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

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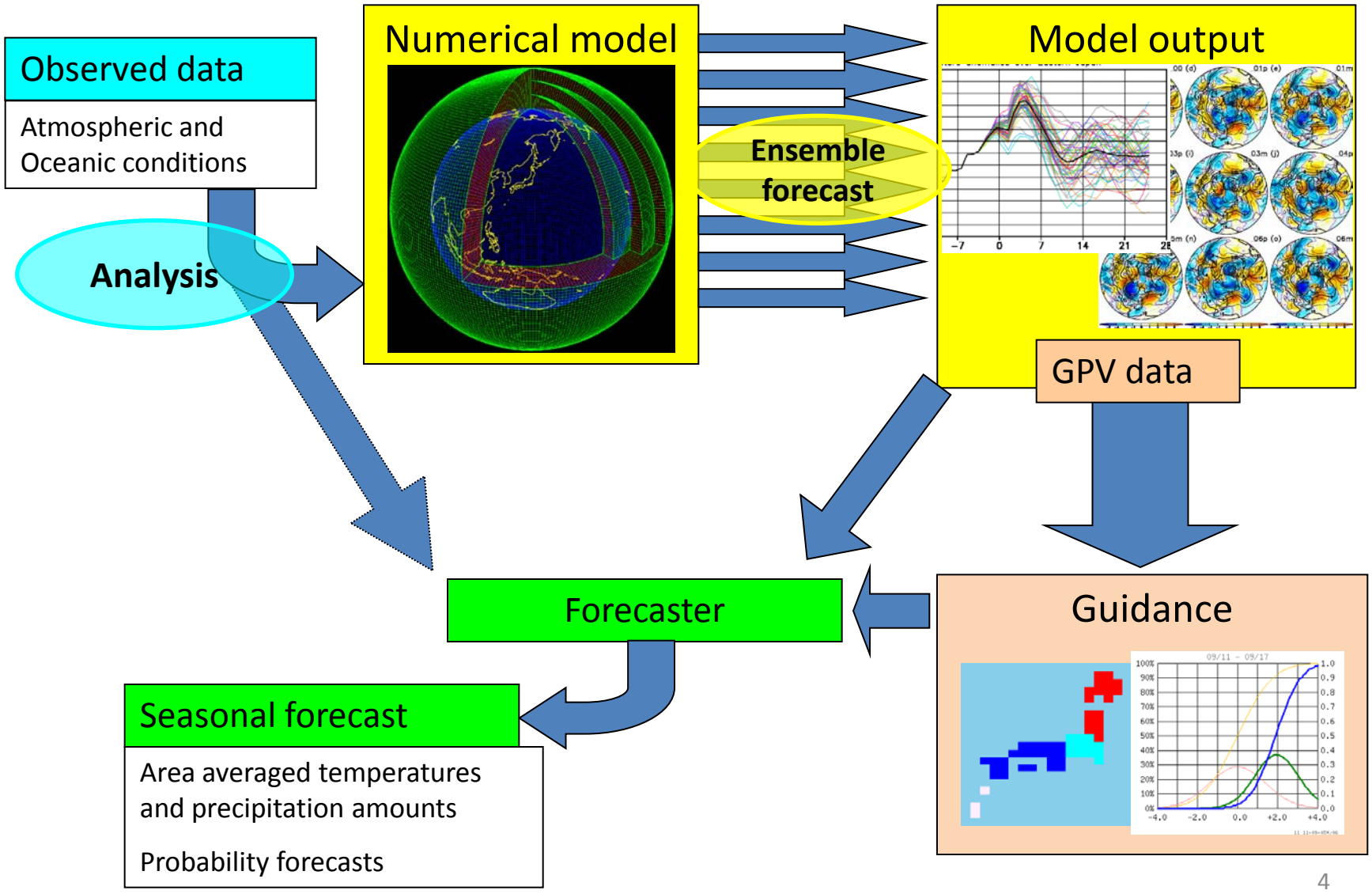
1. Introduction



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.

