Joint ART-APECS Science Workshop

The simulations of circulation in the Laptev Sea using FVCOM

Vera Fofonova* (Vera.Fofonova@awi.de), Sergey Danilov*, Karen Wiltshire*, *Afred-Wegener-Institute

Among the seas of the Arctic Ocean the Laptev Sea receives the input from the largest number of rivers such as Lena, Olenyok, Khatanga, Anabar, Yana, Omoloy, Gusiha and other small rivers. It has been also shown that Laptev Sea can serve as an indicator of climate changing. The Lena river discharge into the Laptev Sea ranks 8th in the world and deserves therefore a special interest. A large number of observed data in this region suggests a strong climate and biological data change within the last 30 years.

The ecosystem dynamics are sensitive to the temperature and salinity variability and are directly connected to the ocean circulation. We investigate temperature and salinity patterns in the Lena Delta region under the influence of various physical and climate factors in the entire mixed layer and over a short period of time. The goal is to assess the degree of influence of Lena river runoff temperature, local wind patterns and tidal dynamics on temperature and salinity variability. In addition, the attention is paid to the assessment of the impact of local bathymetry on local temperature and salinity patterns.

Input data

- Bathymetry and coastline data – NOAA, GEBCO, AWI-Potsdam (P. Overduin)
- Atmospheric data – COSMO model (University of Trier), NCEP reanalysis 1,2
- Salinity, temperature fields – AWI-Bremerhaven (R.Gerdes, P. Rosman Sea-Ice model)
- Tides – tpxo6.2 + Doodson's correction
- Runoff data – State Hydrological Institute-St.Petersburg (observation data)
- Satellite images – AWI-Bremerhaven (T. Krumpen), AWI-Potsdam (B. Heim), University of Trier (S. Willmes)

