気象庁
Japan Meteorological Agency

TCC seminar,
16:15–18:00, 29 January 2018,
14:15–16:45, 30 January 2018,
Tokyo, Japan

# An introduction to iTacs

## - Interactive Tool for Analysis of the Climate System -

Hirotaka Sato
& Staff Members of Tokyo Climate Center

Tokyo Climate Center
Japan Meteorological Agency

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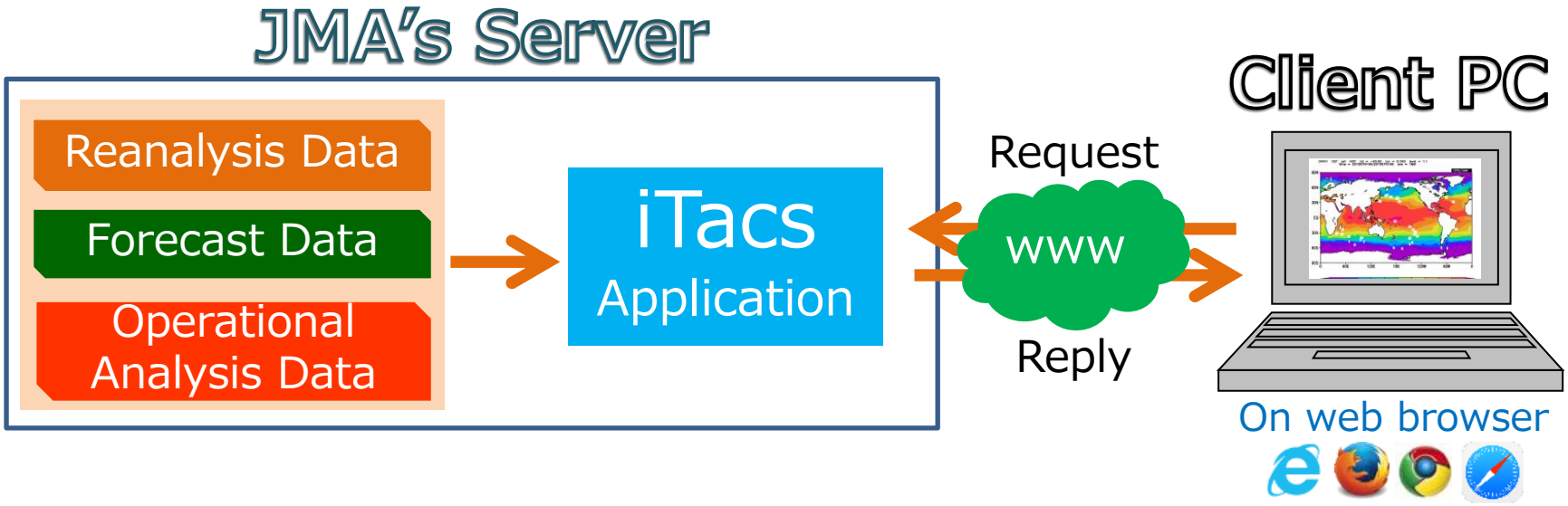
Basic
29 Jan.

Advanced
30 Jan.

# What's iTacs?

- iTacs stands for "Interactive Tool for Analysis of the Climate System".
- Available on web browsers through Graphical User Interface (GUI) with personal IDs.
- Only NMHS staff can use iTacs.
- No additional software or plug-ins are required in user's client PCs.



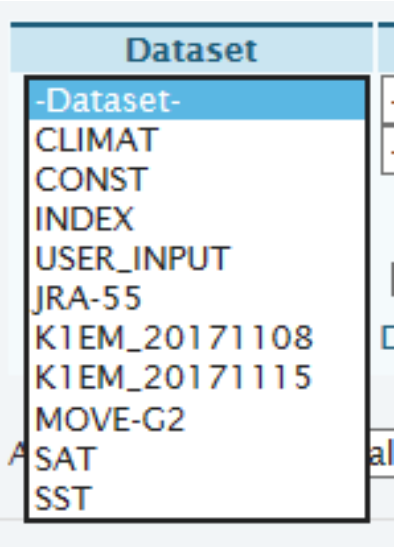
# Available dataset and period

| Atmospheric analysis dataset | | |
|---|---|---|
| JRA-55 | 1958～ | The Japanese 55-year Reanalysis |
| SAT | 1979～ | NOAA's outgoing longwave radiation (OLR) |

| Oceanographic analysis dataset | | |
|---|---|---|
| SST | 1891～ | Sea surface temperature (COBE-SST) |
| MOVE-G2 | 1958～ | Data assimilation by MOVE/MRI.COM-G2 |

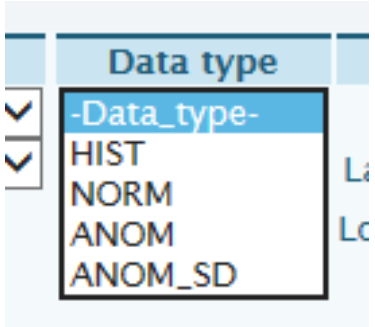
| Forecast dataset |
|---|
| JMA's one-month prediction model output |

| Other dataset | |
|---|---|
| INDEX | ENSO index (NINO.3 etc.) |
| CLIMAT | Monthly CLIMAT reports |
| USER-INPUT | Text data input by user |

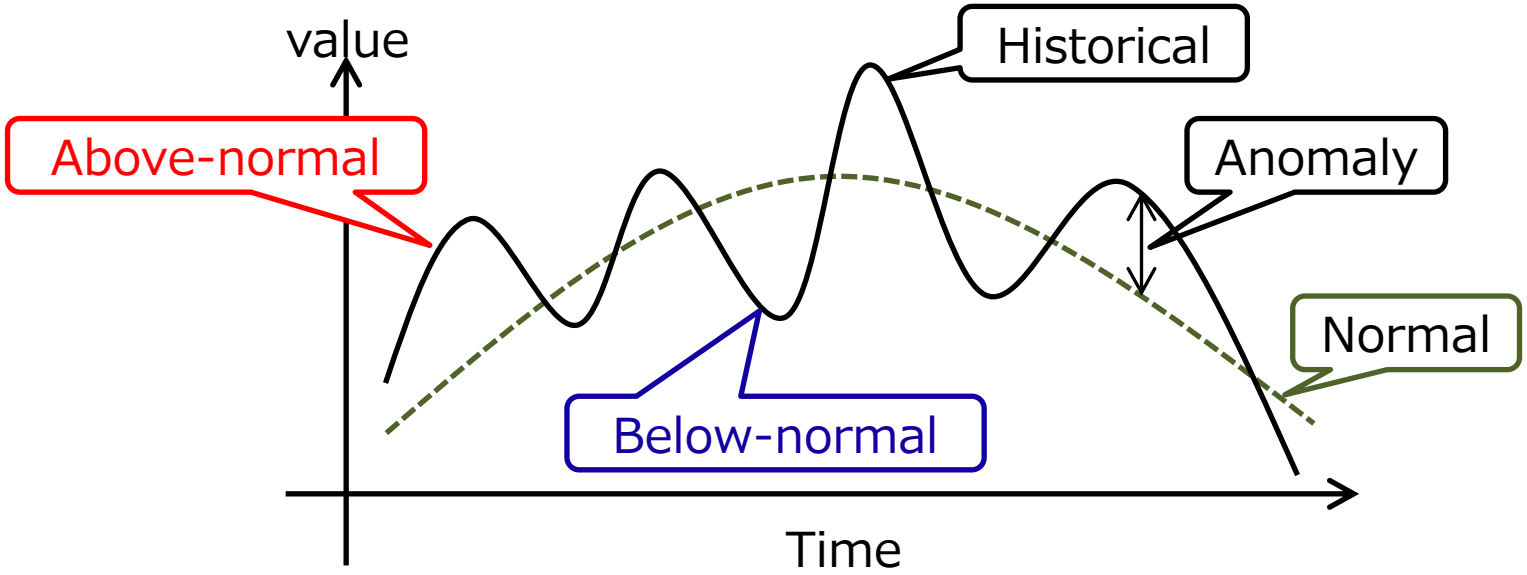


# Available data type

- Various data types are available to perform climate diagnosis.

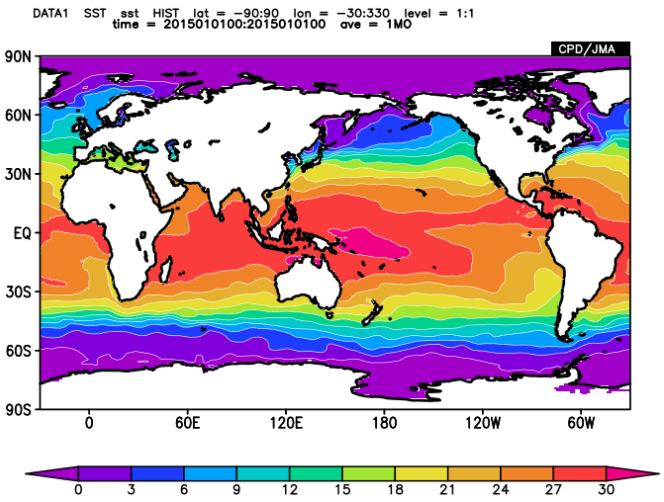



| | |
|---|---|
| **HIST** | Historical actual analysis or observation data |
| **NORM** | Climatological normal data (averaged from 1981 to 2010) |
| **ANOM** | Anomaly data (difference from the climatological normal) |

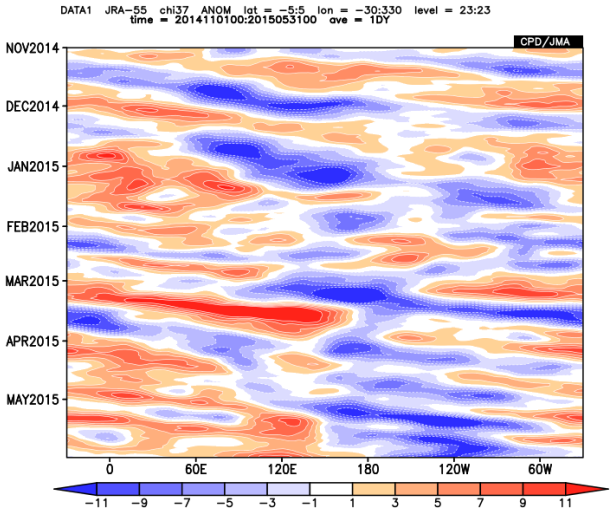


# Samples of charts

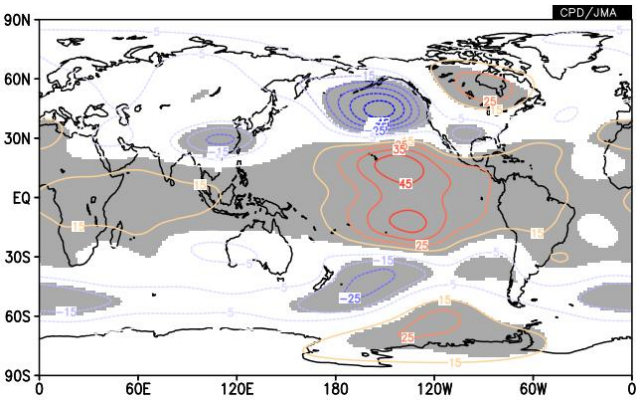
- Various types of charts and statistical analyses are available on iTacs.



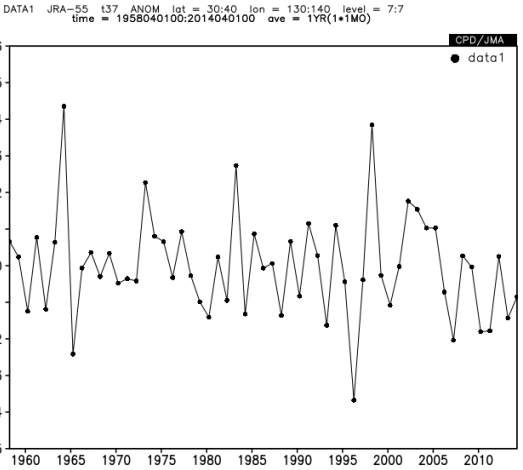

**2-dimensional map**




**Cross section diagram**



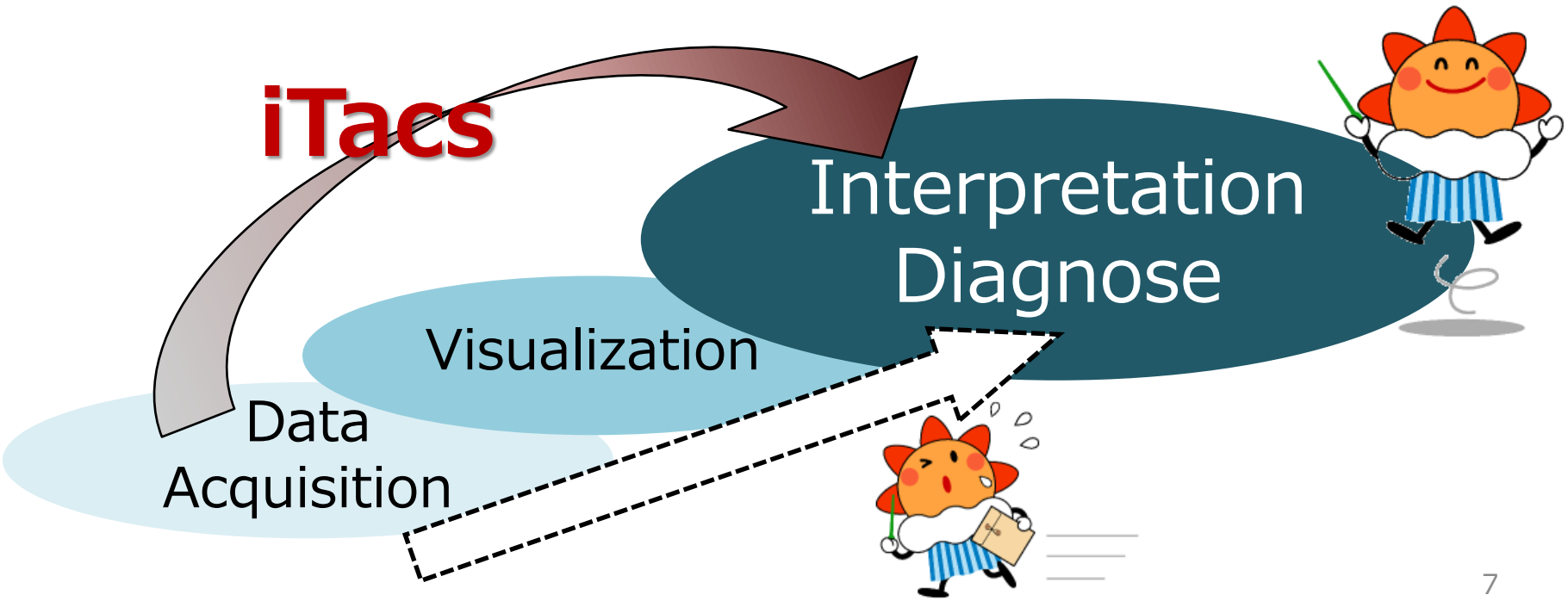

**Regression/Correlation and significance-test**




**Time series graph**

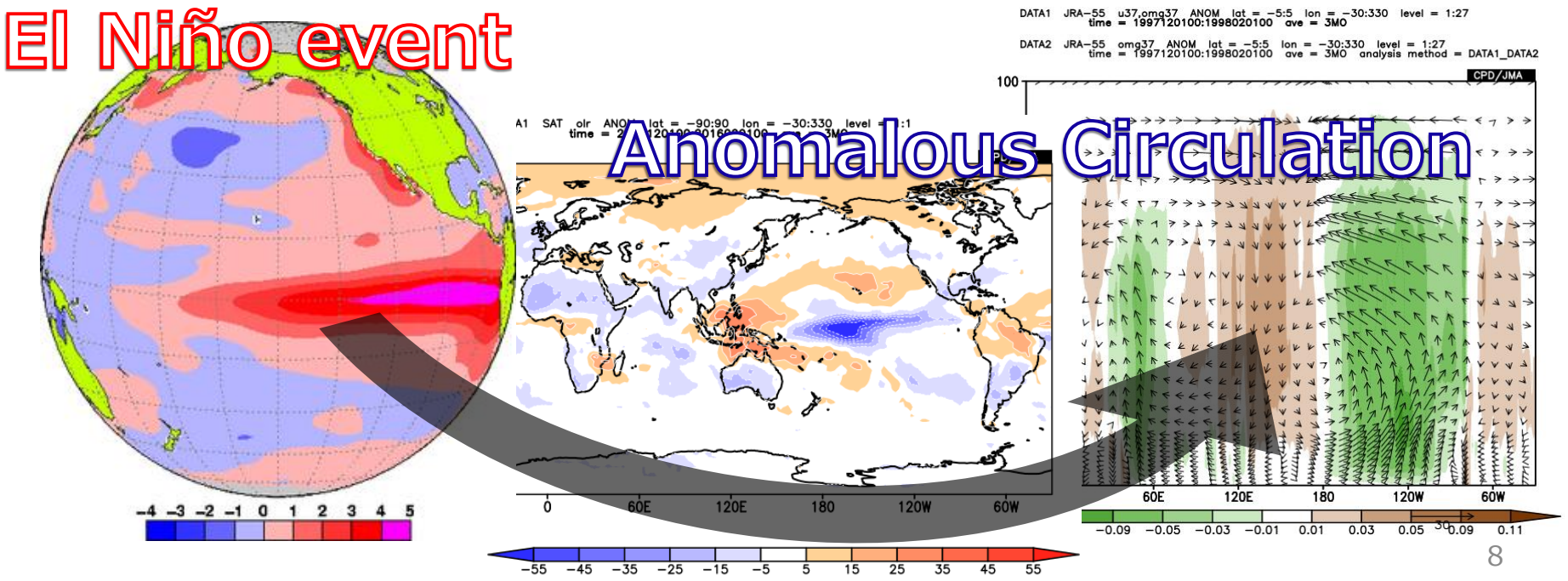
# Advantages of iTacs

- iTacs is one of the most useful tools provided by TCC/JMA, which is designed for climate analysis and will strongly help your work.
- Use of iTacs costs *less time for data handling, more time for interpretation* of the climate system!!



# Object of this lecture

- This lecture demonstrates and performs some exercises the basic operation of iTacs.
- This class overviews the influence of El Niño events on oceanographic condition and atmospheric circulation by utilizing iTacs.



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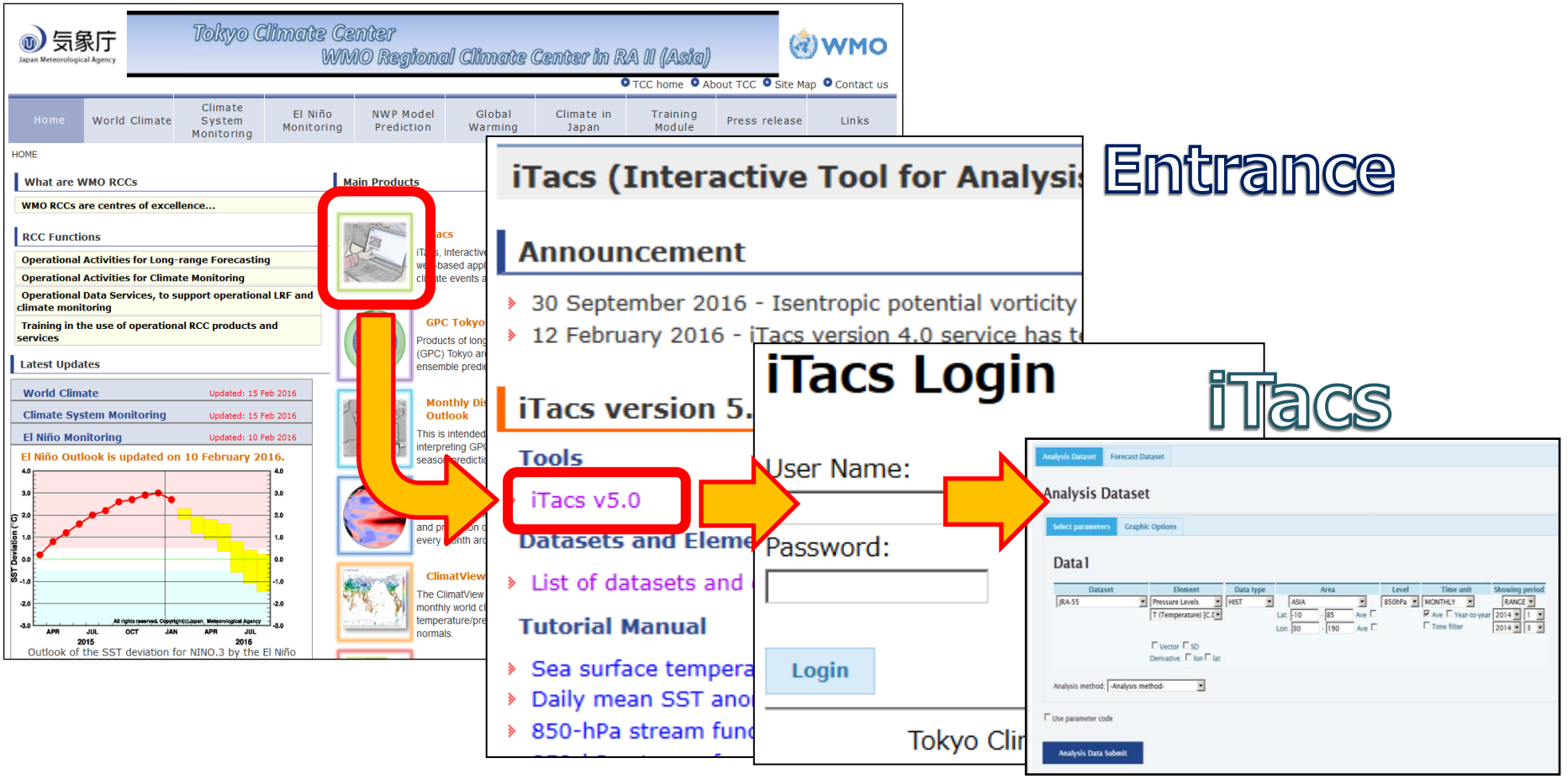
   - Cross section diagram

# Access to iTacs

- Registered users can access iTacs from Tokyo Climate Center (TCC) website.

**TCC website** (http://ds.data.jma.go.jp/tcc/tcc/index.html)



# Basic operating procedure (1)

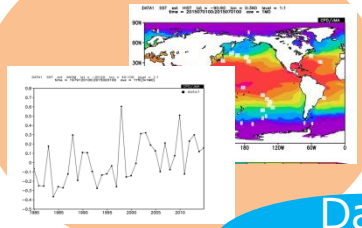
Select Analysis or Forecast dataset

Setting Data parameters

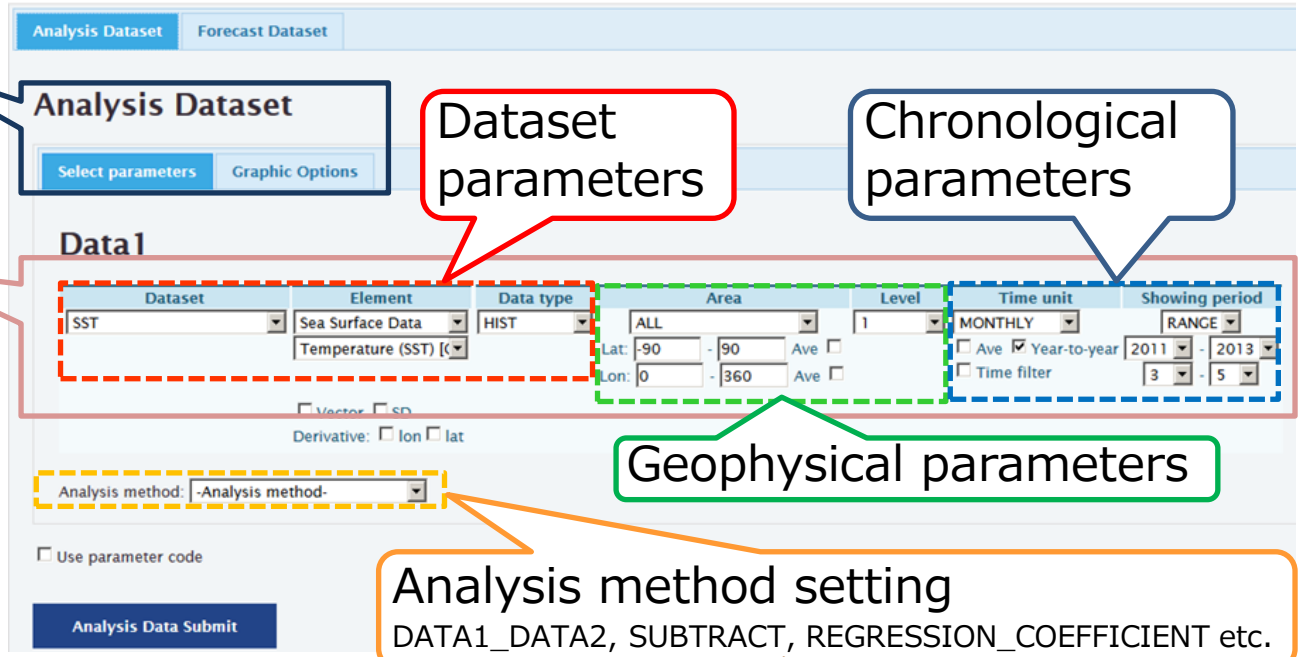
Setting Graphic Options

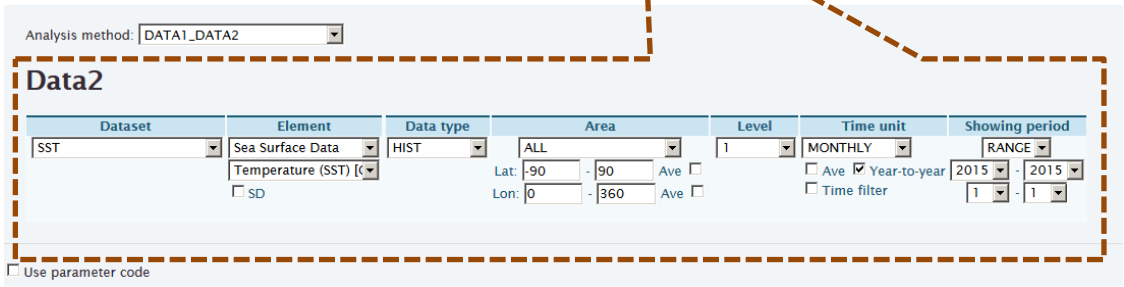
Data Submit

Draw map



Data download




"Data2" field will be appeared depending on types of analysis method.

# Basic operating procedure (2)

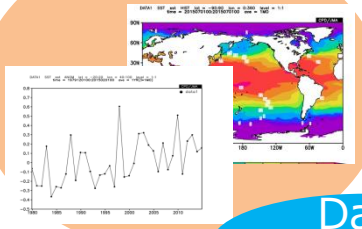
Select Analysis or Forecast dataset

Setting Data parameters

Setting Graphic Options

Data Submit

Draw map



Data download

Select parameters | Graphic Options

## Graphic Options

Graphic Options
Contour, Shade, Color Bar, Axes

Colorizing: COLOR | Drawing: SHADE | Image Format: png | Font: default | Color Table: Rainbow

Show Contour Labels
Show Color Bar
Set Contour Parameters for data1 — interval: min: max:
Set Contour Parameters for data2 — interval: min: max:
Set Vector size: [inch] value: skip: 1

Polar Stereographic: North pole
Logarithmic Coordinates
Reverse the Axes
Flip the X-axis Flip the Y-axis
No Caption

No Scale Labels
Draw Credit Inside
Apply All Pics
picture size %

Detailed Options for Image 1

Checking here, additional field for detailed options will appear.

Analysis Data Submit

Detailed Options for Image 1
For Image 1 Lower layer | apply | apply Default

About Graphics

contour Style: default Color: rainbow
label format: thickness: 1 size: 0.09 skip interval:
contour line thickness: 3
levels: color:
thin contour:
not to draw: -

marker type: closed circle
line style: solid color: black thickness: 6
grid style: none color: orange
vector label vector head size:
define rainbow color:
color bar portrait X: Y: scale: 1.0

About Axis

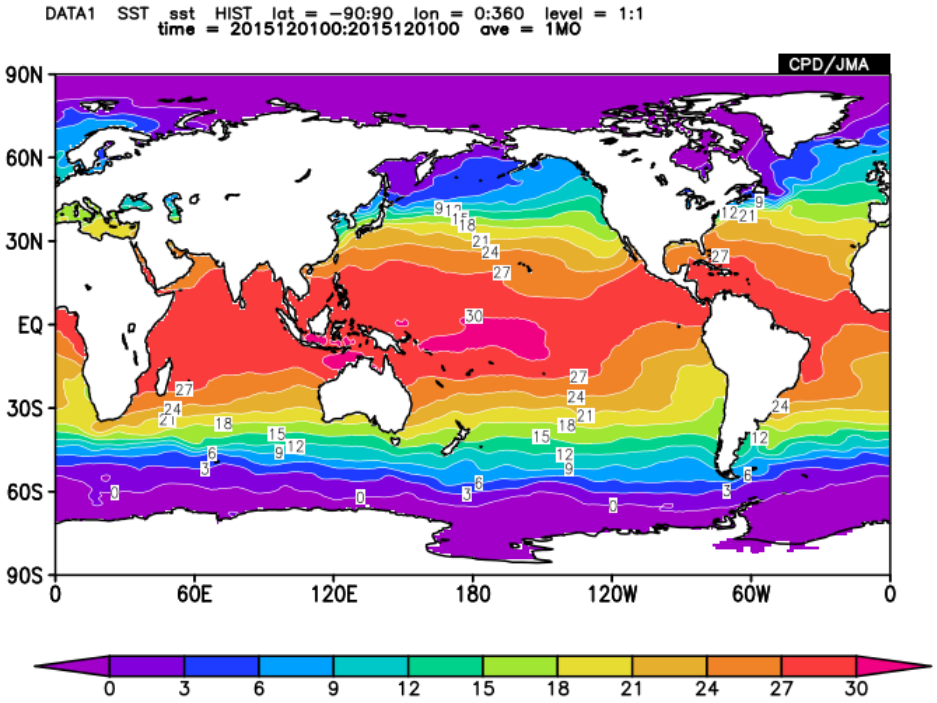
About Map

For Image 1 apply

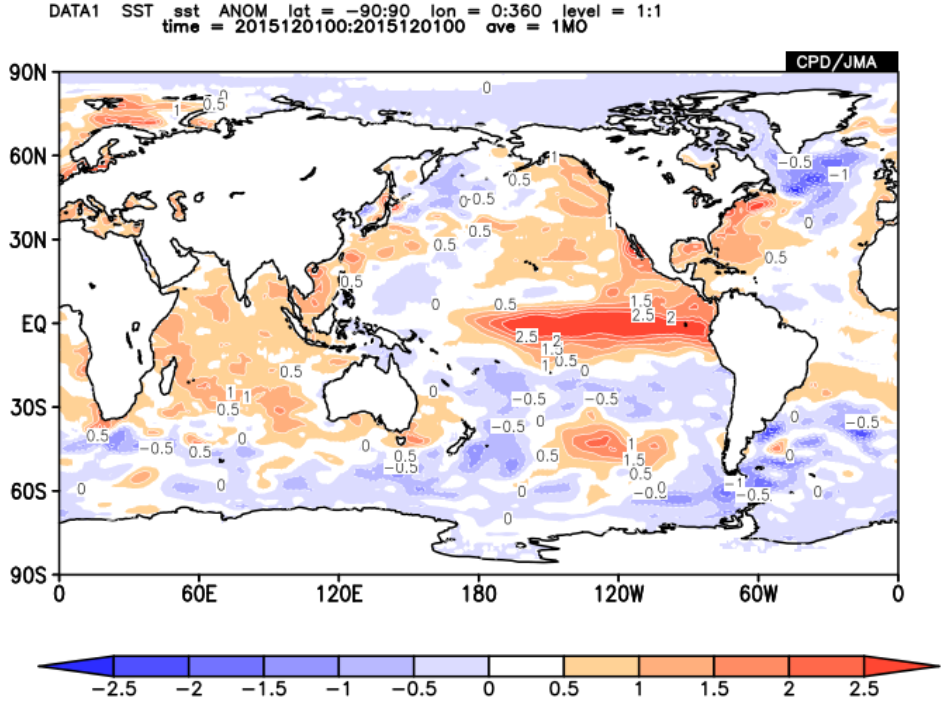
# Longitude-latitude map (1)

- Let's draw monthly mean sea surface temperature (SST) and its anomaly in December 2015.

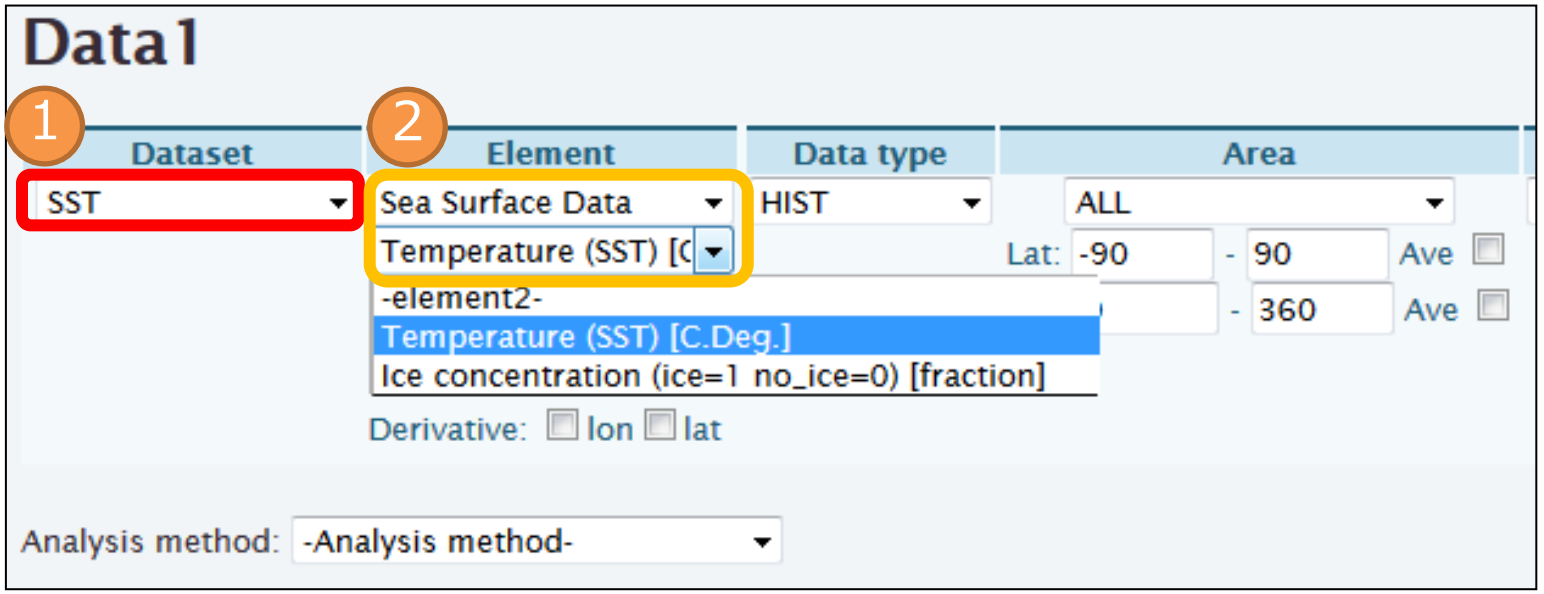
## SST




## SST anomaly

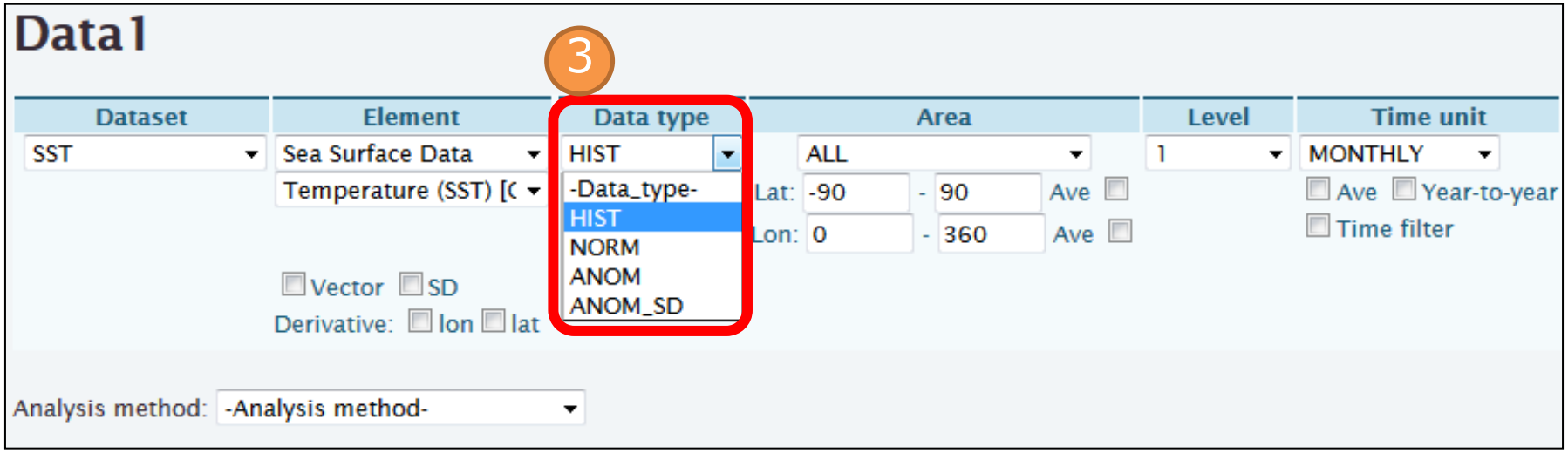


# Longitude-latitude map (2)




1. Select “SST” in the “Dataset” field.
   - Various datasets are available;
     **JRA-55, SST, MOVE-G2, CLIMAT, INDEX, USER-INPUT** etc.
2. Select “Sea Surface Data“ for “element1” and “Temperature” for “element2”.
   - Available elements will be shown in a pull-down menu.

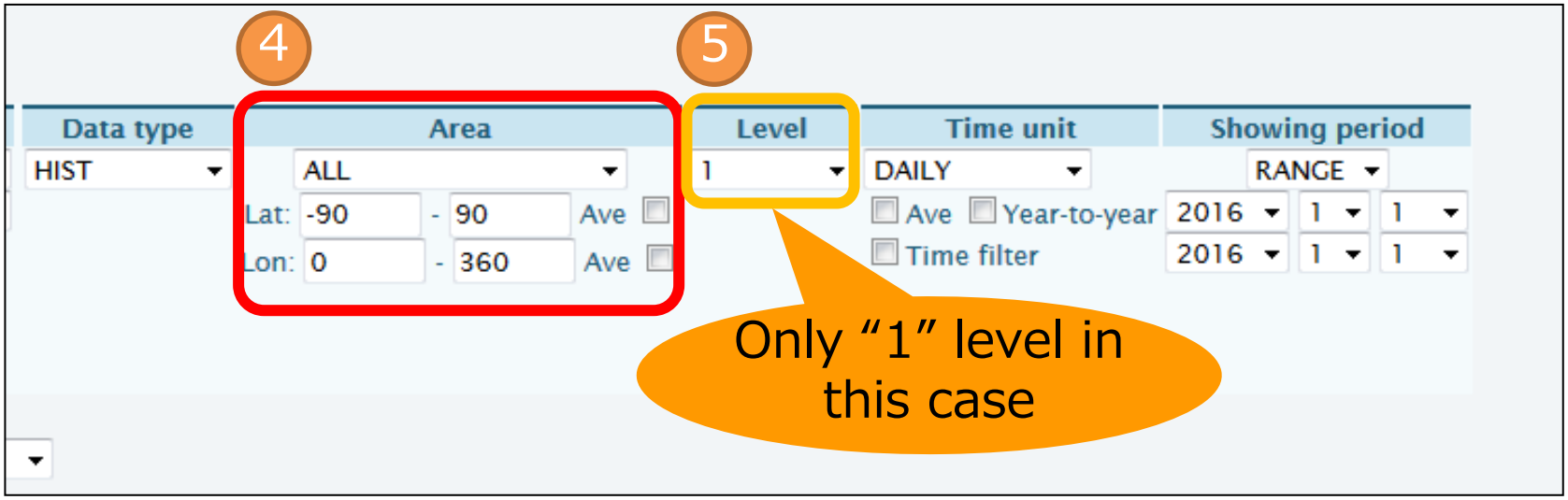
# Longitude-latitude map (3)




3. Select “HIST” for “Data type” .
   Available options are as follows:

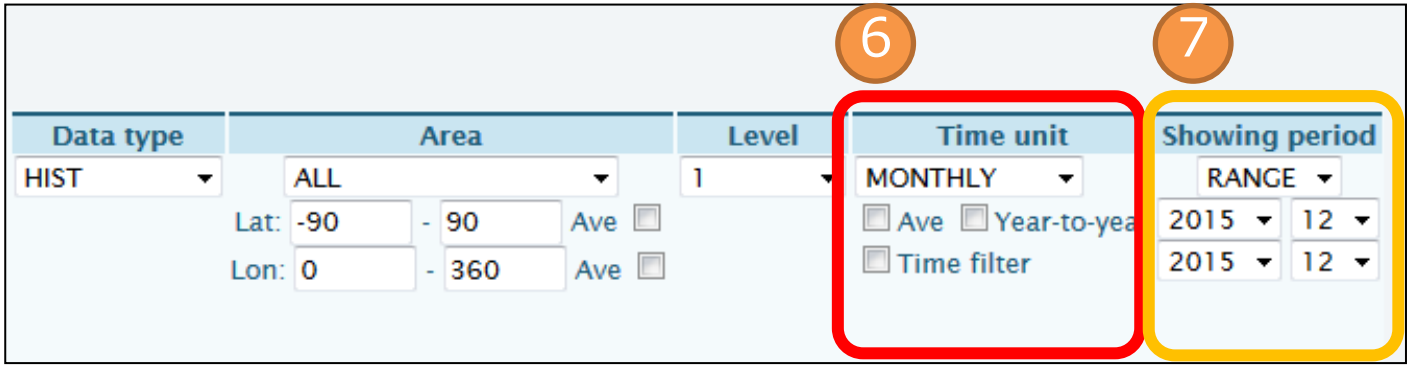
- **HIST** : Historical actual analysis or observation data.
- **NORM** : Climatological normal.
- **ANOM** : Anomaly data.
- **ANOM_SD** : Anomaly data normalized by their standard deviations, indicative of significance for the anomaly.

# Longitude-latitude map (4)




4. Select “ALL” for “Area”.
   - You can change the longitude/latitude range more precisely with setting boxes.
5. Select “1” for “Level”.
   - Options in the “Level” menu will change depending on your selection of “element”.

# Longitude-latitude map (5)

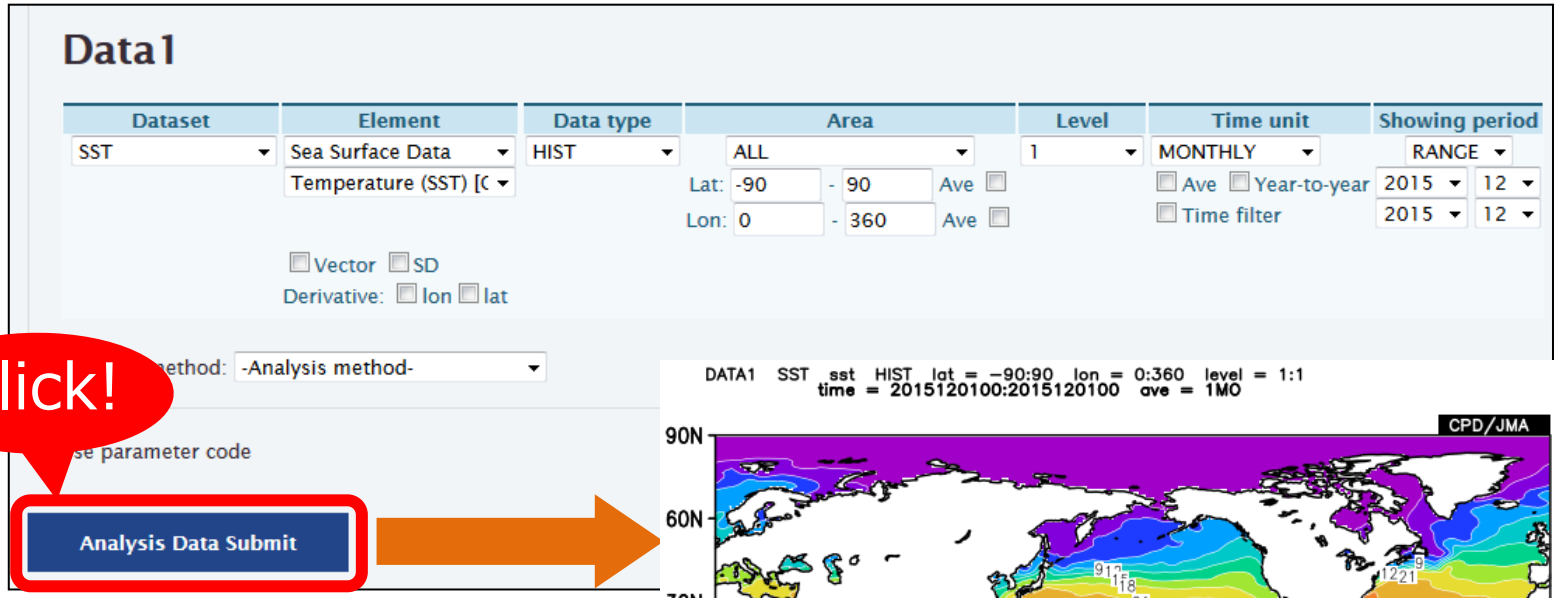


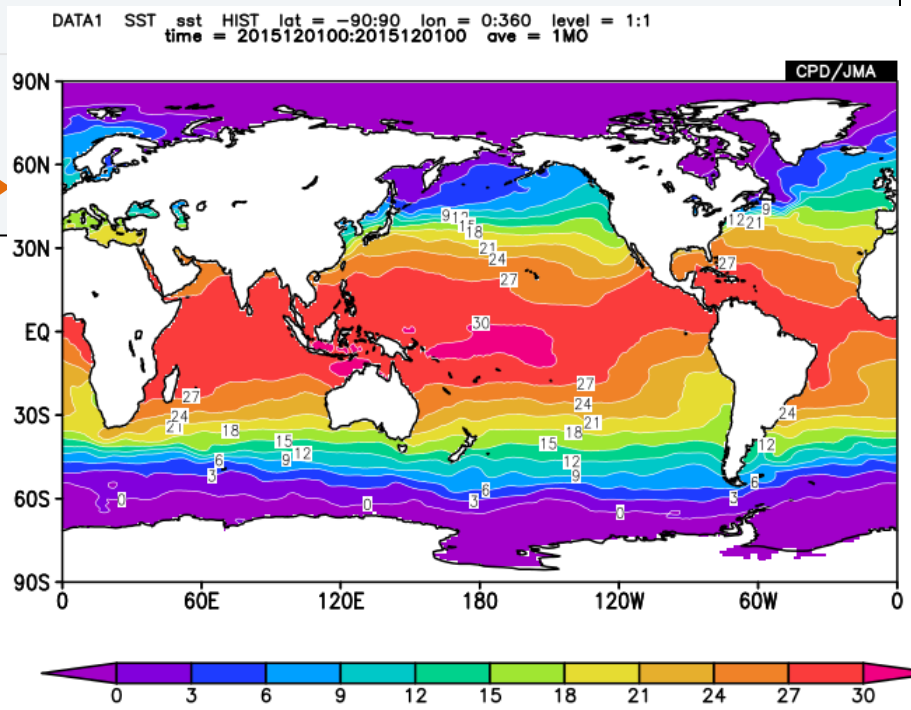

6. Select “MONTHLY” for “Time unit”.
   - There are several styles for range selection: **DAILY, PENTAD DAY, MONTHLY** and **ANNUAL**
7. Select “RANGE” for “Showing period” and “2015 12”, for both upper and lower boxes (left box: year, right box: month).

