Modeling of the Spitsbergen fjords

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Abstract

Recent climate changes have the main reflection in the Arctic ice conditions. In 2007 ice extension has the smallest area in last several decades. One of the most important process that have influence on Arctic ice cover is oceanic heat transport into the Arctic by West Spitsbergen Current (WSC). But WSC also can have impact on the ecosystem of Spitsbergen fjords. There are two fjords that could be under influence of WSC – Hornsund and Kongsfjorden and each of them has different local biological state.

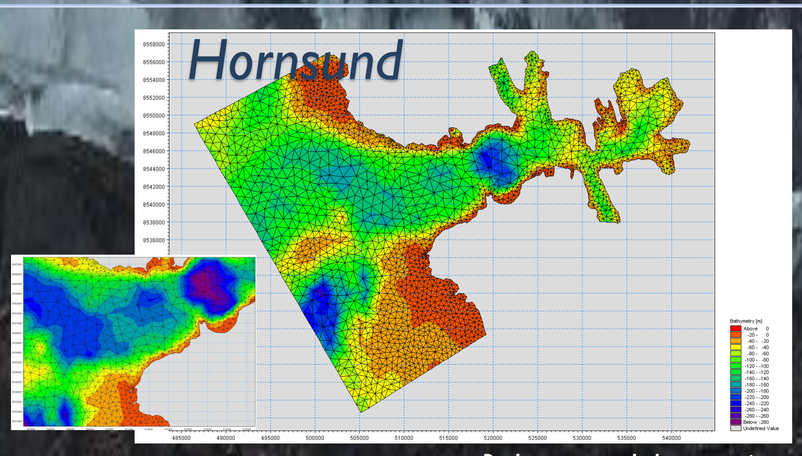
This work is focused on helping to understand influence of climate changes on local state of those fjords and modeling is one of the tool.

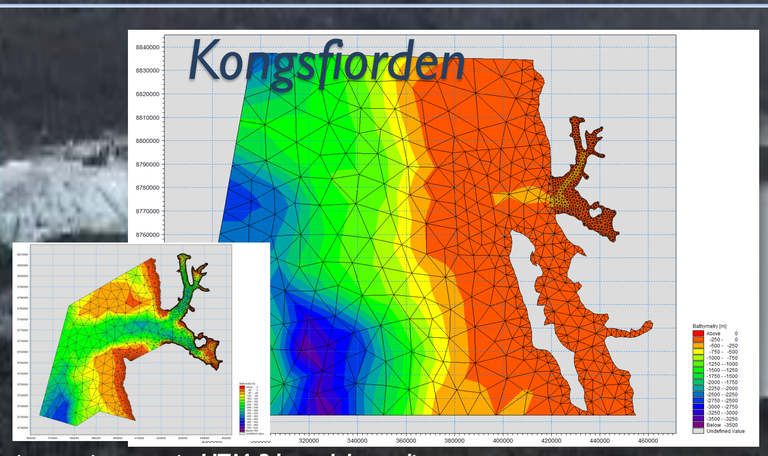
MIKE 3D has been configured for diagnosis what is the main driver of the states of fjords – WSC (or other currentIn example Sorkap Current) or local fresh water discharges. Model domains have been extended for covering fjords and shelf area. Based on archival data together with in situ measurements, numerical simulation will provide part of the study of the complex ecosystems. Model integration will provide spatial and temporal variability of the main physical quantities and it will help for better understanding of the fjords ecosystem.

Model description

The first and very important step taken in modeling was to decide how to map the area that is not a fjord, but having a significant impact on the dynamics of the flow of water masses in the fjord. We have created three versions of each model for each modeled a different amount of shelf and deep ocean areas. As a next step we have selected revisions which is optimal in terms of accuracy of the solution and the required computation time. The shape of the open model borders was determined by the location of the model grid compute nodes TOPAZ4. With this model in the future it is planned to download the boundary conditions for our model in the form of temperature and salinity in order to maintain temperature balance and the actual amount of salt in the fjords.
The use of flexible mesh as a way of discretization the area of integration allowed for a detailed summary of the shoreline inside and outside of the fjords and prioryzation important areas of domains.
Aspects on which we pay special attention to faithfully reproduce the actual conditions affecting the hydrodynamics fjords are:

- Force the models with specific wind conditions.
- The interaction of tion of sea water in the fjords of West-Spitsbergen Current.
- Pay particular attention to areas of the shelf
- Increase grid density.
- Influence of the sea - ice.
- The influx of fresh water from the melting glacier.
- Mapping fjords gutter - drainage glacial origin.





Bathymetry and chosen variant of discretization for integration area in UTM-31 model coordinates.

