TCC Training Seminar on One-month Forecast

1 – 7 December 2021

Tokyo, Japan (Online)

Tokyo Climate Center

Japan Meteorological Agency

TCC Training Seminar on One-month Forecast

1 – 7 December 2019

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Schedule

and

List of Participants

TCC Training Seminar on One-month Forecast
Online, 1 - 7 December 2021

Draft Schedule

Local times to join the meeting
All times in agenda are indicated in Japan Standard Time (UTC+9). For your reference, local time for start of meeting is provided below.

Bangladesh	−3.00 hrs. (Start at 11:00 am)	Pakistan	−4.00 hrs. (Start at 10:00 am)
Bhutan	−3.00 hrs. (Start at 11:00 am)	Papua New Guinea	+1.00 hrs. (Start at 03:00 pm)
Indonesia	−2.00 hrs. (Start at noon)	Philippines	−1.00 hrs. (Start at 01:00 pm)
Laos	−2.00 hrs. (Start at noon)	Sri Lanka	−3.30 hrs. (Start at 10:30 am)
Malaysia	−1.00 hrs. (Start at 01:00 pm)	Thailand	−2.00 hrs. (Start at noon)
Mongolia	−1.00 hrs. (Start at 01:00 pm)	Viet Nam	−2.00 hrs. (Start at noon)
Nepal	−3.15 hrs. (Start at 10:45 am)	Hong Kong, China	−1.00 hrs. (Start at 01:00 pm)

Day 1 - Wednesday, 1 December	
14:00-14:05 (UTC+9)	1. Opening - Welcome Address - Group photo shooting
14:05-14:10 (UTC+9)	2. Introduction: Outline and scope of the Training Seminar
14:10-15:10 (UTC+9)	3. Lecture: "Introduction to Climatology" for experts on climate analysis information
15:10-16:10 (UTC+9)	Break
16:10-17:10 (UTC+9)	4. Lecture: Seasonal Forecast (One-month Forecast)
Day 2 - Thursday, 2 December	
14:00-15:00 (UTC+9)	5. Lecture: Concept of numerical guidance
15:00-16:00 (UTC+9)	Break
16:00-17:10 (UTC+9)	6. Lecture: One-month forecasting - Introduction of the forecast products on TCC Web - Explanation of the exercise - Example of constructing one-month forecast
Day 3 - Friday, 3 December	
Taking questions fron trainees through Email	7. Exercise: Generating one-month forecast for your country - Preparation for presentation (self-study format)
Day 4 - Monday, 6 December	
Taking questions fron trainees through Email	7. Exercise: Generating one-month forecast for your country (cont.) - Preparation for presentation (self-study format)
Day 5 - Tuesday, 7 December	
14:00-15:00 (UTC+9)	8. Presentation by participants (7 participants) - Presentation (5 min.) followed by Q&A (3 min.)
15:00-16:00 (UTC+9)	Break
16:00-17:00 (UTC+9)	8. Presentation by participants (cont.) (7 participants) - Presentation (5 min.) followed by Q&A (3 min.)
17:00-17:10 (UTC+9)	9. Wrap up and closing

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Introduction to Climatology

"Introduction to Climatology"

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1. Climate and Climate system

According to WMO website, "on the simplest level the weather is what is happening to the atmosphere at any given time. Climate, in a narrow sense, can be considered as the 'average weather,' or in a more scientifically accurate way, it can be defined as 'the statistical description in terms of the mean and variability of relevant quantities over a period of time.'" Although climate is the synthesis of the weather, climate is not maintained only by atmosphere itself but is formed in the interactions among many components of the Earth. This system is named as a climate system. The global climate system consists of atmosphere including its composition and circulation, the ocean, hydrosphere, land surface, biosphere, snow and ice, solar and volcanic activities (Fig.1). These components interact on various spatial and temporal scales through the exchanges of heat, momentum, radiation, water and other materials.

The main components of the atmosphere are nitrogen and oxygen, however, water vapor and ozone play a particularly important role in the climatic system. Greenhouse effect gases such as carbon dioxide contribute to raising the temperature near the surface. The ocean is mainly

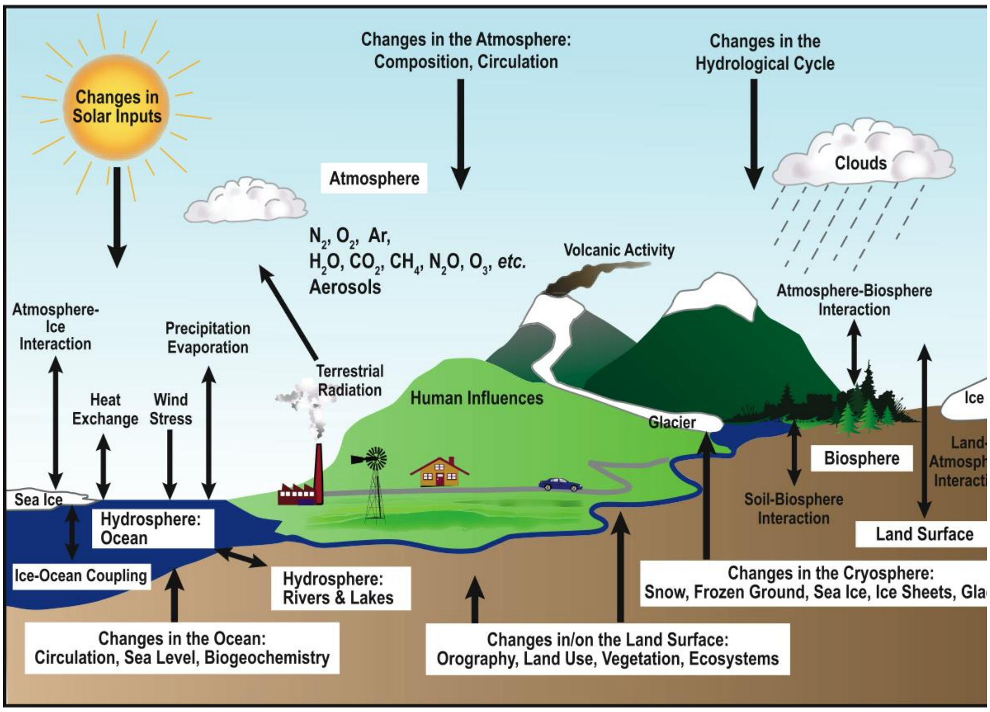


Figure 1 Schematic view of the components of the climate system, there processes and interactions. From IPCC (2007).

composed of water, but the salinity contained in it has a great influence on the ocean circulation through its density. Snow and ice affect the climate system through a strong positive feedback process called ice-albedo feedback. The land surface has a subordinate response to the atmosphere, but it also tends to have some positive feedback processes with the atmosphere.

So far, we have succeeded to describe the complex climate system in science, especially in physics, and we will continue to do it in the future. The atmosphere and ocean are treated as fluids, and their motion can be described by fluid mechanics. Waves are an important concept in the description and prediction. In the atmosphere, the scattering and absorption of radiation from the sun and the earth is formulated by radiation transfer equations, which represent heating and cooling. Parameters such as the absorption coefficient reflect the characteristics of each component. The process by which latent heat is released when water vapor rises and changes to a liquid phase or a solid phase in the air is also formulated. In addition, the atmosphere has chaotic properties due to its strong non-linearity and contains many internal variabilities, so deterministic prediction is limited. Ocean motion follows the equation of motion. The wind stress acts as an external force. The heat that enters the ocean from the atmosphere affects the temperature, and the precipitation and freshwater from the river affect the salinity, which affect the density and create circulations called the thermohaline circulation. On land, there is vegetation, soil, and sometimes snow, which changes due to radiation processes, turbulence processes, heat diffusion, water phase changes with absorption/release of latent heat, and liquid water movement.

The latest climate model is a collection of these understandings of climate systems and their mathematical expressions. Climate models, for example, accurately reproduce global warming and are used for future projections. However, the behavior of climate models is complex and not easy to understand.

We have constructed simpler systems by performing statistical processing such as averaging in the time, longitude, latitude, and/or vertical directions and selecting only essential physical processes for this complicated system expressed in physics. These are useful for expressing the essence of phenomena and states and understanding the behavior of the system. Attempts have also been made to create views of the essence of the phenomenon based on science while applying such statistical processing to complex systems.

The purpose of the lecture is to know how climate is formed and its variability is caused by using these simple systems and views to explain some of the basic concepts of climatology. In the lecture, anthropogenic "climate change" defined by United Nations Framework Convention on Climate Change (UNFCCC) is also included.

2. Global mean temperature and Radiative balance

Global mean temperature of planets, which is the temperature "observed from space", is estimated by global radiation balance between absorbed solar radiation and terrestrial emission from the planet. Incoming solar radiation is reflected back to space by a fraction of the planetary albedo. For the Earth, the observed mean ground temperature (15° C) is warmer by 34° C than the estimated temperature (-19° C). The reason is suggested by comparing other planet cases. The mean ground temperature for Mars with thin atmosphere is warmer only by 1° C than the estimated temperature. For Venus with thick atmosphere, the difference is 503° C. Radiative absorption by greenhouse gas in atmosphere is an important factor to determine mean ground temperature as well as planetary albedo.

The Earth's atmosphere has different characteristics for shortwave and longwave radiations (Fig.2). It is transparent (about 50%) for shortwave radiative flux from the sun as an approximation except for the reflection due to clouds (about 20%). On the other hand, the longwave radiation flux emitted from the Earth's ground is absorbed (about 90%) once in the atmosphere approximately and then mostly emitted back to the ground (greenhouse effect). Upper cold atmosphere and clouds emit less longwave flux to space than the ground emits. As a net, surface ground is heated by shortwave radiation from the sun, and atmosphere is cooled by longwave emission to space. The vertical contrast of the heating between ground and atmosphere creates thermal instability, which is compensated by vertical transport processes of sensible and latent heat energy due to turbulences, convections and waves.

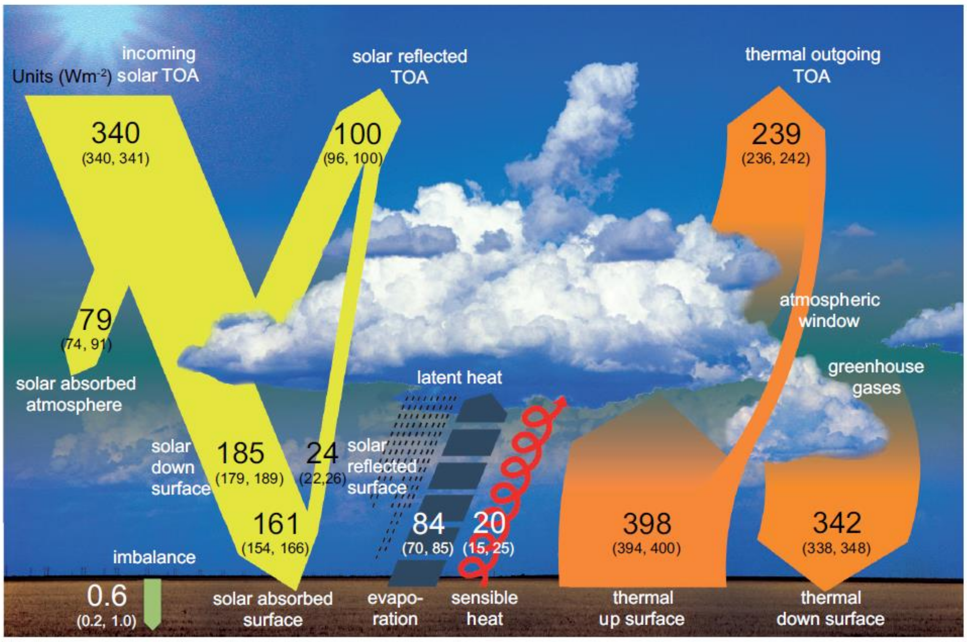


Figure 2 Schematic diagram of the global mean energy balance of the Earth. Numbers indicate best estimates for the magnitudes of the globally averaged energy balance components together with their uncertainty ranges, representing present day climate conditions at the beginning of the twenty first century. Units W/m^2. From IPCC (2014).

3. Annual mean circulation and Horizontal heating contrast

Longitudinal contrast of radiative heating is created between day and night (Fig.3). But, generally, as compared with the annual cycle, the diurnal heating contrast does not produce significant temperature differences between day and night and related global circulations because a relaxation time to a radiative equilibrium is estimated as 30 days for the Earth (James, 1995), which is much longer than a day scale. Latitudinal heating contrast on the Earth is created on seasonal time-scale by the different incoming shortwave radiation between near the poles and the tropics (Fig.3). Local surface temperature determining outgoing longwave radiation is not adjusted instantly enough to compensate for the shortwave radiation contrast. A part of absorbed radiative energy in low latitudes is transported poleward by meridional circulations and waves in atmosphere and ocean, and these heat transports keep high-latitudes warmer than the radiative equilibrium.

Poleward/equatorward air motions form westerly/easterly wind in the upper/lower subtropics (Fig.4) through Coriolis force due to the rotation of the Earth (or the angular momentum conservation about the Earth's rotation axis). Extra-tropical waves are also responsible for creating mid- to high latitude's westerly jets.

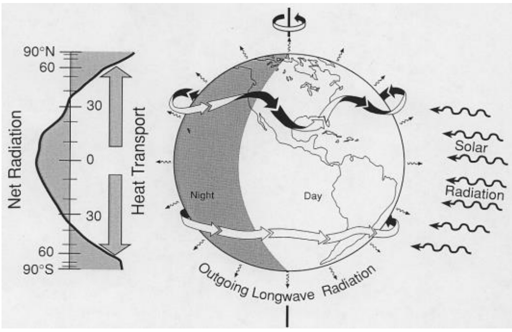


Figure 3 Horizontal radiative imbalance and energy transport by the atmosphere and ocean. From IPCC (1995).

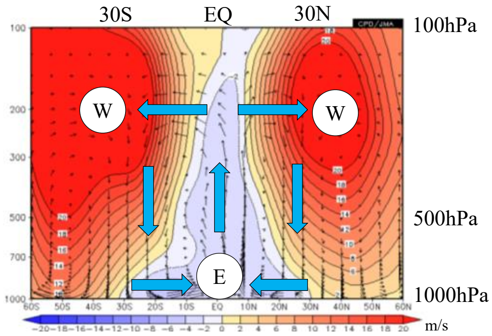
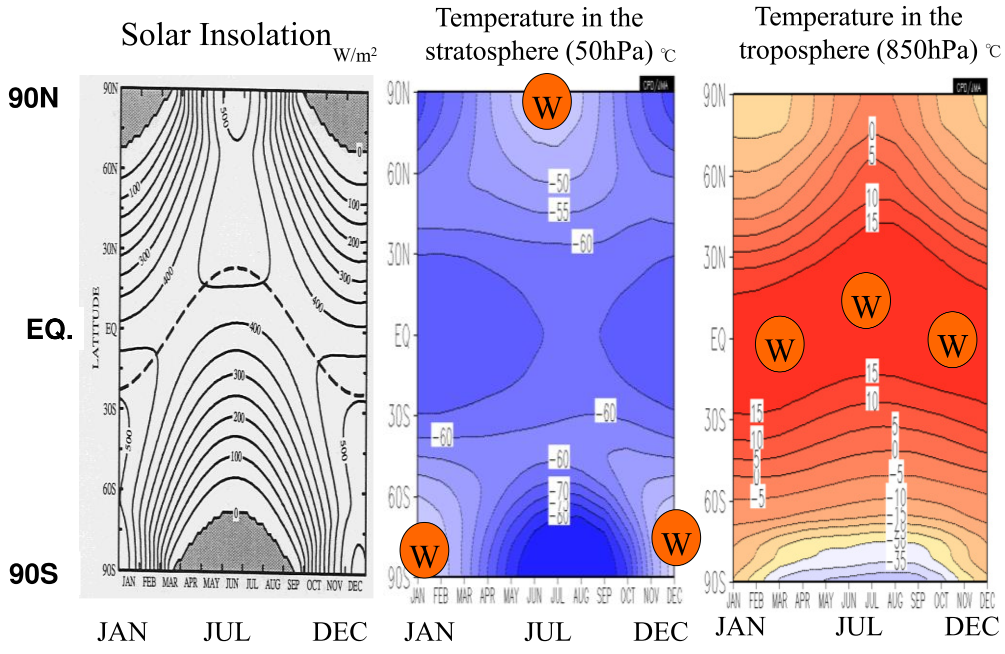


Figure 4 Annual and zonal mean wind. Shade: zonal wind, and arrow: meridional and vertical wind.

4. Seasonal change and Heat capacity

Seasonal change is definitely produced by the seasonally changing solar incidence with its maxima at the South Pole in December and at the North Pole in June. However, zonally averaged features of temperature are not drastically changed in the troposphere (lower than about 100hPa) through the whole year, hot tropics and cold poles (Fig.5). This fact is attributed to basically unchanged distribution of sea surface temperature (SST) due to large heat capacity of the oceans; in the Earth, heat capacity of the ocean is about 1,000 times of that of the atmosphere. SSTs roughly determine the location of deep cumulus occurrences, which leads to vertical energy mixing in the troposphere and drives global circulations (Webster, 1994). Stratospheric climate above 100hPa varies following the seasonal march of the sun (Fig.5) because of the seasonal change of ozone-related shortwave heating and small heat capacity of thin stratospheric atmosphere; cold around a winter pole, warm around a summer pole. Atmospheric circulations also contribute to the stratospheric climate; a cold tropopause in the tropics is steadily created by upward motion.

Heat capacity of land surface is small as compared with that of the oceans. Surface air temperature over the northern continents is much higher than SSTs at the same latitudes in the



Figue 5 Seasonal change of (left)solar insolation, zonally averaged temperature (middle) at 50hPa and (right) at 850hPa. The figure for solar insolation is from IPCC (1995).

northern summer (especially in daytime) and much colder in the northern winter (Fig.6). The large contrasts of surface air temperature between continents and the oceans add a significant feature to regional seasonal changes of rainfall and wind around the continents in low and mid-latitudes, which is named as monsoon. A concentrated subtropical rainfall forms a typical summer monsoon system consisting of an upper-level anti-cyclonic circulation, a monsoon trough, a low-level jet, a subtropical rainfall band expanding north eastward (south eastward) and extensive downward motions causing dry region in the north westward (south westward) area of the Northern (Southern) Hemisphere (Rodwell and Hoskins, 1996), as shown in the Asian region of Fig.6 and Fig. 7.

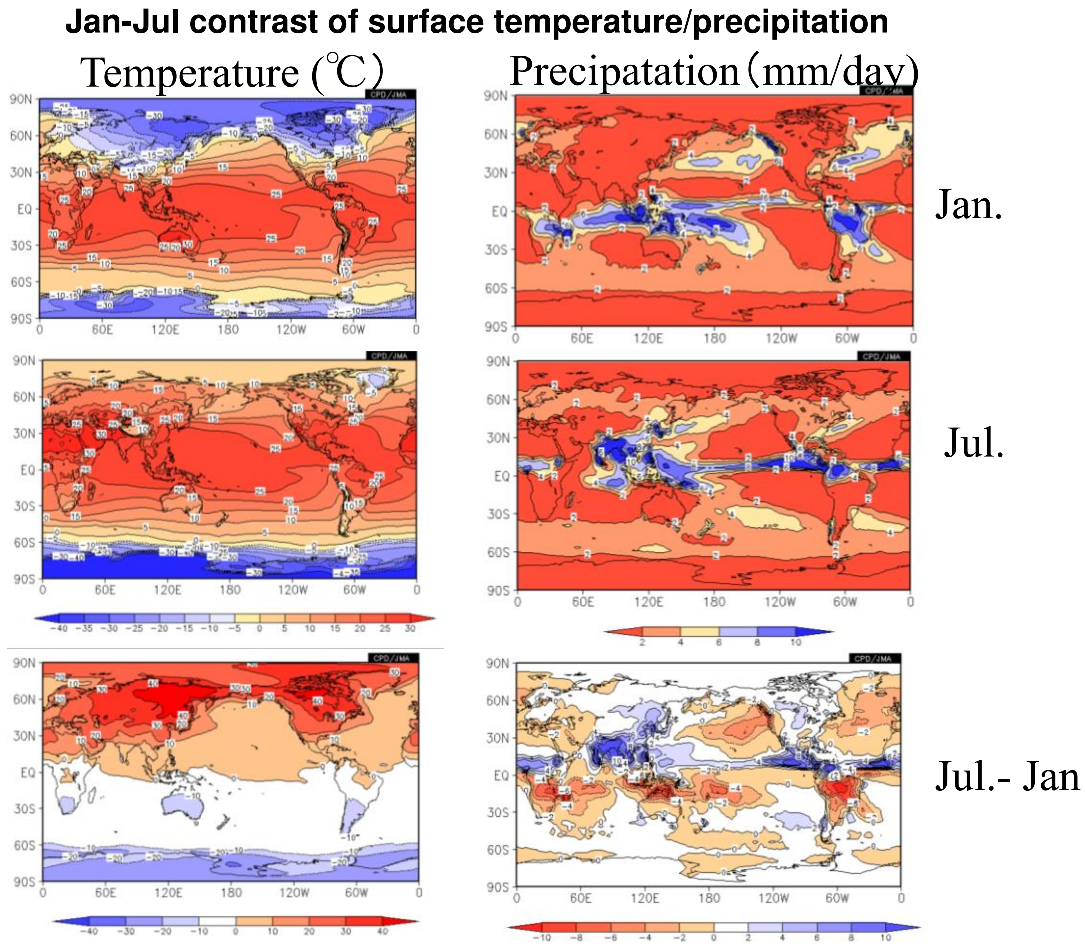


Figure 6 (Left) surface are temperature and (right) precipitation in (upper) January, (middle) July, and (bottom) deference between the two months.

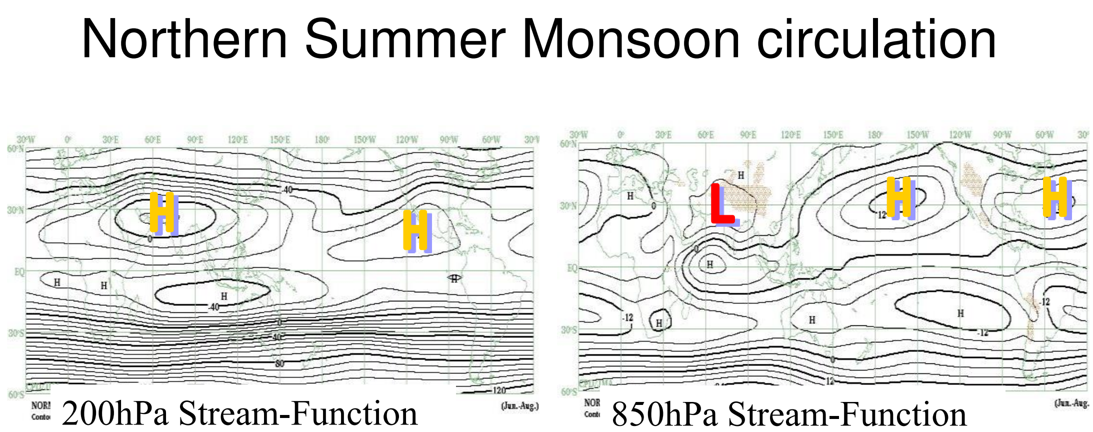


Figure 7 (Left) 200hPa stream function and (right) 850hPa stream function in JJA.

Mountains have also impact on seasonal changes in local climate through thermal and dynamical processes. A good way to understand climate system is to modify or remove some elements of the climate system (Fig. 1). It is not easy to modify a real climate system of the Earth by changing the Earth orbit or removing mountains. Instead, we can easily modify virtual climate systems simulated numerically in climate models based on physics and other fundamental sciences. From the comparison between with/without mountain model experiments (Fig. 8), we can see that mountains would be responsible for the real world climate of humid summer and somewhat cold winter in the eastern parts of the continents.

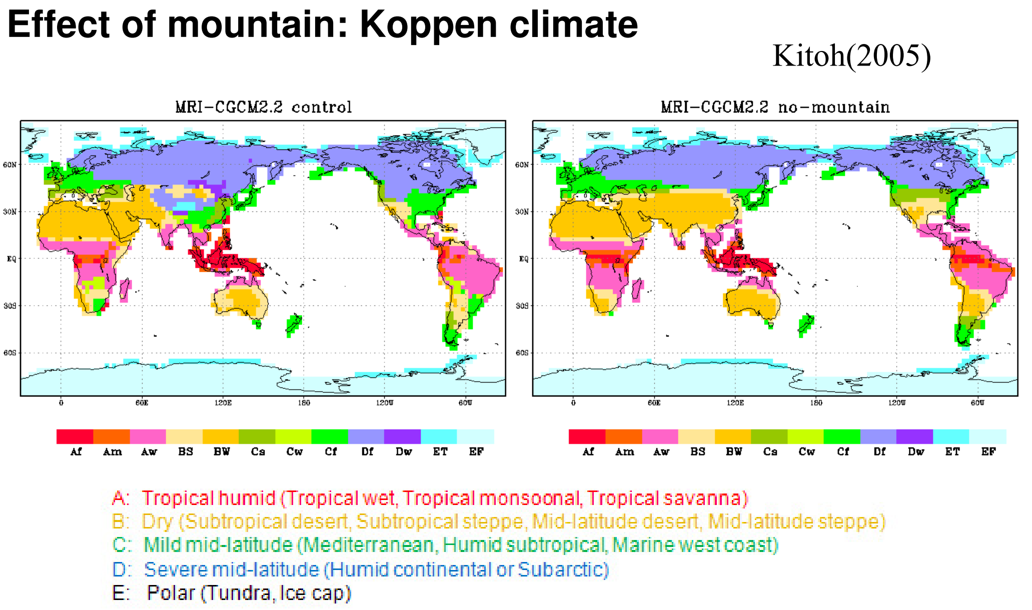


Figure 8 Koppen climate maps simulated by a climate model (left) with mountains and (right) without mountains. From Kitoh (2005) in Japanese.

