The JMA One-month Ensemble Prediction System (EPS)

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Contents

1. Outline of the JMA one-month EPS

2. Examples of observed and predicted Low Frequency Variability (LFV) in the atmosphere

   quasi-stationary Rossby waves, blocking, Arctic Oscillation, Madden-Julian Oscillation (MJO)

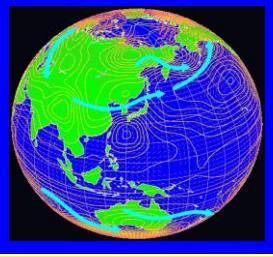
3. Concluding remarks

Official one-month forecasting issued by JMA

Date of Issue	**Every Friday**
Contents	**Probabilistic forecasts of three categories** Monthly mean temperature Monthly precipitation Monthly sunshine duration Monthly snowfall Weekly mean temperature (1st, 2nd, 3rd&4th week) **Features of expected weather**
Forecast Method	**Dynamical method** (Ensemble prediction) since 1996

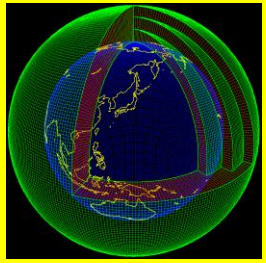
The JMA One-month EPS

4D-VAR Assimilation



Land-Surface Assimilation

JMA Global Atmosphere-Land Model



Products

Forecast charts

Guidance

GPV

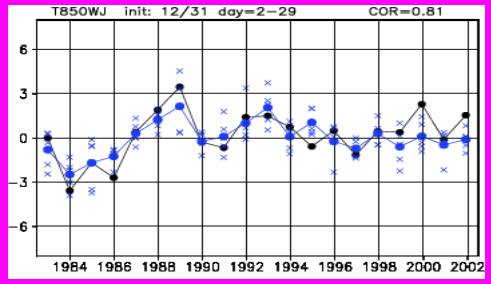
Verification

SST-Analysis

Persistent SST anomaly

Calibration

Hindcast



20 years from 1983 to 2002

Horizontal resolution	TL159
Time integration range	34 days
Executing frequency	Once a week
Ensemble size	50 members
Perturbation	Breeding of Growing Mode and LAF

Features of the EPS

- Land-Surface assimilation
- Breeding of Growing Modes in the tropics
- Many cases of hindcast experiments (re-forecast)
- Many kinds of forecast charts
- Many kinds of verification diagrams and scores

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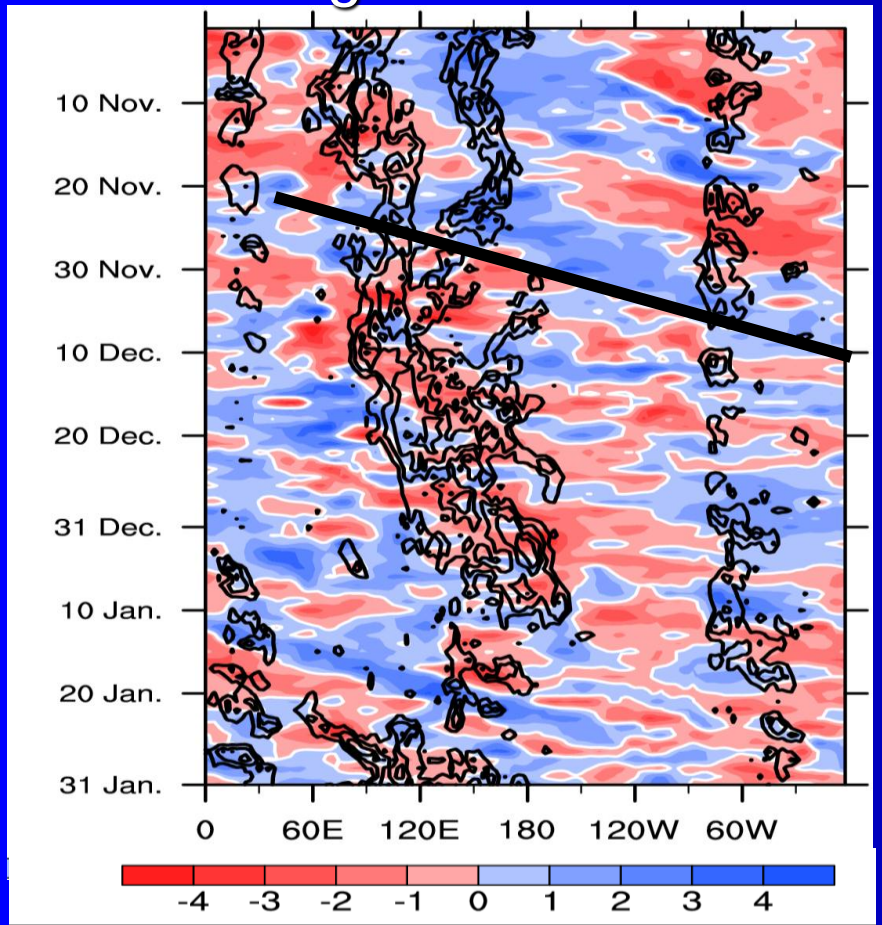
Unstable large scale mode in the tropics found using modified JMA's breeding cycle (Chikamoto et al.,2006: GRL)

X-T Diagram of the 1st BM
X200 averaged over 10S-10N

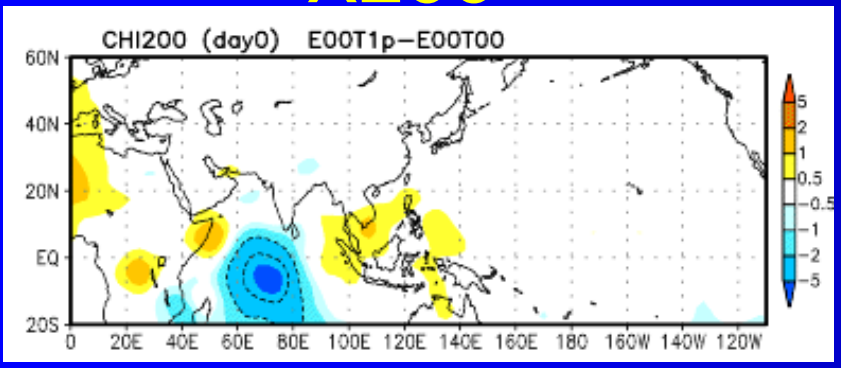


- Propagate eastward of a phase speed of 30 m/s with dominant WN1 components (15-day period).
- Growth rate of 0.1/day

Influence of Tropical Perturbation to the Extratropics

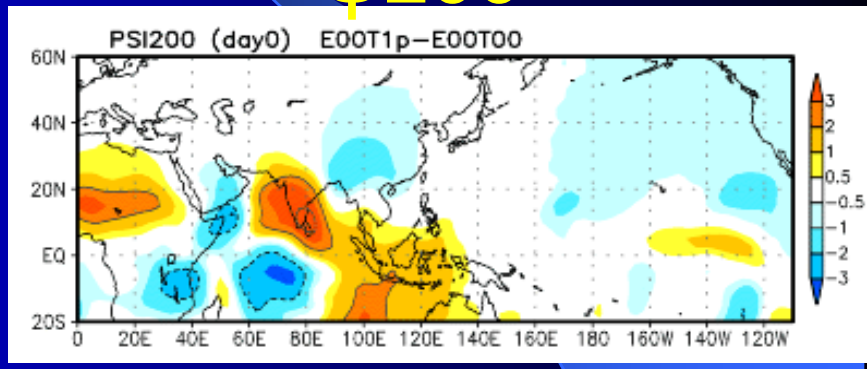
Time Evolution from Dec. 18, 2003 (Sato, et al., 2006)

X200

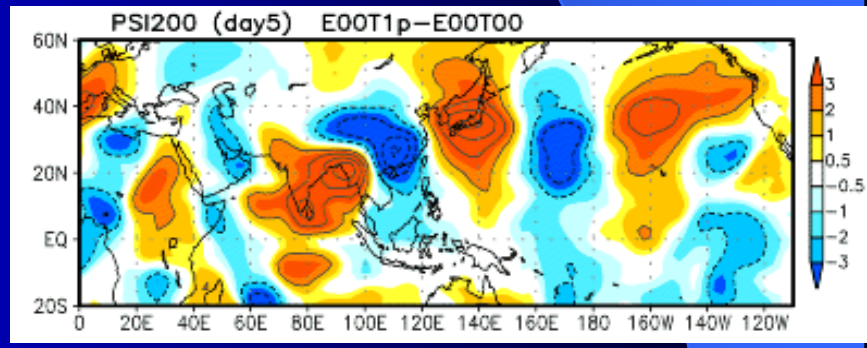


day 0

ψ200



day 5



In March 2007, the BGM was improved to properly manage dynamical instability in the tropics

Features of the EPS

- Land-Surface assimilation
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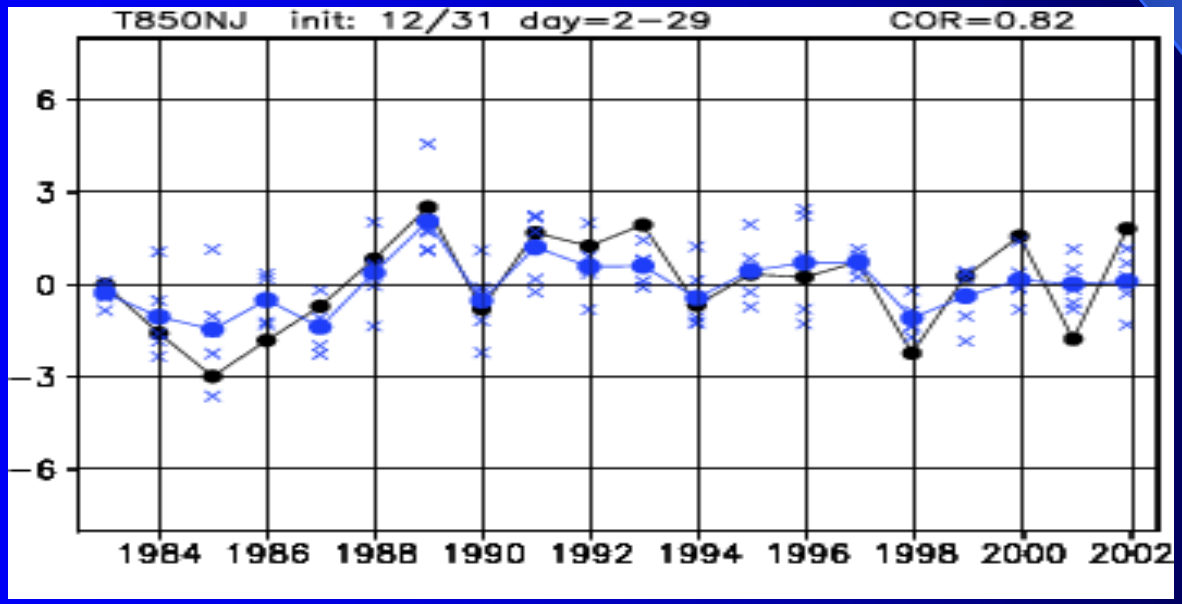
Hindcast experiments : 3,600 cases

- Model : TL159L40 version of JMA_GSM (V0703C)
- Years : 20 years from 1983 to 2002
- Frequency: 3 times per month
- Ensemble size: 5 member

Cor. 0.82



T850, day=2-29, Northern . Japan, initial: 31th Dec

Black: Observation Blue:Forecast

Features of the EPS

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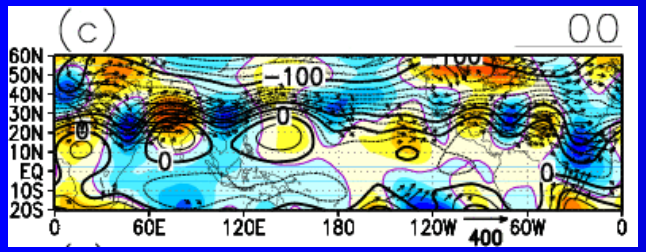
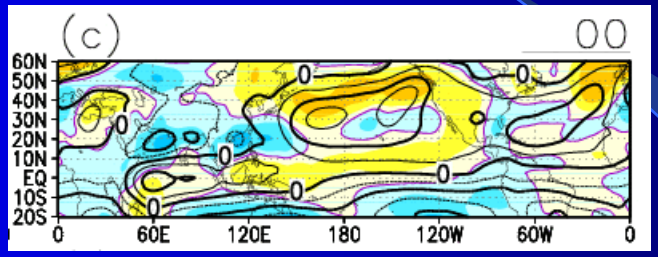
Examples of forecast charts

1) Ensemble mean and stamp maps

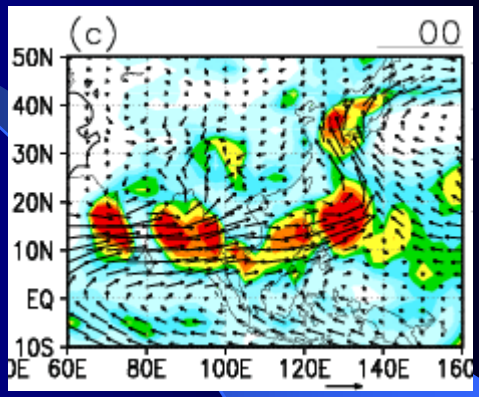
(1st week, 2nd week, 3-4th week, 1-4th week)



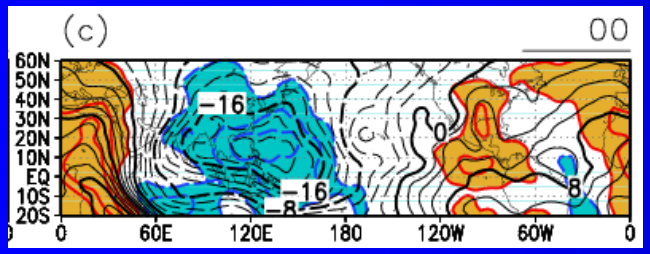
Stream function, anomalies, wave activity flux at 200hPa



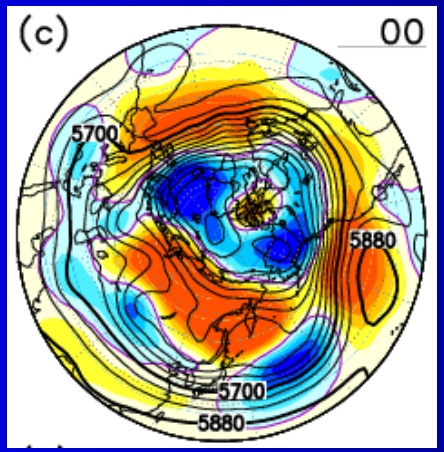
Stream function and anomalies at 850hPa



Water vapor flux at 850hPa and precipitatio



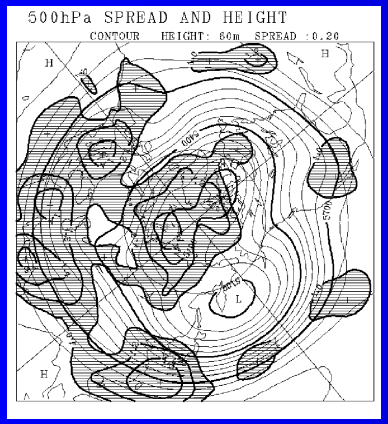
Velocity potential and anomalies at 200hPa



