Interannual variability of relative angular momentum in the Northern Hemisphere and its relationship with the NAO and the AO

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Introduction

The leading EOF of SLIP was called "Arctic Oscillation" (AO) by Thompson and Wallace (1998). AO is a source of atmospheric pressure between the area over the Polar and a ring passing over southern Alaska and Central Europe. It resembles the NAO, but with a zonally symmetric distribution and having the center of action over the polar cap and not on the Atlantic region. The similarities are so evident that many scientists agree with Wallace (2000), who consider both as the same phenomenon. However, it is not yet clear which of the two paradigms (Atlantic mode. Arctic Oscillation or regional mode - North Atlantic Oscillation) defines better the phenomenon (Karl, 1999). According to Thompson and Wallace (2000) and Thompson et al. (2008) NAO is a regional expression of the Northern Hemisphere annular mode. However the lack of an apparent link between Atlantic and Pacific sectors (Dvorak, 1999) questions the annular paradigm. In any case the phenomenon is the largest and most fundamental mode of variability in the Northern Hemisphere troposphere, being responsible not only for important regional changes in temperature and precipitation regimes into Eurasian Continents (Hurrell, 1995) but also for much of the warming in the Northern Hemisphere surface temperature (Hurrell, 1996).

One of the common effects of NAO and AO is their influence on zonal wind anomalies. When AO is in positive phase (pressures drops over the polar cap and rises over the szores of Antarctica) westerly winds from 45º N becomes stronger. The maximum anomaly is centered near 55-57º in the lower troposphere and near 65º in the upper troposphere. A measurement of this anomaly of the westerlies at a planetary scale is the anomaly of the relative atmospheric angular momentum (RAM) from 500 hPa to 200 hPa and from 55º to 90 ºN (RAM,55-90). RAM is due to zonal winds and varies by as much as 10% seasonally, essentially doubling between Northern Hemisphere summer and winter due to the strong annual cycle of the jet stream in that hemisphere.

However much of the interannual variation of the RAM,55-90 must be due to the phenomenon AO/NAO. The first idea is that the influence of AO on RAM,55-90 should be higher than that of NAO because of the hemispheric character of AO. This result would support the annular paradigm.

The analysis results in fields of atmospheric data for the period 1958-present. It provides daily mean atmospheric data with global coverage. The wind, geopotential height, vertical motion, and specific humidity at multiple levels have a horizontal resolution of 2.5ºx2.5º. This was the resolution used in the study.

Results

Geographical distribution & Correlations

The yearly evolution of NAO, AO, and momentum anomalies show many common features:

• Positive trends caused by the anomalous positive values from the early 80's.

• 1988-1995 values are exclusively positive.

• Maximum momentum belts are localised around 55º latitude, both in the 850-500 hPa and in 500-200 hPa layers.

• Correlation coefficients between NAO and momentum caps reach a maximum at 25-30º and keep constant up to 55º. Caps northern than 80-85º show not significant correlations.

• The wavelet analysis of AO and momentum indices shows a common oscillation band centered in 9-10 years.

Data Analysis

Zonal wind (u) data at 850, 500 and 200 hPa levels for the 41 yr from 1958 to 1998 from the National Centers for Environmental Prediction-National center for Atmospheric Research (NCEP–NCAR) reanalysis have been used (Kalnay et al., 1996).

For annual values, anomalies from the period 1958-1998 were calculated. The study includes 3 parts:

• Cross-correlation of RAM,55-90 anomalies with NAO winter and AO winter series. NAO index is computed as the normalized pressure difference between Lisbon (Portugal) and Stykkisholmur (Iceland) and AO index is based on NCEP/NCAR reanalysis. RAM is computed for data from all months, 1958-1997. Index values after 1997 are found by projecting the NCEP/NCAR reanalysis (EOF is computed for data from all months, 1958-1997). Significant trends (95%)

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Wavelet analysis

The wavelet analysis of AO and NAO winter indices and of annual momentum anomalies show a common oscillation band centered in 9-10 years.


The wavelet analysis detects different oscillation bands for the three phenomena: The 8 years oscillation has been detected as:

• 3rd and 4th components for annual momentum anomalies

• 3rd and 4th components for AO winter index

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