Sea ice and atmosphere interactions and predictability: preliminary results using HadGEM3

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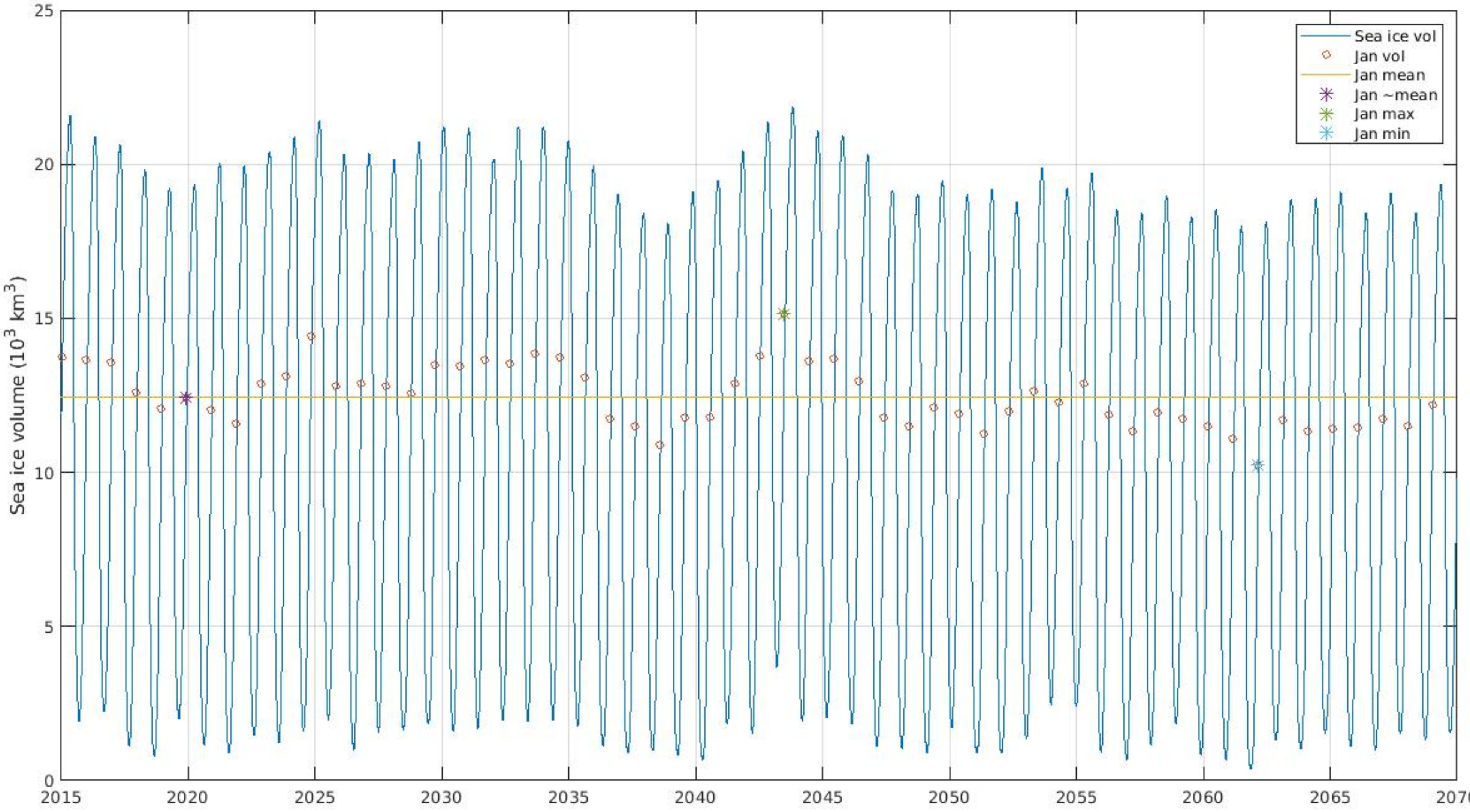
The aim of our project is the assessment of the influence of accurate sea-ice thickness observations on the predictability of the sea-ice and atmospheric circulation in Had-GEM3

