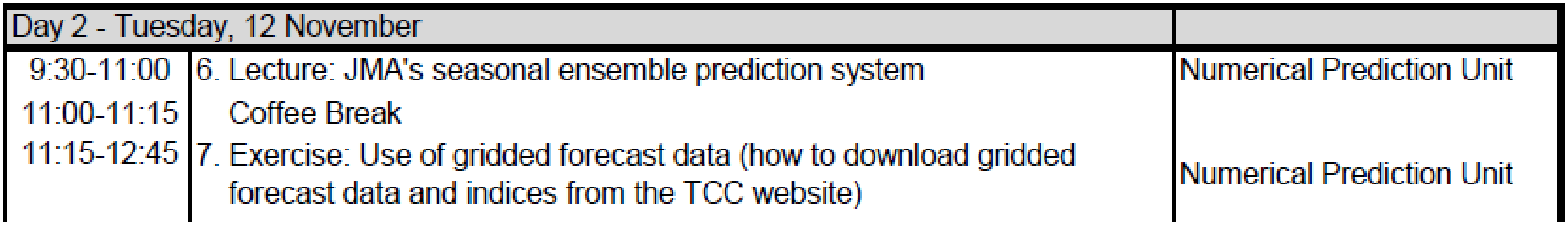
Program of the morning lectures



Day 2 - Tuesday, 12 November		
9:30-11:00	6. Lecture: JMA's seasonal ensemble prediction system	Numerical Prediction Unit
11:00-11:15	Coffee Break	
11:15-12:45	7. Exercise: Use of gridded forecast data (how to download gridded forecast data and indices from the TCC website)	Numerical Prediction Unit

- 09:30~11:00 Lecture
  - Explanation of the numerical weather prediction (NWP) system
  - Introduction of the NWP Products
- 11:15~12:45 Exercise
  - Download of the binary model outputs
  - Visualization of the downloaded model outputs

JMA's seasonal ensemble prediction system

Masayuki Hirai

Tokyo Climate Center (TCC)/
Climate Prediction Division of
Japan Meteorological Agency (JMA)

Outline

- Outline of a numerical weather prediction
  - Numerical weather prediction model
  - Necessary knowledge to utilize NWP products
    - Predictability, Hindcast, Verification ...
- Outline of the JMA's seasonal ensemble prediction system (EPS)
  - Specifications, Prediction skill, Future subjects
- Introduction of the TCC website products relating with seasonal prediction

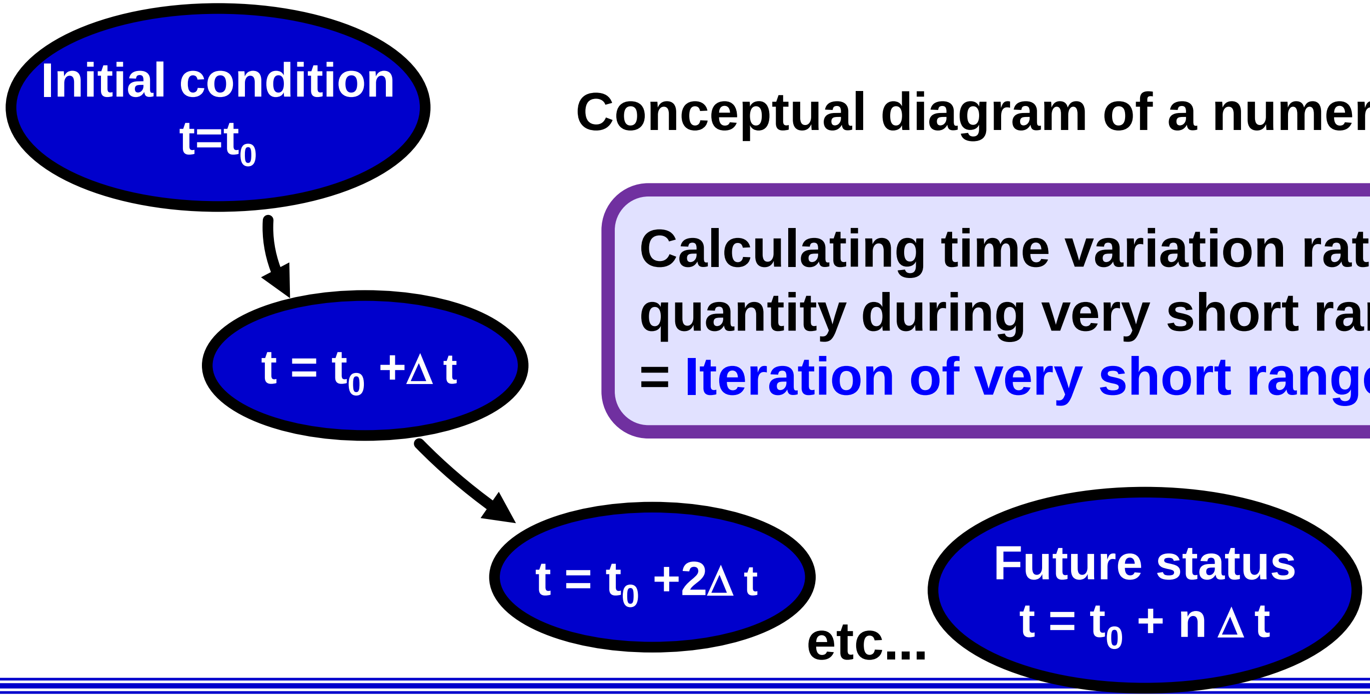
Outline

- Outline of a numerical weather prediction
  - Numerical weather prediction model
  - Necessary knowledge to utilize NWP products
    - Predictability, Hindcast, Verification ...
- Outline of the JMA’s seasonal ensemble prediction system (EPS)
  - Specifications, Prediction skill, Future subjects
- Introduction of the TCC website products relating with seasonal prediction

What is “numerical prediction”?

- Numerical prediction
  - **Calculating future status** inputting current status based on basic principles of physical low
- Numerical prediction model
  - A tool for numerical prediction composed very large-scale programming

Conceptual diagram of a numerical prediction



Initial condition
$t=t_0$

$t = t_0 + \Delta t$

$t = t_0 + 2\Delta t$

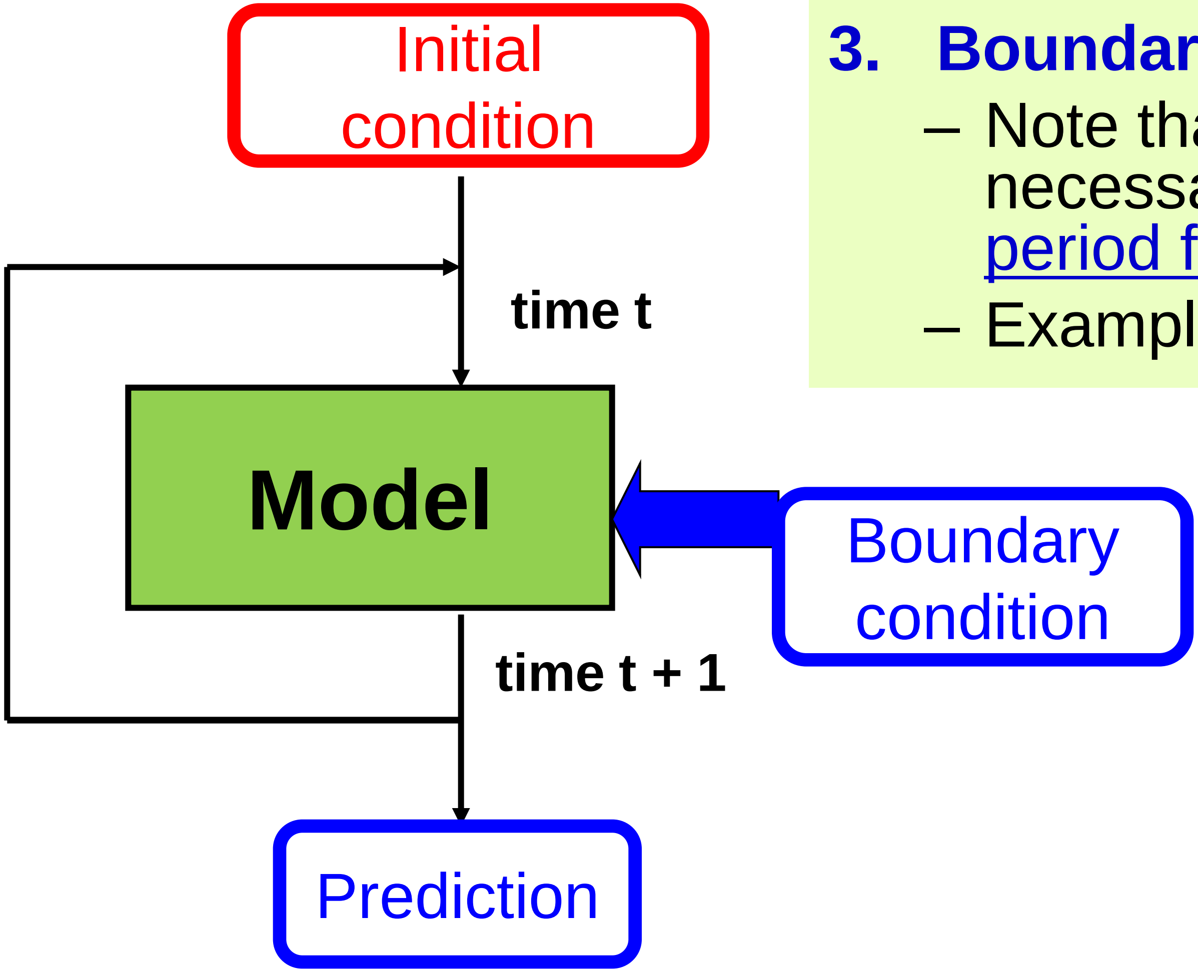
etc...

Future status
$t = t_0 + n \Delta t$

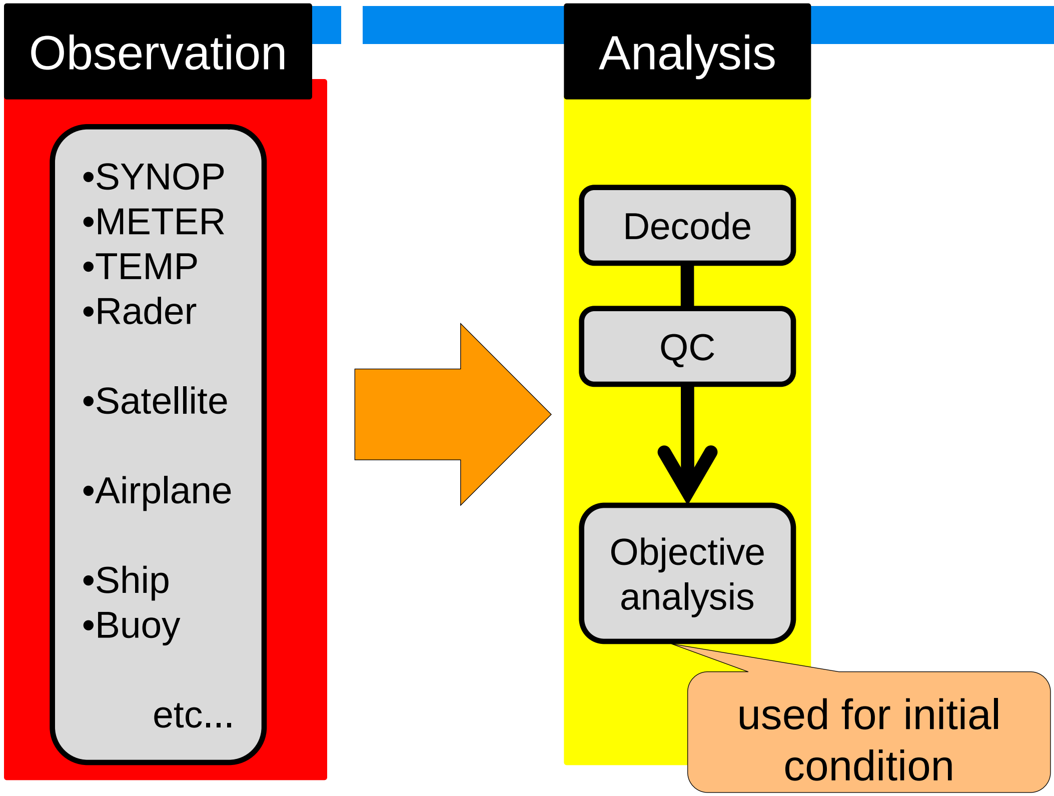
Calculating time variation rate of the physical quantity during very short range (Δ t)
= Iteration of very short range time integration

Requisite for numerical prediction

1. **Numerical prediction model**
2. **Initial condition**: all prognostic variables at initial are required.
3. **Boundary condition**:
   - Note that boundary condition is necessary during the entire period for time integration.
   - Example: SST for AGCM

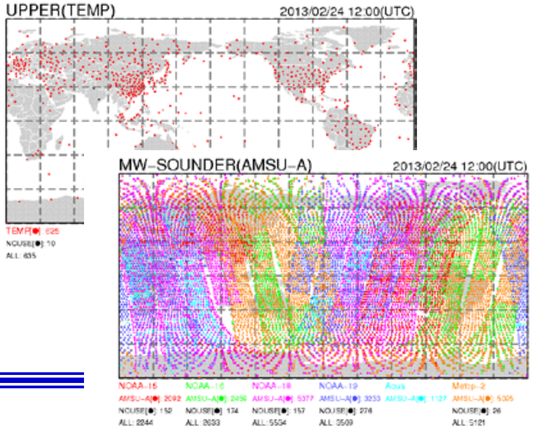


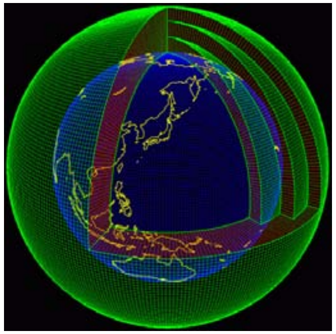
The necessity for initial condition



- Any forecast model requires an initial condition at the beginning.
- Initial condition is created from available observations and the model forecasts. This technique is called “assimilation”.

◆ Requirements for initial condition
  - Presence of value **for all grids**
  - Small error
  - fit into model climate in order to reduce spin-up (initial shock)





Dynamical Processes (AGCM)

- Primitive equations
  - Momentum equations
  - Continuity equation (mass conservation)
  - Water vapor conservation
  - Thermodynamic equation (energy conservation)
  - Ideal gas equation

- Prognostic variables
  - ex. JMA-GSM: U, V, T, Q, cloud water content

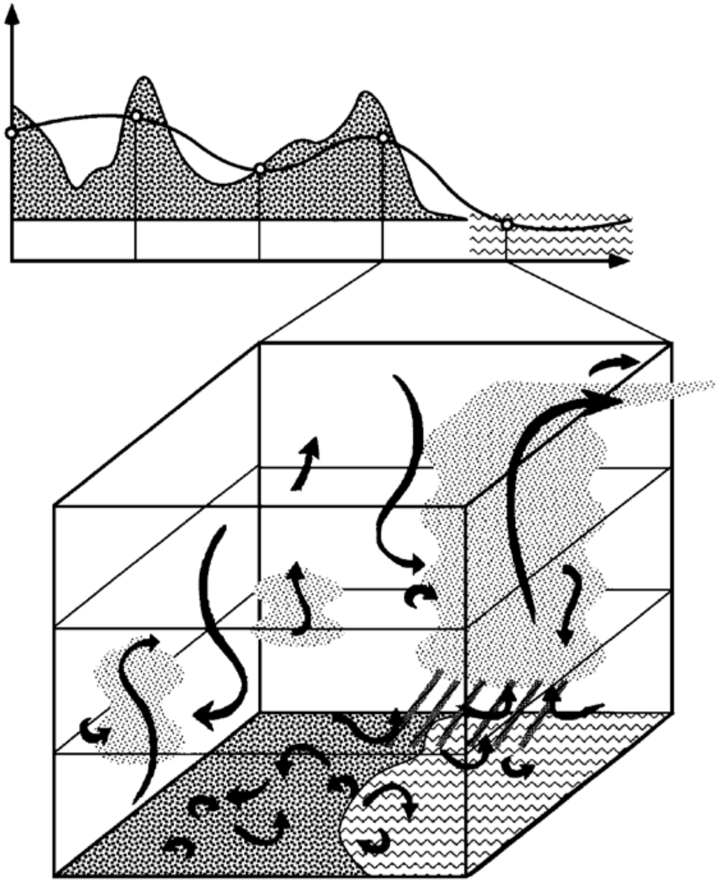
➢**For details of the model, please refer to the web page on http://www.jma.go.jp/jma/jma-eng/jma-center/nwp/nwp-top.htm.**

Parameterizations (AGCM)

- Dynamical processes unable to consider smaller time- and space-scale processes than resolution of model.
- Therefore, those processes are took into account by physical processes, which is named "parameterization".
- Example:
  - Convection
  - Cloud
  - Radiation
  - Diffusion
  - Orographic gravity wave drag
  - land surface (vegetation , snow and soil)

    etc...

Sub-grid scale processes



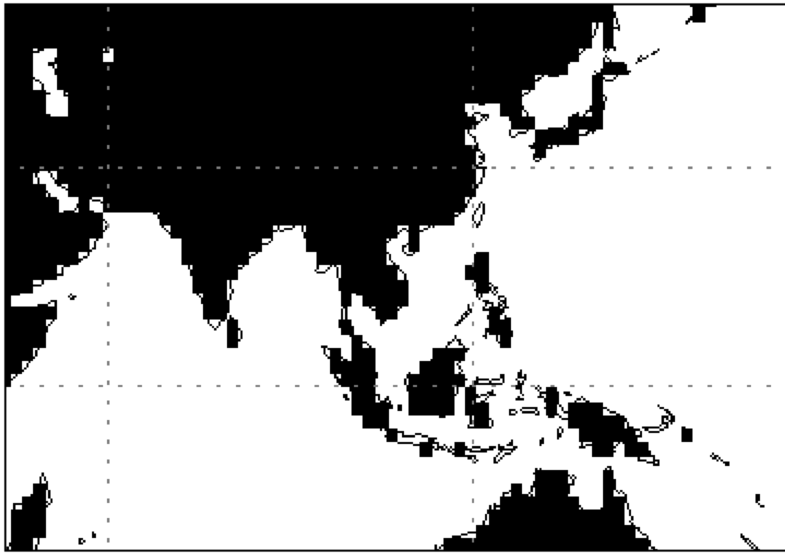
➢**For details of the model, please refer to the web page on http://www.jma.go.jp/jma/jma-eng/jma-center/nwp/nwp-top.htm.**

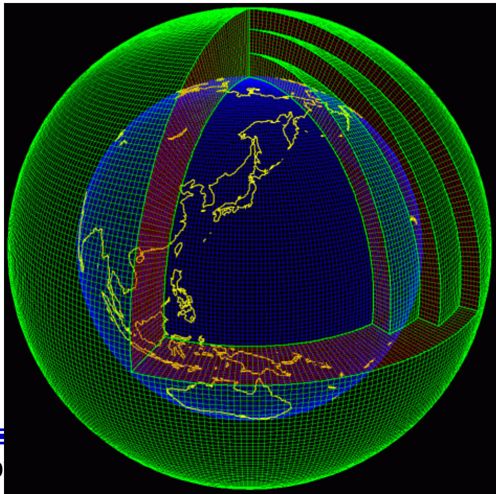
Discretization

- For numerical calculation, atmosphere divide to grid points (discretization), although atmosphere is continuum.

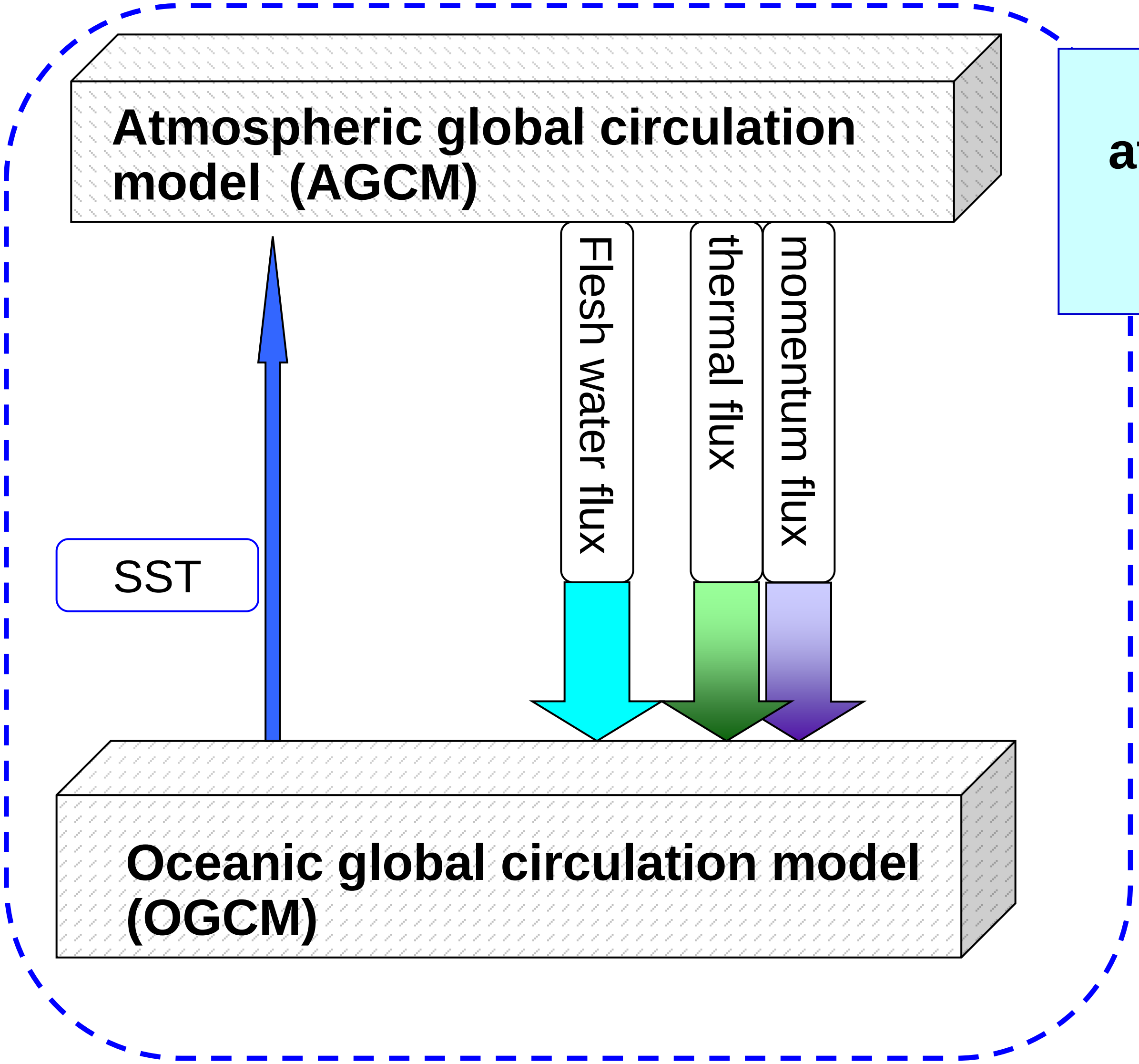
- In principle, increase forecast accuracy the higher resolution is.
- However, in actual, model resolution is determined by computing resources. (computing time vs. resources)
  - As for long-range EPS, model resolution is much lower than the deterministic short-range model.

