The variability of the Eurasian pattern and the Siberian High

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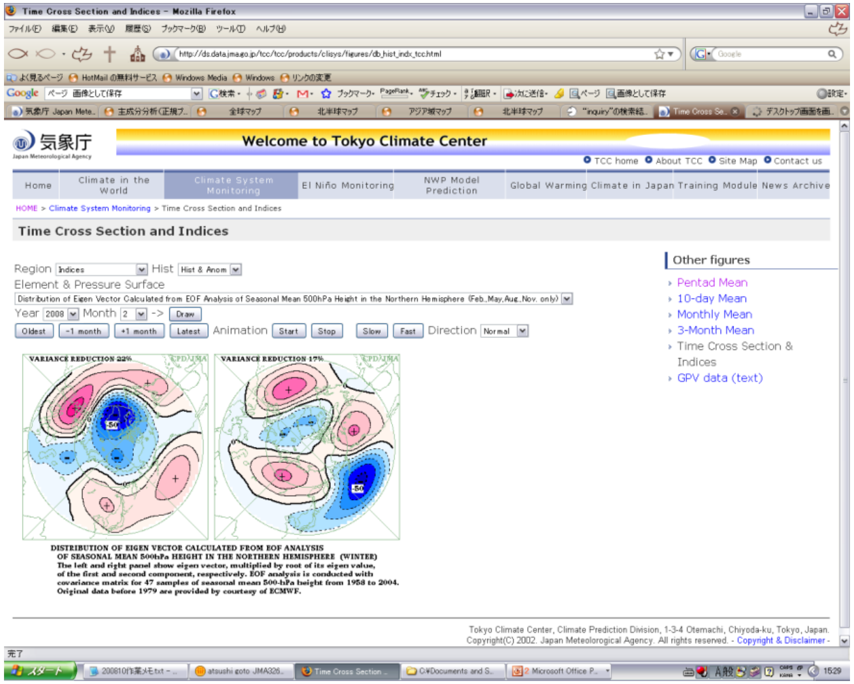
Outline of this presentation

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

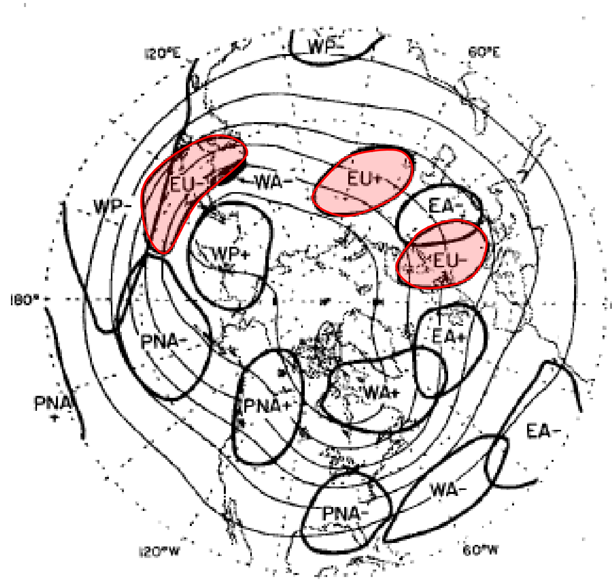
Introduction

- 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

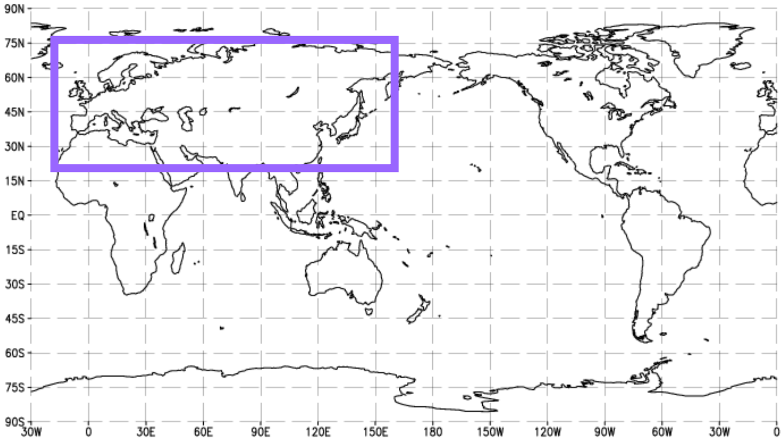
Data and methods

- 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_L159L60 (about 1.125° Gaussian grid ~110km)**
  - Experimental design
    - **5-member** ensemble hindcast (**<u>control run</u>** 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 $\mathbf{Z_{300hPa}}$ over Eurasian Continent (**20°N-75°N, 20°W-160°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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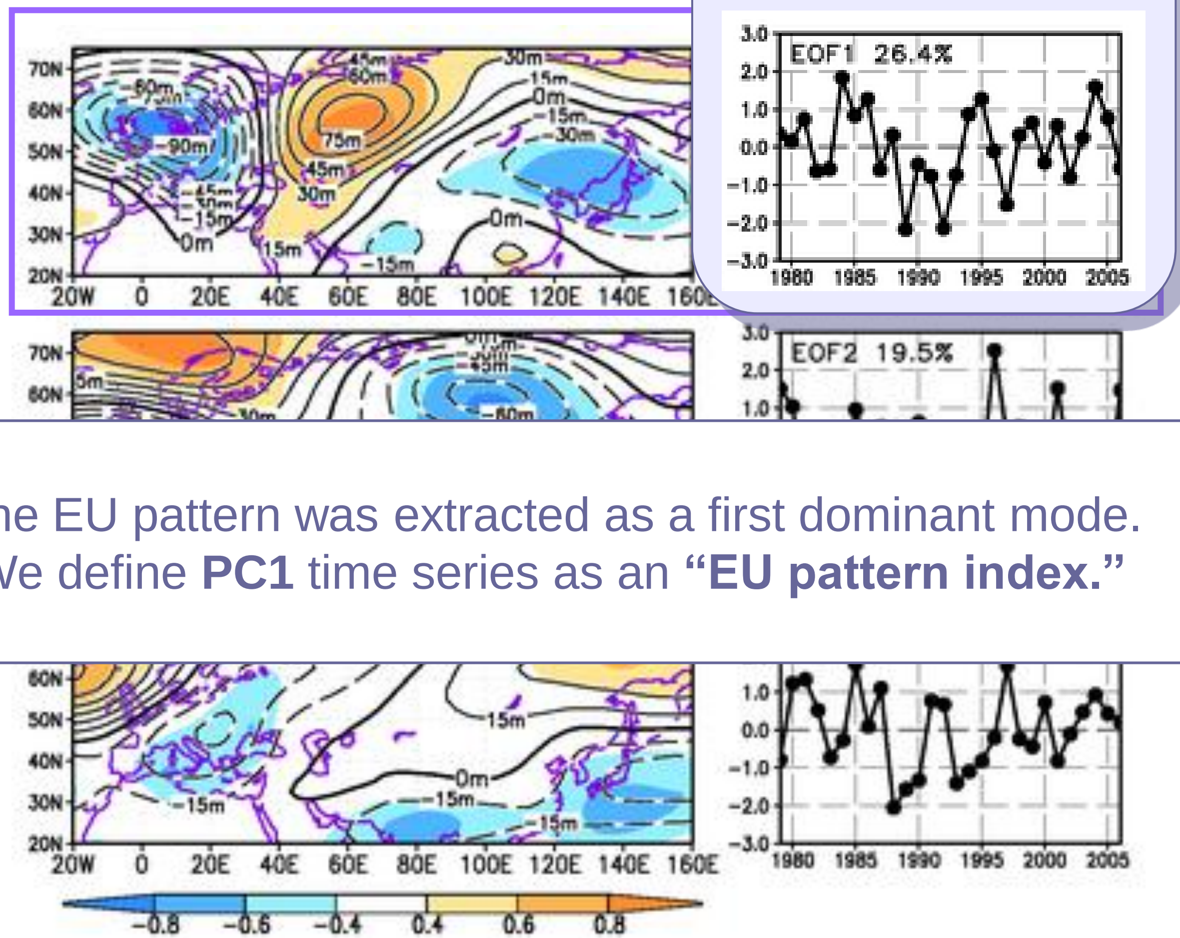
EU pattern in reanalysis data

EU pattern index

EOF1
26.4%

E
1

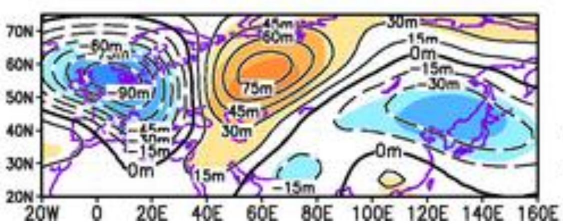
EOF3
13.6%

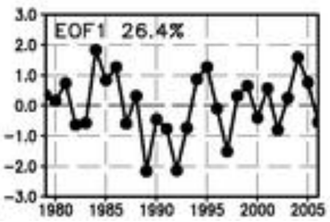


The EU pattern was extracted as a first dominant mode.
We define **PC1** time series as an **"EU pattern index."**

Contour: distribution of EOFs
Shades: correlation coefficients between Z_{300hPa} and PCs

