectivas contribuciones de los datos radar en el mapeo de la extensión de las inundaciones.

Suspended sediment-bound trace consistuents of Rio Negro waters upstream Manaus-Amazonia

W.L.F. BRINKMANN

Suspended sediments contain primarily organic colloids of various kind and some mineral constituents in the form of clays. The bulk of suspended materials are mainly derived from 3 sources :

(1) the organic standing crop of seasonally flooded fringe forest areas (Igapó), which combines the leachates of litter layers and forest stand

(2) regosol and podzol areas, which provide leachates of organic colloid enriched waters

(3) sandy, hydromorphic soils of the valley bottom areas of terra firme forest streams, where the increased residence time of near-surface groundwater produce organic colloid enriched leachates

The organic colloids are primarily produced by processes of biodegradation and biosynthesis of the organic matter standing crop. Leachates contain small amounts of mineral compounds, which might be used as tracer constituents for source discrimination procedures.

The bulk of trace constituents is bound to organic colloids by physical and chemical sorption and complex formation.

Suspended solids were analyzed by a combination of various methods, such as AAS, ICP/MS, INAA, NAA, NAAt and PAA.

Parámetros físicos, químicos y plancton en el Bajo Delta del Río Paraná, en relación con el ciclo hidrológico.

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En sistemas fluviales, al igual que en planicies de inundación y humedales, las variaciones temporales de determinados parámetros físicos y químicos del agua, así como de la flora y la fauna, dependen en gran medida del ciclo hidrológico. El entendimiento de estas relaciones ecohidrológicas resulta fundamental para la posterior evaluación de vulnerabilidad al impacto humano del ecosistema. El Río Paraná presenta un régimen hidrológica con bajantes en agosto-setiembre y crecientes en febrero-marzo, en el curso superior, y rnarzo-abril en la región deltaica. La subcuenca del Paraná Inferior (15.000 km2), de clima templado húmedo, presenta escasos cuerpos de agua lénticos permanentes, a diferencia de la llanura aluvial del Paraná Medio. La hidrología del Delta del Paraná está regulada por el régimen de los ríos Paraná, de la Plata y Uruguay; correspondiendo al primero la mayor influencia en la zona estudiada, franja externa del Bajo Delta, donde se suman efectos de mareas y sudestadas del estuario Río de la Plata. La información édita sobre fisicoquímica y plancton de esta franja deltaica es escasa., a pesar de su ubicación aguas abajo de importantes polos industriales y próxima a la ciudad mas poblada de Argentina. El objetivo del presente trabajo es evaluar las variaciones espaciales y temporales de parámetros físicos y químicos, así como del fito y zooplancton, bajo diferentes condiciones del ciclo hidrológico en aguas superficiales del Bajo Delta del Río Paraná. Esta primera etapa se desarrolló durante 1995, en parte de dos años hidrológicos (períodos septiembre-agosto) cuyas características se contrastaron con la serie de datos diarios de 1905-1996 en Paraná. Asimismo se analizaron las condiciones meteorológicas para evaluar la influencia del fenómeno denominado "sudestada", que afecta la forma de los hidrogramas en el Delta. Se realizaron cuatro muestreos, incluyendo distintos estados del hidrograma mensual, en cinco sitios. Las muestras de agua superficial se tornaron por triplicado en el canal de navegación, midiéndose in situ oxígeno disuelto, pH, conductividad y temperatura, y en laboratorio (filtración en campo y transporte en frío), amonio, nitratos, fósforo reactivo soluble, sulfatos, cloruros, calcio, magnesio y alcalinidad (APHA, 1985). Las muestras cuantitativas de fitoplancton (200 ml) se concentraron por sedimentación y se contaron submuestras de 1 ml (pipeta de Hensen-Stempel) en cámara de Sedgwick-Rafter bajo microscopio. Las muestras cuantitativas de zooplancton se tomaron filtrando 80 l de agua superficial por red (48 µm). Las submuestras (5 ml), tomadas con pipeta de Hensen- Stempel se contaron en cámara de Bogorov bajo microscopio estereoscópico. Las variaciones temporales de la gran mayoría de los parámetros físicos, químicos y biológicos superaron a las espaciales. Tanto los parámetros físicos y químicos coma la abundancia planctónica estuvieron asociados, fundamentalmente, al régimen hidrológico. Los parámetros fisicoquímicos evaluados reflejaron principalmente efectos de la creciente en el Paraná Medio, que al inundar los cuerpos lénticos bajos y suboxigenados de la llanura aluvial, produce disminución de oxígeno disuelto, nitratos, sulfatos y aumentos en fósforo reactivo soluble, conductividad, bicarbonatos y calcio. Las densidades del fitoplancton y del zooplancton aumentaron cuando el nivel hidrométrico fue bajo. Las diferencias espaciales se manifestaron, principalmente, en el sitio correspondiente al frente de avance, reflejando la acción del Río de la Plata y fenómenos locales, relacionados con la muerte y descomposición de los juncales, que crecen intensamente. La fuerte relación observada con el régimen hidrológico enfatiza la necesidad de considerar la importancia de este factor en los emprendimientos que regulen tanto el caudal como las momentos de cambio en el nivel hidrométrico.

Estimation de la vitesse de déplacement du fond mobile de l'Amazone par correction des mesures de débit par mesureur ultrasonique à effet Doppler (ADCP)

J. CALLÈDE, J.L. GUYOT, P. KOSUTH, V. GUIMARÃES

Les hydrologues du Projet HiBAm ont effectué plusieurs centaines de mesures de débits par système ultrasonique (ADCP) sur le Bassin Amazonien depuis 1995. Des erreurs systématiques sur les trajectoires des jaugeages ont été observées durant les crues. La correction de ces erreurs a permis d'estimer la vitesse de déplacement du fond mobile de l'Amazone. Cette vitesse du fond mobile, fortement corrélée à la vitesse de l'eau près du fond, peut atteindre 50 cm/s en crue à Óbidos. A l'avenir, le couplage de GPS à la mesure ADCP devrait permettre d'améliorer cette correction et l'estimation de la mesure du fond mobile.

Descargas líquidas do rio Jaguaribe ao oceano Atlântico após a construção do açude Castanhão : análise da variabilidade

J.N.B. CAMPOS, T.M.C. STUDART, S.R. FRANCO, R. LUNA

A Bacia do Rio Jaguaribe drena uma área de 72.043 km2 que corresponde a 48% da superfície do Estado do Ceará. Sua descarga líquida para o Oceano Atlântico, nas proximidades da cidade de Aracati, será significativamente alterada com a conclusão do Açude Castanhão, ainda em fase de construção. O reservatório deverá ter uma capacidade total de 6,7 bilhões de metros cúbicos, sendo 250 milhões de reserva intangível, 4,2 bilhões de volume útil e 2,25 bilhões para proteção de cheias. Com essas dimensões ele será o segundo maior do Nordeste Brasileiro e o maior do mundo em um encravado em um rio intermitente. O rio Jaguaribe, em condições naturais pode apresentar picos de cheia da ordem de 8.000 m3/s e, por outro lado, passar 18 meses sem nenhum escoamento.

Este artigo apresentará uma análise da variabilidade de três variáveis aleatórias resultantes da operação do reservatório: a descarga líquida para o oceano (representada por suas sangrias), a vazão regularizada com uma dada garantia e a evaporação do seu lago. Para isto, serão utilizadas ferramentas da hidrologia estocástica e a operação fictícia do reservatório.

Serão gerados 5.000 valores de vazões anuais afluentes ao Açude Castanhão, segundo a distribuição de probabilidades Gamma II, com parâmetros calculados a partir da média e do desvio padrão da série histórica de vazões, fragmentadas a nível mensal. Na operação simulada do reservatório, serão atribuídas regras de retirada e condições iniciais ao sistema e estudado o seu comportamento para cada uma das 50 séries sintéticas de vazões afluentes de 10, 20, 30, 40, 50 e 100 anos de duração, como também para 1 série de 5000 anos. Sendo assim, será possível analisar a variabilidade das perdas para o oceano, da vazão regularizada e da evaporação a curto e a longo prazo, assim como no estado de equilíbrio.

Prévision des crues de l'Amazone à Manaus

B. CAPPELAERE, H. NIEL, J.L. GUYOT, M. MOLINIER, M.S. RODRIGUES, E. OLIVEIRA

La capitale de l'état brésilien d'Amazonas, Manaus (1.2 millions d'habitants), est particulièrement exposée aux crues du système fluvial amazonien. L'importance des submersions dues à la topographie extrêmement plate et aux hauteurs parfois considérables pouvant être atteintes par la crue, a motivé la réalisation d'un outil de prévision des niveaux à Manaus. Compte-tenu des particularités de ce système fluvial singulier et des données disponibles, l'approche statistique a été choisie et plusieurs techniques ont été testées (régression, PLS, neurones), ainsi qu'une procédure adaptée de prise en compte des lacunes dans les séries de données. Les équations de prevision élaborées pour diverses échéances (jusqu'à 60 jours) ont été intégrées dans le logiciel opérationnel CHEIAMAZ, qui devrait bientôt être couplé à un système automatisé de télétransmission en temps réel des données.

Avaliação do assoreamento do reservatório de Itá, no Rio Uruguai, e programa de monitoramento a montante e a jusante da barragem

N.O. CARVALHO, J.T.N. SILVA, L.N. PALMA

A barragem da UHE Itá está sendo construída no médio curso do rio Uruguai, em posição de área de drenagem de 44.500km2. Apesar de ficar situada no sul do país em região com razoáveis densidade populacional e uso do solo, a bacia apresenta uma pequena produção de sedimentos devido a boa cobertura vegetal da bacia. No entanto, com o desenvolvimento que está ocorrendo na bacia, é esperado um crescimento populacional e um aumento do uso do solo, o que certamente irá aumentar a erosão das terras e o consequente transporte de sedimento nos rios.

O presente trabalho apresenta um resumo do estudo sedimentológico realizado para a formação do reservatório, considerando o assoreamento e a sua vida útil. Complementarmente, e a partir dos mesmos dados, será efetuado um estudo da distribuição dos sedimentos no lago e a formação do delta (declividades superior e frontal) para poder avaliar a quantidade de depósitos na área do volume útil e os seus reflexos na geração de energia. A previsão do assoreamento foi efetuada a partir de poucas medições de curto período (maio a outubro.87), não podendo representar resultados confiáveis. Por outro lado essas medições foram em sua maior parte efetuadas no período de estiagem, não contendo medições de enchentes ou mesmo permitir que se possa ter a taxa de aumento da carga sólida com o tempo.

Em decorrência, os estudos sedimentológicos realizados deixam a desejar, sendo necessário revisão no futuro, para o adequado acompanhamento das transformações na bacia e no reservatório.

O programa de medições incluirá o monitoramento a jusante da barragem, para acompanhamento da possível erosão da calha fluvial, devido a liberação de água limpa com poder erosivo. Esta possibilidade já apresentou uma ocorrência por ocasião do desvio do rio para construção da barragem. Estão previstos trabalhos de levantamento periódico de seções transversais ao longo do reservatório e no trecho do canal a jusante da barragem, operação e manutenção de rede sedimentométrica, estudos complementares com uso de imagens de satélites, e outros, que certamente fornecerão subsídios importantes para os estudos sedimentológicos pretendidos.

Anomalías climáticas en una subcuenca del Río Iguazú y predicción extendida de volúmenes

D.I. CHAVASSE, R.S. SEOANE

El objetivo de este trabajo es estudiar la capacidad predictiva de un modelo determinístico complejo aplicado a la cuenca baja del río Iguazú y el impacto del fenómeno ENSO (El Niño Oscilación Sur) sobre las variables hidrológicas y los caudales simulados en la subcuenca del río Chopim.

La cuenca elegida es de gran utilidad para la predicción de crecidas en el tramo argentino-paraguayo del río Paraná dado que el aporte del río Iguazú es muy significativo y es el último afluente que recibe antes de ingresar al territorio argentino por su margen izquierda. La cuenca del río Iguazú está ubicada entre los 25° y 27° de latitud Sur y los 49° y 55° de longitud Oeste y su superficie es ligeramente inferior a 70000 km2. Se han modelado la cuenca baja del Iguazú (24000 km2), tramo comprendido entre las estaciones hidrométricas Salto Osorio y Salto Cataratas y el río Chopim (7600 km2), principal subcuenca de ésta.

El aporte de la cuenca baja se simula con el modelo de humedad de suelo de Sacramento y el traslado de los caudales observados a la salida de la cuenca alta con distintas versiones del modelo Muskingum. Se realiza una verificación del ajuste de estos modelos mediante el método Bootstrap y se observa para los períodos de calibración y validación, las diferencias en los estadísticos de control seleccionados.

Para estudiar la capacidad predictiva a corto plazo del modelo determinístico complejo aplicado a la cuenca baja del río Iguazú se estima la función de correlación cruzada entre la precipitación y el caudal. Se propone un experimento numérico para analizar los resultados de esta función y conocer el adelanto de tiempo que permita obtener estimaciones confiables.

Para la cuenca del río Chopim se estudia la influencia de eventos extremos del ENSO sobre los estadísticos de las variables hidrológicas y de la serie de errores que definen la capacidad de simulación del modelo. Se discuten las variaciones observadas en la respuesta del modelo demostrando, en forma estadística, la importancia de la variación de las variables de estado y de los errores. Para investigar la influencia del ENSO se propone un experimento numérico que consiste en realizar simulaciones utilizando trazas registradas de la precipitación clasificadas en años Niño, Niña y años no Niño no Niña.

Basin landscape geochemical method for calculating mineralization of water: Example of the Syrdarya river

E.I. CHEMBARISOV

By the employees of laboratory of hydrochemistry of Institute of water problems Academy of Sciences Republic of Uzbekistan it offered of basin landscape-geochemical a method of account mineralization of river waters. It is based on interrelation revealed by the author between growth irrigated of the area in river basin and size mineralization of river water in closing post of the river.

On an example of separate well investigated river basins of central Asia is shown., that since 1960 size mineralization of river waters was increased in bottom posts proportionally to growth irrigated of the area. Working formula shown this dependence was offered which has the following kind:

$$Mfin = Mint + a\,Fef \qquad (1)$$

where Mfin and Mint : mineralization of river water according at the initial and at the final stations of the river basin (gr./liter) ; Fef : regularly irrigated and drainage area named "efficiency" because it influences mineralization level of river water (thousands of hectares) ; a : coefficient, it is called "integral landscape-geochemical indicator". It depends on salination level of soil and initial consumption in the river.

Equation (1) is a working formula for basin landscape-geochemical way of calculating mineralization changes of river waters. If we know Mint and "a" coefficient, the formula can be used to define the expected mineralization of river water at the final station (Mfin), if we know the change in irrigated area in future.

For example pursued the expects of future mineralization of water Syr-Darya river.

Riverflow Modelling in Two Large River Basins: the Parana (Subtropical) and the Niger (Tropical).

D. CONWAY, G. MAHÉ

Water balance models of varying degrees of complexity have been widely used for a number of hydrological applications. Here we apply a simple conceptual water balance first developed by Thornthwaite (1948) and later Thornthwaite and Mather (1955) in a distributed manner to model riverflow in two very large river systems, the Parana river in South America and the Niger river in west Africa. The approach utilises global data sets of rainfall, potential evaporation and soil available water capacity at 0.5 degree latitude and longitude resolution. The rainfall and PE data sets have been augmented with additional station data from regional sources to provide dense spatial coverage over much of the river basins. River flow data for tributaries ranging in size from 631 km2 to 67,600 km2 for the period 1931-1990 (Parana) and 1951-1990 (Niger) are used to calibrate and validate the model.

The results show varying degrees of model performance during both the calibration and validation procedure. Time series of rainfall and PE were used to reconstruct river flows for the whole river basins back to 1901. These were compared with measurements dating back to 1901 and 1907 for the Parana and the Niger, respectively. There was reasonable agreement between modelled and observed river flows and the prolonged changes in river flow regimes that have occurred since the 1970s (Table 1) are unprecedented in the instrumental records. The analysis highlights some interesting issues pertaining to the development and application of water balance models.

* Varying levels of model performance in different catchments, ranging from acceptable to poor.

* Sensitivity of model performance and parameter values to input data sets, particularly the method chosen to estimate PE. Average annual PE for the period 1961-1990 over each river basin is 552 mm (1666 mm) with a Penman Monteith PE function and 1261 mm (3477 mm) with a standard reference crop Penman function for the Parana and Niger, respectively. Best model results were obtained with the standard reference crop Penman function.

* Both rivers exhibit prolonged large fluctuations in their flow characteristic (volume and timing) before and after the early 1970s which are associated with changes in rainfall, runoff ratios and possibly changes in land use and land cover although these are unquantified. This raises difficulties in defining periods for model calibration and validation and the stability of parameter values during periods where changes in catchment characteristics and runoff processes are taking place.

Principais avanços no monitoramento da rede hidrológica da bacia do rio Itajaí

A. CORDERO, D.L. SEVERO, A.L. TERAN, P.A. MEDEIROS

A intenção deste trabalho é apresentar os avanços obtidos no monitoramento da rede hidrológica na bacia do rio Itajaí. Inicialmente será apresentado a evolução e os avanços obtidos no monitoramento da rede hidrológica da bacia do rio Itajaí, desde a instalações das primeiras estações hidrológicas, operadas manualmente, até hoje com as modernas estações telemétricas automática. Após será apresentado a evolução das obras civis realizadas na referida bacia para o controle das cheias. Por fim será apresentada a variabilidade das vazões máximas registradas no município de Blumenau, desde os seus primeiros registros até os dias atuais.

A bacia do rio Itajaí está localizada na Vertente Atlântica do Estado de Santa Catarina e tem uma área de 15.000 km^2 de área. Seus principais afluentes são o rio Itajaí do Sul, o rio Itajaí do Oeste, o rio Itajaí do Norte ou Hercilio, o rio Benedito e o rio Itajaí Mirim. Ela é considerada uma bacia estadual porque fica totalmente dentro do Estado. A bacia do rio Itajaí tem a sua situação caracterizada pela existência de altas serras nas nascentes sul, norte e oeste (entre 1.000 a 1.750 m) e de planícies pequenas a leste, nas vizinhanças do Oceano Atlântico. Na sua média anual, a temperatura do Vale do Itajaí, em linhas gerais, vai caindo, a partir da foz em direção às encostas de 21o a 18o. As épocas mais quente e fria do ano são bem caracterizadas, subindo a 25o a média do mês mais quente (janeiro ou fevereiro) e descendo a 15o a do mês mais frio (julho).

Podemos dizer que a variação quantitativa da chuva no decorrer do ano se resume: (1) numa estação chuvosa principal no verão com chuvas médias mensais da ordem de 140 mm, que abrange em geral 4 meses (dezembro a março); (2) numa estação chuvosa secundária na primavera (setembro e outubro), com chuvas médias mensais da ordem de 120 mm; (3) num mês relativamente seco (novembro) com cerca de 80 mm; e, (4) num período de 5 meses, que constitui a parte menos chuvosa do ano (abril a agosto), ou seja, outono/inverno, com média mensal de 85 mm.

Diversas obras de contenção de cheias já foram executadas em vários pontos da bacia, sendo que as principais são: a Barragem Sul que tem capacidade para armazenar 93,5.10^6 m^3 de água, a Barragem Oeste que tem capacidade para armazenar 83,0.10^6 m^3 e a Barragem Norte que tem capacidade para armazenar 357,0.10^6 m^3.

Water balance of the Amazon basin: Potential effects of environmental change

M.H. COSTA, J.A. FOLEY

It is generally expected that the Amazon basin will experience at least two major environmental changes during the next few decades and centuries: (1) increasing areas of forest will be converted to pasture and cropland, and (2) concentrations of atmospheric CO2 will continue to rise. Using state-of-the-art numerical models of the interactive physical, chemical and biological systems, this paper evaluates the potential changes in the water balance of the Amazon basin that may result from environmental change on the time scale of centuries. The environmental changes considered are changes in the land use (full deforestation) and a doubling of the atmospheric CO2 concentrations. Furthermore, a distinction is made between the physiological and radiative effects of CO2.

Initially, the effects of deforestation and the physiological effects of CO2 are evaluated in a land-surface model (IBIS - Integrated Biosphere Simulator), running with a prescribed climate. When forests, woodlands and savannas are replaced with grasslands, annual average evapotranspiration decreases by ~0.5 mm/day (~12%), which is comparable to observations. We also perform a model sensitivity study in order to assess the potential physiological effect of doubled CO2 concentrations on stomatal conductance and, as a consequence, on the water balance of the Amazon basin, again without considering feedbacks in the atmosphere. The model results suggest that doubling atmospheric CO2 concentrations would decrease the canopy conductance by 20 to 35% (depending on the vegetation type) and would decrease evapotranspiration by ~4% throughout the region, increasing the annual mean runoff.

In a second part of the study, we use IBIS coupled to the NCAR GENESIS atmospheric general circulation model, to determine the combined effects of large-scale deforestation and doubled CO2 concentrations (including both physiological and radiative effects) on Amazonian climate. In these simulations, deforestation decreases basin-average precipitation by 0.73 mm/day over the basin, as a consequence of the general reduction in vertical motion above the deforested area (although there are some small regions with increased vertical motion). The overall effect of doubled CO2 concentrations in Amazonia is an increase in basin-average precipitation of 0.28 mm/day. The combined effect of deforestation and doubled CO2, including the interactions among the processes, is a decrease in the basin-average precipitation of 0.42 mm/day.

Concluding, runoff is strongly affected by both local and global environmental modifications (individually). The initial simulation of the effect of deforestation (without considering the feedbacks in the atmosphere) revealed a decrease in the evapotranspiration and an increase in the annual mean runoff, consistent with tens of deforestation field studies conducted at the catchment scale. However, when feedbacks in the atmosphere are allowed, a decrease in the precipitation compensates for the decrease in evapotranspiration, making changes in the annual mean runoff small. The further addition of 2xCO2 effects nearly compensates the drop in the runoff caused by deforestation: the basin-wide annual mean runoff in the 2xCO2 deforested scenario is basically the same as the runoff in the 1xCO2 forested scenario. Despite that, there are important changes in the seasonality of runoff. Deforestation and the physiological effects of CO2 tend to increase the runoff in the rainy season, which may lead to increased frequency and intensity of floods.

Minéralogie des sédiments grossiers de l'Amazone Origine et évolution en fonction des apports latéraux

M. DELAUNE

Dans le cadre des campagnes du programme HiBam (DNAEE / CNPq / IRD) il a été procédé à l'analyse minéralogique des sédiments grossiers transportés sur le fond du lit de l'Amazone (partie brésilienne) et de ses principaux affluents. Ces données ont été complétées par des informations sur la minéralogie des affluents issus de la cordillère orientale en Equateur, des rio Ucayali et Maranon au Pérou et de sondages effectués à l'embouchure de l'Amazone.

Le cortège minéralogique des sédiments de l'Amazone varie très peu depuis Tabatinga jusqu'à son embouchure ; il est assez varié (une vingtaine d'espèces minérales ont été observées) mais l'association épidotes / hornblendes / augites / chlorites et minéraux altérés est largement dominante.

Ce cortège est la résultante des apports des principaux affluents : rio Ucayali (minéraux altérés, chlorite, épidote, hornblende, grenat), rio Maranon (épidote, augite) et rio Napo (augite, hornblende, épidote) dont la réunion est à l'origine de l'Amazone.

Ces minéraux proviennent de l'altération des roches du socle andin (hornblende, épidote, chlorite) et des cendres volcaniques déposées sur les versants de la cordillère orientale en Equateur. La forte proportion de minéraux altérés reflète le caractère juvénile du matériel érodé.

Le long de son parcours au Brésil les principaux affluents sont :

- rive gauche : rio Ica, rio Japura, rio Negro.

- rive droite : rio Jurua, rio Purus, rio Madeira, rio Tapajos.

Les rio Ica et Japura ont la même origine et les mêmes cortèges minéralogiques que le rio Napo ; leur contribution ne modifie pas le spectre minéralogique de l'Amazone.

Les sédiments du rio Negro sont caractérisés par de fortes teneurs en zircons et les affluents de la rive droite par l'association zircons / andalousite.

Bien que différents par leur minéralogie des sédiments de l'Amazone, tous ces apports latéraux ne se traduisent pas par des variations sensibles du spectre minéralogique si ce n'est par une légère augmentation des teneurs en andalousite à partir de Manacapuru. Quant au zircon, ses teneurs restent très faibles (inférieures à 2%).

Tout se passe donc comme si il se produisait, soit une dilution des apports des affluents, soit un transport latéral avec l'incorporation graduelle aux sédiments de l'Amazone. Quant à la très faible participation du zircon cela tiendrait au fait qu'il a une densité nettement supérieure à celle des autres minéraux présents ici et qu'il se dépose à proximité des embouchures.

Les prélèvements ayant été effectués dans la partie centrale du fleuve, l'étude de la minéralogie des sédiments proches des berges permettrait de vérifier ces hypothèses.

The geochemical nature of the Paraná river suspended sediment load

P.J. DEPETRIS, J.L. PROBST

The Paraná River basin, being the second largest drainage system in South America (2.6 106 km2), exhibits widely different natural (geology, relief, climate, and biota) as well as man-made environmental factors controlling the nature and export of its total suspended sediment (TSS) load. Current estimates (Depetris and Paolini; 1991; Milliman and Syvitski, 1992) place its mean sediment yield close to 30-t km-2 y-1 (about 80 106-t y-1). Particularly during the high water season, the Andean tributaries (mainly the Bermejo River drainage system) supply as much as 50% of its mean TSS load.

A set of depth-integrated TSS samples collected during 1971-73 within the framework of a UNDP-Argentina project were analyzed to obtain information on major and trace components. Clearly, the analyzed materials were composed of freshly weathered products as well as of recycled detritus supplied by exposed sediments and sedimentary rocks.

The chemical index of alteration {CIA = 100 [Al2O3/(Al2O3 + CaO* + Na2O + K2O)]} was computed for all the analyzed samples. High-relief drainage basins (i.e., San Francisco, Bermejo, and Pilcomayo rivers) exhibited variable CIA values, in the 50-65 range, suggesting scantily weathered materials (values in the 45-55 range indicates no weathering in essence) and a grain-size effect. Conversely, the Paraná main stem TSS reaches CIA values in the 65-77 range. Correlation between the discharge and CIA in the Paraná is not significant, with wider CIA variability during low discharges than at high flow. The discharge-weighted mean CIA for the Paraná River is 70.9.

Upper crust (UCC) normalized diagrams show a significant geochemical difference between the samples collected in Andean tributaries and those obtained in middle course of the Paraná River. The first group shows an enrichment of alkaline earths (Ca, Mg) with respect to the UCC. The second group exhibits a marked depletion of soluble elements (K, Na, Ca, Mg, and Sr) and a significant enrichment of some metals (noticeably, Sc, V, Cr, Ni, Cu, and Zn), likely due to adsorption phenomena.

On the basis of 21 depth-integrated samples collected at the Paraná-Santa Fe cross-section (600 km above the mouth), discharge-weighted means were calculated for Sr, Ba, V, Ni, Co, Cr, Zn, Cu, Sc, Y, Zr, and Mn. With the sole exception of Sr, all elements exhibit means higher than UCC values. Major TSS components have the following discharge-weighted means: SiO2, 59.15%; Al2O3, 16.71%; MgO, 1.67%; CaO, 1.02%; Fe2O3, 7.00%; TiO2, 0.99; P2O5, 0.36%; Na2O, 1.29%; and K2O, 2.89%.

Chemical weathering of Deccan traps determined by river geochemistry Impact on the CO2 cycle and the transport of material to the ocean

C. DESSERT, B. DUPRÉ, P. OLIVA, J. GAILLARDET, S. BAJPAYEE, V. SUBRAMANIAN, G.J. CHAKRAPANI

Recent studies have emphazised the importance of the chemical weathering of basaltic rocks for the transport of dissolved and suspended material by flowing river water to the ocean and associated atmospheric CO_2 (Gislason and al., 1996 ; Louvat and Allègre, 1997; Gaillardet et al., 1999). The global weathering and CO_2 consumption fluxes due to basalt weathering are however still poorly estimated. We focus in this study on the basaltic traps of India. The Deccan basaltic traps are the largest known occurrences of continental flood basalts on the Earth surface. The purpose of this study is to evaluate the impact, in terms of chemical weathering and CO_2 consumption, of the biggest volcanic catastrophe in the last 200 Myr. From the chemical analysis and Sr isotopes systematics of the dissolved and suspended load of the rivers, we estimate the present day erosion rates and atmospheric CO_2 consumption rates for the main rivers draining the Deccan traps basalts. The majority of the Deccan traps lavas of western India were erupted around the Cretaceous/Tertiary boundary 65 Myr ago. This volcanic event was very short (<1 Myr). The traps basalts have an actual volume of 10^6 km^3 and cover an area of 5.10^5 km^2. Courtillot and al. (1986) suggested that the total initial volume of lava was 3.10^6 km^3. Therefore, two third of the initial basalt disappeared during the last 65 Myr. Javoy and Michard (1989) estimated that the total amount of CO_2 outgassed was $1.6.10^{18}$ moles. This very large quantity of CO_2 was released, in a very short period of time, directly into the atmosphere. Chemical erosion rates were estimated from the chemical compositions of the dissolved loads after subtraction of the atmospheric input. After this correction, we calculated the weathering rates by summing the concentrations of the major dissolved elements. The HCO_3^- concentrations did not taken into account because we supposed that this element arises from atmospheric CO_2. The chemical erosion rates of Deccan basalts ranged from 21 to 62 $t/km^2/yr$. These rates are similar of those determined for Iceland and Sao Miguel (Louvat, 1997). But they are relatively high if compared to the estimations of large silicate basins (Gaillardet et al., 1999). These results confirm the high denudation rates of basaltic lithologies reported on volcanic islands. The consumption rates of atmospheric CO_2 associated to the chemical weathering of Ca + Mg and Na + K silicates in basalts were calculated from riverine HCO_3^- concentrations. These rates ranged from 0.58 10^6 to 2.54 10^6 $mol/km^2/yr$. Chemical basalt weathering represents an annual average consumption of 5.9 10^{11} mol C/yr. These estimates correspond to 6.8% of the global riverine silicate alkalinity flux (Gaillardet et al., 1999). It must be highlighted that this flux is higher than silicate alkalinity flux of the Ganges-Brahmaputra system (2.3%, Galy and France-Lanord, 1999). If these rates can be extrapolated to the past, it took about 3 Myr to chemical weathering of newly formed basalts to completely remove the atmospheric CO_2 degassed from Deccan pulses. Thus, we conclude that weathering of Deccan traps appears to be a major control on atmospheric pCO_2. The flux of strontium derived from the weathering of Deccan basalts ranged between 361 and 1080 $mol/km^2/yr$, with an average of 724 $mol/km^2/yr$. This specific flux correspond with an annual average flux of 3.6 10^8 mol/yr to the ocean. Concerning the Ganges and Bramaputra, the two largest Himalayan rivers, the flux of strontium was estimated to 6.5 10^8 mol/yr by Galy and al., 1999. This Himalayan erosion flux is just twice bigger than those determined for Deccan. The flux of strontium, coming from the weathering of the Deccan basalts, should not be yet neglected in the global balance of strontium to the ocean (Palmer and Edmond, 1989). The $^{87}Sr/^{86}Sr$ isotopic ratios of the river samples vary between 0.7082 and 0.7114. These ratios reflect the chemical erosion of the basaltic rocks (the $^{87}Sr/^{86}Sr$ rock isotopic ratios range between 0.708 and 0.715, Cox and Hawkesworth, 1985). These ratios are relatively low, compared to those of Himalayan rivers (0.730) and similar of the mean river composition (0.712). The considerable flux of Sr due to Deccan traps weathering play a role in the global increase of Sr isotopic composition in the ocean. The chemical composition of the river waters reflect the importance of Deccan basalts weathering in the global budjets of elements flux (Sr) to the ocean and atmospheric CO_2 consumption.

Évolution de la pluviométrie et ses implications au Mali

B. DIARRA

Le Mali, situé en Afrique de l'Ouest connaît deux types de saisons et des périodes de transitions. Les différentes saisons sont caractérisées par le déplacement de la zone de convergence intertropicale (ZCIT) liée au centre d'actions anticycloniques (Açors, Libye, Sainte Heline.). L'analyse des données pluviométriques montrent une variation inter et intra – annuelle avec un déficit important en 1972 - 1973 en 1983 – 1984. Une tendance à la baisse est notée depuis les années 1970 entraînant ainsi une diminution de la pluviométrie de 200 mm entre les périodes 1951 – 1969 (normale) et 1970 – 1989 (sèche). Le coefficient de variation est de 15 à 45%respectivement du Sud au Nord. Cette variabilité de régime pluviométrique a occasionné un raccourcissement des cycles végétaux des cultures, la baisse de rendement et de production, la famine, la sécheresse. Des dispositions d'assistance météorologiques sont en cours pour réduire l'effet des impacts climatiques sur les systèmes éco-socio-économiques.

Fluvial geomorphology as an aid to river management in South Africa: The Mkomazi river

E.S.J. DOLLAR, K.M. ROWNTREE, D.A. HUGHES

This paper attempts to show how fluvial geomorphology has become an integral part of the drive to manage South Africa's fluvial Systems. The new South African Water Bill recognises an ecological reserve and a basic human needs reserve. The ecological reserve relates to the water necessary to protect aquatic ecosystems while the basic human needs reserve relates to the water required to protect the needs of the persons served by the water resources concerned. Water in the reserve may not be allocated. The determination of the reserve is complex. As the physical structure of the channel to a large extent determines the aquatic habitat, knowledge of the magnitude and frequency of channel forming flows, both in terms of discharge and sediment transport is required. Data is presented from three South African rivers, the Mkomazi, Mhlatuze and Olifants rivers. Through the use of cross-sectional data, hydrology, hydraulics and bed material, the relationship between channel form and bed load to flow discharge was determined. The determination of a 'channel forming discharge' was then be used in the planning and management of river systems. The data indicates that South African fluvial systems do not comply to the classic 1 to 2 year return period for channel forming discharge on the annual series, but that the river systems show a complex response to the magnitude and frequency of different flow classes.

Biogeochemistry of two Southeastern Brazilian mesoscale watersheds under different anthropogenic Influence

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Natural biogeochemical processes and anthropogenic influences are being evaluated for the Piracicaba and Moji-Guaçu drainage basins. As neighbor mesoscale watersheds (12,400 km2 and 15,390 km2, respectively) both are located in a subtropical region, mainly at the São Paulo State. These areas display distinct human development attained by particular population and industry concentration and distribution, and also by differences in land use. Such contrast was detected on the dynamic of biogeochemical variables from 01/1997 till 06/1998. Total suspended solids, dissolved organic and inorganic carbon, dissolved oxygen, alkalinity, NO2, SO4, Cl, K, Ca, Na, and Mg showed significant differences below 1% between the watersheds; NO3 and respiration rates showed differences below 5%; pH and NH4 didn't show significant differences. During high waters dissolved organic carbon, respiration rates and NO3 showed no significant differences between watersheds indicating that dilution of the anthropogenic sewage loading is apparently occurring on the Piracicaba basin. The total suspended sediments carried by these drainage basins during low waters wasn't significantly different denoting that lower erosive processes are occurring in the Moji-Guaçu in the rainy season.

Reservoirs as an anthropogenic perturbation on the carbon cycle

E. DUCHEMIN, M. LUCOTTE, R. CANUEL, D.C. ALMEIDA, H. C. PEREIRA, J. D. DEZINCOURT, A. G. QUIEROZ

There are number of recognised environmental and socio-economic concerns associated with reservoirs, the most recent of wich are fluxes of greenhouse gases (GHGs) from reservoir surfaces to the atmosphere and carbon retention by sedimentation in reservoirs.

Our studies demonstrate that reservoirs emit significant quantities of the GHGs (CO2 and CH4) to the atmosphere due to the long-term effect of changing terrestrial areas into aquatic ones. Direct measurements on reservoirs in northern Canada (La Grande complex) and in the Brazilian Amazinia region (Curua-Unà reservoir) show that boreal and tropical reservoirs are significant sources of GHGs throught diffusive processes and bubble fluxes. Comparatively, studies reveal that GHGs diffusive fluxes from tropical reservoirs are at the same order of magnitude, but bubbles fluxes approximately ten times higher. The measured fluxes represent carbon emissions of 80 gC m-2 yr-1 and 300 gC m-2 yr-1 for studied boreal and tropical reservoirs, respectively. Moreover, carbon mass balance calculations indicate that the organic matter originally presents in soil cannot solely account for the GHGs emissions from a flooded land over several decades, and that organic carbon leached from the drainage basin (watershed) must be included. At the same time we calculated that reservoirs accumulate an important quantity of organic carbon. In a first approximation, the carbon retention rates were 15 gC m-2 yr-1 and 100 gC m-2 yr-1, respectively, for these reservoirs.

The purpose of this presentation will be to expose the short and long-term impacts of impoundment on regional and global carbon cycle, with an emphasis on Amazonian reservoirs.

Sediment transport and floodplain storage along the Amazon River valley in Brazil

T. DUNNE, L.A. K. MERTES, R.H. MEADE, J.E. RICHEY, B.R. FORSBERG

An investigation of sediment transport along the Brazilian Amazon reveals four processes of sediment exchange between the channel and floodplain. They are: bank erosion; bar deposition; settling from diffuse overbank flow; and sedimentation in floodplain channels. Their magnitudes (both into and out of the channel) exceed the river's sediment discharge past Óbidos (~1200 Mt yr-1). We estimated these exchanges for ten valley reaches, and combined them with transport calculations based on sediment sampling and flow records to define a budget for each reach. The supply of sediment entering the channel from bank erosion was estimated to average 1570 Mt yr-1, while 2070 Mt yr-1 were transferred from the channel to the bars and to the floodplain in channelized and diffuse overbank flow. Another 300-400 Mt yr-1 are deposited in a delta-plain downstream of Óbidos.

Components of the sediment budget reflect hydrologic characteristics of the valley floor and geomorphic characteristics of the channel and floodplain, which in turn are influenced by tectonic features of the Amazon structural trough. Geologic structures transverse to the valley have forced the river to incise its profile in four reaches and thus to form a narrow, relatively confined floodplain with a steeper channel in contrast to the wider floodplains with a more sinuous, lower-gradient channel in the intervening basins. Compared to these narrower floodplain reaches, the wider floodplains receive more sediment from overbank flow, and allow the river to migrate to generate large inputs of sediment to the river from bank erosion.

Balanço hídrico vertical médio mensal e distribuído da Bacia Amazônica

N.J. EID

Ao se dispor de dados climatológicos e de capacidade de retenção de água no solo, geograficamente referenciados, é possível estabelecer-se o balanço hídrico vertical na unidade espacial em consideração. Baseando-se em dados disponíveis a nível global e/ou continental, de temperatura, precipitação, radiação líquida incidente e ainda da capacidade de retenção de umidade do solo, procedeu-se ao balanço hídrico vertical nos limites da bacia amazônica. Ainda que o balanço seja médio mensal, a contabilidade é efetuada diariamene dividindo-se os valores mensais pelo respectivo número de dias. A distribuição espacial do excesso de precipitação na bacia é apresentada em termos dos valores médios mensais e no total anual médio em células reamostradas que correspondem a meio grau terrestre.

Estimativa da vazão média mensal em sub bacia do Rio Negro com o apoio de sistema de informações geográficas

N.J. EID, N.A. CAMPANA

Baseando-se em dados disponíveis a nível global e/ou continental, de temperatura, precipitação, radiação líquida incidente e ainda da capacidade de retenção de umidade do solo, procedeu-se ao balanço hídrico vertical mensal no período de novembro/83 a outubro/90, na bacia do Rio Negro em São Felipe, com área de drenagem da ordem de 110.000 Km2.

A bacia foi delimitada por meio de sistema de informações geográficas, baseando-se em modelo numérico do terreno (MNT) global com resolução aproximada de 1000 metros. Efetuou-se a intersecção da bacia assim delimitada com as células de 0,5 graus terrestres de resolução, nas quais se efetuou o balanço hídrico vertical. Desta forma pôde-se quantificar o excesso de escoamento em células com maior resolução.

Embora a área delimitada da bacia, baseando-se no MNT, para o posto São Felipe, tenha sido determinada aproximadamente 20% superior àquela indicada no Inventário das Estações Fluviométricas do DNAEE, o valor absoluto das vazões mostra-se compatível com os valores observados no mesmo período, à excessão do amortecimento que deve ser introduzido a fim de se obter melhor aderência entre esses valores.

n-Alkanes and PAHs discharged by the Ob and Yenisei Rivers into the Arctic Kara Sea shelf

M.B. FERNANDES, M.A. SICRE

Estuarine ecosystems are subjected to perturbations caused by the introduction of anthropogenic compounds by rivers. Understanding the fate of river-borne particles is a key problem in Siberia because of the presence of many petroleum exploration centers, industrial plants and nuclear dumping sites. In that respect, the Ob and Yenisei River discharges need to be considered as they represent more than 80% of the influxes to the Kara Sea and more than 50% of fluvial waters discharging into the Siberian Arctic (Pavlov and Pfirman, 1995). In this study we evaluate n-alkane and polycyclic aromatic hydrocarbon (PAH) levels in the suspended matter and surficial sediments throughout the Ob and Yenisei estuaries (Fig. 1) and discuss their distribution in the adjacent Kara Sea.

Particulate and sedimentary PAH levels in the Ob and Yenisei estuaries are low. They rarely exceed 300 ng/g (Fernandes and Sicre, in press). Molecular distributions outline major pyrolytic inputs likely brought by aeolian transport of particles from lower latitudes. PAHs of diagenetic origin are also observed. High CPI values, generally >3, and the low abundance of unresolved compounds (UCM) in the n-alkane fraction indicate major terrigenous inputs. From our results we can conclude to the absence of notable hydrocarbon contamination. A close examination of sedimentary n-alkanes and PAH distributions identifies two major depositional areas in the Kara basin: the southeast of the Novaya Zemlya Island and the river mouth. Ice dynamics and estuarine mixing are key factors to the accumulation of n-alkanes and PAHs in these regions. In early winter, ice has already formed along the coast into the Kara Sea. The polynyas along the shore ice front induce vertical convection as the water column destabilizes during brine release (Pfirman et al., 1995). This mechanism causes fine surficial sediment particles to raise up to surface waters, where they can get incorporated into ice crystals. In late spring and summer, the ice front starts to melt around the river mouth, allowing ice-trapped organic matter to settle. When ice breaks up, icebergs are carried offshore by the river flow and coastal circulation. The second depositional center in the northwest Kara Sea may possibly be a site where melting icebergs release particles. Under ice-free conditions, the river plume, driven by winds and river flow, also plays a role in the fate of riverine organic compounds along the coast.

Low PAH levels and the quasi-absence of an UCM indicate that the Ob and Yenisei estuaries can be considered as rather pristine. In Arctic coastal systems, besides estuarine mixing, the seasonal ice formation and melting plays an important role in the transfer of river-borne material along the coast into the Arctic Ocean. These processes likely account for the distribution of n-alkanes and PAHs throughout the Kara Sea.

