Past and Future Climate – Present Weather

Week 9

El Niño/Southern Oscillation (ENSO)

Terry Hart

Dates

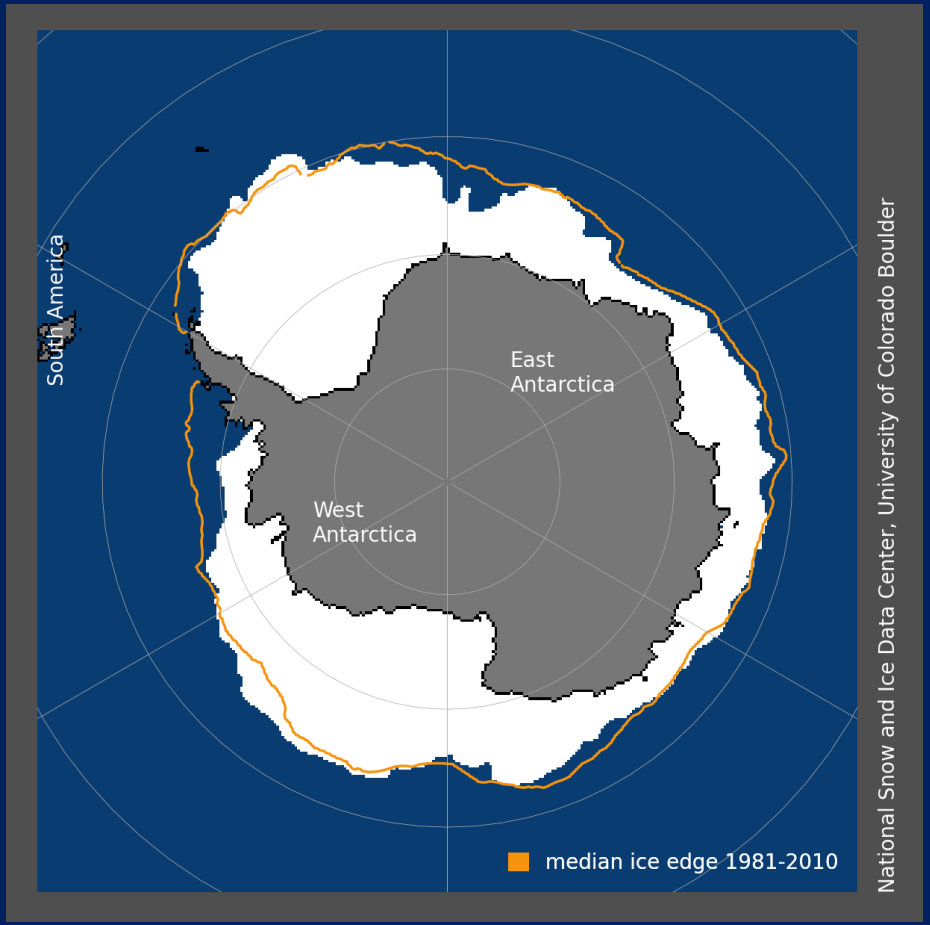
Term 2	
18 June	**El Niño/Southern Oscillation (ENSO)**
Term 3	
23 July	**The last few thousand years**
6 August	**Carbon dioxide and climate**
20 August	**Computer models – or other suggestion?**
3 September	Away
17 September	Away

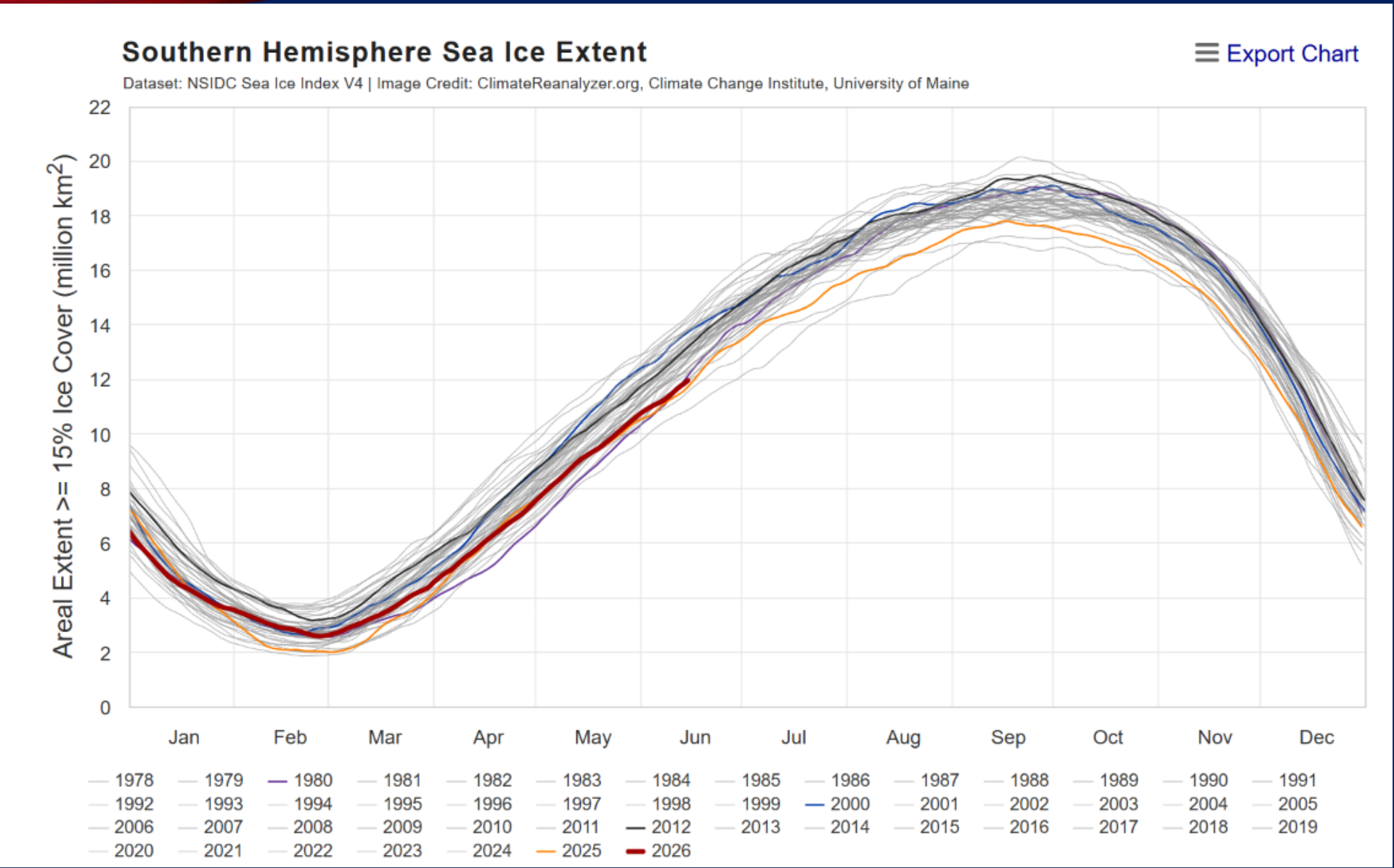
West Antarctic winter ice fails to form in Bellingshausen Sea in area 'size of France'

