Lessons Learned in AOMIP
(Arctic Ocean Model Intercomparison Project)

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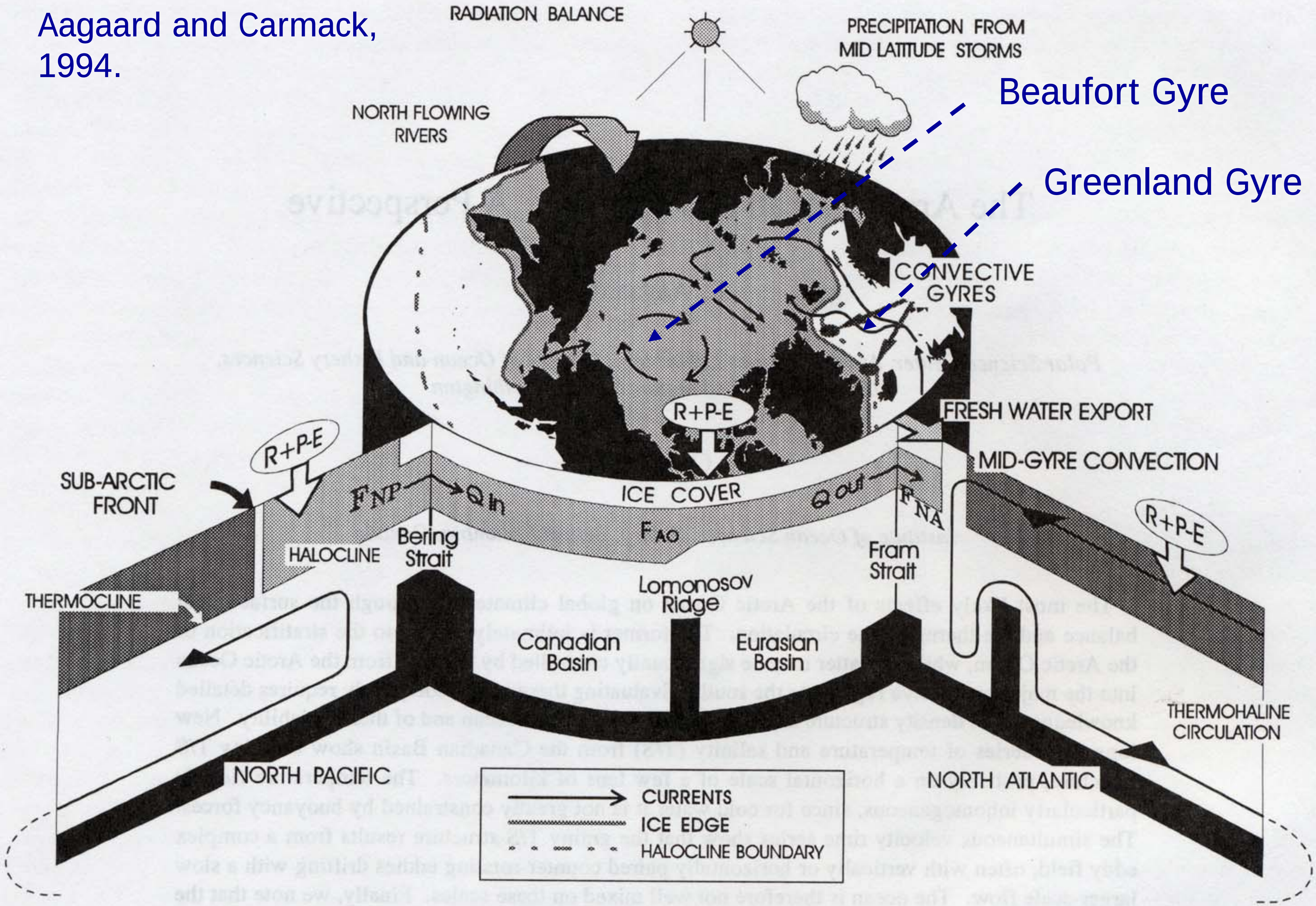
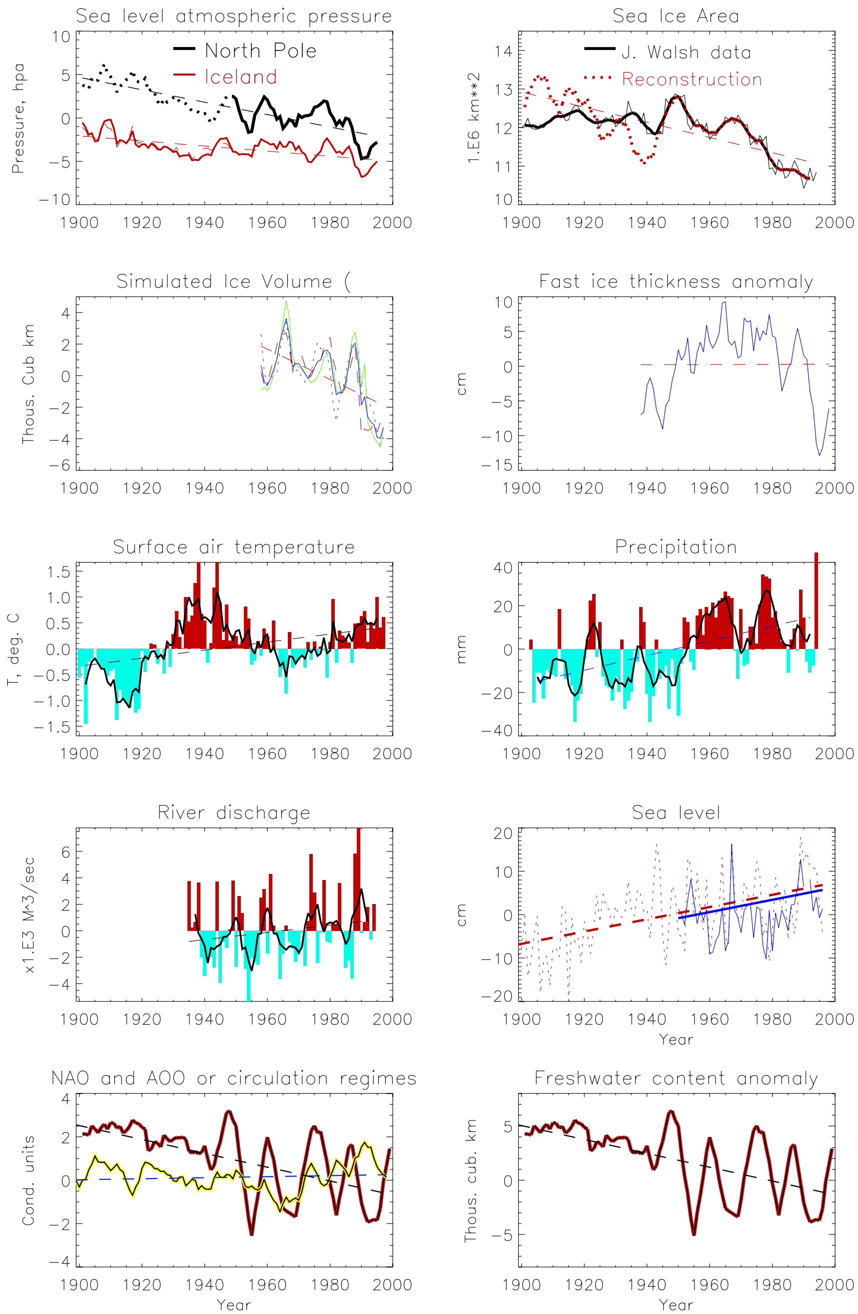
Woods Hole Oceanographic Institution
Arctic Group

Outline:

- AOMIP: goals and objectives
- Intercomparison and science themes
- Preliminary steps
- Coordinated experiments
- Major accomplishments
- Results, lessons and future plans

Aagaard and Carmack, 1994.





