CLIMATE SCIENCE
TRAINING FOR SECTORS

2

SESSION 2 - The climate system

Department Vanuatu Meteorology and Geo-Hazards
SPREP Secretariat of the Pacific Regional Environment Programme
GREEN CLIMATE FUND
Vanuatu Klaemet Infomesen blong Redy, Adapt mo Protekt
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Climate Science Training for Sectors

Session 2: The climate system

Key Climate Drivers

TOPICS

- The difference between weather, climate variability and climate change
- Understanding climate variability:
  - » Key climate drivers
  - » Other climate influences

The difference between weather, climate variability and climate change

It is expected that the participants will be able to utilise the information and learnings in this course to support their particular sector which in turn better protects the people and property of Vanuatu against climate and climate change impacts.

Climate is what you expect…

Weather is what you get…

Weather describes the conditions outside for a particular timeframe at a specific place. For example todays weather in Port Vila is ……(state what the weather is at the time of the presentation)

We can get weather forecast for the next day, next 3 days or next 7 days (weather focuses on short-term conditions)

Climate describes the average weather condition in a location during a particular time of the year. Climate is determined by averaging observed weather over a period of many years, typically 30 years or more. For example average rainfall and average temperature using 30 years of observed data for a particular location will give the climate for that location.

We can get a climate outlook/forecast for the next 3 months or six months. For example in Vanuatu we can say during June to August, it is usually sunny and fine but you may get occasional thunderstorm or heavy rain.

Climate change may change what you expect and what you get…

Climate change is a long-term change in global or regional climate patterns i.e. longer-term change in the pattern of weather, and related changes in oceans, land, surface etc. occurring over decades or longer.

The photos illustrate long term changes in landscape due to long-term changes in rainfall and temperature patterns.

Weather and climate: Time scales

One way to understand the difference between weather, climate variability and climate change is to think about how they operate on different time scales.

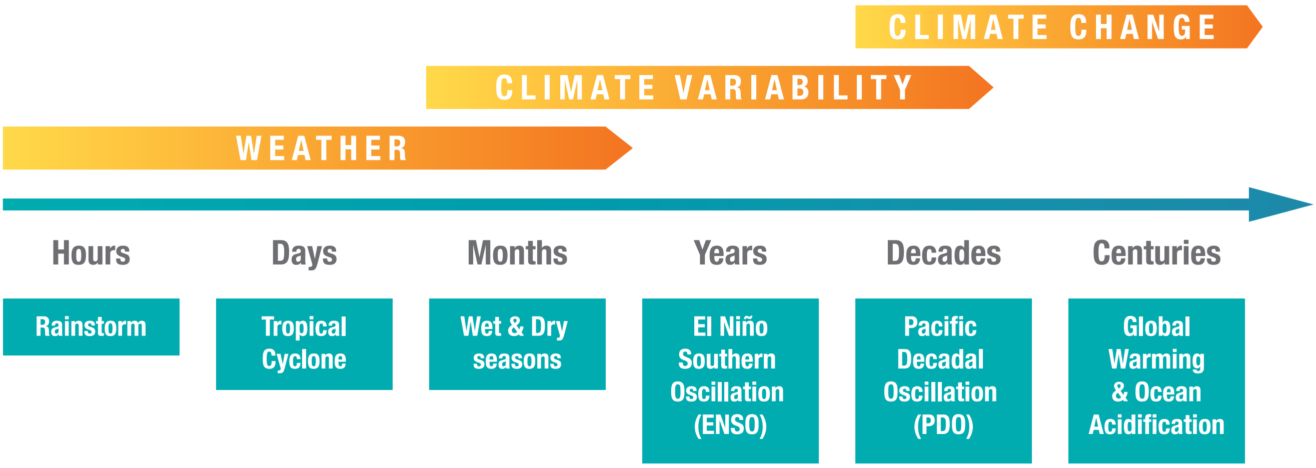
This diagram illustrates different periods of time ranging from hours, days, months, years, decades and centuries.

Weather occurs over hours, days and maybe months. Examples of weather are rainstorms that might last one or two hours, tropical cyclones that may last days, and drier days during dry season.

Climate variability occurs over months and years and can be defined by climate patterns such as the El-Niño Southern Oscillation. There are other climate drivers such as Pacific Decadal Oscillation that can influence climate variability over decades, but we will not cover that in this workshop.

Climate change occurs over decades and centuries, and refers to things which happen over centuries, like global warming.

We will look at climate change in details in the next session; in this session we will focus on climate variability and the key climate drivers that induce climate variability. It should be remembered climate variability and climate change are not the same and should NOT be used interchangeably but they can occur in parallel.



Understanding Climate Variability

Climate variability affecting the Southwest Pacific:

- Seasonal variations (ITCZ, SPCZ and WPM)
  - Lasting 3 to 6 months
- Intraseasonal variations (MJO)
  - Lasting 1 to 2 months
- Interannual variations (El Niño/La Niña)
  - Lasting more than 2 years or year to year

Climate variability describes changes in climate that take place over months, seasons and years.

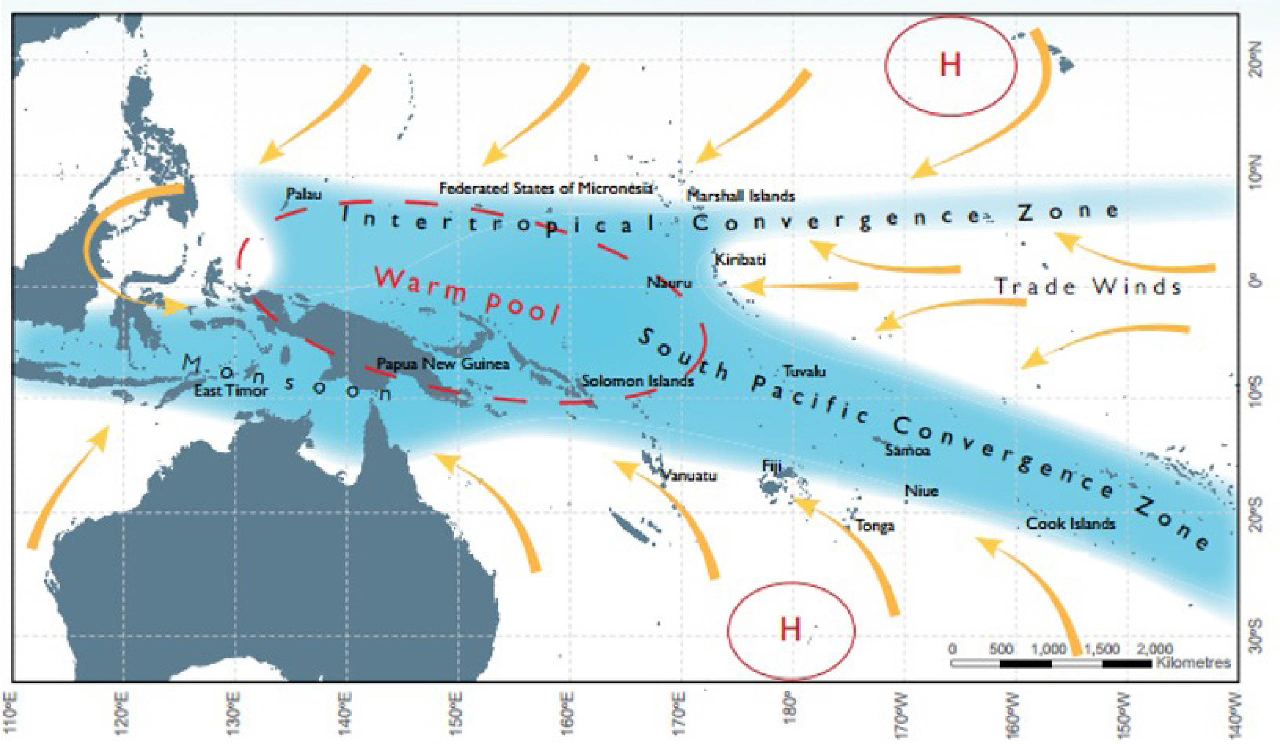
Climate variability is due to the presence (and changes in the positions and intensity) of the main climate features such as ENSO, SPCZ, ITCZ, WPM, MJO

Seasonal variation occurs roughly over 3 to 6 months. Key drivers of seasonal variation are ITCZ, SPCZ and WPM

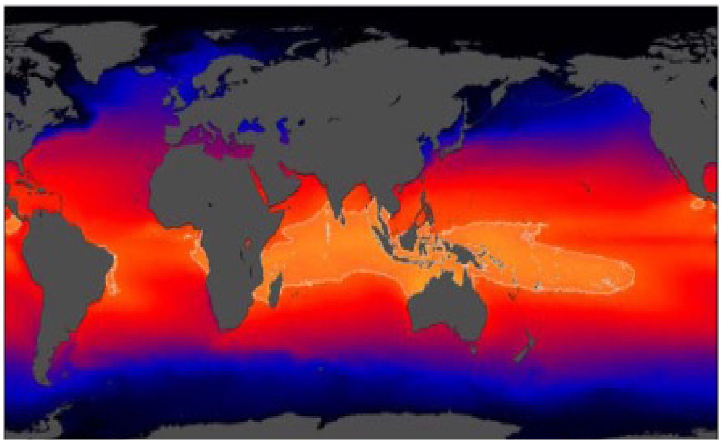
Intra-seasonal variations can occur over one or two months - MJO = Madden-Julian Oscillation

Interannual variations occur year to year or over several years - ENSO (El Niño-Southern Oscillation)

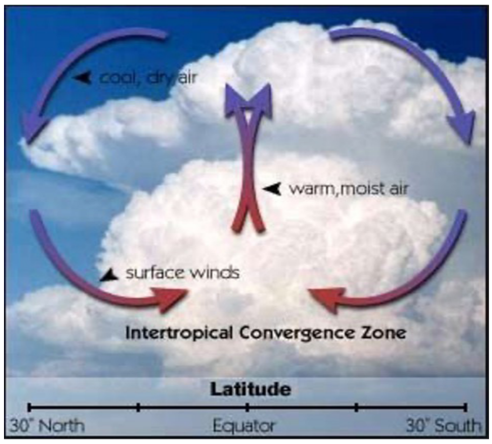
Key Climate features in the Pacific



The water in the Indonesian Pacific tends to be warmer and hence creates a warm pool (area marked in the dashed circled). The Western Pacific Warm Pool has two zones of convergence extending from it. The Intertropical Convergence Zone (ITCZ) and the South Pacific Convergence Zone (SPCZ). A convergence zone in meteorology is a region in the atmosphere where two prevailing flows (wind) meet and interact, usually resulting in cloudiness and rainfall.



This body of water, (orange) which spans the western waters of the equatorial Pacific to the eastern Indian Ocean, holds the warmest seawater in the world.

