# Seasonal Forecasting

TCC Training Seminar on Seasonal Prediction Products

11-15 November 2013

# Outline

- Introduction
- Overview of JMA operational Seasonal Forecast System
- Procedure to make JMA Seasonal Forecast
- Summary

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# Why seasonal forecast is possible?

Because, there are predictable slow variations of the climate system which are deeply influenced by the Ocean

Predictable inter-annual variation such as El Nino, IOD,,,,

By CGCM, El Nino and its instantaneous and delayed influence are well predicted

Decadal, inter-decadal, multi-decadal variation such as PDO

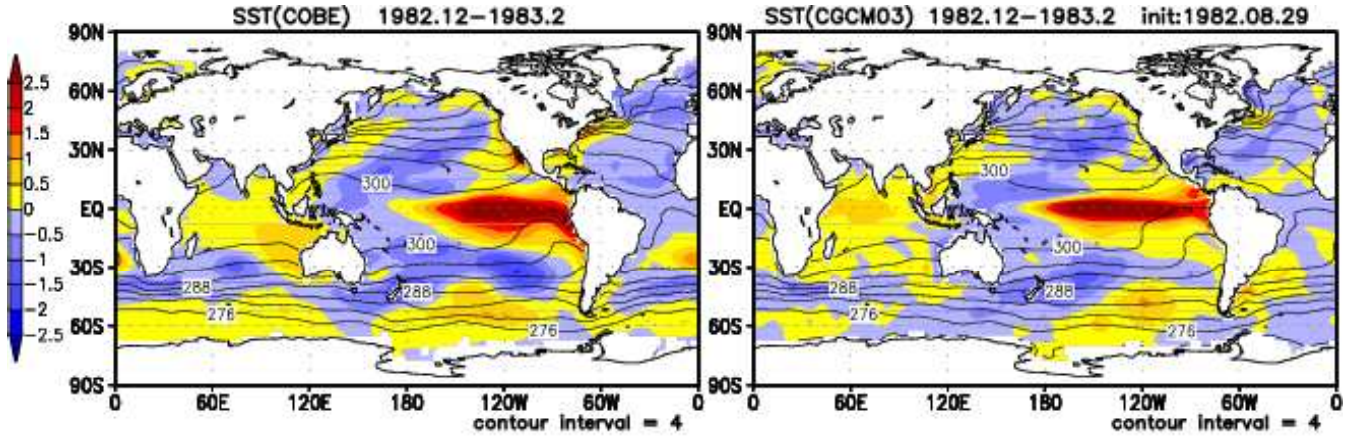
Basically predictable because of its long time scale compared with that of seasonal prediction

Signal for Seasonal Forecast

# Example of El Niño prediction

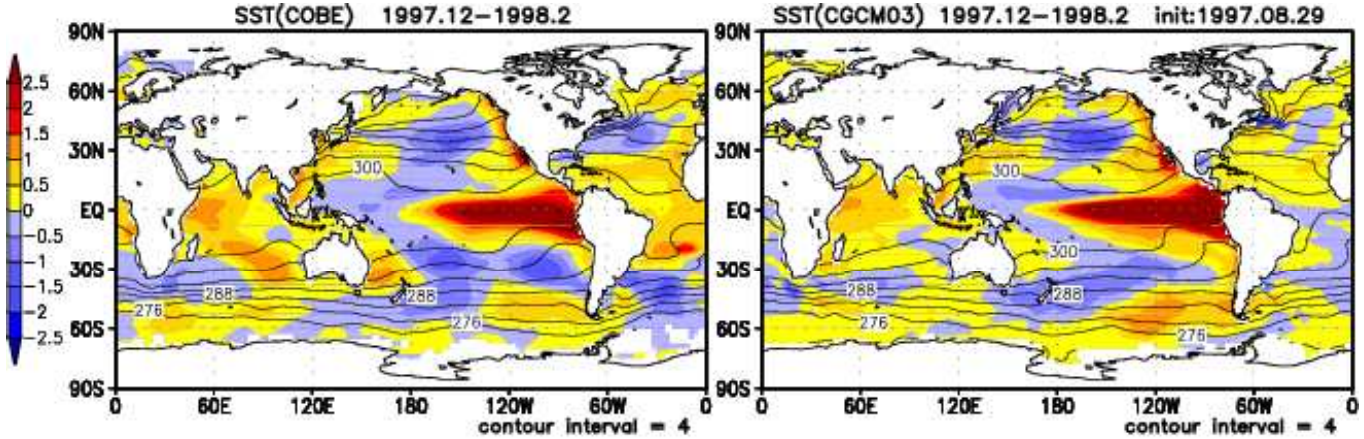
OBS.

Prediction

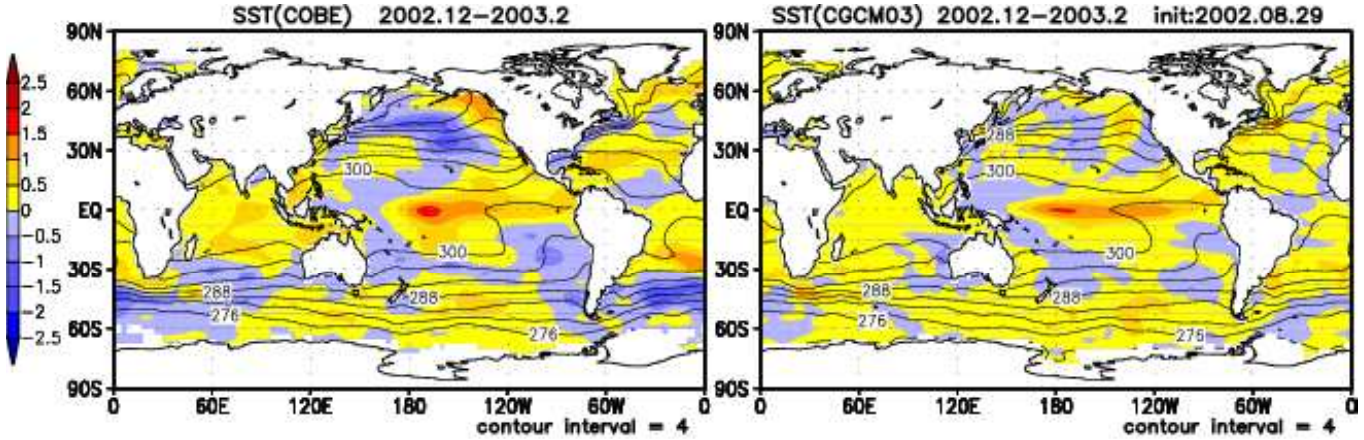



SST and anomaly

Initial Condition :1982.8.29
Prediction
:1982.12～1983.2




Initial Condition :1997.8.29
Prediction
:1997.12～1998.2

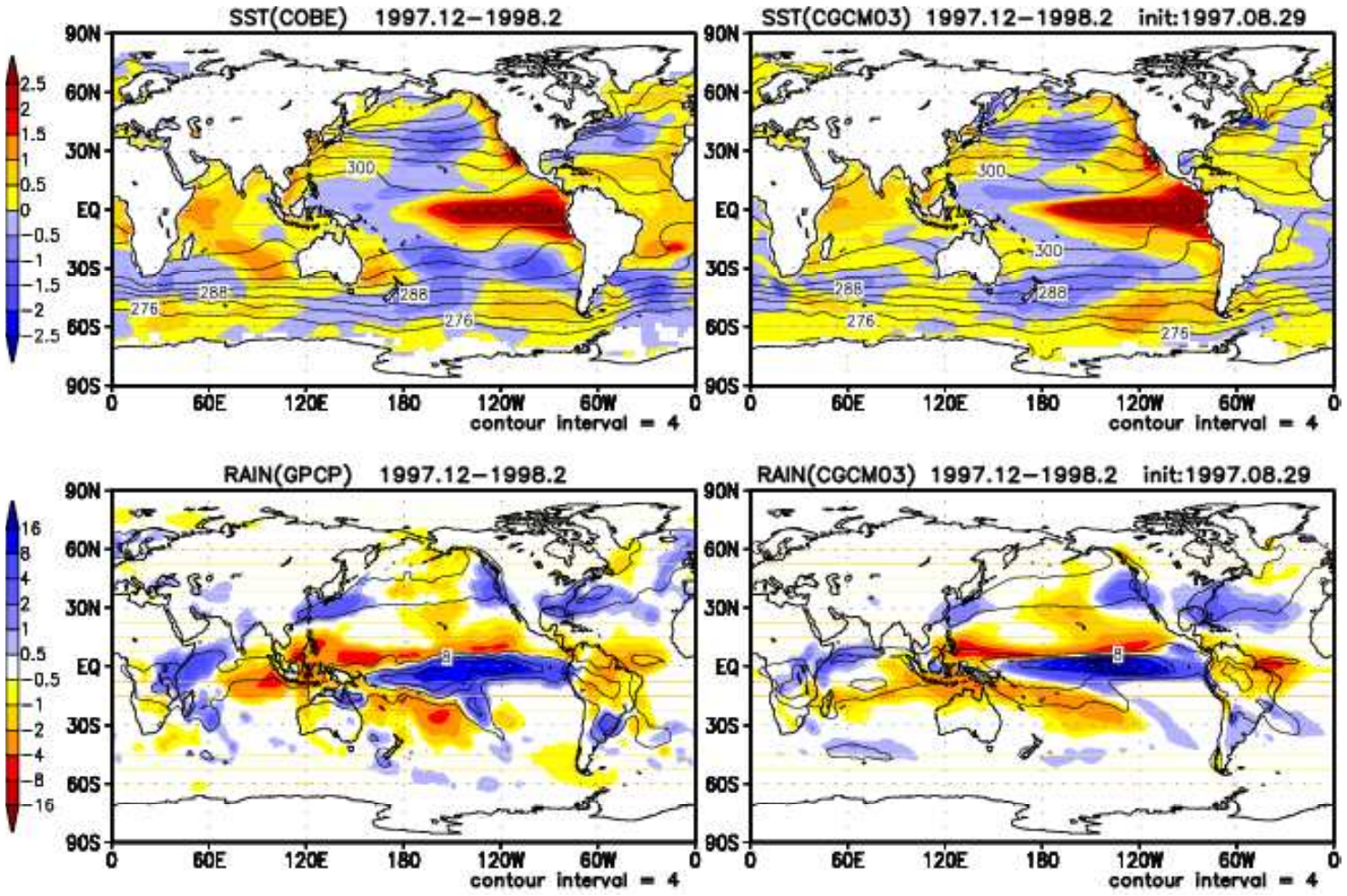



Initial Condition :2002.8.29
Prediction
:2002.12～2003.2

# Example of El Niño prediction

Initial Condition :1997.8.29　Prediction :1997.12～1998.2

**Observation**　　**Prediction**




SST

Precipitation

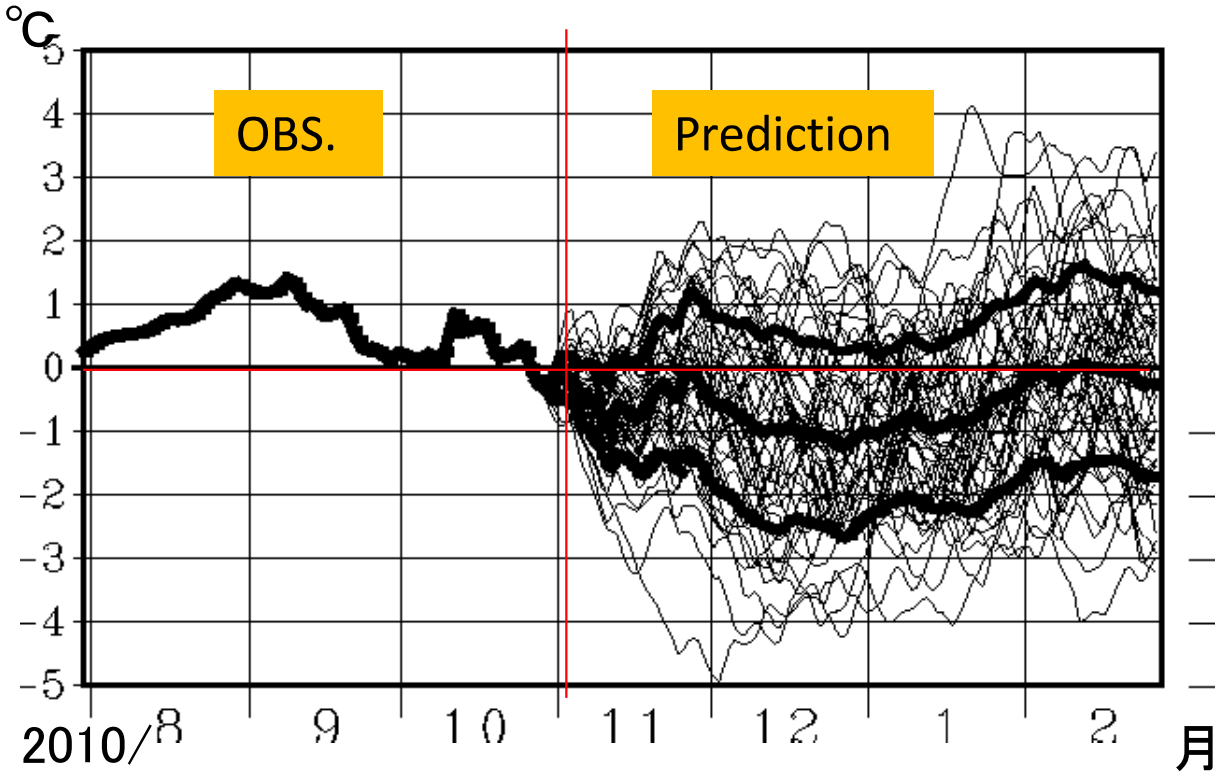
Characteristics of each El Nino are well predicted

# Why seasonal forecast is difficult？

・In the mid– and high latitudes, internal variability of the atmosphere, which is not fully influenced by the ocean, is dominant.
・Since such variability shows chaotic features that small differences in the current status cause huge differences in the future, it is difficult to predict.

## Noise for Seasonal Forecast

Predicted 30–day mean T850 anomalies in Western Japan in 2010/11 winter



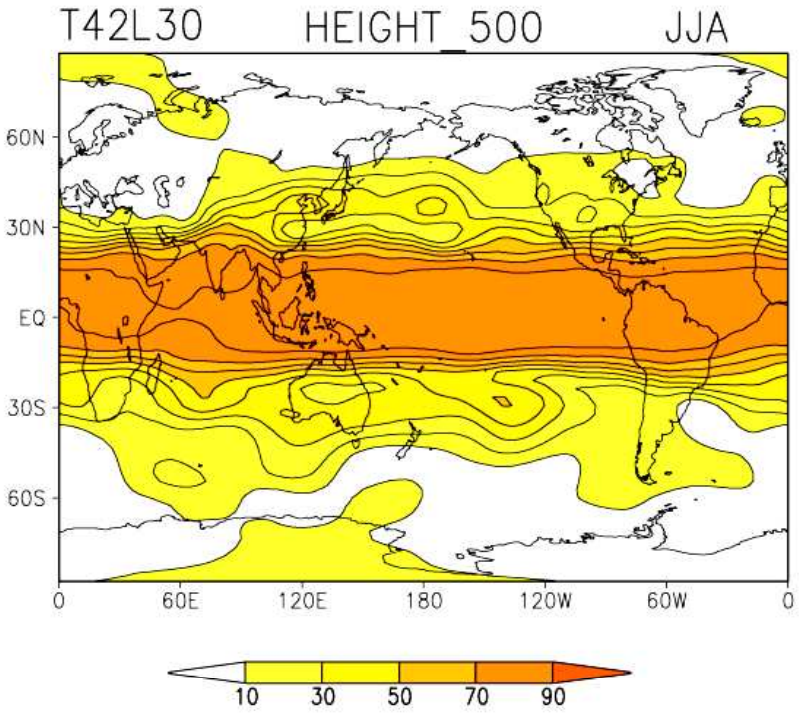

Thin line: each ensemble member
Thick line: Observation and ensemble mean prediction, and ± σ

# How about is Signal/Noise ratio?

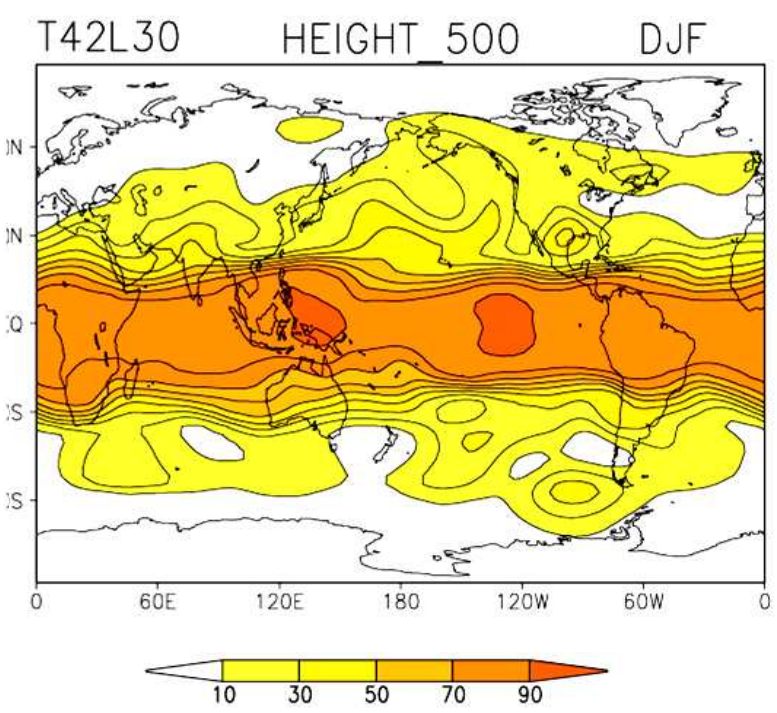
## Predictable variance of Seasonal Mean Fields (500hPa height in JJA and DJF)