Assessment on polar lipid levels and compositions on the Amazon shelf

M.B. FERNANDES, V.O. ELIAS, J.N. CARDOSO

The Amazon River discharges around 1 x 10^9 tonnes/year of suspended sediments on the Amazon shelf (Milliman, 1991). The particulate organic matter (OM) flux reaches 14 x 10^{12} gC/year (Richey et al., 1990), of which about 65-70% might get decomposed or transported outside the shelf before being buried (Aller et al., 1996). The Amazon shelf is also a site of intense marine productivity, where depth integrated rates of primary production reach 2.6 gC/m^2/day, while in other tropical environments typical production rates are around 0.6 gC/m^2/day (DeMaster et al., 1996). In this study, surficial sediment samples collected during the AMASSEDS (A Multidisciplinary Amazon Shelf SEDiment Study) program (Fig. 1) were analyzed for 4-desmethyl sterols and n-alkanols in order to investigate the deposition and fate of terrigenous and marine lipids in the Amazon shelf.

The low OM burial efficiency reported for the Amazon shelf combined to the weathered character of Amazon River suspended particles and the high mineralization of marine detritus results in low sterol and n-alkanol levels in the shelf, individual concentrations rarely exceeding 150 ng/g. The predominance of even n-alkanol chains, ~90% of which of high molecular weight (HMW), suggests that the accumulation of terrigenous detritus is responsible for higher lipid levels in the Northwest, towards stations 4129 and 4223 (Fig. 1). It is also the area where the percentage of C29 sterols, generally ascribed to a terrestrial origin, reaches its maximum. Higher percentages of low molecular weight n-alkanols (LMW) of marine origin are associated with much lower polar lipid levels. The strong allochthonous influence diminishes further up north and in deeper sediments north of Cape Norte shoal. The decrease in HMW n-alkanols and the abundance of C27 sterols such as cholesterol point out to planktonic detritus in those areas as opposed to the Northwest. Lipid levels and distributions in the river mouth indicate the dominance of allochthonous inputs, which decrease in the southwest with distance from the mouth.

The episodic cross shelf transport of fluid muds and direct deposition from the river plume result in an area of enhanced polar lipid accumulation Northwest of the river mouth. Even though primary productivity is estimated to be elevated, the presence of authigenic compounds can only be recognized where lipid levels decrease substantially. The organic matter accumulating in surficial sediments appears to be mainly of terrestrial origin up to many hundreds of km from the river mouth.

Análise da vida útil do empreendimento UHE Coaracy Nunes, Estado do Amapá

C.A.B. FERREIRA, N.O.CARVALHO

A usina hidrelétrica de Coaracy Nunes, localizada no Estado do Amapá teve o enchimento de seu reservatório ocorrido em 1975. Após 22 anos em operação a fio d'água, não há sinais de sedimentação, havendo perspectivas de assim continuar por um tempo maior. Esse trabalho visou avaliar a vida útil do empreendimento, com base em informações coletadas de tres estações hidrométricas localizadas nos rios Araguari, Amapari e uma quarta situada no rio Oiapoque. O trabalho envolveu coletas de dados recentes, regionalização das descargas sólidas e a utilização do método de Colby no cálculo da vida útil.

O transporte de sedimentos na bacia fluvial do rio Aguapeí, afluente do rio Paraná

A.G. FIGUEIREDO

A predominância de fenômenos erosivos provocados pela falta de planejamento do uso e manejo do solo e de orientações técnicas adequadas são os principais fatores responsáveis pela degradação do solo e consequentemente o assoreamento das calhas fluviais devido ao volume de sedimentos que são transportados, após serem desagregados de suas origens, desde as nascentes dos córregos, pequenos tributários, até a calha fluvial do rio principal. No oeste do Estado de São Paulo os fenômenos erosivos, que agem na superfície e sub-superfície do solo, e os assoreamentos nas calhas fluviais são permanentes e progressivos devido: ao tipo de solo arenoso, a declividades acentuadas, ao clima, o uso inadequado do solo, os desmatamentos contínuos nos espigões e nas margens dos rios (matas ciliares), às estradas vicinais sem pavimentações e obras de drenagens.

Após um levantamento preliminar de várias calhas fluviais pertencentes às principais bacias fluviais, localizadas na região oeste do Estado, definiu-se estudar a calha fluvial do rio Aguapeí porque além de representar relativamente bem as principais características climáticas e fisicas da região ainda conta com levantamentos batimétricos, dados de vazões líquidas medidas e dados de concentrações de sedimentos determinadas a partir de amostras colhidas em postos fluvio-sedimentométricos locados em seções da calha do rio situadas nas partes alta e média da bacia.

A bacia fluvial do rio Aguapeí; com uma área de drenagem de 12.120 km2, integra áreas de cinqüenta e oito municípios, sendo 3.670 km2; situada na parte alta, 4.973 km2 situada na parte média (partes; alta mais média = 8.643 km2 e 3.477 km2 situada na parte baixa da bacia. Neste trabalho apresenta-se uma análise da dinâmica dos sedimentos transportados em suspensão, considerada a modalidade de transporte de sedimentos em predominância (cerca de 95%), durante as décadas de 70 e 80, em duas seções da calha fluvial do rio Aguapeí, provenientes dos trechos do rio situados nas partes alta e alta mais média da bacia. Pela metodologia adotada, através de análises e cálculos, com a utilização de valores específicos e totais, determinados a partir de medições e amostras colhidas, diariamente, nas seções da calha do rio, foi possível determinar valores de sedimentos transportados em suspensão, referentes a cinco períodos intercalados adotados. Com os resultados obtidos definiu-se a dinâmica dos sedimentos transportados em suspensão em trechos da calha fluvial do rio Aguapeí, durante o período total estudado.

Suspended sediment yield in the Brazilian Amazon drainage basin

N. FILIZOLA, J.L. GUYOT, G. BOAVENTURA

Some experiments was done regarding the budget of suspended sediment in Amazon Basin and some estimations of the suspended sediment yield, was also made. As a conclusion scientists have cited The Amazon River as one of the biggest rivers on world on suspended solids discharge. Concerning this theme, in this paper, a study was done with DNAEE (actually ANEEL) sedimentometric network, that is a Brazilian government agency that operates 60 stations, since 1977.This agency has done more than 2500 samples for TSS.

That data, from ANEEL, makes possible a good assessment of the TSS-total suspended solids transported by rivers on Amazon Basin and a new estimation, of about 600 106 ton.ano-1, was done for the mean annual discharge of suspended sediments at the mouth of the Amazon River. The results re-classified, that big river, as the third one in the world, concerning the sediment yield.

The Solimões and Madeira, rivers that comes from Andes, are the greatest contributors of the Amazon, in terms of suspended solids transportation. They represents 95% of all the TSS transported on the Amazon Basin. This results reinforce the importance of the Andes in the system of suspended sediments transportation on the rivers of the Amazon Basin in Brazil.

Medição de vazão em grandes rios Amazônicos com o uso do Perfilador Doppler-Acústico de Corrente

N. FILIZOLA, V. GUIMARÃES, J.L. GUYOT

O ADCP é uma ferramenta que, há algum tempo (década de 80), vem sendo utilizada com sucesso no mar, especialmente em estuários. Em grandes rios, as experiências ainda são poucas.

No Brasil este equipamento vem sendo utilizado de modo contínuo em algumas localidades. O marco inicial do uso do ADCP, no Brasil, se deu na Bacia Amazônica, em 1994, através da equipe Franco-Brasileira do projeto HiBAm, na época composta por técnicos do extinto Departamento Nacional de Águas e Energia Elétrica – DNAEE e o Instituto Francês para a Pesquisa e o Desenvolvimento em Cooperação - ORSTOM.

Os trabalhos do HiBAm, 12 campanhas de medições de vazão, com mais de 500 medições de vazão realizadas mostraram a vantagem fundamental deste equipamento para melhorar os conhecimentos sobre a hidrologia e também sobre os fluxos de sedimentos dos grandes rios da região Amazônica.

Esse equipamento possui outras características bastante úteis, pois mede seu movimento e altura em relação ao fundo e dá um perfil de intensidade do eco do material em suspensão na água. Essa última característica possibilita conhecer a distribuição dos sedimentos em suspensão na seção.

Nesse estudo é apresentada uma abordagem resumida o ADCP, de forma a transmitir ao leitor os conceitos principais da técnica com um visão sobre sua utilização em ambiente tropical, já que isso se mostrou importante, tanto do ponto de vista da experiência americana (origem do equipamento), quanto da experiência brasileira.

Como exemplo de experiência do uso do ADCP no Brasil, apresentam-se resultados obtidos em diversas estações hidrológicas na Amazônia e em especial um levantamento de campo comparativo entre as metodologias tradicionais e o ADCP, executado na estação hidrológica de Manacapuru.

A simple model to estimate hourly evapotranspiration over forest and pasture areas in the Amazon region.

G. FISCH, I. VENDRAME, V.F. ALBUQUERQUE

Using hourly measurements of an automatic weather station installed at the forest and the pasture sites in the Amazon region (Ji-Parana - Rondonia, southwest Amazonia), the actual evapotranspiration (EVT) has been investigated. A simple model of estimates of EVT using Penman-MOntheih equation has been derived, with the incorporation of stomatal conductance computed by hourly values of solar radiation, air temperature, vapour pressure deficit and soil moisture deficit. Simulating the integrated daily EVT for 45 golden days during 1992-1993 (Projeto Abracos), these estimates were compared with observed turbulent fluxes measurements done by an eddy-correlation equipment. The results have shonw that the model was able to estimate the real flux with an error of 0.5 mm/day (correlation coefficient of 0.76) for the pasture site and 0.3 mm/day for the forest. These results show that the simple model was better adjusted over forest, probably due to the lower soil moisture deficit related with the pasture, mainly during the dry season. This model is able represent the daily and monthly EVT for hydrology purposes.

Modelo de pronostico de inundaciones en el Río Parana en Corrientes (período Octubre - Marzo) basado en las temperaturas observadas de la superficie del mar (SST) y fenomeno ENSO (El Niño/Oscilación del Sur)

E.A. FLAMENCO

La ocurrencia de episodios fuertes del fenómeno El Niño provoca impactos climáticos severos (sequías, inundaciones) en distintas regiones del planeta, y en particular en el litoral de la República Argentina, donde las consecuencias son inundaciones en el río Paraná (Berri, 1996a).

En Julio de 1997 había evidencias claras del comienzo de un episodio El Niño, dado el calentamiento (anomalías positivas) que se observaba desde Abril en el centro y este del Océano Pacífico Ecuatorial.

Además, los diferentes modelos físicos y estadísticos de pronósticos de éstas anomalías indicaban que este calentamiento se acentuaría hasta fines de 1997 o principio de 1998. En consecuencia era necesario conocer con la mayor antelación posible, la magnitud de la crecida estacional a esperar en el río Paraná.

La experiencia adquirida en el entrenamiento en predicciones climáticas realizado en el International Research Institute (IRI), del Observatorio Terrestre Lamont-Doherty de la Universidad de Columbia (USA), ha permitido elaborar un modelo estadístico de predicción de inundaciones en el río Paraná (período Octubre-Marzo), en la estación fluviométrica Corrientes, basado en la variabilidad climática global (fenómenos acoplado océano-atmósfera).

El modelo es calibrado en el período 1950-1996 aplicando la técnica de Regresión Múltiple Lineal. Usa como predictores observaciones de las temperaturas de la superficie del mar (SST) del Océano Pacífico Ecuatorial, las de una región oceánica ubicada frente a las costas peruanas y el Indice de Oscilación del Sur (SOI), y es posible aplicarlo en los primeros días del mes de Setiembre de cada año Niño.

Con el objeto de evaluar la habilidad predictiva de este modelo, es realizado un análisis entre los volúmenes observados y simulados, aplicando la técnica de validación cruzada, siendo la diferencia promedio histórica entre dichos valores del 7.7%.

No existen antecedentes de pronósticos estacionales de esta naturaleza en el río Paraná y con tan importante antelación. En Setiembre y con motivo de la evolución que había alcanzado el episodio El Niño '97 hasta ese momento, a través de distintos medios de difusión fue publicado el pronóstico estacional Octubre 97-Marzo 98, el cual fue de 445600 hm^3 (± 26882 hm^3).

Regimen hidrológico del Río Parana (Argentina) y su relación con gases de efecto invernadero

E.A. FLAMENCO, E. KRUSE

En los últimos años las predicciones hidrológicas a mediano y largo plazo, han adquirido un interés creciente dado su influencia directa en la actividad socioeconómica de una región. En particular, en el caso del Río Paraná su importancia adquiere un significado trascendente, dado que la alternancia de períodos de inundaciones y sequías afecta al sistema productivo y urbano de varios millones de habitantes.

Existen distintos antecedentes que tienden a demostrar que la distribución de la Temperatura Superficial del Mar (TSM) en el océano Pacífico y la Oscilación Austral entre las presiones del Pacífico e Indico, influye en los patrones de precipitación en la cuenca del Río Paraná, lo cual se vincula directamente con la variabilidad del escurrimiento de este río.

En esta investigación, relacionada a un marco hidrológico global, se reconoce la relación existente entre los caudales del río Paraná en Corrientes (Argentina) con las variaciones que se registran en la concentración de dióxido de carbono atmosférico.

Se efectúa un análisis detallado sobre la base de distintas técnicas estadísticas y se plantean resultados que permiten elaborar hipótesis de comportamiento. A su vez se destaca las posibilidades que ofrece el estudio como base para la predicción hidrológica de largo plazo (1 a 3 años en adelante).

Aplicación de técnicas de medición de caudales mediante perfilador de corriente por efecto Doppler en grandes rios de Argentina

D. FONTANA, E. KRUSE

Se analizan las posibilidades que brindan en los relevamientos hidrométricos las mediciones de caudales efectuadas a través de un perfilador de corriente por efecto Doppler en los ríos Paraná y Uruguay en Argentina.

Se muestran los resultados de las aplicaciones efectuadas, discutiéndose las ventajas que ofrece su uso en los grandes ríos con relación a las técnicas convencionales.

La información correspondiente a los aforos realizados en el Río Paraná (Corrientes e Itá Cuá) y en el Río Uruguay (Garabí y Garruchos) resulta ilustrativa de la aplicación de la metodología. Se comparan los caudales registrados por el perfilador con los realizados en forma convencional, resultando ello de utilidad para verificar la aplicación de ambos procedimientos.

Los resultados obtenidos muestran que se trata de una metodología efectiva y precisa para la medición de caudales de grandes ríos, especialmente cuando se presentan crecidas de cierta magnitud.

Modeling spatial patterns of flooding and methane emission on the Jaú River floodplain using multitemporal JERS-1 SAR imagery

B.R. FORSBERG, A. ROSENQVIST, J.E. RICHEY, T.P. PIMENTEL

Multitemporal JERS-1 L-Band Synthetic Aperture Radar imagery provides a unique and powerful tool for investigating spatial fllooding patterns in wetland environments. When this imagery is used together with field measurements of biogeochemical processes, linked to flooding, it is possible to develop predictive spatio-temporal models of these processes, useful in the calculation of regional biogeochemical balances. We present here an analysis of flooding and methane emission on the Jaú River flood plain (Central Brazilian Amazon) using multitemporal JERS-1 imagery and field measurements of methane emissions. The Jau is a large black water river with an extensive lateral floodplain, covered predominantly with seasonally inundated igapó forest. 25 JERS-1 L-band SAR images of a scene covering 1030 km2 in the central part of the Jaú basin, acquired at 44 day intervals during a period of 3 years, were used to characterise the flooding pattern in the basin. Methane emissions estimated at regular intervals along a gradient of flooding conditions in this same scene were used to characterize the seasonal variations in methane flux and link them to the flooding pattern. Total flooded area within the scene varied from ~0 to 177km2 as a predictable function of stage height measured at a gauging station on the Jau River near the center of the scene. Methane emissions in all flooded environments varied as a function of the rate of change in stage height. Using these relationships together with daily stage readings it was possible to estimate total annual methane emissions from the scene. Annual emissions between 1994 and 1998 were estimated to vary from 1,377 – 2,485 mtonsC/y, with an average value of 2,021 mtonsC/y for the period. The maximum total flooded area of the entire Jau river basin, estimated from multitemperal JERS-1 imagery, was 688 km2. Based on the results from the smaller scene, the average methane emission from this area was estimated to be 7,857 mtonC/y. Considering this flux and the areal extent of this type of habitat in the Amazon basin, flooded back and clear water swamps could contribute significantly to the regional and global fuxes of methane to tlie troposphere.

Biogeochemical characteristics of organic matter in waters of the Amazon river and its tributaries. Their evolution during the water mixing downstream Manaus

F. GADEL, L. SERVE, M. BENEDETTI, J.L. BLAZI

Researches were focused on the Amazon river and its tributaries during the Purus 96 cruise (october 1996) and during the Encontro das Aguas cruise (september 1997), low water periods. The first aimed at the study of organic matter in suspended material and sediments of these rivers. The second (HIBAM 97 project) concerned the study of the particulate (□0,2 µm) and colloidal (0,2 µm- 5kD) fractions in the water mixing downstream the confluence of the main rivers, the rio Negro (black water) and Solimoes (white water). The applied analytical techniques involved the quantitative analysis of organic matter and its qualitative one in samples using colorimetry, high performance liquid chromatography and pyrolysis-gas chromatography-mass spectrometry methods. During the first cruise (Purus 96) in the Amazon river and its tributaries organic matter contents were very variable in suspended material. The highest values were found in the Negro, Trombetas and Tapajos rivers, while in the Madeira and Solimoes rivers they were weaker owing to the high mineral load. The polysaccharide contents were higher in the Tapana and Tapajos rivers (diatoms) and weaker in the Negro and Solimoes. Phenolic compounds decreased downstream. Ligneous phenols predominated, more particularly in deep waters and in deposits. Hydroxybenzyl phenols, rather deriving from phytoplankton, were more abundant in the middle area in the rios Negro and Trombetas. The pyrolysis analysis showed that aromatic hydrocarbons deriving from soil leaching were less abundant during this low water period, while nitrogen containing compounds, carbohydrates and aminosugars were increasing, resulting from the higher phytoplankton activity. Phenols, resistant compounds, increased in deposits and in deep waters. During the second cruise (Encontro das Aguas) raw waters were ultrafiltered on board with a tangential flow equipment using the following cutoffs : 0.2 µm and 5 kD in order to obtain the particulate fraction (□ 0,2 µm) and the colloidal one (0,2 µm-5 kD). The organic compound contents were more variable in the particulate fraction than in the colloidal one in the Negro and Solimoes rivers, therefore showing a higher diversity of sources in the first fraction. The contents of organic carbon, polysaccharides and phenolic compounds were generally higher in the colloidal fraction where the dilution effect by the mineral load did not occur, except in the rio Negro where the highest values were observed in the particulate fraction enriched in organic matter. Related to organic carbon, the contents in polysaccharides and phenolic compounds were more variable in the particulate fraction. The pyrolysis analysis showed that aromatic hydrocarbons were generally concentrated as nitrogen containing compounds in the particulate fraction corresponding to a more degraded material, while sugars, aminosugars and phenols were more abundant in the colloidal fraction, excepting the rio Negro with higher contents of aromatic hydrocarbons in the more degraded colloidal fraction. An opposition was observed in the distribution of these different compounds in the particulate and colloidal fractions showing a possible exchange between them. These facts were apparently confirmed by the values of the characteristic ratios that seemed to testify a lighter degradation of the colloidal fraction (higher values of furfural + acetic acid / pyrrol and lower for benzene / toluene ratio). The progressive homogenizing of surface waters resulting from water mixing, obvious enough downstream, was emphasized by the very similar contents in organic carbon, polysaccharides and phenolic compounds at the different stations. Moreover given the importance of the rio Solimoes with regard to the rio Negro the parameter values then were closer to the Solimoes waters downstream the confluence. Deep waters only showed particularities, certainly resulting from enrichment or impoverishment in organic matter due to currents or to the own water flowing of these two rivers. The pyrolysis analysis also showed that contents of aromatic hydrocarbons and nitrogen containing compounds became homogenous downstream in surface waters in the particulate and colloidal fractions, on the contrary of deep waters. Then contents of sugars and phenols increased slighly in the particulate fraction. These results showed that the study of organic matter thus allowed to precise the participation of labile or resistant, pedogenic or aquagenic compounds in suspended material, deposits and different size fractions according to the river discharge, the drainage basin and the depth.

Chemical weathering mass budgets in the Amazon river Basin

J. GAILLARDET, B. DUPRE, C.J. ALLÈGRE

The Amazon river basin is the largest river basin of the world both in terms of water discharge and surface area. We have sampled the Amazon (between Manaus and Santarem) and its major tributaries (Solimoes Negro, Madeira, Trombetas, Tapajos and Urucara rivers) for a geochemical investigation of both dissolved and suspended phases. These two phases were separated using a 0.2 μm filtration. A conventional view is to consider that during chemical weathering source rock react with soil water to form solutes and a residual phase mainly constituted of clay minerals and oxy-hydroxides. While solutes are continuously leached from soils, residual solids accumulate and are only released to rivers when physical processes of erosion are active. Once corrected from atmospheric inputs, dissolved and particulate phases in rivers should be complementary reservoirs. The basis idea of this work is to test this working hypothesis at the scale of a large drainage basin. In other words, we try to answer to the following question: Is the chemical composition of the dissolved load of the Amazon river consistent with that of the suspended load ?

It is difficult to answer to this question because two major parameters have to be known: the chemical composition of the bedrock and the amount of suspended solids in one liter of river water (i.e. the physical denudation rate). However, we will try to solve the mass budget equations of weathering using two geochemical tools. First we will use elemental ratios combining the most soluble (such as Na, Ca...) and the most insoluble elements such as Th and REEs). In addition to chemical ratios, we will show that isotopic ratios can be used to solve the mass budgets equations and give consistent results. Finally, we will propose some new geochemical tools that should be developed to go further on.

Relações entre o Indice de Oscilação Sul (IOS) e o total mensal de chuva em Maringá, PR

E. GALVANI, A.R. PEREIRA, E.S. KLOSOWSKI

Efetuou-se correlações entre o Índice de Oscilação Sul (IOS) com os desvios do total mensal de chuva para a região de Maringá-PR (Lat.: 23o 25' S, Long.: 51o 57' W e, Alt.: 542 metros), em uma série de 21 anos (1976-1996). Após os cálculos observou-se que o IOS apresenta correlação inversa (-0,14) com o desvio de chuva registrado nesta região, sendo o coeficiente de correlação mais significativo relacionando-se IOS com desvios de chuva de três meses posteriores, ou seja, o IOS de janeiro, reflete uma alteração do total de chuva de abril e maio, mostrando atraso de três a quatro meses entre a ocorrência de uma anomalia de temperatura e pressão no Pacífico, e sua manifestação na região norte/noroeste do Estado do Paraná. Observa-se também que em anos de El Niño de intensidade moderada e forte (IOS negativo) os desvios de chuva apresentam-se positivos em 47% dos meses, podendo assim os valores de IOS serem utilizados na previsão quantitativa do desvio de chuva, com antecedência de 3 a 4 meses e, probabilidade de acerto de até 47%.

ADCP Problemas ou soluções

P.E.M. GAMARO

Com as novas tecnologias e novos equipamentos disponíveis, muitas vezes não conseguimos acompanhar a rapidez do desenvolvimento, e mais fica difícil enquadrar o raciocínio antigo nas novas técnicas, com isto deixamos de utilizar o potencial completo dos equipamentos. Este trabalho mostra algumas possíveis distorções de uso com o equipamento de medição de vazão ADCP (Acoustic doppler Current Profiler), e as ações tomadas para mostrar aos técnicos que o utilizam o potencial real do mesmo, ganhando com isto uma maior produtividade do aparelho

Rare Earth Elements in the Amazon Basin: Encontro das Aguas

M. GERARD, P. SEYLER, F. SONDAG, G. BOAVENTURA, M.F. BENEDETTI

Rare earth elements (REE) abundance patterns of rivers water dissolved, colloidal and suspended material should provide valuable information both for the aquatic cycle of the REE and the knowledge of the weathering processes occurring on the continental crust. Moreover, REE are elements which are sensitive to major geochemical processes occurring in waters such as: surface complexation, redox variation, organic matter complexation. Their properties should help for a better understanding of the above mentioned processes in natural systems. Size fractionation by ultrafiltration coupled with the complexation capacity measurements is a powerful tool to gain knowledge about trace element speciation in aquatic systems. Here we report the distribution of REE. The distribution and the degree of association of major and REE with the discrete size fractions are presented. This study focuses on one of the most important zone for the amazon basin, the "encontro das aguas" area where the two major rivers of the basin, the Rio Solimoes and the Rio Negro meet.

Samples were taken in brazil 1997during a cruise on the Rio Negro and on the Amazon river from Manaus to Obidos devoted to the study of the mixing zone. Water samples at various depth and distance from the mixing were taken and treated on board with sequential cross flow ultrafiltration . All samples were treated in the same way: 2 litres of water were filtered using clean ultrafiltration membranes with the molecular cutoffs of 0.2µm and 5kD. All membranes were cleaned in the lab with 10 litres of MQ water. In the field the first 0.25 litres were systematically discarded to prevent sample contamination during the filtration. Total C and metal ion (Na, K, Ca, Mg, Al, Fe...) concentrations were measured in each concentrated fraction and as well as in the permeate. Metal ions were determined by ICP AES and GFAAS. Mass balance calculations indicate a good recovery of carbon and metal ions (>80%).REE concentrations were measured with ICP-MS. Detection limits are in the range of a few tenth of ppt.

In the present volume, we report data on bulk unfiltered samples, and filtered fractions P1 and P2 corresponding to 0.2 µm and 5000D cut-off membranes, respectively. The first striking result is that the Rio Solimoes has bulk water REE concentrations higher than the Rio Negro. For the smaller fractions this trend is reversed since the REE concentrations in the Rio Negro are always higher. The same trend is observed for mixed samples which have the highest contribution of the Rio Negro end member. The distribution of the REE among the different size fractions is a direct consequence of such a pattern. For the Rio Negro 50 to 30 % of the REE are concentrated in the particulate fraction (>0.2µm). The major part of the REE (50-60%) is therefore found in the colloidal fraction (0.2µm>>5000D) while only 0 to 10% remains in the so called dissolved fraction (<5000D). For the Solimoes a totally different distribution is observed. More than 95% of the REE are located in the particulate fraction. Only a minor amount is found in the colloidal fraction and the dissolved fraction. For samples corresponding to various proportions of the end members all intermediate compositions are found.

When we normalised the first permeate (<0.2µ) to the unfiltered sample a general enrichment for the heavy REE is observed in the REE patterns. Also a strong Eu anomaly is seen on the different REE pattern diagrams irrespective of the proportion of the mixing. When the second permeate (<5000D) is normalised to the first (<0.2µ) the heavy REE enrichment can still be distinguished in the REE pattern diagrams. However the enrichment is much less pronounced than in the first normalisation. Again in this pattern a Eu anomaly is observed. The more classical normalisation to the shale gives very flat REE pattern for most of the water samples fractions. Owing to the knowledge of the mixing proportions of the two end members that are well characterised we can calculate the theoretical composition of the different water samples corresponding to different mixing proportions and compare it to the actually measured concentration. The geochemical implications of this calculation will be discuss in the extended paper.

The effects of landslide disturbance on seasonal cycles of allochthonous Input to Peruvian Amazonian headwaters streams

A.J. GLAUBER, R.J. NAIMAN, D.G. PERALTA

We are examining the seasonal inputs and biogeochemical characteristics of allochthonous riparian material in headwater Amazonian streams.This study is part of AARAM's (Andean Amazon Rivers and Management) Pachitea Project. an investigation of spatial and temporal variability in biogeochemical cycles within an upstream Andean Amazonian river basin. Studies in other regions have shown that biogeochemical influences in upstream reaches partially control downstream river biogeochemistry. It is suspected that seasonal variation in quantity and quality of allochthonous inputs to headwater streams, such as those of the Andean Amazon, may affect the biogeochemistry, biodiversity and productivity of downstream reaches. As part of AARAM's Pachitea Project, we present data on riparian litterfall to quantify potential variations in species composition, nutrient quality (N,P,C) and quantity across a natural landslide disturbance gradient in Peruvian tropical montane rainforest. We suspect that streams adjacent to biodiverse mature riparian forests experience temporally more stable inputs of litter and nutrients than streams adjacent to low-diversity disturbed forests. Additionally, by investigating biogeochemical inputs along a natural disturbance gradient,we will better understand controls on ecosystem recovery within the upper Pachitea River Basin.

Dynamique de la nappe et régime hydrologique des rivières dans le haut bassin amazonien (Humaitá, Brésil)

M. GRIMALDI, X. CARON, V. ALLARD, V. ROSELEN, M. LAMOTTE, E. FRITSCH, R. BOULET, P. MAGAT

L'hydrologie de grands bassins versants, comme celui de l'Amazone, intègre les fonctionnements hydrodynamiques d'unités de paysage, qui varient selon le climat, la couverture végétale, le substrat géologique et son évolution pédogénétique. Sur l'une de ces unités, les bas plateaux de la partie sud du haut bassin amazonien (région d'Humaitá, AM), cette étude montre que les crues des rivières principales sont liées à l'extension et à la dynamique de la nappe en tête de bassin versant.

Ces bas plateaux, à végétation de forêt claire et de savanne, sont constitués des sédiments de la formation Solimões (Pliocène). Ils s'élèvent à 10m environ au-dessus des rivières. Au sommet des plateaux, des dépressions de taille variable et de dénivelée inférieure à 2m sont partiellement inondées en saison des pluies. L'étude porte sur l'une de ces dépressions, drainée par un ruisseau dont le cours traverse plusieurs zones marécageuses avant de rejoindre le rio Açuã, lequel appartient au réseau hydrographique du rio Solimões. L'étude pédologique d'une toposéquence sur un versant de la dépression met en évidence des horizons supérieurs argileux, épais de 1 à 2m, à forte différenciation latérale : leur couleur, indicatrice des transformations minérales liées au régime hydrique du sol, varie en quelques dizaines de mètres, de rouge puis jaune, à l'amont de la toposéquence, à blanc dans les sols hydromorphes du centre de la dépression. Ces horizons sont développés à partir d'une argile tachetée de plusieurs mètres d'épaisseur.

L'évolution de l'état hydrique du sol le long de la toposéquence a été suivie en fonction de la pluviométrie. Six piézomètres et quatre stations tensiométriques ont été reliés à des centrales d'acquisition afin d'analyser les variations saisonnières et à l'échelle de l'averse. La hauteur d'eau dans la rivière a été également mesurée occasionnellement. Enfin, la conductivité hydraulique du sol est déterminée in situ par infiltrométrie en plusieurs points.

En saison sèche, le toit de la nappe, horizontal, se situe à plus de 4m de profondeur au centre de la dépression. Dés le début de la saison des pluies, en novembre 1998, la nappe remonte de 4m sur l'ensemble de la toposéquence, en 20 jours totalisant 206mm de pluie. Plusieurs mécanismes expliquent cette remontée rapide et hors de proportion avec la lame d'eau précipitée, parmi lesquels : l'importance du ruissellement sur le versant, à cause d'une croûte peu perméable, qui concentre la lame d'eau au centre de la dépression où l'infiltration est dix fois plus élevée ; l'extension de la frange capillaire au sein de l'argile tachetée, proche de la saturation en eau en saison sèche. Par la suite, la nappe atteint le sommet de l'argile tachetée à l'amont de la toposéquence et elle affleure au centre de la dépression. La vidange de la dépression par écoulement superficiel est limitée par un seuil, barrage naturel peu élevé. Lors des épisodes pluvieux, le niveau d'eau dans la dépression monte rapidement à cause du ruissellement sur le versant. Cette retenue d'eau joue alors le rôle d'un bouchon hydraulique qui ralentit l'écoulement de la nappe dans le sol, et provoque sa montée rapide - en une heure environ - et croissante de l'aval vers l'amont. Lorsque le niveau d'eau dans la dépression dépasse celui du seuil, le trop-plein est évacué jusqu'au ruisseau, alimenté aussi par la nappe. La vidange superficielle de la dépression et la dynamique de la nappe dans les plateaux se répercutent sur le débit du rio Açuã, avec un retard d'environ 24 heures lié aux zones marécageuses en amont.

Analisis comparativo de modelos de pronostico autorregresivos simples involucrando variables macroclimaticas en dos rios interandinos de Colombia (Cauca y Magdalena)

C.L. GRISALES, J.G. LOZANO, Y. CARVAJAL

Los fenómenos climáticos sobre los océanos ejercen gran influencia en la hidroclimatología de Colombia, en especial el fenómeno El Niño Oscilación del Sur (ENSO), que es responsable de la variabilidad climática en escalas de tiempo que van desde meses hasta décadas. Debido a esta dependencia, se estudio la correlación entre algunas variables indicadoras del clima en los Océanos Pacífico y Atlántico con los caudales medios mensuales de 2 ríos interandinos de Colombia; el río Magdalena localizado entre las cordilleras Central y Oriental, con una longitud aproximada de 1.538 km y 256.622 km2 de cuenca hidrográfica y el río Cauca localizado entre la cordillera central y occidental longitud aproximada 1.350 km y 63.300 km2 de cuenca hidrográfica.

Para el desarrollo del estudio, se estandarizaron las series de caudal y variables macroclimaticas con el objeto de estimar los coeficientes de correlación; posteriormente se suavizaron mediante un promedio móvil de 3 meses, con el fin de filtrar la variabilidad de alta frecuencia, tratando de preservar al máximo la señal original. Seguidamente, se estimaron correlogramas cruzados para valores de los rezagos mensuales entre 12 y -12 meses, seleccionando las variables macroclimticas que presentaron mejor correlación con su respectivo desfase (mejores predictores).

Los resultados muestran las variaciones de la situación hidrológica del país, respecto a las variables macroclimáticas. Los coeficientes de correlación indican que las variables que presentan mayor asociación con los caudales analizados son en su orden: Las temperaturas de la superficie del mar en las regiones Niño 3, Niño 3-4, Niño 4 y SOI, mientras en el Atlántico, las mejores correlaciones las presentan: la Temperatura en el Trópico, en el Atlántico Norte (NATL) y Atlántico Sur (SATL) respectivamente.

La mejor predicción al muy corto plazo (un mes) no hace uso de las variables macroclimáticas, se reduce al tradicional modelo autorregresivo, pero si el horizonte de predicciones es más largo estas variables si aportan información importante. Adicionalmente, las variables macroclimáticas son buenos indicadores de los períodos críticos, ya que la tendencia de los autorregresivos es a predecir la media.

El conocimiento actual de la dinámica de la oscilación del ENSO permite hacer predicciones a largo plazo, superiores a los basados en la mera persistencia estadística. Estos modelos proporcionan una mejor herramienta de predicción a largo plazo que los autorregresivos. Presentando otra gran ventaja, la posibilidad de disponer de la información en forma inmediata.

La posibilidad de pasar de modelos totalmente estocásticos, cuyo único contacto con la realidad hidrológica es a través de los valores medios, sus varianzas y covarianzas, a modelos con base fisica, con ecuaciones bien definidas, y con una amplia red de observación, abre perspectivas importantísimas en la predicción a mediano y largo plazo. Estos modelos sin ser perfectos, son superiores al mero azar y compiten con las herramientas estadísticas más sofisticadas.

Analisis del efecto del fenomeno ENSO en el caudal y el transporte de sedimentos en dos rios interandinos de Colombia (Cauca y Magdalena)

C.L. GRISALES, J.G. LOZANO, Y. CARVAJAL

Colombia es uno de los países que posee mayor abundancia de recursos hídricos de superficie en el mundo, formando una red hidrográfica mayor de 700.000 microcuencas físicamente definidas. La precipitación promedio anual es de (3.000 mm/año), dos veces superior a la de América Latina (1600 mm/año) y tres veces el promedio mundial (900 mm/año). Dispone aproximadamente de mil ríos permanentes cuando en todo el continente africano no hay más de 60. Comparativa y proporcionalmente es el primer país en el mundo en disponibilidad de agua, ya que los países que lo superan, Canadá, Brasil y Rusia, son 8 veces más grandes en extensión. El rendimiento medio anual del escurrimiento (58 l/s/km2) es casi seis veces mayor que el rendimiento promedio de la parte continental del planeta (10 litros/s/km2) y tres veces mayor que el rendimiento promedio para América Latina (21 litros/s/km2).

Las cuatro principales corrientes colombianas son; el río Magdalena localizado entre las cordilleras central y oriental, con una longitud aproximada de 1538 km y 256.622 km2 de cuenca hidrográfica (22.5% del territorio nacional), el río Cauca entre la cordillera Central y Occidental longitud aproximada 1.350 km y 63.300 km2 de cuenca hidrográfica (5.5% del territorio nacional), el río San Juan con una longitud aproximada de 376 km y un área en su cuenca hidrográfica de 14.605 km2 (1.3% del territorio nacional), y el río Atrato entre la cordillera Occidental y la serranía del Baudó y el Darién con longitud aproximada de 750 km y 35.702 km2 (3.1% del territorio nacional). En el área de influencia de estos ríos se encuentra más del 90% de la población del país, lo que los hace de vital importancia para el desarrollo agrícola, económico y social.

El clima de la región es muy afectado por el fenómeno ENSO (El Niño Oscilación del Sur) (evento natural que se da como resultado de la interacción entre el océano y la atmósfera en la región del O. Pacífico Ecuatorial). El ENSO en su fase extrema cálida es un fenómeno cuasiperiódico con una recurrencia promedia de 4 años, que varía entre 2 y 7 años (Trenberth, 1991); mientras que su fase extrema fría, tiene una recurrencia promedia de 7 años; En Colombia, la fase cálida se asocia con sequías, y la fase fría, con exceso de lluvias cuya intensidad, frecuencia y duración aumentan considerablemente el caudal de los ríos y la erosión hídrica favorecida por el tipo y el uso que se le da al suelo. El caudal presenta una relación directa con el transporte de sedimentos, que es un buen indicativo del grado de erosión en las cuencas.

El río Magdalena, con su principal afluente el río Cauca, transporta en ciertos tramos de sus respectivos trayectos, cantidades superiores a 50 millones de toneladas de sedimento por año. En la mayor parte de las zonas hidrográficas no se han alcanzado límites peligrosos comparativamente con otras regiones de Suramérica, Europa, Asia, Africa y Australia. A partir de lo anterior se efectuó un análisis de correlación entre variables macroclimáticas y el transporte de sedimentos en los ríos Magdalena y Cauca en sitios específicos de control, obteniéndose como resultado que las variables que poseen mayor asociación con el transporte de sedimentos son las mismas que las obtenidas al hacer el análisis entre caudal y variables macroclimáticas (Carvajal et al, 1998).

Se hallaron correlaciones menores que las obtenidas con las del caudal medio mensual, sin embargo se observa disminución del transporte de sedimentos diarios durante la fase cálida por debajo de la media histórica e incremento de estos por encima de la media histórica durante la fase fría para el río Magdalena, esto como consecuencia de la ausencia e incremento de lluvias respectivamente, principal factor de erosión en la zona.

A large-scale hydrological model for semi-arid Tropics of North-Eastern Brazil

A. GÜNTNER, A. BRONSTERT

Scarcity of water resources is a major constraint for agricultural production, life quality and development in the semi-arid tropics of north-eastern Brazil. Determination of natural water availability on a large spatial scale is an essential prerequisite to understand and to mitigate economic and social impacts of droughts of regional and state wide extent.

A large-scale hydrological model for the quantification of water availability in the Rio Jaguaribe basin (72 000 km²) in the federal state of Ceará, Brazil, is presented. The study area is characterized by semi-arid tropical hydroclimatological conditions, with high temporal and spatial variability of precipitation. The basin is located predominantly on crystalline bedrock, thus surface water is the major source of water supply. Runoff is captured by several thousands of reservoirs with volumes varying in a wide range.

The hydrological model works in a spatially distributed mode with deterministic conceptual approaches. Spatial discretization is based on physiographical units (topography, soils, vegetation), the lateral connectivity of singular patches is explicitly taken into account. Sub-unit heterogeneity is included by distribution functions of respective model parameters and variables. This applies also for the huge number of small reservoirs which cannot be respected with geographic reference within each modelling unit. Model output in terms of river runoff, reservoir storage or soil moisture is given with daily resolution on the sub-catchment scale or for administrative units (municipios).

Scaling issues due to the wide range of spatial scales between runoff generation at the hillslope scale and water availability at the regional scale are addressed by including simulations in a small representative basin located within the study area. Results which led to the adaptation of the runoff generation approaches to the characteristic semi-arid conditions are presented in this paper. Uncertainty of model results of the large-scale model due to the rough data base are assessed by comparison with results of its application to the small basin for which higher-resolution data are available. Results of model application to the entire Rio Jaguaribe basin are given. Sensitivity studies demonstrate possible effects of land use changes or climate change on water availability while at the same time quantifying model uncertainty.

Caractéristiques hydrologiques du bassin amazonien.

J.L. GUYOT, J. CALLÈDE, G. COCHONNEAU, N.P. FILIZOLA, V.S. GUIMARÃES, P. KOSUTH, M. MOLINIER, E. OLIVEIRA, F. SEYLER, P. SEYLER

Le bassin amazonien s'étend sur plus de 6 millions de km², et apporte à l'océan atlantique 209 000 m3/s, soit un débit spécifique de 34 l/s.km2. La distribution de ce débit spécifique sur l'ensemble du bassin montre de fortes tendances régionales, avec des valeurs de 18 à 30 l/s.km2 pour les affluents méridionaux de l'Amazone (Xingu, Tapajós, Madeira, Purus; Juruá), de 40 à 50 l/s.km2 sur le cours principal (Solimões), et de 50 à 70 l/s.km2 pour les affluents septentrionaux de la zone équatoriale (Içá, Japurá, Uaupés, Negro). Cette variabilité régionale est évidemment très fortement corrélée à la pluviométrie. L'étude du régime saisonnier montre également des particularités régionales. Les tributaires méridionaux présentent un régime tropical austral, avec un maximum hydrologique en mars-avril et une période d'étiage en septembre. La variabilité annuelle des débits mensuels est relativement élevée, avec un rapport des débits moyens mensuels extrêmes (RQm) allant de 5 à 15. Les quelques cours d'eau de l'hémisphère Nord (Branco, Negro) présentent un régime tropical boréal, avec maximum en juin-juillet et un étiage en février-mars, avec des valeurs de RQm variant de 3 à 8. Le cours principal (Solimões/Amazone) est caractérisé par un régime équatorial altéré par les différents apports latéraux, avec un maximum hydrologique en mai vers l'amont et en juin à l'aval. La variabilité saisonnière sur le cours principal, ainsi que celle des rios Içá et Japurá, est très faible, avec des valeurs de RQm variant de 1.7 à 2,5. Sur les 20 années de la période d'étude (1970-1990), la variabilité interannuelle du module est très faible sur le cours principal de l'Amazone et ses affluents de la zone équatoriale, avec un rapport des modules extrêmes observés (RQa) variant de 1,25 à 1,35. Cette variabilité est plus élevée dans les bassins où le débit spécifique, donc la pluviométrie, est plus faible avec des valeurs comprises entre 1,4 et 2,3 pour les affluents méridionaux de l'Amazone, et des valeurs supérieures à 3 dans le bassin du Rio Branco. Enfin, cette variabilité interannuelle des débits est liée pour certains bassins aux variations climatiques globales de type El Niño.

