



One-month Forecast

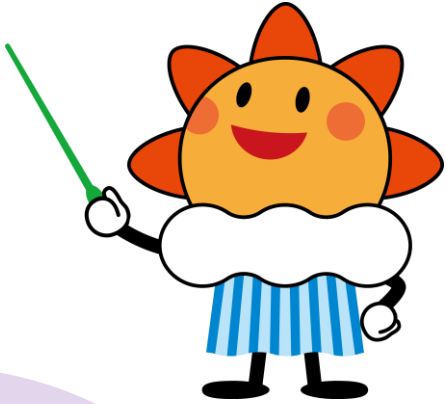
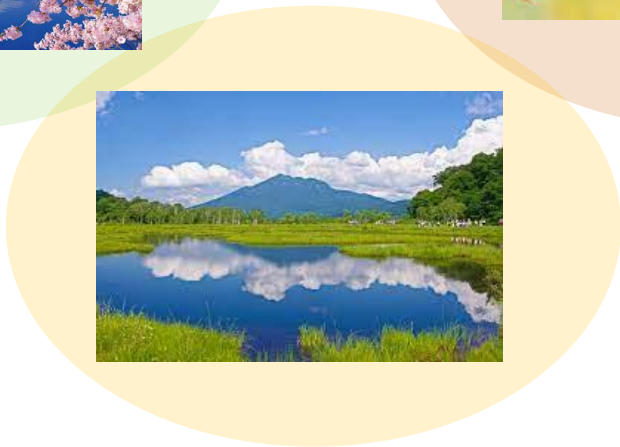
Yoshinori Oikawa
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Japan Meteorological Agency

January 2026
TCC training seminar



Structure

- What is one-month forecast?
- Brief introduction to climate dynamics
- Methodology for JMA's one-month forecast





What is one-month forecast ?



Classification of weather and climate forecasts

According to WMO's *Manual on Global Data-processing and Forecasting System*,

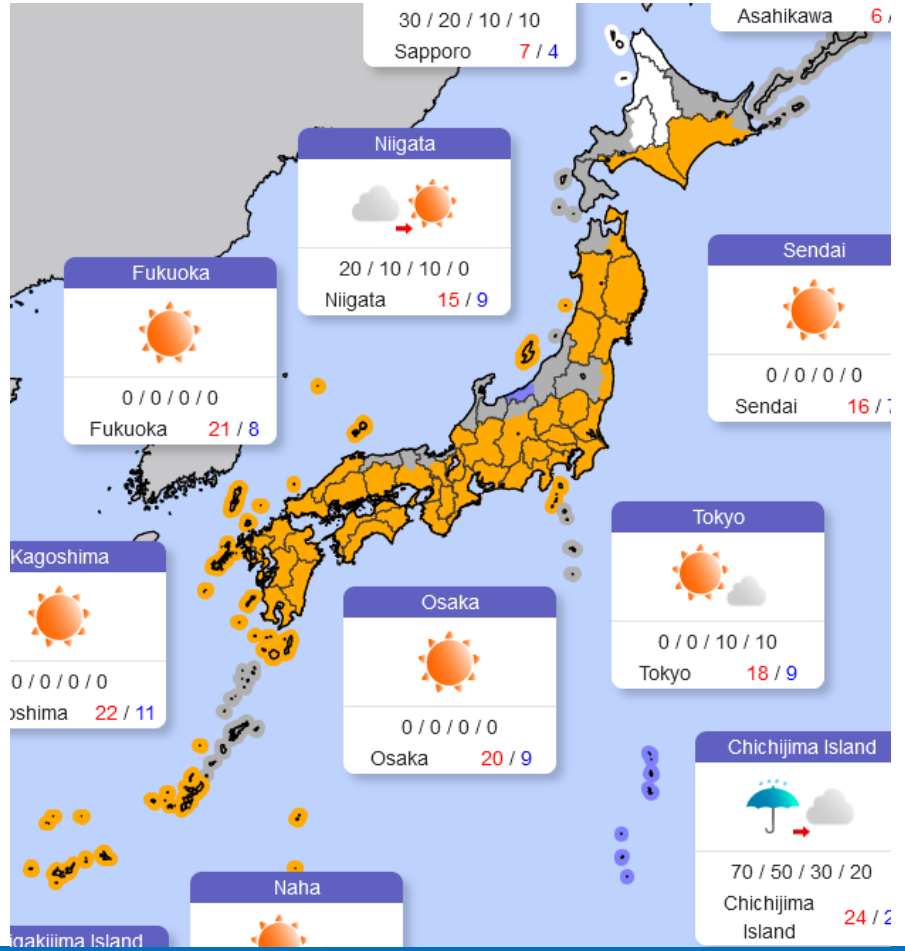
Class	Target forecast range
Nowcasting	Current and forecasted weather up to 2 hrs ahead
Very short-range weather forecasting	Up to 12 hrs ahead
Short-range forecasting	Beyond 12 hrs up to 72 hrs
Medium-range weather forecasting	Beyond 72 hrs up to 240 hrs
Extended-range weather forecasting	Beyond 10 days up to 30 days
Long-range forecasting	Monthly, three-month or seasonal outlook for averaged weather parameters as departure from climate
Climate forecasting	Annual, decadal and beyond, including human-induced climate change projection



What's the difference between short-range and one-month forecasts?

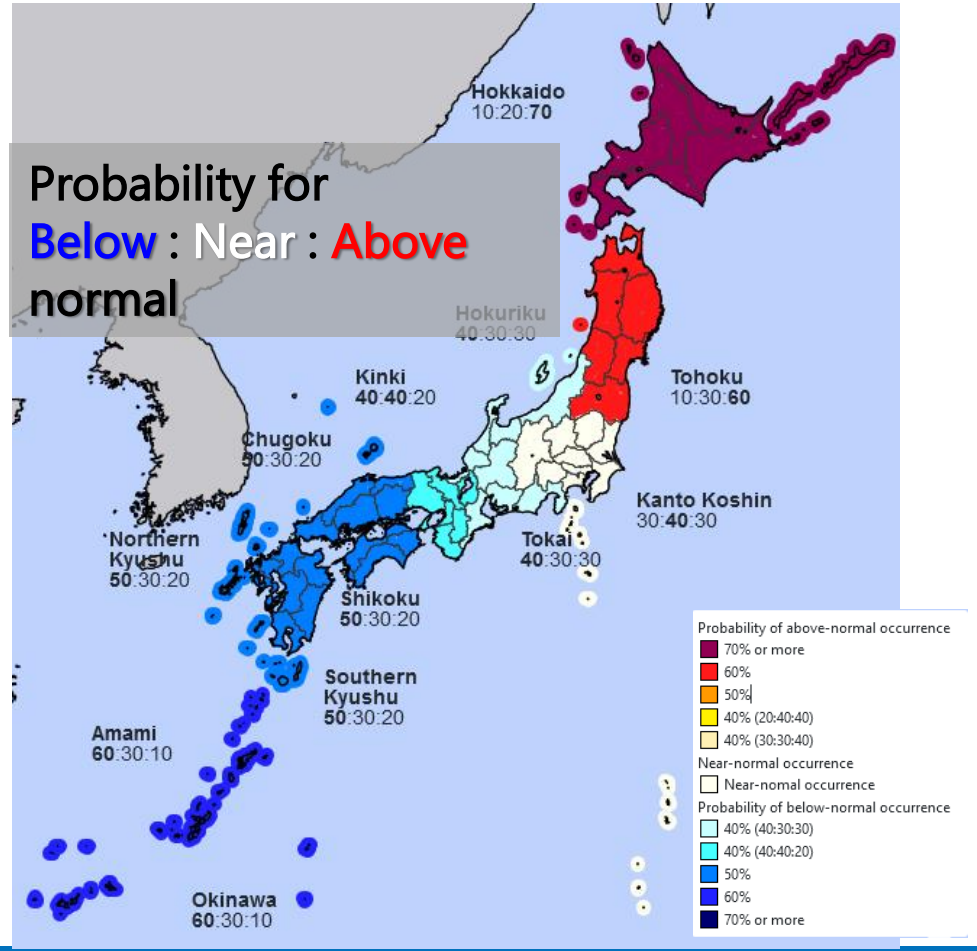
Short-range forecast

- Provides weather parameters (temperatures, precipitation, ...) as they are expected
- Possible to forecast in **deterministic** way



One-month forecast

- Provides expected **deviations** from climatological normals
- Possible to forecast only in **probabilistic** way





Anomaly is what we forecast

Climatological normal: Defined as 30-year average for 1991–2020

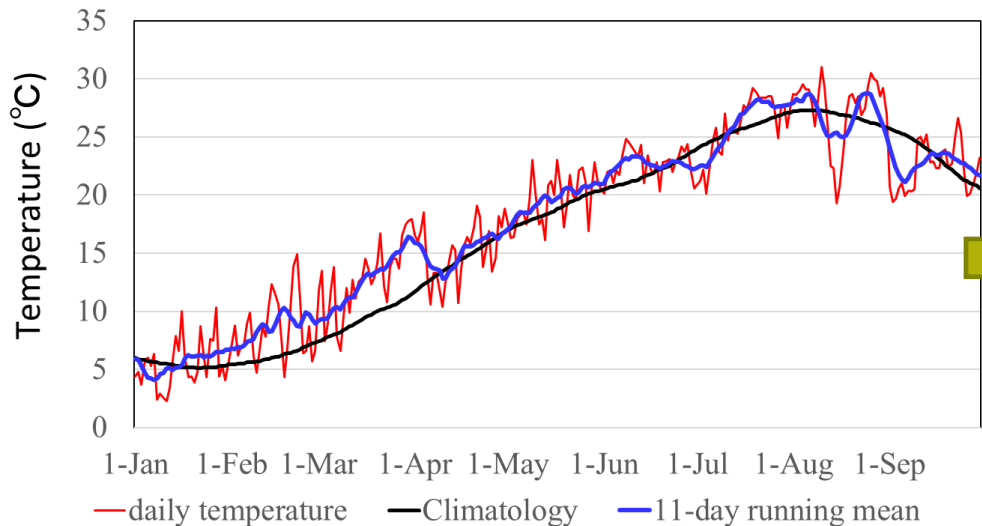
Anomaly: Deviation from the Climatology

$$[\text{Anomaly}] = [\text{Actual Value}] - [\text{Normal}]$$

- “Climate is what we expect, anomaly is what we forecast.”
- It’s often **anomalies** that matter most to industries, societies and economies, because **unseasonable** weather conditions could cause big impacts and adverse effects across multiple sectors, including agriculture, tourism, water resource, and so on.



Temperature in Tokyo for Jan.1 to Sep. 30 in 2021



Temperature deviation from climatology





3-category probabilistic forecast

- JMA provides one-month forecasts in 3 probabilistic categories, namely, **Above/Near/Below** normal

- The 3 categories are defined from historical observations for the 30-year period of 1991-2020, by sorting them in ascending order and dividing into 3 categories.