Example;
horizontal resolution of 180km





Coupling numerical models
(Example: Coupled ocean-atmosphere General Circulation Model)



Coupled ocean-atmosphere General Circulation Model (CGCM)

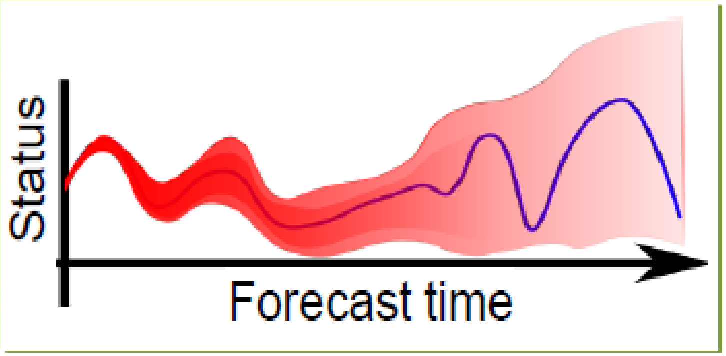
CGCM enable to consider not only variation inside of atmosphere (ocean) but also interaction between ocean and atmosphere.

Outline

- Outline of a numerical weather prediction
  - Numerical weather prediction model
  - Necessary knowledge to utilize NWP products
    - Predictability, Hindcast, Verification ...
- Outline of the JMA's seasonal ensemble prediction system (EPS)
  - Specifications, Prediction skill, Future subjects
- Introduction of the TCC website products relating with seasonal prediction

Chaotic nature of atmosphere

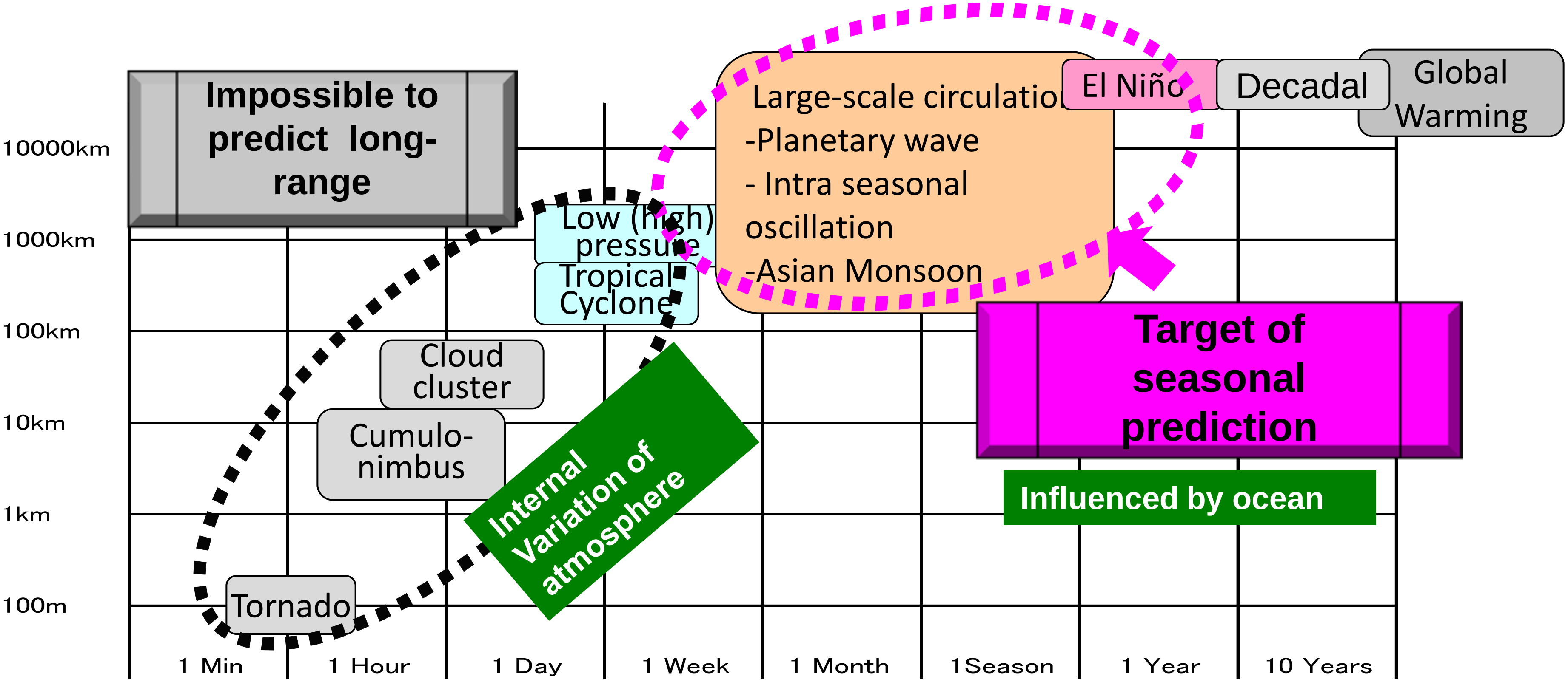
- As fluid (e.g. atmosphere and ocean) moves in accordance with the primitive equations. Therefore, ***in principle***, it is possible to predict future status.
- However, ***in reality***, motion of fluid is very sensitive to initial condition.
  - Prediction results substantially differ according to initial condition.



Predictability of various phenomena

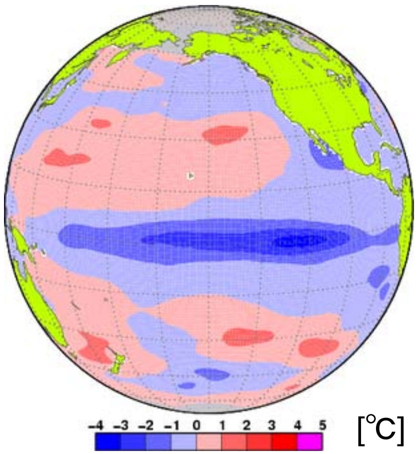
◆**Predictability**: Possibility of prediction for the specific phenomenon

- Because time-scale differs according to phenomena, predictability also differs.
- Targets for seasonal prediction are phenomena with large time- and space-scale (over about one week).



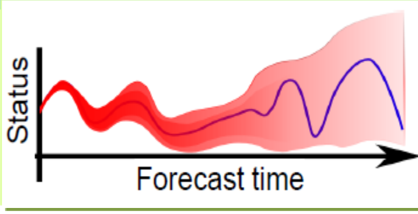
Why long-range forecasting is possible?

- Oceanic variation, which is very slow process because of large heat capacity, is possible to predict for forecasting period.
- In particular, El Niño/La Nina phenomenon, which are the most dominant mode of the climate system, are possible to predict.
  - ➢ most important signal for long range forecasting



La Niña (Dec. 1988)

Concept of two kinds of predictability

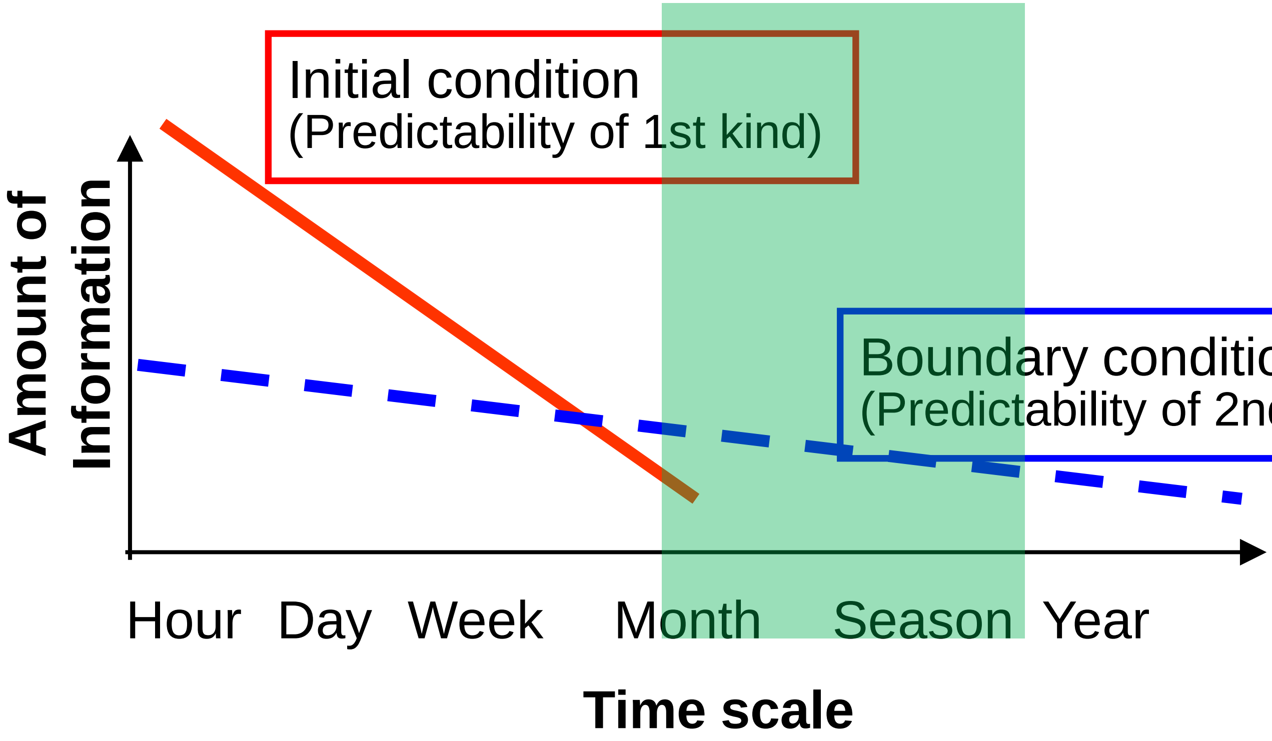


- Uncertainty relating to **initial conditions** (**Predictability of 1st kind**)
  - Uncertainties relating with initial conditions rapidly growth from the beginning of the prediction due to atmospheric characteristic of strong non-linearity.
  - ➢ Ensemble prediction system is essential for long range forecasting.
- Uncertainty relating to **boundary conditions** (**Predictability of 2nd kind**)
  - the influence of boundary conditions is important for longer-range forecasting models.
  - In particular, forcing on the sea surface is an important signal for long range forecasting.

Importance of initial and boundary condition

•The longer lead time, the less information of initial condition.

➢ Long-range forecasting depends on the second kind of predictability from boundary condition and forcing.



How much does SST control atmospheric fields?

Potential predictability of seasonal mean precipitation

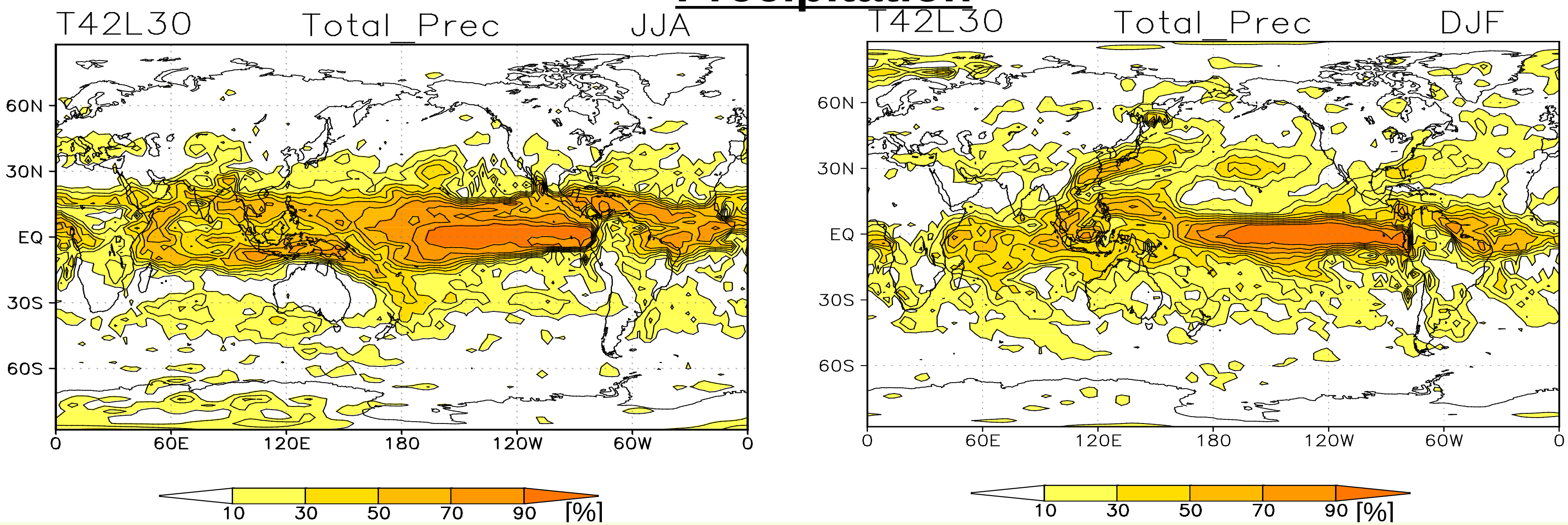
Signal / (Signal + Noise)

Experiment of giving identical SSTs to all ensemble members (9 members, 1979-1993)

- **Signal**: anomaly of ensemble mean
- **Noise**: ensemble spread in case of giving identical SSTs to all members.

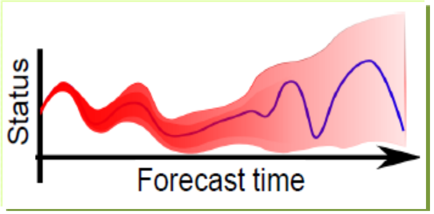
➢Sugi, M., R. Kawamura and N. Sato, 1997, J.Meteor.Soc.Japan**, 75**, 717-736.

Precipitation



Potential predictability deriving from SSTs is high over the tropics, .

Sources of uncertainty



- Uncertainty of an initial condition
  - limitation of observational data
  - error in observation
  - imperfection of an objective analysis (initial field)
- Uncertainty of a boundary condition
  - Evolution of a boundary forcing is unknown.
    - e.g. SSTs for AGCM
- Imperfection of a model
  - Resolution with a limitation (discretisation)
  - Many approximations in the physical processes (Parameterization)

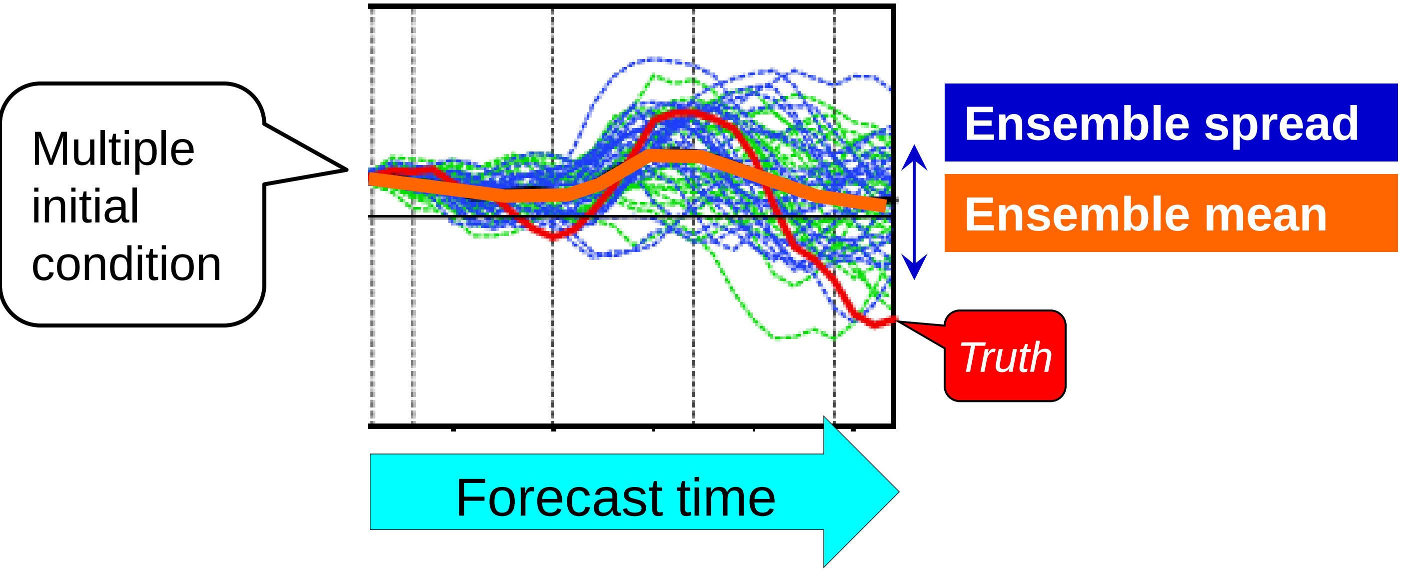
Ensemble prediction is essential for long-range forecasting

Estimating uncertainty with ensemble prediction

Ensemble prediction:
Probabilistically predicting with aggregate of the multiple prediction results.

- Initial ensemble prediction

calculating model using slightly different initial condition **(perturbation)**



Multiple initial condition

Ensemble spread

Ensemble mean

Truth

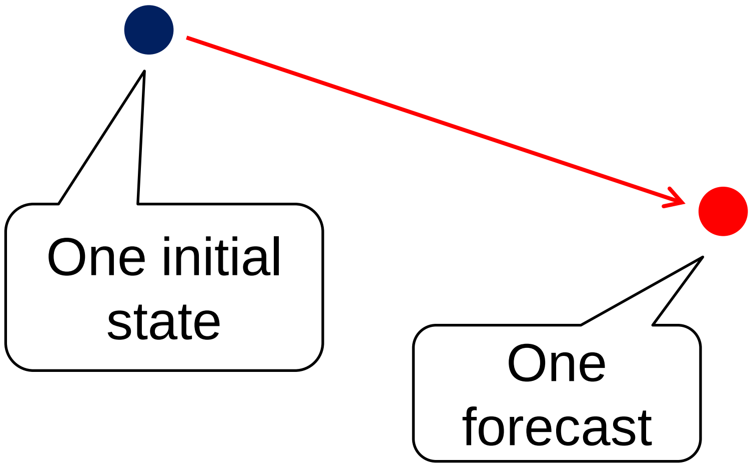
Forecast time

= Standard dev.

= Average of ensemble members outputs, suggesting degree of signal

Deterministic and probabilistic forecast

Deterministic forecast

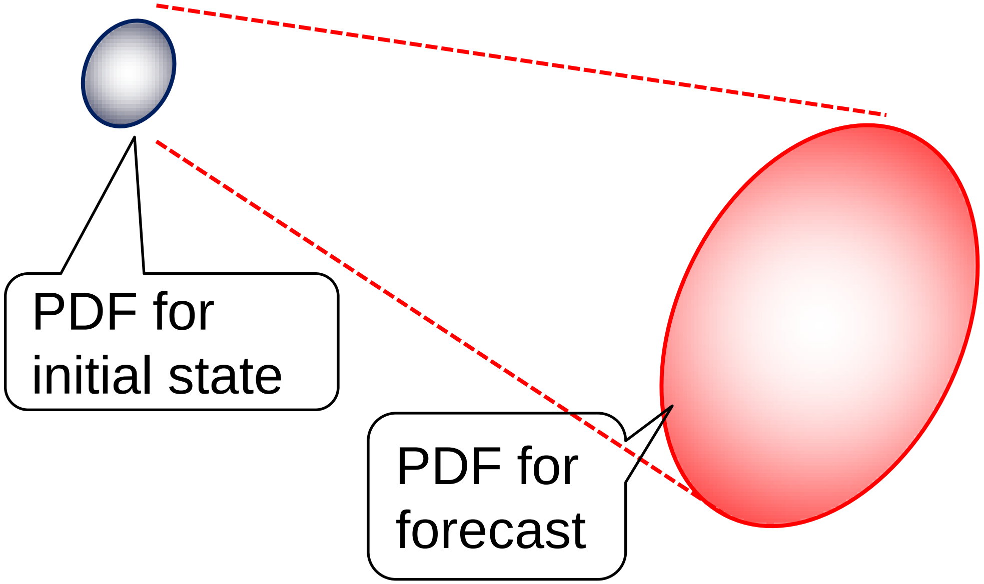


One initial state

One forecast

Calculate one forecast using one initial state

Probabilistic forecast



PDF for initial state

PDF for forecast

- EPS derives PDF for forecast.
  - ➢Possible to predict probability of the targeted phenomena, which add degree of reliability to deterministic forecasting.

Hindcast

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

: A set of systematic forecast experiments for past cases using same EPS as the operational one

- 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)

Essential for long range forecasting!

- Hindcast period is required to be more than 20 years by **SVS-LRF**.
- Difficulty
  - As hindcasting is required huge computing resources due to a large number of initial case, specifications are more limited than those of operational system forecasts.
    - (ex. 51member (operational) -> 5member (hindcast))

Verification of the model

- Model verification is the processes of assessing the quality of forecasts with the model.

- Purposes of verification
  - – For administrator, developer and operator
    - to monitor the quality of forecasts and updates of the prediction system
    - to identify the strengths and weaknesses of the model and to provide information to R&D.
  - – For users
    - to provide prediction skill of the model
    - to help interpreting prediction results

➢ Verification is important both for users and modelers.

➢ It is important to utilize prediction outputs taking into account of prediction skill especially for seasonal prediction.

Two types verification

- Verification of based on operational prediction
  - Monitoring prediction results
    - verification map (prediction vs. actual)
    - transition of verification score
  - Regulation way of verification is not set. However, JMA discloses verification materials based on operation prediction on the TCC web. (after mentioned)
- Verification based on Hindcast
  - WMO conducts SVS-LRF to make users understand appropriately limited prediction skill.
  - GPCs (including JMA) are required to submit verification results of hindcast based on SVS-LRF.
  - Verification results including the except in SVS-LRF based are discloses on the TCC web. (after mentioned)

SVSLRF

(Standardized Verification System for Long-Range Forecast)

- WMO conducts SVS-LRF to make users understand appropriately limited prediction skill.
- GPCs (including JMA) are required to submit verification results of hindcast based on SVS-LRF.

