Stratospheric influence on Northern Hemisphere ENSO teleconnections in winter

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Motivation
There are a number of observational and modelling studies demonstrating a extra-tropical El Niño/La Niña Southern Oscillation (ENSO) signal in the stratosphere (van Loon and Labitzke, 1987; Hamilton et al., 1993a,b; Sassi et al., 2004; Manzini et al., 2006). The influence of ENSO on the European climate is more strongly debated. Here, we investigate ENSO wintertime teleconnections to the extra-tropical Northern winter hemisphere with the help of the general circulation model ECHAM5. In contrast to I) Manzini et al. (2006) we analyse ECHAM5 model results for a longer period including more ENSO events; II) Merkel and Latif (2002) we investigate the effect of different vertical resolutions compared to their study, focusing on the horizontal resolution. Recent observational results indicate a surface signal over Northern Europe during El Niño events resembling the negative North Atlantic Oscillation (NAO-) phase due to the downward propagation of the stratospheric anomalies. Therefore we examine the role of stratosphere-troposphere coupling on the ENSO teleconnections by analysing time-height sections of zonal mean temperature and zonal mean wind differences between ENSO events and neutral conditions. We also show frequency distributions of the NAO index during the different ENSO phases as well as wENSO surface anomalies over Northern Europe.

The comparison of the different model setups with each other and with observations can improve our understanding of the underlying atmospheric processes and assess whether ENSO teleconnections via the stratosphere may be a source of seasonal predictability for the Northern Europe winter.

Model description
General circulation model ECHAM5 (Roeckner et al., 2006; Manzini et al., 2006)
- horizontal resolution: T31 (3.75° x 3.75°)
- vertical resolution: - Low-top model L19 = 19 vertical model levels
  - model top at 10 hPa - 30 km
  - High-top model L39 = 39 vertical model levels
  - model top at 0.1 hPa - 80 km

Experimental setup
- prescribed Sea Surface Temperatures (SSTs) from HadISST1 dataset
- ECHAM5 T31L19 including 6 ensemble members with transient SSTs (1900-1998)
- ECHAM5 T31L39 5 ensemble members with transient SSTs (1x1900-2005, 4x1950-2005)
- For the analysis the overlapping period 1957/58 to 1997/98 between model and ERA-40 data is used.

ENSO simulations
500 hPa DJF geopotential height anomaly [gpm]

The wENSO and cENSO geopotential height anomalies for the L19 and L39 model at 500 hPa correspond with ERA-40 data.

- The wENSO and cENSO geopotential height anomalies for the L19 and L39 model at 500 hPa correspond with ERA-40 data.
- The tropospheric anomalies show a good agreement with former studies (van Loon and Madden, 1981; Hoerling et al., 1997; Hoelzinger et al., 1997; Hoelzinger and Wallace, 1981).

ENSO analysis
ENSO index: time series of the Niño 3.4 index (°F-°S, 120°W-170°W) as 5-month running mean using data from the model, based on the period 1953-2005 (Fig. 2).
- Values above a threshold -1 for at least 4 month are marked as warm ENSO event (wENSO) and values above a threshold 0.4°C for at least 6 month are identified as cold ENSO event (cENSO) (Trenberth, 1997) → Tab. 1.

- Composites for wENSO events show for L39, as observed, weak stratospheric polar vortex.
- The differences in the stratospheric signal for the warm and cold ENSO phase can be explained by different planetary wave forcing for both ENSO events (not shown here).
- For this reason a nearly reversed signal with a strengthening and cooling of the stratospheric polar vortex is found for La Niña events.
- The results for L39 show less agreement with observations.
- The anomalies are weaker for cENSO than for wENSO → Thus only wENSO anomalies are shown for the rest of this paper (Fig. 6-9).

ENSO influence on the NAO
Downward propagation

For spring higher pressure is analysed over Iceland partly over Scandinavia for all 3 data sets, whereas lower pressure is located over central and western Europe only in L19 and L39 model (Fig. 8, top).
- Lower pressures are simulated over North Eastern Europe by the L39 model, as for ERA-40 data (Fig. 8, bottom).
- The anomalies are a magnitude smaller than the observations by Fraedrich and Müller (1992) (Fig. 1).
- In contrast to Fraedrich and Müller (1992) (Fig. 1), we find a NAO-like pattern for the MA season in ERA-40 data, L39 and partly for L19 data.

Conclusion
- Analysing ENSO events for the time period 1957/58 to 1997/98 the teleconnection pattern in the troposphere and stratosphere shows significant differences compared to observations.
- Significant teleconnection patterns in the stratosphere, according to observations, are only found for the high-top model (L39).
- cENSO events don’t show a clear significant signal → more La Niña events and/or more model resolutions are needed to better detect cENSO events.
- NAO-like patterns are found for ERA-40, L39 and partly L19 data during spring (March/April).
- The ECHAM5 simulations for the 1957/58 to 1997/98 period confirms the following ENSO influence on the NAO.

References