- One-month forecasts are provided as probability of weather parameter (e.g. temperature) anomalies falling within

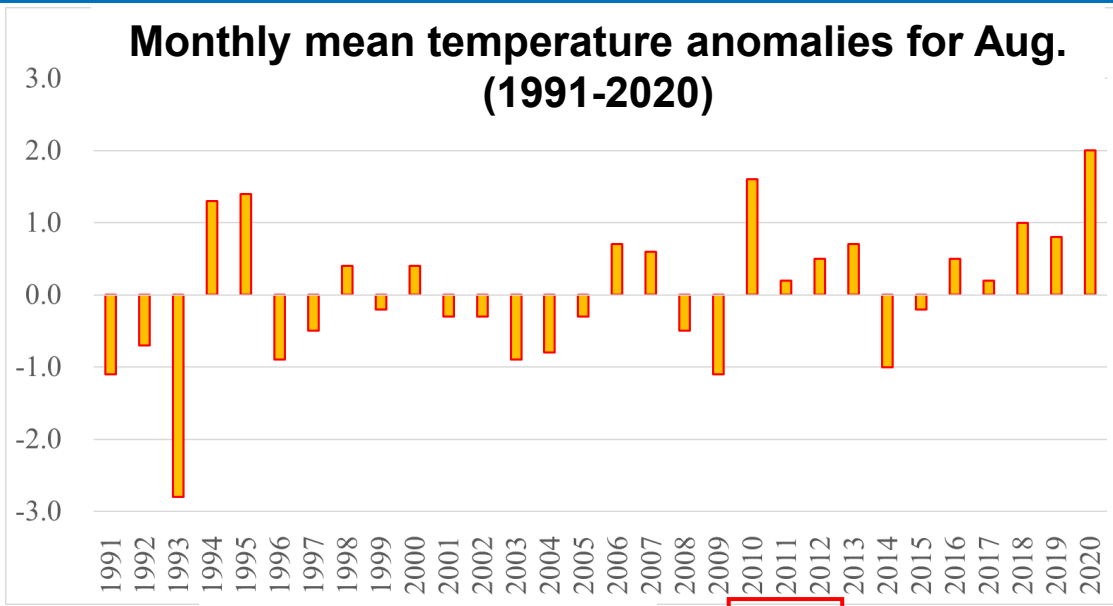
1-10th (Below normal; BN)

11-20th (Near normal; NN)

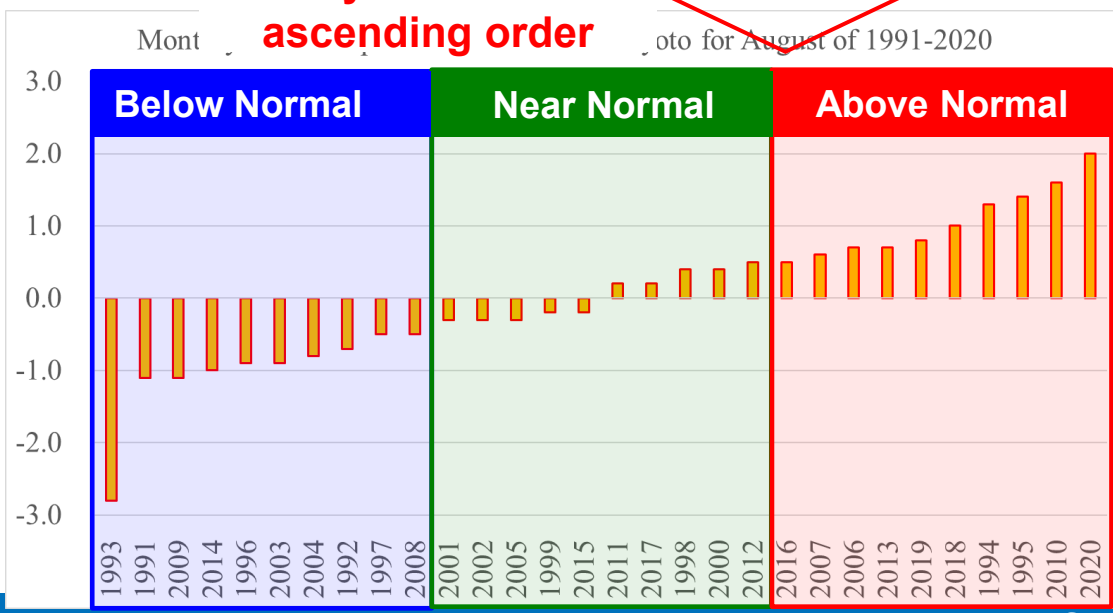
21-30th (Above normal; AN)



Ex.



Sort by anomalies in ascending order

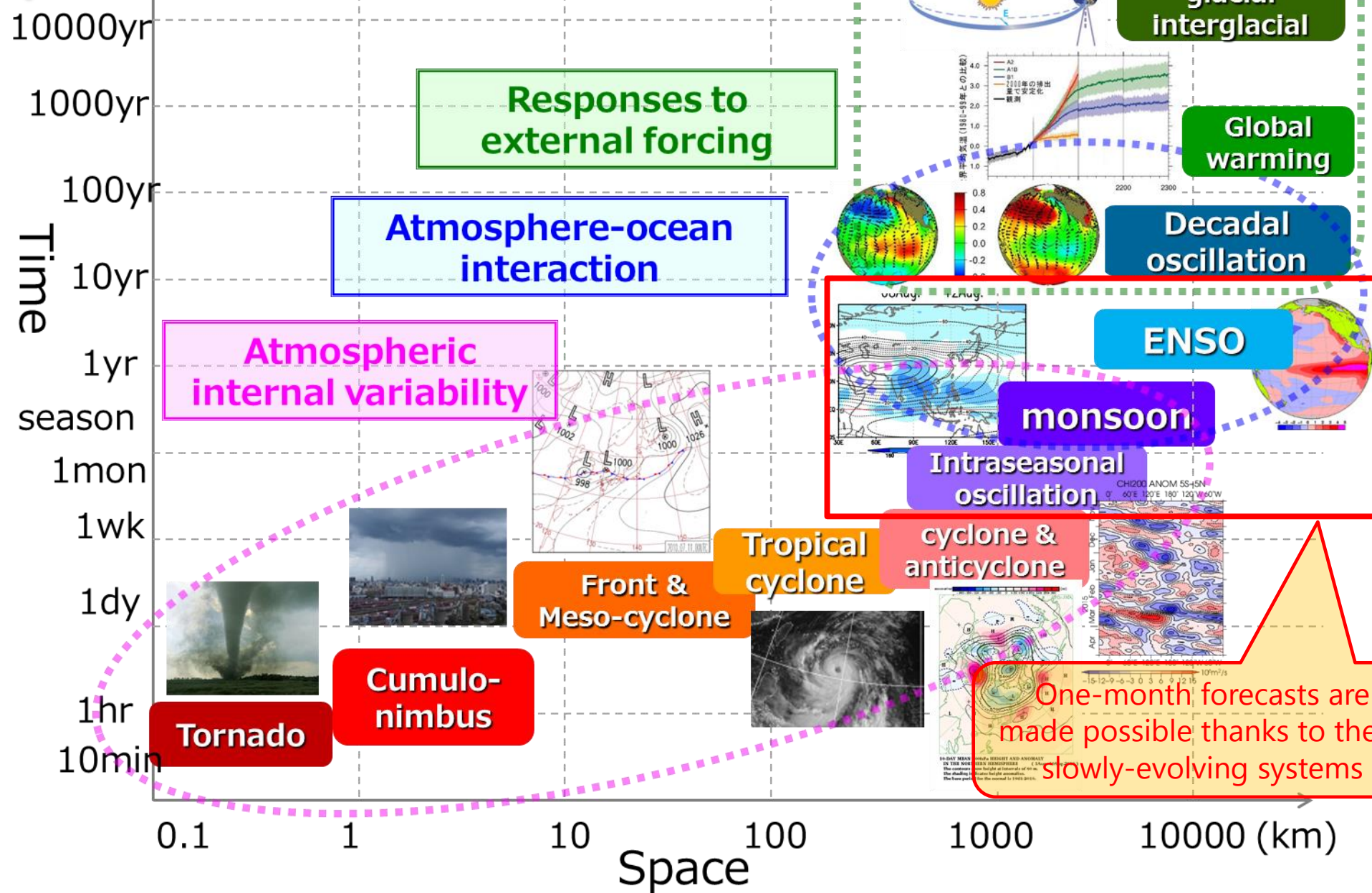




Brief introduction to climate dynamics



Atmosphere ocean variability across multiple space & time scales



One-month forecasts are made possible thanks to these slowly-evolving systems



Stream function & velocity potential

- In discussing one-month forecast, we often encounter these figures.
- Decomposing wind into a rotational part and a divergent part (stream function and velocity potential) is useful to analyze atmospheric circulation.

$$\mathbf{v} = \mathbf{v}_\psi + \mathbf{v}_\chi$$

Rotational wind blows parallel to contours of stream function, with low values of stream function to the left, regardless of the hemisphere.

H: high value
L: Low value

< Rotational wind >

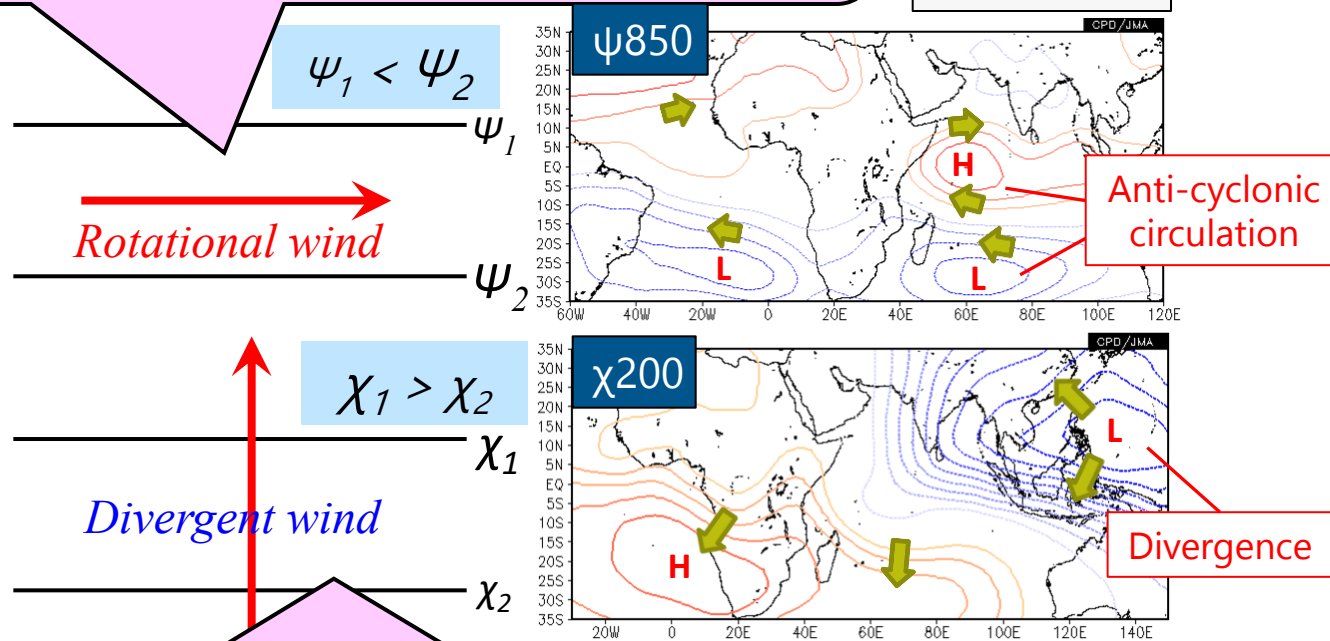
$$u_\psi = -\frac{\partial \psi}{\partial y}, v_\psi = \frac{\partial \psi}{\partial x}$$

Ψ : Stream function

< Divergent wind >

$$u_\chi = \frac{\partial \chi}{\partial x}, v_\chi = \frac{\partial \chi}{\partial y}$$

χ : Velocity potential



Divergent wind blows across contours of velocity potential, from areas of low to high velocity potential, regardless of the hemisphere.

