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Tropical troposphere to stratosphere transport of carbon monoxide and long-lived trace species in the Chemical Lagrangian Model of the Stratosphere (CLaMS)

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Abstract. Variations in the mixing ratio of trace gases of tropospheric origin entering the stratosphere in the tropics are of interest for assessing both troposphere to stratosphere transport fluxes in the tropics and the impact of these transport fluxes on the composition of the tropical lower stratosphere. Anomaly patterns of carbon monoxide (CO) and long-lived tracers in the lower tropical stratosphere allow conclusions about the rate and the variability of tropical upwelling to be drawn. Here, we present a simplified chemistry scheme for the Chemical Lagrangian Model of the Stratosphere (CLaMS) for the simulation, at comparatively low numerical cost, of CO, ozone, and long-lived trace substances (CH_4, N_2O, CCl_3F (CFC-11), CCl_2F_2 (CFC-12), and CO_2) in the lower tropical stratosphere. For the long-lived trace substances, the boundary conditions at the surface are prescribed based on ground-based measurements in the lowest model level. The boundary condition for CO in the lower troposphere (below about 4 km) is deduced from MOPITT measurements. Due to the lack of a specific representation of mixing and convective uplift in the troposphere in this model version, enhanced CO values, in particular those resulting from convective outflow are underestimated. However, in the tropical tropopause layer and the lower tropical stratosphere, there is relatively good agreement of simulated CO with in situ measurements (with the exception of the TROCCINOX campaign, where CO in the simulation is biased low ≈10 – 15 ppbv). Further, the model results (and therefore also the ERA-Interim winds, on which the transport in the model is based) are of sufficient quality to describe large scale anomaly patterns of CO in the lower stratosphere. In particular, the zonally averaged tropical CO anomaly patterns (the so called "tape recorder" patterns) simulated by this model version of CLaMS are in good agreement with observations, although the simulations show a too rapid upwelling compared to observations as a consequence of the overestimated vertical velocities in the ERA-Interim reanalysis data set. Moreover, the simulated tropical anomaly patterns of N_2O are in good agreement with observations. In the simulations, anomaly patterns of CH_4 and CFC-11 were found to be very similar to those of N_2O; for all long-lived tracers, positive anomalies are simulated because of the enhanced tropical upwelling in the easterly shear phase of the quasi-biennial oscillation.

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