**Signal / (Signal+Noise)**

**JJA**




**DJF**




Sugi 2002

Estimation of predictable variance ratio in the atmosphere using GCM with prescribed SST

# Requirements for Seasonal Prediction System

Adequate prediction of both Signal and Noise

- Observation (Atmosphere, Ocean, Land surface) to analyze current situation of climate system
- Numerical Prediction Model to predict Climate System variation
- Ensemble Prediction technique to estimate uncertainty of prediction
- Hindcast (Huge Numerical Experiments for past cases) to assess prediction skill
- Prediction calibration technique using hindcast data

# Requirements for Forecaster

Ability to understand and interpret results of numerical prediction products

Knowledge on

- large scale climate system variation, such as El Nino, and their impacts on local climate
- predictability of variability with seasonal time scale
- characteristic of numerical prediction products

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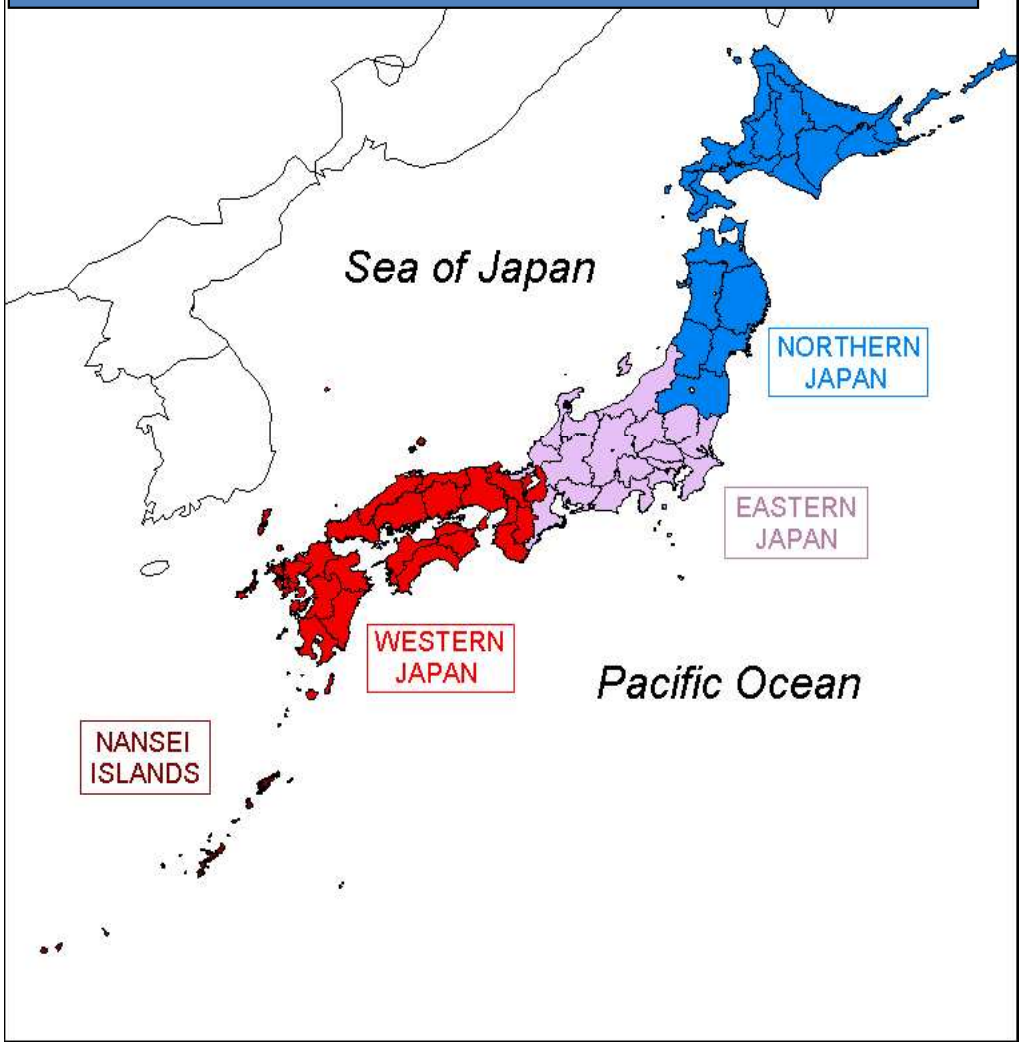
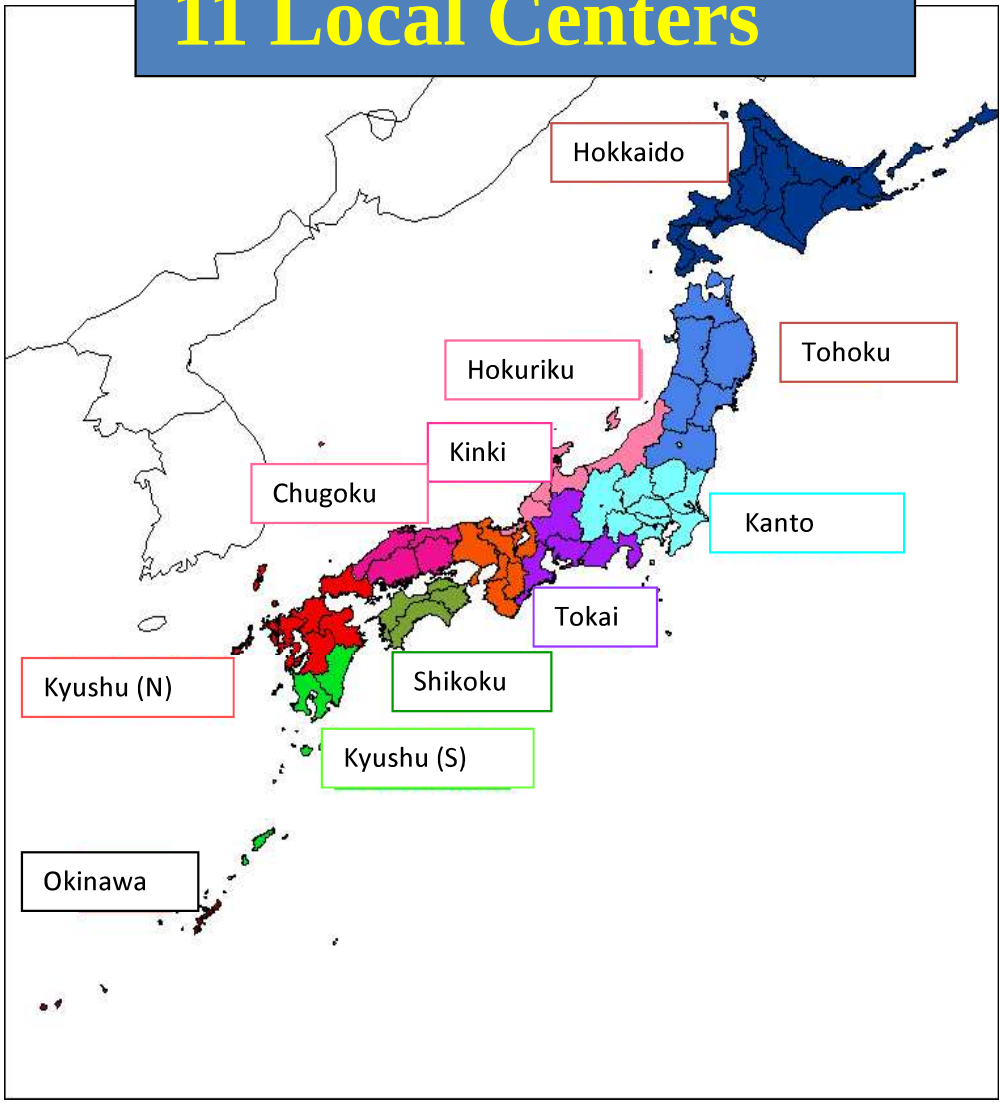
# Operational Seasonal Forecast at JMA

# Forecast regions

## National Center (CPD/JMA)




## 11 Local Centers



# Long-range Forecast Services (1)

| **Cold/Warm season Forecast** (Temperature, Precipitation, Snowfall) | |
|---|---|
| Date of Issue | About 25th in Sep., Oct., Feb., Mar., and Apr. |
| Forecast Period | DJF mean ( Cold season), JJA mean (Warm season) |

**Temperature**

| Forecast Period | 3 months | | |
|---|---|---|---|
| | Dec-Feb | | |
| category | – | 0 | + |
| Northern Japan | 30 | 30 | 40 |
| Eastern Japan | 30 | 40 | 30 |
| Western Japan | 30 | 40 | 30 |
| Okinawa and Amami | 30 | 40 | 30 |


( category – : below normal, 0 : near normal, + : above normal, Unit : %)

**Climate and Outlook in Japan**
**http://ds.data.jma.go.jp/tcc/tcc/products/japan/index.html**

# Long-range Forecast Services (2)

| **Three-month Forecast** (Temperature, Precipitation, Snowfall) | |
|---|---|
| Date of Issue | About 25th in every month |
| Forecast Period | 1st-,2nd-,3rd-month, 3 months mean |

**Temperature**

| Forecast Period | 3 months | | | 1st month | | | 2nd month | | | 3rd month | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct-Dec | | | Oct | | | Nov | | | Dec | | |
| category | – | 0 | + | – | 0 | + | – | 0 | + | – | 0 | + |
| Northern Japan | 20 | 40 | 40 | 20 | 30 | 50 | 30 | 40 | 30 | 40 | 30 | 30 |
| Eastern Japan | 20 | 40 | 40 | 20 | 30 | 50 | 30 | 40 | 30 | 40 | 30 | 30 |
| Western Japan | 20 | 30 | 50 | 20 | 30 | 50 | 30 | 30 | 40 | 40 | 30 | 30 |
| Okinawa and Amami | 20 | 30 | 50 | 20 | 30 | 50 | 20 | 40 | 40 | 40 | 30 | 30 |


( category – : below normal, 0 : near normal, + : above normal, Unit : %)

**Climate and Outlook in Japan**
**http://ds.data.jma.go.jp/tcc/tcc/products/japan/index.html**

# Extended-range Forecast Services (1)

| **One-month Forecast** (Temperature, Precipitation, Sunshine duration, Snowfall) | |
|---|---|
| Date of Issue | Every Friday |
| Forecast Period | 1st-, 2nd-,3rd &4th –week, 1 month mean |

**Temperature**

| Forecast Period | 1 month | | | 1st week | | | 2nd week | | | 3rd-4th week | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.24-8.23 | | | 7.24-7.30 | | | 7.31-8.6 | | | 8.7-8.20 | | |
| category | – | 0 | + | – | 0 | + | – | 0 | + | – | 0 | + |
| Northern Japan | 10 | 30 | 60 | 10 | 20 | 70 | 20 | 40 | 40 | 30 | 40 | 30 |
| Eastern Japan | 10 | 30 | 60 | 10 | 30 | 60 | 20 | 30 | 50 | 30 | 40 | 30 |
| Western Japan | 10 | 30 | 60 | 20 | 40 | 40 | 10 | 30 | 60 | 20 | 40 | 40 |
| Okinawa and Amami | 10 | 30 | 60 | 20 | 40 | 40 | 20 | 30 | 50 | 20 | 30 | 50 |


( category – : below normal, 0 : near normal, + : above normal, Unit : %)

**Climate and Outlook in Japan**
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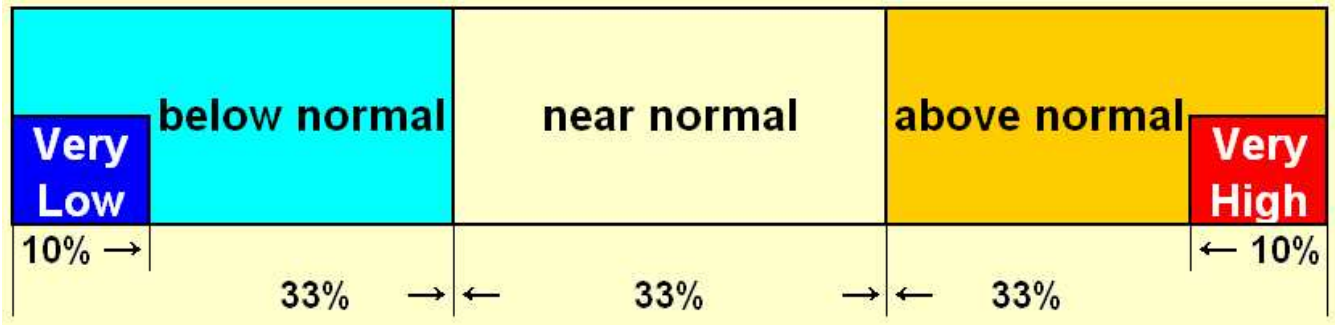
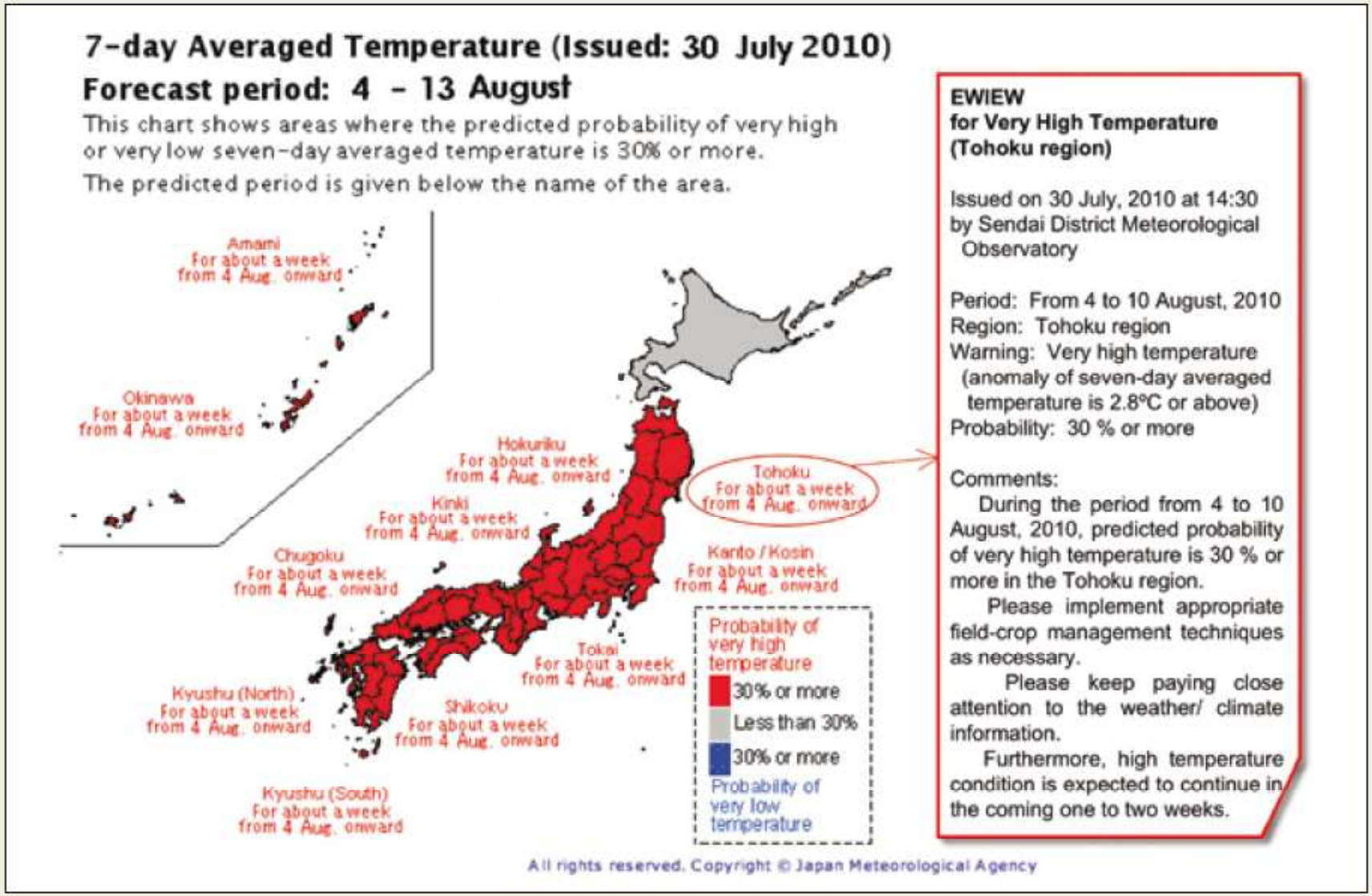
# *Early Warning Information on Extreme Weather*

- **Arbitrary 7-day mean temperature anomaly up to two weeks ahead**
- **Issuing the Information as the probability of very high / low over 30%**
- **11 local centers issuing for each area**
- **Information is updated twice a week (every Tuesday and Friday)**
- **Probabilistic Products are Provided JMA's web site**