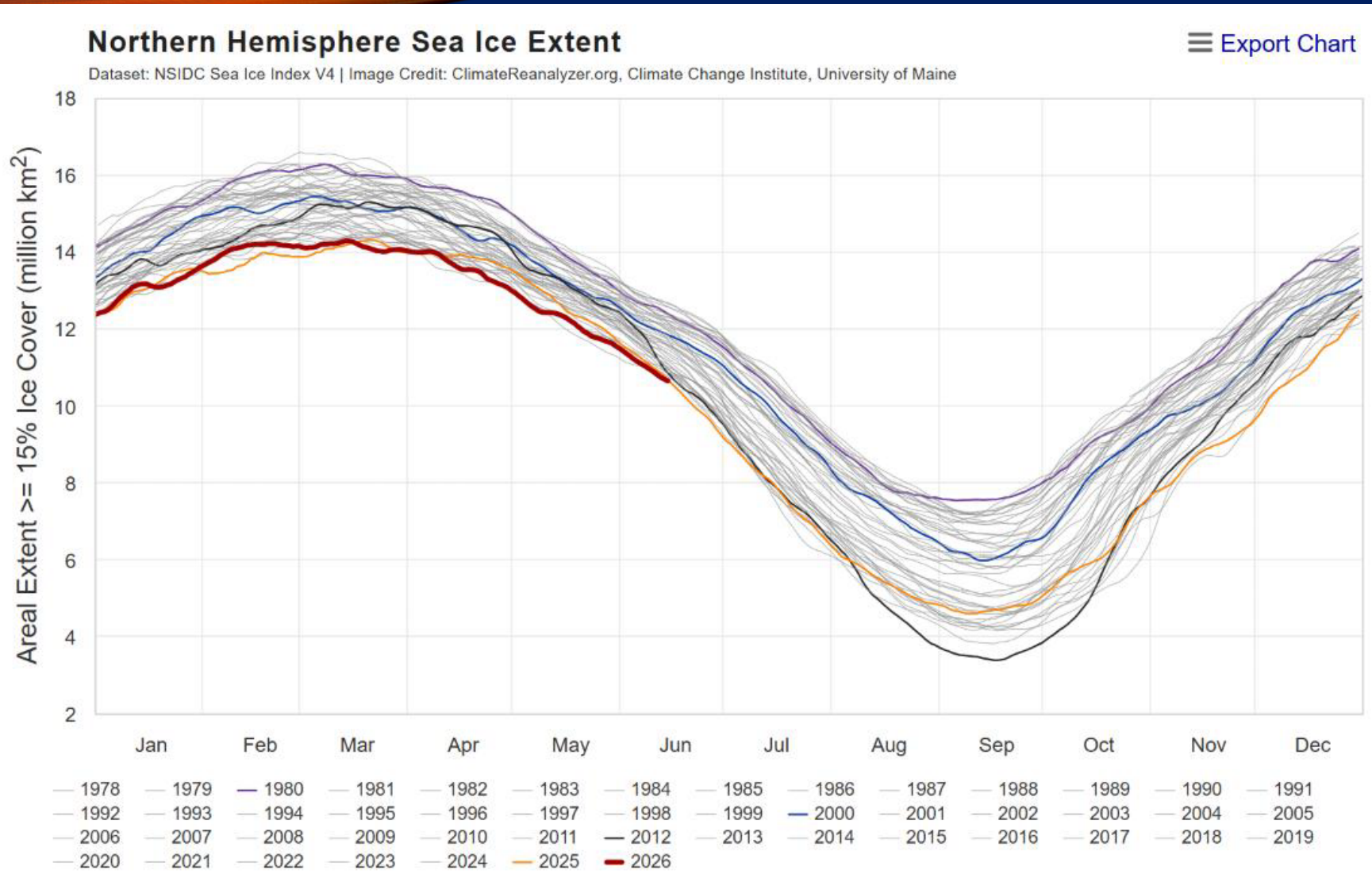
By Jessica Moran | Climate Change

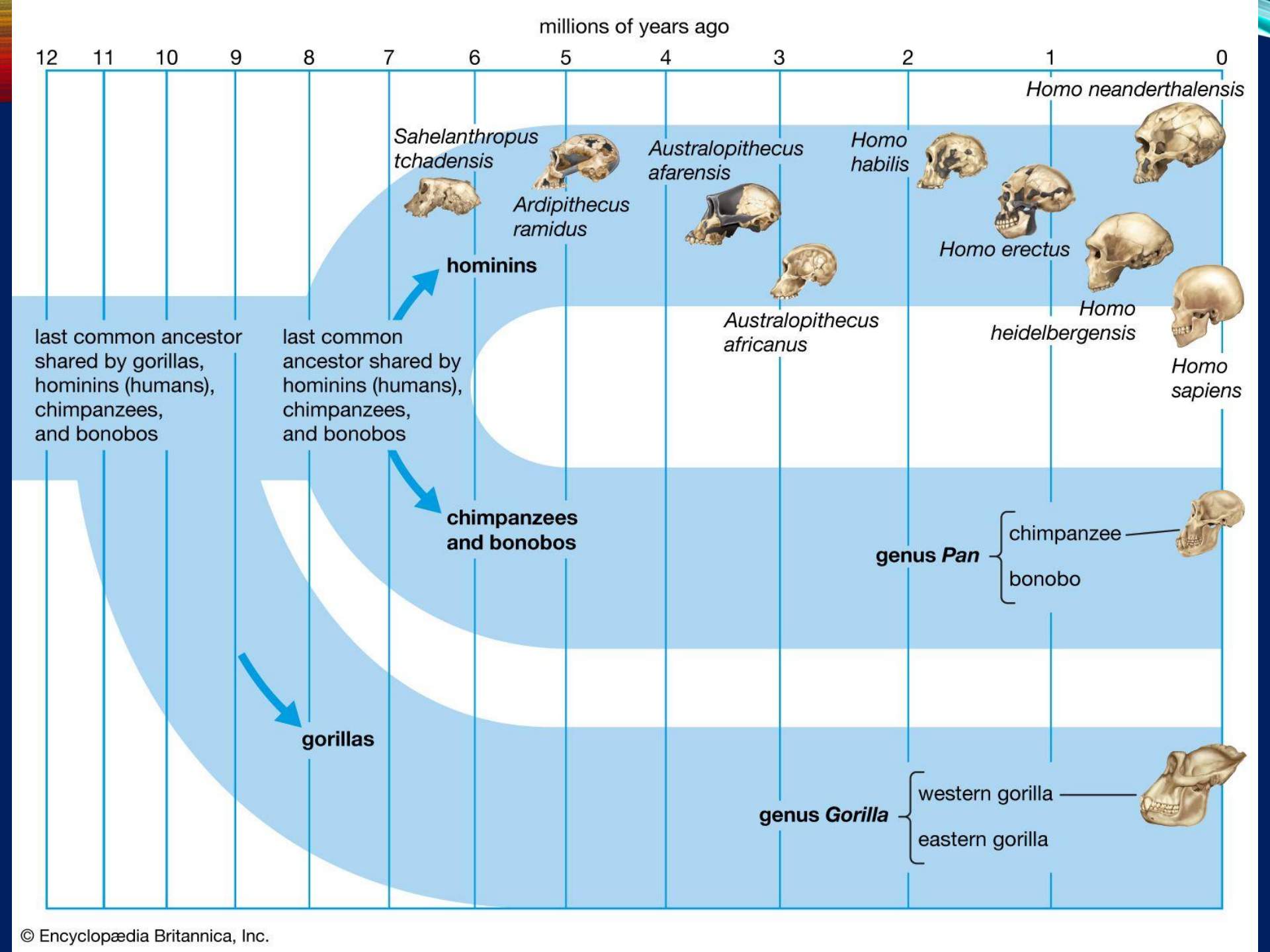
https://www.abc.net.au/news/2026-06-14/west-antarctica-ice-fails-to-form-area-size-of-france/106794526

"Dr Hobbs said the continued loss of sea ice would impact marine life, including threatened penguins that rely on it, and overall sea levels."




Southern Hemisphere Sea Ice Extent
Export Chart
Dataset: NSIDC Sea Ice Index V4 | Image Credit: ClimateReanalyzer.org, Climate Change Institute, University of Maine
Areal Extent >= 15% Ice Cover (million km2)
22
20
18
16
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
2020 2021 2022 2023 2024 2025 2026


Northern Hemisphere Sea Ice Extent
Export Chart
Dataset: NSIDC Sea Ice Index V4 | Image Credit: ClimateReanalyzer.org, Climate Change Institute, University of Maine
Areal Extent >= 15% Ice Cover (million km2)
18
16
14
12
10
8
6
4
2
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
2020 2021 2022 2023 2024 2025 2026



"The collapse of the Laurentide Ice Sheet released a deluge of water that increased global sea levels by up to 1.4 metres (about 8,000 years ago). Before this time, a ridge across the Bosporus Strait dammed the Mediterranean and kept the Black Sea as a freshwater lake. With the rise in sea level, the Bosporus Strait was breached, flooding the Black Sea. This event is now widely believed to be behind the various folk myths that led to the biblical Noah's Ark story."

https://www.eurekalert.org/news-releases/778356

"A 2022 literature review concluded that there was insufficient evidence for a flood scenario. It was more likely that the waters of the Black Sea itself gradually outflowed to the Mediterranean. There was also no archaeological evidence of humans evacuating the area during the relevant time."

El Niño declared by BOM and it could become the strongest on record

By ABC meteorologist **Tom Saunders**

Weather Forecasts

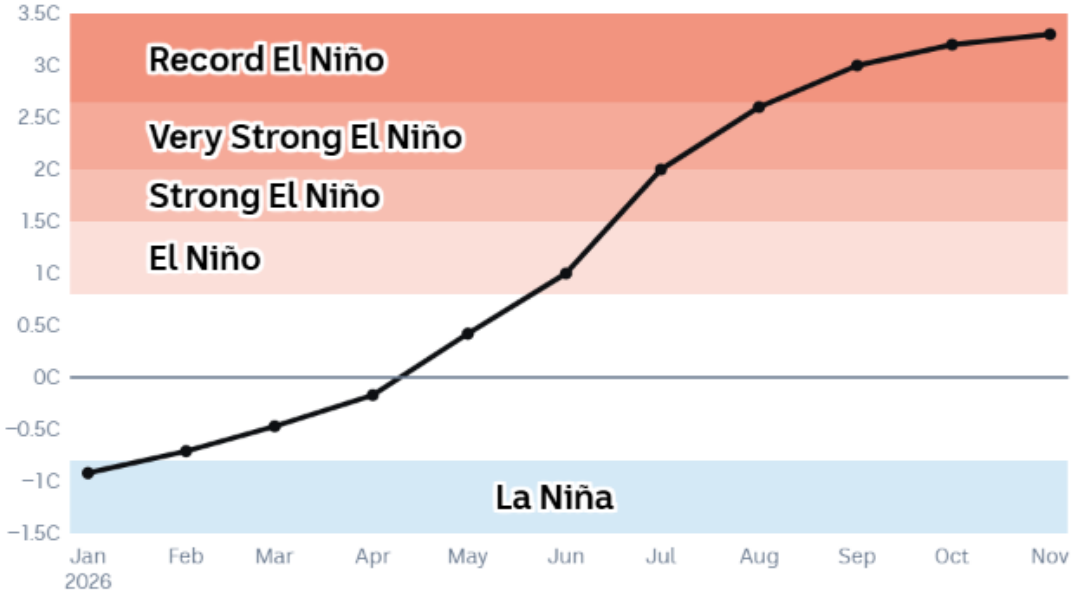
4h ago

https://www.abc.net.au/news/2026-06-16/nsw-bureau-of-meterology-declares-el-nino-weather/106776598

The BOM's seasonal model, called ACCESS-S, is tipping an all-time record later in the year with a peak warming in excess of 3C above normal, comfortably above the previous post-1900 high of 2.65C from November 1902.

