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Predictability of Northern winter stratospheric conditions using JMA one-month ensemble predictions for 2001/02-2009/10

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It has been widely accepted that the troposphere and stratosphere are dynamically coupled especially in the Northern Hemisphere during its winter. There is increasing interest in applying the dynamical coupling to predictability of tropospheric and stratospheric variations.

This study investigates predictability of Northern winter stratospheric conditions for 9 winters of 2001/02 to 2009/10. One-month ensemble predictions by JMA (Japan Meteorological Agency) are compared to JMA objective analysis data. The polar stratosphere is dynamically active for each mid-winter of this period, except for 2004/05, including occurrence of stratospheric sudden warmings (SSWs).

A survey comparison using daily temperatures at the North Pole, 10 hPa of all ensemble members vividly illustrates that the character of the predictions, as seen in PDFs of differences from the analyses, varies on intraseasonal and interannual scales. Such variations are apparent, for example, in looking at two SSW events occurring in January of 2008 and 2009 (Fig. 1). The ensemble forecasts relatively well capture the occurrence of the former SSW case with a lead time of about two weeks (Fig. 1a). On the other hand, the onset of the latter case is unpredictable by the majority of the forecasts with a two-week lead time (Fig. 1b).

A systematic assessment of the predictability is made using root mean square error of weekly-mean polar temperatures. Results show that the predictability is quite different according to the signs of anomalies of the analysis temperatures. When the anomalies are positive, i.e., the polar stratosphere is warmer than normal, the predictions tend to be much lower than the analyses. For the negative anomalies, the predictions are either higher or lower, with smaller errors in magnitude. Such asymmetry is a vital feature of stratospheric predictability reflecting the occurrence of SSWs, or displacement or splitting events of the polar vortex. In contrast, tropospheric predictability is symmetric about the signs of 500-hPa polar temperatures: the error becomes similarly large with increasing temperature anomalies with either sign.

Interannual variability of the predictability is also found by comparing weeks when the analysis temperature anomalies are highest or lowest in each year. In particular, the warmest weeks in 2008/09 and 2002/03, which are closely related to the occurrence of SSWs, are the most difficult cases to predict (See Fig. 1b). The case-to-case variability is most notable for the lead time of 2 and 3 weeks. Such variability is smaller for the coldest conditions. Dynamical origins for such variations of the predictability will be studied with wave activity driving the stratospheric circulation.

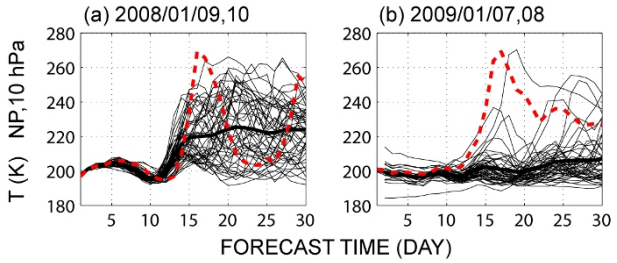

Figure 1: Daily time series of temperature at NP, 10 hPa: red boken line is for GANAL, and thin black lines for ensemble forecasts. Thick black lines denote the ensemble means. Panal (a) is for initial dates of January 9 and 10 of 2008, and (b) for those of January 7 and 8 of 2009.

Keywords: predictability, stratospheric circulation, sudden warming, one-month ensemble prediction