Changing Patterns of Tropospheric Variability in the North Atlantic Region

Katrin Walter

Abstract

The tropospheric variability in the winterly Northern Hemisphere is closely coupled to the variability in the stratosphere. Changes in the strength of the stratospheric polar vortex are related to changes in the planetary wave structure in the troposphere. The polar vortex strength is mainly characterized by two regimes: weak and strong. It is examined how this affects the structure of low frequency teleconnections in the North Atlantic region with regard to the North Atlantic Oscillation (NAO). Changes in the structure and the frequency domain of the NAO and the consequences for the covariability with North Atlantic sea surface temperature (SST) are studied. This is achieved by examining both reanalysis data from the U.S. National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) and the Kaplan SST dataset.

Teleconnections of North Atlantic mid to upper tropospheric geopotential height are examined separately for the two regimes of the stratospheric polar vortex. In both cases, the major teleconnection patterns have north-south dipole structures with opposing centers of action in subpolar and subtropical latitudes. The strong polar vortex case is characterized by a single pattern over the central North Atlantic, whereas there are two patterns in the weak vortex case: one over the western North Atlantic/northeastern Canada and one over the eastern North Atlantic. The growth of streamfunction anomalies related to these teleconnection patterns reveals to be characterized by different dynamical processes. In the weak vortex regime, the growth is mainly driven by transient eddy fluxes, whereas, in the strong vortex regime, forcing resulting from interaction of low frequency transients (periods ≥ 10 days) with stationary eddies is equally important. Composites of the North Atlantic storm track and monthly mean precipitation rates reveal to be dependent on both, the teleconnection pattern and its polarity. Hence, a large part of the tropospheric variability cannot be explained in the classical framework of the NAO without considering the polar vortex strength.

Evidence is presented that not only the structure of the teleconnection patterns but also the covariation between the winterly atmospheric flow and SST is not stationary in the North Atlantic region. During the recent decades since the late 1960s/early 1970s and during the first three decades of the 20th century, the North Atlantic SST is strongly connected with the regional atmospheric circulation in the North Atlantic sector, i.e. the NAO. During these periods the NAO index – defined as the difference of normalized sea level pressures at the Azores and Iceland – is characterized by pronounced decadal variability. In contrast, the NAO index is only weakly correlated with the North Atlantic SST from the 1930s to the early 1960s, when the NAO index is characterized by weak decadal variability. Remote influences, in particular from the tropical Pacific region, become important especially for the SST in the western tropical North Atlantic.