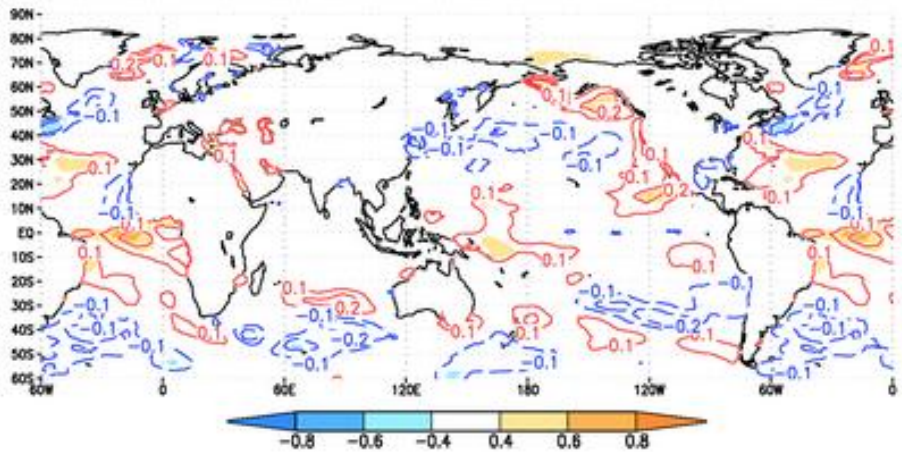
EU pattern in reanalysis data



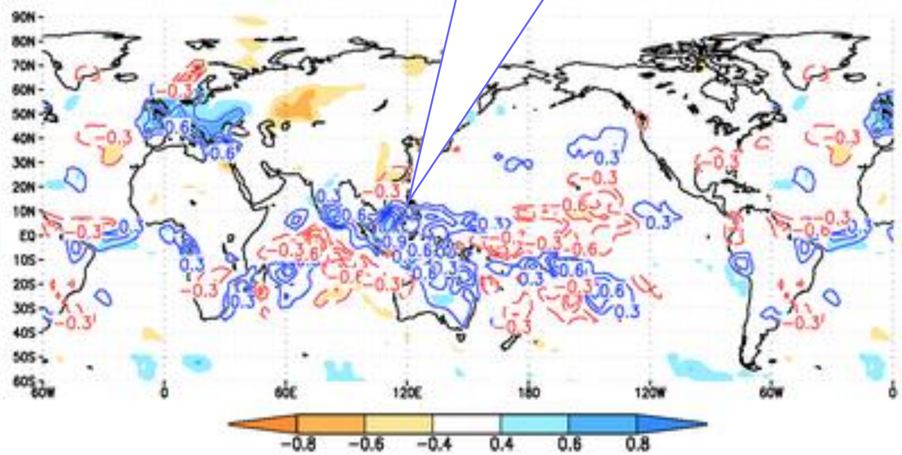


Impact on the rainfall around South China Sea?

SST-EU index



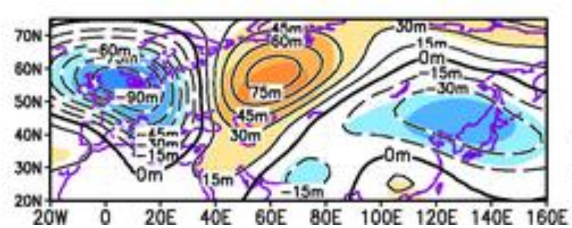
precipitation-EU in

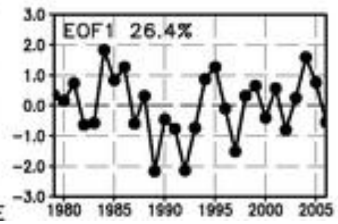


Contour: regression coefficients with EU pattern index
Shades: correlation coefficients with EU pattern index

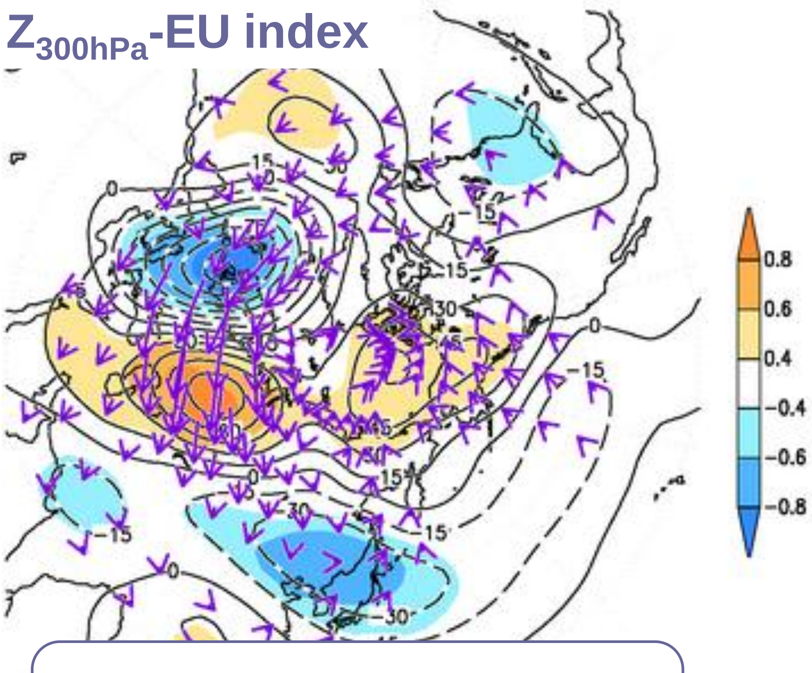
There is **<u>no significant and large SST anomaly</u>** coherent with the EU pattern index.
The EU pattern can be regarded as an <u>internal variation</u> in extratropical atmosphere.

EU pattern in reanalysis data

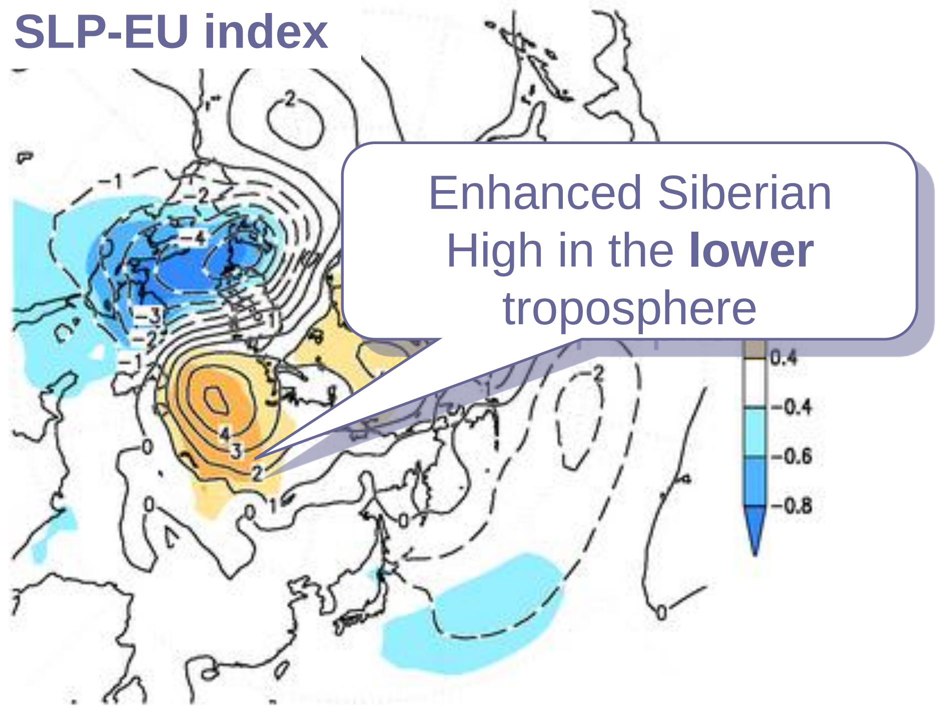




Z$_{300hPa}$-EU index



SLP-EU index



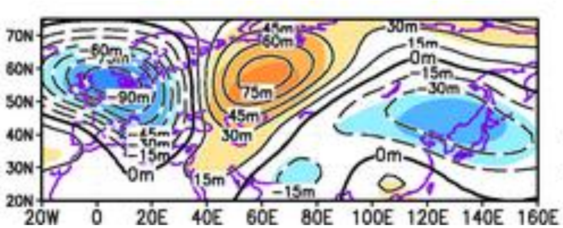
Enhanced Siberian High in the **lower** troposphere

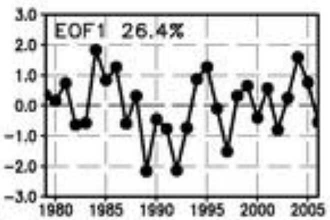
Wave train-like anomalies in the **upper** troposphere

...coefficients with EU pattern index

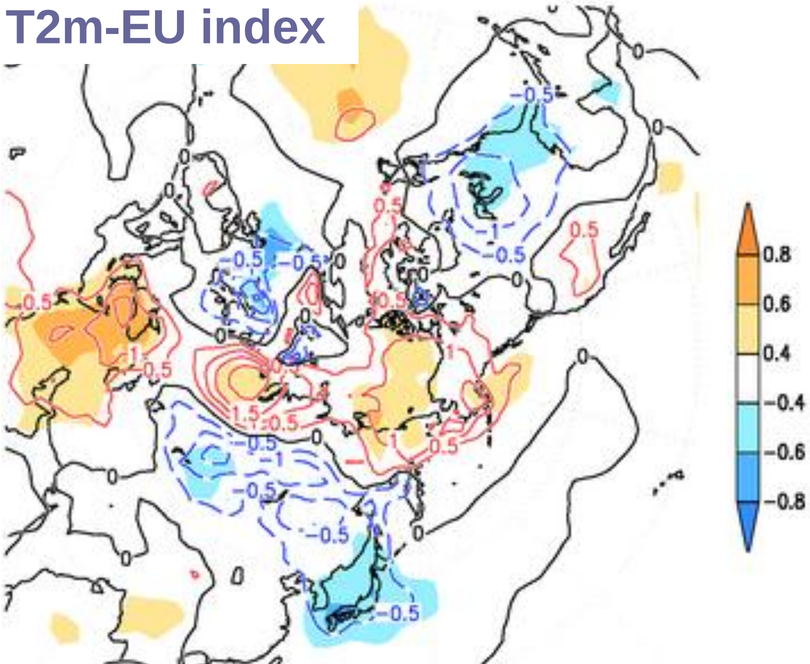
Shades: correlation coefficients with EU pattern index