	Parameters	Verification regions	Deterministic forecasts	Probabilistic forecasts
Level 1	◆T2m anomaly ◆Precipitation anomaly ◆NINO3.4 index	Tropics(20S-20N) Northern extratropics(20N-90N) Southern extratropics(20S-90S) (N/A)	MSSS	ROC curves ROC areas Reliability diagrams Frequency histograms
Level 2	◆T2m anomaly ◆Precipitation anomaly ◆SST anomaly	Grid-point verification on a 2.5° by 2.5° grid	MSSS and its three-term decomposition at each grid-point	ROC areas at each grid-point
Level 3	◆T2m anomaly	Grid-point veri a 2.5° by 2.5° grid	contingency	tables at each grid-

JMA submits level-1 and -2

Examples of graphics on the SVSLRF website

- **Lead centers of SVSLRF:**
  - Australian Bureau of Meteorology (BOM)
  - Meteorological Service of Canada (MSC)

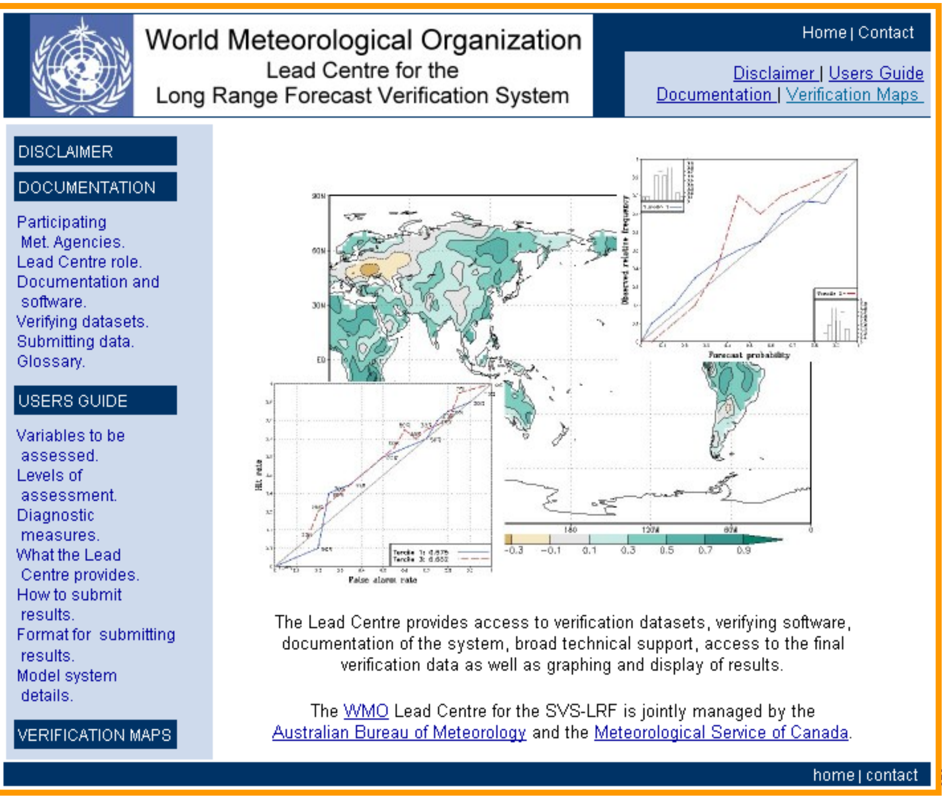
  URL: http://www.bom.gov.au/wmo/lrfvs/

Level1. Region scores

Exp. : ROC curves

Parameter : T2m
Season : DJF
Lead time : 1 month
Area : Tropics

Model : JMA



World Meteorological Organization
Lead Centre for the
Long Range Forecast Verification System

Home | Contact

Disclaimer | Users Guide
Documentation | Verification Maps

DISCLAIMER

DOCUMENTATION

Participating Met. Agencies.
Lead Centre role.
Documentation and software.
Verifying datasets.
Submitting data.
Glossary.

USERS GUIDE

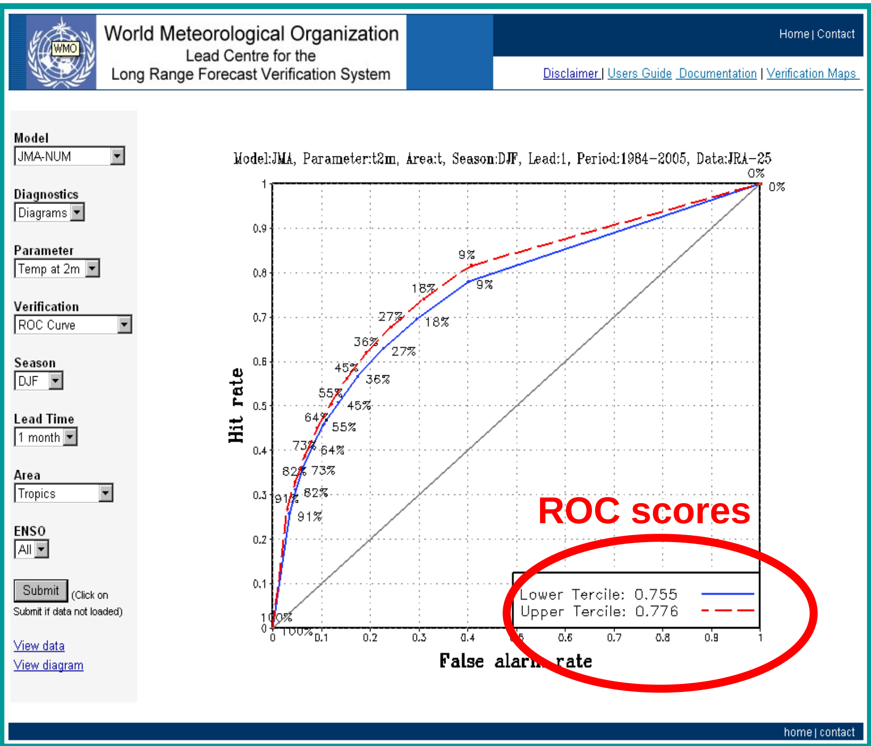
Variables to be assessed.
Levels of assessment.
Diagnostic measures.
What the Lead Centre provides.
How to submit results.
Format for submitting results.
Model system details.

VERIFICATION MAPS

The Lead Centre provides access to verification datasets, verifying software, documentation of the system, broad technical support, access to the final verification data as well as graphing and display of results.

The WMO Lead Centre for the SVS-LRF is jointly managed by the Australian Bureau of Meteorology and the Meteorological Service of Canada.

home | contact



World Meteorological Organization
Lead Centre for the
Long Range Forecast Verification System

Home | Contact

Disclaimer | Users Guide Documentation | Verification Maps

Model
JMA-NUM ▾

Diagnostics
Diagrams ▾

Parameter
Temp at 2m ▾

Verification
ROC Curve ▾

Season
DJF ▾

Lead Time
1 month ▾

Area
Tropics ▾

ENSO
All ▾

Submit (Click on Submit if data not loaded)

View data
View diagram

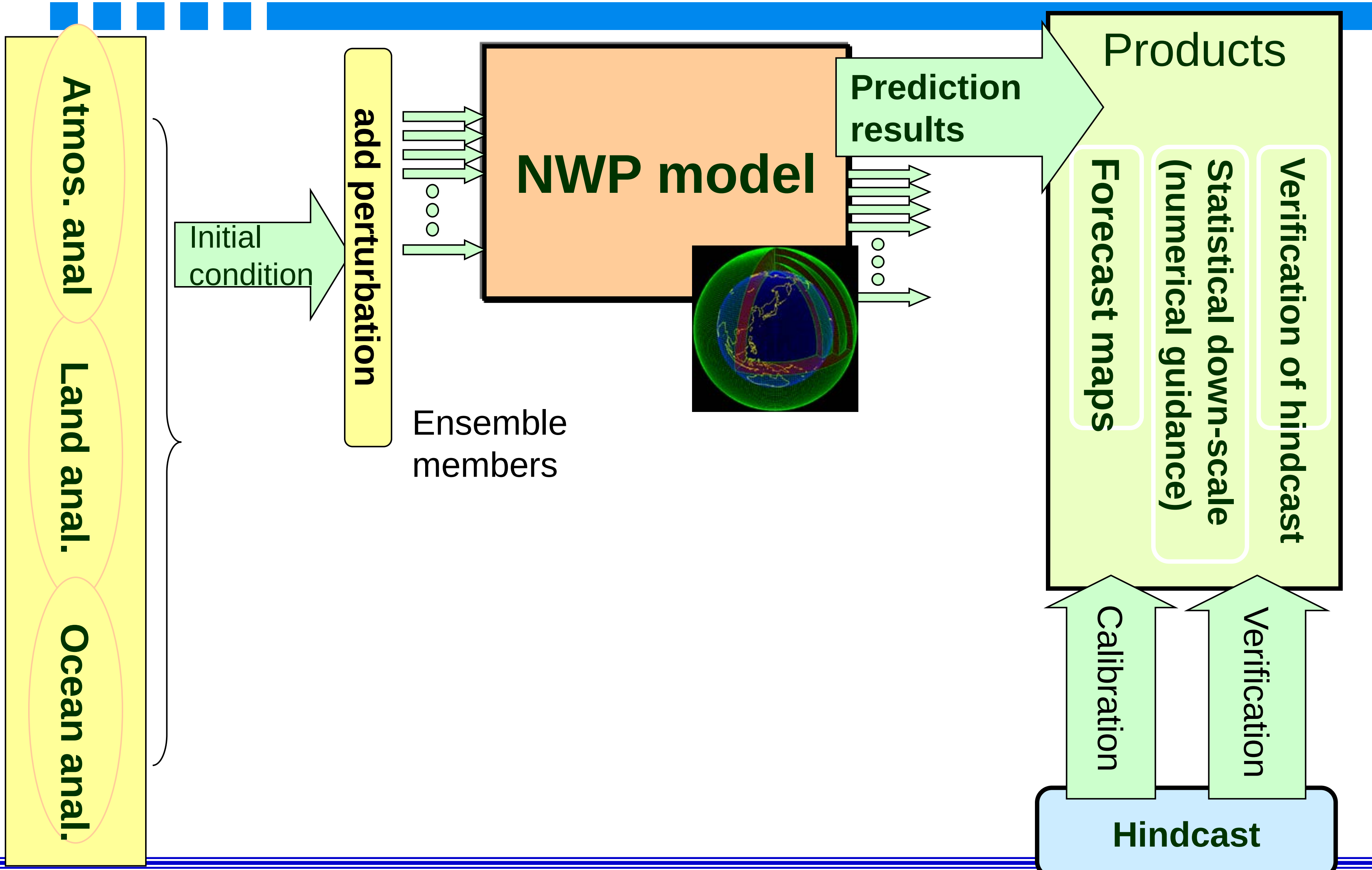
Model:JMA, Parameter:t2m, Area:t, Season:DJF, Lead:1, Period:1984-2005, Data:JRA-25

Lower Tercile: 0.755
Upper Tercile: 0.776

ROC scores

home | contact

Overview of an EPS and its Products to users



Atmos. anal

Land anal.

Ocean anal.

Initial condition

add perturbation

Ensemble members

NWP model

Prediction results

Products

Forecast maps

Statistical down-scale (numerical guidance)

Verification of hindcast

Calibration

Verification

Hindcast

Outline

- Outline of a numerical weather prediction
  - – Numerical weather prediction model
  - – Necessary knowledge to utilize NWP products
    - Predictability, Hindcast, Verification ...
- Outline of the JMA’s seasonal ensemble prediction system (EPS)
  - – Specifications, Prediction skill, Future subjects
- Introduction of the TCC website products relating with seasonal prediction

Operational global NWP models at JMA

	Main target	Horizontal resolution
Global Spectral Model (GSM)	•Short-range forecasting	20km Global
Typhoon EPS (TEPS)	•Typhoon forecasting	60km Global
One-week EPS (WEPS)	•One-week forecasting	60km Global
One-month EPS	•Early warning Information on •Extreme events •One-month forecasting	110km Global
4/7-month EPS (Seasonal EPS)	•Seasonal forecasting •El Niño outlook	180km Global

Numerical Prediction Division/JMA

Climate Prediction Division/JMA

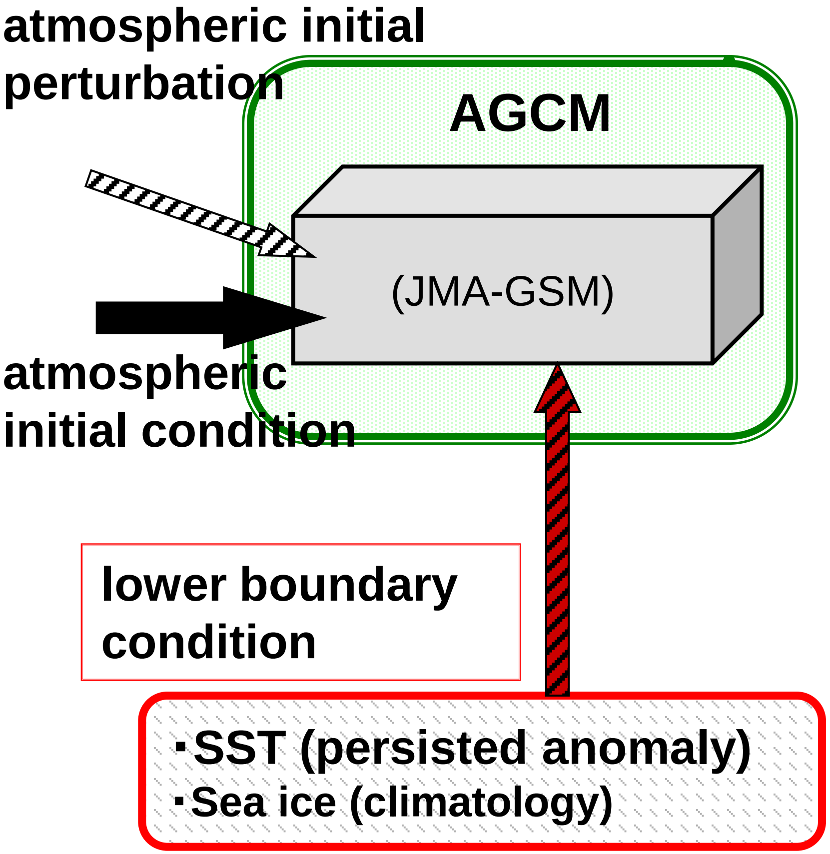
=available on the TCC website

Specification of One-month EPS

as of Nov.2013

One-month EPS

EPS with AGCM



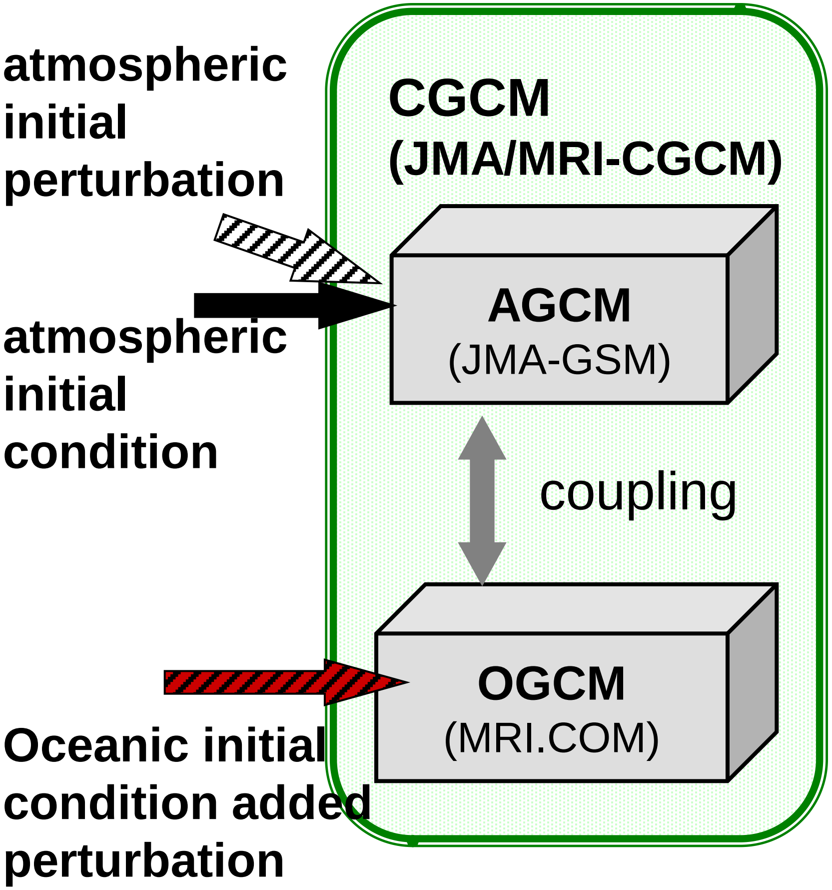
Model	AGCM H: about 110km (TL159) V: 60 levels (up to 0.1 hPa)
Forecast range	34 days
SST	Persisted anomaly with climatological variation
Sea ice	Climatology
Ensemble method	Combination of Breeding of Growing Modes (BGM) and Lagged Average Forecast (LAF)
Ensemble size	50 (25 BGMs & 2 initial days with 1-day LAF)
Freq. of model product creation	Once a week

Specification of Seasonal EPS

as of Nov.2013

Seasonal EPS

EPS with CGCM



atmospheric initial perturbation

atmospheric initial condition

Oceanic initial condition added perturbation

CGCM (JMA/MRI-CGCM)

AGCM (JMA-GSM)

coupling

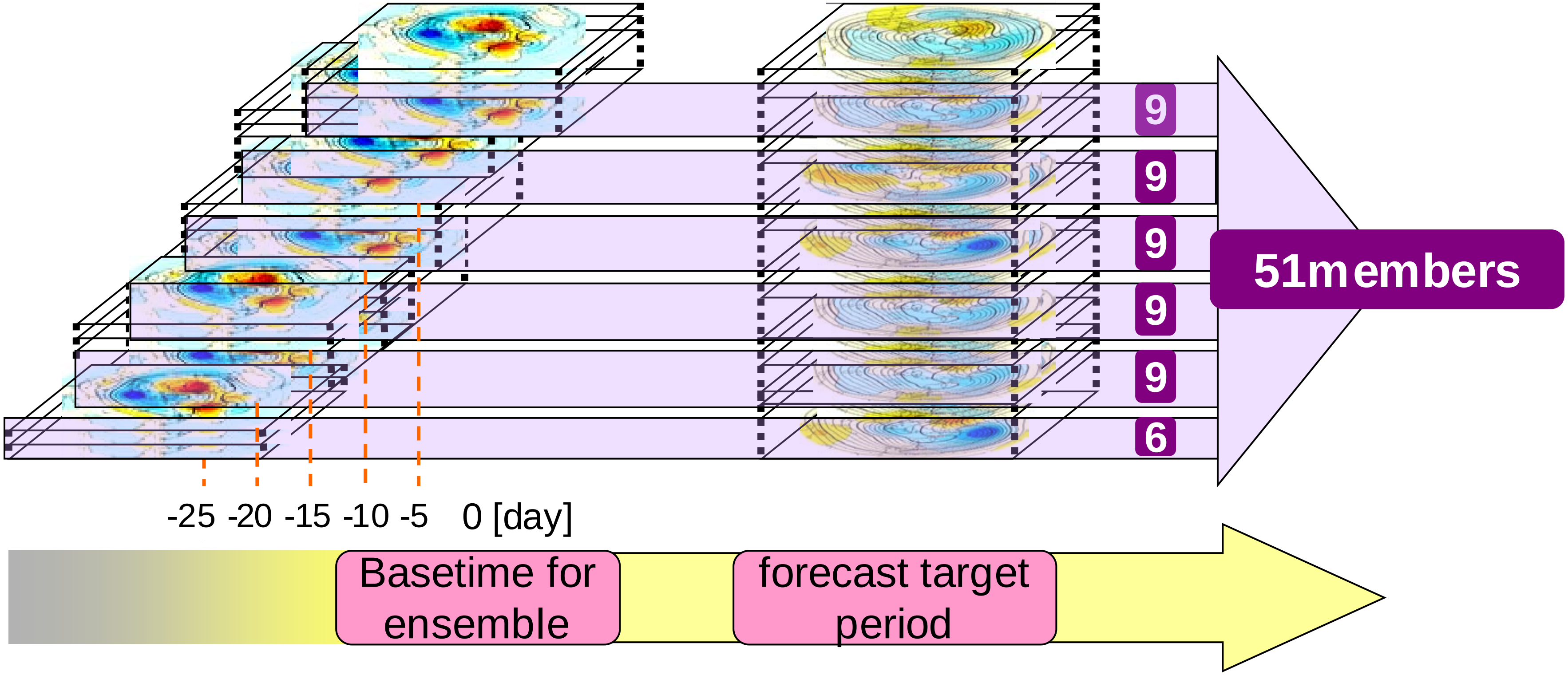
OGCM (MRI.COM)

Model	CGCM (JMA/MRI-CGCM) [A]H: about 180km (TL95), V: L40 (up to 0.4 hPa) [O]H:1.0ºlon.,0.3–1.0ºlat.(75˚S – 75˚N),V: L50
Forecast range	7 months
SST	Predicted
Sea ice	Climatology
Ensemble method	Combination of Breeding of Growing Modes (BGM) and Lagged Average Forecast (LAF)
Ensemble size	51 (9 BGMs & 6 initial days with 5-day LAF)
Freq. of model product creation	Once a month (around 20th of every month)

Schema of aggregation for the ensemble members in the Seasonal EPS

EPS adopts combination of the initial perturbation method and the Lagged Average Forecasting (LAF) method.

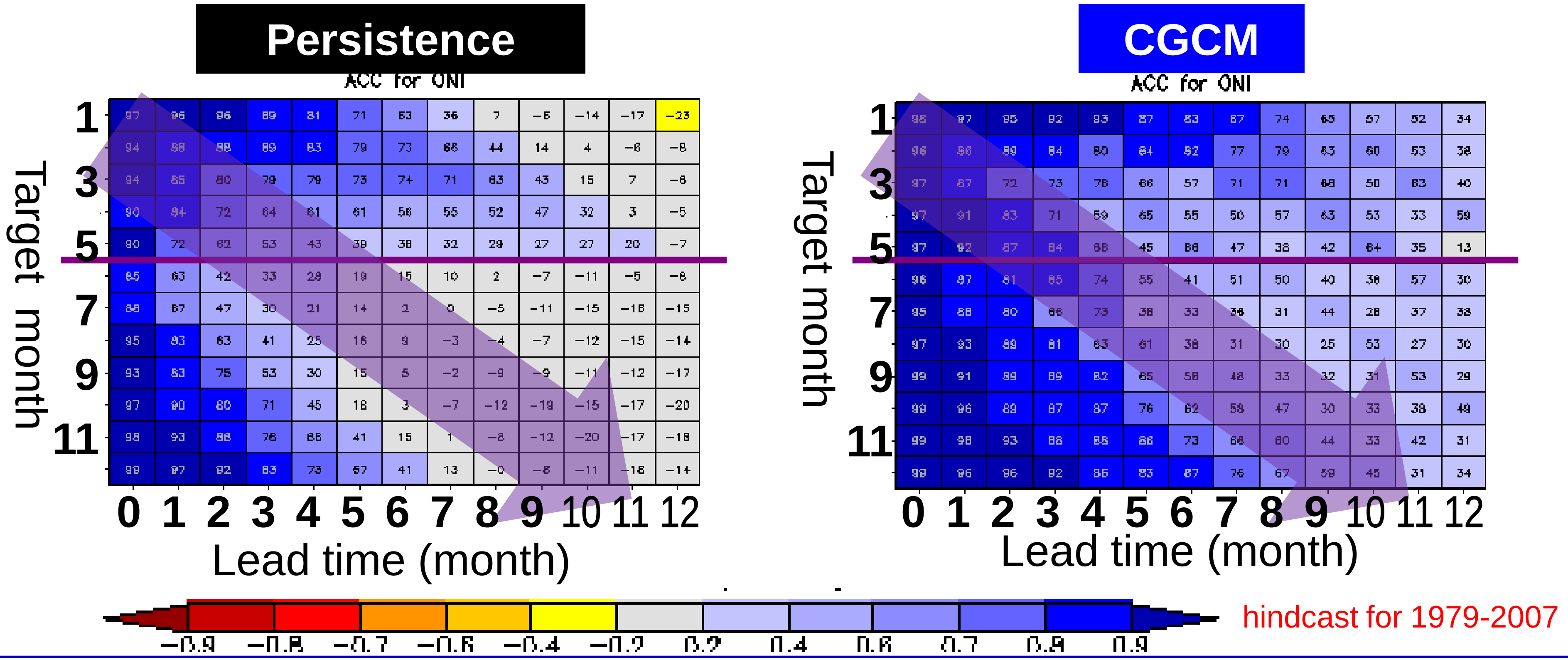
- –to disperse computing resources
- –to get ensemble spread



Anomaly Correlation of NINO.3

- Prediction skill has target month dependency.
- ACC of CGCM is higher than that of persistence.
  - However, ACC is relatively lower from spring to summer.