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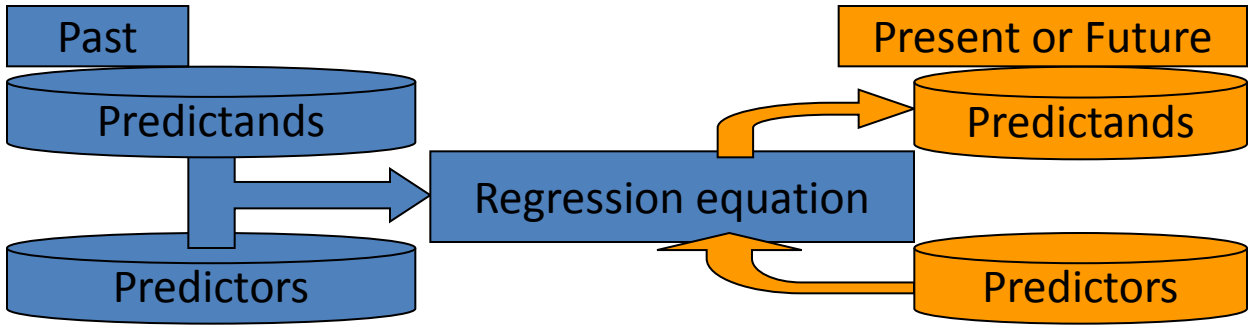
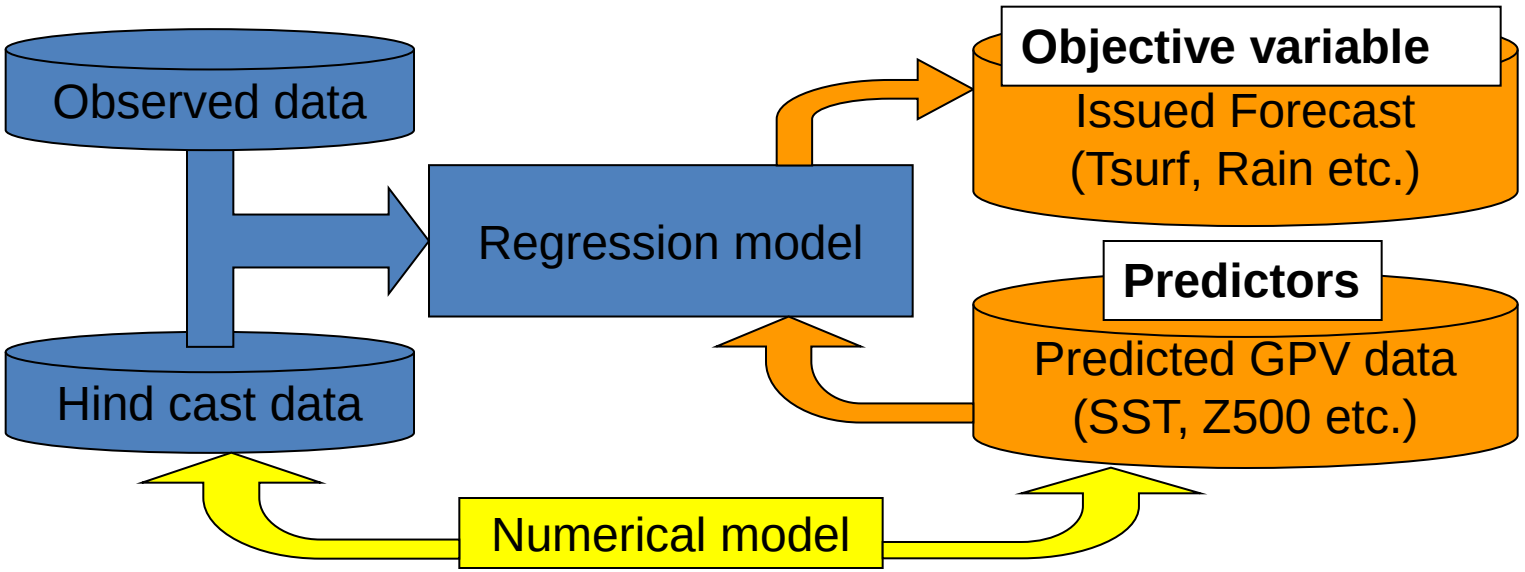
2. Regression method

- 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

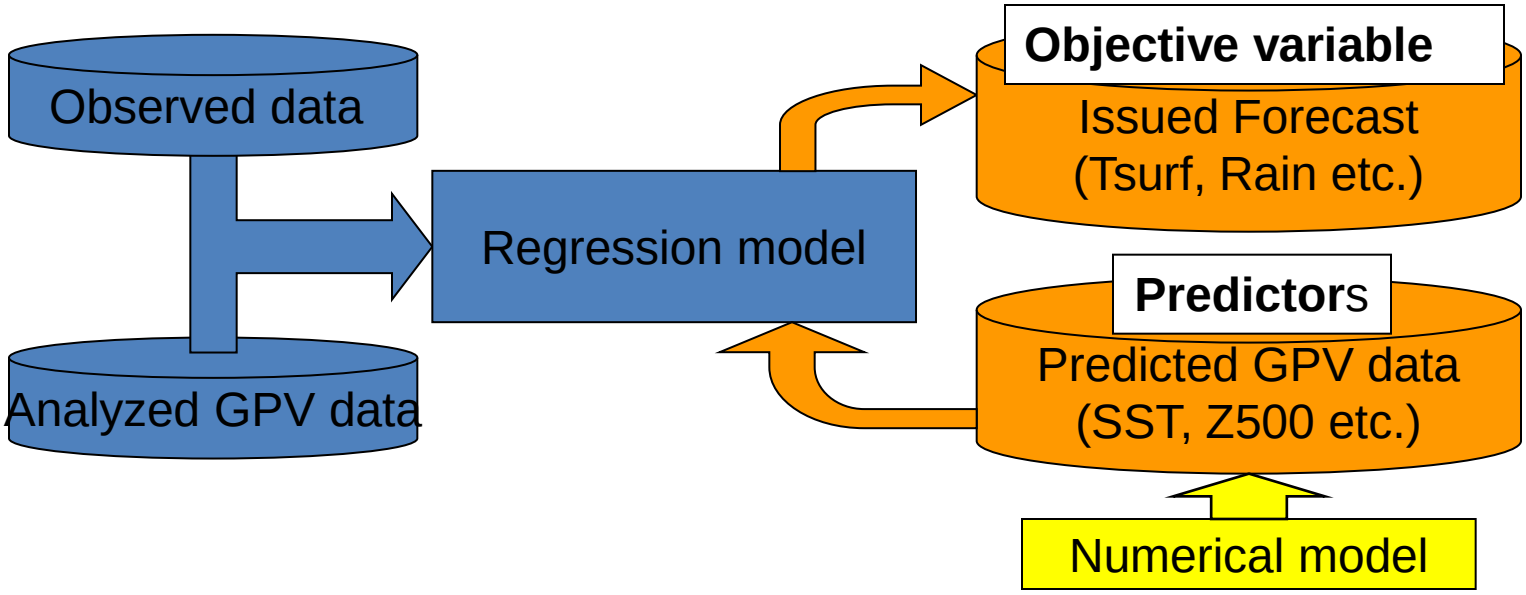
- **MOS**: the Model Output Statistics technique.
  A statistical relationship is established between observed values of the predictand and forecast predictors.
  If the model has a tendency to under- or over-forecast a predictor, this will be compensated for by the MOS technique.



