Exercise

16 November 2016, 9:30 – 11:00 A.M.

Finding Climate Characteristics Associated with Primary Modes of Global Climate Variability

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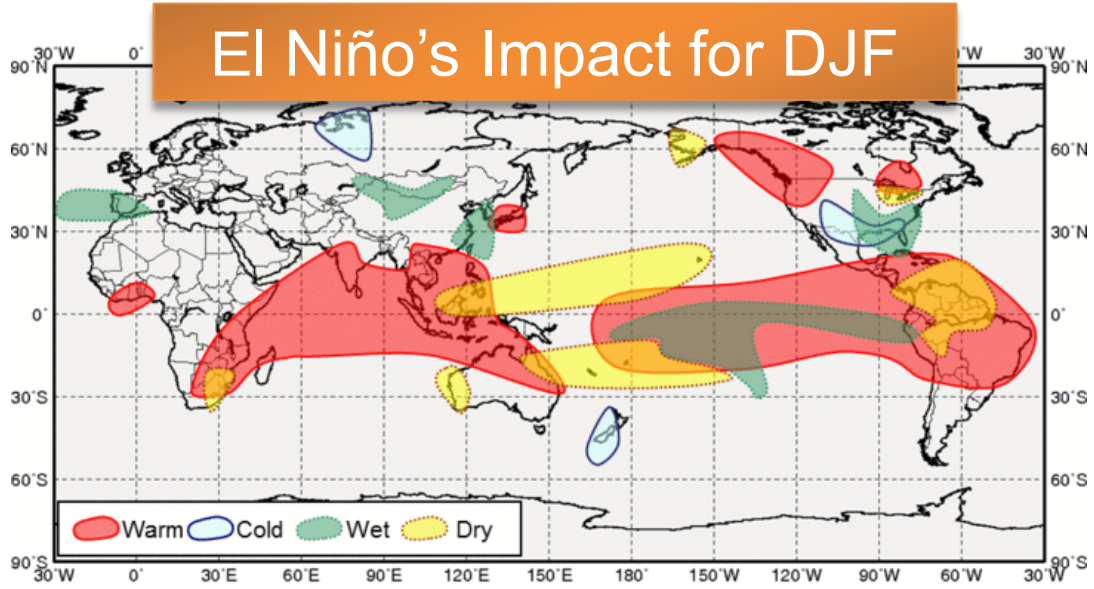
Let Me Introduce Myself……

- I engage in
  - Climate Monitoring
  - CLIMAT Messages Monitoring
- CLIMAT messages are fundamental to climate monitoring and researching.

Typical anomaly patterns of surface temperature and precipitation in past El Niño events for boreal winter.
http://ds.data.jma.go.jp/gmd/tcc/tcc/products/climate/ENSO/elNiño.html



Structure

☆Our goal of this seminar

To understand **statistical** and **dynamical** relationship between primary modes of global climate variability (e.g., El Niño Southern Oscillation) and regional climate anomalies.

☆Work

↓ This Exercise !!

- ✓ Investigate a **statistical relationship** between precipitation and/or temperature anomalies in your country and primary modes of global climate variability of your interests. — Statistical
- ✓ Identify an atmospheric circulation pattern that causally connects the regional climate anomalies to the primary mode of global climate variability. — Dynamical
- ✓ Give a possible explanation for the identified causal connection. — Dynamical
- ✓ Describe their findings at the presentation session.