NINO3.4 Analysis and Forecast

Analysis to June, ACCESS-S model from July



Forecast mean of 99 member ensemble

Source: BOM

Thankfully though for Australia, there is only a very weak relationship between the strength of the Pacific warm signal and the local impacts, so a record event does not mean a record drought.

- 1855 Astronomical and Meteorological Observer, and Head of the Electric Telegraph Department in South Australia.

- Overland Telegraph Line completed 1872
  (Alice Springs named after his wife).

- He and his staff used weather observations from all the Colonies to create synoptic weather charts from 1879 (with greater geographical reach than any other jurisdiction in the world).

- 1888 - one of the first to suggest that local climate could be affected by distant patterns (teleconnections). He noted that abnormally high atmospheric pressure in India was matched with similar extremes in Australia, typically resulting in parallel droughts thousands of kilometres apart.

- 1899 - Worked on wireless telegraphy with his son-in-law William Henry Bragg.

Sir Charles Todd
(1826-1910)

- British mathematician joined the British Colonial Service in 1904 as Director General of Observatories in India.

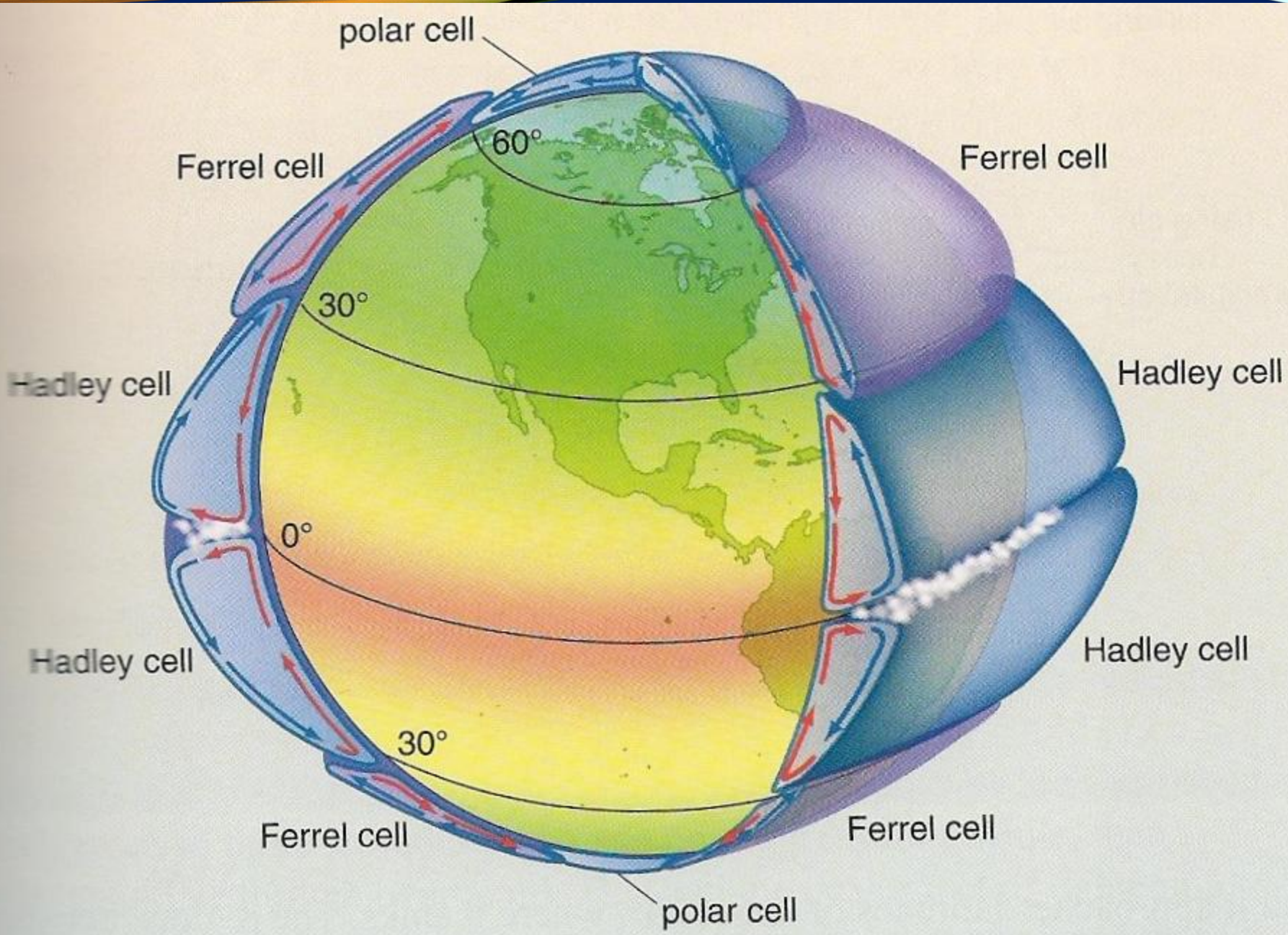
- Aim: predicting Asian monsoon fluctuations to forewarn of famines, as current techniques failed during 1899-1901.

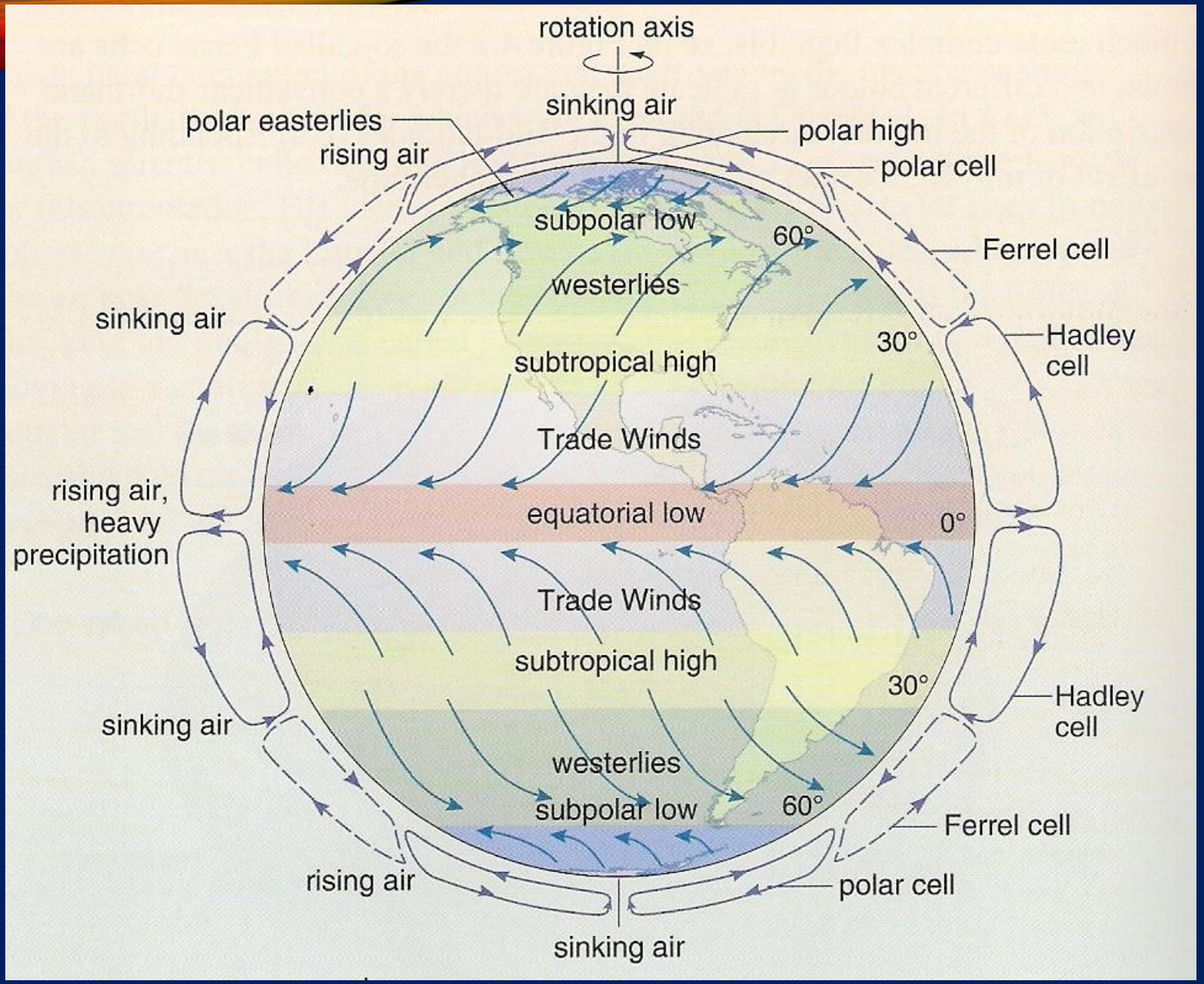
- Does not seem to have known of Todd's work.

