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Stratosphere-Troposphere Coupling and Annular Mode Variability in Chemistry-Climate Models

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The internal variability and coupling between the stratosphere and troposphere in CCMVal-2 Chemistry-Climate Models are evaluated through analysis of the annular mode patterns of variability. The spatial and temporal structure of the models' annular modes is compared with that of reanalyses. As a whole, the models capture the key features of observed intraseasonal variability, including the sharp vertical gradients in structure between stratosphere and troposphere, the asymmetries in the seasonal cycle between the Northern and Southern Hemispheres, and the coupling between the polar stratospheric vortices and tropospheric midlatitude jets. It is also found that the annular mode variability changes remarkably little in time throughout simulations of the 21st century.

There are, however, both common biases and significant differences in performance in the models. In the troposphere, the annular mode in models is generally too persistent, particularly in the Southern Hemisphere summer, a bias similar to that found in CMIP3 coupled climate models. In the stratosphere, the periods of peak variance and coupling with the troposphere are delayed by about a month in both hemispheres. The relationship between increased variability of the stratosphere and increased persistence in the troposphere suggests that some tropospheric biases may be related to stratospheric biases, and that a well simulated stratosphere can improve simulation of tropospheric intraseasonal variability. Other biases appear to be related to tropospheric dynamics and problems with the model climatologies. This suggests that there are still outstanding issues in the modeling of large scale midlatitude dynamics in both the troposphere and stratosphere.