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Impact of land convection on troposphere-stratosphere exchange in the tropics

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Abstract. The mechanism of troposphere-stratosphere exchange in the tropics was investigated from space-borne observations of the horizontal distributions of tropospheric-origin long-lived species, nitrous oxide (N_2O), methane (CH_4) and carbon monoxide (CO), from 150 to 70 hPa in March-April-May by the ODIN/Sub-Millimeter Radiometer (SMR), the Upper Atmosphere Research Satellite (UARS)/Halogen Occultation Experiment (HALOE) and the TERRA/Measurements Of Pollution In The Troposphere (MOPITT) instruments in 2002–2004, completed by recent observations of the AURA/Microwave Limb Sounder (MLS) instrument during the same season in 2005. The vertical resolution of the satellite measurements ranges from 2 to 4 km. The analysis has been performed on isentropic surfaces: 400 K (lower stratosphere) for all the species and 360 K (upper troposphere) only for CO. At 400 K (and 360 K for CO), all gases show significant longitudinal variations with peak-to-trough values of ~5–11 ppbv for N_2O, 0.07–0.13 ppmv for CH_4, and ~10 ppbv for CO (~40 ppbv at 360 K). The maximum amounts are primarily located over Africa and, depending on the species, secondary more or less pronounced maxima are reported above northern South America and South-East Asia. The lower stratosphere over the Western Pacific deep convective region where the outgoing longwave radiation is the lowest, the tropopause the highest and the coldest, appears as a region of minimum concentration of tropospheric trace species. The possible impact on trace gas concentration at the tropopause of the inhomogeneous distribution and intensity of the sources, mostly continental, of the horizontal and vertical transports in the troposphere, and of cross-tropopause transport was explored with the MOCAGE Chemistry Transport Model. In the simulations, significant longitudinal variations were found on the medium-lived CO (2-month lifetime) with peak-to-trough value of ~20 ppbv at 360 K and ~10 ppbv at 400 K, slightly weaker than observations. However, the CH_4 (8–10 year lifetime) and N_2O (130-year lifetime) longitudinal variations are significantly weaker than observed: peak-to-trough values of ~0.02 ppmv for CH_4 and 1–2 ppbv for N_2O at 400 K. The large longitudinal contrast of N_2O and CH_4 concentrations reported by the space-borne instruments at the tropopause and in the lower stratosphere not captured by the model thus requires another explanation. The suggestion is of strong overshooting

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over land convective regions, particularly Africa, very consistent with the space-borne Tropical Rainfall Measuring Mission (TRMM) radar maximum overshooting features over the same region during the same season. Compared to observations, the MOCAGE model forced by ECMWF analyses is found to ignore these fast local uplifts, but to overestimate the average uniform vertical transport in the UTLS at all longitudes in the tropics.

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