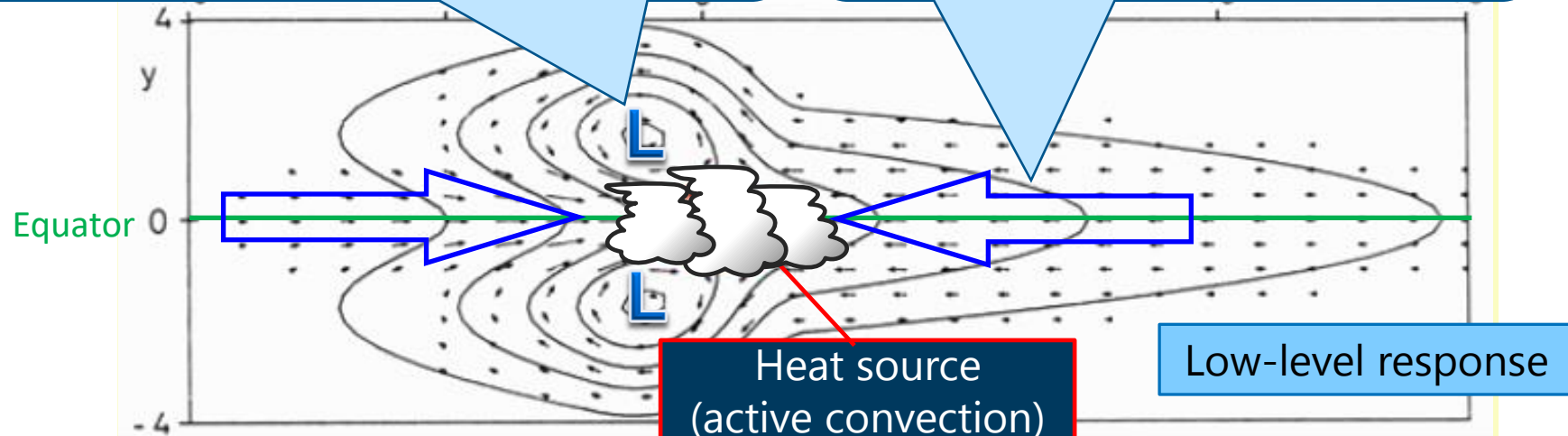


Matsuno-Gill response (in the **lower** troposphere)

- Gill (1980) found how the tropical atmosphere responds to **diabatic heating** (i.e. convective activity).

A pair of cyclonic circulation straddling the equator on the western side of the heating (equatorial Rossby wave).

Low pressure and easterly winds along the equator east of the heating (equatorial Kelvin wave).



Atmospheric response in the **lower troposphere** to the heating symmetric about the equator

Contours indicate perturbation pressure, and vectors denote velocity field.

Red circle indicates the position of the heating.

(Source: Gill 1980)

Upper-level response shows the reverse of the low-level response.

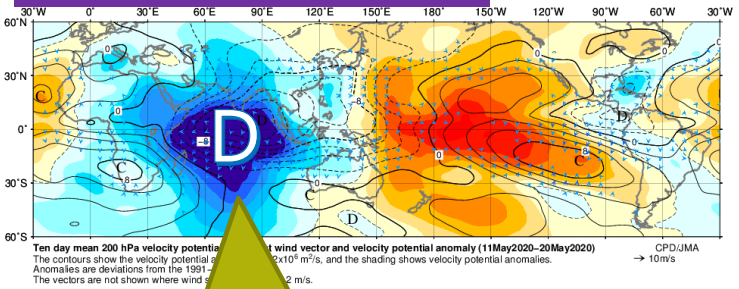


Example of Matsuno-Gill response

Atmospheric circulation anomalies averaged over 11-20 May, 2020

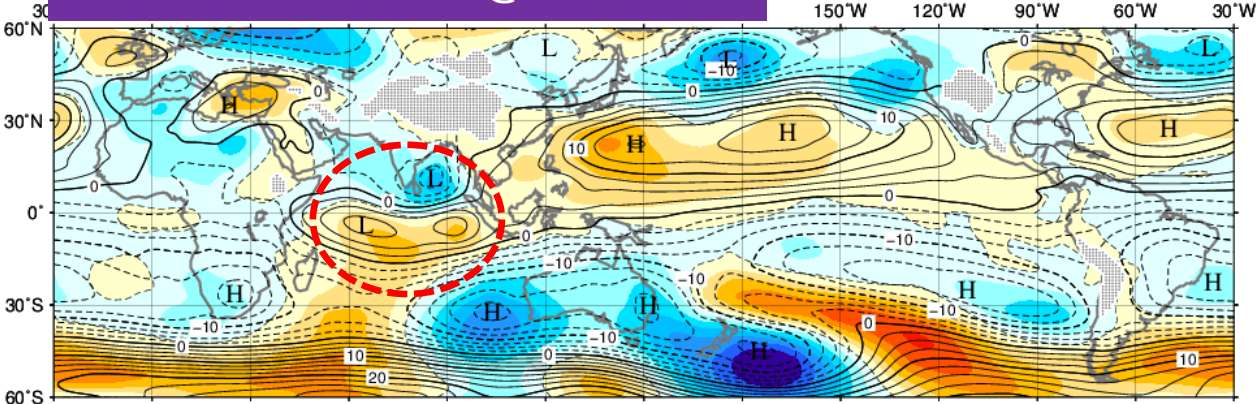
- Enhanced convective activity over the Indian Ocean
- In response, cyclonic circulation anomalies formed in the lower troposphere
- Low pressure area extended along the equator into the western Pacific