6. Intra-seasonal to Interannual variability

Climate varies naturally with time. Atmosphere itself includes internal instability mechanisms, typically the baroclinic instability around the extratropical westerly jets, so that it may be considered as chaotic or unpredictable beyond a few weeks. However, some atmospheric low-frequency (>10days) teleconnections are analyzed such as wave patterns along the westerly jet waveguides and other ones from the northern mid-latitudes across the equatorial westerlies (Fig. 9), which are consistent with the Rossby-wave propagation theory. Also, teleconnections of another type are analyzed such as meridional displacements of the westerly jet (Fig.10), which are maintained by the wave-mean flow interaction (Vallis, 2006). Numerical ensemble predictions from many disturbed atmospheric initials are a reasonable tool to capture mean weathers in next few weeks.

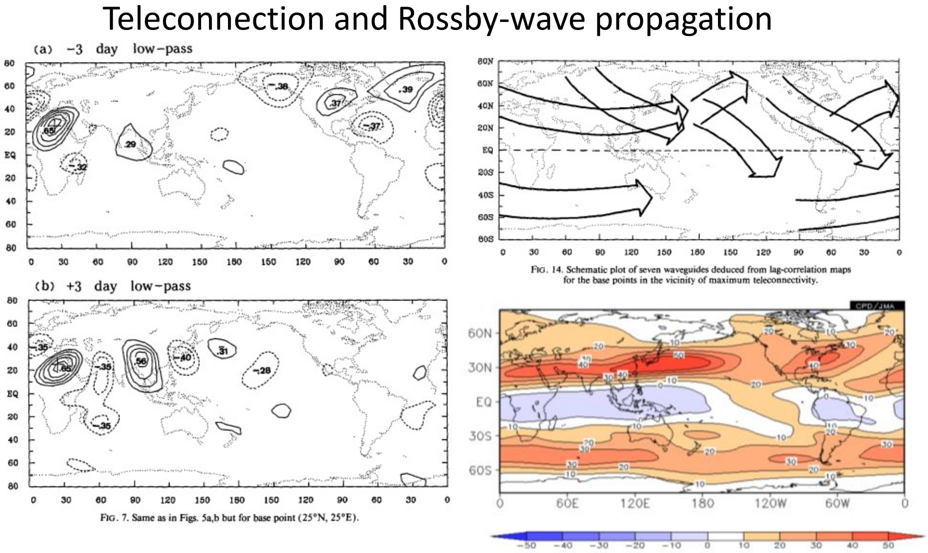


Figure 9 (Left) a teleconnection pattern of 250hPa stream function in boreal winter, (upper-right) various propagations of Rossby-wave and (lower-right) 250hPa climatological zonal wind in DJF. Left and upper-right panels are from Hsu and Lin (1992).

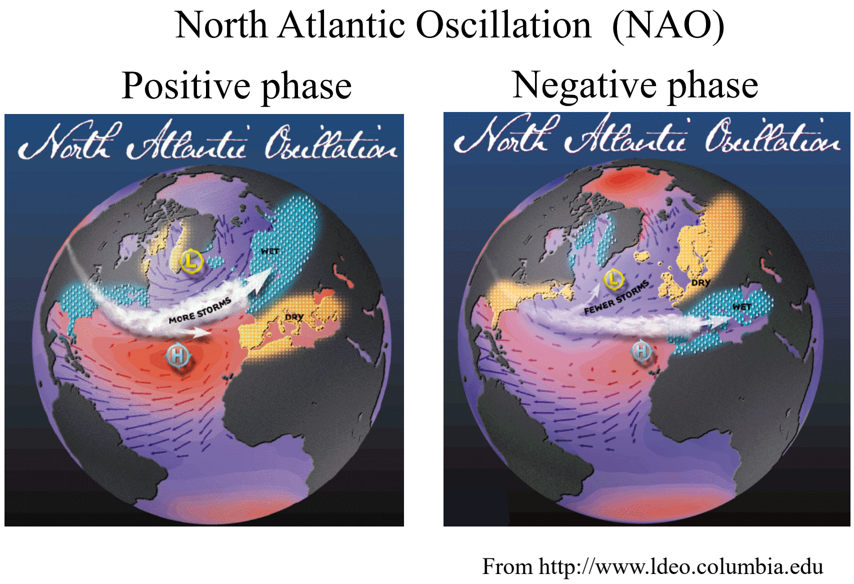
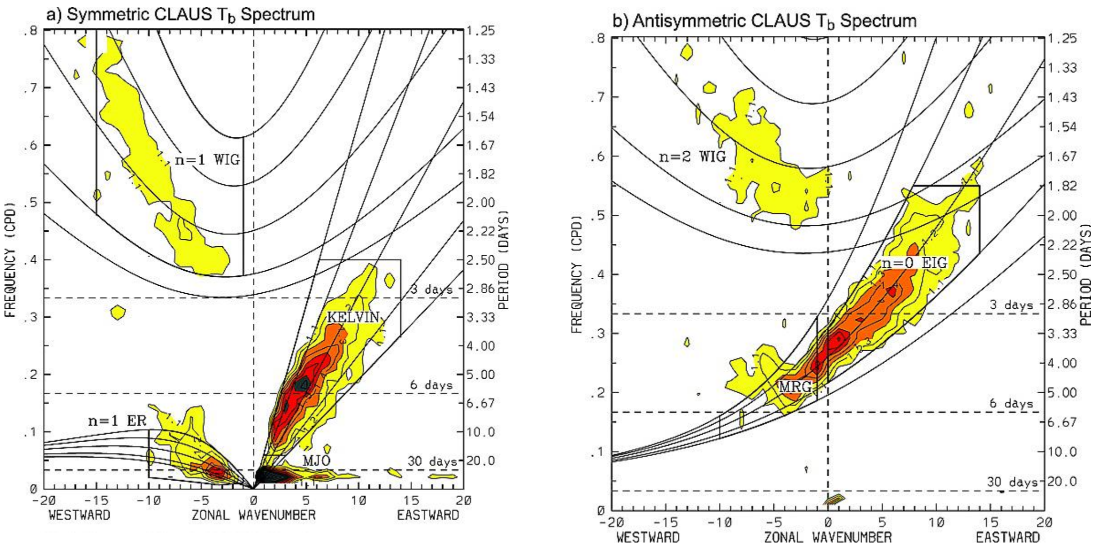


Figure 10 (Left) positive and (right) negative phase of North Atlantic Oscillation (NAO). NAO is one of teleconnections with meridional displacements of the westerly jet. Panels are from http//www.ldeo.columbia.edu.

In the tropics, some peaks in spatial and temporal power-spectrums, indicating organized atmospheric variability coupled with convective activity, are imbedded in red noise backgrounds. Variability of outgoing longwave radiation (OLR) associated with equatorial waves, such as Kelvin waves, equatorial Rossby waves (ER) and mixed Rossby-Gravity waves (MRG), can be detected, in Fig. 11.



Wave number–frequency power spectrum of the (a) symmetric and (b) antisymmetric component of Cloud Archive User Services (CLAUS) T_b for July 1983 to June 2005, summed from 15° N to 15° S, plotted as the ratio between raw T_b power and the power in a smoothed red noise background spectrum (see WK99 for details). Contour interval is 0.1, and contours and shading begin at 1.1, where the signal is significant at greater than the 95% level. Dispersion curves for the Kelvin, $n = 1$ equatorial Rossby (ER), $n = 1$ and $n = 2$ westward inertio-gravity (WIG), $n = 0$ eastward inertio-gravity (EIG), and mixed Rossby-gravity (MRG) waves are plotted for equivalent depths of 8, 12, 25, 50, and 90 m. Heavy solid boxes represents regions of wave number–frequency filtering

Figure 11 Spatial and temporal power-spectrums in the tropics of (left) symmetric and (right) asymmetric OLR variability about the equator. (From Kiladis et al. 2009).

The Madden-Julian Oscillation (MJO) is an eastward-moving oscillation of surface pressure, precipitation and winds along the equator with the period of 30-60 days and planetary scale wavenumbers (Fig. 12). Monitoring MJO or watching OLR and velocity potential anomalies may be very helpful for intra-seasonal prediction in the tropics to the subtropics and even in the mid-latitudes (Fig. 12). Improvement of MJO prediction skill is one of key topics for operational numerical prediction centers in the world.

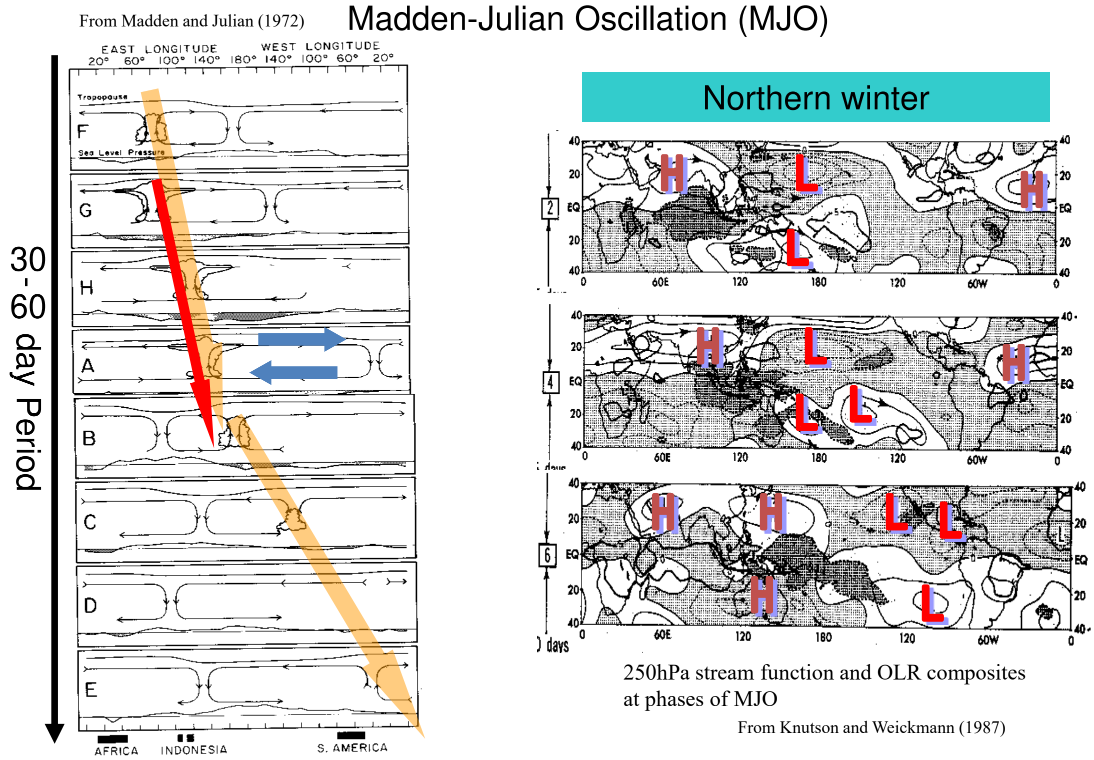


Figure 12 (Left) schematic time-sequence of Madden-Julian Oscillation (MJO) along the equator (from Madden and Julian, 1972). (Right) composite maps of OLR and 250hPa stream function anomaly at MJO phases (from Knutson and Weickmann 1987).

Atmosphere-ocean interactions are able to produce longer time-scale natural variability in atmosphere with periods beyond months up to several and decadal years. A typical example is ENSO (El Niño / Southern Oscillation) with the period of 2-7 years, which is the most dominant interannual climate variability in the earth climate system and has huge sociological and economic impacts globally. El Niño events themselves, and related surface air temperature and precipitation anomalies are predicted successfully on seasonal to inter-annual scales (Fig.13). The SST anomalies with El Niño tend to keep seasonally steady precipitation (heating) anomalies over the equatorial central Pacific. The response of the upper and lower-level tropical atmosphere to these steady heating anomalies can be explained based on forced equatorial waves or the Gill-pattern (or Matsuno-Gill pattern) (Fig. 14). These anomalous steady heating in the tropics forces stationary Rossby waves which propagate to mid-latitudes, and tends to cause teleconnection patterns such as the Pacific North America (PNA) pattern and the Western Pacific (WP) pattern.

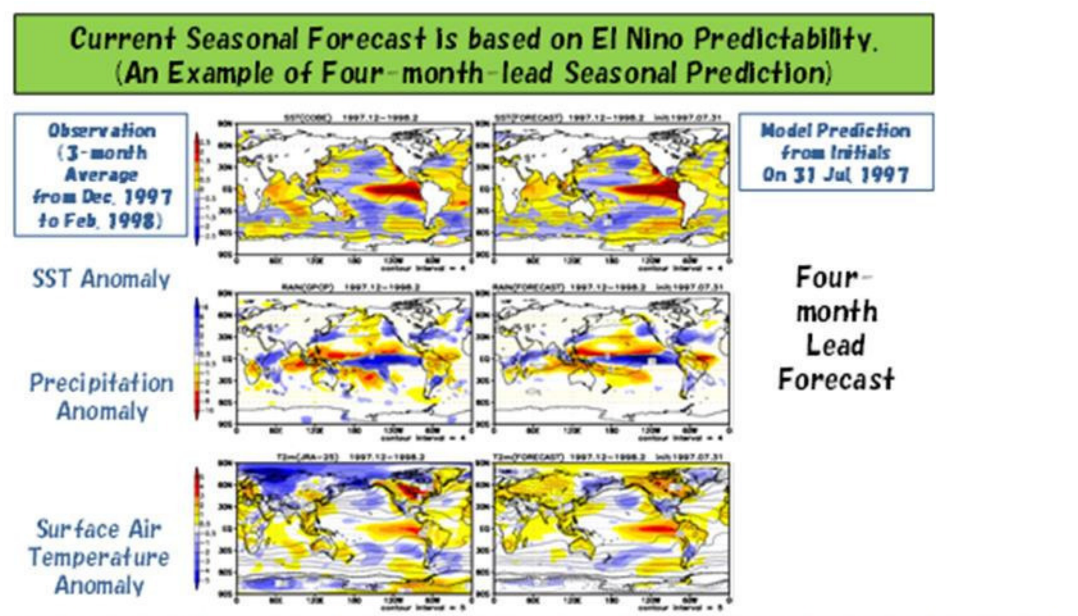


Figure 13 (Left) observed SST, precipitation and surface air temperature anomalies for DJF 1997-98. (Right) the same except for four-month lead prediction.

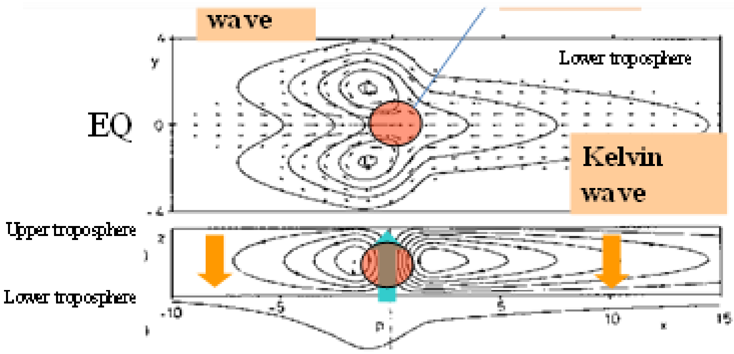


Figure 14 Tropical atmospheric responses to equatorially symmetric heating anomalies. (from Gill 1980).

Recently, terms of “El Niño Modoki” or “Central Pacific (CP)-El Niño” are used to distinguish them from normal El Niño events or Eastern Pacific (EP)-El Niño. They consist of the equatorial Pacific phenomena with warm SST anomalies and enhanced precipitation in the central Pacific, and cold SST anomalies and suppressed precipitation in the eastern Pacific, on contrast. The remote effect of El Niño during the mature stage is stored in the Indian Ocean capacity and still influential to the Indo-western Pacific climate even during summer following the ENSO (Fig.15). A dipole mode with an east-west SST anomaly contrast sometimes occurs around September and October in the tropical Indian Ocean, which is at least partially independent from ENSO events (Fig. 16). Occurrence of this mode affects climate over various regions including tropical eastern Africa and the maritime continent.

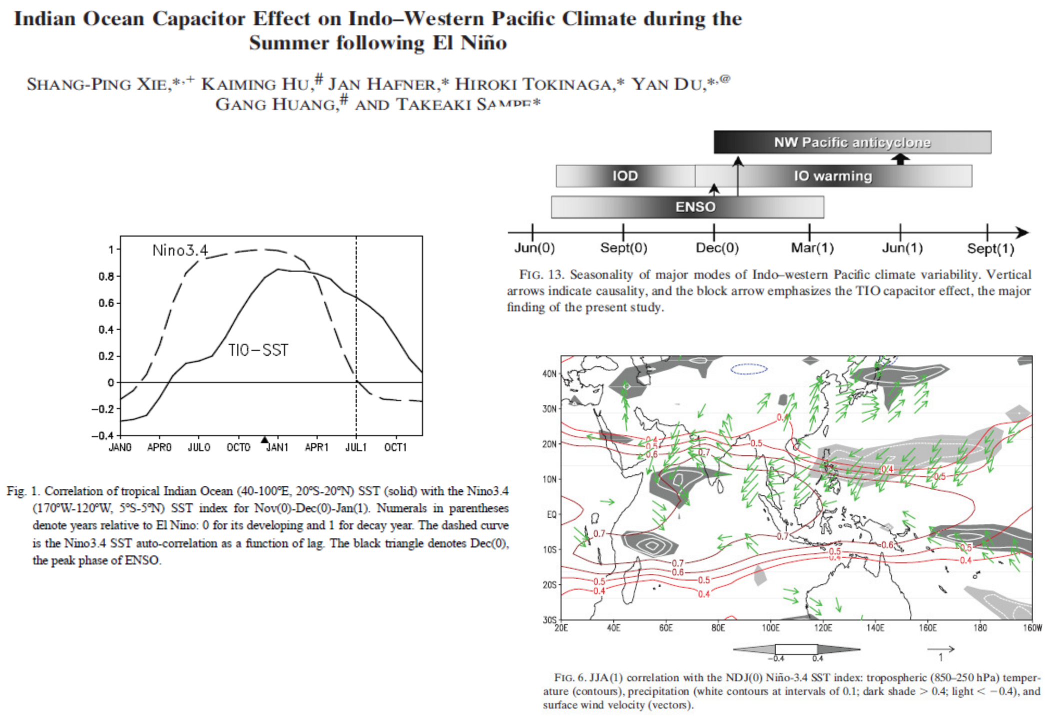


Figure 15 Indian Ocean capacitor effect. (Left) lagged correlation of tropical Indian Ocean SST with Nino 3.4 SST for NDJ. (Upper-right) seasonality of major modes. (Lower-right) correlation of the NDJ Nino3.4 SST with the following JJA climate. From Xie et al. (2009).

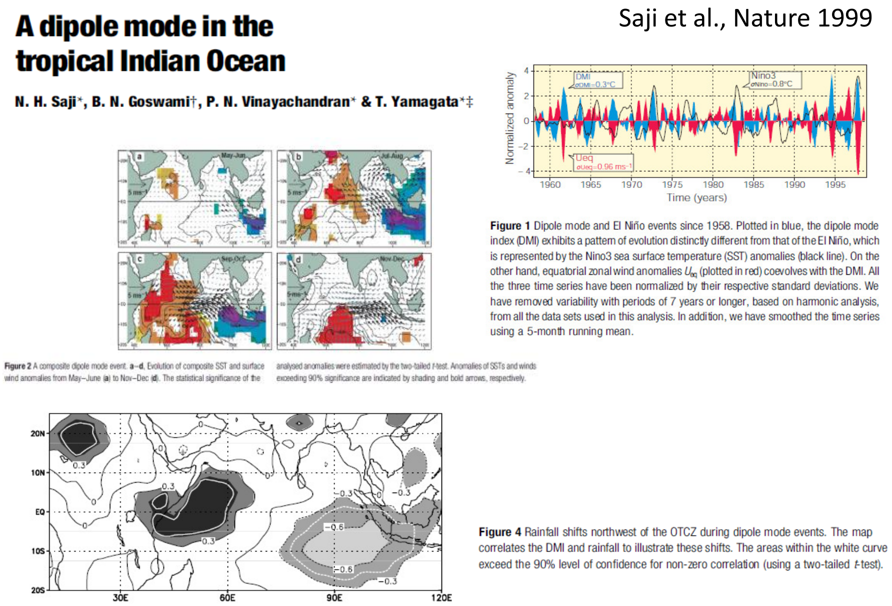


Figure 16 A dipole mode in the tropical Indian Ocean. (Upper-left) time-evolution of the dipole

7. Decadal variability

Decadal variability and climate change involve feedbacks from other elements of the climate system. Changes of vegetation and soil moisture amplify the dramatic drying trend in 1980’s in Sahel region, which is basically forced by a southward precipitation shift of the Inter-tropical Convergence Zone due to cooler/warmer SST anomaly in the northern/southern Atlantic Ocean (Fig. 17).

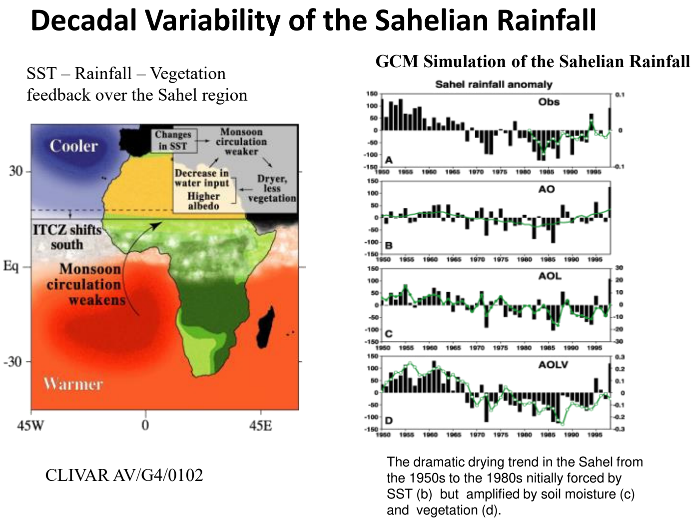


Figure 17 Decadal variability of the Sahel Rainfall. (Left) a possible mechanism, (Right) observed historical Sahel rainfall anomaly and GCM simulations . From Zeng et al. 1999.

Decadal variabilities are also found in SST anomaly from the North Pacific to the tropics (Fig. 18) which is named Pacific Decadal Oscillation (PDO) or Interdecadal Pacific Oscillation (IPO). A possible mechanism of PDO is the subduction hypothesis; high latitudes' cold surface water is subducted in the North Pacific and flows into the subtropical deeper ocean along the surfaces of constant density, then emerges again to the surface of the equatorial Pacific by upwelling. This is consistent with the analysis showing that the decadal SST variability in the central North Pacific spreads into the deep ocean. PDO has impact on ENSO characteristics and regional climate. Several studies indicated that the negative phase of PDO played the major role in the slowdown of the global averaged surface air temperature raise in recent years (Meehl, 2015).

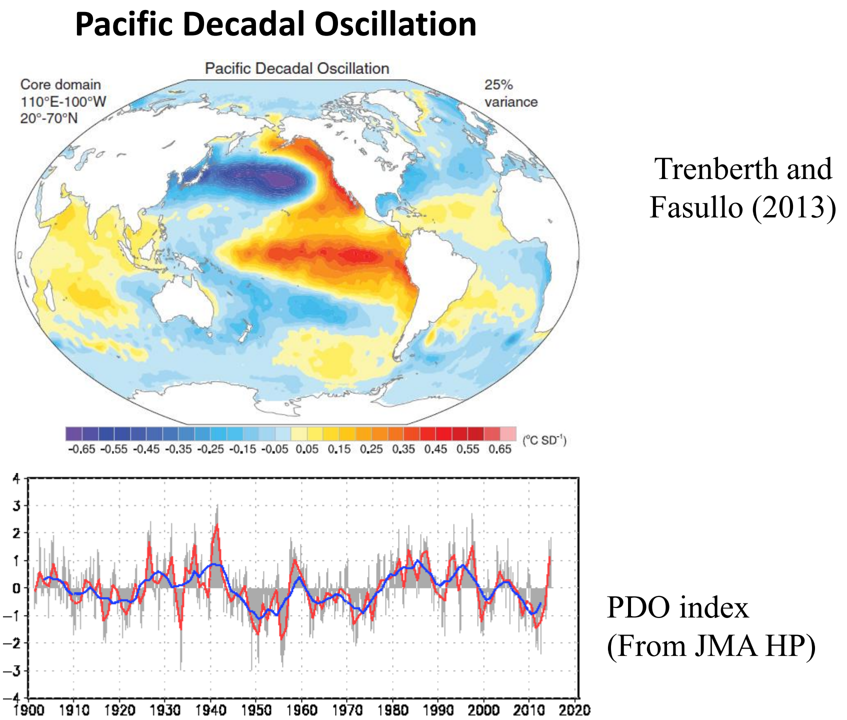


Figure 18 (Upper) SST anomaly pattern in the positive phase of Pacific Decadal Oscillation (PDO)(from Trenberth and Fasullo, 2013) and (lower) PDO index (from http://ds.data.jma.go.jp/tcc/tcc/products/elnino/decadal/pdo.html).

