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Stratosphere-troposphere dynamical coupling in a changing climate

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Several radiative, dynamical and chemical processes are involved in the two-way coupling between the stratosphere and the troposphere. The focus of this study lies on the stratosphere-troposphere dynamical coupling, its response to a changing climate, and possible implications for the troposphere-surface system.
In the northern winter hemisphere, large-scale planetary waves originating from the troposphere propagate up into the stratosphere. Here their dissipation decelerates the polar night jet and, in extreme cases, may trigger a major sudden stratospheric warming (SSW) event. Major SSW events generally coincide with negative anomalies of the Northern Annular Mode (NAM) index in the stratosphere. Several studies showed that in many cases these anomalies in the NAM index propagate downward, yielding implications for the troposphere-surface system. These implications are reflected e.g. by the index of the North Atlantic Oscillation, which is an important proxy for weather and climate in Europe, and can be used to assess the impact of the stratospheric state on the troposphere. However, it is so far not well understood, how the downward propagation of NAM index anomalies reacts to a changing climate.
Increasing greenhouse gas (GHG) concentrations were found to cause tropospheric warming and simultaneous stratospheric cooling. As the temperature trend varies meridionally, thermal wind balance causes the upper flanks of the subtropical jets to strengthen. The change in the zonal-mean zonal wind field modifies the conditions for wave propagation and dissipation. Particularly, the critical layers for resolved wave dissipation underlie an upward shift, allowing more resolved wave activity to penetrate into the subtropical lower stratosphere. In this way, the wave activity flux is redirected and the regions of wave dissipation are modified in a changing climate.
In the CMIP5 simulations performed with the ECHAM6 General Circulation Model we find increased wave dissipation in the northern hemispheric winter stratosphere until the end of the 21st century, causing an increase in frequency of SSW events of roughly 50% in the RCP4.5 and RCP8.5 scenarios. However, after the 21st century, the GHG induced strengthening of the zonal-mean zonal wind field overshoots the effect of increased wave dissipation. This results in a drop of 50% in SSW frequency, and shifts the monthly distribution of SSW events to the late winter.
In this work we present how the downward propagation of stratospheric disturbances reacts to a changing climate, and evaluate possible implications for the troposphere-surface-system.