Geophysical Research Abstracts
Vol. 14, EGU2012-1249, 2012
EGU General Assembly 2012

A global ERA-interim Climatology of Stratosphere-Troposphere Exchange and High-Resolution Model Case Studies

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Stratosphere-troposphere exchange (STE) has an important impact on atmospheric chemistry and potentially also on the climate system. It is thus important to quantify exchange fluxes of air, water vapor, ozone and other chemical constituents on different spatial and temporal scales. In this study we use the ERA-Interim reanalysis data set (1979-2011) from the European Centre for Medium-Range Weather Forecasts (ECMWF) to produce a new trajectory-based climatology of STE. Compared to earlier reanalyses, the increased spatial resolution and the 4D-Var data assimilation scheme constitute two major advances leading to an increased overall quality of the climatology. The Lagrangian methodology to identify STE events is based on backward and forward trajectory calculations initialized from a dense grid in the upper troposphere and lower stratosphere and selects air parcels that (i) cross the 2-pvu dynamical tropopause, and (ii) stay longer than a specified threshold residence time of two days on both sides of the tropopause before and after the STE event, respectively. Our new climatology improves the current understanding of the geographical distribution of exchange events on the global scale and provides insight in the temporal evolution of STE during the last 30 years. Of particular interest are so-called deep exchange events where ozone-rich stratospheric air reaches the planetary boundary layer (PBL) within a few days (deep STT) or where possibly polluted air from the PBL is rapidly transported into the stratosphere (deep TST). Since the processes within the PBL are not well captured with 6-hourly reanalyses, the question whether originally stratospheric air will actually reach the ground can be better addressed with the aid of a high-resolution numerical weather prediction model such as COSMO. We have implemented a passive tracer for stratospheric air in COSMO that allows us to investigate the transport from the stratosphere to the ground, and the turbulent mixing in the PBL, with high spatial and temporal resolution. We can compare our modeling results with observations, e.g., in the north-western USA, where we expect a seasonal peak of deep STT events in spring. For a case study of a pronounced surface ozone peak in spring 2006, high-resolution COSMO simulations provide evidence for a significant stratospheric contribution.