Predictability of Arctic Polar-night Jet Oscillation Events and Its Impact on the Forecast Skill of Tropospheric Circulation

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The predictability of the extratropical stratosphere and its impact on the forecast skill of tropospheric circulation in the Northern Hemisphere are examined in the framework of Polar-night Jet Oscillation (PJO). The PJO is the dominant low-frequency mode in the winter stratosphere characterized by the poleward and downward propagation of the zonal-mean zonal wind anomalies.

By using extended-range ensemble forecast datasets provided by the Japan Meteorological Agency, we have projected statistical properties of forecast results to a phase space spanned by two leading empirical orthogonal functions representing the PJO behavior. As a result, following characteristics of predictability variations during both anomalously weak and strong events of the stratospheric polar vortex (part of such events corresponds to sudden warmings and vortex intensifications) are obtained: (1) During prominent PJO conditions, regardless of weak or strong vortex events, the forecast skill of long-lasting anomalies in the lower stratosphere is significantly enhanced for forecasts starting after the onset of anomalous events. (2) The forecast skill not only in the lower stratosphere but also in the troposphere is improved after the setup of anomalous events. However, the reduction of tropospheric forecast error sometimes becomes obscure due to tropospheric internal variabilities, especially after strong vortex events. (3) In contrast to the same positive impact on the forecast skill in the lower atmosphere, the forecast uncertainty of the stratospheric condition shows different feature depending on the strength of the stratospheric polar vortex: During weak vortex events, the temporal evolution of the ensemble spread changes drastically from the exponential growth (saturates at high level) to the linear one (remains small) associated with the breakdown of the polar vortex. On the other hand, during strong vortex events, forecasts show large uncertainty throughout the event, because the westerly wind condition in several members of ensemble forecast permits intermittent upward propagation of planetary waves although the time-averaged flux from the troposphere is anomalously low.

Thus, this study provides comprehensive knowledge for the impact and uncertainty of stratosphere-troposphere coupling in a state-of-the-art ensemble prediction system. Our results and methodologies would also be particularly useful for real-time monitoring of sub-seasonal to seasonal forecasts.

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