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## Numerical simulation of stratospheric sudden warming in January 2009 using NICAM and the reconsideration of gravity wave

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In this study, the major stratospheric sudden warming (SSW) occurred in January 2009 is simulated using the cloud-resolving non-hydrostatic global model NICAM with G-level 10 (7 km resolution). The results of the prediction are compared with the operational prediction by the Global Spectral Model (GSM) of the JMA with 20 km resolution. According to the results, the major warming was predicted well by NICAM, but the intensity was weaker than the observation and GSM. However, the deceleration of westerly of the polar night jet was stronger in NICAM than GSM. It is interesting to note that large amplitude gravity waves are superimposed in NICAM on the planetary waves of the wavenumber 2 type SSW. Those gravity waves are not seen in GSM and they have been parameterized as the gravity wave drags in the previous global models. We find by NICAM that the stratospheric circulation is filled by abundant gravity waves as inferred by previous observations.

Keywords: Stratospheric Sudden Warming, Cloud resolving GCM, NICAM, Gravity wave drag, Gravity waves, PSC