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The role of the base period in evaluating teleconnection indices and strengths, and how to eliminate it in the snapshot framework using large ensembles

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Different teleconnection index time series are obtained even within a single member of a large ensemble simulation if different base periods are chosen. This also has an effect on the apparent strength of teleconnections. In this study, the reasons behind this caveat are discussed analytically and exemplified for the Arctic Oscillation (AO). Additionally, a solution is presented in the so-called snapshot framework using large ensemble simulations.

The AO is the leading mode of atmospheric variability in the Northern Hemisphere winter. Traditionally, its loading pattern is defined as the leading mode of the empirical orthogonal function (EOF) analysis of sea-level pressure (SLP) from 20° to 90° N for a given base period. The AO index (AOI) time series is constructed by projecting the SLP anomalies on this loading pattern and is standardized for the base period. The strength of the linkages related to AO is generally defined by a correlation coefficient between time series of the AOI and another meteorological variable.

Using the CESM-LE and the MPI-GE, we show that the utilization of different base periods within a single member often results in AOI time series differing by as much as 0.5–0.8. We reveal why such differences can arise in any EOF-based quantity: (1) The loading pattern represents a standing oscillation pattern, treated as constant within the studied time interval, and the time evolution of the corresponding index (e.g. AOI) shows how this pattern oscillates in time. However, when the climate changes, stationarity cannot be assumed: whether the oscillation pattern and its amplitude remain the same within the given time interval is dubious. (2) Any shift in the index time series originates from a change in the mean state of the climate system, e.g., from the change in the temporal mean of the SLP field, which is the center of the oscillation described by a given EOF mode. Beyond the meteorological reasons we also give analytically derived results for the shift and for the change in the oscillation amplitude.

To avoid the problems resulting from the assumption of a constant pattern and climatological mean, the traditional EOF-based description should be replaced by the recently developed

snapshot EOF (SEOF) analysis if an ensemble is available (Haszpra et al. 2019). This method carries out the EOF analysis across the ensemble at each time instant, instead of the time dimension within each member. As a consequence, instantaneous anomalies originating from internal variability are compared only to the set of states permitted by the climate system at the given time instant. Therefore, beyond a correct characterization at each time instant, the time-dependence of an oscillation pattern and the corresponding amplitude can also be monitored. Furthermore, instantaneous correlation coefficients between the instantaneous index and another variable can be computed across the ensemble to reveal the correct teleconnection strengths and their time-dependence.

Haszpra et al. 2019: On the time evolution of the Arctic Oscillation and related wintertime phenomena under different forcing scenarios in an ensemble approach. J. Clim. (submitted)