Seasonal re-forecasts of the winter NAO with EC-Earth

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The North Atlantic Oscillation (NAO) is the main mode of variability of the North Atlantic large-scale atmospheric circulation at monthly to interannual time scales. The relationship between the NAO and storm tracks, temperature and precipitation conditions over the North Atlantic basin and adjacent regions justifies the interest in evaluating the seasonal forecast quality of its state (i.e. the value of the NAO index), especially in winter. Previous studies (e.g. Doblas-Reyes et al., 2003; Palmer et al., 2004; Arribas et al., 2011; Kim et al., 2012) have highlighted the limited seasonal forecast skill of global coupled models in predicting the NAO index. Recent seasonal prediction experiments with the EC-Earth Earth system model (Hazeleger et al., 2012; Du et al., 2012) provide interesting perspectives for improving the winter NAO forecast skill.

A first set of experiments consisted in increasing ocean and atmosphere resolution in the EC-Earth3 ESM. The standard resolution (SR) experiment uses a T255L91 grid for the atmosphere (IFS) and ORCA1 grid with 46 vertical levels for the ocean (NEMO-LIM). The high resolution configuration (HR) implies increasing the IFS horizontal resolution to T511 (approximately 40 km) and the NEMO resolution to ORCA025 and 75 vertical levels. Five-member ensemble forecasts were run starting from ERA-Interim (Dee et al., 2011) and GLORYS2v1 (Ferry et al., 2010) reanalyses every November over 1993-2009 up to four forecast months.

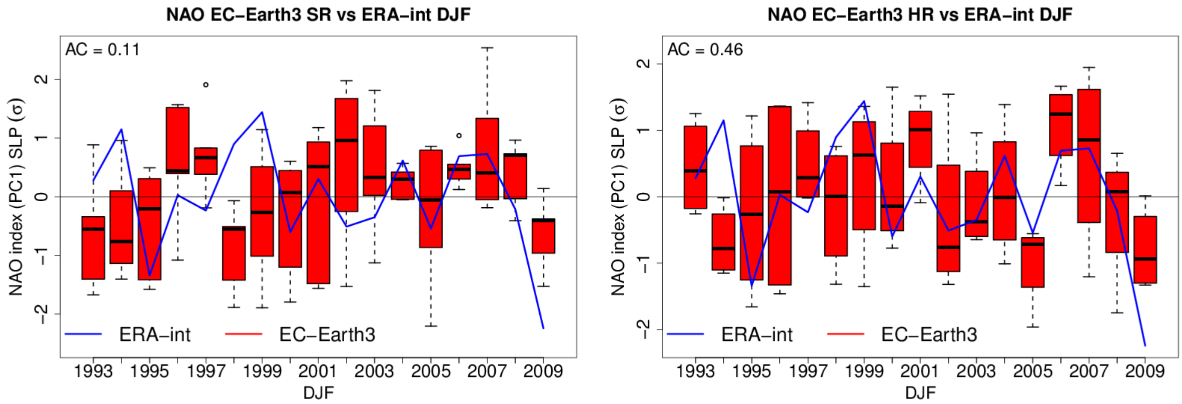

Fig. 1: DJF NAO index in the EC-Earth3 SR (left) and HR (right) hindcasts (red boxes and whiskers) using the Pobs method (see Doblas-Reyes et al. 2003); the black line is the ensemble median and the anomaly correlation between the ensemble mean index and ERA-Interim reanalysis (in blue) is given in the top left corner. Note that undetrended sea-level pressure anomalies have been considered. The year in the abscissa corresponds to that of the start date (first of November of each year).

Results for the December-January-February (DJF) NAO are shown in Figure 1. The ERA-Interim NAO index is computed as the leading principal component of sea-level pressure over the North Atlantic region. The anomaly correlation of the model ensemble mean index is higher in HR. The analysis of individual forecasts such as the 2009/10 extreme winter might require a larger ensemble size, which is currently being prepared. Intermediate experiments using high resolution in one of the two main components of EC-Earth3 should shed further light on the sources of improvement.

A second set of experiments was performed with EC-Earth2.3 over the same hindcast period to investigate the role of sea ice initialization. The reference experiment (INIT) was initialized from the ERA-interim and ORAS4 (Mogensen et al., 2011) reanalyses and from the HistEraNudg sea ice reconstruction (Guemas et al., 2014). The sensitivity experiment (CLIM) only differs from INIT in the initialization of the sea ice component from a climatology of HistEraNudg over the 1981-2010 period.

Figure 2 shows the results from this second set of experiments. It is found that there is a substantial increase of the NAO skill in the INIT re-forecasts. This finding suggests that the sea ice cover state, presumably taken into account in INIT, represents a predictability source of the winter Euro-Atlantic atmospheric circulation. The variance explained by the winter NAO is increased in INIT (50.5%) when compared to CLIM (41.5%), getting closer to the observed one (55.0%) but still underestimated. The results also suggest a role played by sea ice initialization in re-forecasting the negative NAO phase of 2009-10.

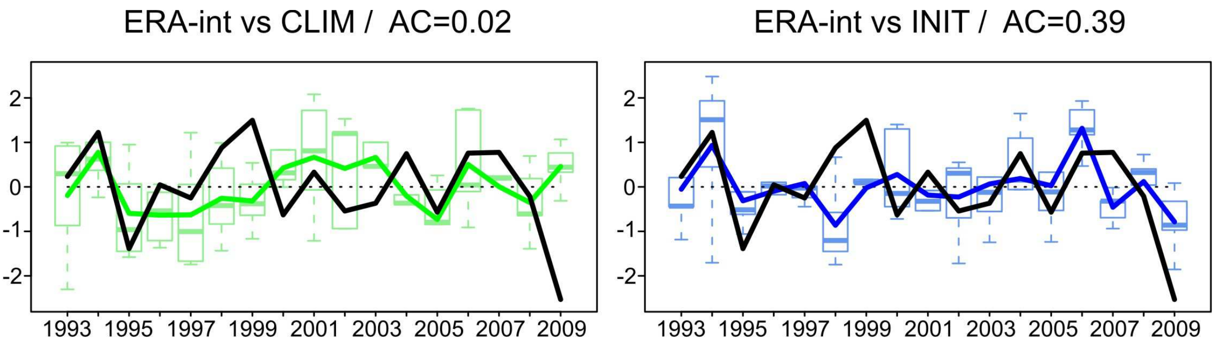

Fig. 2: Same as Fig. 1, but for the seasonal prediction experiments performed with EC-Earth2.3 initialized from climatological sea ice conditions (CLIM; left-green) and realistic sea ice conditions (INIT; right-blue). The ensemble mean index is drawn as a solid line; the anomaly correlation (AC) between the ensemble mean index and ERA-Interim reanalysis (in black) is indicated in the title.

A set of re-forecasts with EC-Earth2.3 where the sea ice restarts will not come from a climatology but from a historical simulation, to have a sea ice state which is approximately in equilibrium with the mean climate at the time of initialization, should allow refining the impact of initializing sea ice variability on the atmosphere skill. Both studies should be extended using longer re-forecast periods and larger ensembles to help draw more robust conclusions.

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Acknowledgements: Simulations were run thanks to PRACE HiResClim project and RES national resources at BSC (Spain), and analyses achieved in the framework of the European Commission FP7-SPECS project (grant agreement 308378) and the MINECO-funded PICA-ICE project (CGL2012-31987). J. G.-S. was supported by the FP7-funded NACLIM project (grant agreement 308299).