TCC Training Seminar on 12 November 2018

Global Ensemble Prediction System (EPS) and Products for One-month Forecast

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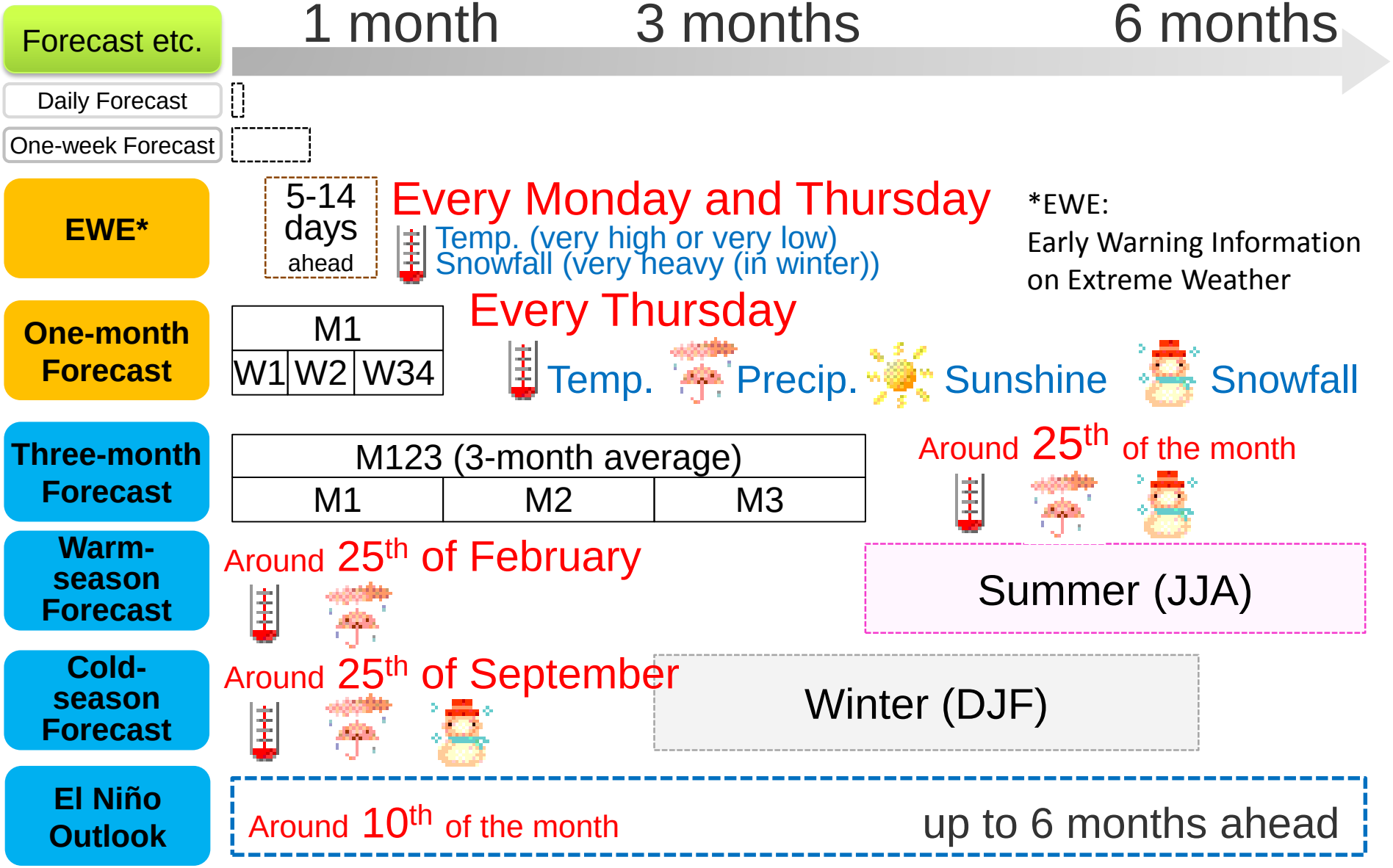
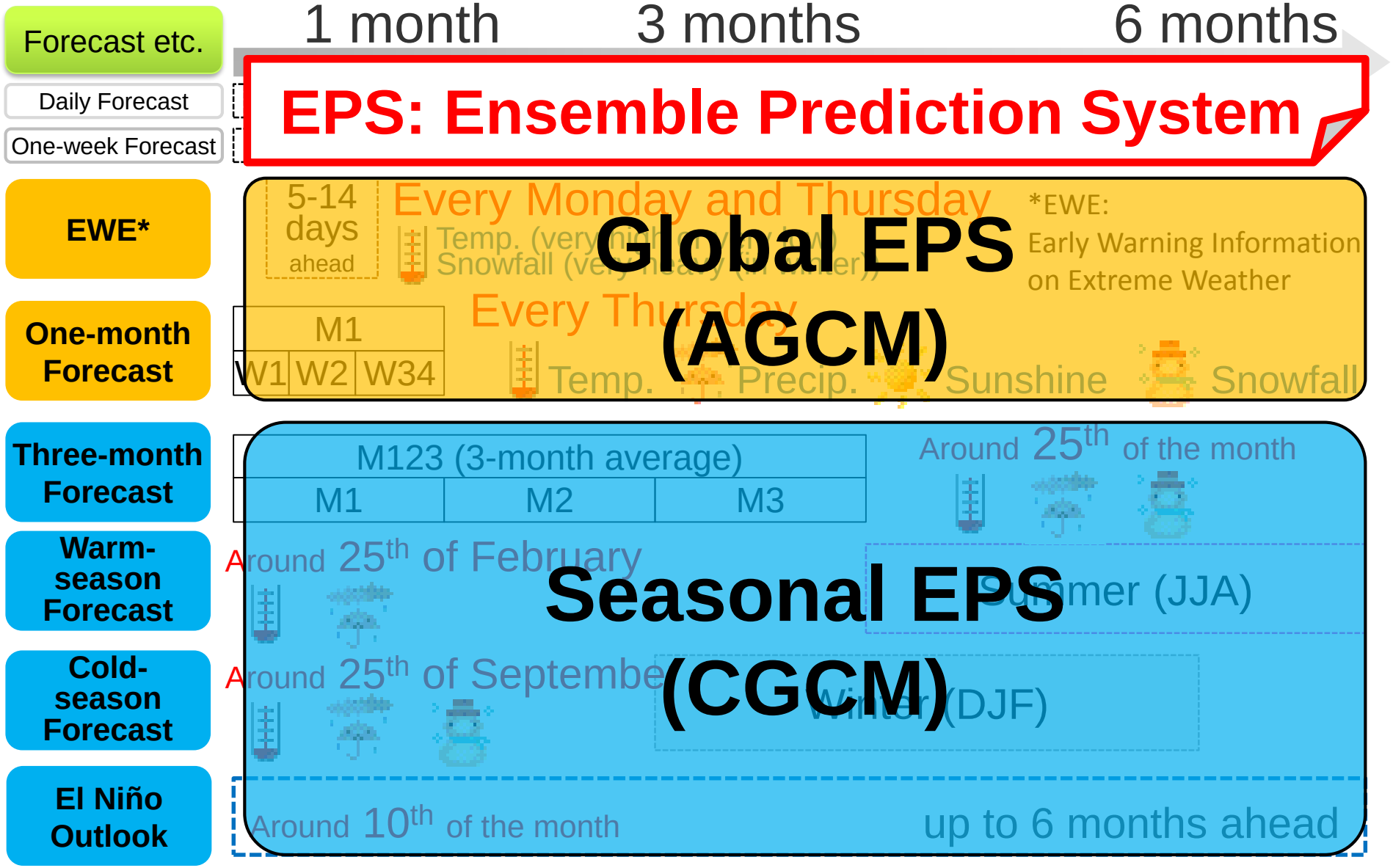
Contents

- Basic Knowledge
  - NWP Model and Predictability
  - Ensemble Prediction and Uncertainty
  - Hindcast
- JMA's Global Ensemble Prediction System
- TCC's Products to support 1-month Forecast

Seasonal forecast issued by JMA (domestic)



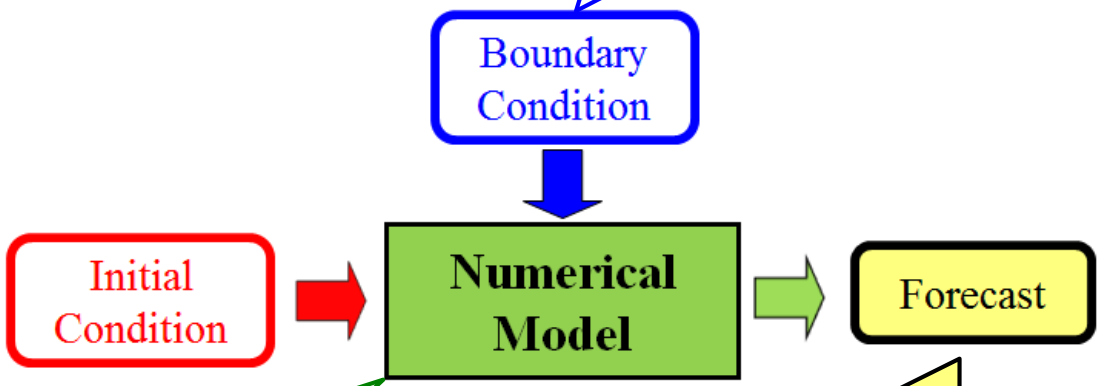
Seasonal forecast issued by JMA (domestic)



Numerical Weather Prediction

■ A Simplified Conceptual Chart of "Numerical Prediction"

In this case, boundary conditions mean many kinds of seasonal variable natural factors except atmosphere such as **sea surface temperatures (SSTs), sea ices and snow covers**. In general, **variations of boundary conditions are slower** than a variation of atmosphere.



A numerical model is made from many kinds of **physical laws** and **a large number of grids**.

If you input an initial atmospheric condition and boundary conditions into a numerical model, you can get to know a future atmospheric condition as an output.

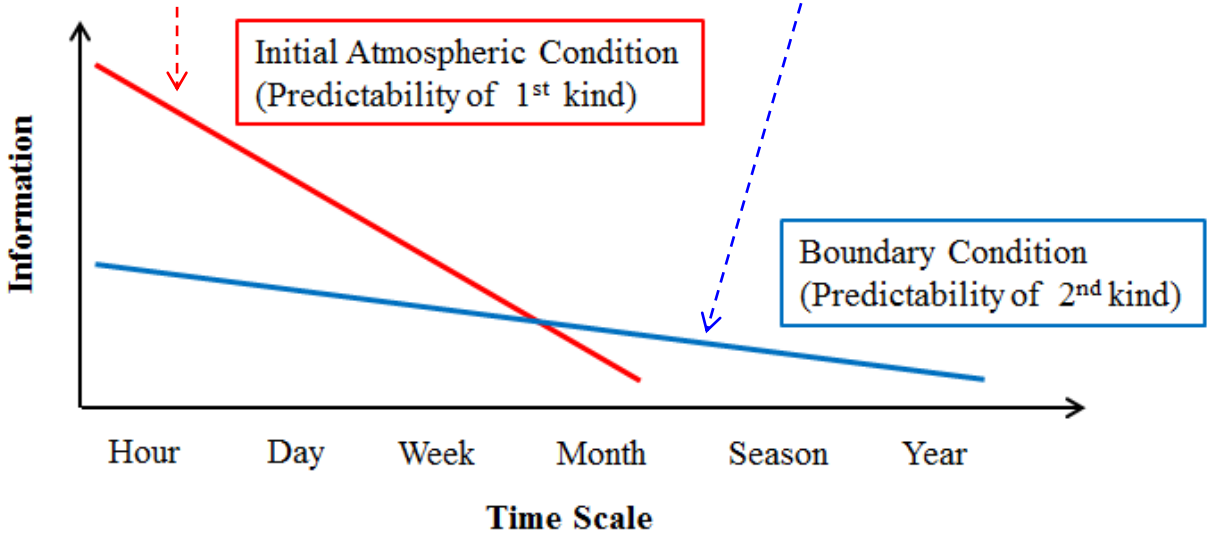
Predictability

■ A Simplified Conceptual Chart of “Predictability”

There are mainly 2 types of predictabilities.

■ **“Predictability of 1st kind”**
depends on an **initial atmospheric condition**. Because a variation of atmosphere is fast, information which an initial atmospheric condition has are lost rapidly.

■ **“Predictability of 2nd kind”**
depends on **boundary conditions** such as **sea surface temperatures (SSTs), sea ices and snow covers**. Because variations of boundary conditions are slow, they make a long-range forecast possible.

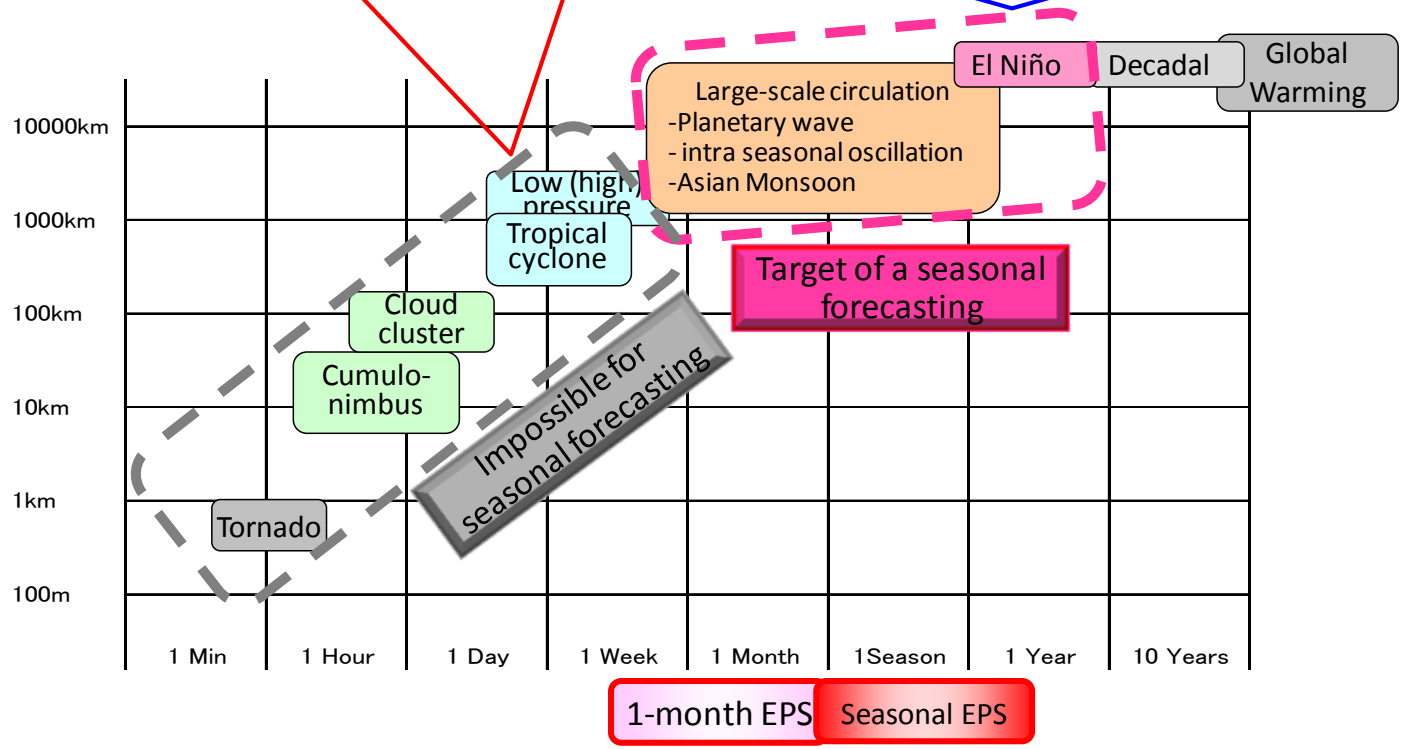


Predictability

■ Temporal and Spatial Scale of Atmospheric Phenomena

■ Short-life and Small-scale Phenomena
(e.g. Tornadoes, Cyclones)
Long-range forecast is impossible,
because they are sensitive to an initial atmospheric condition.

■ Long-life and Large-scale Phenomena
(e.g. Seasonal Oscillations, Monsoons)
Long-range forecast is possible,
because they are sensitive to boundary conditions rather than an initial atmospheric condition.



Predictability

■ Potential Predictability derived by SSTs

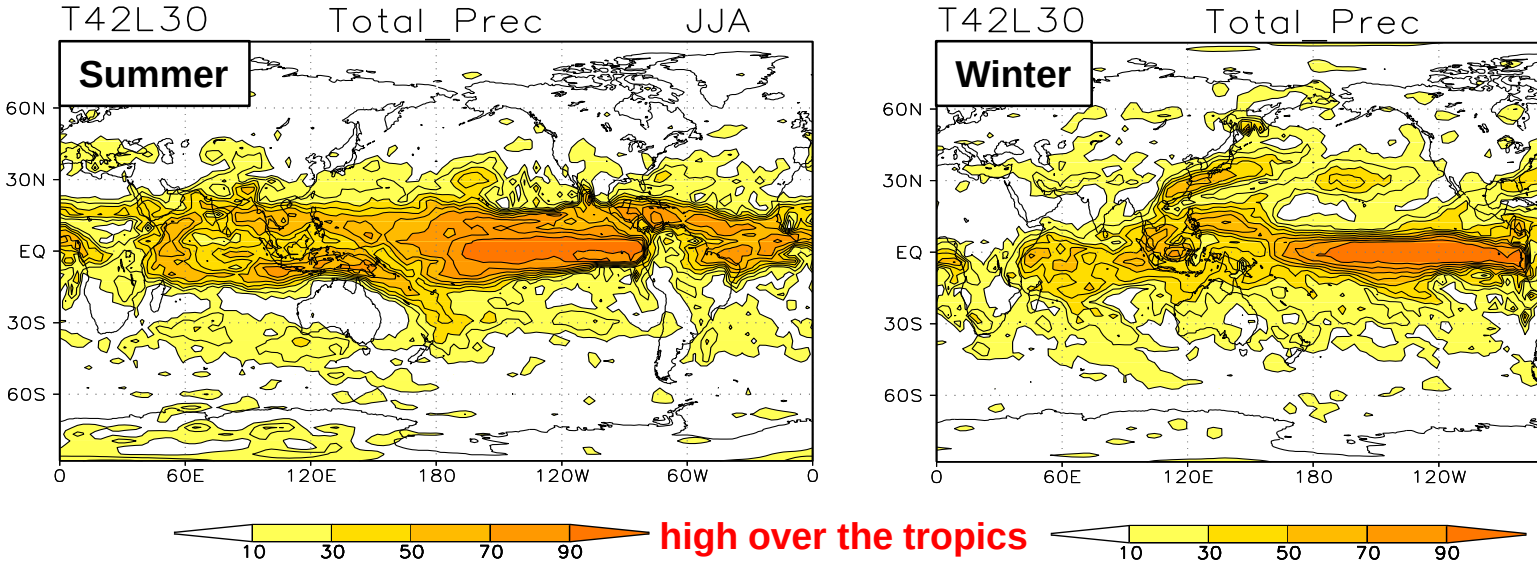
An experiment of giving same SSTs to all ensemble members (9 members, 1979-1993)

Signal: Anomaly of Ensemble Mean

Noise: Ensemble Spread

$$Potential\ Predictability = \frac{Signal}{Signal + Noise} \times 100\ (\%)$$

Potential Predictability for Seasonal Precipitation derived by SSTs



high over the tropics

Sugi, M., R. Kawamura and N. Sato, 1997, J.Meteor.Soc.Japan, 75, 717-736.

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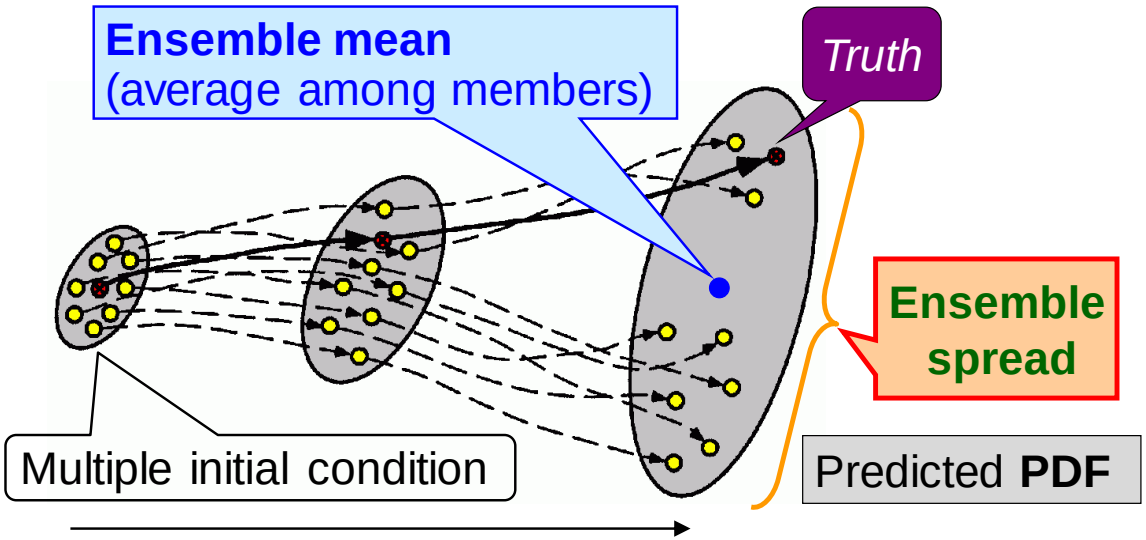
Uncertainty and Ensemble Prediction

■ A Simplified Conceptual Chart of Ensemble Prediction

Because atmosphere has chaotic nature, a small error in an initial condition grows rapidly. However, it is **impossible to know a perfect initial condition** even with the use of high accurate observations. Therefore, it is **essential to consider uncertainty** when forecasting. **Ensemble prediction makes it possible to estimate uncertainty** caused by initial condition errors with similar calculations from a little bit different multiple initial conditions.



