気象庁
Japan Meteorological Agency

TCC seminar,
16:15–18:00, 12 November 2018,
Tokyo, Japan

Introduction and operation of iTacs

- Interactive Tool for Analysis of the Climate System -

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Japan Meteorological Agency

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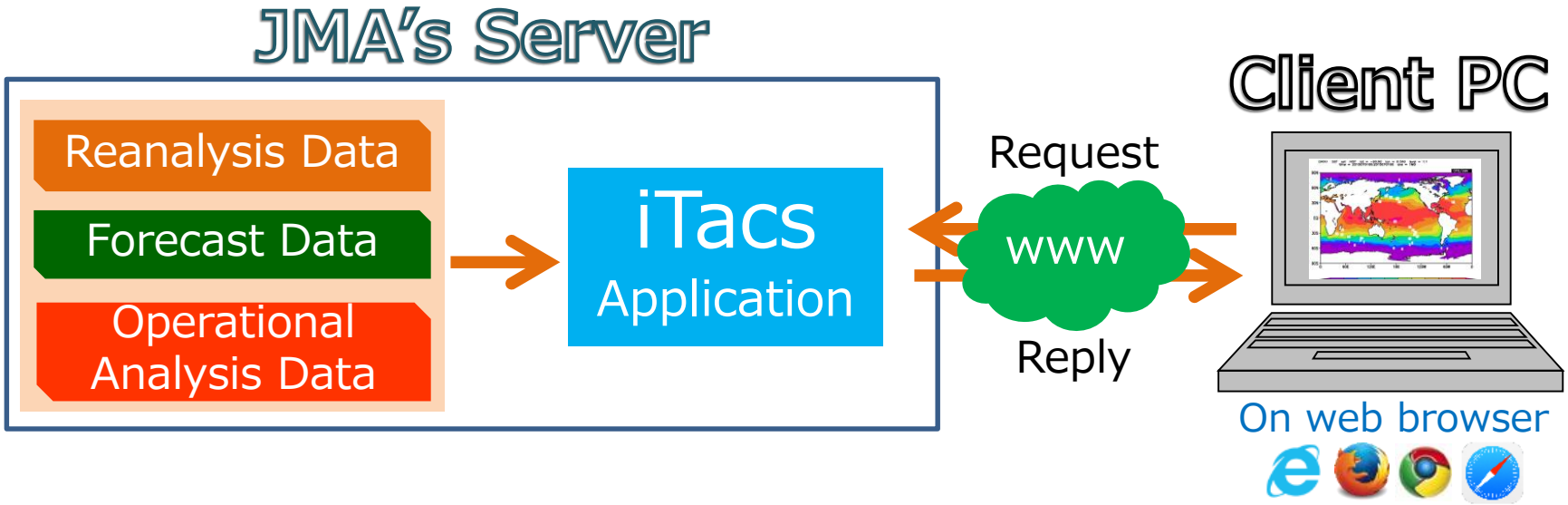
Basic
12 Nov.

Advanced
13 Nov.

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

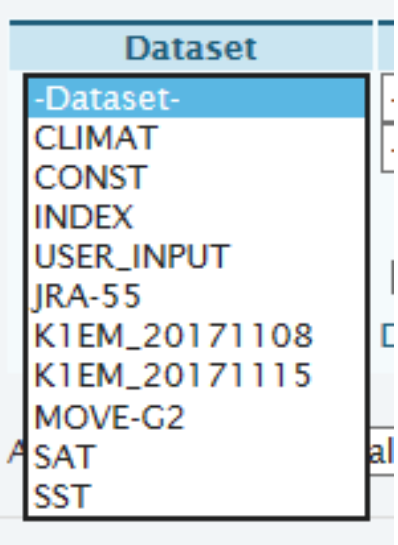
Atmospheric analysis dataset		
JRA-55	1958～	The Japanese 55-year Reanalysis
SAT	1979*～	NOAA's outgoing longwave radiation (OLR)

*full available period. Actually data is available from 1974 but is missing between 1978/3/17-12/31.

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

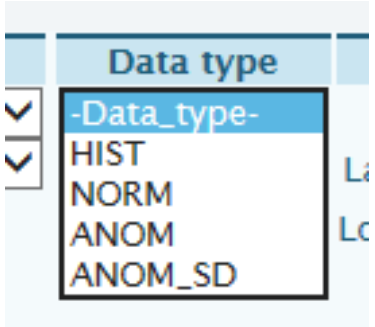
Forecast dataset
JMA's one-month prediction model output

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

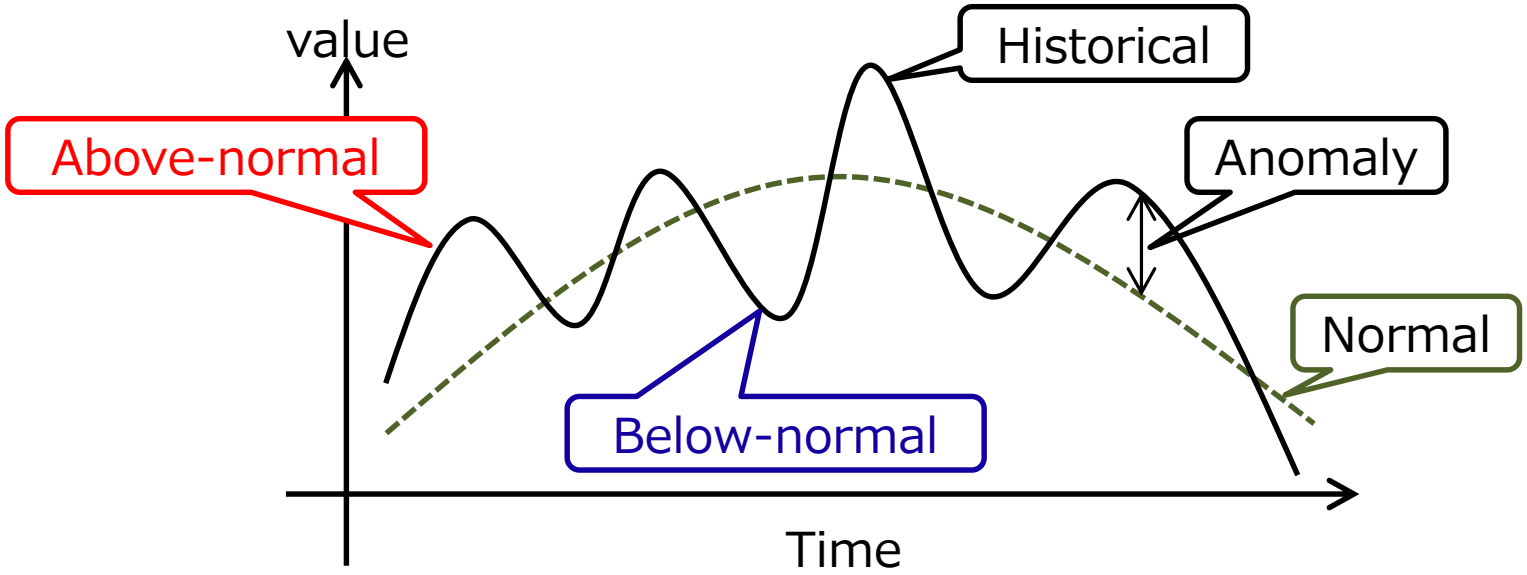


Available data type

- Various data types are available to perform climate diagnosis.

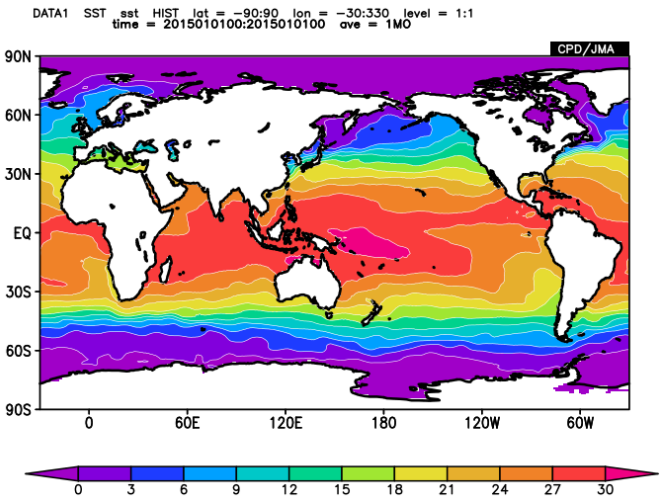


HIST	Historical actual analysis or observation data
NORM	Climatological normal data (averaged from 1981 to 2010)
ANOM	Anomaly data (difference from the climatological normal)

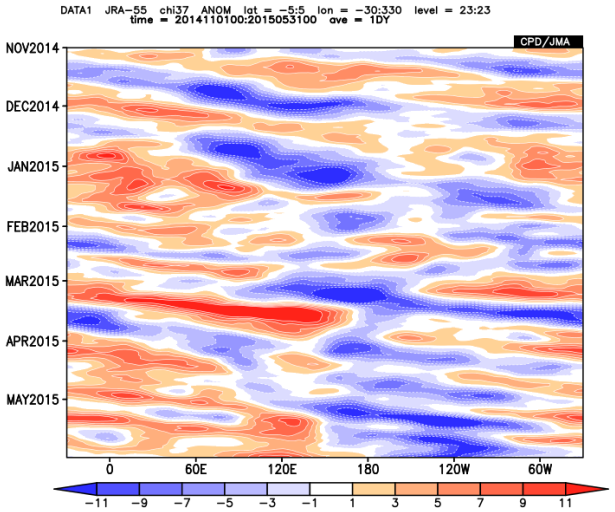


Samples of charts

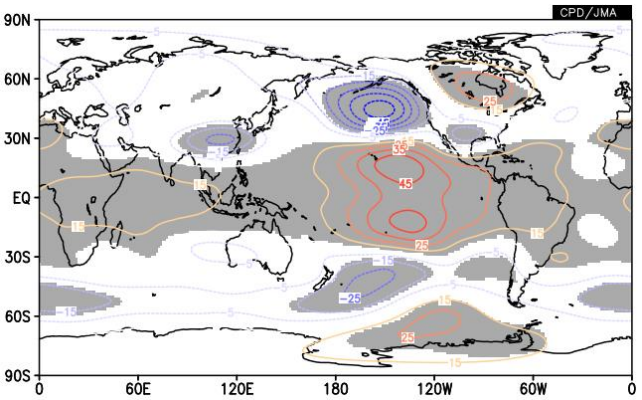
- Various types of charts and statistical analyses are available on iTacs.



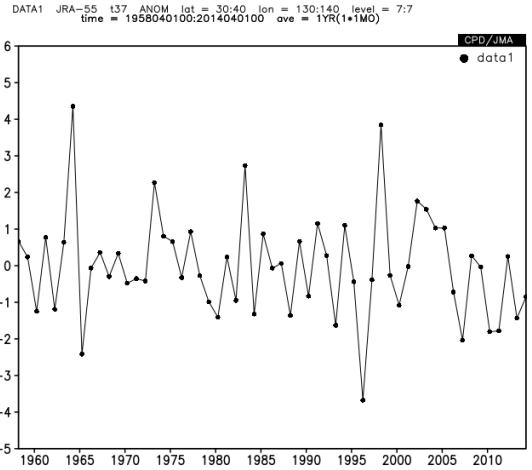
2-dimensional map



Cross section diagram



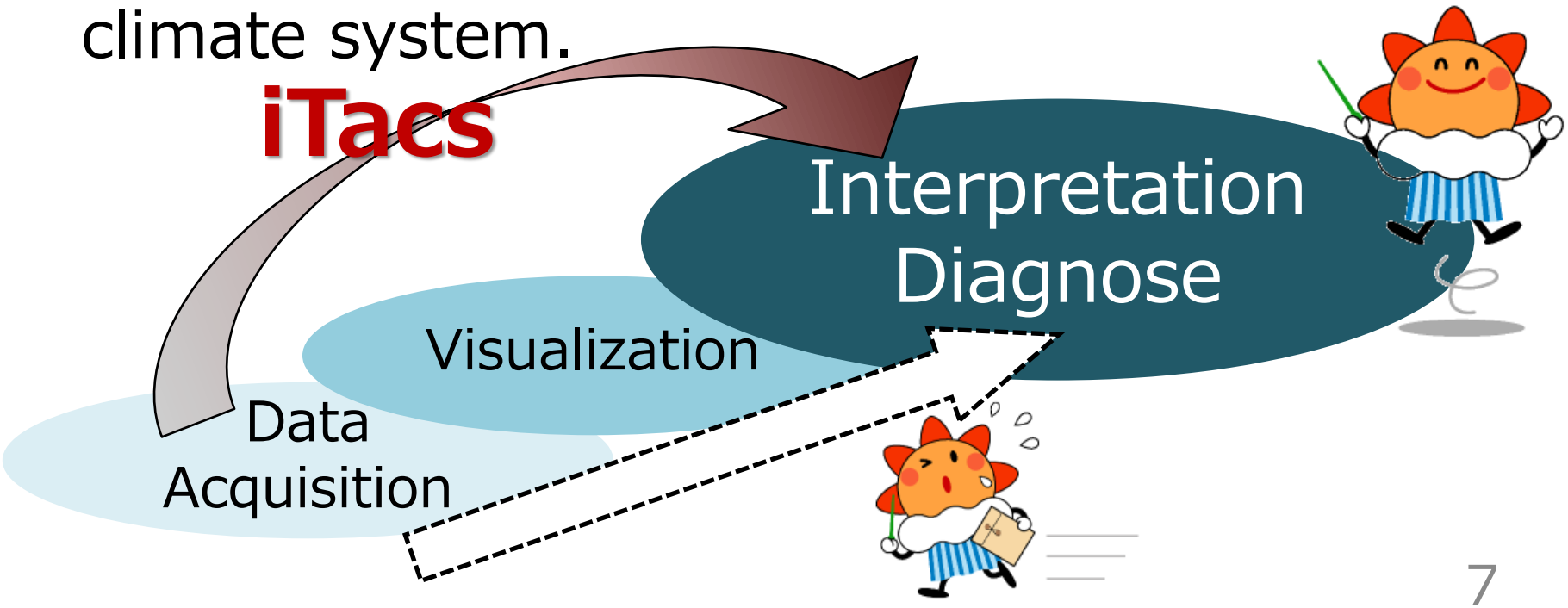
Regression/Correlation and significance-test



Time series graph

Advantages of iTacs

- iTacs is one of the most useful tools developed by JMA to perform climate analysis and will strongly help you in climate monitoring.
- Use of iTacs costs *less time to visualize the data, more time to make interpretation* of the climate system.

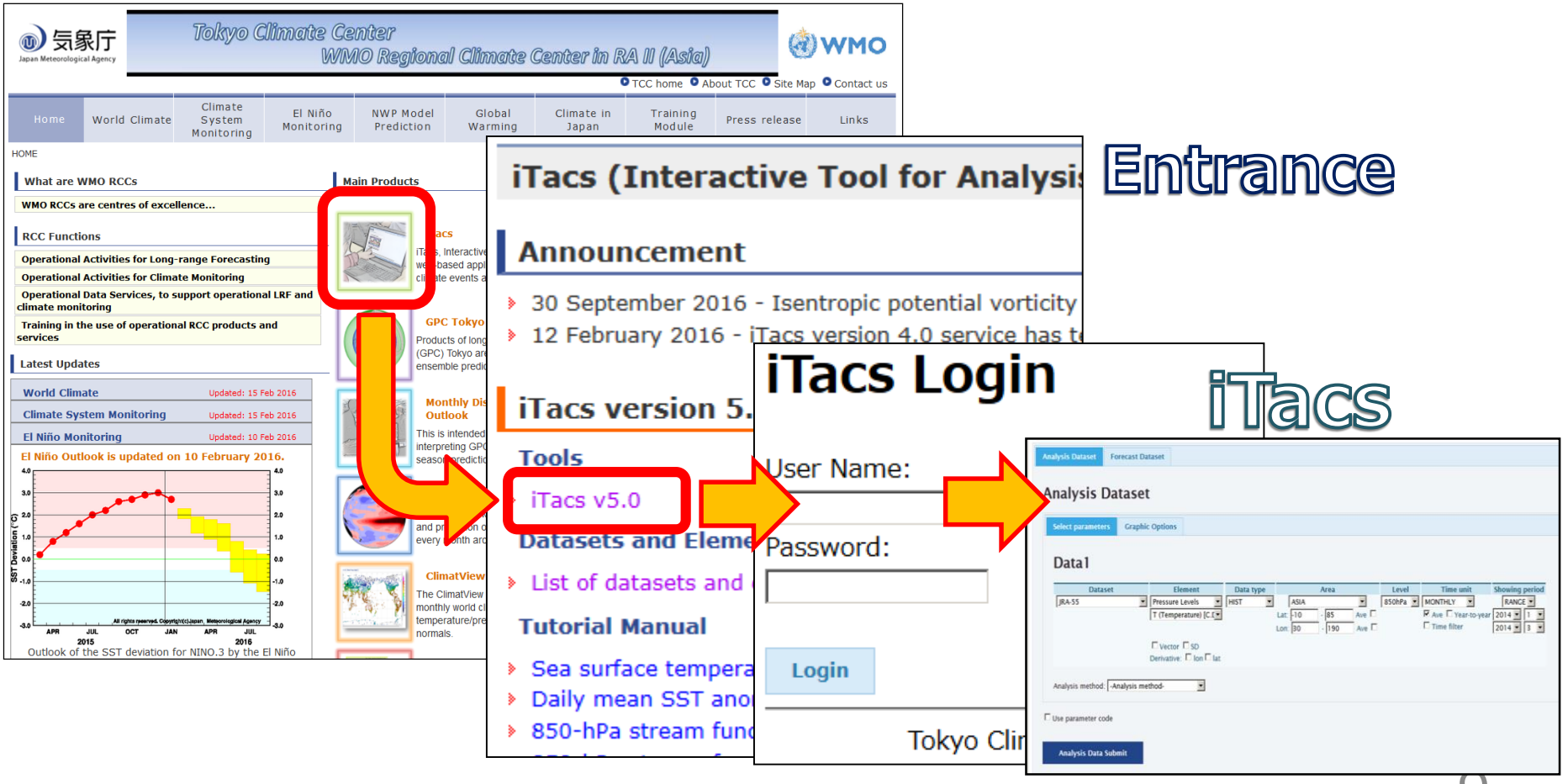


Contents

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)

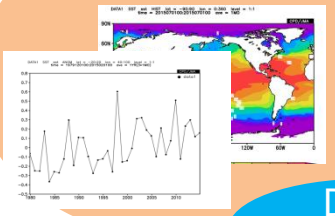
Select Analysis or Forecast dataset

Setting Data parameters

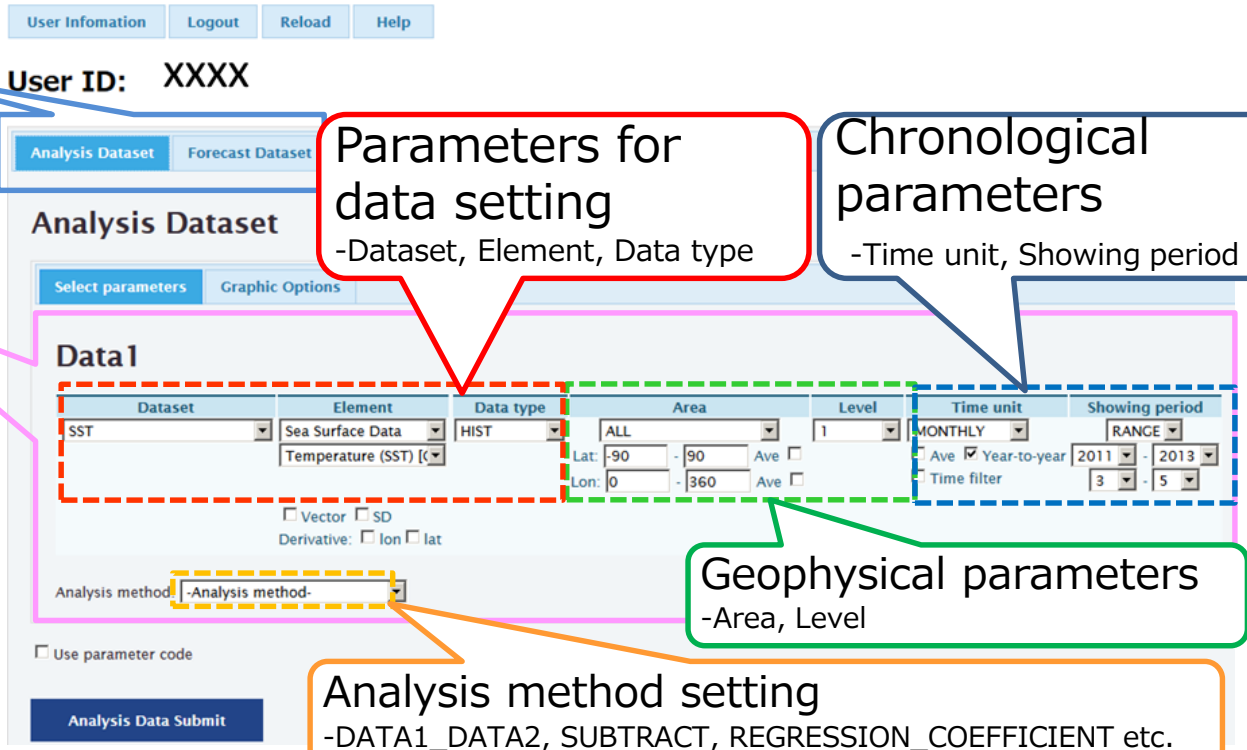
Setting Graphic Options

Data Submit

Draw map



Data download

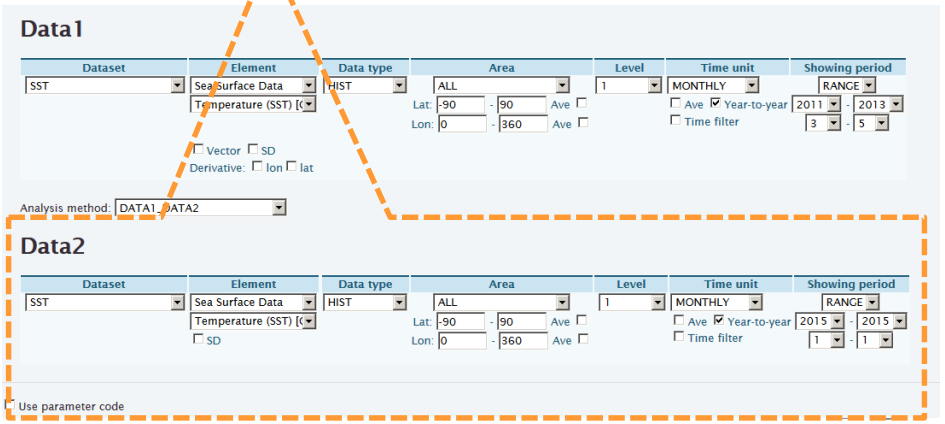


Parameters for data setting
-Dataset, Element, Data type

Chronological parameters
-Time unit, Showing period

Geophysical parameters
-Area, Level

Analysis method setting
-DATA1_DATA2, SUBTRACT, REGRESSION_COEFFICIENT etc.



In some cases, Data2 setting needed.

Basic operating procedure (2)

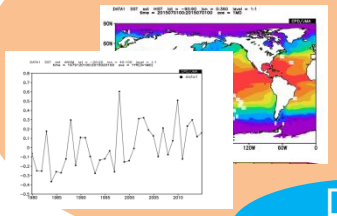
Select Analysis or Forecast dataset

Setting Data parameters

Setting Graphic Options

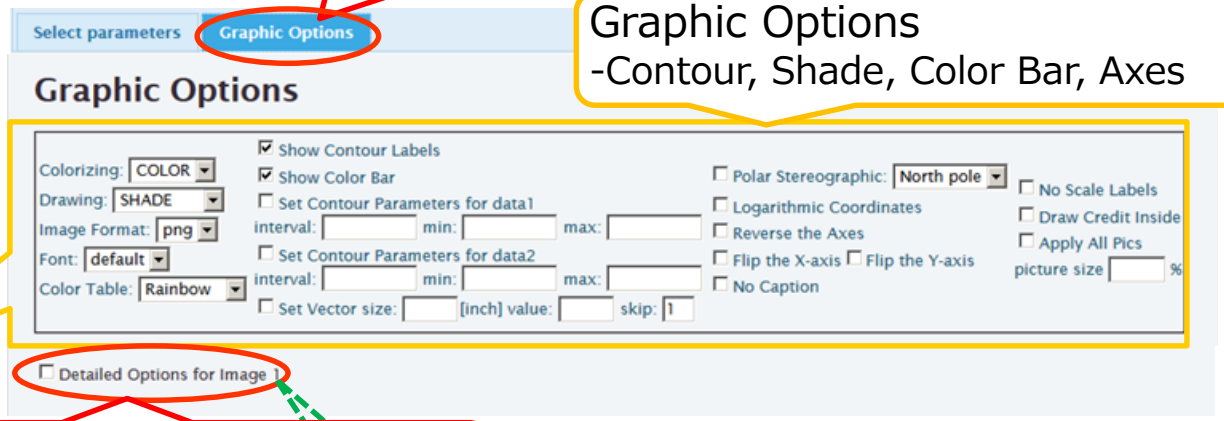
Data Submit

Draw map



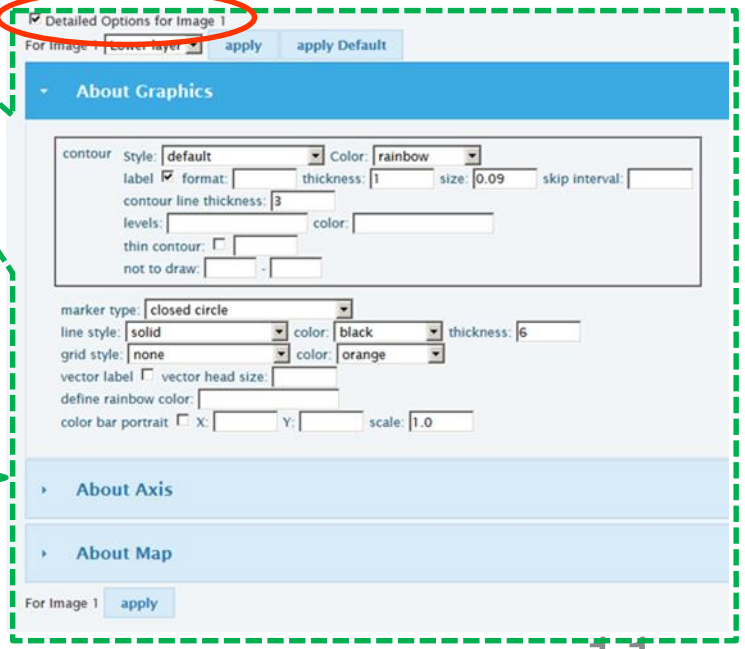
Data download

Select this tab



Graphic Options
-Contour, Shade, Color Bar, Axes

Checking here, additional field for detailed options will appear.

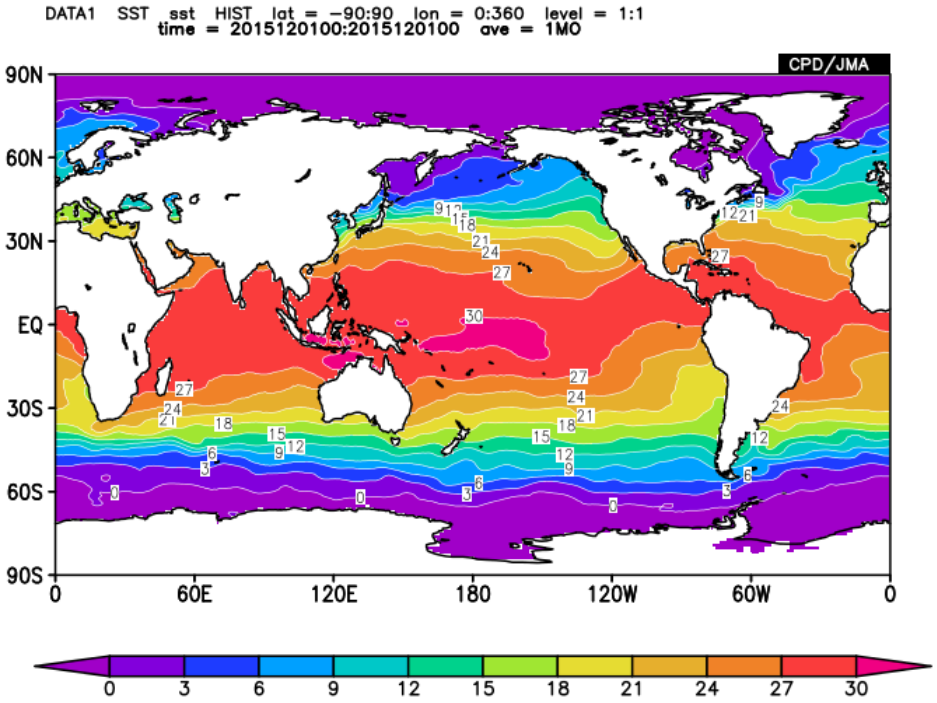


Detailed Options for Image x
-Graphics, Axis, Map

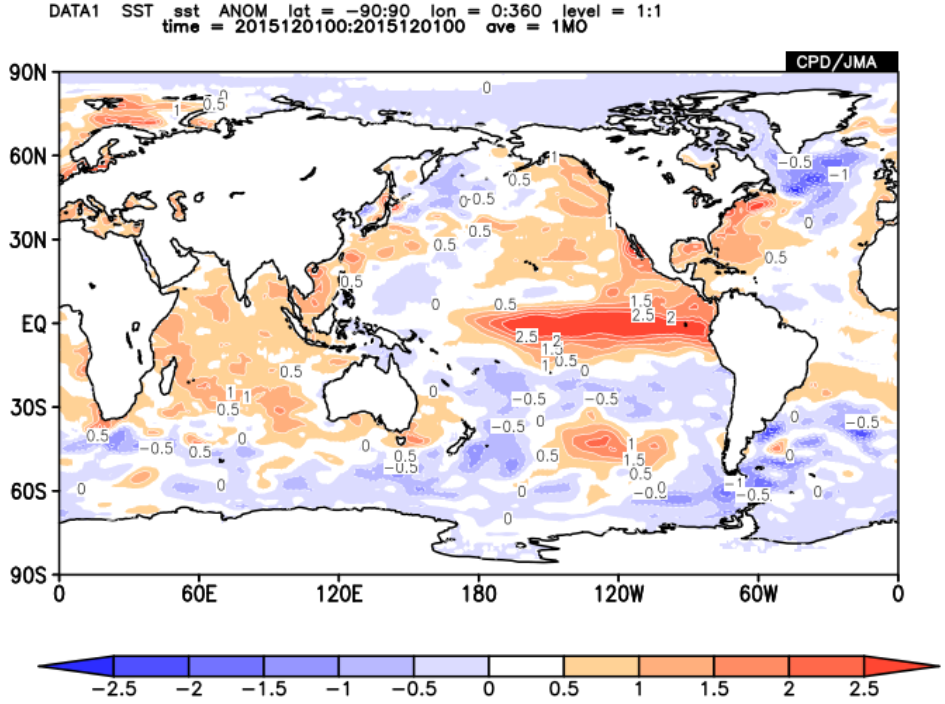
Longitude-latitude map (1)

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

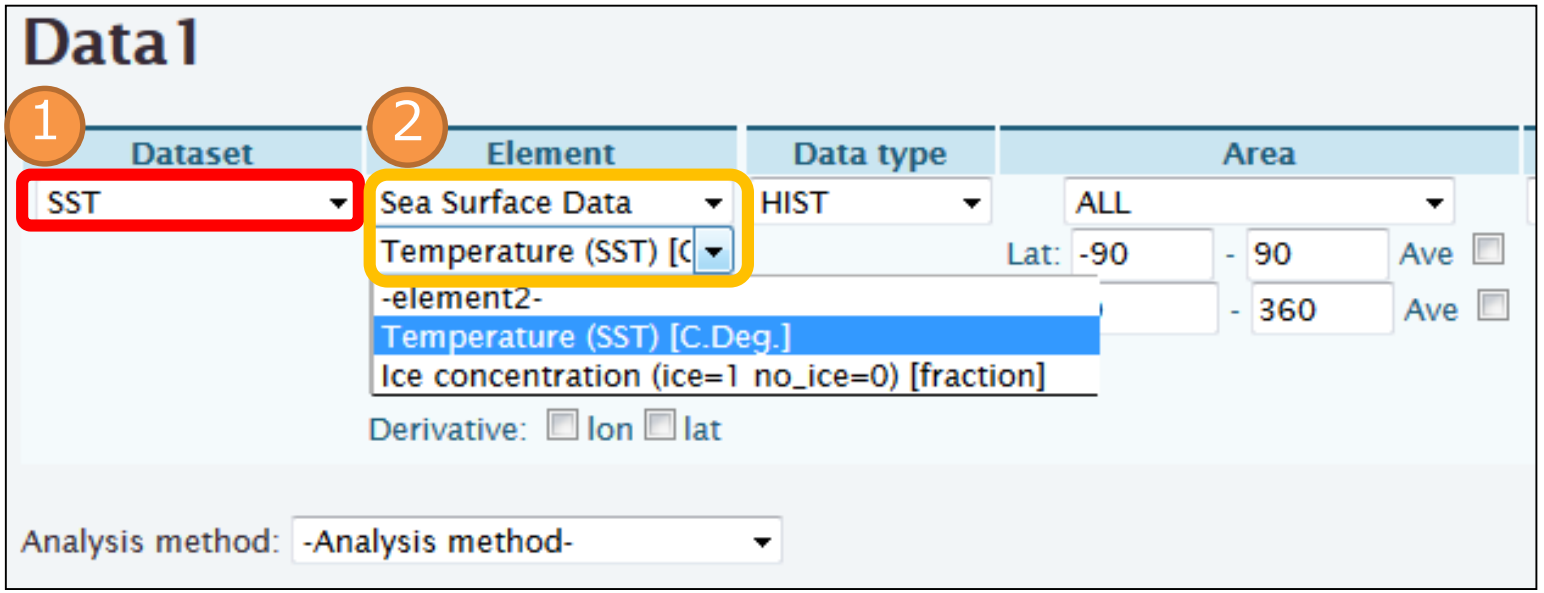
SST



SST anomaly

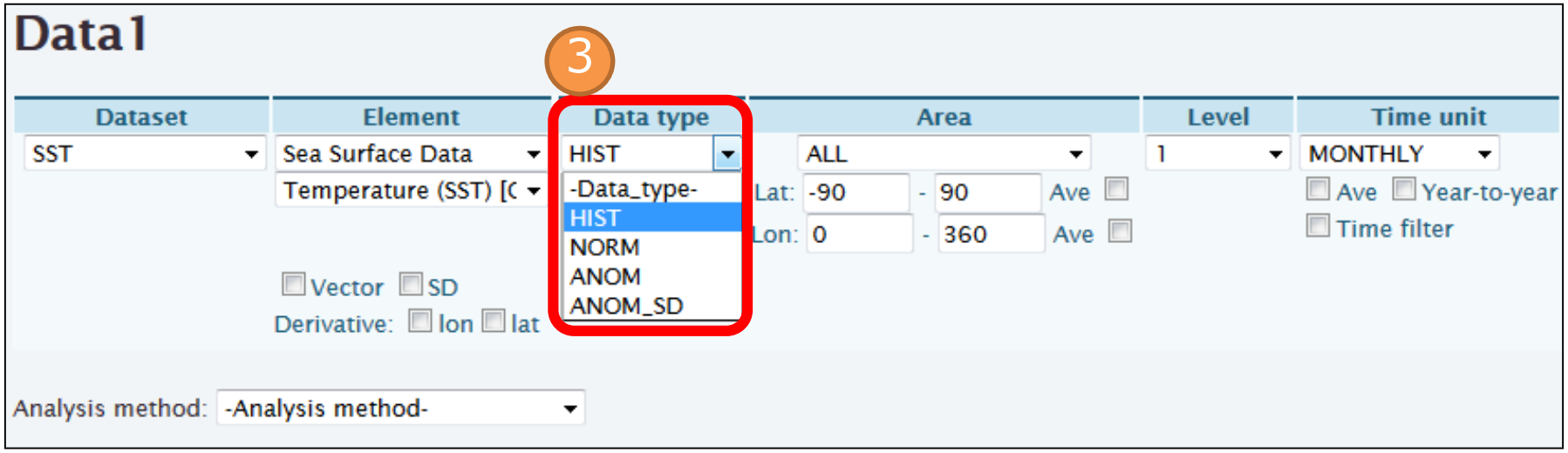


Longitude-latitude map (2)



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.

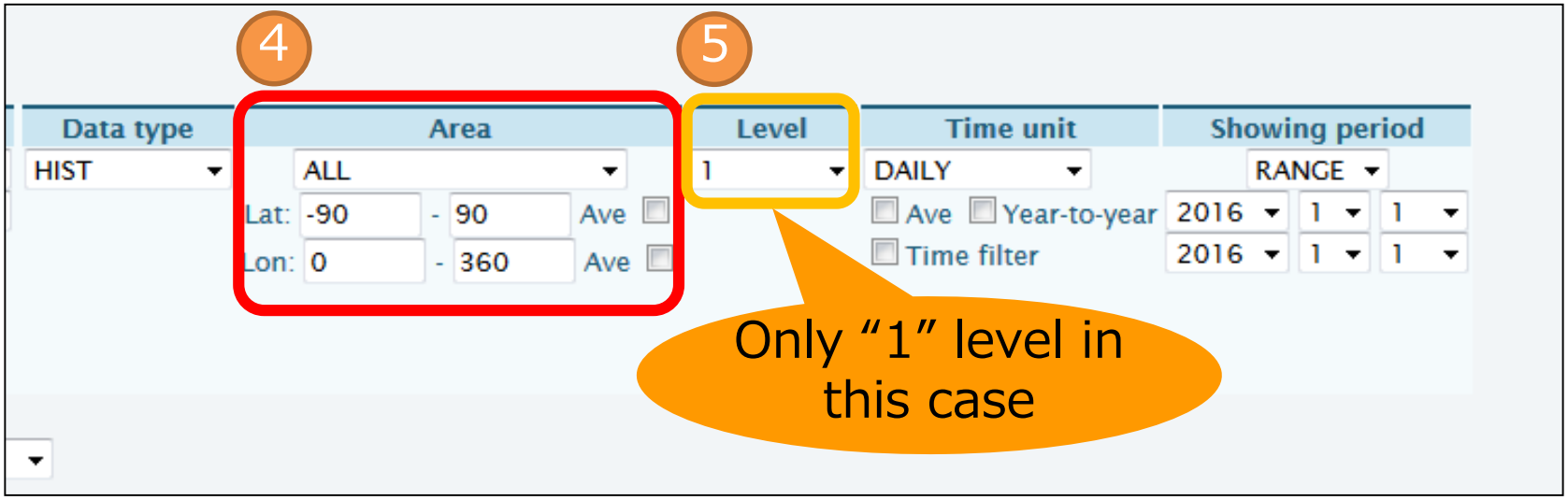
Longitude-latitude map (3)



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

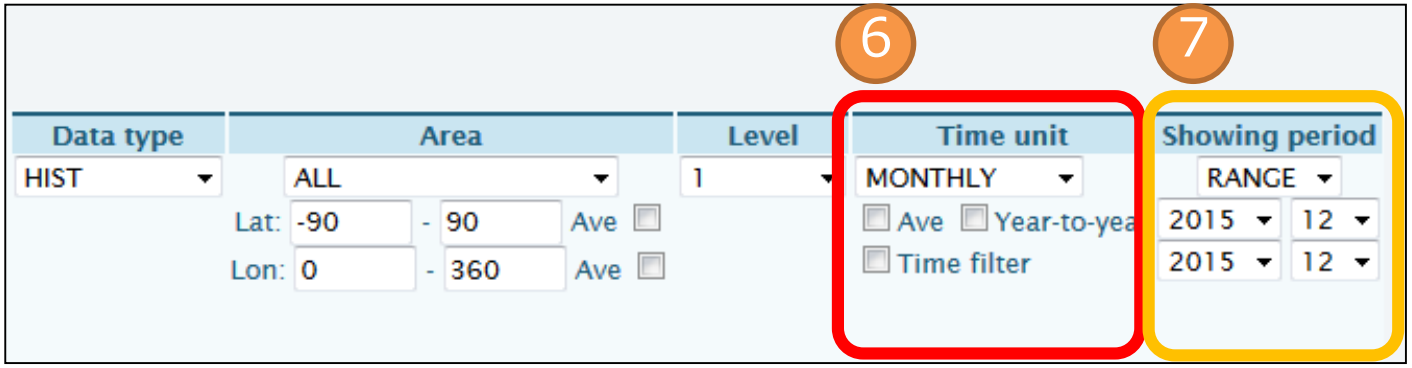
- **HIST** : Historical actual analysis or observation data.
- **NORM** : Climatological normal.
- **ANOM** : Anomaly data.
- **ANOM_SD** : Anomaly data normalized by their standard deviations, indicative of significance for the anomaly.

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)

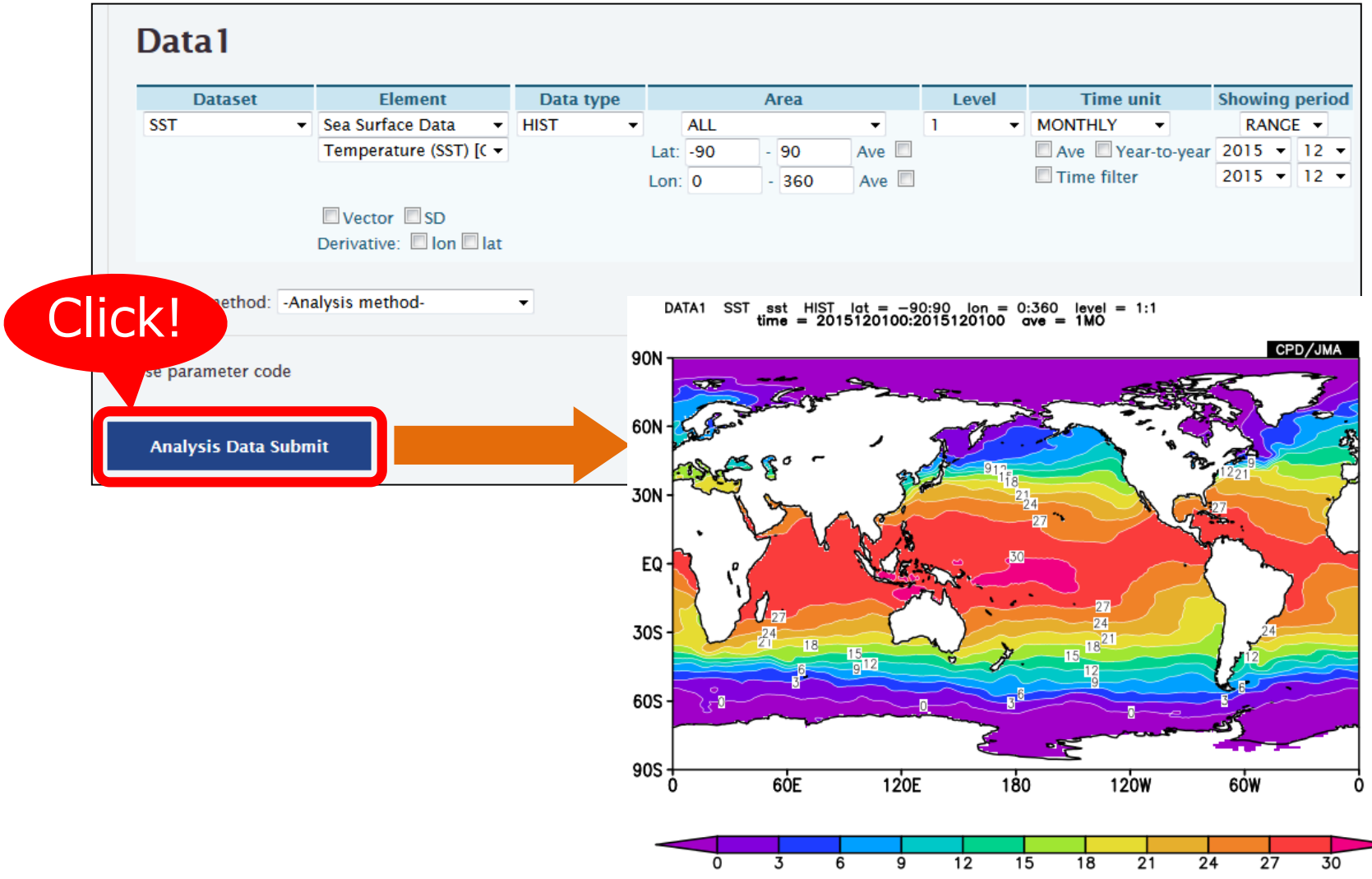


6. Select “MONTHLY” for “Time unit”.
   - There are several styles for range selection: **DAILY, PENTAD DAY, MONTHLY** and **ANNUAL**
7. Select “RANGE” for “Showing period” and “2015 12”, for both upper and lower boxes (left box: year, right box: month).

   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).

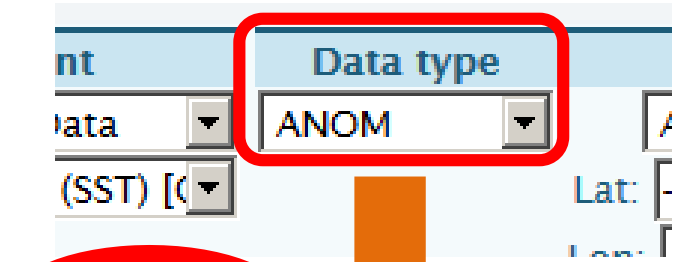
Longitude-latitude map (6)

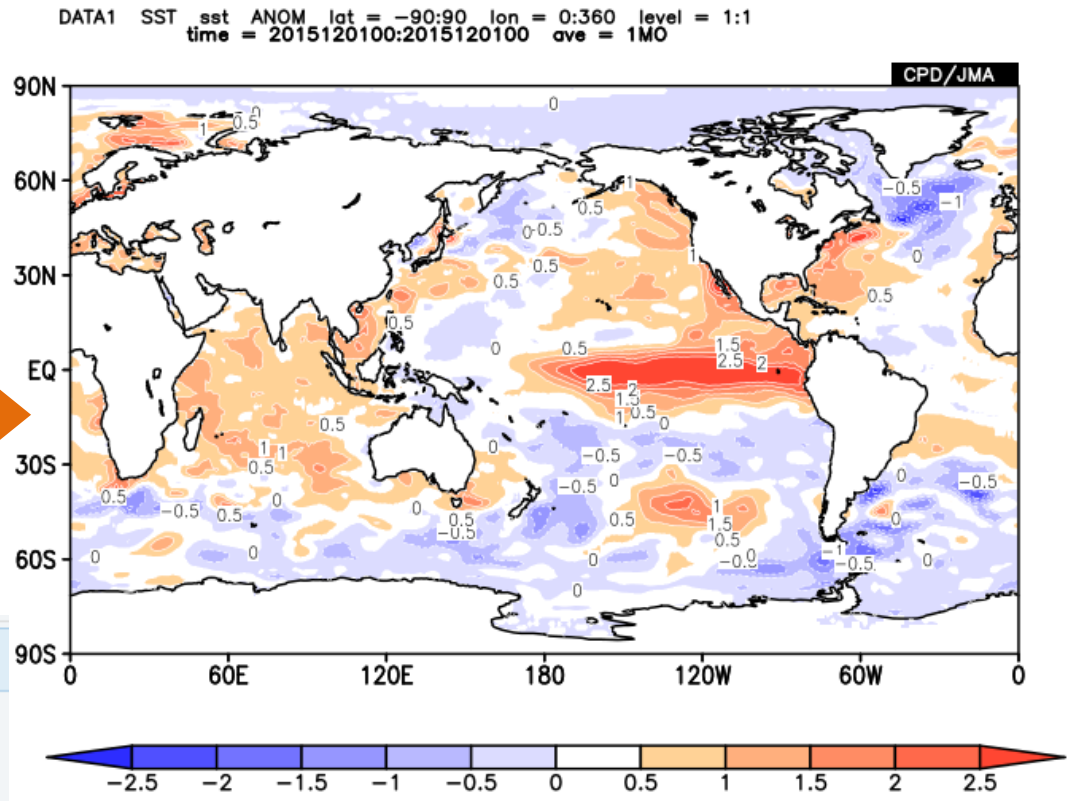
Finally, click the “Analysis Data Submit” button and the image will be displayed.