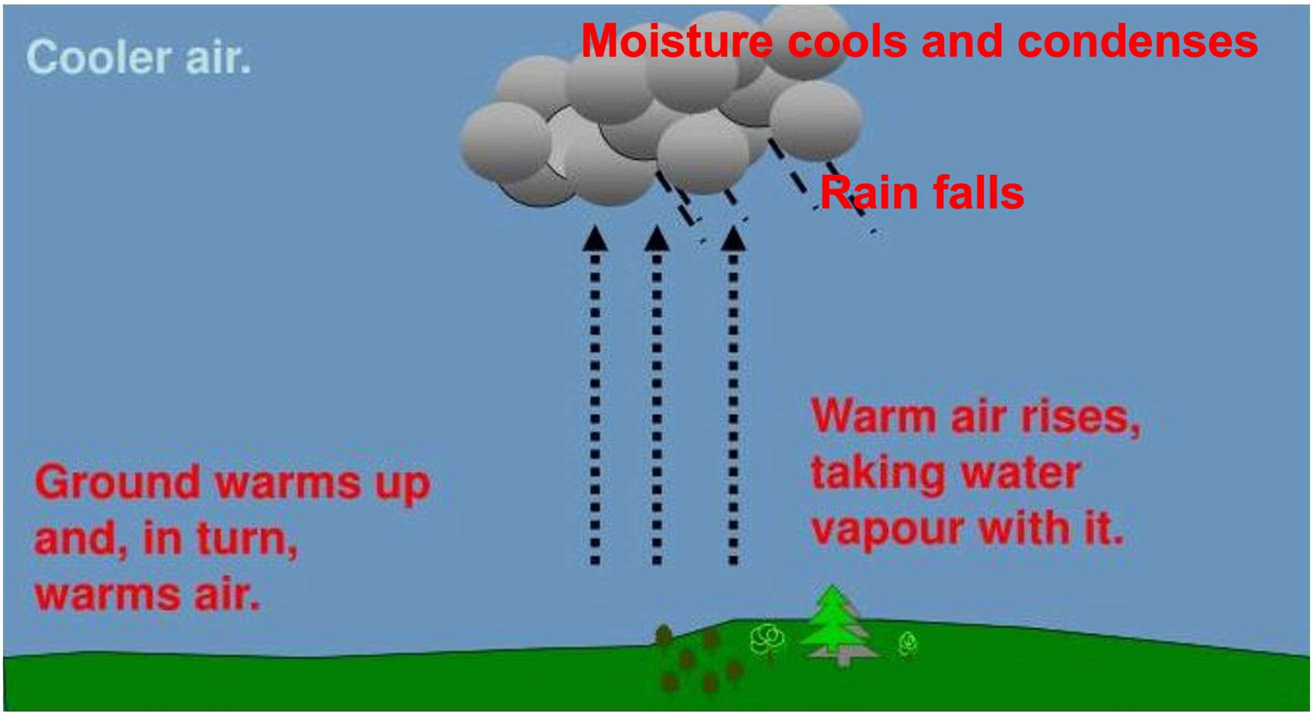


This diagram illustrates convergence of northeasterly and southeasterly winds at the equator, leading to convection (i.e. warm moist air raises) forming cloudiness and rain.

ITCZ is the zone in the central and eastern Pacific. In the western Pacific it becomes broad in association with the West Pacific Warm Pool to the north and south.

The SPCZ is another convergence zone and is most clearly defined and active in the Southern Hemisphere summer, although it is evident all year round.

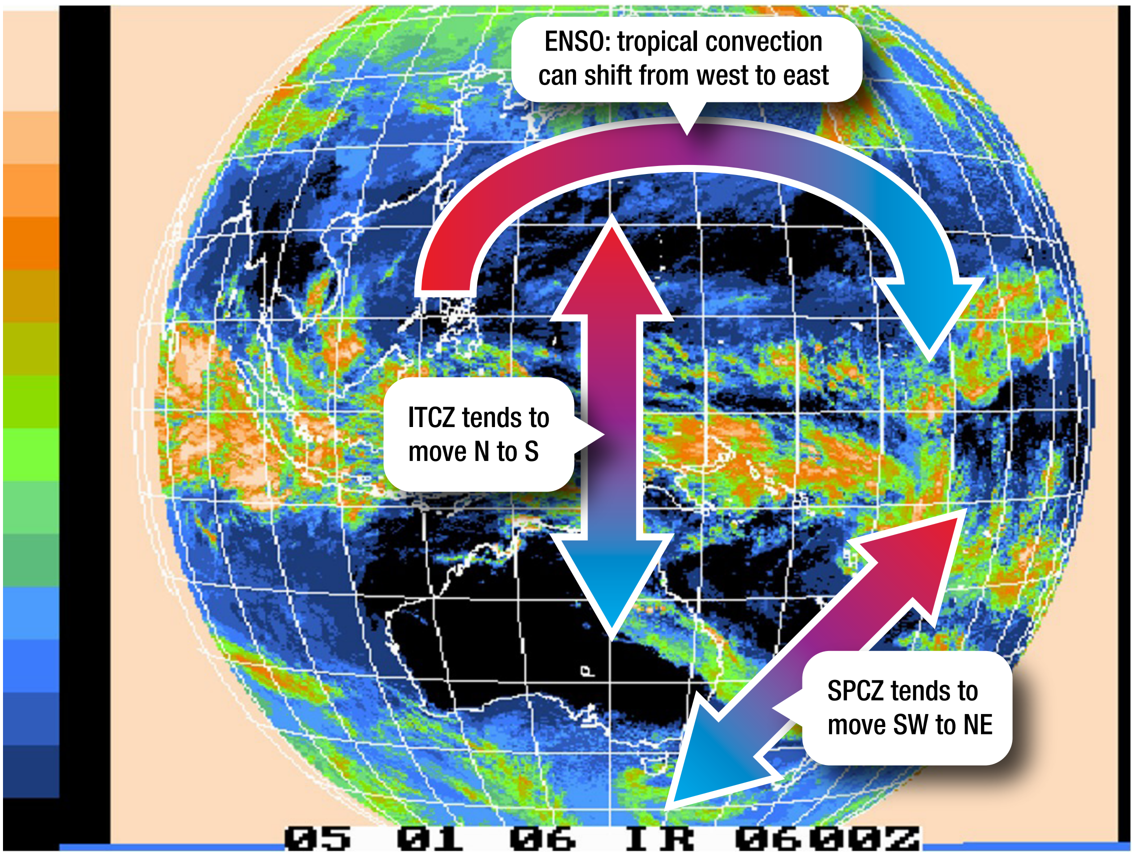
Placement of key climate features



Cloudiness and rainfall are associated with convection zones, and climate variability is mainly caused by the shifting or weakening of these convective zones.

Convection zones are where rainfall occurs when the energy of the sun heats the surface of the Earth (or the surface water), causing water to evaporate to form water vapour. When the surface heats up, it warms the air above it. This causes the air to expand and rise causing low pressure zone. As the air rises it cools and condenses. This process of condensation forms clouds high in the atmosphere. If this process continues rainfall will occur. This type of rainfall is very common in tropical areas.

Remember that LOW PRESSURE is associated with cloudiness and rainfall, whereas HIGH PRESSURE is associated wit clear sky and no rainfall.



SPCZ:

- a belt of high rainfall and cloudiness
- stretches from the Solomon Islands to Fiji, Samoa and Tonga
- associated with a sea surface temperature maximum
- is present year-round but most active in the Southern Hemisphere summer

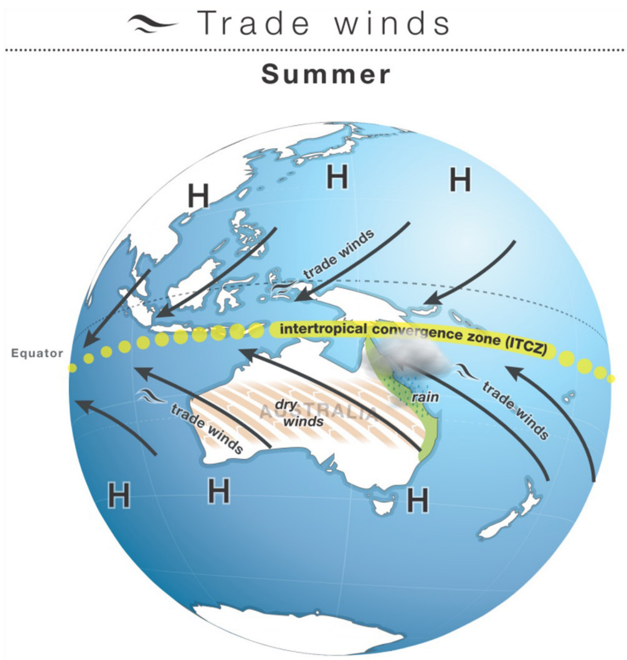
ITCZ:

- zone of high rainfall and much cloudiness
- zone of convergence of the trade winds
- moves north and south with the seasons

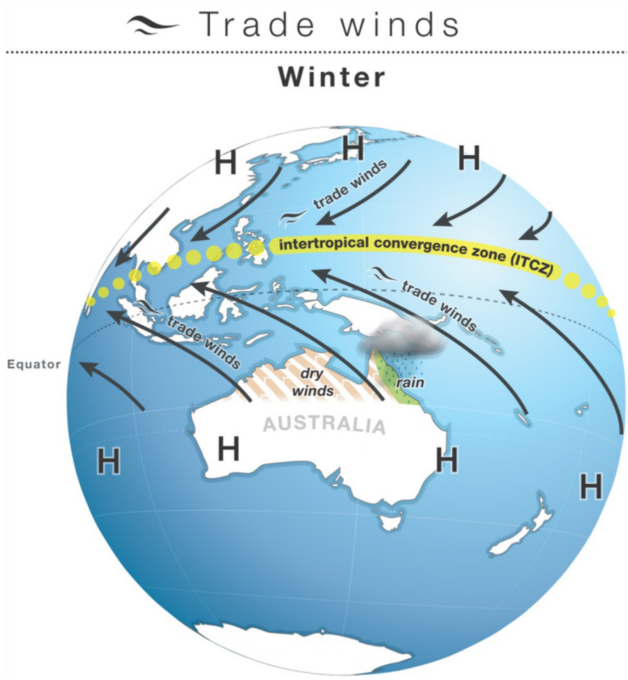
ENSO:

- zone of high rainfall and much cloudiness in the west .
- tends to shift from west to east during El Nino

ITCZ location during wet and dry months



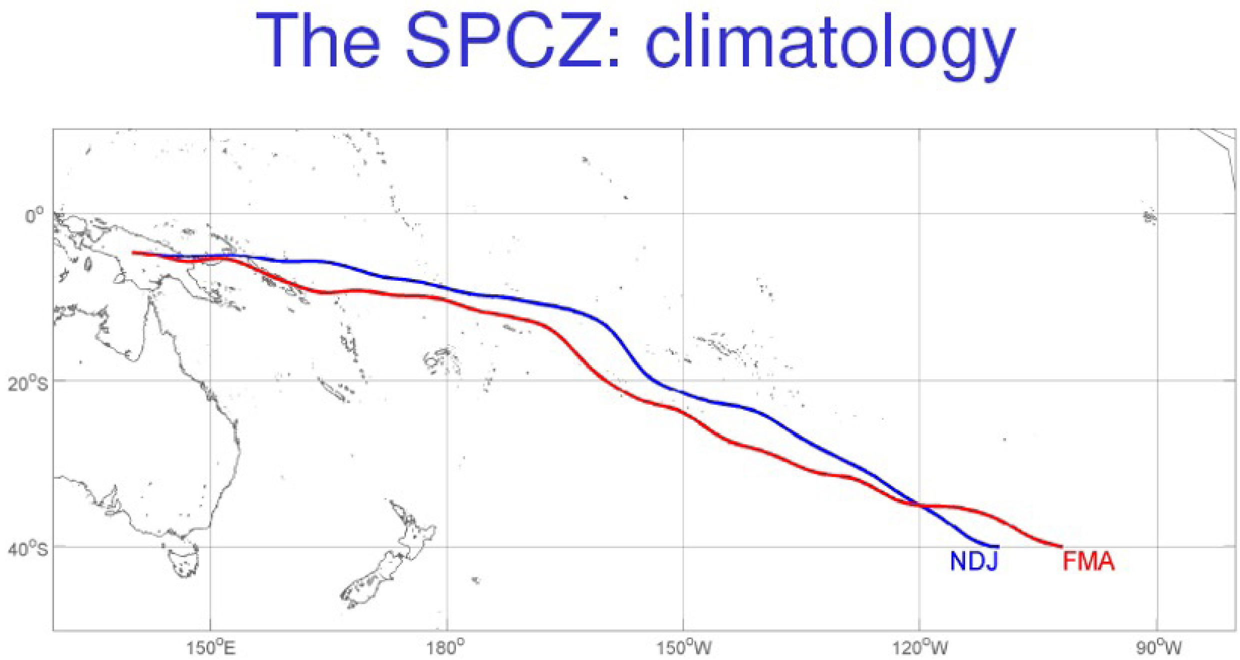
The ITCZ expands over the equatorial Pacific – it is the area where trade winds from the south and north converges (meets) leading to building up of clouds resulting in the development of frequent thunderstorms and heavy rain in this area



During summer (i.e. wet season in Vanuatu), ITCZ tends to move to the southern side of the equator; during winter (i.e. dry season in Vanuatu), it moves to the northern side of the equator.

