Numerical Simulation of the the Bering Sea Water Propagation to the Arctic-North Atlantic System

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Objectives

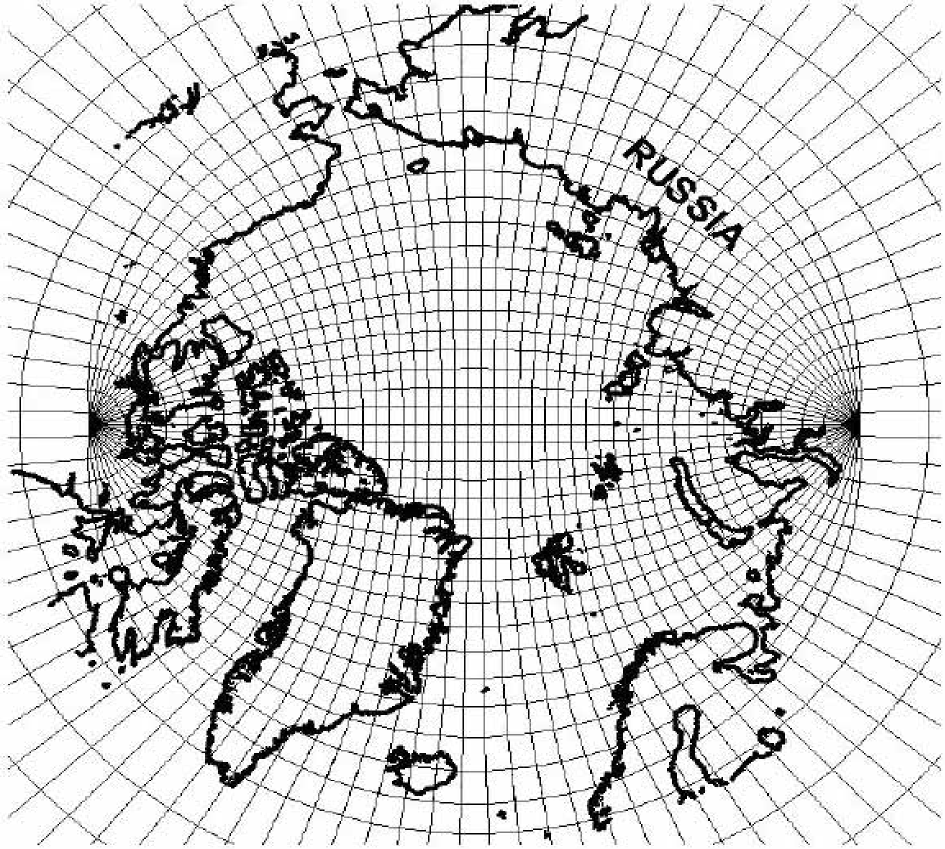
- The priority of the investigation in the Arctic is concentrated on the climatic problems, because Arctic plays the key role in the Earth's climate (J.Fletcher, 1965)
- The freshwater exchange between the polar and the subpolar oceans is the main mechanism of the thermohaline circulation of the World ocean and the global hydrological cycle
- The Arctic ocean accounts about 5 per sent of the World ocean area and 1.5 per sent of the volume, but it transports about 10 per sent of the total freshwater in the World (Ivanov, 1976)
- The Bering throw flow (freshwater flux 1680 km3/yr by Aagaard and Carmack, 1989) play an important role not only in the regional sense for the Chukchi Sea and Arctic Ocean, but globally in the Atlantic deep water formation and global water cycle

General features of the ICM&MG model are as follows:

- MMathematical model is based on the complete “primitive” nonlinear equations of the thermo-hydrodynamics of the ocean;
- TTemperature and salinity distributions are calculated by the fluxes at the surface without “flux correction”;
- TThe interaction with the atmosphere is realized via the upper mixed layer with the model of the ice formation and drift (elastic-viscous-plastic version);
- TThe model is based on a combination of the finite element and splitting methods;

- TThe triangulated quasi-regular B-grid is used;
- TThe model has 33 the vertical z-coordinate levels.

Combined grid for the Arctic-North Atlantic ocean system:
The spherical coordinates in the North Atlantic (res. 1 deg.)
The re-projective grid in the Arctic basin (res. 35 – 50 km)



Data sources

- Reanalysis NCEP/NCAR data (1948-2002) for the Arctic region
- The wind and T/S fluxes from Trenberth et al. for the North Atlantic
- Inflow through the Bering strait from seasonal climatic data (total - 0.8 sv annually mean which gives 1/3 fresh water inflow of the total fresh water flux through Arctic basin – appr. 8.8 km3/day)
- Averaged seasonal climatic Siberian river runoff from the hydrological measurements (1936-1990)

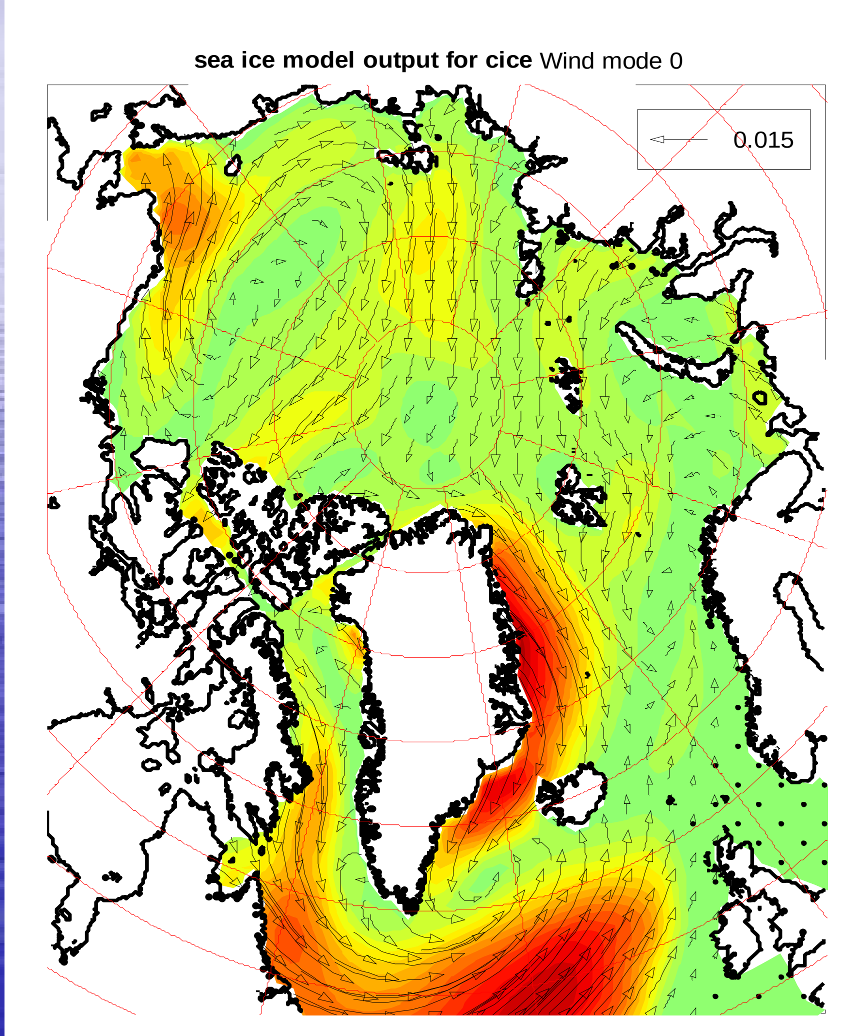
a) Wind-stress averaged for the period 1948 – 2002 (left).

