ESCUELA DE VERANO
Modelación Aplicada al Océano
Uso avanzado del modelo CROCO:
BIOGEOQUÍMICA
25-26 de enero 2021

Validación Biogeoquímica

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PREGA

LOFC
Laboratorio de Oceanografía Física Costera

Validación

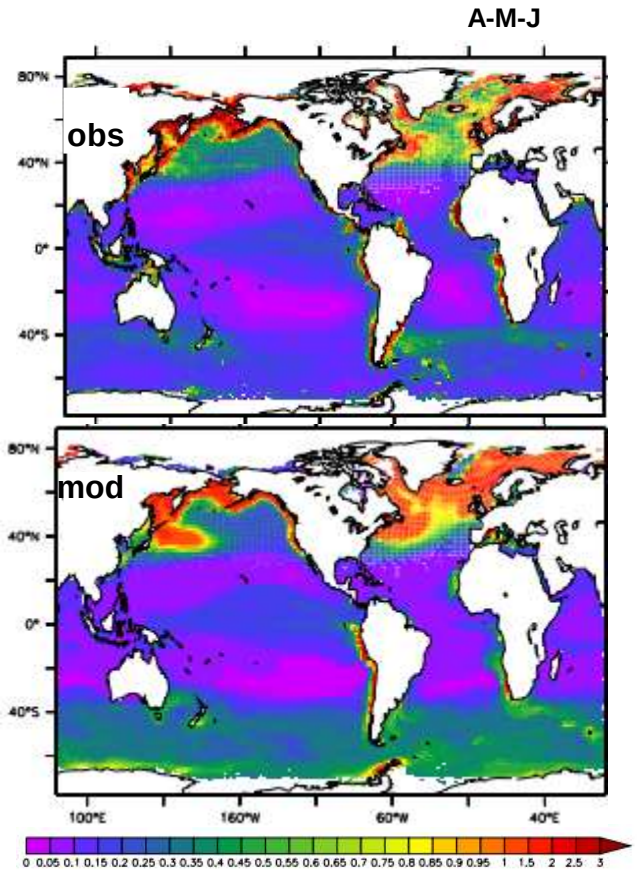
Los procedimientos de validación comúnmente utilizados incluyen **comparaciones** con **observaciones** o resultados de **modelos oceánicos establecidos**. De cualquier manera, se requieren métodos de comparación no ambiguos.

Validación

Los propósitos de la validación de un modelo pueden ser múltiples. La validación puede llevarse a cabo para **evaluar la calidad general** de la simulación de un modelo, y puede realizarse para **identificar las debilidades específicas** de un modelo.

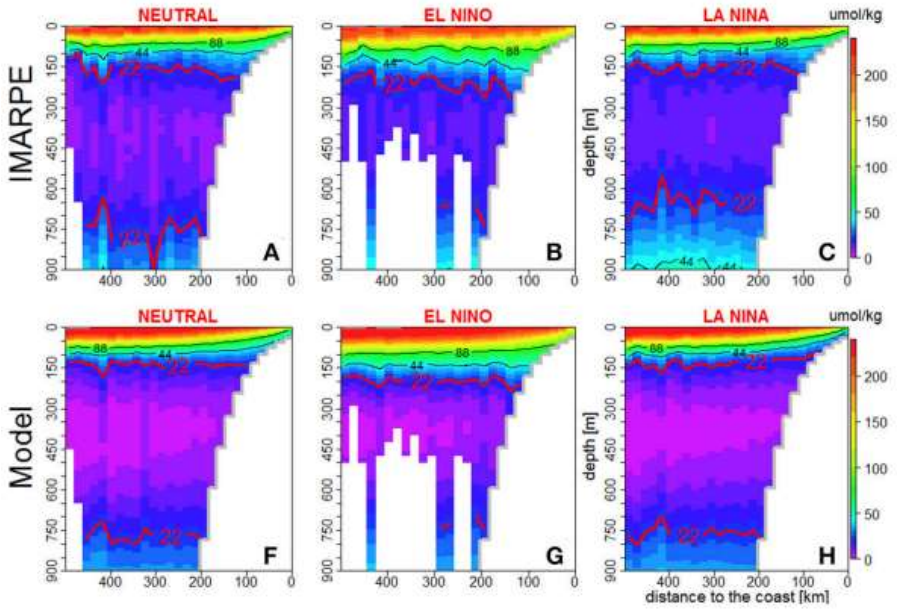
Importante zona de estudio y “pregunta” a evaluar

Patrón superficial estacional chla
- Chla satelital
- Chla in situ (cruceros, bases datos globales)
- Modelos oceánicos establecidos



Aumont et al. (2015)

Variabilidad interanual ZMO
-Datos O_2 in situ, perfiles (cruceros, bases globales)



Espinoza-Morriberón et al. (2019)

Importante zona de estudio y “pregunta” a evaluar

Frecuencia espacial/temporal

Ocean & Coastal Management 83 (2013) 52–66

Use of a high resolution 3D fully coupled hydrodynamic, sediment and biogeochemical model to understand estuarine nutrient dynamics under various water quality scenarios

Jennifer Skerratt [a,*], Karen Wild-Allen [a], Farhan Rizwi [a], Jason Whitehead [b], Christine Coughanowr [b]

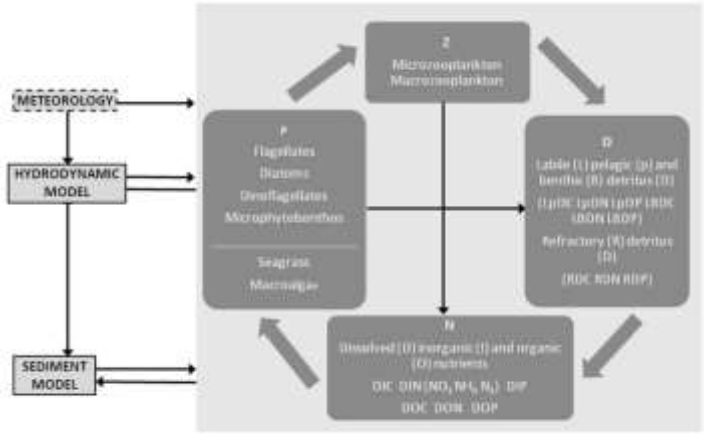
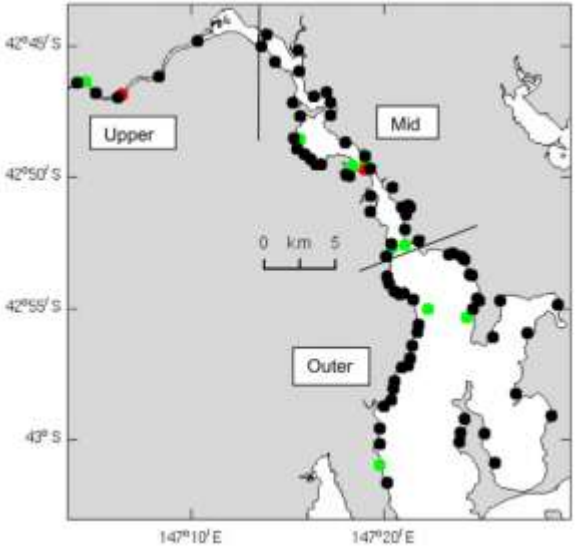
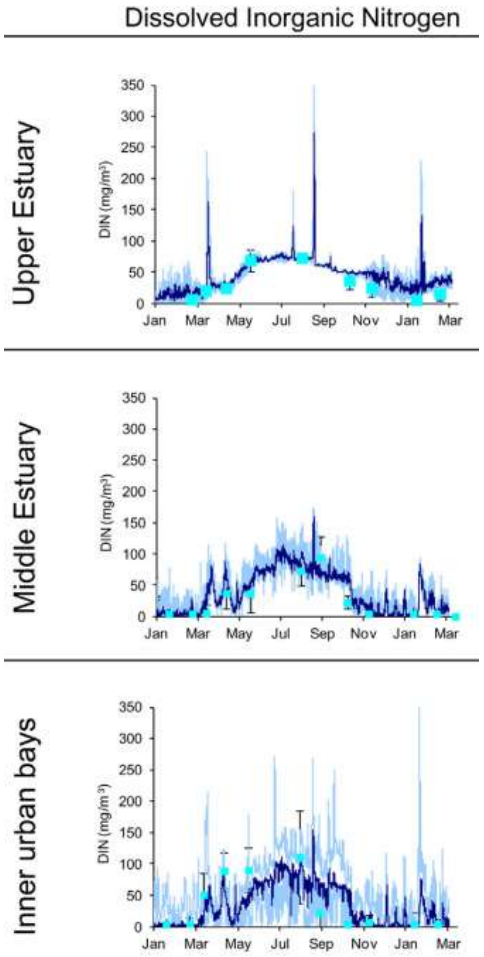


Fig. 2. Schematic diagram of the NPZD biogeochemical model with compartments, major (dark) and minor (light) links.





Tipos de validación

Métodos Directos

-Comparan las variables de dos o más conjuntos de datos en momentos y lugares específicos.

-Comparaciones directas de series de tiempo o gráficos bidimensionales, como secciones transversales verticales u horizontales.

-“Snapshop” de cada conjunto de datos o restando un conjunto del otro (diferencia).

-Estos métodos “intuitivos” permiten estudios detallados de la capacidad de los modelos oceánicos para reproducir fenómenos oceanográficos como remolinos y frentes.

Métodos Estadísticos

-Comparan atributos estadísticos en lugar de datos oceanográficos directamente.

