TCC Training Seminar on 17th Nov 2015

JMA's Ensemble Prediction Systems (EPSs) and their Products for Climate Forecast

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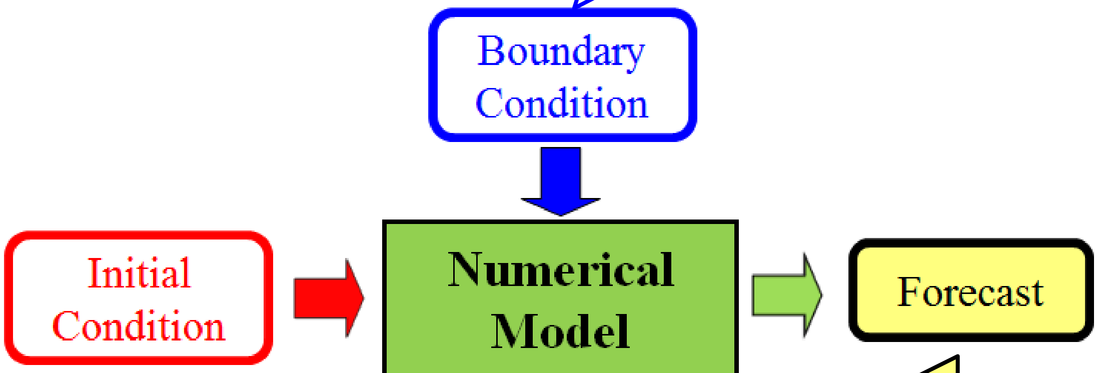
Contents

- Basic Knowledge
  - NWP Model and Predictability
  - Ensemble Prediction and Uncertainty
  - Hindcast
- JMA's NWP Models
  - JMA's One-month Ensemble Prediction System
  - JMA's Seasonal Ensemble Prediction System
- TCC's NWP Model Products

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 <u>**sea surface temperatures (SSTs), sea ices and snow covers**</u>. In general, **variations of boundary conditions are much slower** than a variation of atmosphere.



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

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

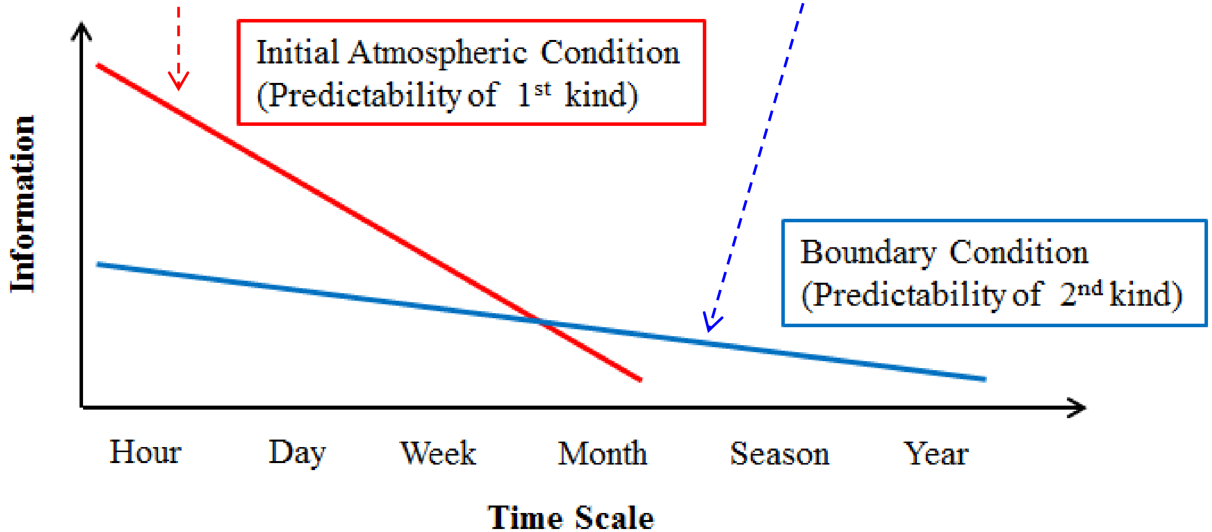
Predictability

■ 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.

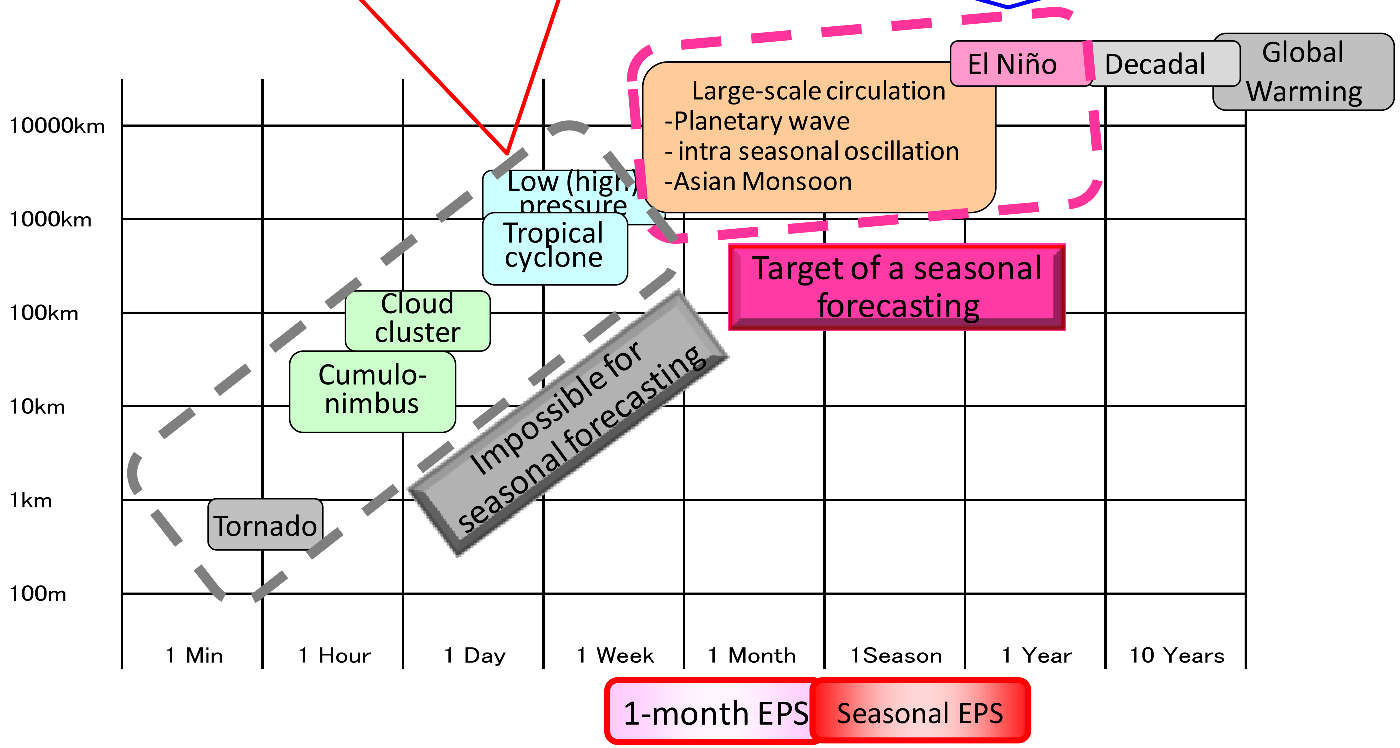


Predictability

■ 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

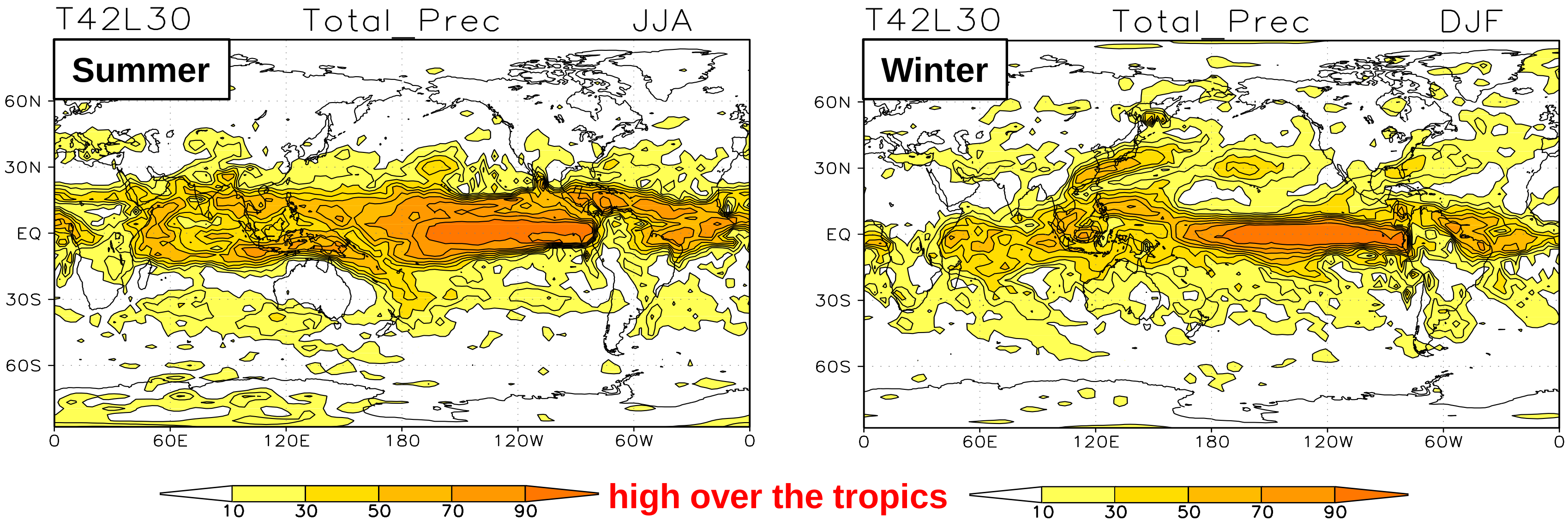
■ Potential Predictability derived by SSTs

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



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

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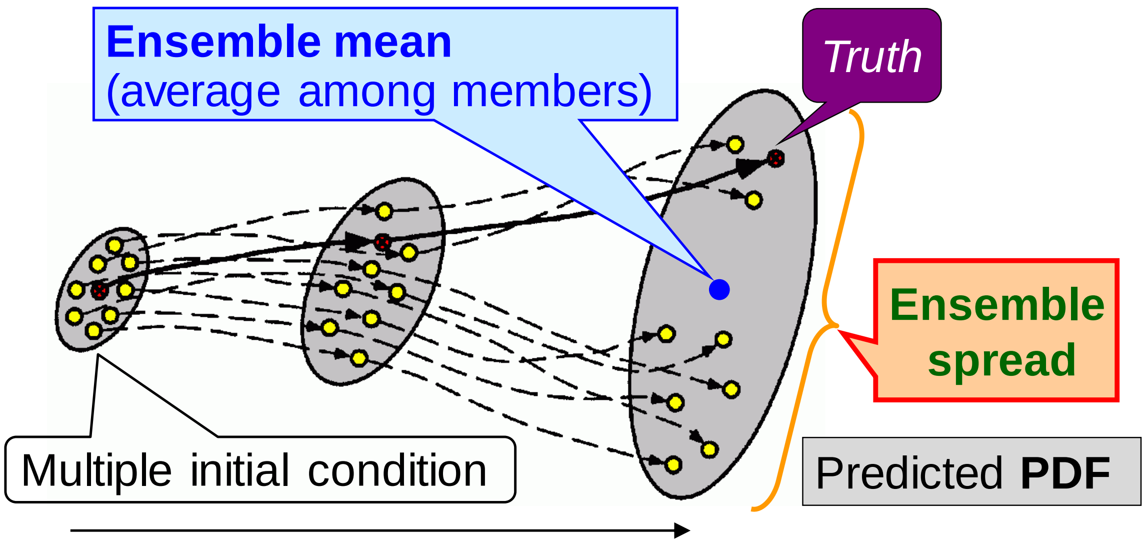
Uncertainty and Ensemble Prediction

■ 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 <u>uncertainty</u>** when forecasting. **Ensemble prediction makes it possible to estimate <u>uncertainty</u>** caused by initial condition errors with similar calculations from a little bit different multiple initial conditions.



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

Initial Perturbation

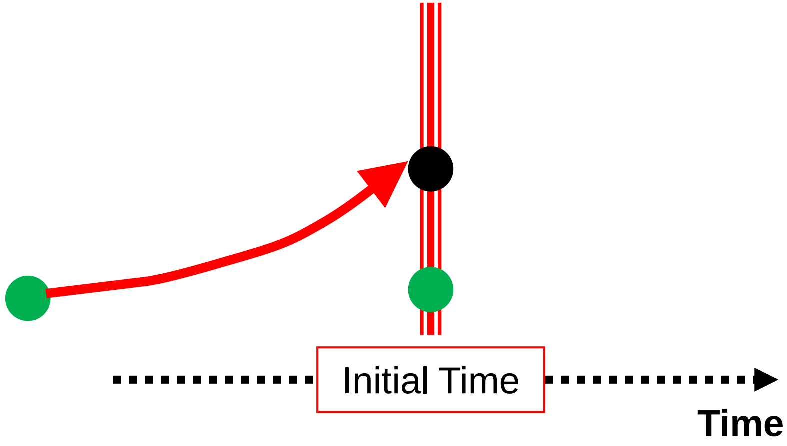
In order to efficiently represent the initial observational error with initial perturbations (multiple initial conditions), the following methods are often used.

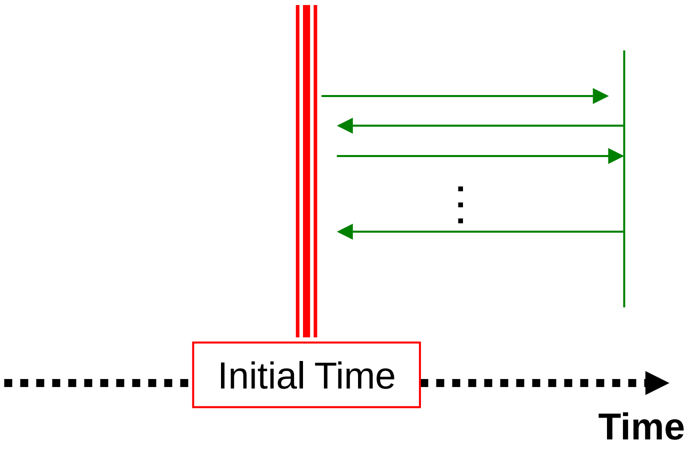
■Breeding of Growing Mode（BGM）

The BGM method **find out the perturbation grew before the initial time** with the forecast and assimilation cycle.
This method is simple but **necessary to keep forecast and assimilation cycle** even when it is not initial time.

■Singular vector (SV)

The SV can **find out the fastest growing perturbation after the initial time** based on a tangent linear model, which is obtained by locally linearizing the original nonlinear NWP model and its adjoint model.
This method **needs heavy development costs**.





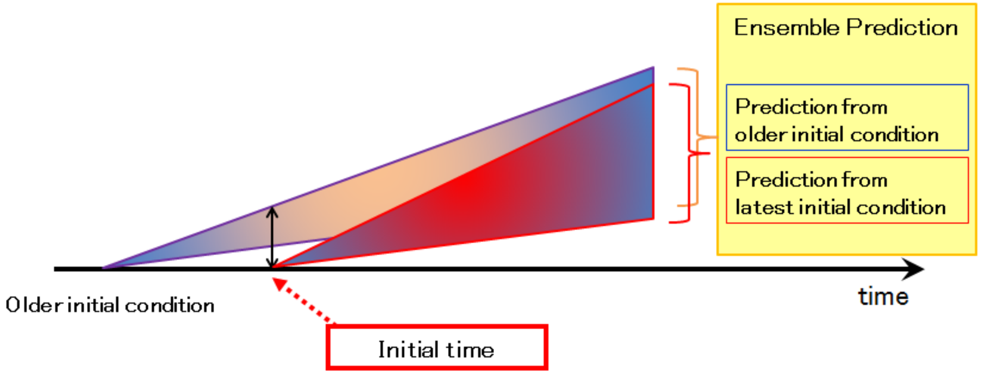
Ensemble Techniques

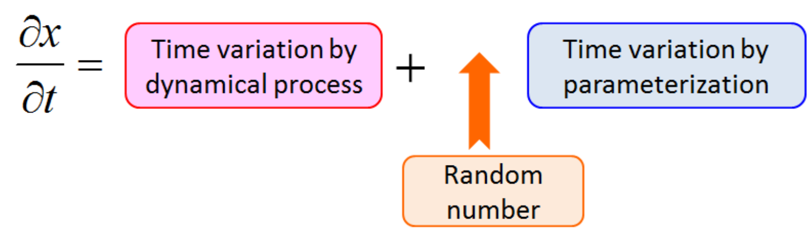
■LAF

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 between some days.
However, the accuracy of prediction from older initial conditions is generally worse than that from latest initial condition.

■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.





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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

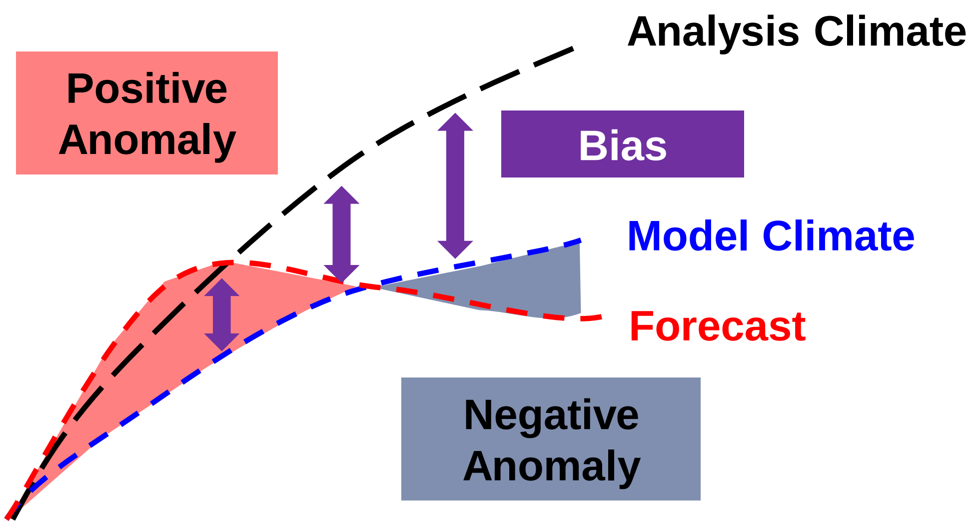
- Bias is systematic errors of the model, calculated as **the difference between model climate and analysis climate**.

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 the TCC seminar, corresponds to extended- and long-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

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

JMA's Operational Global NWP Models

as of Nov.2015

	Main target	Horizontal resolution
Global Spectral Model (GSM)	•Short-range forecasting	20km (TL959)
Typhoon EPS (TEPS)	•Typhoon forecast	40km (TL479)
One-week EPS (WEPS)	•One-week forecast	40km (TL479)
One-month EPS	•Early warning for extreme events •One-month forecast	55km (TL319)
Seasonal EPS (4/7-month EPS)	•3month forecast •Warm/Cold season forecast •El Niño outlook	110km (TL159)

AGCM

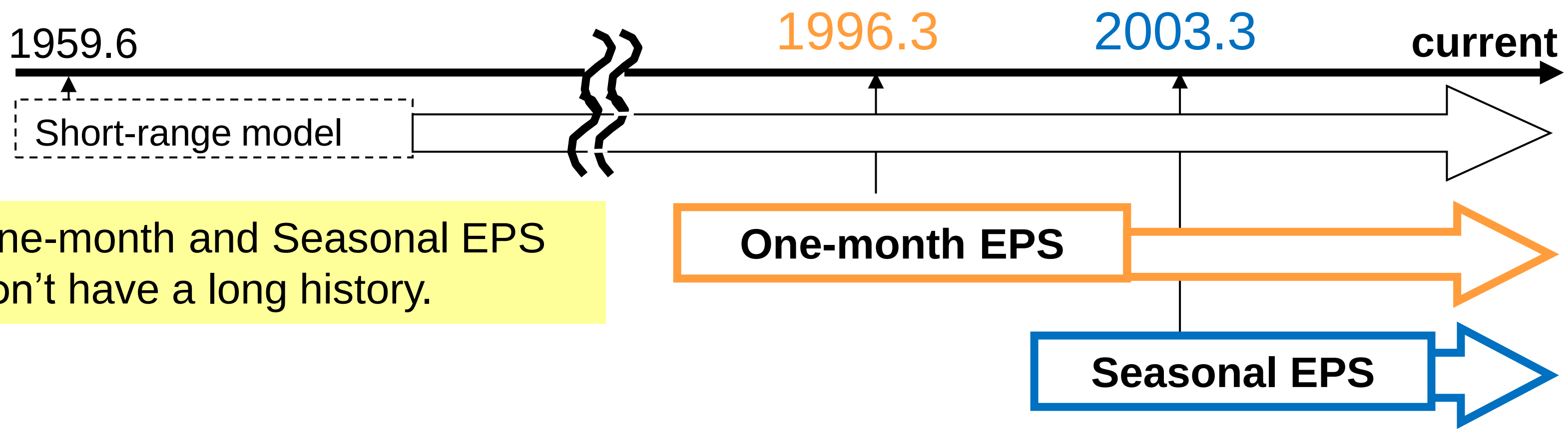
CGCM

Numerical Prediction Division/JMA

TCC

Climate Prediction Division/JMA

History of One-month and Seasonal EPS



One-month and Seasonal EPS don’t have a long history.

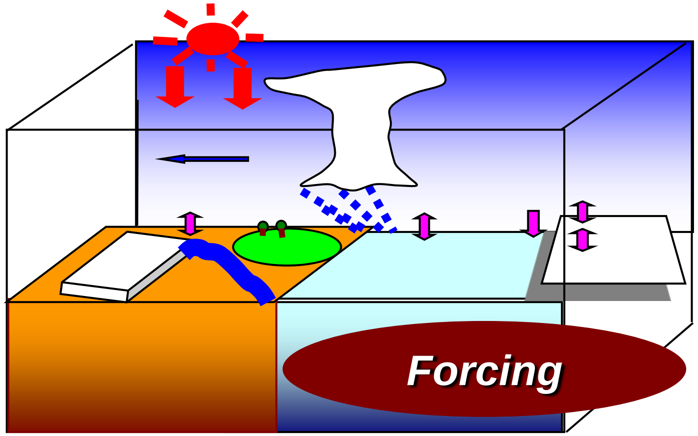
	Mar 1996	Mar 2001	Mar 2003	Mar 2006	Sep 2007	Mar 2008	Feb 2010	Mar 2014	Jun 2015
One-month EPS	**T63 L30 M10**	**T106 L40 M26**		**TL159 L40 M50**		**TL159 L60 M50**		**TL319 L60 M50**	
Seasonal EPS			**T63 L40 M31**	**TL95 L40 M31**	**TL95 L40 M51**		**TL95 L40 M51**		**TL159 L60 M51**

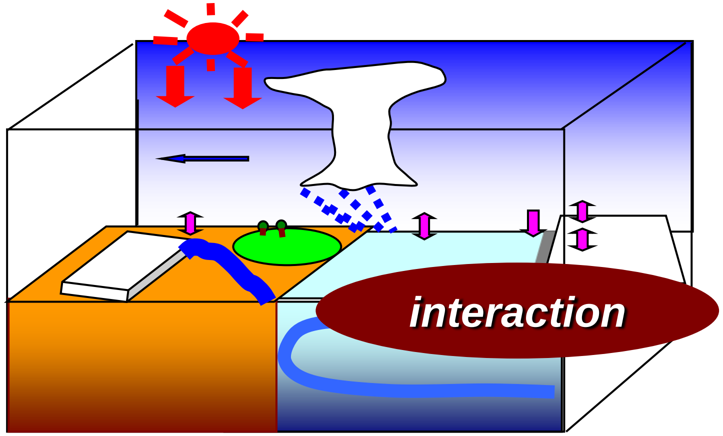
Red: AGCM **Blue: CGCM**

Difference between AGCM and CGCM

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

CGCM
Coupled Ocean-Atmospheric **G**eneral **C**irculation **M**odel





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

Two-tiered method

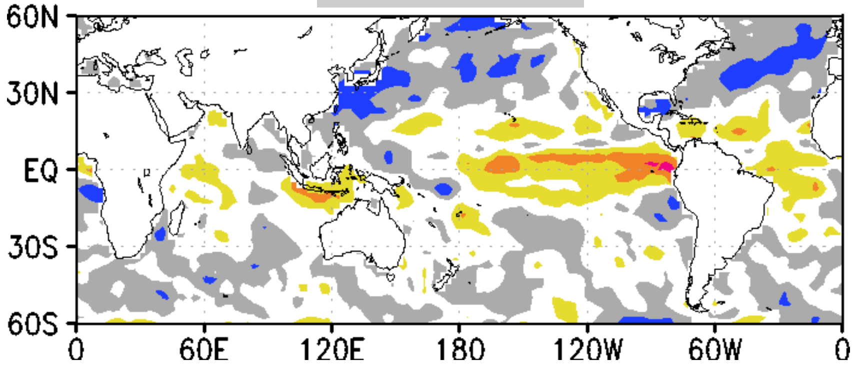
Ocean-atmosphere interaction is considered.