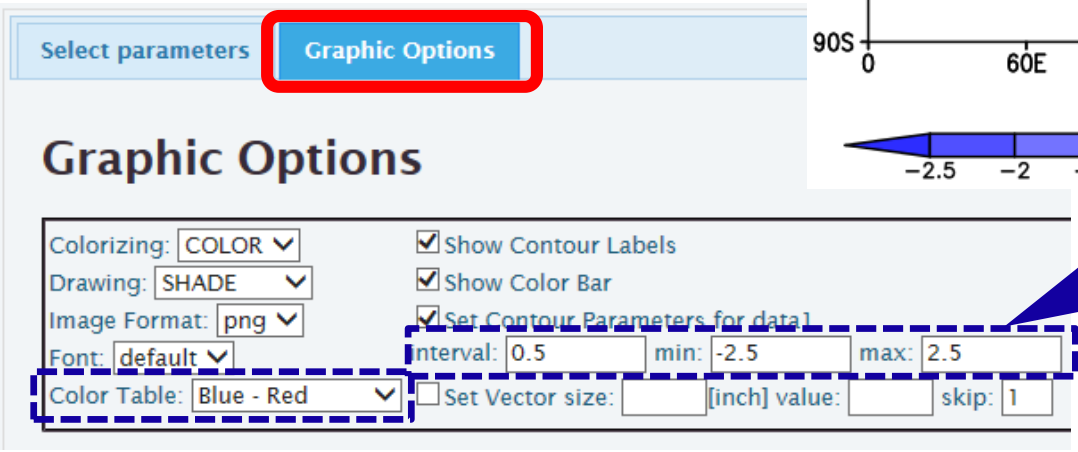


Longitude-latitude map (7)

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







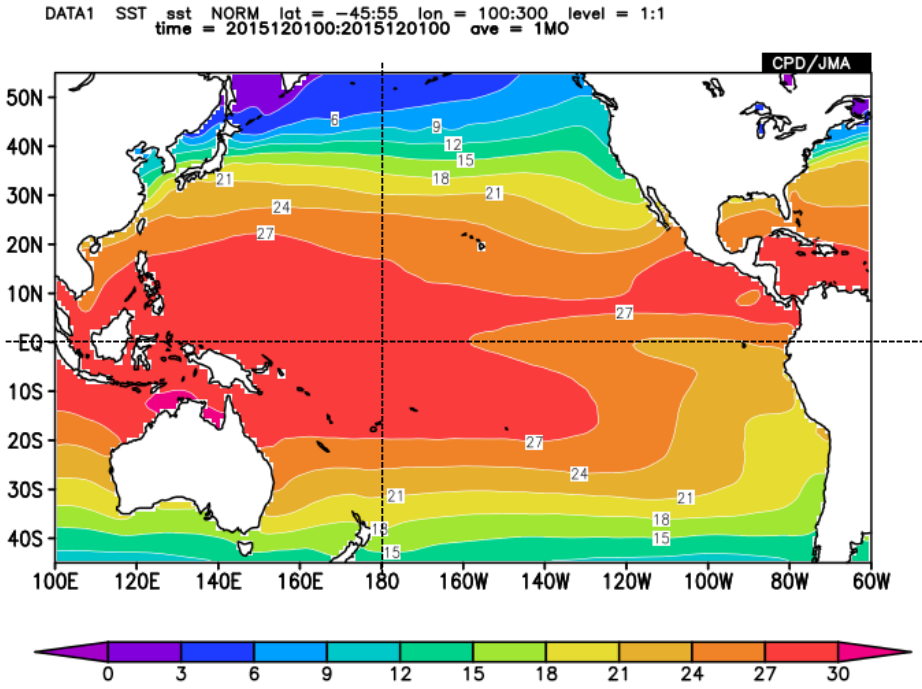
Set
Color Table: Blue - Red
Contour Parameter:
interval: 0.5, min: -2.5, max: 2.5

Topics: El Niño event

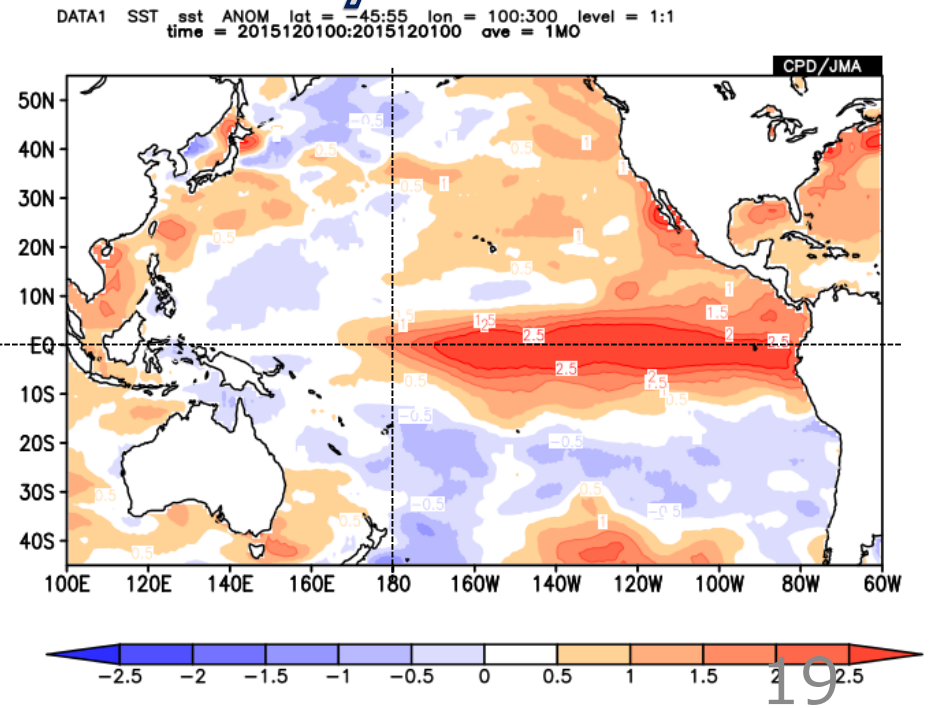
- In winter 2015/16, SST exhibited positive anomaly over the central to eastern equatorial Pacific and negative anomalies over the western tropical Pacific, indicating the occurrence of El Niño event.

SST in December 2015

- Normal -

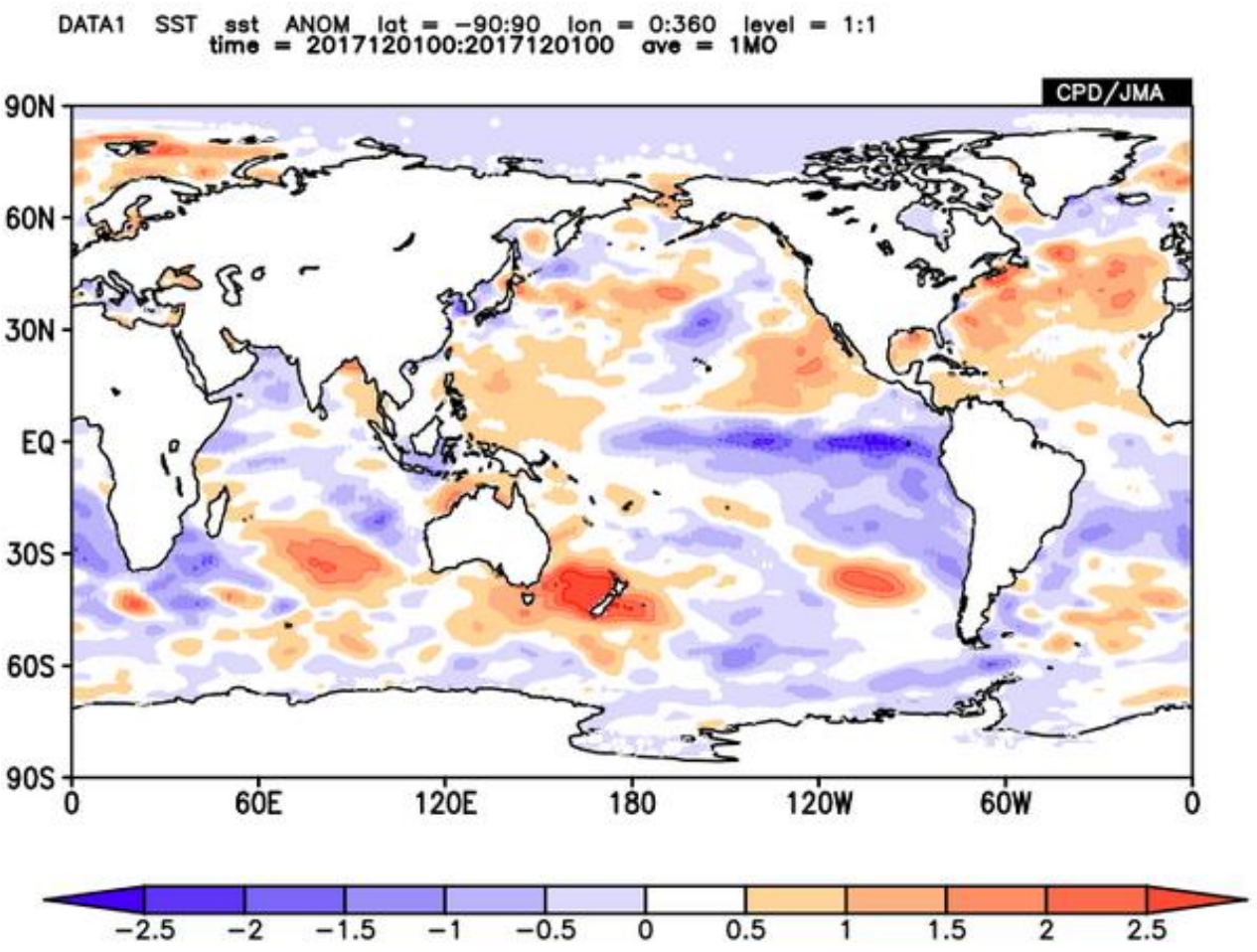


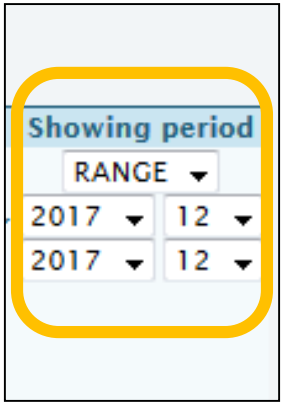
- Anomaly -



Exercise (1)

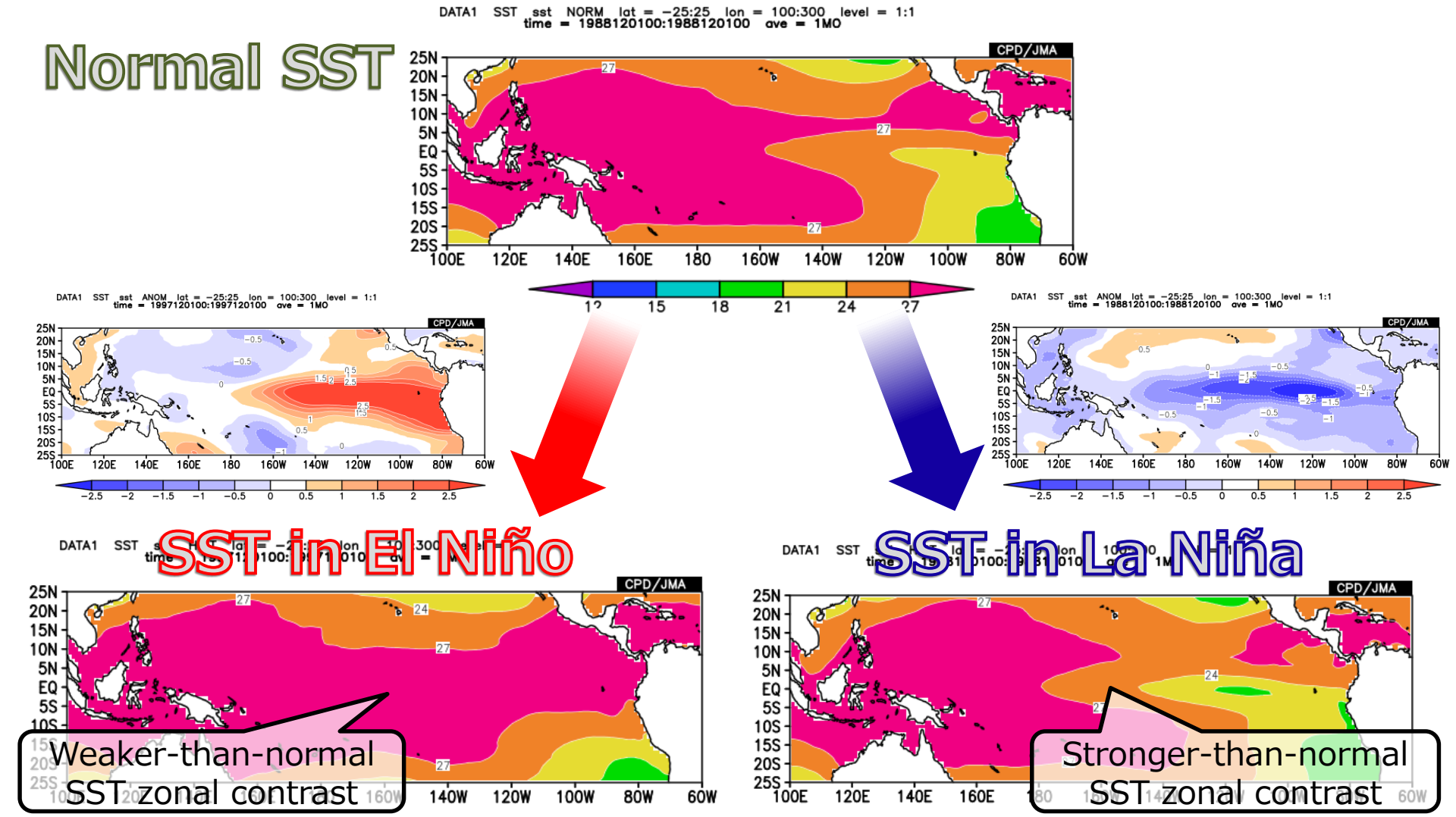
- Let's chart monthly sea surface temperature (SST) anomaly in December 2017.





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.



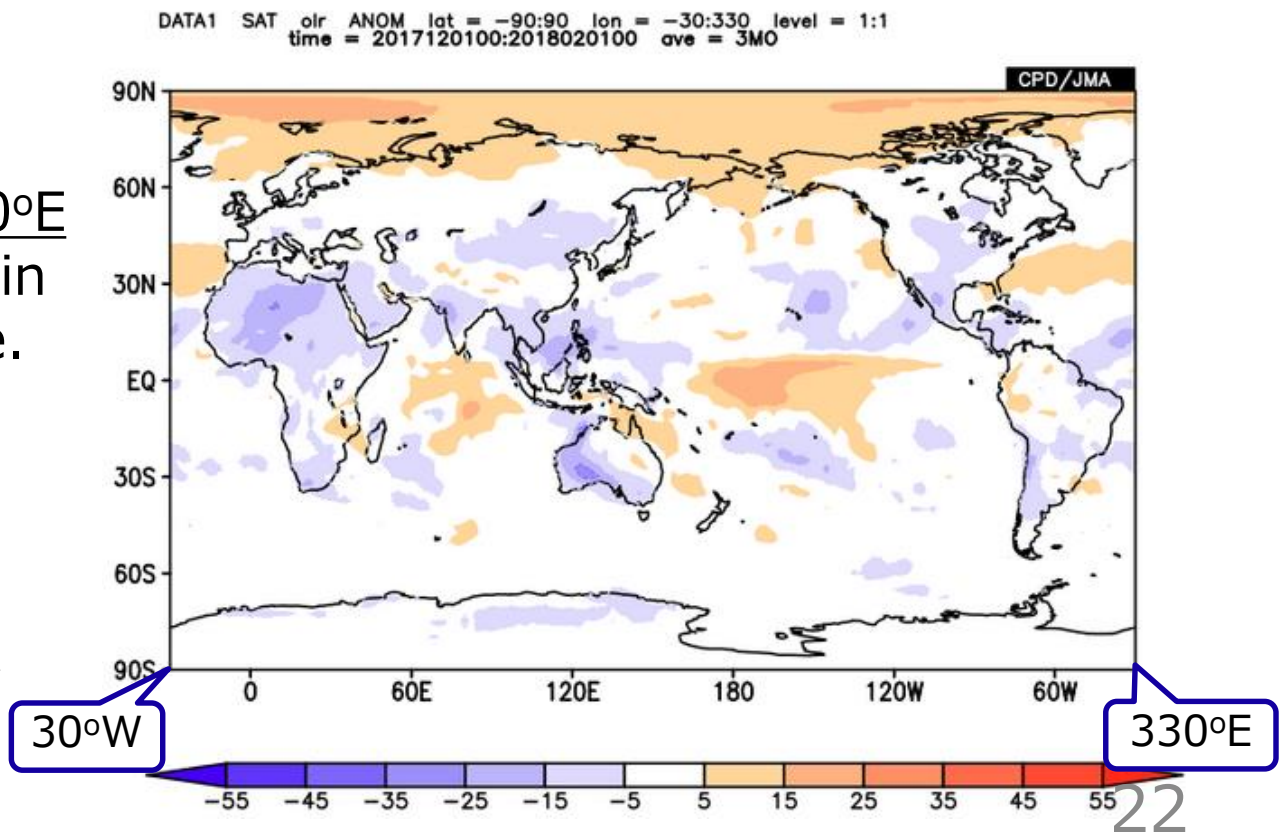
Exercise (2)

- Show OLR anomaly averaged over the period from December 2017 to February 2018 as shown below.

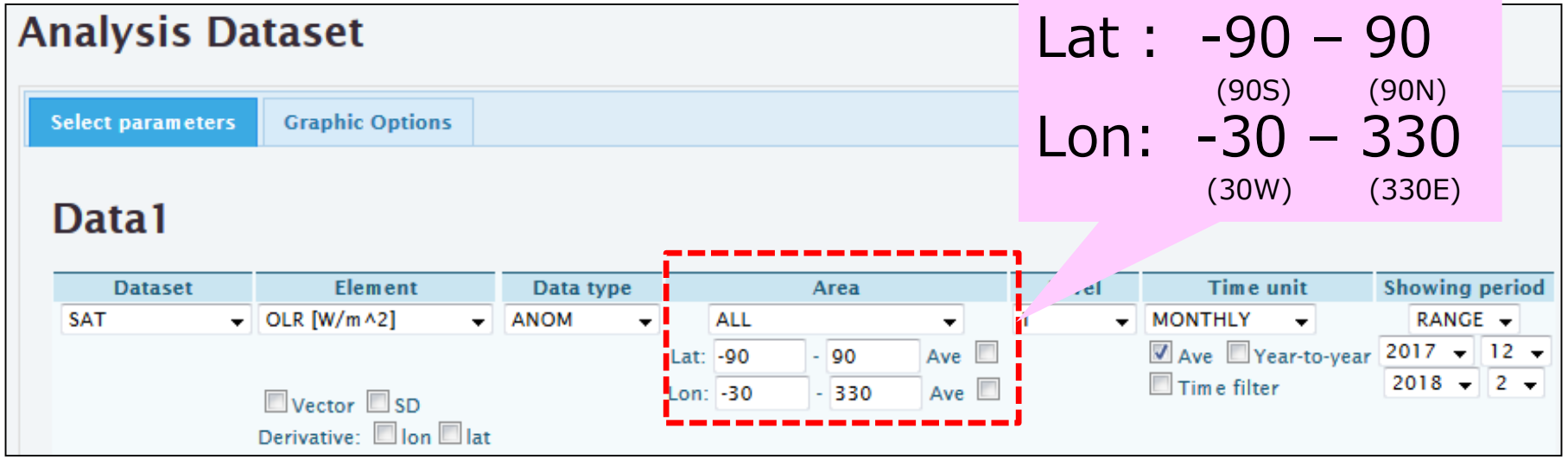
La Niña event was obsereved during this period.

- Dataset "**SAT**" is available to draw the OLR.

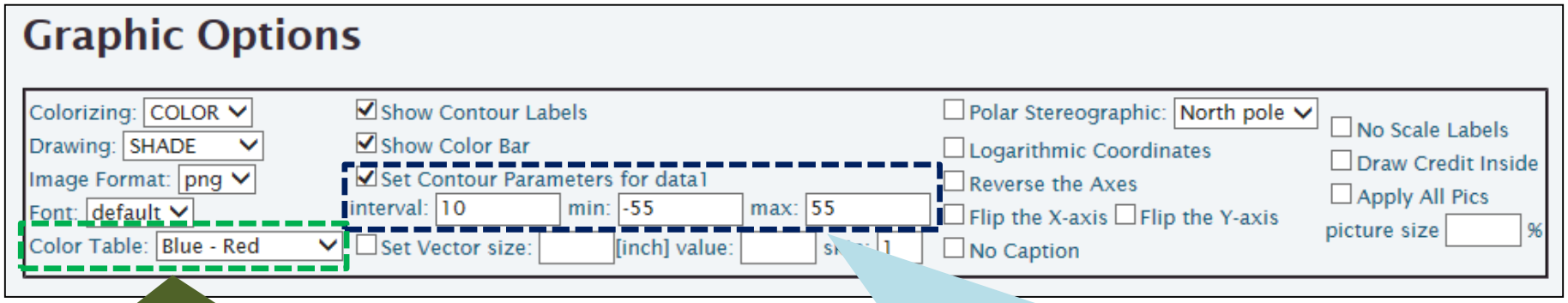
- Please try to set longitude range from 30°W to 330°E not to split areas in Africa and Europe.
- Adjust contour parameters (see color bar of the figure)
- Select "Blue-Red" for "Color Table"



Answers to Exercise (2)



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

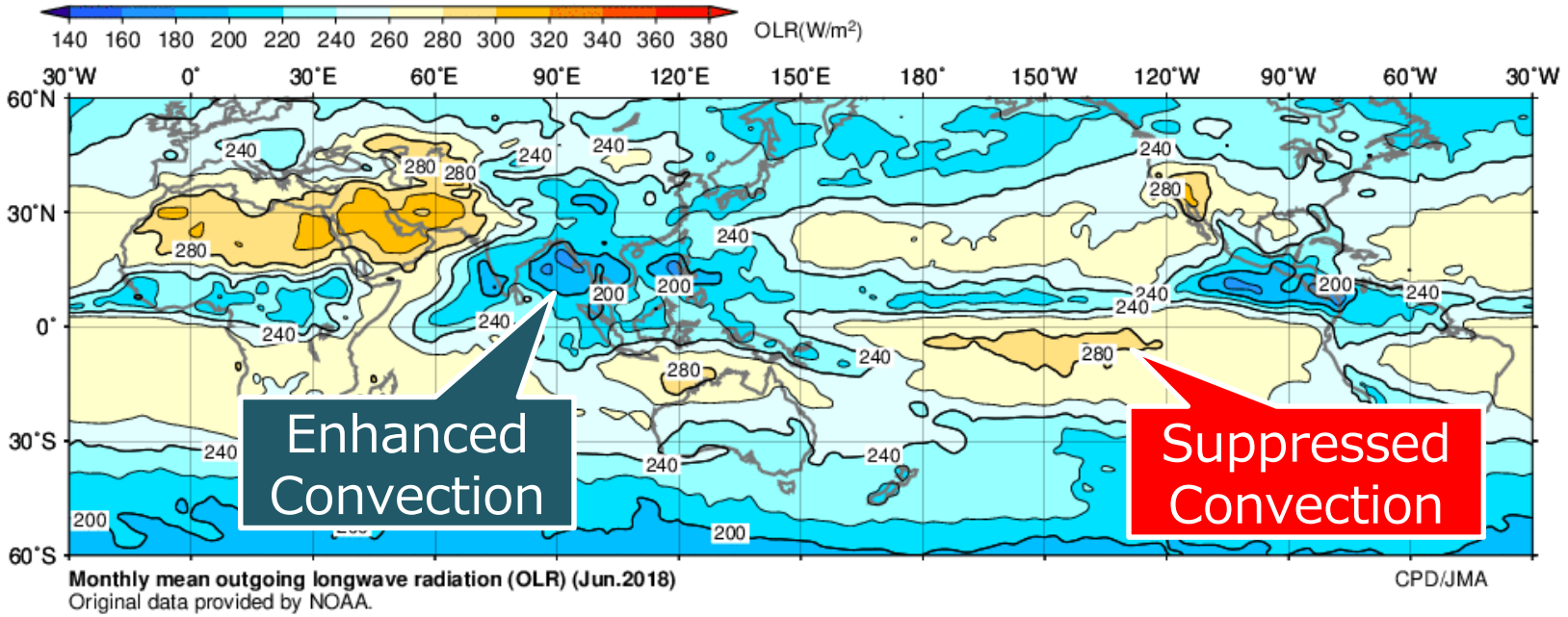


Select “Blue-Red” color table.

Set these boxes as follows
interval: 10, min: -55, max: 55

Tips: 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**



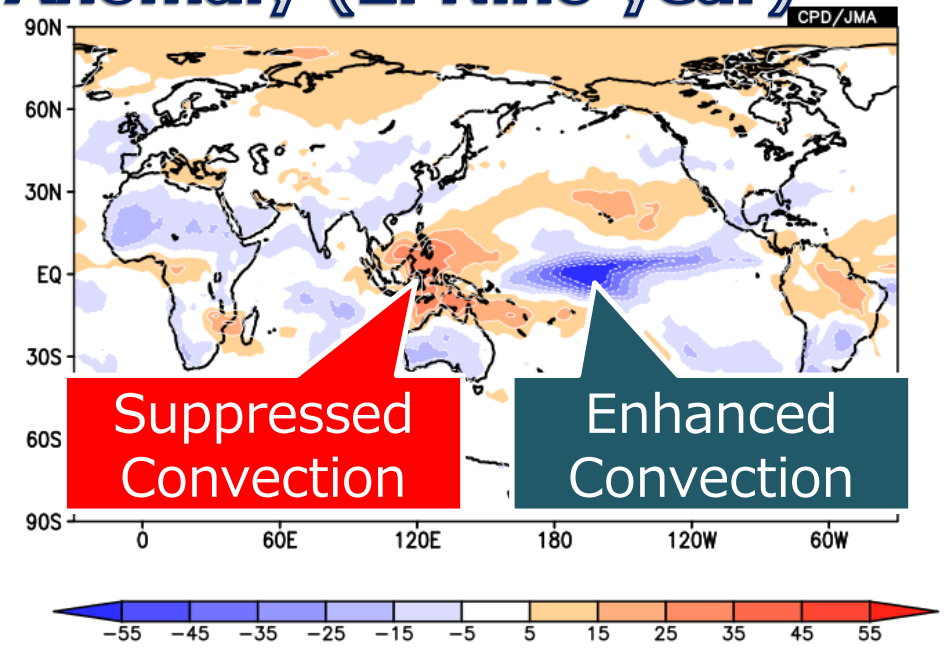
http://ds.data.jma.go.jp/tcc/tcc/products/clisys/figures/db_hist_mon_tcc.html

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.
- Opposite pattern is shown during La Niña events

DJF mean OLR in 2015/2016

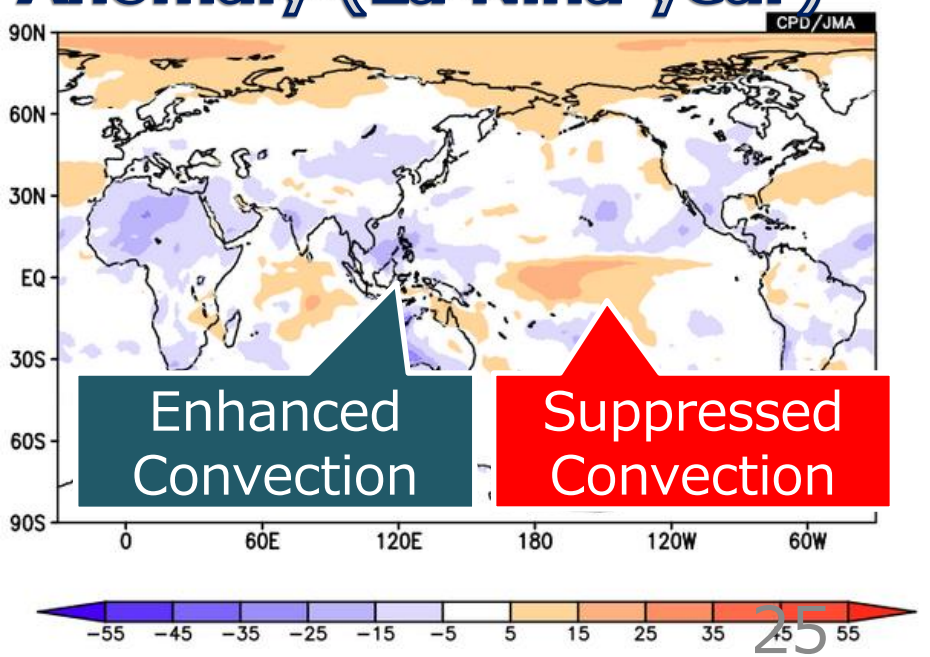
Anomaly (El Niño year)



DJF mean OLR in 2017/2018

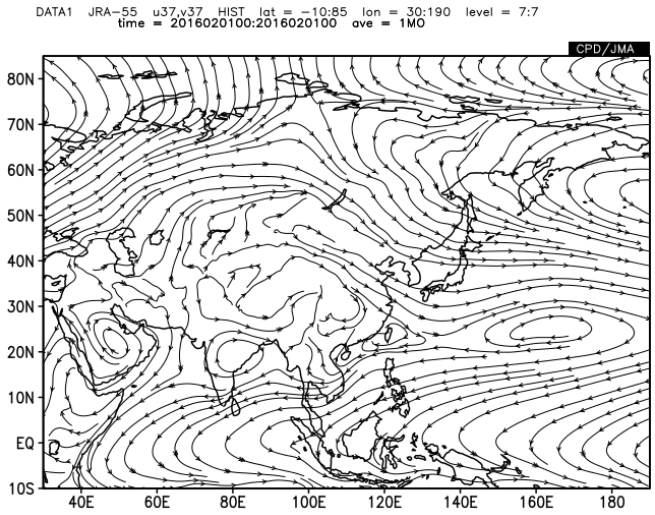
*Answer of Exercise (2)

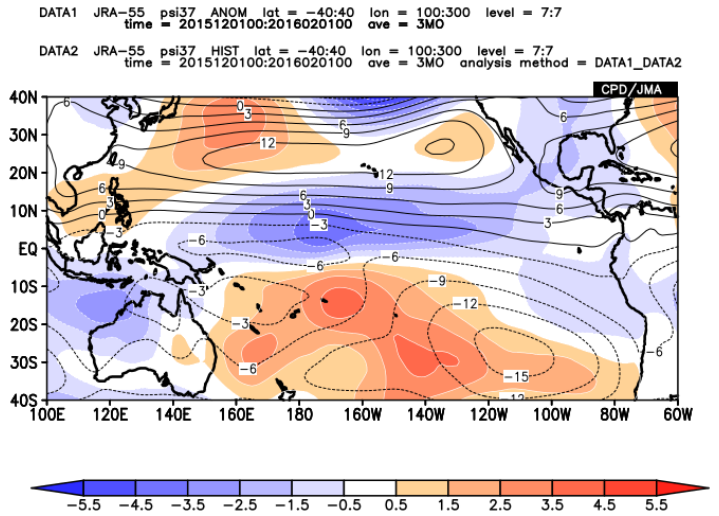
Anomaly (La Niña year)



Multiple Data

- iTacs can hundle multiple data with methods like these:
  - **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.

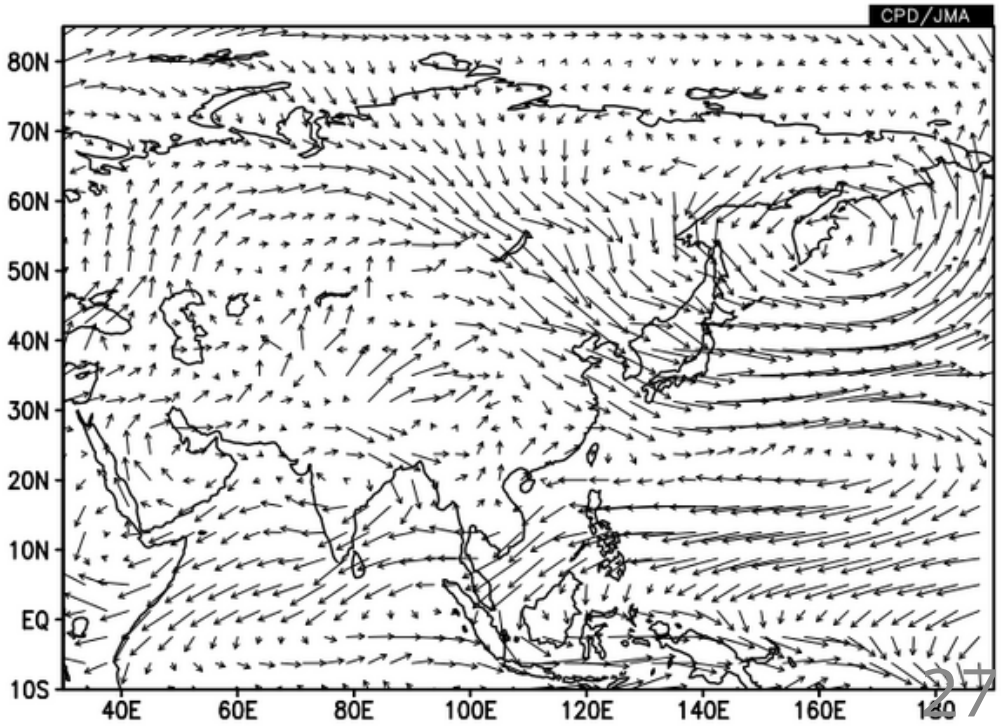




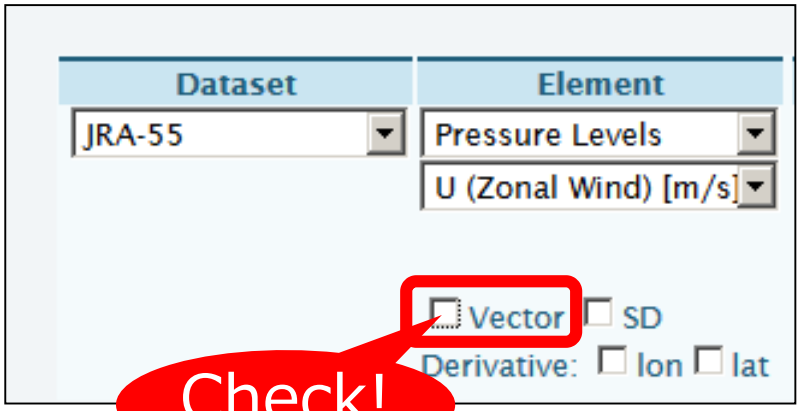
Vectors (1)

- A vector map is available to see flow or flux.
  - For example, set U and V to see blowing wind.
  - Barbs are not available. (Barb:  and)

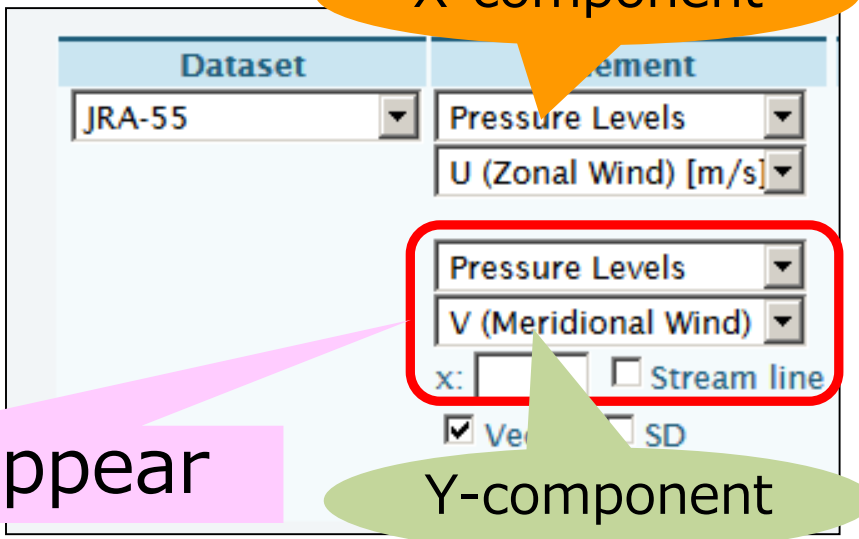
850-hPa wind vector and stream function (contour) in February 2018



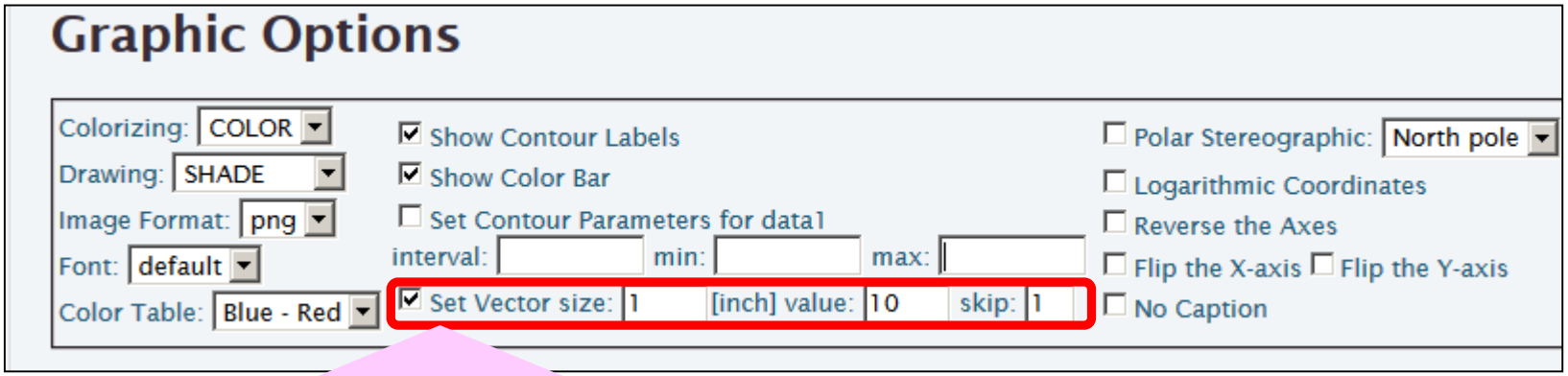
Vectors (2)



Check!



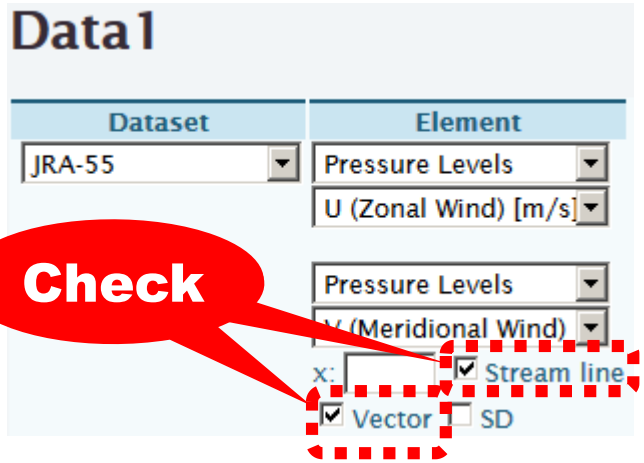
This area will appear

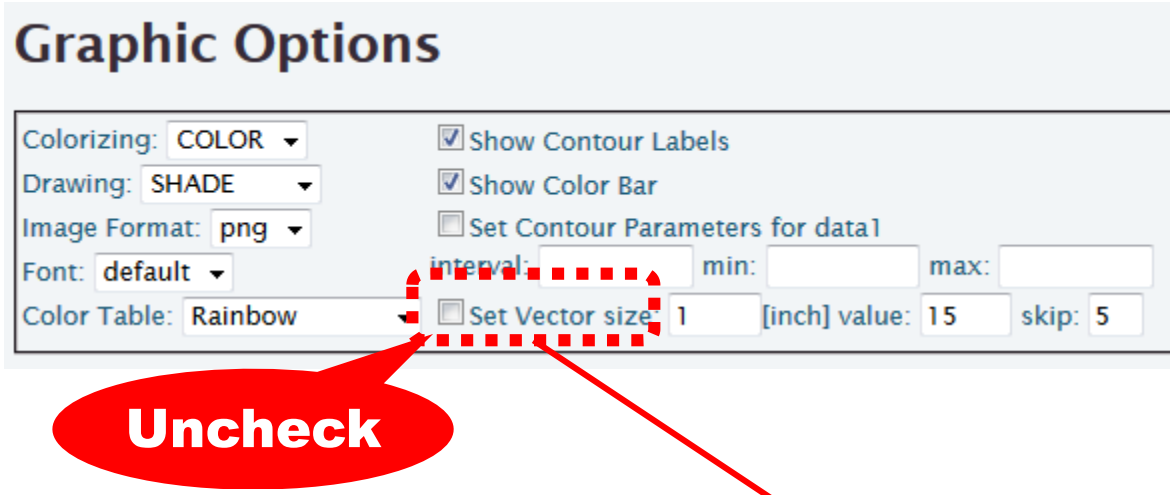


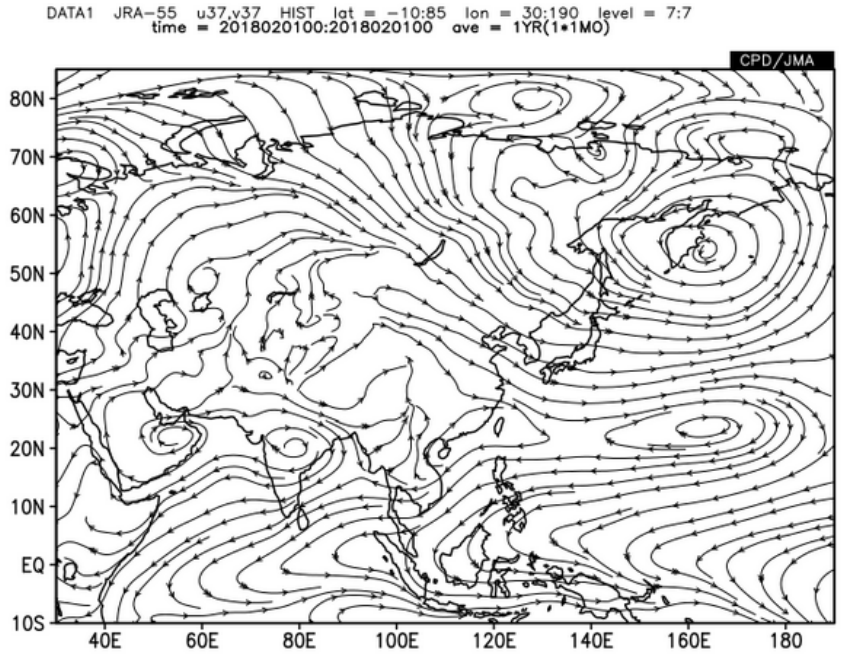
Customize setting in these boxes to change the vector size and interval.

Stream lines

- Drawing stream lines







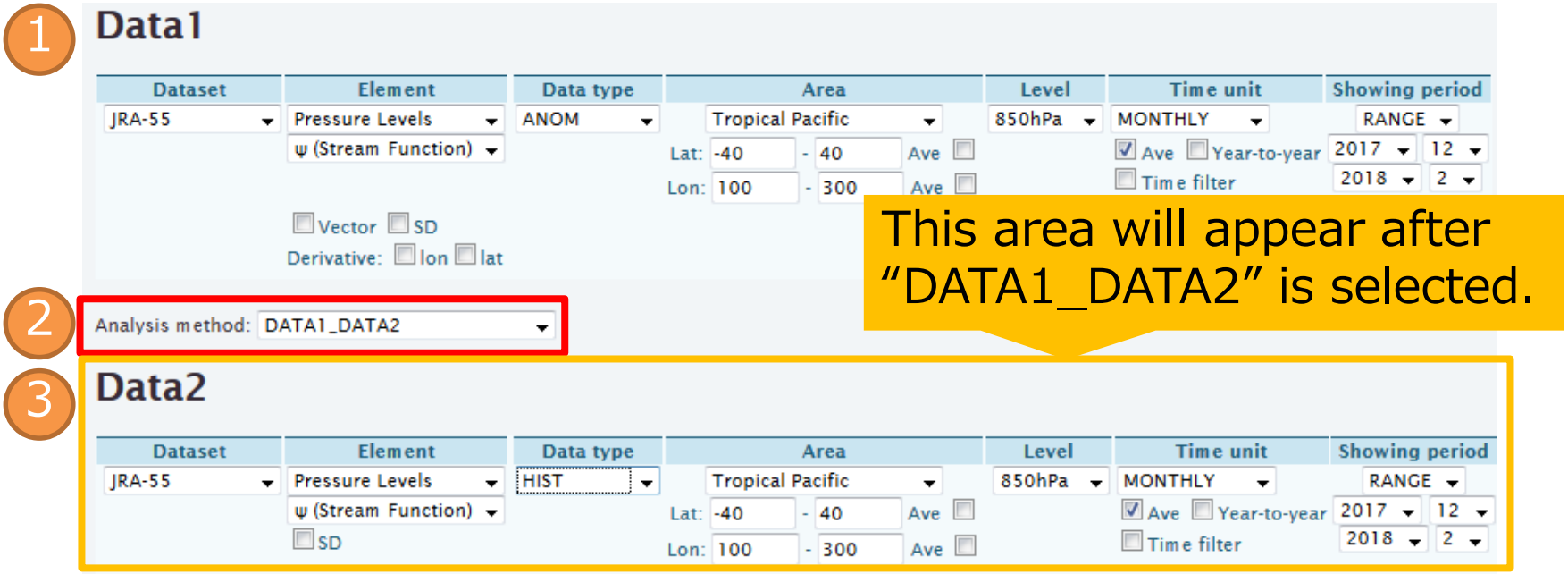
When you draw streamlines, the skip value must be “1”.

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

DATA1_DATA2 : Overlaying two data (1)

- The Data1 is mapped as shading, and Data2 is mapped as contours.

*As an exception, Data2 is mapped as shading when Data1 is mapped as the type of vector or streamline.

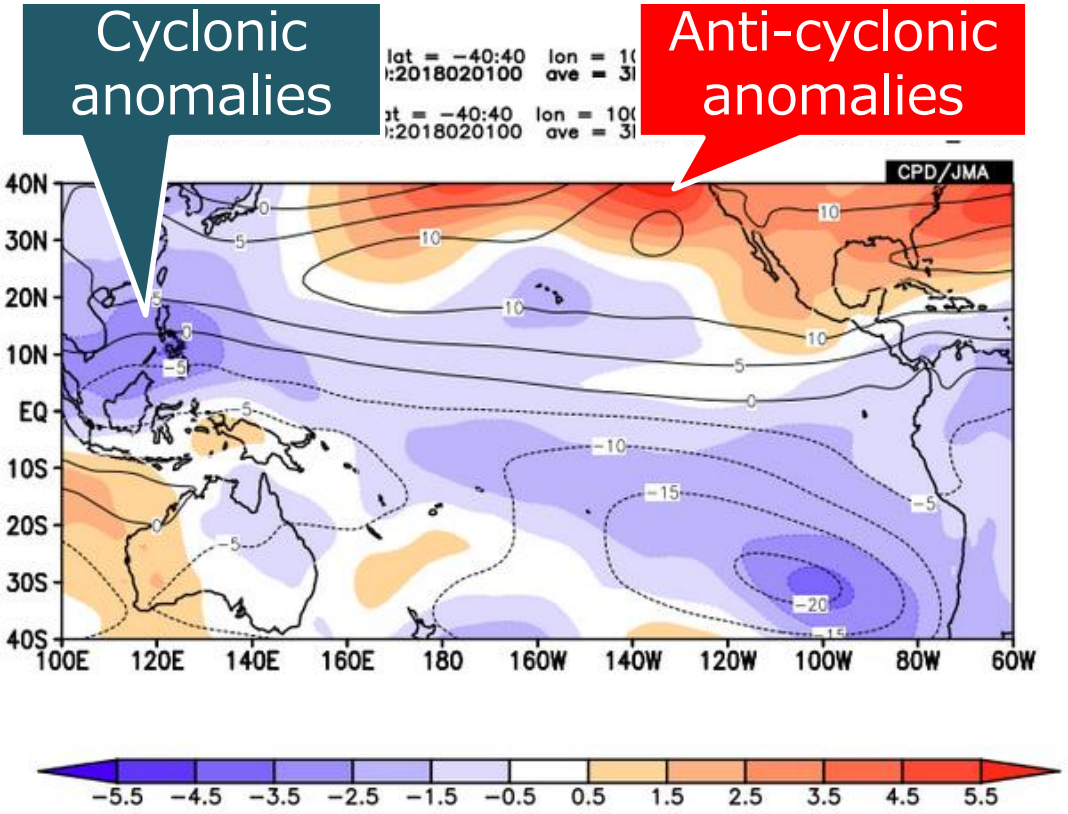


1. Set the "Data1" field.
2. Select "DATA1_DATA2" in the "Analysis method" box.
3. Set the "Data2" field and submit.

DATA1_DATA2 : Overlaying two data (2)

- The steam function (Data2) is mapped as contour, and its anomalies (Data1) is mapped as shading.

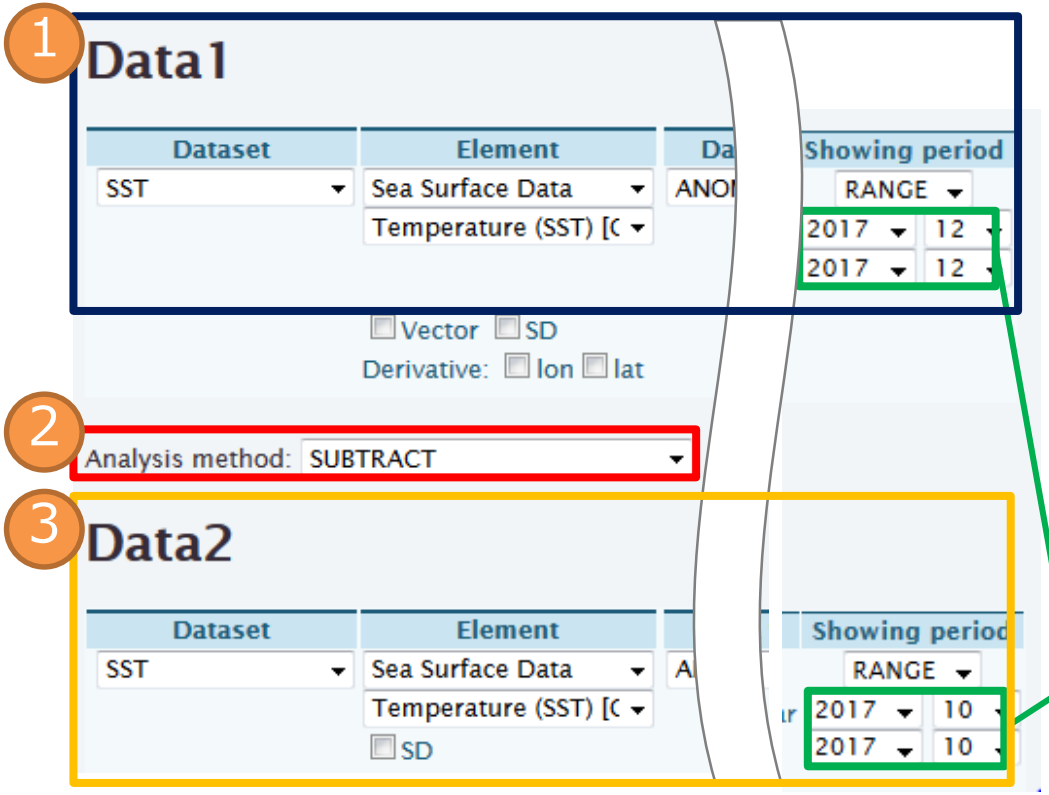
Stream Function in DJF 2017/18



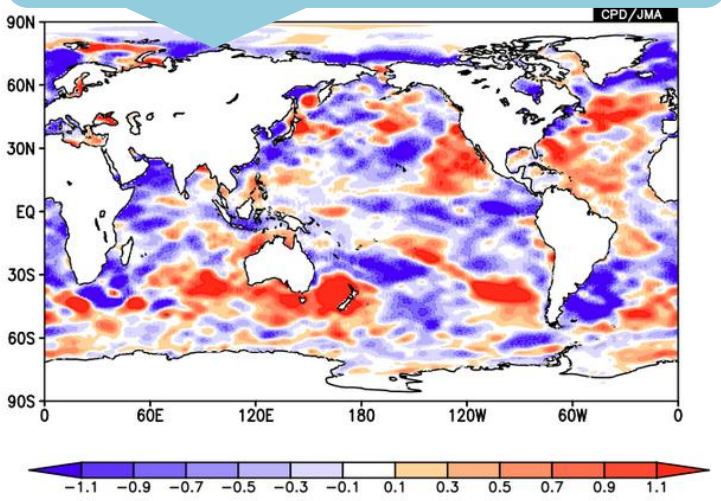
SUBTRACT : Data1 minus Data2

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.