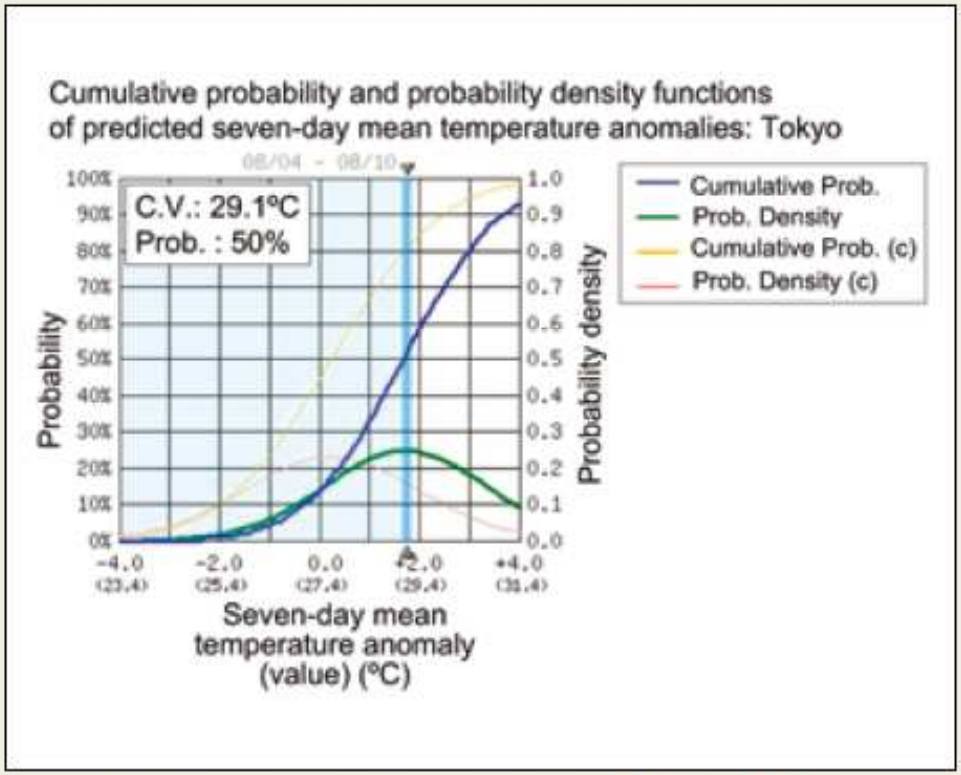


# Early Warning Information on Extreme Weather




An EWIEW map issued on 30 July 2010. EWIEW is in effect in the red and blue areas (with a 30 per cent or more probability of very high or low seven-day mean temperatures respectively). The box on the right shows text information issued for the Tohoku region (originally in Japanese)

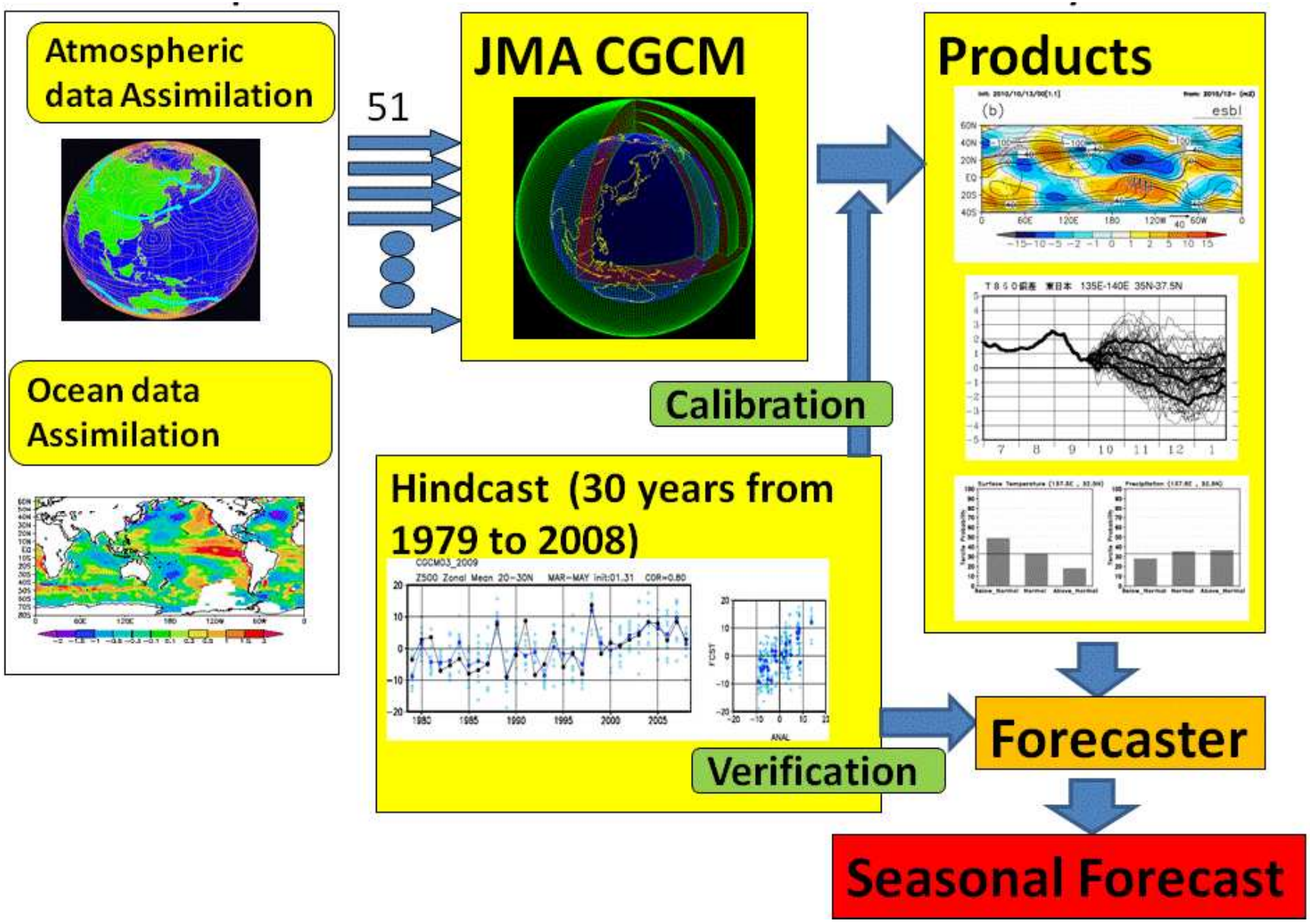
# *Early Warning Information on Extreme Weather*




Cumulative probability function (CPF) and probability density function (PDF) of predicted T7d anomalies for 4-10 August 2010, issued on 30 July for Tokyo. The horizontal axis shows the T7d anomaly. The blue and green lines show the CPF and PDF for the prediction, while the yellow and pink lines show those for the occurrence of climatology values. Users can change the critical value (the light-blue line) on the website to see the cumulative probability applicable to the area shaded in light blue (originally in Japanese).

# Operational Seasonal Forecast System at JMA

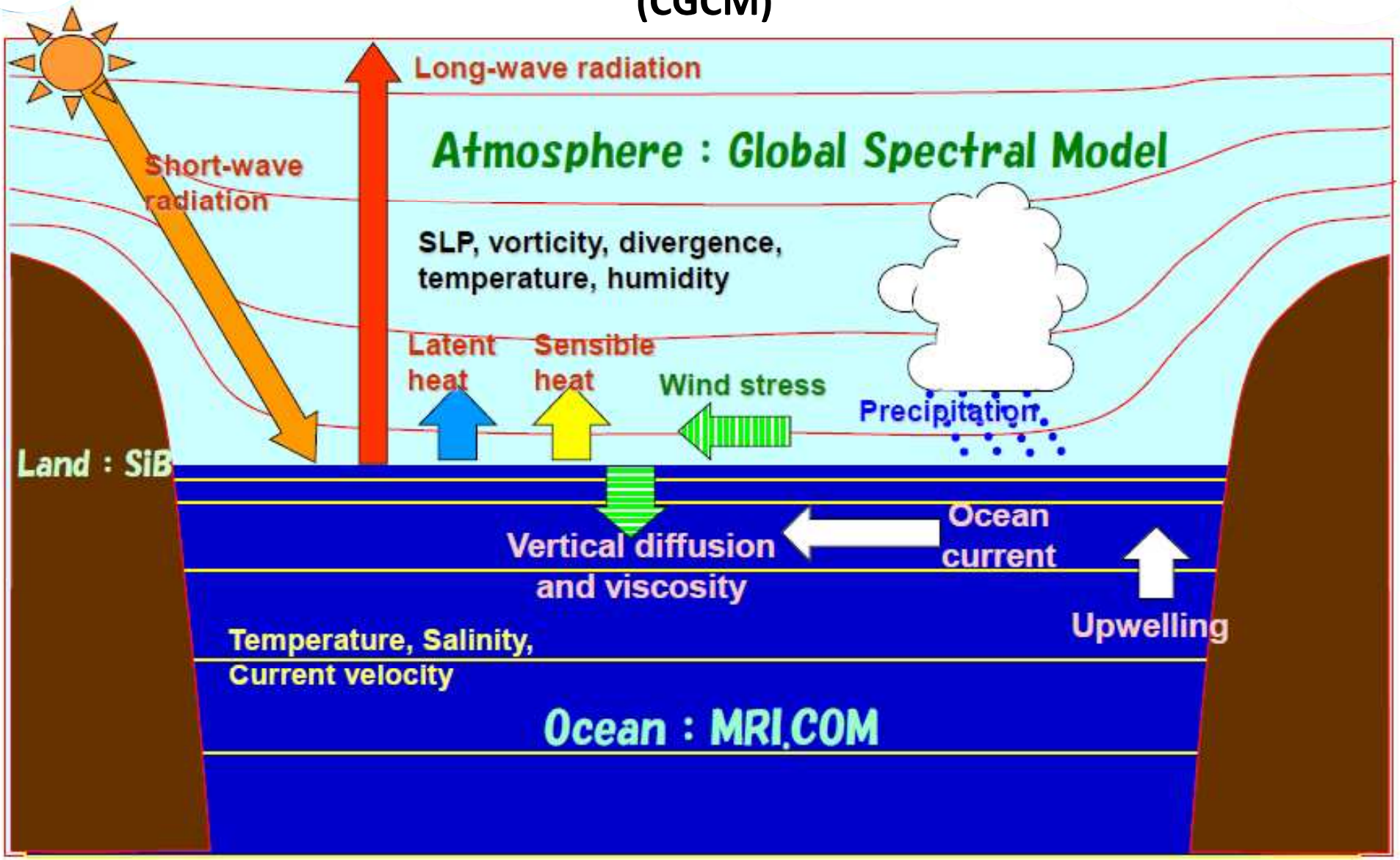
# JMA Operational Seasonal Forecast System




For 3-month, cold season and warm season forecast

# JMA Long-range Forecasting Model

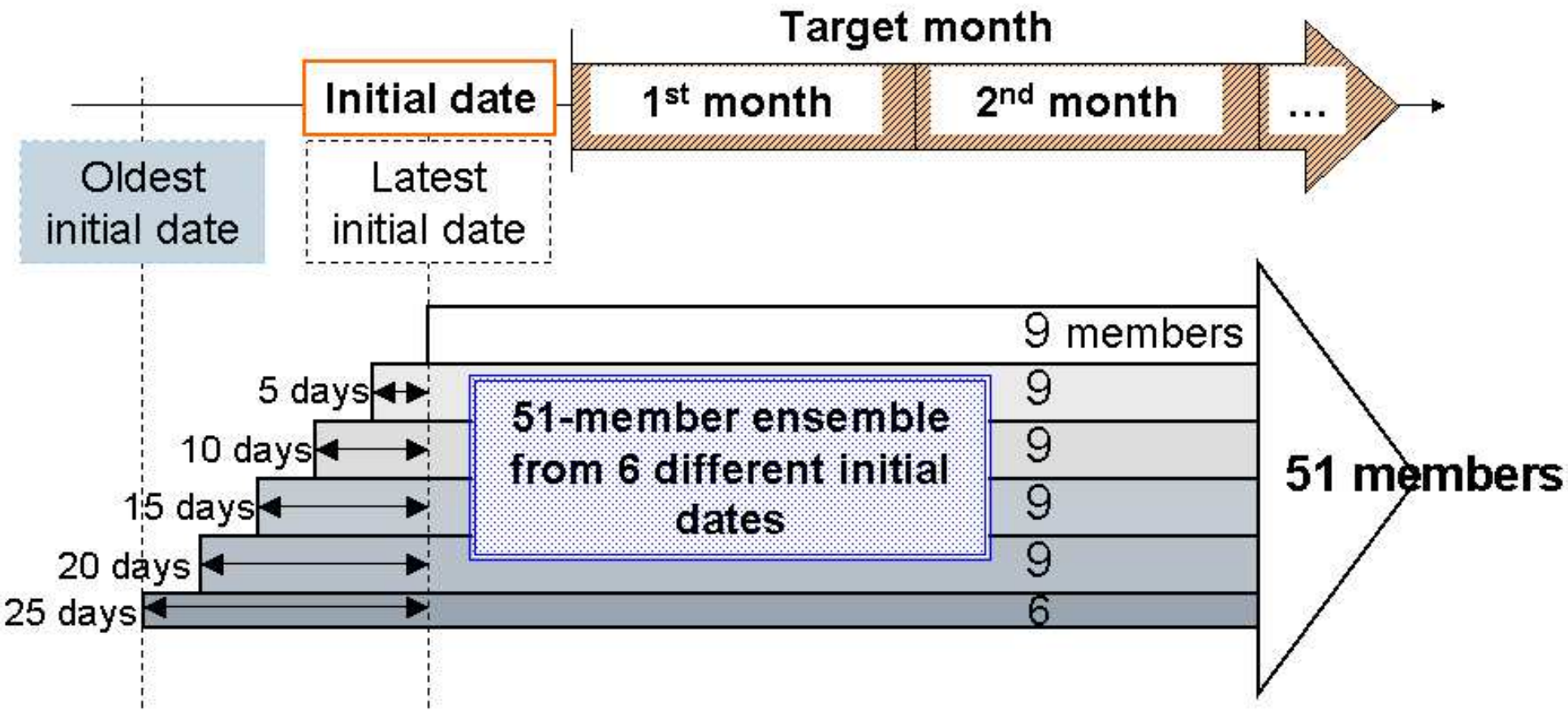
**Coupled ocean-atmosphere General Circulation Model (CGCM)**



# Specifications of the NWP model for Long-range forecast

| | |
|---|---|
| Model | JMA/MRI-CGCM |
| Horizontal resolution | AGCM: TL95 (about 1.875º Gaussian grid ~180km)<br>OGCM: 1.0deg in lon. X 0.3-1.0 deg in lat. |
| Vertical Layers | AGCM: 40 (Top Layer Pressure:0.4hPa)<br>OGCM: 50 |
| Time integration range | 7 months |
| Executing frequency | Every five days (9 members for each initial date) |
| Ensemble size | 51 members from six different initial dates. |
| Perturbation method | Breeding Growing Mode (BGM) & Lagged Average Forecast (LAF) method |
| SST | One-tiered method |
| Land surface Parameters | Climatology |

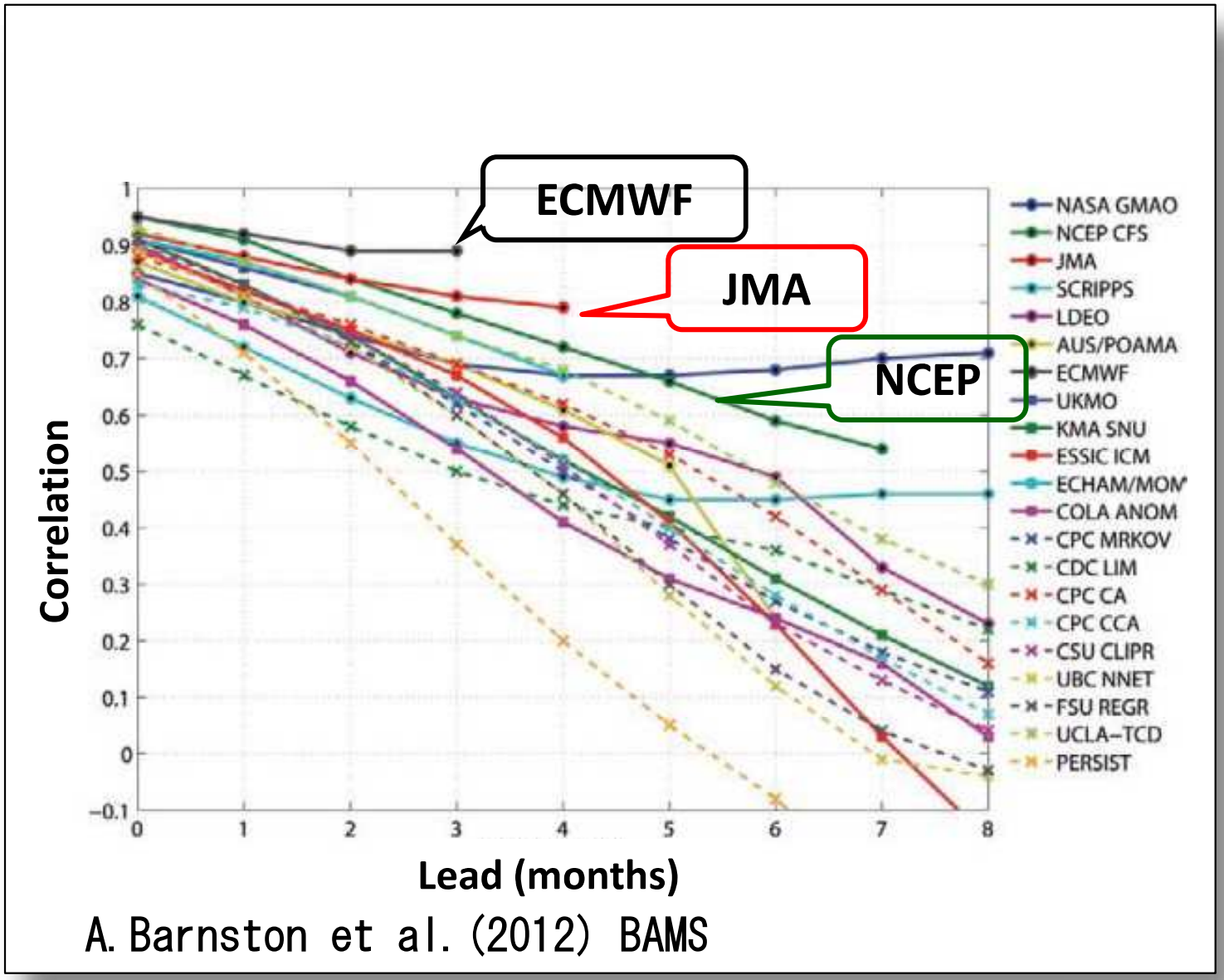
# Schema of aggregation for the ensemble members in the EPS for long-range forecasting



