

Numerical experiments on the predictability of the stratosphere–troposphere coupling during sudden warming events

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Using operational 1-month ensemble forecast conducted by the Japan Meteorological Agency (JMA), Mukougawa et al. (2005: hereafter MSH05) examined the predictability of a stratospheric sudden warming (SSW) event occurring in the late December of 2001, and showed the existence of the high sensitivity to the initial condition for the forecast of the SSW during its onset period. They also found a tropospheric precursory event for the occurrence of the SSW by conducting a regression analysis based on the JMA 1-month ensemble forecast. The precursory event was characterized by the persistent blocking high over the Atlantic. In this study, we will re-examine the existence of the high sensitivity to the initial condition for the forecast of the SSW, the influence of the obtained tropospheric precursory event for the occurrence of the SSW, and also the influence of the stratospheric circulation change associated with the SSW to the tropospheric circulation by conducting a series of hindcast experiments using an atmospheric general circulation model (MRI/JMA-GCM) for the prediction of the SSW occurring in December 2001.

The model used in this study has a horizontal resolution of TL95 and 40 vertical levels with the model top boundary at 0.4 hPa. The hindcast experiment is performed from the initial condition obtained from the operational 1-month ensemble forecasts of the JMA, and reconfirm the existence of the high sensitivity for the forecast of the SSW during the onset period as in MSH05.

By conducting a regress analysis of the hindcast experiments of MRI/JMA-GCM starting from 5 and 6 December 2001 as in MSH05, the tropospheric precursory anomaly related to the occurrence of the SSW during its onset period (13 December) is obtained. The regressed pattern characterized by a positive height anomaly over the Atlantic is significantly related to the occurrence of the subsequent SSW after two weeks, in consistent with the result of MSH05.

Finally, we conduct a series of hindcast experiments starting from 13 December with several initial conditions composed of the predicted ensemble-mean field and the regressed field multiplied by some coefficients. The experiments confirm the dynamical relationship between the tropospheric regressed pattern and the subsequent occurrence of the SSW. Furthermore, it is revealed that the response of stratospheric circulation to the magnitude of the precursory anomaly is nonlinear, which suggests the existence of a threshold magnitude of the precursory anomaly for the occurrence of the SSW. Detailed investigation on the precursory event will enable us to reveal a dynamical relationship between tropospheric circulation anomaly and the subsequent SSW.