EU pattern in reanalysis data

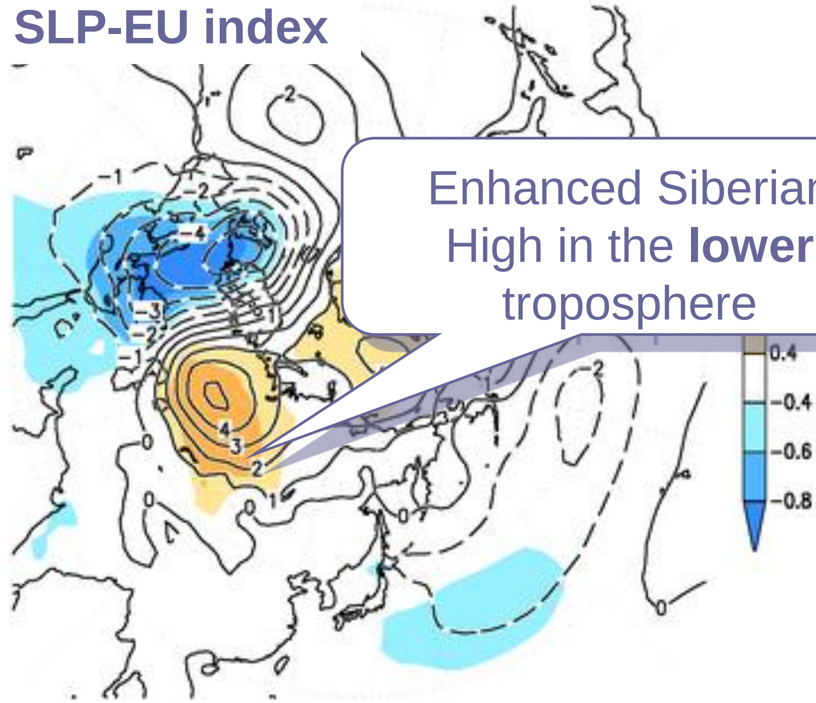




T2m-EU index



SLP-EU index



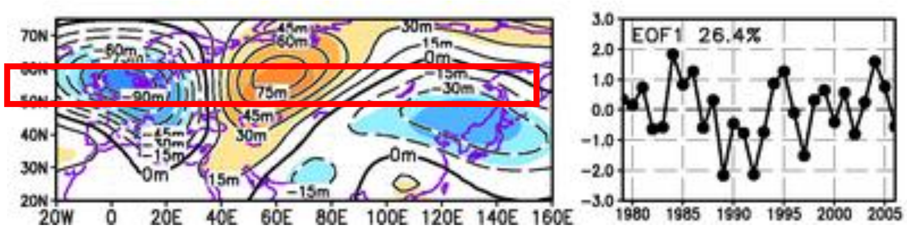
Enhanced Siberian High in the **lower** troposphere

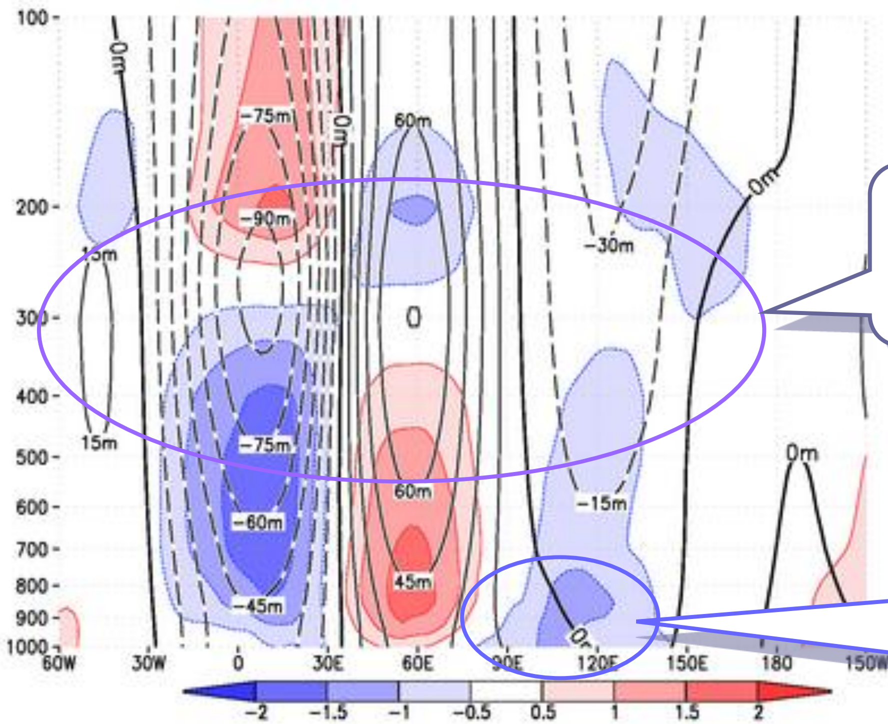
Low temperature anomalies near the surface from central Siberia to around Japan

efficients with EU pattern index

efficients with EU pattern index

EU pattern in reanalysis data





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

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

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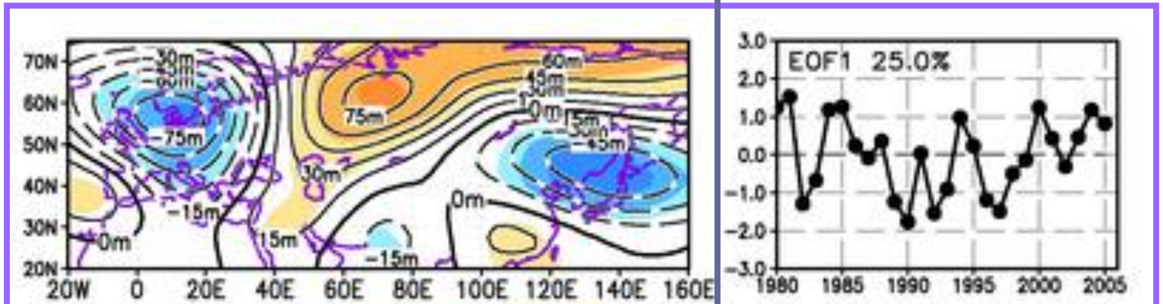
EU pattern in hindcast experiment

EU pattern index

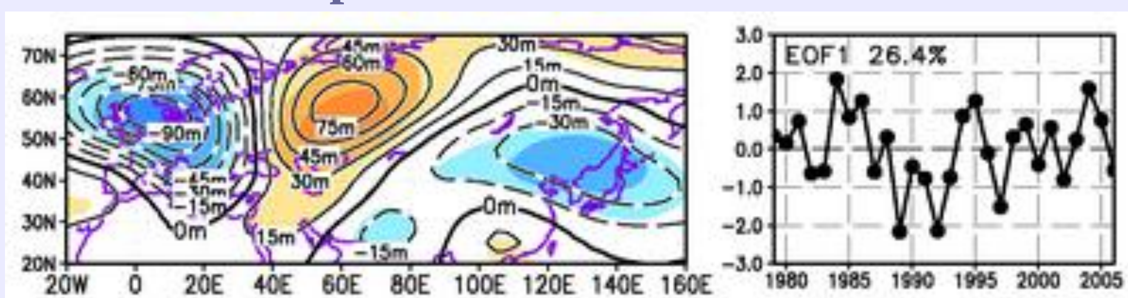
EOF1
25.0%



EO
20.5

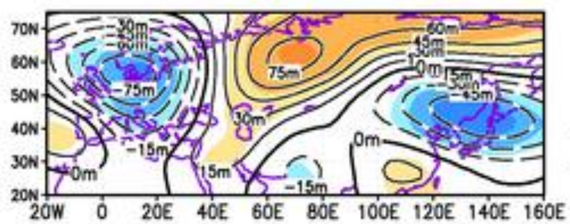
EOF
16.2%

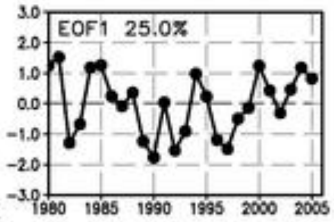
Observed EU pattern



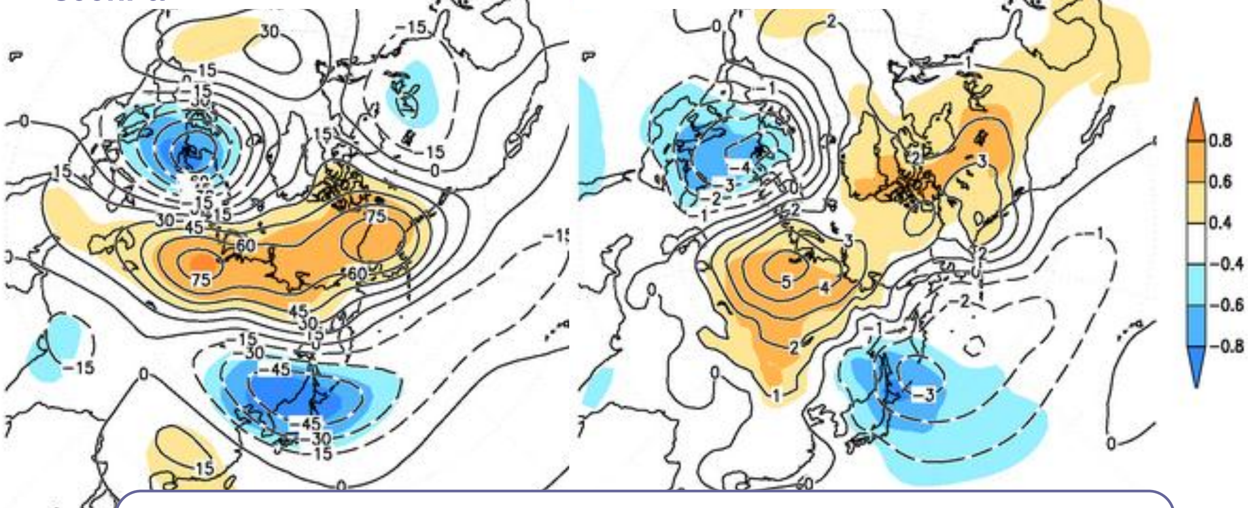
The EU pattern was also extracted as a first dominant mode in 4 of 5 runs in the hindcast experiment.