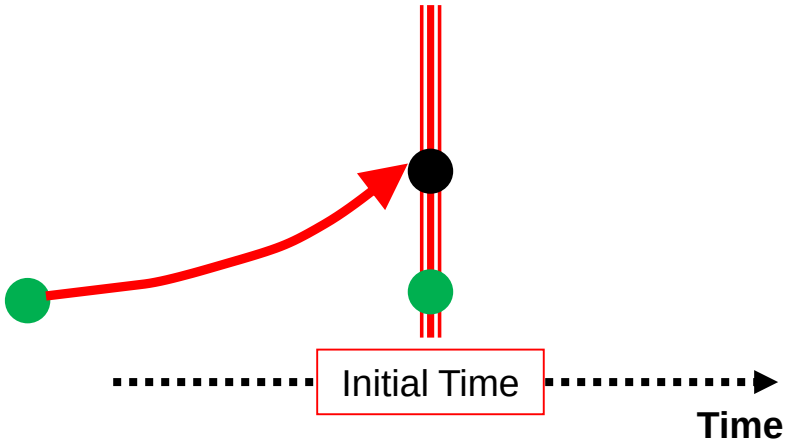
The individual calculation is called "**Ensemble member**" and the standard deviation among all members is called "**Ensemble spread**".

Initial Perturbation

In order to efficiently represent the initial observational error with initial perturbations (multiple initial conditions), the following methods are used.

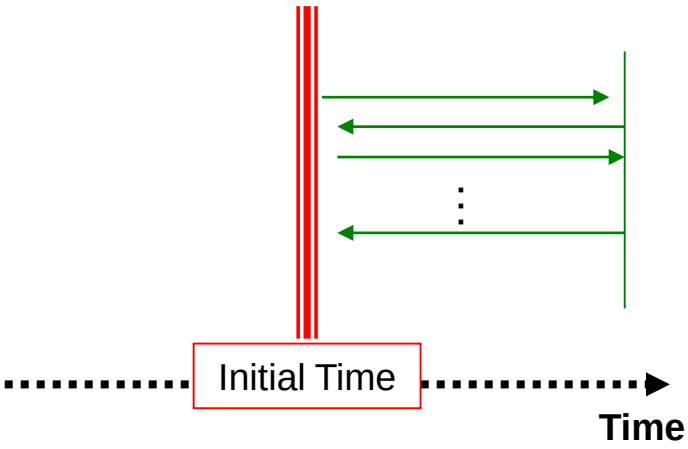
■Breeding of Growing Mode（BGM）

The BGM method **finds out the perturbation grew before the initial time** with a forecast and assimilation cycle.
This method is simple but **necessary to keep a forecast and assimilation cycle** even for the time except the initial time.



■Singular vector (SV)

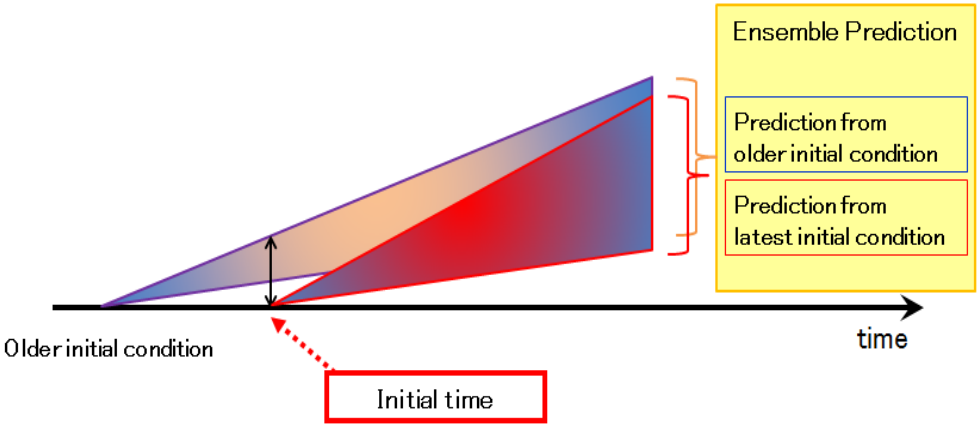
The SV method **finds out the fastest growing perturbation after the initial time** with the use of a tangent linear model which is obtained by locally linearizing the original nonlinear NWP model and its adjoint model.
This method can find better perturbations, but **requires heavier resources for calculation and development.**



Ensemble Techniques

■LAF

Lagged Average Forecasting (LAF) is one of the ensemble prediction techniques.
Ensemble prediction is **calculated with the combination of predictions from not only latest initial condition but also older initial conditions**.
LAF is easy method for ensemble prediction and make it possible to share computer resources among several days.
However, the accuracy of prediction from older initial conditions is generally worse than that from latest initial conditions.



■Stochastic Physics Scheme

Uncertainty is caused by imperfection of not only initial conditions but also numerical prediction models. In order to consider uncertainty caused by imperfection of numerical prediction models, **multi-model ensemble (MME) system and stochastic physics scheme are often used**.
MME is an EPS using some different numerical ensemble prediction models.
Stochastic physics scheme is a calculation method which controls some physical calculations with random numbers.

$$\frac{\partial x}{\partial t} = \text{Time variation by dynamical process} + \text{Time variation by parameterization}$$

Random number

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Hindcast

◆ **Hindcast** (= behind + forecast) ; coined term

Systematic forecast experiments for past cases performed with the use of the operational EPS.

- **Purpose of the hindcast**
  - to **understand prediction skill**
  - to **calculate the model statistics (bias, model climate)** for creating various products (e.g., forecast maps, numerical guidance)
- **Hindcast period** is required to be **more than 20 years**.
- **Difficulty**
  - In order to calculate a large number of past events, huge computer resources are required.

    (Because of limited computer resources, ensemble size and calculation frequency are less than those for operational forecasts in JMA.)

Definition of Bias and Anomaly

Bias

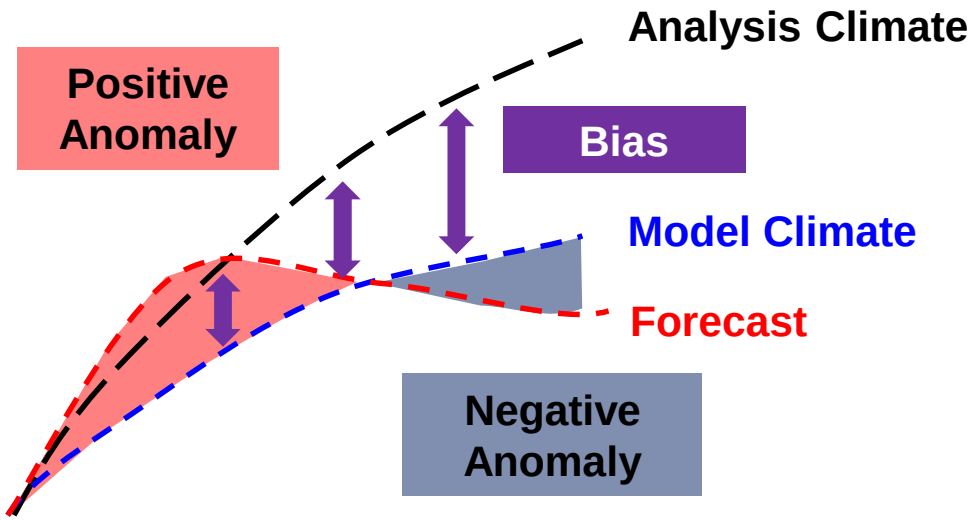
- Bias is systematic errors of the model, calculated as **the difference between model climate and analysis climate**.

Anomaly

- Anomaly is calculated as **the difference between model climate and forecast** to reduce the influence from bias.

Difficulty

- It is **impossible to adjust the systematic positon errors** of jet stream etc.
  Therefore, it is **essential to reduce model prediction bias**.



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WMO Forecast Classification

In line with “WMO’s Manual on the Global Data-Processing and Forecasting System”, forecasts are classified by their ranges. **Seasonal forecasting, which is the main topic of TCC seminar, corresponds to extended- and long- range forecasting.** Especially, this TCC seminar focuses on extended-range forecasting.

	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

https://www.wmo.int/pages/prog/www/DPS/Publications/WMO_485_Vol_I.pdf

JMA's Operational Global NWP Models

as of Nov.2018

	Main target	Horizontal resolution
Global Spectral Model (GSM)	•Short-range forecast	20km (TL959)
Global EPS	•Typhoon forecast	40km (TL479)
	•One-week forecast	
	•Early warnings for extreme events (Two-week forecast)	
	•One-month forecast	55km (TL319)
Seasonal EPS	•3month forecast •Warm/Cold season forecast •El Niño outlook	110km (TL159)

AGCM

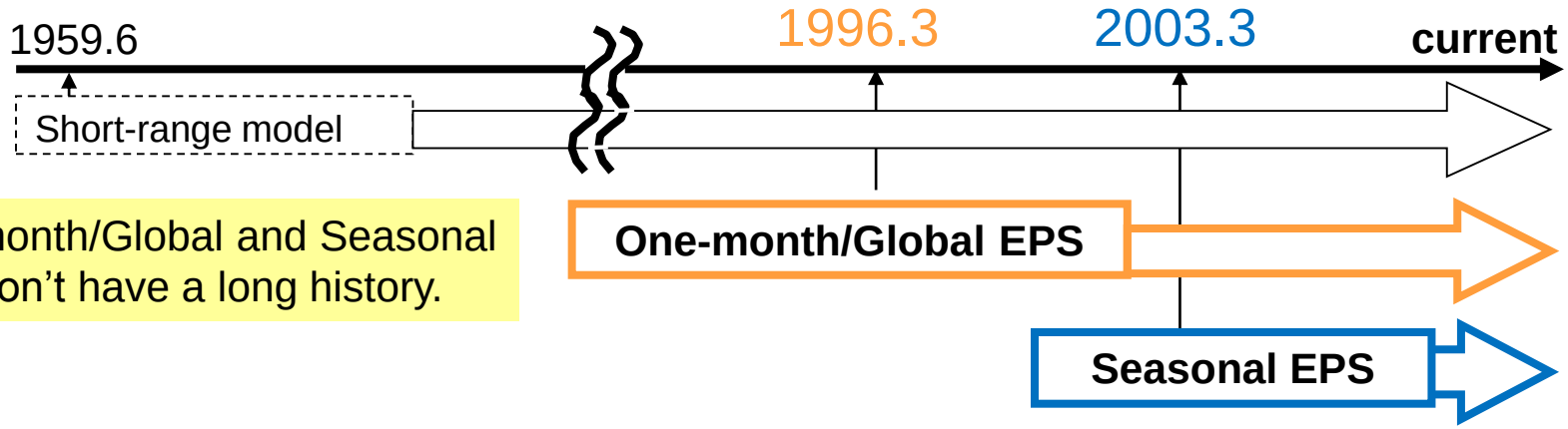
CGCM

Numerical Prediction Division/JMA

TCC

Climate Prediction Division/JMA

History of EPSs



One-month/Global and Seasonal EPS don't have a long history.

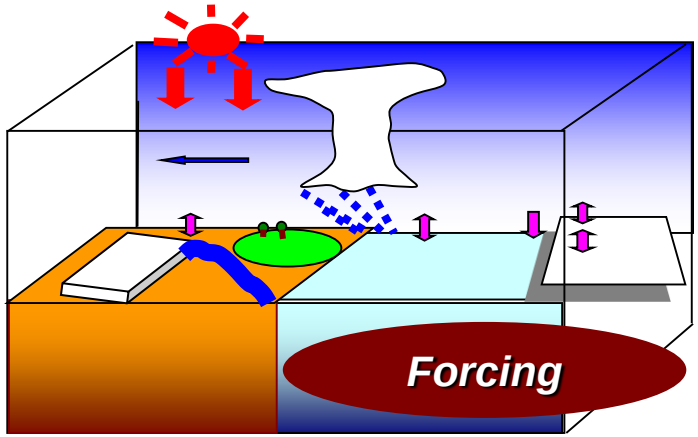
	Mar 1996	Mar 2001	Mar 2003	Mar 2006	Sep 2007	Mar 2008	Feb 2010	Mar 2014	Jun 2015	Mar 2017
One-month/ Global EPS	T63 L30 M10	T106 L40 M26		TL159 L40 M50		TL159 L60 M50		TL319 L60 M50		TL479/319 L100 M50
Seasonal EPS			T63 L40 M31	TL95 L40 M31	TL95 L40 M51		TL95 L40 M51		TL159 L60 M51	

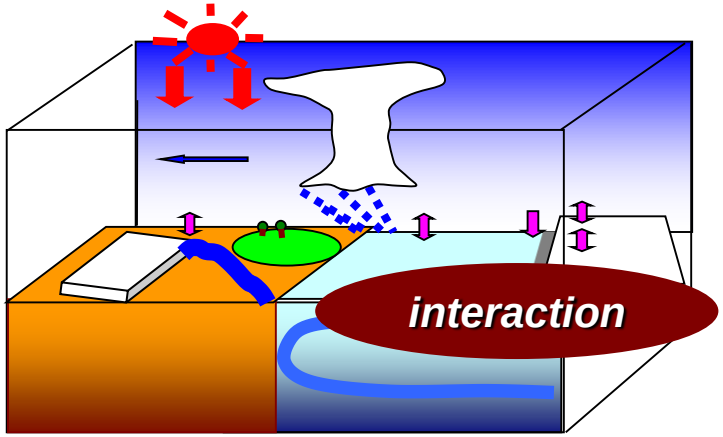
Red: AGCM **Blue: CGCM**

Difference between AGCM and CGCM

AGCM
Atmospheric **G**eneral **C**irculation **M**odel

CGCM
Coupled Ocean-Atmospheric
General **C**irculation **M**odel





Oceanic conditions are given as a forcing. Prescribed anomalies are used for SST forcing.

Two-tiered method

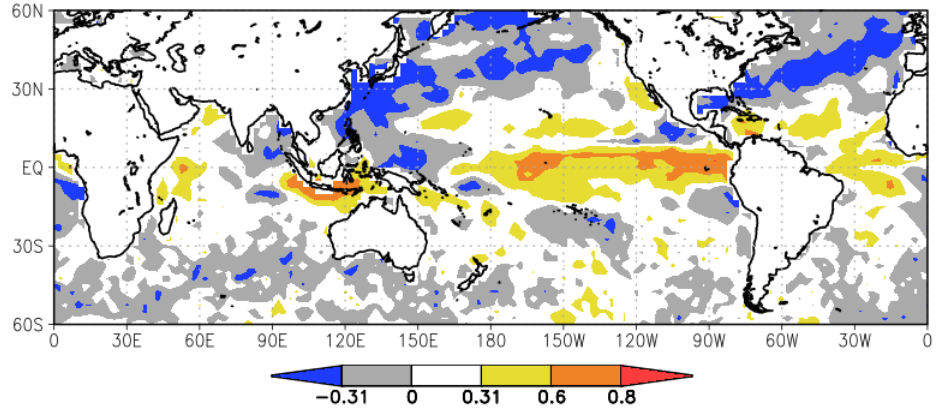
Ocean-atmosphere interaction is considered.

One-tiered method

Difference between AGCM and CGCM

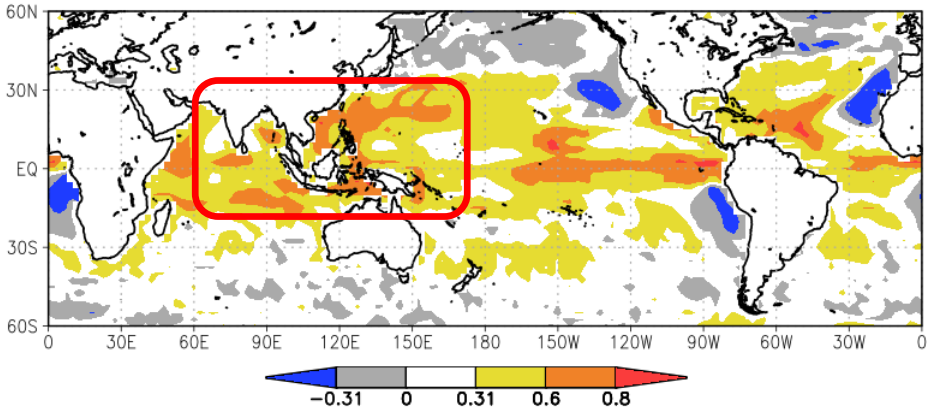
Correlation coefficient between SST and precipitation in July (Initial date: 30 June, 1979-2010)

Analysis

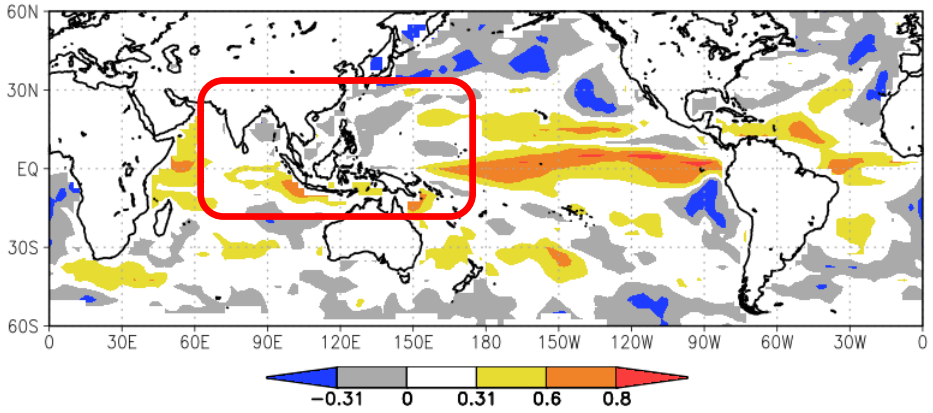


CGCM improves an excess positive correlation between SST and precipitation in tropics, especially over Asian monsoon. CGCM leads to improve prediction skills especially over the tropics, which are affected by tropical oceanic variations.

