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Space and time scales of anti-correlation pattern in the Northern Hemisphere

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The climate variability of the atmospheric circulation is characterized by a number of preferred patterns, the so-called teleconnection patterns. These patterns, like the North Atlantic Oscillation (NAO) or the Pacific North American (PNA) pattern, are defined by anti-correlated centers of action based on seasonal means. Still, the origin of the season-to-season anti-correlation is not fully understood. In this study we apply different time and space filtering to daily 500 hPa geopotential height (Z500) from the ERA-40 data set. Within these filtered data the anti-correlated centers of action in the Northern Hemisphere are identified by estimating the teleconnectivity.

Teleconnectivity of the daily unfiltered Z500 rather weakly agree with the teleconnectivity deduced from seasonal means on the Northern Hemisphere. This weak agreement is induced by the Atlantic, which does not resemble the NAO pattern, whereas a PNA type pattern is already found in the Pacific North America region. This means that the daily time scale seems to be to some extent important for the PNA pattern.

Applying different Fourier high-pass filters (e.g., 1 to 7 days) to the data results in pattern with centers of action in the main storm track areas in the Atlantic and the Pacific, resembling the behavior that low pressure systems succeed high pressure systems. Including lower frequencies (after 10 days) diminish this so-called storm track teleconnection pattern. In addition, we apply a spatial filter, i.e., we transform Z500 in the spectral space and in- or exclude specific wave numbers. In doing so we find that for the high-pass filtered data at least the wave numbers 1 to 7/8 are necessary to obtain the storm track teleconnection pattern. It is even better represented if waves higher than 10 are excluded.

Low-pass filtering Z500 resemble better the PNA pattern, in particular when using 10-12 days (and higher) low-pass filtering. Restricting the spatial scales to waves from 1 to 6/7 emphasize the PNA pattern. A NAO-type pattern is also found in low-pass filtered Z500, however the centers of action are located south with respect to the ones deduced from seasonal means. Applying the space filtering shows that waves from 1 to 4/5 are important.

To further assess the different nature in the Atlantic sector the teleconnectivity based on daily data is estimated for each winter separately. Anti-correlated centers of action are located at similar positions as yearly geopotential height anomalies during years with an extreme negative phase of the NAO, whereas during years with an extreme positive phase, the correspondence between anti-correlation patterns and geopotential height anomalies is less pronounced. Applying different low-pass filters to the data does not improve the correspondence during years with an extreme positive phase of the NAO, suggesting that the high-frequency atmospheric dynamics during years with a negative phase of the NAO is important of the season-to-season anti-correlation.