La variabilité saisonnière des flux sédimentaires dans le bassin de l'Amazone

J.L. GUYOT, N.P. FILIZOLA, A. LARAQUE, P. SEYLER

Les apports de l'Amazone en matières particulaires à l'Océan Atlantique ont jusqu'à présent été calculés à partir d'un échantillonnage restreint, réalisé lors d'une douzaine de campagnes hydrologiques. En 1995, le programme HIBAM (ANEEL-CNPq-IRD-UnB) a installé un réseau de 10 stations de référence en Amazonie brésilienne, avec un échantillonnage décadaire, pour appréhender la variabilité temporelle des fractions dissoutes et particulaires au cours du cycle hydrologique, sur les principaux tributaires de l'Amazone. Les résultats obtenus à la station hydrométrique de Óbidos (Pará, Brésil) - la dernière station de jaugeage sur l'Amazone avant son embouchure - permettent d'estimer avec plus de précision les flux de matières à l'Océan, ainsi que l'impact du phénomène climatique de type « El Niño » de 1997-1998 sur ces flux.

Impact des barrages sur les transports dissous dans un bassin versant semi aride : Le Sebou (Maroc)

S. HAIDA, J.L. PROBST

Le bassin versant du Sebou occupe, au Nord-Ouest du Maroc, une superficie d'environ 40 000 Km2. Ce bassin a fait l'objet, ces dernières années, de l'installation de 16 barrages d'une capacité variant entre 0.12 et 3800 106 m3. Il connaît, également, une forte activité économique dans les secteurs agricole, industriel et urbain qui peut menacer la qualité des eaux de surface.

Au cours de ce travail les eaux du Sebou et de son principal affluent Ouerrha ont fait l'objet de prélèvements hebdomadaires lors des deux cycles hydrologiques 1996/97 et 1997/98. La première année d'échantillonnage a coïncidé avec la mise en service du barrage Al Wahda construit sur l'Ouerrha. Le but de cette étude est de mettre en évidence l'importance des apports dissous dans ce bassin et de suivre leur évolution géochimique après l'installation des barrages. Les éléments chimiques pris en considération dans ce travail sont les éléments majeurs et traces, et le carbone organique dissous (COD).

La composition chimique des eaux du Sebou à l'aval montre une très forte concentration ionique variant selon les saisons entre 912mg/l en période de crues et 1611mg/l en période d'étiage. Ces valeurs, comparées à celles obtenues pour une période avant l'installation des barrages, montrent un facteur de concentration de 1.8. Cette forte minéralisation peut être attribuée à la diminution des débits de l'Ouerrha et à la contribution importante, environ 40%, des affluents qui drainent des formations évaporitiques. Au cours de l'année hydrologique 1997/98, les volumes d'eaux lâchés à partir du barrage Al Wahda sur l'Ouerrha, ont permis une nette dilution des eaux à l'aval du Sebou.

On peut également noter aux cours de ces deux années de mesures de fortes concentrations en carbone organique dissous qui dépassent parfois 50mg/l. Ces concentrations anormales, généralement accompagnées d'une forte alcalinité, peuvent être attribuées aux rejets polluants issus des tanneries, des unités agro-industrièlles et des agglomérations urbaines.

A la lumière de ces résultats, on peut en déduire que les apports dissous du Sebou à l'aval sont étroitement liés au fonctionnement des barrages et surtout à celui du grand barrage Al Wahda. Ainsi, la réduction des apports liquides naturels entraîne de fortes concentrations en éléments chimiques auxquelles, peuvent s'ajouter les rejets anthropiques qui malgré leur caractère essentiellement organique, constituent une grande menace pour la qualité des eaux du Sebou, et notamment pour la complexation et le transport des polluants métalliques.

Determination of inundation patterns in the major floodplains of South America from passive microwave remote sensing

S.K. HAMILTON, S.J. SIPPEL, J.M. MELACK

Seasonal inundation determines the structure and function of tropical floodplain ecosystems, and therefore information on the spatial and temporal variability of inundation is fundamental to understand and manage these ecosystems. We have developed methods and algorithms to determine flooded area from the 37-GHz polarization difference observed by the Scanning Multichannel Microwave Radiometer (SMMR), operated on board the Nimbus-7 satellite from 1979-87. Inundation patterns have been determined in four of the major floodplains of South America: 1) The fringing floodplain of the mainstem Amazon River; 2) The Pantanal wetland of the upper Paraguay River in Brazil; 3) The Llanos de Moxos in Bolivia; and 4) The Orinoco Llanos of Venezuela and Colombia. In each of these regions, we estimated inundation area separately for subregions using mixing models that account for the major landscape units with distinctive microwave emission characteristics. The resultant information provides a detailed view of spatial and temporal patterns in inundation for the 9 years of SMMR data. We have also extended the inundation records into the past using predictive relations between river stage and flooded area; stage records are available for > 95 years in the Amazon and Pantanal, and for several decades in the Moxos and Orinoco. Comparison of the inundation patterns among these four floodplain regions reveals unique hydrological features of each region that help explain their distinct ecological characteristics.

Influencia del ENSO sobre los caudales mensuales de las grandes cuencas hidrográficas del Ecuador

E. HEREDIA CALDERÓN, R. POMBOSA LOZA

El efecto del ENSO sobre el régimen hidrológico de las grandes cuencas hidrográficas ecuatorianas es todavía poco documentado. Varios estudios sobre los efectos del ENSO sobre las precipitaciones, en particular en la costa Ecuatoriana han sido llevados a cabo recientemente, sin embargo los efectos sobre los regímenes de los ríos, y en particular de la región Amazónica no se han estudiado.

En el Ecuador el clima presenta gran variabilidad espacial debido, sobre todo, a su posición geográfica, a la influencia de factores tales como la topografía, la presencia de los glaciares, las corrientes marinas, a esto se suma el efecto de la posición relativa de la ZCIT y del evento ENSO, esta influencia determina un régimen hidrológico complejo.

En el presente trabajo se presenta el estudio comparativo de los efectos del ENSO sobre los caudales mensuales de dos importantes ríos ecuatorianos ubicados en el norte del país, el primero, El río Esmeraldas que drena hacia el Pacífico con una superficie de aproximadamente 20000 km2 y el segundo, el del río Napo que drena hacia el Amazonas con una superficie aproximada de 26000 km2. Se establecen las diferencias existentes entre ellos y la necesidad de estudiar con mayor profundidad las diferentes componentes que modulan la variación estacional de los caudales y los efectos del ENSO sobre ellos.

River water level changes of the Amazon estuary: at Breves, Caxiuanã and Abaetetuba

N. HIDA, J.G. MAIA, M. HIRAOKA, O. SHIMMI, N. MIZUTANI

The objective of this paper is to report on the preliminary findings based on river water level data being collected at Breves and Caxiuanã in the western Amazon estuary. The data is concerned with the period from December 1995 to May 1997. Information includes water level, water temperature, and electric conductivity. Annual Water Level Changes: Extreme tide-induced water level differences are observed twice a month. These variations correspond to the rhythm of spring and neap tides. The phenomenon is clearly visible at both Breves and Caxiuanã. Calculated from the 1996 data, the difference between the high and low water levels caused by the two events are nearly equal, i.e., it averages 36cm at Breves and 33cm at Caxiuanã. On the other hand, the daily changes of water levels at Breves are much bigger than those at Caxiuanã.

Daily Water Level Changes: As expected, the tidal cycles induce the water levels to rise and fall twice-a-day. During the spring tides, associated with the full and new phases of the moon, the curves for water level changes almost coincide. However, they appear in a different pattern during the neap tides. The variations between the high and low levels during the spring tides are 0.89m in April and 1.26m in November at Breves, and 0.20m in April and 0.27m in November at Caxiuanã. Corresponding figures during the neap tides are 0.87m in April and 1.21m in Nobember at Breves, and 0.17m in April and 0.23m in Novemver at Caxiuanã. Monthly mean water levels throughout 1996 are highest in April, -0.89m at Breves and -1.78m at Caxiuanã, and lowest in November, -1.18m at Breves and -2.21m at Caxiuanã. Water Temperature: According to the data measured at Caxiuanã in 1996, the daily mean water temperature varied seasonally from a low of 27.3 °C on April 20th, to a high of 31.5 °C on October 21th. Electric Conductivity: As far as the data obtained at Breves, the amount of daily mean EC (μS/cm, 25°C) was small, and the range of variations was in a level between 33 μS/cm on April 24th, 1997 and 67 μS/cm on December 8th, 1995. Supplement: The average daily tidal range at Abaetetuba is about 2.7 m. Higher than normal tides occur during the spring tides, associated with the full and new phases of the moon.

Hydrochimie du fleuve Tocantins et de rivières côtières de l'Est du Pará

B. HIERONYMUS, J. M. GODOT, J. BOULÈGUE, B. KOTSCHOUBEY

La région du Tocantins et le nord-est est du Pará (Brésil) sont encore peu connus du point de vue de l'hydrochimie et des relations eau-roches. L'importance de la connaissance de cette relation est apparue comme primordiale au cours des études conjointes franco-brésiliennes entreprises sur les gisements d'altération du Tocantins et du nord-est du Pará: latérites et bauxites de Carajas, Açailandia-Paragominas et Tucuruí; kaolins du Capim.

Cela nous a amené à nous intéresser non seulement aux sources et ruisseaux de ces gisements dont l'étude a permis la mise en évidence de phénomènes de dégradations et de transferts actuels, mais aussi aux grands ensembles hydrologiques de la région. Nous avons ainsi étudié sur plusieurs années les caractéristiques chimiques du fleuve Tocantins en amont et en aval du barrage de Tucuruí, ce qui a permis de tester l'impact d'un grand ouvrage sur un fleuve important. Nous avons également étudié des rivières du district bauxitique d'Açailandia-Paragominas.

La chimie des eaux du Tocantins est contrôlée par deux facteurs:

(a) l'alimentation par l'atmosphère: pluies d'origine marine et surtout continentale, dissolution d'aérosols issus des émissions par les plantes et pluviolessivats, les feux de forêts et l'érosion continentale;

(b) la dissolution des roches du bassin versant.

Les éléments dont la chimie est principalement dominée par les apports atmosphériques sont K et Cl. Après estimation et déduction des apports atmosphériques, la quantité d'éléments attribuée à la dissolution des roches a pu être déterminée, en particulier pour 1998 et 1990. Des épisodes importants de sécheresse en 1992 rendent plus délicate l'interprétation des variations spatiales des apports atmosphériques pour cette année.

Les éléments issus de l'altération des roches sont principalement Ca et Mg , une grande partie de Si et localement Na. En effet, si la contribution atmosphérique est importante pour Na, on a pu mettre en évidence dans la région de Tucuruí un apport non négligeable du à l'altération de roches: graywakes à albite et métabasaltes plus ou moins albitisés par des processus hydrothermaux. Le calcium et le magnésium sont issus en quasi totalité de l'altération de roches basaltiques, ou très localement du lessivage de roches carbonatées. Le silicium peut être attribué pour plus de 75% à l'altération de roches sauf lors des épisodes particulièrement secs de 1992 où l'apport atmosphérique a pu être prépondérant. Les teneurs des eaux en aluminium et en fer résultent aussi de l'altération des roches bien que des apports atmosphériques faibles et variables puissent être envisagés dans les zones à bauxites. Les roches lessivées qui influent sur la chimie du Tocantins sont donc principalement d'origine basique (basaltes, ultrabasites) bien qu'au niveau géologique elles n'occupent pas une grande place dans les affleurements reconnus. On peut voir là un effet de la dissolution plus rapide de ce type de roches par rapport aux roches acides et métamorphiques.

La quantification de ces contributions permet de calculer des rapports élémentaires caractéristiques des altérations pour les divers cours d'eau. Les bilans d'altération et d'exportation de matière par le fleuve Tocantins ont pu être calculés en terme de flux.

Erosion, transport and sedimentation in Nestos river basin

V. HRISSANTHOU

Nestos River flows through two European countries, Bulgaria and Greece, and discharges its water into the Aegean Sea. The basin area of Nestos River is about 5760 km2. In the Greek part of Nestos River, two dams were already constructed while a third dam is under construction. The construction of the dams and, therefore, the creation of the corresponding reservoirs implies the decrease of sediment yield at the basin outlet, where the ecologically interesting Nestos delta exists.

In this paper, the estimation of the annual sediment yield, due to rainfall and runoff, is undertaken by means of two mathematical models for that part of Nestos River basin which lies downstream of the dams. The area of this part of Nestos basin is about 830 km2. Both models consist of three submodels: a simplified rainfall - runoff submodel, a surface erosion submodel and a sediment transport submodel for streams. The two models differ only in the surface erosion submodel.

The common rainfall - runoff submodel of both models considers the soil moisture variation in the root zone through rainfall, deep percolation, potential evapotranspiration and runoff. The common sediment transport submodel for streams is based on the concept of stream sediment transport capacity (Yang and Stall, 1976). The first surface erosion submodel is based on the relationships of Poesen (1985) for splash detachment and splash transport, while the second one on the computation of the momentum flux exerted by the droplets and the momentum flux exerted by the overland flow (Schmidt, 1992).

The considered part of Nestos basin was divided into 20 natural subbasins. Monthly rainfall data for 11 years (1980 - 1990) from eight rainfall stations were available. The calculations were carried out on a monthly basis for each subbasin separately. The monthly values of sediment yield at the basin outlet for a certain year were added to produce the annual value of sediment yield due to surface and stream erosion. The comparison results for the annual sediment yield values according to both mathematical models are satisfactory.

Approche multifractale de la définition des régimes hydrologiques

P. HUBERT, H. BENDJOUDI, D. SCHERTZER, S. LOVEJOY

Les changements d'échelle, dans le temps comme dans l'espace, constituent pour l'hydrologie une sorte de pierre philosophale. Il existe dans la littérature de très nombreux travaux de recherches empiriques concernant les débits extrêmes, leurs relations mutuelles et leur dépendance à la taille des bassins hydrographiques. On pourrait en particulier citer le célèbre Essai de classification des crues maximales observées dans le monde de Francou et Rodier publié en 1967. L'approche multifractale, issue de l'étude de la turbulence et fondée sur les symétries de l'équation de Navier et Stokes, permet de considérer certaines de ces études sous un jour nouveau et pourrait leur donner une base rationnelle. Elle conduit en effet à identifier et à formaliser les invariances d'échelle, dans le temps et dans l'espace, des phénomènes hydrométéorologiques, replaçant ainsi dans un même cadre conceptuel les événements normaux et les événements extrêmes, et suggère que ces derniers, pluies comme débits, pourraient être régis, quelle que soit l'échelle de temps considérée, par des lois de distribution à décroissance algébrique et non exponentielle comme on l'a postulé jusqu'à présent. Ces conjectures sont très importantes au plan théorique car elles permettent de replacer le problème de la définition des régimes hydrologiques dans un cadre conceptuel nouveau, issu de la physique, dont l'absence a jusqu'ici cruellement fait défaut et qui à conduit à de multiples modélisations ad hoc sans portée autre que locale. Leurs conséquences pratiques, en particulier au niveau de la prise en compte du risque hydrologique dans l'occupation des sols et la conception des aménagements et des ouvrages, sont également considérables car elles conduisent à attribuer aux événements dits exceptionnels des temps de retour beaucoup plus faibles que les approches classiques.

Limnology of a pre-Amazonian river basin (Itapecuru, MA)

M.S.R. IBAÑEZ, F.J. ARANHA

The water characteristics of the Itapecuru River, a plain river of the Northeastern Brazil (1,450 km) was investigated on ten municipalities, upstream and downstream, in different periods of the dry and rainy seasons (September, 1994 to June, 1995). Water transparency, electrical conductivity, dissolved oxygen and suspended solids presented low variability in the temporal scale, with some exceptions. The behavior of these variables in the source-mouth axis was also discussed. The relative poverty of electrolytes in the upper course with higher values in the middle one and extremely high values in the mouth, is due to geological and geomorphological features of the basin that shows different lithologies. The tidal influence became evident in the ionic composition of the waters.

The late Quaternary river and lake development in Central Amazonia

G. IRION, G. KEIM, J. MULLER, J.N. MELLO, W.J. JUNK

The development of rivers and lakes in Central Amazonia depends to a high degree on the long-time variations of the local water level, which is related directly to the Quaternary sea-level fluctuation. During high sea stages the lower sections of the rivers and creeks were flooded and sedimentation rates increased whereas during low water periods erosion is dominant. 3.5 KHz profiling, coring in lake bottoms and field observations in area of the triangular between lower Rio Negro and Rio Amazon some 100km up and downstream of the Rio Negro junction reveals the widespread distribution of sediments deposited during Pleistocene high sea-level stages. The smaller lakes which have been formed in the lower section of rivers and creeks are filled up totally during the periods of higher water levels by both, the sediments of their own drainage areas and by sediments derived from main stream during seasonal flooding. An exceptional development took place in the lower section of the valley of Rio Negro. This valley is formed in the soft sands of the cretaceous Barreira Formation and has hence an extraordinarily width of up to 20km. In contrast to the smaller valleys only the upper part is filled with sediments deposited most probably during several high sea-level stages forming the islands of the "Arquipelago das Anavilhanas".

When sea-level lowered to more than 100m below MSL 20.000 years ago during Wisconsin maximum, in the investigation area the water level of the Amazon River dropped several 10th of metres. By 3.5 KHz profiling in the mouth of Rio Preta da Eva and of Rio Manacapuru and from sediment distribution at the Ilha do Camarao, situated just in front of Manaus, it can be shown that the local mean river levels has been at least 25m below the today's river mark, and it seems to be most probable that the water level reached a gauche of 40-50m below the today's mean level. This indicates that during Pleistocene low-water periods the inclination of the river table between Manacapuru and the Atlantic has been at least 3 times higher than today. In that period the water velocity and hence the erosion forces must have increased significantly. This correspond with the sediment distribution in the Amazon cone where higher sedimentation rates with coarser particles (up to gravel size) have been described for sediments deposited during Wisconsin cold period. It can be concluded that for long periods of the Wisconsin and during older cold Pleistocene periods the incision of Rio Amazon has been very intense and hence the river bed, at least in the lower 2.000km of its course has had a different shape than today. Most probably it has been more straight with much less tendency of forming separate channels and river branches than today. The seasonal differences of the water tables may have been less distinct and the floodplain has been significantly smaller than today. As can bee concluded from the distribution of channels in the "Arquipelago das Anavilhanas" the course of Rio Negro during Wisconsin maximum has been reduced to a single trench like bed on the right side of the valley.

The most conspicuous sedimentation processes taking place during Holocene is the formation of the várzea (floodplain) of the Amazon River. The formation of the várzea as it is developed today started only when sea level, and hence the river level arrived at the reach of the present MSL some 3.000 years ago. Sediment cores of lakes in the várzea show distinct seasonal varves with a thickness of 4mm for each year. This allows to calculate the age of the lakes as being 2.000 years This result, together with 14C-dating is in good agreement with the estimated age of the present várzea.

In conclusion, glacial maximum conditions differed from present-day conditions in a change from dominance of erosion and the lack of greater seasonal flooding to sediment accumulation and the flooding of large areas: This change from low water to high water levels may have taken place all along the Pleistocene time and will have affected the biological system of the Amazon valley.

Turbidity of Amudarya river in regulated conditions

H.A. ISMAGILOV

AmuDarya river is one of the biggest river with colloidal phase not only Central Asia, but may be in all world. Big turbidity of river had have led to intensive change of river bed process and as a result to erosion of banks, waterlogging of husbandry lands, towns, also silting up and decreasing of conduct: possibility of irrigated changes. Regulation of AmuDarya river in low reach of Tuyamuyun dike in 1982 has led to cut of water turbidity below the waterworks. In natural condition the average monthly turbidity for many years is composed 1.3 -7.2 kg /m3. Maximum turbidity of stream per day is achieve up to 20 kg/m3. In regulated conditions of river (regulated degree from 7 to 20 %) there were observed decreasing of turbidity in comparison with natural from 20 to 50 times. This relationship is actual now for period of reservoir filling (October -April). Stream turbidity, which comes out from dam vegetation period is more than on time of filling. Maximum turbidity in vegetation period is observe in case of many water years in September (i.e. in the end of vegetation) , but in low water years in May (i.e. in the commencement of vegetation). Observations fulfilled the last years had shown the turbidity increase of water that leave the storage for vegetation time in comparison with start of commissioning, and for the filling period the change of turbidity did not observed. There was always observed turbidity decrease on extent of below the low reach, at natural terms. In condition of regulated flow have been occured three cases of turbidity change on length: Initial turbidity of river beyond the dike more than a transfer ability of stream. In this case the stream can not carry all sediments, which comes out and take place washing up of silt at river -bed; Initial turbidity of river stream less than transfer ability of flow. In this case beyond the dam has occurred washing away of banks and additional filling of stream with deposits. Initial turbidity of river is equal for transfer ability of stream. Turbidity change in this case, beyond the water reservoir did not observed. Analysis of results of AmuDarya river data gave a possibility to obtain an equation for transfer ability of stream (turbidity), depending on hydraulic elements of flow for regulated conditions of the river. This equation allows to identify turbidity and deposits discharge on different plots of AmuDarya river by design and maintenance of any kinds of waterworks.

Irrigation methods for conservation soil and economic use of water in arid zone of Central Asia

B.F. KAMBAROV

This work dedicate irrigation engineering allows more economic use of water and reduces soil erosion, increases the protection of soil and water environment from pollution by fertilizers. Intensive use of irrigated soil leads to fertility losses ,- a problem more pronounced in Uzbekistan. Results obtained under natural conditions over a period of some years confirm expectation of improved soil conservation and fertility in the soil by using furrow irrigation and others irrigation systems.

We have developed a polimer " K", which has advantages: it gives a soil structural formation, regulated water permeability on slopes for irrigation, rainfall and makes a protection soil, length of the furrow can be increased by up to 500 m in the slope 0,02-0,22 m/ m, in this case can be used without a network of irrigation ditch in the field.

On soil with hard gypsum and sandy inter layers to a depth of 0,9 m with special tractor implements for loosening and polymer have yielded cotton 37,5 centner/ha against 18,2 centner/ha.

Polimer formed in the upper layers of stony and sandy soil by subsidience of silts with nutrients for plants in the water irrigating.

We propose zigzag-shaped, contour and other types of furrows on slopes 0,1-0,25 m/m. Irrigation methods on the the slope is effective by reliable when theory of irrigation engineering is used corresponding to the standarts for set norms, irrigation , components, programming and improvment of soil fertility, forecasting of yieldes.

This work covers also is description of drip, irrigation, subsoil and bench border irrigation. We use methods of irrigation to increase soil fertility of deserts and recommend that is method and others for development of farms then to meet agricultural requirements, recommend temporary irrigation dithes on slopes of fields in the 600 thousand hectars.

We use methods utilization ecologic dean fertilisers: hlorella, silt of reservoir and aquatic plant for economic chemical fertilisers.

Results obtained: economic use of water namely 110 million m3 , additional irrigation potential- 2034 ha, economic use of irrigation labourers 988 persons.

The sediment deposits of Lago Calado, a Ria Lake in Central Amazonia (Brazil), as indicator for postglacial water level rise of the Amazon River

G. KEIM, G. IRION, H. BEHLING, W.J. JUNK, J.N. MELLO

In order to study the complex paleolimnology of Central Amazonian Ria Lakes (Lagos da Terra Firme), sediment cores of 15m length were recovered from Lago Calado (80km west of Manaus on the left bank of the Amazon River), which is one example out of hundreds of lakes of this type in Amazonia. The sediments were analysed with sedimentological, mineralogical, geochemical, and palynological methods, by which general aspects of the development of the lake can be worked out.

Due to the very low gradient of the Amazon River, the level of the Amazonian waters depends on Quaternary sea level changes far beyond the place, where Lago Calado is situated. Furthermore, the water tables of Ria Lakes like Lago Calado are controlled by the Amazon River. Therefore, the sediment sequence of Lago Calado describes not only the depositional history in the Calado Valley but as well the development of the water level of the Amazon River during the late Pleistocene and Holocene. During the maximum of Wisconsin glaciation, when sea level and hence the level of the Amazon River was low, the Calado Valley was flown through by a minor tributary. Gravel and sand were deposited on top of cretaceous sandstones, which can be observed in the sediment sequence in the lowermost part of the sediment cores. In the earliest Holocene, during rising water levels, an alternation of sands and dark mud deposits (lake sediments) reflects changes between fluviatile and lacustrine environments. About 9500 BP (all ages base on calibrated 14C data) the Amazon River reached a level of 20m below the recent mean water level. 7600 BP, when the water level of Rio Amazon was about 13m below today's level, the valley became permanently flooded and a continuous sedimentation of fine grained lake deposits started. According to our 14C data and the sediment characteristics, the recent water level was not reached prior to 3000 BP, probably later.

The depositional processes in Lago Calado are not only influenced by the long term water level changes but as well by the annual periodic water level variations of the Amazon River. During saisonal rising stage, Amazon water can enter the lake, when the run off from Lago Calado's catchment area can not compensate the necessary water volume of the lake. Therefore, two different sources for allochthone sediment particles exist: the local tributaries and the Amazon water. The origin of the lake deposits can be distinguished by means of mineralogy and geochemistry, since the suspended load of the Amazon River is rich on smectite and illite, whereas kaolinite is the only clay mineral in the suspended matter of the lake's tributaries. In the initial lake phase nearly the whole sediment was delivered by local tributaries. During the transgression phase the local tributaries were still the dominant sediment sources, whereas since 3000 BP a strong increase of Amazon delivered matter can be observed. Despite the changes in the sediment supply the ratio of deposition was relatively constant at 1.5mm/yr.

In the valley of Lago Calado some terraces could be localised several meters above the recent sediment surface. The terraces consist of altered lake sediments. They are interpreted as relicts of the Sangamonian (high sea level) equivalent of the today's Lago Calado. From the position of the terraces it must be assumed that during Sangamonian the mean water level in Central Amazonia was approximately 6m higher than today.

With the investigation of the sediments of Lago Calado, it is possible to get a general idea about the processes which occured during the postglacial transgression phase. It can be assumed that not only during the Late Quaternary but also during the complete Pleistocene the sea level changes were the important driving forces for the sediment dynamics in the Amazonian lowland. During low sea level stages erosional processes and valley deepening dominated, whereas during high sea level extensive aquatic landscapes were formed.

Altimetric reference for Amazon area : first experiments

P. KOSUTH, D. BLITZKOW, I.O. CAMPOS, R.F. BUENO, C.A. CORREA E CASTRO, J. CALLEDE

Knowledge of the altitude above mean sea level of the main hydrometric stations is a prerequisite for an in-depth understanding of rivers hydrodynamics and sedimentologic processes, particularly for the use of models. In tropical regions with dense forest cover, usual geometric land leveling can hardly, if ever, be achieved. This is the case of the Amazon river network where only two of the 220 hydrometric stations in Brazil have been leveled. In such regions, alternative geodesic techniques have to be implemented. This paper presents an altimetric study of the downstream reach of the Amazon River (seven stations on 800 km) using GPS technique for geometric height determination and geoid model to convert geometric to orthometric heights. For these seven stations the average precision on the geometric height was 0.075m (from 0.02m to 0.16m). A comparison of orthometric heights in Santarem derived (1) from available geometric leveling and (2) from GPS measurement coupled with geoid model shows a difference (1)-(2) ranging from –0.103m to +0.743m depending on the geoid model. The development of such "autonomous" altimetric techniques would allow improved monitoring of river networks, including for the study of flooded areas dynamics.

Sea-tide effects on downstream Amazon River flows

P. KOSUTH, J. CALLÈDE, A. LARAQUE, N. FILIZOLA, J.L. GUYOT, P. SEYLER, J.M. FRITSCH

Physical influence of sea tide on downstream Amazon River can be assessed more than 1000 km upstream from the sea.

In order to analyze this phenomenon, over the year recording of water levels (every 30') has been ensured at 5 stations along the downstream Amazon River and measurement campaigns have been organized, for different river discharge rates (low flow 100 000 m3/s and mean flow 150 000 m3/s) and sea tide amplitude (2 meters to 3.5 meters).

During these measurement campaigns, hourly variations of water levels and discharges (using ADCP technique) have been recorded at different stations along the downstream Amazon River. It led to such surprising observations as local changes in discharge from 130 000 m3/s to 40 000 m3/s in 4 hours, cyclic storage of 8 billion m3 in 6 hours, or even local inversion of flow from 60 000 m3/s to – 22 000 m3/s in 4 hours on some branches of the Amazon. Hourly fluctuations in suspended sediment concentrations have equally been monitored.

Damping and time-delay of the tidal signal, depending on water regime and distance to the sea has been analysed. Physical processes of wave propagation and cyclic water storage and release have been studied both through data analysis and confrontation with mathematical hydrodynamic models. The impact of this tidal pulses on sediment transport to the sea has been analyzed.

This study is intended to contribute to increased understanding of physical processes at the interface between large rivers and the ocean, improved methodology to measure and monitor these processes, and better understanding of large rivers hydrodynamics.

Respective effects of climate change and anthropic action on the modification of the annual extension of flooded areas along Senegal river valley

P. KOSUTH, P. VAUCHEL, J.C. BADER, J.P. LAMAGAT

The Senegal River Basin (300 000 km²) can be divided in an upper basin, which constitutes the main catchment area, and a low valley where flood propagation invades large areas. The hydrological monitoring of the Basin is almost complete from 1904 to 1998.A major change in climate has occurred at the beginning of the 70ies and is still over lasting with a persisting drought and a 50% reduction of the mean annual water volume. This has induced drastic reduction of flooded areas and consequent impacts on both human activities and ecosystem dynamics related to the flood regime. At the end of the 80ies a dam has been built on the upstream basin with the objective of regulating the river regime through artificial sustaining of low flows for hydropower, irrigation and navigation, while preserving a minimal flood for environmental purposes through artificial flood support.

The purpose of the present study was to develop a methodology to assess and quantify the respective effects of natural drought and anthropic action (river regulation) on the flooding regime of a given flood plain. The intention is to provide rational quantified elements to feed the debate on respective responsibility of climate change and human action, and help in defining an accurate management strategy for the reservoir.

Various flood plains have been monitored for two years through daily measurement of water levels both in the flood plain and in the river, regular measurements of flooded areas limits through GPS and analyse of remote sensing images. An hydrological modelling of the overall system has been elaborated, from the upstream basin to the flood plain : natural regime or reservoir management regime, flood propagation along the river, flood plain dynamics,... This allows to compare the flooding of the plain for the 1904-1998 period, both under natural conditions (wet period 1904-1972 and dry period 1973-1998) and simulated reservoir management conditions. Methodological problems linked with the extrapolation of results to the overall flood valley are considered.

Studies on the role of nitrogen fixation and denitrification in the floodplain forest of the várzea

H. KREIBICH, J. KERN

A shift of organisms, biomass, and energy between rivers and their inundation areas are dependent on the water level. Therefore, floodplains are dynamic and complex ecosystems which periodically oscillate between terrestrial and aquatic phases. The high level of biomass production in the Amazon whitewater floodplain is closely linked with the supply of nutrients, namely nitrogen.

The largest nitrogen load is transferred to the várzea by the water of the Solimoes river. Alone this can only partially explain the high productivity of macrophytes and of the floodplain forest. With about 20% leguminous trees, there might be a high potential of nitrogen fixation due to the legume-rhizobium symbiosis. Therefore N2 fixation may play an important role as a nitrogen source for the várzea forest.

First results show that nitrogen fixation of rhizobium symbioses as well as of free living bacteria exist in the várzea forest. Active nodules have been found at roots of various leguminous trees as well as of herbaceous plants, bushes, and lianas. Application of the acetylene incubation technique showed high fixing rates in clear forest ground and in the rhizosphere of different tree species. Studies using the natural abundance method resulted in low 15N/14N isotope ratios of woody legumes as well as of woody non-legumes indicating that N2 Fixation is not restricted to legumes. Further studies using the isotope dilution method shall help to quantify the efficiency of tree-rhizobium symbioses to fix N2.

First findings of the factors influencing and regulating N2 fixation and denitrification indicate a high variability of both processes within a few square centimetres of forest ground. A flooding experiment using soil of a Cecropia forest with different amounts of additional water incubated in acetylene atmosphere showed a high increase of denitrification with the maximum activity in the first 4 hours but also a significant increase of nitrogen fixation with a maximum after 2 days of inundation. Since nitrogen fixation and denitrification in the soil are mainly controlled by hydrological processes, the continuous change from aquatic and terrestrial areas seems to be very important for the gaseous nitrogen exchange.

La rencontre des eaux des rivières Solimões et Negro Modèle en 3 dimensions

A. LARAQUE, J.L. GUYOT, G. COCHONNEAU

Dans le cadre du programme HiBAm de l'accord CNPq/ANEEL/ORSTOM/UnB, plusieurs relevés avec un courantomêtre à effet Doppler (ADCP de 300 KHz) ont été effectués sur la zone de rencontre des eaux très contrastées des rios Solimões (beiges) et Negro (noires) juste en aval de la ville de Manaus.

Plus d'une vingtaine de sections perpendiculaires au cours d'eau ont pu être explorées en période de crue comme en étiage entre 1995 et 1998. Ces sections peuvent atteindre 90 mètres de profondeur et des largeurs de 5 000 mètres pour des vitesses de l'eau dépassant souvent 3 m.s-1. L'ADCP envoie un signal acoustique toutes les 5 secondes. Cela permet de découper une section en parfois plus de 250 verticales. Pour chacune d'entre elles, le temps de retour de l'écho et son altération fréquentielle indiquent leur profondeur, ainsi que l'orientation des lignes de courant tout au long d'un découpage en cellules de 2 mètres de haut. En fonction des matières transportées, ce même signal informe de l'intensité en Beam qui y est liée, pour chaque cellule ainsi que de la vitesse moyenne de l'eau. Une répartition spatiale très bonne et très précise est ainsi obtenue. En intégrant toutes ces données sur la section, l'ADCP calcule en instantané le débit liquide. Pour évaluer les flux solides et dissous, nous avons prélevé pour analyses (MES, éléments majeurs dissous, COP, COD, éléments traces), des échantillons d'eau à plusieurs profondeurs sur différentes verticales et effectué des mesures in situ (température, conductivité électrique, turbidité, pH, alcalinité). L'utilisation d'une sonde CTD Profiler (SEABIRD SBE 19) à également permis d'étudier en continu les variations verticales de la température et de la conductivité.

Grâce à la comparaison des différents transects effectués et des résultats sur les paramètres étudiés, ce poster illustre pour la première fois, par un modèle en trois dimensions, la bathymétrie relativement accidentée de cette zone, ainsi que la dynamique du mélange tant du point de vue hydrologique que géochimique.

Dynamique hydrologique et géochimique de la rencontre des eaux des rivières Solimões et Negro dans le bassin de l'Amazone

A. LARAQUE, J.L. GUYOT, P. SEYLER, N. FILIZOLA

Les eaux très contrastées en terme physico-chimique des Rios Negro et Solimões se rencontrent au droit de la ville de Manaus pour former le fleuve Amazone. On peut observer alors sur quelques dizaines de kilomètres une zone de mélange entre les eaux « blanches » chargées en matières en suspension du Rio Solimões et les eaux « noires » riches en matières organiques du Rio Negro.

Afin de déterminer les processus biogéochimiques qui s'y produisent, cette zone a fait l'objet d'une étude scientifique détaillée lors de la campagne fluviale du programme HiBAm qui s'est déroulée en période de basses eaux entre le 16 et le 26 septembre 1997. Durant cette période, la zone de mélange a été échantillonnée selon douze coupes transversales. Chacune d'elle a été étudiée en utilisant un correntomêtre à effet Doppler (ADCP de 300 KHz) qui a permis de représenter les lignes de courant, la répartition des charges solides et de mesurer les débits. De plus, six sections ont été explorées selon plusieurs verticales, sur lesquelles des mesures in situ (température, conductivité électrique, pH, turbidité, alcalinité) et des prélèvements ont été effectuées à différentes profondeurs. Ces derniers ont servis à déterminer la répartition des matières en suspension, des teneurs en éléments majeurs dissous, du COP, COD, et des éléments traces. L'utilisation d'une CTD (Seabird SBE 19) à également permis d'étudier en continu les variations verticales de la température et de la conductivité. A partir de ces données, des calculs de flux de matières ont été réalisés.

L'ensemble des mesures a permis de représenter de façon détaillée la configuration et la dynamique de la zone de mélange des eaux. Les eaux du Negro se différencient de celles du Solimões par des valeurs plus faibles à la fois des vitesses (0,4 à 0,8 contre 3 m.s-1), des conductivités électriques (8 contre 70 □S.cm-1 à 25°C), des turbidités (5 contre 80 NTU), des pH (5,5 contre 7), et par des températures légèrement plus élevées (31,4 contre 30,6 °C) correspondant aux caractéristiques physiographiques particulières de chacun des bassins drainés. Dans la zone de mélange dont la topographie du lit du fleuve est relativement accidentée, les eaux du Solimões plus denses et aux vitesses de courant plus élevées, circulent sous les eaux du Negro. La ligne de contact est franche et quasi verticale au début de la zone de mélange et s'incline progressivement pour devenir horizontale et plus diffuse à proximité de la surface (en fin de mélange). Enfin au gré de la turbulence du courant les dernières cellules d'eaux noires du Negro sont absorbées par celles du Solimões deux fois et demi plus puissant. Les calculs de bilan effectués montrent que la loi de conservation de masse tant pour les éléments majeurs dissous que pour les transports particulaires est respectée.

Enfin, les résultats ADCP présentés ici ont été comparés à ceux des transects effectués pendant d'autres phases hydrologiques (notamment en crue).

Transports spécifiques dans le bassin du Congo

A. LARAQUE , J.C. OLIVRY

Le fleuve Congo, 1er du continent africain et 2ème de la planète, dispose d'une chronique hydrologique qui couvre tout le XXième siècle. Par contre, par comparaison avec d'autres grands fleuves de la planète, il est à déplorer une certaine carence de connaissance sur la qualité des ses eaux et sur leur variabilité tant spatiale que temporelle, faute de données de terrain suffisamment abondantes.

Ce n'est que très dernièrement qu'un quart de son bassin versant de 3,7 millions de km2, a pu faire l'objet d'études et d'un suivi scientifique régulier, de longue durée et courtes fréquences à une échelle spatiale conséquente. En effet de 1987 à 1994, dans le cadre du programme PEGI/GBF , mené par l'INSU/CNRS/ORSTOM , ce fleuve à son exutoire, a bénéficié d'un suivi hebdomadaire de ses concentrations en matières en suspension (MES) et mensuel de ses concentrations en éléments dissous, pendant que ses affluents de rive droite étaient suivis au pas de temps mensuels pour l'ensemble de leurs transports.

Ce travail fait la synthèse pluriannuelle des calculs de bilans d'exportations de matières à son exutoire en affinant les rares estimations antérieures. Il précise leurs fluctuations saisonnières et leur tendance interannuelle. Mais surtout, il permet de comprendre le fonctionnement de l'ensemble de ce bassin en analysant pour la première fois de manière quantitative et qualitative, les contributions de chacune de ses grandes unités physiographiques. La Cuvette Centrale, vaste dépression couverte d'une forêt pluviale en partie inondée en crue, celle de la ceinture de reliefs à cuirasse latéritique plus ou moins élevés et couverts d'une savane arbustive à arborée et les plateaux Batékés constitués d'un immense aquifère sablo-gréseux sont autant d'écosystèmes qui impriment au fleuve de fortes signatures tant en terme d'écoulements que de transports de matières. Les caractéristiques géochimiques associées à chaque typologie des eaux, sont soulignées. L'état d'équilibre du fleuve est décrit, tout comme l'influence des vastes "Pool" qui le jalonnent (Sandy Beach, Stanley Pool) qui servent de "réservoirs temporaires ou saisonniers" de sédiments en étiage, qui sont ensuite repris et retransportés en crue.

Enfin, à la lumière des enseignements précédents et du rôle joué par chacune de ces entités, un modèle de son fonctionnement biogéohydrodynamique est proposé.

Análisis y manejo de rios de la Amazonia Andina - Proyecto ARAM

C.A. LLERENA

Análisis y Manejo de Ríos de la Amazonia Andina (AARAM, por sus siglas en inglés), es un proyecto financiado por el Instituto Interamericano de Investigación del Cambio Global (IAI) que se desarrolla en cuatro cuencas altas del Amazonas, con la participación de científicos de Bolivia, Brasil, Colombia, Ecuador, EE.UU. y Perú en calidad de investigadores principales; y científicos Europeos como activos colaboradores.

AARAM - Perú, el componente peruano de AARAM, se lleva a cabo desde Junio de 1998 en la cuenca andino-amazónica del río Pachitea (4500-300 msnm, 28000 km2) y tiene como sus principales objetivos:

1.- Obtener información hidrológica, meteorológica y sobre el uso de la tierra y el agua en la cuenca con el fin de generar una base de datos que permita mejorar el conocimiento de los procesos hidrológicos y de los impactos de la ocupación humana de la cuenca y de los cambios en el uso de la tierra que esta ocupación genera, especialmente en los ecosistemas ribereños. Este objetivo se complementa con el necesario mejoramiento de las instalaciones y equipos de toma de datos en la cuenca.

2.- Capacitar a científicos jóvenes de la Amazonia andina en hidrología y biogeoquímica amazónicos, compartiendo experiencias interdisciplinarias entre los científicos de los países participantes y colaboradores con el fin de buscar una metodología común de trabajo y desarrollar una masa crítica de especialistas con proyecciones al futuro y capacidad de influencia en los niveles de decisión política. Con fines apoyar a la capacitación en otros niveles y de compartir y difundir información, se espera contactar con organizaciones privadas y gubernamentales locales: ONGs, programas de desarrollo, escuelas y otras.

En este reporte se presentan y discuten los avances del trabajo realizado en la cuenca del Pachitea hasta el mes de Marzo de 1999, siendo los más importantes: tres campañas (dos en período de creciente y una en vaciante) de toma de datos de caudales y calidad del agua en 14 estaciones del río Pachitea y sus tributarios; la firma de un acuerdo de cooperación con el Servicio Nacional de Meteorología e Hidrología (SENAMHI) y los contactos con organizaciones gubernamentales y no gubernamentales que laboran en la cuenca; el inicio de estudios de post-grado (M.Sc.) en la Universidad Nacional Agraria La Molina (UNALM), de sendos profesionales de Bolivia, Colombia, Ecuador y Perú, con apoyo de AARAM - Perú; la visita y participación en una de las campañas de toma de datos del co-PI de Colombia; la conformación de un equipo peruano de AARAM de trece integrantes, que a la fecha vienen produciendo siete tesis de grado en la cuenca del Pachitea; y el reforzamiento y consolidación del equipo internacional de AARAM.

Hidrología y contaminación de los rios de la Amazonía andina por las actividades antrópicas

J.G. MACO

En la Cordillera de los Andes nacen los principales ríos formadores de la gran cuenca hidrológica amazónica, los cuales se caracterizan por ser de cauce pedregoso y/o rocoso, presentando gran pendiente y velocidades muy rápidas cuando discurren a través de los Andes. Sin embargo, ya en el llano amazónico, estos ríos discurren por pendientes más suaves y la velocidad de corriente se torna menos rápida, siendo el cauce compuesto de material arenoso-arcilloso-limoso. Por otro lado, las actividades antrópicas que se desarrollan en la Amazonía peruana, tales como: las auríferas, las petroleras y las urbanas, producen una serie de desechos que son arrojados a los sistemas acuáticos aledaños sin previo tratamiento. En varios cuerpos de agua de las cuencas de los ríos Tigre y Corrientes, donde se produce la mayor actividad petrolera en el Perú, existe contaminación por hidrocarburos y por las aguas de producción. Asimismo, se ha determinado que las aguas de producción afectan seriamente el equilibrio osmótico de los peces lo cual influye en el desarrollo normal de sus funciones vitales. Los cuerpos de agua aledaños a las grandes ciudades, tales como : Iquitos, Pucallpa y Tarapoto, se encuentran seriamente contaminados con hidrocarburos y coliformes totales y fecales los cuales son causantes de una serie de cuadros epidemiológicos en la población. Además, se reportan datos sobre los niveles de contaminación por mercurio en el sistema hidrológicos de la Cuenca del río Madre de Dios.