Velocity potential

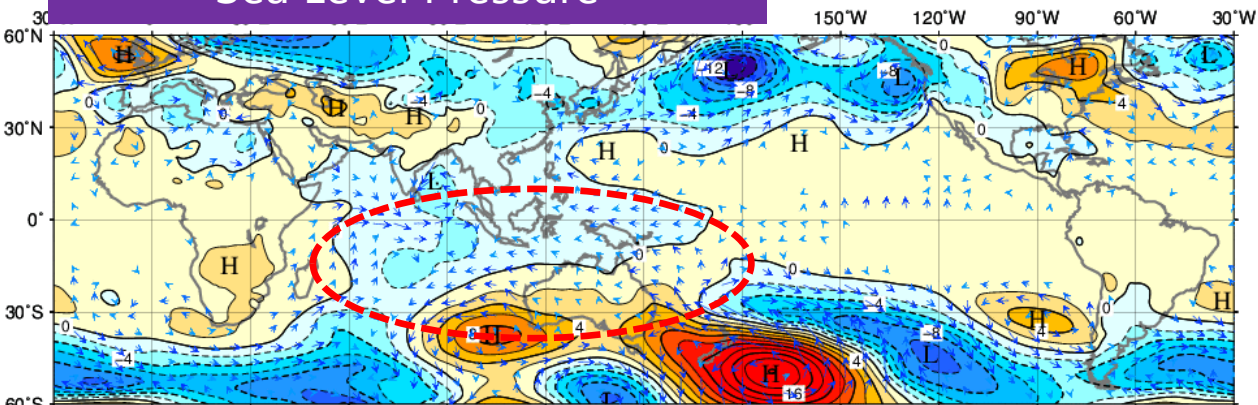


Enhanced convection

Stream function @850hPa



Sea Level Pressure

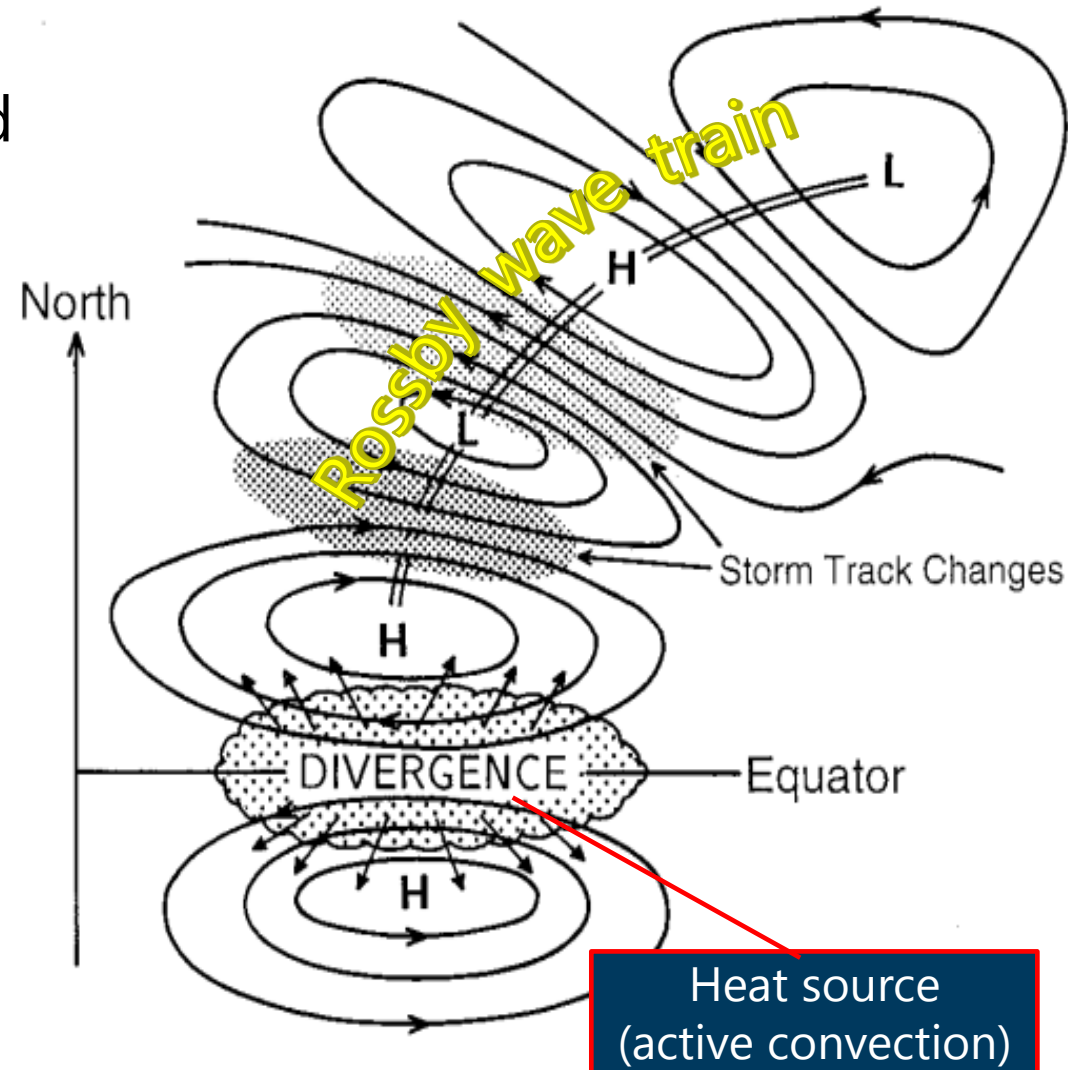


http://ds.data.jma.go.jp/tcc/tcc/products/clisys/figures/db_hist_jun_tcc.html



Response in the upper troposphere

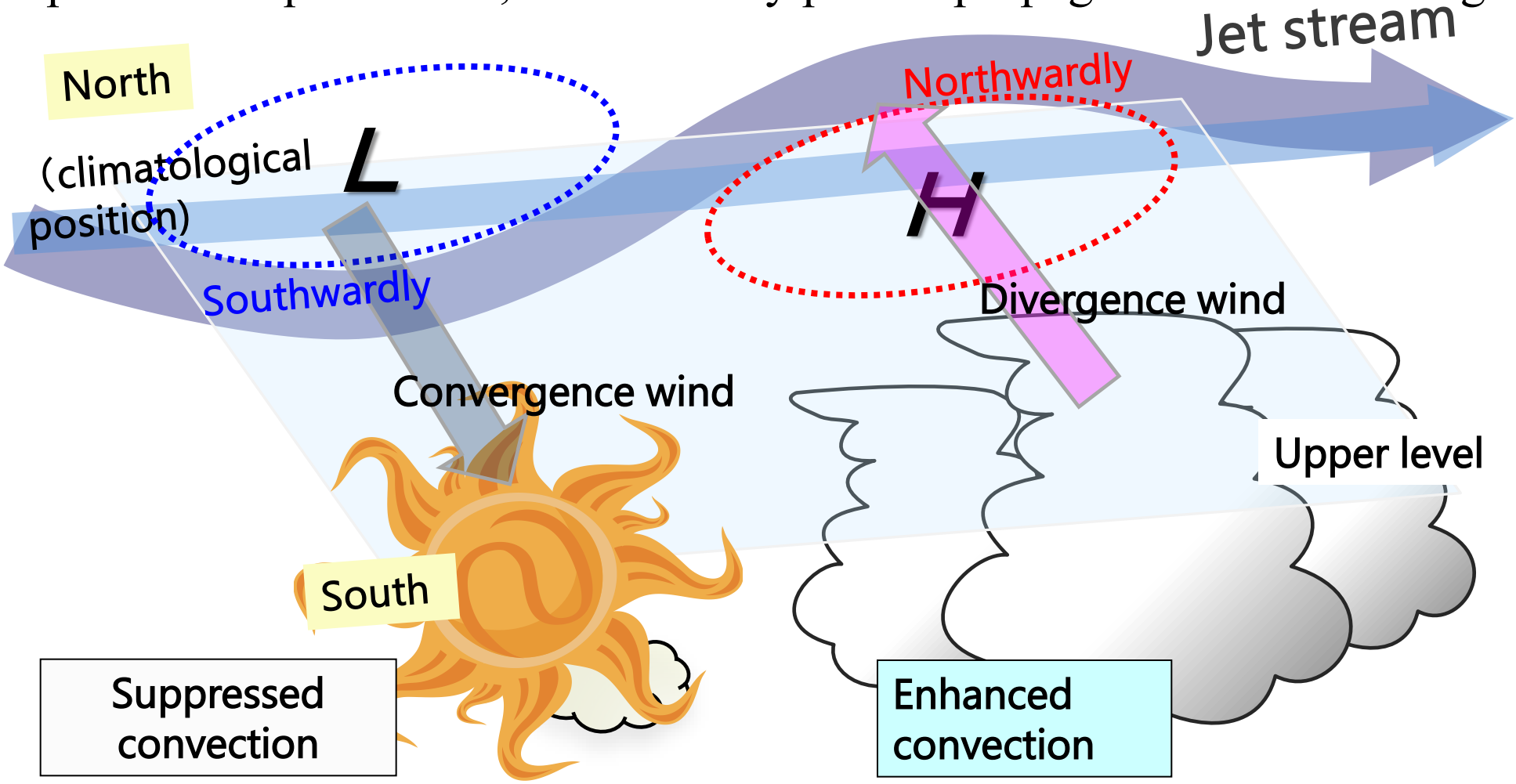
- In the upper troposphere, an **anti-cyclonic circulation anomaly** forms to the north and south of **enhanced** convection.
- The circulation anomaly propagates poleward as a Rossby wave train.
- This sometimes causes anomalous weather conditions in remote areas in subtropics and higher latitudes.
- In jargon of climate dynamics, this is called "**teleconnection**."





Convection changes jet stream

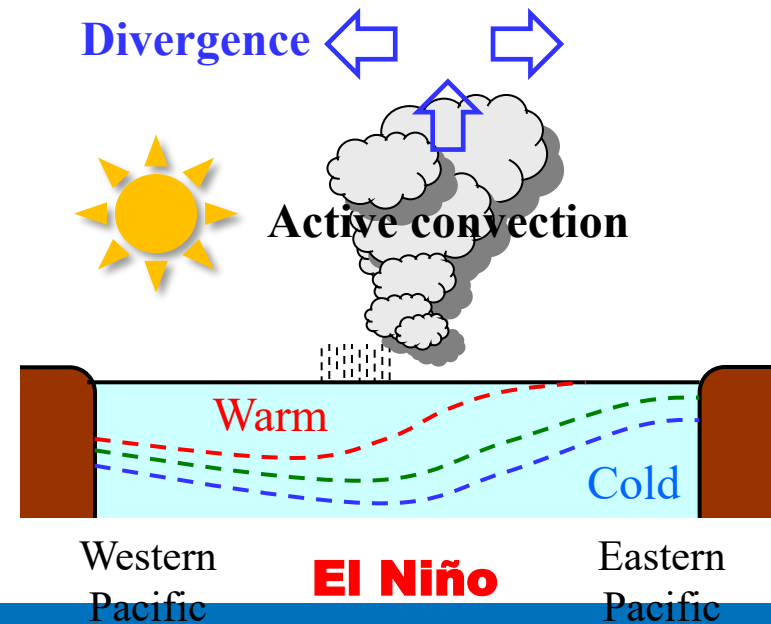
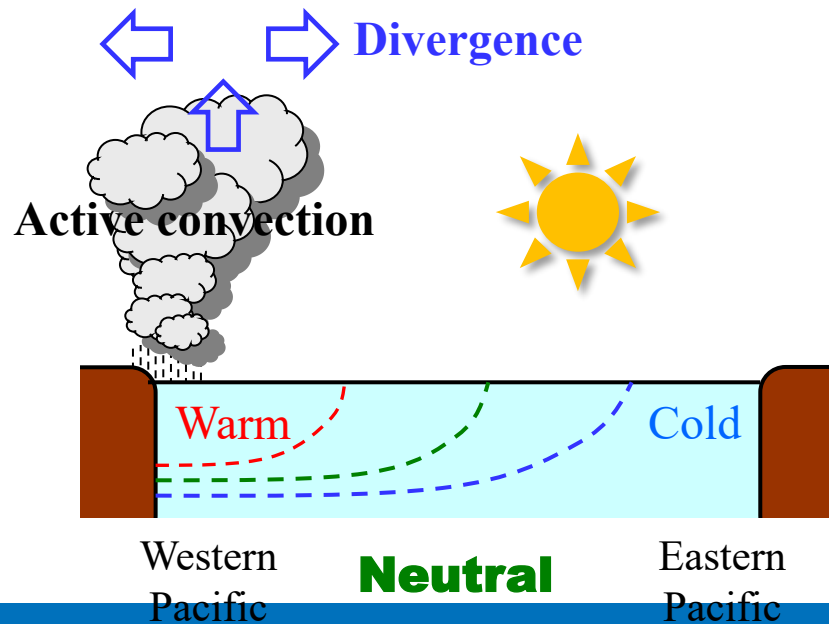
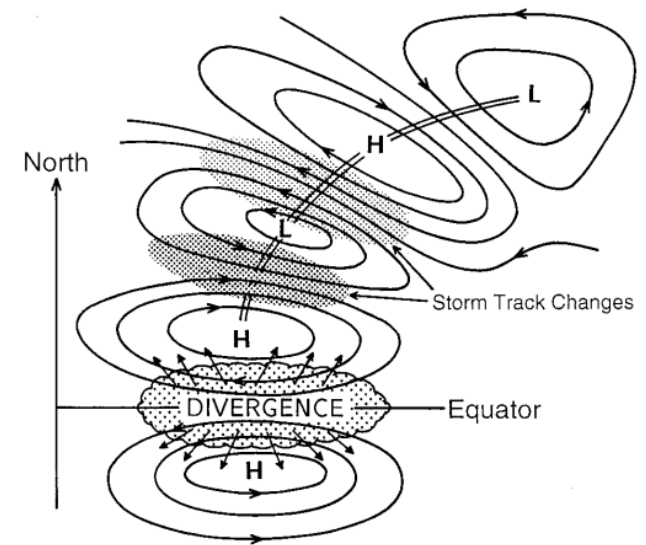
- The **subtropical jet stream (STJ)** flows poleward of tropics.
- In response to enhanced/suppressed convection, STJ meanders poleward/equatorward, and the wavy pattern propagates eastward along STJ.





El Niño Southern Oscillation

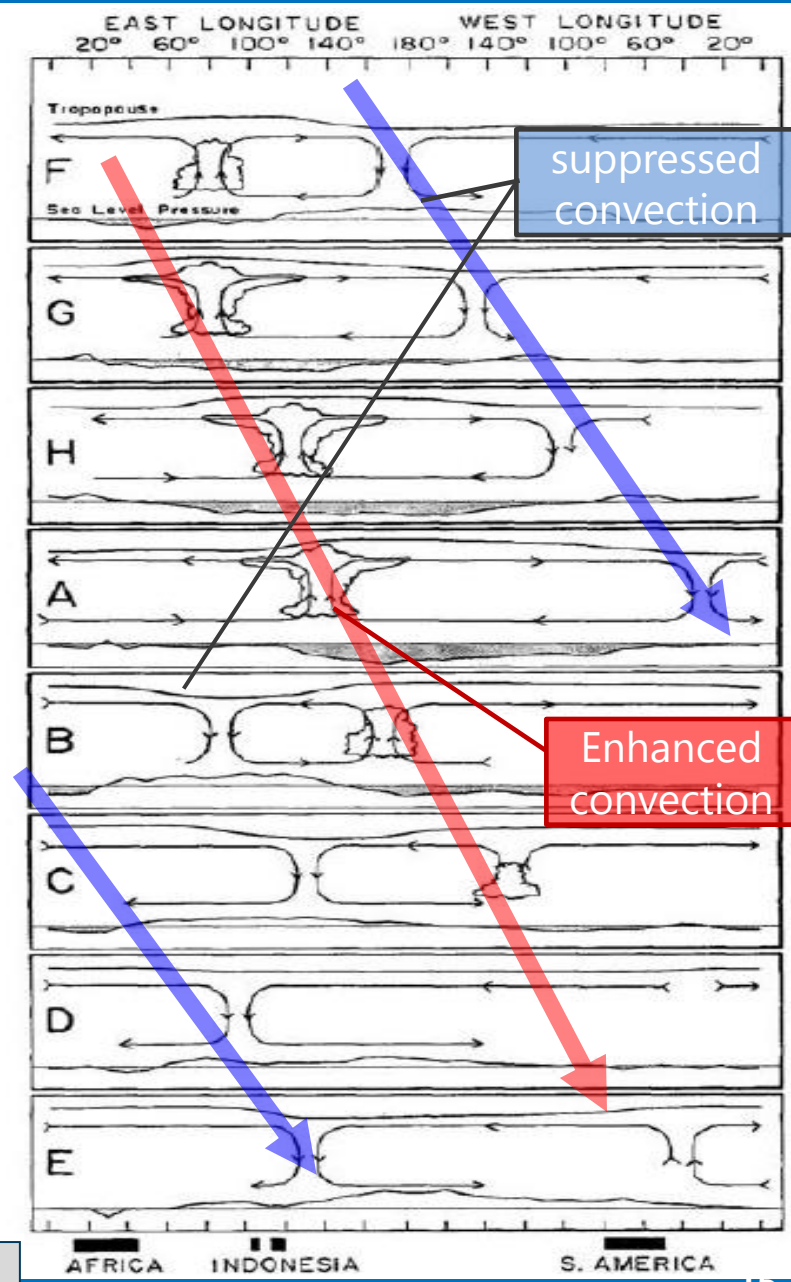
- During an El Niño episode, a significant increase in SST over the central to eastern equatorial Pacific is observed.
- The warmer SSTs induce active convection to shift eastward along the equator.
- These convection anomalies give rise to Rossby waves (Matsuno-Gill!)
- Rossby waves propagate over a large distance and influence the global atmosphere





Madden-Julian Oscillation (MJO)

- MJO is a planetary scale wave of enhanced and suppressed convection extending east-west along the equator
- The most dominant signal over the tropics on weekly to monthly timescale.
- MJO propagates eastward along the equator, taking 30 – 60 days to go around the globe.
- In response to MJO, circulation anomalies form and propagate poleward or eastward. This provides key to one-month forecasts
- MJO is monitored with 200hPa velocity potential (upper-level divergence) field



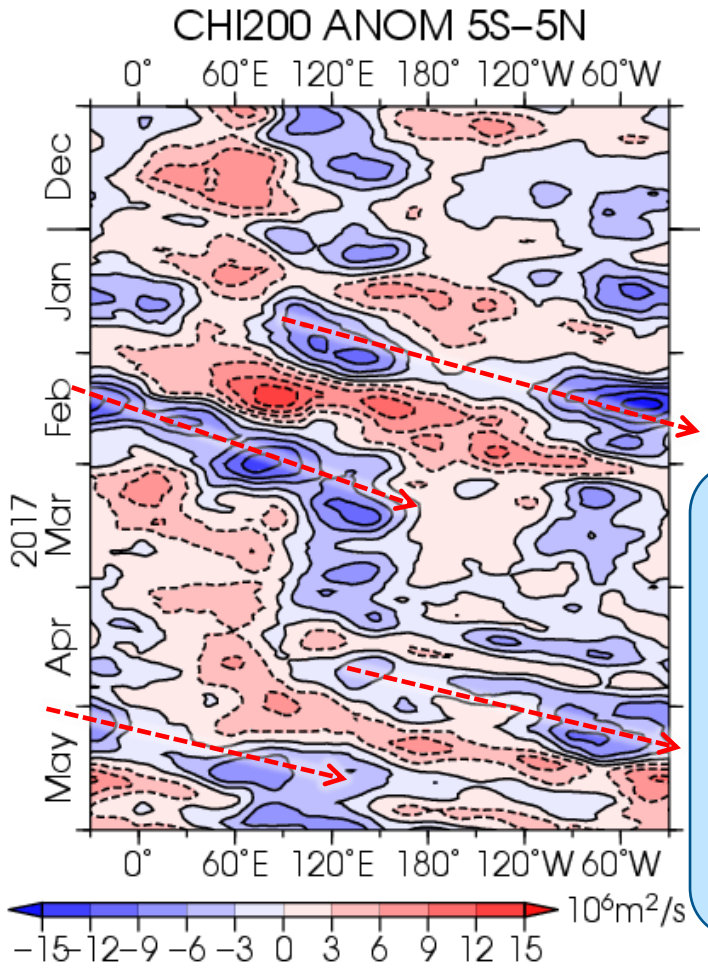
Original; Madden and Julian (1972) Fig.16



How to detect MJO?

