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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Motivation

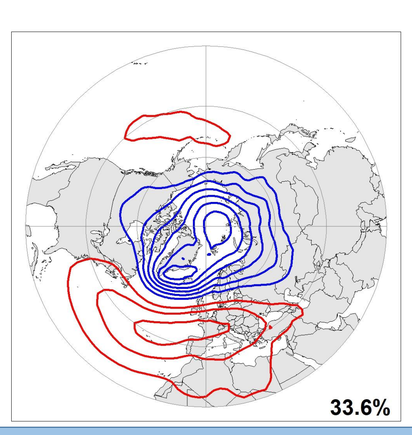
It has been shown several times that rotated principal component analysis (PCA) must be used if one wishes to detect physically sensible modes of variability. When using unrotated PCA, there is a considerable risk that statistical artefacts rather than real modes would be found.

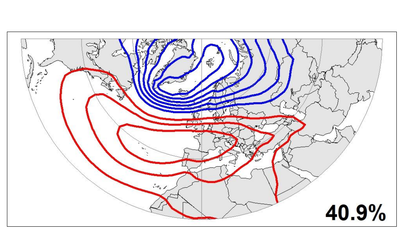
Data

- Sea Level Pressure from the NCEP/NCAR reanalysis
- wintertime (November to March) monthly means
- regular 2.5° by 2.5°grid extending from 20°N northwards
- period 1948-2016
- data weighted by the square root of cosine of the latitude

The Arctic Oscillation (AO)

- defined as the leading unrotated principal component of SLP in the Northern Hemisphere Extratropics
- consisting of a tripolar pattern with centres over central North Atlantic, the Arctic, and central North Pacific

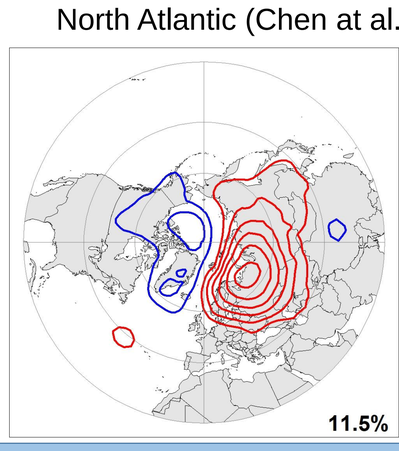


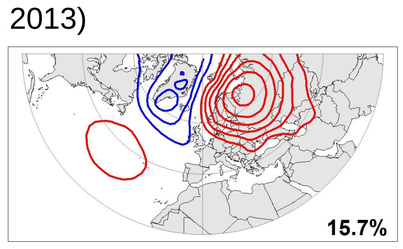


Loadings of the **leading PC** for covariance matrix and percentage of explained variance.

The Barents oscillation (BO)

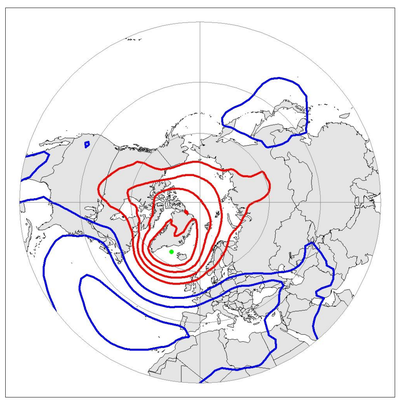
- defined as the second or third PC of SLP over the North Atlantic / European sector (90°W - 90°E)
- consists of a main dipole with centres over the Barents Sea and Greenland and weak centre over central North Atlantic (Chen at al., 2013)



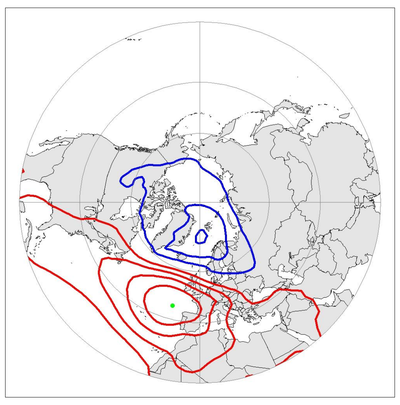


Loading of the **second PC**. Contour interval is 1hPa, zero contour is omitted. Negative contour are in blue, positive in red.