SST anomaly difference from Oct. to Dec. 2017.



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

Multiple Data

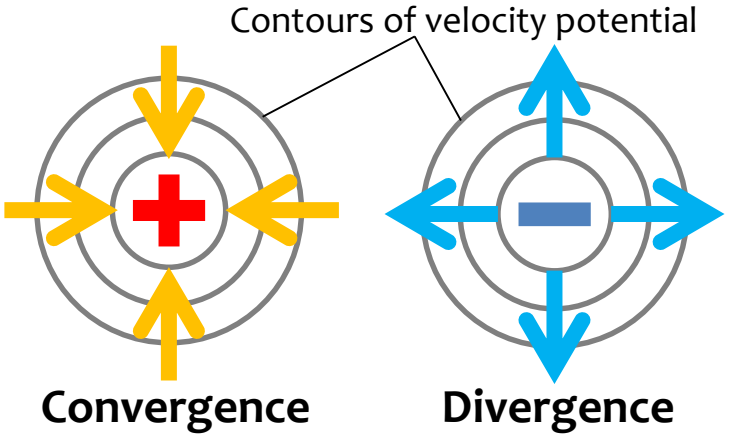
- In a similar way, users can also perform the four basic arithmetic operations of two data by using the corresponding analysis method.

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

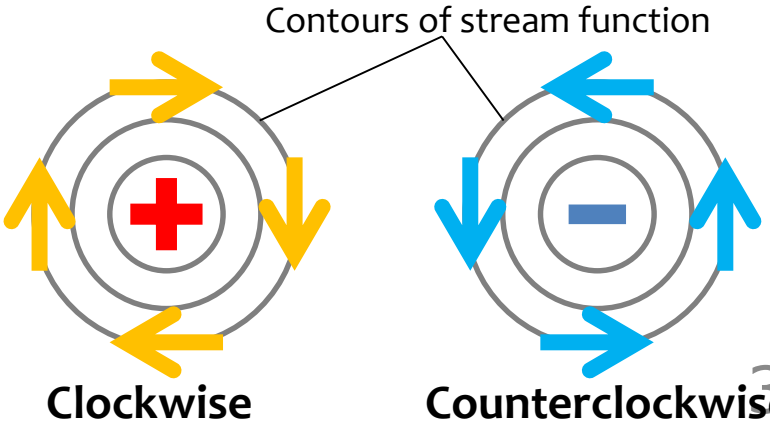
Tips: Velocity Potential and Stream Function

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

Velocity potential (divergent winds)



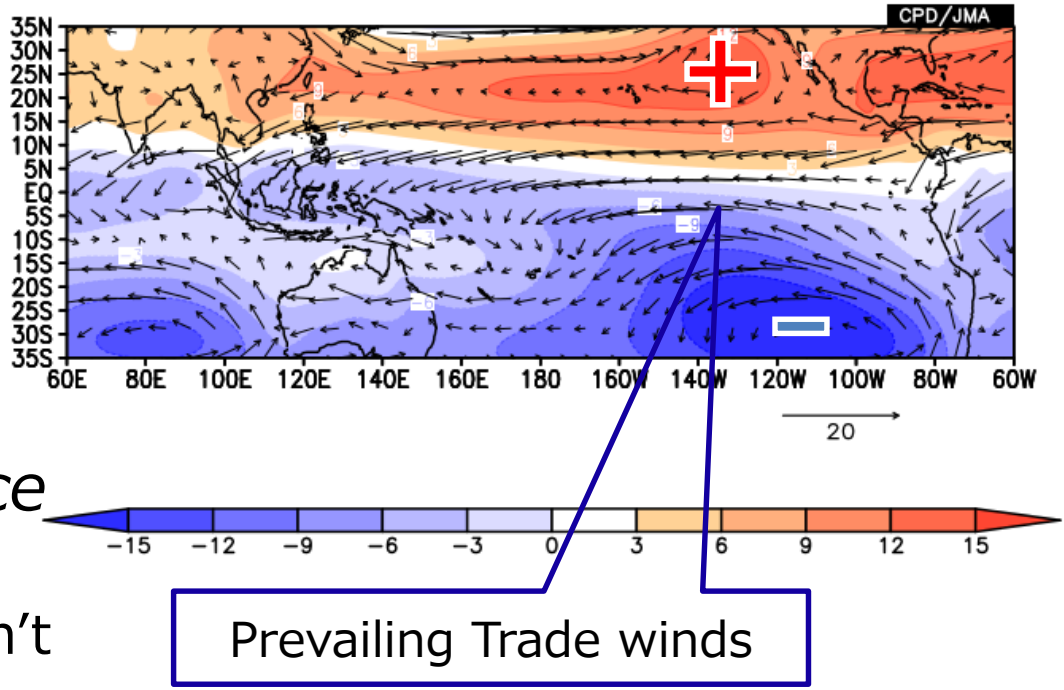
Stream function (rotational winds)

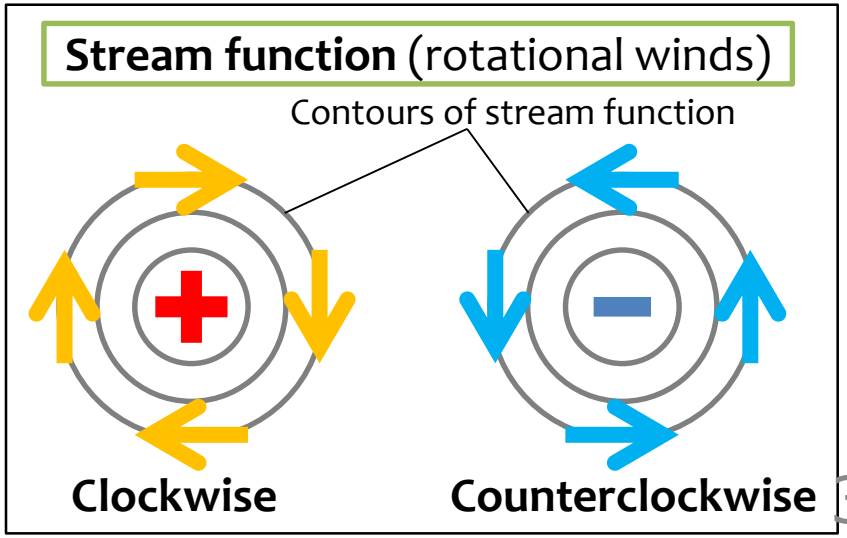


Tips: Stream function (ψ)

Note:

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



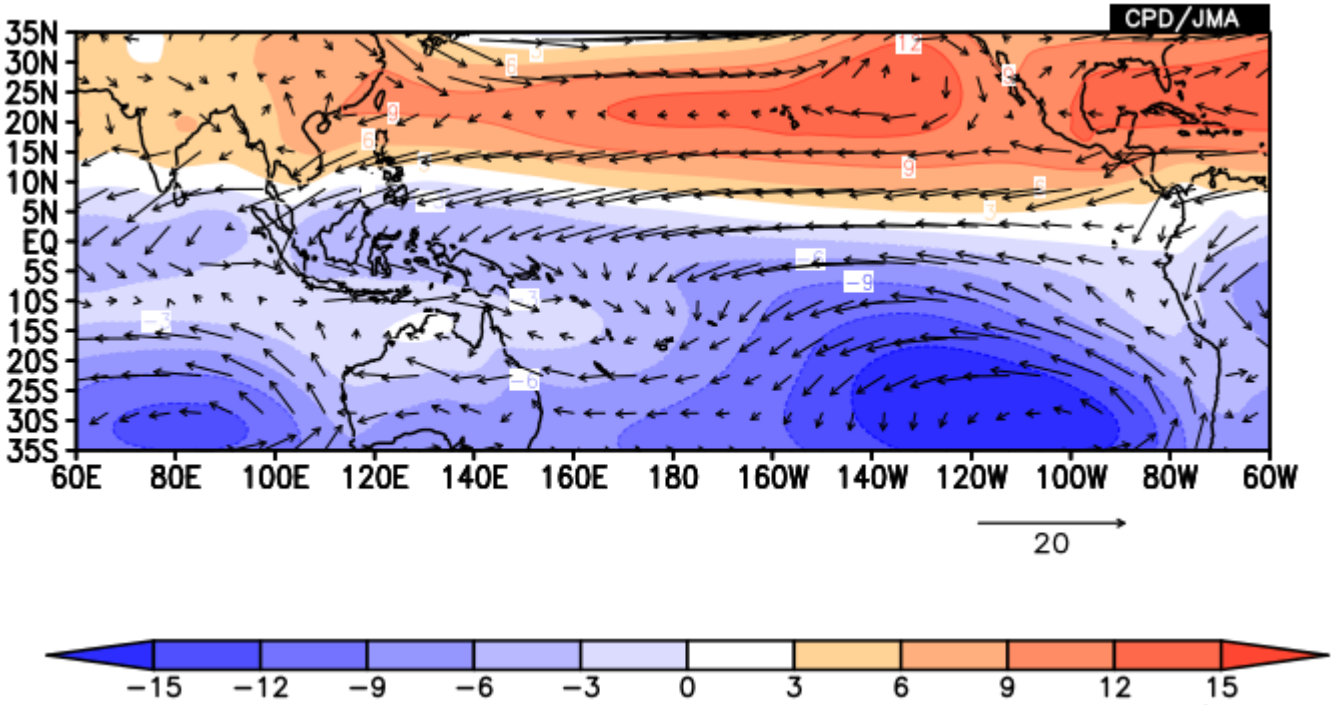


Exercise (3)

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

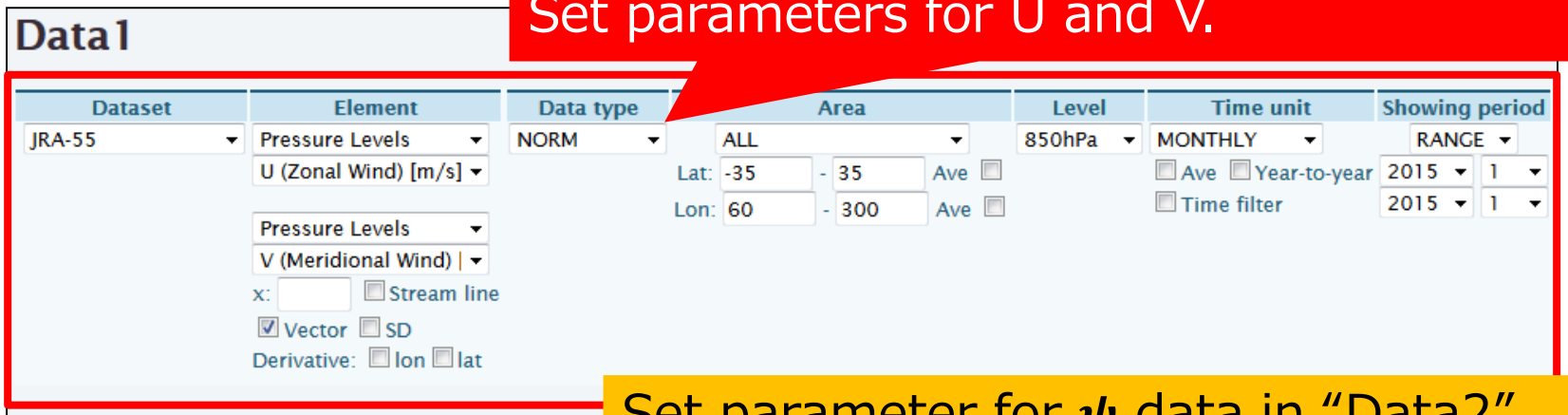
Hint 1: This is a vector and shading plot. A setting for vector is only avalilable for data1, not data2.

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

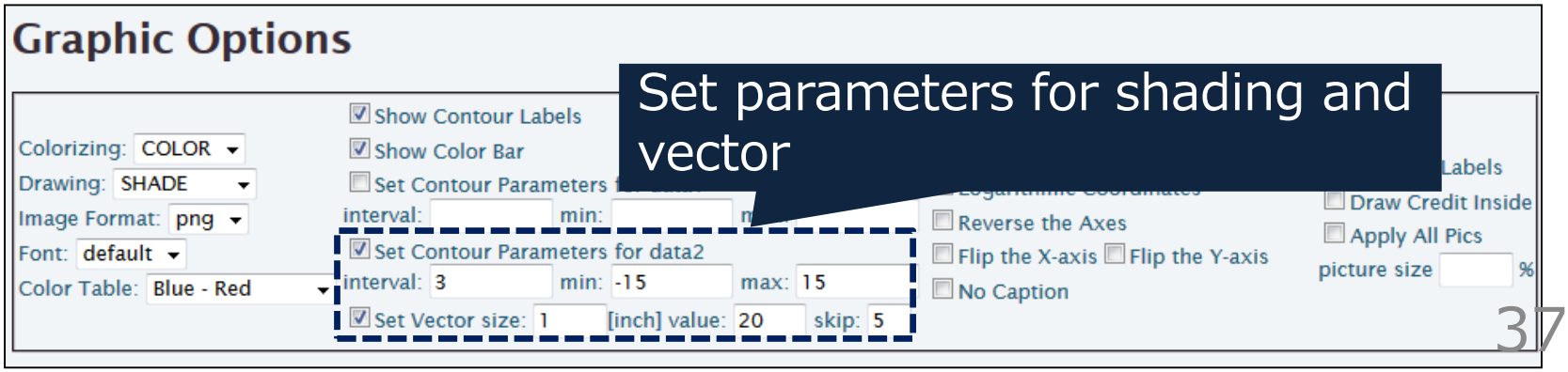


Answers to Exercise (3)

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



Set parameter for ψ data in “Data2” field.

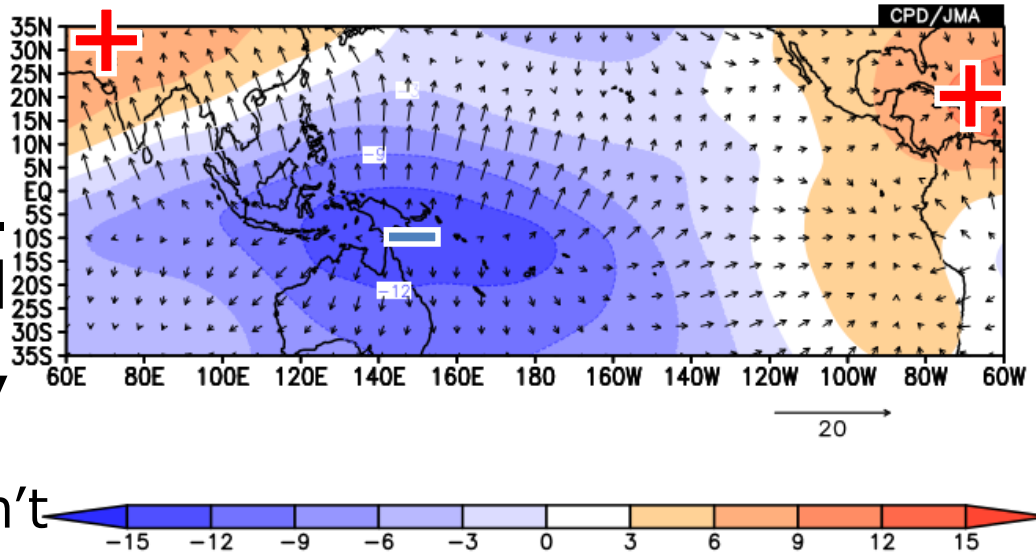


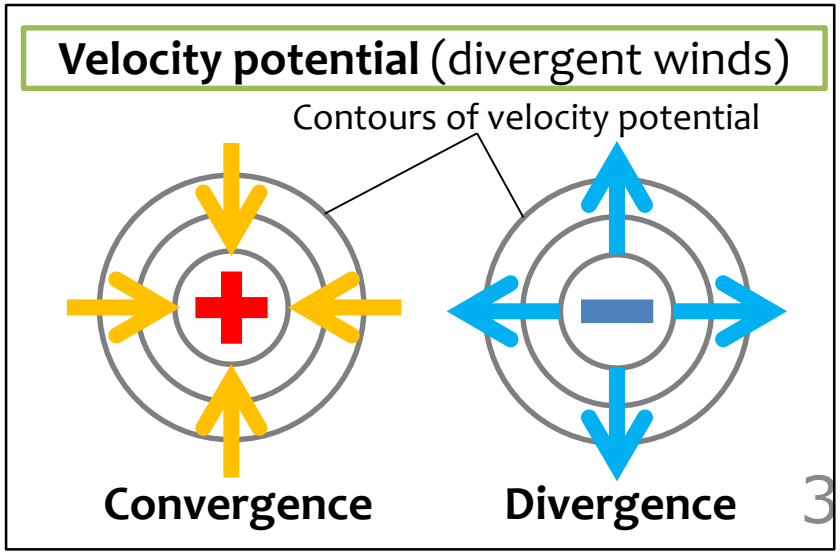
Set parameters for shading and vector

Tips: Velocity potential (χ)

Note:

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

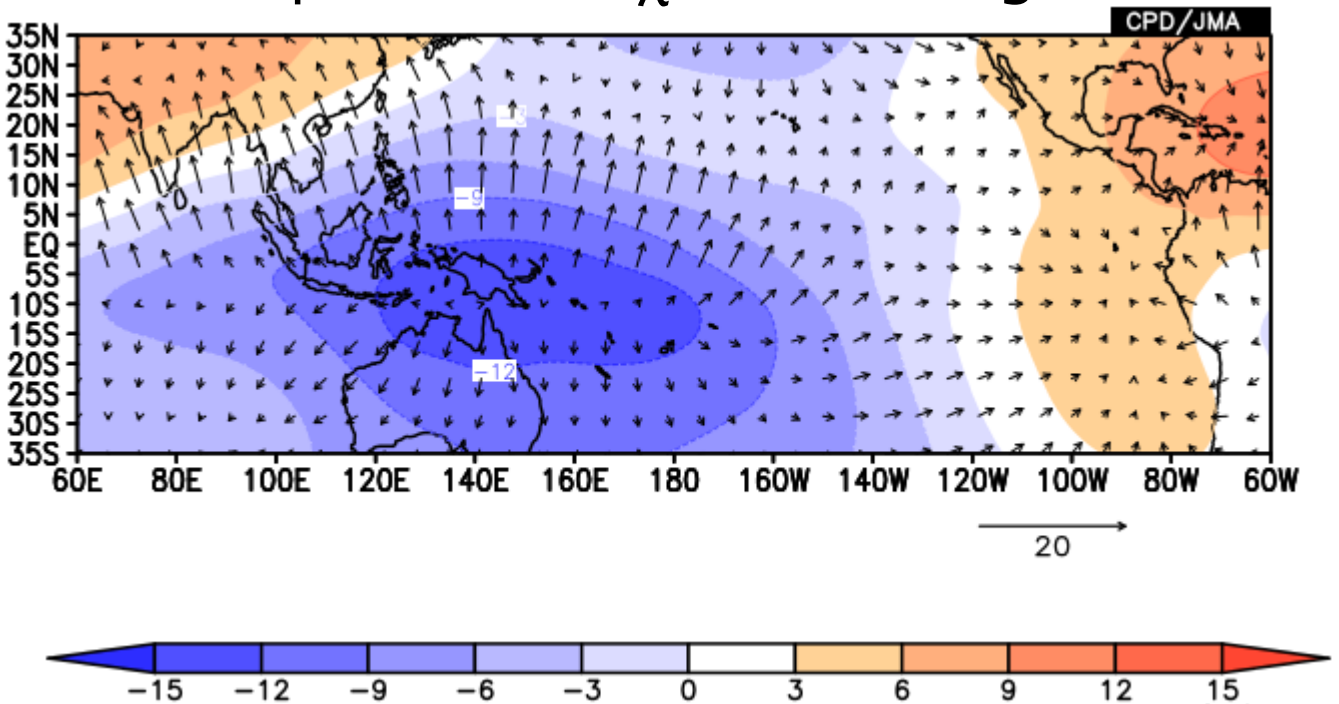




Exercise (4)

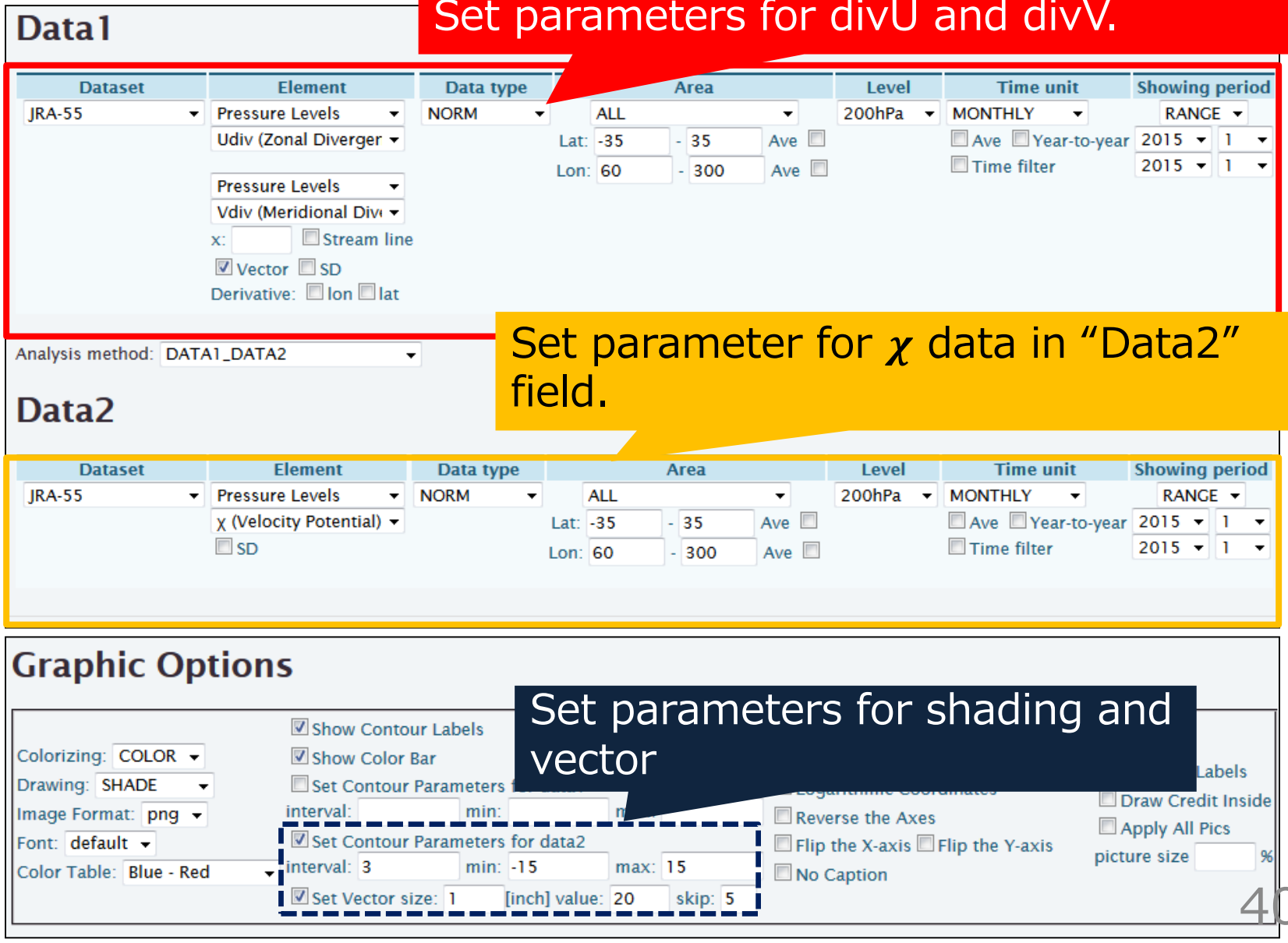
- Let's see the climatological mean velocity potential (χ) and divergent wind vectors at 200hPa for January.
  - Velocity potential (χ) is used for diagnosing large-scale divergent wind fields. In the tropics, those divergent winds are associated with convection.
  - Check the relationship between χ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

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



Answers to Exercise (4)

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



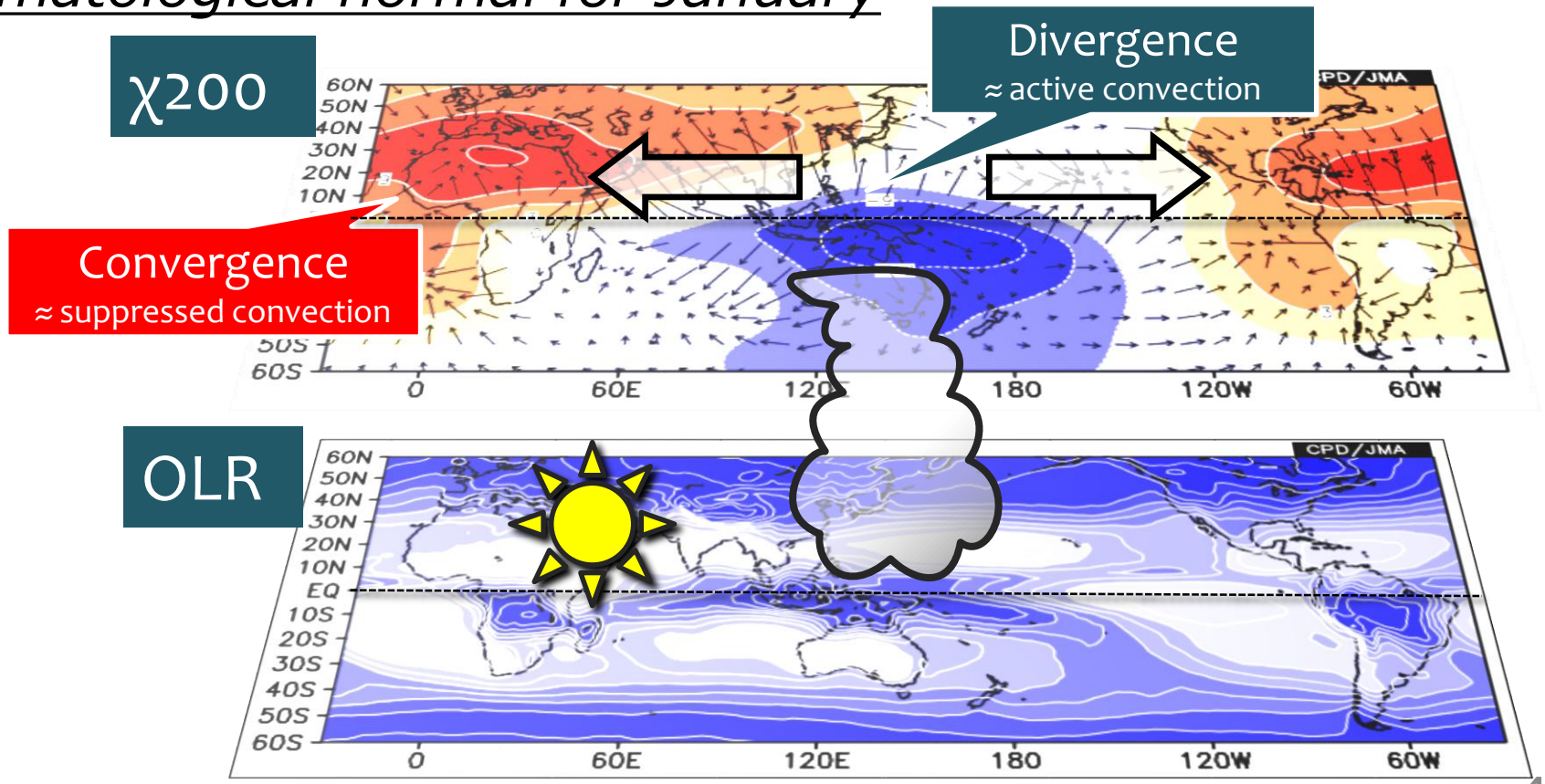
Set parameter for χ data in “Data2” field.

Set parameters for shading and vector

Topics: Tropical Convection and Divergence

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

Climatological normal for January

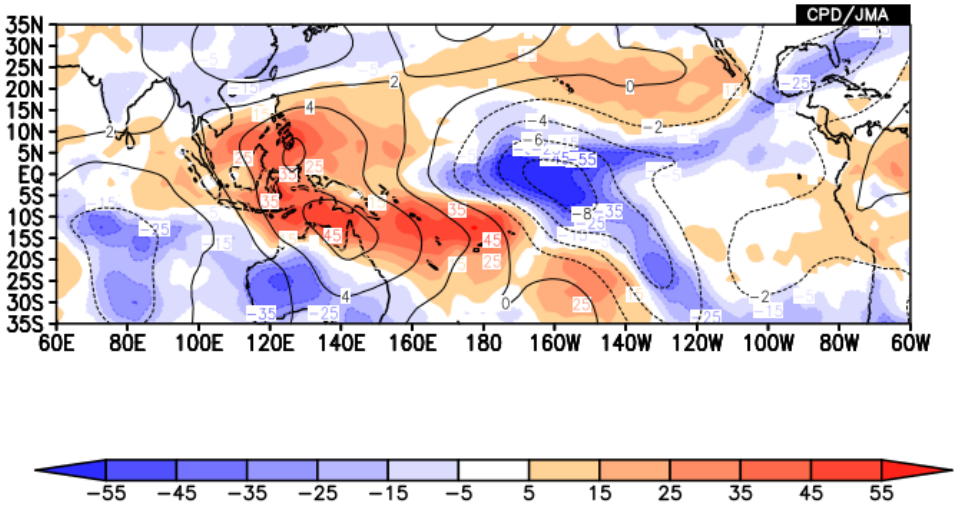


Exercise (5)

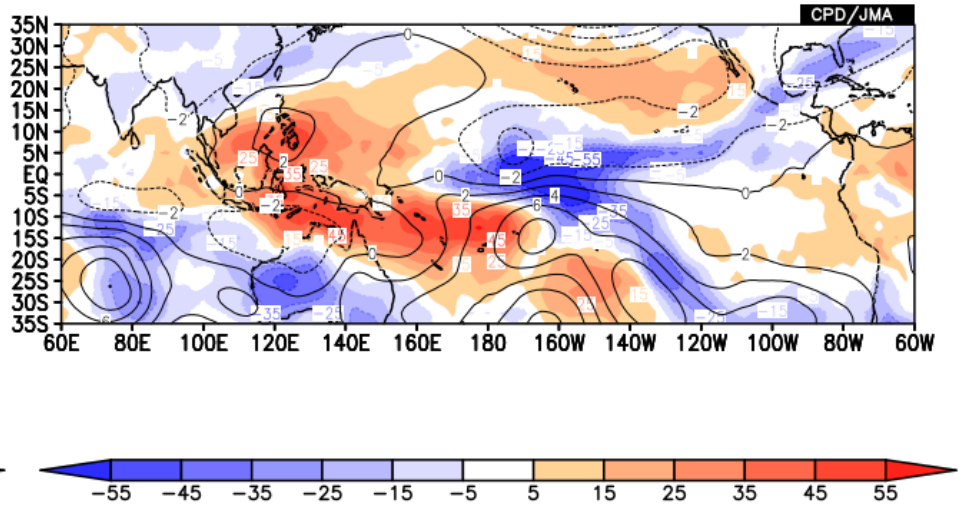
El Niño event was obsereved during this period.

- Make anomalies map for January 2016.
  - [Left] χ200 (contour) and OLR (shade)
  - [Right] ψ850 (contour) and OLR (shade)

χ200 (contour) and OLR (shade)



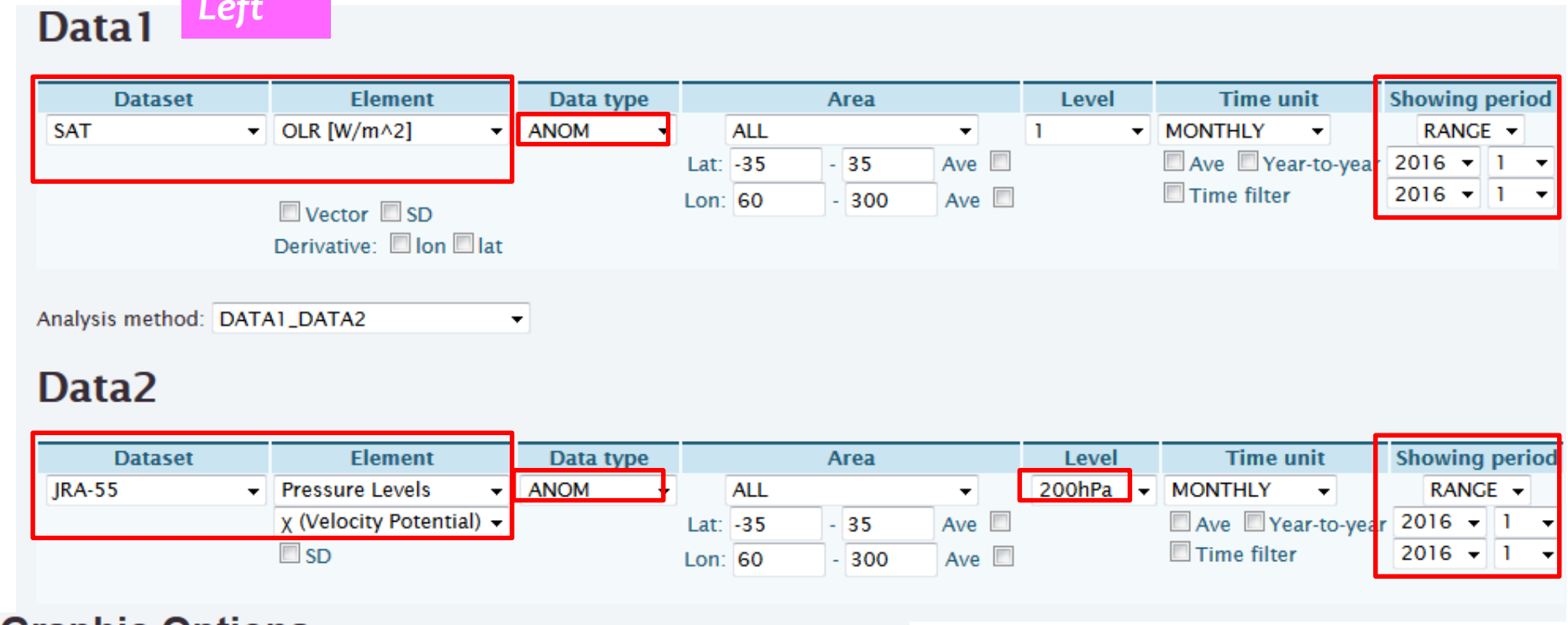
ψ850 (contour) and OLR (shade)

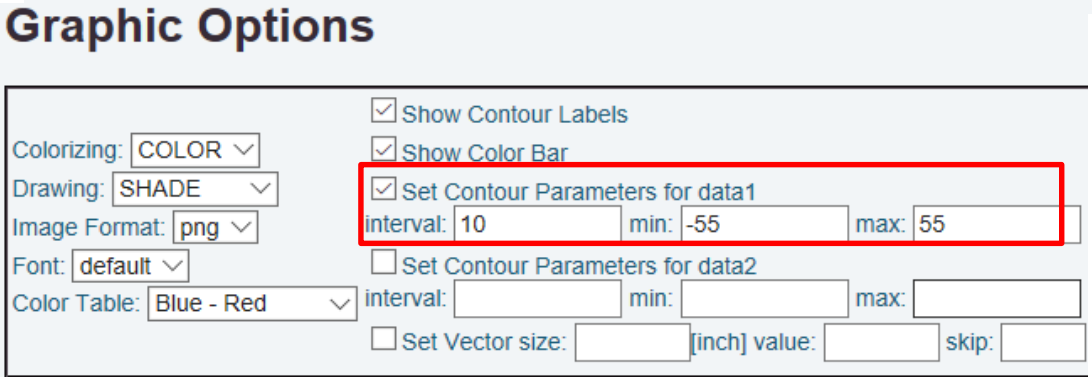


Where are upper-level divergence/convergence anomalies?
How about their relationship with OLR anomalies?
What circulation anomalies is collocated with those OLR anomalies?

Answers of Exercise (5)

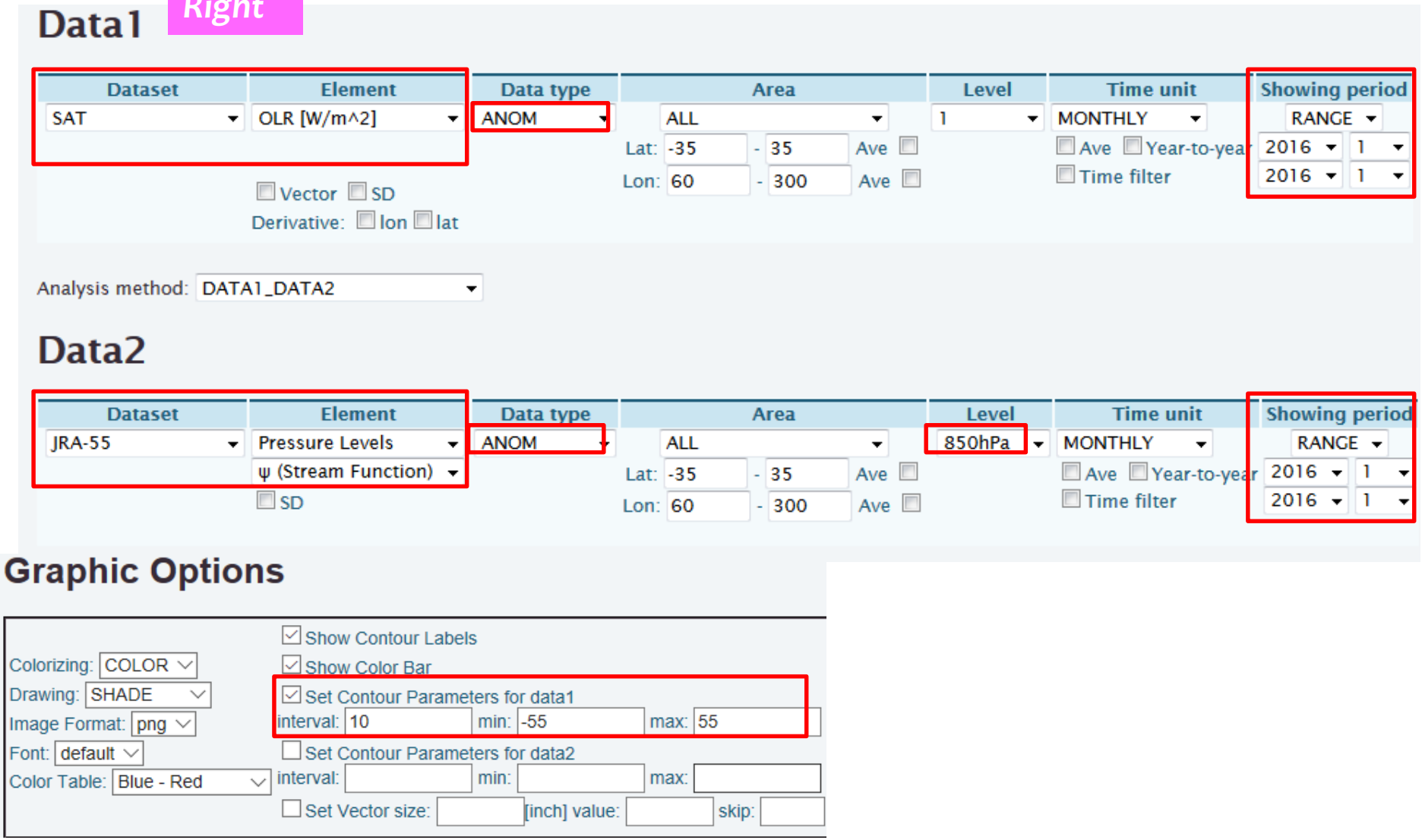
Left





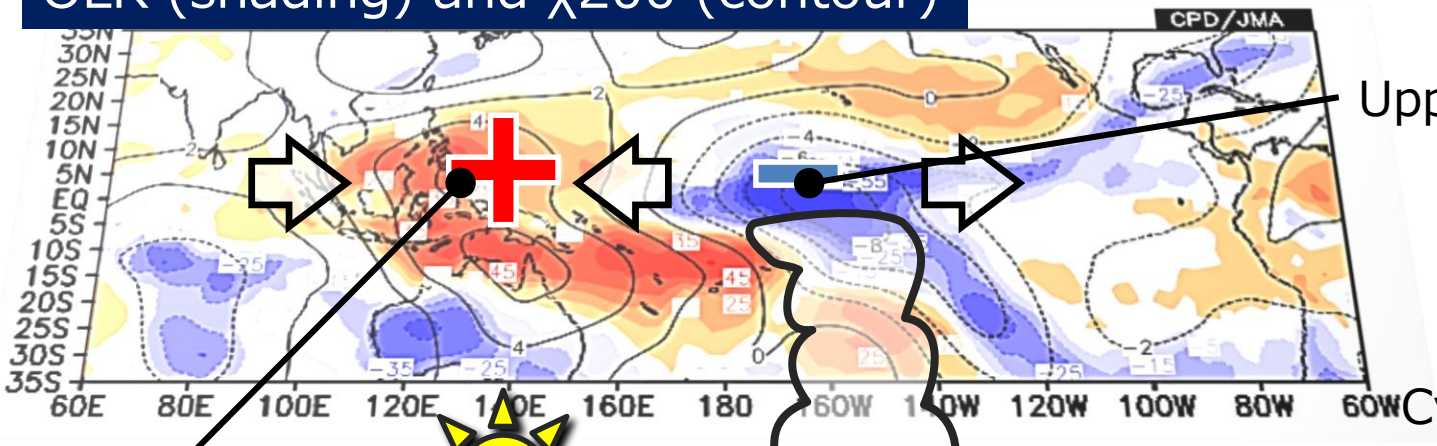
Answers of Exercise (5)

Right



Topics: Anomalies associated with El Nino

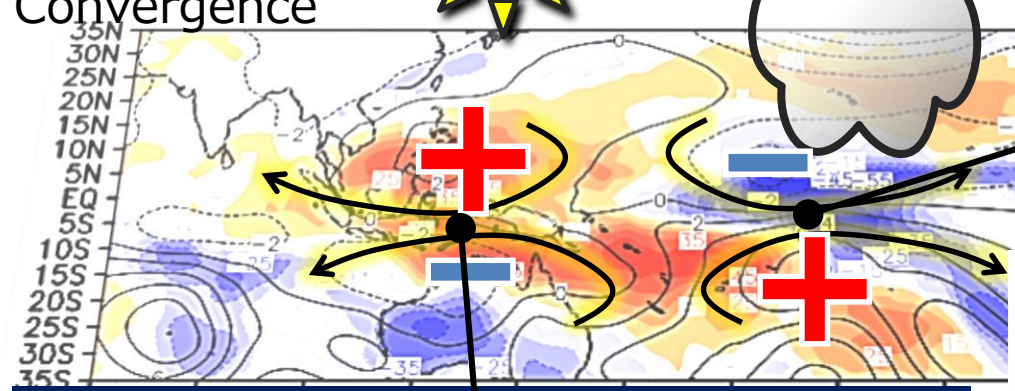
OLR (shading) and χ200 (contour)



Upper-level Divergence

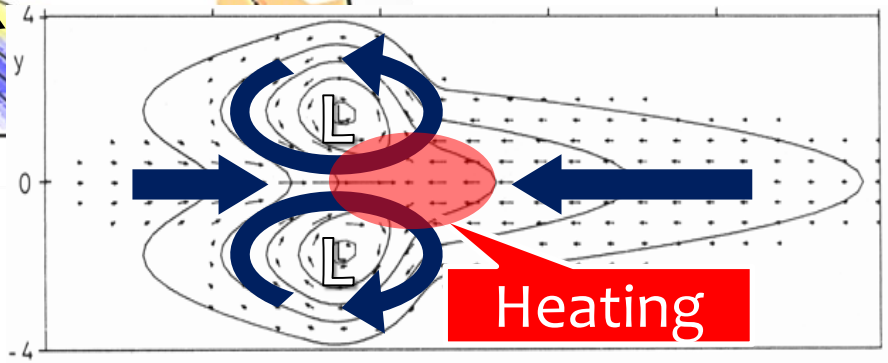
Upper-level Convergence

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



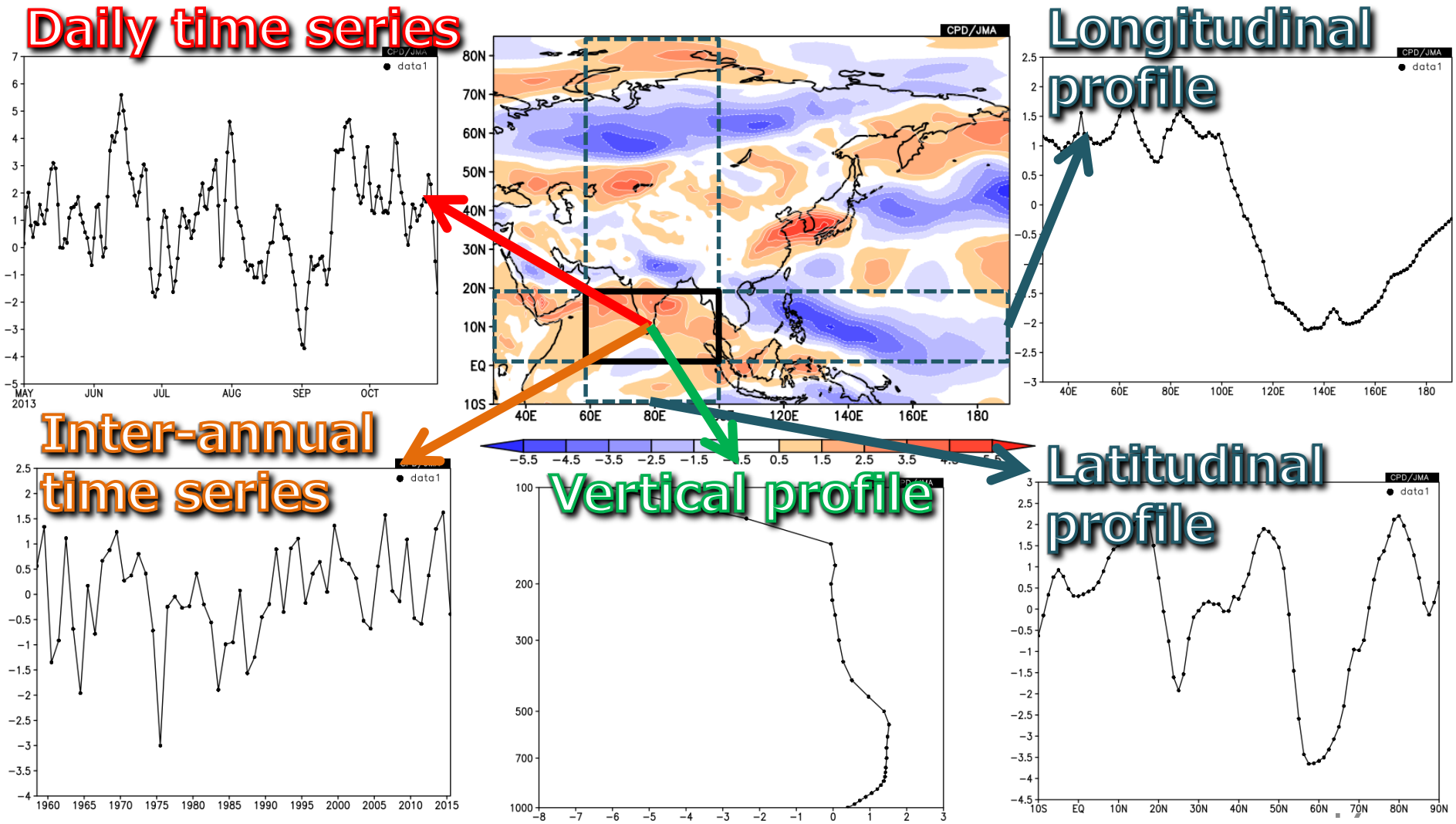
Matsuno-Gill response (Gill, 1980)

Contents

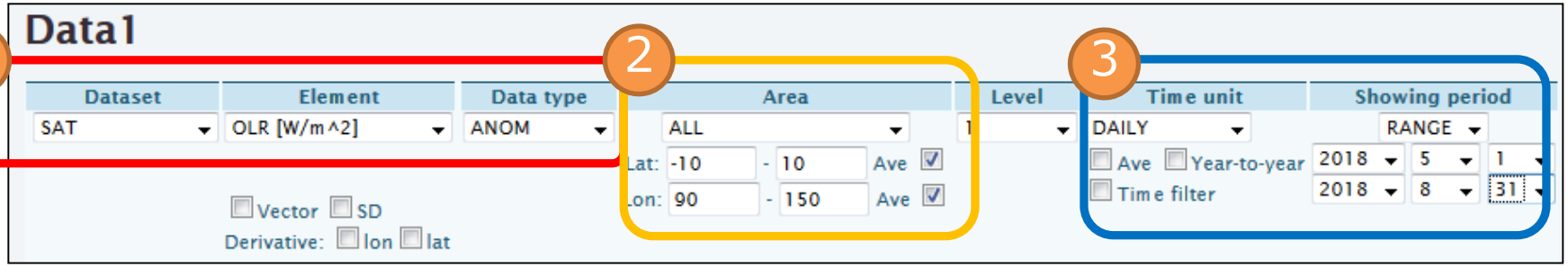
1. What's iTacs?
2. Basic operations –Horizontal map-
   - Access to iTacs
   - Basic operating procedure
   - Longitude-latitude map
   - Multiple data
3. Basic operations –Other kinds of maps-
   - Vertical and latitude/longitude profile
   - Cross section diagram

Line graph & Cross section diagram

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

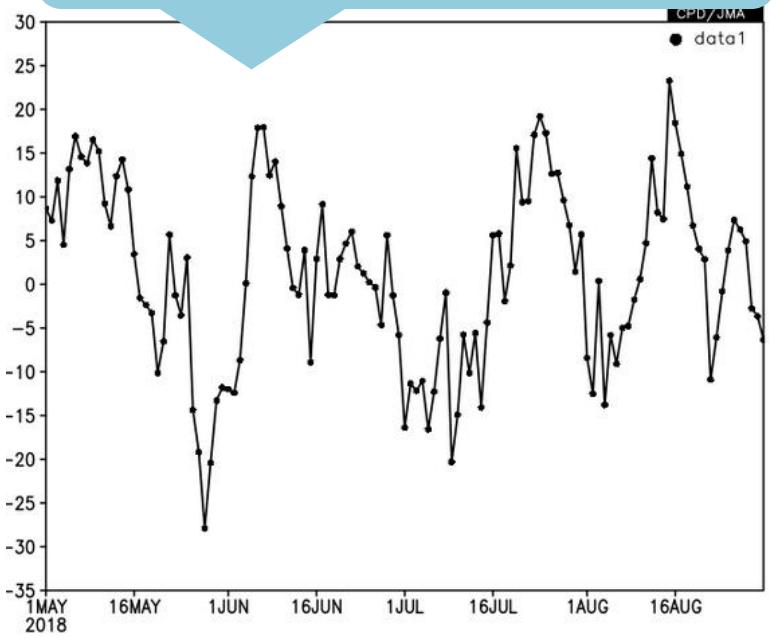


Daily timeseries



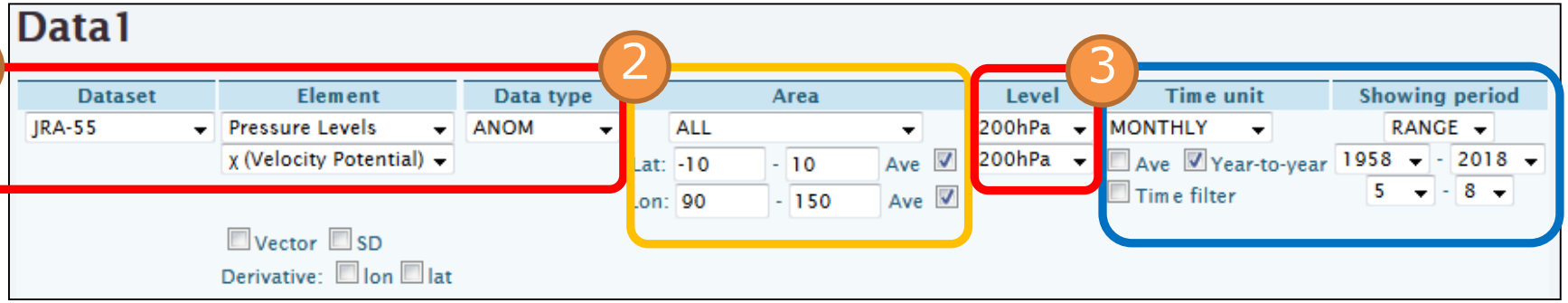
1. Select OLR anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - The area covers the Maritime continent.
   - Check "Ave" boxes.
3. Select "DAILY" for time unit, and showing period
   - Showing period: 1 May 2018 – 31 Aug. 2018.