8. Summary

Unusual weather and climate are attributed to unusual atmospheric flows, storms and convective disturbance. Diagnostic analysis shows that those disturbances are often related to atmospheric intrinsic waves and phenomena. However, atmospheric environment is maintained and influenced by other elements consisting of the climate system. Sometimes, and unusual and steady convective activity is connected to long-term SST anomalies related to ocean variability. Numerical ensemble simulations starting from many disturbed atmospheric and oceanic initials are a reasonable tool to capture the mean state of weathers and climate in a timescale from weeks to seasons. Radiative processes including longwave absorption by greenhouse gases and shortwave reflection by snow, ice, clouds and aerosols determine the local Earth's ground temperature. The distribution of ground temperature is influential to vertical and horizontal atmospheric and oceanic stabilities, the amount of water vapor and the speed of water cycle. Then, those can affect atmospheric and oceanic flows, the features of storms and convections and eventually our daily lives. Therefore, we need to continue careful watches and diagnostics for global and local climate systems (Fig.1), as well as its prediction.

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One-month forecast

One-month Forecast

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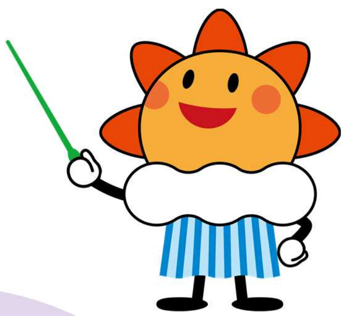
Senior Scientific Officer for Seasonal Forecast
Tokyo Climate Center
Japan Meteorological Agency

December 1, 2021
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

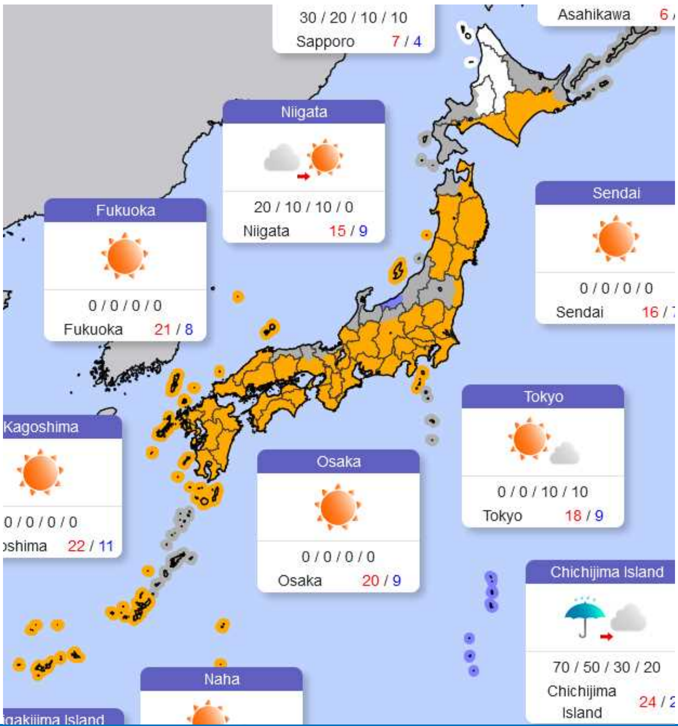
According to WMO's ***Manual on Global Data-processing and Forecasting System***,

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 different between short- and extended- range forecasts?

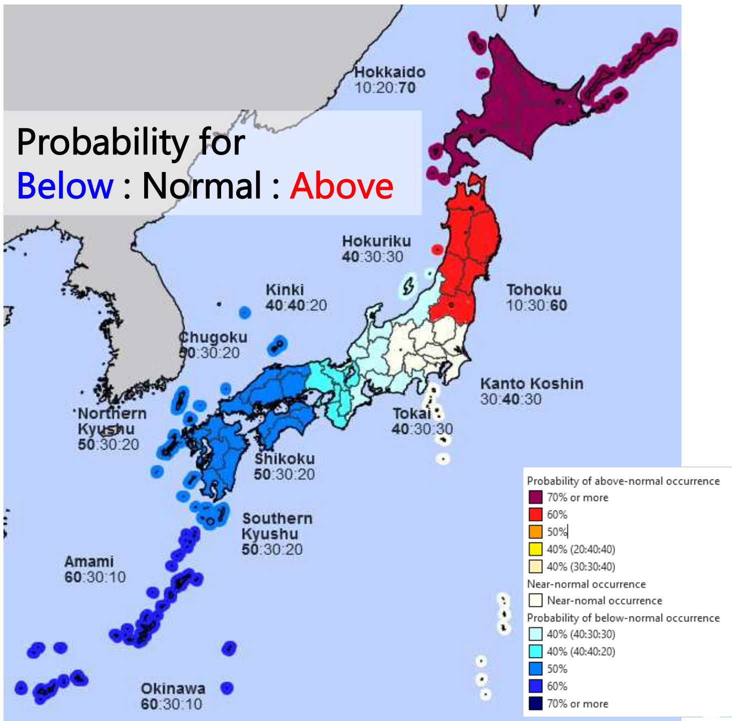
Short-range forecast

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



One-month forecast

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



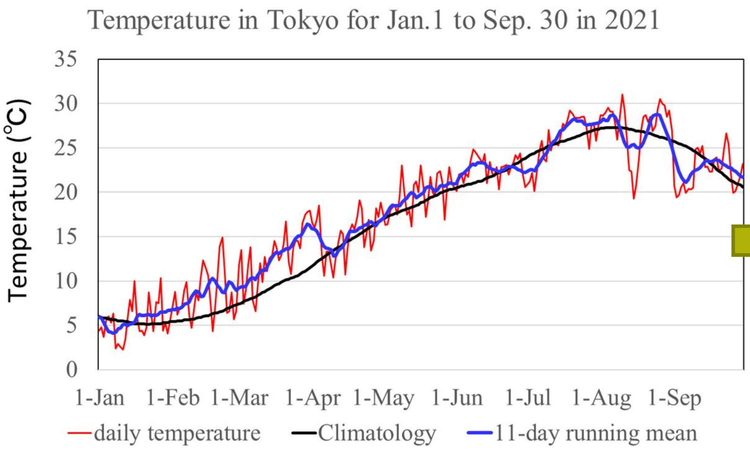
Anomaly is what we forecast

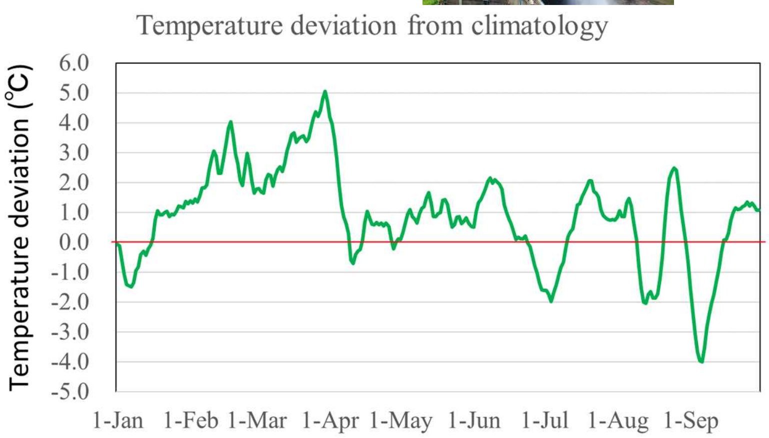
Climatological normal: Defined as 30-year average for 1991–2020

Anomaly: Deviation from the Climatology

[Anomaly] = [Actual Value] – [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 bring adverse effects across multiple sectors, including agriculture, tourism, water resource, and so on.



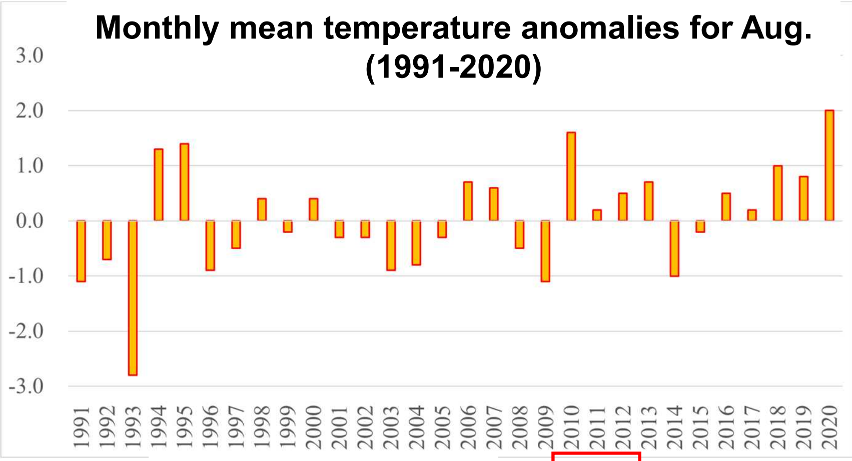


3-category probabilistic forecast

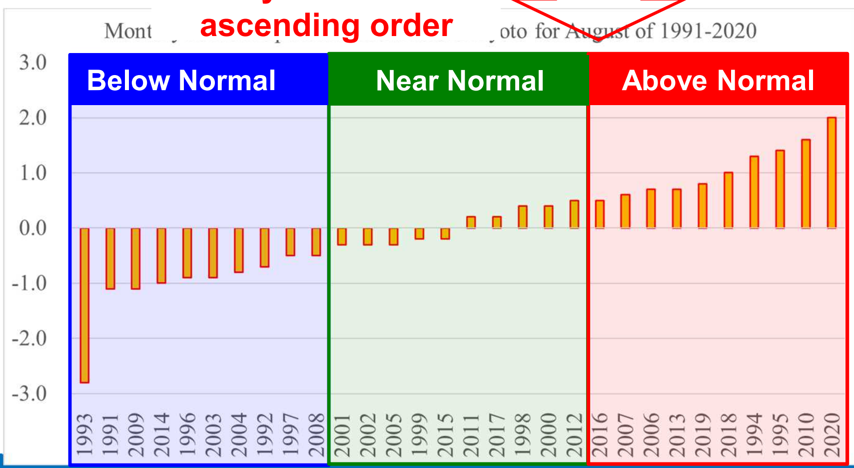
- JMA provides one-month forecasts in 3 probabilistic categories, namely,
  Above/Near/Below normal
- The 3 categories are defined from historical observations for the 30-year period of 1991-2020, by sorting them in ascending order and dividing into 3 categories.
- One-month forecasts are provided as 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.

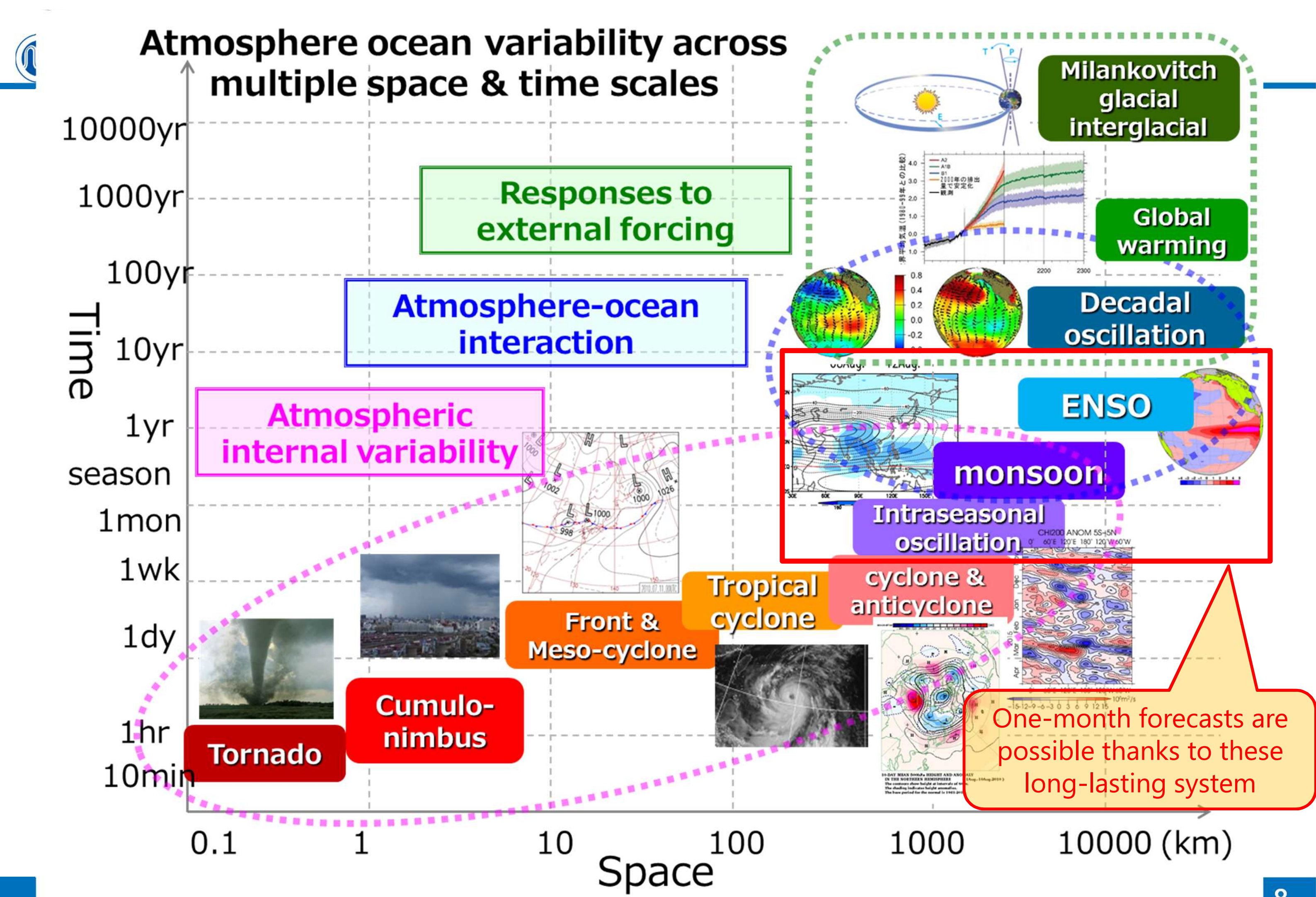
BN	NN	AN
20%	30%	50%



Sort by anomalies in ascending order



Brief introduction to climate dynamics



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.

$$v = v_\psi + v_\chi$$

< Rotational wind >

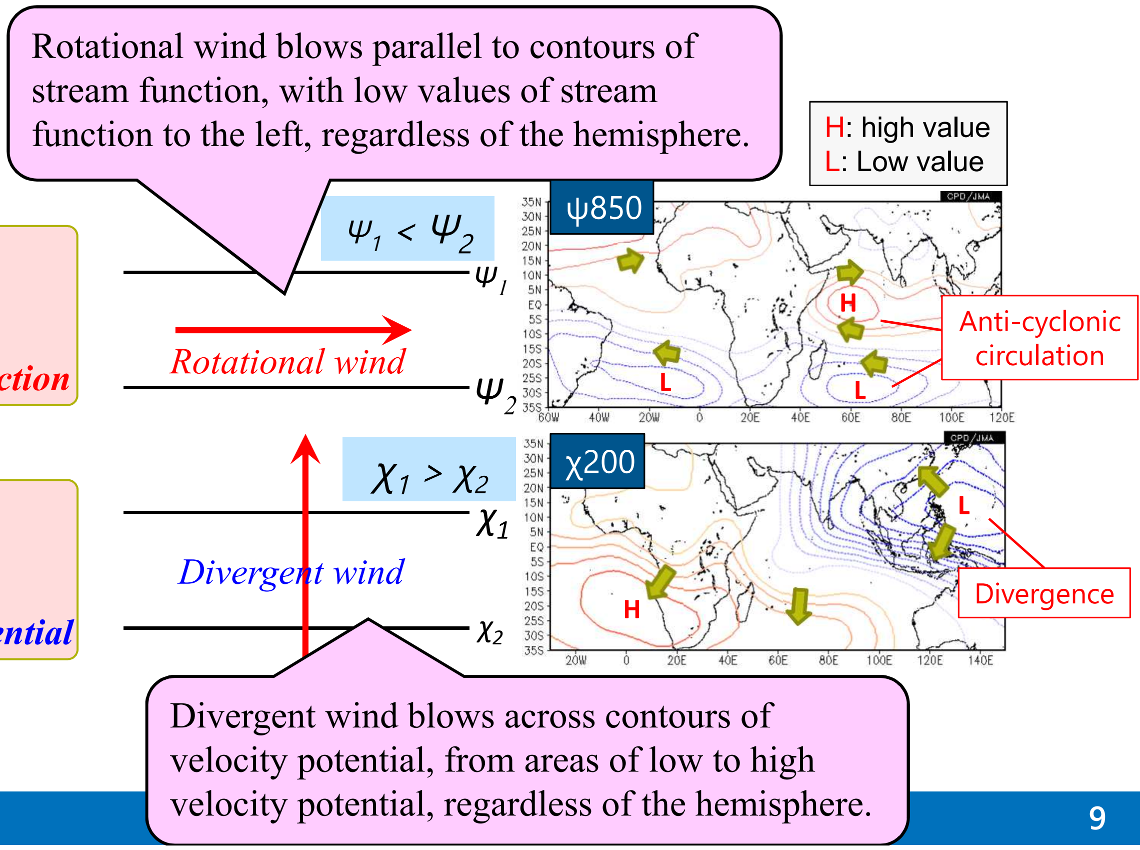
$$u_\psi = -\frac{\partial \psi}{\partial y}, v_\psi = \frac{\partial \psi}{\partial x}$$

Ψ: Stream function

< Divergent wind >

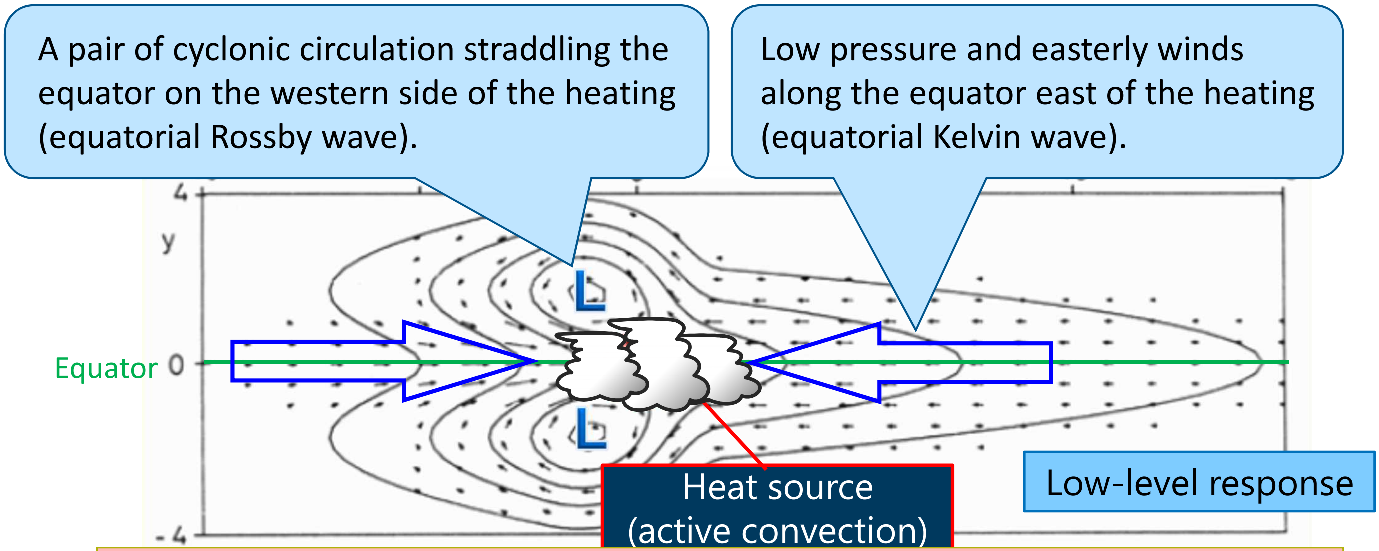
$$u_\chi = \frac{\partial \chi}{\partial x}, v_\chi = \frac{\partial \chi}{\partial y}$$

χ: Velocity potential



Matsuno-Gill response (in the lower troposphere)

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



<u>Atmospheric response in the lower troposphere to the heating symmetric about the equator</u>

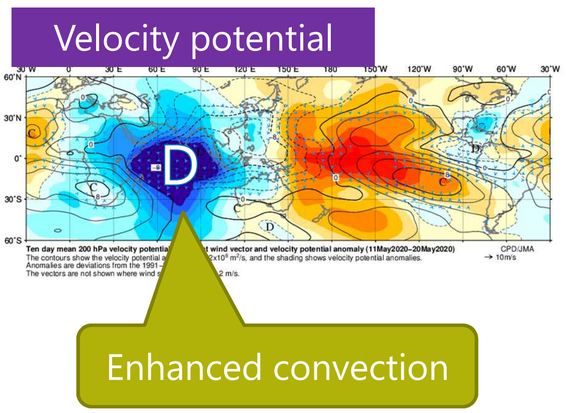
Contours indicate perturbation pressure, and vectors denote velocity field.
Red circle indicates the position of the heating. (Source: Gill 1980)

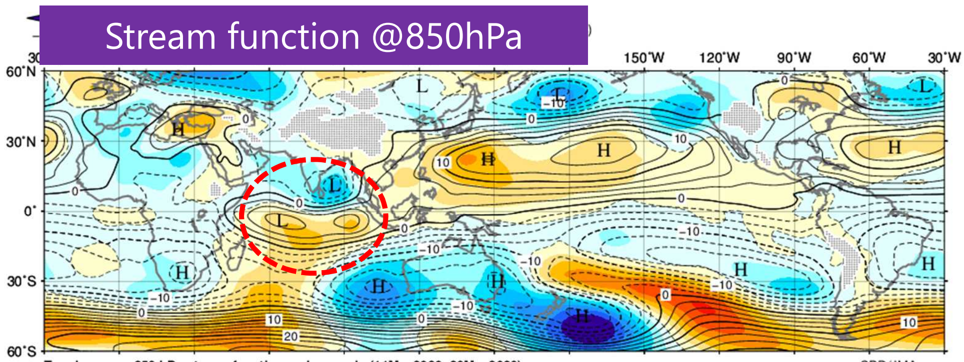
Upper-level response shows the reverse of the low-level response.

Example of Matsuno-Gill response

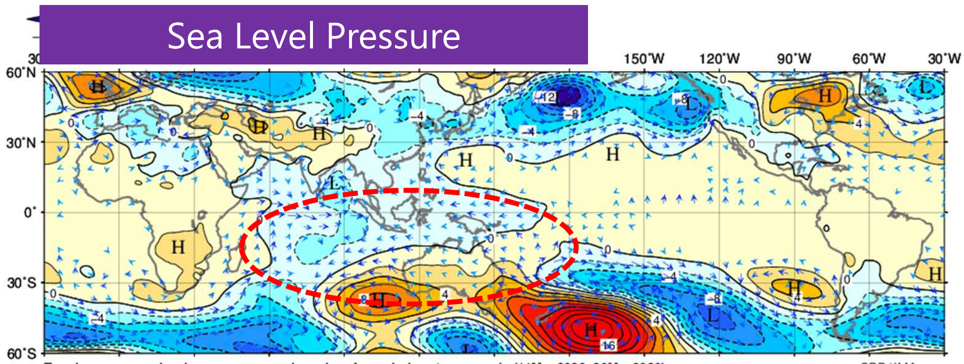
Atmospheric circulation anomalies averaged over 11-20 May, 2020

- 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





Ten day mean 850 hPa stream function and anomaly (11May2020–20May2020)
The contours show the stream function at intervals of 2.5x10^6 m^2/s, and the shading shows stream function anomalies.
The hatch patterns indicate areas with altitudes exceeding 1,600 m.
Anomalies are deviations from the 1991–2020 average.

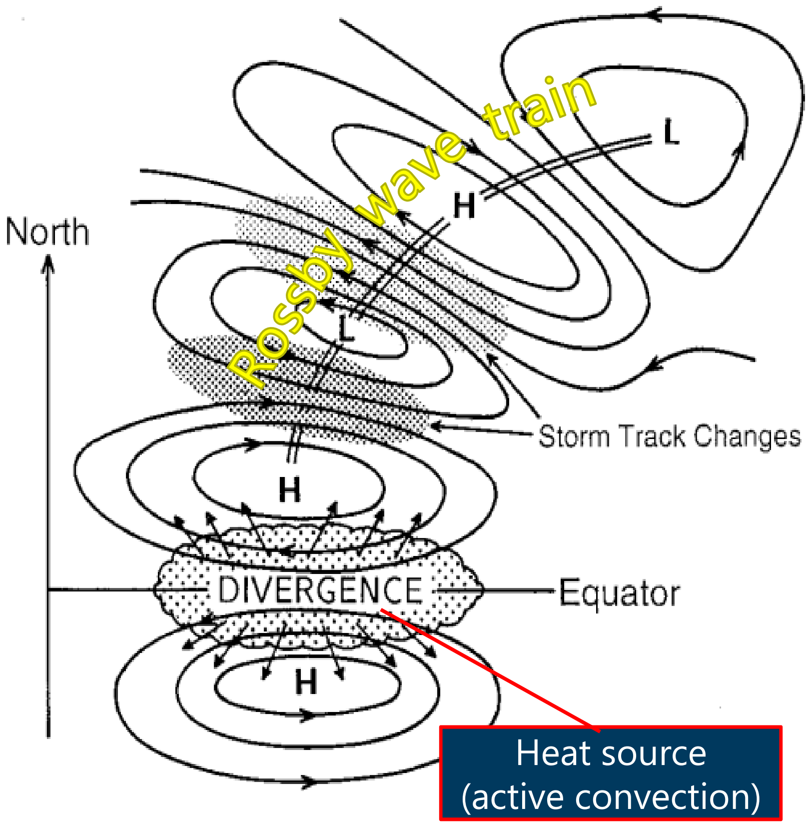


Ten day mean sea level pressure anomaly and surface wind vector anomaly (11May2020–20May2020)
The contours show sea level pressure anomalies at intervals of 2 hPa.
Anomalies are deviations from the 1991–2020 average.
The vectors are not shown where wind speed is less than 1 m/s.