EU pattern in hindcast experiment





Z$_{300hPa}$-EU index **SLP-EU index**

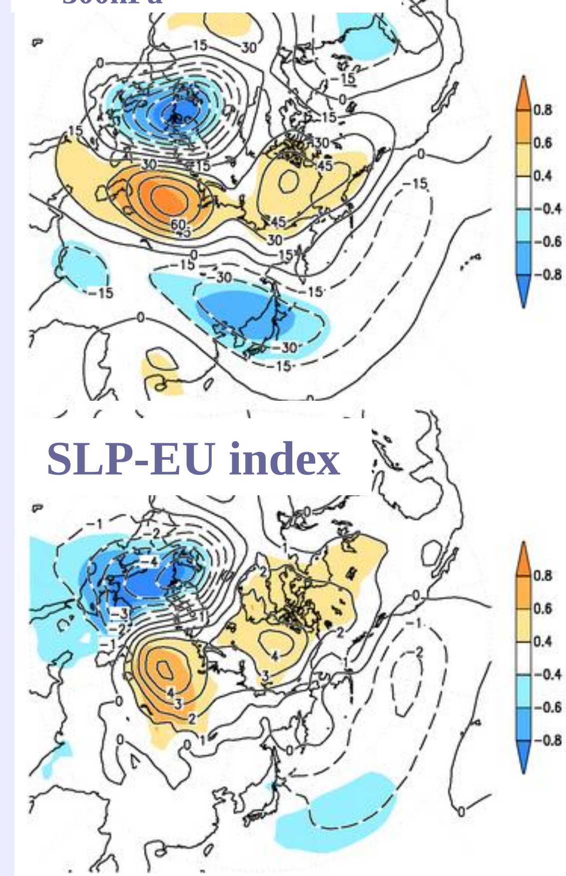


Circulation anomalies associated with EU pattern resembled those in reanalysis data.

Observed EU pattern

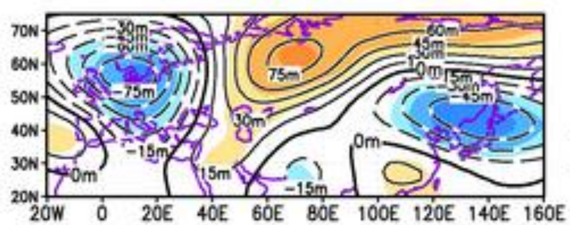
Z$_{300hPa}$-EU index

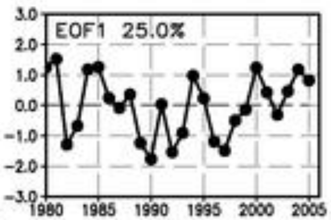
SLP-EU index



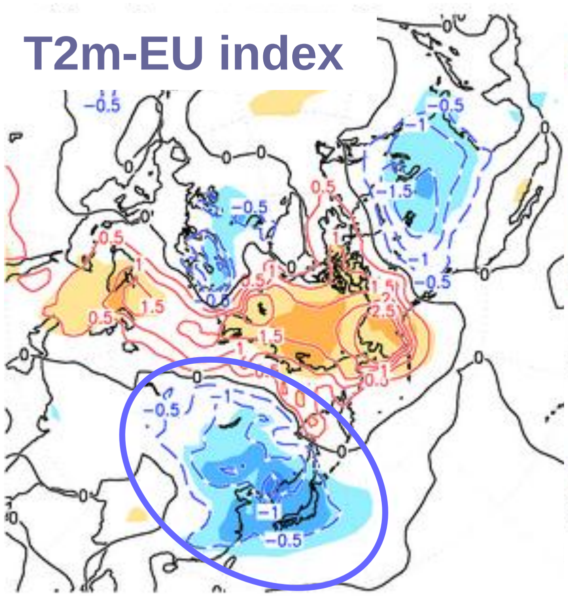
Contour: regression coefficients with EU pattern index
Shades: correlation coefficients with EU pattern index

EU pattern in hindcast experiment

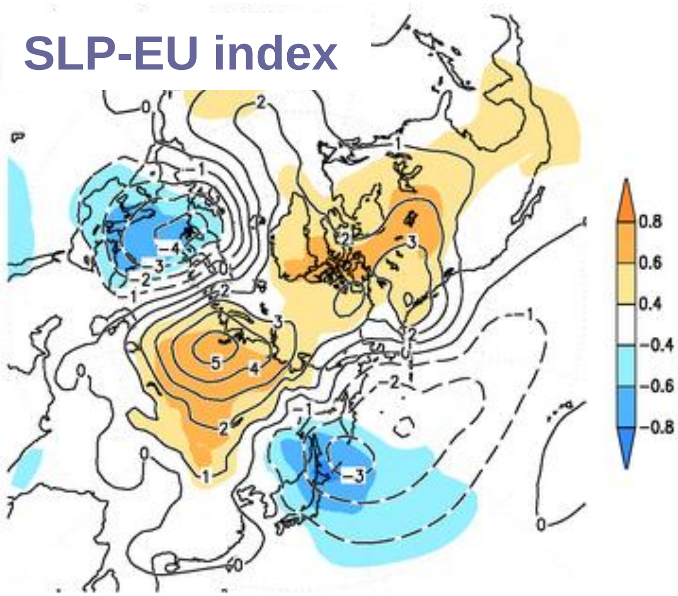




T2m-EU index

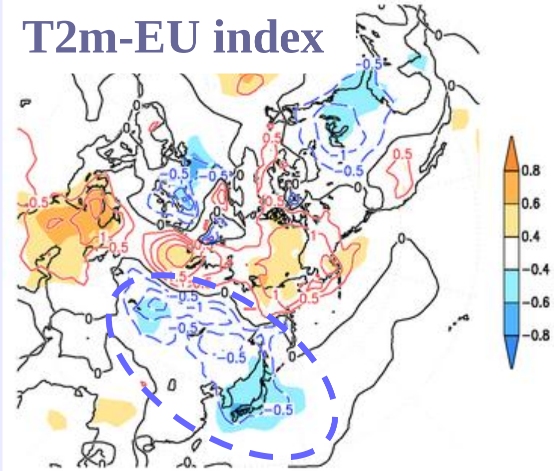


SLP-EU index



Observed EU pattern

T2m-EU index

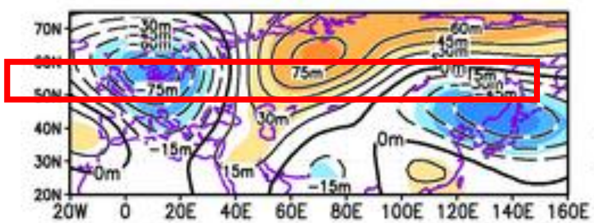


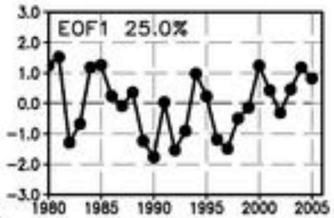
Cold anomalies from Siberia to around Japan were more apparent than those in reanalysis data.

Contour: regression coefficients with EU pattern index

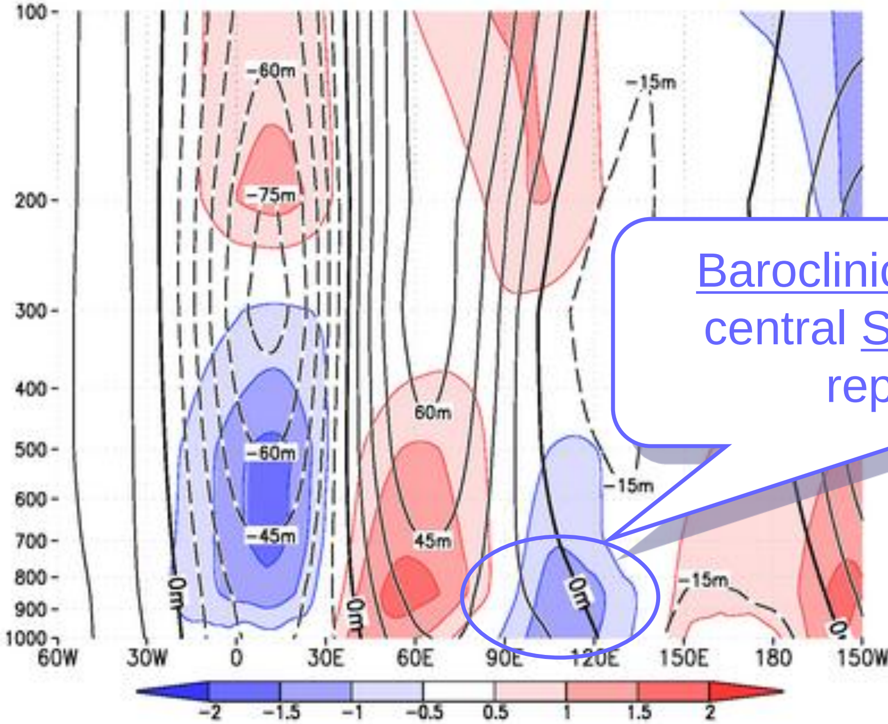
Shades: correlation coefficients with EU pattern index