SUMMARY:

Variability of all parameters listed here is consistent with our understanding of climate change in the Arctic and we can conclude that with global warming SLP decreases over the Arctic, ice area, ice thickness, and ice volume decrease, air temperature, precipitation, sea level, river discharge, permafrost temperature increase and wind driven ice and water circulation alternates between cyclonic and anticyclonic. Climatic indices show more or less stable conditions before 1940th and then have a well pronounced decadal variability and trends associated with the increase of cyclonicity over the Arctic Ocean.

AOMIP: goals (1)

- The overarching project goal is to determine major directions for Arctic Ocean model improvements based on coordinated numerical experiments and intercomparisons across an international suite of participating models.

One of the most difficult tasks is to identify causes of differences among model results and causes of differences between model results and observations.

A logical continuation of this work (when causes of differences are identified) is model improvement based on implementation of new physics and parameterizations. Diagnostic and specially designed studies will address model- model and model-observations differences.

AOMIP: goals (2)

- The second goal is to investigate the variability of the Arctic Ocean climate at seasonal to decadal time scales based on model results and observations.

A community-based modeling approach provides the unique opportunity to coordinate the investigation of different aspects of Arctic Ocean dynamics and thermodynamics because it allows for the purposeful design of a set of carefully-planned numerical experiments covering the most important processes and interactions. A clear advantage is that each PI will be able to work with his or her specific research theme using simulation results from all AOMIP models, and will be able to analyze differences among all model results. This approach will allow AOMIP PIs to carry out comprehensive studies of different processes and interactions, and to investigate their temporal and spatial variability.

AOMIP: objectives (1)

Project objectives for model intercomparison and improvement studies:

- Run and analyze 50-year and 100-year coordinated AOMIP model simulations and determine major differences among model results and differences between model results and observations;
- determine major causes of model errors and propose model improvements;
- design a set of idealized numerical experiments in order to test improved models; and
- repeat 50-year and 100-year coordinated experiments with improved models.

AOMIP: objectives (2)

The second AOMIP objective is to tackle major research questions in Arctic Ocean science:

- Accumulation and Release of Freshwater in the Arctic Ocean
- Processes of Shelf-basin Interactions in Different Regions of the AO based on High and Very High-Resolution Results
- Role of Thermohaline and Wind-driven Forcing in the Arctic Ocean Circulation
- Processes of Mixing in the Arctic Ocean
- Processes of Sea Ice Dynamics and thermodynamics
- Origin and variability of the Atlantic Water Circulation in the Arctic Ocean
- Interactions with the North Atlantic in collaboration with Global Ocean circulation projects

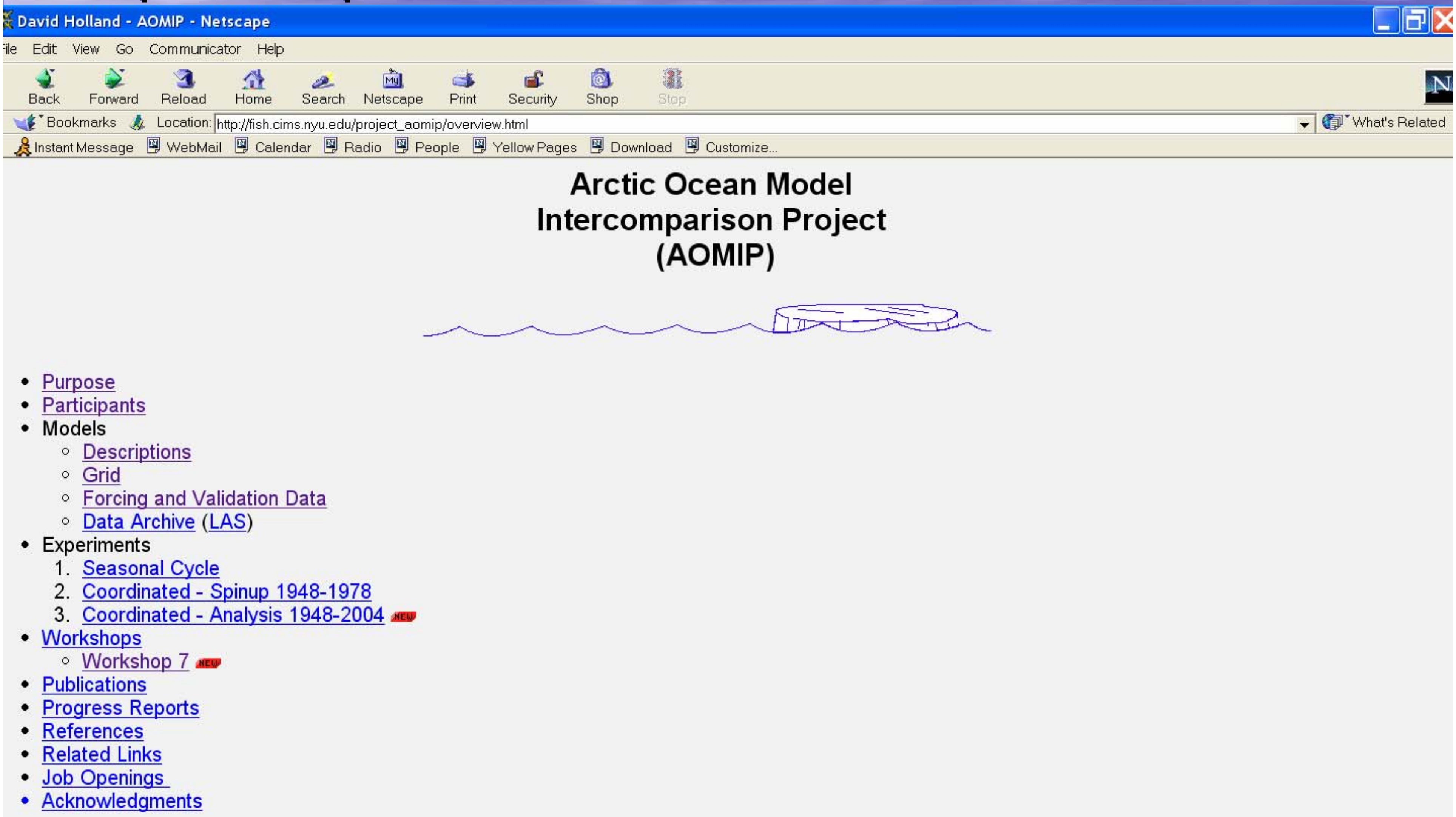
Project Organization:

- Project web site reflects AOMIP activity and also is used for data exchange

- The most important element of the web site is Live Access Server (LAS). This is a node of the National Virtual Ocean Data System (NVODS). This cyber infrastructure allows for efficient model-data exchange among AOMIP participants.

- The AOMIP common-forcing data sets, archived at the AOMIP website, are available through the AOMIP-LAS. The model results from each AOMIP group are stored on a group's home-institute website but are directly accessible to all through the AOMIP-LAS.

a) New York University (D. Holland)
http://fish.cims.nyu.edu/project_aomip/overview.html
b) Planetwater (G. Holloway):
http://www.planetwater.ca/research/AOMIP.html