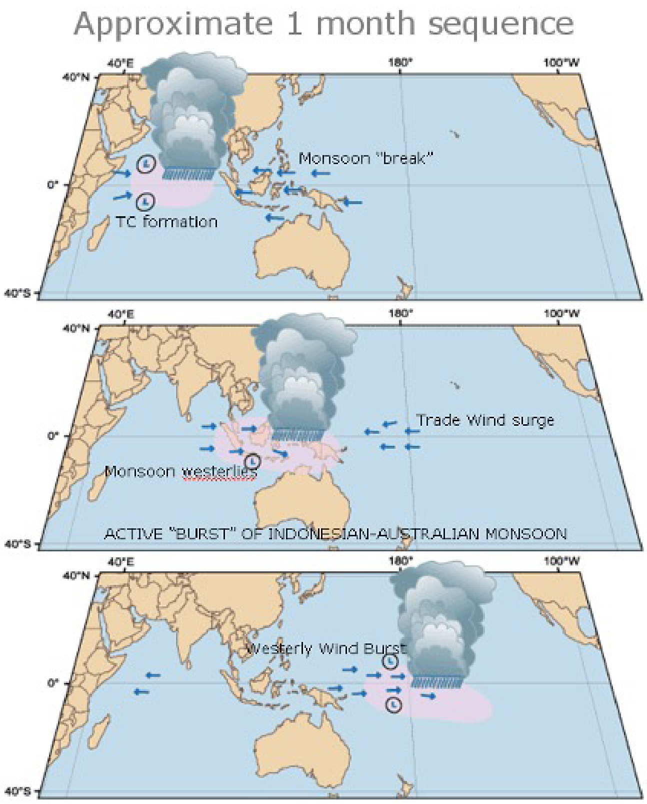
> **Remember**:
>
> warm sea surface temperature means low pressure leading to cloud formation resulting in rainfall and thunderstorm.

SPCZ during most active months



The diagram shows where SPCZ is generally positioned during two periods: November to January and February to April In Feb to April it moves slightly to the southeast

The Madden-Julian Oscillation (MJO)



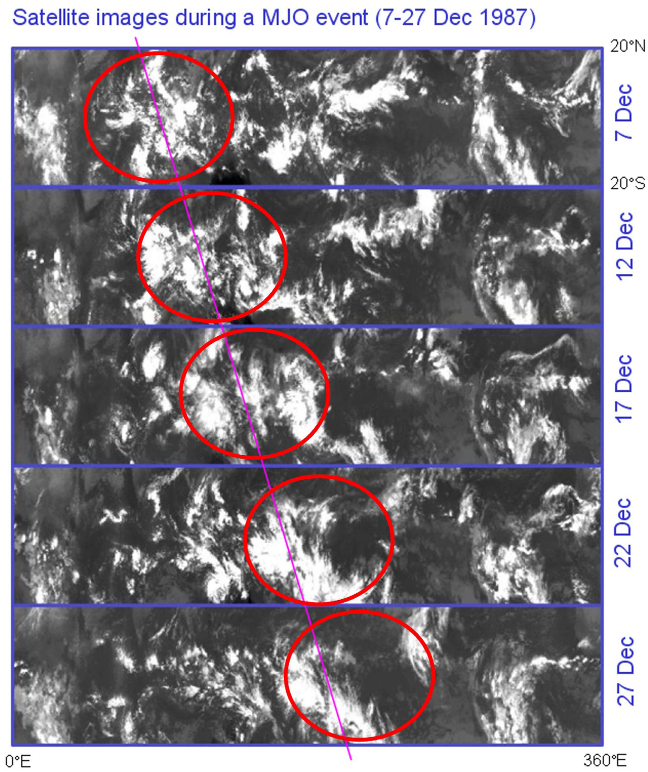


Image courtesy of *Duane Waliser*

The MJO was first studied in the 1970s. It's the strongest mode of intraseasonal variability on Earth, lasting 1 to 2 months.

The MJO is the major fluctuation in tropical weather on weekly to monthly timescales. It is characterized by an eastward movement of large regions of both enhanced and suppressed tropical rainfall, observed mainly over the Indian Ocean and Pacific Ocean, typically recurring every 30 to 60 days.

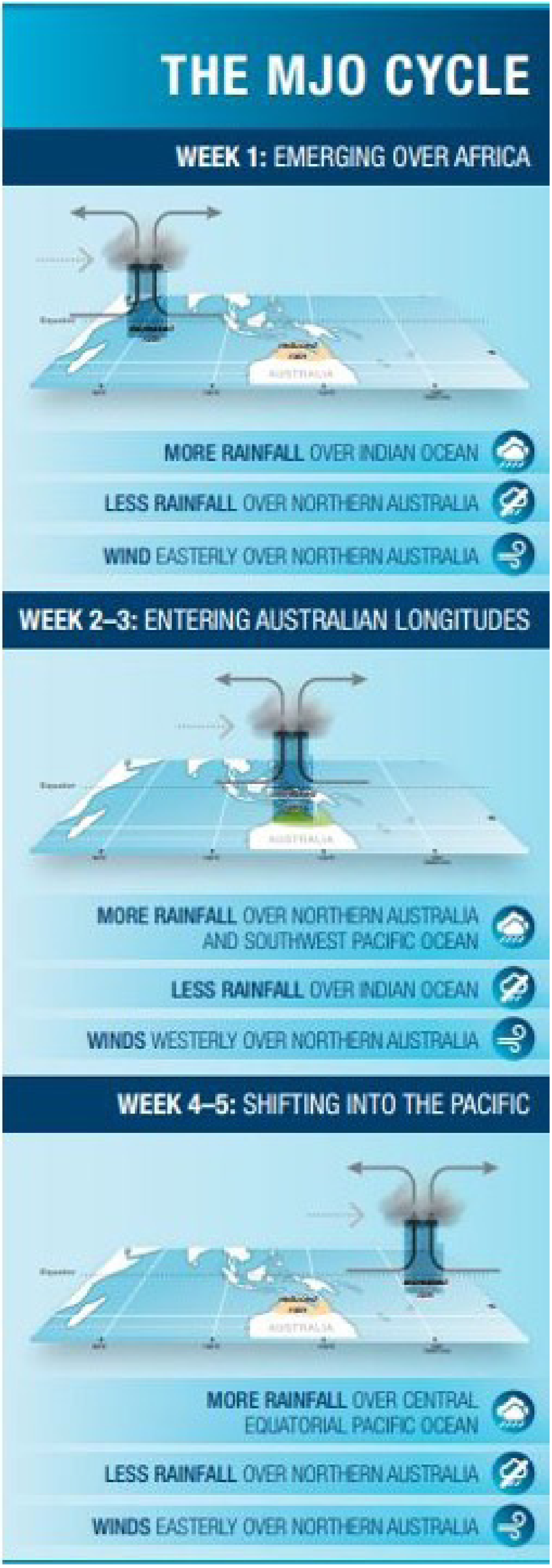
The anomalous rainfall is usually first evident over the western Indian Ocean and remains evident as it moves eastward over the very warm ocean waters of the western and central tropical Pacific.

The MJO is not always present but tends to occur from October to April.

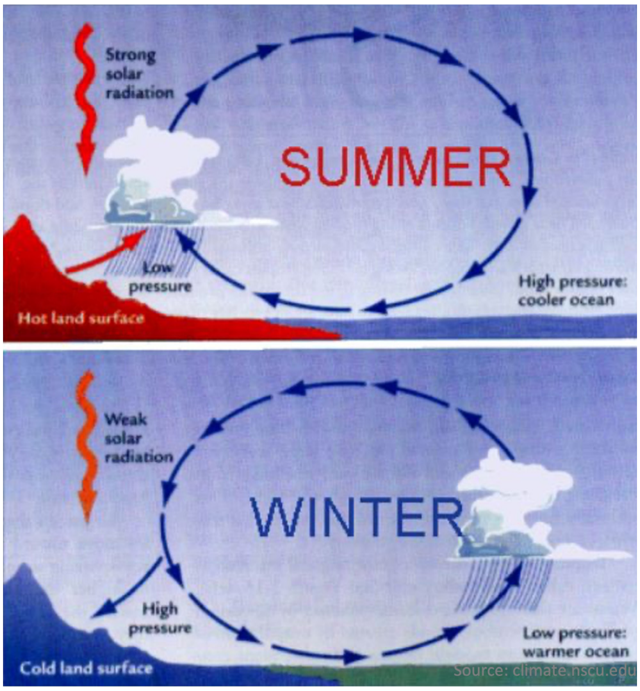
Why is it important?:

1. Brings active and break phases of the monsoon or wet season.
2. Increases the chance of tropical cyclones.
3. Associated westerly wind burst (WWB) can play a critical role in the development of El Nino events
4. More active in the southern summer/autumn.
5. Generally less prevalent during ENSO events, especially the stronger ones (either La Nina or El Nino)

Point out that the MJO is moving from west to east over the period of 1 to 5 weeks, and how it affects the rainfall and the wind.



The West Pacific Monsoon (WPM)



A monsoon is not a single storm; rather, it is a seasonal wind shift over a region. The shift may cause heavy rains in the summer, but at other times, it may cause a dry spell.

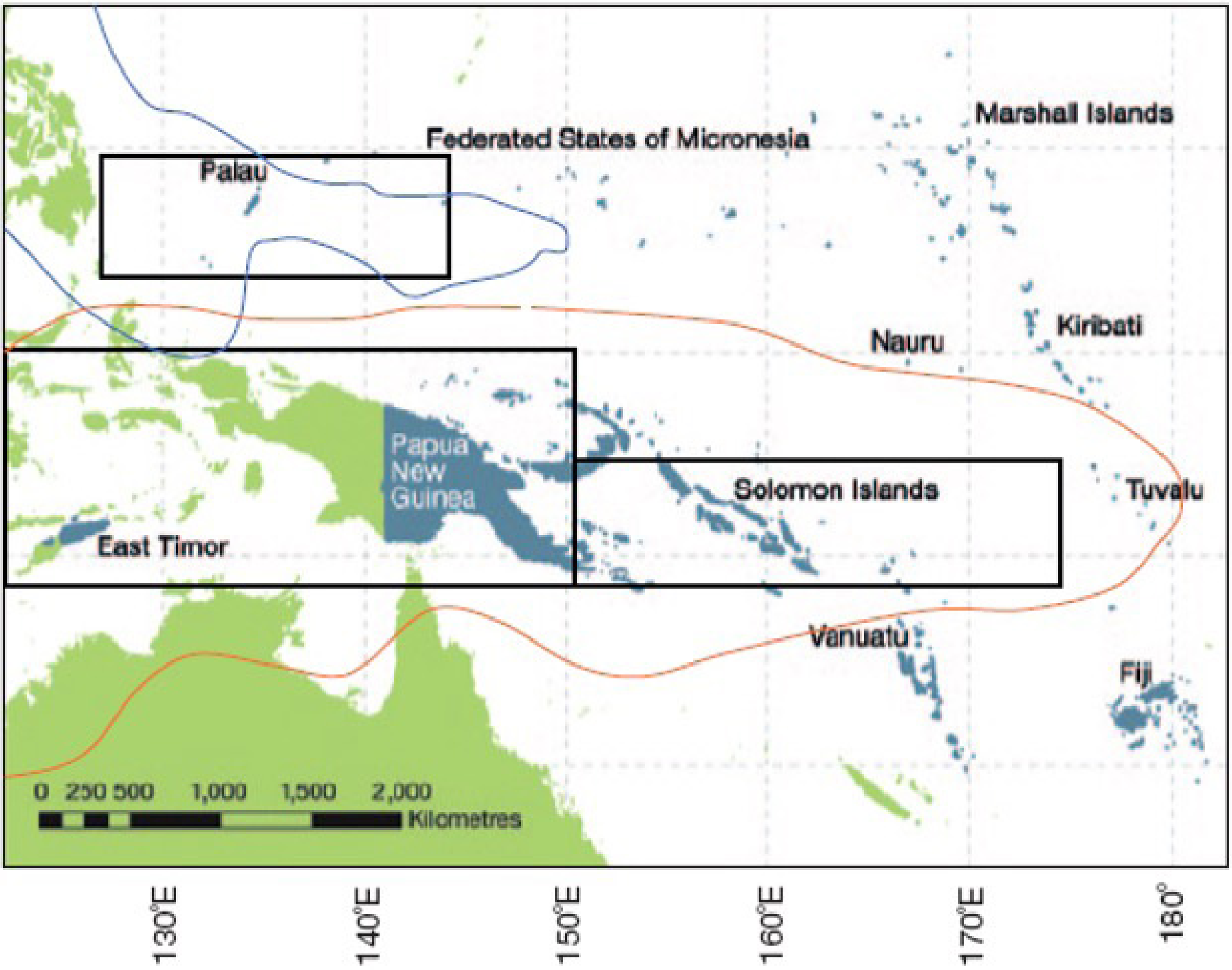
The West Pacific Monsoon is an element of seasonal climate variability in the tropics. The movement of the ITCZ across the equator along with the largescale changes in wind direction brings about heavy precipitation in the effected areas. This is known as the monsoon.

