Physical properties of the Atlantic - Arctic water exchange formation

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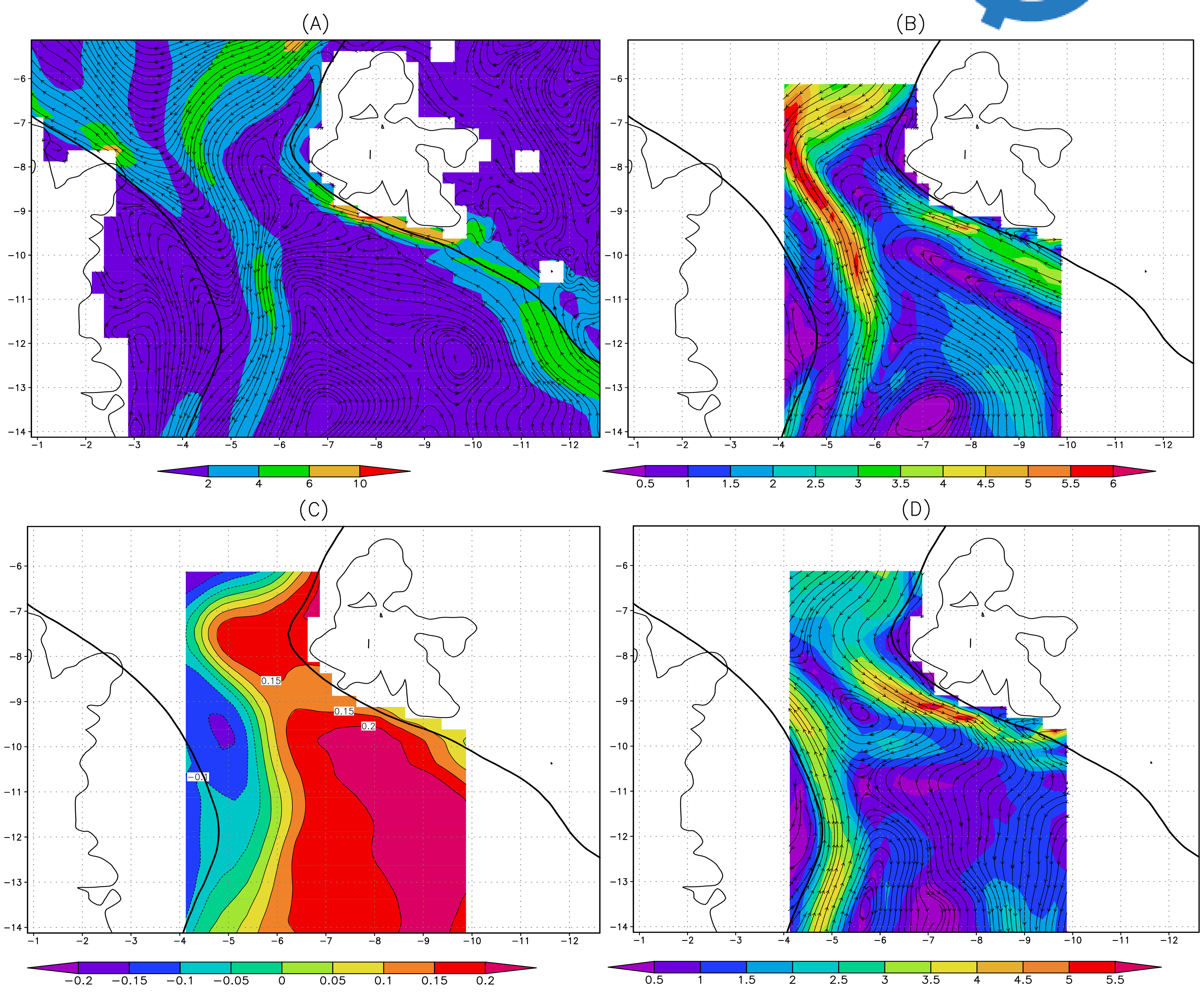
Baroclinic response of the ocean stabilizes Atlantic-Arctic water exchange through the Fram Strait