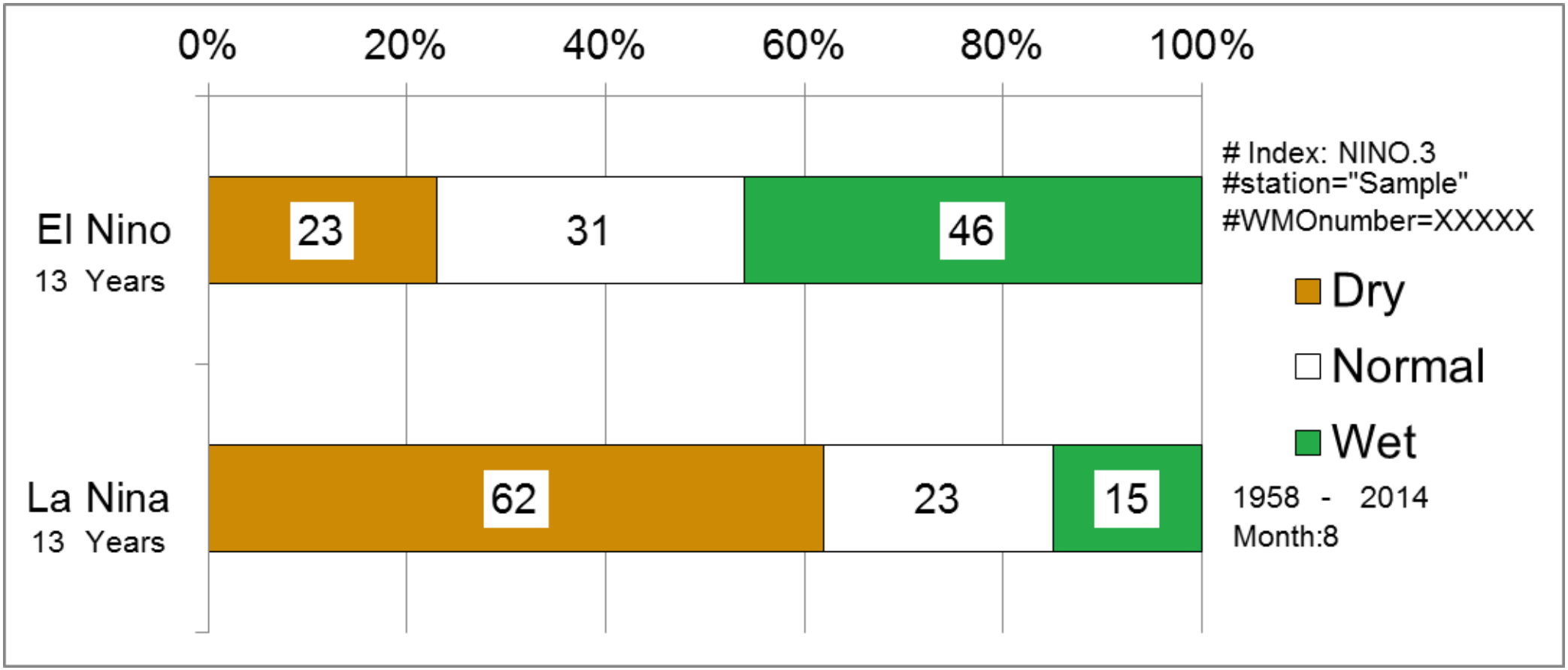
Motivation

- Some questions can be raised, for example……
  - Do we have much rain in summer under El Niño condition?
  - I experience cold winter in a certain La Niña year. Are there relationship between both?
- Our motivation can be summarized as below.

To investigate **the occurrence probability of warm/cold and wet/dry years when El Niño or La Niña condition** persists based on the data you have already prepared

In a Nutshell……

- We will make figures like this.



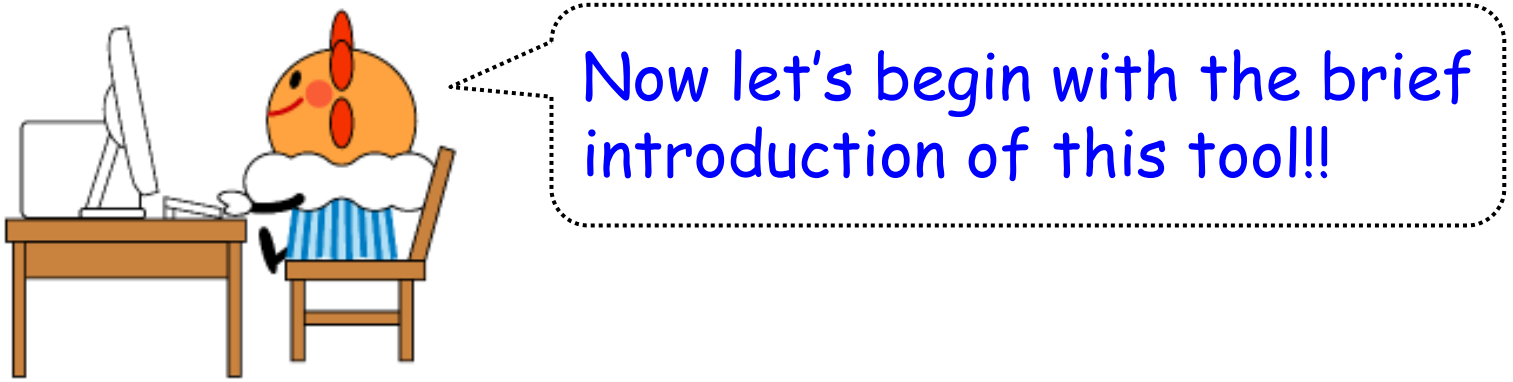
Outline

- Introduction ←Done.
- A MS-Excel tool for this exercise
- How to process data
- Statistical test
- Exercise using data of your country

A TOOL FOR THIS EXERCISE

A Tool for This Exercise

- We use a simple MS-Excel tool for this exercise. You can make occurrence probability figures and also check the statistical significance with this tool.



How to Use

1. Copy the data and paste it to A1 on “climat” sheet.

sample_data.csv

Copy and Paste!!

TRstats_tool.xlsm

	A	B	C	D
1	#station=“Sample“			
2	#WMOnumber=XXXXX			
3	Year	Month	Mean Tem	Precip.
4	1958	1	5	69.5
5	1958	2	6	67.1
6	1958	3	8.4	62.9
7	1958	4	13.9	47.5
8	1958	5	18	80.3
9	1958	6	22	63
10	1958	7	24.9	197.5
11	1958	8	25.8	83.4
12	1958	9	23.2	670.9
13	1958	10	16	275.9
14	1958	11	11.1	89.4
15	1958	12	7.9	97.5
16	1959	1	3.7	54.7
17	1959	2	7.3	115.3
18	1959	3	8.9	92.3
19	1959	4	15.3	162.7
20	1959	5	18.5	196.9

Set Year&Month parameter

Reset Data

Index | Event index | climat | Precip. | Temp. (raw) | Temp. (detrend) | Work

Tips: Shortcut keys

Select whole data: Select A1 sell & Ctrl + Shift + End

Copy: Ctrl + C Paste: Ctrl + V

How to Use

2. Move to “Precip.” sheet. And input three parameters “Start Year”, “End Year” and “Calendar Month”. Now we input “1958”, “2014” and “8”, respectively and click “Calculate and Draw”.