   Available options are as follows:
   - **RANGE**: Setting the start and end points of the targeted time period.
   - **YEARS**: Setting individual years.
   - **INDEX**: Setting a SST index border to pick up years (e.g. NINO.3).

# Longitude-latitude map (6)

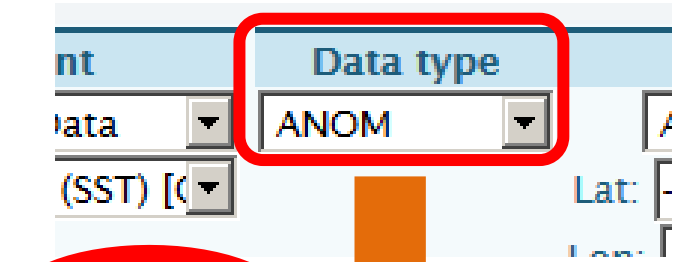
Finally, click the “Analysis Data Submit” button and the image will be displayed.

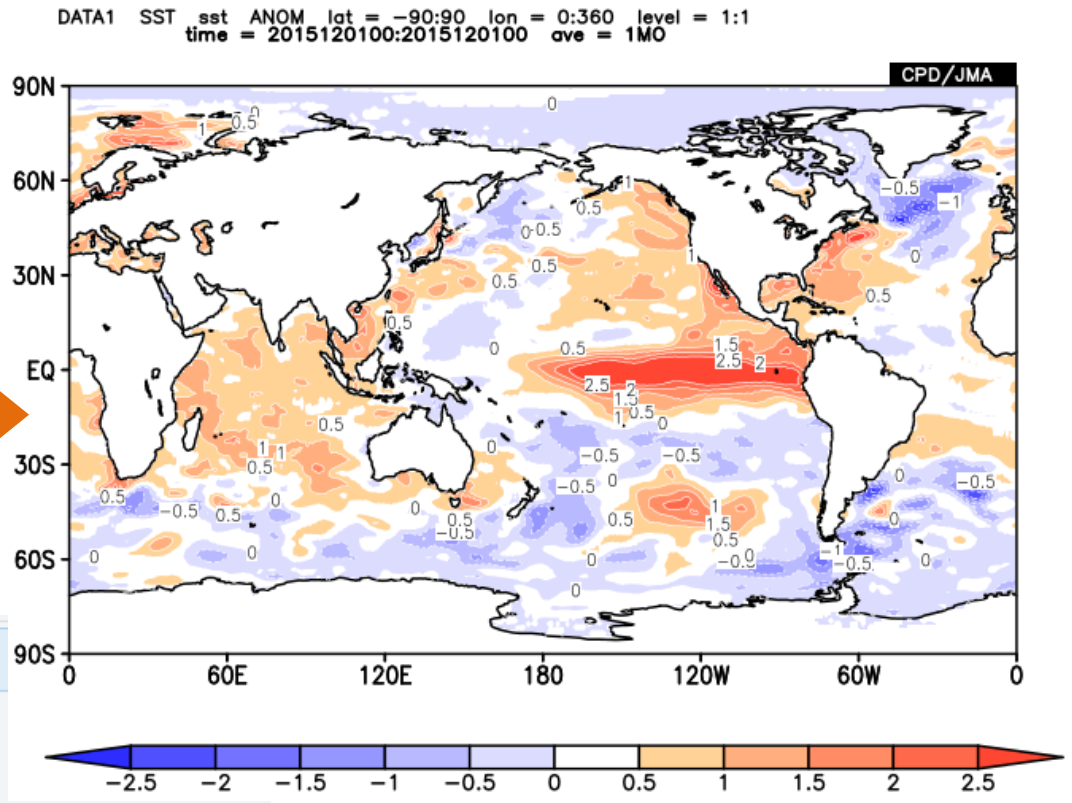


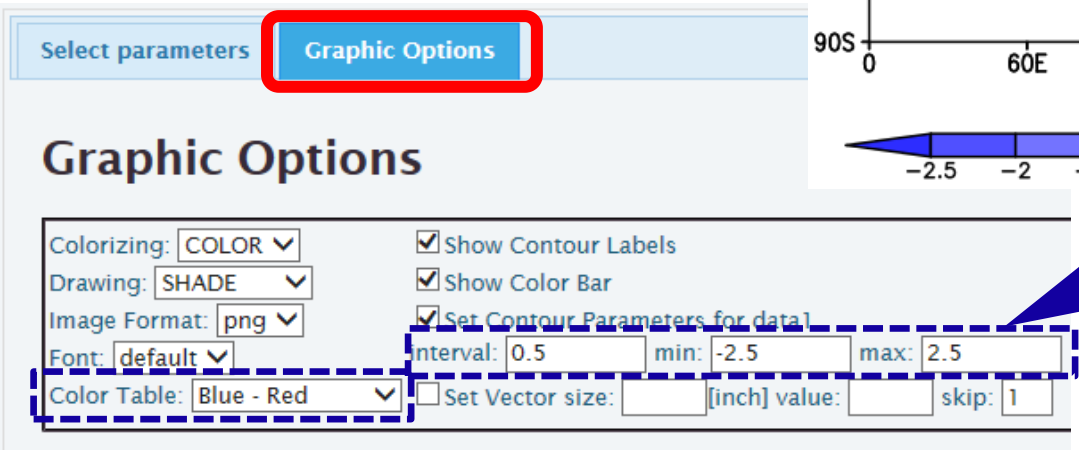



# Longitude-latitude map (7)

- You can also draw anomaly charts by selecting “ANOM” for “Data type”.



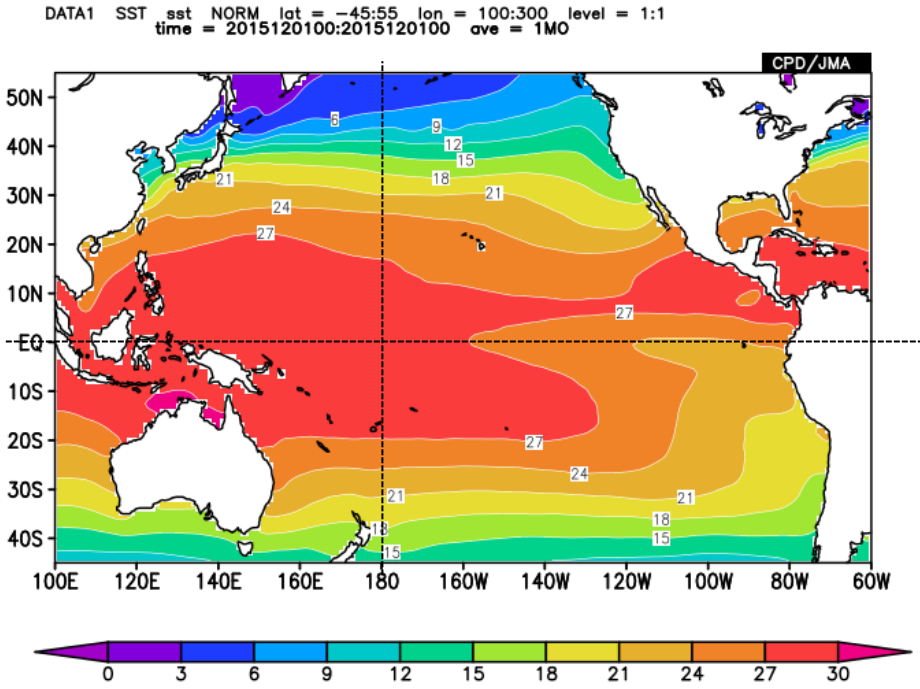

Set
Color Table: Blue - Red
Contour Parameter:
interval: 0.5, min: -2.5, max: 2.5

# Topics: El Niño event

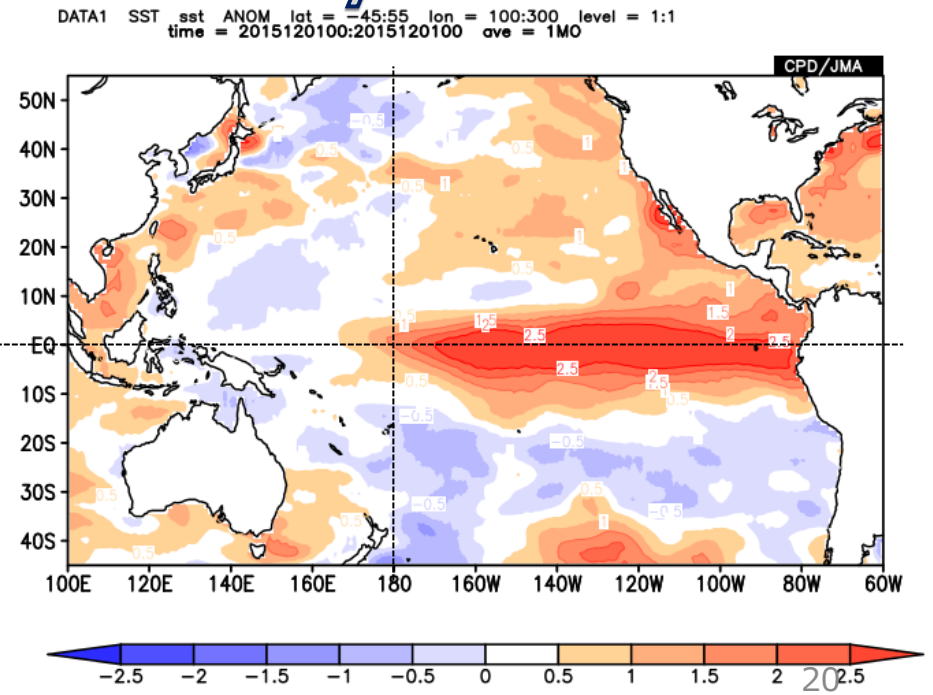
- In winter 2015/16, SST exhibited positive anomaly over the central to eastern equatorial Pacific and negative anomalies over the western tropical Pacific, indicating the occurrence of El Niño event.

SST in December 2015

## - Normal -

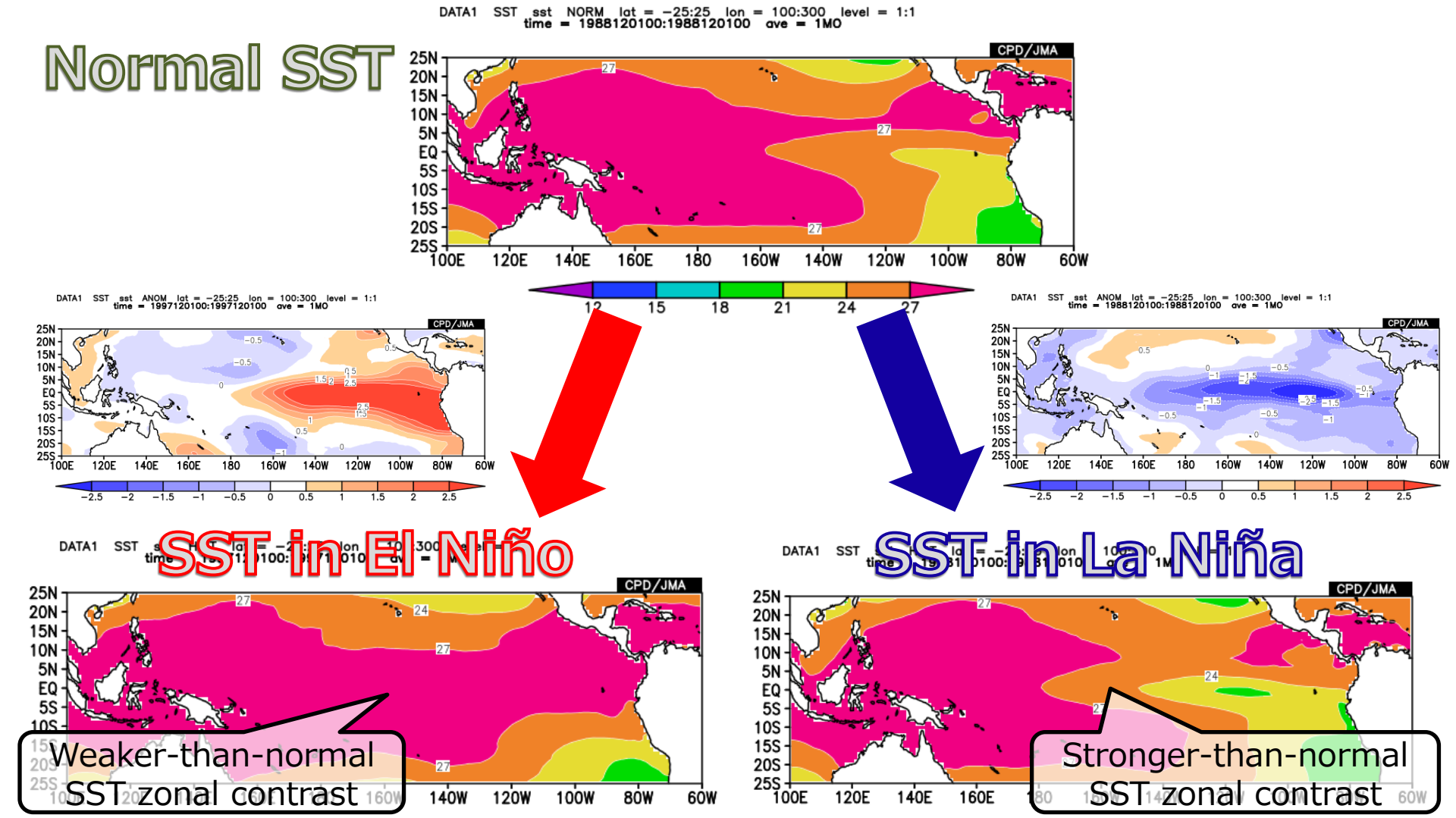



## - Anomaly -



# Topics: El Niño Southern Oscillation (ENSO)

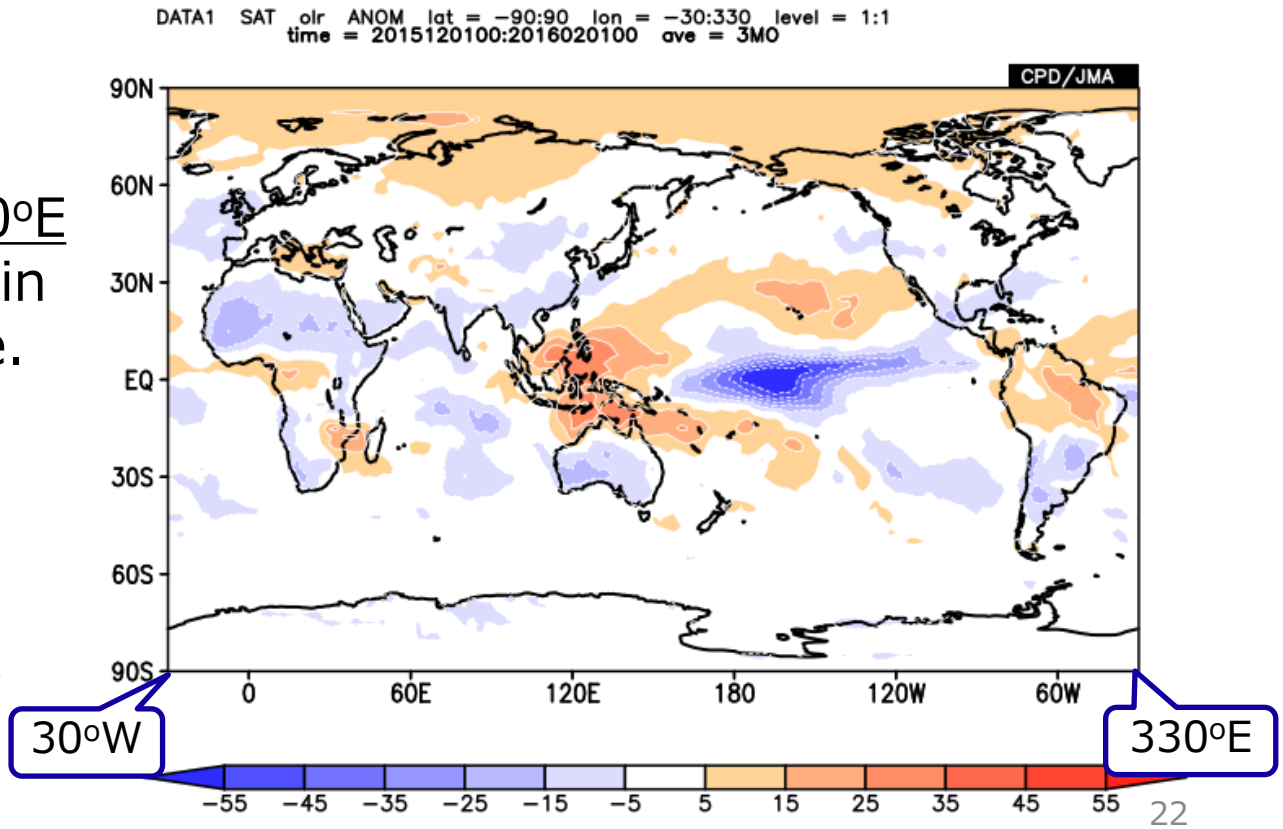
- The occurrence of El Niño and La Niña events (ENSO) modulate zonal contrast of SST in the equatorial Pacific.



# Exercise (1)

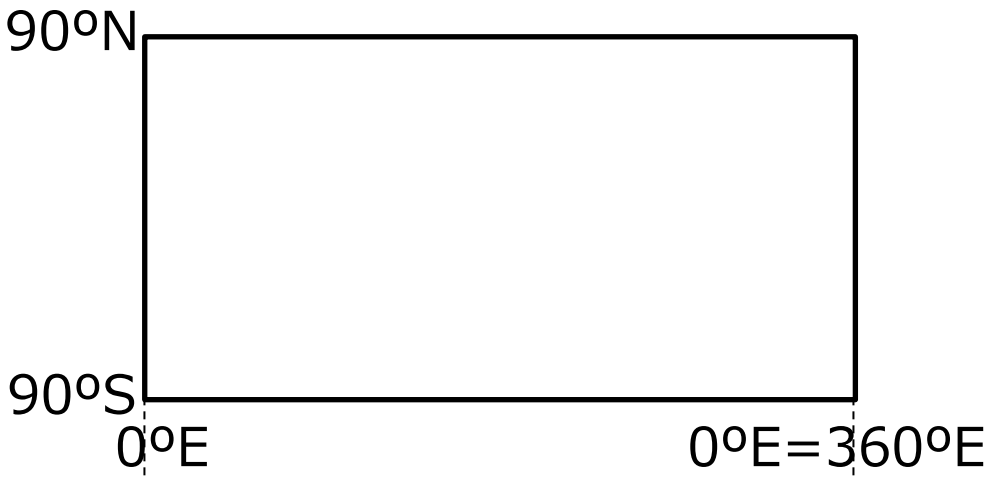
- Show OLR anomaly averaged over the period from December 2015 to February 2016 as shown below.
- Dataset "**SAT**" is available to draw the OLR.

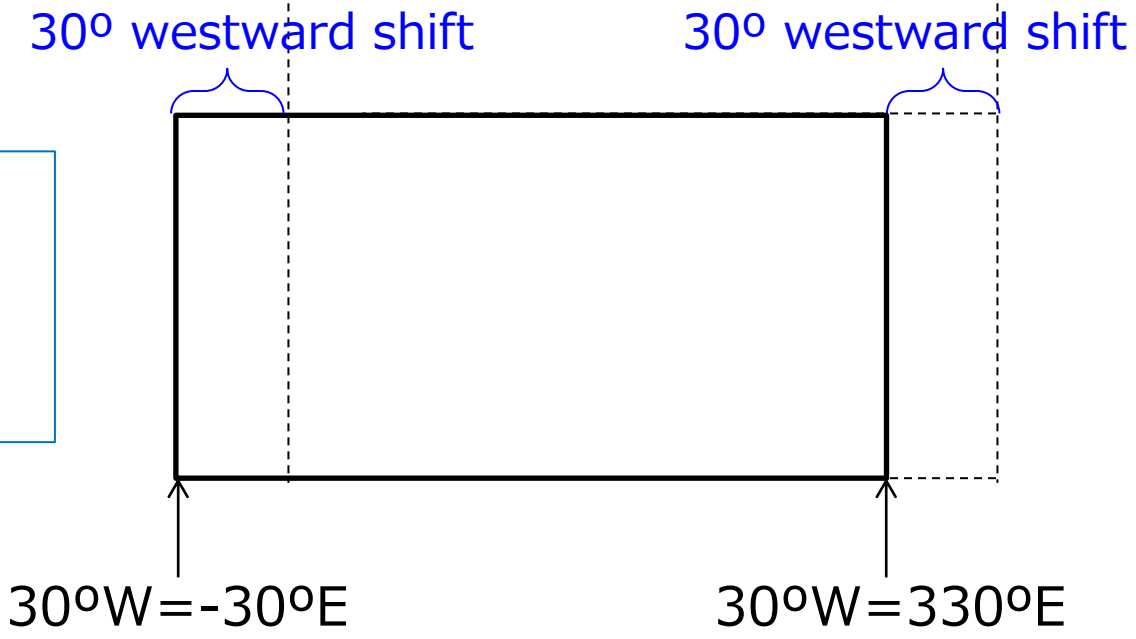
- Please try to set longitude range from 30°W to 330°E not to split areas in Africa and Europe.
- Adjust contour parameters (see color bar of the figure)
- Select "Blue-Red" for "Color Table"



# Hint: Area setting

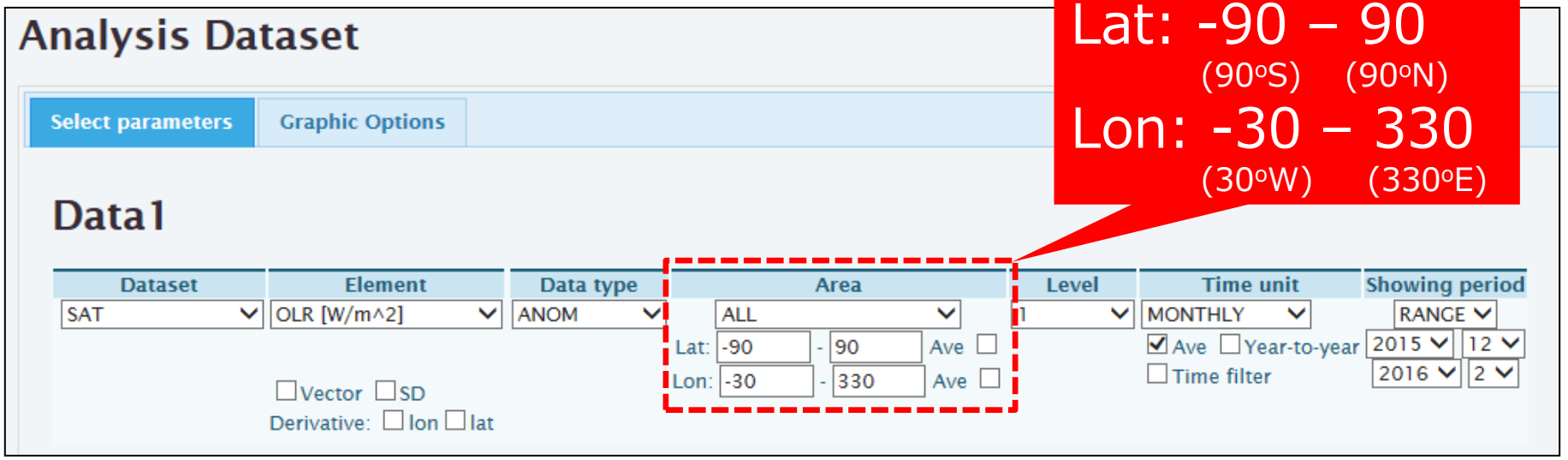
Lat : -90 – 90
(90S) (90N)
Lon: 0 – 360
(0) (0)

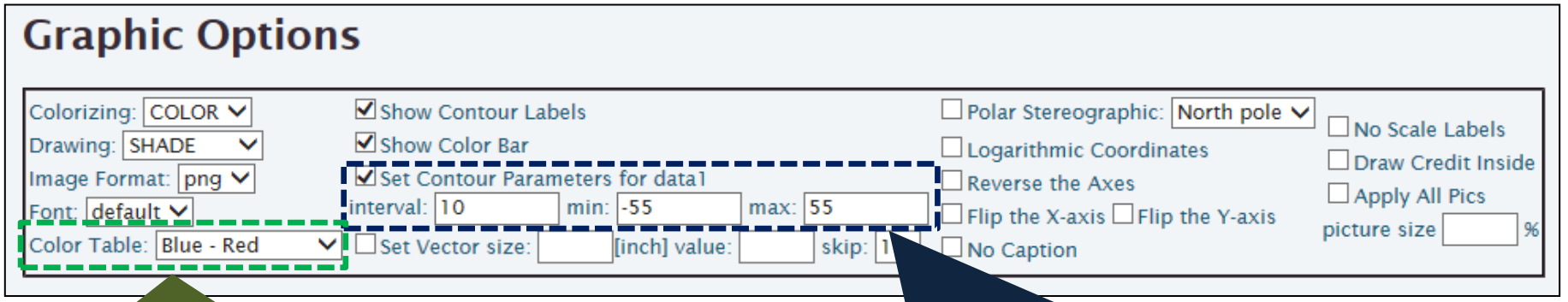



Lat : -90 – 90
(90S) (90N)
Lon: -30 – 330
(30W) (330E)

# Answer to Exercise (1)



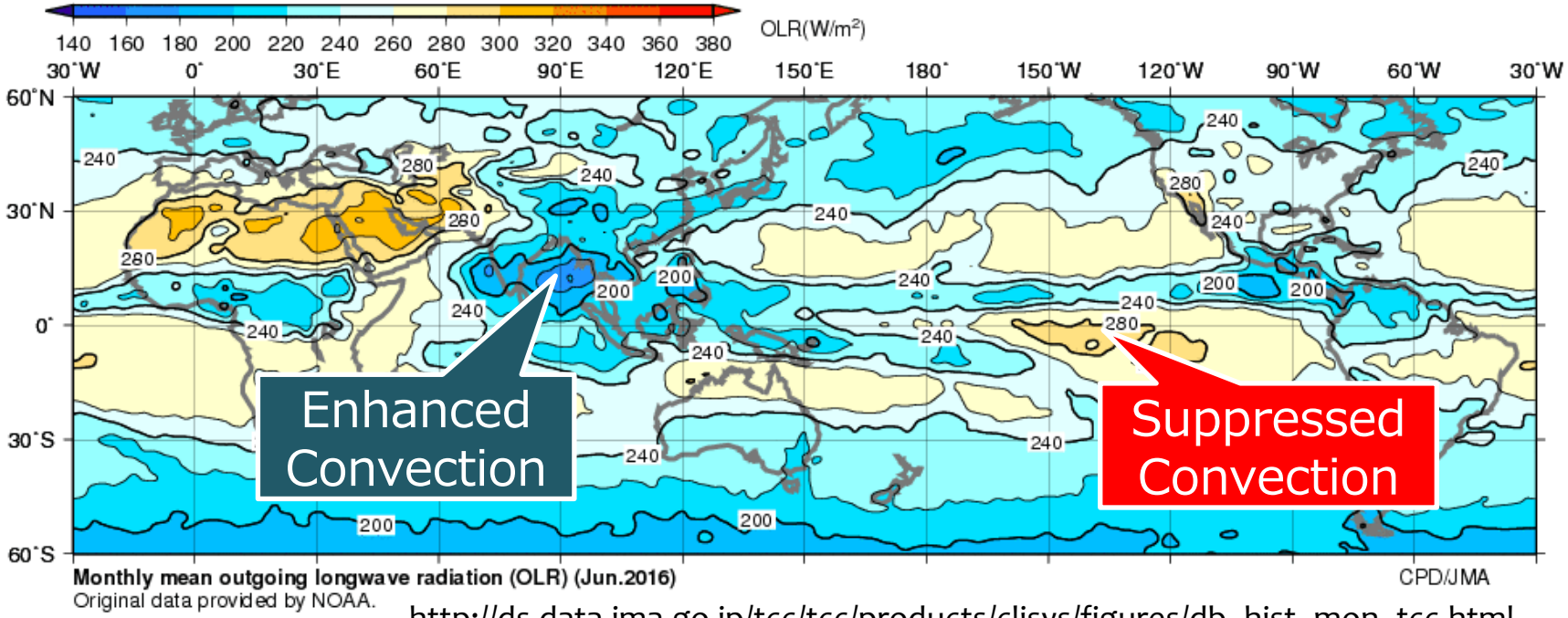




Select “Blue-Red” color table.

Set contour parameters as follows.
interval: 10, min: -55, max: 55

# Outgoing Longwave Radiation (OLR)

- OLR is an index representing brightness temperature observed from space.
- Take note: In the tropics,
  - **Lower OLR** – Cooler temp. seen from space
    - Top of cumulonimbus – **Active convection**
  - **Higher OLR** – Warmer temp. seen from space
    - Near the earth surface – **Suppressed convection**



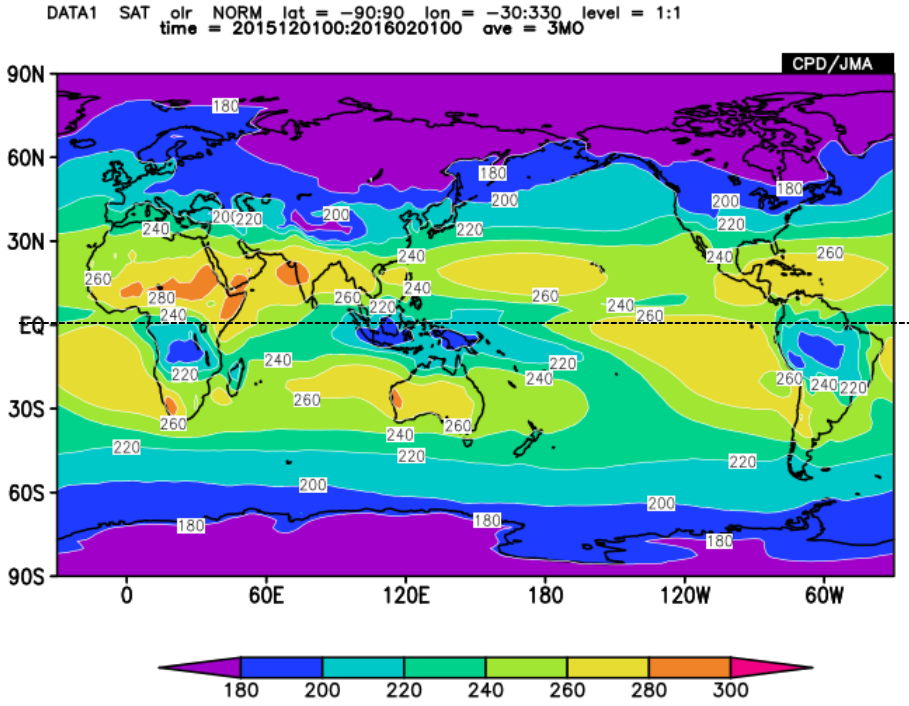

http://ds.data.jma.go.jp/tcc/tcc/products/clisys/figures/db_hist_mon_tcc.html

# Topics: Anomalous convective activity associated with the El Niño event

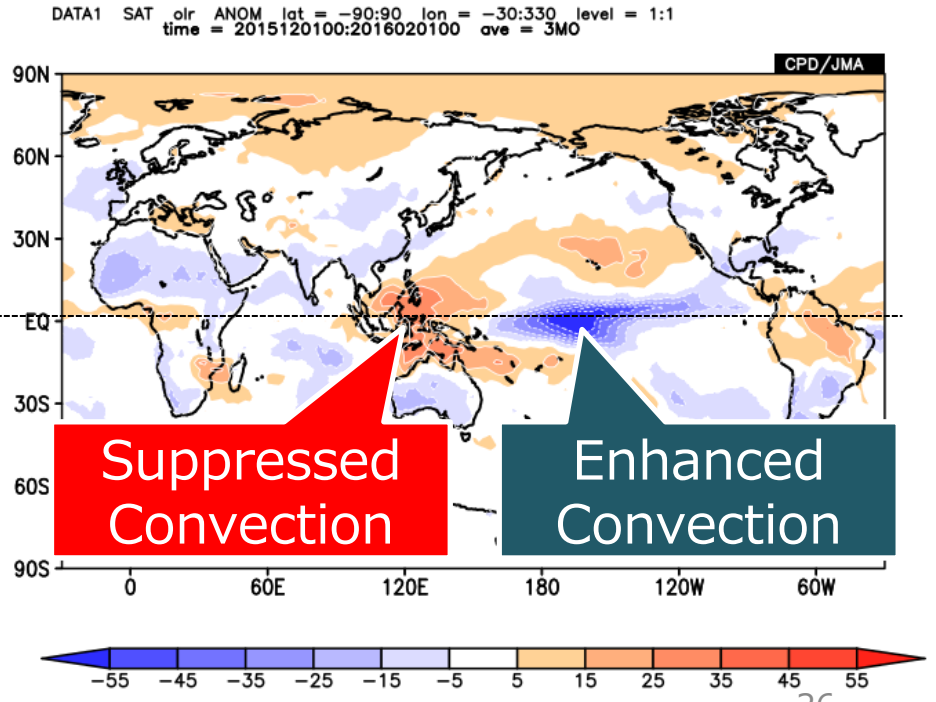
- During El Niño events, enhanced (suppressed) convective activity is statistically seen over the central to eastern (western) equatorial Pacific.

DJF (Dec, Jan & Feb) mean OLR

## - Normal -

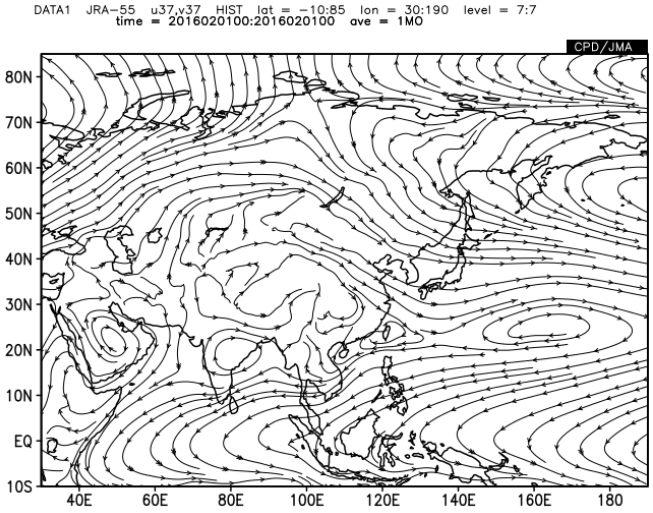


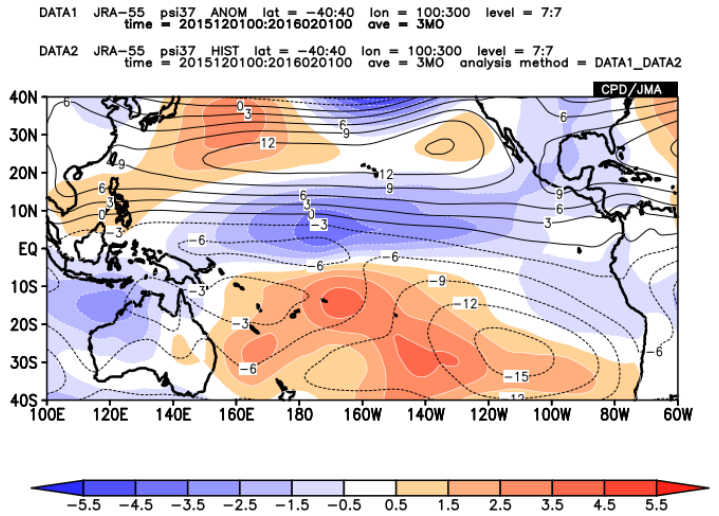

## - Anomaly -



# Multiple Data

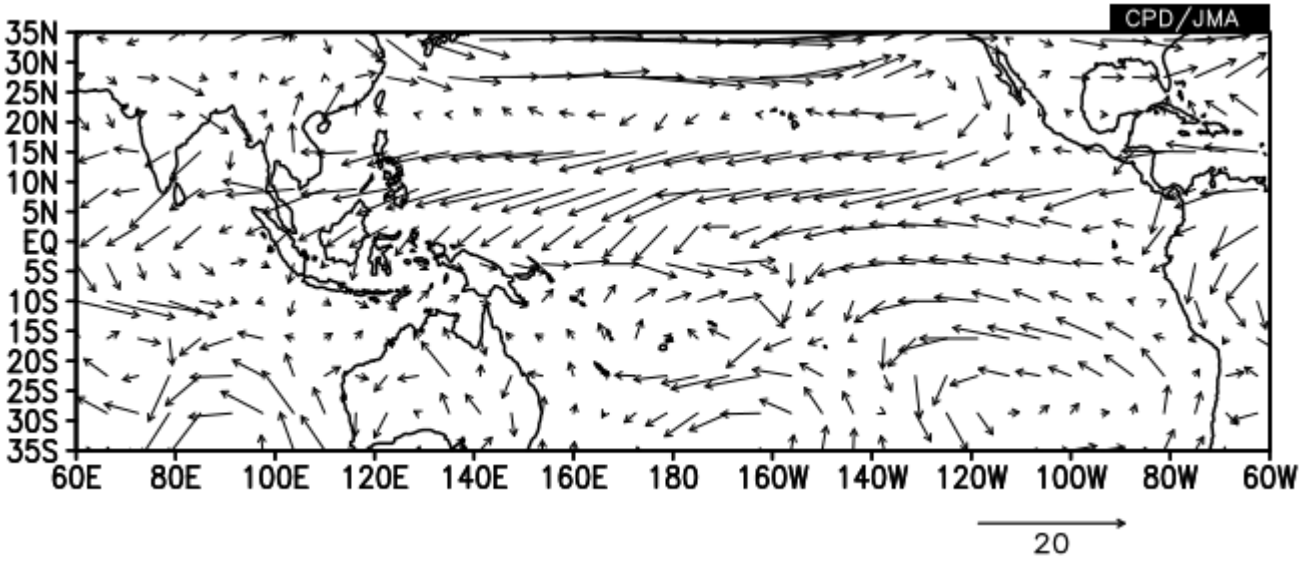
- **Vector** or **Stream-line**: Map vectors or stream lines.
- **DATA1_DATA2**: Overlay two kinds of elements on one map at the same time.
  - Contour lines are overlaid on a shaded map.
- **SUBTRACT**: Map the difference of two data.
  - This function is mainly used to show time variation or the difference between two levels.



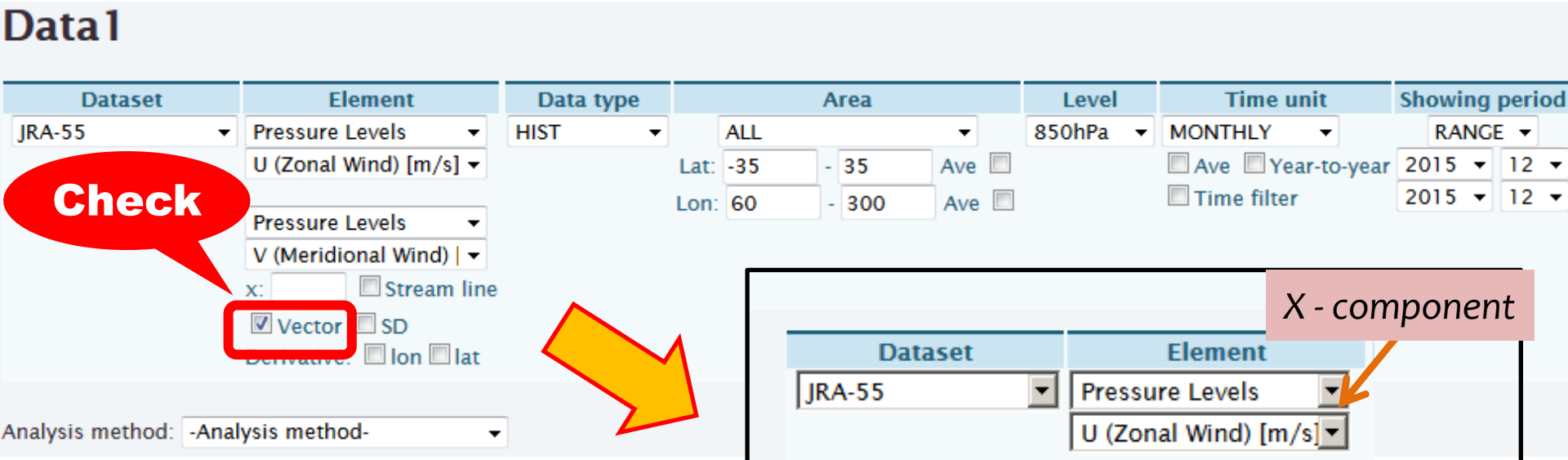
# Vectors (1)

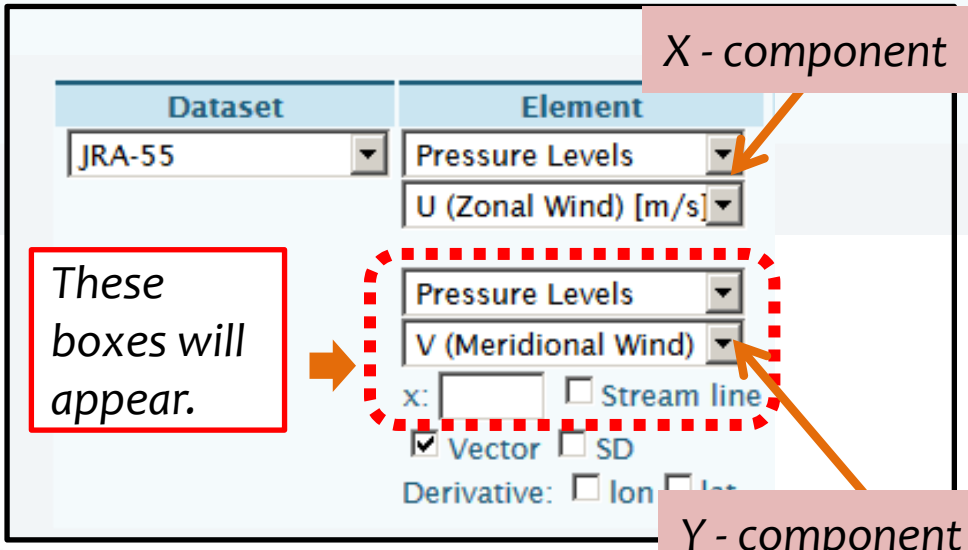
- How to draw vector maps
  - For example, let's make a low-level wind field map step by step.
  - Barbs are not available. ( Barb : and )



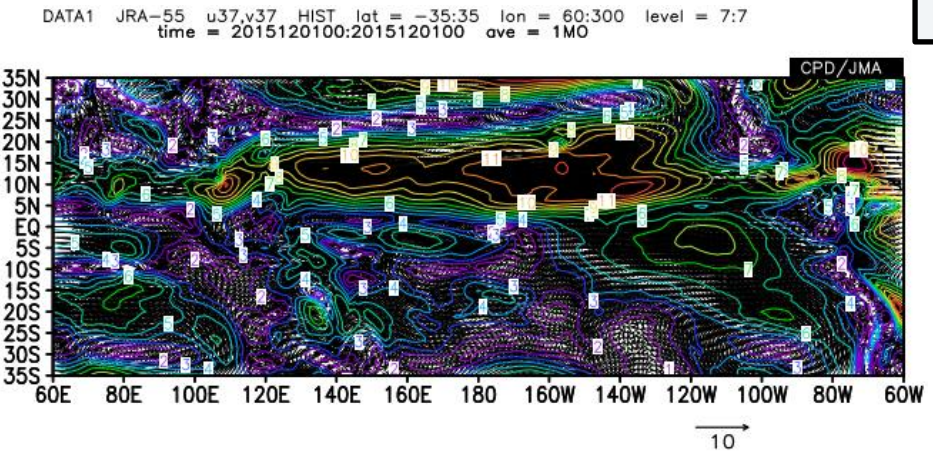

Wind vector at 850hPa in January 2016

# Vectors (2)



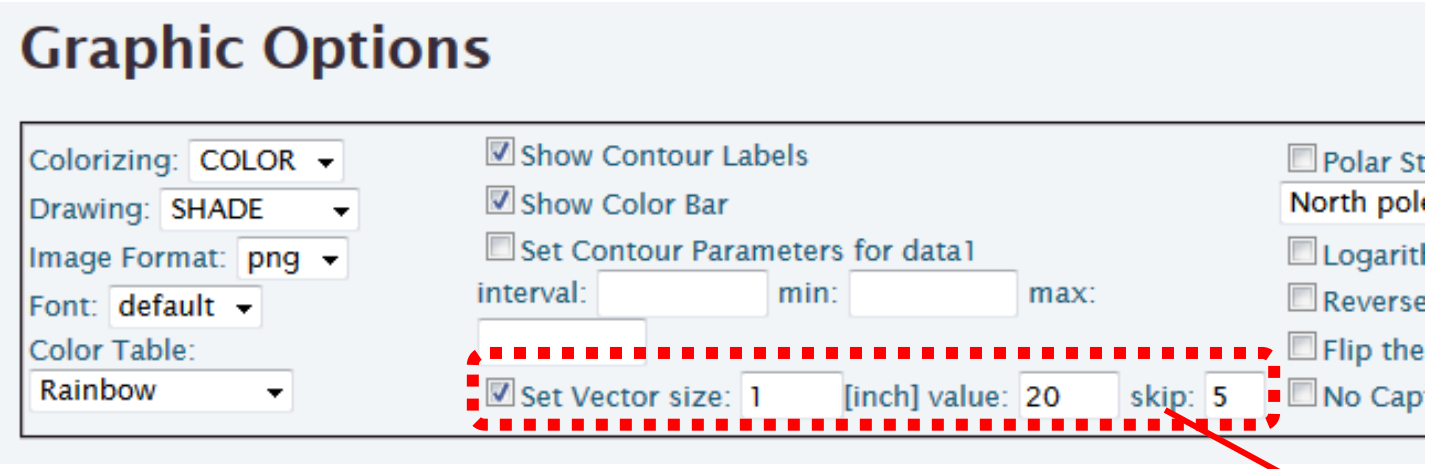



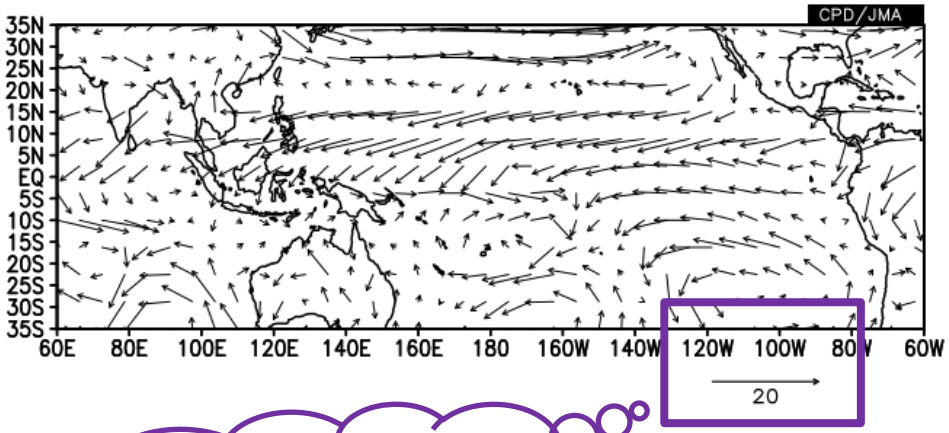

Submit




*Oops!*

# Vectors (3)



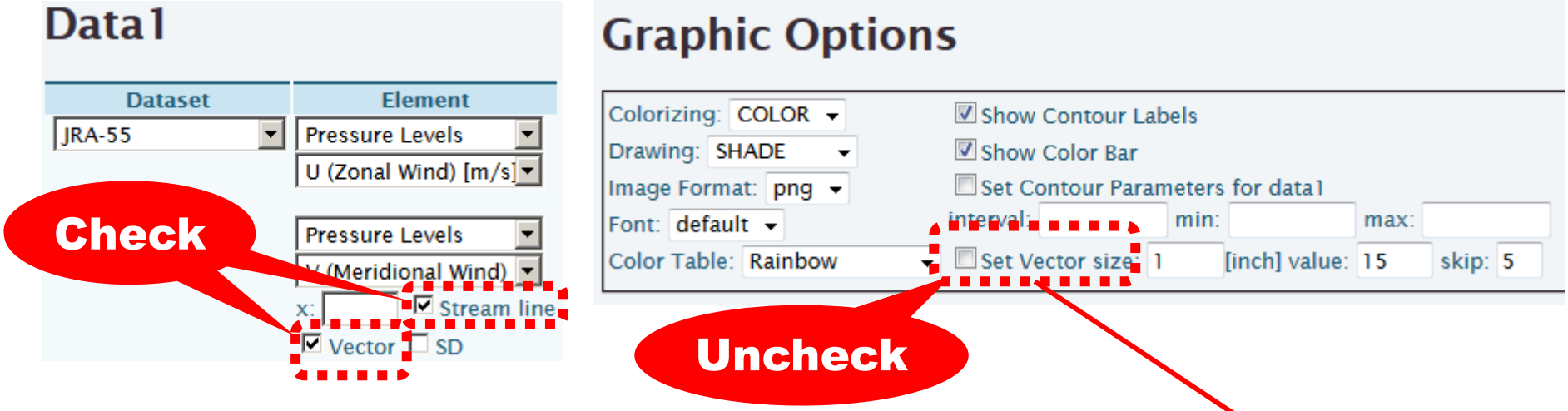

In this setting,
1 inch
= 20 m/s.