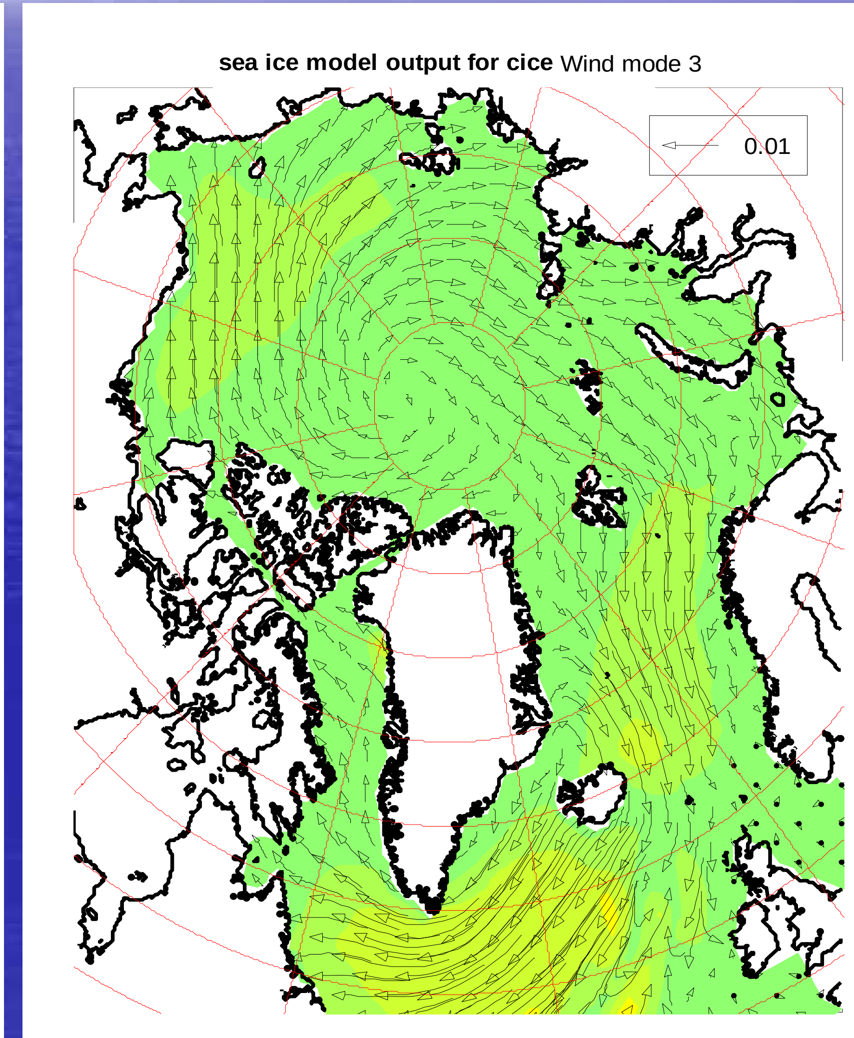
b) The third EOF mode (right).

The value of the wind-stress in N/m^2 is presented in the cones.

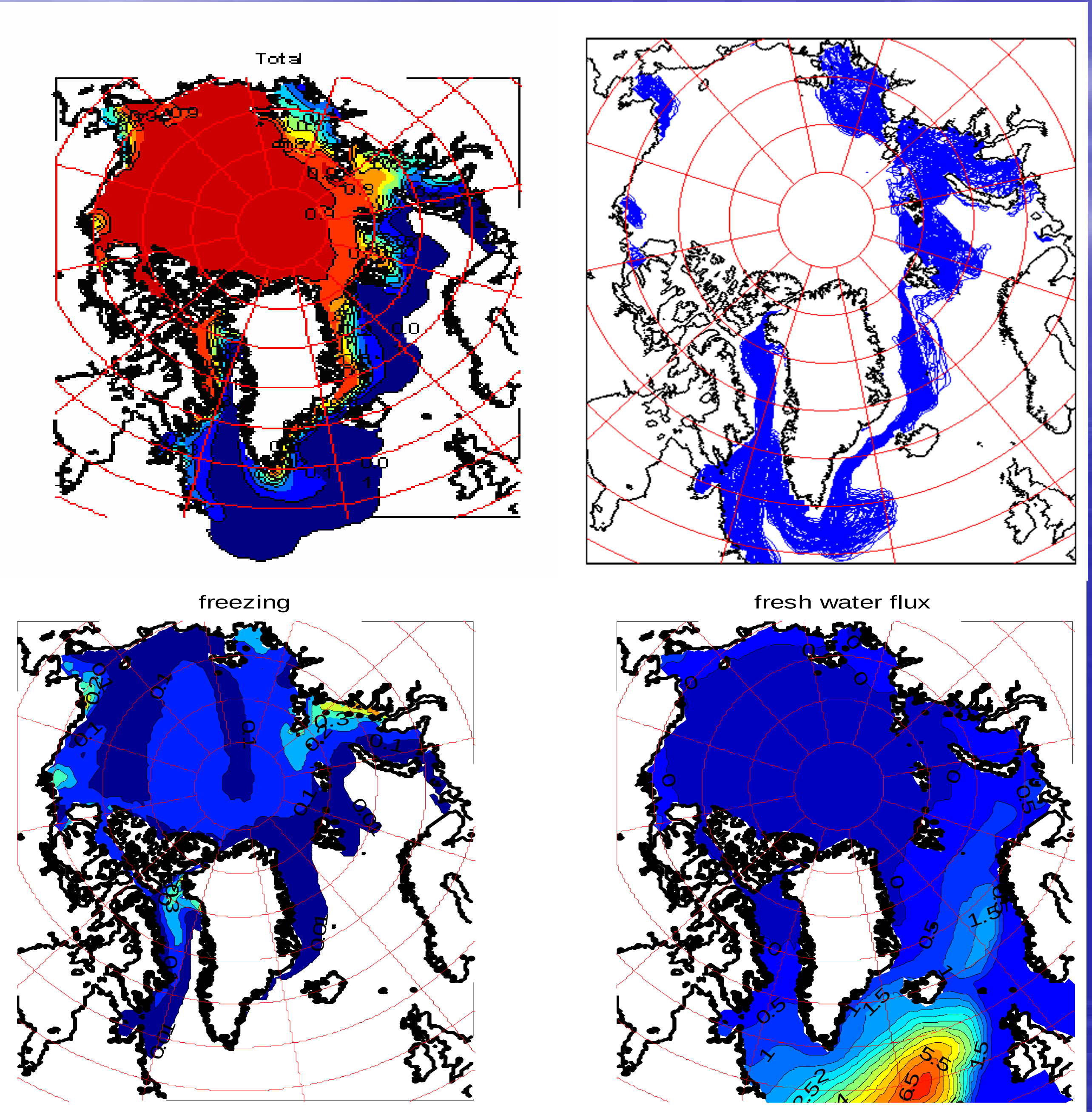
The color represents the module of the wind.

The warmer color consequences to the higher values.





Ice formation in the model



The upper panels:

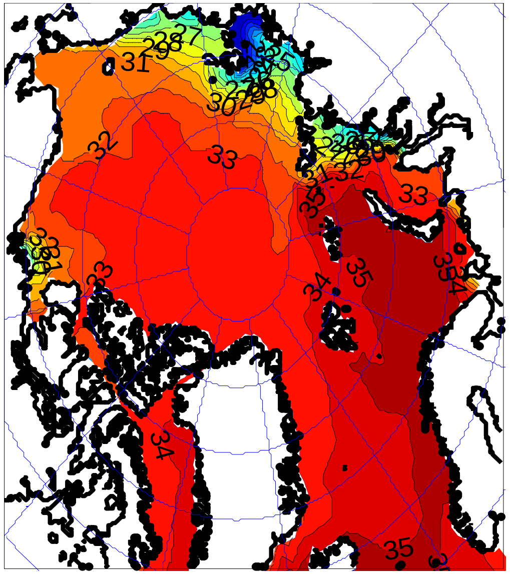
- Averaged field of the ice compacting (in parts from 0 to 1 from the area of the surface, left)
- The monthly position of the ice boundary for the period 1948–1960 (right)

The low panels:

- The intensity of the ice formation (sm/day, left)
- Freshwater flux to the upper layer of the ocean (right)

Salinity at the depth 300 m : 1-1952, 2-1967, 3-1976, 4 –1995.

1



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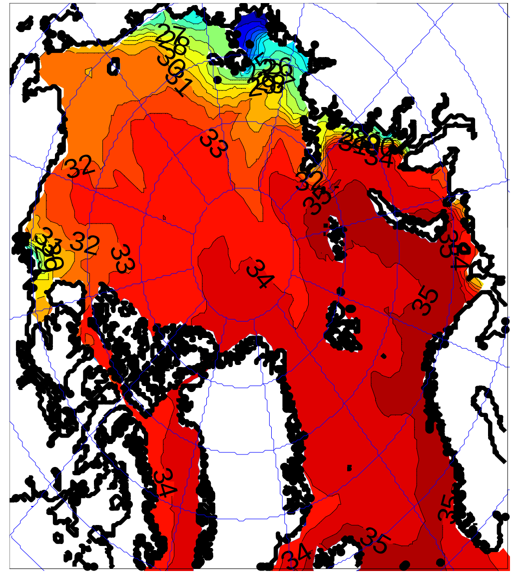

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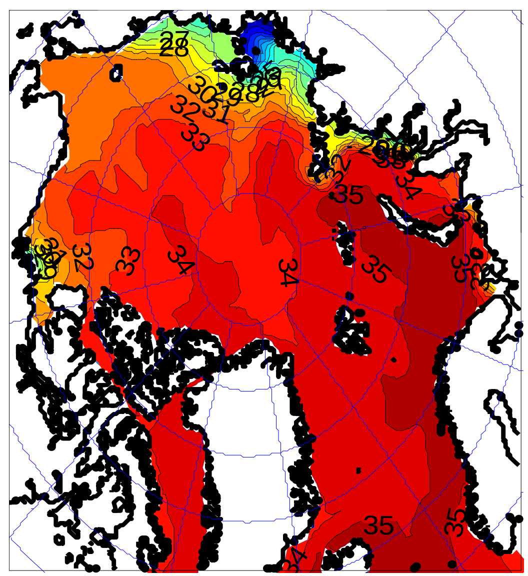