Propagation of MJO is visualized through **Hovmöller diagram** and **phase diagram**

Time-longitude section of **chi200** anomaly along the EQ.

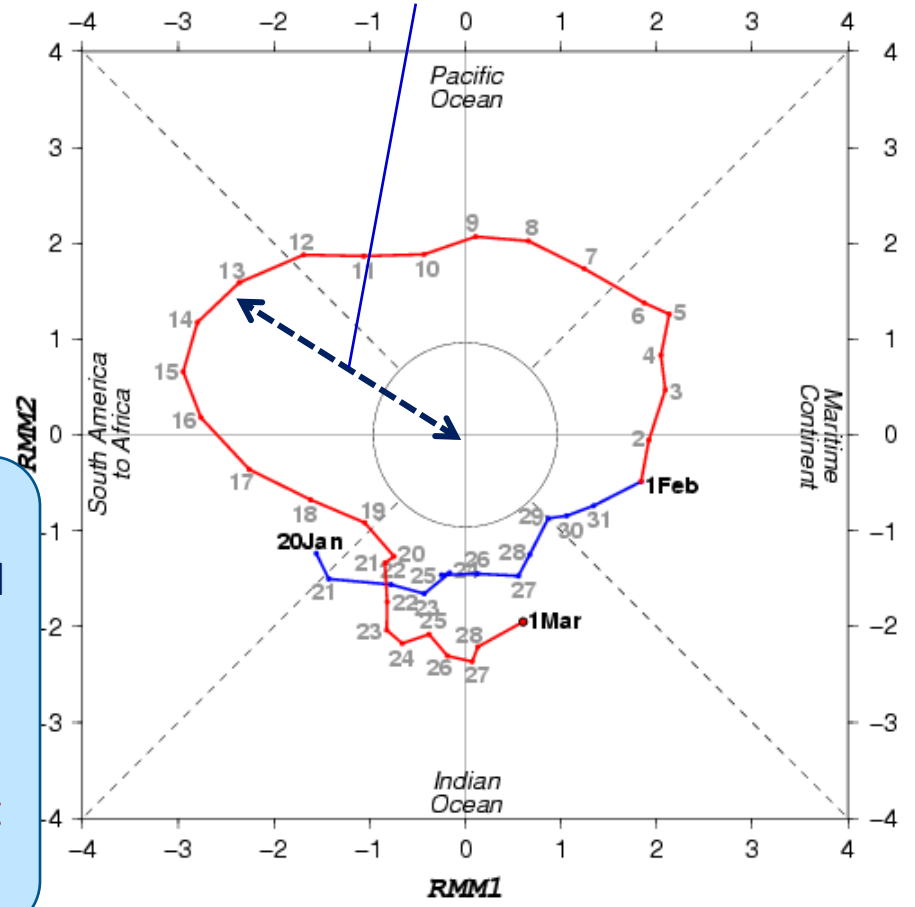


Blue:
Upper-level
Divergent
anomaly

Red:
Convergent
anomaly

phase diagram

Amplitude: distance from the center



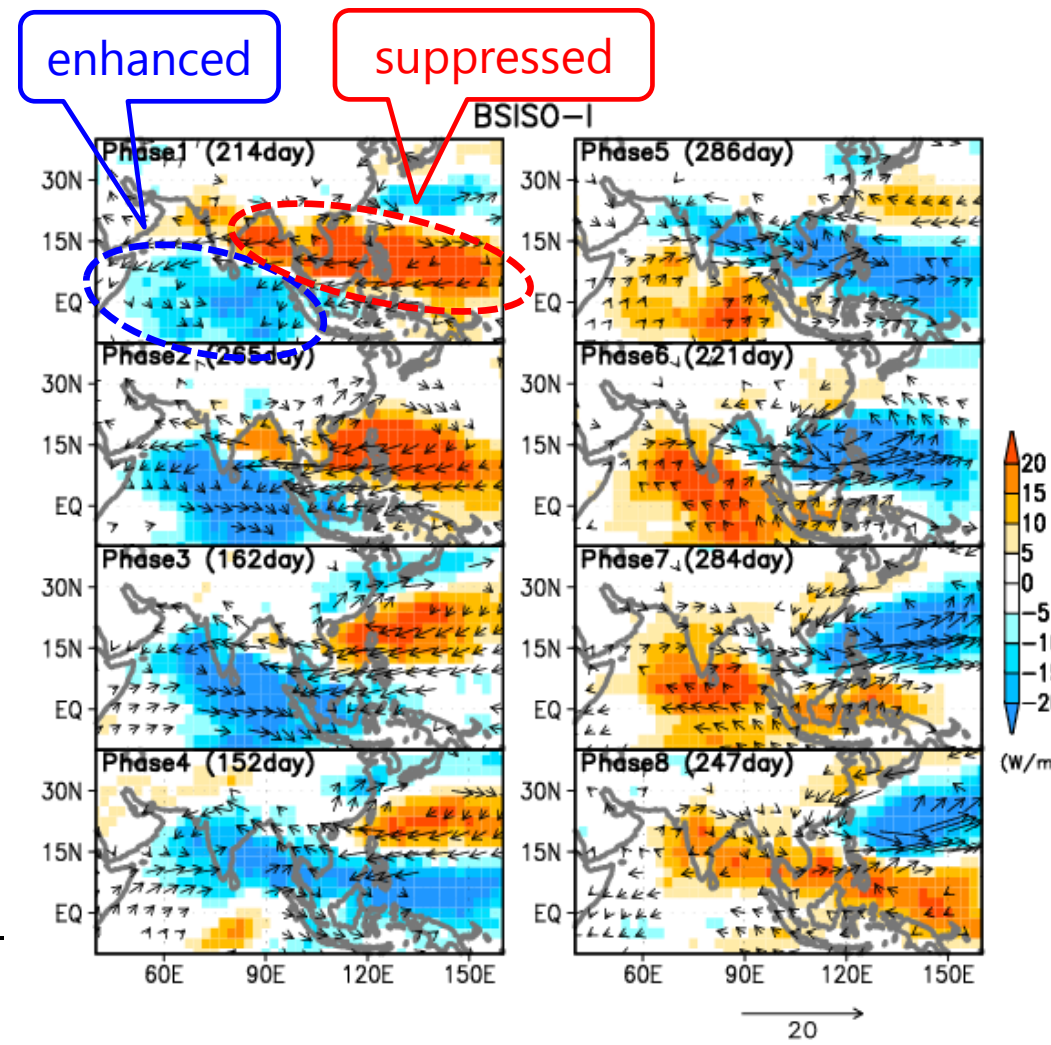
http://ds.data.jma.go.jp/tcc/tcc/products/clisys/ASIA_TCC/mjo_cross.html

<http://ds.data.jma.go.jp/tcc/tcc/products/clisys/mjo/monitor.html>



Another "Oscillation" - BSISO

- During (northern hemisphere) summer, enhanced or suppressed convection is seen to **propagate northward**, instead of eastward, over the Indian Ocean and the western Pacific
- This is called "**B**oreal **S**ummer **I**ntra-**S**easonal **O**scillation".
- **BSISO** can have as much impact on weather conditions as MJO across Asia during the summer monsoon.
- This is another factor that makes extended-range forecasts possible.