One-tiered method

Difference between AGCM and CGCM

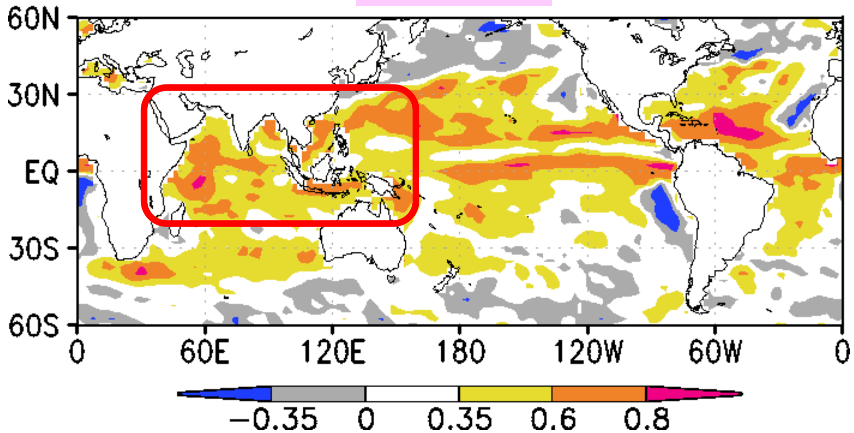
Correlation coefficient between SST and precipitation in July (Initial date: 30 June, 1979-2010)

Analysis

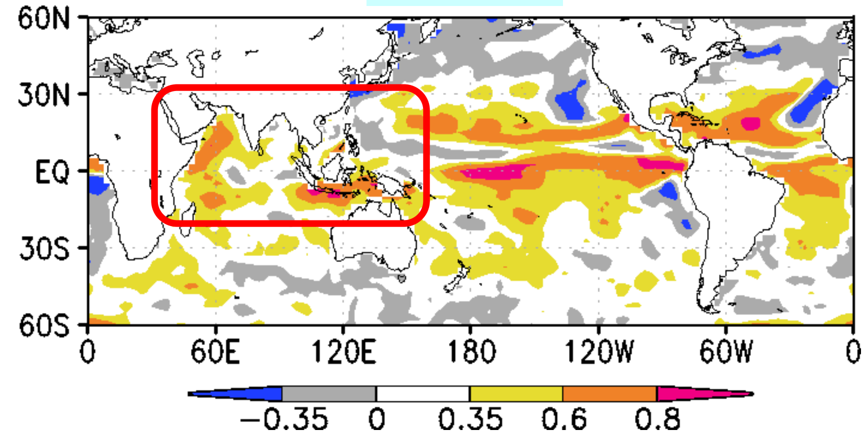


CGCM improves excess positive correlation between SST and precipitation in the tropics, especially over Asian monsoon.
CGCM leads to improve prediction skill especially in the tropics, which is affected by tropical oceanic variation

AGCM



CGCM



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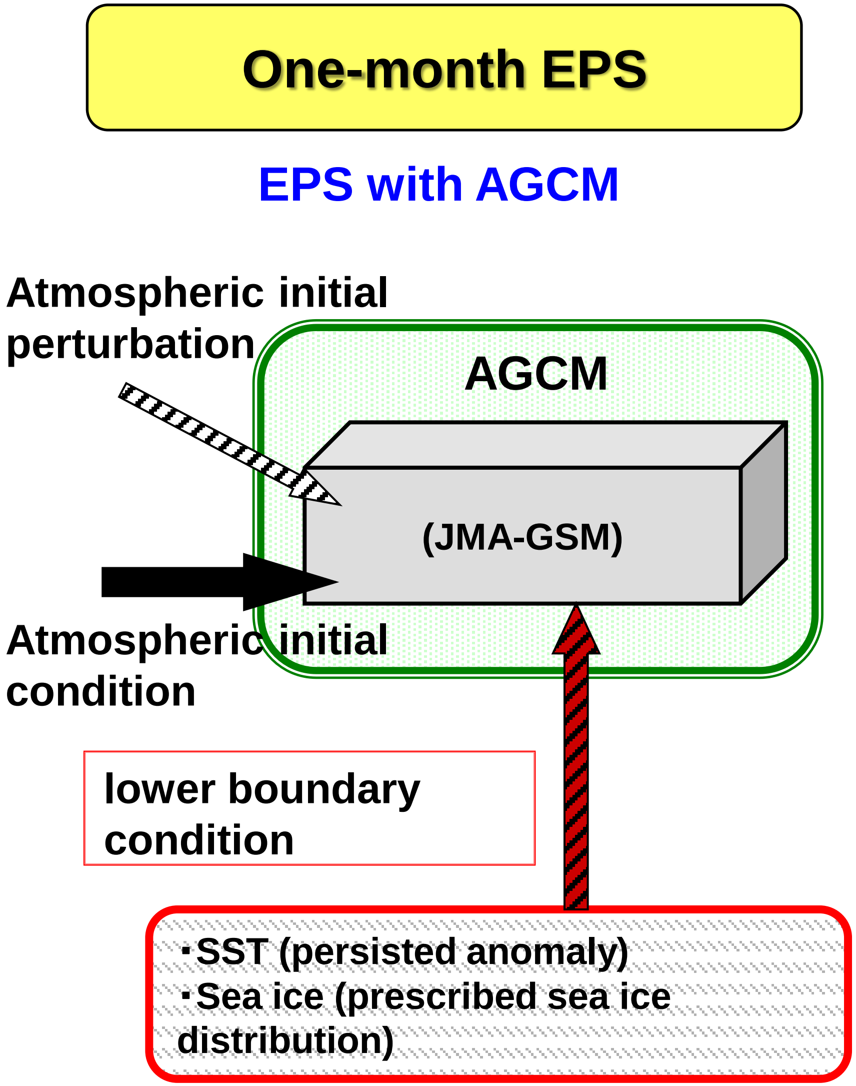
Specification of One-month EPS

as of Nov.2015



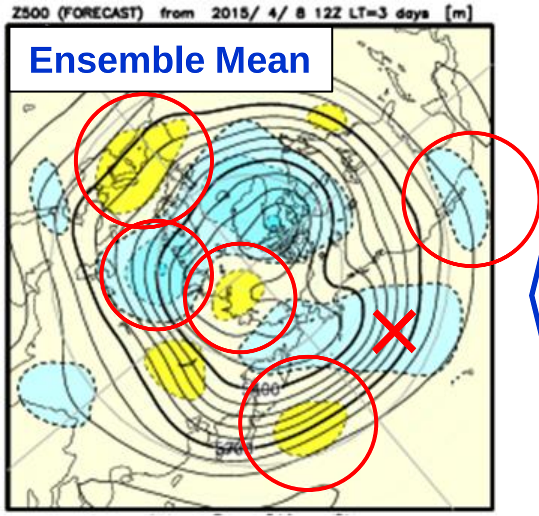
Upgrade	Last: March 2014 Frequently: Every few years
Model	AGCM
Resolution	Horizontal: 55km (TL319) Vertical: 60 levels up to 0.1hPa
Forecast range	Up to 34 days
SST	Persisted anomaly with climatological variation
Sea ice	Prescribed sea ice distribution (Sugimoto and Takaya, 2014)
Ensemble method	BGM, LAF, Stochastic physics scheme
Ensemble size	50 (25 BGMs & 2 days LAF with 1-day interval)
Freq. of operation	Every Tuesday and Wednesday
Freq. of model product creation	Once a week (Thursday)

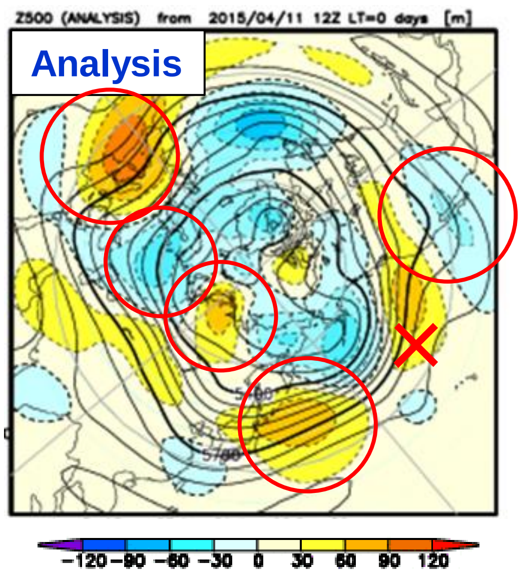
Specification of One-month EPS Hindcast

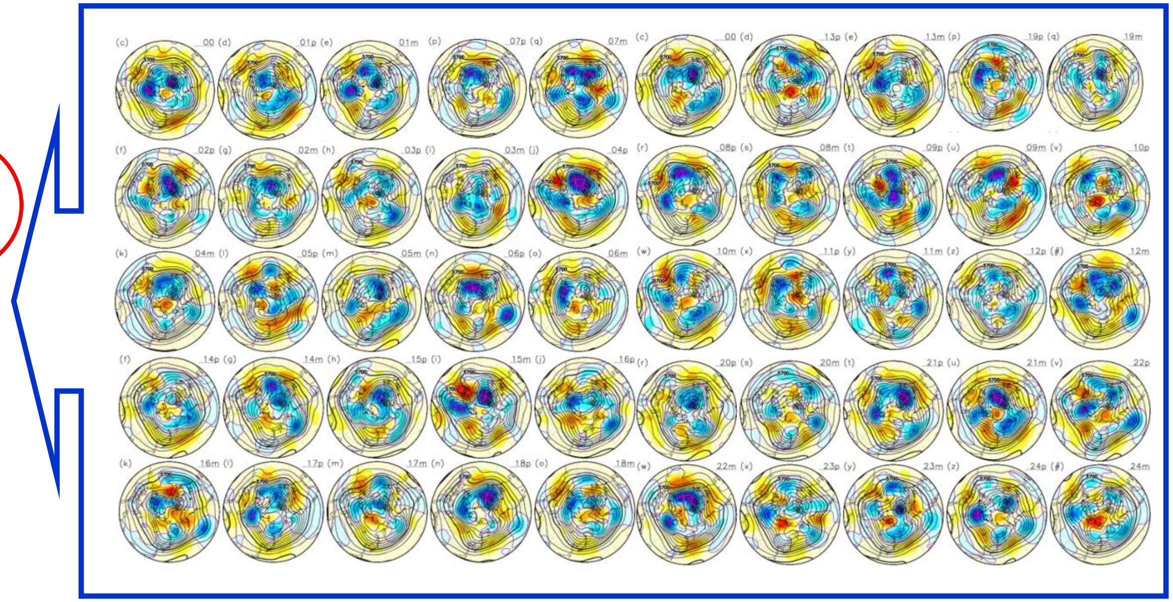
	Hindcast	Operational system
Initial Condition	JRA-55 Reanalysis	Global Analysis (Newer System than JRA-55)
Ensemble Size	5 (5 BGMs, no using LAF)	50 (25 BGMs & 2 days LAF with 1-day interval)
Forecast range	Initial date +40days	2,3,4,…,31,32days from the latest initial date (Wednesday)
Initial date	3 times a month (10th, 20th, end of month)	Every Tuesday and Wednesday
Target period for hindcast	Available: 1981–2012 Verification: 1981-2010	---

Because of the limited computer resources, ensemble size and calculation frequency for hindcasts are less than those for operational forecasts.

Example of One-month Forecast







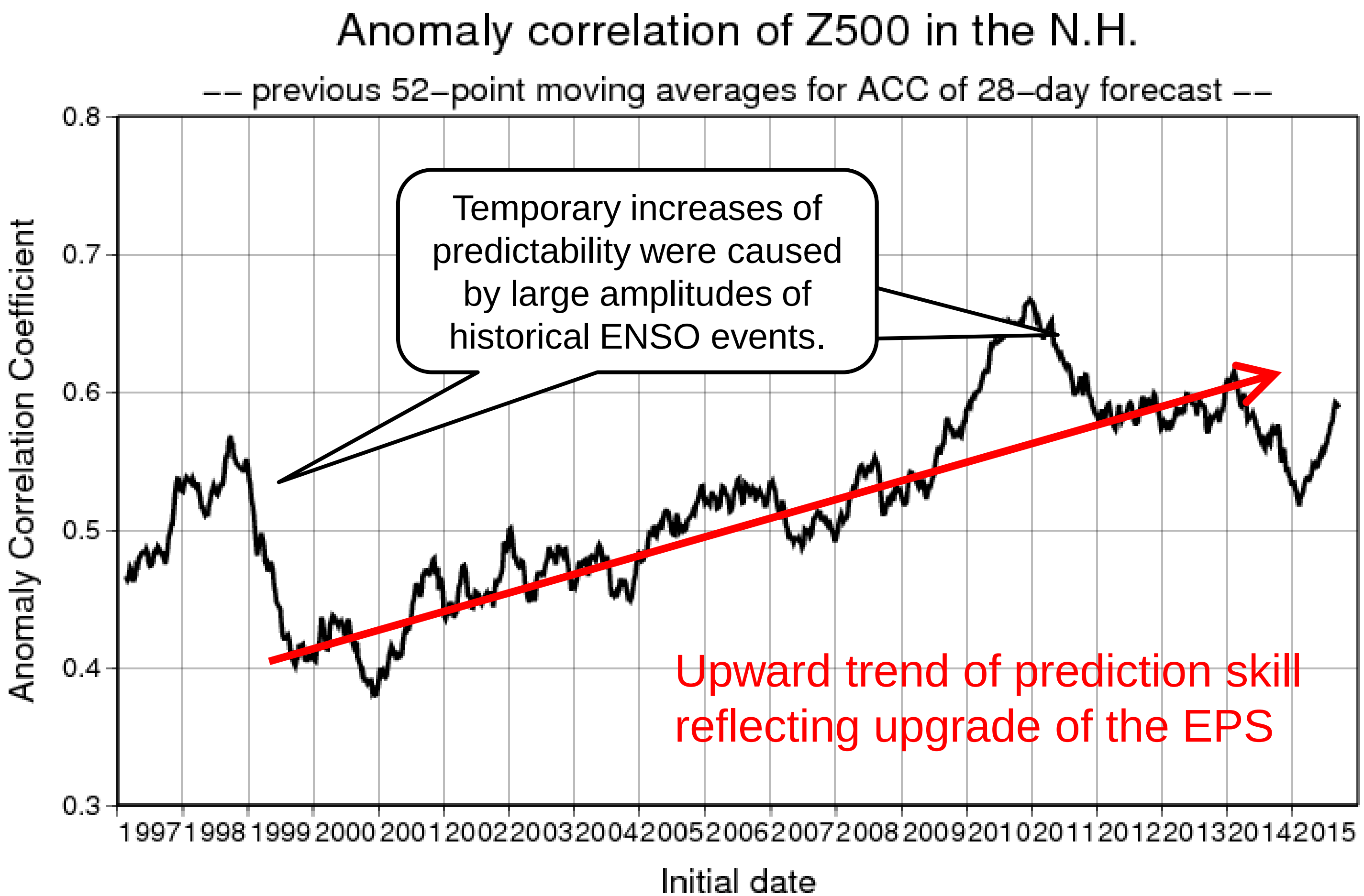
50 Ensemble Members

○ ・・・ Good Forecast

× ・・・ Bad Forecast

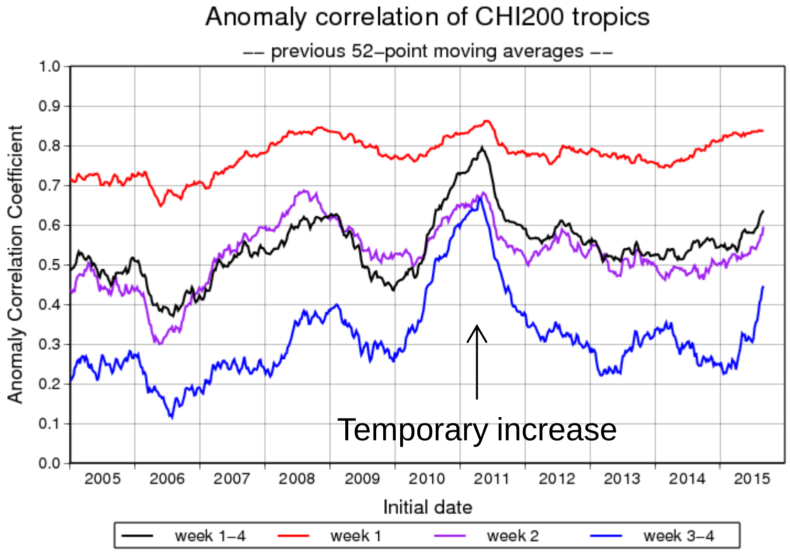
Contours indicate predicted values. Shading indicates anomaly.

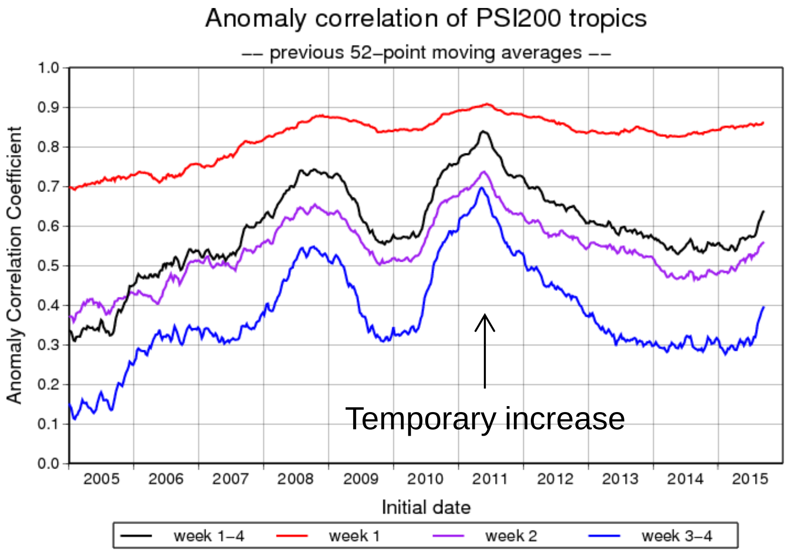
Prediction Skill of Operational One-month EPS



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

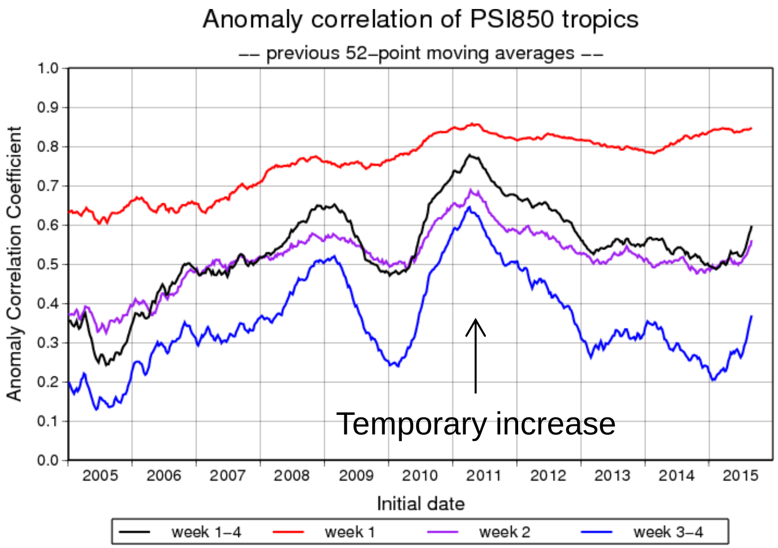
Prediction Skill of Operational One-month EPS





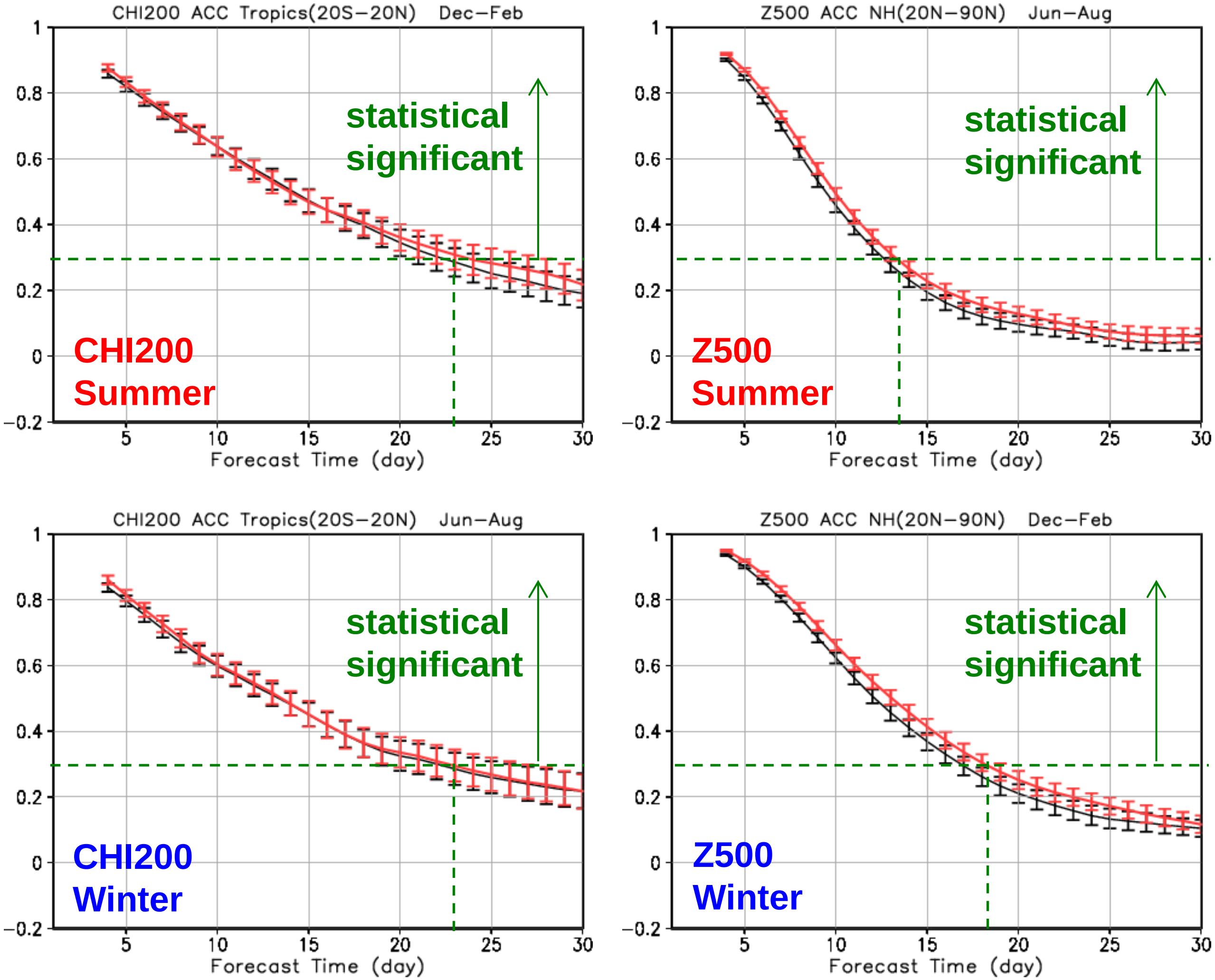
Scores for Tropics.
Upward trend can be seen but scores longer than 2-week forecast is well influenced by climatological events such as ENSO.