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

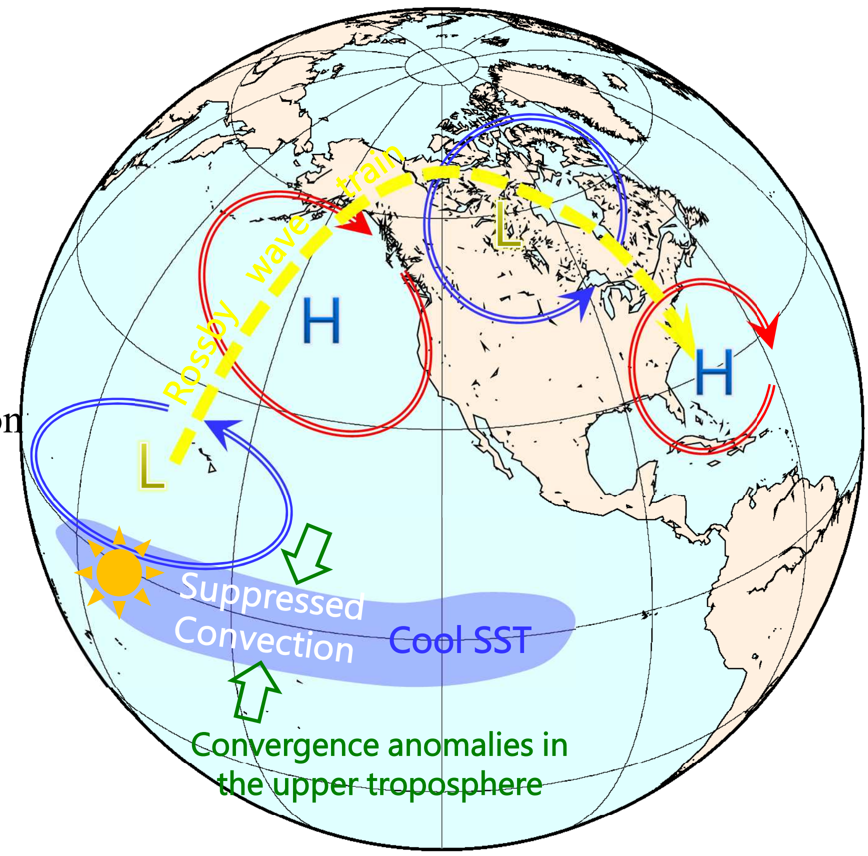
Response in the upper troposphere

- 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.



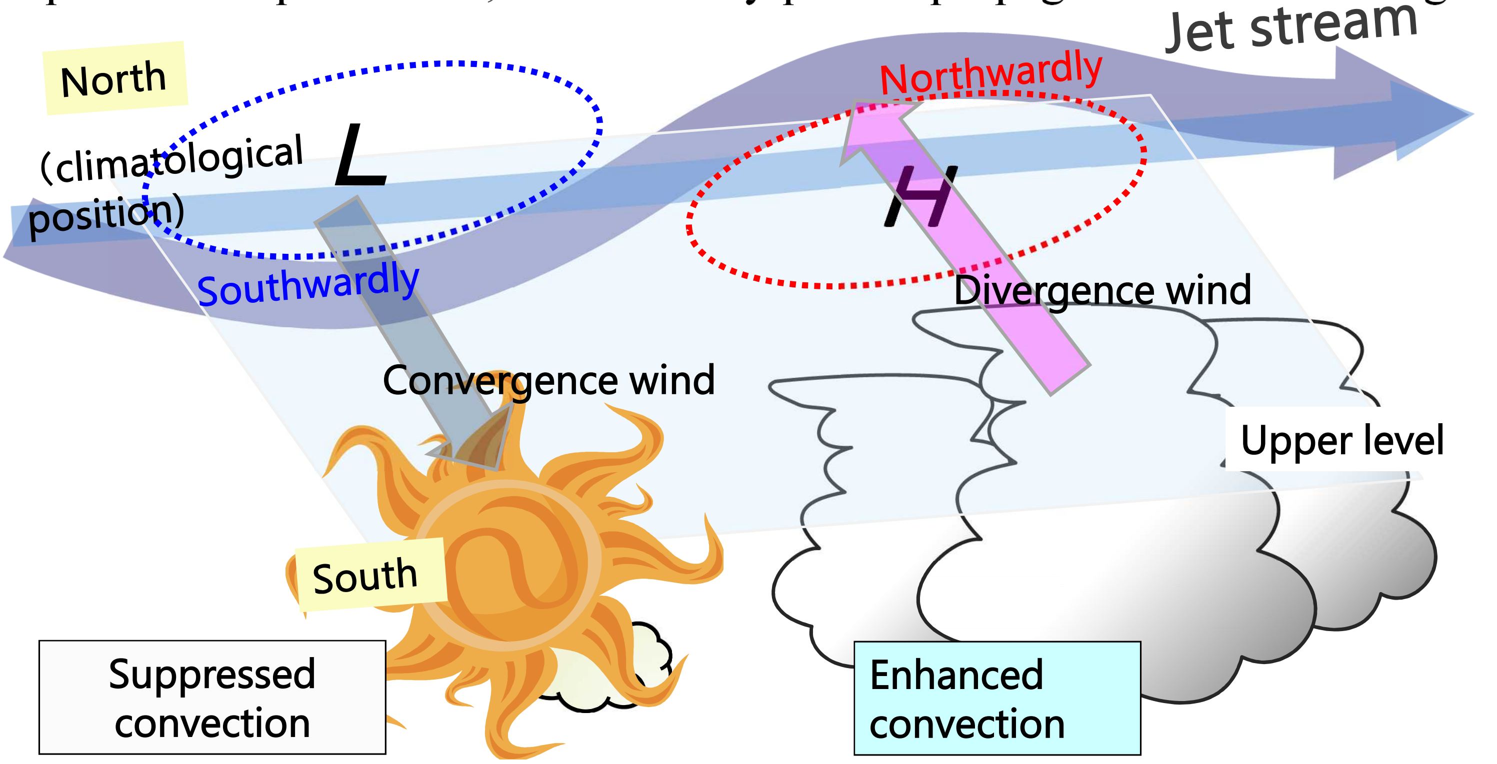
Response to suppressed convection

- Conversely, a **cyclonic circulation anomaly** forms to the north and south of **suppressed** convection
- This propagates poleward as a Rossby wave train and brings anomalous weather in higher latitudes.
- In other words, near-equator convection activity (whether enhanced or suppressed) provides a good signal for long-range forecasts
- In jargon of climate dynamics, this is called "**teleconnection**"



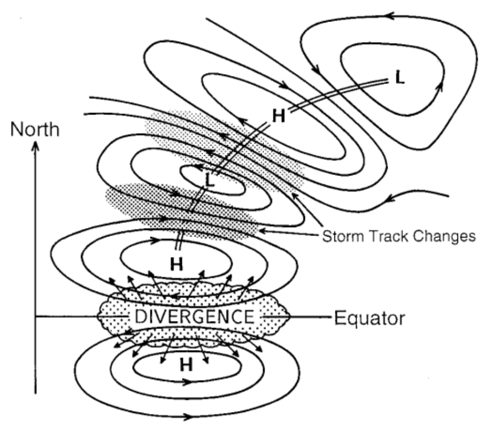
Convection changes jet stream

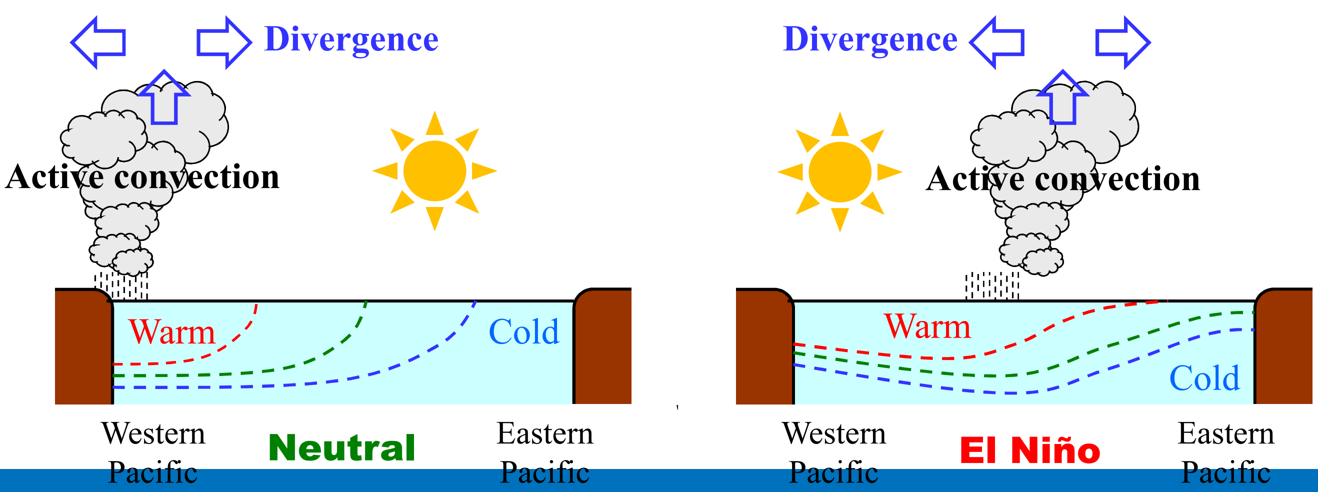
- The **subtropical jet stream (STJ)** flows poleward of tropics.
- In response to enhanced/suppressed convection, STJ meanders poleward/equatorward, and the wavy pattern propagates eastward along STJ.



El Nino Southern Oscillation

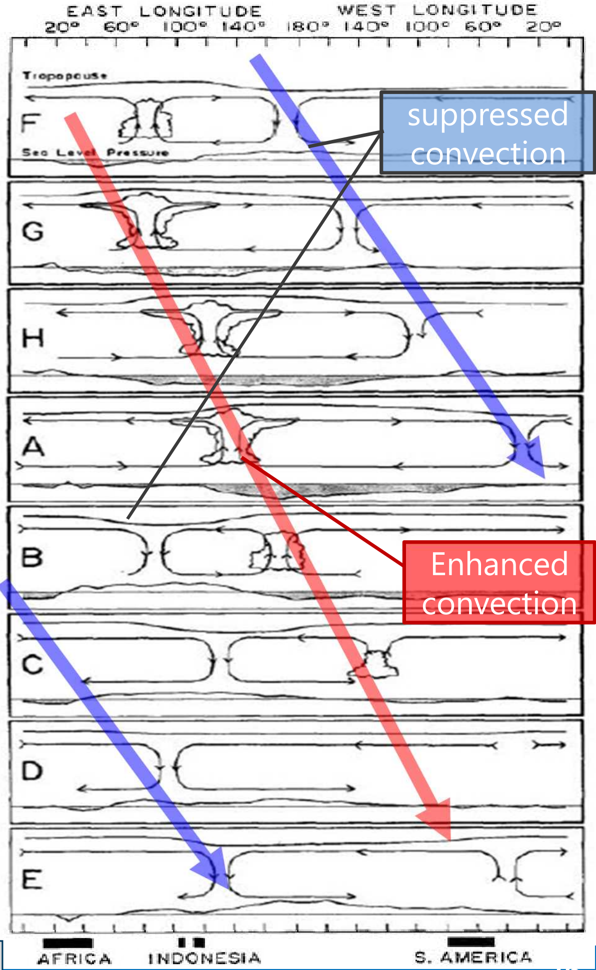
- During an El Niño episode, a significant increase in SST over the central to eastern equatorial Pacific is observed.
- The warmer SSTs induce active convection to shift eastward along the equator.
- These convection anomalies give rise to Rossby waves (Matsuno-Gill!)
- Rossby waves propagate over a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

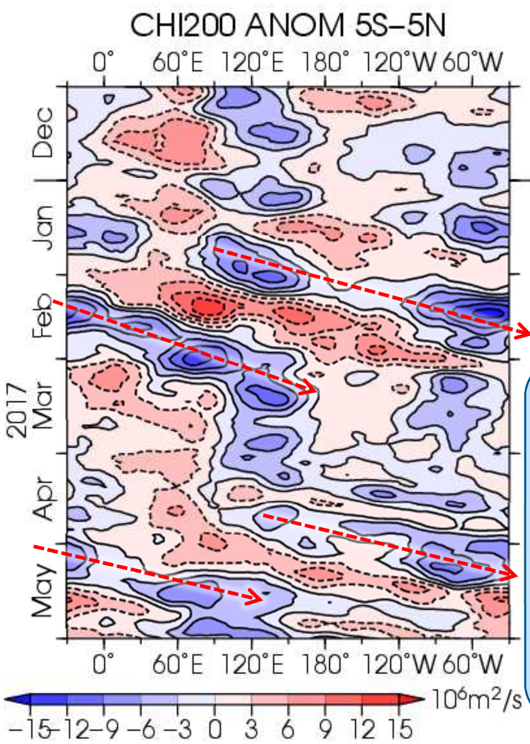


Original; Madden and Julian (1972) Fig.16

How to detect MJO?

Propagation of MJO is visualized through Hovmöller diagram and phase diagram

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

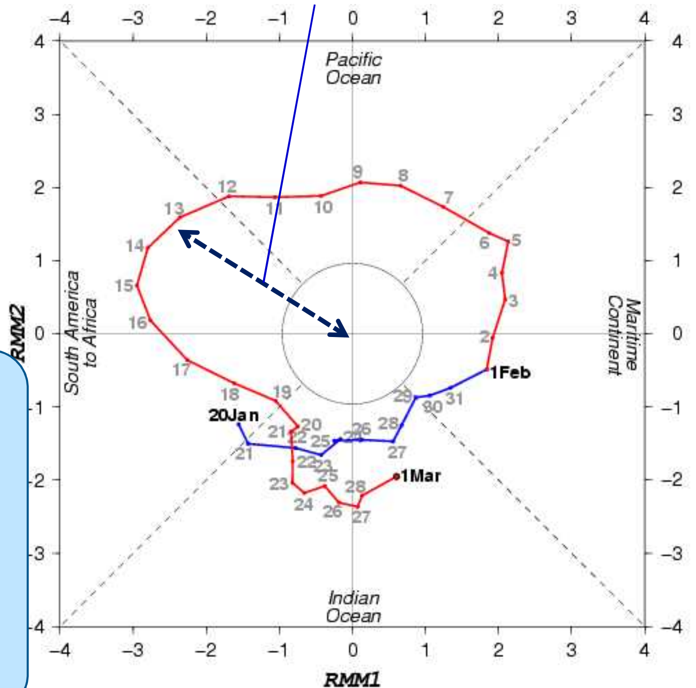


Blue: Upper-level Divergent anomaly
Red: Convergent anomaly

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

phase diagram

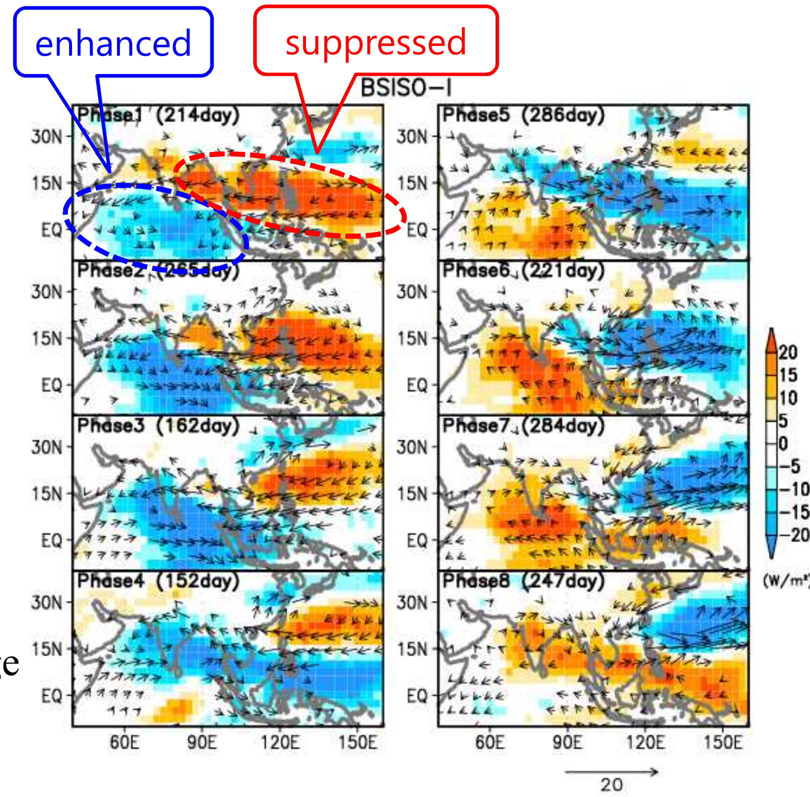
Amplitude: distance from the center



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

Another "Oscillation" - BSISO

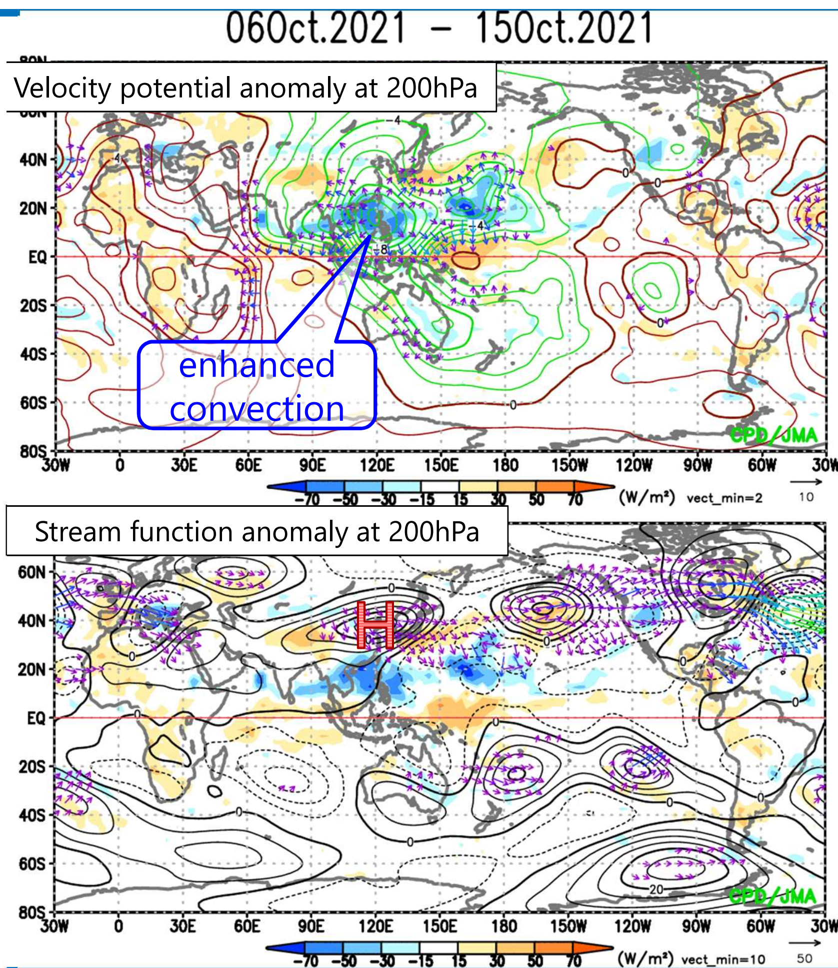
- During (northern hemisphere) summer, enhanced or suppressed convection is seen to **propagate northward**, instead of eastward, over the Indian Ocean and the western Pacific
- This is called "**B**oreal **S**ummer **I**ntra-**S**easonal **O**scillation".
- BSISO can have as much impact on weather conditions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



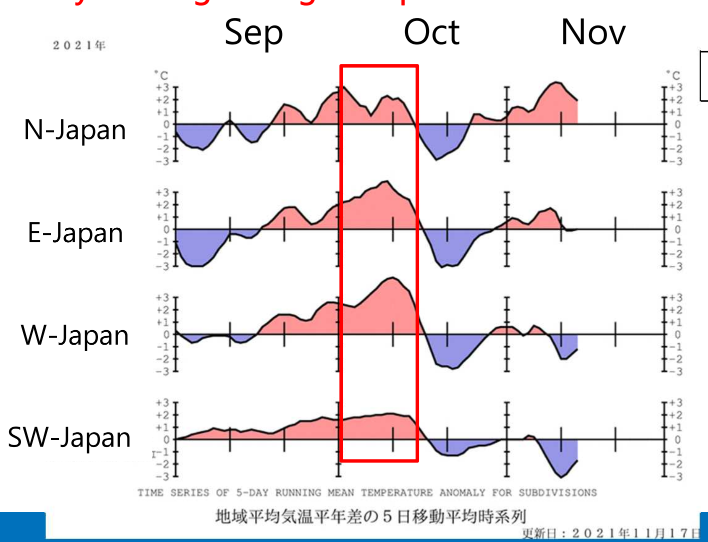
typical time evolution of BSISO

Recent notable weather events

- Early last October, Japan experienced very warm weather exceptionally for the time of the year.
- 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 western Pacific.

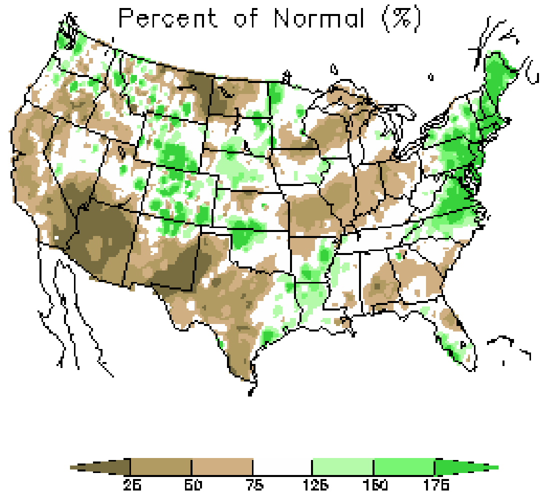


5-day running average temperature anomalies

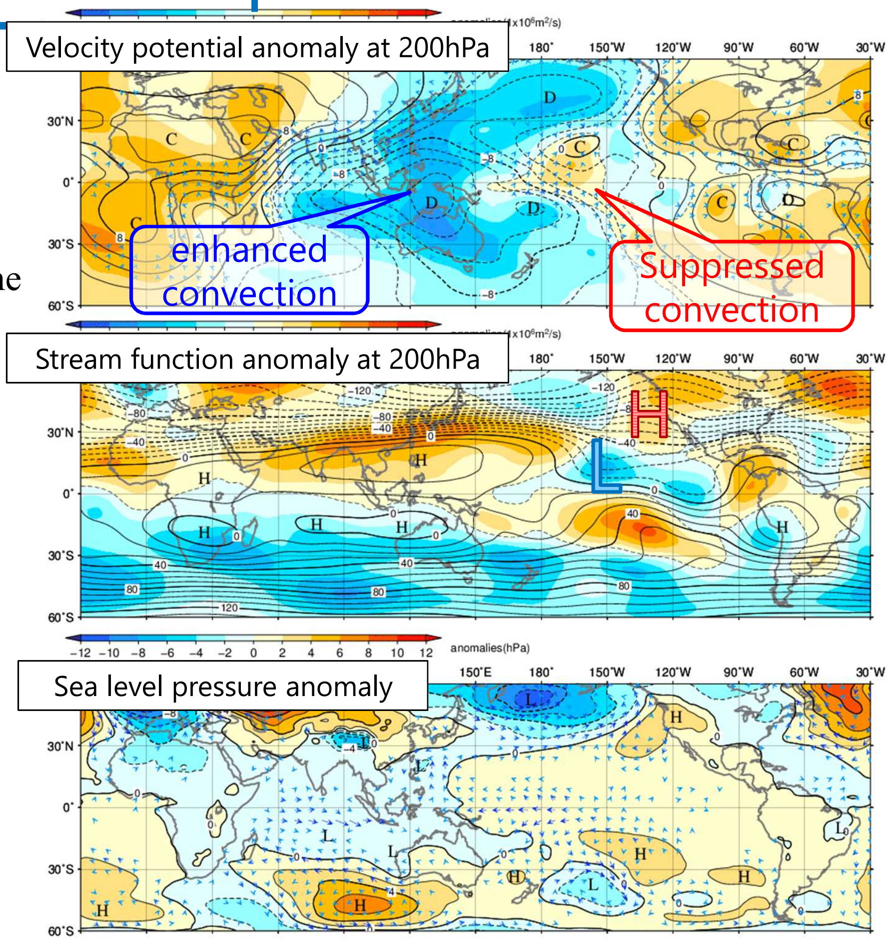


Recent examples

- Dec. 2020 brought notably dry weather to the southwest U.S.
- This is attributable to intense anti-cyclone persistent over the region.
- The cause of the anomalous anti-cyclone can be traced back to the suppressed convection in the tropics.