Daily timeseries of OLR anomalies



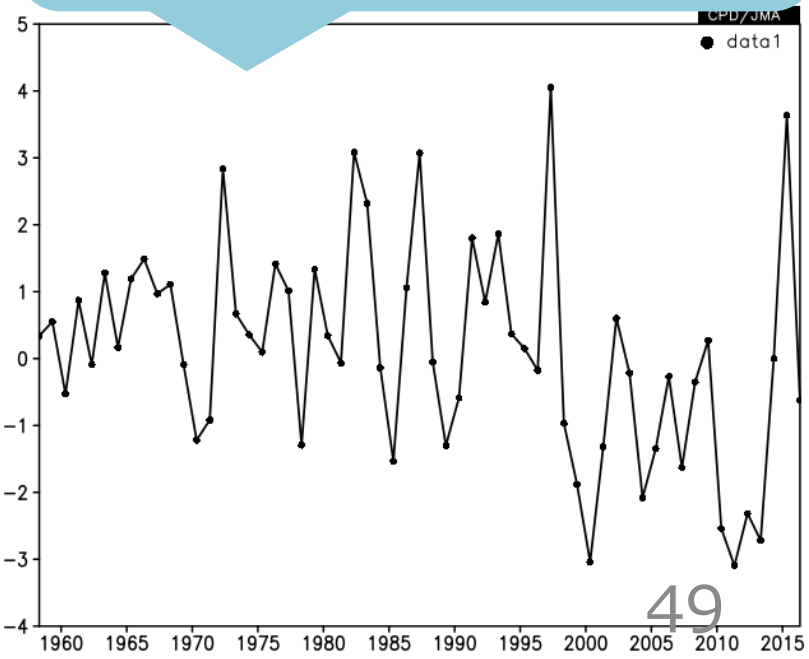
- Similarly, you can draw monthly or annual timeseries by setting "Time unit".

Inter-annual timeseries



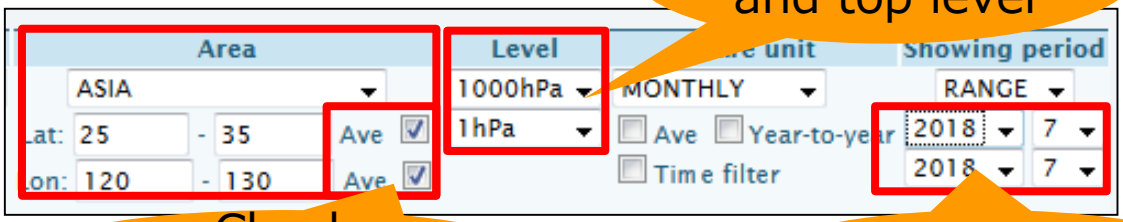
1. Select 200-hPa velocity potential anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - The area covers the Maritime continent.
   - Check "Ave" boxes.
3. Select "MONTHLY" for time unit, and showing period
   - Check "Year-to-year".
   - Showing period: 1958 – 2018, 5 – 8.

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



Vertical and lat/longitude profile

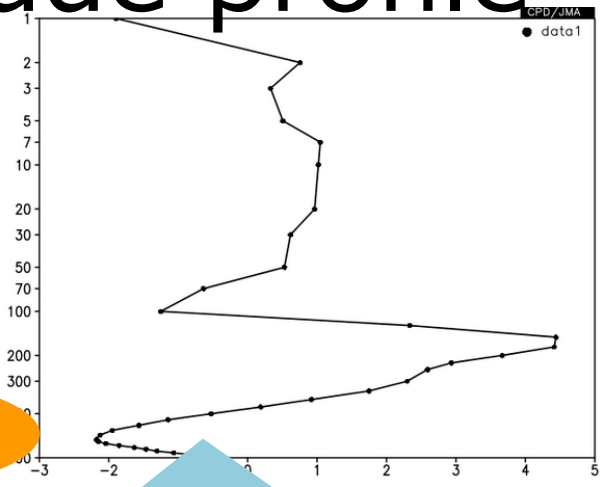
- Vertical profile



Select bottom and top level

Check (Regional mean)

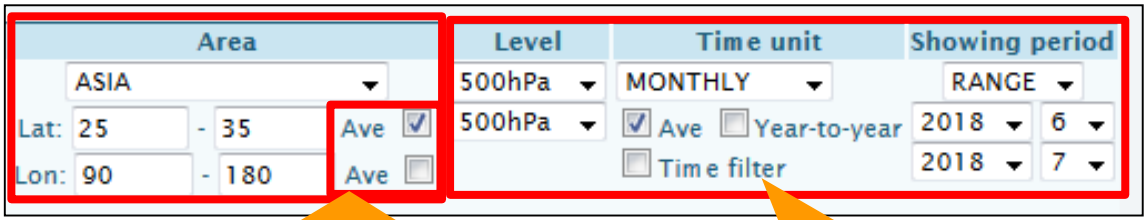
Set a specific period



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

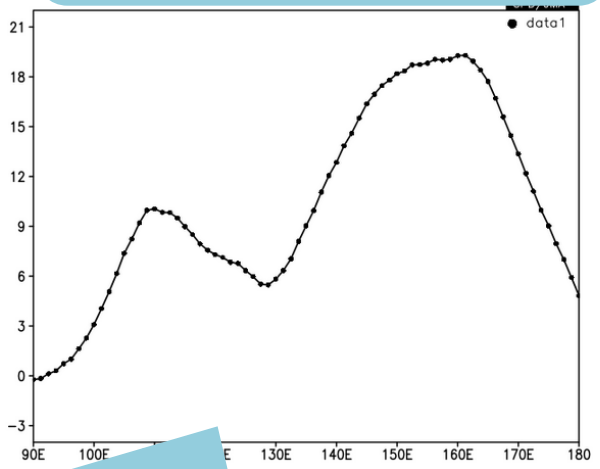
"Logarithmic Coordinates" option is recommended in vertical profile graph.

- Lat/Longitude profile



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

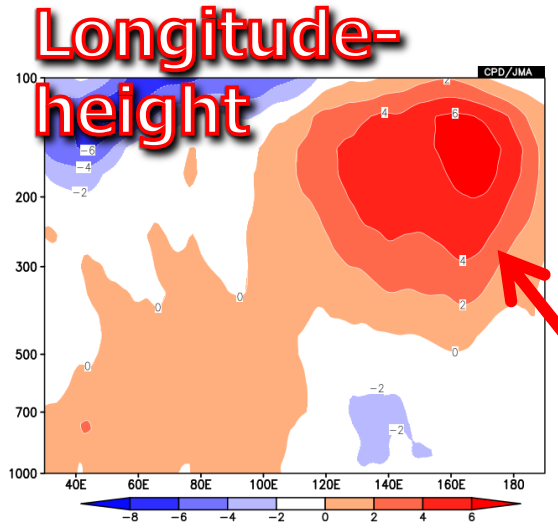
Select a specific level and period

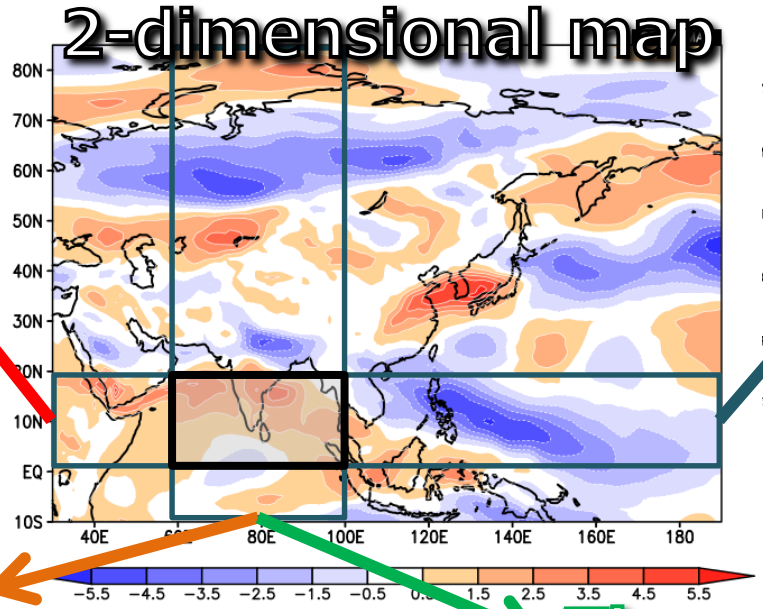


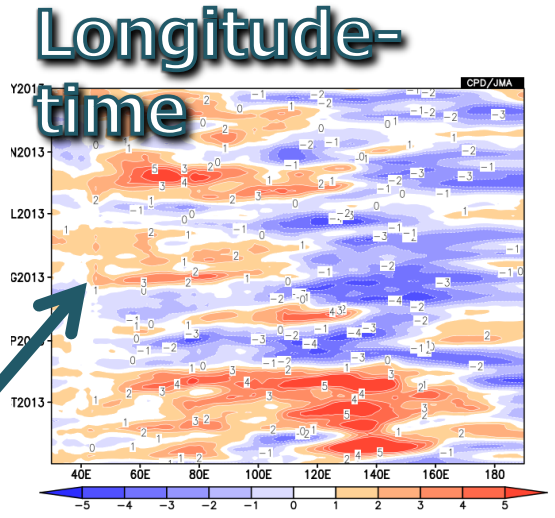
Longitude profile of 500-hPa height anomalies over 25°–35°N

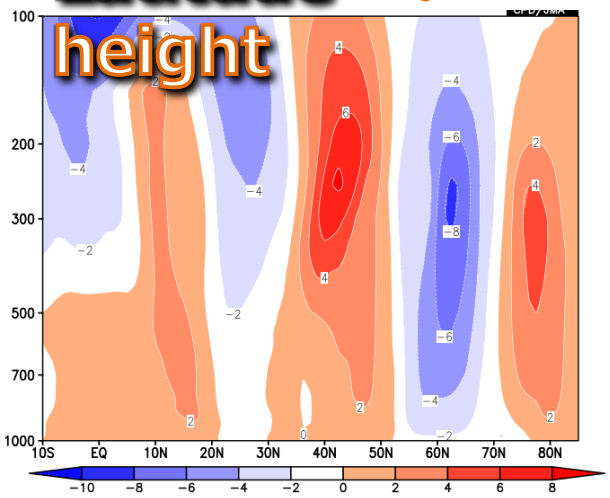
Cross section diagram

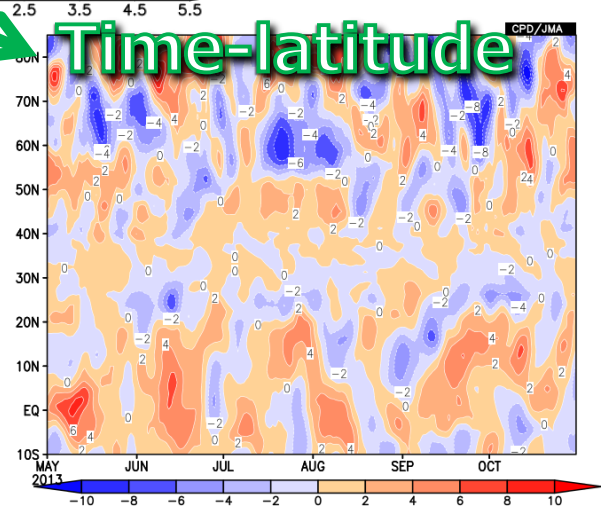
- Cross section diagram is also useful to see the variability or spatial structure.











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

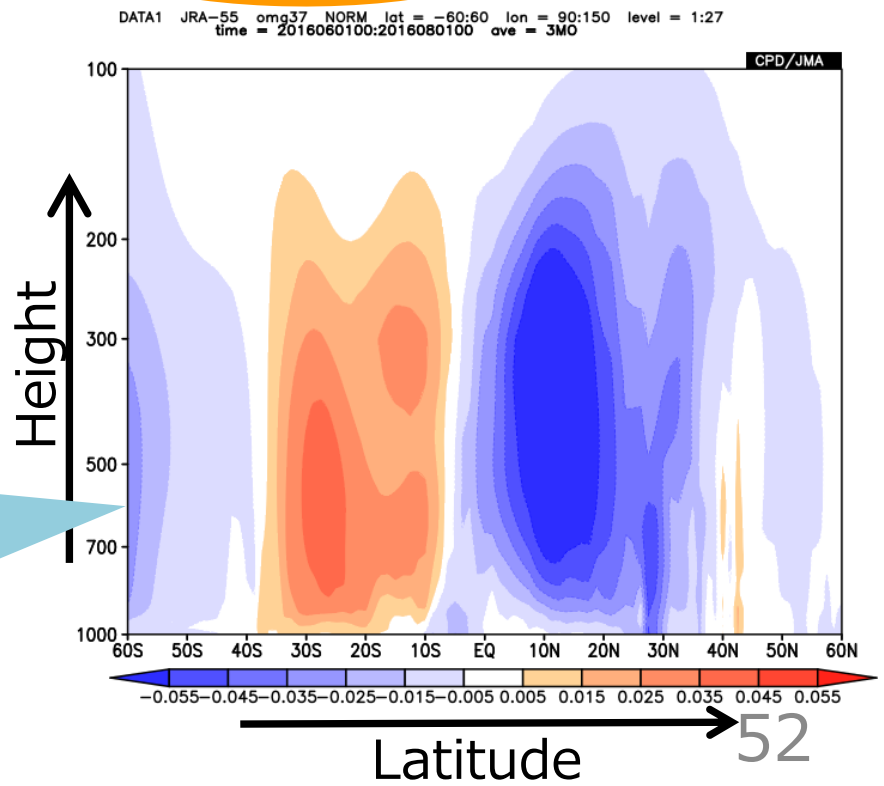
Input western and eastern border and check “Ave” box.

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

Set a specific period

5°S–5°N averaged

Data1

Dataset	Element	Data type	Area	Level	Time unit	Showing period
JRA-55	Pressure Levels χ (Velocity Potential)	ANOM	ALL Lat: -5 - 5 Ave Lon: 0 - 360 Ave	200hPa 200hPa	DAILY Ave Year-to-year Time filter	RANGE 2018 6 1 2018 8 31

Vector SD
Derivative: lon lat

200-hPa

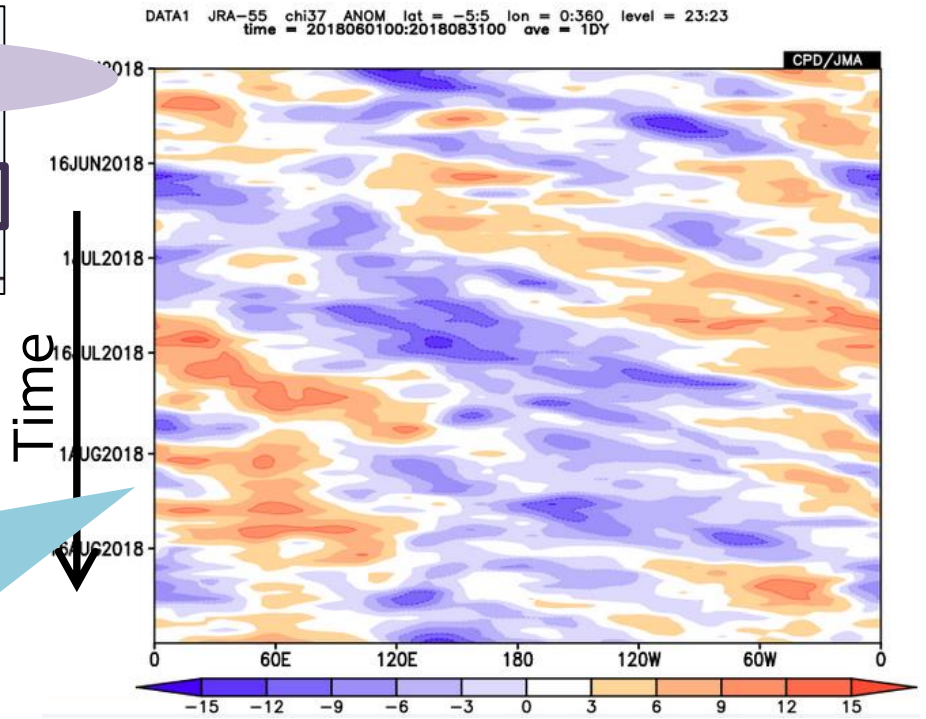
Graphic Options

Contour interval:3

Colorizing: COLOR
Drawing: SHADE
Image Format: png
Font: default
Color Table: Blue - Red

Show Color Bar
Set Contour Parameters for data1
interval: 3 min: -15 max: 15
Set Vector size: [inch] value: skip: 1

Blue-Red colored shading



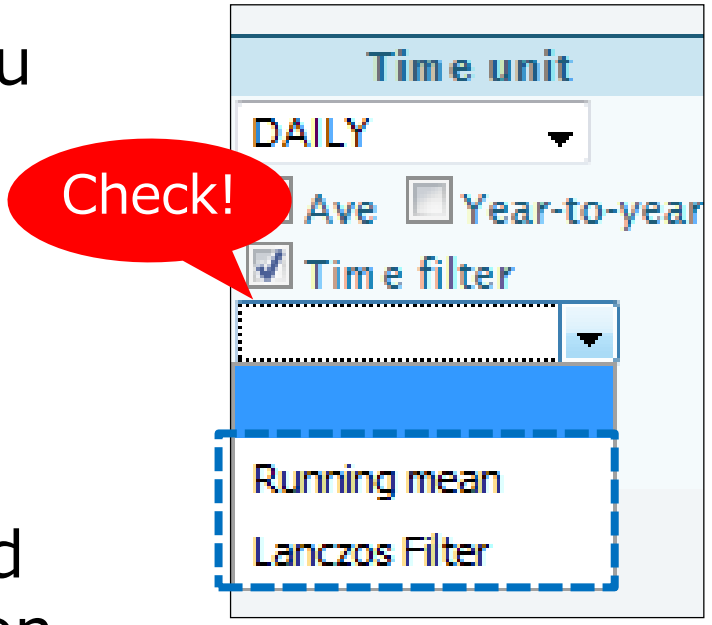
Longitude-time cross section of 200-hPa velocity potential anomalies averaged over 5°S – 5°N from 1 Jun to 31 August 2018.

Time filter

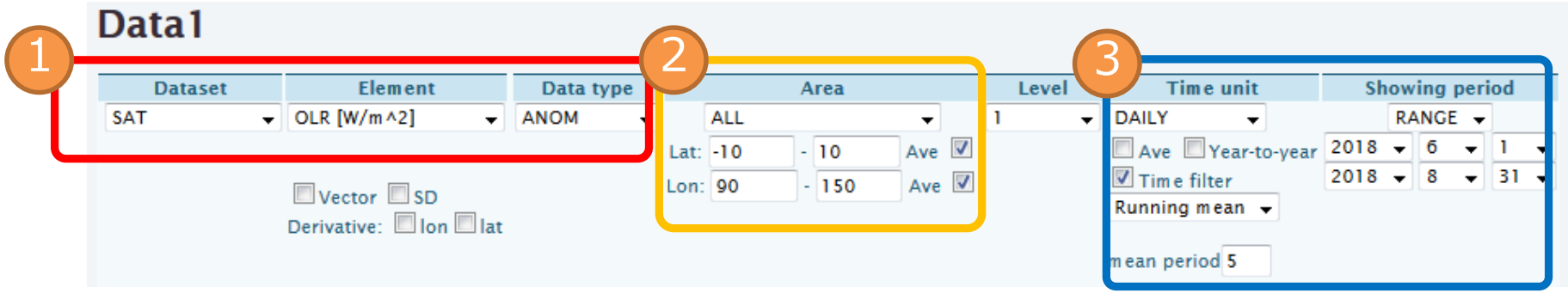
- Time filter should be used to create a time series image in the climate analysis.
- Climatological events are emphasized by a time filter, because it can remove high frequency variations.

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).

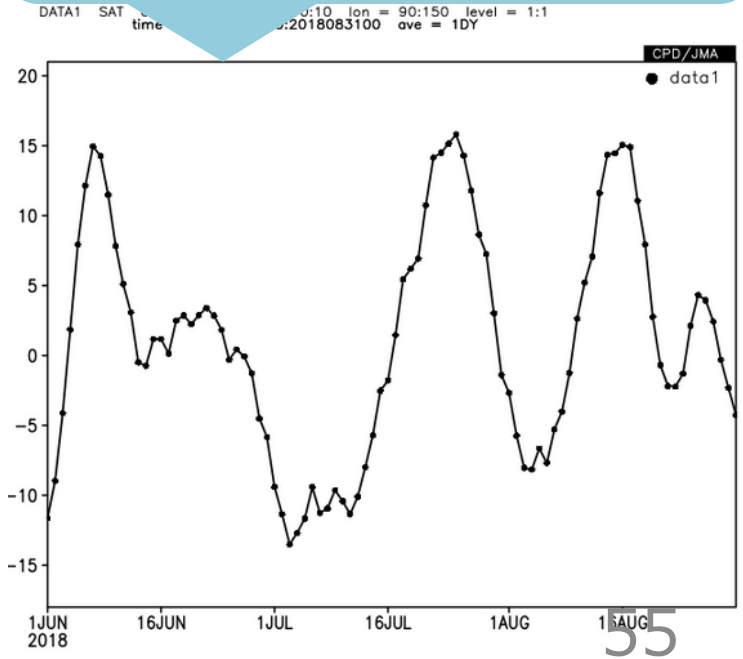


Running mean daily timeseries



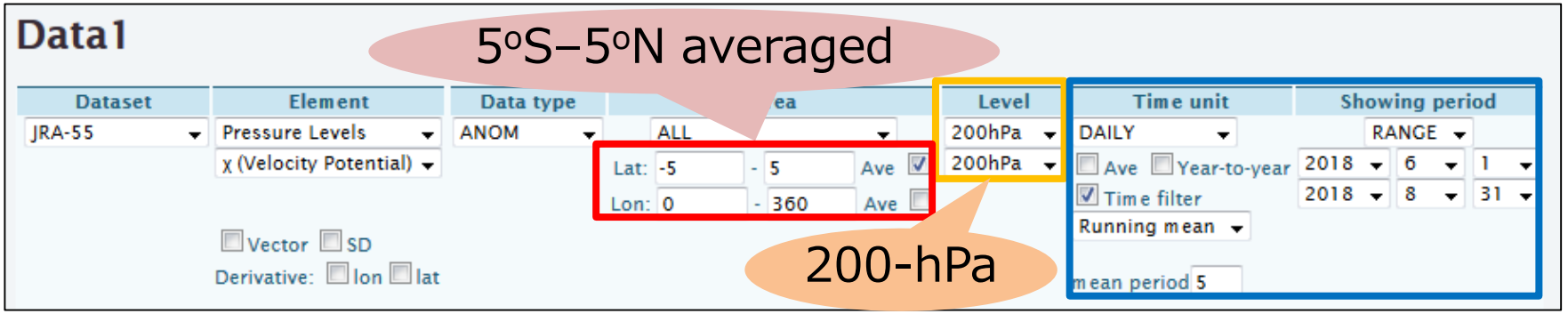
1. Select OLR anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - Check "Ave" boxes.
3. Select "DAILY" for time unit, and showing period.
   - Showing period: 1 Jun 2018 – 31 Aug. 2018.
   - Check "Time filter" in time unit box, and select "Running mean" and "5(day)" in "mean period" box.

5-day running mean daily timeseries of OLR anomalies



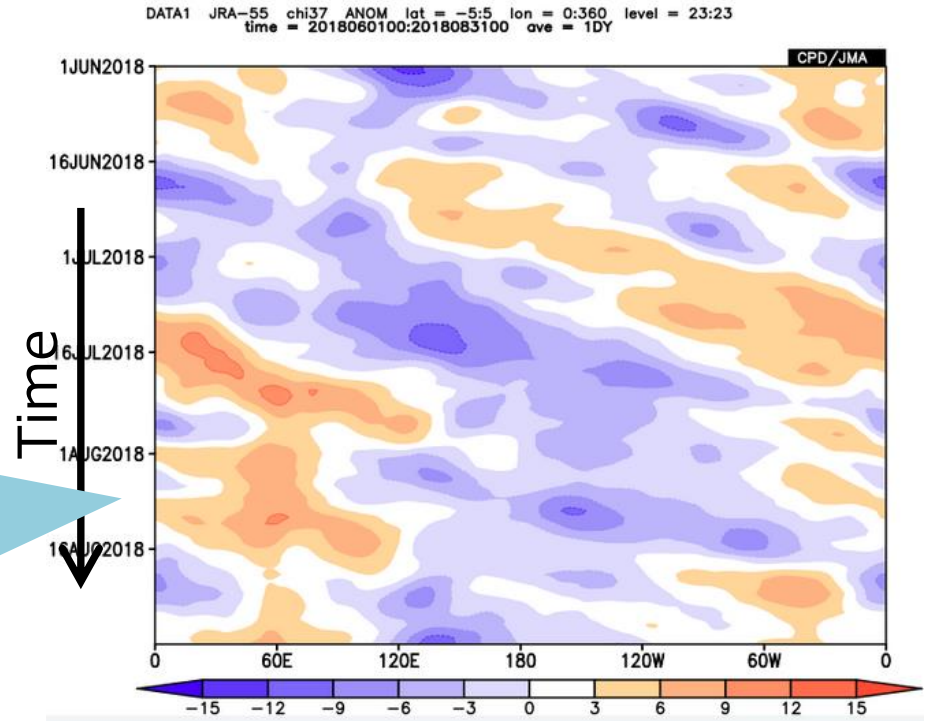
Time cross section

- Running mean longitude-time cross section



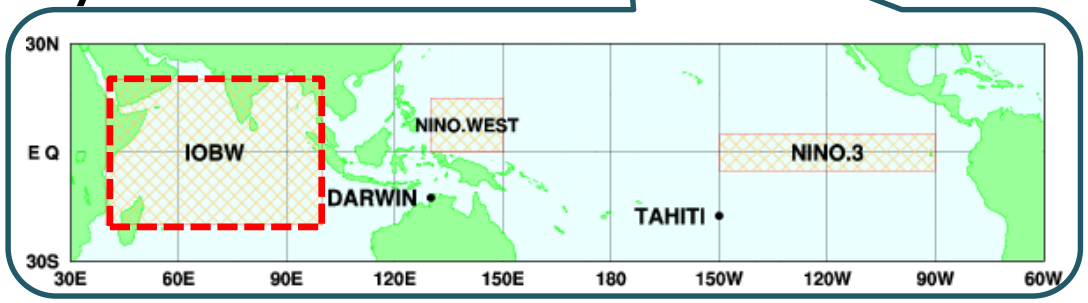
1. Select 5°S–5°N mean 200-hPa velocity potential anomalies.
2. Set 5-day running mean in “Time unit” box.

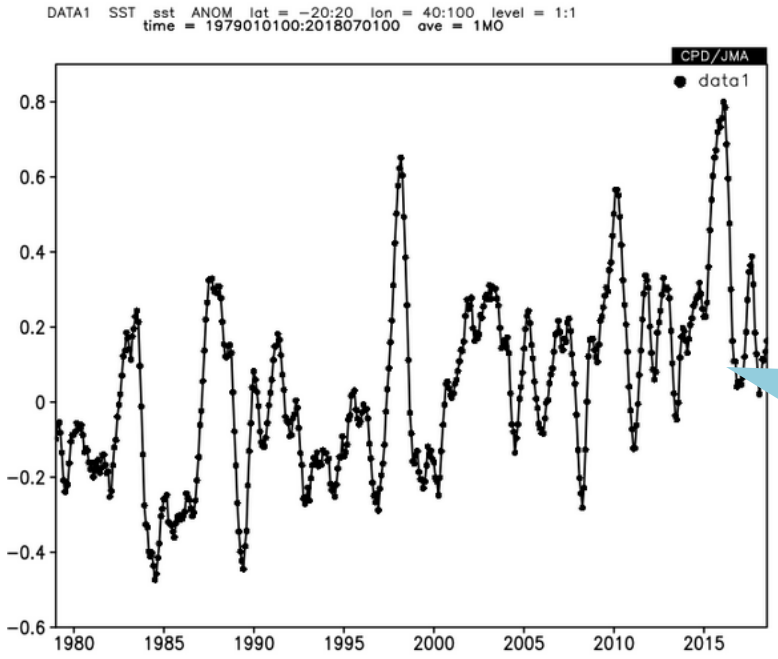
Longitude-time cross section of 5-day running mean 200-hPa velocity potential anomalies averaged over 5°S–5°N from 1 Jun to 31 August 2018.



Exercise (3)

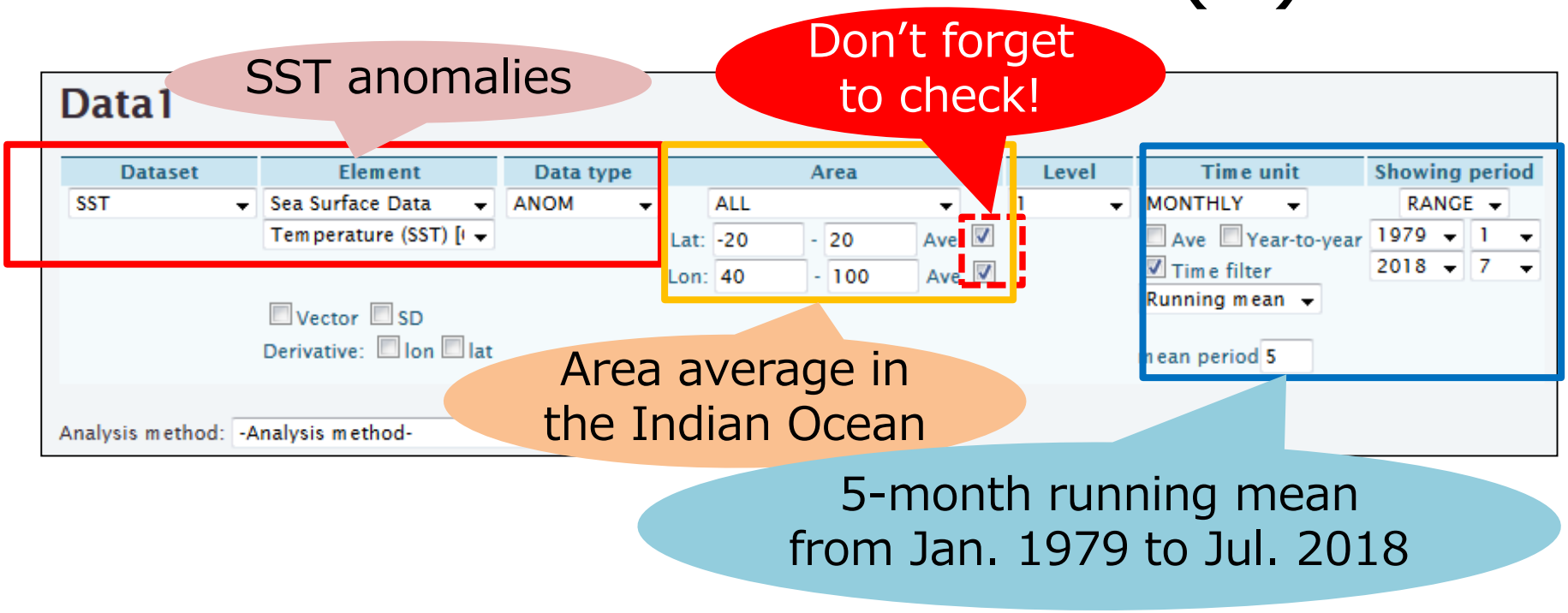
- Show a time series of 5-month running mean monthly SST anomalies averaged over the Indian Ocean (20°S–20°N, 40°–100°E) from January 1979 to July 2018.





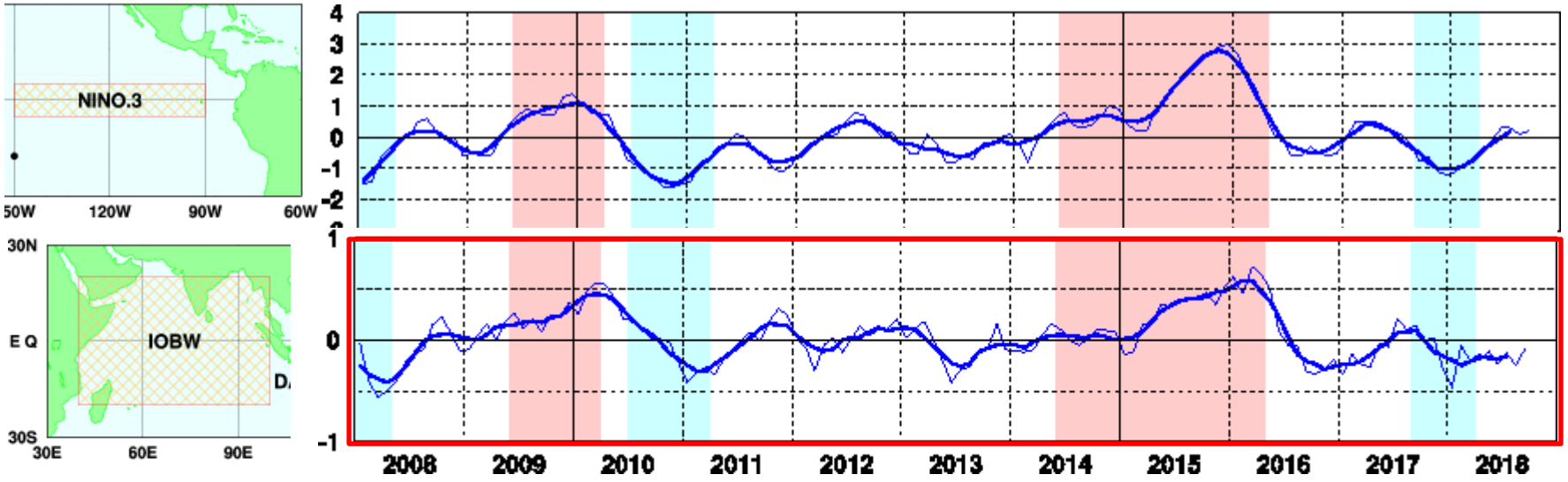
Monthly timeseries of 5-month running mean SST anomalies averaged over the Indian Ocean

Answers to Exercise (3)



Topics: Tropical Indian Ocean (IOBW)

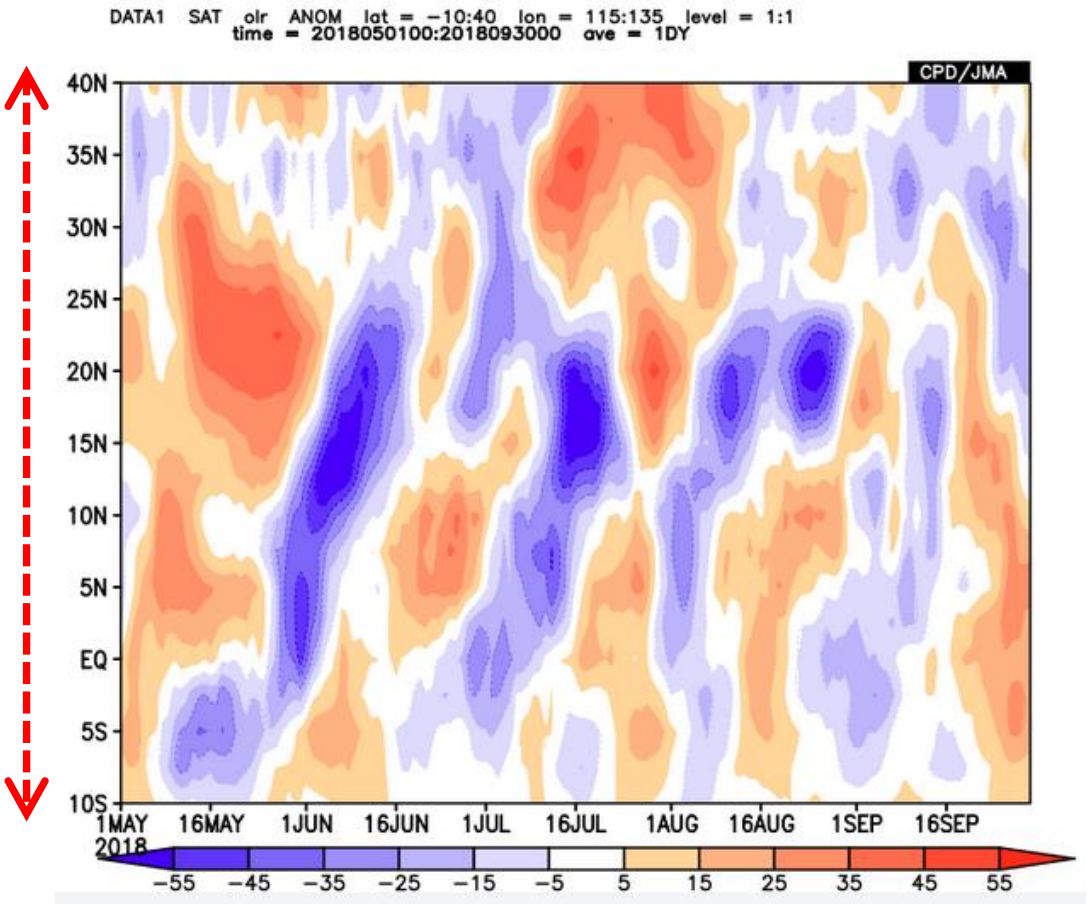
- which are identified by SST fluctuations from the central to the eastern equatorial Pacific (NINO.3), are widely-known eand
- In addition to El Niño/La Niña events, the tropical Indian Ocean (IOBW) may also have significantly affect climate conditions around the world. JMA surveyed the IOBW indice to monitor its impacts.



Exercise (5)

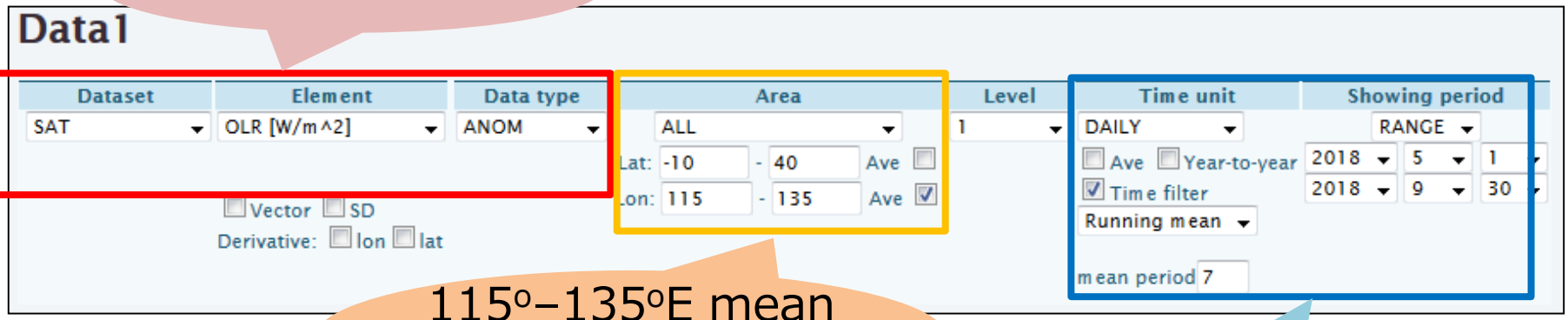
- Show a time-latitude cross section of 7-day running mean OLR anomalies averaged over 115°–135°E from 1 May to 30 September 2018.

Latitude range is 10°S–40°N.



Answers to Exercise (5)

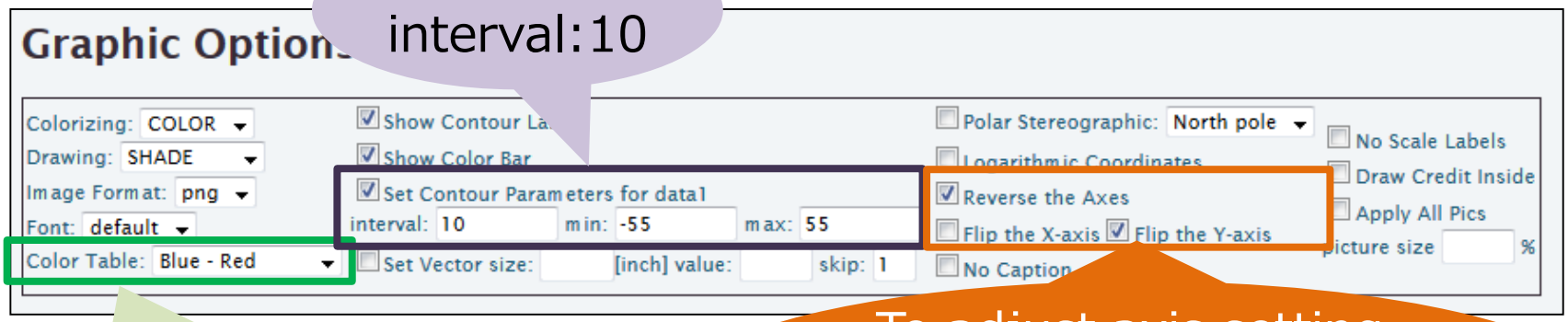
OLR anomalies



115°–135°E mean from 10°S to 40°N

7-day running mean from 1 May to 30 Sep. 2018

Contour interval:10



Blue-Red colored shading

To adjust axis setting, check “Reverse the Axes” and “Flip the Y-axis”.

This lecture will be continued to the lecture of

Advanced operation of iTacs

See you tomorrow!

気象庁
Japan Meteorological Agency

TCC seminar,
14:00–16:30, 13 November 2018,
Tokyo, Japan

Operation of iTacs (advanced)

- Interactive Tool for Analysis of the Climate System -

Shunya Wakamatsu
& Staff Members of Tokyo Climate Center

Tokyo Climate Center
Japan Meteorological Agency

Contents

Statistical Analysis in iTacs

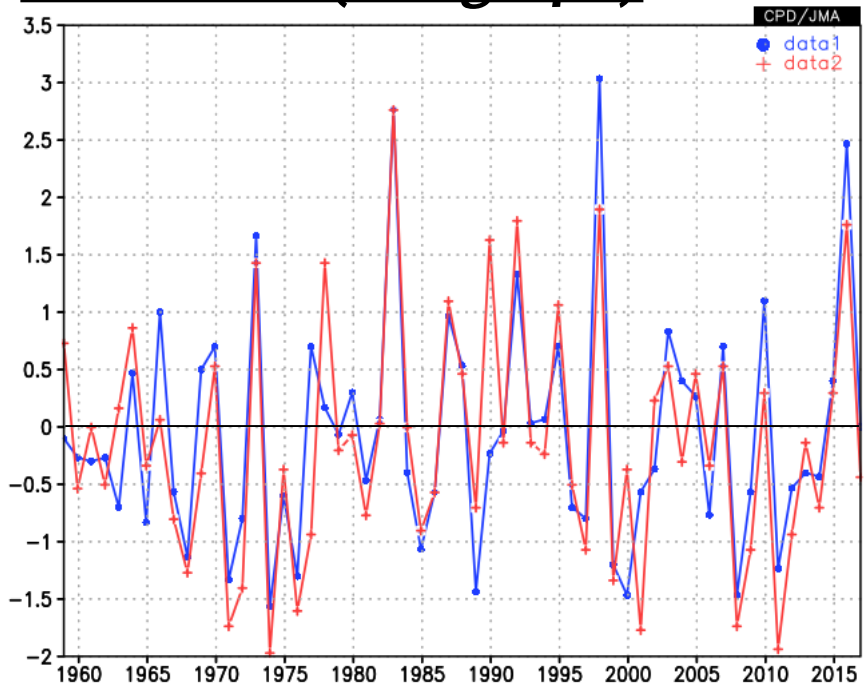
- Various statistical analysis methods are available.
  - Correlation/Regression analysis
  - Composite analysis
  - Single/multi EOF, SVD analysis
  - FFT analysis
  - Wavelet analysis
- They can be powerful and helpful for understanding our climate system. Of course, statistics is also necessary for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

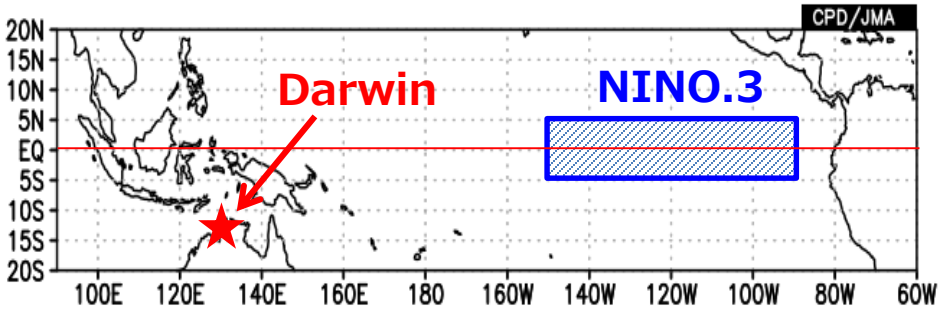
*Keep in mind that statistical results **DO NOT ALWAYS** give us the physical nature of the target systems or phenomena. Statistics is just a matter of mathematics. We need physical interpretation after statistical analysis.*

Contents

Tips: Correlation analysis

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

12.5S,130.8E

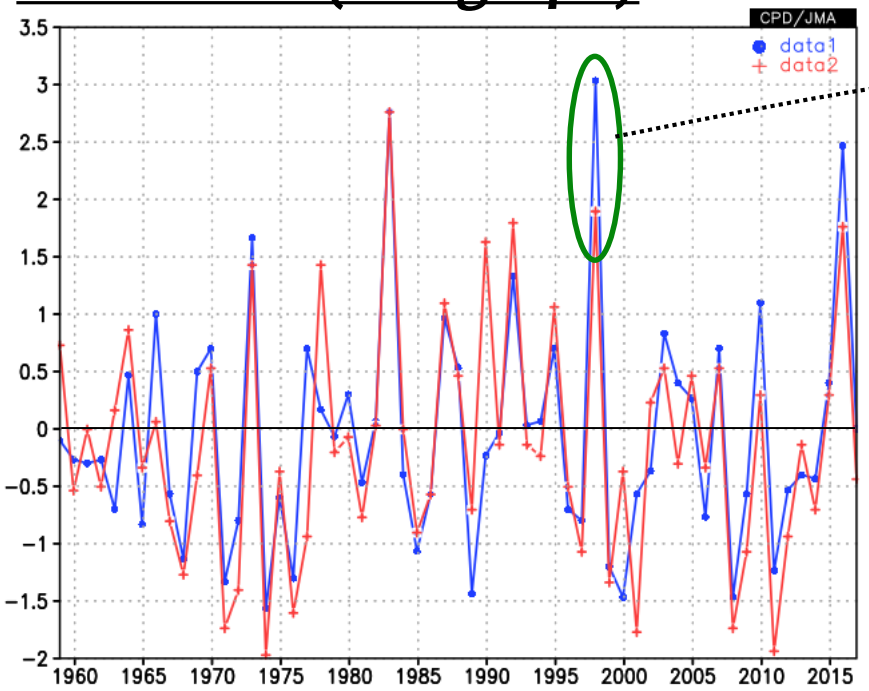
When NINO.3 SST anomalies are positive, SLP anomalies at Darwin tend to be positive.

