The variability of the Eurasian pattern and the Siberian High

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Outline of this presentation

- Introduction
- Data and methods
- Results
  - EU pattern in reanalysis data
  - EU pattern in hindcast experiment
  - Reproducibility and Predictability
- Summary and Discussion
Introduction

- Seasonal and sub-seasonal variability
  - Seasonal variability
    - Arctic Oscillation or circulation anomalies associated with ENSO
    - Target of the *seasonal* forecast
  - Sub-seasonal variability
    - Teleconnections or internal variation in the mid- and high latitudes
    - Target of the *monthly* forecast
Introduction

- From previous studies...
  - Wallace and Gutzler (1981)
    - Various teleconnection patterns in the boreal winter were summarized.
  - Takaya and Nakamura (2005)
    - Positive EU pattern circulation anomalies can reinforce the Siberian High.

- Focus of this presentation
  - the overview of the EU pattern
  - the reproducibility and predictability of the EU pattern in the JMA’s monthly forecast model
Data and methods

- **Reanalysis data**
  - **JRA-25** (from 1979 to 2004) and **JCDAS** (2005, 2006)
  - "climatological means" were calculated for the period from 1979 to 2004.

- **Hindcast experiment data**
  - **Model**
    - Operational monthly forecast model
    - $T_L^{159L60}$ (about 1.125° Gaussian grid ~110km)
  - **Experimental design**
    - 5-member ensemble hindcast (**control run** was mainly used in analysis)
    - Initiated from **the end of December** (from 1979 to 2004)
    - Results in the period **from 1 to 31 January** were used.
Data and methods

- **EOF analysis**
  - To extract the dominant modes in the boreal winter
  - EOF analysis was operated January mean $Z_{300hPa}$ over Eurasian Continent ($20^\circ N$-$75^\circ N$, $20^\circ W$-$160^\circ E$)

- **Regression map**
  - Regress the EU pattern index (based on the EOF analysis) onto atmospheric variables

  *The long-term linear trend in each datum was removed before analysis.*
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The EU pattern was extracted as a first dominant mode. We define PC1 time series as an "EU pattern index."

Contour: distribution of EOFs
Shades: correlation coefficients between $Z_{300\text{hPa}}$ and PCs
EU pattern in reanalysis data

Contour: regression coefficients with EU pattern index
Shades: correlation coefficients with EU pattern index

There is no significant and large SST anomaly coherent with the EU pattern index. The EU pattern can be regarded as an internal variation in extratropical atmosphere.
EU pattern in reanalysis data

- Contour: regression coefficients with EU pattern index
- Shades: correlation coefficients with EU pattern index

$Z_{300\text{hPa}}$-EU index

SLP-EU index

Enhanced Siberian High in the **lower** troposphere

Wave train-like anomalies in the **upper** troposphere
EU pattern in reanalysis data

- T2m-EU index: Low temperature anomalies near the surface from central Siberia to around Japan
- SLP-EU index: Enhanced Siberian High in the lower troposphere

Coefficient with EU pattern index
EU pattern in reanalysis data

Contour: regression coefficients between Z and EU pattern index (m)
Shades: regression coefficients between T and EU pattern index (K)

Z&T-EU index cross section along 50-60N

Equivalent barotropic wave train in the **upper** troposphere

Baroclinic structure over central and western Siberia in the **lower** troposphere
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EU pattern in hindcast experiment

The EU pattern was also extracted as a first dominant mode in 4 of 5 runs in the hindcast experiment.
EU pattern in hindcast experiment

Observed EU pattern

Contour: regression coefficients with EU pattern index
Shades: correlation coefficients with EU pattern index

Circulation anomalies associated with EU pattern resembled those in reanalysis data.

Contour: regression coefficients with EU pattern index
Shades: correlation coefficients with EU pattern index
EU pattern in hindcast experiment

Cold anomalies from Siberia to around Japan were more apparent than those in reanalysis data.

Contour: regression coefficients with EU pattern index
Shades: correlation coefficients with EU pattern index
EU pattern in hindcast experiment

Baroclinic structure over central Siberia was well reproduced.

