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Altered middle atmospheric responses driven by two types of Sudden Stratospheric Warming

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Two distinctive evolutions of Sudden Stratospheric Warming (SSW) for Northern winter and their impacts on the middle atmosphere are addressed by both composite analysis and model simulation. Whole Atmosphere Community Climate Model Version 4 (WACCM4) is used for this study. A simple method for the categorization of SSW events into the split and displacement type is devised by measuring the amplitude ratio of wavenumber 1 and 2 during the SSW evolution. Applying the devised method to the two independent reanalysis data and model simulation data, we confirmed that WACCM4 simulates the two distinctive evolutions of different SSW reasonably well. In both types of SSW, temperature anomaly over polar region in the stratosphere shows positive and negative in the mesosphere. Evolution of area-weighted meridional heat-flux anomaly which is indicative of vertical wave activity is also qualitatively similar in both types, indicating that the hemispheric integrated planetary wave activities propagating to stratosphere are similar in both cases. Differences are also clearly captured in both observational data and model simulation. For SSW split type, the polar temperatures are colder in upper stratosphere and warmer in lower mesosphere after the onset of SSW. Analysis results from transformed Eulerian mean diagnostics indicate that the changes in the residual circulations in the stratosphere and mesosphere are controlled by both planetary wave forcings and gravity wave forcings. Especially, in the mesosphere, gravity wave forcings contribute and the corresponding residual circulation contribute polar temperature anomaly as a consequence of the adiabatic warming. This provides the evidence of the different manifestation of gravity wave filtering processes during the different SSW types.