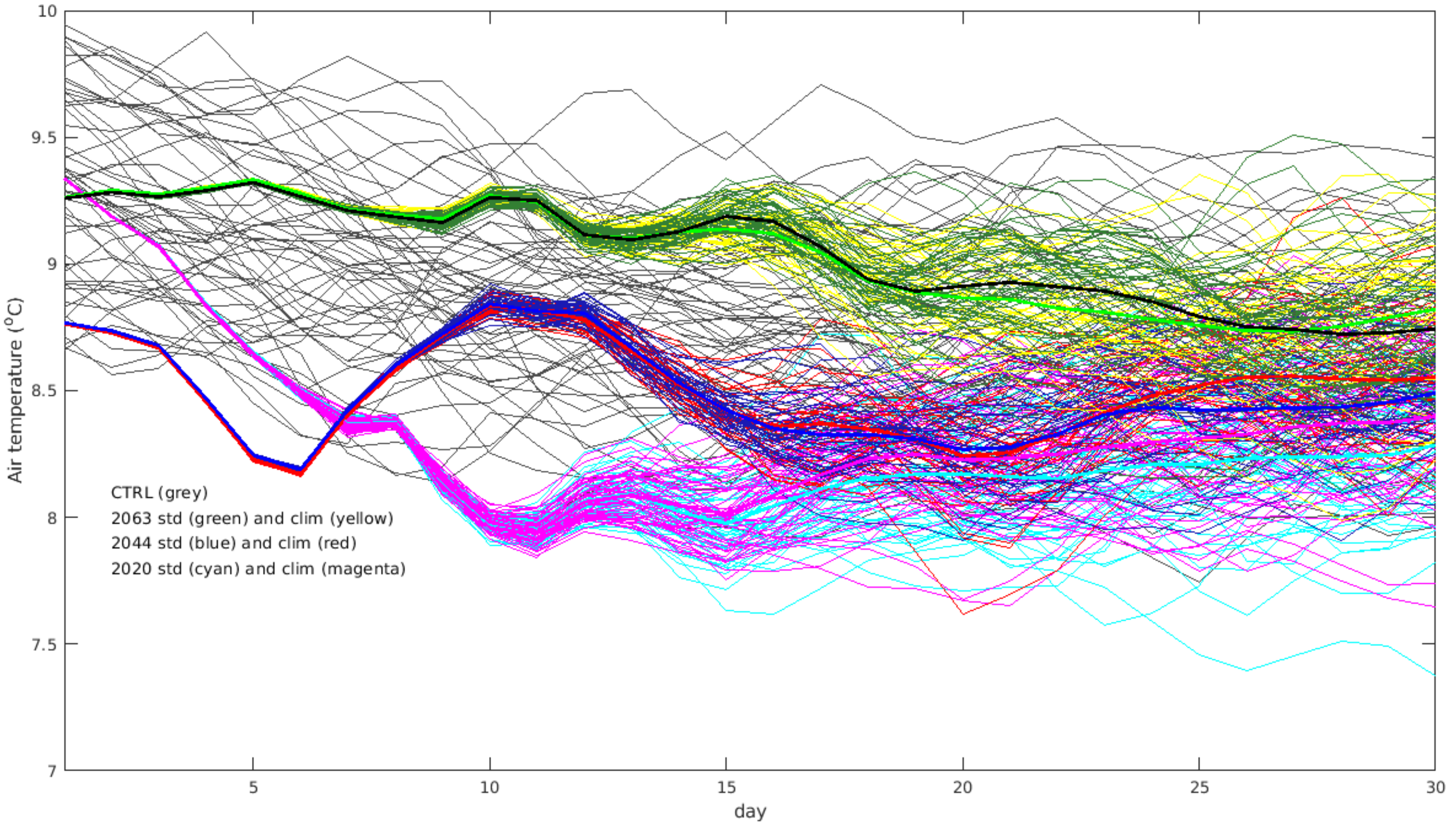
We perform paired sets of ensembles with the HadGEM3 GCM starting from different initial conditions in a present-day control run. One set of ensembles start with complete information about the sea-ice conditions, and one set have degraded information. We investigate how the pairs of ensembles predict the subsequent evolution of the sea-ice, sea level pressure and circulation within the Arctic and beyond with the aim of quantifying the value of sea-ice observations for improving predictions.

We have run a CTRL simulation using constant forcing of 2015 for 55 years



2020, 2044 and 2063 were chosen as years of equal, highest and lowest sea ice volume (compared to 2015) and three sets of experiments were run with these starting dates.

For each start date we have perturbed one atmospheric variable (O~10^{-4}) and create a 50 members ensemble. By performing a denial experiment substituting the initial sea ice thickness with its climatological value in each grid cell, we have run three more set of 50 ensembles starting in the same years. Below we show the Northern hemisphere air temperature (2m).