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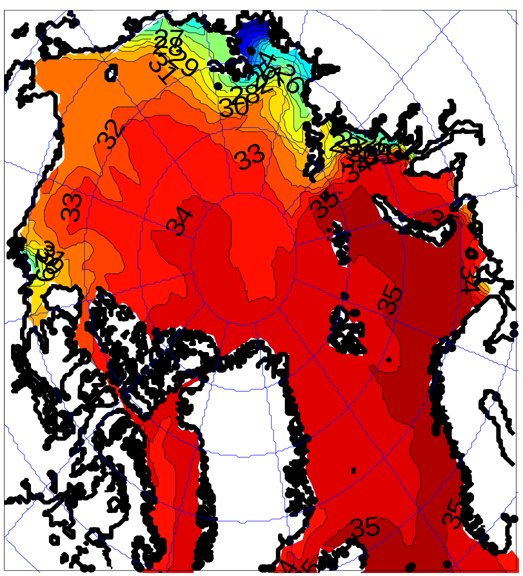
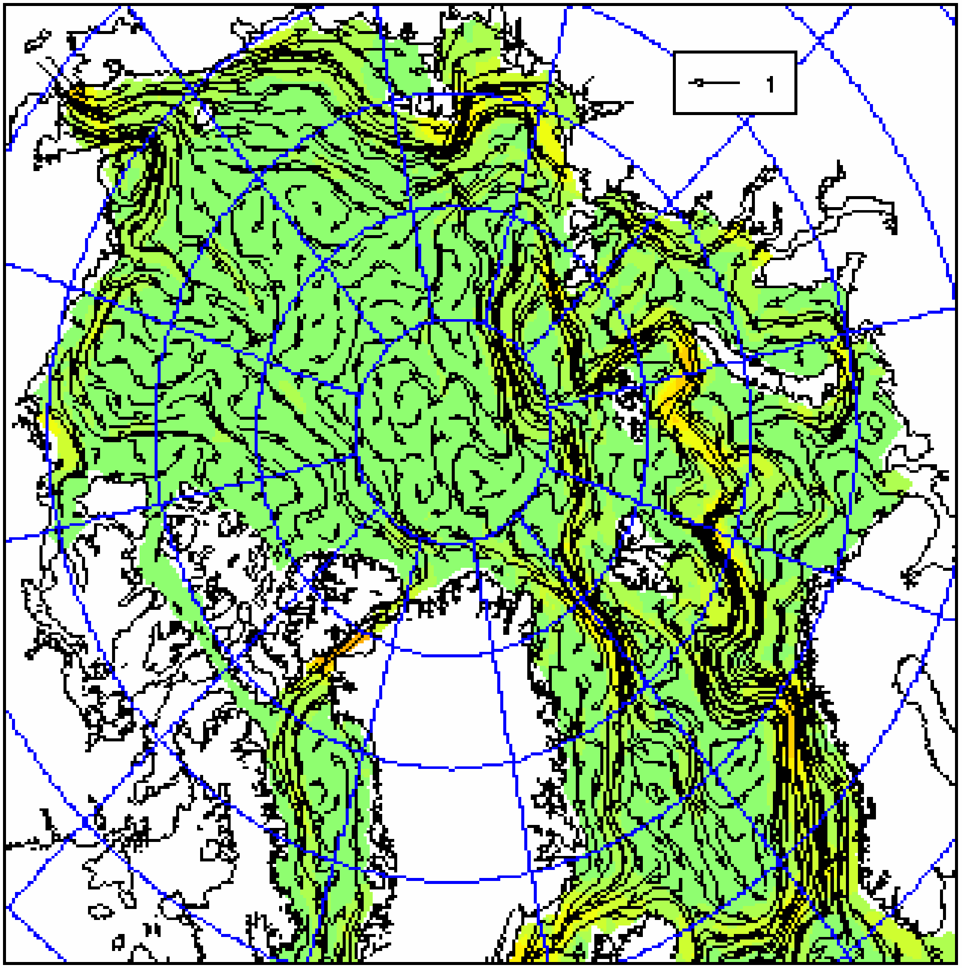
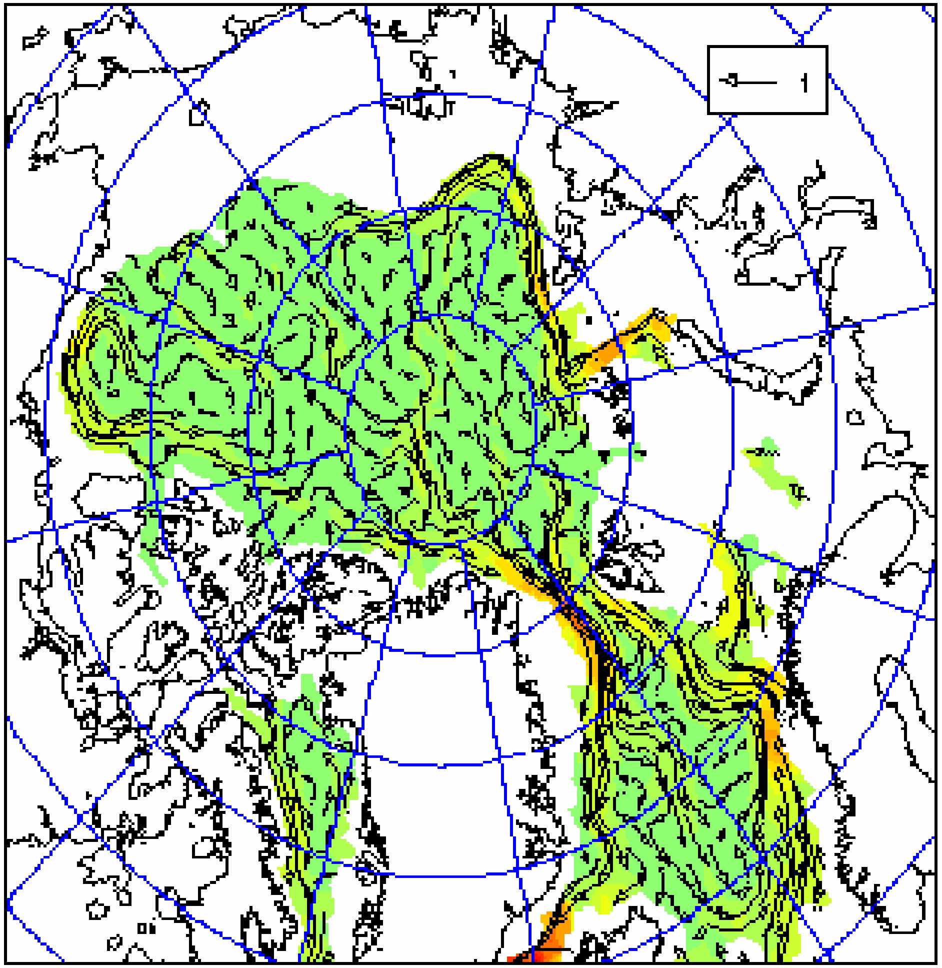
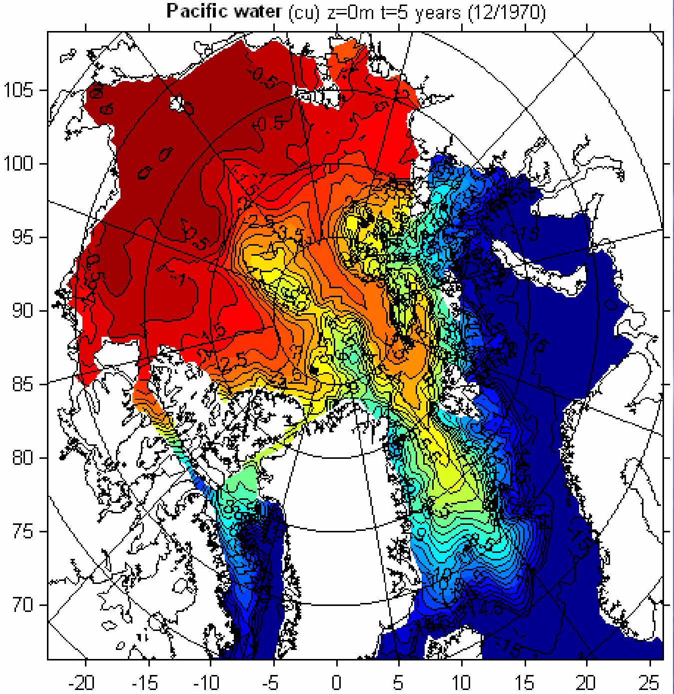
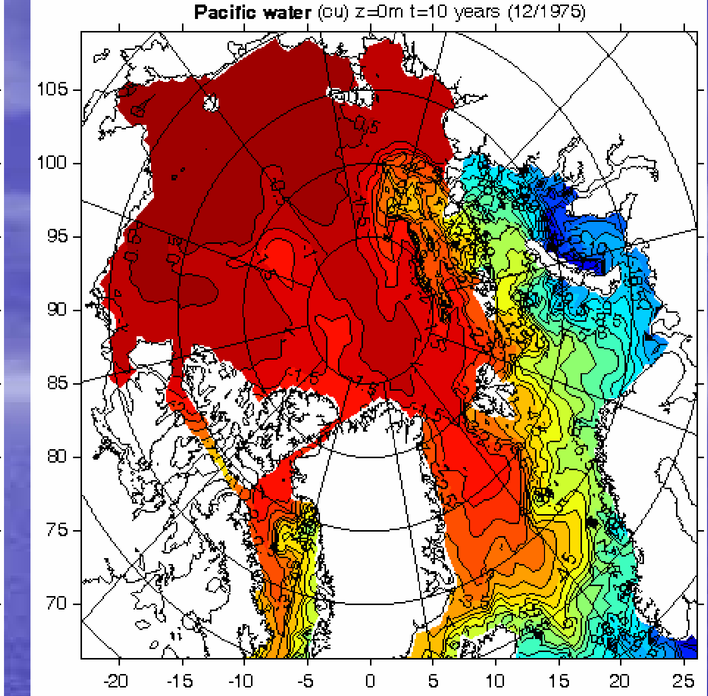