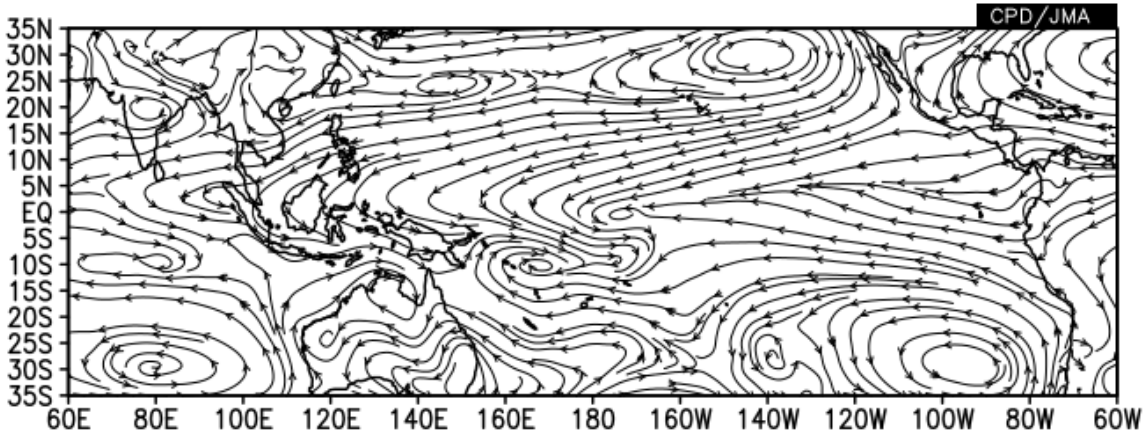
Modify the vector size and its skip interval.

- If you want to make vector size larger, make “size” larger or “value” smaller.
- If vectors are too crowded, you should change “skip” value. In this setting, vectors are drawn at every 5 grids.

# Stream lines

- Drawing stream lines



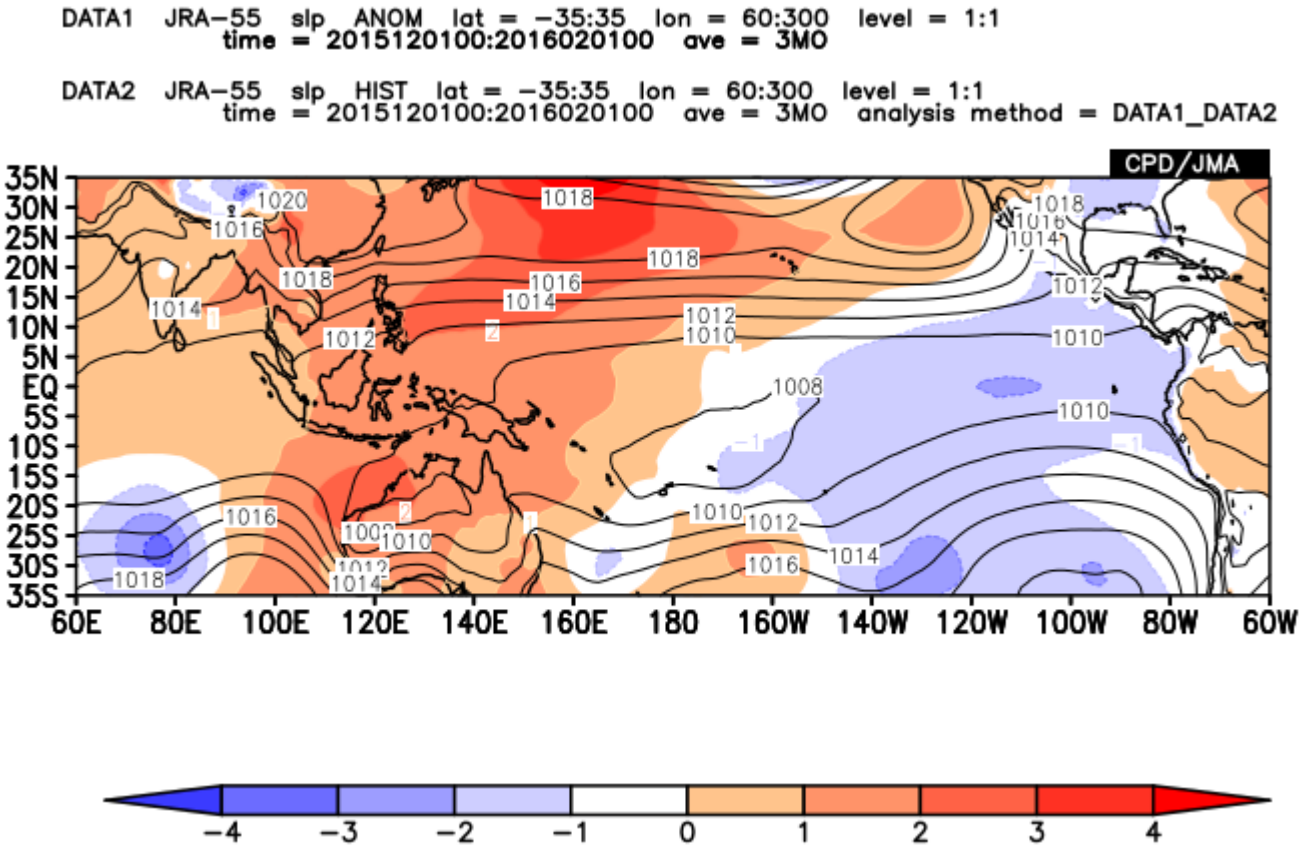

When you draw streamlines, the skip value must be “1”.

It is easier and safer to just uncheck the vector options box.

# DATA1_DATA2:Overlaying two data

- How to draw two data
- Sea level pressure (contour) and its anomalies (shading).

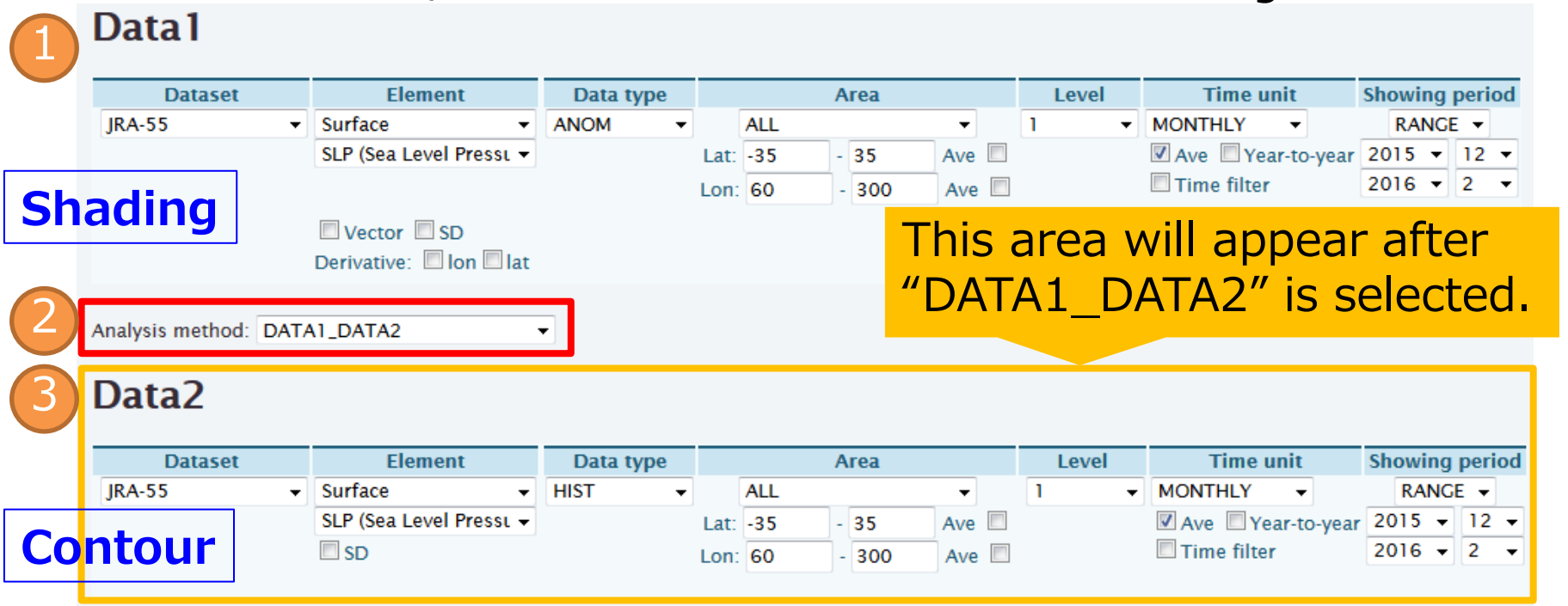
3-month mean sea level pressure and its anomalies from Dec. 2015 through Feb. 2016



# DATA1_DATA2:Overlaying two data

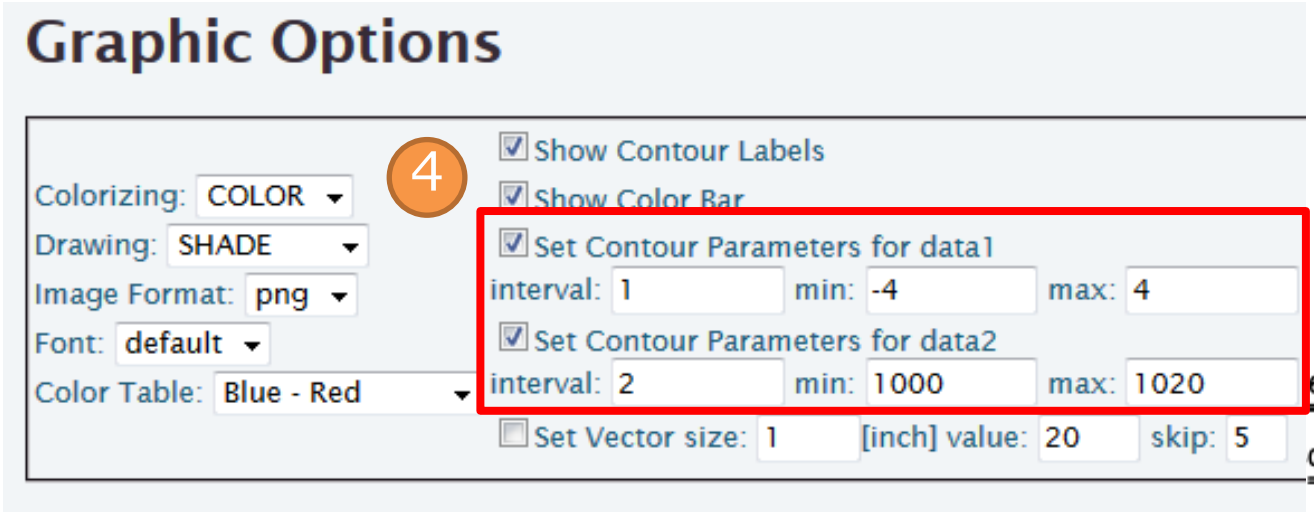
Basic Rule: The Data1 for shading (the lower layer) and Data2 for contours (the upper layer).

*As an exception, when you make a vector/stream line map, Data 1 must be for vector/stream line and Data 2 is for shading or contours.

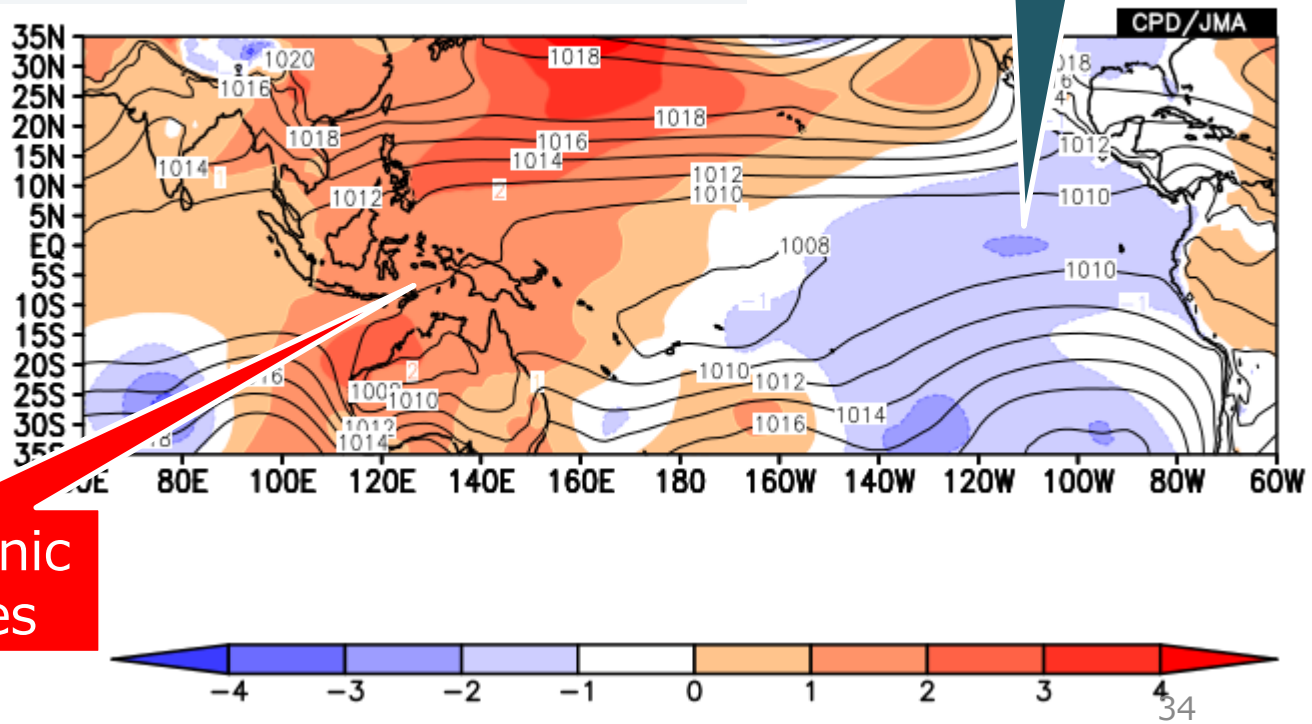



1. Set parameters in "Data1" field.
2. Select "DATA1_DATA2" in the "Analysis method" box.
3. Set parameters in "Data2" field and submit.

# DATA1_DATA2:Overlaying two data



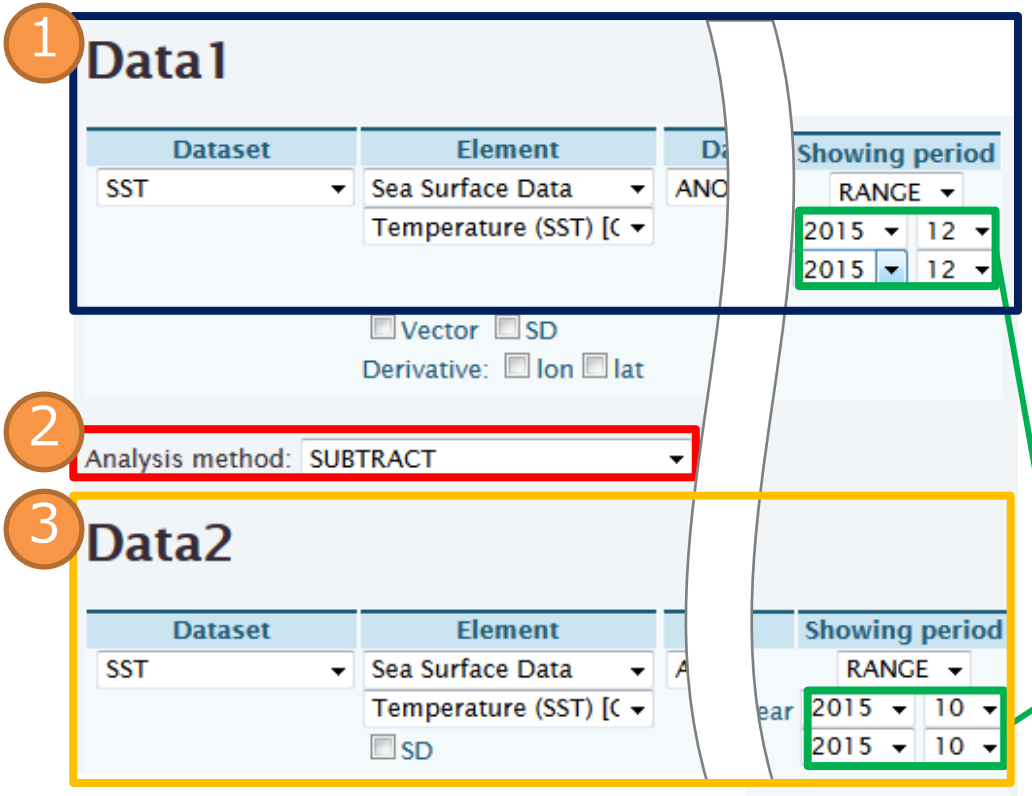

4. Set Contour parameters for data1 (SLP anomalies) and data2 (SLP).

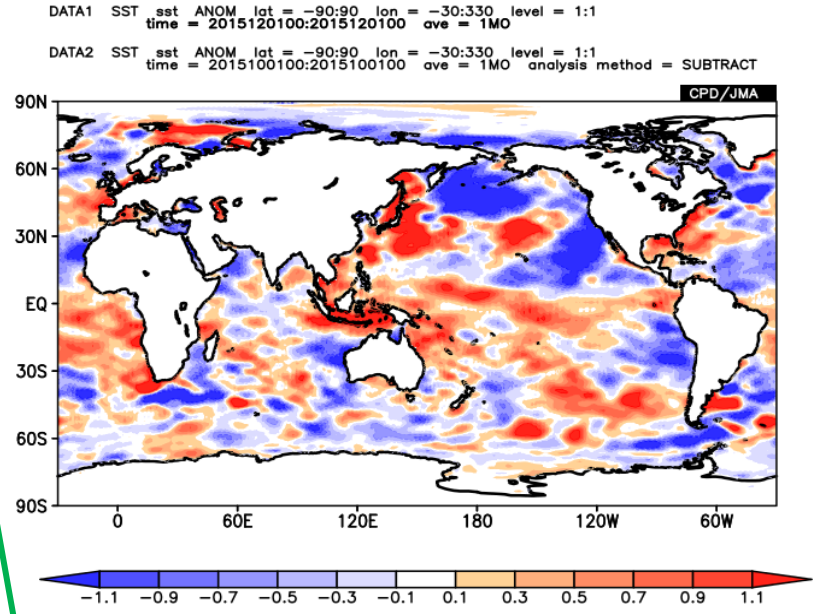


# SUBTRACT: Data1 minus Data2

- The value of “Data1 minus Data2” will be mapped.

1. Set the “Data1” (the base data).
2. Select “SUBTRACT” in the “analysis method” box.
3. Set the “Data2” field and submit.



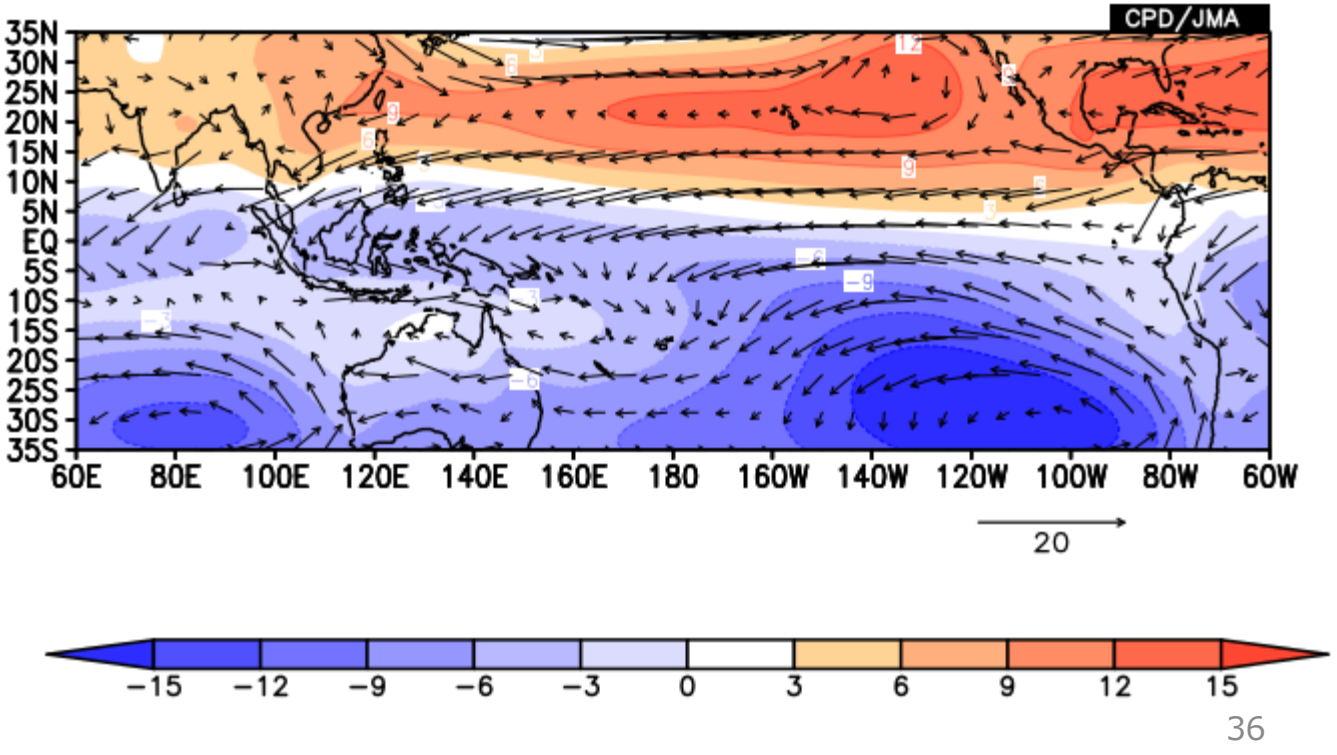

Data1 minus Data2 is mapped (In this case, December minus October).

# Exercise (2)

- Let's see the climatological mean stream function ($\psi$) and wind vector at 850hPa for January.
  - Stream function ($\psi$) is used for diagnosing large-scale non-divergent ( i.e. rotational) wind fields.
  - Check the relationship between $\psi$ and wind fields.

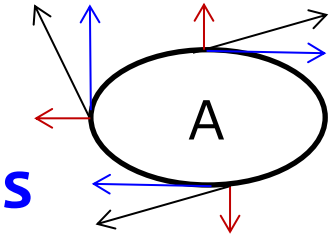
Hint 1: This is a vector and shading plot. In this case, is the data1 vector or shading?

Hint 2: When you draw climatological normal fields, you don't care about year setting (any year is OK).

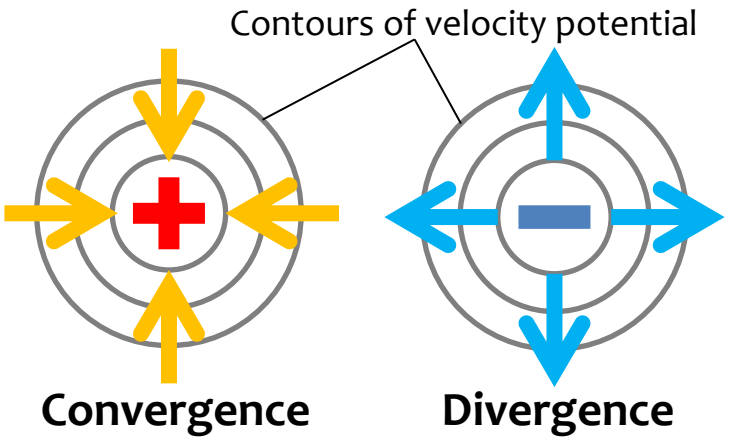


# Velocity Potential and Stream Function

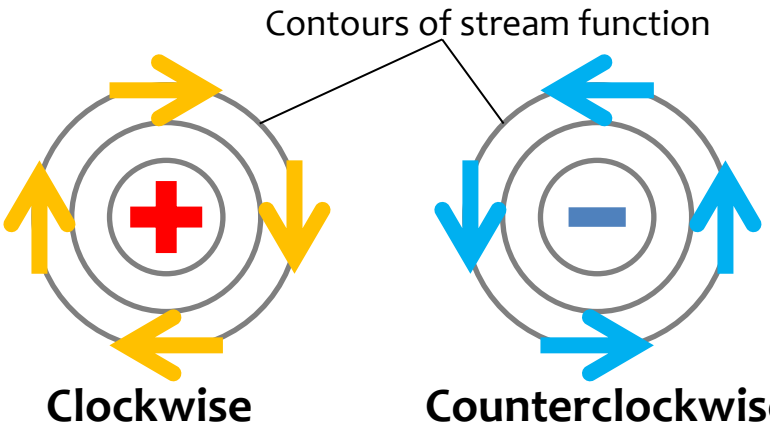
- **Wind fields = Divergent winds + Rotational winds**
  - Under an assumption of perfect fluid (i.e. no viscosity).
- **Divergent winds = $\nabla\chi$, where $\chi$ is Velocity potential**
  - Divergent wind blows in the upgradient direction of $\chi$.
- **Rotational winds = $\mathbf{k} \times \nabla\psi$, where $\psi$ is Stream function ($\mathbf{k}$ is a unit vector in vertical direction)**
  - Rotational wind blows parallel to the contours of $\psi$, with low value to the left, regardless of which hemisphere you think.
  - Air flow around a local $\psi$ maximum (i.e. clockwise ) corresponds to anti-cyclonic rotation in the N.H. and cyclonic rotation in the S.H.




**Velocity potential** (divergent winds)

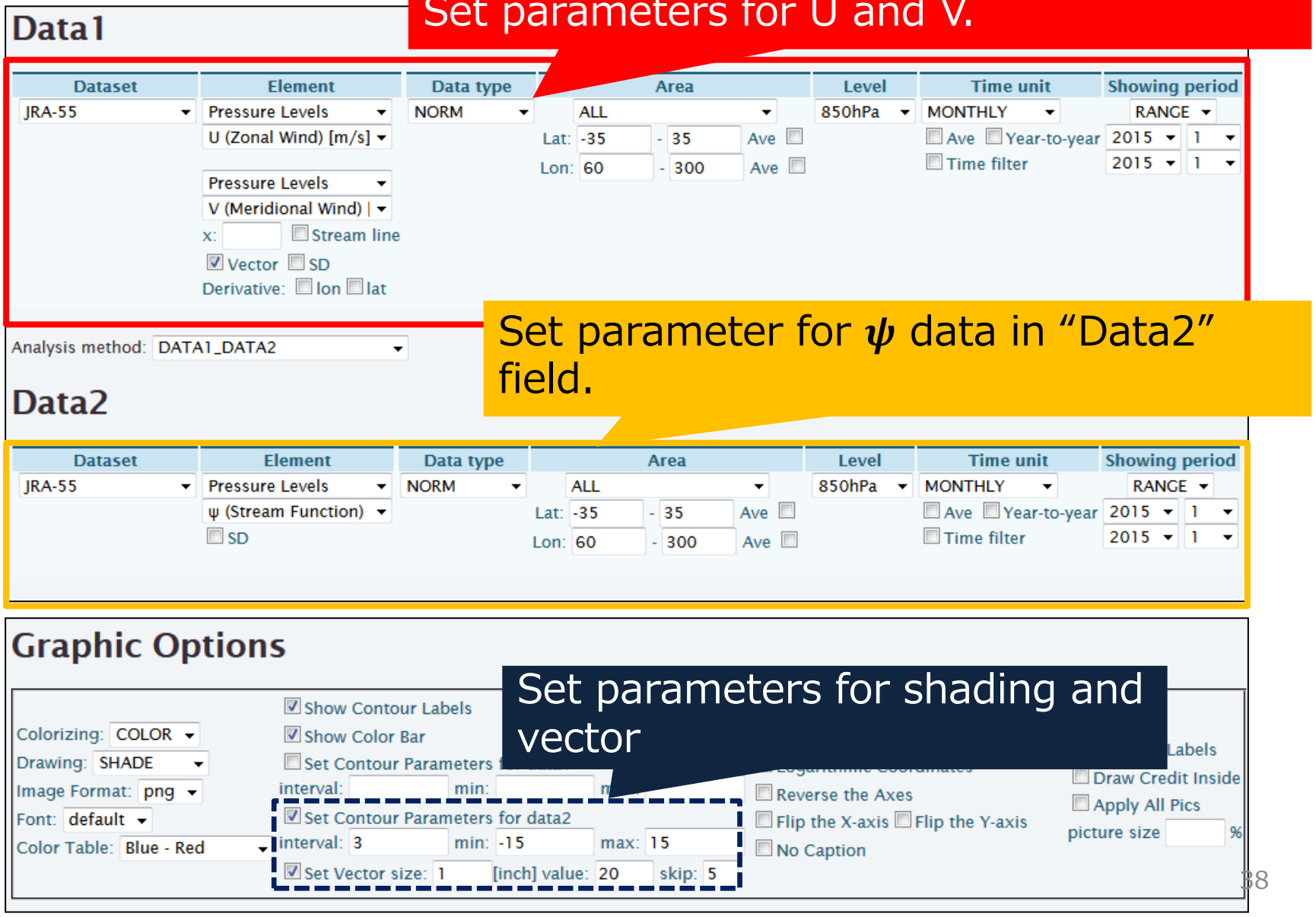



**Stream function** (rotational winds)



# Answers to Exercise (2)

Vector variables must be set as “Data 1”.
Set parameters for U and V.



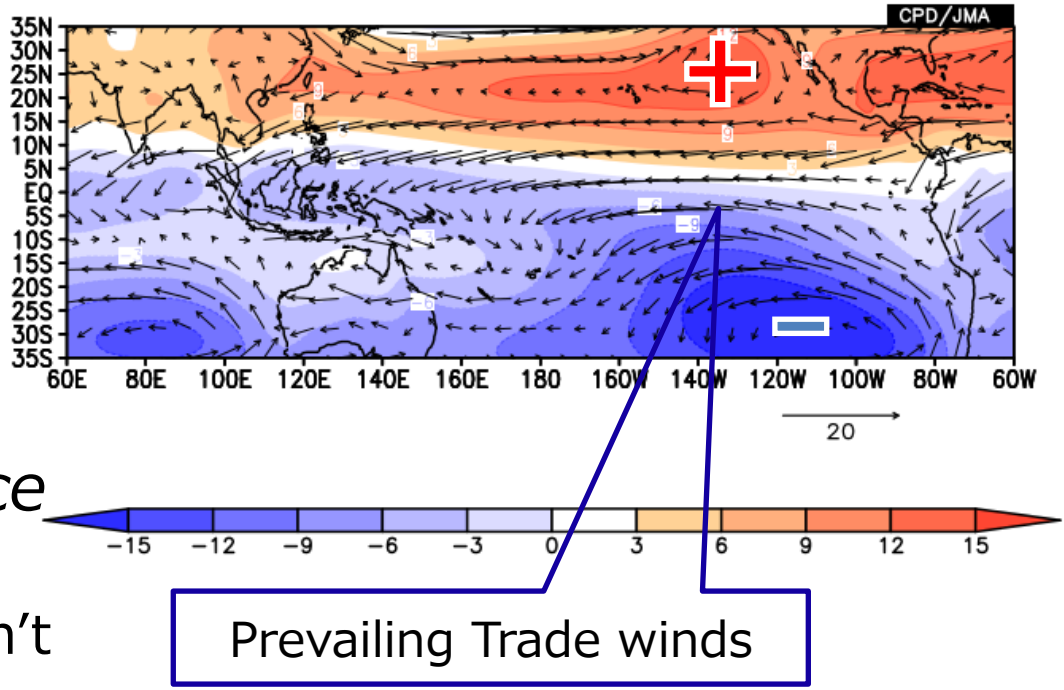

Set parameter for $\psi$ data in “Data2” field.

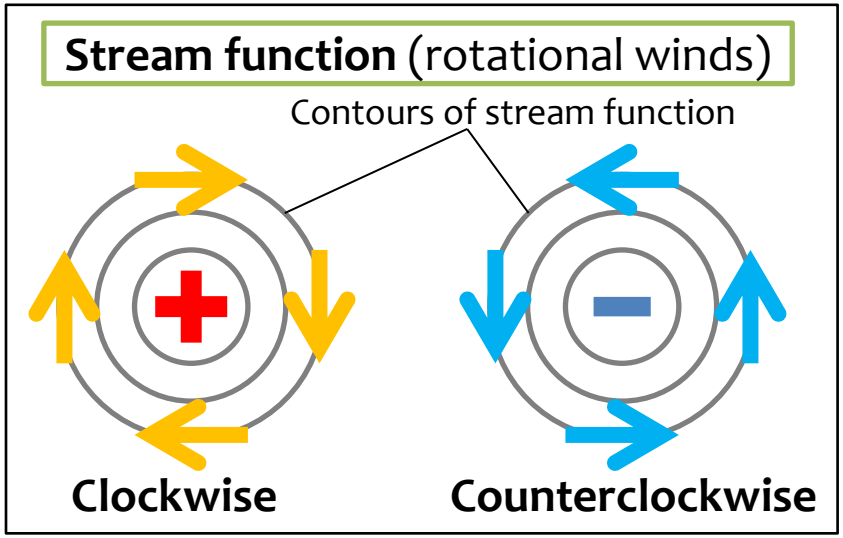
Set parameters for shading and vector

# Tips: Stream function ($\psi$)

Note:

- Wind vectors are nearly parallel to the $\psi$ lines.
- **Clockwise circulations** around the **local maximum of $\psi$**, and *vice versa*.
  - <!> Positive $\psi$ values don't always mean clockwise circulations. You should see $\psi$'s maximum/minimum rather than the value itself.
- The magnitude of $\psi$'s gradient corresponds to the rotatiinal wind speed.

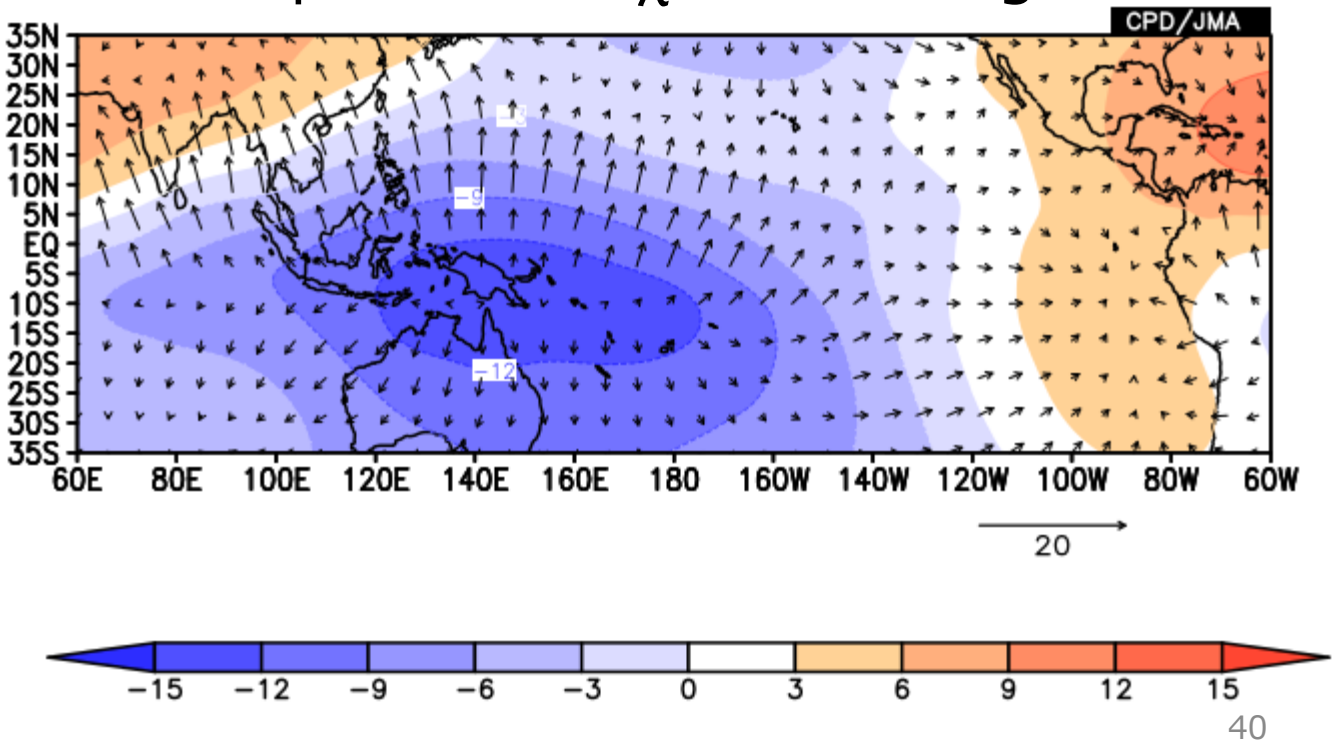


# Exercise (3)

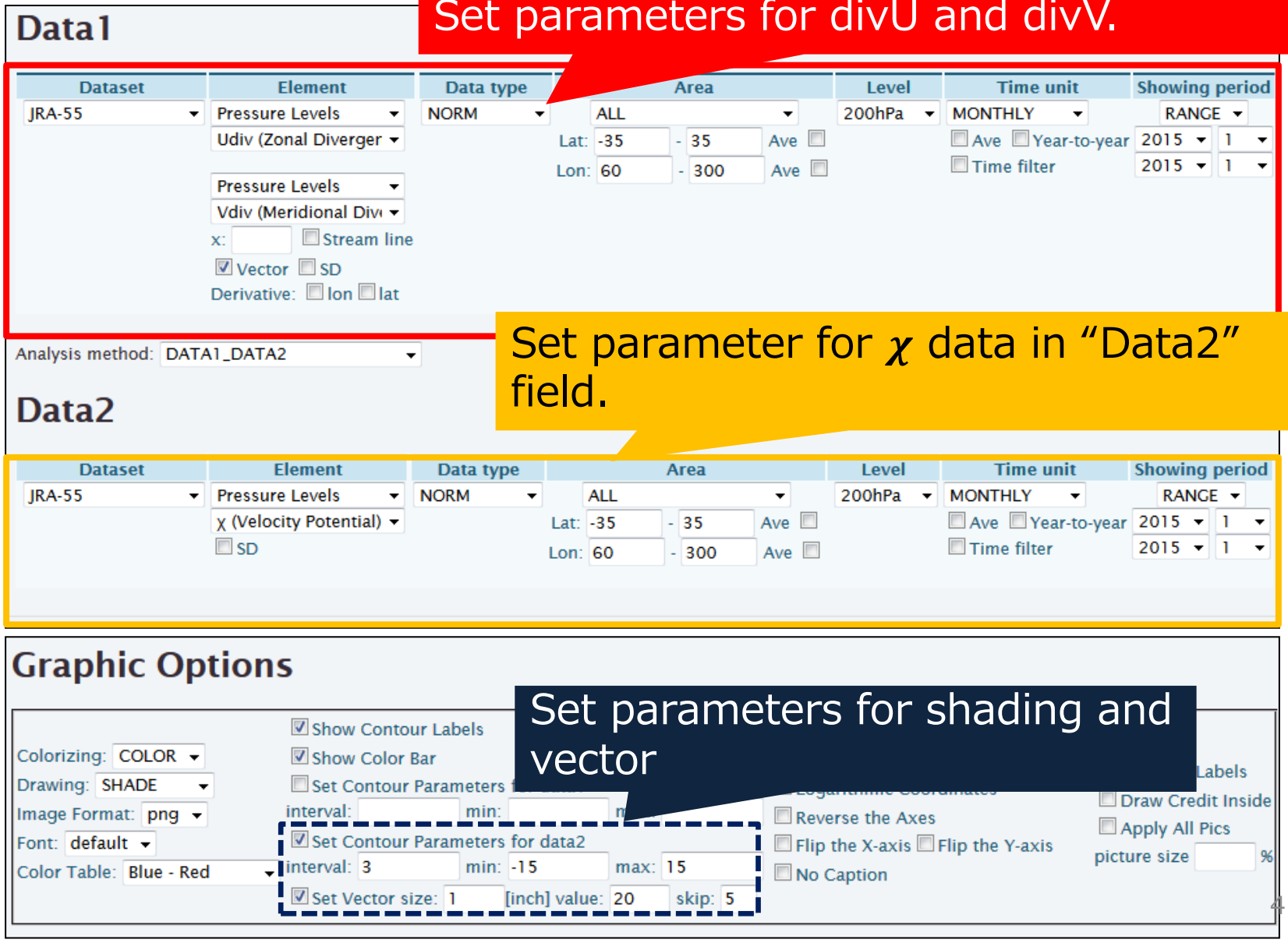
- Let's see the climatological mean velocity potential ($\chi$) and divergent wind vectors at 200hPa for January.
  - Velocity potential ($\chi$) is used for diagnosing large-scale divergent wind fields. In the tropics, those divergent winds are related with convective activity.
  - Check the relationship between $\chi$ and divergent wind fields.

Hint:
To draw divergent wind vectors, select "Udiv" and "Vdiv" from pressure-level data of JRA-55.



# Answers to Exercise (3)

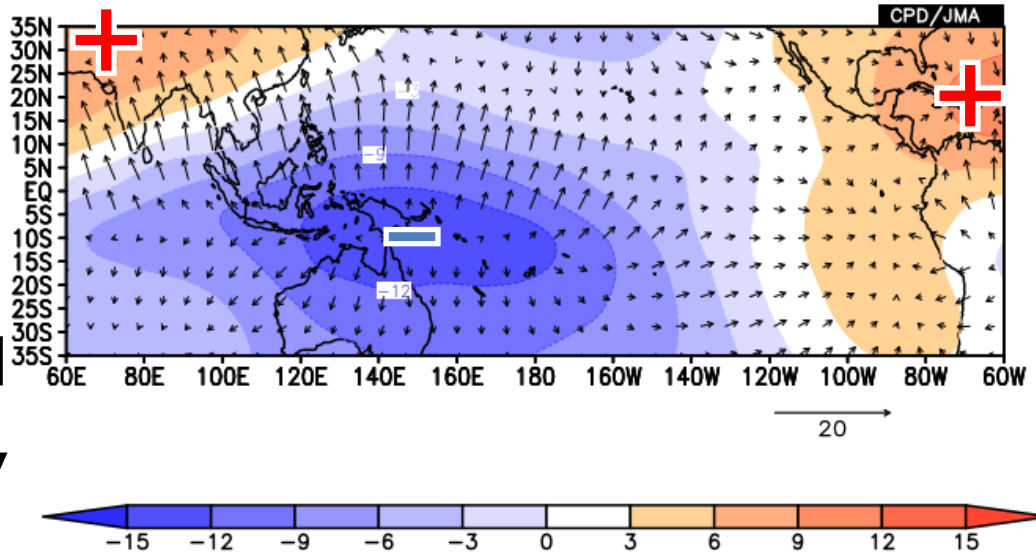
Vector variables must be set as “Data 1”.
Set parameters for divU and divV.

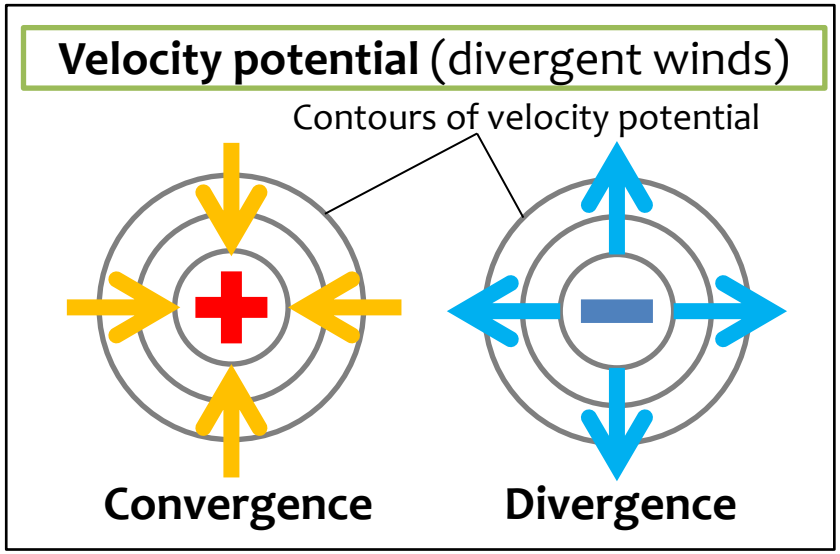


# Tips: Velocity potential ($\chi$)

Note:

- Divergent wind vectors are perpendicular to the $\chi$ lines.
- **Divergent winds** around the **local minimum of $\chi$**, and *vice versa*.
  - <!> Negative $\chi$ values don't always mean divergent winds. You should see $\chi$'s maximum/minimum rather than the $\chi$ value itself.
- The magnitude of $\chi$'s gradient corresponds to the divergent wind speed.