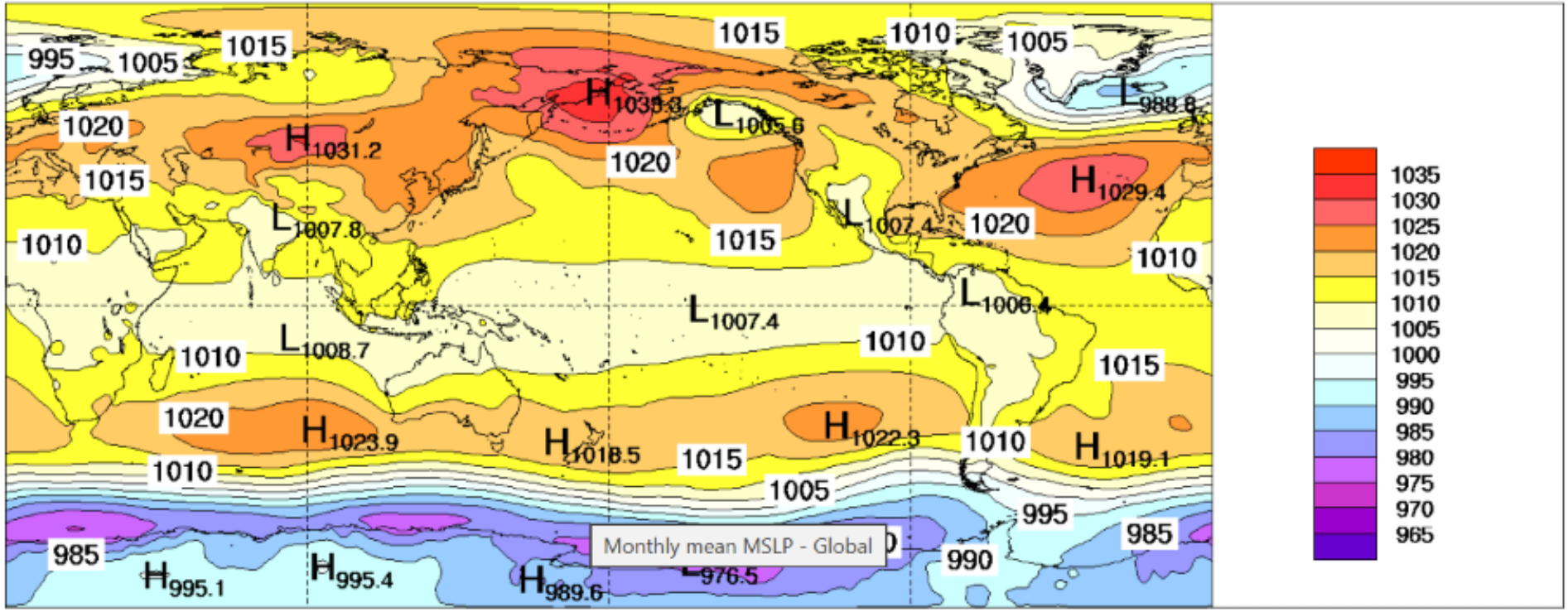
- Over the next 15 years he published the first descriptions of the **great seesaw oscillation of atmospheric pressure between the Indian and Pacific Ocean**, and its connection to temperature and rainfall patterns across much of the Earth's tropical regions, including India.

- It was called the **Southern Oscillation.**

Sir Gilbert Walker (1868-1958)


polar cell
60°
Ferrel cell
Ferrel cell
30°
Hadley cell
Hadley cell
0°
Hadley cell
Hadley cell
30°
Ferrel cell
Ferrel cell
polar cell


rotation axis
sinking air
polar easterlies
rising air
polar high
polar cell
subpolar low
60°
Ferrel cell
westerlies
sinking air
30°
Hadley cell
subtropical high
Trade Winds
rising air, heavy precipitation
equatorial low
0°
Trade Winds
subtropical high
30°
Hadley cell
sinking air
westerlies
subpolar low
60°
Ferrel cell
rising air
polar cell
sinking air



Average Mean Sea Level Pressure (hPa) – March 2026

Note: Tropical areas have very little difference in surface pressure.

- Normally, **sea level pressure (SLP)** is relatively high in the south-central Pacific (e.g. Tahiti) and relatively low over Northern Australia (e.g. Darwin).

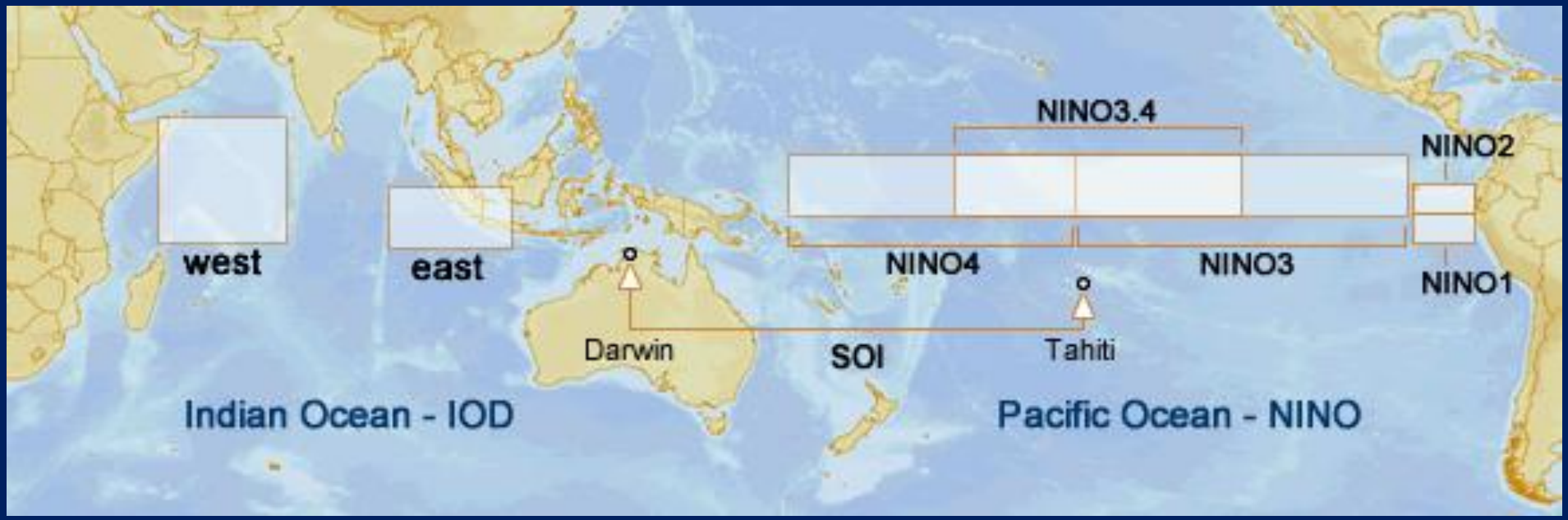
- With this pressure difference, winds blow from east to west in the tropics (called the *trade winds*).

- Occasionally the pressure difference between east and west weakens, the trade winds relax and there is often drought in India and Australia.

- These stations are useful as their records go back to the 1880s.