Balbina, 10 ans après...

M.D. MAGALHÃES, A. M. FIGUEIREDO, A. LARAQUE

Le barrage Amazonien de Balbina situé sur le Rio Uatuma et alimenté par un bassin de 18 862 km2 a maintenant 10 ans. D'un volume de 17 533 x 106 m3, il a fait l'objet durant toute cette période, d'un suivi physico-chimique (T°C, CE, turbidité, MES, résidu sec, pH, transparence, couleur, chlorophylle, O2, phosphates, ammonium, Fe2+, Fe3+, H2S) de ses eaux (famille des black waters) sur 7 stations réparties sur sa superficie. Ce travail présente les premiers résultats provenant de l'exploitation des chroniques décennales des données de la station M1, la plus proche du barrage, la plus profonde (35 mètres), et la mieux suivie (pas de temps hebdomadaire des paramètres, enregistrés tous les 2 mètres de profondeur).

Il permet d'ores et déjà de suivre l'évolution temporelle de ces paramètres au sein d'une colonne d'eau, comme d'apporter un jugement sur leur état "d'équilibre ou de déséquilibre" par rapport à un état initial connu. On peut interpréter ces états et même prédire leur évolution, comme la date de retour à un état originel, grâce à un modèle simple, basé sur des courbes de tendances.

Par exemple, la conductivité électrique, montre une variation verticale brusque (halocline) aux alentours de 10/15 mètres du fond. Dès la mise en eau du barrage, elle a fortement augmentée avec un gradient vertical dépassant 70 uS/cm à 25°C au fond de la retenue, suite aux perturbations apportés au sol. En moins de 2 ans ses valeurs de surface et de milieu ont été divisées par 2, puis depuis 8 ans, elles connaissent un retour régulier et plus lent à une "normale" ou situation initiale (6-7 uS/cm à 25°C), qu'elles atteignent en fin 1997. La conductivité de fond quant à elle subit des variations plus erratiques et prononcées tant au niveau saisonnier que interannuel. L'utilisation du modèle prédictif précédemment annoncé, amène à penser, dans l'hypothèse d'une poursuite continue de l'évolution actuelle, que la conductivité de fond rejoindra les valeurs de surface (actuellement à l'équilibre avec celles des apports latéraux et atmosphériques) que vers mi 2002.

Les tendances des autres paramètres confirment ce diagnostique. Par contre, l'oxygène dissous montre la persistance d'une couche de fond abiotique, suggérant un faible brassage vertical des eaux.

Enfin, des corrélations entre différents paramètres sont présentées (turb.-MES, CE-RS,...), ainsi que des bilans de matières tant en suspension que dissoute.

Des études plus amples se poursuivent sur toute la base de données disponibles afin de caractériser et comprendre plus finement cette dynamique spatio-temporelle et les processus en jeu dans le but de pouvoir les comparer avec d'autres milieux similaires.

Pertes en eau dans la cuvette lacustre du Niger : Bilan hydrologique et surfaces inondées

G. MAHÉ, F. BAMBA, L. DEMBÉLÉ, D. ORANGE, J.C. OLIVRY

La cuvette lacustre du Niger couvre une superficie totale d'environ 73 000 km2, et s'étend à l'aval des stations hydrologiques de KéMacina sur le fleuve Niger (147 000 km2) et de Douna sur le Bani (102 000 km2), jusqu'à Diré et Tombouctou au nord. Elle est divisée en une partie sud (58 000 km2), et nord (15 000 km2), de part et d'autre d'un chapelet de lacs centraux dont les débits sont contrôlés à leurs exutoires. Pluies et débits diminuent sur la période d'observation commune 1955/1996. Le débit entrant est de 1490 m3s-1, le débit sortant à Diré est de 900 m3s-1. La perte totale moyenne est de 40 % du débit entrant moyen, 18,6 km3, variant sur la période entre 24 et 48 %, soit 4 et 39 km3. Les pluies sur la région varient entre 356 et 682 mm, pour une moyenne de 545 mm. Les pertes annuelles sont plus fortes dans la cuvette nord (10,5 km3) que dans la cuvette sud (8,2 km3), cette dernière étant pourtant 5 fois plus grande en surface. Le sud est une plaine de transit, où l'écoulement est seulement retardé. Dans le nord l'inondation alimente de très nombreuses dépressions latérales où l'eau est piégée, l'ETP y est aussi plus forte. Le total évaporé au-dessus de la cuvette serait en moyenne de 800 mm annuels, mais pourrait varier entre 400 mm (1984/85) et 1300 mm (1924/25).

Ces pertes en eau dans la cuvette sont d'environ 430 mm de 1955 à 1970, puis de 215 mm durant les années 70 et enfin d'à peine plus de 100 mm durant les années 80. Les pertes en eau dans la cuvette nord, plus importantes que celles de la cuvette sud diminuent depuis 1955, alors que dans la cuvette sud les pertes ont augmenté jusqu'au milieu des années 60 avant de diminuer également jusqu'à des valeurs comparables à celles de la cuvette nord. Il y a une relation linéaire entre les pertes et les débits entrants. Les pertes dans la cuvette sud augmentent linéairement aux débits d'entrée jusqu'à 1500 m3s-1. Pour des débits supérieurs les pertes augmentent peu. Le schéma est inverse pour la cuvette nord, où les pertes sont plus faibles que dans le sud pour des débits entrants inférieurs à 1500 m3s-1, mais où les pertes augmentent ensuite formtement. Il semble par ailleurs y avoir un changement de relation entre les inondations des deux cuvettes autour de 1971, année de rupture statistique des séries.

Les surfaces inondées ont été calculées par deux méthodes différentes, basées sur l'équation du bilan hydrologique (Olivry), l'autre sur une relation qui prend en compte les hauteurs d'eau à Mopti, station hydrologique située au milieu de la cuvette lacustre (Cissé-Gosseye). Les valeurs des deux modèles sont parfois assez différentes mais les sens de variations sont concordants. Les surfaces inondées vont de 3000 km2 à 40 000 km2 pour les valeurs extrêmes. La perte augmente avec la surface inondée, ainsi en 1955 elle est de 540 mm pour une surface inondée de plus de 40 000 km2, et en 1984 elle est de 61 mm pour une surface inondée entre 3000 et 9000 km2 selon les modèles. Une étude est en cours pour calculer les surfaces inondées à l'aide de l'imagerie satellitaire NOAA AVRHH.

Si l'essentiel des pertes est évaporé, la cuvette fournit chaque année en moyenne plus de 15 milliards de m3 d'eau à l'atmosphère en plus des 35 milliards de m3 fournis par la pluie au-dessus de cette région. Cette cuvette lacustre constitue un réservoir d'eau pour l'évaporation sur le trajet des lignes de grain qui traversent l'Afrique de l'Ouest d'Est en Ouest, bien que l'inondation n'atteigne son maximum qu'à la fin de la saison pluvieuse. L'influence de la pluie sur l'écoulement dans la cuvette serait très faible, entre 5 et 10% pour les extrêmes avec un coefficient d'écoulement supposé de 5%.

The threat of sand on the Niger river in Mali

H.A. MAIGA, A. GERBE

The Niger, the largest river in West Africa, crosses the country of Mali on 1 750 km travelling from humid areas in the South-West to semi-arid zones in the North-East. In these regions bordering the Sahara desert, the river, which flows practically between sand dunes, has an influence on the natural environment and puts rhythm into all the economic activities of native populations. In addition be under a subdesertic climate, the river valley is submitted to recurrent droughts. The deficit in rainfall, and the decrease in the discharges noticed since 1970 had catastrophic impacts like the progression of sand dunes into the floodplain of the river, the drying of lakes, the reduction of both area and duration of floodings, the degradation of the vegetation.

The semi-arid climate of the area is characterized by very small rainfall, high temperatures and dominant winds from East et North-East. Since the occurrence of the last drought in 1965 in this zone, it has been observed an increase in the sand movement and deposits in particular in the valley the Niger river.

The riverside populations are made anxious in one hand by the invasion of their fields and habitations by eolian sand after storms and on the other by the fast generation of sandbanks and sandbars in the main channel of the river by water erosion. The dunes bordering the river have moved several tens of meters into the floodplain reducing the agricultural land traditionally devoted rice irrigated by natural flooding. This situation is made worse by the ephemeral streams flowing during the rainy season which discharge a good quantity of sand in the floodplain.

Because of the reduction of inundated areas, the farmers have moved their new fields into the mean water bed of the river destroying the natural vegetation, which induced a stronger erosion of the banks and bed in several reaches.

The causes and consequences of the increase of sandbanks and sandbars movement into the Niger river are diverse; they strengthen each other ; one can cite among the most important, drought, desertification and the pressure of mankind and livestock on the environment. the directs effects are among others. villages and cities threatened, agricultural land reduced, a stronger depopulation from rural areas towards the towns or more wealthy countries, a navigation becoming more difficult on the river.

The fight against sand dust, sandbanks, and sandbars in the river valley comprises today several forms whether it concerns the reduction of eolians deposits or the protection of the river banks erosion. Against the eolian hazard, one proceeds in one hand by fixing mechanically and biologically the sand dunes and in the other hand by promoting tree plantations to serve as windbreak around irrigated perimeters and habitations. To protect the bank against waves, natural vegetation called « bourgou » is intensively replanted.

Interdecadal and long-term variability of the hydrometeorology of the Brazilian Amazon basin

J.A. MARENGO

Rainfall indices were constructed for both northern and southern Amazonia, and together with river data were used to identify possible climate trends in Amazonia. Besides the fact that no systematic long-term trends towards drier or wetter conditions were identified since 1920's, it was observed a 20-year time scale variation of rainfall in northern Amazonia, a similar variation of rainfall in southern Amazonia, an opposite tendency of rainfall in both regions, and an effect of the SO that is stronger in northern Amazonia, and very weak in the southern basin. This tendency or cycle is somewhat observed on the Rio Negro water levels at Manaus but it is absent from the records of other rivers in Northern or Southern Amazonia.

Some of the observed long-term variations, especially in northern Amazonia are consistent with previous identified interdecadal variability in circulation and sea surface temperature meridional gradients in the tropical Atlantic, and do not seem to show a direct relation to changes in land-use in Amazonia.

Total mercury distribution in the Bolivian tributaries of the Madeira River. Importance of the biomagnification process in the aquatic food-chain

L. MAURICE-BOURGOIN, O. MALM, P. COURAU

Mercury contamination from amalgamation of gold in small scale gold mining is an environmental problem of increasing concern, particularly in tropical regions like Amazon, where a new boom of such gold mining started in the 1970s. Results on the mercury concentration in two abiotic compartments (water and sediments) and two biotic compartments (fish and human hair) from the gold-mining areas of the Bolivian Amazon basin, are presented. Total mercury concentration range measured in surface waters of the upper Beni river basin vary from 2.24 - 2.57 ng l-1 in glacial waters of the Zongo river, to 7.22 - 8.22 ng l-1, in the Beni River at the end of the Andean piedmont. The highest mercury concentrations were not found in the rivers where the mining activities take place but at the outlet of the Andean sub-basins exploited for their alluvial gold.

Total mercury concentrations measured in sediments vary from 0.012 in the Beni river downstream to 0.244 µg Hg g-1 in the Mapiri river. The quite low concentration of Hg in the sediments indicate a low sedimentary contamination due to the high particulate transport in the Beni river, especially in its Andean tributaries.

The mercury concentrations found in carnivorous fishes vary in the Beni River from 0.8 to 1.8 µg Hg g-1, in the Mamore River, from 0.4 to 2.1 µg Hg g-1, and in the Madeira River at its formation from 0.3 to 5.2 µg Hg g-1. This results indicate, on one hand, that each of the carnivorous fishes collected is contaminated and on the other hand, that high mercury concentrations can nearly exceed 10 times the WHO (1976) safety limit. Although main gold-mining activities take place in the headwaters of the Beni river and at the confluence of the Mamore and Beni rivers, the Mamore ecosystem in the flood plain is also contaminated. This means that vapour mercury released in atmosphere during burning operations may be easily reoxidised, due to the high humidity, and deposited again by wet or dry precipitation in the plain. The mercury accumulated by carnivorous fishes is mainly present on its organic form ; methylmercury represents 70 to 100% of the total mercury analysed, confirming the methylation and the accumulation of Hg in the food chain. Thirty persons have been studied in all the Bolivian Amazonian basin ; seven of them present elevated levels (> 6 µg g-1 ww, limit WHO for beginning poisoning). Our results show that the major health impact caused by mercury affects people who are not working directly in gold cooperatives but who have a regular fish diet.

Transport and behaviour of total mercury in the Amazon River at the confluence of black and white waters

L. MAURICE-BOURGOIN, B. QUÉMERAIS, J.L. GUYOT, A. LARAQUE

Transport and transformation of mercury and the role of organic matter in these processes have been studied in the Amazon river at its confluence of the Negro ('black water'), Solimões and Madeira ('white waters') rivers. With the Tapajós R., the Negro R. presents the highest total Hg content (11,6 to 18,2 ng l- 1). This high Hg concentrations measured in the Negro R. are due to the extreme particulate Hg content which reach values (2074 ng g-1 at the surface) 10 to 20 times higher than these measured in the other Amazon tributaries. Beyond flood hydrological period, the mercury comportment is mainly conditioned by the colloidal and particulate carbon. The total organic carbon analysed in the Negro R. waters is constituted mainly with particulate carbon (54,8%) whereas the dissolved organic carbon is composed mainly with humic compounds (50%), carriers for most of the metal ions transported in the rivers. The high Hg concentrations observed in the Negro waters can be explained by the run-off processes in the drainage basin associated with the Hg speciation processes in the forest soils. The comportment and the accumulation of Hg are controlled by complexing and mobile humic compounds and by their adsorption on the Fe and Al oxy-hydroxydes.

At the confluence of the Negro R. black waters and the Solimões R. white waters, we can observe an abrupt decrease of the Hg content. The Hg fluxes carried by the Negro and Solimões rivers, in dry hydrological season, reach respectively 39 and 55 kg Hg d-1 ; 60 km downstream their confluence, this flux decreases to 73 kg Hg d-1, which represents a net loss of 5 kg dissolved Hg d-1 and 15 kg particulate Hg d-1. This losses must be correlated with the comportment of the total suspended matter and with the particulate and colloïdal organic carbon. In black waters, mercury is mainly adsorbed on organic particles, linked to Fe and Al oxy-hydroxydes of the colloïdal fraction, and can floculate and deposit in the confluence zone with white waters.

On the other hand, downstream the confluence of the Amazon with the Madeira R., mercury is conservative. Its total concentration reaches 9,8 ng l-1 downstream which differs from 2,8% with the theoretical value, which is in the same range of the analytical precision.

Trace elements distribution in the Andean sub-basins of the Madeira river : role of the weathering processes in the freshwaters geochemistry

L. MAURICE-BOURGOIN, F. GASC, F. ELBAZ-POULICHET, P. SEYLER

The distribution of trace elements (V, Mn, Co, Ni, Cu, Zn, As, Rb, Sr, Mo, Cd, Sb, Cs, Ba, Pb, and U) was investigated in surface waters and associated particles in the upper Amazonian basins, in Bolivia. Three main factors of the geochemical characterisation of the studied rivers explained mainly by weathering and dilution processes, are : i) substrate lithology, ii) mining activities, and iii) organic matter content. Using statistical methods (PCA), the combined use of this geochemical data with geological information on each watershed demonstrates the fundamental role of the weathering processes on the trace chemistry of the Andean rivers. The geochemistry of dissolved elements reflects the lithological differences between the Mamore and Beni basins. Andean tributaries of the Mamore R. are characterised by high concentrations of Mn, Sr, Mo, Ba and U while high concentrations of As, Zn, Cd and Cs characterise Andean tributaries of the Beni R. Dissolved Sr, Ba, Mo, Rb, U and to a lesser extend Zn and Cd correlate with major ions and appear to be predominantly derived from soluble rocks (carbonates, evaporites or sulfides essentially contained in shale). Influence of the shale erosion from Silurian and Devonian series explain the high concentrations of V, Zn, Cu and Pb measured in Beni tributaries. Additionally, the high values of Co, Ni and Mn reflects the Palaeozoic detritical series from the drainage basins of the Tipuani and Challana rivers. The higher content of Mn in the Ichilo river may reflects the predominance of carbonate rocks in this Mamore sub-basin. Regarding to the anthropogenic influence, the high Zn, As, and Cd concentrations measured in the Taquesi river can be explained by important mining activities. High values of V measured at the end of the dry season in plain rivers ('black waters') can be correlated with the decreasing of the phytoplancton biomass.

The fractionation of trace elements in SPM has been attributed to the sorting of feldspars during transport in water, and to the mixing between clay minerals and quartz. These minerals, refractory to weathering and introduced in water rivers by mechanical erosion, have not contributed to the dissolved load and the contribution of silicate phases remains rather small.

Towards a mechanistic, remote-sensing driven model of organic matter cycling linking the land surface and river system in the Amazon basin

E. MAYORGA, J.E. RICHEY, A.K. AUFDENKAMPE

The biogeochemical imprint of large rivers results from a complex mixture of materials originating in heterogeneous regions and transformed during transit through the fluvial system. A number of approaches have been used to explain river observations in terms of key determining processes and dominant regions of influence. These include careful mass balance and compositional studies in small catchments, considering the major sources and transformations along flowpaths; statistical identification of aggregated controlling variables in the drainage areas; extensive analysis of the elemental, molecular, and isotopic composition of riverine organic matter (OM), coupled to lab experiments and understanding of the effects of different basic processes; and models of particular environments or flowpaths. While each method has unique strengths, they can suffer from difficulties in extrapolating to larger rivers draining heterogeneous environments, lack of mechanistic underpinning and validation, or an inability to make quantitative statements about the relative importance of different processes. We will present our current developments towards an integrated modeling framework aimed at quantitatively describing the dynamics of OM cycling in mesoscale to large rivers by mechanistically tracking the evolution of OM from the land, through the river corridor, to the river. The biogeochemical model is tightly coupled to spatially distributed models of water and sediment cycling and transport. Development and testing center on the Amazon basin, building on nearly two decades of detailed biogeochemical studies in a large variety of riverine environments under the CAMREX project (Carbon in the Amazon River Experiment); and other projects focusing on mesoscale basins in human-impacted regions (as part of LBA: Large scale Biosphere-Atmosphere experiment in Amazonia), and using long, continuous time series of basin-wide satellite images to detect land surface dynamics and force hydrological and biosphere models (as part of NASA's Earth Observing System). We intend to synthesize the understanding gained from the different approaches listed above, from the Amazon and other regions. Already in place is a system of linked land-surface hydrological and biosphere models forced by a time series (1981 to 1998) of climate and biophysical variables derived from the NOAA-AVHRR sensor at 5 km resolution. The biosphere model currently implemented is CASA, which includes net primary production, litter and root turnover, and soil organic matter (SOM) cycling. Like CENTURY, it divides SOM into conceptual pools with characteristic turnover times. Like most current land-surface biosphere models, these models generally do not handle the export of OM to the river system in any detail. Results from CAMREX have emphasized the key role of sorptive processes in controlling the cycling of OM and the distinct compositional imprint of different particulate and dissolved size fractions, and have made clear the need for OM models that are more geochemically based and applicable to both terrestrial and aquatic environments. These requirements have led us to adopt a conceptualization of measurable OM pools based on density or size fractions. Current concepts and plans for numerical implementation will be discussed. We are using a linear routing scheme for moving water and materials from the land through the river network. In conjunction with the development of a new geochemical model, the river system will be subdivided into at least three scales: the smallest streams at "sub-pixel" scale receiving direct input from the land, medium-scale streams handled in a generalized fashion, and larger-scale rivers (drainage areas of ~ 2000 km2 and larger) treated explicitly. Our focus lies on the larger-scale rivers, but this hierarchical framework can be modified when finer resolution regional data becomes available. More realistic surface water routing and geochemical transport-reaction will be implemented at this scale. Another key component that must be developed is sediment cycling. We plan to start with simple assumptions about erosion and sediment transport regime, and later implement schemes from related projects. This system of coupled models is being developed with several objectives. First it will be used to quantitatively evaluate current hypotheses of organic matter cycling, using the river datasets from CAMREX and LBA. In the future, it can be used to predict the composition and fluxes in ungaged systems, and the impact of anthropogenic scenarios on river systems. Lastly, when coupled to detailed riverine measurements, it may serve to provide indirect constraints and validation for land-surface biosphere models.

Water quality in the Peruvian Amazon: A survey of results from environmental impact assessments

M.E. MCCLAIN, M. GOMEZ-BARRIOS, M. GONZALES

Reliable data on the quality of water in the Amazon basin are exceedingly rare and generally limited in their geographical extent. This lack of data weakens our ability to evaluate the condition of surface waters of the region and to identify sensitive or vulnerable areas. Consequently, little informed advice can be given to planners and policy makers who must decide issues of water protection and development in the region.

As one alternative means of filling data needs, we have acquired and tabulated the results of several baseline environmental studies conducted in areas of potential petroleum exploration. These data have been generated as part of official environmental impact assessments (EIAs) which are required by the Peruvian Ministry of Energy and Mines prior to the final approval of any petroleum exploration/exploitation plans. In all cases, the sampling was carried out by independent contractors and analyses were made in laboratories in Lima, Peru. Both sampling and analytical methodologies generally corresponded to those recommended by the US Environmental Protection Agency (EPA). The variety of water quality parameters analyzed are shown in the table.

Physical	Temperature, Conductivity, FTU, Total Suspended Sediments
Biological	Total Coliform Bacteria, Fecal Coliform Bacteria
Nutrients	Nitrate, Ammonia, Phosphorus
Organics	BOD, COD, Phenols, Oil & Grease, Hydrocarbons
Major Ions	Chloride, Sulfate, Ca, Mg, Alkalinity
Trace Metals	Ag, Ar, As, Ba, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Se, Zn

Physical characteristics and major ion concentrations reported in EIAs are generally within the same ranges as those reported in academic investigations, while trace metal concentrations are generally below detection limits. Nutrient levels reported in EIAs are similar to, or greater than, academic investigations. Perhaps the most intriguing results are the biological and organic parameters, as these are rarely included in academic research programs from the Peruvian Amazon. Oil and Grease was detected in 38 of 63 samples. Assuming the measurements to be accurate, this organic contamination may derive either from spills in nearby oil-producing areas or from natural oil seeps. Coliform bacteria counts and BOD values also reveal higher levels of organic contamination than is generally expected in the remote areas sampled.

We will present and discuss these data in light of existing datasets to achieve a more comprehensive assessment of the water quality status of rivers in the Peruvian Amazon.

Large rivers and their floodplain as conveyors and storers of sediment. An overview.

R.H. MEADE

Large rivers are continental-scale conveyance systems for moving sediment. The three major river systems of South America, for example, convey massive quantities of sediment from the leading edge of the drifting continent to its trailing edge. Between original source and ultimate sink, the sediment can be subjected to multiple episodes of storage into and remobilization out of floodplains and other alluvial features. Residence times of sediment in storage may be sufficiently long (i.e., millennia) in some floodplains to allow the pedochemical transformation of the mineral compositions of the sediment particles.

Sources of sediment in large river systems are heterogeneous and variable in space and time. Exchanges of sediment between channels and floodplains, in sufficiently long reaches of river, can store and remobilize quantities of sediment that are greater than the net downriver fluxes. In the lower reaches of most large river systems, floodplains are net sinks for riverine sediment. The seaward transfers of river sediment into deltas, estuaries, and onto continental shelves are complex responses to ocean tides, ocean currents, and the spatial configurations of coastlines.

Ligaciones entre el régimen hidrológico y la productividad biológica en la planicie de inundación del Río Paraná

E.M. MENDIONDO, J.J. NEIFF

El sistema Paraguay-Paraná (Área > 2x106 km2) presenta su eje mayor orientado en sentido N-S, cortando fajas climáticas y territorios litoestructurales diferentes, siendo la vía natural de transporte de sedimentos para el Océano Atlántico. Además, presenta un valle de inundación con alta productividad biológica, con más de 300 especies peces, cuya producción supera 1 ton.ha-1.año-1. En esta extensión de 800 km en sentido N- S, con ancho medio de 15 km, se desarrolla la explotación pecuaria, forestal, de pesca y de turismo, localizándose junto al Proyecto Hidrovía, vía comercial para los países del MERCOSUR.

Los ciclos bio-hidroquímicos de la zona estudiada está en continuo cambio durante estos últimos años, tanto por disturbios antrópicos a través de obras de ingeniería dentro del valle y, en términos moderados, por la construcción de represas aguas arriba. Existen también alteraciones en los regímenes de precipitaciones a partir de 1970 cuando se denota una mayor frecuencia entre eventos extremos a causa del ENSO (p.e. 1983, 1992 e 1998). Este cuadro leva a una alteración en los ciclos de nutrientes y a un ciclo de paulatina fragmentación del paisaje. La metodología usada trata de índices de vegetación NDVI (Normalized Difference Vegetation Index), que infieren sobre la tasa de consumo de agua por las plantas. Fueron analizadas las series temporales de los niveles de agua en el valle de inundación y relacionados con las respuestas de NDVI para los períodos Abril/1992 hasta Setiembre/1993, y Febrero/95 hasta Enero/96 con paso de tiempo de □t = 10 días, a través imágenes NOAA-AVHRR. Conforme si la zona analizada dentro del valle de inundación está conectada o no al cauce principal, su crecimiento vegetativo resulta diferenciado. Así lo indican las curvas de crecimiento de Eichornia spp monitoreadas en el período.

Los valores de NDVI medios areales são contrastados con las oscilaciones naturales del hidrómetro local. Los resultados indican que existen zonas con decaimiento temporal de NDVI sujeto a la posición relativa que éstas ocupan dentro del valle, lo que interfiere en la productividad. Los índices vegetativos fueron evaluados en función de la fragmentación del paisaje para diferentes niveles de inundación y para diferentes rangos de biomasa. Estos indicadores são correlacionados con el hidroperíodo del humedal (Mendiondo, 1998), por funciones del tipo FITRAS (Neiff, 1996) y discutidas sus relaciones entre ellas.

Resiliência das bacias fluvias a partir de intervalos de variação de vazões máximas

E.M. MENDIONDO, R.T. CLARKE

A resiliência de um sistema hidrológico natural permite absorber as perturbações que sobre ele incidem. Esta habilidade dos sistemas hidrológicos é traduzida pela sua capacidade de dissipar energia ante eventos extremos. O Método Clássico trata este tópico através da análise dos intervalos de confiança das vazões extremas, isto é ante eventos com baixa probabilidade de ocorrência. No entanto, o Método Clássico admite uma visão parcial, considerando somente leis estatísticas e não necessariamente físicas.

Neste trabalho é introduzido um Método Alternativo que estima a resiliência ante eventos extremos de forma combinada i) fazendo uso da abordagem clássica e ii) pelo uso intensivo de reamostragens dos dados obtidos da partir da natureza física presente nas medições de vazão. Esta metodologia foi aplicada em dois ambientes geográficos : i) em bacias de clima subtropical de até 3x104 km2 de área de captação, afluentes ao rio Uruguai no Brasil, sendo algumas delas embutidas espacialmente e ii) no sistema do Rio Paraná de 2 x 106 km2 de área, onde se desenvolvem grandes zonas ribeirinhas e planícies de inundação, drenando águas de Brasil, Paraguay e Argentina. Em ambos casos foram testados diferentes coeficientes de aproveitamento do inventário histórico de medições.

Os resultados mostraram que i) o aumento do número de medições de vazão se traduz em intervalos de variação menores, ii) a resiliência estimada, interpretada através dos intervalos de confiança, pelo Método Alternativo foi sensivelmente menor à estimada pelo Método Clássico usando vários tipos de distribuições teóricas e dois métodos de estimativa de parâmetros; iii) embora os intervalos pelo Método Alternativo sejam reduzidos, na maioria dos testes realizados, eles contém a estimativa original. Os resultados indicam uma evidência forte de distorção das larguras dos intervalos entre os dois métodos conforme diminue a freqüencia de ocorrência do evento extremo.

A degradação destes intervalos por unidade de área tem um comportamento errático para bacias menores, porém numa faixa entre 2,7x104 a 3,1x104 km2 os resultados apresentam uma certa "regionalização", mostrándo-se a nova metodologia consistente com o aumento da bacia. A interpretação dos resultados permite discutir os alcances de nova metodologia conforme a disponibilidade de dados.

Towards typologies of major world river basins

M. MEYBECK, C. VOROSMARTY, P. GREEN

Depending on their definition, from 550 to more than 1,000 rivers have been registered as major world rivers (Meybeck and Ragu 1995, Milliman et al 1996). The biogeochemical functions of these systems in terms of network organization, transfer and storage of water, particulates, dissolved matter, originating from natural or anthropogenic sources, provides unique information on chemical weathering, soil formation and erosion, formation of detrital sedimentary rocks, inputs to oceans, aquatic biota and its diversity. In turn world rivers can be affected by human activities through various activities and misuses along various gradients of pollution and of artificial control. The combination of these may lead to an infinite number of river types. We are proposing here a small set of major differenciations mostly associated with river fluxes as proposed within IGBP (Vorosmarty et al 1997, Meybeck 1998) which will be illustrated for the 30 largest world basins according to their potential drainage area.

The selected basins are described with a 30-minute spatial resolution using the Simulated Topology Network (Vorosmarty et al 1999A). Each river basin is described with a set of both non-hydrological attributes (dry data) and hydrological attributes (wet data). The potential river network differentiate between the inland drainage or endorheism and the drainage to oceans or exorheism. Our global runoff model (Vorosmarty et al 1998) simulating the yearly average runoff field as well as the seasonal runoff variations permits the separate rivers with permanent, intermittent and ephemeral flows (rheism) from non-flowing or occasional flow (arheism), based on a 3 mm average runoff model also used to differentiate within river systems their active and passive subbassins in terms of lateral transfer of water. Some of the world's major rivers are only partially active such as the Orange, Nile, Niger, Tarim. Using whole-basin attributes to understand the functioning of these systems leads to severe bias where only their active parts should be considered.

Basin heterogeneity, even for the 100 % active basins, should also be carefully considered using both dry data (e.g. elevation, climate, soil, lithology that control the potential sources of riverborne constituants) and wet data (e.g. surface runoff, wetland occurrence, lake occurrence [limnic index, Meybeck 1995], reservoir distribution [neo-Castorization; Vorosmarty et al 1997]) that control lateral transfer and sinks of material. The time scale of water transfer in river systems and its alteration (river aging, Vorosmarty et al 1997), is much linked to nutrient cycling and particulate retention (sediment delivery).

Surface water engineering (rivier damming, diversion, irrigation) now widespread, results in significantly decreased water discharge over the last fifty years : Colorado, Nile, Indus, may eventually lose their connection to coastal seas. Another major linkage between human activities and river systems is described by the distribution of both urban and rural population with regard to the surface river runoff. There is an extreme range of potential population pressure on rivers, over several orders of magnitude. Eventually this index and others (such as the fertilization rate of cropland) will be compared to the changes of world river quality.

Modelo matemático para pasar la información pluviométrica a información menor a 24 horas y su aplicación en caudales máximos en la cuenca del rio Uchusuma-Mizque

G. MIRANDA

En base a fórmulas matemáticas existentes para el cálculo de intensidades de precipitaciones inferiores a 24 horas, se ha obtenido un modelo matemático de transformación de la información colectada cada 24 horas y distribuir esta información en períodos de 10 minutos para la estación meteorológica de AASANA-Cochabamba. Los resultados que se obtienen con este modelo se asemeja en un 90 % a la información que se registra en el pluviógrafo, por lo que se considera este modelo adecuado para ser empleado en otras cuencas bajo condiciones de clima semiárido y con características fisiográficas similares a la zona estudiada. Además se aplico el modelo para la estimación de caudales máximos de la cuenca Uchusuma-Mizque.

La variabilité hydrologique du bassin amazonien et la circulation atmosphérique océanique

M. MOLINIER, J.L. GUYOT, G. COCHONNEAU, V. GUIMARÃES, E. OLIVEIRA

Une première exploitation de la banque de données hydrologiques du projet HiBAm (CNPq - IRD \ DNAEE \ UnB) orientée vers l'étude de la variabilité climatique (Guyot et al., 1997) avait montré qu'il existait de bonnes corrélations entre l'indice d'oscillation austral (South Oscillation Index - SOI) et l'indice des débits dans la partie nord-est du bassin amazonien. Pour le reste du bassin, des tendances régionales ont aussi été observées, mais n'étaient pas toujours significatives.

Cette note se propose d'affiner cette première étude en prenant en compte l'ensemble du bassin amazonien, et non plus seulement 17 stations hydrologiques, et de la comparer à quelques grands bassins tropicaux du continent africain comme le Niger, le Sénégal et le Congo.

Les résultats ne sont pas fondamentalement différents pour le bassin amazonien. On retrouve les zones sous l'influence directe de ce phénomène, comme le nord-est du bassin (bassins du Jari et du Rio Branco) où les phases "El Niño" (El Niño South Oscillation - ENSO) correspondent à des diminutions assez marquées des précipitations régionales ce qui entraîne une baisse importante des débits des rivières. Dans une moindre mesure, le bassin du Rio Negro et la partie aval de l'Amazone peuvent être classés dans cette catégorie. À l'inverse, les débits du Rio Madeira augmentent durant les phase "El Niño" et diminuent lors des période de "La Niña", mais de façon assez peu sensible.

À ce phénomène "El Niño" associé aux anomalies de circulation générale de l'atmosphère (Walker), se superpose un autre phénomène qui a une grande influence sur la variabilité du climat du continent américain (Hastenrath and Heller, 1977, Nobre et Shulka, 1996) et du continent africain (Parker et al., 1988, Folland, 1991). Il s'agit de la circulation méridionale (Hadley) liée au gradient des anomalies de température de surface de la mer (Sea Surface Temperature - SST) de l'Atlantique tropical. Ces deux phénomènes modulent, de manière conjuguée, la variabilité du climat de l'Amérique du Sud en général, et de la région amazonienne en particulier. Bien que les effets du phénomène ENSO se fassent sentir de façon plus intense sur la pluviométrie et donc sur les débits des cours d'eau amazoniens, on constate que les anomalies de SST sur l'Atlantique tropical influencent egalement le climat de cette région. Cette double influence est particulièrement perceptible sur les fleuves Jari et Rio Branco et, à un degré moindre, sur l'Amazone à Óbidos. En effet, on observe, comme dans le cas de la région Nordeste du Brésil (Aragão et al., 1994, Aragão, 1997), des épisodes de déficit plus intense lorsque se conjuguent les effets d'ENSO (océan Pacifique chaud) et une anomalie négative du dipôle atlantique (océan Atlantique Sud chaud et océan Atlantique Nord froid). Ce phénomène a été particulièrement ressenti en 1998.

Les régimes des grands fleuves de l'Afrique tropicale ne semblent pas être aussi directement affectés par ces phénomènes. C'est tout au moins le cas pour le Congo à la station de Brazzaville (3 475 000 km²) et pour le Niger à Koulikouro (120 000 km²). Une étude plus fine, englobant d'autres bassins africains, est cependant nécessaire pour confirmer ce point, en particulier en ce qui concerne les anomalies du Dipôle Atlantique.

Mercury contamination in fish of an old Amazonian reservoir (Curuá Una)

S.S. MORAIS, M. ROULET, C.J. SOUSA PASSOS, E. DUCHEMIN

There are in the amazonian region large and small hydroelectric reservoirs such as Tucuruí and Balbina. Furthermore the amazonian watershed have a great potential for further hydroelectric development. However, studies carried out in fish of northern reservoirs, located in Québec and Ontario (Canada), showed an increase in the Hg concentration in fish which feed on planckton and insects, the maximum concentrations of Hg are reached in about five years. Fish which feed mainly on other fish seem to reach their highest Hg concentrations ten to fiften years after flooding. Depending on the species studied Hg concentrations have been observed to increase as much as six times in reservoirs as compared with the natural environment.

Furthermore, the ingestion of food contaminated by methylmercury (MeHg) has already been cause for intoxication in regional scale. The practice of commercial and subsistence fishing is very common in reservoirs. At present, there are a lot of studies about Hg contamination in fish of reservoirs, but at our knowledge only one was conducted on a tropical reservoir, the Tucuruí reservoir. However, the results of this study are not so meaningful since they are based on few samples and that the sampling stations are located near a gold extraction site.

During the beginning of september 1998 we have performed a preliminary toxicological study of Hg contamination in fish from 21 old years impoundment, Curuá-Una reservoir, near Santarém. Curuá-Una reservoir is not affected by gold extraction but we observed a large deforestation area around it. This deforestation could affect the Hg concentration since it permits the erosion and lexiviation of Hg naturally contained in soils. This study is conducted to assess if the ingestion of fish from an old reservoir could be dangerous for the human populations that live in this region and sometimes have restricted feed habits. Finally, the Hg concentrations of these fish will be compared to those found in fish of the Amazon river during a previous study.

Chemical erosion of silicates in the Amazon basin

J. MORTATTI, J.L. PROBST

A detailed hydrogeochemical study of the dissolved load transported by the Amazon river and major tributaries was carried out to investigate the chemical erosion process of silicate rocks in the Amazon basin.

The total solute transport by the Amazon river to the Atlantic ocean was estimated to be 254.3 x 106 tons per year, where 80 % is from Andean origin, the highest contributions were from HCO3, SiO2 and Ca, 131.5, 38.1 e 33.9 x 106 tons per year, respectively. The contribution of the atmospheric inputs on the dissolved load transported by the Amazon river to the ocean was estimated for each chemical species to 56.9 % for SO42-, 21.9 % for Cl-, 6.0 % for Ca2+, 3.7 % for Mg2+, 13.8 % for Na+ and 32.3 % for K.

After corrections for atmospheric inputs, the contribution of atmospheric/soil CO2 to the total HCO3- river fluxes was estimated by geochemical modeling, based on the chemical water control by the main weathering reactions of different minerals. The results showing that at Óbidos, the average contribution of the atmospheric/soil CO2 to the total HCO3- river flux is around 68 %, which corresponds to a total atmospheric/soil CO2 consumed by the rock weathering of the 331 x 103 moles /km2/a.

The chemical denudation rate of silicate rocks for the whole Amazon basin was represented by the value observed at Óbidos was estimated to 22.6 t/km2/a, while in the upper part of the basin, at Vargem Grande, the weathering rate was higher (40.9 t/km2/a). During the low water period, the chemical denudation rates of silicate rocks were lower than that observed during the high water river stage, 17.6 and 41.7 t/km2/a, respectively for Vargem Grande, and 19.6 and 32 t/km2/a for Óbidos.

The chemical weathering rate of silicate rocks, for the Amazon basin, calculated from the flux of dissolved silica in the river waters, knowing the chemical composition of the parent rock and of the saprolite, was about 14.8 m/My. For low and high river water stages, the values calculated are ranged between 9.4 and 18 m/My, respectively.

Erosion balance of the Piracicaba river basin (São Paulo, Brazil)

J. MORTATTI, J.C. RODRIGUES, F.F.B. FERRAZ, M. BORTOLETTO, J.L. PROBST

It was carried out the characterization of the mechanical and chemical erosive processes in the Piracicaba river basin, in terms of the fluvial transport of dissoved and particulate material. The hydrochemical behaviour of the Piracicaba was verified by comparison with the observed concentrations and theoretical dillution curves. It can be observed that HCO3- was a chemical specie with a bigger specific transport with 14 t/km2/y, while the NO3- given the smallest specific transport (0.70 t/km2/y). The calculated value of the TDS was about 35.5 t/km2/y.

The influence of the atmospheric inputs to the total dissolved load of Piracicaba river was important for SO42+, Ca2+ and Mg2+ (79.6; 63.8 and 41.8 % respectively), while for Na+ and Cl-, the contribuition values shows to be modest (3.0 and 8.2 %, respectively). The values obtained for NO3- and K+ were similar (21.5 and 20.6 % respectively) and for SiO2 the contribution was around 23.8 %.

After the atmospheric input corrections, it was verified the consumptions of atmospheric/soil CO2 during the rock alteration process, estimated from the transport of riverine HCO3-. An average value of the atmospheric/soil CO2 flux, of about 2.61 x 105 moles/km2/y, was calculated for the period 1992 – 1996.

A detailed study of the suspended sediment transport in the Piracicaba river basin was performed during the 1992 – 1996 period. It was possible to evaluate the effective mechanical erosion in the drainage area of about 0.76 x 106 t/y.

The classical method for hydrograph separation, envolving the mass balance equation, was used to estimate the surface runoff contribution to river flow (18.8 %) it was calculated about, The solid load calculated in the surface runoff (1.17 g/L) showed to be of the same order of magnitude as the main river in the world.

The specific physical degradation, calculated for drainage basin was around 51 t/km2/a, corresponding the velocity of the soil thickness reduction of about 28 m/My. The transport of dissolved material was 0.24 106 t/y, corresponding to a specific chemical erosion rate of 25.2 t/km2/y, with a velocity of the silicate rock profile reduction of about 1.9 m/My).

Transport du carbone organique dissous, colloïdal et particulaire par les grands fleuves amazoniens : caractérisation et mélange

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L'Amazone est le mélange de deux types d'eaux très différents : les eaux blanches (Rio Madeira et Solimões) et les eaux noires (Rio Negro). Des prélèvements provenant de ces fleuves sont fractionnés sur place par ultrafiltration tangentielle séquentielle (UFTC) afin d'obtenir des domaines de tailles séparés. Un suivi sur plusieurs mois (1994-1997) des apports en matière organique particulaire, colloïdale et dissoute montre des différences de plus de 20% dans les concentrations avant et après le mélange. Cette variation peut s'expliquer par des phénomènes de coagulation et floculation dans la zone rencontre des eaux. Ces modifications physico-chimiques de la matière organique ne sont pas constantes au cours d'un cycle hydrologique annuel. Les périodes de grandes transformations se produisant juste avant les périodes de crue et d'étiage.

Une étude spectrofluorométrique de la matière organique transportée par les fleuves du bassin amazonien à également été entreprise afin de comprendre les phénomène de mélange. Cette étude est accompagnée par des mesures dans les différents domaines de taille de la capacité de transport des métaux trace (sonde Cu++). Grâce au mesure de flux faites lors des différentes campagnes, l'étude saisonnière met en évidence un comportement différent de la zone de mélange au cours d'une année.

Une estimation du flux donne une valeur de 28 Tg par an de carbone organique, ainsi qu'une perte moyenne de 9 Tg de carbone organique par an dans la zone de mélange comprise en Manaus et Óbidos soit environ 30%.

