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Advances in the representation of stratospheric transport by the Brewer-Dobson circulation by use of Lagrangian modelling with CLaMS

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The global stratospheric Brewer-Dobson circulation (BDC) is expected to accelerate with rising Greenhouse gas concentrations, in turn changing the stratospheric trace gas composition and providing an important feedback via radiation on climate change. However, trends in the BDC are largely uncertain, with current climate model results disagreeing with existing observations of mean age of air, the average transit time for an air parcel since entering the stratosphere.

We present advances in representing stratospheric trace gas transport caused by the Brewer-Dobson circulation by using the Chemical Lagrangian model of the Stratosphere (CLaMS), a global Lagrangian chemistry transport model with a physically-based parameterization of small-scale mixing. Mean age simulated with CLaMS driven by reanalysis meteorology agrees well with satellite and in-situ observations. Regarding the inter-annual and decadal changes, like increasing age in the Northern hemisphere and decreasing age in the Southern hemisphere during 2002-2012, the natural variability (e.g., QBO, ENSO, volcanic aerosols) is found to play a key role. Age of air spectra simulated with CLaMS provide further insights into the processes involved. Our analysis reveals a crucial effect of mixing on mean age and its decadal change pattern, suggesting that differences between climate models and observations likely involve differences in the effect of mixing.

This progress in modelling stratospheric transport has recently been transferred to climate modelling by coupling the Lagrangian transport scheme CLaMS into the global atmosphere-chemistry model EMAC. First results show improvements of stratospheric transport compared to the standard flux-form semi-Lagrangian transport scheme. These improvements are found particularly in regions of strong transport barriers like the polar vortex, with Lagrangian CLaMS transport resulting in a stronger and more realistic transport barrier.