Project: **1206**

Project title: **High-resolution modeling of the interaction of physical and biogeochemical processes in the Kara Sea**

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The current project is aimed on the study of hydrodynamics and biogeochemical processes of the Kara Sea by means of numerical modeling. We use a MITgcm-based [Marshall et al., 1997] regional high-resolution **Ka**ra **S**ea **M**odel (**KASM**) with effective horizontal resolution of 900 m and 1500 m, which allow to resolve the first baroclinic Rossby radius and simulate the mesoscale eddy dynamics explicitly almost everywhere in the Kara Sea except for the very vicinity of the Ob and Yenisei estuaries. According to the Project roadmap, the first stage of the Project was the calibration and verification of KASM. It included the model's preliminary tuning, spin-up run, and different sensitivity experiments - a large number of short-term experiments 2-5 years long performed in order to reach the best agreement between the model's results and available observational data. At this first stage, only the KASM's physical module was considered and calibrated in order to configure a stable and reliable basis for further biogeochemical simulations. <u>In the following we briefly report our main results obtained during this first stage:</u>

1) A local database of in-situ water temperature and salinity vertical profiles has been prepared for the Kara Sea, based on the UDASH database [Behrendt et al., 2018] and satellite data of SST and sea ice area [https://cds.climate.copernicus.eu] for successive KASM calibration and verification. Several examples of comparison of KASM results with observations and ocean reanalysis are shown in Fig. 1 and 2. We find calibration and verification results of KASM quite satisfactory, taking into account the complexity of dynamical and thermohaline processes in the Kara Sea and the fact that KASM does not use any kind of assimilation or restoring (intentionally, in order to investigate the characteristics and interaction of physical and biogeochemical processes in their pure formulation in the model).

2) We have found that it is necessary to use the calculated sea ice velocities at the open boundaries of KASM during outflow, because the use of clamped boundary conditions (i.e., Dirichlet boundary conditions) for the sea ice velocities leads to rapid sea ice mass convergence along the boundary and unrealistic sea ice thickness.

3) The use of no-slip boundary condition for the sea ice leads to some accumulation of sea ice along the southern coast of the Kara Sea (Yamal peninsula coast, Taymyr coast). This effect helps to simulate the spatial distribution of fast ice which is present in observations according to the Arctic and Antarctic Research Institute data [http://www.aari.ru/].

4) Comparison of model results with observed sea ice area and SST has shown that the water type Jerlov III should be used in KASM simulations. KASM uses a two-band parameterization of light attenuation by [Paulson & Simpson, 1977]. This result agrees well with satellite data of diffuse attenuation coefficient [https://oceancolor.gsfc.nasa.gov/] for the most part of the Kara Sea, except for estuary areas where the attenuation coefficient increases up to 1.0 m^{-1} for the blue fraction of SWR.

5) We have found that the use of previously determined estimate of mean background diapycnal diffusion coefficient for the Kara Sea, equal to 1.57e-3 m^2/s [Kagan & Sofina, 2018], leads to the significant overestimation of vertical mixing. Numerical experiments with KASM have shown that the background vertical mixing coefficient which gives the best agreement between observations and KASM is of the order of 1.0e-5 m^2/s, the main turbulent closure used in the KASM being the scheme by [Gaspar et al., 1990].

6) A large number of numerical experiments with KASM have shown that the best agreement between the modeled and observed sea ice spatial distribution throughout the years considered (2012-2020) is achieved with the following sea ice albedo values for the Kara Sea: dry Ice Albedo = 0.60, wet Ice Albedo = 0.50, dry Snow Albedo = 0.80, wet Snow Albedo = 0.60. Also, the use of free-water albedo equal to 0.07 gives the best agreement with observations for SST and sea ice area. Though this value is a little bit smaller than the one generally used in climate simulations (0.1), it is in a good accordance with results reported by [Feng et al., 2016].