Next step is…,

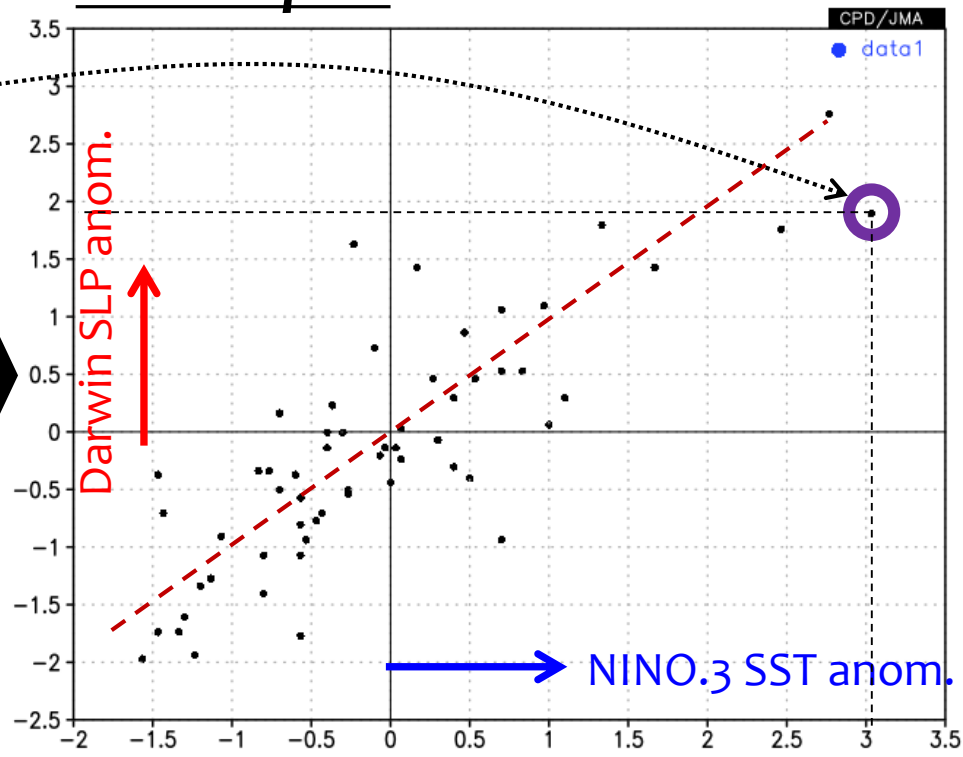
How can we evaluate the relationship objectively and quantitatively?

Tips: Correlation analysis

Time series (line graph)



Scatter plot

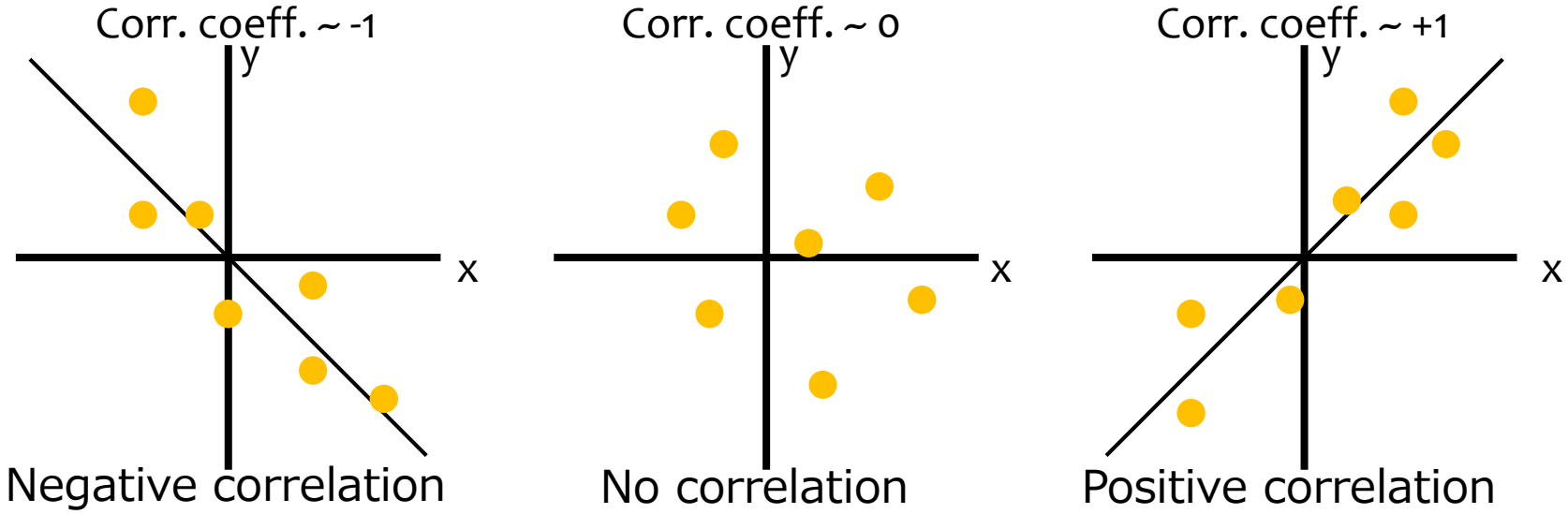


If we link **each pair** of NINO.3 SST and Darwin's SLP values to **a point** on a x-y map, we can clearly see a **linear relation** between them. We can evaluate the relationship with **correlation coefficients**.

Correlation coefficient: How close they have a linear relationship

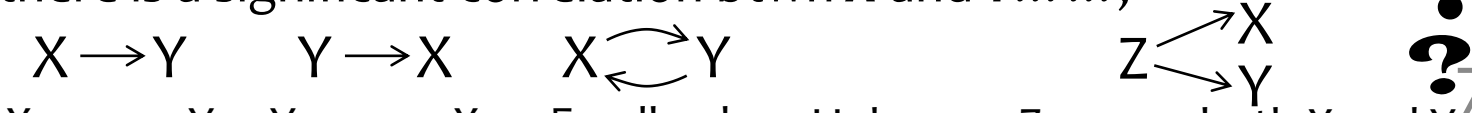
Tips: Correlation analysis

- **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!

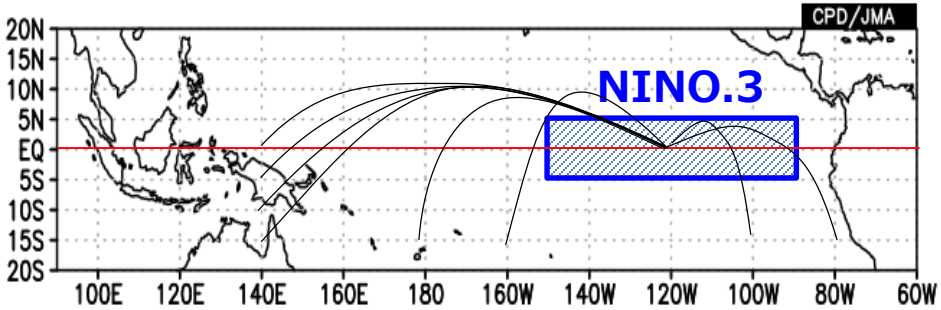
If there is a significant correlation btwn ***X*** and ***Y*****……,**



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?*

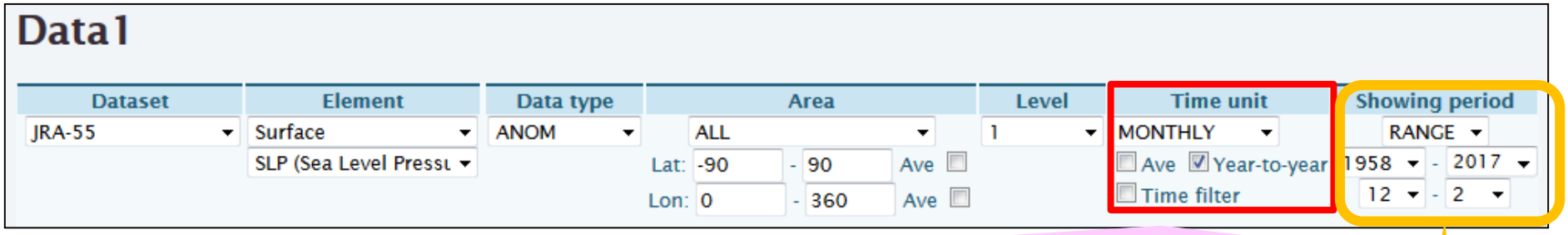


***Evaluating the correlation coefficients** between NINO.3 SST and SLP at every grid points and then **mapping** each value on each grid.*

- 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 2017/2018.

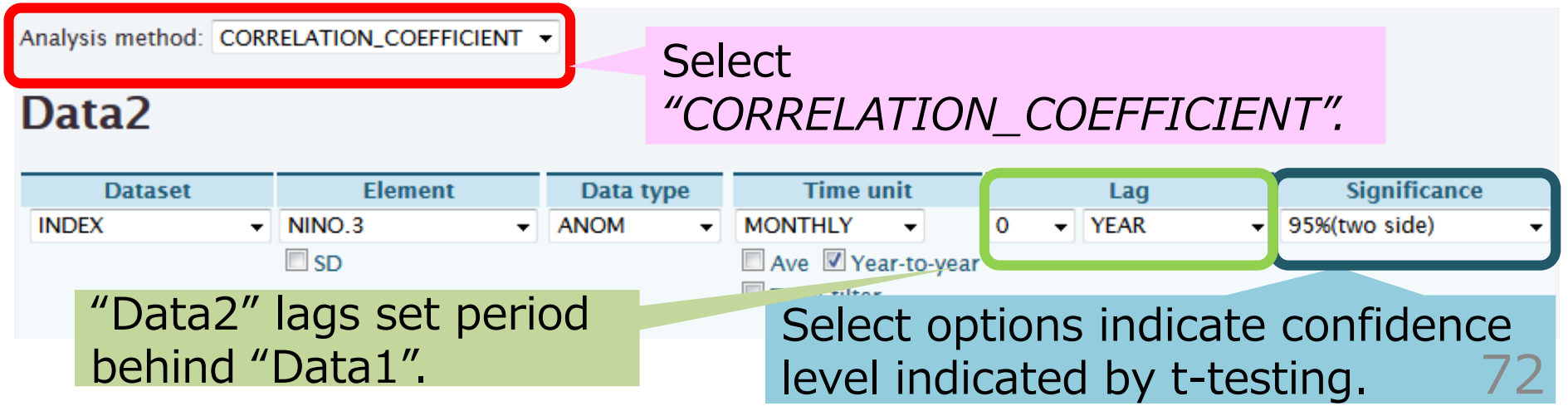
Correlation Analysis (2)

- Setting “Data1” and “Data2”.



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

This setting means DJF average
from 1958/1959 (December 1958 to February 1959)
to 2017/2018 (December 2017 to February 2018).
Consider the setting for year and month separately.



Select *“CORRELATION_COEFFICIENT”.*

“Data2” lags set period behind “Data1”.

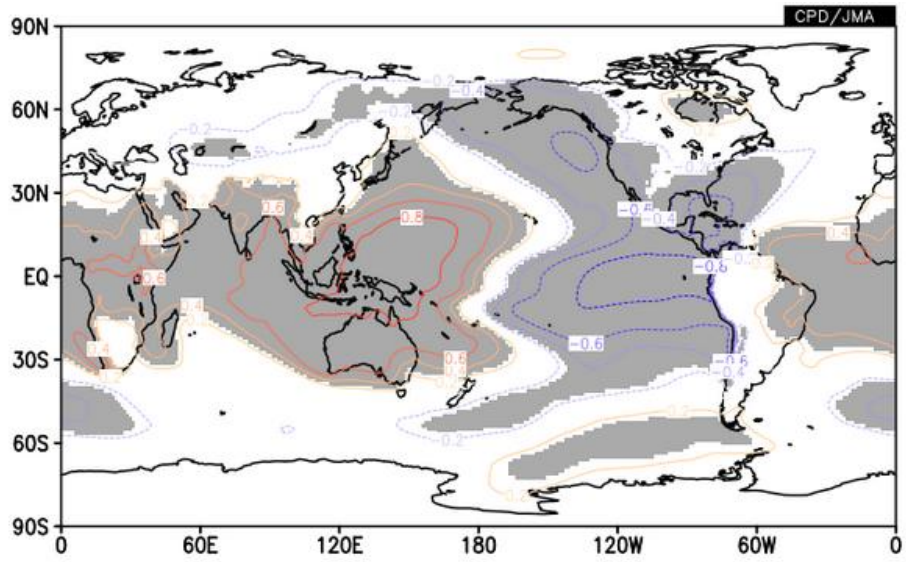
Select options indicate confidence level indicated by t-testing.

Correlation Analysis (3)

- Setting Graphic Options.

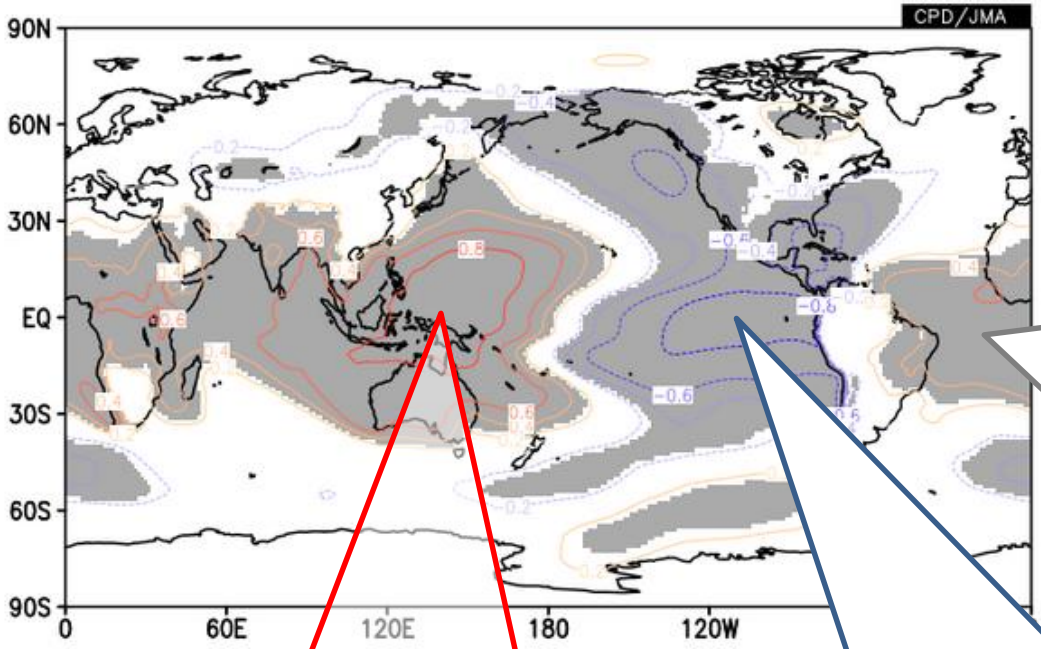
Set “Drawing” “CONTOUR” to shade the grids exceeding confidence level.

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 2016/17.



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.

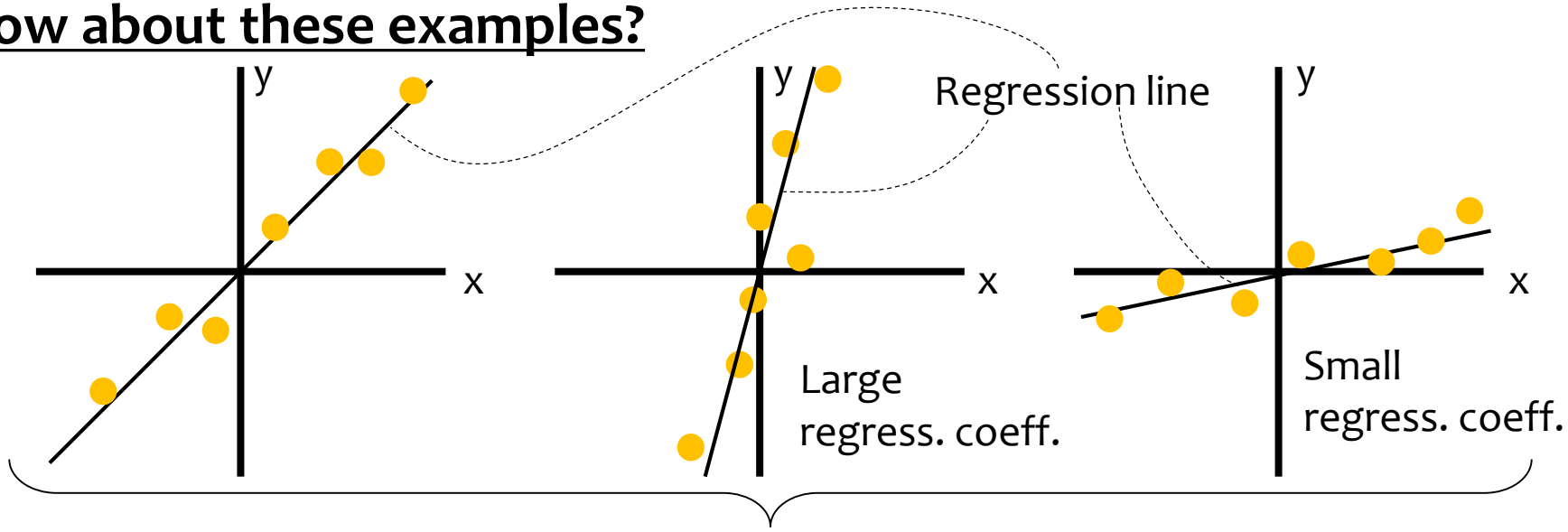
The red contours indicate positive values of correlation coefficients.
Simply stated, **positive** (**negative**) SLP anomalies during **El Niño** (**La Niña**).

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**).

Tips: Regression analysis

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**.

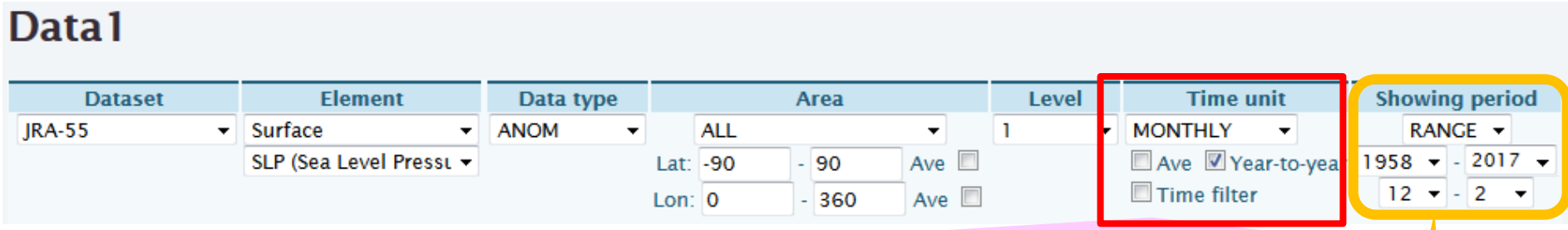
Regression Analysis (1)

- 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 2017/2018.

- 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.

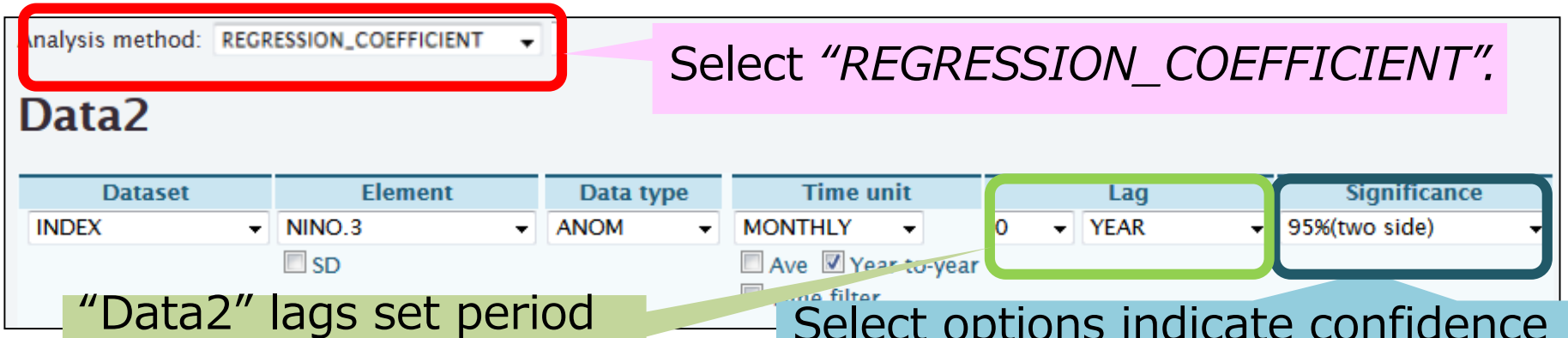
Regression Analysis (2)

- Setting “Data1” and “Data2”.



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

This setting means DJF average
from 1958/1959 (December 1958 to February 1959)
to 2017/2018 (December 2017 to February 2018).
Consider the setting for year and month separately.



Select *“REGRESSION_COEFFICIENT”.*

“Data2” lags set period behind “Data1”.

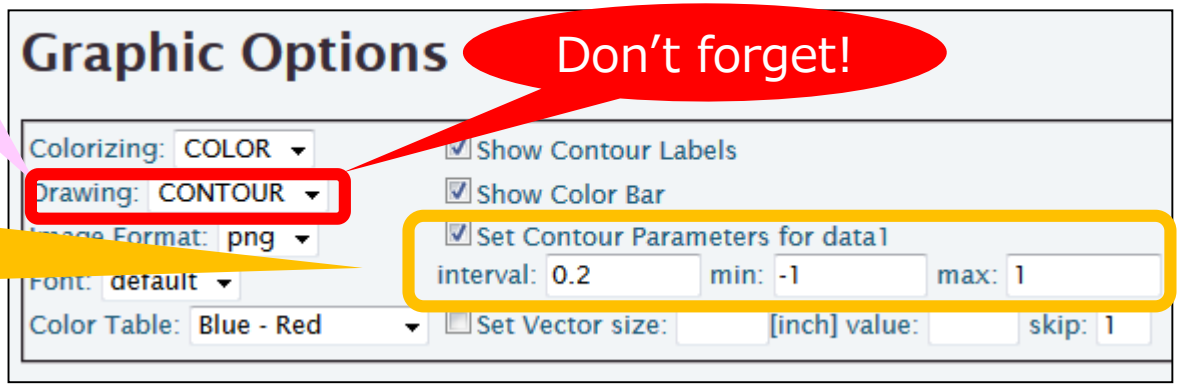
Select options indicate confidence level indicated by t-testing.

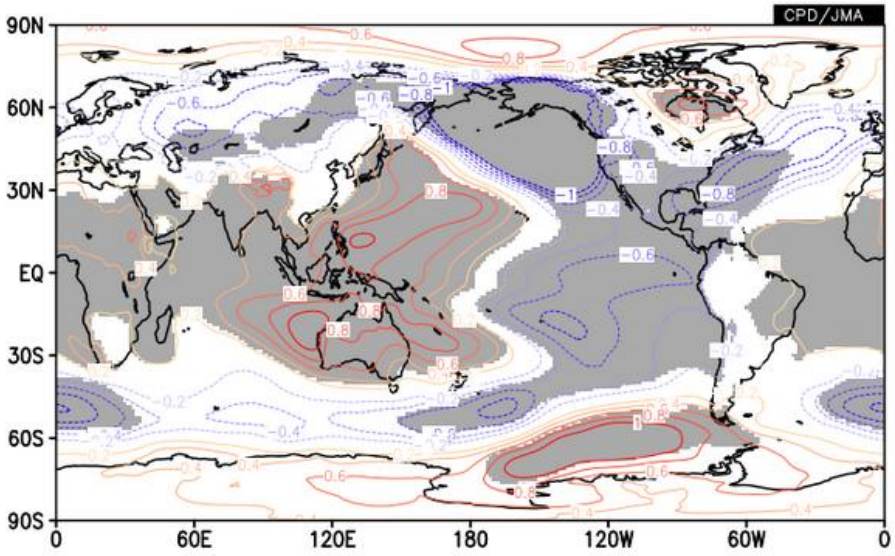
Regression Analysis (3)

- Setting Graphic Options.

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

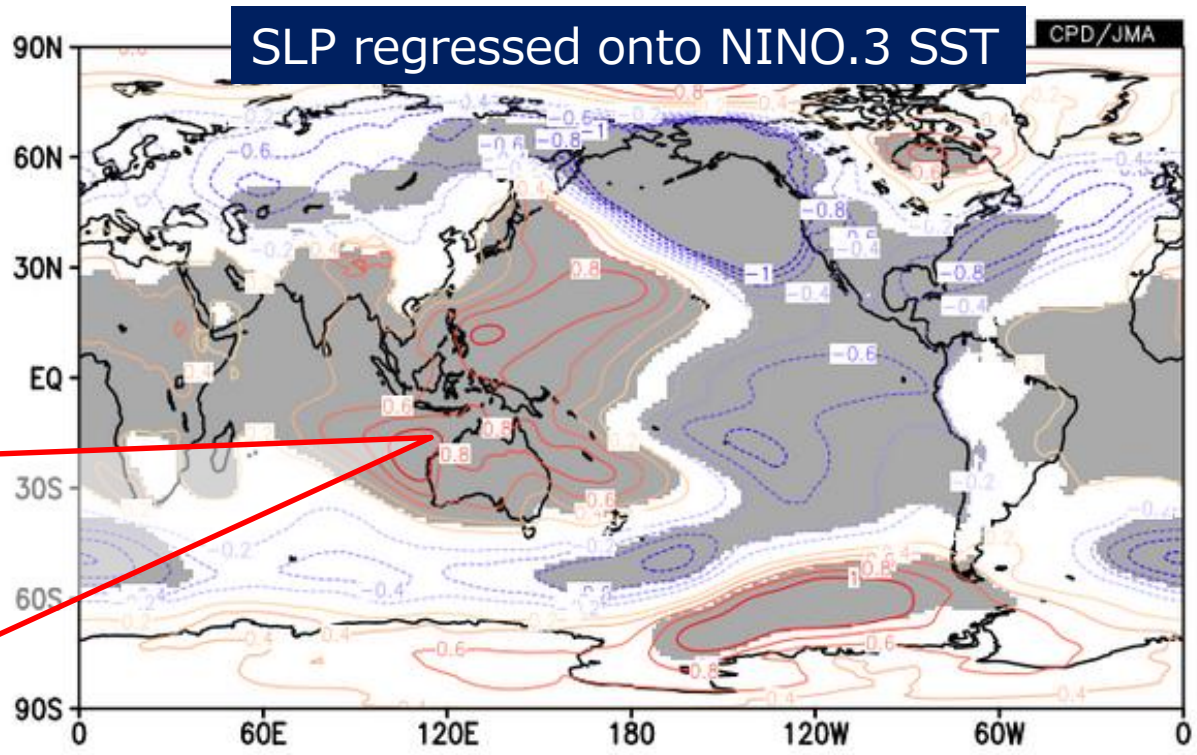
Set contour line (i.e., regression coefficient) properties.

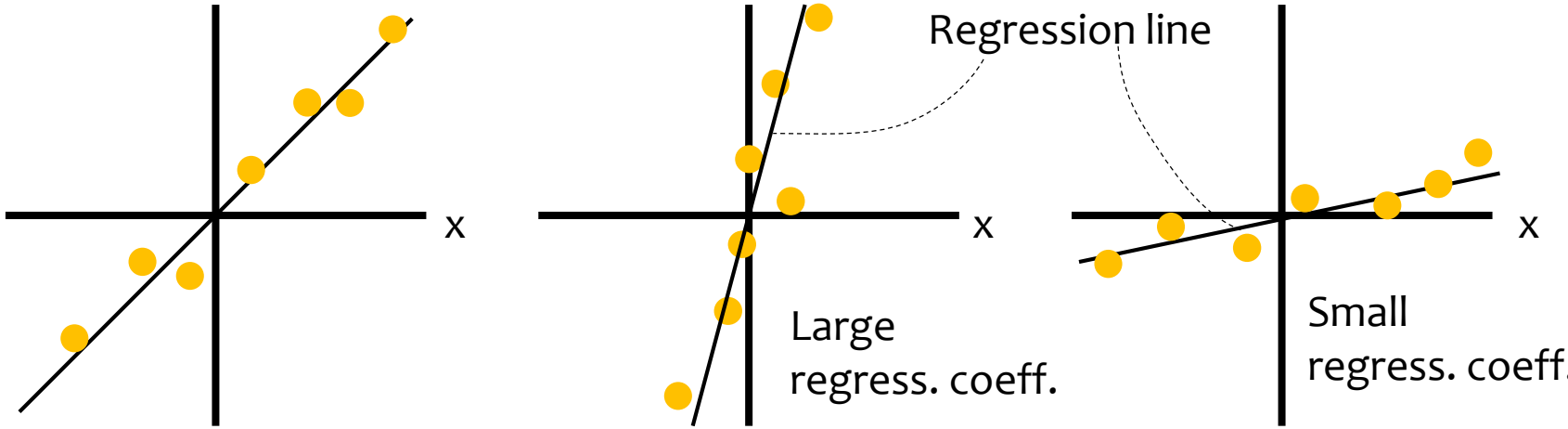




Regression Analysis (4)

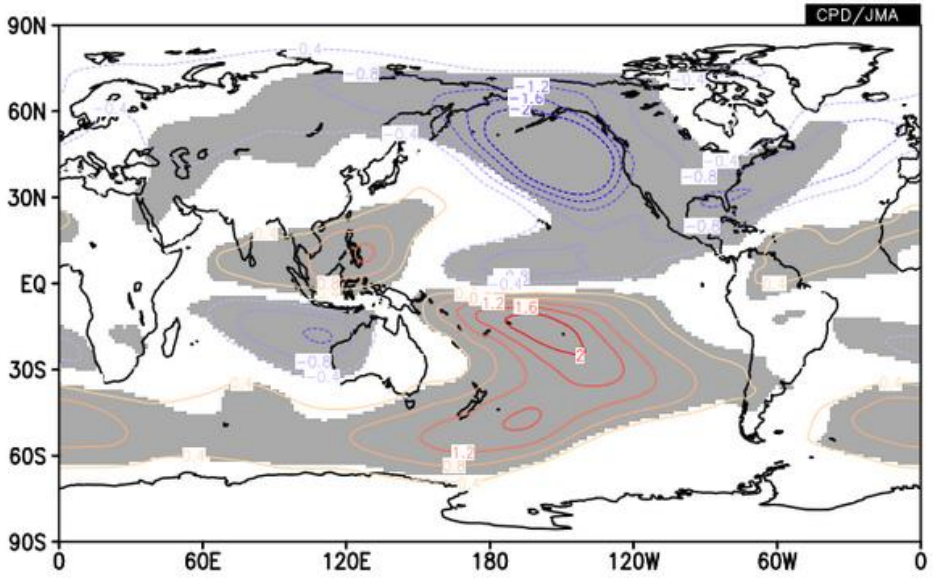
Regression coefficient is +0.8.
This means SLP tends to be +0.8hPa higher than normal here when NINO.3 SST index is +1.0 higher than normal.
Recall that regression coefficients are the slope of regression lines, $\Delta y/\Delta x$. In this case, x is NINO.3 SST index and y is SLP.





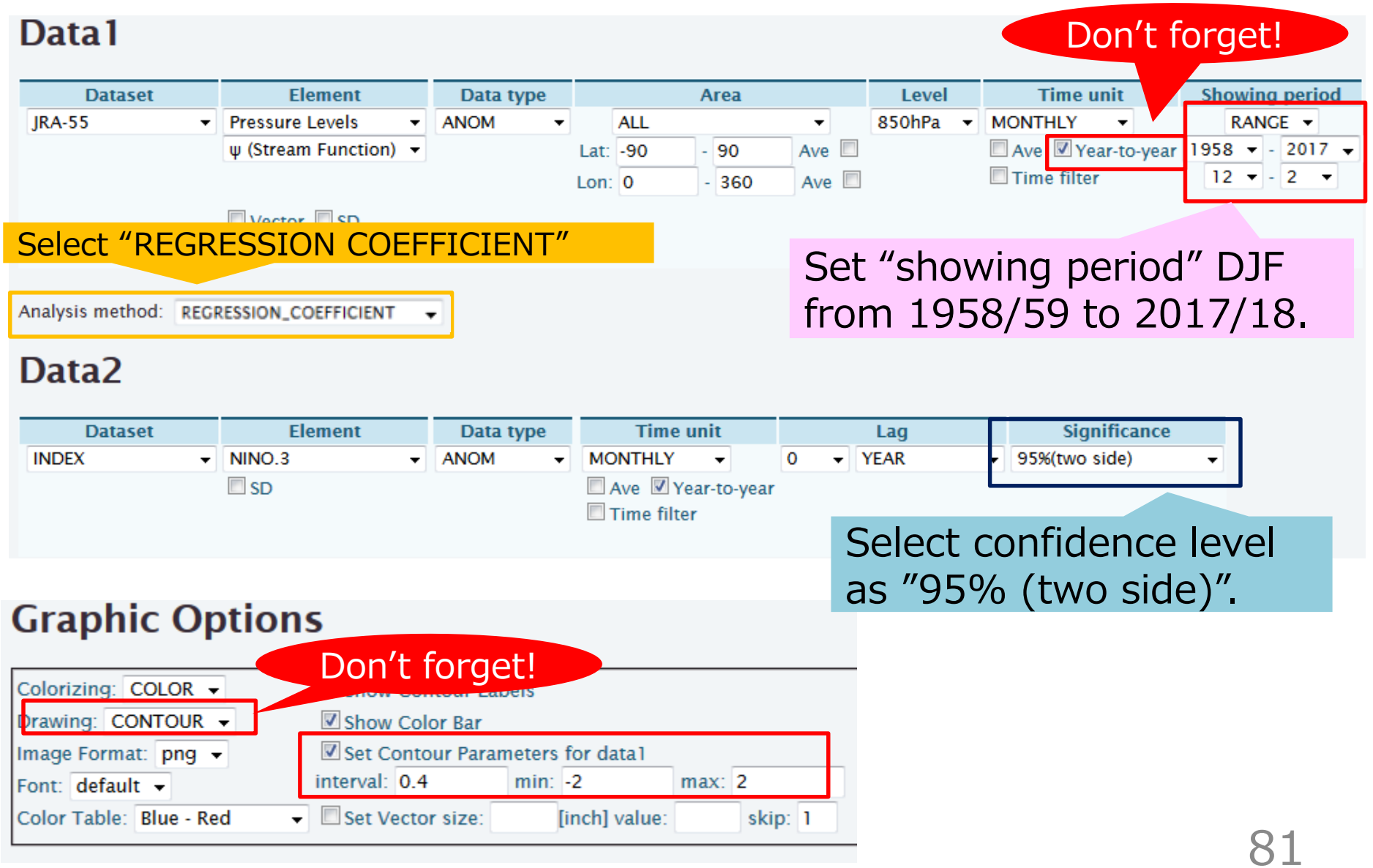
Exercises (6)

- 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 2017/18.
  - 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)**.

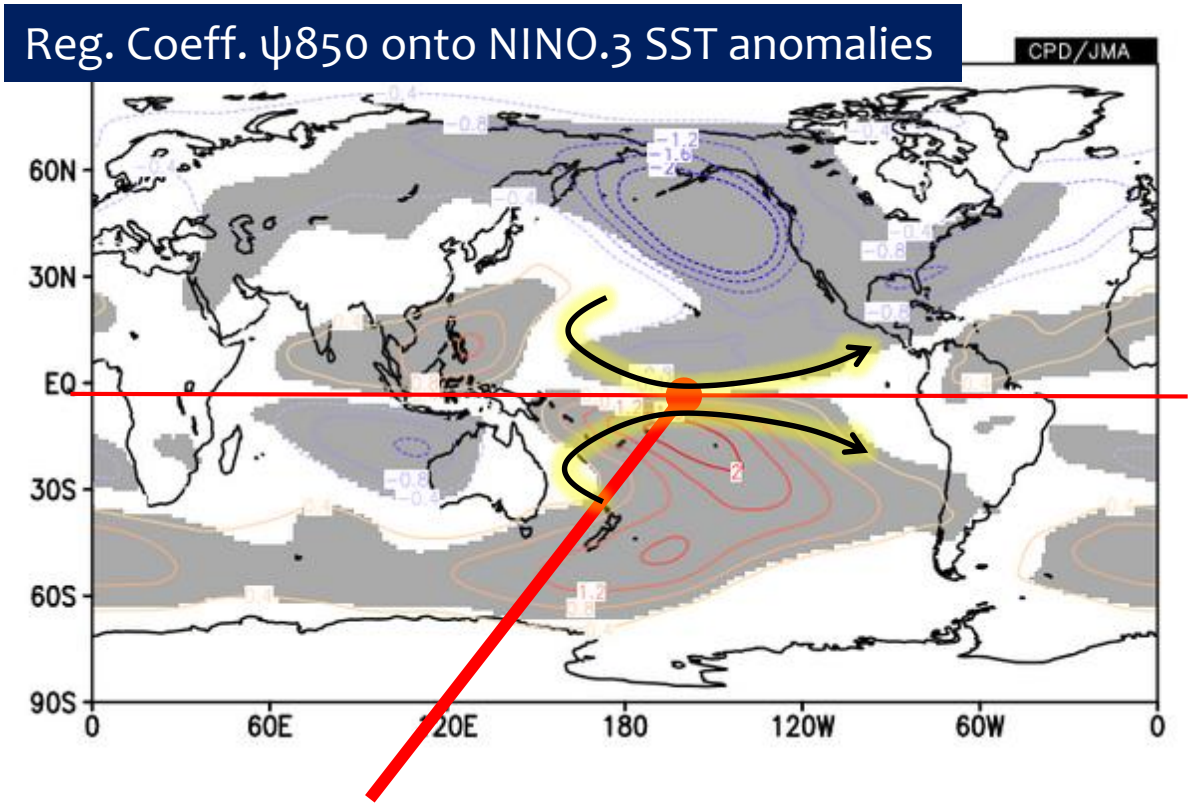


Regression coefficient of ψ850 onto NINO.3 SST anomalies for DJF.

Answers to Exercises (6)



Topics: Typical Anomalies associated with El Niño



When El Niño events occur, there is a positive westerly anomaly (= Weak Trade winds).

Contents

4. Statistical Analysis in iTacs
   - Introduction
   - Regression / Correlation Analysis
   - Composite Analysis

5. Other Advanced operations
   - Data download
   - User data input

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
.
.
.
2016
2017
2018

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

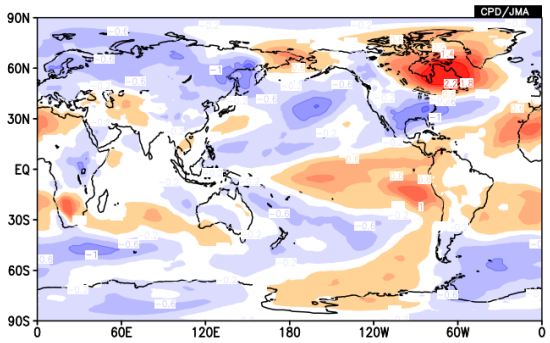
Pick out years matching a given condition

Subset of data

1963
1965
.
.
1997
2002
2009
2015

Average

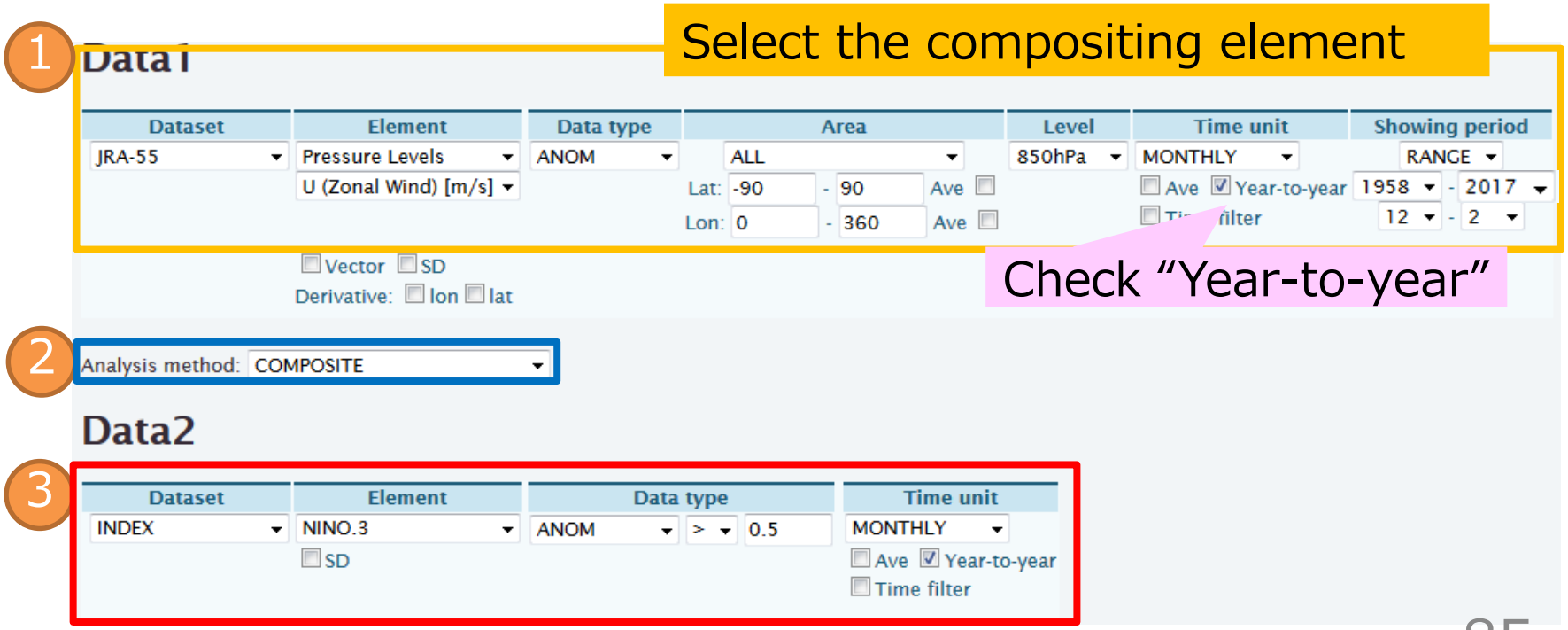
Composite map



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).



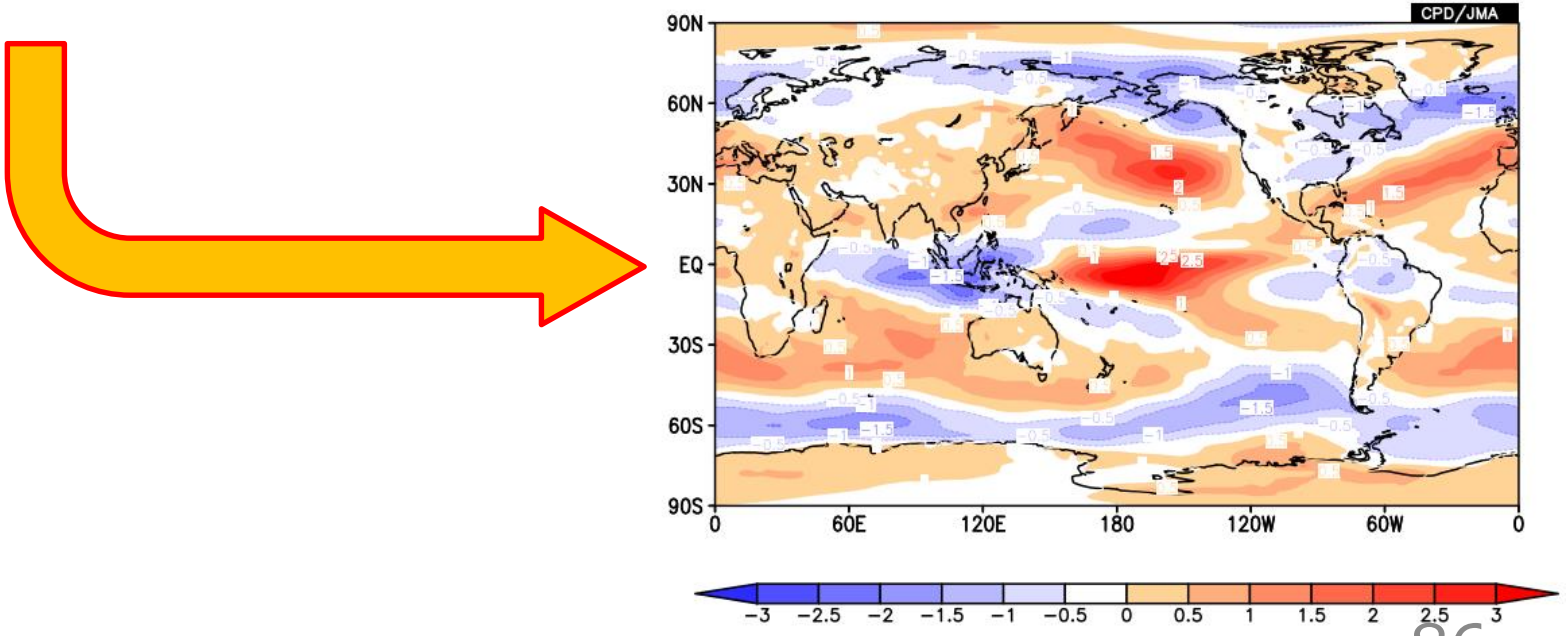
Composite analysis (3)

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

Graphic Options

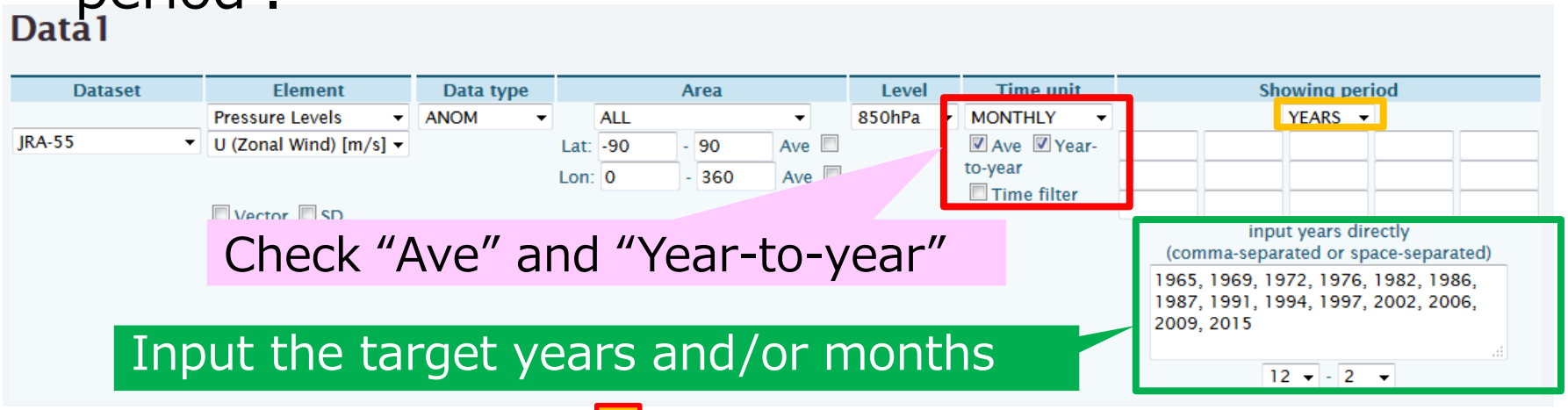
Colorizing: COLOR
Drawing: SHADE
Image Format: png
Font: default
Color Table: Blue - Red

Show Contour Labels
Show Color Bar
Set Contour Parameters for data1
interval: 0.5 min: -3 max: 3
Set Vector size: [inch] value: skip: 1

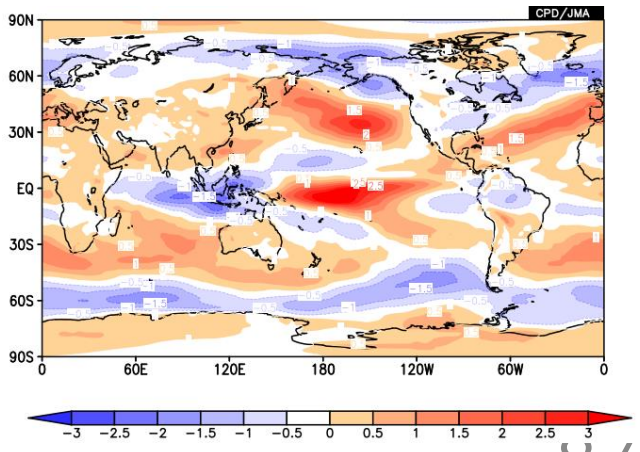


Composite analysis (4): “Another Way”

- 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”.