Numerical experiments with eddy-permitting ocean circulation model carried out for the Atlantic and Arctic oceans domain and 1948-2009 period. Greenland Sea current field near the Fram Strait for 50-500m layer demonstrated at panel (A) (cm/s by shading, model coordinates, isobath 500 m is shown). Results of SVD-analysis for water density and velocity anomalies in the 0-300 m layer are demonstrated at panels (B)-(E) and in the table. The basic Atlantic-Arctic water exchange occurs here in this layer. The 1st SVD mode is identical to the mean circulation. The 2nd mode of water density anomaly (panel (E), kg/m^3 x10^2), caused by changes of heat and salt transports in the West-Spitsbergen (WSC) and East-Greenland (EGC) currents, promotes to generation of the 2nd mode of current anomaly (panel (D), cm/s x10^2), which stabilizes water exchange through the Fram Strait between Arctic basin and Greenland Sea. This process of stabilizing amplitude of increasing-decreasing water exchange through the Fram Strait takes about ¼ of the total short-range climatic variability of density field and 15% of velocity field variability, which is comparable to the 1st mode dispersion of circulation in 76-80°N between Svalbard and shallow zone near Greenland (see Table). With the variable time lag, baroclinic modes balancing strengthening or weakening of WSC and EGC intensity, always follow the 1st basic mode of circulation variability evolution called by atmospheric forcing. One can speak about quasi-local (300–400 km scale) oceanic mechanism of partial stabilization of Atlantic-Arctic water exchange, which influences the global short-range (5–15 years) ocean climate variability.



Institute of Numerical Mathematics Ocean Model (INMOM). Numerical experiments.

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 realized for joint Atlantic ocean (north of 30°S, including Mediterranean Sea) - Arctic Ocean – Bering Sea.

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.

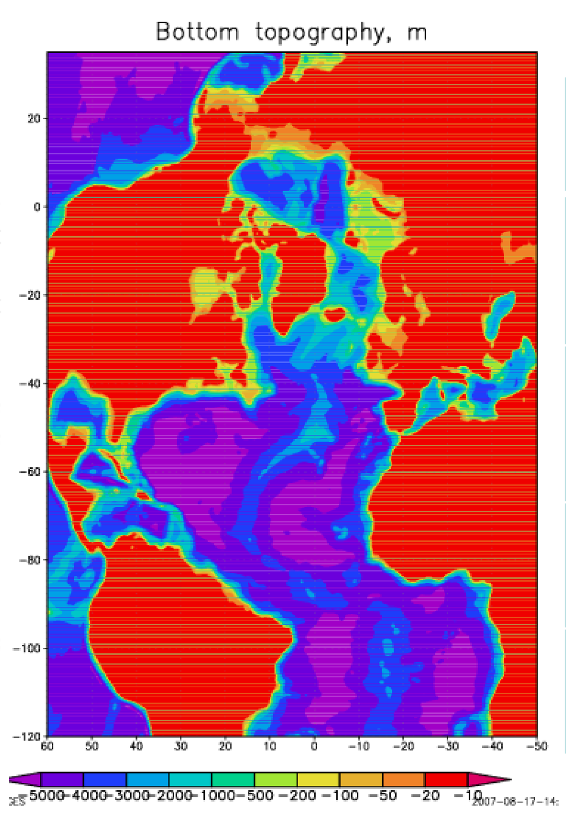
IV. 1/4° horizontal eddy-permitting resolution is used (620x440 grid points) and 40 unevenly spaced vertical levels.