	A	B	C	D	E	F	G	H	I
1	Year	Month	Precip.	Index	Event				
2	1958	8	83.4	0.2	0		Start Year	1958	
3	1959	8	137.2	-0.1	0		End Year	2014	
4	1960	8	215	0	0		Calendar Month	8	
5	1961	8	30.9	-0.4	0				
6	1962	8	50.1	-0.2	0		Calculate and Draw !!		
7	1963	8	382.2	0.9	1				
8	1964	8	77.8	-0.8	-1		Total Year	57	
9	1965	8	234.5	1.3	1		Effective Year	57	
10	1966	8	54.5	-0.1	0				
11	1967	8	67.3	-0.4	0		Sampling bias rate(%)	0	
12	1968	8	256	0.4	0				
13	1969	8	131.5	0.7	1				
14	1970	8	20.5	-1	-1				
15	1971	8	171.3	-0.6	-1				
16	1972	8	73.5	1.8	1				

Index | Event index | climat | Precip. | Temp. (raw) | Temp. (detrend) | Work

←Input 1958, 2014 and 8, respectively.

←Cilck this button.

How to Use

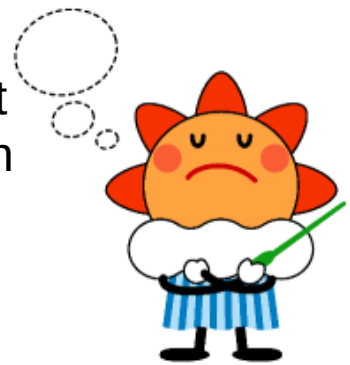
3(cont.). Data will be copied to the column A through E. As the initial settings, NINO.3 SST index values are input in the column D. Event values in the column E are +1/0/-1 corresponding El Niño/Neutral/La Niña, respectively.

	A	B	C	D	E	F
1	Year	Month	Precip.	Index	Event	
2	1958	8	83.4	0.2	0	
3	1959	8	137.2	-0.1	0	
4	1960	8	215	0	0	
5	1961	8	30.9	-0.4	0	
6	1962	8	50.1	-0.2	0	
7	1963	8	382.2	0.9	1	
8	1964	8	77.8	-0.8	-1	
9	1965	8	234.5	1.3	1	
10	1966	8	54.5	-0.1	0	
11	1967	8	67.3	-0.4	0	
12	1968	8	256	0.4	0	
13	1969	8	131.5	0.7	1	
14	1970	8	20.5	-1	-1	
15	1971	8	171.3	-0.6	-1	
16	1972	8	73.5	1.8	1	
17	1973	8	50	-0.9	-1	

Index | Event Index | climat | Precip. | Temp.(raw) | Temp

El Niño…Event value = +1
…Red-colored cells !!
La Niña…Event value = -1
…Blue-colored cells !!

*Note:
NINO.3 SST index and event value has been already set in “Index” and “Event Index” sheet, respectively.



How to Use

4. Tables on the sheet will be filled automatically and then you will get an occurrence probability figure.

Options of tertile thresholds		Dry	Normal	Wet	S1-Value	S2-Value
78.93333333	179.83333	19	19	19	0	0
77.93333333	179.83333	19	19	19	0	1
78.93333333	178.83333	19	18	20	0.0006156	1
77.93333333	178.83333	19	18	20	0.0006156	2

Tertile thresholds		Probability	Dry	Normal	Wet
78.93333333	179.83333		0.3333333	0.3333333	0.3333333

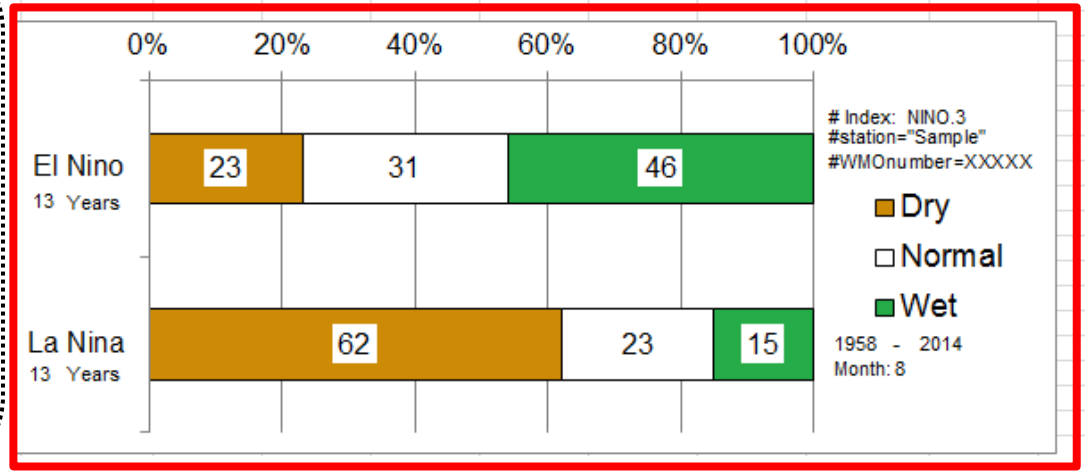
Count	Dry	Normal	Wet	Sum.
El Nino	3	4	6	13
Neutral	8	12	11	31
La Nina	8	3	2	13

Percentage	Dry	Normal	Wet	Sum.
El Nino	23	31	46	100
Neutral	26	39	35	100
La Nina	62	23	15	100

Binomial test: (p-value)	Dry	Normal	Wet	Not Dry	Not Wet
El Nino	0.8612678	0.677576	0.2413081	0.322424	0.8964608
Neutral	0.8608653	0.3225039	0.4662455	0.2462713	0.6774961
La Nina	0.0346548	0.8612678	0.9614633	0.9911768	0.1387322

Correlation	r	t-value	p-value
	0.1957617	1.4804521	0.1444587

I did it! But now I wonder how the data was processed to make this figure.



←Final product

HOW TO PROCESS DATA

What was done automatically?