Models: currently we have

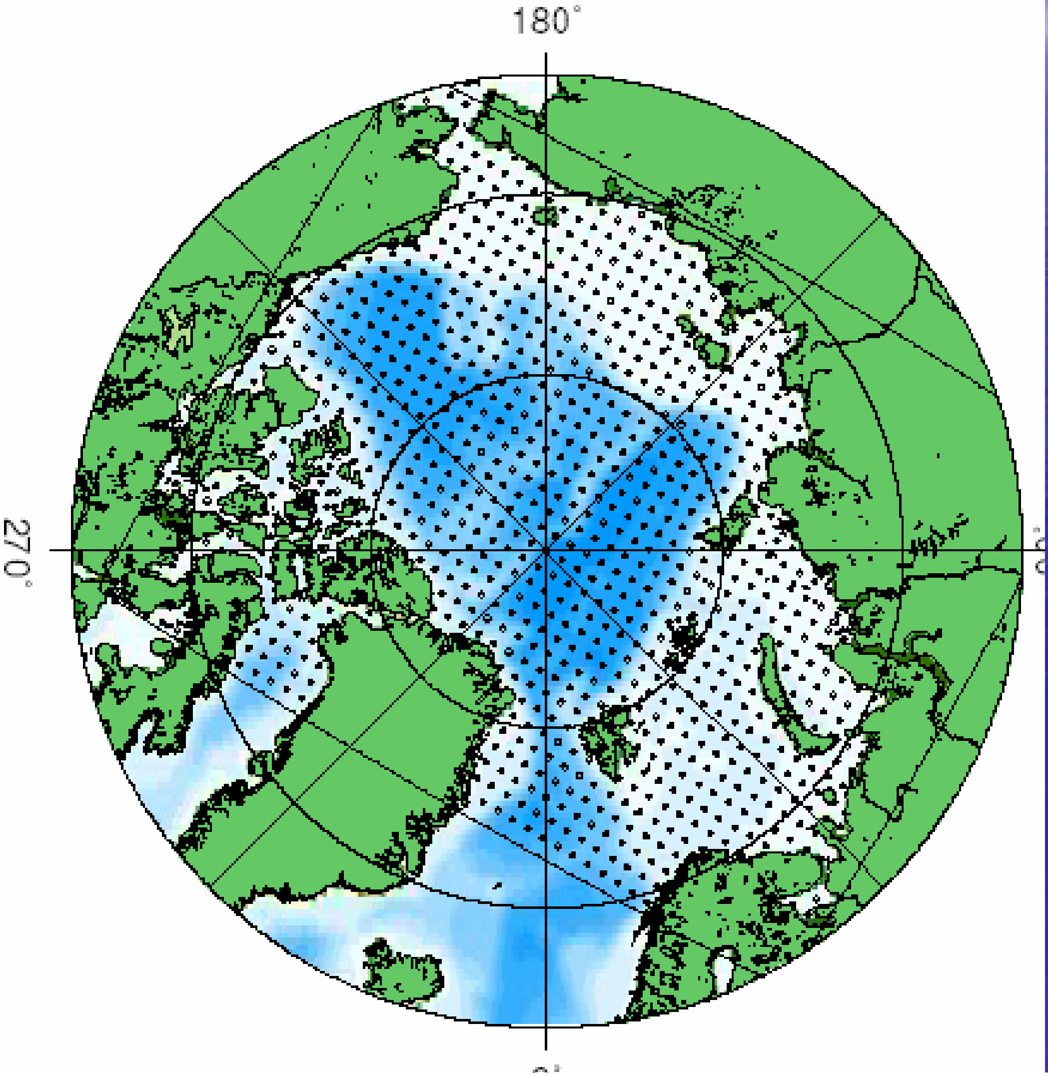
AOMIP Model ID	AWI	GSFC	IARC	ICMMG	IOS	LLN
Home Institute	Alfred Wegener Institute	Goddard Space Flight Center	International Arctic Research Center	Institute of Computational Mathemetics and Mathematical Geophysics	Institute of Ocean Sciences	Louvain La Neuve
Ocean Model Pedigree	MOM	POM	POM	Finite Elements	MOM	OPA
Coupled Sea-Ice Model	Yes	Yes	Yes	Yes	Yes	Yes

AOMIP Model ID	NPS	NYU-a	NYU-b	RAS	UW
Home Institute	Naval Postgraduate School	New York University	New York University	Russian Academy of Sciences	University of Washington
Ocean Model Pedigree	MOM	MICOM	MOM	Finite Element	MOM
Coupled Sea-Ice Model	Yes	Yes	Yes	Yes	Yes

Model details:

AOMIP Model ID	AWI	GSFC	IARC	IOS	LLN	NPS	NYU	RAS	UW
Barotropic/Baroclinic Treatment							Split-explicit		
Horizontal Advection Scheme							Potential-Vorticity Conserving, Sadourny (1975)		Centered-differencing
Horizontal Mixing							Laplacian		
Horizontal Diffusivity (m^2/s)							1.00e-3 x (grid-cell width)		
Vertical Mixing							Laplacian layer-interfacial friction		
Vertical Diffusivity (m^2/s)							1.00e-5		

AOMIP model intercomparison region for all models



This region is represented by a latitude-longitude grid with a spatial resolution of 1 degree (now this grid has resolution of 0.5 degree which represents much better individual model results).

Intercomparison approach

- Each group/scientist is responsible for analysis and intercomparison activity for one or two parameters or processes and:
- Collects data representing this parameter from all models using LAS
- Carries out intercomparison, analyzes results, prepares publications and proposes model improvements
- Major results, plans and other project activity are discussed during annual workshops

- Principal Investigator (PI) responsibilities for model intercomparisons and improvements:

- community awareness of AOMIP - Proshutinsky;
- sea level variability - Proshutinsky;
- horizontal volume transports - Holloway;
- vertically-integrated heat and freshwater contents - Holloway;
- kinetic and potential energy budgets - Holland, Uotila;
- transports through lateral boundaries - Hakkinen, Maslowski;
- volumetric temperature and salinity analysis - Steele, Zhang;
- surface heat and freshwater fluxes - Steele, Zhang;
- sea-ice deformation fields - Hibler;
- sea-ice concentration, thickness, drift - Gerdes and Koeberle;
- Atlantic water parameters and dynamics - Karcher, Steele;
- data collection from observations and from model results - Johnson, Makshtas, Uotila.

Model Initialization and Forcing

To ensure an accurate intercomparison experiment, and to eliminate ambiguities in interpretation of model results, it is necessary to force and validate all models in as similar a manner as possible. To this end, we have collected and created a variety of standardized model forcing and validation data sets:

- For bathymetry, we have created a global merged data product that blends the InternationalBathymetric Chart of the Arctic Ocean data with the Earth Topography Five Minute data (Holland, 2000).
- For river-runoff, we will be using the hydrographic data product for the arctic region developed at the University of New Hampshire (Lammers et al., 2000). For sea-ice we will use data sets archived at the National Snow and Ice Data Center (NSIDC).
- For hydrography, we have produced a global merged data product , where various high-quality Arctic Ocean data sets have been blended with the World Ocean Atlas (Steele et al., 2001).
- For atmospheric forcing, we will be using derived reanalysis products from the National Centers for Environmental Protection (NCEP).

AOMIP experiments

- The first AOMIP experiment involved an intercomparison of the seasonal cycle of the various AOMIP models. That experiment did not involve common forcing, but rather each AOMIP model was run using forcing data sets exactly as had been used by any given model prior to the beginning of the AOMIP.
- The second (and current) AOMIP experiment involves a coordinated intercomparison of the last 50 years (1948 - present) as simulated by the various AOMIP models using a carefully-defined common forcing data set. The experiment consists of a coordinated spin-up phase (1948 - 1978) and a coordinated analysis phase (1979 - 2004).
- In the future, a third AOMIP experiment will be carried out involving a coordinated intercomparison of the last 100 years (1901 - present).

