Exploring Climate Variability

-Defining climate variability: Natural fluctuations in climate patterns due to major climate drivers.
-Understanding short-term variations (locations and intensity) and their impacts on weather patterns

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What's the difference between "Climate" and "Weather"? What is climate variability?

Weather = behaviour of the atmosphere over a **short period of time**

(days to weeks)

E.g., storms or sunny days

Climate = behaviour of the atmosphere over a **long period of time or long-term average weather pattern**

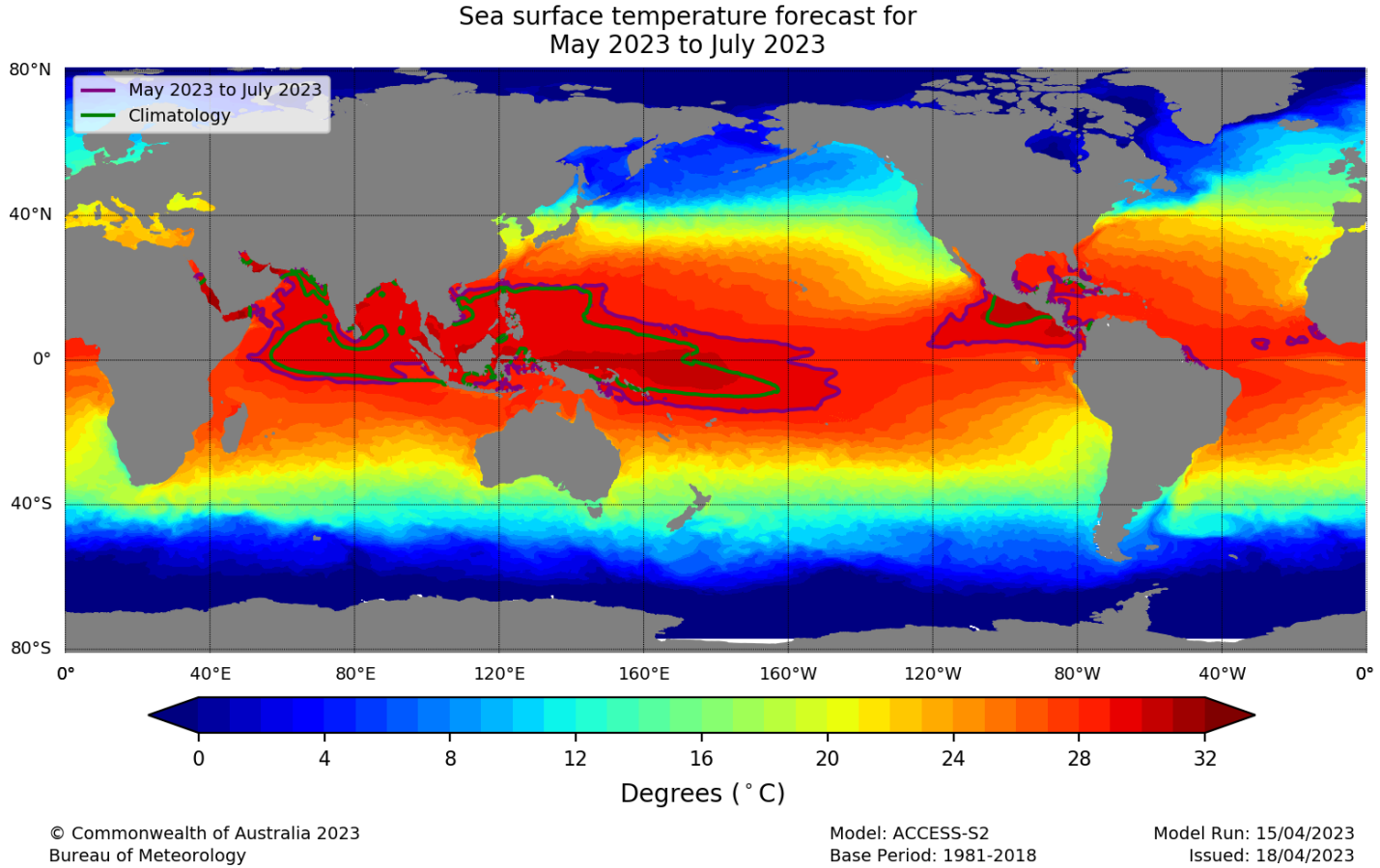
(months to years)

E.g., wet seasons or dry seasons

Climate variability = A natural variation in the **long-term average weather patterns (Climate)** that occur over time scales ranging from weeks, months, seasons, years, or even decades

Many factors influence the climate

- Ocean temperature
- Main wind direction
- Land surface
- Mountains and valleys
- Large-scale climate drivers
  - E.g., the convergence Zone



Key Climate Drivers in the Pacific

Pacific Community
Communauté du Pacifique

Climate drivers affecting the Pacific:

- **Western Pacific Warm Pool (WPWP)**
- **Intertropical Convergence Zone (ITCZ),**
- **South Pacific Convergence Zone (SPCZ)**
- **Trade Winds**
- **The Madden-Julian Oscillation (MJO)**
- **El Niño–Southern Oscillation (ENSO) comprising of Neutral/El Niño/La Niña conditions**

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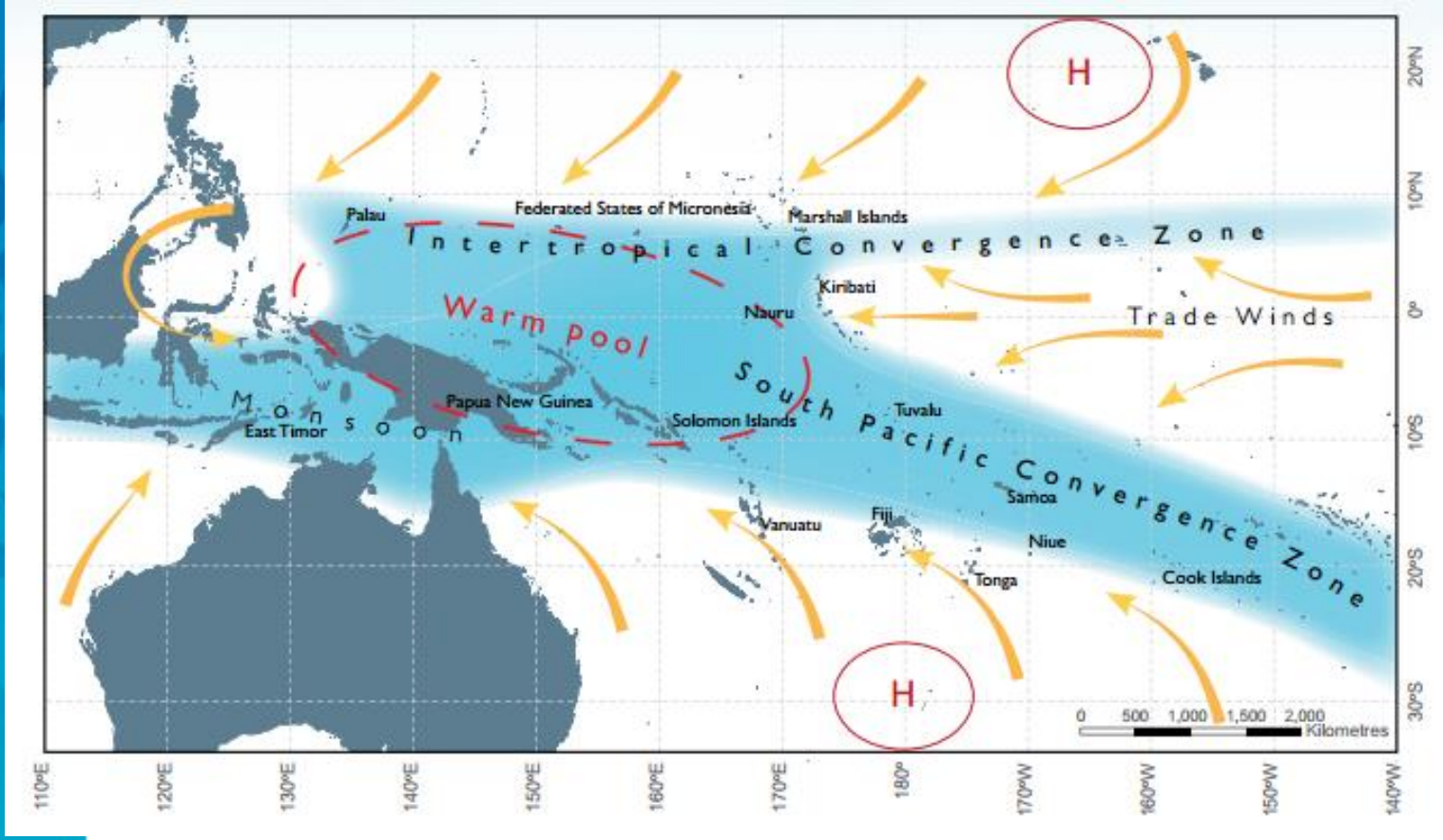
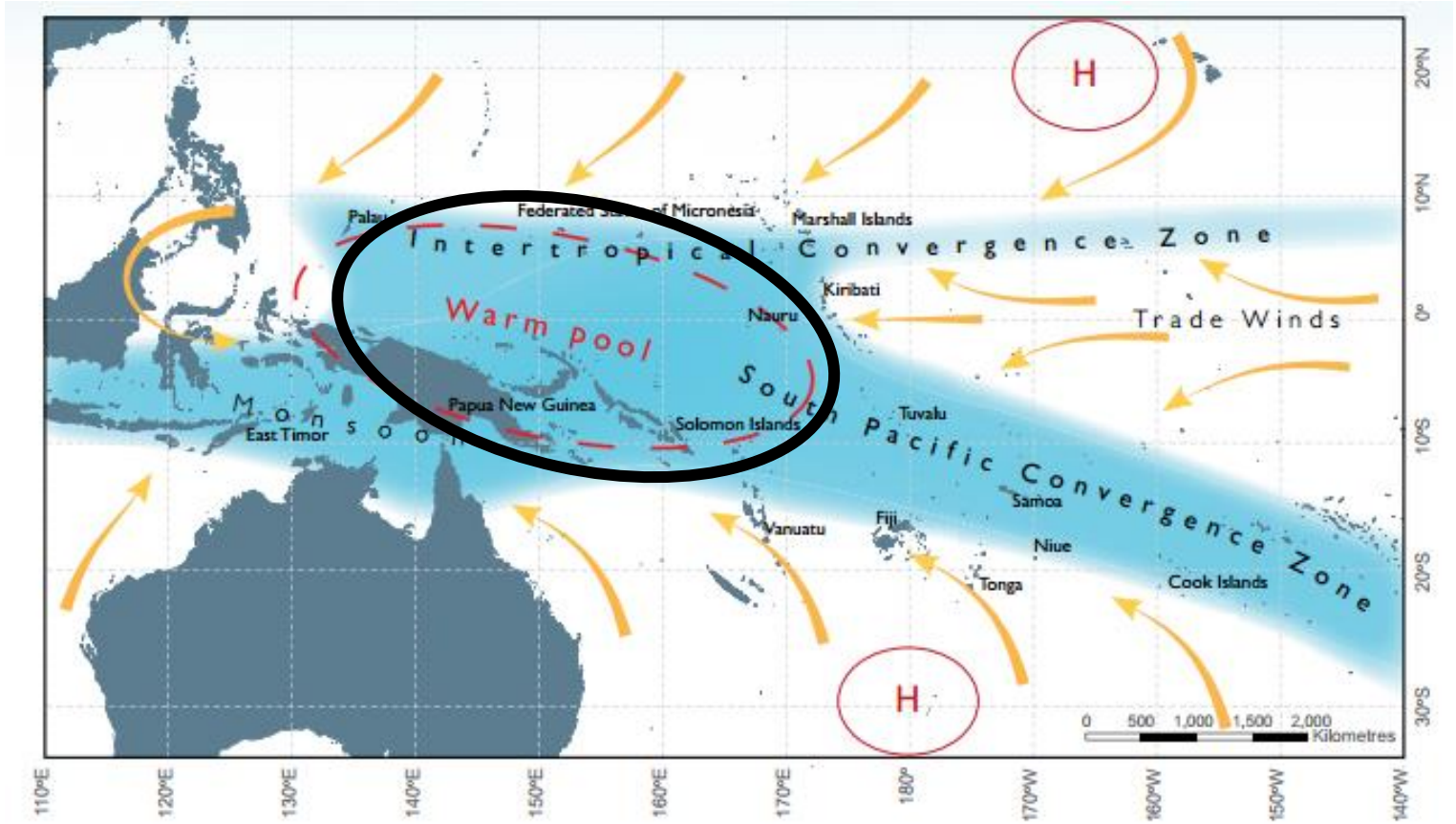
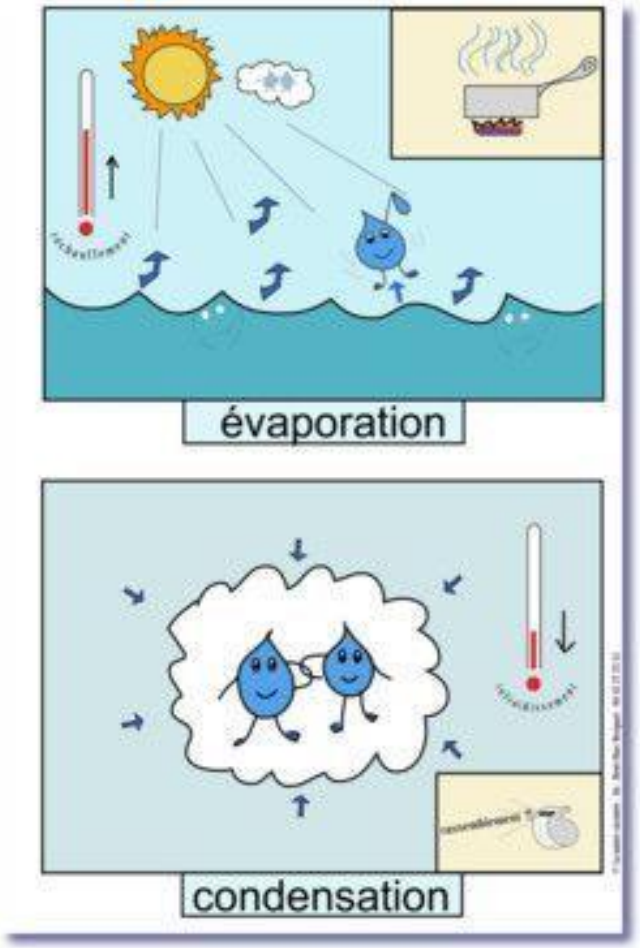
Schematic of Large-scale Climate drivers in the Pacific