	A	B	C	D
1	#station="Sample"			
2	#WMOnumber=XXXXX			
3	Year	Month	Mean Tem	Precip.
4	1958	1	5	69.5
5	1958	2	6	67.1
6	1958	3	8.4	62.9
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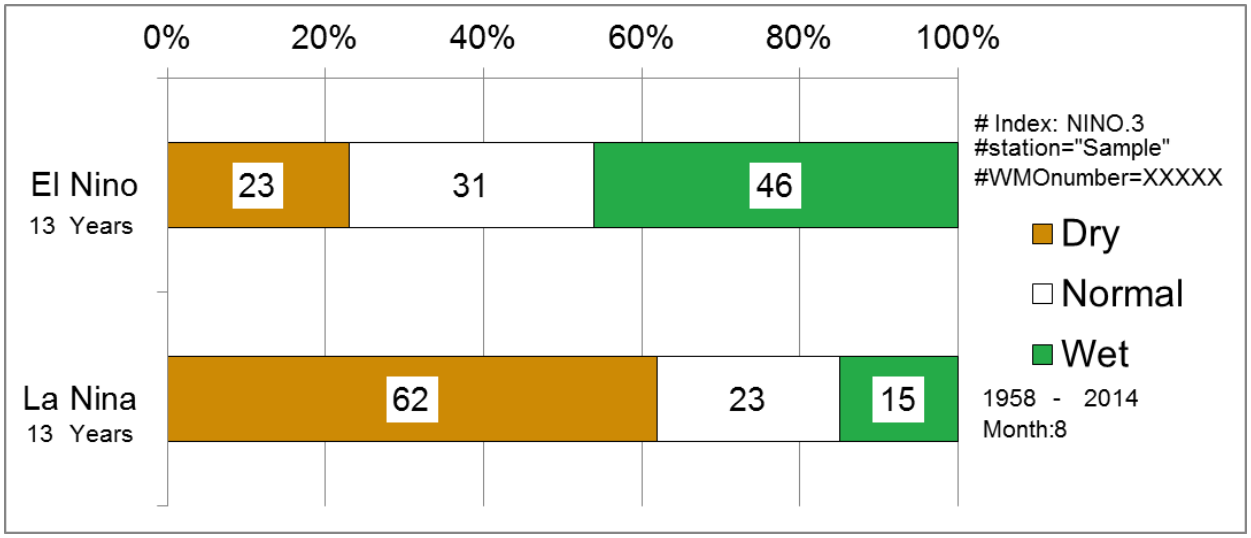
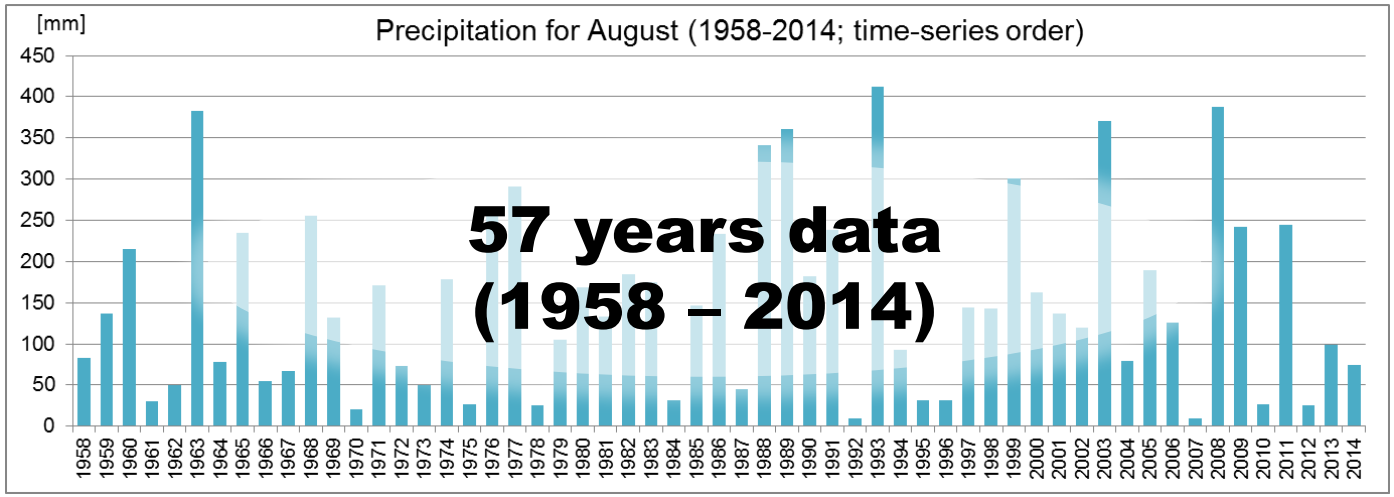
16	1959	1	3.7	54.7
17	1959	2	7.3	115.3
18	1959	3	8.9	92.3
19	1959	4	15.3	162.7
20	1959	5	18.5	196.9

- So what was done automatically by the tool to make this figure?

