APPOSITE: Arctic Predictability and Prediction on Seasonal to Inter-annual Timescales

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Summary

The Arctic exhibits large natural variability on seasonal to inter-annual time scales which may be potentially predictable. The APPOSITE project performed the first multi-model comparison of Arctic predictability, involving 7 GCMs in a coordinated set of 'perfect model' ensemble experiments. Some key findings are:

1. **Each GCM shows predictability for Arctic sea ice extent, which is larger in winter, but potential skill varies amongst GCMs (Fig. 1)**
2. **A Spring predictability 'barrier' limits the skill of forecasts started before May (Fig. 2)**
3. **Initialisation of sea ice thickness and the upper ocean state are both crucial for skillful predictions of summer sea ice extent (Fig. 3)**

The APPOSITE dataset is now freely available.

2. Importance of initial conditions

Additional experiments were performed with the HadGEM1 GCM to examine the role of sea ice thickness initialisation in providing skill in summer sea ice extent (Day et al. 2014b). Fig. 3 shows that a parallel set of simulations with the initial sea ice thickness set to climatological values (red lines) show much less potential skill than the standard set (black lines) for forecasts started from both January and July.

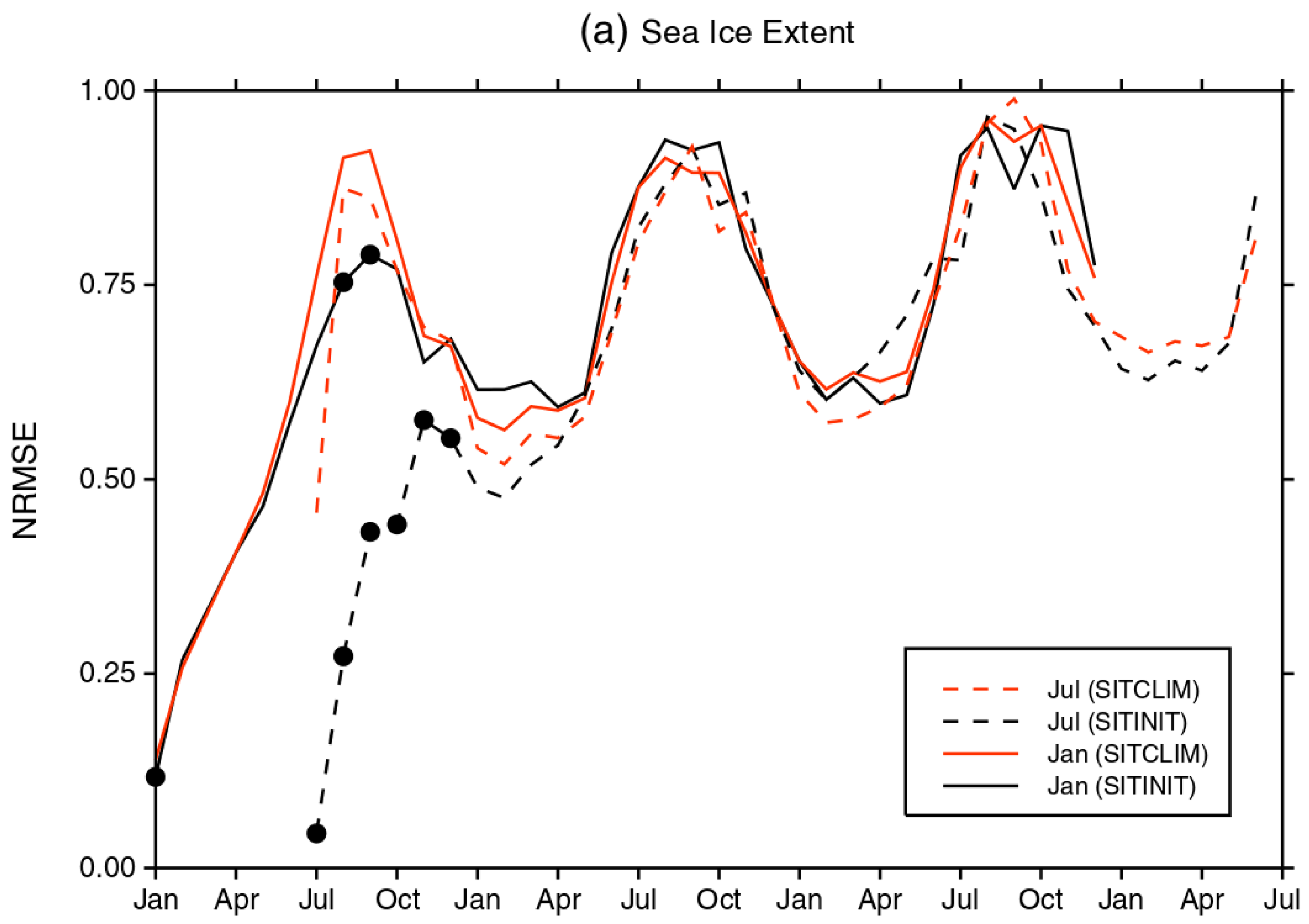

Figure 3: Normalised RMSE in sea ice extent for standard (SITINIT) and climatological sea ice thickness (SITCLIM) initialisations starting from January (solid) and July (dashed). [Day et al. 2014b]

Analysis of the mechanisms responsible for growth of errors in the ensemble predictions show that irreducible forecast uncertainty exists due to both atmospheric variability (advection of sea ice), surface heat fluxes and ocean heat flux variability (Tietsche et al. 2014; Tietsche et al. 2016).

