A seasonal re-forecast of mid-latitude circulation over the 20th century

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Preliminary studies in the framework of the European FP7-SPECS research project have shown that the mid-latitude circulation scores of an ensemble forecast are extremely sensitive to the sample of ensemble members. Even with a 50-member ensemble, some uncertainty remains, which can be evaluated from a larger ensemble by random sub-sampling. However, even with a very large ensemble (several hundred members) the forecast score will be representative of the re-forecast period (typically 1979-2012 in SPECS). If the period is short (less than 15 years), the score may poorly estimate the actual predictive skill, because, in the mid-latitudes, the verification is a single realization of a chaotic process (Shi et al., 2015). If the evaluation period is very long (more than 30 years), the re-forecasts include initial conditions of poorer quality (in the ocean and the stratosphere) than in present operational forecasts.

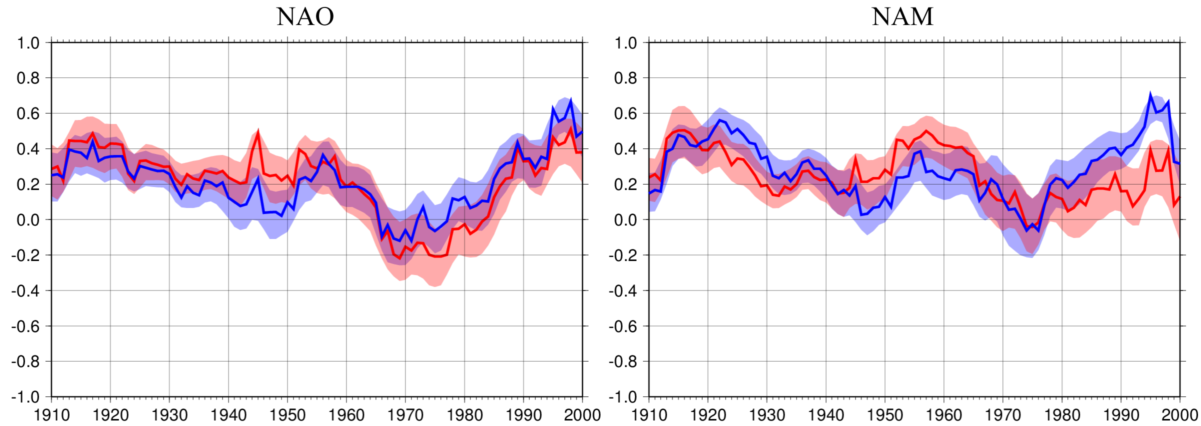
The recent ERA20C reanalysis 1900-2010 (Hersbach et al., 2015) offers the opportunity to test the homogeneity of the scores along the 20th century, and, in case of such a homogeneity, the confidence interval for a score calculated with a re-forecast period of n years. Preliminary attempts using ocean initial conditions derived from flux-driven ocean integrations have shown almost no skill in the first half of the century. Therefore, we use a pseudo-forecast approach with an atmosphere model forced by monthly observed sea surface temperature. The initial conditions, as well as the verification data are extracted from Stream 1 of ERA20C. If we focus on mid-latitude tropospheric general circulation and restrict to forecast months 2 to 4, this methods yields, for the last 20 years, similar scores as a fully-coupled model properly initialized. Indeed, the progress in ocean modelling and observation make the prediction of tropical sea surface temperatures during the very first months a well-solved problem. The mid-latitude sea surface temperatures are more difficult to predict, but play a minor role in the large-scale tropospheric circulation in seasonal runs, at least in the present generation of numerical models (Stockdale et al., 2015).

The experimental design is the following. The atmospheric component of CNRM-CM5 (Voldoire et al, 2013) is initialized from 1 Nov. 1900 to 1. Nov. 2010. Sixty model integrations with monthly SST from ERA20C are produced each year until the end of Feb. (4 months). Individual circulation indices are computed for each year, each member, and DJF averages. Then 30-member sub-samples are drawn at random to evaluate the 2.5%, 50%, and 97.5% percentiles of the correlation coefficient. The correlation is calculated for 21-year windows centered at 1910, 1911, ... 2000. This avoids the inclusion of the century trend which could artificially inflate the scores.

NAO (Fig. 1a). This index is calculated as the area-average sea level pressure (SLP) or 500 hPa height geopotential (Z500) difference between 20°N-55°N/90°W-60°E and 55°N-90°N/90°W-60°E . The correlation is higher with SLP during the first half of the century, then higher with Z500, reaching 0.60 in the last decade. The most salient feature is the multidecadal variability: the scores decrease from 1900 to 1970, then increase. Shorter increase phases can be observed in 1900-1910 and 1950-1960. Changes in the observation network used for the atmospheric reanalyses could explain part of this inhomogeneity, but certainly not the 70-year decrease phase obtained. This feature is not due to sampling, because the 95% interval due to the choice of the members excludes the possibility of a constant correlation. Note that the 2.5% and 97.5% percentiles (shaded area), which were originally as noisy as the 50% percentile (solid line), have been filtered by a 9-point parabolic filter for the sake of clarity. At this stage, we can claim that the low predictability of the NAO in 1960-1980 is not an artifact. However we cannot tell yet if this feature is a natural phenomenon, independent of the model.

NAM (Fig 1b): This index corresponds to 34°N-36°N minus 64°N-66°N zonal averages. It is often considered as an extension of the NAO, but the seasonal scores for a given 20-year period may be different. However, the increasing and decreasing phases we got for the NAO are found again here.

SAM (Fig 1c): This index corresponds to 39°S-41°S minus 64°S-66°S zonal averages. It is almost symmetrical to NAM. We are in austral summer, but this is the season of ENSO peaks, and the summer SAM is as predictable as the winter SAM (this feature is different with NAM or NAO which have low scores in boreal summer). The multi-decadal trends are almost opposite to NAM/NAO, with a 0.80 correlation maximum in the 1960s.



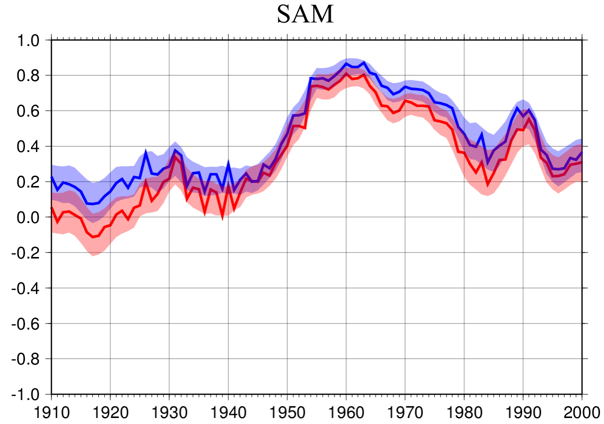


Figure 1: 21-year moving correlation for 3 circulation indices (blue color for Z500, red color for SLP). The solid line corresponds to the median of 30-members ensembles drawn amongst a 60-member ensemble; the shaded area corresponds to the 95% interval for the score distribution.

These results suggest that seasonal predictability of mid-latitude circulation is not constant during the 20th century. This implies that in future decades, seasonal re-forecast scores may decline in the northern hemisphere, notwithstanding scientific progress in the representation of the mid-latitude circulation at this time scale. In the meantime, the variability and uncertainties of such correlation scores show that results in seasonal forecast assessments over these regions should be interpreted with caution.

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