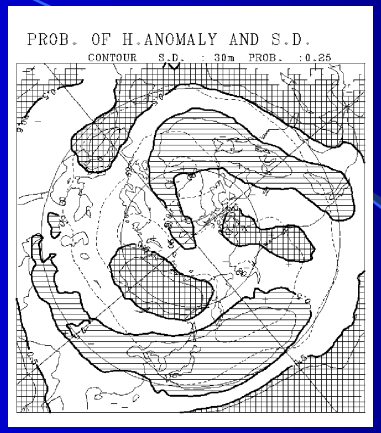
Height and anomalies at 500hPa

2) Spread and probability maps

(1st week, 2nd week, 3-4th week, 1-4th week)

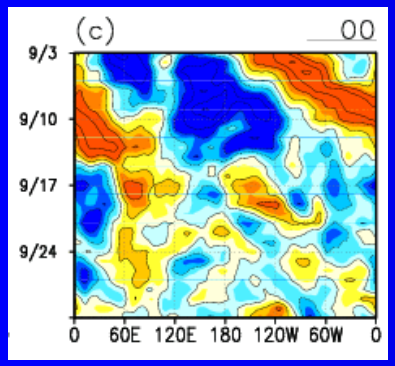


Spread of Z500 among ensemble members

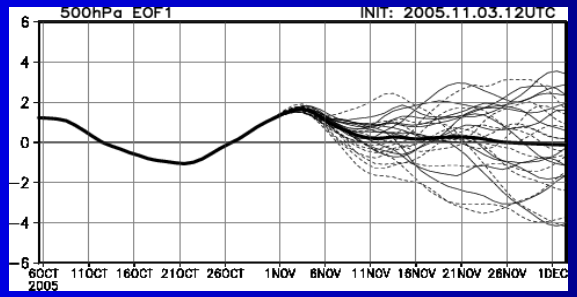


Probabilities of Z500 anomalies exceeding ±0.5SD

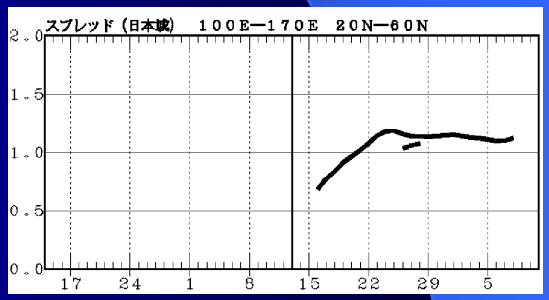
3) Time series and cross section



Velocity potential anomalies at 200hPa in the equatorial region (5S-5N)



7 day running mean EOF1 scores of Z500 in winter



Z500 spread of 7-day and 28-day mean in East Asia

Features of the EPS

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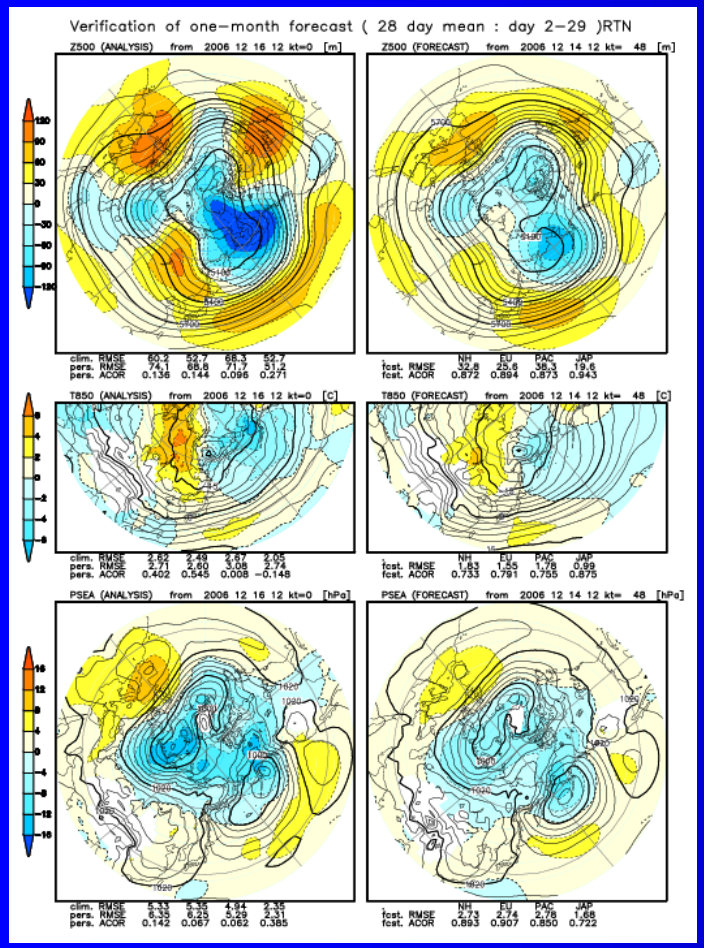
Examples of verification diagrams

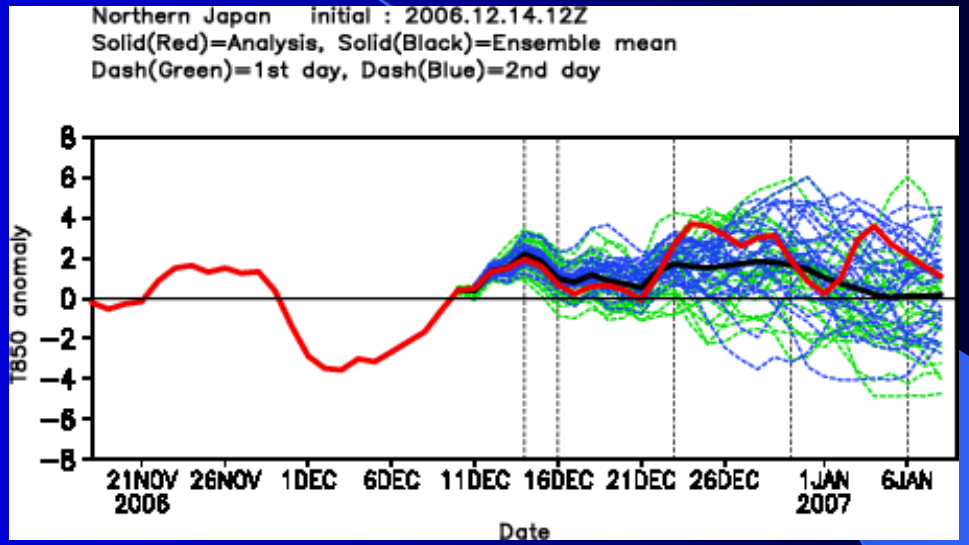
1) Near real-time verifications of each prediction

Observation Ensemble mean

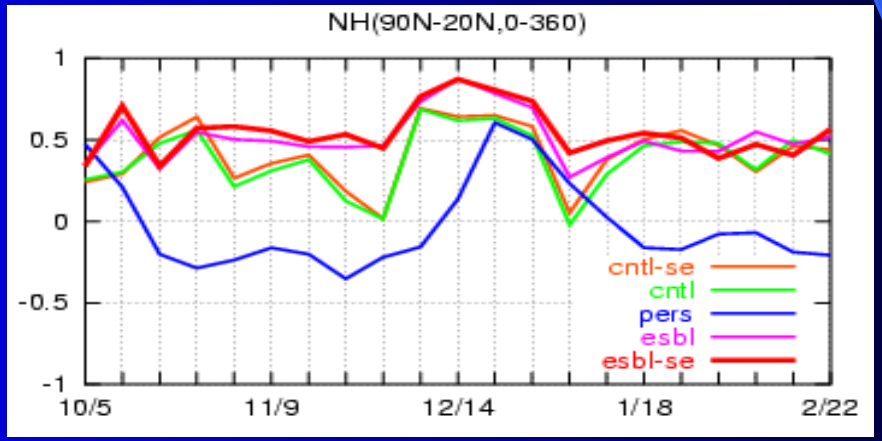


Upper:Z500, Middle: T850, Lower: SLP
Initial: 12th Dec 2006, day=2-29

Time series of 7-day running mean T850 in the Eastern Japan



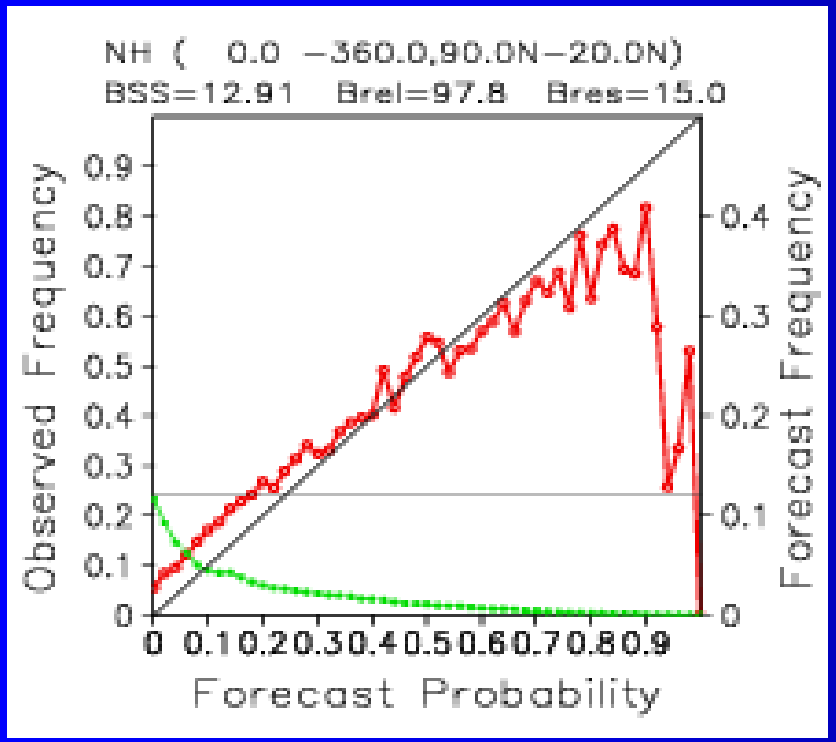
Time series of Anomaly Correlation Coefficients of Z500 in NH



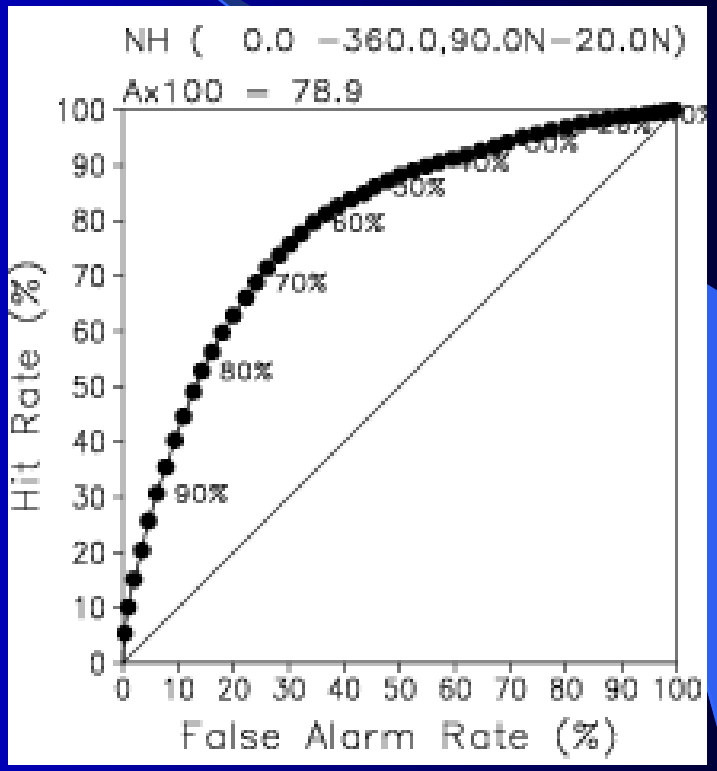
2) Seasonal verifications of probabilistic prediction

Z500 > 0, Northern Hemisphere, day=2-29, autumn in 2006

Reliability diagram



ROC curve



2. Examples observed and predicted Low Frequency Variability (LFV)

Atmospheric phenomena closely related to one-month forecast ?

LFV such as quasi-stationary Rossby wave, blockings, AO, MJO,ISO of Asia monsoon……

It is important for operational forecasters to understand the mechanisms and predictabilities of LFV

2.1 Quasi-stationary Rossby wave

Examples: 2002/1, 2005/2

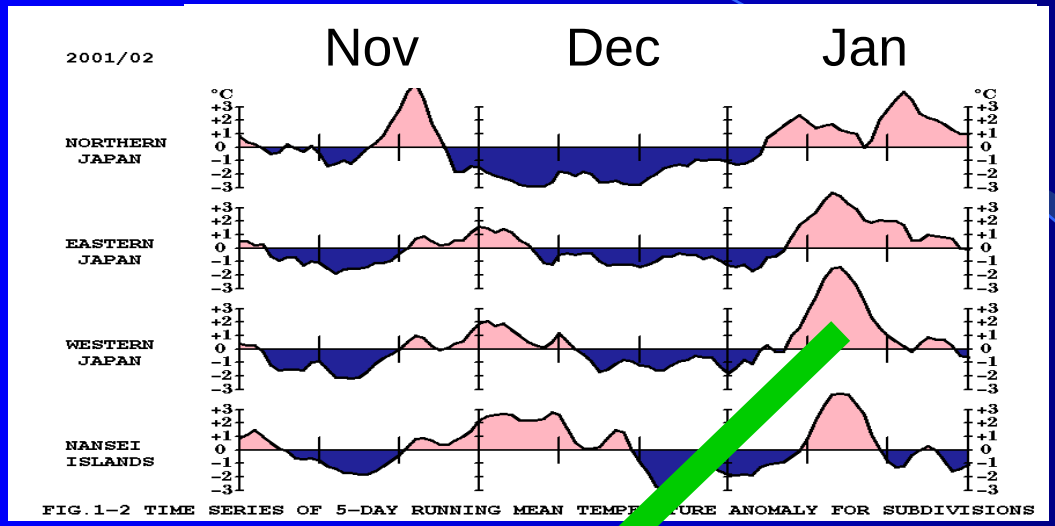
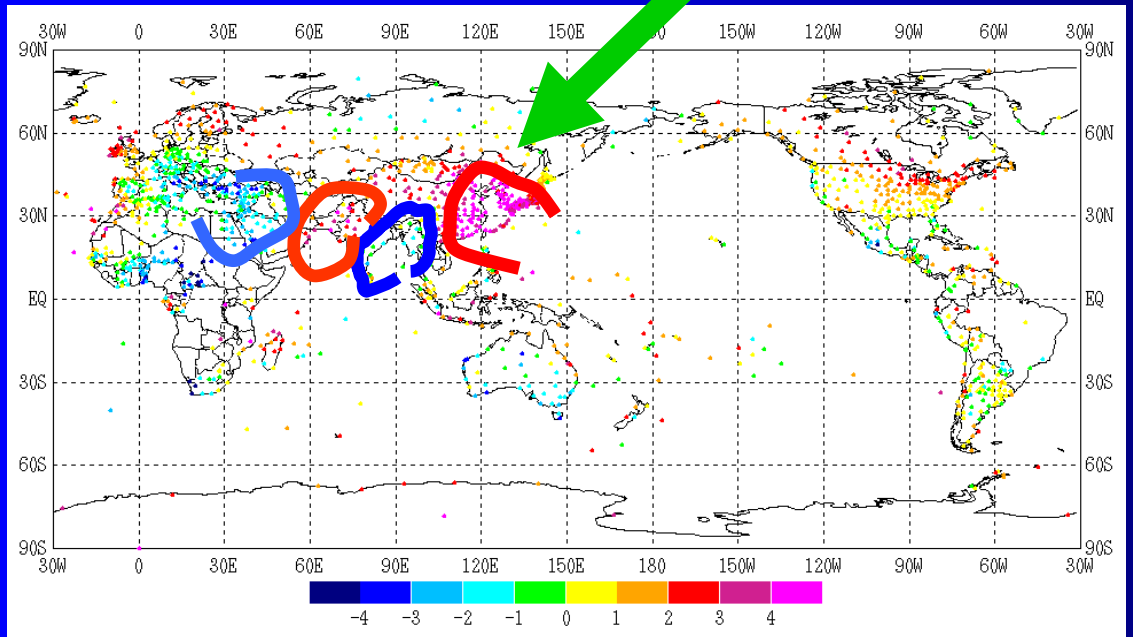