1. Sea ice predictability

Seven GCMs produced 'perfect model' experiments to quantify the potential predictability of Arctic sea ice. Fig. 1 shows how the predictability declines over the lead time of the forecasts but tends to be larger in winter than summer (Tietsche et al. 2014; Day et al 2016). Fig. 2 highlights the existence of a Spring predictability 'barrier' with forecasts started in July being significantly more skillful than those started in May.

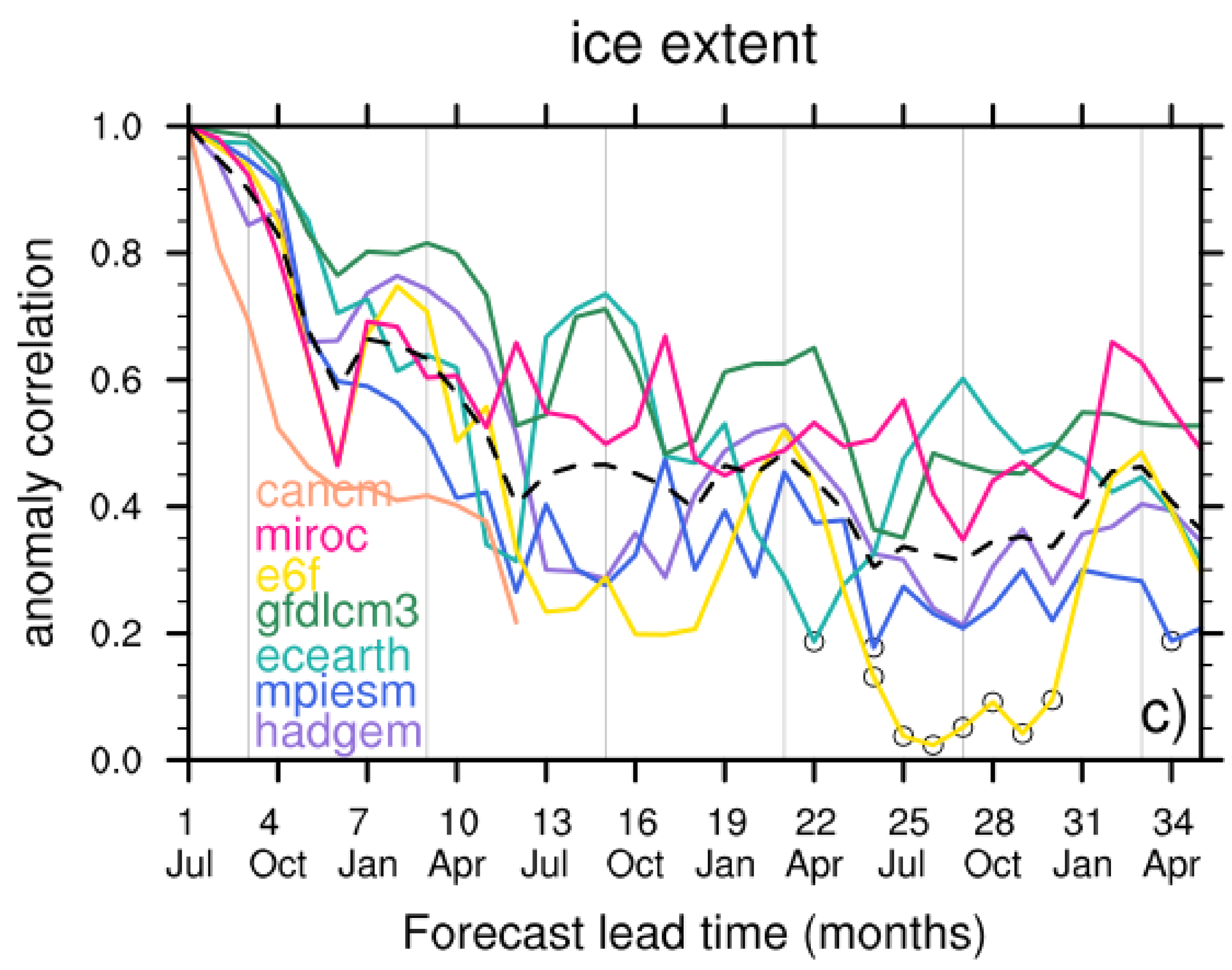

Figure 1: Potential predictability (correlation) of Arctic sea ice extent in seven GCMs during the three year 'perfect model' experiments. [Day et al. 2016]

