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Seasonal variability in transport in the tropical mid-stratosphere and its impact on ozone and key trace gases

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Stratospheric ozone, O_3, in the tropical middle stratosphere is controlled by a balance between photochemical production and loss. These processes are strongly influenced by atmospheric dynamics, which is dominated by the Brewer-Dobson Circulation (BDC). Seasonal variations of the strength of BDC in the tropical mid-stratosphere, which are commonly described by the mean age-of-air parameter, have been identified to impact the annual mean trends of nitrous oxide (N2O), nitrogen dioxide (NO_2), and therefore O_3. However, the reasons for the changes in seasonal transport in this region are not yet clear. This has implications for the detection and attribution of stratospheric ozone recovery in this region.

This study investigates and identifies possible reasons for the seasonal variability in the speed of vertical transport in the tropical mid-stratosphere. In particular, we investigate whether the observed behaviour is caused by (a) shift of subtropical transport barriers, (b) different behaviour of BDC branches, (c) cooling of the eastern Pacific, which leads to changes in upwelling, or (d) the changing contributions from the wave forcing.

In our analysis, we use observational data for O_3 profiles retrieved at the University of Bremen from limb-scanning instruments SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) and the Ozone Mapping and Profiler Suite (OMPS). We also use time series of gravity wave (GW) potential energy retrieved at the Finnish Meteorological Institute from high-resolution temperature profiles (HRTP) measured by the GOMOS satellite instrument and output from the TOMCAT global offline 3-D chemistry-transport model (CTM). The model contains a detailed description of stratospheric chemistry and it is driven by ERA-Interim reanalysis from the European Centre for Medium-Range Weather Forecasts (ECMWF). We performed TOMCAT simulations with different chemical and dynamical forcings for the period 2003-2018 to interpret their possible changes and impact on stratospheric ozone.