Geophysical Research Abstracts,
Vol. 11, EGU2009-12825, 2009
EGU General Assembly 2009

Stratospheric transport in a CTM using DAS and GCM winds: Identifying effects

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Off-line chemical transport models (CTMs) can be driven by meteorological fields from a data assimilation system (DAS) or from a general circulation model (GCM). The major advantage of using DAS fields is that results from the CTM are then directly comparable with observations on a particular day. However, the data assimilation process itself introduces discontinuities in the physical state of the numerical weather prediction (NWP) model that can affect the assimilated winds and consequently the modelled tracer transport.

This study compares new ECMWF ERA-Interim reanalyses with previous existing datasets and shows large improvements in stratospheric transport, due to recent developments included in the ECMWF NWP/DAS system. The TOMCAT/SLIMCAT off-line 3D CTM has been run with different assimilation products from the ECMWF: ERA-40 reanalyses (3D-Var), operational analyses (4D-Var), several ERA-Interim experiments (3D-Var and enhanced 4D-Var) and ERA-Interim reanalyses (enhanced 4D-Var). A set of GCM winds based on the ECMWF model used to produce ERA-40 has also been used to force the CTM. Reanalysis data from the Canadian Middle Atmosphere Model (CMAM) have been used for additional Lagrangian CTM runs.

Diagnostics performed include age-of-air calculations (mean-age and spectrum), 'tape recorder' representation and Lagrangian simulations. Trajectory calculations with ECMWF data show how the use of a 4D-Var assimilation technique considerably reduces vertical spurious diffusion, compared to the less sophisticated 3D-Var technique. The tape recorder signal obtained with ERA-Interim is in good agreement with observations, and more realistic than that obtained with assimilated winds from previous ECMWF systems (ERA-40 and operational). Age-of-air calculations demonstrate that the improvements consistently extend outside the tropical region.

The effect of different frequencies for the winds update in the CTM is also discussed. Results show there is a threshold to the analysis frequency CTMs can use to correctly simulate stratospheric transport. In particular, the use of 12 hourly winds results in very unrealistic transport in the stratosphere. Some transport deficiencies attributed in the past to the use of ECMWF DAS winds in CTMs appear to be due to the use of unsuitable too long update frequencies. The effect of different (re)analysis read-in frequencies is further explored with reanalysis data from the Canadian Middle Atmosphere Model (CMAM), that enable a clean comparison of trajectories obtained with 3-hourly and 6-hourly atmospheric data.