FIG.1−2 TIME SERIES OF 5−DAY RUNNING MEAN TEMPERATURE ANOMALY FOR SUBDIVISIONS

Time sequences of temperature anomalies in Japan (5 day running mean)

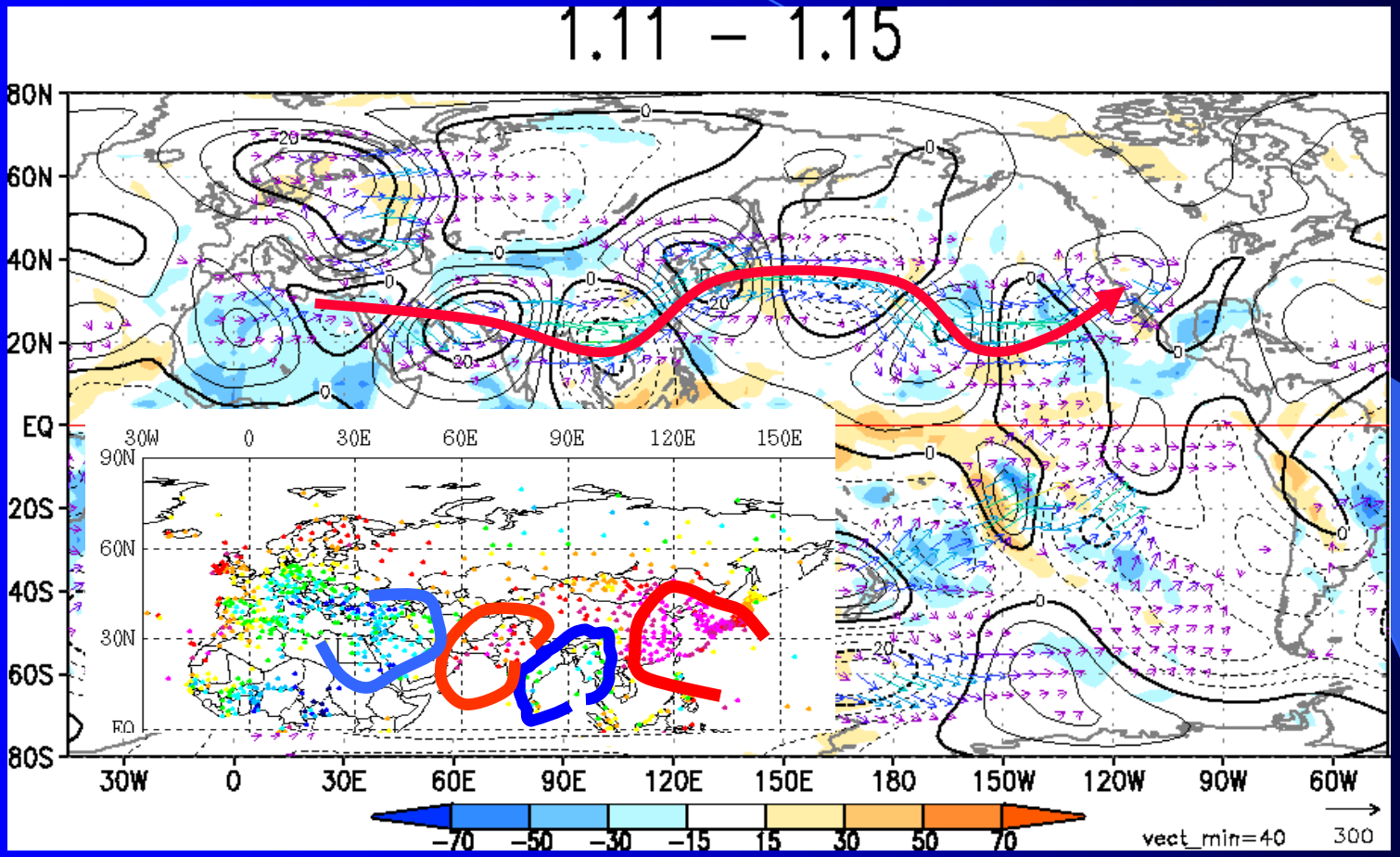
2001.11-2002.2



Observed normalized temperature anomalies

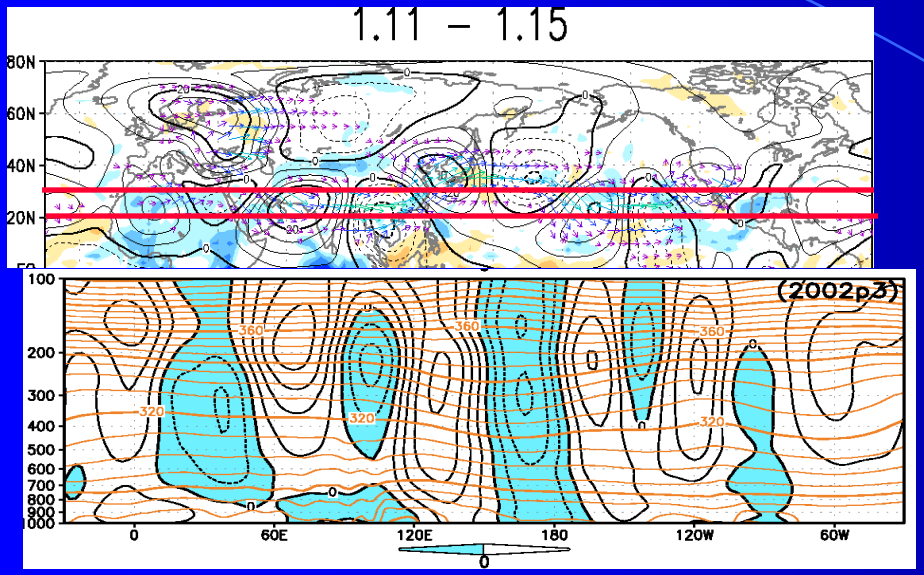
2002.1.11-15

Wave train along the Asian jet



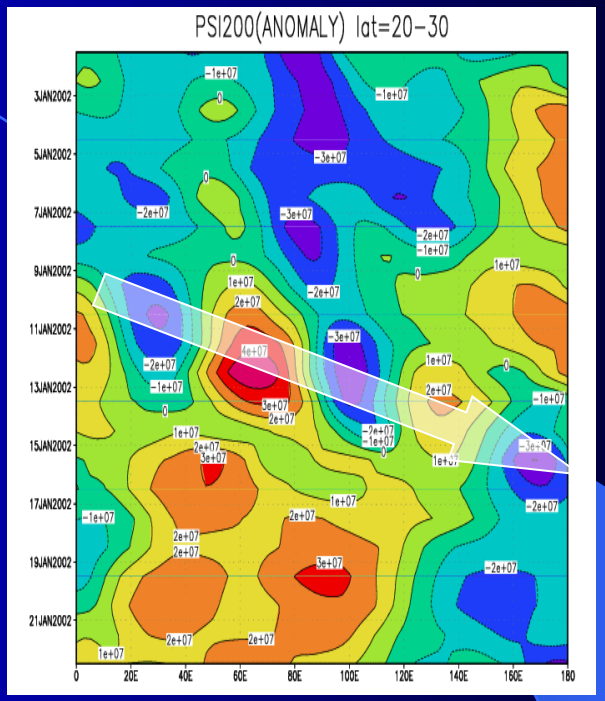
Observed 5-day mean stream function anomalies at 200hPa (contours) 2002.1.11-1.15

Structure of the wave train



Observed Longitude-height cross section of 20N-30N mean stream function anomalies

2002.1.11-1.15



1 JAN

23 JAN

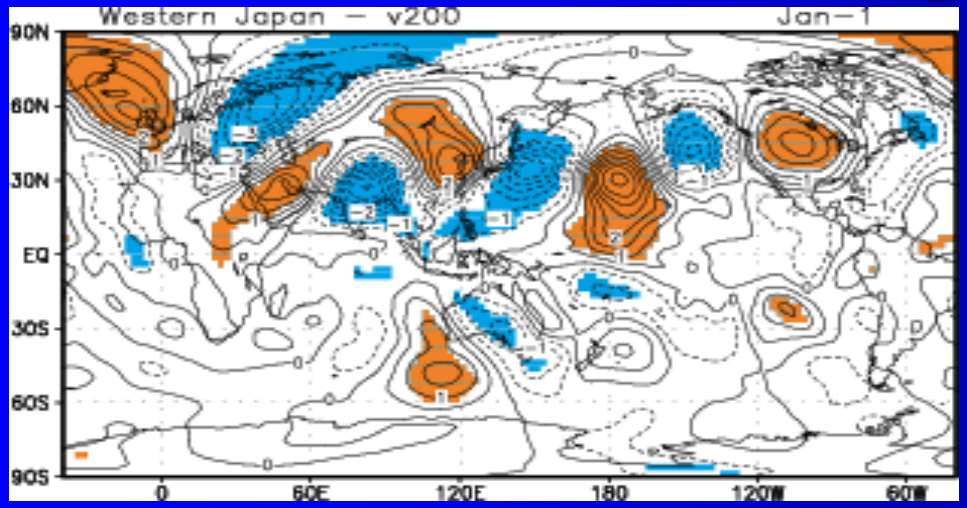
0E 180E

Observed Longitude-time cross section of 20N-30N mean stream function anomalies at 200hPa

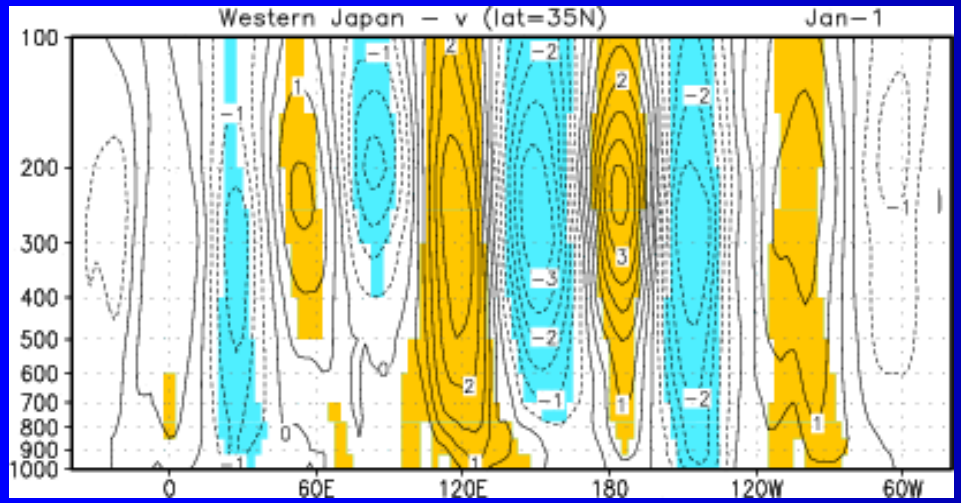
2002.1.1-1.23

Equivalent barotropic stationary Rossby wave.
Wave length: 70 ˚ Group velocity 30˚/day

Statistical relationship between 10-day mean temperature in western Japan and wave trains along the Asian jet

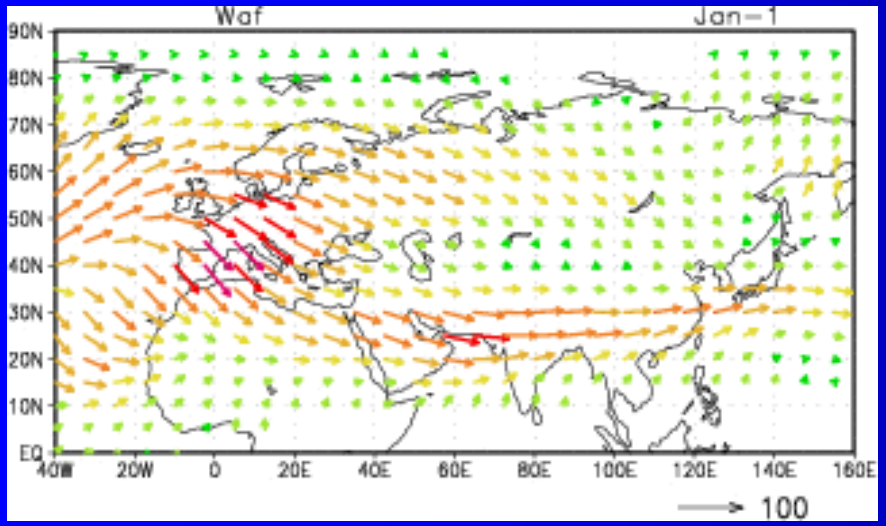


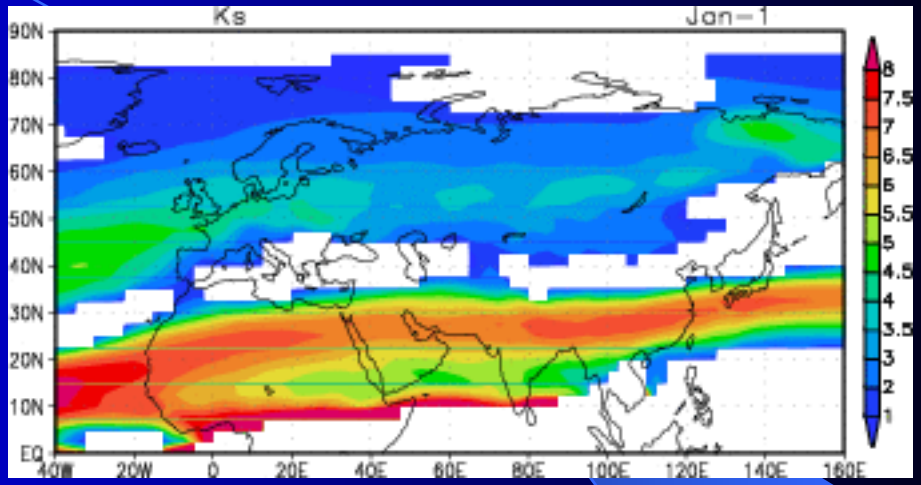
Regression of meridional wind v at 200hPa on 10-day mean temperature in western Japan . 1 Jan.-10 Jan.



