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ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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Predictability of Deformation Features in Arctic Sea Ice

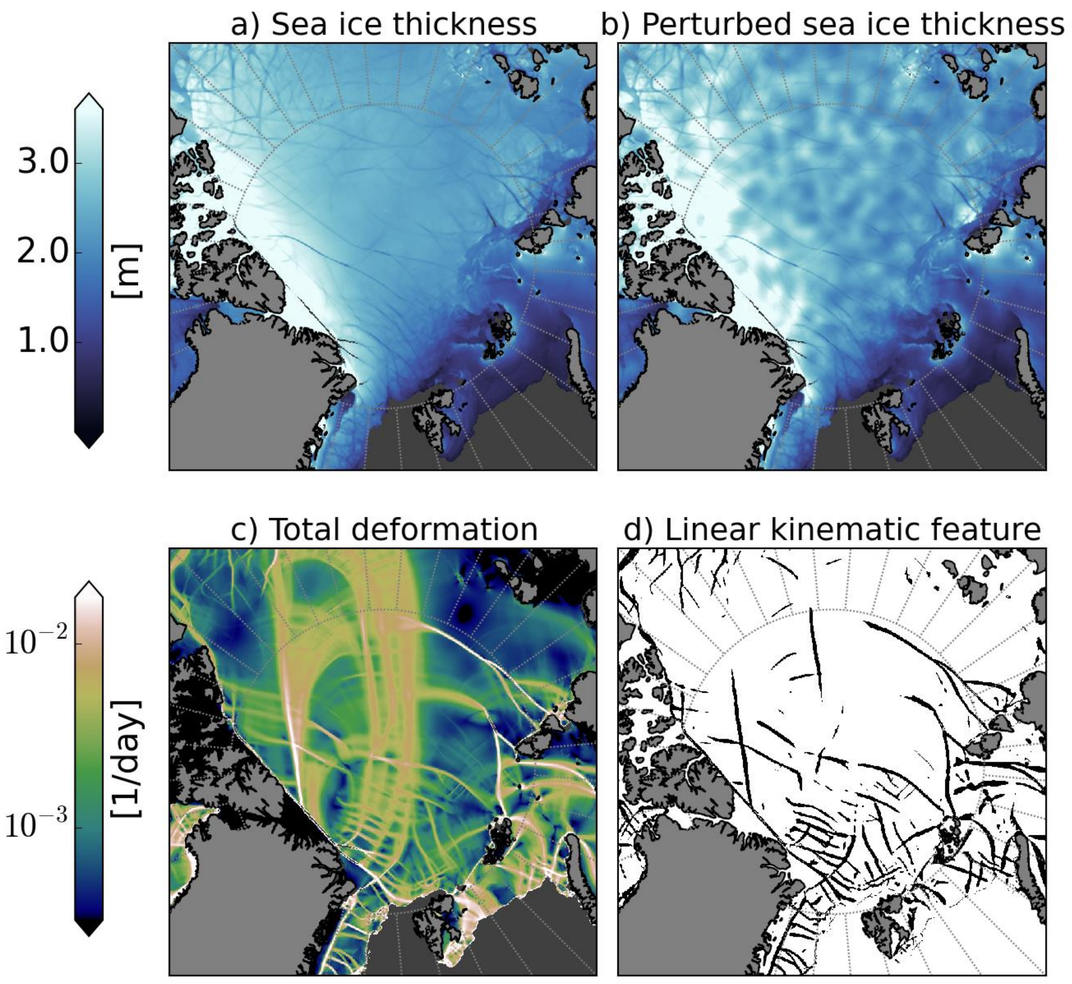
Abstract

Sea ice deformation localizes along Linear Kinematic Features (**LKFs**) that are relevant for the air/ocean/sea-ice interaction and for shipping and marine operations. At high resolution (< 5km) viscous-plastic sea ice models start to resolve LKFs. Here, we study the short-range (up to 10 days) potential predictability of LKFs in Arctic sea ice using ensemble simulations of an ocean/sea-ice model with a grid point separation of 4.5 km. We analyze the sensitivity of predictability to idealized initial perturbations, mimicking the uncertainties in sea ice analyses, and to growing uncertainty of the atmospheric forcing