AGCM

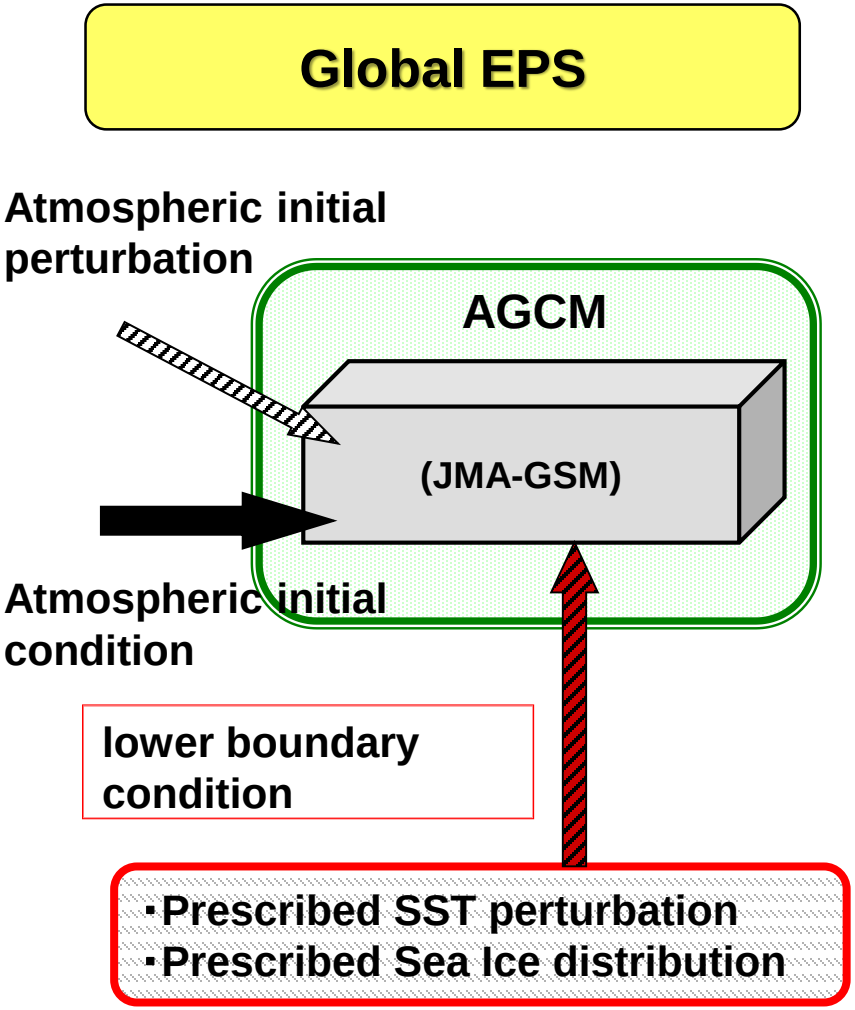


CGCM



Specification of Global EPS

as of Nov.2018



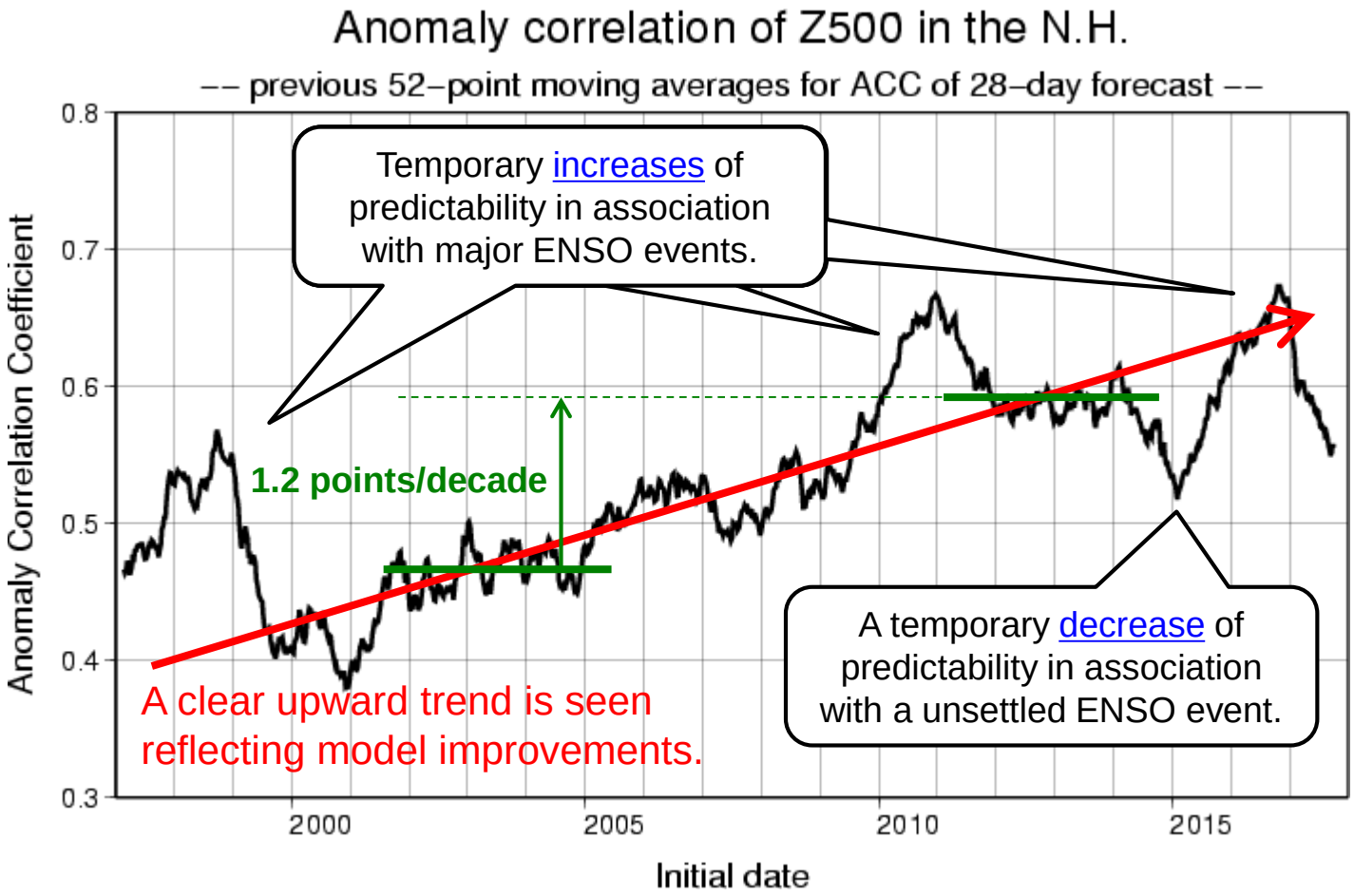
Upgrade	Last: March 2017 Frequently: Every few years
Model	AGCM
Horizontal Resolution	40km (TL479) up to 18 days 55km (TL319) after 18 days
Vertical Resolution	100 levels up to 0.01hPa
Forecast range	Up to 34 days
SST	Prescribed SST perturbation
Sea ice	Prescribed Sea Ice distribution (Sugimoto and Takaya, 2014)
Ensemble method	SV, LAF, LETKF (based on Hunt et al., 2007) Stochastic physics scheme
Ensemble size	50 (13-11 SVs x 4 initial LAFs at 12hour interval)
Freq. of operation	Every Tuesday and Wednesday
Freq. of model product creation	Once a week (Thursday)

Specification of Global EPS Hindcast

	Hindcast	Operational system
Initial Condition	JRA-55 Reanalysis	Global Analysis (Newer System than JRA-55)
Ensemble Size	5 (5 SVs, no using LAF)	50 (13-11 SVs x 4 initial LAFs with 12hour interval)
Forecast range	Initial date +40days	2,3,4,…,31,32days from the latest initial date (Wednesday)
Initial date	3 times per month (10th, 20th, end of month)	4 times per week (00 & 12 UTC on Tuesday and Wednesday)
Target period for hindcast	Available: 1981.1 - 2017.3 Verification: 1981.1 - 2010.12	---

Because of the limited computer resources, ensemble size and frequency of calculation for hindcasts are less than those for operational forecasts.
For the initial date on which no hindcast was performed, virtual hindcast data is created with a linear interpolation method using before and after initial dates on which hindcasts were performed.

Scores of Operational One-month Prediction

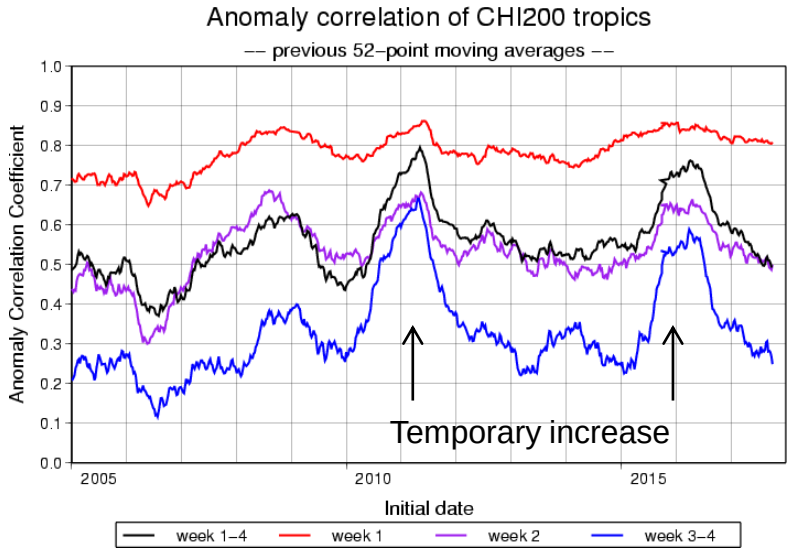


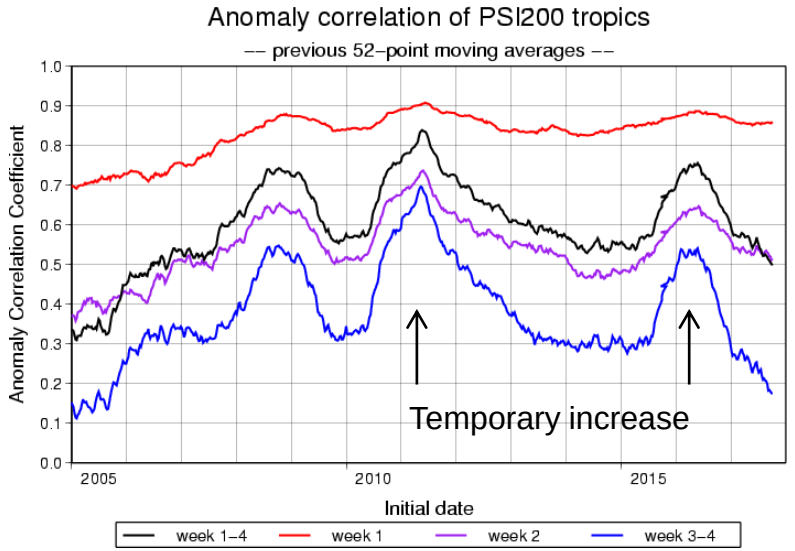
0.6 is the limit for deterministic forecast.

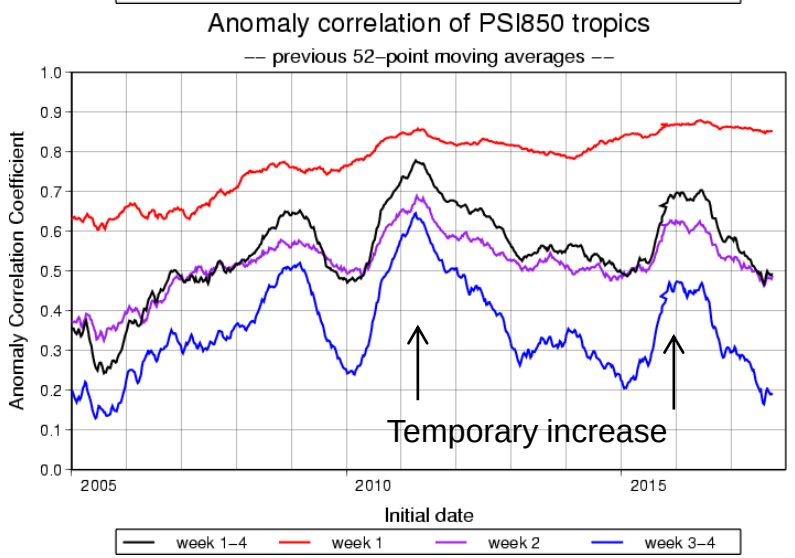
0.3 is the limit for probabilistic forecast.

http://ds.data.jma.go.jp/tcc/tcc/products/model/verif/1mE/Map_discussion/ACOR/vrfmap_acc_z500_nh_52wmean.e.html

Scores of Operational One-month Prediction





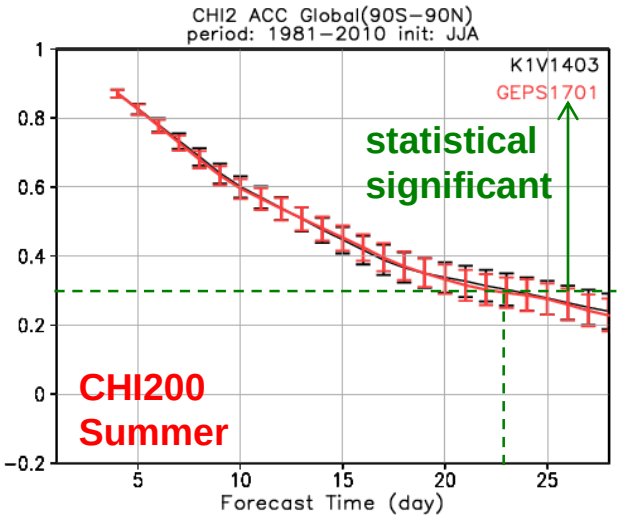


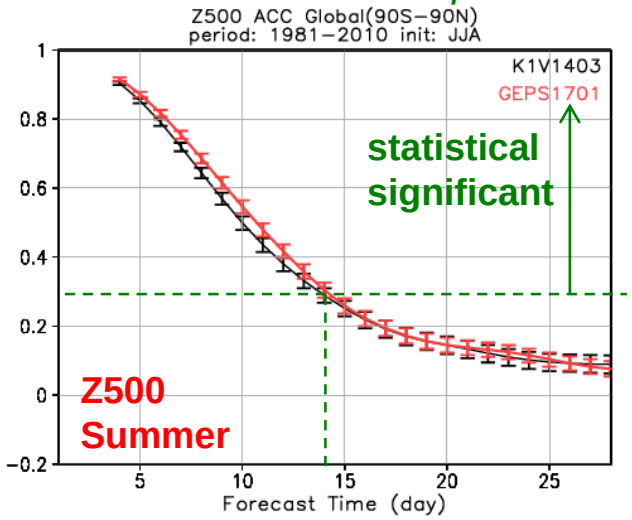
Scores for Tropics.
Clear upward trends are seen but scores longer than fortnight forecast are largely influenced by variations of predictabilities in association with ENSO events.

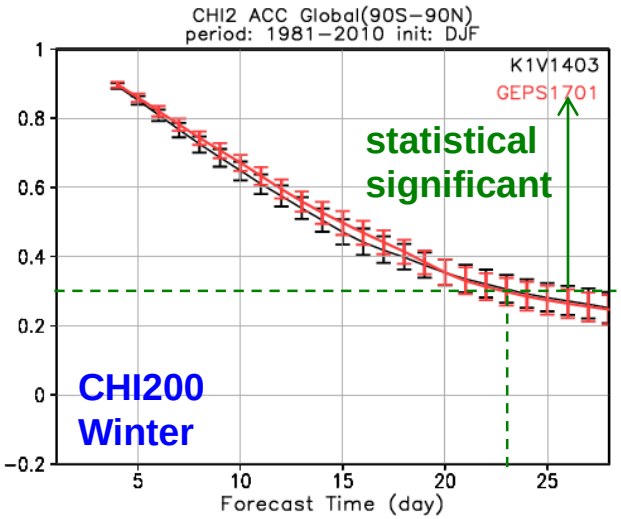
http://ds.data.jma.go.jp/tcc/tcc/products/model/verif/1mE/Map_discussion/ACOR/vrfmap_acc_tr_52wmean.e.html

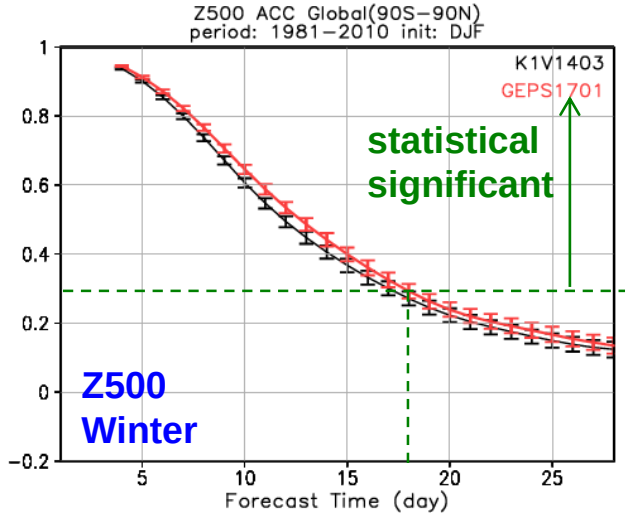
Prediction Skill of One-month EPS

Hindcast experiments for 30 years (1981 – 2010)









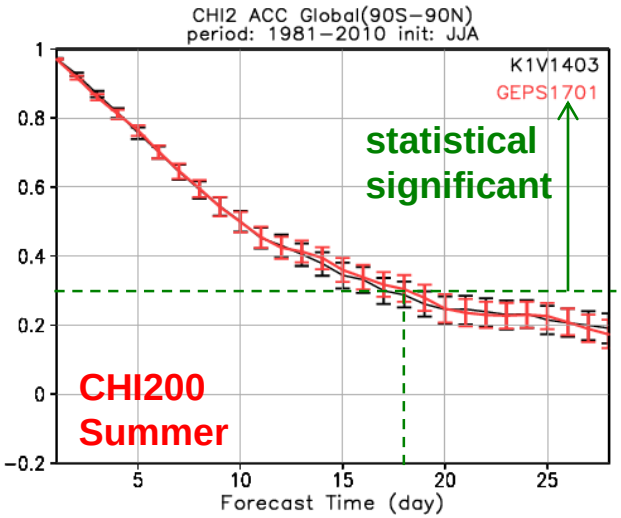
How many days are predictable for weekly mean forecast by 5-member ensemble?

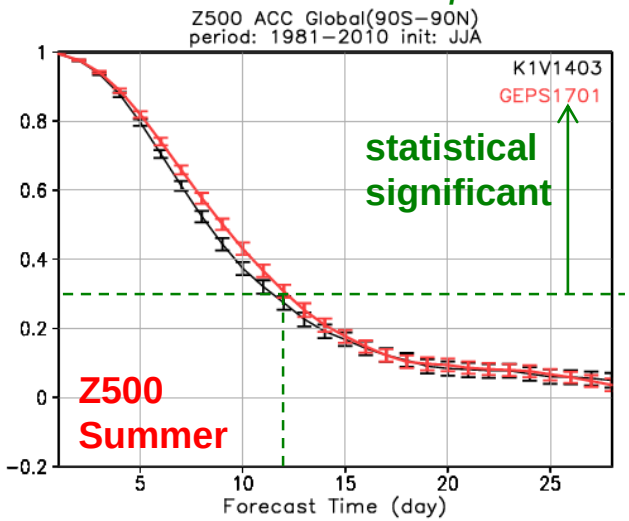
- **CHI200** in the tropics is averagely predictable **up to 21-25days** with small seasonal dependency.
- **Z500** in the Northern Hemisphere is averagely predictable **up to 14-18 days** with large seasonal dependency.

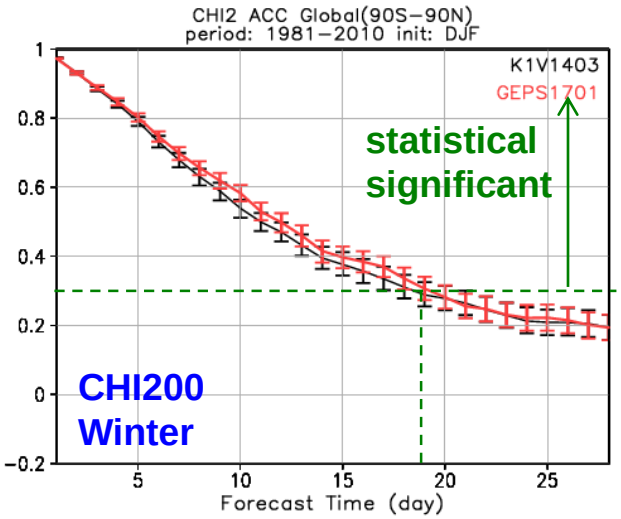
The larger ensemble size is, the higher scores is.

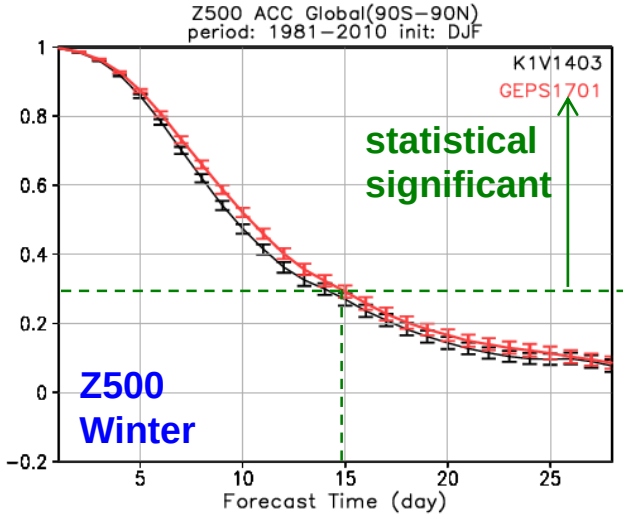
Prediction Skill of One-month EPS

Hindcast experiments for 30 years (1981 – 2010)









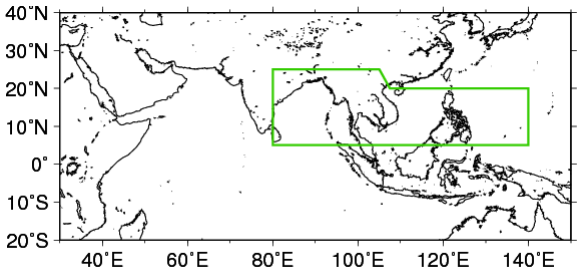
How many days are predictable for daily forecast by 5-member ensemble?

- **CHI200** in the tropics is averagely predictable up to 16-20days with small seasonal dependency.
- **Z500** in the Northern Hemisphere is averagely predictable up to 12-15 days with large seasonal dependency.

Predictable days for daily forecasts are a few days less than that for weekly mean forecasts.

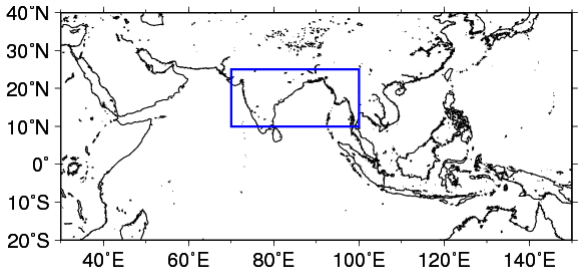
Prediction Skill of One-month EPS for Monsoon Rainfall

Hindcast experiments for 30 years (1981 – 2010)



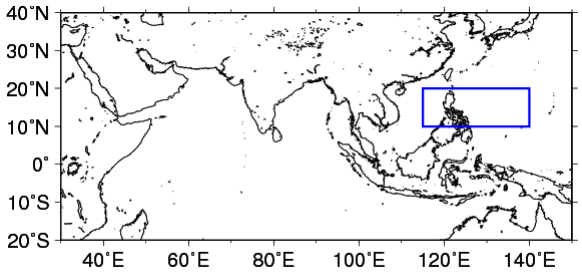
Initial month	Daily Rainfall Correlation (28day mean)
May	0.46
June	0.09
July	0.38
August	0.30

Skill for onset season is good but those for offset season and for mature season are not good.



Initial month	Daily Rainfall Correlation (28day mean)
May	0.48
June	0.05
July	0.31
August	0.14

Skill for onset season is good but those for offset season and for mature season are not good.



