



Predictability over the North Atlantic ocean in hindcast ensembles of MPI-ESM initialized by EnKF and three nudging systems

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We investigate hindcast skill for surface air temperature and upper ocean heat content (0-700m) in the North Atlantic for yearly mean values from 1960 to 2014 in four prediction systems based on the global coupled Max Planck Institute for Meteorology Earth System Model (MPI-ESM). We find that in the North Atlantic and within the four prediction systems under consideration only the EnKF initialized hindcasts reproduce the variability of the reference data well both in terms of anomaly correlation and representation of the probability density function. The systems under consideration only differ in the method how they incorporate surface and sub-surface oceanic temperatures and salinities during assimilation: ensemble Kalman Filter (EnKF), anomaly nudging of ORA reanalysis (BS-1), full field nudging of ORA and GECCO reanalysis, respectively (PT-ORA, PT-GEC). We assess the hindcast skill of each prediction system with reference to HadCRUT4 near surface air temperature data (Morice et al. 2012) and NOAA OC5 upper ocean heat content data (Levitus et al. 2012) using anomaly correlation (ACC) and by analysing the interquartile range (IQR) of the probability density function (PDF).

Firstly, we calculate hindcast skill in terms of ACC and IQR against reference data over the whole time period. Here, the hindcast skills of EnKF and BS-1 are better for both ACC and IQR in lead years 2 to 5 when compared to PT-ORA and PT-GEC, their hindcast skill drops off after lead year 1. Secondly, the PDF of the reference data is not uniformly distributed over time. We therefore calculate ACC and IQR for a 20 year moving window. We find hindcast skill in terms of ACC for EnKF and BS-1 in the 1960s and from the 1990s onwards, up to eight lead years in advance, with almost no skill for the time period inbetween. In contrast, there is no skill for PT-ORA and PT-GEC in any period after lead year one. The IQR of reference data is best captured by the EnKF, in the 1960s and 1990s up to lead year eight. In contrast to the skill shown for ACC and for the IQR over the whole time period, BS-1 does not reproduce the IQR of reference data as good as the EnKF. Also, the IQR of both PT-ORA and PT-GEC is too small compared to reference data for lead years greater than 1.