-Pueden dividirse en dos grupos; los métodos que toman en cuenta la distribución espacio-temporal y los métodos que ignoran la distribución espacio-temporal.

Métodos Directos

Perfiles

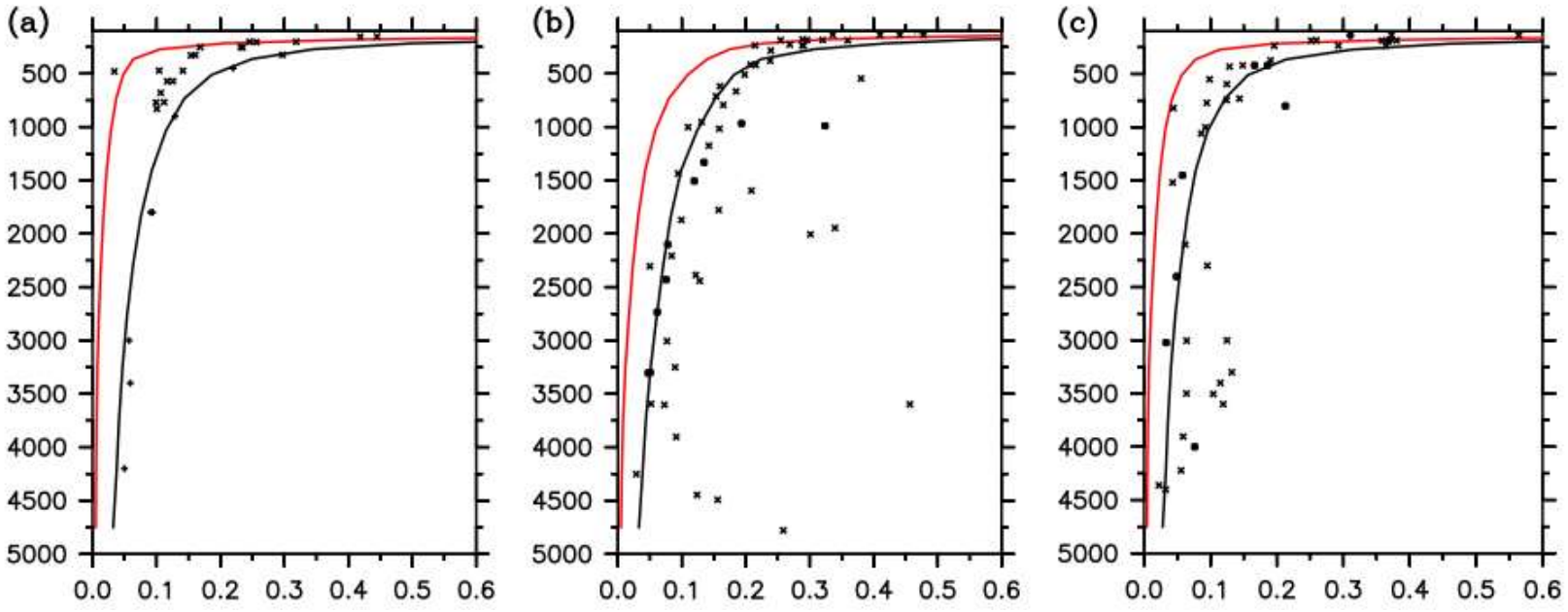


Figure 4. Modelled and observed total POC concentrations (μM) in different regions of the ocean: **(a)** western, **(b)** oligotrophic, and **(c)** eastern North Atlantic Ocean;

-Dos simulaciones: PISCES estándar (**rojo**) y experimento con “labilidad variable” de POC (**negro**).

Aumont et al. (2017)

Series de tiempo

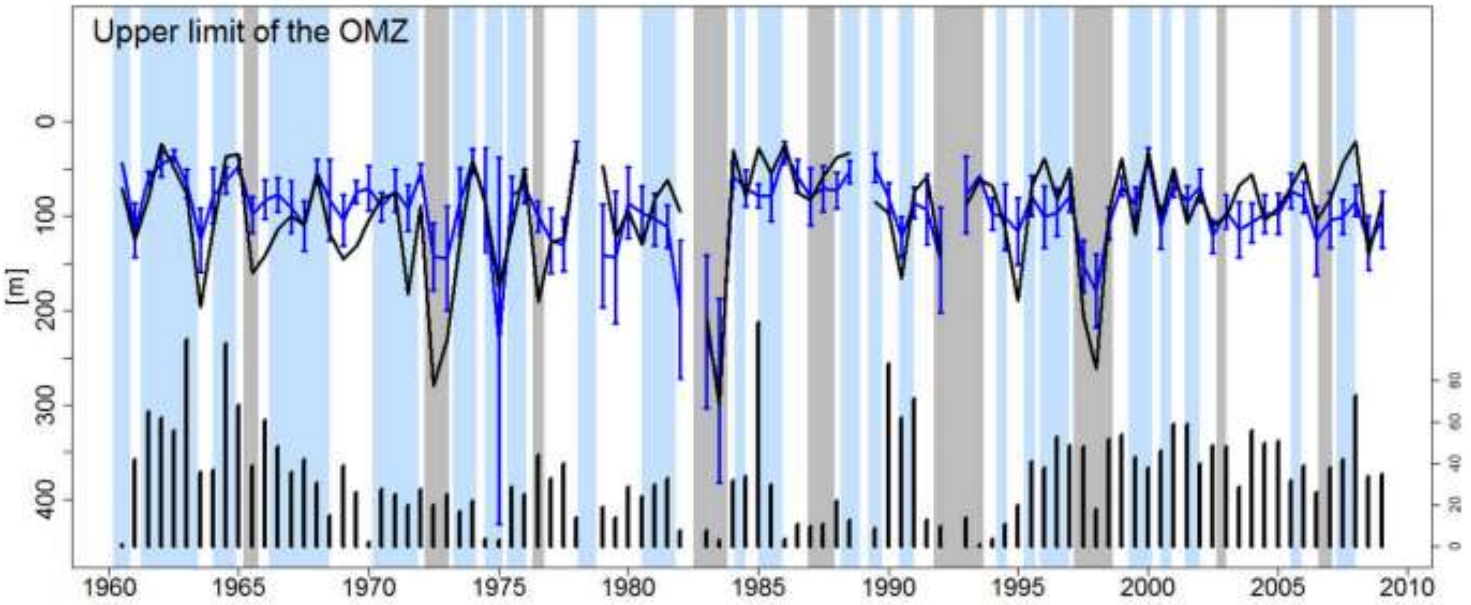


FIGURE 4 | ZO2 time series (in meters). Data was averaged each semester for IMARPE (blue line) and model output (black line) in a coastal box (6°S–16°S and 100 km from the coast). Error bars represent the standard deviation from IMARPE data. Black bars (at the bottom of the figure) represent the coverage ratio (number of sampled points/ total number of points). The modeled ZO2 was computed using the same sampling as IMARPE observations (gaps mean there is no data). Gray and blue shading represent EN and LN period, respectively.

Espinoza-Morriberón et al. (2019)

Métodos Directos

Superficiales (diferencia)

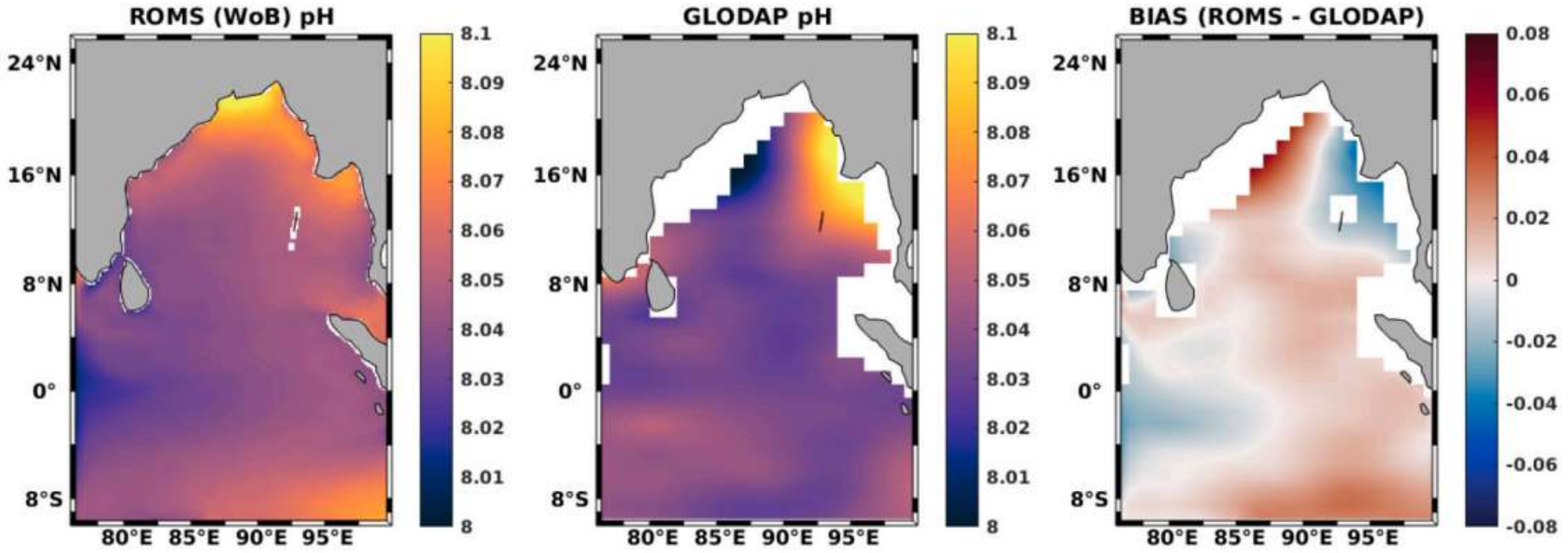


Fig. 16. Comparing spatial distribution of modelled pH with the observed pH. All figures represents annual mean of pH in total scale.