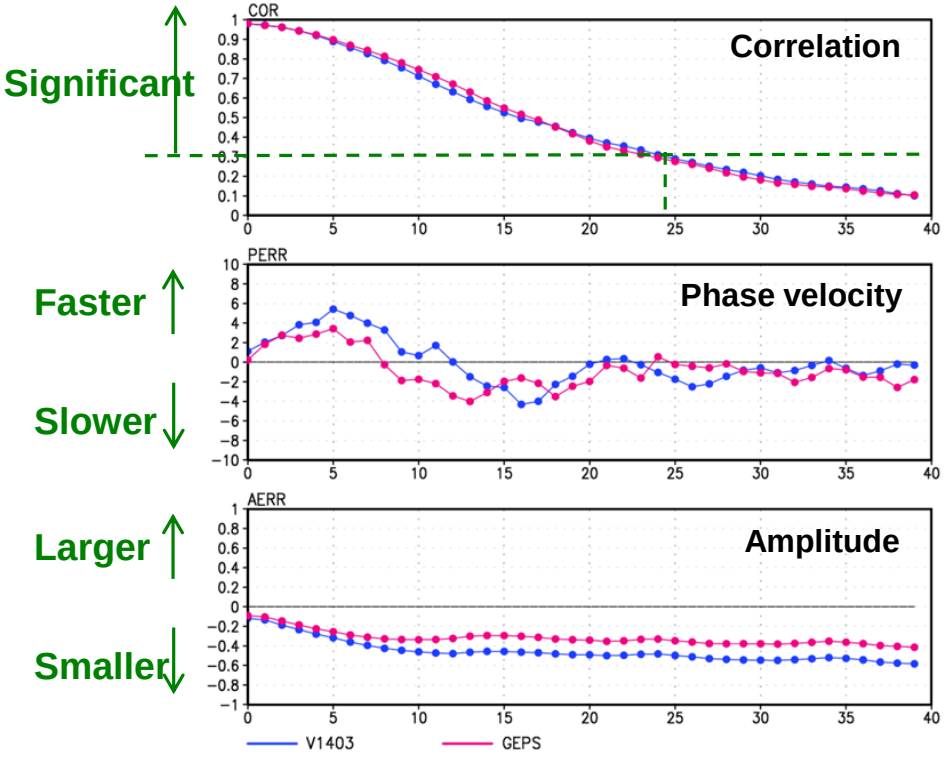
Initial month	Daily Rainfall Correlation (28day mean)
May	0.33
June	0.49
July	0.28
August	0.48

Skills are largely good through the whole season.

In case of weekly or monthly average rainfall, correlations are higher than daily rainfall.
Seasonal oscillations such as MJO and BSISO make a monsoon rainfall forecast difficult.

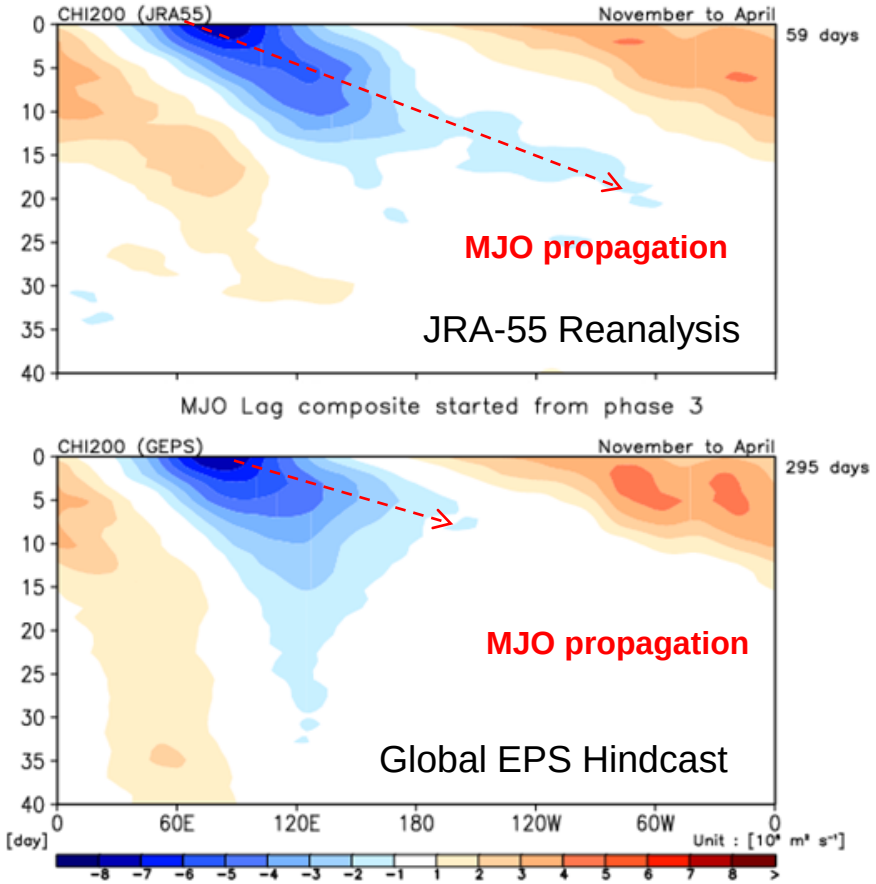
Verification of Global EPS for MJO

Hindcast experiments for 30 years (1981 – 2010)



Red: Global EPS, Blue: Previous EPS

MJO is **predictable up to 25 days**. However, **faster phase velocity bias up to 8days, slower phase velocity bias after 8days** and **smaller amplitude bias** can be seen.



CHI200 Hovemoller diagram from MJO phase 3

Forecast skill beyond 2 weeks: Sub-seasonal to Seasonal (S2S) time-scale

METEOROLOGICAL APPLICATIONS
Meteorol. Appl. **24**: 315–325 (2017)
Published online 6 April 2017 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/met.1654

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Royal Meteorological Society

Review

Potential applications of subseasonal-to-seasonal (S2S) predictions

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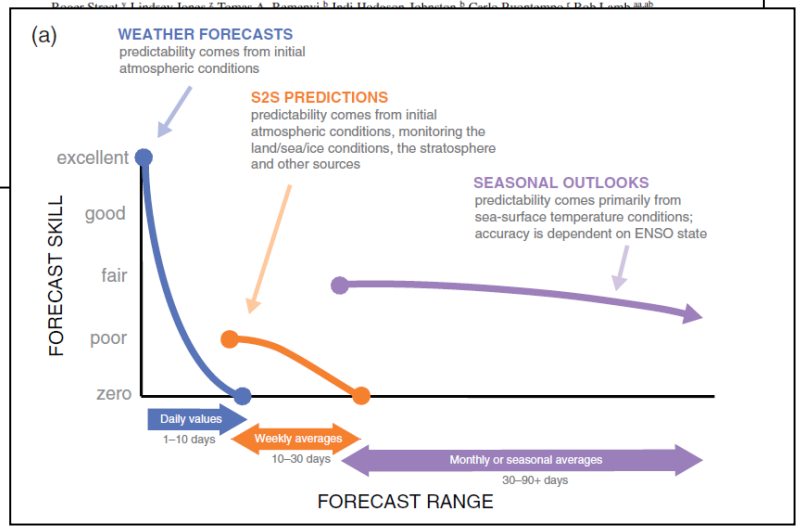

White et al. (2017)

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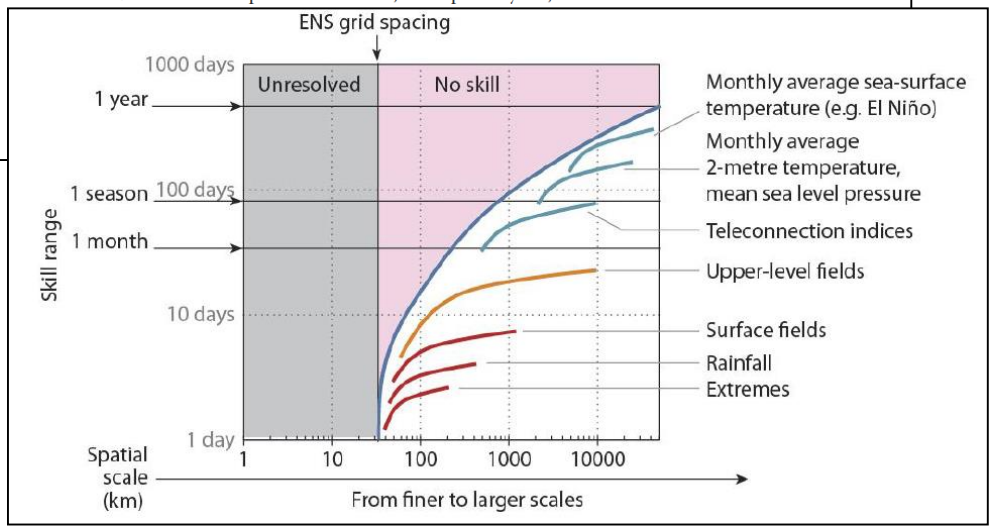
The forecast skill horizon

Roberto Buizza* and Martin Leutbecher
European Centre for Medium-Range Weather Forecasts, Reading,UK
*Correspondence to: R. Buizza, ECMWF, Shinfield Park, Reading, RG2 9AX, UK. E-mail: buizza@ecmwf.int

Numerical weather prediction has seen, in the past 25 years, a shift from a 'deterministic'



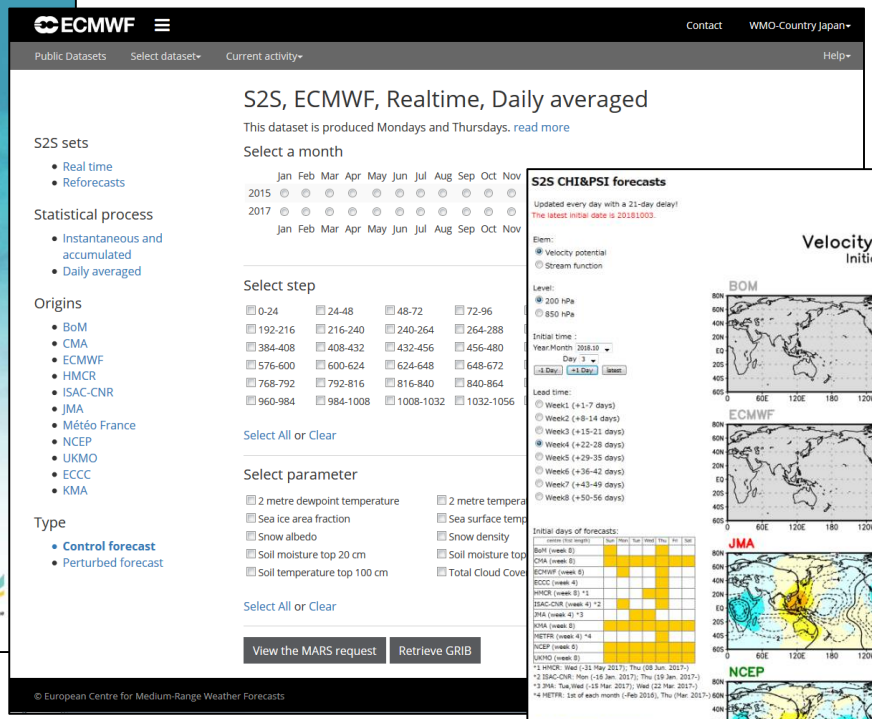
https://www.ecmwf.int/sites/default/files/elibrary/2017/17631-forecast-skill-horizon.pdf

- "Errors propagate from poorly initialized smaller/faster scales."
- "Predictive signals propagate from better initialized larger/slowly-evolving scales."

The Sub-seasonal to Seasonal (S2S) Prediction Project

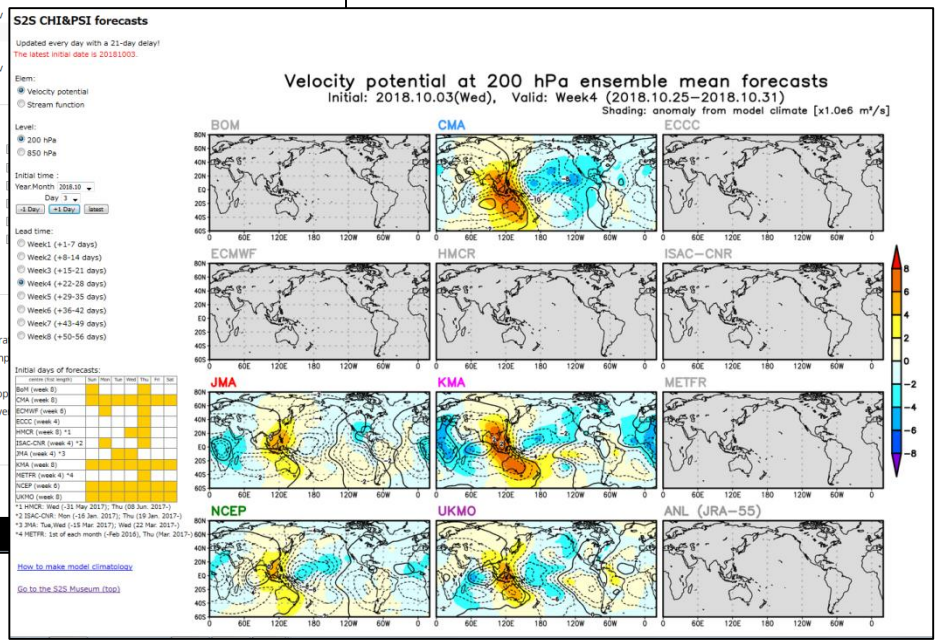
http://www.s2sprediction.net/file/documents_reports/WWRP_2018_4_S2S_Phase_II_Proposal.pdf

ECMWF Data Server



http://apps.ecmwf.int/datasets/data/s2s/levtype=sfc/type=cf/

S2S Museum



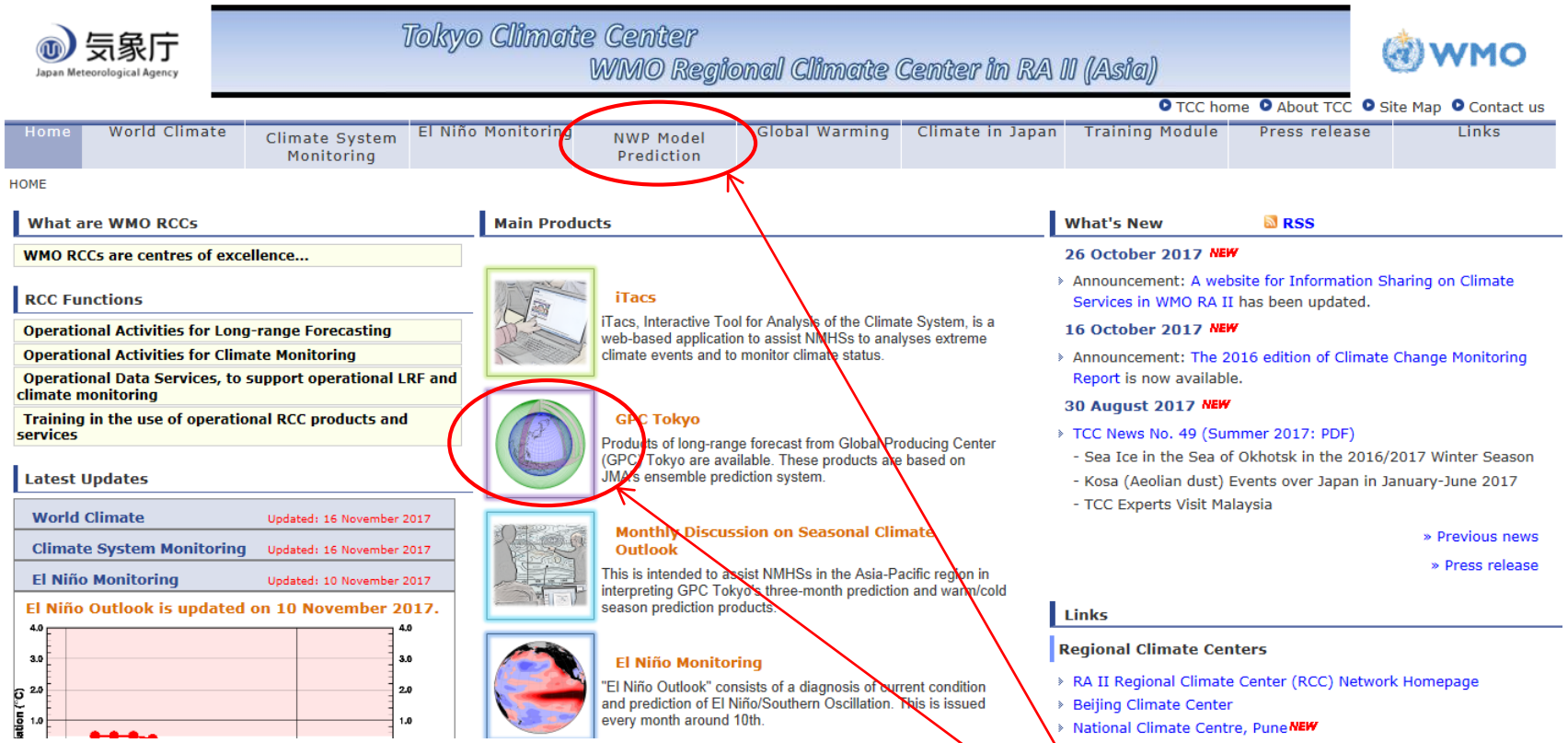
http://gpvjma.ccs.hpcc.jp/S2S/S2S_CHIPSI.html

- S2S Phase 1 started in Nov. 2013 as 5-year project. The Phase 2 has just started from Nov 2018 (to Dec 2023).
- The data provided from 11 operational centers is freely available with 3-week delay for research and education purposes.

Contents

- Basic Knowledge
  - NWP Model and Predictability
  - Ensemble Prediction and Uncertainty
  - Hindcast
- JMA's Global Ensemble Prediction System
- TCC's Products to support 1-month Forecast

TCC's NWP Model Products



Click "NWP Model Prediction" Tab or "GPC Tokyo" Icon on the top page of TCC website.

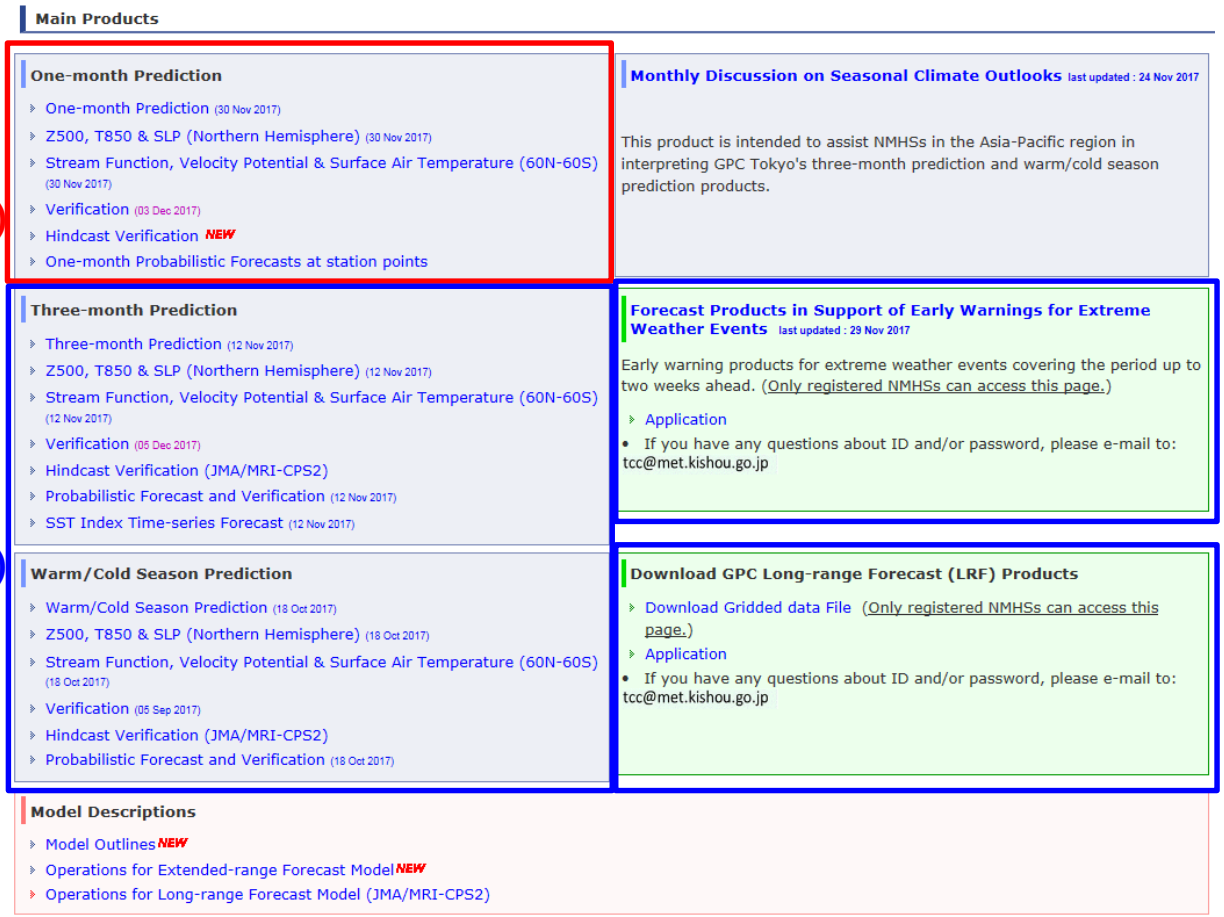
TCC website
http://ds.data.jma.go.jp/tcc/tcc/

TCC's NWP Model Products

NWP products are available smoothly through the NWP Model Products page.

