TCC Training Seminar on Seasonal Prediction Products

11 – 15 November 2013

Tokyo, Japan

Tokyo Climate Center
Japan Meteorological Agency

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Contents

Schedule

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Draft Schedule

Day 1 - Monday, 11 November		
10:00-10:30	1. Opening - Welcome Address - Self-introduction by participants - Group photo shooting - Courtesy call on JMA's Director-General	
10:30-10:45	Coffee Break	
10:45-11:00	2. Purpose of the Seminar and Program	
11:00-12:45	3. Lecture: Introduction to Climatology	Meteorological Research Institute/JMA
12:45-14:15	Lunch	
14:15-16:15	3. Lecture: Introduction to Climatology (cont.)	Meteorological Research Institute/JMA
16:15-16:30	Coffee Break	
16:30-16:50	4. Lecture: Introduntion of JRA-55	Reanalysis Unit
16:50-18:15	5. Lecture and exercise: Introduction of ITACS (Interactive Tool for Analysis of the Climate System) and basic operation	Monitoring and Analysis Unit
18:30-20:00	Reception	
Day 2 - Tuesday, 12 November		
9:30-11:00	6. Lecture: JMA's seasonal ensemble prediction system	Numerical Prediction Unit
11:00-11:15	Coffee Break	
11:15-12:45	7. Exercise: Use of gridded forecast data (how to download gridded forecast data and indices from the TCC website)	Numerical Prediction Unit
12:45-14:00	Lunch	
14:00-16:00	8. Lecture: Seasonal Forecasting	Forecast Unit
16:00-16:15	Coffee Break	
16:15-18:00	9. Lecture: Introduction of seasonal forecast guidance	Forecast Unit
Day 3 - Wednesday, 13 November		
9:30-12：30	10. Exercise: Seasonal Forecast - Producing guidance and verification	Guided by Forecast Unit
Around 11:00	Coffee Break	
12:30-14:00	Lunch	
14:00-18:00	10. Exercise: Seasonal Forecast (cont.) - Producing guidance and verification	Guided by Forecast Unit
Around 16:00	Coffee Break	
Day 4 - Thursday, 14 November		
9:30-12:30	10. Exercise: Seasonal Forecast (cont.) - Producing forecasts of winter 2013/14 - Preparation of presentation	Guided by Forecast Unit
Around 11:00	Coffee Break	
12:30-14:00	Lunch	
14:00-15:00	10. Exercise: Seasonal Forecast (cont.) - Preparation of presentation	Guided by Forecast Unit
15:00-15:15	Coffee Break	
15:15-18:00	11. Presentation by participants	Presentation (17 min.) followed by Q&A (3 min.)
Day 5 - Friday, 15 November		
9:30-12:10	11. Presentation by participants (cont.)	Presentation (17 min.) followed by Q&A (3 min.)
Around 11:00	Coffee Break	
12:10-12:30	12. Wrap up and Closing	
12:30-13:30	Lunch	
13:30-18:00	Technical Tour	

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Introduction to Climatology

Introduction to Climatology

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1. Climate and Climate system

According to WMO website, “At the simplest level the weather is what is happening to the atmosphere at any given time. Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time.”

Although climate is the synthesis of the weather, climate is not maintained only by atmosphere itself but is formed in the interactions among many components of the Earth. This system is named as climate system. The global climate system consists of atmosphere including its composition and circulation, the ocean, hydrosphere, land surface, biosphere, snow and ice, solar and volcanic activities (Fig.1). These components interact on various spatial and temporal scales through the exchanges of heat, momentum, radiation, water and other materials.

The purpose of the lecture is to know how climate and its variability is formed and changed in the global climate system and what kind of role each component of the climate system plays.

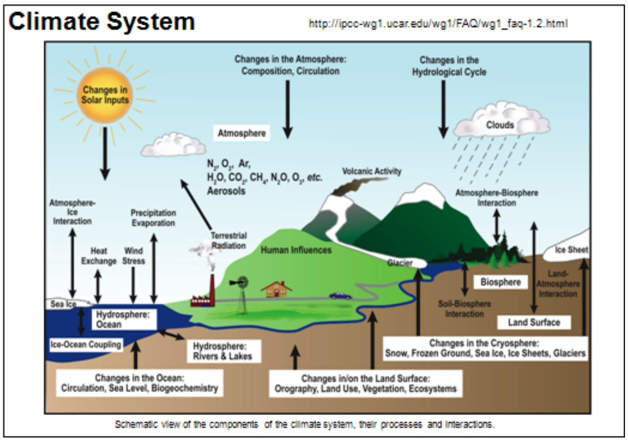


Figure 1 Climate system.
(From ipcc-wg1.ucar.edu)

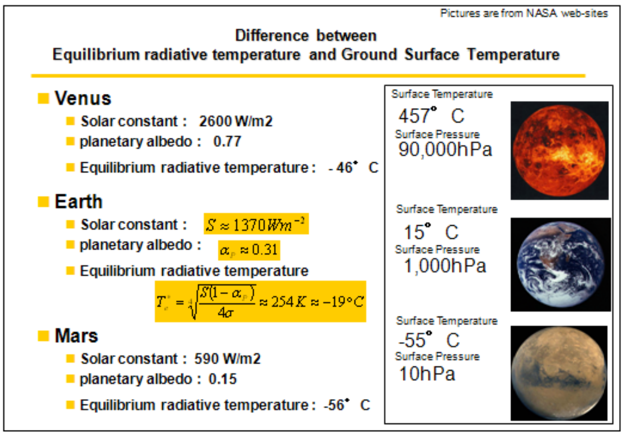
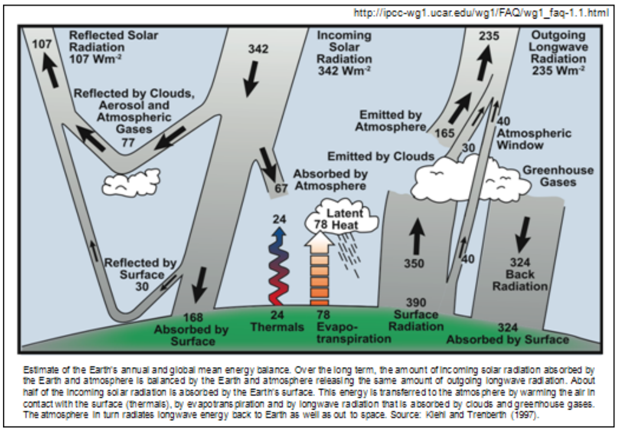


Figure 2 Raditive balance of planets.
(Pictures are from NASA website)

2. Global mean temperature and Radiative balance

Global mean temperature of planets, which is the temperature “observed from space”, is estimated by global radiation balance between absorbed solar radiation and terrestrial emission from the planet. Incoming solar radiation is reflected back to space by a fraction of the planetary albedo. For the Earth, the observed mean ground temperature (15℃) is warmer by 34℃ than the estimated temperature (-19℃). The reason is suggested by comparing other planet cases (Fig.2). The mean ground temperature for Mars with thin atmosphere is warmer only by 1℃ than the estimated temperature. For Venus with thick atmosphere, the difference is 503℃. Radiative absorption by greenhouse gas in atmosphere is an important factor to determine mean ground temperature as well as planetary albedo.

The Earth's atmosphere has different characteristics for shortwave and longwave radiations (Fig.3). It is transparent (58%) for shortwave radiative flux from the sun as an approximation except for the reflection due to clouds (23%). On the other hand, the longwave radiation flux emitted from the Earth's ground is absorbed (90%) once in the atmosphere approximately and then mostly emitted back to the ground (greenhouse effect). Upper cold atmosphere and clouds emit less longwave flux to space than the ground emits. As a net, surface ground is heated by shortwave radiation from the sun, and atmosphere is cooled by longwave emission to space. The vertical contrast of the heating between ground and atmosphere creates thermal instability, which is compensated by vertical transport processes of sensible and latent heat energy due to turbulences, convections and waves.



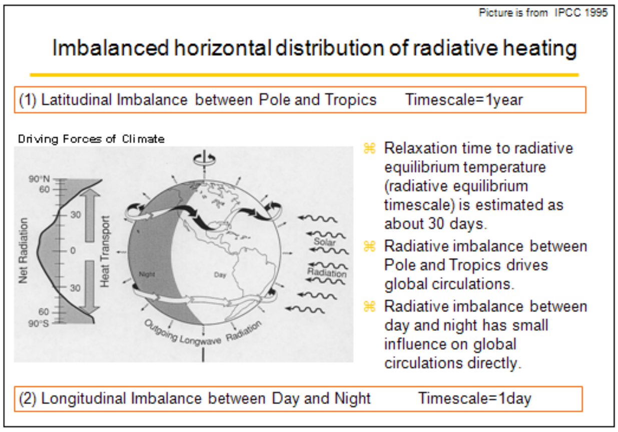


Figure 3 Vertical energy balance. (From ipcc-wg1.ucar.edu)

Figure 4 Horizontal radiative imbalance. (Picture is from IPCC 1995)

3. Annual mean circulation and Horizontal heating contrast

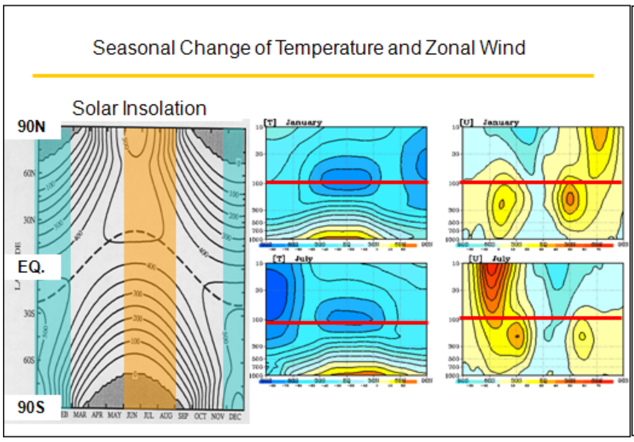
Longitudinal contrast of radiative heating is created between day and night (Fig.4). But, generally, as compared with the annual cycle, the diurnal heating contrast does not produce significant temperature differences between day and night and related global circulations because a relaxation time to a radiative equilibrium is estimated as 30 days for the Earth (James, 1995), which is much longer than a day scale. However, diurnal cycles play a dominant role in local precipitation occurrences particularly in the tropical to subtropical lands and surrounding seas.

Latitudinal heating contrast on the Earth is created on seasonal time-scale by the different incoming shortwave radiation between near the poles and the tropics (Fig.4). Local surface temperature determining outgoing longwave radiation is not adjusted instantly enough to compensate for the showtwave radiation contrast. A part of absorbed radiative energy in low latitudes is transported poleward by meridional circulations and waves in atmosphere and ocean, and these heat transports keep high-latitudes warmer than the radiative equilibrium. Poleward/equatorward air motions form westerly/easterly wind in the upper/lower subtropics (Fig.5) through Coriolis force due to the rotation of the Earth (or the angular momentum conservation about the Earth's rotation axis). Extra-tropical waves are also responsible for creating mid- to high latitude's westerly jets.

4. Seasonal change and Heat capacity

Seasonal change is definitely produced by the seasonally changing solar incidence with its maxima at the South Pole in December and at the North Pole in June. However, zonally averaged features of wind and temperature are not drastically changed in the troposphere (lower than about 100hPa) through the whole year; westerly jets in both hemispheres, hot tropics and cold poles (Fig.5). This fact is attributed to basically unchanged distribution of sea surface temperature (SST) due to large heat capacity of the oceans. SSTs roughly determine the location of deep cumulus occurrences, which leads to vertical energy mixing in the troposphere and drives global circulations (Webster, 1994).

Stratospheric climate above 100hPa varies following the seasonal march of the sun (Fig.5) because of the seasonal change of ozone-related shortwave heating and small heat capacity of thin stratospheric atmosphere; cold around a winter pole, warm around a summer pole, westerly jet in a winter hemisphere and easterly in a summer hemisphere. Atmospheric circulations also contribute to the stratospheric climate; a cold tropopause in the tropics is steadily created by upward motion.



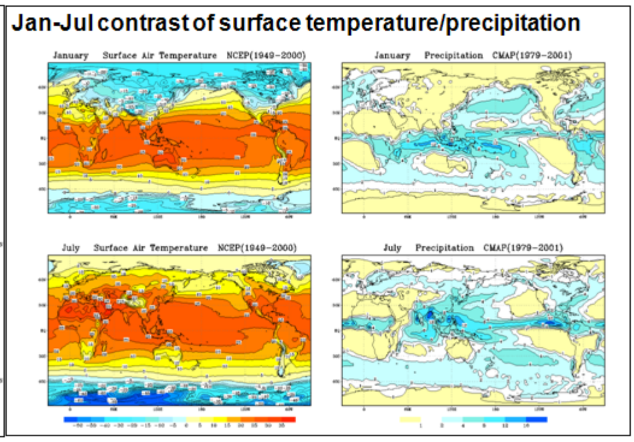


Figure 5 (Left) seasonal change of solar insolation and (right) zonally averaged temperature and winds in January (uppers) and July (lower). (the figure for solar insolation is from IPCC 1995)).

Figure 6 (Left) surface air temperature and (right) precipitation in (upper) January and (lower) July.

Heat capacity of land surface is small as compared with that of the oceans. Surface air temperature over the northern continents is much higher than SSTs at the same latitudes in the northern summer (especially in daytime) and much colder in the northern winter (Fig.6). The large contrasts of surface air temperature between continents and the oceans add a significant feature to regional seasonal changes of rainfall and wind around the continents in low and mid-latitudes, which is named as monsoon. A concentrated subtropical rainfall forms a typical summer monsoon system consisting of an upper-level anti-cyclonic circulation, a monsoon trough, a low-level jet, a subtropical rainfall band expanding north(south)eastward and extensive downward motions causing dry region in the north(south)westward area of the northern (southern) hemisphere (Rodwell and Hoskins, 1996), as shown in the Asian region of Fig. 7.

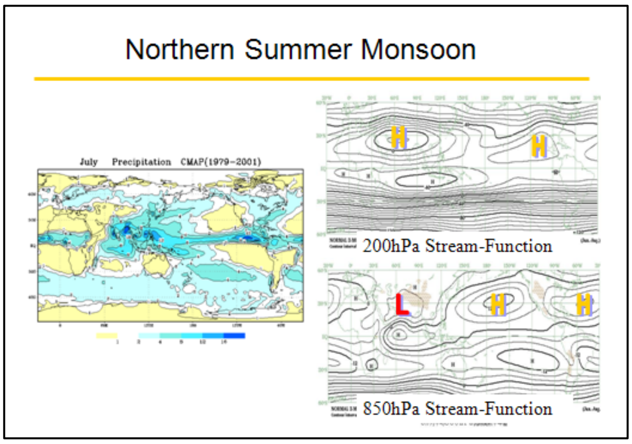


Figure 7 (Left) precipitation, (upper-right) 200hPa streamfunction and (lower-right) 850hPa streamfunction in July.

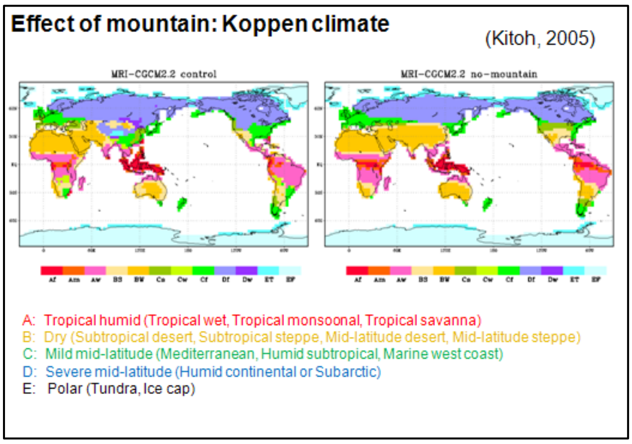


Figure 8 Koppen climate maps simulated by a climate model (left) with mountains and (right) without mountains.
(From Kitoh 2005 in Japanese)

5. Climate model and Experiments

A good way to understand climate system is to modify or remove some elements of the climate system (Fig. 1). It is not easy to modify a real climate system of the Earth by changing the Earth orbit or removing mountains. Instead, we can easily modify virtual climate systems simulated numerically in climate models based on physics and other fundamental sciences. From the comparison between with/without mountain model experiments (Fig. 8), we can see that mountains would be responsible for the real world climate of humid summer and somewhat cold winter in the eastern parts of the continents. Paleo climate is another climate system we can confirm based on observational evidences. It gives us a chance to test the ability of climate models to simulate another different climate.

6. Intra-seasonal to Interannual variability

Climate varies naturally with time. Atmosphere itself includes internal instability mechanisms, typically the baroclinic instability around the extratropical westerly jets, so that it may be considered as chaotic or unpredictable beyond a few weeks. However, some atmospheric low-frequency (>10 days) teleconnections are analyzed such as wave patterns along the westerly jet waveguides and other ones from the northern mid-latitudes across the equatorial westerlies (Fig. 9), which are consistent with the Rossby-wave propagation theory. Numerical ensemble predictions from many disturbed atmospheric initials are a reasonable tool to capture mean weathers in next few weeks.

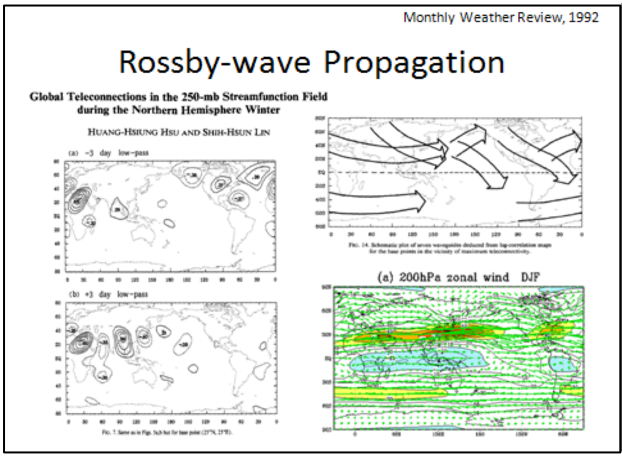


Figure 9 (Left) a teleconection pattern of 250hPa streamfunction, (upper-right) various propagations and (lower-right) 200hPa climatological zonal wind in DJF. (From Hsu and Lin 1992)

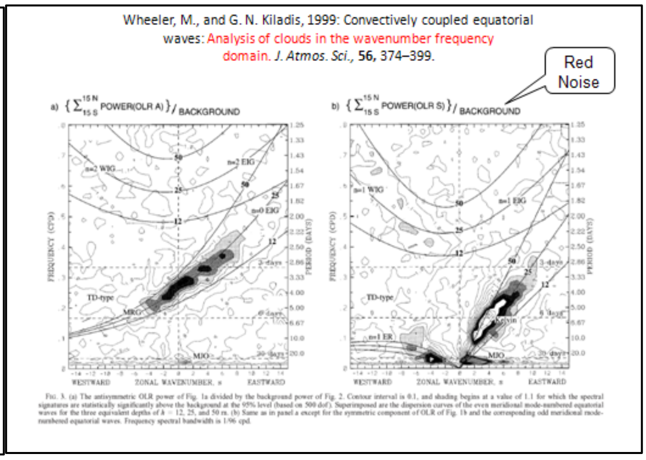


Figure 10 Spatial and temporal power-spectrums in the tropics of (left) asymmetric and (right) symmetric OLR variability about the equator. (From Wheeler and Kiladis 1999).

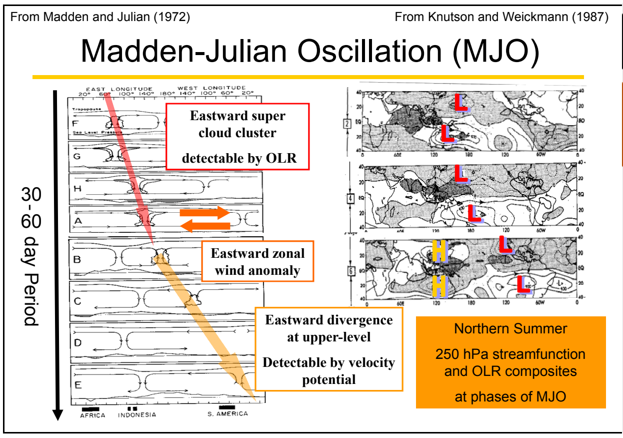


Figure 11 (Left) schematic time-sequence of Madden-Julian Oscillation (MJO) along the equator (from Madden and Julian, 1972). (Right) composite maps of OLR and 250hPa streamfunction anomaly at MJO phases (from Knutson and Weickmann 1987).

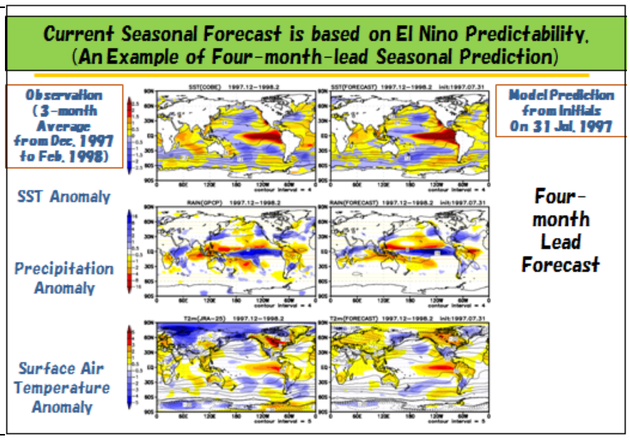
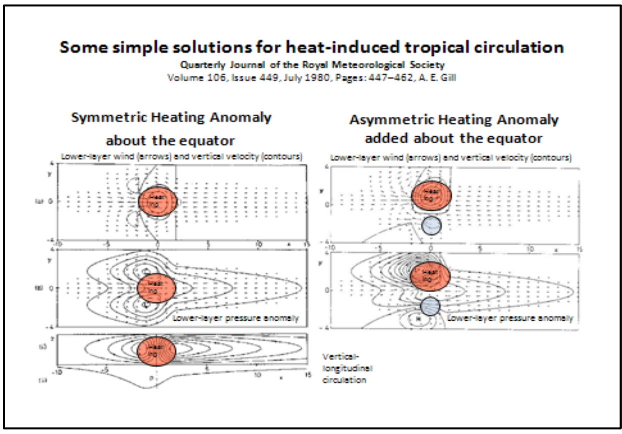


Figure 12 (Left) observed SST, precipitation and surface air temperature anomalies for DJF 1997-98. (Right) the same except for four-month lead prediction.

Some time-space power-spectrum peaks, indicating organized atmospheric variability coupled with convective activity, are imbedded in red noise backgrounds in the tropics. Variability of outgoing longwave radiation (OLR) associated with equatorial waves, such as Kelvin waves, equatorial Rossby waves (ER) and mixed Rossby-Gravity waves (MRG), can be detected, as well as tropical depressions and easterly waves (TD-type) in Fig. 10. Madden-Julian Oscillation (MJO) is an eastward-moving oscillation of surface pressure, precipitation and winds along the equator with the period of 30-60 days and planetary scale wavenumbers (Fig. 11). Monitoring MJO or watching OLR and velocity potential anomalies may be very helpful for intra-seasonal prediction in the tropics to the subtropics and even in the mid-latitudes (Fig. 11).

Atmosphere-ocean interactions are able to produce longer time-scale natural variability in atmosphere with periods beyond months up to several and decadal years. A typical example is ENSO (El Niño / Southern Oscillation) with the period of 2-7 years, which is influential to worldwide climate even out of the tropical Pacific. El Niño events, related surface air temperature and precipitation anomalies are predicted successfully on seasonal to inter-annual scales (Fig.12). The El Niño SST anomaly tends to keep seasonally steady precipitation (heating) anomalies over the equatorial central Pacific. Upper and lower-level tropical atmospheric response to a steady heating anomaly can be explained based on forced equatorial waves or the Gill-pattern (or Matsuno-Gill pattern) (Fig. 13). Recently, terms of El Niño Modoki or Central Pacific (CP)-El Niño are used for the equatorial Pacific phenomena with warm SST anomaly and enhanced precipitation in the central Pacific but cold SST anomaly and suppressed precipitation in the eastern Pacific, distinctive from normal El Niño events or Eastern Pacific (EP)-El Niño (Fig. 14).



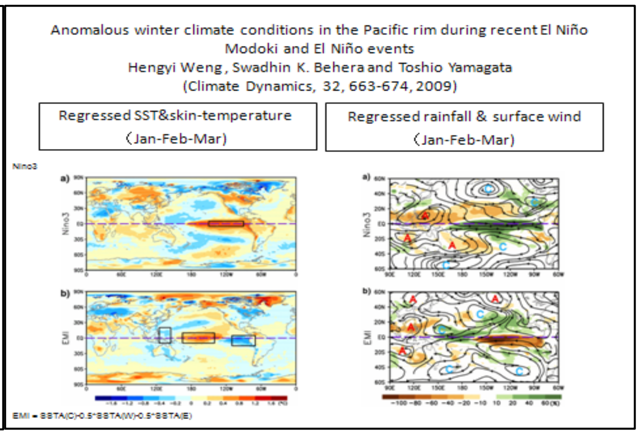


Figure 13 Tropical atmospheric responses to equatorially (left) symmetric and (right) plus asymmetric heating anomalies (from Gill 1980).

Figure 14 Comparison between (lower) El Niño Modoki or CP-El Niño and (upper) normal El Niño or EP-El Niño events. (Left) related surface air temperature anomalies, (right) precipitation anomalies. (From Weng et al. 2009)

The remote effect of El Niño during the mature stage is stored in the Indian Ocean capacity and still influential to the Indo-western Pacific climate even during summer following the ENSO (Fig.

15). A dipole mode with an east-west SST anomaly contrast sometimes occurs around Sep-Oct in the tropical Indian Ocean, which is at least partially independent from ENSO events (Fig. 16). Occurrence of this mode affects climate over various regions including tropical eastern Africa and the maritime continent.

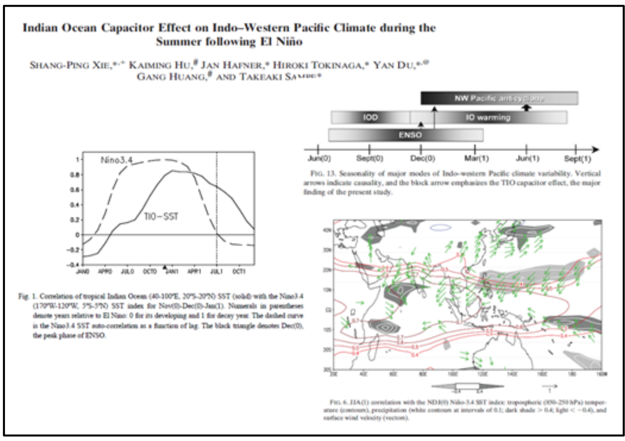


Figure 15 Indian Ocean capacitor effect. (Left) lagged correlation of tropical Indian Ocean SST with Nino 3.4 SST for NDJ. (Upper-right) seasonality of major modes. (Lower-right) correlation of the NDJ Nino3.4 SST with the following JJA climate. (From Xie et al. 2009)

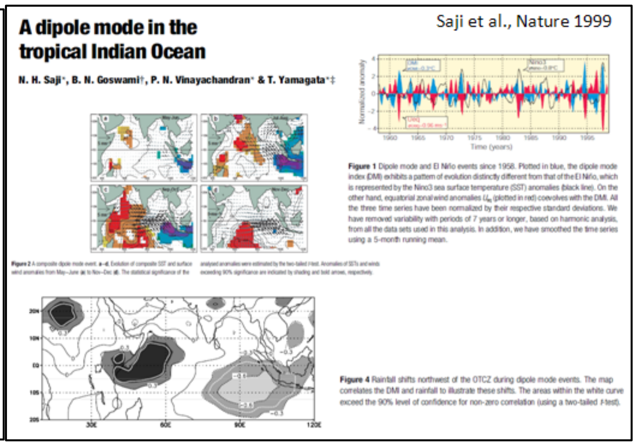


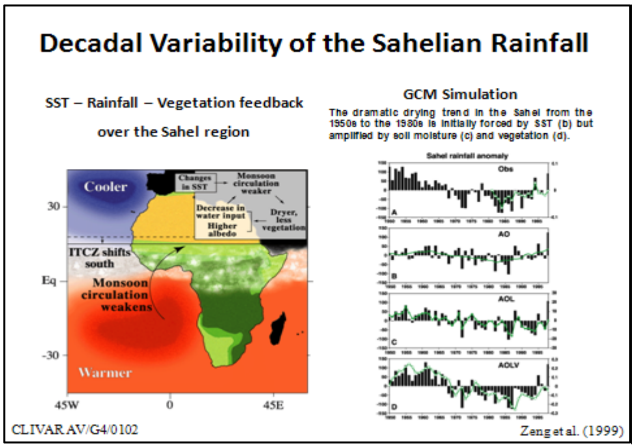
Figure 16 A dipole mode in the tropical Indian Ocean. (Upper-left) time-evolution of the dipole mode SST anomaly, (lower-left) rainfall shift during the dipole mode, (right) historical records for dipole mode and El Niño events. (From Saji et al. 1999).