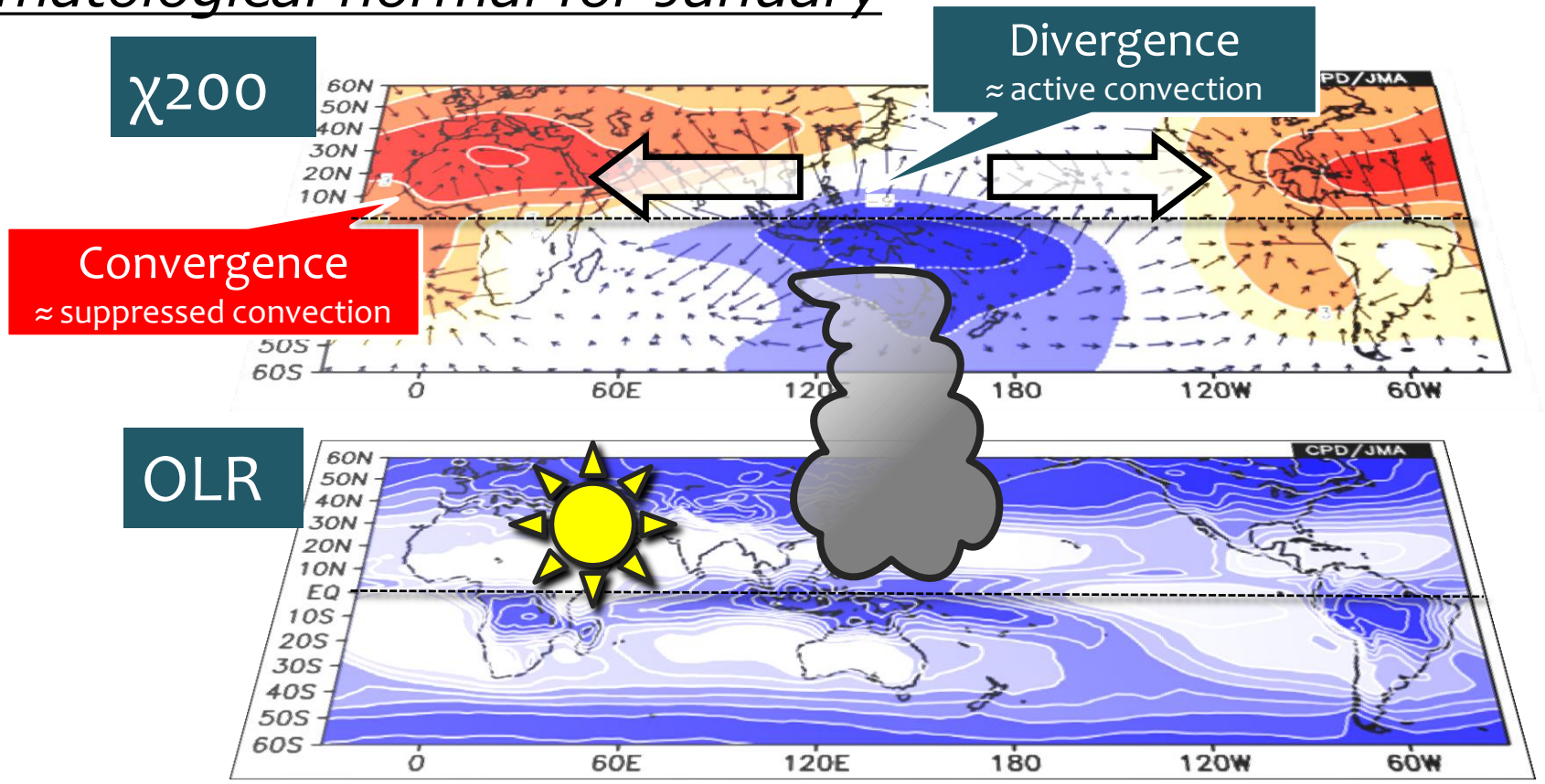


# Topics: Tropical Convection and Divergence

- In the tropics, upper-level divergence (i.e., the minimum of $\chi$) is associated with deep convection.
- Active convection over the Maritime continent.

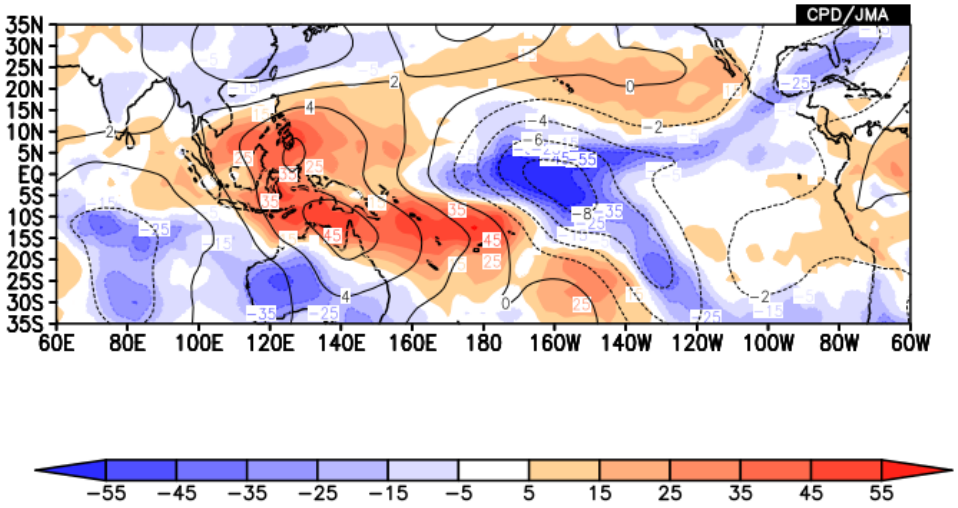
*Climatological normal for January*



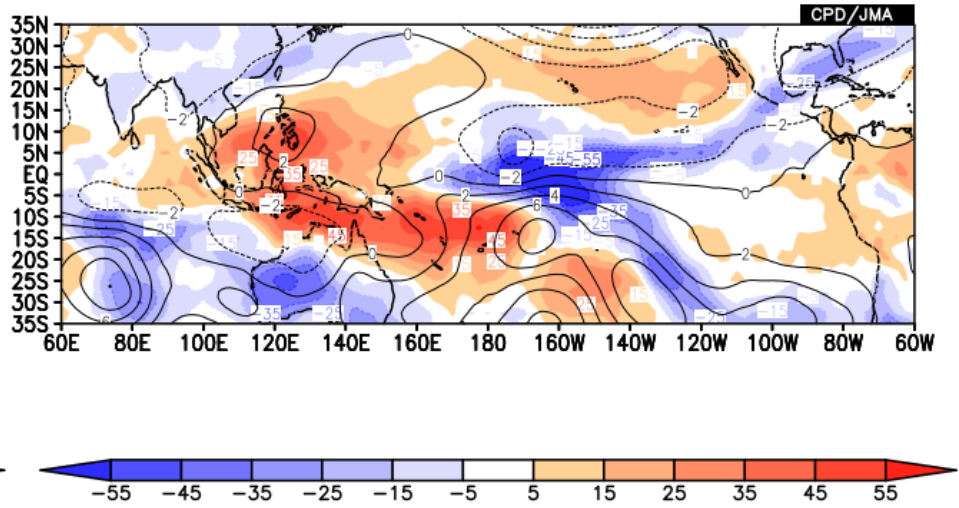
# Exercise (4)

- Make anomaly maps for January 2016.
  - [Left] $\chi$200 (contour) and OLR (shade)
  - [Right] $\psi$850 (contour) and OLR (shade)

χ200 (contour) and OLR (shade)



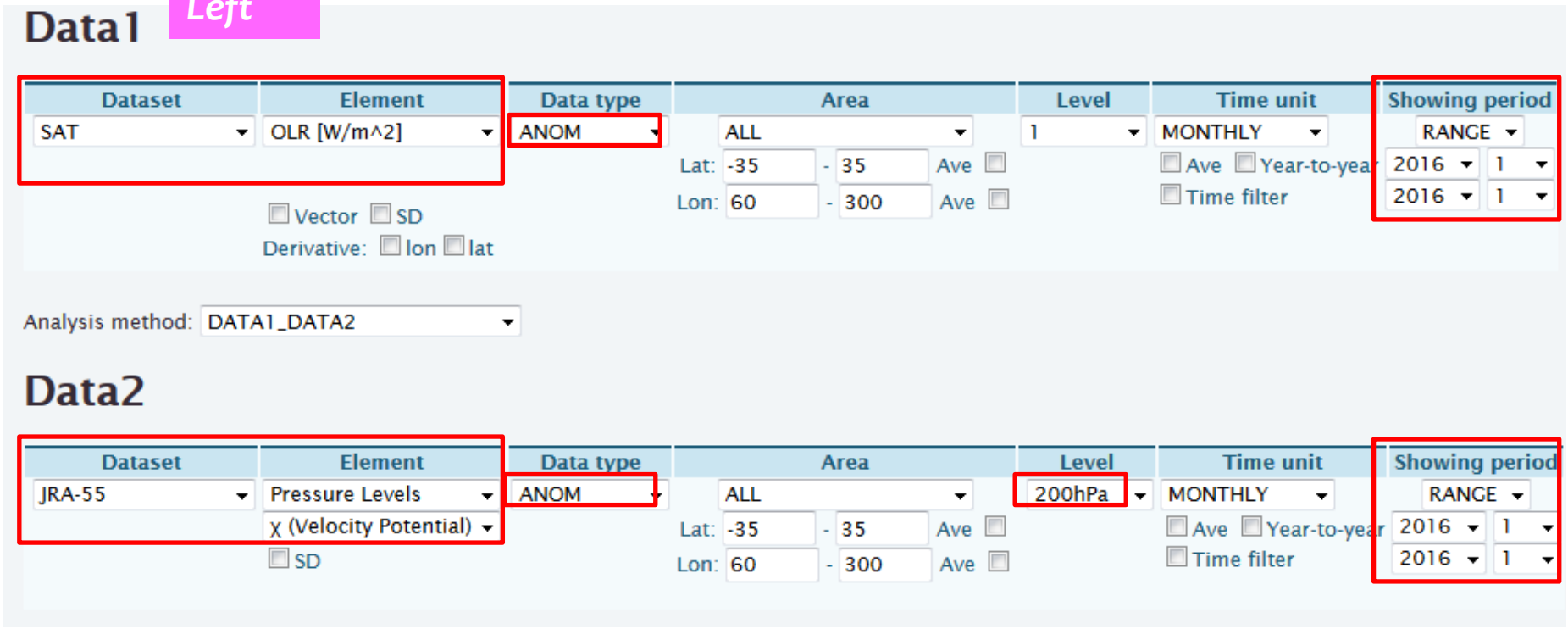

ψ850 (contour) and OLR (shade)

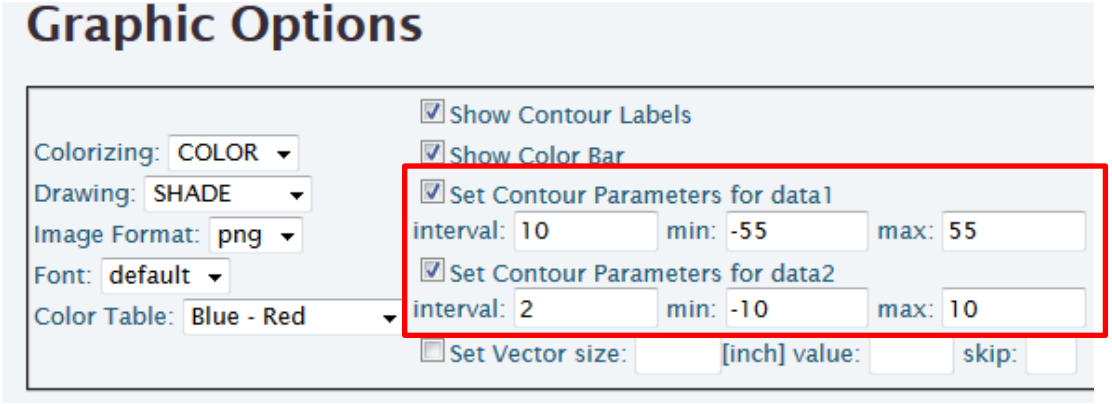



Where is upper-level divergence/convergence anomalies?
How about their relationship with OLR anomalies?
What circulation anomalies is collocated with those OLR anomalies?

# Answers of Exercise (4)

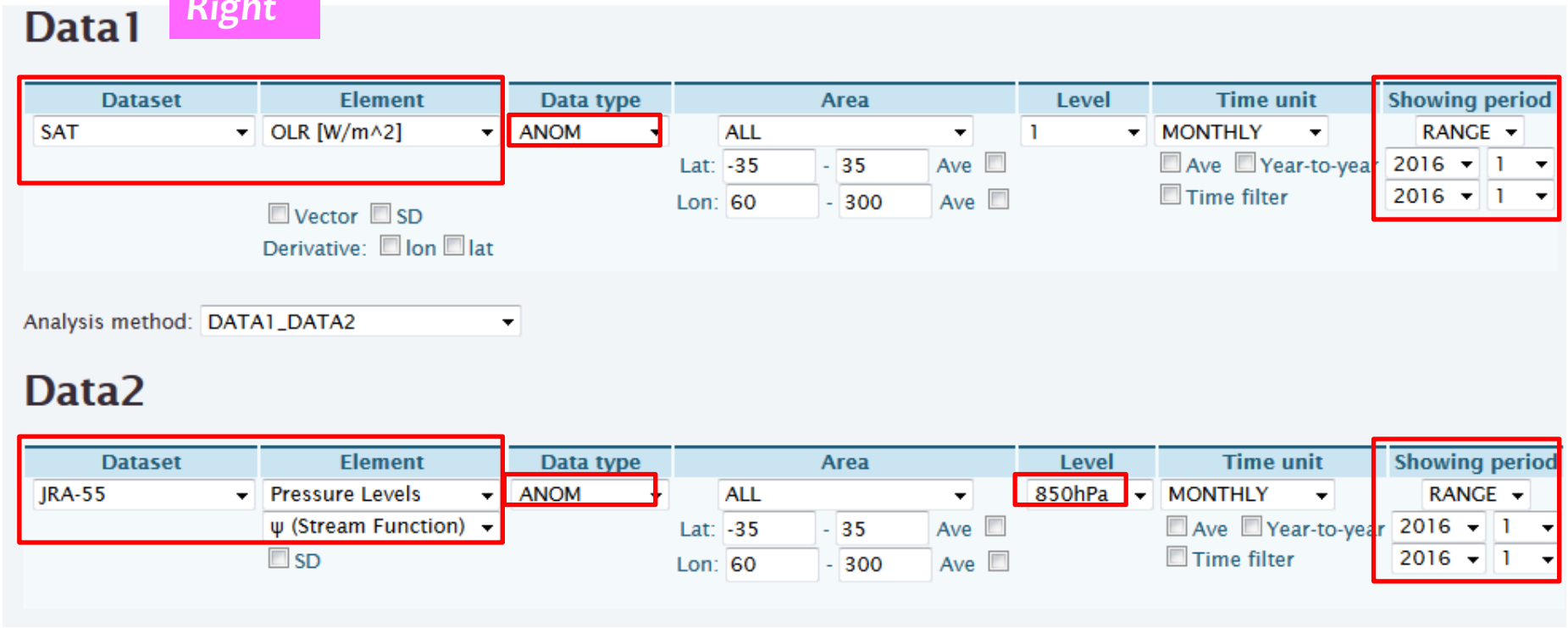
*Left*

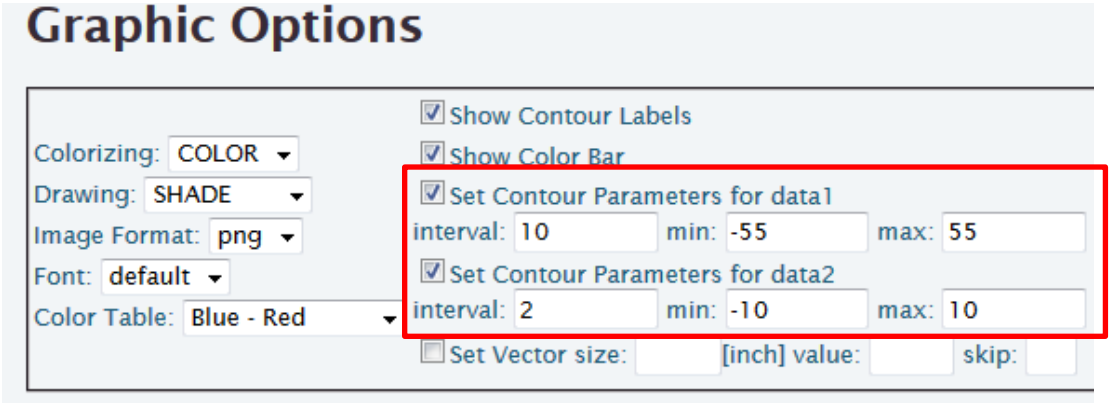


# Answers of Exercise (4)

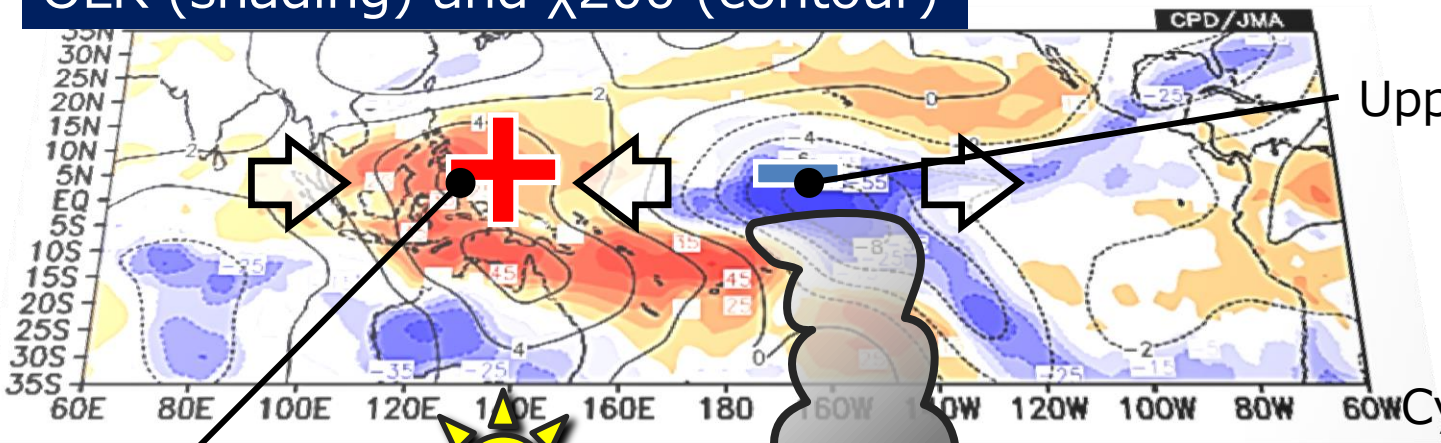
*Right*



# Topics: Anomalies associated with El Nino

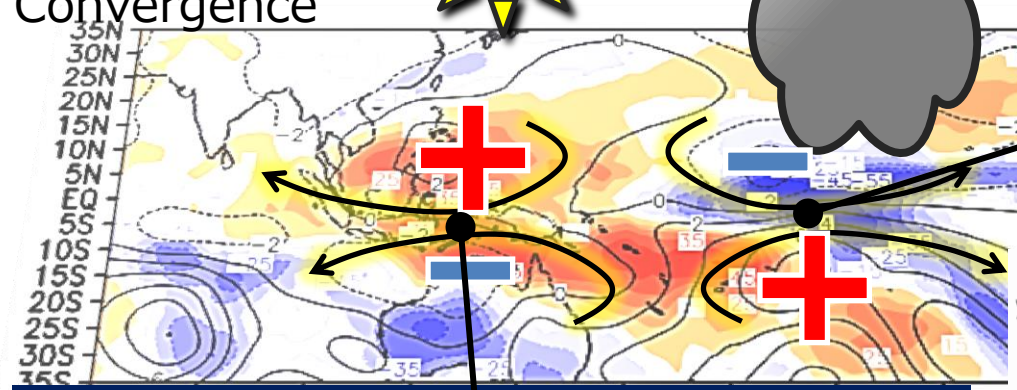
## OLR (shading) and χ200 (contour)




Upper-level Divergence

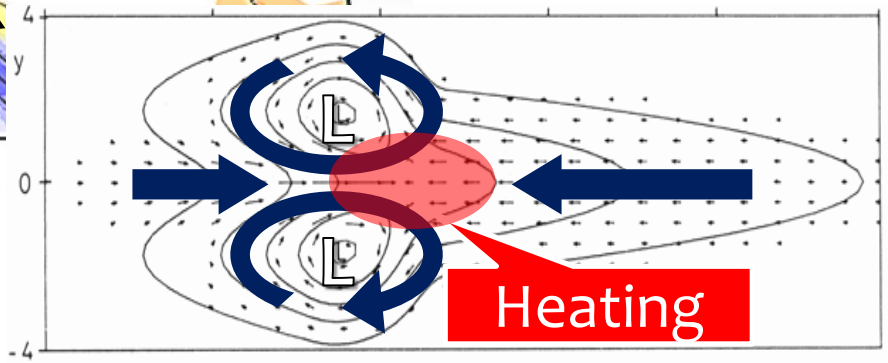
Upper-level Convergence

Cyclonic circulation anomalies straddling the equator
(Negative anomalies in N.H. -> cyclonic
Positive anomalies in S.H. -> cyclonic)




## OLR (shading) and ψ850 (contour)

Anti-cyclonic circulation anomalies straddling the equator



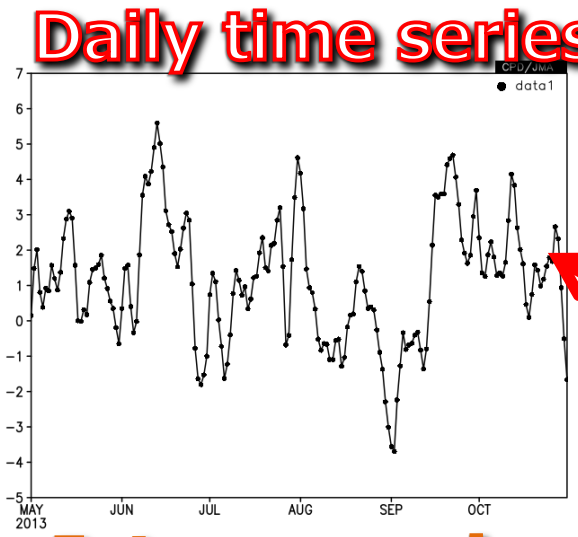

Matsuno-Gill response (Gill, 1980)

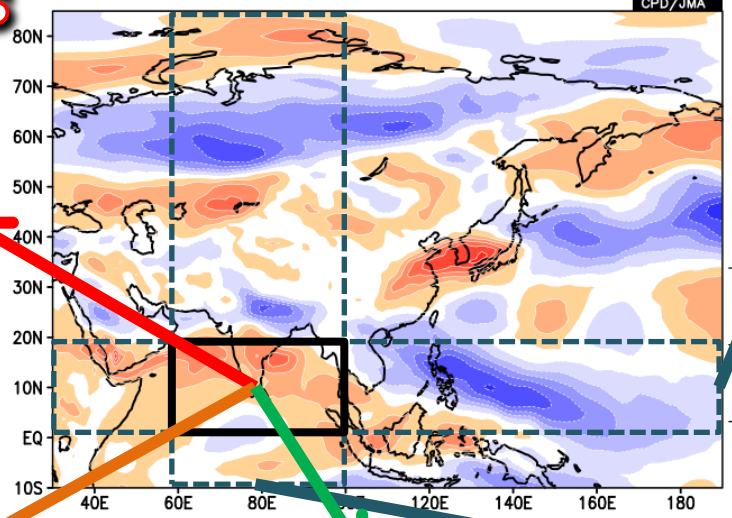
# Contents

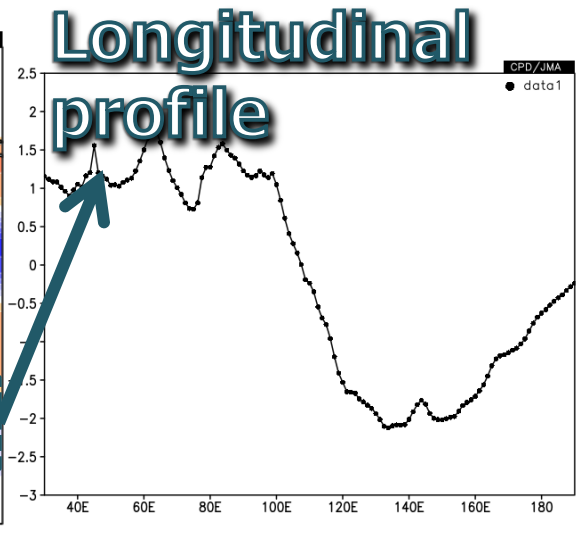
1. What's iTacs?
2. Basic operations –Horizontal map-
   - Access to iTacs
   - Basic operating procedure
   - Longitude-latitude map
   - Multiple data
3. Basic operations –Other kinds of maps-
   - Vertical and latitude/longitude profile
   - Cross section diagram

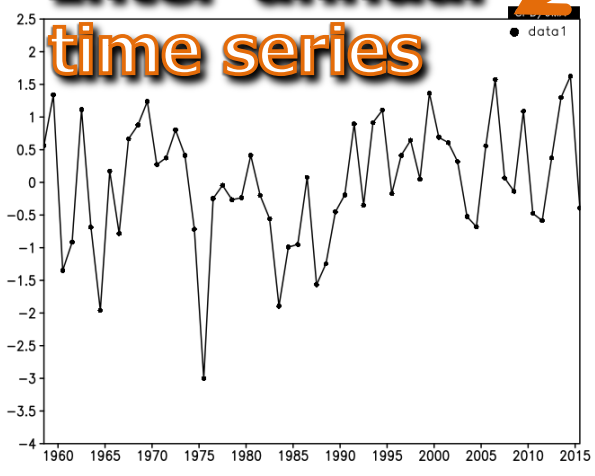
# Line graph & Cross section diagram

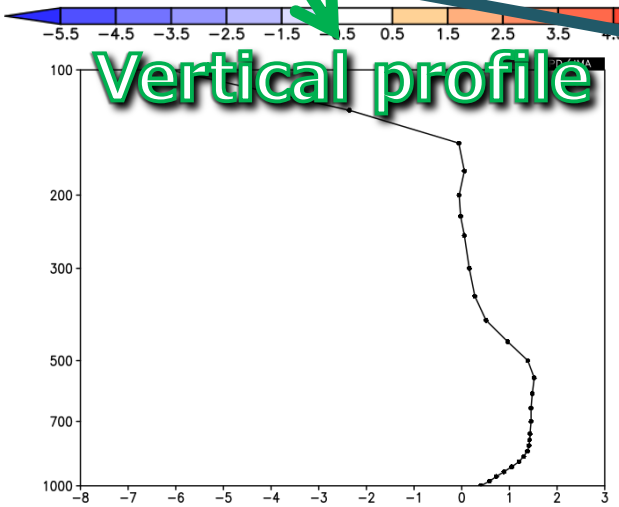
- Time series and profile graph are useful to see the variability or spatial structure simply.

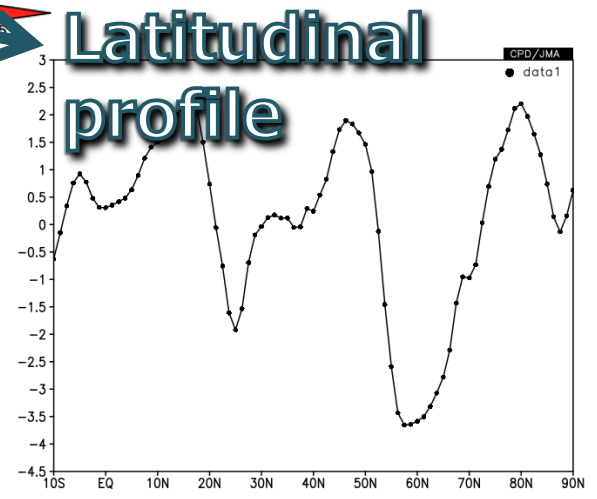


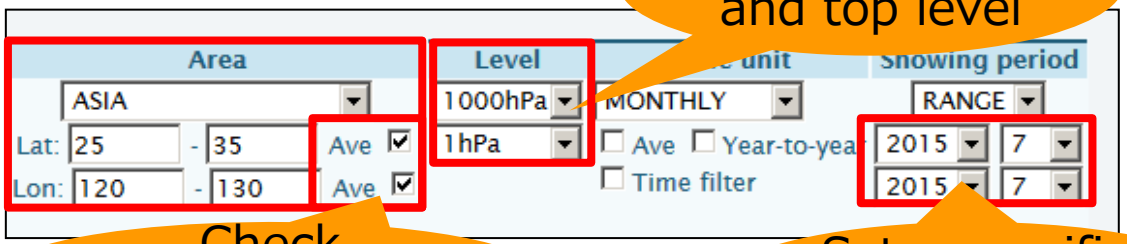



# Vertical and lat/longitude profile

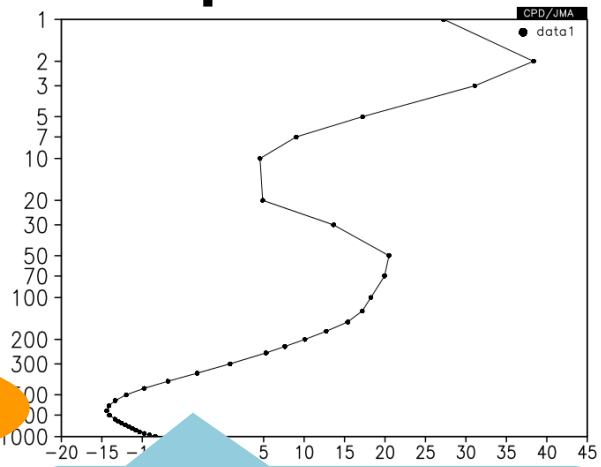
- Vertical profile




Select bottom and top level

Check (Regional mean)

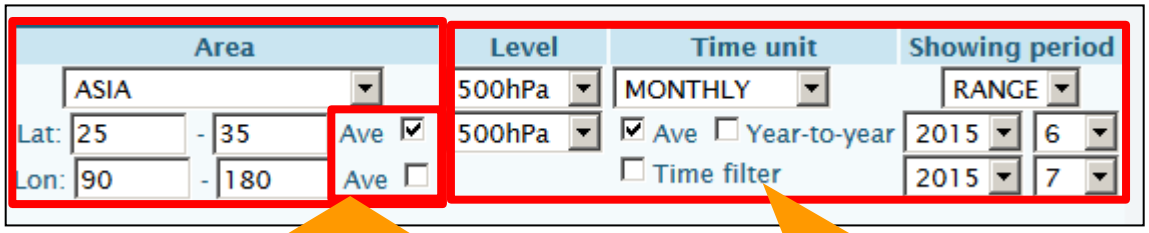
Set a specific period




Height anomalies averaged over 25°–35°N, 120°–130°E

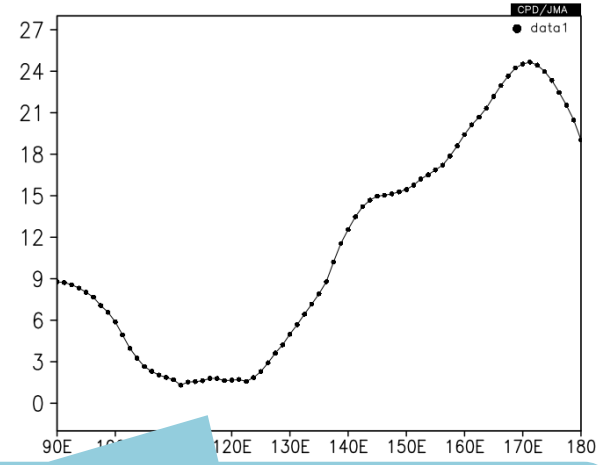
"Logarithmic Coordinates" option is recommended in vertical profile graph.


- Lat/Longitude profile




Check either "Ave" boxes (latitudinal or longitudinal mean)

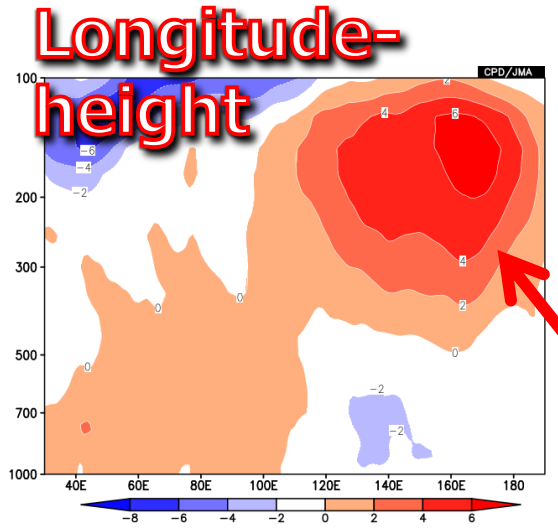
Select a specific level and period

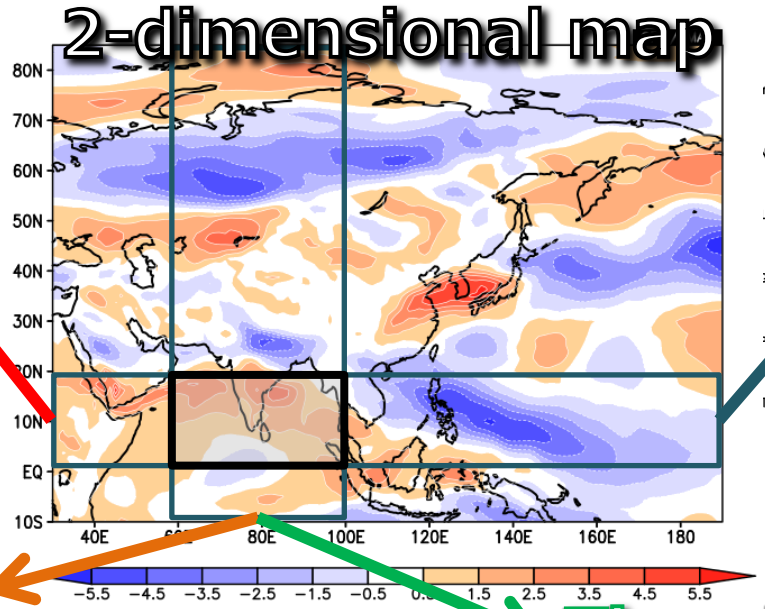


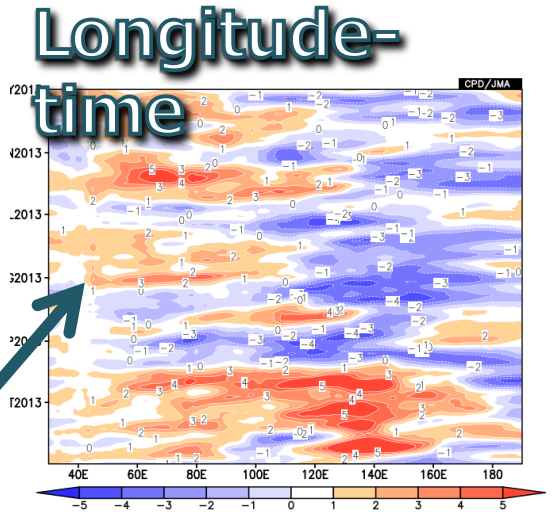

Longitude profile of 500-hPa height anomalies over 25°–35°N

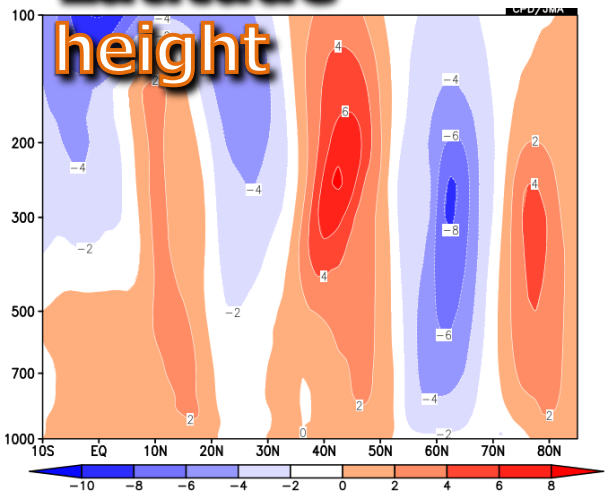
# Cross section diagram

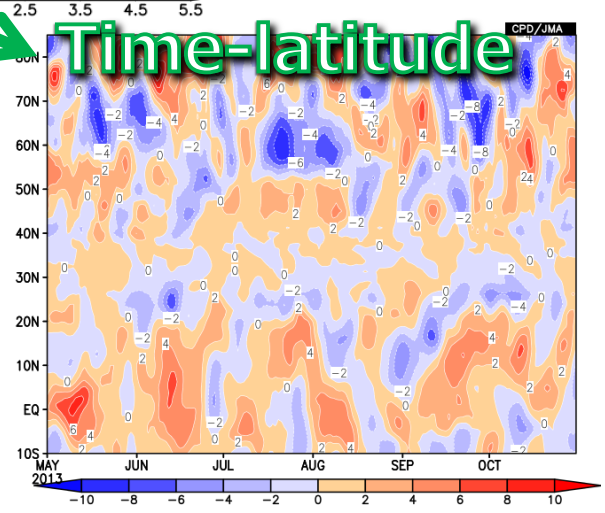
- Cross section diagram is also useful to see the variability or spatial structure.



# Vertical cross section

- Latitude-height cross section

Set a specific period

Input southern and northern border

Data1

| Dataset | Element | Data type | | Level | Time unit | Showing period |
|---|---|---|---|---|---|---|
| JRA-55 | Pressure Levels | NORM | ALL | 1000hPa | MONTHLY | RANGE |
| | ω (Pressure Vertical | | Lat: -60 - 60 Ave ☐ | 100hPa | ☑ Ave ☐ Year-to-year | 2016 6 |
| | | | Lon: 90 - 150 Ave ☑ | | ☐ Time filter | 2016 8 |

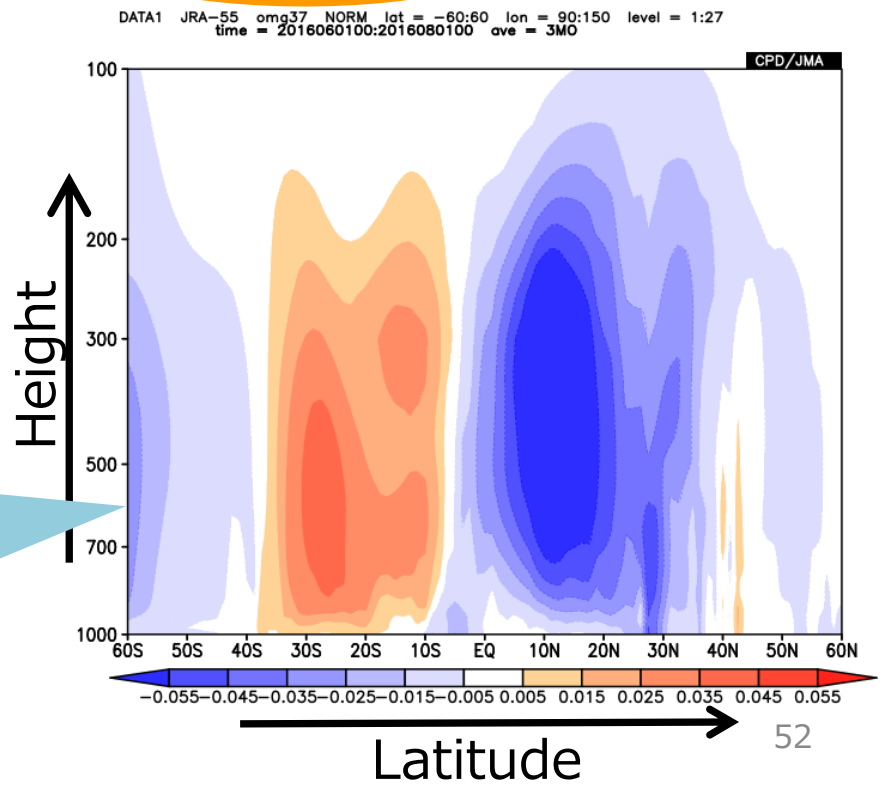
Input western and eastern border and check “Ave” box.

Set bottom and top level

☐ Polar Stereographic: North p

☑ Logarithmic Coordinates

“Logarithmic Coordinates” is recommended to draw vertical profiles.

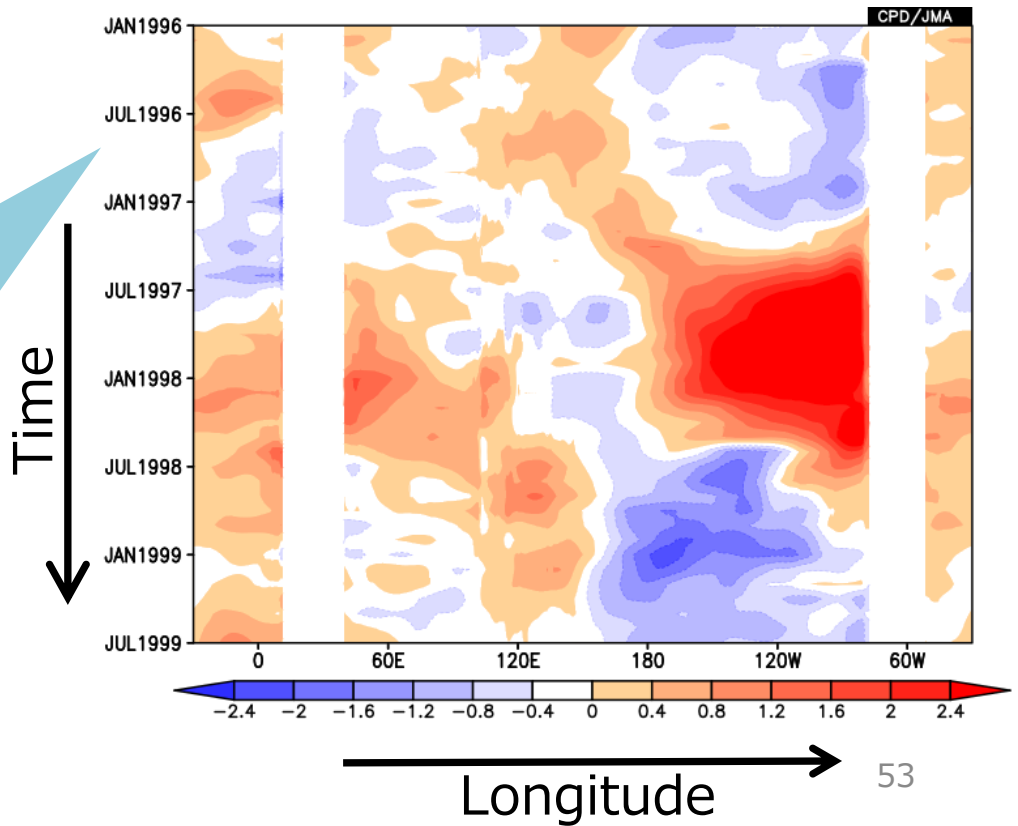



Latitude-height cross section of normal pressure vertical velocity averaged between 90°E and 150°E in summer 2016

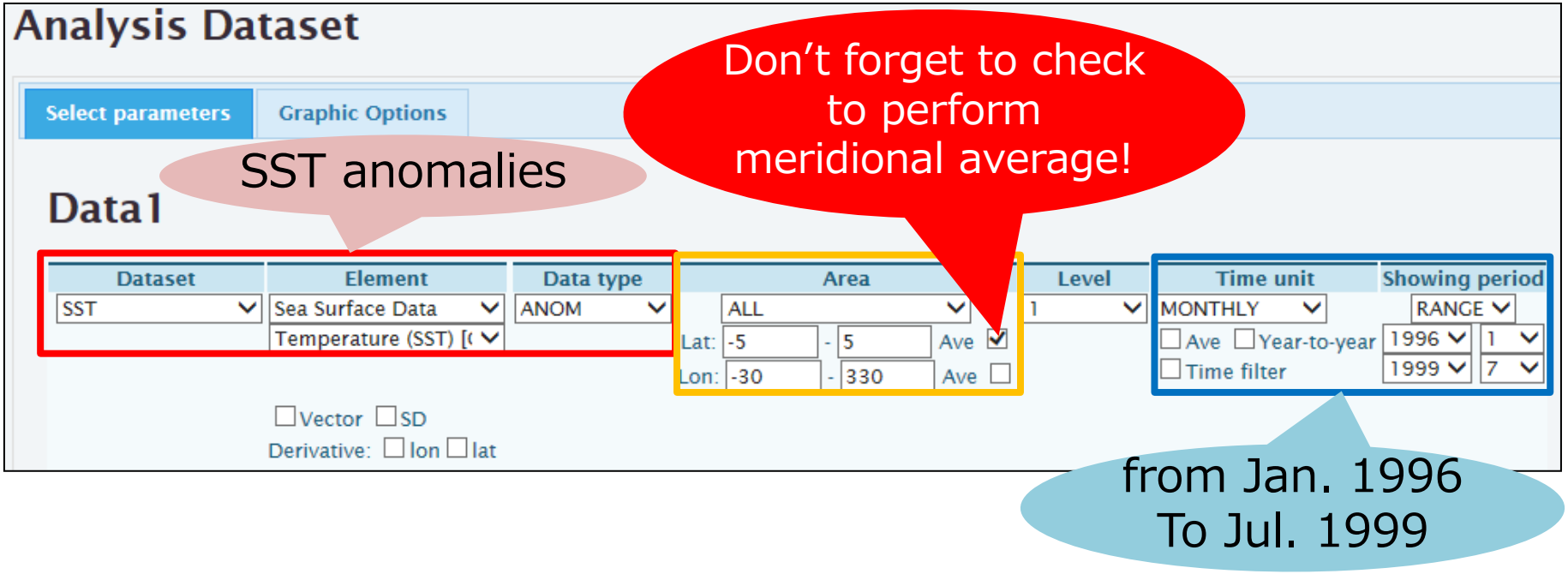
# Time cross section

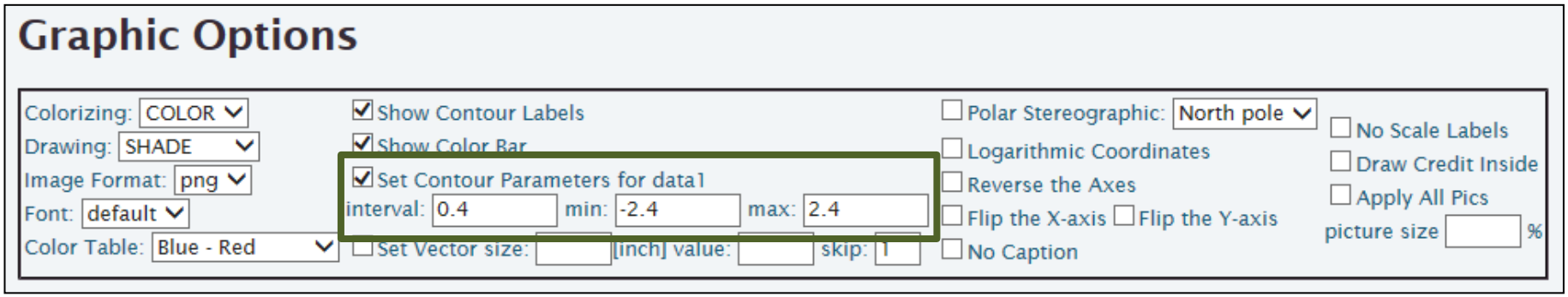
- Longitude-time cross section
- To see time evolution and highlight some wave propagation
- Let's see the time evolution of the equatorial SST anomalies associated with the 1997/98 big El Niño event.

Longitude-time cross section of SST anomalies averaged over 5°S – 5°N (i.e. along the equator) from January 1996 to July 1999.