    = **"spring barrier"** ; common issues for all numerical model



Persistence

ACC for ONI

	0	1	2	3	4	5	6	7	8	9	10	11	12
1	97	96	96	89	81	71	63	36	7	−6	−14	−17	−23
	94	98	98	89	83	79	73	66	44	14	4	−6	−8
3	94	85	80	79	79	73	74	71	63	43	15	7	−8
	90	94	72	64	61	61	56	55	52	47	32	3	−5
5	90	72	62	53	43	39	38	32	29	27	27	20	−7
	95	63	42	33	29	19	15	10	2	−7	−11	−5	−8
7	98	67	47	30	21	14	2	0	−5	−11	−15	−16	−15
	95	93	63	41	25	16	9	−3	−4	−7	−12	−15	−14
9	93	83	75	53	30	15	5	−2	−9	−9	−11	−12	−17
	97	90	80	71	45	18	3	−7	−12	−19	−15	−17	−20
11	98	93	88	76	66	41	15	1	−8	−12	−20	−17	−18
	98	97	92	83	73	57	41	13	−0	−8	−11	−16	−14

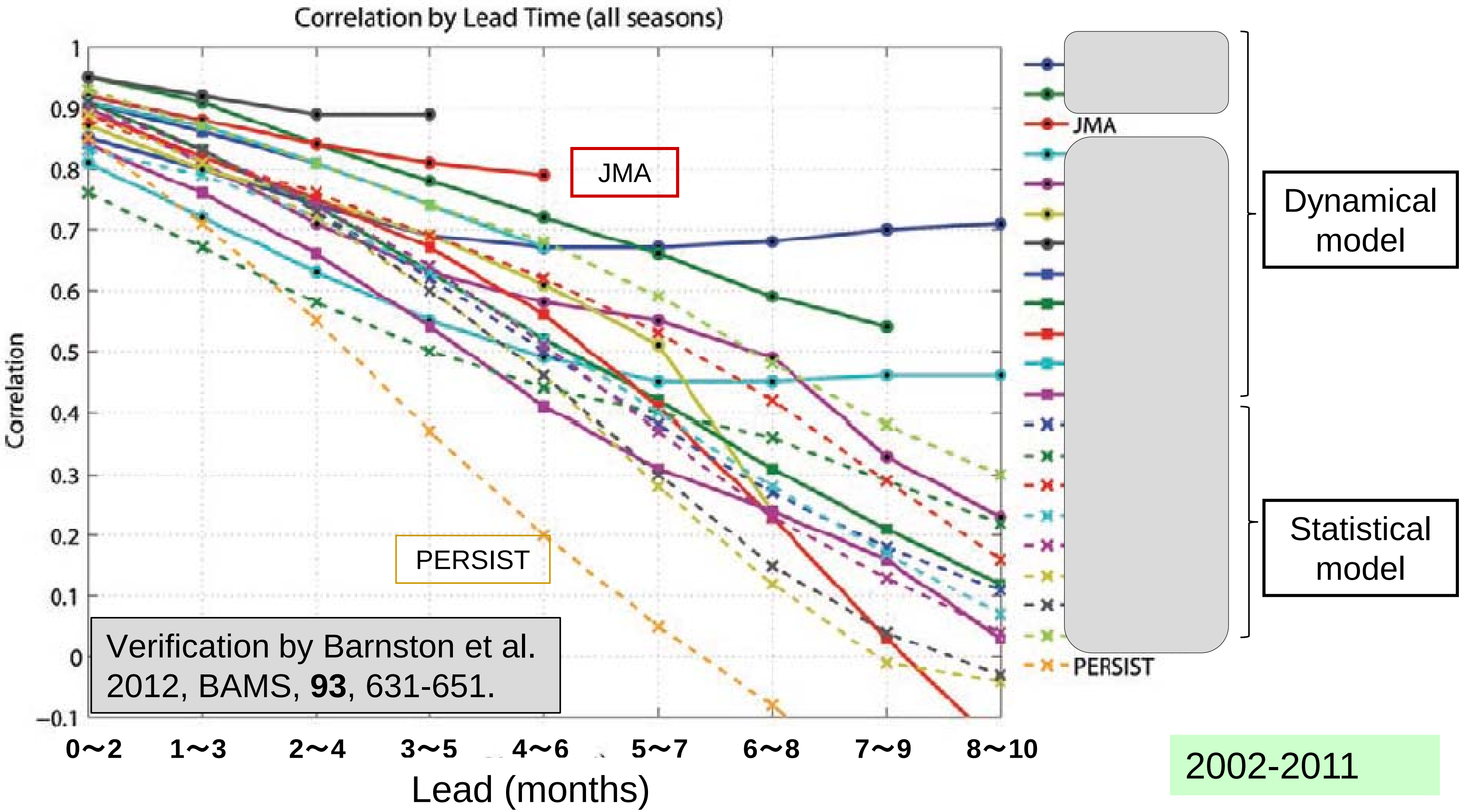
CGCM

ACC for ONI

	0	1	2	3	4	5	6	7	8	9	10	11	12
1	98	97	95	92	93	87	83	87	74	65	57	52	34
	96	96	89	84	80	84	82	77	79	63	60	53	38
3	97	87	72	73	78	66	57	71	71	68	50	63	40
	97	91	83	71	59	65	55	50	57	63	53	33	59
5	97	92	87	84	66	45	68	47	38	42	64	35	13
	96	97	91	85	74	55	41	51	50	40	38	57	30
7	95	88	80	66	73	38	33	36	31	44	28	37	38
	97	93	89	81	63	61	38	31	30	25	53	27	30
9	99	91	89	89	82	65	58	48	33	32	31	53	29
	98	96	89	87	87	76	62	58	47	30	33	38	49
11	99	98	93	88	88	88	73	68	80	44	33	42	31
	98	96	96	92	86	83	87	76	67	58	45	31	34

hindcast for 1979-2007

Prediction skill for NINO3.4-SST of the operational system



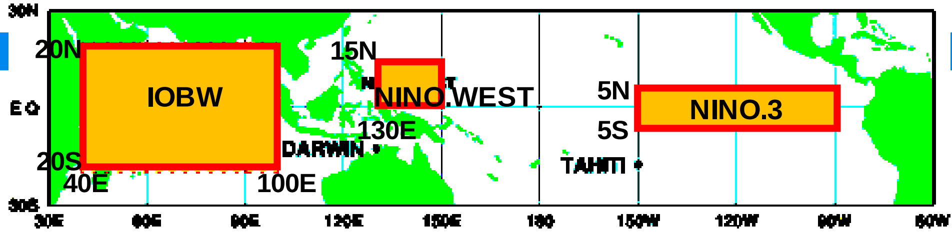
Verification by Barnston et al. 2012, BAMS, **93**, 631-651.

2002-2011

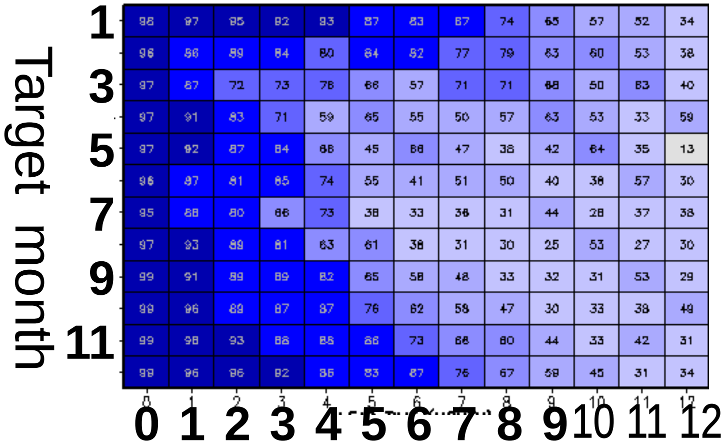
Anomaly Correlation of NINO.WEST and IOBW

CGCM

hindcast for 1979-2007



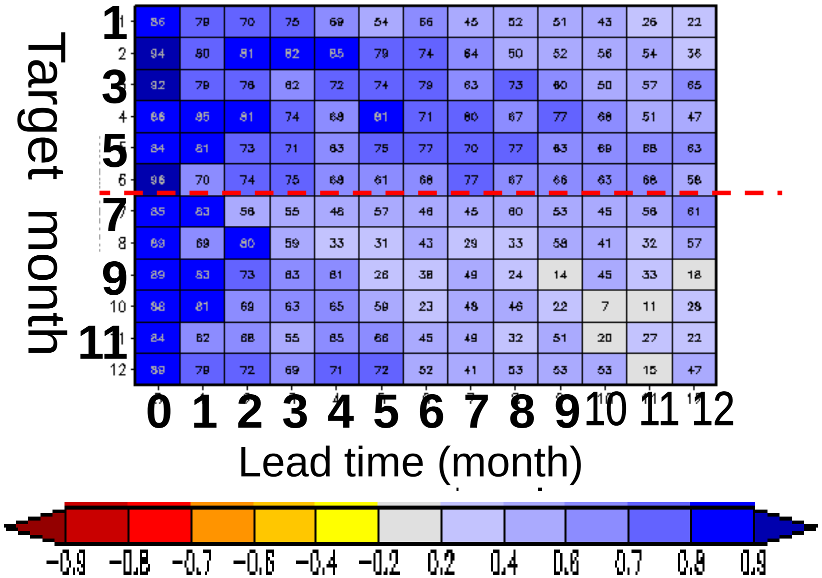
NINO.3



Target month	0	1	2	3	4	5	6	7	8	9	10	11	12
1	98	97	95	92	93	87	83	87	74	65	57	52	34
2	96	86	89	84	80	84	82	77	79	63	60	53	38
3	97	87	72	73	78	66	57	71	71	68	50	63	40
4	97	91	83	71	59	65	55	50	57	63	53	33	59
5	97	92	87	84	66	45	66	47	38	42	64	35	13
6	96	87	81	85	74	55	41	51	50	40	38	57	30
7	95	88	80	66	73	38	33	36	31	44	28	37	38
8	97	93	89	81	63	61	38	31	30	25	53	27	30
9	99	91	89	89	82	65	58	48	33	32	31	53	29
10	99	96	89	87	87	76	62	58	47	30	33	38	49
11	99	98	93	88	85	86	73	68	60	44	33	42	31
12	99	96	96	92	86	83	87	76	67	59	45	31	34

Relatively high during winter

IOBW



Target month	0	1	2	3	4	5	6	7	8	9	10	11	12
1	86	78	70	75	69	54	66	45	52	51	43	26	22
2	94	80	81	82	85	79	74	64	50	52	56	54	36
3	92	78	76	62	72	74	79	63	73	60	50	57	65
4	86	85	81	74	69	81	71	80	67	77	68	51	47
5	84	81	73	71	63	75	77	70	77	63	69	66	63
6	96	70	74	75	69	61	68	77	67	66	63	68	58
7	85	83	56	55	46	57	46	45	60	53	45	56	61
8	89	69	80	59	33	31	43	29	33	58	41	32	57
9	89	83	73	63	61	26	38	49	24	14	45	33	18
10	88	81	69	63	65	58	23	48	46	22	7	11	28
11	84	62	68	55	65	66	45	49	32	51	20	27	22
12	88	78	72	69	71	72	52	41	53	53	53	15	47

Relatively high (low) during spring to early summer (autumn to early winter)

- about one or two season <u>behind</u> comparing with NINO.3 and NINO.WEST

Variation of SSTs over the Indian Ocean relating with El Niño/ La Nina

SSTs over the IO varies behind El Niño/ La Nina because of oceanic circulation in the IO and interaction between atmosphere-ocean.

➢ IO plays role of “Capacitor” relating with ENSO (Xie et al. 2009)

- Tropical IO SSTs (TIO-SST) is about 3-months later than NINO.3

- In case of terminating El Niño (La Nina) in spring, TIO-SST tends to continue to be positive (negative) until summer.

Xie et al. 2009 J. Climate, 22, 730-747.

lag correlation with NINO3.4 in NDJ

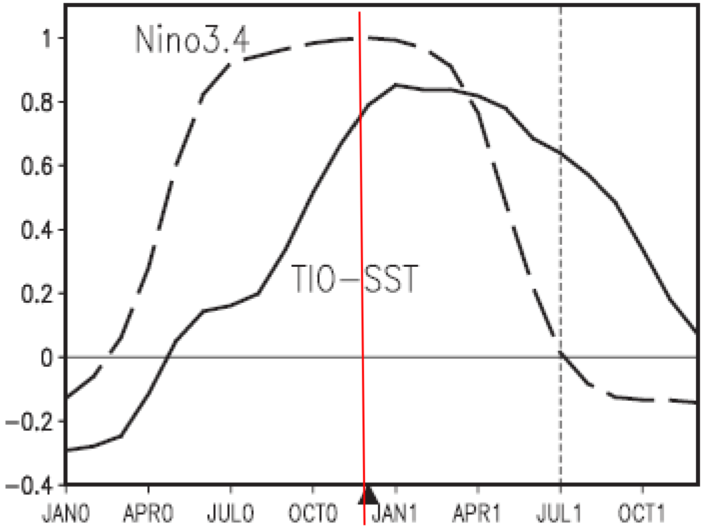
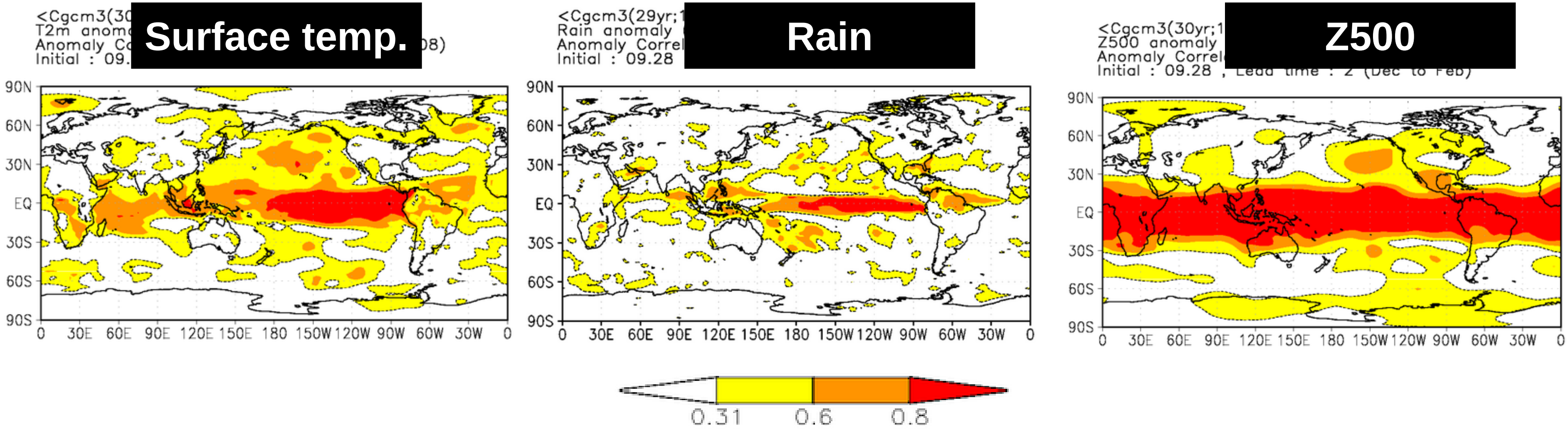


FIG. 1. Correlation of tropical Indian Ocean (20°S–20°N, 40°–100°E) SST (solid) with the Niño-3.4 (5°S–5°N, 170°–120°W) SST index for November(0)–December(0)–January(1). Numerals in parentheses denote years relative to El Niño: 0 for its developing and 1 for decay year. The dashed curve is the Niño-3.4 SST autocorrelation as a function of lag. The black triangle denotes December(0), the peak phase of ENSO.

Prediction skill of the seasonal EPS

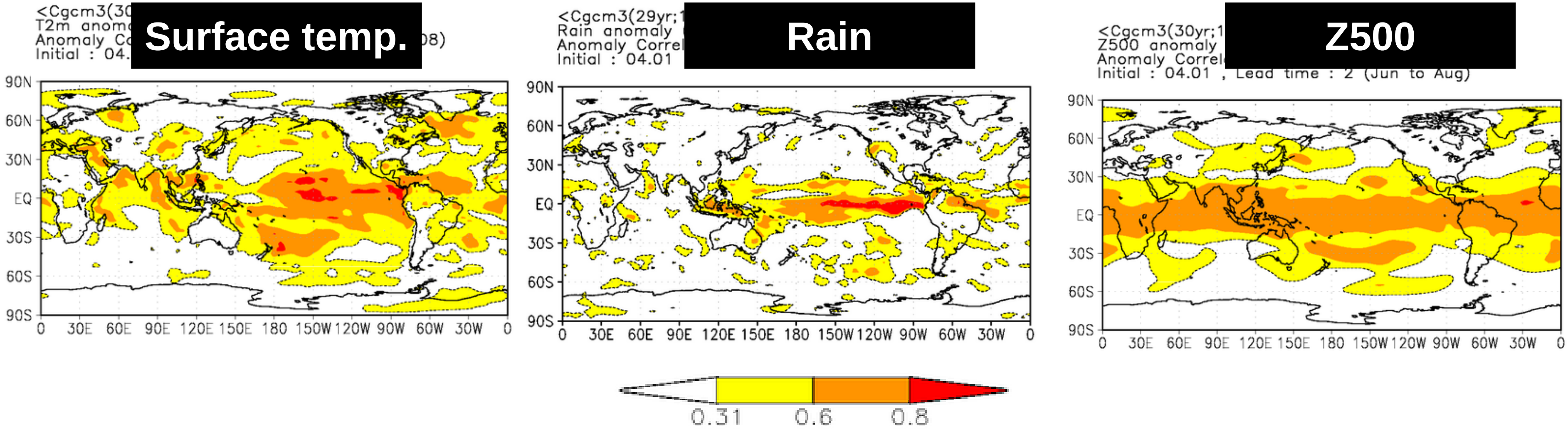
Anomaly correlation for DJF (initial of October, hindcast 79-08)



- Prediction skill is higher in the tropics
  - correlating highly with ENSO
- Even in the mid-latitudes, there are the area with relatively high prediction skill, reflecting teleconnection with ENSO

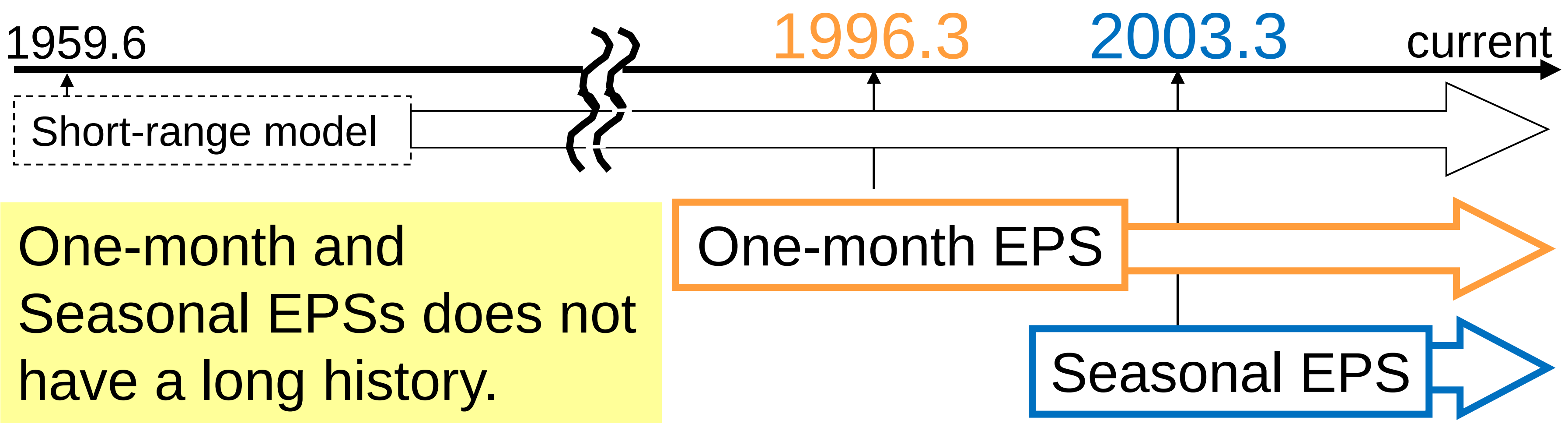
Prediction skill of the seasonal EPS

Anomaly correlation for JJA (initial of April, hindcast 79-08)



- Prediction skill is higher in the tropics
  - – correlating highly with ENSO
- Even in the mid-latitudes, there are the area with relatively high prediction skill, reflecting teleconnection with ENSO

History of the One-month & Seasonal EPSs at JMA



One-month and Seasonal EPSs does not have a long history.

