Numerical simulation of feedbacks in climate-processes in GIN seas

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Numerical model

I. Multicomponent splitting method with respect to the physical processes and space coordinates (use of implicit schemes owing to this method).

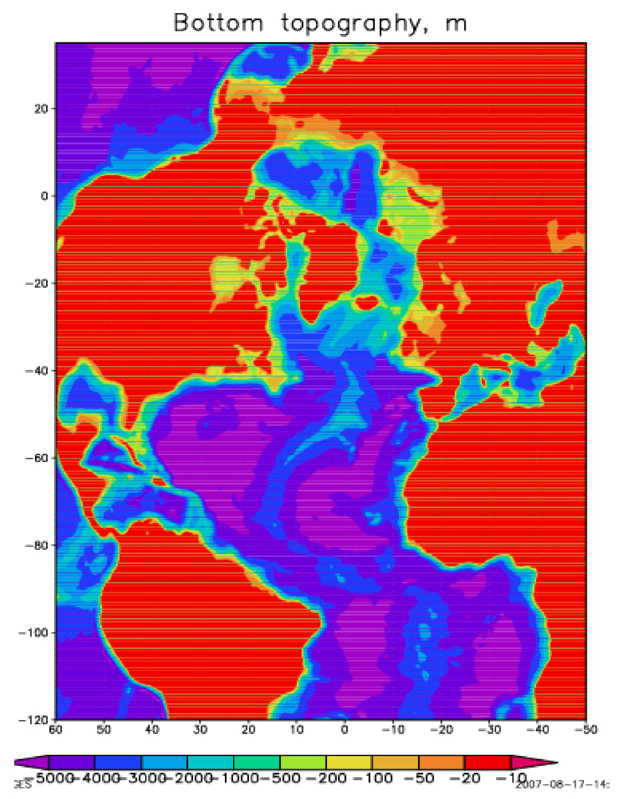
II. The present version of the model is realize for coupled North Atlantic (open boundary at 30°S) - Arctic Ocean – Bering Sea region including Mediterranean and Black Seas.

III. A rotation of the model grid is employed to avoid the problem of converging meridians over the Arctic ocean. The model North Pole is located at geographical equator, 120°W.

IV. 1/4° horizontal eddy-permitting resolution is used (620x440 grid points) and 40 unevenly spaced vertical levels.

V. Biharmonic operator is used for lateral viscosity.

VI. The EVP (elastic- viscous- plastic) dynamic - thermodynamic sea ice model (Hunke, 2001; Yakovlev, 2003) is embedded.



The design of the experiment

The numerical experiment was carried out using the realistic global atmosphere forcing for years 1958-2006 provided by GFDL for CLIVAR Common Ocean-ice Reference Experiments (CORE).
http://data1.gfdl.noaa.gov/nomads/forms/mom4/CORE.html

The heat, salt and momentum fluxes at the sea surface are calculated using 6hr wind, pressure, temperature and humidity; daily shortwave and longwave radiation; monthly precipitation and year mean river runoff.