7. Decadal variability and Climate change

Decadal variability and climate change involve feedbacks from other elements of the climate system. Changes of vegetation and soil moisture amplify the dramatic drying trend in 1980's in Sahel region, which is basically forced by a southward precipitation shift of the Inter-tropical Convergence Zone due to cooler/warmer SST anomaly in the northern/southern Atlantic Ocean (Fig. 17). Decadal variabilities are also found in SST anomaly from the North Pacific to the tropics. A possible mechanism is the subduction hypothesis; high latitudes' cold surface water is subducted in the North Pacific and flows into the subtropical deeper ocean along the surfaces of constant density, then back up to the equatorial Pacific surface again by upwelling. This is consistent with the analysis showing that the decadal SST variability in the central North Pacific spreads into the deep ocean (Fig. 18).

Natural change in external conditions of climate system (e.g., the increase of aerosol by volcano eruption) forces climate to change. Paleo climates may be related to different external conditions of the Earth orbit, greenhouse gas concentrations, land-sea distribution, topography, solar and volcano activities. Various feedbacks may be caused through relevant responses of ice coverage, clouds, dust and deep ocean circulations.

Human activity also changes external conditions of the climate system, typically the increase of greenhouse gases (CO_2, CH_4, N_2O, etc.) which are leading to warmer climate during relatively short periods. The climate models driven with natural forcing only cannot explain the observed increase of the global mean temperature in the 20th century while the models with anthropogenic forcing included capture the real global warming (Fig. 19). The influences of global warming appear not only in global mean temperature but also in future regional precipitation (Fig. 20), where wet/dry region generally tends to become further wetter/drier due to enhanced horizontal moisture transports.



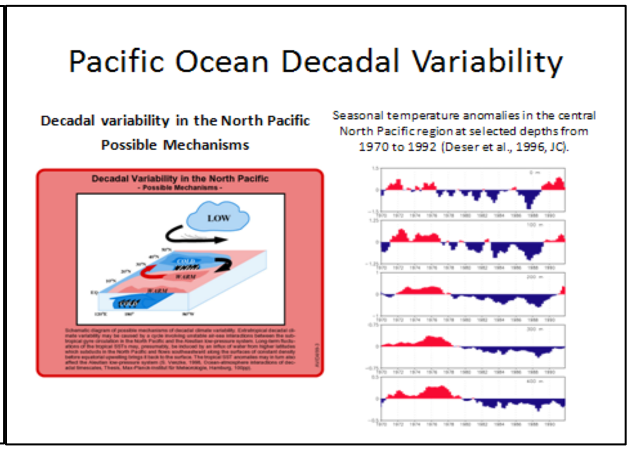
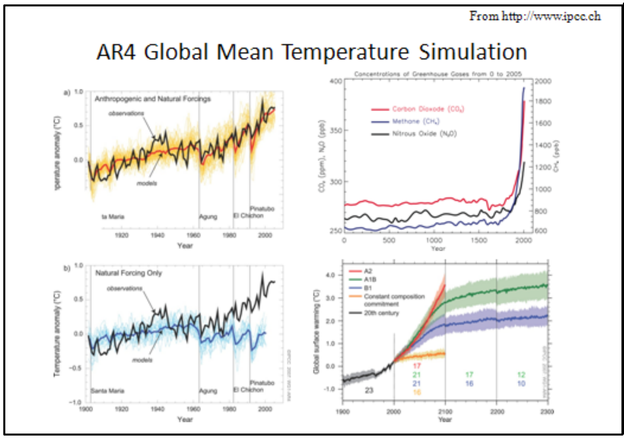


Figure 17 Decadal variability of the Sahel Rainfall. (Left) a possible mechanism, (Right) observed historical Sahel rainfall anomaly and GCM simulations (from Zeng et al. 1999).

Figure 18 Decadal variability of the North Pacific Ocean. (Left) a possible mecanism, (right) time-sequence of ocean temperature at various depths (from Deser et al. 1996).



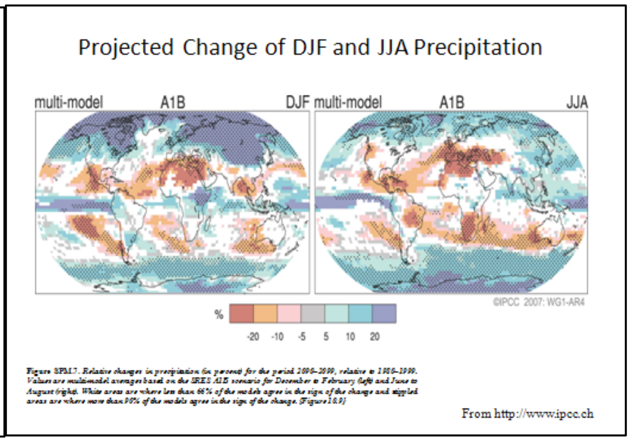
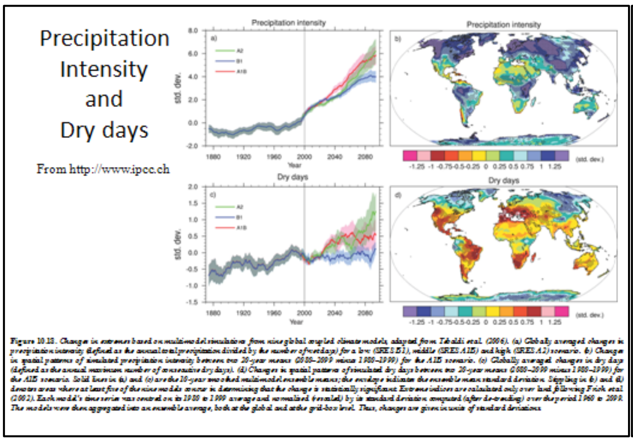


Figure 19 Observation and simulations for global mean temperature change in 20th century (upper-left) with and (lower-left) without anthropogenic forcing. (Right) Future projections of global mean temperature under various scenarios. (From http://www.ipcc.ch).

Figure 20 Future projection of relative precipitation changes (%) between 2090-2099 and 1980-1999. (Left) Dec-Jan-Feb and (right) Jun-Jul-Aug. (From http://www.ipcc.ch).

The global warming tends to change not only average climate but also the strength and frequency of extreme weather events because of moisture increase. Precipitation intensity increases over most regions of the world, especially over the northern extratropics and the equatorial lands (Fig. 21). This is the case even for drier future mean climate regions. On the other hand, the annual maximum number of consecutive dry days also tends to increase in most of the tropics, the subtropics and the mid-latitudes (Fig. 21), where drier future mean climate is projected seasonally. Tropical cyclone frequency tends to decrease over active tropical cyclone regions at present and increase over the other regions (Fig. 22). This fact may be explained from the projection that mean vertical circulations triggering tropical cyclone occurrences tend to be suppressed on average because of upper troposphere further warmer than near-surface in the future mean climate. At the same time, the frequency of strong tropical cyclones is projected to increase due to moisture increase (Fig. 22).



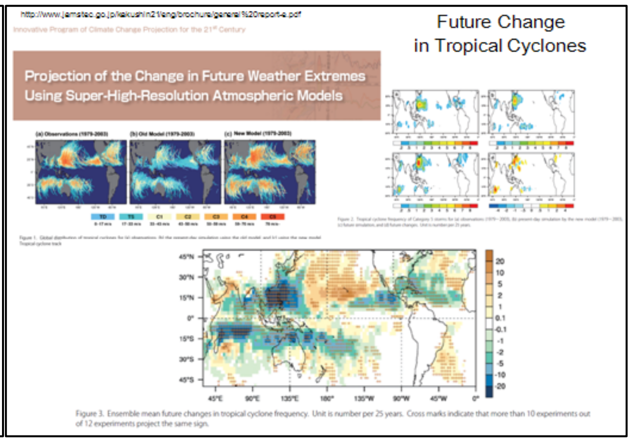


Figure 21 Future projections for changes of (uppers) precipitation intensity and (lowers) dry days. Those are normalized with their standard deviations. (From http://www.ipcc.ch).

Figure 22 Future projection of changes of (lower) tropical cyclone frequency and (upper-right) strong tropical cyclone frequencies. (From http://www.jamstec.go.jp/kakushin21/eng/brochure/general%20report-e.pdf)

8. Summary

Unusual weather and climate are attributed to unusual atmospheric flows, storms and convective disturbance. Diagnostic analysis shows that those disturbances are often related to atmospheric intrinsic waves and phenomena. However, atmospheric environment is maintained and influenced by other elements sustaining the climate system. Sometimes, unusual and steady convective activity is connected to long-term SST anomalies related to ocean variability. Numerical ensemble simulations starting from many disturbed atmospheric and oceanic initials are a reasonable tool to capture mean weathers and climate in weeks to seasons.

Radiative processes including longwave absorption by greenhouse gases and shortwave reflection by snow, ice, clouds and aerosols determine the local Earth's ground temperature. The distribution of ground temperature is influential to vertical and horizontal atmospheric and oceanic stabilities, the amount of water vapor and the speed of water cycle. Then, those can affect atmospheric and oceanic flows, the features of storms and convections and eventually our daily lives. Therefore, we need to continue careful watches and diagnostics for global and local climate systems (Fig.1), as well as its future projection.

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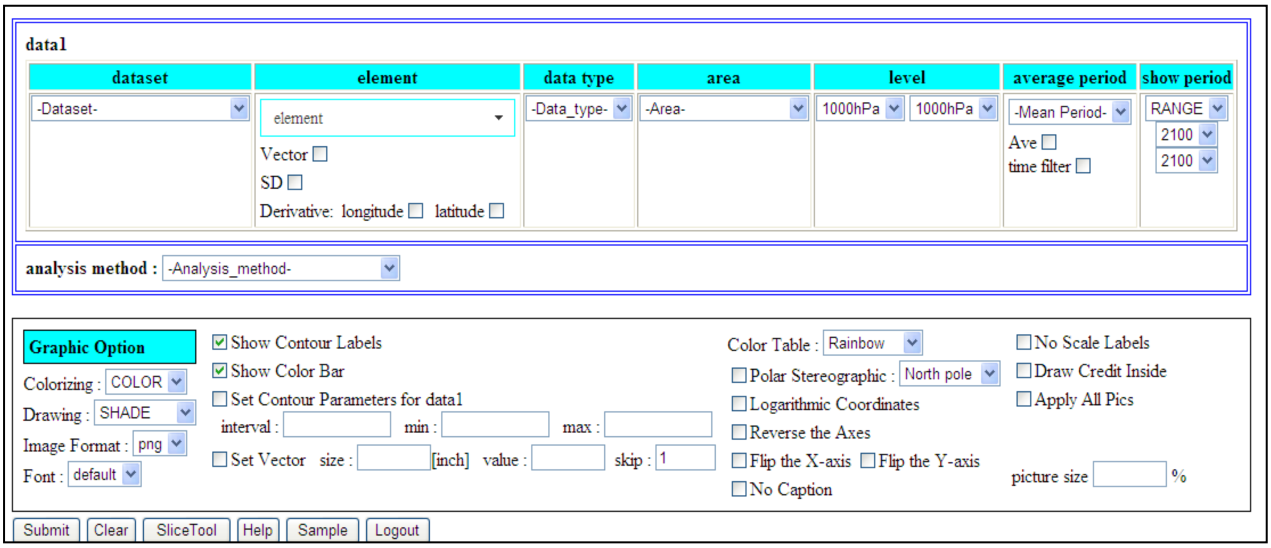
A Quick Tutorial of the ITACS

Chapter 1 Introduction to the ITACS

What is the ITACS?

The ITACS is a web-based application for climatological analysis.

"ITACS", is an acronym of "Interactive Tool for Analysis of the Climate System".



The main display of the ITACS

Features of the ITACS

Various climatological datasets (atmospheric and oceanographic) are available.

Atmospheric analysis data (JRA/JCDAS), outgoing longwave radiation (provided by NOAA), sea surface temperature (COBE-SST), ocean analysis data (MOVE/MRI.COM-G), etc.

Various types of charts are supported.

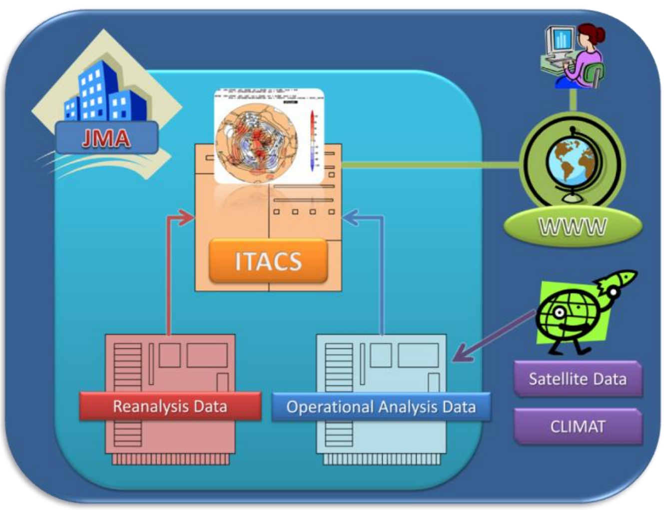
Plain longitude-latitude map, polar stereographic map, cross section, time series graph, etc.

Various statistical functions are built in.

Linear regression, correlation coefficient, EOF, SVD, FFT, etc.

Requirement to use the ITACS is only a web browser with accessibility to the World Wide Web.

Conceptual Outline of the ITACS



Chapter 2 Basic Operation

How to access to the ITACS

Start a web browser and access the following URL.

http://extreme.kishou.go.jp/tool/anatools/analyze4.0-pub/index1.php

Input ID and Password provided to you.

So, you will see main display of the ITACS as shown below.

Setting parameters

The procedure for drawing a chart by the ITACS is as shown below.

Select data-set, element, and data-type.

Set geophysical parameters:

Plotting area (latitude and longitude)

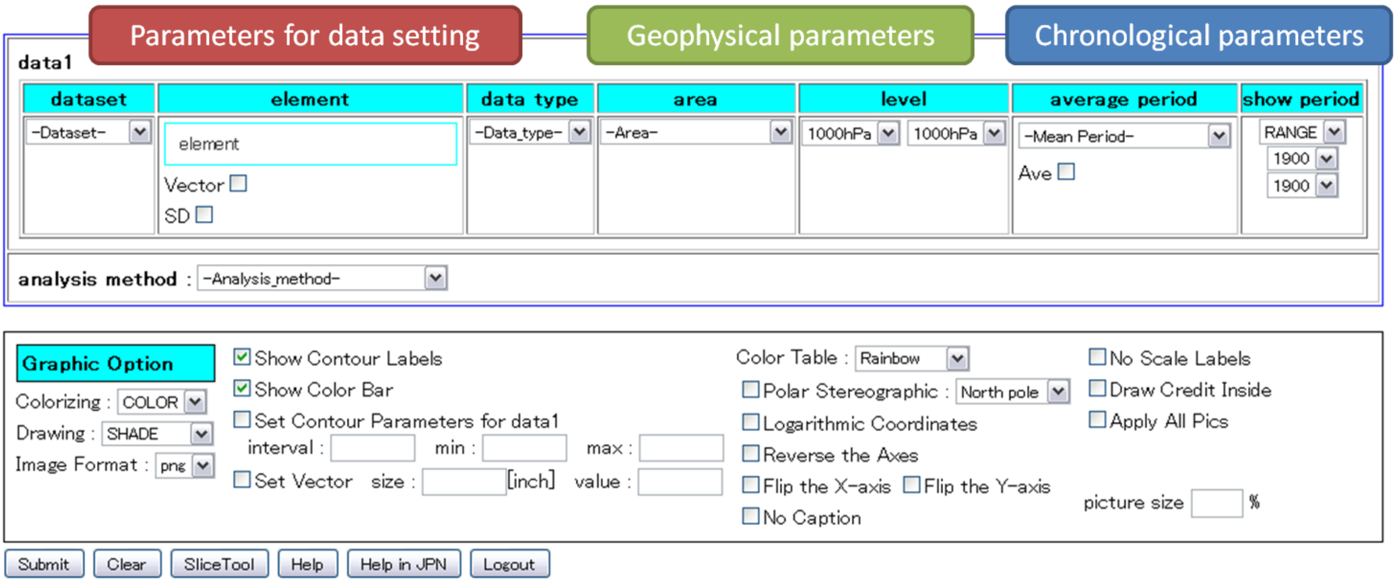
Pressure level (for atmospheric data) or depth (for oceanographic data).

Set chronological parameters:

Average period (e.g., daily, monthly) and period to show (e.g., year, month)

Select analysis method (depending on intended use).

Set graphic parameters (depending on intended use).



An example of drawing a latitude-longitude map for one element

As the first step in using the ITACS, let’s try to draw a distribution map of 200-hPa stream function in October 2010.

Set parameters as shown below.

“data1”

dataset: JRA-JCDAS

element: Pressure-levels - Stream function

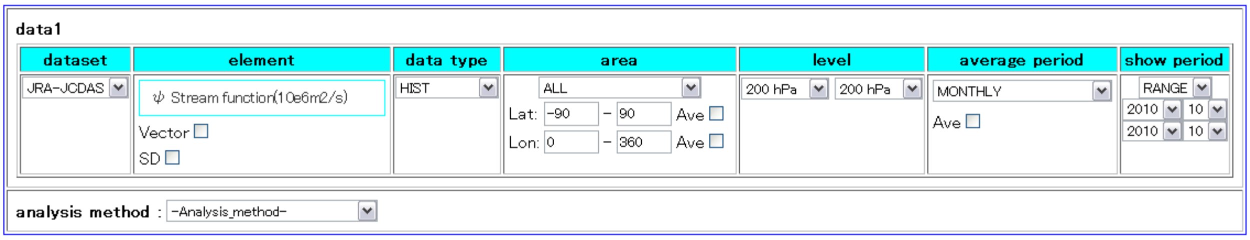
data type: HIST (“Hist” means historical actual observation or analysis data)

area: ALL (90°S – 90°N latitude, 0° – 360° longitude)

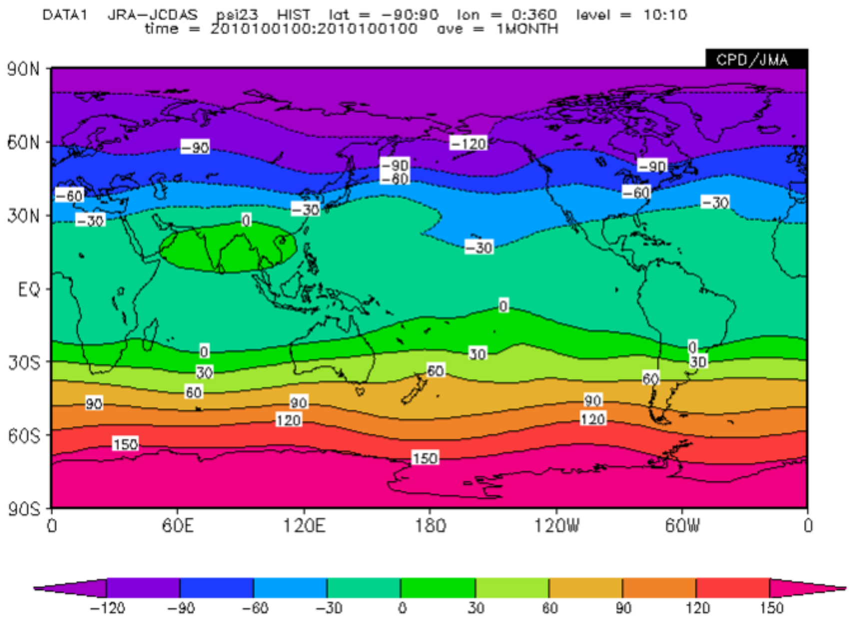
level: 200 hPa

average period: MONTHLY

show period: RANGE, 2010 10



Press “submit” button, and the following chart will be shown.



An example for drawing a latitude-longitude map for two-element

The second step is to make a distribution map of 3-month mean 200-hPa stream function with anomaly from September to November 2010.

Set parameters as followings.

“data1”

dataset: JRA-JCDAS

element: Pressure-levels - Stream function

data type: ANOM (“ANOM” means anomaly)

area: ALL

level: 200 hPa

average period: MONTHLY, and check “Ave” box

show period: RANGE, 2010 09 - 2010 11

analysis method

DATA1_DATA2

“data2”

data type: HIST

Other parameters are the same as for data1.

“Graphic Option”

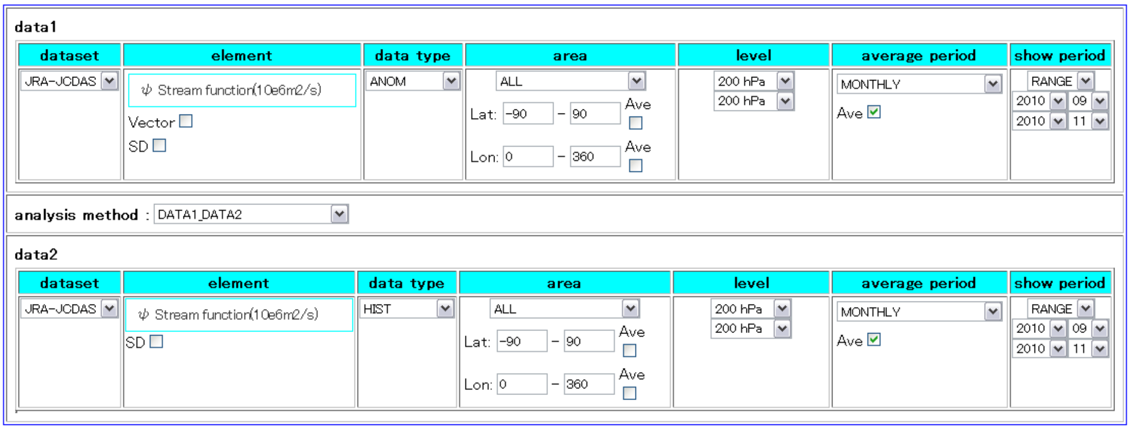
Set Contour Parameters for data1

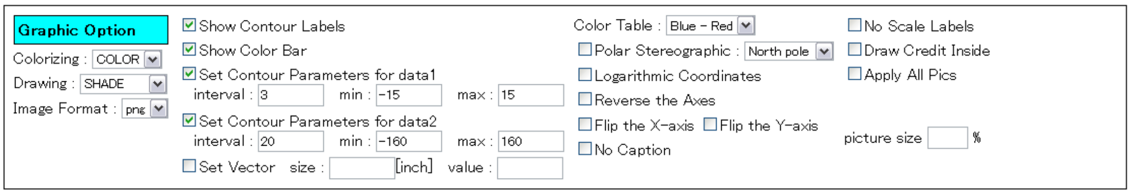
interval: 3 min: -15 max: 15

Set Contour Parameters for data2

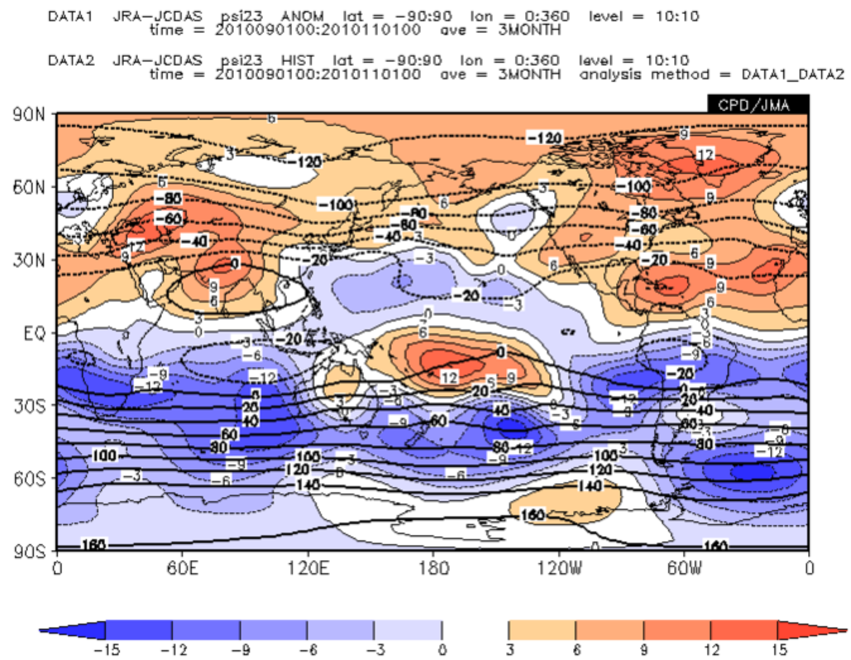
interval: 20 min: -160 max: 160

Color Table: Blue-Red





Press “submit” button, and the following chart will be shown.



Chapter 3: Regression Analysis

How to perform regression analysis on the ITACS

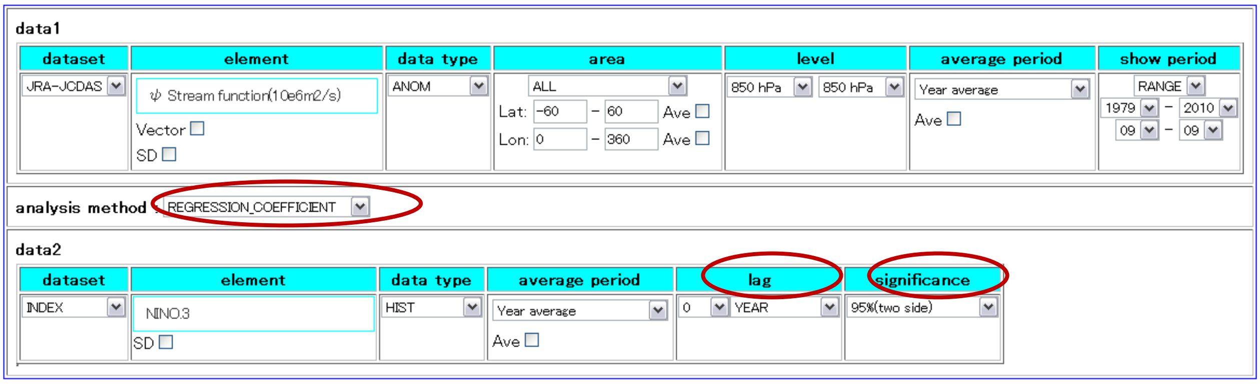
Select “REGRESSION COEFFICIENT” in “analysis method”.

Parameters for regression (or correlation) analysis

lag: data2 lags behinds data1

For example, setting “show period in data1: 7 (July)” and “lag: -6 month in data2” means data2 leads 6 months to data1, namely data2: January.

significance: confidence level based on t-test



Important notice for regression analysis by the ITACS

“data2” is for independent variable.

“data1” is for dependent variable.

An example of regression analysis by the ITACS

When you try to draw a distribution map of regression coefficient between sea surface temperature for NINO.3 region and 850-hPa stream function, please set parameters as shown below.

For data1 (dependent variable)

dataset: JRA-JCDAS, element: Stream-function, data type: ANOM

Lat: -60 – 60, Lon: 0 – 360, level: 850hPa

average period: Year average

show period: RANGE, 1979/09 – 2010/09

“Year Average” means sampling data in the same month of consecutive years. In this case, data in all Septembers from 1979 to 2010 are extracted as samples for the analysis.