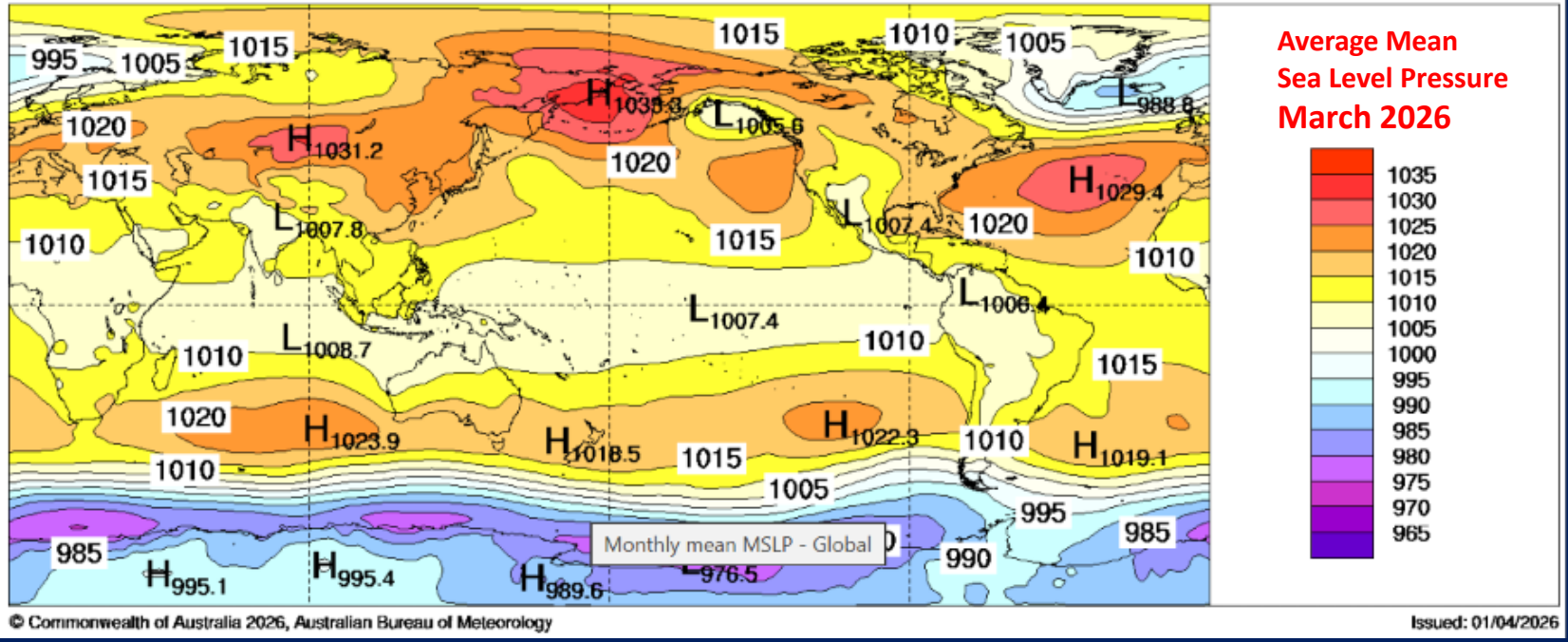
- The **Southern Oscillation Index (SOI):**
    - Calculates: SLP at Tahiti - SLP at Darwin.
    - Compares that with the average pressure difference between Tahiti and Darwin
    - Creates an index that measures how big that difference is compared with normal conditions (and uses a factor of 10 for ease of use).

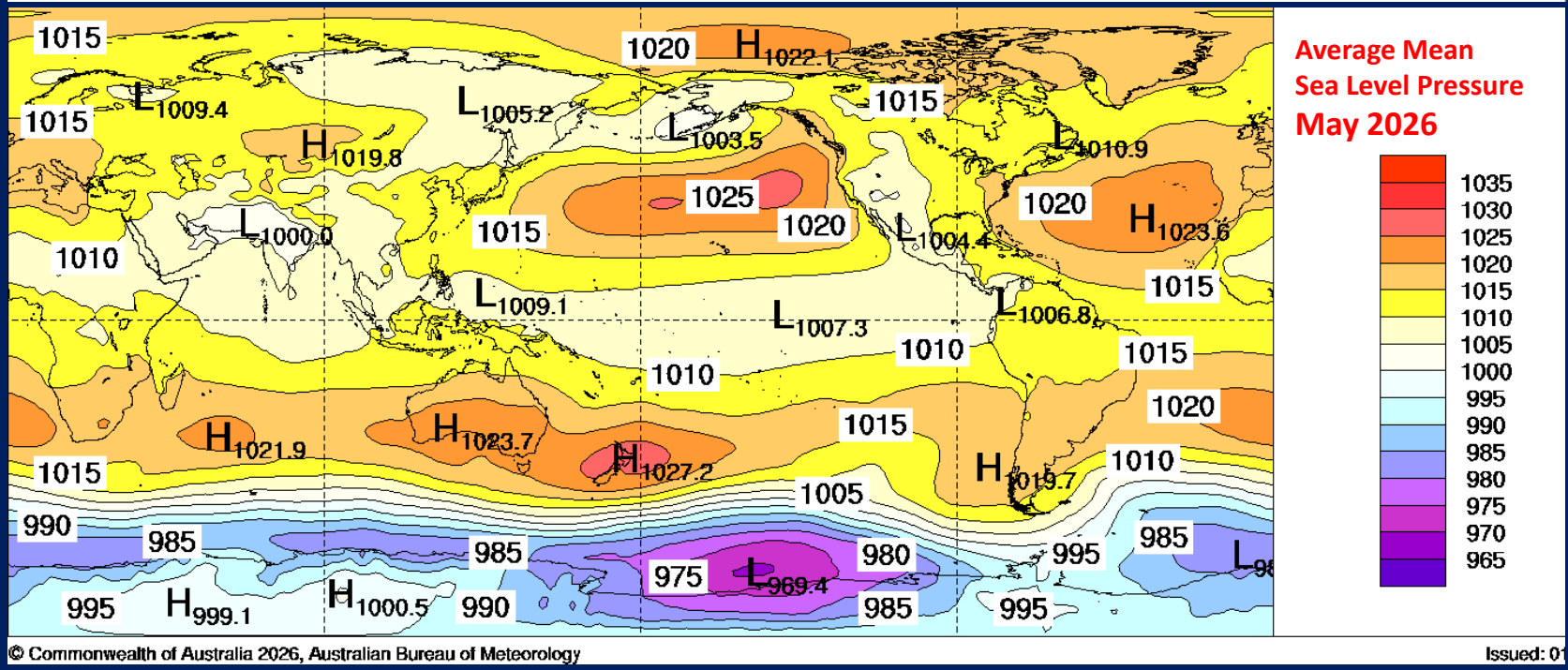
- The concept of a **zonal (east-west) circulation** along the equatorial regions became known as the **Walker Circulation**. (The Hadley circulation is a meridional (north-south) circulation).



Tahiti (Papa'ete): 17°40' S 149°25' W

Darwin: 12°28' S 130°51' W


Average Mean
Sea Level Pressure
March 2026
1035
1030
1025
1020
1015
1010
1005
1000
995
990
985
980
975
970
965
Monthly mean MSLP - Global
© Commonwealth of Australia 2026, Australian Bureau of Meteorology
Issued: 01/04/2026


Average Mean
Sea Level Pressure
May 2026
1035
1030
1025
1020
1015
1010
1005
1000
995
990
985
980
975
970
965
© Commonwealth of Australia 2026, Australian Bureau of Meteorology
Issued: 01

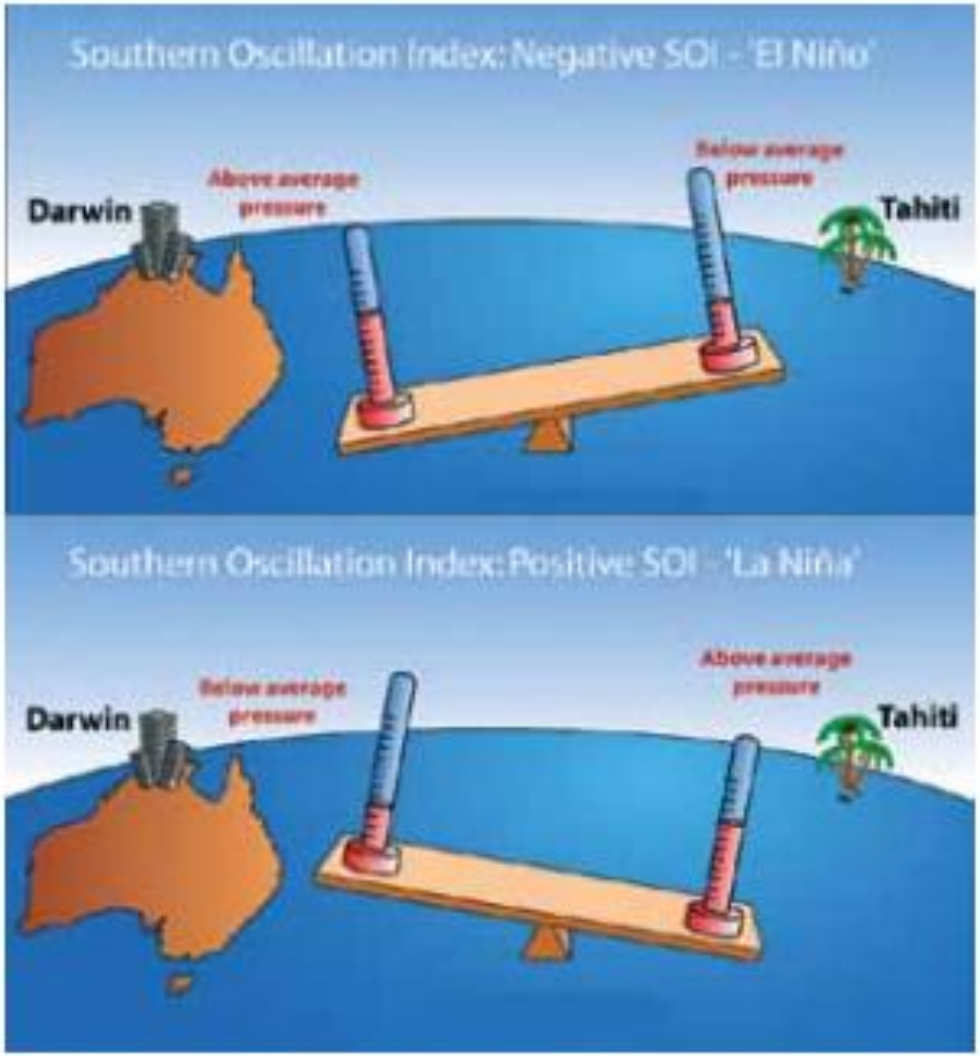


Figure 3.1. The Southern Oscillation is a see-saw of atmospheric pressure between the Indonesian region and the east equatorial Pacific.