Longitude-height cross section of regression of meridional wind v at 35N

Climatology of stationary Rossby wave packets propagation (1-10 JAN,1971-2000)





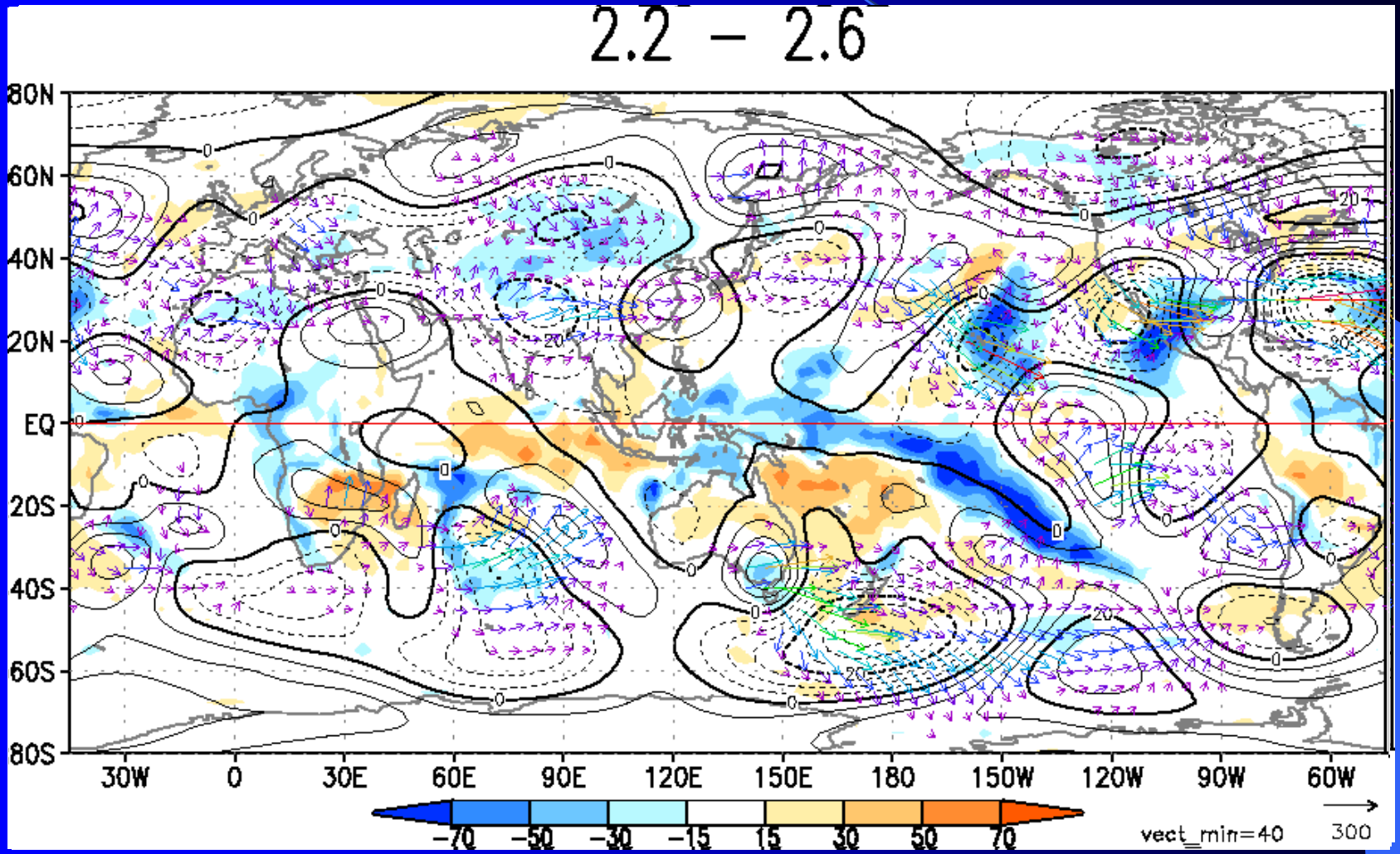
Wave activity flux (Takaya and Nakamura,2001,JAS,608-) at 200hPa

Stationary Rossby wave number Ks (Hoskins and Ambrizzi,1993,JAS,1661-) at 200hPa

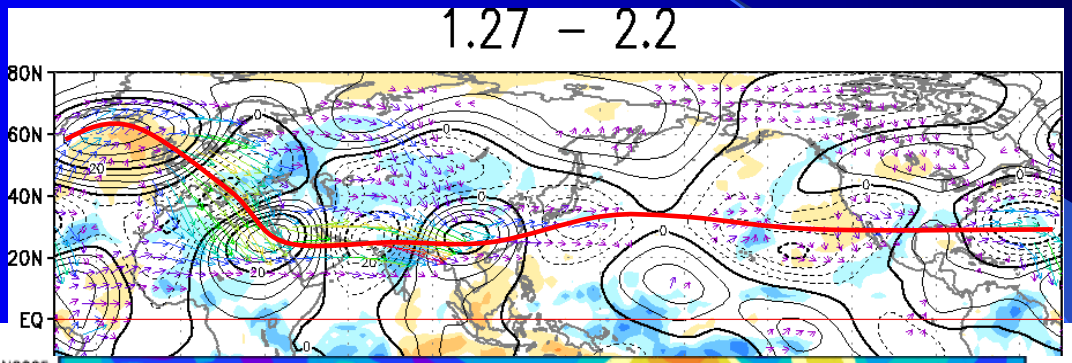
Source of Rossby wave train along the Asian jet ?

Blocking over the North Atlantic and Rossby wave trains along the Asian jet

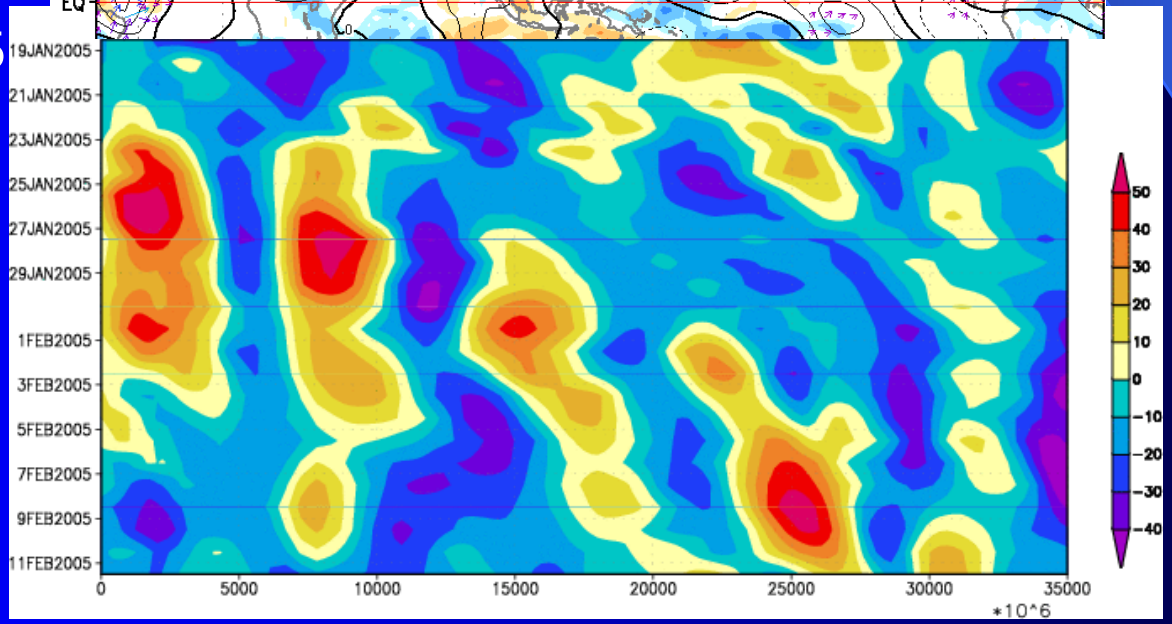
5-day mean stream function anomalies at 200hPa 2005.1.18-



Time cross section of stream function anomalies at 200hPa
x-axis : distance along the red line from a base point (60W,60N)

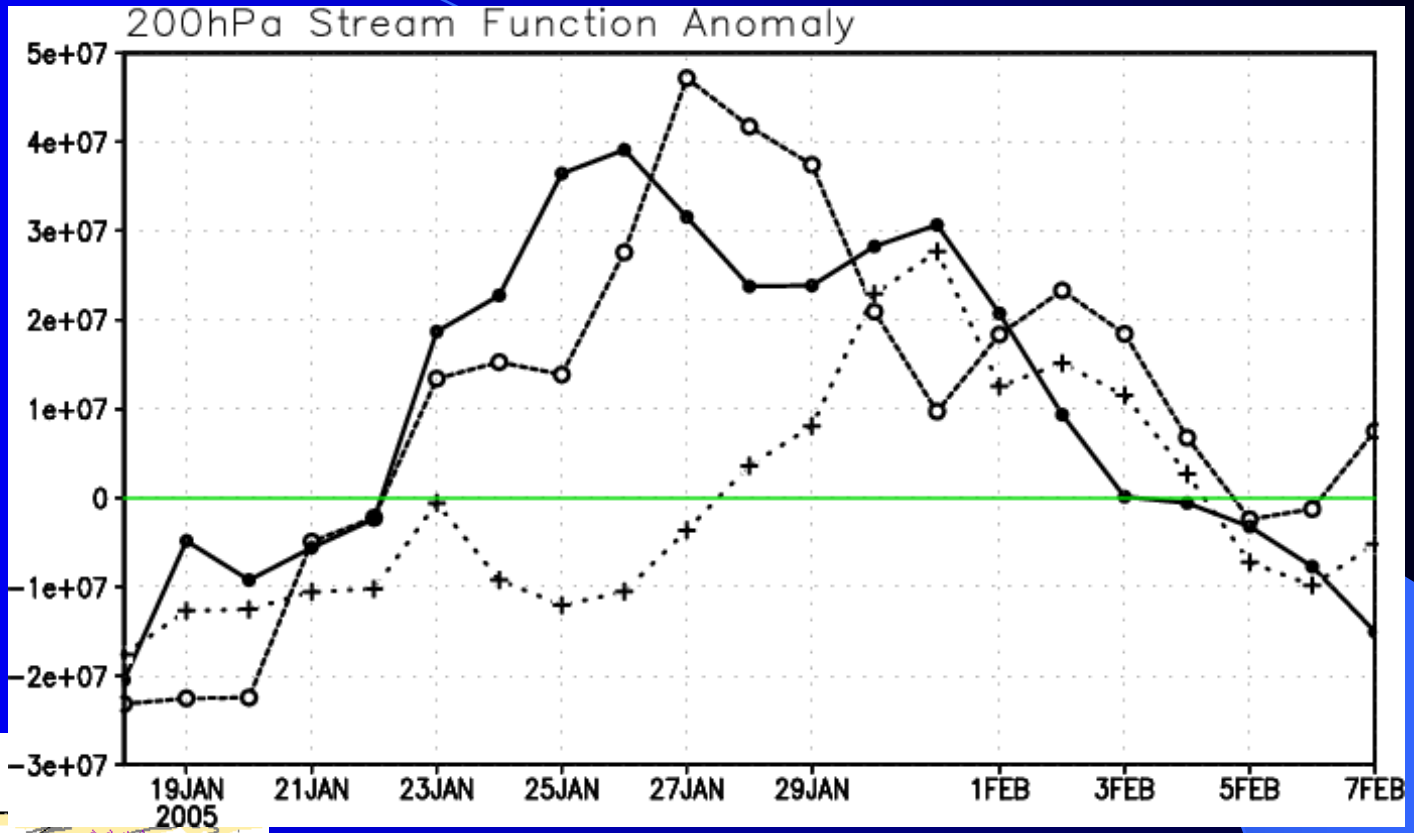


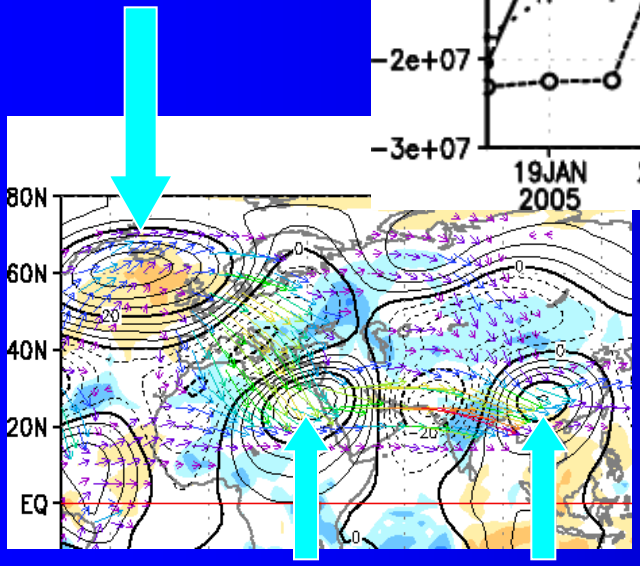
19Jan2005



11Feb2005

Decay of Blocking due to Rossby wave radiation



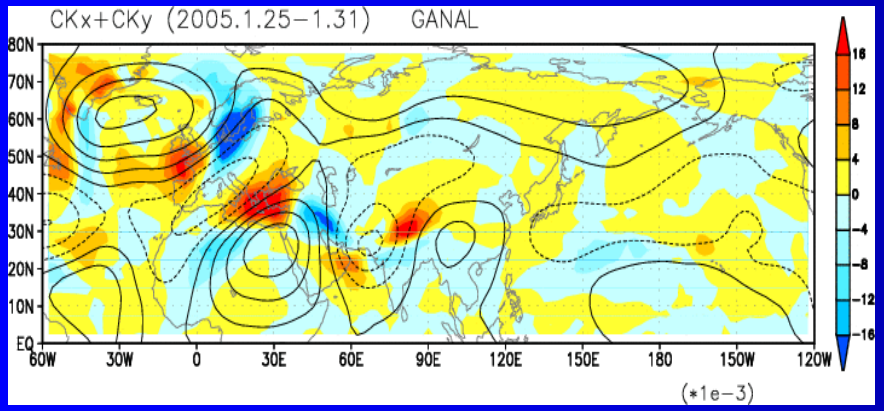


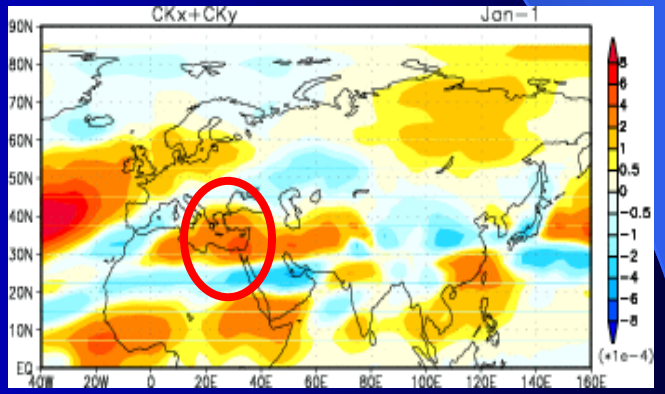
Amplification of Rossby wave in the entrance of the Asian jet