Joshi et al. (2020)

Secciones verticales

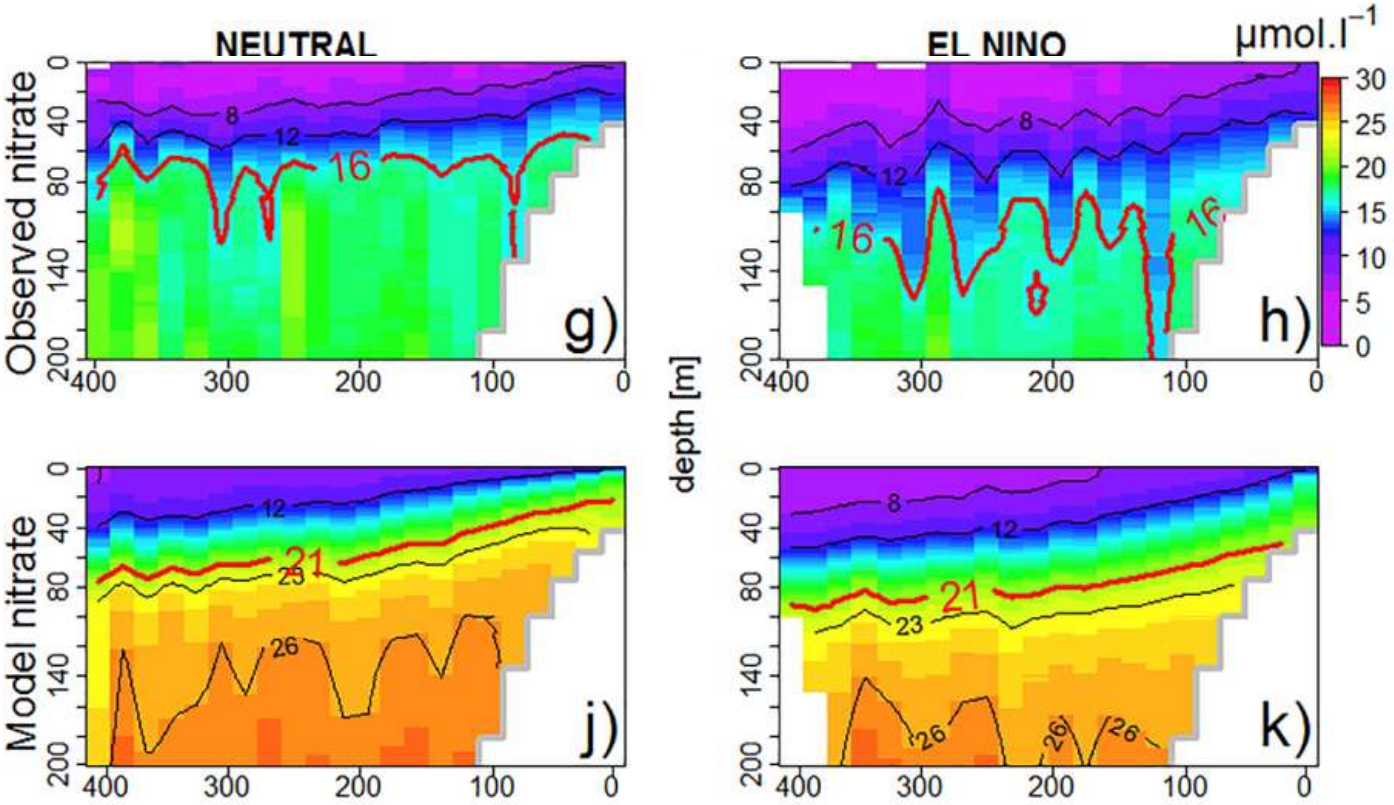
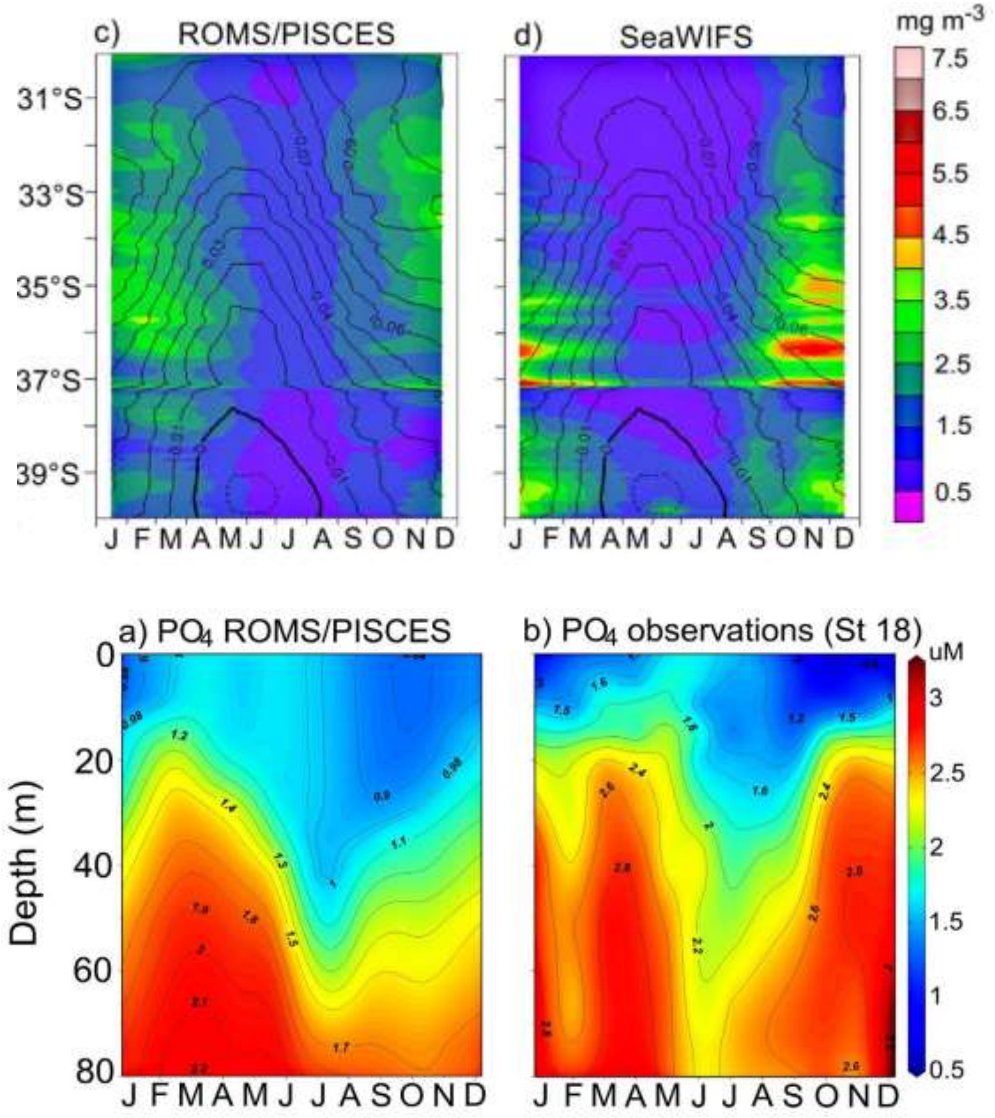


Figure 3. Along-shore averaged vertical section (between 6°S and 16°S) of observational data from IMARPE and model variables

Espinoza-Morriberón et al. (2017)

Métodos Directos

Hovmoller



Vergara et al. (2017)