Model configuration

MIKE 3D is very flexible, but also with many limitations modeling tools. To have pretty well starting point it is required to have initial conditions. One of the most important data set for the initial state of the model is temperature and salinity. Institute of Oceanology have been doing in situ measurements in Svalbard area since over fifteen years. One of the main goal of each Arctic expedition is exploration of the Svalbard fjords. During such expeditions standard CTD measurements are taken in the fjords. Transects are presented on the images. Recorded transects are extended to entire fjord numerically and then interpolated in to model domain and levels. Pictures present measured transects from measurements and then extrapolated into model levels.
The main problem is with availability of such data. Measurements are limited by weather and ice conditions in the fjords. Also depends on other expeditions aims

Flather's boundary condition (1976) let us to force the model with combined information. At the same time tidal ordinate and barotropic component of velocity that reflects the West Spitsbergen Current are implemented. The Flather (1976) condition is very efficient in connection with downscaling coarse modelsimulations to local areas (Oddo and Pinardi (2007)).

Tidal forces heve been created using the Global Tide Model. The Global Tide Model data pepresents the major diurnal (K1, O1, P1 and Q1) and semidiurnal tidal constituents (M2, S2, N2 and K2) with a spatial resolution of 0.25 ° × 0.25 ° based on TOPEX / POSEIDON altimeters data.

For representation of the impact of West Spitsbergen Current on fjords, barotropic velocity component have been applied in the models.
It was assumed that background constant velocity is 7 cm/s for Hornsund and Kongsfjorden. Only velocity component along the shelf isobaths was taken into account for each fjord.

BOUNDARY CONDITIONS

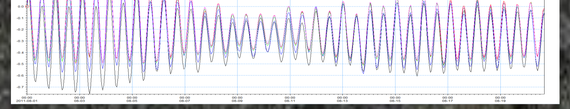
Flather conditions:

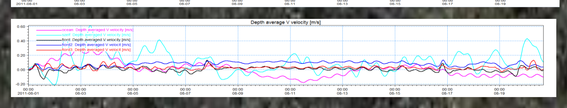
Constant velocity vector:

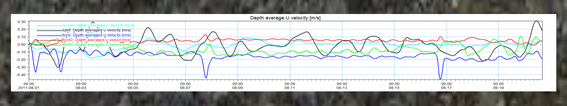
- constant u-velocity: -0.035 [m/s]
- constant v-velocity: 0.0606 [m/s]

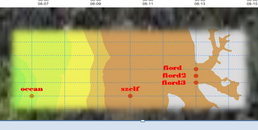
Level:

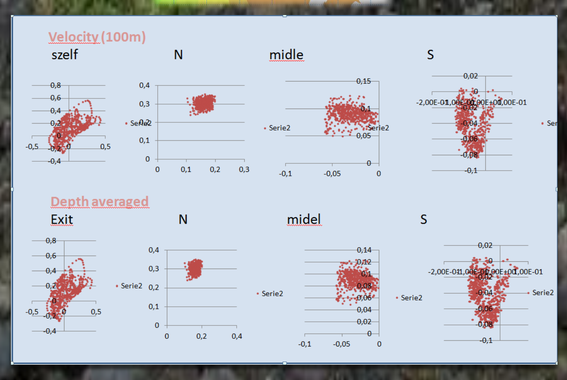
Tides varing in time and along boundary





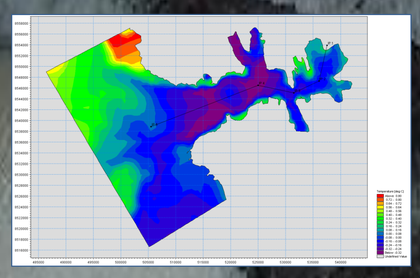


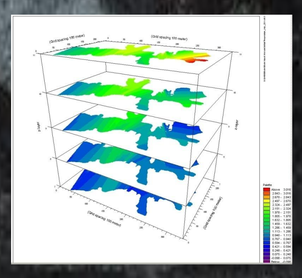


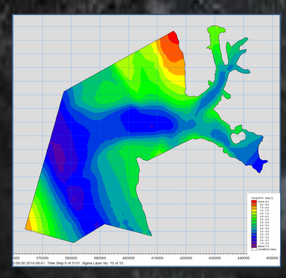


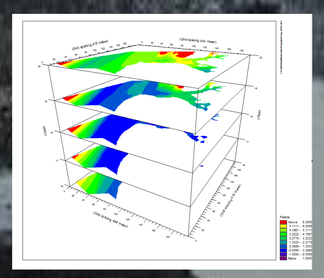
INITIAL CONDITIONS

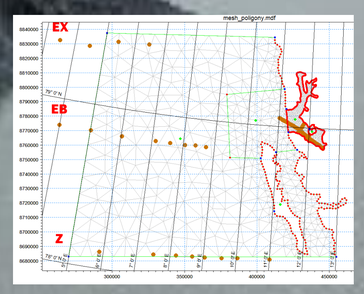
Initial temperature and salinity (IOPAS)