	Mar 1996	Mar 2001	Mar 2003	Mar 2006	Sep 2007	Mar 2008	Feb 2010	Mar 2014 (plan)
One-month EPS AGCM	T63 L30 M10	T106 L40 M26		TL159 L40 M50		TL159 L60 M50		TL319 L60 M50
Seasonal EPS A → CGCM			T63 L40 M31	TL95 L40 M31	TL95 L40 M51		CGCM M51	

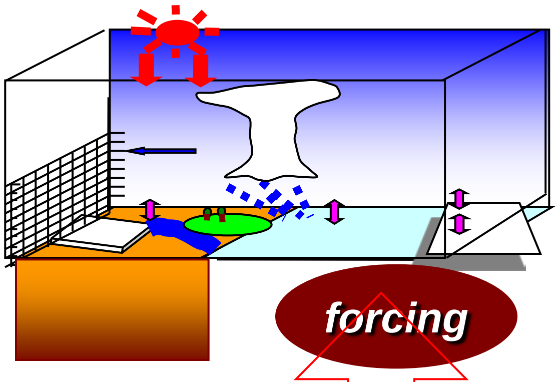
Difference of NWP system with AGCM and CGCM

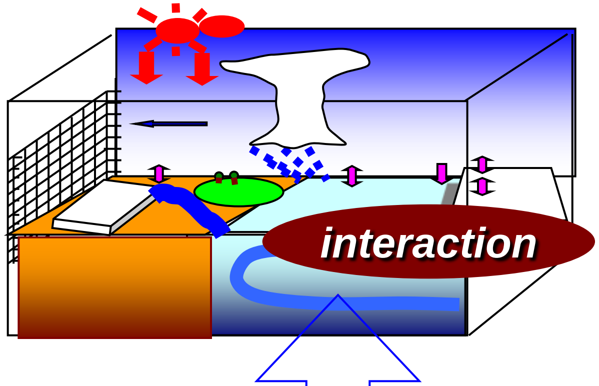
AGCM

two-tiered method

CGCM

one-tiered method





SSTs as forcing for AGCM is "prescribed" using statistics (e.g., persisted anomaly, climatology ENSO prediction by CGCM)

Coupling atmospheric and oceanic model

- ➢ocean-atmosphere interaction is considered in the model

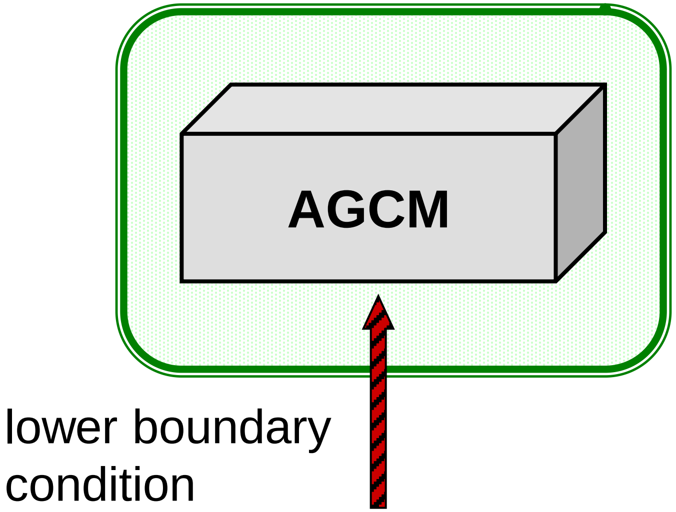
Difference of NWP system with AGCM and CGCM

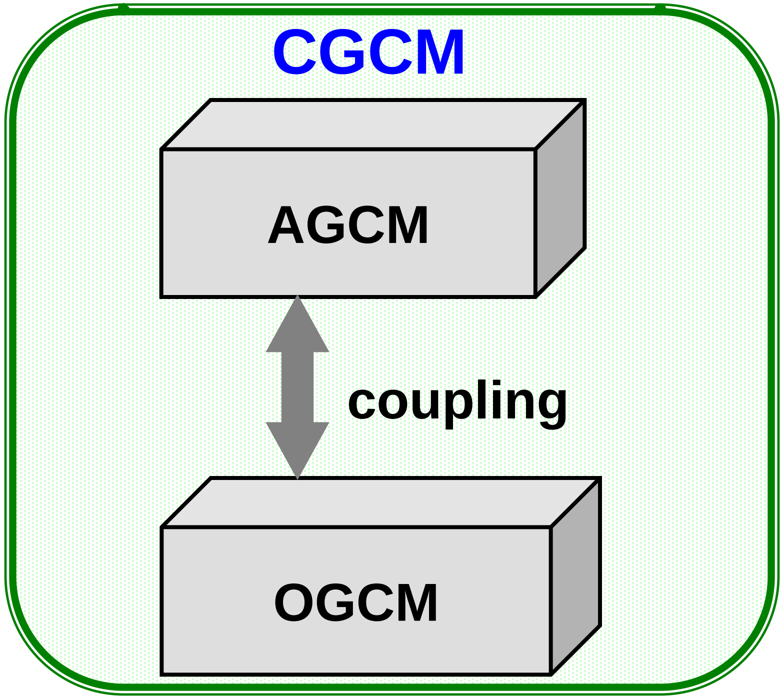
AGCM

two-tiered method

CGCM

one-tiered method





Prescribed SSTs

SSTs as forcing for AGCM is "prescribed" using statistics (e.g., persisted anomaly, climatology, ENSO prediction by CGCM)

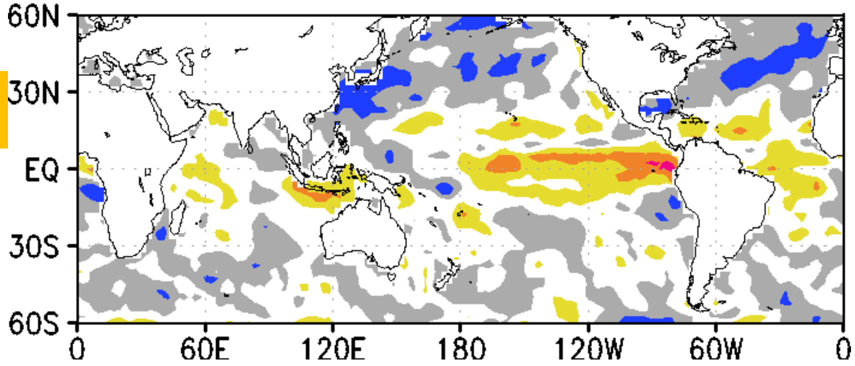
Possible to consider ocean-atmosphere interaction in the model

Reasons for improvement of prediction skill using CGCM

(1) Improvement of SST-rainfall relationship

Correlation coefficient between SST and rainfall for July
(initial date of 30 Jun, 1979-2010)

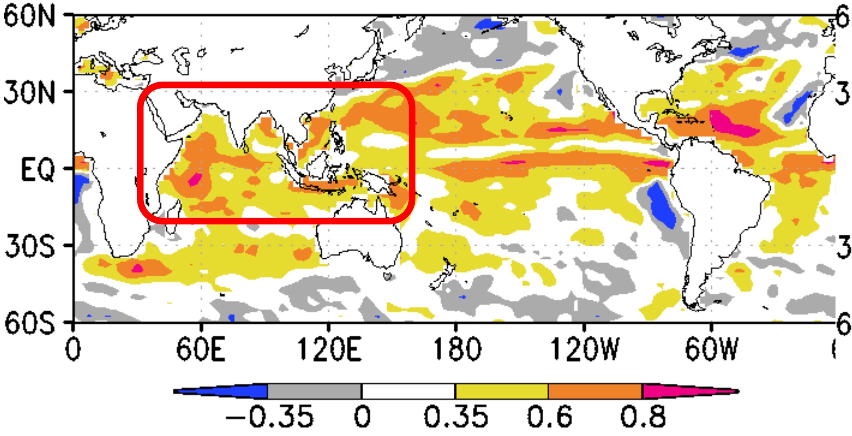
Analysis



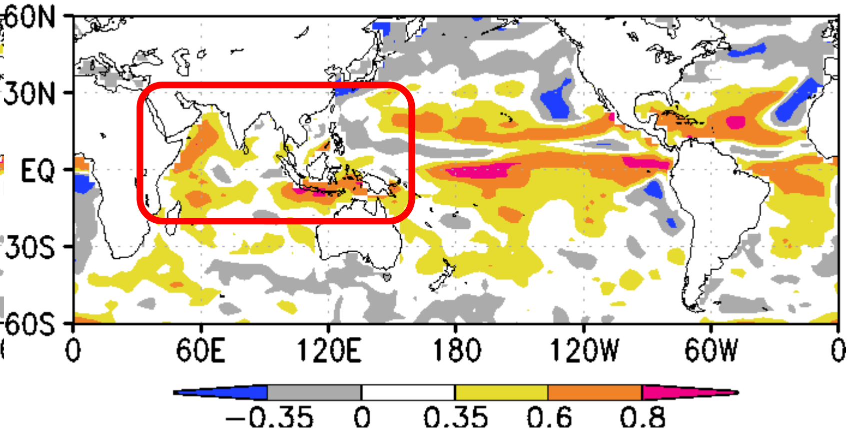
- CGCM improves excess positive correlation in the tropics, especially over Asian monsoon region, found in AGCM.

Model

AGCM



CGCM

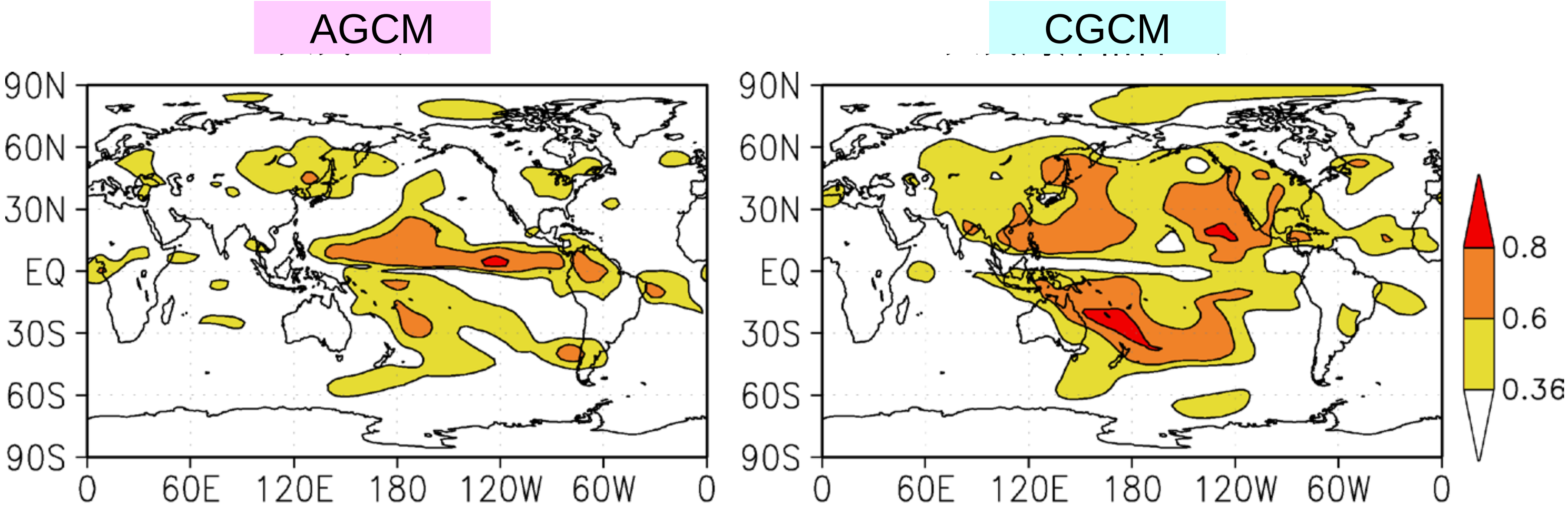


Reasons for improvement of prediction skill using CGCM

(2) Possible to reproduce ocean-atmosphere coupled process

- CGCM enable to take into account Ocean-atmosphere interaction, such as variation over the Indian Ocean relating with ENSO.
- Accordingly, CGCM leads to improve prediction skill especially in the tropics, which is affected by tropical oceanic variation.

Anomaly correlation for 850Hpa stream function (JJA,with initial of Feb.)

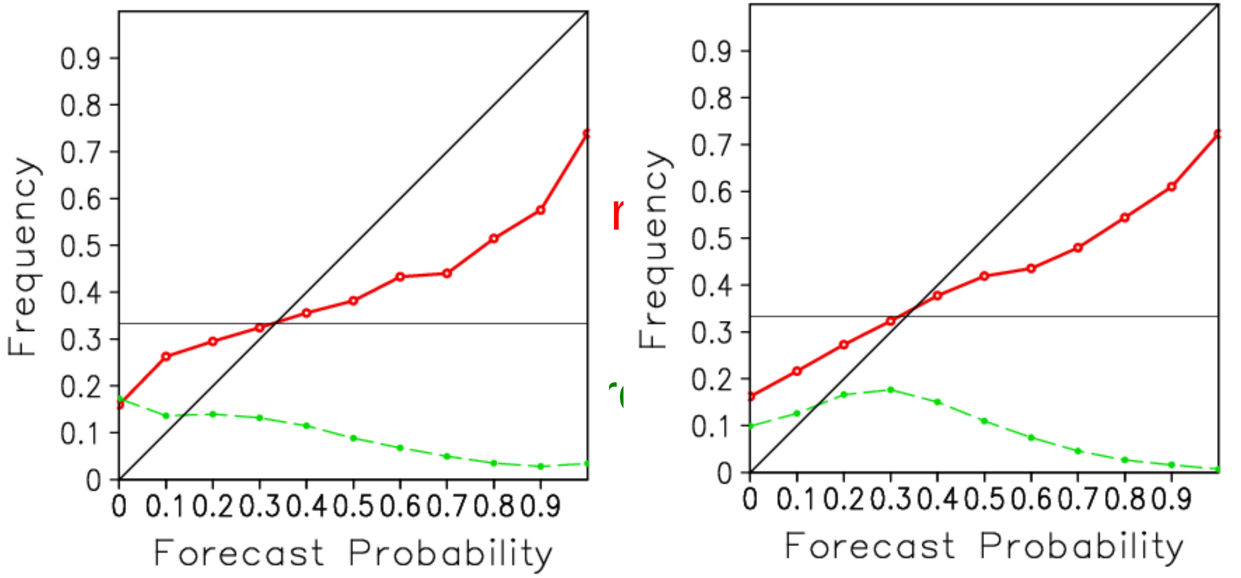


ハインドキャスト 1984～2005年

Shortcomings of the current system
(1) Improvement of Signal/ Noise rate

- Underestimation of spread
  - ➢Users should be correct the predicted probabilistic distribution using statistical method (guidance).

Reliability diagram for the upper tercile (JJA with the initial of May)

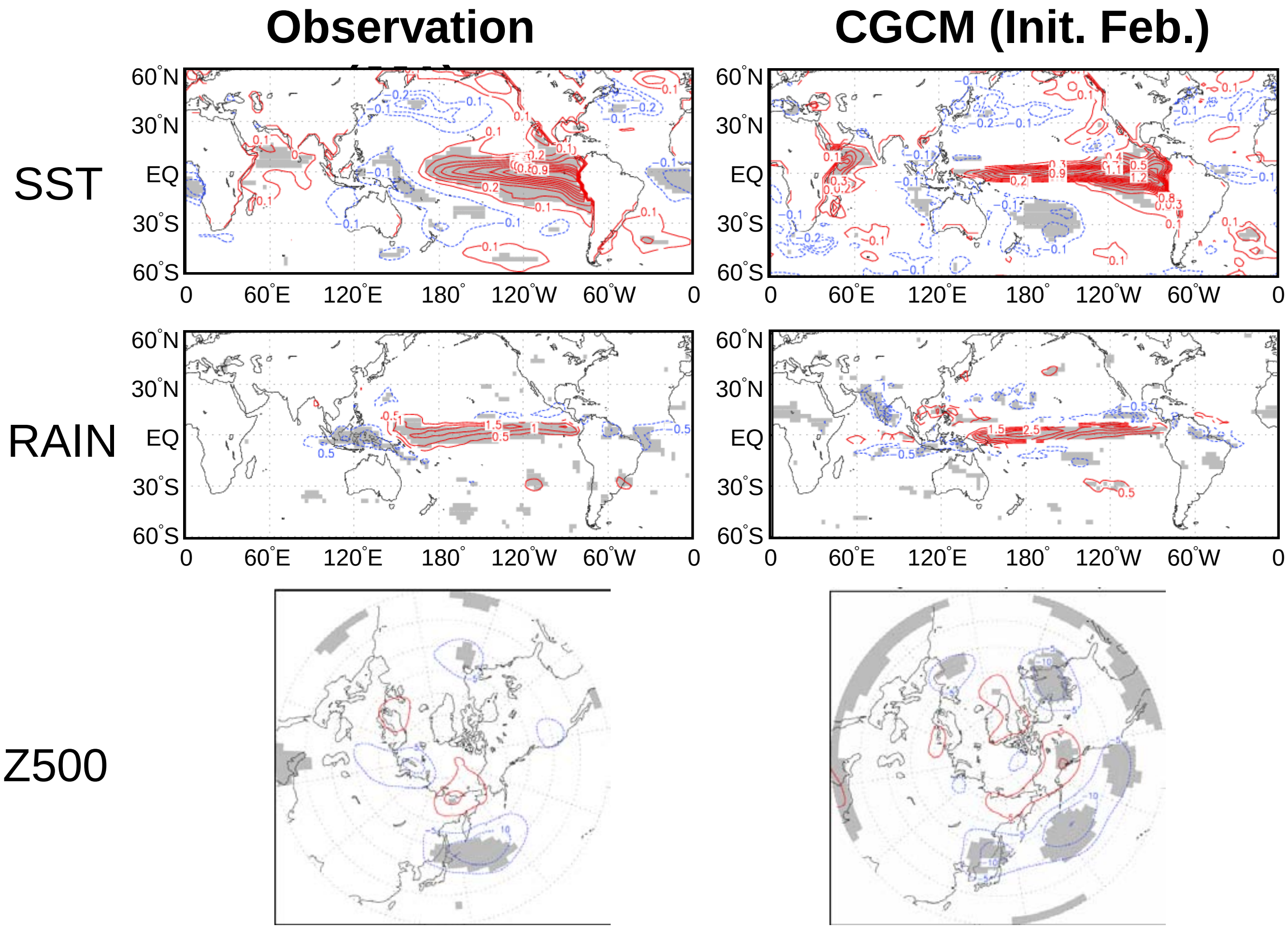


Rainfall (Tropics)

Z500 (N.H.)

Shortcomings of the current system
(2) Reproducibility of ENSO

Regression on Nino.3 in JJA



Due to bias of both models (AGCM and OGCM), teleconnection pattern of the model become deformed.

Forecasters look “distorted” ENSO and its influence.

➢**Users should be look <u>not only the prediction results at overhead</u> <u>but also general pattern</u>.**

Development of JMA Seasonal EPS

JMA plans to upgrade the seasonal EPS in 2015

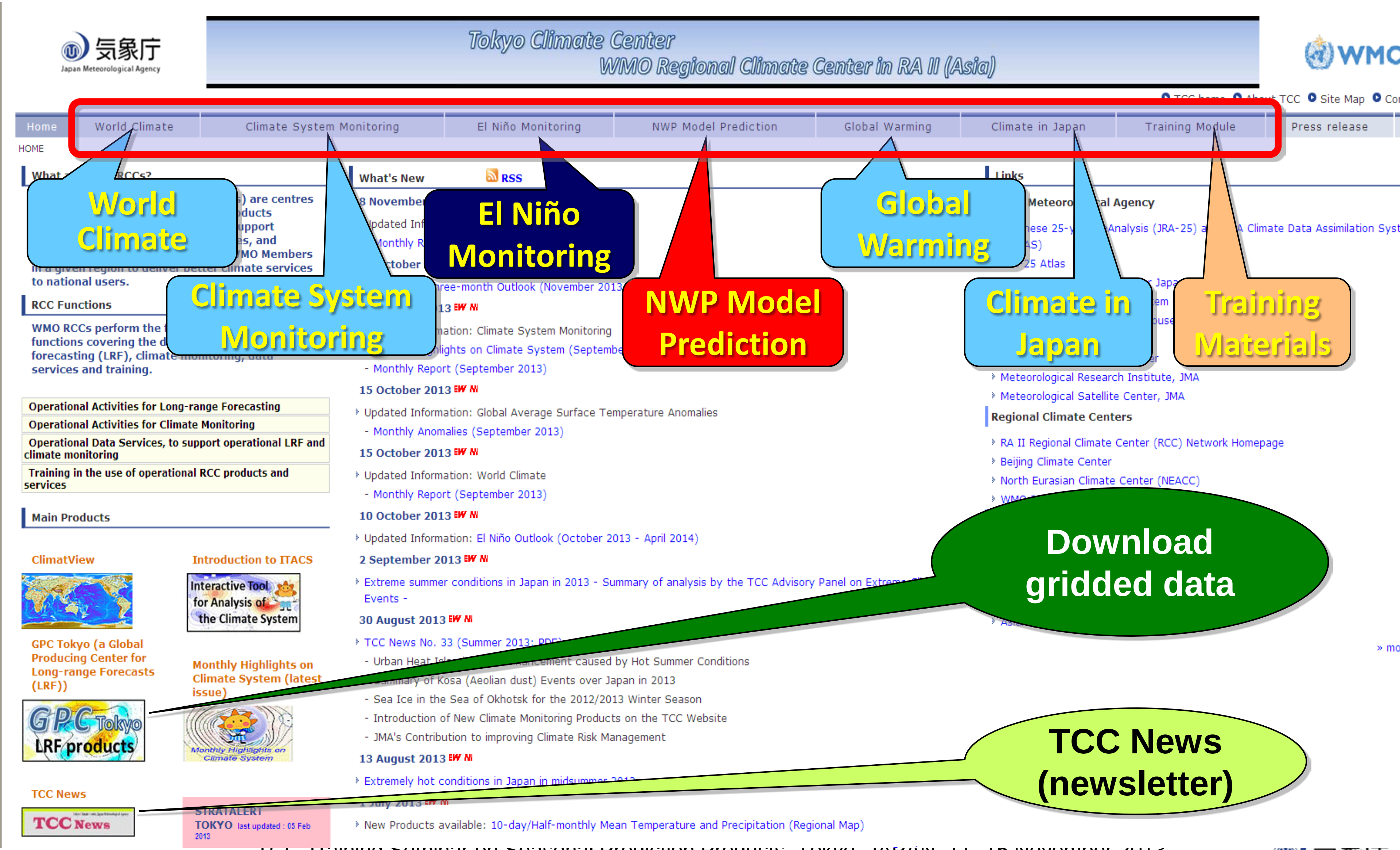
- AGCM
  - Increasing resolution (TL95L40 -> TL159L60)
  - Improvement model physics
  - introducing stochastic parameterization
- OGCM
  - Expansion of target area
  - to whole globe
  - Improvement of model physics
  - Introduction of sea-ice model
- Improvement of atmospheric analysis for initial condition and creating perturbation

Outline

- Outline of a numerical weather prediction
  - – Numerical weather prediction model
  - – Necessary knowledge to utilize NWP products
    - Predictability, Hindcast, Verification ...
- Outline of the JMA's seasonal ensemble prediction system (EPS)
  - – Specifications, Prediction skill, Future subjects
- Introduction of the TCC website products relating with seasonal prediction

TCC website

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



Tokyo Climate Center
WMO Regional Climate Center in RA II (Asia)

TCC home · About TCC · Site Map · Co

Home | World Climate | Climate System Monitoring | El Niño Monitoring | NWP Model Prediction | Global Warming | Climate in Japan | Training Module | Press release

HOME

What RCCs?