For analysis method

REGRESSION COEFFICIENT

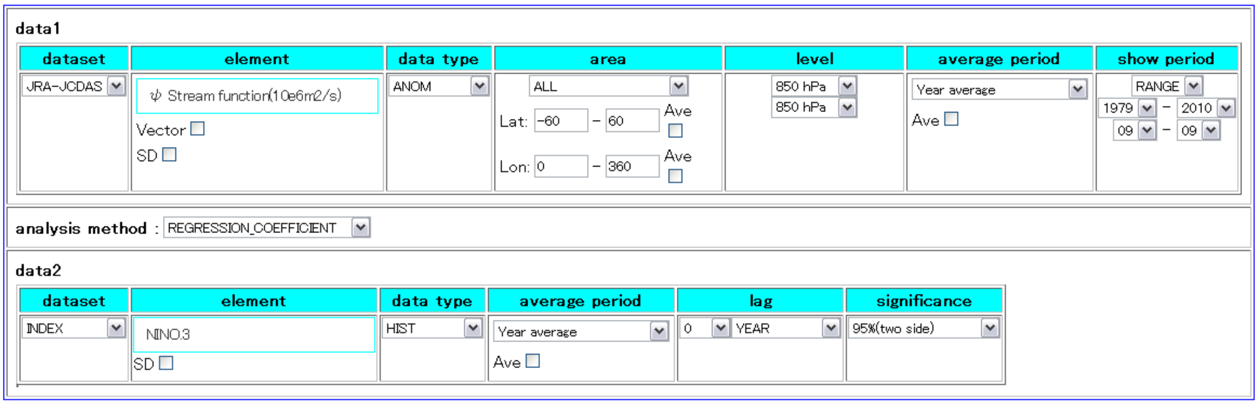
For data2 (independent variable)

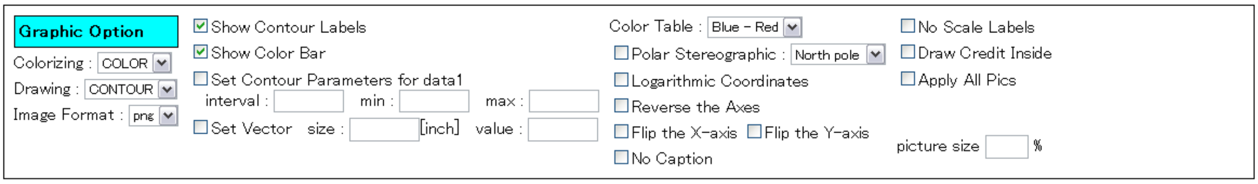
dataset: INDEX, element: NINO3, data type: HIST

Significance: 95%(two side)

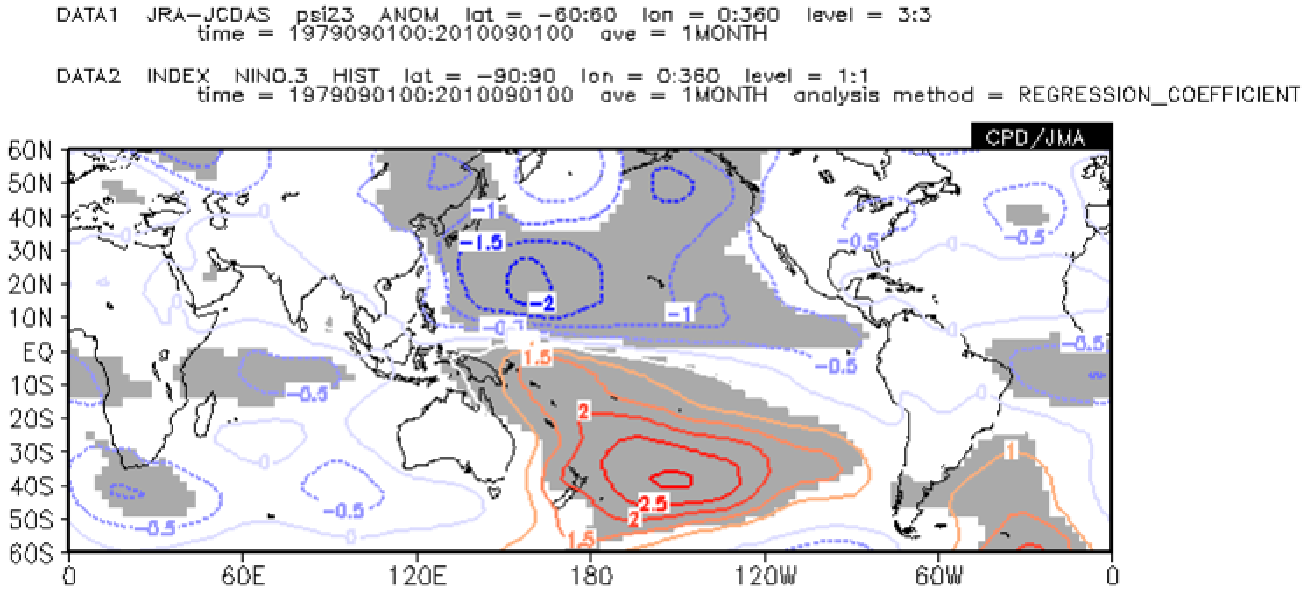
For graphic option

Coloring: COLOR, Drawing: CONTOUR, Color Table: Blue-Red





Press “submit” button, and then the following picture will be shown.



Gray shading indicates 95% confidence level (same as 5% significance level).

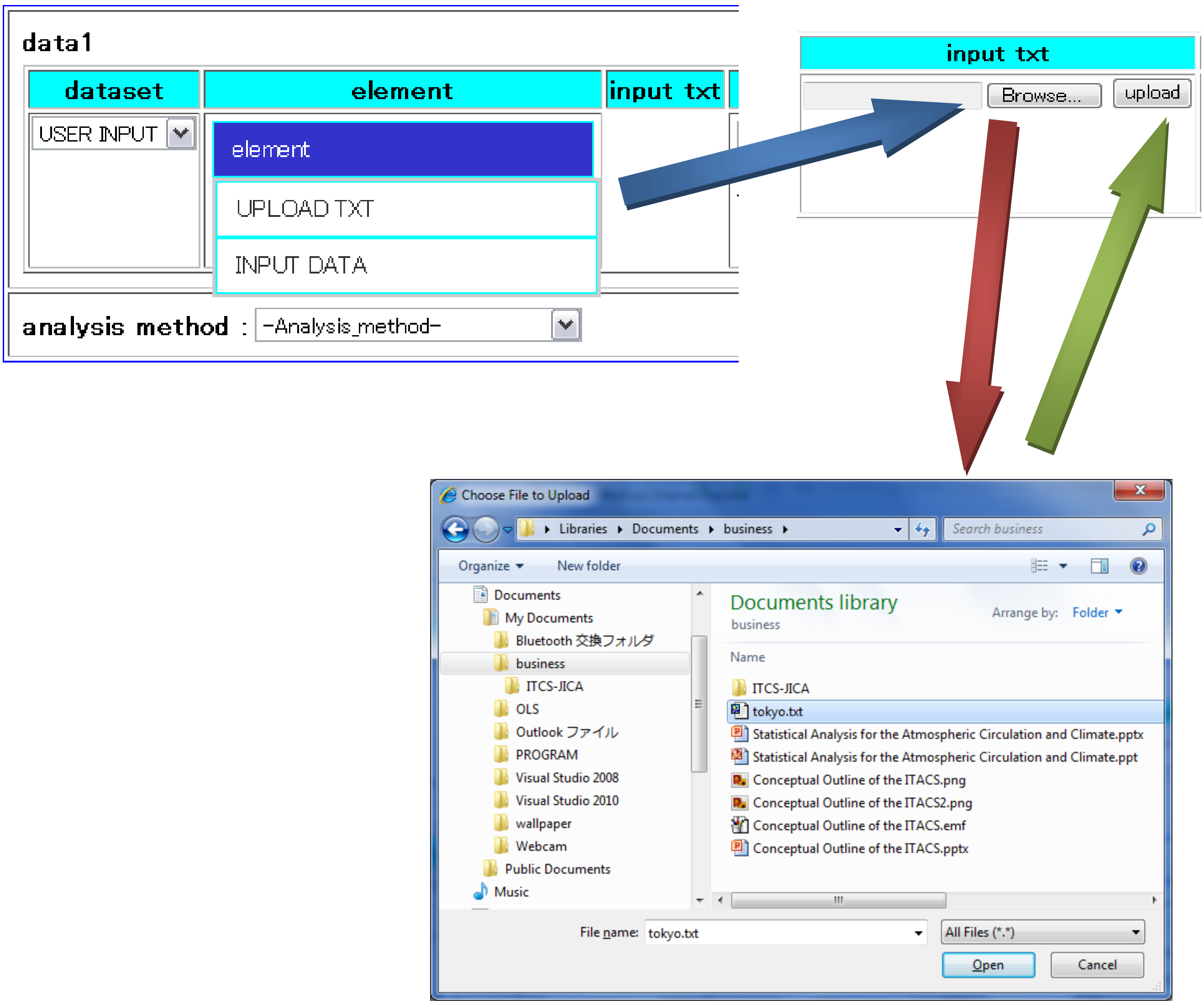
Chapter 4: How to use the data prepared by users on the ITACS

Requirements on the data file for user input

The data file must be a text file in CSV (Comma Separated Values) format.
Time series data of one element is supported.
Only single station data is supported, not multi stations or GPV data set.
The order of fields in one record should be as below.
<year>, <month>, <day>, <data value>
See Appendix I for details.

How to input data by users to the ITACS

There are two methods, and "UPLOAD TXT" is suitable for usual purpose.
The procedure of "UPLOAD TXT" is as follows.
Select "USER INPUT" for "dataset"
Select "UPLOAD TXT" in "element".
Press "Browse…" button in "input txt" dialogue box, select the data file ("tokyo.txt" in this example) and press "upload" button.



An example of correlation analysis using user prepared data

When you try to draw a distribution map of correlation coefficient between temperature of Tokyo (user prepared data) and 500-hPa geopotential height (JRA/JCDAS), please set parameters as shown below.

For data1 (dependent variable)

dataset: JRA-JCDAS, element: Geopotential height, data type: ANOM

area: ALL, level: 500hPa

average period: Year average

show period: RANGE, 1979/09 – 2010/09

For analysis method

CORRELATION COEFFICIENT

For data2 (independent variable)

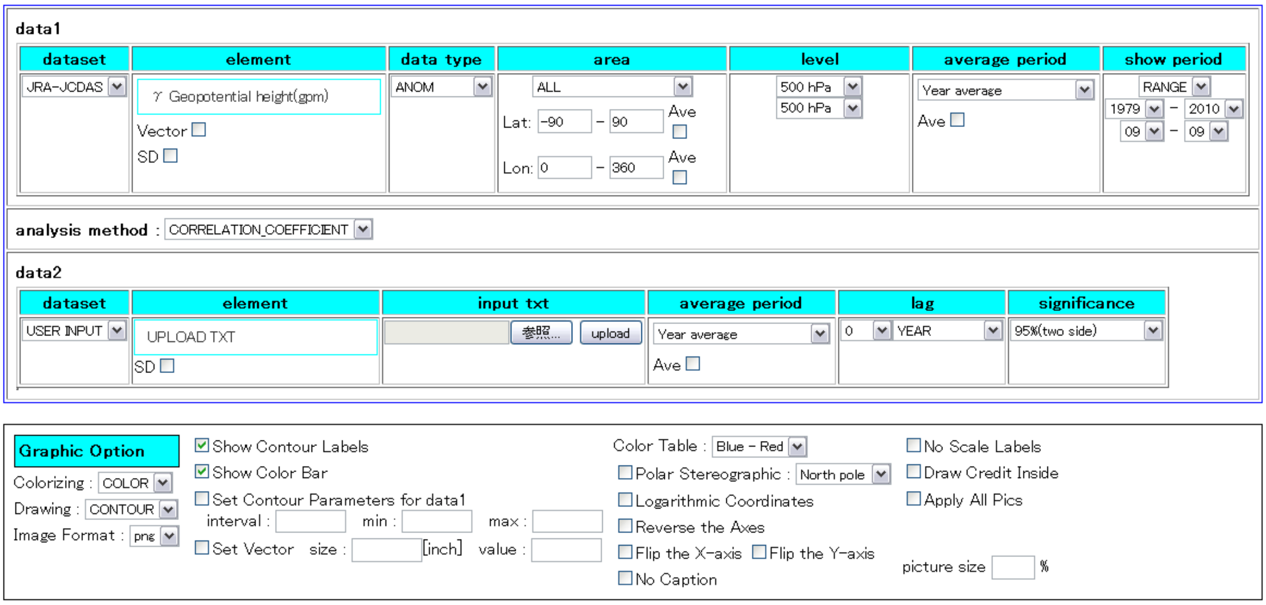
dataset: USER INPUT

element: UPLOAD_TEXT (upload a user-prepared-data file of Tokyo temperature)

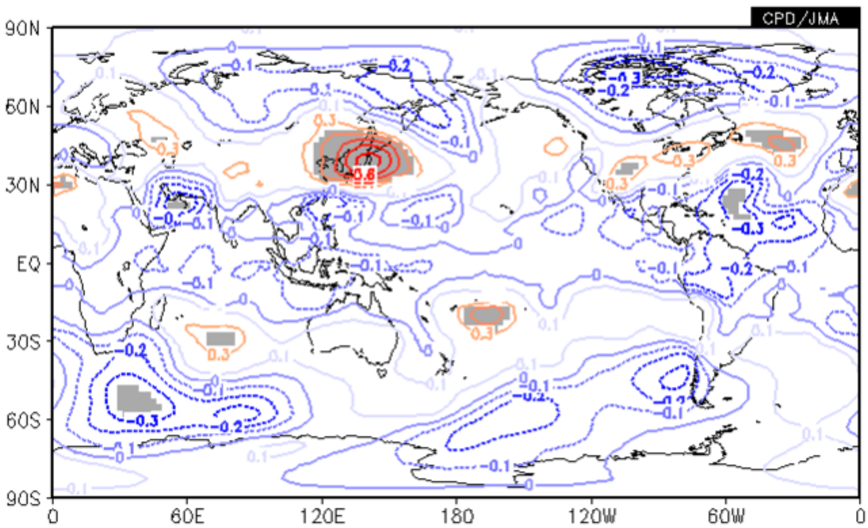
Significance: 95%

For graphic option

Coloring: COLOR, Drawing: CONTOUR, Color Table: Blue-Red



Please press "submit", and then the picture below will be shown.



Appendix I: A sample for user input data

```
#Monthly mean temperature of Tokyo
#element=Temperature_of_Tokyo
#undef=9999
#year,month,day,temp.
1979,1,1,6.6
1979,2,1,8.4
1979,3,1,9.9
1979,4,1,13.9
1979,5,1,18.6
1979,6,1,24.4
1979,7,1,25.2
1979,8,1,27.4
1979,9,1,24.1
1979,10,1,19.6
1979,11,1,14.3
1979,12,1,10.1
1980,1,1,5.6
1980,2,1,5.2
```

Commentary

A line beginning with "#undef" is used for the definition of undefined value (default value: -9999).
A line beginning with "#element" is used for denoting element name (not required).
A line beginning with "#" except for "#undef" and "#element" is treated as comment line.
Every line must be terminated with a newline code.

Appendix II: Detailed tutorial for the ITACS

The present quick tutorial explains minimum operation of the ITACS that is required for exercises of the training seminar on seasonal prediction products. For persons who want to learn moreover about climatological analysis by the ITACS, comprehensive tutorials are available at the ITACS website (following URL).

http://extreme.kishou.go.jp/tool/itacs-tcc2011/

Tools and documents

ITACS ver 4.0
ITACS ver 3.0

Sample images for ITACS ver.4.0
Tutorial for ver.4.0
- Sea surface temperature(SST)
- Average of SST anomaly
- Stream function of historical data on 850hPa
- Stream function of historical data and anomaly data on 850hPa
- Subtraction of monthly SST
- 500-hPa height and anomaly
- Time-longitude cross section of 200-hPa velocity potential
- Water vapor flux(vector) anomaly and specific humidity anomaly
- Interannual variation of monthly mean 850-hPa air temperature
- SST composite of La Nina years
- Regression Analysis : NINO.3 SST and 850hPa Stream Function / Correlation analysis
- boundaries +

Tutorial of the ITACS ver 3.0 (2.85MB)

JMA's Ensemble Prediction System (EPS) for Seasonal Forecasting

JMA's Ensemble Prediction System (EPS) for Seasonal Forecasting

1. Concept of numerical prediction

(1) What is numerical prediction?

"Numerical prediction" is to calculate future status inputting current status based on basic principles of physical low. A tool for numerical prediction is a "numerical prediction model", which is a large-scale programming.

Basal principle of numerical prediction is common between short- and long-range forecasting; iterating very short-range time integration. Numerical prediction requires the following components (Figure 1)

* Numerical model
* Initial condition
* Boundary condition

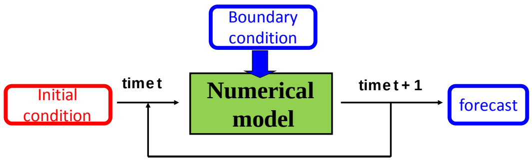


Figure 1 Operation of numerical prediction

Both atmospheric- and oceanic- global circulation model (e.g. AGCM and OGCM) have been developed. For long-range forecasting, interaction between ocean and atmosphere is important for long-range forecasting. Therefore, coupled atmosphere and ocean global circulation model (CGCM) has been developed. Nowadays numerical prediction system adopting CGCM prevails for numerical long-range forecasting.

(2) Predictability

In principle, it is possible to predict future status of atmosphere considering principle primitive equations of atmosphere. However, in reality, motion of atmosphere is very sensitive to initial condition due to the chaotic nature of the atmosphere.

There is a concept "predictability", which means possibility of predicting the specific phenomenon. Space- and temporal-scale of variation differs according to phenomenon; therefore those predictabilities are also different. The main target of seasonal prediction is large-scale variation. In particular, variation on the sea surface, such as ENSO, is an important signal for long-range forecasting.

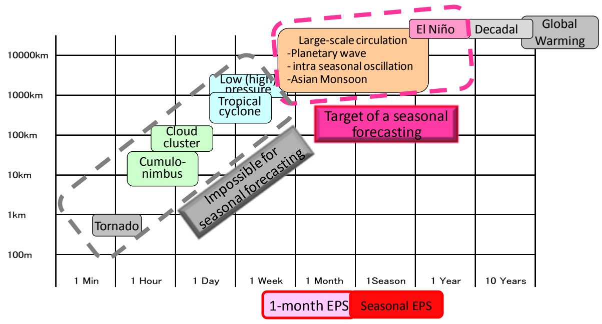


Figure 2 Special and temporal scale of forecasting target

There are three basic types of uncertainty in forecasting:

- Uncertainty relating to initial conditions: predictability of the first kind
- Uncertainty relating to boundary conditions: predictability of the second kind
- Uncertainty relating to models (not discussed here)

Due to the chaotic nature of the atmosphere, which stems from its characteristic of strong non-linearity, the limit for deterministic forecasting is about two weeks. Accordingly, the ensemble prediction system (EPS) is essential in seasonal forecasting.

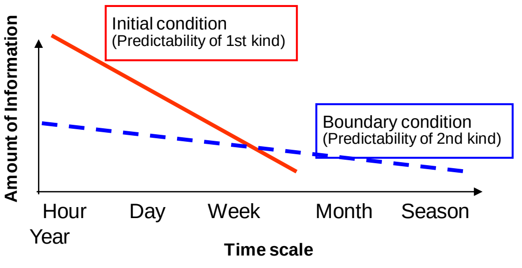


Figure 3 Importance of initial and boundary condition

However, the influence of boundary conditions is important for longer-range forecasting models. In particular, forcing on the sea surface is an important signal in seasonal forecasting. However, in extended-range forecasting, initial conditions (the first kind) and boundary conditions (the second kind) are both important.

(3) Ensemble prediction

Ensemble prediction is to predict future status aggregating multiple forecast results. The most common method of ensemble prediction is called "initial ensemble", which is multiple running a model from very slightly different initial conditions (Figure 4). Average of individual forecast is "ensemble mean", indicating signal for forecasting. Standard deviation among individual member forecast is "ensemble spread", indicating degree of uncertainty. In addition, output of an ensemble prediction is probabilistic density function (PDF); therefore uncertainty in forecast is able to be estimated using EPS products.

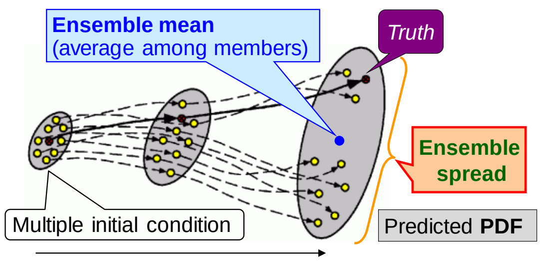


Figure 4 Concept of ensemble prediction

2. Outline of JMA's EPS for seasonal forecasting

(1) WMO Forecast classification

In line with "WMO's Manual on the Global Data-Processing and Forecasting System"[1], forecasts are classified by their ranges as Table 1. Seasonal prediction, which is the main topic of the TCC seminar, corresponds to extended-range and long-range forecasting (shaded in table 2).

Table 1 Definitions of meteorological forecasting range classified by WMO

	Forecasting target period
Nowcasting	Up to 2 hours
Very short-range weather forecasting	Up to 12 hours
Short-range forecasting	Beyond 12 hours and up to 72 hours
Medium-range weather forecasting	Beyond 72 hours and up to 240 hours
Extended-range weather forecasting	Beyond 10 days and up to 30 days
Long-range forecasting	Beyond 30 days up to two years
Climate forecasting	Beyond two years

(2) Operational global NWP system at JMA

Table 2 shows the operational global NWP system at JMA. TCC provides model products with the one-month and the seasonal EPS (red box in Table 3).

Table 2 Operational global NWP system at JMA

	Main target	Horizontal resolution
Global Spectral Model (GSM)	•Short-range forecasting	20km Global
Typhoon EPS (TEPS)	•Typhoon forecasting	55km Global
One-week EPS (WEPS)	•One-week forecasting	55km Global
One-month EPS	•Early warning Information on •Extreme events •One-month forecasting	110km Global
4/7-month EPS (Seasonal EPS)	•Seasonal forecasting •El Niño outlook	180km Global

[1] http://www.wmo.int/pages/prog/www/DPS/Publications/WMO_485_Vol_I.pdf

(2) Ensemble prediction system for seasonal forecasts

CPD/TCC of JMA operates two ensemble prediction systems (EPSs) for seasonal prediction. These are the one-month EPS and the 4/7-month EPS (seasonal EPS). The specifications of the two EPSs run by JMA/CPD are shown in table 3. For further information on the NWP system, see Numerical Weather Prediction of JMA on http://www.jma.go.jp/jma/jma-eng/jma-center/nwp/nwp-top.htm.

Table 3 Specification of the One-month and Seasonal EPS (as of November 2013)

	One-month EPS	Seasonal EPS
Model	AGCM (Atmospheric General Circulation Model)	CGCM (Coupled Ocean-atmosphere General Circulation Model)
Resolution	Horizontal: approx. 110 km (TL159) Vertical: 60 levels up to 0.1 hPa	* Atmospheric component Horizontal: approx. 180 km (TL95) Vertical: 40 levels up to 0.4 hPa * Oceanic component Horizontal: 1.0º longitude, 0.3–1.0º latitude (75˚S – 75˚N) Vertical: 50 levels
Forecast range	Up to 34 days	7-month (initial month of Sep., Oct., Feb., Mar., Apr) 4 months (other initial month)
Ensemble method	Combination of Breeding of Growing Modes (BGM) and Lagged Average Forecast (LAF)	
Ensemble size	50 (25 BGMs & 2 days with 1-day LAF)	51 (9 BGMs & 6 days with 5-day LAF)
Frequency of operation	Every Wednesday and Thursday	Every 5 days
Frequency of model product creation	Once a week Every Friday (*)	Once a month Around the 20th (no later than the 22nd) of every month

(3) Hindcasts

A hindcast is a set of systematic forecast experiments for past cases. Hindcast experiments are performed using a forecasting model identical to the current operational model. Hindcast datasets are used to determine the systematic bias and skill of models and to establish/evaluate statistical models.

As hindcasting involves model calculations for a large number of past events, huge computing resources are required. Accordingly, hindcast specifications (e.g., ensemble size, calculation frequency) are more limited than those of operational system forecasts, having a smaller ensemble size and a longer initial-date interval. Differences between hindcasts and operational system output are shown in table 4.

Table 4 Differences between hindcast and operational system

* 1-month EPS

	Hindcast	Operational system
Ensemble size	5 (5 BGMs, not using LAF)	50 (25 BGMs & 2 days with 1-day LAF)
Forecast range	Initial date + 33 days	2, 3, 4,...31, 32 days from the later initial date (Thursday)
Initial date	10th, 20th, end of month	Every Wednesday and Thursday
Target period of hindcast	1979 – 2010	---

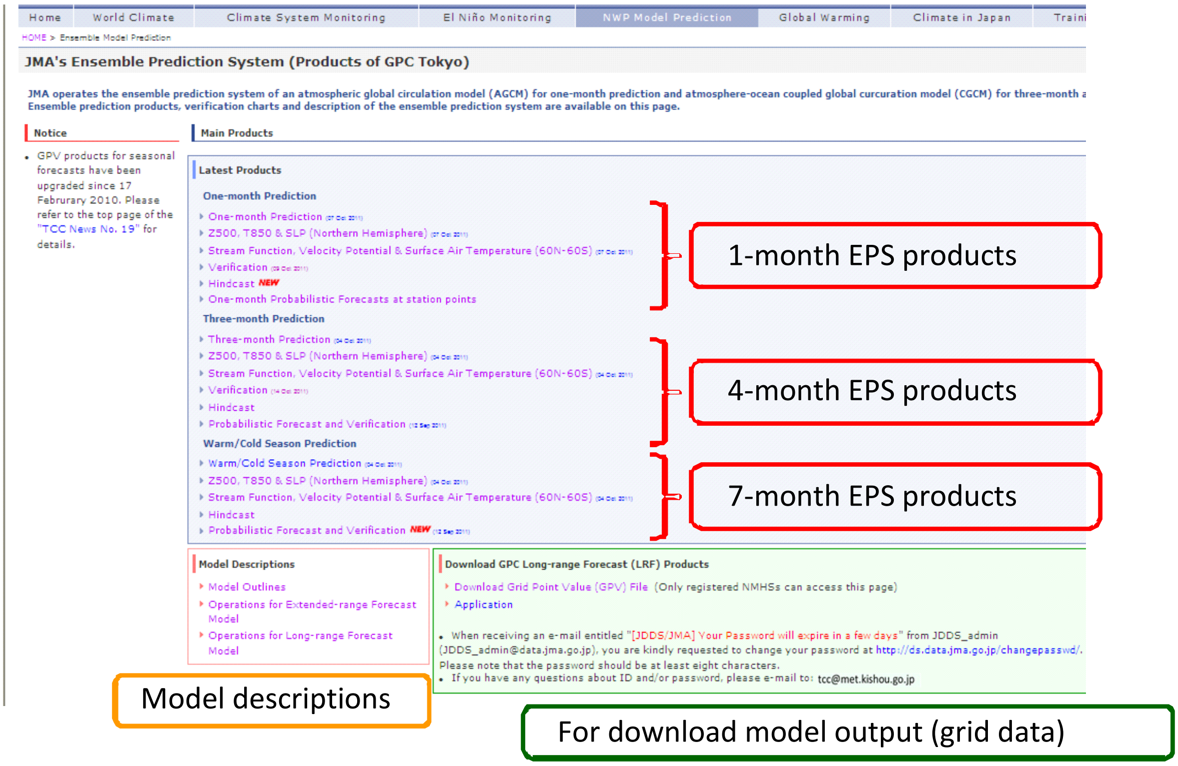
* 4/7-month EPS

	Hindcast	Operational system
Ensemble size	5 (5 BGM)	51 (9 BGMs & 6 days with 5-day LAF)
Forecast range	Lead time from 0 to 6 months as shown in the correspondence table below	(4-month EPS) Lead time from 1 to 3 as shown in the correspondence table below (7-month EPS) DJF (initial month of Oct.) JJA (initial months of Feb., Mar. and Apr.)
Initial date	24 initial dates a year (1st Jan., 16th Jan., 15th Feb., 2nd Mar., 17th Mar.,... 2nd Dec. and 17th Dec.	Once a month
Target period of hindcast	1979 – 2010	–

Correspondence between lead times (months) and initial dates

Target month / Initial date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1-Jan, 17-Dec	0	1	2	3	4	5	6					
31-Jan, 16-Jan		0	1	2	3	4	5	6				
2-Mar, 15-Feb			0	1	2	3	4	5	6			
1-Apr, 17-Mar				0	1	2	3	4	5	6		
1-May, 16-Apr					0	1	2	3	4	5	6	
31-May, 16-May						0	1	2	3	4	5	6
30-Jun, 15-Jun	6						0	1	2	3	4	5
30-Jul, 15-Jul	5	6						0	1	2	3	4
29-Aug, 14-Aug	4	5	6						0	1	2	3
28-Sep, 13-Sep	3	4	5	6						0	1	2
28-Oct, 13-Oct	2	3	4	5	6						0	1
2-Dec, 17-Nov	1	2	3	4	5	6						0

3. Seasonal forecasting model products on the TCC website



Model product page on the TCC website
(http://ds.data.jma.go.jp/gmd/tcc/tcc/products/model/index.html

3.1 1-month EPS products

* Forecasting maps — Weekly forecasting maps
  Animated forecasting maps (experimental)
* Real-time verification of routine model forecasts
* Hindcast verification charts
* Calibrated probabilistic forecasts at station points

3.2 4/7-month EPS products

* Forecasting maps — Monthly forecasting maps
* Hindcast verification charts
* Calibrated probabilistic forecasts

Use of gridded forecast data

(How to download gridded and indices forecast data from the TCC website, and how to visualize using GrADS)

Use of gridded forecast data

(How to download gridded and indices forecast data from the TCC website,
and how to visualize using GrADS)

1 Outline

The Tokyo Climate Center (TCC) provides gridded forecast data for one-month and seasonal (three-month and warm/cold season) forecasts, and a set of indices defined as area-averaged forecasts for seasonal forecasts. The data can be downloaded from the TCC website by the following procedure:

Visit the **TCC top page**

URL: http://ds.data.jma.go.jp/tcc/tcc/index.html

Click on **NWP Model Prediction** in the top menu

Click on **Download Gridded data File** in “Download GPC Long-range Forecast (LRF) Products”

Note that only registered NMHSs can access this page.