Métodos Directos

Scatter plot

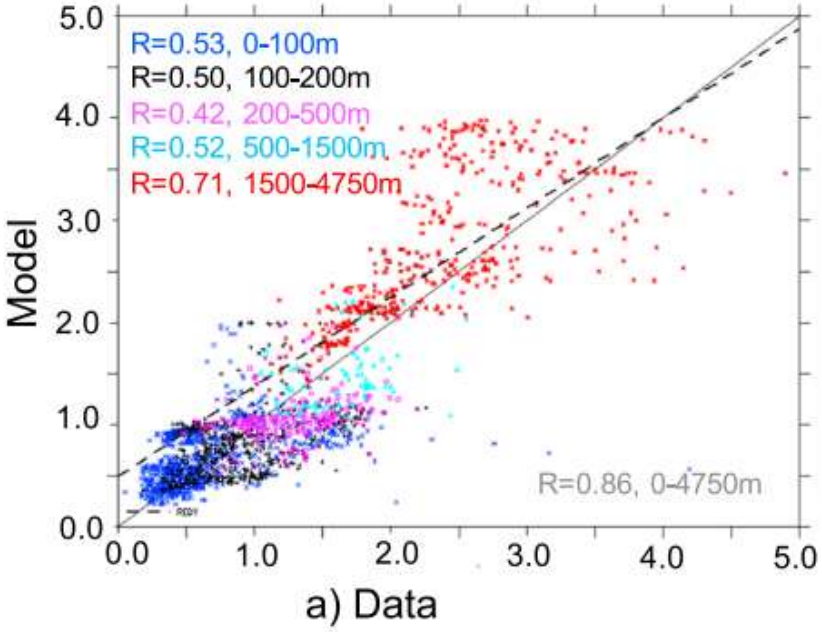
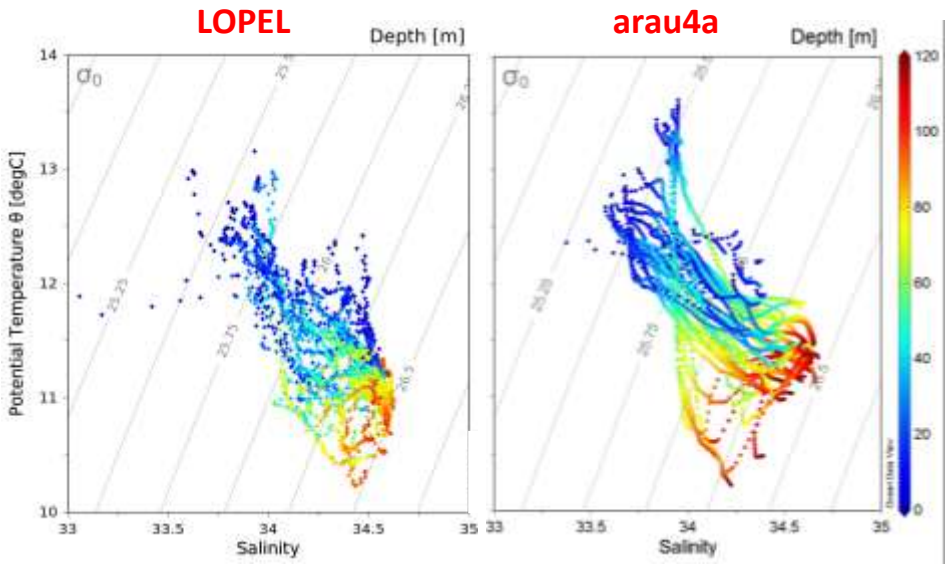


Figure 3. (a) Scatter plot of DCu concentration (nmol/L) in the model versus measured concentrations

Richon and Tagliabue (2019)



Vergara et al. en prep.

Métodos Estadísticos

RMSE – the root-mean-squared error

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} (P_i - O_i)^2}{n}}.$$

AE – the average error (bias):

$$\mathrm{AE} = \frac{\sum_{i=1}^{n} (P_i - O_i)^2}{n} = \overline{P} - \overline{O}$$

AAE – the average absolute error

$$\mathrm{AAE} = \frac{\sum_{i=1}^{n} |P_i - O_i|}{n}.$$

BAMEF – the bias-adjusted modelling efficiency:

$$\mathrm{BAMEF} = \frac{\left(\sum_{i=1}^{n} (O_i - \overline{O})^2 - \sum_{i=1}^{n} (P_i - \overline{P} - (O_i - \overline{O}))^2\right)}{\sum_{i=1}^{n} (O_i - \overline{O})^2}$$

RI – the reliability index:

$$\mathrm{RI} = \exp \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(\log \frac{O_i}{P_i}\right)^2}$$

Pr – the Pearson correlation coefficient:

$$\mathrm{Pr} = \frac{\sum_{i=1}^{n} (O_i - \overline{O})(P_i - \overline{P})}{\sqrt{\sum_{i=1}^{n} (O_i - \overline{O})^2 \sum_{i=1}^{n} (P_i - \overline{P})^2}}.$$

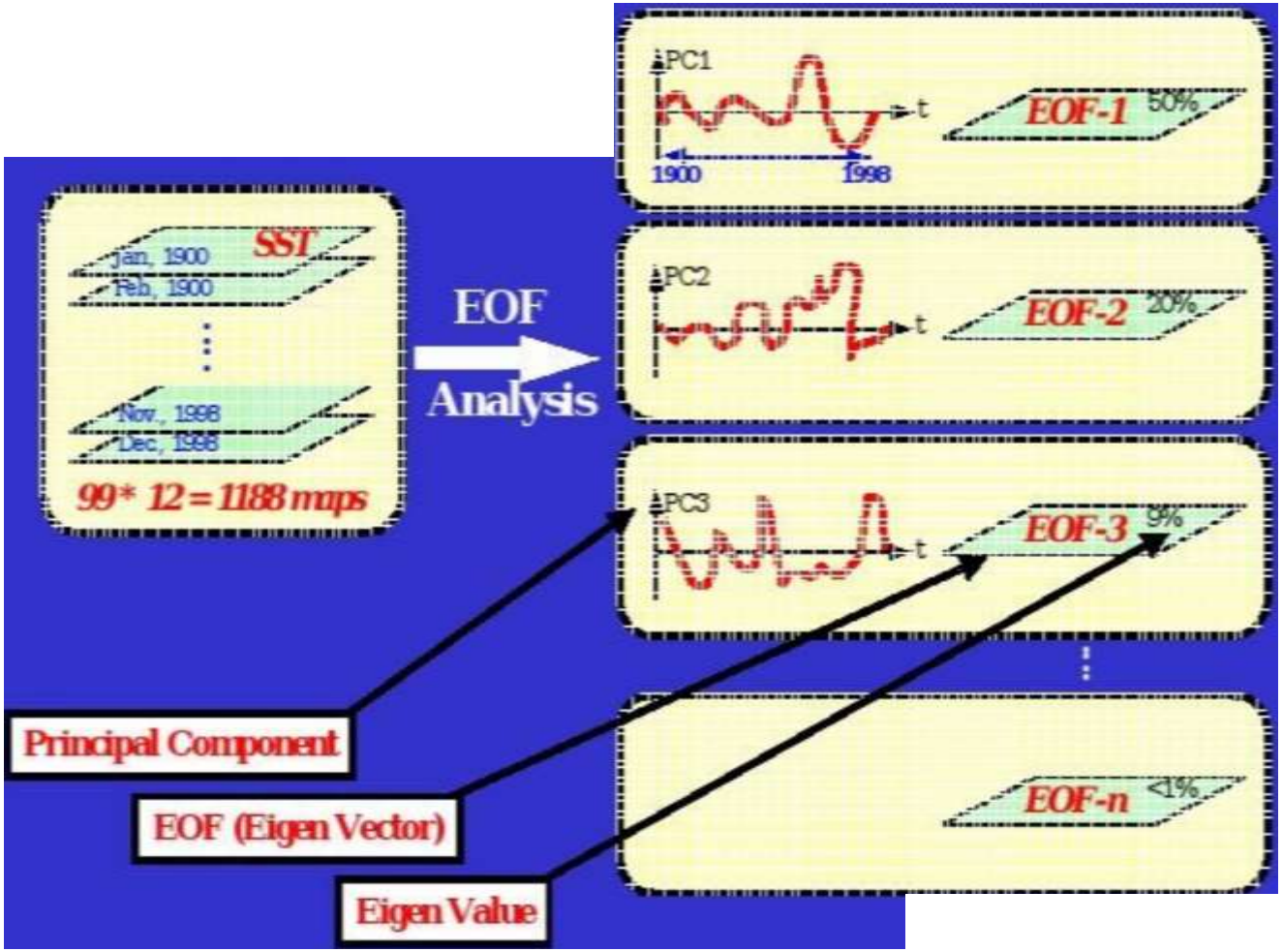
O_i is the ith of n observations

P_i is the ith of n model chlorophyll predictions

$\overline{O}$ and $\overline{P}$ are the satellite observation and model prediction averages

Métodos Estadísticos

Las EOF permiten cuantificar la varianza total de las series (Ejemp. clorofila, corrientes, viento, TSM, etc.) para obtener modos o estructuras espaciales (modo espacial) que contienen el mayor porcentaje de la varianza de la variable la que además fluctúa temporalmente (modo temporal).



Métodos Estadísticos

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 106, NO. D7, PAGES 7183–7192, APRIL 16, 2001

Summarizing multiple aspects of model performance in a single diagram

Karl E. Taylor

Diagrama que puede proporcionar un resumen estadístico conciso de qué “tan bien” coinciden entre sí los patrones en términos de su correlación, su diferencia de raíz cuadrática media y el radio de sus varianzas. Es especialmente útil para evaluar modelos.

$$R = \frac{\frac{1}{N}\sum_{n=1}^{N}(f_n - \bar{f})(r_n - \bar{r})}{\sigma_f \sigma_r}, \qquad (1)$$

$$E' = \left\{\frac{1}{N}\sum_{n=1}^{N}[(f_n - \bar{f}) - (r_n - \bar{r})]^2\right\}^{1/2}. \qquad (2)$$