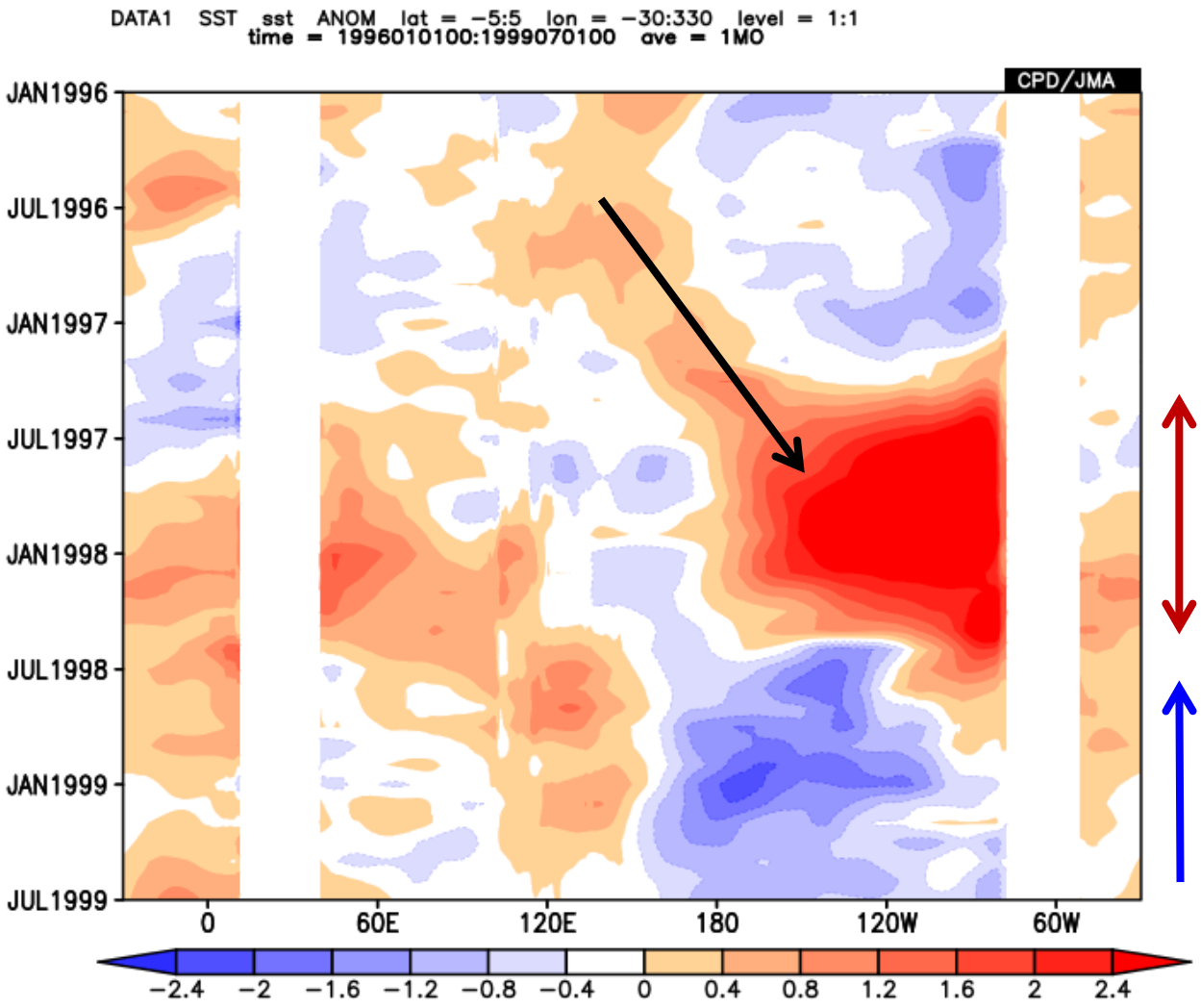


# Time cross section



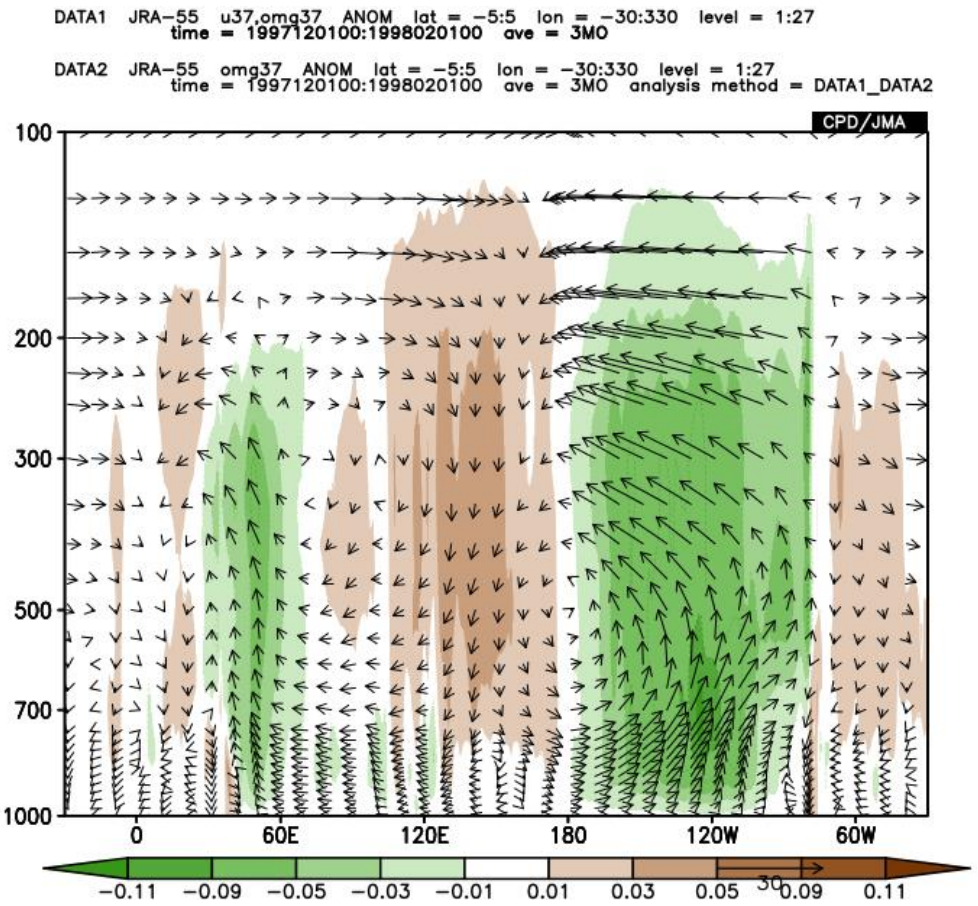
# Time cross section



# Integrated Exercise (1)

- Show longitude-height cross section of zonal/vertical wind anomaly vector and vertical wind anomaly (shading) averaged from 5°S to 5°N during the period from December 1997 to February 1998.

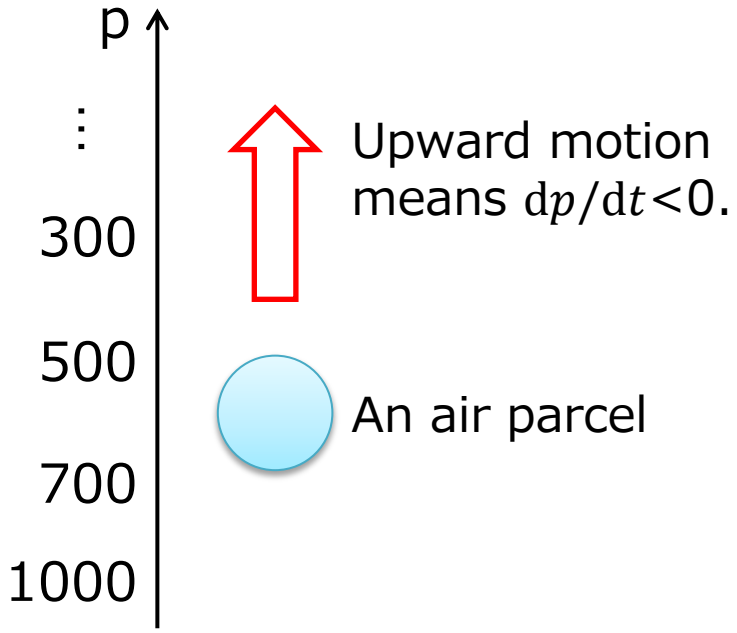
- Try to adjust vector scale and skip interval to improve the visibility of the figure.
- Select logarithmic coordinates for vertical axis.
- Adjust contour parameters (see color bar of the figure).
- Select “Green-Brown” for “Color Table”.



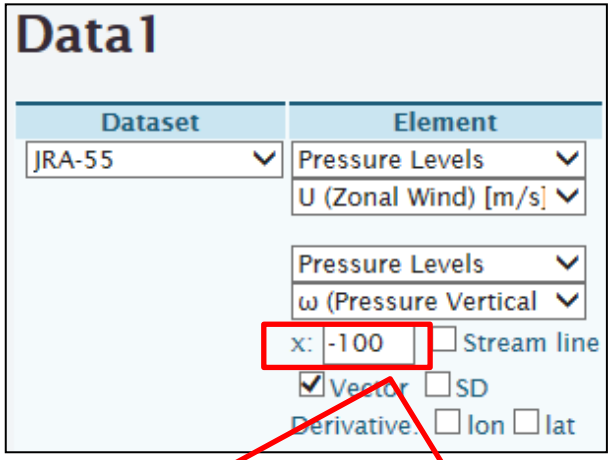
# Hint: How to draw vertical motion by vectors

In pressure coordinate data set, vertical motion is given by pressure velocity $\omega$ , where $\omega \equiv \mathrm{d}p/\mathrm{d}t$.

If $\omega < 0$, it means the pressure of an air parcel there becomes lower, which corresponds to upward motion because pressure becomes smaller towards upper levels in general.

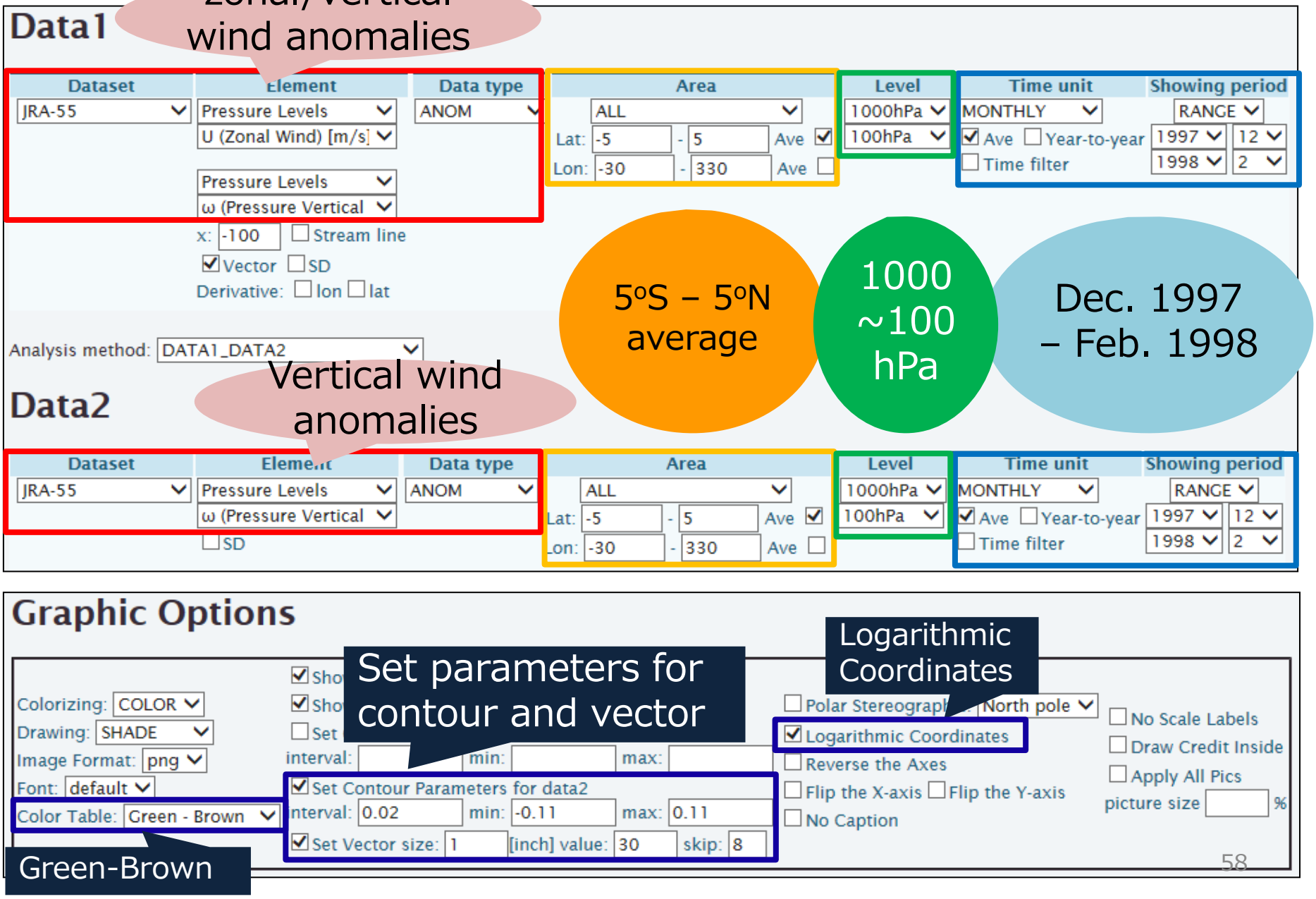



In iTacs……,



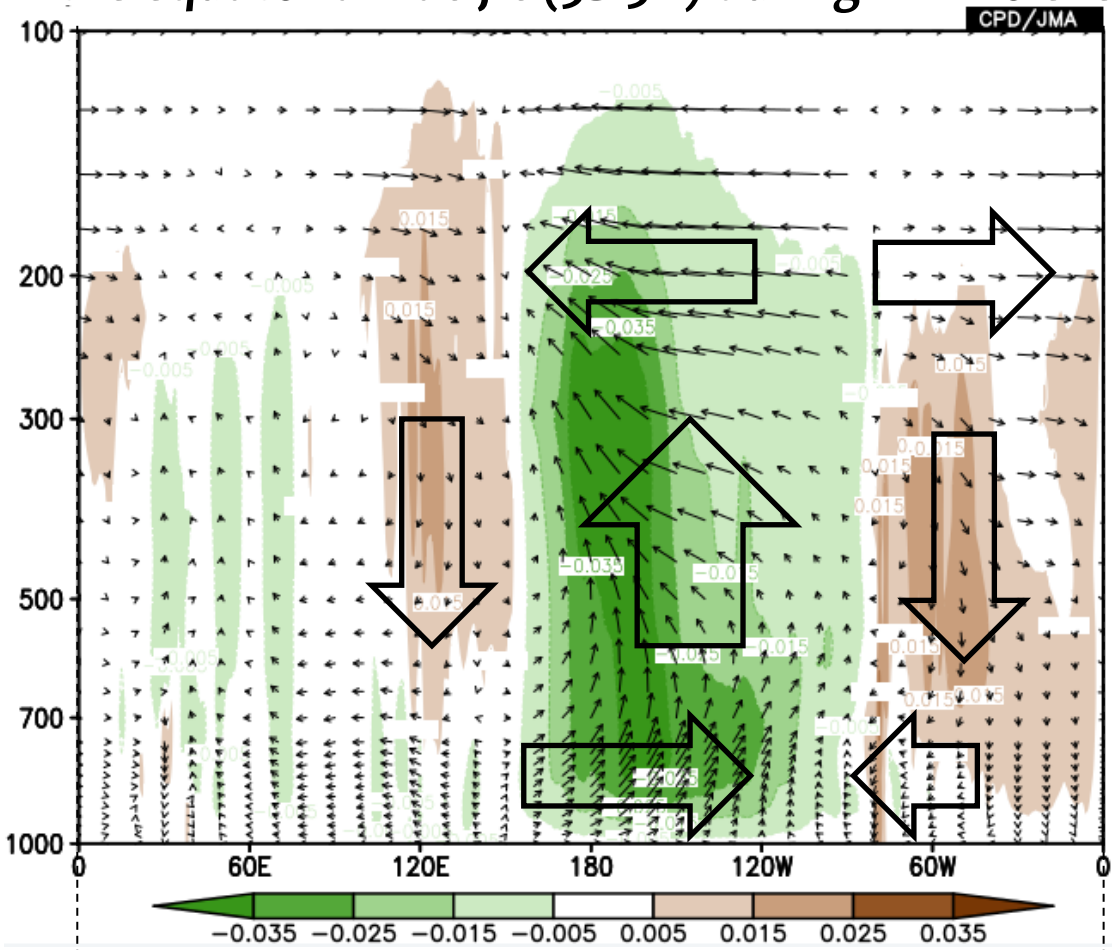

This means multiplying the second component by -100. There is two reasons.
#1: **To reverse the vector direction for understanding the true wind direction intuitively**.
#2: To highlight vertical component because omega values are too small compared to meridional winds in general.

# Answers to Integrated Exercise (1)

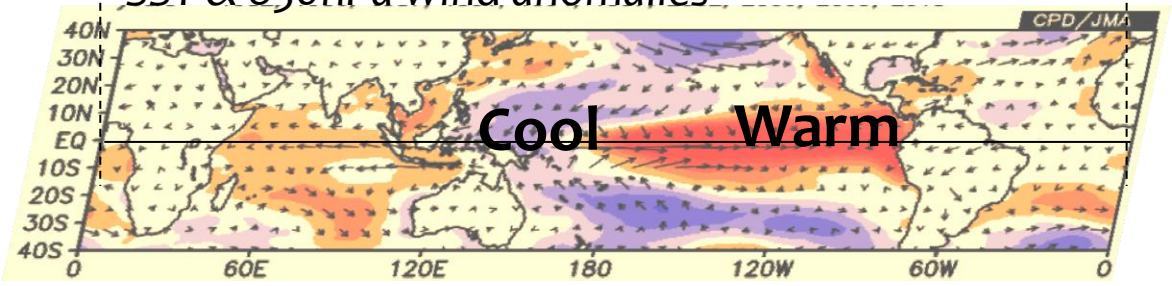


# Topics: Ocean-Atmosphere Coupled System

***In the equatorial Pacific (5S-5N) during El Niño events……,***




*SST & 850hPa wind anomalies*




→ Warmer SST in the E. Pacific
Cooler SST in the W. Pacific
↓
Convection anomalies
↓
Low-level convergence
Low-level westerlies

Actually, the induced low-level westerlies can enhance SST anomalies in turn (this is oceanic dynamics).

This is referred to as the ***Bjerknes Feedback*** (but we cannot say what the initial trigger is).

El Niño/La Niña is an **Ocean-Atmosphere coupled** phenomenon !!

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# Statistical Analysis in iTacs

- Various statistical analysis methods are available.
  - Correlation/Regression analysis
  - Composite analysis
  - Single/multi EOF, SVD analysis
  - FFT analysis
  - Wavelet analysis
- They can be powerful and helpful for understanding our climate system. Of course, statistics is also necessary for seasonal forecast.

*Keep in mind that statistical results **DO NOT ALWAYS** give us the physical nature of the target systems or phenomena. Statistics is just a matter of mathematics. We need physical interpretation after statistical analysis.*

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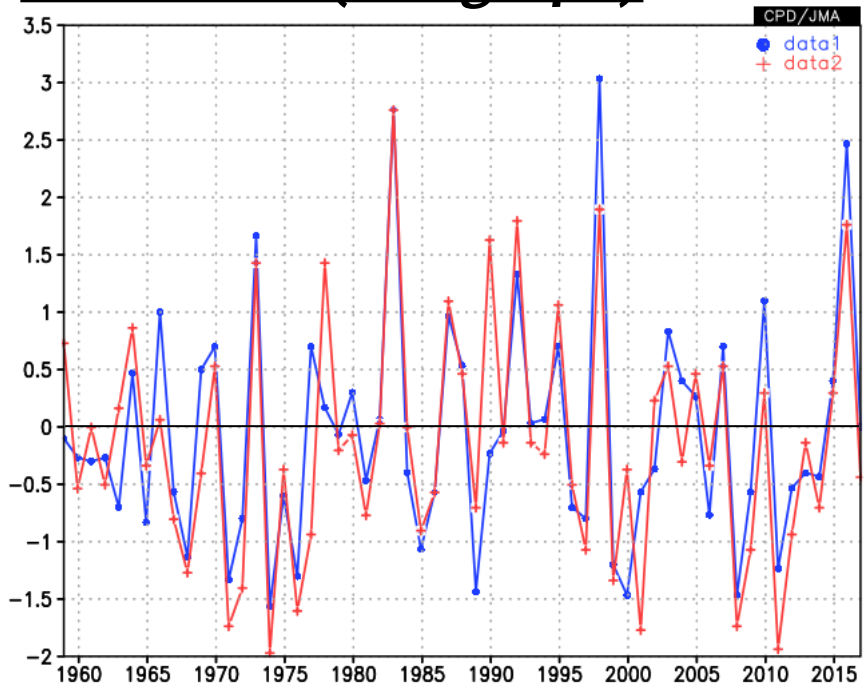
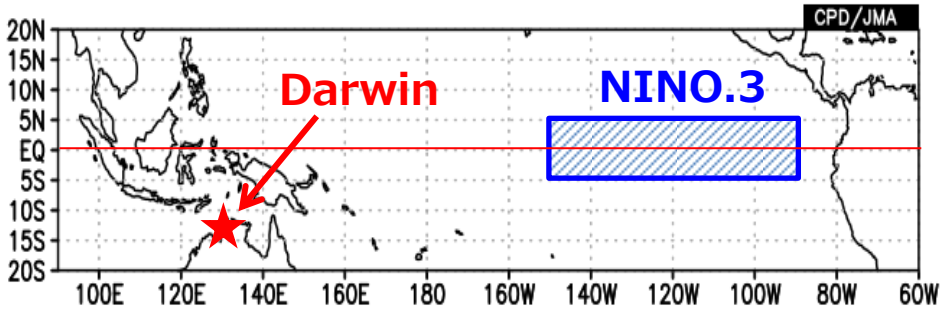
# Basic Statistics in Brief

***Time series (line graph)***




For Dec. thru Feb. (DJF) 3-month mean,

Blue: NINO.3 SST anomaly

(Positive: El Nino-like, Negative: La Nina-like)

Red: SLP anomaly at Darwin

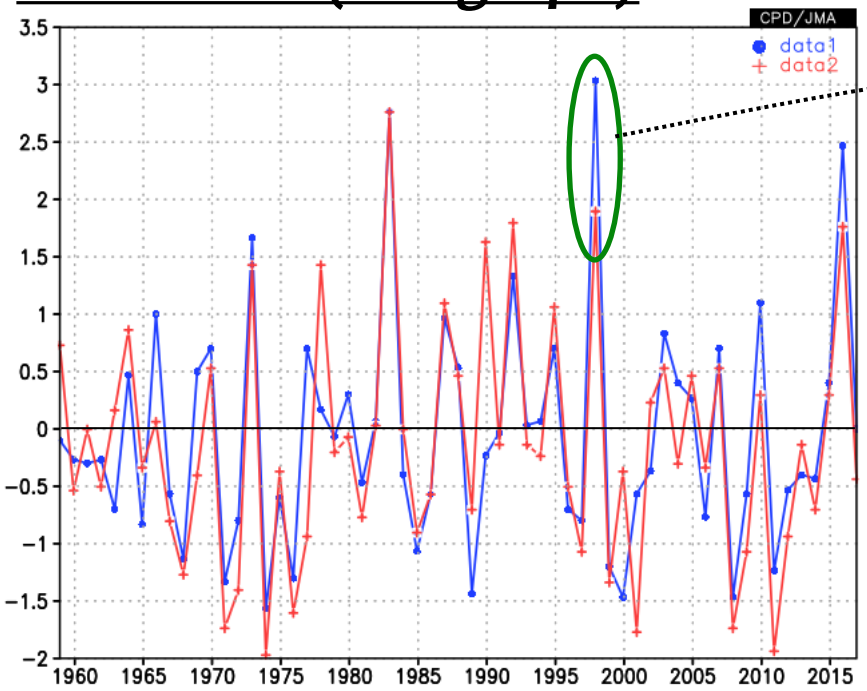
When NINO.3 SST anomalies are positive, SLP anomalies at Darwin tend to be positive.

Next step is…,

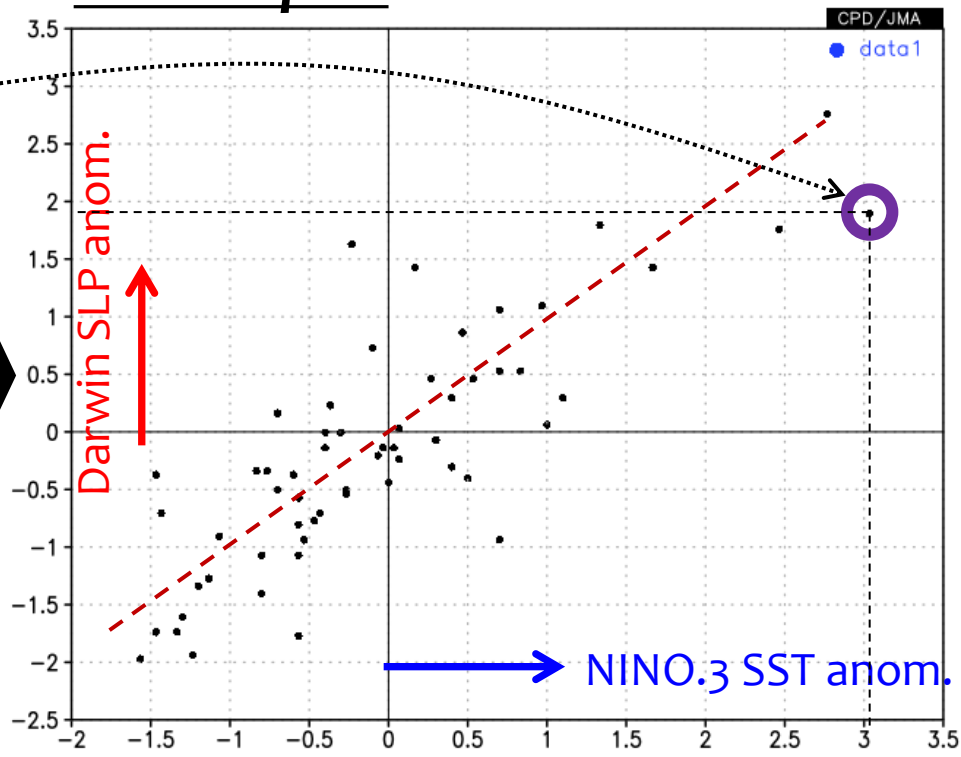
**How can we evaluate the relationship objectively and quantitatively?**

# Basic Statistics in Brief

***Time series (line graph)***




***Scatter plot***

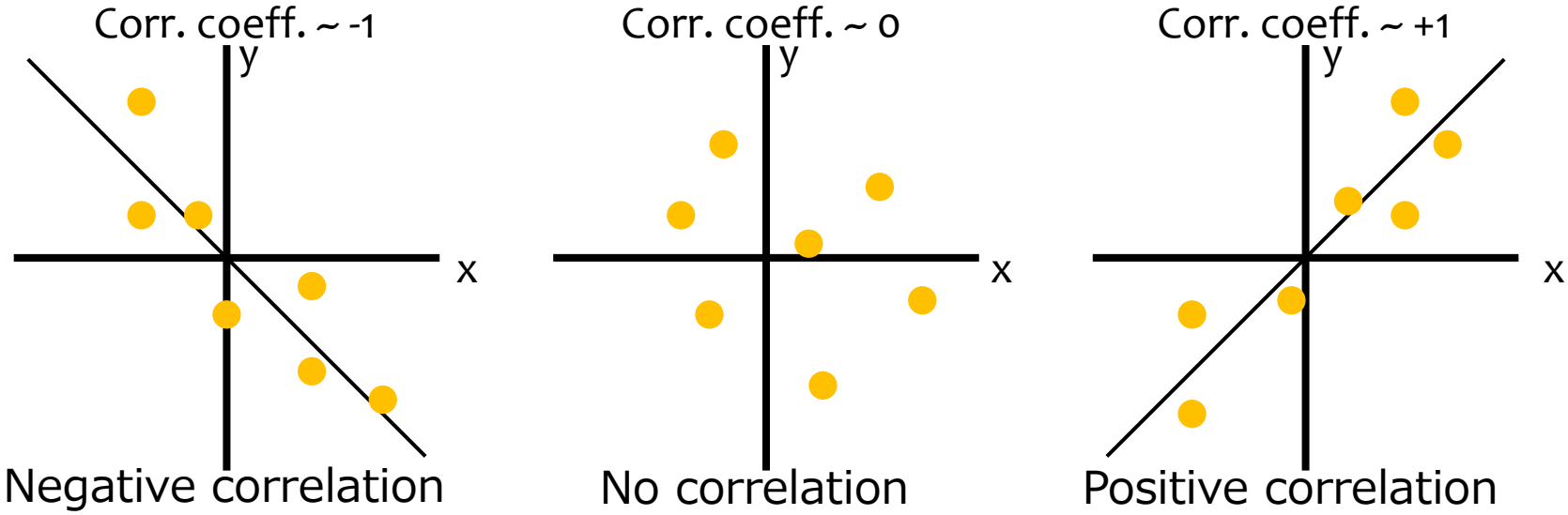



If we link **each pair** of NINO.3 SST and Darwin's SLP values to **a point** on a x-y map, we can clearly see a **linear relation** between them. We can evaluate the relationship with **correlation coefficients**. In this case, the correlation coefficient is **+0.82**.

**Correlation coefficient: How close they have a linear relationship**

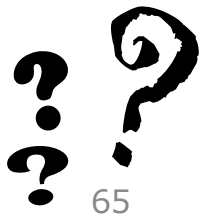
# Basic Statistics in Brief

- **Correlation coefficient: How close they have a linear relationship**
  - Correlation coefficient values are between -1 and +1.
  - The value close to +1 (or -1) means there is a clear positive (negative) linear relationship between the targeted data pair, and the value around zero means there is little (or weak) relation between them.




**Correlation does not imply causality!**

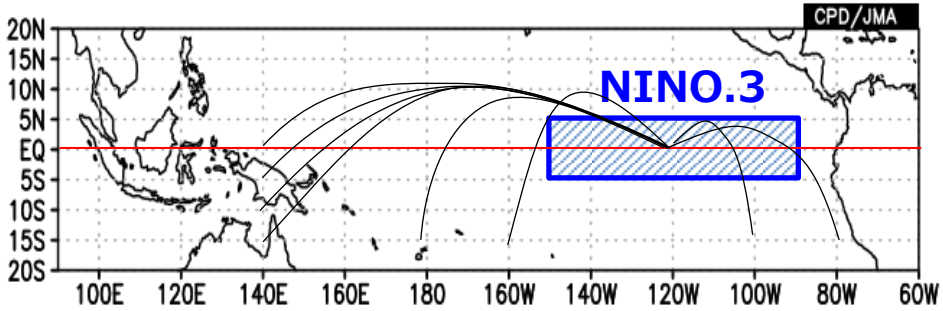
If there is a significant correlation btwn ***X*** and ***Y*****……,**

# Correlation Analysis (1)

- We confirmed that there is a strong positive correlation between NINO.3 SST anomalies and Darwin sea level pressure (SLP) anomalies.

*Question: How about another station's SLP? Rather, how about **every grid points** throughout the world?*

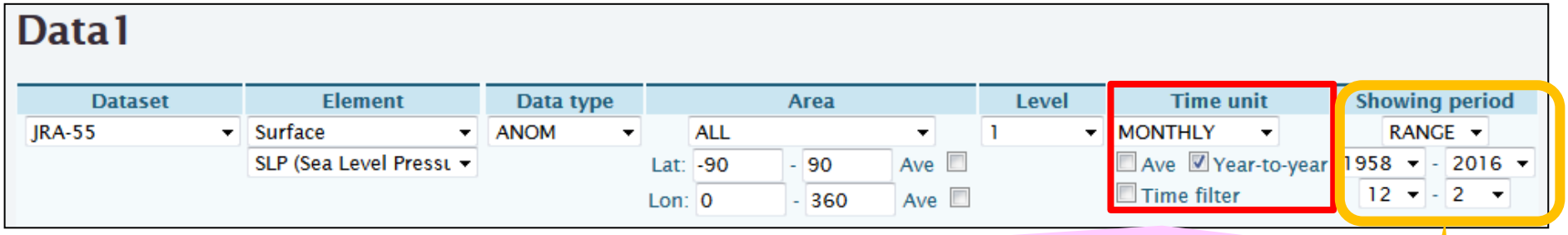



***Evaluating the correlation coefficients** between NINO.3 SST and SLP at every grid points and then **mapping** each value on each grid.*

- Let's make a correlation map between three-month mean sea level pressure (SLP) and SST anomaly in NINO.3 for DJF from 1958/1959 to 2016/2017.

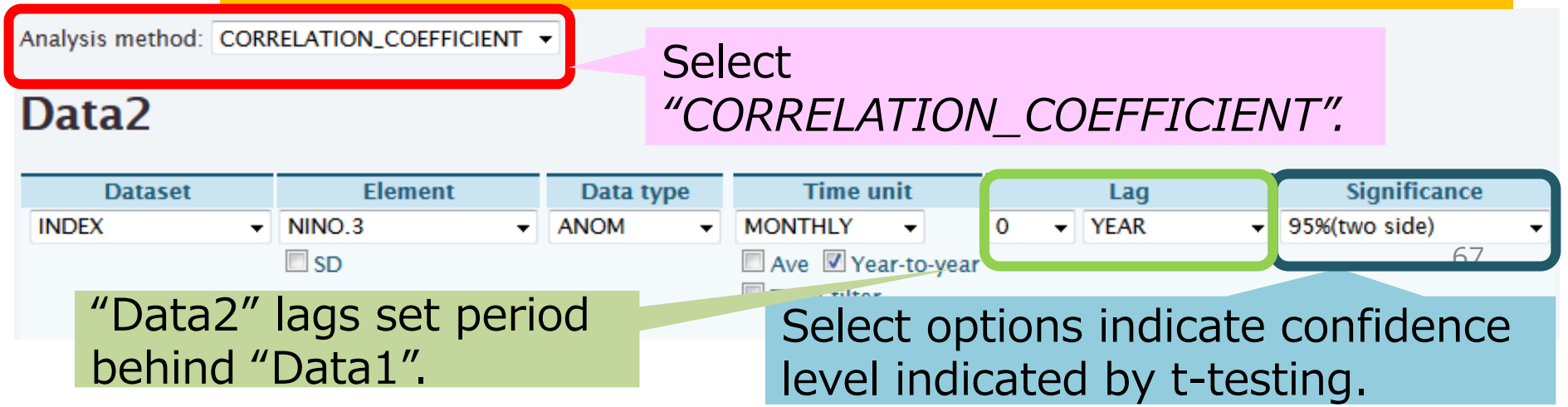
# Correlation Analysis (2)

- Setting “Data1” and “Data2”.




“Year-to-year” must be checked in correlation and regression analysis.

Although the end of the period may appear to be February 2016, this setting means DJF average
from 1958/1959 (December 1958 to February 1959)
to 2016/2017 (December 2016 to February 2017).
Consider the setting for year and month separately.




Select *“CORRELATION_COEFFICIENT”.*

“Data2” lags set period behind “Data1”.

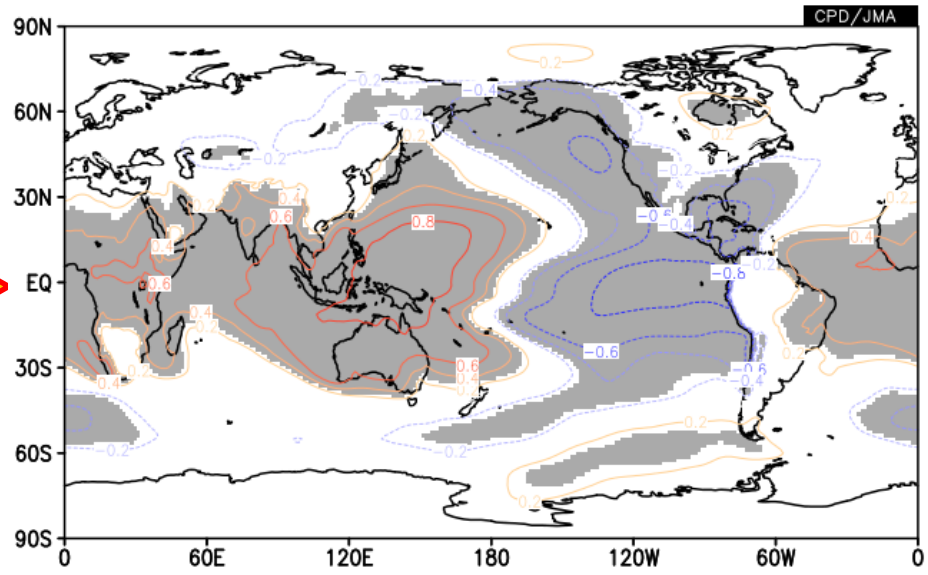
Select options indicate confidence level indicated by t-testing.

# Correlation Analysis (3)

- Setting Graphic Options.

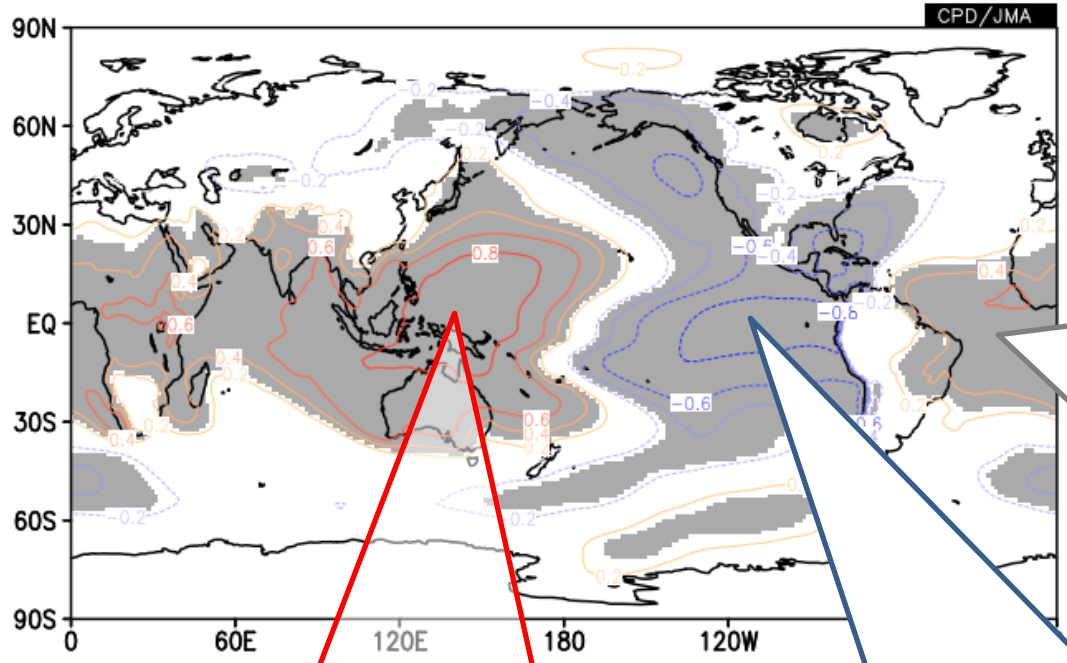
Set “Drawing” “CONTOUR” to shade the grids exceeding confidence level.

Set contour line (i.e., correlation coefficient) properties.

# Correlation Analysis (4)

Correlation coefficient between NINO.3 index and SLP in DJF from 1958/59 to 2015/16.




The gray shading indicates a 95% confidence level as indicated by t-testing. In other words, **their relationships are robust**.

SLPs tend to increase associated with positive NINO.3.

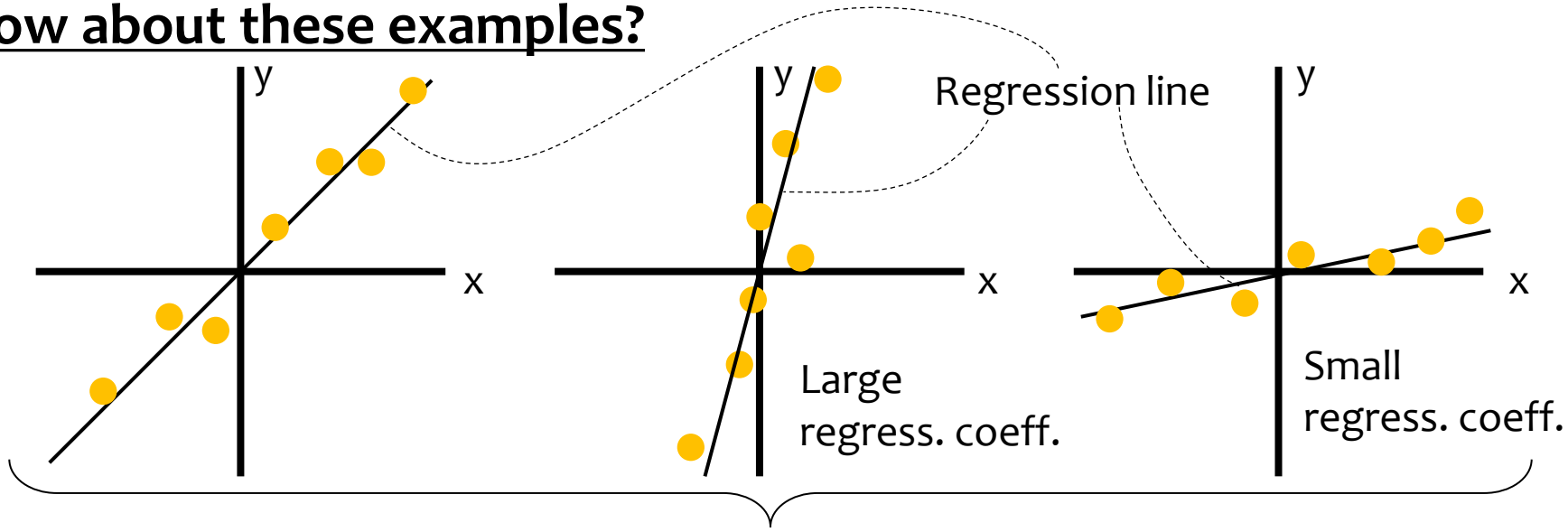
The red contours indicate positive values of correlation coefficients.
Simply stated, **positive** (**negative**) SLP anomalies during **El Niño** (**La Niña**).

SLPs tend to decrease associated with positive NINO.3.

The blue contours indicate negative values of correlation coefficients.
Simply stated, **positive** (**negative**) SLP anomalies during **La Niña** (**El Niño**).

# Basic Statistics in Brief

**How about these examples?**




*Corr. coeff. ~ +1 for all of them, but regression coefficients are different.*

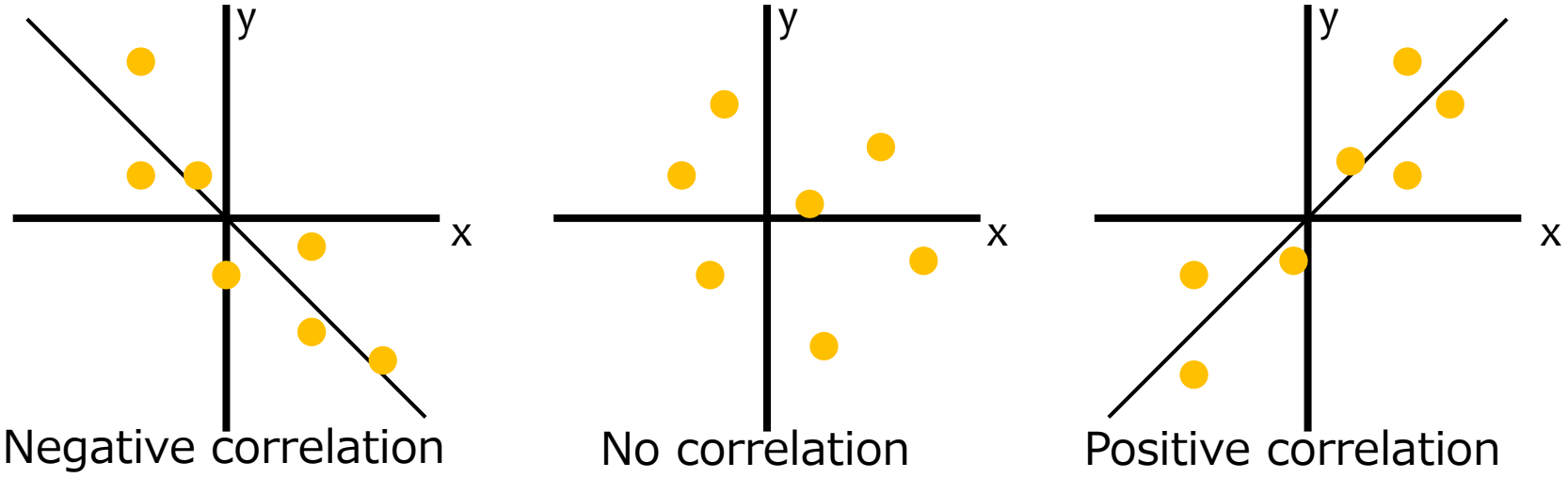
- All of these examples have strong positive linear relationships.
- We also use regression coefficients to evaluate their relationship.

**(Linear) Regression coefficient: The slope of a regression line**

Since the slope is given by $\Delta y/\Delta x$, regression coefficients mean **how much the variable y changes when the variable *x* changes**.

# Correlation and Regression analysis

- **Correlation coefficient means the degree of the correlation**, and **the regression coefficient means the gradient of the regression line**.
  - Correlation coefficient close to +1 or -1 means there is a clear linear relation between the targeted data pair, and that around zero means there is little (or weak) relation between them.




Regression and correlation analysis are often used to examine the circulation pattern related to the focused one-dimensional time series.