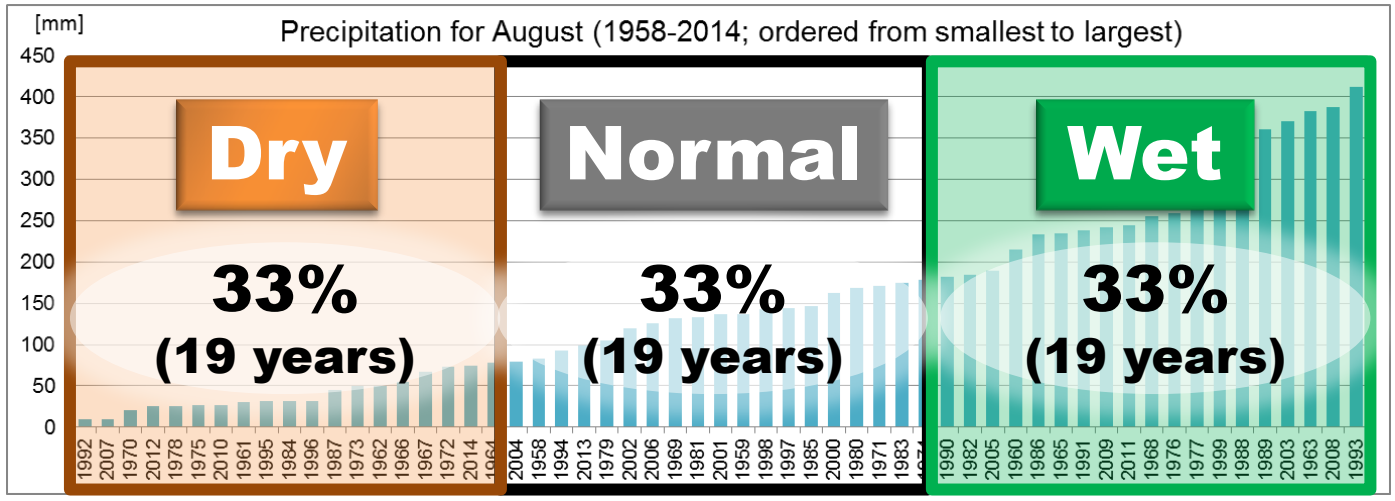


How to Classify the Data

- The observation data was divided into 3 classes.
- Each class contains 33% of the whole data.
- The occurrence probability of each class is equal. This is climatological probability.



Sorting the data
from the smallest to largest



On your sheet……,

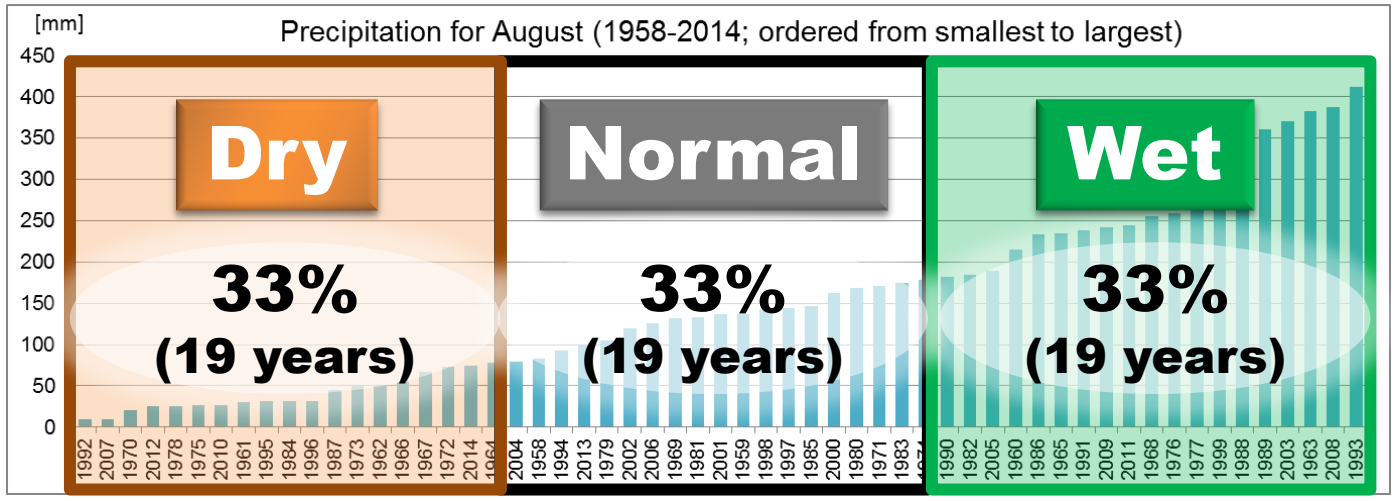
Here you can find the thresholds and the probabilities of each class!

J	K	L	M	N	O	P	Q
Options of tertile thresholds			Dry	Normal	Wet	S1-Value	S2-Value
82.1	182.6667		19	19	19	0	0
81.1	182.6667		19	19	19	0	1
82.1	181.6667		19	19	19	0	1
81.1	181.6667		19	19	19	0	2

Tertile thresholds		Probability	Dry	Normal	Wet
82.1	182.6667		0.333333	0.333333	0.333333

Now let me skip this table because it is too technical. There are some calculation processes in case there are several years with same value around a threshold.

In other words, we can assume that every August has an equal chance of falling into the “Dry”, “Normal” or “Wet” class.

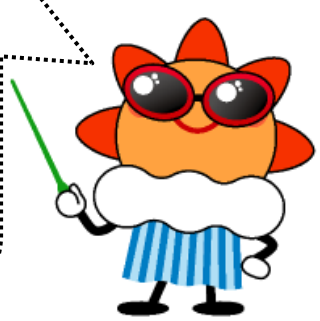


Cross Tabulations

- Now we can count the frequencies about each class and summarize them as a cross-table like that.

Count	Dry	Normal	Wet	Sum.
El Nino	3	4	6	13
Neutral	8	12	11	31
La Nina	8	3	2	13

For example, there were 8 "Dry" August among 13 La Niña years.