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)



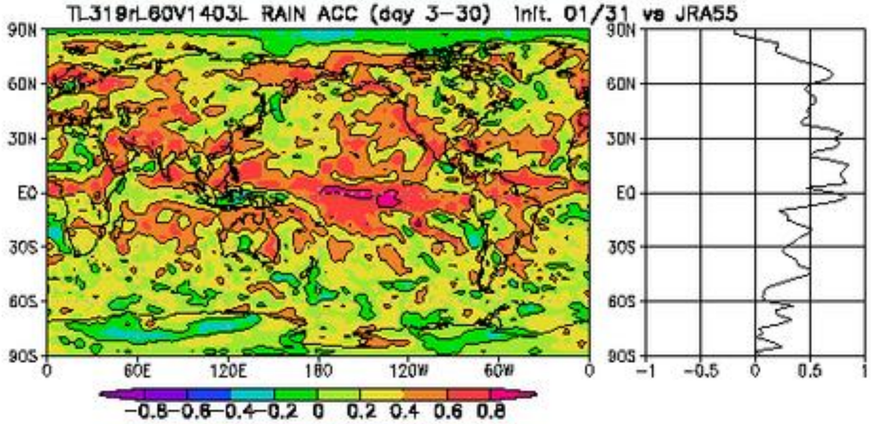
How many days are predictable?

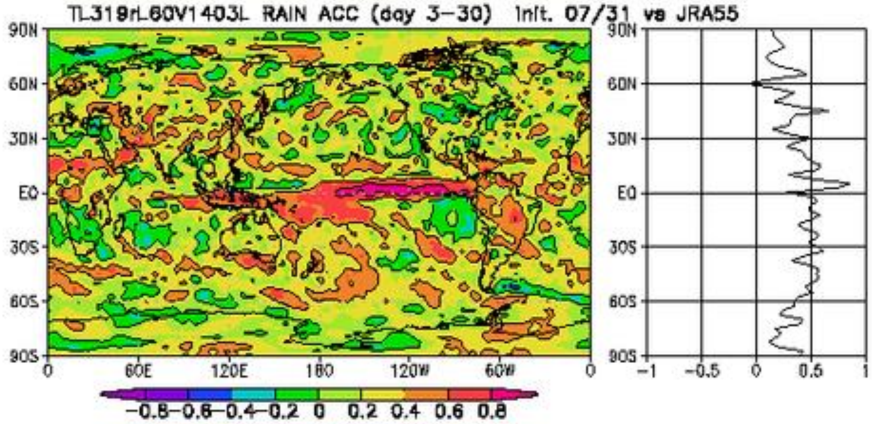
- **CHI200** in tropics is averagely predictable **up to 20-25days** with small seasonal dependency.
- **Z500** in northern hemisphere is averagely predictable **up to 14-18 days** with large seasonal dependency.

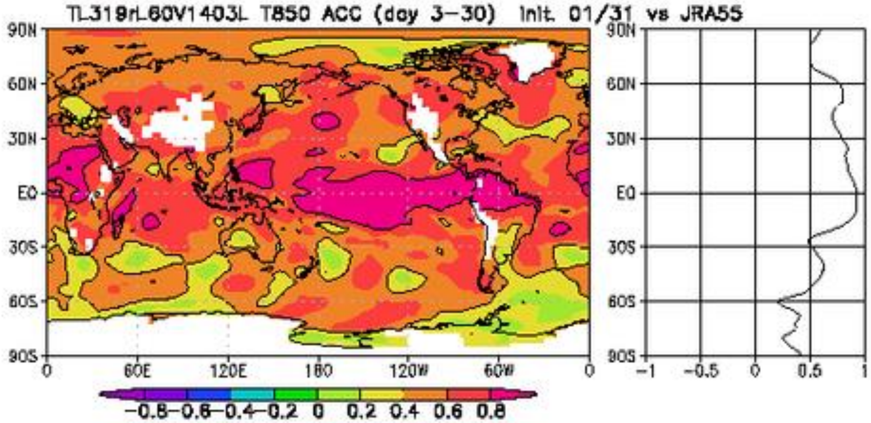
according to anomaly correlation scores.

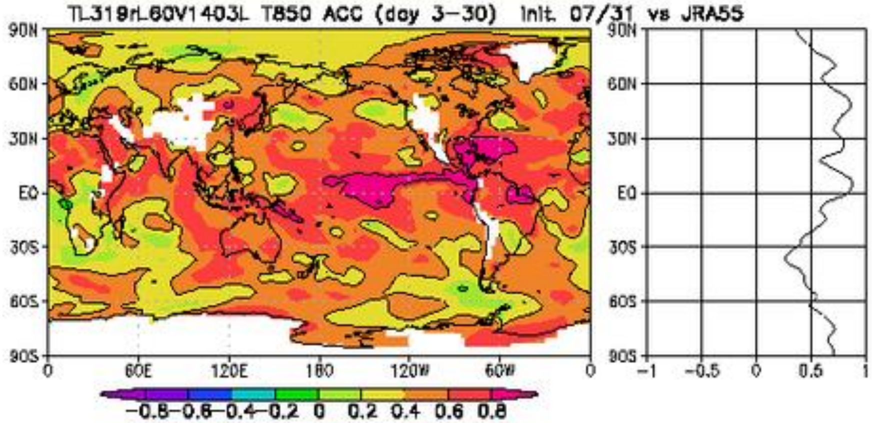
Spatial Prediction Skill of One-month EPS

Hindcast experiments for 30 years (1981 – 2010)









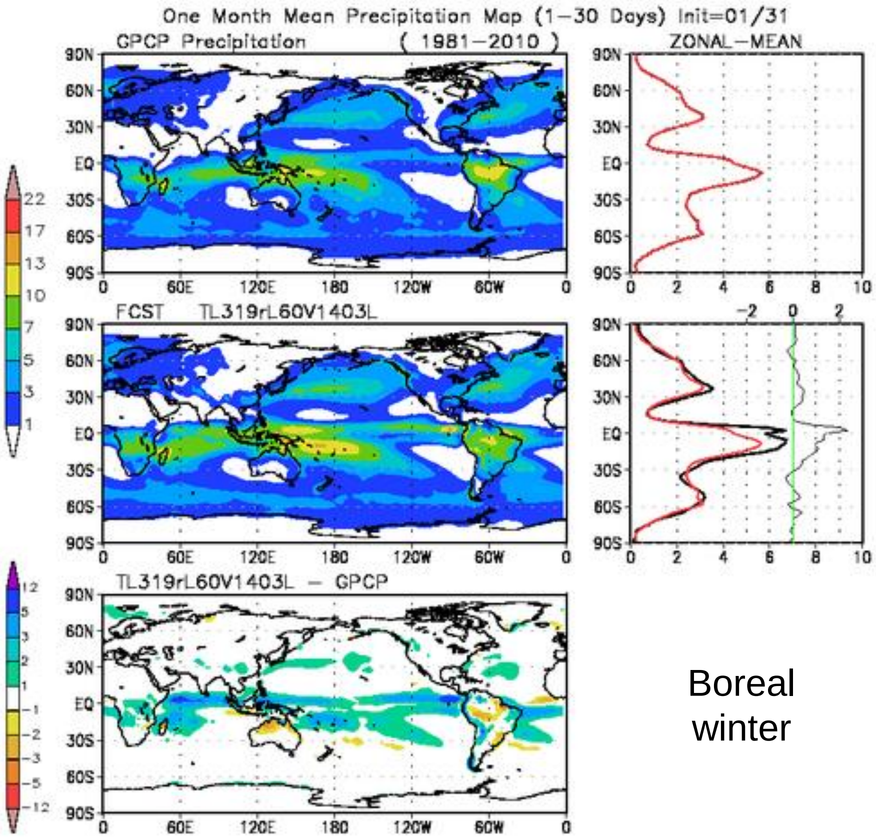
Boreal winter

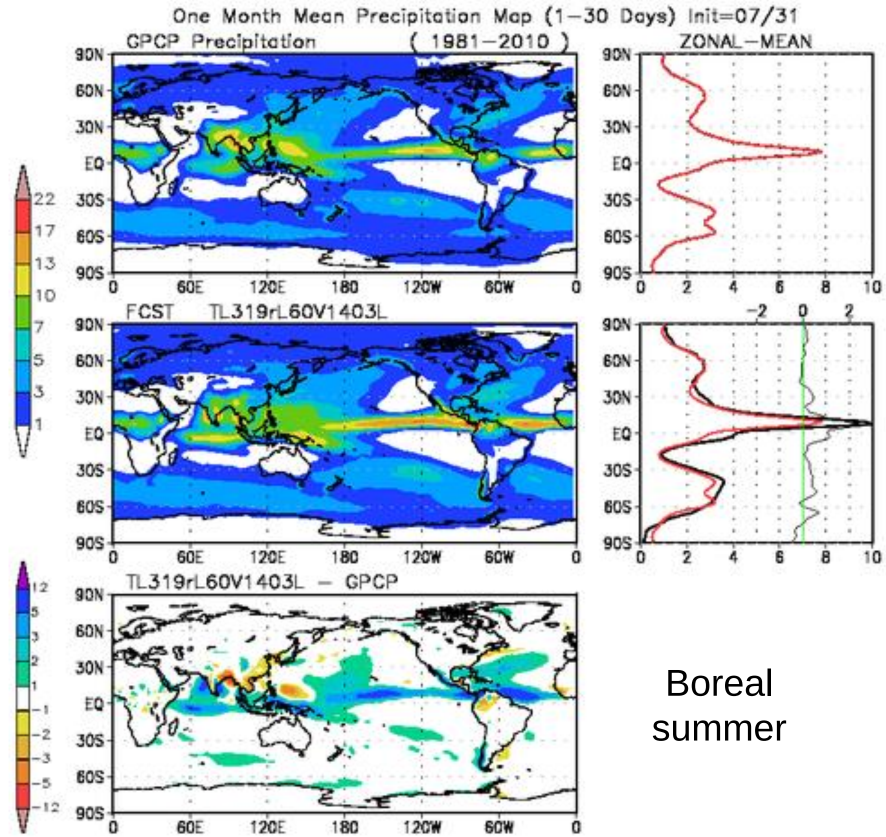
Boreal summer

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

Verification of One-month EPS for Precipitation

Hindcast experiments for 30 years (1981 – 2010)



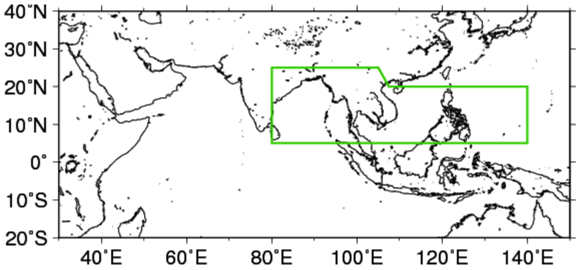


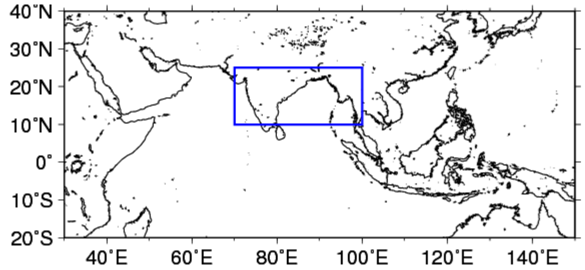
The distribution of predicted zonal mean precipitation is similar to that of observation, but overestimated in tropics regardless of season.

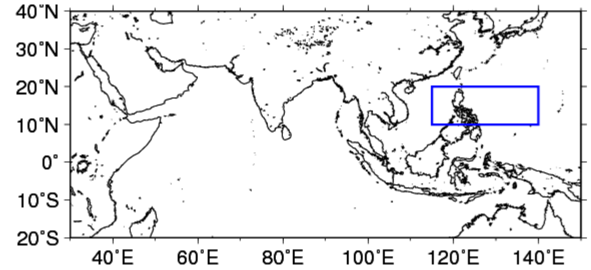
http://ds.data.jma.go.jp/tcc/tcc/products/model/hindcast/1mE/tromap.html

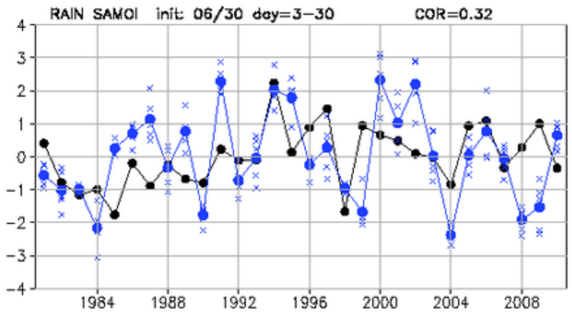
Verification of One-month EPS for Monsoon

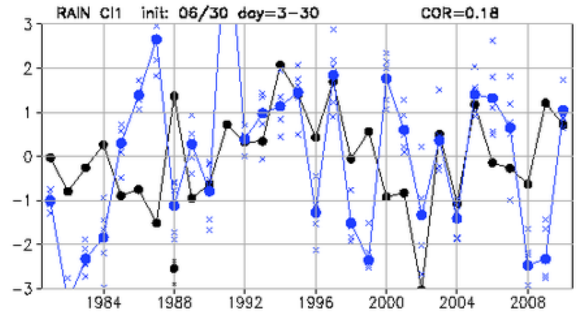
Hindcast experiments for 30 years (1981 – 2010)

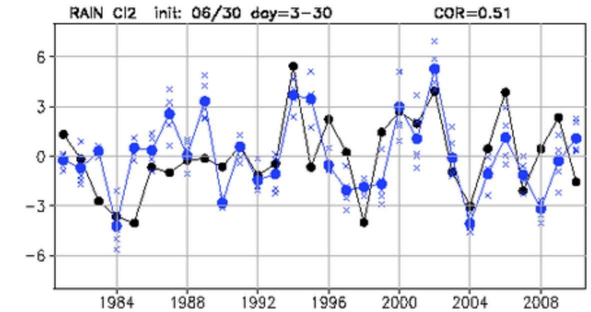


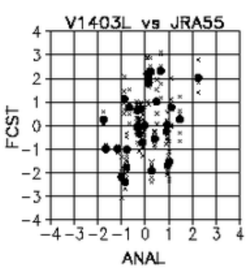




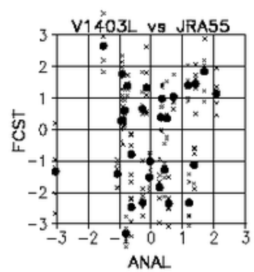




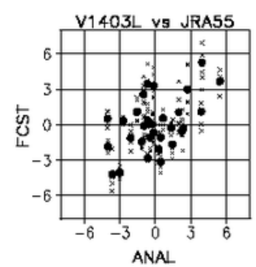




Significant



Low

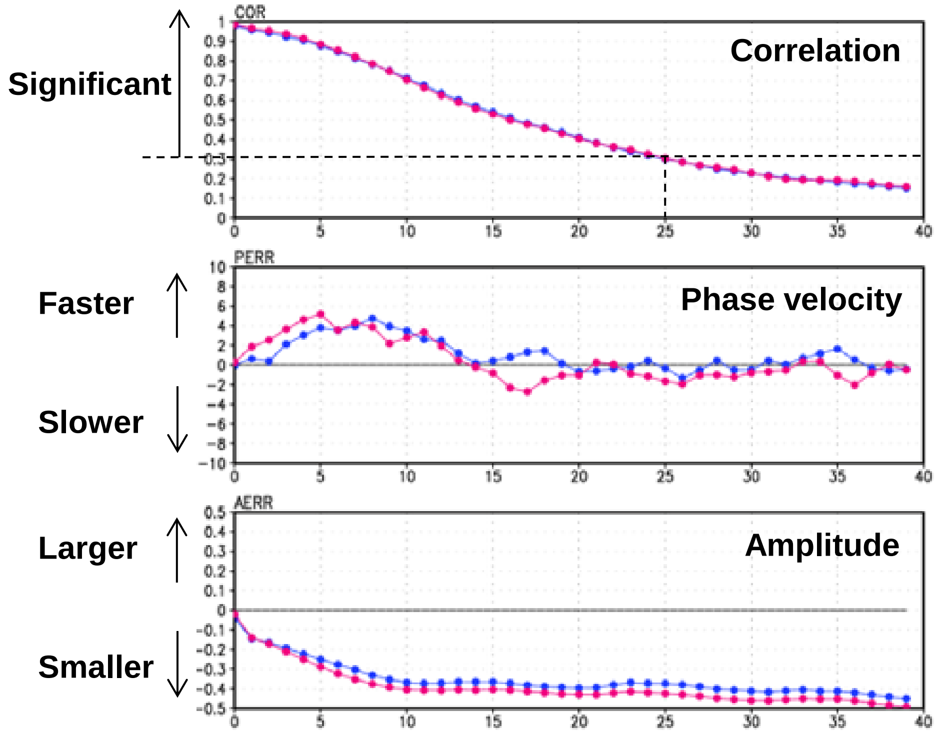


Good

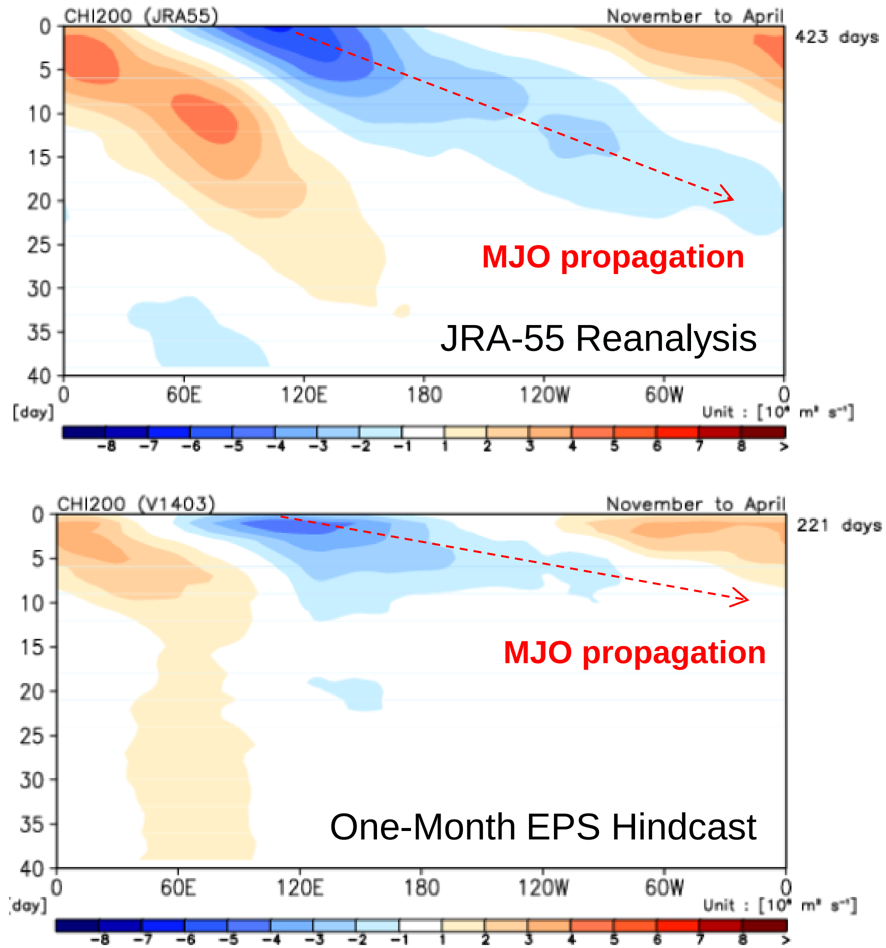
http://ds.data.jma.go.jp/tcc/tcc/products/model/hindcast/1mE/tromap.html

Verification of One-month EPS for MJO

Hindcast experiments for 30 years (1981 – 2010)



Red: Current Model, Blue: Previous Model

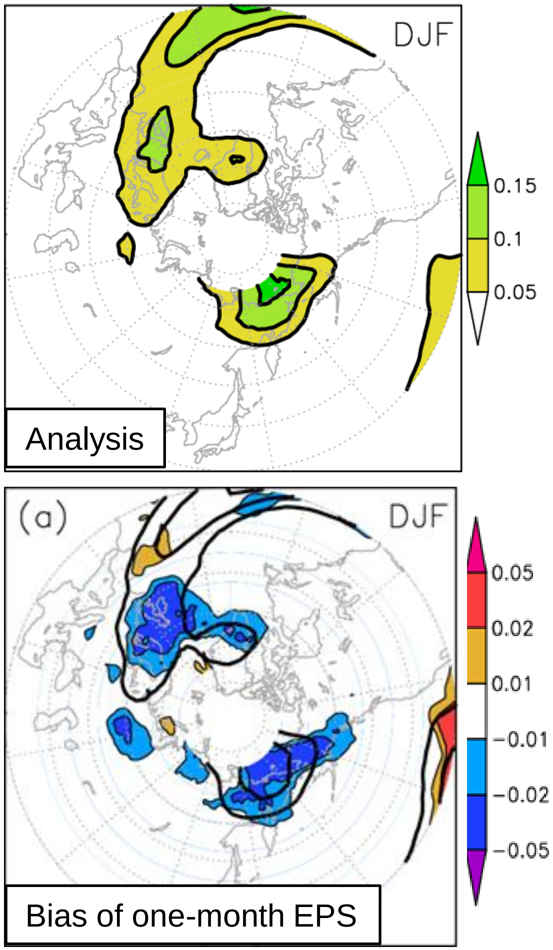


CHI200 Hovemoller diagram from MJO phase 3

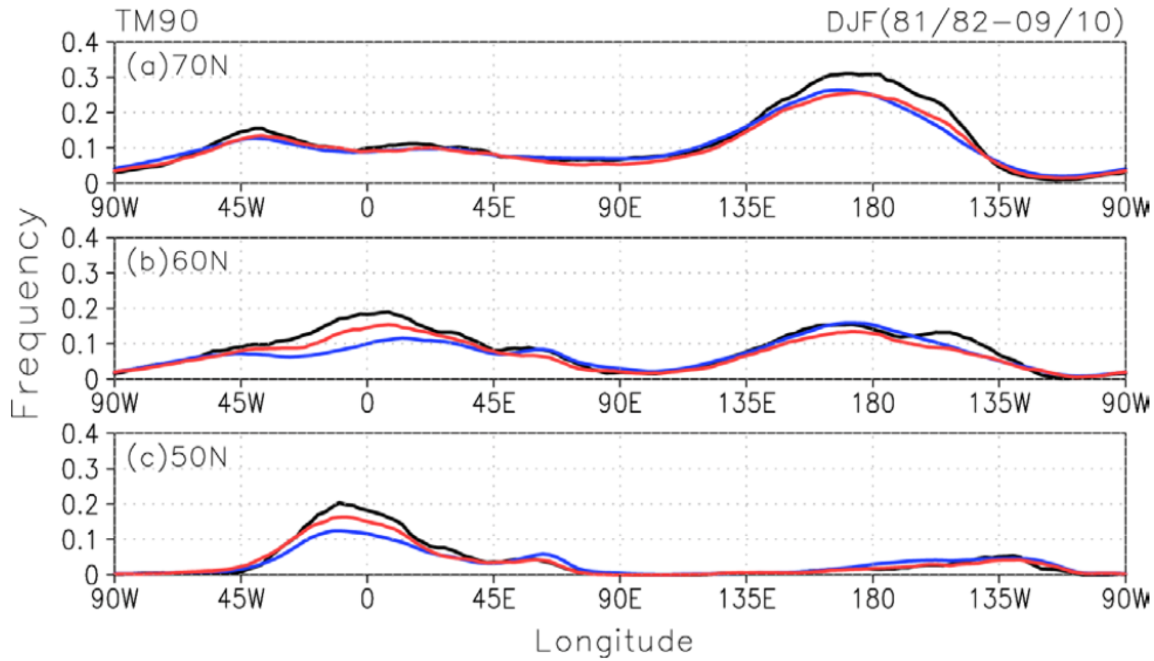
MJO is **predictable up to 25 days**.
However, **faster bias of phase velocity** and **smaller bias of amplitude** can be seen.