) are centres
ducts
upport
es, and
MO Members
in a given region to deliver better climate services
to national users.

RCC Functions

WMO RCCs perform the
functions covering the
forecasting (LRF), climate monitoring, data
services and training.

- Operational Activities for Long-range Forecasting
- Operational Activities for Climate Monitoring
- Operational Data Services, to support operational LRF and climate monitoring
- Training in the use of operational RCC products and services

Main Products

ClimatView

Introduction to ITACS

Interactive Tool for Analysis of the Climate System

GPC Tokyo (a Global Producing Center for Long-range Forecasts (LRF))

Monthly Highlights on Climate System (latest issue)

GPC Tokyo LRF products

Monthly Highlights on Climate System

TCC News

TCC News

STRATALERT
TOKYO last updated : 05 Feb 2013

What's New RSS

8 November
Updated Inf
- Monthly R
ctober
- Three-month Outlook (November 2013
13 EW NI
Updated Information: Climate System Monitoring
- Highlights on Climate System (Septembe
- Monthly Report (September 2013)

15 October 2013 EW NI
Updated Information: Global Average Surface Temperature Anomalies
- Monthly Anomalies (September 2013)

15 October 2013 EW NI
Updated Information: World Climate
- Monthly Report (September 2013)

10 October 2013 EW NI
Updated Information: El Niño Outlook (October 2013 - April 2014)

2 September 2013 EW NI
Extreme summer conditions in Japan in 2013 - Summary of analysis by the TCC Advisory Panel on Extreme Events -

30 August 2013 EW NI
TCC News No. 33 (Summer 2013; PDF)
- Urban Heat Isl enhancement caused by Hot Summer Conditions
- Summary of Kosa (Aeolian dust) Events over Japan in 2013
- Sea Ice in the Sea of Okhotsk for the 2012/2013 Winter Season
- Introduction of New Climate Monitoring Products on the TCC Website
- JMA's Contribution to improving Climate Risk Management

13 August 2013 EW NI
Extremely hot conditions in Japan in midsummer 2013

1 July 2013 EW NI
New Products available: 10-day/Half-monthly Mean Temperature and Precipitation (Regional Map)

Links

Meteoro al Agency
ese 25-y Analysis (JRA-25) a A Climate Data Assimilation Syst
S)
25 Atlas
Japa
em
ouse
r
Meteorological Research Institute, JMA
Meteorological Satellite Center, JMA

Regional Climate Centers

RA II Regional Climate Center (RCC) Network Homepage
Beijing Climate Center
North Eurasian Climate Center (NEACC)
WMO
Asia

» mo

World Climate

Climate System Monitoring

El Niño Monitoring

NWP Model Prediction

Global Warming

Climate in Japan

Training Materials

Download gridded data

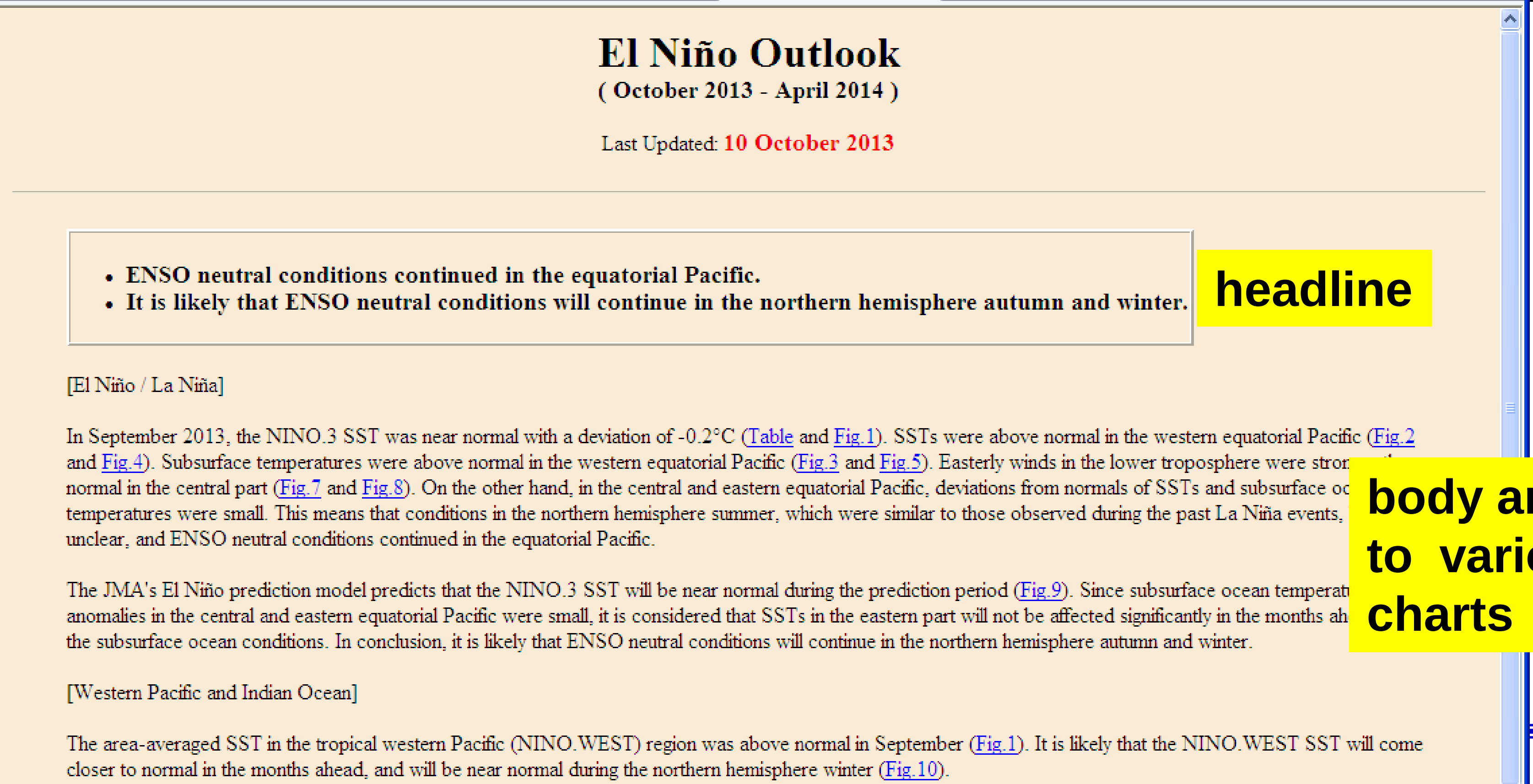
TCC News (newsletter)

El Niño Monitoring & Outlook

TOP PAGE > El Niño Monitoring

JMA operates the Ocean Data Assimilation System and the El Niño Prediction System (an ocean-atmosphere coupled model) for monitoring and prediction of ENSO.

Monthly diagnosis reports, ENSO monitoring products, ENSO indices and El Niño outlooks are available on the TCC website.



El Niño Outlook

(October 2013 - April 2014)

Last Updated: 10 October 2013

- **ENSO neutral conditions continued in the equatorial Pacific.**
- **It is likely that ENSO neutral conditions will continue in the northern hemisphere autumn and winter.**

headline

[El Niño / La Niña]

In September 2013, the NINO.3 SST was near normal with a deviation of -0.2°C (Table and Fig.1). SSTs were above normal in the western equatorial Pacific (Fig.2
and Fig.4). Subsurface temperatures were above normal in the western equatorial Pacific (Fig.3 and Fig.5). Easterly winds in the lower troposphere were stron
normal in the central part (Fig.7 and Fig.8). On the other hand, in the central and eastern equatorial Pacific, deviations from normals of SSTs and subsurface oc
temperatures were small. This means that conditions in the northern hemisphere summer, which were similar to those observed during the past La Niña events,
unclear, and ENSO neutral conditions continued in the equatorial Pacific.

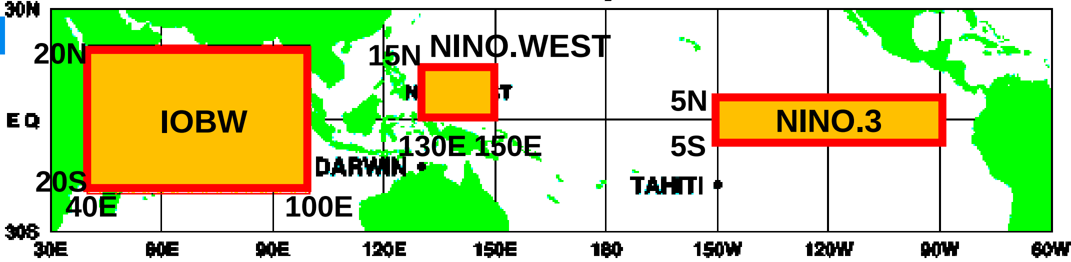
The JMA's El Niño prediction model predicts that the NINO.3 SST will be near normal during the prediction period (Fig.9). Since subsurface ocean temperat
anomalies in the central and eastern equatorial Pacific were small, it is considered that SSTs in the eastern part will not be affected significantly in the months ah
the subsurface ocean conditions. In conclusion, it is likely that ENSO neutral conditions will continue in the northern hemisphere autumn and winter.

[Western Pacific and Indian Ocean]

The area-averaged SST in the tropical western Pacific (NINO.WEST) region was above normal in September (Fig.1). It is likely that the NINO.WEST SST will come closer to normal in the months ahead, and will be near normal during the northern hemisphere winter (Fig.10).

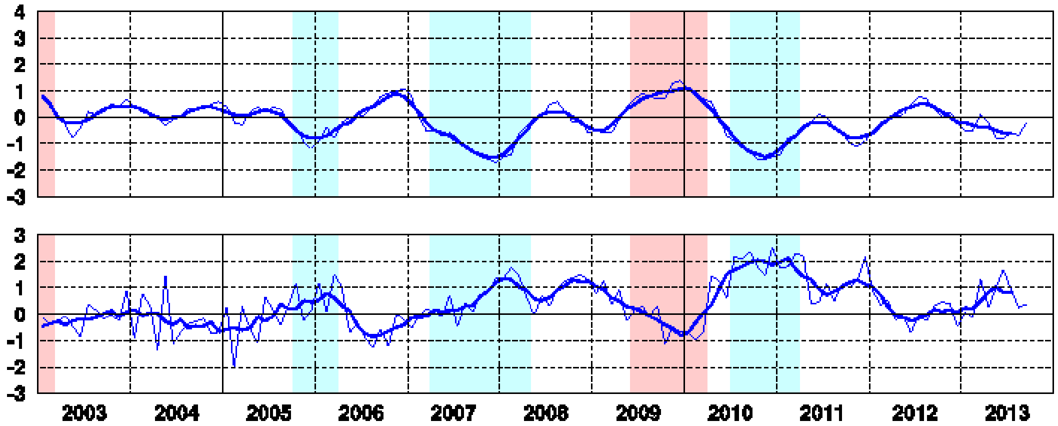
body and links to various charts

El Niño Monitoring & Outlook
(Ex.1 Current status of indices)



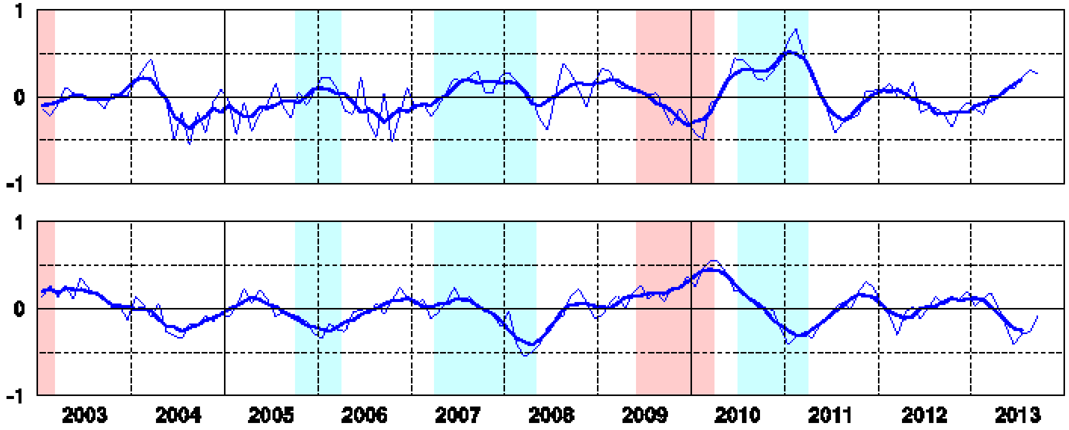
NINO.3

SOI

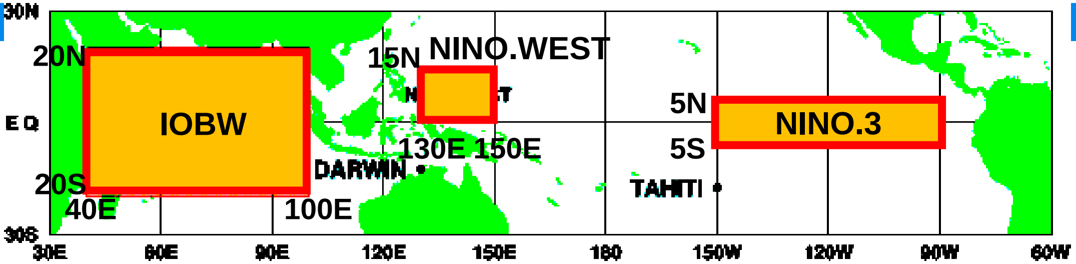


NINO.WEST

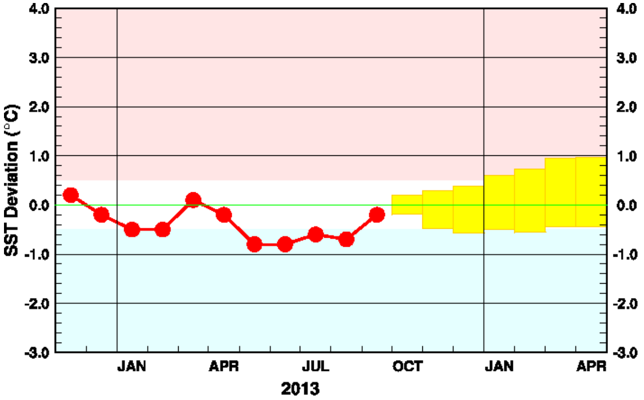
IOBW



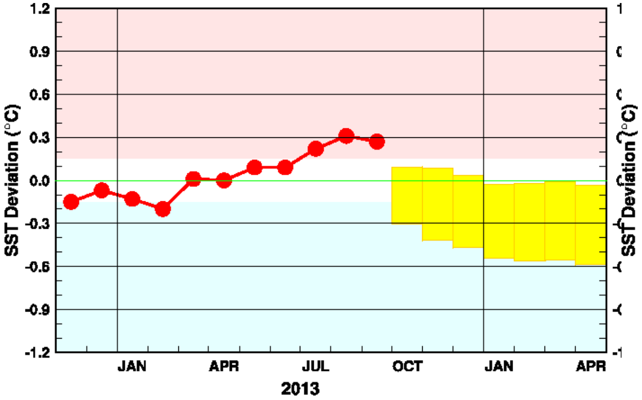
El Niño Monitoring & Outlook
(Ex.2 Outlook of the indices)



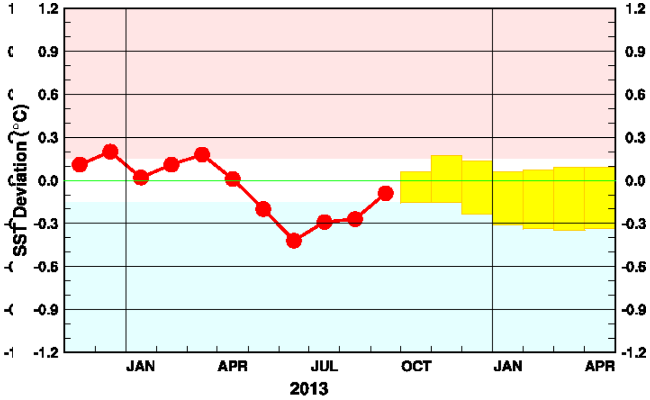
NINO.3



NINO.WEST



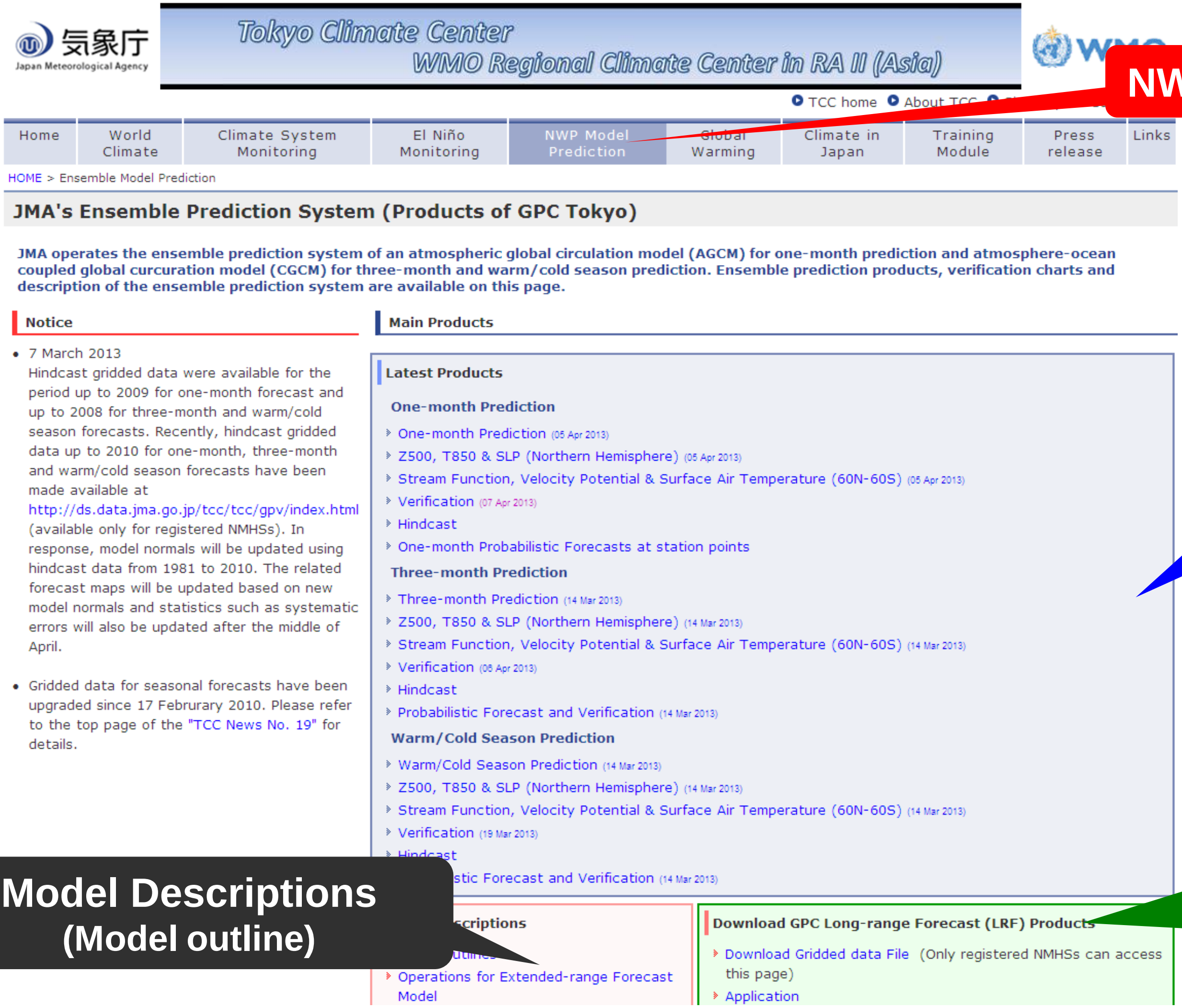
IOBW



NWP model products in the TCC-Web

TOP PAGE > NWP Model Prediction

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



HOME > Ensemble Model Prediction

JMA's Ensemble Prediction System (Products of GPC Tokyo)

JMA operates the ensemble prediction system of an atmospheric global circulation model (AGCM) for one-month prediction and atmosphere-ocean coupled global curcuration model (CGCM) for three-month and warm/cold season prediction. Ensemble prediction products, verification charts and description of the ensemble prediction system are available on this page.

Notice

- 7 March 2013
  Hindcast gridded data were available for the period up to 2009 for one-month forecast and up to 2008 for three-month and warm/cold season forecasts. Recently, hindcast gridded data up to 2010 for one-month, three-month and warm/cold season forecasts have been made available at http://ds.data.jma.go.jp/tcc/tcc/gpv/index.html (available only for registered NMHSs). In response, model normals will be updated using hindcast data from 1981 to 2010. The related forecast maps will be updated based on new model normals and statistics such as systematic errors will also be updated after the middle of April.

- Gridded data for seasonal forecasts have been upgraded since 17 Februrary 2010. Please refer to the top page of the "TCC News No. 19" for details.