Get to the web page for “Downloaded Gridded Data files” shown in Figure 1.

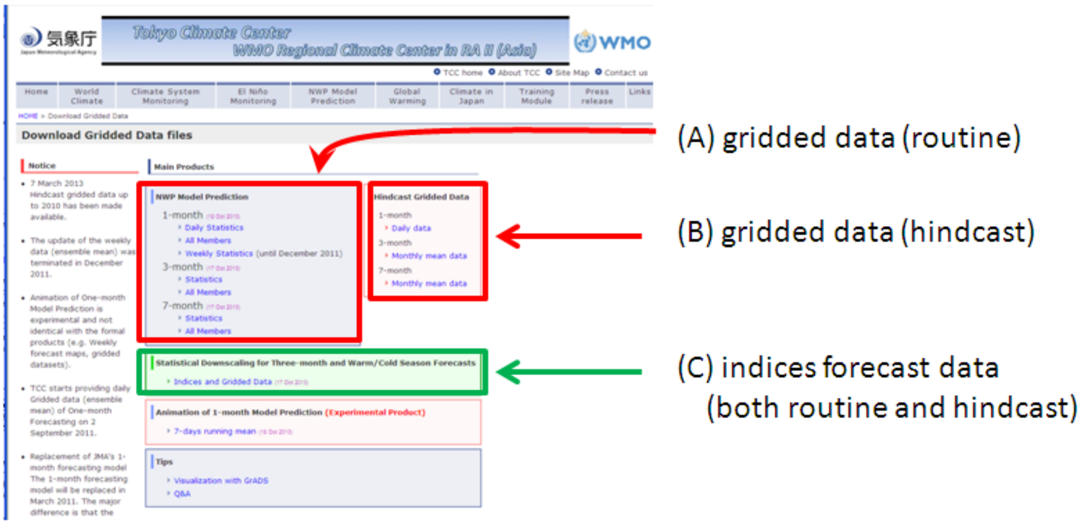


Figure1 TCC Web page for “Downloaded Gridded Data files”
(http://ds.data.jma.go.jp/tcc/tcc/gpv/index.html)

Table 1 shows outline of the gridded and indices forecast datasets on the TCC web. The indices are stored as the comma separated values (CSV) file format. Meanwhile, the gridded forecast data is coded in GRIB2 format (GRIB Edition 2; http://www.wmo.int/pages/prog/www/WMOCodes.html), which is standard for disseminating gridded dataset in WMO.

Table 1 Summary of the gridded and indices forecast data on TCC web

	Indices	Gridded data
File format	CSV	GRIB2
One-month forecast		O
Seasonal (3-month and 7-month) forecast	O	O

O: Available

This document is organized as follows: how to download indices forecast data and gridded forecast data are described in section 2 and 3. In section 4, GRIB2 format data is decoded and visualized using wgrib2 and GrADS (Grid Analysis and Display System).

2 Indices forecast data

The indices forecast data is available on the web page (figure 2):

http://ds.data.jma.go.jp/tcc/tcc/gpv/indices/index.html,

which is linked from the page shown in figure 1C. By selecting forecast [Three-month Forecast or Warm/Cold Season Forecast] (figure 2A) and the initial date, indices CSV files can be found in the directory (figure 2B). Figure 3 shows an example of the indices forecast file for three-month forecast with the initial month of October 2013. As the file format is CSV, it is possible to read using spreadsheet software, such as Microsoft-Excel. Definitions of the indices are referred to the definition table linked from the page shown in figure 2A.

Although two CSV files:

(a) GPV_*.csv: gridded forecast data (deprecated)

(b) INDEX_*.csv: indices forecast data

are on the specific initial date page (Figure 2B), **the CSV gridded data named GPV_*.csv will be discontinued near future. GRIB2 gridded data described in the next section continues to be available.**

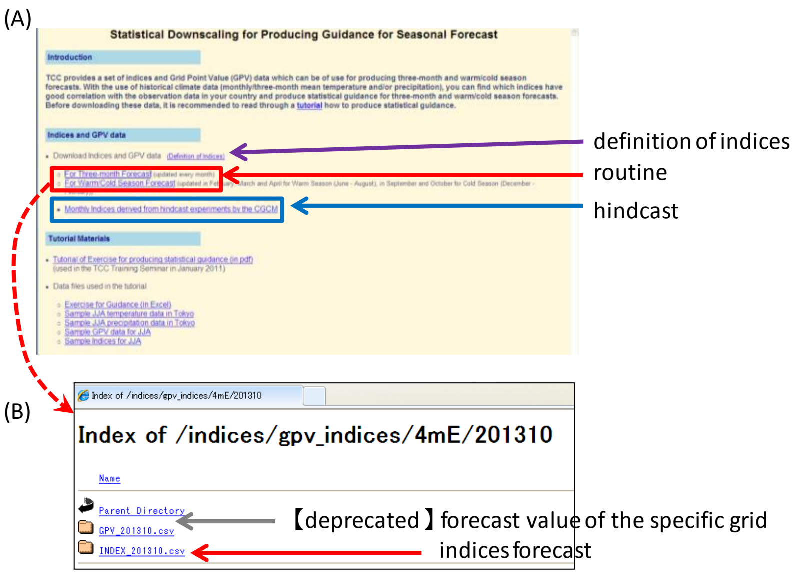


Figure 2 Web page for indices forecast data

(A) parent page, (B) an example of the specific forecast directory.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	INDEX	NINO3SST	NINOWEST	IOBW SST	WIO SST	EIO SST	IOBWRAIN	WIO RAIN	EIO RAIN	SAMOIRAI	WNP RAIN	SEAsiaRA	MC RAIN	DL RAIN	Z5002030	Z5003040	Z5004050	Z5005060
2	DEGREE	K	K	K	K	K	mm/day	mm/day	mm/day	mm/day	mm/day	mm/day	mm/day	mm/day	m	m	m	m
3	NDJ	−0.12	0.14	0.14	0.15	0.05	0.12	0.11	0	−0.02	0.16	0.22	−0.01	−0.2	1.88	3.4	3.23	2.52
4	Nov.	−0.24	0.08	0.19	0.29	0.04	0.1	0.3	−0.15	−0.35	0.11	−0.01	−0.14	−0.79	2.26	4.7	6.11	6.18
5	Dec.	−0.14	0.15	0.15	0.13	0.07	0.21	0.08	0.09	0.05	0.09	0.1	0.14	−0.08	1.71	2.19	1.92	1.79
6	January	0.01	0.2	0.07	0.02	0.03	0.05	−0.06	0.04	0.25	0.28	0.59	−0.04	0.27	1.67	3.3	1.65	−0.39
7																		

Figure 3 Example of the indices forecast data.

3 Gridded forecast data

The gridded forecast data coded in GRIB2 is available on “Download Gridded Data files” page (figure 1 A and B). In this section, specification of the gridded forecast data such as element and target time (validtime) are explained. Concrete method of decoding a GRIB2 file is described in section 4.

3.1 Differences between operational system and hindcast experiments

A hindcast is a set of systematic forecast experiments for past cases. Hindcast experiments are performed using the current operational model. Table 2 shows specifications of the operational system and the hindcast system for one-month and seasonal ensemble prediction. Note that ensemble size and forecast frequency for hindcast experiments are limited due to computing resources. As for the seasonal ensemble prediction system (EPS), initial date for hindcast set 24 per year. Concrete initial dates are shown in table 2.

Table 2 Specifications of operational system and hindcast experiments

* One-month EPS

	Hindcast	Operational system
Ensemble size	5 (5 BGMs, not using LAF)	50 (25 BGMs & 2 days with 1-day LAF)
Forecast range	Initial date + 33 days	
Frequency of forecasting	10th, 20th, end of month	Once a week
Target period of hindcast	1981 – 2010	---

* Seasonal (3-month and 7-month) EPS

	Hindcast	Operational system
Ensemble size	5 (5 BGMs)	51 (9 BGMs & 6 days with 5-day LAF)
Forecast range	Lead time from 0 to 6 months as shown in the correspondence table below	(3-month EPS) Lead time from 1 to 3 as shown in the correspondence table below (7-month EPS) DJF (initial month of Sep. and Oct.) JJA (initial months of Feb., Mar. and Apr.)
Frequency of forecasting	24 initial dates a year (1st Jan., 16th Jan., 31th Jan., 15th Feb., 2nd Mar.,... 2nd Dec. and 17th Dec.)	Once a month
Target period of hindcast	1981 – 2010	–

Correspondence between lead times (months) and initial dates

Initial date \ Target month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1-Jan, 17-Dec	0	1	2	3	4	5	6					
31-Jan, 16-Jan		0	1	2	3	4	5	6				
2-Mar, 15-Feb			0	1	2	3	4	5	6			
1-Apr, 17-Mar				0	1	2	3	4	5	6		
1-May, 16-Apr					0	1	2	3	4	5	6	
31-May, 16-May						0	1	2	3	4	5	6
30-Jun, 15-Jun	6						0	1	2	3	4	5
30-Jul, 15-Jul	5	6						0	1	2	3	4
29-Aug, 14-Aug	4	5	6						0	1	2	3
28-Sep, 13-Sep	3	4	5	6						0	1	2
28-Oct, 13-Oct	2	3	4	5	6						0	1
2-Dec, 17-Nov	1	2	3	4	5	6						0

3.2 Grid data of operational one-month forecast

(1) Daily data on statistics (ensemble mean and anomaly)

Forecasting target period for each record:

Forecast day 2, 3, 4,...31, 32 from the later initial date

Elements:

Ensemble mean forecast and anomaly

Level	Pressure or height (Z)	Rain	T	U	V	RH	Stream function	Velocity potential
Surface	O (SLP)	O	O (2 m)					
850 hPa			O	O*	O*	O*	O	
700 hPa			O					
500 Pa	O (Z)							
200 Pa				O*	O*		O	O
100 hPa	O (Z)							

*: Ensemble mean only (anomaly not included)

(2) Daily data on individual ensemble members

Forecasting target period for each record:

Forecast day 0, 1, 2,...33 from the initial date

Elements:

Individual ensemble member forecast

(Anomalies not included)

Level	Pressure or height (Z)	Rain	T	U	V	RH	Stream function	Velocity potential
Surface	O (SLP)	O	O (2 m)					
1,000 hPa	O (Z)		O	O	O	O	O	
850 hPa	O (Z)		O	O	O	O		
700 hPa	O (Z)		O	O	O	O		
500 Pa	O (Z)		O	O	O	O		
300 Pa	O (Z)		O	O	O	O	O	O
200 hPa	O (Z)		O	O	O			
100 hPa	O (Z)		O	O	O			

3.3 Grid data of hindcast experiments for one-month forecast

Only individual ensemble member forecast is available.

(1) Daily data on individual ensemble members

Forecasting target period for each record:

Forecast day 0, 1, 2,...33 from the initial date

Elements:

Individual ensemble member forecast

(Anomalies not included)

Level	Pressure or height (Z)	Rain	T	U	V	RH	Stream function	Velocity potential
Surface	O (SLP)	O	O (2 m)					
1,000 hPa	O (Z)		O	O	O	O	O	
850 hPa	O (Z)		O	O	O	O		
700 hPa	O (Z)		O	O	O	O		
500 Pa	O (Z)		O	O	O	O		
300 Pa	O (Z)		O	O	O	O	O	O
200 hPa	O (Z)		O	O	O			
100 hPa	O (Z)		O	O	O			

3.4 Grid data of <u>operational</u> seasonal forecast

(1) Monthly data on ensemble statistics (ensemble mean and anomaly)

Forecasting target period for each record:

- 3-month mean (record 1)
  - Lead 1 month for 4-month EPS
  - DJF or JJA mean for 7-month EPS
- 1-month mean (records 2 to 4)
  - Lead 1, 2 and 3 months from the initial month for 4-month EPS
  - Each month of DJF or JJA for 7-month EPS

Elements:

Ensemble mean forecast, anomaly and spread

Level	Pressure or height (Z)	Rain	T	U	V	RH
Surface	O (SLP)	O	O (2 m, SST*)			
850 hPa			O	O	O	
500 Pa	O (Z)					
200 Pa				O	O	

*: Ensemble mean and anomaly only (ensemble spread not included)

(2) Monthly data on individual ensemble members (forecast and anomaly)

Forecasting target period for each record:

- 1-month mean
  - Lead 1, 2 and 3 months (records 1 to 3) from the initial month for 4-month EPS
  - Every month from lead 1 month to February or August for 7-month EPS

Elements:

Individual ensemble member forecast and anomaly

Level	Pressure or height (Z)	Rain	T	U	V	RH	Specific humidity
Surface	O (SLP)	O	O (2 m, SST*)				
850 hPa	O (Z)		O	O	O	O	O
500 Pa	O (Z)		O	O	O		
300 hPa	O (Z)						
200 Pa	O (Z)		O	O	O		
100 hPa	O (Z)						

3.5 Grid data of hindcast experiments for seasonal forecast

(1) Monthly data on individual ensemble members (forecast and anomaly)

Forecasting target period for each record:

Lead 0, 1, 2,...6 months from the initial month (7 records)

Elements:

Individual ensemble member forecast

Level	Pressure or height (Z)	Rain	T	U	V	RH	Specific humidity
Surface	O (SLP)	O	O (2 m, SST*)				
850 hPa	O (Z)		O	O	O	O	O
500 Pa	O (Z)		O	O	O		
300 hPa	O (Z)						
200 Pa	O (Z)		O	O	O		
100 hPa	O (Z)						

4 Decoding and visualizing the gridded forecast data

Gridded forecast data coded in GRIB2 format can be decoded using a free tool called wgrib2 developed by NOAA in USA. In addition, a free software called GrADS (Grid Analysis and Display System) developed by COLA/IGES in the USA visualizes gridded data.

Figure 4 shows processes for decoding and visualizing the gridded forecast data. In this section, the processes are described, taking ensemble statistics of surface temperature (Tsurf) forecast for 7-month EPS with the initial month of October 2013 as an example.

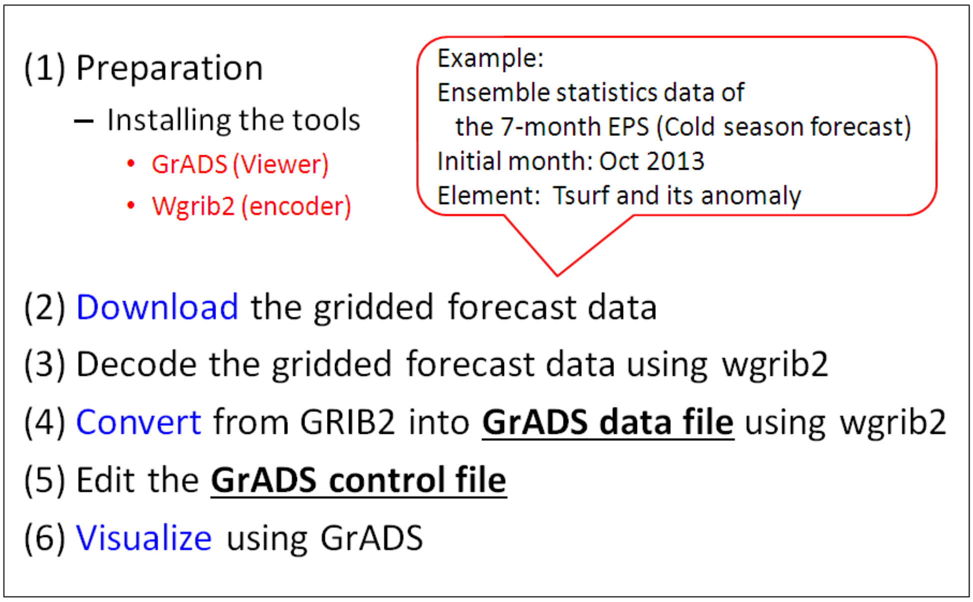


Figure 4 Procedure for visualizing the gridded forecast data

4.1 Installation of the tools GrADS and wgrib2

A computer which can run GrADS and wgrib2 is required. MS Windows, Linux and most UNIX computers are appropriate.

(1) Installing for MS-Windows

While COLA/IGES provides a Windows version of GrADS, US-based company SourceForge has developed and provides an extension version of GrADS called "OpenGrADS", which offers useful utilities including wgrib2. As a result, **Windows users should install only one tool – OpenGrADS –.**

The procedure for installing "OpenGrADS" is described here. (Note that the procedure may change with their web design policy.)

Go to the Website of the OpenGrADS

http://sourceforge.net/projects/opengrads/

Click on the banner **"Download"** and save the file to the desired directory.

(2) Installing for Linux and UNIX

For Linux and UNIX, the two tools (GrADS and wgrib2) should be install separately.

*** Installation of GrADS**

Go to the toppage of GrADS

http://grads.iges.org/grads/index.html

Go to the "**Downloading the Software"** link

Choose the appropriate version and download it

Extract the downloaded file

```
tar zxvf grads-1.9b4-linuxRH9.tar.gz
```

Run the program.

Implement path setting.

```
export GRADSHOME=/user/local/grads
```

(The path depends on the installation location.
Check where GrADS is installed and replace the text here with the relevant path.)

```
export PATH=$PATH:${GRADSHOME}/bin
export GADDIR=${GRADSHOME}/data
```

(Add above lines to the file "bash_profile" or "bashrc" for convenience.)

*** Installation of wgrib2**

Go to ftp://ftp.cpc.ncep.noaa.gov/wd51we/wgrib2

Download wgrib2.tgz

Run the following commands in the directory to which the file has been downloaded:

```
tar zxvf wgrib2.tgz
cd grib2
gmake -f makefile_all_libs_new
cd wgrib2
```

Copy the wgrib2 program to the directory, in which GrADS is installed.

4.2 Downloading the gridded forecast data

The gridded forecast data is downloaded from the web page in the following way.

Visit the web page for disseminating forecast data (See section 1 and Figure 1)

Click on **Statistics** or **All members** for the specific EPS (Figure 5 (A)~(F))

- For example, select 7-month "**Statistics**" for the ensemble statistics of 7-month EPS (Figure 5E).

Choose **Download Grid Point Value (GPV) Data (201002 – present)**. (Figure 5 (G))

Select **initial date** (Figure 5 (H))

- Select **201310** for the forecast starting in October 2013.

Select and save **GRIB2 files**

- Select **h2_Ptt_em.201310** and **h2_Patt_em.201310** for surface temperature (Tsurf) ensemble mean forecast (h2_Ptt_em.201310) and its anomaly (h2_Patt_em.201310).

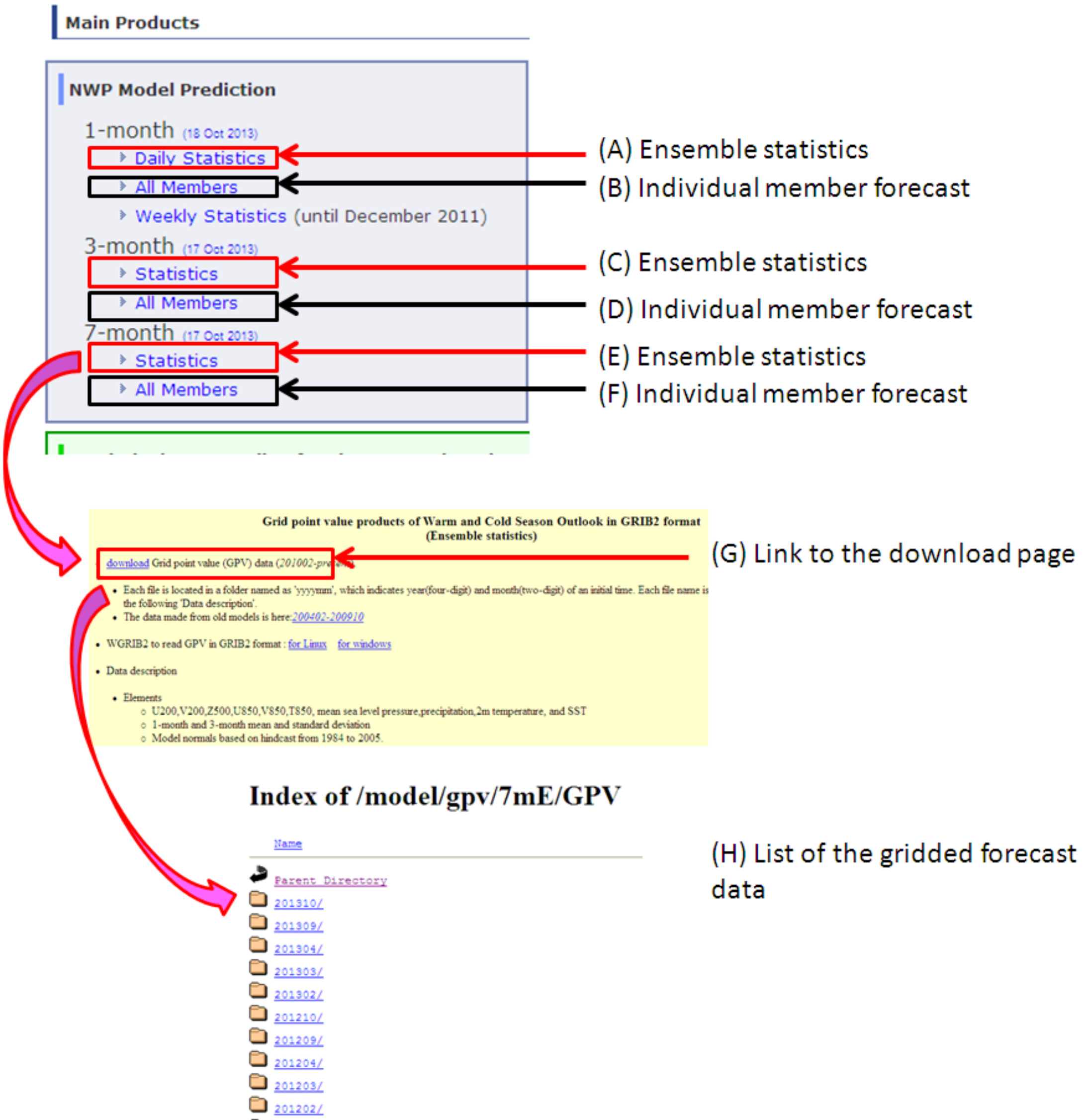


Figure 5 Web page for downloading the gridded forecast data

From here on, it is assumed that the example files (h2_Ptt_em.201310 and h2_Patt_em.201310) are saved in the directory E:¥/grib2test (Figure 6).

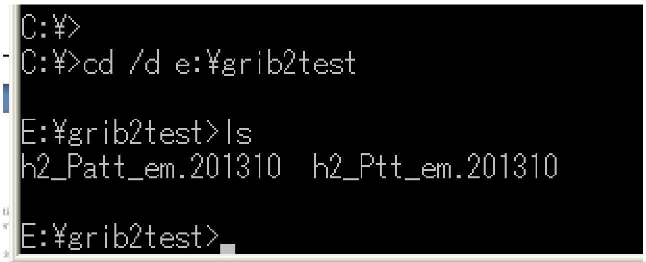


Figure 6 Status after downloading GRIB2 file.
GRIB2 files are saved in the directory E:¥grib2test.

4.3 Decoding the GRIB2 file using wgrib2

'wgrig2' is a very useful tool to handle wgrib2 files. In this subsection, basic commands for decoding GRIB2 files are described. Commands need to be executed on a console (Linux, UNIX) or by the command prompt (Windows). The command prompt window can be opened by clicking on the command icon for the accessories section in the pull-down menu activated from the Start button. On the console or the command prompt, change directory to which the data files have been downloaded. For details of wgrib2, please refer to the wgrib2 web page:

http://www.cpc.ncep.noaa.gov/products/wesley/wgrib2/.

Additionally, the help command

> wgrib2 –h

is useful to confirm various options.

(1) Confirming data arrangement

The following command enables users to confirm data arrangement.

wgrib2 (-v, -V) *GRIB2_filename*

-v, -V : options

(Example of <u>ensemble statistics</u> of the 7-month EPS)

wgrib2 *h2_Patt_em.201310*

```
E:¥grib2test>wgrib2 h2_Patt_em.201310
1.1:0:d=2013100100:var discipline=0 master_table=4 parmcat=0 parm=9:2 m above ground:2 month-(2 month+2160 hour ave@6 hour fcst,missing=0:ens-mean
1.2:0:d=2013100100:var discipline=0 master_table=4 parmcat=0 parm=9:2 m above ground:2 month-(2 month+744 hour ave@6 hour fcst,missing=0:ens-mean
1.3:0:d=2013100100:var discipline=0 master_table=4 parmcat=0 parm=9:2 m above ground:3 month-(3 month+744 hour ave@6 hour fcst,missing=0:ens-mean
1.4:0:d=2013100100:var discipline=0 master_table=4 parmcat=0 parm=9:2 m above ground:4 month-(4 month+672 hour ave@6 hour fcst,missing=0:ens-mean
```

Record-1 Mon 2-4(DJF) (3-month mean)
Record-2 Mon 2(Dec)
Record-3 Mon 3(Jan)
Record-4 Mon 4(Feb)

In this example, it is found that the initial month is October 2013 and the GRIB2 file composes 4 records. The first record stores 3-month mean field (month 2 to 4 (=2160 hour), DJF). The second, third and fourth records store month-2 (December 2013), month-3 (January 2014), and month-4 (February 2014), respectively.

(2) getting a text dump (csv) at specific points from a GRIB2 file
As an example of convenience of wgrib2, getting a text dump at a specific point from a GRIB2 file is described.

wgrib2 *GRIB2_filename* -undefine out-box *lon1:lon2 lat1:lat2* -csv *CSV_filename*

(Example 1) Specific point:

GRIB2 file: h2_Patt_em.201310

Target point: (140°E, 35°N)

On the command prompt, change directory to which the data file has been downloaded, and then run the command.

wgrib2 *h2_Patt_em.201310* -undefine out-box *140:140 35:35* -csv *out1.csv*

The produced file (out1.csv) includes grid values at 140°E, 35°N as shown below.

2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above ground	140	35	0.044916
2013/10/1 0:00	2013/12/31 0:00	var0_0_9	2 m above ground	140	35	0.218459
2013/10/1 0:00	2014/1/31 0:00	var0_0_9	2 m above ground	140	35	−0.0418936
2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above ground	140	35	−0.050786

Record-1: Mon-2 to 4
Record-2; Mon-2
Record-3: Mon-3
Record 4: Mon-4

(Example 2) Specific bounding box:

GRIB2 file: h2_Patt_em.201310 (Same as Example 1)

Target point: (135°E-137.5°E, 35°N-37.5°N)

On the command prompt, change directory to which the data file has been downloaded, and then run the following command.

wgrib2 *h2_Patt_em.201310* -undefine out-box *135:137.5 35:37.5* -csv *out2.csv*

The produced file (out2.csv) includes grid values in the bounding box (135°E-137.5°E, 35°N-37.5°N) as shown below.