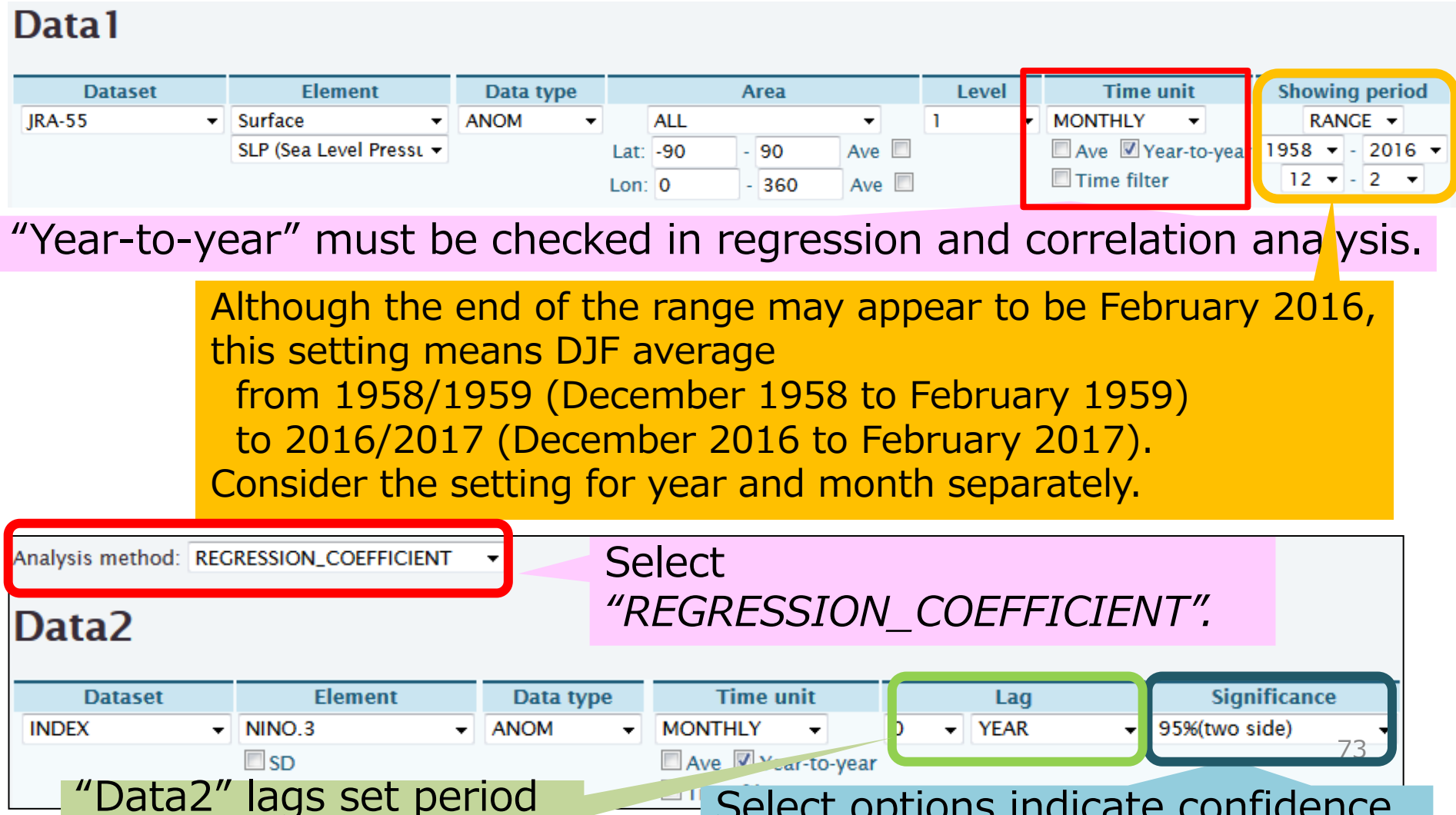
# Regression Analysis (1)

- Let's make a regression map of three-month mean sea level pressure (SLP) onto SST anomaly in NINO.3 for DJF from 1958/1959 to 2016/2017.

- For a regression analysis, "Data1" is a responsible (dependent or y-axis) variable, and "Data2" is an explanatory (independent or x-axis) variable.
- In this case, "Data1" is SLP and "Data2" is SST anomaly in NINO.3.

# Regression Analysis (2)

- Setting “Data1” and “Data2”.

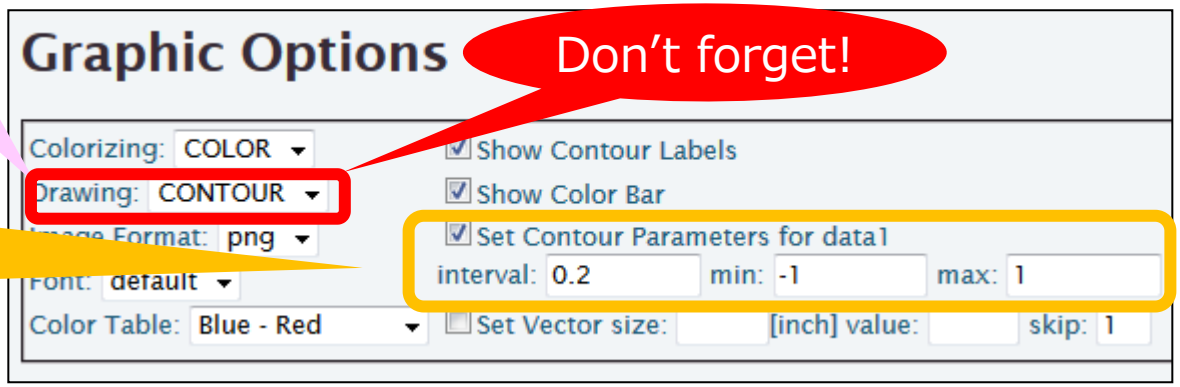


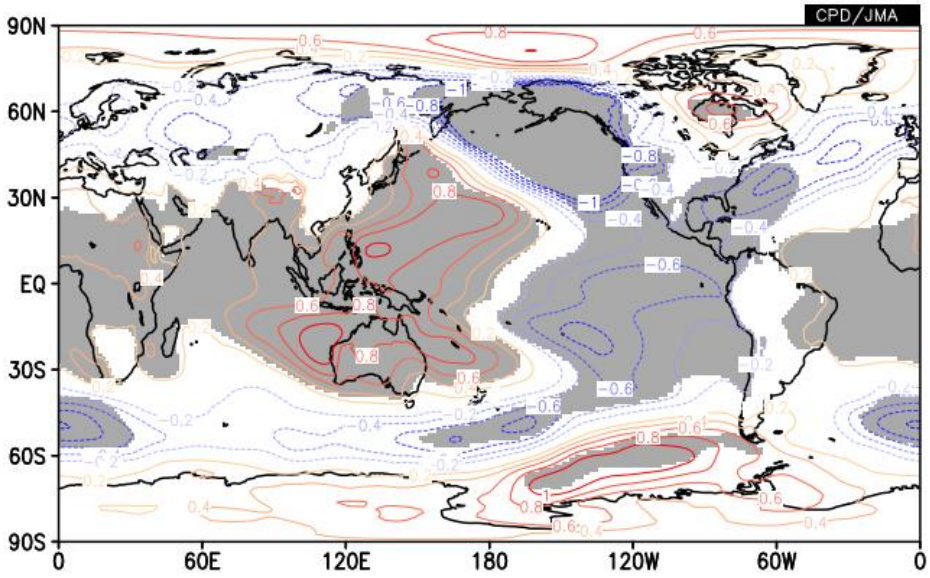
# Regression Analysis (3)

- Setting Graphic Options.

Set “Drawing” “CONTOUR” to shade the grids exceeding confidence level.

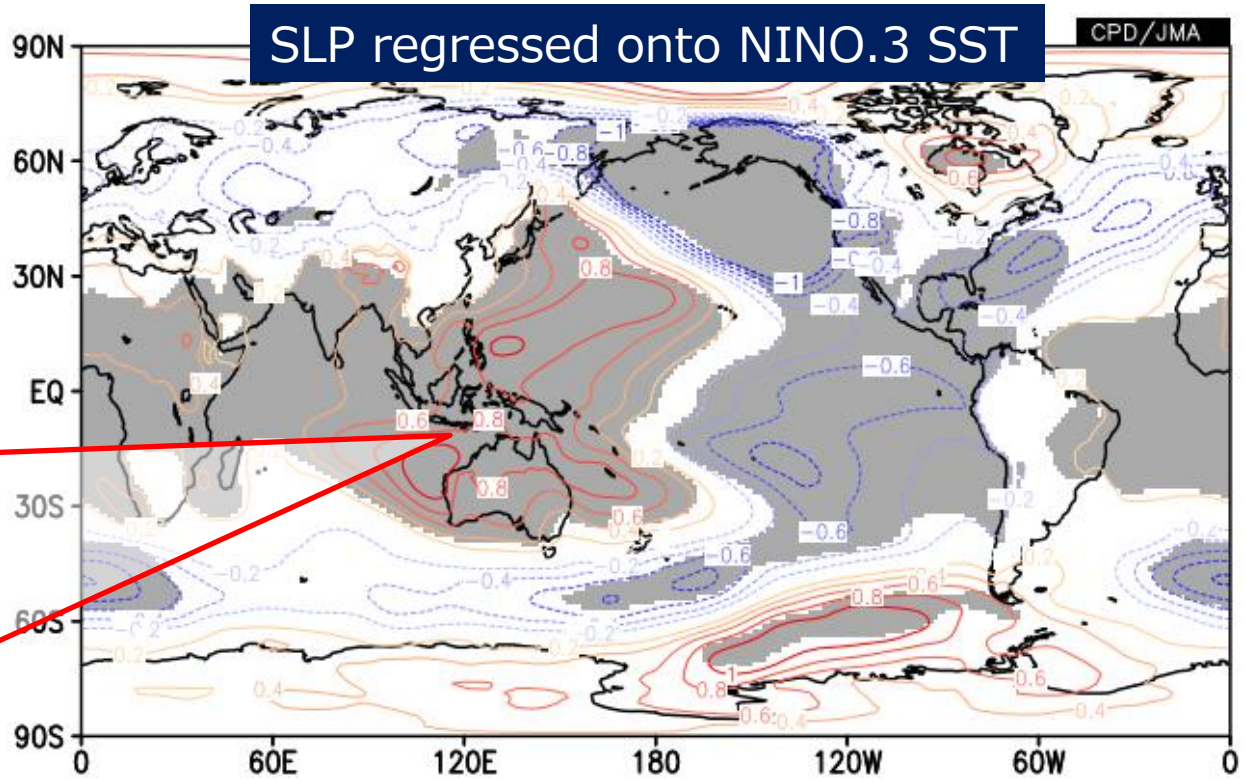
Set contour line (i.e., regression coefficient) properties.

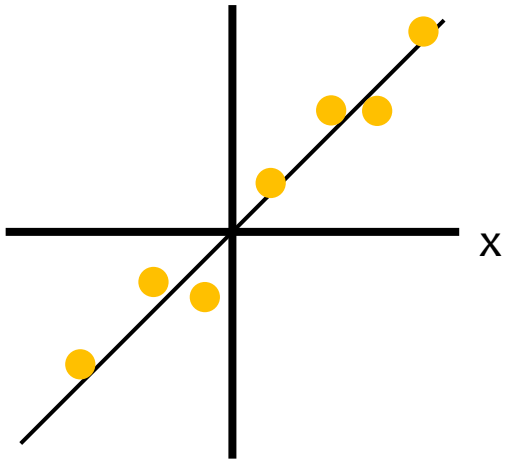


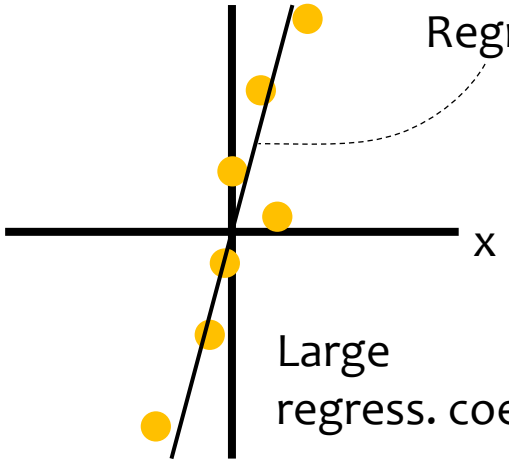



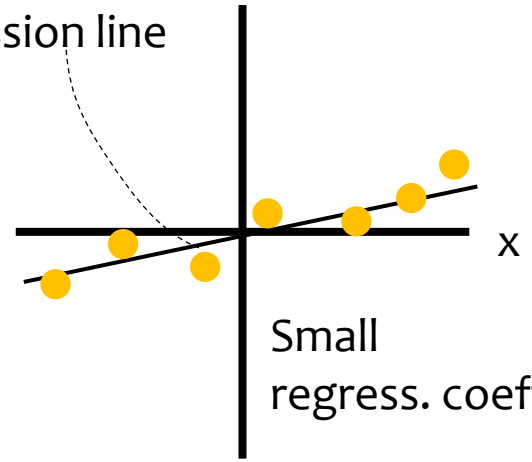
# Regression Analysis (4)

Regression coefficient is +0.8.
This means SLP tends to be +0.8hPa higher than normal here when NINO.3 SST index is +1.0 higher than normal.
Recall that regression coefficients are the slope of regression lines, $\Delta y/\Delta x$. In this case, x is NINO.3 SST index and y is SLP.



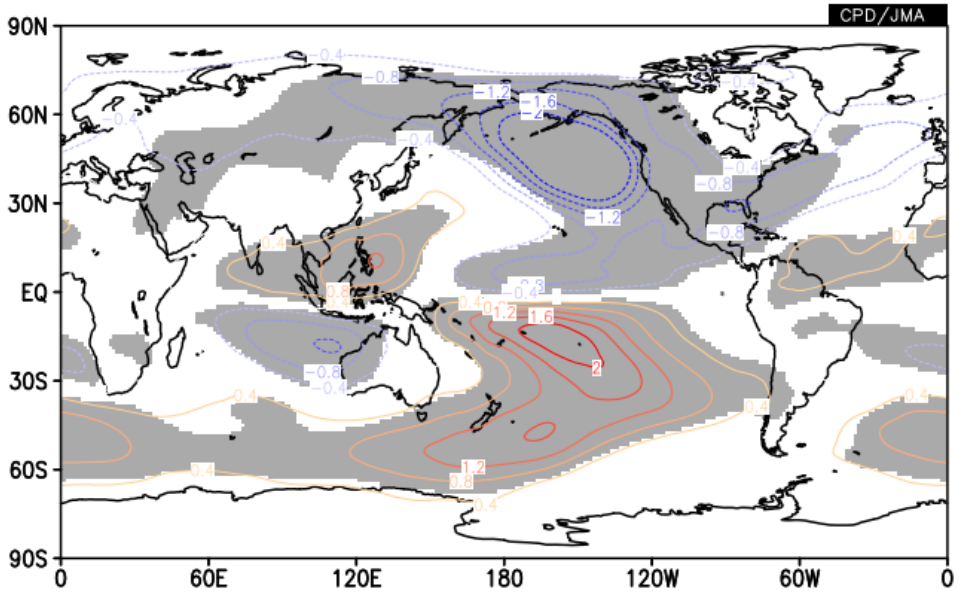



# Exercises (5)

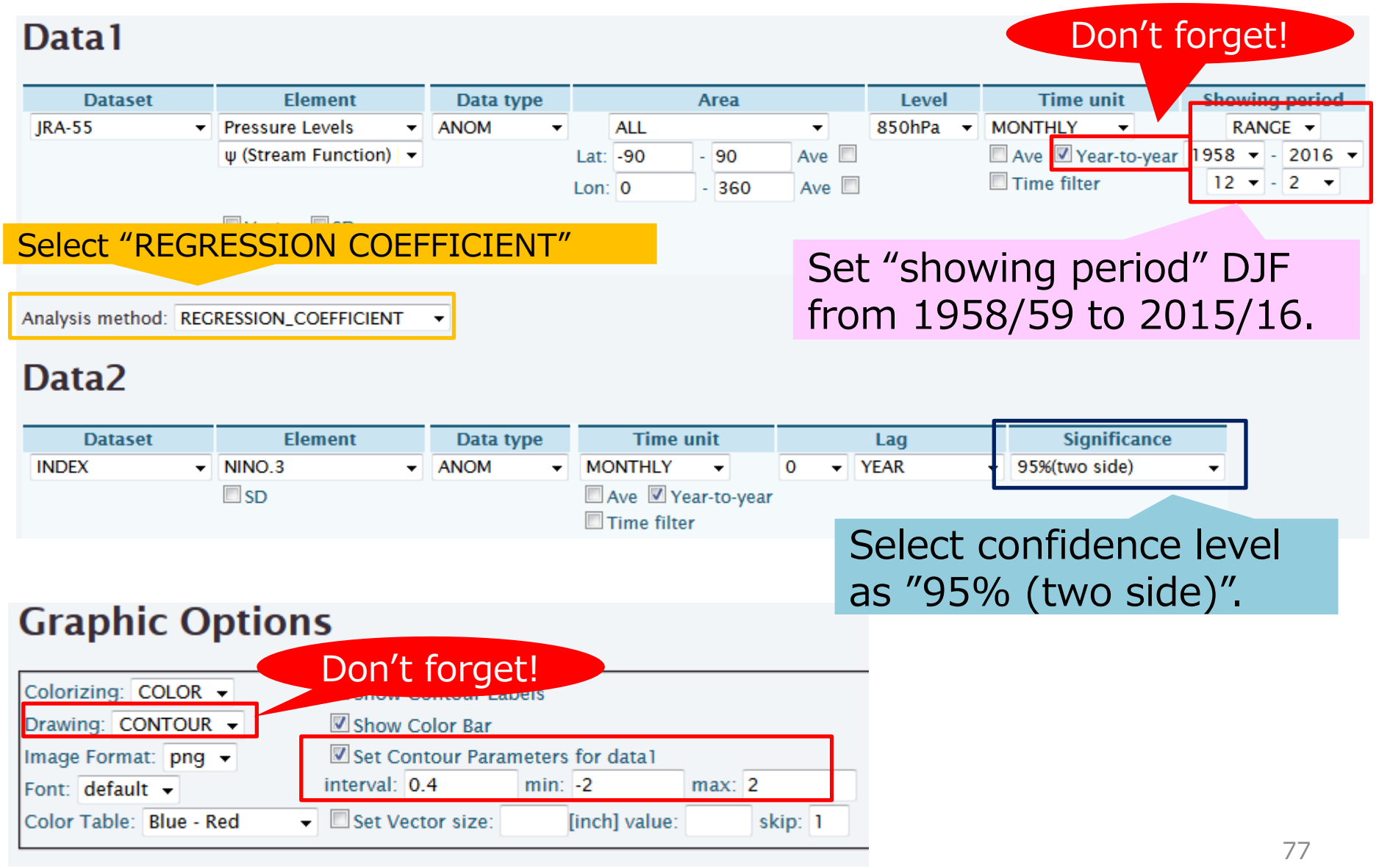
- Make a regression coefficients map of 850hPa stream function (ψ850) anomalies onto NINO.3 SST anomalies for DJF.
  - Set the statistical period from 1958/59 to 2016/17.
  - Stream function can be found in Dataset of “JRA-55”, Element of “Pressure Levels”.
  - NINO.3 is defined as the area in 5°S–5°N,150°–90°W.
  - Set the confidence level **95% (two side)**.




Regression coefficient of ψ850 onto NINO.3 SST anomalies for DJF.

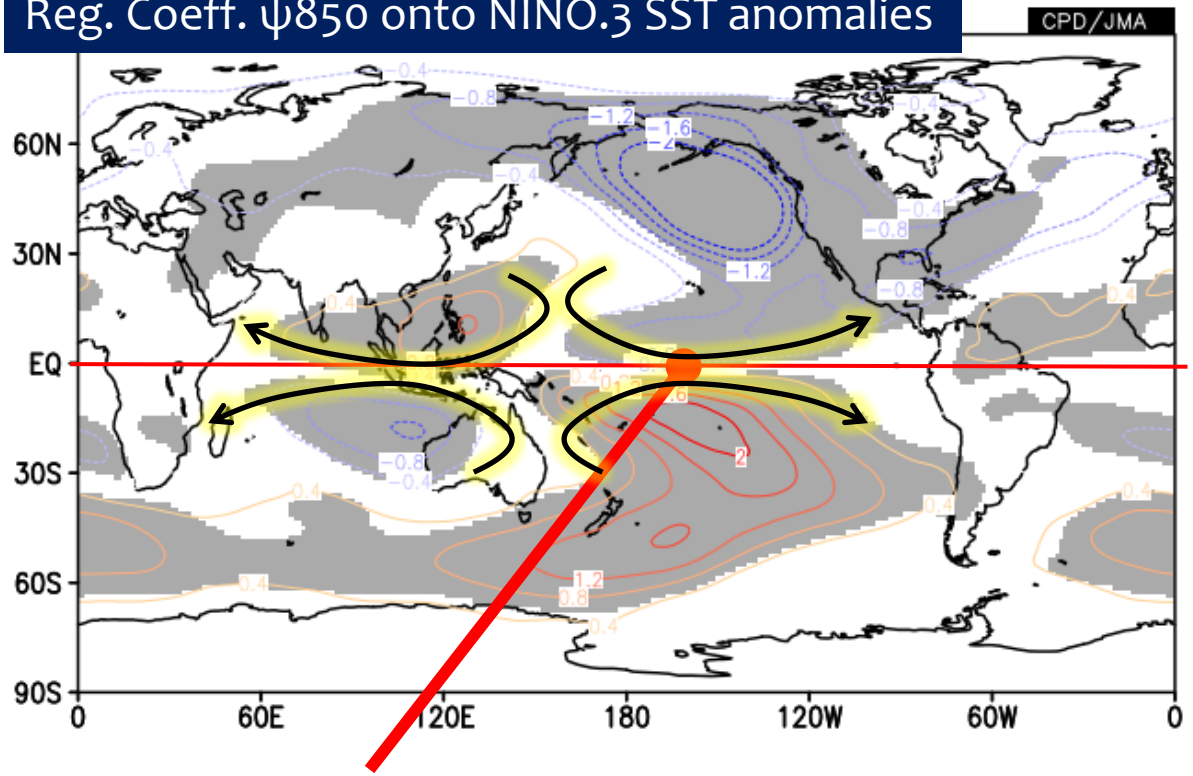
Can you imagine the circulation pattern?

# Answers to Exercises (5)



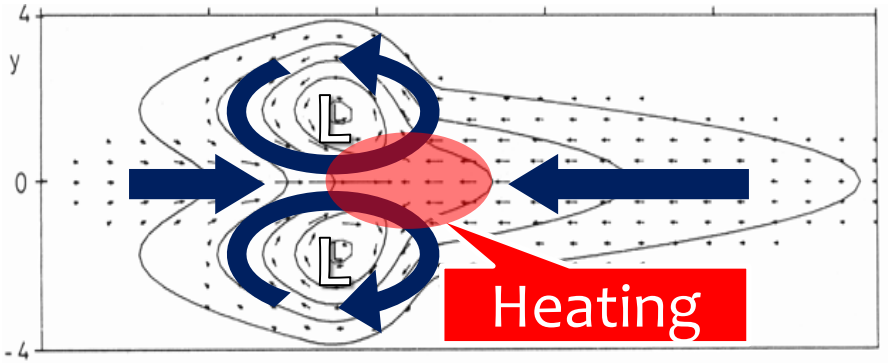
# Topics: Typical Anomalies associated with El Niño

Reg. Coeff. ψ850 onto NINO.3 SST anomalies




When El Niño events occur,
positive westerly anomaly = Weak Trade winds

Do you remember the Matsuno-Gill response pattern?




Matsuno-Gill response (Gill, 1980)

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# Composite analysis (1)

- **Composite analysis**: To collect many samples matching given conditions (e.g., El Nino condition) and do statistical analysis of them (e.g., taking an average). It is a kind of conditional sampling.

Example

*By composite analysis…, we can get common characteristics associated with a given condition.*

*Full set of data*

| |
|---|
| 1958 |
| 1959 |
| 1960 |
| 1961 |
| 1962 |
| . |
| . |
| . |
| 2014 |
| 2015 |
| 2016 |

Designated Condition
(eg. SSTA in NINO.3 > 0.5 C)

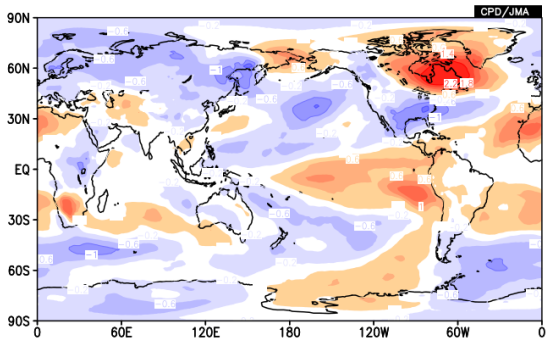
Pick out years matching a given condition

*Subset of data*

| |
|---|
| 1963 |
| 1965 |
| . |
| . |
| 1997 |
| 2002 |
| 2009 |
| 2015 |

Average

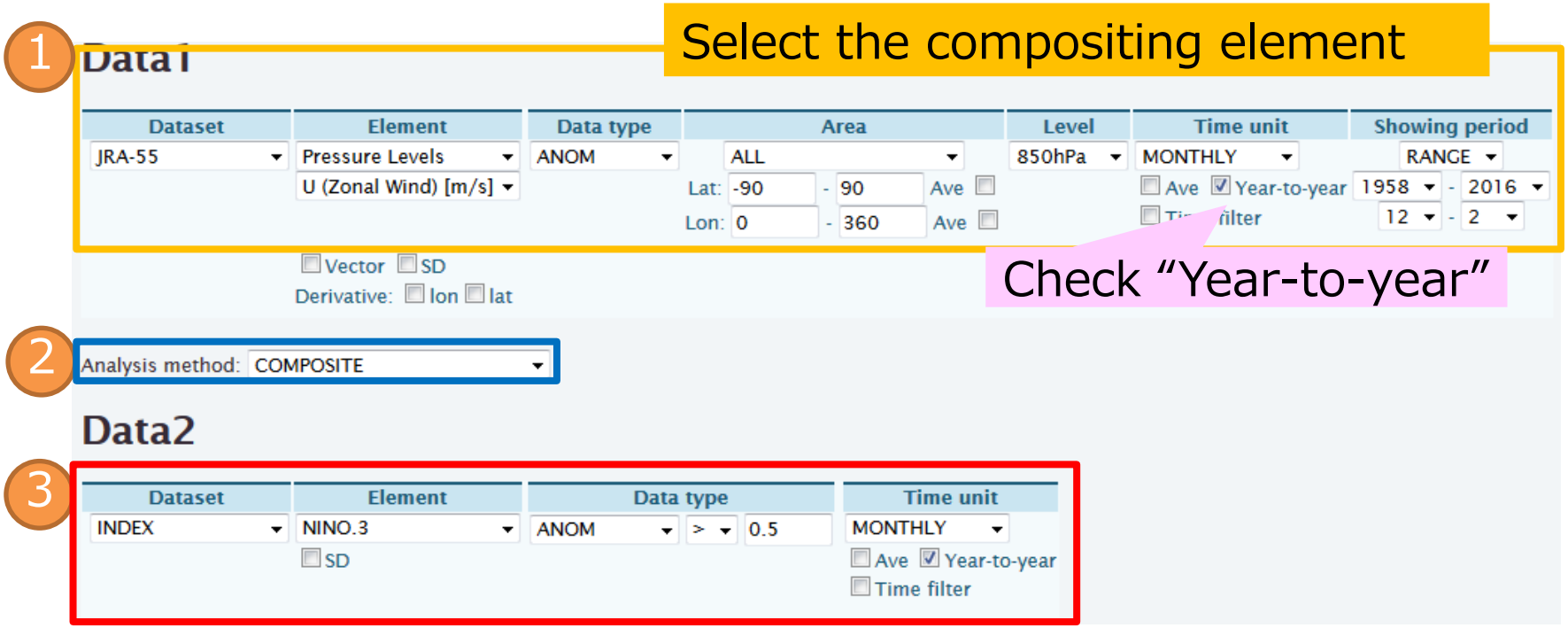
Composite map



# Composite analysis (2)

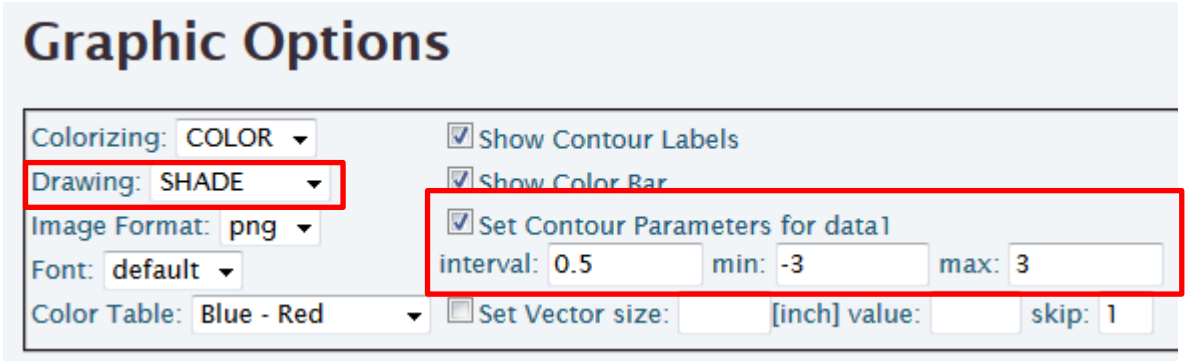
Let's make a composite map of 850-hPa zonal wind when NINO.3 SST anomalies for DJF > 0.5 (i.e. El Nino –like condition).

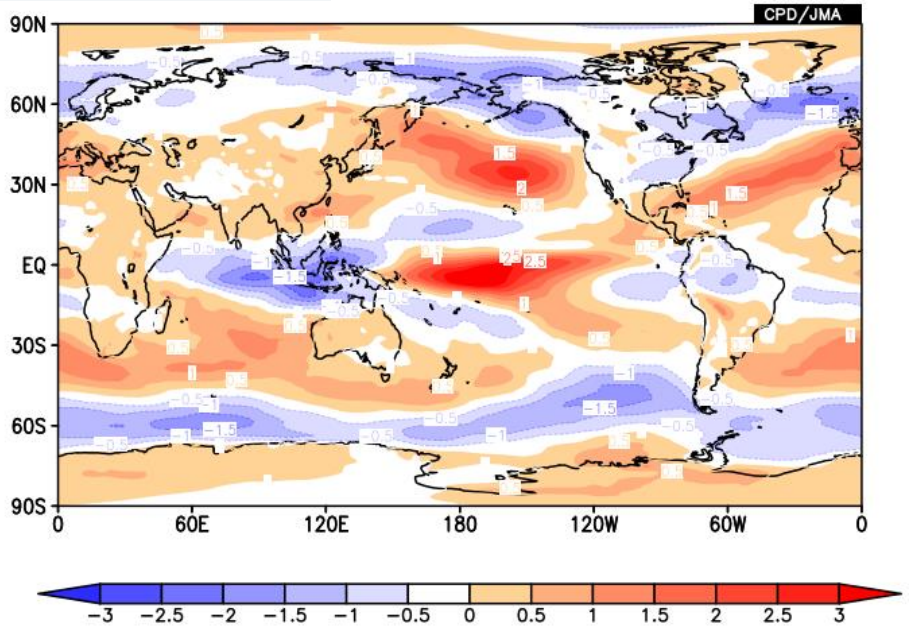
1. Set the "Data1".
2. Select "COMPOSITE" in the "analysis method" box.
3. Set the "Data2" (give a composite condition).



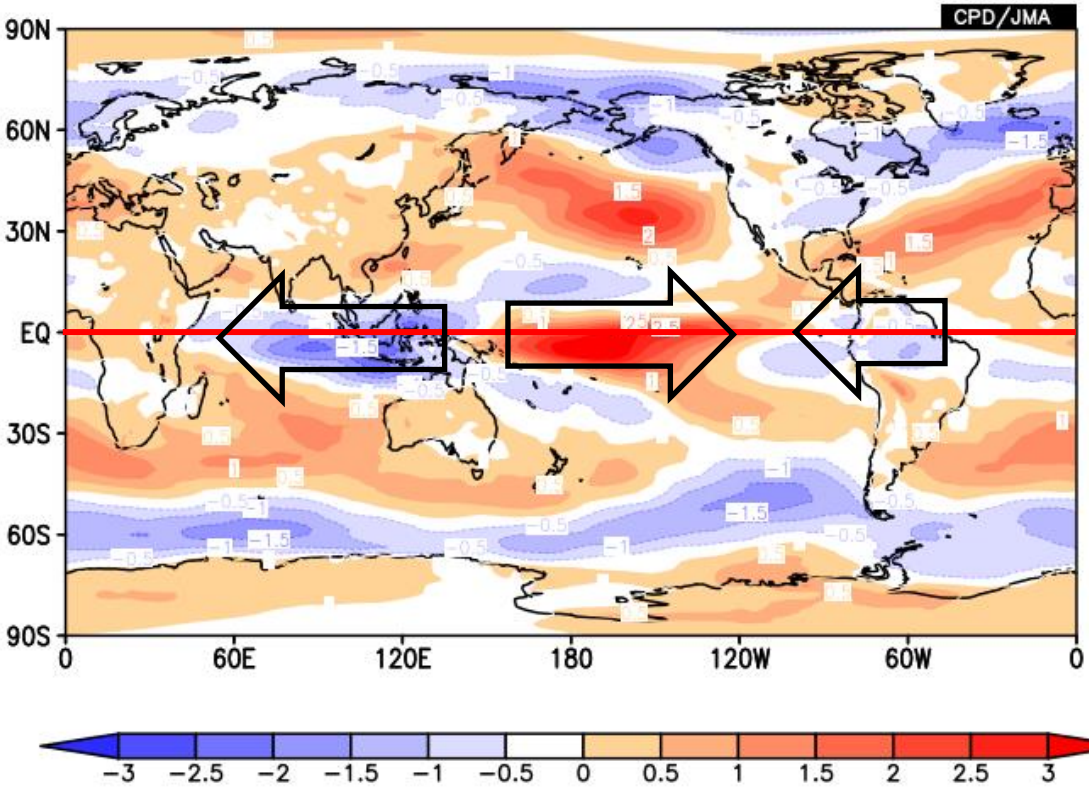
# Composite analysis (3)

Let's make a composite map of 850-hPa zonal wind when NINO.3 SST anomalies for DJF > 0.5.

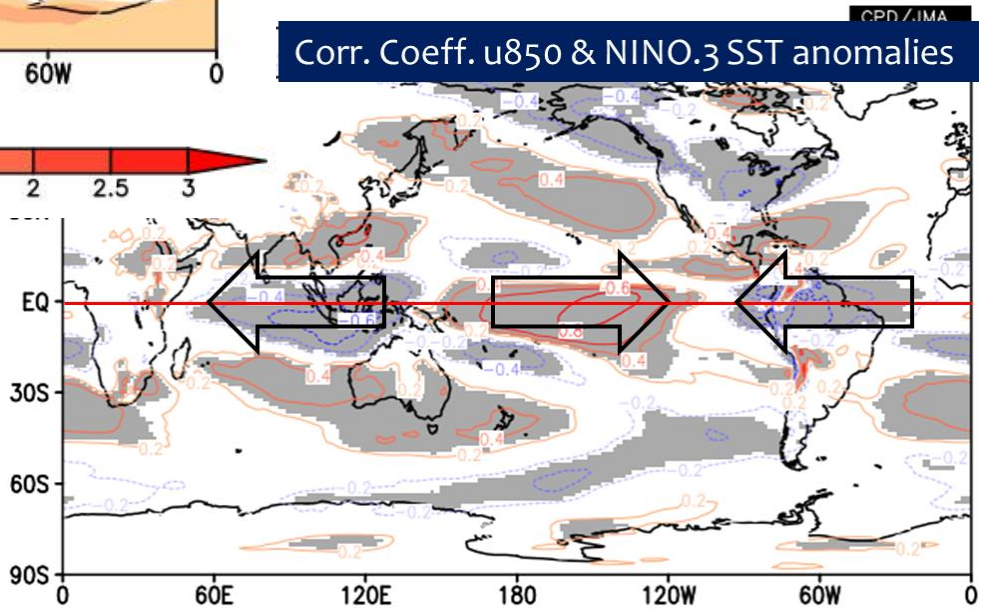


# Composite analysis (4)

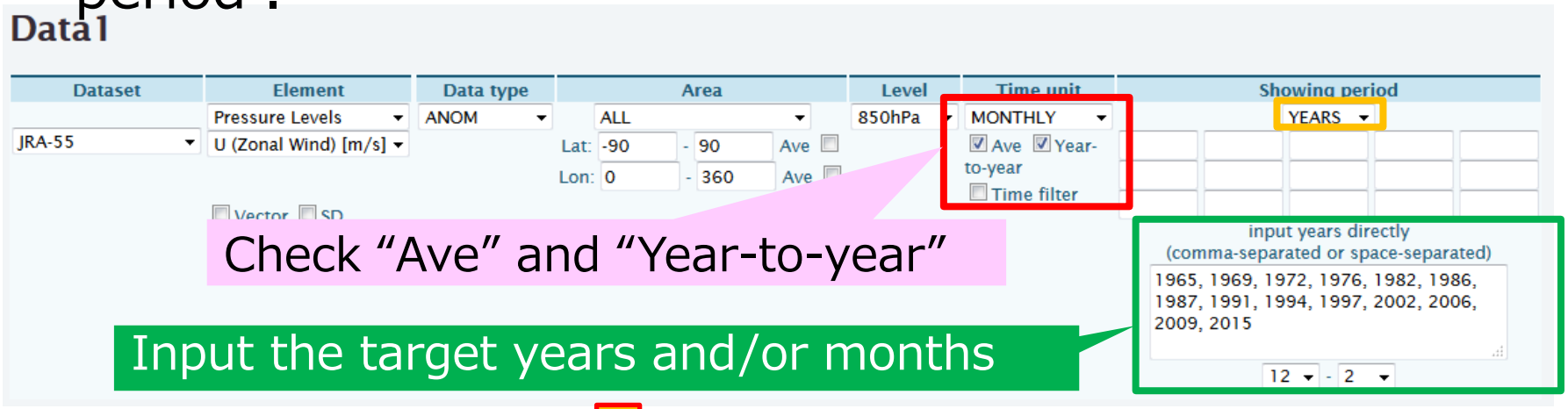



Of course the composite result is consistent with the corr. coeff. map we made just before.

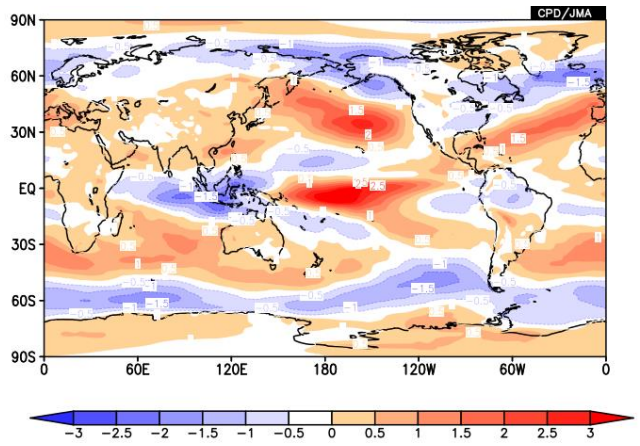


# Composite analysis (5): “Another Way”

- If you know already target years for compositing, you do not have to use “COMPOSITE” method. Select “YEARS” and input the years and months in “Showing period”.



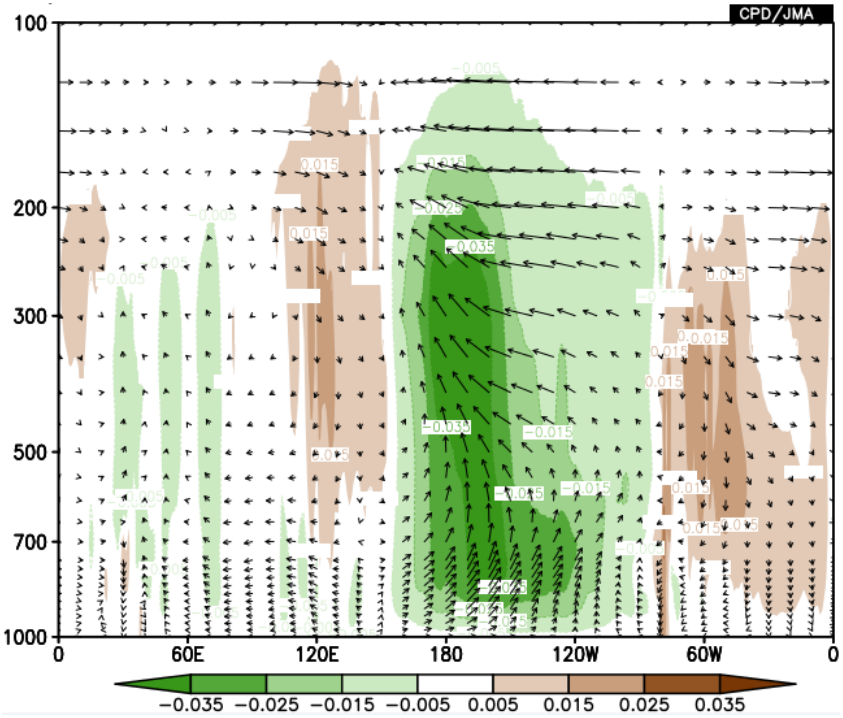

Composite of 850hPa westerly anomalies.




We can get same figure!!

# Exercise (6)

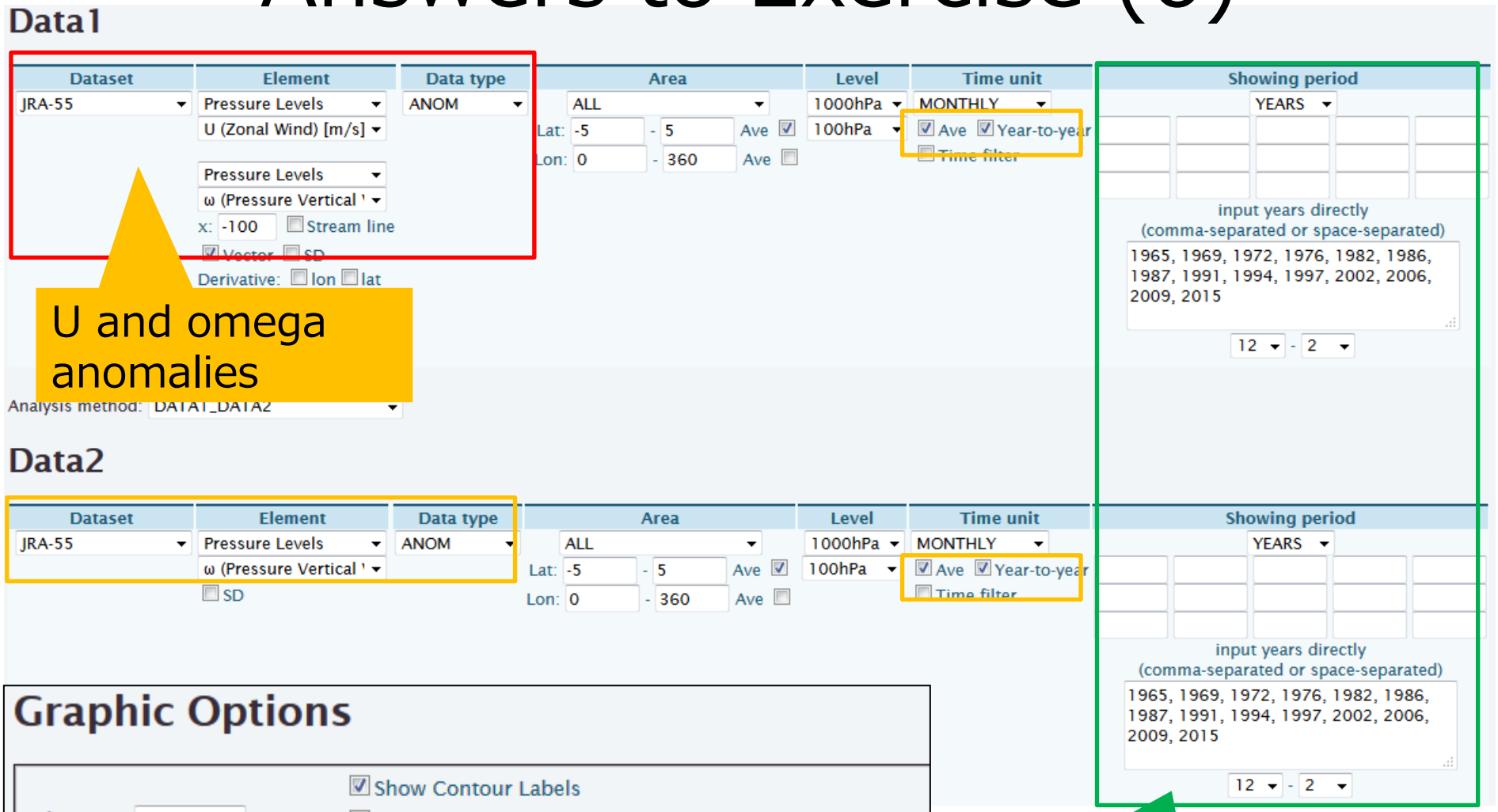
- Make a composite map of longitude-height cross section of zonal/vertical wind anomaly vector and vertical wind anomaly (shading) averaged from 5°S to 5°N for El Niño-like condition DJF.
  - The El Niño-like condition years are **1965, 1969, 1972, 1976, 1982, 1986, 1987, 1991, 1994, 1997, 2002, 2006, 2009, 2015**, where El Niño-like condition means NINO.3 SST anomalies > 0.5.




You can draw multi variable composite maps with “another way”.

Composite of wind anomalies along the equator in DJF during El Niño years.

# Answers to Exercise (6)



# Contents

## 4. Statistical Analysis in iTacs

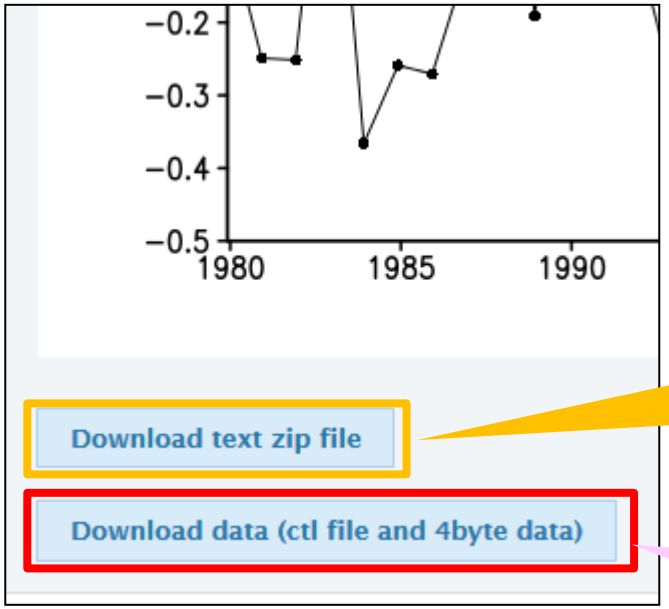
- Introduction
- Regression / Correlation Analysis
- Composite Analysis

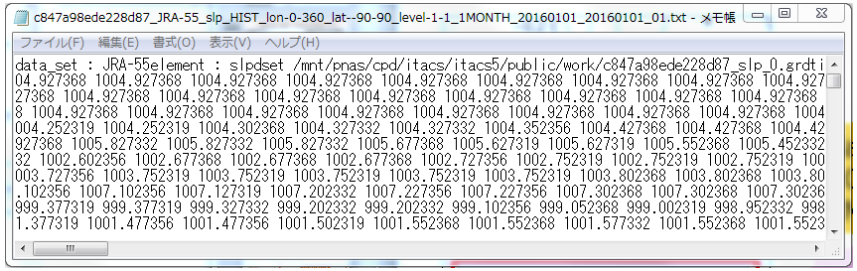
## 5. Other Advanced operations

- Data download
- User data input

# Data download

- Users can download the data used to create a map.
- A plain text file and GrADS format files (control file and data file) are available.




Plain text data file
- Gridded value
- Map information (area, elements)

- GrADS format data file
- GrADS control (*.ctl) file

(GrADS official website; http://grads.iges.org/grads/head.html)
(GrADS tutorial on TCC;
http://ds.data.jma.go.jp/tcc/tcc/products/model/tips/tutorial.html)

# Using user input data (1)

- The time series data made by individual users is available in a dataset name “USER_INPUT”.
  - The data must be **one-dimensional**.
  - For example, a correlation or regression coefficient map between single station data or user’s original index and another dataset like JRA-55 can be created by this function.
- There are two ways for inputting data.
  - **UPLOAD_TXT** : Data are given by an uploaded text file.
  - **INPUT_DATA** : Data are directly input to the box.