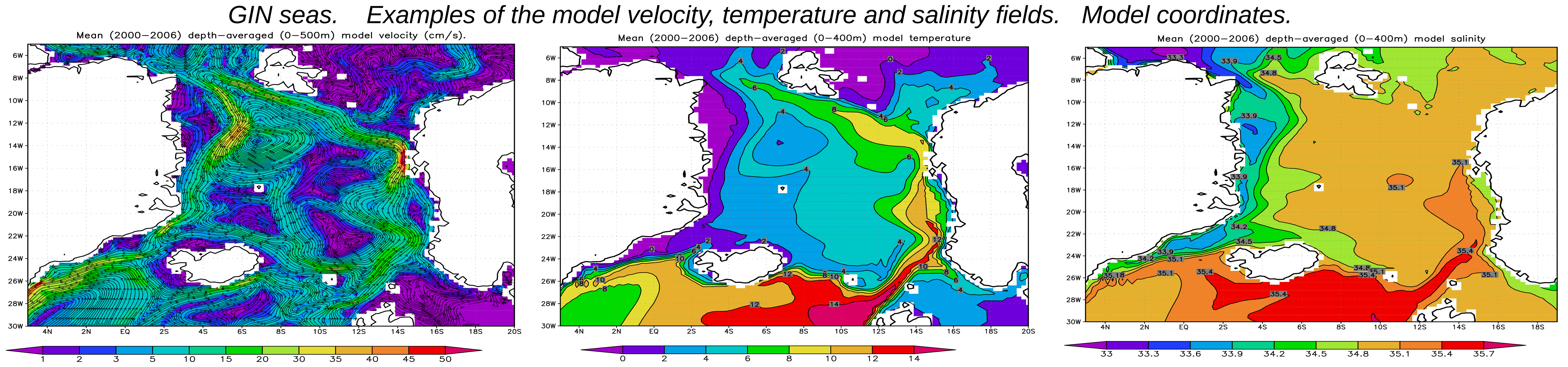
Sensible and latent heat fluxes employ bulk formulas using CORE data and model SST.

Restoring to observed sea surface salinity with coefficient of 1/(30 days) is used for salt flux.

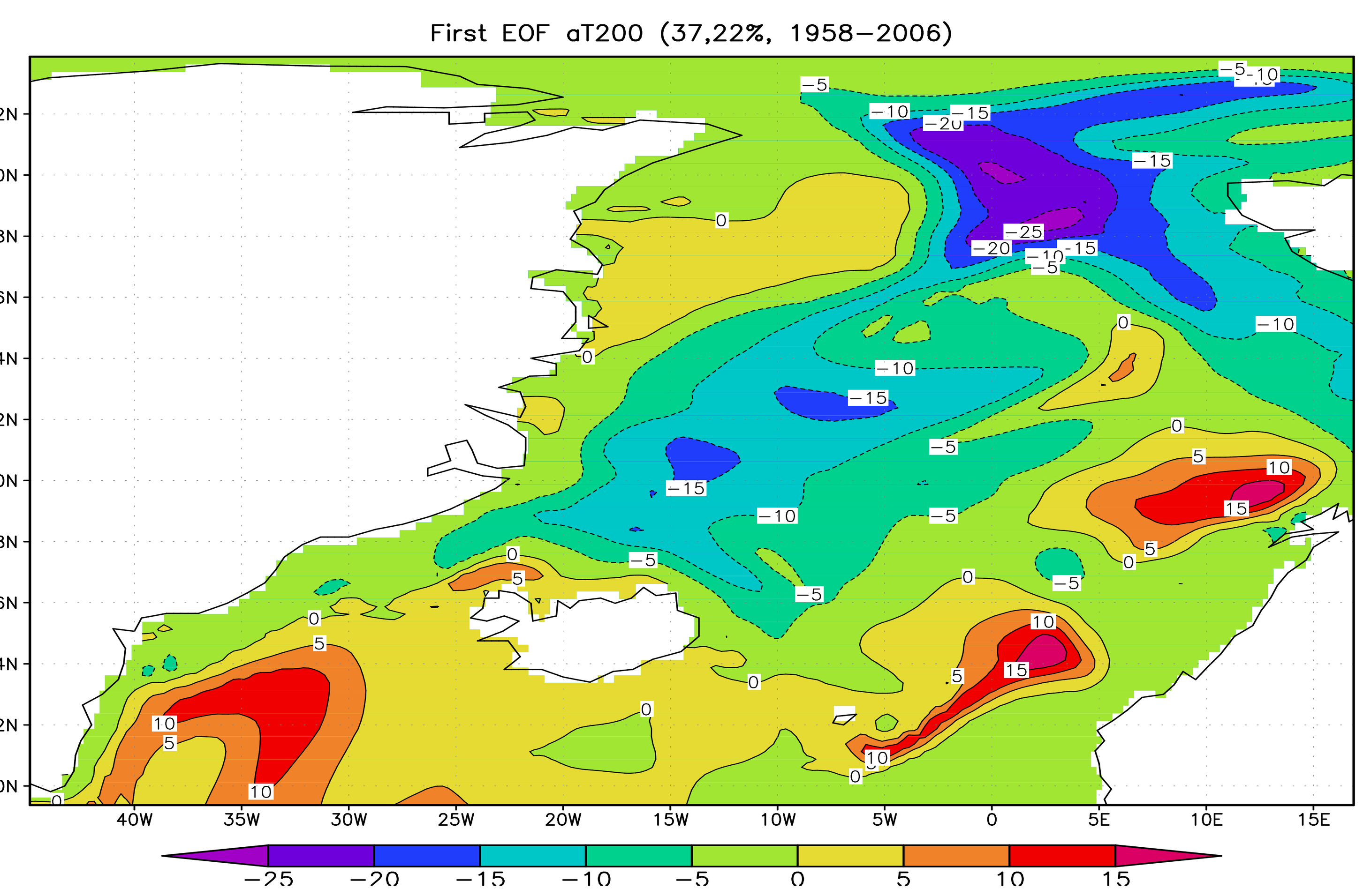
Time step: 1 hour.