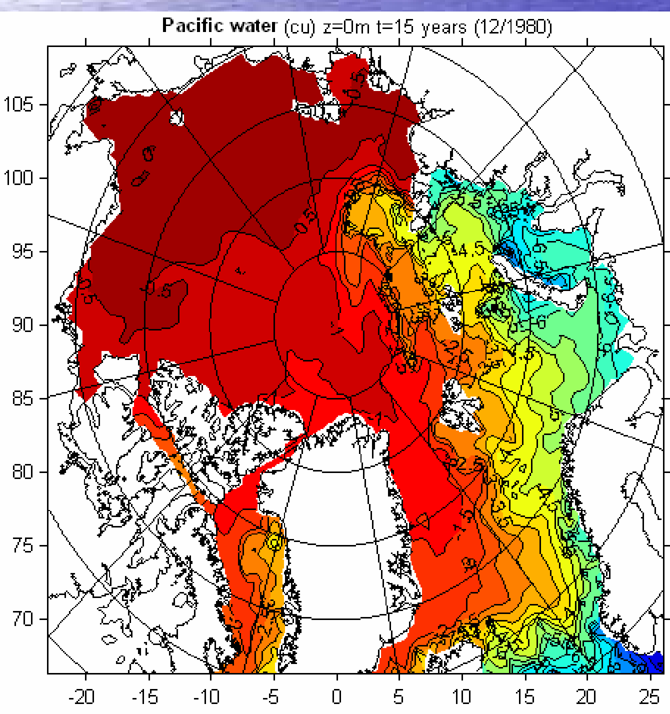
Velocity field at the depth 250 m (left), 500 m (right).
Arrays denote the the velocity 1 sm/s.
The color consequences to the module of the velocity.
More warm color corresponds to the higher velocity.