V. Biharmonic operator is used for lateral viscosity.

VI. The EVP (elastic- viscous- plastic) dynamic - thermodynamic sea ice model (Hunke, 2001; Iakovlev, 2005) is embedded.

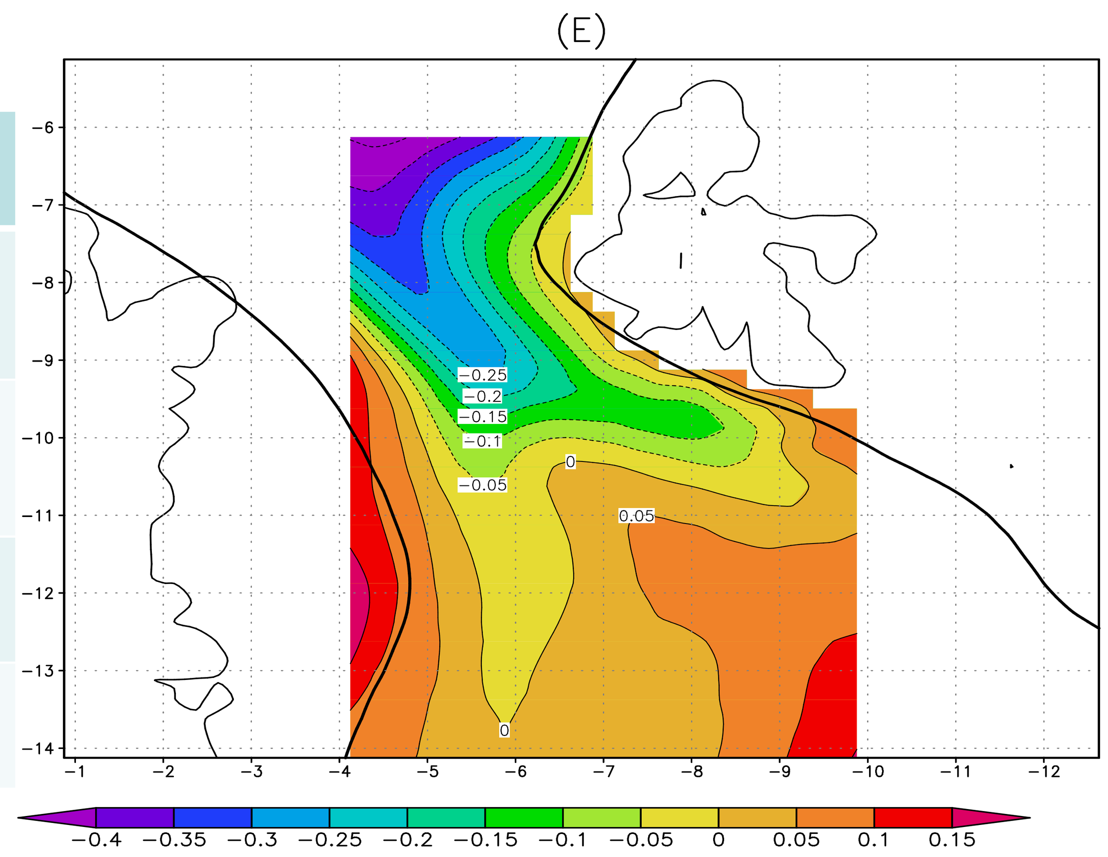
VII. Splitting equations for turbulence characteristics is used for vertical diffusion and viscosity parameterization.

