Predictability of sea ice linear kinematic features evaluated from the neXtSIM ensemble forecasts

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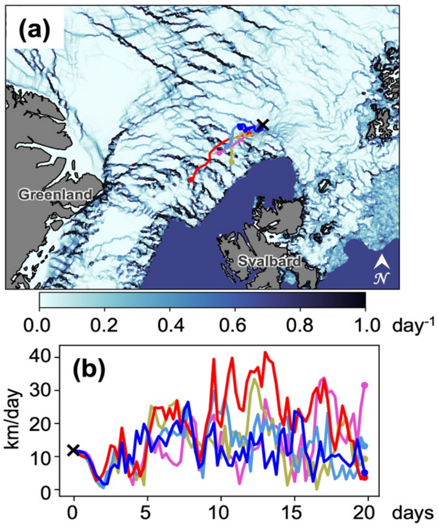
Motivation

Sea ice linear kinematic features (Kwok et al. 1998), such as leads and ridges, play an important role in daily sea ice forecasts:

(a) Sea ice condition simulated by neXtSIM. Blue shadings (ice deformation; 1/day) highlight the ice features. Trajectories starting from **x** show an ensemble forecast driven by the ECMWF forecast winds.

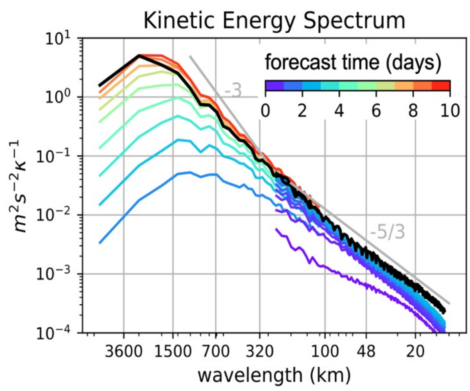
(b) Time series of drift speed (km/day) along the ensemble trajectories.

Small fluctuations in ice drifts can accumulate fast and lead to large position errors in just a few days — *how predictable are these sea ice feature?*



Surface wind uncertainties

Wind plays a significant role in driving the ice motion, it is crucial source of uncertainty for daily sea ice prediction (Schweiger and Zhang 2015; Rabatel et al. 2018).

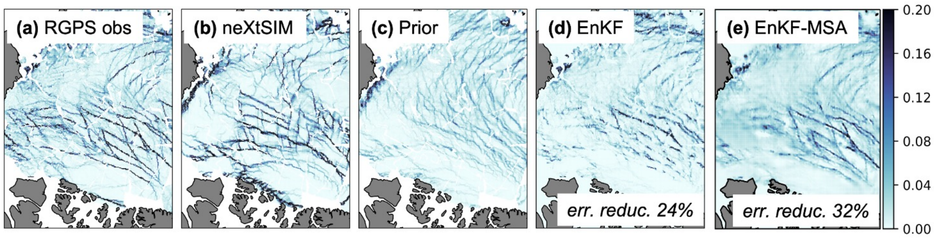


We characterised the wind uncertainties across scales based on ECMWF and AROME-Arctic ensemble forecasts. The kinetic energy spectra show wind errors at different forecast lead time (colored lines) and different spatial scales.

These error statistics are then used in generation of boundary perturbations for the neXtSIM ensemble forecasts.

neXtSIM ensemble forecasts and data assimilation

neXtSIM (Rampal et al. 2016) introduces a new Brittle-Bingham-Maxwell (BBM) rheology (Ólason et al. 2022) that improves simulation of ice feature by using a sub-grid-scale parameterisation of ice fracturing and damage.

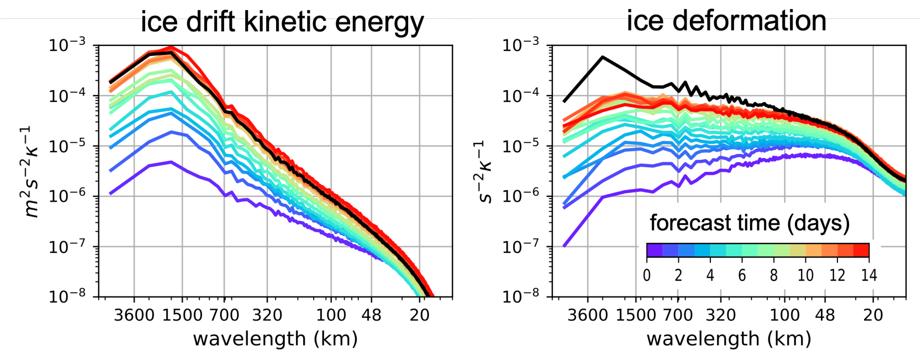


(a) Observed ice deformation from RADARSAT Geophysical Processing System (RGPS) satellite images, **(b)** neXtSIM simulation. neXtSIM simulation matches well the observed distribution and multifractal scaling of ice deformation.

An ensemble DA system based on neXtSIM is being developed at NERSC, a simple test is done using 20 neXtSIM members as the prior and assimilate deformation to update the model simulated deformation. **(c)** Prior ensemble mean, **(d)** EnKF analysis mean, and **(e)** EnKF-MSA analysis mean are compared. We introduced a multiscale alignment (MSA; Ying 2019) method to make better utilisation of the small-scale observations. Ongoing research is testing the impact of the updates on other model variables and on subsequent forecast skills.

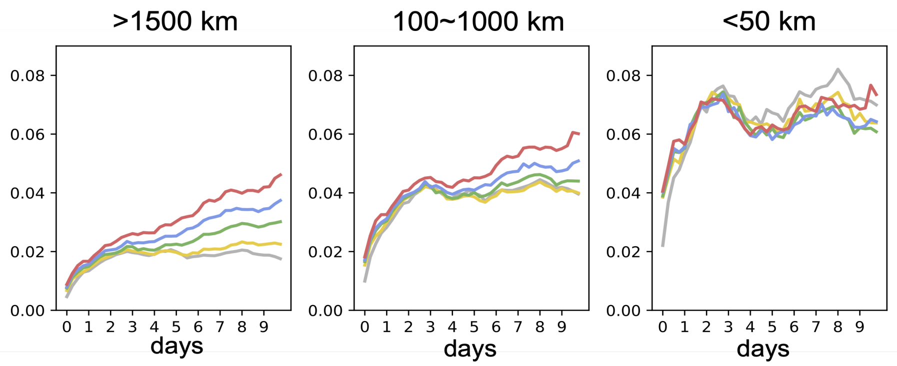
Ice feature predictability depends on scales

The neXtSIM ensemble driven by the ECMWF forecast winds show overall the same drift error growth rate as the wind (slightly slower for intermediate scales). Smaller scale has limited predictability due to the chaotic nature of ice fracturing dynamics.



Error growth time series and predictability benchmarks

Benchmark cases: 0%, 25%, 50%, 75% and 100% wind uncertainties from ECMWF forecasts. Deformation (ice features) error growth time series for (left to right) large to small scales:



Ongoing research is evaluating the relative impact from wind and rheology parameter uncertainties on ice feature predictability, also in terms of feature-based metrics (drifter trajectory position error, etc.)