Will it rain?

https://www.longpaddock.qld.gov.au/about/resources/

Southern Oscillation Index (SOI)

The Southern Oscillation Index, or SOI, gives an indication of the state and intensity of ENSO, from an atmospheric perspective. The SOI is calculated using the pressure differences between Tahiti and Darwin.

Sustained negative values of the SOI below −7 often indicate El Niño is active while sustained positive values above +7 are typical of a La Niña.

Technical details

There are a few different methods for calculating the SOI. The method used by the Australian Bureau of Meteorology is the Troup SOI which is the standardised anomaly of the Mean Sea Level Pressure difference between Tahiti and Darwin. The base period used in the SOI calculation is 60 years (1933–1992).

Calculation

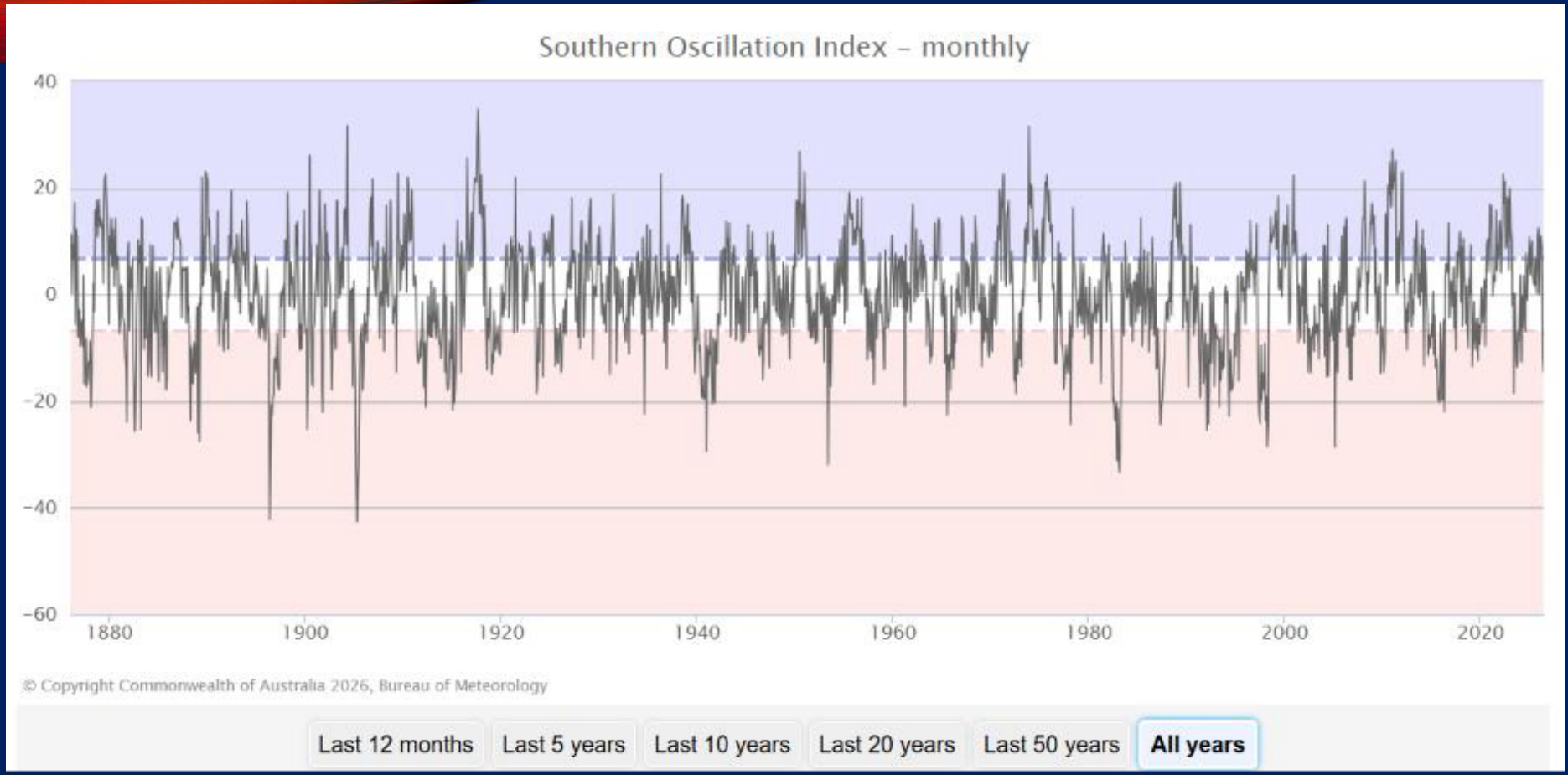
$$SOI = 10 \times \frac{Pdiff - Pdiffav}{SD(Pdiff)},$$

where:
Pdiff = (average Tahiti MSLP for the period) − (average Darwin MSLP for the period),
Pdiffav = long term average of Pdiff for the period in question, and
SD(Pdiff) = long term standard deviation of Pdiff for the period in question.

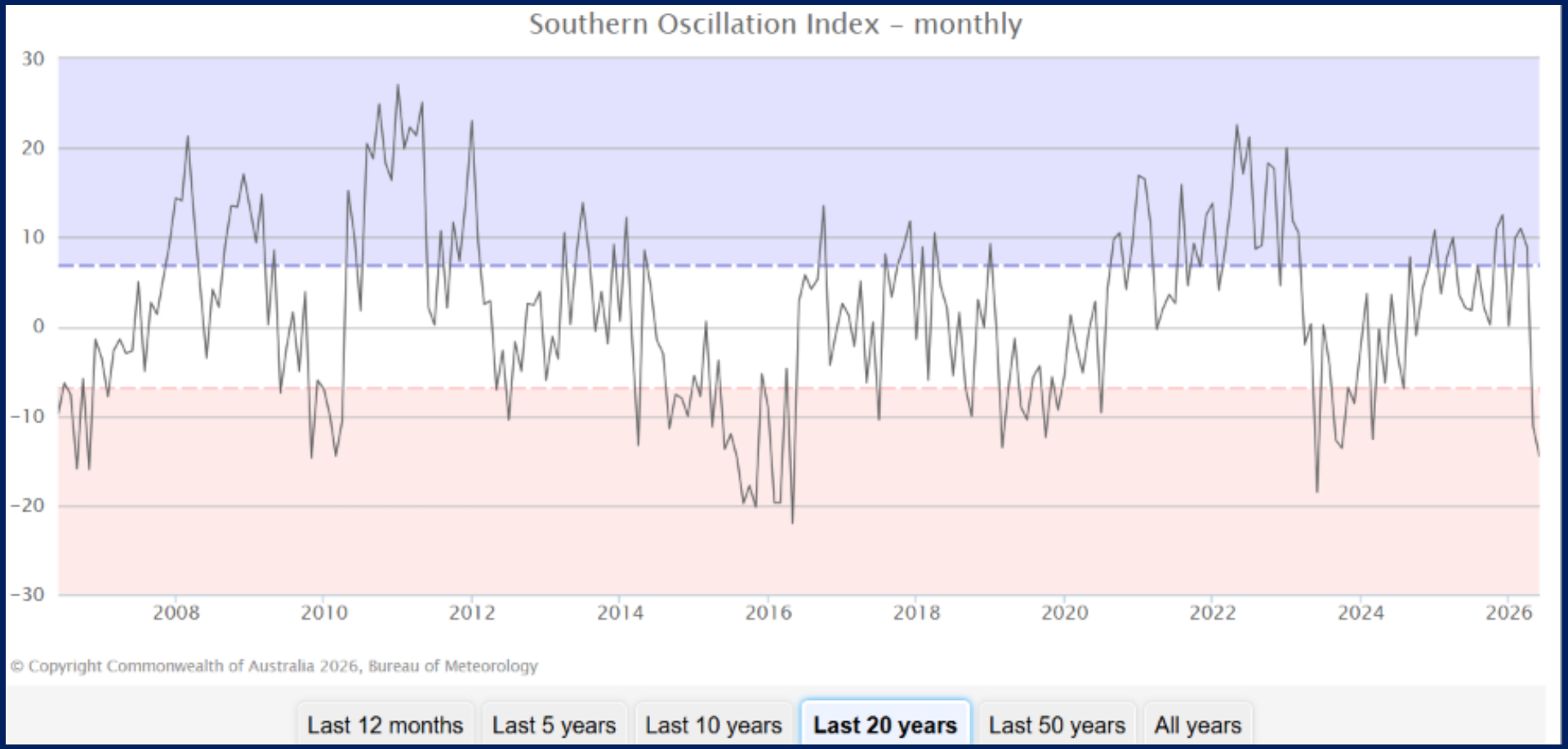
The multiplication by 10 is a convention to make the final value more readable. Using this convention, the SOI ranges from about –35 to about +35, and the value of the SOI can be quoted as a whole number. The SOI is usually computed on a monthly basis, with values over longer periods such a three-month average being sometimes used. Daily values can also be averaged over a longer period to form a multi-day average. Single-day or weekly values of the SOI are not so useful for information on the current state of the climate, as these values are dominated by the effects of short-term weather variability, and accordingly the Bureau of Meteorology does not issue them. In particular, single-day values can fluctuate markedly because of daily weather patterns, and should not be used for climate purposes.