Batoropic kinetic energy conversion (Simmons et al., 1983, JAS, 1363-)

$$\partial Ke/\partial t = CKx + CKy$$

$$CKx = -(u^2 - v^2)\,\partial u_b/\partial x, \quad CKy = -uv\,\partial u_b/\partial y$$



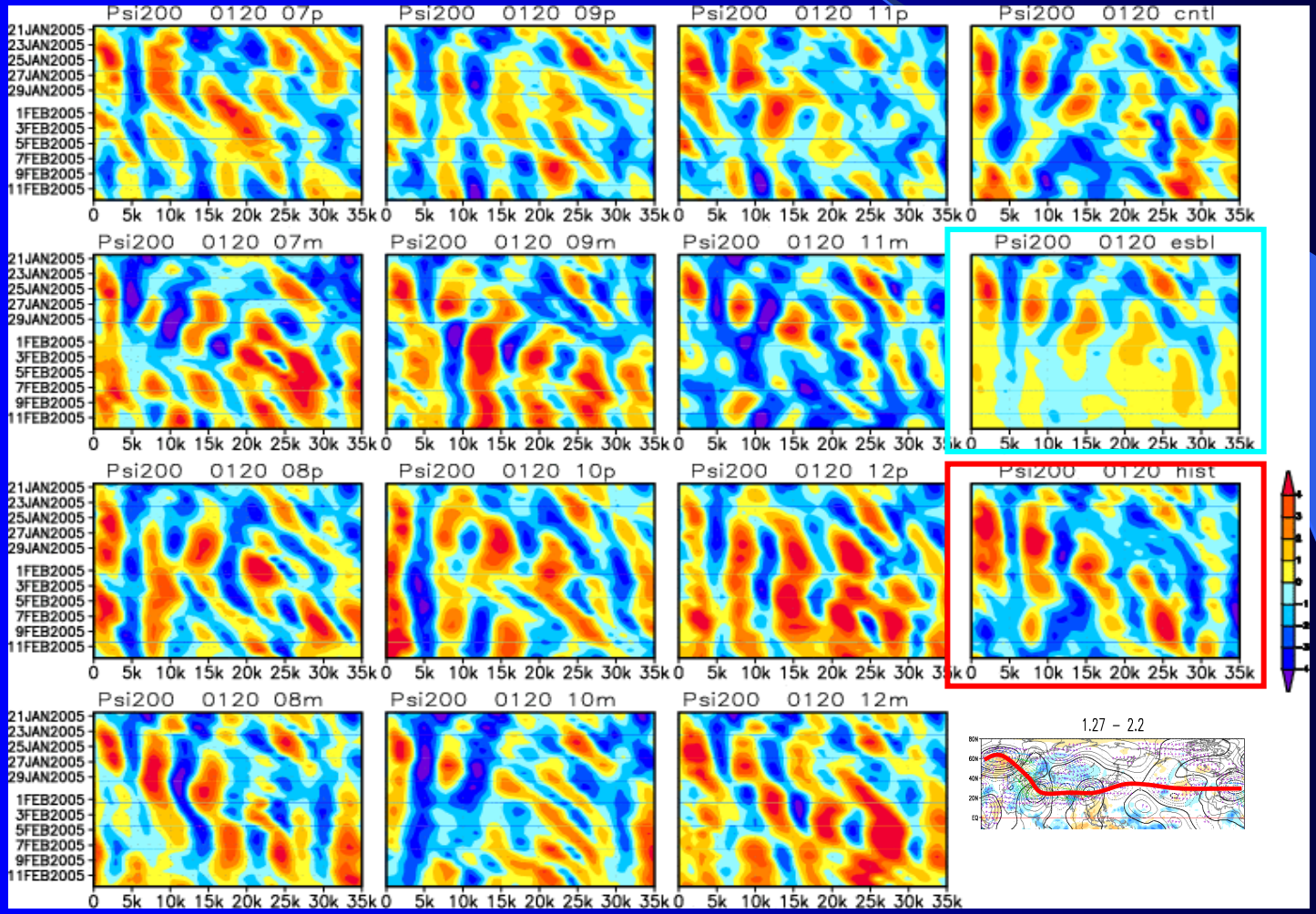


25-31 JAN2005

Climatology 1-10 JAN 1971-2000

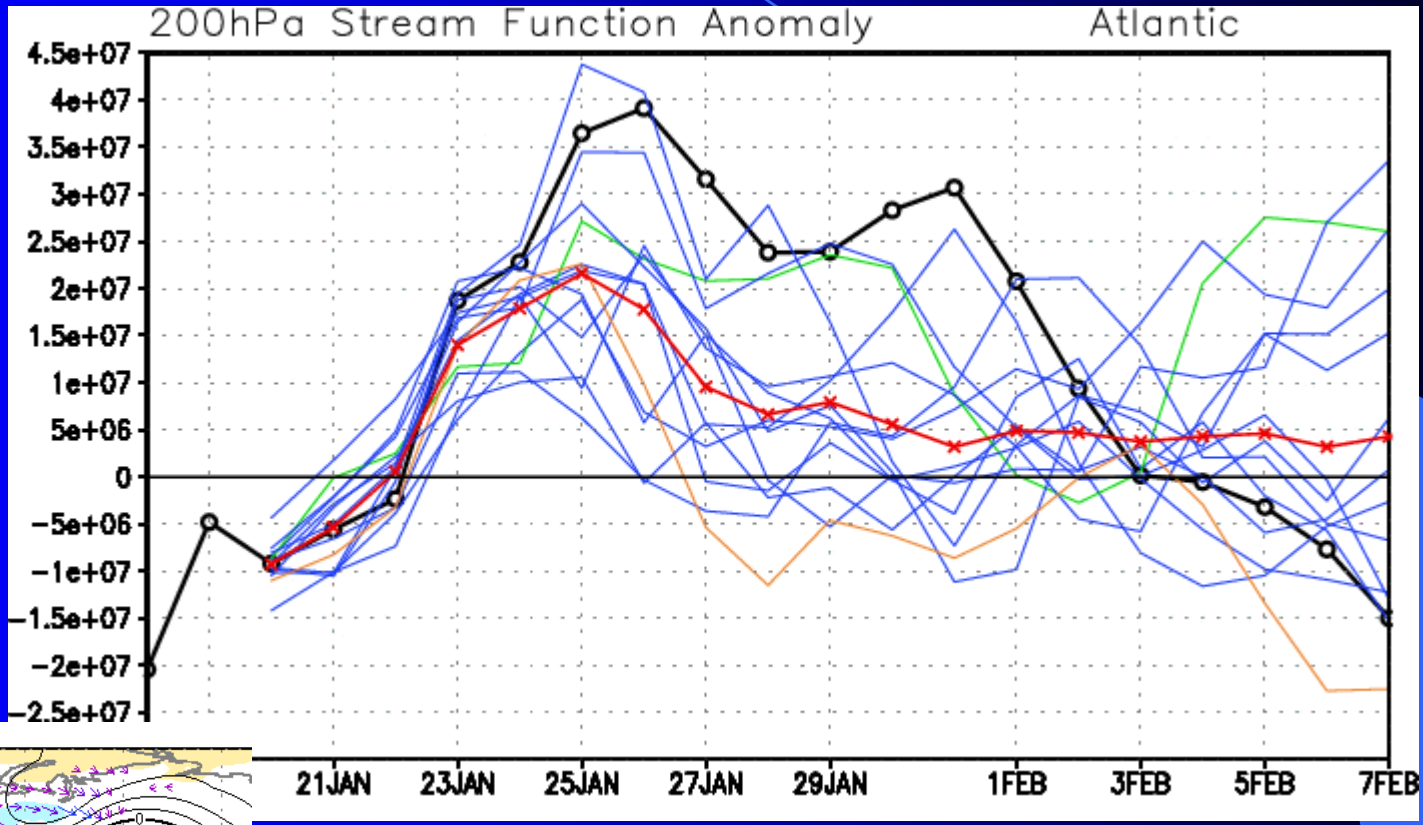
Prediction of these processes by the JMA EPS for one-month forecast