**Sample text file**

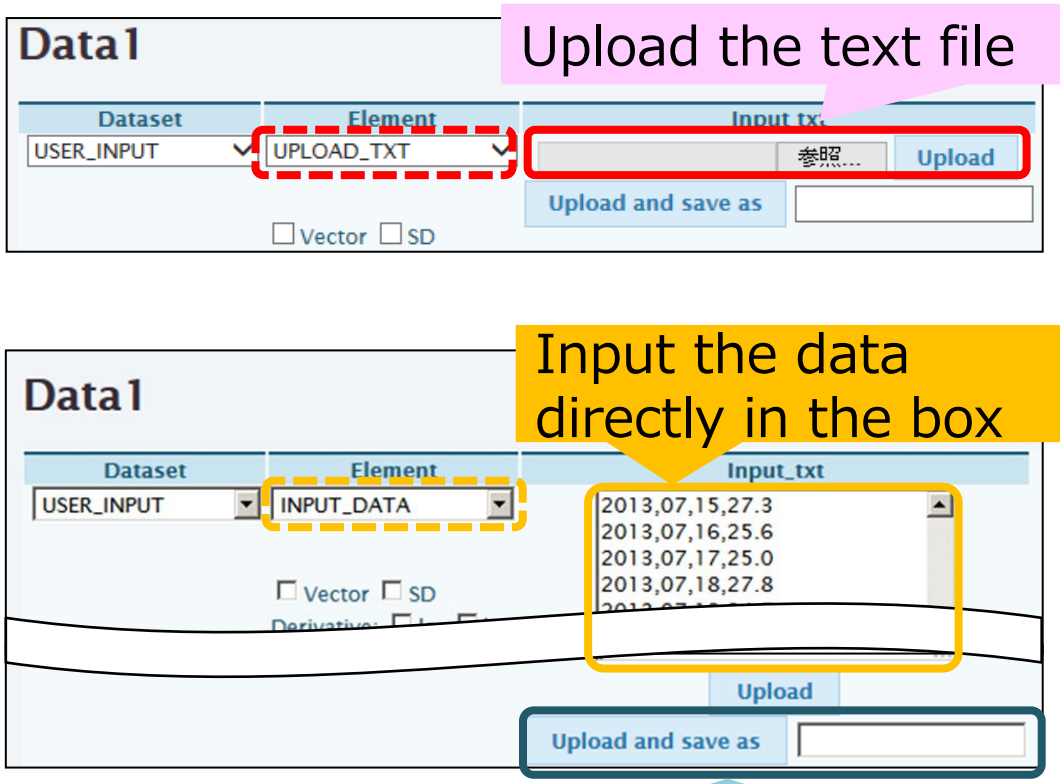
```
#Daily temperature
#undef = 9999
#element = Daily Ts
2013,07,01,23.6
2013,07,02,24.3
2013,07,03,24.5
2013,07,04,9999
2013,07,05,27.4
2013,07,06,28.9
```

**<Data format>**

- **Data must be separated by commas** and must be given by specified format as “**year, month, day, value**”. In case of monthly data, “day”s are always given as “1”.
- Sentences beginning with “#” have special meanings.
  - # : Comment (except for two cases shown below).
  - #undef = : Definition of missing data (default is -9999).
  - #element = : Data name used to save them on the server.

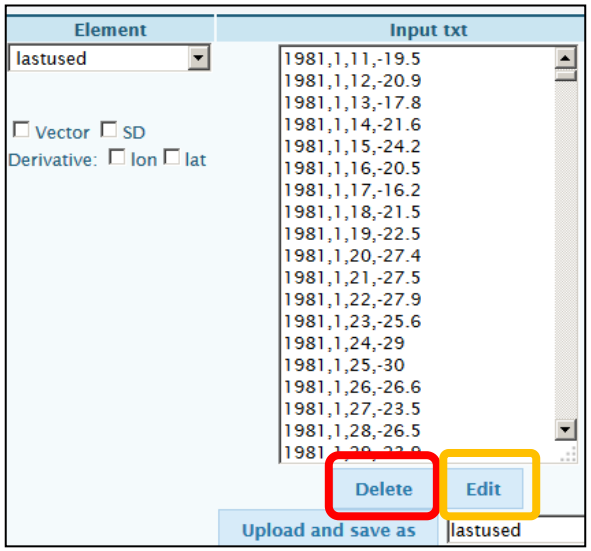
# Using user input data (2)

- Upload/input the data




Input the name to save them on the server, and click the “upload and save as” button.

- Control the uploaded data

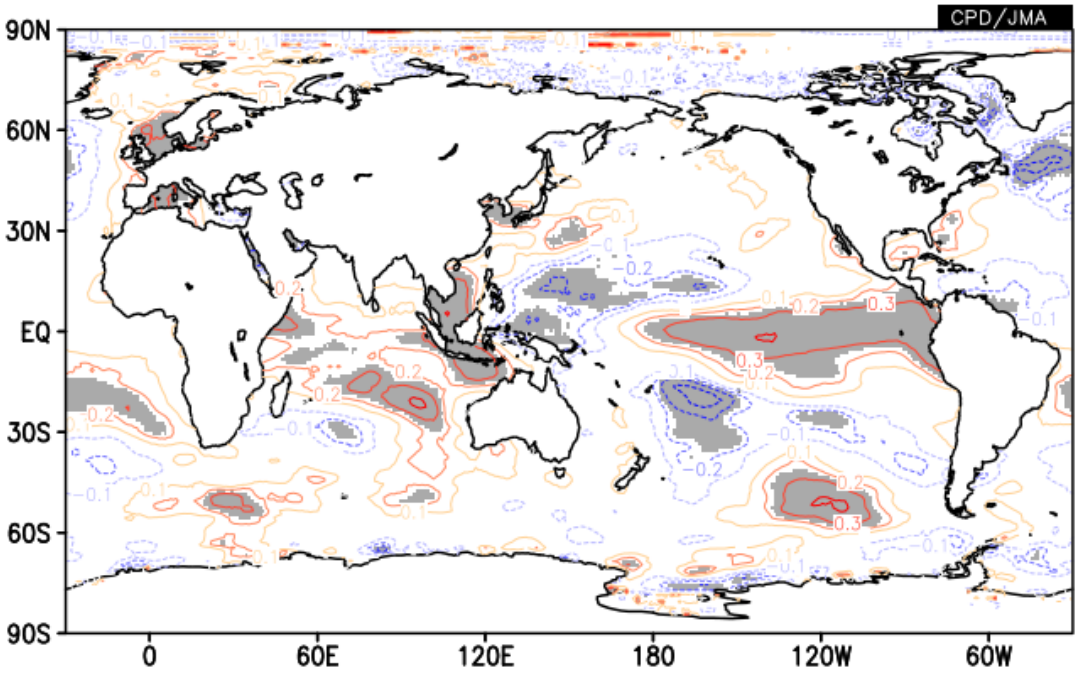



- Select the data name and click “Delete” button to delete the data from the server.
- Click “Edit” button to edit the data in the box.

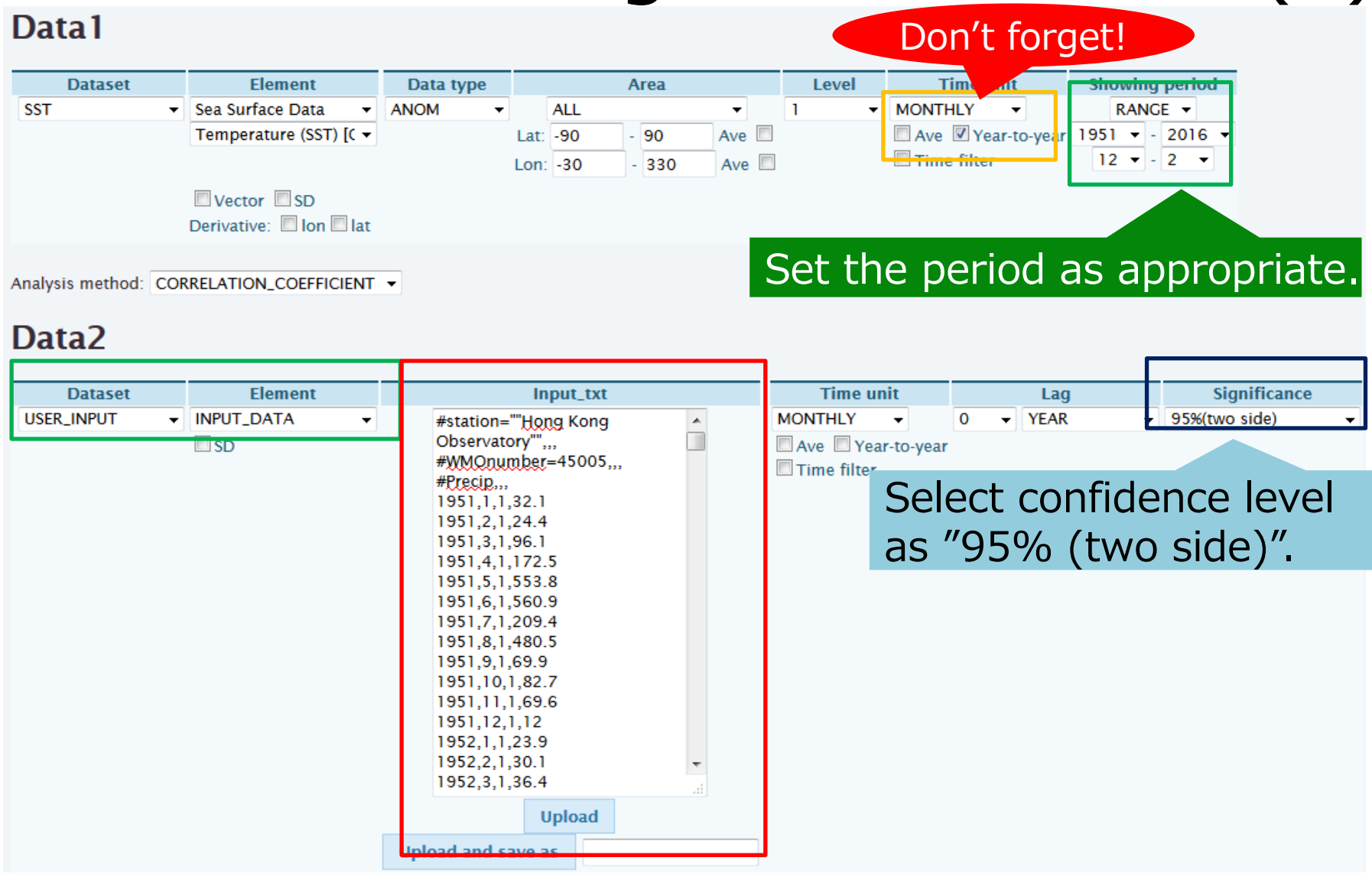
# Integrated Exercise (2)

- Let's make a correlation map between monthly precipitation data you prepared and global SST anomaly for a specific calendar month(s). Set the period as appropriate.
  - Use "USER_INPUT" method. Set the confidence level **95% (two side)**.

[Example]
Station:
Hong Kong Observatory
Month: Dec-Feb
Period:
1951/52 – 2016/17



# Answers to Integrated Exercise (2)

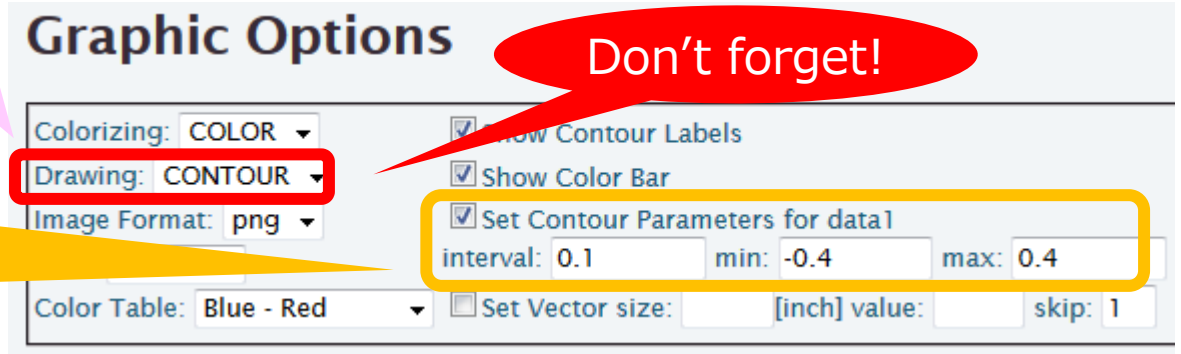


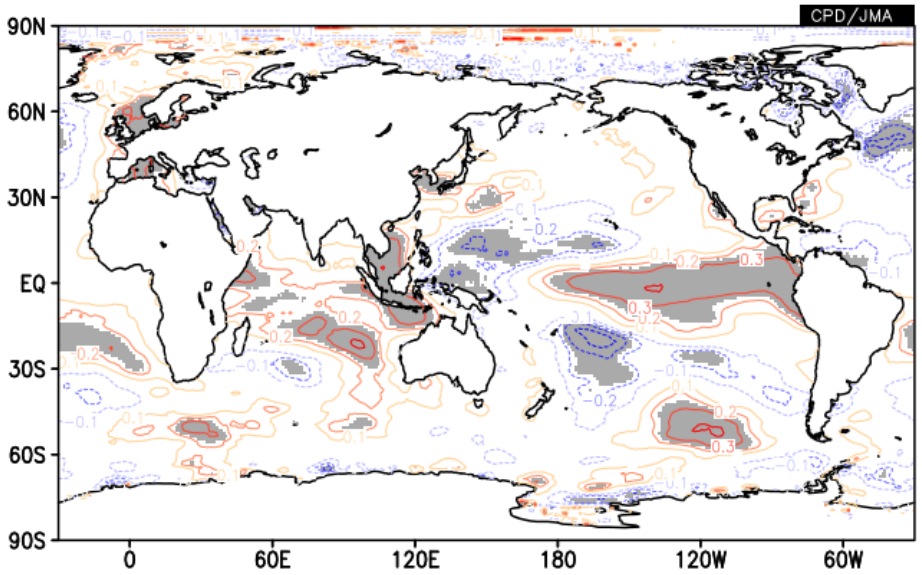
# Answers to Integrated Exercise (2)

- Setting Graphic Options.

Set “Drawing” “CONTOUR” to shade the grids exceeding confidence level.

Set contour line (i.e., correlation coefficient) properties.



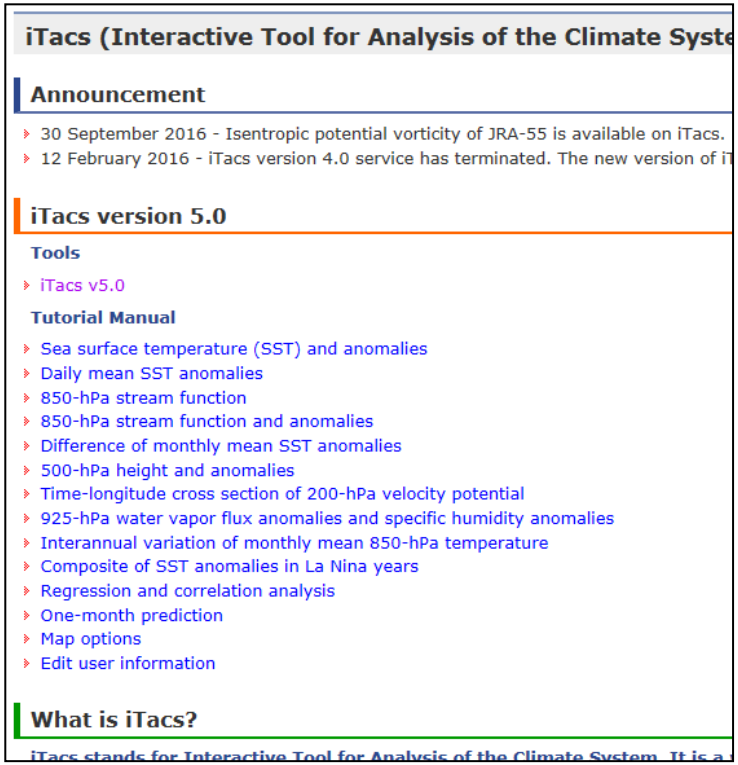
# Further Exercise

- How about other month(s)?
- How about relationships between other variables related to precipitation(like stream function, velocity potential, moisture flux, etc.)?
- How can you explain the relationship you found?
  - It is beyond this lecture.

# To learn more about iTacs

- Online help page and tutorial manual are available on the iTacs website.

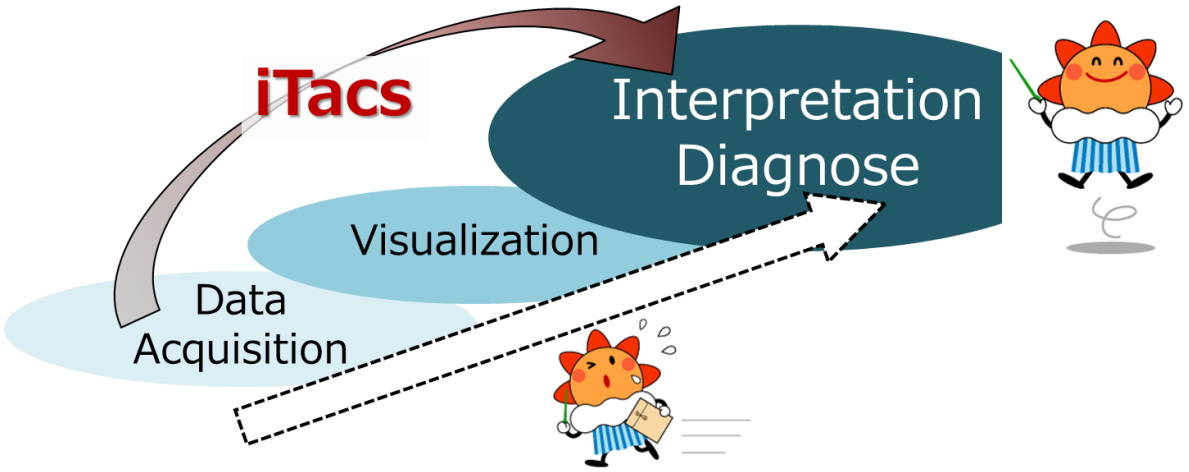
- Tutorial: http://extreme.kishou.go.jp/tool/itacs-tcc2015/
- Help page: http://extreme.kishou.go.jp/itacs5/assets/help.html




# Thank you for your attention!

If you are interested or have any questions, please feel free to contact us.

- TCC Web Site: http://ds.data.jma.go.jp/tcc/tcc/index.html
- TCC E-mail: tcc[at]met.kishou.go.jp



# References


- Duchon, 1979: Lanczos Filtering in One and Two Dimensions, *J. Applied Met*., **18**, 1016-1022.
- Gill, 1980: Some simple solutions for heat-induced tropical circulation. *Q.J.R. Meteorol. Soc.*, **106**: 447–462.
- Ishii et al., 2005: Objective Analyses of Sea-Surface Temperature and Marine Meteorological Variables for the 20th Century using ICOADS and the Kobe Collection. Int. *J. Climatol*., **25**, 865-879.
- Kobayashi et al., 2015: The JRA-55 Reanalysis: General Specifications and Basic Characteristics. *J. Meteorol. Soc. Japan*, **93**, 5-48.
- Toyoda et al., 2013: Improved Analysis of Seasonal-Interannual Fields Using a Global Ocean Data Assimilation System, *Theoretical and Applied Mechanics Japan*, **61**, 31-48.

# Useful Link

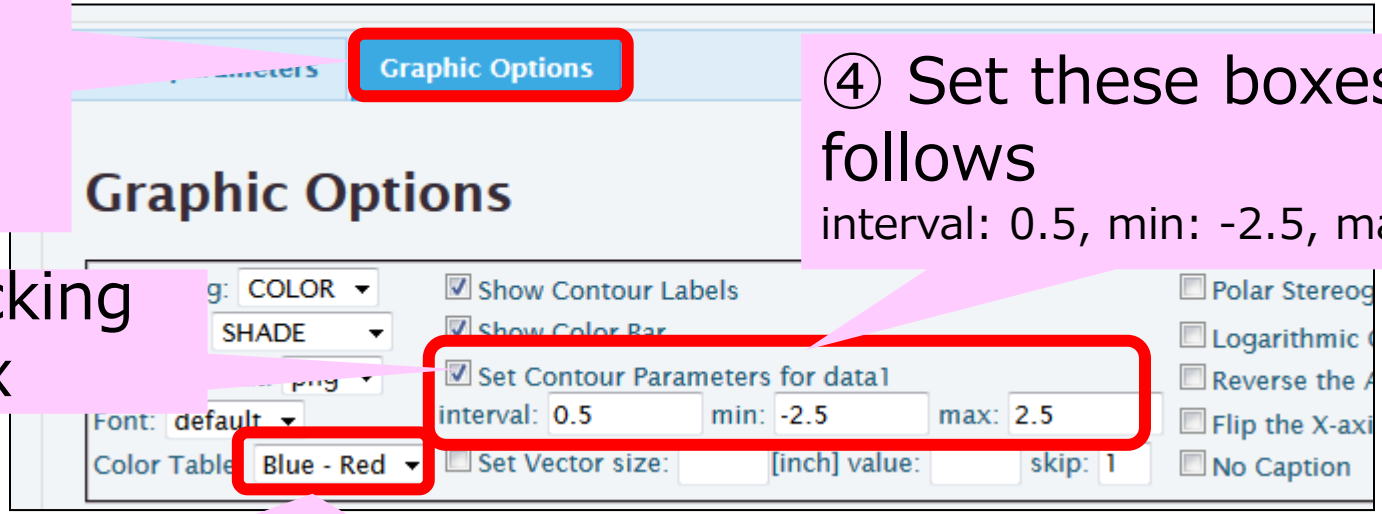
- iTacs
  - http://extreme.kishou.go.jp/tool/itacs-tcc2015/
- Analysis charts
  - http://ds.data.jma.go.jp/tcc/tcc/products/clisys/acmi.html
- Composite maps for El Niño / La Niña events
  - http://ds.data.jma.go.jp/tcc/tcc/products/clisys/enso_statistics/index.html

# Supplement

# Contour parameter and color table

- Changing **intervals for contour/shading**, you can easily see the above- and below-normal SST areas.

① Click "Graphic Options"



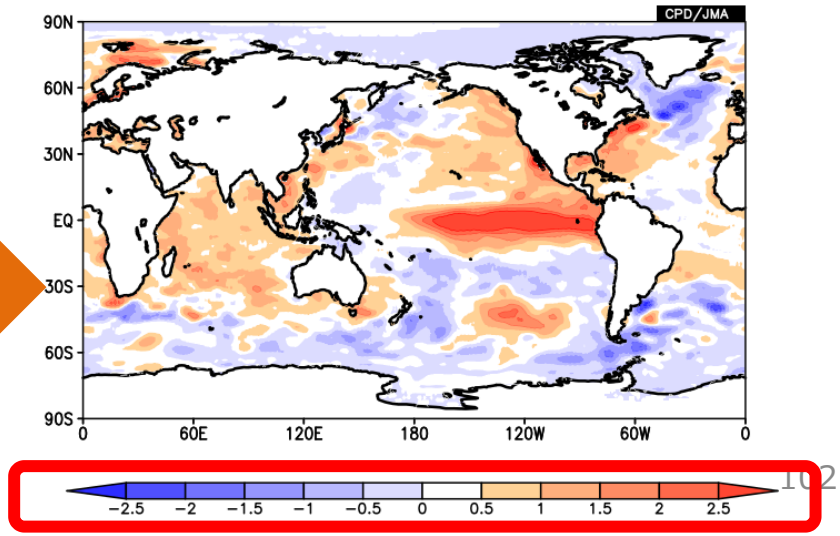

③ Checking this box

④ Set these boxes as follows
interval: 0.5, min: -2.5, max: 2.5

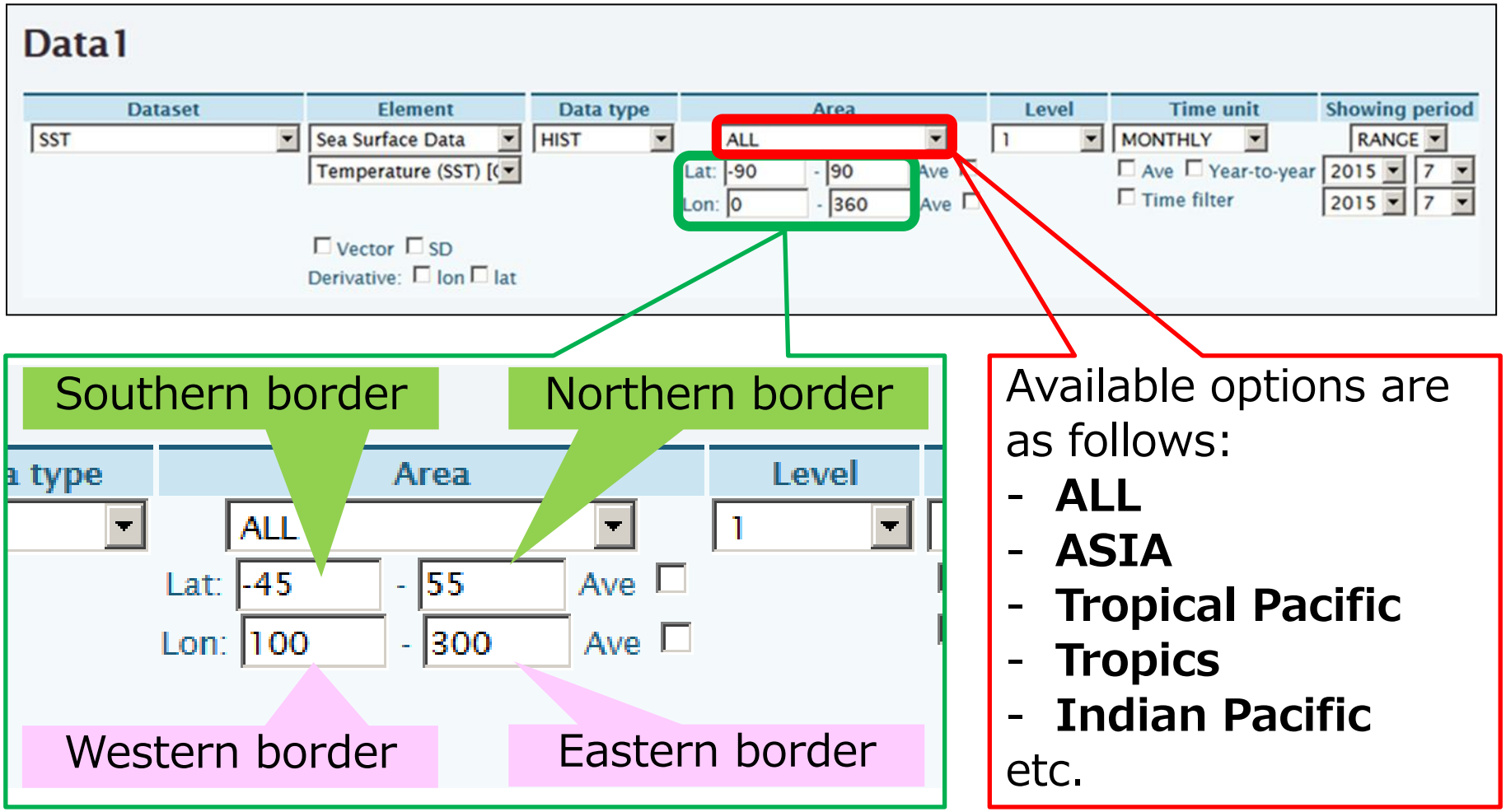
② Select "Blue - Red"

Click!

Analysis Data Submit



# Area setting (1)

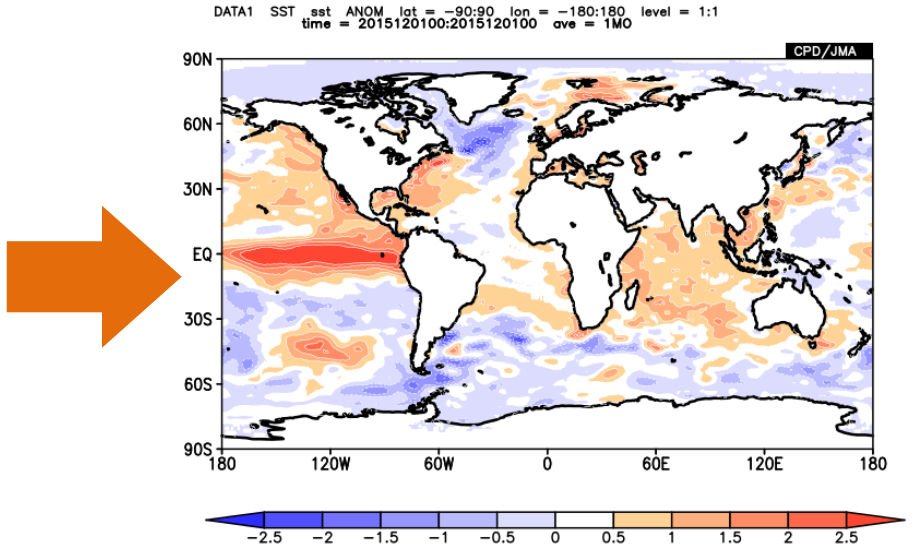



Setting boxes will appear in the “Area” field and after selection for more precise area adjustment.

# Area setting (2)

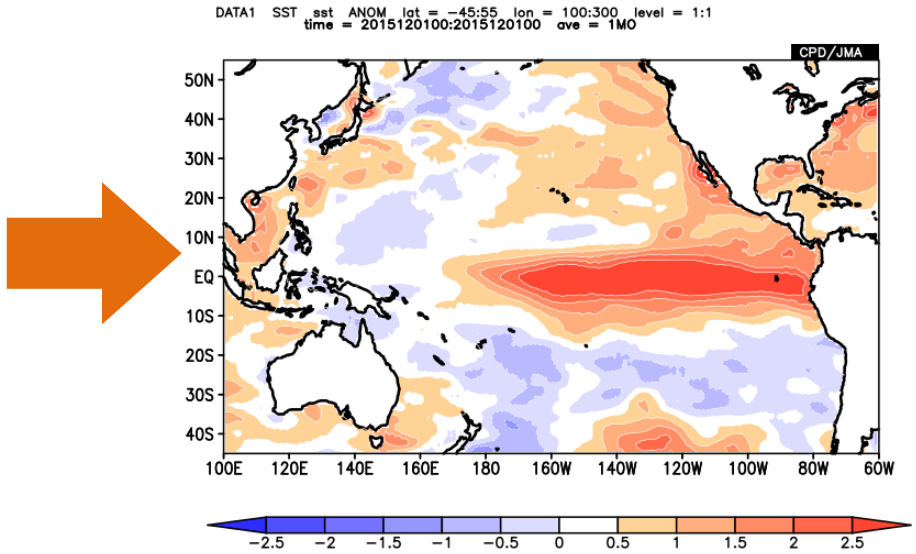
- Shift the area

| | | |
|---|---|---|
| Lat : | -90 – | 90 |
| | (90S) | (90N) |
| Lon: | -180 – | 180 |
| | (180W) | (180E) |




- Change the area

| | | |
|---|---|---|
| Lat : | -45 – | 55 |
| | (45S) | (55N) |
| Lon: | 100 – | 300 |
| | (100E) | (300E=60W) |




You can adjust zonal and meridional range by setting "Lat" and "Lon" parameters in the "Area" field.

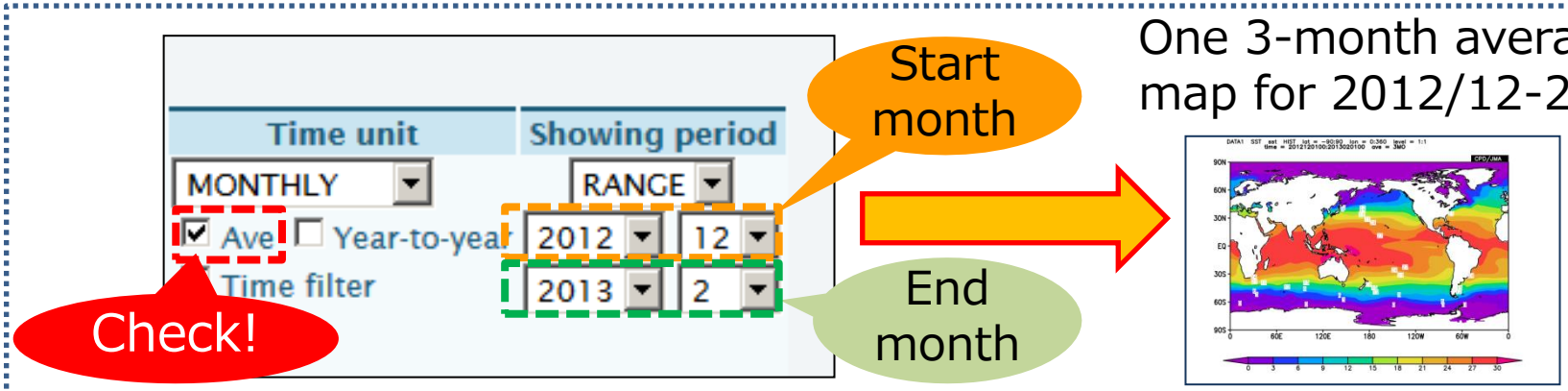
# Time setting (1)

- Setting for **a consecutive period**.

<Calendar>

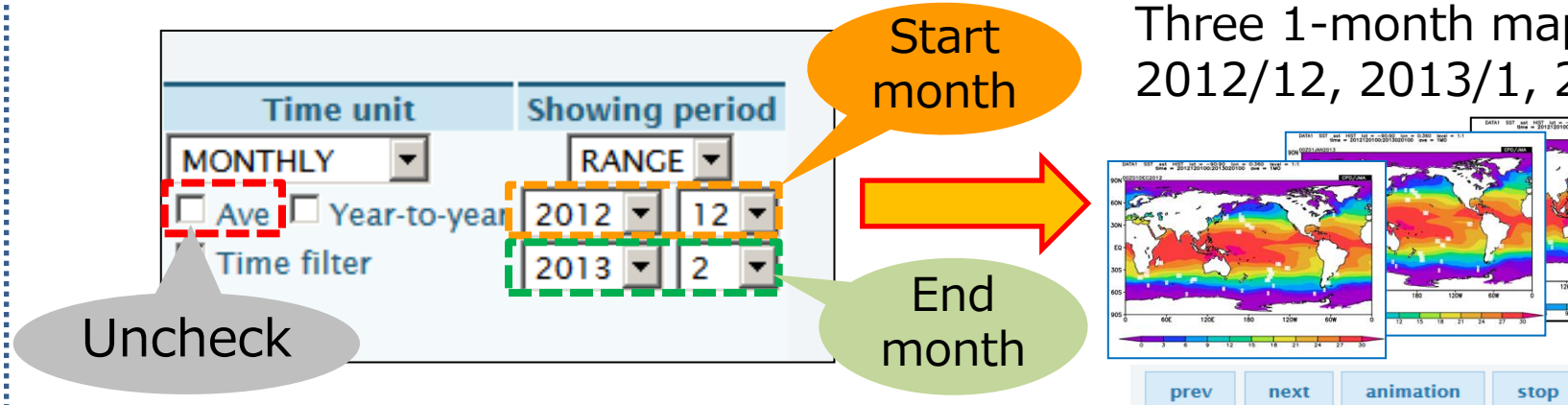
**2012** **2013**

J F M A M J J A S O N D J F M A M J J A S O N D




One 3-month averaged map for 2012/12-2013/2






Three 1-month maps for 2012/12, 2013/1, 2013/2

# Time setting (2)

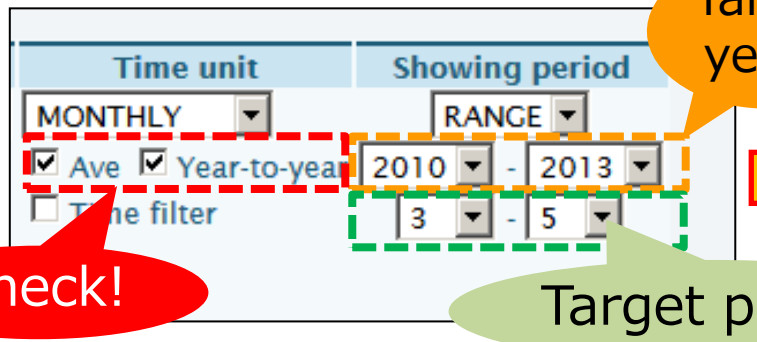
- Setting for **a specific period of each year.**

Target years

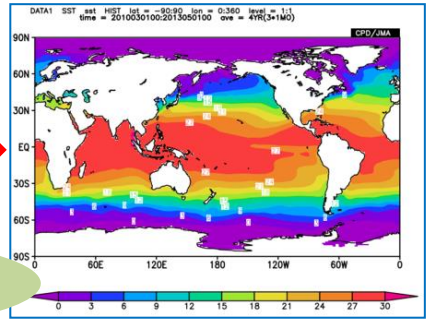
<Calendar>
2010 : J F M A M J J A S O N D
2011 : J F M A M J J A S O N D
2012 : J F M A M J J A S O N D
2013 : J F M A M J J A S O N D

Target period

*Check "Year-to-year"*

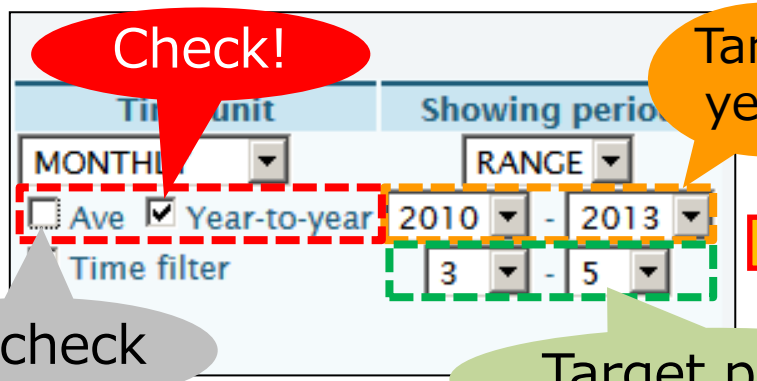



One 4-year-MAM averaged map



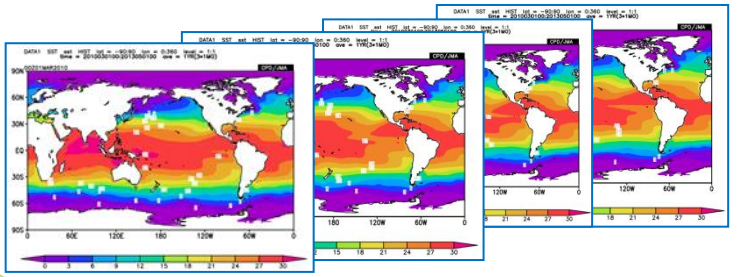
MAM 2010
MAM 2011
MAM 2012
MAM 2013

averaged




Four MAM averaged maps

MAM 2010, MAM 2011, MAM 2012, MAM 2013



# Multiple Data

- In a similar way, users can also perform the four basic arithmetic operations of two data by using the corresponding analysis method.

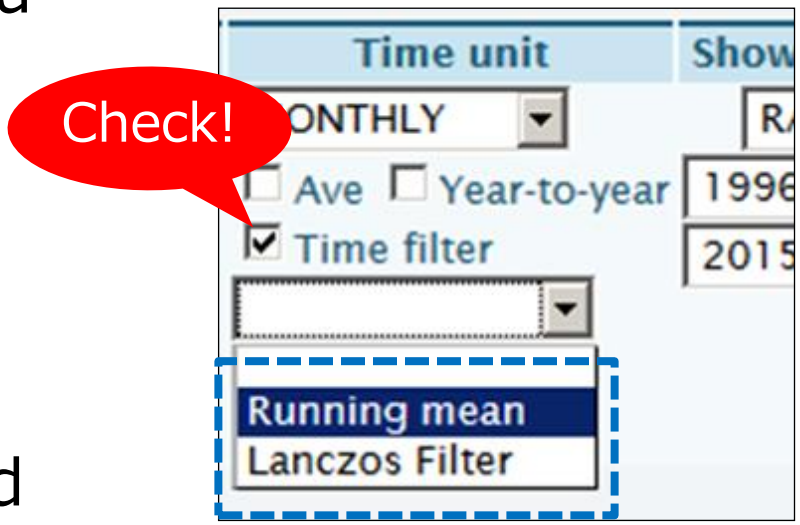
| Analysis method | Mapped value | Usage example |
|---|---|---|
| **ADD** | Addition<br>(“Data1” plus “Data2”) | – |
| **SUBTRACT** | Difference<br>(“Data1” minus “Data2”) | Time difference, vertical shear. |
| **MULTIPLY** | Multiplication<br>(“Data1” times “Data2”) | – |
| **DIVIDE** | Division<br>(“Data1” divided by “Data2”) | Precipitation ratios (“HIST” divided by “NORM”). |

# Time filter

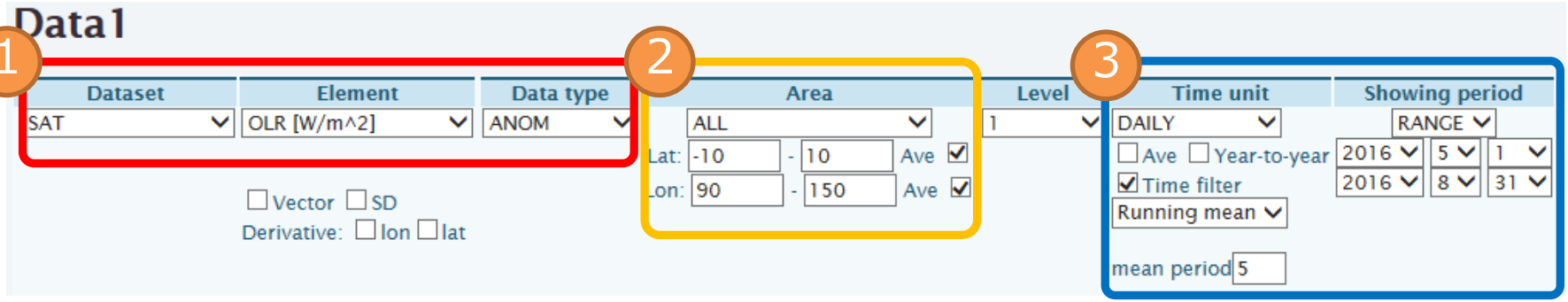
- Time filter should be used to create a time series image in the climate analysis.
- Climatological events are emphasized by a time filter, because it can remove high frequency variations.

Checking “Time filter” box, you can select two types of the time-filter.

- Running mean: Smooth the original data simply.
- Lanczos filter: Pick up the given period component and mean them based on Duchon (1979).

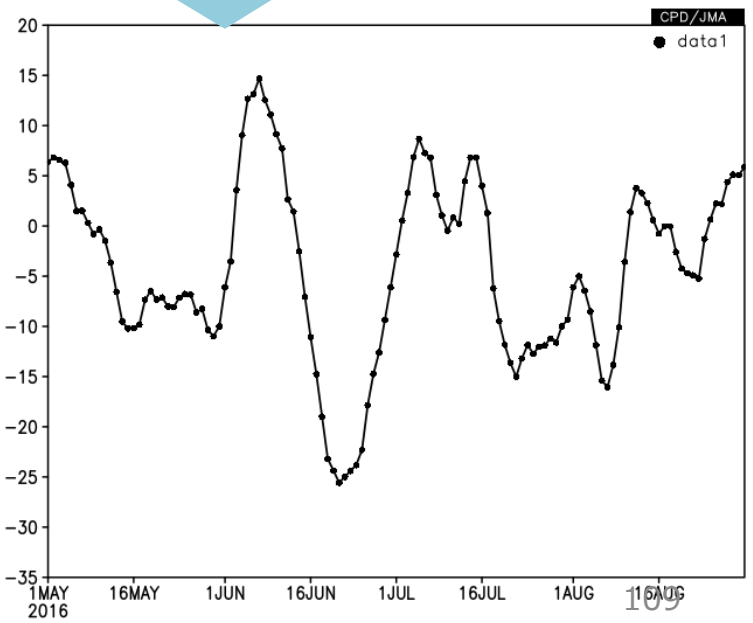


# Running mean daily timeseries



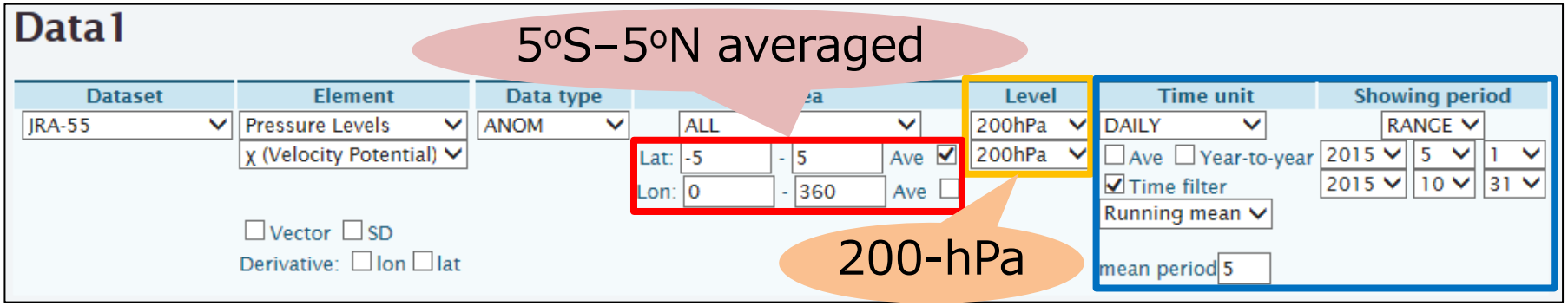

1. Select OLR anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - Check "Ave" boxes.
3. Select "DAILY" for time unit, and showing period.
   - Showing period: 1 May 2016 – 31 Aug. 2016.
   - Check "Time filter" in time unit box, and select "Running mean" and "5(day)" in "mean period" box.