*** 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.



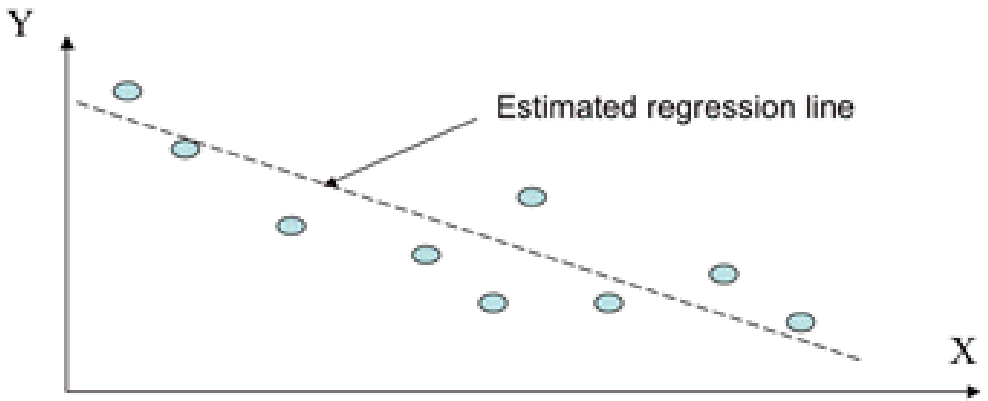
*** Now, JMA does not use PPM technique to make guidance.**

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

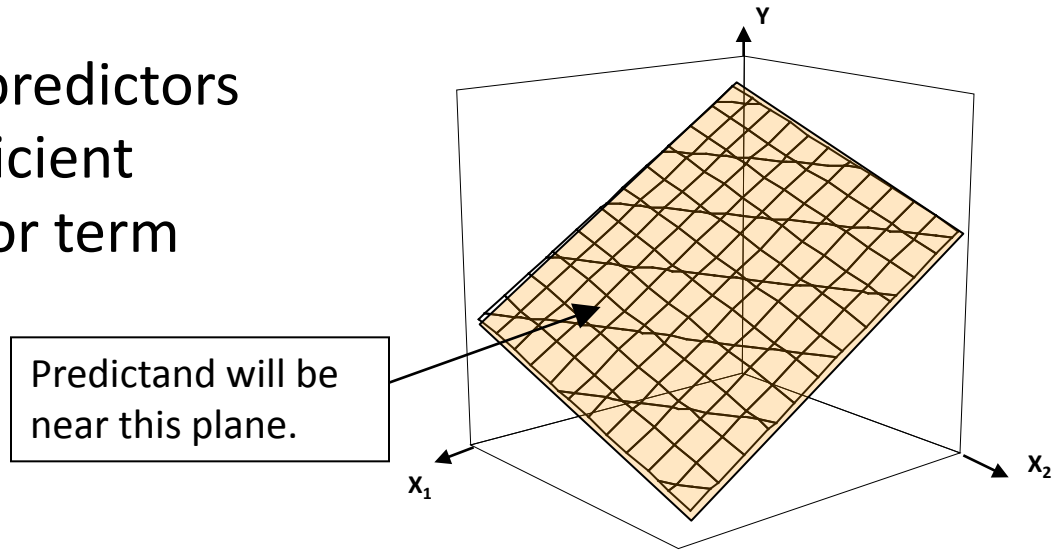


Multiple regression

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

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

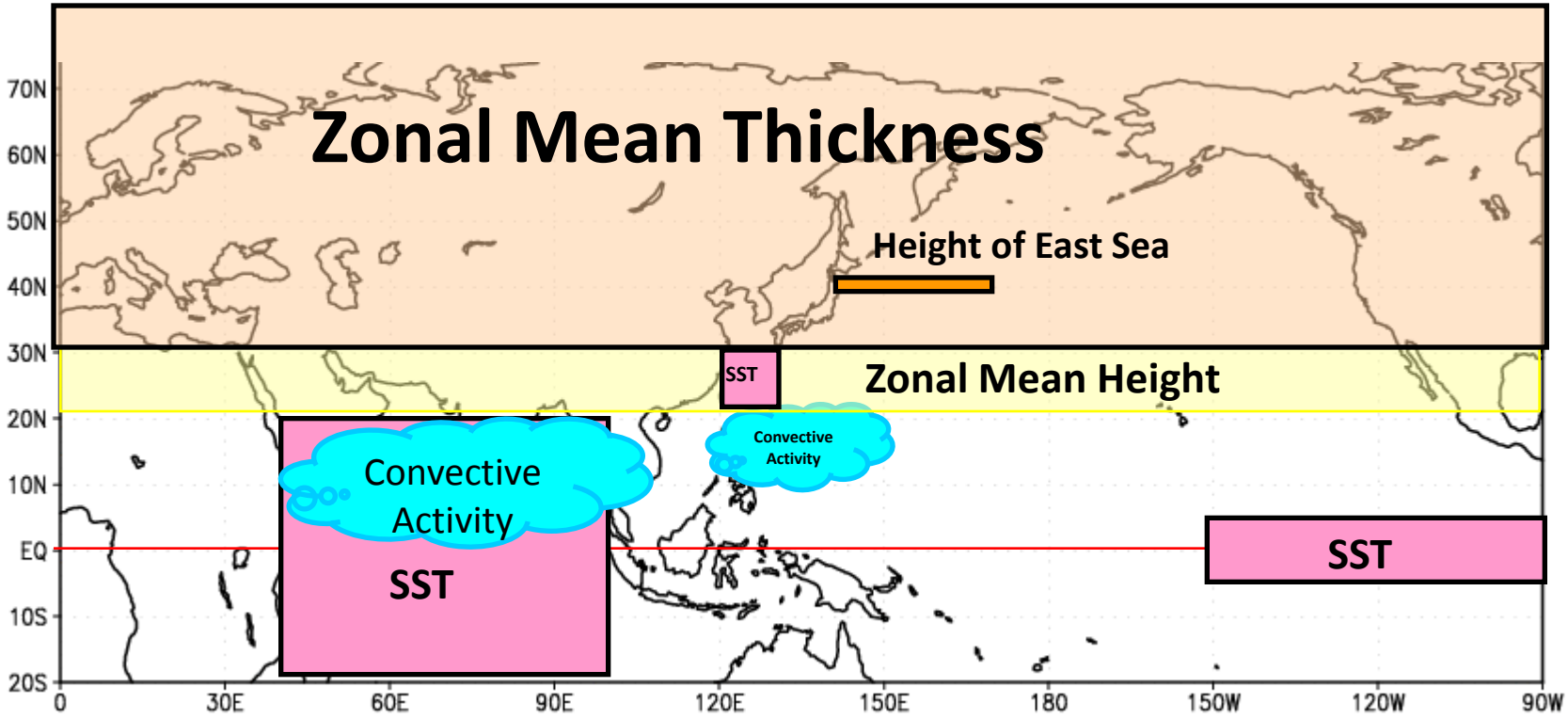
k=1,2,…,n
Y: predictand X: predictors
a: regression coefficient
b: constant ε: error term



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.