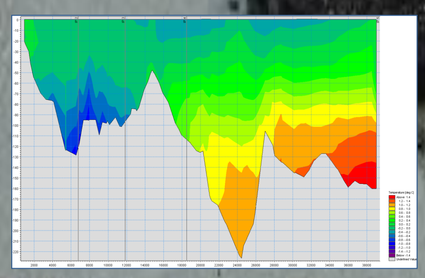


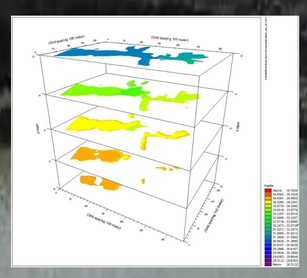


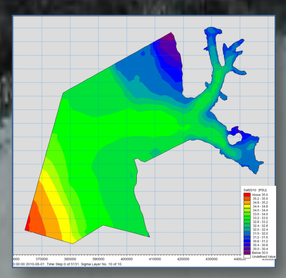


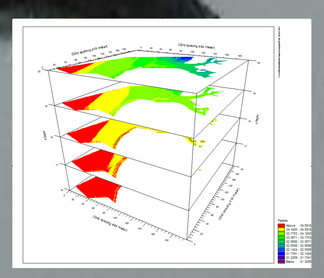


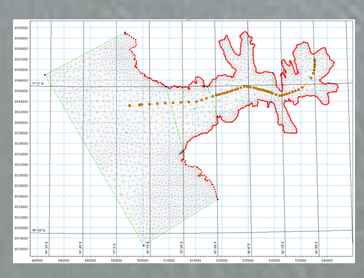




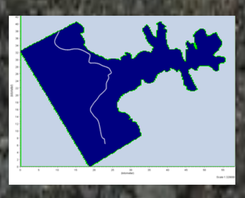


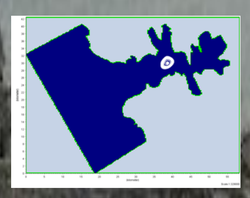


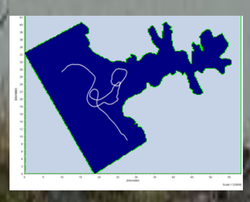


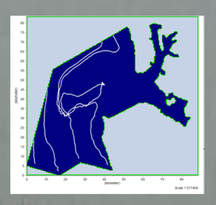


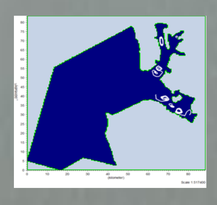
Preliminary results

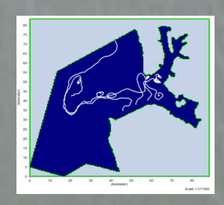




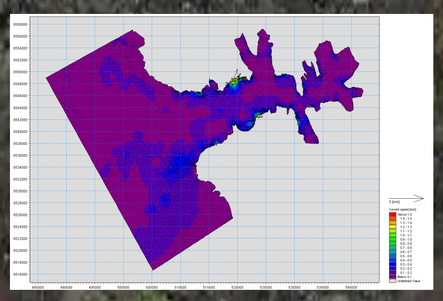


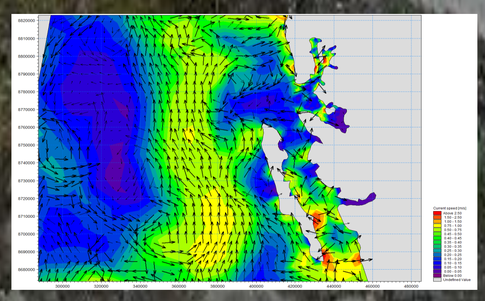




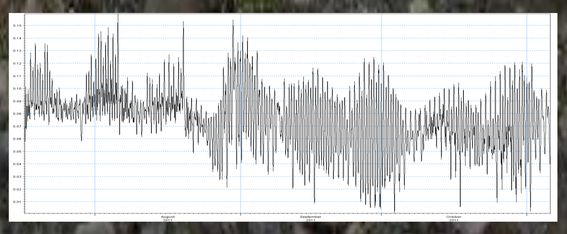


The velocity at the Hornsund and Kongsfjord entrance

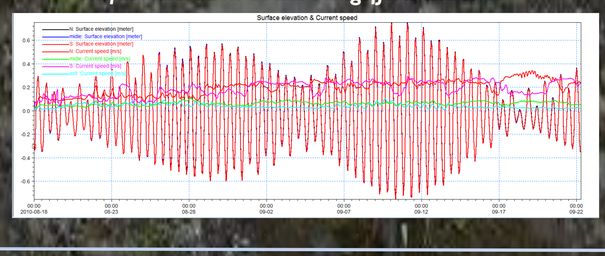




The velocity at the Hornsund entrance



Surface elevation at the Kongsfjord entrance



Summary

Currently we present preliminary results and our work is in progress.

In the future we are planning to:

- Increase vertical resolution (more vertical levels)
- add rivers
- add influence of specific wind conditions
- try to implement influence of ice cover as a modified fluxes
- add fresh water discharge from the melting glaciers and other sources

GAME

Growing of the Arctic Marine Ecosystem