2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above	135	35	0.080011
2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above	137.5	35	0.051508
2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above	135	37.5	0.07818
2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above	137.5	37.5	0.19433
2013/10/1 0:00	2013/12/31 0:00	var0_0_9	2 m above	135	35	0.283766
2013/10/1 0:00	2013/12/31 0:00	var0_0_9	2 m above	137.5	35	0.215285
2013/10/1 0:00	2013/12/31 0:00	var0_0_9	2 m above	135	37.5	0.332289
2013/10/1 0:00	2013/12/31 0:00	var0_0_9	2 m above	137.5	37.5	0.404982
2013/10/1 0:00	2014/1/31 0:00	var0_0_9	2 m above	135	35	−0.02145
2013/10/1 0:00	2014/1/31 0:00	var0_0_9	2 m above	137.5	35	−0.02511
2013/10/1 0:00	2014/1/31 0:00	var0_0_9	2 m above	135	37.5	−0.10787
2013/10/1 0:00	2014/1/31 0:00	var0_0_9	2 m above	137.5	37.5	0.037818
2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above	135	35	−0.03296
2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above	137.5	35	−0.04523
2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above	135	37.5	0.002925
2013/10/1 0:00	2014/2/28 0:00	var0_0_9	2 m above	137.5	37.5	0.134334

Record-1: Mon-2 to 4
Record-2: Mon-2
Record-3: Mon-3
Record-4: Mon-4

4.4 Converting GRIB2 to GrADS data format

A set of grads files:

* grads data file (--> section 4.4) and
* grads control file (--> section 4.5)

are required for visualizing. One is the grads data file consisting of 4-byte (single precision real number) binary created by the wgrib2 command. Another file is the grads control file described in section 4.5. The following command enables users to convert from GRIB2 to GrADS data format.

wgrib2 *GRIB2_filename* -no_header -bin *output_file*

(Example of <u>ensemble statistics</u> of the 7-month EPS)

wgrib2 *h2_Ptt_em.201310* -no_header -bin *tsurf.dat*
wgrib2 *h2_Patt_em.201310* -no_header -bin *tsurf_anm.dat*

```
E:¥grib2test>wgrib2 h2_Patt_em.201310 -no_header -bin tsurf_anm.dat
1.1:0:d=2013100100:var discipline=0 master_table=4 parmcat=0 parm=9:2 m
above ground:2 month-(2 month+2160 hour ave@6 hour fcst,missing=0:
ens-mean
1.2:0:d=2013100100:var discipline=0 master_table=4 parmcat=0 parm=9:2 m
above ground:2 month-(2 month+744 hour ave@6 hour fcst,missing=0:
ens-mean
1.3:0:d=2013100100:var discipline=0 master_table=4 parmcat=0 parm=9:2 m
above ground:3 month-(3 month+744 hour ave@6 hour fcst,missing=0:
ens-mean
1.4:0:d=2013100100:var discipline=0 master_table=4 parmcat=0 parm=9:2 m
above ground:4 month-(4 month+672 hour ave@6 hour fcst,missing=0:
ens-mean

E:¥grib2test>ls -l
total 4544
-rwx------ 1 mkgroup    84577 2013-10-25 11:56 h2_Patt_em.201310
-rwx------ 1 mkgroup    84577 2013-10-25 11:56 h2_Ptt_em.201310
-rwx------ 1 mkgroup   168192 2013-10-25 14:57 tsurf.dat
-rwx------ 1 mkgroup   168192 2013-10-25 14:57 tsurf_anm.dat
```

(Messages during conversion)

GRIB2 files for input

GrADS data files

In this demonstration, both h2_Patt_em.201310 and h2_Ptt_em.201310 are converted to tsurf_anm.dat and tsurf.dat, respectively.

In case of individual member files, it is recommended to convert by individual member using ‘grep’ command.

(Example)

wgrib2 *GRIB2_filename* | grep d=*(initial date)*| grep ENS=*(member name)* | wgrib2 –i *GRIB2_filename* -no_header -bin *output_file*

4.5 Editing the GrADS control file

The format of grads control file is text, containing meta-information of grads data such as data dimensions, time, elements, etc. The text file is written in a text editor such as Notepad. The text should be as follows.

dset ^*GrADS data filename*
undef (UNDEF value)9.999e+20
xdef (num. of grids along X-axis) linear (start) (increment)
ydef (num. of grids along Y-axis) linear (start) (increment)
zdef (num. of vertical levels) levels (list of levels)
tdef (num. of time steps) linear (starting time) (increment)
vars (num. of parameters)
(parameter_name) 0 0 (remarks)
endvars

```
dset ^tsurf_anm.dat
undef 9.999e+20
xdef 144 linear    0 2.5
ydef  73 linear  -90 2.5
zdef   1 levels   1000
tdef   4 linear   Nov2013 1mon
vars   1
Tanm   0   0  tanm
endvars
```

```
dset ^tsurf.dat
undef 9.999e+20
xdef 144 linear    0 2.5
ydef  73 linear  -90 2.5
zdef   1 levels   1000
tdef   4 linear   Nov2013 1mon
vars   1
T   0   0  t
endvars
```

(Examples of ensemble statistics of the 7-month EPS issued in October 2013)

In these examples, we have known that the GRIB2 files compose 4 records (Section 4.3 (1)). Therefore the number of time level is 4 (i.e. tdef 4.linear ...).

As a result, the following 4 files are created.

tsurf_anm.dat
tsurf_anm.ctl
tsurf.dat
tsurf.ctl

4.6 Visualizing using GrADS

(1) Startup GrADS on the "Command Prompt"

```
E:¥grib2test>grads
Starting X server under C:¥OPENGR~1¥Contents¥Resources¥Xming
Starting grads under C:¥OPENGR~1¥Contents¥Cygwin¥Versions¥20A9OG~1.
1¥i686 ...

Grid Analysis and Display System (GrADS) Version 2.0.a9.oga.1
Copyright (c) 1988-2010 by Brian Doty and the
Institute for Global Environment and Society (IGES)
GrADS comes with ABSOLUTELY NO WARRANTY
See file COPYRIGHT for more information

Config: v2.0.a9.oga.1 little-endian readline printim grib2 netcdf hdf4-sds hdf5
 opendap-grids,stn athena geotiff shapefile
Issue 'q config' command for more detailed configuration information
Loading User Defined Extensions table </cygdrive/c/OPENGR~1/Contents/Cy
gwin/Versions/20A9OG~1.1/i686/gex/udxt> ... ok.
Landscape mode? ('n' for portrait):
GX Package Initialization: Size = 11 8.5
ga->
```

(Messages on the command prompt)

Return (Enter) for landscape

Waiting for command input

(2) Opening the grads control file and displaying data

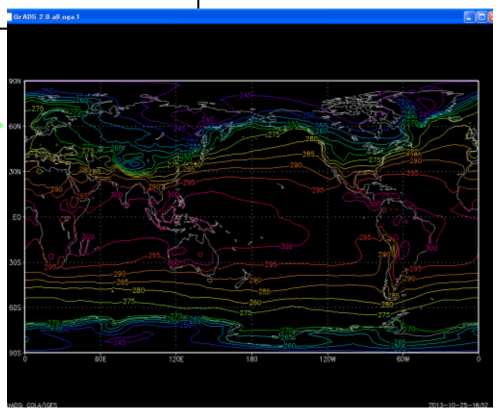
```
ga-> open tsurf.ctl
Scanning description file:   tsurf.ctl
Data file Tsurf.dat is open as file 1
LON set to 0 360
LAT set to -90 90
LEV set to 1000 1000
Time values set: 2013:11:1:0 2013:11:1:0
E set to 1 1
ga-> d t
Contouring: 240 to 305 interval 5
ga->
```

Open grads control file

(Messages on the command prompt)

Command for displaying:
d (Element name)

Then, the first record of the grads data
which is Tsurf 3-month mean field for DJF is plotted.



GrADS has various commands. Here is an example of plotting two parameters (Tsurf and its anomaly) for January 2014 (record-3).

```
ga-> open   tsurf.ctl
ga-> open   tsurf_anm.ctl
ga-> set   t   3
Time values set: 2014:1:1:0 2014:1:1:0

ga-> set gxout shaded
ga-> set clevs -4 -3 -2 -1 -0.5 0 0.5 1 2 3 4
Number of clevs = 11
ga-> d tanm.2
Contouring at clevs =    -4 -3 -2 -1 -0.5 0 0.5 1 2 3 4
ga-> run cbar.gs

ga-> set gxout contour
ga-> set cint 3
cint = 3
ga-> d t.1
Contouring: 237 to 306 interval 3

ga->printim testimg.png white
```

Open 2 grads control files

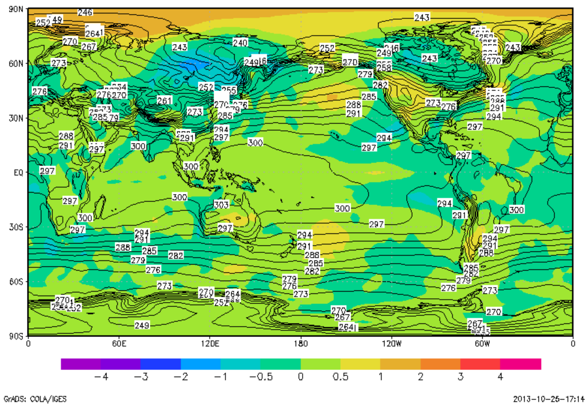
Time level 3 denotes reading third record, which stores Month-2 (January 2014) forecast.

Shading for Tsurf anomaly
(tanm from file-2)

Contour for Tsurf
(t from file-1)

Output image file (png format)

The forecast map of Tsurf and its anomaly for January 2014 is created as a png format file.



Appendix 1 Advanced techniques for visualizing

(1) Pointers for data handing in GrADS

GrADS data has four dimensions: X, Y, Z and T. However, as display is two-dimensional, the degree of freedom needs to be restricted to a maximum of two dimensions (except for time sequences expressed as animations). To achieve this, a ‘set’ command such as ‘set t 1’ is used.

Example (typical GrADS data)

```
-----------------------------------------------------------------------------------------
dset ^mg1ws
undef -19999.0
title 1mE_GPV.20070920
xdef 144   linear     0.0    2.5
ydef    73    linear -90.0    2.5
tdef      4    linear 20Sep2007 7dy
zdef      7    levels 1000 900 850 700 500 300 150
vars    20
Z500    0 99 ** Geopotential height at 500 hPa [gpm]
T850    0 99 ** Temp. at 850 hPa [K]
………..
      (continues)
………..
PSEAA 0 99 ** Sea level pressure anomaly [Pa]
Z100A 0 99 ** Geopotential height anomaly at 100 hPa [gpm]
ENDVARS
-----------------------------------------------------------------------------------------
```

Display types: contours, shading, barbs, etc.
Projection: latlon, polar stereo, etc.

GrADS script library: Useful scripts can be downloaded from
http://grads.iges.org/grads/gadoc/library.html.

GrADS data sets
Data file: a binary file with 4-byte floating point values
Ctl file: a file describing the corresponding data file
GrADS script file: a file containing a collection of commands

Command to run the GrADS program with a GrADS script file (gsfile) silently:
echo “quit” | grads –lbc “run *gsfile*”

(2) Advanced techniques for obtaining and using TCC data

A combination of tools available on the Internet will facilitate the use of data provided by TCC in terms of automatic downloading and visualization.

1. Shell scripts: Scripts can be used to execute a collection of commands at one time. They can also be used to control commands such as repeating and conditional reactions.
   Linux: installed by default
   Windows: use the cygwin system available at http://www.cygwin.com/.

2. wget commands: Commands can be used for automatic ftp and http access when operated within a shell script.
   Linux: installed by default
   Windows: choose wget from the web components upon cygwin system installation.
   Alternatively, download the Windows version of wget from
   http://users.ugent.be/~bpuype/wget/.

   Use .wgetrc (or wgetrc) files to set web IDs, passwords and proxies as necessary.

3. Running GrADS with GrADS scripts
   Typing the command
   grads -bcl "run sample1.gs"
   on a Linux or UNIX machine runs GrADS without opening the GrADS interactive screen and allows access to png image files. This is convenient for automatic processing of download data and for visualization. However, this approach does not work on the Windows version of GrADS.

4. The crontab command can be used in Linux to set scheduled commands for a particular time/day either on a single occasion or repeatedly.

(3) GrADS data format

GrADS data consist of a simple series of floating computer point values. The data alignment is shown in the corresponding control file. Here is an example of a control file (slightly modified for simplicity).

```
-----------------------------------------------------------------------------------------
dset ^mg1ws
undef -19999.0
title 1mE_GPV.20070920
xdef 144 linear 0.000000 2.5
ydef    73 linear -90.0000 2.5
zdef      3 levels 1000 850 700
tdef      4 linear 20Sep2007 7dy
vars 2
Z    3 99 ** Geopotential height at 3 levels
T    3 99 ** Temp. at 3 levels
ENDVARS
-----------------------------------------------------------------------------------------
```

The GrADS data file would be as follows:

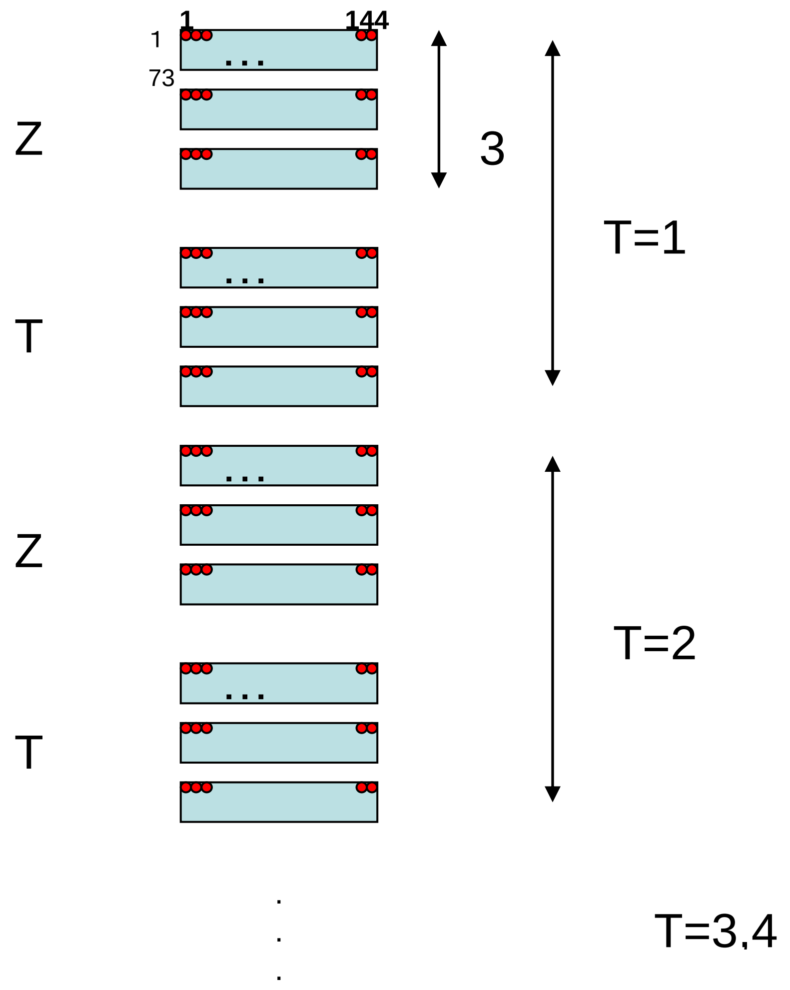


Figure A.1 Summary of handling for data provided by TCC

Appendix 2 Basic GrADS commands

a) General
> open ctl_file
> q file (Query info of the open file) or q ctlinfo
> quit (Leave GrADS)
> reset (Reset to the initial state without closing the file)

b) Displaying variables
> d variable_name
> d expression ex.) tempe-273.15, mag(ugrd,vgrd)
> clear

c) Changing area, level, time or map projection
> set lon lon1 lon2 ex.) set lon 0 180
> set lat lat1 lat2 ex.) set lat 0 90
> set z level1 level2 (If a 3D representation is specified as a single level, the chart will be a cross section.)
> set t n m (If nm is set, the chart shows time changes as for an animation.)
> set mproj nps (For northern polar stereo projection)

d) Changing graphic type
> set gxout [contours, shading, vectors, streams, grids, etc.] (Choose one of the parameters in parentheses.)

e) Changing graphic options
> set ccolor color_index ex.) set ccolor 1 (white) : set color
> set cint interval_value : set interval
> set cmin minimum_value : set minimum value
> set clab on/off : control label
> set cthick [1-10] : set line width

f) Changing map data set resolution
> set mpdset lowres | mres | hires

g) Output of GrADS metafiles (*.gmf)
> enable print filename.gmf
> d variable_name
> print
> disable print

h) Viewing GrADS metafiles (*.gmf)
> gv32 filename.gmf
With Gv32 (GrADS Metafile Viewer), it is possible to print images and save files as Windows metafiles, allowing charts to be included in Windows applications (e.g., Microsoft PowerPoint).

i) Outputting png/gif files (*.png/*.gif)
> printim *fname.(png / gif)*

j) Using scripts for GrADS
GrADS scripts allow construction of if/while/for clauses, etc. and keyboard input. Examples:
> set gxout shaded
> d expression
> run cbarn.gs

k) Changing graphic options (alternative way)
> run color_k.gs
> set ccols 47 46 45 44 43 23 24 25 26 27
> set clevs -120 -90 -60 -30 0 30 60 90 120

l) Creating titles
> draw title *String*

Seasonal Forecasting

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

Outline

- Introduction
- Overview of JMA operational Seasonal Forecast System
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- Summary

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,,,,

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

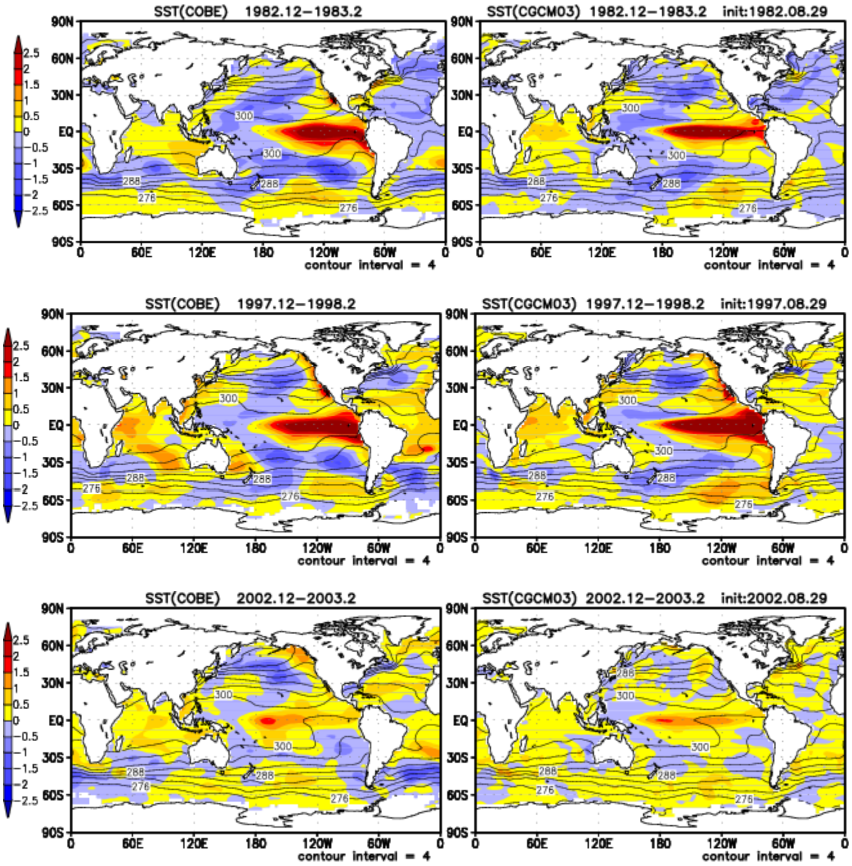
By CGCM, El Nino and its instantaneous and delayed influence are well predicted

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

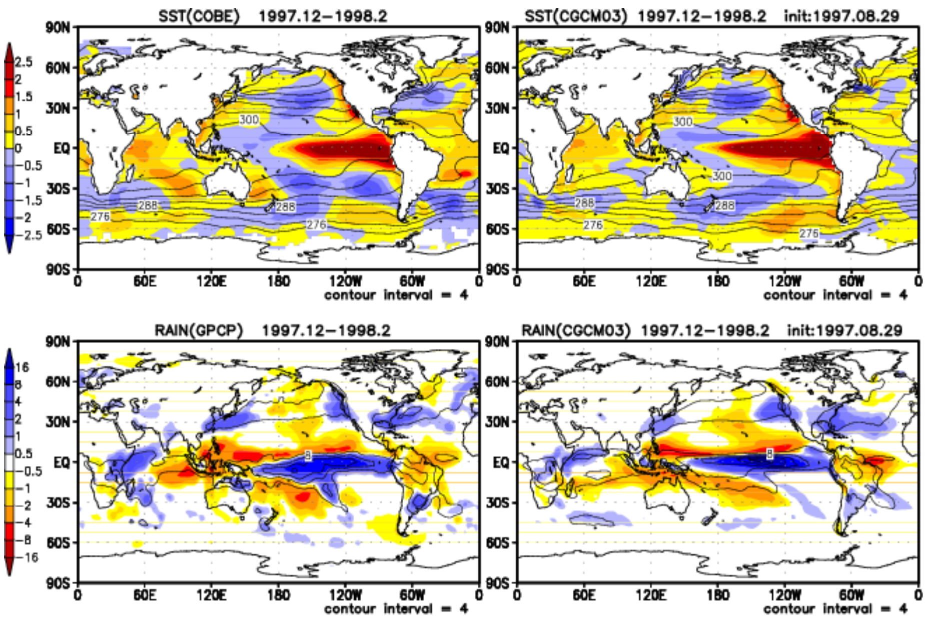
Initial Condition :1997.8.29
Prediction
:1997.12～1998.2

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

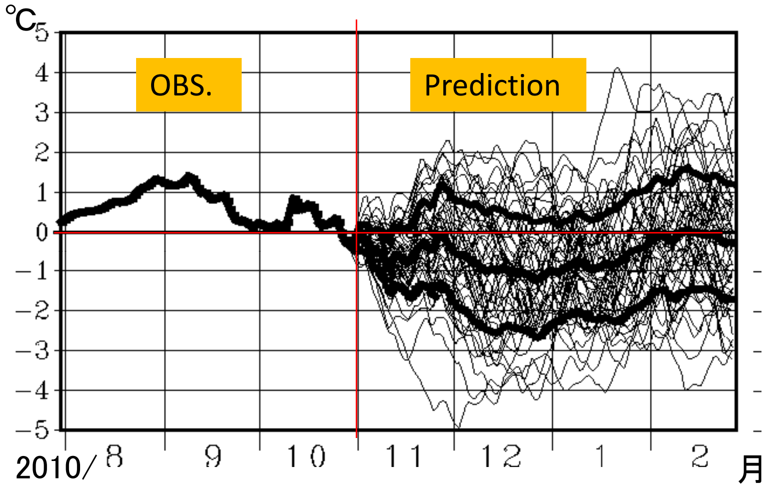
Characteristics of each El Nino are well predicted

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

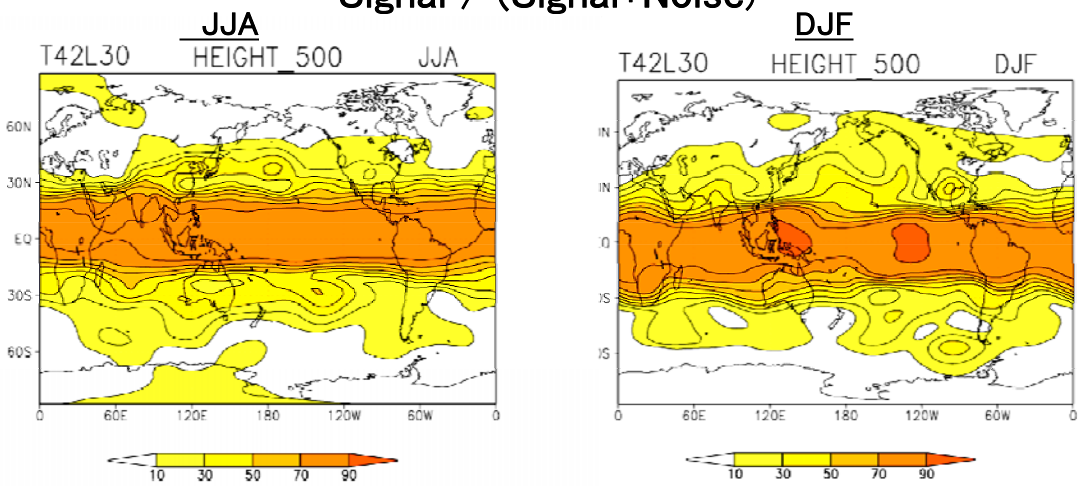


Thin line: each ensemble member
Thick line: Observation and ensemble mean prediction, and ±σ

How about is Signal/Noise ratio?

