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Equatorial transport as diagnosed from nitrous oxide variability

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Abstract. The mechanisms of transport on annual, semi-annual and quasi-biennial time scales in the equatorial (10° S–10° N) stratosphere are investigated using the nitrous oxide (N_2O) measurements of the space-borne ODIN Sub-Millimetre Radiometer from November 2001 to June 2005, and the simulations of the three-dimensional chemical transport models MOCAGE and SLIMCAT. Both models are forced with analyses from the European Centre for Medium-range Weather Forecast, but the vertical transport is derived either from the forcing analyses by solving the continuity equation (MOCAGE), or from diabatic heating rates using a radiation scheme (SLIMCAT). The N_2O variations in the mid-to-upper stratosphere at levels above 32 hPa are generally well captured by the models though significant differences appear with the observations as well as between the models, attributed to the difficulty of capturing correctly the slow upwelling associated with the Brewer-Dobson circulation. However, in the lower stratosphere, below 32 hPa, the observed variations are shown to be mainly seasonal with peak amplitude at 400–450 K (~17.5–19 km), totally missed by the models. The minimum N_2O in June, out of phase by two months with the known minimum seasonal upwelling associated with the Brewer-Dobson circulation and moreover amplified over the Western Pacific compared to Africa is incompatible with the seasonal change of upwelling evoked to explain the O_3 annual cycle in the same altitude range (Randel et al., 2007). Unless the 1.5 ppbv amplitude of N_2O annual cycle in the upper troposphere is totally wrong, the explanation of the observed N_2O annual cycle of 15 ppbv in the lower stratosphere requires another mechanism. A possible candidate for that might be the existence of a downward time-averaged mass flux above specific regions, as shown by Sherwood (2000) over Indonesia, required for compensating the energy sink resulting from the deep overshooting of cold and heavy air at high altitude over intense convective areas. But, since global models do currently not capture this subsidence, it must be recognised that a full explanation of the observations cannot be provided for the moment. However, the coincidence of the peak contrast between the Western Pacific and Africa with the maximum overshooting volume in May reported by the Tropical Rainfall Measuring Mission (TRMM)

Precipitation Radar, suggests a strong influence of deep convection on the chemical composition of the tropical lower stratosphere up to 500 K (21 km).

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