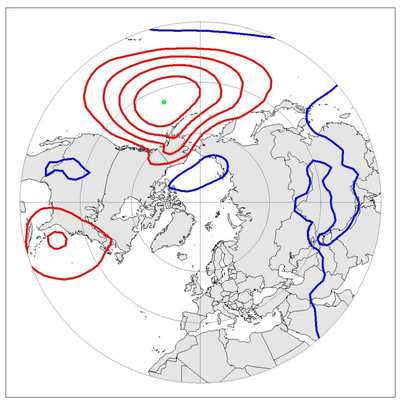
One-point correlation maps



base point: 30°W 65°N
Arctic centre of AO

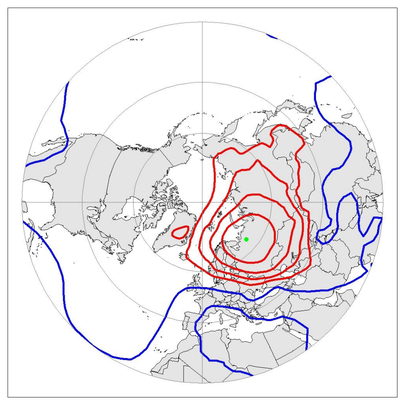


point: 15°W 45°N
Atlantic centre of AO

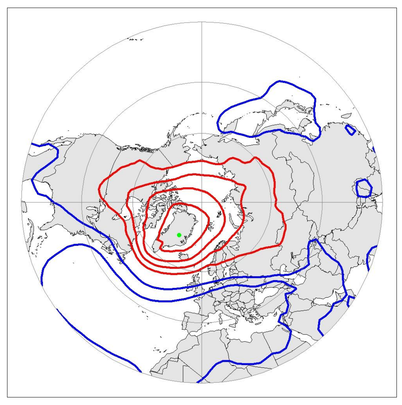


point: 160°W 45°N
Pacific centre of AO

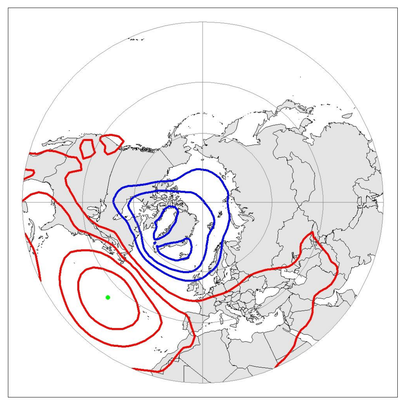
- the Arctic centre is correlated with the Atlantic centre; over Japan only a small area with correlations exceeding 0.2 occurs
- the Atlantic centre exhibits no teleconnection with the Pacific area
- the Pacific centre is teleconnected with Sargasso Sea, but not at all with the areas where the Arctic and Atlantic centres are located



point: 50°E 65°N
Barents Sea centre of BO



point: 35°W 72.5°N
Greenland centre of BO

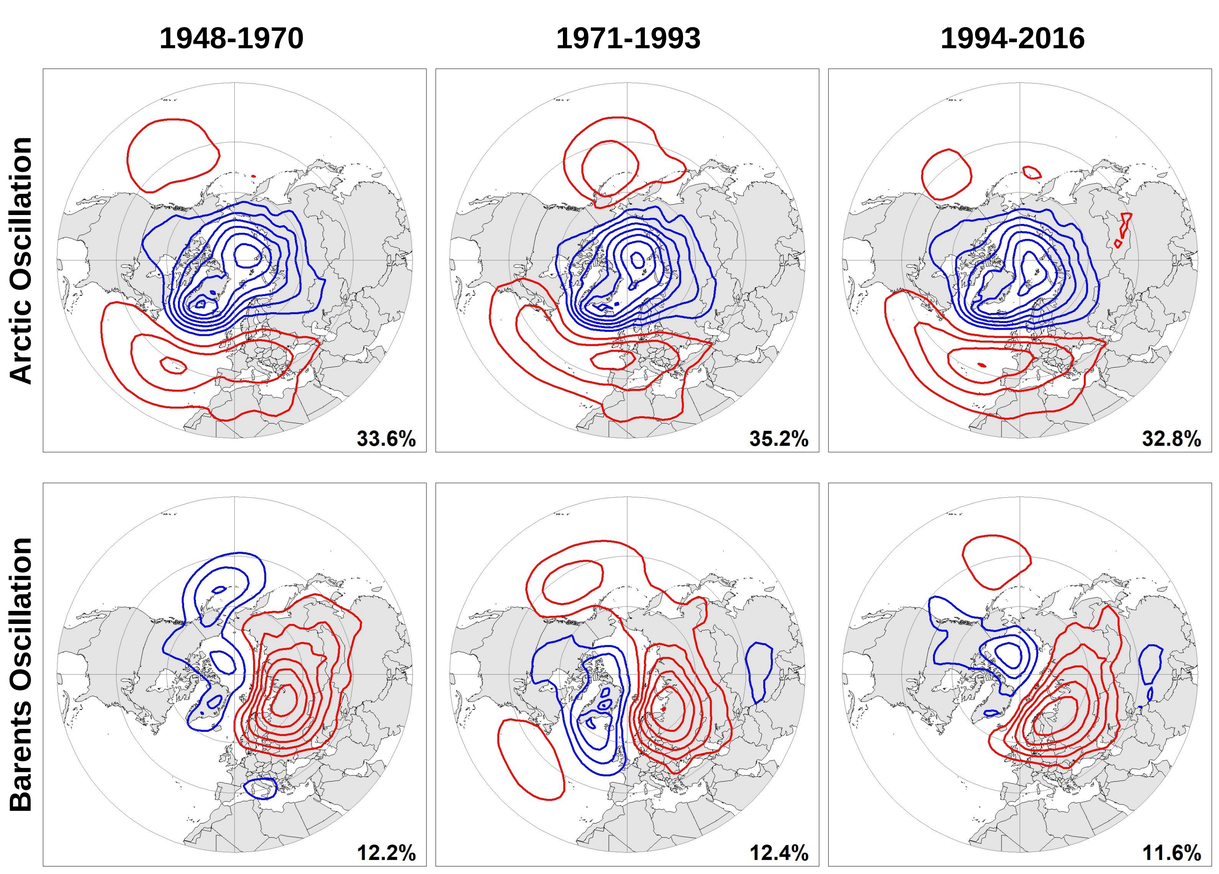


point: 45°W 35°N
Atlantic centre of BO

All action centres are for the correlation-based analysis. Contour interval is 0.2; the zero contour is omitted; negative contours are in blue and positive in red.

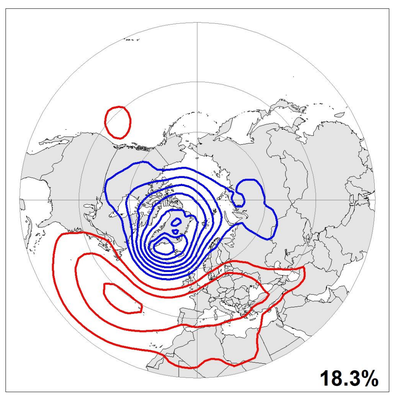
- the Barents Sea centre is connected only with area over the northern Africa and Mediterranean Sea; there is no teleconnection neither with the Greenland nor the Atlantic centre
- the Greenland and the Atlantic centre are connected each other, and may be associated with the North Atlantic Oscillation

Temporal stability



- the Pacific centre of AO is not stable in time
- the BO shows a high sensitivity to temporal sampling; some new centres appeared in different periods and both Barents Sea and Greenland centre changed shape and position

The North Atlantic Oscillation



- consists of a north-south dipole with one centre located over the Azores high and the other centre of opposite sign over the Icelandic low
- is usually defined using the rotated PCA

Map of **rotated PCA**, the **third PC loading** for covariance matrix with using 9 PCs retained for rotation

Conclusions

- the differences between the loadings patterns and corresponding one-point correlation maps for the action centres together with a high sensitivity to temporal sampling may mean that **the real existence of the both AO and BO is doubtful**
- the interpretation of PCA results in terms of **modes of variability should be based on rotated PCs**

References

Chen H. W., Q. Zhang, H. Körnich, D. Chen, 2013: A robust mode of climate variability in the Arctic: The Barents Oscillation, Geophysical research letters, 40: 2856–2861.

Huth R., 2007: Arctic or North Atlantic Oscillation? Arguments based on the principal component analysis methodology, Theoretical and Applied Climatology, 89:1-8.

Acknowledgments

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