Fitness of meteorological analyses by ECMWF and CMC to model tracer transport in the Arctic vortex 2010-2011

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We evaluate the capacity of several recent models of stratospheric chemistry (BASCOE CTM, MOZART, IFS-MOZART, SACADA, GEM-BACH) to simulate transport in the exceptional vortex of the Arctic winter 2010-2011. Correct modelling requires an adequate representation of subsidence in the well-isolated vortex, which must lead to vortex-averaged abundances of N2O decreasing with time until a final sudden stratospheric warming ends the event. This decrease is readily observed by Aura-MLS and is a standard diagnostic of transport in the polar vortex.

Here we use as reference the analyses of Aura-MLS observations, as delivered by the BASCOE 4D-VAR system. All the models are based on the same hybrid-pressure vertical grid as the underlying NWP system. It is shown that none of these models is able to simulate correctly the descent of N2O-poor air masses in the lower part of the vortex (where ozone depletion occurs), independently of their advection algorithm or coupling scheme with the meteorological assimilation system. Hence this failure is attributed to the meteorological analyses themselves. We show the results obtained with four datasets of meteorological analyses: three delivered by ECMWF (Operational, ERA-interim, MACC) and one by CMC (Operational GEM 4D-VAR). One model (BASCOE CTM) was driven by all four datasets, allowing a rigorous comparison. Each dataset leads to different disagreements between the CTM simulations and the chemical analyses, even though there is good agreement between the temperature analyses.

These comparisons point to some areas requiring improvement in current NWP systems to allow correct modelling of the polar stratosphere. These areas include at least the gravity wave breaking parameterizations (physics modules) and the (lack of) observational constraints on the vertical wind fields.