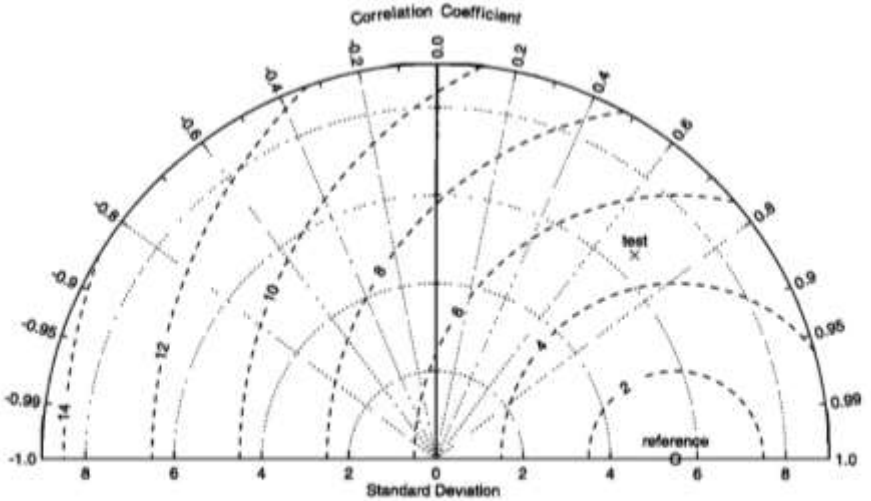
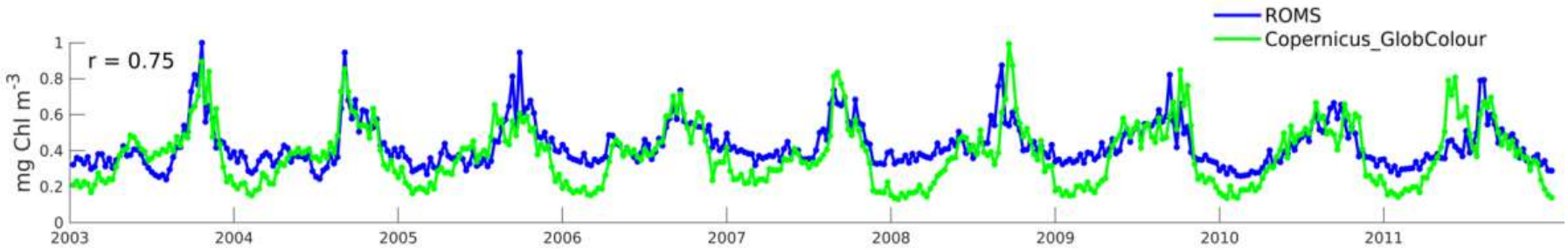
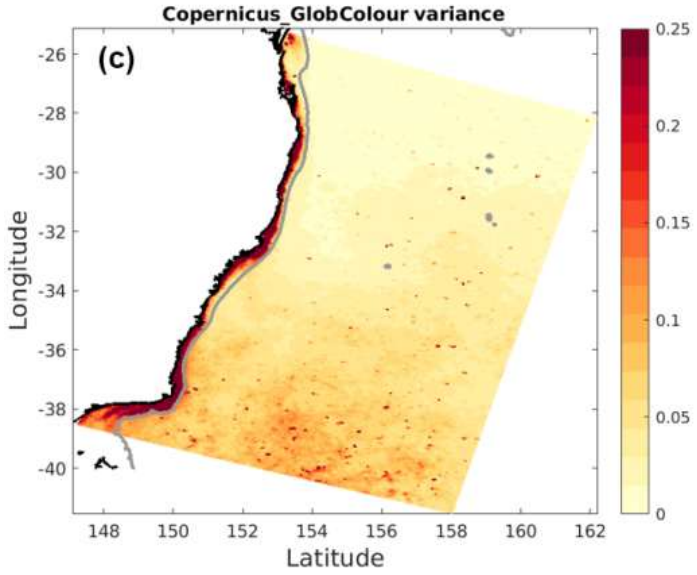
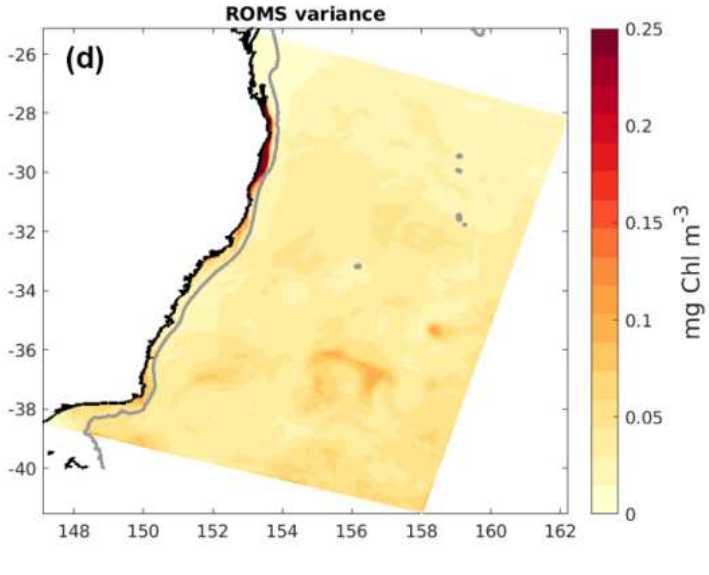


Figure 2. Diagram for displaying pattern statistics. The radial distance from the origin is proportional to the standard deviation of a pattern. The centered RMS difference between the test and reference field is proportional to their distance apart (in the same units as the standard deviation). The correlation between the two fields is given by the azimuthal position of the test field.

Métodos Estadísticos







Rocha et al. (2019)

Métodos Estadísticos

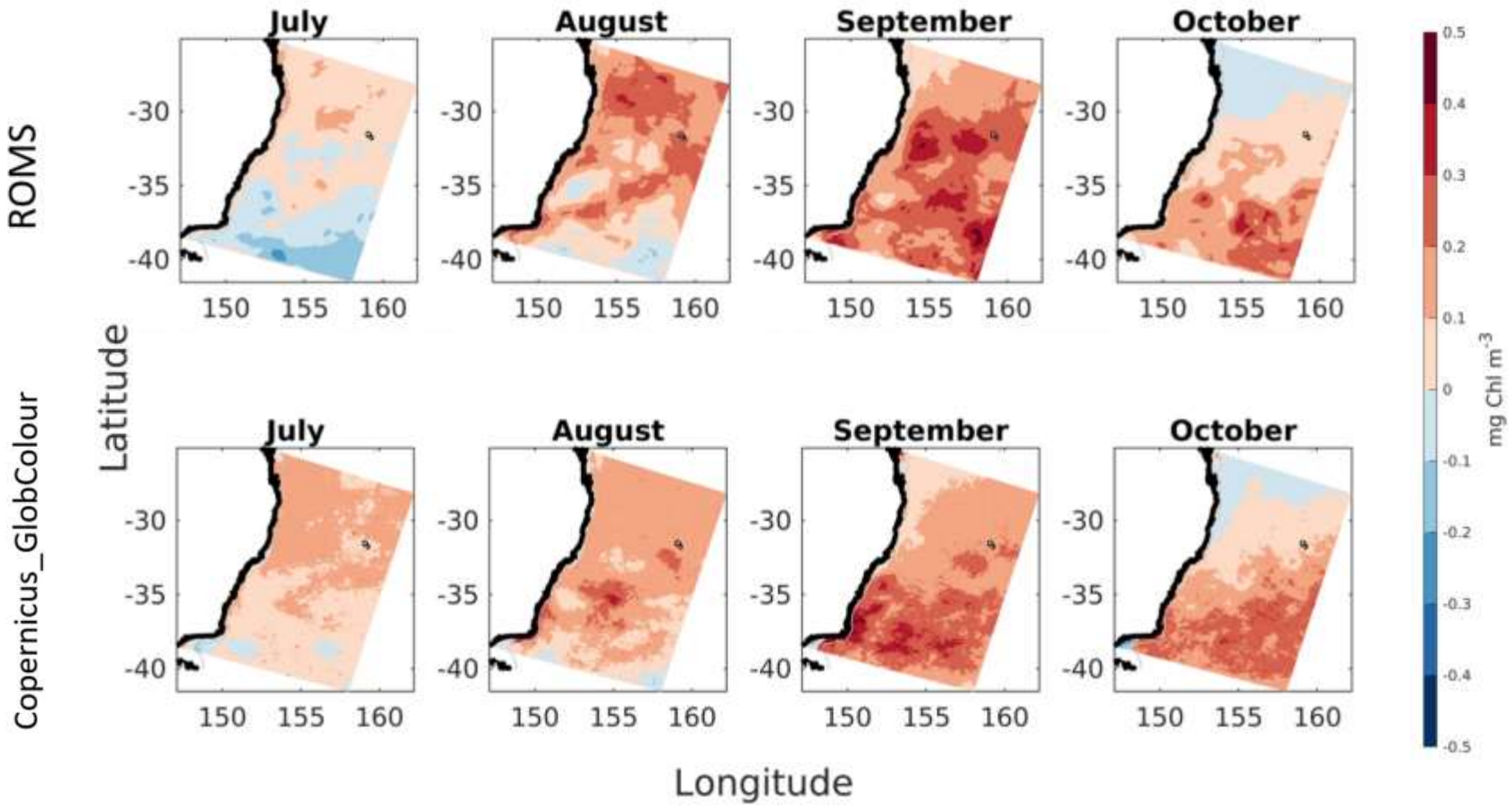


Figure 4. Monthly anomalies of chlorophyll concentration from model **(a)** and from satellite observations **(b)**

Rocha et al. (2019)