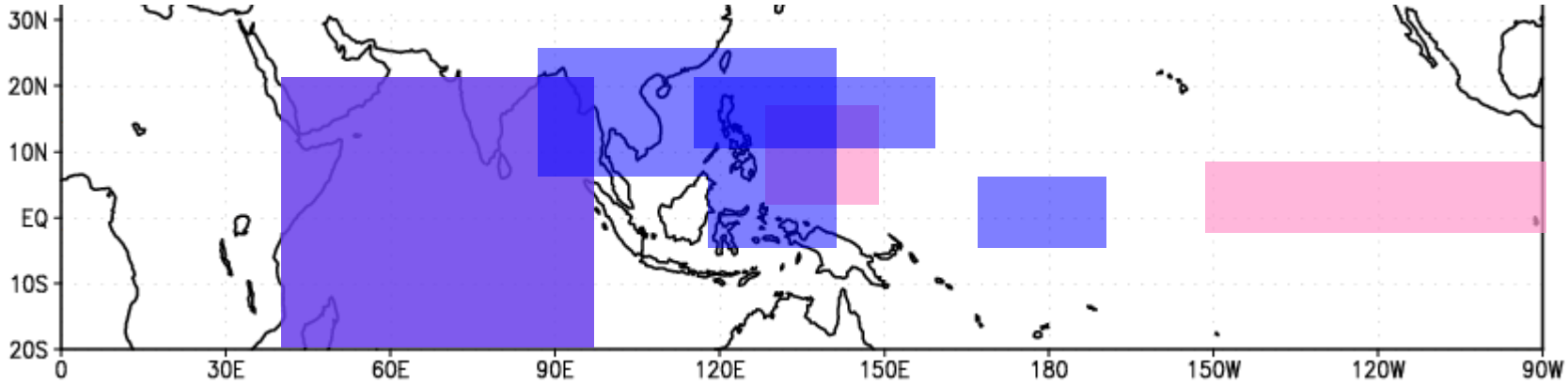
List of predictors selected many times in each target season

These predictors are anomalies except thickness extratropic.

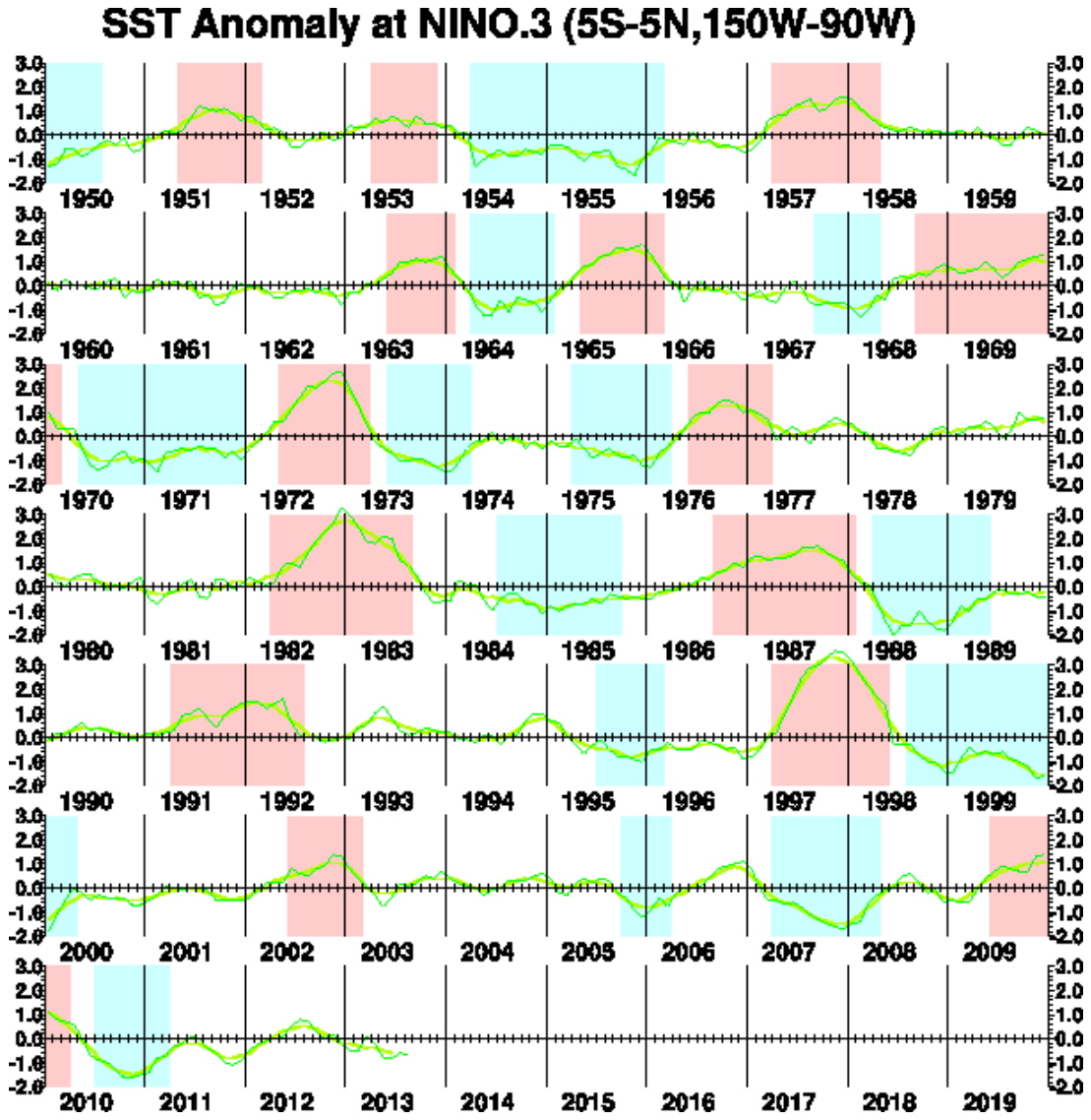
Temperature	Spring	Thickness extratropic	IOBW SST	Zonal mean 500hPa height of Mid lat
	Summer	Thickness extratropic	NIO RAIN	Okinawa SST
	Autumn	Thickness extratropic	NINO.3 SST	Zonal mean 500hPa height of Mid lat
	Winter	Thickness extratropic	Okinawa SST	WNP RAIN
Precipitation	Spring	Okinawa SST	WNP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