Verification of One-month EPS for Blocking-High

Hindcast experiments for 30 years (1981 – 2010)



Averaged frequency of Bloking High



Frequency of Blocking High for DJF

Red: Current Model, Blue: Previous Model

Based on the detection method of Tibaldi and Molteni (1990) and Scherrer et al. (2006), the frequency of blocking high predicted by one-month EPS tends to be a little underestimated.

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  - NWP Model and Predictability
  - Ensemble Prediction and Uncertainty
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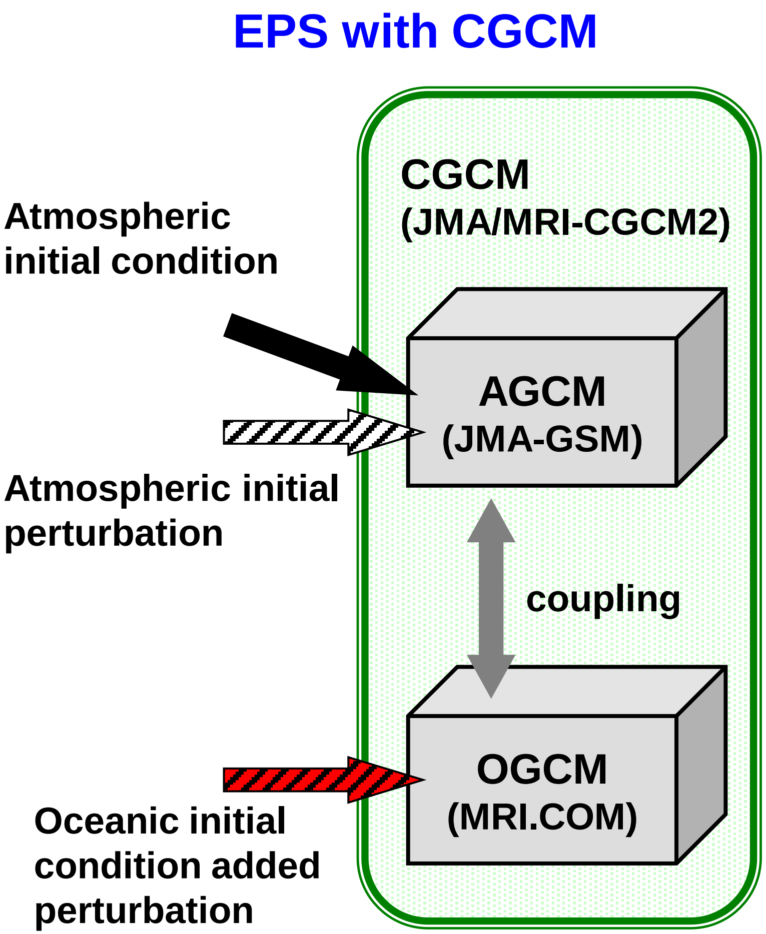
- JMA’s NWP Models
  - JMA’s One-month Ensemble Prediction System
  - JMA’s Seasonal Ensemble Prediction System
- TCC’s NWP Model Products

Specification of Seasonal EPS

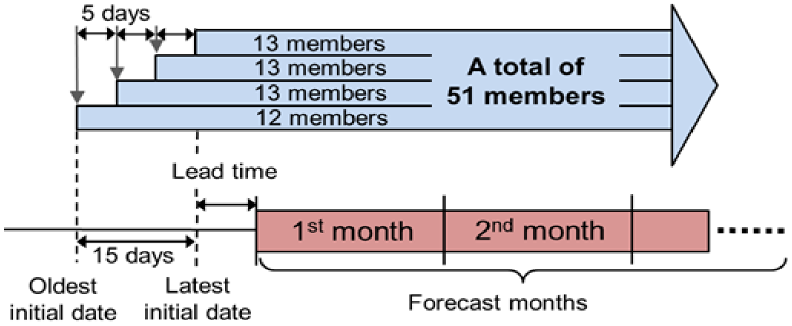
as of Nov.2015

Seasonal EPS

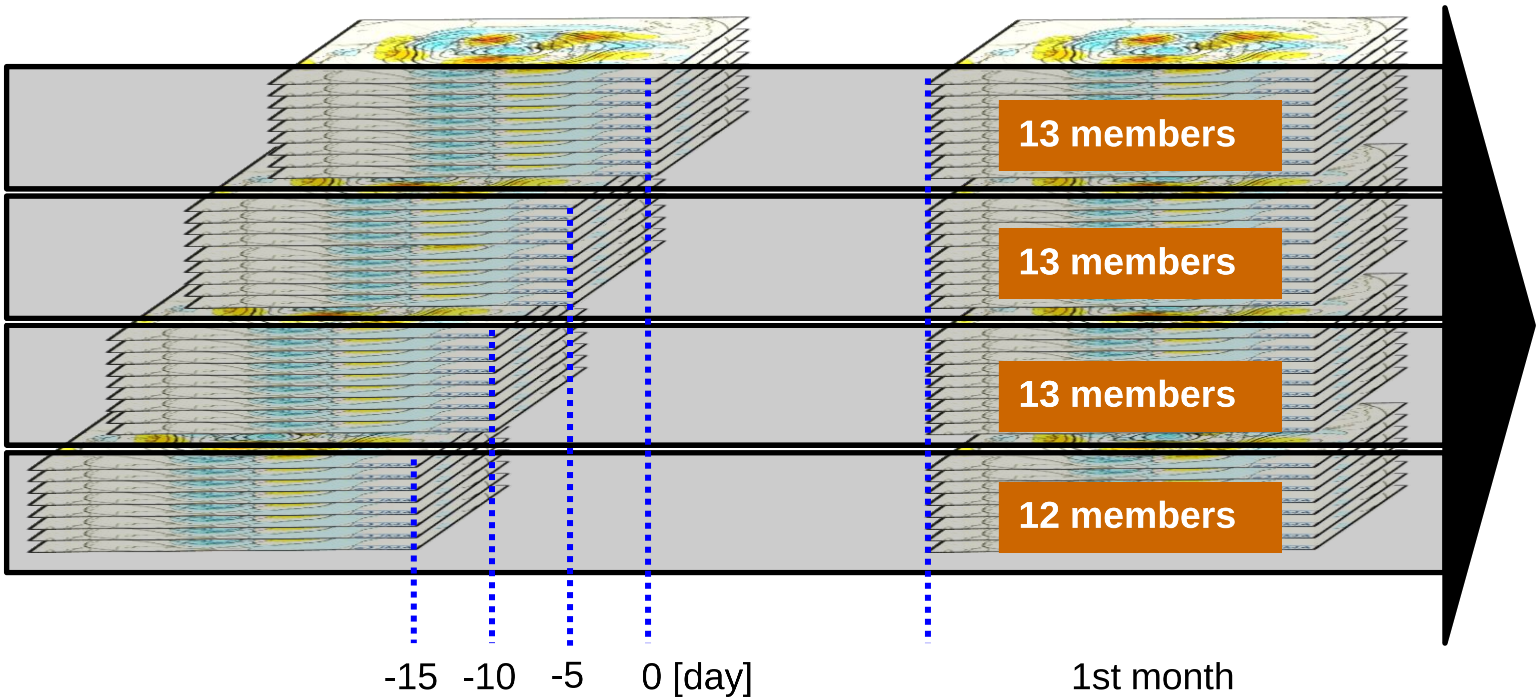


Upgrade	Last: June 2015 Frequently: Every Half Decade
Model	CGCM
Atmosphere Resolution	Horizontal: 110km (TL159) Vertical: 60 levels up to 0.1hPa
Ocean Resolution	Horizontal: 1.0 Lon x 0.3-0.5 Lat Vertical: 52 Levels + BBL With Tri-polar Grid
Forecast range	Up to 4 or 7 months
Initial Condition	Atmosphere: JRA-55 Land: JRA-55 Ocean: MOVE/MRI.COM-G2
Ensemble method	BGM, LAF, Stochastic Physics Scheme
Ensemble size	51 (13 BGMs & 4 days LAF with 5-day interval)
Freq. of model product creation	Once a month (Around 20th of every month)

Ensemble techniques for Seasonal EPS

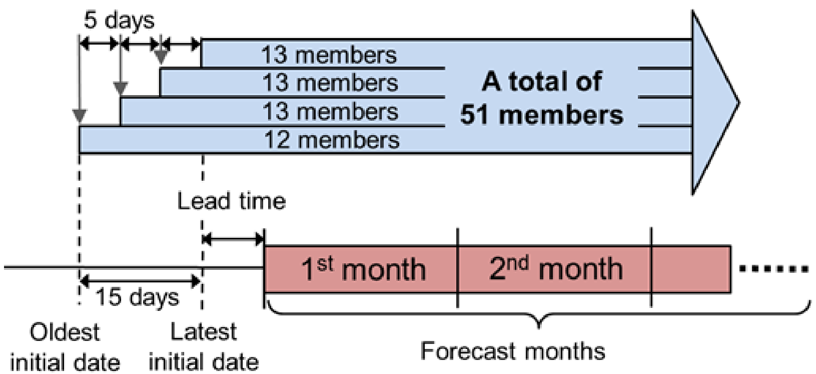


Initial perturbations are created with **the combination of BGM and LAF** method
- to disperse computing resources
- to get ensemble spread



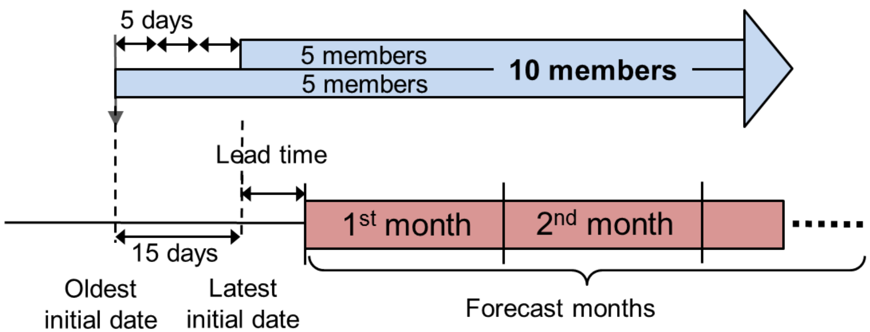
Hindcast for Seasonal EPS

■Operational Forecast



Initial Month	Initial dates of the LAF ensemble
January	27 Dec., 12 Dec.
February	31 Jan., 16 Jan.
March	25 Feb., 10 Feb.
April	27 Mar., 12 Mar.
May	26 Apr., 11 Apr.
June	31 May, 16 May
July	30 Jun., 15 Jun.
August	30 Jul., 15 Jul.
September	29 Aug., 14 Aug.
October	28 Sep., 13 Sep.
November	28 Oct., 13 Oct.
December	27 Nov., 12 Nov.

■Hindcast



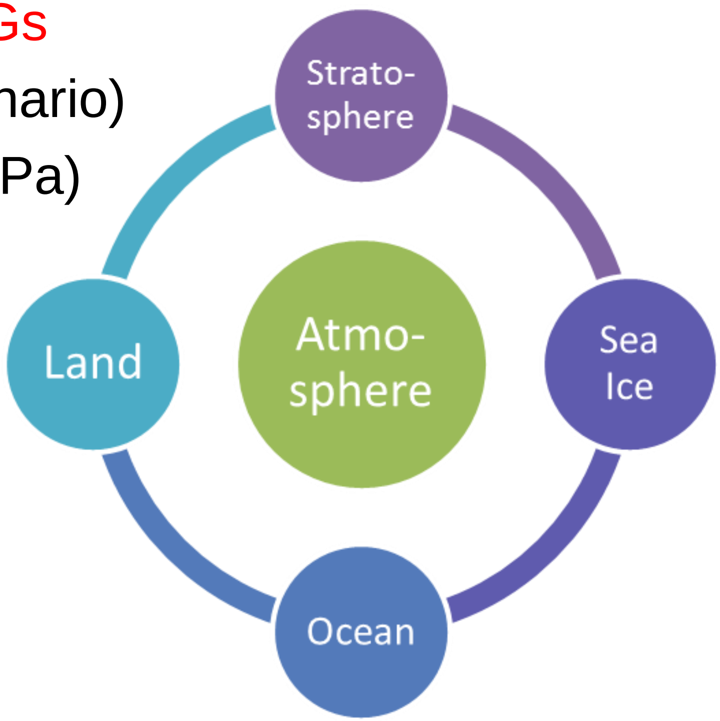
- Hindcast model is essentially same as operational forecast model in terms of initial conditions and sampling strategy except for ensemble size and initial date.
- The number of ensemble size is smaller than operational forecast and the initial date is only twice a month.
- The period for hindcast is 36 years from 1979 to 2014.

New Sources of Predictability

New Predictability Sources since Last Update (June 2015)

1. Dynamical sea ice simulation
2. Land initialization with JRA-55
3. Global ocean domain
4. More sophisticated description of GHGs
   (6 gases prescribed with RCP4.5 scenario)
5. Fully covered stratosphere (Top: 0.1hPa)

The new system since June 2015 is capable of incorporating a full range of potential sources of the predictability.



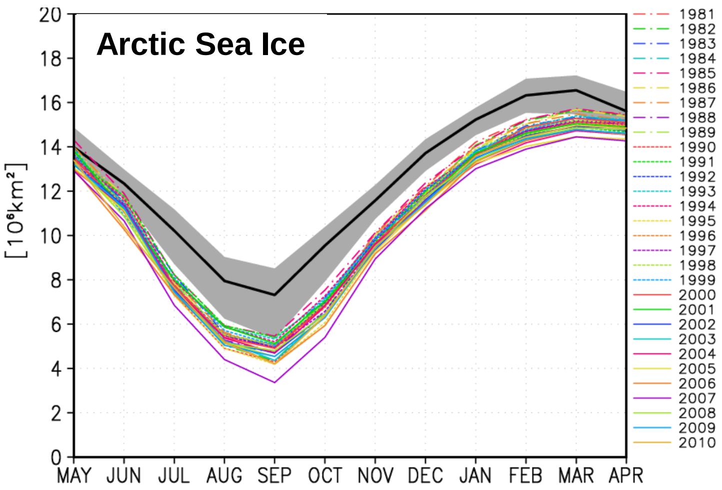
Dynamical Sea Ice Simulation

■ Interactive sea-ice model

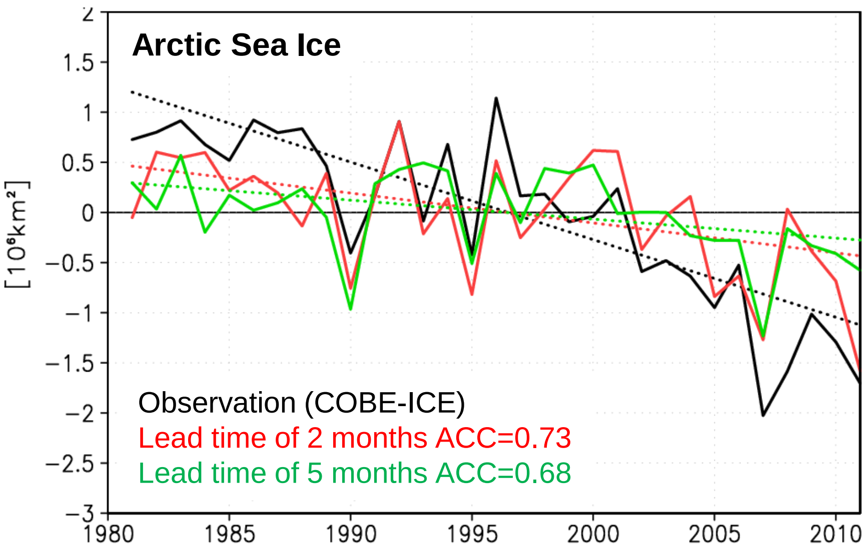
Hindcast experiments for 30 years (1981 – 2010)

– Thermodynamic model (sea-ice production / melting)

– Dynamic model (momentum equation)



Color: Individual forecast
Black and Grey: Observed climatology (COBE-ICE)
(Grey) minimum and maximum



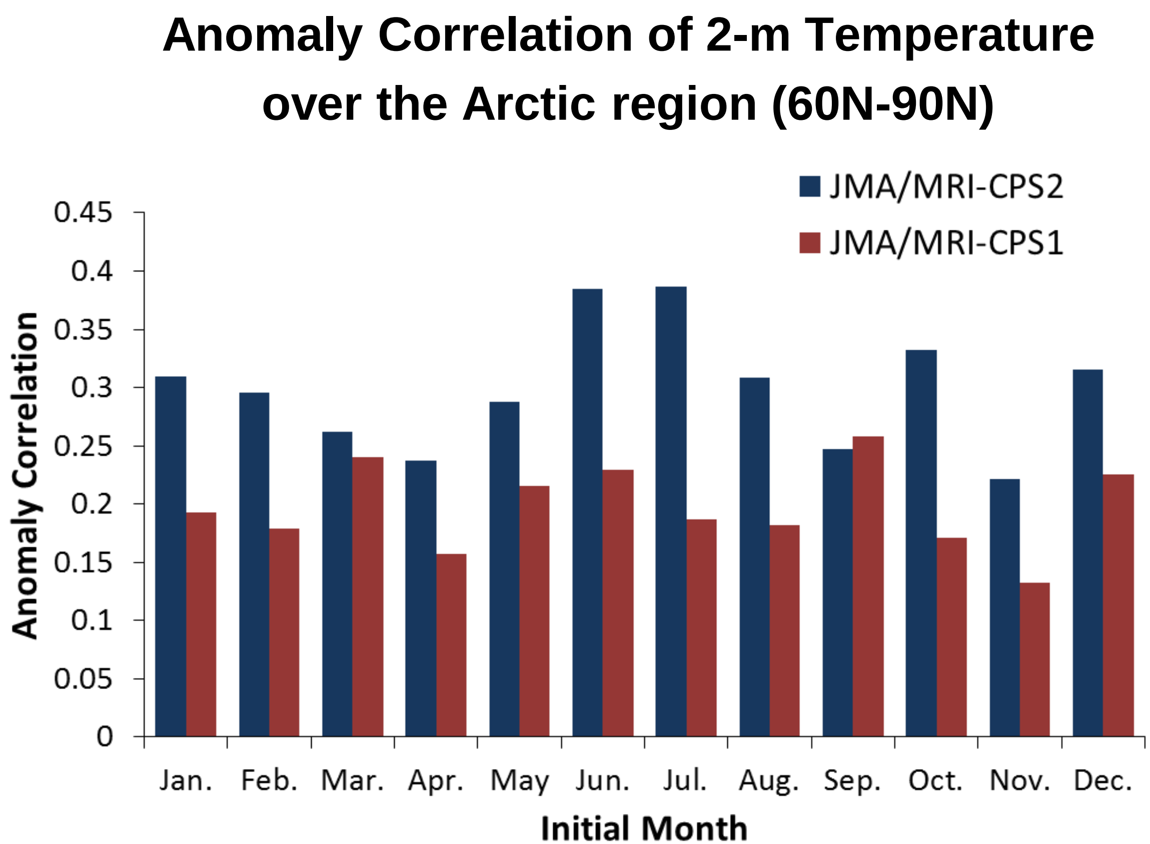
Annual variation is good but smaller bias can be seen.

Sea ice melting trend is smaller than observation.

This sea ice model can represent
- Seasonal variation of sea ice extent
- Inter-annual variability and reduction trend of sea-ice extent

Dynamical Sea Ice Simulation

Hindcast experiments for 30 years (1981 – 2010)

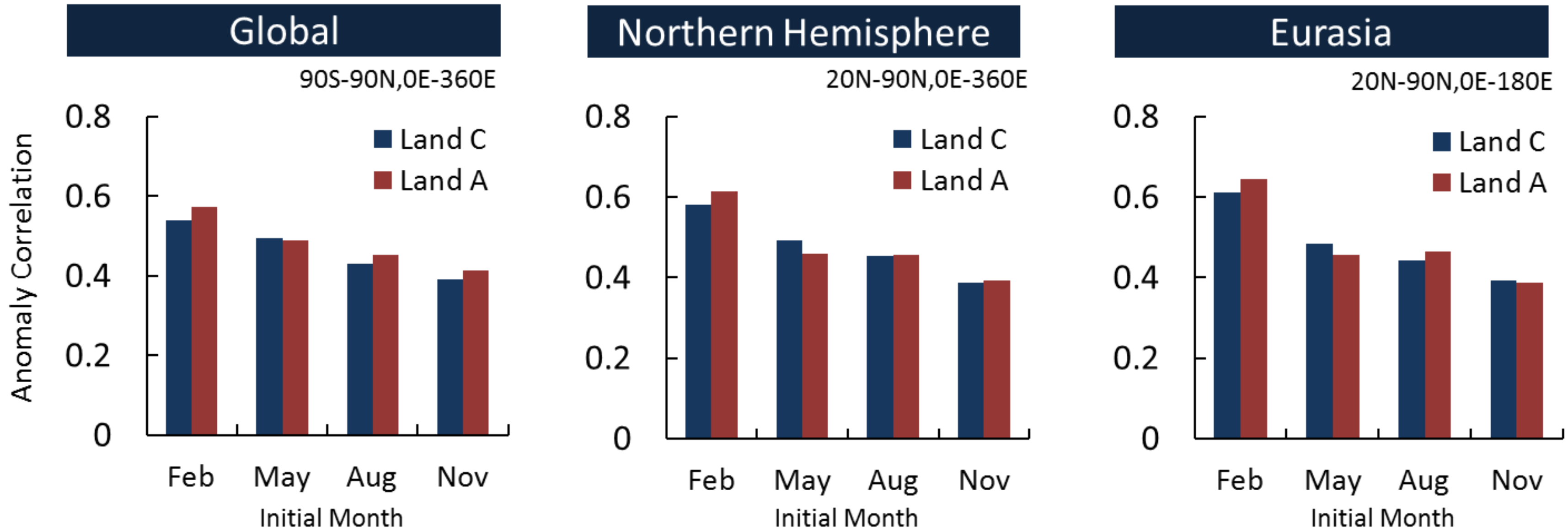


Prediction skill of 2-m temperature is much improved over the Arctic region for most of initial month, suggesting sea-ice model contribution to this improvement.