EU pattern in hindcast experiment



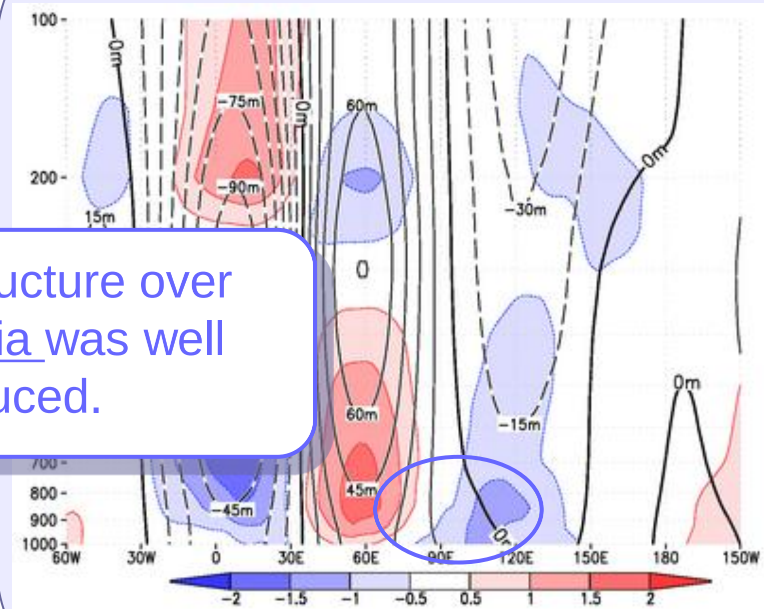


Z&T-EU index cross section along 50-60N



Baroclinic structure over central Siberia was well reproduced.

Observed EU pattern



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

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

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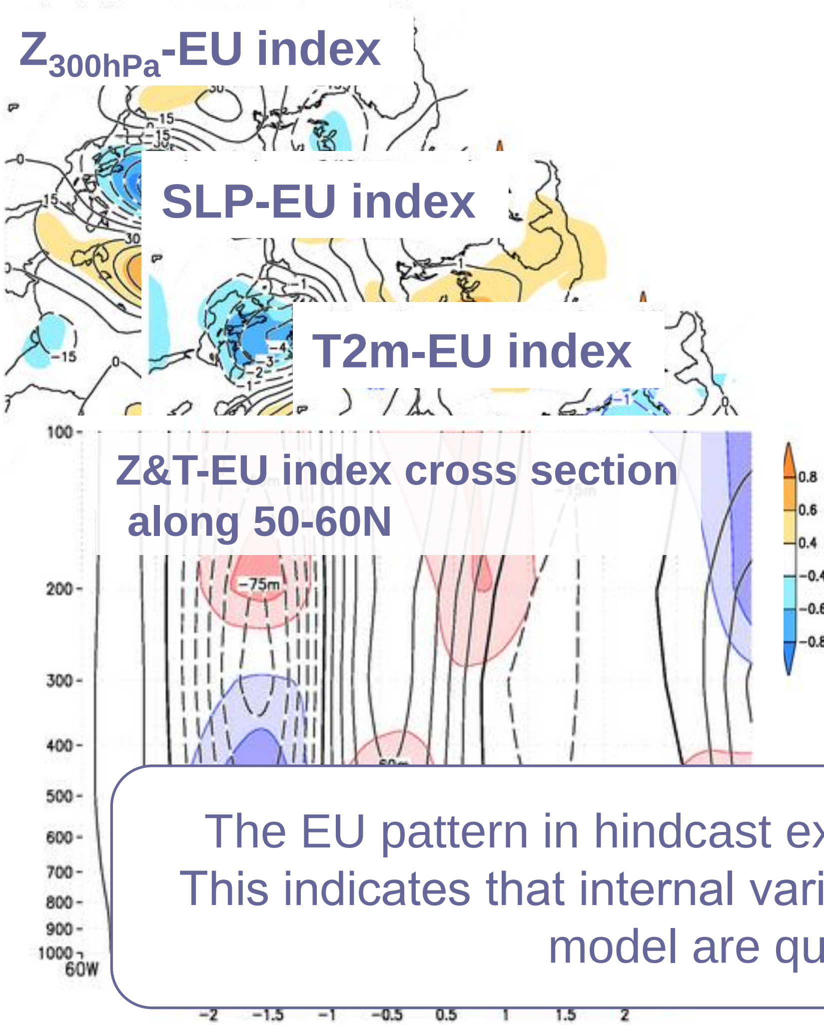
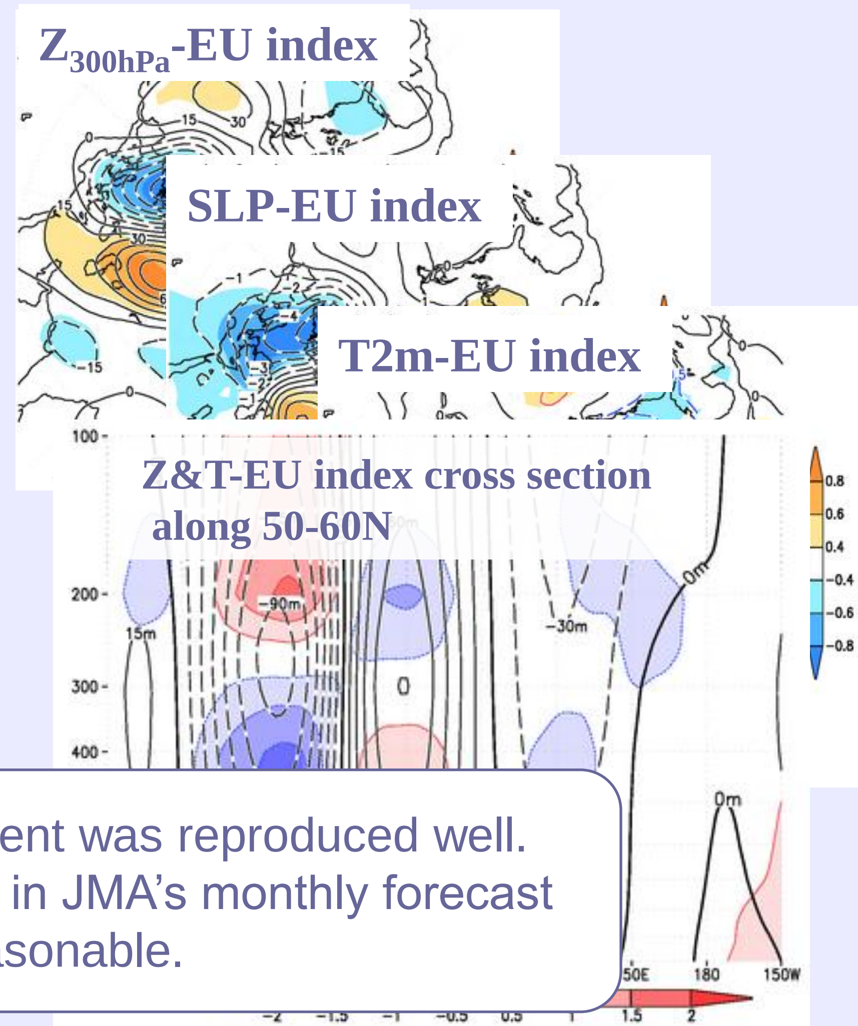
Reproducibility of the EU pattern

Hindcast EU pattern



Observed EU pattern

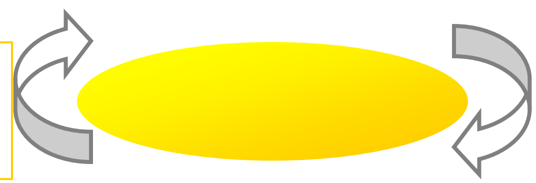


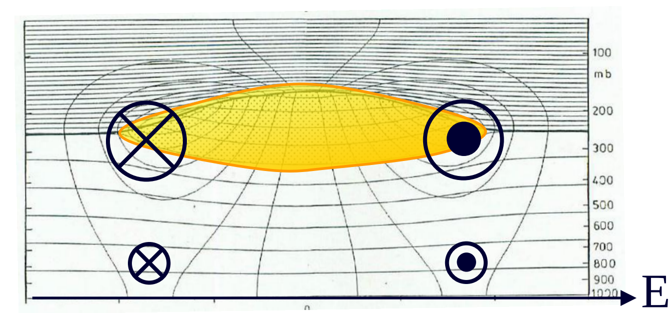
The EU pattern in hindcast experiment was reproduced well.
This indicates that internal variations in JMA's monthly forecast model are quite reasonable.