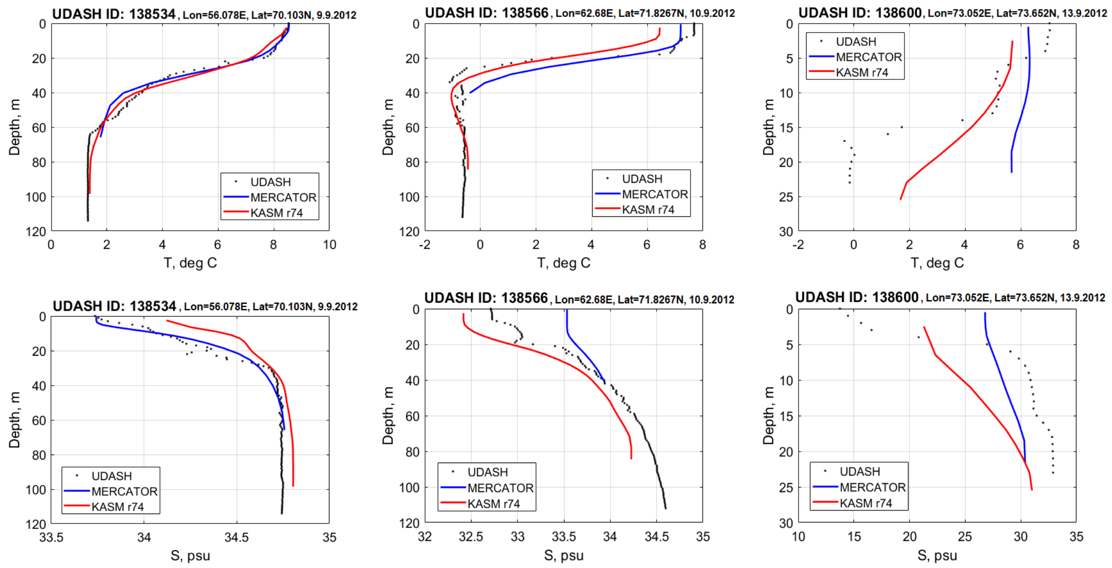

Fig. 1. Vertical profiles of water temperature T(upper panel) and salinity S (lower panel) according to in-situ data (UDASH), Mercator Ocean reanalysis, and regional model KASM

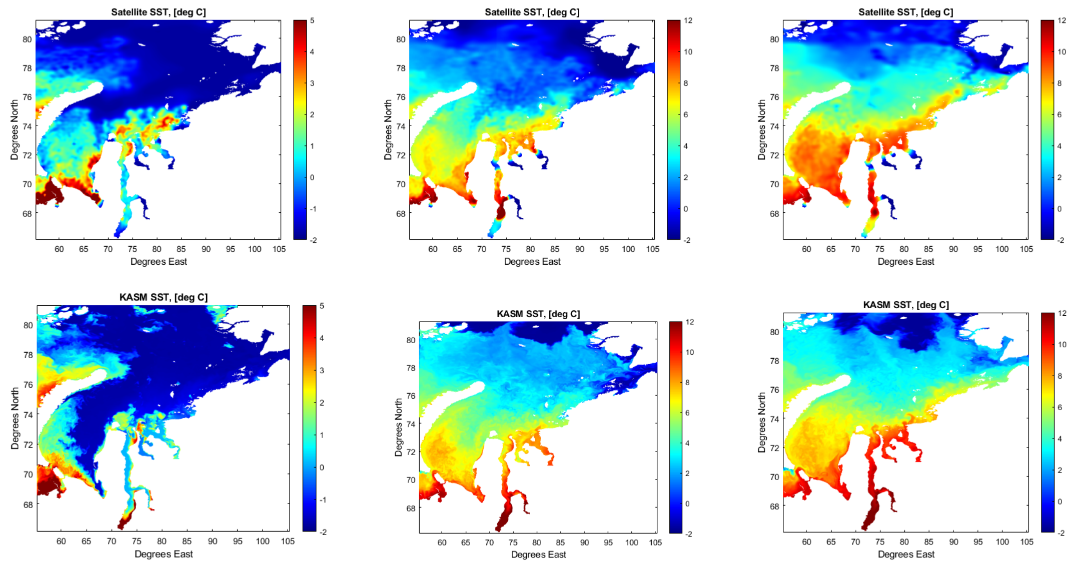

Fig. 2. SST spatial distribution on 15 of June (left column), July (middle column) and August (right column) 2012 according to satellite measurements (upper panel) and KASM simulation (lower panel).

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