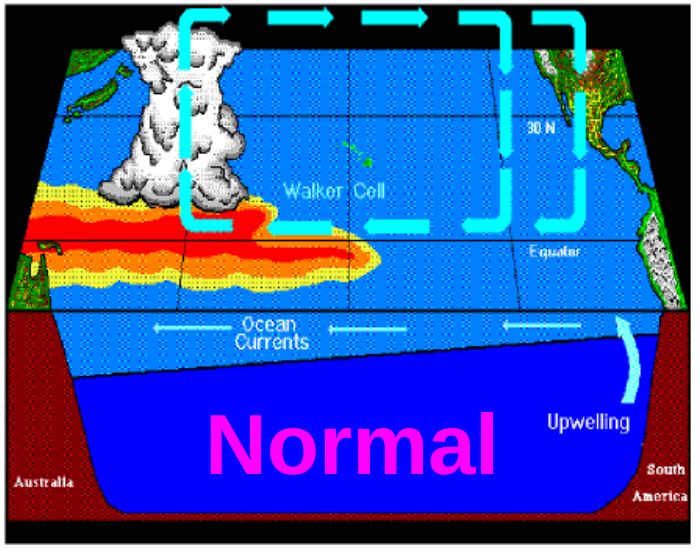
Selection of variables (in this seminar)

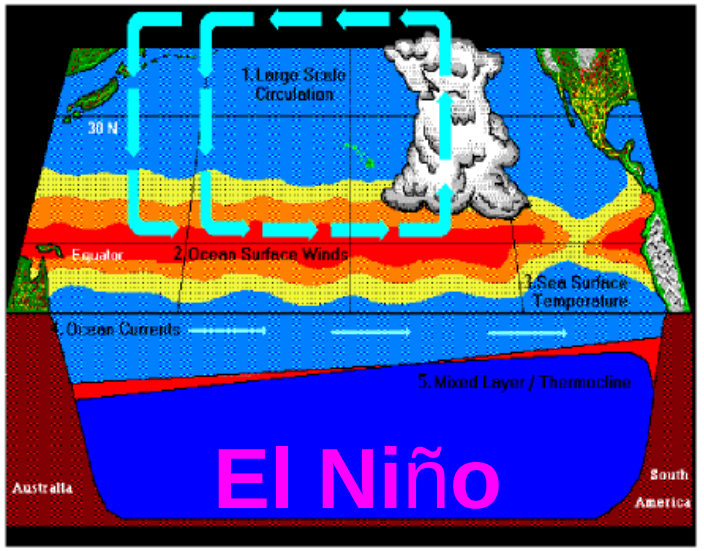
	indices	variables	areas
SST	NINO3 SST	SST	(150W-90W, 5S-5N)
	NINOWEST SST	SST	(130E-150E, EQ-15N)
	IOBW SST	SST	(40E-100E, 20S-20N)
	WIO SST	SST	(40E-70E, 0-20N)
	EIO SST	SST	(70E-100E, 0-20N)
RAIN	IOBW RAIN	RAIN	(40E-100E, 20S-20N)
	WIO RAIN	RAIN	(40E-70E, 0-20N)
	EIO RAIN	RAIN	(70E-100E, 0-20N)
	SAMOI 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)



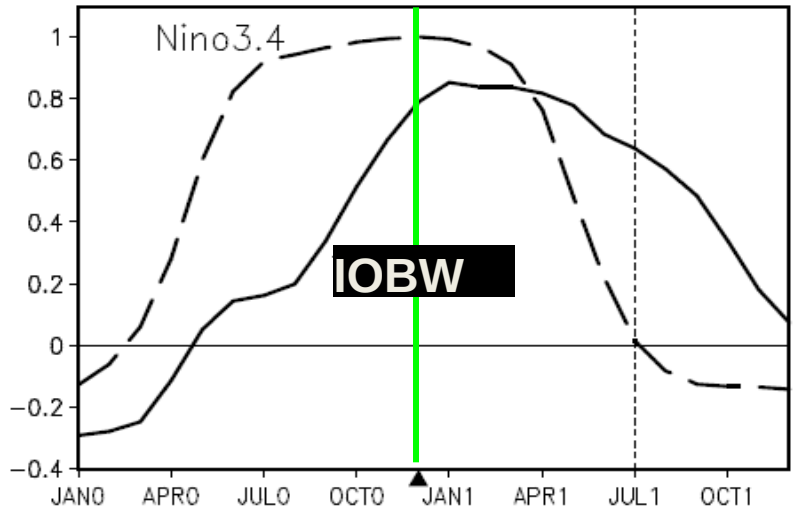
El Niño Southern Oscillation (ENSO)