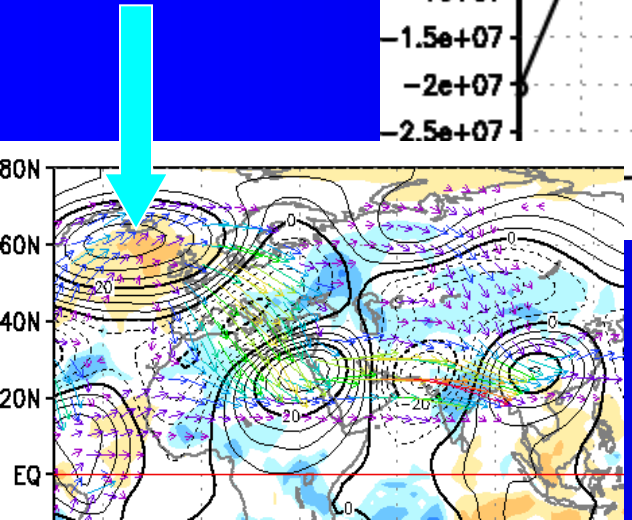
Initial : 20th JAN 2005



Prediction of development of Blocking

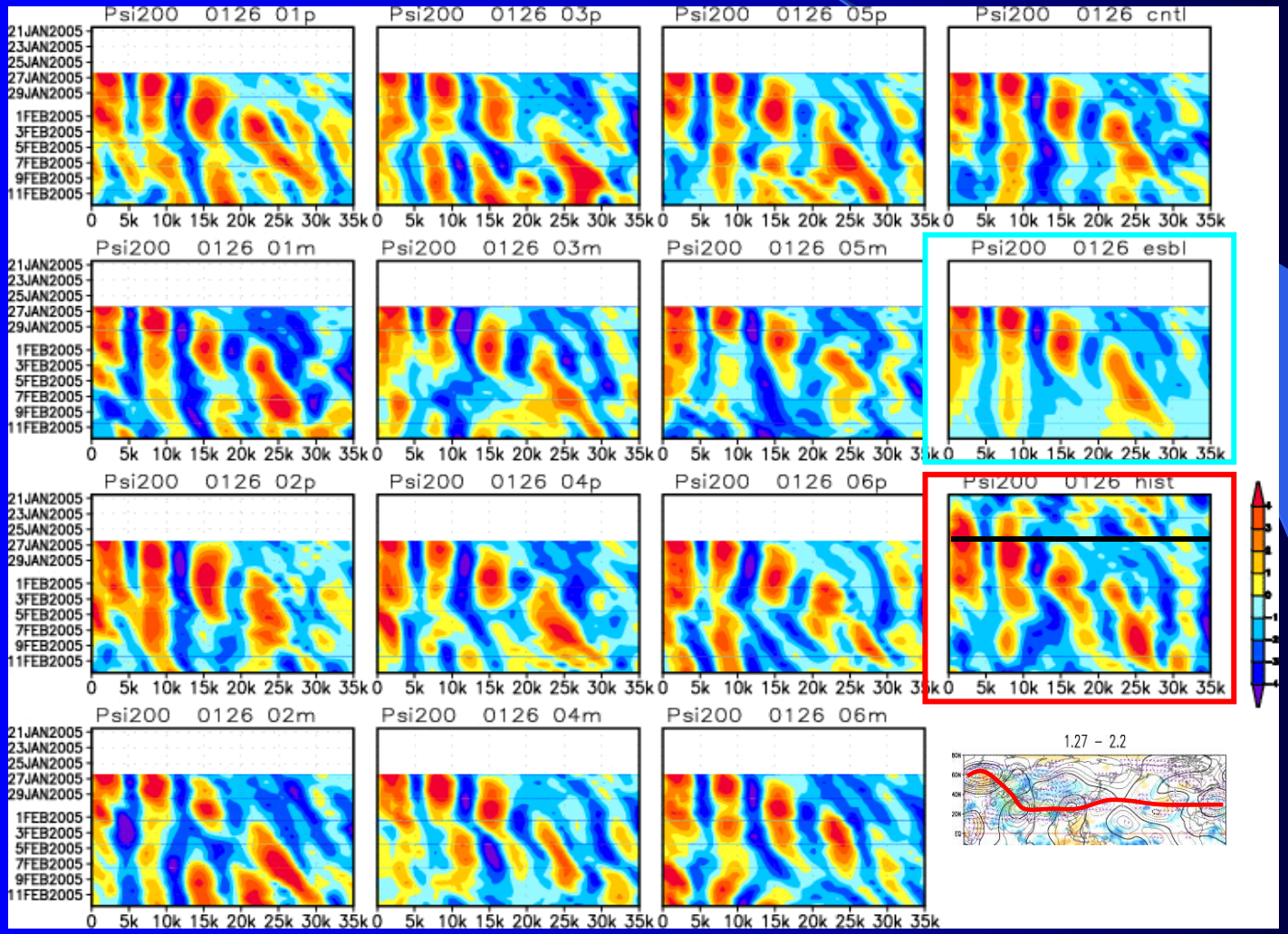
Initial : 20th JAN 2005





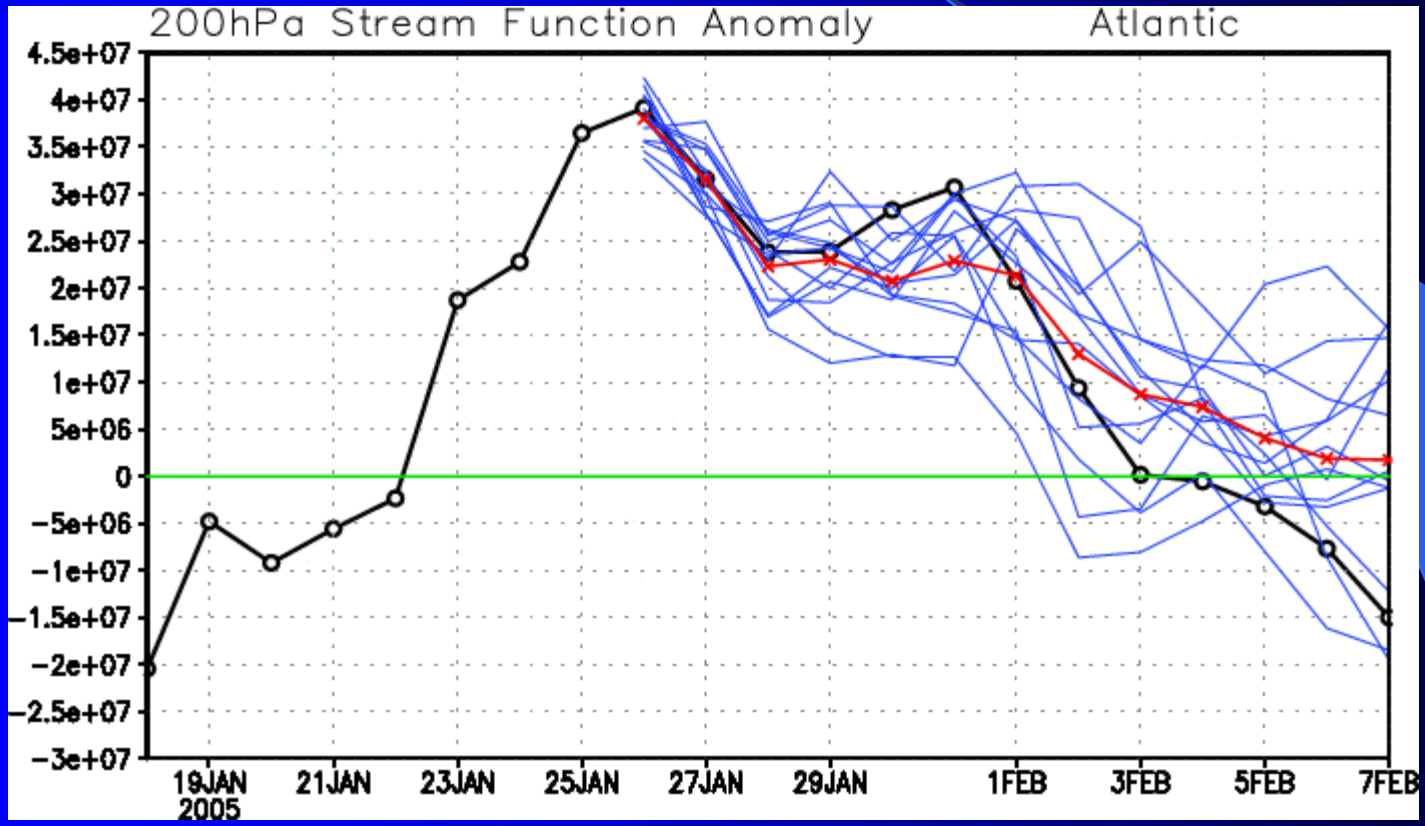
Prediction of decay of Blocking due to Rossby wave radiation

Initial : 26th JAN 2005



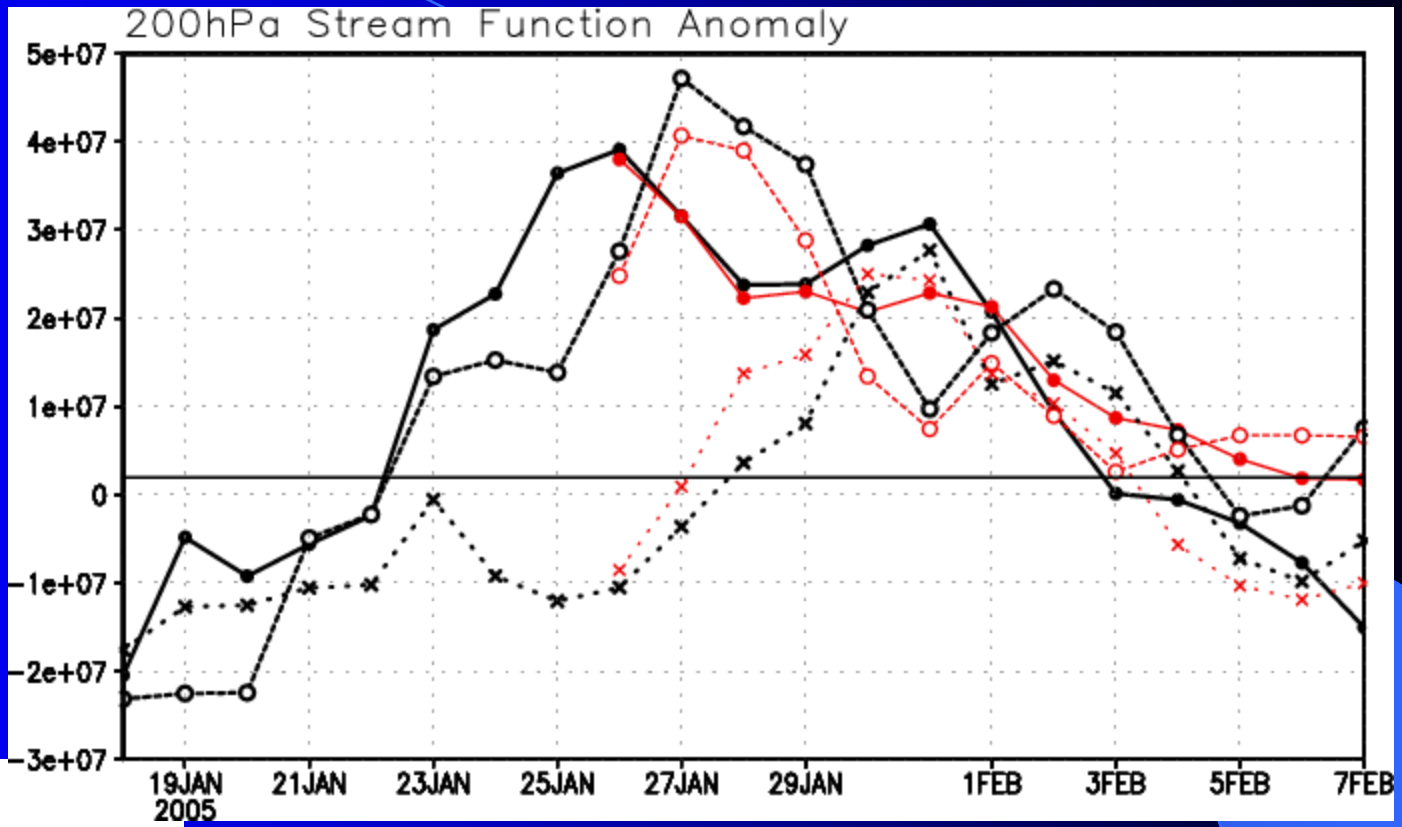
Prediction of decay of Blocking

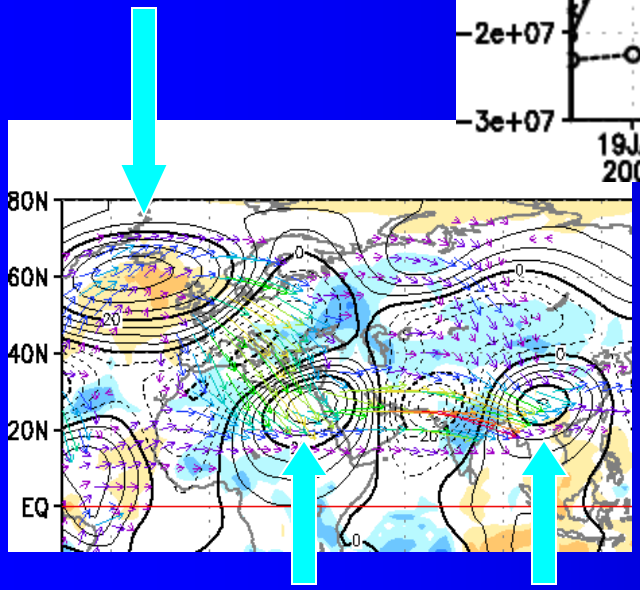
Initial : 26th JAN 2005



Prediction of decay of Blocking due to Rossby wave radiation

Initial : 26th JAN 2005

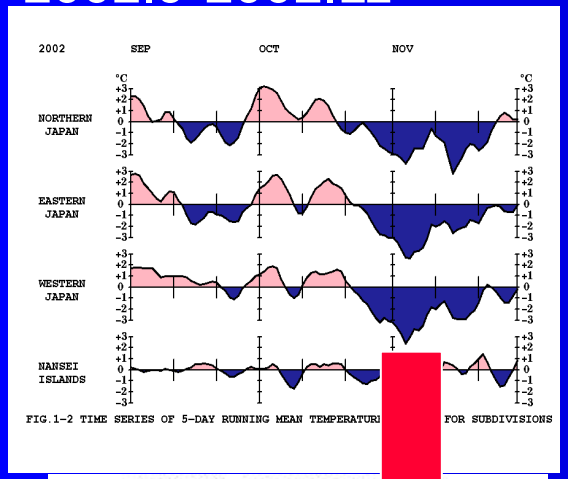




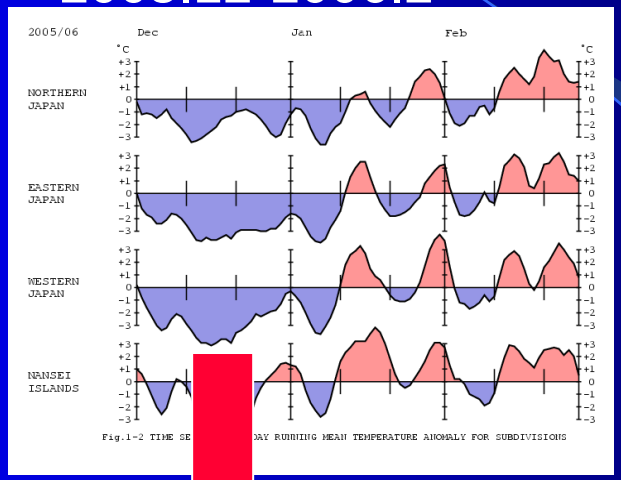
2.2 The Arctic Oscillation :2002/11,2005/12,2006/12

Time sequences of temperature anomalies in Japan (5 day running mean)

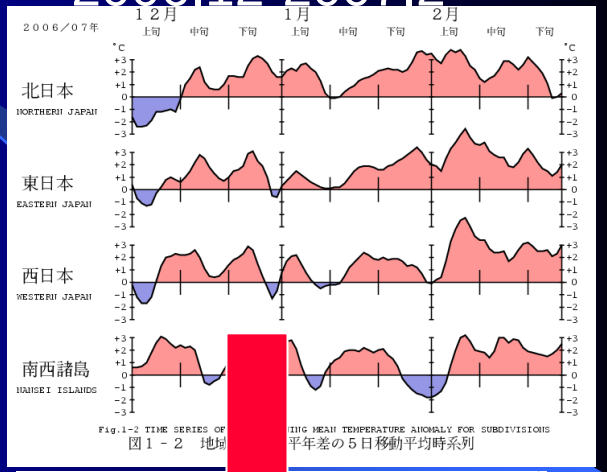
2002.9-2002.11

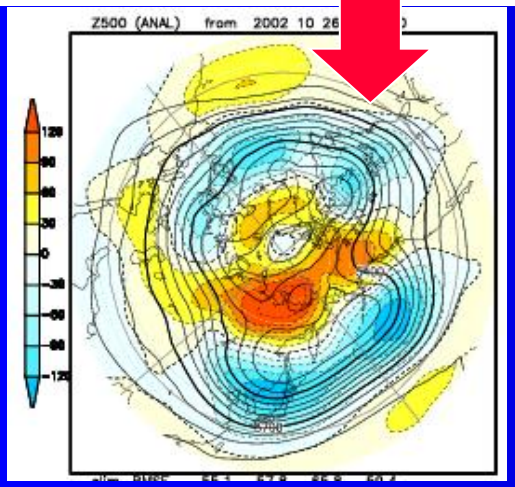


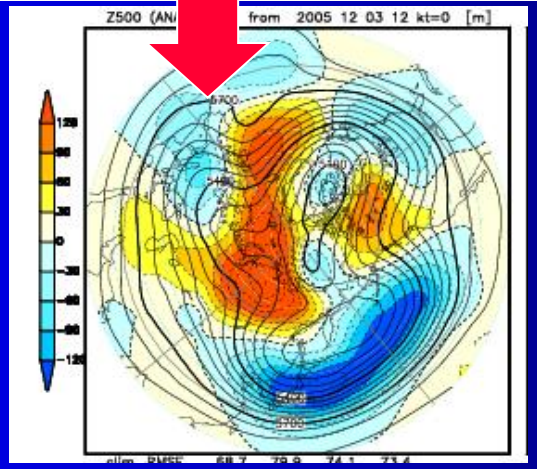
2005.12-2006.2

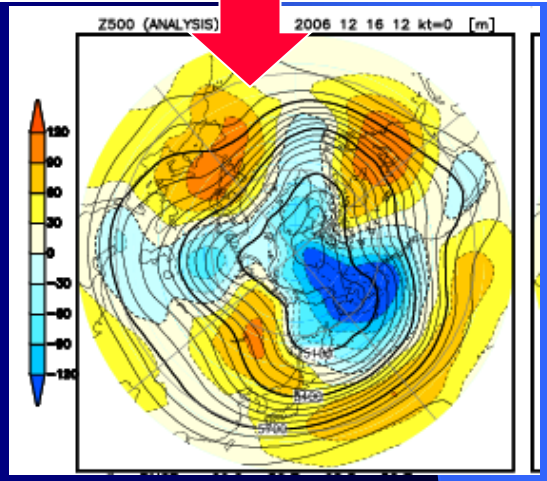


2006.12-2007.2









2002.10.26-11.22

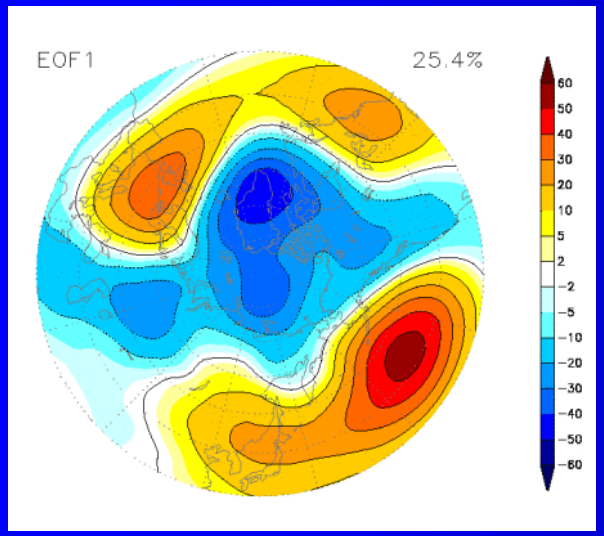
2005.12.3- 12.30

2006.12.16-2007.1.12

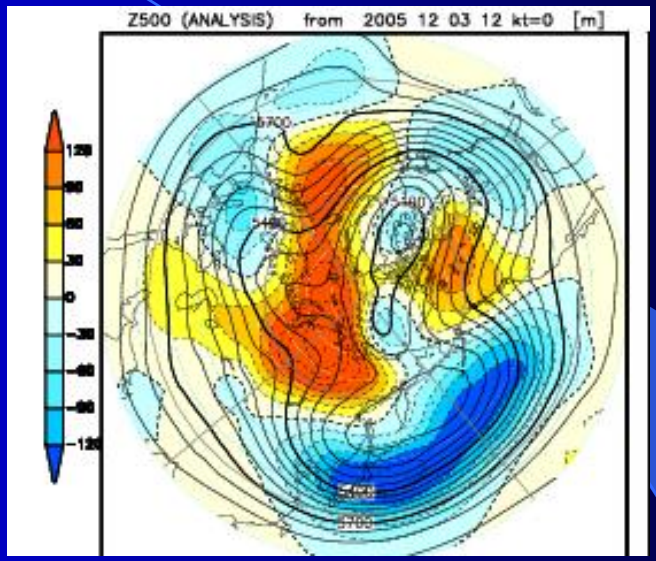
Z500 Observation

Z500 EOF 1 (≒ Arctic Oscillation)

