LEVERAGING DIGITAL TWIN OPPORTUNITIES FOR KEY SEA-ICE IMPACT SECTORS IN THE NORDIC AND BALTIC CONTEXT

NOrdic CryOSphere Digital Twin – NOCOS DT

project duration: 2022–2024

Explore and pilot the digital twin technology opportunities and showcase how output from key initiatives like the Destination Earth (DestinE) Climate Adaptation Digital Twin (Climate DT) could be leveraged for key sea ice impact sectors in the Nordic and Baltic context.

In the longer term, deliver a major Arctic and Baltic contribution to the climate change information system developed by Climate DT, with cryosphere-related use cases at the interface between science and policy, in line with the overarching Destination Earth approach.

DEM-based sea ice model development

(led by CSC)

Current sea ice models used in short term forecasting and climate research are typically based on finite difference (FD) methods due to the fact that some other numerical methods have been computationally too demanding for sea ice applications. The finest useful resolution for the FD models is typically 1–10 kilometres. An alternative to FD models are discrete element models (DEM) which resolve sea ice physics on the scale of a few metres. DEMs are computationally very demanding and have mainly been used for process studies. However, the advent of exascale computing facilities will allow utilisation of DEMs for geophysical applications. Better forecasts for sea ice break-up, including the formation of leads, and sea ice drift, are of crucial importance for shipping and infrastructure in the Arctic and sub-Arctic regions, like the Baltic and the Barents Sea, as well as the entire Arctic Ocean. Furthermore, the understanding of long-term changes in the behaviour of drift ice in a warming climate is highly important for the research related to Arctic biodiversity changes, conservation policies and support measures for traditional hunting and fishing by indigenous people.

Goal

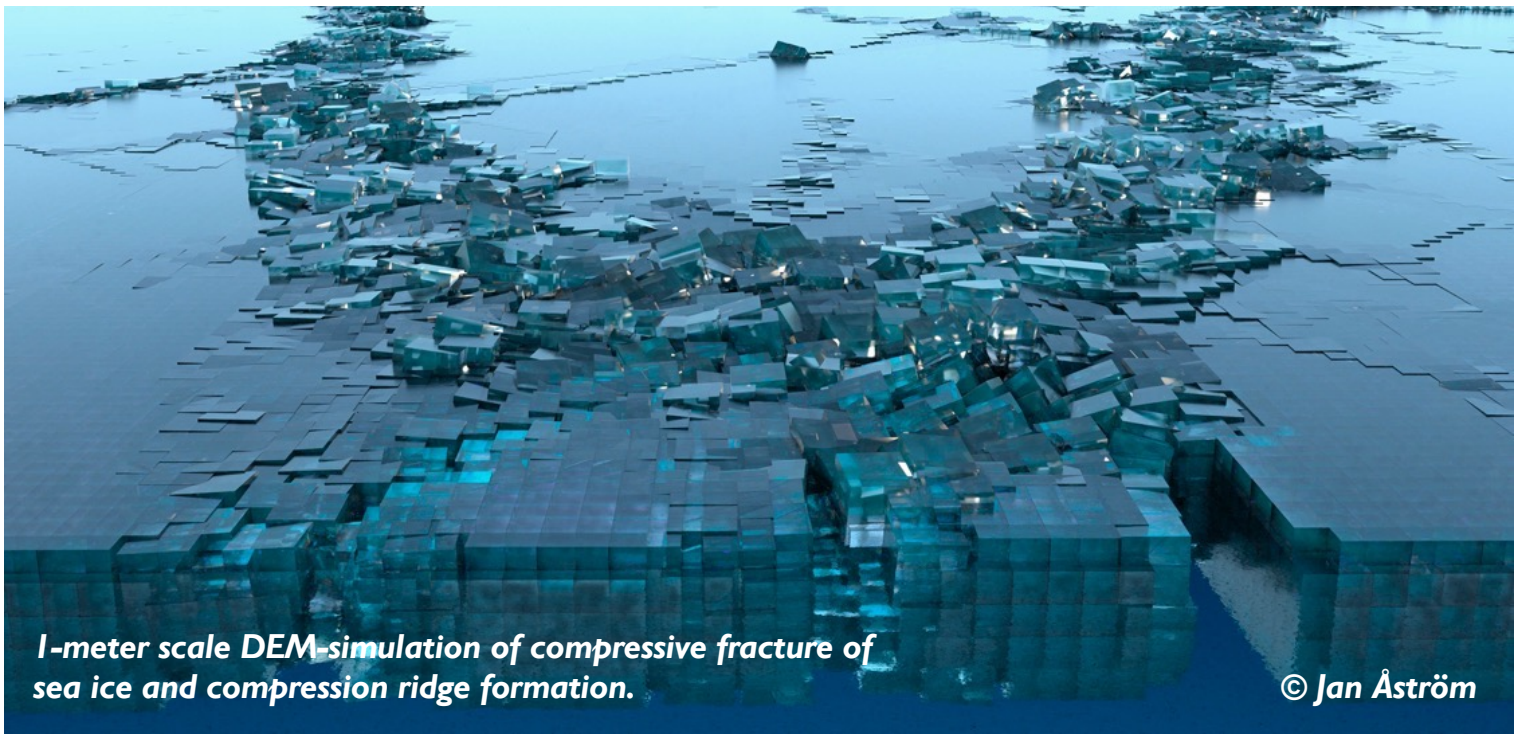
A DEM-based computer code suitable for HPC than can be applied to sea ice simulations. Peer-reviewed papers based on model computations.

Potential users

- In the first phase, scientists
- Later potentially forecast providers as a service to the public

Models and data

- A Discrete Element Model implemented in the HiDEM code. Boundary conditions, driving forces, and bathymetry is needed as input data.



1-meter scale DEM-simulation of compressive fracture of sea ice and compression ridge formation. *© Jan Åström*

Developments

Employ a general DEM developed by Åström and Robertsen (Åström et al., 2013; Åström & Benn, 2019) to simulate in detail the breakup of sea ice driven mainly by wind and currents and the subsequent formation of drift ice and its dynamics. The main focus of model simulations in the coming years will be to increase our understanding of the sea-ice/drift-ice/ice-rubble dynamics and their connection to climate and weather forcing, and thereby contribute to and interact with the Climate DT.

Key innovations

A DEM code that that has extreme computational capacity.

Foreseen DestinE capabilities

Sea ice dynamics forecast and simulation capabilities

Capabilities provided to DestinE

The HiDEM code that is being developed for sea ice applications provides an opportunity to investigate e.g. the interaction between sea ice and wind power plant pylons, which allows for optimisation of their structure. The HiDEM code can also, with further fine tuning, be used for improving sea ice forecast models.

Funding

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Partners

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