Initial conditions: Levitus data for January temperature and salinity and no motion for velocity.

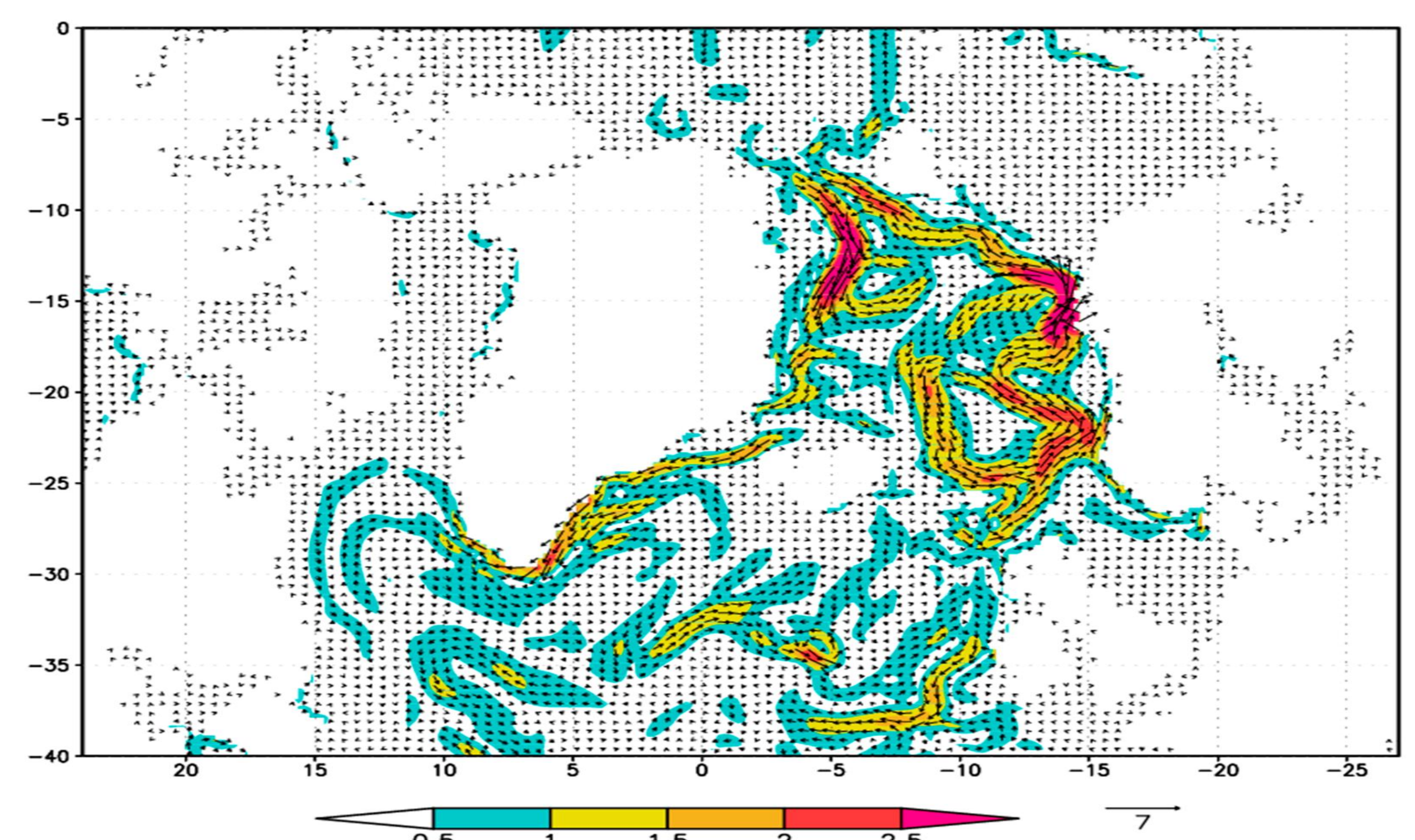
GIN seas. Examples of the model velocity, temperature and salinity fields. Model coordinates.