Métodos Estadísticos

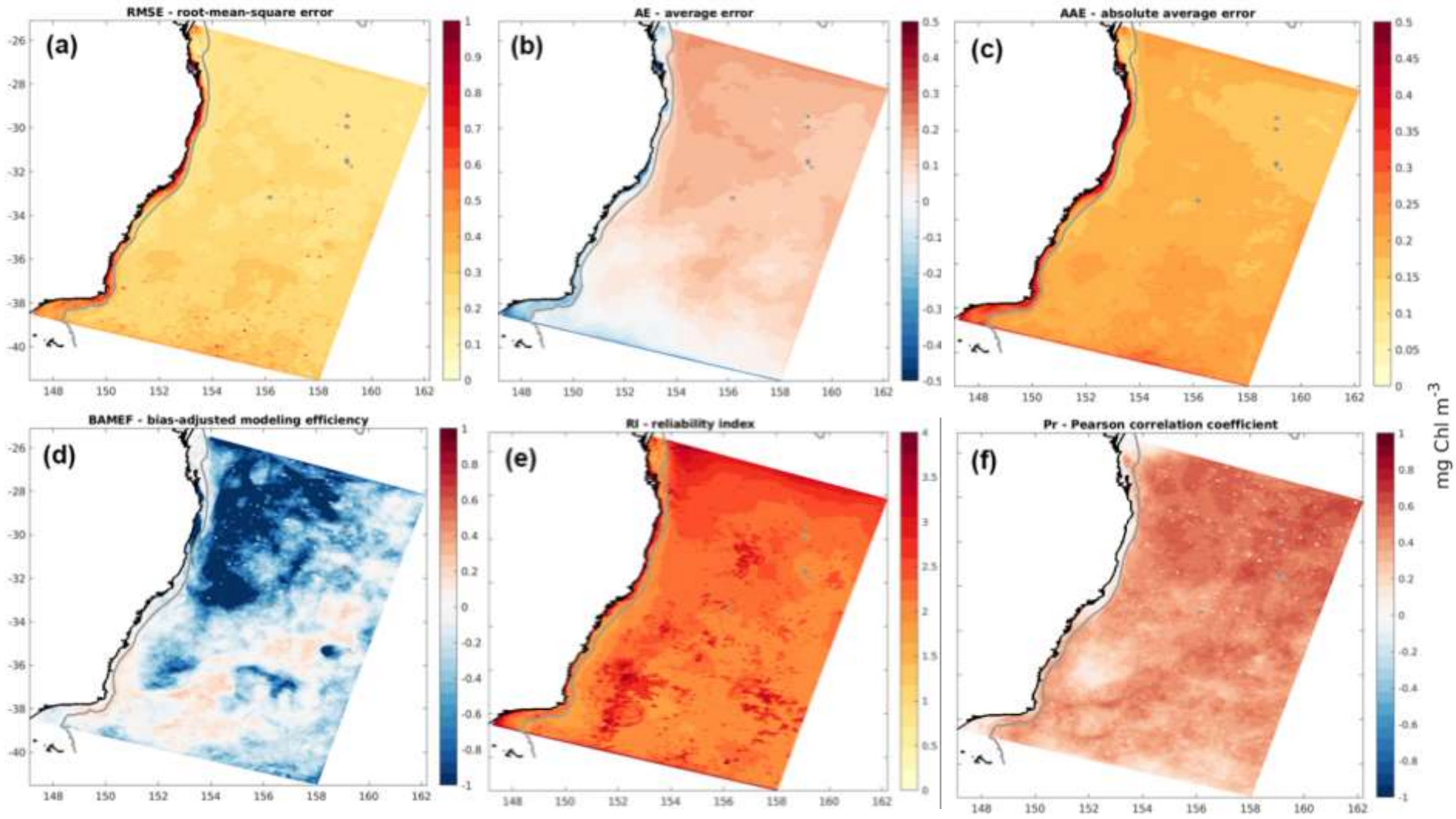
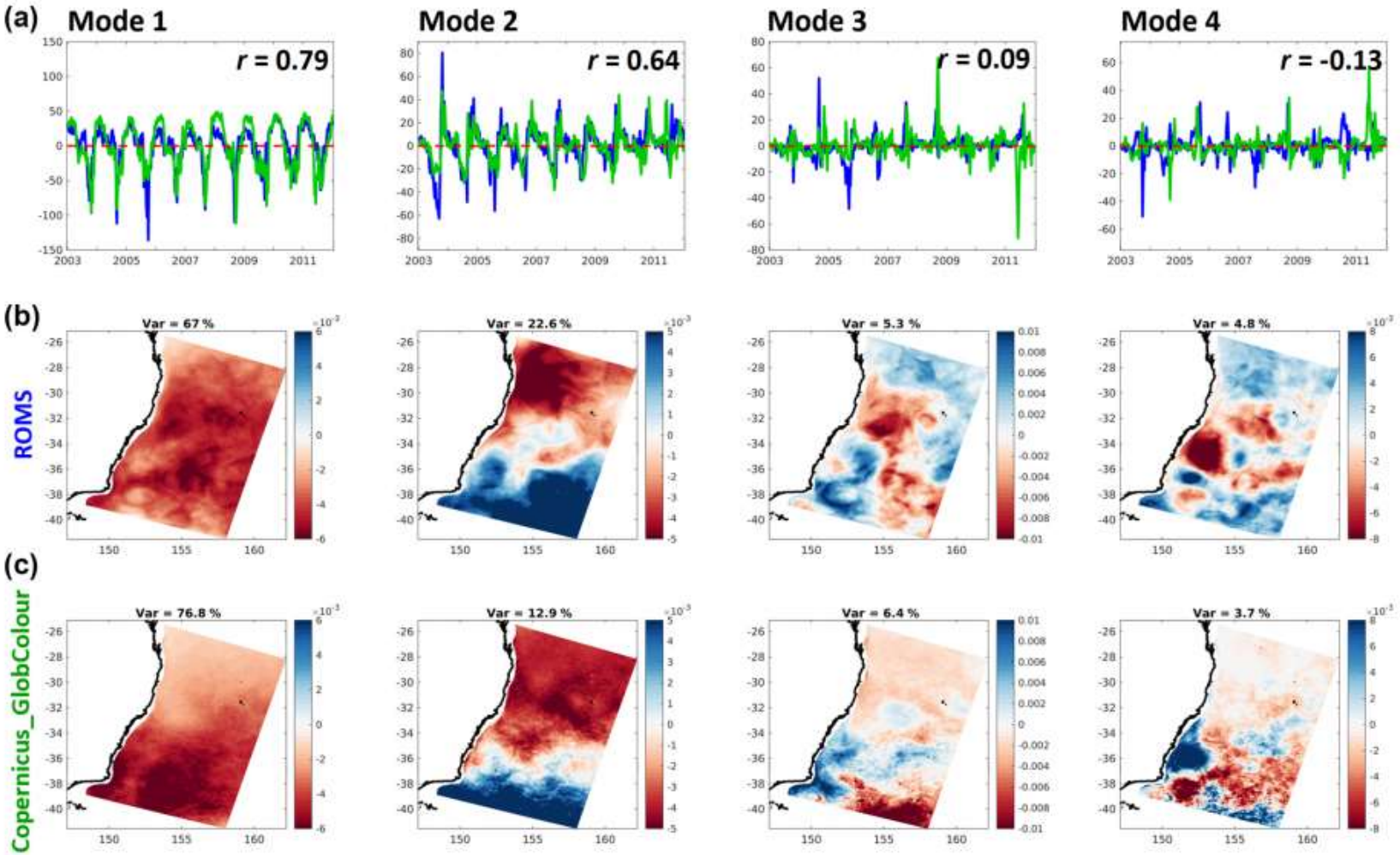


Figure 5. Maps of **(a)** root-mean-square error; **(b)** average error; **(c)** absolute average error; **(d)** bias-adjusted modelling efficiency; **(e)** reliability index; and **(f)** Pearson correlation coefficient generated by comparison of simulated 8-daily surface chlorophyll concentrations with 8-daily satellite observations.

Rocha et al. (2019)

Métodos Estadísticos

Empirical Orthogonal Function (EOF)



Rocha et al. (2019)

Métodos Estadísticos

Taylor Diagram

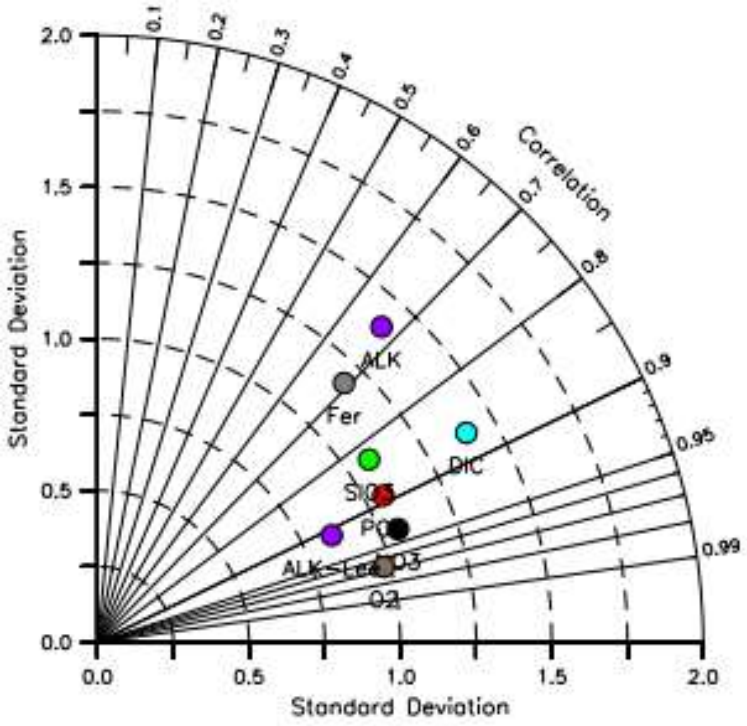


Figure 17. Taylor diagrams of model-observation comparisons for nutrients using monthly mean fields restricted to the top 100 m of the ocean