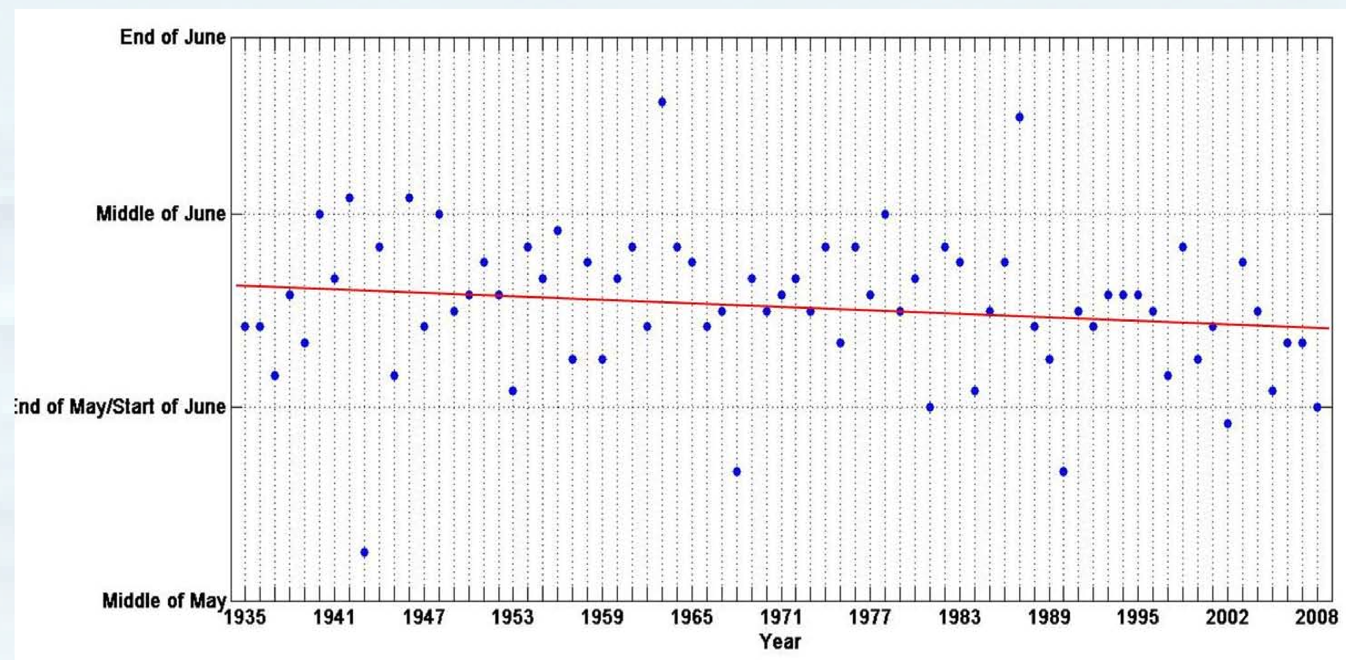
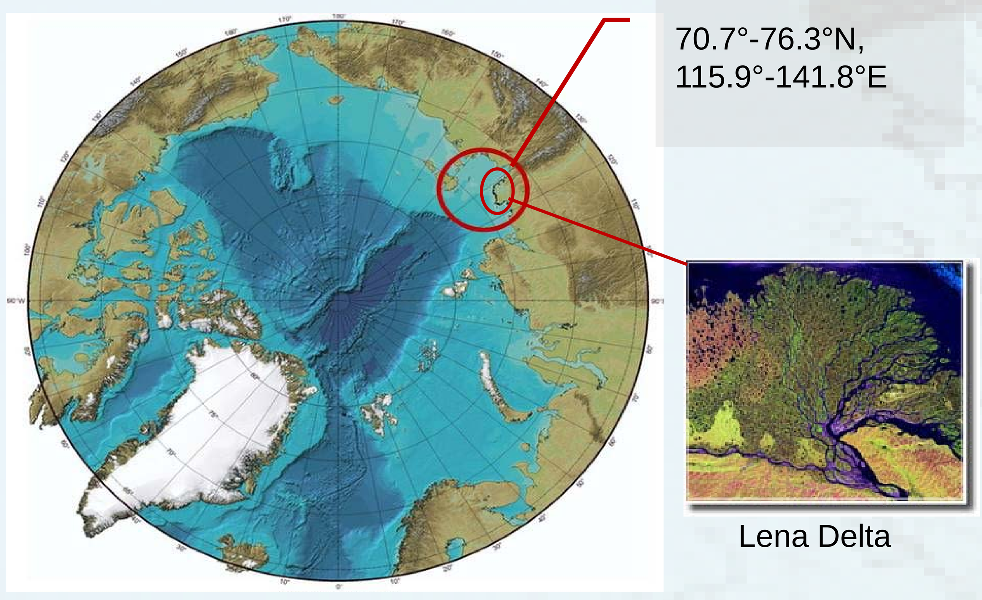


Fig. 2. The time of the year when the daily flow of Lena reaches its maximum. The regression line is shown in red. The theoretical slope of the line is significantly different from 0 at the 18% level.



