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Key aspects of stratospheric tracer modeling using assimilated winds

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Abstract. This study describes key aspects of global chemistry-transport models and their impact on stratospheric tracer transport. We concentrate on global models that use assimilated winds from numerical weather predictions, but the results also apply to tracer transport in general circulation models. We examined grid resolution, numerical diffusion, air parcel dispersion, the wind or mass flux update frequency, and time interpolation. The evaluation is performed with assimilated meteorology from the "operational analyses or operational data" (OD) from the European Centre for Medium-Range Weather Forecasts (ECMWF). We also show the effect of the mass flux update frequency using the ECMWF 40-year re-analyses (ERA40).
We applied the three-dimensional chemistry-transport Tracer Model version 5 (TM5) and a trajectory model and performed several diagnoses focusing on different transport regimes. Covering different time and spatial scales, we examined (1) polar vortex dynamics during the Arctic winter, (2) the large-scale stratospheric meridional circulation, and (3) air parcel dispersion in the tropical lower stratosphere.

Tracer distributions inside the Arctic polar vortex show considerably worse agreement with observations when the model grid resolution in the polar region is reduced to avoid numerical instability. The results are sensitive to the diffusivity of the advection. Nevertheless, the use of a computational cheaper but diffusive advection scheme is feasible for tracer transport when the horizontal grid resolution is equal or smaller than 1 degree. The use of time interpolated winds improves the tracer distributions, particularly in the middle and upper stratosphere. Considerable improvement is found both in the large-scale tracer distribution and in the polar regions when the update frequency of the assimilated winds is increased from 6 to 3 h. It considerably reduces the vertical dispersion of air parcels in the tropical lower stratosphere.

Strong horizontal dispersion is not necessarily an indication of poor wind quality, as observations indicate. Moreover, the generally applied air parcel dispersion calculations should be interpreted with care, given the strong sensitivity of dispersion with altitude.

The results in this study provide a guideline for stratospheric tracer modeling using assimilated winds. They further demonstrate significant progress in the use of assimilated meteorology in chemistry-transport models, relevant for both short- and long-term integrations.

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