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Definition of Stratospheric Sudden Warming Events for Multi-Model Analysis and Its Application to the CMIP5

Junsu Kim (1), Seok-Woo Son (1), and Hyo-Seok Park (2)

(1) School of Earth and Environmental Sciences, Seoul National University, Seoul, South Korea, (2) Korea Institute of Geoscience and Mineral Resources, Daejeon, South Korea

The onset of major stratospheric sudden warming (SSW) events has been often defined as the date when the westerly at 10 hPa and 60°N turns to easterly during winter, corresponding to warmer polar stratosphere than mid latitudes. This simple definition effectively detects the observed characteristics of SSW, but its application to climate models, which have different background flow and temporal variability, is often challenging. For example, the model whose stratospheric mean wind is too weak tends to overestimate the frequency of zonal-wind reversal and SSW events.

In this study we propose a simple definition of major SSW events that is applicable to multi-model analysis. Specifically, SSW events are defined when the tendency of zonal-mean zonal wind at 10 hPa at 60°N crosses -1 m/s/day within 30 to 40 days while growing in magnitude. This tendency-based definition, which is independent of mean wind, is applied to both ERA40 reanalysis and CMIP5 models. The models are further grouped into the high-top models with a well-resolved stratosphere and low-top models with a relatively simple stratosphere.

A new definition successfully reproduces the mean frequency of SSW events that is identified by wind reversal approach, i.e. about 6 events per decade in ERA40. High-top models well capture this frequency. Although low-top models underestimate the frequency, in contrast to previous studies, the difference to high-top models is not statistically significant. Likewise, no significant difference is found in the downward coupling in the high-top and low-top models. These results indicate that model vertical resolution itself may not be a key factor in simulating SSW events and the associated downward coupling.