From NOAA CPC



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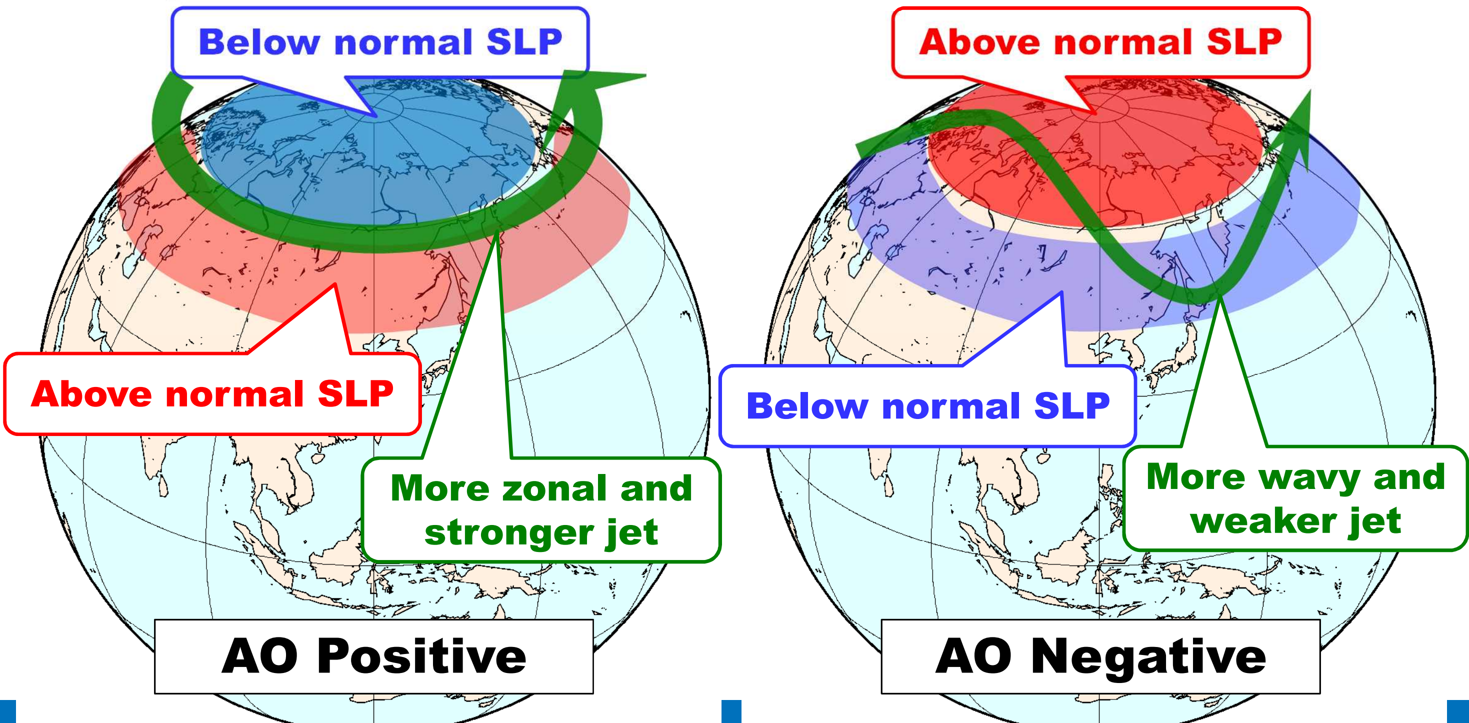
Oscillation in mid- and high latitudes (AO)

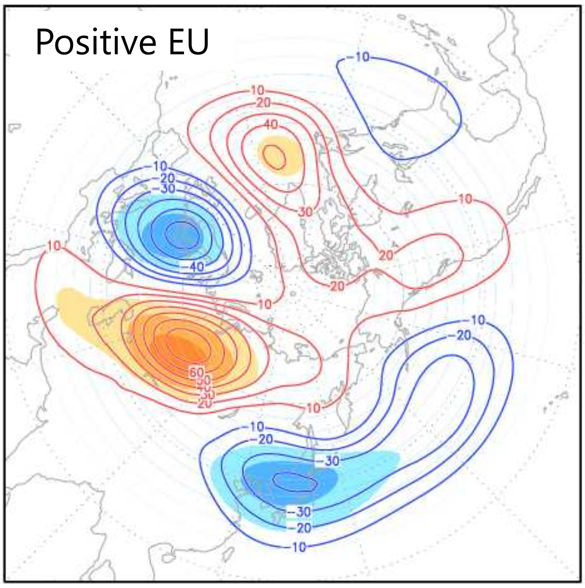
- A seesaw-like oscillation of pressure anomalies between the Arctic and mid-latitudes which dominates climate variability in boreal winter.
- In a positive phase of AO, cold air mass tends to be confined in the Polar region, leading to a warm winter in mid-latitudes.
- In a negative phase of AO, cold air mass flows southward from the Polar region, leading to a cold winter in mid-latitudes.

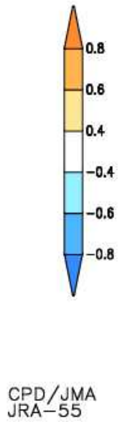


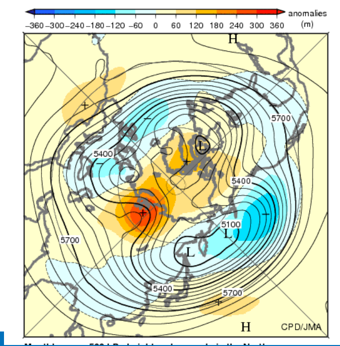
Eurasia (EU) pattern

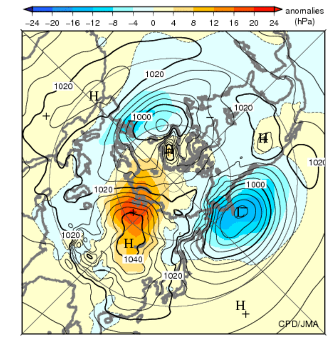
- Rossby wave train along the Polar Front Jet (PFJ), with a ridge over western Siberia and troughs over Europe and East Asia.

- When this pattern appears, Siberian High intensifies and brings cold air outbreak to East and Southeast Asia.



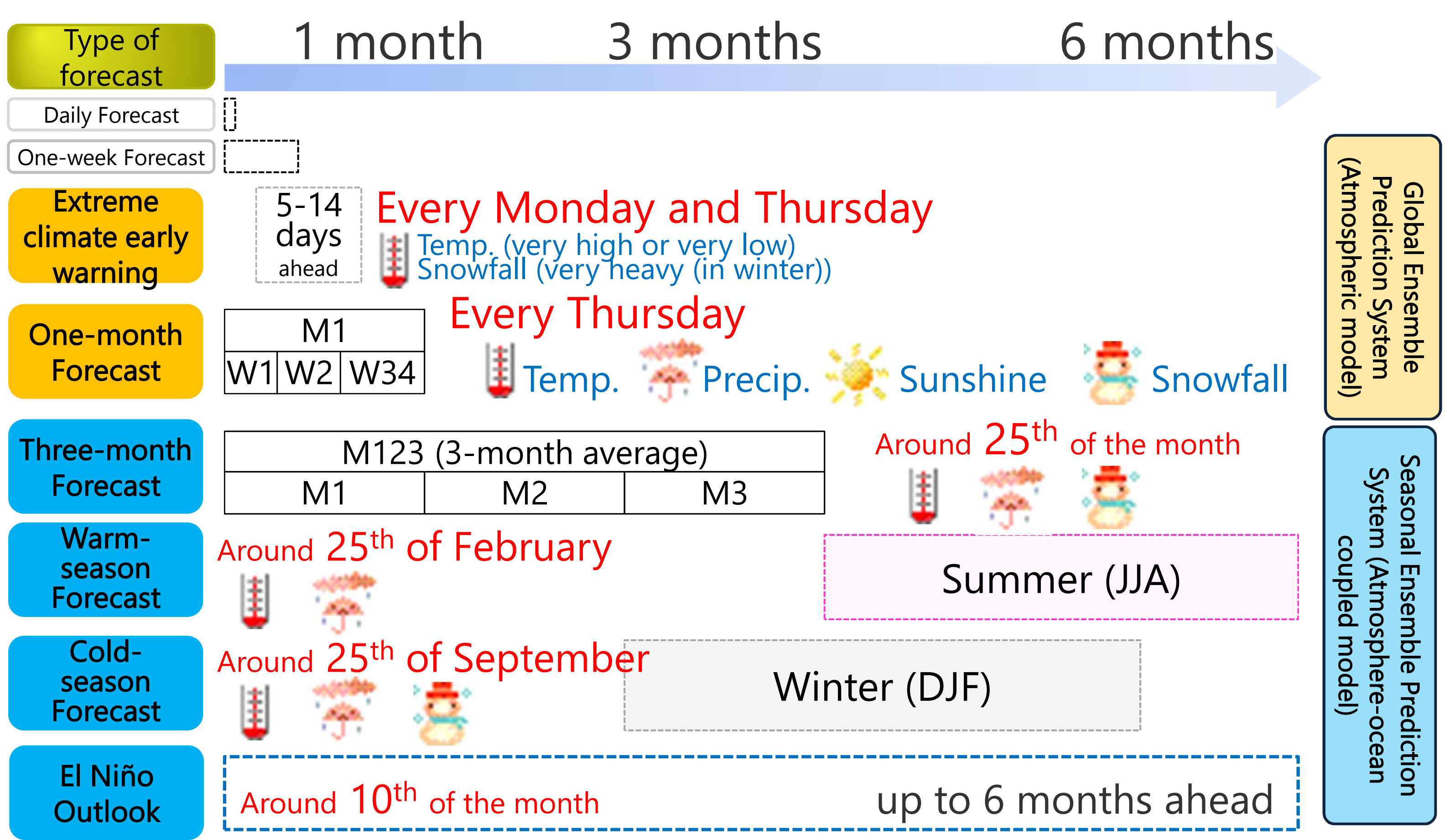






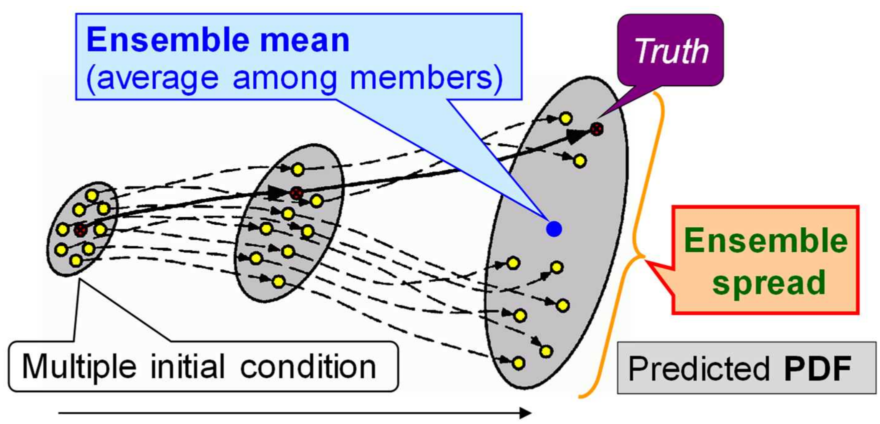
Methodology for JMA's one-month forecast

JMA's extended & long-range forecast models



Concept of ensemble prediction

- The atmosphere and ocean is a chaotic system
- Even the tiniest error in an initial condition grows rapidly and errors are unavoidable
- 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)



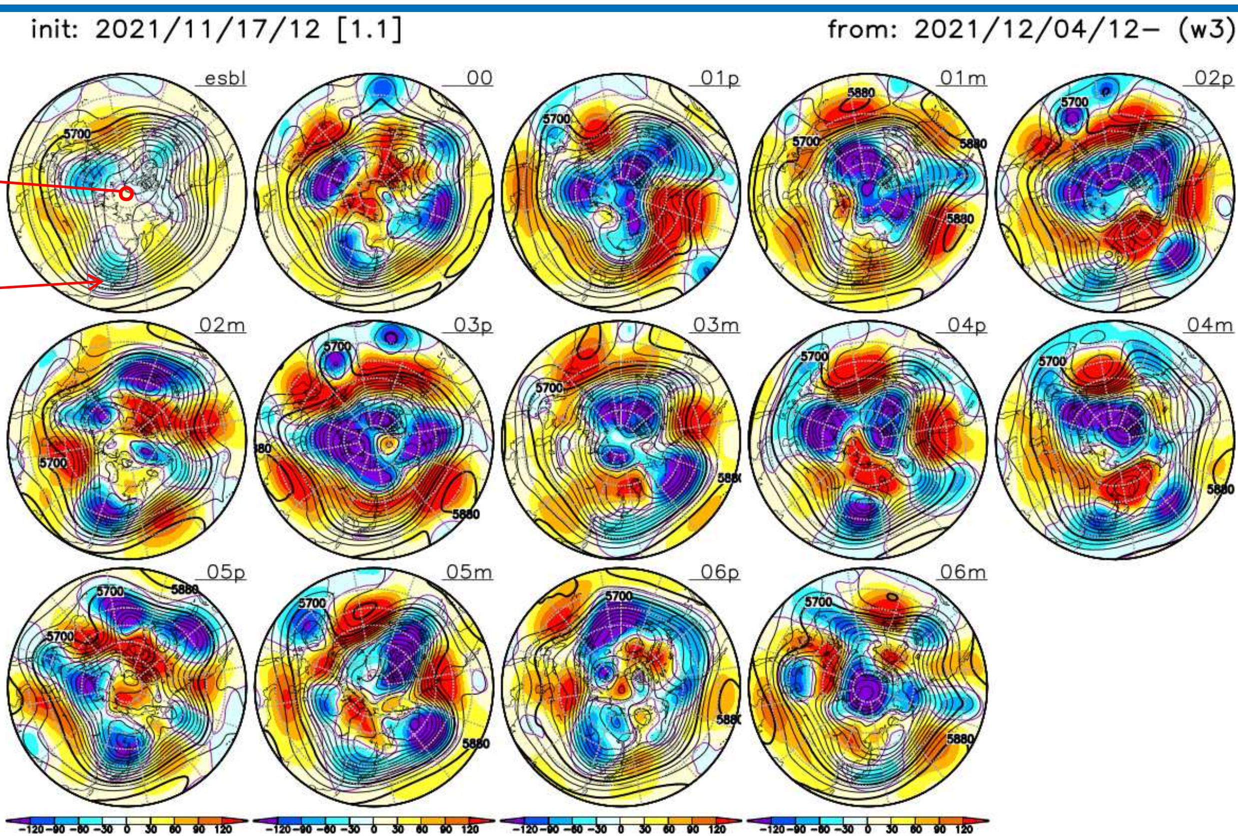
The individual calculation is called "Ensemble member" and the standard deviation among all members is called "Ensemble spread".

Example of individual ensemble members

Polar stereo projection

North Pole

Japan here



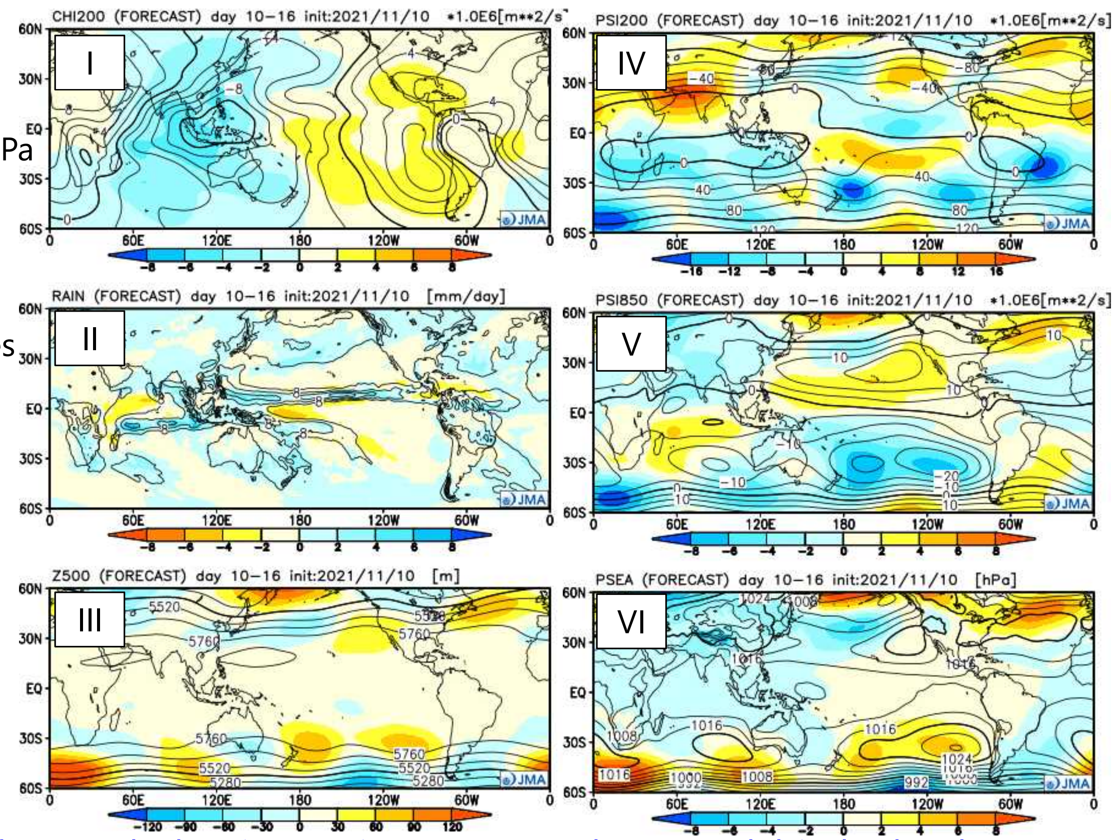
Geopotential height anomalies at 500hPa for the week-3 forecast of 1-month prediction run, initialized on 17, Nov. 2021. The ensemble mean and 13 members out of 51 are shown.

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

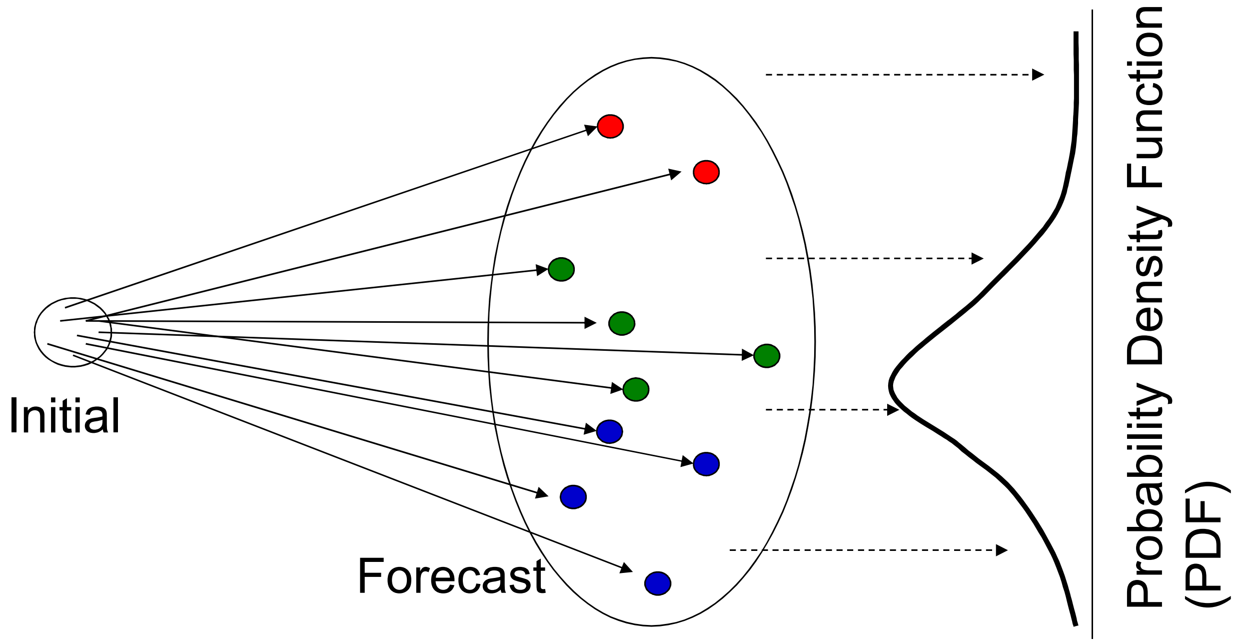
Color shades indicate anomalies



Available at: https://ds.data.jma.go.jp/tcc/tcc/products/model/index.html

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.

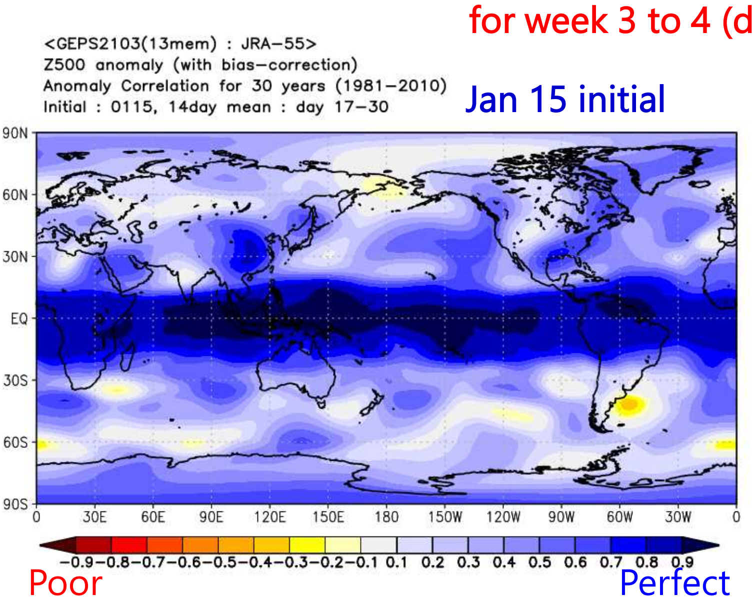


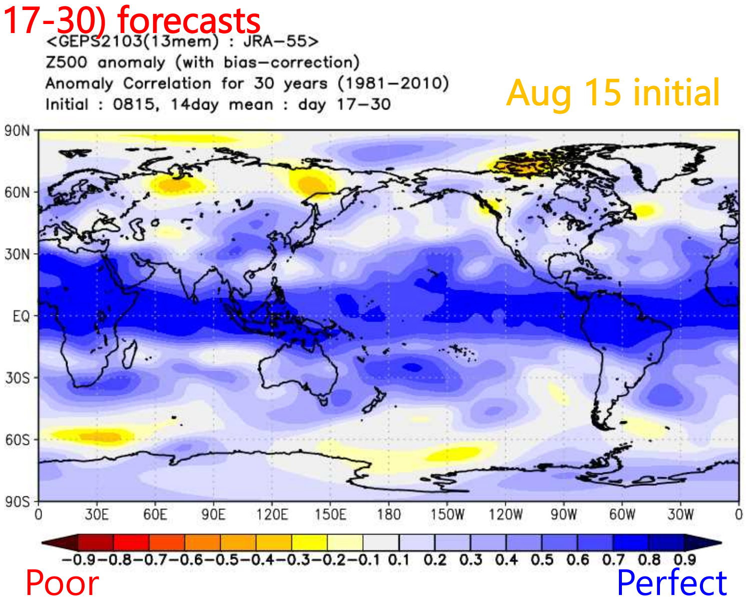
Verification of JMA Ensemble Prediction System

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!

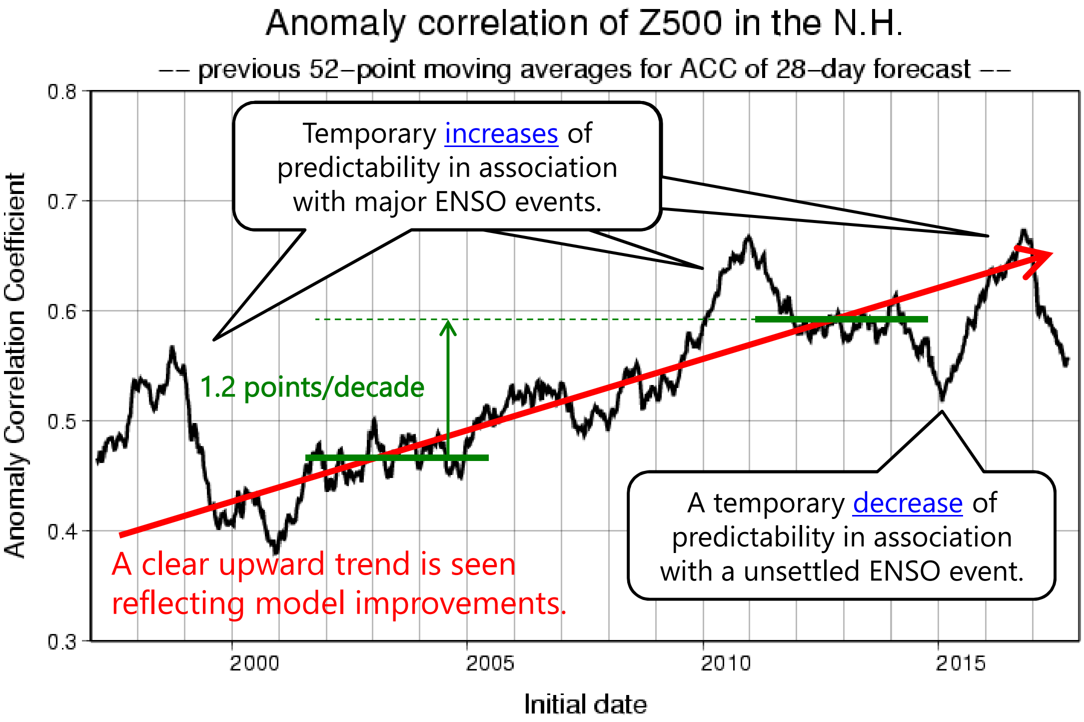
Anomaly correlation for geopotential height at 500hPa for week 3 to 4 (day 17-30) forecasts





https://ds.data.jma.go.jp/tcc/tcc/products/model/hindcast/1mE.GEPS2103/tro_acor.html

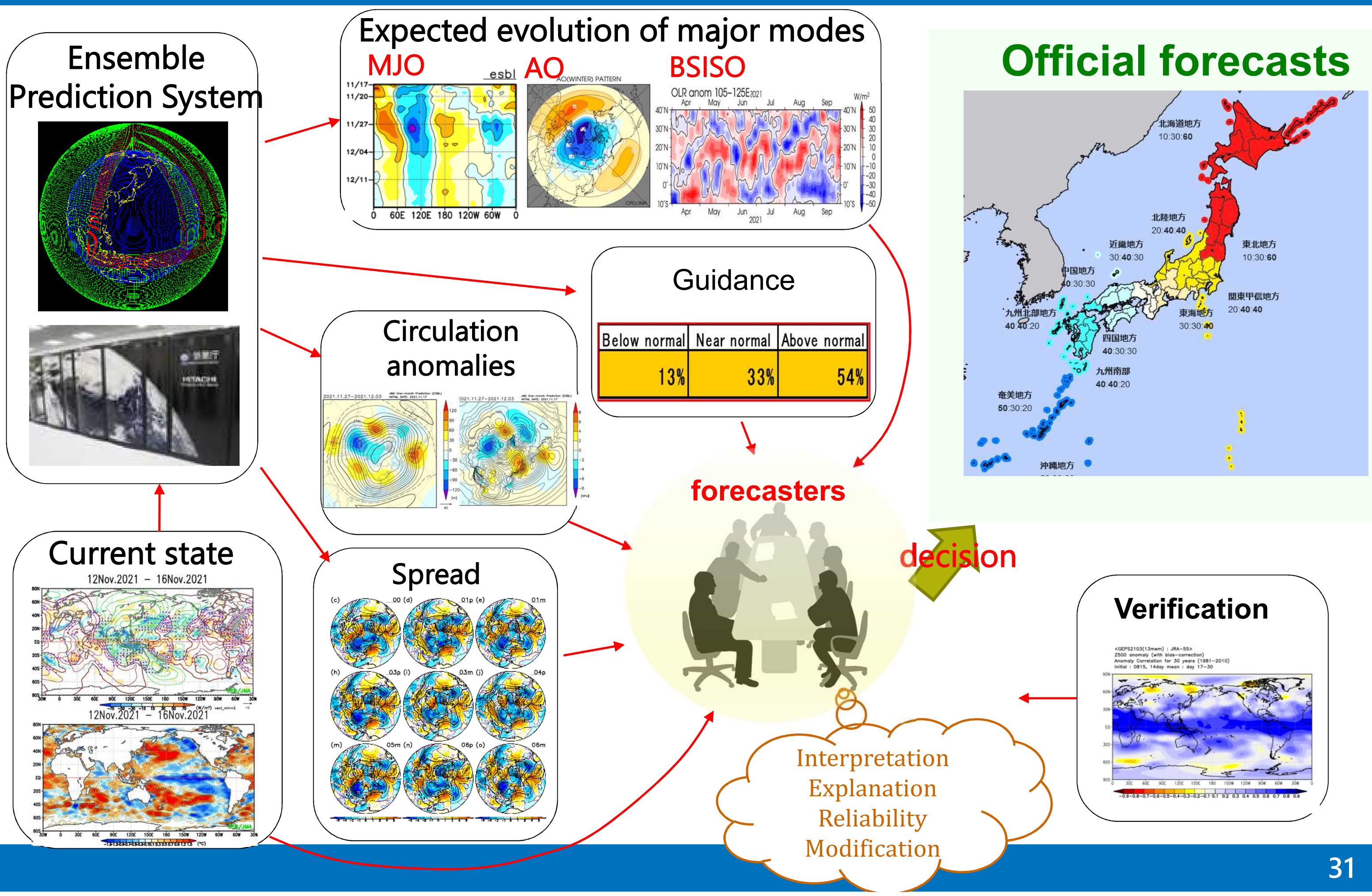
Model skill gradually gets better



0.6 is the limit for deterministic forecast.