Utilisation d'imagerie radar (ROS) JERS-1 pour l'obtention de réseaux de drainage. Exemple du Rio Negro (Amazonie)

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L'utilisation d'images radar JERS-1, acquises dans la région du bassin amazonien entre septembre et novembre 1995 a permis d'extraire pour le bassin versant du Rio Negro, le réseau de drainage ainsi que les limites et superficies de certaines de ses sous-unités hydrographiques. Le réseau de drainage a été obtenu à partir d'images radar en plusieurs étapes, 1) par extraction automatique du réseau principal (Rio Negro et ses principaux affluents), limitée en raison de l'existence de différents types de rivières dans la région se traduisant par des signatures hétérogènes, 2) par des opérations de filtrage et de nettoyage, et 3) essentiellement des compléments manuels pour les drains de plus petit ordre. La détermination des sous-unités hydrographiques correspondant à des stations hydrométriques du réseau national brésilien, a dès lors été possible en tenant compte du réseau obtenu et de la topographie telle que représentée par le radar. Il est montré ici que le système hydrographique obtenu s'avère d'une plus grande qualité que des objets issus de la digitalisation de cartes au 1:1000000 (réseau million) et le Digital Chart of the World (réseau DCW). Cette plus grande qualité s'exprime pour les rivières par une densité de drainage supérieure (seulement par rapport au réseau DCW), par une représentation plus fidèle de leur tracé (longueurs supérieures par rapport au réseau million), par la précision géographique du tracé, par l'adéquation avec les limites des sous-bassins versants déterminées (l'homogénéité globale des objets déterminés). Quantitativement, la méthode de détermination des sous-bassins versants augmente quelquefois la valeur des superficies de manière significative même si cette augmentation demeure négligeable à l'échelle du Rio Negro entier. Ce travail se situant en amont d'une prochaine modélisation hydrologique par SIG, ce système hydrographique (réseau et sous-bassins extraits) devrait apporter de notables améliorations d'une part par son homogénéité et d'autre part par l'affinement des limites des bassins versants et de la longueur du chemin hydraulique pour chacune des rivières.

Impact of major river valley projects: India

K.S. MURTY

Water is the heart of the Indian economy. Indian civilisation evolved on the banks of the mighty rivers of the country, like the Ganga, Yamuna , Godavari, Krishna and Kaveri and indeed these are worshipped as Goddesses! Historically, the art of irrigation was known to Indians from early times. The Grand Anicut of the Cauveri (Kaveri) is a weir approximately 300 meters long, 12 to 18 meters wide and 5 to 6 meters high, and was constructed sometime in the 2nd century of the Christian era. It irrigates as much as 250000 hectares. The Moghuls initiated the canal system in northern India, while the Vijayanagar kings developed the system in South India. During the British rule, Sir Arthur Cotton and Proby T Cautley took up the delta irrigation schemes in the Godavari and Krishna basins. Irrigation and hydroelectric power generation have made large strides since Independence and the country has invested over Rs.100000 million in the last five decades on 600 storage dams of various sizes on major and minor rivers, accounting for storage capacity of more than 16 million hectares for irrigation, flood control and power generation. Such developmental activities, imperative as they are, have caused a variety of environmental impacts which can be classified as physical, chemical, biological, social, economic and cultural. Unfortunately, adequate assessment of these possible impacts were not made before the projects were sanctioned or executed. Submergence of fertile land, villages, displacement of people from such areas, loss of forest area and precious fauna, water logging, salinity of soils, flood incidence, induced seismicity in quake-prone areas and loss of cultural assets are some of such environmental consequences of the large projects. That the government became conscious of these could be understood from the fact that it refused to sanction the SILENT VALLEY project in Kerala. However, the dams on Tehri, Narmada and other rivers have been opposed on environmental and technical grounds and mass movements have been launched by people in the areas likely to be affected by these projects. The department of Environment has stipulated that no project proposal would be cleared unless proper assessment of the environmental impact has been made and a report is submitted. There are adequate laws and legislations approved by the parliment in this regard.

Catchment based integrated water resources management (IWRM) in the Rift valley, Kenya. The small reservoir approach

F. MWAURA

The biophysical characteristics, socio-economic benefits, and environmental problems in eight small [0.1-1.0 km2] public man-made reservoirs in central rift valley, Kenya were studied between 1995 and 1998. The results revealed that average water transparency and pH was between 0.3-1.0 m and 6.0-9.5, respectively, while total dissolved solids [TDS] and specific conductance ranged from 20 to 150 mg/l and 60 to 230 □s/cm, respectively. The concentration of dissolved oxygen [DO] was between 2.0 and 9.0 mg/l while those of total phosphorus [TP; 28-472 □g/l] and total nitrogen [TKN; 315-39 000 □g/l] showed that the reservoirs were in polytrophic state. Phytoplankton composition was found to be rather low, rarely exceeding 10 species per site while the zooplankton community did not exceed ten species per site either. The dominant macrobenthic invertebrate groups included oligochaeta, diptera and insecta whose abundance was greater after the rains. An average of 60 birds per reservoir were counted during the dry period while the number of species per site usually ranged between 5 and 25. During the wet season, the diversity of water birds was found to increase tremendously although the total count declined remarkably probably due to increased short range dispersal. Large scale breeding by Black-headed Herons and little Egrets was established to occur in at least one site. The reservoirs were found to support an average of 2000 people per site in various ways including domestic and livestock water supply and grazing but the importance of these values varied from season to season. Most of the reservoirs were found to possess a good unexploited fishery and recreation potential. The common environmental problems observed in the reservoirs included increasing infestation by cyanobacterian blooms and invasive macrophytes as well as rapid sedimentation. The results of the study showed that the reservoirs can act as good early warning systems of watershed degradation through regular monitoring of water quality and hydroperiodicity. From the findings of the study it is recommended that the rural communities be assisted to realize greater benefits from their reservoirs through integrated wetland and water resource management [IWRM] and thereafter they will definitely take greater interest in the protection of reservoirs which will ultimately enhance watershed conservation.

Evolution hydrologique du bassin versant de l'oued Zeroud

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En Afrique du Nord, le cours des rivières éphémères appelés « oueds » est aussi soudain, aussi abondant et aussi violent que les averses sous le régime Méditerranéen. Ils sont signalés par des lits vides et des encaissements secs au fond des vallées en été. Mais, aussitôt après un orage, ils se transforment pour quelques heures ou pour quelques jours en d'immenses fleuves rugissants, animés d'un courant si puissant qu'il emporte tout sur son passage. Leur passage cause d'importants dégâts, dont les moindres seraient les lessivages des sols, l'érosion des terres et les dépôts d'alluvions pas souvent fertiles. L'un de ces tonitruants oueds et non des moindres est l'oued Zéroud, situé dans le centre de la Tunisie. Pour protéger la région de ses crues dévastatrices, il a été érigé un barrage sur son cours : le barrage de Sidi Saad. Depuis la mise en service de ce dernier, bien des changements hydrologiques et pédologiques ont eu lieu.

ETAT DES LIEUX AVANT LA CONSTRUCTION DU BARRAGE.

A l'occasion de chaque grande pluie, le centre ouest de Tunisie était souvent le théâtre de destructions catastrophiques autant en biens qu'en vies humaines causées par les crues de l'oued Zéroud. L'immense plaine de son bassin versant, d'une superficie de 10000 km2, était souvent inondée. Toute suralimentation des nappes, normalement peu profondes, provoquait en période de crues, une remontée des niveaux qui entretenait la salinisation des terres, les eaux de lessivage étant chargés en sels, ce qui tendait à dégrader les terres et à transformer la plaine en une zone désertique. Du point de vue hydrogéologique, le bassin versant de l'oued Zéroud se caractérise par une roche mère sédimentaire présentant des affleurements de calcaire. Il est de nature sablonneuse à l'amont de l'oued, argilo-sablonneuse dans la zone médiane, argileuse à l'aval de l'oued, ce qui explique l'inondation fréquente de la plaine située en aval. Les niveaux piézométriques étaient environ de 150m en amont, 100m sur le cours médian et 50m à 30m à l'aval de l'oued.

ETAT DES LIEUX APRÈS LA CONSTRUCTION DU BARRAGE.

La pluviométrie annuelle est toujours du même ordre, prise sur une décade, c'est à dire, oscillant autour de 300 mm. Seulement, maintenant, il n'y a plus de crues ni d'inondations de terres agricoles, terres dont la superficie a plus que quintuplé. Un périmètre irrigué de plus de 5000 ha s'est installé dans cette zone. Le niveau piézométrique se situe entre 50 et 60m à l'amont, à 40m dans la zone médiane du cours de l'oued et à 10 à 2m à l'aval de l'oued. Il existe une nappe phréatique et une nappe profonde dans le deuxième horizon.

L'effet dévastateur dû aux crues de l'oued Zéroud a disparu depuis la mise en place d'un barrage à l'amont de cet oued. Hormis l'aspect socio-économique en pleine expansion aujourd'hui, l'exploitation de cet ouvrage se traduit maintenant par des effets bénéfiques, notamment par l'arrêt des crues, l'arrêt de l'érosion, la suppression des dépôts et alluvions, la diminution du lessivage, le gain en qualité de l'eau qui perd sa salinité et la gestion rationnelle de l'eau notamment.

Comparaison des transports de matières dans les écosystèmes tropicaux du sud Cameroun : exemple des bassins des fleuves Nyong et Sanaga et de la rivière Dja-Ngoko

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Cette étude a pour objectif de comparer les flux et les formes de transfert dans les deux principaux fleuves du Sud Cameroun, le Nyong et la Sanaga, ainsi que dans la rivière Mbam, affluent majeur de la Sanaga. Ces travaux ont été réalisés dans le cadre du programme PROSE/PEGI (INSU-CNRS-ORSTOM). Les données ont été acquises entre août 1994 et décembre 1996 pour le Nyong et entre août 1995 et décembre 1996 pour la Sanaga et le Mbam. Le Sud Cameroun est caractérisé par des couvertures de sols très épaisses, principalement latéritiques. Les portions des bassins étudiés ont été choisies selon des critères climatique, géologique et anthropique. Les portions de bassin prises en compte sont les suivantes : - le bassin amont du Nyong à Mbalmayo (13555 km2, 48,4% de la totalité du bassin fluvial). Il est soumis à un climat équatorial de transition et entièrement couvert par la forêt dense humide. Le substratum se compose de roches silicatées du craton du Congo et de la chaîne panafricaine (migmatites, granito-gneiss, schistes). Ce bassin est très peu anthropisé, - le bassin amont de la Sanaga à Ebebda (76000 km2, 57% de la totalité du bassin fluvial). Il est soumis à un climat tropical de transition et couvert principalement par une savane arborée. Le substratum est constitué de roches silicatées acides du socle précambrien (chaîne panafricaine) et de formations volcaniques de l'Adamaoua. Les roches du socle sont majoritaires. Le bassin est très peu anthropisé, - le bassin du Mbam à Ebebda - confluence avec la Sanaga - (43000 km2, 100% du bassin). Soumis à un climat équatorial d'altitude, il draine la région volcanique des hauts plateaux Bamiléké (basaltes, andésites...). A la différence des deux précédents bassins, celui-ci est très anthropisé. Dans l'ensemble, les eaux du Sud-Cameroun sont très peu minéralisées (12 < TDS < 43 mg.L-1). Les charges cationiques (TZ+ = [H+] + 2[Ca2+] + 2[Mg2+] + [K+] + [Na+]) sont assez voisines pour la Sanaga et le Mbam, respectivement 280 et 330 µéq.L-1. Elles sont plus faibles pour le Nyong (210 µéq.L-1). Les rapports Si/TZ+ sont de 0.3 pour le Nyong et de 0.4 pour la Sanaga et le Mbam. A la différence de ces dernières rivières dont le pH est neutre et les teneurs en COD faibles (2-3 mg.L-1), les eaux du Nyong sont légèrement acides (pH = 5,6) et riches en COD (15 mg.L-1). La NICB (Normalized Inorganic Charge Balance = [TZ+-TZ-]/TZ+) est fortement déficitaire en anions (46%) pour le Nyong du fait de la présence d'acides fulviques. Pour la Sanaga et le Mbam, la NICB est faible (1-5%). Les formes de transfert de carbone sont différentes pour les rivières sous forêt et sous savane. Dans le Nyong, le carbone est essentiellement transporté sous forme organique ([COD] = 4170 mole.ha-1.an-1 ; [HCO3-] très faible). Dans la Sanaga et le Mbam, le carbone est transporté sous les deux formes : organique ([COD]Sanaga = [COD]Mbam = 1250 mole.ha-1.an-1).et inorganique ([HCO3-]Sanaga = 1080 et [HCO3-]Mbam = 1950 mole.ha-1.an-1). Il est à noter également que le rapport des flux de carbone organique dissous et particulaire [COD/(COD+COP)] est de 87% pour le Nyong, 60% pour la Sanaga, mais seulement de 25% pour le Mbam. Les flux de fer et d'aluminium dans le Nyong, principalement associés à la matière organique colloïdale (Viers et al., 1997), sont relativement très importants ([Fe]Total = 30 mole.ha-1.an-1 ; [Al]Total = 18 mole.ha-1.an-1). Par contre, dans la Sanaga, Fe et Al sont associés à des phases colloïdales minérales (Olivie-Lauquet, 1996). Les flux sont de 8 mole.ha-1.an-1 pour Fe et de 11 mole.ha-1.an-1 pour Al. Le transport fluvial des matières dissoutes (TDS) et en suspension (TSS), exprimé en t.km-2.an-1, est sensiblement égal, sur le Nyong (TSS = TDS = 5) et la Sanaga (TSS = 18 et TDS = 16) tandis qu'il varie considérablement sur le Mbam (TSS = 98 et TDS = 28). Le rapport COP/TSS est de 0,20 pour le Nyong et seulement de 0,06 et 0,04 pour la Sanaga et le Mbam. Pour le bassin du Nyong, sous forêt tropicale humide, le taux d'érosion total estimé est extrêmement faible (□ = 5 mm/1000 ans). Il est un peu plus fort pour le bassin de la Sanaga sous savane (□ = 15 mm/1000 ans). Ces taux sont équivalents à ceux estimés pour le bassin de l'Orénoque (Edmond et al., 1995) et du Congo (Gaillardet et al., 1995). Ces faibles taux d'érosion sont à mettre en relation avec l'épaisse couverture de sols latéritiques qui protègent de l'altération les roches vulnérables (Stallard, 1995). La plateau du Sud Cameroun est l'une des régions du monde où l'érosion chimique et physique est la moins active. Ceci conduit, comme dans le cas du bassin du Nyong, aux taux d'érosion les plus faibles rencontrés dans les zones tropicales humides. Par contre, pour le Mbam, le taux d'érosion total est de l'ordre de 60 mm/1000 ans. Ceci peut être relié (i) au substratum volcanique basique plus vulnérable à l'érosion que les roches silicatées ignées, (ii) à la géomorphologie de cette zone tectoniquement active aux reliefs accusés ainsi que (iii) à l'anthropisation très importante provoquant la dégradation des sols de ce bassin.

Variation des niveaux du Lac Tchad : Les effets de la sécheresse dans le bassin du Chari

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La république du Tchad, pays sahélien s'étend du tropique du cancer 23°27' N au Nord à 7°30'N au Sud et du 14° E à l'Est au 24°E à l'Ouest sur une superficie de 1 284 000 Km2. Son extension beaucoup plus en latitude qu'en longitude est à l'origine des variations hydro-climatiques (de la zones humides à la zone désertique). Le bassin a un caractère endoréique, mais les deux grands cours d'eau, Chari et Logone sont appelés des fleuves du fait qu'ils se jettent dans le Lac Tchad, une vaste mer intérieur, le mieux connu en Afrique centrale. Le système Chari-Logone véhicule en période d'hydraulicité normale plus de 40 milliards de m3 dans le Lac Tchad. Ces volumes d'eau varient suivant les débits du Chari et de la pluviométrie de chaque année. Les plus hautes eaux de 1961 correspondent au volume évacué de 57 milliards de m3. La sécheresse de 1972-73 et celle de 1984-85 la plus sévère ont réduit considérablement le niveau du lac et les apports du Chari à 6 milliards de m3 soit 10 fois moins que la période humide. Certains tributaires du Chari-Logone ont été asséchés suite aux sécheresses sévères favorisant ainsi l'avancée du désert vers les zones humides.

The effects of land-use on runoff generation for hillslopes on deeply weathered Precambrian basement rocks in the state of Rondonia, Brazil

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The focus of soil physical investigations on oxisols (latosols in the Brazilain system) has created the widely accepted belief in predominantly vertical flowpaths due to uniformly high hydraulic conductivities to a depth of one meter or deeper. Surface and near-surface hydraulic conductivities of soils control the partitioning of runoff into surface and shallow subsurface flow and the recharge of groundwater. We investigated vertical profiles of saturated hydraulic conductivity, Ksat in latosols developed on Precambrian basement rocks under three land-cover histories: primary rainforest, pasture converted from primary rainforest, and teak planted on pasture after primary rainforest. Simple flow models were used to explore runoff response from forested and deforested hillslopes.

The research sites are located at Rancho Grande (10□ 18' S, 62□ 52' W, 143m amsl) in the state of Rondonia, Brazil. Hillslope lengths are approximately 175m-to-325m with average gradients of 0.02. We measured saturated hydraulic conductivity, Ksat, at 25-m intervals along interfluve-stream channel transects under the bunch grass B. brizantha (n=10), on bare soil between B. brizantha bunches (n=15), B. decumbens (n=7), and rainforest (n=48), respectively, and in a grid pattern in the teak plantation (n=23). We calculated surface Ksat from disc permeameter measurements of K at supply potentials of -3 and -6 cm. We measured Ksat over an integrated depth of 5-15 cm with a Guelph permeameter, and 12-30, 32-50, and 72-90 cm with an amoozemeter, a constant-head well permeameter.

In all cases Ksat decreased with depth, with most of the decrease occurring between the surface and a depth of 30cm. In conjunction with prevailing rainfall intensities and frequencies, this anisoptropy supports a transient perched water table and a lateral component of hillslope flowpaths, and under pasture also overland flow. Our results are at variance with the data from other latosols where Ksat tends to increase with depth.

Modelling process driven sediment storage response in typical pool-rapid channel types

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The maintenance of ecological integrity of natural river systems is a function of channel morphology since various biotic species respond differently to alluvial and bedrock morphologies for their establishment, procreation, feeding, recreation and habitation. Sedimentation studies in bedrock-controlled Sabie River in Kruger National Park, South Africa have established siginificant sediment accumulation in pool-rapid channel types and therefore it is important to develop spatial and temporal sedimentation and erosion models to form the basis for understanding how such bedrock morphologies control sediment deposition and erosion in order to set precedence for engineering and ecological management.

The transport, erosion and deposition of sediment in a channel is influenced by the channel morphology, sediment availabilty, the magnitude of discharge and the local hydraulics. Deposition and /or erosion of sediment leads to new morphological states with time and continuously changes the hydraulics of flow and shear stress distribution, tending towards an equilibrium state for a particular flow condition. The equilibrium state is therefore important since it is the ultimate state of sediment storage or erosion and is thus useful in identification of the influence of the various interacting factors.

Sediment accretion graphs (SAGs) and/or sediment erosion graphs (SEGs) that take into consideration the influence of the channel width, the average depth of flow of the upstream pool of an obstruction, the dimensions of the upstream face of the obstruction and the flow magnitude have been developed in a laboratory based investigation. These empirical graphs, together with suitably scaled sediment characteristics, permit the prediction of sediment storage and/or erosion resulting from various flow scenarios for natural rivers with pool-rapid channel reaches. The applicalibilty of SAGs and/or SEGs in sediment modelling studies is potentially useful to overcome difficulties encountered in the application of conventional models of sediment transport. Sediment transport rates estimated from conventional sediment transport models deviate significantly due to inability to predict sediment delivered into the channels accurately and the difficulties experienced in measuring the sediment output rate. However, the determination of SAGs and/or SEGs considers specific sediment input values that can be related to sediment supply estimated from the catchment erosion models and thus facilitates the determination of the sediment transport rates in natural channel reaches when applied together with a sediment budget equation.

Evaluation de l'écoulement inter-annuel des rivières sous forêt intertropicale humide à partir des précipitations

J.C. OLIVRY

A partir des chroniques hydro-pluviométriques acquises pendant trois décennies sur les bassins de dix sept stations hydrologiques de fleuves côtiers du Cameroun, caractérisés par l'importante couverture forestière de leurs bassins soumis aux climats équatorial de transition boréal et tropical humide, un modèle simple a été établi permettant le calcul de l'écoulement inter-annuel d'un cours d'eau en fonction de la hauteur inter-annuelle de précipitations moyennes reçues par son bassin versant (Olivry, 1986). Le bilan hydrologique inter-annuel a montré pour ces bassins des déficits d'écoulement de 960 mm à 1240 mm, correspondant aux valeurs de l'évapotranspiration réelle et semblant indiquer que sous la grande forêt humide, «the evergreen rain forest », l'évapotranspiration potentielle est satisfaite toute l'année ; celle-ci est en moyenne de l'ordre de 1100-1150mm et varie peu en regard de la répartition géographique des précipitations. L'intérêt de l'échantillon camerounais est, en effet, de présenter une gamme de hauteurs de précipitations inter-annuelles variant de 1500 mm à plus de 5000 mm et couvrant largement les variations observées sur l'ensemble du domaine forestier tropical humide de la planète.

Le modèle a été appliqué à différents bassins forestiers de la ceinture intertropicale dont les précipitations moyennes et les débits sont connus à travers différentes publications, sans que l'on puisse juger pour autant de la qualité de l'information disponible. Les données de vingt-six bassins ont été utilisées ; ces bassins sont situés en Afrique équatoriale, en Asie du Sud-Est, sur le versant indien de Madagascar, en Amérique centrale et en Amérique du Sud. Les modules spécifiques calculés ont été comparés aux valeurs observées. Les écarts relatifs sont inférieurs à 15% dans 80% des cas, à 10% pour 60% des cas, mais inférieures à 5% pour seulement 25% de l'échantillon étudié. Les résultats sont discutés : représentativité des bassins choisis (couverture forestière et anthropisation, géomorphologie), qualité de la détermination des précipitations moyennes, climat et calcul de l'évapotranspiration. Le cas du Xingu, du Japura et du Purus en Amazonie sont plus particulièrement évoqués.

Cette approche, en caractérisant un fonctionnement global des cours d'eau sous forêt tropicale humide, permet une évaluation acceptable de la ressource en eau disponible pour des bassins non jaugés à partir de la seule précipitation et, a contrario, une analyse critique des données publiées.

Evolution des flux de matières le long de l'Oubangui et du fleuve Congo

D. ORANGE, A. LARAQUE, J.C. OLIVRY

Plusieurs descentes fluviales ont eu lieu entre Bangui sur l'Oubangui et Brazzaville sur le Congo de 1988 à 1992, toujours en période de hautes eaux. Elles avaient pour objectif principal d'apprécier la variation longitudinale de la qualité des eaux et des suspensions de l'amont vers l'aval de deux grands fleuves de la zone équatoriale et d'identifier la part et la nature des apports des différents affluents.

Les concentrations en matières en suspension présentent une faible décroissance régulière sur l'Oubangui, entre 30 mg/l à l'amont et moins de 20 mg/l à la confluence. Cette évolution est caractéristique d'une baisse par simple dilution de l'apport de l'amont avec les apports latéraux peu importants de matières solides provenant de bassins sous forêt. Après la confluence avec le haut Zaïre, où la charge solide est légèrement supérieure à celle de l'Oubangui, de l'ordre de 25 mg/l, les concentrations du Congo décroissent régulièrement jusqu'à la confluence avec le Kasaï. A ce point, elles passent de 10 mg/l à 20 mg/l pour atteindre 25 mg/l à Brazzaville.

La concentration en matières dissoutes des eaux a une évolution inverse de celle des matières particulaires. Elle passe de 44 mg/l à Bangui à 54 mg/l à la confluence avec le haut Zaïre pour rester relativement stable jusqu'à Brazzaville. En fait, malgré cette homogénéïté spatiale d'ensemble, la répartition entre la phase dissoute minérale et la phase dissoute organique évolue. En effet, la matière organique dissoute est pratiquement absente des eaux de l'Oubangui sur 300 km en aval de Bangui. Puis elle apparaît progressivement pour représenter 17 mg/l à la confluence avec le haut Zaïre. Ensuite, le long du Congo, la concentration en matière organique dissoute diminue légèrement jusqu'à Brazzaville par simple effet de dilution.

L'Oubangui et surtout le Congo sont deux axes fluviaux énormes par rapport à leurs affluents. Leurs eaux ne subissent donc pas de fortes variations spatiales. Les changements sont progressifs même si ponctuellement il existe une différence notable de qualité entre les deux rives d'une même section. Cela est très sensible dans la cuvette congolaise au niveau de chaque confluence avec une «coca-cola river» qui apporte des eaux acides à concentration en matière organique dissoute importante.

Enfin, le Congo et l'Oubangui sont deux fleuves qui exportent tout le long de leur trajet durant leur période de hautes eaux de l'ordre de 25 mg/l de matières en suspension et de 45 à 51 mg/l de matières dissoutes, respectivement de l'amont à l'aval. En crue, tout le long de cet axe fluvial principal, les flux de matières particulaires ne représentent en fait que le tiers des flux totaux transportés.

Evolution des flux de matières le long de l'Oubangui et du fleuve Congo

D. ORANGE, A. LARAQUE, J.C. OLIVRY

Plusieurs descentes fluviales ont eu lieu entre Bangui sur l'Oubangui et Brazzaville sur le Congo de 1988 à 1992, toujours en période de hautes eaux. Elles avaient pour objectif principal d'apprécier la variation longitudinale de la qualité des eaux et des suspensions de l'amont vers l'aval de deux grands fleuves de la zone équatoriale et d'identifier la part et la nature des apports des différents affluents.

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Análisis y tendencia de los años de El Niño en la cuenca Amazónica Peruana

J.J. ORDOÑEZ GALVEZ

Sabido es que la cuenca Amazónica peruana representa el 74% del territorio nacional, la cual esta conformada por 08 cuencas que son: Amazonas, Ucayali, Marañon, Madre de Dios, Putumayo, Yaravi, Alto Purus y Alto Yurua, siendo las cuencas con mayor superficie: Amazonas con 104 875 Km^2, Marañon con 303 200 Km^2 y Ucayali con 346 975 Km^2.

Con la finalidad de conocer el comportamiento, variabilidad y tendencia de las variables hidrometeorológicas; durante la ocurrencia del Fenómeno el Niño, se realizó un análisis de la precipitación, niveles de agua y caudales, ha nivel medio anual, para la cuenca amazónica peruana.

El período de información utilizada para el presente análisis corresponde a 1965/97, lo cual ha permitido conocer que la ocurrencia de dos períodos bien definidos en el régimen pluviometrico:

- Período1 1965/82 (régimen creciente
- Período2 1982/97 (régimen decreciente

para los niveles de agua y caudales, el período análizado es de:

Período 1968/87 (régimen creciente

Período 1987/97 (régimen decreciente

Obteniéndose para cada uno de ellos expresiones matemáticas que representan el comportamiento de las variables analizados.

Modelo regional de simulación de niveles en rios amazónicos

J.J. ORDOÑEZ GALVEZ

Sabido es que la cuenca Amazónica peruana representa el 74% del territorio nacional, la cual esta conformada por 08 cuencas que son: Amazonas, Ucayali, Marañon, Madre de Dios, Putumayo, Yaravi, Alto Purus y Alto Yurua, siendo las cuencas con mayor superficie: Amazonas con 104 875 Km², Marañon con 303 200 Km² y Ucayali con 346 975 Km².

El río Amazonas recibe los aportes de agua de los ríos Marañon y Ucayali, principales tributarios que nacen en territorio peruano, el período utilizado para el presente estudio corresponde a 169/97.

Con el fin de saber el comportamiento, variabilidad y tendencia de los incremento y descensos del régimen hídrico de los ríos Amazonas, Marañon y Ucayali, se realizo un análisis regional del comportamiento de dichas variables así como también la aplicación de un modelo regional:

Y = (* U(2 M(1

Donde:

Y (Incrementos y descensos de niveles del río Amazonas

U (Incrementos y descensos de niveles del río Ucayali

M (Incrementos y descensos de niveles del río Marañon

(,(2(1 (Coeficientes a determinar por correlación múltiple.

Los resultados obtenidos en el presente estudio, ha permitido determinar expresiones matemáticas que refleja el comportamiento de las variables hidrológicas del río Amazonas en función de los ríos Marañon y Ucayali, contribuyendo de esta manera a tener un mejor conocimiento de recurso agua en la amazonía peruana.

Evolución de la físico-química del agua durante las operaciones de vaciado total del embalse de Barasona (Río Esera, Huesca)

A. PALAU YBARS

Entre 1995 y 1997 se llevaron a cabo tres vaciados totales (uno por año) del embalse de Barasona (río Esera, Huesca. España), con el objeto de habilitar sus antiguos e inoperantes desagües de fondo. Esta actuación fue objeto de un exhaustivo seguimiento de las afecciones ambientales, destacando en particular la evolución de las características físico-químicas del agua antes, durante y después de los tres vaciados consecutivos.

El embalse de Barasona presentaba, como rasgos propios destacables, su condición de meso-oligotrófico y un alto grado de aterramiento (entre un 20-25% de su capacidad total, con una altura de 28 m de sedimentos en el paramento aguas arriba de la presa), hecho este que condicionaba las capacidades de gestión hidráulica de la presa y que influyó en gran medida, en las operaciones de vaciado y también en sus consecuencias sobre el medio fluvial.

El presente artículo expone los resultados del seguimiento de la físico-química del agua, durante los tres vaciados, en el río aguas abajo del embalse. Los resultados muestran la magnitud y duración de los cambios, que son ciertamente espectaculares a escalas de tiempo muy breves, en el caso de algunos parámetros y variables como las materias en suspensión, el oxígeno disuelto, el pH, la alcalinidad, el amonio y la conductividad eléctrica en las proximidades de la presa. En todos los casos, los cambios de la físico-química del agua, derivados del vaciado del embalse, se atenuaron con rapidez aguas abajo, especialmente cuando se incorporan caudales importantes. También se aportan datos sobre la dinámica de los nutrientes (nitrógeno y fósforo) así como de algunos metales pesados.

Behaviour of a little Solimoes's tributary: the Purus

N. PATEL, S. MOUNIER, J.L. GUYOT, C. BENAMOU, J.Y. BENAIM

The first study of the molecular size distribution and fluxes of organic carbon from the Rio Purus to the Amazon River is reported in this talk. The Rio Purus, which drains the sediments of the sub-Andean trough and of the central plain, is a tributary of the Rio Solimoes. Organic carbon measurements using sequential tangential ultrafiltered (STUF) and discharge measurements give original information of the Purus basin, which has not been studied much until now. Firstly for the rivers of this basin the total organic carbon values and the molecular size distribution are similar to those found for white waters. In addition two sampling sites of the Purus River show a very large concentration (>80%) in the dissolved material. This distribution is similar to those of the Rio Madeira and this is all the more curious since the Rios Purus and Madeira do not drain the same kind of soil. Afterwards, the Rio Purus distribution is severely modified by two small tributaries, inducing non-conservative transformation.

Moreover a good estimate of the Rio Amazonas carbon flux and discharge at the Óbidos station was also determined. For the Amazon basin, this work has confirmed the carbon size redistribution and flocculation/coagulation phenomena at the confluence. Indeed during this seasonal campaign, there was a large size transfer from particulate to colloidal and dissolved form during water mixing of fresh waters but no significant loss of carbon was observed after the formation of the Amazon River. This dynamic exchange between the fractions is important for some phenomena such as metals transport by the organic matter because the metals transport and the molecular mass distribution of associated metals to organic matter are closely linked to the size of the organic material.

A Maré em ambientes estuarinos de interesse à navegação : caso Barra Norte do Rio Amazonas

A.C. PAULA

As condições ambientais reinantes no litoral brasileiro (processos de sedimentação, correntes, descarga fluvial e extensão da plataforma continental) são muito dinâmicas, principalmente na Barra Norte do Rio Amazonas (AP e PA), na Lagoa dos Patos (RS), na Baía de São Marcos (MA), Baía de Paranaguá (PR), entre outros locais. Levantaram-se os dados de maré arquivados na Diretoria de Hidrografia e Navegação, em diferentes mídias, a partir de 1970, principalmente observações com ecogramas em fundeios ao largo, e maregramas na costa.

De forma a assegurar a navegação e auxiliar o tráfego mercante na Barra Norte do Rio Amazonas (cartas náuticas nos. 200, 201, 210 e 220), foi desenvolvido um modelo empírico com os dados maregráficos para a redução das sondagens batimétricas na área, considerando níveis de redução escalonados e o amortecimento da onda de maré, aumentando-se a profundidade local de forma segura para o navegante.

Influencia de la topología de la red de desagüe en la respuesta hidrológica de una cuenca

A. PEÑA, J.L. AYUSO, J.V. GIRÁLDEZ

El Hidrograma Unitario Instantáneo Geomorfológico está basado en el análisis cuantitativo de la red de desagüe de la cuenca bajo un enfoque "hortoniano". Así, la geomorfología de la cuenca es descrita asignando un orden a cada tramo de canal y agrupándolos después en estados que, conteniendo las características medias de todos ellos en número, longitud y área de drenaje, proporciona la respuesta de la cuenca a un impulso unitario de precipitación.

Sin embargo, existen otros esquemas para modelar la red, como el modelo topológico aleatorio de Shreve (1966). Bajo este nuevo enfoque, el análisis hortoniano es cuestionado en base a dos postulados básicos: (1) en ausencia de controles geológicos, las redes de canales naturales son, de forma muy aproximada, topológicamente aleatorias (Shreve, 1966) y (2) las longitudes de los canales interiores y exteriores y sus superficies asociadas en cuencas con características geológicas y climatológicas homogéneas, poseen distribuciones estadísticas diferentes que son aproximadamente independientes de su localización en la cuenca, por lo que los cocientes de Horton estarían determinados, principalmente, por su aleatoriedad subyacente (Shreve, 1967). Además, y lo que es más importante, el cálculo de los cocientes de Horton implica el sumatorio de gran número de magnitudes, longitudes o áreas, asociadas a los canales, tal que muchos de los detalles responsables de las diferencias en la estructura de la red son promediadas (Shreve, 1969).

En definitiva, la cuantificación de la red de desagüe mediante el análisis hortoniano enmascararía la verdadera organización de los diferentes canales en la red. Redes de desagüe de igual orden, □, con valores similares de RB, RA y RL, pueden, no solo tener estructuras topológicas muy distintas, sino diferentes distribuciones para las longitudes o las superficies asociadas a los canales dependiendo de su posición en la red, cuestionándose así el HUIG desarrollado por Rodríguez Iturbe y Valdés (1979) y Gupta y col. (1980). Por otra parte, el núcleo de la formulación del HUIG original tiene su origen en la teoría de las redes topológicamente aleatorias de Shreve (1966, 1967 y 1969) y en los trabajos posteriores de Smart (1972), resultando que el conjunto de aproximaciones e hipótesis asumidas dan lugar a estimaciones especialmente imprecisas, sobre todo en grandes cuencas, donde la red de canales presenta importantes desviaciones con respecto a la teoría de redes topológicamente aleatorias y cuando los controles geológicos configuran un patrón geomorfológico que varía espacialmente dentro de la cuenca.

La idea es permitir que la verdadera organización de la red sea la responsable de su respuesta hidrológica. Si la red es tal que cada uno de sus elementos individuales contienen idénticos valores de sus magnitudes, entonces los valores promedio de esas magnitudes serán parámetros adecuados para describir el comportamiento de la cuenca. Por el contrario, si los canales de la red presentan una distribución irregular en el espacio, y contienen información cuantitativa distinta a la media, el resultado debe responder a esa irregularidad sin pérdida de información relevante.

En este trabajo se parte del soporte conceptual que proporciona el HUIG desarrollado por Rodríguez Iturbe y Valdés (1979) que ha mostrado su validez en cuencas naturales. Sin embargo, algunos aspectos son cuestionados y los resultados obtenidos en su aplicación presentan imprecisiones bajo determinadas circunstancias, en concreto con respecto a la probabilidad que tiene una gota de seguir una u otra trayectoria en la red de canales.

Aspectos geoquímicos do material particulado da plataforma continental do Amazonas

S.B. PEREIRA, M. EL-ROBRINI

O sistema Rio/Plataforma do Amazonas é um dos mais importantes do mundo, em termos de tamanho, de descarga aquosa (1,0 - 2,8 X 105 m3/s) e sólida (1,2 X 109 ton/ano).

Optou-se pela análise de elementos maiores e associou-se a variação destes com a composição mineralógica e teores de C e N na pluma estuarina do Amazonas que estende-se offshore durante a descarga máxima e confina-se na parte interna da Plataforma do Amapá, durante a descarga mínima. As coletas de amostras de material em suspensão referentes a este trabalho foram realizadas durante a descarga mínima no decorrer do 2□ cruzeiro da Operação Norte II do Programa REVIZEE (Recursos Vivos da Zona Econômica Exclusiva), no período de 13 a 23/10/97 na Plataforma Continental do Amazonas. Na quantificação do material empregou-se métodos clássicos de análises como a gravimetria, além de espectrofotometria de absorção atômica, espectrometria de infravermelho e difração de raios-X.

A concentração de material em suspensão variou de 2300 mg/L (mínimo de salinidade em 24,31‰, próximo à costa) até um mínimo de 20 mg/L (salinidade em 35,86‰) resultado, este associado ao aumento da salinidade. No que se refere a composição mineralógica há predominância do argilomineral caolinita em grande parte das amostras e este domínio provavelmente está associado aos teores elevados de Al2O3 (máximo de 25,6%). Em parte das amostras há uma certa predominância de ilita, que possivelmente associa-se à substituição de alumínio por ferro, que apresenta valores mais elevados nessas amostras (máximo de 9,54% em Fe2O3). Outro grupo de amostras exibe alternância de domínio entre ilita/clorita e teores baixos em esmectita havendo diminuição de caolinita, o que estaria associado à adsorsão de cátions (Ca2+, Mg2+ , Na+, K+), que tendem a promover o enriquecimento desses argilominerais, através de processos geoquímicos como o intemperismo e neoformação. O intemperismo parece estar mais associado às alterações de feldspatos, a julgar pela presença de vestígios destes nos difratogramas. Espera-se que haja neoformação, considerando as reações de troca e adição, envolvendo os argilominerais em zona de convergência. Observou-se que nos pontos de coleta mais próximos da costa os teores de caolinita se mostraram mais expressivos, em contraste com os teores de ilita, clorita e traços de esmectita, que se apresentaram mais elevados com o aumento da salinidade e o conseqüente afastamento da costa. Isto parece confirmar os resultados obtidos por outros pesquisadores, no que diz respeito ao assentamento diferenciado desses silicatos pela variação da salinidade. A razão C/N alta (máximo em torno de 40 e mínimo em torno de 9) na maioria das amostras investigadas indica uma predominância constante de compostos orgânicos não nitrogenados sobre os nitrogenados, o que pode indicar disponibilidade de nitrogênio para o meio.

Intercomparation of lumped and semi distributed watershed models on Brazilian river basins

C. PERRIN, C. MICHEL, M.D. MELO, N.O. NASCIMENTO

Rainfall-runoff watershed models are widely applied in the field of water resources. Conceptual modelling has proved relatively efficient in catching the main features of hydrological time series. However, the use of these models is often thought to be restricted to the regions where they have been developed. Moreover, models existing in the literature have been mostly, tested in countries with abundant hydrological data. It is therefore very useful to compare their merits in countries with comparatively scarce data especially when climatic conditions of these countries are far from those prevailing in catchments used for model development. In the present paper several models developed in Europe, Australia and Brazil are compared on fairly large river basin data. The additional interest of such a comparison lies in the fact that some models are lumped whereas others are spatially distributed. It is generally admitted that large basins, say more than then thousand square kilometres in area, cannot he reasonably dealt with using lumped models. This comparison provides an opportunity to test this assumption. The economical weight of water resources in a country such as Brazil puts a strong emphasis of rainfall runoff modelling, and therefore, it of prime importance to find out which models are best suited to hydrological applications. In this comparison exercise, the performance of four watershed models (GR3J ; IPH3 ; TOPMODEL and IHACRES) are assessed on eight Brazilian river basins larger than ten thousand square kilometres in the State of Minas Gerais.

Essai de modélisation du régime du transport particulaire sur les fleuves tropicaux d'Afrique : le Niger supérieur

C. PICOUET, B. HINGRAY, J.C. OLIVRY

Estimer l'évolution de la charge en suspension à partir de l'hydrogramme de crue afin de quantifier le régime des flux de matières transportées dans un grand cours d'eau conduit naturellement à rechercher un modèle de calcul du transport particulaire à partir de variables hydro-pluviométriques : leurs chroniques sont généralement plus longues ce qui permet la reconstitution des flux de matières transportés par le fleuve pour la période d'observations.

Il est classique de chercher à corréler les concentrations des matières en suspension mesurées avec les débits pour calculer les flux transportés. Ces relations entre charge solide C et débit liquide Q s'avèrent plus ou moins complexes suivant les bassins étudiés mais sont généralement ajustées à des équations de la forme $C = aQb$ (avec $b>1$).

Pour les fleuves tropicaux unimodaux d'Afrique, la relation entre C et Q présente des hystérésis de crues orthogrades à l'échelle annuelle : Cameroun, Oubangui, Niger (Olivry et al., 1977, 1988,1995), Chari, Sénégal (Gac et al. 1980, 1992, Orange 1991,1994).Les quelques modèles proposés relient directement flux liquides et flux particulaires pour lesquels la variation de débit est plus déterminante que celle des concentrations de matières. Or l'hystérésis des courbes Concentration = f(Débit) traduit bien des processus se succédant en 3 phases (érosion précoce et forte de l'ensemble du bassin , érosion atténuée et transport dans le réseau hydrographique, érosion limitée aux berges en phase de récession) au cours desquelles la dynamique des transports de matières en suspension est différente et fortement liée aux caractéristiques annuelles des pluies (conséquence sur les écoulements et le cycle de la végétation...)

Le Fleuve Niger à Banankoro (71 000 km2) est caractérisé par un cycle annuel de ce type avec des distinctions entre années de bonne ou mauvaise hydraulicité. Une étude antérieure (Picouet et al., 1998) a montré l'importance du volume écoulé, avant et après la mise en place effective de la végétation sur la variabilité de la charge en suspensions dans le fleuve : au début de la crue, plus le volume écoulé est important et plus les concentrations seront importantes (on retrouve la forme classique présentée ci-dessus) ; lors du reste de la montée de la crue, la proportion des particules prêtes a être arrachées aux sols est moindre et la végétation joue son rôle protecteur, le volume écoulé depuis le début de la crue aura donc des effets inverses, i.e., plus le volume écoulé sera important et plus la concentration sera faible (plus il y aura dilution) ; par la suite, avec la décrue et la fin de la saison des pluies, les matières en suspension sont diluées par la part prépondérante que prend l'écoulement d'origine souterraine.

La modélisation, présentée ici, est basée sur ces considérations et a été appliquée aux moyennes mensuelles sur l'ensemble des années étudiées. Elle permet de calculer la concentration en matière en suspensions d'un mois considéré, à partir d'une première fonction liée au débit moyen mensuel et d'une autre qui dépend du volume écoulé depuis le début de la crue. Le principe de départ est de définir une fonction théorique de type $C=aQb$ qui représenterait, s'il n'y avait pas d'influence saisonnière, l'érosion moyenne possible sur le bassin versant (versants et berges) tant qu'il pleut. Ensuite, la différence entre la concentration observée (Cobs) et la concentration théorique (Ctheo) est reliée avec le volume écoulé depuis le début de l'année hydrologique. Ce dernier paramètre permet de prendre en compte les effets antagonistes évoqués ci-dessus. Les résultats de la modélisation sont discutés.