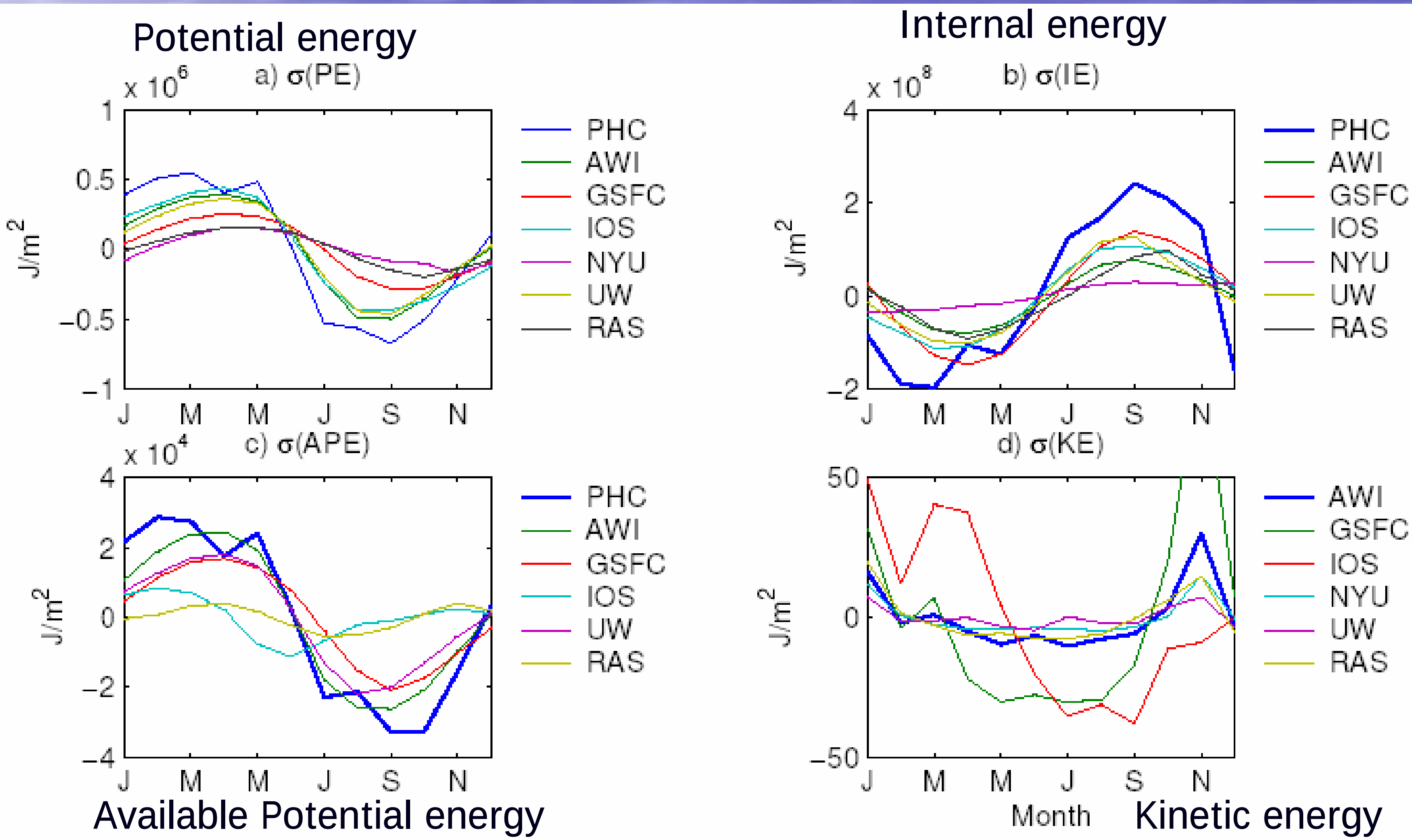
Some results:

-Energy

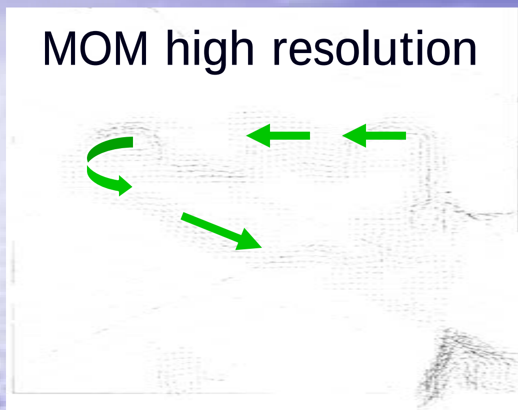
-Atlantic water circulation

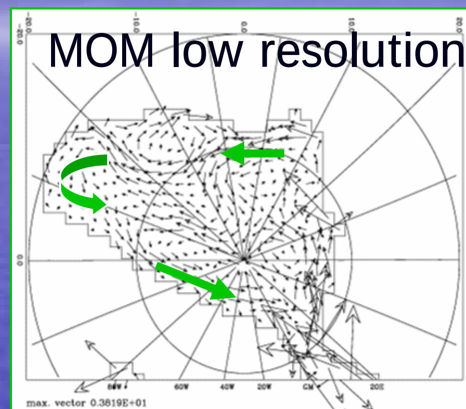
-Freshwater content

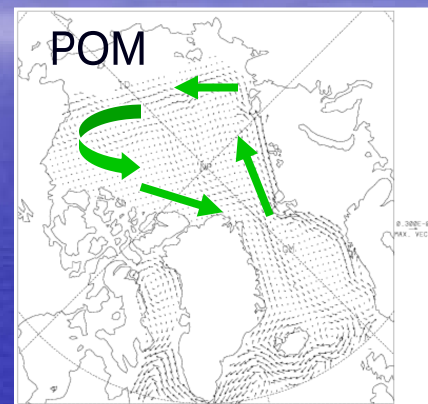
Seasonal variability of ocean energy (Uotila et al., 2004, submitted)

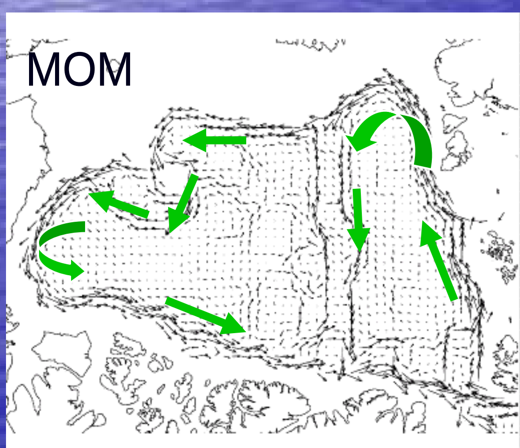


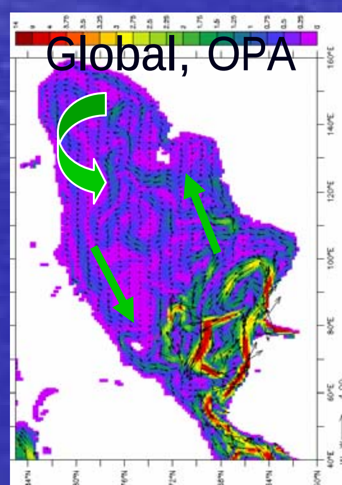
Models with cyclonic circulation of Atlantic water