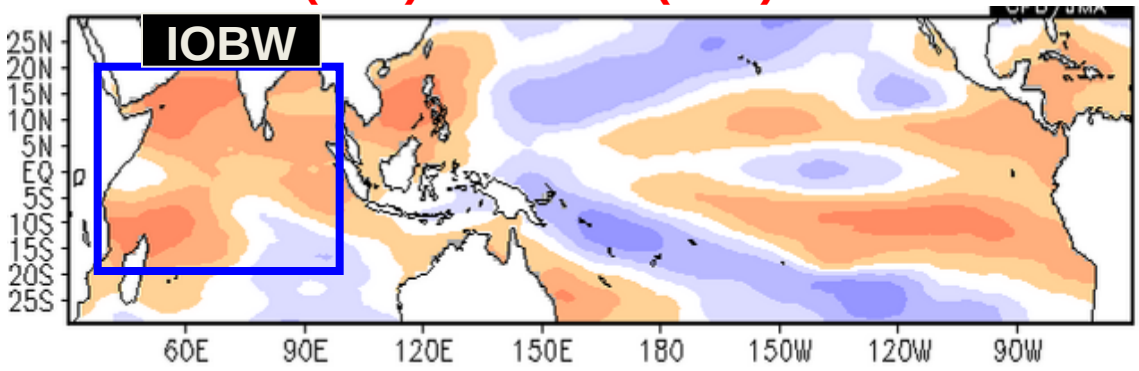


Delayed Influence from ENSO



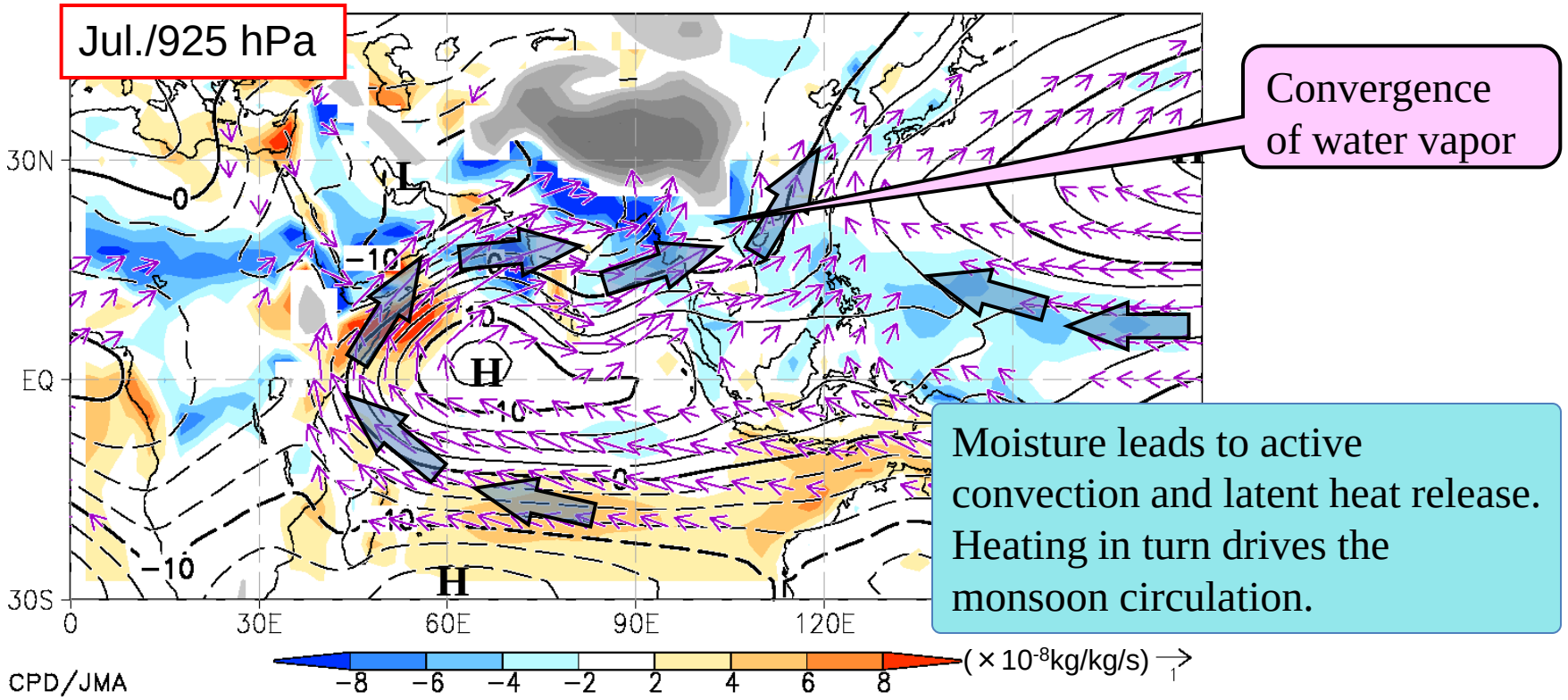
Time evolution of correlation coefficient to NINO3.4 in December

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



Asian summer monsoon

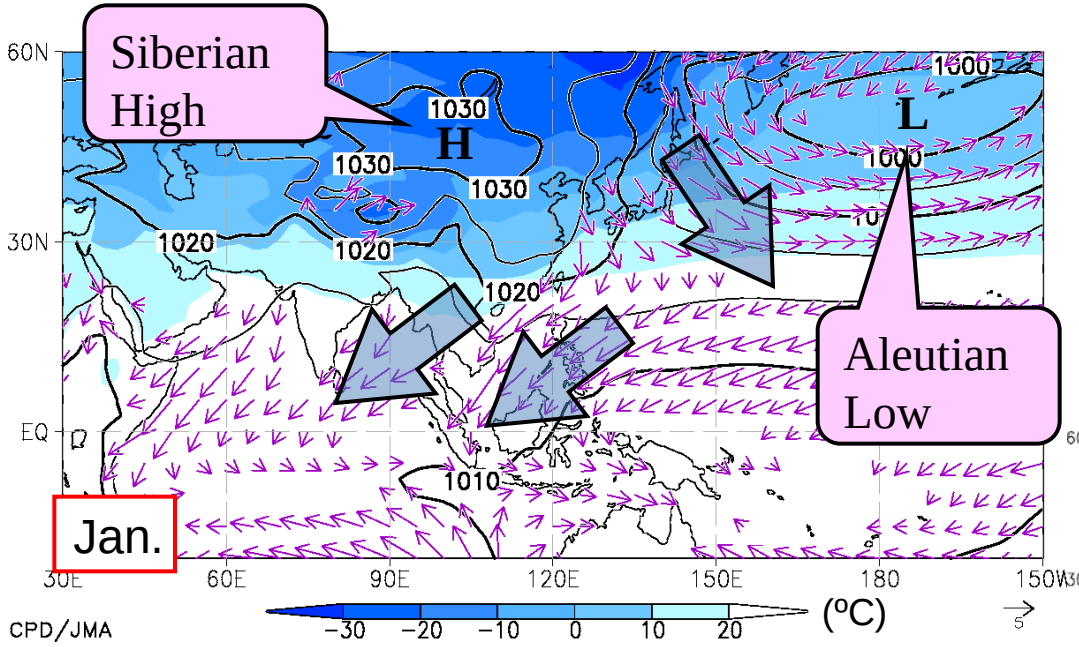
- Asian summer monsoon is a large scale motion with moisture transport from Southern Hemisphere to South and East Asia.