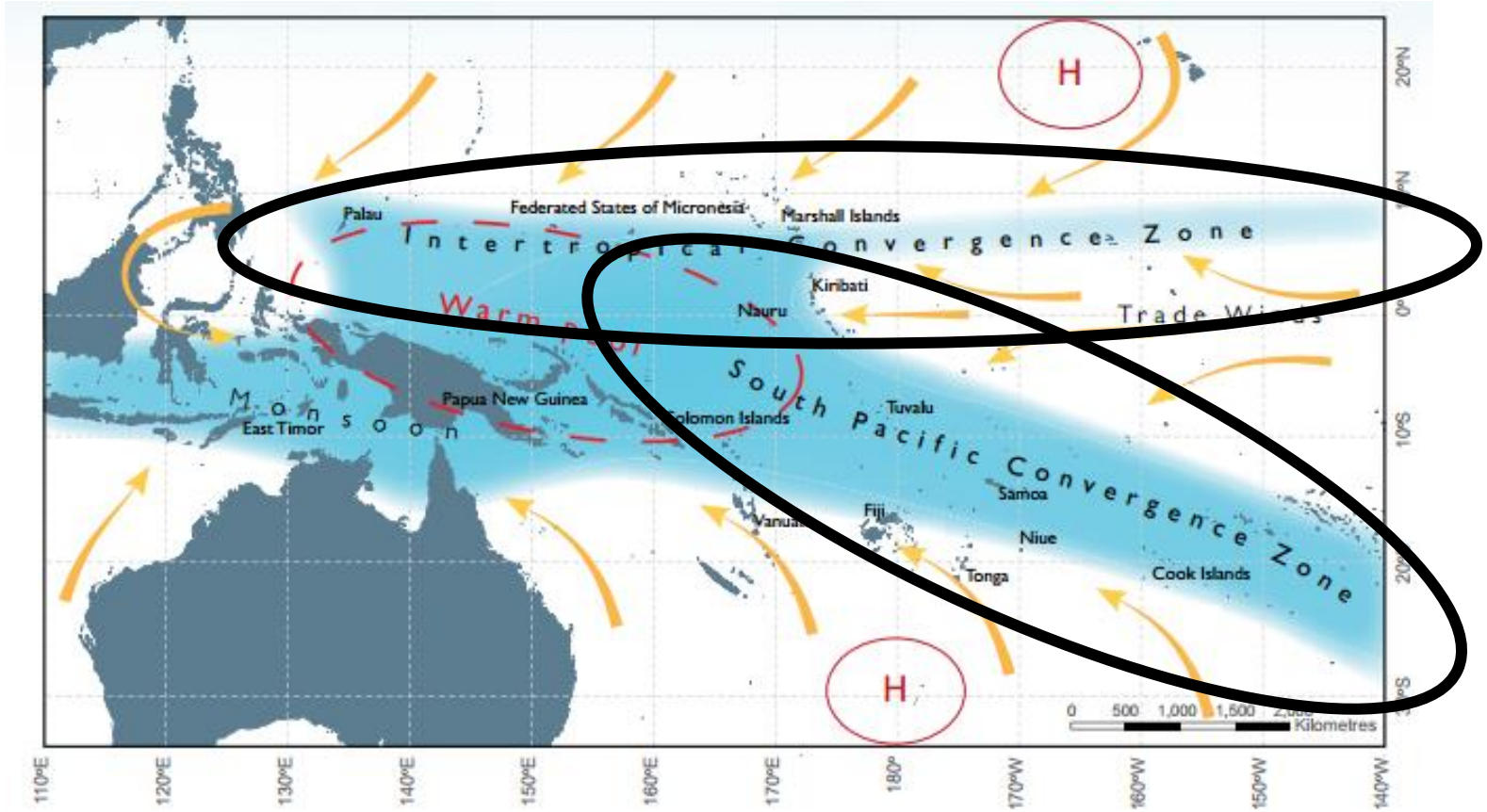
- Western Pacific Warm Pool
- Trade winds
- Convergence zones
  - Intertropical Convergence Zone
  - South Pacific Convergence Zone
- Monsoon
- El Niño–Southern Oscillation (ENSO)

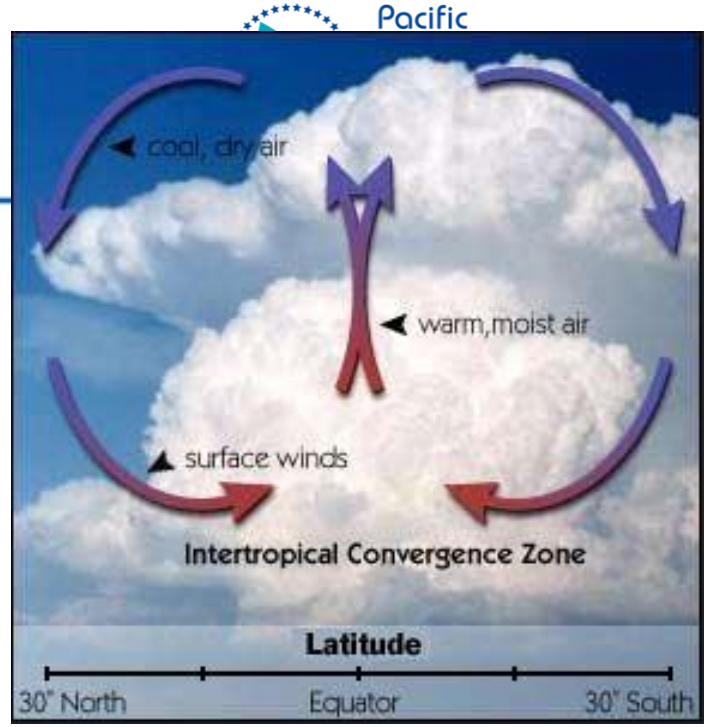
West Pacific Warm Pool





Convergence zones





"Convergence zone" =
Place in the atmosphere where two winds meet

Usually causes cloudiness, thunderstorms and rainfall.