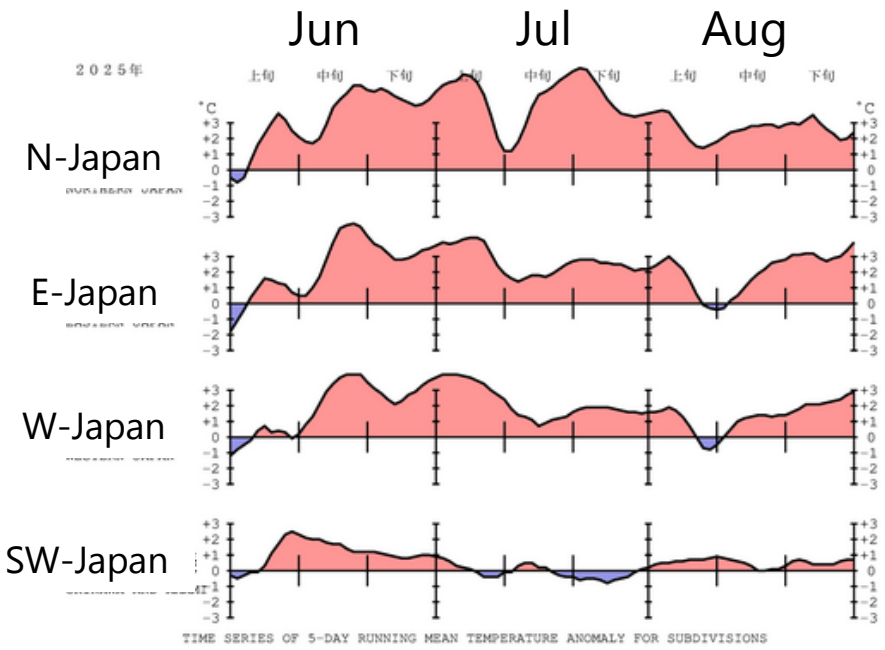
typical time evolution of BSISO



Recent notable weather events

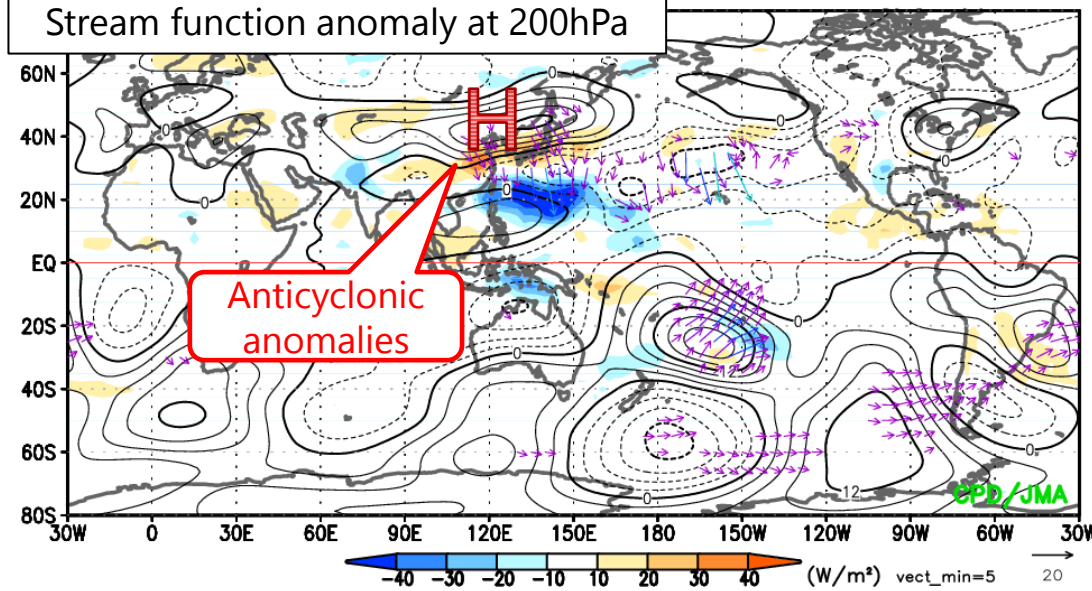
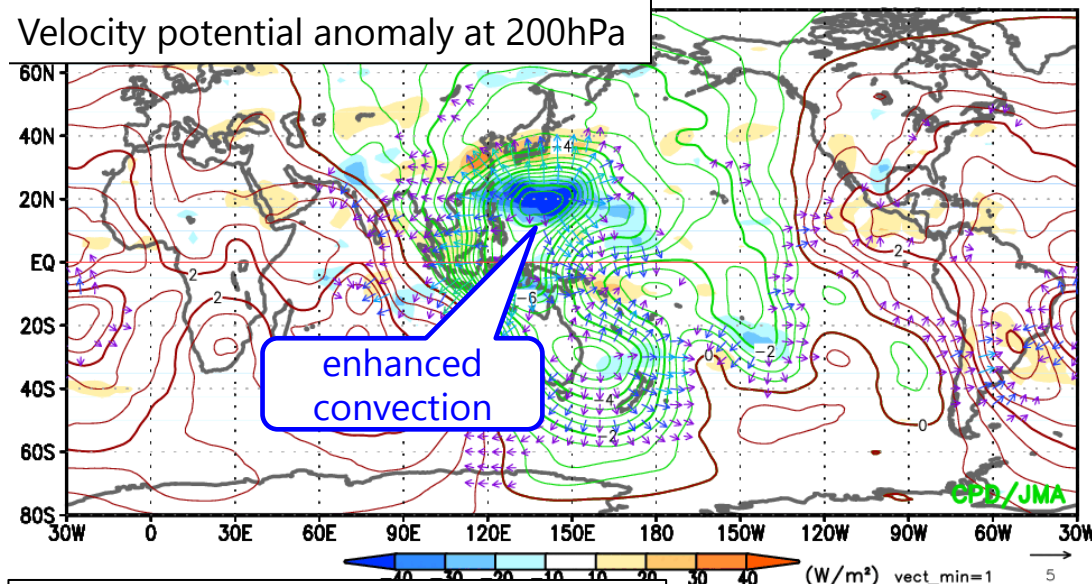
- In summer 2025, Japan experienced **exceptionally** hot weather conditions that broke the temperature record since 1898.
- This is due to anti-cyclonic anomalies persistent over the country.
- The cause of these anomalies is traced back to enhanced convection over the South China Sea to the tropical western Pacific.

5-day running average temperature anomalies



地域平均気温年差の5日移動平均時系列
更新日：2025年9月10日

01Jul.2025 – 30Jul.2025





Methodology for JMA's one-month forecast



JMA's extended & long-range forecast models



Type of forecast

Daily Forecast

One-week Forecast

Extreme climate early warning

One-month Forecast

Three-month Forecast

Warm-season Forecast

Cold-season Forecast

El Niño Outlook

5-14 days ahead

Every Monday and Thursday

Temp. (very high or very low)
Snowfall (very heavy (in winter))

M1			
W1	W2	W3	W4

Every Thursday

Temp.

Precip.

Sunshine

Snowfall

M123 (3-month average)		
M1	M2	M3

Around 25th of the month

Temp. Precip. Snowfall

Around 25th of February

Temp. Precip.

Summer (JJA)

Around 25th of September

Temp. Precip. Snowfall

Winter (DJF)

Around 10th of the month up to 6 months ahead

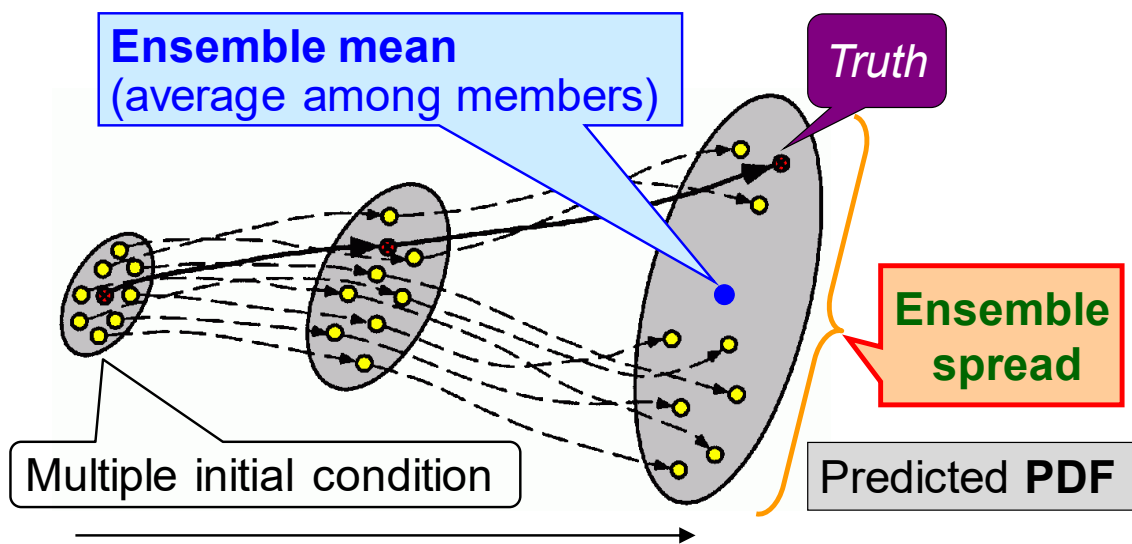
Global Ensemble Prediction System (Atmospheric model)

Seasonal Ensemble Prediction System (Atmosphere-ocean coupled model)



Concept of ensemble prediction

- The atmosphere and ocean is a chaotic system
- Even the tiniest error in an initial condition grows rapidly and unavoidably
- This nature disrupts deterministic numerical prediction beyond about two weeks
- To produce a seasonal forecast, “**ensemble prediction**” is indispensable.
- Ensemble prediction system (EPS) starts with similar, but slightly different, multiple initial conditions, and produces multiple forecasts.
- With the results from EPS, we can get the most likely atmospheric conditions (**ensemble mean**) in future, along with an estimation of degree of uncertainty (**spread**)



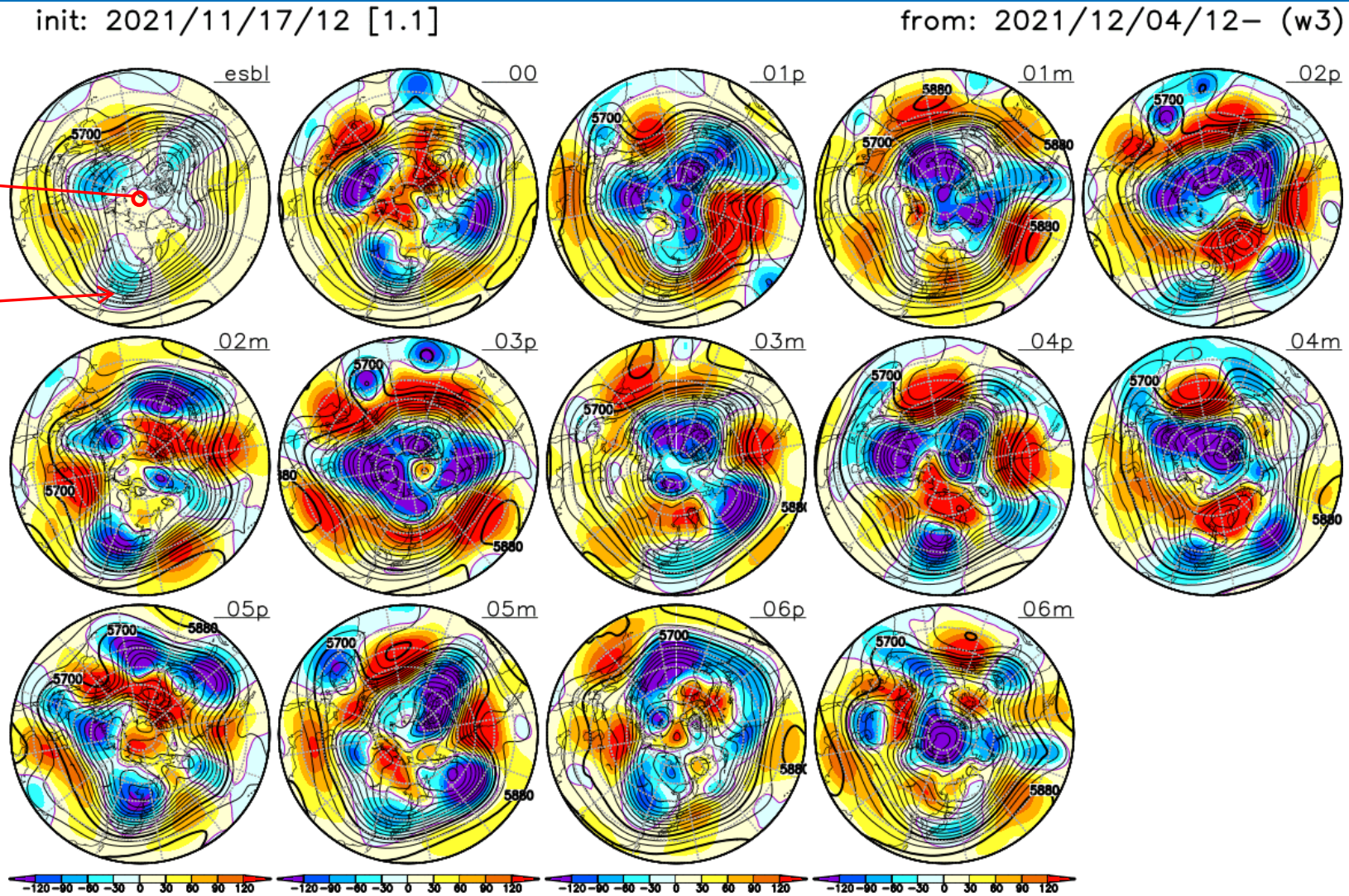
The individual calculation is called “**Ensemble member**” and the standard deviation among all members is called “**Ensemble spread**”.

Example of individual ensemble members

Polar stereo
projection

North Pole

Japan here



Geopotential height anomalies at 500hPa for the week-3 forecast of 1-month prediction run, initialized on 17, Nov. 2021. The ensemble mean and 13 members out of 51 are shown.