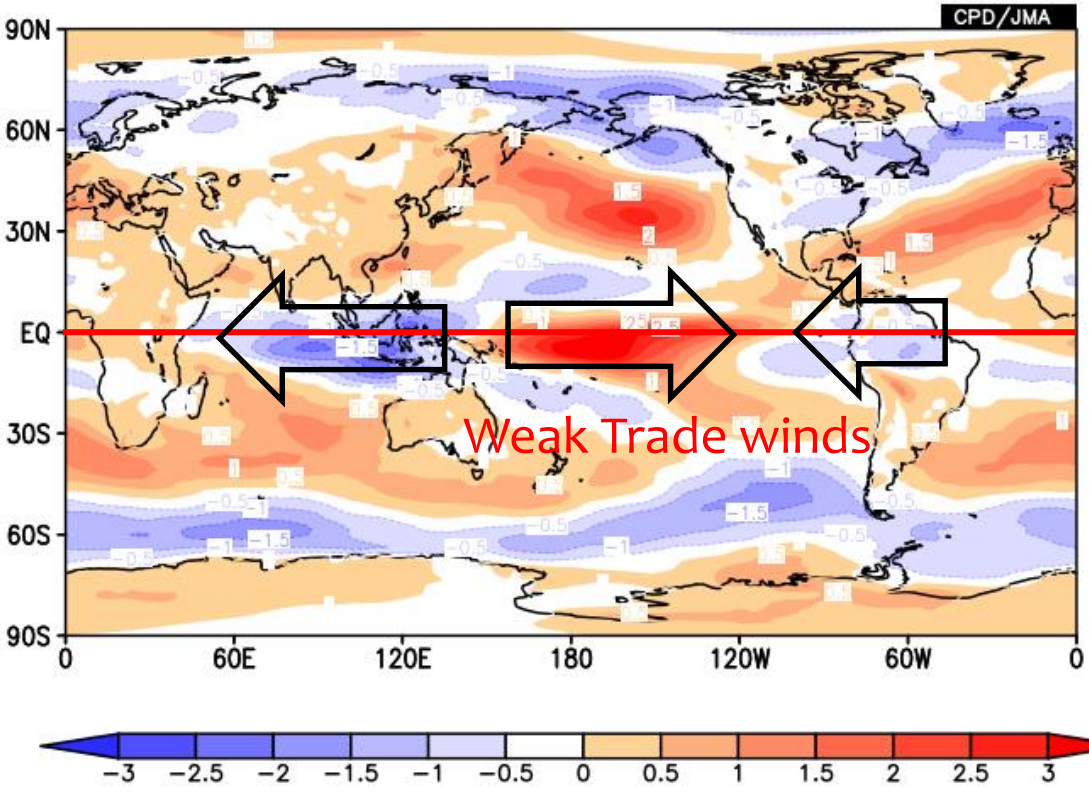


Composite of 850hPa westerly anomalies.



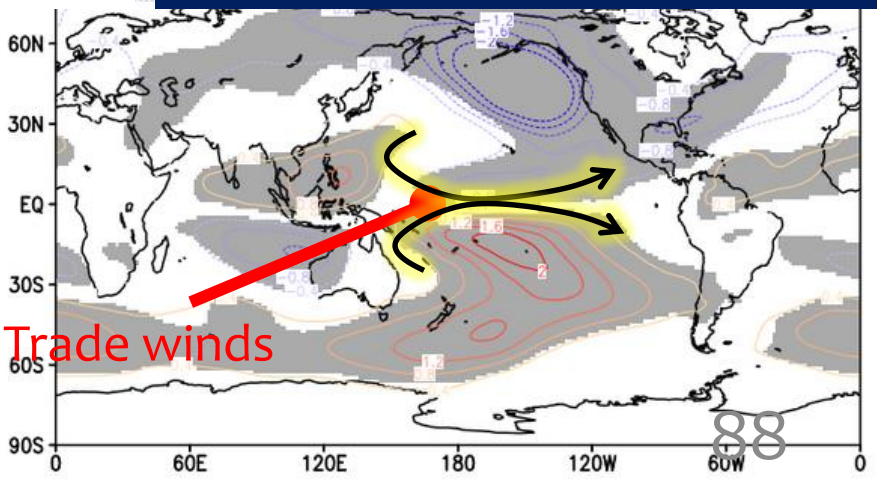
We can get same figure!!

Topics: Typical Anomalies associated with El Niño



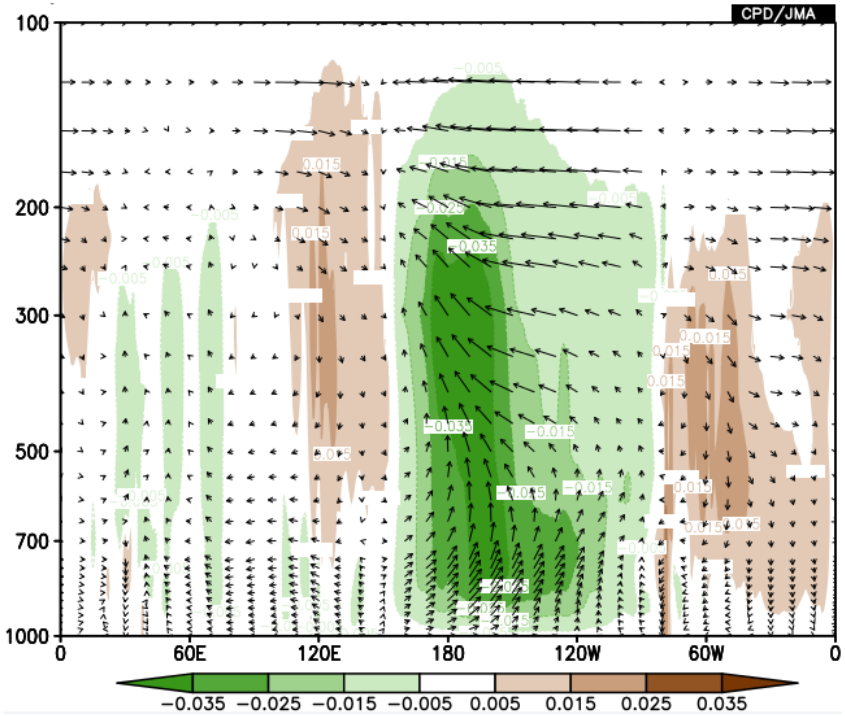
Of course the composite result is consistent with the corr. coeff. map we made just before.

Reg. Coeff. ψ850 onto NINO.3 SST anomalies (Ans. Of Exercise 6)



Exercise (7)

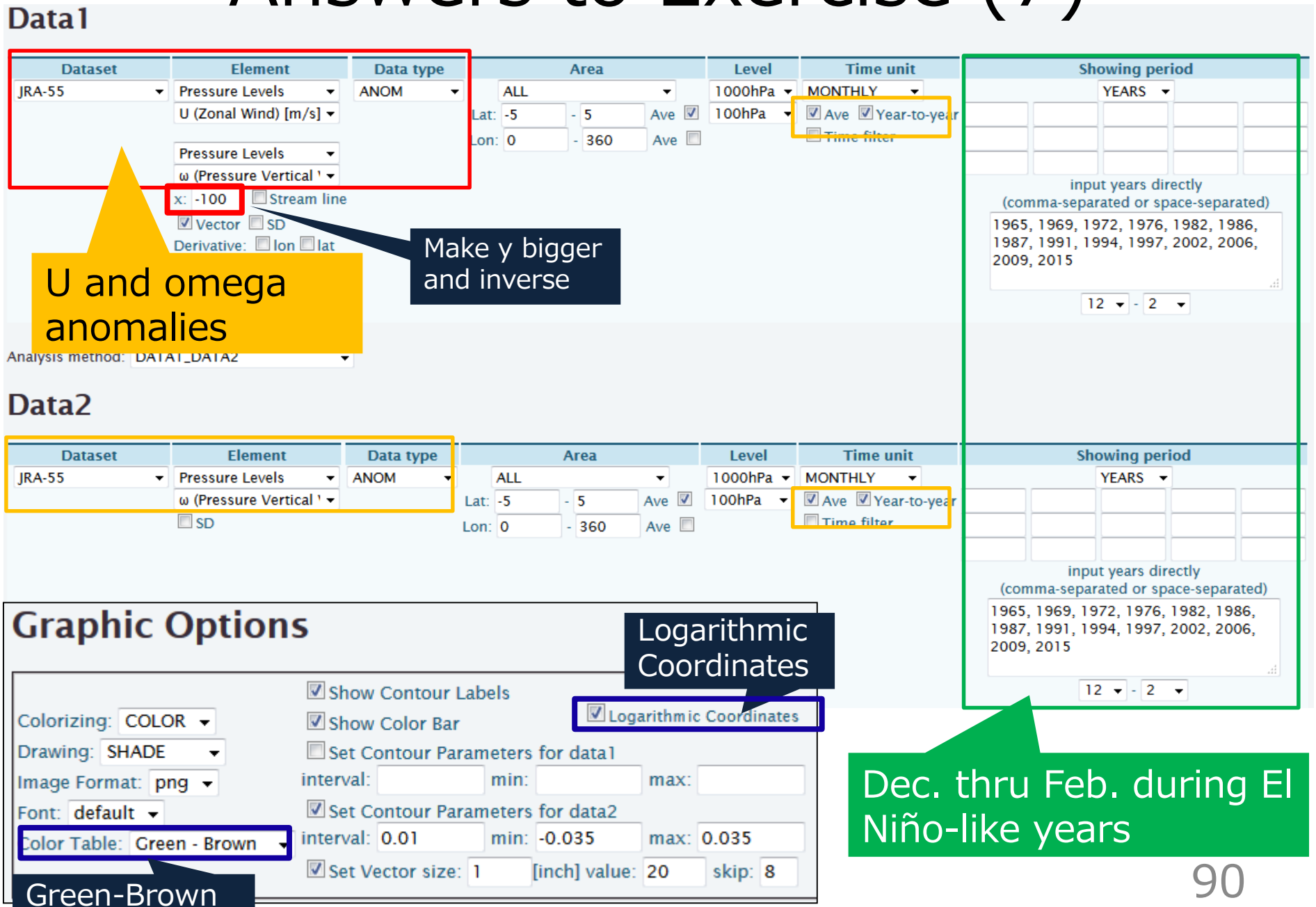
- Make a composite map of longitude-height cross section of zonal/vertical wind anomaly vector and vertical wind anomaly (shading) averaged from 5°S to 5°N for El Niño-like condition DJF.
  - The El Niño-like condition years are **1965, 1969, 1972, 1976, 1982, 1986, 1987, 1991, 1994, 1997, 2002, 2006,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



- Try to adjust vector scale and skip interval to improve the visibility of the figure.
- Be aware of the direction of ω [Pa/s] vector.
- Select “Green-Brown” for “Color Table”.

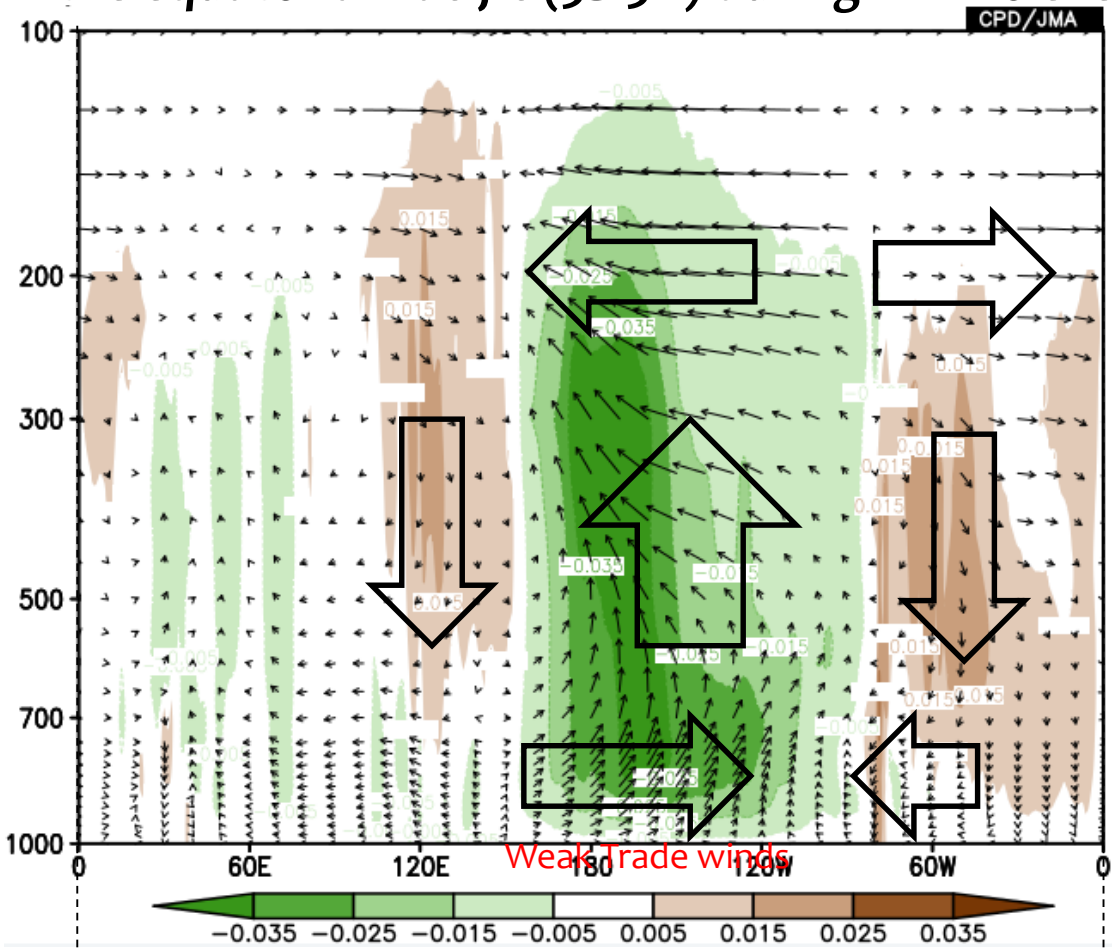
Composite of wind anomalies along the equator in DJF during El Niño years.

Answers to Exercise (7)

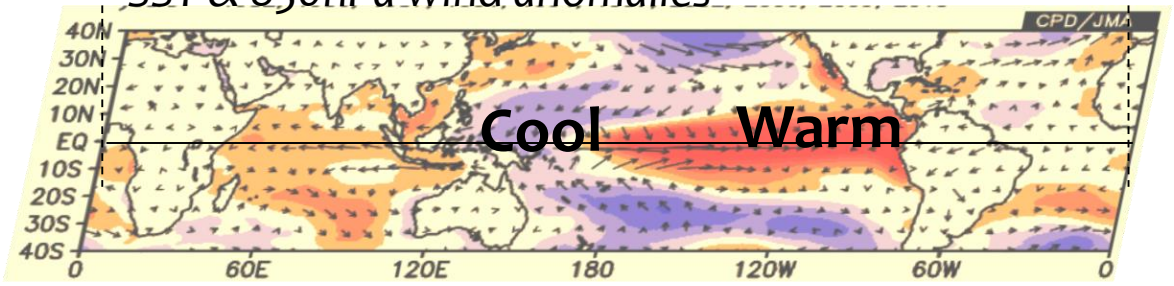


Topics: Ocean-Atmosphere Coupled System

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 !

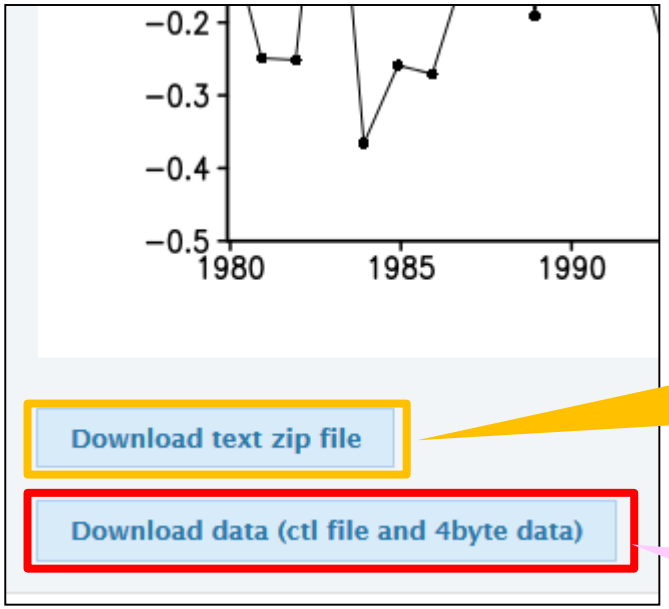
Contents

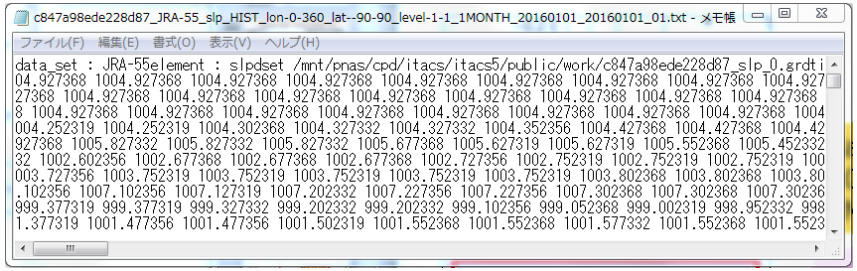
4. Statistical Analysis in iTacs
   - Introduction
   - Regression / Correlation Analysis
   - Composite Analysis

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://cola.gmu.edu/grads/)
(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

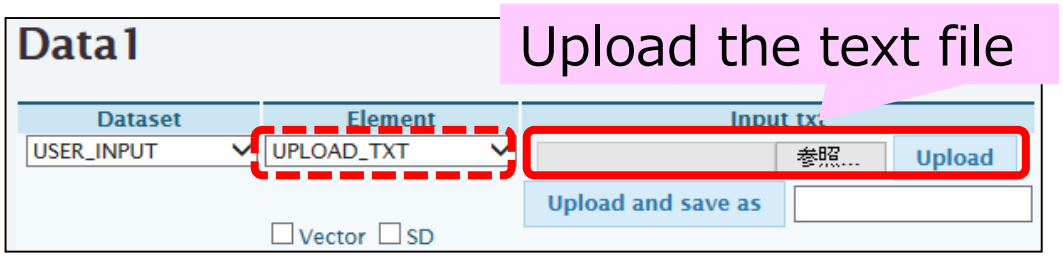
```
#Daily temperature
#undef = 9999
#element = Daily Ts
2013,07,01,23.6
2013,07,02,24.3
2013,07,03,24.5
2013,07,04,9999
2013,07,05,27.4
2013,07,06,28.9
```

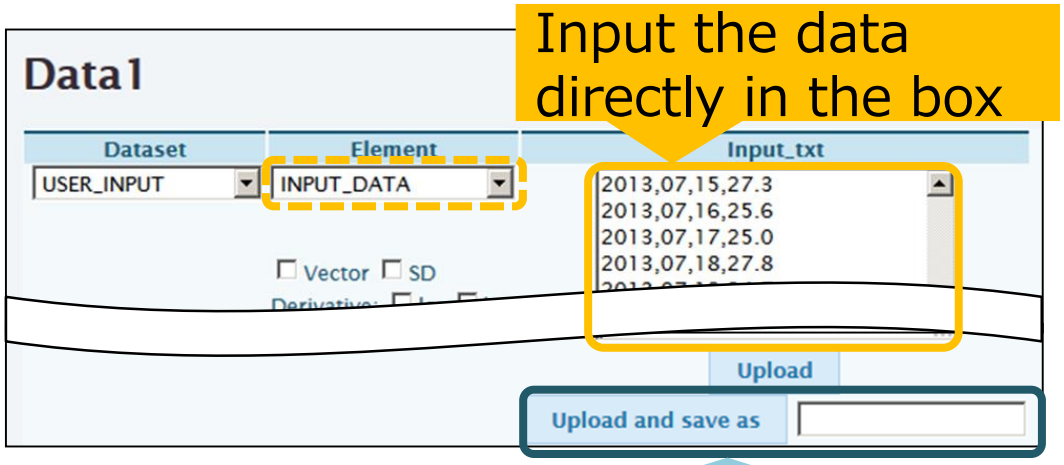
<Data format>

- **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)

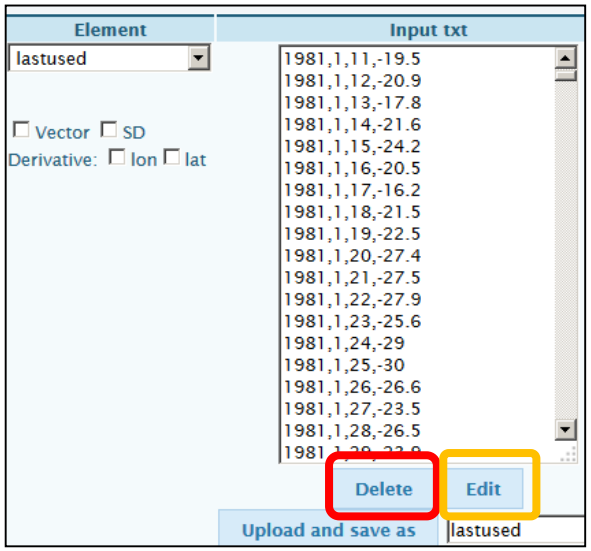
- Upload/input the data





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

- Control the uploaded data

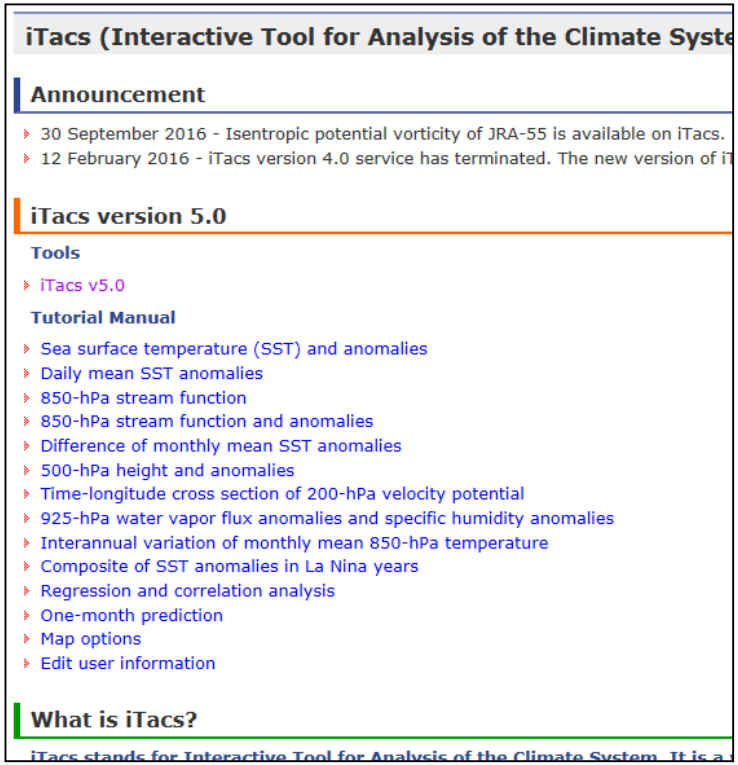


- Select the data name and click “Delete” button to delete the data from the server.
- Click “Edit” button to edit the data in the box.

To learn more about iTacs

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

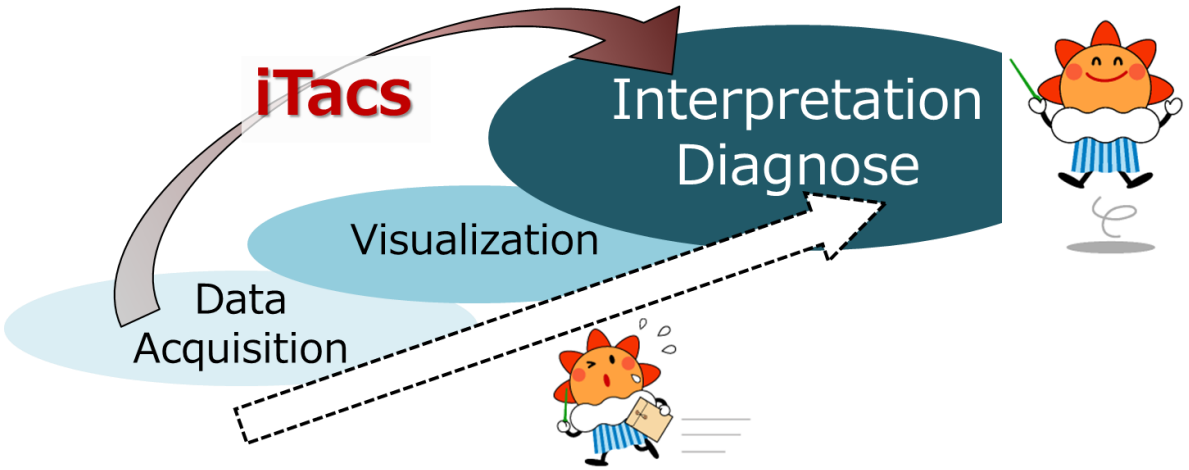
- Turorial: http://extreme.kishou.go.jp/tool/itacs-tcc2015/
- Help page: http://extreme.kishou.go.jp/itacs5/assets/help.html



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



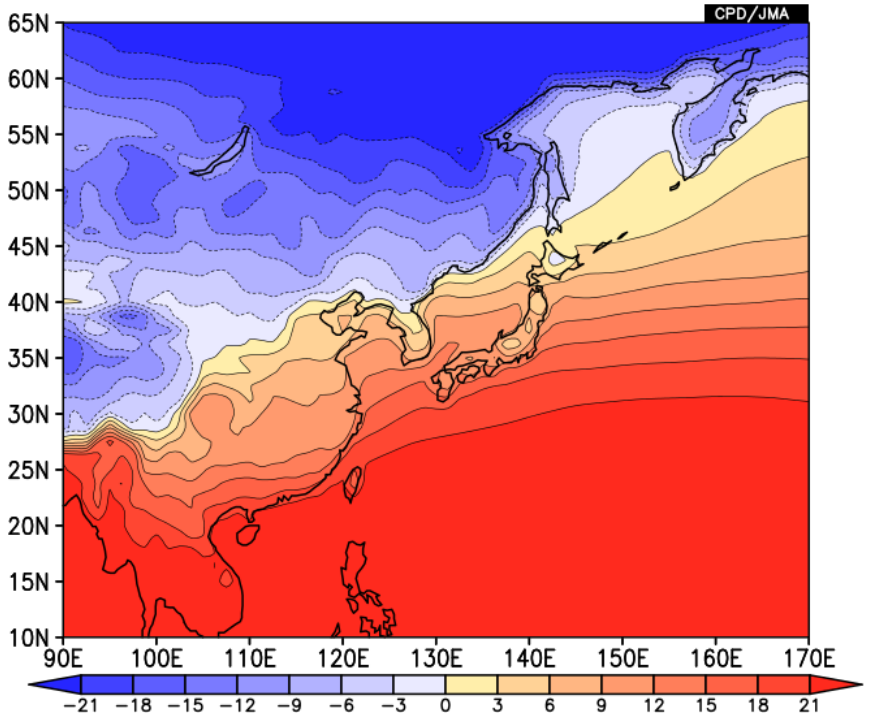
References

- 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.

Integrated Exercise (1)

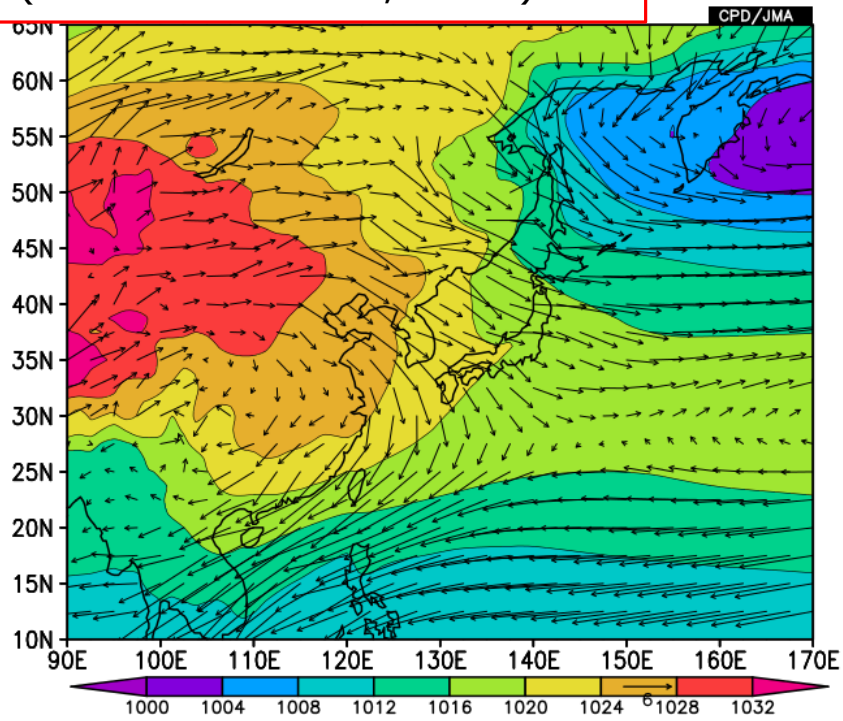
- Check the normal fields around your country with iTacs. These are examples focusing on Japan.

Normal of surface temp.
(10 Nov. – 7 Dec., 2017)



* Here, “Normal” means climatological normal averaged from 1981 to 2010.

Normal of 925hPa wind and SLP
(10 Nov. – 7 Dec., 2017)

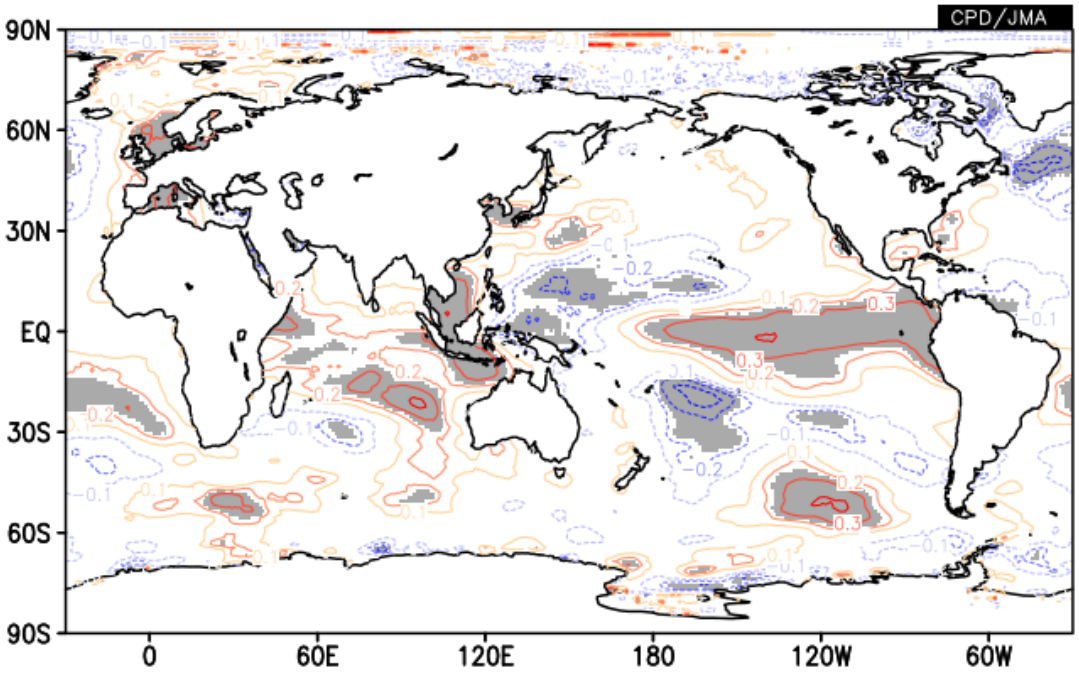


The example of drawing vectors with shade can be found in Exercise (3).

Integrated Exercise (2)

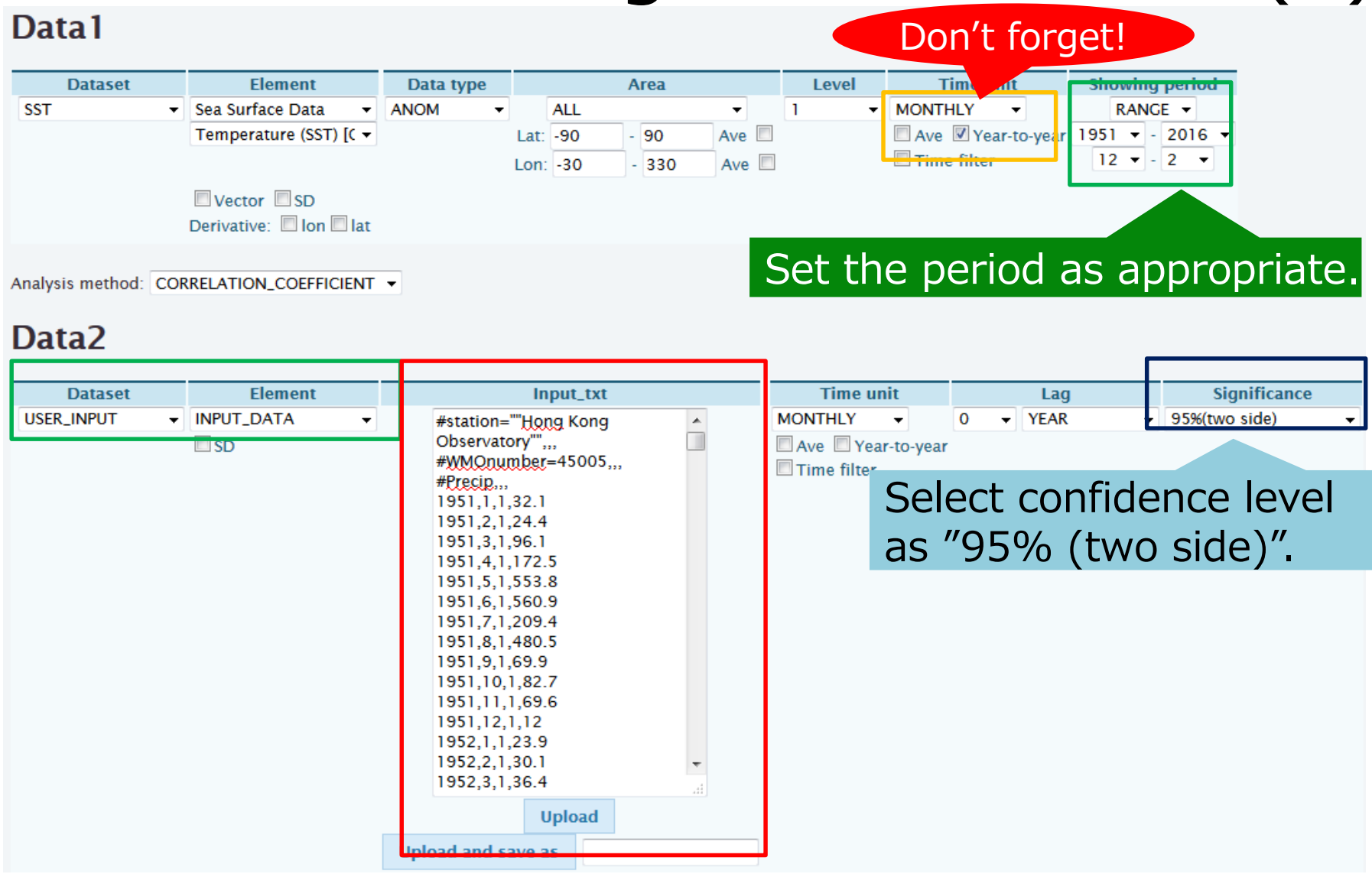
- Let's make a correlation map between monthly precipitation data you prepared and global SST anomaly for a specific calendar month(s). Set the period as appropriate.
  - Use "USER_INPUT" method. Set the confidence level **95% (two side)**.

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



Hint: check Excercises (6).
But in this case, select "Analysis method" for correlation coefficient.

Answers to Integrated Exercise (2)

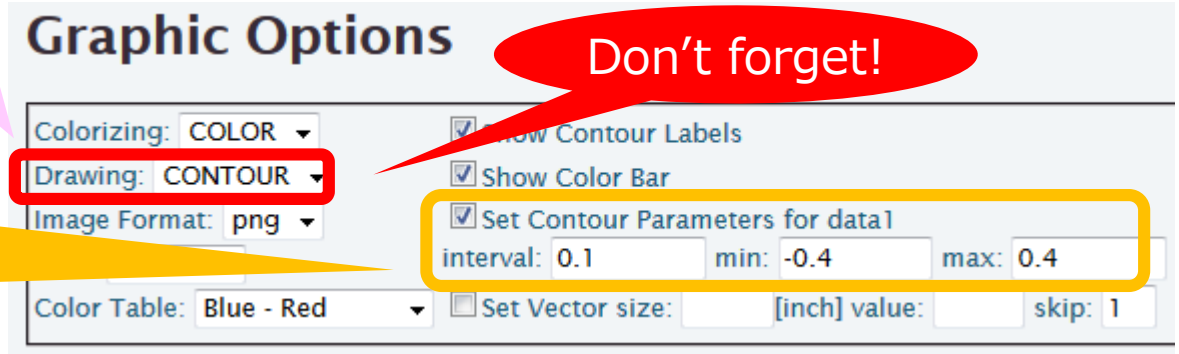


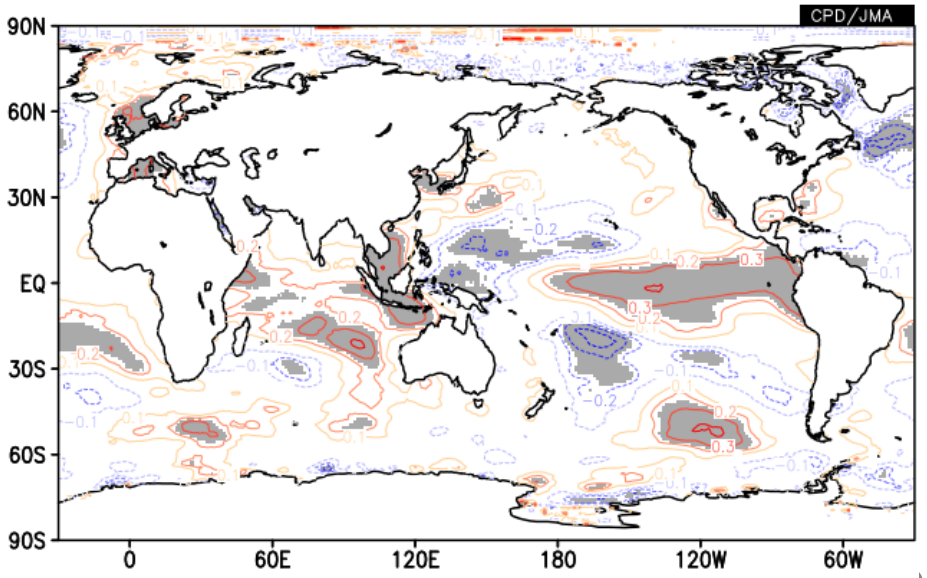
Answers to Integrated Exercise (2)

- Setting Graphic Options.

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

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





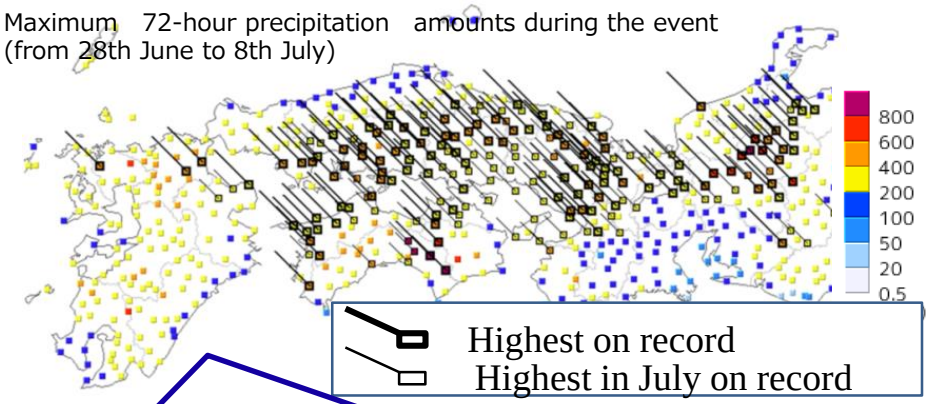
Exercise (8)

- This summer, especially in July, two record phenomena occurred in Japan.

Early July

Record precitipation was obserbed over wide areas

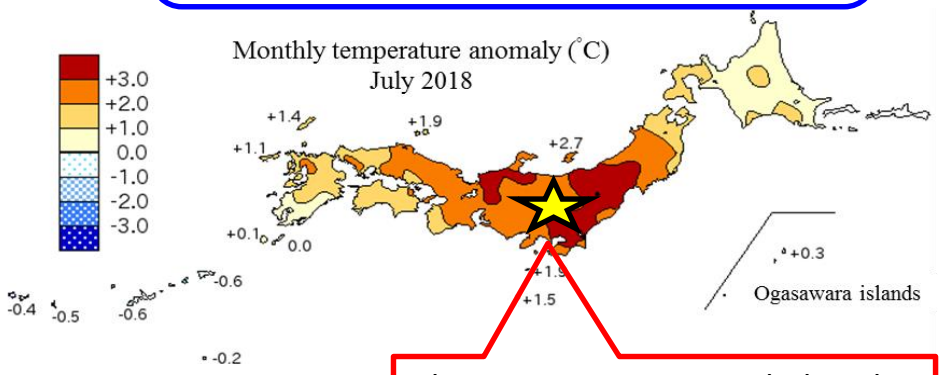
Maximum 72-hour precipitation amounts during the event (from 28th June to 8th July)



Also 72-hour precipitation amounts on 7th July averaged over Japan was **the highest since 1988**.

After mid-July

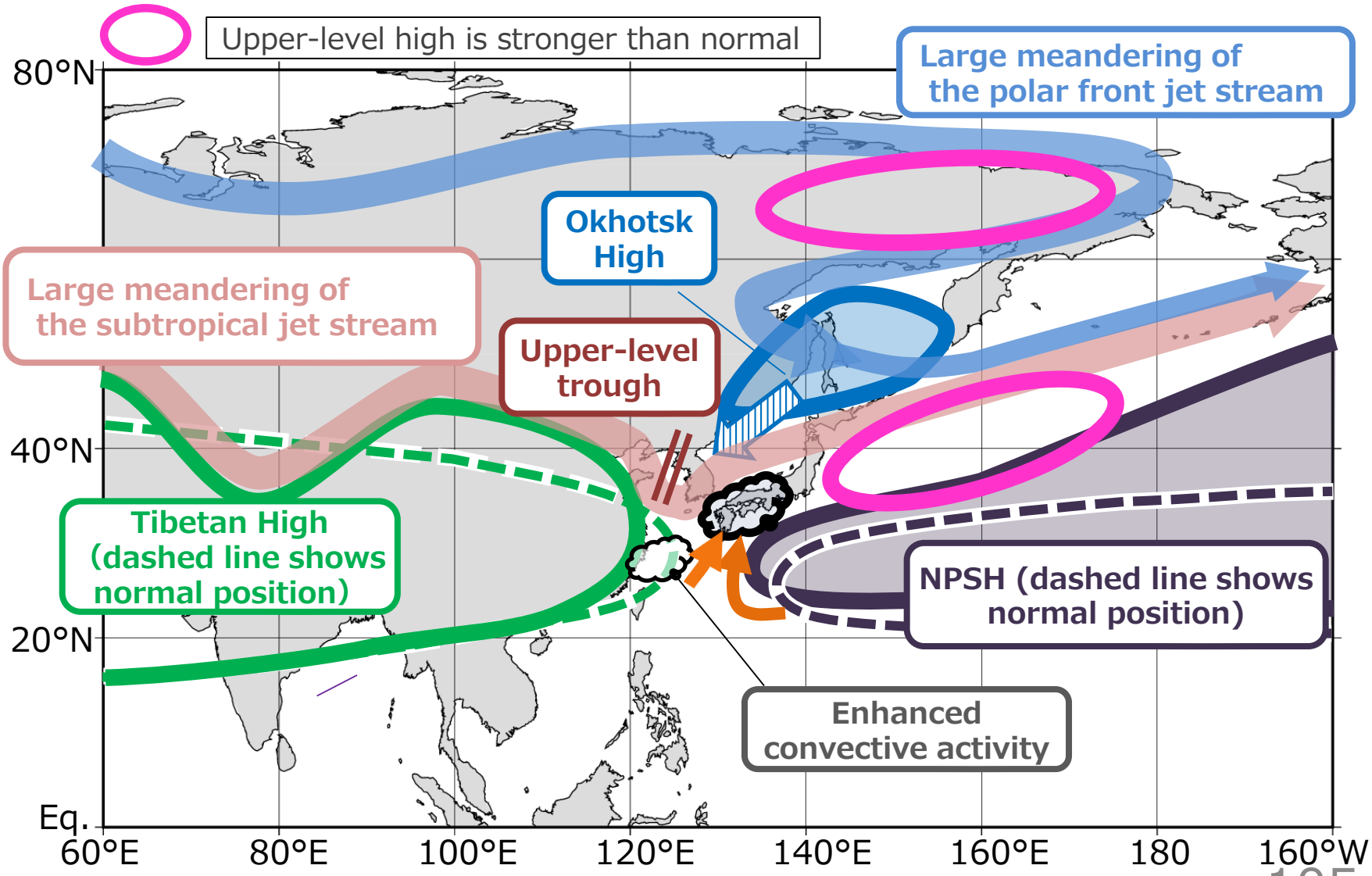
temperature anomaly of July in Eastern Japan was 2.8°C **(the highest since 1946)**



Also 41.1°C was recorded in the Saitama Prefecture on 23rd July.