One-month Prediction (Free accessible)

Seasonal Prediction (Free accessible)



Extreme Weather Prediction (Authentication is required)

Gridded data (Authentication is required)

NWP Charts for One-month Prediction

Some NWP charts for tropics are available on the One-month prediction menus.

Select forecast period, initial date and area type on these menu.

One-month Prediction (Tropics and Asia)

This product is displayed for use by National Meteorological and Hydrological Services (NMHSs). It does not constitute an official forecast for any nation.

Forecast Maps

forecast period: the first week

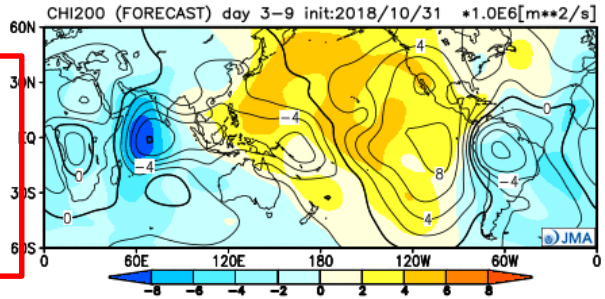
initial date: 2018.10.31.12 Z

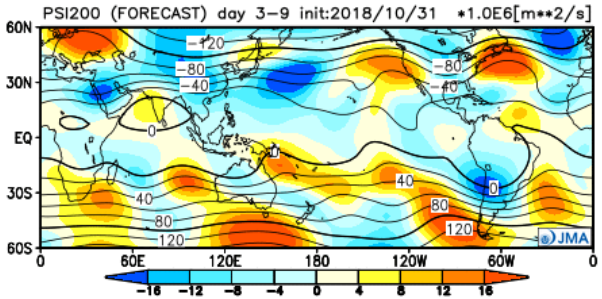
area: 60N-60S / Asia

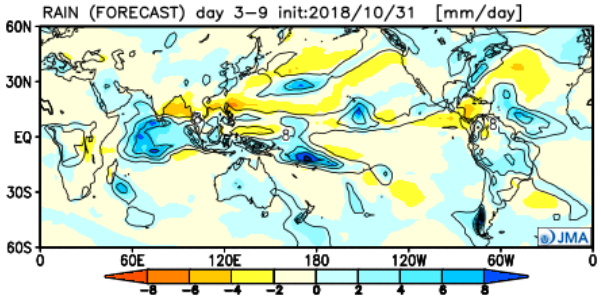
corresponding verification

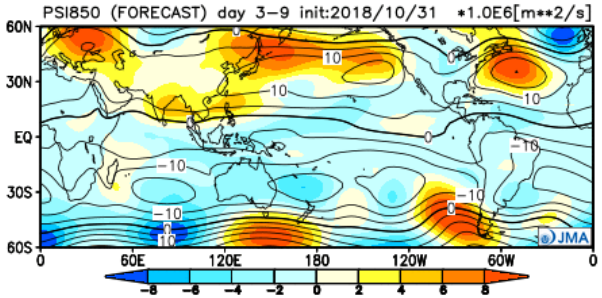
[Contour interval]
CHI200 : 2x1.0E6m^2/s
RAIN : 4mm/day
Z500 : 120m
TS : 4C
PSI200 : 20x1.0E6m^2/s
PSI850 : 5x1.0E6m^2/s
PSEA : 4hPa

(Shaded patterns show anomalies.)





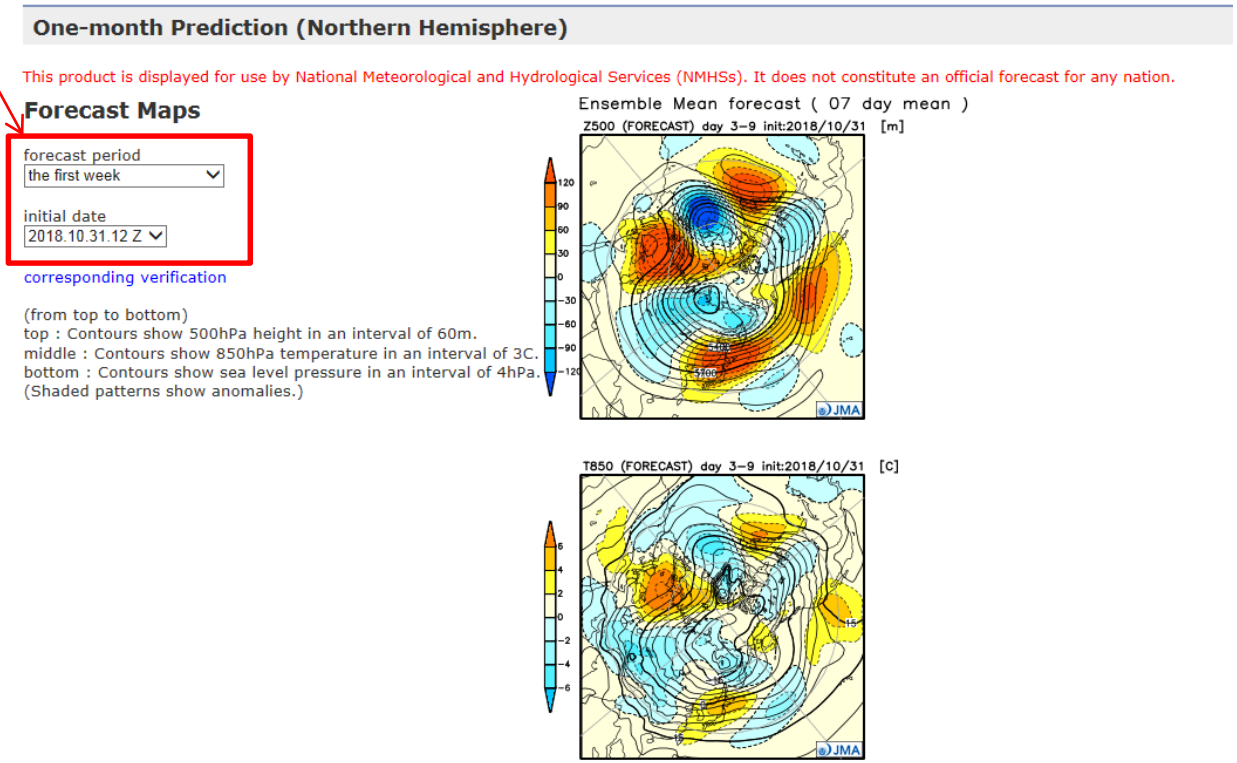




NWP Charts for One-month Prediction

Some NWP charts for the Northern Hemisphere are available on the One-month prediction menus.

Select forecast period and initial date on these menu.



TCC's NWP Model Products

NWP products are available smoothly through the NWP Model Products page.

One-month Prediction (Free accessible)

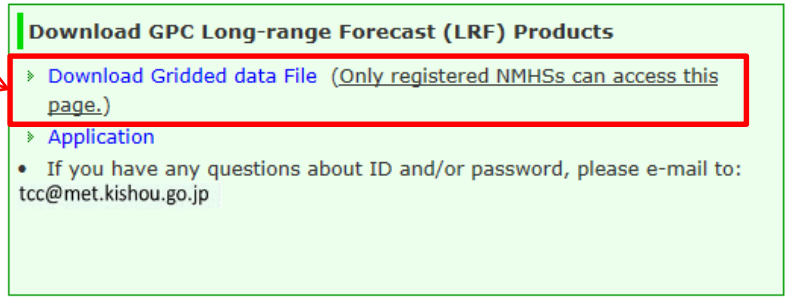
Seasonal Prediction (Free accessible)

Extreme Weather Prediction (Authentication is required)

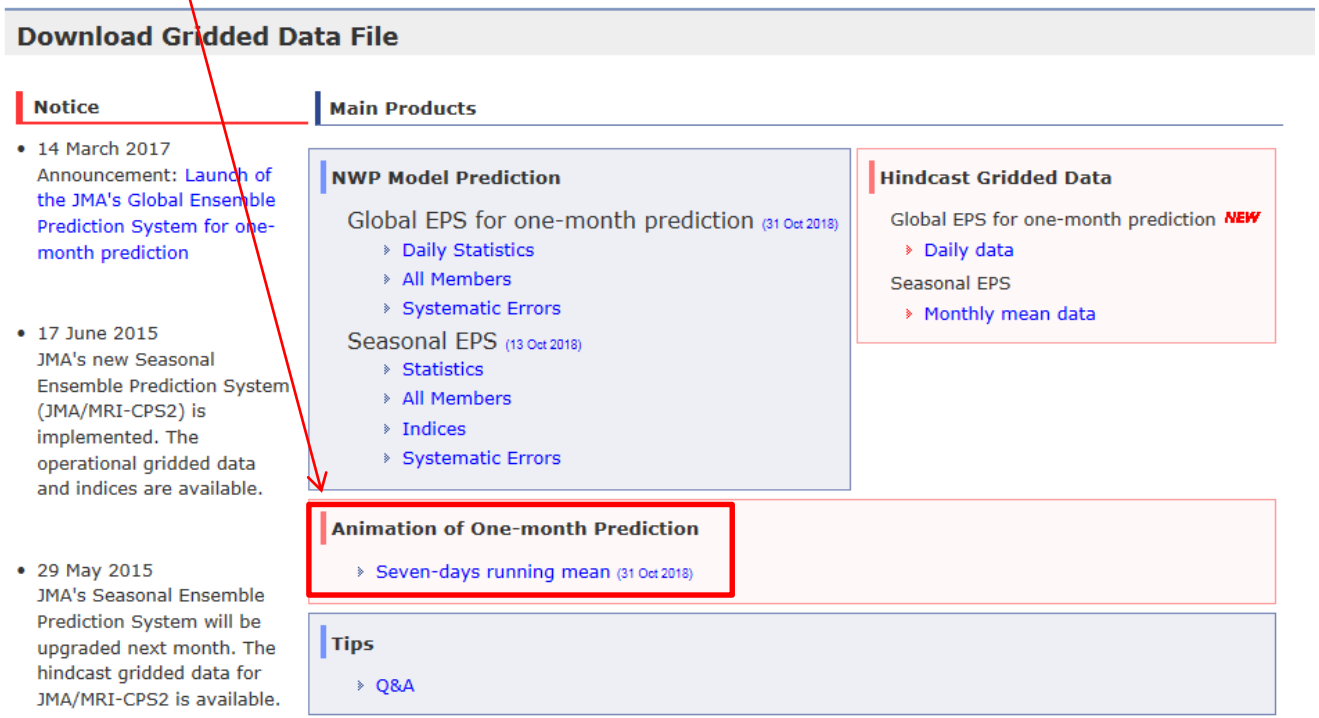
Gridded data (Authentication is required)

GPC Long-range Forecast (LRF) Products

Select “Download Gridded data File” on GPC LRF Products menu.



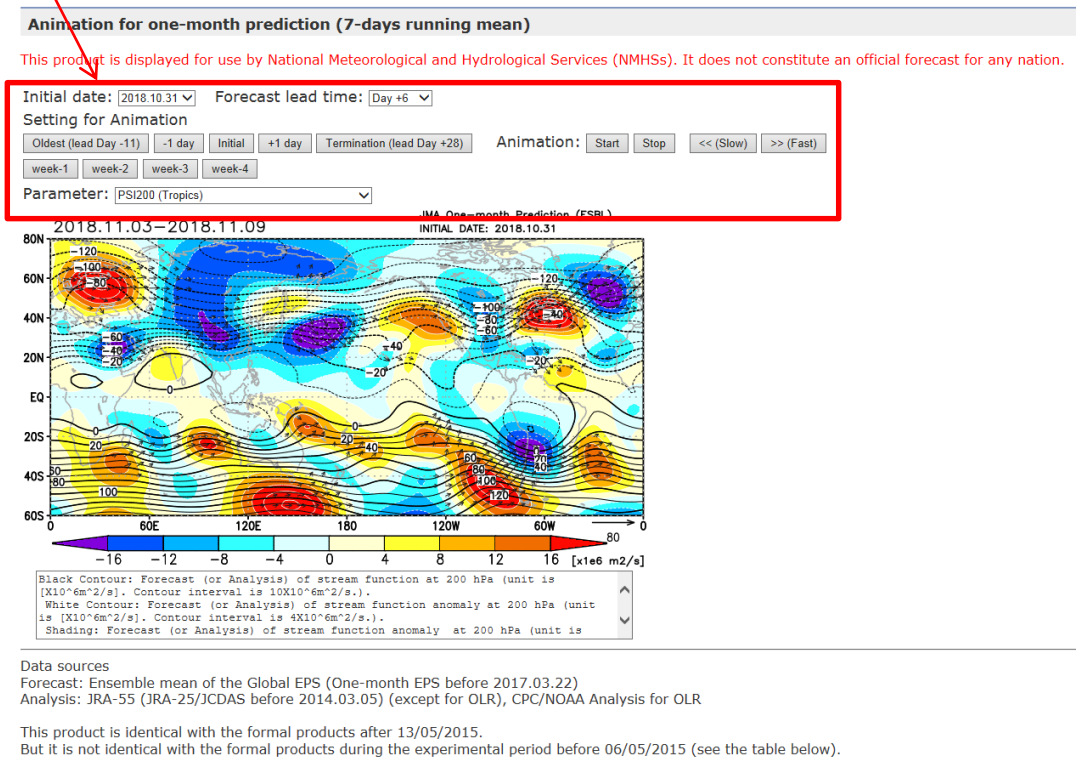
Some additional charts of One-month Prediction are available here.



Additional Charts of One-month Prediction

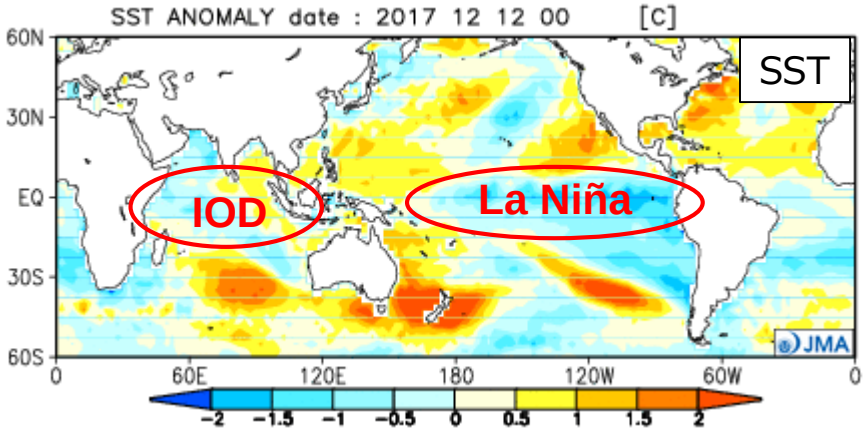
Click “Seven-days running mean”.

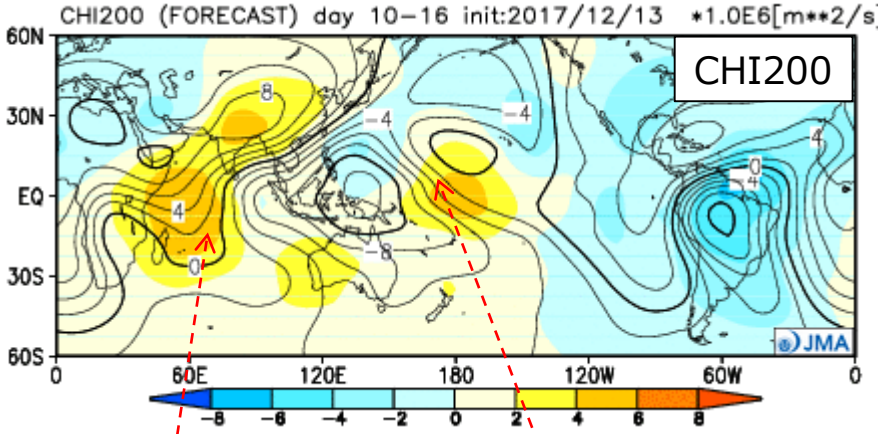
Select initial date, forecast lead time and parameter on these menu.

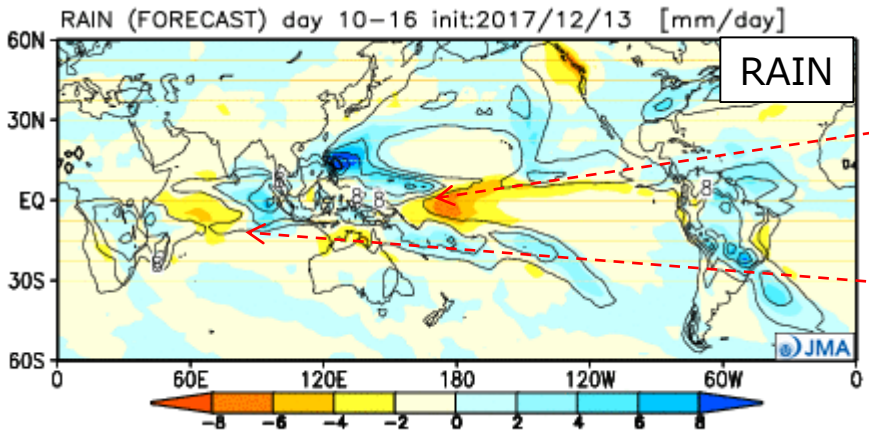


How to use NWP charts

【Step 1】Let's check predicted SST conditions and tropical convection fields.







In this case, a response associated with La Niña like SST conditions is clear.

In this case, a response associated with positive IOD like SST conditions can be seen.

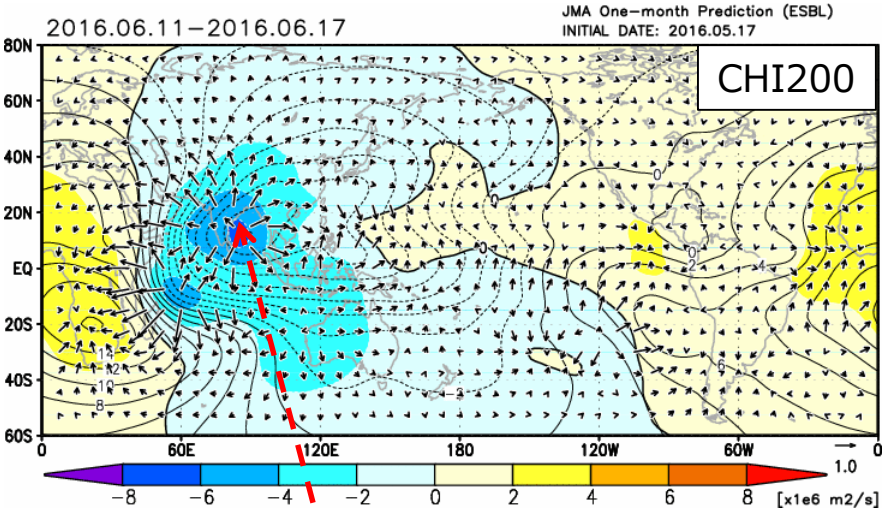
Contours indicate predicted values. Shading indicates anomaly.

CHI200 (Velocity potential at 200hPa)

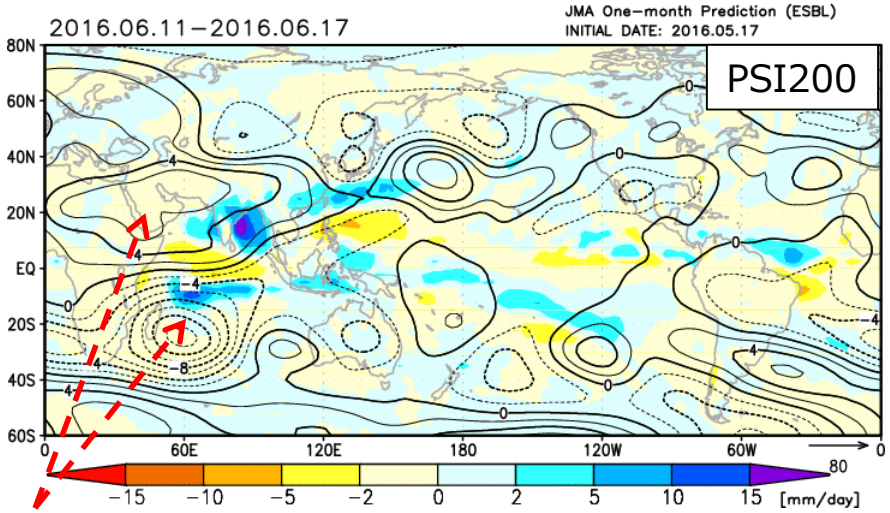
・Positive values indicate convergence, and negative values indicate divergence.

How to use NWP charts

【Step 2】Let's check fields responding to the tropical convection.