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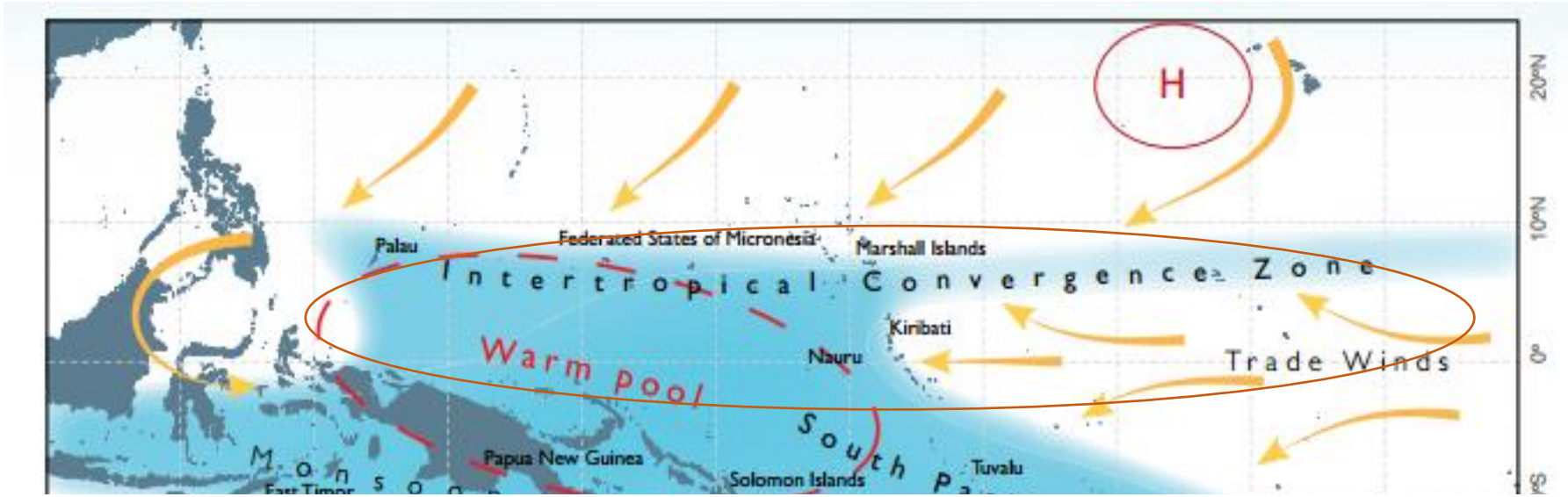
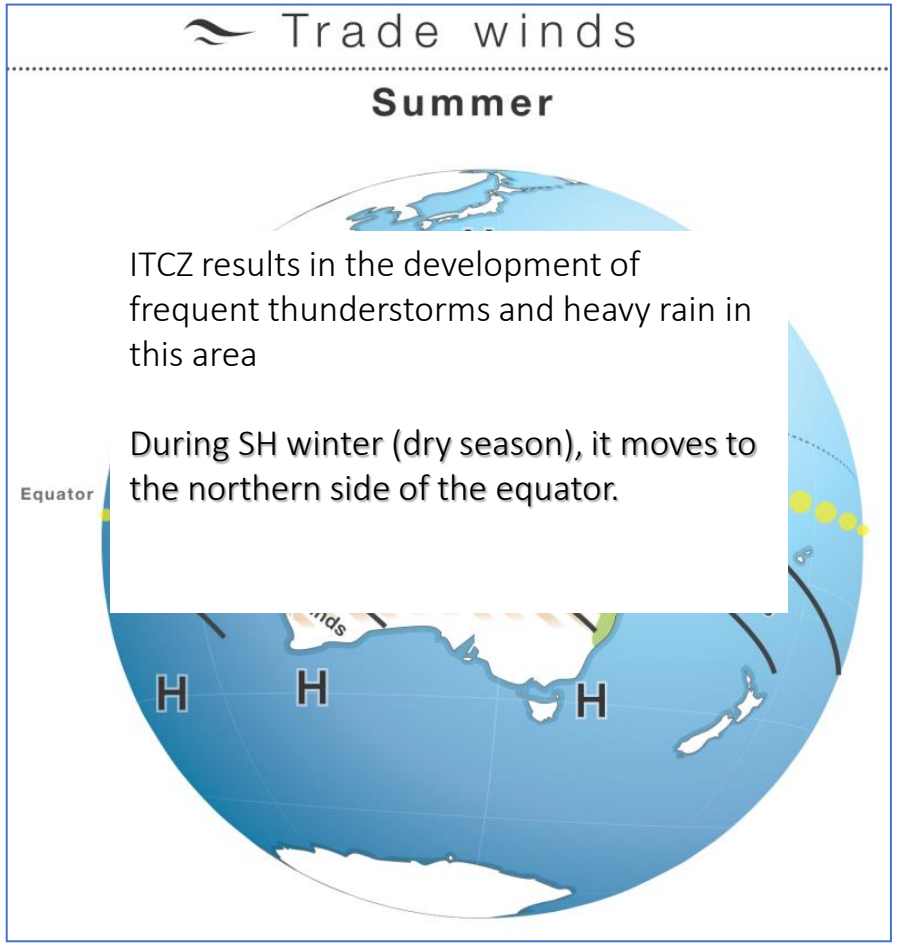
Seasonal Variations - ITCZ



ITCZ

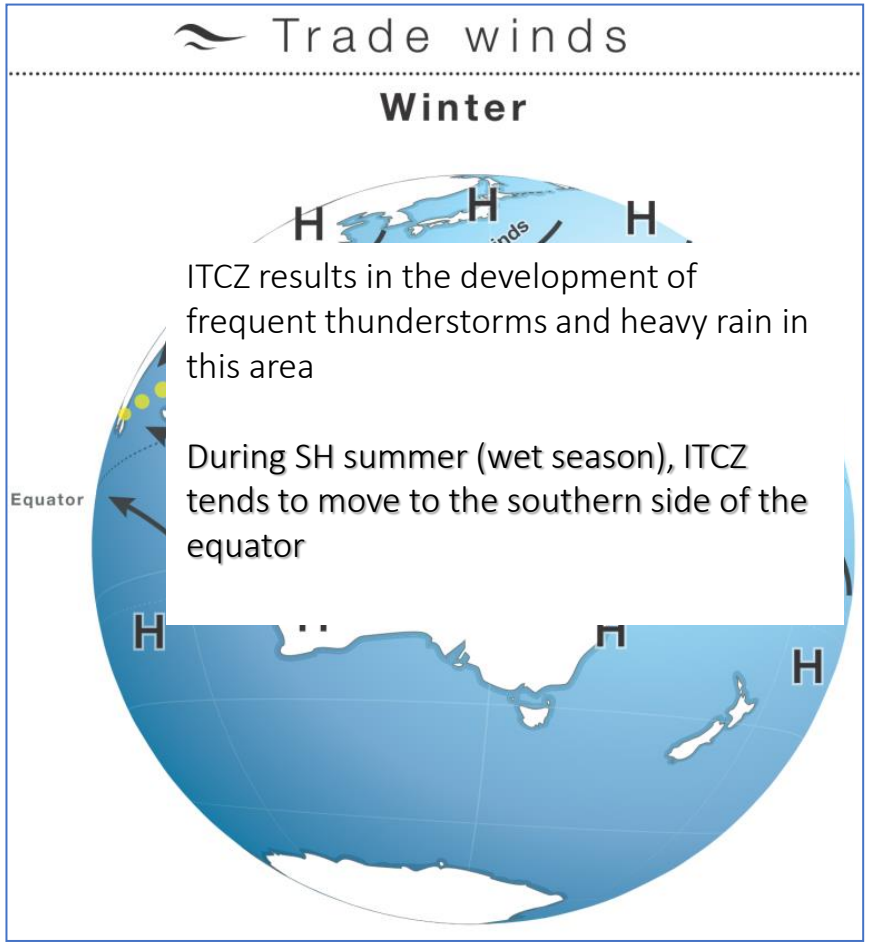
- ITCZ convergence region is where the convergence of northeasterly and southeasterly winds occur at the equator, leading to convection (i.e. warm moist air raises) forming cloudiness and rain.
- ITCZ is the zone in the central and eastern Pacific. In the western Pacific it becomes broad in association with the West Pacific Warm Pool to the north and south.
- It is a zone of high rainfall and much cloudiness; and a zone of convergence of the trade wind.
- Active ITCZ can result in high rainfall in northern Pacific Islands.

ITCZ location



ITCZ results in the development of frequent thunderstorms and heavy rain in this area

During SH winter (dry season), it moves to the northern side of the equator.

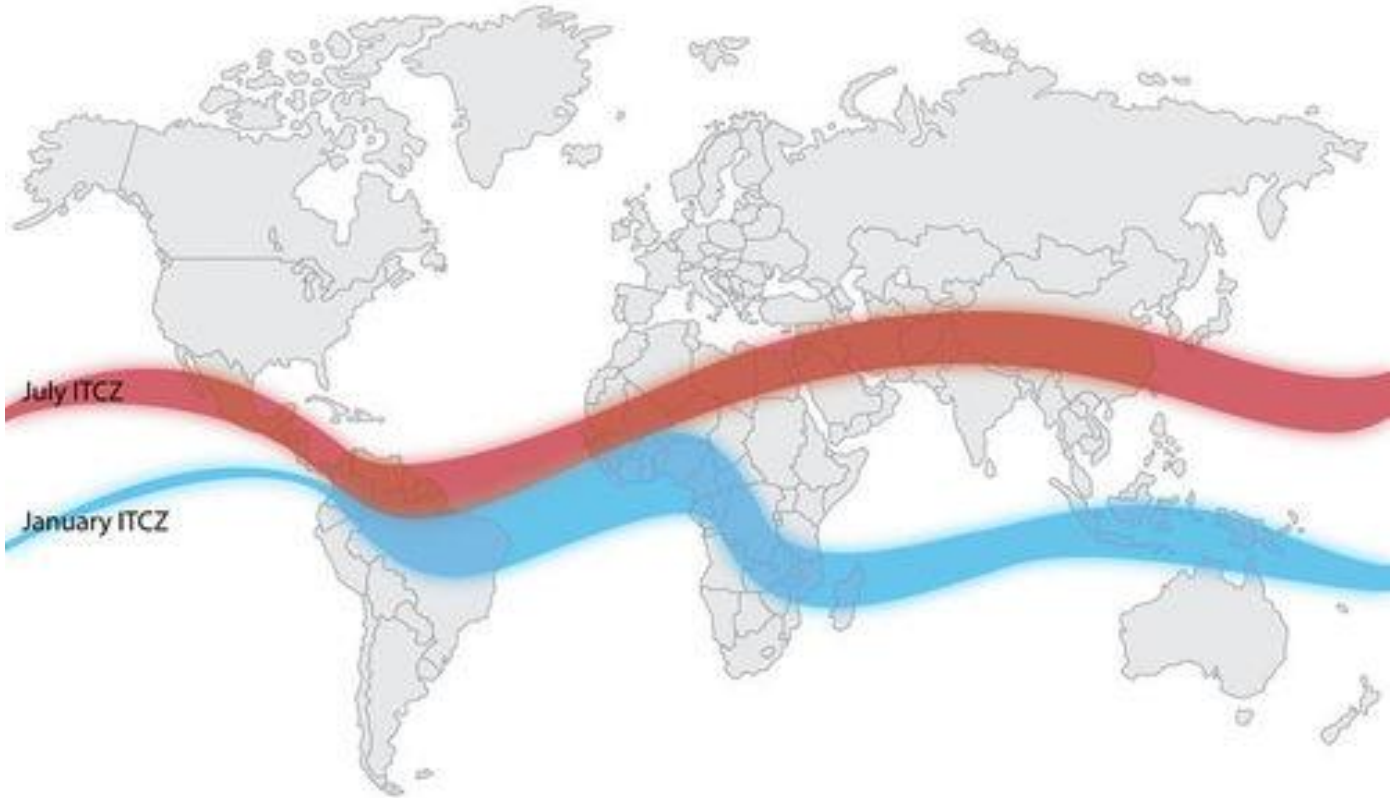


ITCZ results in the development of frequent thunderstorms and heavy rain in this area