Start Year	1958	Options of tertile thresholds		Dry	Normal	Wet	S1-Value	S2-Value
End Year	2014	78.93333333	179.83333	19	19	19	0	0
Month	8	77.93333333	179.83333	19	19	19	0	1
Averaging Month		78.93333333	178.83333	19	18	20	0.0006156	1
Calculate and Draw !!		77.93333333	178.83333	19	18	20	0.0006156	2
Total Year	57							
Effective Year	57	Tertile thresholds		Probability	Dry	Normal	Wet	
		78.93333333	179.83333		0.3333333	0.3333333	0.3333333	
Sampling bias rate(%)	0							

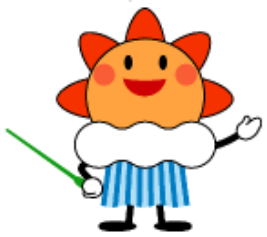
Count	Dry	Normal	Wet	Sum.
El Nino	3	4	6	13
Neutral	8	12	11	31
La Nina	8	3	2	13

Percentage	Dry	Normal	Wet	Sum.
El Nino	23	31	46	100
Neutral	26	39	35	100
La Nina	62	23	15	100

Cross Tabulations

- Cross-tables are also expressed as percentages, on which the occurrence probability figure is based.

Sampling bias rate(%)	0



In this case, the bias rate is (13-13)/31 = 0.

Count	Dry	Normal	Wet	Sum.	
El Nino	3	4	6	13	A
Neutral	8	12	11	31	C
La Nina	8	3	2	13	B

Percentage	Dry	Normal	Wet	Sum.
El Nino	23	31	46	100
Neutral	26	39	35	100
La Nina	62	23	15	100

- You should also check the sampling bias rate.

Sampling bias rate (%)

$$= \left| \frac{\text{Num. of El Niño Years (A)} - \text{Num. of La Niña Years (B)}}{\text{Num. of Neutral Years (C)}} \right| * 100$$

* It is preferable that sampling bias rates should be less than 20% because it is not desirable that data are biased on either side of El Niño or La Niña events.

The Figure

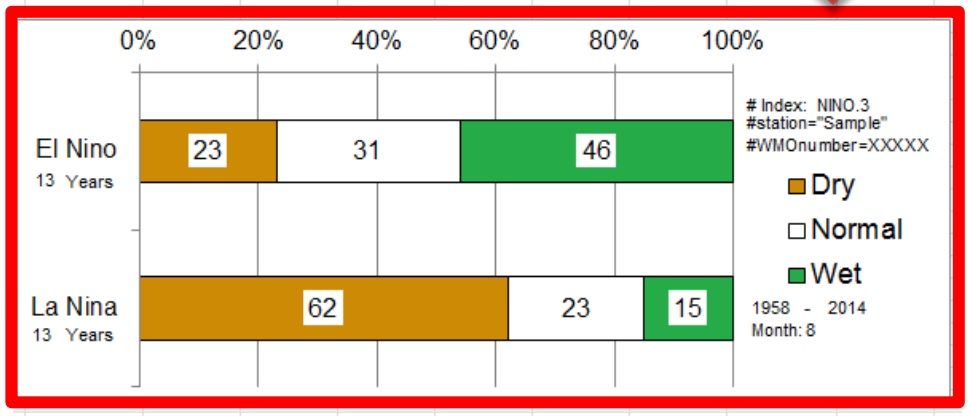
- Based on the cross-table, occurrence probability figures are generated.
- In this case, this figure suggests "There is less (much) precipitation in August associated with La Niña (El Niño) condition".

Hmm…, it is informative enough even if only this figure.
But can I say that climate characteristics confidently? Some people could suspect it is just by chance.

Percentage	Dry	Normal	Wet	Sum.
El Nino	23	31	46	100
Neutral	26	39	35	100
La Nina	62	23	15	100

Binomial test: (p-value)	Dry	Normal	Wet	Not Dry	Not Wet
El Nino	0.8612678	0.677576	0.2413081	0.322424	0.8964608
Neutral	0.8608653	0.3225039	0.4662455	0.2462713	0.6774961
La Nina	0.0346548	0.8612678	0.9614633	0.9911768	0.1387322

Correlation		t-v
	0.1957617	1.



