Lower stratospheric control of the frequency of sudden stratospheric warming events

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Simple atmospheric models are often used to investigate the dynamical coupling between the stratosphere and the troposphere. Several studies have examined, using such models, the sensitivity of stratospheric polar vortex variability to the upper-stratospheric relaxation temperatures. Although it is known that the lower stratosphere can act as a valve for the upward propagation of planetary-scale waves and thus a regulator for the occurrence of SSW events, the sensitivity of the model setup to lower-stratospheric temperatures was not thoroughly investigated.
We contrast in this work the sensitivity of stratospheric variability to the lower and upper stratospheric temperatures by performing parameter-sweep experiments. It is found that lower-stratospheric temperature is of prime importance to regulate the temporal variability of the vortex. Against the common intuition that a warm high-latitude polar stratosphere results in a weaker vortex and more frequent reversals of zonal-mean zonal wind, we find that a cold lower stratosphere at the pole is crucial for the occurrence of sudden stratospheric warming (SSW) events. We hypothesize that a stronger meridional temperature gradient helps to maintain a waveguide between the troposphere and the stratosphere.
The wave-1 and wave-2 SSW events generated in our model runs are further studied with the transformed Eulerian mean and finite amplitude wave activity frameworks. It is shown that the evolution of SSW events in the model are qualitatively similar to SSWs seen in observations. Interestingly, while the wave activity signal propagates downward in wave-1 events, it is propagating upward in wave-2 events, hinting to different wave-mean flow interactions.