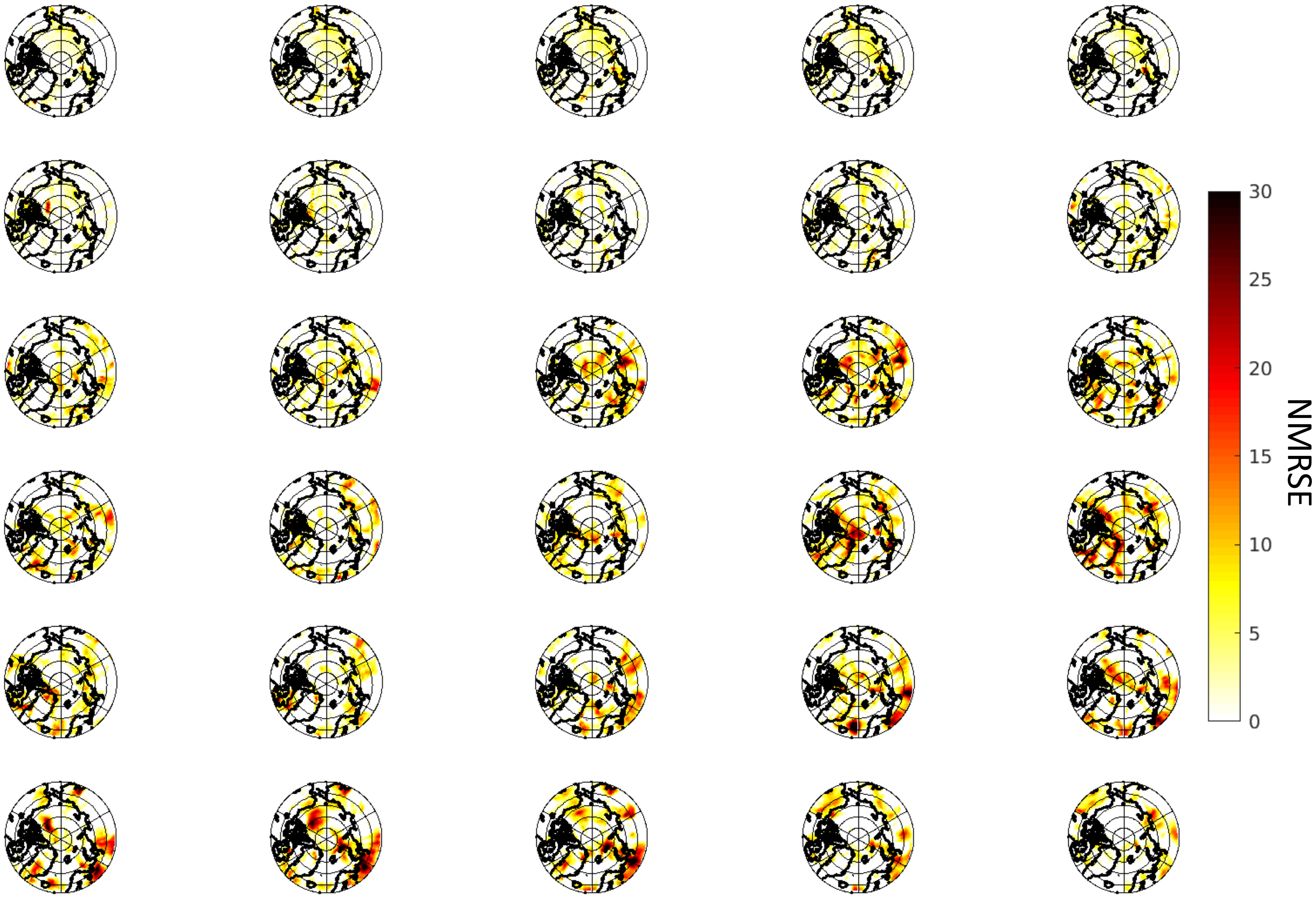


Ensemble RMSE

$$\mathrm{RMSE} = \sqrt{\frac{1}{n_d n_m (n_m - 1)} \sum_{j=1}^{n_d} \sum_{i=1}^{n_m} \sum_{k \neq i} (x_{kj} - x_{ij})^2}$$

where $x_{ij}(t)$ is the sea ice extent at lead time t for the *i*th member of the *j*th ensemble, *nd* is the number start dates, and *n* is the number of ensemble members.
By treating the variable x as the "truth" we calculate the RMSE of the atmospheric perturbed ensembles and then the RMSE of the ensembles using the climatological sea ice initial conditions (Collins, 2002; Day et al., 2014).

NRMSE January



This figure show the gain in daily NRMSE in the January 2m air temperature. This is obtained by calculating the RMSE for the “perturbed atmosphere” ensembles (RMSExx) and subtract it from the RMSE of the ensembles using the climatological sea ice initial conditions (RMSExy), and then normalize by the RMSExy.

The increased RMSE shows how the skill of the ensembles predicting the air temperature degrades within the first month of simulation when using a climatological sea ice initial thickness rather than an accurate one.

Ensemble RMSE

- Accurate initial condition of the sea ice thickness impact the model skills when forecasting atmospheric variables.
- We performed a denial experiment degrading the sea ice volume by substituting it with its climatological value and have calculated the ensemble RMSE for both experiments.
- We used the gain in the ensemble as a measure of the loss of skill in the ensembles using the climatological sea ice conditions
- Our preliminary results a loss in air temperature prediction skills up to 30% within a month from the start of the simulation when using a climatological sea ice initial condition rather than an accurate one.