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Satellite observations and modeling of transport in the upper troposphere through the lower mesosphere during the 2006 major stratospheric sudden warming

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Abstract. An unusually strong and prolonged stratospheric sudden warming (SSW) in January 2006 was the first major SSW for which globally distributed long-lived trace gas data are available covering the upper troposphere through the lower mesosphere. We use Aura Microwave Limb Sounder (MLS), Atmospheric Chemistry Experiment-Fourier Transform Spectrometer (ACE-FTS) data, the SLIMCAT Chemistry Transport Model (CTM), and assimilated meteorological analyses to provide a comprehensive picture of transport during this event. The upper tropospheric ridge that triggered the SSW was associated with an elevated tropopause and layering in trace gas profiles in conjunction with stratospheric and tropospheric intrusions. Anomalous poleward transport (with corresponding quasi-isentropic troposphere-to-stratosphere exchange at the lowest levels studied) in the region over the ridge extended well into the lower stratosphere. In the middle and upper stratosphere, the breakdown of the polar vortex transport barrier was seen in a signature of rapid, widespread mixing in trace gases, including CO, H_2O, CH_4 and N_2O. The vortex broke down slightly later and more slowly in the lower than in the middle stratosphere. In the middle and lower stratosphere, small remnants with trace gas values characteristic of the pre-SSW vortex lingered through the weak and slow recovery of the vortex. The upper stratospheric vortex quickly reformed, and, as enhanced diabatic descent set in, CO descended into this strong vortex, echoing the fall vortex development. Trace gas evolution in the SLIMCAT CTM agrees well with that in the satellite trace gas data from the upper troposphere through the middle stratosphere. In the upper stratosphere and lower mesosphere, the SLIMCAT simulation does not capture the strong descent of mesospheric CO and H_2O values into the reformed vortex; this poor CTM performance in the upper stratosphere and lower mesosphere results primarily from biases in the diabatic descent in assimilated analyses.

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