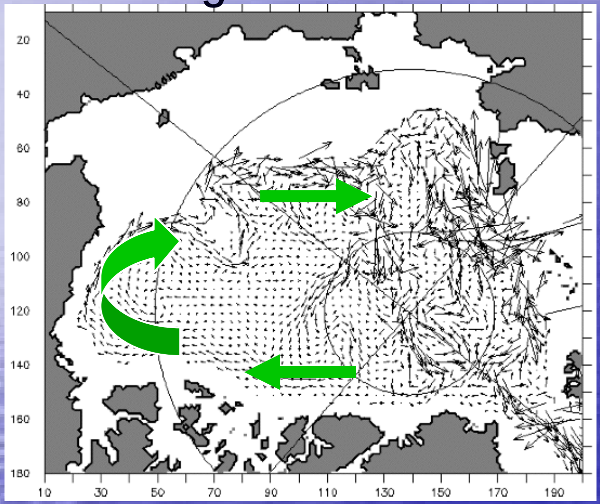




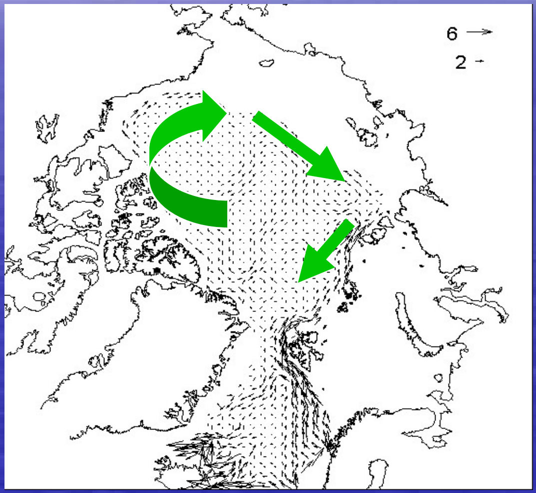


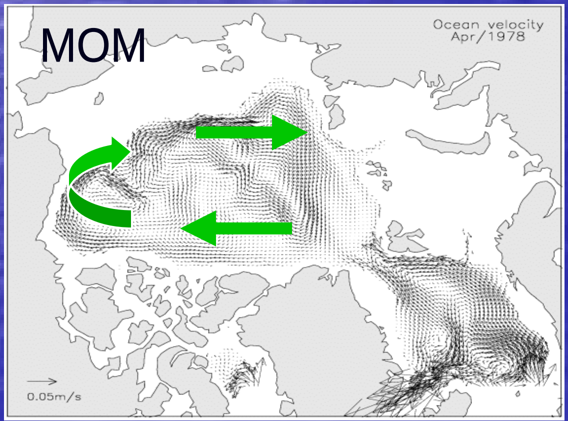
Models with anticyclonic circulation of Atlantic layer