VIII. CORE-2 data are used for boundary conditions (1948-2009)

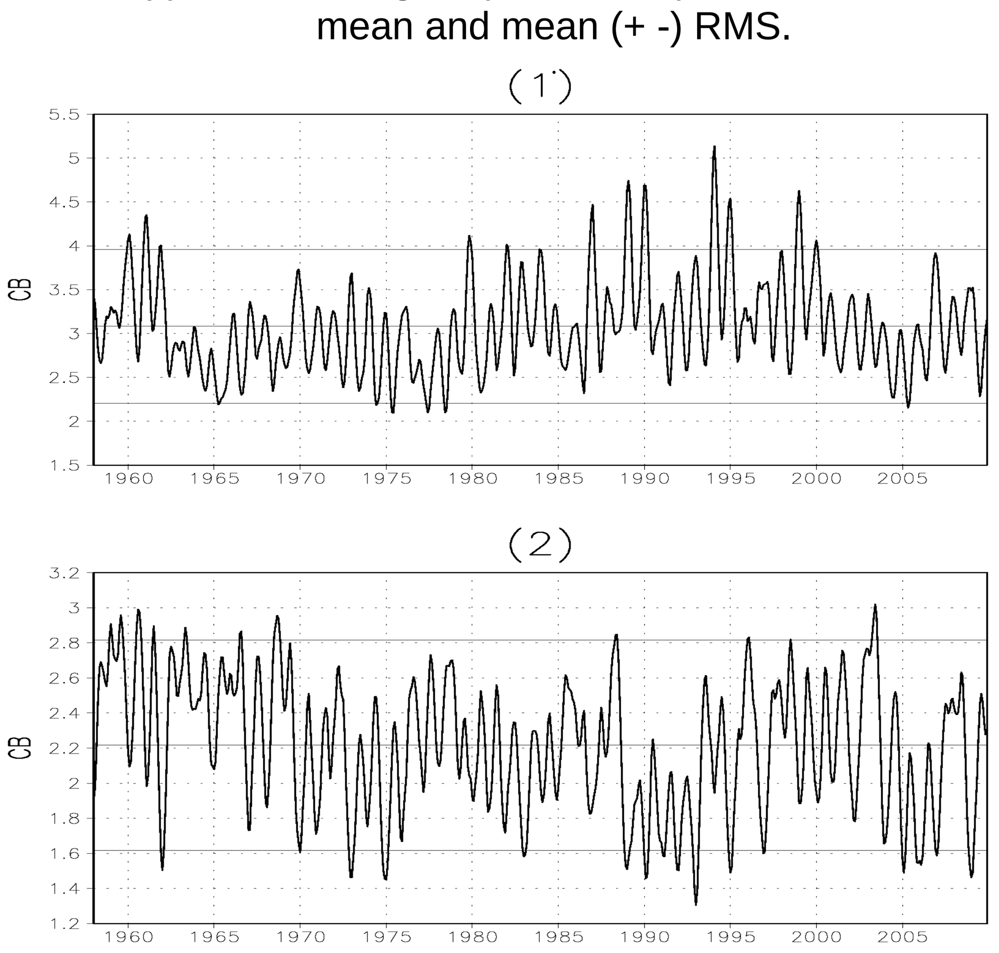


SVD characteristics (water density anomalies /velocity anomalies). Layer 0-300m.

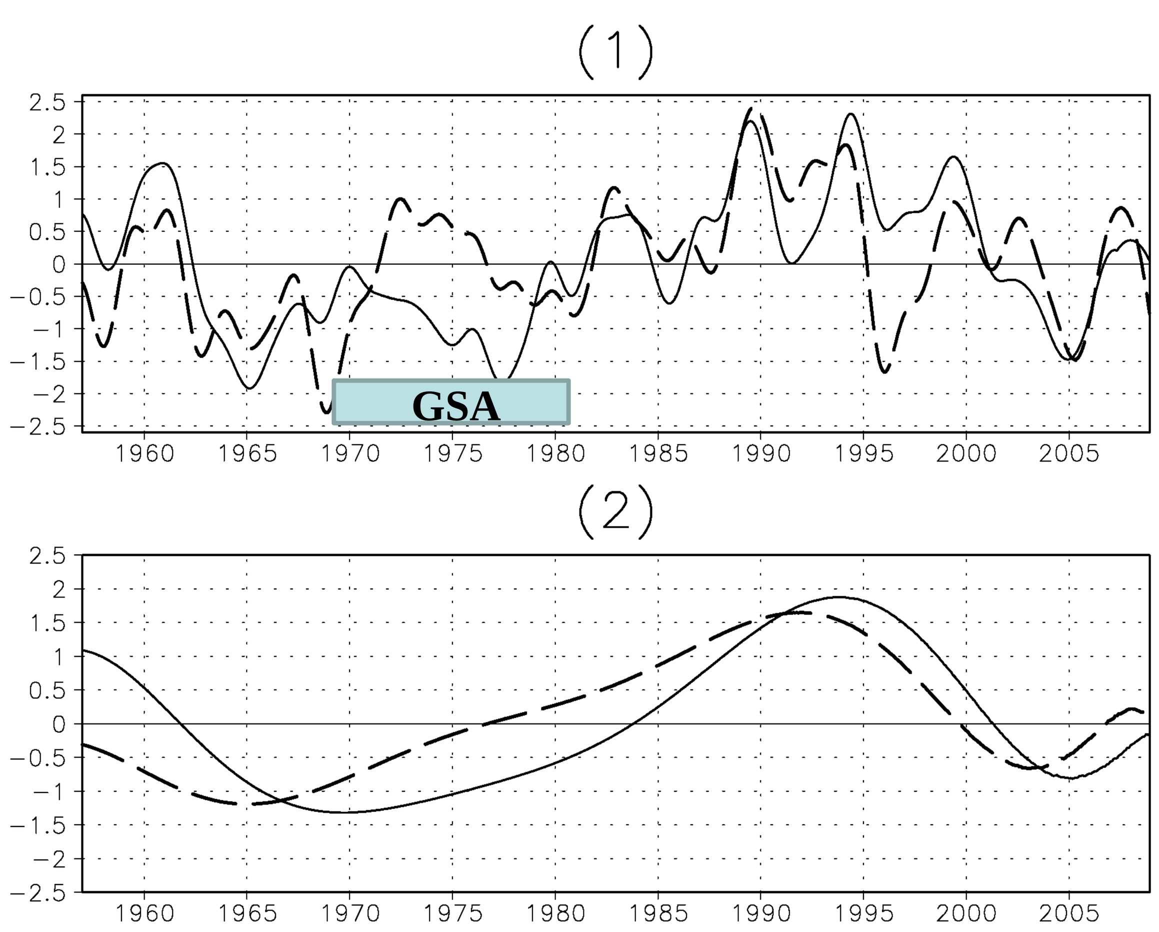
No. SVD component	1	2	3	4	Sum 1-10
Input in total covariance (%)	70.71	20.85	4.66	1.01	99.48
Correlation coefficient density/velocity(%)	79.99	60.00	71.53	52.20	- -
Density: input in total dispersion (%)	30.65	22.91	15.55	3.46	87.76
Velocity: input in total dispersion (%)	22.05	15.47	3.58	6.54	65.36