Those regions near the limits of the ITCZ extent (e.g. northern Australia, Solomon Is) experience active and inactive periods in the monsoon as the ITCZ (monsoon trough) fluctuates in its location. The Western Pacific Monsoonaffects those areas under the direct influence of the ITCZ (image above, circled in red)

A monsoon (from the Arabic mawsim, which means "season") arises due to a difference in temperatures between a land mass and the adjacent ocean. The sun warms the land and ocean differently, eventually switching directions bringing the cooler, moister air from over the ocean. The winds reverse again at the end of the monsoon season.

The West Pacific Monsoon (WPM)

The countries affected include Australia, PNG, Solomon Islands and parts of Vanuatu.



Exercise: Pacific Climate Drivers

Exercise 1 Multiple Choice

Exercise 2 Identify the timescales for each of these climate drivers:

- ITCZ, PSCZ, WPM
- MJO
- El Niño/La Niña

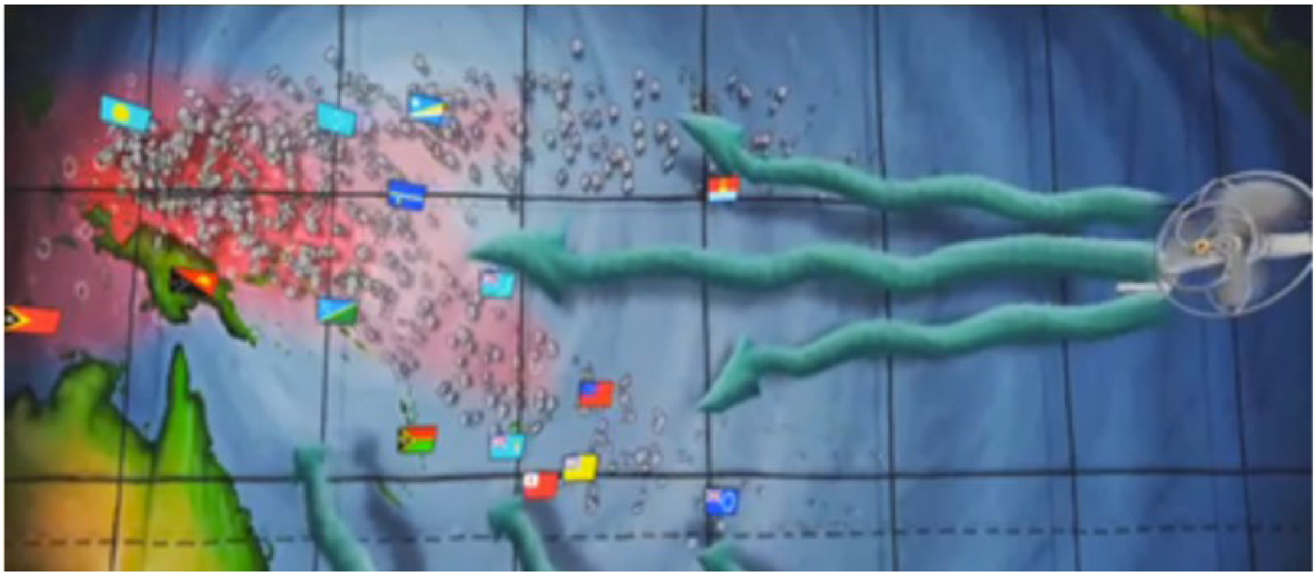
ANSWERS:

Seasonal variations (ITCZ, SPCZ and WPM) - Lasting 3 to 6 months

Intraseasonal variations (MJO) Lasting 1 to 2 months

Interannual variations (El Niño/La Niña) - Lasting more than 2 years or year to year

El Niño–Southern Oscillation (ENSO) – normal conditions



ENSO is the most important driver of year-to-year variability in climate in the Pacific region. Throughout the region, ENSO affects the year-to-year risk of droughts, floods, tropical cyclones, extreme sea levels and coral bleaching.

ENSO has two extreme phases – El Niño and La Niña.

There is also a neutral phase.

Each El Niño and La Niña event are different, so they have different impacts.

El Niño and La Niña events drive changes in circulation, winds, rainfall and ocean surface temperatures.

- Normal conditions, or the neutral phase of ENSO, are shown here.
- The trade winds blow to the west and cause a build up of warm surface water and higher sea level in the west Pacific.

Therefore in normal conditions the surface water in the west is warmer and higher than the east.

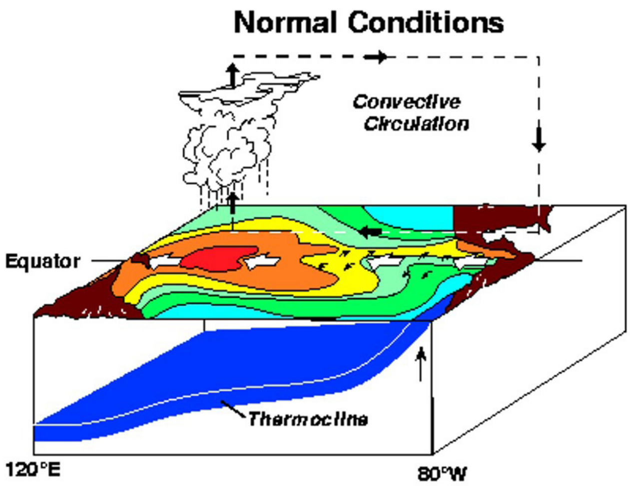
Remember warm waters creates low pressure regionS leading to cloudiness and rain.

In normal, non-El Niño conditions, the sea surface is about 0.5 m higher in the western Pacific compared to the eastern Pacific. The sea surface temperature is about 8°C higher in the west, with cool temperatures off South America.

Rainfall occurs in the region of low pressure where you have rising air over the warmest water. The now-drier air in the upper atmosphere travels east before descending over the cooler eastern tropical Pacific. The eastern Pacific is relatively dry due to subsiding air and cool ocean waters. The pattern of air rising in the west and falling in the east with westward moving air at the surface (equatorial easterly trade winds) is referred to as the Walker Circulation.

Below the ocean surface, there is a distinct east-west differences too. The thermocline, the relatively sharp boundary between the warm surface waters and the cooler denser water underneath is affected. Because of the volume of water dragged westward, the thermocline is angled downwards to the west. One major result of this is the rising or upwelling of cold water along the eastern Pacific coastline. Here the pull of the tradewinds and associated currents drags warmer surface water away from the coast in turn pulling water up to replace it from below. Because this is also the region where the thermocline is shallowest, it is cold water that brought to the surface.

The overall picture of the atmosphere and ocean is a self-sustaining cycle. Each component is linked to each other. The distribution of cold and warm water determines the pressure differences and hence the winds. The winds in turn influences the angle of the thermocline and degree of upwelling. The upwelling reinforces both the temperature and the pressure gradient and so on. The result of this cycle is the continuation/persistence of the east-west differences.

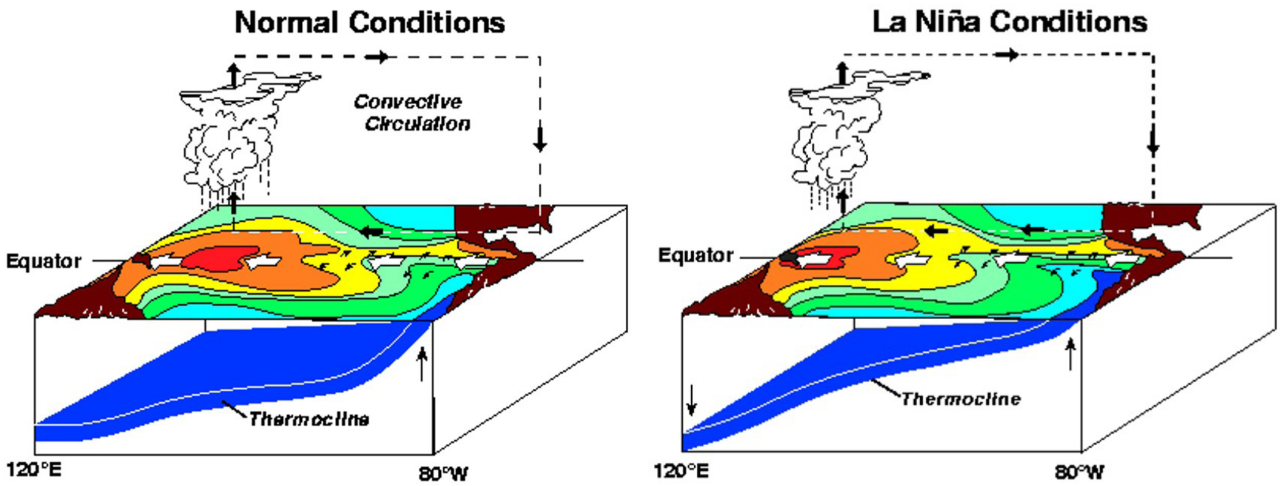


La Niña

La Niña refers to a broad scale cooling of water in the central and eastern tropical Pacific Ocean.

In summary La Niña is the enhancement of the Walker Circulation

- La Niña is associated with cooler than normal ocean temperatures across the central and eastern tropical Pacific Ocean and stronger than normal (easterly) trade winds across the Pacific Ocean.
- La Niña usually brings wetter than normal conditions to countries like Australia, Niue, Vanuatu and Tonga because rainfall moves even more to the south-west than during normal conditions.
- The trade winds from the east have moved the cloud meeting places, or the South Pacific Convergence Zone, to a difference position than it was in normal conditions on the previous slide.



The Walker Circulation and trade winds **strengthen**.

Ocean temperatures become **cooler** than average in the central and eastern Pacific.