Reproducibility of the EU pattern

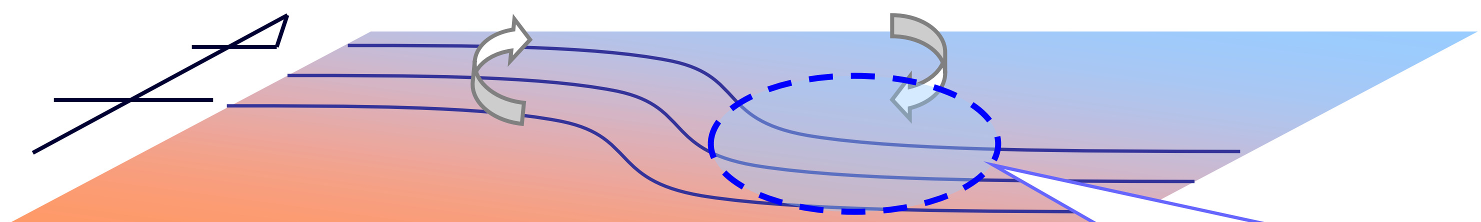
The baroclinic structure over Siberia plays a key role in the development of the Siberian High.

upper ridge associated with EU pattern





Hoskins et. al. (1985)



eastern Siberia

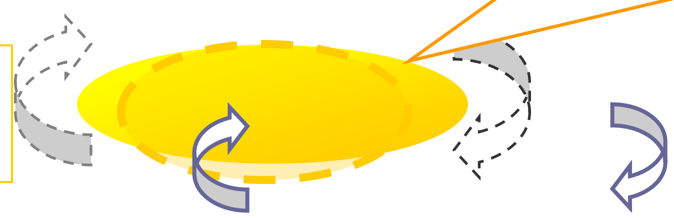
Cold air advection is induced over eastern Siberia.

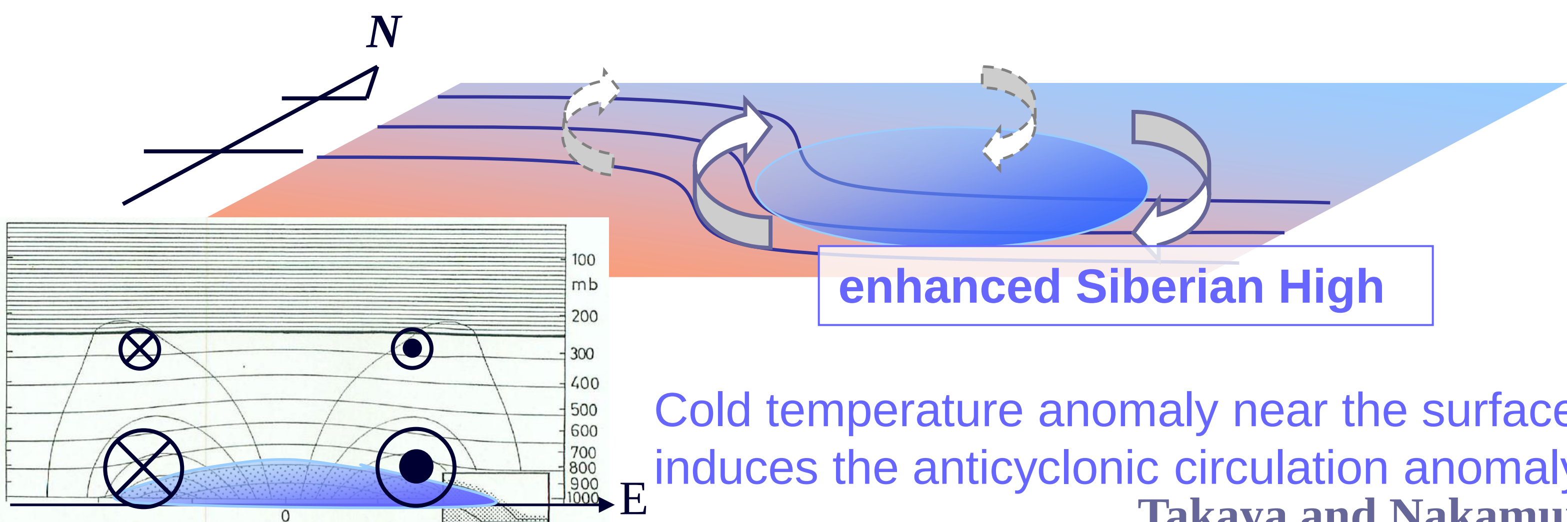
Takaya and Nakamura (2005)

Reproducibility of the EU pattern

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

upper ridge associated with EU pattern





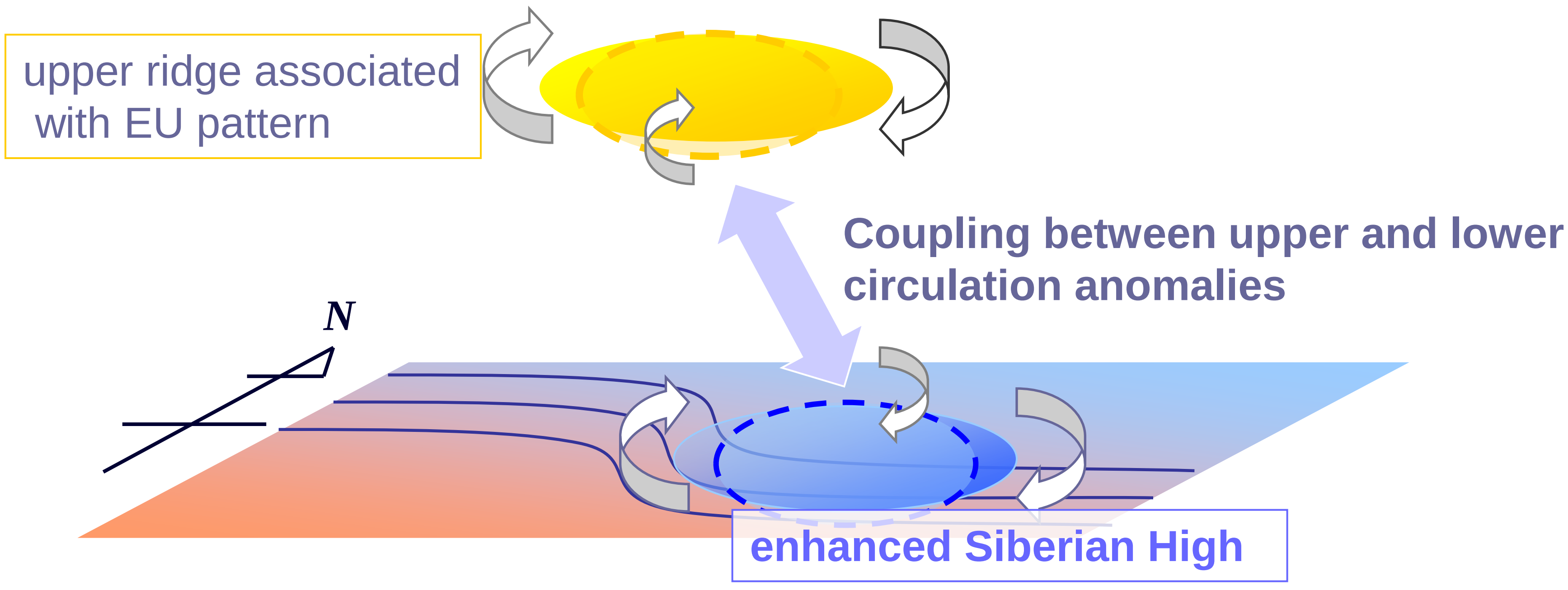
Hoskins et. al. (1985)

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

Takaya and Nakamura (2005)

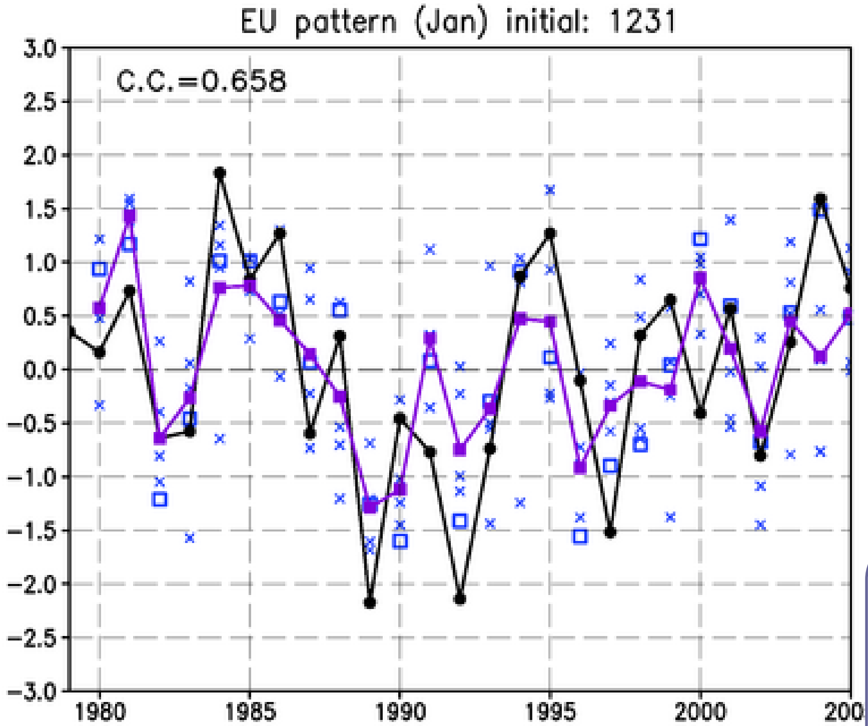
Reproducibility of the EU pattern

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.