Exercise (8)

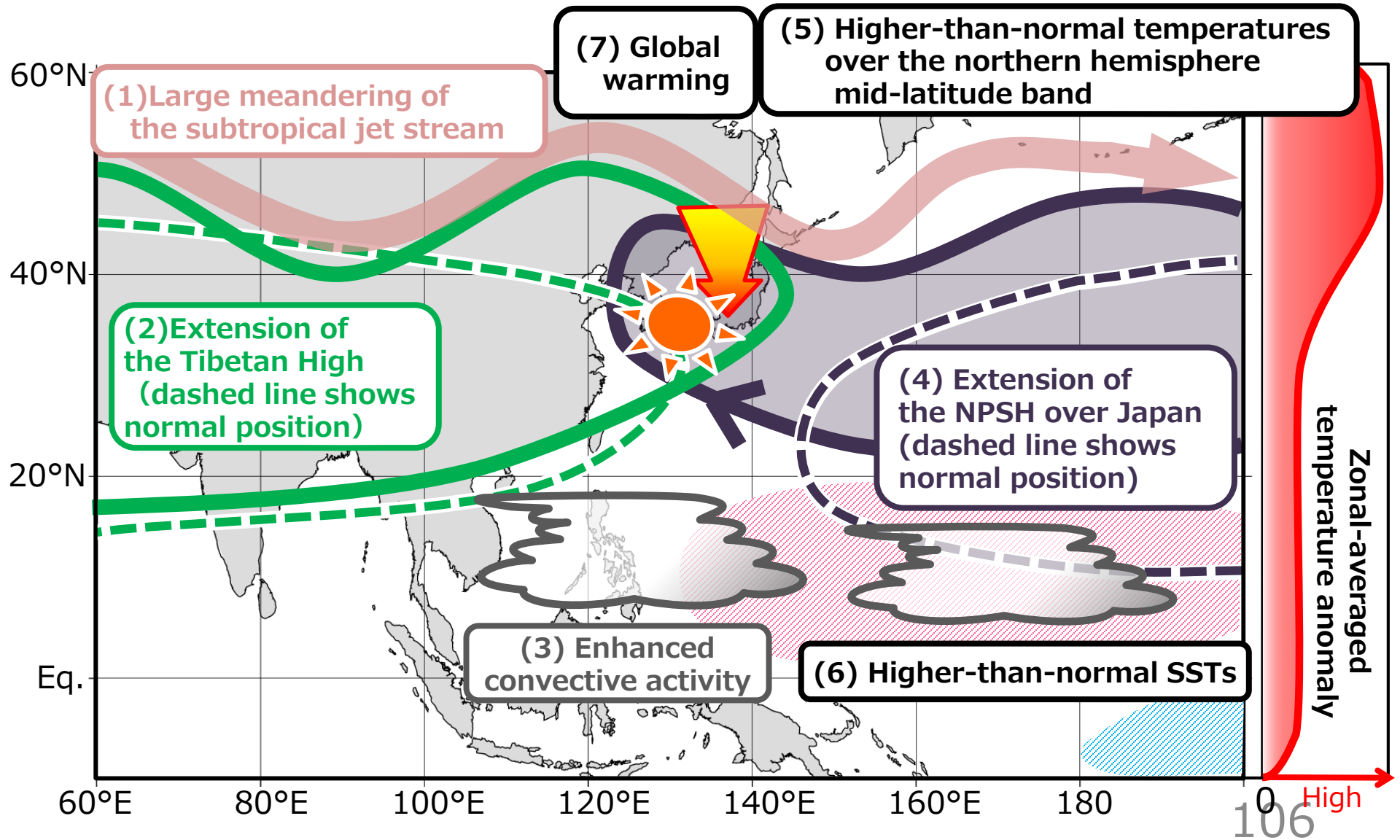
- Primary factors behind the unprecedentedly heavy rain



NPSH: the North Pacific Subtropical High

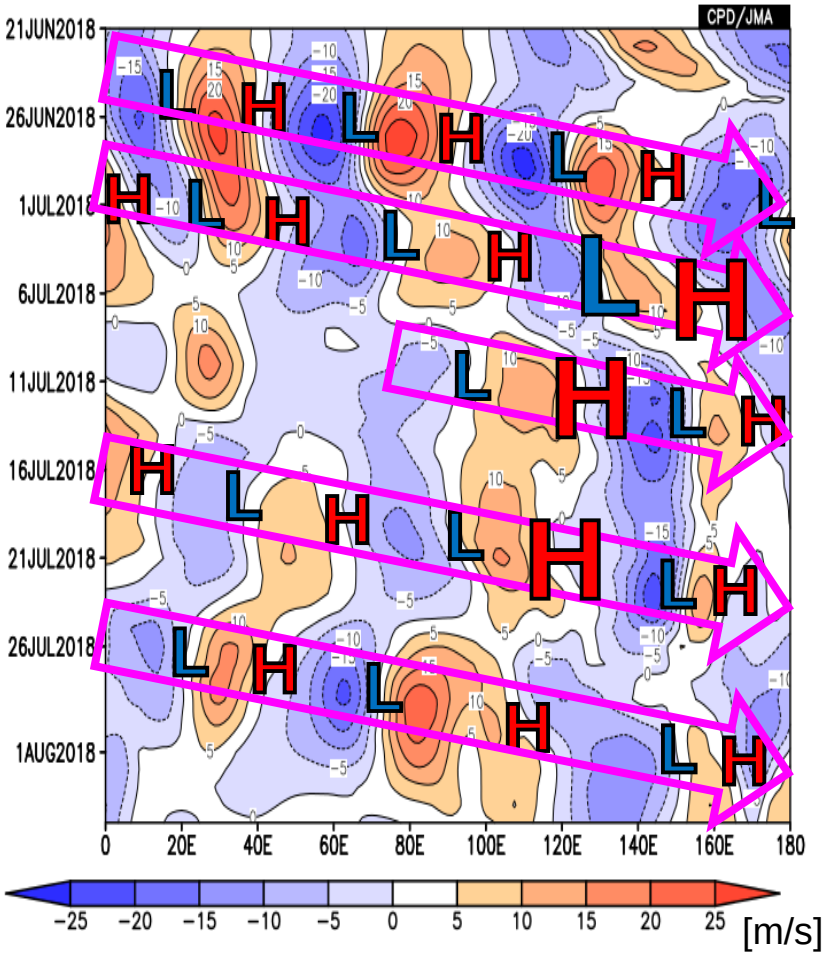
Exercise (8)

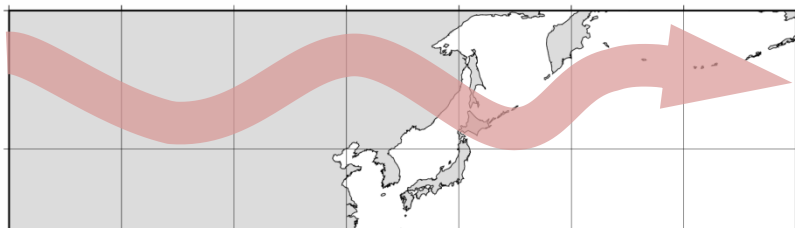
- Primary factors behind the unprecedentedly hot conditions



Exercise (8)

- Now we want to focus on one factor which afftected the two phenomena. That is the stationary Rossby wave along subtropical jet stream, which made significant and persistent meandering jet over East Asia.





Try to make the Longitude-time cross section of 5-days running mean meridional wind anomalies at 200hPa in the latitude 35N-45N from 21st June to 5th August.

- This is just the advanced exercise of Exercise (5).

Answer to Exercise (8)

Data1

Dataset	Element	Data type	Area	Level	Time unit	Showing period
JRA-55	Pressure Levels	ANOM	ALL	200hPa	DAILY	RANGE
	V (Meridional Wind) |		Lat: 35 - 45 Ave ☑	200hPa	☐ Ave ☐ Year-to-year	2018 6 21
			Lon: 0 - 180 Ave ☐		☑ Time filter	2018 8 5
					Running mean	
	☐ Vector ☐ SD					
	Derivative: ☐ lon ☐ lat				mean period 5	

Graphic Options

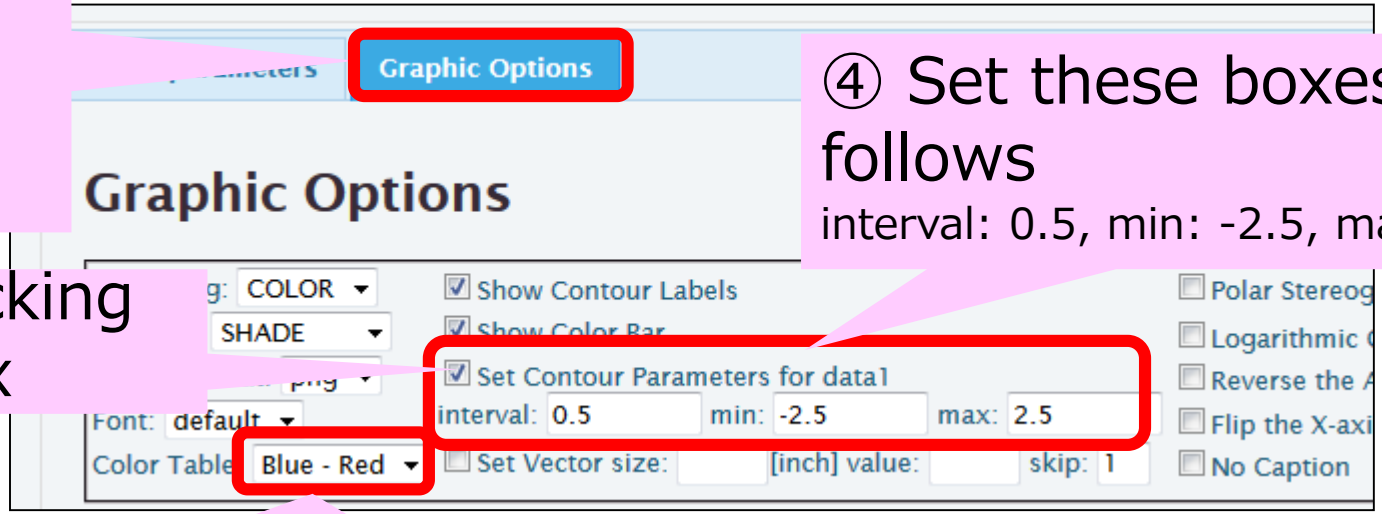
Colorizing: COLOR	☑ Show Contour Labels	
Drawing: SHADE	☑ Show Color Bar	
Image Format: png	☑ Set Contour Parameters for data1	
Font: default	interval: 5	min: -25 max: 25
Color Table: Blue - Red	☐ Set Vector size: [inch] value:	skip: 1

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"



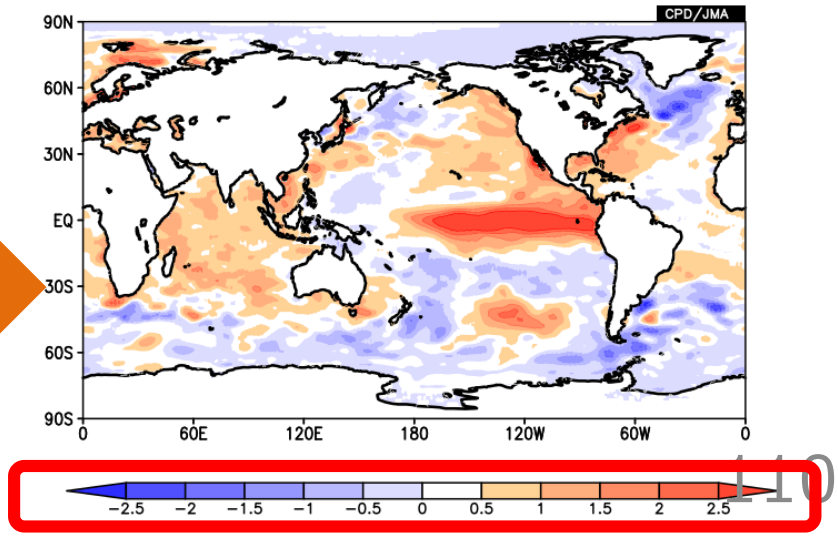
④ Set these boxes as follows
interval: 0.5, min: -2.5, max: 2.5

③ Checking this box

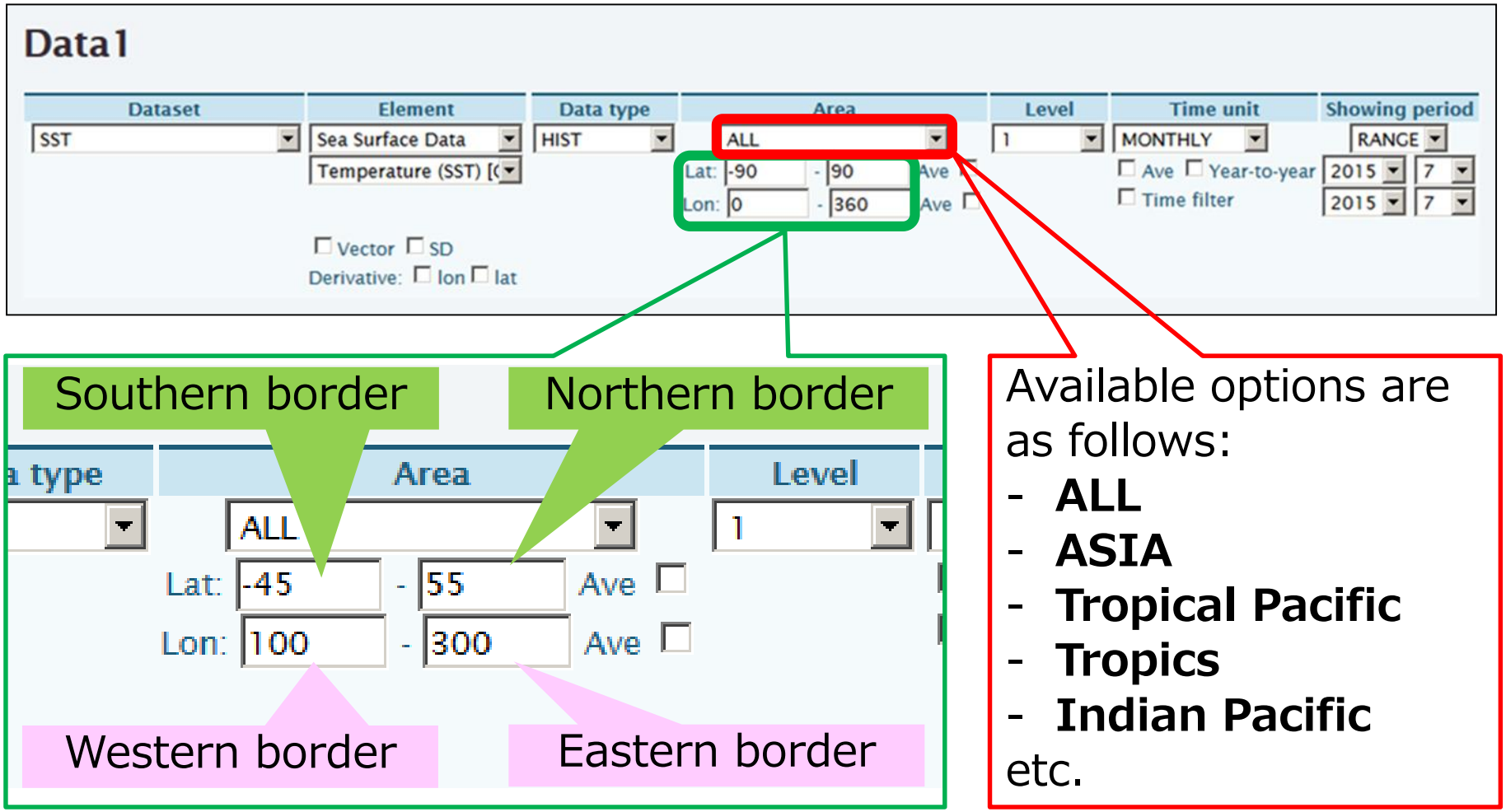
② Select "Blue - Red"

Click!

Analysis Data Submit



Area setting (1)

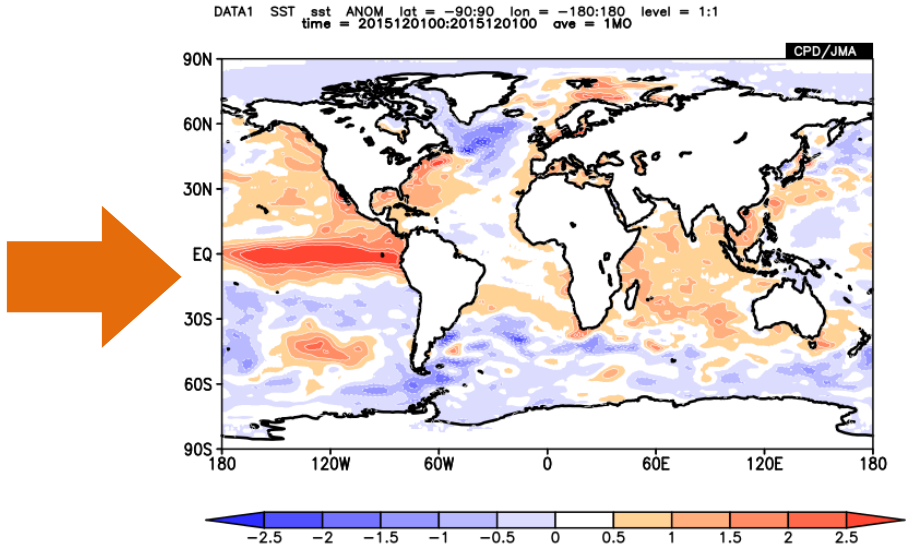


Setting boxes will appear in the “Area” field and after selection for more precise area adjustment.

Area setting (2)

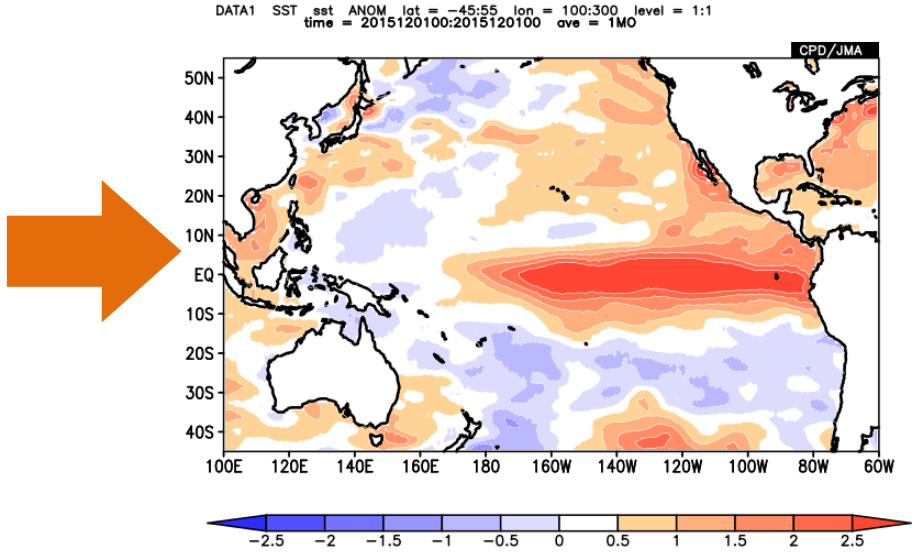
- Shift the area

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.

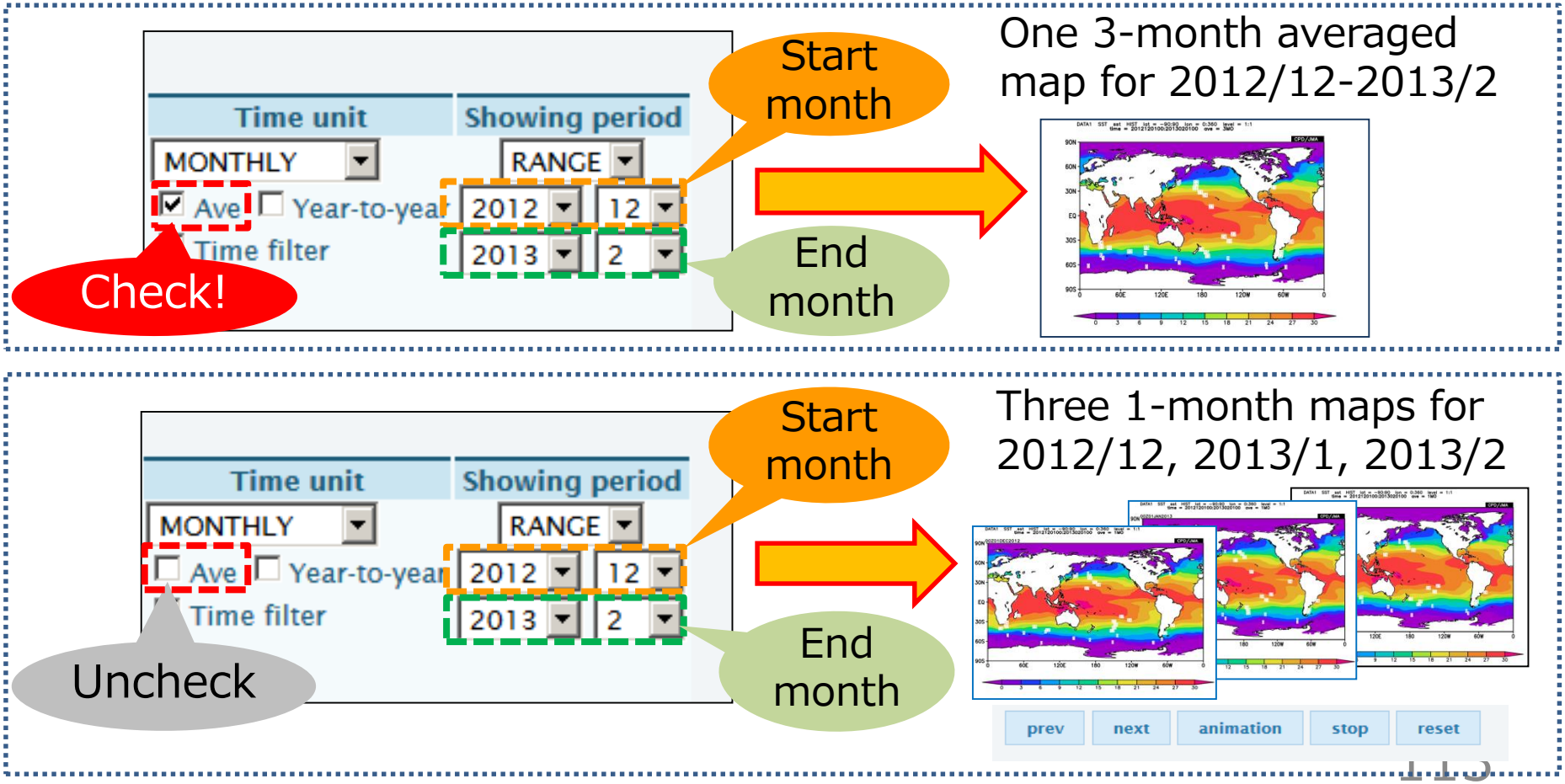
Time setting (1)

- 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



Time setting (2)

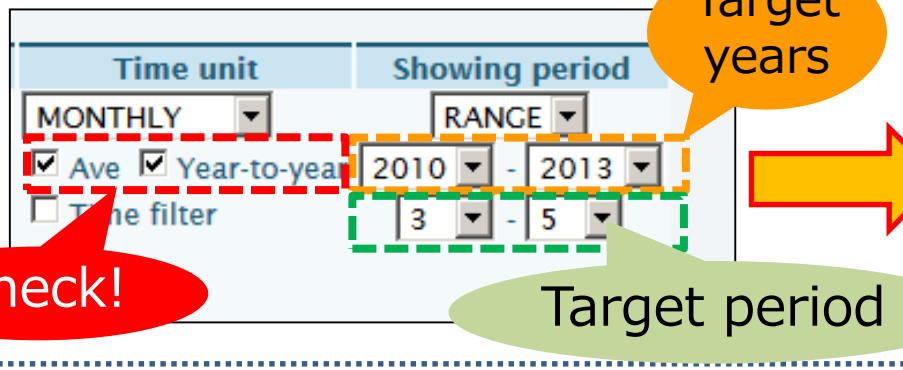
- Setting for **a specific period of each year.**

Target years

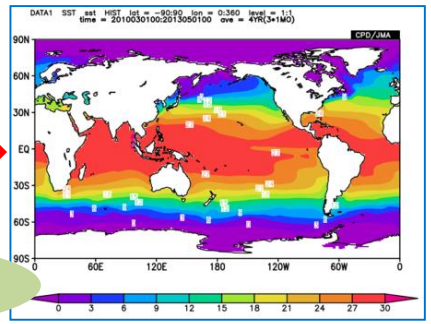
<Calendar>
2010 : J F M A M J J A S O N D
2011 : J F M A M J J A S O N D
2012 : J F M A M J J A S O N D
2013 : J F M A M J J A S O N D

Target period

Check "Year-to-year"

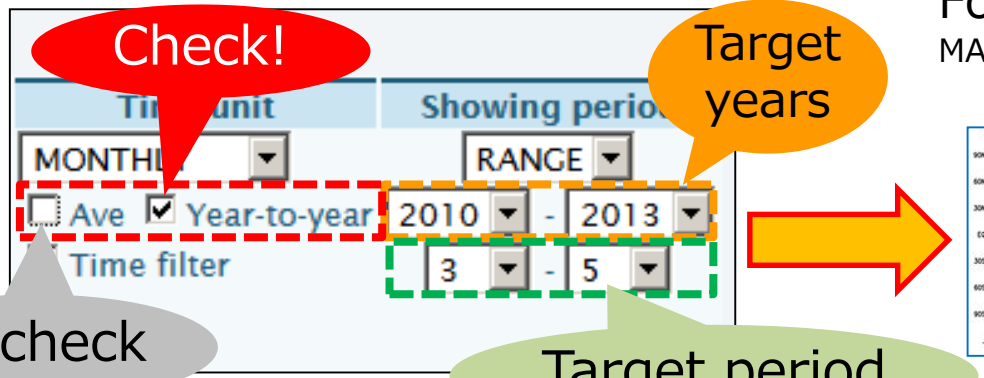


One 4-year-MAM averaged map



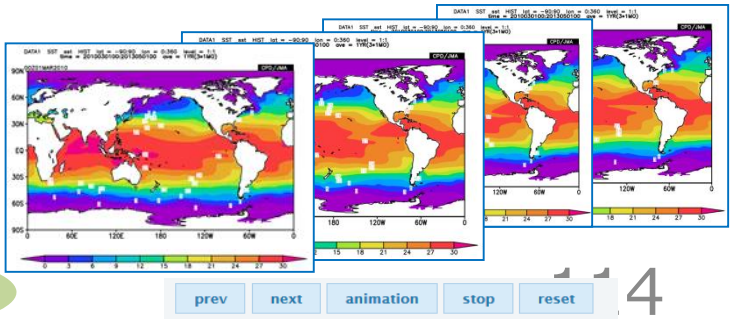
MAM 2010
MAM 2011
MAM 2012
MAM 2013

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.

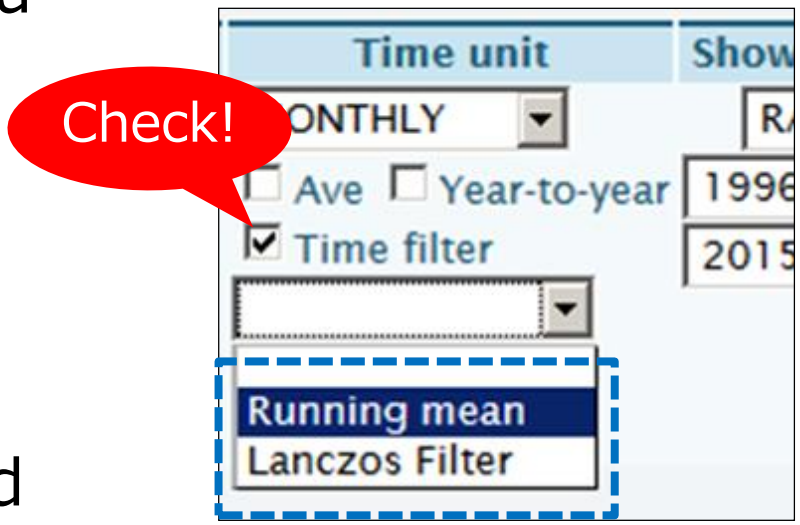
Analysis method	Mapped value	Usage example
ADD	Addition (“Data1” plus “Data2”)	–
SUBTRACT	Difference (“Data1” minus “Data2”)	Time difference, vertical shear.
MULTIPLY	Multiplication (“Data1” times “Data2”)	–
DIVIDE	Division (“Data1” divided by “Data2”)	Precipitation ratios (“HIST” divided by “NORM”).

Time filter

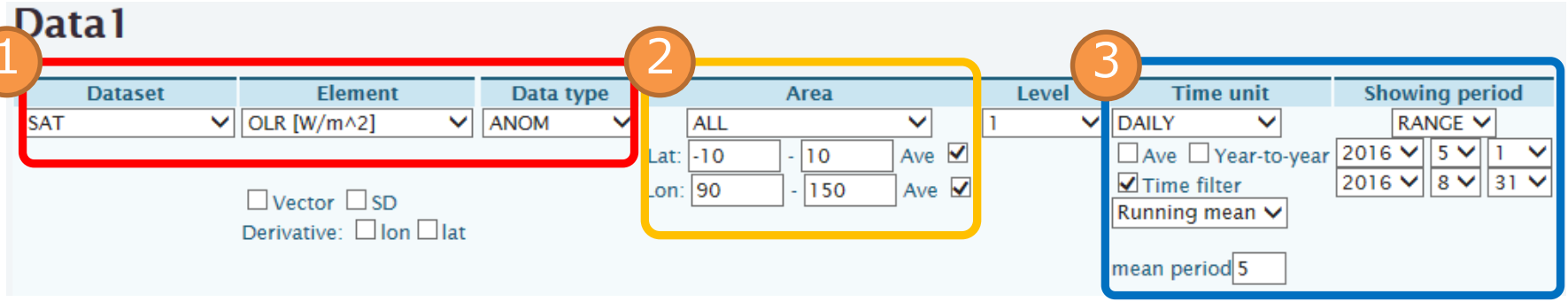
- Time filter should be used to create a time series image in the climate analysis.
- Climatological events are emphasized by a time filter, because it can remove high frequency variations.

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).

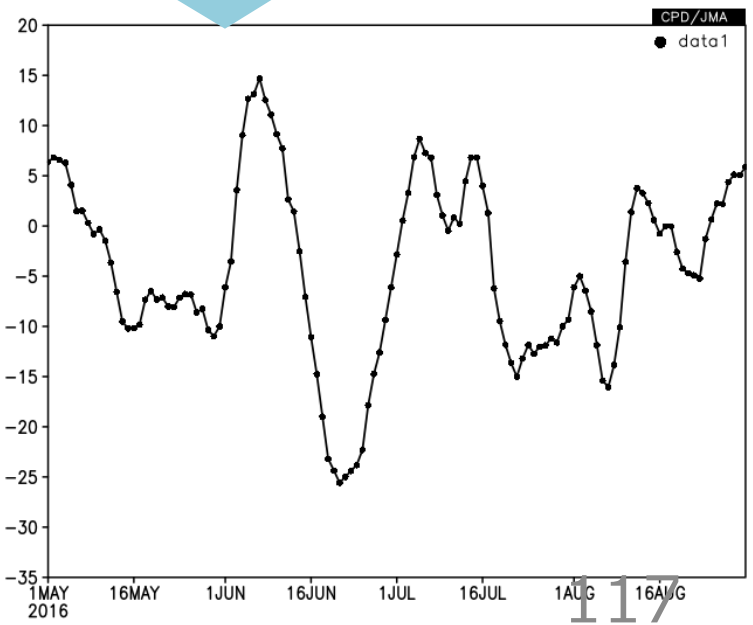


Running mean daily timeseries



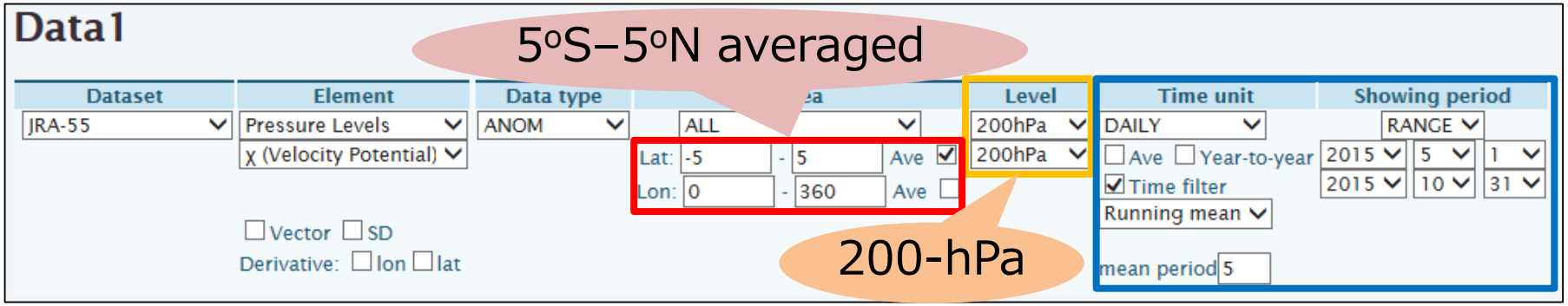
1. Select OLR anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - Check "Ave" boxes.
3. Select "DAILY" for time unit, and showing period.
   - Showing period: 1 May 2016 – 31 Aug. 2016.
   - Check "Time filter" in time unit box, and select "Running mean" and "5(day)" in "mean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

5-day running mean daily timeseries of OLR anomalies



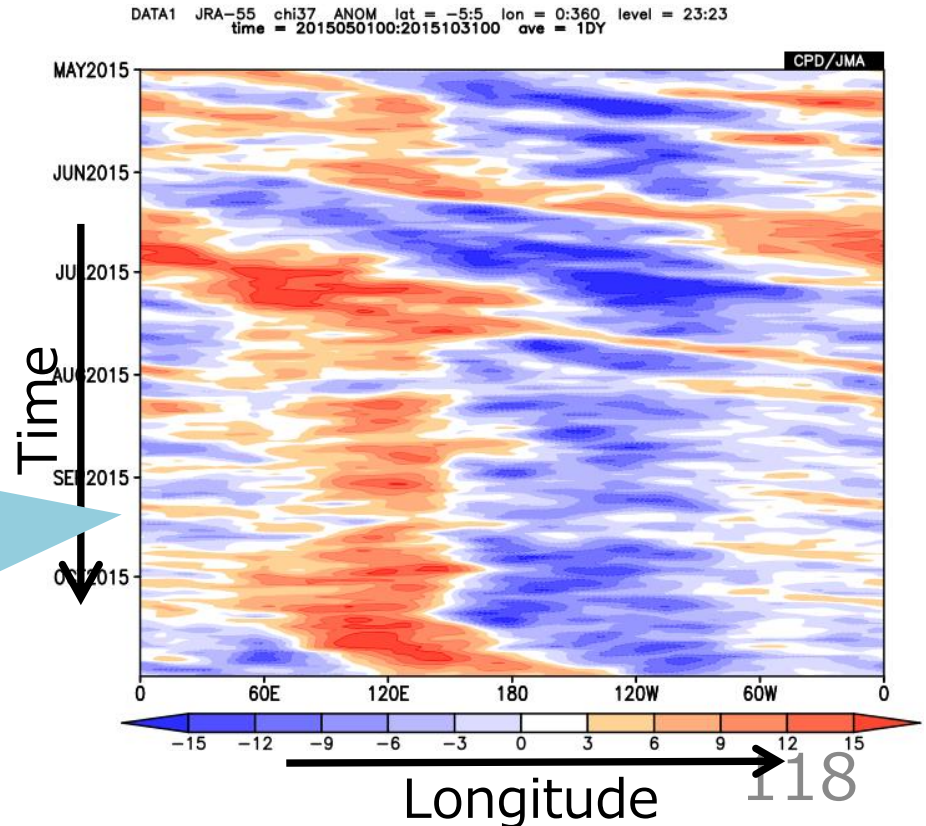
Time cross section

- Running mean longitude-time cross section

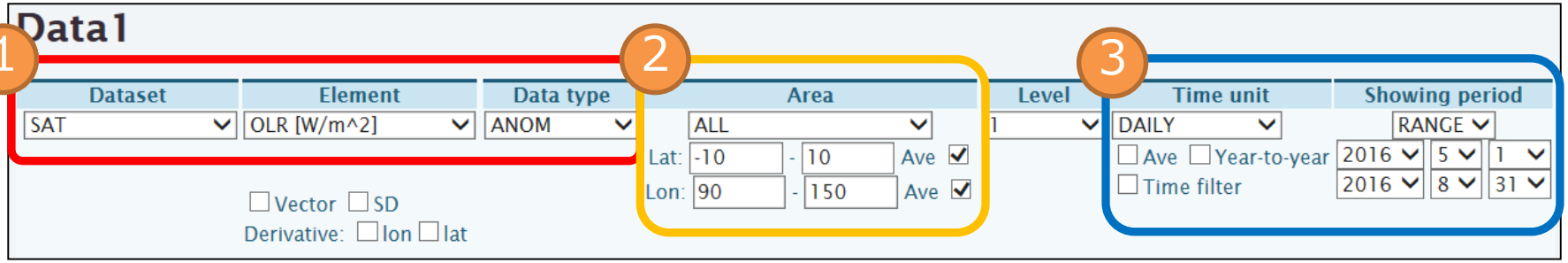


1. Select 5°S–5°N mean 200-hPa velocity potential anomalies.
2. Set 5-day running mean in “Time unit” box.

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.

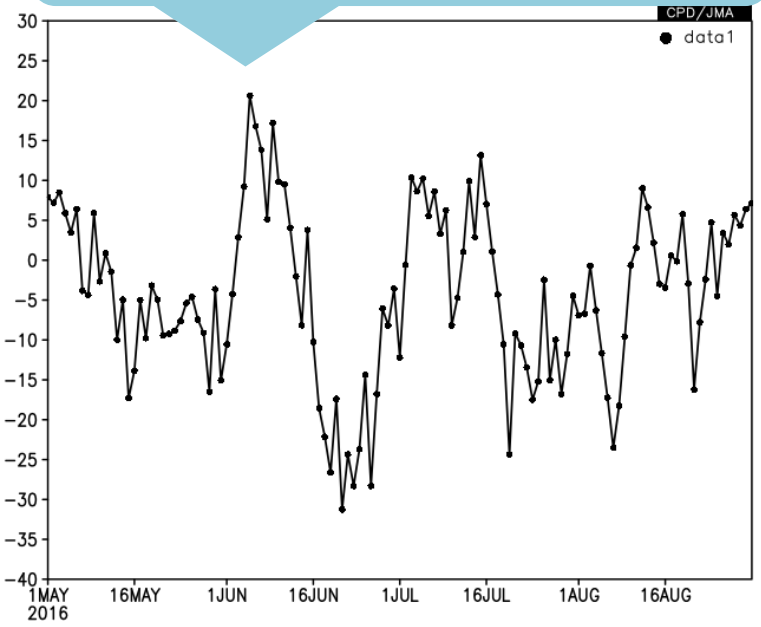


Daily timeseries



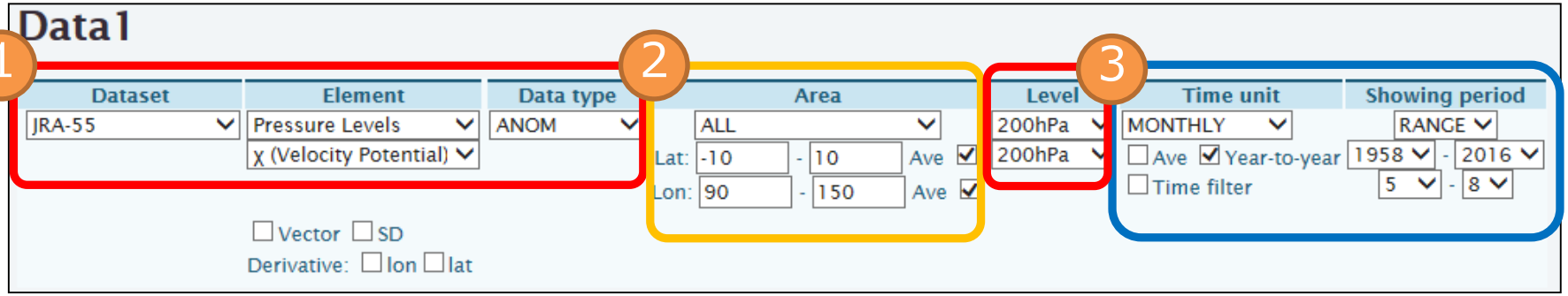
1. Select OLR anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - The area covers the Maritime continent.
   - Check "Ave" boxes.
3. Select "DAILY" for time unit, and showing period
   - Showing period: 1 May 2016 – 31 Aug. 2016.

Daily timeseries of OLR anomalies



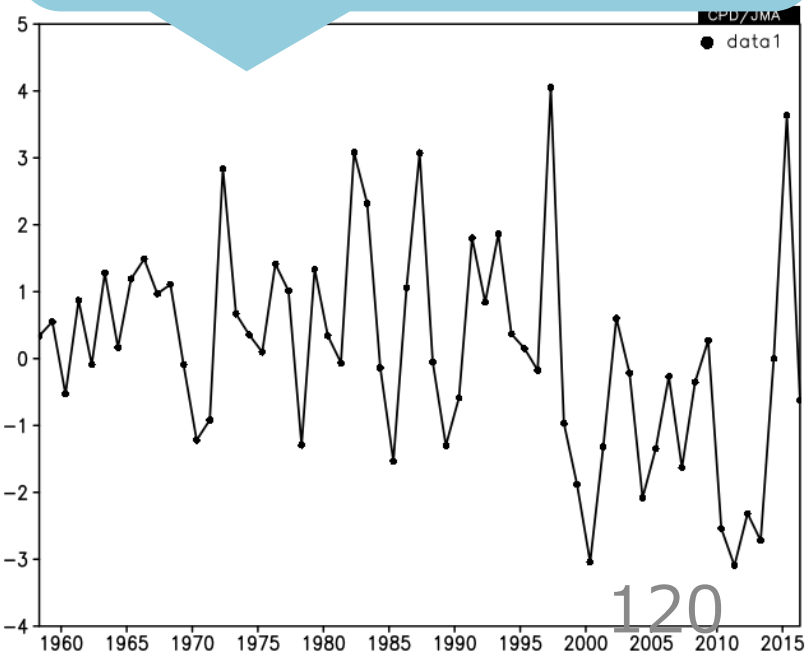
- Similarly, you can draw monthly or annual timeseries by setting "Time unit".

Inter-annual timeseries



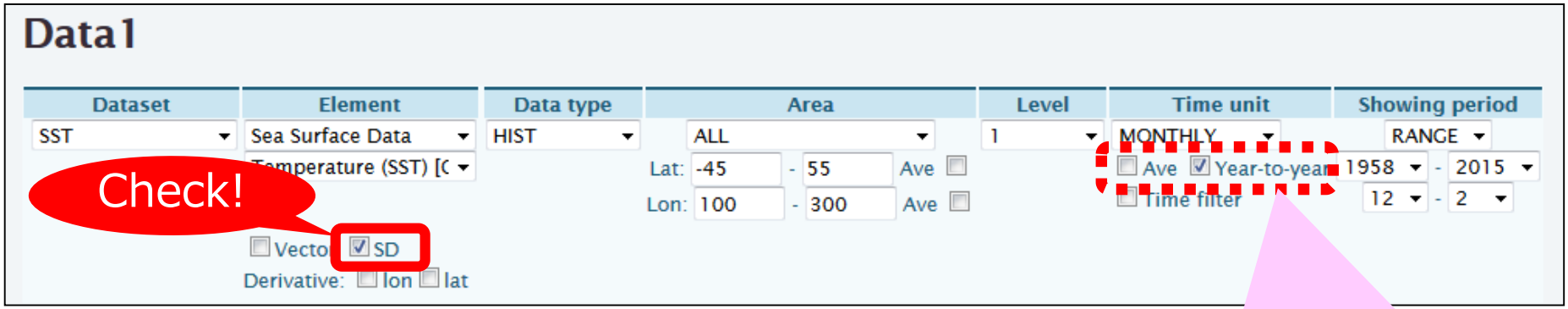
1. Select 200-hPa velocity potential anomalies for element boxes.
2. Select 10°S–10°N, 90°–150°E for "Area" box.
   - The area covers the Maritime continent.
   - Check "Ave" boxes.
3. Select "MONTHLY" for time unit, and showing period
   - Check "Year-to-year".
   - Showing period: 1958 – 2016, 5 –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

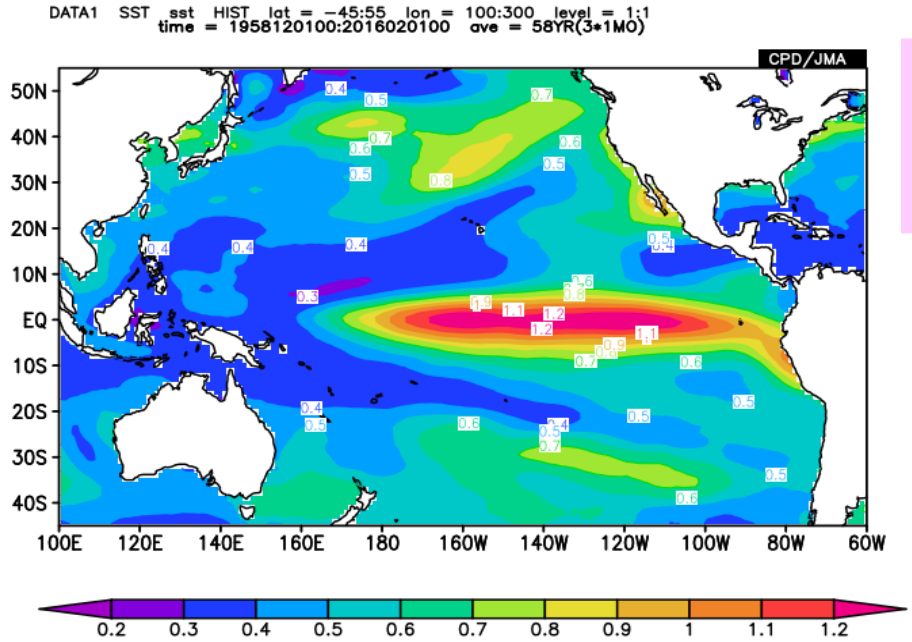
Inter-annual timeseries of 4-month (May – August) mean 200-hPa velocity potential anomalies



Standard deviation map

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





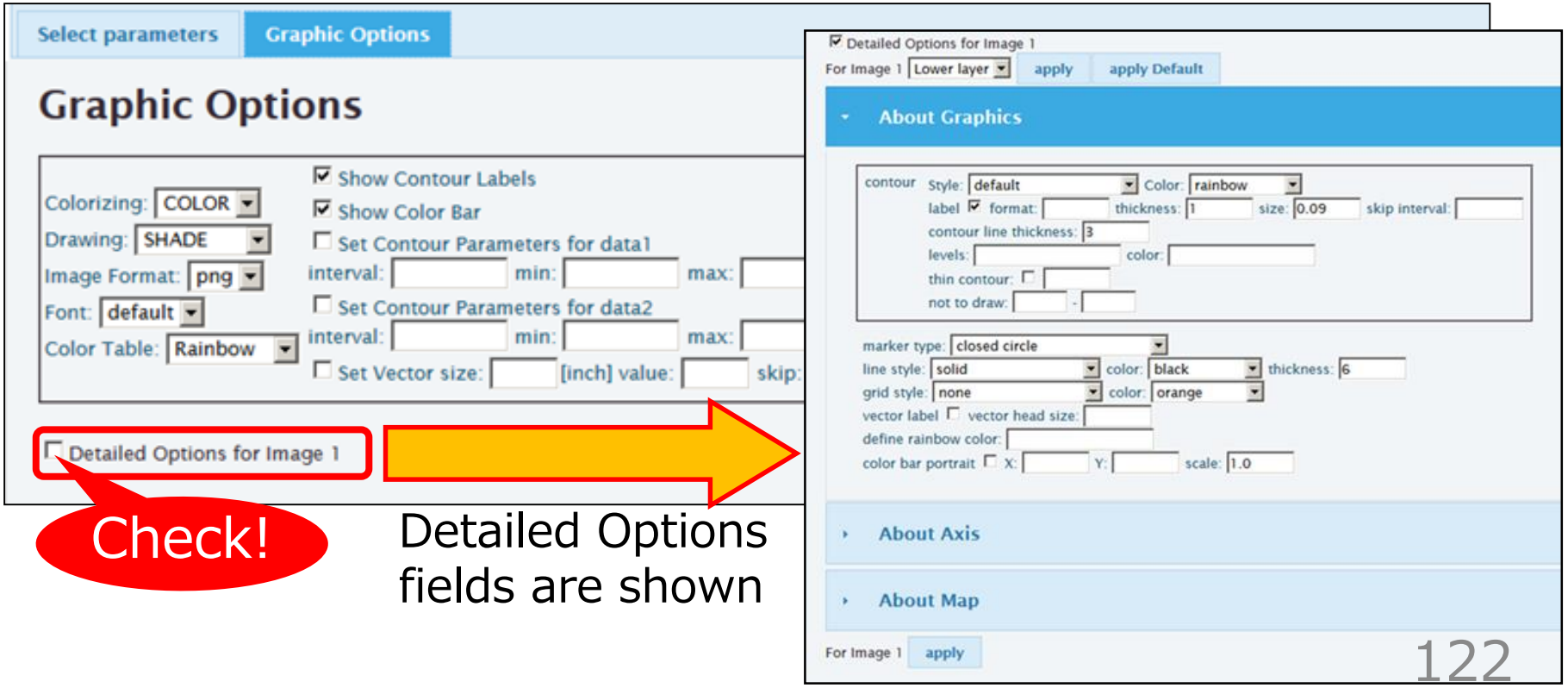
For standard deviation, don't check "Ave" box.

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.



Procedure of setting detailed options

1. Select target

Lower layer: Data1
Upper layer: Data2

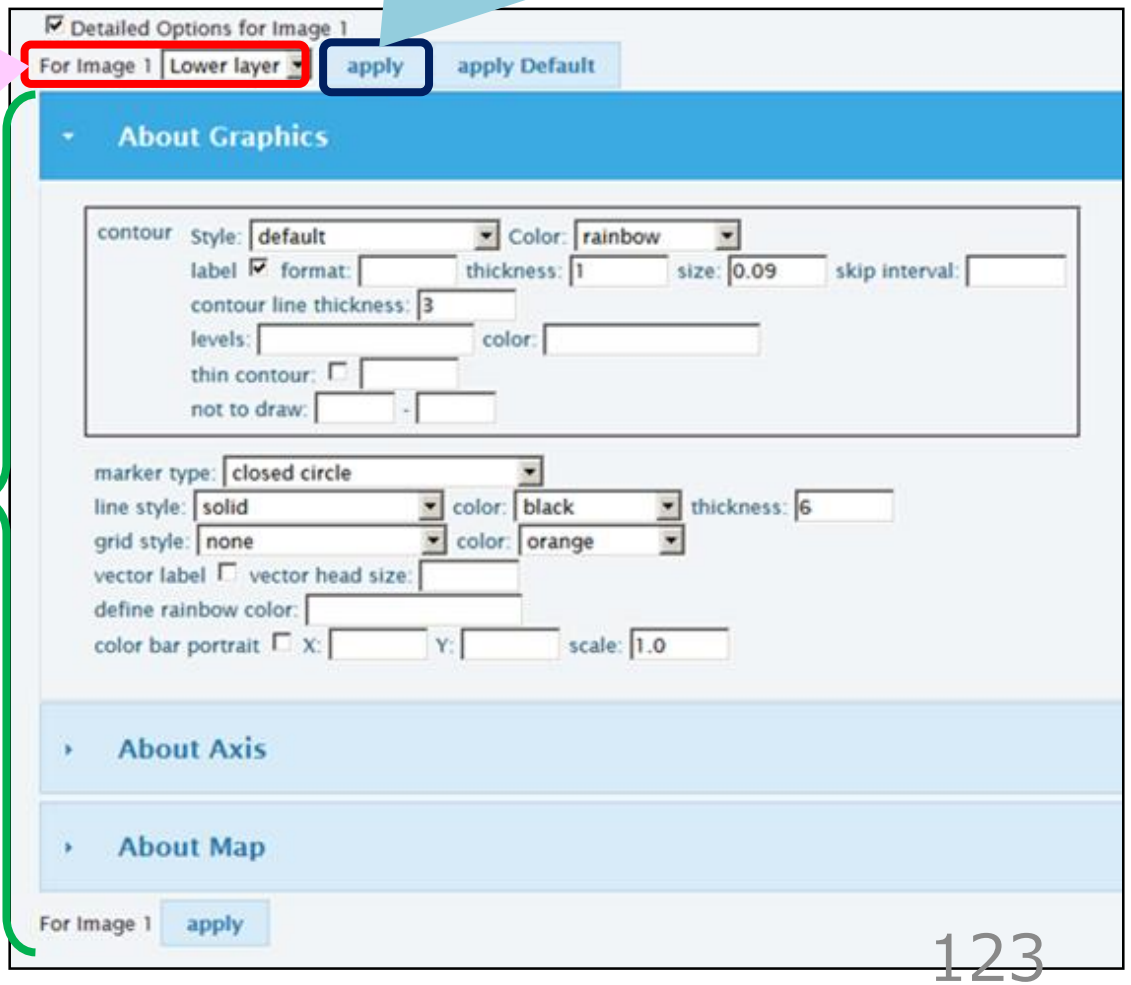
In the case of vector map
Lower layer: Data2
Upper layer: Data1

2. Set options

Set contour style, color, thickness, etc.