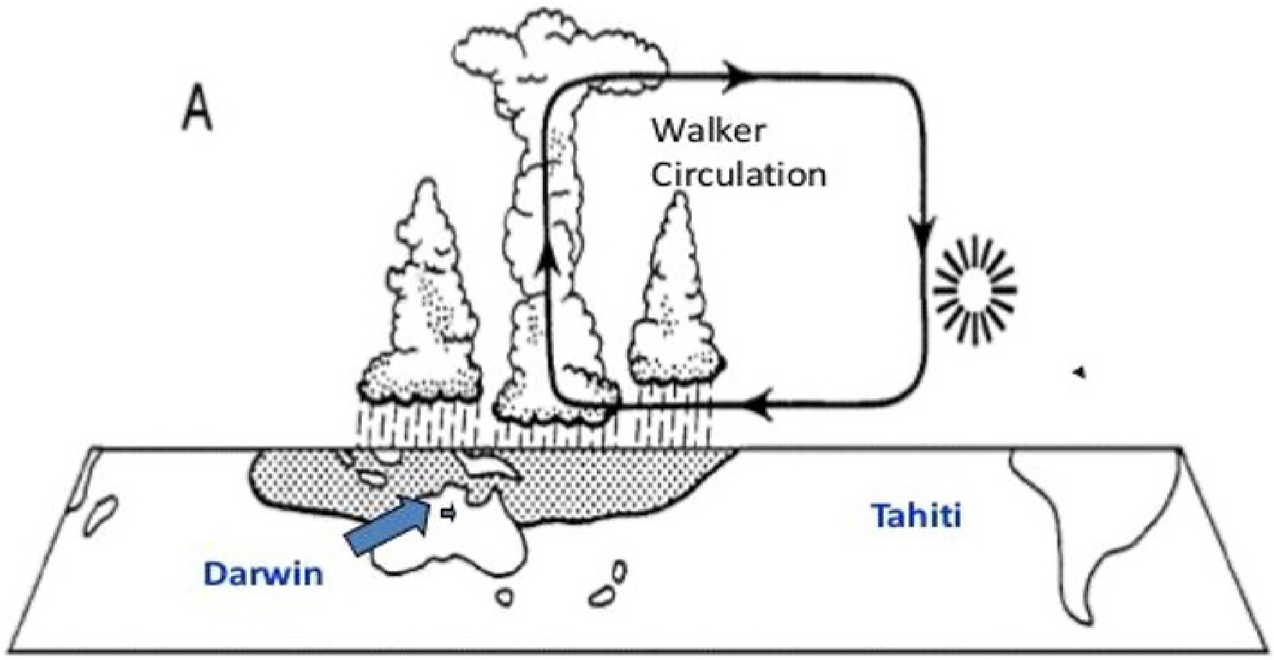
Cloud and rainfall **decrease** over the central and east Pacific. **Increases** in the west - over Australia, Indonesia, Solomon Islands etc.

The Southern Oscillation Index (SOI) remains positive for several consecutive months.

During a La Niña event, the Walker Circulation intensifies with greater convection over the western Pacific and stronger trade winds.

As the trade winds strengthen, the pool of warmer water is confined to the far western tropical Pacific, resulting in warmer than usual sea surface temperatures in the region north of Australia. Sea surface temperatures across the central and eastern tropical Pacific Ocean become cooler than usual and the thermocline moves closer to the surface – cool waters from the deep ocean are drawn to the surface as upwelling strengthens.

Convection and hence cloudiness over the region north of Australia increases as stronger winds provide more moisture to the overlying atmosphere and the Walker Circulation intensifies.



Walker Circulation and Southern Oscillation

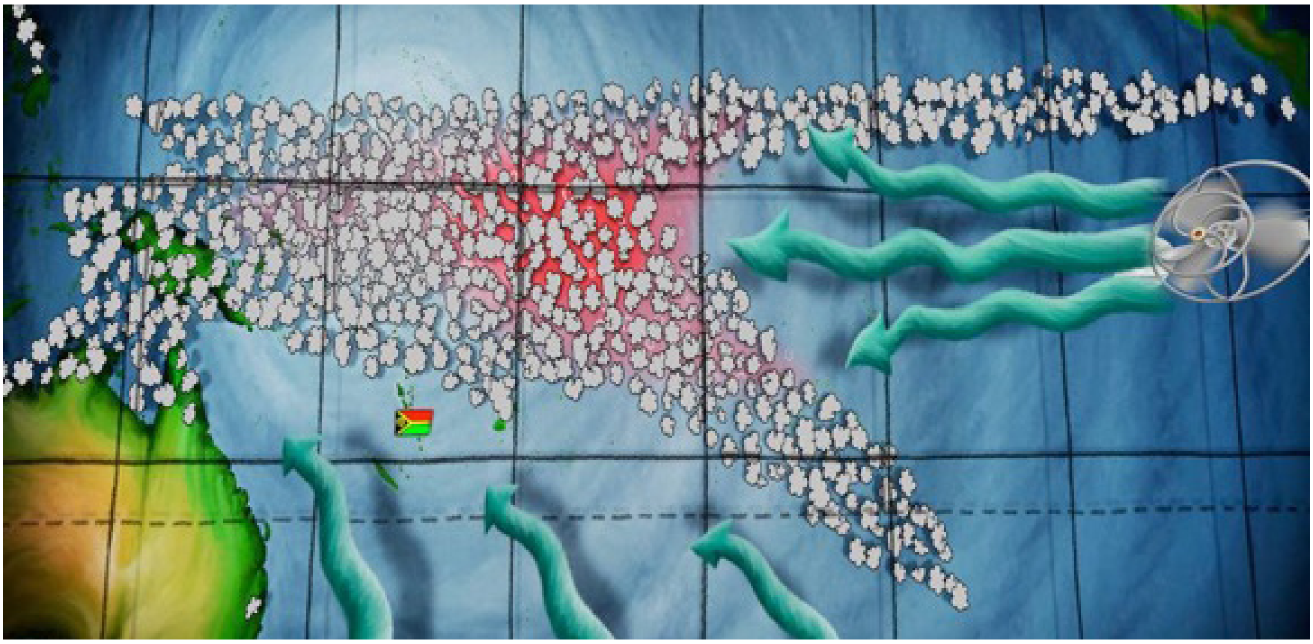
Southern Oscillation Index is the surface air pressure difference between Tahiti (east) and Darwin (west) – this indicates the strength of Walker Circulation.

During La Nina:
air pressure is lower in the west and higher in the east therefore the SOI is sustained positive values above +7

During El Nino:,
air pressure is higher in the west and lower in the east therefore the SOI is sustained negative values below -7

During neutral or normal phase,
the SOI is sustained between -7 to+7 (BoM)

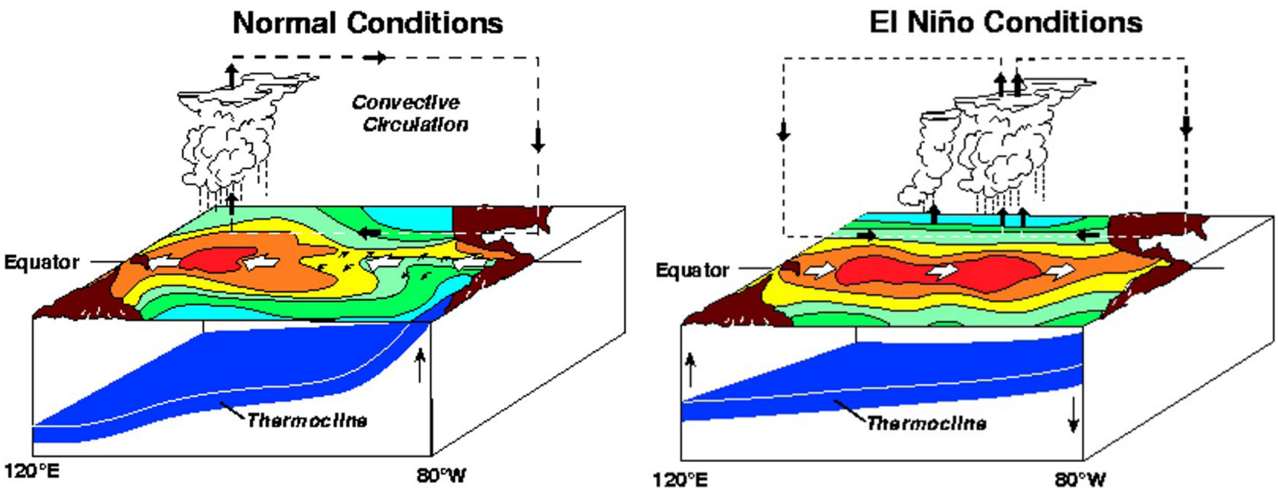
El Niño



El Niño refers to a broad scale warming of water in the central and eastern tropical Pacific Ocean.

In summary El Niño is the reversal of the Walker Circulation

- El Niño brings extensive warming of the central and eastern Pacific and weaker than normal (easterly) trade winds leading to a major shift in weather patterns across the Pacific.
- Typical El Niño conditions in the northern hemisphere winter result in the western Pacific experiencing very dry conditions and the central Pacific around the equator experiencing wetter conditions.



The Walker Circulation and trade winds **weaken**.

Ocean temperatures become **warmer** than average in the central and eastern Pacific.

The Southern Oscillation Index (SOI) remains **negative** for several consecutive months.

Cloud and rainfall **increase** over the central and east Pacific. **Decreases** in the west - over Australia, Indonesia, Solomon Islands etc.

The normal easterly trade winds reverse in the western-central tropical Pacific, usually due to one or several westward-moving bursts of tropical convection (Madden-Julian Oscillation). As this occurs, the warm water in the western tropical Pacific sloshes eastward. This warms the central-eastern tropical Pacific waters, which flattens the thermocline and further weakens the easterly trade winds. The weaker trade winds result in less upwelling in the eastern tropical Pacific, which further warms the eastern tropical Pacific.

The Walker Circulation is shifted eastward as a result of the eastward-displaced ascent, leaving the normally wet western tropical Pacific abnormally dry and high pressure.

ENSO explained – kloud nasara

Play the video

The typical cycle of El Nino

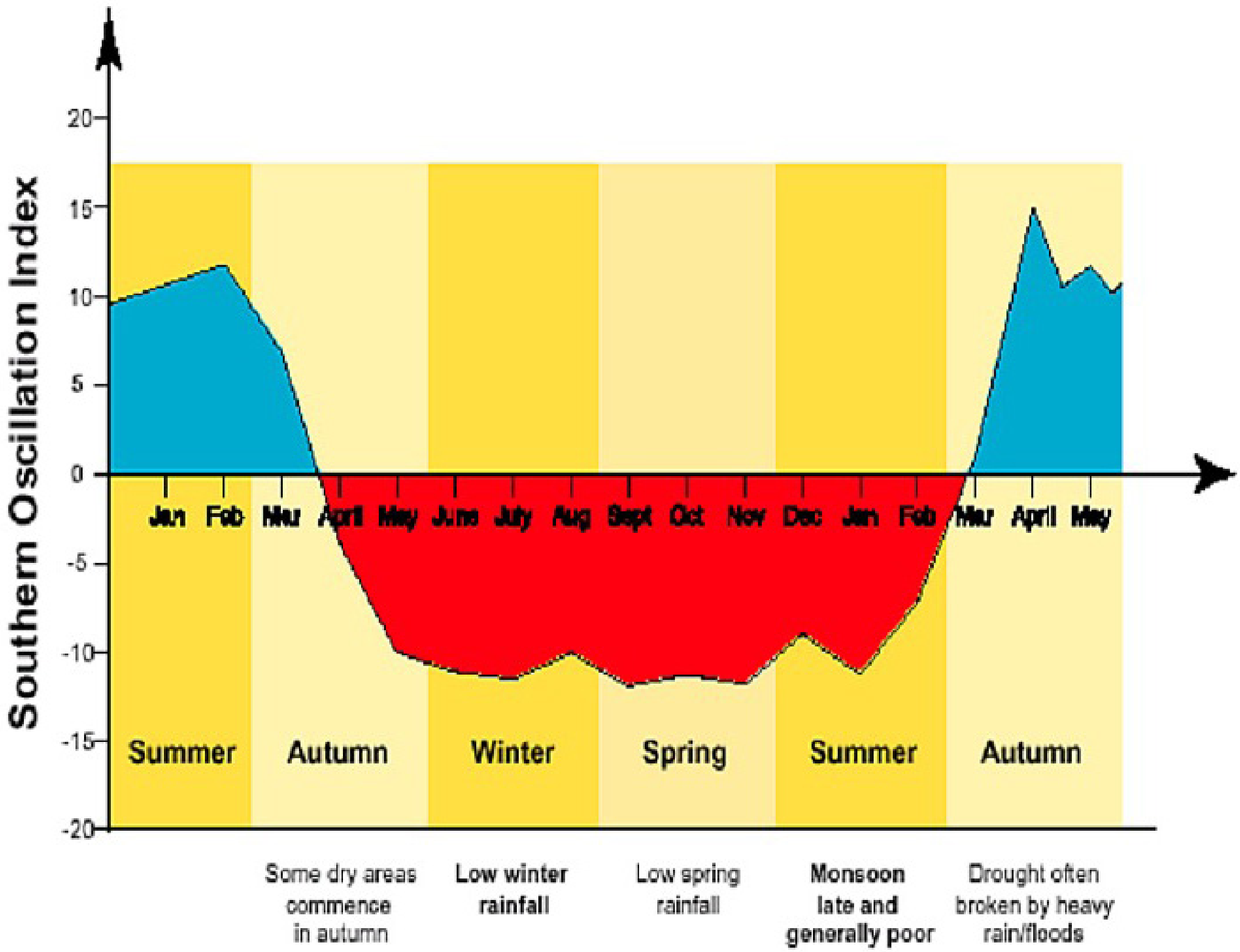
Normally El Nino or La Nina starts developing around autumn (March to June) – but this is not the case for all events. During this period since ENSO is transitioning, it is a difficult time to predict whether the upcoming southern winter will be El Niño, La Niña, or neutral. This is usually due to the rapid changes occurring in the sea surface temperatures and pressure systems around the equatorial Pacific.

