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What Controls the Overturning Circulation of the Stratosphere?

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Tracer analysis is blended with traditional geophysical fluid dynamics techniques to understand the stratospheric overturning circulation, or Brewer-Dobson Circulation, in an idealized general circulation model. In particular, we focus on the role(s) of the troposphere and the stratosphere in controlling the strength and depth of the circulation. We find that while the troposphere appears to set the input of planetary and synoptic waves into the stratosphere, their propagation and dissipation is substantially affected by the climatology of the stratosphere. Thus the overturning circulation depends critically on coupling between the two layers of the atmosphere.

The stratospheric flow is analyzed with the residual mean circulation, downward control analysis, and the age of air spectrum based on tracer transport, to provide a comprehensive picture of mass transport in the stratosphere. The investigation provides an example of the benefit of incorporating tracer analysis in studying fundamental questions in geophysical fluid dynamics. We also find that that overturning circulation can be quite sensitive to model numerics and numerical truncation, highlighting the importance of small scale motions in the stratosphere, even though its energy spectrum is dominated by large scale planetary waves. Implications of this sensitivity in more comprehensive models are explored.