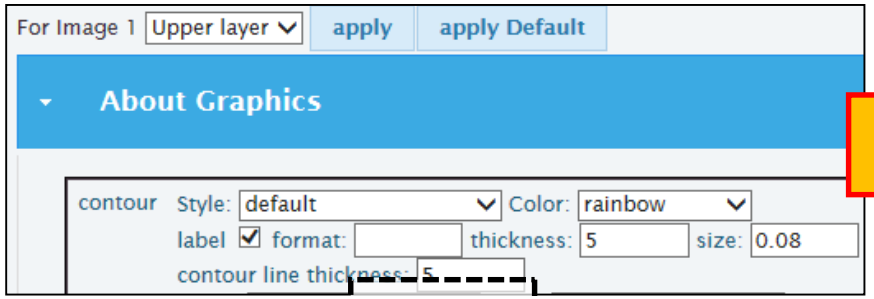
3. Apply the settings

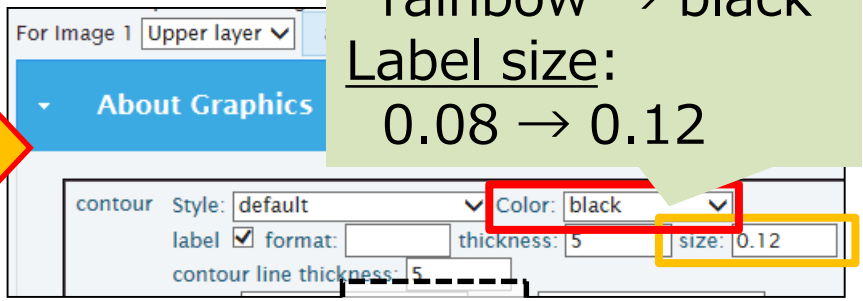
Click the "apply" button before "Submit" is clicked.



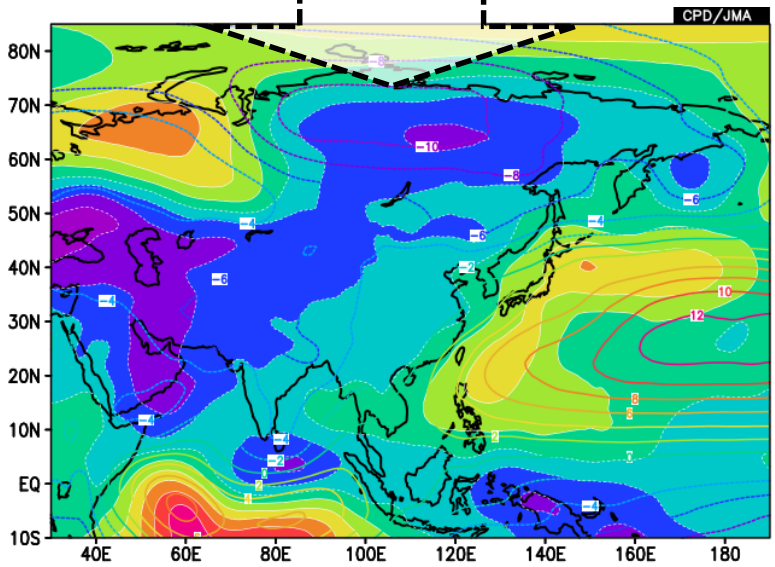
About Graphics: Contour color and label

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

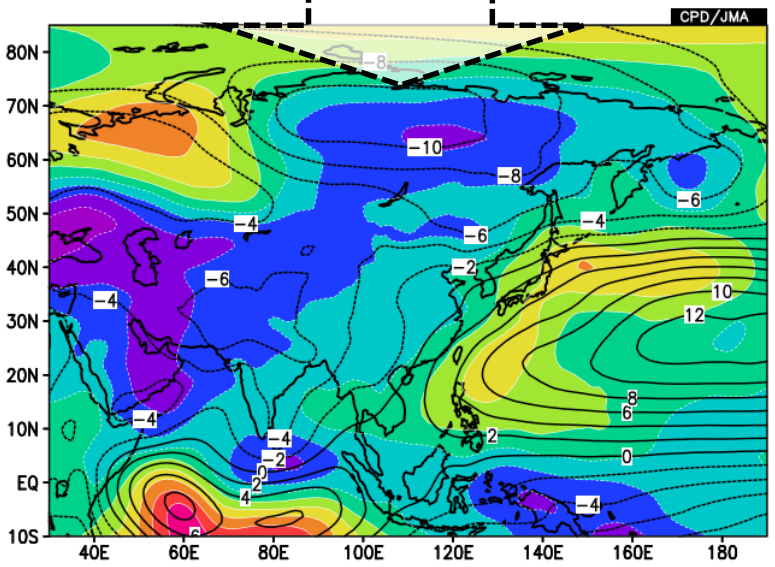




Color:
rainbow → black
Label size:
0.08 → 0.12



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



The problems are cleared.

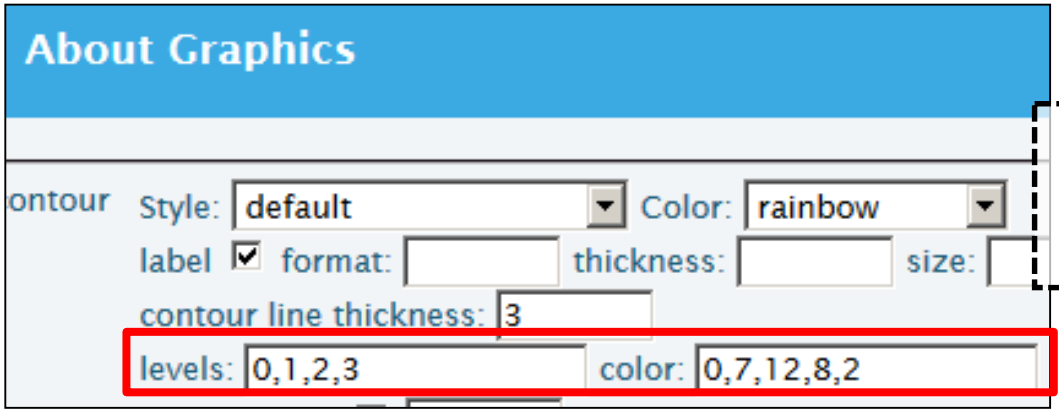
About Graphics: Color table

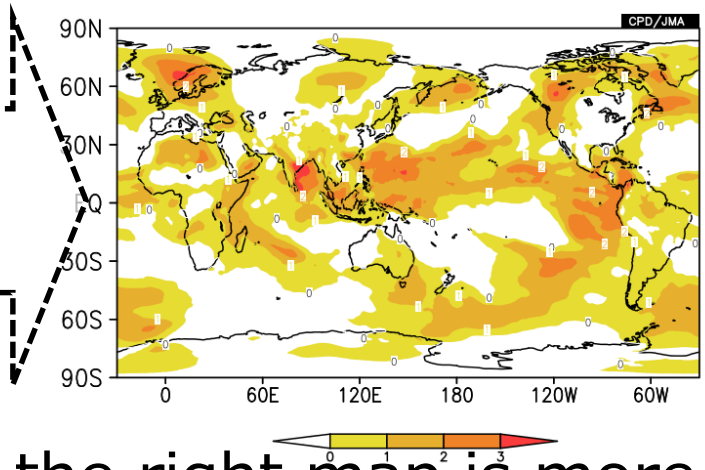
- Set levels and colors separated by comma in the boxes to define the color table by yourself. The color numbers are defined as the right table.

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

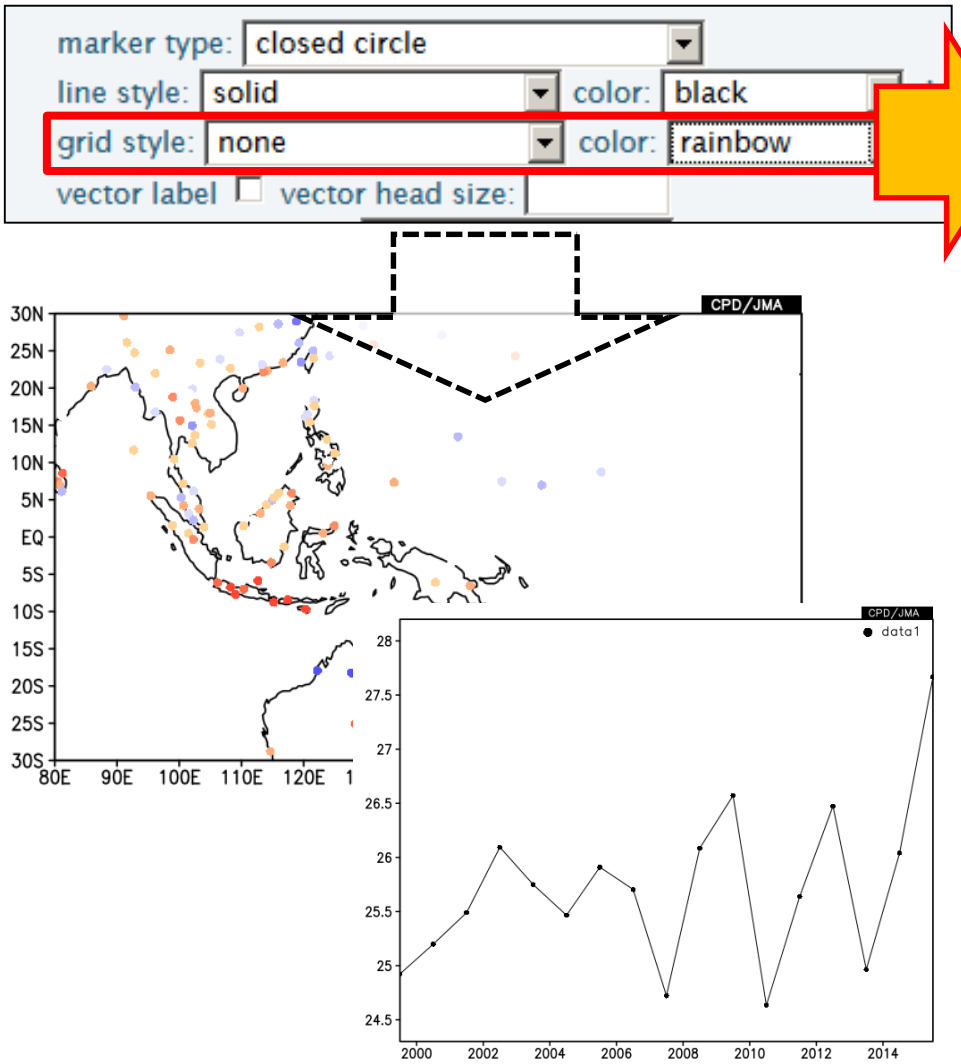
orange	8
purple	9
yellow green	10
medium blue	11
dark yellow	12
aqua	13
dark purple	14
gray	15

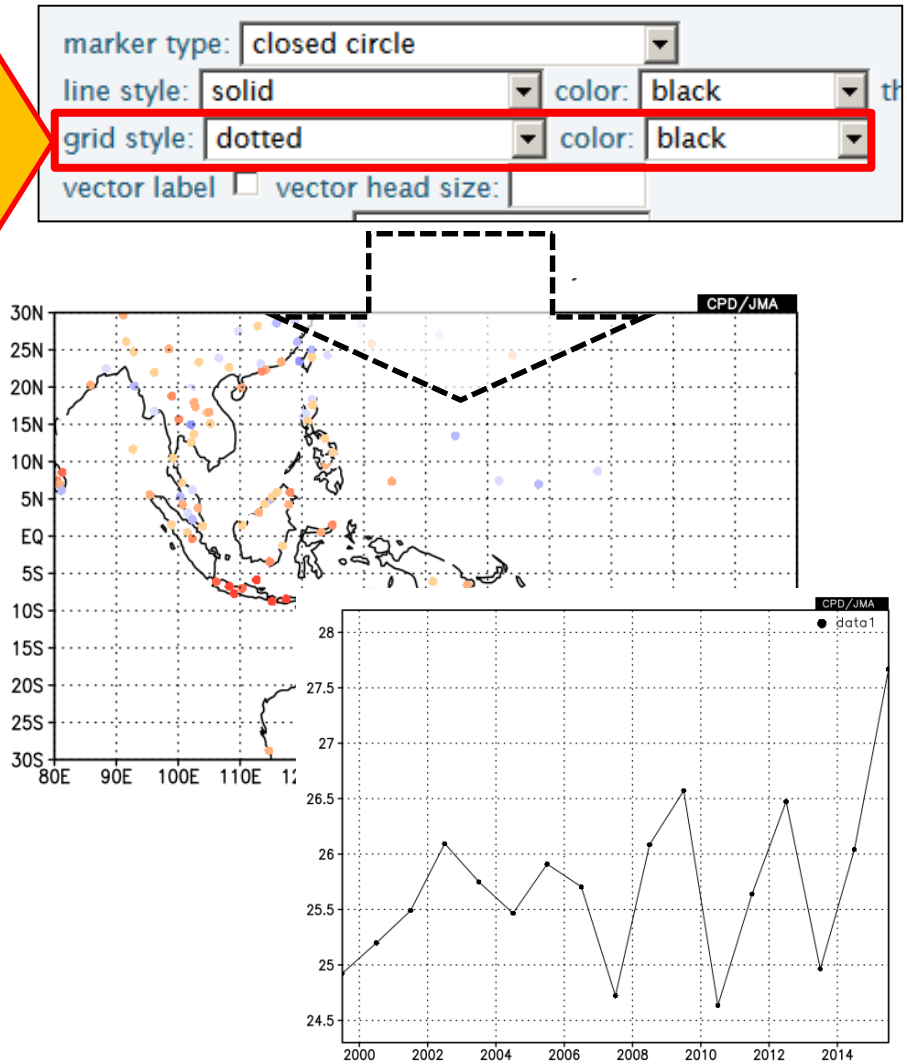




For example, the color setting like the right map is more suitable to focus on the positive value.

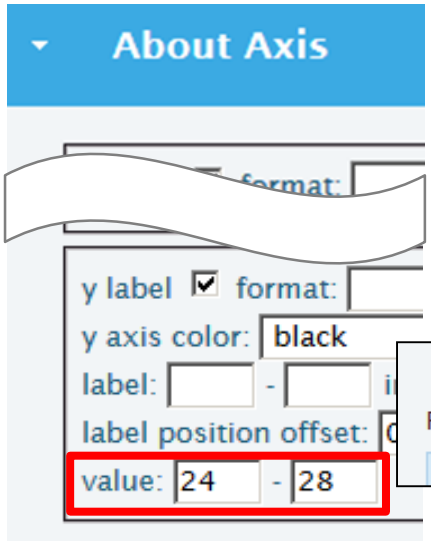
About Graphics: grid style

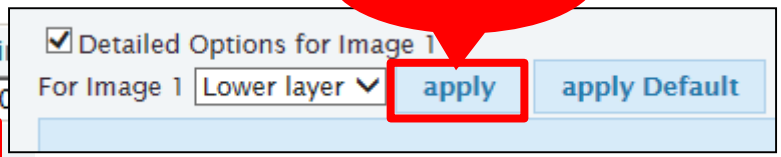




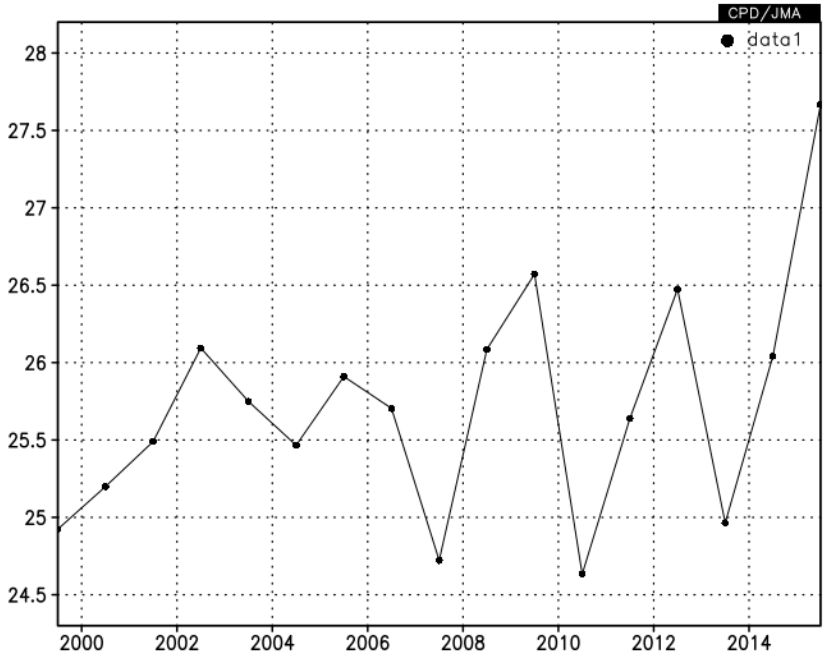
The grid line in the panel like the right map is available.

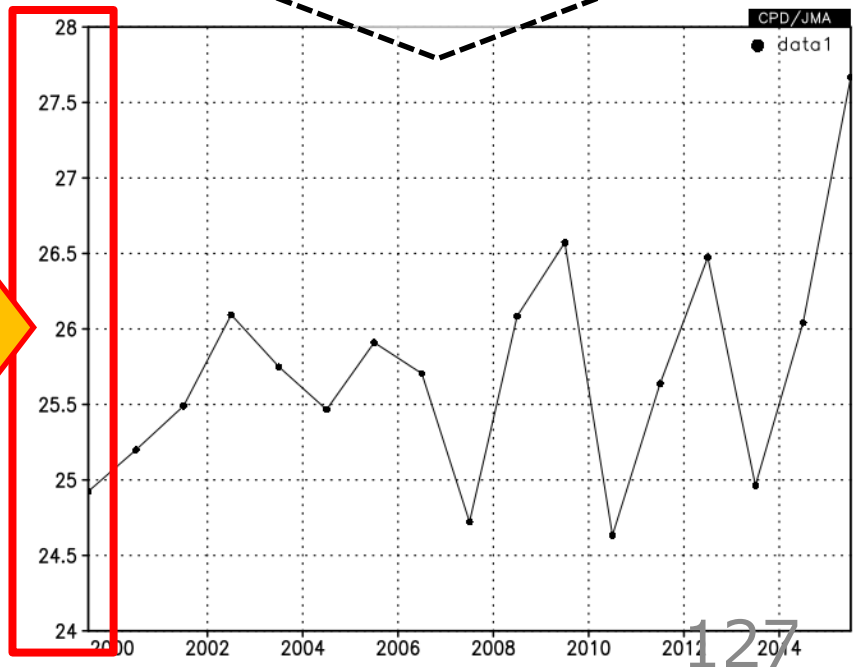
About Axis: value





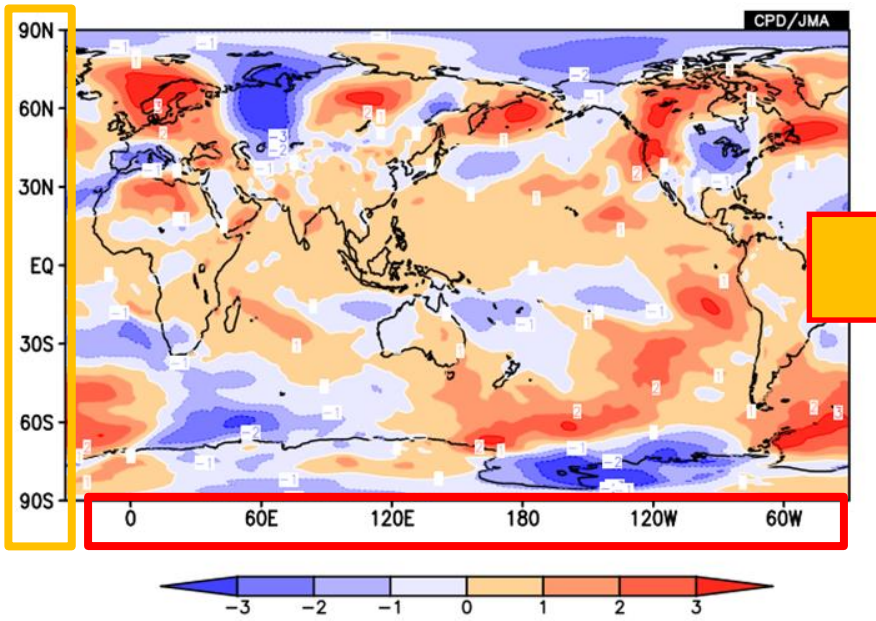
Default



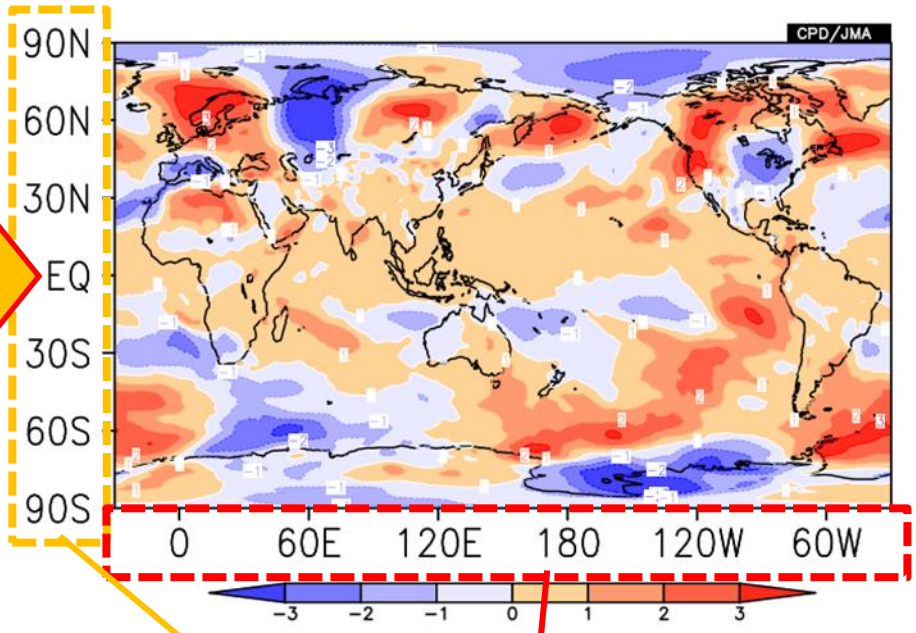


About Axis: Label size

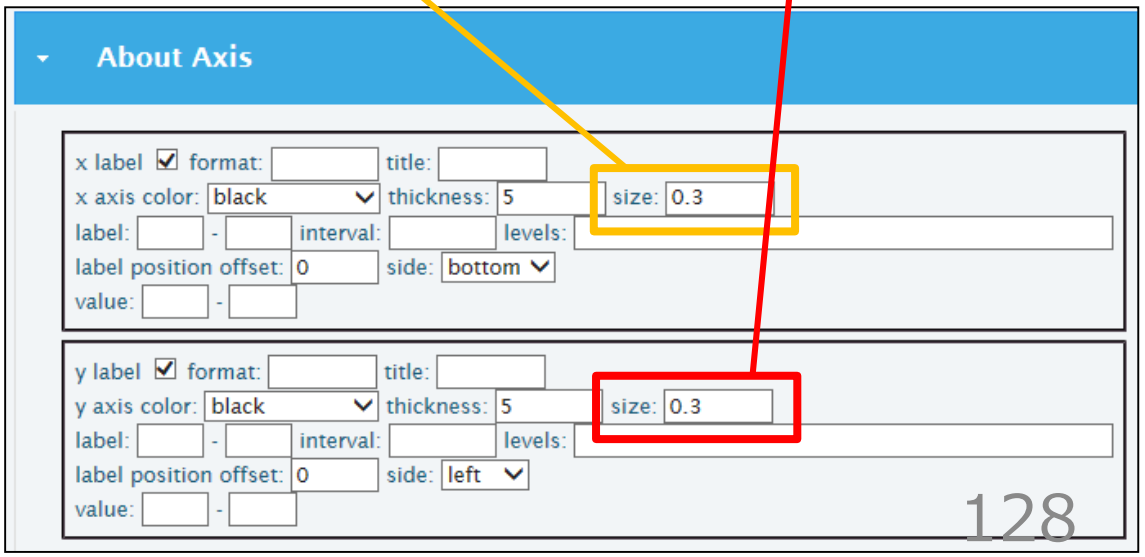
Default size



Label size: 0.3

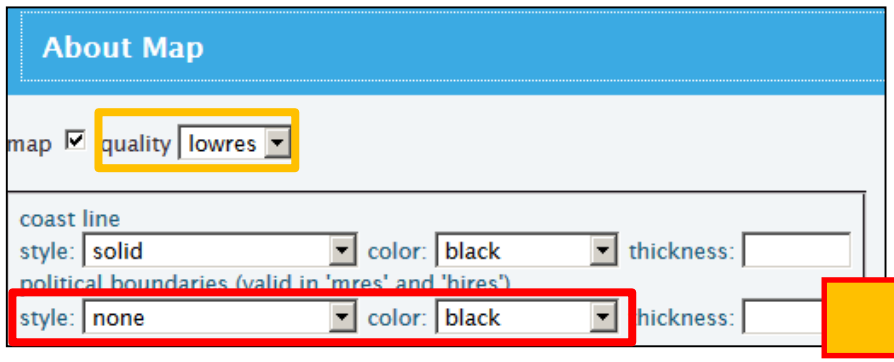


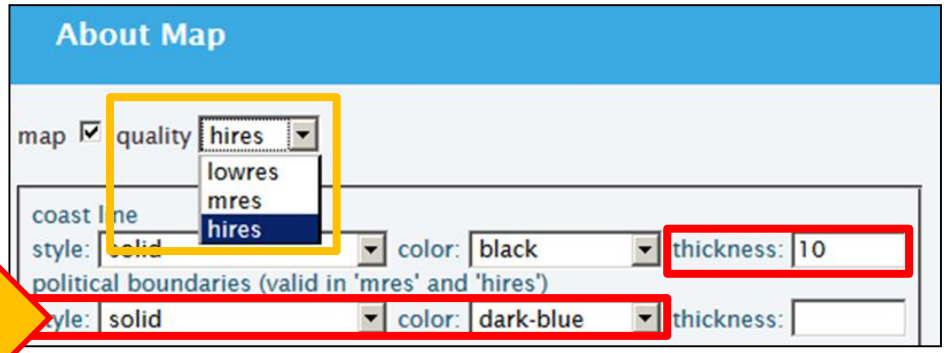
The label size is customizable in the “About Axis” box.

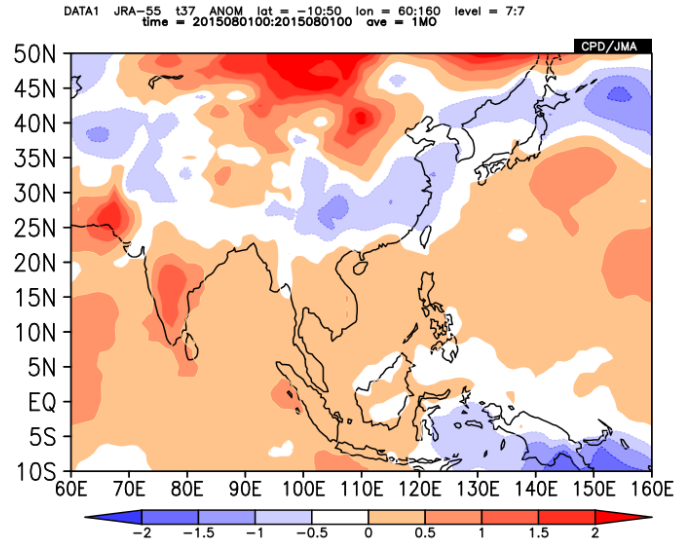


About Map

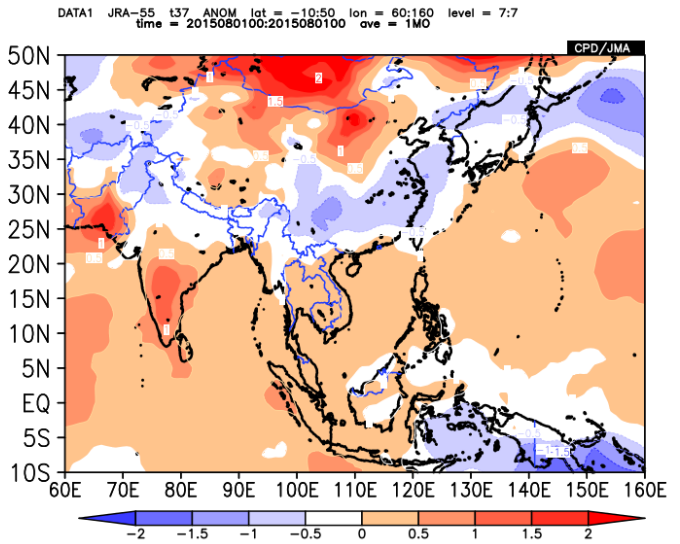
- Map resolution, political boundaries are customizable in the “About Map” box.







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

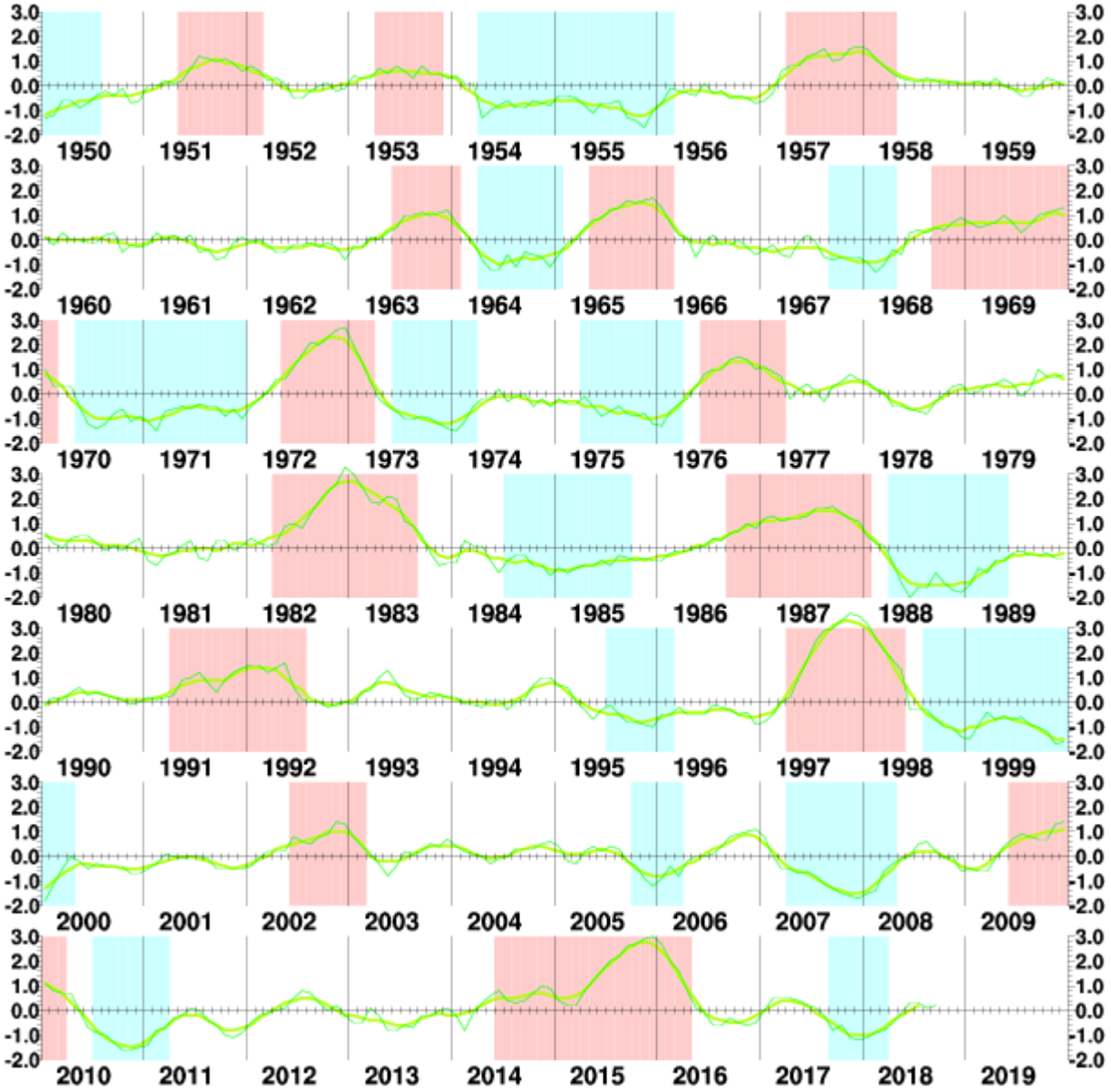


Quality must be set “mres” or “hires” to show political boundaries.

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**.

SST Deviation at NINO.3 (5S-5N,150W-90W)

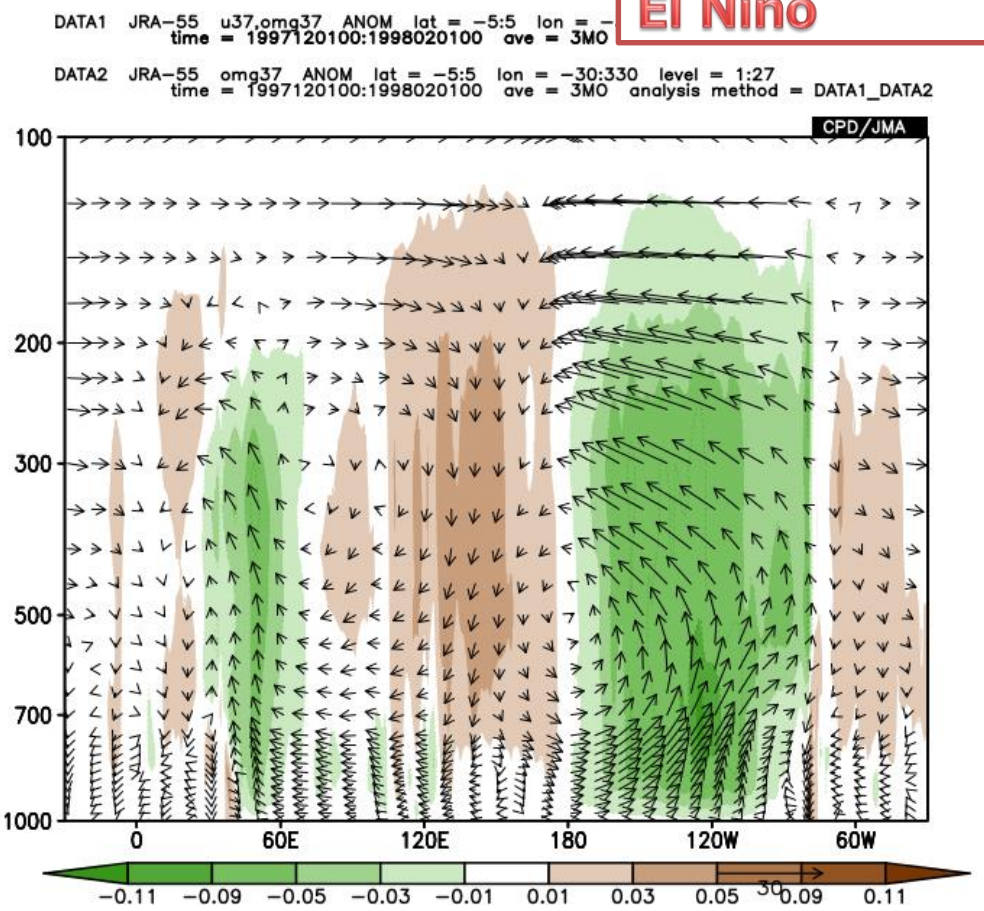


Integrated Exercise (1)

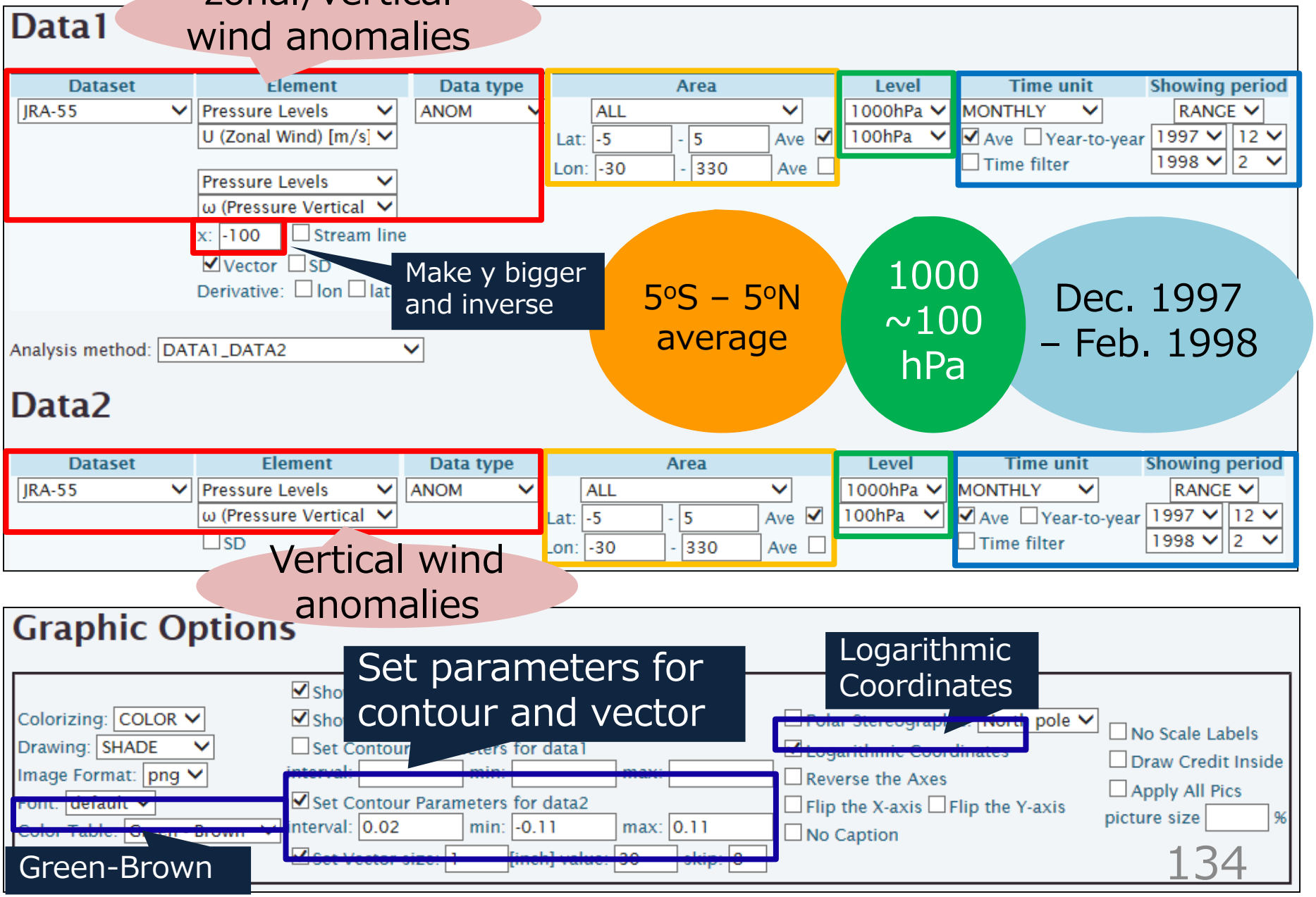
- Show longitude-height cross section of zonal/vertical wind anomaly vector and vertical wind anomaly (shading) averaged from 5°S to 5°N during the period from December 1997 to February 1998.

The winter of El Nino

- Try to adjust vector scale and skip interval to improve the visibility of the figure.
- Be aware of the direction of ω [Pa/s] vector.
- Select logarithmic coordinates for vertical axis.
- Adjust contour parameters (see color bar of the figure).
- Select “Green-Brown” for “Color Table”.



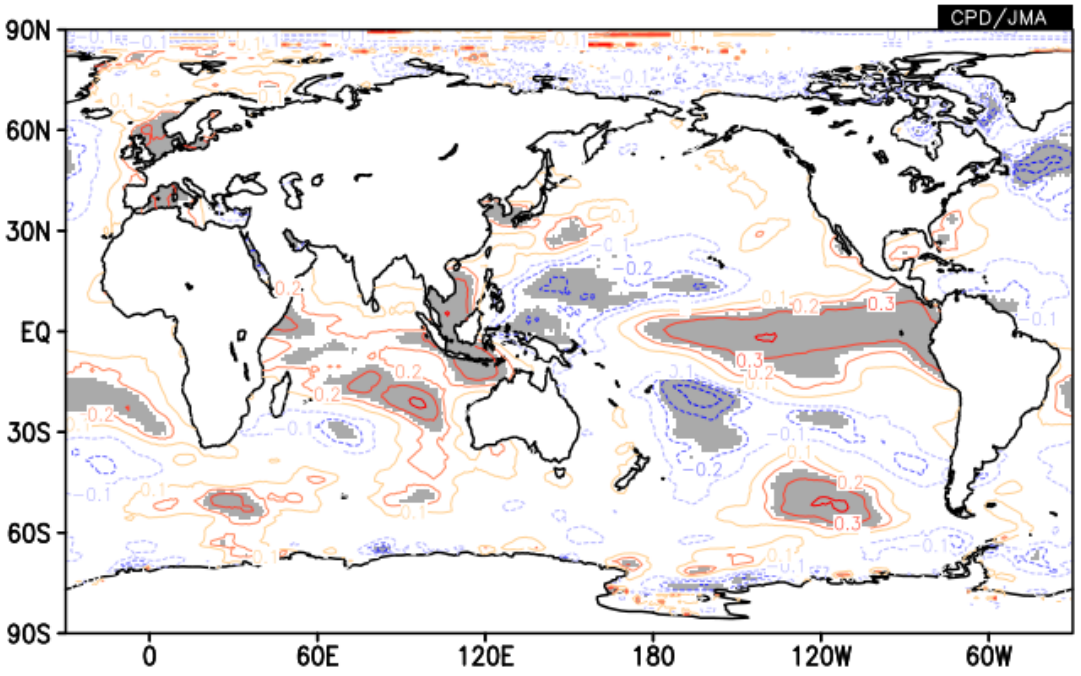
Answers to Integrated Exercise (1)



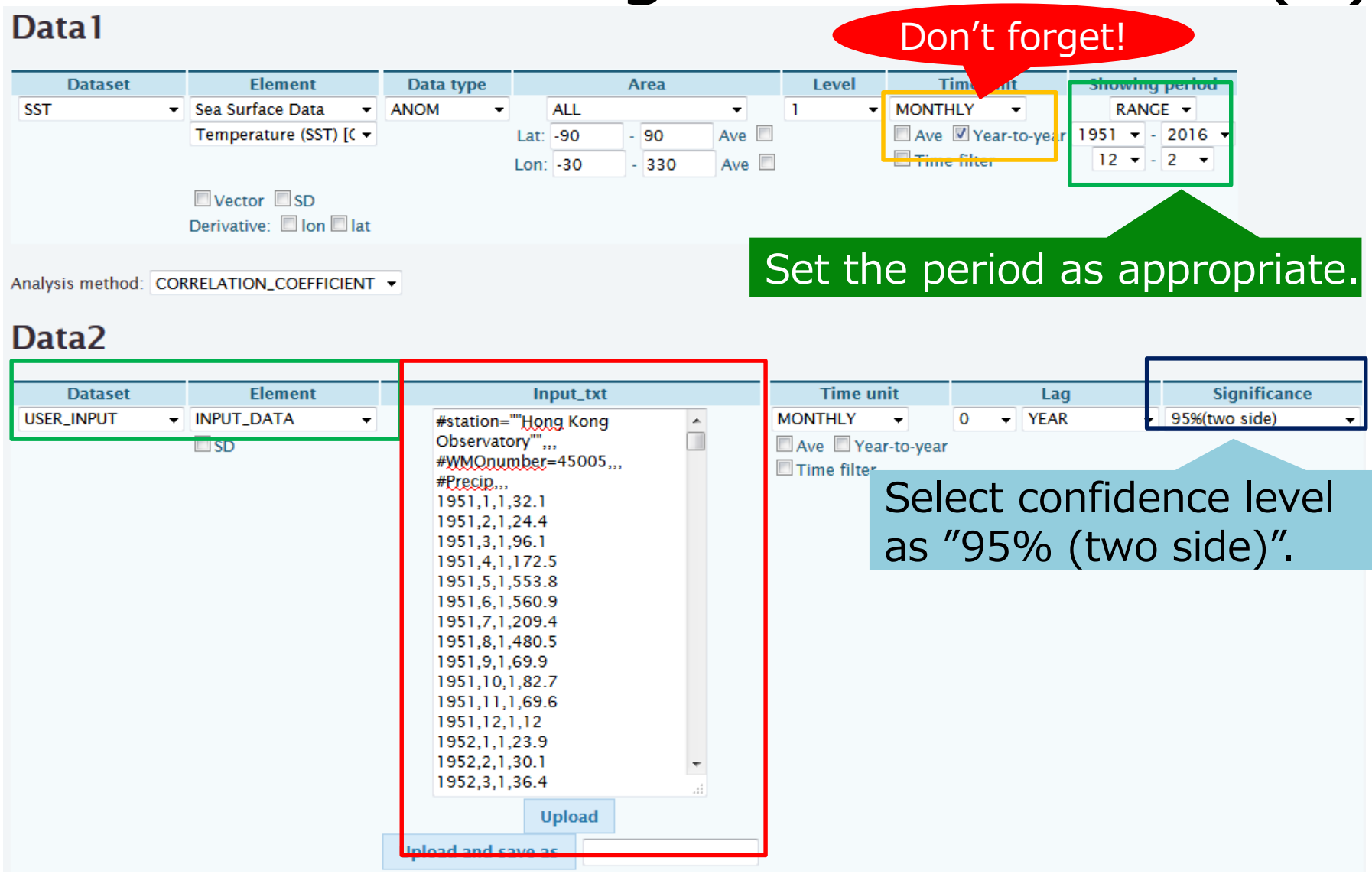
Integrated Exercise (2)

- 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)

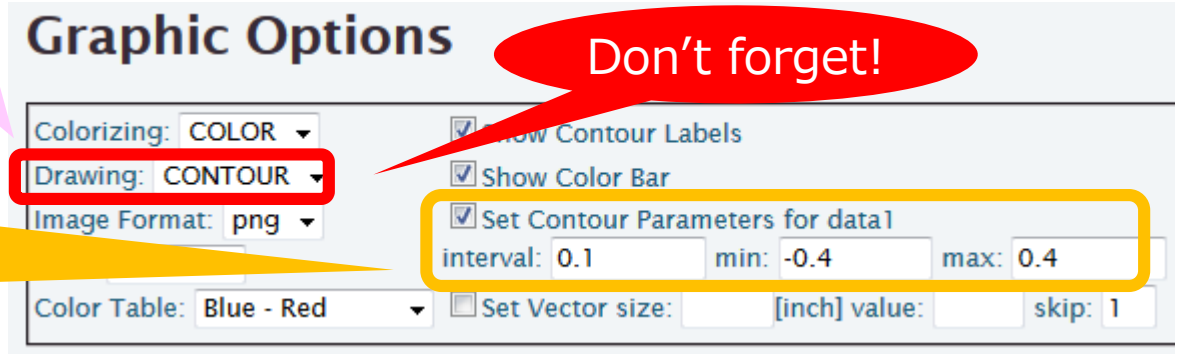


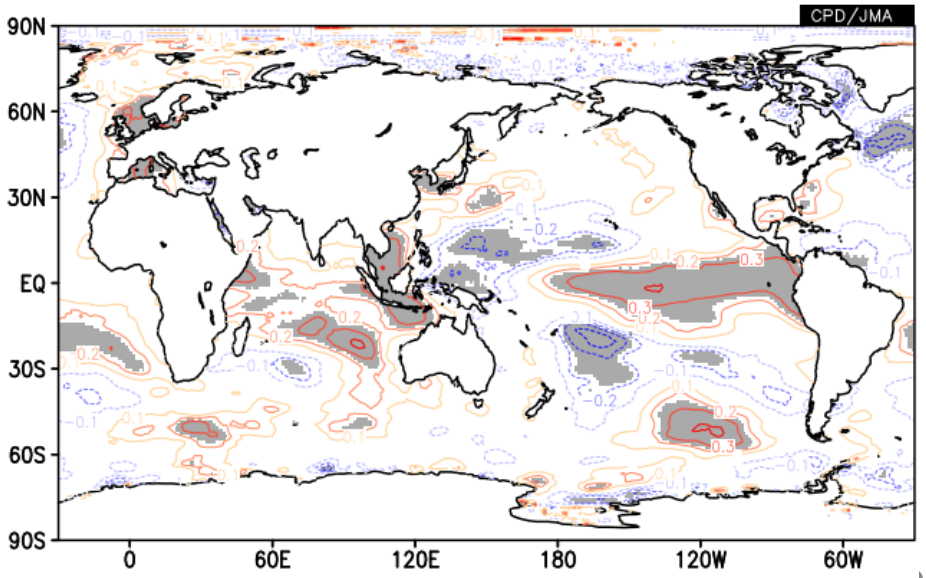
Answers to Integrated Exercise (2)

- 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.