Land Initialization

Hindcast experiments for 30 years (1981 – 2010)

Comparison of Anomaly Correlation of 2-m Temperature
(Lead Time: 0 month)



Land C ･･･ Land Initialization is Climatology

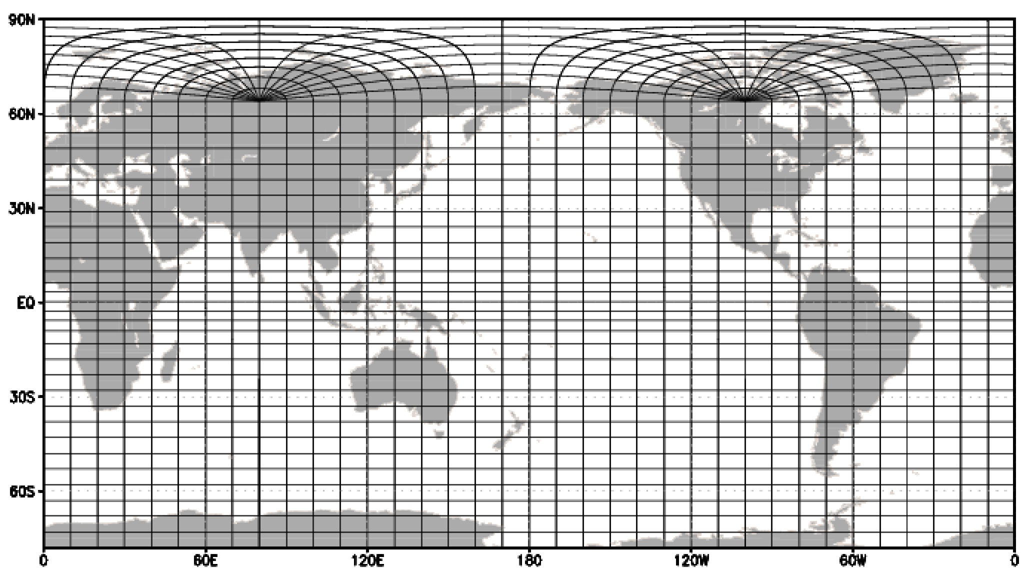
Land A ･･･ Land Initialization is Analysis with JRA-55

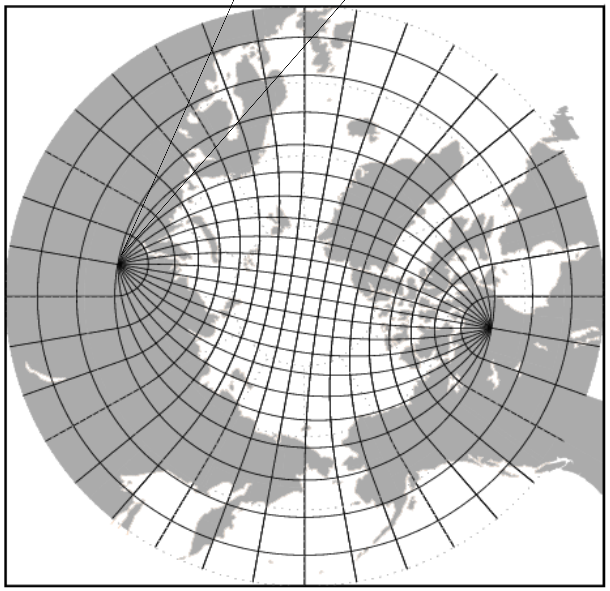
Land Initialization slightly improved prediction skill.
(except for May)

Global Ocean Domain

- Horizontal resolution
  - Longitude direction: 1° (approximately 100km)
  - Latitude direction: 0.3-0.5° (approximately 30-50km) with finer resolution near the equator
- Vertical level: 52 and BBL(bottom boundary layer)
- Global ocean with tri-polar grid

Singular grid is located on land for tri-polar grid

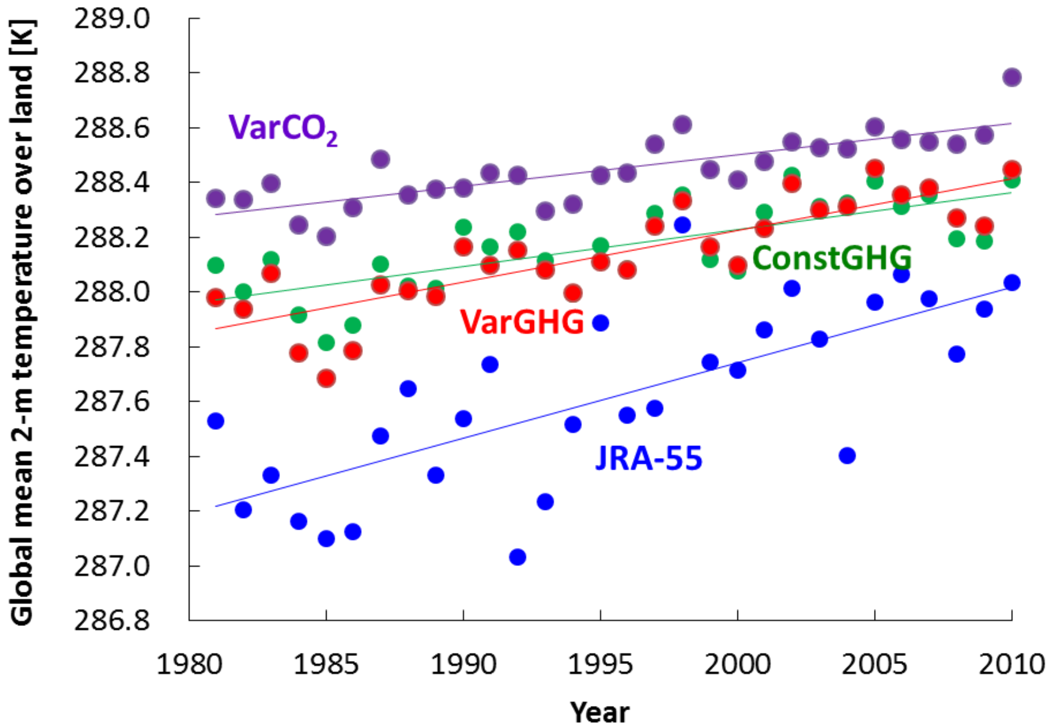




Green House Gases Forcing

Hindcast experiments for 30 years (1981 – 2010)

2-m temperature Trend over Land (JJA)   (Initial: May)



VarCO$_2$
- JMA/MRI-CPS1
- CO$_2$ Trend

VarGHG
- **JMA/MRI-CPS2:**
- CO$_2$, CH$_4$, N$_2$O, CHC-11, CHF-12, HCFC-22 (GHGs) Trend (Based on RCP 4.5 scenario)

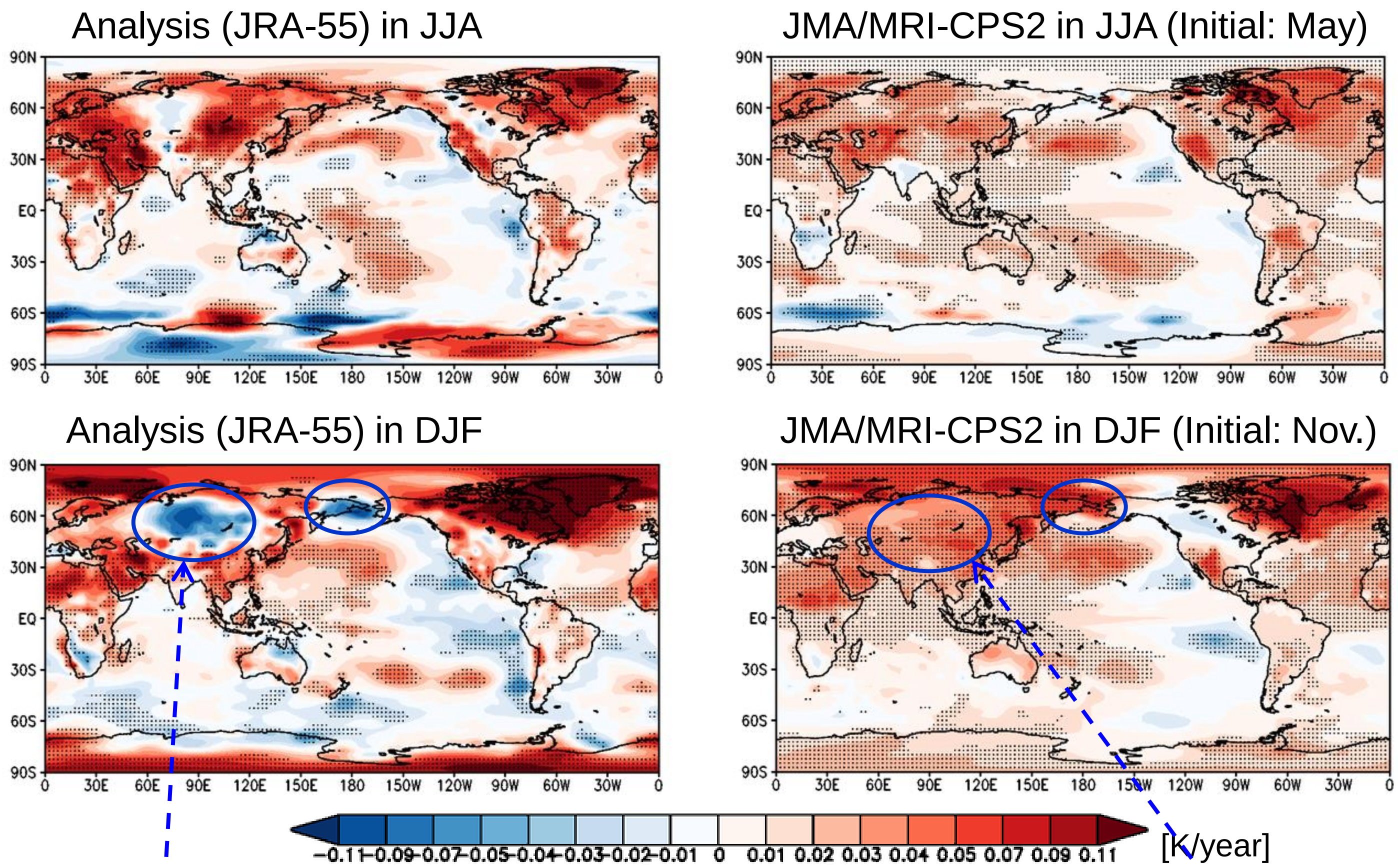
ConstGHG
(Additional experiment)
- JMA/MRI-CPS2
- Constant GHGs

linear trend of 2-m temperature over land
ConstGHG ≒ VarCO$_2$ < VarGHG < JRA-55(Analysis)

Global Warming Trend

Hindcast experiments for 30 years (1981 – 2010)

2-m temperature linear trend



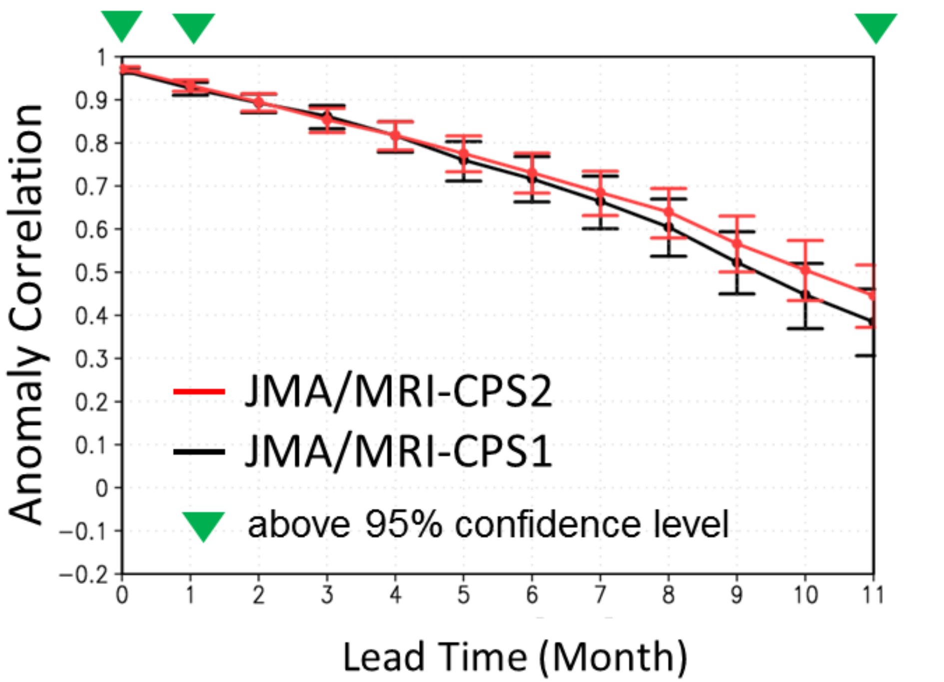
Cooling trend is visible in winter.

Cooling trend is invisible in winter.

Prediction Skill for El Niño forecast

Hindcast experiments for 30 years (1981 – 2010)

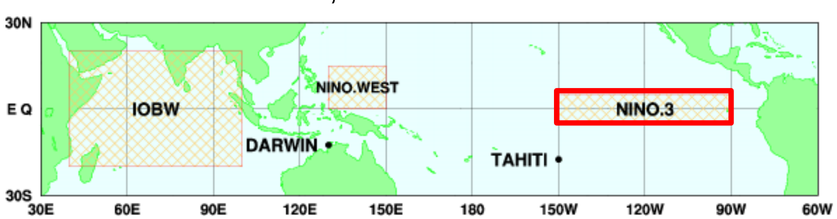
ACCs of NINO3 SST (all months, 10 members)



ACC Cgcm5 1981–2010
SST NINO3 En10

MONTH \ Lead Time [mon]	0	1	2	3	4	5	6	7	8	9	10	11
1	0.95	0.94	0.92	0.91	0.88	0.82	0.84	0.80	0.76	0.68	0.58	0.46
2	0.94	0.91	0.87	0.82	0.81	0.81	0.71	0.75	0.73	0.69	0.59	0.44
3	0.93	0.87	0.83	0.77	0.78	0.77	0.78	0.69	0.76	0.71	0.70	0.60
4	0.94	0.88	0.81	0.77	0.74	0.72	0.73	0.73	0.63	0.70	0.72	0.65
5	0.94	0.88	0.83	0.80	0.71	0.61	0.58	0.61	0.59	0.44	0.49	0.53
6	0.94	0.88	0.82	0.77	0.73	0.64	0.51	0.53	0.57	0.48	0.38	0.38
7	0.93	0.86	0.81	0.74	0.71	0.70	0.56	0.45	0.54	0.54	0.40	0.41
8	0.94	0.91	0.86	0.80	0.73	0.69	0.66	0.52	0.41	0.50	0.51	0.39
9	0.95	0.90	0.88	0.82	0.76	0.70	0.67	0.57	0.46	0.30	0.42	0.46
10	0.95	0.93	0.88	0.88	0.80	0.75	0.68	0.66	0.58	0.40	0.28	0.43
11	0.96	0.94	0.92	0.88	0.89	0.81	0.77	0.70	0.66	0.58	0.45	0.32
12	0.96	0.95	0.93	0.89	0.85	0.87	0.82	0.77	0.70	0.62	0.54	0.43

NINO.3 150W-90W, 5S-5N



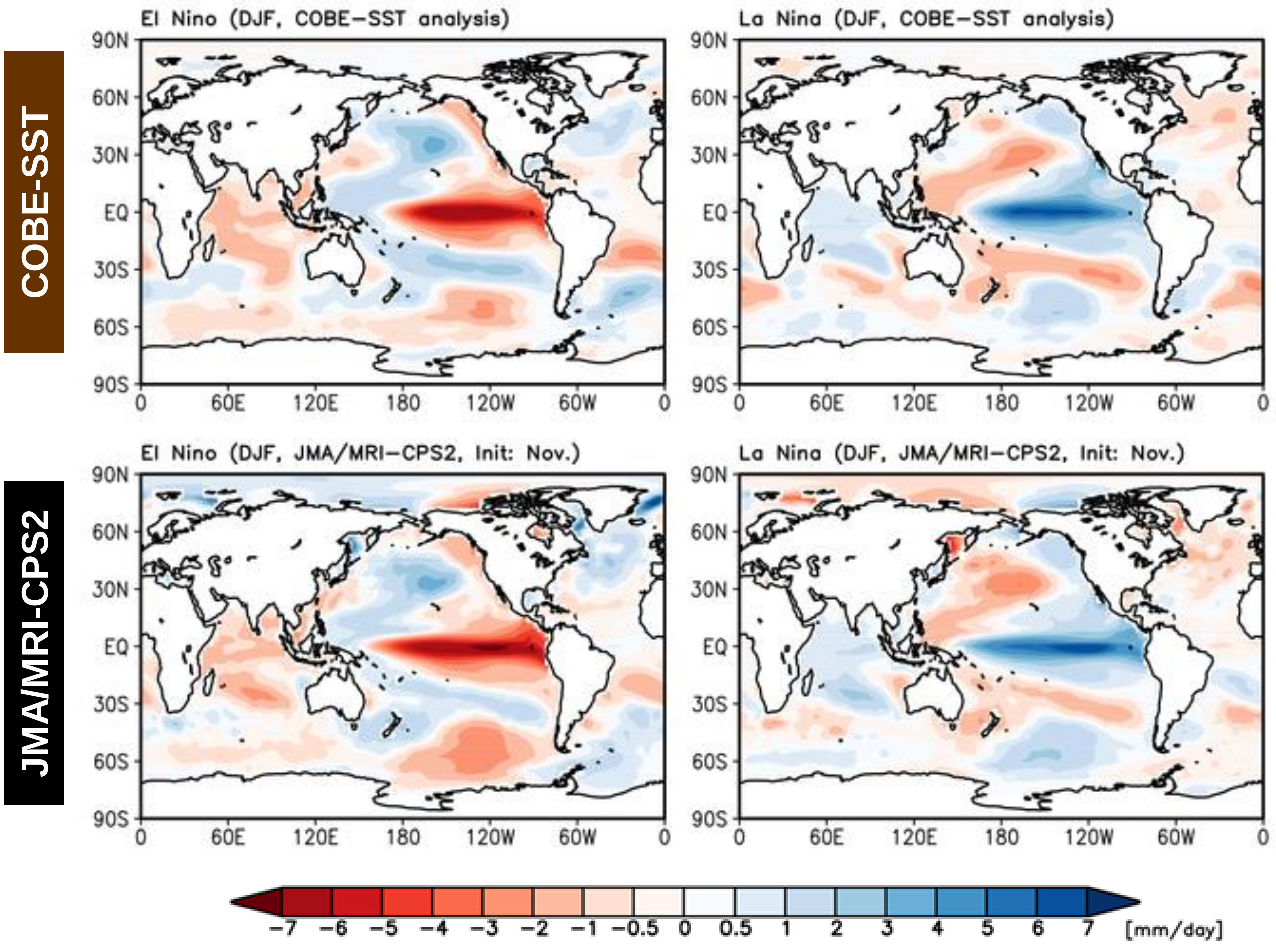
Forecasts through autumn and winter are **high skill**.

Spring Barrier
Forecasts through spring season are **low skill**.

Prediction Skill for El Niño forecast

Hindcast experiments for 30 years (1981 – 2010)

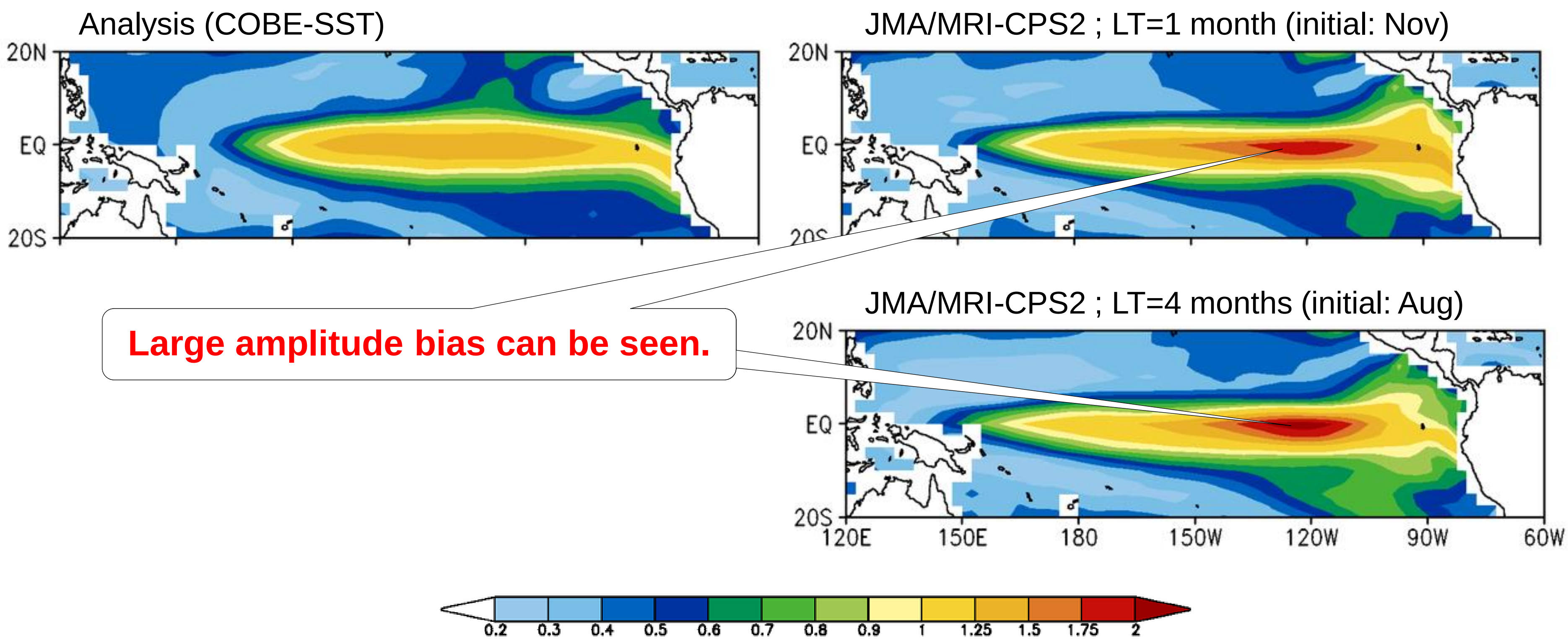
El Niño / La Niña SST Composite



Prediction Skill for El Niño forecast

Hindcast experiments for 30 years (1981 – 2010)

SST Standard Deviation for DJF



Prediction Skill for Niño.WEST and IOBW

Forecasts through **spring is high skill**.

