A Stratospheric Perspective of a GCM Dynamical Core Intercomparison

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The Quasi-Biennial Oscillation (QBO) in the tropics and Sudden Stratospheric Warmings (SSWs) in the polar regions are the two major dynamic phenomena in the stratosphere. The QBO is mainly generated and influenced by tropical waves, which consist of large-scale equatorially-trapped Kelvin waves, mixed Rossby-gravity waves, inertio-gravity waves and small-scale gravity waves. SSWs are generated by large-scale planetary waves. These waves are generated in the troposphere, propagate upwards and deposit their momentum in the upper atmosphere once they break. The ability of a General Circulation Model (GCM), and in particular their dynamical cores, to simulate the waves and the corresponding wave-mean flow interactions is very important in simulating the QBO and SSWs. This ability varies with the chosen vertical and horizontal resolutions, but it is also dependent on the details of the numerical schemes, the strengths of explicit vertical or horizontal diffusion, and the characteristics of the sponge layer near the model top. We discuss the curious result that both QBO-like oscillations and SSWs can already be simulated without moisture or topographic effects which are generally believed to be the main wave triggering mechanisms.

In particular, the QBO and SSWs are simulated with version 5 of the NCAR/DOE Community Atmosphere Model (CAM 5) with a high model top at 0.1 hPa and 55 levels. The QBO and SSWs are modeled with the spectral transform semi-Lagrangian (SLD) and spectral transform Eulerian (EUL), Finite Volume (FV) and Spectral Element (SE) dynamical cores, which are configured for a dry and flat earth. The simulations are driven by the Held-Suarez forcing (with modifications by Williamson et al., 1998) which provides a Newtonian temperature relaxation and Rayleigh damping.

These mimic the effects of radiation, boundary-layer friction, and additional sponge layer dissipation at the model top. The characteristics of the QBO-like oscillation and SSWs vary greatly among the dynamical cores. Wave analysis is performed to understand their driving mechanisms. In particular, the Transformed-Eulerian-Mean analysis will be used to explore the relative roles of the forcing by the resolved waves and the explicit/implicit diffusion in the dynamical cores.