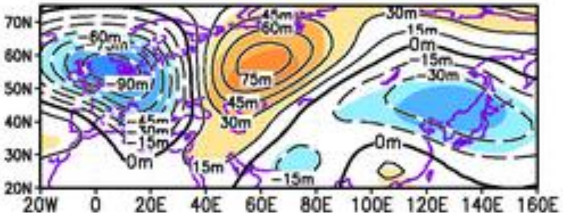


Takaya and Nakamura (2005)

Predictability of the EU pattern



Project Z_{300hPa} 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.**

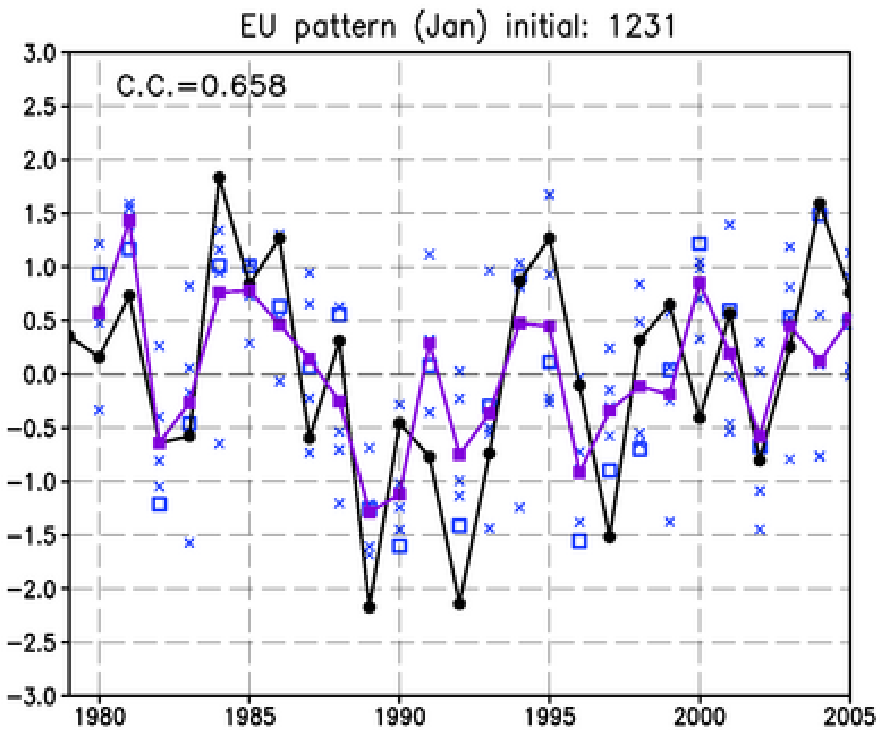
Black line: EU pattern index in reanalysis data

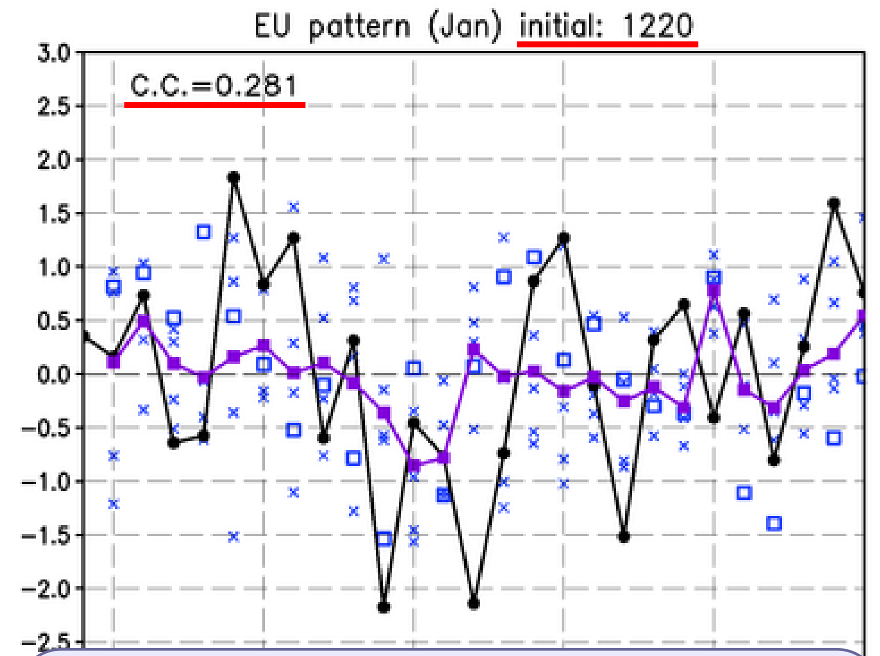
Blue marks: score of EU pattern of each hindcast run

(open squares indicate the score of control run)

Purple line: 5-member mean scores of hindcast experiment

Predictability of the EU pattern





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

Black line: EU pattern index in reanalysis data

Blue marks: score of EU pattern of each hindcast r

(open squares indicate the score of control run)

Purple line: 5-member mean scores of hindcast experiment

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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

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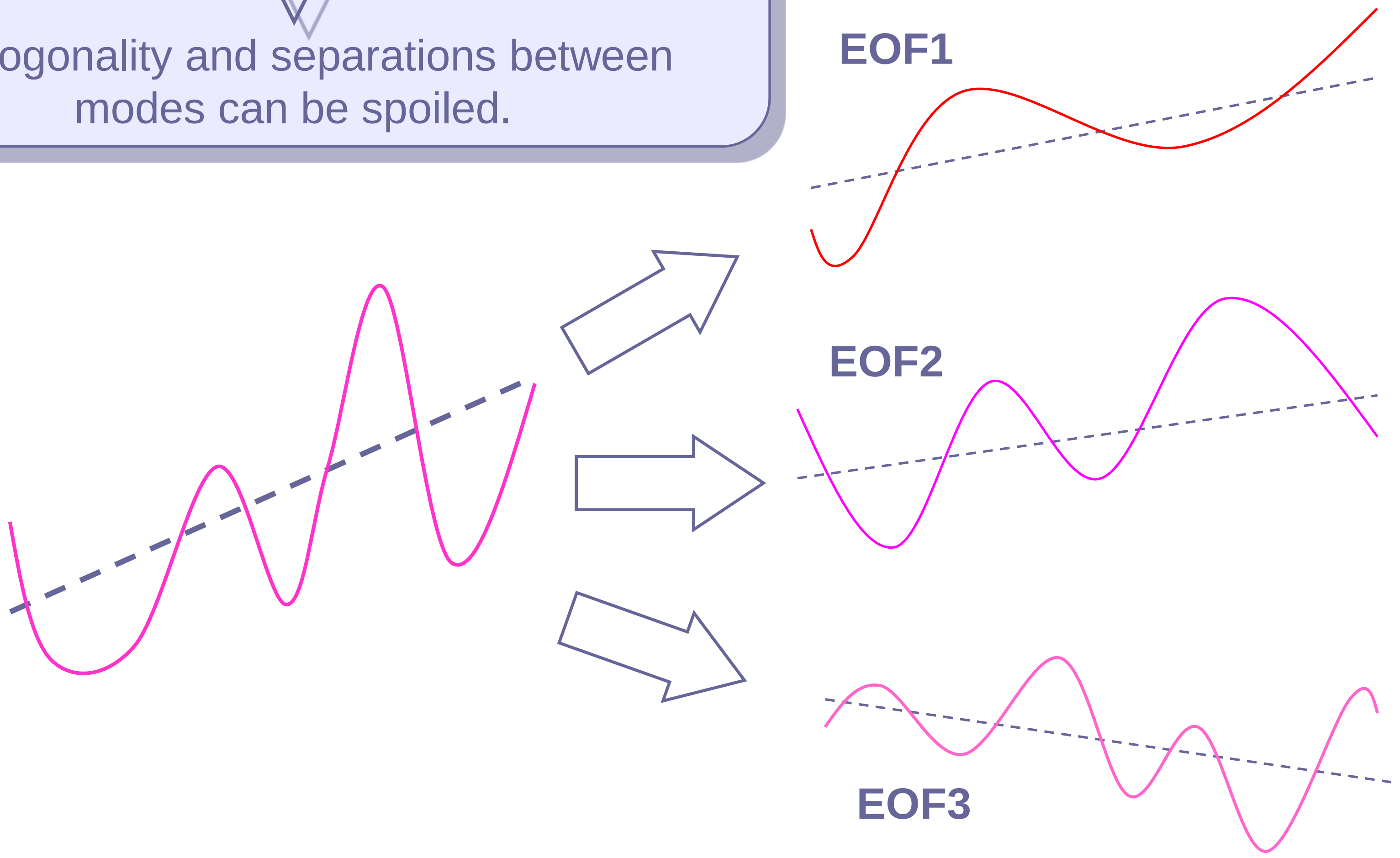
Influence of the long-term trend in data

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.

$$V = \left(\begin{array}{ccc|ccc} \sigma_{1,1} & \cdots & \sigma_{1,i} & \sigma_{1,i+1} & \cdots & \sigma_{1,i+j} \\ \vdots & & & & & \\ \sigma_{i,1} & & \sigma_{i,i} & & & \\ \hline \sigma_{i+1,1} & & & \sigma_{i+1,i+1} & & \\ \vdots & & & & & \\ \sigma_{i+j,1} & \cdots & & & \cdots & \sigma_{i+j,i+j} \end{array}\right)$$

EOF analysis for data 1

EOF analysis for data 2

SVD analysis between data 1 and data 2

Combined EOF analysis for data 1 and data 2

Percentage of the variance explained by EOFs

Monthly forecast model

initial: 31Dec

	control	01m	01p	02m	02p
EOF1	EU (25.0%)	30.5%	EU (27.1%)	EU (33.8%)	EU (21.3%)
EOF2	20.5%	EU(16.5%)	17.8%	15.9%	19.7%
EOF3	18.2%	16.2%	11.7%	11.6%	12.0%

initial: 20Dec

	control	01m	01p	02m	02p
EOF1	25.4%	EU(22.7%)	EU(19.2%)	21.4%	EU(26.2%)
EOF2	EU(21.7%)	15.6%	16.9%	EU(17.6%)	19.1%
EOF3	11.3%	14.1%	11.7%	13.8%	16.9%