# Hindcast

Period : 30 years from 1979 to 2008
Initial date : around the end of every month
Integration time : 7 months
Ensemble size : 10

NINO.3.4 SST ACC: dependency on lead time



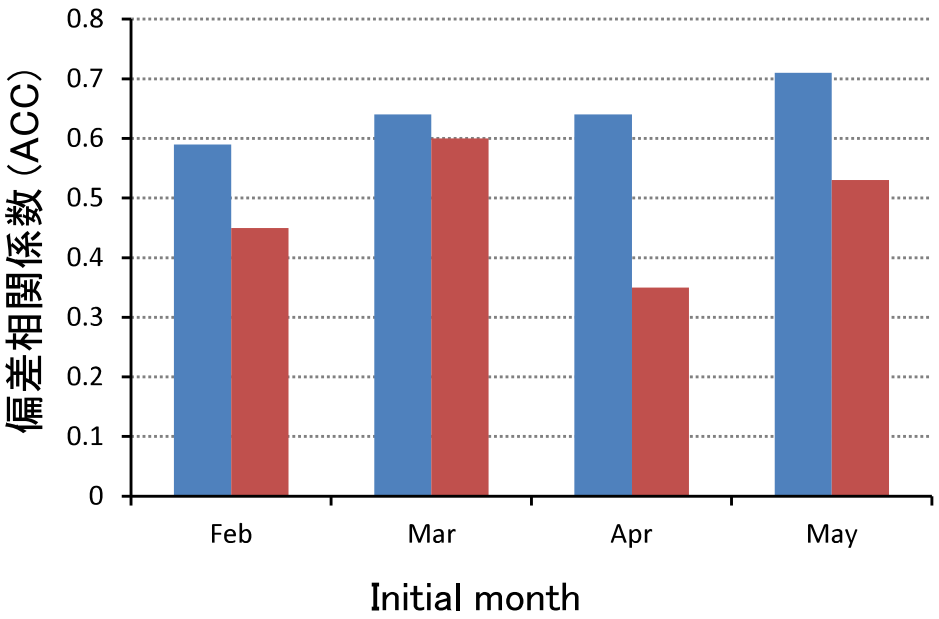

A. Barnston et al. (2012) BAMS

**JMA's ENSO prediction is one of the best in the world!**

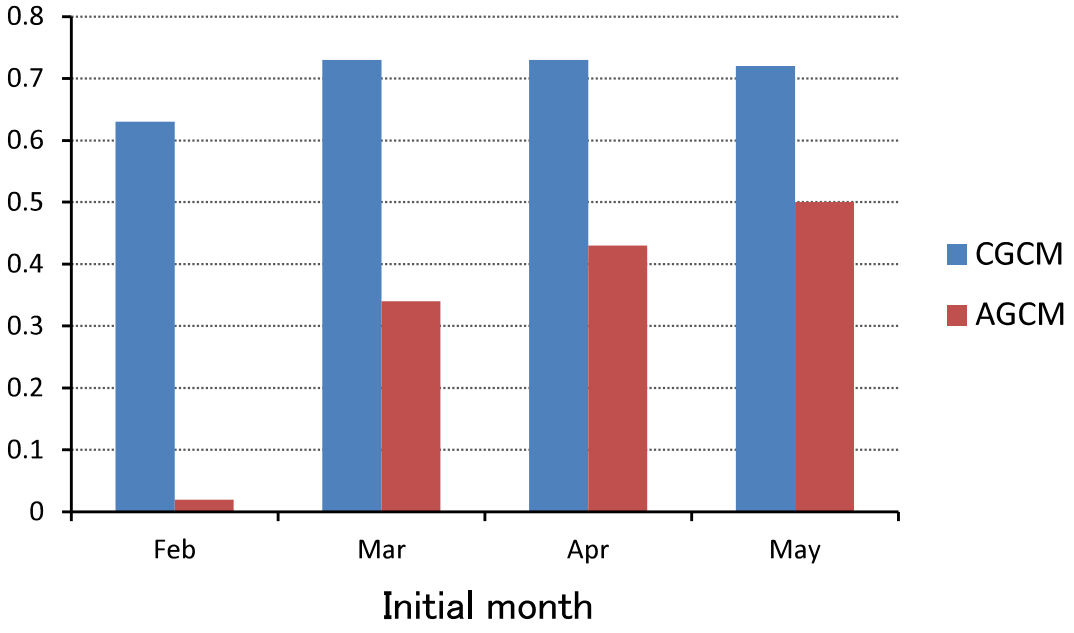
Temporal correlation between model forecasts and observations for all seasons combined, as a function of lead time. Each line highlights one model. The eight statistical models and the persistence model are shown with dashed lines and the cross symbol.

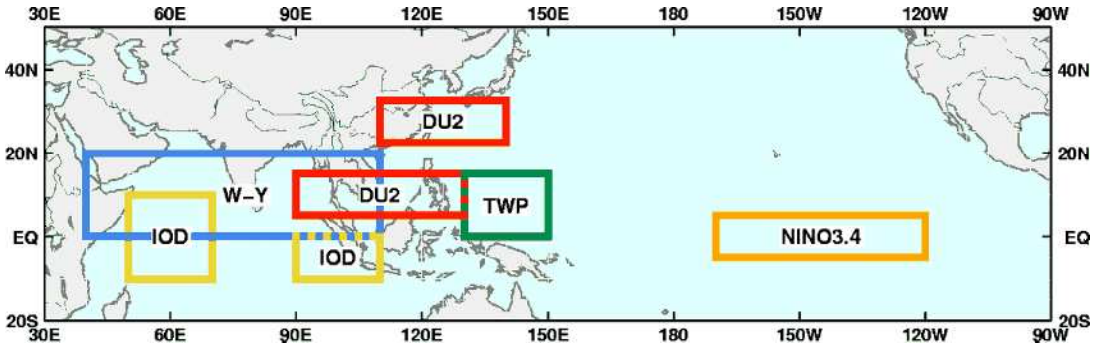
# Asia Monsoon Circulation (JJA)

## WY : Webster Yang (1992)




## DU2 : Wang and Fan (1999)

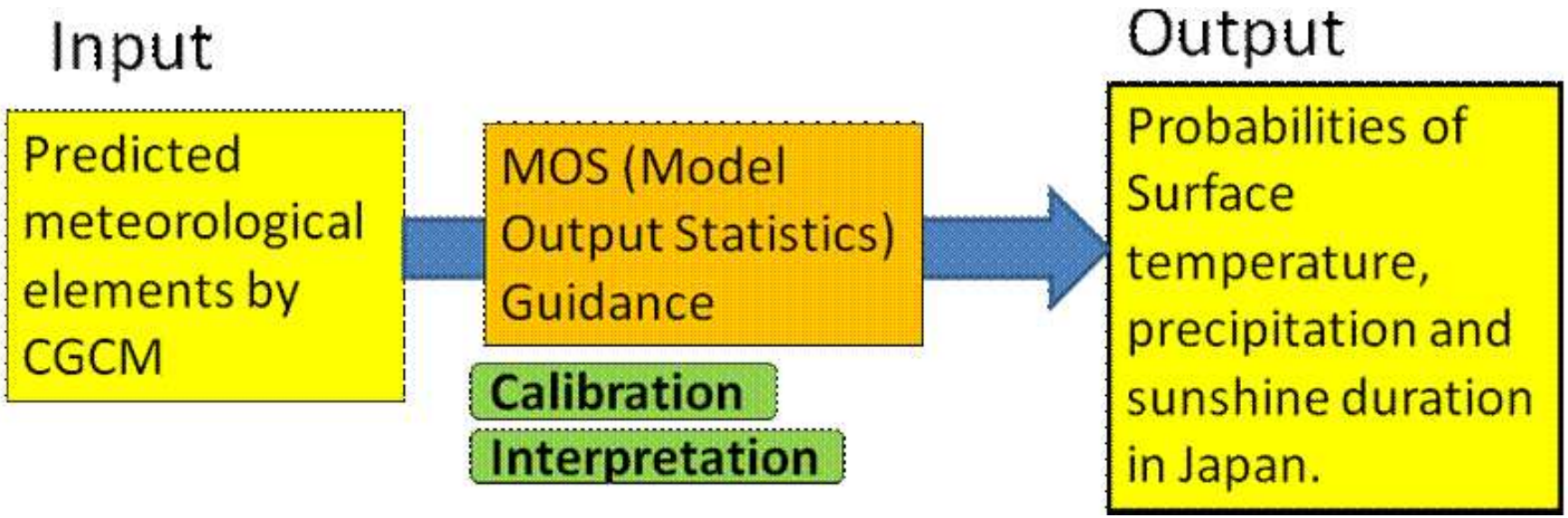



WY index : U850−U200
(0−20N, 40−110E)
DU2 index: U850 (5−15N,90−130E)
− U850(22.5−32.5N,110−140E

**Based on hindcast with the new seasonal forecast system (1984−2005)**

# NWP Guidance




Surface temperature

| Category | − | 0 | + |
|---|---|---|---|
| Northern Japan | 20 | 40 | 40 |
| Eastern Japan | 20 | 40 | 40 |
| Western Japan | 20 | 40 | 40 |
| Okinawa and Amami | 30 | 40 | 30 |

(Category −: below normal, 0 : normal, + : above normal, Unit: %)

**Outlook for summer 2013 temperature probability in Japan**

Precipitation

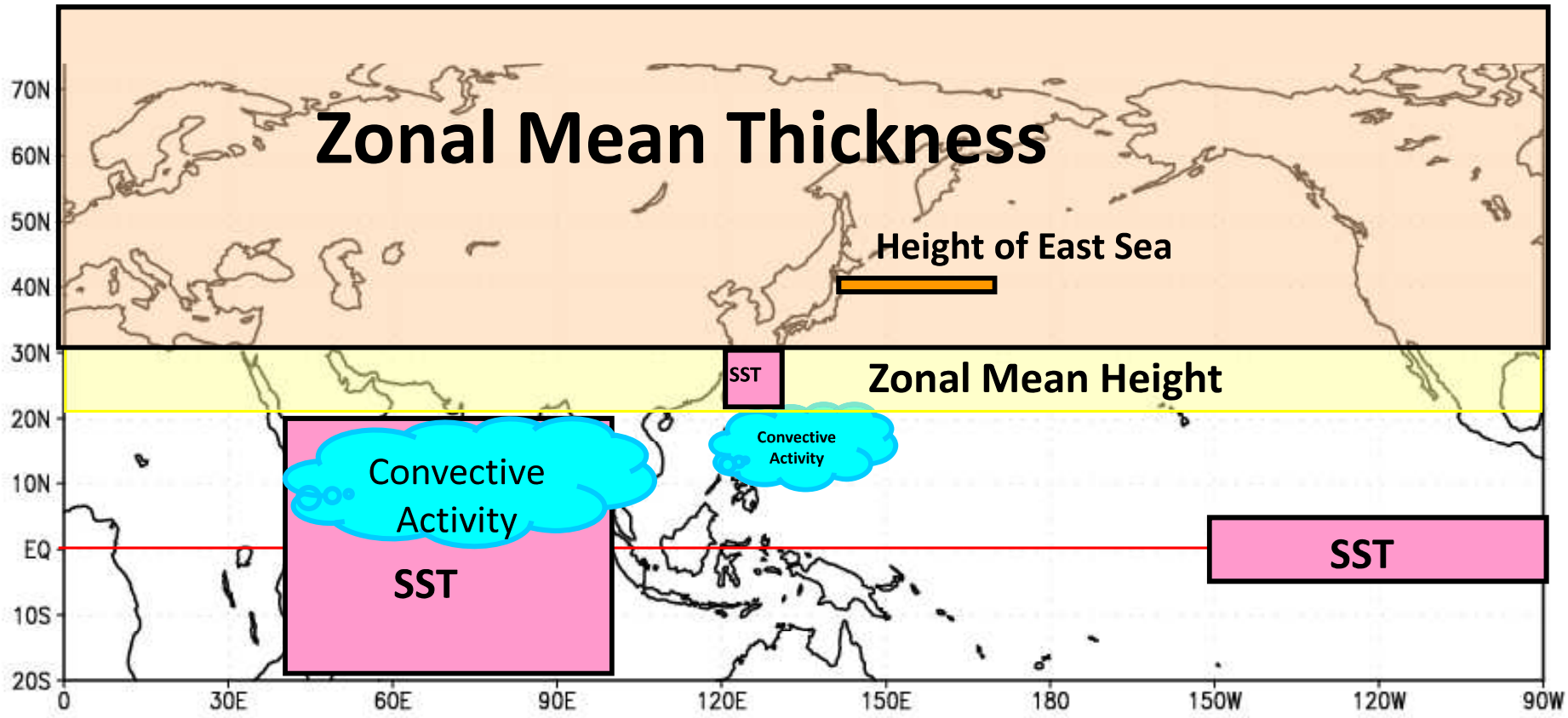
| Category | | − | 0 | + |
|---|---|---|---|---|
| Northern Japan | Sea of Japan side | 40 | 30 | 30 |
| | Pacific side | 40 | 30 | 30 |
| Eastern Japan | Sea of Japan side | 40 | 30 | 30 |
| | Pacific side | 40 | 30 | 30 |
| Western Japan | Sea of Japan side | 30 | 40 | 30 |
| | Pacific side | 30 | 40 | 30 |
| Okinawa and Amami | | 20 | 40 | 40 |

(Category −: below normal, 0 : normal, + : above normal, Unit: %)

**Outlook for summer 2013 precipitation probability in Japan**

# Predictors

We considered the predictors to grasp signals of the tropical variation and global warming.




Predictands are surface temperature, precipitation and sunshine duration in Japan.

