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Overview of Large-scale Tropospheric Transport in the Chemistry Climate Modeling Initiative (CCMI) Models

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The transport of chemicals is a major uncertainty in the modeling of tropospheric composition. Here we compare the large-scale tropospheric transport properties among different models in the Chemistry Climate Modeling Initiative (CCMI) with a focus on transport defined with respect to the Northern Hemisphere (NH) midlatitude surface. Among simulations of the recent past (1980-2010) we show that there are substantial differences in their global-scale tropospheric transport properties. For example, the mean transit time since Southern Hemisphere (SH) air last contacted the NH midlatitude surface differs by ∼30-40% among simulations. We show that these differences are most likely associated with differences in parameterized convection over the oceans, such that the spread in transport among simulations constrained with analysis fields is as large as the spread among free-running simulations.

Among simulations of the 21st century we find that models project a consistent, albeit small (∼5-10%), reduction in interhemispheric transport between the northern and southern hemispheres and enhanced transport from the troposphere into the stratosphere. The changes in interhemispheric transport are correlated with the amplitude of upper tropospheric tropical warming, such that models that warm more also feature larger decreases in (parameterized) convection and a stronger weakening of the boreal winter Hadley Circulation. Finally, a budget analysis performed on tracers integrated in the Goddard Earth Observing System Model reveals that small tropospheric transport trends largely reflect compensating trends between (parameterized) convection and the large-scale circulation. Our results indicate that more attention needs to be paid to convective parameterizations in order to understand large-scale tropospheric transport in models, particularly in simulations constrained with analyzed winds.