0.3 is the limit for probabilistic forecast.

Steps in the process to produce one-month forecast



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.

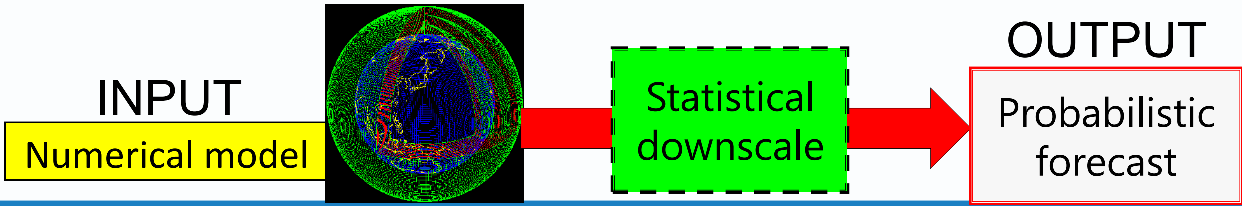
- Judging from the verification data, model prediction skill is sufficient or poor?
- Are you sure the model prediction is sufficiently reliable? If not, what aspect is questionable and why?
- Can the predicted anomalies be interpreted and explained in terms of climate dynamics?

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

4. Adjust and modify the prediction if needed.

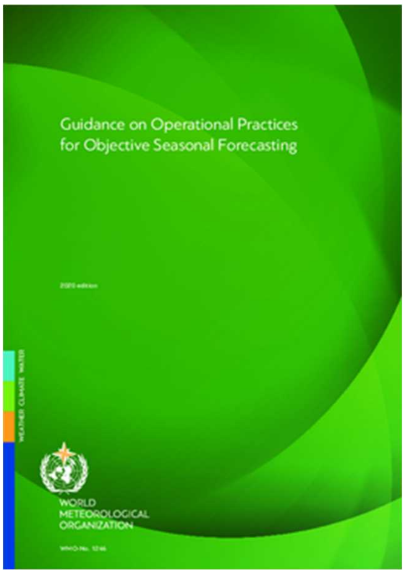
5. Assign probability to above/near/below normal categories.

- 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? Need forecaster's intervention?

WMO's Guidance on Operational Practices for Objective Seasonal Forecasting



https://library.wmo.int/index.php?lvl=notice_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

Concept of numerical guidance

Concept of numerical guidance

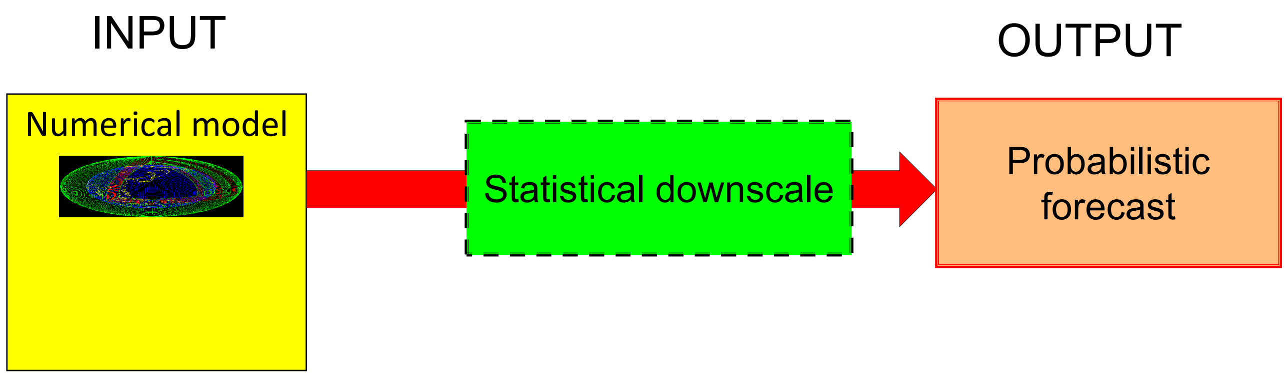
Masayuki HIRAI
Tokyo Climate Center (TCC)/
Climate Prediction Division of
Japan Meteorological Agency (JMA)

Outline

- Outline of Guidance
  - Objective of Guidance
  - MOS Technique
  - Regression Model
  - Estimation of Probability
- Verification
  - Verification Score

Outline of Guidance

Guidance

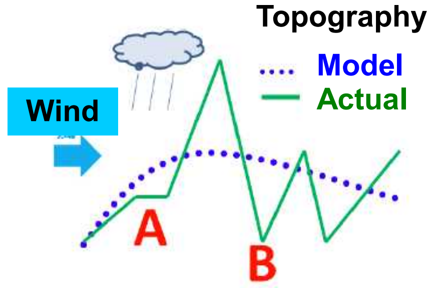


- “Guidance” is an application to translate model output values into target of forecasting.
- Principle of guidance is based on statistical relationship using model forecasts and observation data for past cases.

TCC Training Seminar on One-month forecast, 1 – 7 Dec. 2021, JMA, Tokyo, JAPAN

Role of Guidance

- To extract effect of sub-grid scale topography
  - Model may not reproduce effect of local topography due to limited resolution, while enable to reproduce large-scale field.
- To reduce imperfection of the model, such as systematic error (bias error).
- To estimate degree of uncertainty, considering prediction skill



A: Upwind side
➢Model may underestimate precipitation
B: Bottom of the valley
➢Model may have warming bias

"Guidance" enable to improve prediction skill, compared with the direct model output.

Principle of Guidance – MOS Technique

MOS (Model Output Statistics):

Calculation of statistical relationship between observation and model forecast for past cases, and apply to the real-time forecast

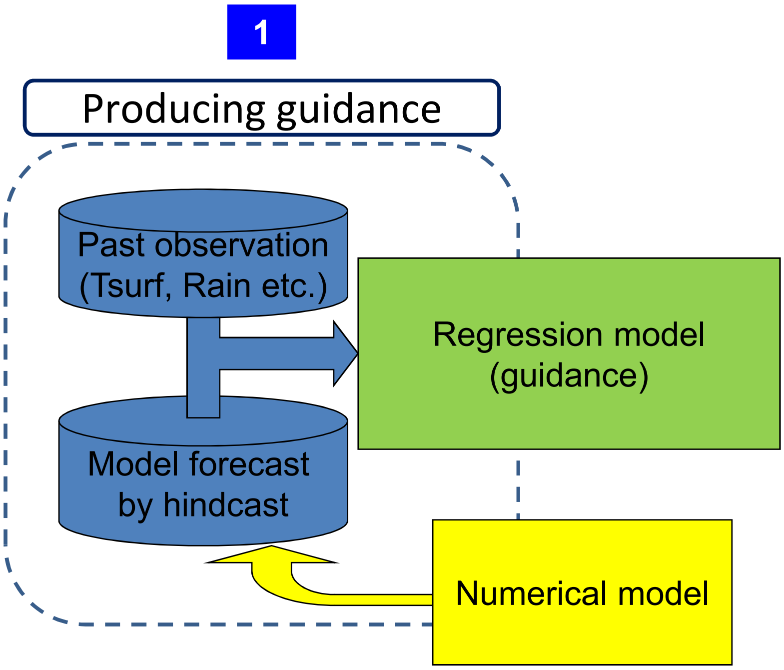
➢ Two types of the time series data are necessary in order to produce guidance.
  - 1. Past observation (Variable to be predicted; Predictand)
  - 2. Past model forecast by hindcast (Predictor)

Prepared by users

On guidance Tool

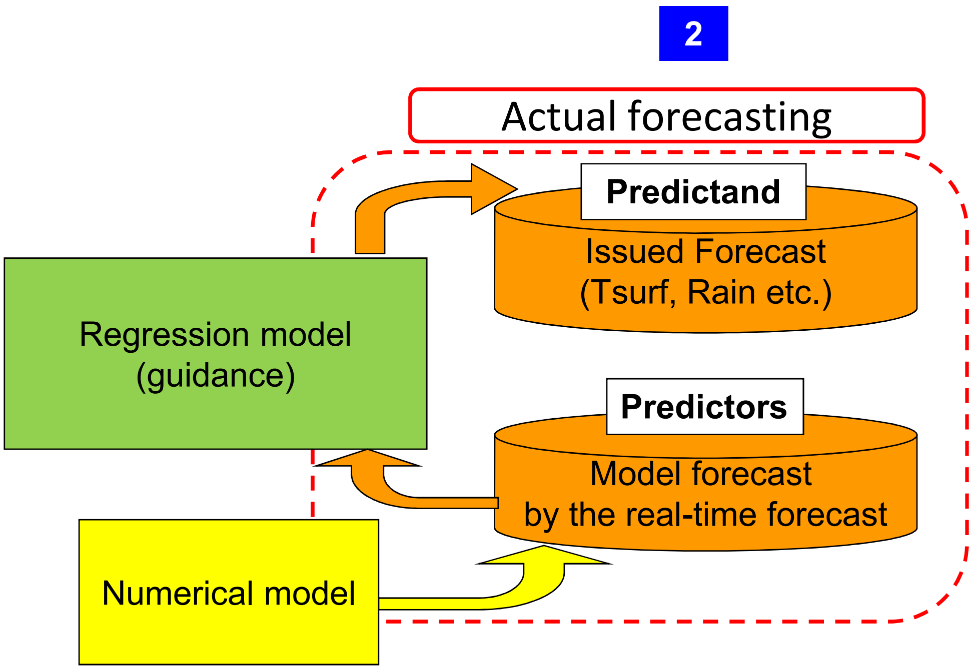
Concept of MOS Technique (1)

- **Statistical relationship** is estimated using observation and model forecast for past cases.



Concept of MOS Technique (2)

- In the real-time forecast, predicted value is calculated applying to the statistical relationship.



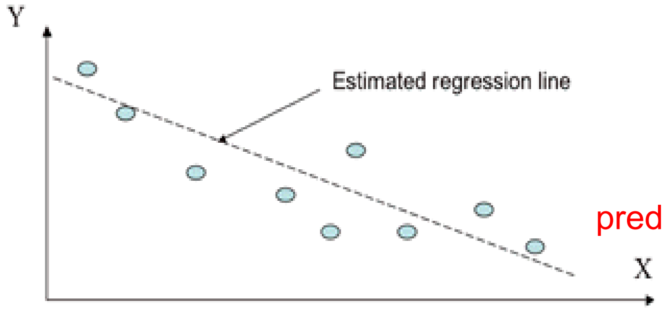
Single Regression

- Single regression is modeled the relationship between **one explanatory variable** (predictors) and **objective variable** (ex. temp. rainfall).
- Single regression model is written as

$$Y = aX + b + \varepsilon$$

Y: predictand X: predictor
a: regression coefficient b: constant,
ε: error term

objective variable



predictors

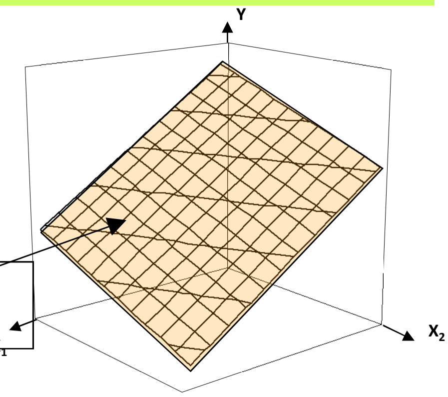
Multiple Regression

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

$$Y = a_1X_1 + a_2X_2 + b + \varepsilon$$

a_1, a_2: regression coefficient
b: constant
ε: error term

Example: two predictors

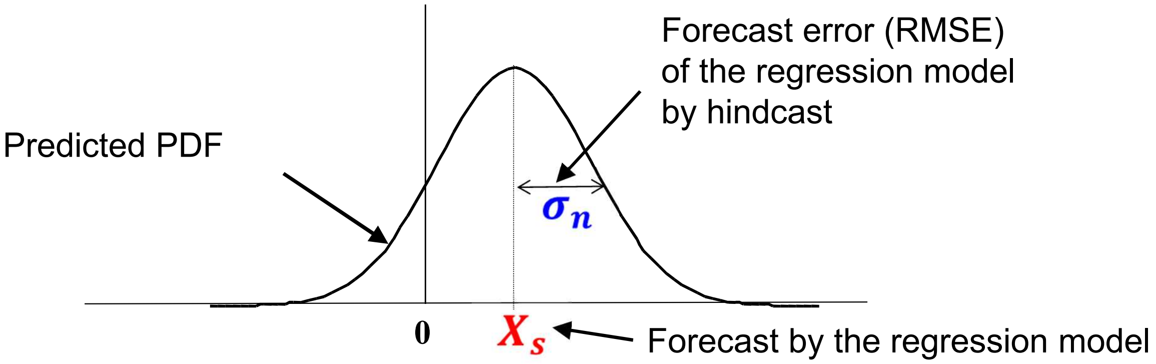


Predictand will be near this plane.

Translation to PDF in the regression model

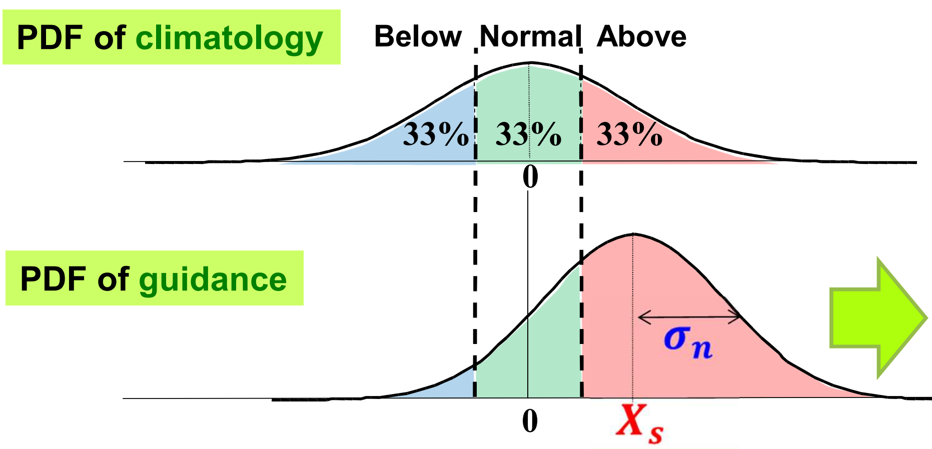
- Probabilistic forecast is essential for seasonal prediction.

➢ In the guidance tool, Probability Density Function (PDF) is assumed to be a **normal distribution.**
  - **Mean (x_s)** : prediction value by the regression model
  - **Standard deviation (σ_n)** is error of the regression model, which is assumed to be forecast error (RMSE) of the regression model using hindcast.



Estimation of Tercile probability with regression model

- The threshold values for tercile categories determined from the past observation (1991 to 2020).
- Probability for each tercile category (below-, near-, above-normal) is calculated by referring to the PDF of guidance and the threshold values for tercile categories.



Tercile Probabilities		
Below	Normal	Above
10%	30%	60%

Normalization of Precipitation Data

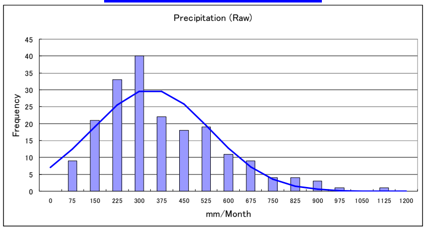
- **Normal distribution** is assumed in the regression model.
- As for temperature, its distribution is generally approximated by a normal distribution.

Meanwhile,

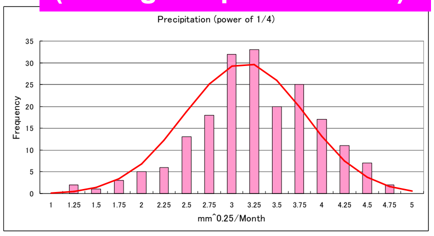
- As for precipitation, its distribution does not represent a normal distribution, and it's usually approximated by a gamma distribution.
- In order to create guidance, precipitation data need to be normalized.
- Power of 1/4 for precipitation ($RAIN^{1/4}$) is approximated by a normal distribution.

Ex. Precipitation over Japan

(Raw value)



(Taking the power of 1/4)



Verification

Verification scores for Deterministic Forecast

● Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)^2}$$

F_i: Forecast
O_i: Observation
C_i: Climatology
N: Sample size

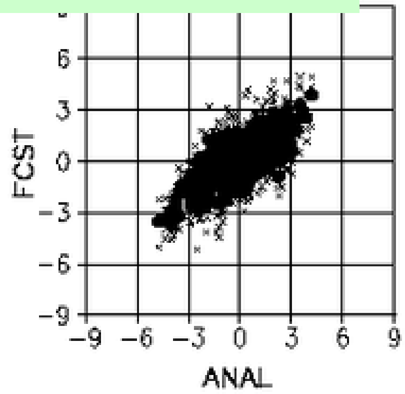
Perfect score: 0

● Anomaly Correlation Coefficient (ACC)

$$ACC = \frac{\sum_{i=1}^{N}(F_i - C_i)(O_i - C_i)}{\sqrt{\sum_{i=1}^{N}(F_i - C_i)^2}\sqrt{\sum_{i=1}^{N}(O_i - C_i)^2}}$$

1: Perfect score
0.31: 95% significance level of t-test (30 samples)
0: No signal

Correlation=+0.77



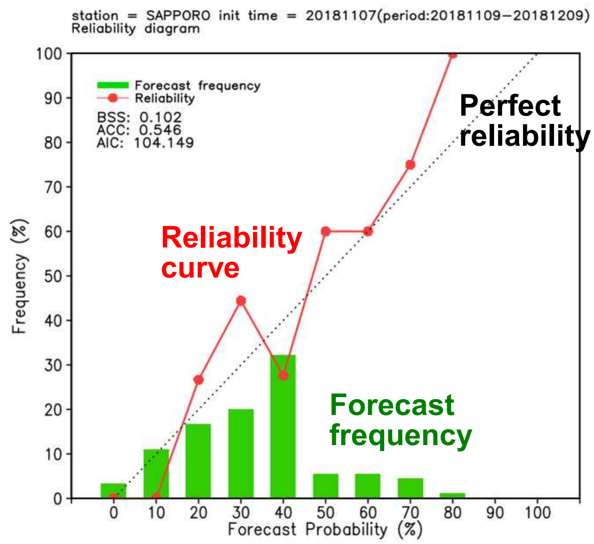
Probabilistic forecast

Reliability Diagram

● Red line (reliability curve);
- plotted the observed frequency (Y-axis) against the forecast probability (X-axis)

Probabilistic forecast becomes better the more the reliability curve fit to 45° line (perfect reliability).

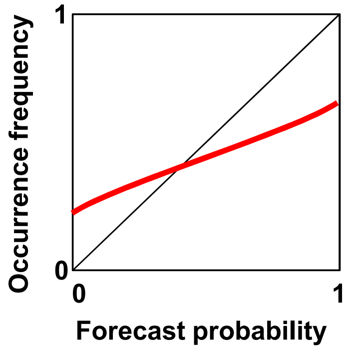
●Green line denotes forecast frequency (sharpness diagram);
- •If most of the forecast probabilities are near the climatological frequency (33%) => **unsharp**
- •If probabilities near 0% or 100% are often calcurated => **sharp**



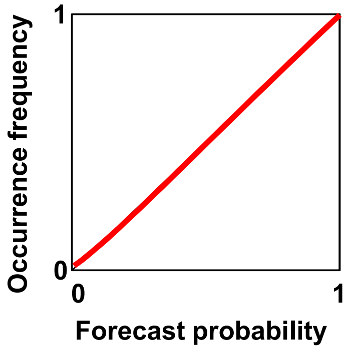
Probabilistic forecast

Over/under Confidence

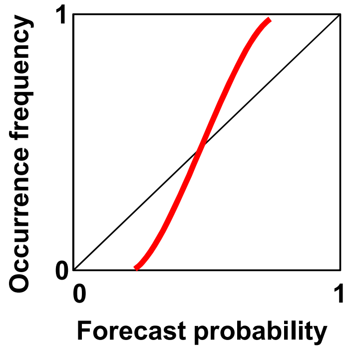
Over confidence



Perfect reliability



Under confidence

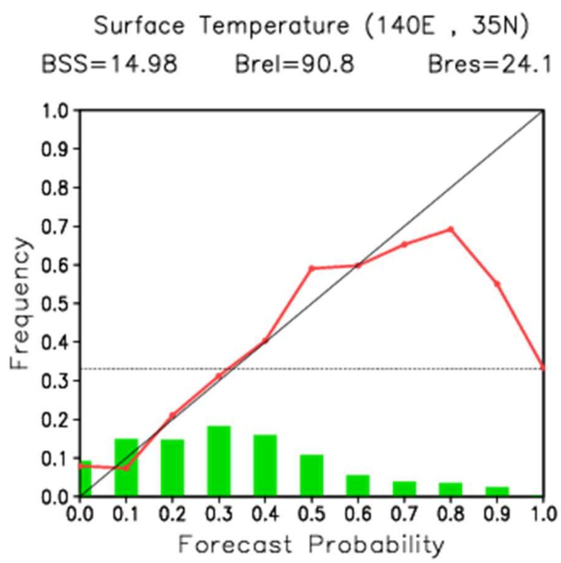


- ✓ Predicted probabilities are overestimated as compared with actual
- ✓ Predicted probabilities are underestimated as compared with actual

Probabilistic forecast

Interpretation of Reliability Diagram

Example



- The forecast is generally reliable for below 60%, while over-confident over 70%.

✓ Maximum probability should be suppressed under 60%

- In actual, reliability curve may not such smooth "curve".
- If so, the forecaster should moderate the probabilities, taking account of the other information, such as the verification scores (e.g., ACC, BSS).

Probabilistic forecast

Brier Score (BS)

- Brier score is mean squared error of the probability forecasts.

$$BS = \frac{1}{2N} \sum_{i=1}^{N} \sum_{m=1}^{3} (p_i^m - o_i^m)^2$$

p_i^m : forecast probability

o_i^m : observed occurrence (0 or 1)

N : forecast frequency

m : category

Range: 0 to 1

Smaller score indicates better forecast (Perfect score: 0)

Forecast (Below, Near, Above): (0.1, 0.3, 0.6)

Observation: Above normal (0, 0, 1)

BS: $\{(0.1-0)^2+(0.3-0)^2+(0.6-1)^2\}/2 = 0.13$

Probabilistic forecast

Brier Skill Score (BSS)

- Brier skill score is ***skill*** relative to a reference forecast (usually climatology).

$$BSS = 1 - \frac{BS}{BS_{reference}}$$

$$BSr = \frac{1}{3}$$

- Perfect score: 1
- BSS>0 : better than the climatological forecast.
- BSS<0 : worse than the climatological forecast.

