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Impact of Lagrangian transport on lower-stratospheric water vapor and radiative balance in a climate model

Edward Charlesworth[1], Felix Plöger[1,2], and Patrick Jöckel[3]
[1]Forschungszentrum Jülich, IEK-7 Stratosphäre, Jülich, Germany
[2]Institut für Atmosphären- und Umweltforschung, Universität Wuppertal, Wuppertal, Germany
[3]Deutsches Zentrum för Luft- und Raumfahrt, Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany

A robust result of climate model simulations is the moistening of the stratosphere.
Many models show their strongest changes in stratospheric water vapor in the extratropical lowermost stratosphere, a change which could have substantial climate feedbacks (e.g. Banerjee et al. 2019). However, models are also heavily wet-biased in this region when compared to observations (Keeble et al. 2020), presenting some uncertainty on the robustness of these model results.

In this study, we investigate the contribution of the choice of model transport scheme to this wet bias using a climate model (EMAC) coupled with two transport schemes: the standard EMAC flux-form semi-Lagrangian (FFSL) scheme and the fully-Lagrangian scheme of CLaMS. This experiment has the advantage of analytical clarity in that the dynamical fields driving both transport schemes are identical. Prior work using this tool has shown large differences in transport timecales within the extratropical lowermost stratosphere depending on the transport scheme used (Charlesworth et al. 2020).

These results also suggested that EMAC-CLaMS should reduce the transport of water vapor into this region, but calculations of water vapor fields using this tool were not performed until now. We present the results of that work, comparing the water vapor fields calculated using EMAC-CLaMS and EMAC-FFSL online. Two model simulations were performed, wherein each water vapor field was used to drive radiation calculations, such that the radiative consequences of applying one transport scheme or the other could be assessed.

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