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The role of wave-wave interaction during stratospheric splits

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Sudden Stratospheric Warmings (SSWs) are the most studied example of troposphere-stratosphere coupling. They are often categorized as either splits (dominated by wavenumber 2) or displacements (wavenumber 1) and many studies (e.g. Charlton and Polvani (2007)) found statistically significant differences between the zonal wind fields and associated momentum fluxes. These differences are observed from the stratosphere to the surface. Our study focuses on how wave-wave interactions within the stratosphere can determine the type of SSW. We derive an energy budget for each wavenumber that allows us to quantify the major stratospheric processes within each wavenumber as well as the energy transfer from one wavenumber into another. Calculating these budgets, using MERRA reanalysis data, we find that for many split events the energy flux into the stratosphere is predominantly in wavenumber one. Thus, wave-wave interactions within the stratosphere, which can flux energy between wavenumbers, play a key role in splitting the polar stratospheric vortex. However, the signal is weak when we calculate composites over all splits as the timing of wave-wave interactions is unrelated to classic definitions (e.g. central date) highlighting the need for a dynamically more meaningful definition of SSWs.

In order to better understand the role of wave-wave interactions, we employ GFDL's FMS shallow water model to simulate the stratospheric vortex under idealized forcings (similar to Polavani et al. (1994)). Contrary to many other idealized experiments, we are able to simulate both types of warmings with pure wavenumber one or two forcings. We further explore the strength of the necessary forcing to cause stratospheric splits in relation to the state of of the polar vortex. These results are compared to the work of Matthewman and Esler (2011) on splits being a result of resonance. We finally use the energy budget described above to determine the importance of wave-wave interaction in this idealized setting.