STATISTICAL TEST

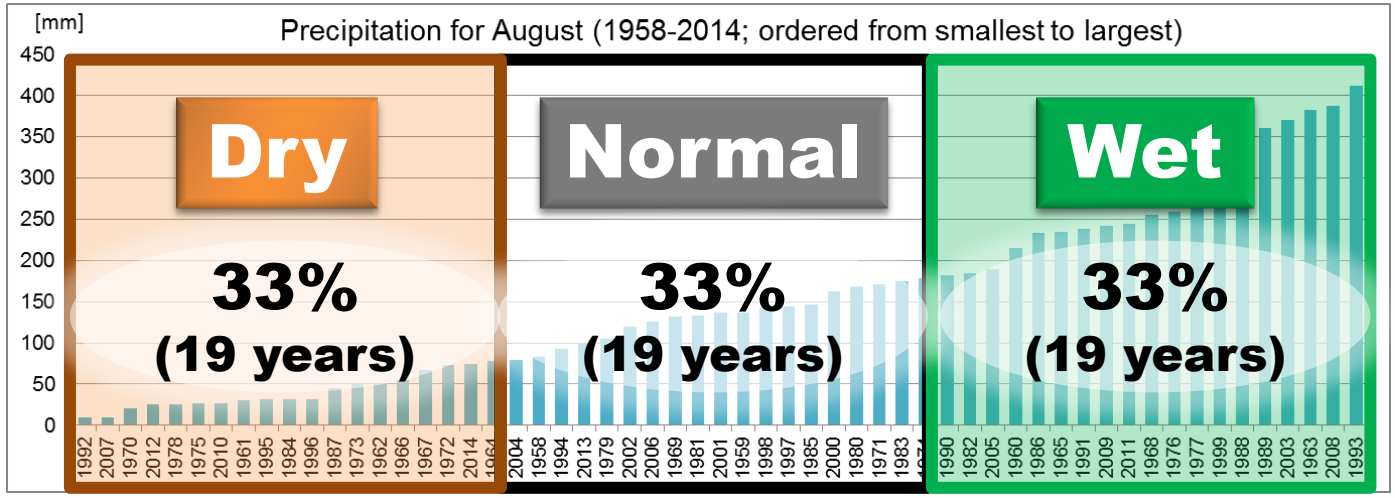
Doubt the Result to Believe It

- We have just done our minimum work.
- To evaluate whether our results are by chance or not (namely, “significant”), actually statistical testing was performed by the MS Excel-tool.

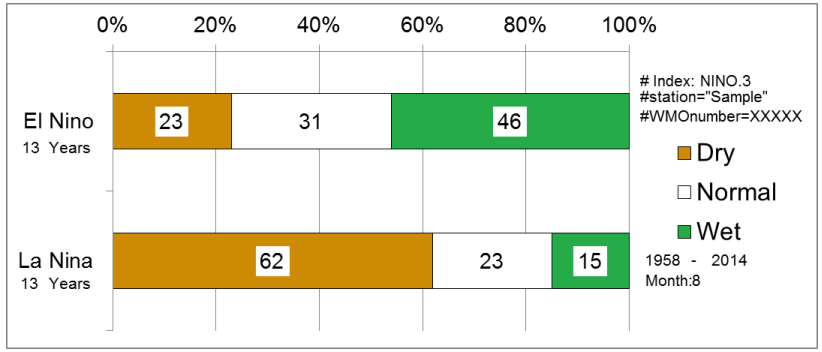
I don’t think you have to understand the details of this statistical test completely for this seminar, but I hope you to understand the basic concept.

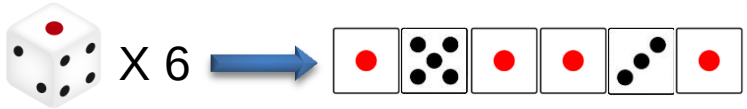
Doubt the Result to Believe It

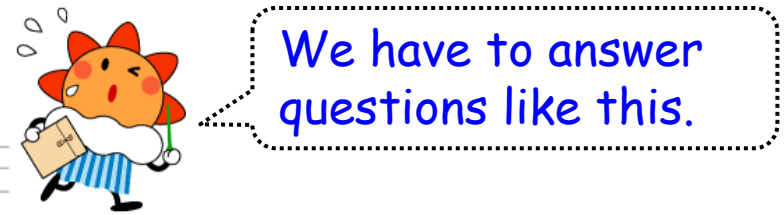
In other words, we can assume that every August has an equal chance of falling in the "Dry", "Normal" or "Wet" class.



- Is it true that there are likely to be more "Dry" year under La Niña condition? Is it by chance?
  - For example, when you cast a die six times, sometimes it can happen that you get 4 pips of "1" even if it is rare.



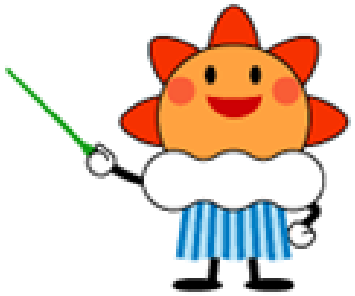




Doubt the Result to Believe It

- Now we assume that La Niña events cause more "Dry" years (A). But some people suspect……(B)

La Niña has so significant influence that **the distribution was no longer based on climatological probability**.



La Niña has little influence. **The distribution should have followed the climatological probability**, and it was just by chance that there were more "Dry" years.

From the Speculation (B)……

- From the point of view of the speculation (B), every August still has an equal chance of falling into the “Dry”, “Normal” or “Wet” class.
- Under this assumption, we can calculate the probability that there is at least 8 “Dry” years among 13 La Niña events.
  - The answer is $P(X \geq 8) = \sum_{k=8}^{13} \frac{13!}{(13-k)!k!} \left(\frac{1}{3}\right)^k \left(1-\frac{1}{3}\right)^{13-k}$,

  where X is the number of “Dry” years.

It is just a mathematical problem. If you are interested, think about this at the hotel tonight.

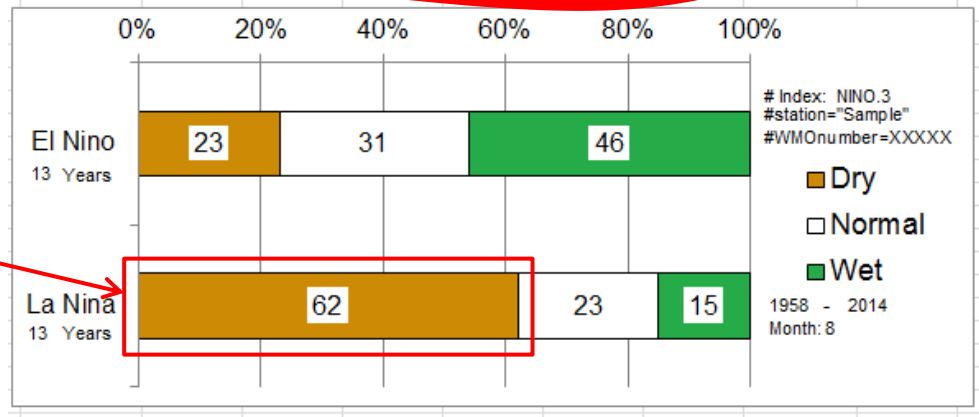
Statistical Testing

- These probabilities (p-values) are given by this table on your sheet.
- For example, $P(X \geq 8) = \sum_{k=8}^{13} \frac{13!}{(13-k)!k!} \left(\frac{1}{3}\right)^k \left(1-\frac{1}{3}\right)^{13-k}$ is found here.

