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Meteorological implementation issues in chemistry and transport models

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Abstract. Offline chemistry and transport models (CTMs) are versatile tools for studying composition and climate issues requiring multi-decadal simulations. They are computationally fast compared to coupled chemistry climate models, making them well-suited for integrating sensitivity experiments necessary for understanding model performance and interpreting results. The archived meteorological fields used by CTMs can be implemented with lower horizontal or vertical resolution than the original meteorological fields in order to shorten integration time, but the effects of these shortcuts on transport processes must be understood if the CTM is to have credibility. In this paper we present a series of sensitivity experiments on a CTM using the Lin and Rood advection scheme, each differing from another by a single feature of the wind field implementation. Transport effects arising from changes in resolution and model lid height are evaluated using process-oriented diagnostics that intercompare CH_4, O_3, and age tracer carried in the simulations. Some of the diagnostics used are derived from observations and are shown as a reality check for the model. Processes evaluated include tropical ascent, tropical-midlatitude exchange, poleward circulation in the upper stratosphere, and the development of the Antarctic vortex. We find that faithful representation of stratospheric transport in this CTM is possible with a full mesosphere, ~1 km resolution in the lower stratosphere, and relatively low vertical resolution (>4 km spacing) in the middle stratosphere and above, but lowering the lid from the upper to lower mesosphere leads to less realistic constituent distributions in the upper stratosphere. Ultimately, this affects the polar lower stratosphere, but the effects are greater for the Antarctic than the Arctic. The fidelity of lower stratospheric transport requires realistic tropical and high latitude mixing barriers which are produced at 2°×2.5°, but not lower resolution. At 2°×2.5° resolution, the CTM produces a vortex capable of isolating perturbed chemistry (e.g. high Cl_y and low NO_y) required for simulating polar ozone loss.

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