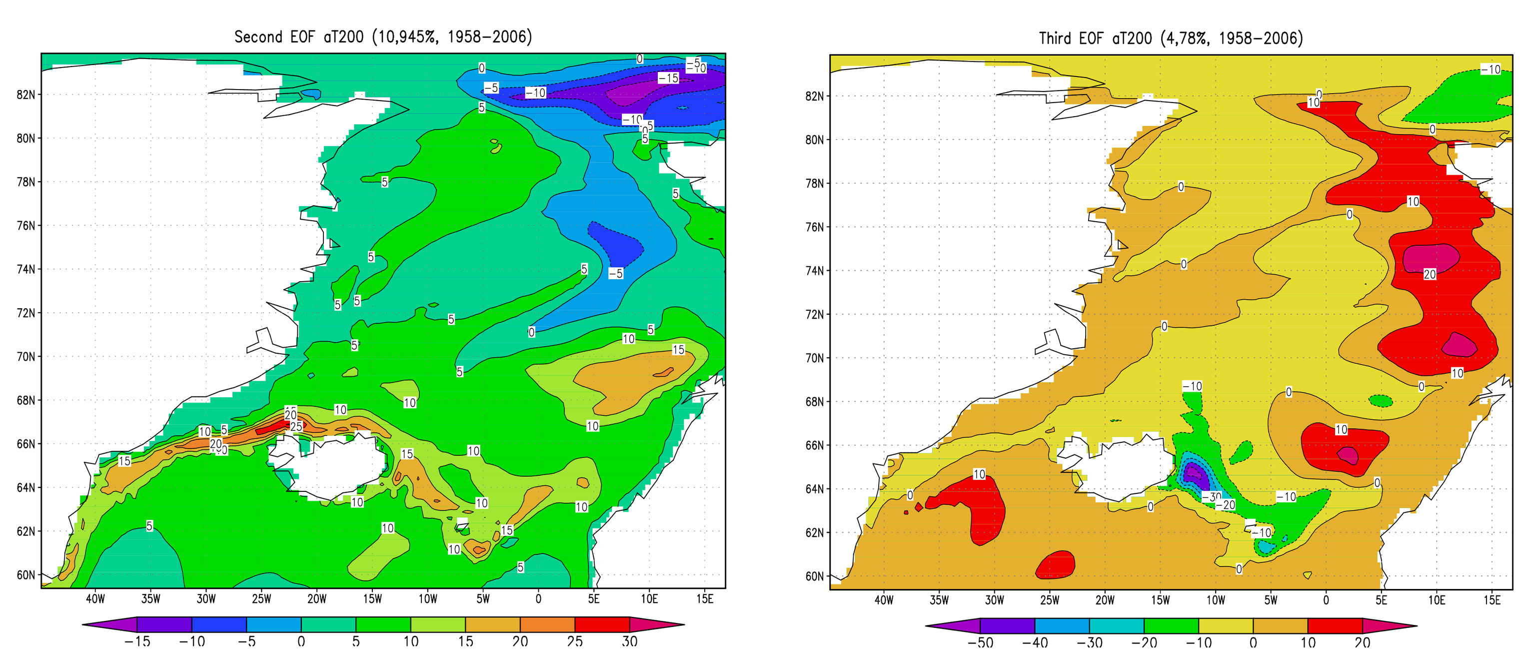
GIN seas. Heat storage anomalies (0-200m). First EOF (**37.2%**, main part of the baroclinic layer thermohaline variability), I.1958 – XII.2006. Conditional units.



