The issues in the detection of teleconnection patterns by principal component analysis: Examples of the Arctic, Barents, and North Atlantic Oscillations

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It has been shown several times that rotated principal component analysis (PCA) must be used if one wishes to detect physically sensible modes of variability (teleconnections). When using unrotated PCA, there is a considerable risk that statistical artifacts rather than real modes would be found. In spite of this, unrotated PCA has been used to detect teleconnections in many studies.

There are two striking examples of structures that are defined and identified by unrotated PCA. The Arctic Oscillation (AO), consisting of a tripolar pattern with centres over central North Atlantic, the Arctic, and central North Pacific, is defined as the leading unrotated principal component (PC) of sea level pressure (SLP) in the Northern Hemisphere Extratropics. Its physical realism has been questioned many times, mainly on the grounds of the lack of correlation between its centres; in spite of this, the concept of AO has been widely used until the present. The second example is the Barents Oscillation (BO), which is defined as the second or third PC of SLP over the North Atlantic / European sector and consists of a dipole with centres over the Barents Sea and western North Atlantic. Its existence has been doubted by arguments similar to the concerns about the AO.

The objective of this contribution is to evaluate the realism of the AO and BO by (i) assessing the degree of similarity between their loading maps (teleconnection patterns) and corresponding autocorrelaton maps; (ii) the stability of their patterns relative to changes in the position and size of the analysis domain, and (iii) the stability of their patterns relative to temporal subsampling. A close similarity between the teleconnection pattern and the autocorrelation structure, a small sensitivity to temporal sampling, and a small sensitivity to the choice of the analysis domain are all indicators of a physical realism of teleconnections; the opposite points to the suspicion that the pattern is a statistical artifact rather than a real teleconnection. The detectability and behaviour of AO and BO is contrasted to one of the patterns the existence of which is undoubted, namely, the North Atlantic Oscillation (NAO), for the definition of which rotated PCA is used as a standard detection method.