Active Convection



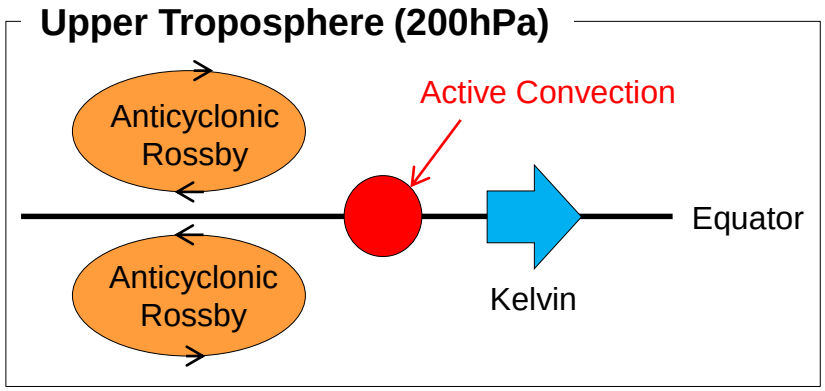
Anticyclonic Rossby response

CHI200 (Velocity potential at 200hPa)

・Positive values indicate convergence, and negative values indicate divergence.

PSI200 (Stream function at 200hPa)

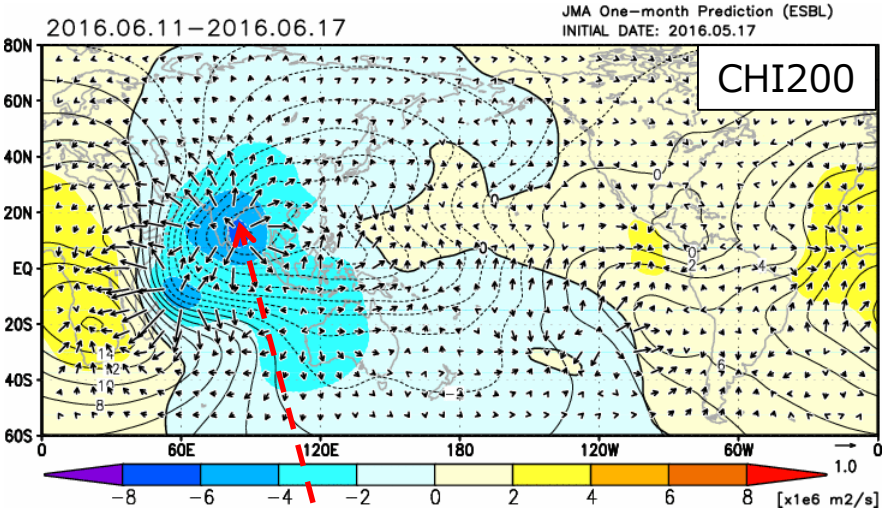
・Positive values indicate anticyclone, and negative values indicate cyclone in Northern Hemisphere.



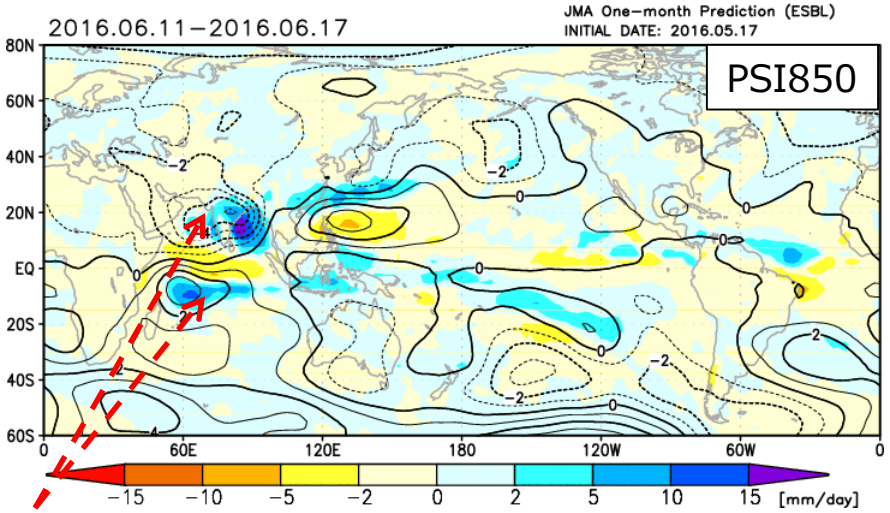
Typical Response Pattern (The Matsuno-Gill Response)

How to use NWP charts

【Step 2】Let's check fields responding to the tropical convection.



Active Convection



Cyclonic Rossby response

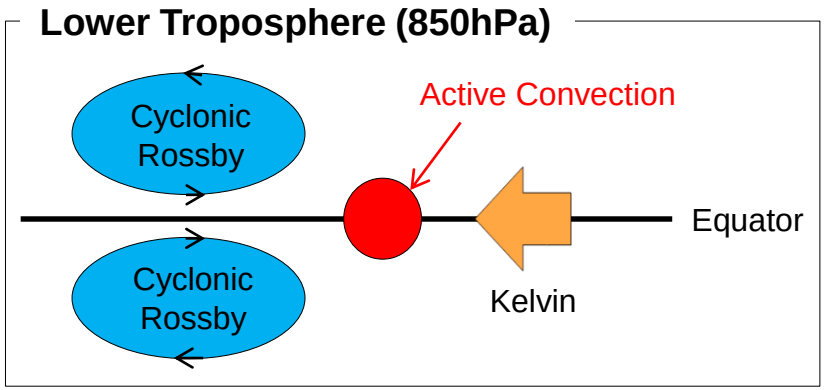
CHI200 (Velocity potential at 200hPa)

・Positive values indicate convergence, and negative values indicate divergence.

PSI850 (Stream function at 850hPa)

・Positive values indicate anticyclone, and negative values indicate cyclone in Northern Hemisphere.

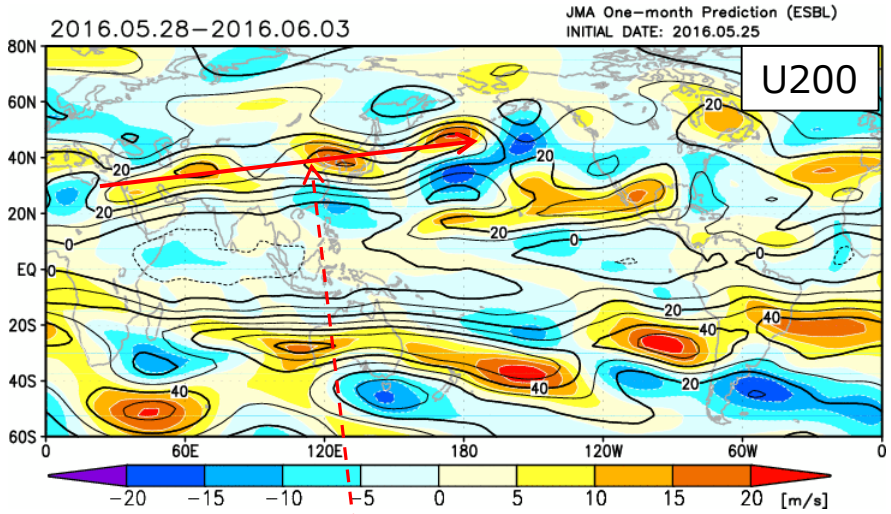
・Tropical cyclones are sometimes generated in strong cyclonic circulations.

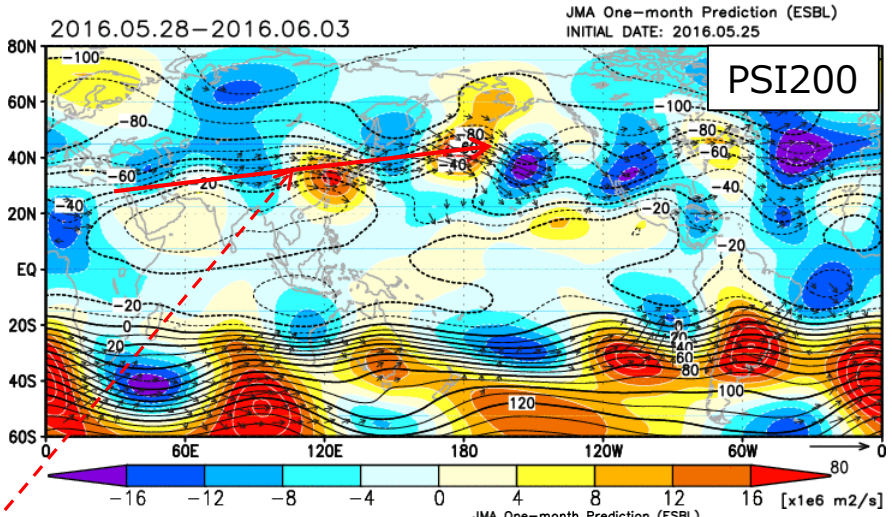


Typical Response Pattern (The Matsuno-Gill Response)

How to use NWP charts

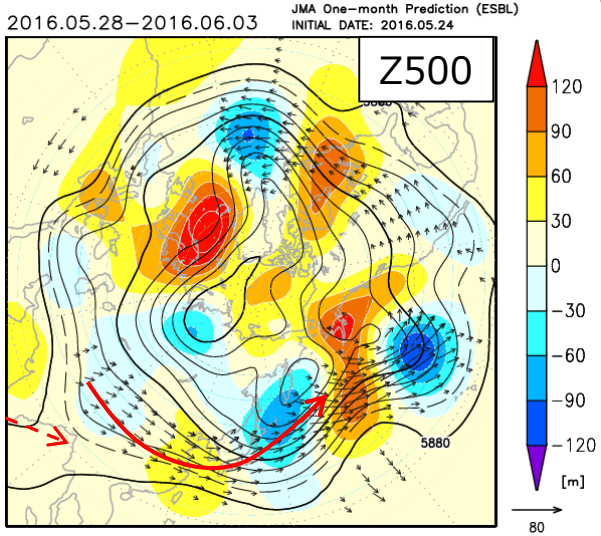
【Step 3】Let's check wave energy propagations along the sub-tropical jet.





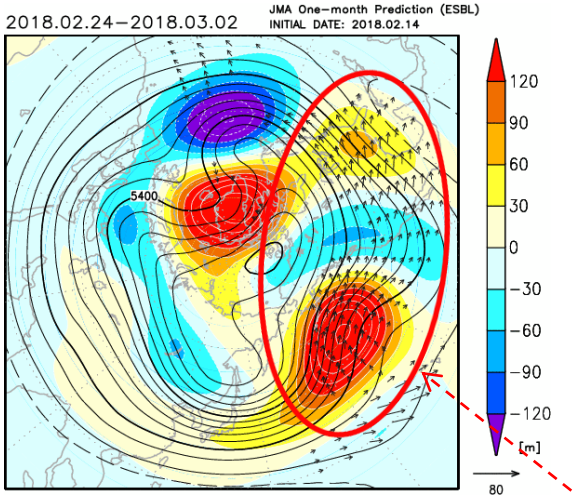
Subtropical Jet

The subtropical jet plays a role of wave guide to propagate the wave energy downward.



How to use NWP charts

【Step 4】Let's check teleconnection patterns.



Z500 (i.e. Geopotential Height at 500hPa)

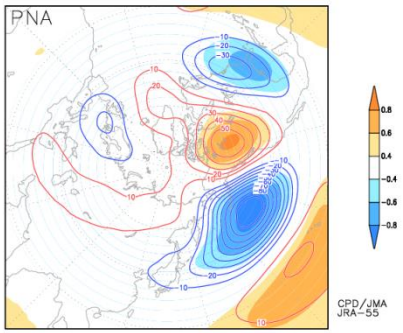
・In general, predictabilities over mid- and high- latitude are small, but teleconnection patterns associated with tropical convection patterns are relatively reliable.

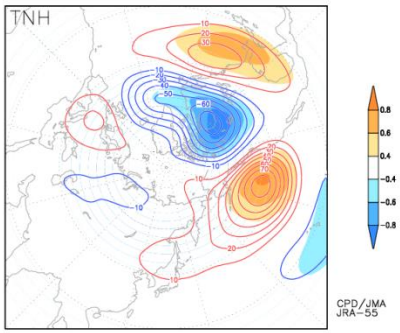
・Positive/Negative Pacific-North America (PNA) pattern and Negative/Positive Tropical-Northern Hemisphere pattern are often seen with El niño/La niña.

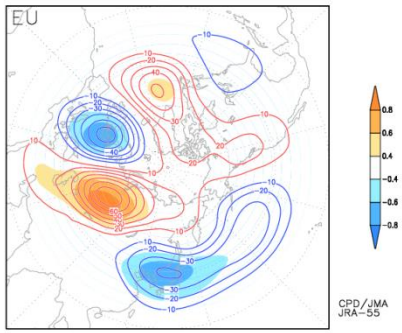
・Eurasia(EU) pattern has strong correlation with PNA.

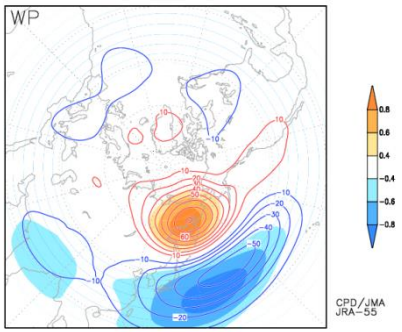
・Western Pacific (WP) pattern has strong correlation with tropical convection over NINO.WEST.

In this case, negative PNA and positive TNH are dominant.





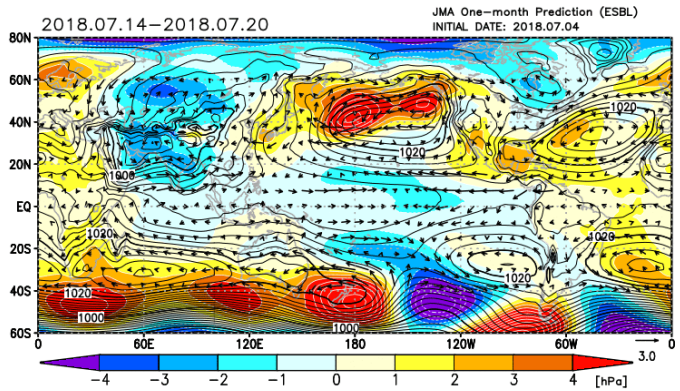


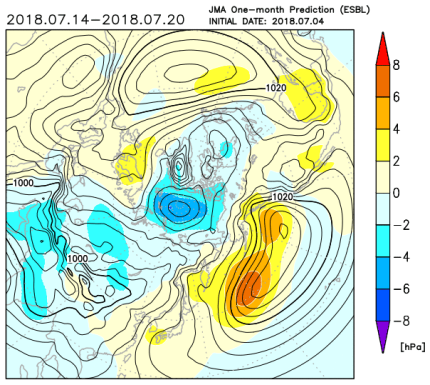


Contours indicate predicted values. Shading indicates anomaly.

How to use NWP charts

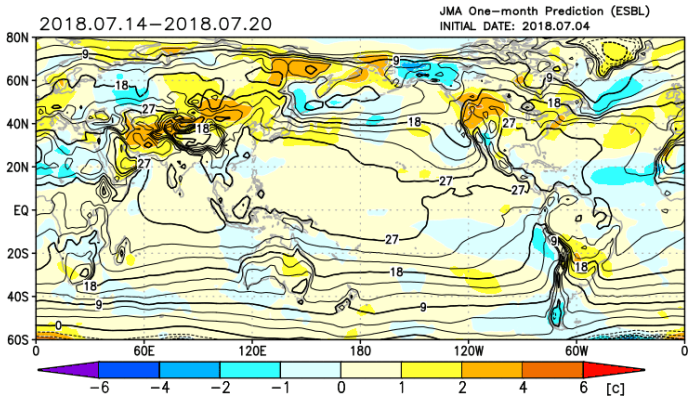
【Step 5】Let's check the other figures.

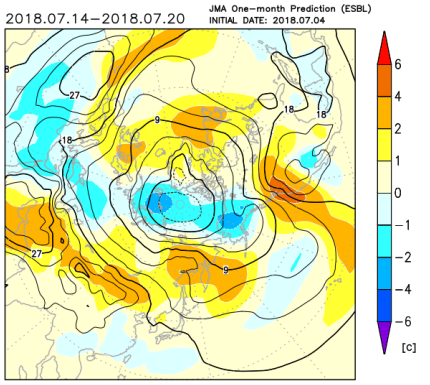




PSEA（i.e. Sea Surface Pressure)

Sea Surface Pressure is useful to understand Arctic Oscillation (AO), North Atlantic Oscillation (NAO) and the strength of North Pacific High, Siberian High, Aleutian Low and so on.
Both tropical and northern hemisphere maps are available.





Temperature

Model output temperature is necessary to check statistical guidance reliability.
If temperature in guidance is different from that in model, you should investigate the reason.
A tropical map of surface temperature and a northern hemisphere map of 850hPa temperature are available.

Contours indicate predicted values. Shading indicates anomaly.

Hindcast Verification Charts for One-month forecast

Hindcast verification charts are available on the One-month prediction menus.

Verifications of Global EPS for one-month prediction using its Hindcast

Hindcast Verification

- Bias map (Mean error map)
  - Northern hemisphere map
  - Global map
  - Zonal mean map
- Hindcast maps for every initial date
  - Northern hemisphere map
  - Global map
- Verification score
  - Time-series Circulation Index
  - Verification Score Maps
    - Variables to be Assessed: RAIN, Z500, T850, SLP, CHI200, PSI200, PSI850
    - Diagonostic Measures:
      - Anomaly Correlation(ACOR)
      - Root Mean Squared Error(RMSE)

Specifications of the hindcast

- Model: JMA-GSM
- Resolution: TL479L100 (up to 18 days) , TL319L100 (after 18 days)
- Target period for verification: 1981-2010
- Ensemble size: 5
- Initial condition (Atmosphere): JRA-55
- Initial condition (Land): Land surface values estimated with the land-surface model in the Global EPS using atmospheric forcing from JRA-55

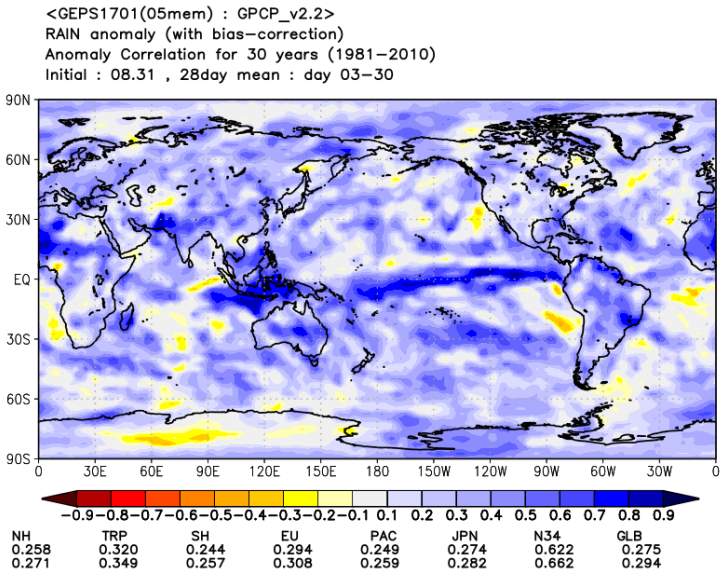
Verification data

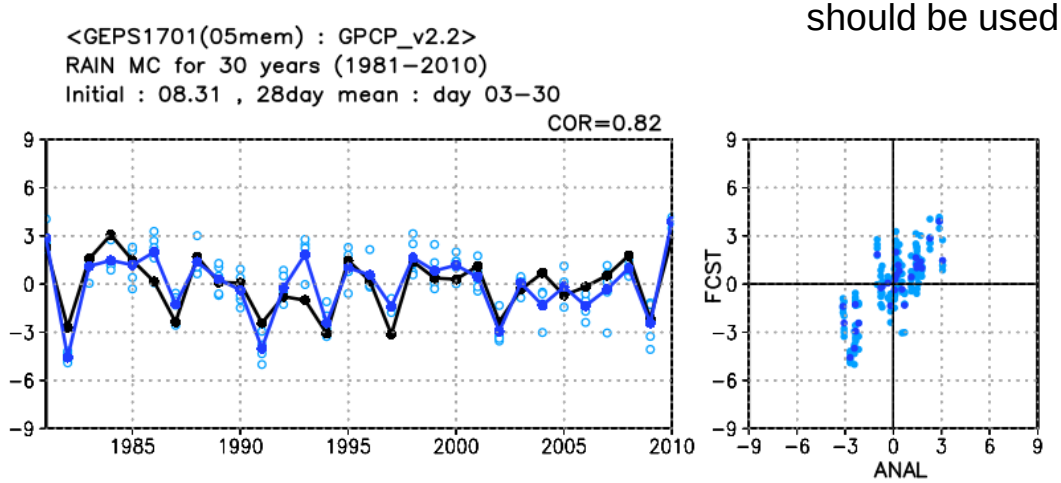
- Precipitation (RAIN) : GPCP (Global Precipitation Climatology Project) precipitation dataset (version 2.2)
- Atmospheric Analysis (such as Z500 and T850): JRA-55

page top

http://ds.data.jma.go.jp/tcc/tcc/products/model/hindcast/1mE/index.html

Verification scores for One-month forecast





Verification Score Maps

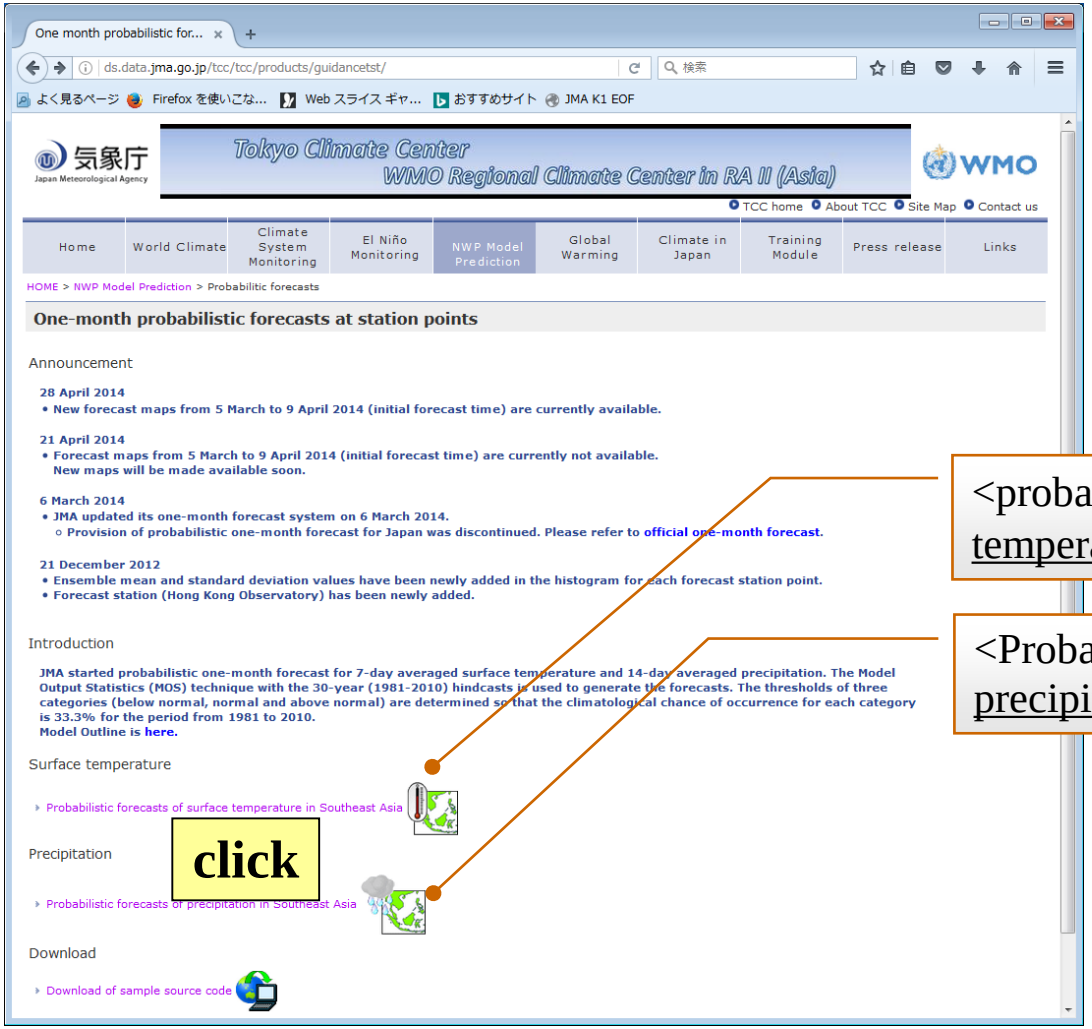
Hindcast score maps are useful to understand the spatial prediction skills. In the low prediction skill region, it is not recommended to use model output directly. Statistical relationships to the high skill region and calibration using past observation should be considered.