Details about: SOI

https://www.bom.gov.au/climate/enso/soi/



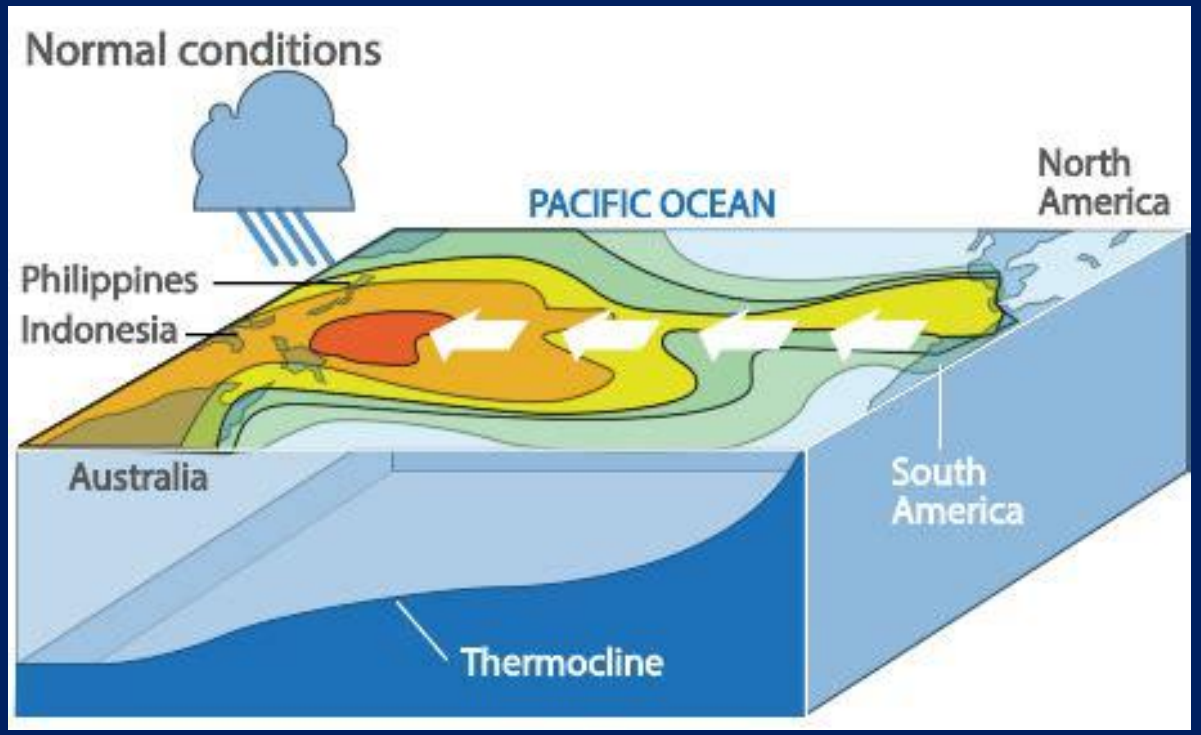
Sustained negative values of the SOI below −7 often indicate El Niño is active while sustained positive values above +7 are typical of a La Niña


Southern Oscillation Index – monthly
30
20
10
0
−10
−20
−30
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
© Copyright Commonwealth of Australia 2026, Bureau of Meteorology
Last 12 months
Last 5 years
Last 10 years
Last 20 years
Last 50 years
All years

Oceanographers were interested in a warm current that occasionally appeared along the Peruvian coast. It could devastate the catch of anchovies. It seemed strongest around Christmas time so fishermen gave it the nick-name ***El Niño*** (the boy child).

In 1969 **Jacob Bjerknes** (1897-1975) proposed that there was a connection between the atmospheric cycle, and ocean temperatures and currents in the Pacific. This led to the hybrid term **El Niño – Southern Oscillation (ENSO)**.

He suggested that an anomalously warm spot in the eastern Pacific can weaken the normal east-west temperature difference, disrupting the trade winds, which normally push warm water to the west. The result would be warmer than normal water in the east.



A positive feedback - atmospheric changes alter the sea temperatures, that in turn alter the atmospheric winds.

One effect in the Ocean:

El Niño reduces the upwelling of cold, nutrient-rich water in the Peru (Humboldt) current that sustains large fish populations, which in turn sustain abundant sea birds, whose droppings support the fertilizer industry. The reduction in upwelling leads to fish kills off the shore of Peru.

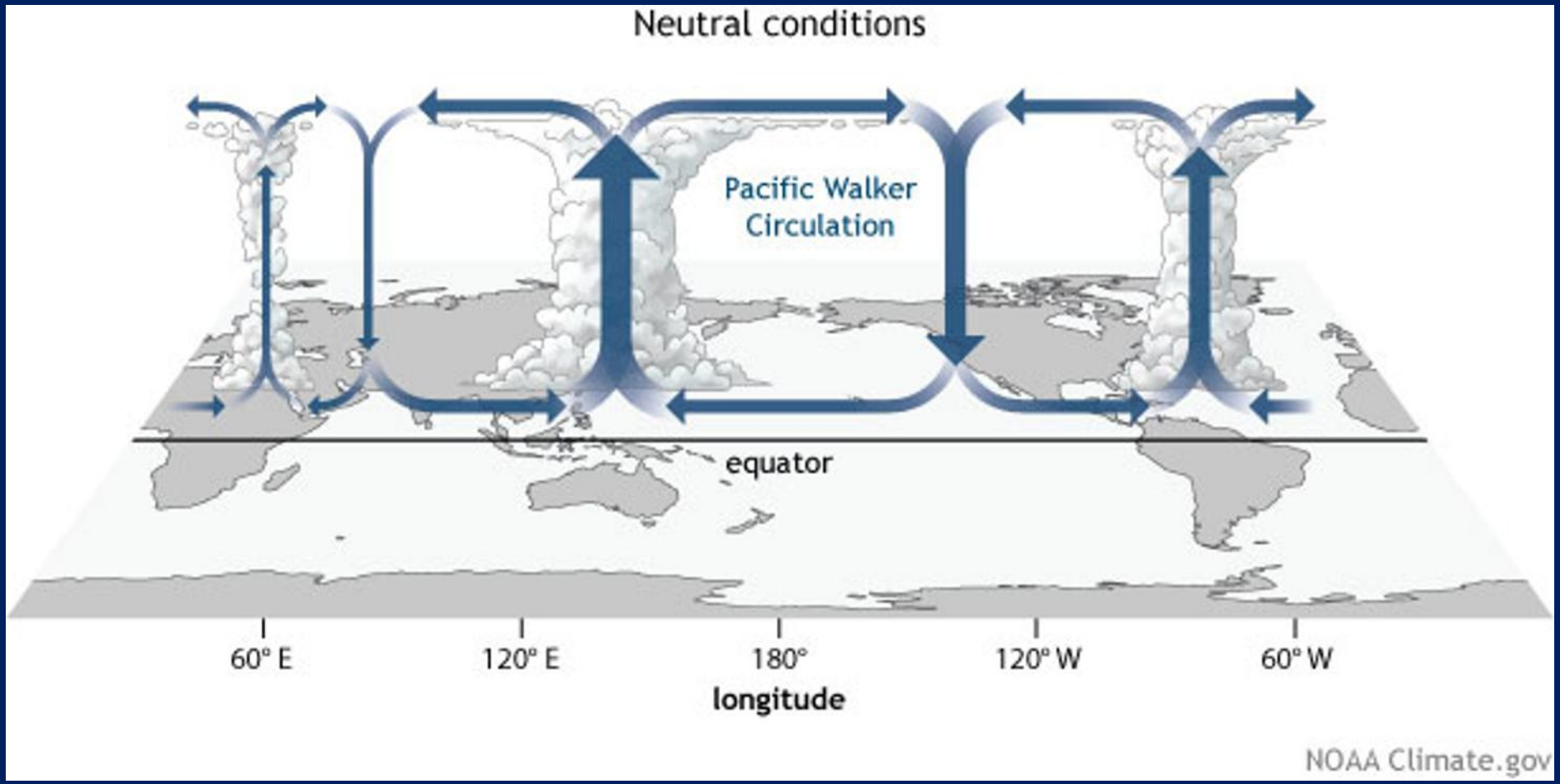
Near the Equator the normally northward flowing cold current is replaced by a warm current flowing southwards.