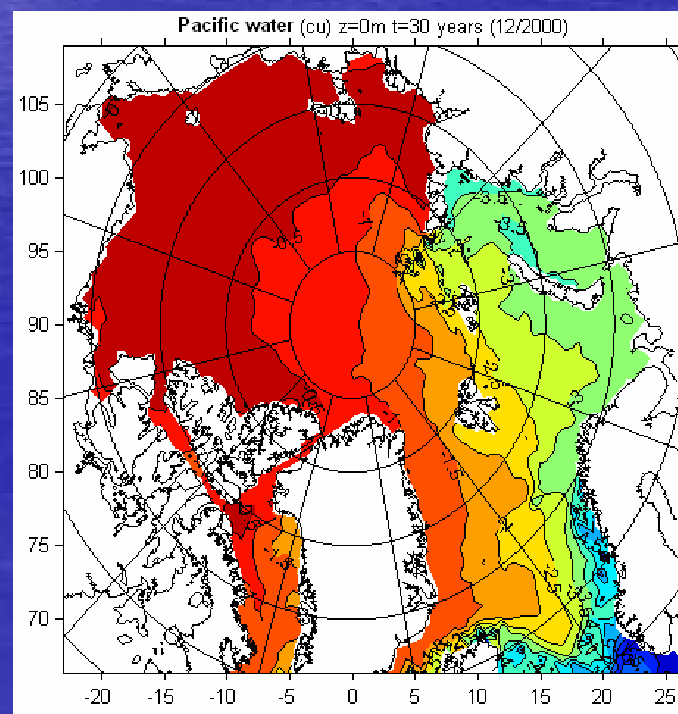






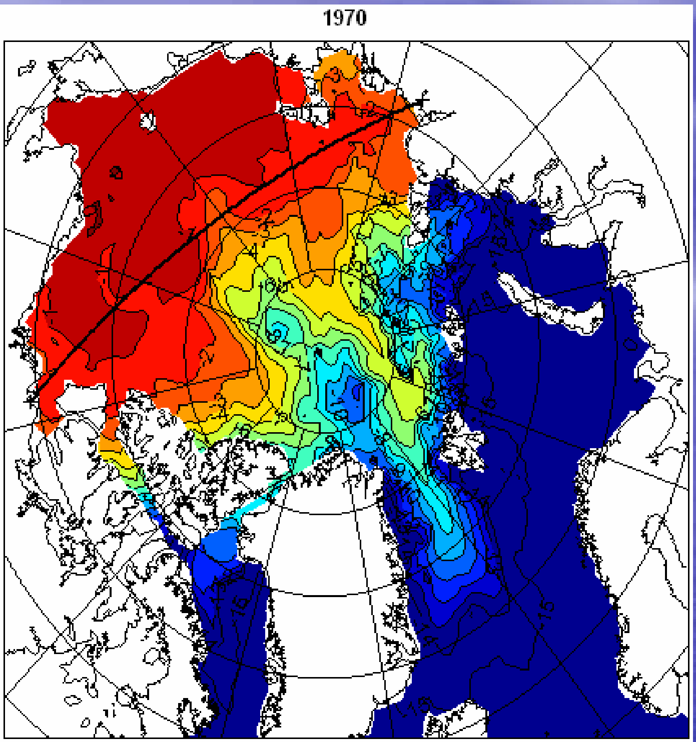


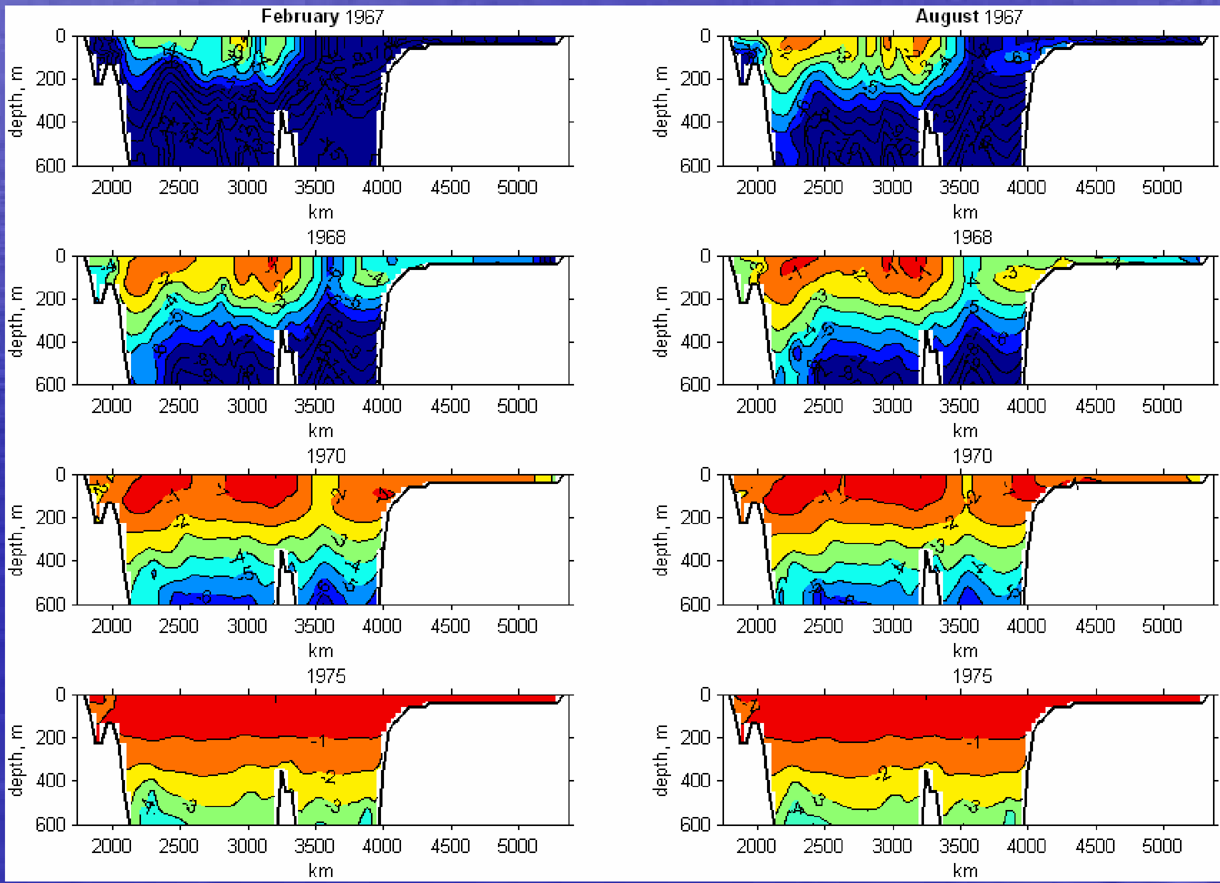




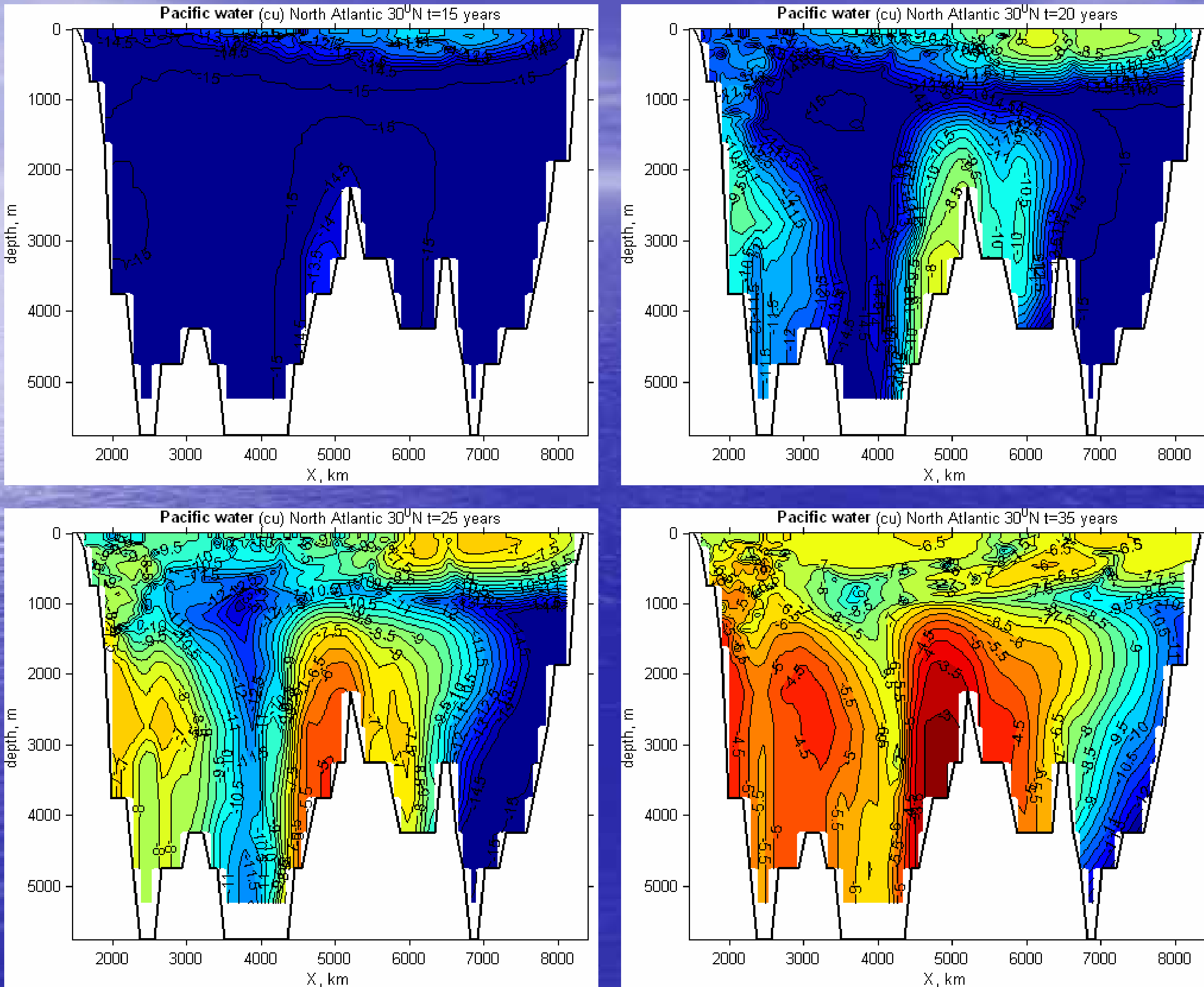
Pacific Ocean water spreading after 5, 10 , 15 and 30 years after beginning of the emission (1965)

Pacific water on the cross-section alone the solid line after 1, 2, 5 and 10 years of emission (February-left, August – right)

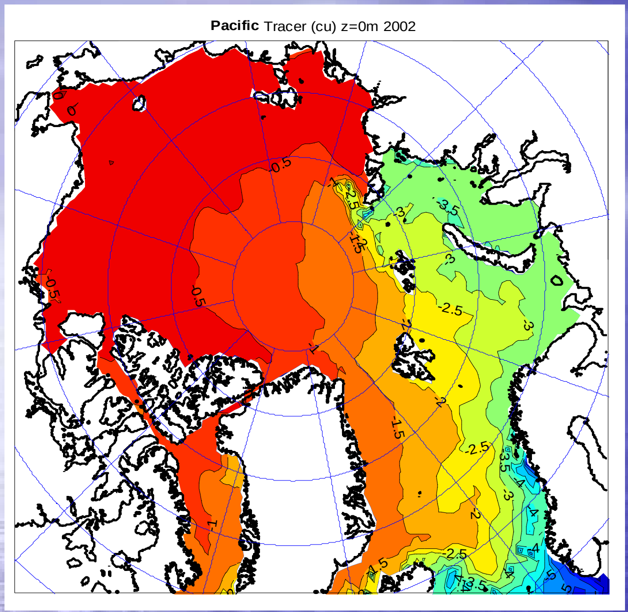


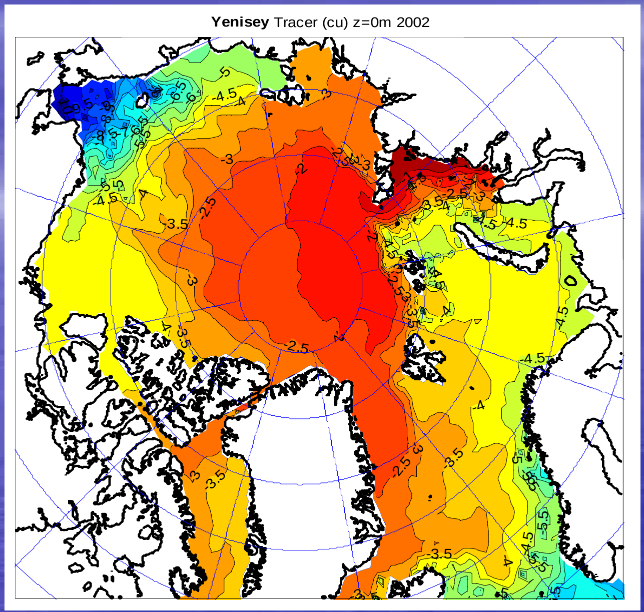


The vertical cross-section of the concentration of the Pacific water through the latitude 30 N after 15, 20, 30, 35 years (the West is in the right)



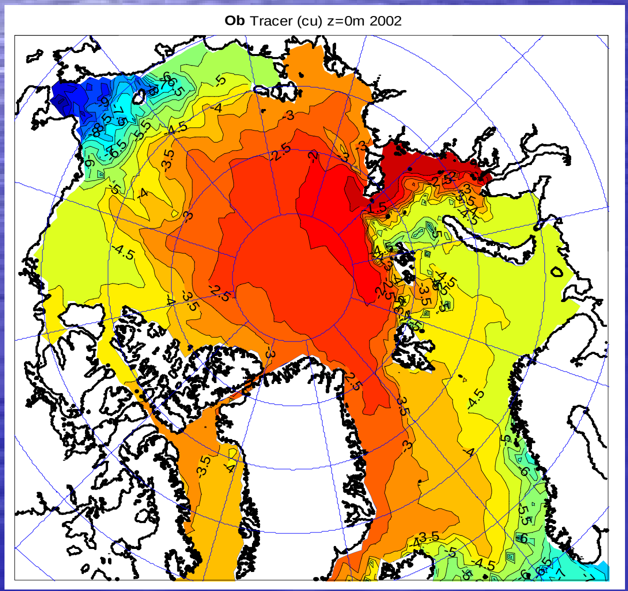
Transport of the freshwater after 37 years of the emission beginning (1966) :