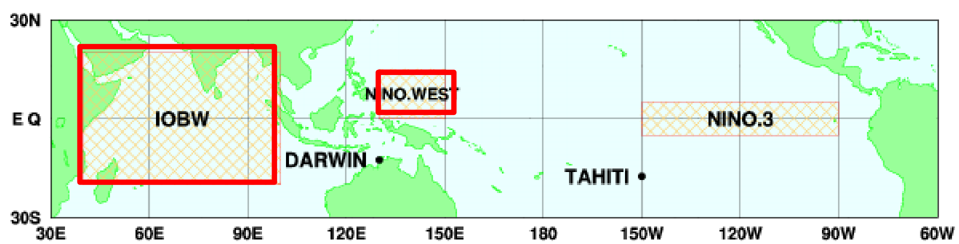
IOBW

MONTH \ Lead Time [mon]	0	1	2	3	4	5	6	7	8	9	10	11
1	0.87	0.83	0.84	0.82	0.82	0.83	0.80	0.76	0.69	0.73	0.72	0.68
2	0.91	0.84	0.83	0.82	0.80	0.81	0.80	0.75	0.72	0.69	0.68	0.70
3	0.89	0.85	0.79	0.76	0.75	0.76	0.78	0.78	0.77	0.75	0.73	0.72
4	0.88	0.88	0.89	0.84	0.82	0.83	0.85	0.85	0.84	0.85	0.78	0.76
5	0.82	0.78	0.76	0.79	0.80	0.78	0.82	0.83	0.80	0.79	0.84	0.79
6	0.87	0.75	0.65	0.70	0.79	0.79	0.77	0.80	0.80	0.81	0.77	0.80
7	0.87	0.78	0.59	0.57	0.58	0.72	0.67	0.67	0.70	0.68	0.73	0.68
8	0.87	0.81	0.75	0.54	0.52	0.52	0.63	0.55	0.60	0.69	0.67	0.72
9	0.89	0.79	0.70	0.68	0.50	0.43	0.42	0.53	0.45	0.50	0.59	0.56
10	0.88	0.81	0.78	0.74	0.67	0.53	0.47	0.32	0.52	0.39	0.41	0.53
11	0.85	0.77	0.77	0.77	0.78	0.70	0.62	0.59	0.48	0.56	0.43	0.34
12	0.89	0.79	0.79	0.81	0.82	0.76	0.72	0.71	0.72	0.67	0.68	0.57

Niño.WEST

MONTH \ Lead Time [mon]	0	1	2	3	4	5	6	7	8	9	10	11
1	0.94	0.91	0.86	0.78	0.71	0.66	0.66	0.70	0.75	0.65	0.59	0.44
2	0.93	0.89	0.87	0.81	0.76	0.68	0.66	0.69	0.69	0.74	0.64	0.55
3	0.91	0.90	0.85	0.81	0.76	0.73	0.71	0.68	0.64	0.64	0.70	0.67
4	0.85	0.80	0.81	0.75	0.74	0.69	0.67	0.69	0.61	0.62	0.49	0.49
5	0.83	0.77	0.64	0.65	0.56	0.61	0.51	0.51	0.53	0.46	0.50	0.37
6	0.77	0.62	0.61	0.48	0.44	0.45	0.54	0.52	0.54	0.52	0.53	0.42
7	0.77	0.80	0.70	0.53	0.52	0.50	0.35	0.47	0.37	0.41	0.43	0.39
8	0.85	0.72	0.70	0.63	0.57	0.47	0.25	0.17	0.26	0.18	0.08	0.15
9	0.83	0.75	0.69	0.71	0.64	0.62	0.49	0.29	0.26	0.35	0.24	0.18
10	0.82	0.72	0.65	0.66	0.67	0.51	0.52	0.47	0.24	0.28	0.33	0.36
11	0.76	0.70	0.64	0.57	0.51	0.56	0.57	0.54	0.52	0.40	0.39	0.50
12	0.88	0.78	0.74	0.63	0.61	0.55	0.65	0.67	0.54	0.59	0.42	0.43

Forecasts through **autumn is low skill**.

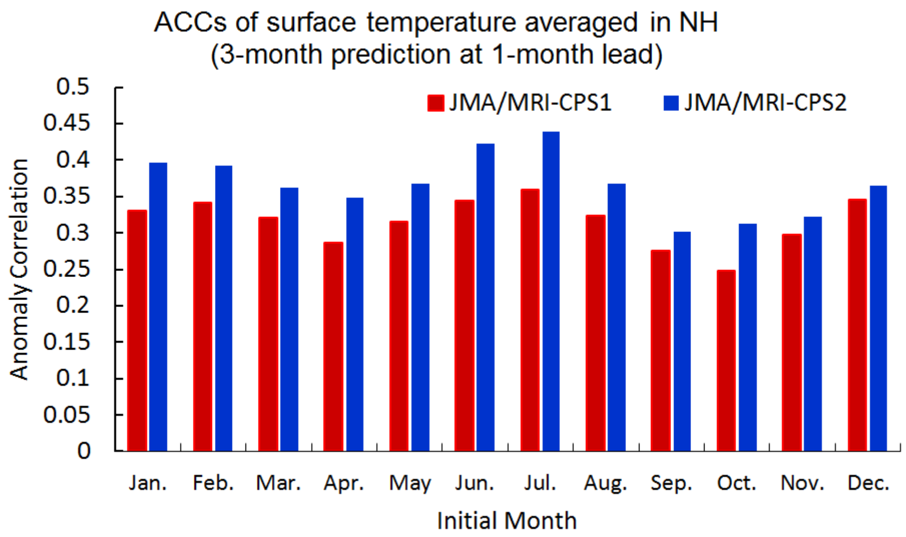


Forecasts through **tropical cyclone season is low skill**.

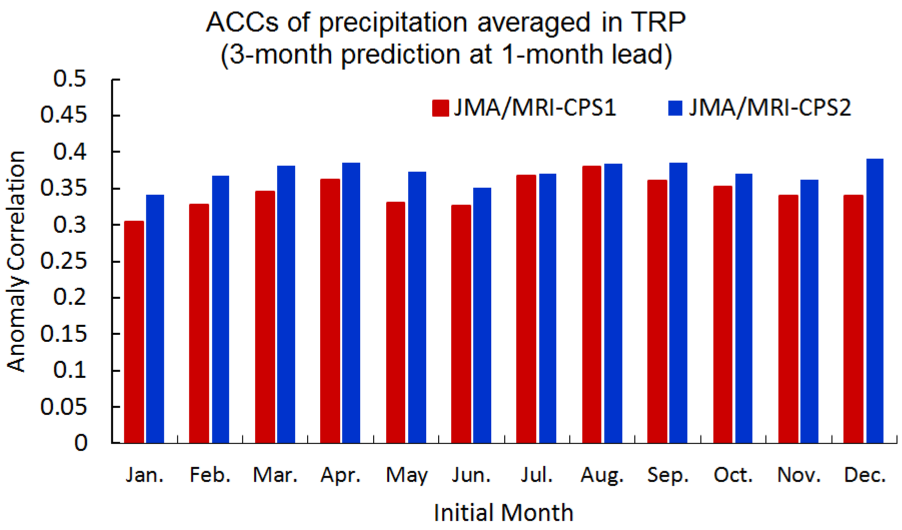
Prediction Skill for Seasonal forecast

Hindcast experiments for 30 years (1981 – 2010)

2m Temperature
(Northern Hemisphere)

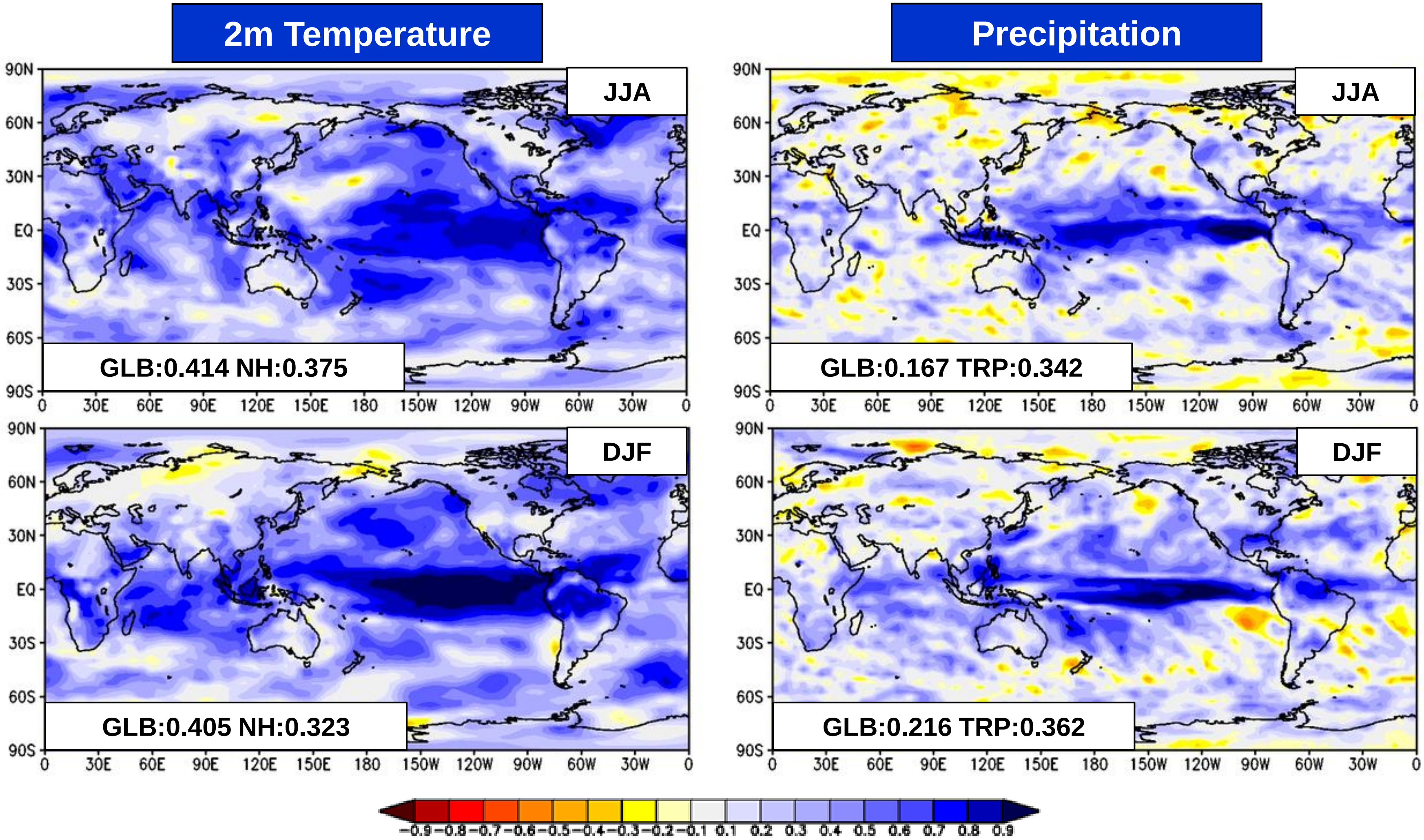


Precipitation
(Tropics)



Spatial Prediction Skill for Seasonal forecast

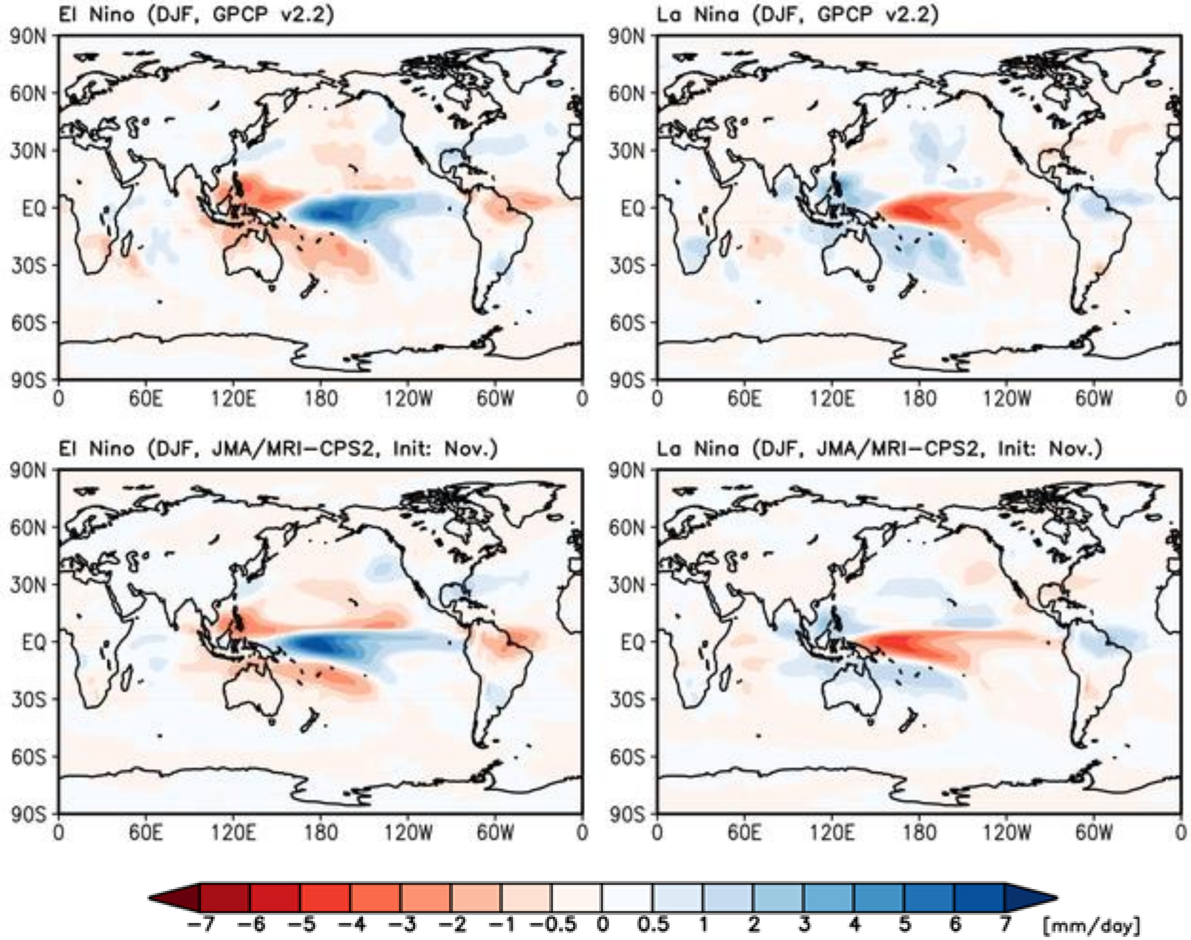
Hindcast experiments for 30 years (1981 – 2010)



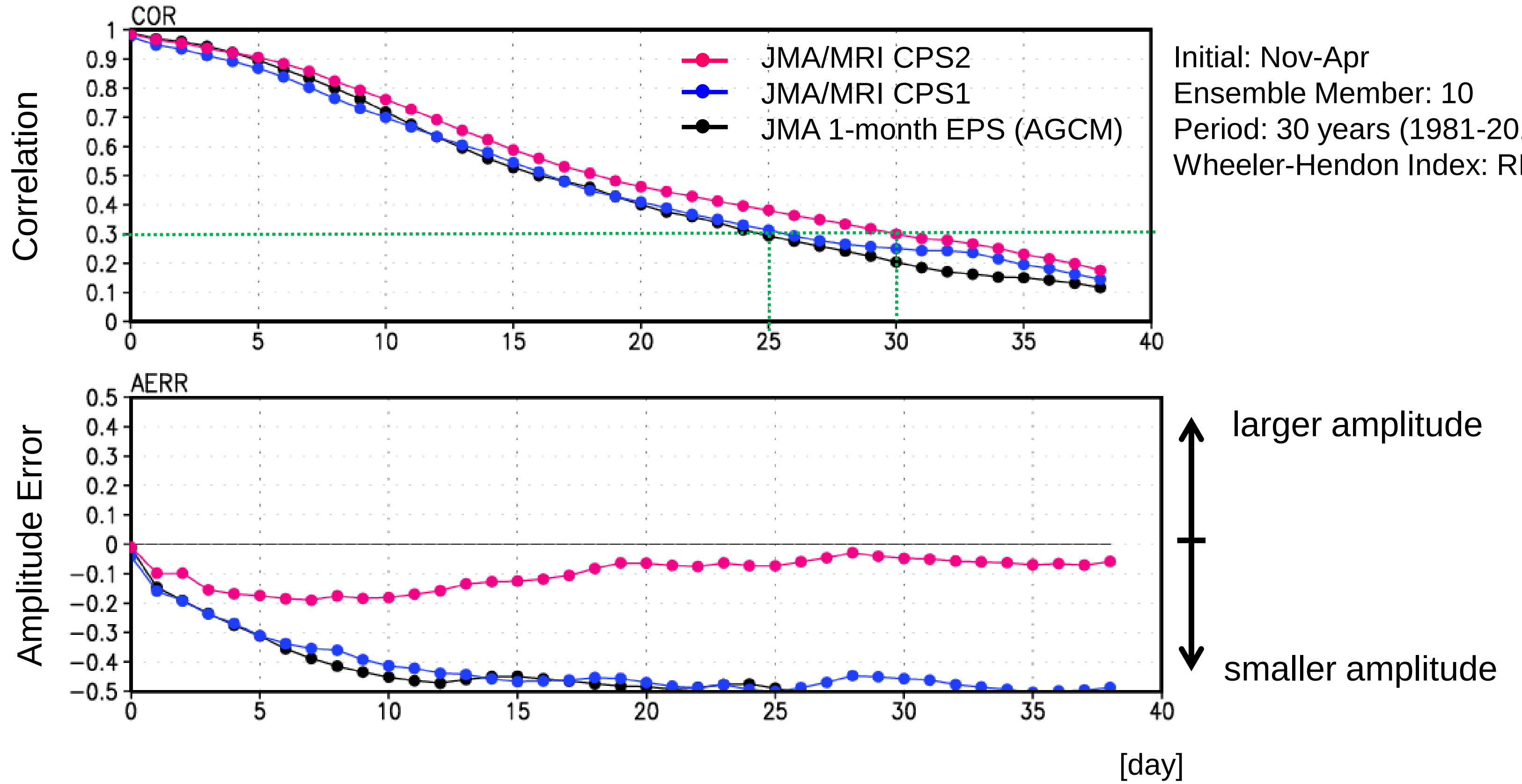
El Niño / La Niña Composite

Hindcast experiments for 30 years (1981 – 2010)

El Niño / La Niña Precipitation Composite



Verification of Seasonal EPS for MJO



Initial: Nov-Apr
Ensemble Member: 10
Period: 30 years (1981-2010)
Wheeler-Hendon Index: RMM1, RMM2

The MJO forecast skill of Seasonal EPS is better than that of one-month EPS.
Especially, the MJO amplitude error of Seasonal EPS is much smaller than that of one-month EPS.

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- TCC's NWP Model Products

Introduction of TCC's NWP Model Products

Click "NWP Model Prediction" Tab on the top page of TCC website.

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

Introduction of TCC's NWP Model Products

A lot of NWP products are available smoothly through the NWP Model Products page.

Main Products

One-month Prediction

One-month Prediction (17 Sep 2015)
Z500, T850 & SLP (Northern Hemisphere) (17 Sep 2015)
Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (17 Sep 2015)
Verification (13 Sep 2015)
Hindcast
One-month Probabilistic Forecasts at station points

Monthly Discussion on Seasonal Climate Outlooks last updated : 28 Aug 2015

This product is intended to assist NMHSs in the Asia-Pacific region in interpreting GPC Tokyo's three-month prediction and warm/cold season prediction products.

Seasonal Prediction

Three-month Prediction

Three-month Prediction (10 Sep 2015)
Z500, T850 & SLP (Northern Hemisphere) (10 Sep 2015)
Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (10 Sep 2015)
Verification (06 Sep 2015)
Hindcast Verification (JMA/MRI-CPS2) NEW
Probabilistic Forecast and Verification (15 Sep 2015)
SST Index Time-series Forecast NEW (10 Sep 2015)

Warm/Cold Season Prediction

Warm/Cold Season Prediction (10 Sep 2015)
Z500, T850 & SLP (Northern Hemisphere) (10 Sep 2015)
Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (10 Sep 2015)
Verification (30 Mar 2015)
Hindcast Verification (JMA/MRI-CPS2) NEW
Probabilistic Forecast and Verification

Extreme Weather Prediction (need Authentication)

Forecast Products in Support of Early Warnings for Extreme Weather Events NEW last updated : 17 Sep 2015

Early warning products for extreme weather events covering the period up to two weeks ahead. (Only registered NMHSs can access this page.)

Application
- If you have any questions about ID and/or password, please e-mail to: tcc@met.kishou.go.jp

Gridded data (need Authentication)

Download GPC Long-range Forecast (LRF) Products

Download Gridded data File (Only registered NMHSs can access this page.)
Application
- If you have any questions about ID and/or password, please e-mail to: tcc@met.kishou.go.jp

Model Descriptions

Model Outlines NEW
Operations for Extended-range Forecast Model
Operations for Long-range Forecast Model (JMA/MRI-CPS2) NEW

NWP Charts for One-month Prediction

You can find some NWP charts for tropics on the one-month prediction menu.

One-month Prediction

- One-month Prediction (17 Sep 2015)
- Z500, T850 & SLP (Northern Hemisphere) (17 Sep 2015)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (17 Sep 2015)
- Verification (13 Sep 2015)
- Hindcast
- One-month Probabilistic Forecasts at station points

Select the initial date and the region with 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

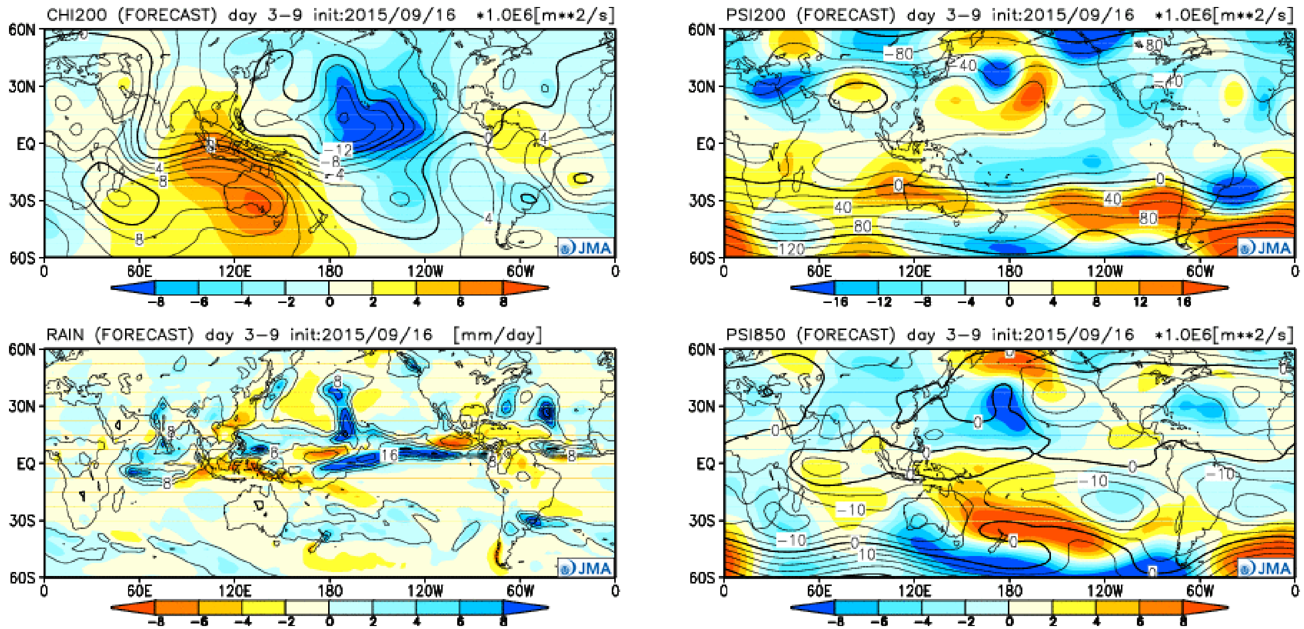
initial date
2015.09.16.12 Z

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

You can also find some NWP charts for Northern Hemisphere on the one-month prediction menu.

One-month Prediction

- One-month Prediction (17 Sep 2015)
- Z500, T850 & SLP (Northern Hemisphere) (17 Sep 2015)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (17 Sep 2015)
- Verification (13 Sep 2015)
- Hindcast
- One-month Probabilistic Forecasts at station points

Select the initial date with these menu.

One-month Prediction (Northern Hemisphere)

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

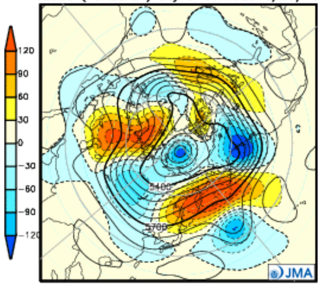
initial date
2015.09.16.12 Z

corresponding verification

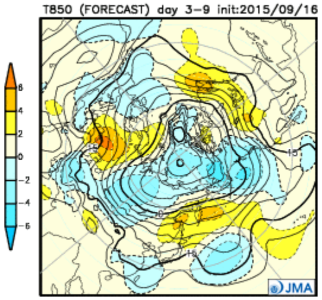
(from top to bottom)
top : Contours show 500hPa height in an interval of 60m.
middle : Contours show 850hPa temperature in an interval of 3C.
bottom : Contours show sea level pressure in an interval of 4hPa.
(Shaded patterns show anomalies.)