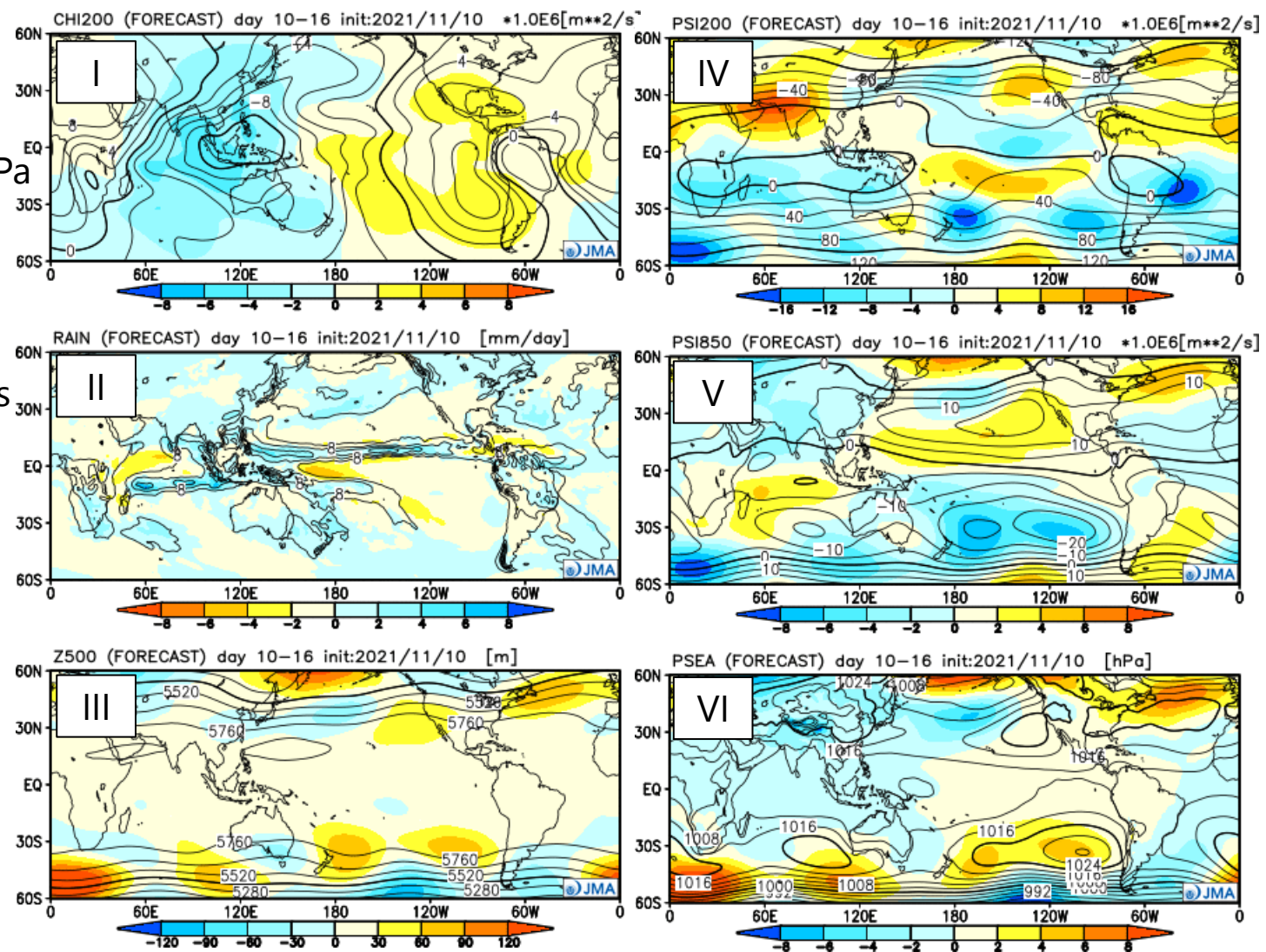


Products from EPS

Ensemble means of :

- I : Velocity potential at 200hPa
- II: Precipitation
- III: Geopotential height at 500hPa
- IV: Stream function at 200hPa
- V: Stream function at 850hPa
- VI: Sea level pressure

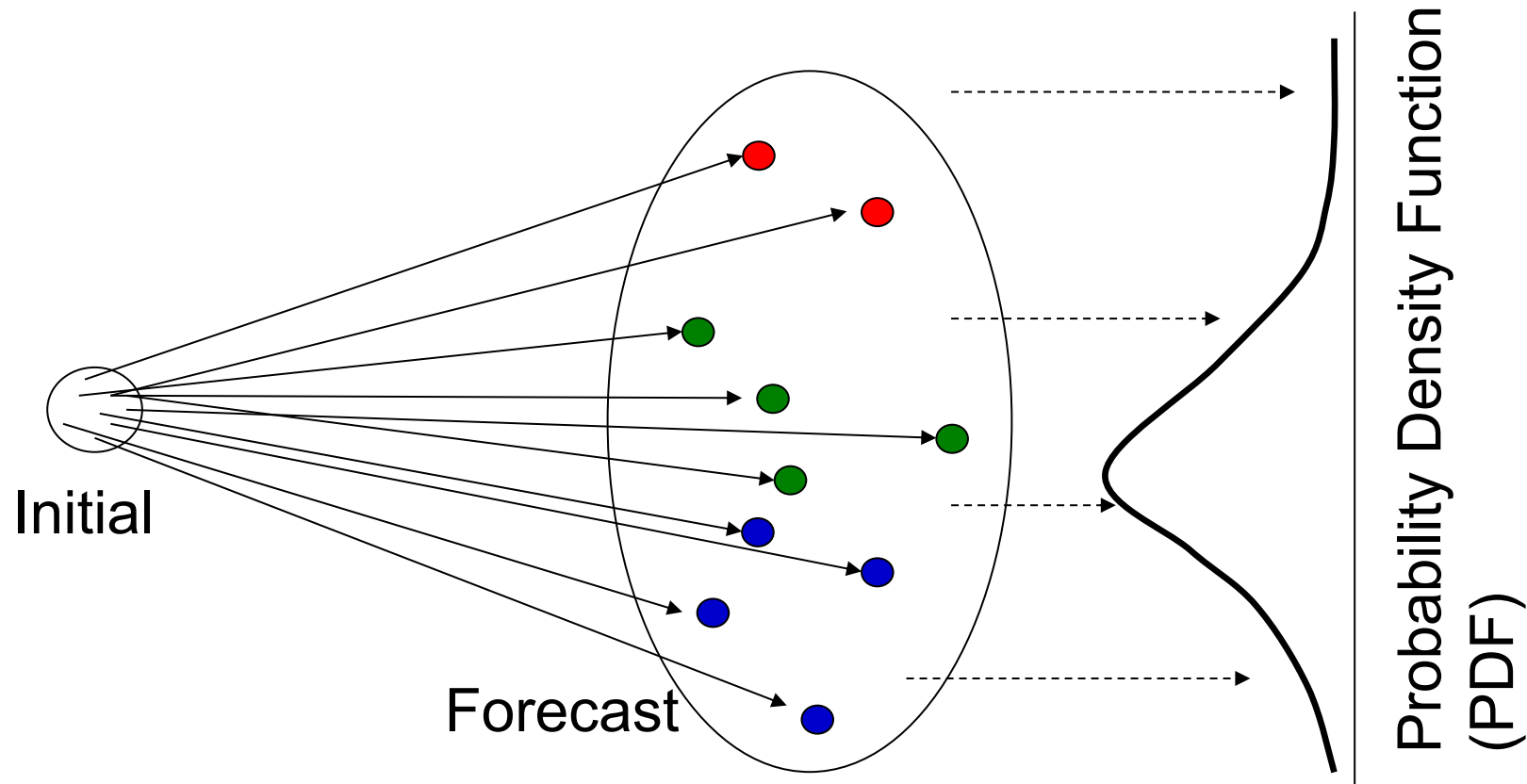
Color shades indicate anomalies



Available at: <https://ds.data.jma.go.jp/wmc/products/model/map/1mE/map1/zpcmap.php>

From ensemble to probability forecast

- From results of EPS, a probability distribution can be derived
- The probability distribution can be translated into, say, a three-category forecast in the form of above/near/below normal.





Verification of JMA Ensemble Prediction System

In general,

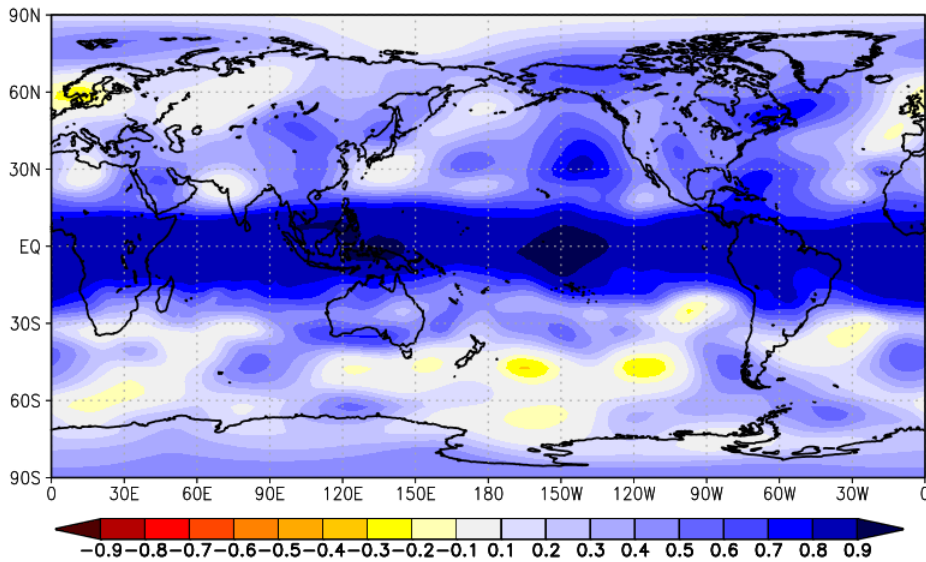
- Better forecast skill in (boreal) winter than in summer
- Better forecast skill in tropics than in higher latitudes

Forecasters need to be aware of where and how numerical model skills are good and poor!

Anomaly correlation for geopotential height at 500hPa for week 3 to 4 (day 17-30) forecasts

<GEPS2503(13mem) : JRA-3Q>
 Z500 anomaly (with bias-correction)
 Anomaly Correlation for 30 years (1991-2020)
 Initial : 0115, 14day mean : day 17-30

Jan 15 initial

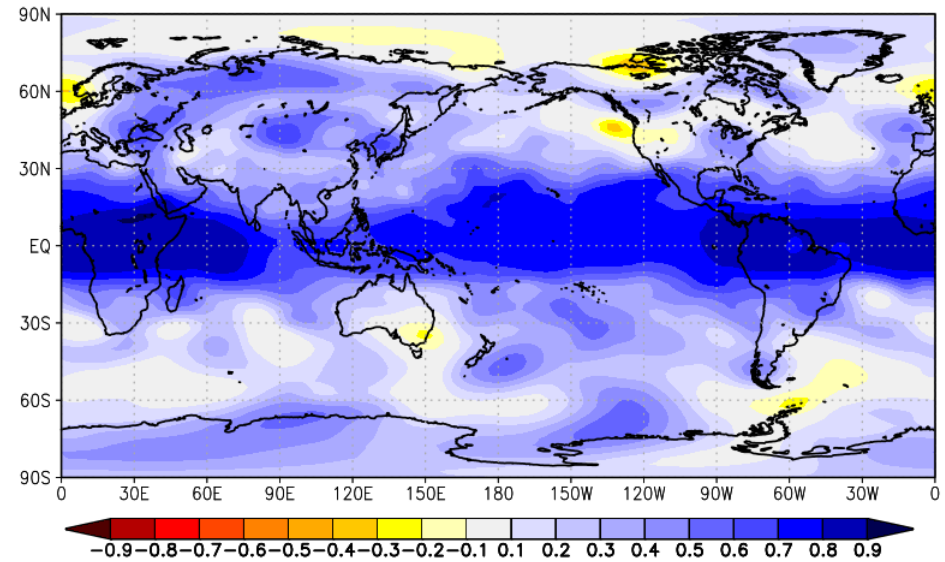


Poor

Perfect

<GEPS2503(13mem) : JRA-3Q>
 Z500 anomaly (with bias-correction)
 Anomaly Correlation for 30 years (1991-2020)
 Initial : 0715, 14day mean : day 17-30