MOM high resolution

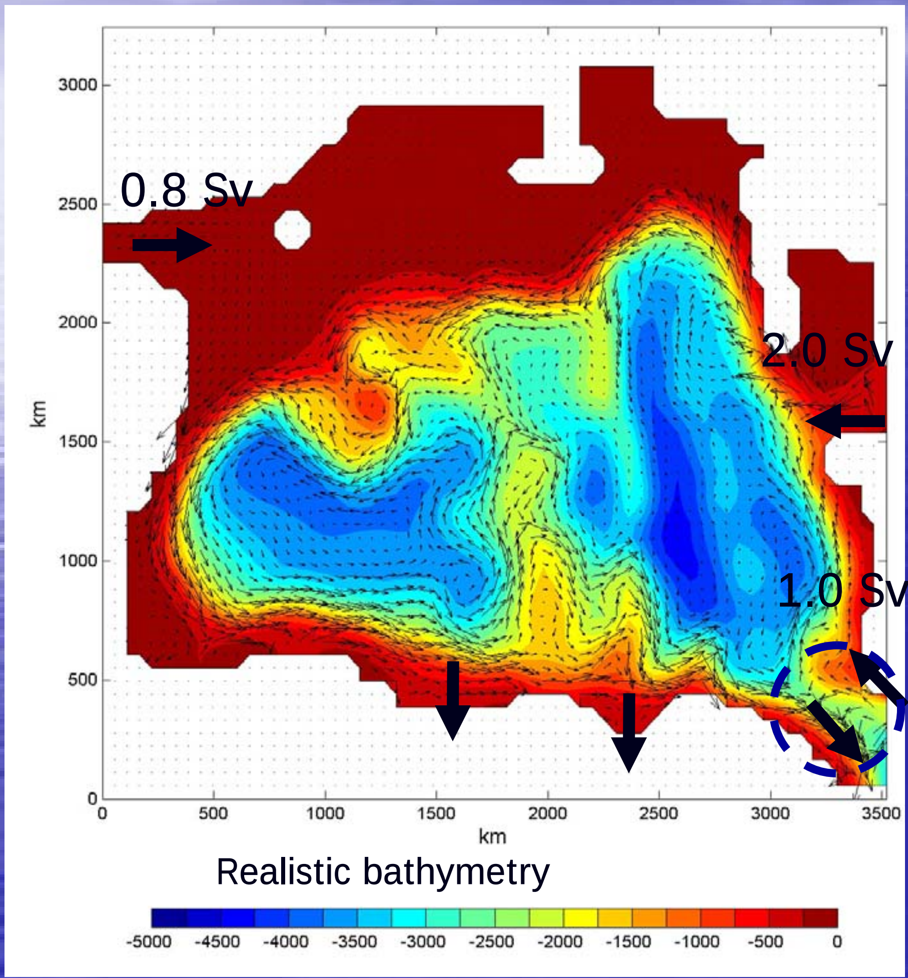


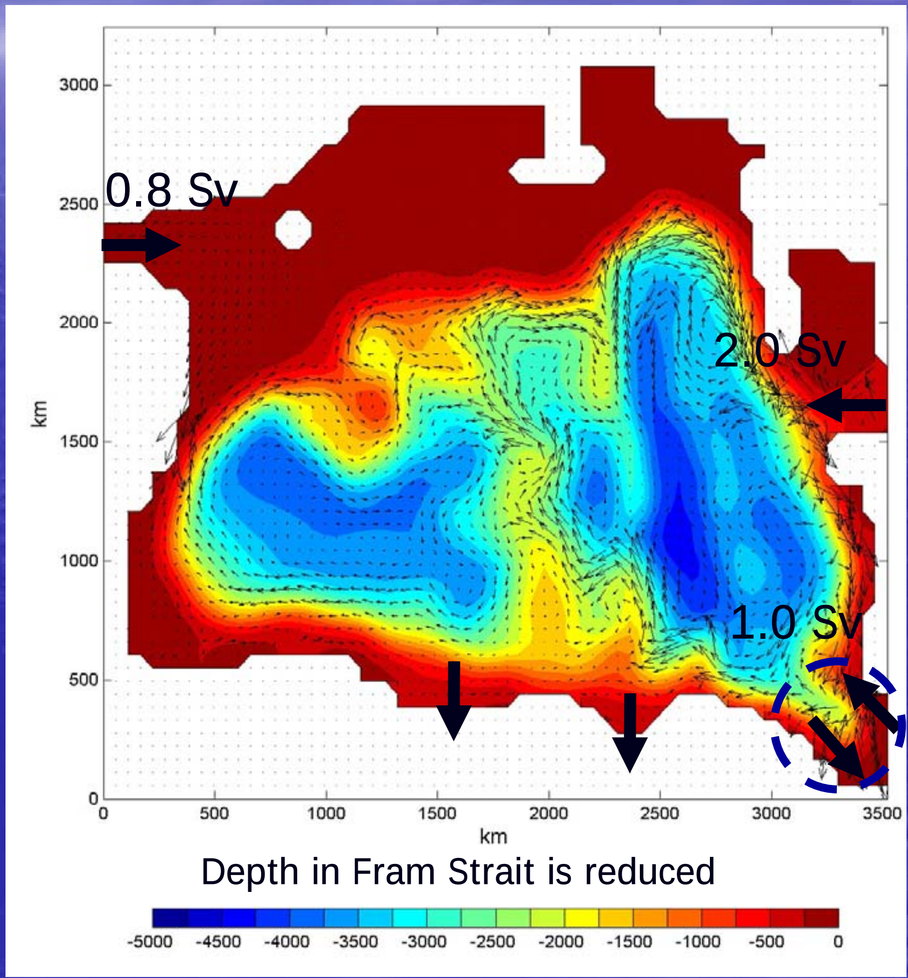
Finite elements



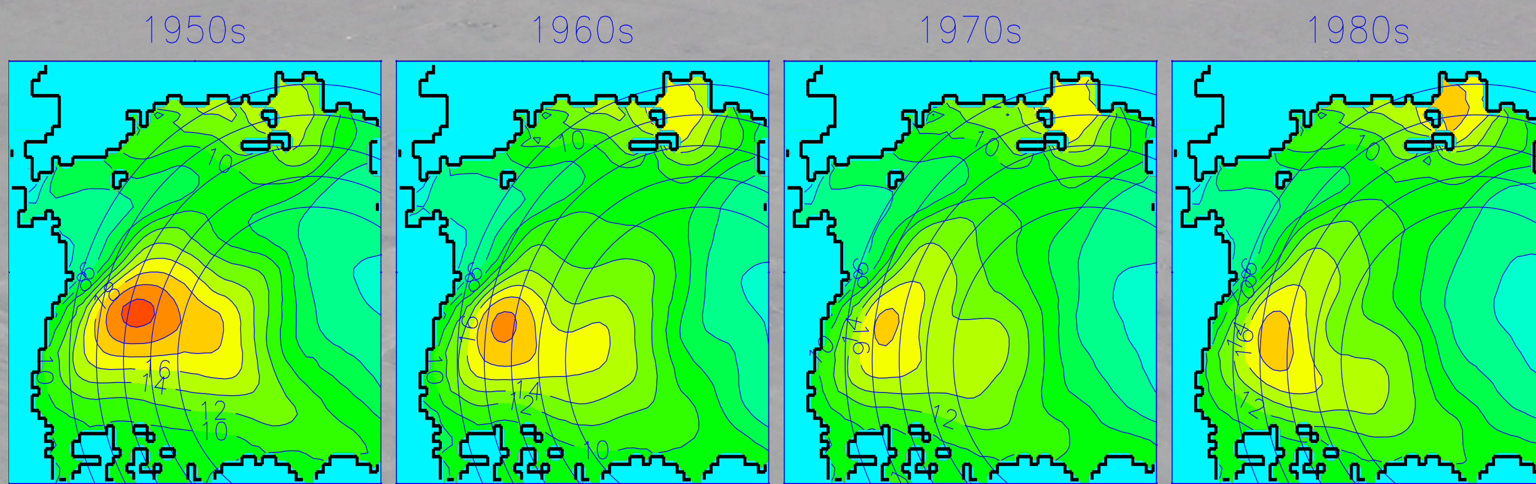


Circulation and potential vorticity (courtesy of Jiayan Yang, WHOI)

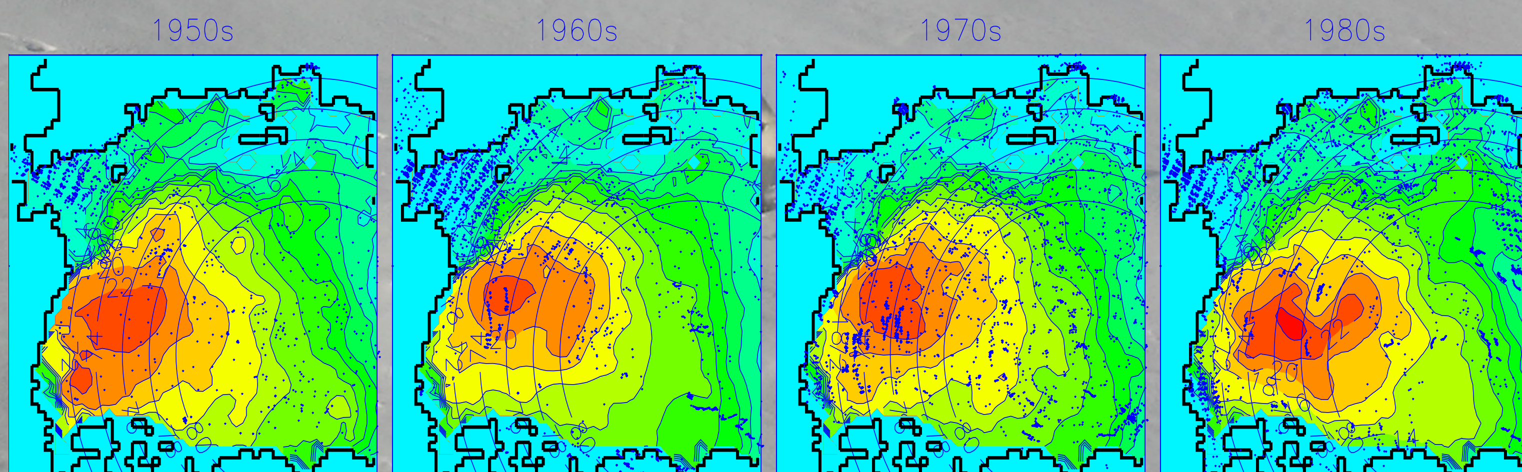




Freshwater content variability



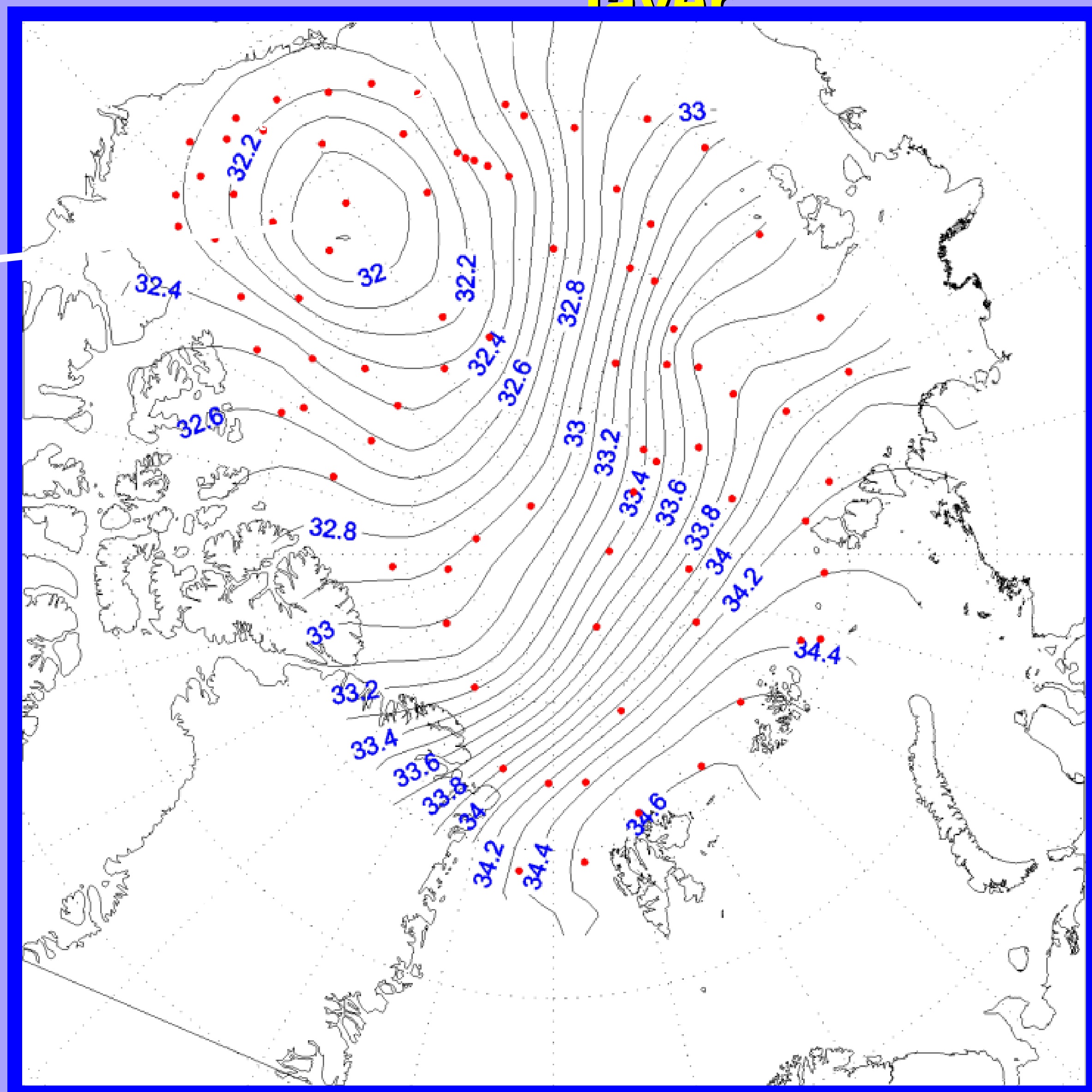
Based on results of Alfred Wegener high resolution Arctic Ocean Model



Based on observations (Environmental Working Group Atlas, EWG-1998)