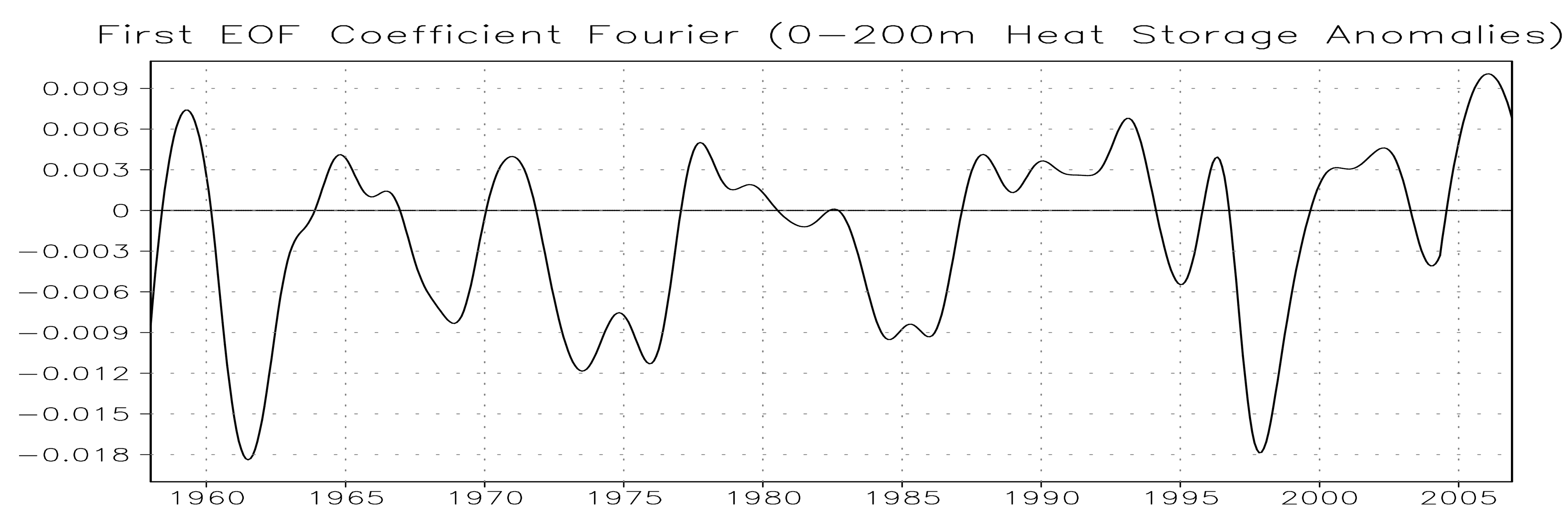
GIN seas. **Current response to the NAO (cm/s).** Regression between normalized NAO index and velocity anomalies (**0-200m**). 1958-2006. Model coordinates. Compare with I & II heat storage EOF