Main Products

Latest Products

One-month Prediction

- One-month Prediction (05 Apr 2013)
- Z500, T850 & SLP (Northern Hemisphere) (05 Apr 2013)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (05 Apr 2013)
- Verification (07 Apr 2013)
- Hindcast
- One-month Probabilistic Forecasts at station points

Three-month Prediction

- Three-month Prediction (14 Mar 2013)
- Z500, T850 & SLP (Northern Hemisphere) (14 Mar 2013)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (14 Mar 2013)
- Verification (06 Apr 2013)
- Hindcast
- Probabilistic Forecast and Verification (14 Mar 2013)

Warm/Cold Season Prediction

- Warm/Cold Season Prediction (14 Mar 2013)
- Z500, T850 & SLP (Northern Hemisphere) (14 Mar 2013)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (14 Mar 2013)
- Verification (19 Mar 2013)
- Hindcast
- stic Forecast and Verification (14 Mar 2013)

scriptions

- utlines
- Operations for Extended-range Forecast Model

Download GPC Long-range Forecast (LRF) Products

- Download Gridded data File (Only registered NMHSs can access this page)
- Application

NWP Model Prediction

Latest Products
(--> Various predictions maps)

Download GPV
(Recent predictions and hindcast

Model Descriptions
(Model outline)

Products available on TCC website

- map
  - Ensemble mean forecast map
  - Calibrated probabilistic forecast
  - Verification (near real-time, hindcast)

- Gridded data (GRIB2)
  - Operational run
  - Hindcast
    - Ensemble statistics
    - All ensemble members
- Indices (CSV)

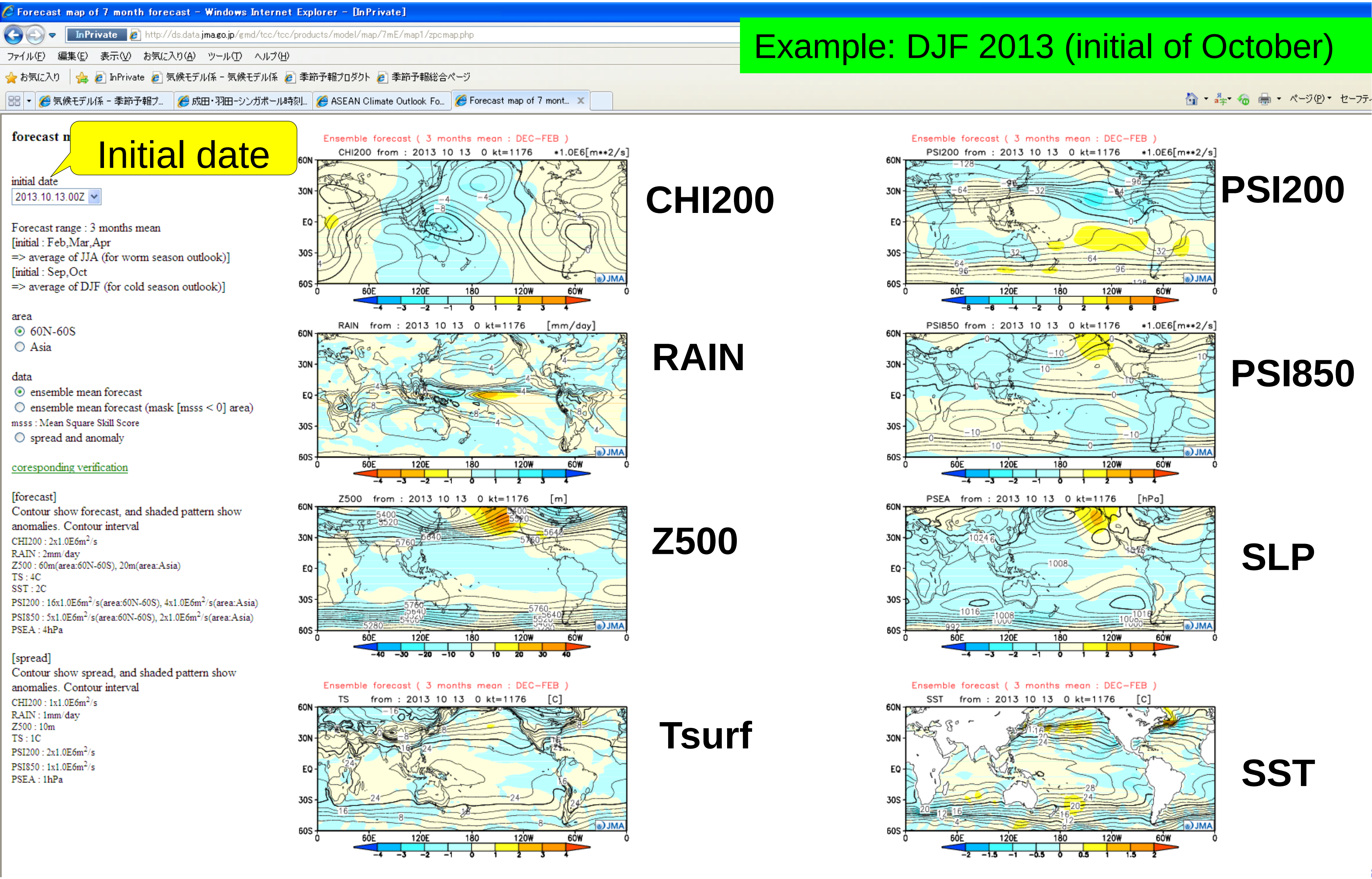
(Only registered NMHSs users available)

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

➢**ID/password will be issued at the beginning of the next lecture.**

Forecast map (Ensemble mean)

Example: DJF 2013 (initial of October)



forecast m

Initial date

initial date

2013.10.13.00Z

Forecast range : 3 months mean
[initial : Feb,Mar,Apr
=> average of JJA (for worm season outlook)]
[initial : Sep,Oct
=> average of DJF (for cold season outlook)]

area
- ● 60N-60S
- ○ Asia

data
- ● ensemble mean forecast
- ○ ensemble mean forecast (mask [msss < 0] area)

msss : Mean Square Skill Score
- ○ spread and anomaly

coresponding verification

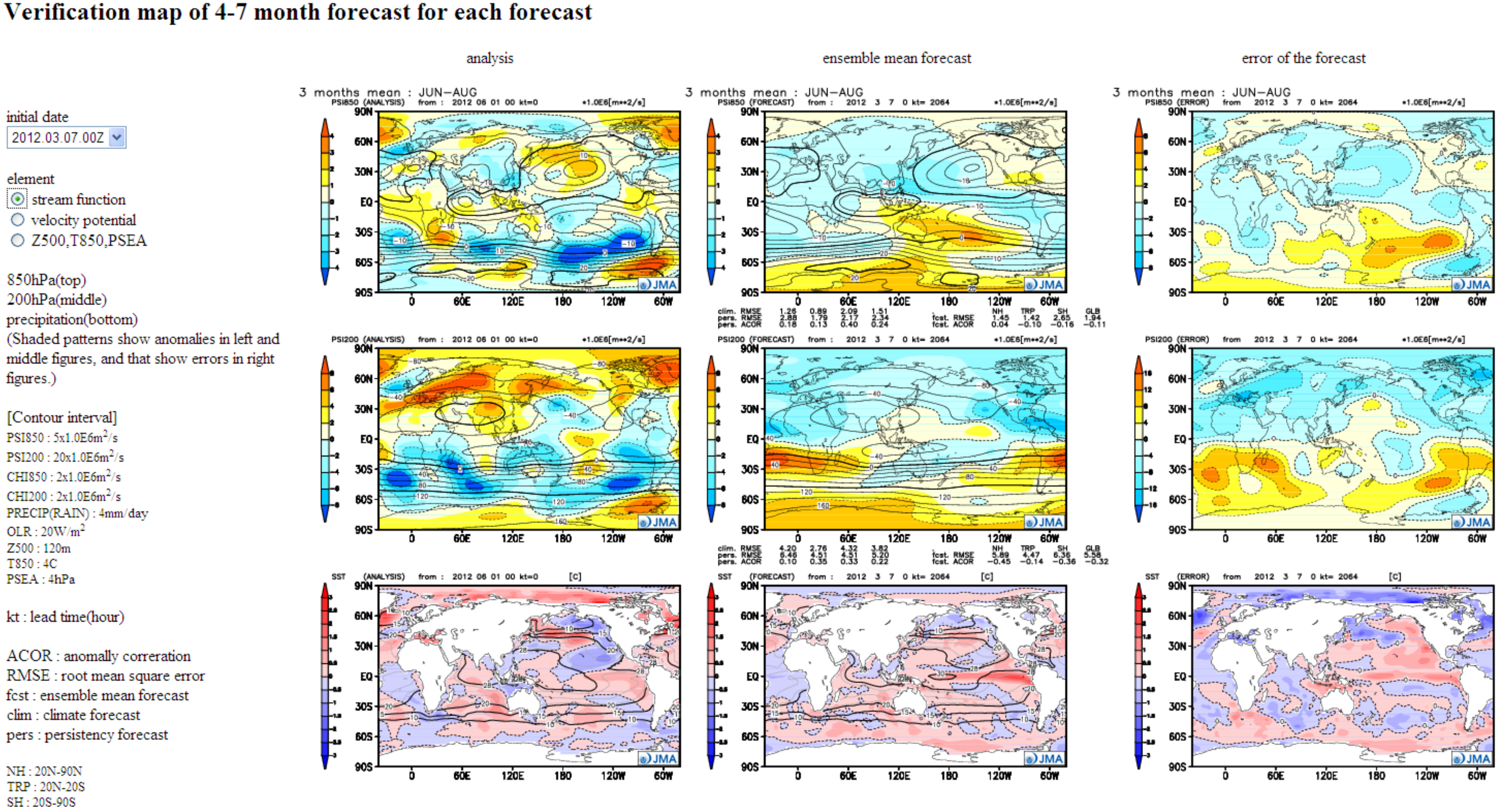
[forecast]
Contour show forecast, and shaded pattern show anomalies. Contour interval

CHI200 : 2x1.0E6m^2/s
RAIN : 2mm/day
Z500 : 60m(area:60N-60S), 20m(area:Asia)
TS : 4C
SST : 2C
PSI200 : 16x1.0E6m^2/s(area:60N-60S), 4x1.0E6m^2/s(area:Asia)
PSI850 : 5x1.0E6m^2/s(area:60N-60S), 2x1.0E6m^2/s(area:Asia)
PSEA : 4hPa

[spread]
Contour show spread, and shaded pattern show anomalies. Contour interval

CHI200 : 1x1.0E6m^2/s
RAIN : 1mm/day
Z500 : 10m
TS : 1C
PSI200 : 2x1.0E6m^2/s
PSI850 : 1x1.0E6m^2/s
PSEA : 1hPa

Verification maps for each prediction case



Verification map of 4-7 month forecast for each forecast

initial date
2012.03.07.00Z

element
● stream function
○ velocity potential
○ Z500,T850,PSEA

850hPa(top)
200hPa(middle)
precipitation(bottom)
(Shaded patterns show anomalies in left and middle figures, and that show errors in right figures.)

[Contour interval]
PSI850 : 5x1.0E6m^2/s
PSI200 : 20x1.0E6m^2/s
CHI850 : 2x1.0E6m^2/s
CHI200 : 2x1.0E6m^2/s
PRECIP(RAIN) : 4mm/day
OLR : 20W/m^2
Z500 : 120m
T850 : 4C
PSEA : 4hPa

kt : lead time(hour)

ACOR : anomally correration
RMSE : root mean square error
fcst : ensemble mean forecast
clim : climate forecast
pers : persistency forecast

NH : 20N-90N
TRP : 20N-20S
SH : 20S-90S

```
clim. RMSE    1.26   0.89   2.09   1.51           NH     TRP     SH     GLB
pers. RMSE    2.88   1.79   2.17   2.34   fcst. RMSE   1.45    1.42   2.65   1.94
pers. ACOR    0.18   0.13   0.40   0.24   fcst. ACOR   0.04   -0.10  -0.16  -0.11
```

```
clim. RMSE    4.20   2.76   4.32   3.82           NH     TRP     SH     GLB
pers. RMSE    6.46   4.51   4.51   5.20   fcst. RMSE   5.89    4.47   6.36   5.58
pers. ACOR    0.10   0.35   0.33   0.22   fcst. ACOR  -0.45   -0.14  -0.36  -0.32
```

Analysis

Forecast

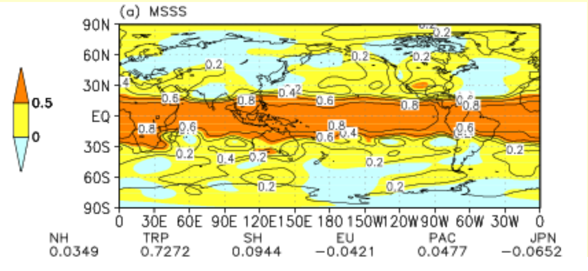
Error

Verification of hindcast

Verification of hindcast based on WMO Standard Verification System (SVS)

Verification of deterministic forecasts

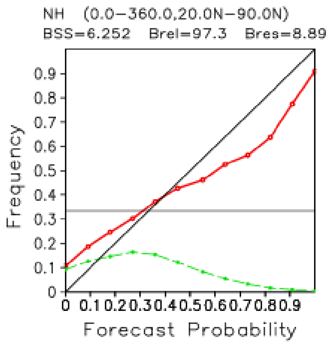
- Mean Square Skill Score
  RAIN | T2m | PSEA | Z500 | T850
  Dependence of MSSS on Initial date



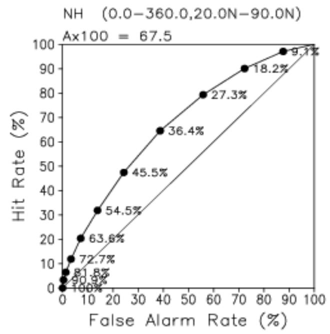
- 3 by 3 contingency tables (in Japan)
  (Category : Below Normal, Near Normal, Above Normal)
  RAIN | T2m | PSEA | Z500 | T850

Verification of Probabilistic forecasts

- Reliability diagrams (Aggregated verification)
  (Anomaly > 0, Below Normal, Near Normal, Above Normal)
  RAIN | T2m | PSEA | Z500 | T850



- Relative Operating Characteristics
  - ROC curves, ROC areas (Aggregated verification)
    (Anomaly > 0, Below Normal, Near Normal, Above Normal)
    RAIN | T2m | PSEA | Z500 | T850
    Dependence of ROC areas on Initial date
  - ROC areas (Grid point verification)
    (Anomaly > 0, Below Normal, Near Normal, Above Normal)
    RAIN | T2m | PSEA | Z500 | T850



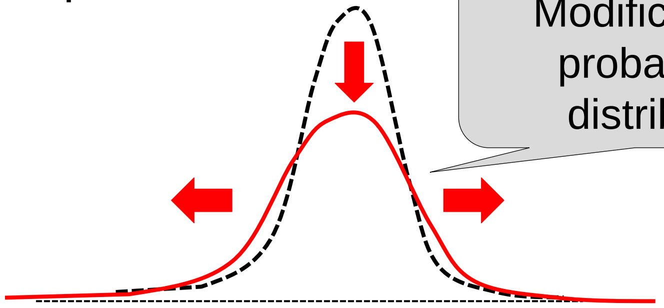
Calibrated probabilistic forecast

Probability distribution from the direct model output

Numerical guidance
(Statistical technique based on hindcast)

Calibrated probabilistic forecast
(one of the statistical guidance)

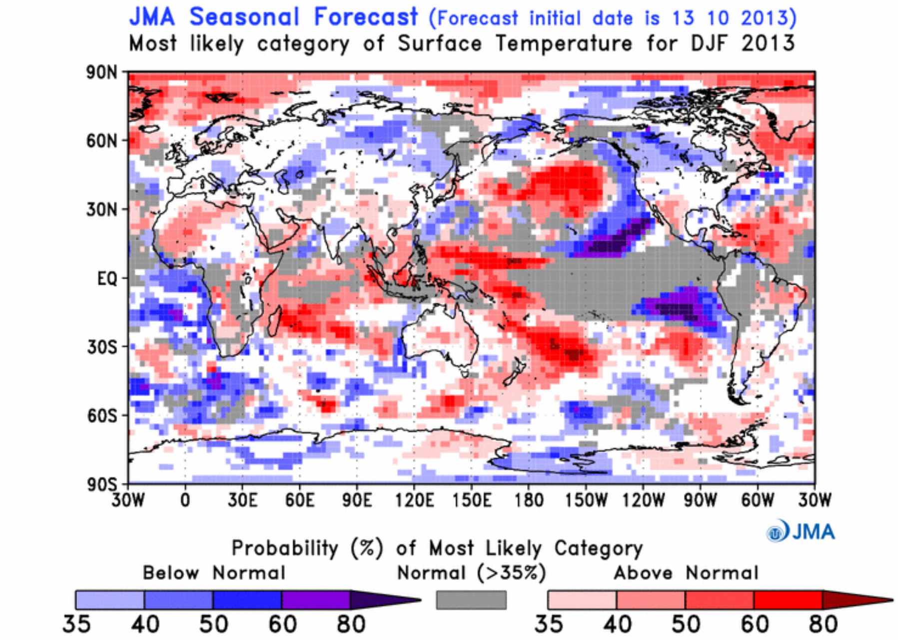
Example of calibration



Modification of probabilistic distribution

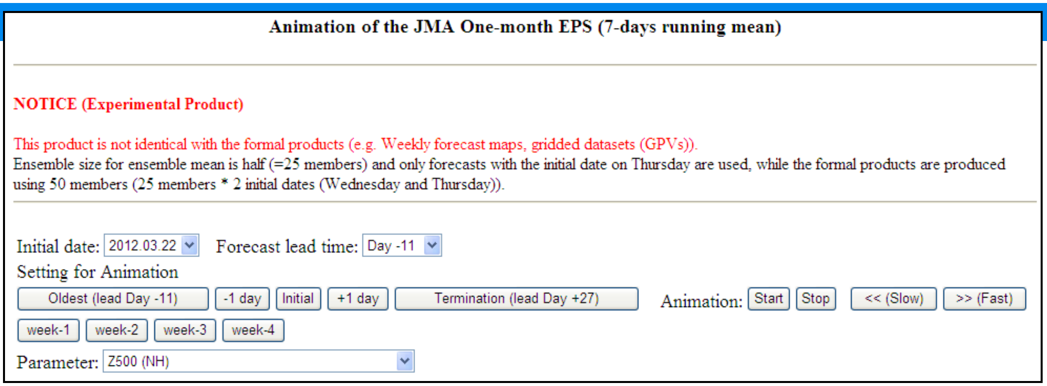
Most Likely Category

DJF 2013 (initial of October)



Animation of one-month prediction

TCC provides **animation of JMA one-month prediction** on an experimental basis.



Animation of the JMA One-month EPS (7-days running mean)

NOTICE (Experimental Product)

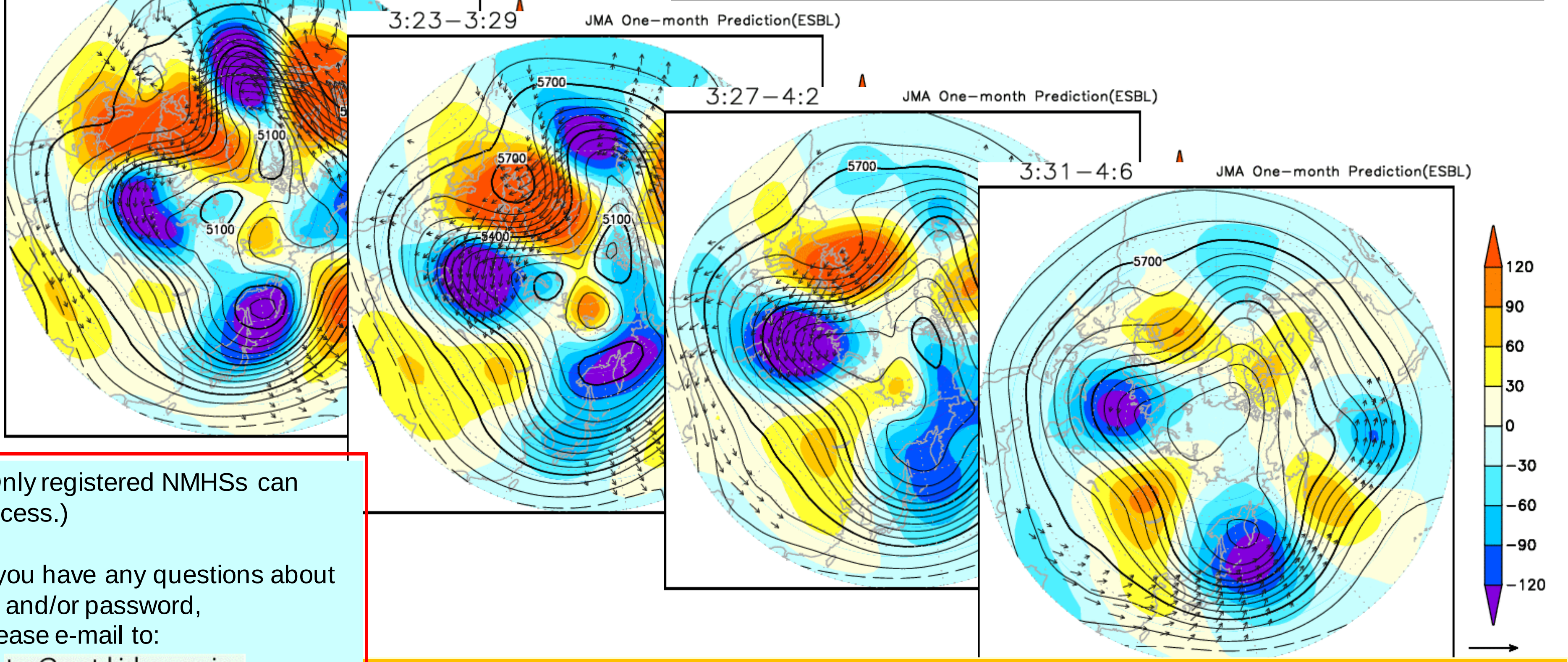
This product is not identical with the formal products (e.g. Weekly forecast maps, gridded datasets (GPVs)).
Ensemble size for ensemble mean is half (=25 members) and only forecasts with the initial date on Thursday are used, while the formal products are produced using 50 members (25 members * 2 initial dates (Wednesday and Thursday)).

Initial date: 2012.03.22 Forecast lead time: Day -11

Setting for Animation

Animation:

Parameter: Z500 (NH)



3:19−3:25 JMA One-month Prediction(ANL/ESBL)

3:23−3:29 JMA One-month Prediction(ESBL)

3:27−4:2 JMA One-month Prediction(ESBL)

3:31−4:6 JMA One-month Prediction(ESBL)

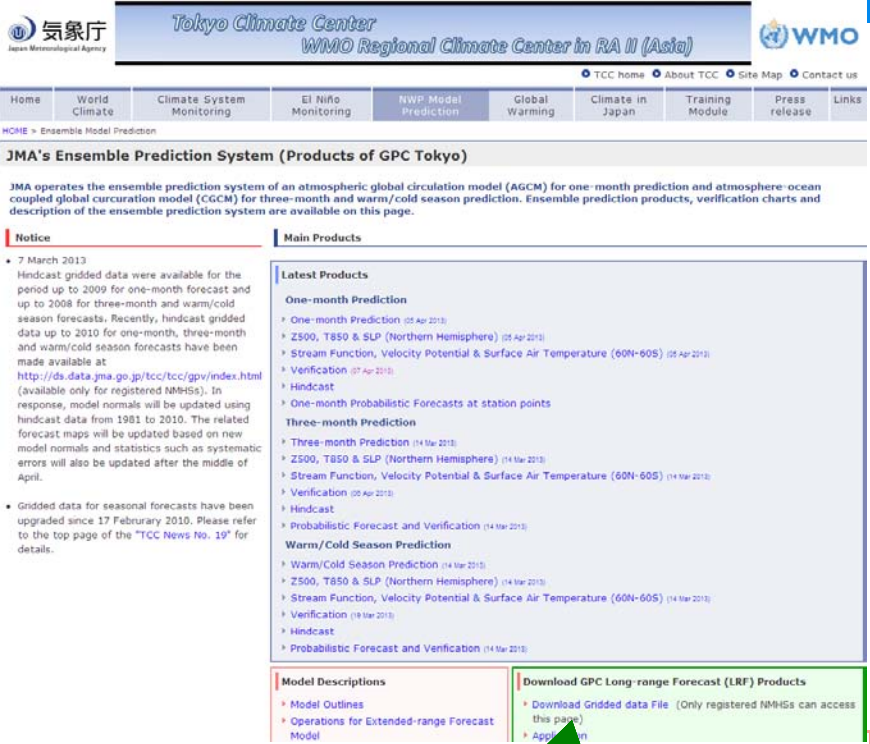
(Only registered NMHSs can access.)