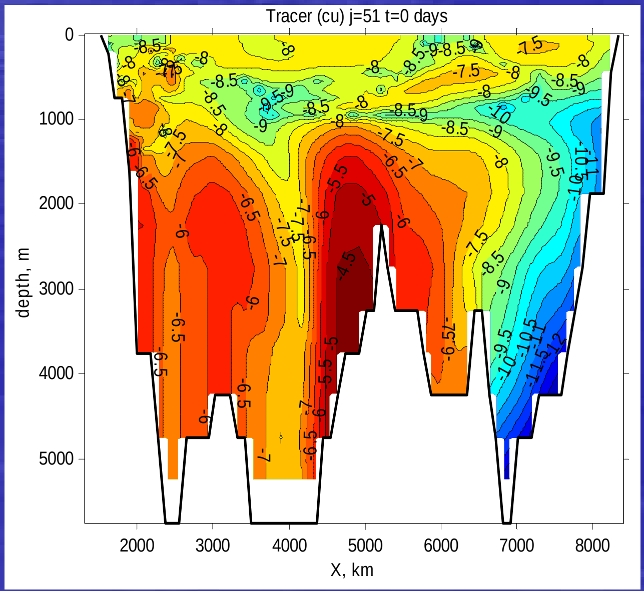




Pacific water from Bering strait (upper left);

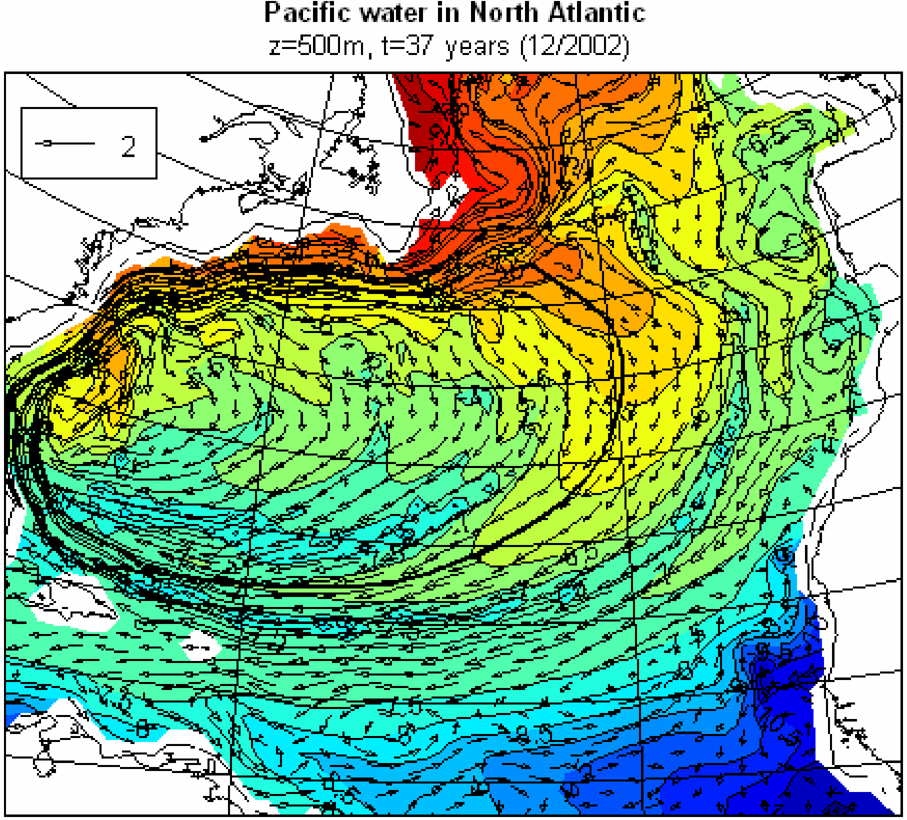
Enisey river water (upper right);





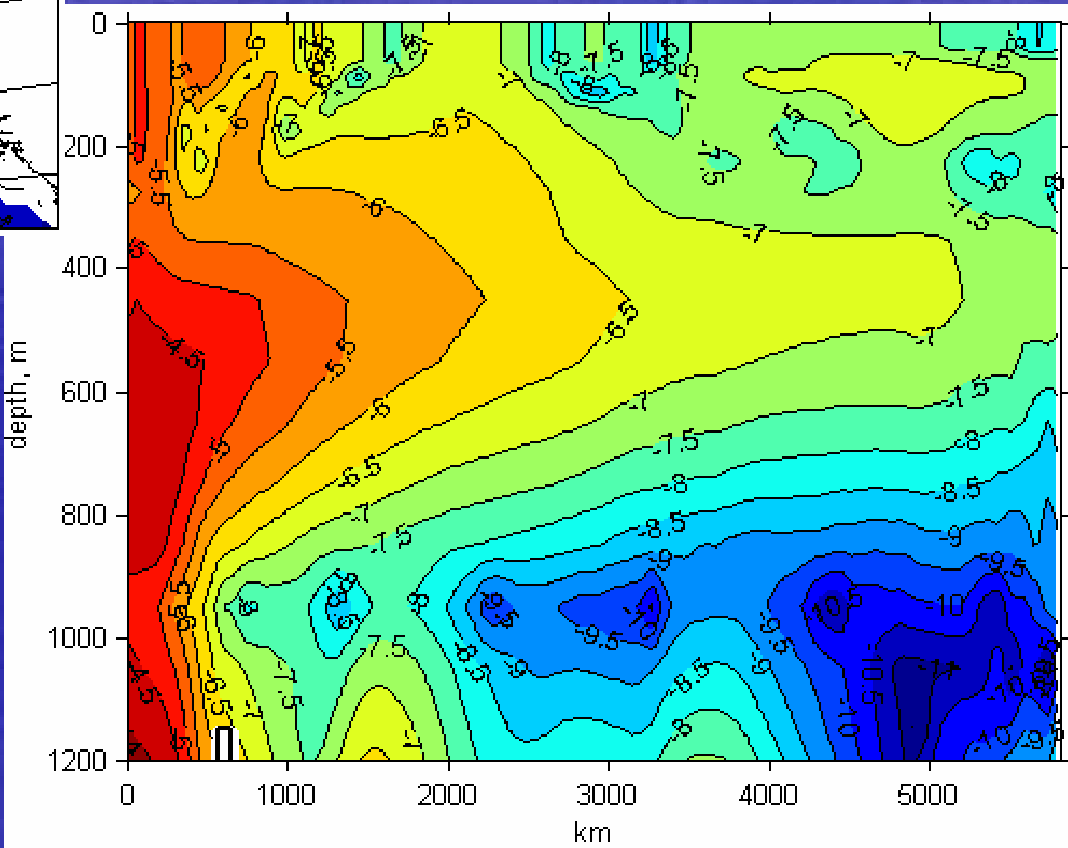
Ob river water (low left);

The vertical cross-section of the concentration of the Ob river freshwater through the latitude 30 N (low right) (the West is in the right)