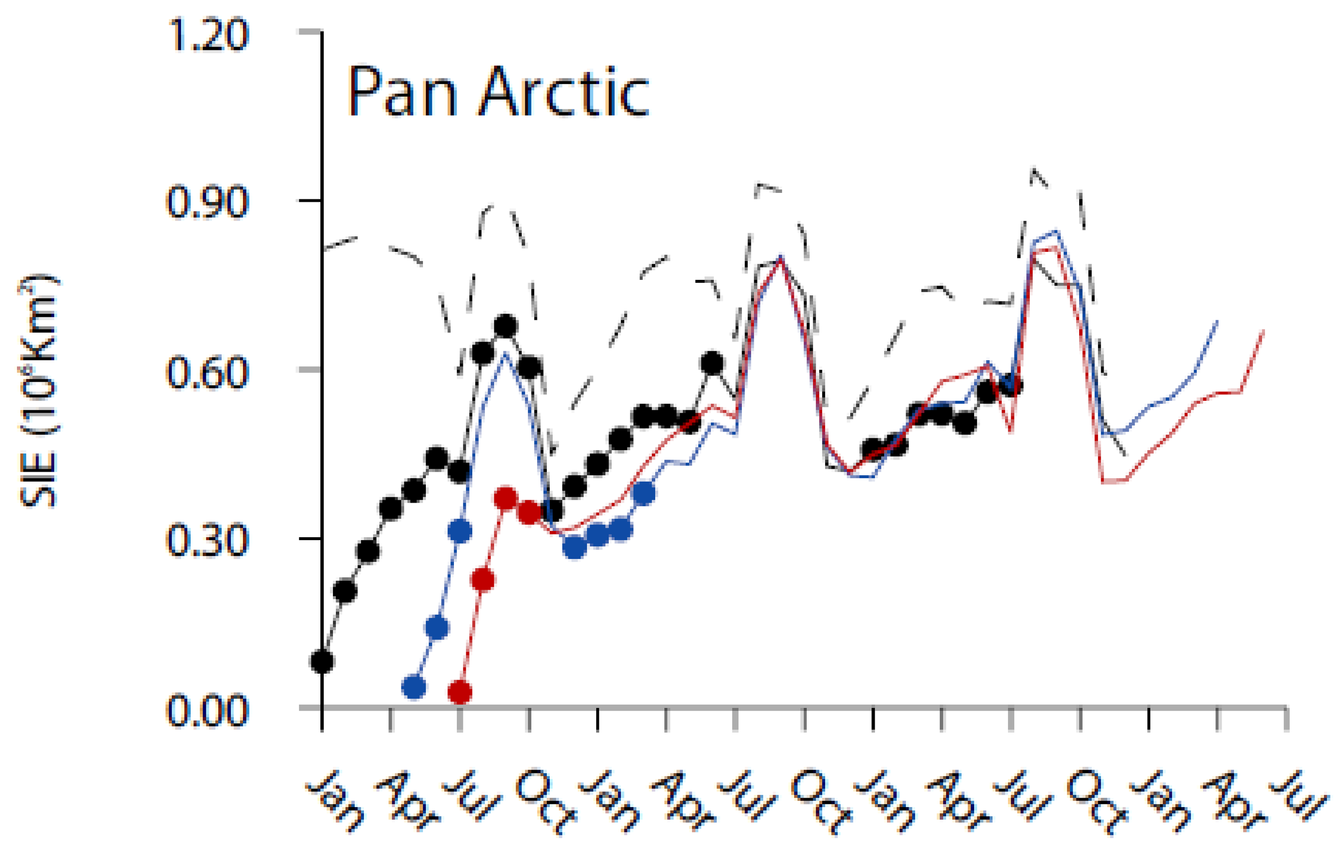

Fig. 2: Predictability (ensemble spread) of Arctic sea ice extent in HadGEM1 varies with lead time & start date (black – Jan, blue – May, red – July). [Day et al. 2014a]

More details in APPOSITE publications

- Tietsche et al., 2014, 'Seasonal to interannual Arctic sea-ice predictability in current GCMs', *GRL*, 41, 1035
- Day et al., 2014a, 'Pan-Arctic and regional sea ice predictability: initialisation month dependence', *J. Climate*, 27, 4371
- Day et al., 2014b, 'Will Arctic sea ice thickness initialization improve seasonal forecast skill?', *GRL*, 41, 7566
- Melia et al. 2015, 'Improved Arctic sea ice thickness projections using bias corrected CMIP5 simulations', *The Cryosphere*, 9, 2237
- Tietsche, Hawkins & Day, 2016, 'Atmospheric and oceanic contributions to irreducible forecast uncertainty of Arctic surface climate', *J. Climate*, 29, 331
- Goessling et al., 2016, 'Predictability of the Arctic sea-ice edge', *GRL*, 43, 1642
- Hawkins et al., 2016, 'Aspects of designing and evaluating seasonal-to-interannual Arctic sea-ice prediction systems', *QJRMS*, 142, 672
- Day et al., 'The Arctic Predictability and Prediction on Seasonal-to-Interannual TimEscales (APPOSITE) data set', GMDD, in discussion

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