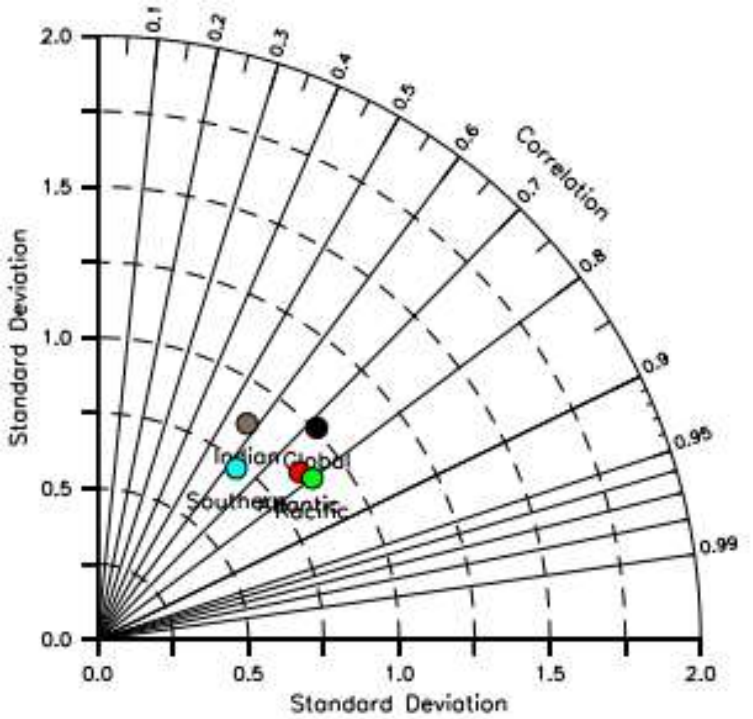
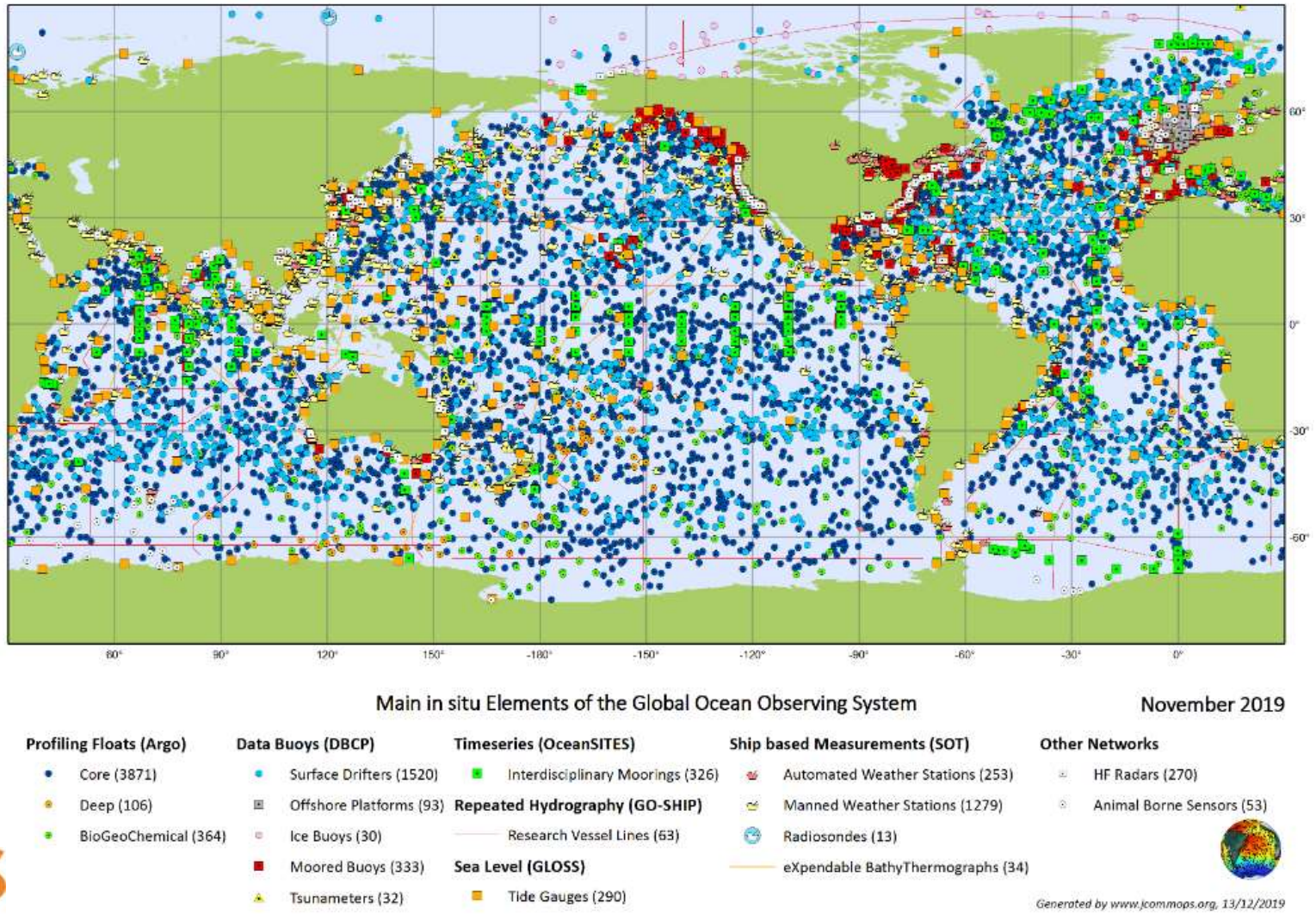


Figure 15. Taylor diagrams of model-observation comparisons for surface chlorophyll annual mean fields

Aumont et al. (2015)

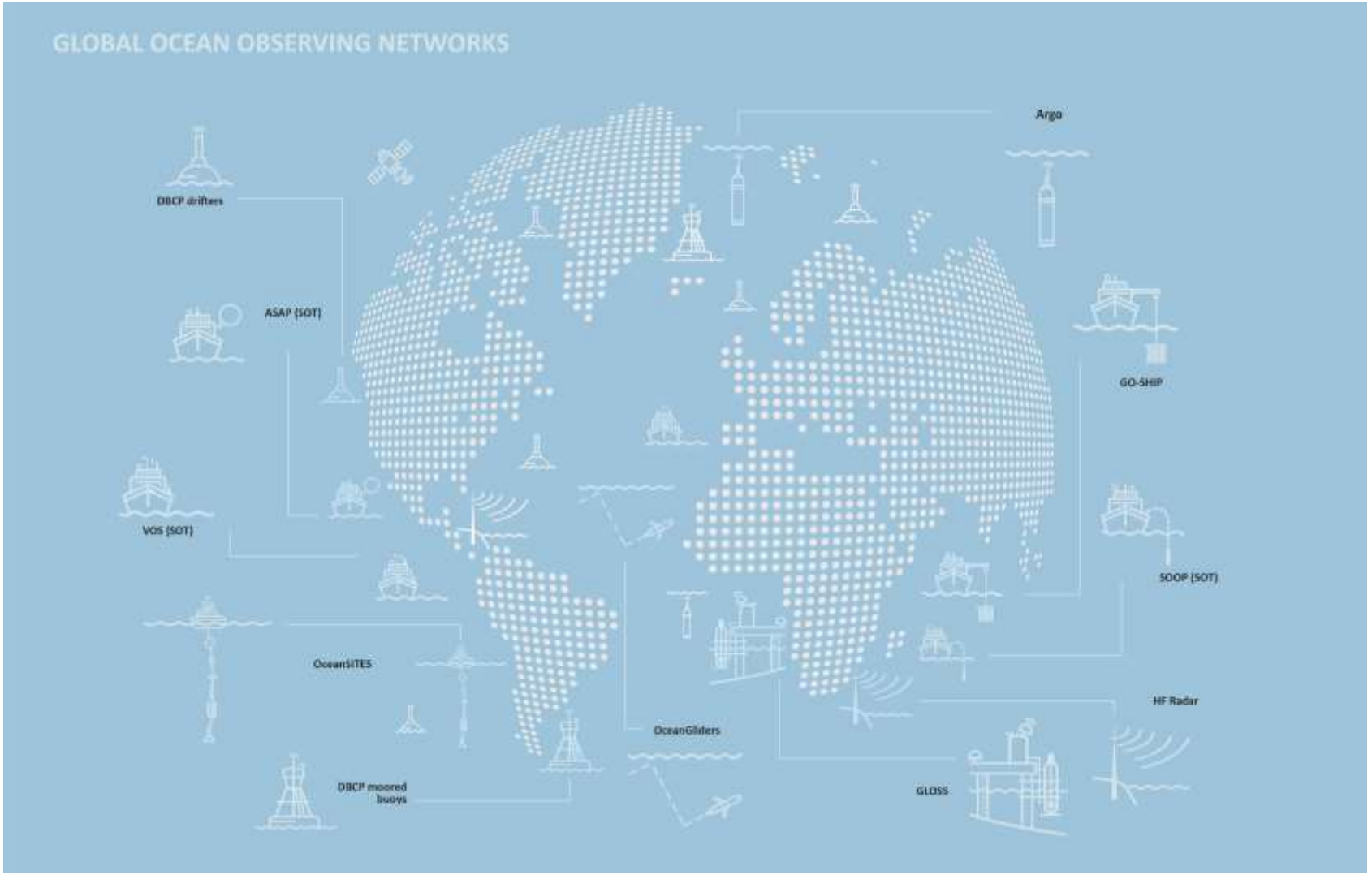
Bases de datos Globales Disponibles

- GOOS (http://www.goosocean.org/ : The global Ocean Observing System)



The Global Ocean Observing System

Bases de datos Globales Disponibles



The Global Ocean Observing System

https://uk-ioc.org/global-ocean-observing-system

Bases de datos Globales Disponibles

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Found 5 ocean products matching your criteria.