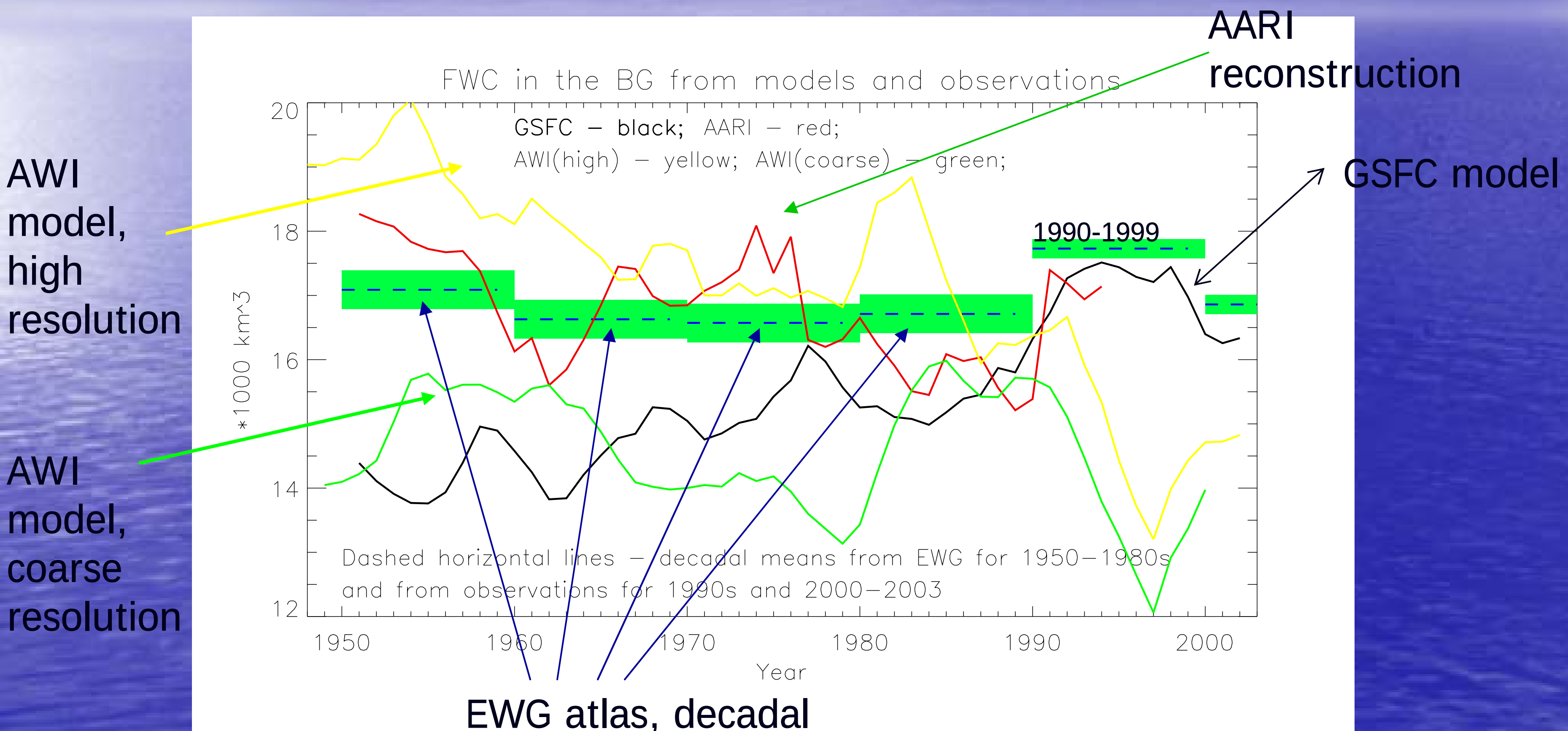
Typical salinity distribution in the upper 200-meter layer

Beaufort Gyre



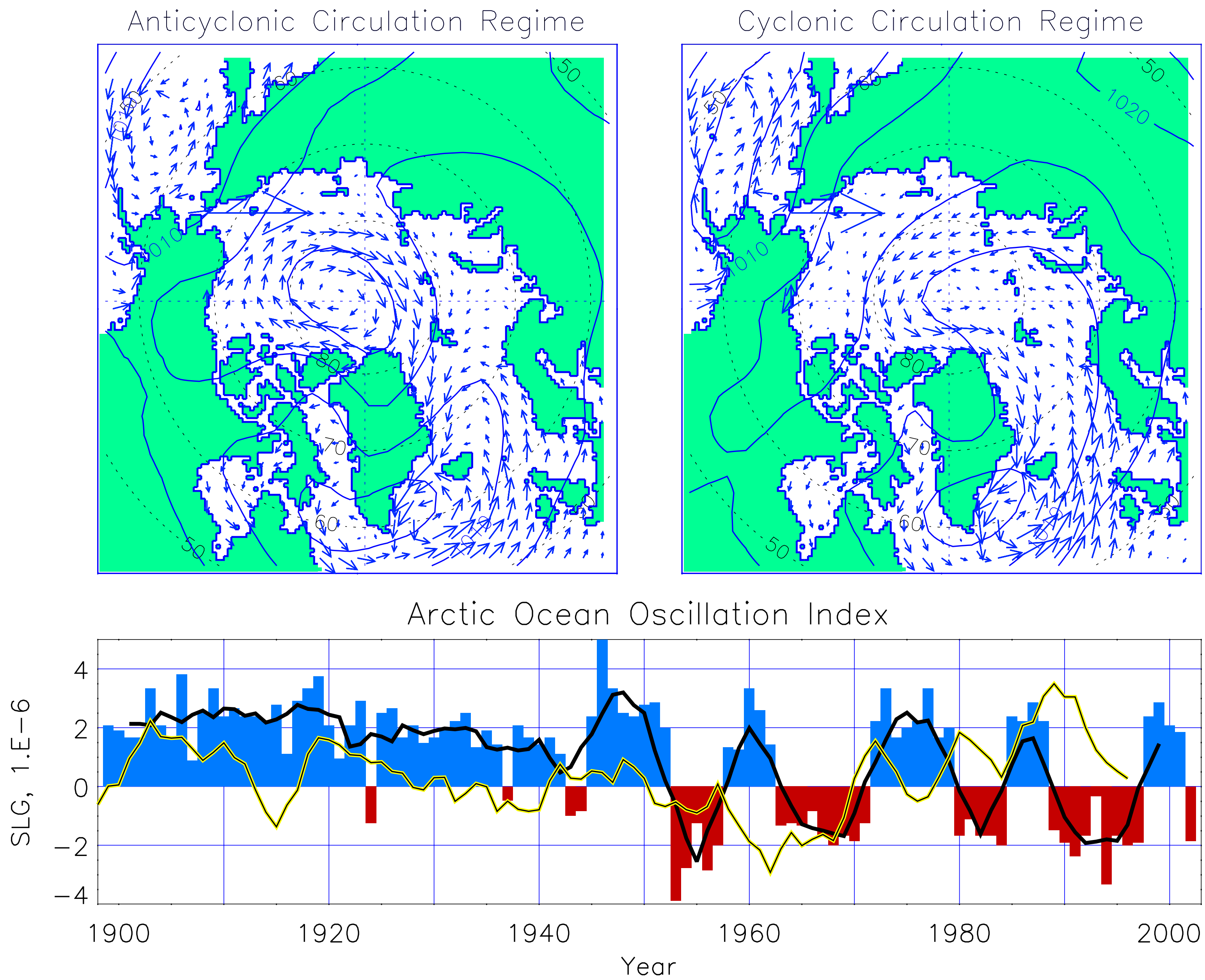
AARI EWG joint USA – Russia data archive 1948-1993