This suggests the situation like (B) rarely occurs (less than 4%). So we can consider that this distribution was **not by chance**, that is to say, **we can reject (B)**!!

Binomial test: (p-value)	Dry	Normal	Wet	Not Dry	Not Wet
El Nino	0.8612678	0.677576	0.2413081	0.322424	0.8964608
Neutral		0.3225039	0.4662455	0.2462713	0.6774961
La Nina	0.0346548	0.8612678	0.9614633	0.9911768	0.1387322

Correlation	t-v
0.1957617	1.



Note: Now we consider a distribution to be rare if the p-value is less than 0.1, which is indicated by yellow color. Actually the threshold is arbitrary but 0.1 or 0.05 is common in climate researches.

For Guys Familiar with Statistics

- Simply stated, we assessed the population proportion via binomial testing.
- (A) is an alternative hypothesis H_1 and (B) is a null hypothesis H_0.
  - $H_0 : p = 1/3$ and $H_1 : p > 1/3$,

  where $p = \frac{X}{n} = \frac{\text{Num. of years in a class}}{\text{Num. of Events}}$.
- The probability distribution function $P(X)$ can be given by binomial distribution.

$$P(X) = \frac{n!}{(n-X)!X!}\left(\frac{1}{3}\right)^X\left(1-\frac{1}{3}\right)^{n-X}$$

- Reject H_0 when the p-value is low enough (less than 0.10).

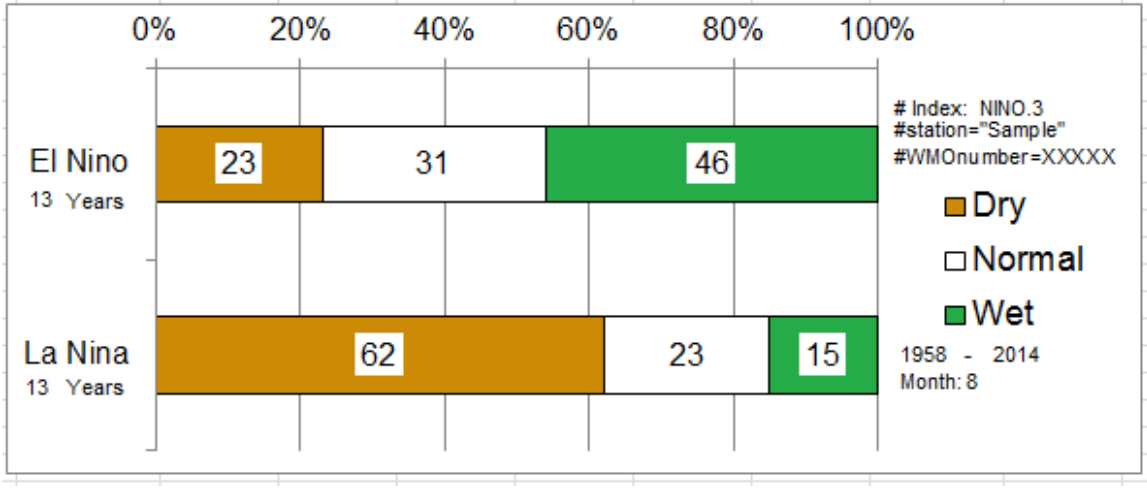
Statistical Testing

- Is it statistically significant that there are more “Wet” years associated with El Niño?
- Considering the p-value is 0.24, the possible answer is……,

  It is likely that there are more “Wet” years under El Niño condition. But it is not statistically significant.

Binomial test: (p-value)	Dry	Normal	Wet	Not Dry	Not Wet
El Nino	0.8612678	0.67757	0.2413081	0.322424	0.8964608
Neutral	0.8608653	0.3225039	0.4882453	0.2462713	0.6774961
La Nina	0.0346548	0.8612678	0.9614633	0.9911768	0.1387322

Correlation	r	t-v
	0.1957617	1.



Concluding Remarks

- Our motivation was……

  To investigate **the occurrence probability of warm/cold and wet/dry years when El Niño or La Niña condition** persists based on the data you have already prepared

- We have just understood how to investigate it. We made a occurrence probability figure and interpreted the result statistically.

Now It's Your Turn!!

- Now you can apply this tool to your data.
  - You can change station, the analysis period, calendar month and weather element (precipitation/temperature).
  - You can also change the climate variability mode's index (e.g., Arctic Oscillation(AO), IOBW SST index (tropical Indian Ocean) and others).
  - Also see the supplement.
- Please feel free to ask our TCC staff your question.

Useful Links

- TCC HP
  - Impacts of Tropical SST Variability on the Global Climate
    - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/climate/ENSO/index.htm
  - Composite maps for El Niño / La Niña events
    - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/clisys/enso_statistics/index.html
  - Download El Niño Monitoring Indices
    - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/elNiño/index/
  - ClimatView - a tool for viewing monthly climate data
    - http://ds.data.jma.go.jp/gmd/tcc/tcc/products/climate/climatview/frame.php
    - You can download monthly mean precipitation and temperature data at each station in csv format. You can input downloaded data into the MS-Excel tool.