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What drives the Brewer-Dobson Circulation?

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The Brewer-Dobson Circulation describes the slow overturning circulation of the stratosphere, which, in concert with chemical processes, sets the distribution of stratospheric ozone and water vapor. The circulation can be understood as a response to mechanical wave driving through the “downward control" principal. Planetary-scale Rossby waves and small-scale gravity waves are the primary sources of wave driving, but as the latter cannot be properly resolved in most models, their influence must be parameterized. Comprehensive climate models almost uniformly project an increase in the Brewer-Dobson Circulation in response to anthropogenic forcing, but differ significantly in explaining how this change is effected. Some models suggest that resolved waves are primarily responsible for the increase, while others suggest parameterized waves play an important role. Given this uncertainty, there has been justifiable concern about the model projections.

An idealized atmospheric model allows us to explore the interaction between resolved Rossby waves and parameterized gravity waves. We find that these interactions are significant, to the degree that the use of downward control to linearly partition the influence of different waves is not well posed. The tuning of the gravity wave parameterization heavily influences the relative roles of the different waves, and can in part explain how comprehensive models have come to such different conclusions. These interactions lead us to suggest a new framework for interpreting downward control, and demand a more nuanced answer to the question, "What drives the Brewer-Dobson Circulation?"