Contour: regression coefficients between Z and EU pattern index (m)
Shades: regression coefficients between T and EU pattern index (K)
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Reproducibility of the EU pattern

Hindcast EU pattern

Z_{300hPa}-EU index

SLP-EU index

T2m-EU index

Z&T-EU index cross section along 50-60N

Observed EU pattern

Z_{300hPa}-EU index

SLP-EU index

T2m-EU index

Z&T-EU index cross section along 50-60N

The EU pattern in hindcast experiment was reproduced well. This indicates that internal variations in JMA’s monthly forecast model are quite reasonable.
Reproducibility of the EU pattern

The baroclinic structure over Siberia plays a key role in the development of the Siberian High.

Cold air advection is induced over eastern Siberia.

Hoskins et. al. (1985)

Takaya and Nakamura (2005)
Reproducibility of the EU pattern

Planetary vorticity advection from lower latitude enhances the upper ridge of EU pattern.

Cold temperature anomaly near the surface induces the anticyclonic circulation anomaly.

Hoskins et al. (1985)

Takaya and Nakamura (2005)
Reproducibility of the EU pattern

The baroclinic structure over central Siberia plays a key role in the development of the Siberian High. JMA's monthly forecast model can reproduce this process well.

upper ridge associated with EU pattern

Coupling between upper and lower circulation anomalies

enhanced Siberian High

Takaya and Nakamura (2005)
Predictability of the EU pattern

Project $Z_{300\text{hPa}}$ anomalies in the hindcast experiment onto the observed EU pattern

the “scores” of EU pattern in each run were available and compared with that of the observed EU pattern score.

From the comparison of the, interannual variation, the hindcast runs could predict the EU pattern relatively well.

Black line: EU pattern index in reanalysis data
Blue marks: score of EU pattern of each hindcast run
(open squares indicate the score of control run)
Purple line: 5-member mean scores of hindcast experiment
Predictability of the EU pattern

Black line: EU pattern index in reanalysis data.
Blue marks: score of EU pattern of each hindcast run.
Purple line: 5-member mean scores of hindcast experiment.
(open squares indicate the score of control run)

The predictability of the EU pattern seems to decrease with the increase in the lead time.
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Summary

- EU pattern circulation anomalies influence the Asian winter monsoon through the variation of the Siberian High.

- From hindcast experiment for January…
  - High reproducibility of the EU pattern
  - Relatively high predictability in case without lead time (31 Dec. initial)
  - Predictability of the EU pattern seems to decrease with lead time (20 Dec. initial)
Discussion

- **Influence on the southeastern Asian monsoon**
  - Severe cold surges were sometimes corresponding to the development of the Siberian High or anticyclones over southern China.

- **Possible cause of the decrease of predictability**
  - The origins of the EU pattern were troughs or blocking systems developed through a non-linear process.
  - Forecast model fails to form them without precursors.

- **From perspective of the seasonal forecast**
  - EU pattern can be regarded as a noise for the seasonal forecast.
  - However, the frequency of intraseasonal variations is thought to be influenced by seasonal scale variation of atmosphere or SST.
  - **Possibility of the “frequency forecast” of cold surges is suggested.**
References


The long-term trend can be decomposed into several modes.

Orthogonality and separations between modes can be spoiled.
About EOF analysis and SVD analysis

- **EOF analysis**: To extract the spatial/time structure of the most dominant variation in one variable field.

- **SVD analysis**: To extract spatial/time structures of the most correlated variation in two variable fields.
Percentage of the variance explained by EOFs

Monthly forecast model

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Seasonal forecast model

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Dominant mode in hindcast experiment

Initial: 31Dec

Initial: 20Dec
Cold air advection induced by an upper circulation anomalies

**Reanalysis**

**Hindcast (Initial: 31 Dec.)**

Contours: Climatological mean of 1000 hPa air temperature
Vectors: 1000 hPa anomalous wind induced by the anticyclonic circulation in association with the EU pattern at 300 hPa
Shade: temperature advection at 1000 hPa level with the induced wind (K/month).