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The variability of the Eurasian pattern and the Siberian High

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Introduction

So-called ‘teleconnections’ have been at the center of attention with respect to their mechanism, their impacts on climate and their predictability. The Eurasian pattern (hereafter the EU pattern), one of the well-known teleconnection patterns in boreal winter, has a wave-train like structure in the geopotential height field across Eurasian Continent (Wallace and Gutzler (1981)). Recent study pointed out that the circulation anomalies associated with the EU pattern could influence the development of the Siberian High, which is one of the dominant factors of Asian winter monsoon.

In this study, we focused on the impact of the EU pattern on the climate in eastern Asia and discussed about the predictability of the climate variability associated with the EU pattern.

Data and analysis methods

Datasets used in this study are the reanalysis dataset and the hindcast one. The reanalysis dataset was based on JRA-25 and JCDAS, from 1979 to 2006 (for more detail about JRA-25, please refer to Onogi et. al (2007)). The hindcast dataset was provided from the hindcast experiments of the JMA’s monthly forecast model (data range is from 1980 to 2005). The model has T_L159 spectral resolution and 60 vertical levels. A 5-member ensemble hindcast experiment was carried out and hindcast runs were initiated from the end of December. We used the results of each run in the experiment, from 1 to 31 January.

At first, we operated an empirical orthogonal function (EOF) analysis to the monthly-mean geopotential height field at 300 hPa level over Eurasian Continent (20N-75N, 20W-160E) in January. Fig. 1 shows the result of the EOF analysis in the reanalysis dataset. From this result, we defined the time series of the first principal component as the index of the EU pattern. And then, we made regression maps between this index and various atmospheric parameters to investigate the circulation anomalies. The same analysis was operated every run of the hindcast experiment and we compared these results.

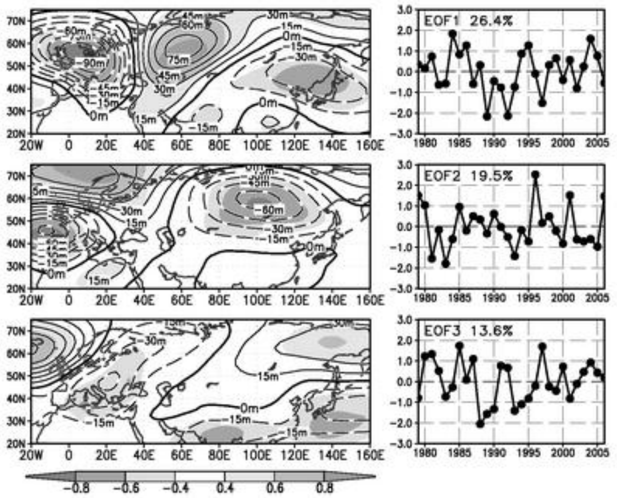

Fig. 1
(left) Distributions of the leading EOFs in the 300 hPa monthly mean geopotential height field in January and (right) their scores. Contours indicate the height anomalies in each EOFs and shadings indicate the correlation coefficients between height anomalies on each grid points and scores of the EOFs.

Characteristics of the Eurasian pattern

The positive phase of the EU pattern is characterized by negative height anomalies in Europe and around Japan, and positive ones in western Siberia (Fig. 1). In winter when the EU pattern is positive, the Siberian High tends to be stronger than its normal and it likes to be severer winter in eastern Asia. Seeing the vertical cross section of circulation anomalies along the wave-train, we can notice the baroclinicity of circulation anomalies in lower troposphere in central Siberia (Fig. 2). This baroclinicity is pointed out as one of the essential factors for the development of the Siberian High in mid-winter (Takaya and Nakamura (2005)). These characteristics are recaptured very well in the hindcast experiment. This indicates that the behavior of the JMA's operational model is reasonable with respect to the variability of the extratropical atmosphere.

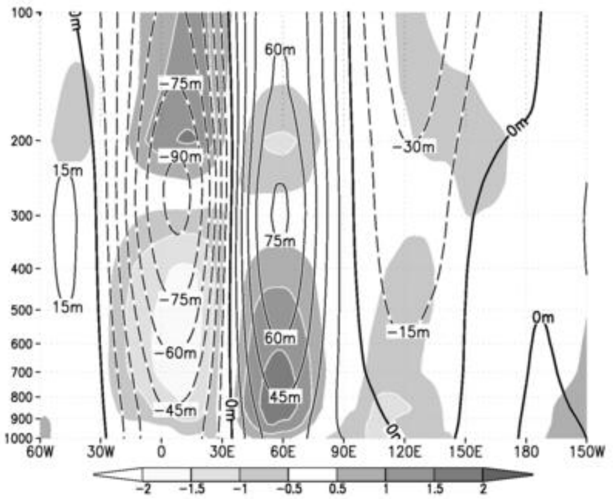

Fig. 2
Vertical cross section of the geopotential height (contours) and air temperature anomalies (shadings) associated with the EU pattern in reanalysis dataset. Anomalies are averaged from 50N to 60N.

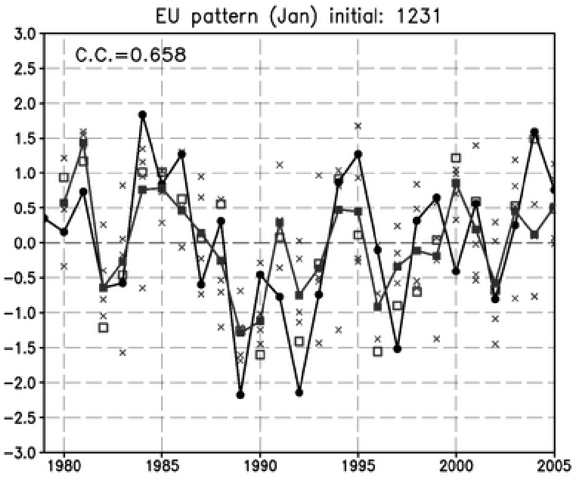

Fig. 3
Time series of observed and predicted scores of the EU pattern in January.
Line with closed circles shows the observed score of the EU pattern. Open squares show the score of the control run and cross marks indicate the scores in other hindcast runs. The line with closed squares indicates the 5-member mean score. The scores in the hindcast experiment were derived from the projection of the 300-hPa geopotential height anomalies onto the observed height anomalies in association with the EU pattern. The correlation coefficient between observed score and hindcast score (5-member mean) is 0.658.

Prediction of the EU pattern in JMA's monthly forecast model

The hindcast runs initiated from the end of December could predict the EU pattern in the following January relatively well. Fig. 3 shows the score of the EU pattern in analysis and each run of the hindcast experiment. However, the reproducibility of the EU pattern decreases in case of the hindcast run initiated from 21 December. From this result, the longer lead time in forecast, the more difficulty there will be in the prediction of the EU pattern. Taking the developing process of the EU pattern into account, this may result from the difficulty in the realistic formations of the Blocking systems in the northern Atlantic in our forecast model.

References

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