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

Asian winter monsoon

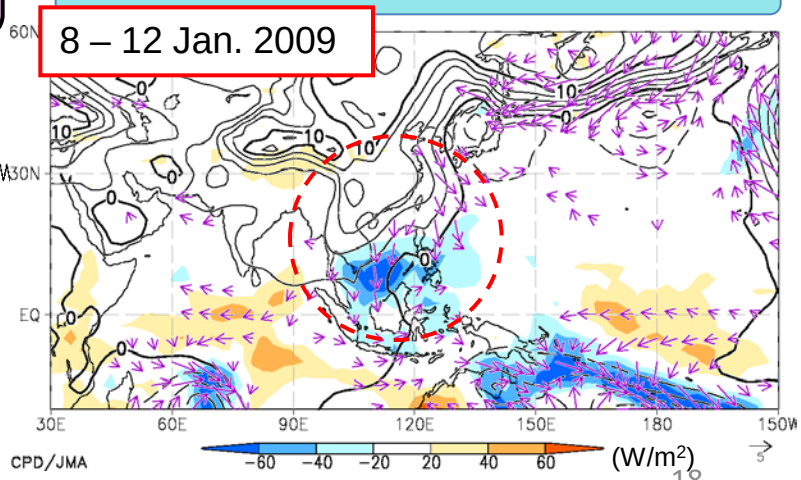
- In boreal winter, Siberian High and Aleutian Low are developed.
  - North-westerlies to East Asia, North-easterlies to South Asia



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.

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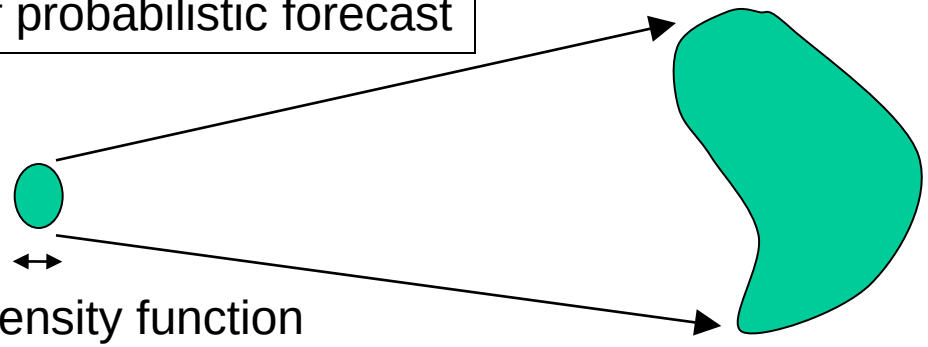
3. Probability Forecast

- 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.