caused by the chaotic nature of the atmosphere. The similarity between pairs of ensemble members is quantified by Pearson correlation and Modified Hausdorff Distance (MHD). In our perfect model experiments, the potential predictability of LKFs, based on the MHD, drops below 0.6 after 4 days in winter. We find that forcing uncertainty (due to limited atmospheric predictability) largely determines LKF predictability on the 10-day time scale, while uncertainties in the initial state impact the potential predictability only within the first 4 days.

Model and Experimental setup

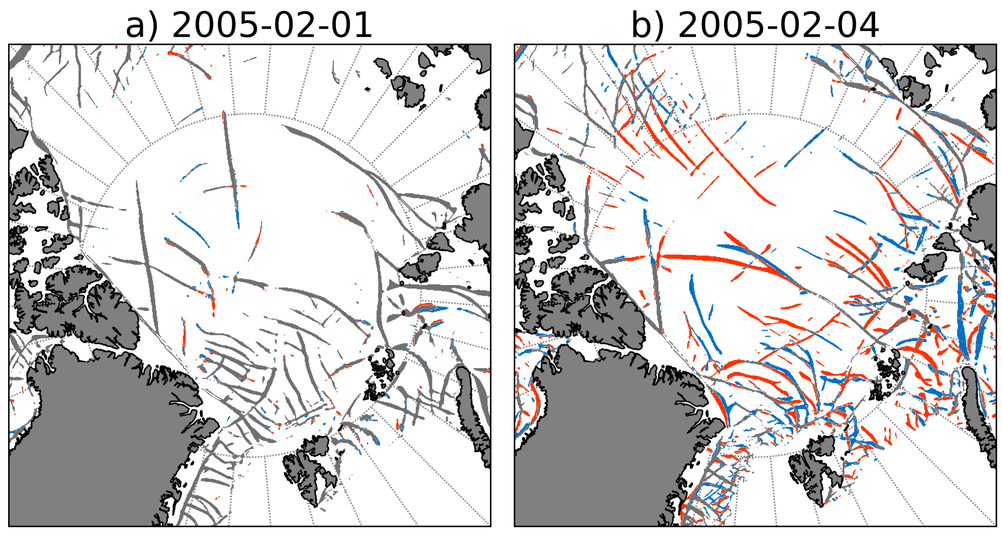
We use an Arctic-wide MITgcm setup at a spatial resolution of ~4.5 km. Two 15-member ensembles with different initial perturbations and atmospheric forcings are analysed here.

	AtmU	AtmU+IcU
Initial perturbations	None	Gaussian 50 km
Forcing	ECMWF ensemble	ECMWF ensemble

