Geophysical Research Abstracts, Vol. 8, 04191, 2006
SRef-ID: 1607-7962/gra/EGU06-A-04191

Forecasting cirrus clouds and water vapour in the tropical tropopause layer

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A better understanding of the dehydration mechanism in the Tropical Tropopause Layer (TTL) is of great importance for interpreting changes in stratospheric water vapour, which is one of the factors influencing the ozone layer and climate change. In the present study, the conservation of total water in the tropical tropopause layer is described by applying parameterised cirrus cloud microphysics to air parcel trajectories (Lagrangian air-parcel cirrus model, LACM). When domain-filling backward trajectories are used, cirrus cloud and water vapour fields can be reconstructed in the domain. Using trajectories generated from ECMWF operational forecasts, cirrus cloud forecasts were provided for flight planning during the TROCCINOX and SCOUT-O3 field campaigns in 2005.

The mixing ratios of total water in the TTL, measured by a high-altitude aircraft over Brazil (TROCCINOX campaign), have been reconstructed by LACM using trajectories generated from ECMWF analyses. The reconstructed total water mixing ratios along aircraft flight tracks are campared with observations. Process-oriented analysis shows that modelled cirrus cloud events are responsible for dehydrating the air parcels coming from lower levels by down to 2 ppmv. Without adding water to the 10-day-long trajectories, reconstructed total water mixing ratios are apparently lower than the observations in some parts of the flight tracks, especially in the lower TTL. Adding water back to those trajectories when convection is moistening them dramatically in the ECMWF model removes the dry bias, indicating that the ECMWF model captures the gross features of the rehydration of air by convection.

By picking up the main contributing processes to dehydration and rehydration in the TTL, LACM reconstructs total water mixing ratios along aircraft flight tracks in better agreement with observations than the ECMWF analyses themselves.