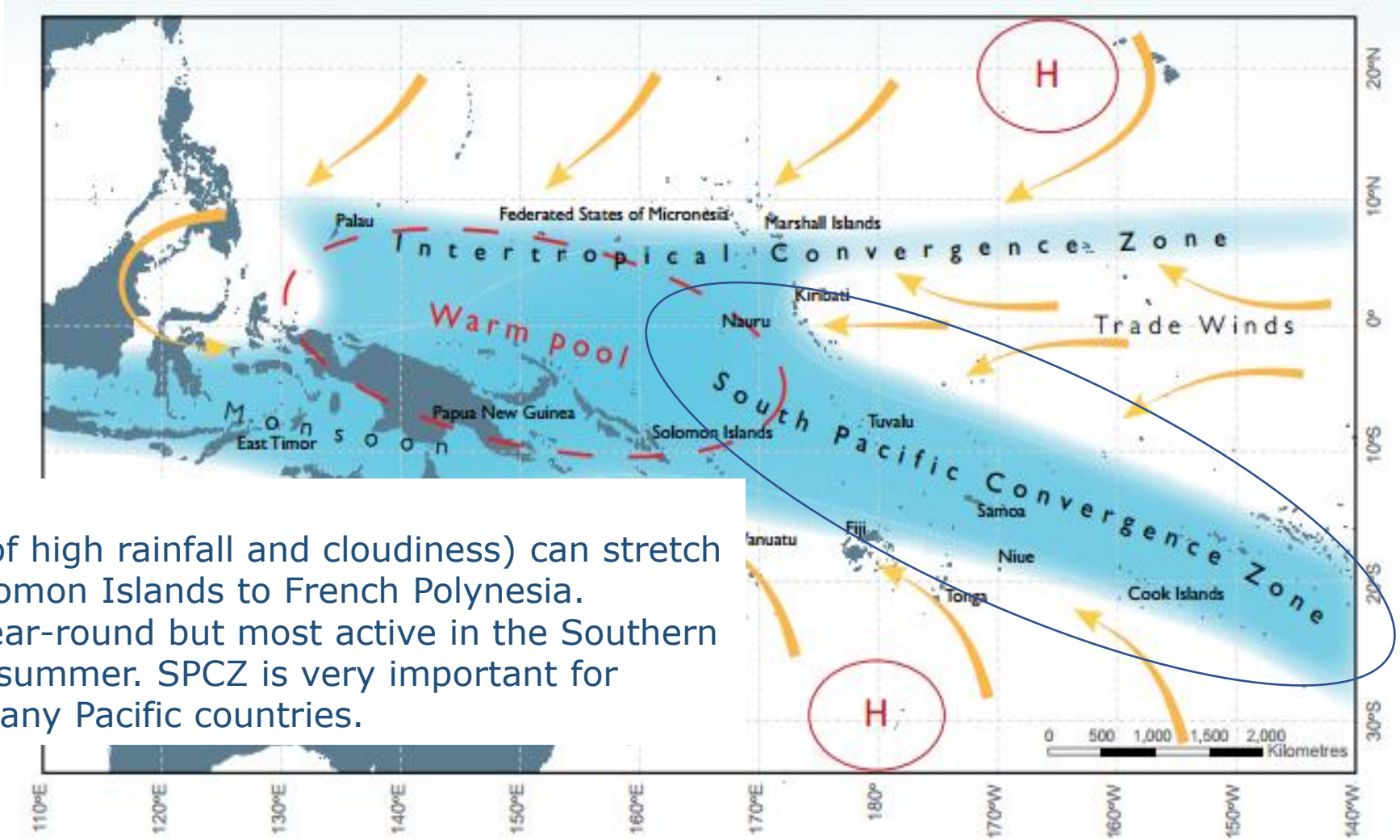
During SH summer (wet season), ITCZ tends to move to the southern side of the equator

Convergence zones (ITCZ)

- **Location** and **intensity** vary during the year



Seasonal Variations - SPCZ



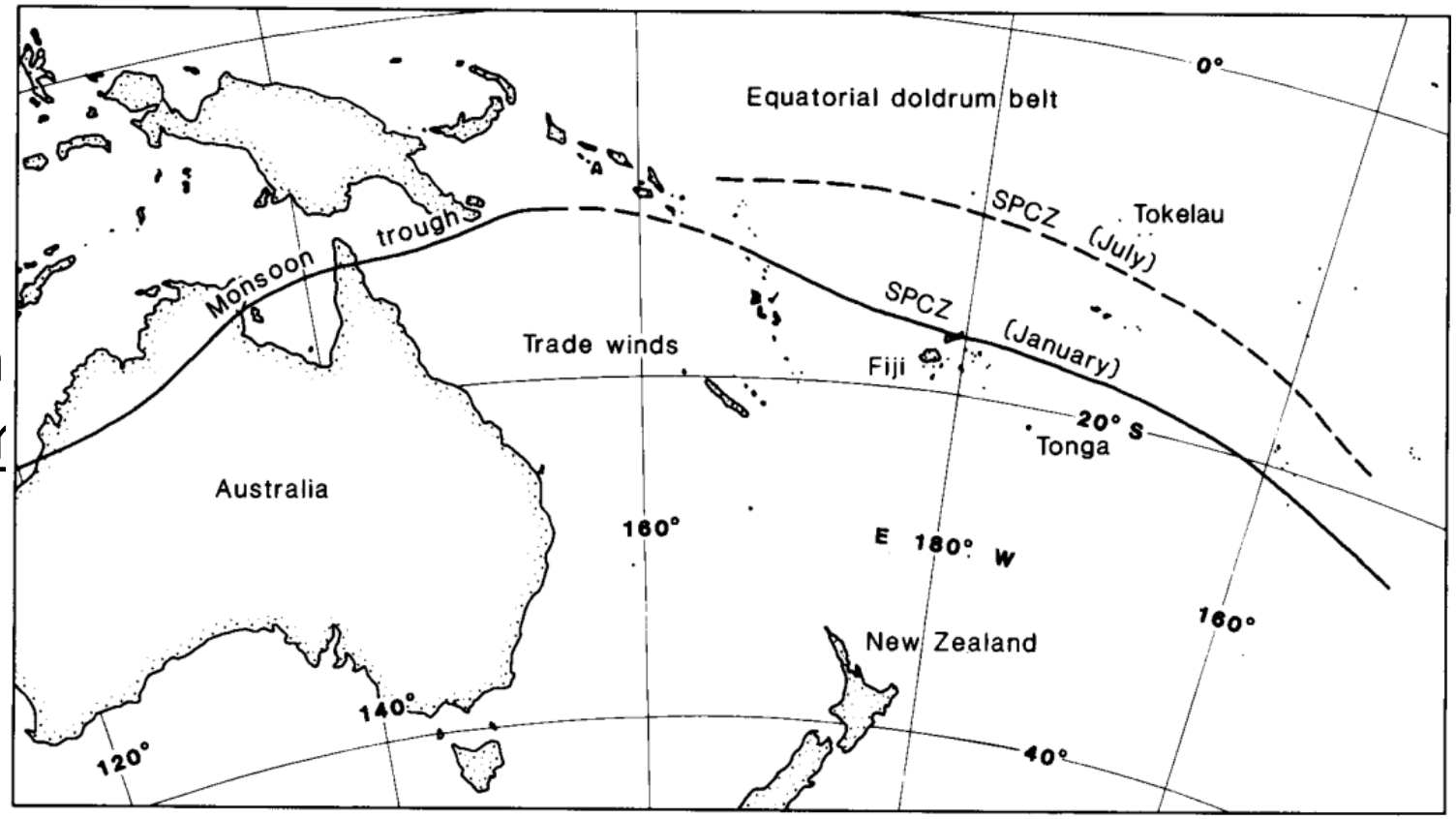
SPCZ

- SPCZ (belt of high rainfall and cloudiness) can stretch from the Solomon Islands to French Polynesia.
- Is present year-round but most active in the Southern Hemisphere summer. SPCZ is very important for rainfall for many Pacific countries.

Convergence zones (SPCZ)

- **Location** and **intensity** vary during the year

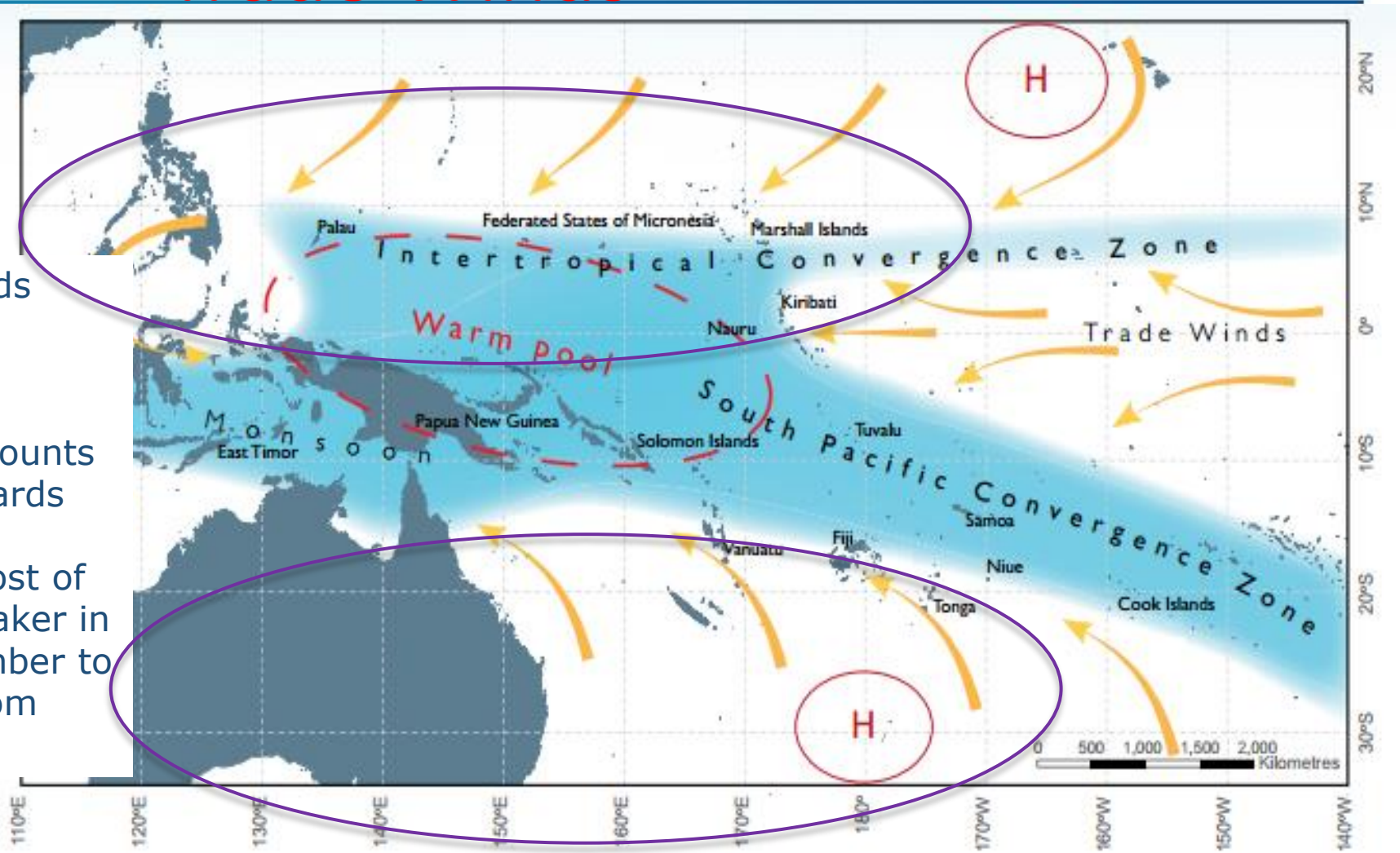
- Location and intensity can be different from one year to the next