Time-series circulation Index

Time-series circulation indexes are useful to understand model predictabilities of various kinds of focal phenomena such as El Niño/La Niña, Indian Ocean Dipole (IOD), monsoon rainfalls and circulations. Higher skill phenomena should be used for explanation of forecast reasons.

One-month probabilistic forecast at station points

Top page

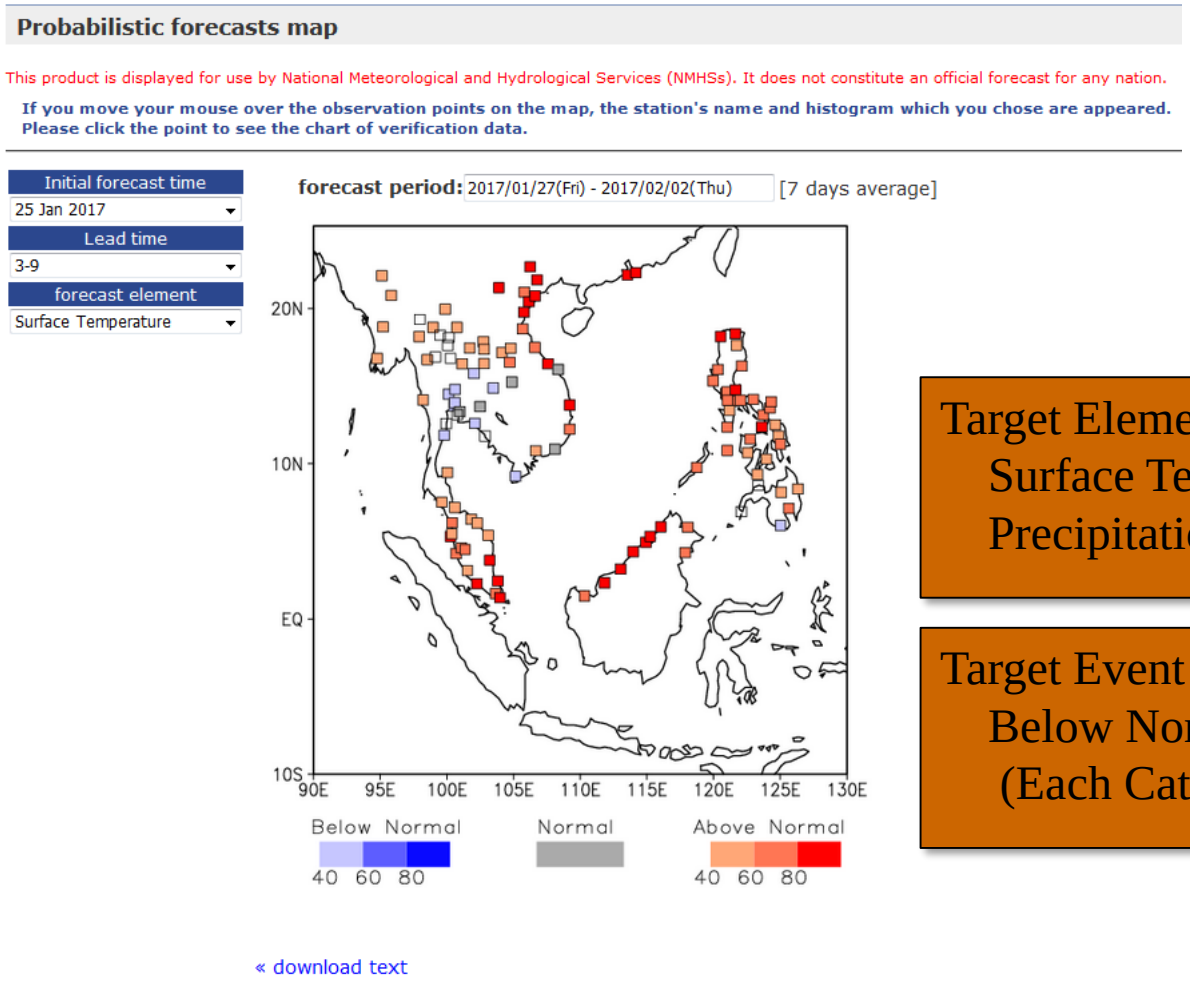


<probabilistic forecast map in Southeast Asia>
temperature

<Probabilistic forecast map in Southeast Asia>
precipitation

One-month probabilistic forecast at station points

Probability map page http://ds.data.jma.go.jp/tcc/tcc/products/guidancetst/

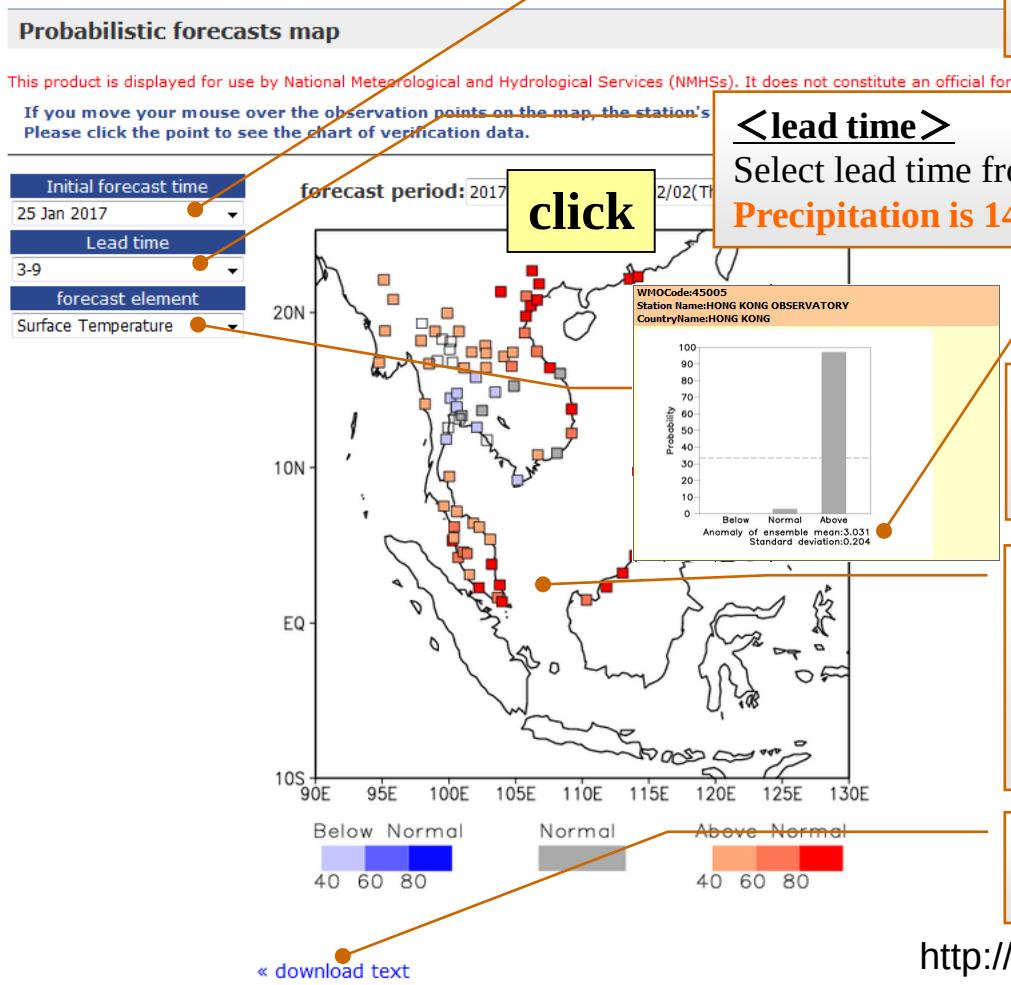


Target Element
Surface Temperature (7Day Average)
Precipitation (14Day Average; Power of ¼)

Target Event
Below Normal; Normal; Above Normal
(Each Category: 33.3%)

One-month probabilistic forecast at station points

Probability map page



＜initial time＞
Select initial forecast date

＜lead time＞
Select lead time from forecast date.
Precipitation is 14 days averaged data, temperature is 7days averaged

＜Mean & Standard Deviation＞

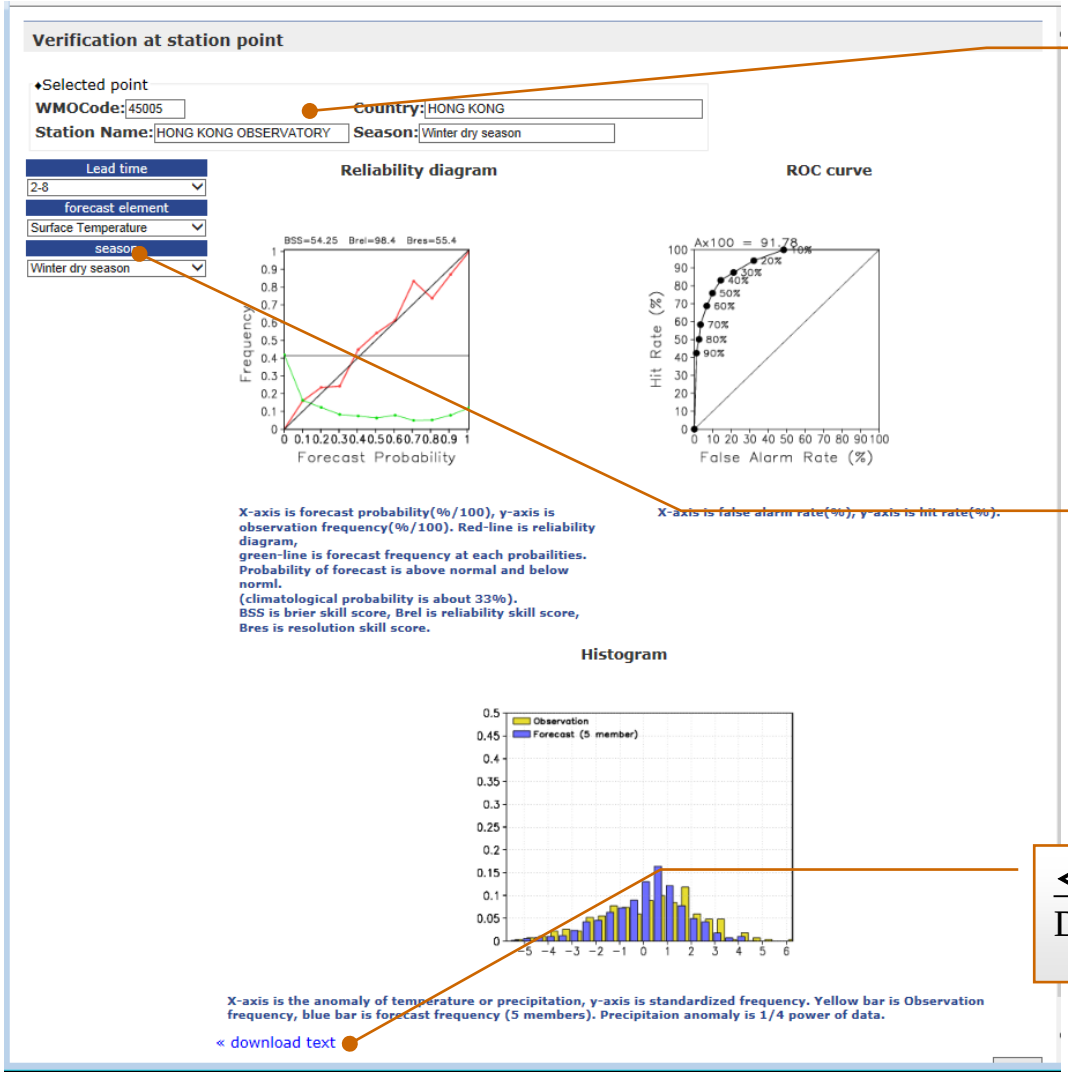
＜element＞
Select **temperature or precipitation**.
If you change this, lead time is also changed

＜stations＞
Colors indicate probability.
When mouse point is on a station, **bar graph** is appear.
If you click a station, new window is open,
you can see **verification graph** on clicked station.

＜download＞
Download text file written every stations probability.

http://ds.data.jma.go.jp/tcc/tcc/products/guidancetst/

One-month probabilistic forecast at station points



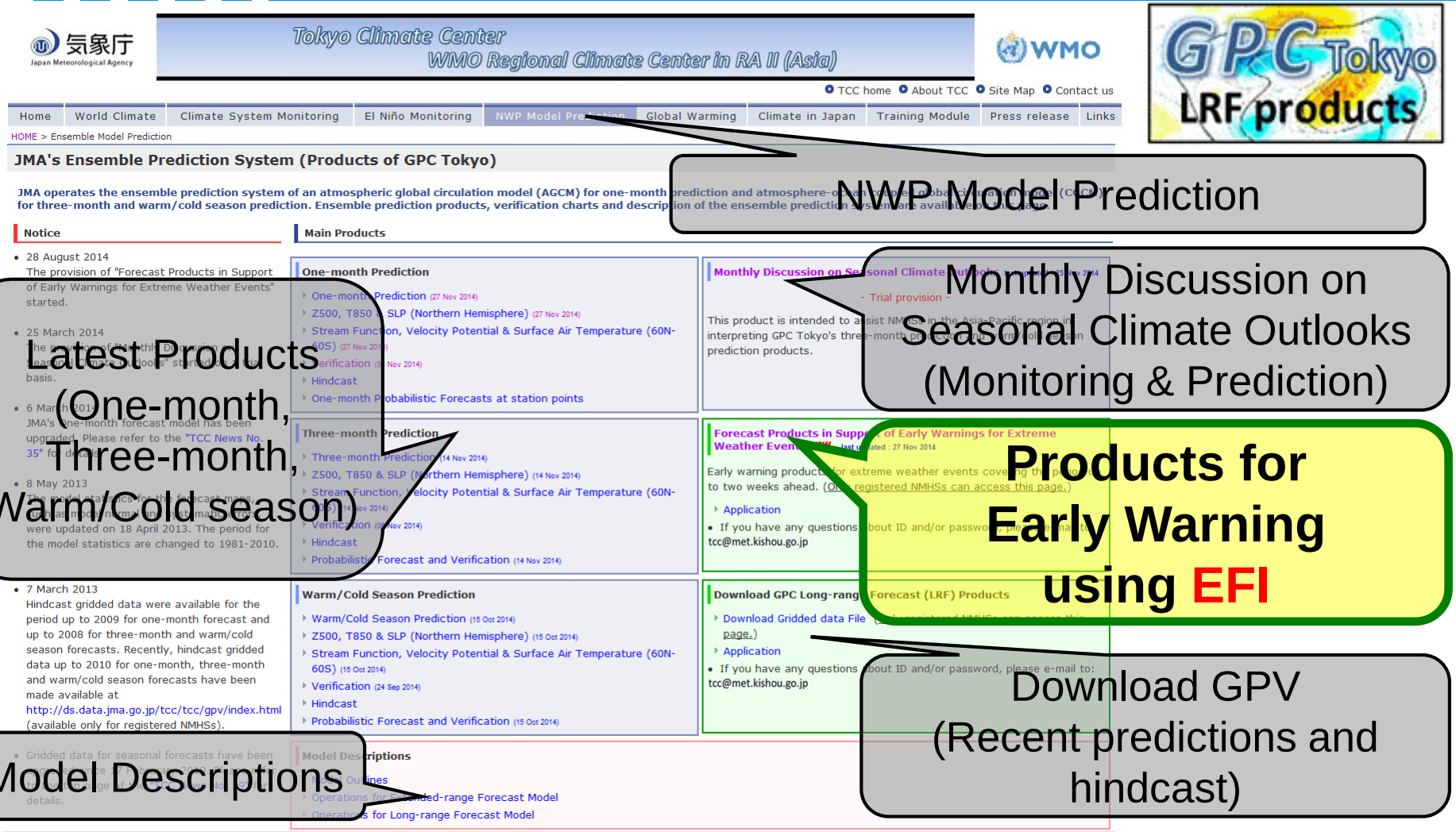
＜station information＞
Information of Clicked station

＜season＞
Seasons that statistics equation made in.

- winter dry season (Jan-Mar)
- pre-monsoon season (Apr-May)
- summer monsoon season (Jun-Sep)
- post-monsoon season (Oct-Dec).

＜download＞
Download text written verification data.