One-month forecasting (lecture and exercise)

– Introduction of the forecast products on TCC Web –

One-month forecasting
(lecture and exercise)

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

Content

2 Dec.	Introduction of the forecast products on TCC Web • Forecast maps • Guidance tool	lecture
	Explanation of the exercise	lecture
	Example of constructing one-month forecast	lecture
3 to 6 Dec.	Generating one-month forecast for your own country - Preparation of the presentation	exercise
7 Dec.	Presentation by participants	**presentation!**

- Please keep in mind that toward the end of the seminar, you will be requested to **make a brief presentation** on one-month forecast for your own country.

Introduction of the forecast products on TCC Web

Content

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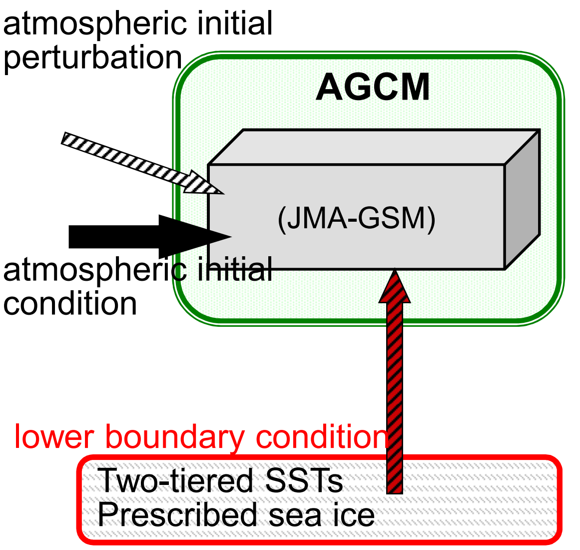
Operational global NWP models at JMA

	Main target	Integration range Horizontal resolution
Global Spectral Model (GSM)	•Short-range forecasting	up to 11 days approx. 20km
Global EPS	•Typhoon information •One-week forecast •Two-week temperature forecast •One-month forecast	34 days about 40 km(up to day-18), about 55 km(after day-18)
Seasonal EPS (JMA/MRI-CPS2)	•Seasonal forecast •El Niño outlook	7months About 110 km (atmosphere) 1.0º longitude, 0.3º–0.5º, latitude (ocean)

Specification of Global EPS

One-month forecasting

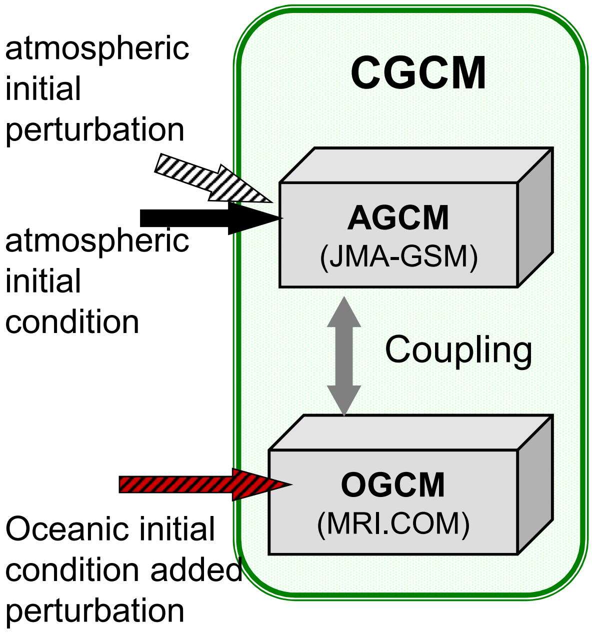


Two-tiered SSTs;
- (Up to Day-11) Persisted anomaly with daily climatological SST
- (After that) Relaxed to the ensemble-mean SST operationally predicted by JMA's coupled Seasonal EPS in tropics

Model	AGCM H: (up to day-18) about 40 km (TL479), (after day-18) about 55 km (TL319) V: 128 levels (up to 0.01 hPa)
Forecast range	34 days
SST	two-tiered SSTs with the operational seasonal EPS
Sea ice	prescribed sea ice distribution estimated using initial anomaly and climatology
Ensemble size	50
Freq. of model product creation	once a week

Specification of Seasonal EPS

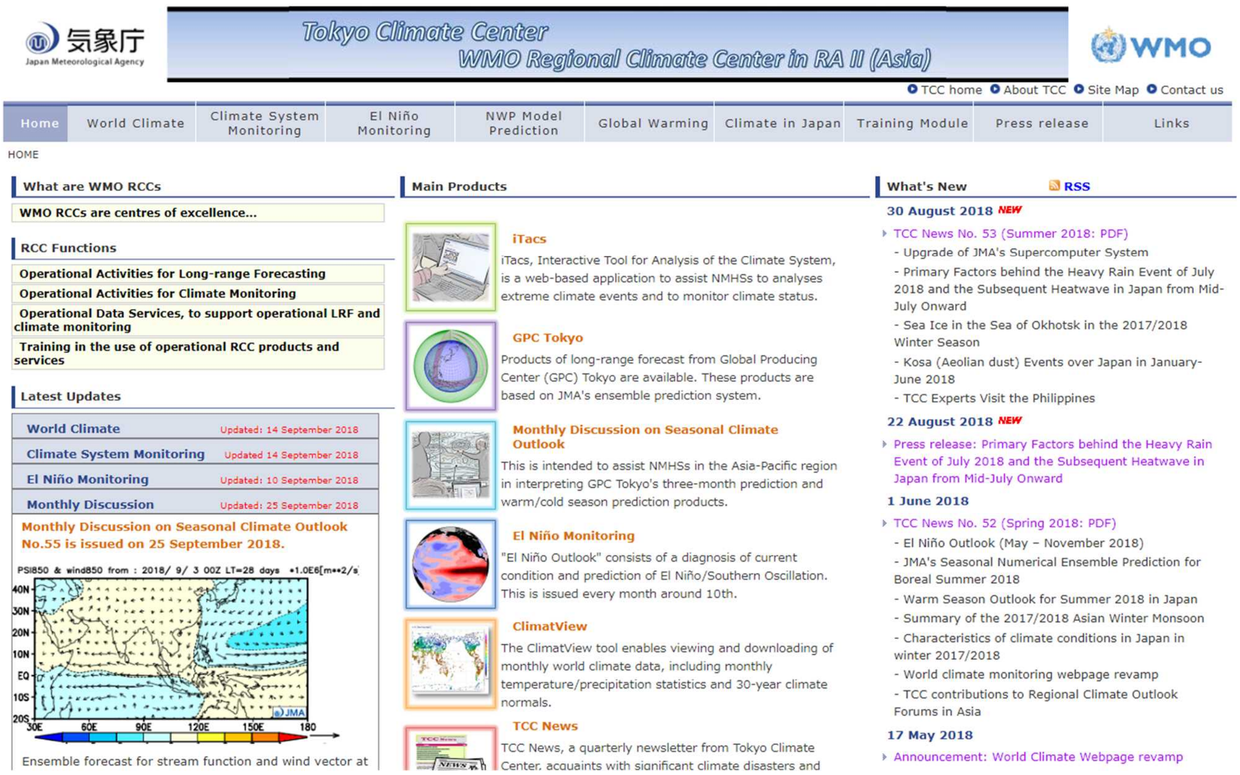
(JMA/MRI-CPS2)



Model	CGCM H: about 110 km (TL159) V: 60 levels (up to 0.1 hPa)
Forecast range	7 months
SST	one-tier method
Sea ice	interactive sea ice model
Ensemble size	51
Freq. of model product creation	once a month (around 20th of every month)

TCC Website (top page)

- https://ds.data.jma.go.jp/tcc/tcc/index.html



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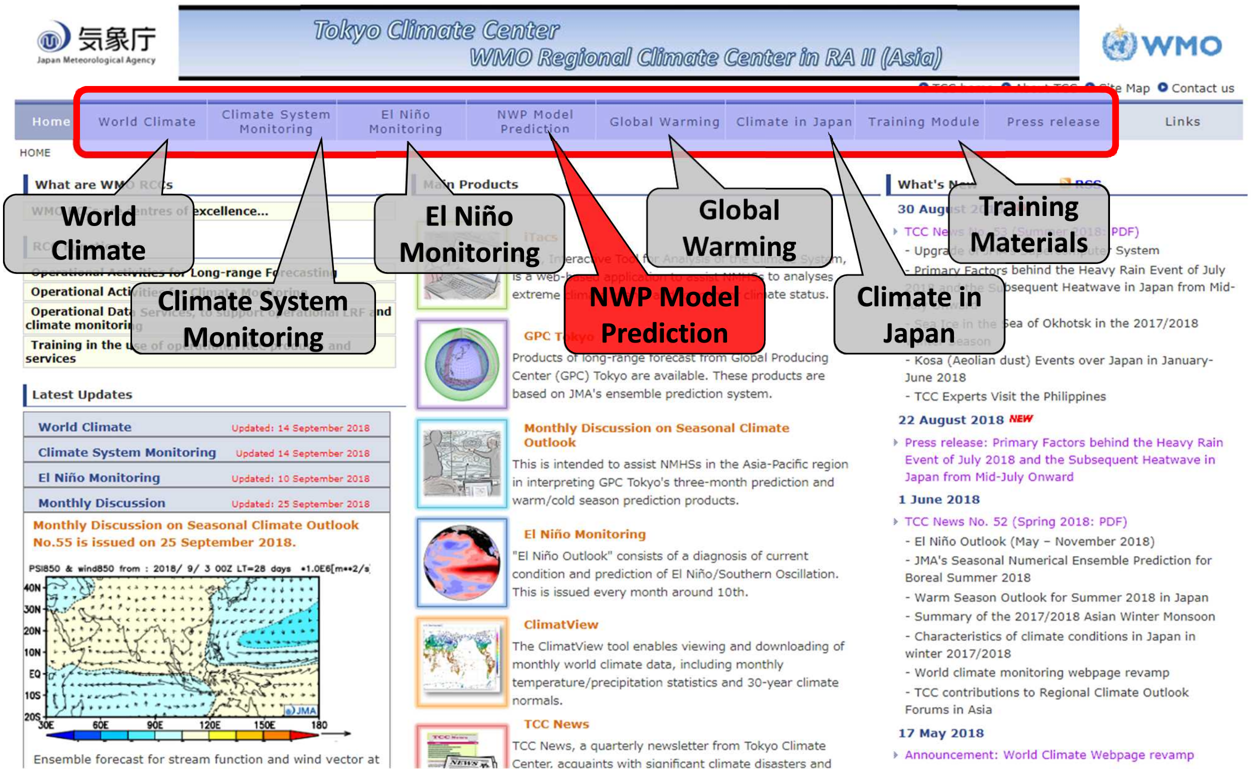
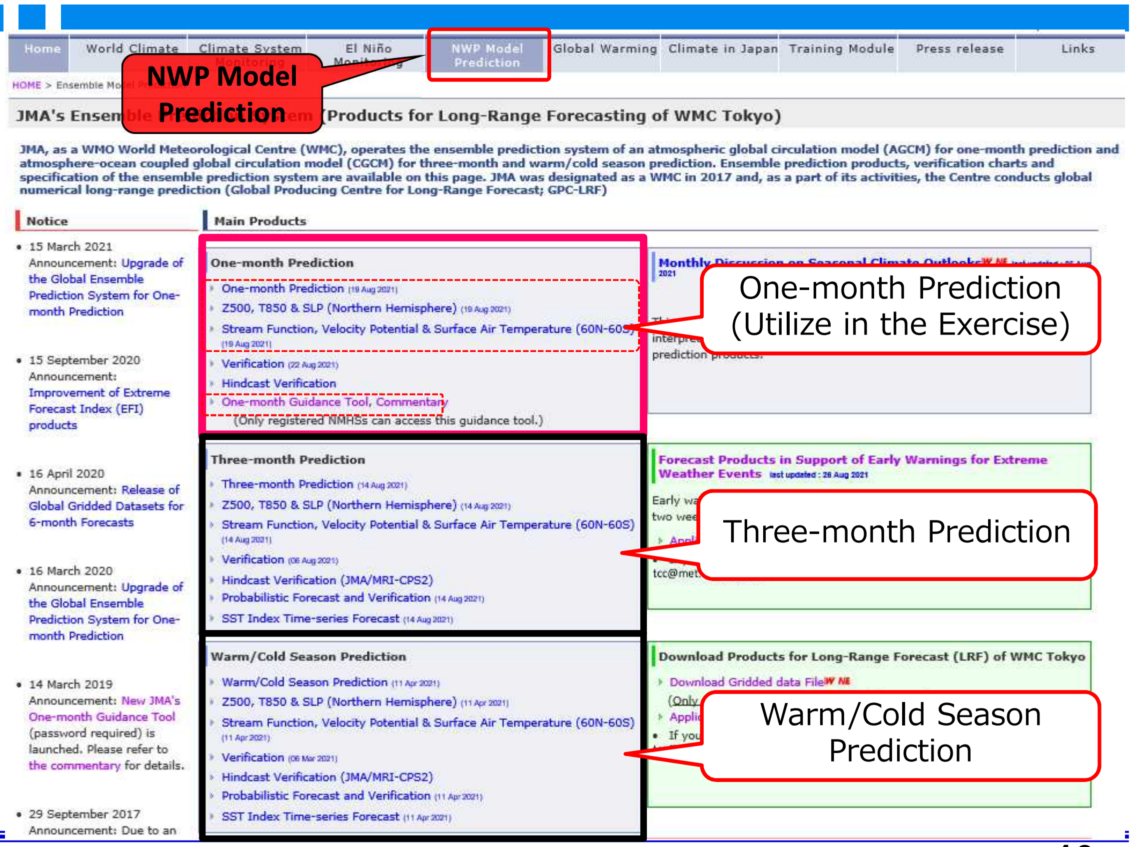
➢ https://ds.data.jma.go.jp/tcc/tcc/index.html



TCC Website
(NWP model prediction)

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



TCC website
(Focusing on one-month prediction)

➢ https://ds.data.jma.go.jp/tcc/tcc/index.html

One-month prediction

Main Products

One-month Prediction

- One-month Prediction (04 Nov 2021)
- Z500, T850 & SLP (Northern Hemisphere) (04 Nov 2021)
- Stream Function, Velocity Potential & Surface Air Temperature (60N-60S) (04 Nov 2021)
- Verification (07 Nov 2021)
- Hindcast Verification
- One-month Guidance Tool, Commentary

(Only registered NMHSs can access this guidance tool.)

Forecast maps

Hindcast verification

Guidance tool

Forecast Maps
(Tropical)

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

✓ Forecast period
1st week: Day 3-9
2nd week: Day 10-16
3rd & 4th week: Day 17-30
28 days mean: Day 3-30

✓ Initial date

✓ Area
(60N-60S/ Asia)

✓ Ensemble mean

✓ **Contour: forecast value**

✓ **Shading: Anomaly**

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.

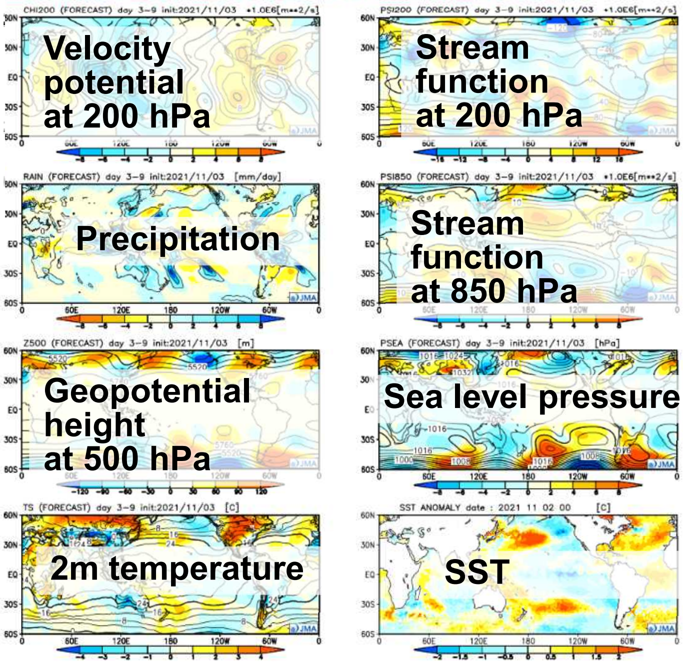
forecast period
the first week

initial date
2021.11.03.12 Z

area
◉ 60N-60S
○ Asia

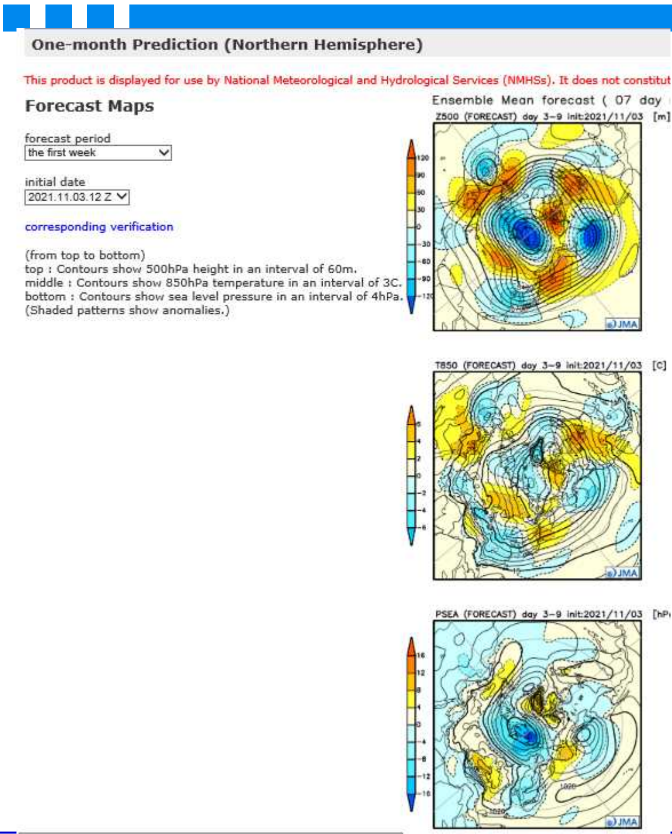
Z500 : 120m
TS : 4C
PSI200 : 20x1.0E6m²/s
PSI850 : 5x1.0E6m²/s
PSEA : 4hPa

(Shaded patterns show anomalies.)



Forecast Maps (Northern Hemisphere)

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



Geopotential height at 500 hPa

Temperature at 850hPa

Sea level pressure

Hindcast verification

➢ https://ds.data.jma.go.jp/tcc/tcc/products/model/hindcast/1mE.GEPS2103/index.html

- It is important to utilize prediction outputs taking into account of prediction skill especially for seasonal prediction.
- In this exercise, we are going to check the verification score maps with the hindcast.

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

Hindcast Verification

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

Verification score map

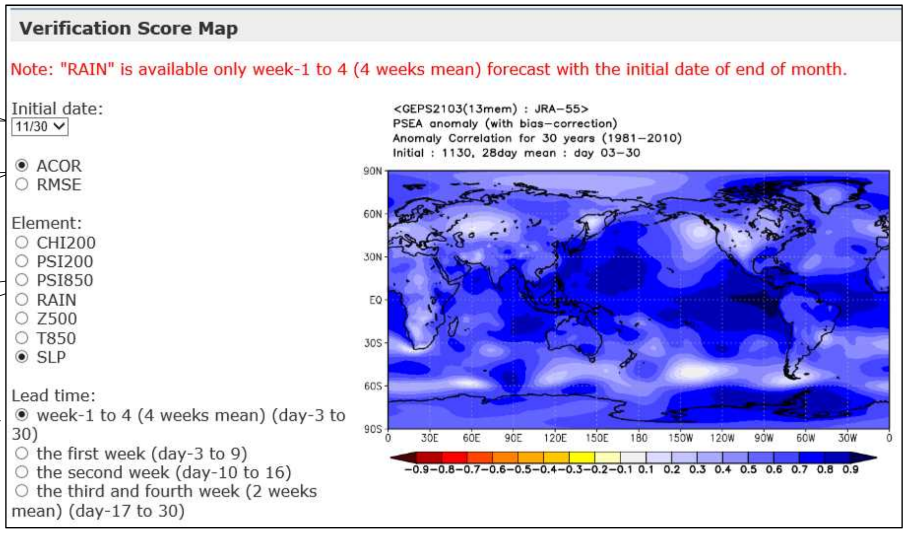
Verification score map (Hindcast)

Initial date.
In this seminar,
11/30

ACOR
(anomaly correlation)

Select parameter

Select forecast lead time



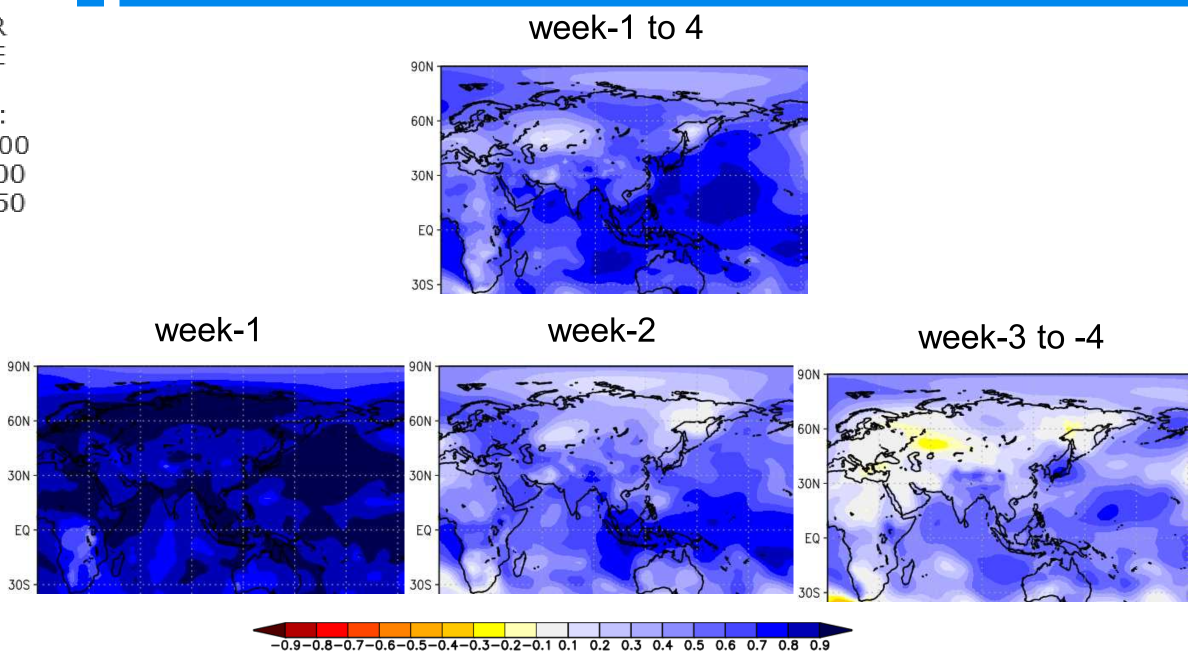
(Notice)
"RAIN" is available <u>only week-1 to 4 (4 weeks mean) forecast</u> with the initial date of end of month..

Example of the score
(anomaly correlation for SLP)

Initial date:
11/30

ACOR
RMSE

Element:
CHI200
PSI200
PSI850
RAIN
Z500
T850
SLP



◆ **For Anomaly correlation map,**
blue color indicates positive correlation (high prediction skill)

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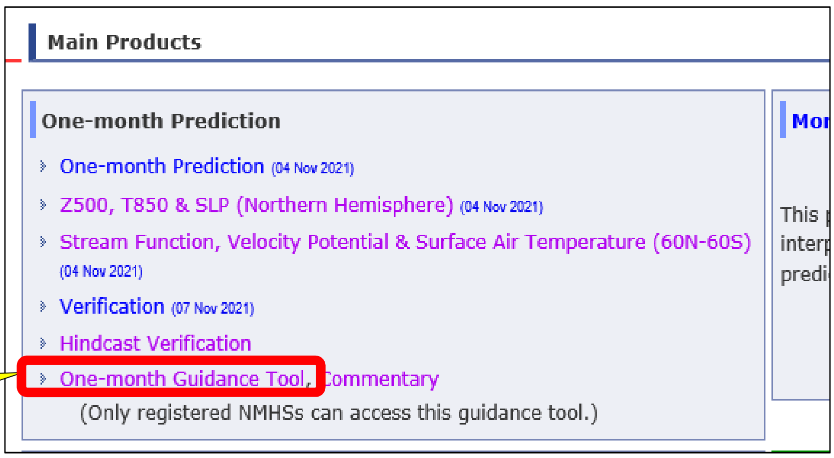
One-month guidance tool (on TCC web)

- https://extreme.kishou.go.jp/cgi-bin/simple_guidance/index.cgi

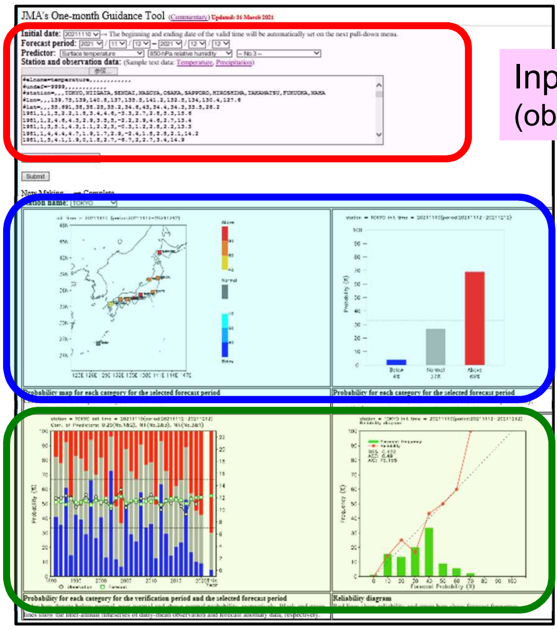
- Web-based APP operated in JMA's virtual server system.
  - ✓ Any browser plug-ins and update of the APP by users are NOT required.



Guidance tool

Overview of the guidance tool

- Set the observational data and some parameters, and the tercile probabilities and verification results are automatically displayed.



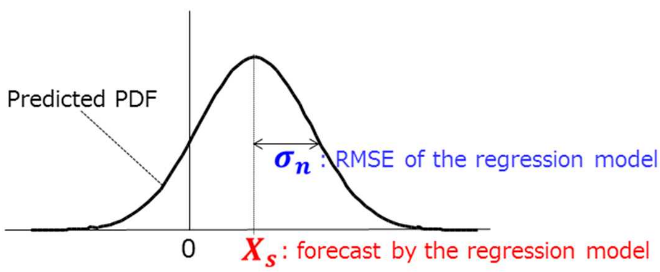
Input by users
(observational data and some parameters)

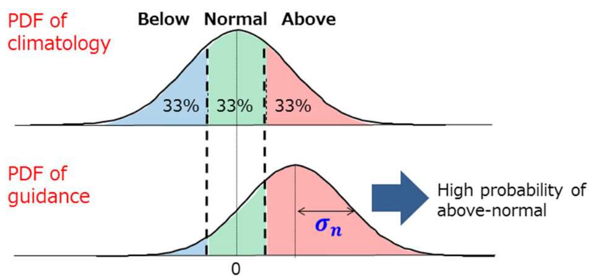
Output
(tercile probabilities)

Output
(verification of the guidance)

Specifications of the guidance

- Threshold of the tercile categories;
  based on the past observation data during verification period for years
- Prediction method;
  multi-regression (up to 3 elements)
- Estimation of uncertainty;
  assuming PDF with the forecast error (RMSE) of the past cases (hindcast)





Workflow of the guidance tool

1. (Preparation)
   1. Create the past observation file (csv format)
      - Need to prepare by users

Thank you for sending us climate data in your country!

2. (Using the guidance tool)
   1. Input data
      - initial date, forecast target period and observation data
   2. Produce guidance and get the outputs
      - Select “predictor” and check the verification (automatically output)
      - Get the outputs (tercile probabilities)

1. Preparation

(1) Observation data (example)

Line.1: #elname={temperature or precipitation}
2: #undef={undefined value}
3: #station=,,,{station name}
4: #lon=,,,{longitude of the obs. point}
5: #lat=,,,{latitude of the obs. point}

(The other words are NOT available)

(Up to 10 stations)

After line.6: observation data
{Year},{Month},{Day},{Observational value}

<Example>

```
#elname=temperature,,,
#undef=-9999,,,
#station=,,,TOKYO,NIIGATA,SENDAI,NAGOYA,OSAKA,SAPPORO,HIROSHIMA,TAKAMATSU,FUKUOKA
,NAHA
#lon=,,,140,139,140.8,137,135.5,141.2,132.5,134,130.4,127.6
#lat=,,,35,38,38.25,35.2,34.6,43,34.4,34.3,33.5,26.2
1981,1,1,5,2.2,1.8,3.4,4.6,-3.3,2.7,2.8,5.3,15.6
1981,1,2,4.6,4.3,2.9,3.5,5,-2.2,2.9,4.6,2.7,13.4
1981,1,3,5.1,4.3,1.1,2.2,3,-0.3,1.2,2.8,2.2,13.3
```

1. Preparation

(2) Observation data (supplement)

- Element;
  - Daily temperature or daily precipitation
- File format;
  - CSV (comma-separated values)
- Period;
  - As a minimum, daily data covering the verification period (from 1 January 1991 to 31 January 2021 by default) are required.
- Observation data;
  - Maximum 10 stations (possible to calculate simultaneously)
  - Embed undefined value for missing data.
  - Station name should be one-word

  (In case of ¥more than two-words, connect with hyphen "-" or under bar "_".)

Workflow of the guidance tool

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Thank you for sending us climate data in your country!

2. (Using the guidance tool)
   1. Input data
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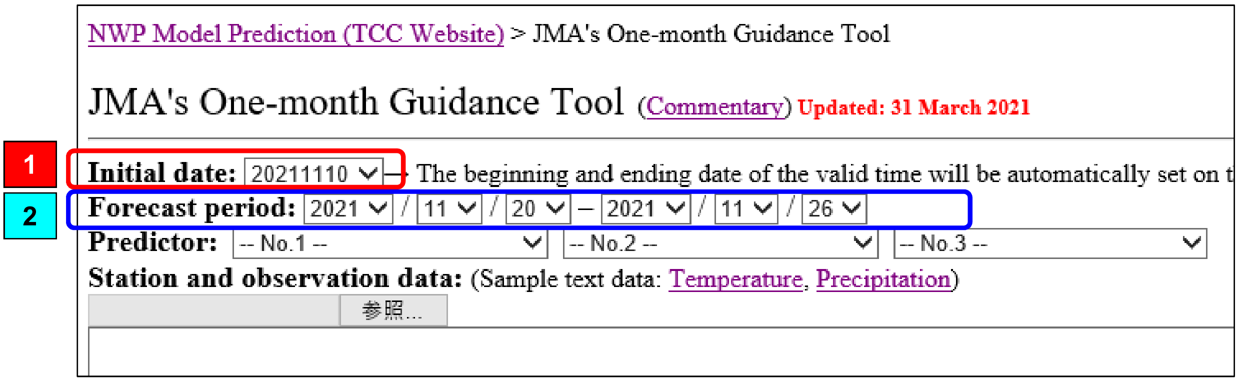
   2. Produce guidance and get the outputs
      - Select "predictor" and check the verification (automatically output)
      - Get the outputs (tercile probabilities)

2.1. Input data

(1) Setting the initial date and the target period

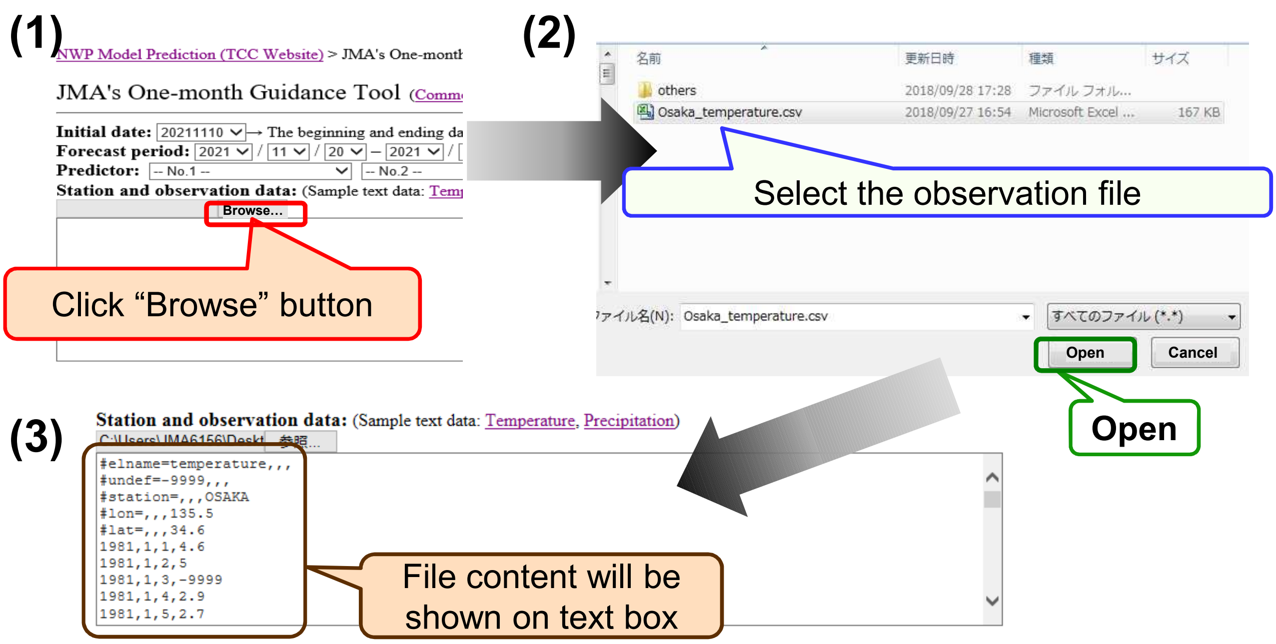
➢ https://extreme.kishou.go.jp/cgi-bin/simple_guidance/index.cgi



1. Initial date
   (Select "Initial date" from a pull-down menu)
2. Forecast period
   (Select "Forecast period" within the forecast range from a pull-down menu.)
   ✓ In the below example, a target period is set as 20 to 26 Nov. 2018 (2nd week).

2.1. Input data

(2) Setting the observation data



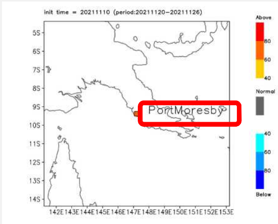
2.1. Input data
(3) (Optional) Detailed options

↓ Detailed Options ↓

Verification period: 1991 – 2020
Character size of station name: 0.09
Normalization of precipitation data: 0.25 → Power of 0.25 is default. Power of 1 denotes non-normalization.

↑ Close Detailed Options ↑

- Verification period
  - Users can adjust verification period so as not to choose inappropriate period during which most of the data are missing.
  - Unless there is no particular reason, it should be recommended to leave the verification period as the default (30-year period from 1991 to 2020).
- Character size of station name
  - Setting the character size for the station



- Normalization of Precipitation
  - Parameter for normalization of precipitation

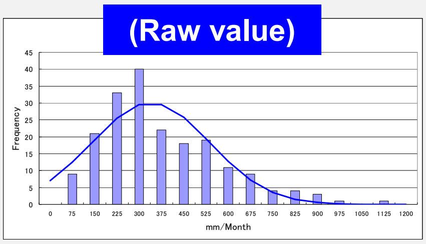
(→ Look at the next slide)

2.1. Input data
(4) [Tips] Normalization of Precipitation

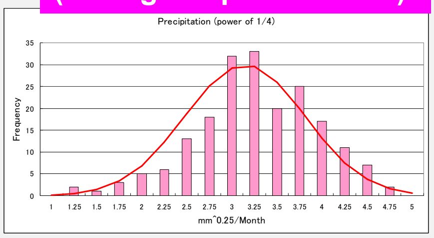
- Temperature is generally approximated by a normal distribution.
- Meanwhile, precipitation doesn't represent a normal distribution, and it's usually approximated by a gamma distribution.
- To approximate by a normal distribution, the guidance tool performs a normalization of precipitation data by its power of 1/4 to calculate the guidance forecast.

Ex. Precipitation over Japan

(Raw value)



(Taking the power of 1/4)



✓ Changing the value from **0.25** (i.e., 1/4) to **1.0**, precipitation data will be non-normalized.

Verification period: 1991 – 2020
Character size of station name: 0.30
Normalization of precipitation data: 0.25 → Power of 0.25 is default. Power of 1 denotes non-normalization.

Workflow of the guidance tool

1. (Preparation)

1. Create the past observation file (csv format)
   - Need to prepare by users

Thank you for sending us climate data in your country!

2. (Using the guidance tool)

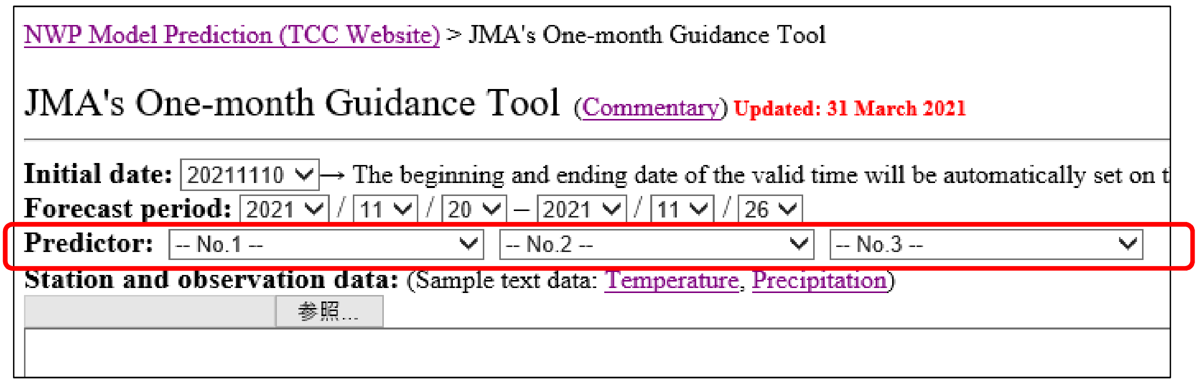
1. Input data
   - initial date, forecast target period and observation data
2. Produce guidance and get the outputs
   - Select “predictor” and check the verification (automatically output)
   - Get the outputs (tercile probabilities)

2.2. Produce guidance and get the outputs

(1) Select “Predictor”

- Select “**Predictor**” elements from a pull-down menu.
  - Users can set up to three predictors from the left (No.1~3).

✓ In actual, the users need to find better combination of predictors, confirming the prediction skill (as shown below)

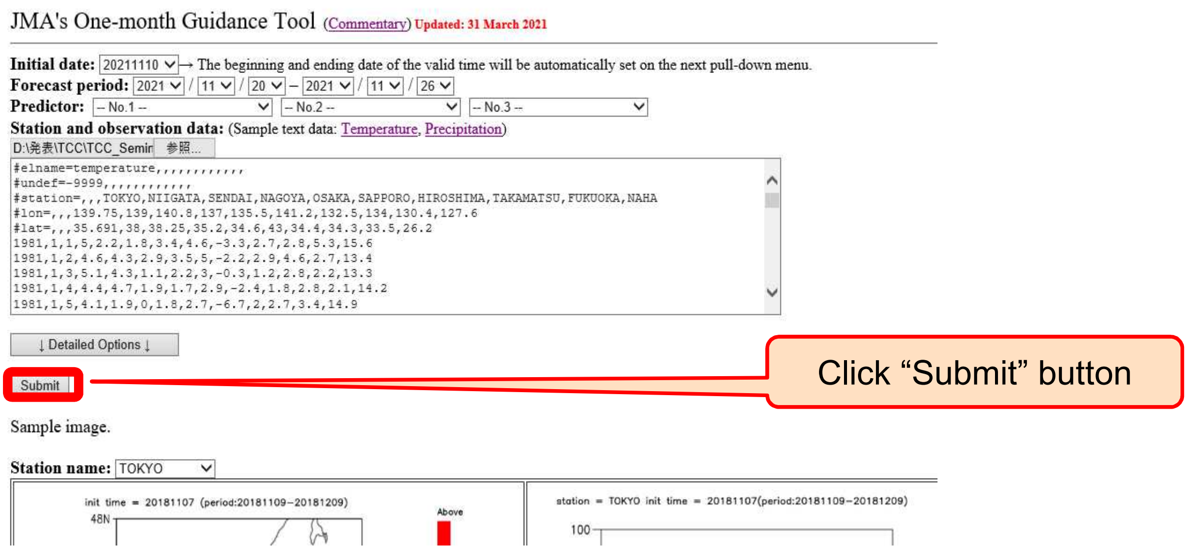


2.2. Produce guidance and get the outputs

(2) Execute calculation of guidance

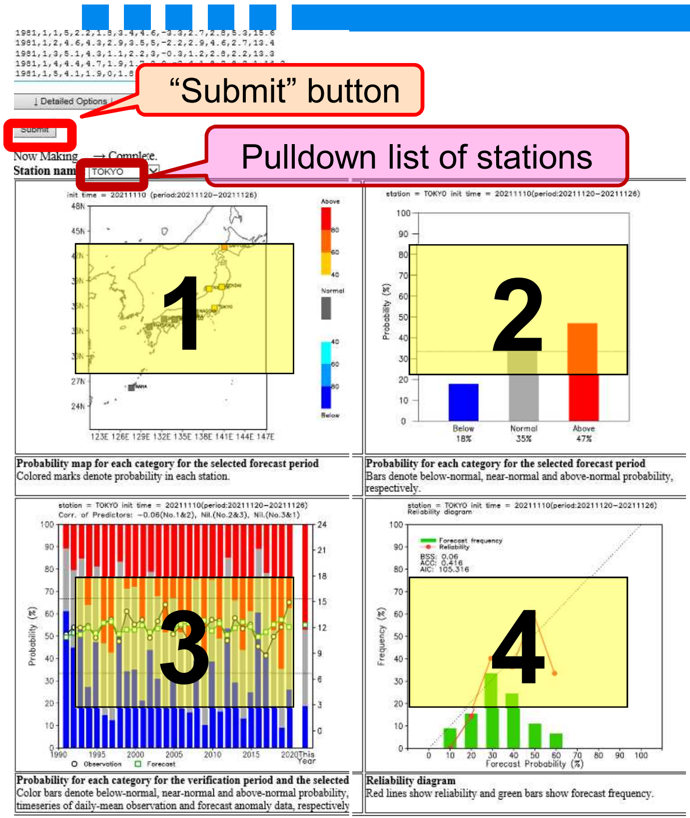
- Clicking "Submit" button, and execute calculations of the guidance automatically.

(After a short time, output the tercile probabilities and forecast skill according to the hindcast.)



2.2. Produce guidance and get the outputs

(3) Output of the guidance tool



After click the "submit" button, the following 4 charts are output.

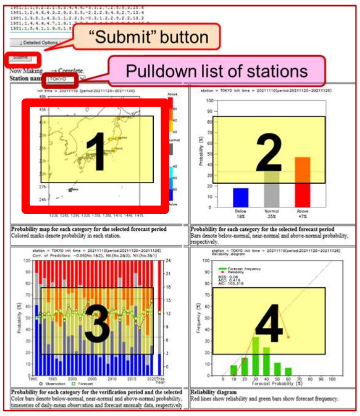
1. Color-coded probability map
2. Tercile probability forecast at the station
3. Inter-annual time series of tercile probability during the verification period
4. Verification scores and the reliability diagram

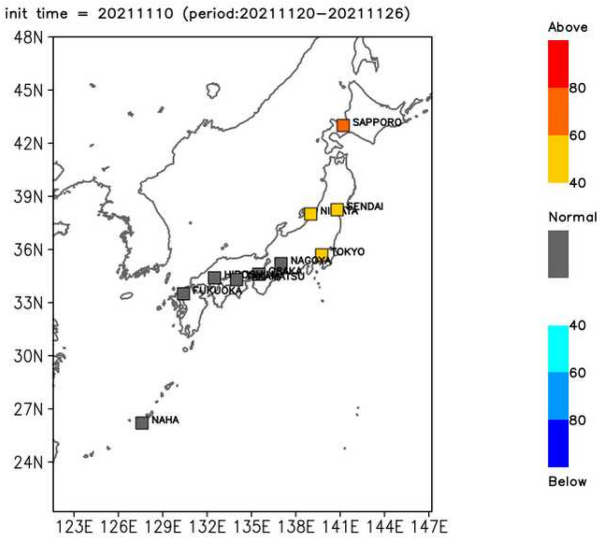
2.2. Produce guidance and get the outputs

Output-1; Color-coded probability map

1. Color-coded probability map (upper left)

- Illustrate the most –likely categories and probabilities for all station



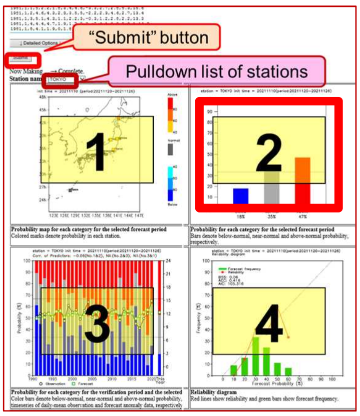


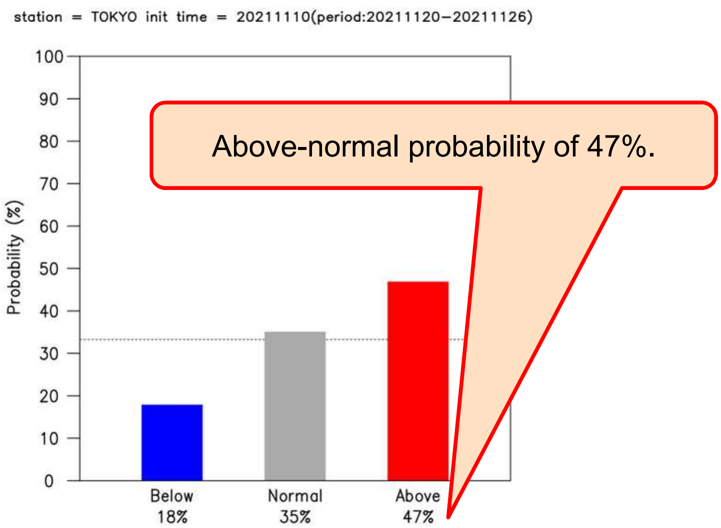
2.2. Produce guidance and get the outputs

Output-2; Tercile probability forecast at the station

2. Tercile probability forecast at the station (upper right)

- Illustrate the tercile probabilities for the selected station

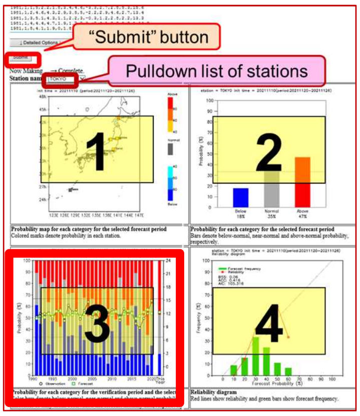


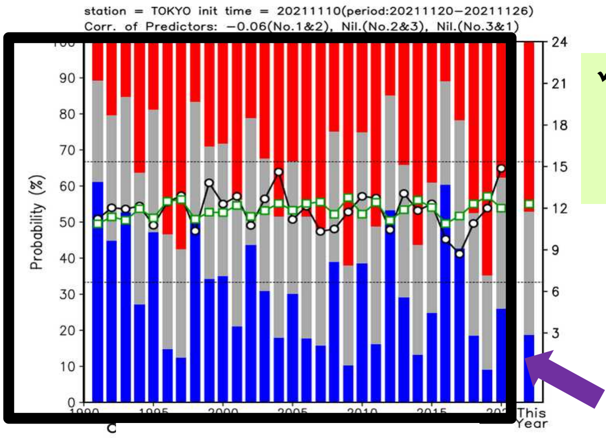


2.2. Produce guidance and get the outputs

Output-3; Inter-annual time series of tercile probability

3. Inter-annual time series of tercile probability during the verification period (below left)





- ✓ Check up past prediction result for the noticeable year.

Hindcast period

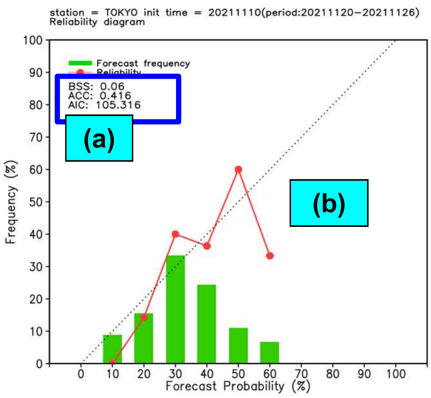
Colored-bars: Tercile probability

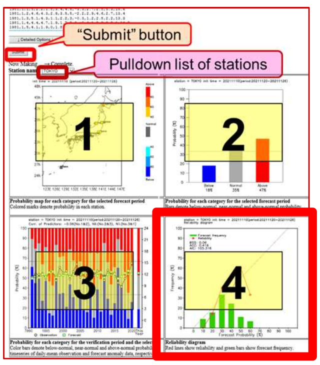
-O-: Anomaly of daily-mean obs.

-□-: Anomaly of daily-mean forecast

2.2. Produce guidance and get the outputs

Output-4; Verification scores and the reliability diagram





4. Verification scores and the reliability diagram (below right)

(a) Check up the verification scores
- ACC (Anomaly correlation coefficient)
- BSS (Brior skill score)

BSS: 0.06
ACC: 0.416
AIC: 105.316

- ➢ ACC is the most important score (as an indicator of the skill of tendency forecasting)
- ➢ Nextly, BSS (the skill of probability values)

(b) Check up the reliability diagram
- ✓ Whether the reliability curve has a positive slope

(Hint) Recommended combination of predictors (1)

☐ For ***Temperature*** forecast,

- One predictor is recommended to be set temperatures (surface, 850 hPa or 700 hPa temperatures).
  - ✓ As for the island point, to avoid using surface temp. might be better (i.e. using 925, 850hPa temp.).
- Other predictors are selected except for temperature, such as wind or lower relative humidity.
  - ✓ To prevent the "multicollinearity" problem, poorly correlated predictors are recommended to be selected.

For example;

o "*Surface temp.*" and "*850-hPa meridional wind*"

x "*Surface temp.*" and "*850-hPa temp.*"

✓ At first, I recommend the forecast skill of one-predictor (surface temperature) to check up a basic performance of the model.

(Hint) Recommended combination of predictors (2)

☐ For ***Precipitation*** forecast,

- One predictor is recommended to be set to be set as "Rainfall".
- Other predictors are selected depending on locality, such as the lower-tropospheric wind to consider terrain conditions.

For example;

- "Rainfall" and "850-hPa meridional wind"
- "Rainfall" and "850-hPa zonal wind"
  - (in consideration of terrain condition)

✓ At first, I recommend the forecast skill of one-predictor (rainfall) to check up a basic performance of the model.

Users' Guide

- *Online user guides* are also available for more details on the guidance tool.
  - ✓ https://extreme.kishou.go.jp/tool/simple_guidance/help/
- If you have any questions for the guidance tool, please feel free to ask TCC staffs.