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Relationship among SSW, PJO and AO in an Idealized Stratosphere-Troposphere Coupled Model

S. Yoden (1), M. Kohma (1), and S. Nishizawa (2)

(1) Kyoto University, Graduate School of Science, Department of Geophysics, Kyoto, Japan (yoden@kugi.kyoto-u.ac.jp), (2) Kobe University, Department of Earth and Planetary Sciences, Kobe, 657-8501, Japan

Internal intraseasonal variability in the stratosphere-troposphere coupled system contains multiple time-scale variation from stratospheric sudden warming (SSW) to polar-night jet oscillation (PJO) and Arctic oscillation (AO) in the northern hemisphere winter. Relationship among SSW, PJO and AO is investigated with a 14,000-year dataset originally obtained by Nishizawa and Yoden (2005), who performed numerical time integrations of an idealized stratosphere-troposphere global circulation model with sinusoidal surface topography of zonal wavenumber one under a purely periodic annual forcing.

Deviation of the pole temperature at 2.6 hPa from the minimum value for each calendar day is analyzed to identify an SSW event with two threshold temperatures, following the analysis procedure introduced by Naito et al. (2003). Statistics of some characteristic values such as the maximum temperature during each SSW event and length of the event are calculated and their seasonal dependence is clarified.

As for PJOs, fundamentally the same analysis method as Kodera and Kuroda (2000) is adopted; an EOF analysis is done for the temperature field averaged in the polar region with multiple levels from the surface to the lower mesosphere, after applying a low-pass filter of 15 days for the deviation from the climatological seasonal march. Contributions of EOF1 and EOF2 are 73.8% and 20.5%, respectively. PJOs are identified in a normalized PC1-PC2 phase space, and their statistics are obtained to identify the seasonal dependence. AOs are also studied by a similar EOF analysis on the area-weighted zonal mean sea-level pressure in the northern hemisphere.

One of the novel aspects of the present study is the statistical significance of the analyzed results based on the long enough dataset. Seasonal dependence of the features of SSW, PJO and AO is clearly obtained. Another is the finding of statistically significant relationship among SSW, PJO and AO. Both SSW and PJO events are observed in over 8,000 years out of 14,000 years, and the relationship between SSW and PJO is classified into three groups; (1) an SSW event over 10 days before the maximum of PJO, (2) nearly the same timing of SSW and PJO, and (3) PJO without any precursor of SSW. Downward propagation of signals with time is largely different between the groups. Significant increase of the AO index is also obtained before the occurrence date of SSW events.

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