The above diagram shows the periods of high and low predictability.

ENSO events usually develop around autumn, reach maturity around December or January and then decay to neutral by around April or May. This typical life cycle is the source of the climate predictability across the Pacific.

Therefore it is harder to predict seasonal rainfall around autumn. You will hear more about seasonal rainfall prediction in later sessions.

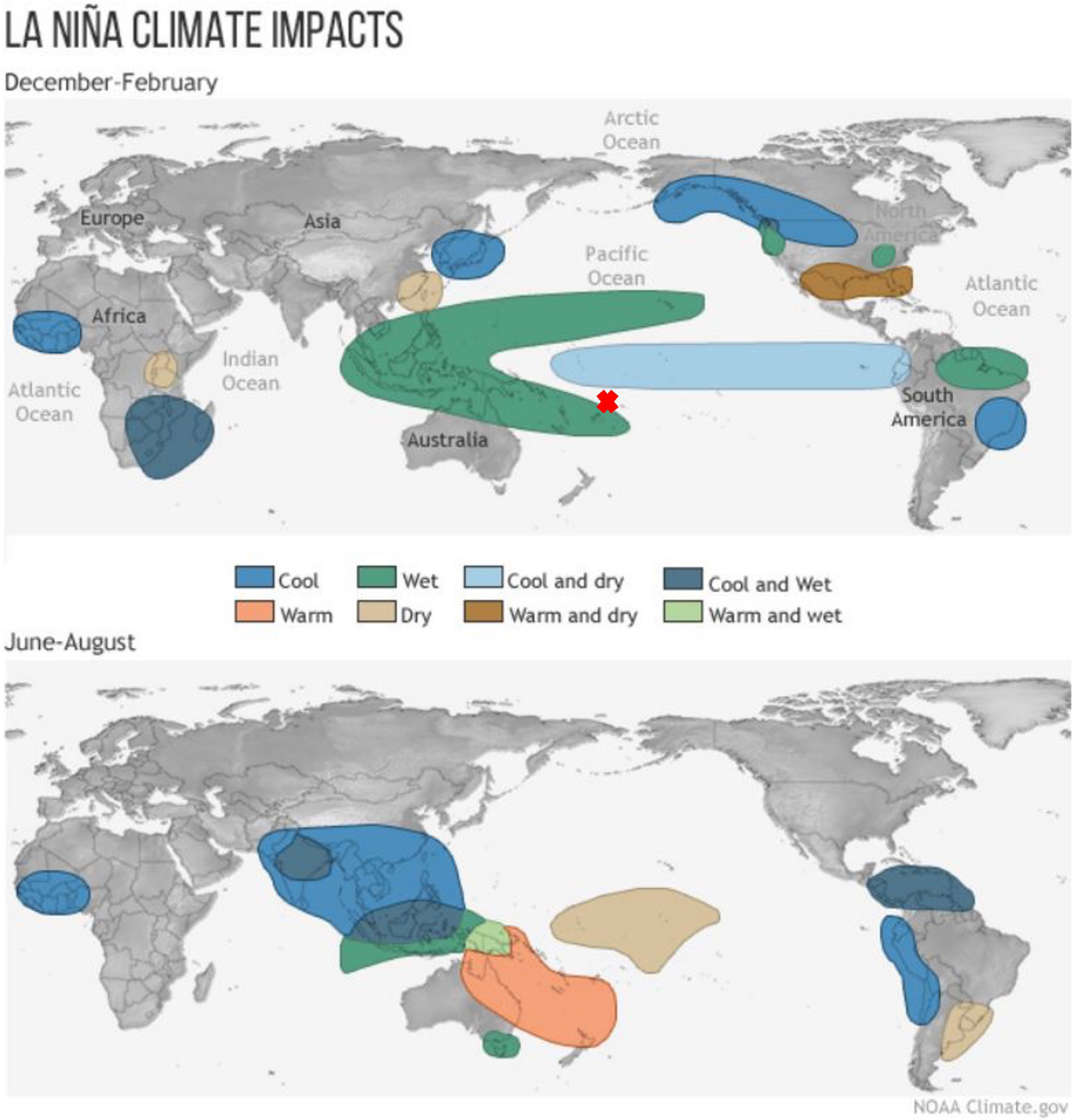
Note SOI: measures the pressure difference between Darwin, Australia and Pape'ete, French Polynesia. This is one of the indicators used to measure the intensity and duration of ENSO.



Typical El Niño/La Niña signature

This diagram shows the warm tongue and cold tongue extending from the eastern equatorial Pacific which illustrates typical El Niño and La Niña characteristics (1997 El Niña event was followed by 1998 La Niña event)

Double click on the image to play the animation of the changes in the sea temperature during the 2015 – 2016 ENSO events



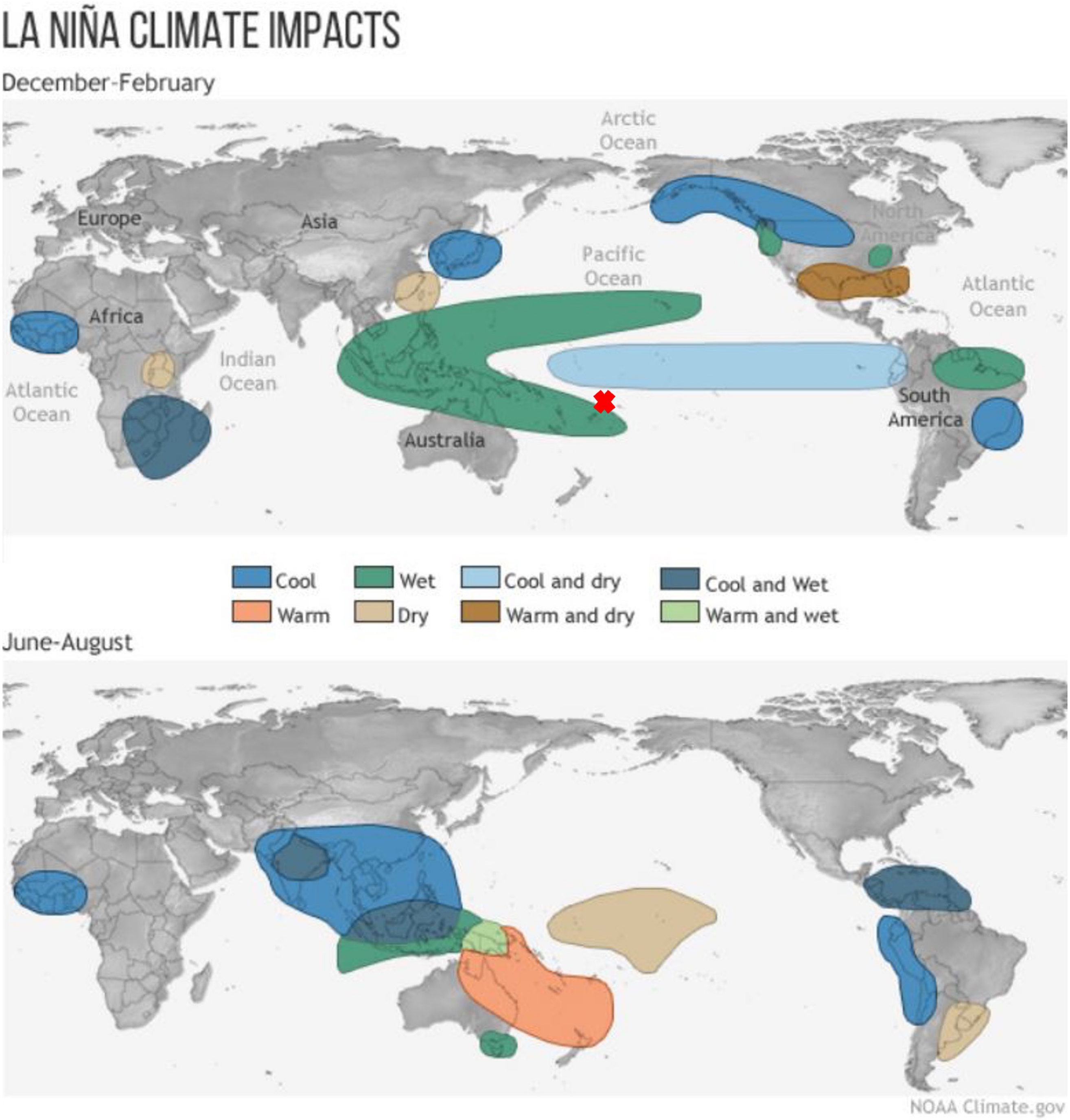
Global impacts: La Niña

ENSO has many very important local and global impacts: Its impact can be felt across the globe depending on its intensity and duration.