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

Signal / (Signal+Noise)



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

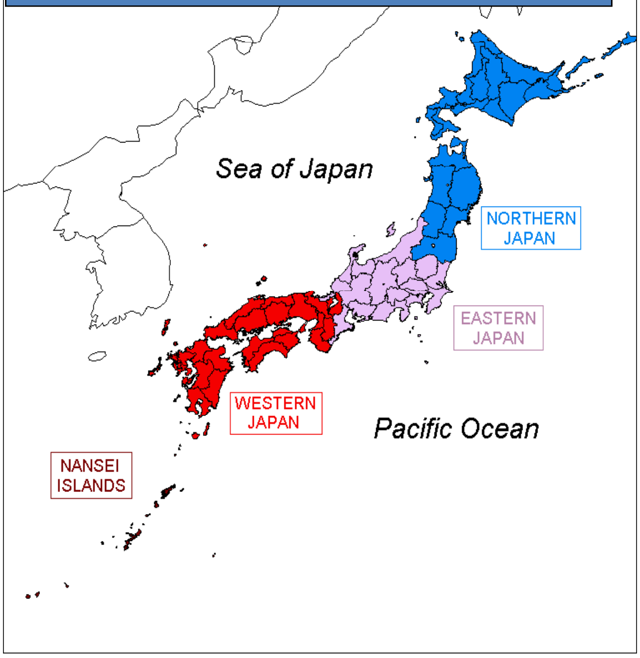
Outline

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

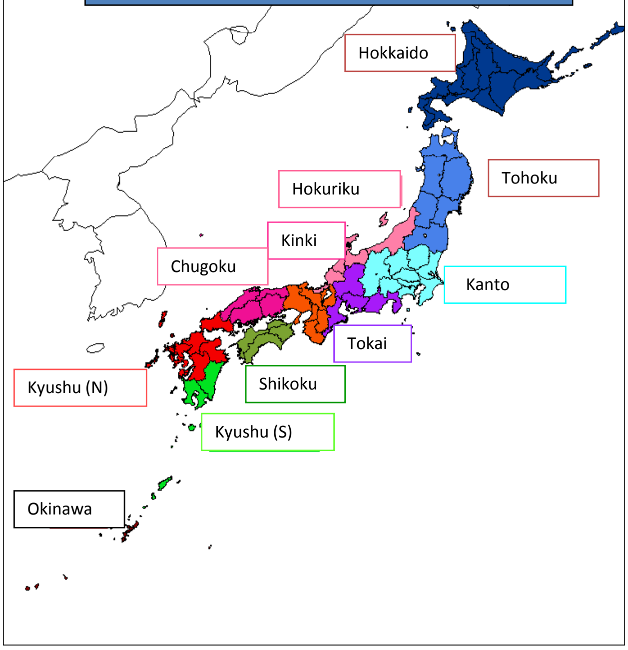
Operational Seasonal Forecast at JMA

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)
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			1^{st} month			2^{nd} month			3^{rd} 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 : %)

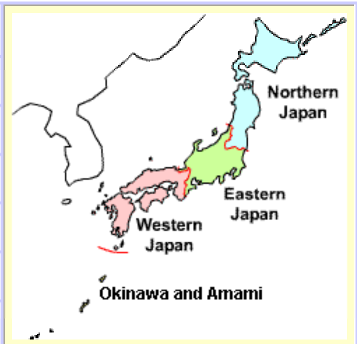
[Climate and Outlook in Japan](http://ds.data.jma.go.jp/tcc/tcc/products/japan/index.html)
http://ds.data.jma.go.jp/tcc/tcc/products/japan/index.html

Extended-range Forecast Services (1)

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

Temperature

Forecast Period	1 month			1^{st} week			2^{nd} week			3^{rd}-4^{th} 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

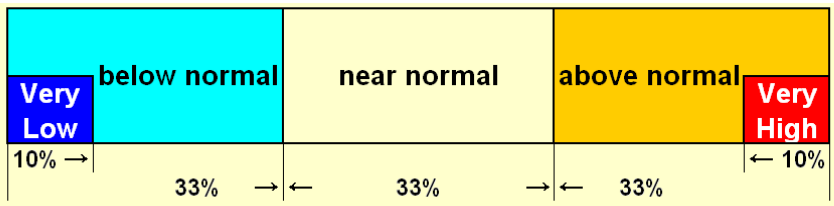


(category –: below normal, 0 : near normal, + : above normal, Unit : %)

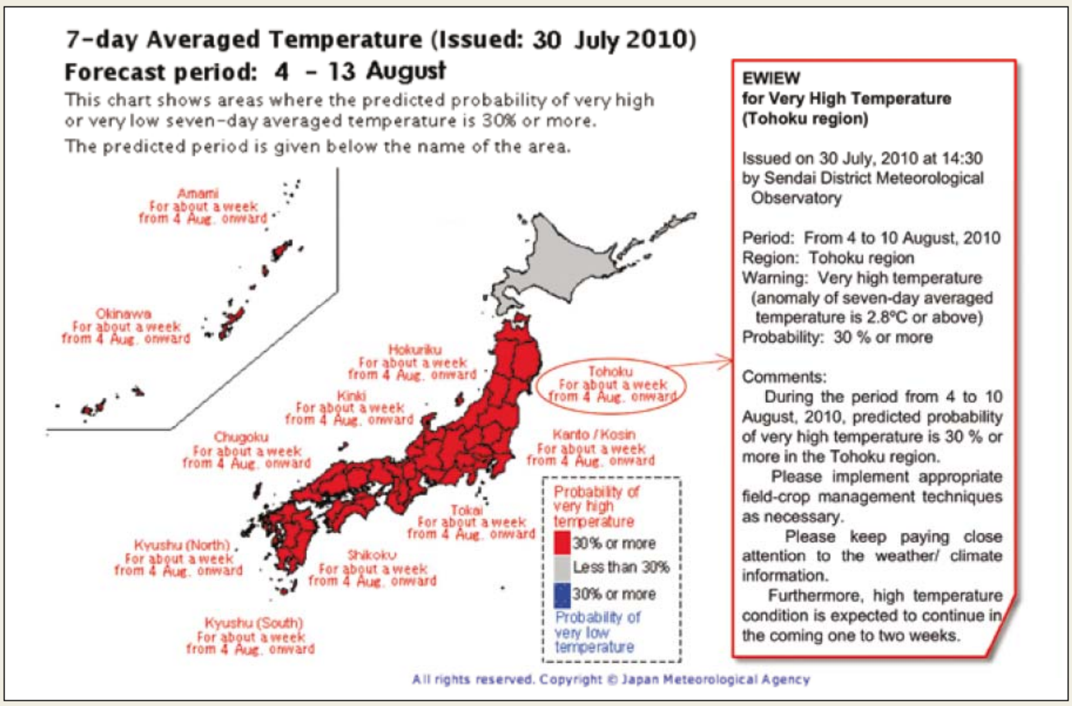
[Climate and Outlook in Japan](http://ds.data.jma.go.jp/tcc/tcc/products/japan/index.html)
http://ds.data.jma.go.jp/tcc/tcc/products/japan/index.html

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

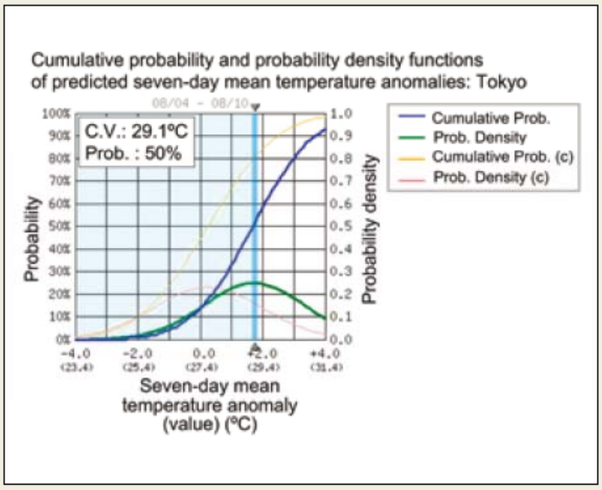


Early Warning Information on Extreme Weather



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)

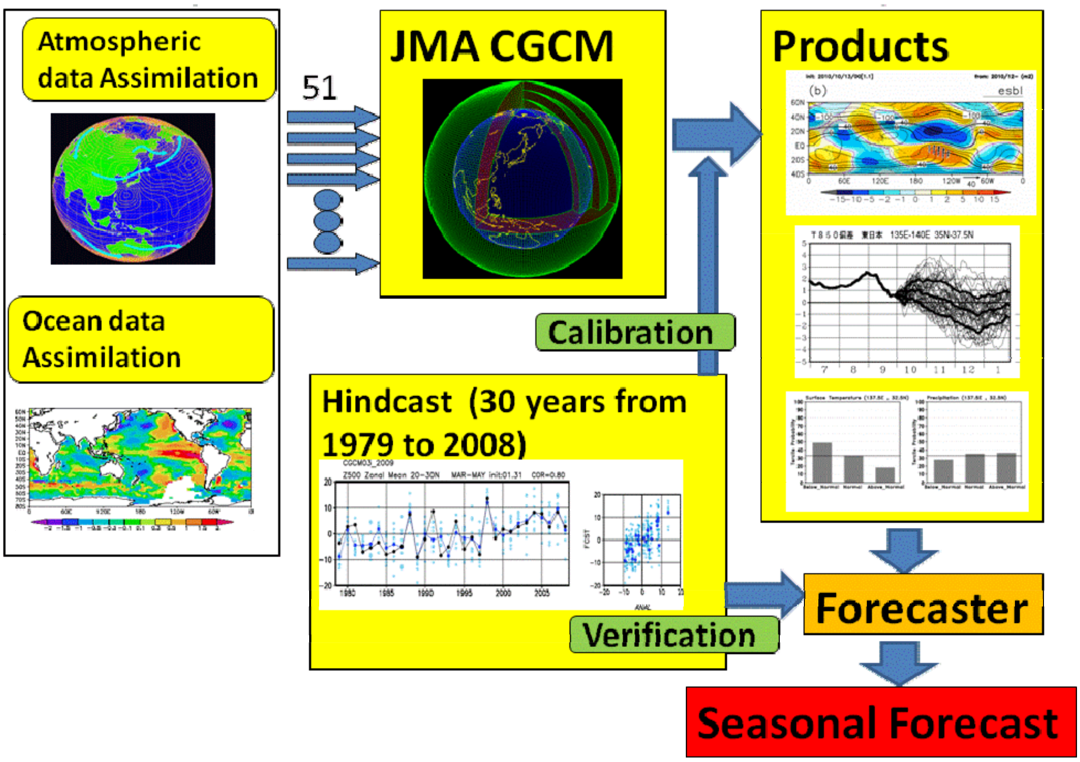
Early Warning Information on Extreme Weather



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

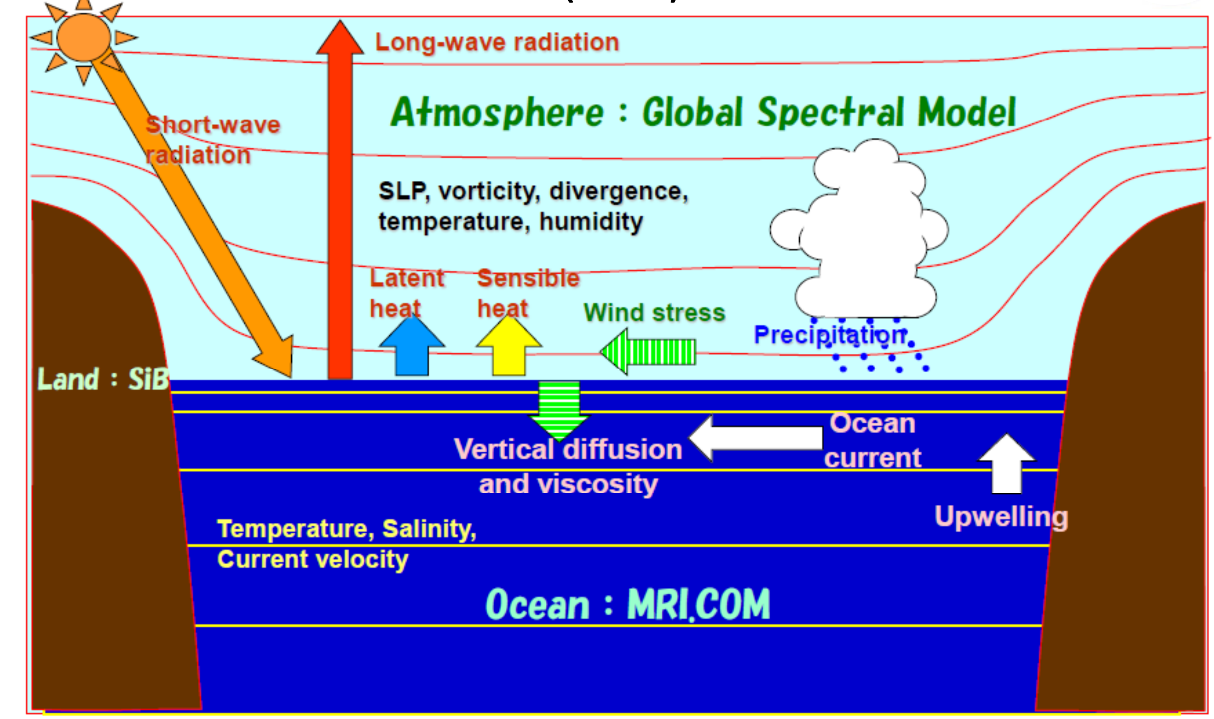
JMA Operational Seasonal Forecast System



For 3-month, cold season and warm season forecast

JMA Long-range Forecasting Model

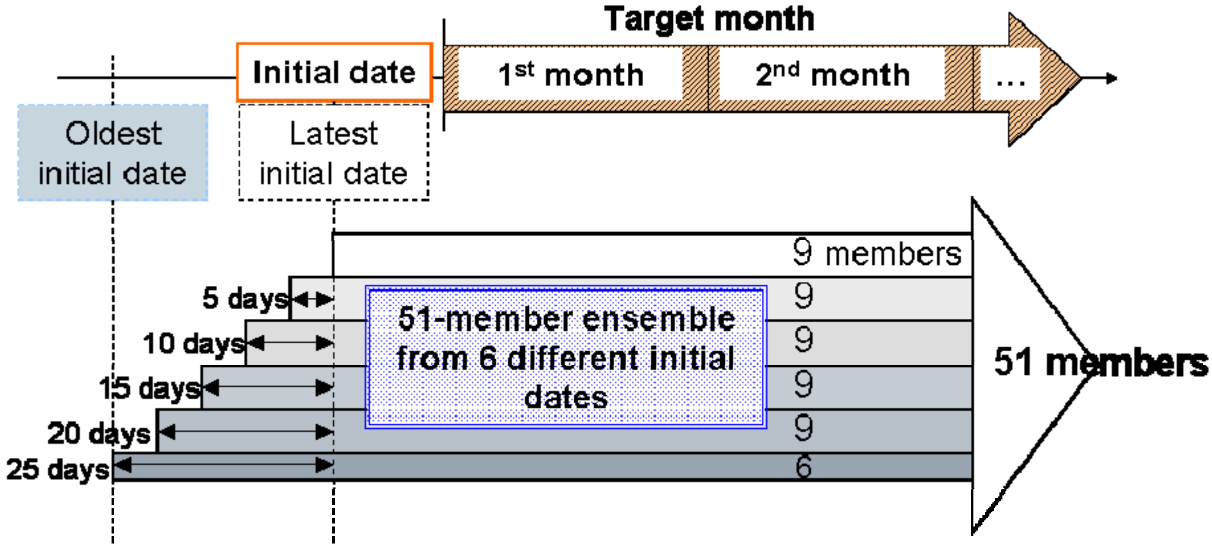
Coupled ocean-atmosphere General Circulation Model (CGCM)



Specifications of the NWP model for Long-range forecast

Model	JMA/MRI-CGCM
Horizontal resolution	AGCM: TL95 (about 1.875° Gaussian grid ~180km) OGCM: 1.0deg in lon. X 0.3-1.0 deg in lat.
Vertical Layers	AGCM: 40 (Top Layer Pressure:0.4hPa) 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

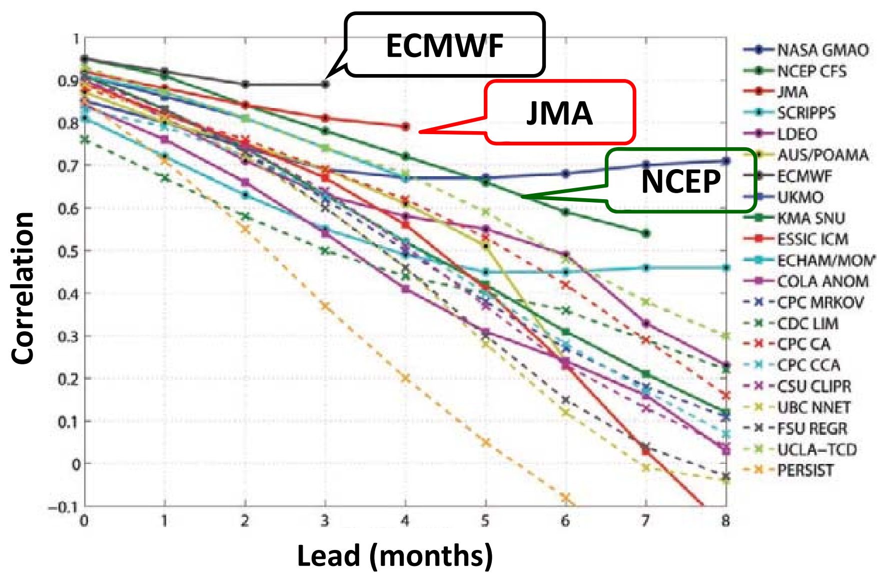
Schema of aggregation for the ensemble members in the EPS for long-range forecasting



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



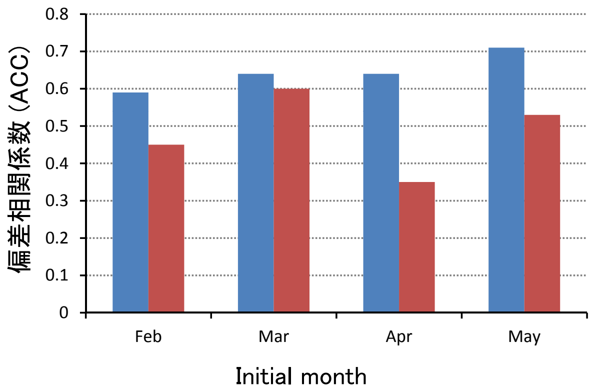
A. Barnston et al. (2012) BAMS

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

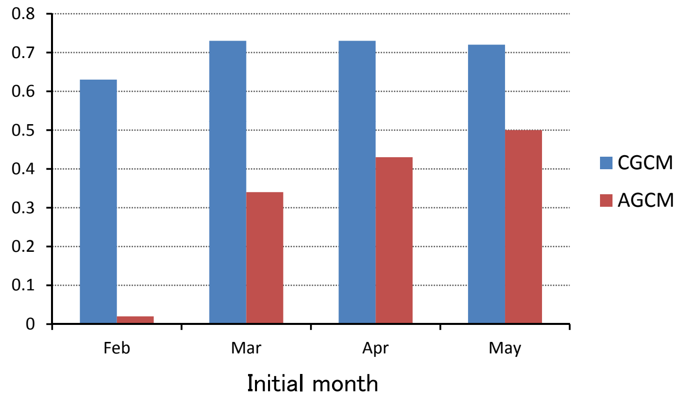
Temporal correlation between model forecasts and observations for all seasons combined, as a function of lead time. Each line highlights one model. The eight statistical models and the persistence model are shown with dashed lines and the cross symbol.

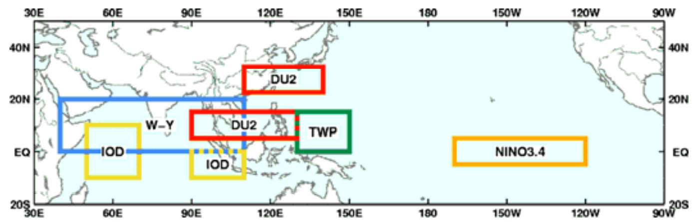
Asia Monsoon Circulation (JJA)

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

Input

Predicted meteorological elements by CGCM

MOS (Model Output Statistics) Guidance

Calibration

Interpretation

Output

Probabilities of Surface temperature, precipitation and sunshine duration in Japan.

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

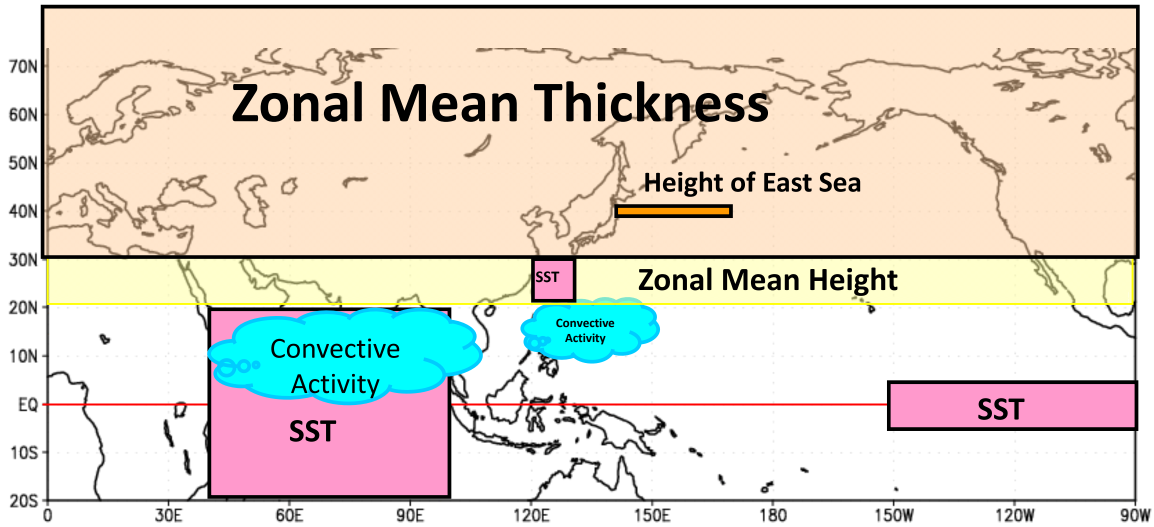
Category		−	0	+
Northern Japan	Sea of Japan side	40	30	30
	Pacific side	40	30	30
Eastern Japan	Sea of Japan side	40	30	30
	Pacific side	40	30	30
Western Japan	Sea of Japan side	30	40	30
	Pacific side	30	40	30
Okinawa and Amami		20	40	40

(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.

Outline

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

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)

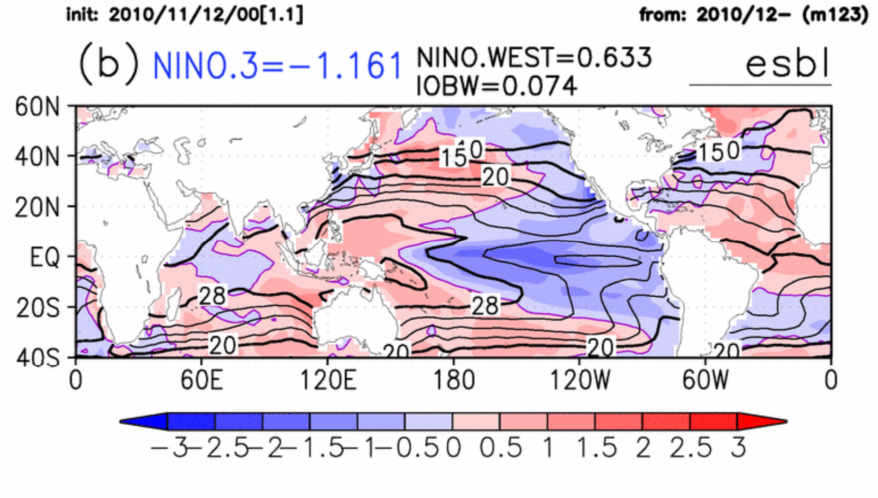
Check up predicted probabilities by NWP guidance, and modify the probabilities of NWP guidance based on results of procedure 1 & 2, skills of the guidance, and characteristic of recent climate

↓

Make decision

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

Predicted DJF SST anomalies (ensemble mean)

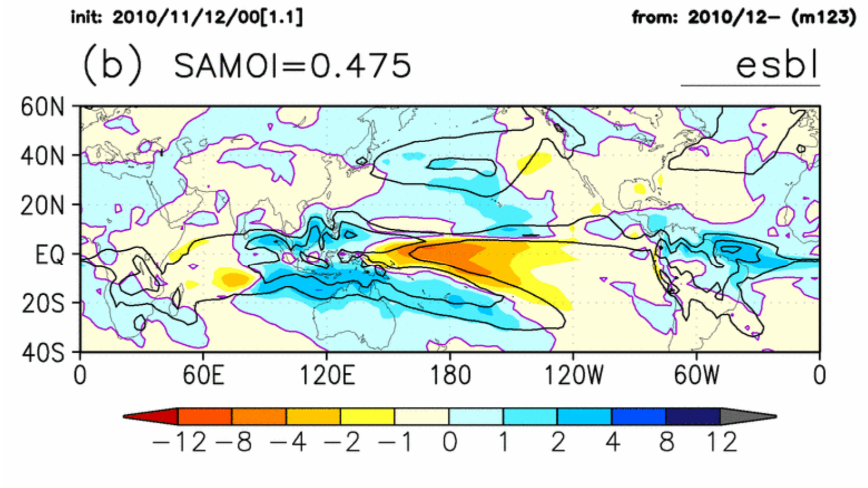


@La Nina will continue

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

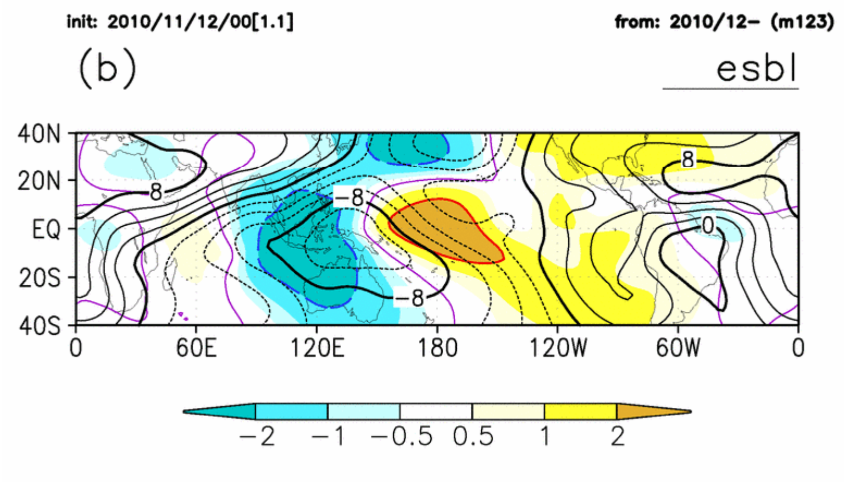
Signal predicted by the Numerical Model

Predicted DJF precipitation anomalies (ensemble mean)



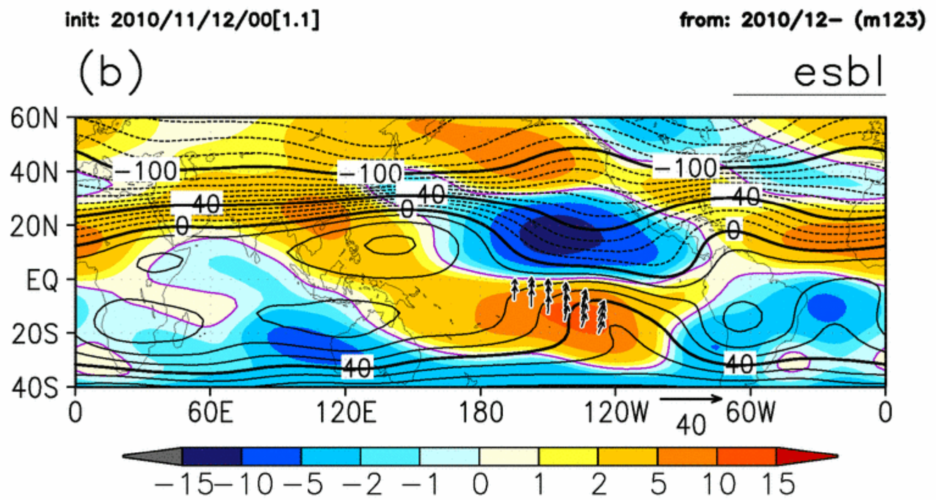
@Positive Precipitation anomalies around the Maritime Continent and the tropical Western Pacific associated with the La Nina condition

Predicted DJF 200hPa velocity potential anomalies
(ensemble mean)



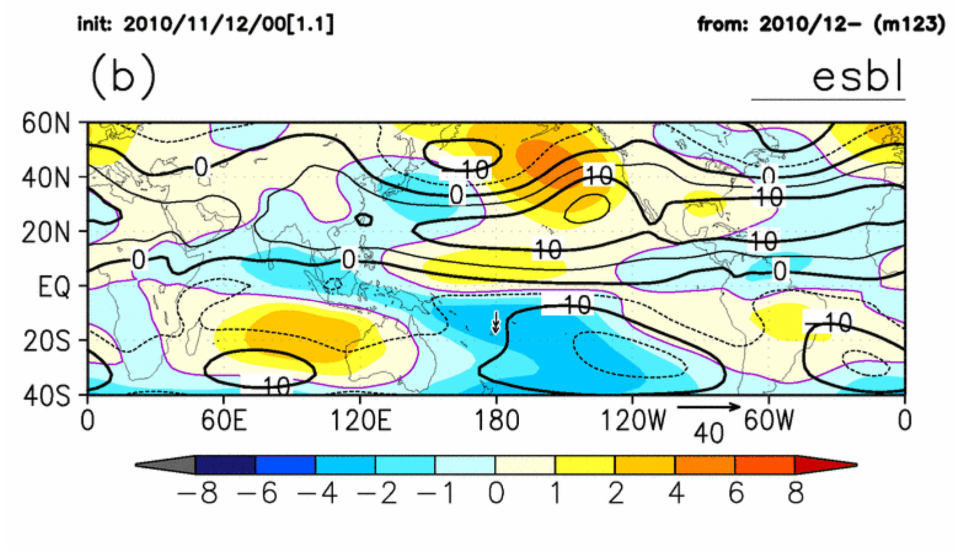
@ Divergence flow anomalies in the upper troposphere around the Maritime Continent associated with precipitation anomalies

Predicted DJF 200hPa stream function anomalies
(ensemble mean)



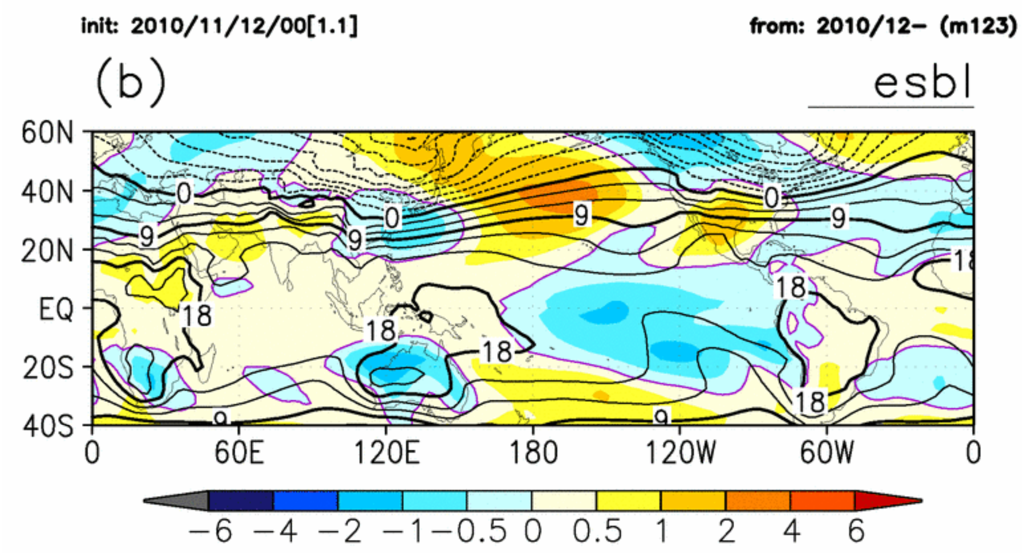
@ Anticyclonic circulation anomalies in the upper troposphere around the south-east Asia, and cyclonic circulation anomalies near Japan. This wave like pattern is suggested to be a stationary Rossby wave train forced by divergence flow anomalies in the upper troposphere around the Maritime Continent

