Stratosphere-troposphere coupling in ensemble simulations with fast stratospheric ozone chemistry

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A good representation of the stratosphere in climate and weather prediction systems is vital to realistically represent the influence of the stratosphere on tropospheric circulation and predictability on different time scales. While a fairly good representation of the stratosphere and its coupling to the troposphere are now included in most of these an important factor modulating the stratosphere-troposphere coupling (STC) is often missing: a realistic representation of stratospheric ozone. Due to high computational costs of interactive chemistry schemes, ozone is prescribed in most models as a climatological monthly and zonal mean boundary condition. Several aspects of the stratospheric ozone field that are important for its interaction with the atmosphere are neglected through this treatment of ozone: realistic daily variations in ozone, zonal anomalies in ozone, and dynamically consistent feedbacks between ozone chemistry and atmospheric radiation and dynamics. Including a realistic ozone field in model simulations influences the stratospheric polar temperature and vortex, the polar vortex breakup date, as well as wave propagation in the middle atmosphere. In the troposphere a realistic representation of stratospheric ozone may affect the annular modes, storm tracks, surface temperature, and precipitation [1]. The dynamic state of the polar lower stratosphere in winter is of paramount importance for the STC and its alterations in a changing climate. Due to the high interannual variability of this region, especially in the Northern Hemisphere, ensemble simulations are necessary to separate the effect of internal variability and long term changes on this coupling.

In this study, a chemistry-climate model with a fast stratospheric polar ozone scheme (SWIFT) [2] that interactively calculates heterogeneous ozone chemistry inside the polar vortex with minimal increase in computational costs compared to a GCM is used. With an ensemble of multi-decadal climate simulations, we investigate the changes in stratospheric dynamics in a changing climate and with changing concentrations of ozone depleting substances while accounting for zonal anomalies in polar ozone and the internal variability of the atmosphere. We examine the effect of the polar azonal polar ozone on the wave propagation in different levels of the polar stratosphere, as well as changes in the STC and its effects on the troposphere.

Key words: stratospheric ozone, stratosphere-troposphere interaction, climate modelling

References

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