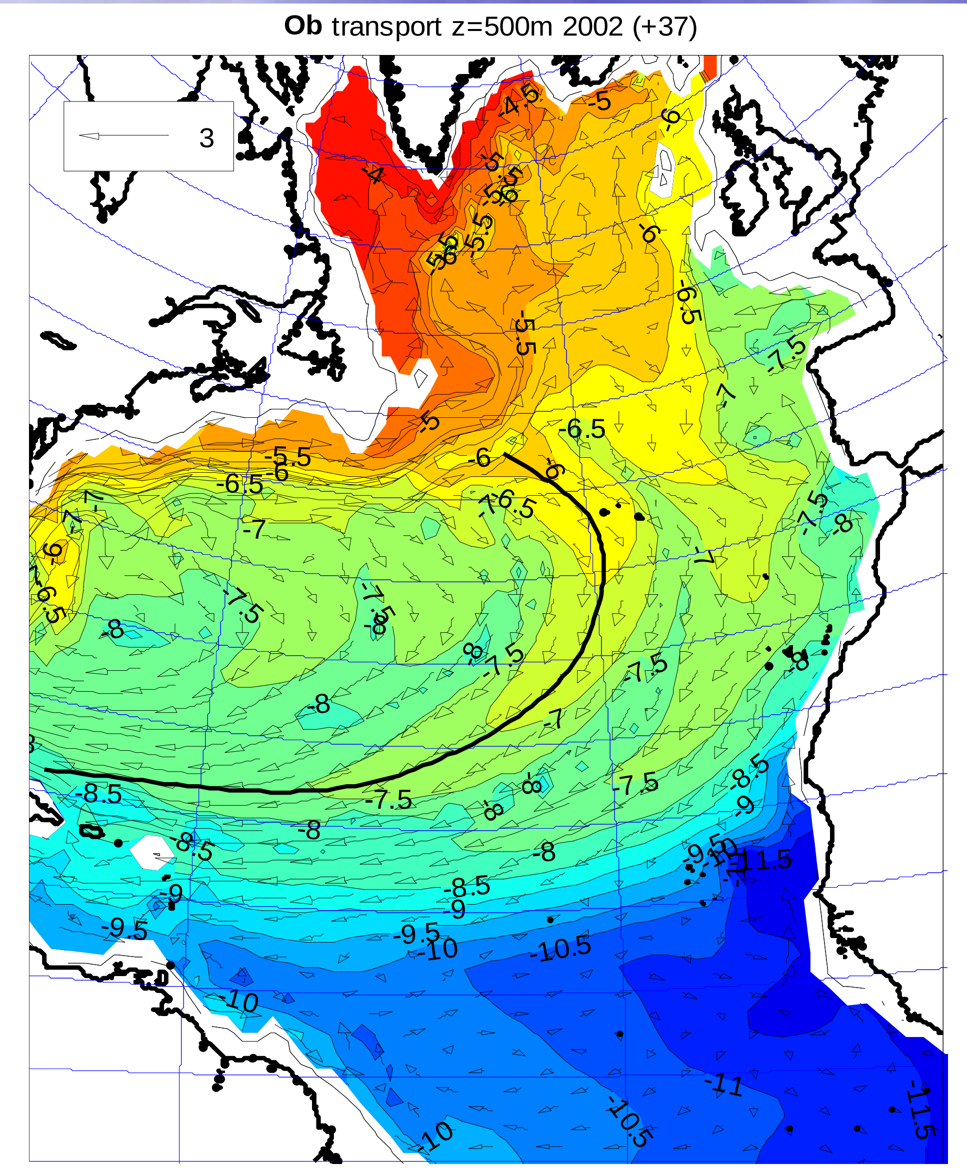


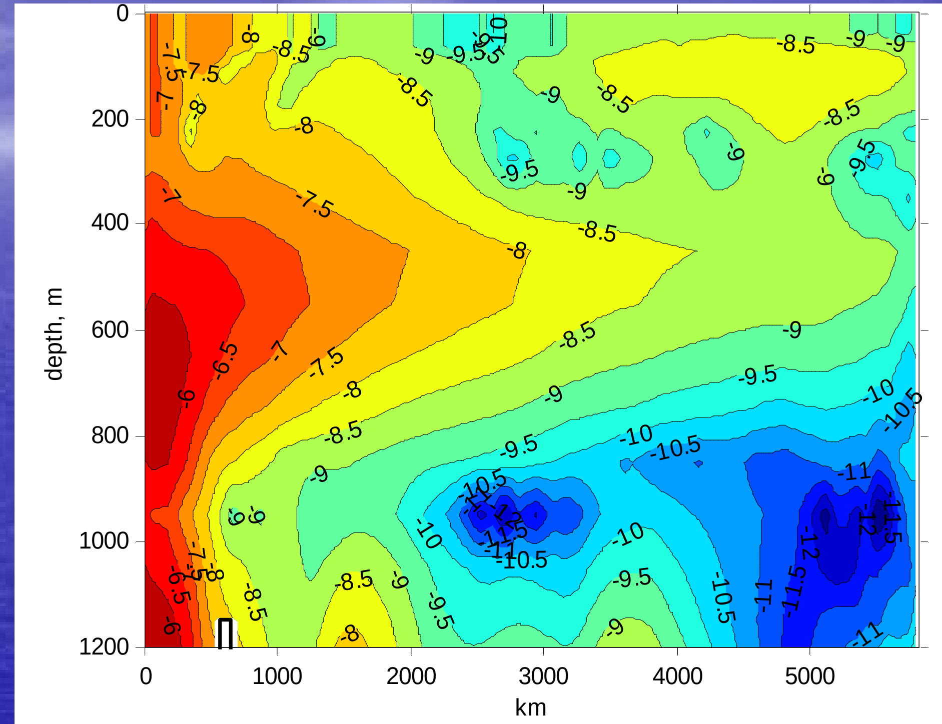
The Pacific water distribution the depth 500 m in the North Atlantic after 37 years of the emission. The arrays denote the velocity field. (The scale 2 cm/s is presented in the corner)

The cross-section of the Pacific water along the line marked in the left picture as the solid line

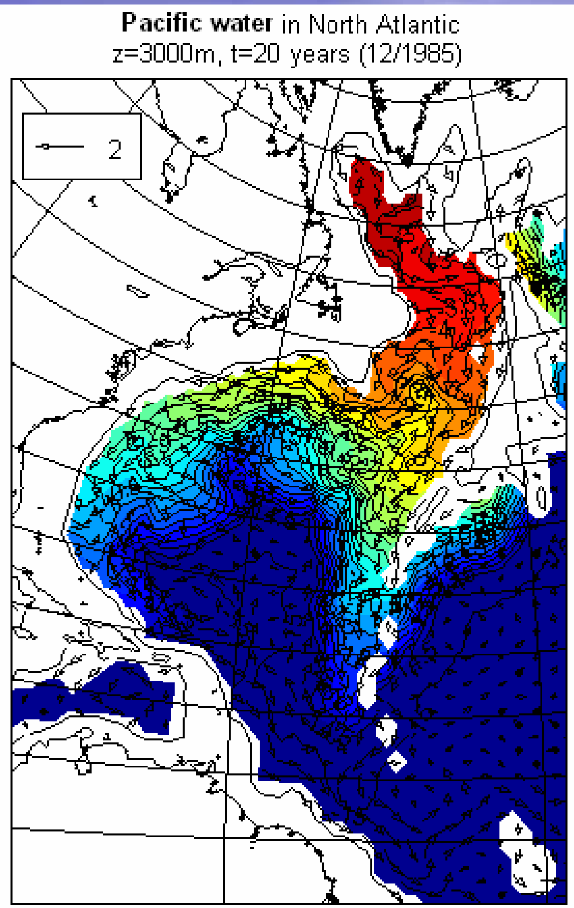


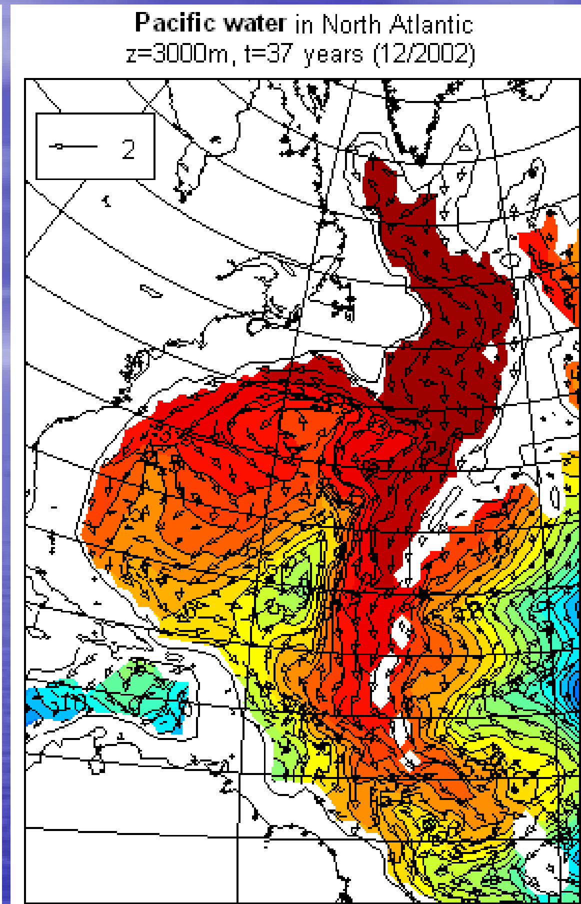
The Ob river freshwater distribution the depth 500 m in the North Atlantic after 37 years of the emission. The arrays denote the velocity field. (The scale 3 sm/c is presented in the corner)