The hydrological signal of ENSO in the Upper Paraná drainage basin

E.L. PIOVANO, P.J. DEPETRIS, J.L. PROBST

The tropical-temperate Paraná River is one of the largest rivers in the world (2.6 106 km2). Rivers flowing in the tropics exhibit a significant correlation with ENSO (Amarasekera et al., 1997). Mossman (1924) and Bliss (1928) -- members of Sir Gilbert Walker's research group -- first hinted a cause-effect relationship between the Southern Oscillation in the Equatorial Pacific and the Paraná River flow. Recently, Depetris et al. (1996) have examined the 1904-1991 discharge anomalies record of the Paraná at Corrientes, and found a spectral peak at a period of 40 months. Cross-spectral analysis revealed a significant coherence squared (5% confidence level) in the neighborhood of the 30-month period range between the equatorial Pacific Ocean sea-surface temperature (SST) anomalies and the Paraná River deseasonalized discharge. Exceptional discharges at Corrientes lags by about 8 months behind positive SST anomalies in the Pacific.

The tropical Upper Paraná supplies most of the total discharge (ca. 450 km3). Its mean contribution to the total discharge is about 80% during high flow (Jan.-Apr.) and decreases to 65 % during the low discharge period (Jun.-Aug.). The remainder is mostly supplied by the Paraguay River, which drains Brazil's Mato Grosso as well as the Andean eastern slope (Bermejo and Pilcomayo rivers).

The almost 100-year long deseasonalized record of Paraná's discharge in its heterogeneous headwater shows ample variability, with conspicuous, rather short-lived positive departures from the mean (mainly associated to El Niño events) and longer lasting dry spells. The river's accumulated anomalies show a dry period during 1917-20, another one with its onset during the late 40's, and a steep water positive departure from the mean that started in the early 80's, in agreement with the 1982-83 El Niño event. Most striking is the positive trend observable in the Paraguay's deseasonalized data during the last 20 years, possibly caused by Mato Grosso's increased deforestation.

The harmonic analysis of deseasonalized sea level pressure at Pt. Darwin and dicharge anomalies at the upper Paraná (in Posadas) and at the Paraguay River shows: a) significant periodogram peaks at discharge anomaly frequencies coincidental with the occurrence of ENSO events in the Pacific; b) significant and high squared coherency between sea level pressures and discharge anomalies in both sub-basins; and c) evidence of a weaker ENSO signal in the Paraguay drainage basin.

Balance hídrico superficial de la cuenca del Río Napo, Pastaza y Santiago

R. POMBOSA LOZA, E. HEREDIA CALDERÓN, R. HOORELBECKE, V. PEREZ, J. ROURA, A. ERAZO

El presente estudio comprende el Balance Hídrico de la Cuenca del Río Napo, el río más grande del Ecuador, localizado en la parte norte de la Amazonía ecuatoriana. La cuenca, de aproximadamente 27860 km² hasta la localidad de Nuevo Rocafuerte, recoge las aguas de los deshielos del Antisana, Sincholagua, Cotopaxi y Llaganates en su parte andina y drena las aguas provenientes de las altas precipitaciones del pie de monte andino oriental y de la cuenca media Amazónica.

El Balance Hídrico se fundamenta en la aplicación de ecuaciones que igualen entradas, salidas, y almacenamientos de agua en la cuenca, por el principio de Conservación de Masa. Dado que ningún Balance puede ser generalizado en el tiempo o en el espacio, puesto que es específico para un período y espacio considerados, para este estudio se tomo un periodo de 15 años, sin embargo se cuenta con información de aproximadamente 25 años. El balance se desarrolla a escala mensual.

Para el estudio minucioso del ciclo hidrológico, se deben determinar las componentes de la circulación del agua entre la atmósfera y el suelo, lo cual permite establecer el Balance de la región, que puede expresarse en forma simplificada como: $P - Q = ETR + \square$

Donde P es la precipitación media, es decir, la componente del agua que proviene de la humedad atmosférica que cae sobre la superficie terrestre; Q es el caudal medio; ETR representa la evapotranspiración media, que es la suma de la cantidad de agua que pasa a la atmósfera por los procesos de evaporación del agua interceptada por el suelo y la transpiración de las plantas; y □ es un término de discrepancia, debido a posibles errores de medición y de estimación de los parámetros del estudio. Esta ecuación es aplicable bajo la hipótesis de que los cambios de almacenamiento en un período largo de tiempo, en áreas extensas tiende a minimizarse y se puedan suponer nulos.

Es evidente que la calidad del balance hídrico depende en gran medida de la calidad de los datos que se utilizan para el análisis, por tanto, para poder tener resultados significativos, es necesario realizar un proceso de control de calidad de la información existente, identificación de errores y corrección de los mismos. En éste ámbito, se ha puesto especial énfasis en la depuración de los datos de niveles registrados y aforos, así como de los datos pluviométricos. El cálculo de caudales diarios, mensuales y anuales se derivan del análisis de aforos, niveles y curvas de descarga, estos valores provienen de mediciones están expuestos a errores, por ello es necesario realizar análisis de consistencia. Para la información meteorológica, este análisis se realizará mediante curvas de doble masa y mediante la aplicación del paquete Climan. El cálculo de la evapotranspiración se realizará por varios métodos.

Se está elaborando un banco de datos con la información hidrometeorológica y con las características topográficas y fisiográficas de la cuenca, tipo y uso del suelo. Con esta información se generarán mapas de isoyetas, isotermas, isolíneas de evapotranspiración y de isolíneas de escorrentía.

Régimes hydrologiques des hauts bassins nivo-glaciaires boliviens et variabilité pluviométrique des vallées andines en condition El Niño et La Niña

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L'IRD (anciennement ORSTOM) et son partenaire l'entreprise hydroélectrique COBEE exploitent depuis 1991 des stations hydrométriques de hautes altitude (4800 m) à l'aval de 3 bassins versants glaciaires du Huayna Potosi (6088 m), sur le versant amazonien de la Cordillère Royale de Bolivie. A partir de ces observations récentes de bonne précision, il a été possible de reconstituer 3 chroniques hydrologiques longues d'une vingtaine d'années chacune, comprenant donc plusieurs événements importants El Niño et La Niña. L'emprise glaciaire de ces bassins versants est comprise entre 15 et 70 % et ils ont des orientations fortement contrastées. L'évolution annuelle et infra annuelle de leur hydraulicité peut être clairement mise en corrélation, positive ou négative, avec l'occurrence des événements El Niño et La Niña. L'explication de ces fonctionnements parfois opposés des bassins versants glaciaires est fournie par le pourcentage d'englacement et l'orientation des bassins versants, mettant ainsi en évidence, en Bolivie, la dépendance étroite aux événements ENSO de l'hydrologie glaciaire des fleuves composants primaires du bassin amazonien.

La pluviométrie dans la vallée du rio Zongo (tributaire du rio Coroico, puis du rio Beni et enfin du Madeira), à 10 stations pluviométriques contrôlées par la compagnie hydroélectrique « COBEE », échelonnées entre 4800 et 1200 mètres d'altitude, est connue depuis une trentaine d'année de façon suffisamment précise pour permettre une étude statistique à l'échelle annuelle et mensuelle. La comparaison des valeurs de pluies centrées réduites à l'échelle de l'année et de la saison avec les valeurs du SOI confirme l'atténuation du signal ENSO sur les précipitations, lorsque l'on va vers l'aval et la plaine amazonienne, alors que ce signal ENSO est encore bien marqué aux stations d'altitude par un net affaiblissement des précipitations en phases El Niño.

Les deux approches précédentes, complémentaires, donnent les clés du fonctionnement hydrologique des hautes vallées andines tributaires de la plaine amazonienne, et notamment de sa dépendance vis-à-vis des événements ENSO.

Variabilité interannuelle des caractéristiques hydrologiques du rio Beni au site du projet de barrage de Angosto del Bala, et conséquences prévisibles

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Lorsqu'à Angosto del Bala, le rio Beni (l'un des 4 principaux constituants du rio Madeira) sort des dernières chaînes des contreforts andins, à 10 km à l'amont de Rurrenabaque (Bolivie), il emprunte une gorge étroite de moins d'une centaine de mètres de largeur et profonde d'un demi km. Le fleuve peut lui-même y atteindre une cinquantaine de mètres de profondeur. Le site de la gorge taillée dans les grès tertiaires est extrêmement favorable à la construction d'un barrage de grande capacité, compte tenu de la taille imposante de la plaine amont dont on connaît l'hypsométrie. Les débits liquides sont relativement bien connus depuis une vingtaine d'années et permettent une étude statistique classique. Les débits solides (Guyot, 1993) sont estimés sur une période de référence nettement plus courte, mais suffisante pour approcher les volumes annuels de sédiments transportés en suspension ou dilution. Les paramètres hydrologiques nécessaires à une pré-étude de faisabilité du barrage sont donc réunis.

Diverses hypothèses faites sur la hauteur du barrage et sur ses règles hydroélectriques de gestion permettent d'anticiper les conséquences hydrologiques, économiques et humaines de la mise en œuvre éventuelle d'un tel barrage, qui seraient a priori plutôt positives sur son cours aval (régulation des débits), mais au contraire catastrophiques sur la cuvette amont (submersion des richesses de la biodiversité), actuellement occupée par un parc naturel où vivent notamment de nombreux représentants des ethnies Chimane et Mosetene exploitant le potentiel piscicole et botanique de cet espace encore préservé.

L'influence fort peu visible des événements ENSO sur l'hydraulicité du rio Beni à Angosto del Bala est également rapidement présentée et discutée.

Biogeochemistry of the Cauvery flood plain sediments, Southern India : Implications to their origin and farming

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Soil, an essential earth resource for food production is formed by the interaction of the physical, biological and chemical forces of nature. Alluvial soils and flood plain sediments are known to be very fertile and rich in plant nutrients. The nutrient elements are derived from rocks in the catchment areas by complex weathering processes. Rock weathering, soil erosion, transportation and deposition of these weathered materials has resulted in the formation of nutrient enriched, easily weatherable sediments. The alluvial sediments are home to billions of organisms, which utilise the bio-available nutrients, in turn accelerating the process of bio-weathering by secreting various kinds of organic acids and complex chemical compounds into the sediments. Action of these compounds leads to further weathering and release of nutrients, thus making the area a highly fertile farmland. Understanding this complex biogeochemical process is very important for sustainable agriculture. Cauvery constitutes a major river system of southern India. It originates in the western ghats, in the Mysore plateau, flows eastward and finally drains into the Bay of Bengal. Along the way it flows through granitic, gneissic and charnockitic terranes which are subjected to repeated uplifts, and forms a vast and highly fertile flood plain in the down stream area.. Sediment samples from the flood plain areas were collected from a depth of 0 - 20 cm, within 200 m on either side of the river channel. The dominant type of fungi present in the samples were isolated, cultured and identified using techniques in microbiology. Aspergillus niger, A. terreus var. terreus, Byssochlamys nivea (Westling), Rhizomucor pusillus and Fusarium solani were the major fungi identified. All these organisms are known to secrete organic acids and hence may play an active role in bio-weathering. Humic acids (HA) and fulvic acids (FA) extracted from the sediment samples, were analysed by ICP-AES for various elements, and by XRD and IR spectroscopy for mineralogy and organic characteristics. The analyses indicate that, possibly, the humus is fresh and not very complex in nature. Concentrations of all major oxides in bulk samples, including the calculated Chemical Index of Alteration (CIA), suggest little chemical weathering, of the samples as well as their sources. The samples are predominantly alkaline in nature, with low EC values indicating very little free ions. The organic carbon content is well below the average expected values (< 1.5 %) and constitutes nearly 80 % of the total carbon in the soil samples. Nitrogen content is also at best low to average. Organic acid concentration is low and does not seem to have influenced the pH of sediments to any great extent. Neither the texture nor the composition of the sediments show any perceptible variation along the course of the river downstream, to suggest any further chemical weathering. Most of the nutrients are still trapped in the minerals of the sediments, perhaps because of their very recent origin (<10,000 years, Pramod Singh, unpublished data).

Trace element and rare earth speciation in river sediments by new sequential extraction procedure. Implications for continental erosion and river transports into the oceans

J.L. PROBST, L. LELEYTER, P.J. DEPETRIS, S. HAIDA, J. MORTATTI

Part of the elements which are transported in rivers as particulate phases belong in fact to the dissolved phases and they are adsorbed onto suspended matters. In order to assess the origin, the fate and the bioavailability of these elements, the speciation of particulate elements (alkalines: Rb, Cs - alkaline earth: Sr, Ca - metals: Fe, Mn, Co, Pb - actinides: Th, U - lanthanides (REE): La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Y, Ho, Er, Tm, Yb, Lu) has been determined thanks to a new sequential extraction procedure (Leleyter and Probst, 1998). This 7-step sequential scheme is designed to dissolve and to separate chemical phases of the sediment sample which can be affected by changes of physico-chemical conditions, in the following order: elements dissolved with water, really exchangeable, bound to carbonates, bound to manganese oxides, bound to amorphous iron oxides, bound to crystalline iron oxides and bound to organic matter. At the end of the extraction procedure, the remaining elements, not bioavailable, are in the residual fraction which is mainly composed of primary minerals and clay minerals. 37 river sediment samples (suspended matters and bottom sediments)) which have different mineralogical and chemical compositions have been studied from Argentina (Patagonian rivers: Chico, Colorado, Coyle and Deseado), Brazil (Piracicaba river), France (Garonne and Ill rivers) and Morocco (Sebou river).

The results show that the elements which belong to the same chemical group have the same preferential scavenged sites. Alkalines are mainly associated with the residual fraction. Alkaline earth elements are very bioavailable (40-90%, 40-65% and 65-100% of Sr is bioavailable in the Piracicaba, Ill and Sebou river sediments respectively) and are mainly controlled by exchangeable and carbonate fractions. The 87Sr/86Sr isotopic signatures of bioavailable particulate Sr fractions are close to that of the dissolved Sr. Metals are also very bioavailable (30-60% and 50-100% of Co in the Patagonian rivers and in the other rivers respectively, 78% of Pb in the Ill river) and they are mainly bound to the iron and manganese oxides. The actinides are mainly associated to the oxides but sometimes uranium is controlled by carbonates too. Nevertheless, U and Th have the same biovailability in a given sediment but it varies from one river to another (7-82%). The REE are mainly linked to the carbonates, to the iron oxides and to the organic matter. The PAAS normalized REE distribution of the residual fraction can be different from that of the total sediment, indicating some REE fractionation during the fluvial transport. These results are fundamental to study the signature of the continental crust erosion using the river transports of dissolved and suspended matters and the signature of river inputs to the oceans. Most of previous studies on REE distribution and Sr isotopic signature in riverine material could be revised taking account our results.

Silicate rock weathering and atmospheric/soil CO2 uptake estimated from river transports of alkalinity, cations and silica

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The chemical erosion of inorganic materials consists in dissolving or hydrolyzing primary minerals of rocks and soils, releasing dissolved elements which are drained into groundwater and rivers. The chemical weathering processes require CO2 and the natural weathering pathway caused by the carbonic acid reaction with minerals produce dissolved inorganic carbon. Nevertheless, on a geological time scale, the flux of CO2 consumed by carbonate dissolution on the continents is balanced by the CO2 fluxes released to the atmosphere by carbonate precipitation in the oceans. Consequently, with regard to the CO2 content in the atmosphere, it is only the fluxes of CO2 consumed by silicate rock weathering which represent a non-negligible sink of CO2. Then, this study is focussed mainly on the CO2 uptake by silicate rock weathering and on the subsequent riverine alkalinity transport.

The CO2 fluxes consumed by silicate weathering could be calculated for about forty large river basins from river fluxes of alkalinity, silica, cations and anions (data from the literature) after correction from the atmospheric inputs. We used a geochemical modelling (MEGA) based on the stoichiometry of the chemical reactions which control the dissolution and hydrolysis of the different minerals and on the ionic ratios in streamwater draining major rock types. The results show that the flux of CO2 consumed by silicate weathering is directly proportional to the silicate rock weathering rate.

As previously shown by different authors, climate (e.g. precipitation, runoff and temperature) is one of the main factors controlling silicate rock weathering and consequently, atmospheric/soil CO2 consumption. For large river basins, it is shown that the riverine dissolved silica fluxes are mainly proportional to the runoff intensity. A temperature effect could be pointed out (higher silica fluxes in tropical-equatorial areas than in temperate and subarctic regions for the same runoff), but this effect is much less important than the runoff control. The results of our geochemical modelling allow to determine good linear relationships between CO2 fluxes and runoff for the major world river basins. Nevertheless, it appears clearly that, for similar runoff, the CO2 flux consumed by silicate weathering is lower for lateritic drainage basins than for non-lateritic ones. For a mean runoff of 250 mm.y-1 , the chemical weathering of silicate consumes a specific CO2 flux about 1.8 times lower in lateritic drainage basins than in non-lateritic ones. It is important to consider such a difference because the lateritic covers occupy 33% of the whole continental areas. However, this difference cannot necessarily be attributed to lower weathering intensity in lateritic regions, but also to other parameters such as relief, mineralogical weathering stage and particularly, thickness of soil profiles.

To reconstruct the geological fluctuations of CO2 consumed by silicate weathering, it is interesting to derive directly alkalinity produced by silicate weathering from riverine discharge of dissolved silica. But, there is no correlation between alkalinity and dissolved silica content in large rivers because lithologies and weathering types and rates are so different from one river basin to another. Nevertheless, it has been possible in this study to determine a good relationship between the weathering types as calculated using the weathering index Re (calculated from riverine fluxes of cations and silica, after corrections for atmospheric inputs) and the ratio between alkalinity derived from silicate mineral hydrolysis and silica concentrations in large river basins. The results show that when the Re increases going from allitization processes (Re tends to 0: genesis of gibbsite) to monosillitization (Re tends to 2: formation of kaolinite) and to bisiallitization (Re tends to 4: weathering products are smectites), the molar ratio alkalinity/silica increases respectively from less than 1, to 1-2 and to more than 2. By combining this modelling with the worldwide spatial distributions of weathering types and of runoff intensity, it is possible to reconstruct the average ratio alkaliny/silica discharged by world major rivers into the oceans.

Caracterización de la respuesta unitaria de una gran cuenca tropical

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Las características climáticas de las zonas tropicales confieren especial importancia a la hidrología de sus cuencas, en particular por las fuertes intensidades de lluvia debidas a los fenómenos de tipo ciclónico.

La caracterización de la respuesta unitaria de una cuenca en la que se disponga de registros de aforo, es una de las técnicas más usadas dentro de la práctica de la ingeniería a la hora de predecir los volúmenes de escorrentía y los caudales punta de avenidas futuras, ocasionando por aguaceros de proyectos.

La teoría del Hidrograma Unitario (HU) conforma un modelo conceptual que a pesar de sus limitaciones, constituye una útil herramienta para el diseño de estructuras para la protección contra las avenidas y la gestión de los recursos hídricos .

Se presenta en este trabajo los resultados de aplicar diversos métodos y modelos en la identificación del HU de la cuenca del río San Diego, ubicada en la provincia mas occidental de la isla de Cuba, a 85 km. de la ciudad de La Habana, con una superficie de 262 km2, este río nace en el macizo montañoso de la Cordillera de los Organos y desemboca al sur de la provincia en el mar Caribe, atravesando en su recorrido de norte a sur, paisajes montañosos y la llanura costera sur de la provincia de Pinar del Río. Tras analizar tres episodios registrados de lluvia - escorrentía, en el que las intensidades de lluvia fueron significativamente importantes, los HU obtenidos después de aplicar las técnicas de mínimos cuadrados , mínimos cuadrados suavizados, y obtener las funciones matemáticas con el HU instantáneo de Nash y el Hidrograma Unitario Geomorfológico Instantáneo (HUIG), se aprecia que los hidrogramas obtenidos mediante estos modelos no difieren de los hidrogramas observado en la estación de aforos Gavilanes, donde vierte una superficie de 155 km2, destacando la precisión de la reproducción de dichos hidrogramas en la mayoría de los modelos estudiados, analizados los episodios individualmente o agrupados fueron evaluados siguiendo los criterios de Zhao (1986), identificando la mejor respuesta unitaria

También para facilitar el análisis hidrológico de la cuenca se ha desarrollado un conjunto de algoritmos que sintetizan la información topográfica existente en los modelos digitales de elevación obtenidos por los SIG matriciales (Grass4.2) ó, extraible simplemente de la cartografía, generando una estructura topológica de la que se puede obtener el Hidrograma Unitario Instantáneo Geomorfológico (HUIG), delimitando automáticamente la cuenca y su magnitud gemorfológica de cada canal.

El Hidrograma Unitario (HU) de 1h, obtenido a partir del HUIG, propuesto por Rodríguez Iturbe y Valdés (1979) y Gupta y col. (1980) según la formulación de Peña y col. (1999), que considera la distribución topológica de los canales de la red como un factor a tener en cuenta en la respuesta hidrológica de la misma, son similares a los del modelo de Nash, por cuanto, el HUIG, se traduce en una expresión de suma de funciones exponenciales.

Evolución espacio temporal de la hidrogeoquímica de la cuenca amazónica de Bolivia

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La cuenca amazónica de Bolivia con una superficie de 872.000 Km2 corresponde a la parte alta de la cuenca del río Madera, principal afluente meridional del Amazonas. El río Madera tiene como afluentes principales a los ríos Beni y Mamoré, cuyas cuencas corresponden a medios biogeográficos muy contrastados desde los glaciares de la cordillera Oriental de Los Andes (6500 msnm) , hasta la selva tropical húmeda del piedemonte y las sabanas de la planicie amazónica (95 msnm).

Del análisis generai de la evolución de los elementos mayoritarios de los ríos de la cuenca andino – amazónica de Bolivia, se nota una clara predominancia del ión sulfato respecto al bicarbonato, existiendo una correlación directa con el calcio, magnesio y sodio.

Globalmente, las aguas de la llanura amazónica se distinguen de las aguas de los tributarios andinos por un color negro (aguas negras), pH más bajo, conductividad baja y abundancia relativa en potasio, hierro y a veces sílice disuelta.

En lo referente a los nutrientes, en los contenidos de las aguas de esta cuenca se puede notar una baja incidencia en concentración, lo cual se ve reflejado en el mínimo proceso de eutroficación de la región.

En la región andina la facies predominante es sulfato cálcico – magnésico y descendiendo geográficamente se inicia el cambio de facies hacia bicarbonato cálcico – sódico.

El río Orthon tiene una facies bicarbonato sódico – cálcico, en cambio el río Mamoré, tiene actualmente una facies sulfato cálcico – sódico.

Finalmente en toda la cuenca, se mantiene un bajo tenor de: cloruros, hierro y boro; incrementándose en cambio el potasio, sílice disuelta y la turbidez.

Regional -scale biogeochemical cycles of the Amazon: A riverine perspective

J.E. RICHEY, R.L VICTORIA

How does a large river system obtain and subsequently modify its biogeochemical composition? While it is often stated that, at regional to continental scales, river basins are natural integrators of surficial processes, the mechanics of how to interpret such information is far from understood. Overall, the challenge is to link the flow of water through the landscape down river channels to the ecological and chemical attributes of basins at scales larger to much larger than typical small watersheds. How to define these linkages between regional-scale land surface processes and the capability of river systems to transport and process land-derived materials is the key issue. In practice, this involves development of large-scale river models.

In this presentation, the Amazon River system is used as a test case for developing a model of the dynamics of a large floodplain river which has as its goal the quantitative understanding of the sequence of processes from uplands to floodplains that produce the integrated hydrological, chemical, and biological signals at the mouths of the major tributary basins (scale: 50,000 to 1 million km2). The summary working hypothesis is that, "The quantity and composition of dissolved and particulate bioactive materials in a parcel of water at any downstream node in the river system is predictable as the product of a common set of processes which occur differentially according to upstream conditions of relative topography, soil organic content and texture, water residence time, and floodplain extent."

The central premise of river basin models is that the constituents of river water provide a continuous, integrated record of upstream processes whose balances vary systematically depending upon changing interactions of flowing water with the landscape and the interplay of biological and physical processes This approach, as embodied originally by the River Continuum Concept, is based on the concept of a dynamic interaction of the landscape with its fluvial system. River properties should vary systematically downstream as processes affecting primarily the interactions of flowing water with the landscape give way to within river transport and processing. They should respond with differing magnitudes and lags to natural or manmade perturbations depending on the processes involved and the downstream transfer rates of their characteristic products.

Therefore, the chemical signatures of riverine materials should be able to identify different drainage basin source regions, reaches or stages and can be tied to landscape-related processes such as chemical weathering and nutrient retention by local vegetation. The chemical composition of river water is sensitive to both underground and surficial processes acting over a wide range of characteristic temporal and spatial scales. The information richness of riverine chemical recordings is potentially immense, especially for organic substances, and is limited largely by availability and application of appropriate analytical methods and conceptual models. Importantly, with proper sampling, both the concentrations and fluxes of riverborne materials can be directly quantified and related to specific source regions. The chemical signature of riverine materials can be used to identify different drainage basin sources and the unique balance of processes acting within them. Area- or rainfall-normalized export fluxes can be determined for different drainage basins and tied to landscape-related processes such as chemical weathering and nutrient retention by local vegetation. Fluxes of measured constituents can be compared over any segment of the water flowpath to establish local mass balances and budgets. Such comparisons are particularly useful in establishing the magnitudes of unknown sources (e.g. photosynthesis or groundwater inputs) or sinks (e.g. respiration or gas exchange) of bioactive materials within critical sections of the water network.

Diagnóstico ambiental da bacia do Rio Araguaia (Área Piloto) Mapa de vulnerabilidade natural das terras

A.J.W. RIOS, I. TARAPANOFF, J.O. DEL'ARCO

A Administração das Hidrovias do Tocantins-Araguaia – AHITAR, orgão vinculado a Cia. Docas do Pará do Ministério dos Transportes, preocupada em compatibilizar a hidrovia a ser implantada no sistema hidrográfico Araguaia-Tocantins com a legislação e o uso ambientalmente correto das terras a serem incorporadas ao processo produtivo, estabeleceu um convênio de cooperação técnico-científica com a Fundação Instituto Brasileiro de Geografia e Estatística-IBGE, para a realização de um Diagnóstico Ambiental em parte da bacia hidrográfica do rio Araguaia, trecho compreendido entre a cidade de Barra do Garças/MT e a localidade de Luiz Alves/GO, com uma área aproximada de 80.000 Km², escolhida como área piloto. O Diagnóstico Ambiental visa determinar e conhecer as diferenças geoambientais na área considerada, determinar a vulnerabilidade de suas terras no que diz respeito a erosão e a pressão decorrente do uso atual das terras, com o propósito de estabelecer áreas favoráveis para a implantação de experimentos para o controle de erosão e do aporte de sedimentos para a rede de drenagem. Pretende-se, ainda, gerar parâmetros ambientais passíveis de referencial e indicadores metodológicos para estudos e aplicação em outros trechos do sistema hidro-viário Araguaia-Tocantins. O Diagnóstico Ambiental esta sendo realizado de maneira multi e transdisciplinar pôr uma equipe técnica do IBGE/DIGEO-CO, composta pôr geólogos, agrônomos e engenheiro florestal, que sob enfoque calcado na Teoria Geral de Sistemas e o modelo de compartimentação da paisagem física de Bertrand (1971), considera as inter-relações vigentes entre os componentes do meio físico-biótico: rocha – relevo – solos – hidrografia – vegetação – clima. A visão holística e sistêmica decorrente deste estudo permite estabelecer os distintos compartimentos da paisagem, avaliar como cada um reage às pressões antrópicas e, então, indicar as áreas mais favoráveis para estudos posteriores. As análises temáticas foram efetuadas a partir de pesquisa bibliográfica, material cartográfico na escala 1:250.000 (bases plani-altimétricas; imagens de radar de visada lateral de 1976; imagens de TM Landsat 5, bandas 3,4 e 5 de 1996, estas últimas em meio analógico e digital) e trabalhos de campo para descrição dos aspectos físico-bióticos e antrópicos e coleta de amostras de rochas, solos e de espécimes botânicos para classificação. Todos os dados obtidos foram tratados em ambiente computacional,com emprego dos software MICROSTATION 95, MICROSOFT ACCESS 97 e MODULAR GIS ENVIRONMENT.

O produto final está consubstanciado em cinco (5) mapas na escala 1:500.000, conforme segue: MAPA GEOAMBIENTAL. O Mapa Geoambiental compartimenta a paisagem de acordo com suas caracteísticas físico-bióticas (rochas-relevo-solos-hidrografia-vegetação-clima), hierarquizada em taxons – do maior para o menor –em: Domínios, Regiões, Geossistemas e Geofacies. Representa a radiografia do meio físico com a cobertura vegetal primitiva, mostrando quais são e como se distribuem os recursos naturais da área. Mostra como a área é. MAPA DE VULNERABILIDADE DAS TERRAS. Mostra a capacidade de evolução da paisagem física face a ação das águas superficiais (erosão pluvial, principalmente). Separa as áreas com vulnerabilidade: muito fraca, fraca a moderada, moderada, moderada a forte, forte e muito forte, além de uma classe especial relacionada aos depósitos flúvio-lacustres do Quaternário. Mostra com a área funciona. MAPA AGROECOLÓGICO. Mostra o potencial agrícola e a capacidade de suporte dos diferentes tipos de solos identificados, face aos diversos usos da terra (pastagem, lavoura, mineração ...), racional e ecológicamente eqquilibrada. MAPA DE QUALIDADE AMBIENTAL. Mostra a situação atual do meio ambiente face a ação antrópica, distinguindo Áreas Conservadas (com vegetação remanescente) e Áreas Derivadas, indicando, aqui, as que se encontram em situação de Equilíbrio Dinâmico (com uso compatível), Alerta e Crítica (com graves impactos ambientais). Mostra como a área está. MAPA DE ZONAS PARA DETALHAMENTO, EXPERIMENTAÇÕES E AÇÕES CORRETIVAS. Mostra as intervenções que deverão ser implementadas para o aproveitamento racional e o controle e manutenção do equilíbrio dinâmico vigente nos sistemas ambientais caracterizados.

Aquisição automática de dados em hidrologia

M.S. RODRIGUES, V.S. GUIMARÃES, E. OLIVEIRA, J.J. SILVA, J. CALLÈDE, A.M. OLIVEIRA

Com o advento da informática, a partir da década de 80 e a utilização de novas tecnologias na área de hidrologia, na década de 90, as informações hidrológicas passaram a ser aquisitadas automaticamente através de sensores modernos, armazenadas "in loco" em Plataformas de Coleta de Dados e em alguns casos teletransmitidas. Esta modernização melhora a qualidade dos dados; permite a avaliação "instantânea" da disponibilidade hídrica; melhorara a avaliação do potencial energético; permite realizar o balanço hídrico em tempo "quase real"; melhora o controle dos recursos hídricos e permite disponibilizar dados mais atualizados para a sociedade, como por exemplo dados instantâneos para alimentar modelos de previsão de tempo.

As informações, após aquisitadas e tratadas, podem ser disponibilizadas em várias mídias, como a Internet.

Este trabalho mostra tanto a experiência no planejamento, operação e manutenção de sistema telemétrico de informações hidrológicas, quanto a implementação de um sistema para aquisição, tratamento e disponibilização das informações.

Weakness of the relationship between rainfall and ENSO in the lowlands of Bolivia

J. RONCHAIL

In the lowlands of Bolivia, drained by the tributaries of the Rio Madeira, rainfall are seldom dependant of El Niño and La Niña events:

-during El Niño events, there is no significant rainfall anomaly;

-during La Nina events, since 1970, negative anomalies are significant during the second half of the rainy season and during the winter (Ronchail, 1999). But negative anomalies can also occur during non-La Nina periods.

These results are consistent with the negative relation between a discharge index of the Rio Madeira in Porto Velho and the Southern Oscillation Index (SOI) during the 1970-1995 period (Guyot et al., 1997), and, above all, with the weakness of this relation.

The weakness of the relationship between ENSO and the discharge in Porto Velho may be explained by the fact that a quarter of the Rio Madeira drainage basin is located in the Andes (Guyot, 1993); now, in the Northern Altiplano negative rainfall anomalies are significant during El Niño events, so that the anomalies are opposite in the Andes and in the lowlands and may compensate their effects on the discharge.

Further, the weakness of the relations discharge-ENSO and rainfall-ENSO in the south-west of the Amazon basin is may be due to the distance of this place to the ocean and also to its specific atmospheric circulation.

Meridional wind variability in continental South America is very strong. Northerly tropical circulation often alternate with southerly temperate circulation. Both are modified in opposite ways during ENSO events and an hypothesis is that they could produce compensatory effects on the Bolivian lowlands rainfalls.

Circulation during ENSO and the relation between meridional circulation and the Bolivian lowlands rainfall will be documented.

Biogenic gas production from major Amazon dams, Brazil

L.P. ROSA, M.A. SANTOS, B. MATVIENKO, E.M. SIKAR, R.S.M. LOURENÇO, C.F MENEZES

The present study is the outcome of two projects submitted to ELETROBRAS, first of one was performed between 1992-1993 and the second from 1997-1999. The idea was to establish a direct cooperation between COPPE/UFRJ and CRHEA-USP/S. Carlos, with the support of ELETROBRAS, for carrying out technical and experimental research on greenhouse gas emissions of hydroelectric plants in the Amazon region.

COPPE could offer the experience acquired through the Energy Planning Program's work on calculating Carbon Dioxide (CO2) emissions in the course of production and use of the various types of energy, as well as the fact that a research on Methane (CH4) emissions was already on the way. CRHEA in S. Carlos had experience in limnology, together with some research on measuring the gas emissions of hydroelectric plants.

The data on CH4 and CO2 generation through organic decomposition in the flooded areas, comprising the dam, are rather sparse and difficult to organize into a working body of information. Most certainly, the decomposition of part of the biomass, such as large tree trunks, does not lend itself to observation within a feasible time horizon, while the decomposition half-life of leaves and/or thin branches requires only few months or years.

Two types of measurement were performed to cover both emission by bubbles and diffusive gas exchange at the water air interface. The equipment would be taken by motor boat to the sampling location. Spontaneously rising bubbles were caught by funnels each kept hanging from pairs of 2L volume plastic floats. The funnel's mouth diameter was 0.7m, the angle at the tip being 60o. The tip ended in a 20mm polyamide piece over which a test tube or a larger collection vessel could be fastened. Collection vessels were originally water filled. Rising bubbles reaching the funnel's mouth would be channeled to the collection vessel where they were allowed to accumulate over 24 hour periods, being then harvested and, after noting total collected volume, taken to the laboratory for chromatographic analysis.

Gas exchange at the water atmosphere interface was evaluated through an equilibration method in which confined portions of air were allowed to partly equilibrate with the gas dissolved in the water, over 5 and 10 minute periods, using the diffusion chambers.

In bubbles there is mainly methane (up to 97.7 mole %) while CO2 release dominates in diffusion (99.0%). A thermal conductivity gas chromatograph was used to analyze samples for CO2. Methane was analyzed using a flame ionization detector.

In order to predict future development of gas emissions a mathematical model was developed based on gas emission data. It is also based on the supposition that part of the original biomass flooded by the reservoir decomposes in a relatively short period of time, falling exponentially within a few years, while trunks and thick branches decompose slowly, their emissions adding to that of the lake throughout its life span.

A conceptual model of hydrogeomorphological-vegetation interactions within the confluence zone of large tropical rivers : Orinoco, Venezuela

J. ROSALES, C. BRADLEY, G. PETTS, D. GILVEAR

This paper presents a model describing the significance of hydrogeomorphic process in determining the ecological characteristics of tributary confluence zones.

Theses zones are typified by highly dynamic hydrological and geomorphological variability in which timing, magnitude, duration of flood events, water source areas, sediment transport rates, and hydraulic forces can vary significantly in different years. Greatest variability being exhibited in the lateral and longitudinal borders of the confluence area. The model has been developed following detailed studies along the Rivers Mapire and Caura and a reconnaissance survey of eight other lowland tributaries of the Orinoco River. Model parameters include water quality, flooding regime and current and historical channel dynamics.

The model suggests that in large tropical rivers, channel confluences exhibit high beta-diversity due to strong gradients of water quality and flooding regime and a high degree of channel instability inducing high spatial variation in vegetation patches. In areas of intense flooding specialist communities with low diversity exist whereas in areas of less pronounced inundation more diverse communities are found.

The extent of floodplain subject to a confluence effect varies seasonally and from year to year and can be predicted on the basis of differing hydrological conditions in major river in comparison with a tributary. The ability of these hydrological processes to predict vegetation communities in this variable zone is assessed.

The use of spaceborne radar data for inundation modelling and subsequent Estimations of trace gas emissions in Tropical wetland areas

A. ROSENQVIST, B.R. FORSBERG, T. PIMENTEL, Y.A. RAUSTE, J.E. RICHEY

River floodplains are the dominant wetland habitat in the Amazon basin. These flooded environments provide important habitat for aquatic flora and fauna and they play a key role in sustaining regional fish production. They are also a globally significant source of methane and other trace gases essential to climate regulation. Accurate information on wetland spatial distributions is however needed to improve estimates of habitat availability and calculate regional contributions of trace gases, in particular methane (CH4), to the troposphere. The spatial distribution of wetland ecosystems can to a certain extent be mapped by means of ground surveys, or by use of optical remote sensing data from aerial or spaceborne platforms, often by using indicators such as e.g. tree species distribution. Such traditional methods do however not provide any information about parameters such as the spatial extent of inundation at a given time, flood duration etc.

Microwave signals from spaceborne remote sensing platforms have the specific property of penetrating clouds and haze, thereby providing a clear view of the forest regardless of the weather. If the sensor operates with a sufficiently long wavelength, the signal will in addition also penetrate the forest canopy, thereby rendering information about the woody biomass, the forest floor and its prevailing water status. As a consequence, inundated igapó forest will appear differently (brighter) in a radar image than non-flooded igapó, thereby providing a unique tool for monitoring the instantaneous spatial extent of flooding.

Within the framework of the Global Rain Forest Mapping (GRFM) project, the Jau river in the central part of the Amazon basin, has been monitored with the L-band SAR on the JERS-1 satellite, and a spatial model of the inundation patterns of the river has been developed. The satellite measurements have been complemented on the ground by monthly measurements of CH4 emissions along a transect through the seasonally flooded forest in the Jau. The ground measurements verify the clear relationship between the L-band backscatter and the status of inundation, which in turn proved to be closely correlated with the emissions of CH4. By the use of the spatial/temporal JERS-1 inundation model, the daily CH4 fluxes could be estimated.

ENSO et précipitations sur le bassin versant du Guayas (Equateur)

F. ROSSEL, E. CADIER

L'influence de l'ENSO sur les précipitations a fait l'objet de nombreuses études dans différentes régions de la planète et de l'Amérique du Sud en particulier. L'Equateur, situe entre le Pérou et la Colombie, est particulièrement touché par ce phénomène. Le réchauffement de l'océan qui caractérise ce phénomène entraîne des précipitations et des inondations qui amènent des pertes matérielles et humaines parfois considérables. Cependant, peu d'études précises et sur une période comprenant plusieurs événements ont été réalisées pour ce pays. La critique et l'homogénéisation des séries pluviométriques de 210 stations réparties entre les régions côtières, la cordillère des Andes et le versant amazonien de l'Equateur ont permit d'étudier pour la première fois, sur une période de 30 ans, l'influence du Niño sur les précipitations annuelles et mensuelles de ce pays et d'estimer les possibilités de prévision des précipitations. A partir d'une régionalisation et d'une zonification de la pluviométrie, les relations entre l'ENSO et les totaux pluviométriques annuels sont étudiées. Cette analyse a permit de diviser l'Equateur en trois régions : une ou l'influence de l'ENSO sur les totaux pluviométriques annuels est forte, une ou elle n'est pas significative et une intermédiaire ou l'influence varie selon les événements. La première correspond à la majorité des régions côtières, la deuxième aux vallées inter-andines et au versant amazonien, la troisième aux flancs occidentaux de la cordillère des Andes, au nord des régions côtières et au versant est du relief côtier. La grande plaine côtière de la rivière Guayas, dont le bassin versant a une superficie totale de 31500 km2, est la plus importante zone d'habitation, d'activité industrielle et de production agricole du pays. Elle est située dans la région la plus fortement influencée par l'ENSO. L'étude des mécanismes à l'origine des précipitations sur les régions côtières de l'Equateur, des anomalies de température superficielle de la mer et de vent à proximité du continent ont permit de définir un schéma type d'apparition de précipitations abondantes. Ces dernières correspondent généralement à un réchauffement de l'océan et à un affaiblissement des alizés. Conditions habituellement observées à proximité des cotes de l'Equateur et du Pérou au cours d'un ENSO. L'étude des relations numériques entre les anomalies de pluie, de température et de vent du Pacifique oriental a permit de déterminer des modèles prévisionnels mensuels des précipitations de la plaine de la rivière Guayas. Les corrélations linéaires multiples déterminées permettent d'expliquer de 60 a 80 % de la variance des précipitations des mois de février à mai à partir des conditions observées le mois précédent. Les prévisions obtenues avec les données disponibles en temps réel sont relativement satisfaisantes pour la saison des pluies exceptionnelle de 1998.

Modern cycle of mercury in the Amazon

M. ROULET, M. LUCOTTE

During the past 20 years, researchers have particularly studied the Hg dynamic in goldmining regions, where indiscriminate Hg use for gold purification results in a strong contamination of nearby ecosystems. The long distance influence of these new releases of anthropogenic Hg on the natural background levels of the metal in the Amazonian environment have not been elucidated. High human exposure to Hg through fish ingestion have been measured in various regions of Amazon without goldmining activities. Based on an extensive study of Hg concentrations and burdens in forest and aquatic ecosystems of the Tapajós river basin and comparison with data from other Amazonian basins, we propose that relatively high burdens of naturally accumulated Hg in Amazonian soils could significantly influence the Hg burdens of aquatic systems following the podzolisation and/or erosion of the equatorial soil cover. These processes can explain Hg burdens observed in river water depending on geochemistry and anthropogenic activities in the watershed. The sensibility of Amazonian aquatic ecosystems to new Hg inputs seems to depend on the relative intensity of these two geochemical processes that affect a major reservoir of natural Hg. In newly colonized Amazonian environments, soil erosion, a process highly increased after deforestation, is the major process increasing the loading of Hg in aquatic systems.

Particulate heavy metal dynamic and mass balance in the lower Paraíba do Sul river watershed, Southeastern, Brazil

M.S.M.B. SALOMÃO, M.M. MOLISANI, A.R.C. OVALLE, C.E. REZENDE, L.D. LACERDA, C.E.V. CARVALHO

The Paraiba do Sul River (PSR) can be considered as a medium size river, with an extension of approximately 1,145 km, and a watershed of 55,400 km2. Located in Southeastern Brazil, the river drains the most industrialized states of Brazil: Rio de Janeiro, São Paulo and Minas Gerais. Maximum river flow is observed during summer (4,380 m3/s) and the lower discharges generally occur in the winter (180 m3/s). The dynamic and balance of heavy metals associated with particulate matter in the lower Paraíba do Sul River watershed and the influence of it's main tributaries was studied. During low, medium and high discharge period the observed metal abundance was similar Fe>Mn>Zn>Cr>Cu, only Cu presented higher concentrations than Cr during the wet season. The heavy metal concentrations showed two distinct patterns during the different discharge regimes studied. Fe and Cu presented their concentrations increasing with the crescent river discharge, following the SPM variations and Cr, Mn and Zn presented an opposite trend. The highest metal loads were related with the highest water flows and consequently with the highest suspended particulate matter loads, increased by the surface runoff and sediment ressuspension. The importance of the tributaries input for the total transported load of the Paraíba do Sul river was generally lower than 10%. Although in some months where the Paraíba do Sul river presented low water flux and strong local rain occurs this importance reached up to 40%.