- Pacific rainfall and temperatures vary strongly from year-to-year due to ENSO
- Tropical cyclones, sea level, trade winds, all vary with ENSO
- Year-to-year variations in global mean temperature, Atlantic hurricanes and the Indian monsoon are due to ENSO
- Variations in climate due to ENSO is often greater than seasonal and decadal variability and sometimes larger than global warming trends

Vanuatu is marked with a red cross:

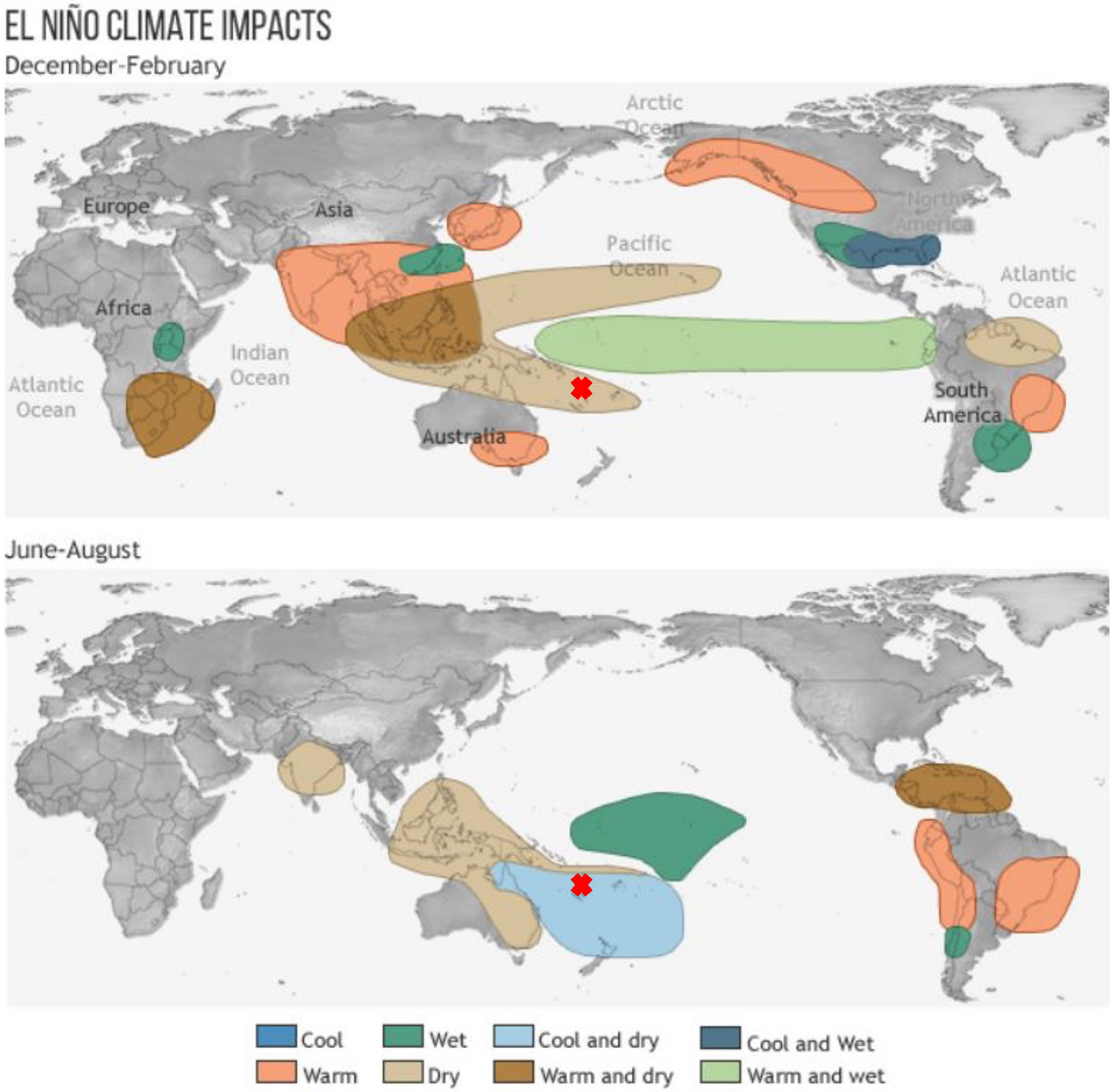
During La Nina: The wet season is likely to be cooler and wetter than normal; the dry season can be warmer than normal



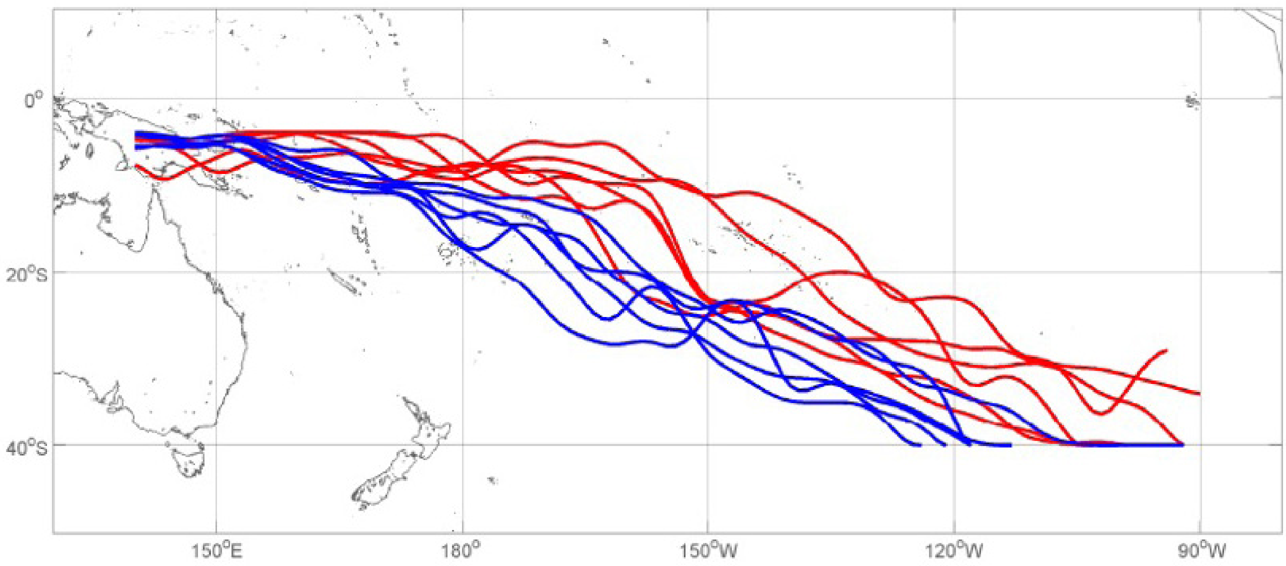
Global impacts: El Niño

Vanuatu is marked with a red cross:

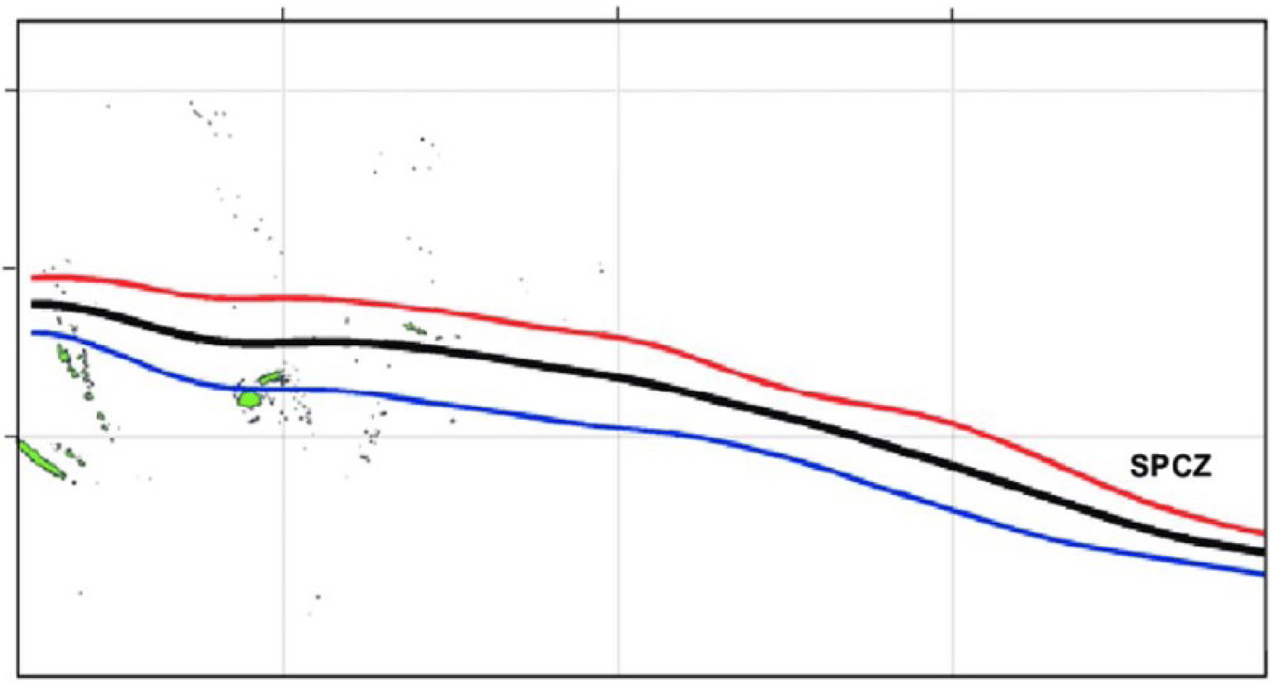
During El Nino: The wet season is likely to be drier than normal; The dry season is likely to be cooler and drier than normal



Impact of ENSO on SPCZ



This diagram illustrates the Nov-Apr mean locations for the six largest El Niño and La Niña events (El Nino in red, La Nina in blue). Neutral years tend to fall in the middle.



This diagram shows 17 Average positions of the South Pacific Convergence Zone (SPCZ) from November to April during El Niño (red), ENSO-neutral (black) and La Niña (blue) events.

SPCZ's mean position migrates Northeast during El Niño and Southwest during La Niña

This shift in position induces massive rainfall variability in affected countries

Impact of ENSO on tropical cyclones

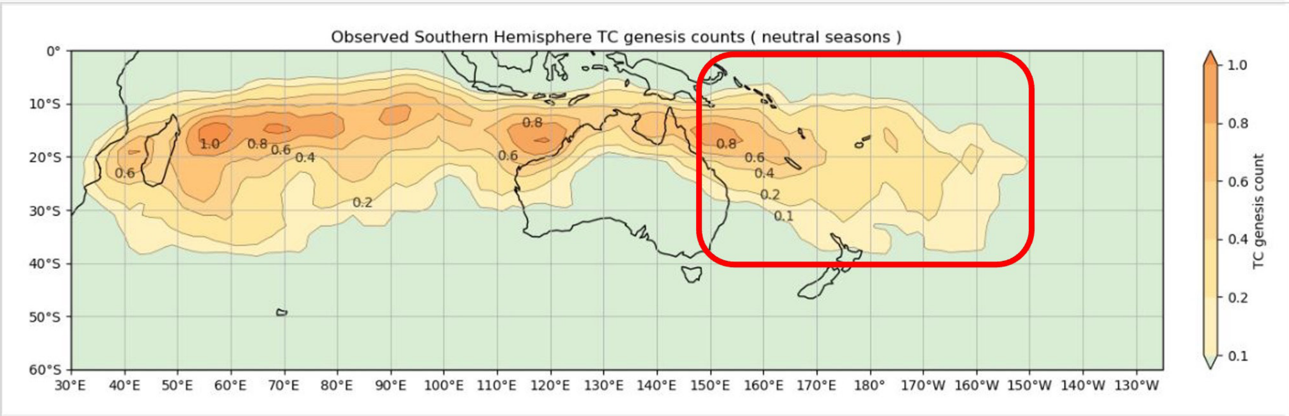
These maps show the average annual number of tropical cyclones through the Australian region in El Niño, La Niña and neutral years. The data are based on a 48-year period from the 1969/70 to 2017/18 tropical cyclone season.