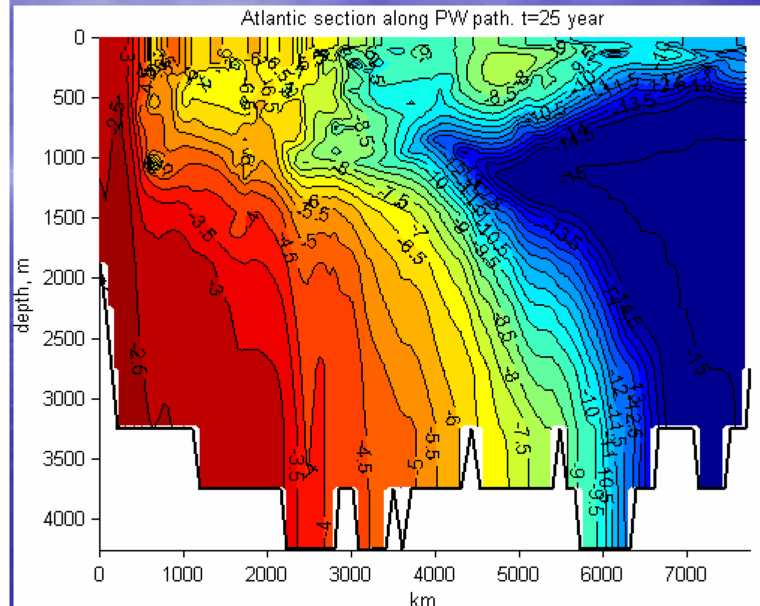


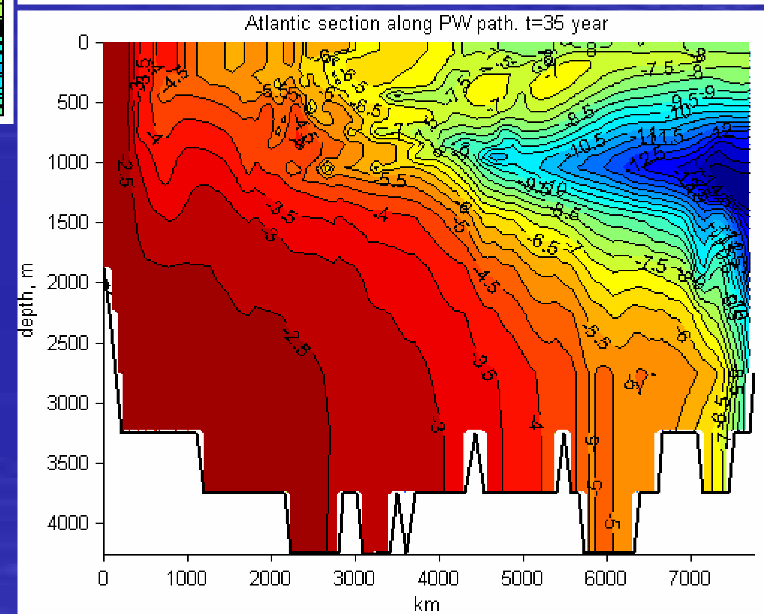
The cross-section of the Ob river freshwater along the line marked in the left picture as the solid line





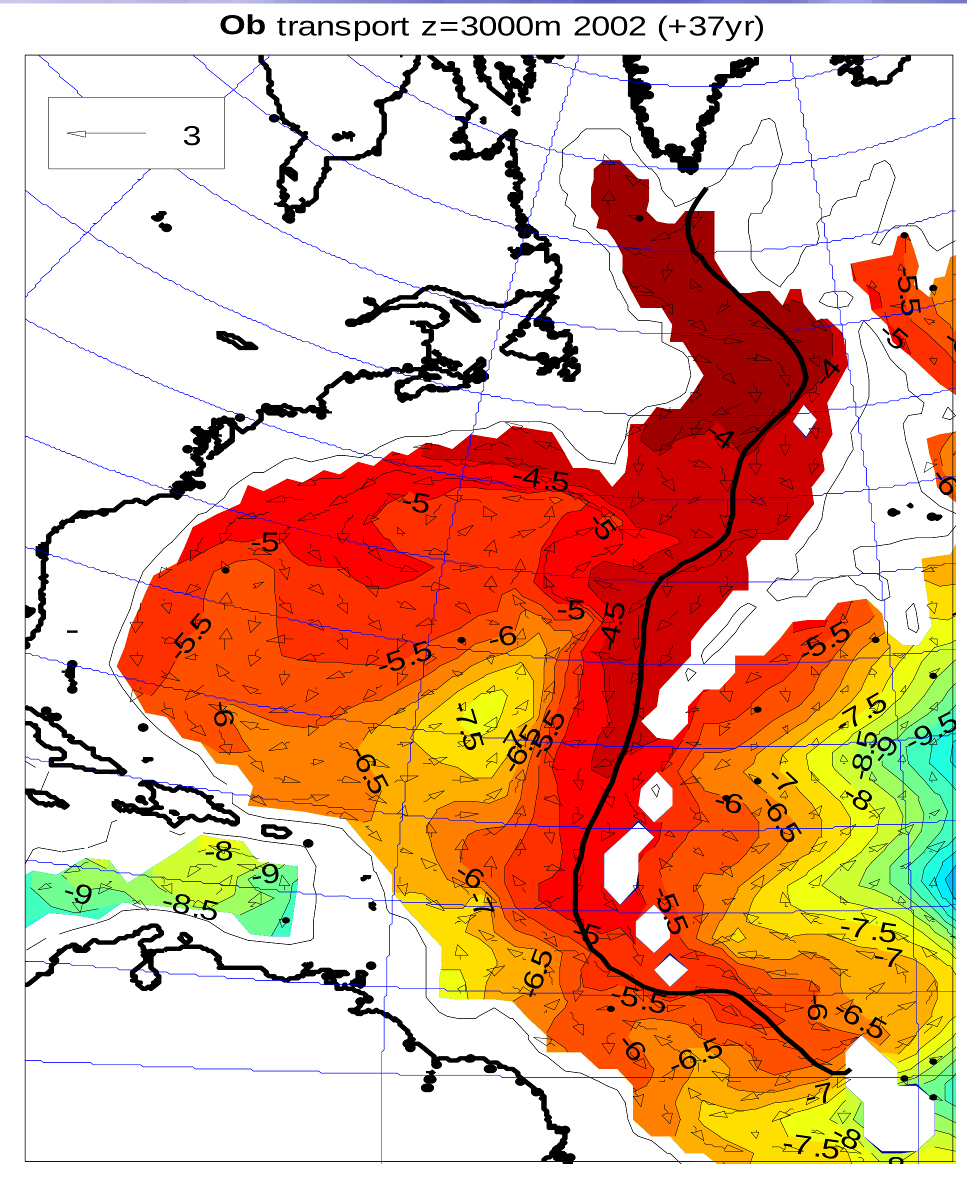
The cross-section of the Pacific water spreading along the Mid-Atlantic ridge

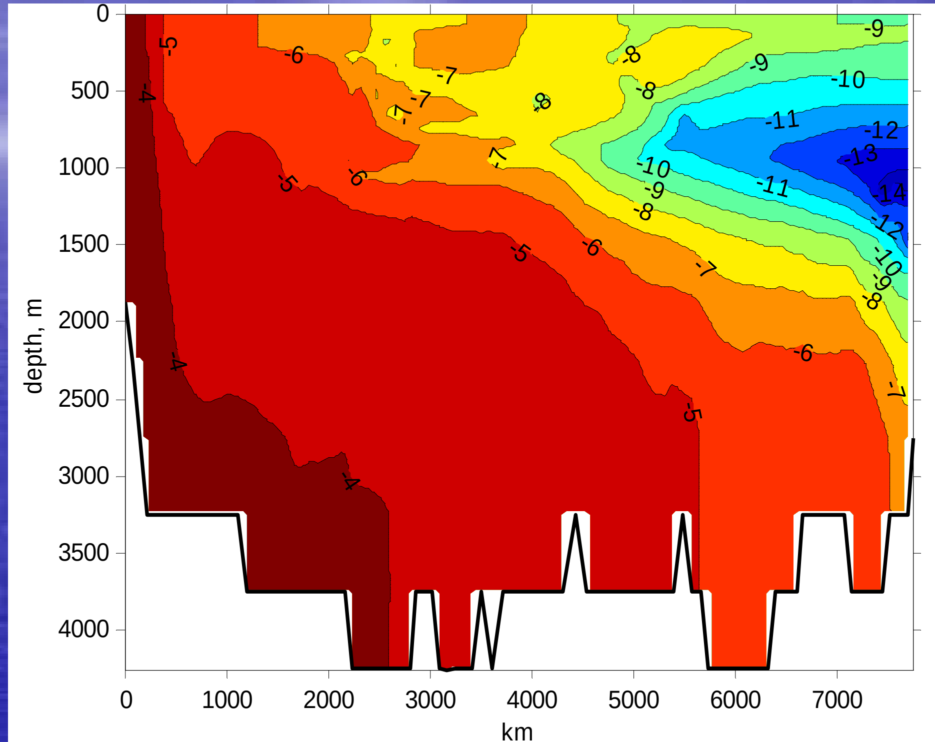




The Pacific water distribution the depth 3000 m in the North Atlantic after 20 and 37 years of the emission. The arrays denote the velocity field.

The Ob river water distribution the depth 3000 m in the North Atlantic after 37 years of the emission. The arrays denote the velocity field. (The scale 3 cm/s is presented in the corner)





The cross-section of the Ob river freshwater along the line marked in the picture as the solid line

Conclusion

- The Bering Strait throwflow play an important role not only in the regional sense for the Chukchi Sea and Arctic Ocean, but globally in the Atlantic deep water formation and global water cycle
- The comparison of the water spreading from the Bering strait and the Siberian rivers in the ICM&MG model has some common features, but there exist some differences in the water masses distribution both in Arctic and in North Atlantic
- The Pacific water masses tends to the Canadian coast and spreads mainly through Beaufort Sea, whereas the Siberian rivers water propagate through the Polar region from the Siberian shelf side
- The Pacific water propagates to the North Atlantic both through the Canadian Archipelago and the Fram Strait, whereas the Siberian rivers water spreads mainly to the East of the Greenland
- The common features of the both water masses propagation is the deepening some part of them up to 3003 m in the Labrador and the Greenland seas and spreading along the Mid-Atlantic Ridge off American coast
- Some part of the refreshed waters are transported by Atlantic subtropical gyre