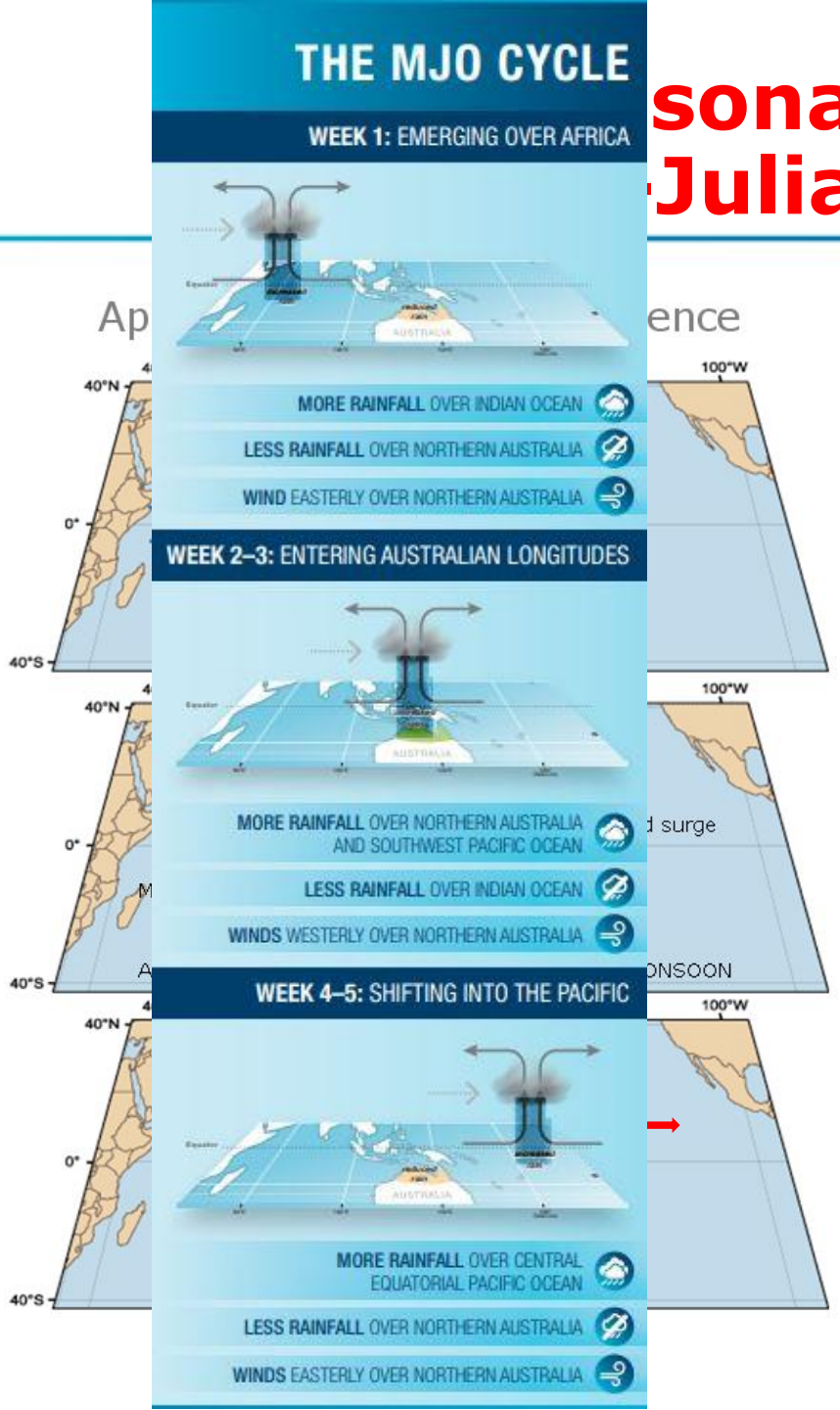
Trade Winds

Southeast and Northeast Trade Winds

- Most of the western region of the tropical Pacific benefits from the Southeast Trade Winds.
- The Trade Winds collect large amounts of moisture as they traverse towards the equator.
- Trade winds are persistent for most of the year, although tend to be weaker in the summer season (from November to April), and stronger in winter (from May to October).



sonal Variation: -Julian Oscillation (MJO)



Satellite images during a MJO event (7-27 Dec 1987)

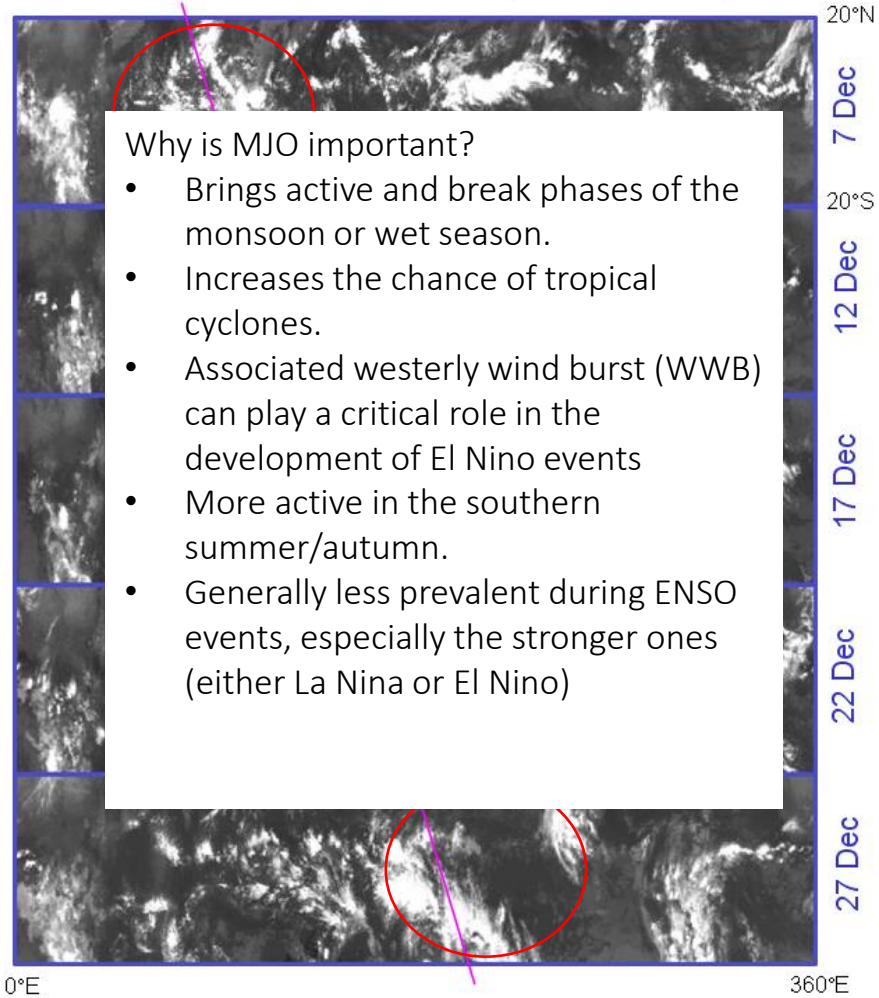


Image courtesy of *Duane Waliser*

Why is MJO important?

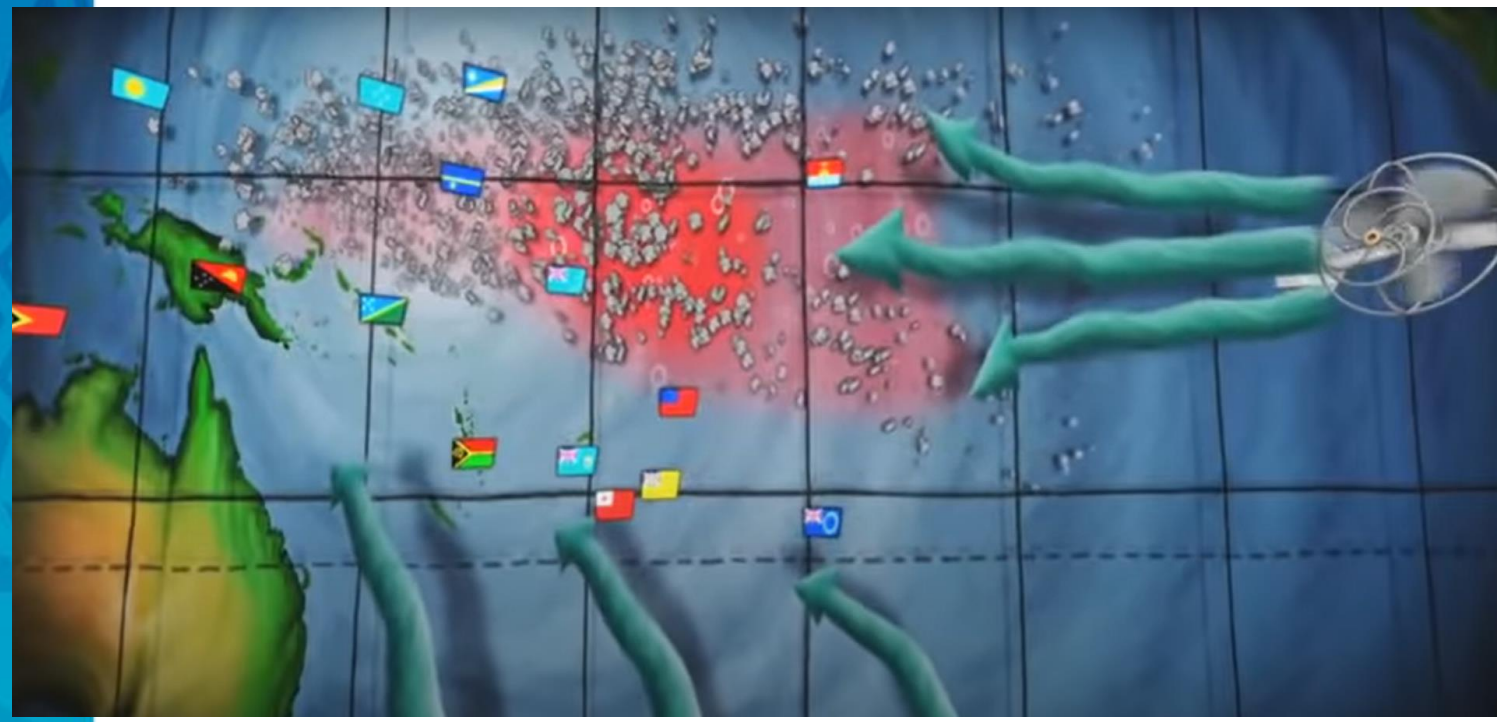
- Brings active and break phases of the monsoon or wet season.
- Increases the chance of tropical cyclones.
- Associated westerly wind burst (WWB) can play a critical role in the development of El Nino events
- More active in the southern summer/autumn.
- Generally less prevalent during ENSO events,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

The El Niño–Southern Oscillation(ENSO)

- ENSO has three phases

1. Neutral
2. El Niño
3. La Niña

The El Niño – Southern Oscillation (ENSO)

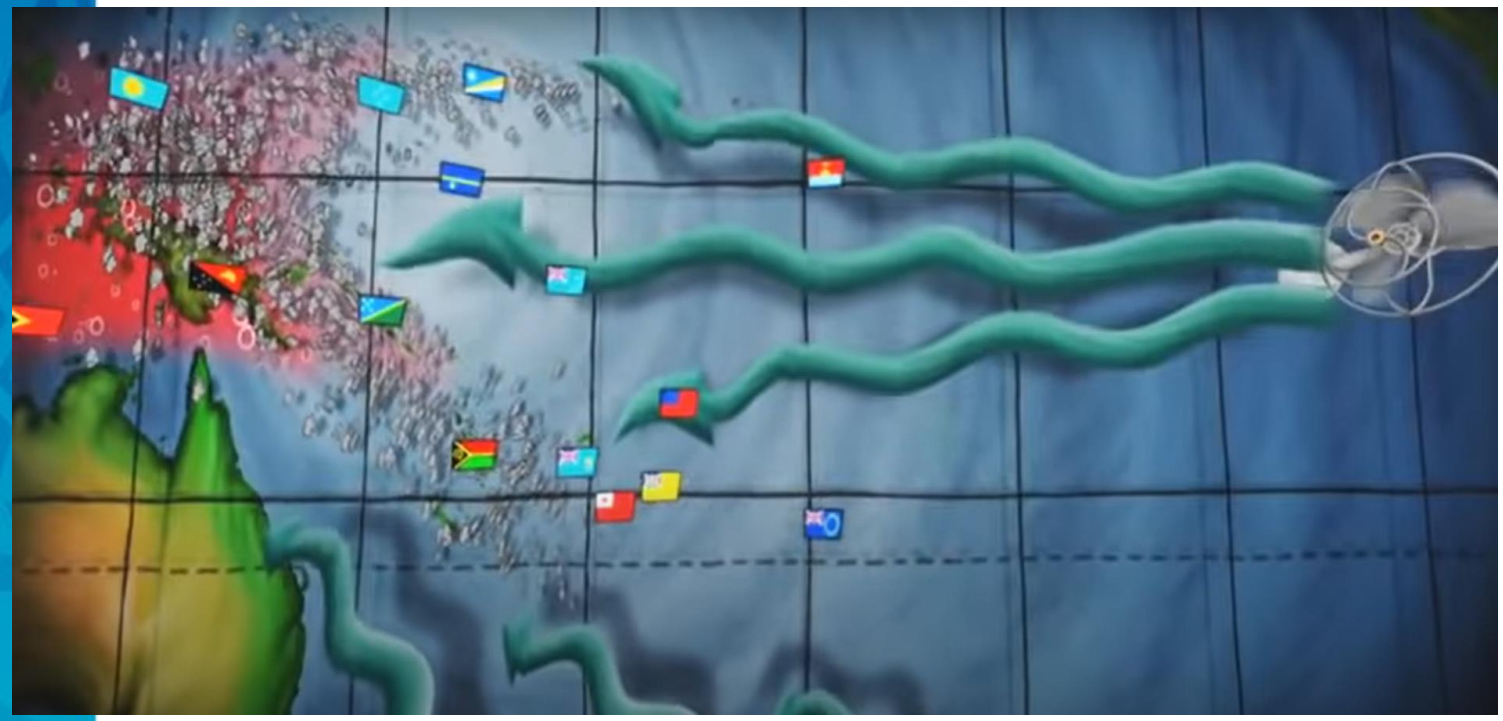


1. El Niño

During El Niño, the trade winds weaken, and warm water moves to the central Pacific

Typical El Niño conditions in the western Pacific experiencing very dry conditions and the central Pacific around the equator experiencing wetter conditions

The El Niño – Southern Oscillation (ENSO)



2. La Niña

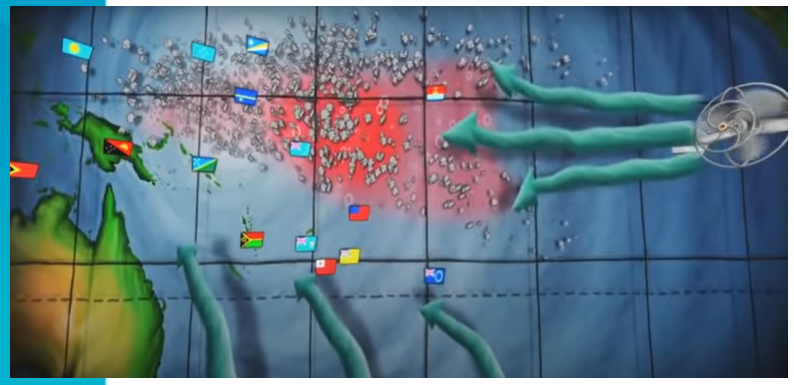
During La Niña, the trade winds get stronger, and warm water moves to the western Pacific

ENSO impacts rainfall, sea level and air temperature

- Where the **ocean is warmer**
  - More rain
  - Higher sea levels
  - Warmer air temperatures

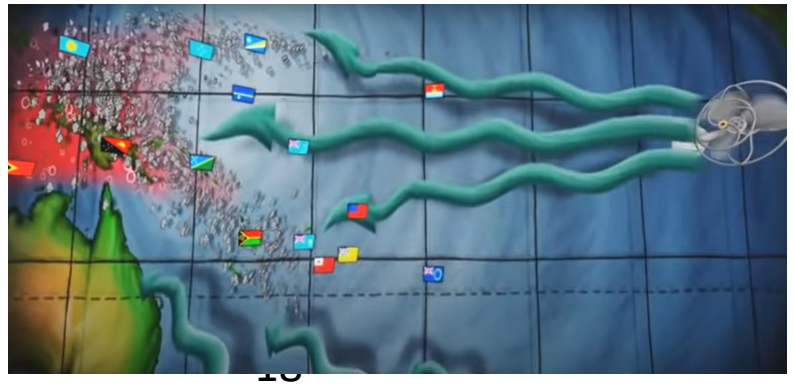
- Where the **ocean is cooler**
  - Less rain, drought can occur
  - Lower sea levels
  - Cooler air temperatures

1. El Niño

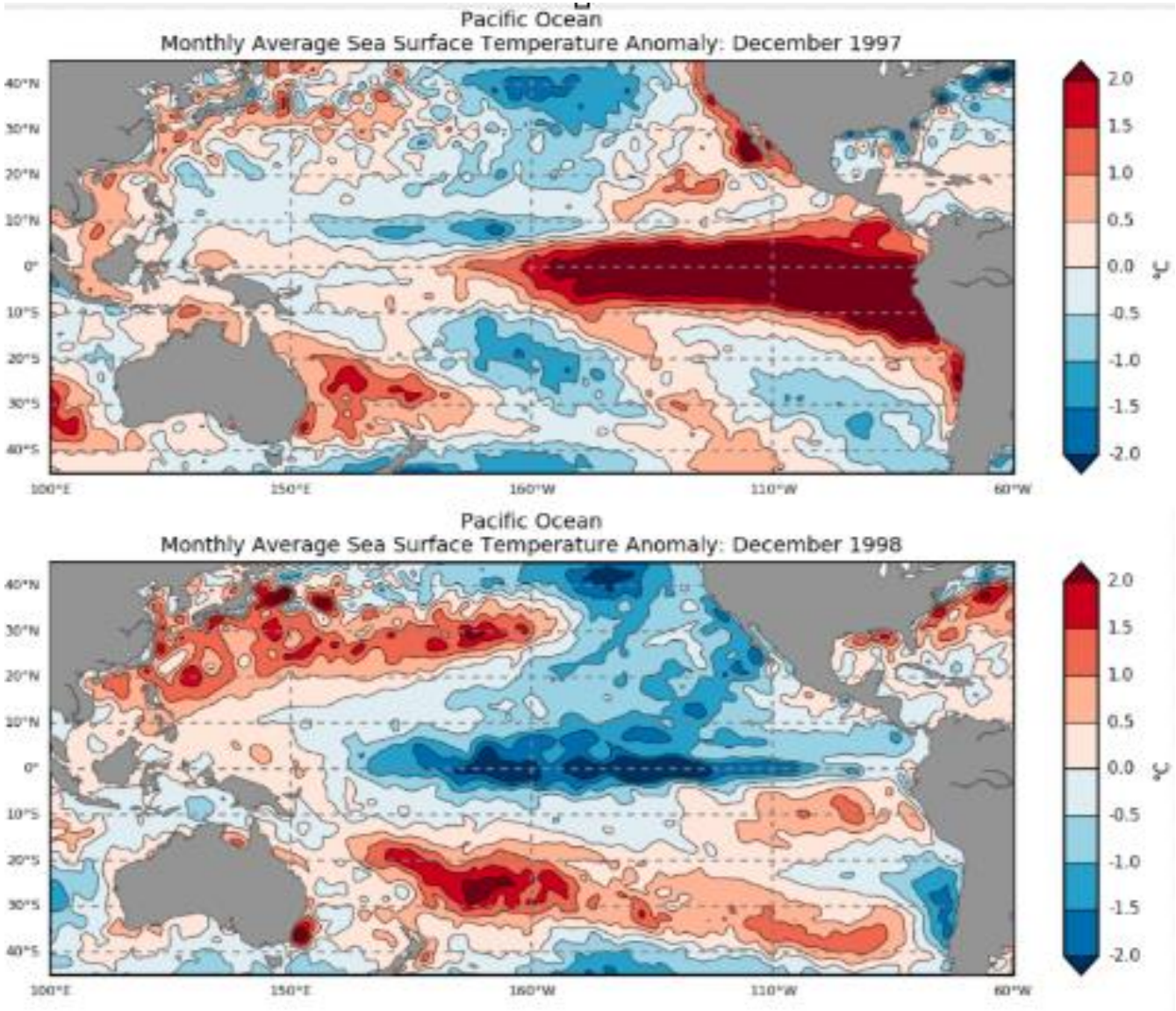


Neutral

2. La Niña

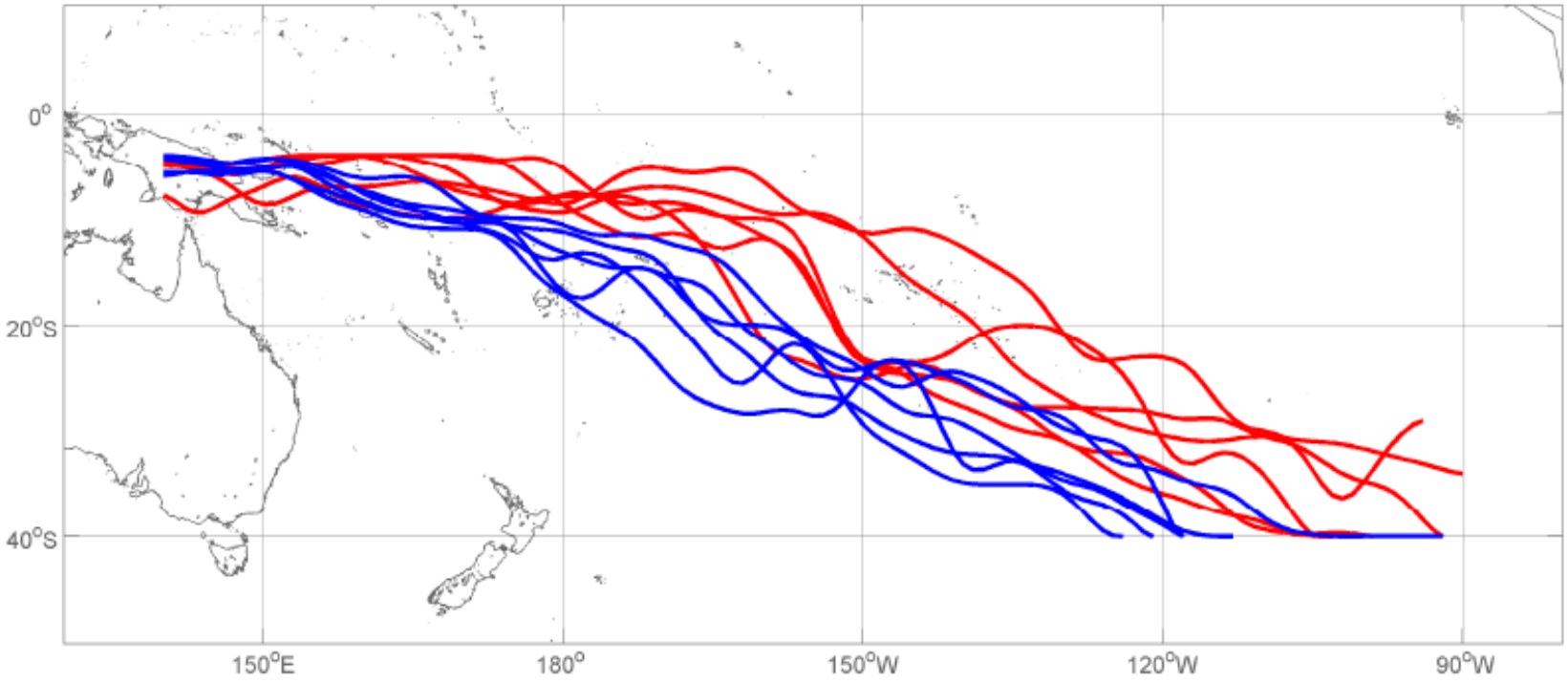


Typical El Niño/La Niña signature



Source: IRI

ENSO and the South Pacific Convergence Zone (from James Renwick & Brett Mullan, NIWA, N.Z.)



El Niño

La Niña

Shift in SPCZ position = large rainfall variability in affected countries

ENSO and rainfall in the Pacific

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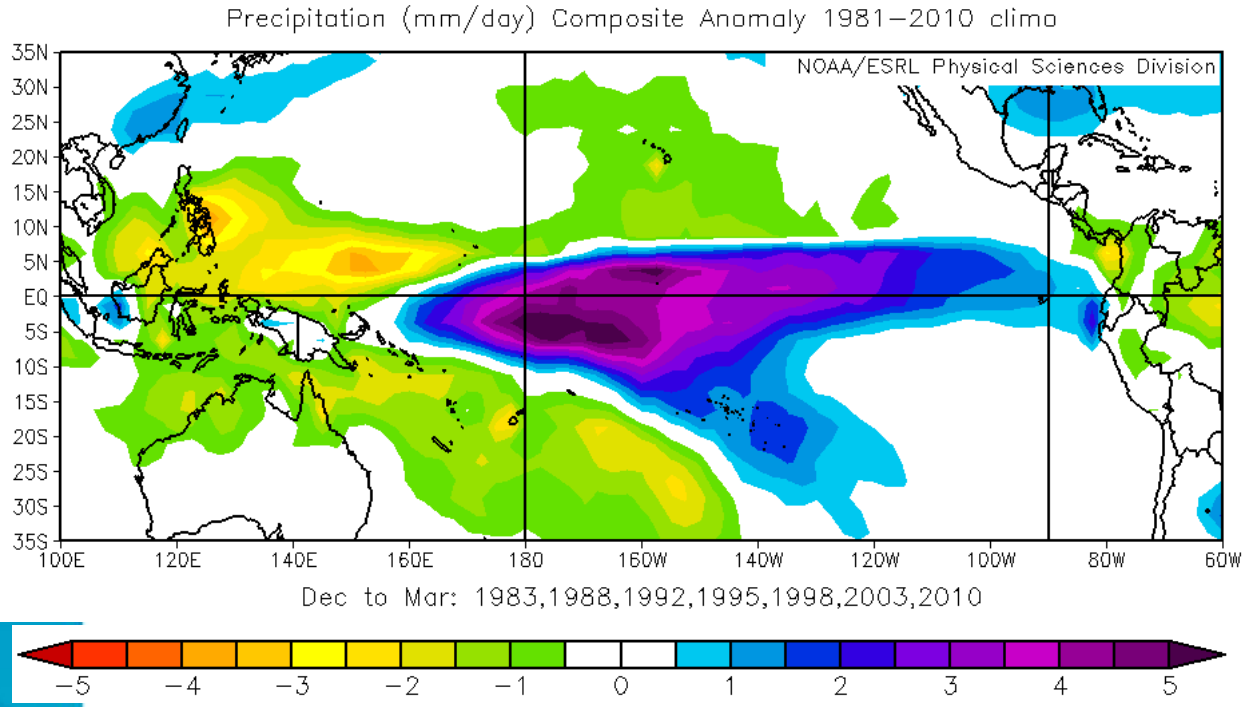
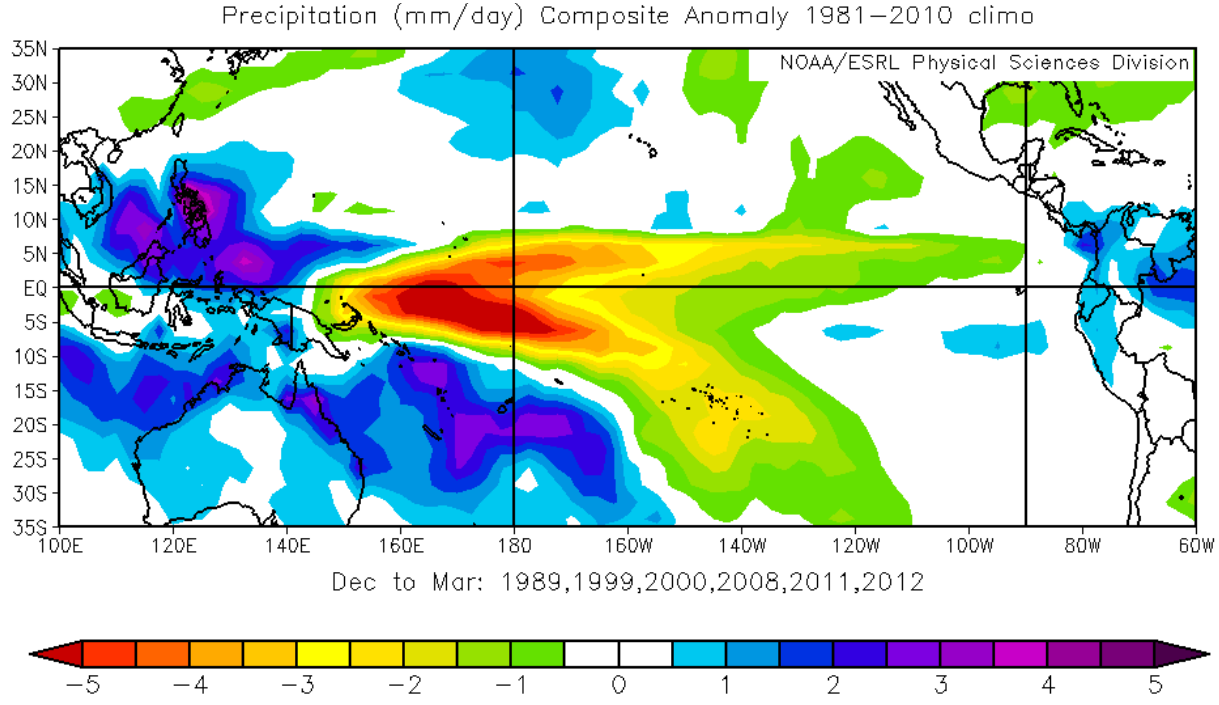
Communauté du Pacifique

El Niño



La Niña



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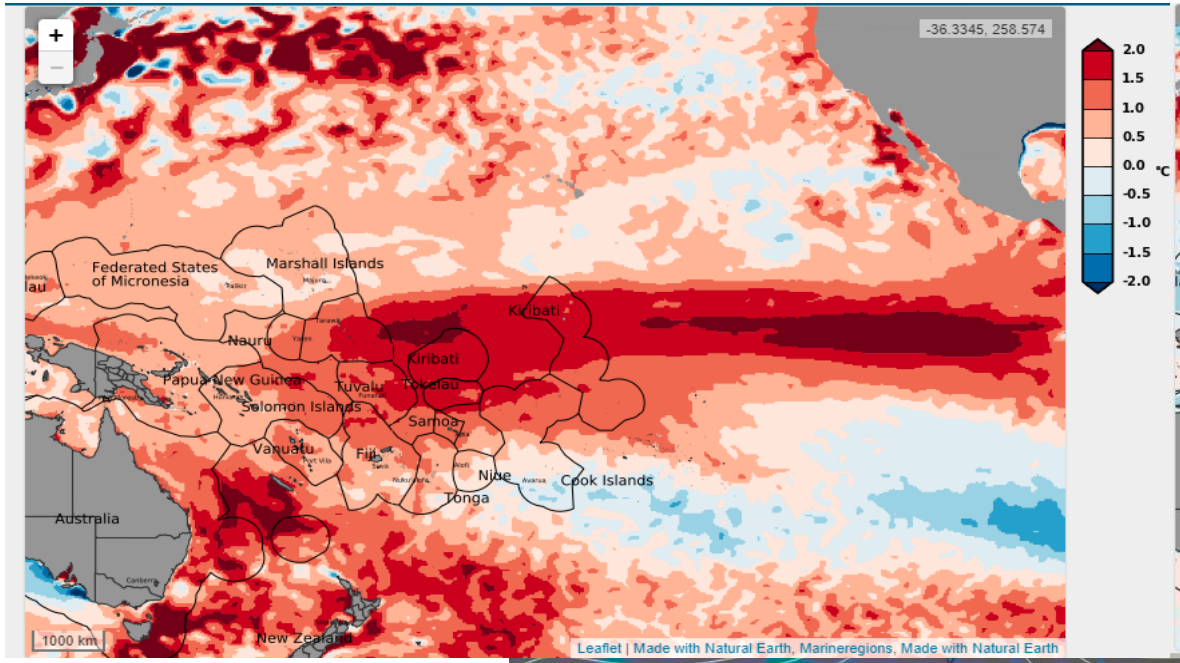
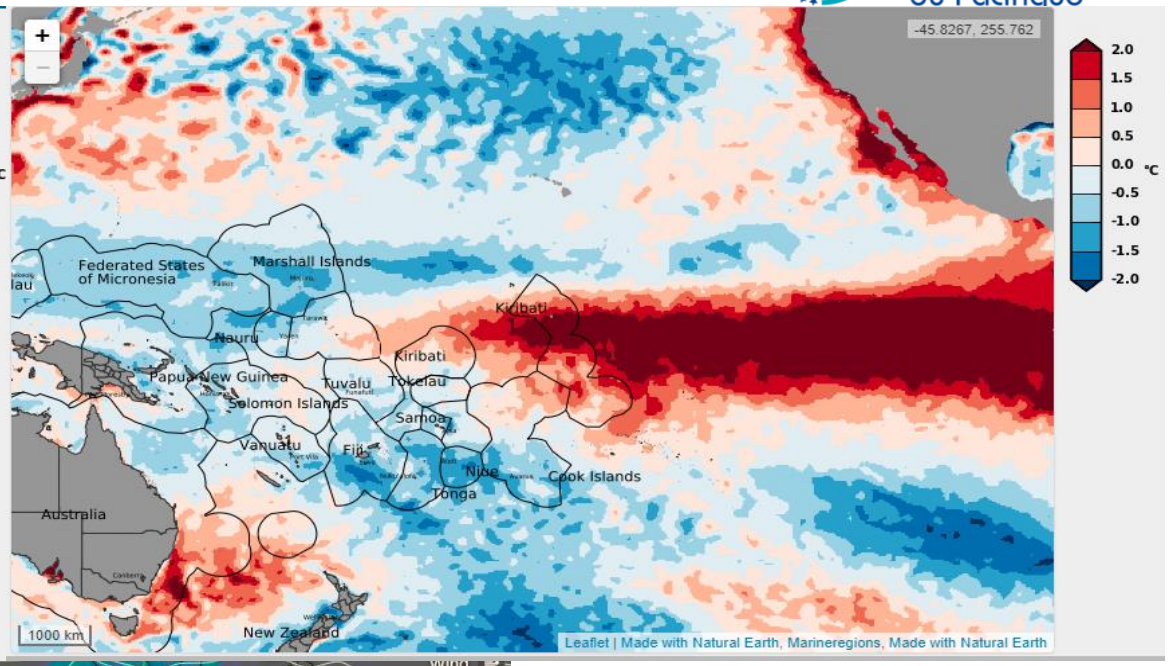
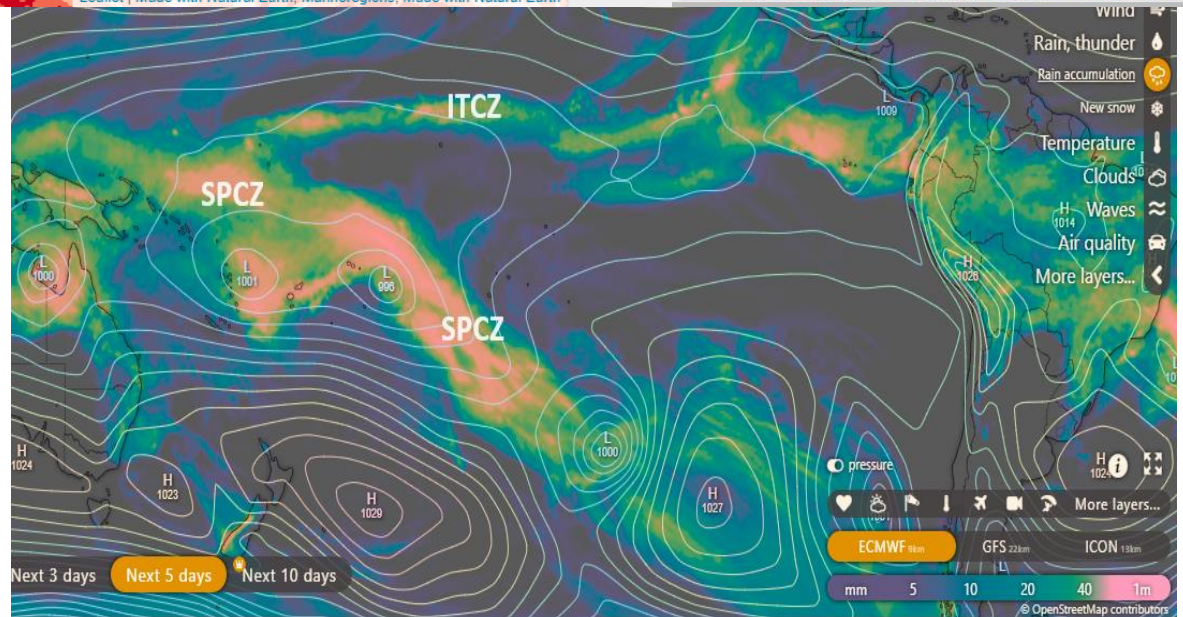
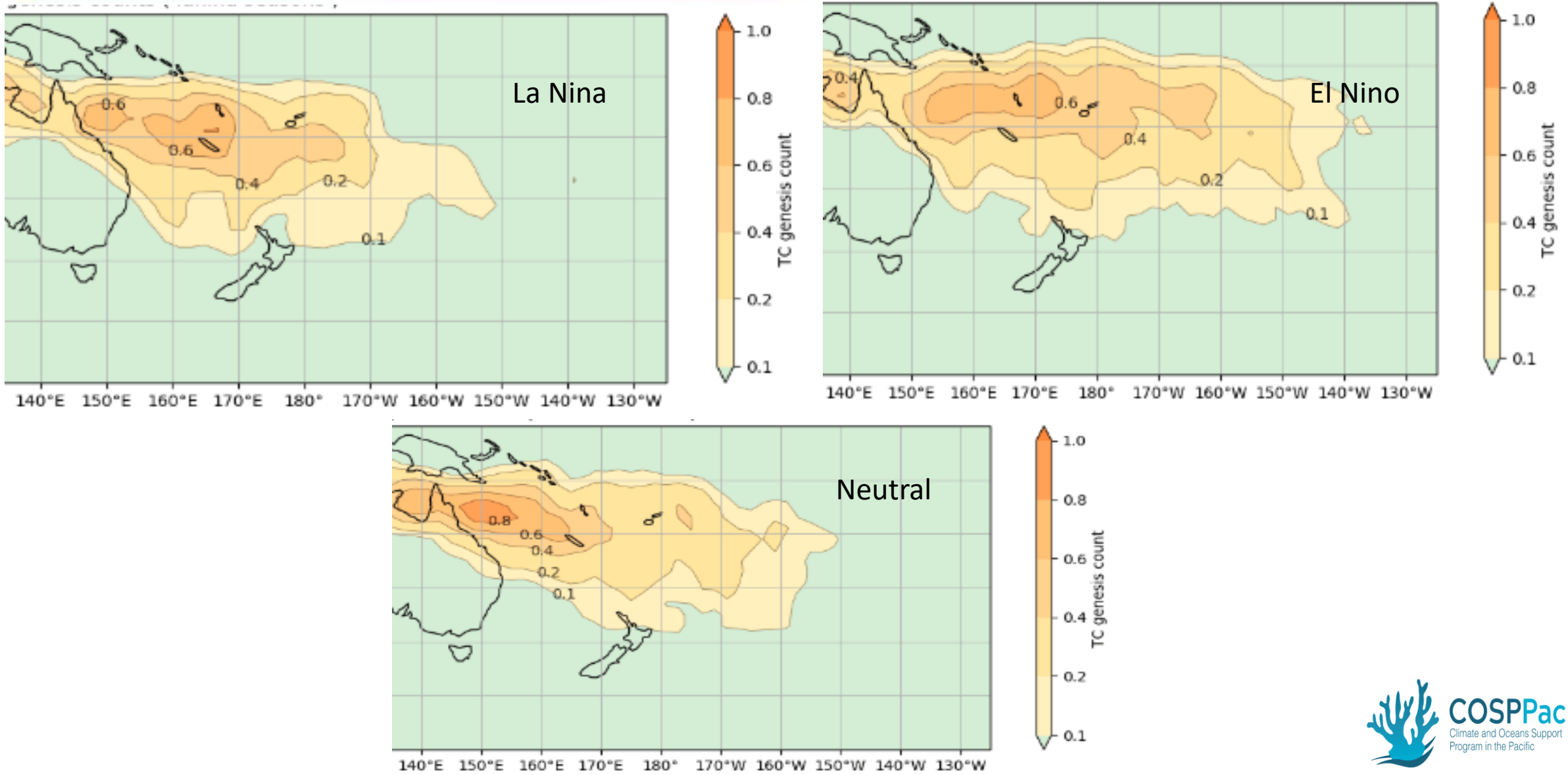
SST anomalies in January 2024 vs January 1998



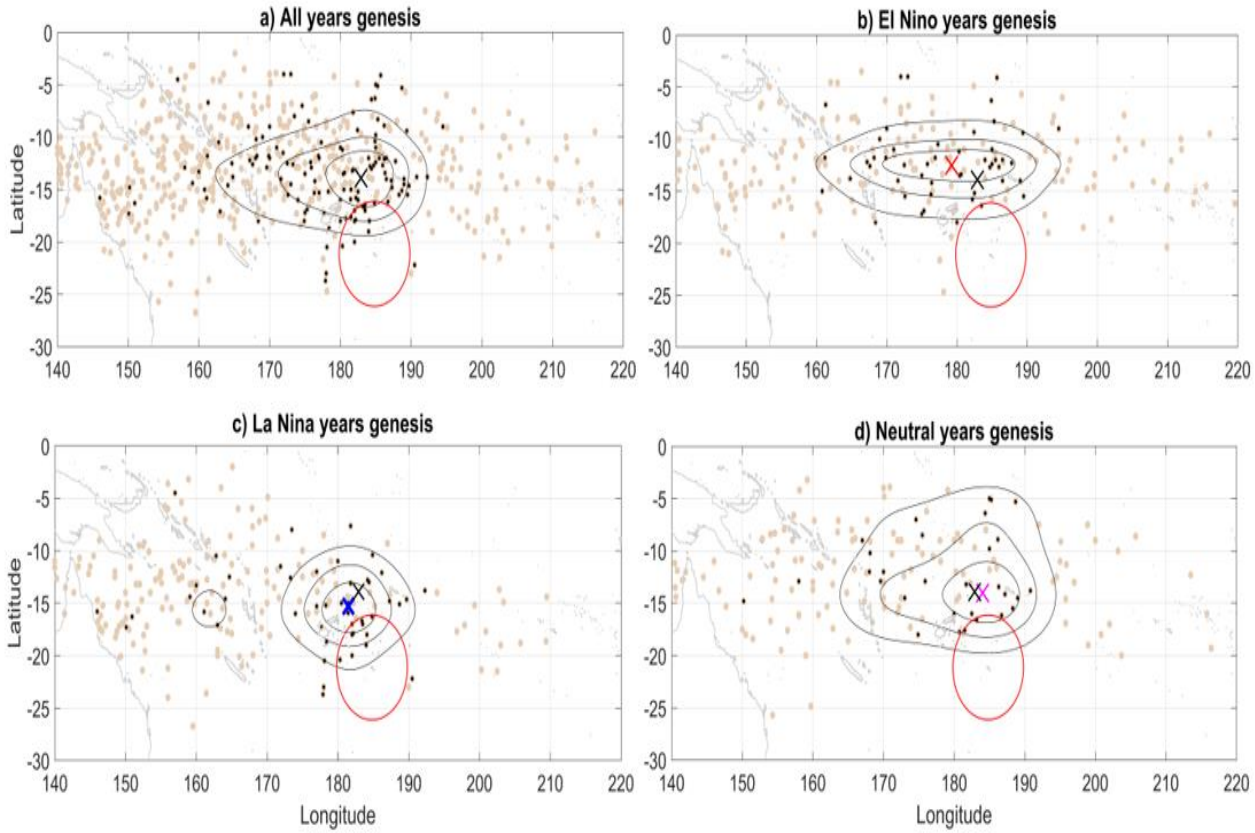




ENSO and TC genesis in the Pacific



Local ENSO impacts



Subregion (Tonga)

- Sea surface temperature is cooler during El Nino and warmer during La Nina, so is the surface air temperature
- Trade winds are weaker during La Nina and stronger during El Nino
- TCs affecting Tonga shift NW (Tonga)

Monthly SST anomalies impacts on Tropical Cyclone genesis (i.e., where tropical cyclone forms)