Image chart of probabilistic forecast

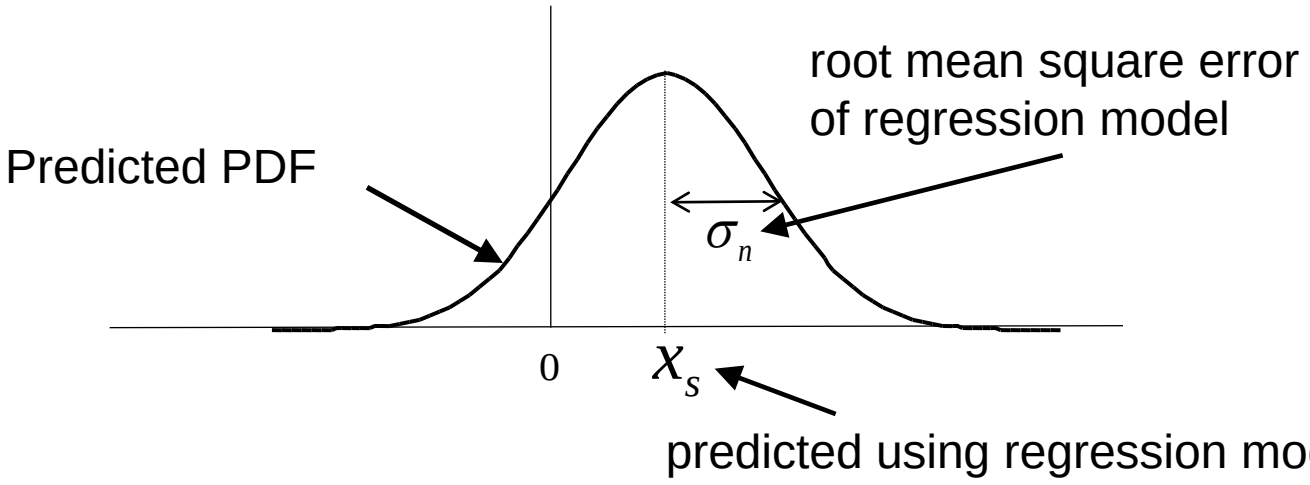


Probability density function corresponding to initial values and errors

Predicted probability density function

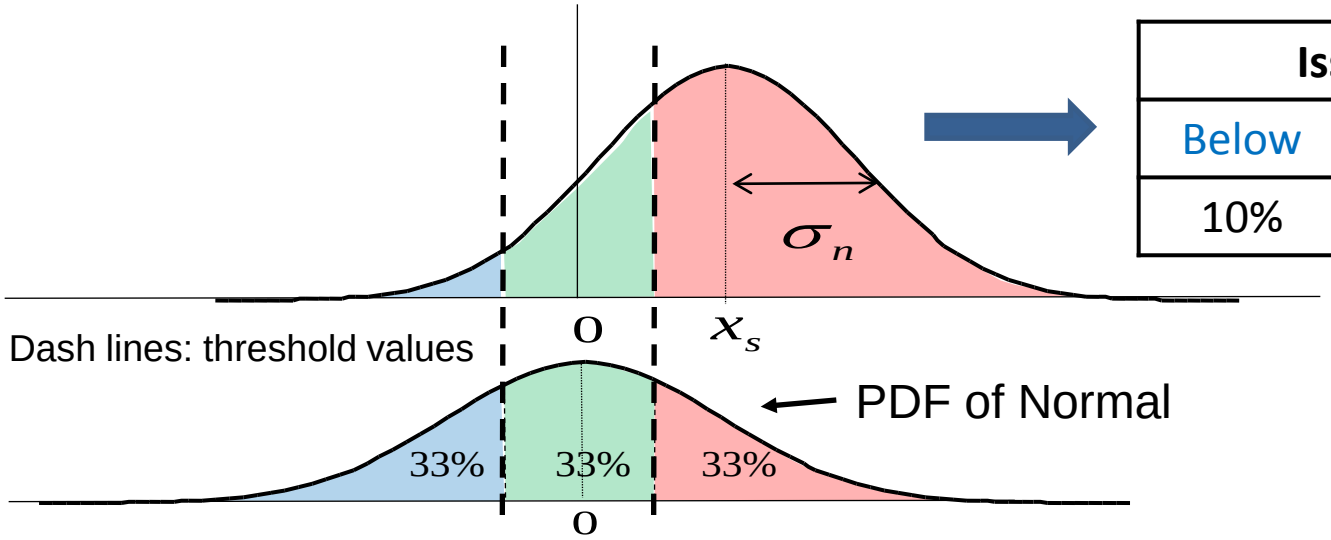
3. Probability Forecast

- 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

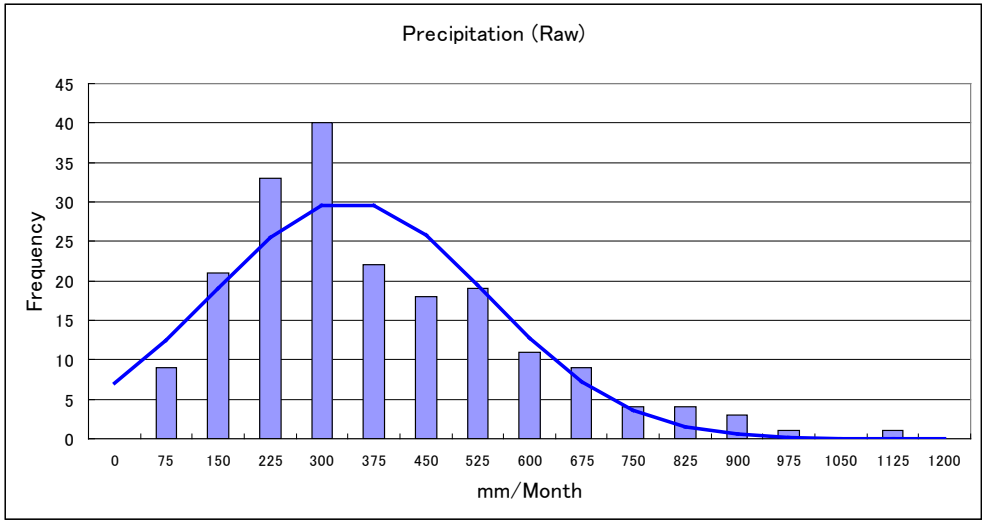
- Probabilistic Forecast of JMA has 3 categories, Below Normal, Near Normal and Above Normal.
- The threshold values are determined from the observational data of 30 years. JMA uses the data of 1981-2010.



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.

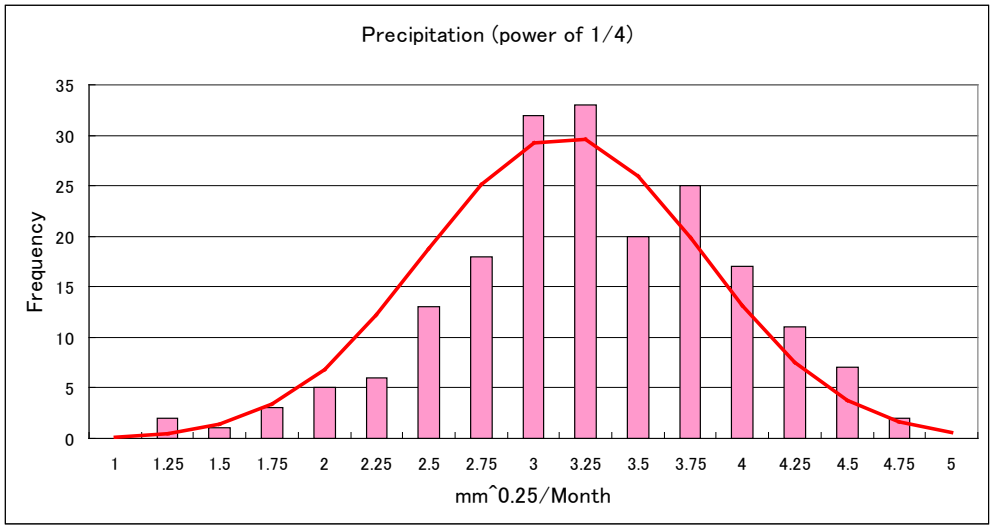


An example of histogram of observed monthly precipitation in Japan. This has a gap from a normal distribution.

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.