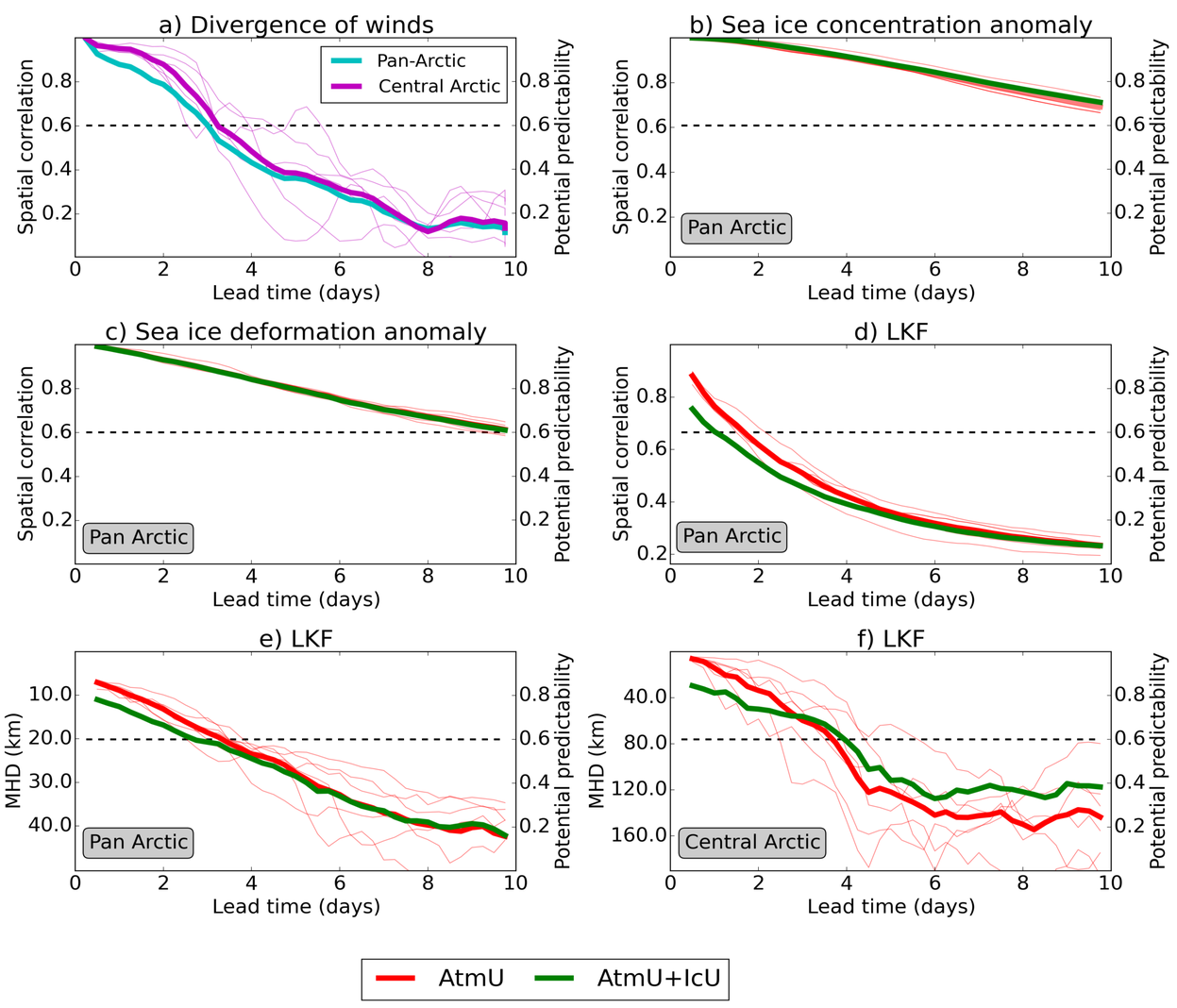


Distance Metrics

Upper row: Overlay of LKFs in two ens. members initially and after 4 days.
Lower rows: Evolution of different distance metrics over 10 days.



Grey: LKF in both; red/blue: LKF only in one.



Conclusions

1. Forcing uncertainty (due to limited atmospheric predictability) largely determines LKF predictability.
2. The Modified Hausdorff Distance appears to be the most useful metric because it captures pattern similaritiy also if LKFs are spatially offset.
3. Spatial correlation is not meaningful to measure the distance between fields with highly localized features: Total deformation fields remain strongly correlated due to large-scale gradients even when features become clearly dissimilar, whereas correlation between binary LKF fields decreases rapidly even when features are only slightly shifted.
4. Comparison between the potential predictability of the divergence of the wind and deformation of sea ice suggests some inertia in the sea ice dynamics.
5. Uncertainties in initial sea ice thickness reduces the predictability only during the first four days of the forecasts.

Outlook

1. We have simulation data for many more forecast cases in the entire year 2005 and additional combinations of initial perturbations and forcing that are waiting to be analyzed.
2. Other possible metrics should be devised, in particular probabilistic scores. For example, the probability to encounter leads with a certain orientation within a given radius might be useful, also from a user perspective.
3. Using new rheologies that produce more intermittency in models may provide more reliable estimates of potential predictability.

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