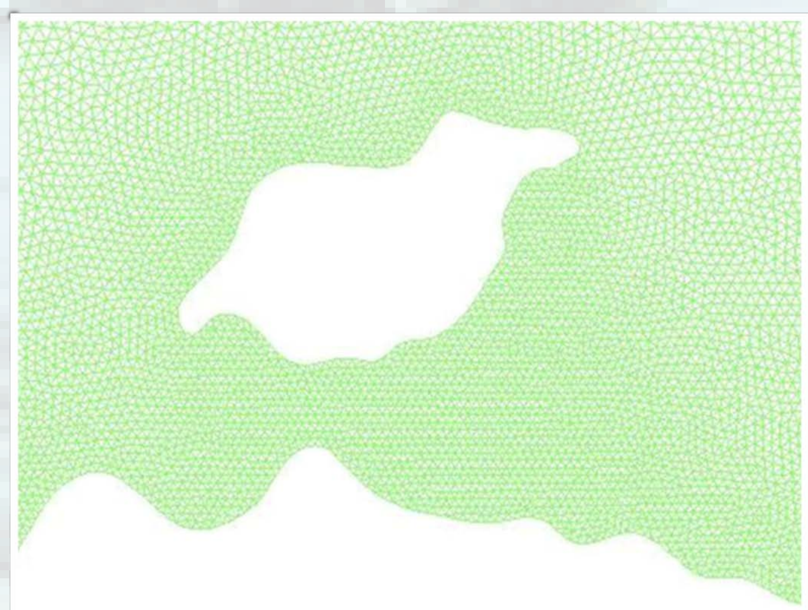


Fig. 1. a) The domain under consideration. *b) Grid quality.*

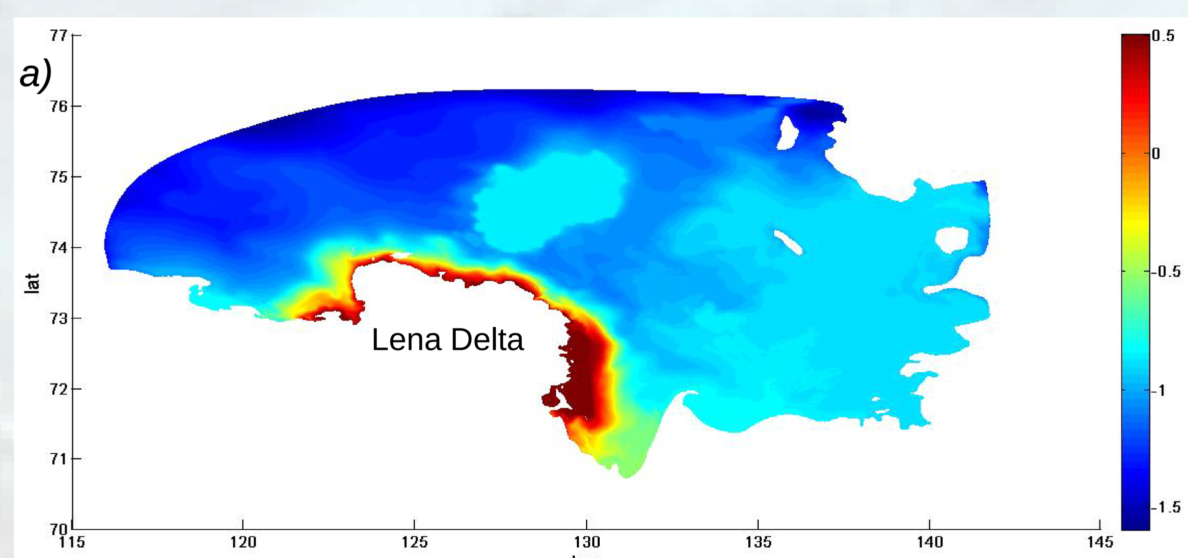
Model features

- Unstructured grid, size of elements varies from 400 m to 5 km
- 6 vertical layers
- Include wet/dry treatment of domain
- Use GOTM turbulence model
- Use open boundary Temperature/Salinity time series nudging
- External time step is 6 sec, ratio of internal mode time step to external mode time step is 10

Model description

To perform designated tasks we used Finite Volume Coastal Ocean Model (called FVCOM). FVCOM was originally developed for the flooding/drying process in estuaries and the tidal-, buoyancy- and wind driven circulation in the coastal region featuring with complex irregular geometry. FVCOM is a prognostic, unstructured-grid, finite-volume, free-surface, 3-D primitive equation coastal ocean circulation model.

The simulated periods are late spring/summer months. We assumed that during May a thin layer of movable ice preserved in the considered domain, except for the zone of polynyas. The fast-ice in the Laptev Sea, in particular in Lena Delta region, generally, breaks up when freshwater runoff reaches its maximum. For the last 100 years a tendency towards earlier daily maximum flow formation was observed (Fig.2).