Near Bottom Current Mass Transport (NBCMT) in Sverdrups (1Sv=10^6 m^3/s) into the North Atlantic from the Denmark Strait (1) and Faroe Channels (2) under isopycn **1027.7 kg/м³** (1958-2009). Horizontal lines – mean and mean (+ -) RMS.



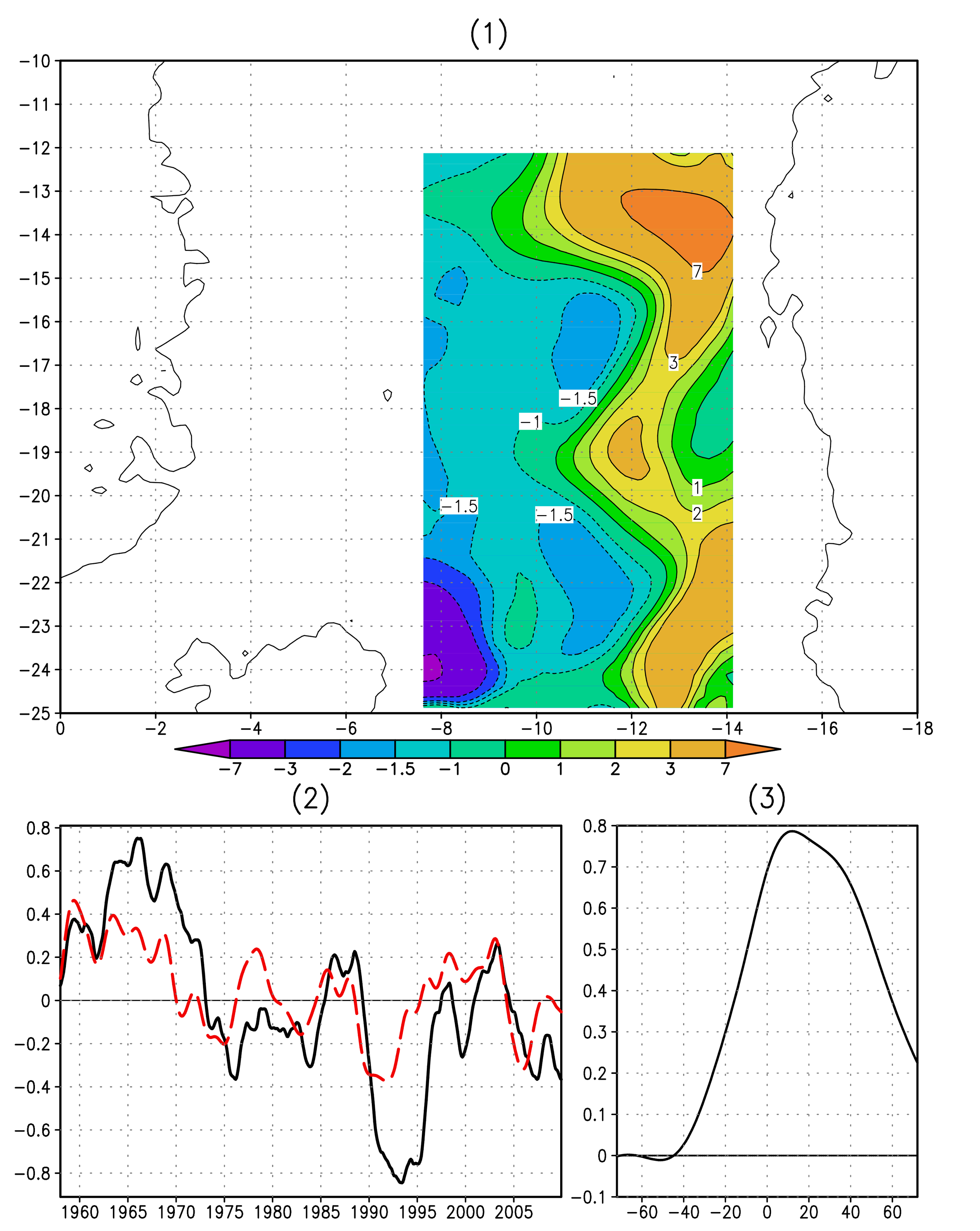
Solid line: NBCMT from Denmark Strait. **Dashed line**: NAO index (realizations are RMS normalized and mean value excluded). (1)- seasonal cycle elimination, (2) – time scales less than 15 years eliminated. **GSA – Great Salinity Anomaly**



Panel (1): second EOF (19.1%) of the water density anomalies (kg/м^{3}x10^2) for 300m level. Frontal zone of Norway Current on the GIN Seas background (model coordinates).

Panel (2) –Fourier coefficient (FC) of this second EOF (red dashed line, conditional units) and NBCMT from Faroe Channels minus mean value (black solid line).

Panel (3) – Correlation function FC and NBCMT (abscissa units in months). Seasonal cycle was eliminated by filtration.



Physical features of the dense water outflow from the Greenland and Norway Seas into the North Atlantic

Near Bottom Current Mass Transport (NBCMT) under isopycn **1027.7 kg/м³** into the North Atlantic from the Denmark Strait and Faroe Channels was simulated for 1948-2009 on the basis of numerical experiments with eddy-permitting ocean circulation model (upper left panel (1) and (2)). NBCMT monthly scale reaction onto the NAO was found for the Denmark Strait (upper right panel (1)). Baroclinic factor can destroys this reaction owing to long-life salinity anomaly. Such a destruction took place during the Great Salinity Anomaly in 1969-1978 (upper right panel (1)). The second statistically significant time scale of the Denmark NBCMT reaction onto NAO is revealed equal to 39 months (upper right panel (2)). Norway Current Frontal Zone (NCFZ) transverse oscillations influence on the dense intermediate waters of the GIN Seas in high extent (low panel (1)-(3)). These oscillations generate the one fifth part of the water density anomalies full dispersion at the NCFZ. NBCMT from the Faroe Channels to the North Atlantic responds to NCFZ transverse oscillations as whole with time lag of one year (low panel (2) and (3)). As a result, Faroe Channels NBCMT can be considered as the integral index of the formation of new portions of dense intermediate waters owing to mixing Atlantic and Arctic waters in the GIN seas.