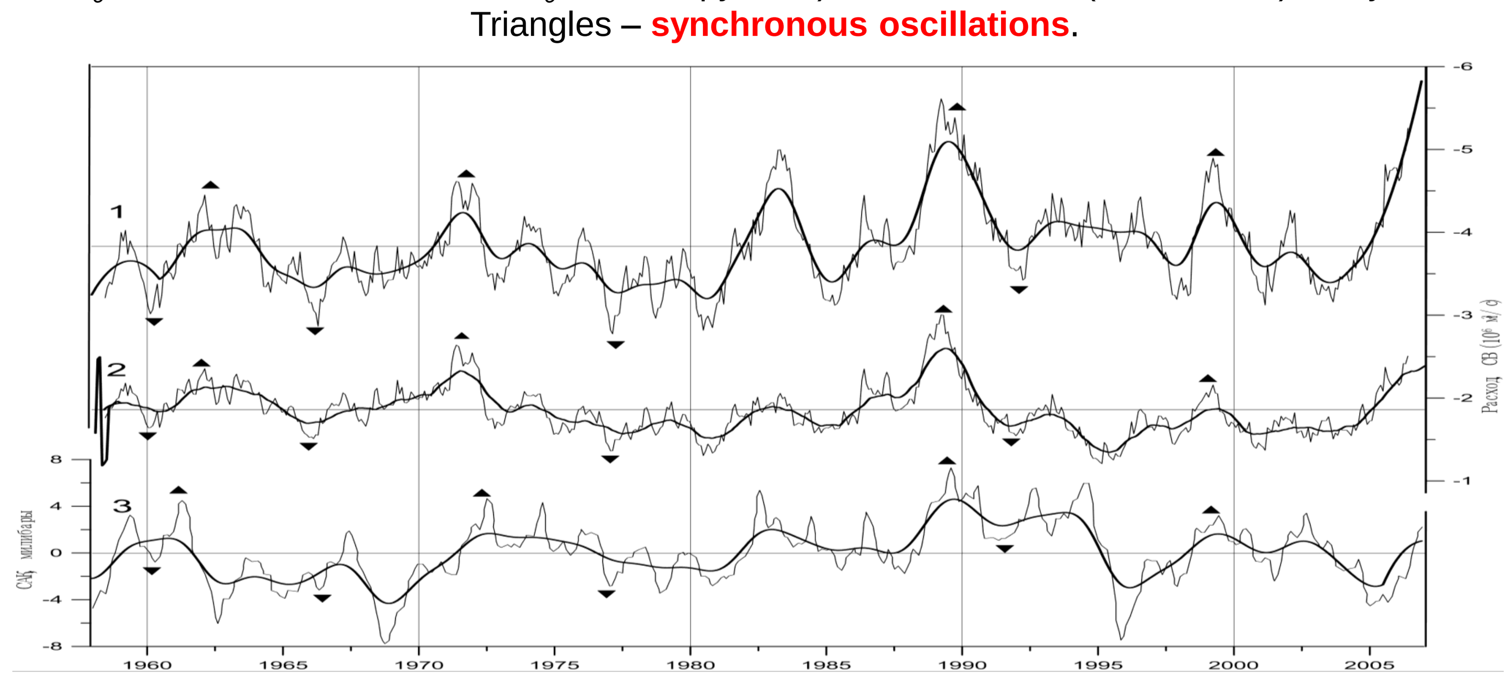
GIN seas. Heat storage anomalies (0-200m). Second (**11.0%**) and Third (**4.8%**) EOFs 1958 – .2006. Conditional units.