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# Procedure (1)

Check up 'signal' using ensemble mean prediction maps

SST in the tropics → Precipitation in the tropics → Upper tropospheric large scale divergent flow in the tropics → Lower and upper tropospheric large scale rotational flow in the tropics → their influences to Japan

Figure out the relationship between predicted large scale predictable climate variability, such as El Nino, and variability around Japan

# Procedure (2)

Check up prediction skill using hindcast  verification charts

Check up ‘noise’ using each member prediction maps

Figure out uncertainty of predicted fields

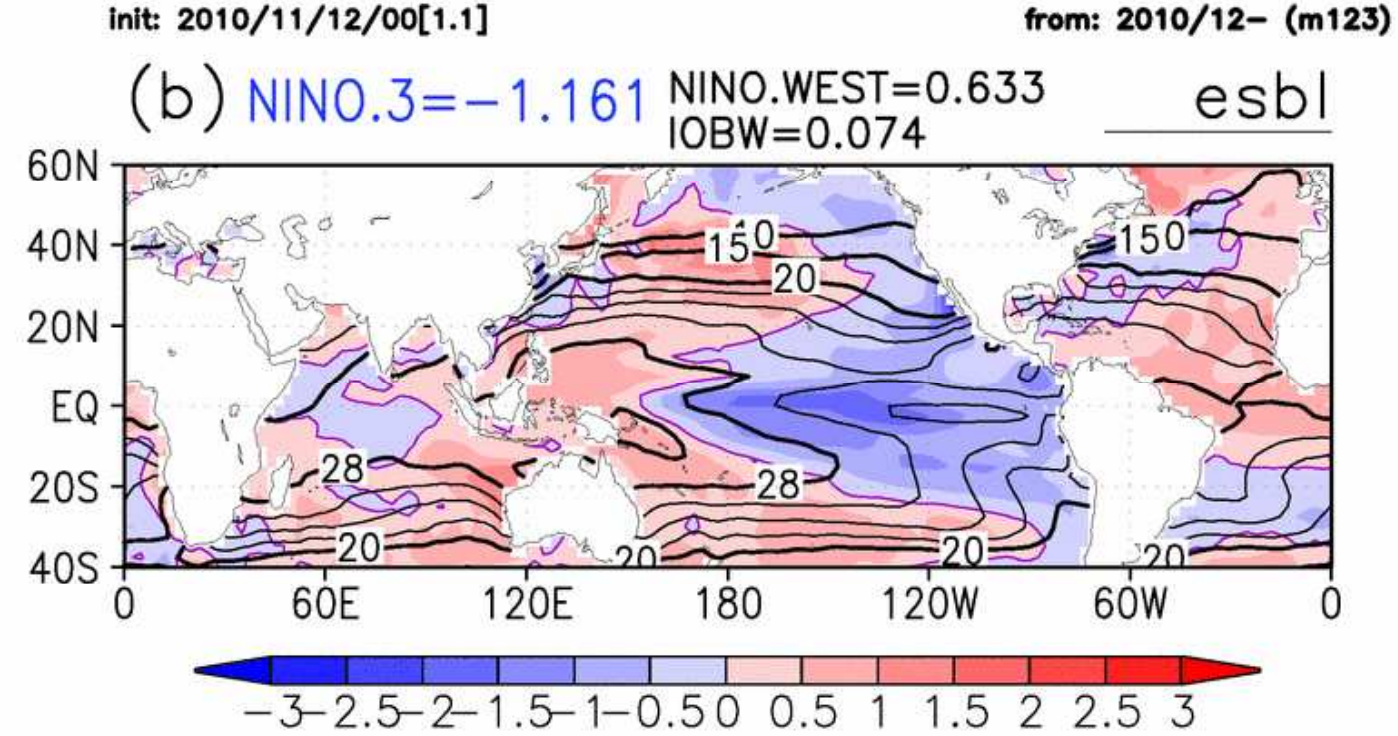
# Procedure (3)

Check up predicted probabilities by NWP guidance, and modify the probabilities of NWP guidance based on results of procedure 1 & 2, skills of the guidance, and characteristic of recent climate

Make decision

# Ex. Seasonal forecast for 2010/2011 winter from Nov. 2010

Predicted DJF SST anomalies ( ensemble mean)

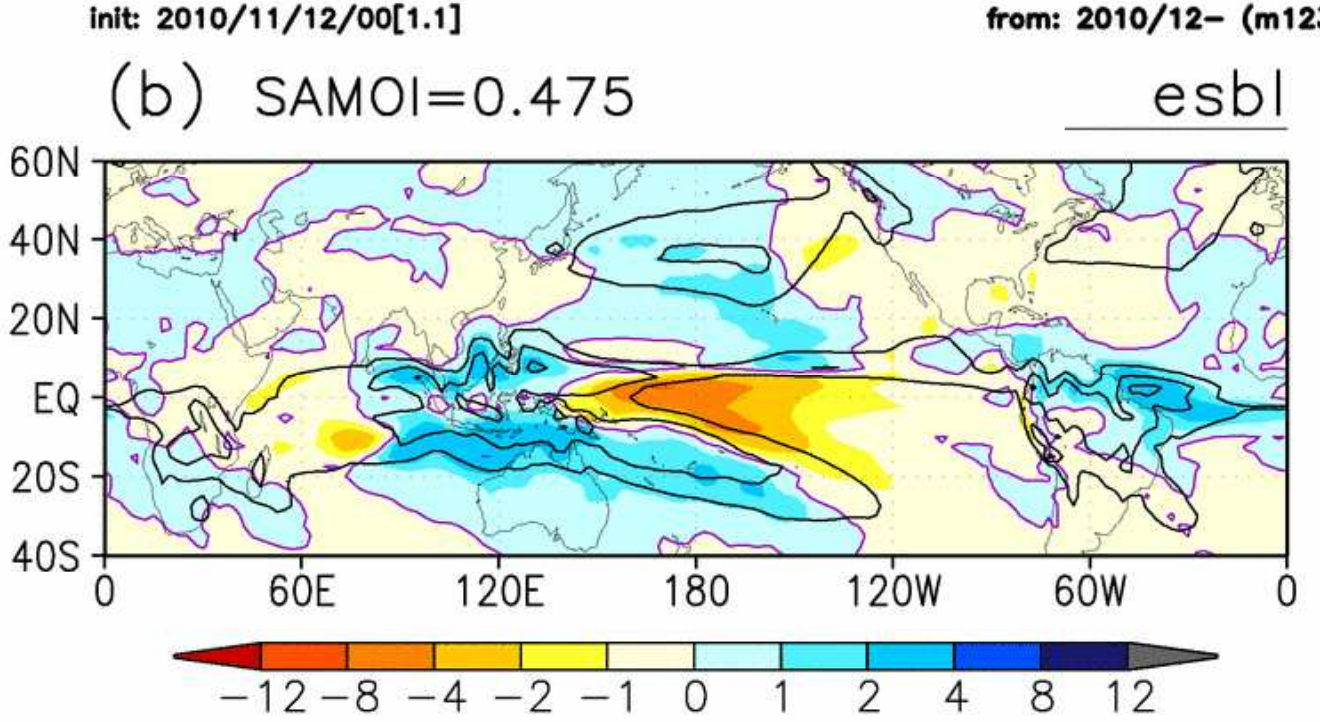



@La Nina will continue

@ Positive SSTA around the Maritime Continent and the tropical Western Pacific

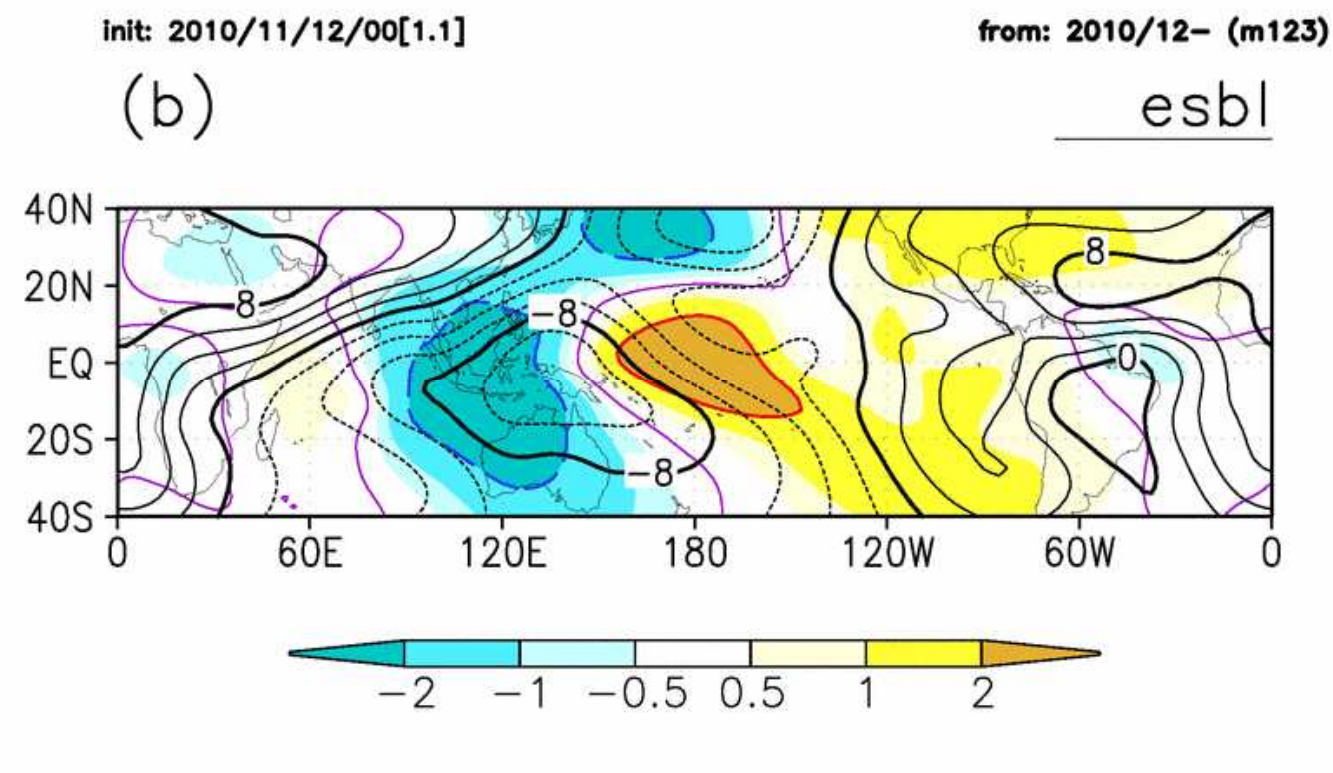
# Signal predicted by the Numerical Model

Predicted DJF precipitation anomalies ( ensemble mean)



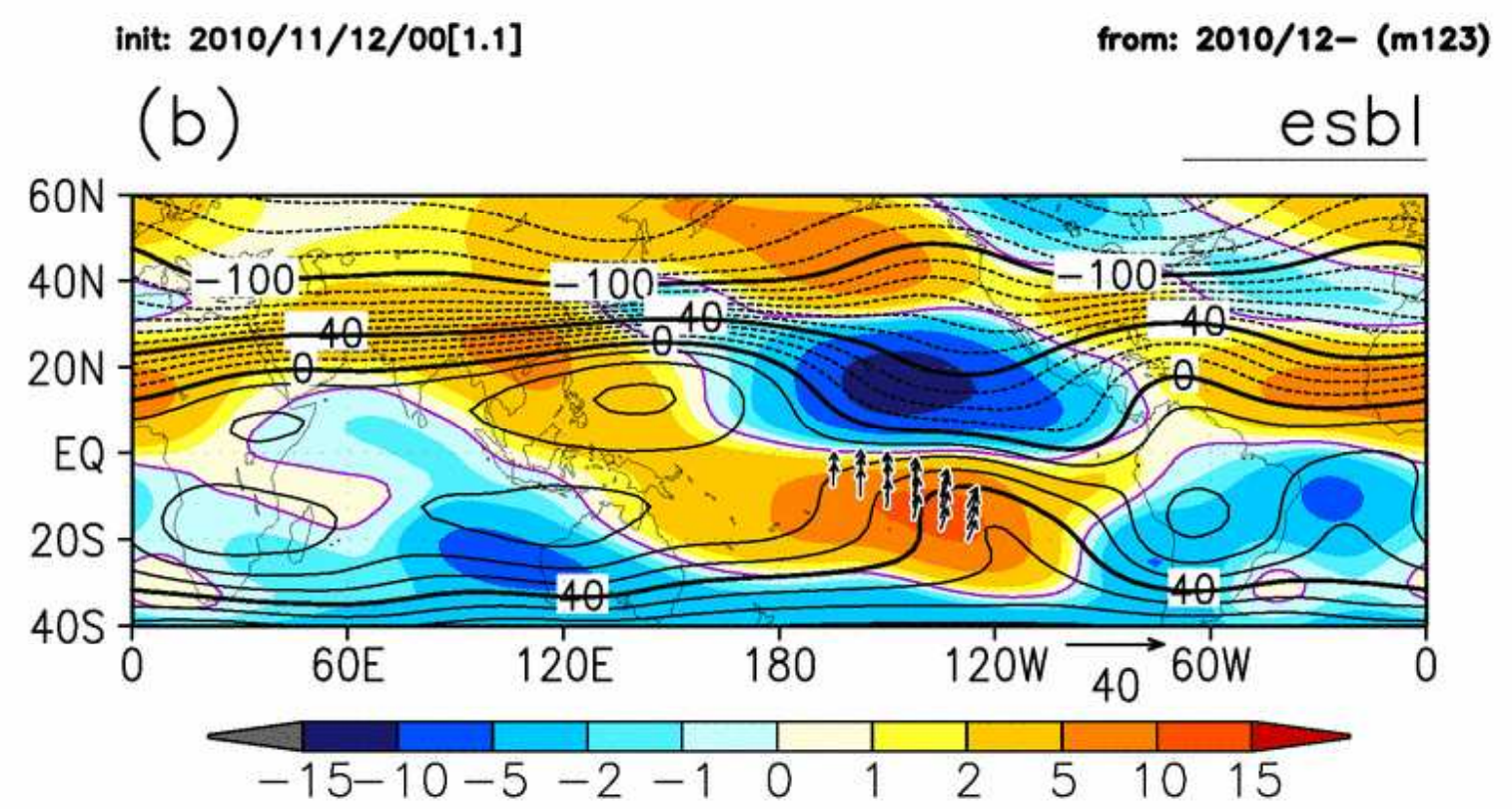

@Positive Precipitation anomalies around the Maritime Continent and the tropical Western Pacific associated with the La Nina condition

Predicted DJF 200hPa velocity potential anomalies ( ensemble mean)



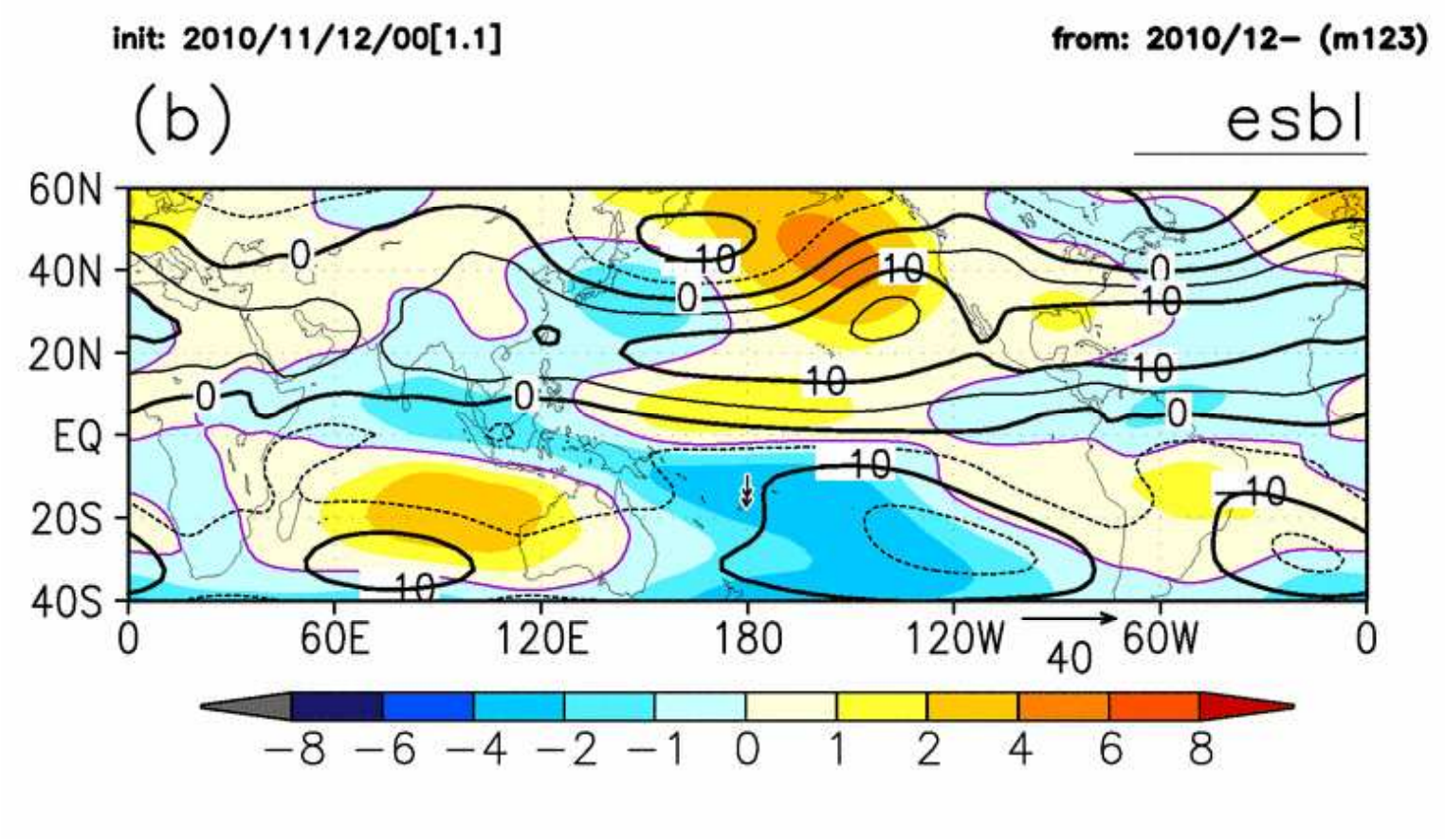

@ Divergence flow anomalies in the upper troposphere around the Maritime Continent associated with precipitation anomalies

Predicted DJF 200hPa stream function anomalies
( ensemble mean)



