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Influence of stratospheric dynamics on the extra-tropical circulation: Comparison of High-top/Low-top versions of a climate model

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Recently it has become clear that the stratosphere impacts the surface/troposphere system on time-scale ranging from seasonal to climatic. On seasonal time-scales anomalies descend from the stratosphere to the troposphere providing potential skills for extended range forecasts. On climatic time-scales stratospheric changes such as the SH ozone hole has been shown to significantly change the surface climate. In this study we investigate to what extend this downward coupling is already represented in current climate models and if it could be improved by including a better resolved stratosphere. The difference between two versions of the newly developed global climate system model, EC-Earth, have been studied. The two versions, a low-top and a high-top, differ in their representation of the stratosphere.

The components of EC-Earth are IFS, NEMO and LIM for the atmosphere, ocean and sea-ice, respectively. The low-top version is the standard configuration of EC-Earth with 62 vertical levels (top at 1 hPa) and T159 horizontal spectral resolution for the atmosphere. The high-top version has a better resolved stratosphere with a total of 91 vertical layers and the top at 0.01 hPa.

Experiments with the two versions include AMIP runs (1979-2008), CMIP5 historical simulations (1850-2005), and RCP4.5 scenario simulations (2006-2100). The AMIP and CMIP experiments are compared to ERA40/ERA-Interim reanalyses.

The main characteristic of the atmospheric and oceanic circulation are compared. The possible influence of the stratosphere on the circulation is investigated. For the atmospheric analysis we will focus on extra-tropical circulation described by annular modes, blockings, EP-flux etc.

Preliminary results from the analysis of the experiments show that in comparison with the reanalysis the high-top version has the most realistic stratosphere both regarding climatology and variability. The latter is demonstrated in, e.g., stronger and more pronounced winter warmings. These improvements are probably connected to an improved representation of the EP-flux coupling the stratosphere and the troposphere. Both the high-top and the low-top simulations show a realistic downward propagation of zonal mean zonal wind anomalies from the stratosphere to the troposphere/surface.