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

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

Gridded data download

TOP PAGE > NWP Model Prediction



JMA's Ensemble Prediction System (Products of GPC Tokyo)

JMA operates the ensemble prediction system of an atmospheric global circulation model (AGCM) for one-month prediction and atmosphere-ocean coupled global curcuration model (CGCM) for three-month and warm/cold season prediction. Ensemble prediction products, verification charts and description of the ensemble prediction system are available on this page.

Notice

- 7 March 2013
  Hindcast gridded data were available for the period up to 2009 for one-month forecast and up to 2008 for three-month and warm/cold season forecasts. Recently, hindcast gridded data up to 2010 for one-month, three-month and warm/cold season forecasts have been made available at http://ds.data.jma.go.jp/tcc/tcc/gpv/index.html (available only for registered NMHSs). In response, model normals will be updated using hindcast data from 1981 to 2010. The related forecast maps will be updated based on new model normals and statistics such as systematic errors will also be updated after the middle of April.
- Gridded data for seasonal forecasts have been upgraded since 17 Februrary 2010. Please refer to the top page of the "TCC News No. 19" for details.

Main Products

Latest Products

One-month Prediction

- One-month Prediction (05 Apr 2013)
- Z500, T850 & SLP (Northern Hemisphere) (05 Apr 2013)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (05 Apr 2013)
- Verification (07 Apr 2013)
- Hindcast
- One-month Probabilistic Forecasts at station points

Three-month Prediction

- Three-month Prediction (14 Mar 2013)
- Z500, T850 & SLP (Northern Hemisphere) (14 Mar 2013)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (14 Mar 2013)
- Verification (05 Apr 2013)
- Hindcast
- Probabilistic Forecast and Verification (14 Mar 2013)

Warm/Cold Season Prediction

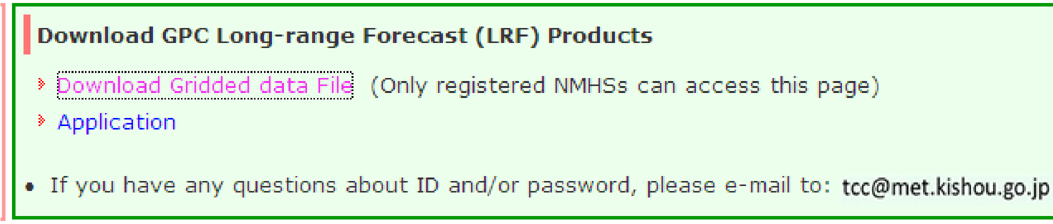
- Warm/Cold Season Prediction (14 Mar 2013)
- Z500, T850 & SLP (Northern Hemisphere) (14 Mar 2013)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (14 Mar 2013)
- Verification (19 Mar 2013)
- Hindcast
- Probabilistic Forecast and Verification (14 Mar 2013)

Model Descriptions

- Model Outlines
- Operations for Extended-range Forecast Model

Download GPC Long-range Forecast (LRF) Products

- Download Gridded data File (Only registered NMHSs can access this page)
- Application



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

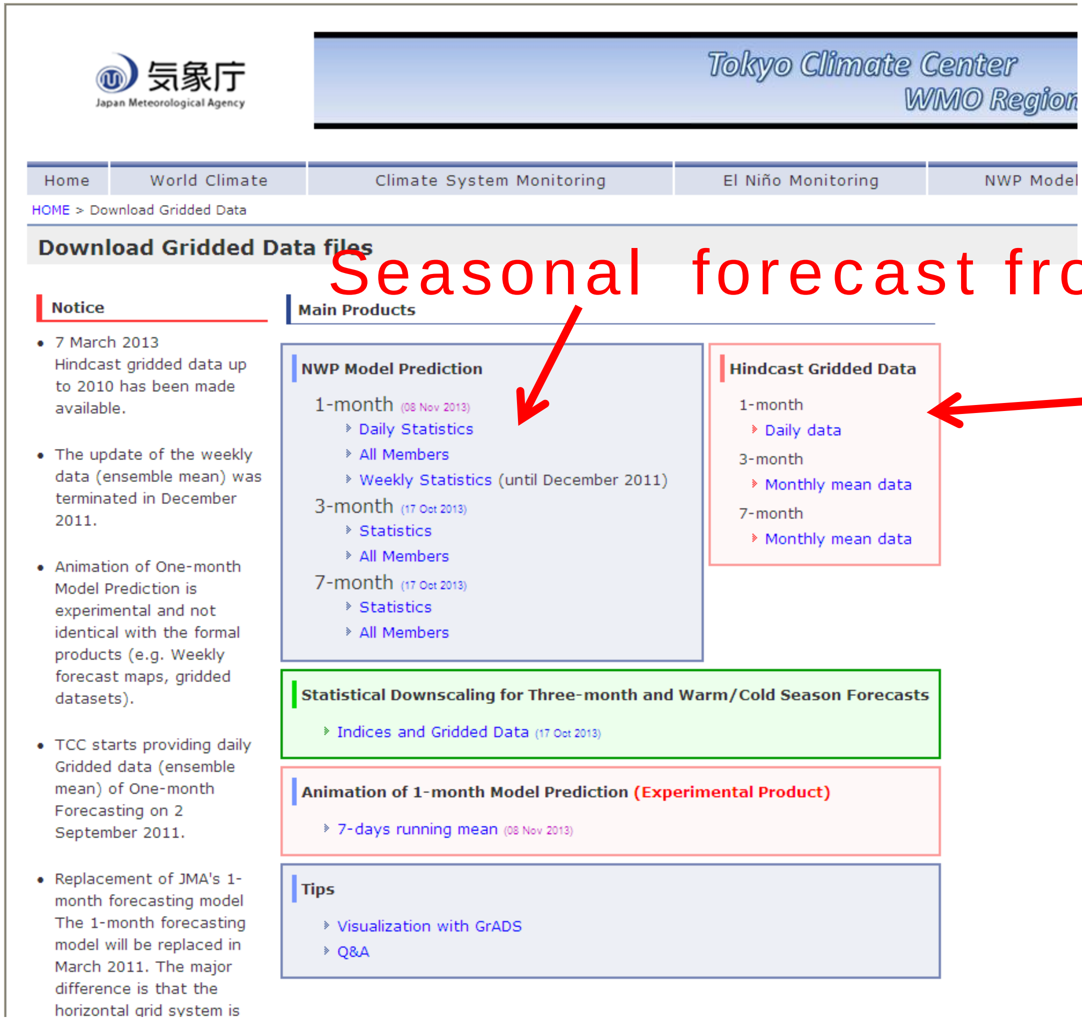
Download GPV (Recent predictions and hindcast

ID/PW are required

Gridded data download

TOP PAGE > NWP Model Prediction > Download GPC Long-range Forecast (LRF) Products

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



HOME > Download Gridded Data

Download Gridded Data files

Notice

- 7 March 2013 Hindcast gridded data up to 2010 has been made available.
- The update of the weekly data (ensemble mean) was terminated in December 2011.
- Animation of One-month Model Prediction is experimental and not identical with the formal products (e.g. Weekly forecast maps, gridded datasets).
- TCC starts providing daily Gridded data (ensemble mean) of One-month Forecasting on 2 September 2011.
- Replacement of JMA's 1-month forecasting model The 1-month forecasting model will be replaced in March 2011. The major difference is that the horizontal grid system is

Main Products

NWP Model Prediction

1-month (08 Nov 2013)
- Daily Statistics
- All Members
- Weekly Statistics (until December 2011)

3-month (17 Oct 2013)
- Statistics
- All Members

7-month (17 Oct 2013)
- Statistics
- All Members

Hindcast Gridded Data

1-month
- Daily data

3-month
- Monthly mean data

7-month
- Monthly mean data

Statistical Downscaling for Three-month and Warm/Cold Season Forecasts
- Indices and Gridded Data (17 Oct 2013)

Animation of 1-month Model Prediction (Experimental Product)
- 7-days running mean (08 Nov 2013)

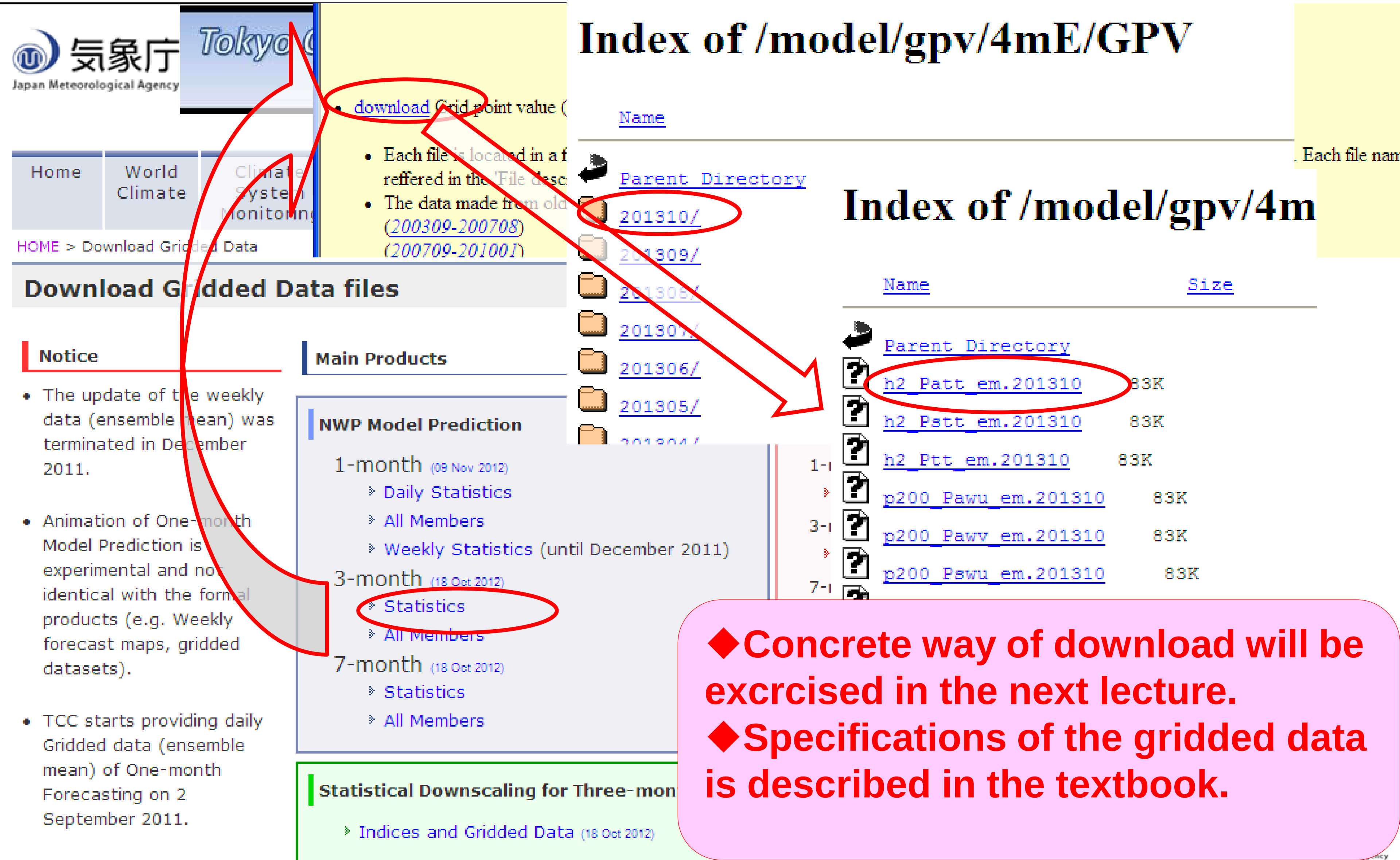
Tips
- Visualization with GrADS
- Q&A

Seasonal forecast from past to present

Hindcast

Gridded data download

(download of the specific data)



気象庁
Japan Meteorological Agency

Tokyo C

Home | World Climate | Climate System Monitoring

HOME > Download Gridded Data

Download Gridded Data files

Notice

- The update of the weekly data (ensemble mean) was terminated in December 2011.
- Animation of One-month Model Prediction is experimental and not identical with the formal products (e.g. Weekly forecast maps, gridded datasets).
- TCC starts providing daily Gridded data (ensemble mean) of One-month Forecasting on 2 September 2011.

Main Products

NWP Model Prediction

1-month (09 Nov 2012)
- Daily Statistics
- All Members
- Weekly Statistics (until December 2011)

3-month (18 Oct 2012)
- Statistics
- All Members

7-month (18 Oct 2012)
- Statistics
- All Members

Statistical Downscaling for Three-mon
- Indices and Gridded Data (18 Oct 2012)

- download Grid point value (
  - Each file is located in a f reffered in the 'File desc
  - The data made from old (200309-200708) (200709-201001)

Index of /model/gpv/4mE/GPV

Name

Parent Directory
201310/
201309/
201308/
201307/
201306/
201305/
201304/

. Each file nam

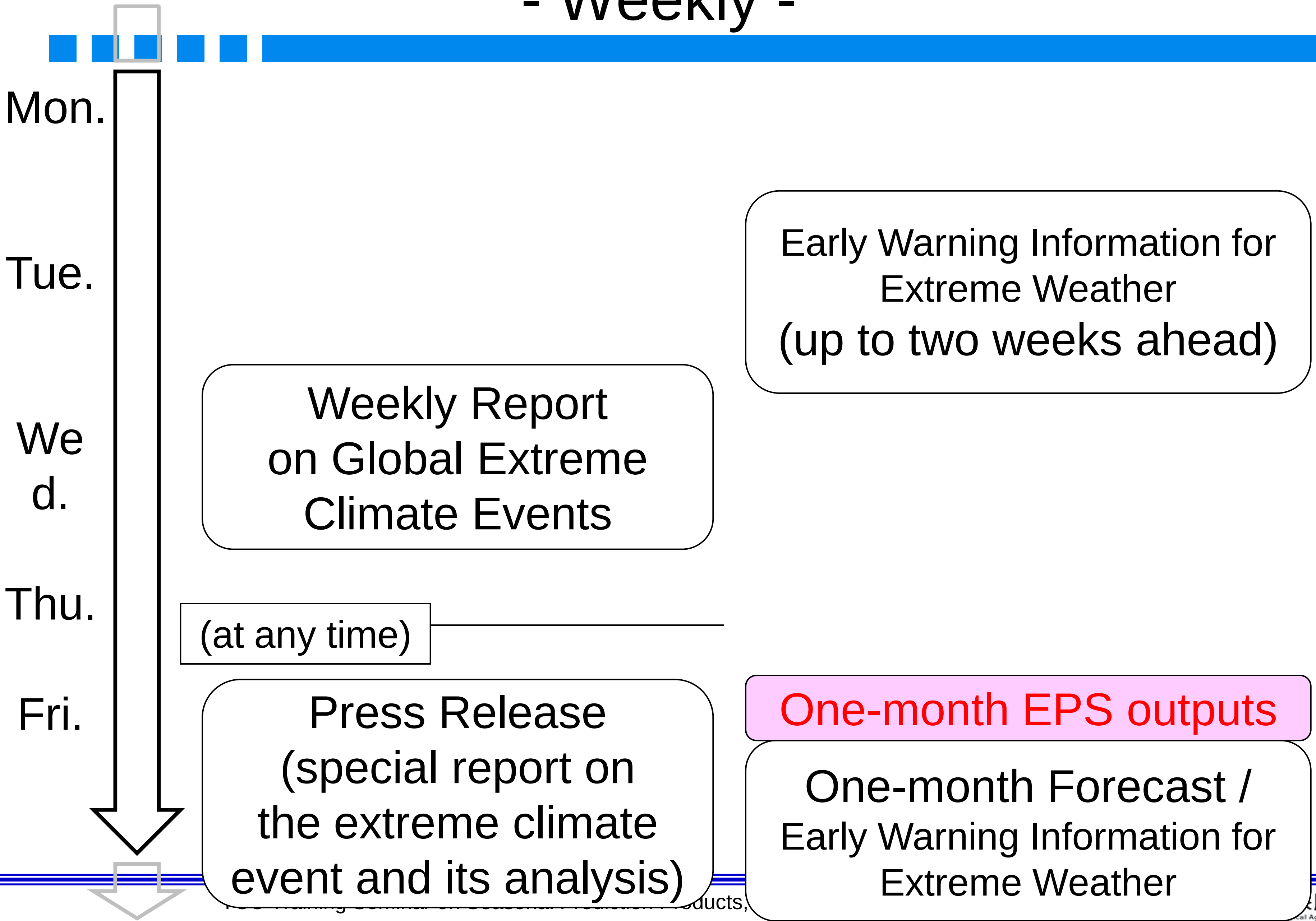
Index of /model/gpv/4m

Name	Size
Parent Directory	
h2_Patt_em.201310	83K
h2_Pstt_em.201310	83K
h2_Ptt_em.201310	83K
p200_Pawu_em.201310	83K
p200_Pawv_em.201310	83K
p200_Pswu_em.201310	83K

◆Concrete way of download will be excrcised in the next lecture.

◆Specifications of the gridded data is described in the textbook.

Schedule of provision of climate information
- Weekly -



Mon.

Tue.

Early Warning Information for Extreme Weather
(up to two weeks ahead)

Wed.

Weekly Report
on Global Extreme
Climate Events

Thu.

(at any time)

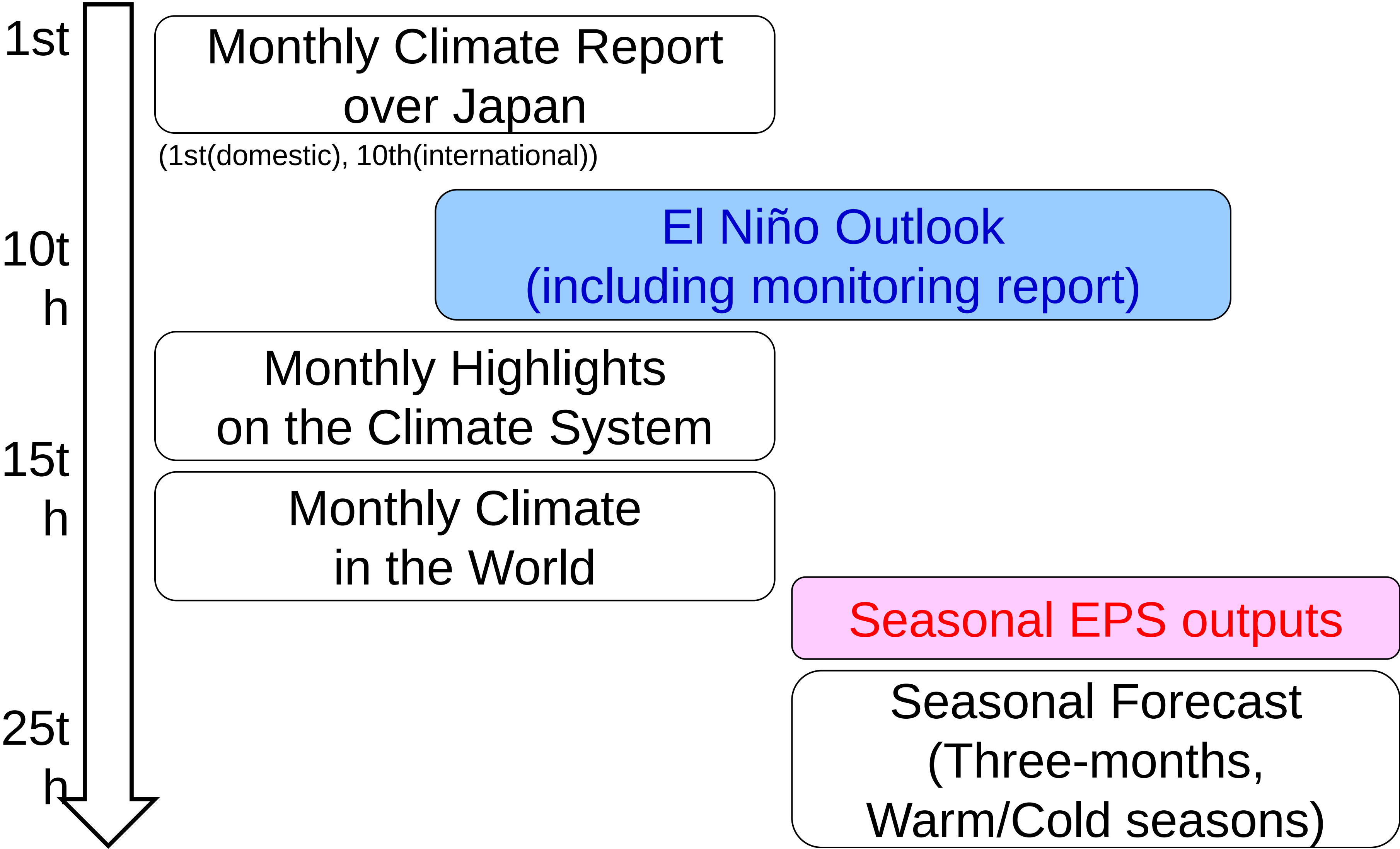
Fri.

Press Release
(special report on
the extreme climate
event and its analysis)

One-month EPS outputs

One-month Forecast /
Early Warning Information for
Extreme Weather

Schedule of provision of climate information
- Monthly -



1st

Monthly Climate Report over Japan

(1st(domestic), 10th(international))

10th

El Niño Outlook (including monitoring report)

Monthly Highlights on the Climate System

15th

Monthly Climate in the World

Seasonal EPS outputs

25th

Seasonal Forecast (Three-months, Warm/Cold seasons)

Summaries

- For longer time-scale, deterministic forecast is impossible due to the chaotic nature.
  - Probabilistic forecast is essential for seasonal prediction.
- Ensemble prediction, which enables to estimate the degree of both signal and uncertainty, is essential for seasonal prediction.

- Prediction skill of EPS has been increased. But, there is still room for improvement of reproducibility of climate fields.
- ➢ Forecasters are required of the technique for interpret model outputs.
  - Statistical downscale, which extracts predicted signal and estimates the degree of signal, is one of the techniques for interpretation.

References

- Tokyo climate center
  - Top page
    - http://ds.data.jma.go.jp/gmd/tcc/tcc/index.html

- JMA El Niño outlook
  - http://ds.data.jma.go.jp/tcc/tcc/products/elnino/outlook.html
- Numerical model prediction
  - Top page
    - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/model/index.html
  - Forecast maps (Ensemble mean forecast map)
    - 3-month prediction
      - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/model/map/4mE/index.html
    - Warm/Cold Season Prediction
      - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/model/map/7mE/index.html
  - Probabilistic Forecast with the numerical guidance
    - 3-month prediction
      - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/model/probfcst/4mE/index.html
    - Warm/Cold Season Prediction
      - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/model/probfcst/7mE/index.html
- Climate monitoring
  - Top page
    - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/clisys/index.html