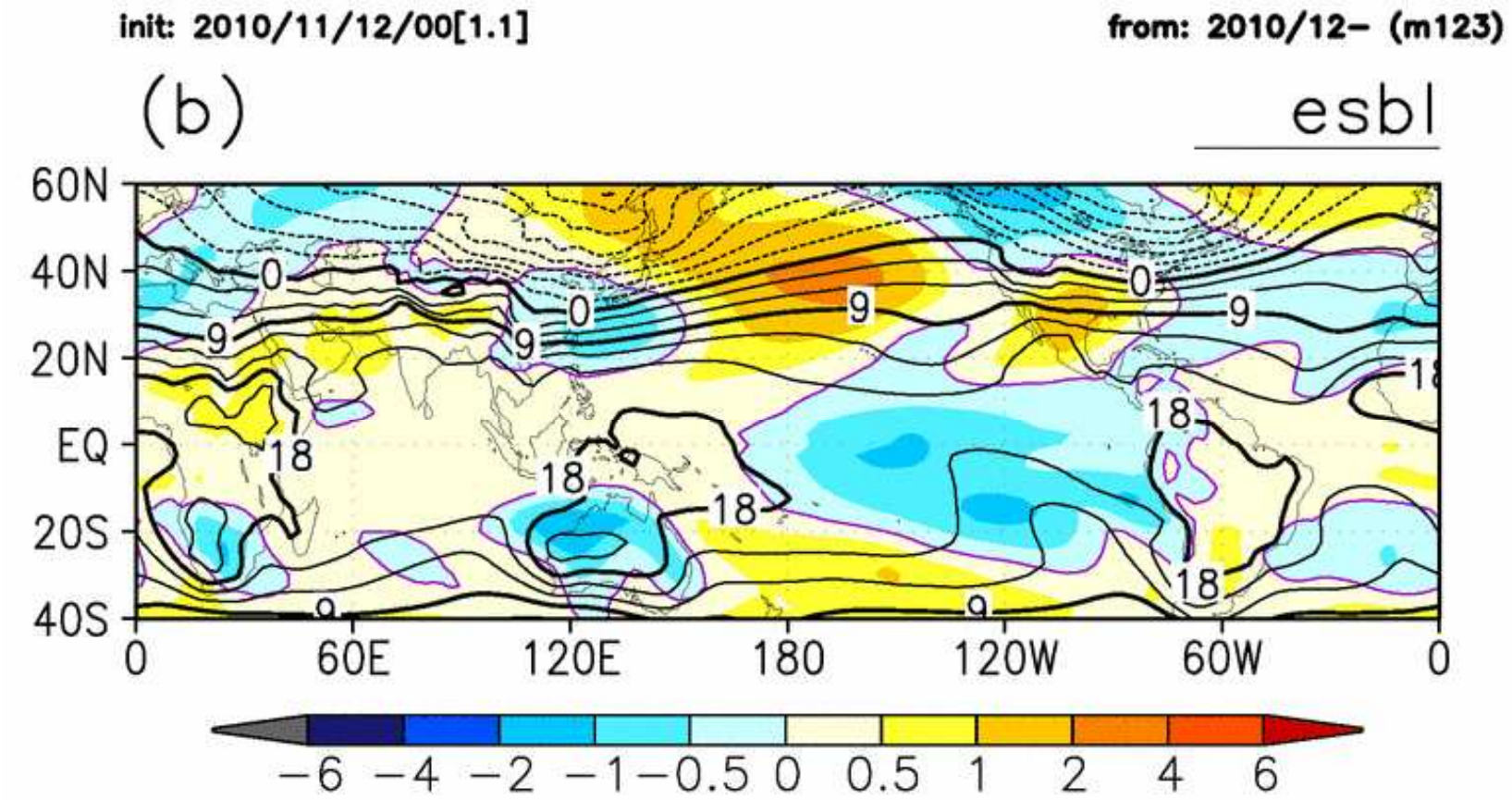

@ Anticyclonic circulation anomalies in the upper troposphere around the south-east Asia, and cyclonic circulation anomalies near Japan. This wave like pattern is suggested to be a stationary Rossby wave train forced by divergence flow anomalies in the upper troposphere around the Maritime Continent

Predicted DJF 850hPa stream function anomalies
( ensemble mean)




@ Cyclonic circulation anomalies in the lower troposphere, which is corresponding to the cyclonic circulation anomalies in the upper troposphere around Japan

Predicted DJF 850hPa temperature anomalies ( ensemble mean)

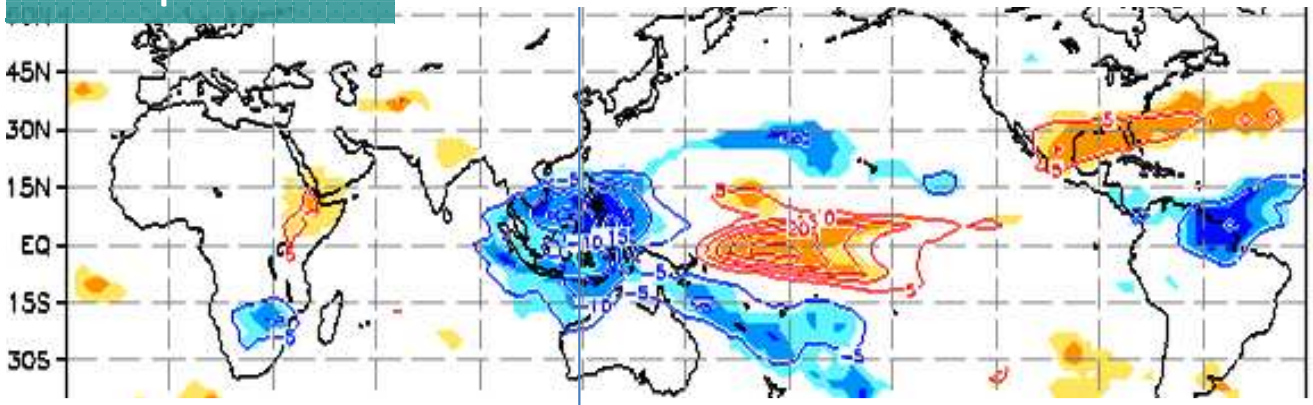



@ Negative T850 anomalies around the Western Japan and Okinawa/Amami, and positive T850 anomalies around the Eastern and Northern Japan corresponding to the circulation anomalies.

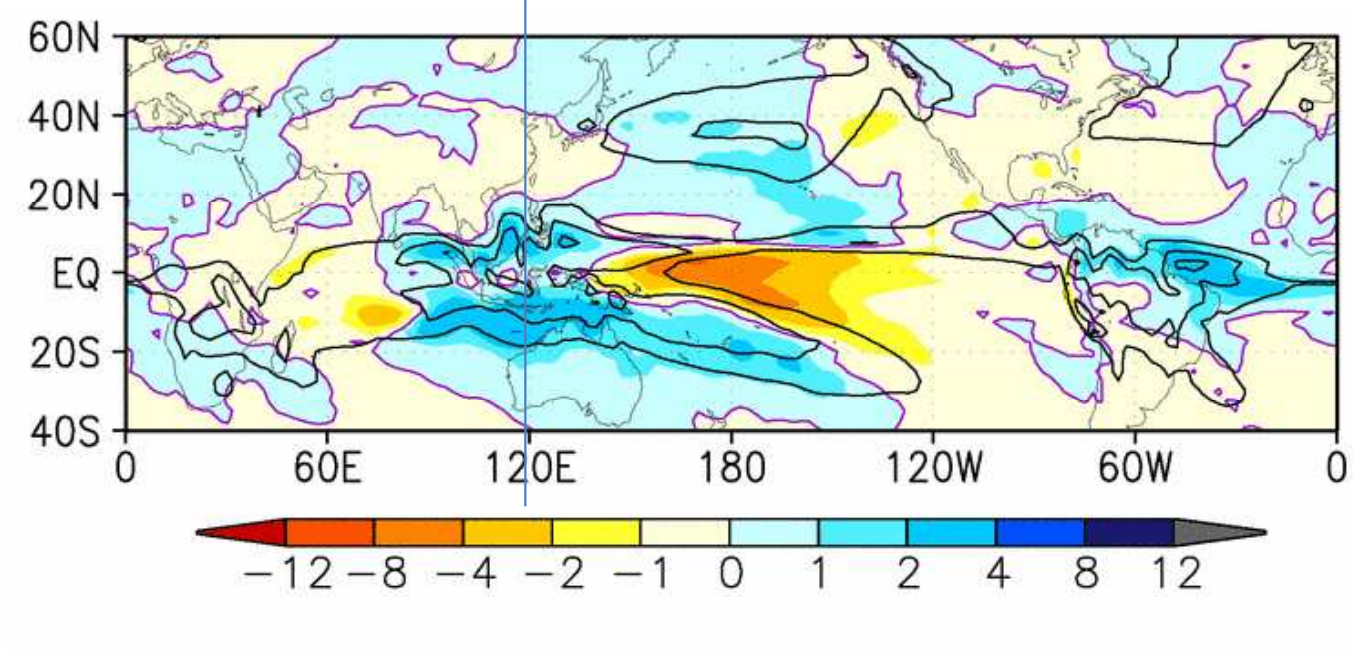
# Comparison with observed La Nina winters