Time-series of freshwater content from models and observations

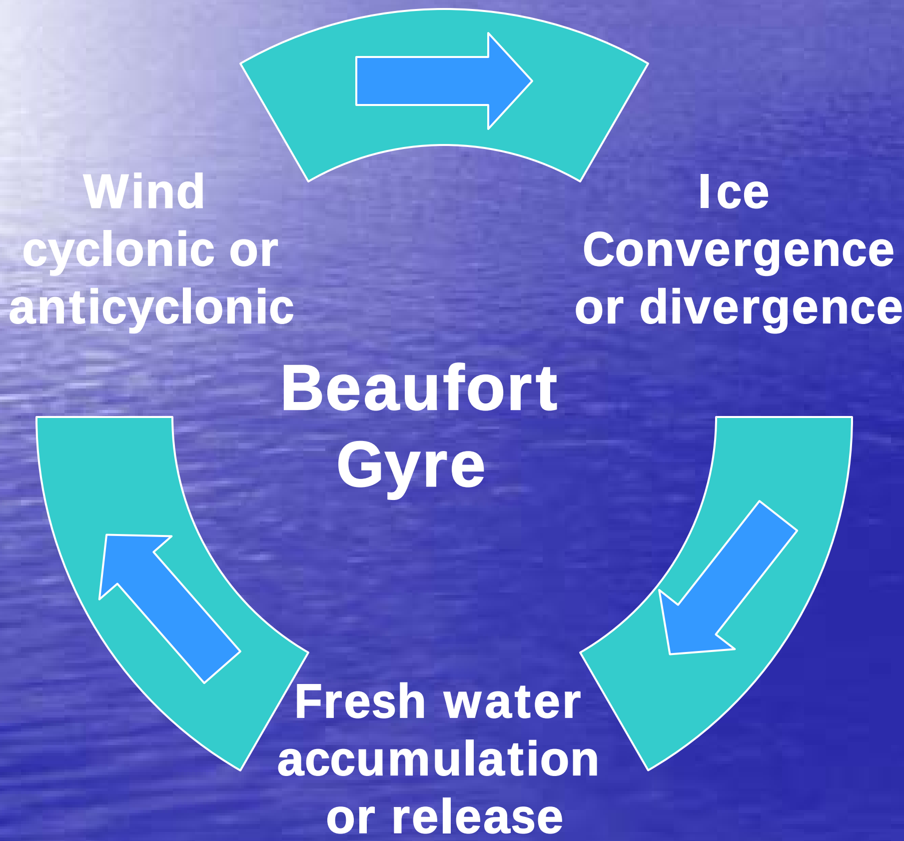


Forcing and circulation regimes

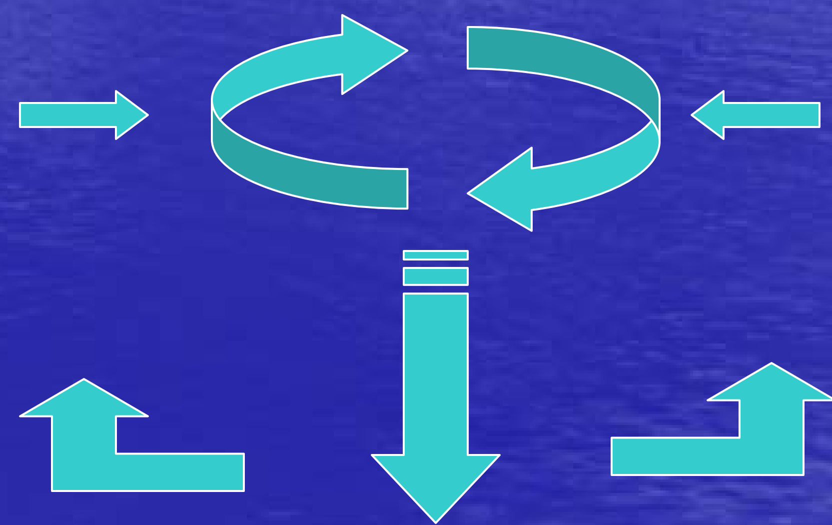
Circulation regimes 1900-2002



Beaufort Gyre mechanism of fresh water accumulation and release

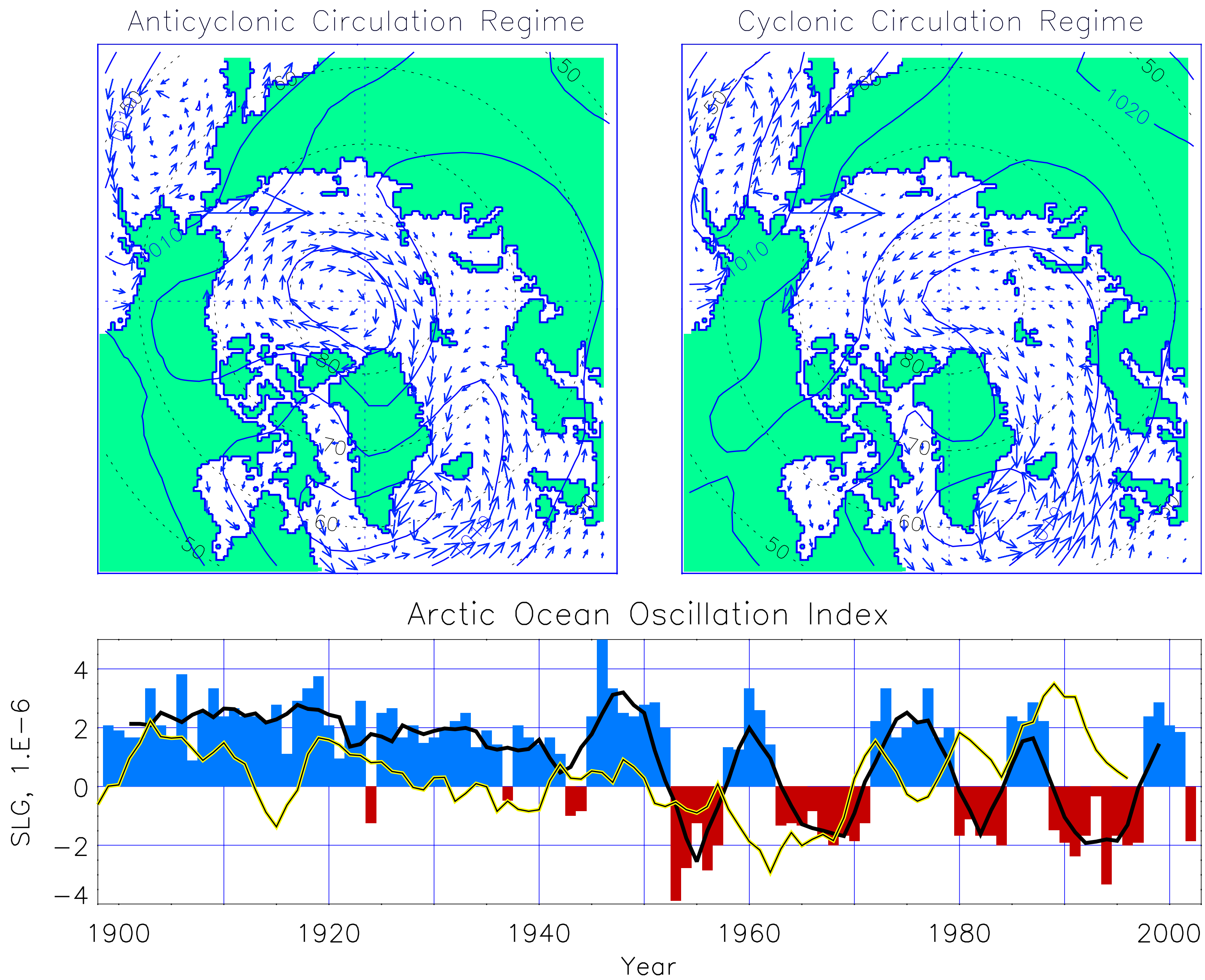


Ice and water convergence, Fresh water accumulation due to Ekman pumping and sea ice accumulation due to ridging and cooling



Downwelling in the center and upwelling along continental slope

Circulation regimes 1900-2002




QUESTIONS?