Identification d'un modèle de régression linéaire pour la prévision des crues du Fleuve Sénégal

S. SAMBOU, C. THIRRIOT

Le basin du fleuve Sénégal a une superficie de 300000 km². Il se divise en deux parties qui s'articulent autour de Bakel : le Haut bassin très accidenté et la basse vallée plate, avec un lit majeur communiquant avec le lit mineur par le biais de chenaux entrelacés. Depuis la construction des barrages de Manantali et de Diama, la prévision des crues du cours d'eau est devenue une priorité pour la gestion intégrée des deux ouvrages, en ce qui concerne en particulier les applications hydroagricoles. Nous commencons par faire une typologie des crues de part et d'autre de Bakel, en mettant l'accent sur les temps de propagation déterminés à partir des indices de coordination (qui sont les homologues des coefficients de propagation pour les variables à seuils) et sur l'effet du lit majeur sur l'écoulement. Une procédure d'identification d'un modèle de régression linéaire basée sur les écarts quadratiques résiduels relatifs exprimés par anticipation à l'aide des indices de coordination a permis de déterminer l'ordre du modèle ainsi que le réseau optimal de prévision. Les essais de prévision réalisés ont été analysés et critiqués à l'aide de critères de qualité choisis. Les résultats obtenus ont été améliorés en temps réel à l'aide du filtre de Kalman.

Application of a physically-based erosion model for a large river basin in Japan

C.A.G. SANTOS, K. SUZUKI, M. WATANABE

Physically-based models have proved to be very useful for modeling the runoff-erosion process for small basins. However, the application of such models to large river basins could be compromised due to the difficulty of applying average parameter values for large areas with heterogeneous reality but the authors have been studying a way to use physically-based erosion models for practical prediction of sediment yield in large areas. Thus, a physically-based erosion model, which was firstly calibrated to erosion plots of 100 m2 and then applied to micro-basins of around 0.5 ha in semiarid region of northeastern Brazil is used in this present paper in order to simulate the runoff and erosion for a 14,000 times larger river basin in Japan named Ishite.

Since the tested model is physically based it can in principle overcome many of the deficiencies of empirical models, therefore making them available and suitable for simulation in areas with climatic differences. Thus, the authors collected results of their studies with a distributed physically-based model in a typical semiarid area to be applied to a total different environment. The results proved that the tested physically-based model could simulate the runoff-erosion process with reasonable results in spite of the difference of the basin with which the model was firstly applied and the present tested river basin. Thus, the model can be considered very promising to further simulations in larger river basin as the Amazon Basin.

Influencia de los embalses en el transporte de sedimentos hasta el delta del río Ebro (España)

M. E. SANZ MONTERO; C. AVENDAÑO SALAS, R. COBO RAYÁN

Los embalses son elementos que reportan numerosos beneficios a nuestra sociedad. También causan una serie de efectos en el medio fluvial donde se asientan. Dentro de España, el Río Ebro con una cuenca vertiente de aproximadamente 85500 km2 y más de 184 presas construidas, tiene una capacidad total de embalse de 7762 hm3. Muchos de ellos son anteriores a 1950 lo que ha supuesto una gran retención de las aportaciones sólidas del río en sus vasos, de tal manera que el delta formado en su desembocadura ha experimentado un déficit de sedimentos durante las últimas décadas.

En este trabajo se analiza la cantidad de sedimentos en suspensión que transporta el Río Ebro a la entrada y salida del complejo de embalses formado por Mequinenza, Ribarroja y Flix, dispuesto en su curso medio-bajo. Para el estudio se han considerado las medidas realizadas intermitentemente en seis estaciones de aforo a lo largo de un período comprendido entre 1975 y 1990 y los resultados obtenidos de los reconocimientos fotogramétricos-batimétricos de los embalses.

Los resultados indican que el complejo de embalses estudiado recibe de sus alimentadores principales (río Ebro, Cinca y Segre) una aportación anual media de sólidos en suspensión que asciende aproximadamente a 1 millón de toneladas. De éstas, casi el 70% ha sido suministrado por el propio Río Ebro y el 30% por sus afluentes de la margen izquierda (ríos Cinca y Segre), mientras que de los cauces situados en la margen derecha (ríos Martín y Guadalope) recibe menos del 1%.

La mayor parte de los sólidos transportados en suspensión por los cauces considerados, algo menos del 75%, queda retenida en los embalses ya que por la salida del complejo (sección de Flix) pasan anualmente una media de 263.000 t. Si consideramos este porcentaje medio como representativo del período, el Delta del Ebro habrá dejado de recibir, entre 1966, año en el que se construyó el embalse de Mequinenza, y el año 2000, alrededor de 25,5 x 106 toneladas de sólidos en suspensión. Esta cifra justifica por sí sola el deterioro del Delta descrito por distintos autores. Sin embargo, estos números aumentan de forma considerable si tenemos en cuenta otros embalses de la cuenca. Así, sólo por mostrar ejemplos de los cauces citados, se puede indicar que, según los datos de Avendaño et al. (1997), en los embalses de Joaquín Costa y Mediano, situados en los tramos más altos del Río Cinca se acumulan anualmente 437.500 t y 334.900 t, respectivamente. El embalse de Oliana dispuesto en el Río Segre recibe en el mismo período 662.700 t. A su vez, los ríos citados de la margen derecha presentan en cabecera los embalses de Cueva Foradada, en el Río Martín y Santolea en el Río Guadalope. El primero retiene al año 113.250 t de sedimento y el segundo 21.980 t.

Todo lo expresado anteriormente confirma la influencia de los embalses de la cuenca, en el estado actual del delta.

Biogeochemical studies of the floodplain sediments of Yamuna river (tributary of Ganga) during recent past

D.P. SAXENA, V. SUBRAMANIAN

The floodplain sediments of river Yamuna has been studied , which is the largest tributary of the river Ganga, originates from Yamuntori Glacier ,in the Mussorie range of the lower Himalayas.

The core samples were collected by manual drilling from the floodplain of Yamuna Basin , at five sampling stations, Sharanpur (next to Himalayas), Delhi , Jagmanpur, Hamirpur, and Allahabad. The analysis of core sediments were done for metals (Pb, Zn, Fe, Cu, Ni, Cr, Ti, Ba, and Al), and Phosphorus by using XRF techniques . Carbon and Sulphur by using Leco Carbon and Sulphur analyzer respectively.

All the studied metals show, higher concentration in the upper part of the core except , Jagmanpur core sediments . The higher values is due to the increase of industrialization and urbanization in the recent past. The Jagmanpur core is not following the trend as a result of turbulent mixing of sediments from a large number of small streams . All the metals at Delhi region reported higher values in comparison to the down stream cores (except Cr) because Delhi is the highly industrialised area in the entire basin. The Industrial effulents of Delhi contribute large amount of metals to the main stream and other drainage channels carry them from the catchment area and deposited with the floodplain sediments.

Phosphorus concentration ranges from 272 mg/g to 940 mg/g . This is comparable to the range of average content of Phosphorus in the sediments of Indian rivers , 11000 mg/g (Subramanian 1993) . Delhi sediments reported highest values 321 - 940 mg/g . Carbon and Sulphur values are higher in younger strata(upper) then older strata of floodplain . It signifies the change in nutrition dynamic of basin in recent past as a result of anthropogenic activity.

The rate of sedimentation values with both techniques , Cs137 and Pb210 are reasonably similar. The Sharanpur area has highest rate of sedimentation (5.99cm/yr).

Biogeochimistry of organic matter transfered from soils to rivers in small tropical catchment basins (Manaus, Brazil)

P. SCRIBE, G. BRIAND, C. PÈPE, J. DAGAUT, A. SALIOT, A. BRUCHET, D. RYBACKI

Tributaries of the Rio Negro upstream Solimoes River are currently divided into three broad categories: whitewater, colored-water and blackwater.

C/N ratio, organic carbon isotope, Rock-Eval pyrolysis, Curie Point Pyrolysis-Gas Chromatography-Mass Spectrometry, and sterol and phenol analyses were performed to characterize the organic matter associated with particles and sediments of four rivers, and present in the soils of their basin.

Two of these small basins (<10 Km2) draining black waters, have sandy podzolic soils; the third basin drains clear waters out off latosolic (clay) soils ; the fourth one has clayous soils on the upland, sandy soils on the slope, and drain coloured waters Pyrolysis-GC-MS of the soils allowed to discriminate organic matter associated with the clay from that associated with the podzol. To assist in the comparison between samples, the proportion of four main types of fragments (carbohydrates, proteinaceous materials, N-acetylamino sugars and polyhydroxyaromatic-like compounds) are calculated relative to a known biopolymer standards which are submitted to pyrolysis . Podzolic soils, as well as the particles of their rivers, contained clearly higher amounts of polysaccharides (1). □13C of the particles showed their terrigenous origin and sterol distribution confirm the low contribution of the autotrophic sources of organic matter.

24-ethyl-cholest-5-en-3□-ol was the preponderant terrigenous sterol in the soils from the surface horizons and in the particles of few colored rivers, whereas 24-methyl-cholesta-5,22 dien-3□-ol was preponderant in (Bh) horizon of podzols and hydromorphous soils (2).

This last sterol was also predominant in particles and sediment from blackwater rivers which suggest that dissolved organic matter in this case .could issued from the washing of (Bh), and adsorbed on particulate material.

These data allowed to differenciate the organic matter transfered to rivers from two pedologic systems, characteristic of large intertropical zones.

Variación estacional de variables hidrológicas y su relación con eventos extremos del ENSO

R. SEOANE, I. OBERTELLO

El objetivo de esta investigación es avanzar en el conocimiento de la relación entre distintas variables hidrológicas y meteorológicas y la ocurrencia de fenómenos extremos del ENSO (El Niño-Oscilación del Sur).

El ENSO constituye la mayor fuente de variabilidad en la circulación atmosférica e influye sobre las principales componentes del ciclo hidrológico, responsables de la ocurrencia de eventos extremos de crecidas y sequías. El análisis de sus efectos sobre distintas variables hidrológicas y meteorológicas es importante debido a las consecuencias de la ocurrencia de eventos extremos sobre el medio ambiente y las actividades humanas.

Se presenta un análisis estadístico de distintas series de valores mensuales de caudal, temperatura y precipitación en la cuenca del río Neuquén. El área de aporte de este río en la sección de aforos de Paso de los Indios es de 30800 km2 y su régimen de alimentación es pluvionival, con año hidrológico abril-marzo.

En una primera etapa se compara, para cada serie, la variación estacional de los dos primeros momentos (media y desvío estandar) de la serie total con los correspondientes a los años de ocurrencia de "El Niño" y del fenómeno opuesto "La Niña". Las diferencias entre estos estadísticos descriptivos fueron analizadas utilizando distintos métodos para mostrar la significación de los valores estimados.

En la segunda parte del trabajo se aplica un modelo de balance hidrológico seriado con el propósito de estudiar los efectos en escala mensual del ENSO sobre una variable de estimación indirecta como es la humedad del suelo. Se estiman los estadísticos de los errores del modelo para los años de ocurrencia de los fenómenos "El Niño" y "La Niña" y se comparan con los correspondientes a la serie total.

Délimitation de bassins versants à partir d'un modèle numérique de terrain. Comparaison de différentes méthodes pour le bassin du Rio Negro (Amazone)

F. SEYLER, F. MULLER, G. COCHONNEAU, J.L. GUYOT

Ce travail combine les outils des systèmes d'information géographique (SIG), de la télédétection spatiale, et des modèles numériques de terrain (MNT), dans une perspective de modélisation hydrologique spatialisée. Il a pour objectif particulier de tester les méthodes employées pour l'extraction automatique des bassins de drainage, les sources de données disponibles, leur précision et leur qualité, et de mettre au point une démarche homogène pouvant être appliquée à l'ensemble d'un grand bassin fluvial. Les résultats obtenus pour le bassin du Rio Negro, affluent de l'Amazone, montrent que les sources de données existantes sont d'une qualité et d'une précision suffisante pour la modélisation, et que les méthodes à mettre en oeuvre sont également suffisamment robustes.

How significant is the pollution of the Amazon by trace elements?

P. SEYLER, G.R. BOAVENTURA

Measurements of trace metals in rivers are of substantial interest for researchers examining basic scientific questions related to geochemical weathering and transport and to scientists involved in pollution control evaluation. Trace metals in natural waters include essential elements such as cobalt, copper, zinc, manganese, iron, molybdenum, nickel, which may also be toxic at higher concentrations, and non-essential elements, which are toxic, such as cadmium, mercury and lead. The release of potentially large quantities of these toxic metals, particularly in the river systems of industrialized countries, but also in tropical rivers, is an acute problem of great environmental concern. With few exceptions (e.g. the Hg in the Amazonian region) emission inventories of antropogenic sources are still rare for developed countries and almost non-existent for developing countries. We tent here to present a first quantitative estimate of anthropogenic and natural fluxes of trace metals in the Amazon basin. We have limited our inventory to the principal industrial sources known in the Amazon Basin.

Concerning use-related sources, Mn ore mining activities taking place as open pits (for instance in the Serra do Navio, Amapa State), represent a potentially source of associated ferrous metals (such as Ni, Cr, Cu, As...). Wind dispersal of material from unstable spoil heaps can result in local or regional atmospheric contamination. Currently, the manufacture and disposal of trace metals-containing products (e.g. battery production in the industrial district of Manaus) are also a source of metals.

Concerning the inadvertent discharges, a source of metallic contamination in the studied region comes from the residual oil combustion using for electric utilities and fluvial and terrestrial transportation. Using the selected emission factors (Nriagu and Pacyna, 1988; Nriagu, 1989), the electric-power production installed in the Amazonian states and the fuel consumption using for transportation (Ministério de Minas e Energia, 1995), the emissions of trace elements from fossil fuel burning have been estimated. Another important sources of metals in the Amazonian atmosphere, is due to forest burning. Based on the past 10 years-deforestation rates , this inventory suggests that forest fires will be the far more major source of Cr, Cu, Mn, Ni, Pb, V, As, and Zn, released annually to the atmosphere from anthropogenic sources. Fuel burning source account for less than 1 % of the trace element emissions, except for V (10%).

In order to compare the magnitude of anthropogenic transport of trace metals to the Amazonian atmosphere and the riverine fluxes from the Amazon system to the Atlantic Ocean, we computed the amount of trace elements as particulate and dissolved forms transported at Óbidos, using the systematic relationships obtained between dissolved trace elements and discharge. A comparison of these values with those termed as the anthropogenic sources suggests that industrial emissions of trace metals exceed the total flux from Amazon River by factors of 10-30 for Mn and Cu, 1-15 for V, 0-50 for As, and 30-90 for Ni. Antropogenic discharges, essentially due to forest fires, are apparently exercising a profound influence on the global scale-fluxes of these trace metals. Thus, it seems, even in the Amazon basin, that manking has become the key agent in the global biogeochemical cycles of trace elements.

Distribution and partition of trace elements in the Amazon mainsteam

P. SEYLER, G.R. BOAVENTURA, F. SONDAG, V.P. ALVES

Since 1995 in the framework of the the UnB-ANELL-IRD joint project, the HiBAM program has carried out a systematic sampling survey of the Amazon River and its major tributaries. The aim of this program is to explain and quantify the actual geochemical processes controlling the input to the ocean of large tropical hydrosystems. For this purpose trace elements are assessed in order to characterize and quantify the weathering and transport mechanisms. This understanding may also provide a scientific basis for the anticipated development of the Amazon basin. The work reported here derives from a new set of data on both dissolved and solid load of trace metals (V, Cr, Mn, Co, Cu, Zn, As, Rb, Sr, Mo, Cd, Sb, Cs, Ba, U) of the Solimões-Amazon mainstream and its tributaries between Tabatinga, situated on the boundary between Colombia and Brazil and Santarem situated upstream the marine influence. Moreover, a monthly time series covering a whole hydrological cycle was obtained at the Óbidos gauging station during the 1997 year. Concerning the origin of the trace elements, the close correlation between V, Cu, As, Sr, Ba, U and major ions and pH suggest that these elements have a common carbonate and/or evaporite source. However, in waters with high DOC content as Negro and the Upper Solimões rivers, Cu could be strongly complexed by organic ligands. Cr, Mn, Co, Ni are well correlated and Cr and Co are rather well correlated with Dissolved organic carbon, reflecting probably their relative abundance in dolomitic formations occurring in the upper Madeira basin and in the ferricrete soils of the lower parts of the basins. The correlation between Zn and Pb reflect a control by source rocks, probably sulfide mineralization where Zn and Pb are commonly associated. Rb and Cs are well correlated together but the origin are more difficult to precise, since their concentrations are in the same order of magnitude in the Amazon tributaries. The trace element concentrations in the particulate matter show a clear relationship with the location of the samples. For instance, V, Co Cr, Mn, Sr, Cs, Ba concentrations are higher in the Solimões left-bank tributaries than in its right-bank tributaries. Left bank tributaries come from the Andean Cordillera (Iça and Japura rivers), while right bank tributaries (Javari, Jurua, Purus) drain the soils and sediments of the subandean trough and of the central plain. The composition of suspended sediments in the Solimões mainstream reflects the mixing of both but is closer to the composition of its Andean tributaries. Concerning the transport of dissolved trace metals in the Amazon mainstream, the concentrations decrease downstream from Tabatinga to Óbidos, as previously observed for the major elements. The common concentration decrease is a consequence of the dilution of the high-concentration waters coming from the Andes by the low-concentration waters originating in drainage basins of the lowland and shield areas. Downstream the Negro and Solimões junction, the increase of Cs, Cr is due to the inputs of more concentrated waters coming from Rio Negro. In suspended matter, the trace elements concentrations are rather uniform for each sub-basin All the trace elements are highly auto-correlated. Flat patterns are observed for the samples from the Solimões, Madeira and Amazon mainstream. By contrast, the Rio Negro is enriched in Fe and impoverished in Mn, Co and Ni. The Trombetas shows enrichment of Mn and to a lesser extent of Zn. In order to compare the dissolved and suspended trace elements loads of the different types of rivers of the Amazon basin, we computed the mass of each element in one liter of river water. - In the Rio Solimões, V, Cr, Mn, Co, Ni, Zn, Cs, and Pb are almost entirely carried by the river particulate matter; Cu, Rb, Sr, Ba and U are transported mainly by the suspended particles, but dissolved phase contribute to the transport. Only As is transported predominantly in a dissolved form. In the Rio Negro, the proportion of the elements transported by the dissolved phase is higher for the whole set of elements The proportion of V, Cr, Mn, Rb, Sr, Ba and U associated with the dissolved phase accounts for more than a half of the total transport. In the Rio Amazon at Óbidos, the proportion between the dissolved and particulate transport clearly shows an intermediate pattern. The increase of the dissolved transport observed from the Solimões to the Rio Negro can be explained by the degree of mobility for a given element during the weathering As already emphasized, and concerning at least the tropical weathering type, As, Cu, Rb, Sr, Ba and U are the most easily leached trace elements, whereas V, Cr, Mn, Co, Ni, Zn, Cs and Pb are less "mobile" From a monthly time series of dissolved concentrations measured at Obidos station, several observations can be found. -Variations of river chemistry may reflect variations of the sources The increased proportion of waters from the less solute-rich rivers during the high discharge period of the Amazon contributes to the observed decrease of U, Sr, Ba, Cu and V concentrations - Elements such Mn and As are mainly transported by the flood flows, suggesting that these elements are washed away in solution during the high discharge. Moreover, these elements can be stored in the surrounding floodplain areas (varzea) where the deposition/resuspension cycle as well as the exchange rate between floodplain and mainstream channel may control at least partially their temporal variation. - Elements such as Co, V, Cd that show a peak concentration during the falling stage are not conservative upon mixing, since a large percentage of the reactive forms of some of those elements are adsorbed. The "black" waters of the varzea show pH values about 2 units more acid than the Solimões. These differences lead to some desorption when the waters from the main channel mix with the acidic waters of the varzea. - At least, Ni and REE have a very limited solubility and are transported mainly in the particulate form

Water resources variability of inland lakes at Central Asia

E. SHERMATOV, B.S. NURTAYEV, T.U. YULDASHEV, B.O. RAISOV

Regime of Eurasian inland lakes is consequence of periodical climate change. In accordance with study the number of scientists, fluctuation of climatic indices depends from energy of solar activity.

The analysis indicates that the mean of humidity indices of inland lakes depending on Solar activity can be described as following:

K=A+ B* W

Where k-indices of drought, or index of humidity; ratio of transpiration to precipitation.

A and B-constant parameters of equation.

W-Sunspot Number.

Coefficient of correlation is in the intervals:

rw.k.=0.67-0.98.

We analyzed also dependence of precipitation from evaporation, that expresses as following equation:

O=1012,925-1.046E

where: O-precipitation, E-evaporation, and numbers - constant parameters of

relationship.

In particular, interrelation between evaporation and precipitation, for inland Issik-Kul lake is determine as: r = -0.86.

Water content of Eurasian inland lakes depends from atmosphere circulation.

The problems of the rivers pollution of Uzbekistan

J. SHIROKOVA, I. FORKUTSA, G. STULINA

Rivers are the main irrigation sources in the territory of Uzbekistan: Amudarya (its length is 1440 km, Sirdarya, Surkhandarya, Chirchic, Ahangaran, Zarafshan and Kashkadarya. The majorities of rivers are fully regulated and do not have a natural flow. The total water use in the Republic of Uzbekistan has stabilized at a level of 62-65 cubic kms, of which 11 cubic kms is taken from Sirdarya, and 25 cubic kms from Amudarya. The remaining 29 cubic kms is taken from small rivers, underground sources of overflow disposal and collector and drainage water, as well as by circulation of the water supply in agriculture.

The major consumers of water are agriculture - 85% (53-55 km3), industry - 12% (6 km3), and the municipal economy - 3% (1.7 km3). 53 reservoirs and irrigation channels with a length of 171 thousand kms have been constructed in the Republic to provide services for agriculture.

As a consequence of the total flow regulation the natural hydraulic regime of large rivers has been broken. Some rivers often lack water after large water take-off and are maintained only by spare outflow and recycled water. Increase in water take-off is accompanied by increase in outflow of collector and drainage water (CDW). From 1960 to 1985 total outflow of CDW in Sirdarya increased from 7.3 to 12.7 km3/year, in Amudarya - from 3.1 to 17.9 km3/year.

As a result of the intensive take-off and multiple use of river flow in the middle and lower parts of rivers their outflow is formed to a great extent by recycled water with a high content of salts and chemicals. Collector and drainage water flows to rivers without appropriate control and sewage disposal. Water users in the lower parts of rivers use bad quality water. Water quality in details does not meet the requirements.

Rivers are mainly polluted by industry and the municipal economy, as well as by irrigated agriculture and large urbanized territories. Industrial enterprises return up to 50% of the volume of water taken from irrigation sources in the form of sewage. The most dangerous sewage content are salts of heavy metals (mining industry, car manufacturing), oil products, carbolic acids, nitrogen compounds (oil-refining and chemical industries); SPAV, dye, organic and biogene stuff (light industry), mineral salts, fertilizers and chemicals (irrigated agriculture). The large volume of sewage constrains options for their disposal.

In the report detailed situation of river's pollution caused by collector-drainage water will be shown and proposals for improvement of control and ecological situation of rivers in Uzbekistan will be given.

Volga river basin: Generalize estimates of the evapotranspiration losses from agricultural fields

N.A. SHUMOVA

Presented is the results of calculating of the agricultural field evapotranspiration in the Volga river basin under natural and optimal water supply conditions and potential evapotranspiration. The evapotranspiration model worked out in the Water Problems Institute of the Russian Academy of Sciences and standard observational data of agrometeorological stations including the leaf area index were used for calculations. The foundation of the present approach is the calculation of the quantitative consumption of water by agroecosystems during their growth and development. The actual regularity of the formation of the soil-hydrology conditions and their variability from year to year are considered too.

Under natural water supply conditions normal agricultural fields evapotranspiration changes from 500 mm at the north-west to 200 mm on the lower reaches of the Volga river. One can see from an analysis of the values of evapotranspiration and precipitation that an average of 75% was formed from precipitation over the frost-free period. The other part (an average of 25%) of evapotranspiration was formed from the spring soil water storage. The average squared deviation of evapotranspiration varies from 56 to 62 mm, the variation coefficient changes within range of 0.13 to 0.26. Notice that the normal agricultural field evapotranspiration remains practically unchanged if the crops being cultivated do not have a noticeable effect on spatial redistribution of the snow cover and on a change in the portion of meltwater and rain precipitation on imbibition of water into soil and on surface runoff. Moreover the normal agricultural field evapotranspiration approximately equals to the normal annual evapotranspiration from the catchment basin estimated by water balance method as the difference between precipitation and runoff.

Under optimal water supply condition (plants are well provided with water, for example under irrigation) normal evapotranspiration depends on the length of growing season and for spring wheat changes from 500 mm at the north-west to 600 mm on the low reaches of the Volga river. These values were formed from precipitation over frost-free period (50%), spring soil water storage (15%), and irrigation water (35%). In the case of optimal water supply conditions the average squared deviation varies from 36 to 75 mm, the variation coefficient changes within range of 0.06 to 0.13.

Potential evapotranspiration in the Volga river basin varies from 600 mm at the north-west to 1100 mm on the lower reaches of the Volga river. The average squared deviation of potential evapotranspiration varies from 46 to 111 mm, the variation coefficient changes within range of 0.06 to 0.15.

Clastic sediment flux into the Indian and Pacific oceans by rivers in Central Southern Africa and Western Canada

H.M. SICHINGABULA

Continental erosion by world large rivers accounts for most of the sediment deposited in the oceans. This paper examines clastic sediment flux of large unregulated rivers in the tropics (Luangwa River, in Central-southern Africa) and temperate (Fraser River, in Western Canadian Cordilerra) regions, accessing varied physiographies and experiencing different climatic conditions. An assessment of flood sediment yields, mean annual and total annual sediment yields led to the conclusion that, estimates of annual sediment yields by flood events instead of mean values of discharge and sediment concentration should be used in the determination of rates of sediment flux into oceans by large rivers.

Luangwa River is located in eastern Zambia and joins the Zambezi River which drains into the Indian Ocean. It has a mean annual discharge of 626 m3s-1 and an area of 140,922 km2 at Luangwa Great East Road bridge station (5-940). Luangwa valley is underlain by rock types varying in age from pre-Cambrian to Quarternary times. Similarly, the Fraser valley which has a mean annual discharge of 3,350 m3s-1 and a drainage area of 219,000 km2 at Mission station (08MH024), is located largely in British Columbia, Canada. Its basin is composed of mountain ranges, plateaux, deep valley floors and coastal lowlands which characterize the basin's major physiographic regions.

On data and analysis, for Luangwa River, discharge (1960-1996) and suspended sediment concentration (1978-1984) data were monitored by the Department of Water Affairs. The archival discharge (1913-1988) and daily sediment concentration (1966-1988) for the Fraser River were obtained from Water Survey of Canada, Ottawa, and from published sources. Computations of annual sediment yields of rivers were based on mean annual values of discharge and sediment concentration. Total annual sediment yields were based on daily discharge and associated sediment concentrations. Analysis has shown that in 1982, Luangwa River transported 24.5 million tonnes of sediment load with an average of 67,043 tonnes being moved per day. These loads are in the same order of magnitude as those of the Fraser River which transported 25.6 million tonnes with a mean of 70,034 tonnes of clastic sediment per day in the same year. Moderate and high magnitude flows with low durations were responsible for transporting most of the sediment loads. This is typical of most years for the two rivers. However, on Luangwa River the high flows tended to proportionately transport more sediment loads than did those on the Fraser largely due to the highly seasonal character of the flows in Zambia characterized by long low flow periods. Conversely, high flows on the Fraser are influenced by spring snowmelt, intense summer and fall (autumn) storminess and by short periods of low winter flows.

Additionally, between 1960-1991, Luangwa River transported a total of 457 million tonnes with an annual mean of 15 million tonnes of clastic sediment deposited into the Zambezi River. However, on average only about 20 million tonnes per annum of clastic sediment is ultimately deposited into the Indian Ocean owing to two major impoundments on the Zambezi River. In contrast, the Fraser River from 1966-1988 transported 378.6 million tonnes with a mean annual of 16.4 million tonnes of sediment being deposited into the Pacific Ocean. The long-term trend of sediment yields for Fraser River was downward partly accounted for by decreased discharge after 1970 whereas on the Luangwa River the trend was upward. This could have been the consequence of increasing tree cutting for settlements and agriculture in Luangwa's headwaters region. But more data are required on sources and factors controlling sediment supply to river channels.

An assessment of flood annual sediment yields on Fraser River (1966-1988) revealed that a total of 9.1 million tonnes of sediment with a mean of 377,435 tonnes per year were transported by single flood events into the Pacific Ocean. Compare this to the total mean loads of 616,239 tonnes and a mean annual load of 26,793 tonnes in the same period. Quite clearly, estimates based on mean values grossly underestimate actual sediment loads of rivers with obvious implications. It is therefore concluded that at least annual flood discharge and sediment data instead of averages should be used in the determination of annual sediment flux into oceans by large rivers. This calls for increased monitoring of flow and sediment discharges of large rivers by various agencies charged with this task worldwide.

The hierarchical system of alluvial relief at the large rivers

A. SIDORCHUK

Interaction between the river flow and channel bed is the main cause of alluvial forms generation. The hierarchy of alluvial forms consists of 3-8 levels. The number of levels (the complexity of the system) generally increases with the river size. Investigations on the largest rivers (Amazon, Niger, Lena, Ob', Enisey and others) shows typical sequence of alluvial forms: 1) ripples, megaripples and antidunes (ultramicroforms); 2) dunes of the first and second order (microforms); 3) large dunes of third order and small bars of the first order (mesoforms); 4) large bars and meanders (macroforms); 5) parallel braids, complicated bends (megaforms). The variability of length for alluvial forms of different hierarchical level is described with gamma-distribution. This variability generally decreases with increase of hierarchical level of alluvial form 0.4-0.45 for megaripples to 0.20-0.35 for large bars. The ratio between mean length of alluvial forms from adjacent levels of hierarchy is rather constant at different rivers. It is about 6 for pair dune_1 - megaripple, is 3.6 for microforms and is 3.2 for meso and macroforms. Individual alluvial forms on different levels of hierarchy are rather independent: correlation between mean length of small forms on the surface of large one and the length of this large form is very weak.

Alluvial forms of low hierarchical levels depend mainly on channel depth and Froude number. They can rapidly change their parameters with the river flow change. Alluvial forms of the higher levels of hierarchy also depend on river channel width. They are formed during maximum flow and their geometry is relatively stable. Therefor the river channel pattern is related to maximum discharges, and for the same annual flow the arctic rivers with more variable flow regime have large alluvial forms, than tropical rivers with more uniform flow regime.

Influence des prélèvements pour irrigation sur l'hydrosystème du Lac Tchad Exemple de la SEMRY au Cameroun.

D. SIGHOMNOU, L. SIGHA NKAMDJOU, M. MOLINIER

De nombreux auteurs sont d'accord pour reconnaître que le lac Tchad était jadis une mer qui se serait étendue jusqu'aux limites du bassin du Nil. Sa superficie était évaluée à près de 350.000 km² au cours de l'Holocène. De nos jours, et suivant l'importance des crues du fleuve Chari, sa principale source d'alimentation, le lac n'occupe que 10.000 à 25.000 km², ce qui représente une baisse très considérable. Situé en région sahélienne, l'hydrosystème du lac Tchad, avec ses nombreuses plaines d'inondation, constitue un écosystème d'une très grande valeur au plan de la nature et de l'économie rurale de la sous région. Les précipitations et les inondations sont les principaux facteurs déterminant sa productivité.

La péjoration climatique que connaît la région depuis trois décennies a conduit à une forte baisse de la productivité naturelle de ces plaines, d'où un accroissement de la pression sur les ressources naturelles avec les conséquences qui en découlent. Pour résoudre le problème, on a de plus en plus cherché à modifier les modes d'utilisation des ressources en eau de la région, en construisant notamment des barrages hydro-agricoles, afin de réduire la dépendance de l'agriculture vis-à-vis des précipitations et des inondations. C'est ainsi qu'au Cameroun il a été mis sur pied en 1979, un projet rizicole dénommé SEMRY, avec à la base la création du barrage hydro-agricole de Maga.

Pour permettre de comprendre et limiter les conséquences négatives de ce projet sur les inondations et le milieu naturel du Yaéré, des investigations sont entreprises sur le terrain depuis 1994. Dans cet article, outre la caractérisation des effets de la restauration des inondations dans la plaine, les premiers résultats de l'étude sont utilisés comme outils de diagnostic pour évaluer et discuter l'impact des aménagements de la SEMRY sur le système hydro-écologique du bassin du lac Tchad dans son ensemble. Ces résultats enregistrés après quatre années d'essai pilote de réinondation, sont révélateurs de ce qui adviendrait des populations et de la diversité biologique de ce milieu, en cas de retour à une hydraulicité normale ou excédentaire. Il s'agit en particulier de la disparition progressive de certaines espèces végétales au profit de nouvelles espèces mieux adaptées aux nouvelles conditions écologiques, de la reconstitution de la population animale sur le plan de la faune, du retour progressif des populations de la plaine suite à l'amélioration des conditions socio-économiques.

Não-estacionaridade do escoamento do Rio Jacuí/RS

A.L.L. SILVEIRA

A bacia do rio Jacuí, com 72.000 km2, é a maior bacia contribuinte ao lago Guaíba que margeia Porto Alegre e caracteriza-se por nela terem sido construídas várias barragens para exploração hidroenergética e para navegação fluvial. O impacto destas obras na série histórica dos escoamentos não foi ainda objetivamente quantificado, apesar de haver um senso comum de que o conjunto das obras amortece as cheias da bacia, havendo menor perigo da grande cheia de 1941 se repetir em Porto Alegre.

Este artigo é uma contribuição a este assunto que não responde a todas às questões, mas que pretende analisar com métodos objetivos a estacionaridade ou não-estacionaridade de algumas séries hidrológicas longas do rio Jacuí. Resultados de testes estatísticos paramétricos e não-paramétricos foram confrontados com os períodos de implantação das obras para avaliar o impacto destas no regime de escoamento. A análise estendeu-se às séries mensais e anuais, enfocando principalmente as suas médias e variânças. Como outros fatores, entre os quais as modificações de uso do solo, o consumo d'água para irrigação, assim como os fenômenos El Nino e La Nina, podem afetar as séries hidrológicas, o artigo procura estabelecer sua influência potencial nos resultados.

Hydrologic variability and floodplain sedimentation of major West Siberian Rivers

L.C. SMITH, A. SIDORCHUK

The Russian Federation contains the worlds largest Arctic land mass and contributes about 85% of the total terrestrial runoff to the Arctic Ocean. Combined annual flows of the Yenisey, Ob and Lena Rivers total more than 1500 km3, a significant freshwater input that affects the thermohaline circulation and sea-production of the Arctic Ocean. Despite the very large size of the Ob and Yenisey rivers, suspended sediment yields are well below the world average, whereas in eastern Siberia yields are significantly higher. This difference corresponds to a physiographic contrast between low-relief basins of Western Siberia and high-relief basins of the eastern Siberian Platform. On the Ob River, station measurements by the Russian Hydrometeorology Survey show a net reduction in sediment load between Belogor'ye and Salekhard through a several hundred km reach of anastomosing channels and floodplain lakes. Like most Arctic rivers, flows in the high-latitude parts of Ob, Yenisey, Taz, and Pur Rivers are seasonally controlled and closely follow the annual temperature cycle. Peak discharge typically occurs in late May or early June, with at least half of the total annual flow occurring during the spring flood. Synthetic aperture radar (SAR) data collected over the area from 1993 to 1996 suggest that floodplain lakes, anastomosing channels, and wetlands are linked in a seasonally inundated network, enhancing sediment deposition on the floodplain. Hydrologic exchange with these aquatic ecosystems is also thought to enrich the total organic carbon content of channel waters. The satellite data show that during the spring flood, over 90% of the floodplain actively exchanges with primary and secondary river channels. This area shrinks one order of magnitude by September. Our results indicate that hydrology and floodplain geomorphology play a critical role in determining the volume and composition of the major West Siberian rivers prior to their entry to the Arctic Ocean.

Variabilidade das taxas de sedimentação na várzea de Óbidos

L. SOARES, J.M. JOUANNEAU, G.R. BOAVENTURA, J.L. GUYOT, D. WALLING

A aplicação do método de 210Pb é relativamente recente para a obtenção da idade de sedimentos. Esse método funciona muito bem para sedimentos lacustres pouco perturbados e para o estudo de pacotes de neves depositadas no último século. A aplicação desse método em ambientes fluviais é algo mais recente ainda. No entanto, devido à dinâmica constante desse ambiente, fica restrita sua aplicação e confiabilidade. Os estudos mais recentes mostram que é preciso entender o que ocorre com o elemento (210Pb) durante a sedimentação nas planícies de inundação e nos demais depósitos associados diretamente aos rios. A atividade de 210Pb está diretamente relacionada ao conteúdo de argilominerais e consequentemente à granulometria. Assim, um bom local para o estudo da taxa de sedimentação de um rio é a planície de inundação, pois é relativamente rica em material fino (silte e argila). O presente trabalho vem mostrar um dos mais novos estudo sobre a taxa de sedimentação na Bacia Amazônica. Como área alvo, foi escolhida a planície de Óbidos que margeia o ponto mais estreito do Rio Amazonas. Grande parte da área dessa planície é banhada por águas diretamente carreadas pelo rio. A maior parte do material em suspensão é proveniente dos Andes ou da erosão interna da bacia. Os resultados preliminares mostram uma esperada diminuição da atividade de 210Pb em profundidade , porém montra uma variação da atividade ao longo do perfil do sedimento. Essa variação é difícil de ser explicada, pode ser associada ao período de seca onde não ocorre sedimentação e sim um pouco de erosão no início das chuvas. Pode ser associada à atividade biológica. Outro fator importante, seria a atribuição dessa variação aos grandes fenômenos climáticos globais que podem contribuir de uma forma ou de outra ao aumento e diminuição da taxa de sedimentação da bacia causando esse efeito da curva do perfil.

The Mississippi river basin - An examination of major -element, nutrient, and sedimentary biogeochemistry as related to the global carbon cycle

R.F. STALLARD

The Mississippi Basin Carbon Project (MBCP) of the United States Geological Survey (USGS) is currently studying whether human-modified terrestrial erosion and sedimentation is a substantial additional carbon sink (on the order of 1015 g yr-1 globally) in terms of the technologically perturbed carbon cycle. This project requires characterization of today's carbon, nutrient, and sedimentary cycles and reconstruction of the same cycles in the pre-technological past. To do this, comprehensive water-quality data (major constituents, nutrients, carbon, sediment, trace constituents) archived by the US Geological Survey and other agencies and institutions are being assembled, standardized, and quality controlled. From the assembled data, constituent discharges and yields are being calculated for more than one hundred subbasins distributed throughout the Mississippi Basin. Analyses are used to describe bedrock weathering reactions, which are then related to geology and soils of individual subbasins. Carbon, nutrient and sediment yields for pre-technological times will be constructed using "best" estimates obtained from non-developed sites and equilibrium-erosion models derived from the major-element data, and historical information. Because the Mississippi Basin is so thoroughly developed, reasonably natural sites are difficult to identify within the basin or even through comparison with other temperate-climate regions. Accordingly, the Mississippi data set will be compared to data from three large, reasonably natural, river systems of the Western Hemisphere along an equator-to-pole climate gradient: the Amazon, Orinoco, and Mackenzie systems.

Major-element data demonstrates that river chemistry correlates strongly with the geology and soils of the river catchment. For example, the formation of 2:1 clays is clearly indicated by water chemistry for rivers that drain sedimentary terrains having calcareous sediments or loess as bedrock or mollisols as soils. This strong relation between water chemistry, geology, and soils is also seen in the Amazon, Orinoco, and Mackenzie River Basins. Finally, in contrast, concentrations of nutrients are far greater within the Mississippi Basin than in the other large rivers, reflecting loadings from fertilizer applications and excessive atmospheric inputs caused by human activities. Unlike the other three watersheds, vast quantities of sediment derived from agricultural erosion are trapped as colluvial and alluvial deposits in low-order streams and in thousands of artificial reservoirs. The burial of associated carbon derived from a soil source or autochthonous production is perhaps a significant carbon sink.

Whole-basin syntheses such as the MBCP of the USGS are essential to linking human modifications to effects. Modifications of hydrologic and biogeochemical processes in temperate watershed are enormous. Tropical and boreal river basins are being rapidly and extensively developed. Not only do such syntheses enrich our perspective of complex Earth-surface phenomena, but they can provide clear guidance for planners and policy makers in other regions.

Geochemical processes in the Ganges-Brahmaputra river system

V. SUBRAMANIAN

The mighty rivers draining the Himalayan range show several features that are unique to large rivers of the world. Similar to any other river-large or small, there are prounced spatial and temporal variations both with respect to water chemistry and sediment properties. The Ganges show certain aspects of sediment load and mineralogical and chemical variations that differ considerably from the Brahmaputra. While the Ganges show the impact of large urban and other landuse components in its properties, the Brahmaputra is relatively uncontaminated since it flows through less densely populated region. Major water quality parameters such as HCO3-, SO42-, PO33-, SiO20, etc are generally higher in the Ganges compared to the other river system. Also, within basin variations are common for the Ganges than for the Brahmaputra since the former river system has several large tributaries. Some of the tributaries of the Ganges carry more sediment load than the Ganges at certain places. The Brahmaputra has about less than 50% of individual solute concentrations (TDS of Brahmapurtra 100 mg/l) compared to the Ganges and its tributaries. In the Bengal basin area in Bangladesh the two mighty rivers merge to form a combined system along with that of Megna draining the shield area of northeast India and water and sediment properties in this region differ from the upper reaches in India. Both the rivers carry a predominant coarse sediment load (with a mean size about 60 micron) with a similar clay mineral population consisting of variable proportions of illite, kaolinite and chlorite. There is very little organic C and P- most of the P is inorganic. While the Ganges in India throughout its 2200 Km stretch shows various levels of pollution with respect to heavy metals, the upper reaches of Brahmaputra in India and the combined system in Bangladesh can be considered relatively clean.

The erosion rates throughout the river system is perhaps one of the highest in the world but this may not necessarily imply large scale sediment export to the open ocean since the estuary region of the Ganges below Calcutta seems to be geochemically active.

Artificial neural networks for streamflow forecasting

P.C. SWAIN, N.V. UMAMAHESH, B. KRISHNA

A new methodology for predicting the flood flow is presented. In literature we come across number of approaches for predicting streamflow. Neural network (NN) is a fairly recent technique which has been suggested and applied for many problems in water resources. To demonstrate the procedure and Neural network-based approach, the case of the Mahanadi river basin in India is selected for analysis and discussion.

The Mahanadi, literally meaning the great river , is the biggest river flowing through the State of Orissa. It drains an area of 1.416x105 km2. The Hirakud Dam is a multipurpose project built across the Mahanadi at latitude 21o 32'N and longitude 63o 52'E, about 3km upstream of Burla town. The mean annual rainfall over the basin is 1402mm where as the average monsoon (June to October) rainfall over the catchment upto Hirakud reservoir is 1138mm. For efficient operation of the reservoir, a realistic estimate of the volume of water entering the reservoir is required, particularly during the monsoon when the regulation becomes critical.

