

Dynamics and Predictability of Downward Propagating Stratospheric Planetary Waves Observed in March 2007

Hitoshi MUKOUGAWA¹, Shunsuke NOGUCHI², Yuhji KURODA³, Ryo MIZUTA² and
Kunihiko KODERA⁴

¹ *Graduate School of Science, Kyoto University, Kyoto, Japan*

² *Meteorological Research Institute, JMA, Tsukuba, Japan*

³ *Meteorological Collage, JMA, Kashiwa, Japan*

⁴ *STEL, Nagoya University, Nagoya, Japan*

The predictability of a downward propagating event of planetary waves in the lower stratosphere observed in early March 2007 (Kodera et al. 2008) is examined by conducting ensemble forecasts using an AGCM. It is determined that the predictable period of this event is about 7 days. Regression analysis using all members of an ensemble forecast also reveals that the downward propagation is significantly related to an amplifying quasi-stationary planetary-scale anomaly with barotropic structure in polar regions of the upper stratosphere. Moreover, the anomaly is 90° out of phase with the ensemble mean field. Hence, the upper stratospheric anomaly determines the subsequent vertical propagating direction of incoming planetary waves from the troposphere by changing their vertical phase tilt, which depends on its polarity. Furthermore, the regressed anomaly is found to have similar horizontal structure to the pattern of greatest spread among members of the predicted upper-stratospheric height field, and the spread growth rate reaches a maximum prior to the occurrence of the downward propagation. Hence, we propose a working hypothesis that the regressed anomaly emerges due to the barotropic instability inherent to the upper stratospheric circulation.

In fact, the stability analysis for basic states comprised of the ensemble-mean forecasted upper-stratospheric streamfunction field using a non-divergent barotropic vorticity equation on a sphere supports our hypothesis. Thus, the barotropic instability inherent to the distorted polar vortex in the upper stratosphere forced by incoming planetary waves from the troposphere determines whether the planetary waves are eventually absorbed in the stratosphere or emitted downward into the troposphere.

Key words: planetary wave, downward propagation, predictability, instability, polar vortex

References

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