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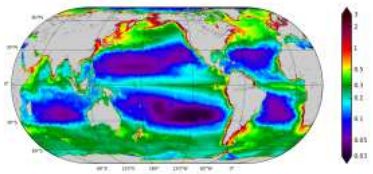
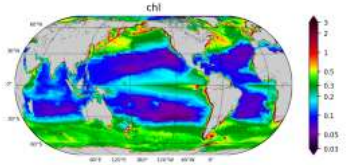
GLOBAL_ANALYSIS_FORECAST_BIO_001_028

GLOBAL OCEAN BIOGEOCHEMISTRY ANALYSIS AND FORECAST

MODEL	GLO
CHL PHYC O2 NO3 PO4 SI FE SPCO2 PH PP	
0.25 degree x 0.25 degree (50 depth levels)	
From 2018-07-07 to Present	
daily-mean,monthly-mean	
MORE INFO ADD TO CART WMS Sub-setting	

GLOBAL_REANALYSIS_BIO_001_029

GLOBAL OCEAN BIOGEOCHEMISTRY HINDCAST

MODEL	GLO
CHL PHYC O2 NO3 PO4 SI FE SPCO2 PH PP	
0.25 degree x 0.25 degree (75 depth levels)	
From 1993-01-01 to 2019-12-23	
daily-mean,monthly-mean	
MORE INFO ADD TO CART WMS Sub-setting	

https://resources.marine.copernicus.eu/?option=com_csw&task=results

Bases de datos Globales Disponibles

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

formerly the National Oceanographic Data Center (NODC)... more on NCEI

NCEI is transitioning to a new website and paths to data resources will be changing. Please contact NCEI.Info@noaa.gov with any questions of issues. See the new website at www.ncei.noaa.gov.

You are here: Home > Ocean Climate Laboratory > OCL Products

Data Sets & Products

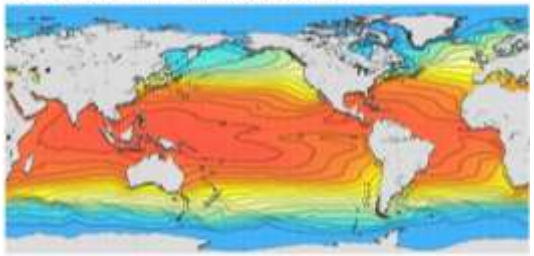
World Ocean Database and World Ocean Atlas Series

Note: The World Ocean Database 2018 expands (0.1 MB) and replaces all previous versions.

WODselect Online Data Retrieval System
The WODselect interface allows a user to search World Ocean Database using a user-specified search criteria. A distribution map and station count of these search criteria will give the user the option to have the data extracted and placed on the NODC FTP site.

- New WORLD OCEAN DATABASE Quarterly updates and new data added after the release of the WOD18
- New WORLD OCEAN ATLAS 2018 Climatological field and statistic data
- New WORLD OCEAN ATLAS 2018 FIGURES Climatological field and statistic figures
- MBT BIAS Depth and Temperature Corrections
- New REGIONAL CLIMATOLOGIES Regional climatological fields, statistic data, and figures
- WORLD OCEAN DATABASE 2013 Geographic and year sorted data
- WORLD OCEAN ATLAS 2013 V2 Climatological field and statistic data
- WORLD OCEAN ATLAS 2013 V2 FIGURES Climatological field and statistic figures
- WORLD OCEAN DATABASE 2009 Geographic and year sorted data
  *Important note about BT bias corrections in WOD09
- WORLD OCEAN ATLAS 2009 Climatological fields and statistics data files
- WORLD OCEAN ATLAS 2009 FIGURES Climatological field and statistic figures
- New GLOBAL OCEAN HEAT AND SALT CONTENT Temperature and salinity anomaly, and heat and salt content fields, data distrib

WORLD OCEAN ATLAS 2018 (WOA18)



The WOA18 updates previous versions of the World Ocean Atlas to include approximately 3 million new oceanographic casts added to the World Ocean Database and renewed quality control.

Access to WOA 2018 data

- Temperature (°C)
- Salinity (unitless)
- Dissolved Oxygen (µmol/kg)
- Percent Oxygen Saturation (%)
- Apparent Oxygen Utilization (µmol/kg)
- Silicate (µmol/kg)
- Phosphate (µmol/kg)
- Nitrate (µmol/kg)

The WOA18 temperature, salinity, oxygen, and nutrients fields are being released in July 2019. However data were still the peliminary files until August 27, 2019.

The WOA18 objective analyses and statistics data are presented in ASCII, comma separated value (CSV), ArcGIS compatible and netCDF formats.

For any questions about this product, please e-mail OCLhelp desk.

https://www.nodc.noaa.gov/OC5/woa18/woa18data.html

Bases de datos Globales Disponibles

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- Salinity
- Nutrients
- Bathymetry
- SST
- Sea level
- Surface pressure
- Surface winds
- Precipitation
- Ocean currents
- Sensible heat flux
- Latent heat flux
- Short wave radiation
- Long wave radiation
- Net heat flux
- Clouds
- Air temperature
- Humidity

Data

Search Dataset Titles:

- CSIRO Atlas of Regional Seas (CARS) LAS LAS 8 OPeNDAP DChart ERDDAP
- World Ocean Atlas (Levitus; WOA) LAS LAS 8 OPeNDAP DChart ERDDAP
- World Ocean Database 2013 OPeNDAP DChart

ERDDAP > griddap > Make A Graph

Dataset Title: CSIRO Atlas cars2006 nit
Institution: APDRC (Dataset ID: hawaii_soest_d7fc_ffbe_3019)
Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Data Access Form

Graph Type: surface
X Axis: longitude
Y Axis: latitude
Color: nit

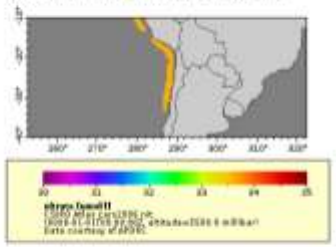
Dimensions | Start | Stop
time (UTC) | specify just 1 value → | 0000-01-01T00:00:00Z
LEV (millbar) | specify just 1 value → | 5500.0
latitude (degrees_north) | -40.0 | -10.0
longitude (degrees_east) | 253.0 | 322.5

Graph Settings
Color Bar: Rainbow | Continuity: | Scale: Linear
Min: 30 | Max: 35 | N Sections:
Draw the land mask:
Y Axis Minimum: | Maximum: | ascending

Redraw the Graph (Please be patient. It may take a while to get the data.)

Optional
Then set the File Type: .htmlTable and Download the Data or an Image
or view the URL: http://apdrc.soest.hawaii.edu/erddap/griddap/hawaii_soest_d7fc_ffbe_3019.htmlTable?nit[]
(Documentation / Bypass this form) (File Type information)

Click on the map to specify a new center point.
Zoom: Data Out 8x Out 2x Out In In 2x In 8x



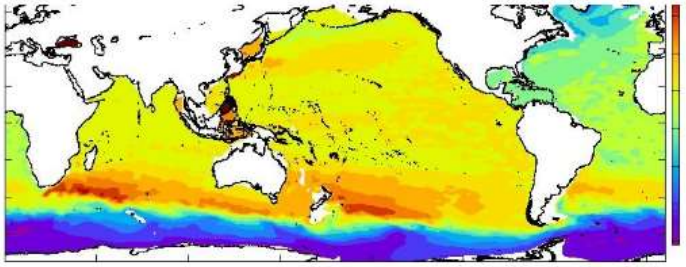
http://apdrc.soest.hawaii.edu/datadoc/cars2009.php/

Bases de datos Globales Disponibles

CSIRO ATLAS OF REGIONAL SEAS (CARS)

CARS is a digital climatology, or atlas of seasonal ocean water properties. It comprises gridded fields of mean ocean properties over the period of modern ocean measurement, and average seasonal cycles for that period. It is derived from a quality-controlled archive of all available historical subsurface ocean property measurements - primarily research vessel instrument profiles and autonomous profiling buoys. As data availability has enormously increased in recent years, the CARS mean values are inevitably biased towards the recent ocean state.

A number of global ocean climatologies are presently available, such as NODC's World Ocean Atlas. CARS is different as it employs extra stages of in-house quality control of input data, and uses an adaptive-lengthscale loess mapper to maximise resolution in data-rich regions, and the mapper's "BAR" algorithm takes account of topographic barriers. The result is excellent definition of oceanic structures and accuracy of point values.



Dynamic height 1000/2000m revealing global deep circulation, derived from CARS2009

Mapped Properties

Water properties	Versions	Units	Derived properties	Units	Versions
temperature	2009, Argo-only	DegC (detail)	Bottom water	.	2009
salinity	2009, Argo-only	PSU (detail)	Mixed Layer Depth	m	2009, Argo-only
oxygen	2009	ml/l (detail)	Dynamic Height wrt 2000m	m	2009, Argo-only
nitrate	2009	umol/l (detail)	.	.	.
silicate	2009	umol/l (detail)	.	.	.
phosphate	2009	umol/l (detail)	.	.	.

CARS2009

CARS2009 covers the full global oceans on a 1/2 degree grid, but until June 2011 only included temperature and salinity fields. The T and S fields were created in July 2009 and were was based on World Ocean Database 2005 (WOD05) [July 2008 Update], surface-pressure-corrected Argo global archives to May 2009, WOCE Global Hydrographic Program (v3.0), and many other datasets available up to 2008. See the updates section below for history of occasional sub-version releases. The nutrient fields created in June 2011 were based on WOCE and WOD09 (March 2011 download).

http://www.marine.csiro.au/~dunn/cars2009