Ensemble Mean forecast (07 day mean)RTN

Z500 (FORECAST) day 3-9 init:2015/09/16 [m]

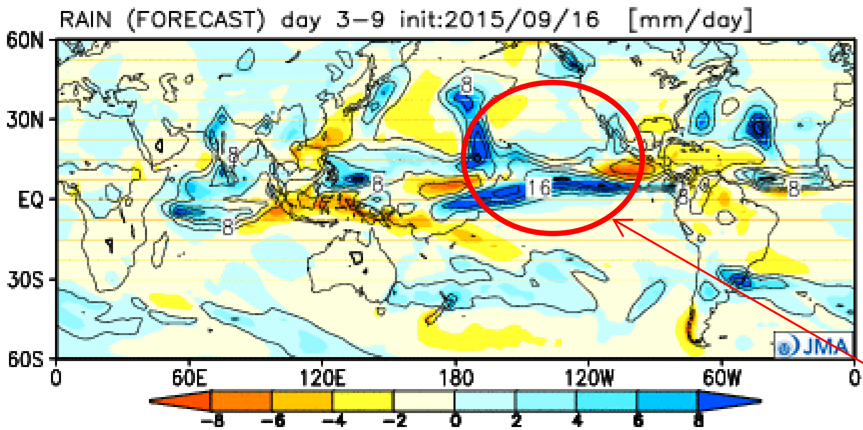


T850 (FORECAST) day 3-9 init:2015/09/16 [C]



How to use NWP charts for One-month forecast

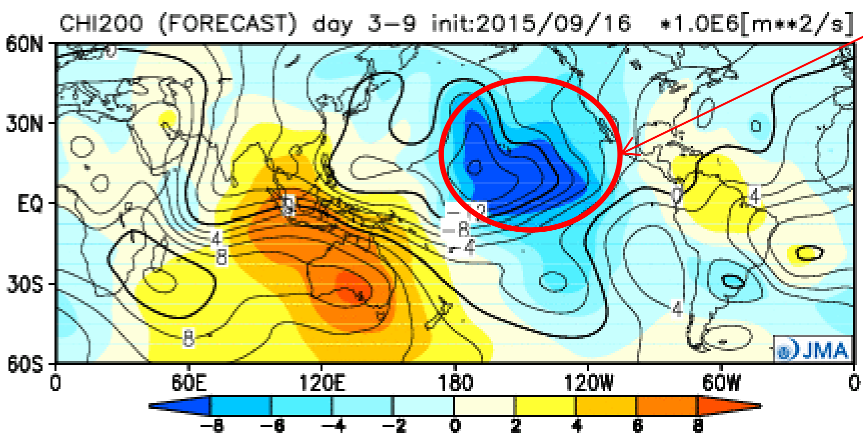
【Step 1】Check out convections in the tropics.



RAIN

・Positive anomalies indicate active convection.
・Negative anomalies indicate inactive convection.
・Tropical convection anomalies are associated with SST anomalies and MJO.

Active Convection.



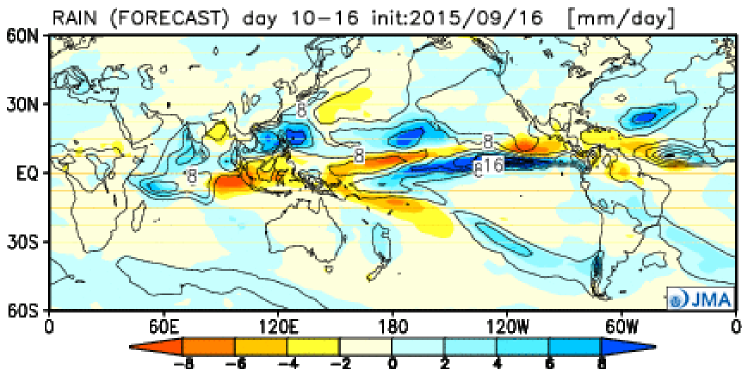
CHI200 (i.e. Velocity Potential at 200hPa)

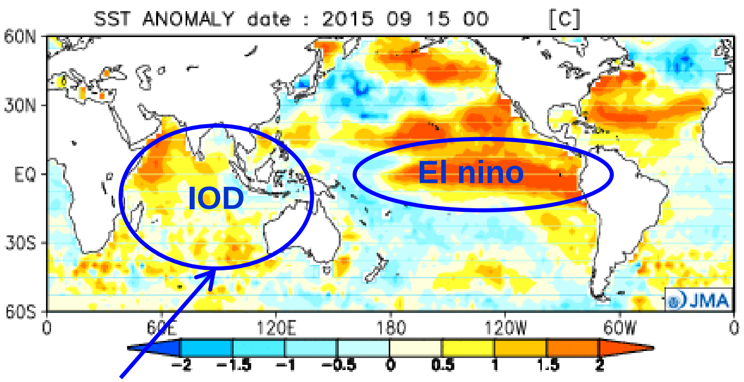
・Negative anomalies indicate divergence winds at upper troposphere in association with active convection.
・Positive anomalies indicate convergence winds at upper troposphere in association with inactive convection.
・CHI200 anomalies are consistent with RAIN anomalies.

Contours indicate predicted values. Shading indicates anomaly.

How to use NWP charts for One-month forecast

【Step 2】Check out the cause of tropical convection

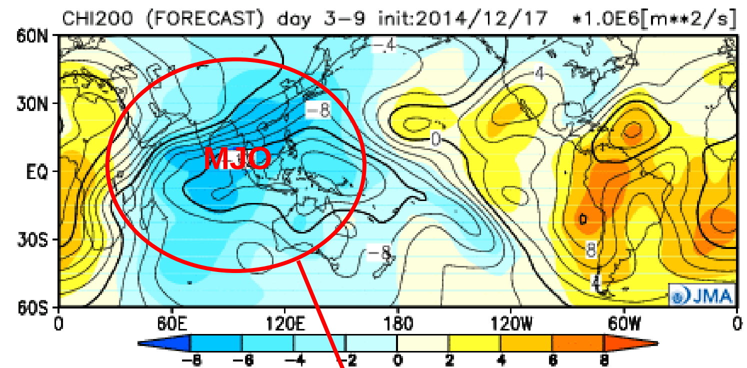




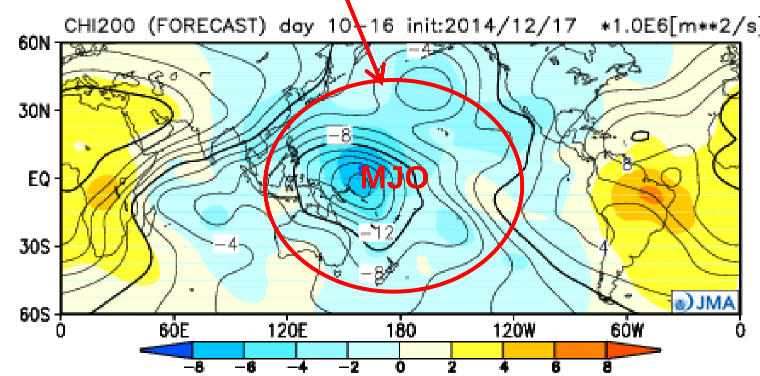
Indian Ocean Dipole (IOD)
like anomaly pattern

SST (i.e. Sea Surface Temperature)

In many cases, tropical convection anomalies corresponds to SST anomalies.



1st week



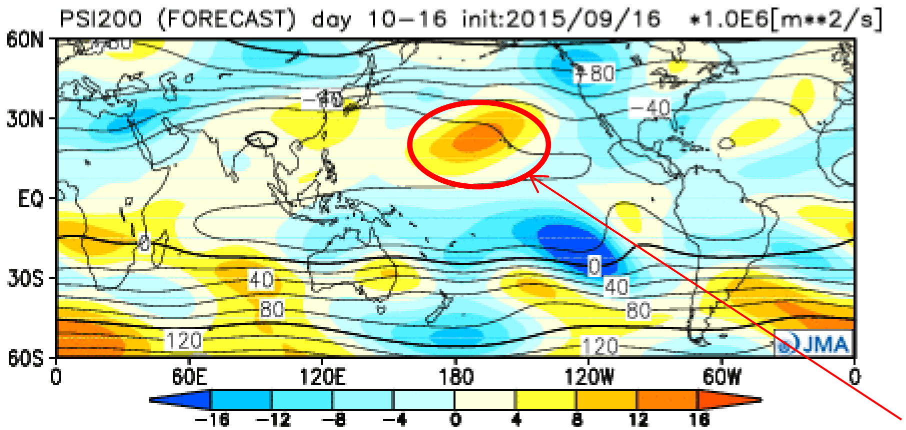
2nd week

When the amplitude of Madden Julian Oscillation (MJO) is large, you can find its eastward propagation from CHI200 figures.

Contours indicate predicted values. Shading indicates anomaly.

How to use NWP charts for One-month forecast

【Step 3】Check out tropical convection response.

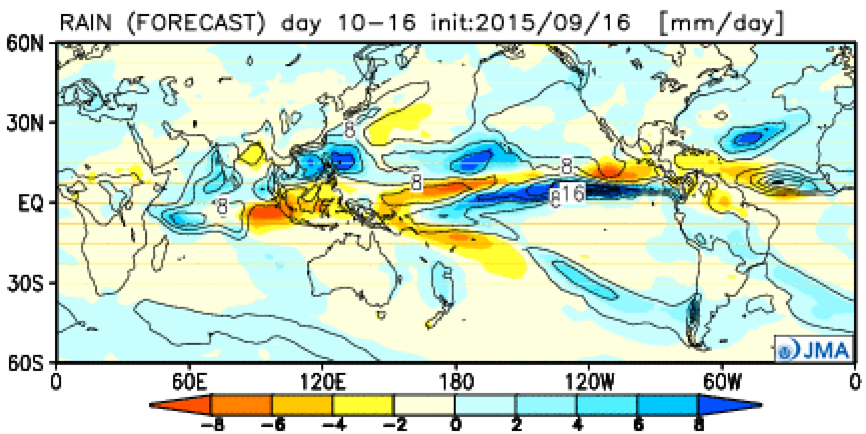


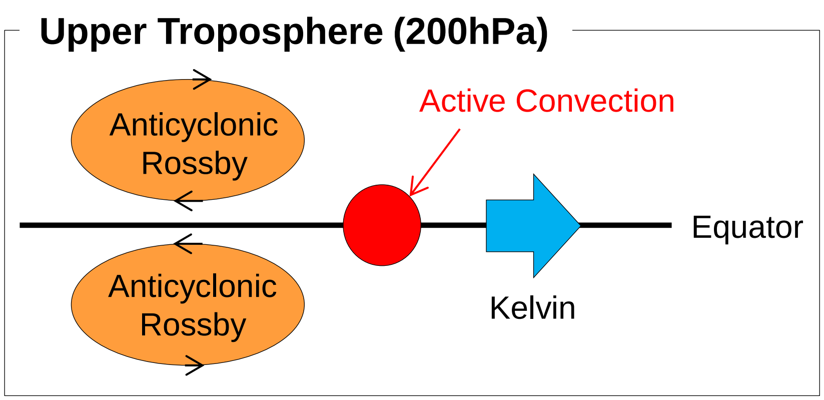
PSI200 (i.e. Stream function at 200hPa)

・Positive values indicate anticyclone in Northern Hemisphere and cyclone in Southern Hemisphere

・Negative values indicate cyclone in Northern Hemisphere and anticyclone in Southern Hemisphere

Anticyclonic Rossby Response



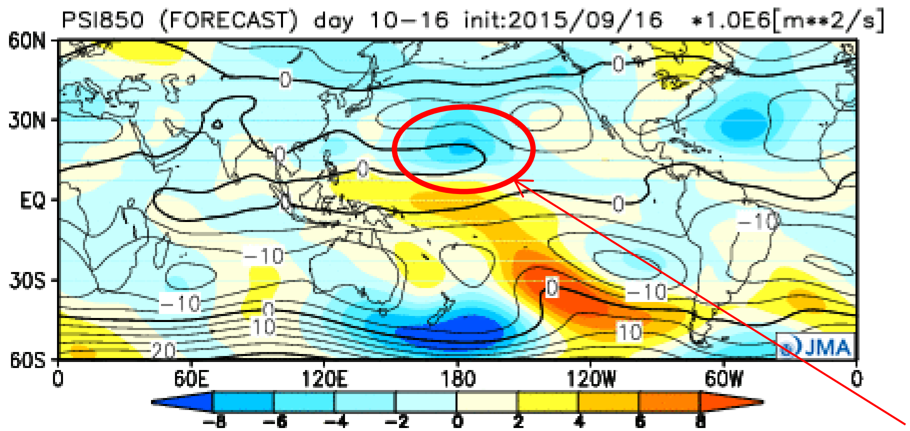


Typical Response Pattern

Contours indicate predicted values. Shading indicates anomaly.

How to use NWP charts for One-month forecast

【Step 3】Check out tropical convection response.



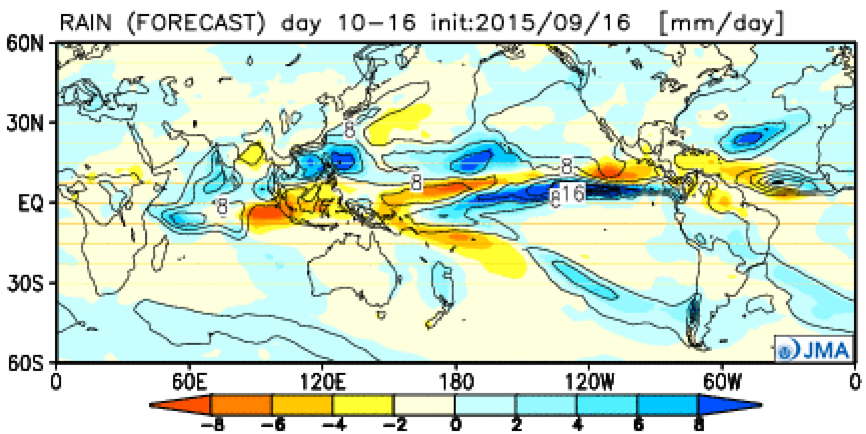
PSI850 (i.e. Stream function at 850hPa)

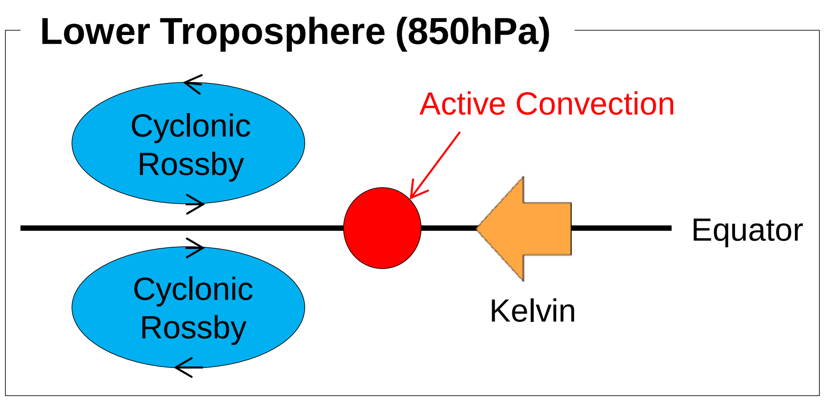
・Positive values indicate anticyclone in Northern Hemisphere and cyclone in Southern Hemisphere

・Negative values indicate cyclone in Northern Hemisphere and anticyclone in Southern Hemisphere

・Tropical cyclones sometimes genesis in strong cyclonic circulations.

Cyclonic Rossby Response





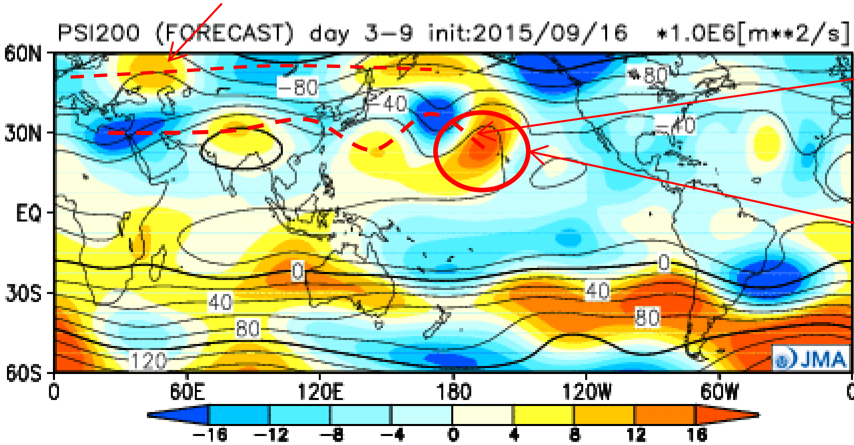
Typical Response Pattern

Contours indicate predicted values. Shading indicates anomaly.

How to use NWP charts for One-month forecast

【Step 4】Check out Rossby wave activities

A Rossby Wave train is seen along polar jet stream

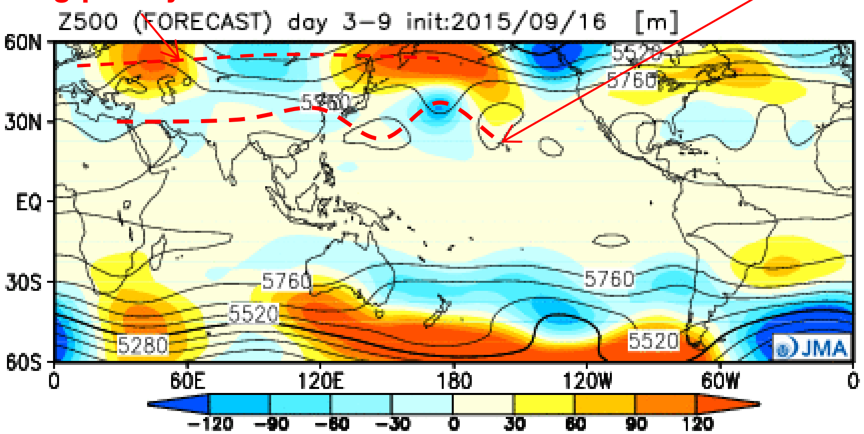


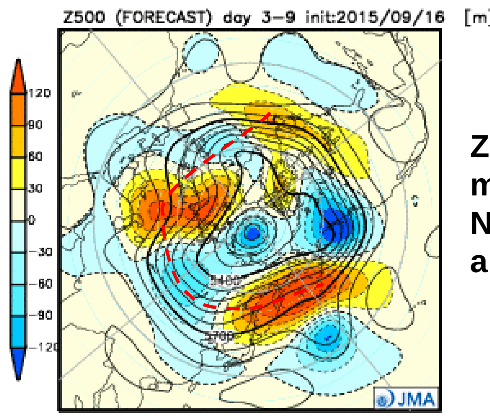
A Rossby Wave train is seen along subtropical jet stream

It is guessed that the strong positive anomaly over the North Pacific is caused by not only tropical convection but also Rossby wave train along the subtropical jet stream.

A Rossby Wave train is seen along subtropical jet stream but unclear in Z500 figures.

A Rossby Wave train is seen along polar jet stream



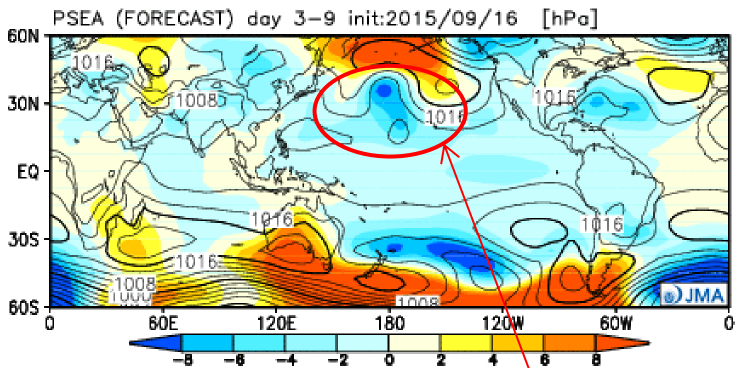


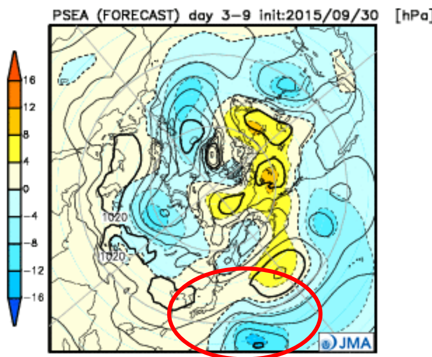
Z500 maps are well used for mid- and high- latitude forecast. Northern hemisphere maps are also available for Z500.

Contours indicate predicted values. Shading indicates anomaly.

How to use NWP charts for One-month forecast

【Step 5】Check out the other figures

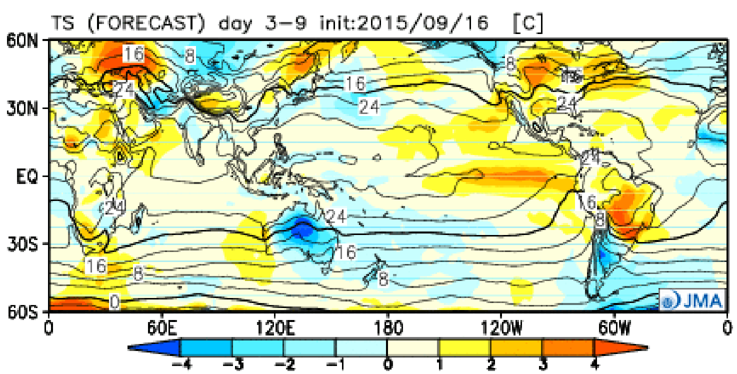


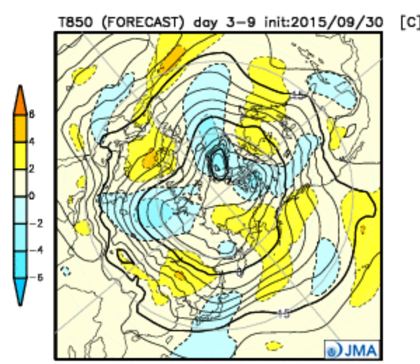


Weak North Pacific High

PSEA（i.e. Sea Surface Pressure)

Sea Surface Pressure is often used to know the strength of Pacific High, Siberian High, Aleutian Low and so on. These are important for mid- and high-latitude forecast.
Both tropical and northern hemisphere view are available.