5-day running mean daily timeseries of OLR anomalies



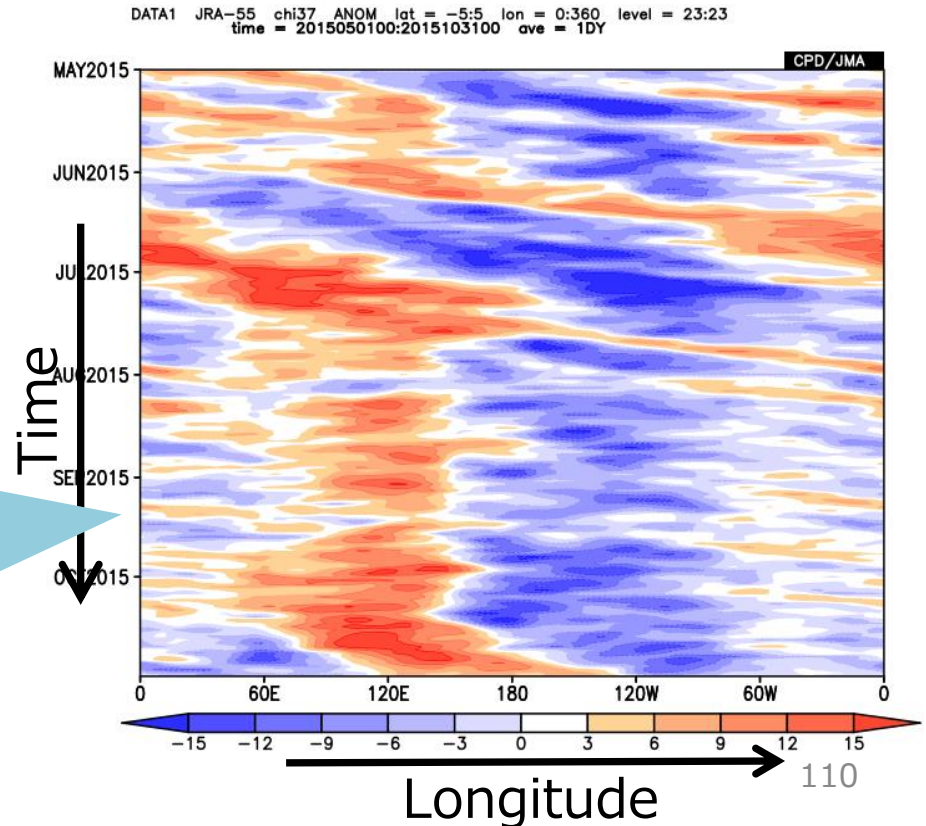
# Time cross section

- Running mean longitude-time cross section

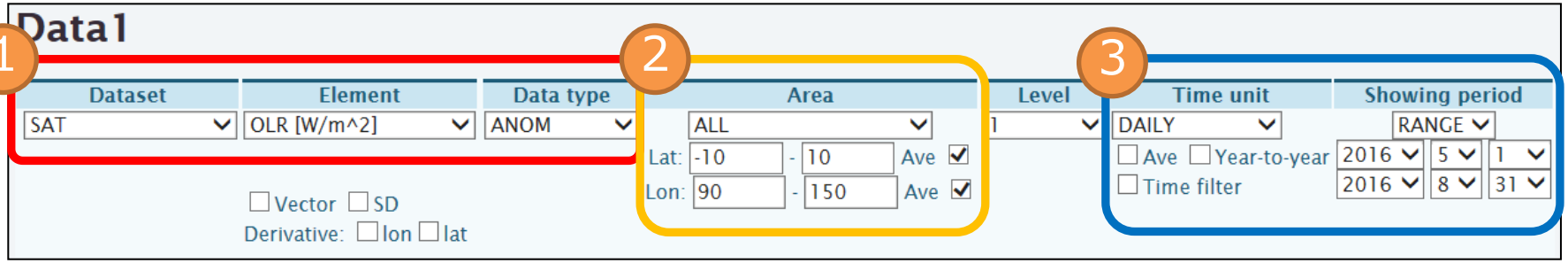



1. Select 5°S–5°N mean 200-hPa velocity potential anomalies.
2. Set 5-day running mean in “Time unit” box.

Longitude-time cross section of 5-day running mean 200-hPa velocity potential anomalies averaged over 5°S–5°N from 1 May to 31 October 2015.

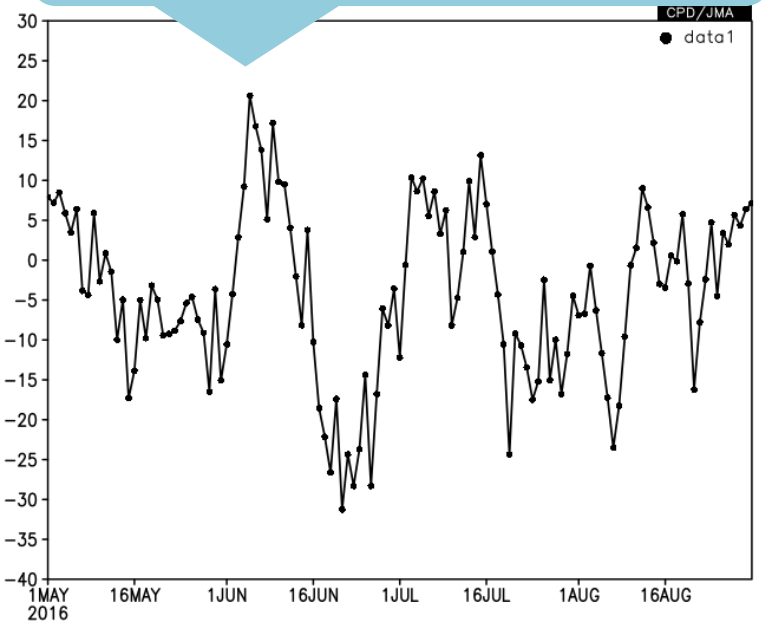


# Daily timeseries



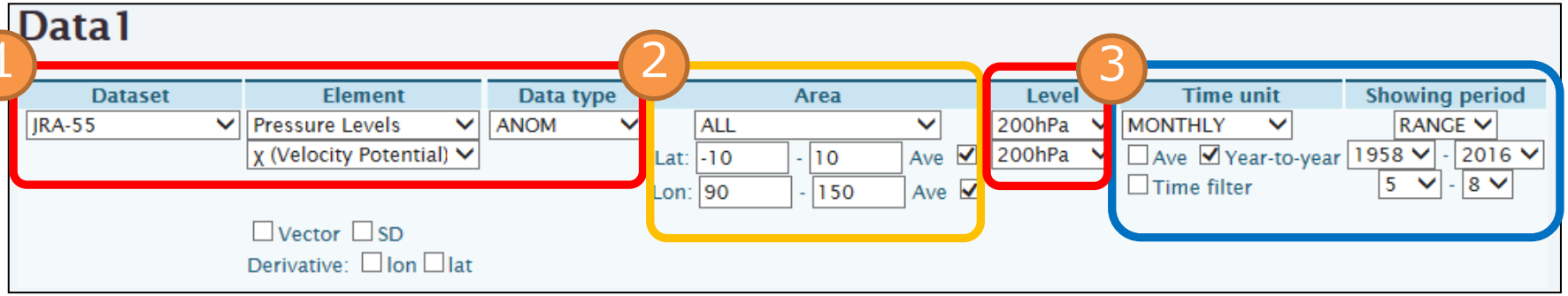

1. Select OLR anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - The area covers the Maritime continent.
   - Check "Ave" boxes.
3. Select "DAILY" for time unit, and showing period
   - Showing period: 1 May 2016 – 31 Aug. 2016.

Daily timeseries of OLR anomalies



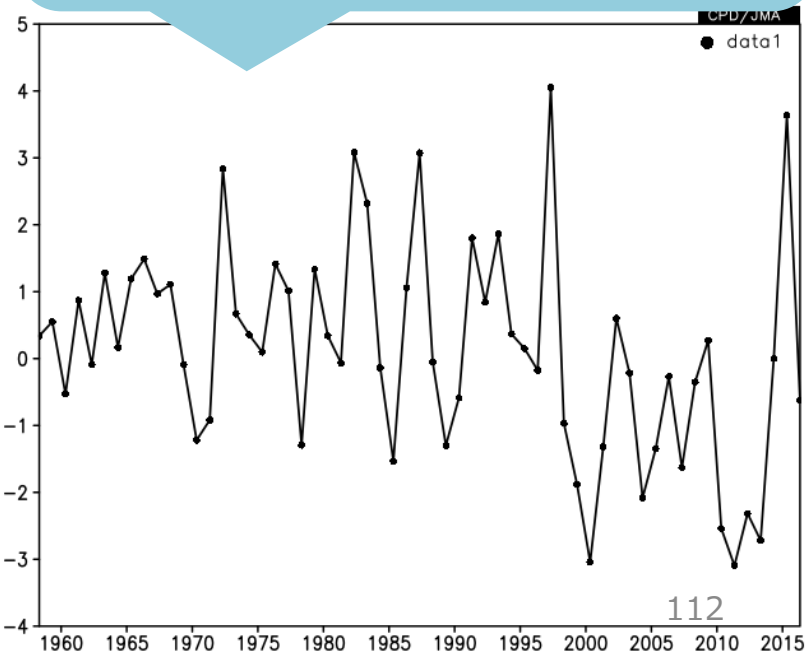

- Similarly, you can draw monthly or annual timeseries by setting "Time unit".

# Inter-annual timeseries



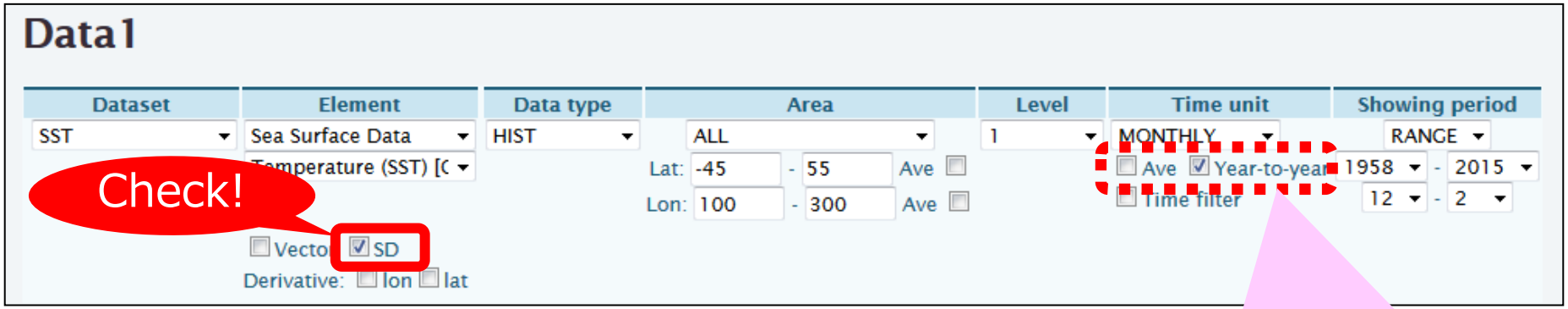

1. Select 200-hPa velocity potential anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - The area covers the Maritime continent.
   - Check "Ave" boxes.
3. Select "MONTHLY" for time unit, and showing period
   - Check "Year-to-year".
   - Showing period: 1958 – 2016, 5 – 8.

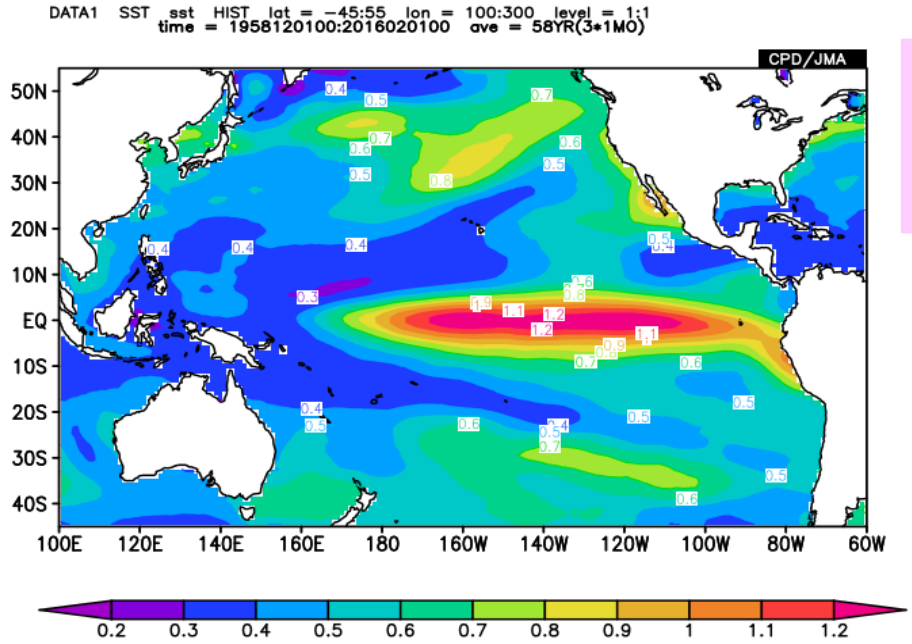
Inter-annual timeseries of 4-month (May – August) mean 200-hPa velocity potential anomalies



# Standard deviation map

- A standard deviation map is available to see the variability of the selected element over the selected period.



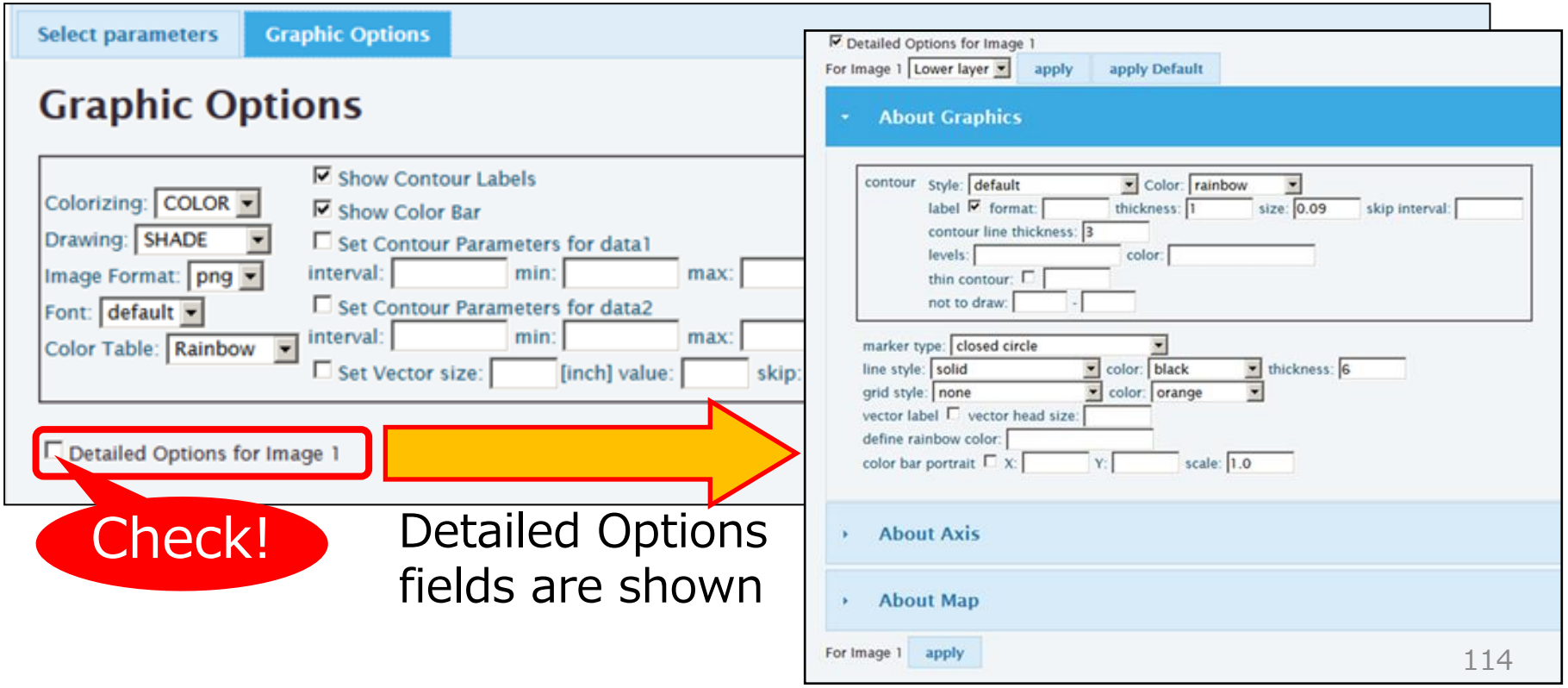




For standard deviation, don't check "Ave" box.

The standard deviation of DJF averaged SST from 1958/59 to 2015/16.

# Detailed Options

- There are a lot of visual options to create maps.
  - Contour : Color, thickness, style, label etc.
  - Axis : Color, interval, style and others.
  - Map : Color, resolution, style and others.




Detailed Options fields are shown

# Procedure of setting detailed options

## 1. Select target

Lower layer: Data1
Upper layer: Data2

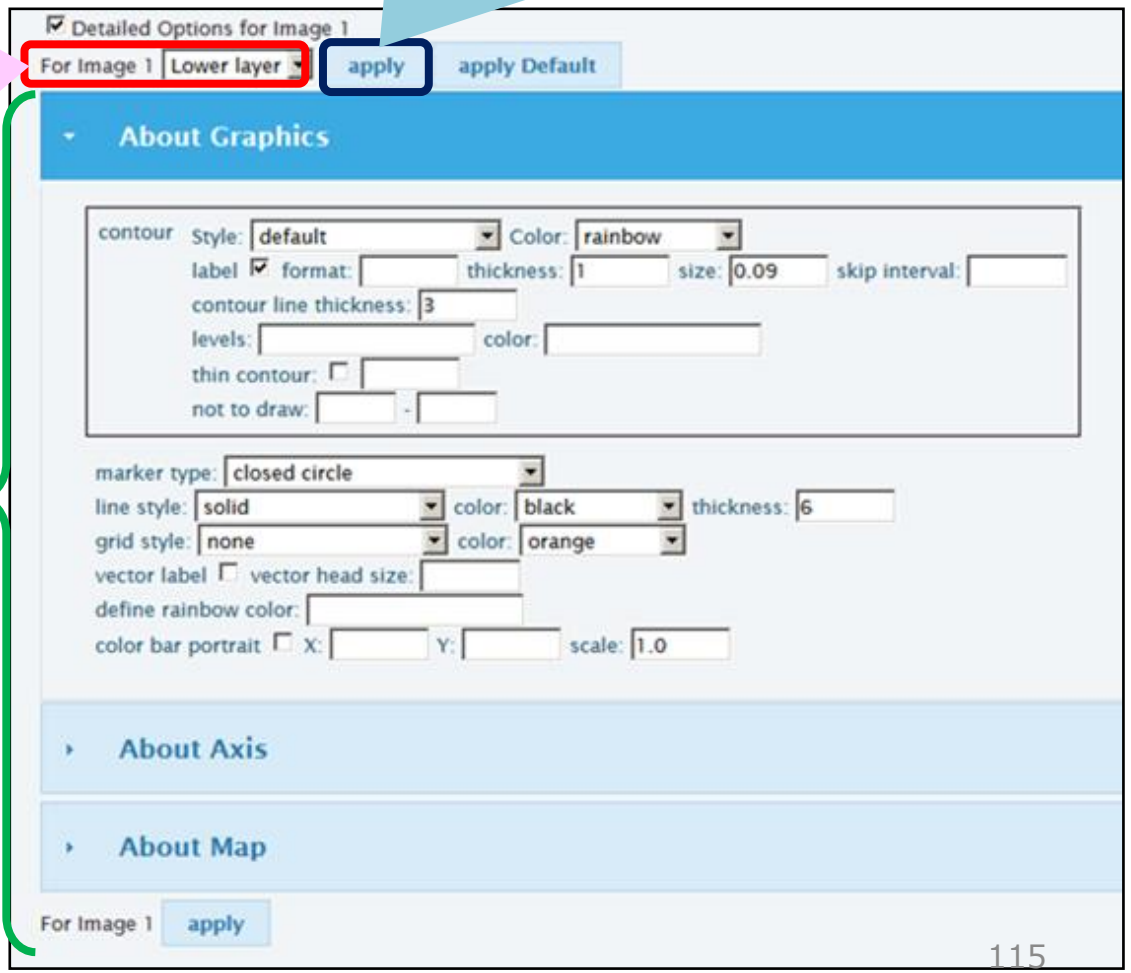
In the case of vector map
Lower layer: Data2
Upper layer: Data1

## 2. Set options

Set contour style, color, thickness, etc.

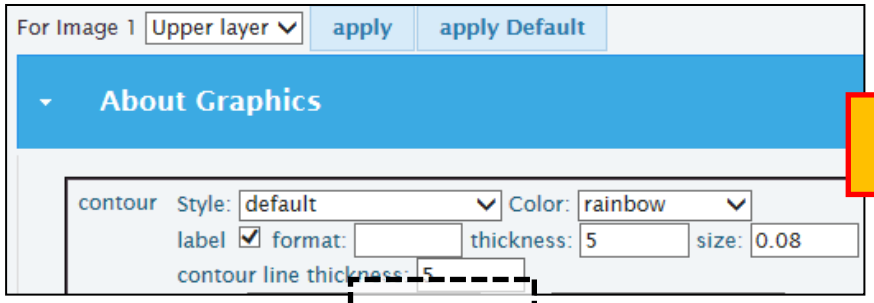
## 3. Apply the settings

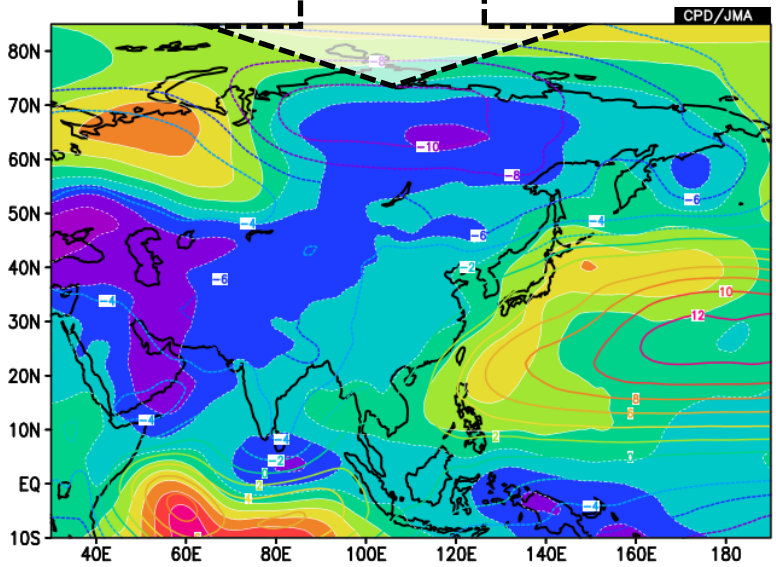
**Click the "apply" button before "Submit" is clicked.**



# About Graphics: Contour color and label

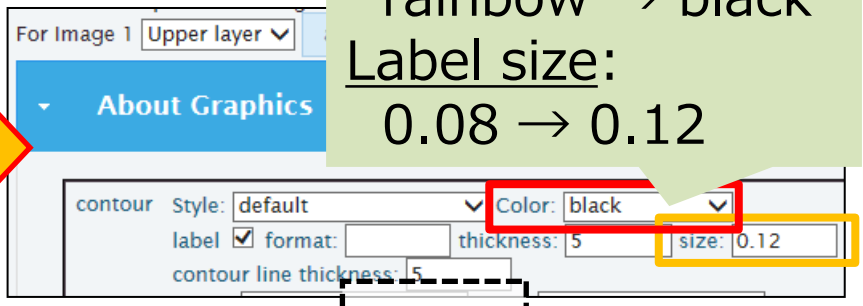
- After selecting the layer, set color and label to change contour properties.

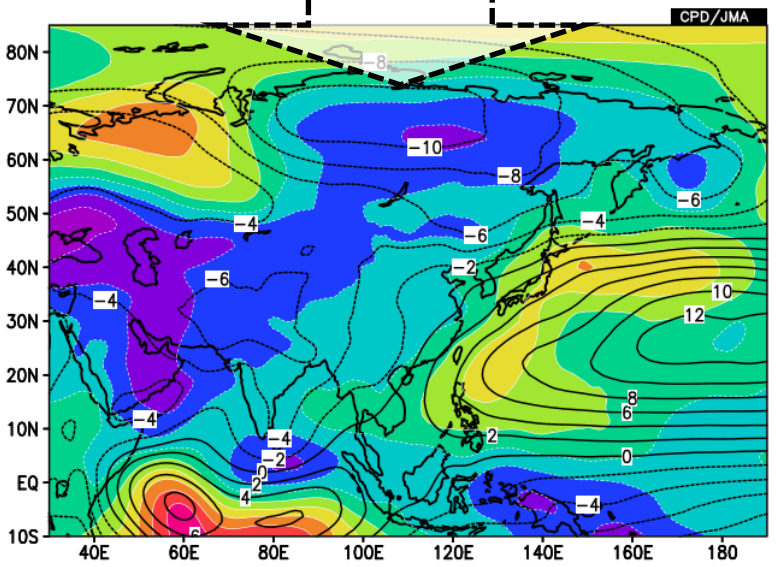



It's hard to see contours and its label because its color is similar to shade color.

Color:
rainbow → black
Label size:
0.08 → 0.12




The problems are cleared.

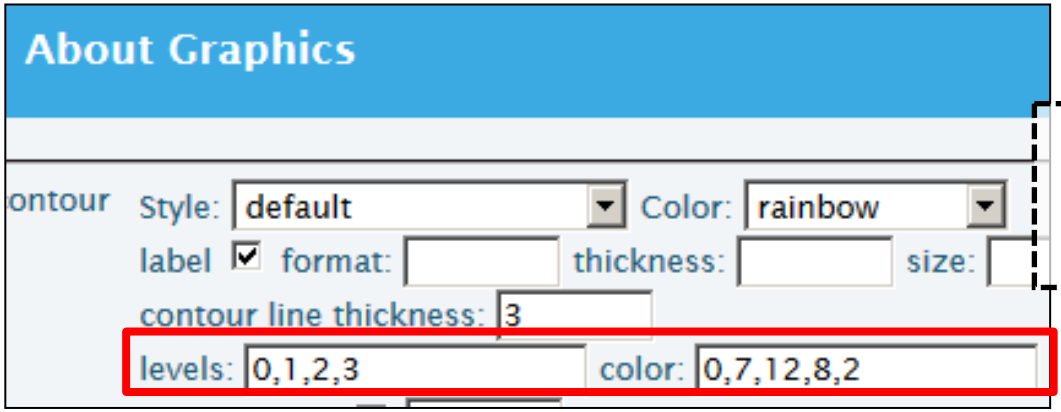
# About Graphics: Color table

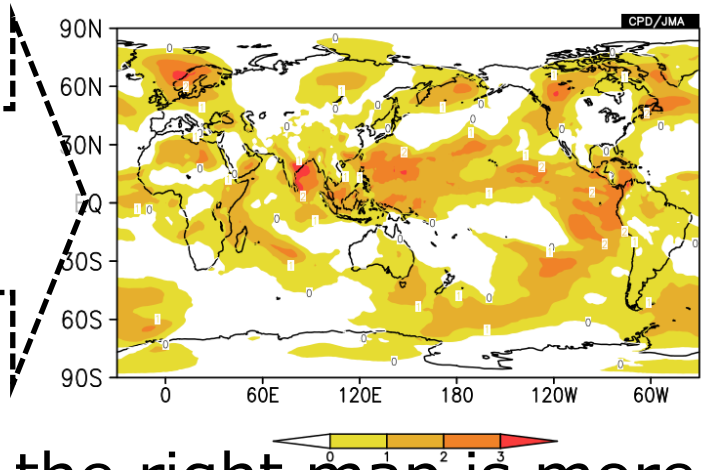
- Set levels and colors separated by comma in the boxes to define the color table by yourself. The color numbers are defined as the right table.

e.g.) levels:-2,-1,0,1,2
color: 4,11,5,7,12,2


| | |
|---|---|
| white | 0 |
| black | 1 |
| red | 2 |
| green | 3 |
| dark blue | 4 |
| light blue | 5 |
| magenta | 6 |
| yellow | 7 |

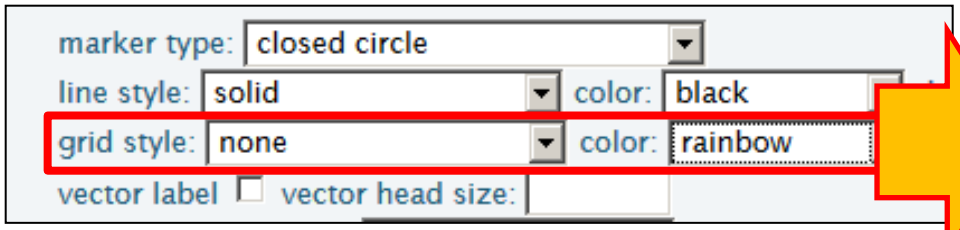
| | |
|---|---|
| orange | 8 |
| purple | 9 |
| yellow green | 10 |
| medium blue | 11 |
| dark yellow | 12 |
| aqua | 13 |
| dark purple | 14 |
| gray | 15 |

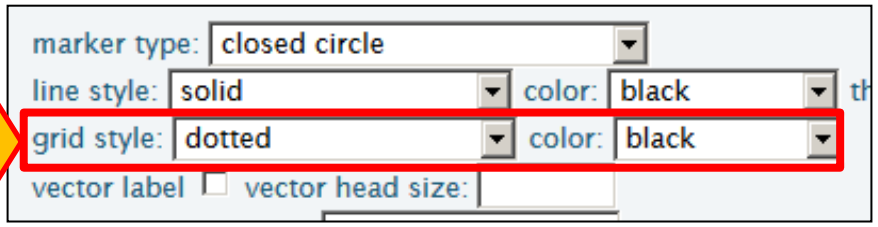


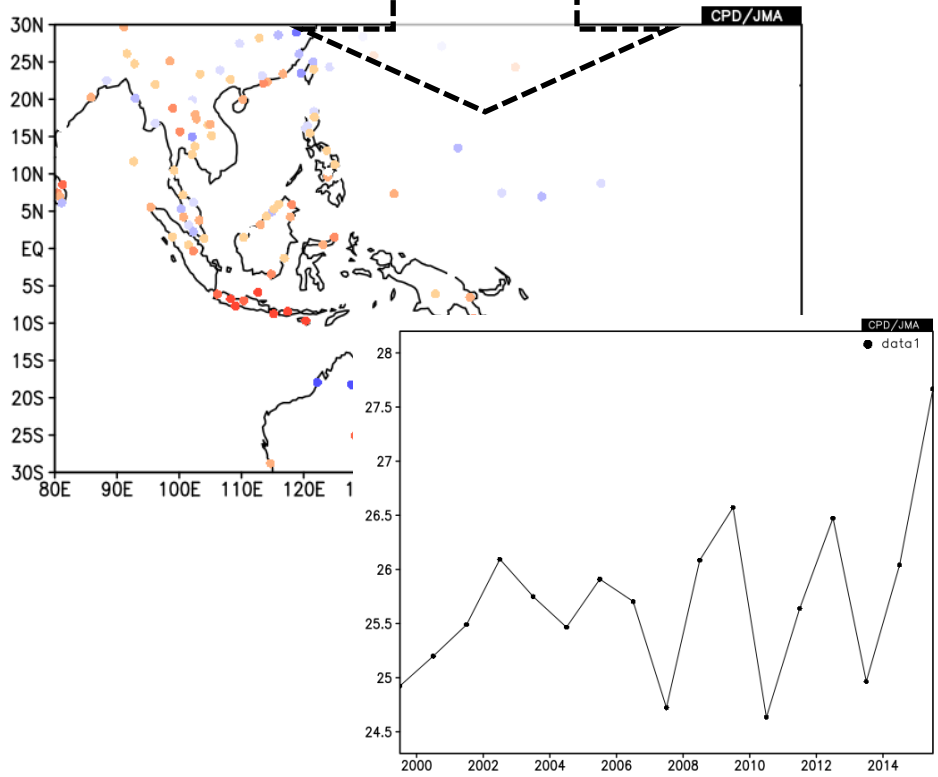



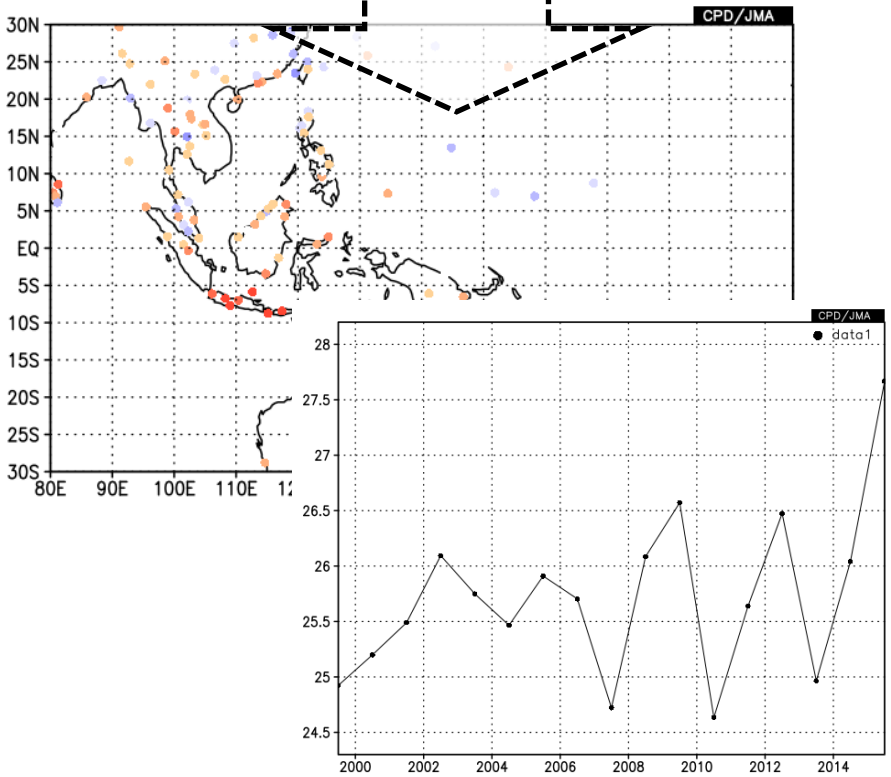

For example, the color setting like the right map is more suitable to focus on the positive value.

# About Graphics: grid style



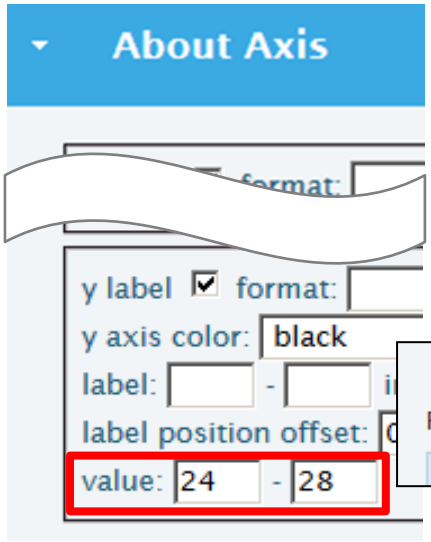



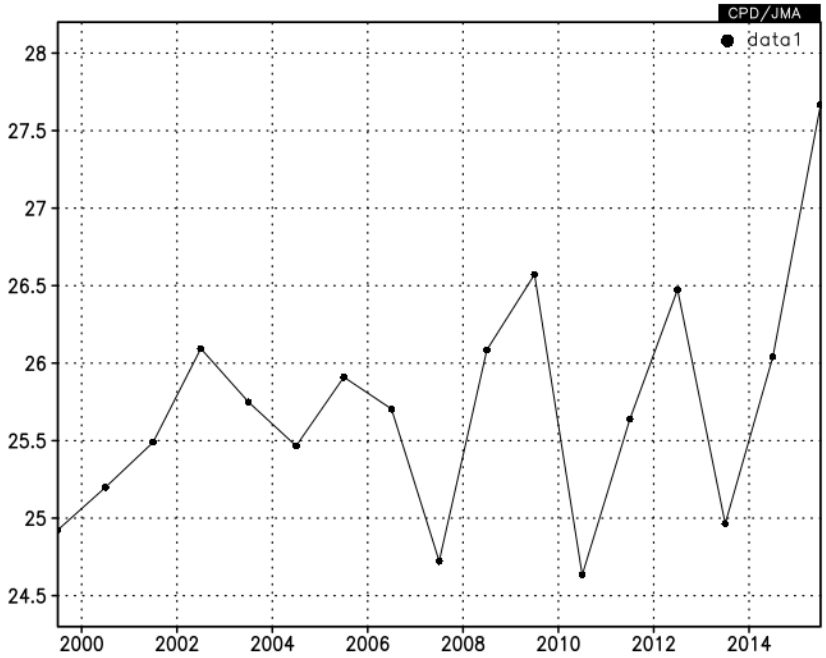

The grid line in the panel like the right map is available.

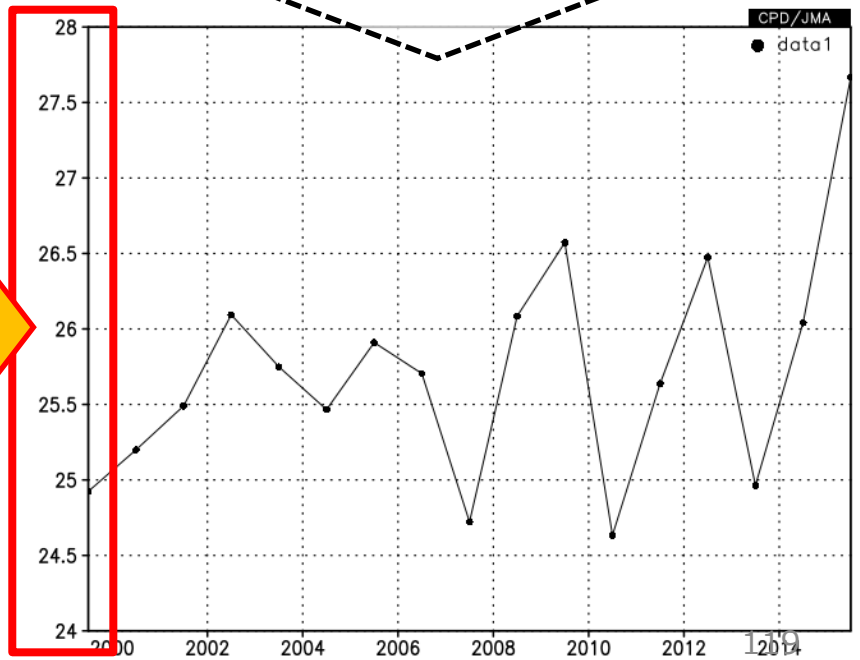
# About Axis: value





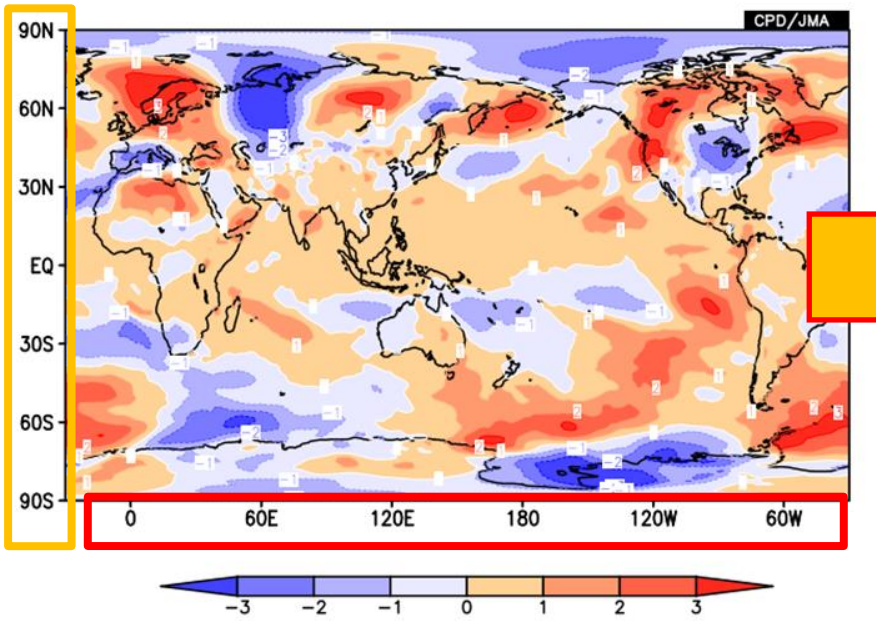
Default



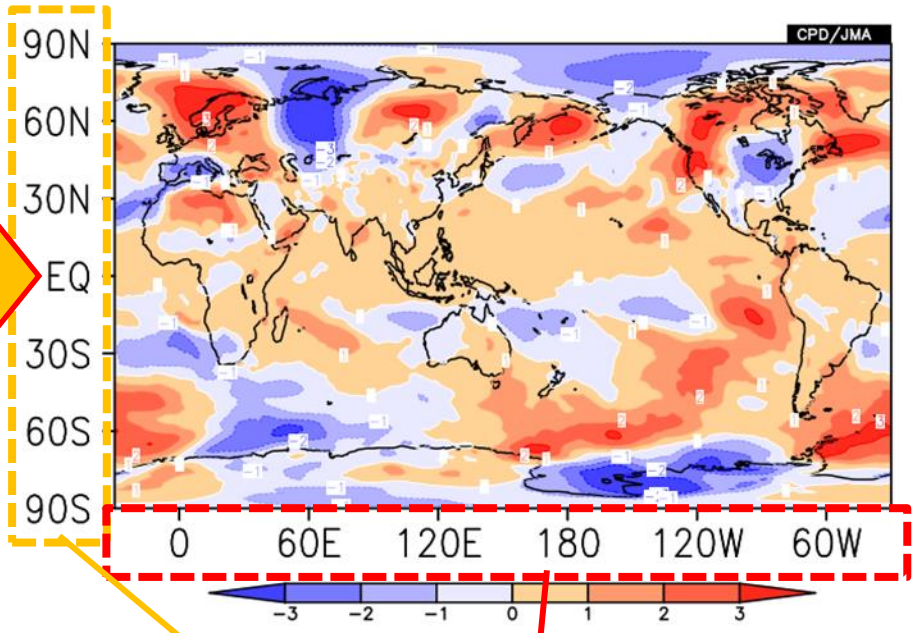



# About Axis: Label size

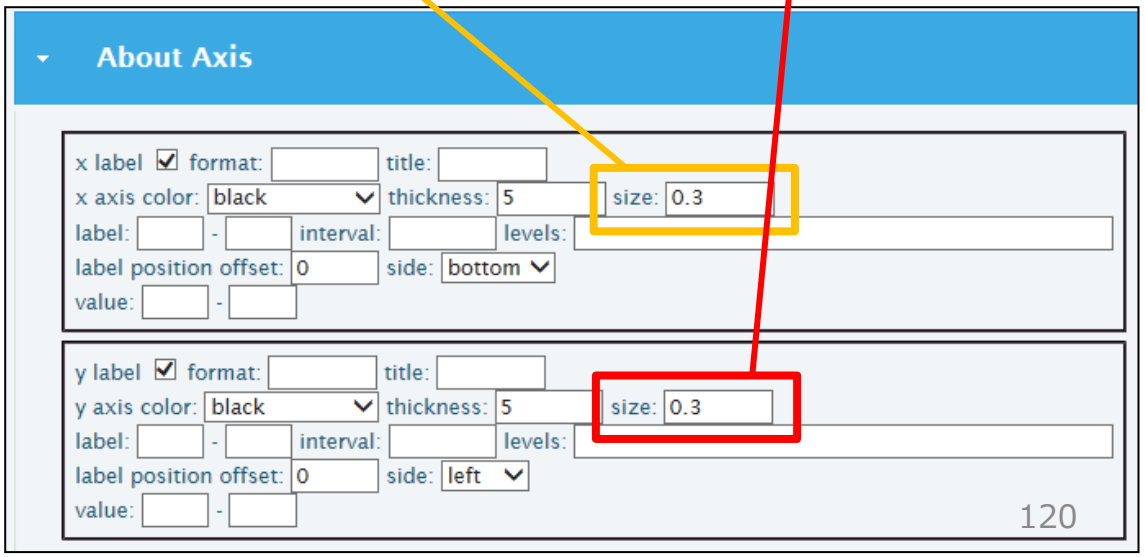
Default size




Label size: 0.3

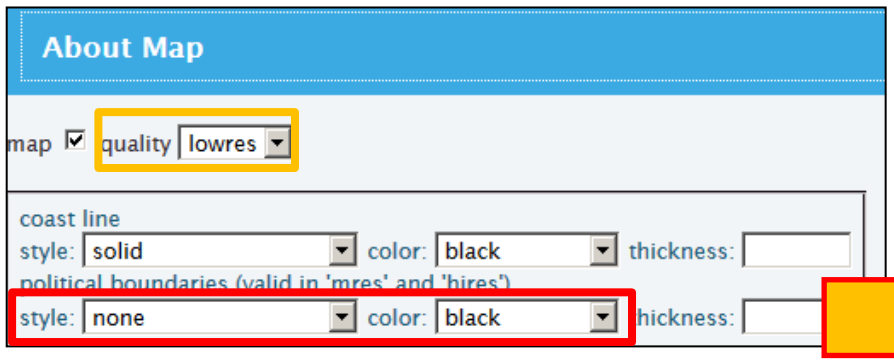


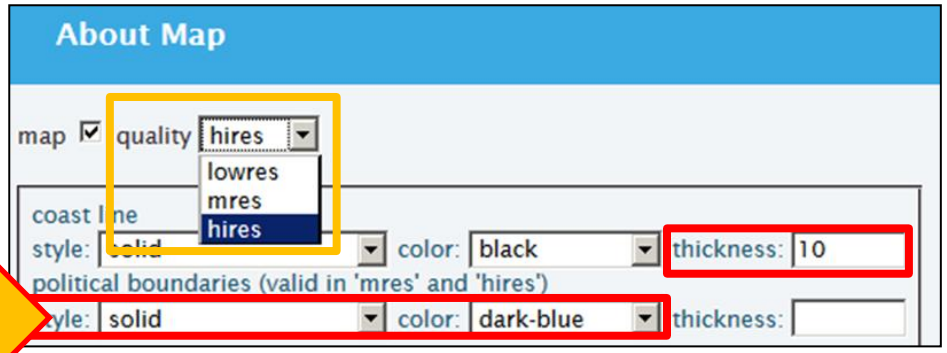

The label size is customizable in the “About Axis” box.

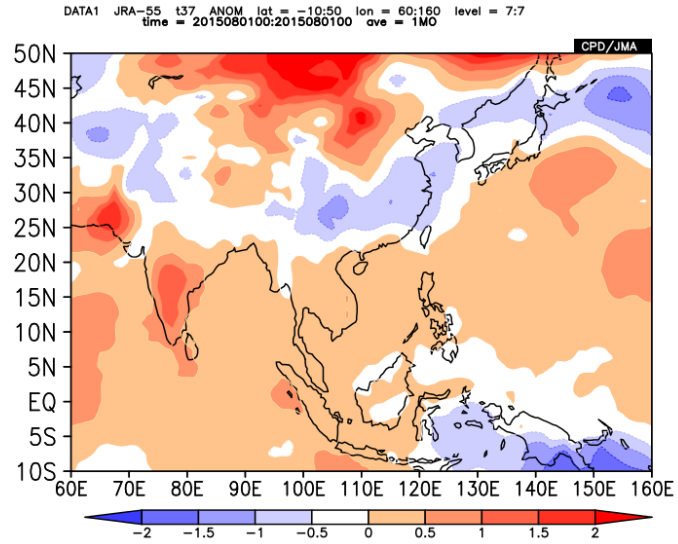


# About Map

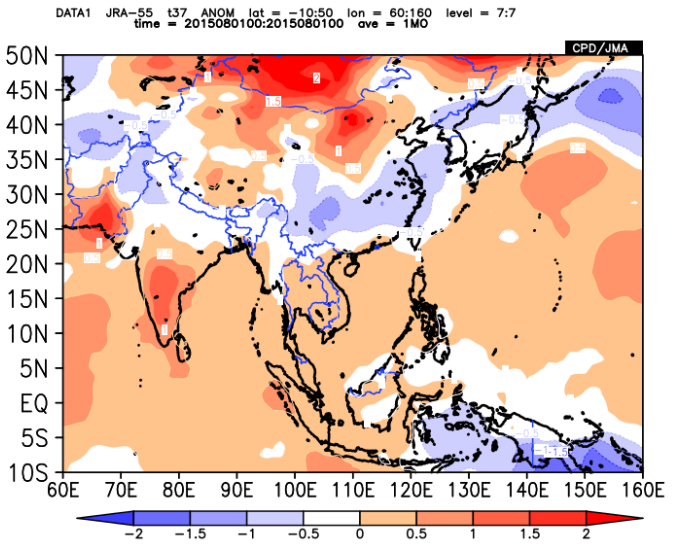
- Map resolution, political boundaries are customizable in the “About Map” box.




**lowres**:
low resolution
**mres**:
middle resolution
**hires**:
high resolution




Quality must be set “mres” or “hires” to show political boundaries.

# Notice about detailed options

- In iTacs, **the detailed options' settings are always saved per individual user IDs.**
  - If several people share the same iTacs ID and one of them changes some of detailed options, the changes will **influence the other people's use** of course.
  - Users **must explicitly set** detailed options again by themselves **to return to the default settings**.
  - Unlike the other settings such as element, period, analysis method, they **cannot be shared by user parameter code**.