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Impact of rheology on probabilistic forecasts of sea ice trajectories: application for search and rescue operations in the Arctic

Matthias Rabatel (1), Pierre Rampal (1), Alberto Carrassi (1), Laurent Bertino (1), Chris Jones (2), and Ali Aydogdu (1)

(1) Nansen Environmental and Remote Sensing Center - NERSC, Data Assimilation Group, Bergen, Norway, (2) Dept. of Mathematics, University of North Carolina in Chapel Hill, USA

We present a sensitivity analysis, and discuss the probabilistic forecast capabilities, of the novel sea ice model neXtSIM used in hindcast mode. The study pertains to the response of the model to the uncertainty on winds using probabilistic forecasts of ice trajectories. neXtSIM is a continuous Lagrangian numerical model, and uses an elasto-brittle rheology to simulate the ice response to external forces.
The sensitivity analysis is based on a Monte Carlo sampling of 12 members. The response of the model to the uncertainties is evaluated in terms of simulated ice drift distances from their initial positions, and from the mean position of the ensemble, over the mid-term forecast horizon of 10 days. The simulated ice drift is decomposed into advective and diffusive parts that are characterised separately both spatially and temporally and compared to what is obtained with a free-drift model, that is, when the ice rheology does not play any role on the modelled physics of the ice.
The seasonal variability of the model sensitivity is presented, and shows the role of the ice compactness and rheology in the ice drift response at both local and regional scales in the Arctic. Indeed, the ice drift simulated by neXtSIM in summer is close to the one obtained with the free-drift model, while the more compact and solid ice pack shows a significantly different mechanical and drift behaviour in winter. For the winter period analysed in this study, we also show that, in contrast to the free-drift model, neXtSIM reproduces the sea ice Lagrangian diffusion regimes as found from observed trajectories. The forecast capability of neXtSIM is also evaluated using a large set of real buoy's trajectories, and compared to the capability of the free-drift model.
We found that neXtSIM performs significantly better in simulating sea ice drift, both in terms of forecast error and as a tool to assist search-and-rescue operations, although the sources of uncertainties assumed for the present experiment are not sufficient for a complete coverage of the observed IABP positions.