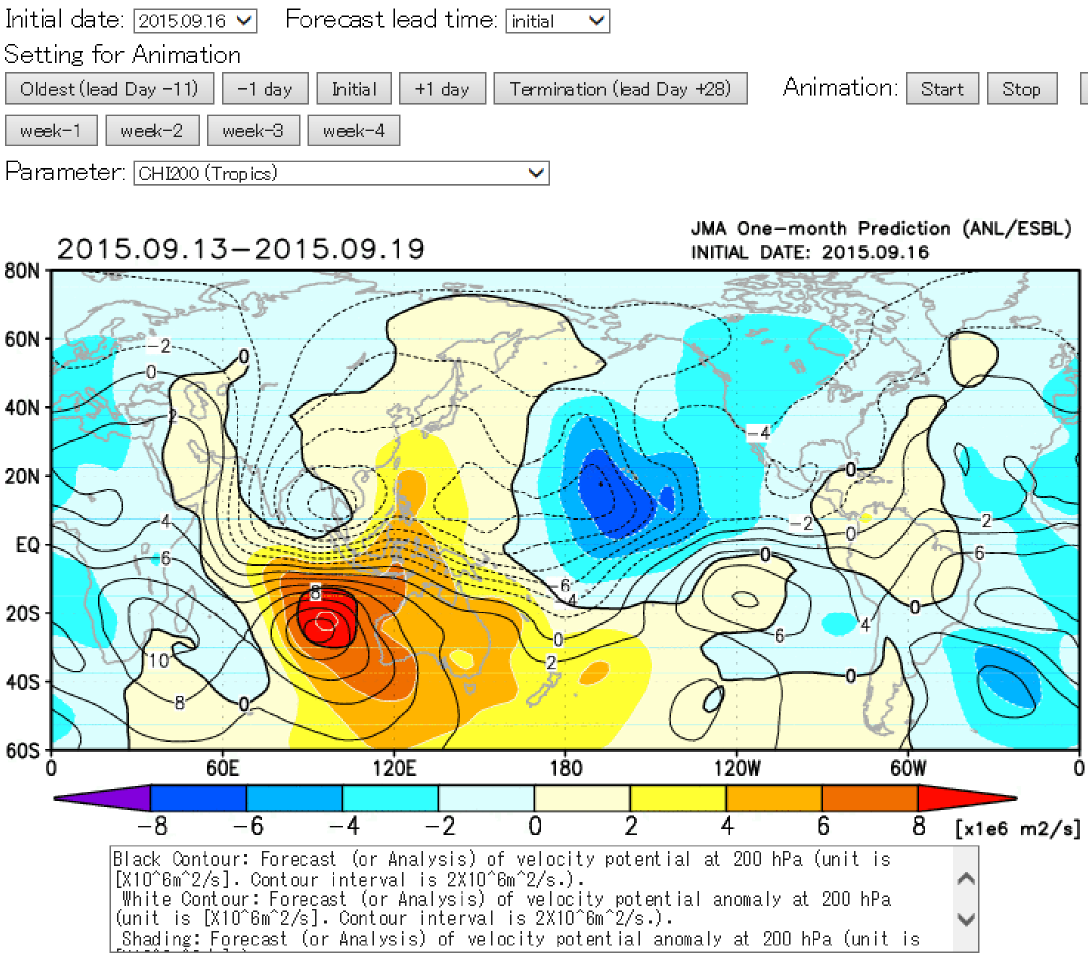


Temperature

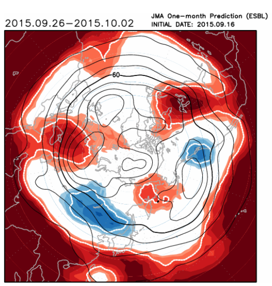
Model output temperature is important to check statistical guidance reliability.
If temperature of guidance is different from that of model, you should investigate the cause.
Surface temperature with tropical view and 850hPa temperature with northern hemisphere view are available.

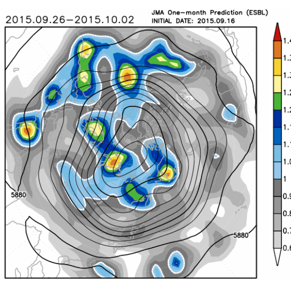
Contours indicate predicted values. Shading indicates anomaly.

Animation for One-month Prediction



Forecast charts for one-month forecast are also available as a daily animation. But authentication is required to access the animation product.
In addition, high speed internet access Is necessary for smooth animation.





You can see additional contents such as probability and spread maps for Z500 in the animation product.

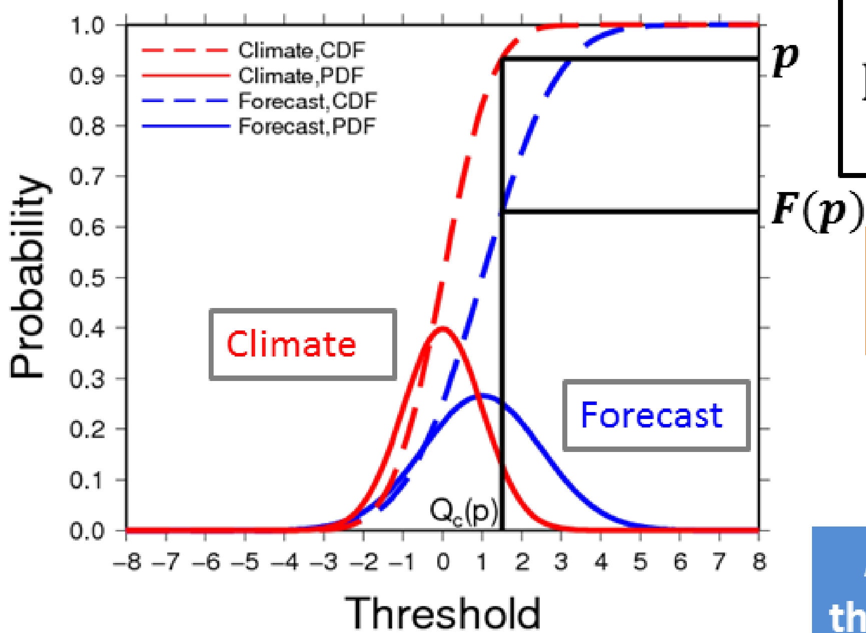
http://ds.data.jma.go.jp/tcc/tcc/gpv/model/Anime.1mE.experiment/anime.e.php

Contours indicate predicted values. Shading indicates anomaly.

Extreme Weather Forecast

- The EFI is measure of the difference between the probability distribution of a real-time forecast and a climatological distribution (Lalaurette 2002, 2003).
- JMA uses a revised version of the EFI called the **Extreme Forecast Index (revised)** in which weight is added to the tails of probability distributions (Zsótér 2006).

Cumulative (dashed line) and probabilistic density (solid line) distribution of forecast and climate



Definition of the revised EFI (Zsótér 2006)

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

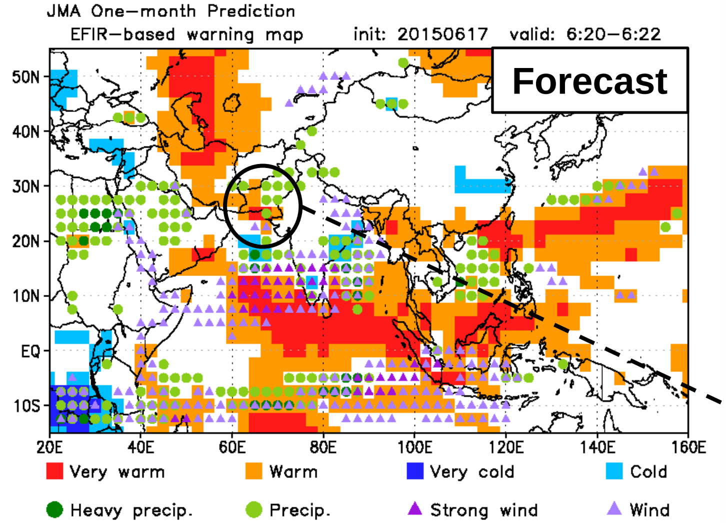
All forecast members exceed the 100th percentile of the climatology

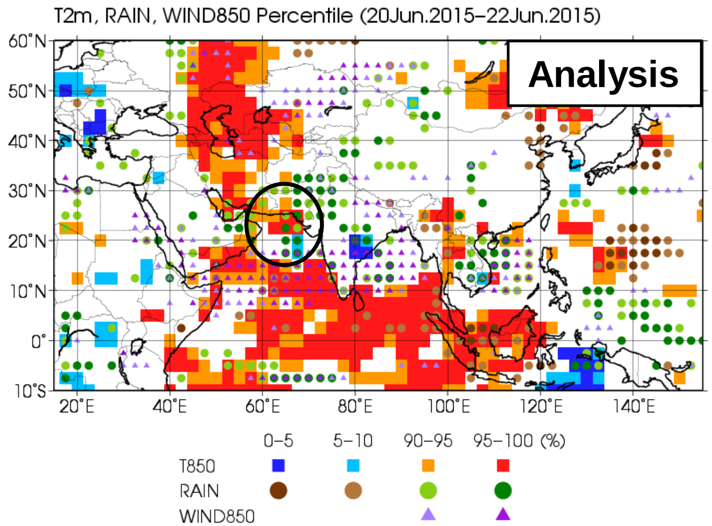
$$-1 \le \mathbf{EFI} \le 1$$

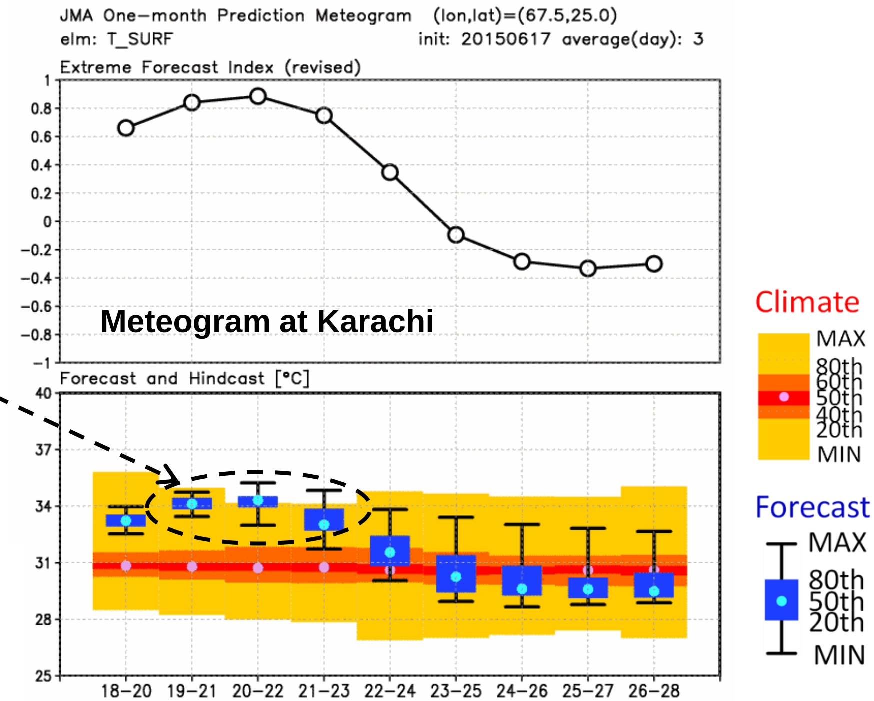
All forecast members are bellow the 0th percentile of the climatology

http://ds.data.jma.go.jp/tcc/tcc/gpv/EFI/index.php

Extreme Weather Forecast

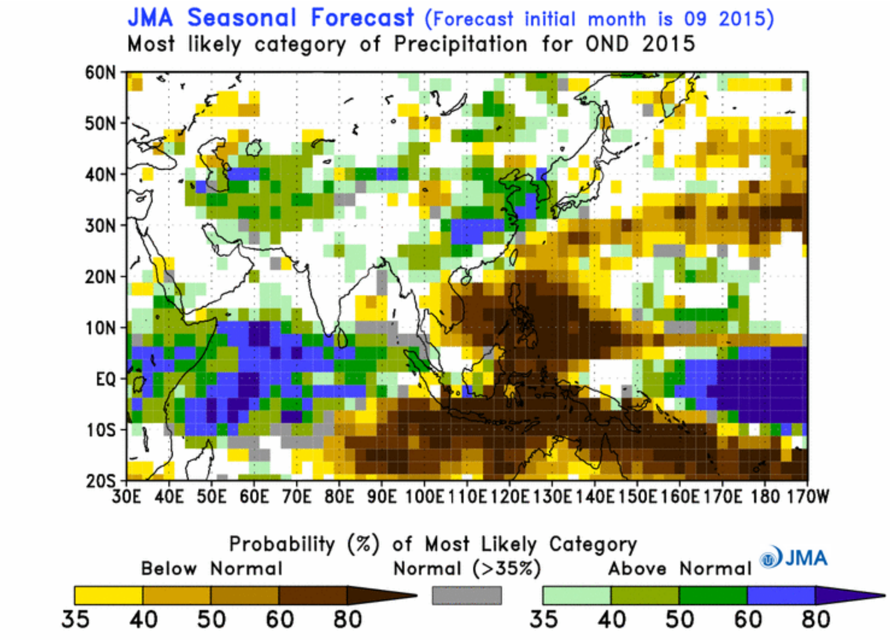


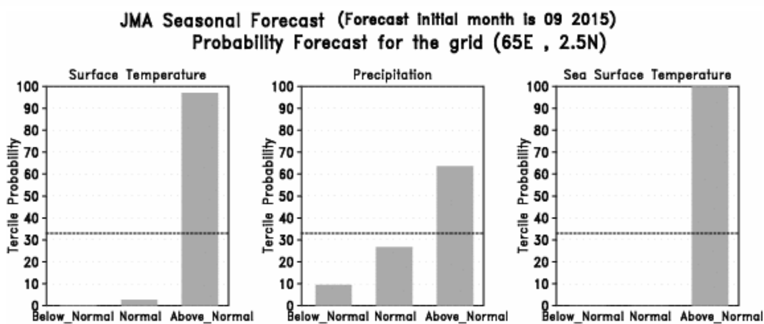




This is an example succeeded to forecast extreme weather. A heat wave hit Karachi city in Pakistan on 19-23 June 2015. Then the 3-day mean EFI warned “very warm” condition and the 3-day mean EPS meteogram also indicated extreme hot temperature at Karachi.

Probabilistic Forecast for Seasonal Prediction



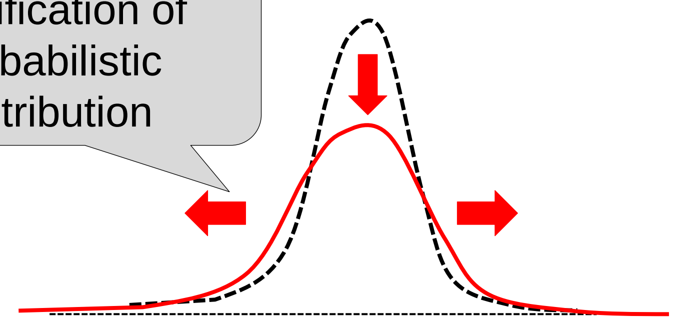


Probability distribution from the direct model output

Numerical guidance
(Statistical technique based on hindcast)

Calibrated probabilistic forecast
(one of the statistical guidance)

Modification of probabilistic distribution



Example of calibration

http://ds.data.jma.go.jp/tcc/tcc/products/model/probfcst/3-mon/index.html
http://ds.data.jma.go.jp/tcc/tcc/products/model/probfcst/warm_cold_season/index.html

El Niño Monitoring & Outlook

Click "El Niño Monitoring " Tab on the top page of TCC website.

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

El Niño Monitoring & Outlook

El Niño Monitoring and Outlook

JMA operates the Ocean Data Assimilation System and the El Niño Prediction System (an ocean-atmosphere coupled model) for monitoring and prediction of El Niño-Southern Oscillation (ENSO). Monthly diagnosis reports, ENSO monitoring products, ENSO indices and El Niño outlooks are available on this page.

Main Products

You can confirm current oceanic condition and future outlook here.

Latest Products last updated : 20 Oct 2015

- El Niño Outlook
- Figures and Tables
- Historical El Niño and La Niña Events
- Download El Niño Monitoring Indices
- Model forecast of SST anomalies for Niño regions

Animations

- SST and Anomaly
- Longitude-Depth Cross Section along the Equator

Gridded Data

- Download SST (COBE-SST from 1891 to the latest month)

ENSO Impacts

- Global Climate
- Atmosphere Circulation (Explanatory Notes)

Model Descriptions & Analysis Procedures

- Explanation of El Niño Monitoring Indices
- Description of JMA's Seasonal Ensemble Prediction System (JMA/MRI-CPS2) since June 2015 NEW
- Description of Ocean Data Assimilation System (MOVE/MRI.COM-G2) since June 2015 NEW
- Description of Daily Sea Surface Temperature Analysis for Climate Monitoring (COBE-SST)
- The Characteristics of the Global Sea Surface Temperature Data (COBE-SST)
  - Monthly Report on Climate System Separated Volume No.12 -

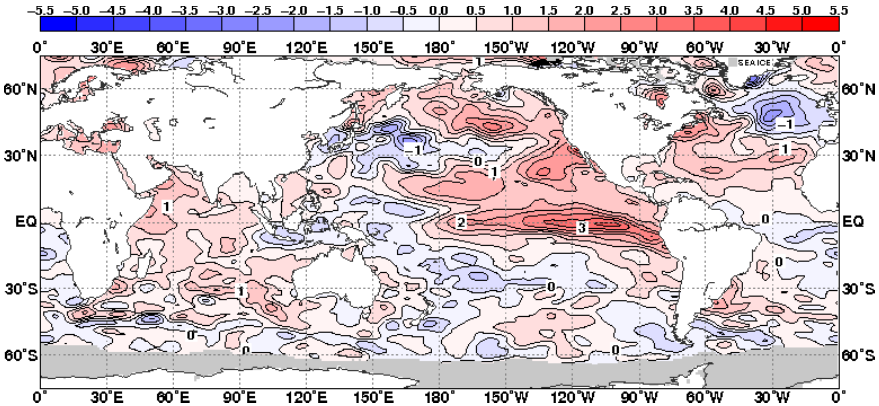
Decadal Oscillation

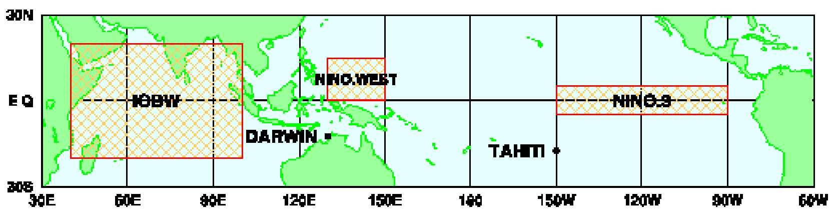
- Pacific Decadal Oscillation (27 Apr 2015)
- Explanation

page top

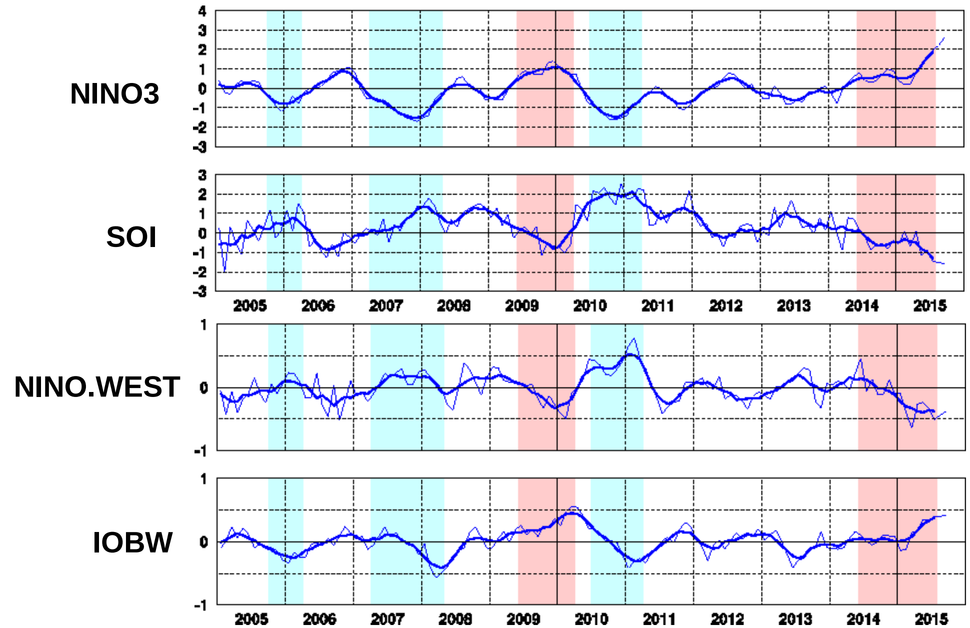
El Niño Monitoring & Outlook

Current Oceanic Condition

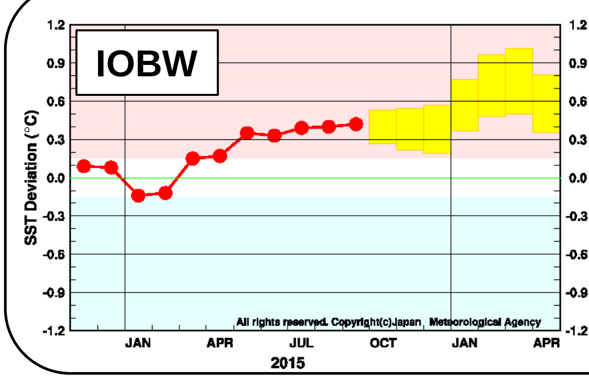


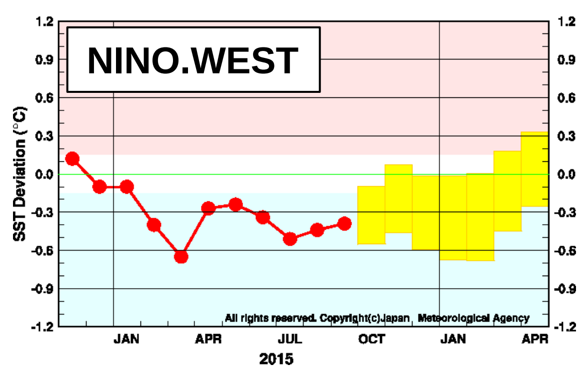


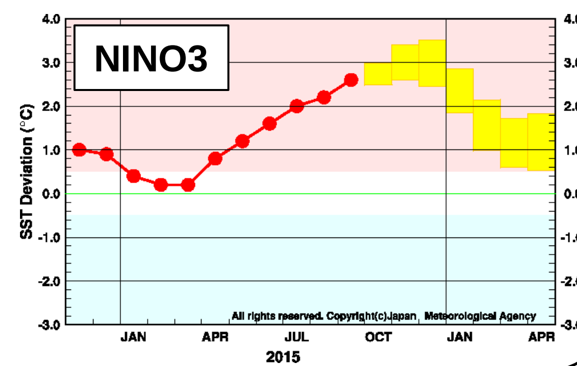
Indices



Future Outlook







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.

■One-month EPS

・High-resolution AGCM is used for one-month forecast (Predictability of 1st kind).

・Predicted precipitation tends to be larger than analysis in tropics.

・MJO is predictable up to 25 days.
However, the biases of smaller amplitude and faster propagation is seen.

・Frequency of blocking-high is a little less than that of analysis.

■Seasonal EPS

・CGCM is used for seasonal forecast (Predictability of 2nd kind).

・Not only ocean model but also sea ice model were coupled.

・Tri-polar grid made it possible to cover full ocean.

・Representation of historical warming trend has been improved by consideration of 6 GHGs.

・Prediction skill for NINO3, NINO.WEST and IOBW depends on season.

References

■NWP Model Prediction

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

・One-month EPS

NWP charts

http://ds.data.jma.go.jp/tcc/tcc/products/model/map/1mE/map1/zpcmap.php
http://ds.data.jma.go.jp/tcc/tcc/products/model/map/1mE/map1/pztmap.php

Animation

http://ds.data.jma.go.jp/tcc/tcc/gpv/model/Anime.1mE.experiment/anime.e.php (authentication required)

Forecast Products in Support of Early Warnings for Extreme Weather Events (Extreme Forecast Index)

http://ds.data.jma.go.jp/tcc/tcc/gpv/EFI/index.php (authentication required)

Verification

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

・Seasonal EPS

NWP charts

http://ds.data.jma.go.jp/tcc/tcc/products/model/map/4mE/map1/zpcmap.php
http://ds.data.jma.go.jp/tcc/tcc/products/model/map/4mE/map1/pztmap.php
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http://ds.data.jma.go.jp/tcc/tcc/products/model/map/7mE/map1/pztmap.php

Probabilistic Forecast

http://ds.data.jma.go.jp/tcc/tcc/products/model/probfcst/3-mon/index.html
http://ds.data.jma.go.jp/tcc/tcc/products/model/probfcst/warm_cold_season/index.html

Verification

http://ds.data.jma.go.jp/tcc/tcc/products/model/verif/4mE/index.html
http://ds.data.jma.go.jp/tcc/tcc/products/model/hindcast/CPS2/index.html

・Gridded Data

http://ds.data.jma.go.jp/tcc/tcc/gpv/index.html (authentication required)

■El Niño Monitoring & Outlook

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