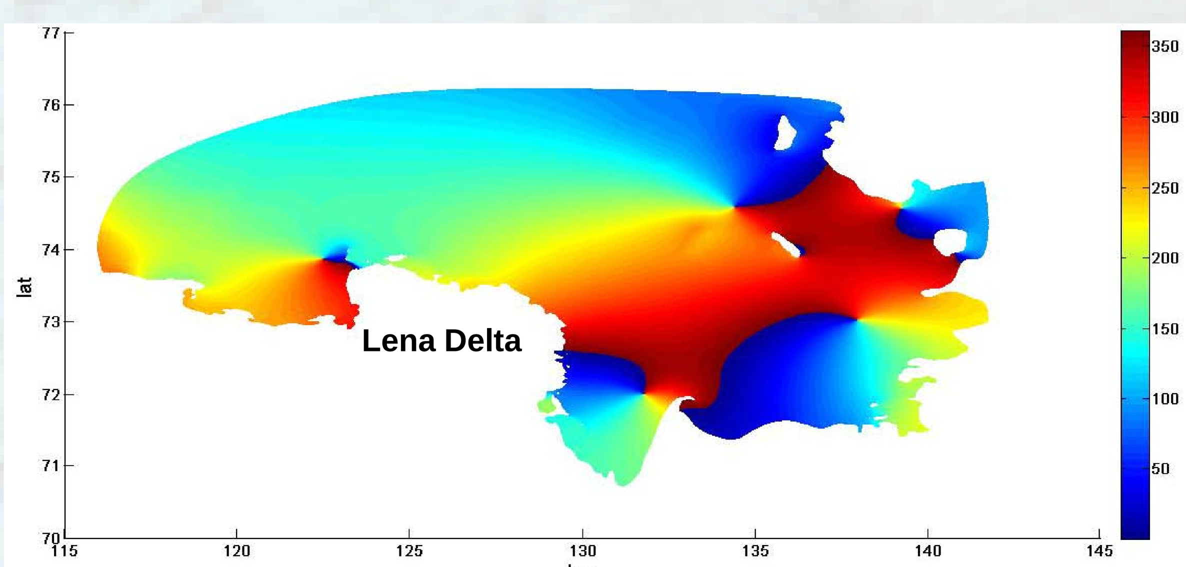


Fig. 3. Barotropic case. The tidal map for M2 constituent on the assumption that the Laptev Sea is free of ice.

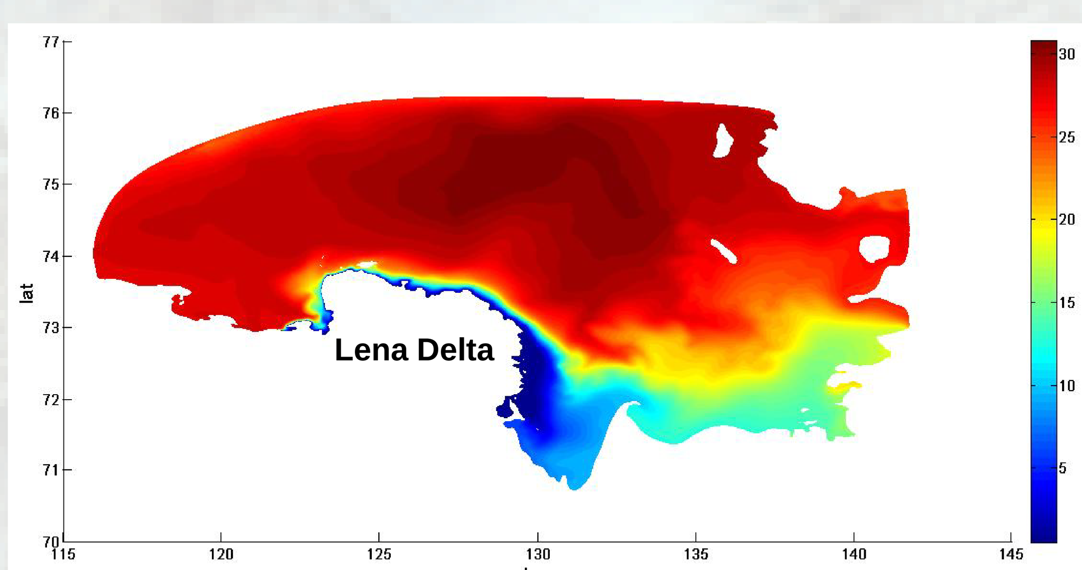


Fig. 4. (Baroclinic case) The salinity field, PSU. The simulation period – summer months with prevailing cyclonic regime.