Extreme Forecast Index (EFI) products



NWP Model Prediction

Monthly Discussion on Seasonal Climate Outlooks (Monitoring & Prediction)

Latest Products (One-month, Three-month, Warm/Cold season)

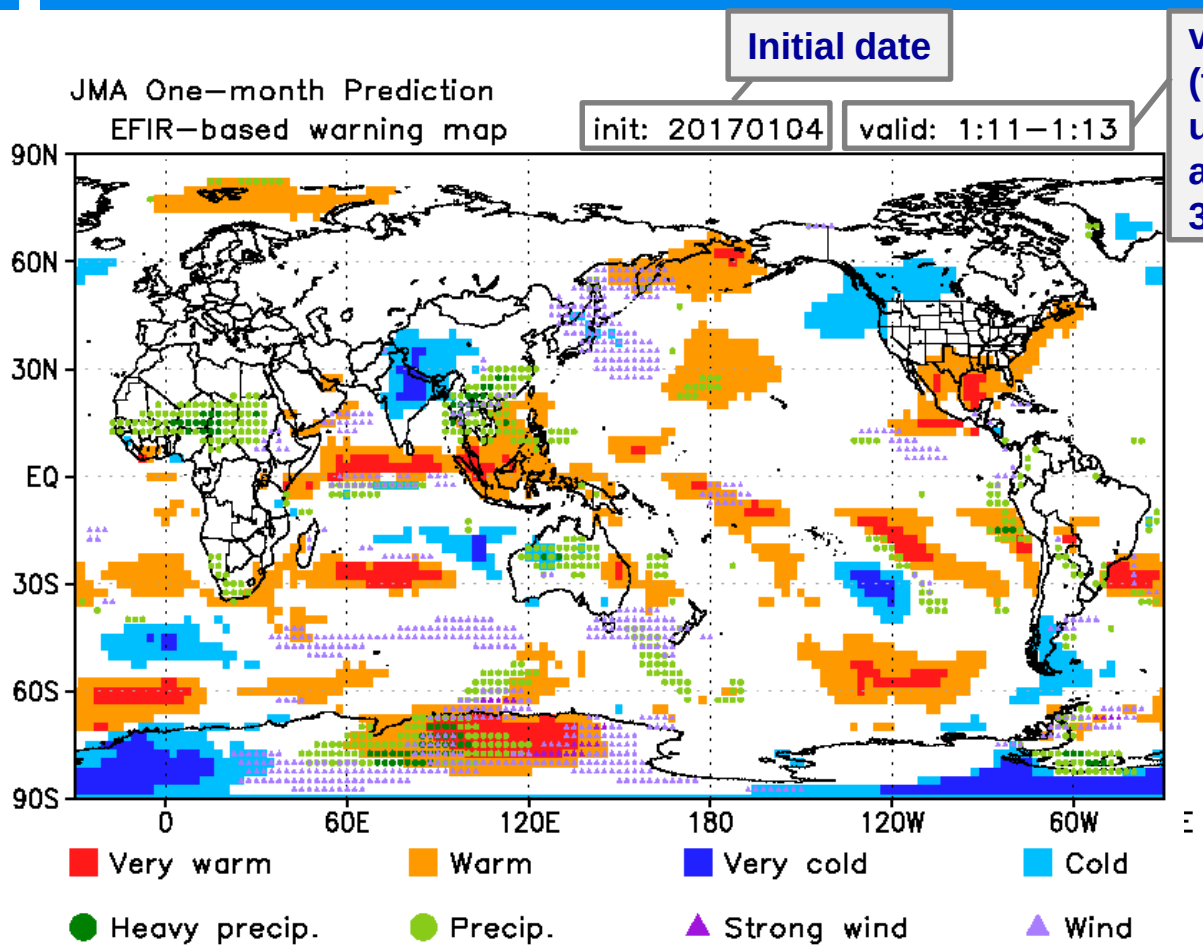
Products for Early Warning using EFI

Download GPV (Recent predictions and hindcast)

Model Descriptions

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

Extreme weather warning map

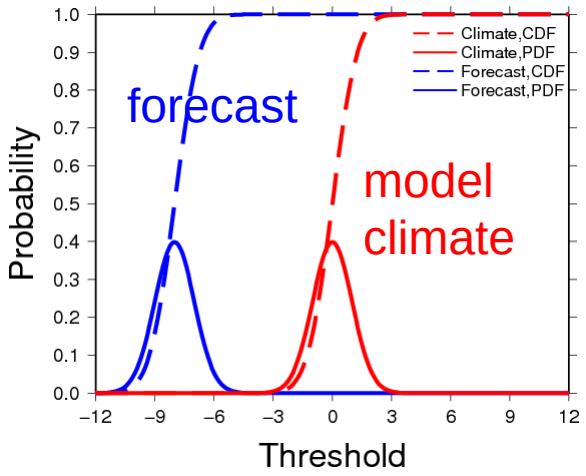


Occurrence probabilities for various extreme events are plotted on one map based on the following EFI thresholds.

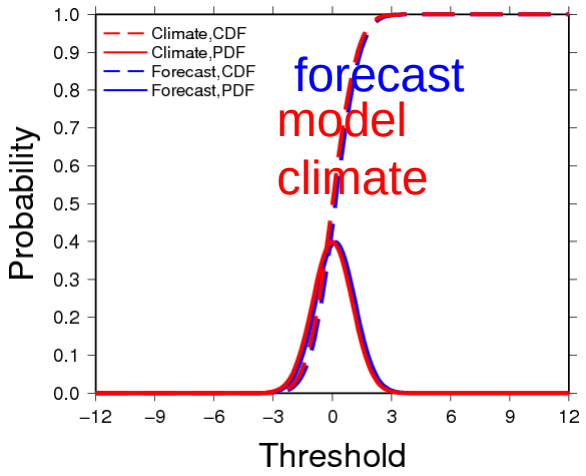
Very warm, Very cold, Heavy precip. and Strong wind : |EFI| ≥ 0.8
Warm, Cold, Precip. and Wind : |EFI| ≥ 0.5

The Extreme Forecast Index (EFI)

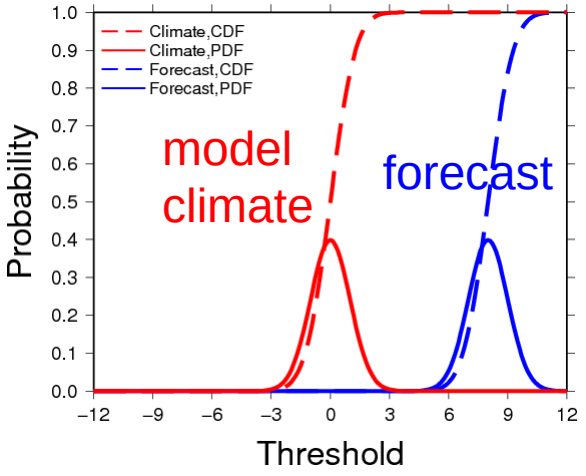
- The EFI value (from -1 to 1) is computed from the difference between cumulative distribution function (CDF) curves of the real-time forecast distribution and model climate distribution (Lalaurette 2002, 2003).
- Underlying assumption: if a forecast is extreme with respect to model climate, the real world is also likely to be extreme compared to the real climate



EFI=-1.0 (minimum)
All forecast values are below the minimum of model climate

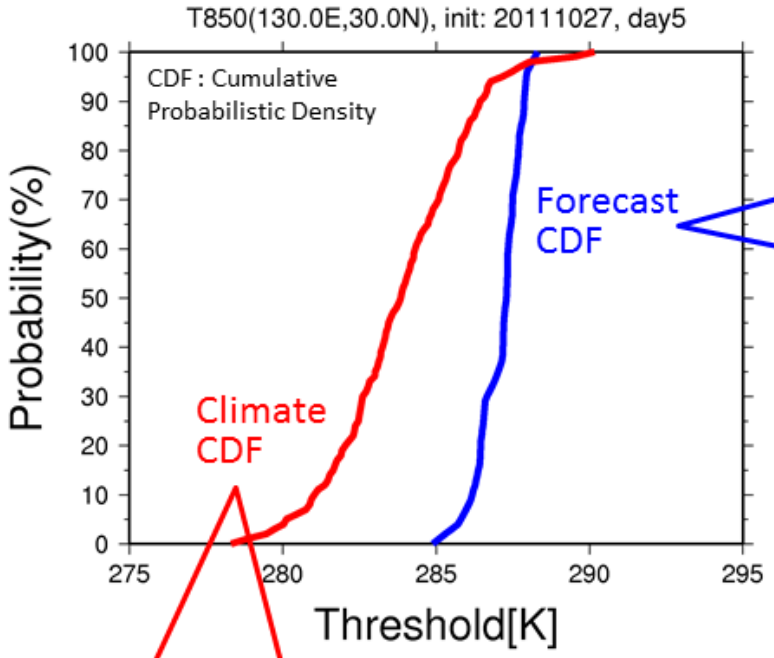


EFI=0
Forecast distribution agrees with model climate distribution



EFI=+1.0 (maximum)
All forecast values are above the maximum of model climate

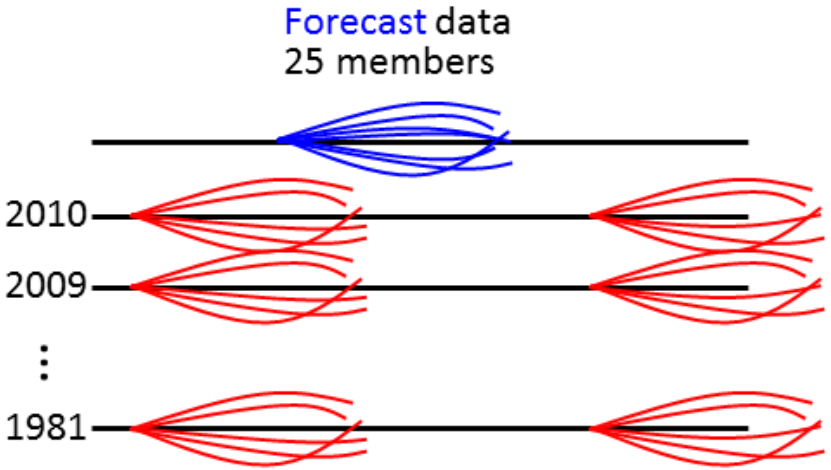
How to obtain probabilistic distributions



Forecast CDFs (cumulative distribution functions) are produced from JMA's operational One-month EPS (25 members for each initial day).

Climate CDF estimation is based on five-member hindcasts starting with the nearest two initial calendar dates for the one-month EPS initial date.

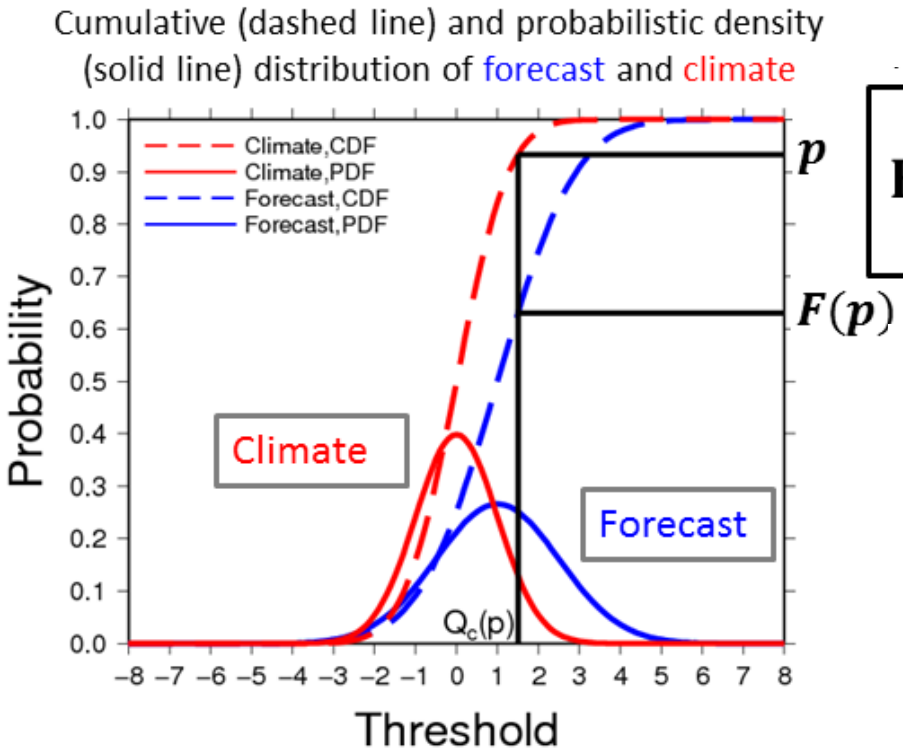
size : 5-member × 30 years × 2 initials = 300 members



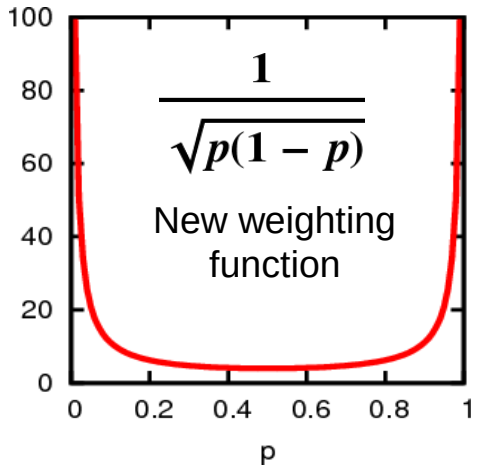
Compare [Forecast FT=○]and [model climate FT=○].

The revised EFI on the JMA's TCC website

- To add more weights in the tails of the probability distributions, the EFI calculation is revised with new weighting function (Zsótér 2006).
- The EFI products on the JMA's TCC website are based on the revised EFI.

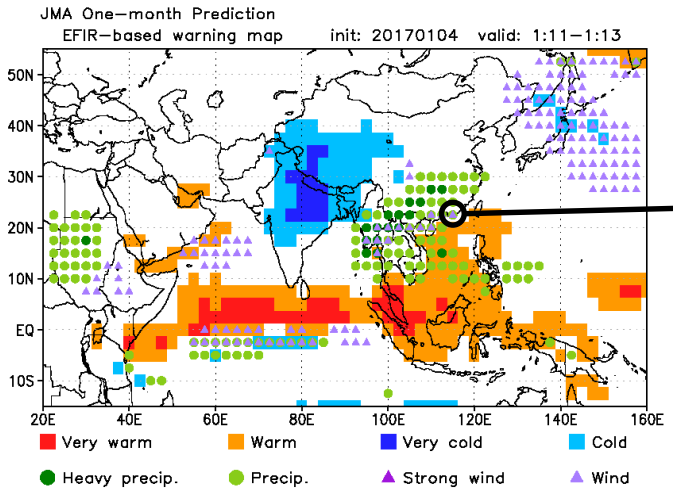


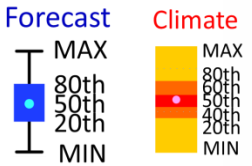
$$\mathbf{EFI}_{revised} = \frac{2}{\pi}\int_0^1 \frac{p - F(p)}{\sqrt{p(1-p)}}dp$$

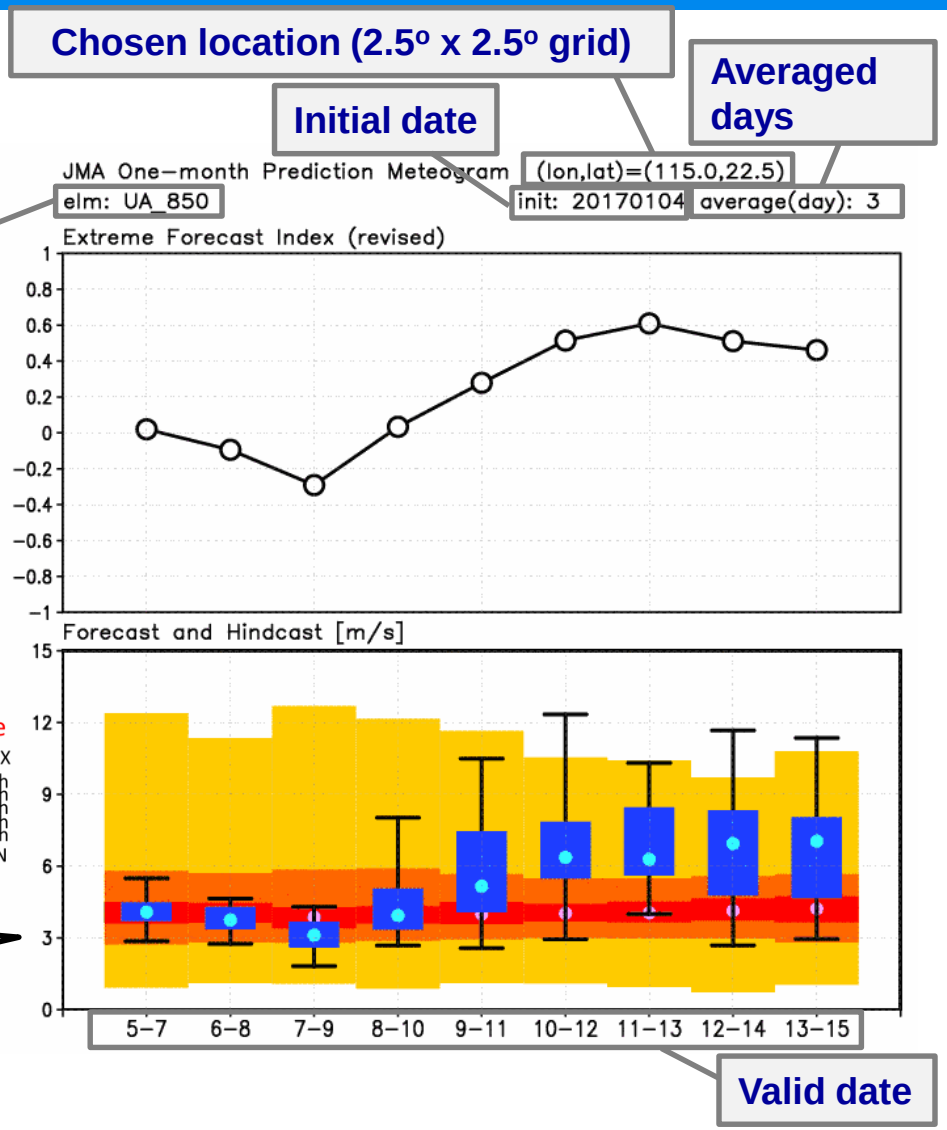


EFI time-series and Meteogram

- Comparing EFI value with PDF is important before issuing warnings or undertaking any action, because the EFI values do not indicate probabilities.



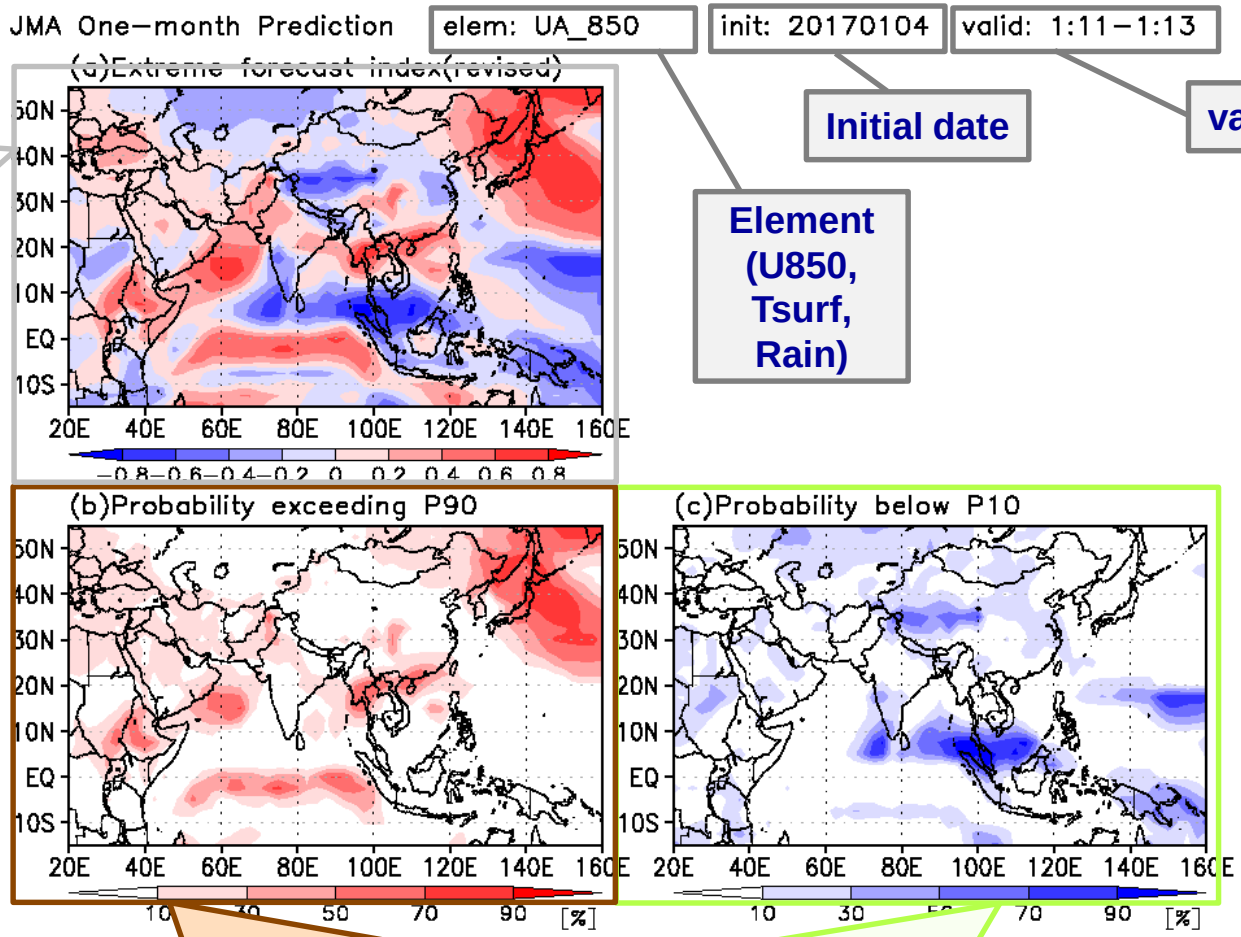




EPS probability distributions of the forecast (25 members) and the model climate (300 members)

EFI map and probability map

Horizontal map of the revised EFI



Initial date

valid term

Element (U850, Tsurf, Rain)

The fraction of ensemble members that predict a value **above the 90th percentile** of the model climatology to 25 members

The fraction of ensemble members that predict a value **below the 10th percentile** of the model climatology to 25 members

Summaries

■Predictability

- There are 2 kinds of predictability.
  Predictability of 1st kind depends on an initial condition.
  Predictability of 2nd kind depends on boundary conditions.
- Temporal and spatial scales of forecast targets should be considered.

■Uncertainty

- Because of chaotic nature, it is essential to consider uncertainty.
- Ensemble prediction system (EPS) make it possible to estimate uncertainty.

■ Hindcast

- Hindcast is essential to understand prediction skill and to make model climate.

■Global EPS

- A high-resolution AGCM is used for extended range forecast (Predictability of 1st kind).
- Seasonal oscillations such as MJO and BSISO make a monsoon rainfall forecast difficult.
- MJO is predictable up to 25 days, but velocity and amplitude bias should be cared.
- Sub-seasonal to seasonal (S2S) prediction project

■TCC products to support 1-month forecast

- NWP charts
- Verification charts
- Probabilistic products
- Extreme Forecast Index (EFI) products