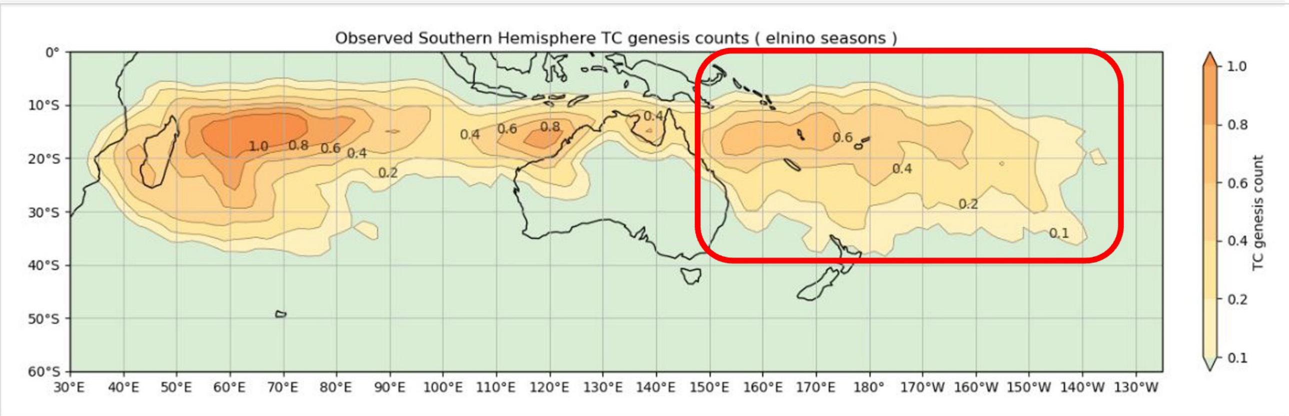
The first image shows that during ENSO neutral years, tropical cyclones tend to occur more in the western to central Pacific with higher frequency in the far west over Solomon Islands, Vanuatu and New Caledonia

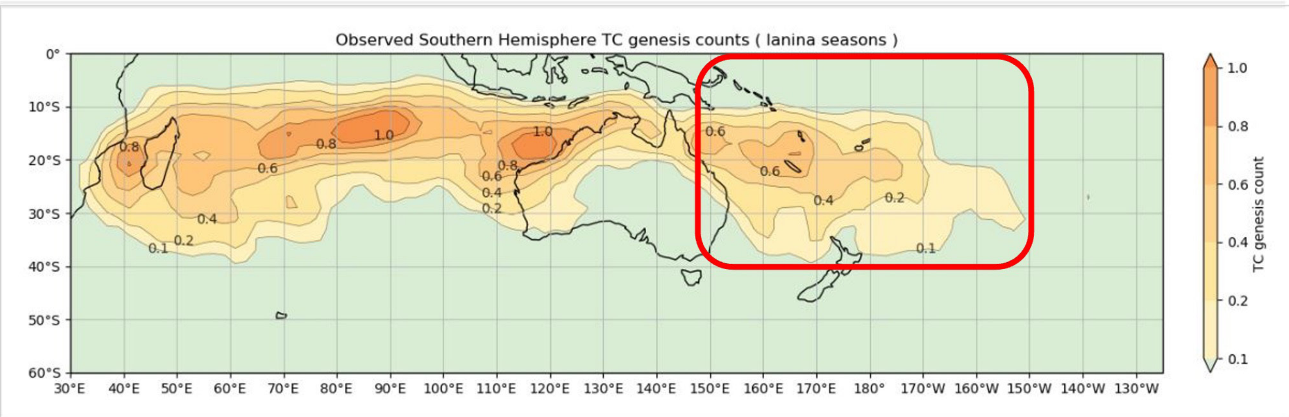
The second image shows that during El Niño, the area where tropical cyclones tend to occur extend to the eastern Pacific as far as Cook Islands and French Polynesia

The third and last image shows that during La Niña, the area where TCs tend to occur is similar to neutral years but with a slightly increased frequency in the central Pacific.

In summary the chance of Vanuatu experiencing tropical cyclone in any year is more or less the same.







Other climate influences

- Sub-tropical highs, trade winds, tropical cyclones
- Island geographic features
    - » Low-lying islands – climate at a key location representative of rest of island/nearby islands
    - » Elevated islands – climate at a key location different to climate several kilometres away
- Differences occur within countries spread over a large area

Other aspects of the climate also have an impact on countries in the Pacific such as sub-tropical highs, trade winds and tropical cyclones, all these events can influence the climate in Vanuatu

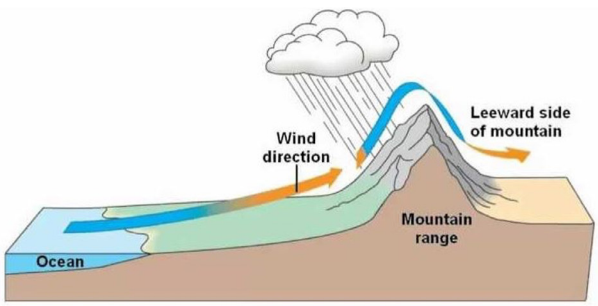
Island geographic features such as mountains also play a key role in the climate.

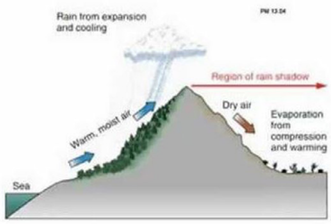
On small low-lying islands, the climate at a key location may represent that of the rest of the island and nearby islands for example one climate station in Funafuti Lagoon in Tuvalu can be sufficient to represent the general climate of the nation.

On larger elevated islands, topography can have a significant effect, so the climate at a key location may not be the same climate being experienced several kilometres away.

In this picture, you can see rainfall tends to occur on the windward side of the mountains, then dry air flows to the other side of the mountain creating a dry zone.

There is also notable differences in climate within countries that are spread over a large geographic region (e.g. the northern and southern Cook Islands where the impact of El Niño and La Niña is totally opposite in the north and south islands). This is mainly due to exposure to trade winds.





Session 4 will focus on key drivers influencing climate variation, and their impact across the Vanuatu

Exercise: What do you know about ENSO?

- Exercise 3 What are the key differences between El Niño and La Niña?
- Exercise 4a What are some of the impacts of El Niño?
- Exercise 4b What are some of the impacts of La Niña?

El Niño events are associated with a warming of the central and eastern tropical Pacific, while La Niña events are the reverse, with a sustained cooling of these same areas. These changes in the Pacific Ocean and its overlying atmosphere occur in a cycle known as the El Niño–Southern Oscillation (ENSO).

El Niño: The Walker Circulation and trade winds weaken.

Ocean temperatures become warmer than average in the central and eastern Pacific.

The Southern Oscillation Index (SOI) remains negative for several consecutive months.

Cloud and rainfall increase over the central and east Pacific. Decreases in the west - over Australia, Indonesia, Solomon Islands etc.

La Niña: The Walker Circulation and trade winds strengthen.

Ocean temperatures become cooler than average in the central and eastern Pacific.

Cloud and rainfall decrease over the central and east Pacific. Increases in the west - over Australia, Indonesia, Solomon Islands etc.

The Southern Oscillation Index (SOI) remains positive for several consecutive months.

SESSION 2 - QUESTIONS
EXERCISE: PACIFIC CLIMATE DRIVERS

EXERCISE 1: MULTIPLE CHOICE ANSWERS

TICK BOX	QUESTIONS	MULTIPLE CHOICE QUESTIONS
	Q1	**QUESTION ONE: WHAT IS THE DIFFERENCE BETWEEN WEATHER AND CLIMATE?**
	A	There is no difference between the terms weather and climate, both terms mean the same thing.
	B	Weather is the long-term, climate is short term
	C	Weather is the prediction between the current period & up to 7 days. Climate is generally longer-term weather patterns
	Q2	**QUESTION TWO: WHAT IS THE CORRECT DEFINITION OF CLIMATE VARIABILITY?**
	A	Climate variability describes changes in climate that take place over months, seasons and years.
	B	Climate variability describes changes in climate that take place over hours, days and weeks.
	C	Climate variability describes permanent changes in the climate
	Q3	**QUESTION TWO: WHAT IS THE NAME OF THE AIR CIRCULATION AT THE EQUATORIAL PACIFIC?**
	A	The Walker Circulation
	B	La Nina
	C	El Nino

EXERCISE 2: FILL IN THE BLANKS

QUESTION ONE: IDENTIFY TIMESCALE FOR EACH OF THESE CLIMATE DRIVERS
ITCZ ...
MJO ...
SPCZ ...
El Niño/La Niña ...
WPM ...

EXERCISE 3: FILL IN THE BLANKS

QUESTION ONE: THE TEMPERATURE OF THE OCEAN IS ONE KEY DIFFERENCE BETWEEN EL NIÑO AND LA NIÑA IN THE PACIFIC, WHICH EVENT IS WARMING, WHICH EVENT IS COOLING?
El Niño events are associated with a .... of the central and eastern tropical Pacific.
La Niña events are the reverse, with a .... of the central and eastern tropical Pacific.

EXERCISE 4a: CIRCLE CORRECT RESPONSE

QUESTION ONE: WHAT ARE SOME OF THE IMPACTS OF EL NINO IN THE PACIFIC?
The Walker Circulation and trade winds **WEAKEN / STRENGTHEN**
Cloud and rainfall **INCREASE / DECREASE** over the central and east Pacific.
Cloud and rainfall **INCREASE / DECREASE** the west - over Australia, Indonesia, Solomon Islands etc.
The Southern Oscillation Index (SOI) remains **NEGATIVE / POSITIVE** for several consecutive months.

EXERCISE 4b: CIRCLE CORRECT RESPONSE

QUESTION TWO: WHAT ARE SOME OF THE IMPACTS OF LA NINA ON THE PACIFIC?
The Walker Circulation and trade winds **WEAKEN / STRENGTHEN**
Cloud and rainfall **INCREASE / DECREASE** over the central and east Pacific.
Cloud and rainfall **INCREASE / DECREASE** in the west - over Australia, Indonesia, Solomon Islands etc.
The Southern Oscillation Index (SOI) remains **NEGATIVE / POSITIVE** for several consecutive months.

SESSION 2 - ANSWERS

EXERCISE: PACIFIC CLIMATE DRIVERS

EXERCISE 1: MULTIPLE CHOICE ANSWERS

TICK BOX	QUESTIONS	MULTIPLE CHOICE QUESTIONS
	Q1	**QUESTION ONE: WHAT IS THE DIFFERENCE BETWEEN WEATHER AND CLIMATE?**
✓	C	Weather is the prediction between the current period & up to 7 days. Climate is generally longer-term weather patterns
	Q2	**QUESTION TWO: WHAT IS THE CORRECT DEFINITION OF CLIMATE VARIABILITY?**
✓	A	Climate variability describes changes in climate that take place over months, seasons and years.
	Q3	**QUESTION TWO: WHAT IS THE NAME OF THE AIR CIRCULATION AT THE EQUATORIAL PACIFIC?**
✓	A	The Walker Circulation

EXERCISE 2: FILL IN THE BLANKS

QUESTION ONE: IDENTIFY TIMESCALE FOR EACH OF THESE CLIMATE DRIVERS
ITCZ ... **seasonal or 3 to 6 months**
MJO ... **Intra seasonal or 1 to 2 months**
SPCZ ... **seasonal or 3 to 6 months**
El Niño/La Niña ... **Inter annual or more than 2 years or year to year**
WPM ... **seasonal or 3 to 6 months**

EXERCISE 3: FILL IN THE BLANKS

QUESTION ONE: THE TEMPERATURE OF THE OCEAN IS ONE KEY DIFFERENCE BETWEEN EL NIÑO AND LA NIÑA IN THE PACIFIC, WHICH EVENT IS WARMING, WHICH EVENT IS COOLING?
El Niño events are associated with a **WARMING** of the central and eastern tropical Pacific.
La Niña events are the reverse, with a **COOLING** of the central and eastern tropical Pacific.

EXERCISE 4a: CIRCLE CORRECT RESPONSE

QUESTION ONE: WHAT ARE SOME OF THE IMPACTS OF EL NINO IN THE PACIFIC?
The Walker Circulation and trade winds **WEAKEN / STRENGTHEN**
Cloud and rainfall **INCREASE / DECREASE** over the central and east Pacific.
Cloud and rainfall **INCREASE / DECREASE** the west - over Australia, Indonesia, Solomon Islands etc.
The Southern Oscillation Index (SOI) remains **NEGATIVE / POSITIVE** for several consecutive months.

EXERCISE 4b: CIRCLE CORRECT RESPONSE

QUESTION TWO: WHAT ARE SOME OF THE IMPACTS OF LA NINA ON THE PACIFIC?
The Walker Circulation and trade winds **WEAKEN / STRENGTHEN**
Cloud and rainfall **INCREASE / DECREASE** over the central and east Pacific.
Cloud and rainfall **INCREASE / DECREASE** in the west - over Australia, Indonesia, Solomon Islands etc.
The Southern Oscillation Index (SOI) remains **NEGATIVE / POSITIVE** for several consecutive months.

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