Composite in La Nina winter

Precipitation



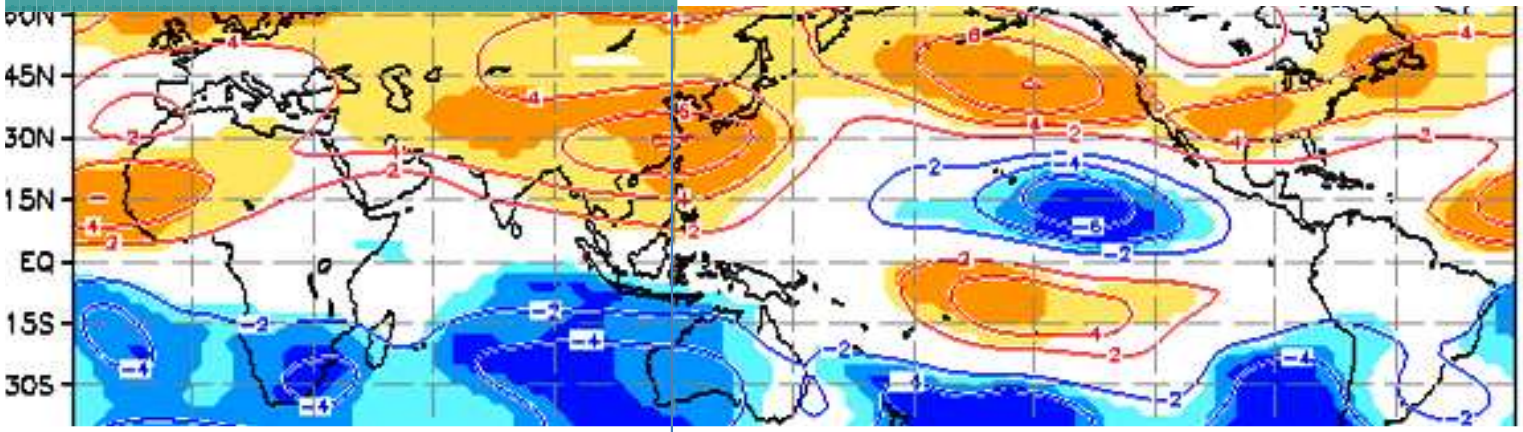

Prediction



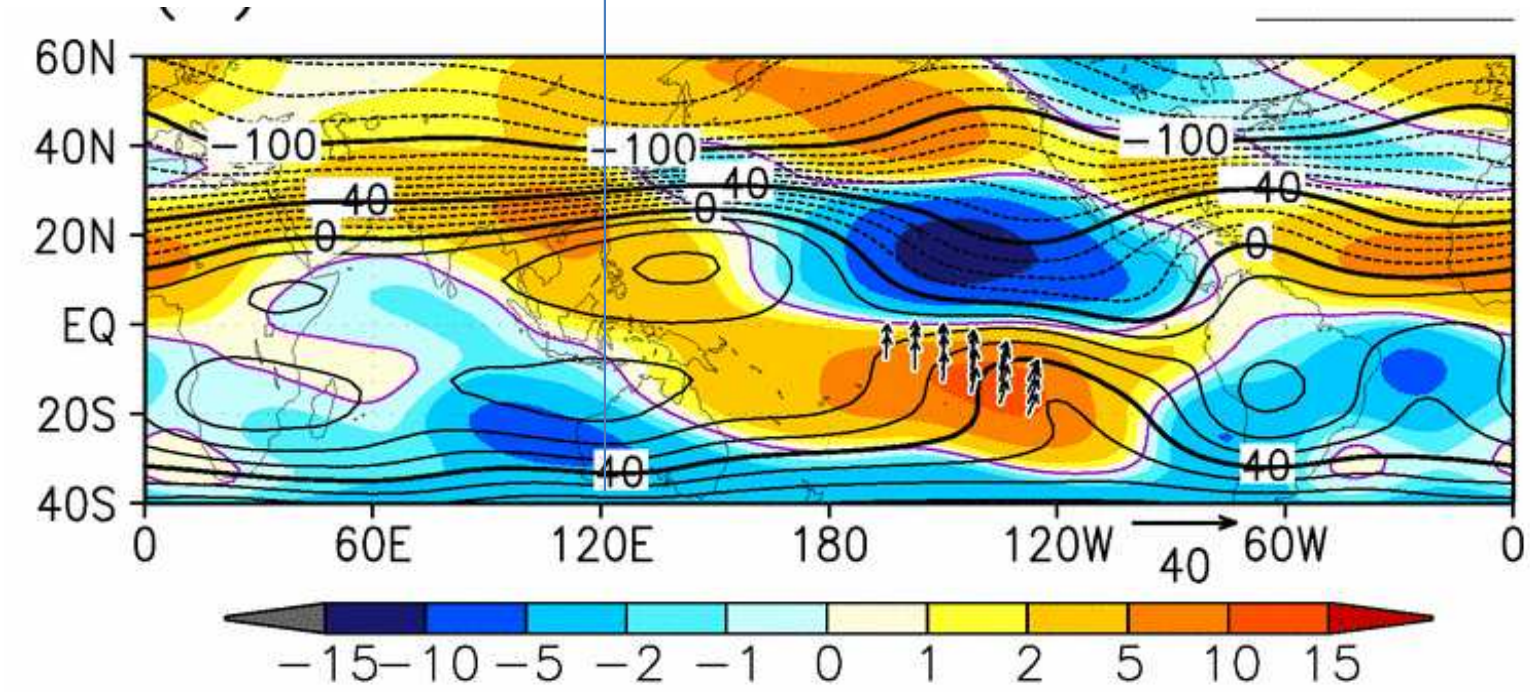

Westward shift

# Composite in La Nina winter

## 200hPa stream function



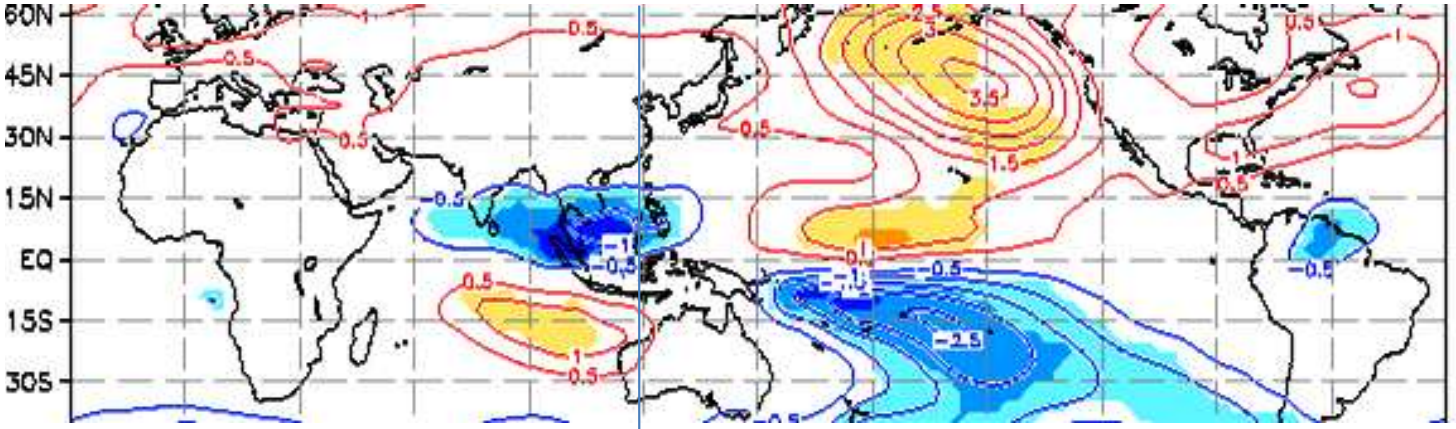

Prediction



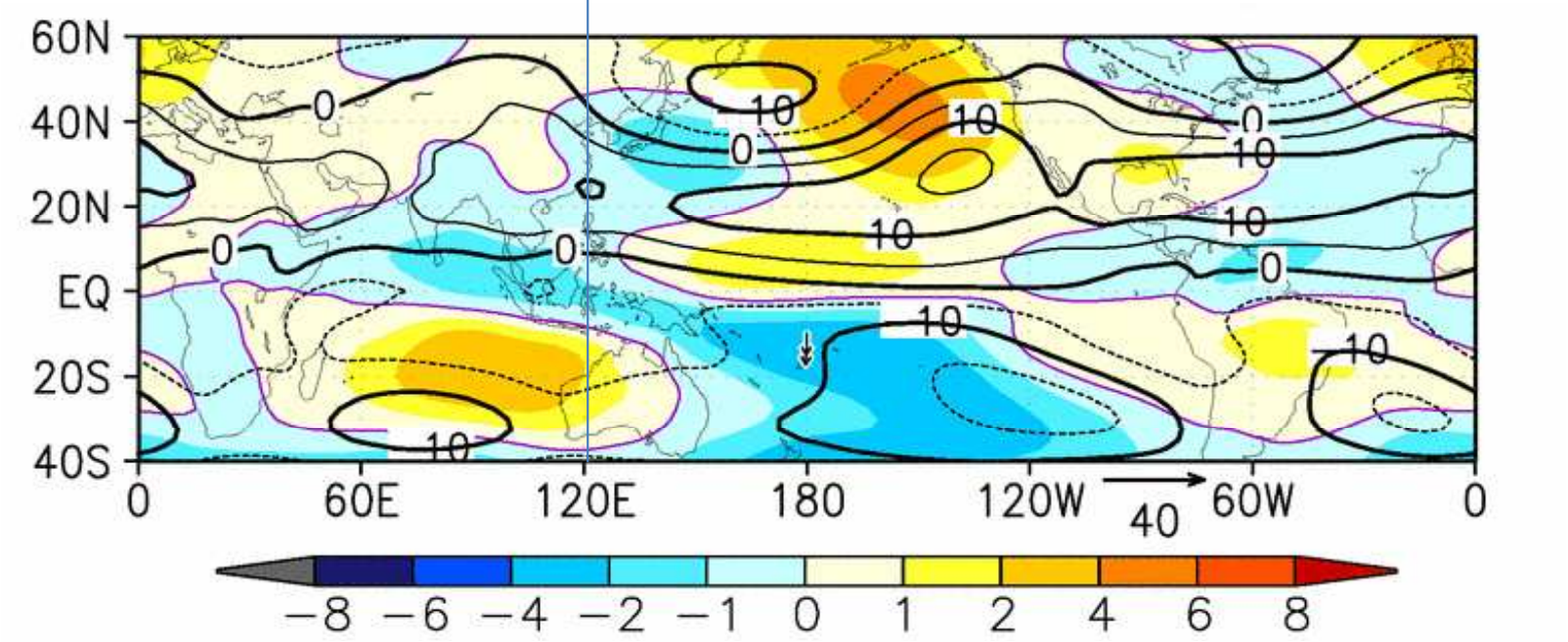

Westward shift and clear cyclonic circulation anomalies near Japan

# 850hPa stream function

Composite in La Nina winter




Prediction



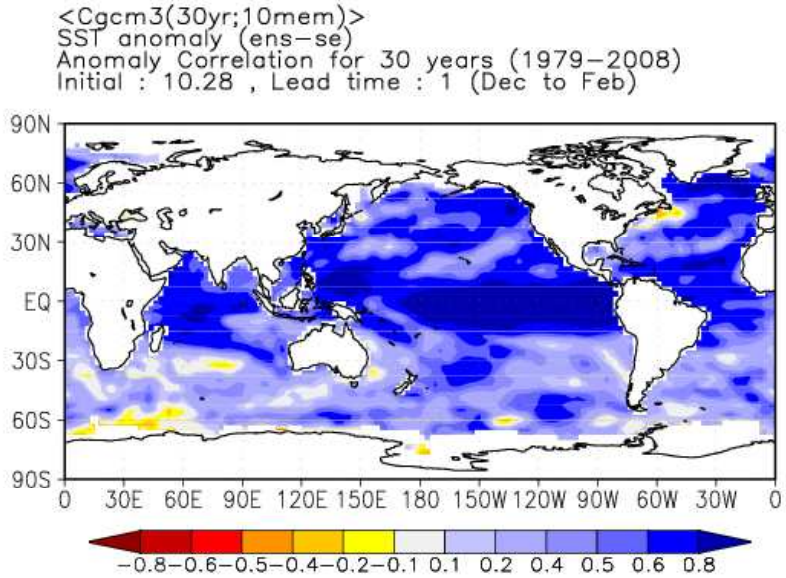

Westward shift and clear cyclonic circulation anomalies near Japan

# Summary of Predicted Signals

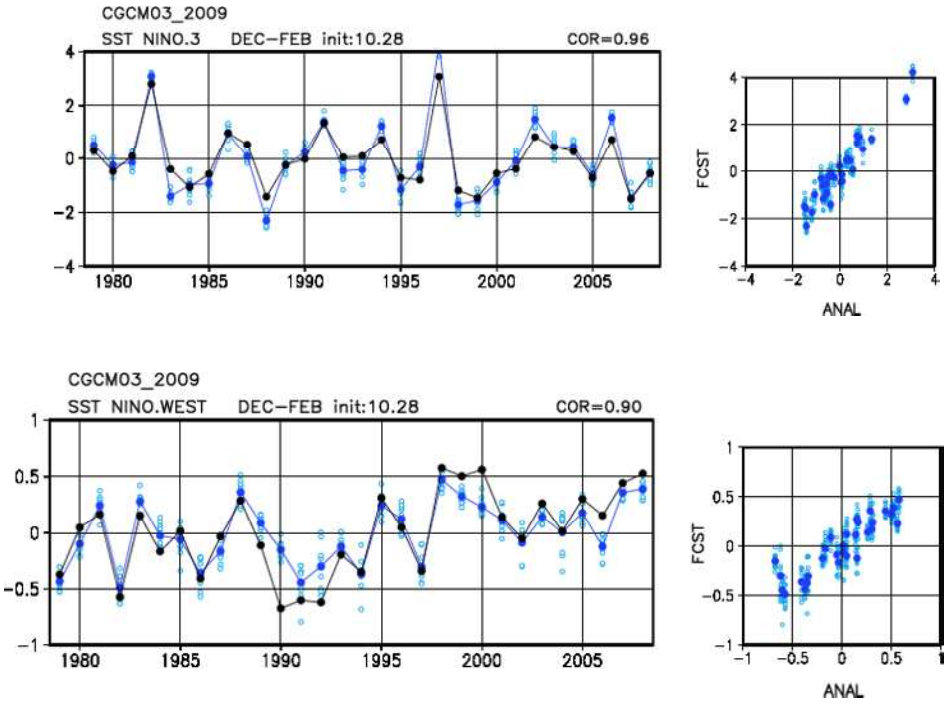
@La Nina will continue
@Around Japan, circulation pattern which is expected in La Nina winter is predicted, but the pattern is predicted to shift westward compared with the typical circulation anomalies in La Nina winters

@Corresponding to the circulation pattern, negative temperature anomalies in the Western Japan and Okinawa/Amami, and positive temperature anomalies in the Northern Japan are predicted

# Prediction Skill evaluated by 30 years Hindcast



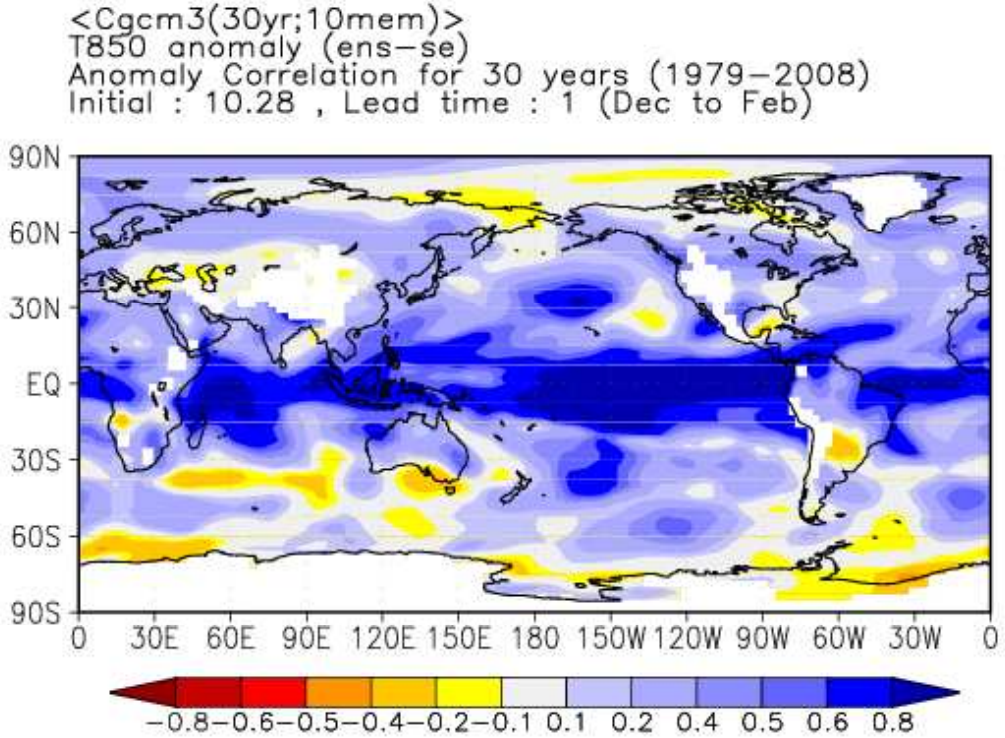

SST Anomaly Correlation for DJF prediction from the end of Oct.



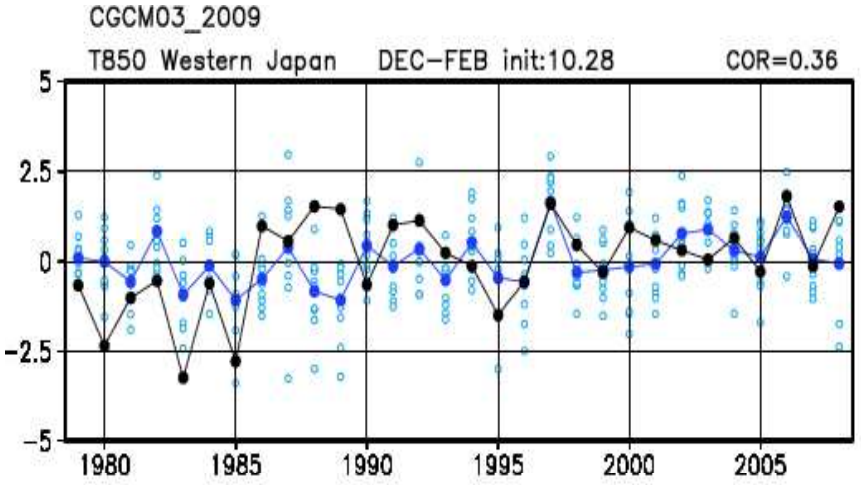

SST Anomalies in NINO.3 (upper)and the NINO.WEST(lower)for DJF prediction from the end of Oct.

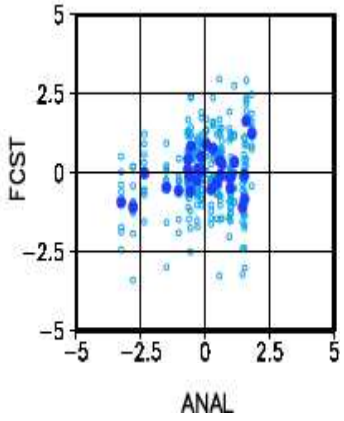
Prediction skill of SST in the tropics is very good!!

# Prediction Skill evaluated by 30 years Hindcast




T850 Anomaly Correlation for DJF prediction from the end of Oct.



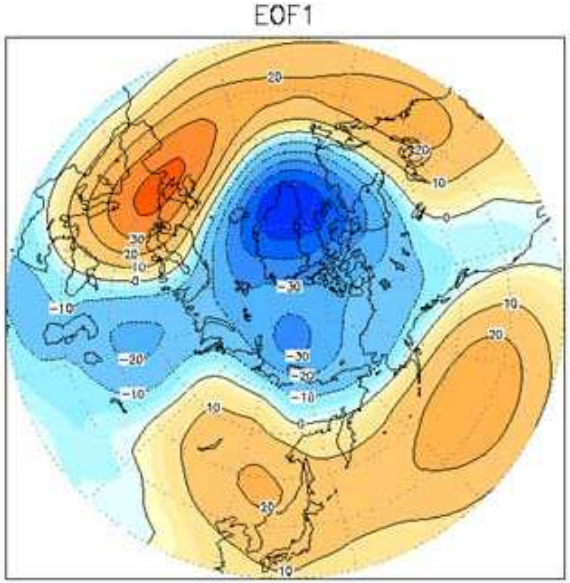



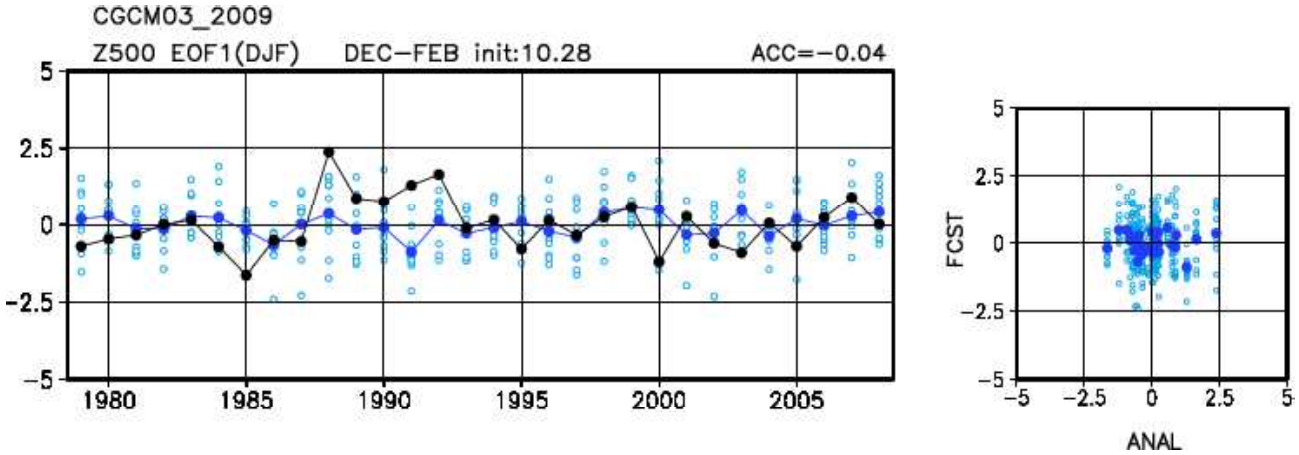

T850 Anomaly in the Western Japan for DJF prediction from the end of Oct.

Prediction skill of T850 near Japan is not so good but positive!!

# Prediction Skill evaluated by 30 years Hindcast

EOF1 of NHZ500 in DJF (AO)

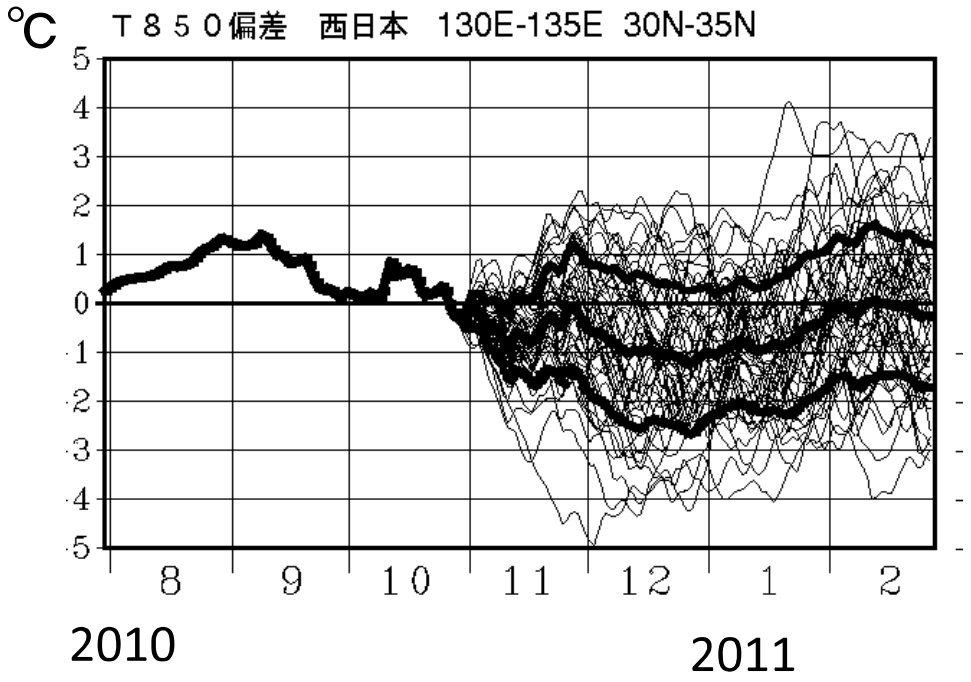



NHZ500 EOF1 (AO) for DJF prediction from the end of Oct.

Prediction skill of AO is near zero

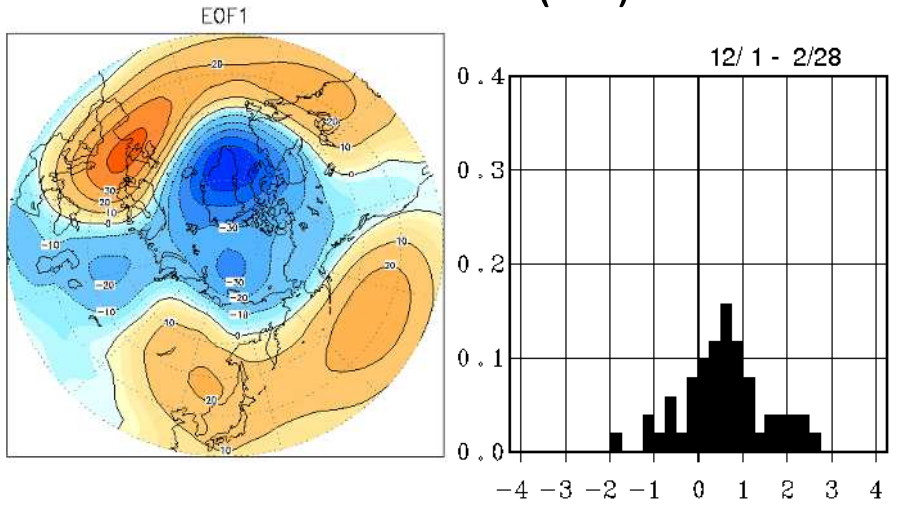
# Noise estimation by each member prediction




T850 Anomaly (30 day running mean) prediction in the Western Japan for DJF prediction from the end of Oct.

