Geophysical Research Abstracts,
Vol. 10, EGU2008-A-02307, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-02307
EGU General Assembly 2008

The Development of Potential Vorticity Intrusions over the Tropical North Atlantic

P. Knippertz, L. Fröhlich and F. Meier
Institute for Atmospheric Physics, Johannes Gutenberg University Mainz, Germany
(knippertz@uni-mainz.de / Phone: +49-6131-3926756)

Intrusions of high potential vorticity (PV) into the Tropics are a common feature of the large-scale circulation over the North Atlantic during the northern hemisphere cool season from October to March. Their occurrence is often accompanied by extensive cloud bands and sometimes by extreme precipitation events. The physical processes in the upstream extratropical storm track that allow such intrusions to occur are still not well understood. Here we address this issue with the help of both a composite and a numerical modelling approach.

Using European Centre for Medium-Range Weather Forecasts (ECMWF) re-analysis data for the period 1980-2001, an objective identification based upon vertical averages of PV in the 400-100 hPa layer shows a distinct occurrence maximum of intrusions just off the northwest African coast. 87 intense systems have PV values higher than 1.5 PVU as low as 400 hPa to the south of 25°N. System-relative composites for these disturbances allow an analysis of the typical evolution of vertically averaged PV anomalies. Already six days before the intrusion, coherent PV structures are found upstream in the stormtrack regions of the northern hemisphere: (a) A Rossby wave over the northeastern Pacific and western North America; (b) a northwest-southeastward oriented dipole with a large PV reservoir over the North Atlantic and a negative anomaly, i.e. a blocking, over Europe. Until day -4 the Rossby wave intensifies and approaches the rather stationary dipole from the west. On day -3 and -2 a negative PV anomaly forms and explosively intensifies east of the approaching Rossby wave. It “pulls” air with high PV values out of the PV reservoir and quickly advects it toward low latitudes. On day -1 this PV streamer cuts off and finally reaches the Tropics on day 0,

when a breaking of the wave with a reversal of the meridional PV gradient is observed. The final stage of this process positively projects onto the North Atlantic Oscillation, as has been found in earlier work.

While the composite analysis unveils the typical evolution upstream of a PV intrusion, it cannot reveal the relative importance of single ingredients and different physical processes. Therefore we conducted sensitivity studies with the global model (GME) of the German Weather Service (DWD) with a 40 km horizontal resolution. We chose a case of a very pronounced PV intrusion on 05 January 2002 with an evolution similar to the composite average that was successfully reproduced by the model in a 5-day free forecast mode. In a first step we eliminated single PV features from the simulation with the help of a PV inversion technique to get balanced initial conditions. These experiments show that the by far most important prerequisite for the intrusion is the blocking followed by the PV reservoir, while modifications to the Rossby wave have smaller impacts. Additional experiments with suppressed latent heating over the North Atlantic reveal that diabatic PV reduction east of the Rossby wave is also of second order, in strong contrast to previous case studies. The synthesis of the statistical and sensitivity studies clearly points to an importance of the PV dipole over the North Atlantic and Europe out to six days ahead of the event. The latter point suggests a relatively high predictability of PV intrusions. Further studies based on ECMWF ensemble predictions are on the way to clarify this aspect.