Existing methods for predicting streamflow are based on multiple regression analysis, time series analysis or empirical formulae. More recently Neural Networks (NN) has been proposed for a number of applications in water resources. There is a rapid growing interest among water resources specialists in using NN for various water resources problems.

The attractiveness of NN to streamflow forecasting is threefold. Firstly, NN can represent arbitrary non-linear function given sufficient complexity of the trained network. Secondly, NN can find relationship between different input samples and , if necessary, can group samples in analogous fashion to cluster analysis. Finally, and perhaps most importantly, NN is able to generalize a relationship from small subsets of data whilst remaining relatively robust in the presence of noisy or missing inputs, and can adopt or learn in response to changing environments.

The Feed Forward Neural Network (FFNN) with one hidden layer is used for forecasting flood flows. The available flood flow data for 34 years [1959-92] is divided into training data (96 sets) for estimating the parameters of the model and testing data (40 sets) for testing the forecast results with an independent data set. The rainfall and runoff during the previous time period are taken as input for predicting present time period flow. The network is trained using the data in the training set. The training of the network is done using back propogation algorithm. The trained network is then used to predict flows using data from testing set and the predicted values are compared with the observed values. The present study reveals the capability of the neural network for floodflow prediction.

Mixing at the Rio Negro/Solimões confluence: Isotopic constraints and major element redistribution

F. TAO, A.M. AUCOUR, S. SHEPPARD, M. BENEDETTI, J.L. GUYOT

The objective of the 1997 HIBAM project cruise on the Amazon, during the low water period, was to characterise the mixing processes and the distribution of carbon and trace elements between the different size or molecular weight fractions, at the confluence of the Rio Negro (black water) with the Rio Solimoes (white water). Water samples were collected in the Negro (Paricatuba) and in the Solimoes (Manacapuru) before the confluence and at seven sites downstream from the confluence (Punta do Solimoes to Jatuarana). At each site, samples were taken at 3 or 4 depths in the water column that is up to 35-40 meters thick. "Raw" water samples were ultrafiltered on board with a tangential flow system using the following cutoffs: 0.2□m and 5000D. We present here the hydrogen isotope results of the unfiltered water samples and the organic carbon isotopic composition in the different size fractions.

The D/H ratios of water samples from both the Negro (□D = -14.4‰) and Solimoes (□D = -26.7‰) do not vary with depth. Because of the marked isotopic difference (i.e. 12‰) between the two rivers, water-mixing can be calculated from hydrogen isotope mass-balance. Waters from the Negro preferentially flow over those from the Solimoes: the Negro contribution ranges from 100% to 75% for surface samples closer to Manaus (Pta do Solimoes). This contribution decreases to 45% with depth. The water columns are isotopically uniform at sites closer to Jatuarana where the mixing is assume to be completed. The Negro contribution ranges from 100% close to Manaus to 30% at Jatuarana further downstream. The Negro contribution based on D/H at Jatuarana is similar to that in the total river discharge, indicating complete mixing of the waters. Concentrations of Cl- of the Negro (13□M) and Solimoes (117□M) are quite different. Assuming a conservative behaviour, mixing calculations for Cl- generally agree with those for hydrogen. At some sites, however, the Cl-concentrations are higher than expected from the H-isotope mass balance.

A preliminary investigation of the 13C/12C ratio on organic carbon of the different size fractions was made from the Negro and Solimoes. For Solimoes surface waters, the particulate (>0.2□m) and the colloidal fraction (0.2□m-5kD) show no isotopic difference (□13C = -28.3‰). The particulate fraction presents a weak variation with depth in the Negro (□13C = -27.6 to -28.1‰) and no difference with the similar fraction from the Solimoes. This suggests that DOC □13C cannot be used to trace Negro/Solimoes organic C contributions or organic C transfer between different size fractions.

Mercury in the Tapajós river basin - The significance of suspended sediments from alluvial gold mining, Pará, Brazilian Amazon

K. TELMER, E.S. ARAUJO, R.S. ANGÉLICA, Y. MAURICE

Method: All water samples are filtered through 0.45u membranes to separate the dissolved from suspended load and are then treated and stored at 4oC (in iced coolers in the field) for chemical analysis. Water for the determination of Hg is processed immediately to avoid any Hg loss by volatolization. Water is filtered by syringe pressure through a millipore sterivex syringe-tip cartridge filter and collected as a separate aliquot in centrifuge falcon tubes that have been pre-injected with a precise ammount of BrCl by pipette to stabilize and oxidize all Hg species to Hg2+. Disolved Hg is subsequently analysed by hydride generation and ICP-MS or by Cold Vapor Atomic Fluorescence Spectrophotometry for very low concentration samples. The residue on cellulose membranes used to filter water for the determination of cations (250ml aliquot) are retained and collected in small polyethylene vials for the determination of inorganic suspended solids. As well, 500ml of sample is pushed through a 47mm pre-ignited glass fibre filter membrane. The residue is used for the determination of Hg in the suspended load by analyses on a Milestone AMA 254 Mercury Analyser and simultaneous analyses of particulate organic carbon (POC) by LOI on the same sample.

Results: Dissolved mercury concentrations are elevated in waters affected by mining operations when compared to concentrations in pristine rivers. However, essentially all dissolved mercury concentrations fall below the Canadian aquatic life limit 0.1 ppb. Mercury bound to suspended sediment tells another story It is roughly 100 times the concentration of dissolved mercury per litre of water and thus, represents the major pathway of river-borne mercury. Suspended load Hg concentrations are proportional to the concentration of total suspended solids suggesting that the source of mercury is the sediment itself and not mercury discharge from Garimpos. This observation is further supported by observed Hg concentrations of 50 to 300 ppb in regional laterite profiles - this is not unusual and falls within the normal range of surficial materials worldwide. Further, mercury released by garimpeiros is almost exclusively atmospheric as mercury is no longer used directly in sluice boxes. Although a portion of the Hg released to the atmosphere may find its way back into the river, the calculated annual export of mercury from the Crepori River, 4 tonnes, is difficult to account for by Garimpo discharge alone. This is not to say that direct discharge of mercury is insignificant. Analyses of river sediments shows localized hot spots of contamination. But the regional problem - riverine mercury at 100 times background levels is dominantly caused by the enhanced physical erosion of garimpo sluicing and dredging operations than by direct mercury discharge. This has major implications for remediation and prevention. Simply halting the use of mercury is surely a step in the right direction but regional mercury pollution will only be reduced when the dredging is stopped or contained.

Erosion velocity on the left margin of the Parana river gullies: Mesopotamia region, Northeastern Argentina

R. TORRA

The object of this communication is to present preliminary erosion rates measurements. They show rapid erosion velocity on the left margin of the Parana river gullies', all along Corrientes and Entre Rios Provinces at Argentina.

Sandy-muddy lithofacies sediments are clearly verified at the left margin of the Parana river. There is a full superiority of heterolithic succession. They are the physical constitution of sections of the Mesopotamia region.

The physical properties of the sediments called Ituzaingo Formation are constituted of an outstanding lithofacies of very "friable" arenaceous beds interleaved with mud layers. This secuency of about 20 m thickness is underlying down soft, friable silty-clay sediments of about 8 m thickness.

Sandy-muddy lithofacies is now interpreted as intertidal to subtidal in origin. Silty-clay thin beds are interpretated as a non-tidal offshore sand bodies, both Miocene aged.

During ten years, measurements were carried out over the left margin of the Parana river in order to verify the backwasting of sediments.

Preliminary measures made during the last ten years at the field gave a rate of only 10 cm of backwearing per year. This is interpretated as indicious of an actual morphoclimatic stable period.

The width of the young fluvial valley of the Paraná river is of about 30 km. This led us to age it in aproximately 300.000 years BP. Changes in the erosion velocity may be inferred, and that may result an antropic problem. We assume the age of the actual Paraná river valley in 30.000 years BP.

Provenance of surface sediments of the Amazon mouth: interpretation from mineralogical and geochemical analyses

A.M. TORRES, K. STATTEGGER

Sediment samples from the Amazon mouth in the North and South channels were taken to get information about the nature of the provenance. Results indicate that the abundance and distribution of minerals and elements in the sediments of the Amazon mouth are controlled by differences in grain size and by variations in composition of the source areas. Clay and heavy minerals analyses reveal two main source areas. A clay mineral assemblage with concentrations illite > smectite > kaolinite is representative of the Amazon sediments derived from the Andes Mountains, whereas a second assemblage with concentration illite > kaolinite > smectite indicates the influence of sediments from Precambrian shields and of the Amazon Basin. The typical heavy mineral assemblage of the Amazon fluvial system is dominated by hornblende, epidotes and hypersthene and, to a lesser extent, by basaltic hornblende, garnet and augite. The second assemblage is dominated by epidotes, hornblende, zircon and hypersthene, with garnet and basaltic hornblende regularly present. The first assemblage is derived mainly from the uplifted terranes of the Andes where the upper Amazon drains a source area that supplies a large amount of unstable minerals that were subjected to minimal chemical weathering. The latter assemblage suggests that more stable minerals are abundant among the heavy minerals and are strongly influenced by Brazilian and Guiana shields and recycled sources.

Geochemical analyses suggest that fine sediments from the Amazon mouth are characterized by a chemical index of alteration (CIA) between 67 to 70, close to the average cratonic shales values. By contrast, both coarse and fine sediments (quartz- zircon- and kaolin-rich) derived predominantly from Precambrian rocks of the crystalline shields are characterized by CIA values highest. In general, South Channel sediments are enriched in La, Th, Hf and Zr relative to those from the North Channel, suggesting they are derived from the most felsic sources of the Brazilian Shield and recycled sediments from the Paleozoic Amazon Basin mixed in various proportions. The Amazon sediments have high □REE, high La/Yb, and negative Eu-anomalies, similar or more than those of the cratonic shales, supporting the suggestion of a granitic-granodioritic source area. High □REE values probably characterizes an Andes provenance, whereas some low □REE represent highly quartzose sediments from Precambrian sources that were subjected to severe chemical weathering. The Amazon mouth is thus considered a mixing zone of the sediments that reflects different provenance and climatic range.

Potenciais impactos e o desenvolvimento do Alto Paraguai

C.E.M. TUCCI

A bacia do Alto Paraguai contém um dos três mais importantes biomas brasileiros, o Pantanal, uma área de cerca de 134.000 km2 com funcionamento de banhado (wetlands) gerada pelos condicionantes físicos regionais. Esta bacia tem uma divisão física, econômica e ambiental bem definida entre o Planalto, na sua parte superior (acima de 200 m de altitude) e o Pantanal, que é a planície formada por rios lagos e baixios inundados grande parte do ano. O Planalto tem comportamento hidrológico semelhante a maioria das bacias hidrográficas do país, ou seja, com precipitações acima de 1400 mm anuais, vazão específica da ordem de 20 l/s/km2 e um balanço hídrico com superavit hídrico. O escoamento do Planalto escoa diretamente para o Pantanal, dessa forma, todas as ações produzidas no Planalto podem produzir impactos diretos sobre o Pantanal e para jusante em águas internacionais de Paraguai, Bolívia e Argentina.

O Pantanal tem um comportamento singular, já que cerca de 50 a 70% do volume de água e sedimentos de montante é retido pelas depressões no período de inundação devido a baixa capacidade de escoamento da rede fluvial, representando a fonte de vida para este sistema de áreas inundadas. O Balanço hídrico do Pantanal, sem considerar a entrada de montante é negativo, ou seja sem alimentação do fluxo de água e sedimentos de montante a tendência é do sistema se manter seco, alterando toda a vegetação, já que as precipitações chegam a cerca de 1000 a 1200 mm anuais e a evapotranspiração potencial da ordem de 1400 a 1600 m.

O Pantanal tem mostrado uma sustentatibilidade importante através da convivência entre o gado e a preservação do ecossistema. Nas últimas décadas alguns impacto ambientais potenciais e desenvolvidos podem comprometer esta convivência harmoniosa. Os principais são os seguintes: (I) aumento de sedimentos contaminados de montante pela mineração (Mato Grosso) ou degradação solo pela agropecuária (Mato Grosso do Sul), criando depósitos com material tóxico, além do próprio assoriamento, a medida que o Pantanal retém 60% dos sedimentos; (II) construção de obras hidráulicas como diques para reduzir as áreas inundadas, como foi construída numa fazenda em Mato Grosso; (III) projeto da construção da hidrovia entre Corumbá em Cáceres, alterando o leito do rio Paraguai. A alteração do leito, aumentando a sua capacidade de descarga poderá reduzir a quantidade de água escoada para as baías e áreas inundadas. Como o balanço é negativo a área inundada do Pantanal poderia ser muito menor nos anos mais secos, criando condicionantes diferentes dos naturais no Pantanal

A bacia do Alto Paraguai ainda se encontra relativamente pouco habitada, mas tenderá a médio prazo a um desenvolvimento econômico que poderá agravar os impactos existentes e ainda criar novos condicionantes. A água é o fator de sustentação do ecossistema da bacia e deve ser utilizada de forma racional não somente para a conservação ambiental como também para garantir a sustentabilidade do desenvolvimento regional.

Characterization of suspended particulates and dissolved adsorbed organic matter in Amazon river

P.M. TURCQ, P. SEYLER, J.L. GUYOT

Suspended matter has been characterized in mixing zone of black (Rio Negro) and white (Rio Solimões) waters in Amazon River, during a very dry season (September 1997). The aim of this study was to constrain the influence of particle nature on the different processes occuring in the very specific region of water mixture.

Samples were collected along horizontal and vertical profiles in river waters. Organic matter was characterized physically and chemically by Fourier Transformed Infra-Red spectroscopy (FTIR) and by elemental C/H/N analysis. Chlorophyll and phaeopigments were also analyzed by colorimetric methods. Mineral contents were characterized and quantified by FTIR.

Suspended matter concentration varied between 7 mg.l-1 (Rio Negro) and 90 mg.l-1 (Rio Solimões) and between 30-40 mg.l-1 in the mixing zone. Particulate organic carbon content represent 16% in Negro and 2% in Solimões waters of total suspended particles. Rio Negro provides c.a. 18 KgC.s-1 and Solimões c.a. 96 KgC.s-1 of particulate organic carbon to Amazon River. Similarly particulate organic nitrogen flux was 5 time more in Solimões than Negro. Mean C/N ratio was 9. Mean chlorophyll concentration was 5 µg. l-1 but phaeopigments concentration was considerable indicating degradation processes.

Infra-red spectroscopy shows marked differences in the mineral composition of the two waters characterized by the presence of mainly kaolinite and gibbsite in Rio Negro and kaolonite and quartz in Rio Solimões. Infra-red analysis of organic matter point out different peaks of humic substances.

Comparison between linear and non-linear methods of forecasting discharge in the Amazon one season in advance

C.B. UVO, U. TÖLLE

The inter-annual variability of precipitation and water availability observed during the main discharge season of the Amazon Basin has been shown to be related to the sea surface temperature (SST) pattern over the Atlantic and the Pacific Oceans. However, the links between large-scale atmospheric motion and local and regional runoff patterns are complex and still not fully understood. Here, the development of two methods of forecasting seasonal discharge one season in advance at twelve sites in the Northeastern South America from Pacific and Atlantic Ocean SST is presented. They are a statistical, linear, model and a non-linear artificial neural network. Results from the two methodologies are compared. Both methods are better able to forecast discharge at some sites than at others. Discharges from sub-basins in the northern part of the Amazon Basin are better forecasted from Pacific Ocean SST while those from southern sub-basins are better forecasted from Atlantic Ocean SST. Forecasts are also more accurate in years when ENSO SST patterns are well defined over the Pacific or when a meridional SST gradient is observed over the Atlantic Ocean compared to years when no special SST pattern is observed in either ocean. However, the forecasts given by the artificial neural network are considerably more accurate than those of the statistical model. This difference in accuracy provides a further indication that the linkages between large and small scales processes are non-linear.

Étude de régionalisation de débits maxima en grands bassins : cas de la région du Alto São Francisco – Minas Gerais

B.R. VERSIANI, G.S. SOUTO, T. LEBEL

Un des principaux sujets de recherche en hydrologie est l'estimation des débits maxima pour l'étude des évacuateurs de crue ou pour la prévision des niveaux en aval. Parmi les méthodes d'estimation le □ index est une des plus connues. Dans cette méthode, on étudie les relations entre les caractéristiques géomorphologiques et climatiques du bassin avec les débits moyens annuels et ensuite les lois de probabilité des débits maxima annuels. Néanmoins, pour les grands bassins où on a souvent des séries de données moins fournies, deux problèmes se posent : la variabilité spatiale et les problèmes d'échantillonnage dans l'analyse statistique des séries courtes disponibles.

Cet article présente brièvement une méthode de régionalisation des débits maxima basée sur la fonction de distribution TCEV (Two Componemt Extreme Value), proposée par Rossi et al (1984) et son application à des séries de débits maxima annuels dans la région de Minas Gerais (Brésil) . Ce modèle statistique est composé du produit de deux exponentielles, chacune représentant un processus de Poisson: le premier correspond aux débits maxima générées plus fréquemment et l'autre aux débits maxima plus rares, les horsains ('outliers'). Avant de faire la mise en œuvre de l'application de la méthode, une étude d'échantillonnage est faite pour toutes les séries de données disponible, pour analyser la variabilité spatio-temporelle des débits, inclus les horsains.

La région d'étude est un bassin de 50000 km2 situé dans une zone représentative du climat tropical de la région Sud-Est du Brésil et dispose d'un réseau de 65 limnimètres , d'où l'intérêt de l'étude de la régionalisation.

La technique de régionalisation est divisée en trois parties. Le premier niveau de régionalisation consiste à étudier toute la région , c'est à dire caler le modèle statistique pour tout les points de mesure de débit, et vérifier la variabilité des estimateurs des paramètres du modèle sur toute la région.

Le deuxième niveau de régionalisation consiste à mieux définir les régions homogènes. Une région homogène est définie comme une zone où les coefficients d'asymétrie des débits extrêmes sont à peu près constants. Le troisième niveau de régionalisation consiste à définir des sous-régions homogènes et à définir la loi de probabilité régionale. Ensuite on cherche la détermination du □ index, qui permettra mieux estimer les quantiles de débits maxima pour toute la région d'étude.

Distribuição vertical de velocidade e concentração de sedimentos no rio Solimões

R.C. VIEIRA DA SILVA, J.O. GOULART PECLY

O objetivo deste trabalho é ajustar dados de velocidades e concentrações de sedimentos em suspensão medidos em rios da bacia amazônica, pelas equações universais que governam a distribuição destas variáveis Foram utilizadas neste caso, uma lei logarítmica, para a distribuição de velocidades na vertical, e a equação de O'Brien-Rouse para a distribuição de concentrações de sedimentos em suspensão. Foram analisados dados obtidos em seções dos rios Amazonas e Madeira por equipes e técnicos da ANEEL/ORSTOM, com a utilização de equipamentos "Acoustic Doppler Current Profiler" (ADCP).Os resultados obtidos indicam que, apesar das grandes dimensões dos rios monitorados, as leis universais apresentaram uma boa adequabilidade nas verticais. As distribuições transversais, todavia, apresentaram distorções em algumas medições. Tabelas mostrando alguns parâmetros de turbulência característicos de cada seção, como o coeficiente "k" de Karman e o expoente "z" da distribuição de concentração de sedimentos são apresentadas. Foram efetuadas as extensões de curvas teóricas ajustadas nas zonas não amostradas pelo ADCP permitindo estimar valores para as concentrações e velocidades nestas regiões. A quantidade de dados obtidos para os dois nos não é suficiente para assegurar uma calibragem dos parâmetros característicos da hidráulica fluvial. Todavia, levando-se em conta a grande carência de dados hidrológicos da bacia amazônica, os resultados obtidos sempre podem apresentar um avanço a mais no conhecimento dos processos fluvio-morfológicos dos rios da região.

Potencialidades do uso de satélites para o monitoramento da concentração de sedimentos no rio Amazonas

R.C. VIEIRA DA SILVA, E.M.L. MORAES NOVO, J.O. GOULART PECLY

A obtenção de dados sobre concentração média de sedimentos em cursos d'água a partir das características de imagens de satélite, constitue-se atualmente numa das mais promissoras tecnologias de monitoramento de dados fluviométricos. Embora as estimativas feitas até o presente não tenham contemplado rios de grandes profundidades, procurou-se neste trabalho, a partir do conhecimento da distribuição vertical de sedimentos em suspensão obter-se dadas que permitam correlacionar a radiância superficial obtida pela imagem do satélite com a concentração média de sedimentos no trecho imageado. Para isto foi utilizado um mosaico de imagens de trecho do rio Amazonas elaborado pelo Instituto Nacional de Pesquisas Espaciais (INPE) onde a radiância produzida pelos sedimentos em suspensão foi determinada para as diversas unidades do mosaico. Estes valores foram comparados com medições pontuais da concentração de sedimentos realizados com o auxílio de equipamentos "Accoustic Doppler Current Profilers (ADCP) por equipes da ORSTROM/ANEEL em diversas seções do rio Amazonas. Estes dados foram ajustados pela equação universal de O'Brien & Rouse com vistas a sua generalização. Embora os resultados obtidos refiram-se a um pequeno número de medições in-situ e de passagens de satélites, o nosso estudo permitiu estimar a grande potencialidade futura da metodologia em análise.

Modelling human influence on heavy metal flow from source to river mouth: the Elbe

R.J. VINK

Achieving efficient management strategies to reduce pollutant loads to the sea requires a good comprehension of how much each source in each sub-basin contributes to the river-mouth transport. The lack of water quality models for such large scale river basins with a sufficient spatial and temporal resolution called for a new modelling approach.

The River Elbe is one of the fastest changing river basins in Europe due to the sudden change of a centrally planned economy to a free-market economy in 1989. This economic transformation also caused a change in material fluxes in the Elbe river basin. To allow efficient management to bring about a reduction in the input of heavy metals to surface water and the North Sea, the relative contribution of point and diffuse sources to the total heavy metal load and their spatial and temporal distribution must be analyzed. The analysis of such large river basins as the Elbe requires detailed information on the spatial and temporal characteristics of both emissions and physical information of the entire river basin. Although the extent of such large river basins limits the resolution of such a study and therefore the results of this analysis will evaluated on a yearly basis. Since the up-scaling of detailed small-scale analyses to large-scale analyses is generally not successful, the approach used for this large-scale analysis closely resembles the techniques used for quantifying nitrogen and phosphorous. GIS-based modelling techniques are used to estimate point and diffuse pathways of metals into the river system by using a variety of digital map data sets. In this paper the methodology of this GIS-based computational framework to support policy analysis of water quality management for large transboundary river basins will be described.

Aspectos da dinâmica dos sedimentos na foz do rio Amazonas

S.B. VINZON

Dados experimentais do escoamento e da dinâmica dos sedimentos obtidos pelo AMASSEDS (A Multidisciplinary Amazon Shelf Sediment Study) foram analisados com o auxílio de um modelo numérico, examinando a interação fluido-sedimento. Neste modelo, a velocidade de queda das partículas foi considerada como uma função da concentração dos sedimentos, e a taxa de erosão no fundo foi ajustada utilizando medições de velocidade e concentração perto do leito assim como uma relação entre a resistência à erosão e a densidade derivada de medições de laboratório. O amortecimento da turbulência devido à estratificação foi também considerada na análise.

As séries temporais de medições de perfis de concentração de sedimentos foram comparados com simulações do modelo visando obter um melhor entendimento dos processos que ocorrem na coluna d'água. Foi encontrado que a ação da maré é preponderante no mecanismo de resuspensão de sedimentos do fundo. Por outro lado, o espalhamento dos sedimentos na plataforma continental do Amazonas é basicamente determinado pelos processos de transporte que acontecem nas proximidades do leito. Assim, utilizando uma aproximação simples da interação fluido-sedimento que acontece onde estão presentes altas concentrações de sedimentos, a dinâmica desta pequena camada foi analisada.

Variabilité des apports liquides et solides dans un grand bassin endoréique du Nord Mexique : le bassin Nazas-Aguanaval

D. VIRAMONTES, L. DESCROIX, J.F. NOUVELOT, J.L. GONZALEZ BARRIOS

Les zones arides sont en général soumises à une variabilité spatio-temporelle élevée des précipitations et des écoulements. Dans le cas du Nord-Mexique, la Sierra Madre Occidentale sert de « château d'eau » et ses apports expliquent l'existence d'oasis et de périmètres irrigués dans le désert de Chihuahua et sur la plaine côtière du Pacifique, localement aride. Si l'influence du Niño est faible, par contre on peut craindre une modification des apports du fait de la transformation du milieu dans la Sierra Madre, où déforestation et surpâturage conduisent à une rapide diminution de la couverture végétale.

On cherche à déterminer l'éventuel impact de ces transformations sur les apports annuels d'un bassin d'alimentation qui est aussi la principale zone d'apport en eau souterraine ; cela est particulièrement important dans la mesure où la nappe phréatique profonde de la Laguna, exutoire du bassin -endoréique- du Nazas, et aussi principal bassin laitier mexicain, est surexploitée depuis une cinquantaine d'années déjà, ce qui conduit à une dégradation de la qualité de ses eaux profondes (risque de salinisation et alcalinisation des sols). Les apports et les régimes sont déjà profondément modifiés par deux retenues importantes sur le bassin versant. Des analyses isotopiques ont permis de déterminer que la Sierra Madre était la principale zone d'alimentation des aquifères. On cherche à déterminer les principales composantes du ruissellement grâce à une série de données de plus de cinquante années.

Le bassin étant endoréique, la sortie du système ne se fait que par recharge de la nappe profonde et surtout par évaporation. L'érosion et les transports solides sont relativement modérés pour une zone semi-aride (500 t/km2/an en moyenne) du fait de l'importance de la couverture végétale dans le haut bassin ; cependant, la rapide dégradation de celle-ci ne risque-t-elle pas de modifier sensiblement ce bilan ?

Pour le moment, cela ne semble pas avoir modifié le bilan à l'échelle du bassin, mais des mesures sur petits bassins versants et sur parcelles ont mis en évidence une évolution du comportement hydrodynamique des sols ; de plus, la récurrence des sécheresses (comme durant les années 40 et 50, ou durant les années 90) fait craindre l'apparition de phénomènes irréversibles dans la dégradation de l'espace et les conditions d'approvisionnement naturel en eau de surface et en eaux profondes.

Influencia de variables macroclimáticas asociadas al ENSO en la hidroclimatología del municipio de Santiago de Cali (Colombia)

J.M. VIVAS, H.M. ESCUDERO, Y. CARVAJAL

Santiago de Cali (Colombia), es la segunda ciudad en importancia del País; ésta presenta una red hídrica de 7 ríos y por su estratégica ubicación, reviste gran importancia para la comunidad como fuente de abastecimiento, recreación, ornamentación, paisaje, además de pertenecer a la estrella fluvial más importante del Alto Cauca y al Parque Natural - Nacional Los Farallones de Cali, tercero en importancia en los Andes Americanos por su alta biodiversidad. La relación entre la hidroclimatología colombiana y la oscilación ENSO es clara e indiscutible. La tendencia es un clima más seco cuando el Pacífico está en una fase cálida (Niño) y la oscilación del sur es negativa. De otro lado la fase fría va acompañada de mayores lluvias (Niña).

Las grandes consecuencias que ha tenido el fenómeno ENSO (El Niño – Oscilación del Sur) en todo el País, especialmente en esta ciudad por su cercanía al Océano Pacífico, han despertado el interés de establecer la relación entre variables macroclimáticas asociadas al fenómeno y la hidroclimatología de esta zona. Asi como de diseñar modelos matemáticos de pronóstico para las variables hidroclimatológicas. Este estudio se ha venido realizando satisfactoriamente empleando la siguiente metodología:

Se recopiló la información y se le efectuó una suavización mediante un promedio móvil de tres meses, preservando al máximo la señal original, también se realizó un análisis descriptivo, calculando los principales estadísticos de cada serie, como son la media, desviación estándar, valor máximo, mínimo y el coeficiente de variación. Seguidamente, cada variable hidroclimatológica se correlacionó con cada variable macroclimática, desfasandola desde -12 hasta +12 meses (variable macroclimática desfasada t meses frente a la variable hidroclimatológica); y dependiendo del tipo de variable hidroclimatológica y de su interpretación física se realizó una autocorrelación, para hallar su asociación con sus registros antecedentes. Finalmente, se estimaron los coeficientes de correlación.

Para la calibración de los modelos matemáticos de pronóstico; se escogieron las variables macroclimáticas (explicativas) de los resultados obtenidos en la estimación de los coeficientes de correlación más altos; posteriormente se emplearon la elaboración de modelos de Regresión Lineal Múltiple, incluyendo la variable hidroclimatológica a estudiar como variable dependiente y las variables explicativas seleccionadas como variables independientes, consideradas como predictoras. Luego, se evaluaron las estadísticas de la regresión y el análisis de varianza, estimando los coeficientes de regresión, el coeficiente de determinación R2 ajustado, el error típico, la probabilidad de error, el estadístico F y el estadistico t; también se emplearon métodos de bondad de ajuste como la prueba ji-cuadrado y el análisis de las correlaciones ó de la independencia de las variables explicativas entre sí, determinando si las variables realmente influían en los pronósticos y si los modelos eran confiables. Para juzgar la validez de los modelos se utilizó la comparación gráfica entre los pronósticos y las ocurrencias históricas, usando para esto un período no utilizado para estimar el modelo.

Cabe anotar que los resultados obtenidos hasta ahora son satisfactorios, aportando adelantos en los estudios hidroclimatológicos, aportando una nueva herramienta para una mejor planeación del recurso hídrico en la región, y para la mitigación y prevención de desastres, que generalmente ocurren durante las fases extremas del ENSO.

Longer-term variability of sediment transport to the oceans

D.E. WALLING, D. FANG

Recent interest in Global Change has focused attention on both the impact of climate change and human activity on the global system and the natural variability of this system Any attempt to decipher change must clearly take account of such natural variability. The increasing availability of information on the suspended sediment loads of the world's rivers now provides an effective basis for estimating the global flux of sediment from the land to the oceans and it is timely consider the evidence for recent changes in this flux and its natural variability. Although there are few long-term records of suspended sediment transport by the world's major rivers, the expansion of sediment monitoring activity since the 1960s now provides a substantial number of records spanning several decades and it possible to use this information to begin to assess the evidence for change and to establish natural patterns of variability. Reservoir construction on many major rivers has caused a marked reduction in their suspended sediment loads and similar reductions can be linked to reduced transport capacity caused by overabstraction for water supply. The Yellow River in China affords a classic example of such reductions in sediment transport, such that the mean annual flux of 1.6 x109 tonnes frequently cited in the literature and which is based on records from the middle part of the 20th century is no longer representative of the contemporary load. In other cases, however, there is evidence of increased sediment loads as result of both land use change and climate change. For many rivers of Asia, intensification of land use has undoubtedly caused substantial increases in sediment yield. In some cases, however, rivers, such as the Yangtze River in China, show little evidence of changing suspended sediment loads despite major increases in population and associated expansion of land clearance and agricultural activity. Although most river basins will inevitably have been impacted to some degree by human activity and other components of global change, it is also possible to build up an improved picture of the 'natural' variability of annual sediment fluxes to provide a context against which other trends may be assessed. This variability is closely linked to inter-annual variability in precipitation and runoff but also reflects a number of other controls. This paper will present the results of an ongoing assessment of trends and variability of the global transfer of sediment from the land to the oceans.

Hydro-écorégions et facteurs de contrôle physiques et chimiques des hydrosystèmes dans le bassin amazonien bolivien

J.G. WASSON, B. BARRÈRE, J.L. GUYOT, F. GOURDIN, D. BINET

La partie bolivienne du bassin amazonien, qui recouvre environ 700.000 km2, présente des paysages extrêmement contrastés. Or l'influence de l'hétérogénéité géographique sur la diversité naturelle des hydrosystèmes est encore peu documentée, surtout en milieu tropical L'un des objectifs du programme BIOCAB (BIOdiversidad Acuática en la Cuenca Amazónica Boliviana), mené en commun par l'IRD et l'Université de La Paz, est de mettre en évidence les facteurs physiques et chimiques qui expliquent à l'échelle régionale la distribution actuelle de la biodiversité aquatique dans ce bassin.

L'approche scientifique se base sur les concepts de contrôle hiérarchique des hydrosystèmes, qui reconnaissent dans la structure géophysique et climatique du bassin les déterminants primaires du fonctionnement écologique des cours d'eau. Le relief, la nature des roches, le régime des températures et des précipitations, et la couverture végétale qui en résulte déterminent à l'échelle locale les caractéristiques morpho-dynamiques et hydro-chimiques des cours d'eau, auxquelles répondent les peuplements aquatiques.

Sur la base de ces concepts ont été définies des Hydro-écorégions (HER) à partir de diverses cartes et images satellitaires existantes (géologie, géomorphologie, modèle numérique de terrain, températures, précipitations, cartes de végétation et zones forestières, images ERS, NOAA et Radarsat). Ces données ont été intégrées dans un SIG (sous ArcView®). Les HER constituent donc une méthode de régionalisation a priori des hydrosystèmes, assortie de l'hypothèse que les cours d'eau présenteront à la fois des caractéristiques physiques et biologiques et un patron d'évolution longitudinal différent dans chaque région. Cette hypothèse demande évidemment à être validée sur des données acquises de manière indépendante.

Dans ce travail, nous présentons la carte des HER du bassin amazonien bolivien. Pour la plupart des régions, des données caractérisant la géomorphologie des vallées et des cours d'eau ont été recueillies sur des cartes topographiques au 1/50.000eme. Par ailleurs un échantillonnage physico-chimique extensif avait été réalisé au cours d'un programme antérieur (PHICAB). Ces données sont confrontées au cadre des HER, et la validité de cette approche pour régionaliser les caractéristiques physiques et chimiques des hydrosystèmes est discutée.

Au dela de son aspect descriptif, l'approche par hydro-écorégions présente un intérêt certain pour comprendre l'organisation des hydrosystèmes à l'échelle d'un grand bassin. Les HER constituent un cadre pertinent pour interpréter la distribution régionale des peuplements aquatiques, et des résultats significatifs ont déjà été obtenus sur la partie andine du bassin. En mettant en évidence les facteurs qui contrôlent au plus au niveau le fonctionnement écologique des hydrosystèmes, cette démarche autorise une vision globale des potentialités et des sensibilités des milieux, particulièrement utile pour la définition de politiques regionales de gestion.

Water resources and its management in Tarim river basin, China

WEI WENSHOU, HU XUNLONG

Tarim River basin is the largest continental river basin in China and its catchment area is 1.02×106 km2. Tarim River is 2 437 km long, is mainly consisted of 9 tributary systems, and its annual runoff volume varies in a range of 1.0×109 ~ 5.0×109 m3 . The topography in the watershed and its surrounding regions is that, Kunlun Mountain, the Pamirs and the Tianshan Mountains are located on its southern, western and northern sides respectively, and Tarim Basin and the well-known Taklamakan Desert are in the middle part. The tributaries rising in the surrounding mountainous regions concentrate towards the central area of Tarim Basin, thus the main stream of Tarim River forms.

Tarim River is fed by melting water of the glaciers and snow cover in the upper reaches of its tributaries and groundwater mainly, and a small amount of surface runoff formed by rainfall subsidiarily. Its runoff distributes in a great disparity from different seasons, during a period from June to August, it takes about 60% of the total annual runoff volume, and only 15% during a period from March to May. The areas of runoff formation of both surface water and groundwater are extremely less, thus a character of continental river forms along the main stream of Tarim River, that is the streamflow varies greatly between flood season and low-water season. Meanwhile, since recent 50 years, the streamflow of the main stream of Tarim River is reduced and the intra-annual distribution of runoff is more concentrated due to the rapid growth of population, enlargement of the reclaimed area, and continuous increase of water consumption in the upper reaches.

Management of the water resources in Tarim River basin plays an important role in enlargement and economic development of the oases or development of desertification in the basin. It not only affects the ecological and environmental protection and development, but also determines growth of plant and habitation or migration of wild animals in the marginal zones of the deserts. The remains of Loulan Ancient City is a historical lesson of changes of the water resources in Tarim River basin. Therefore, scientifical management, rational planning and distribution of water resources are the ensurings of regional sustainable development for arid and semi-arid areas. Only by strengthening the environmental protection can a virtuous circle of ecosystem in the oases be achieved.

Discharge, recharge and evapotranspiration of groundwater determined by baseflow separation

H. WITTENBERG

By analysis of observed time series of streamflow, the main components of the underlying groundwater balance of a basin, namely, discharge, evapotranspiration loss, storage and recharge, can be identified and quantified. This holistic estimation method is demonstrated for the Collie River basin in Western Australia. The relationship between groundwater discharge and reservoir storage of unconfined aquifers was found to be nonlinear based on analysis of numerous streamflow recession curves. However, depletion of groundwater by evapotranspiration losses, through the water uptake of tree roots in forested catchments, was found to bias the recession curves and the estimated reservoir parameters. Due to the seasonality of both rainfall and potential evaporation, analysis of the recession curves, stratified according to time of the year, allowed the quantification of evapotranspiration loss as a function of calendar month and stored groundwater depth. Time series of recharge to the groundwater aquifer were computed from baseflow separated from observed total streamflows, using the nonlinear reservoir algorithm and the found evapotranspiration relationships, by inverse nonlinear reservoir routing. Comparison of the computed recharge hydrographs with measured daily rainfalls revealed a typical travel time distribution of percolating water. Unit responses of groundwater recharge were found for these data by least squares fitting. The shapes of the estimated unit response functions showed no significant seasonal variation.

Hydrodynamique fluviale de l'Oued Medjerdah à l'aval du barrage Sidi Salem. Evolution récente

Y. ZAHAR, J. ALBERGEL

La Medjerdah (23 700 km2) est le principal cours d'eau de la Tunisie, et constitue, totalement ou partiellement, le château d'eau pour plus de la moitié de la population Tunisienne (5.5 millions d'habitants). De lui dépend la sécurité alimentaire du pays, notamment par la mobilisation et la régularisation maximale de ses ressources en eau (8 barrages aménagés, d'une capacité totale de 1 milliard de m3), et par le développement de l'irrigation tout au long de ses berges (90 000 hectares).

Depuis ces aménagements, et plus précisément à la suite de la mise en eau du plus grand barrage en 1981 (Sidi Salem : 555 millions de m3), on assiste à un rétrécissement rapide de la section d'écoulement du lit en aval. Les perturbations occasionnées par ce barrage sur les conditions hydrodynamiques du cours d'eau sont pour le moins inquiétantes, notamment une diminution très sensible de la débitance (70% de chute de débitance par endroits). Les dépôts solides dans le lit qui ont lieu aux moments des lâchés turbides de dévasement de la retenue du barrage, sont la cause principale de ces bouleversements pour le cours d'eau. Il est par conséquent manifeste que ces rétrécissements peuvent engendrer à terme des perturbations graves aux comportements hydrologiques de la Medjerdah, notamment une diminution irréversible des caractéristiques d'écoulements, suite à l'engraissement du lit, qui se traduirait notamment par une incapacité à évacuer les débits de crues (naturelles ou artificielles) sans risques de débordements. Ces risques de débordement menacent les villes et les populations rurales riveraines au lit, ainsi que les infrastructures importantes qui le bordent ou l'enjambent (périmètres irrigués, ponts, etc.).

Après avoir analysé la problématique passée et récente de l'évolution du lit, l'étude propose un nouveau mode de gestion des barrages, notamment en ce qui concerne les dévasements.

Application of ecohydrological approach for restoration and sustainable management of river basin

M. ZALEWSKI

The one of the fundamental tenets of the concept sustainable development is the maintenance of homeostatic equilibrium of ecosystem. It is because over exploitation or biotic structure degradation, alters the ecosystem processes to the point in which ecosystem ability to produce desired resources is seriously diminished. The degradation of the river ecosystems has been of two dimensional character, first pollution, which can be eliminated to serious extent by technologies, second much more complex - degradation of evolutionary established water and nutrients cycling. The last one might be improved by the application of ecohydrological approach. The progressing understanding the biogeochemical and biological processes in the catchment scale create background for control and regulation of nutrients and water dynamics toward enhancement of resistance /robustness and resilience of river ecosystem to human impact and in consequence improvement of water quality and biodiversity of the system.

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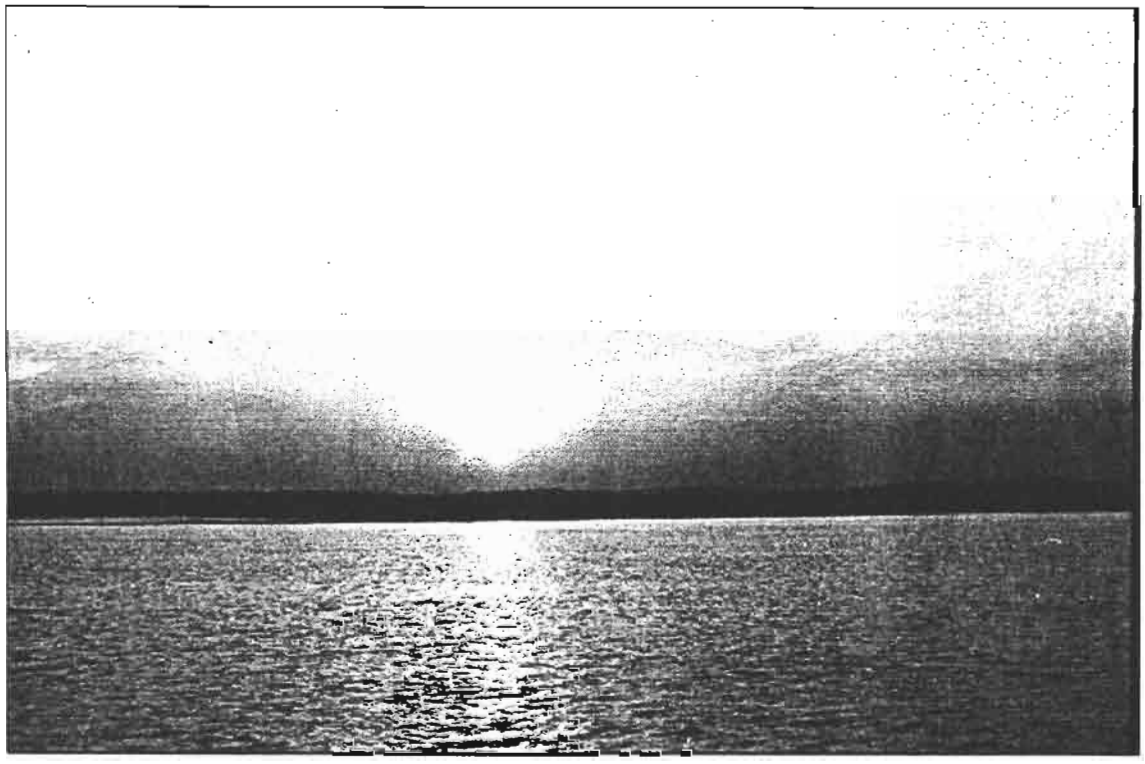

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BAHC - Biospheric Aspects of the Hydrological Cycle
IGBP - International Geosphere Biosphere Program

IHP - International Hydrological Programme of the UNESCO

IWRA - International Water Resources Association

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