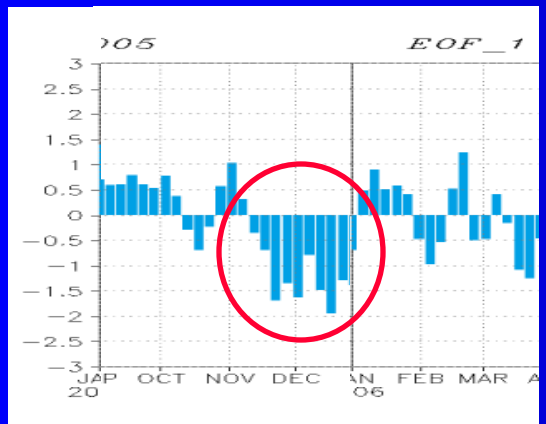
Z500 EOF1 in winter



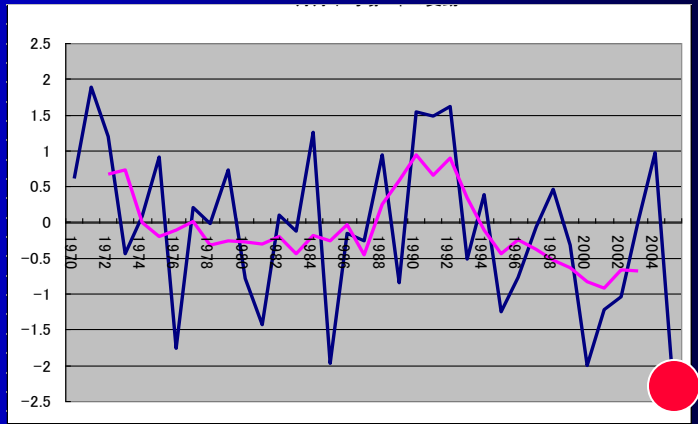
Observed Z500 2005.12.3-12.30



Time series of 'AO' index in 2005/06 winter



Time series of 'AO' index in December from 1979 to 2005



Prediction of the AO

OBS FCST

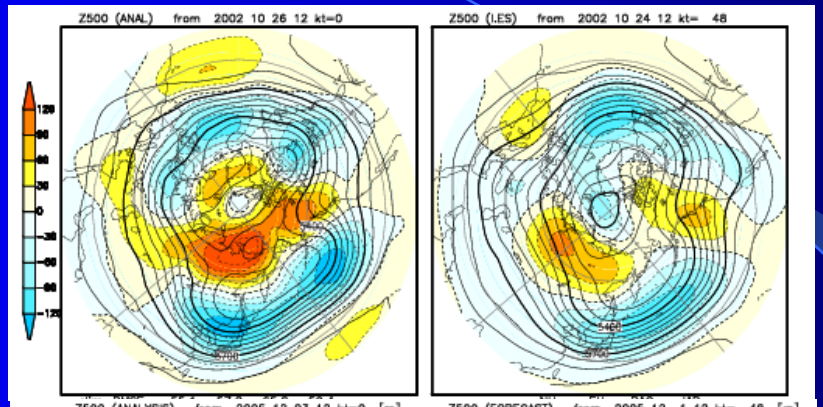
ensemble mean

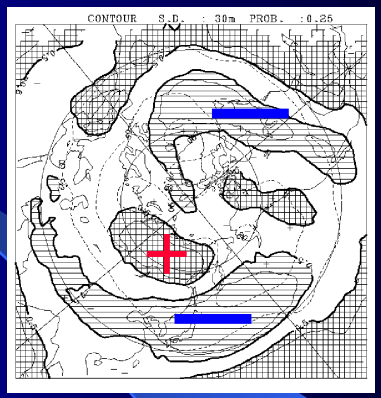
Probabilities of exceeding ±0.5SD

Z500

2002.10.26-11.22

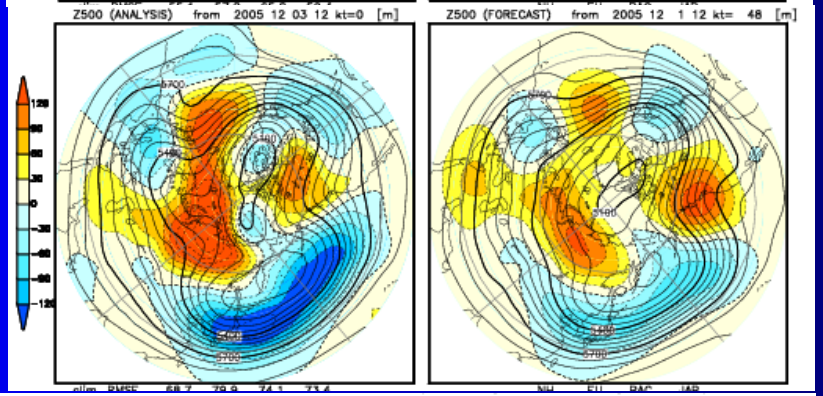
Init: 24th Oct (2-29 day)

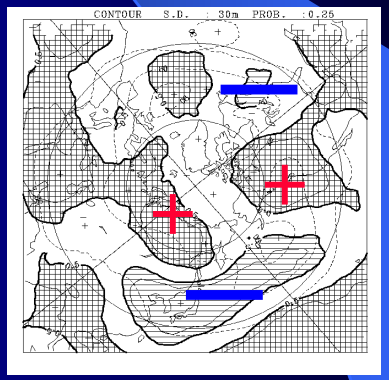




2005.12.3-12.30

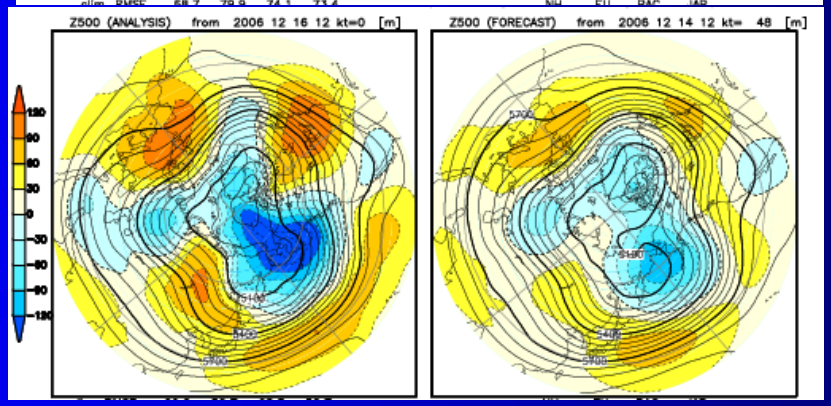
Init: 1st Dec (2-29 day)

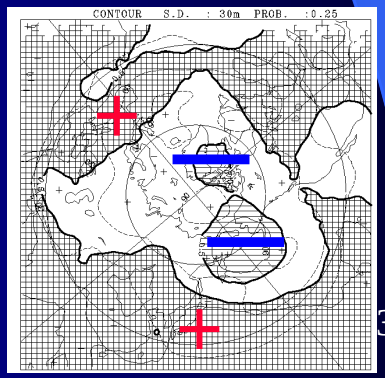




2006.12.16-1.12

Init: 14th Dec (2-29 day)

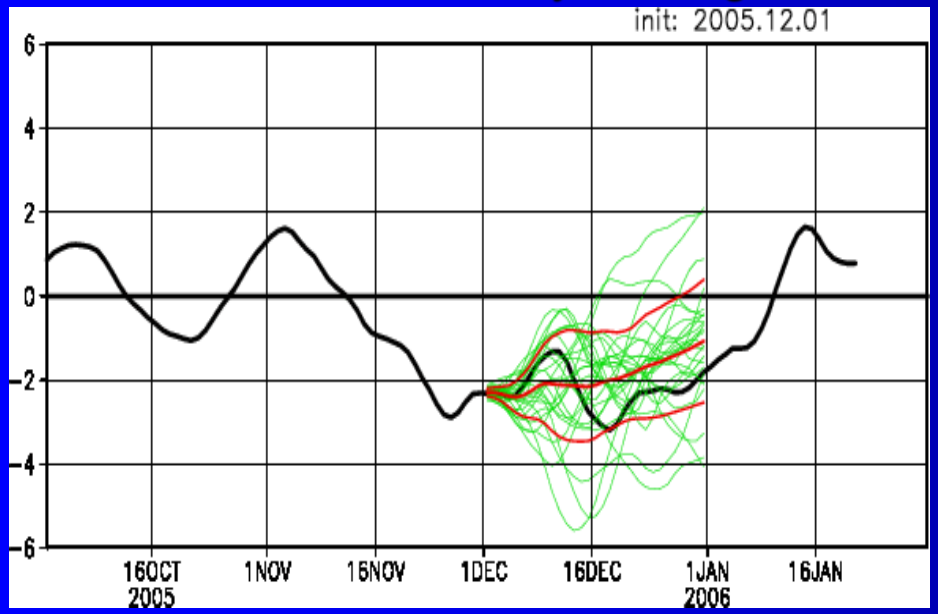




Prediction of EOF1 scores (AO index)

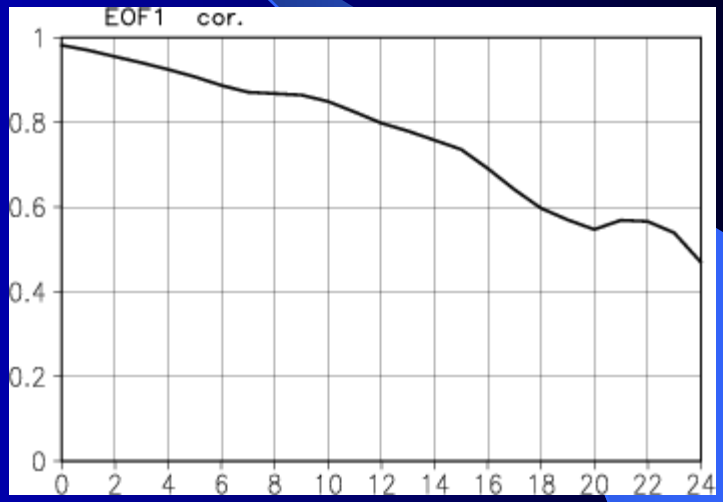
Observed and predicted 7-day running mean AO index .

Init: 1st Dec 2005, 7-day running mean



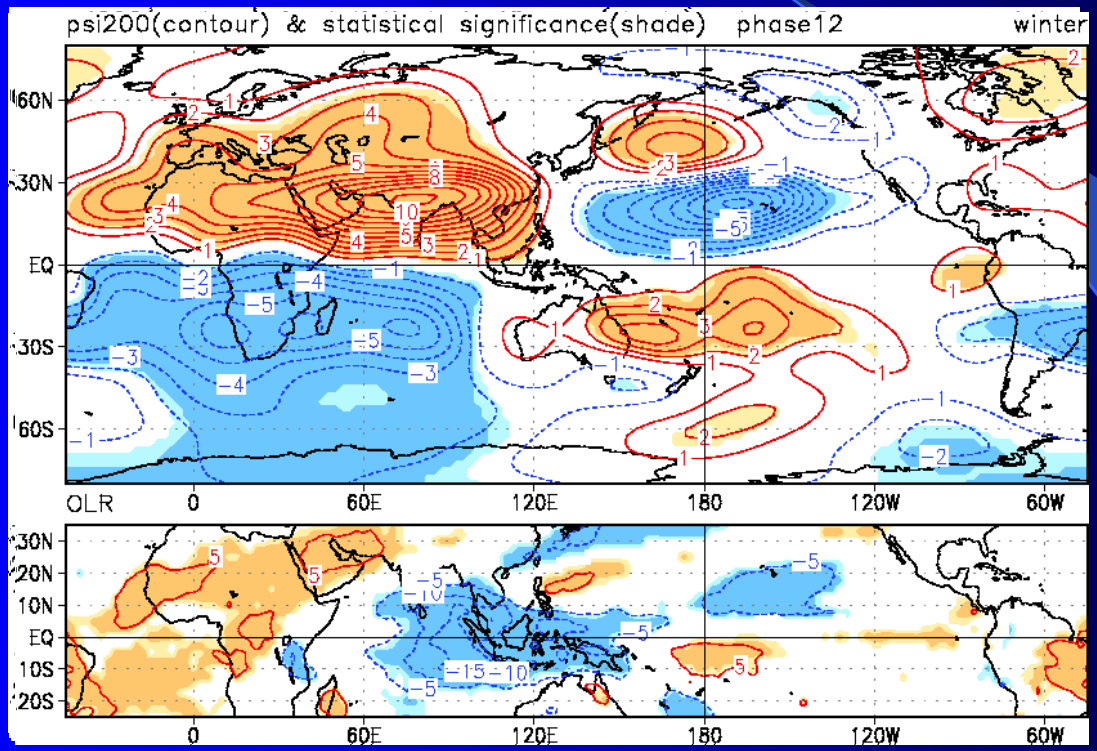
Correlation between observed and predicted (ensemble mean) 7-day running mean AO index .