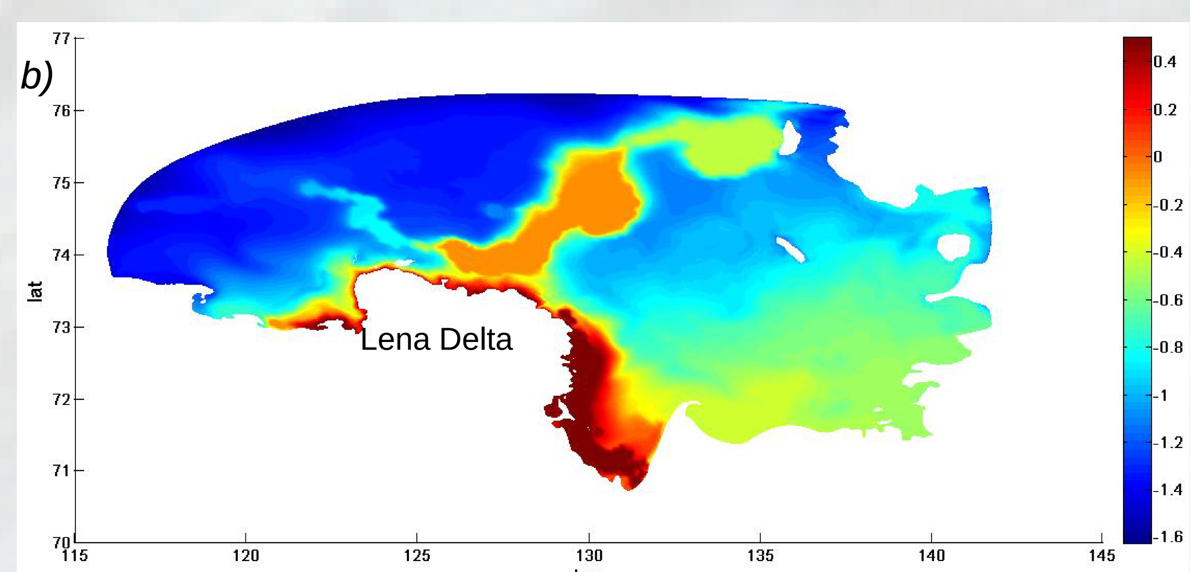


Fig. 5. (Baroclinic cases with different structure of heat fluxes) The temperature fields at 3m depth, simulation period from 9 of May 2008 to 31 of May 2008, the wind pattern is the same for all simulations, °C:
a) atmospheric forcing from COSMO without open polynya assumption,
b) atmospheric forcing from COSMO with open polynya assumption.

For barotropic case we constructed the tidal maps for M2 (Fig.3) and S2 constituents on the assumption that the Laptev Sea is free of ice. For baroclinic case we compared salinity and temperature fields in mixed layer between simulations with prevailing cyclonic and anticyclonic regimes (Fig.4) and different structure of heat fluxes (Fig.5). We also analyzed the role of tidal dynamics (Fig.6), different temperature of freshwater input and its implementation techniques.

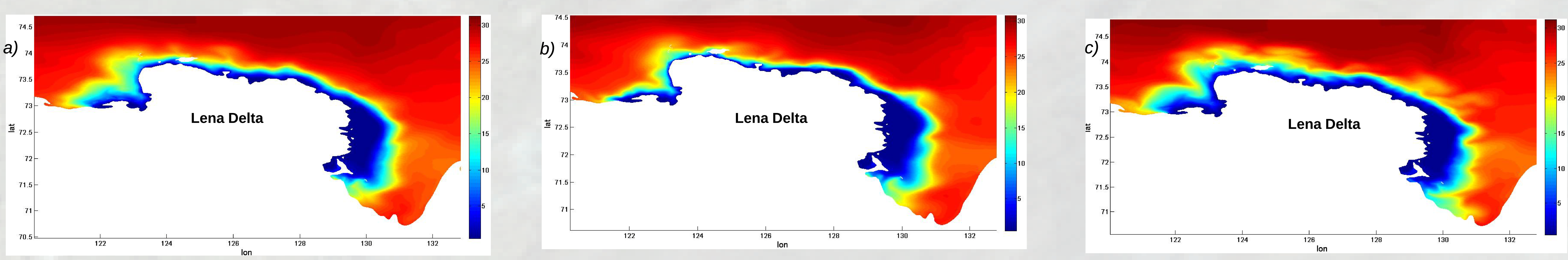


Fig. 6. The salinity fields, freshwater runoff input from the boundary, calculation period from 9 of May 2008 to 31 of May 2008, PSU: a) atmospheric forcing from COSMO without open polynya assumption, b) no atmospheric forcing, c) atmospheric forcing is the same as in a), but no tidal dynamics.