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

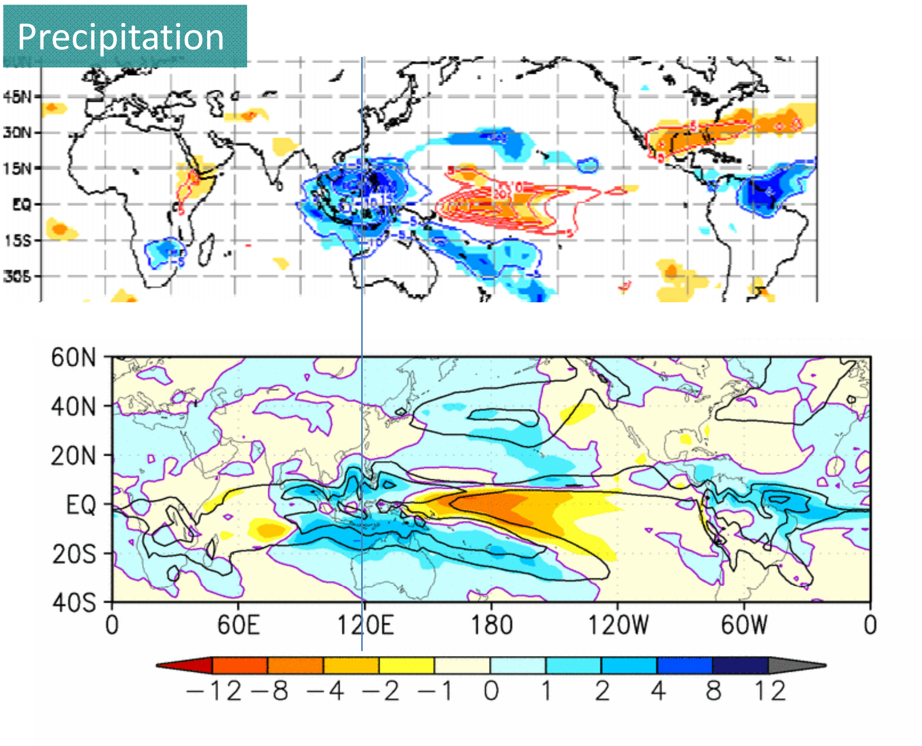
Predicted DJF 850hPa temperature anomalies (ensemble mean)



@ 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

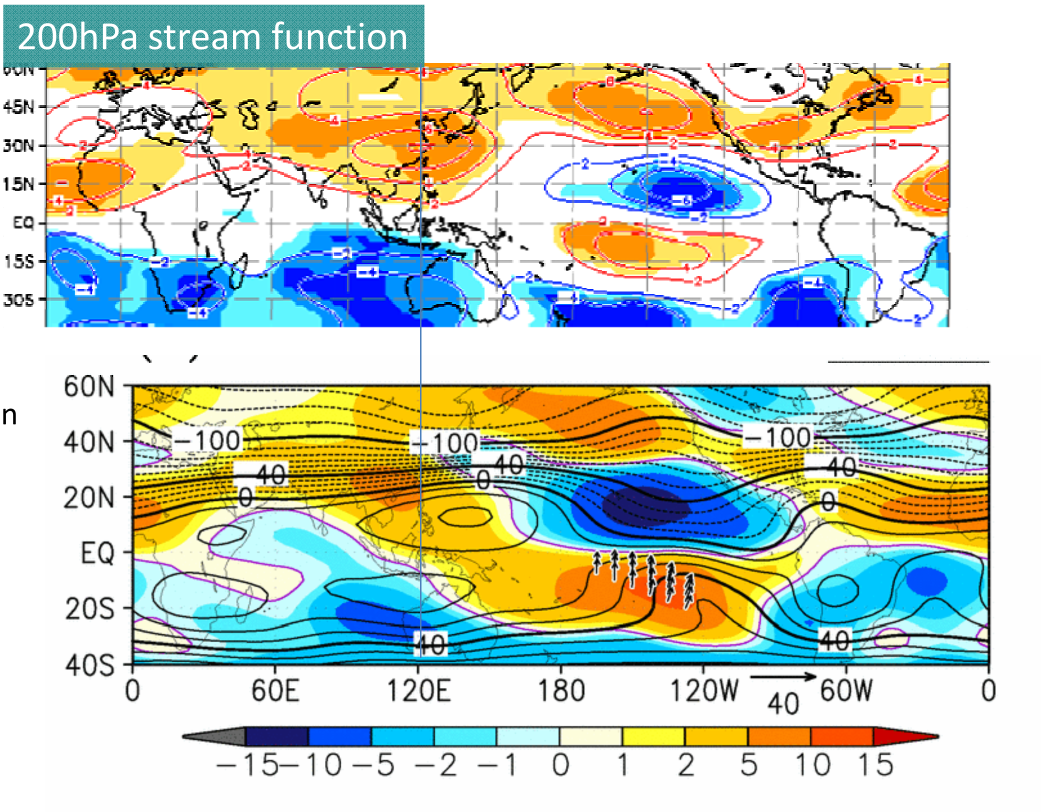
Composite in La Nina winter



Prediction

Westward shift

Composite in La Nina winter



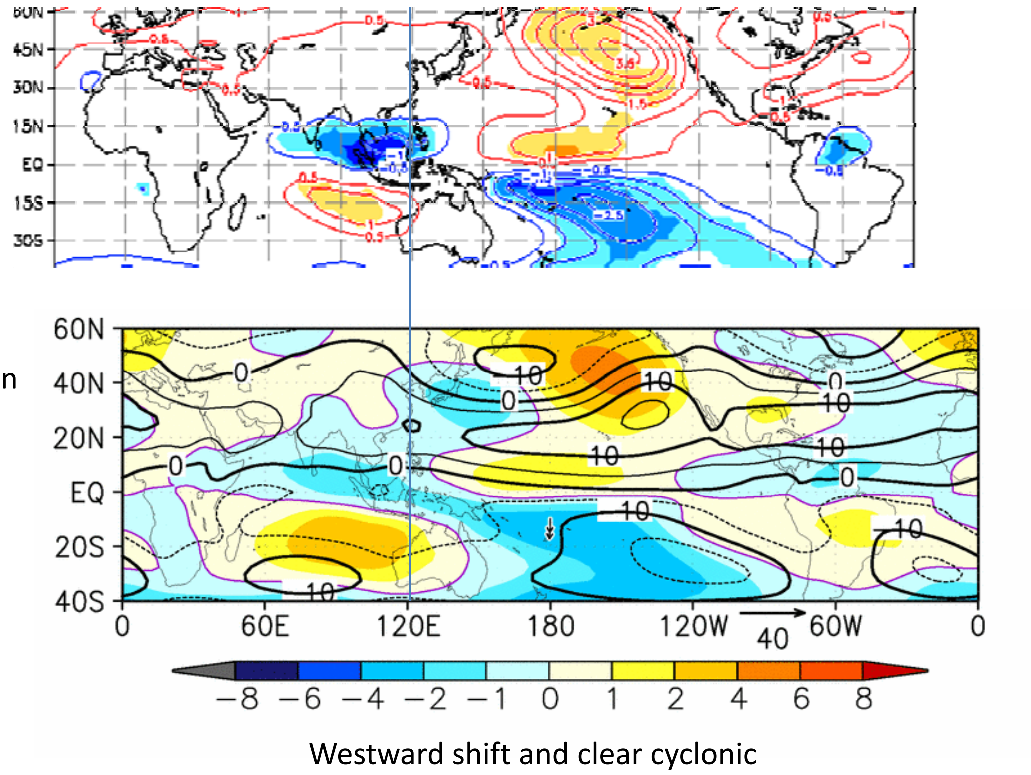
Prediction

Westward shift and clear cyclonic circulation anomalies near Japan

850hPa stream function

Composite in La Nina winter

Prediction



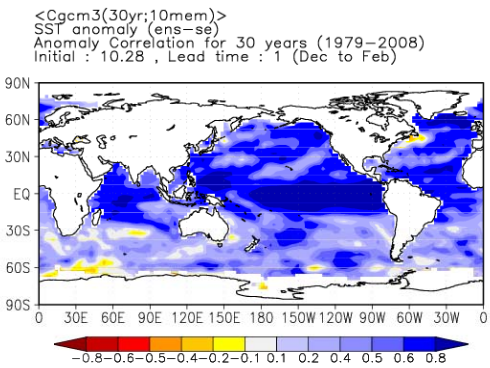
Westward shift and clear cyclonic circulation anomalies near Japan

Summary of Predicted Signals

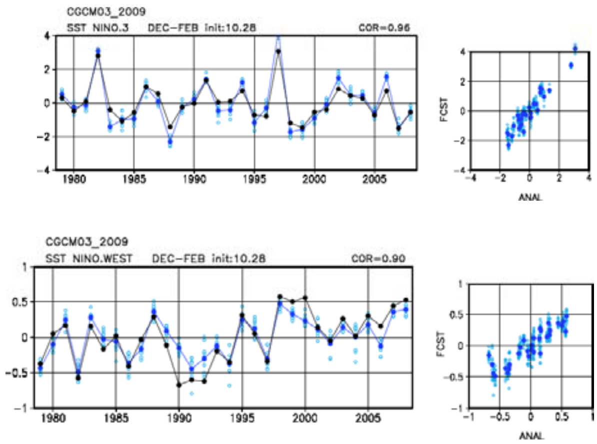
@La Nina will continue
@Around Japan, circulation pattern which is expected in La Nina winter is predicted, but the pattern is predicted to shift westward compared with the typical circulation anomalies in La Nina winters

@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



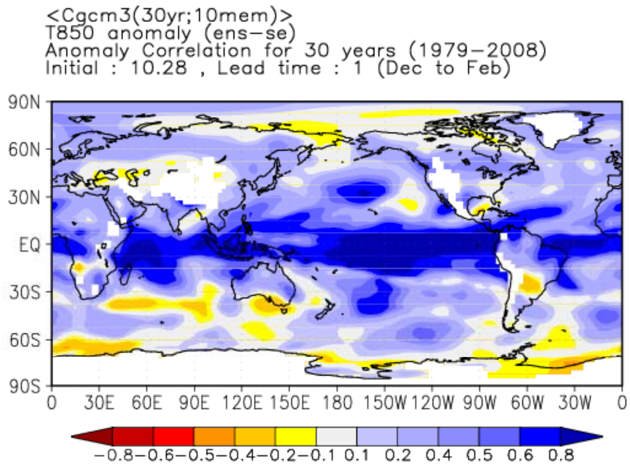
SST Anomaly Correlation for DJF prediction from the end of Oct.



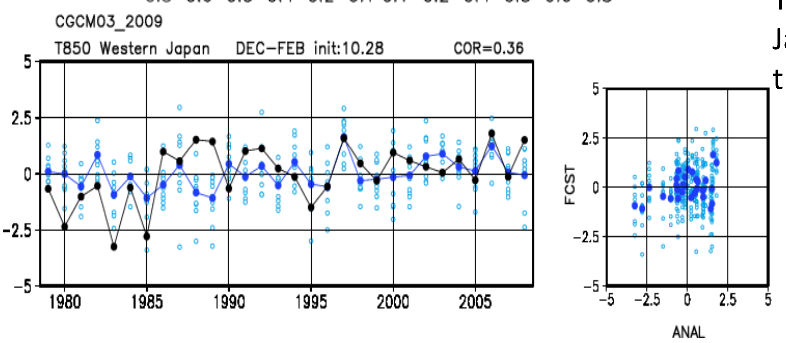
SST Anomalies in NINO.3 (upper)and the NINO.WEST(lower)for DJF prediction from the end of Oct.

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.

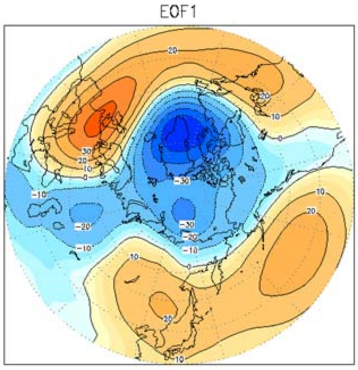


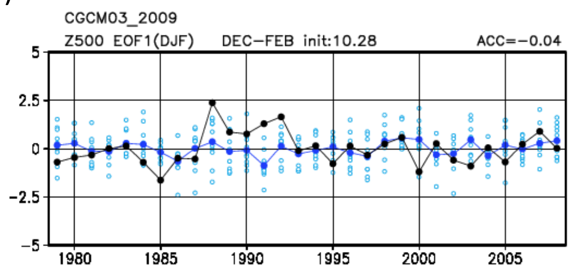
T850 Anomaly in the Western Japan for DJF prediction from the end of Oct.

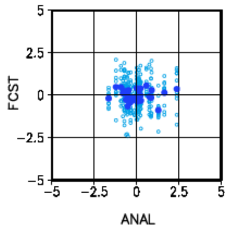
Prediction skill of T850 near Japan is not so good but positive!!

Prediction Skill evaluated by 30 years Hindcast

EOF1 of NHZ500 in DJF (AO)



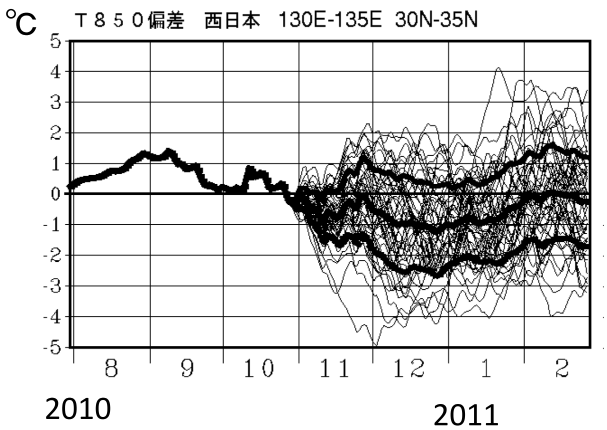




NHZ500 EOF1 (AO) for DJF prediction from the end of Oct.

Prediction skill of AO is near zero

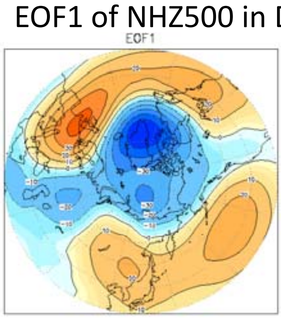
Noise estimation by each member prediction

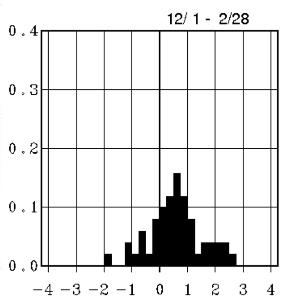


T850 Anomaly (30 day running mean) prediction in the Western Japan for DJF prediction from the end of Oct.

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

EOF1 of NHZ500 in DJF (AO)

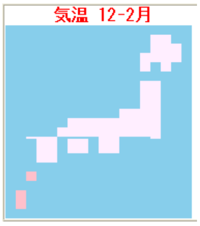




DJF AO index is predicted to be +0.5 with large spread

NWP Guidance

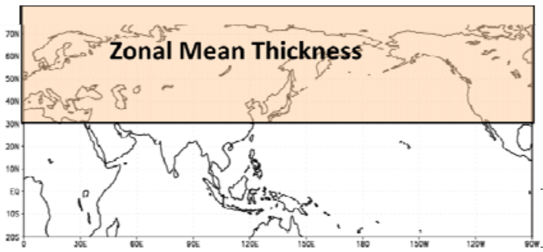
DJF Temperature

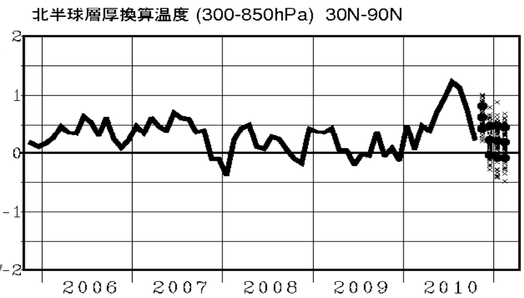


Probability

		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

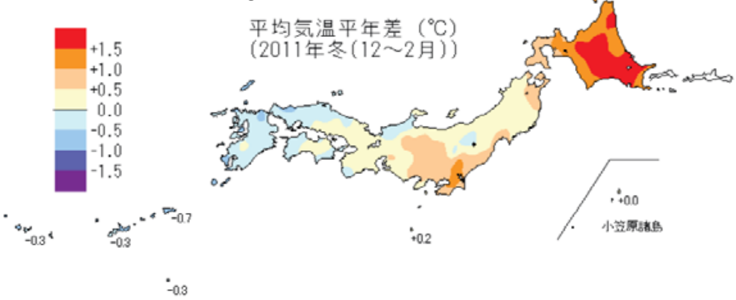
Observed DJF mean temperature

Dec.2010 –Feb.2011

	気温 平年差 ℃（階級）
北日本 N. Japan	0.9（+）
東日本 E. Japan	0.5（+）
西日本 W. Japan	-0.2（0）
沖縄・奄美 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.

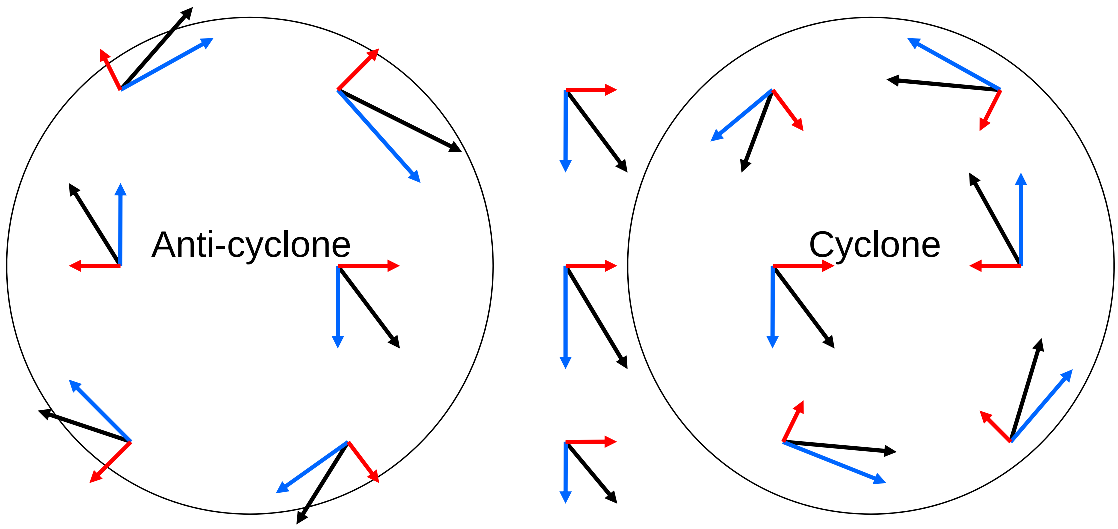
Thank you!

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

Real velocity vector
Divergent component
Rotational component

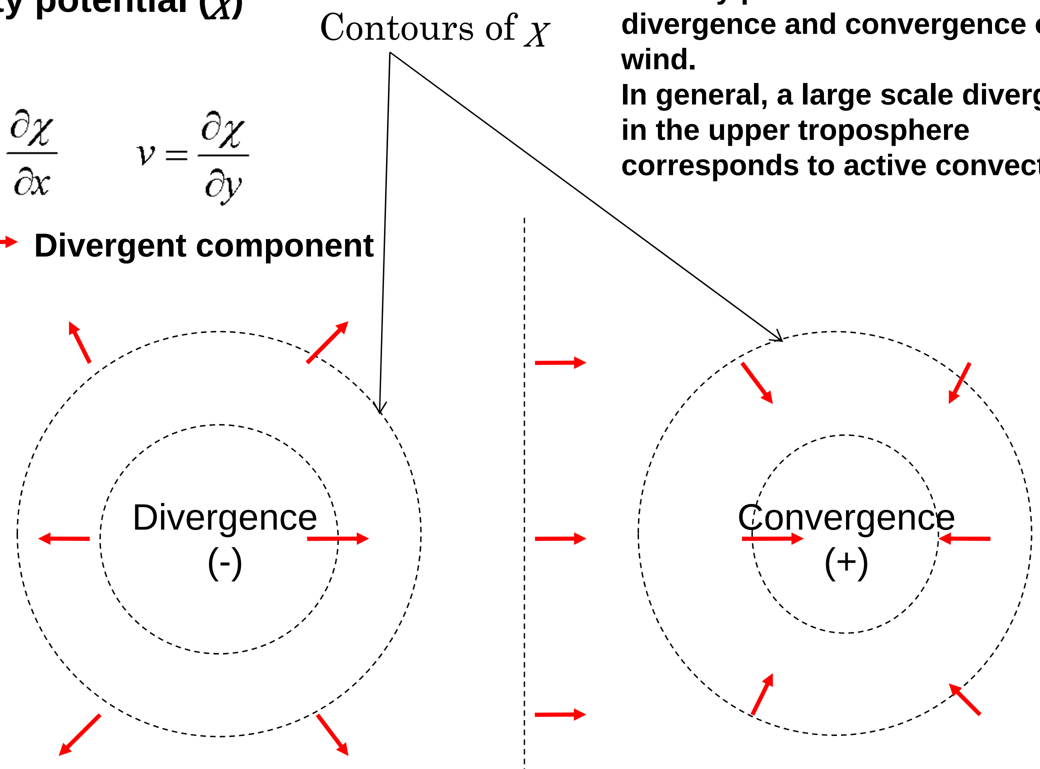


Velocity potential (χ)

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

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

Divergent component



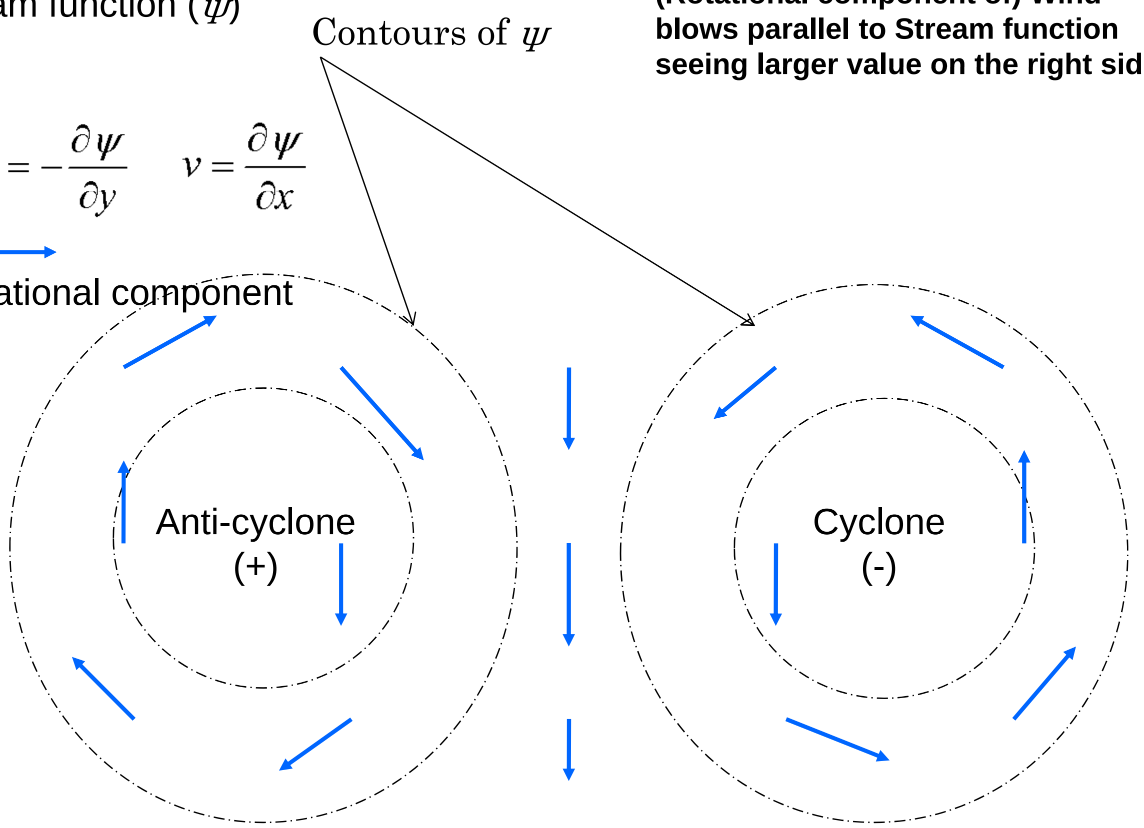
Active convection … Convergence in the lower troposphere and divergence in the upper troposphere.
Inactive convection … Divergence in the lower troposphere and convergence in the upper troposphere.

Stream function (ψ)

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

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

Rotational component



Introduction of Seasonal Forecast Guidance

Introduction of Seasonal Forecast Guidance

TCC Training Seminar on Seasonal Prediction Products
11-15 November 2013

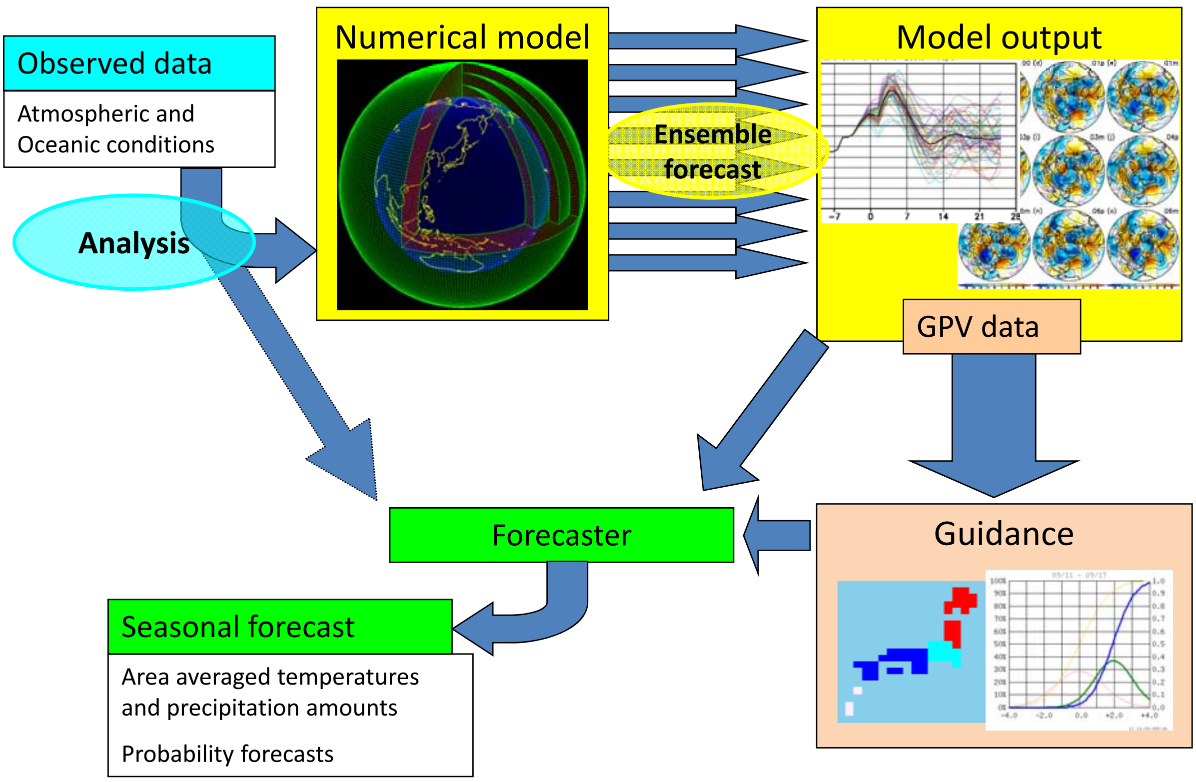
Outline

1. Introduction
2. Regression method
   - Single/Multi regression model
   - Selection of variables
3. Probability Forecast

Outline

1. Introduction
2. Regression method
   - Single/Multi regression model
   - Selection of variables
3. Probability Forecast

1. Introduction



1. Introduction

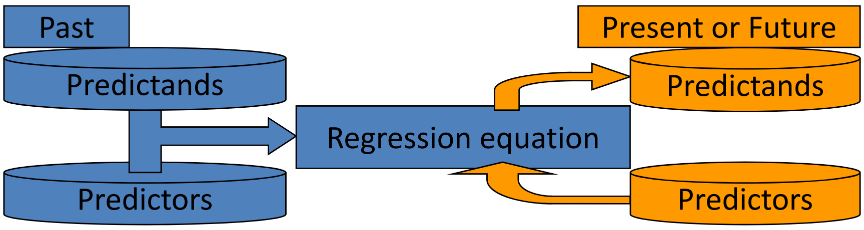
- "Guidance" is a statistical downscaling technique based on grid point value (GPV) data predicted by a numerical model.
- "Guidance" has a possibility to increase reliability of forecasts.
- For seasonal forecast, the indices associated with the tropical phenomena, including ENSO, may be more effective.