Spread (= standard deviation of predictions) is more than 1℃

EOF1 of NHZ500 in DJF (AO)




DJF AO index is predicted to be +0.5 with large spread

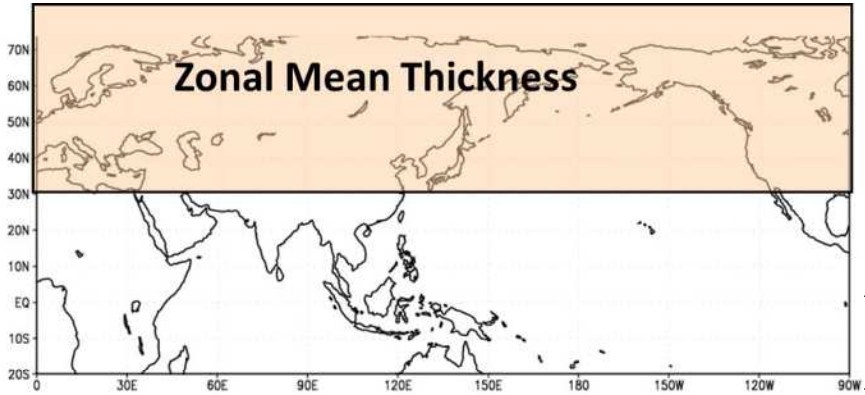
# NWP Guidance

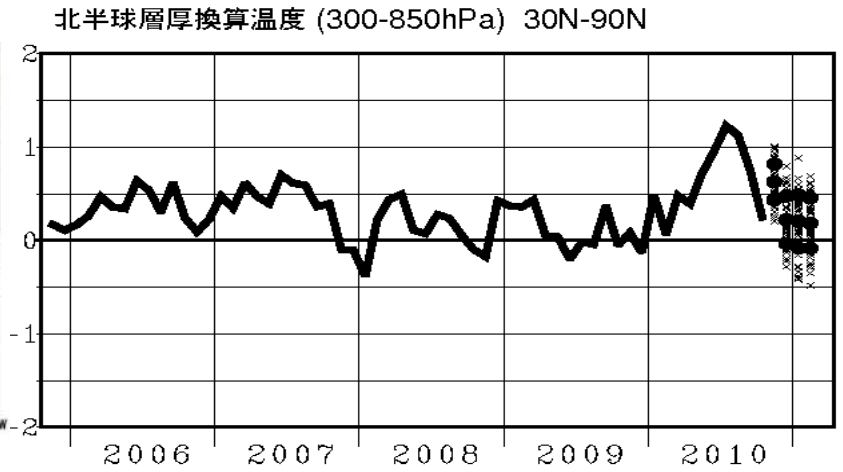
DJF Temperature


Probability

| | B | N | A |
|---|---|---|---|
| N. Japan 北日本 | 29 | 24 | 47 |
| E. Japan 東日本 | 19 | 32 | 49 |
| W. Japan 西日本 | 18 | 40 | 42 |
| Okinawa/ Amami 沖縄・奄美 | 21 | 27 | 52 |

Zonal Mean Thickness (850hPa-300hPa) in NH :one predictor




Guidance shows Near or Above Normal DJF Temperatures nationwide associated with positive zonal mean thickness temperature in NH

# Recent winter climate in Japan

| DJF | DJF Temperature anomalies(0.1°C) and rank | | | |
|---|---|---|---|---|
| | N. Japan | E. Japan | W. Japan | Okinawa/Amami |
| 2000/01 | -14 (-) | -01 (0) | 04 (0) | 14 (+)* |
| 02 | 05 (+) | 07 (+) | 08 (+) | 04 (+) |
| 03 | -06 (-) | -01 (0) | 03 (0) | 04 (+) |
| 04 | 14 (+)* | 09 (+) | 06 (0) | 02 (0) |
| 05 | 02 (0) | 07 (+) | 05 (0) | 07 (+) |
| 06 | -06 (-) | -08 (-) | -05 (-) | 03 (0) |
| 07 | 16 (+)* | 17 (+)* | 16 (+)* | 12 (+)* |
| 08 | -01 (0) | 01 (0) | 03 (0) | 06 (+) |
| 09 | 16 (+)* | 15 (+)* | 11 (+) | 11 (+)* |
| 10 | 06 (+) | 09 (+) | 10 (+) | 06 (+) |

(+)* : significantly above normal

In recent 10 years, near or above normal temperatures are frequently observed nationwide

# Summary of NWP prediction and recent climate

Signal

@Around Japan, circulation pattern which is expected in La Nina winter is predicted, but the pattern is predicted to shift westward compared with the typical circulation anomalies in La Nina winters

@Corresponding to the circulation pattern, negative temperature anomalies in the Western Japan and Okinawa/Amami, and positive temperature anomalies in the Northern Japan are predicted

# Summary of NWP prediction and recent climate

Noise/uncertainty & prediction skill

@Prediction skill for temperature around Japan is not so good, but positive !!

@Spread of temperature prediction is very large

@No skill for AO prediction

NWP guidance

@Above normal : 40-50%, Below normal: 20-30% nationwide associated with positive zonal mean thickness of the troposphere in NH.

Recent Climate

@In recent 10 years, near or above normal temperatures are frequently observed nationwide

# Issued forecast : DJF mean temperature 2010/11/25

| | Probability(%) |
|---|---|
| | B N A |
| N. Japan | **30:30:40** |
| E. Japan | **30:40:30** |
| W. Japan | **40:30:30** |
| Okinawa/Amami | **40:30:30** |

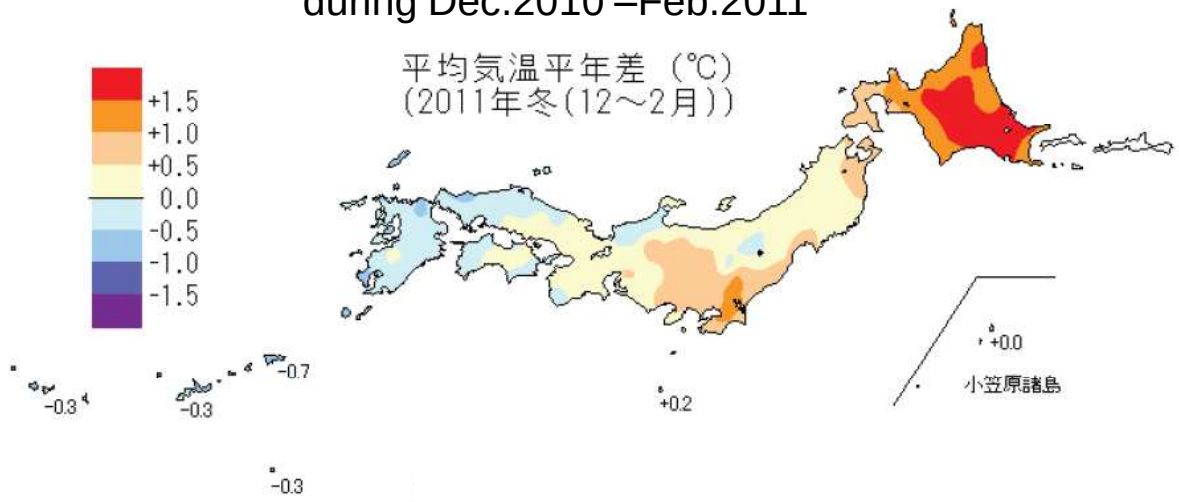
# Observed DJF mean temperature

Dec.2010 –Feb.2011

| | 気温<br>平年差<br>℃（階級） |
|---|---|
| 北日本<br>N. Japan | 0.9（+） |
| 東日本<br>E. Japan | 0.5（+） |
| 西日本<br>W. Japan | -0.2（0） |
| 沖縄・奄美<br>Okinawa/Amami | -0.5（−） |

**Temperature anomalies ℃(category)**

Mean temperature anomalies during Dec.2010 –Feb.2011



# Outline

- Introduction
- Overview of JMA operational Seasonal Forecast System
- Procedure to  make JMA Seasonal Forecast
- Summary

# Summary

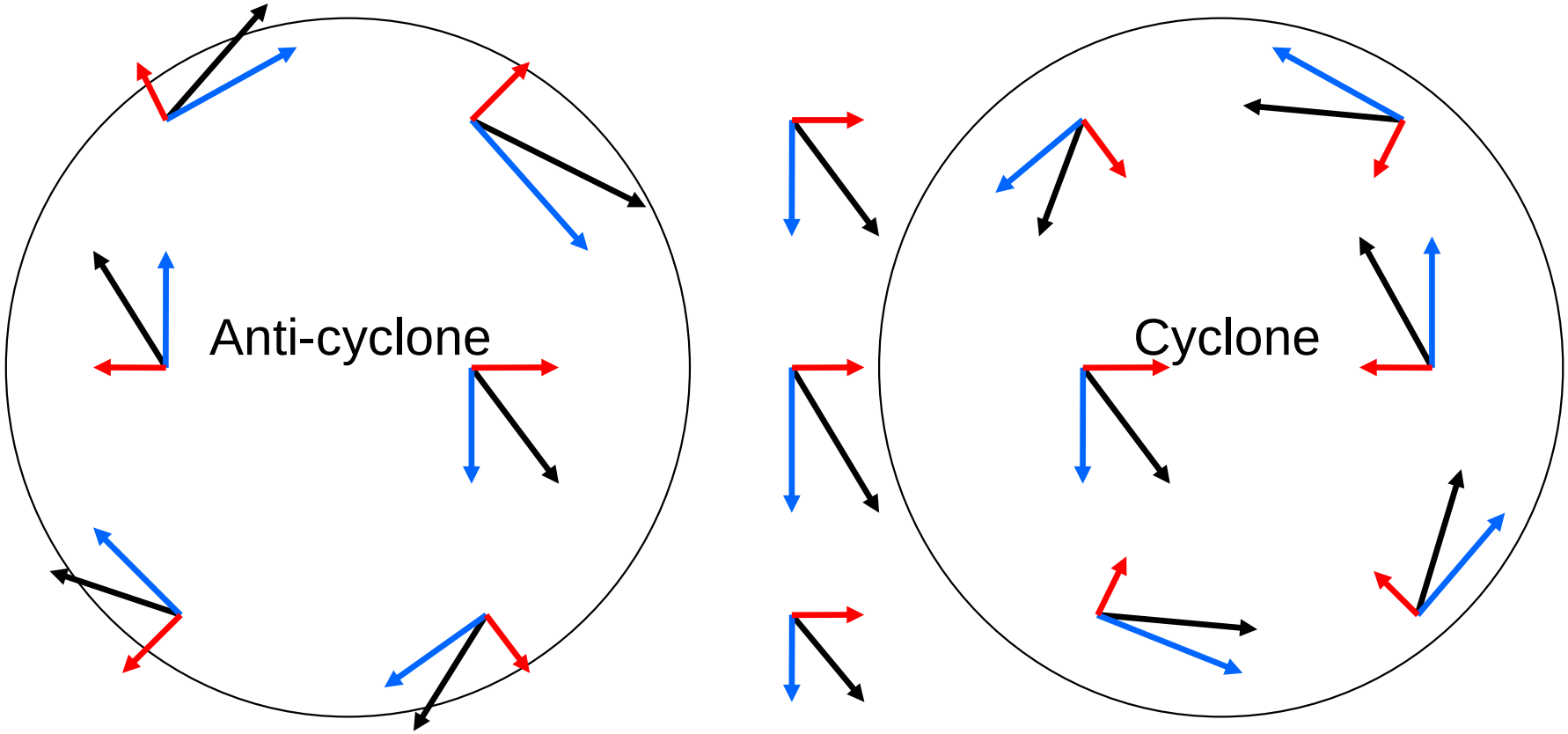
- By using ensemble prediction technique, it is possible to estimate not only ‘signal’ but also ‘noise’ for seasonal forecast.
- Signals for seasonal forecast are ocean-atmosphere variation in the tropics such as ENSO, decadal variation such as PDO, human-induced global warming, and so on.
- To make seasonal forecast, it is necessary to interpret the results of numerical prediction and guidance considering their predictability.
- It is also necessary to build a forecast considering the characteristics of the atmospheric circulation associated with your country’s climate.

# Thank you!

JMA Mascot Character ‘Hare-run’
‘Hare’ means sunny weather in Japanese
‘Hare-ru’ means ‘it becomes sunny’.
‘Run-run’ means happiness feeling.

# Velocity potential and stream function

**Decomposition of 2-D velocity fields into divergent and rotational components**



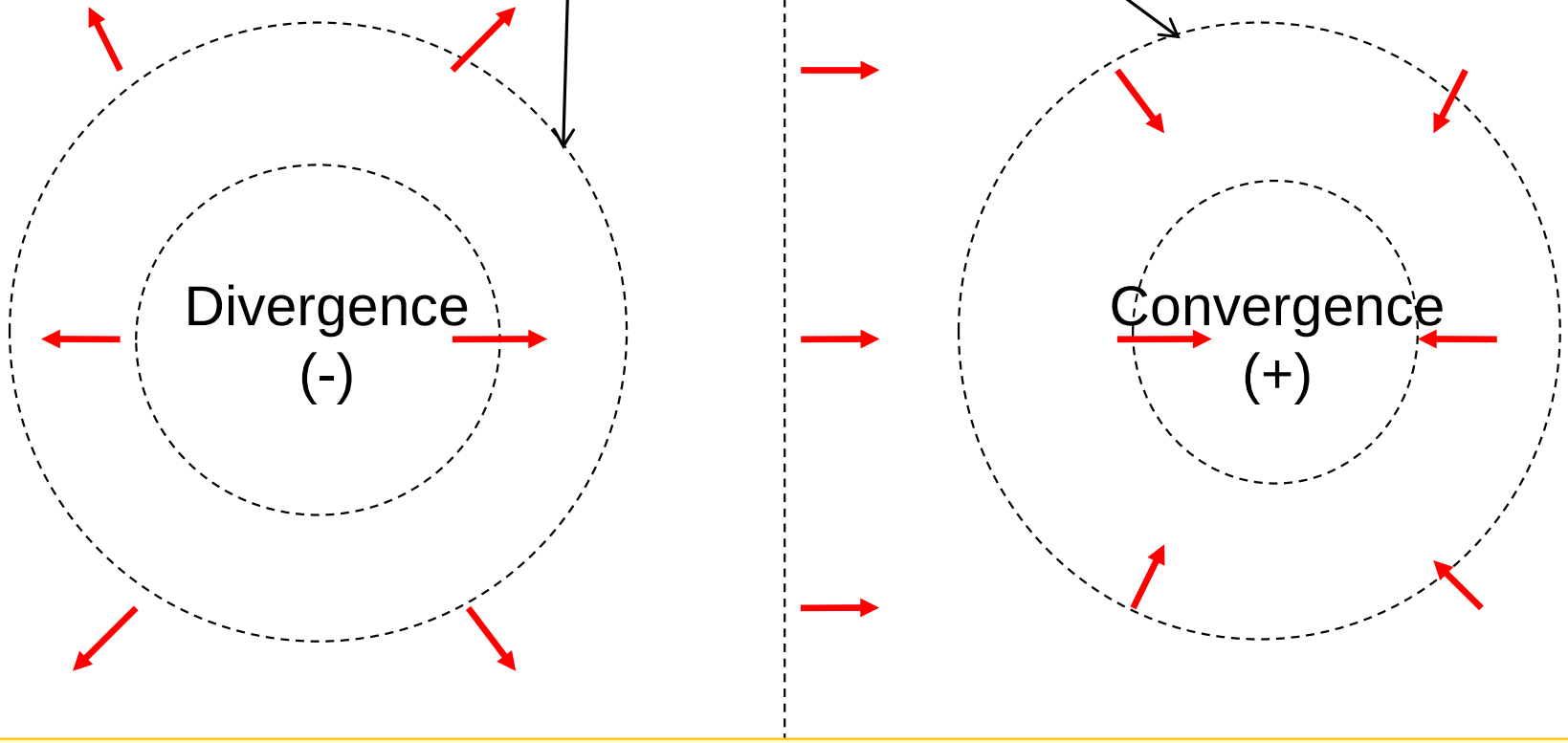
# Velocity potential ($\chi$)

$$u = \frac{\partial \chi}{\partial x} \qquad v = \frac{\partial \chi}{\partial y}$$

Contours of $\chi$

**Velocity potential indicates divergence and convergence of wind.**
**In general, a large scale divergence in the upper troposphere corresponds to active convection.**

**Divergent component**




**Active convection … Convergence in the lower troposphere and divergence in the upper troposphere.**
**Inactive convection … Divergence in the lower troposphere and convergence in the upper troposphere.**

Stream function ($\psi$)

Contours of $\psi$

**(Rotational component of) Wind blows parallel to Stream function seeing larger value on the right side.**

$$u = -\frac{\partial \psi}{\partial y} \qquad v = \frac{\partial \psi}{\partial x}$$

Rotational component