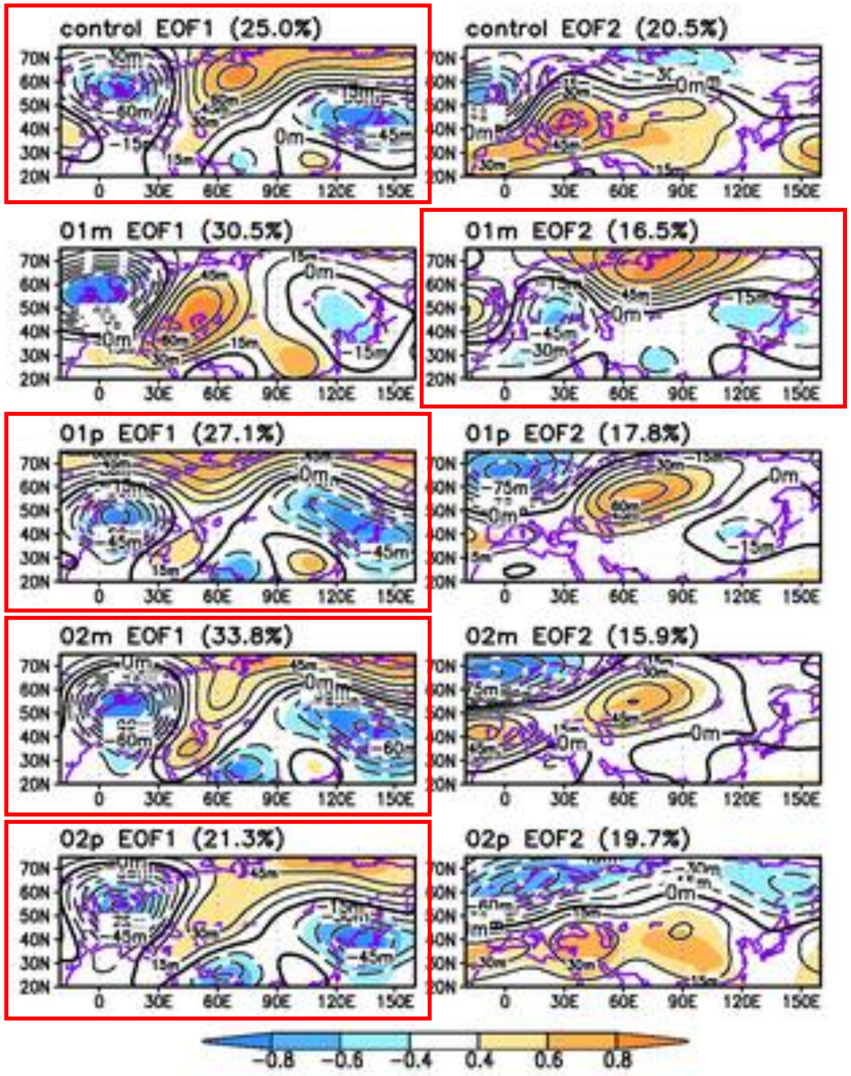
Seasonal forecast model

initial: 10Dec

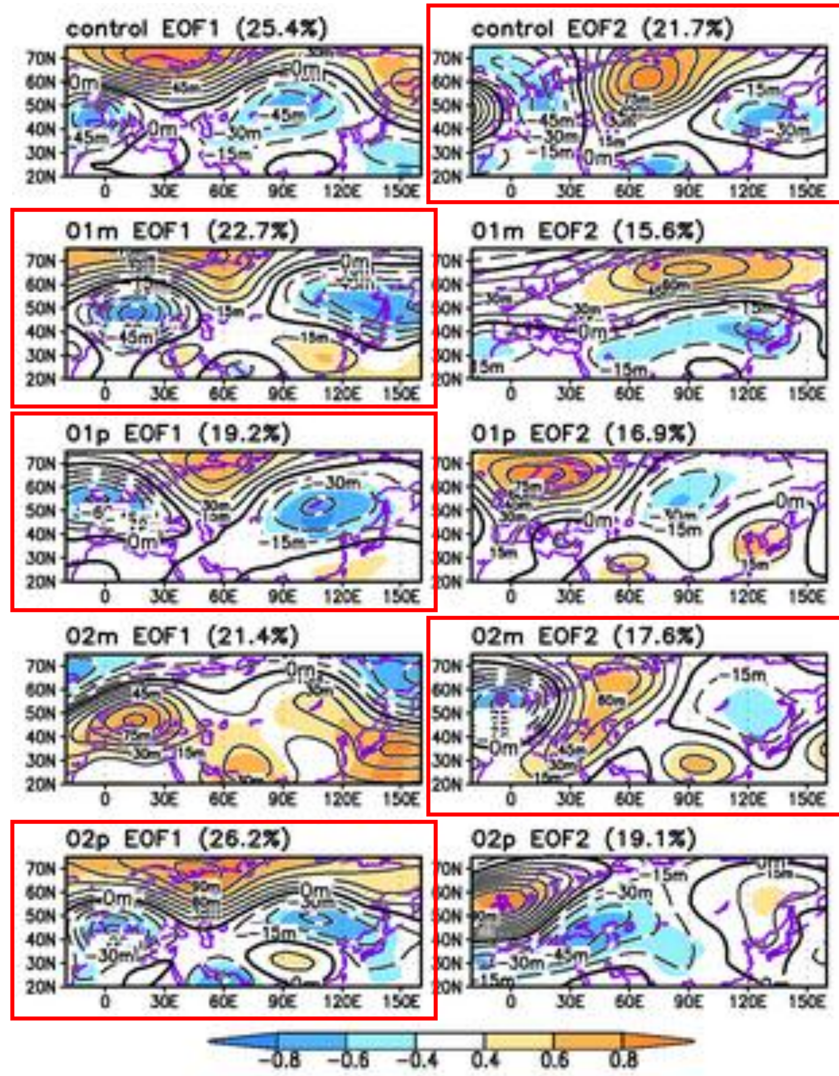
	control	01m	01p	02m	02p	03m	03p	04m	04p	05m	05p
EOF1	27.4%	EU(20.4%)	EU(29.4%)	21.7%	29.2%	EU(23.7%)	27.3%	29.7%	24.5%	24.5%	EU(30.4%)
EOF2	EU?(19.3%)	14.5%	18.1%	EU(18.0%)	18.3%	17.6%	20.7%	15.9%	19.7%	18.9%	18.6%
EOF3	12.7%	11.3%	11.8%	14.0%	11.7%	11.9%	12.3%	11.7%	17.9%	13.4%	13.3%

Dominant mode in hindcast experiment

Initial: 31Dec

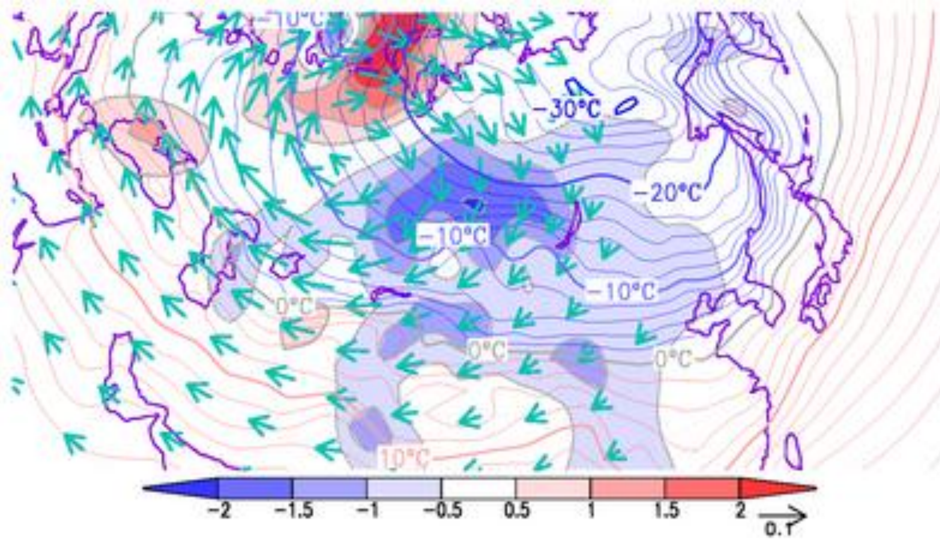


Initial: 20Dec

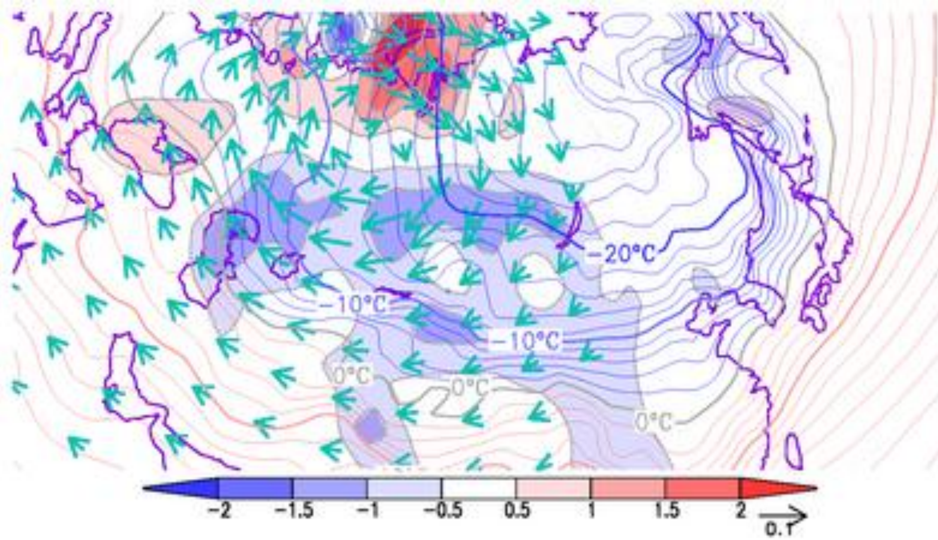


Cold air advection induced by an upper circulation anomalies

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).