INFLUENCE OF THE NORTH ATLANTIC OSCILLATION ON WINTER EQUIVALENT TEMPERATURE

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Introduction

Increases in both troposphere temperature and water vapor concentrations are among the expected climate changes due to variations in greenhouse gas concentrations (Kattenberg et al., 1995). However, both increases could be due to changes in the frequencies of natural atmospheric circulation regimes (Wallace et al., 1995; Cort et al., 1999).

Changes in the long-wave patterns, dominant anomalous waves, strength and position of climatological “centers of action” should have important influences on local humidity and temperatures regimes. It is known that the recent upward trend in temperature is significantly associated with some of the most important regional trends (Hurrell et al., 1995; Humlum, 1995; Humlum, 1996). However, our knowledge about the influence of NAO on humidity distribution is limited. In the three recent global humidity climatologies (Peixoto and Oort, 1996; Ross and Elliot, 1996 and Randel et al., 1996), nothing is said about the role that NAO can play on humidity distribution.

The objective of this study is to analyze the influence of NAO on the regional temperatures in terms of the frequencies of natural atmospheric circulation regimes in the North Atlantic region for the period 1958-1998. We considered as in positive NAO phase and negative NAO phase the years mean +1SD and 41-year trends patterns. To determine these years we use the NAO index, which is defined as the winter (January, February, and March) difference between Northern Hemisphere January to March and December to February sea-level atmospheric pressure anomalies at Iceland and 41-year mean (1958-1998) as thresholds. Seven years were chosen as in positive NAO phase and other seven as in negative.

The equivalent Temperature is the temperature that an air parcel would have if water vapor were condensed out at constant pressure, the latent heat released being used to heat the air. The mixing rate (w) has been calculated from: latent heat: equivalent temperature: dry air specific heat. The mixing ratio (e) has been calculated from: latent heat: equivalent temperature: dry air specific heat. The monthly, seasonal and annual mean anomalies were constructed from daily means. Seasonal means were defined as Winter (January, February, and March), Spring (April, May, and June), Summer (July, August, and September) and Fall (October, November and December).

Data Analysis

The distribution shows a very zonal pattern. Absolute maxima are located over continental regions. One of them over the African equatorial region, and other two in mid latitudes, one over Africa and the other over Australia. Rossby waves are easily detectable in northern hemisphere mid and high latitudes. In the southern hemisphere those waves are not so marked. Absolute minimum values are detected over Greenland.

Overview

The equivalent Temperature is the temperature that an air parcel would have if water vapor were condensed out at constant pressure, the latent heat released being used to heat the air. The mixing rate (w) has been calculated from:

\[
T_e = \frac{L_e}{C_p w}
\]

where:

- \( T_e \) = equivalent temperature
- \( L_e \) = latent heat
- \( C_p \) = dry air specific heat
- \( w \) = mixing ratio

We used temperature and humidity data at 850 hPa level for the 41 yr from 1958 to 1998 from the National Centers for Environmental Prediction-National Center for Atmospheric Research (NCEP-NCAR) reanalysis.

We calculated daily values of equivalent temperature for every grid point in the NCEP data to the expression in figure-1. The monthly, seasonal and annual mean anomalies were constructed from daily means. Seasonal means were defined as Winter (January, February, and March), Spring (April, May, and June), Summer (July, August, and September) and Fall (October, November and December).

For every season and for annual values, anomalies from the period 1958-1998 were calculated. Anomalies field was then used to calculate the NAO index.

CORRELATIONS BETWEEN NAO AND T_e

In this plot the correlation coefficients locate those regions mostly influenced by this phenomenon. For high negative values are observed over Greenland and the Northeastern coast of northern Asia. Positive anomalies are observed over the African equatorial region, and other two in mid latitudes, one over Africa and the other over Australia. Rossby waves are easily detectable in northern hemisphere mid and high latitudes. In the southern hemisphere those waves are not so marked. Absolute minimum values are detected over Greenland.

COMPOSITE OF T_e ANOMALIES FOR NEGATIVE NAO YEARS

The negative NAO composites of T_e show a pattern very similar to that of the positive NAO, but as a negative image. The highest positive anomalies are located over Greenland and the central Sahara, and the lowest negative anomalies over northeastern America, Europe and central Siberia.

COMPOSITE OF T_e ANOMALIES FOR POSITIVE NAO YEARS

In positive NAO years a high negative T_e anomaly is observed over the North Atlantic and the central Sahara, while positive anomalies are observed over a long belt that goes from near Alaska to New England, and from there crosses the Atlantic Ocean and intensifies the positive anomaly over Europe and throughout most of central and northeastern Asia.

DIFFERENCE BETWEEN T_e FOR POSITIVE AND NEGATIVE NAO YEARS

In this map the highest absolute values locate those regions where the amplitudes of the oscillations and their origin by NAO reaches its maximum amplitude. These regions are Greenland, the Sahara, the Europe and most of Siberia and the western Canada. All these regions are located in mid and high latitudes in the Northern Hemisphere. This implies an almost hemispheric-wide influence of NAO.

References: