Variability in the tropical oceans

- Monitoring and prediction of El Niño and La Niña -

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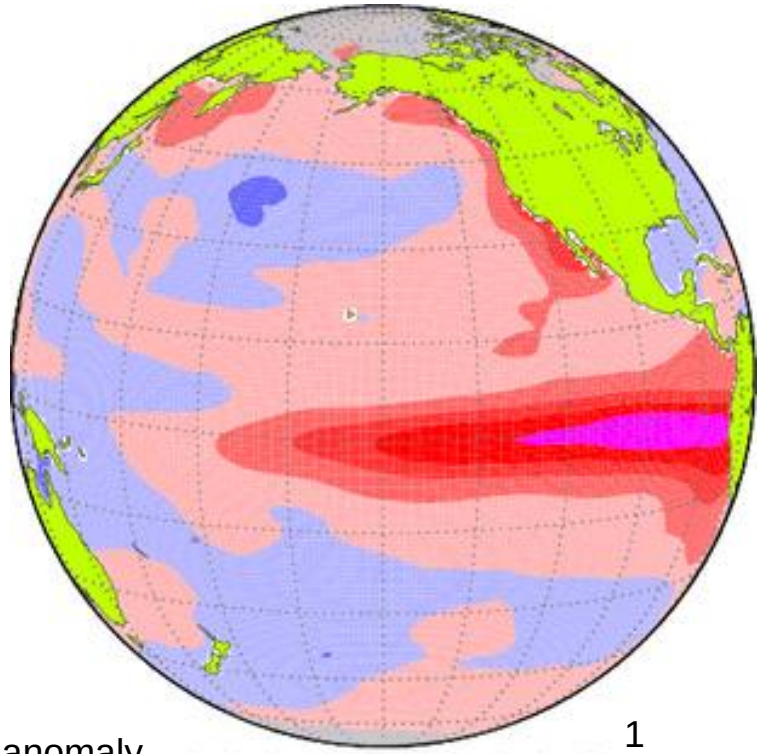


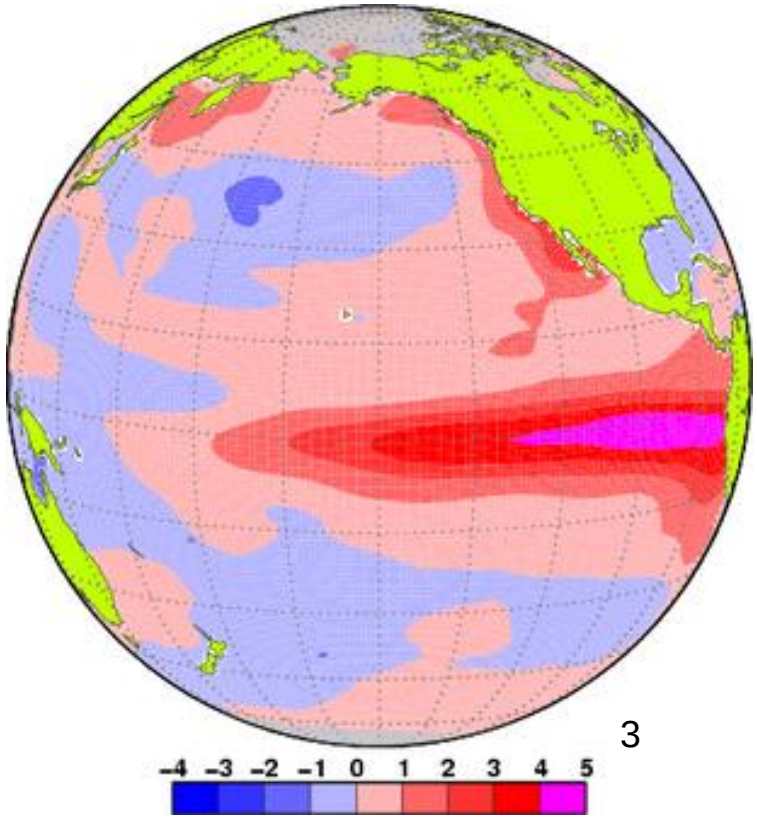
Outline

1. Introduction of El Niño / La Niña phenomena
2. El Niño monitoring and prediction
3. JMA's products for El Niño / La Niña phenomena

The latter half of this lecture

- Impact on global atmosphere and climate (more detailed)

1. Introduction of El Niño / La Niña phenomena



El Niño”(“La Niña”) refers to:

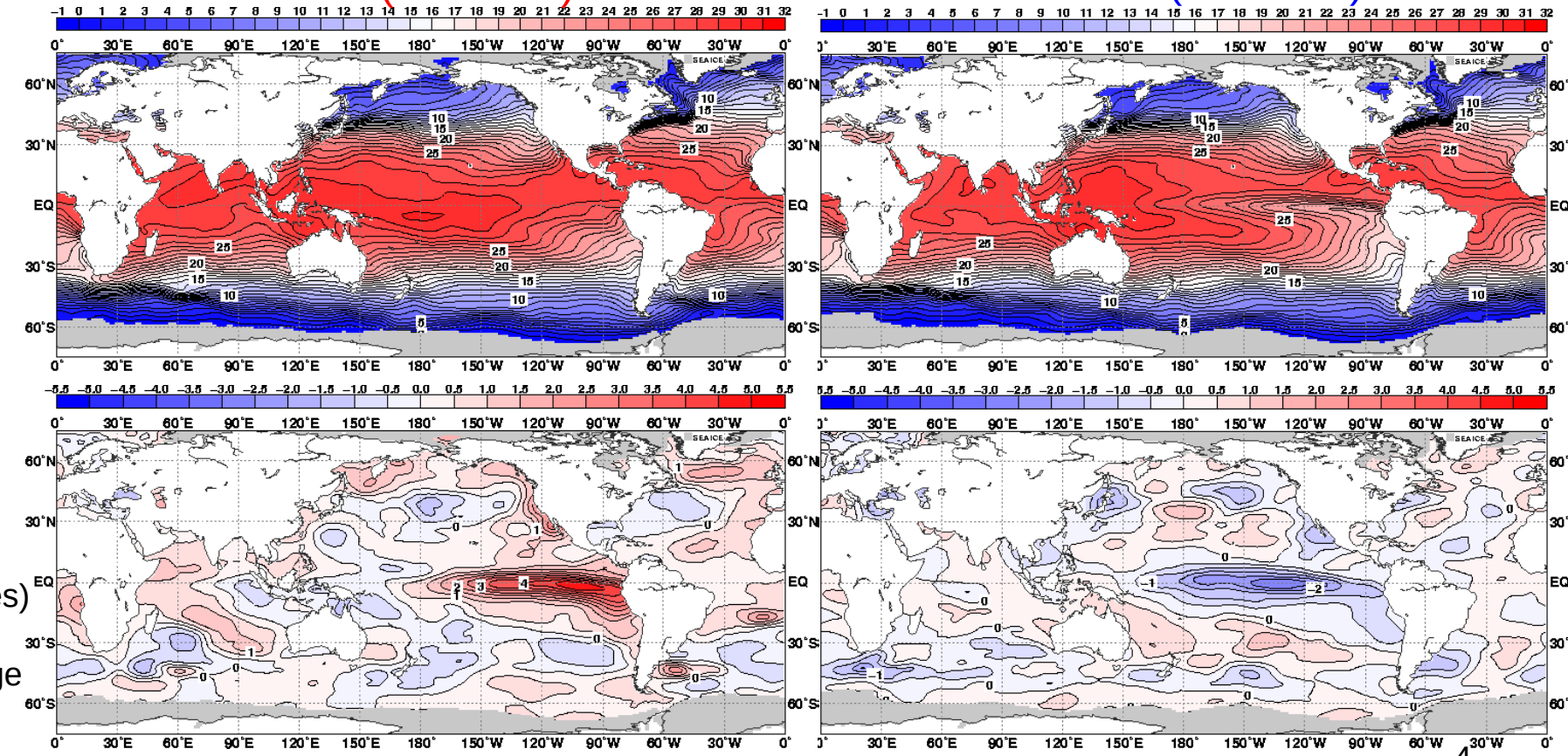
A large-scale ocean climate phenomenon linked to
a periodic rise (fall) in sea surface temperatures (SSTs)
across the central and eastern equatorial Pacific

El Niño (Nov1997) | La Niña (Nov1988)

sea surface temperature (SST)

departure from normal (SST anomalies)

normal: average for 1981-2010



Why is El Niño or La Niña important ?

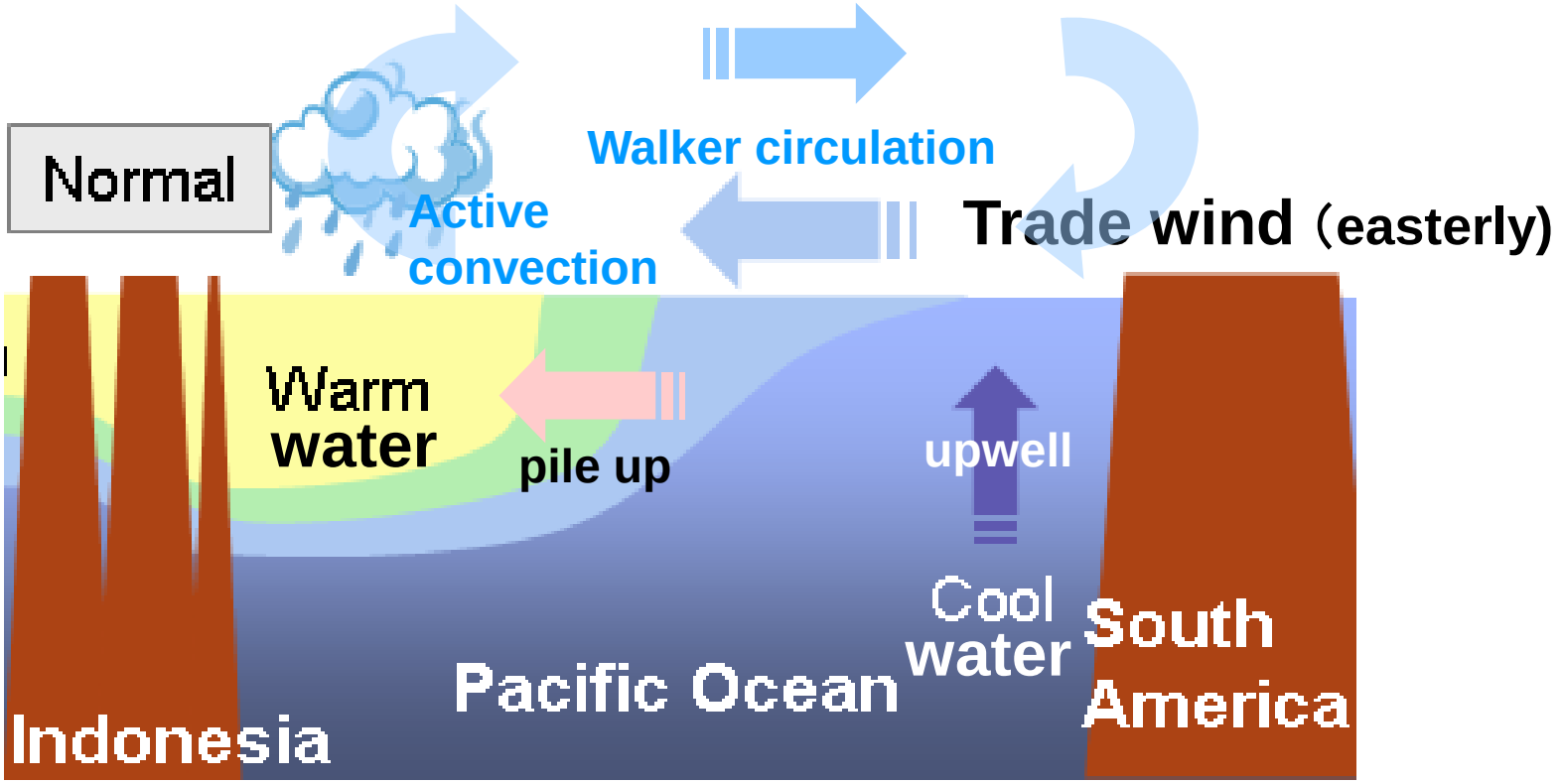
1. Predominant inter-annual climate variability
2. Big Impact on the world climate
3. Predictable with one or two seasons lead time

The prediction of El Niño or La Niña is a base of our long range forecast.

When we discuss our long range forecast, at first we check the ENSO conditions.

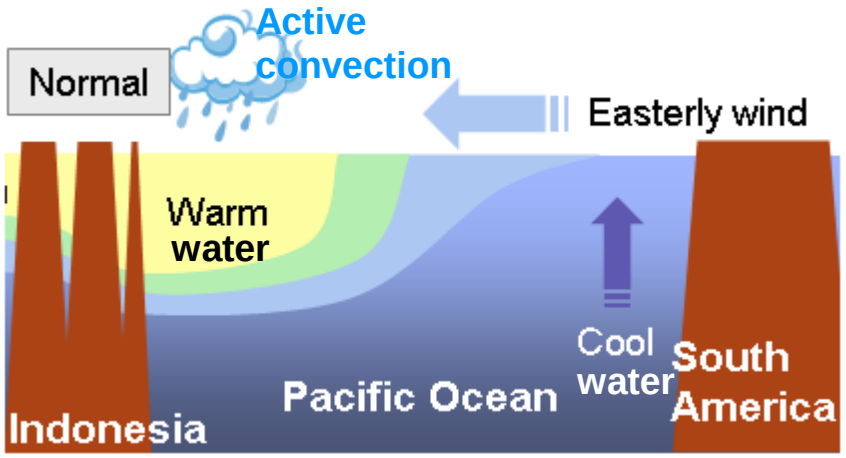
Normal condition in the equatorial Pacific

Trade wind, a persistent easterly atmospheric flow blowing over the equatorial Pacific Ocean, sustains warmer-western, cooler-eastern sea surface condition.

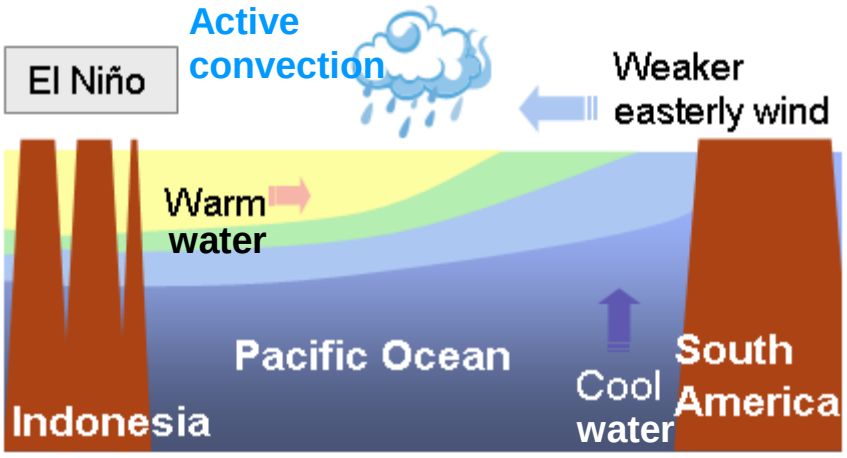


Atmosphere-ocean interaction during El Niño

Normal condition



El Niño condition



Warmer SST in the eastern Pacific → Eastward shift of active convection

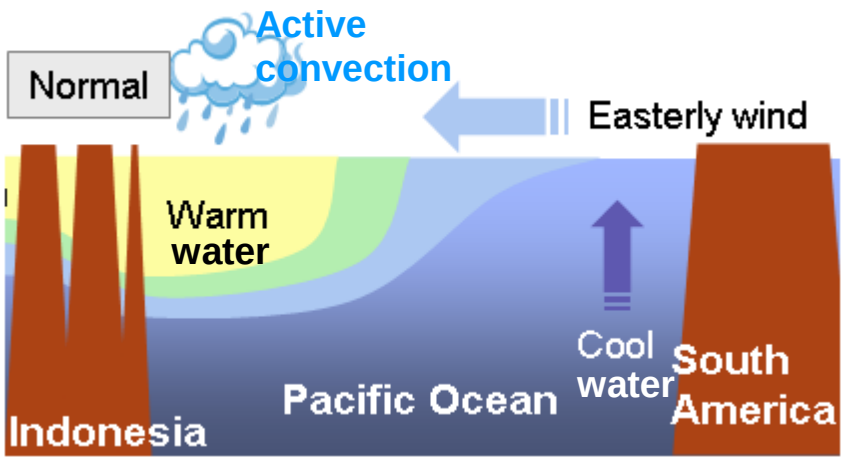
↓

Weaker easterly trade wind → Eastward shift of warm water

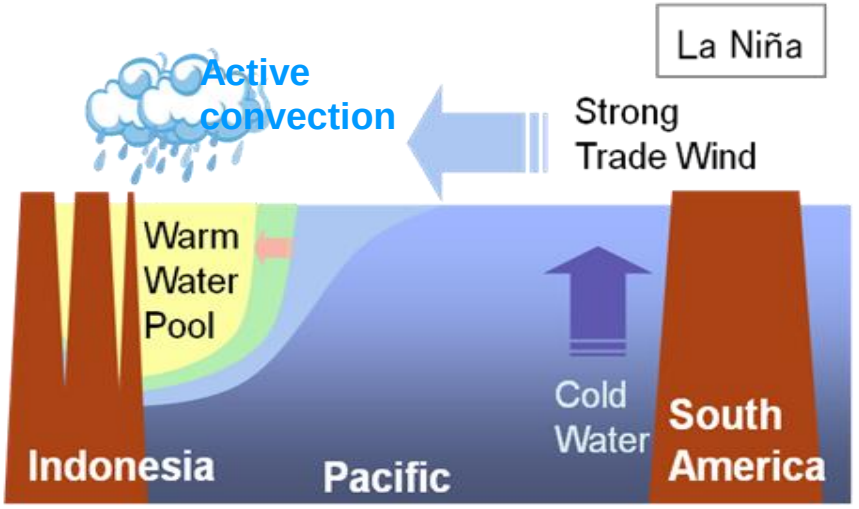
↑

Atmosphere-ocean interaction during La Niña

Normal condition



La Niña condition

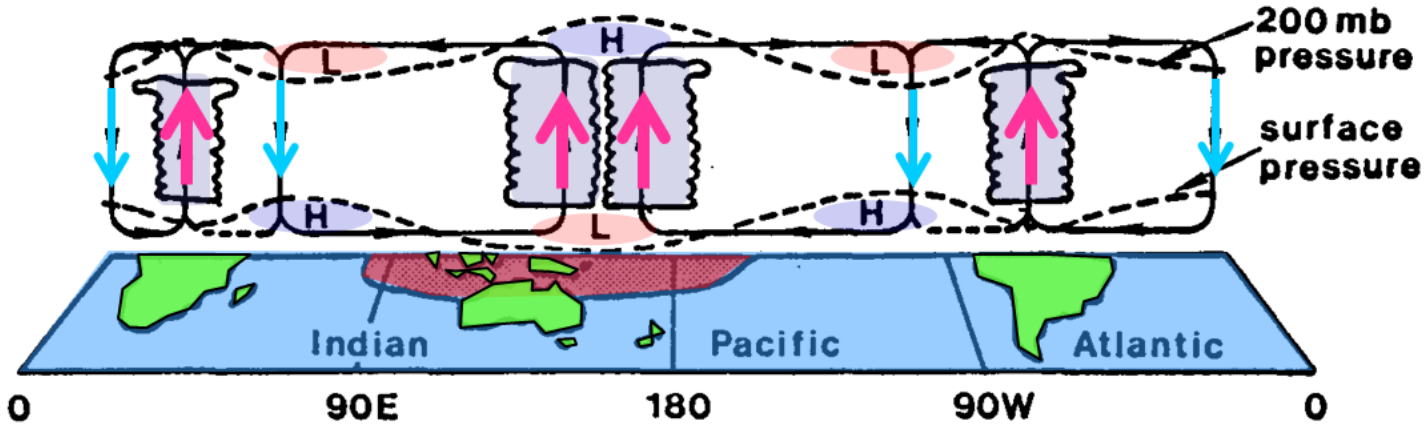


Colder SST in the eastern Pacific → Westward shift of active convection → Stronger easterly trade wind → Westward shift of warm water → Colder SST in the eastern Pacific

Changes in the Walker Circulation

Webster and Chang 1988

La Niña



El Niño

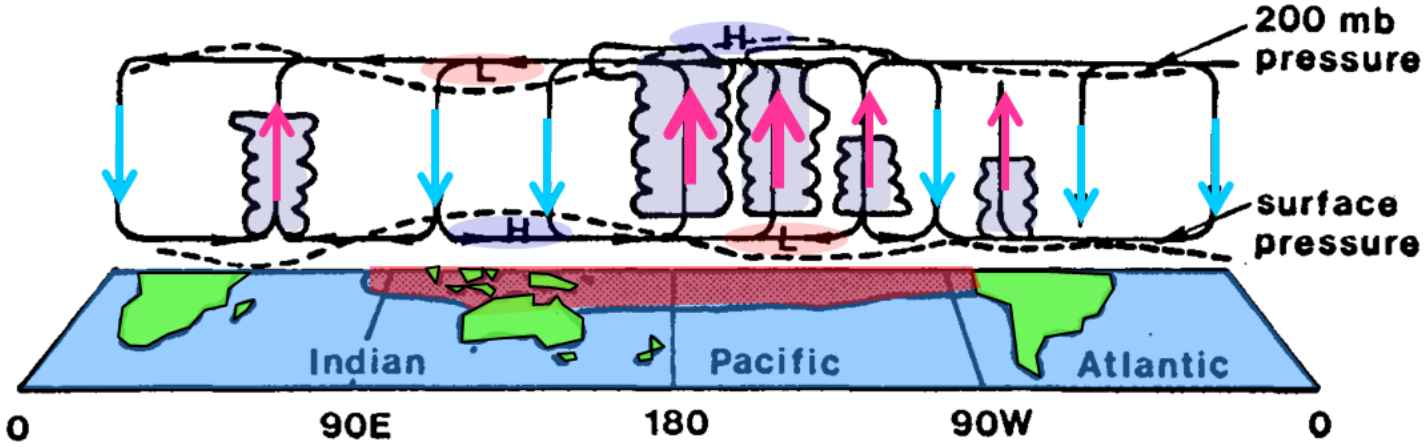


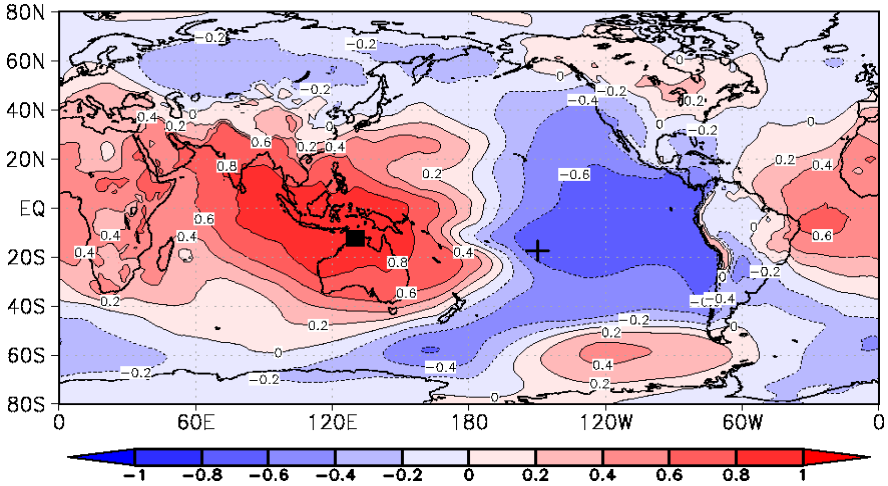
FIG. 1. Schematic view of the Walker Circulation along the equator during El Niño (lower panel) and La Niña (upper panel) periods that occur at the extremes of the Southern Oscillation. The shaded areas indicate sea surface temperatures warmer than 27°C and the dashed lines show relative horizontal pressure variations in the lower and upper troposphere. (From Webster, 1983)

El Niño/Southern Oscillation (ENSO)

Variation of sea level pressure (SLP) difference between eastern and western parts of the Pacific which closely related to strength of trade winds = Southern Oscillation

El Niño + Southern Oscillation = ENSO

Correlation coefficients of annual mean SLP of Darwin (■) and other points



Trade wind (easterly)
～Zonal gradient of SLP
(Tahiti [+] minus Darwin [■])

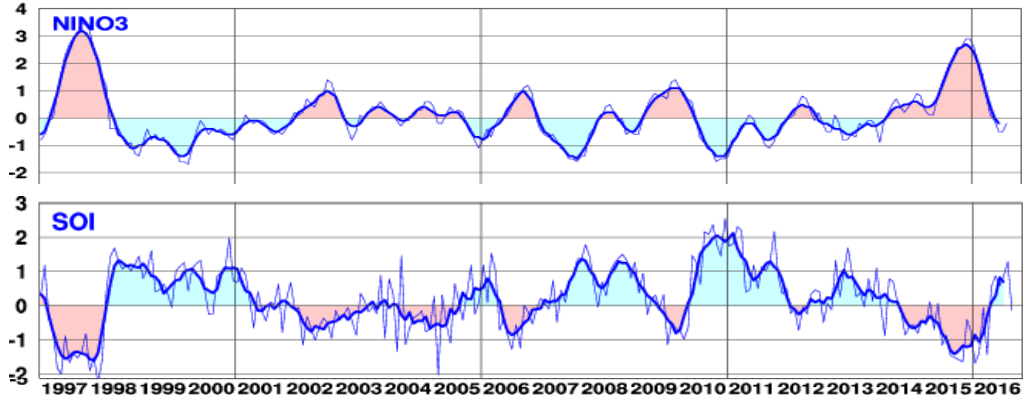
Southern Oscillation (Index)
positive: easterly anomaly
negative: westerly anomaly

El Niño event

La Niña event

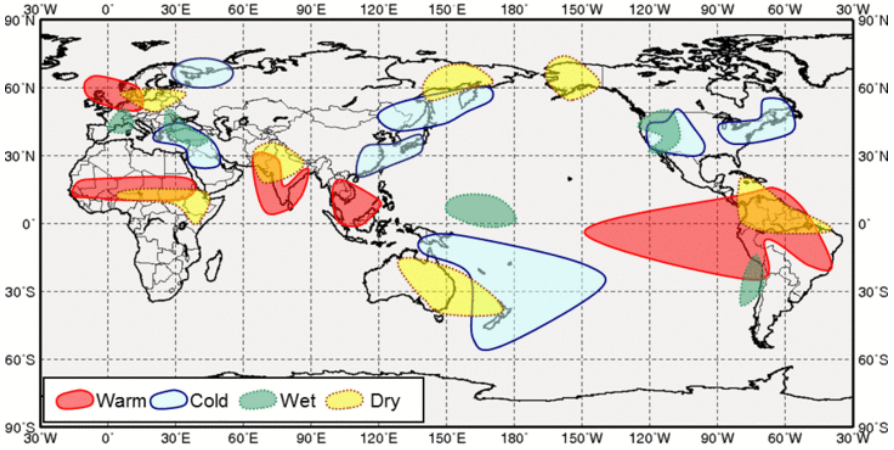
La Niña event

El Niño event

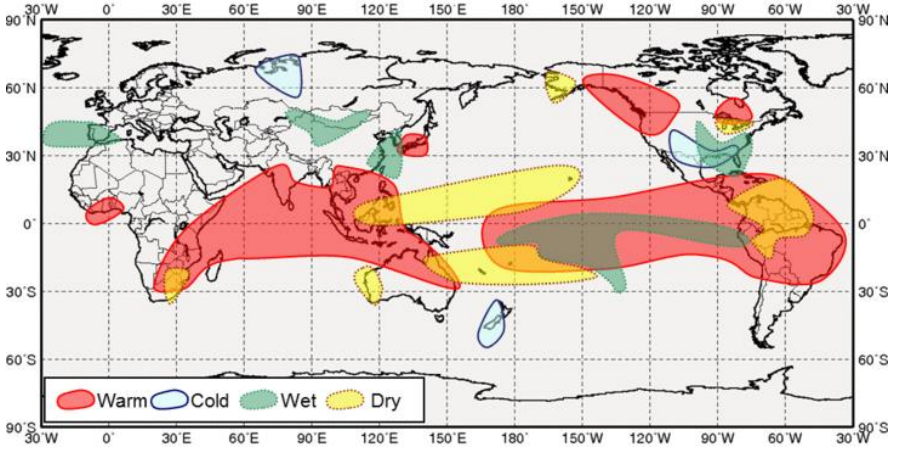


Climate tendencies during El Niño/La Niña

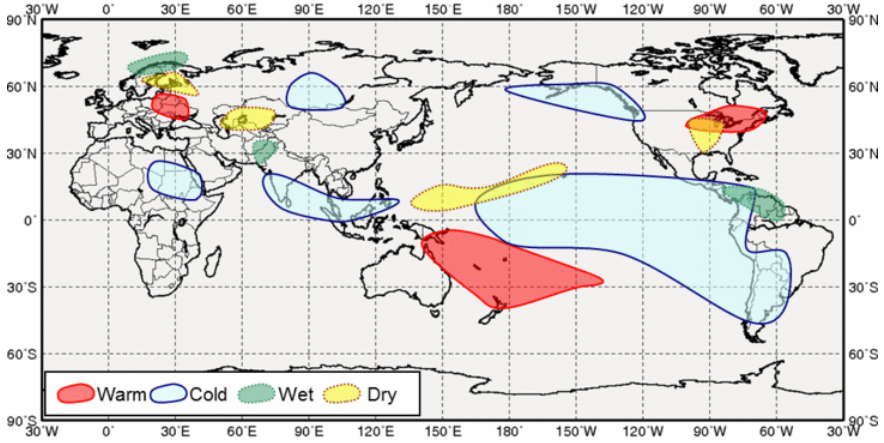
EL in boreal summer



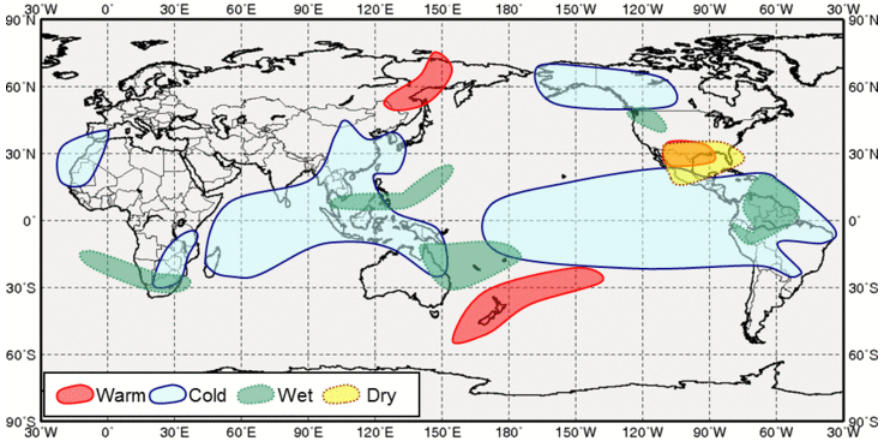
EL in boreal winter



LA in boreal summer



LA in boreal winter



These maps show the regions where climate tendencies observed during El Niño/La Niña events (1958-2012) are statistically significant in boreal summer/winter.

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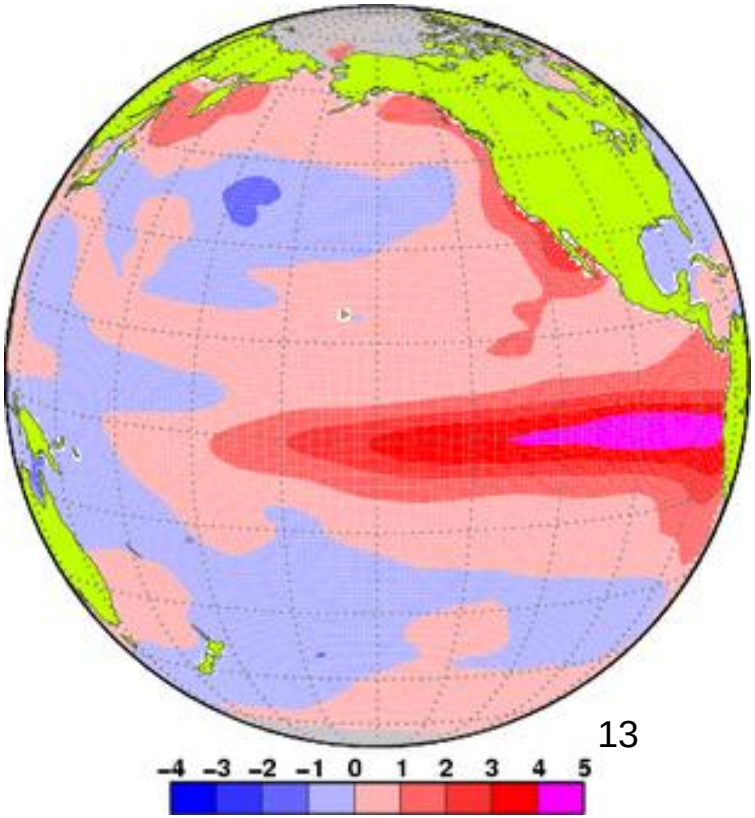
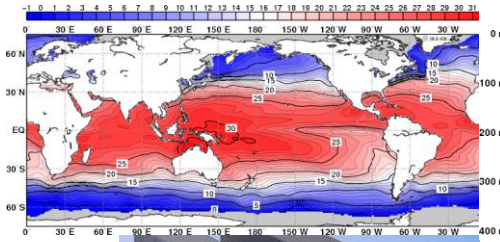
2. El Niño monitoring and prediction

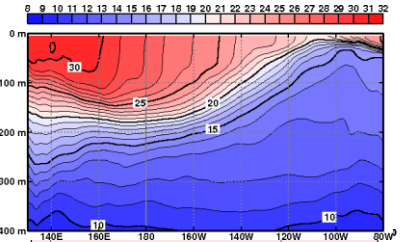


Workflow of monitoring and prediction

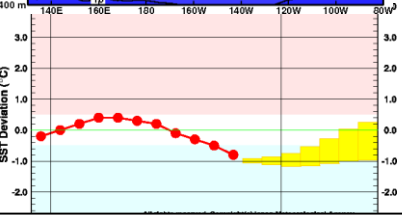
1. Acquiring observational data

2. Data quality control & assimilation into the regular grids





result of ocean assimilation data



3. Numerical prediction (Atmosphere-Ocean coupled model)

4. Analysis & examination of the model results

HOME > El Niño Monitoring > El Niño Outlook

El Niño Outlook (January 2018 - July 2018)

Last Updated: **11 January 2018**
(Next update will be on 9 February 2018)

- **It is considered that La Niña conditions continue in the equatorial Pacific.**
- **It is likely that La Niña conditions will persist through to boreal spring (70%).**

[El Niño / La Niña]

In December 2017, the NINO.3 SST was below normal with a deviation of -1.2°C and five-month running mean of the NINO.3 SST deviation was -0.8°C in October (Table and Fig.3). SSTs in December were above normal in the western equatorial Pacific and below normal in the central and eastern parts (Fig.4 and Fig.6). Subsurface temperatures were above normal in the western equatorial Pacific and below normal in the central and eastern parts (Fig.5 and Fig.7). Atmospheric convective activity was below normal near the date line over the equatorial Pacific (Fig.8, Fig.9 and Fig.10). As these oceanic and atmospheric conditions indicate common features of past La Niña events, it is considered that La Niña conditions continue in the equatorial Pacific.

Cold subsurface waters, which were observed in the central and eastern equatorial Pacific, are likely to move eastward and maintain cooler-than-normal SST conditions in the eastern part during the months ahead. JMA's El Niño prediction model suggests that the NINO.3 SST will be below normal within boreal winter, and below or near normal in boreal spring (Fig.11). In conclusion, it is likely that La Niña conditions will persist through to boreal spring (70%) (Fig.1 and Fig.2).

[Western Pacific and Indian Ocean]

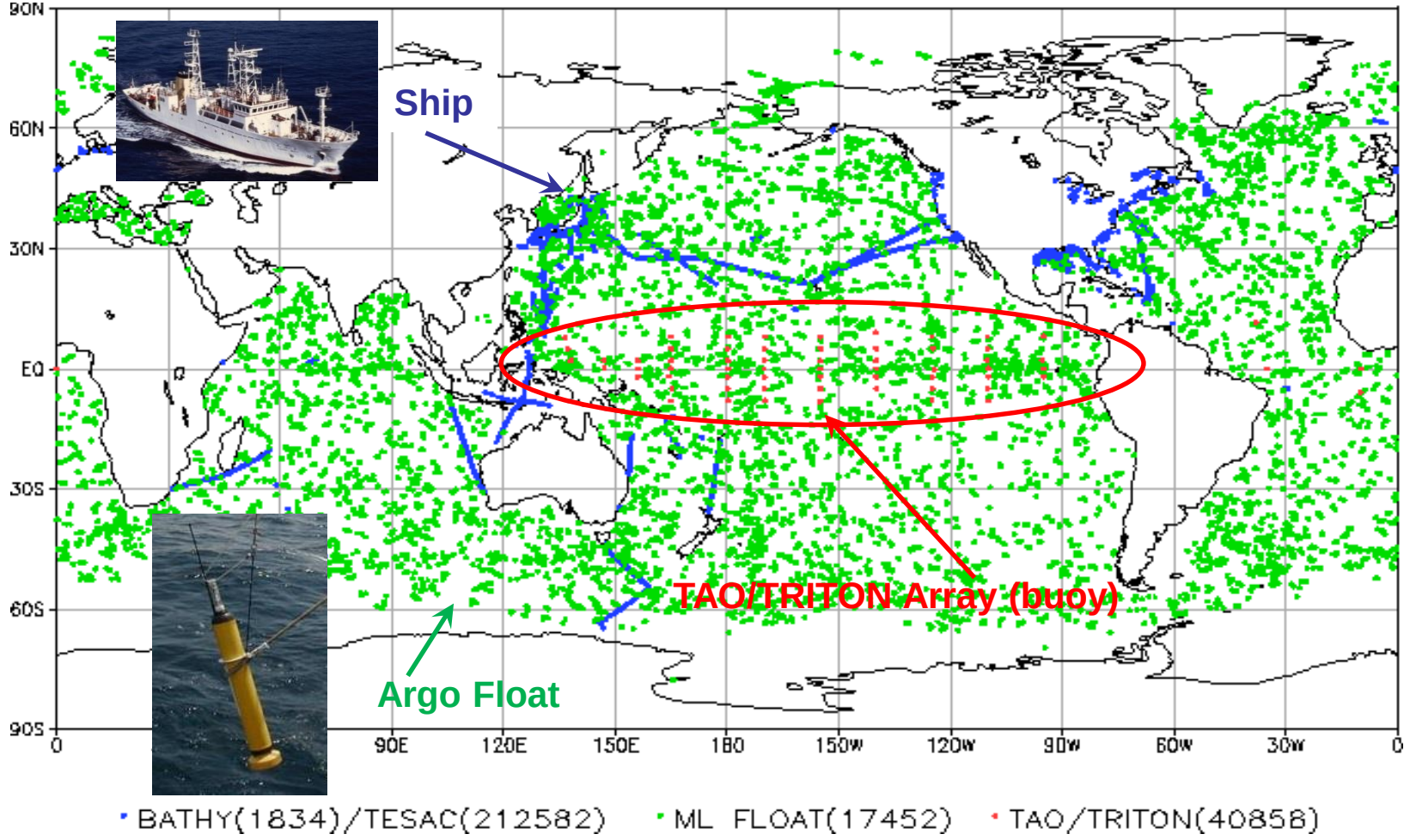
The area-averaged SST in the tropical western Pacific (NINO.WEST) region was above normal in December (Fig.3). It is likely that values will come gradually closer to normal until boreal spring (Fig.12).

The area-averaged SST in the tropical Indian Ocean (IOBW) region was below normal in December (Fig.3). It is likely that values will be below normal until boreal spring (Fig.13).

5. Products publication

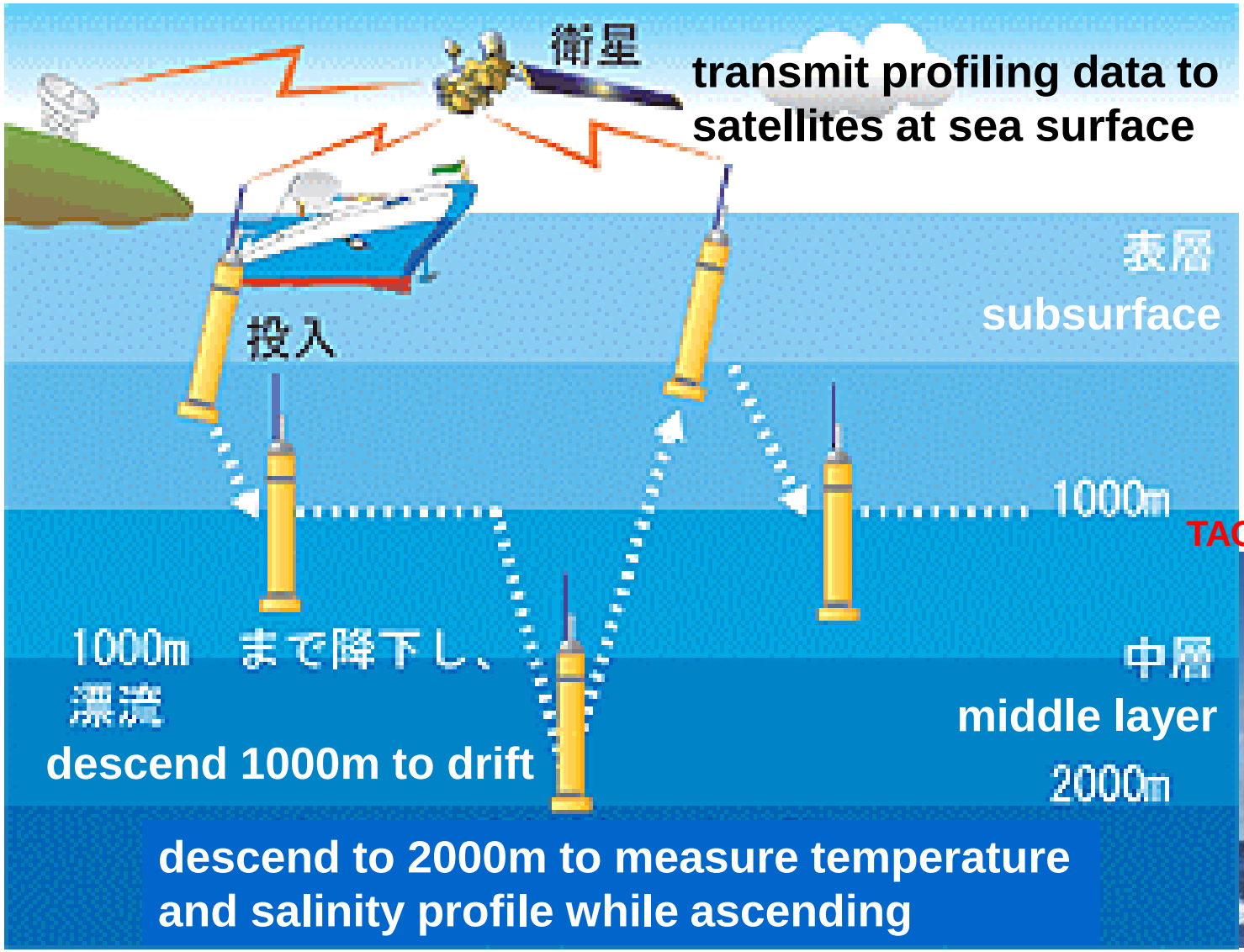
Ocean observation

Distribution of oceanic observation（Oct. 2016）

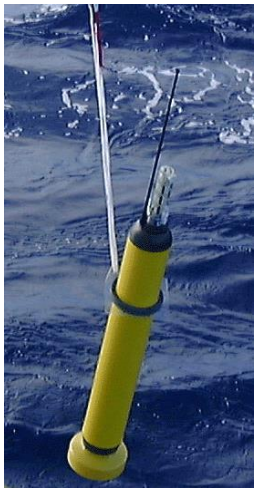


International Corporation

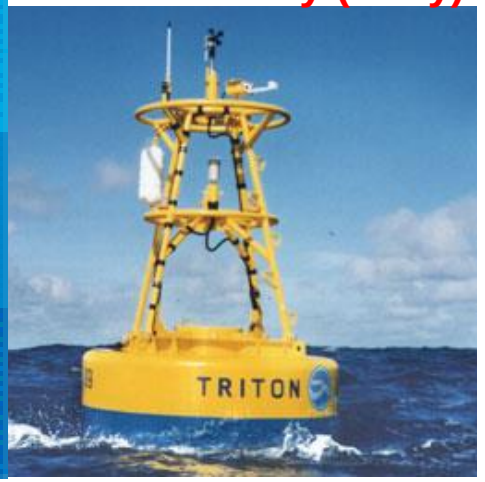
Ocean observation



Argo Float



TAO/TRITON Array (buoy)



Ocean Data Assimilation System (MOVE-G2)

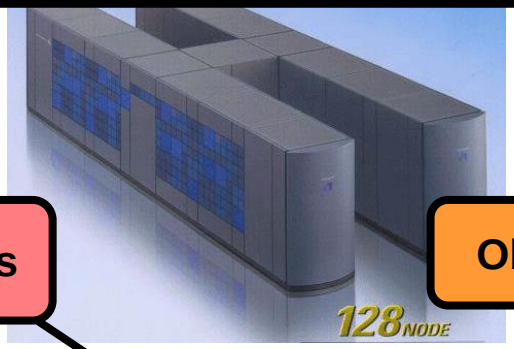
Past

Ocean General Circulation Model (MRI.COM)

Prediction

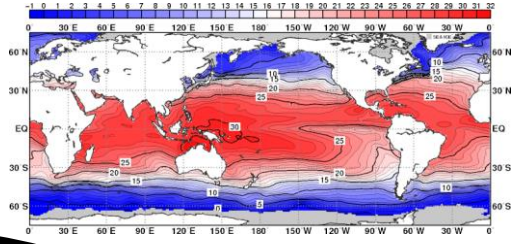
Future

IAU (Incremental Analysis Update)



First Guess

Objective Analysis

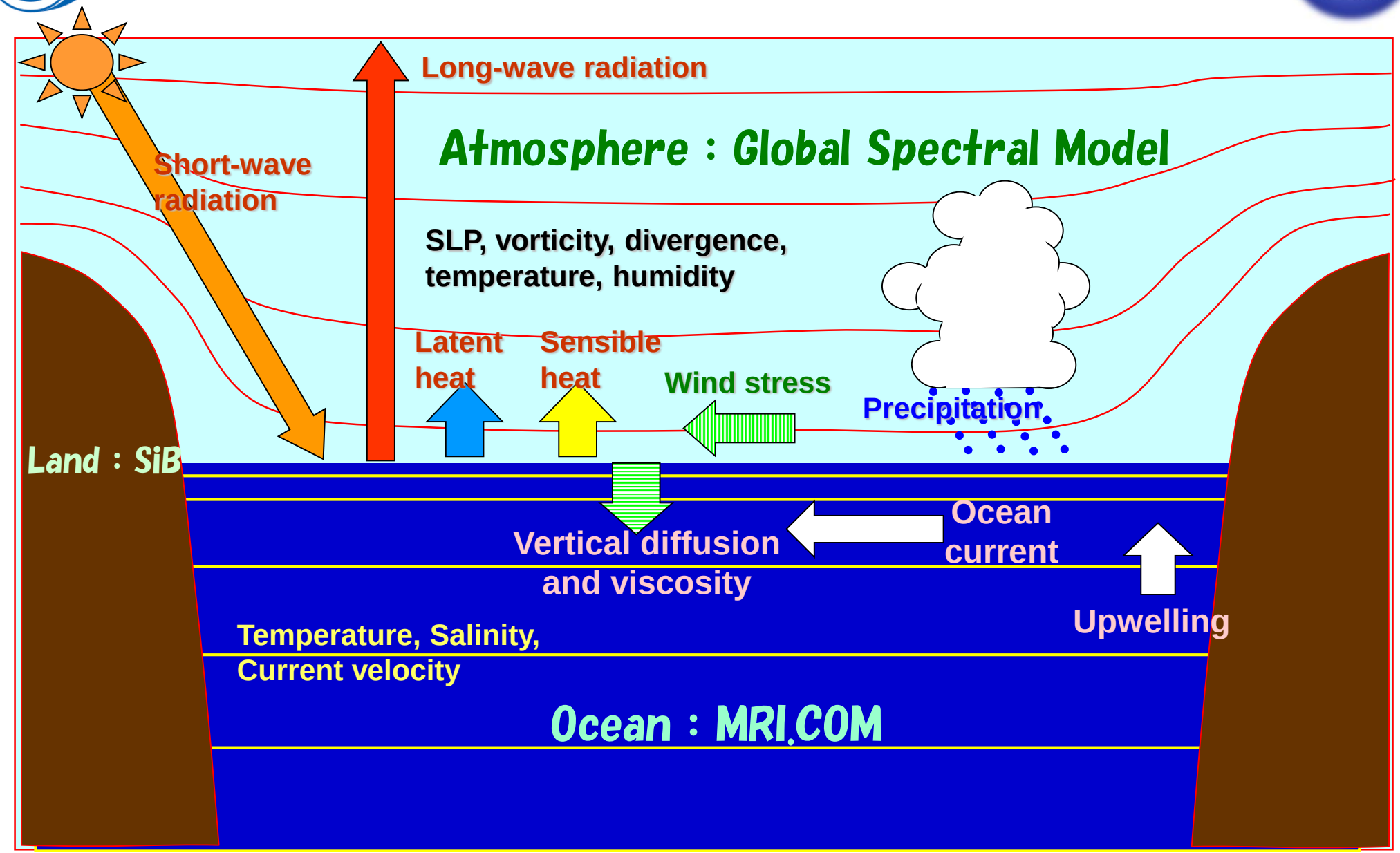


Observations
- Temperature
- Salinity
- Sea surface height

3-D Variational Method

3DVAR: An analysis method for seeking for the physically-consistent optimal data field that is expected to have the least deviation from the true value based upon statistical assumptions.

Atmosphere-Ocean coupled prediction model

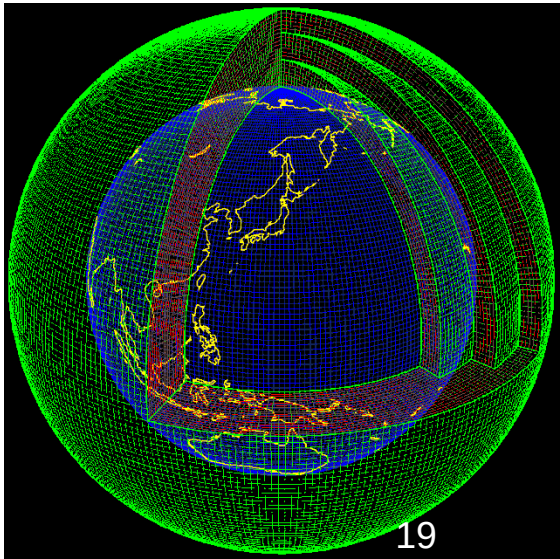


Prediction model specifications

- Atmospheric component : spectral model (T_L159, 60 vertical levels)
  [about 1º]
- Ocean component : grid model (1º x 0.3-0.5º, 52 vertical levels)
- Initial condition :

  [atmosphere] provided by JRA-55 (Japanese 55-year Reanalysis)

  [ocean] provided by MOVE-G2 (ocean data assimilation system)
- Prediction period : up to 7 months ahead
- 51-member ensemble forecast



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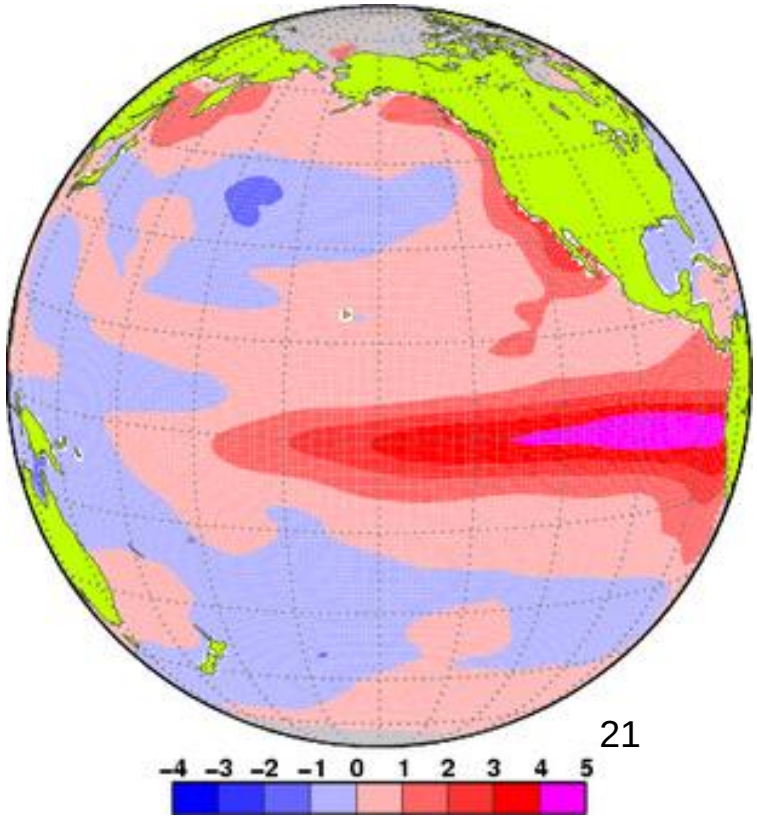
3. JMA's products for El Niño / La Niña phenomena



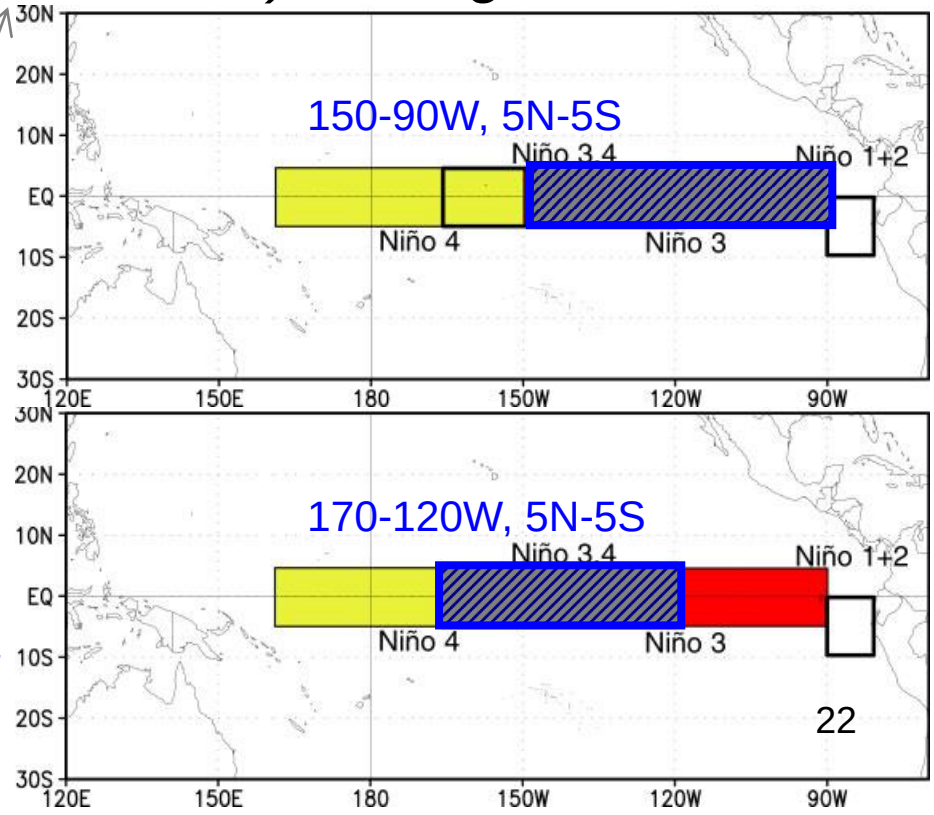
Quantitative definition of El Niño (La Niña) event

- Definition by JMA:

  5-month running mean of NINO.3 SST deviation stays +0.5ºC or higher (-0.5ºC or lower) for 6 consecutive months or longer. NINO.3 SST deviation is defined as deviation from the latest 30-year (e.g. 1988-2017 for the year 2018) average.

ENSO is a long term phenomenon

By using this SST deviation, we remove long term trends such as global warming.



Definition by NOAA

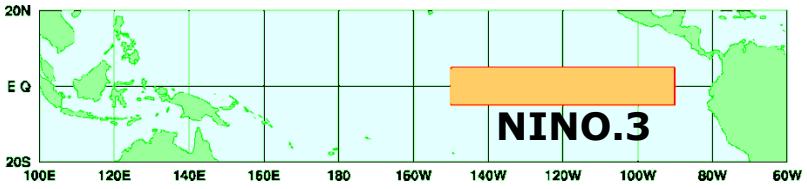
3-month running mean of NINO.3.4 SST deviation from climatological mean stays more than 0.5ºC (less than -0.5ºC) for the consecutive period longer than 5 months.

Definitions of terms

Climatological average …. Time mean from 1981 to 2010 (modified every 10 years)

Anomaly …. Deviation from the climatological average

(NINO.3 SST) deviation…. Deviation from the **latest** 30-year average (modified every year)
(e.g. 1987-2016 for 2017)
(e.g. 1988-2017 for 2018)



Remove trend of global warming

Historical look at NINO.3 SST variations

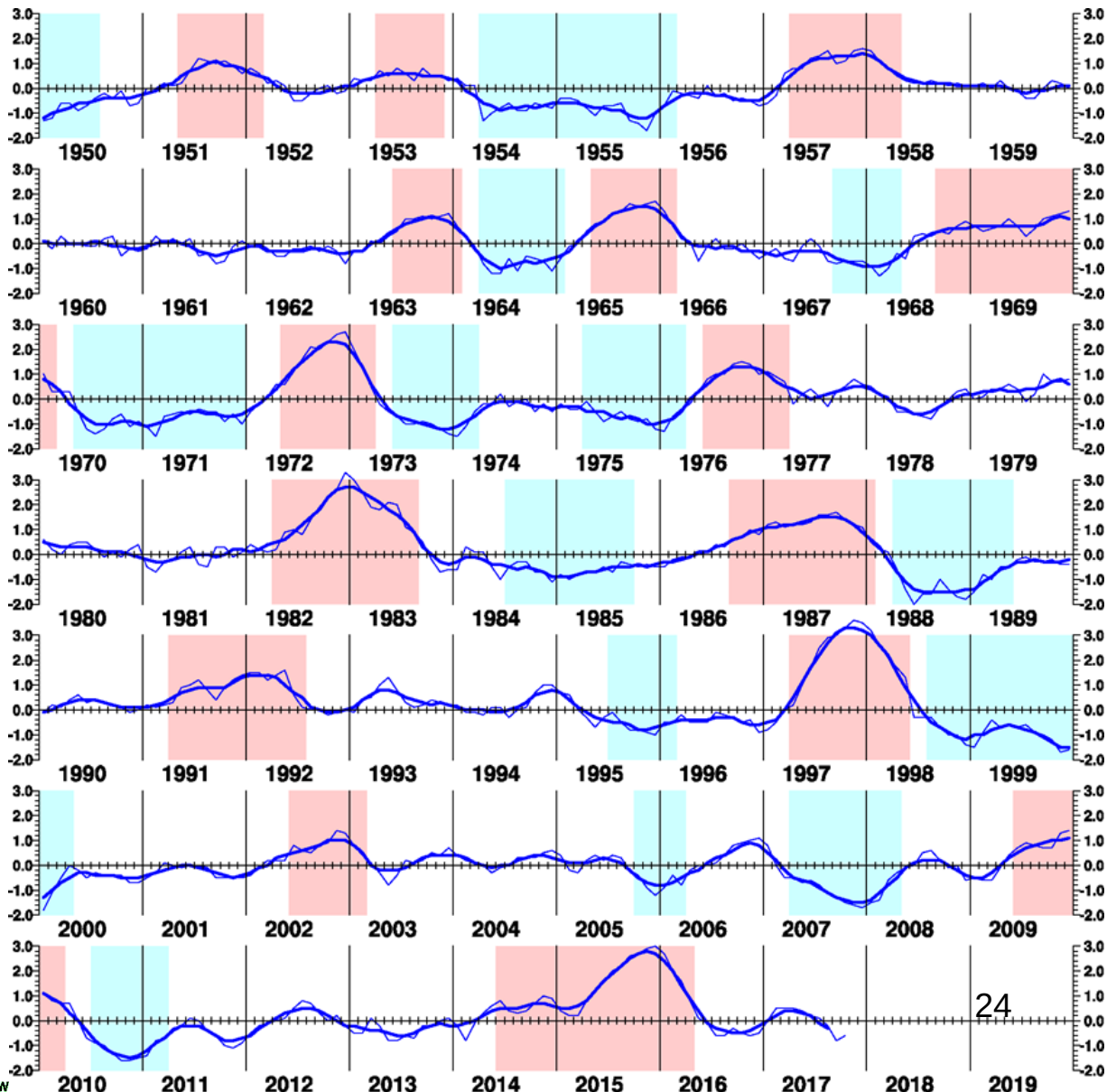
Periods of El Niño and La Niña events by JMA's definition (1950-2017)

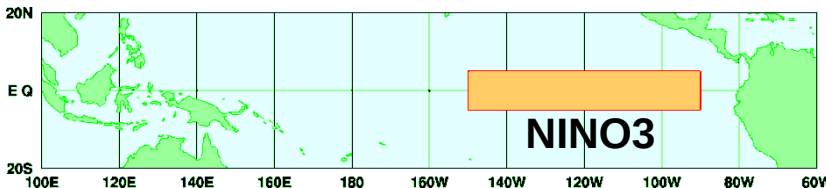
Thin line: monthly NINO.3 SST deviation from the latest 30-year average

Thick line: 5-month running mean

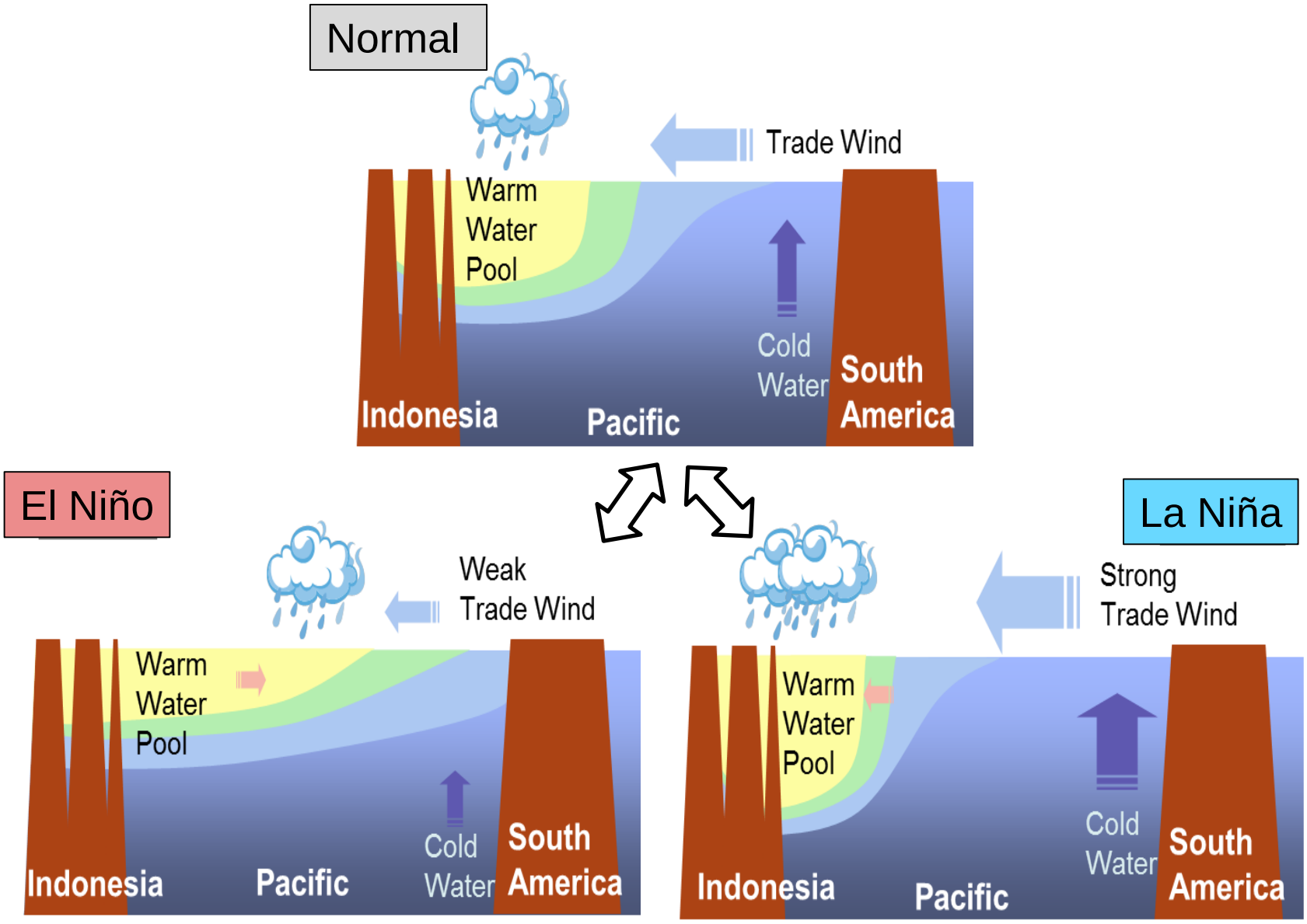
Red shade: El Niño period (15)

Blue shade: La Niña period (14)

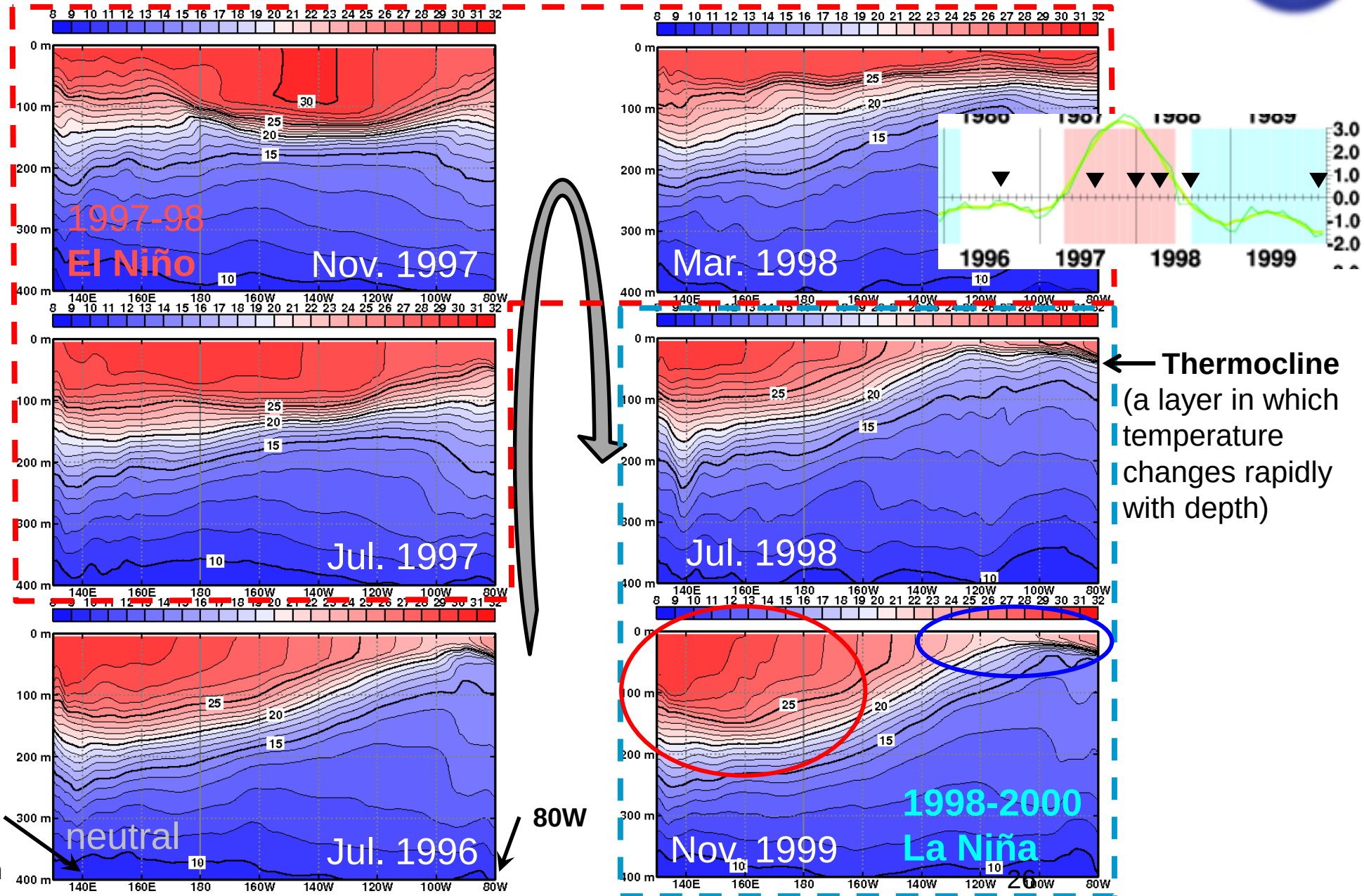




El Niño and La Niña event



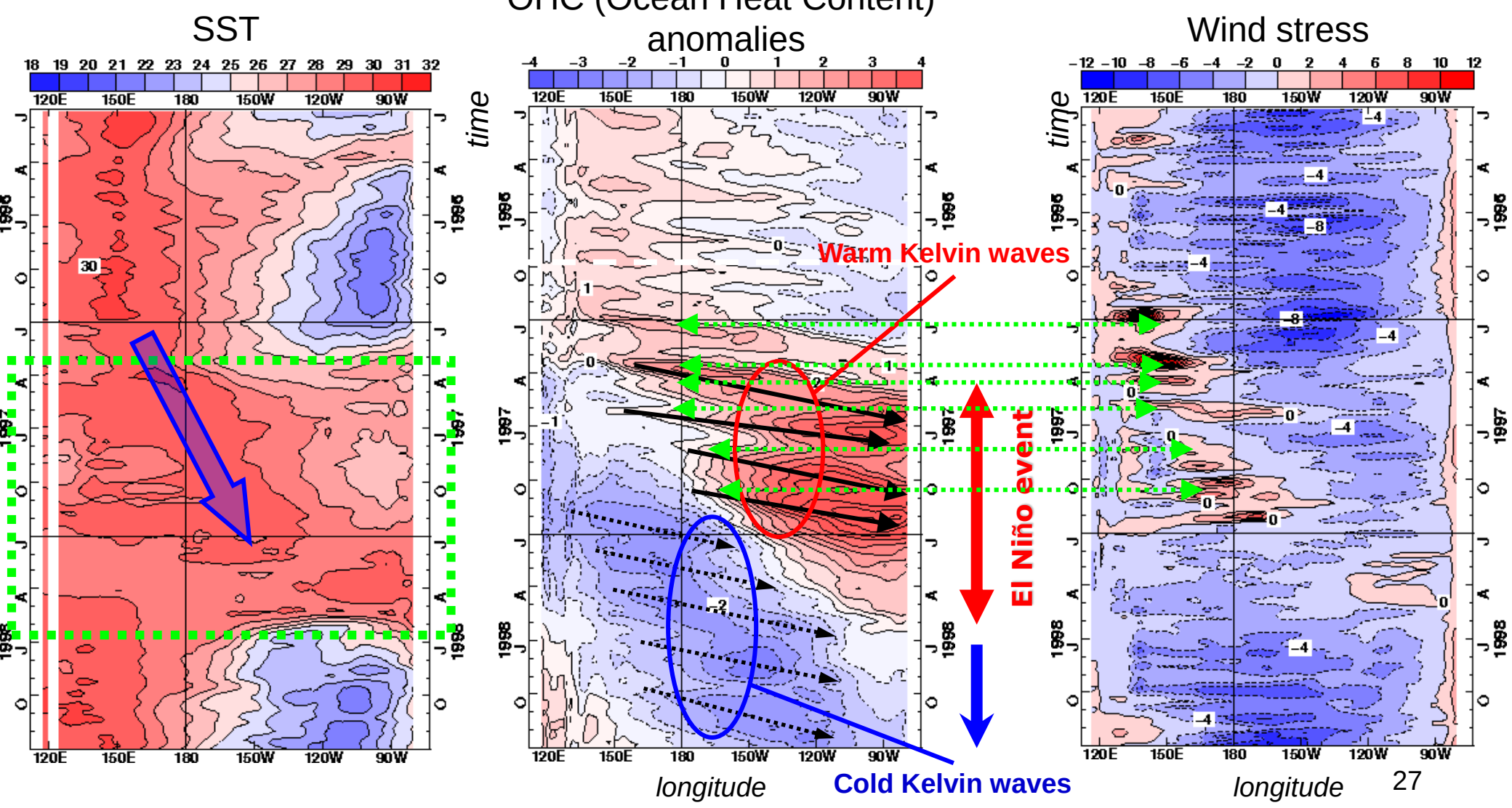
1997-98 El Niño event



Thermocline
(a layer in which temperature changes rapidly with depth)

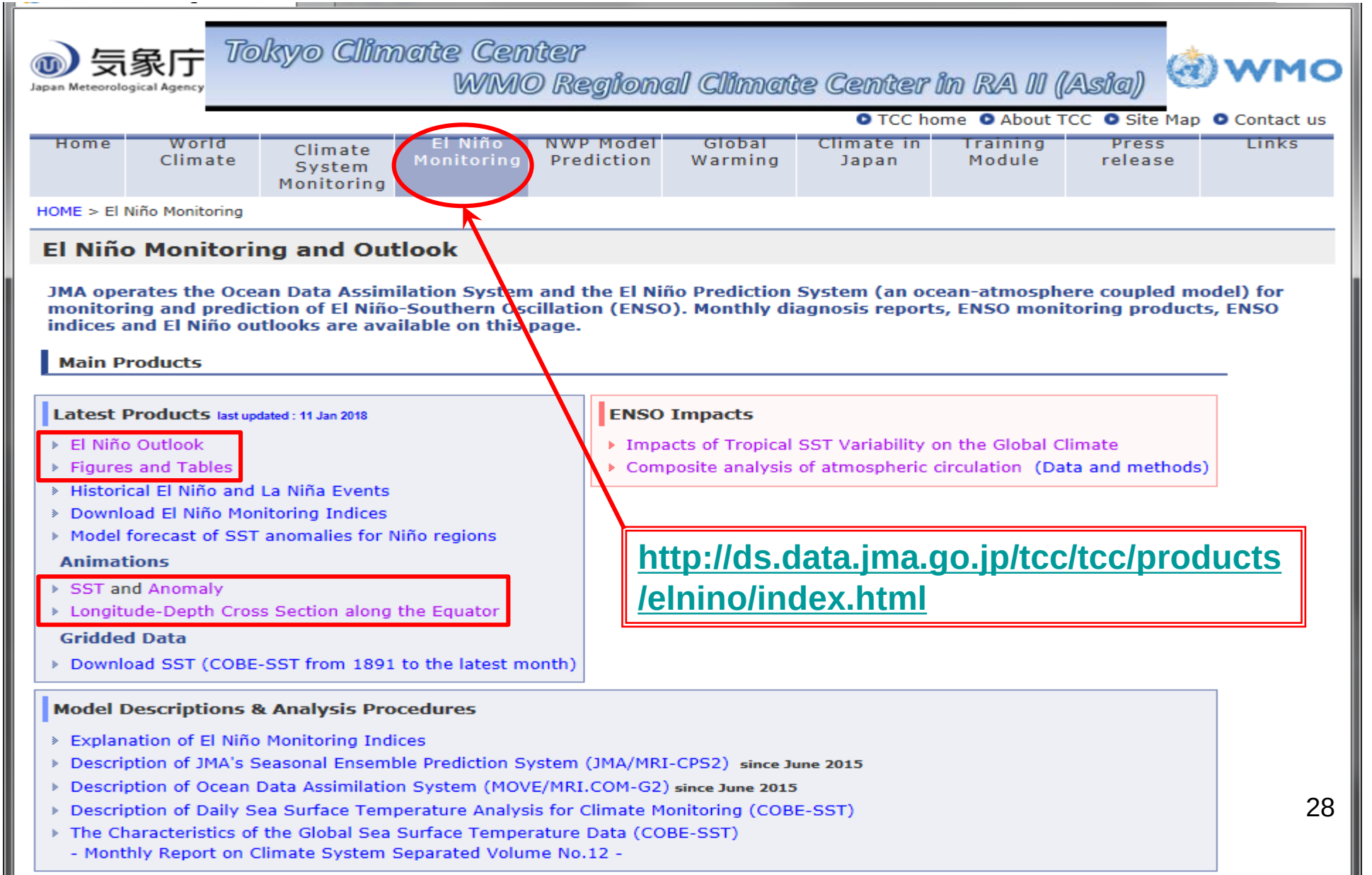
1997-98 El Niño event

Hövmoeller diagram (Longitude-time section) in equatorial Pacific



OHCs are defined as vertically averaged temperatures from sea surface to 300m depth.

TCC Website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Japan Meteorological Agency
Tokyo Climate Center
WMO Regional Climate Center in RA II (Asia)
WMO
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World Climate
Climate System Monitoring
El Niño Monitoring
NWP Model Prediction
Global Warming
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El Niño Monitoring and Outlook
JMA operates the Ocean Data Assimilation System and the El Niño Prediction System (an ocean-atmosphere coupled model) for monitoring and prediction of El Niño-Southern Oscillation (ENSO). Monthly diagnosis reports, ENSO monitoring products, ENSO indices and El Niño outlooks are available on this page.
Main Products
Latest Products last updated : 11 Jan 2018
El Niño Outlook
Figures and Tables
Historical El Niño and La Niña Events
Download El Niño Monitoring Indices
Model forecast of SST anomalies for Niño regions
Animations
SST and Anomaly
Longitude-Depth Cross Section along the Equator
Gridded Data
Download SST (COBE-SST from 1891 to the latest month)
ENSO Impacts
Impacts of Tropical SST Variability on the Global Climate
Composite analysis of atmospheric circulation (Data and methods)
http://ds.data.jma.go.jp/tcc/tcc/products/elnino/index.html
Model Descriptions & Analysis Procedures
Explanation of El Niño Monitoring Indices
Description of JMA's Seasonal Ensemble Prediction System (JMA/MRI-CPS2) since June 2015
Description of Ocean Data Assimilation System (MOVE/MRI.COM-G2) since June 2015
Description of Daily Sea Surface Temperature Analysis for Climate Monitoring (COBE-SST)
The Characteristics of the Global Sea Surface Temperature Data (COBE-SST)
- Monthly Report on Climate System Separated Volume No.12 -

El Niño Outlook

HOME > El Niño Monitoring > El Niño Outlook http://ds.data.jma.go.jp/tcc/tcc/products/elnino/ocean/index_tcc.html

El Niño Outlook (January 2018 - July 2018)

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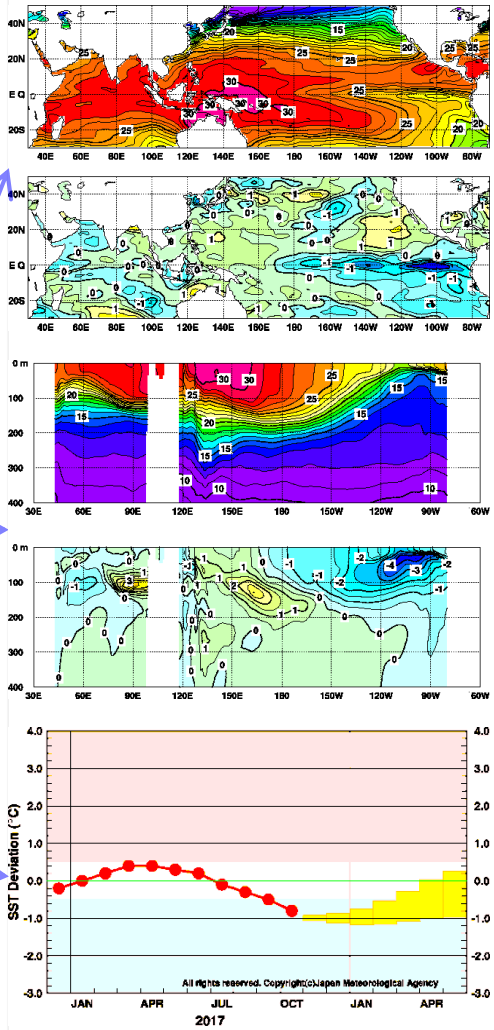


Figures in El Niño Outlook

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

El Niño Monitoring and Outlook

11 January 2018

Produced by Climate Prediction Division, Japan Meteorological Agency
E-mail: tcc@met.kishou.go.jp

El Niño Outlook

- Fig.1) Five-month running mean of the SST deviation for NINO.3 predicted by JMA's El Niño prediction model (JMA/MRI-CGCM2).
- Fig.2) ENSO Forecast Probabilities based on JMA/MRI-CGCM2.

El Niño Monitoring

The latest analysis of oceanic and atmospheric conditions in the equatorial Pacific is shown in Table and Figs. 3-10. This analysis is produced routinely by the Japan Meteorological Agency. Figs. 5 and 7 are based on the ocean data assimilation system (MOVE/MRI.COM-G2) of JMA.

- Table) El Niño Monitoring Indices
- Fig.3) Time series of sea surface temperature (SST) deviations for NINO.3, NINO.WEST, and IOBW, and the Southern Oscillation Index.
- Fig.4) Monthly mean SST and anomalies in the Pacific and Indian Oceans.
- Fig.5) Depth-longitude cross sections of temperatures and anomalies along the equator in the Indian and Pacific Oceans by ocean data assimilation system.
- Fig.6) Time-longitude cross section of SST anomalies along the equator in the Indian and Pacific Oceans.
- Fig.7) Time-longitude cross section of ocean heat content (OHC; vertically averaged temperature in the top 300 m) anomalies.
- Fig.8) OLR and Equatorial Zonal Wind Indices.
- Fig.9) Monthly-mean Outgoing Longwave Radiation (OLR) and anomalies.
- Fig.10) Time-longitude cross sections of velocity potential anomalies at 200 hPa and zonal wind anomalies at 850 hPa along the equator.

Model Predictions of ENSO monitoring indices

Model predictions of SST deviations from the climatological reference based on the latest sliding 30-year period for NINO.3, NINO.WEST, and IOBW are presented in Fig.11, Fig.12, and Fig.13, respectively. This outlook is produced based on JMA's El Niño prediction model (JMA/MRI-CGCM2). The JMA official announcement is produced by considering not only the results of the prediction model, but also the analysis of the latest atmosphere-ocean conditions.

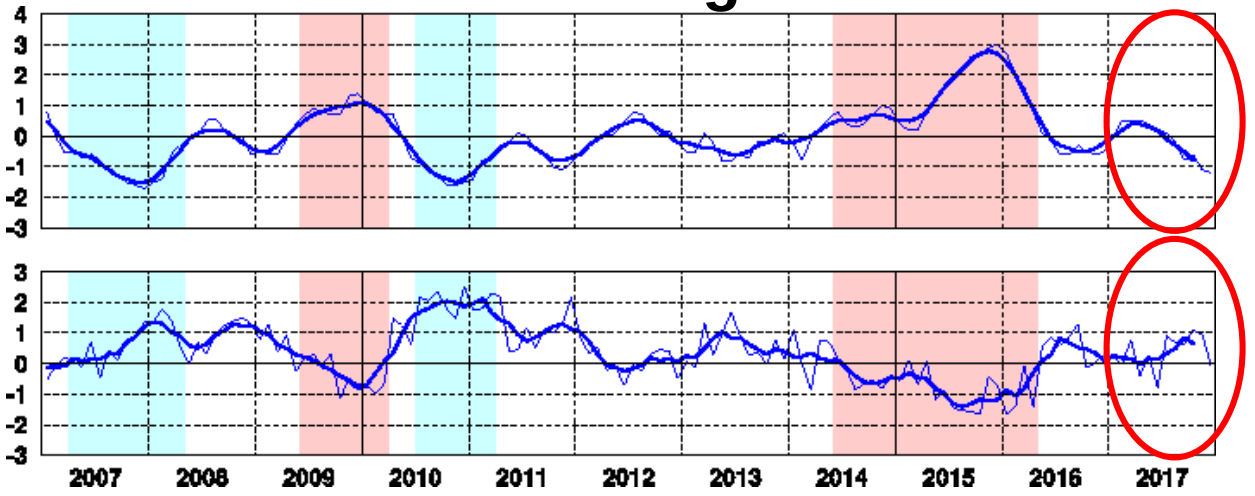
- Fig.11) Outlook of the SST deviation for NINO.3 by the El Niño prediction model.
- Fig.12) Outlook of the SST deviation for NINO.WEST by the El Niño prediction model.
- Fig.13) Outlook of the SST deviation for IOBW by the El Niño prediction model.

ENSO monitoring indices

NINO.3 SST and SOI
(JMAs El Niño Outlook **Fig. 3** the 1st and 2nd panel)

NINO.3

SOI

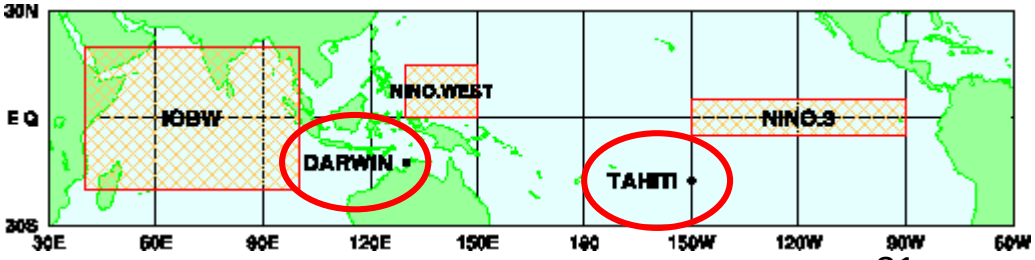


Thin lines indicate a monthly mean value,
and smoothed thick curves, a 5-month running mean.

Red shade: El Niño event above 0.5℃

Blue shade: La Niña event below -0.5℃

In JMA, **SOI** is defined as normalized difference between normalized SLP anomalies at Darwin and Tahiti.



ENSO monitoring indices

NINO.3 SST deviations and SOIs
(JMAs El Niño Outlook **Table**: El Niño Monitoring Indices)

	2017											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Monthly mean SST (℃)	25.6	26.9	27.6	28.0	27.5	26.7	25.9	24.9	24.2	24.4	24.0	24.0
SST deviation (℃)	0.0	+0.5	+0.5	+0.5	+0.4	+0.2	+0.1	-0.2	-0.8	-0.6	-1.1	-1.2
5-month mean (℃)	0.0	+0.2	+0.4	+0.4	+0.3	+0.2	-0.1	-0.3	*-0.5*	*-0.8*	not yet	not yet
SOI	+0.2	0.0	+0.8	-0.4	+0.3	-0.8	+0.9	+0.7	+0.6	+1.1	+1.0	-0.1

negative anomaly

Months that meet the definition of La Niña by JMA **:**

5-month running mean of NINO.3 SST deviation stays
-0.5ºC or lower for 6 consecutive months or longer → La Niña

Figures in Oceanographic Condition

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

HOME > El Niño Monitoring > Figures of Oceanographic Condition

Not in the menu in the top page of El Niño monitoring

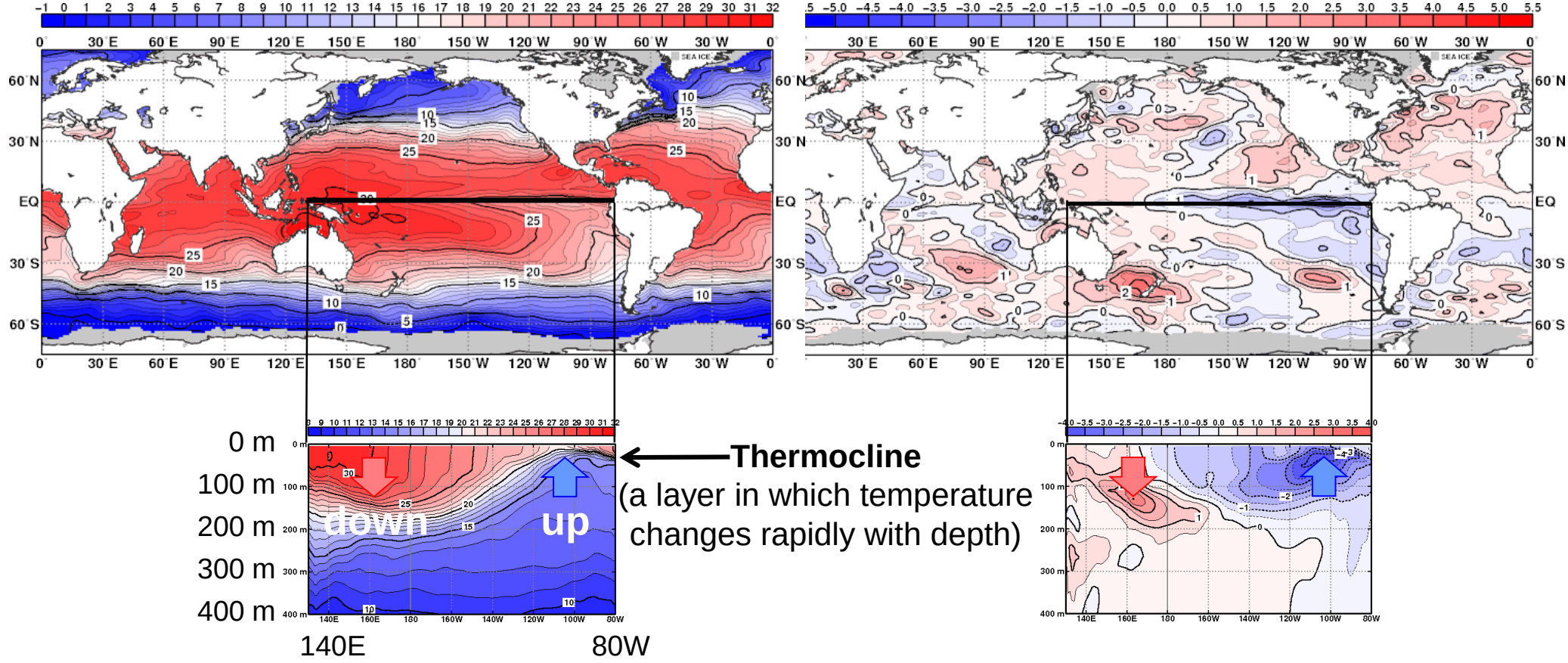
Figures of Oceanographic Condition

Global	Monthly Mean Sea Surface Temperature Monthly Mean Sea Surface Temperature Anomalies 3-Month Mean Sea Surface Temperature 3-Month Mean Sea Surface Temperature Anomalies
The equatorial Pacific	Sea Surface Temperature and Anomalies along the Equator (Time - Longitude) Temperature and Anomalies along the Equator (Depth - Longitude) Sub-surface Temperature along the Equator (Depth - Time) 20°C Depth and Anomalies along the Equator (Time - Longitude) Ocean Heat Content and Anomalies along the Equator (Time - Longitude) Ocean Heat Content and Anomalies along 6°N (Time - Longitude) Ocean Heat Content and Anomalies along 6°S (Time - Longitude) Surface Zonal Wind Stress and Anomalies along the Equator (Time - Longitude)

Monthly Mean Sea Surface Temperature (SST)

(left) and Anomalies (right) in December 2017

[similar to JMAs El Niño Outlook Fig. 4, different in color]



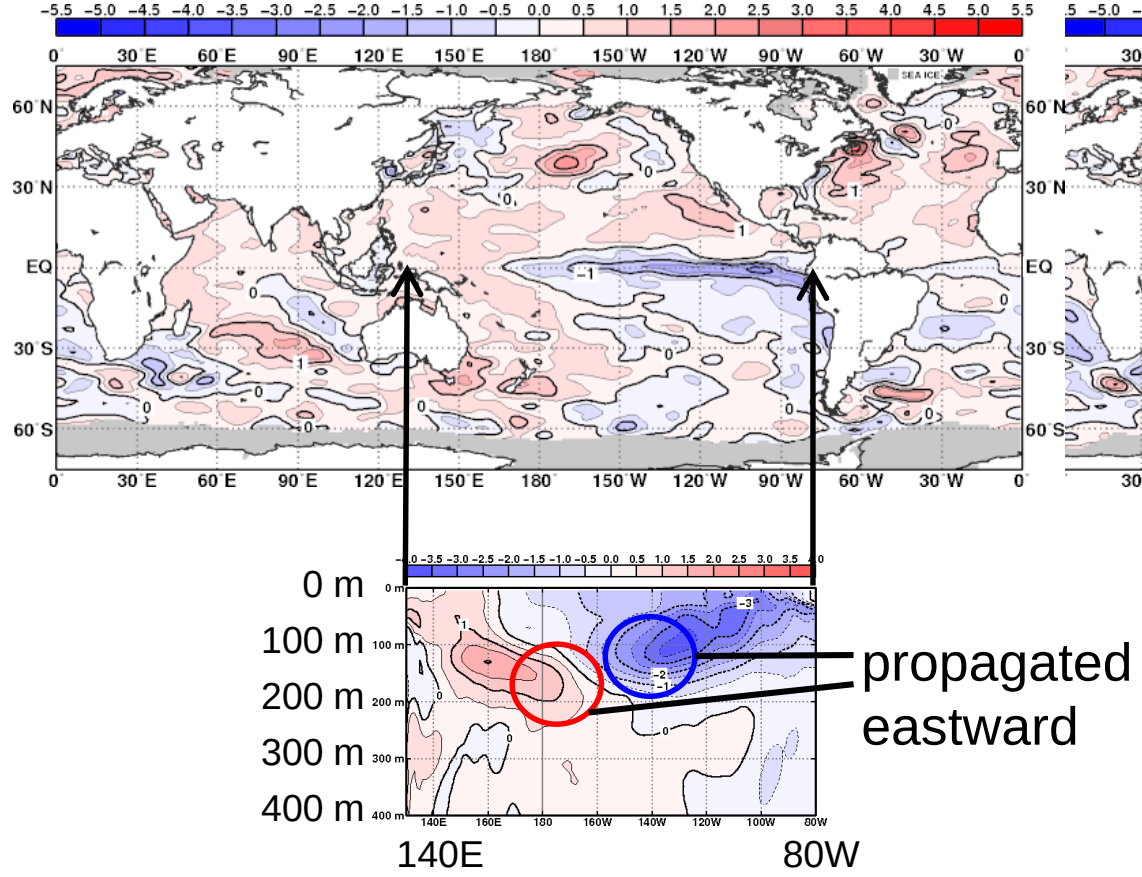
Bottom: Depth-Longitude Cross Sections of Temperature (left) and Anomalies (right) along the Equator in the Pacific Ocean

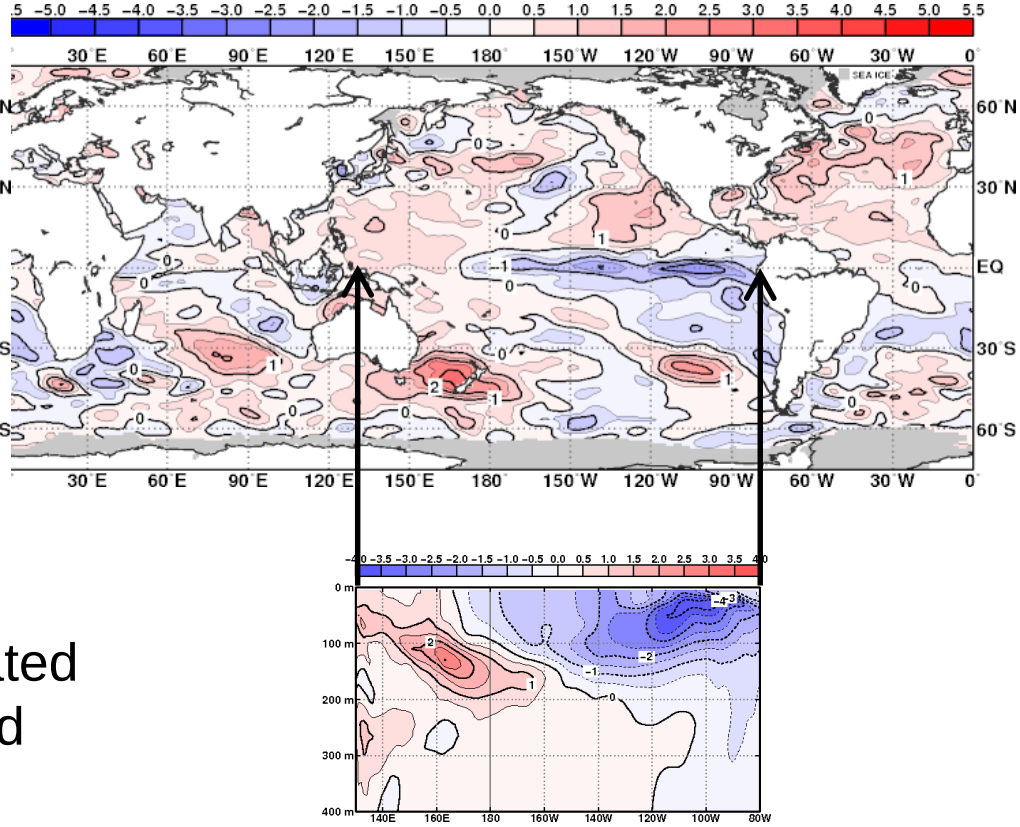
[similar to JMAs El Niño Outlook Fig. 3, different in color]

Monthly Mean SST Anomalies

Nov. 2017 **Dec. 2017**

[similar to JMAs El Niño Outlook Fig. 4, different in color]



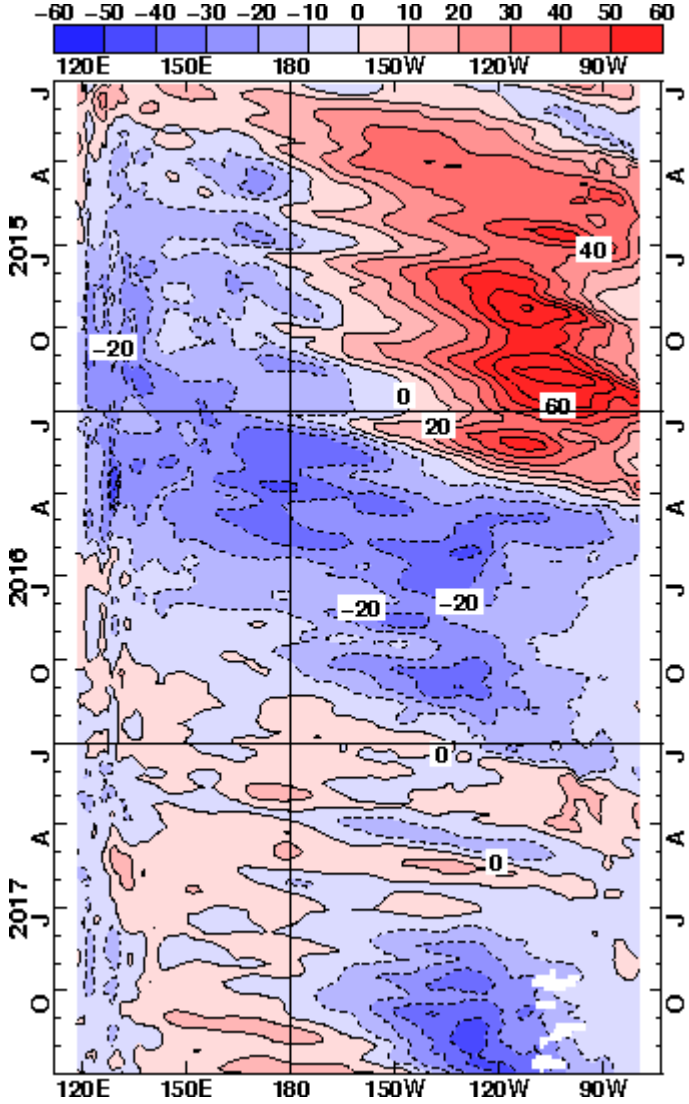


Bottom: Depth-Longitude Cross Sections of Temperature (left) and Anomalies (right) along the Equator in the Pacific Ocean

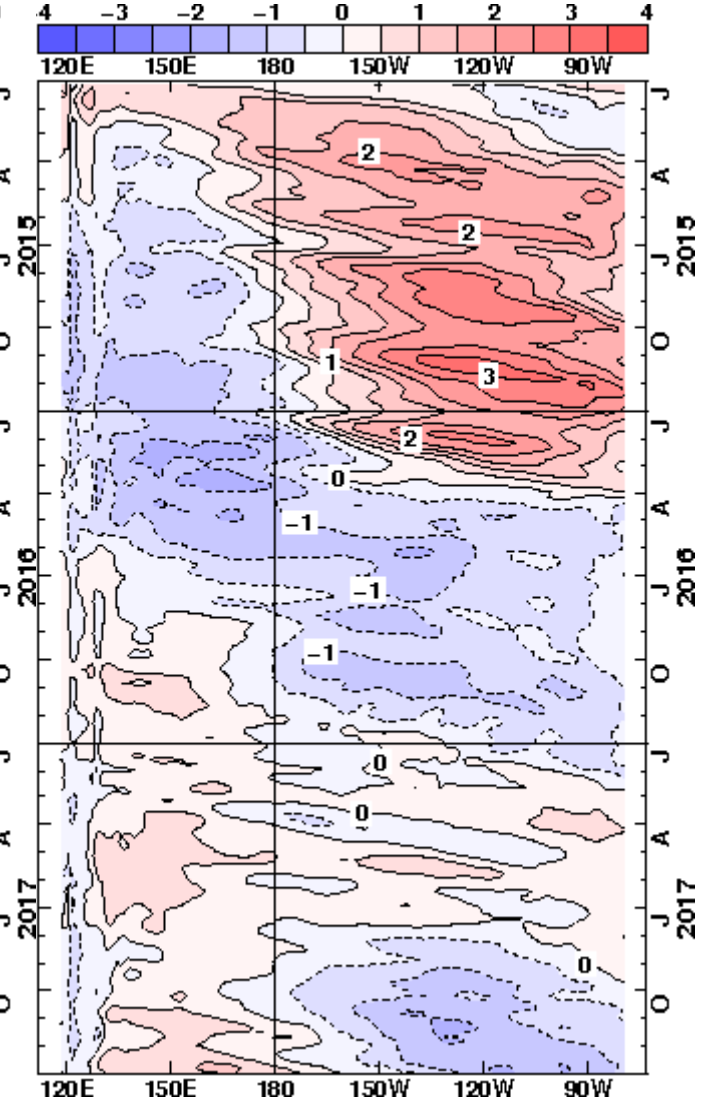
[similar to JMAs El Niño Outlook Fig. 3, different in color]

The latest conditions in the equatorial Pacific Ocean

Depth of the 20℃ Isotherm anomalies



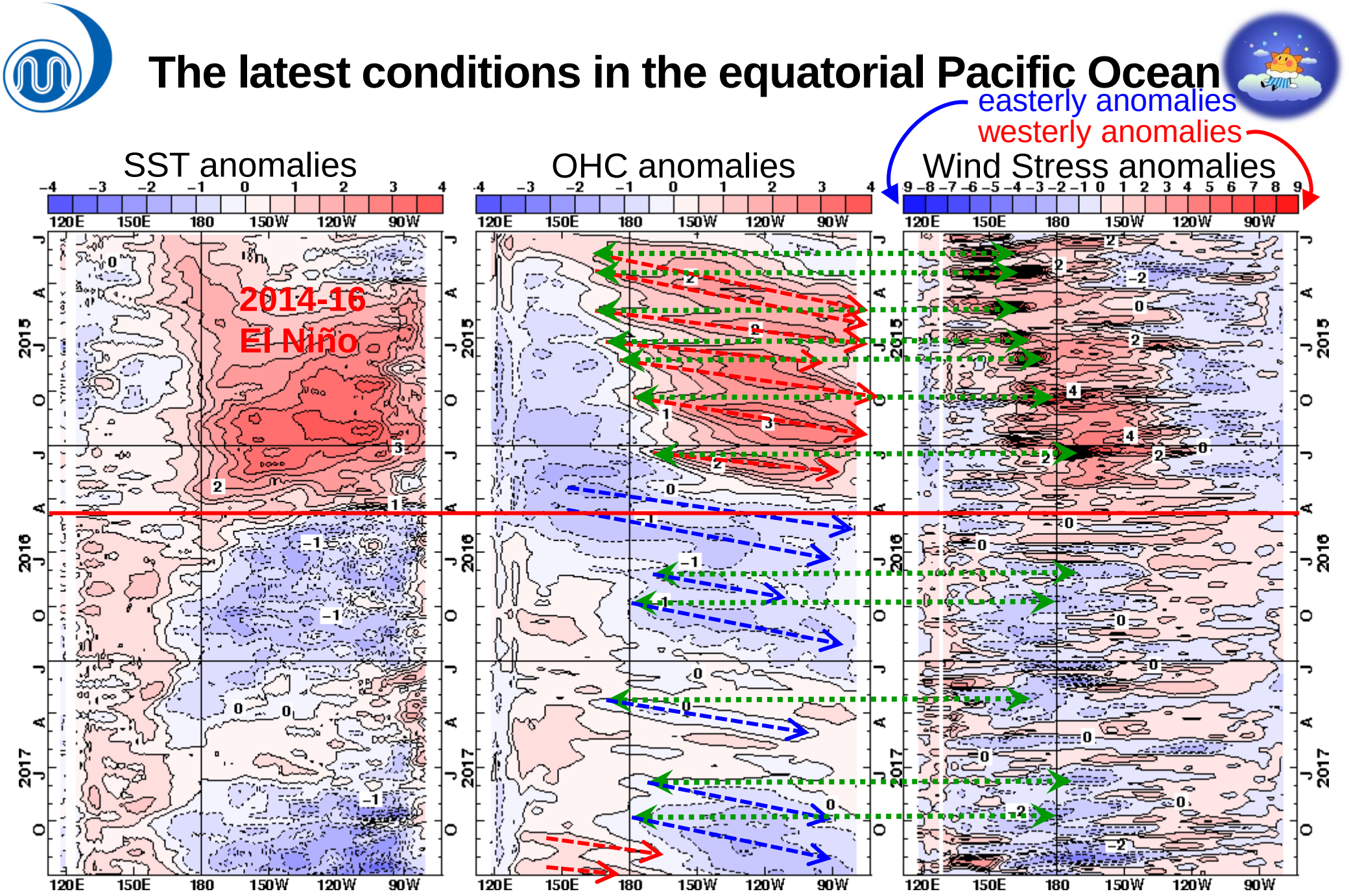
OHC anomalies



Hövmoeller diagram (longitude-time section)

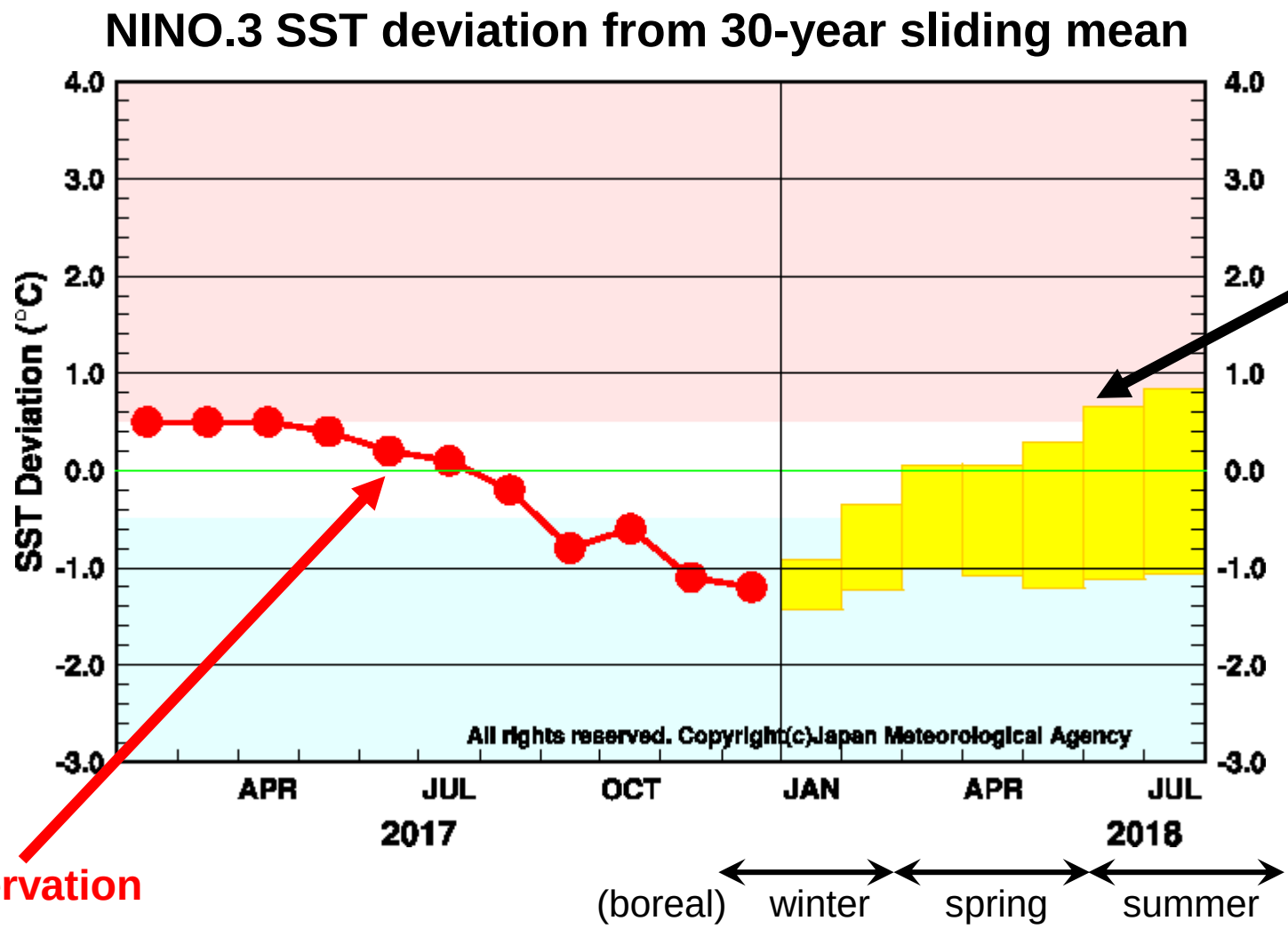
OHC
(Ocean Heat Content) **:**
vertically averaged
temperatures from
sea surface to 300m depth

The latest conditions in the equatorial Pacific Ocean



When will La Niña conditions continue?

The latest model prediction



Each box denotes the range where the SST deviation will be included with the 70% or more probability.

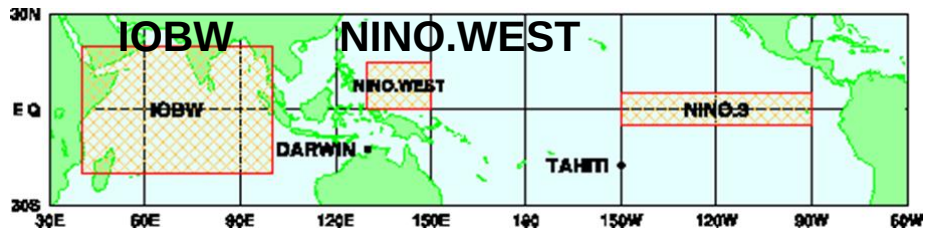
NINO.3 SST will be below normal during boreal winter.

NINO.WEST / IOBW and ENSO

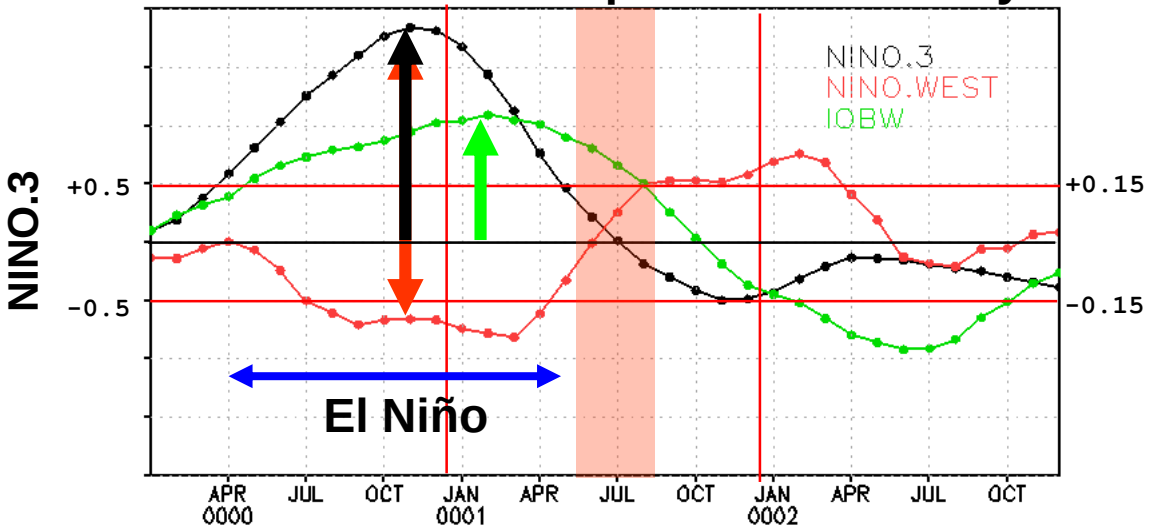
NINO.WEST SST deviation tends to vary with NINO.3, with an opposite sign.

IOBW SST deviation tends to lag about a couple of months behind NINO.3.

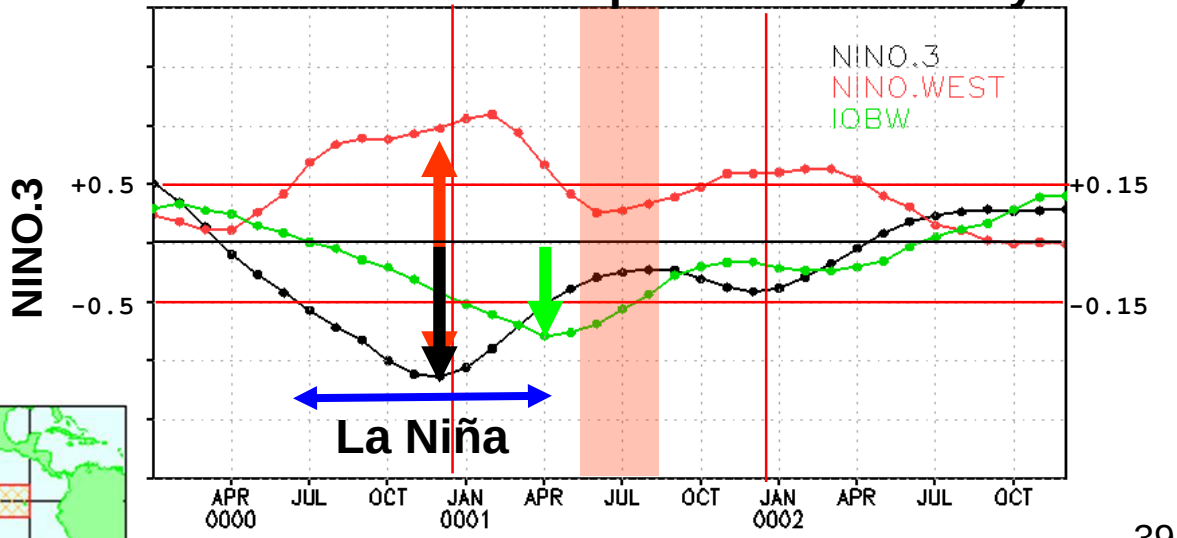
After end of El Niño (La Niña) in spring, IOBW tends to stay above (below) normal in summer.



Time evolution of composite of El Niño years

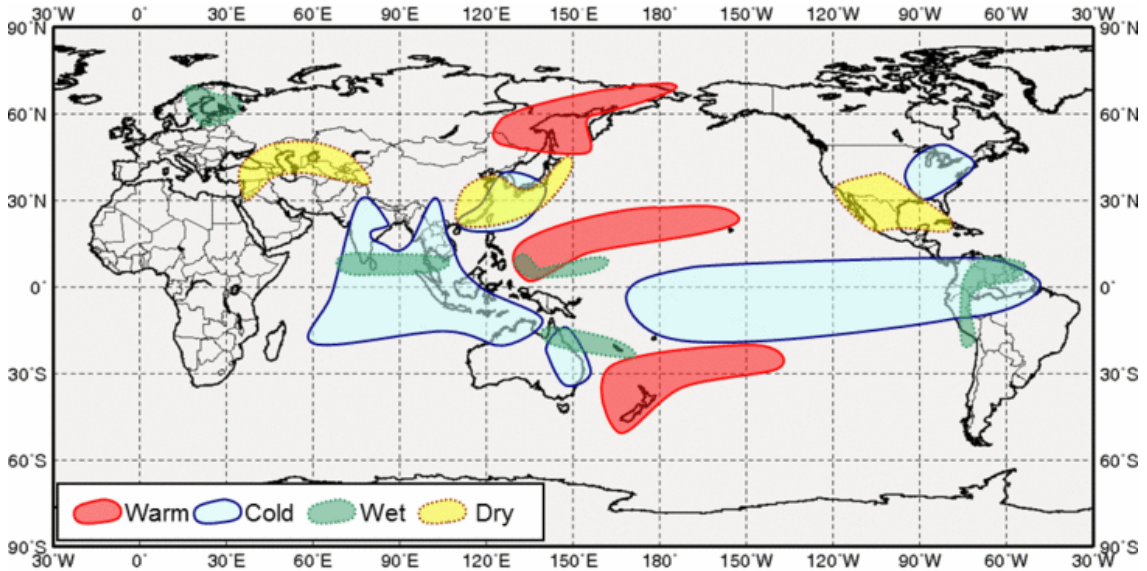


Time evolution of composite of La Niña years

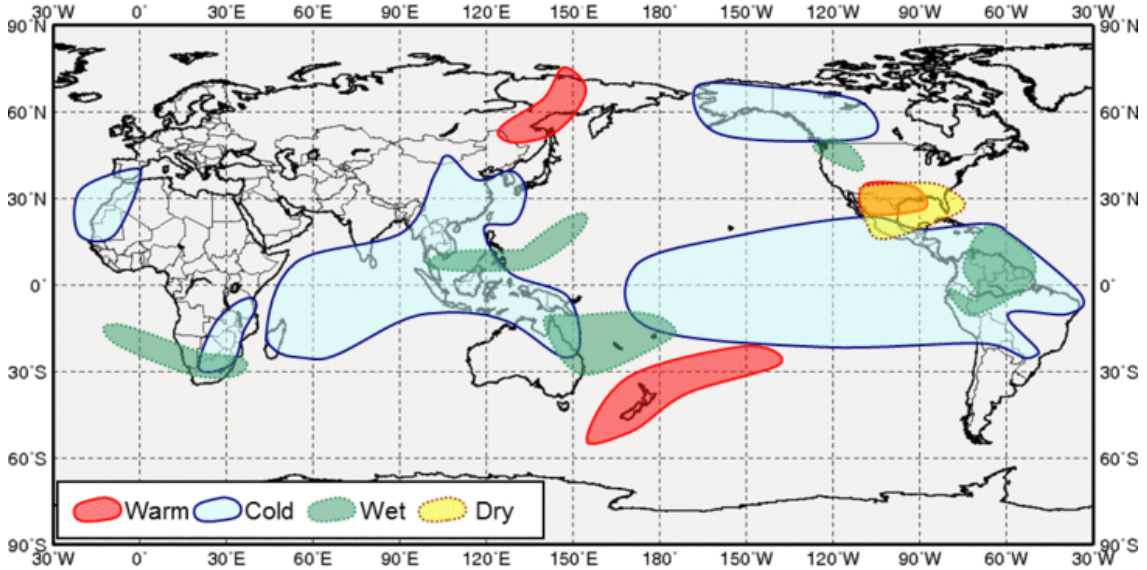


Climate tendency and NINO.WEST SST (DJF)

Climate tendency with above-normal **NINO.WEST SST** in boreal winter

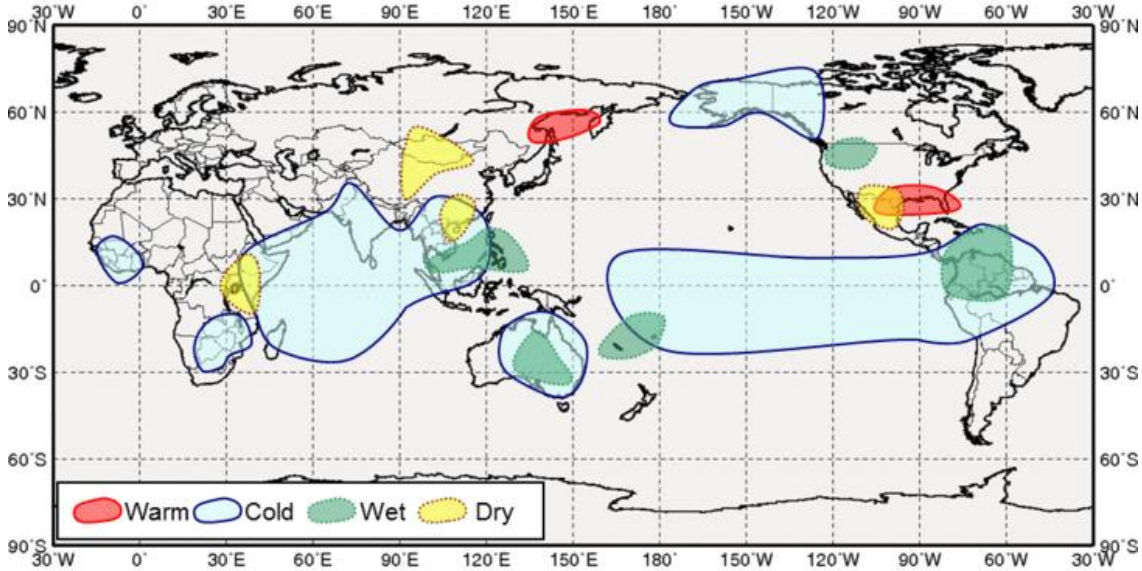


Climate tendency with below-normal **NINO.3 SST** in boreal winter

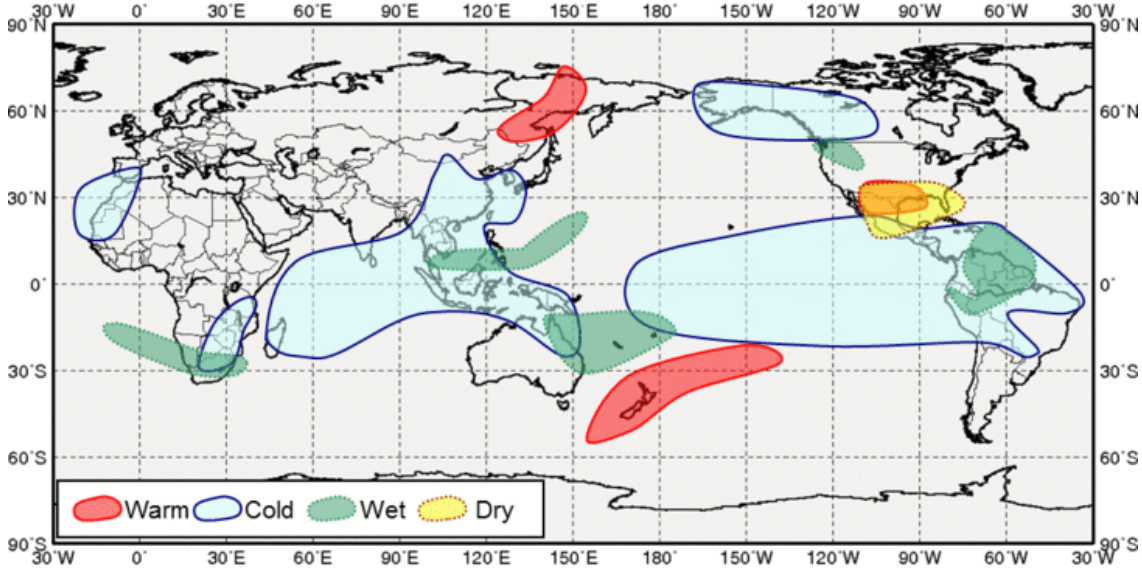


Climate tendency and IOBW SST (DJF)

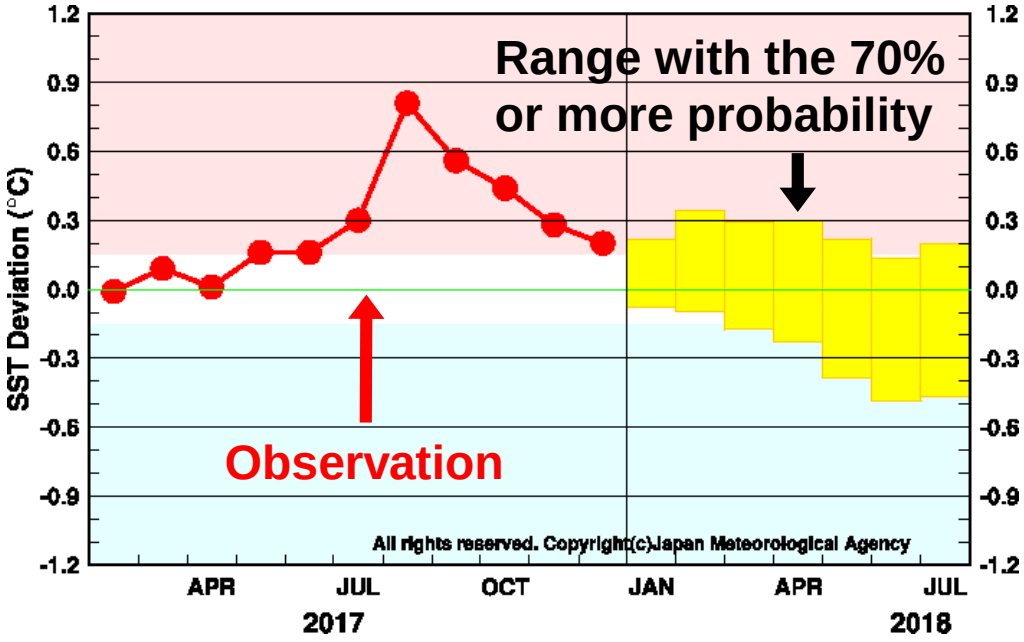
Climate tendency with below-normal **IOBW SST** in boreal winter



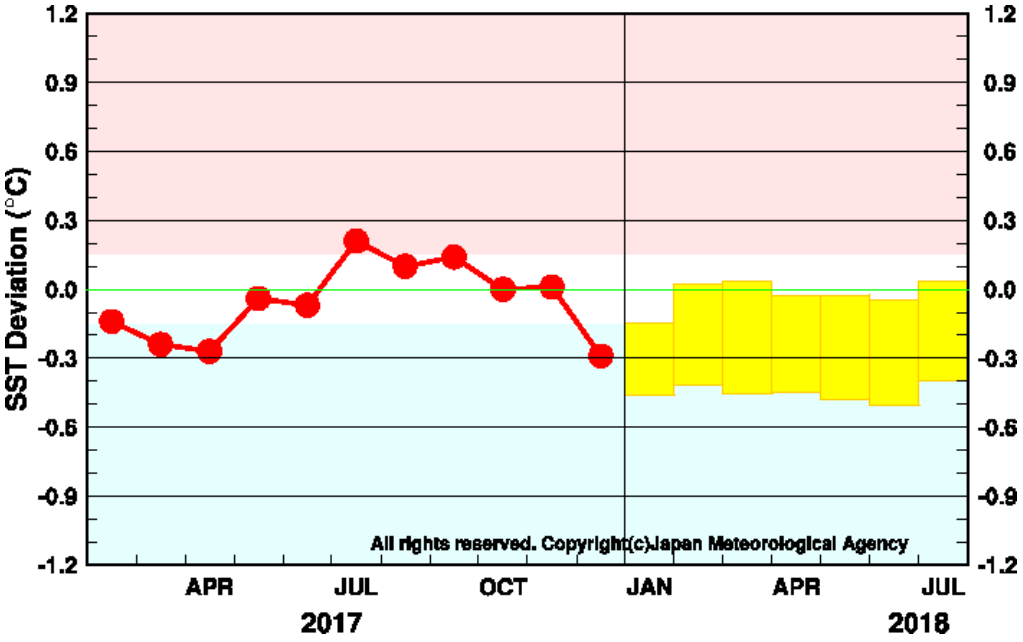
Climate tendency with below-normal **NINO.3 SST** in boreal winter



Prediction of NINO.WEST and IOBW



SST deviations for **NINO.WEST**
after removed the linear trend in 30years



SST deviations for **IOBW**
after removed the linear trend in 30years

It is likely that the **NINO.WEST** SST will come gradually closer to normal until boreal spring.
It is likely that **IOBW** SST will be below normal until boreal spring.