10 cases (3rd Nov 2005 –5th Jan 2006)



2.3 The Madden-Julian Oscillation (MJO)

Composition maps of stream function at 200hPa and OLR at each phase (1-12) of MJO in winter



Stream function at 200hPa

OLR

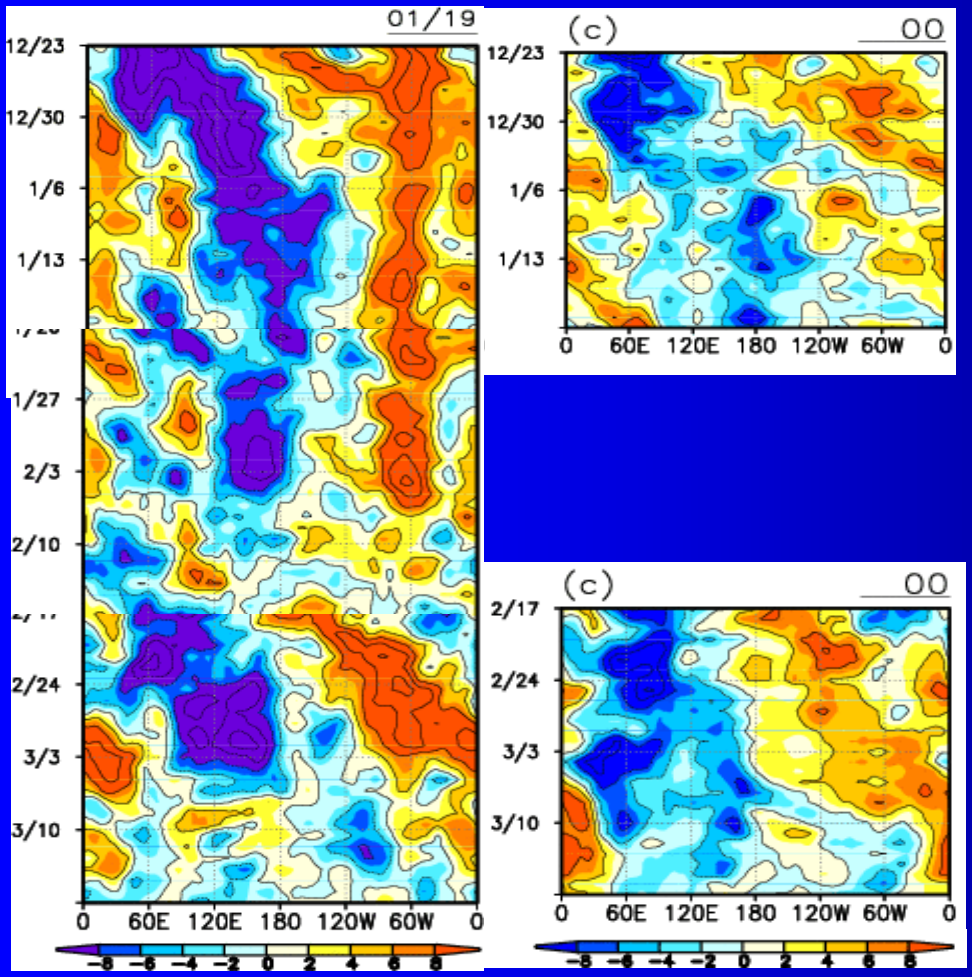
Endoh and Harada (2005)

Prediction of MJO

X-T Diagram of X200 averaged over 5S-5N

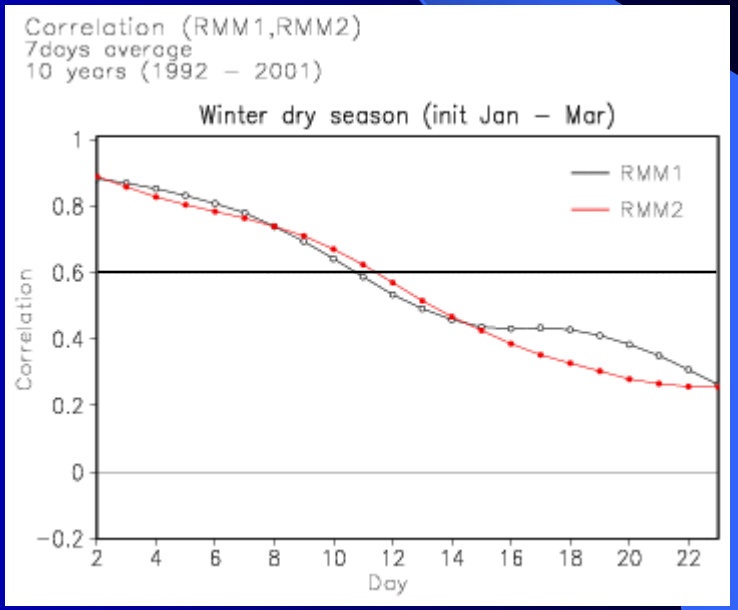
Left: Observation 23th Dec 2006 – 17th Mar 2007

Right: Forecast (initial) 21th Dec 2006 & 15th Feb 2007



Correlation between observed and forecasted (ensemble mean) 7-day running mean MJO index .

Winter dry season (Jan-Mar),10 years hindcast



Lead time (day)

Concluding remarks

1. The JMA one-month EPS

@GPV, forecast charts, verification diagrams are available at TCC Web site

@Users could use these products after checking performance of the EPS

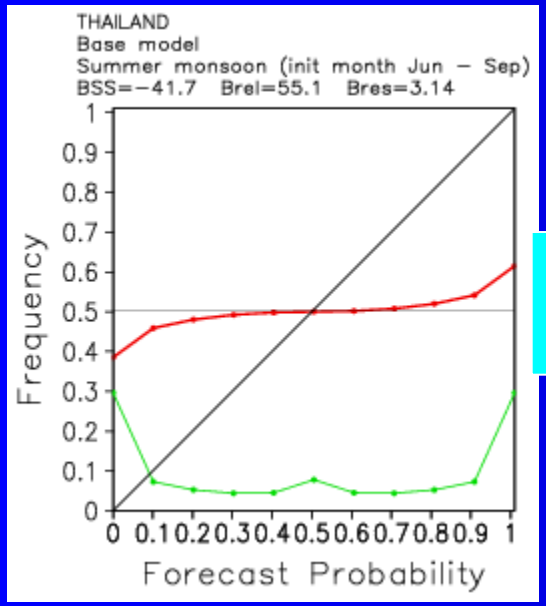
2. Examples of observed and predicted LFV

@To improve our one-month forecasting skills, it is important for operational forecasters to understand the mechanisms and predictabilities of LFV

Thank you

Calibrated Prediction Products

Reliability diagram for 14-day precipitation forecast in Thailand

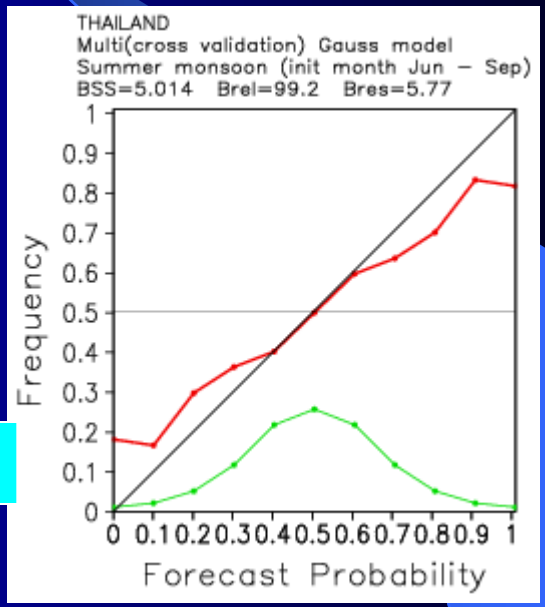


Above/below median Probability

Not reliable
(Overconfident)

Direct use of EPS outputs

Fairly reliable

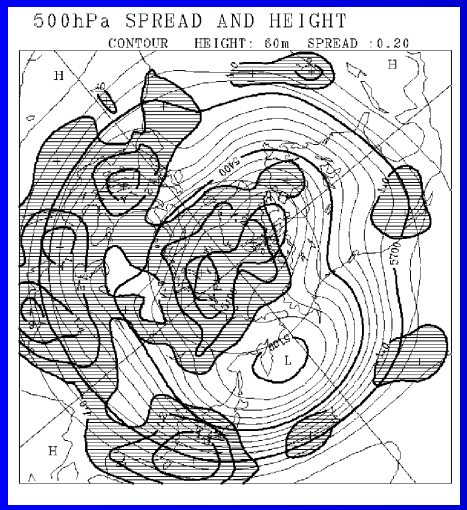


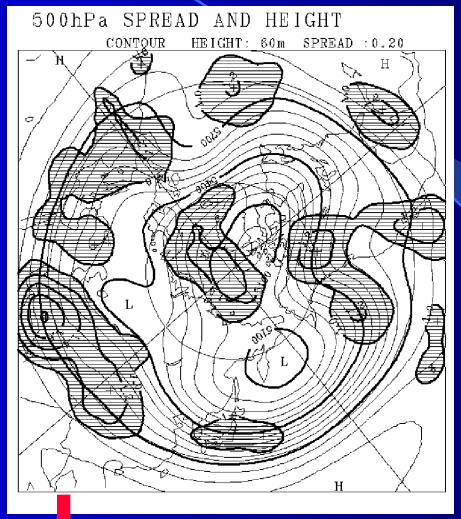
Statistical calibration
(cross validation)

(in developing)

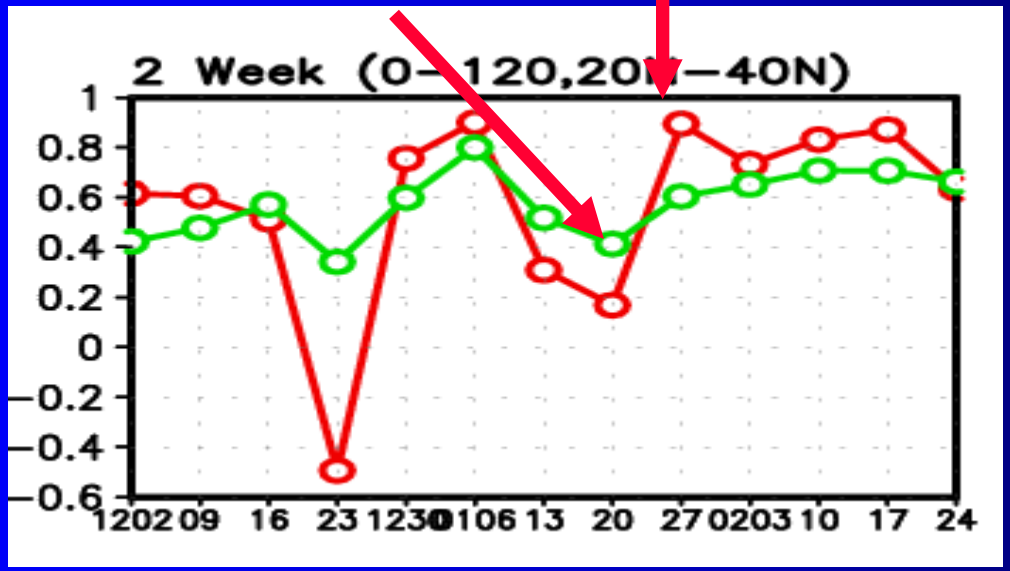
Spread-skill relationship of 2nd weak prediction around the Asian jet in 2004/05 winter

Initial : 20JAN 2005 27JAN2005





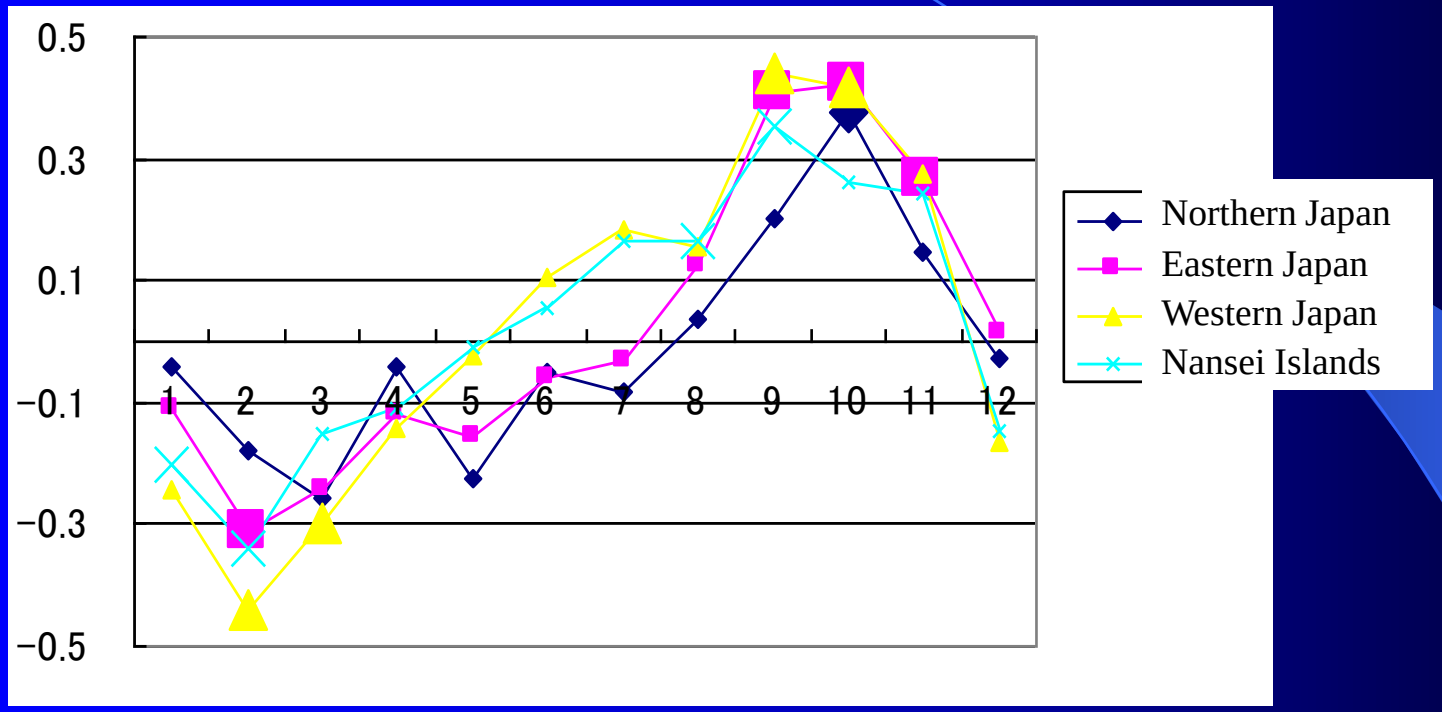
Spread among ensemble members Z500 ; 7-day mean (9-15 day)



Spread (evaluated by anomaly correlation in 0-120E,20-40N) among ensemble members (green) and skill (red) of ensemble mean stream function at 200hPa;7-day mean (9-15 day)

Influence of MJO on temperature in Japan

- ℃ MJO phase and temperature anomalies in winter



Endoh and Harada (2006)

excitation of PNA, Pacific-Japan (PJ) pattern, generation of typhoons, ,,,,,,