Outline

1. Introduction
2. Regression method
   - Single/Multi regression model
   - Selection of variables
3. Probability Forecast

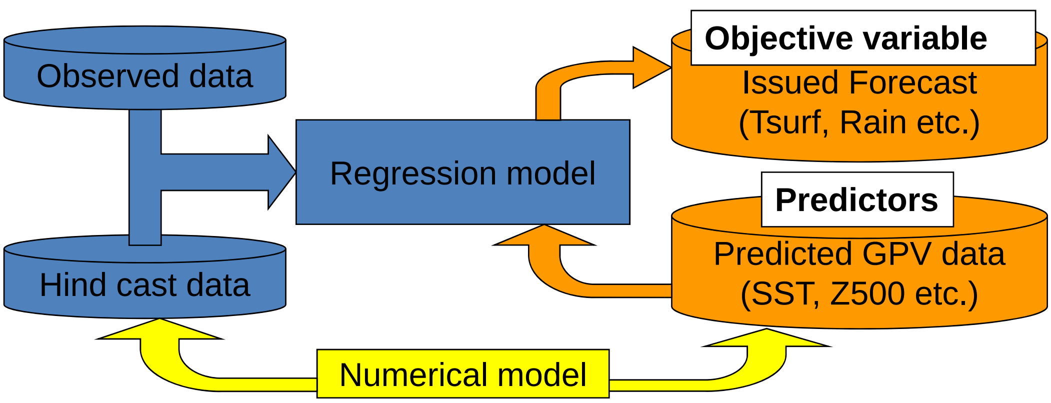
2. Regression method

- Two types of time series data are used to make guidance.
  – variables for issued forecast, ex) Temperature, Precipitation (Response variables, i.e. Predictands)
  – variables predicted by the numerical model, ex) SST, Z500 (Explanatory variables, i.e. Predictors)
- Our purpose is to predict the future values of predictands using the statistical relationship between predictands and predictors.



2. Regression model

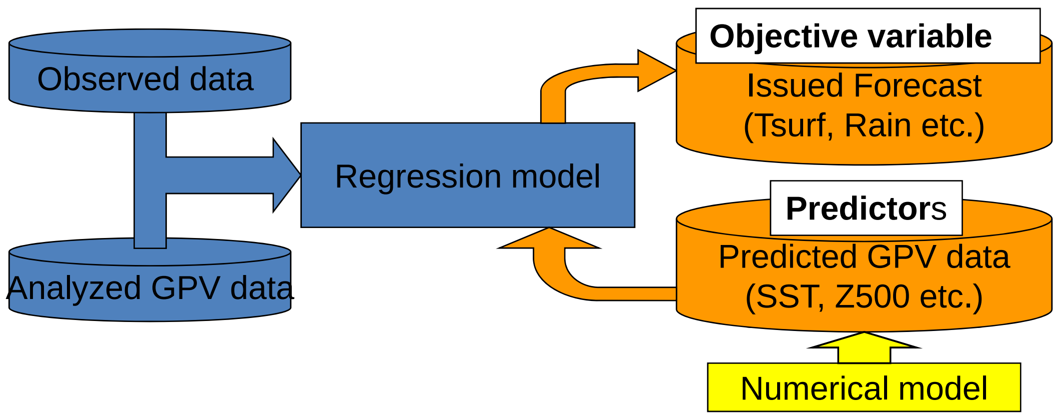
- **MOS**: the Model Output Statistics technique.
  A statistical relationship is established between observed values of the predictand and forecast predictors.
  If the model has a tendency to under- or over-forecast a predictor, this will be compensated for by the MOS technique.



*** Now, JMA uses MOS technique to make guidance.**

2. Regression model

- PPM: the Perfect Prognostic Method
  A statistical relationship is established between observed values and the analyzed variables.



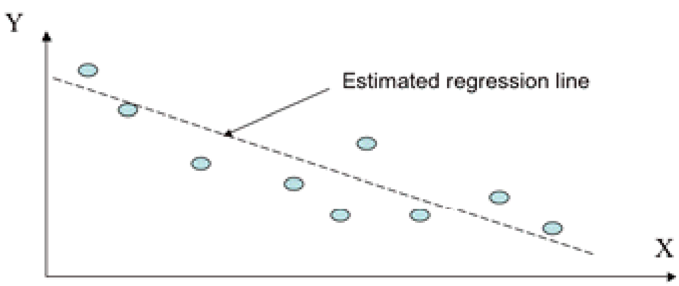
*** Now, JMA does not use PPM technique to make guidance.**

Single regression

- Single regression is the simplest regression using one single predictor.
- Single regression model is written as

  $Y = aX + b + \varepsilon$

  Y: predictand X: predictor
  a: regression coefficient b: constant
  ε: error term



Multiple regression

- Multiple regression is assumed that predictands are the sum of a linear combination of plural predictors.
- Multiple regression model is written as

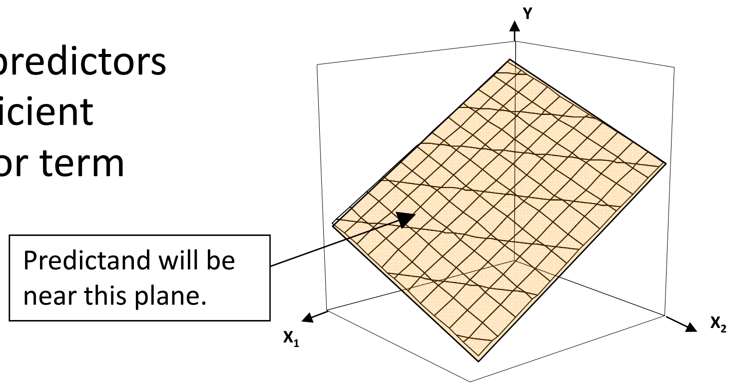
$$Y = a_k X_k + b + \varepsilon$$

$k=1,2,\ldots,n$

Y: predictand X: predictors

a: regression coefficient

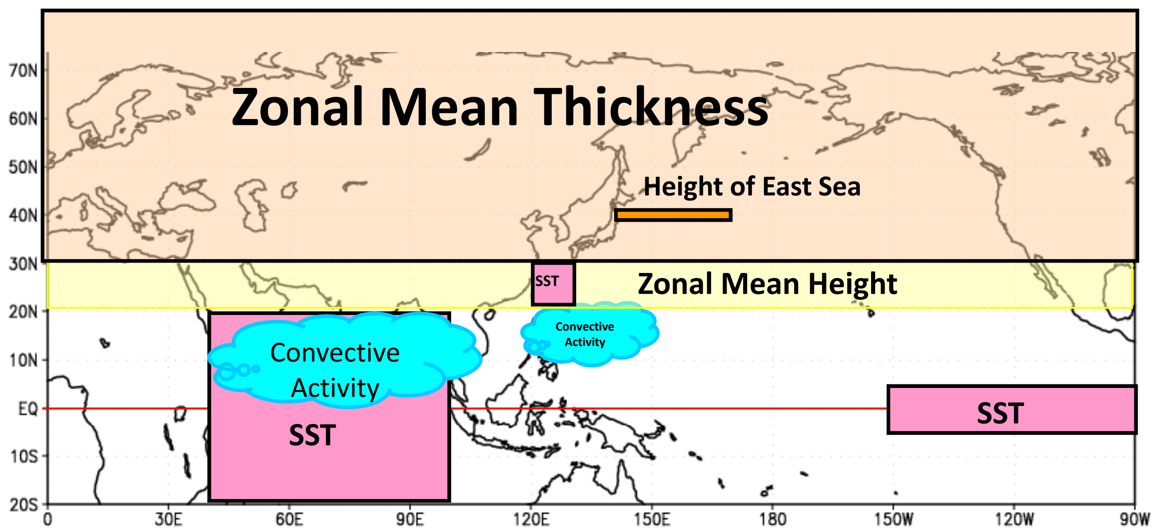
b: constant ε: error term



Example: two predictors

Selection of variables (in JMA)

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



Selection of variables (in JMA)

- Seasonal forecast Guidance of JMA uses multiple regression model by the MOS technique.
- Predictors related with climate in Japan are selected from the variables by stepwise procedure.

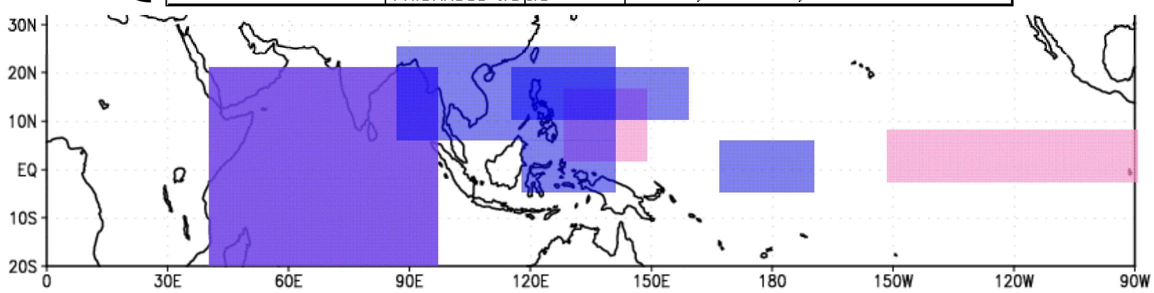
List of predictors selected many times in each target season

These predictors are anomalies except thickness extratropic.

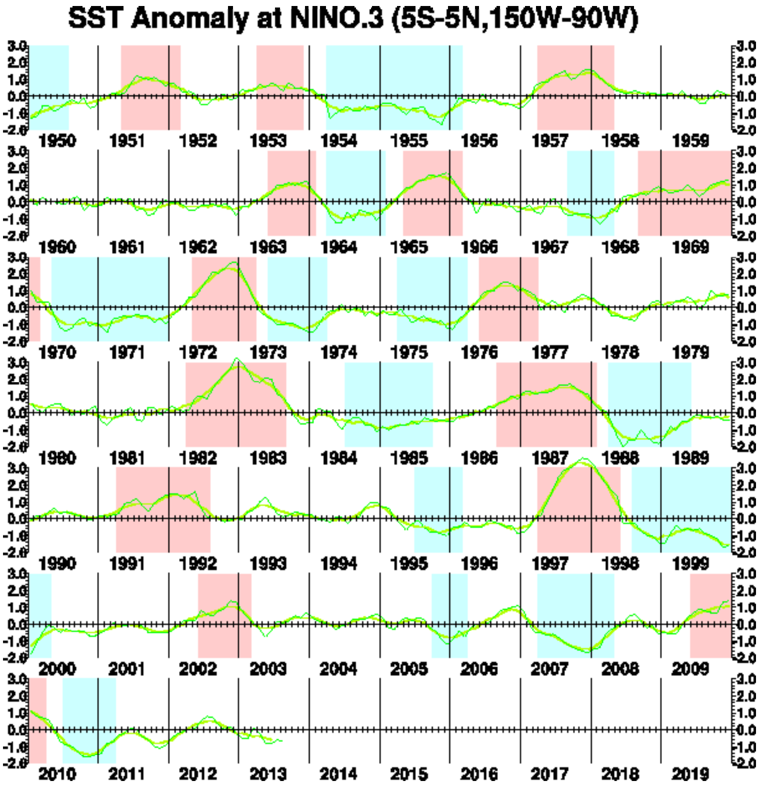
Temperature	Spring	Thickness extratropic	IOBW SST	Zonal mean 500hPa height of Mid lat
	Summer	Thickness extratropic	NIO RAIN	Okinawa SST
	Autumn	Thickness extratropic	NINO.3 SST	Zonal mean 500hPa height of Mid lat
	Winter	Thickness extratropic	Okinawa SST	WNP RAIN
Precipitation	Spring	Okinawa SST	WNP RAIN	NINO.3 SST
	Summer	Zonal mean 500hPa height of Mid lat	IOBW SST	WNP RAIN
	Autumn	NINO.3 SST	Thickness extratropic	IOBW SST
	Winter	Thickness extratropic	NINO.3 SST	Okinawa SST

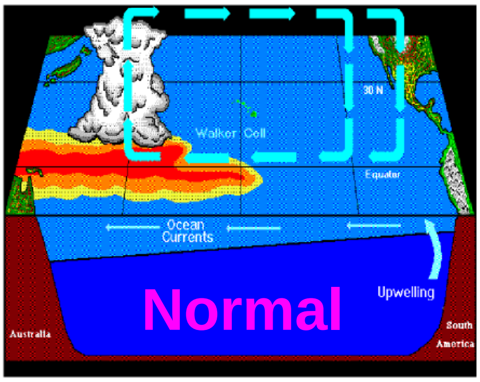
Selection of variables (in this seminar)

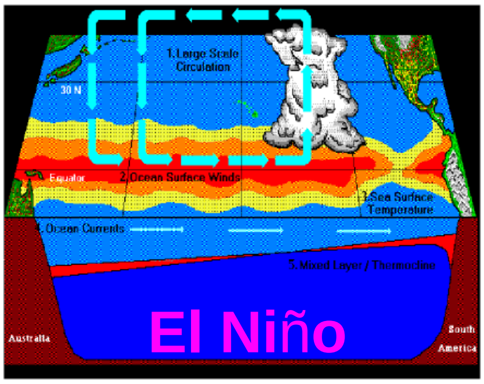
	indices	variables	areas
SST	NINO3 SST	SST	(150W-90W, 5S-5N)
	NINOWEST SST	SST	(130E-150E, EQ-15N)
	IOBW SST	SST	(40E-100E, 20S-20N)
	WIO SST	SST	(40E-70E, 0-20N)
	EIO SST	SST	(70E-100E, 0-20N)
RAIN	IOBW RAIN	RAIN	(40E-100E, 20S-20N)
	WIO RAIN	RAIN	(40E-70E, 0-20N)
	EIO RAIN	RAIN	(70E-100E, 0-20N)
	SAMOI RAIN	RAIN	(80E-140E, 5N-25N)
	WNP RAIN	RAIN	(110E-160E, 10N-20N)
	SEAsia RAIN	RAIN	(115E-140E, 10N-20N)
	MC RAIN	RAIN	(110E-135E, 5S-5N)
	DL RAIN	RAIN	(170E-170W, 5S-5N)
Z500	Z2030	500hPa Height	(0-360, 20N-30N)
	Z3040	500hPa Height	(0-360, 30N-40N)
	Z4050	500hPa Height	(0-360, 40N-50N)
	Z5060	500hPa Height	(0-360, 50N-60N)
Thickness	THMD	Thickness Middle	(0-360, 30N-50N, 300hPa-850hPa)
	THEX	Thickness extratropic	(0-360, 30N-90N, 300hPa-850hPa)
	THTR	Thickness tropic	(0-360, 25S-25N, 100hPa-850hPa)



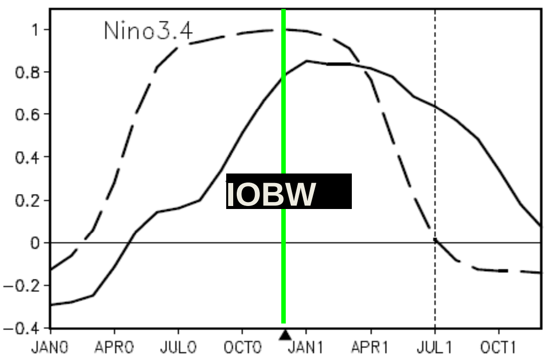
El Niño Southern Oscillation (ENSO)





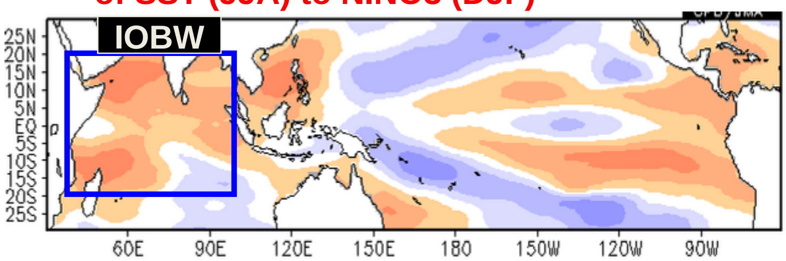


Delayed Influence from ENSO



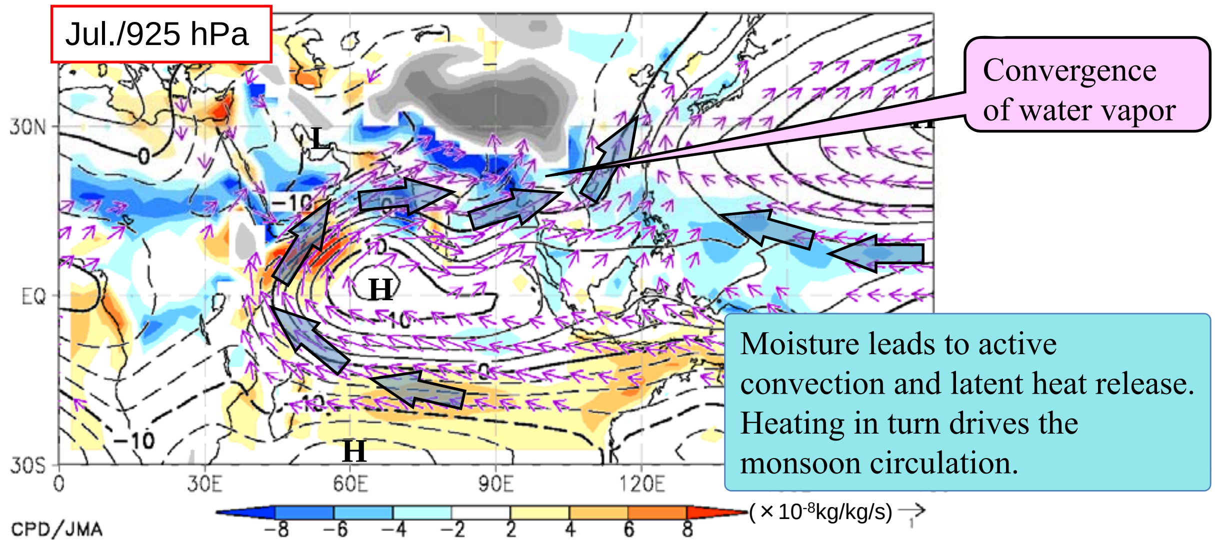
Time evolution of correlation coefficient to NINO3.4 in December

6-month lag correlation coefficient of SST (JJA) to NINO3 (DJF)



Asian summer monsoon

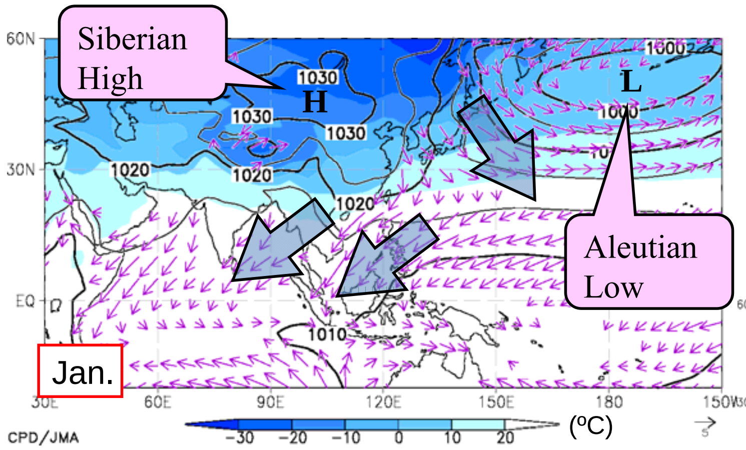
- Asian summer monsoon is a large scale motion with moisture transport from Southern Hemisphere to South and East Asia.



Monthly mean 925-hPa Stream function (contours, ×10^{6}m^{2}/s), divergence of Water vapor flux (shadings, ×10^{-8}kg/kg/s) and Water vapor flux (vectors, m/s*kg/kg) (1979 – 2004 mean) Gray shadings show topography (≥1500 m).

Asian winter monsoon

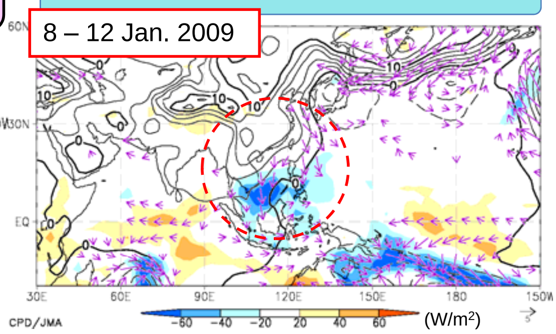
- In boreal winter, Siberian High and Aleutian Low are developed.
  - North-westerlies to East Asia, North-easterlies to South Asia



Monthly mean surface 2 m temperature (shadings, ºC), Sea Level Pressure (contours, hPa) and surface 10 m wind (vectors, m/s) (1979 – 2004 mean)

Sometimes, north-easterlies bring "Cold Surge" over South Asia.

→ enhanced convection and cold weather



Shadings: OLR anomalies

Selection of variables (in this seminar)

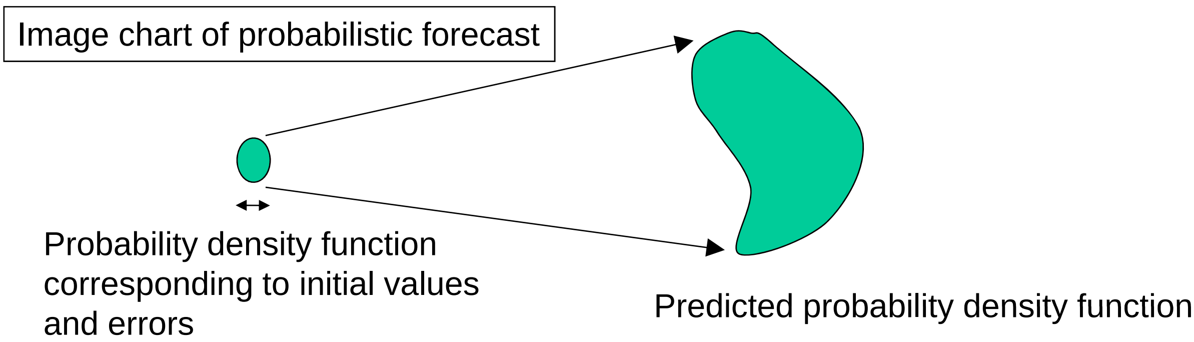
- You will select one variable or three variables from the list when you make your country's guidance.
- "SST" and "Rain" variables are associated with the tropical phenomena (ENSO, Indian Ocean basin-wide mode, Asian monsoon, and so on).
- "Z500" variables represent the atmospheric circulation in the troposphere over the subtropics, mid-latitudes, mid to high latitudes, and high-latitudes.
- "Thickness" variables correspond to zonal mean temperature anomalies in the troposphere over mid-latitudes, the extratropics, and the tropics. These variables are useful to grasp signals of global warming.

Outline

1. Introduction
2. Regression method
   - Single/Multi regression model
   - Selection of variables
3. Probability Forecast

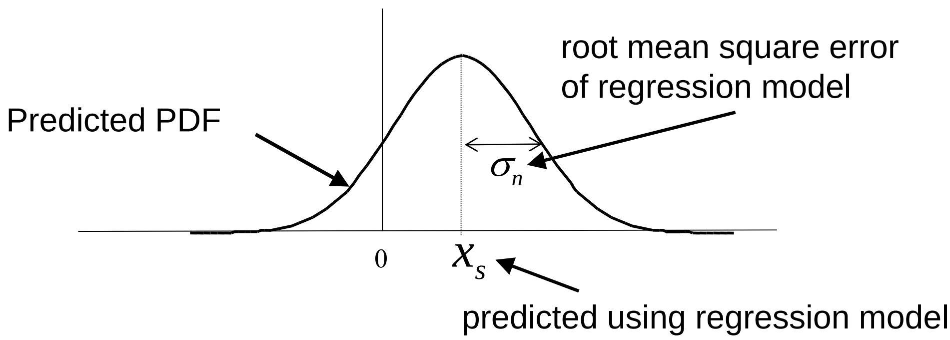
3. Probability Forecast

- Long-range forecasting involves the uncertainty due to the chaotic nature of atmospheric flow.
- It is necessary to take this uncertainty into account, and probabilistic forecasting is essential.



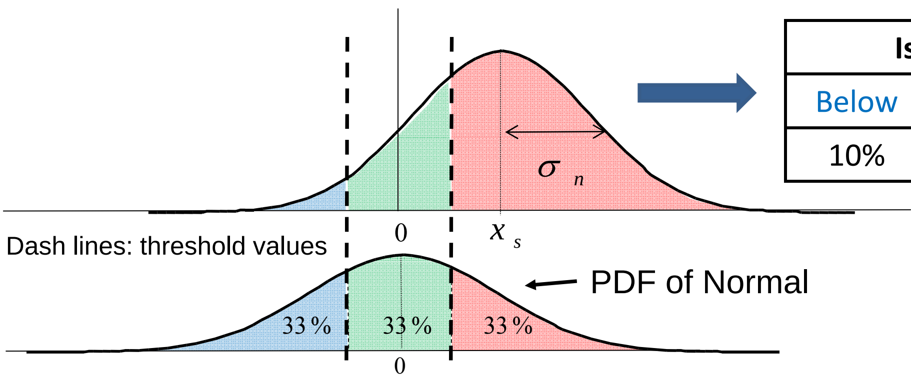
3. Probability Forecast

- The Probability Density Function (PDF) is assumed to be a normal distribution with its mean x_s and standard deviation σ_n.
- The mean x_s is predicted using the regression model and the standard deviation σ_n is assumed to be the root mean square error of the regression model.



3. Probability Forecast

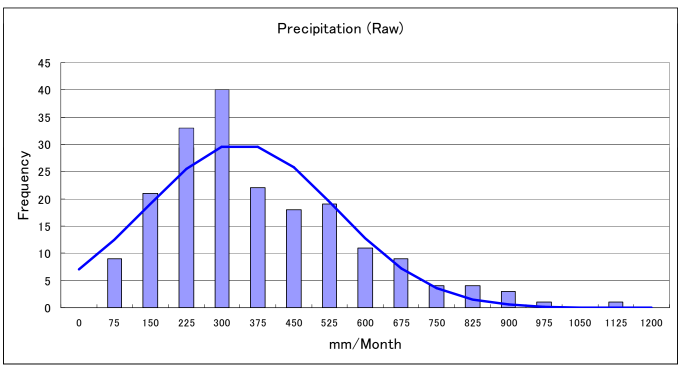
- Probabilistic Forecast of JMA has 3 categories, Below Normal, Near Normal and Above Normal.
- The threshold values are determined from the observational data of 30 years. JMA uses the data of 1981-2010.



Issued Forecast		
Below	Normal	Above
10%	30%	60%

Normalization of precipitation data

- Temperature histogram is generally approximated by a normal distribution, while precipitation histogram is usually approximated by a gamma distribution as for Japan.
- The error distribution of regression models is assumed to be approximated by a normal distribution, which is important presumption to make a probabilistic forecast.

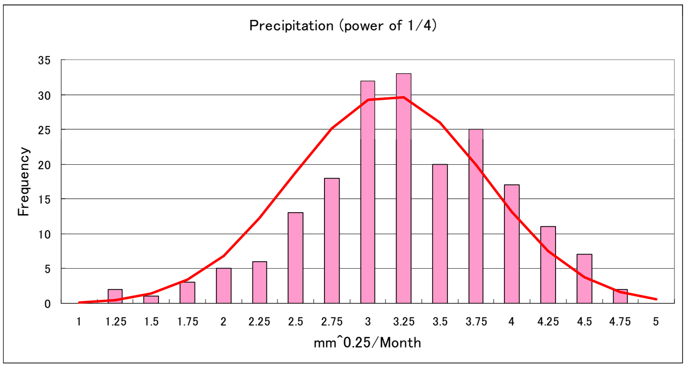


An example of histogram of observed monthly precipitation in Japan. This has a gap from a normal distribution.

Bold line indicates a normal distribution.

Normalization of precipitation data

- To make guidance, precipitation data need to be normalized.
- To achieve this, JMA's seasonal forecast guidance uses the power of 1/4 for precipitation.



The histogram of observed precipitation after taking the power of 1/4. This is approximated by a normal distribution.

Bold line indicates a normal distribution.

Thank you!

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