Aug 15 initial



Poor

Perfect

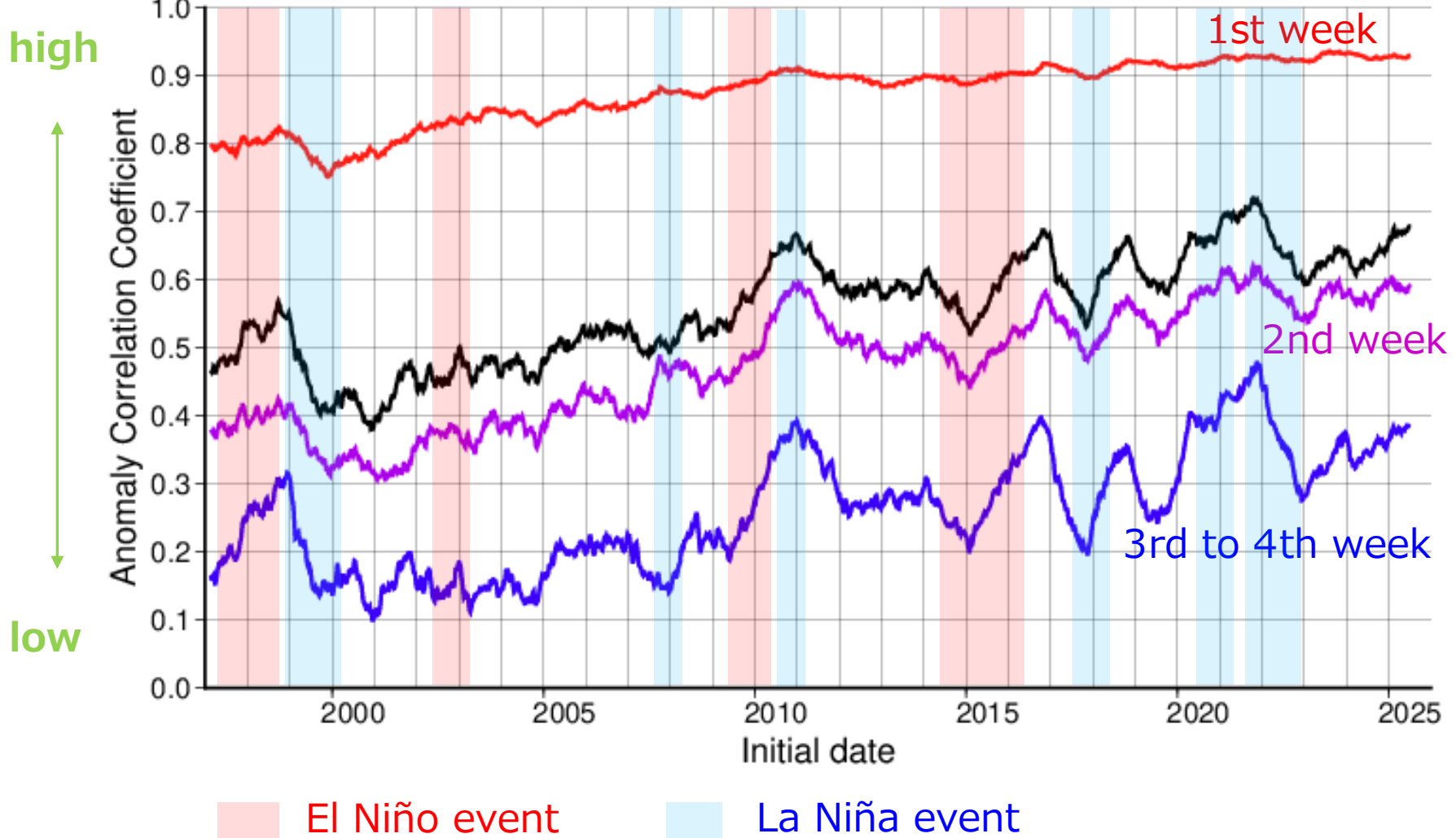
<https://ds.data.jma.go.jp/wmc/products/model/verif/1mE/index.html>



Model forecast skill gradually improved over the years

Anomaly correlation of GPH at 500hPa for the northern hemisphere

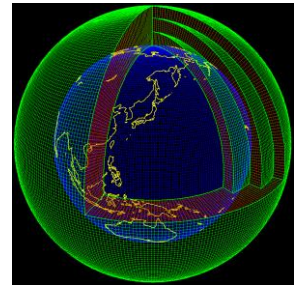
-- previous 52-point moving averages --



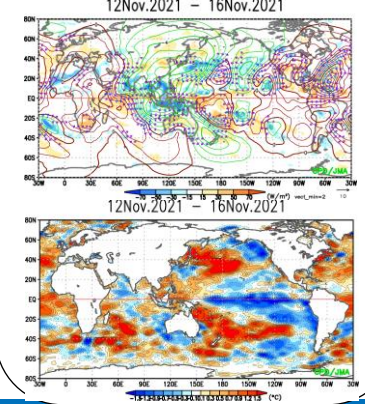


Steps in the process to produce one-month forecast

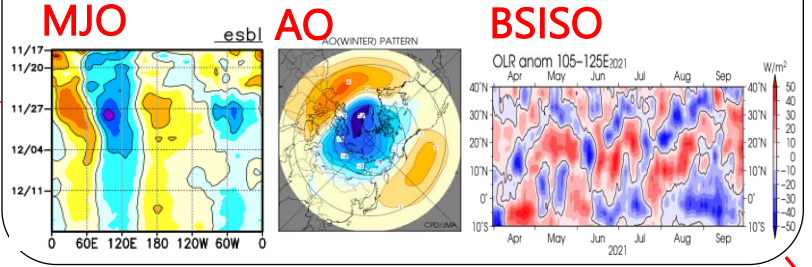
Ensemble Prediction System



Current state



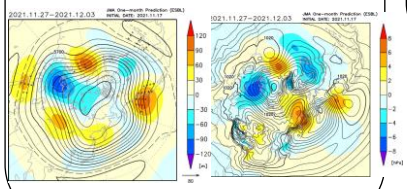
Expected evolution of major modes



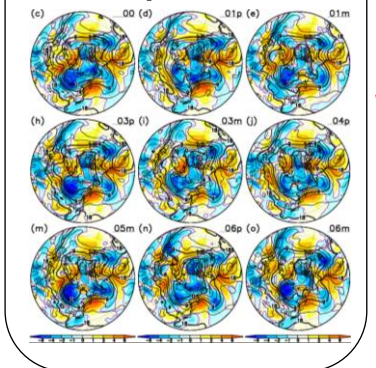
Guidance

Below normal	Near normal	Above normal
13%	33%	54%

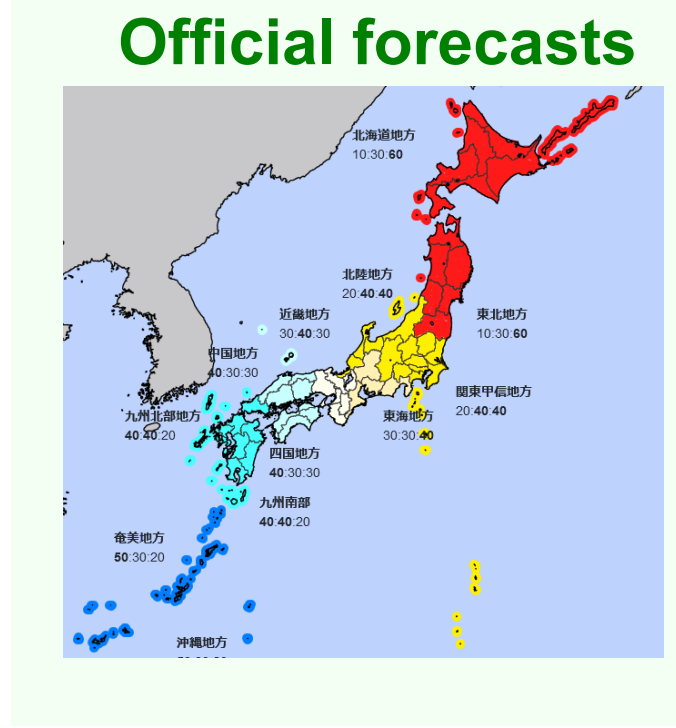
Circulation anomalies



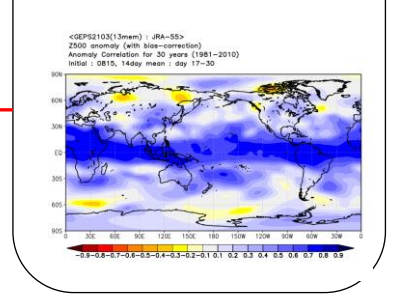
Spread



Interpretation
Explanation
Reliability
Modification



Verification





Steps to produce one-month forecast (in text)

0. Before starting to think about forecasts, be aware of what's going on in the current atmosphere and ocean.

1. See results from the numerical model prediction;

- Expected evolution of the major oscillation modes; ENSO, MJO, BSISO, AO, ...
- Atmospheric circulation anomalies globally and over your country
- Degree of uncertainty (spread among individual ensemble members)

2. Think how do you interpret and explain these predicted modes and anomalies.

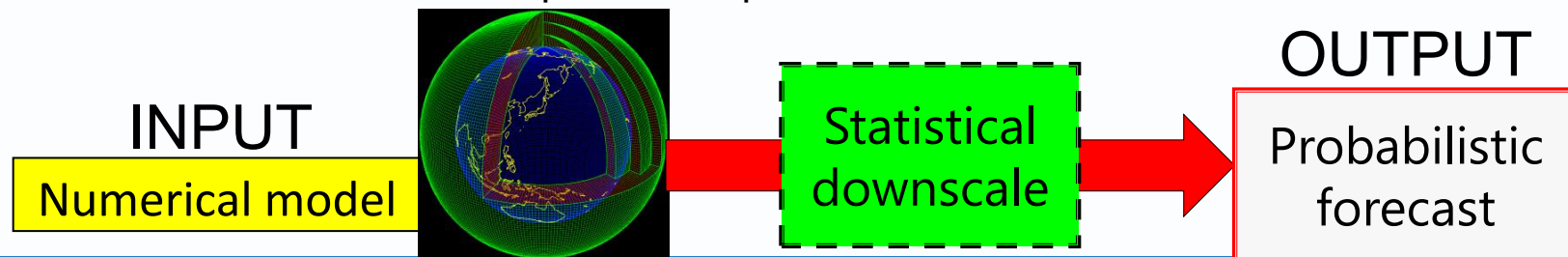
- Judging from the verification data, model prediction skill is sufficient or poor?
- Are you sure the model prediction is sufficiently reliable? If not, what aspect is questionable and why?
- Can the predicted anomalies be interpreted and explained in terms of climate dynamics?

3. Look to guidance (this is a topic of next day's lecture)

4. Adjust and modify the prediction if needed.

5. Assign probability to above/near/below normal categories.

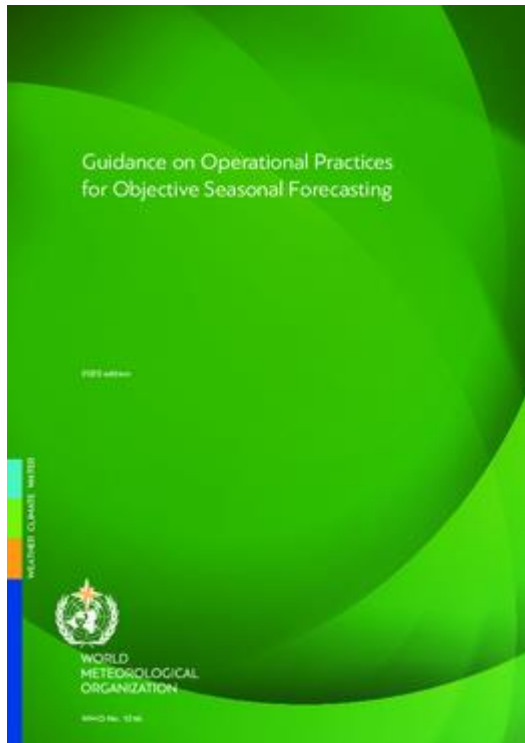
- **Guidance** is used to translate raw model outputs into forecasts more understandable and manageable to human forecasters
- This relies on statistical relationship between past forecasts and observations.





Objective forecast? Needs human forecaster's intervention?

WMO's Guidance on Operational Practices for Objective Seasonal Forecasting



https://library.wmo.int/index.php?lvl=not_ice_display&id=21741#.YZYmpbpUuUk

In the seasonal process recommended above, while it has been a routine practice to take forecast products from GPCs-LRF or LC-LRFMME and *frequently modify these products manually, this practice is not encouraged without (a) strong justification, (b) relevant expertise and (c) proper documentation.* If the above-mentioned forecast products are modified manually, the modifications should be carried out using methods which have been previously documented and have led to improvements in seasonal forecasts. A manual modification of a forecast should be supported by a detailed and transparent discussion of climate drivers, and all forecasts should be verified as per standard practices; this verification should include documenting the skill of the MME and using statistical forecasts as the baseline over which manual intervention shows improvement. *The process of manual intervention requires significant knowledge and expertise to be able to improve on the MME and statistical forecasts and detailed knowledge of global, regional and local drivers of climate variability and teleconnections.*

Thank you