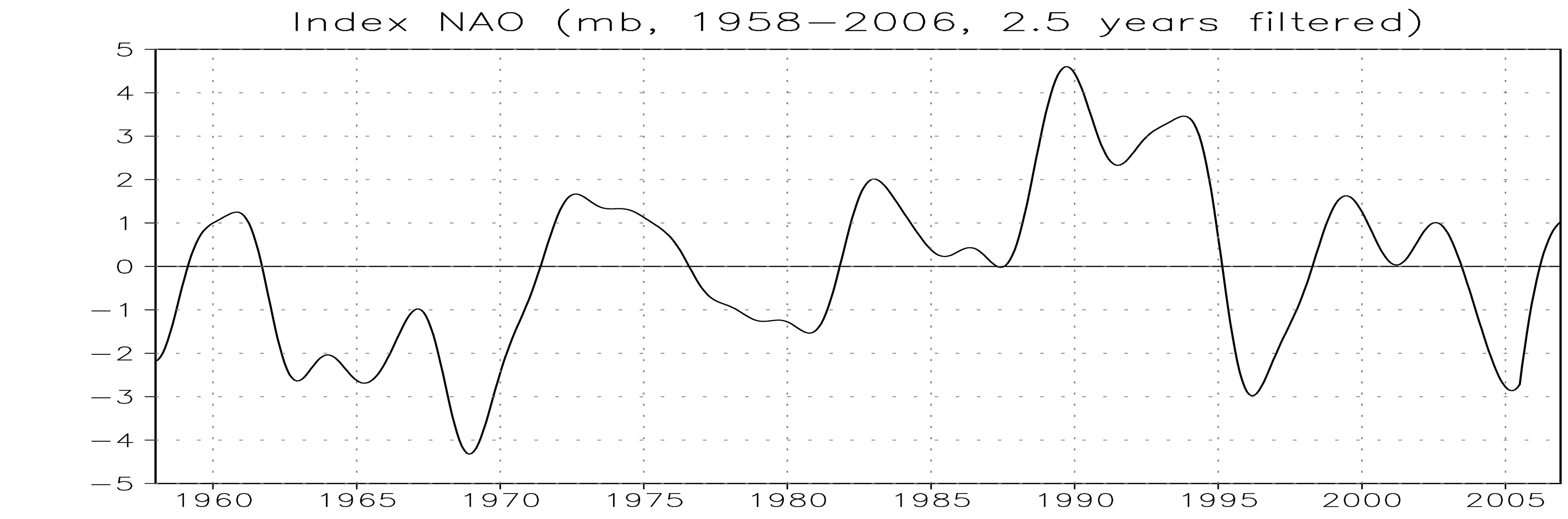


Fourier Coefficient (FC) of **First** heat storage anomalies (**0-200m**) **EOF** and NAO Index (2.5 years filtered). Evolutions of NAO and FC are mainly asynchronous.



Model Mass Transport (in Sverdrups) of the near bottom dense water through **Denmark Strait** (curve *1*- under σ_0=27.5 and curve *2* – under σ_0=27.8 isopycnals) and NAO index (mb, curve *3*). 2.5 years filtered. Triangles – **synchronous oscillations**.





Anomalies of heat content in 0-200m layer (AH) characterize the main part of thermohaline circulation in the baroclinic layer. We use anomaly of total current in the layer (AV) as well. The EOFs are obtained for AH and AV. The regression of AV to NAO index is computed. The velocity response to NAO follows the configuration of the mean circulation in GIN seas. When NAO index grows the circulation intensifies too (corrlelation is >0) because when NAO grows the Iceland atmospheric cyclone intensifies, as well barotropic velocity in the ocean. In the recirculation region near Fram strait the 1st AH mode shows disturbance of anticyclonical anomaly of bariclinic origin (JEBAR) that counteracts to intensifying of barotropic cyclonical recirculation happening by NAO growth. This balances long-term water exchange between Arctic and Atlantic oceans. Over Lofoten and Norwegian basins cyclonical circulations appear. These structures are well expressed in the main AH mode (37.22%). Such AH structures are disturbed in response to any external forcing among which the NAO signal dominates. The reason of their appearance is joint effect of baroclinity and relief (JEBAR) over slopes of Lofoten and Norwegian basins. When NAO grows here, cyclonical circulations intensify (barotropic effect). It is also influenced by baroclinic effect (see main AH mode). These stable cyclones in the ocean are specific “traps” of Atlantic waters on their way to the Barents Sea. They move cold waters to Norwegian coast (see mean temperature field) and cause upwelling. Therefore, in GIN seas the feedbacks are realized of barotropic and baroclinic velocity components which stabilize long-term water exchange between Arctic and Atlantic oceans and keep their specified climatic state.