The local fishing industry along the affected coastline can suffer during long-lasting El Niño events.

The world's largest anchovy fishery collapsed due to overfishing during the 1972 El Niño Peruvian anchovy reduction.

Bjerknes proposed that there was an east–west overturning atmospheric cell above the Pacific, which he named the **Walker Circulation**.

The rising branch of the cell is associated with high sea temperatures, convection and rainfall in the western Pacific, while the downward branch occurs over cooler sea surface temperatures in the central and eastern Pacific.

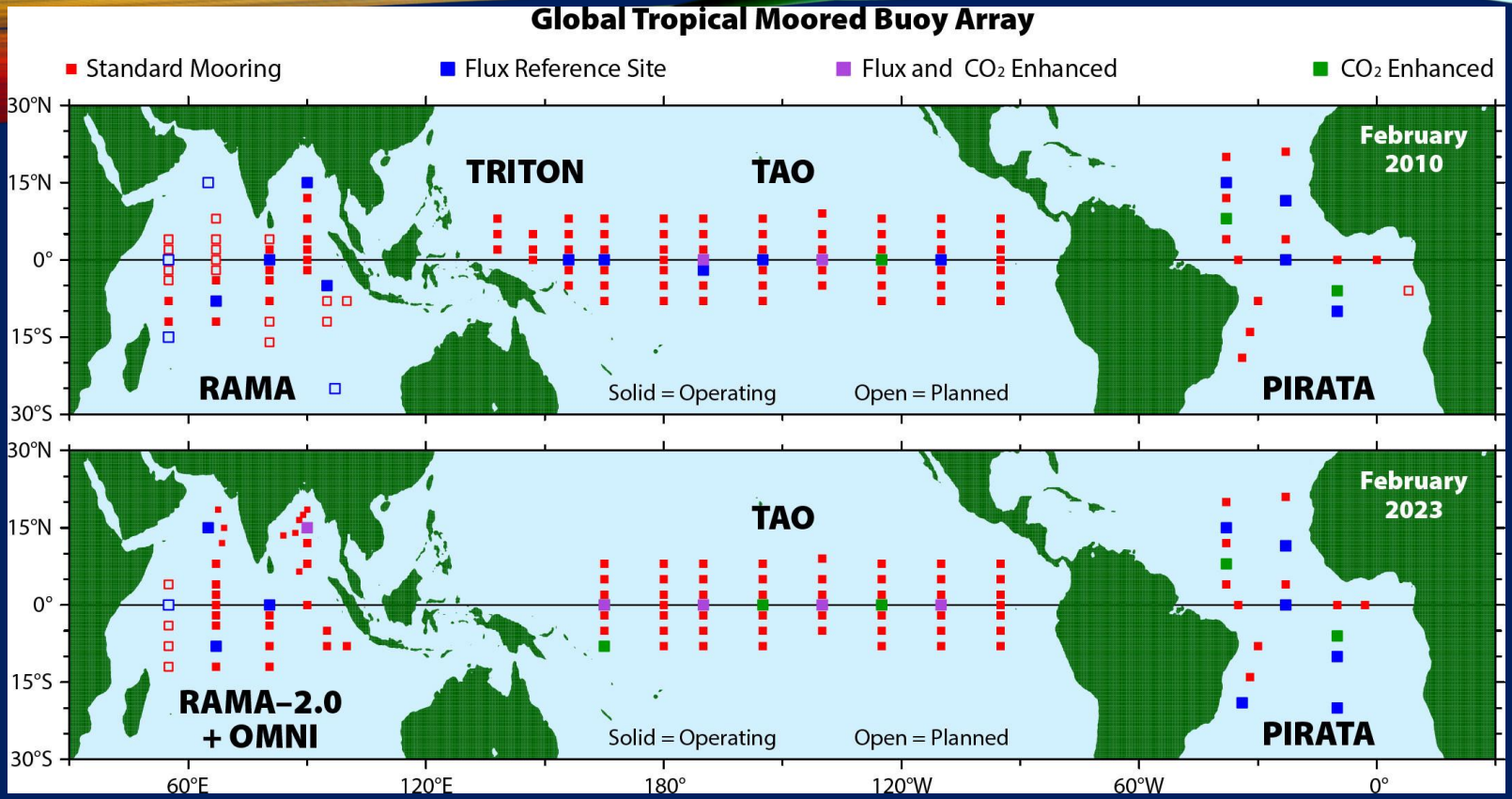


More contributions from the oceanographers.

1985 – George Philander and Mark Cane (USA) described how tropical winds and currents could lead to the opposite effect – with warm temperatures in the western Pacific called *La Niña.*

Cane and Stephen Zebiak developed a forecast model coupling the oceanic and atmospheric data, that successfully predicted the emergence of an El Niño episode in 1986-7.

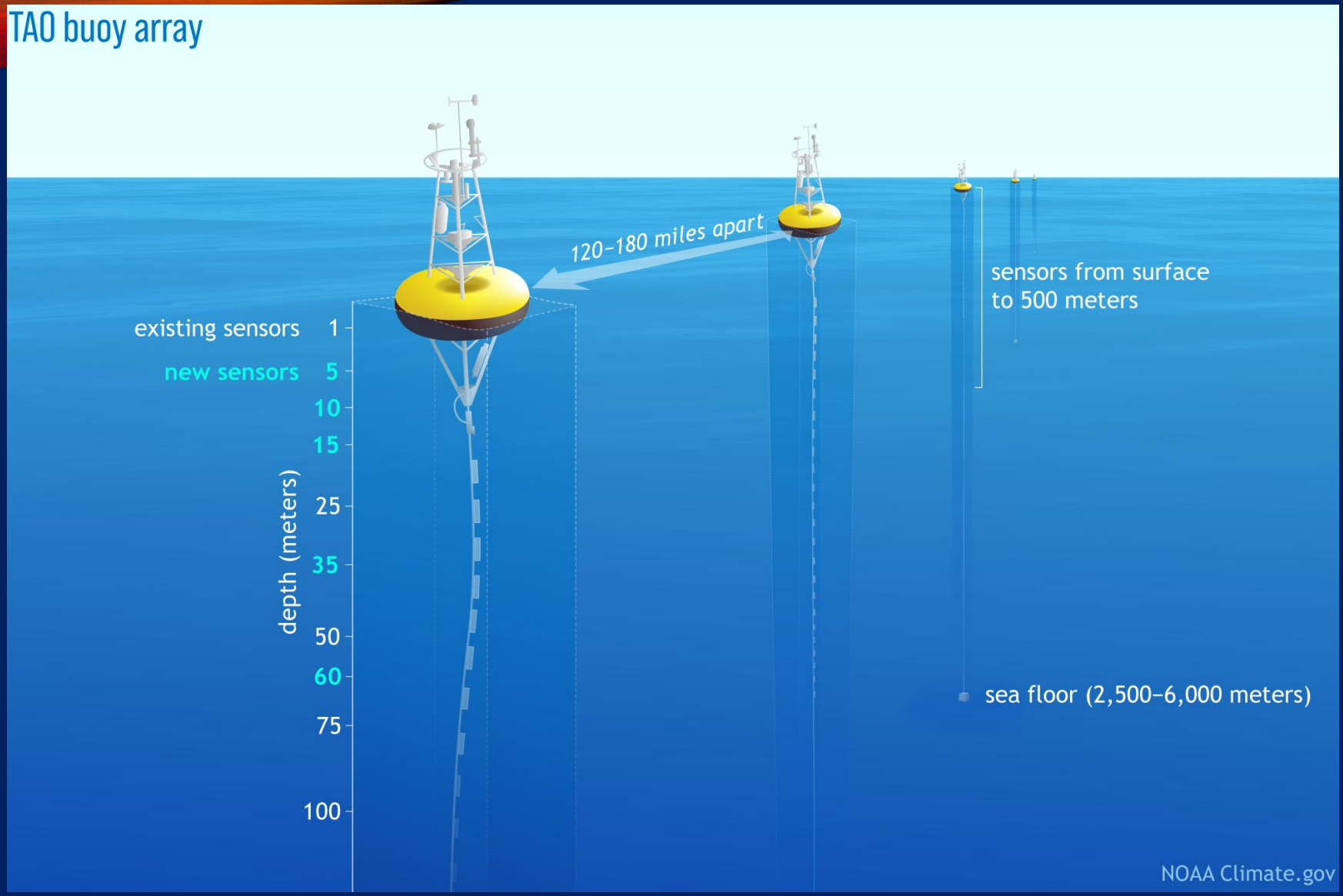
This really established the science of ENSO.



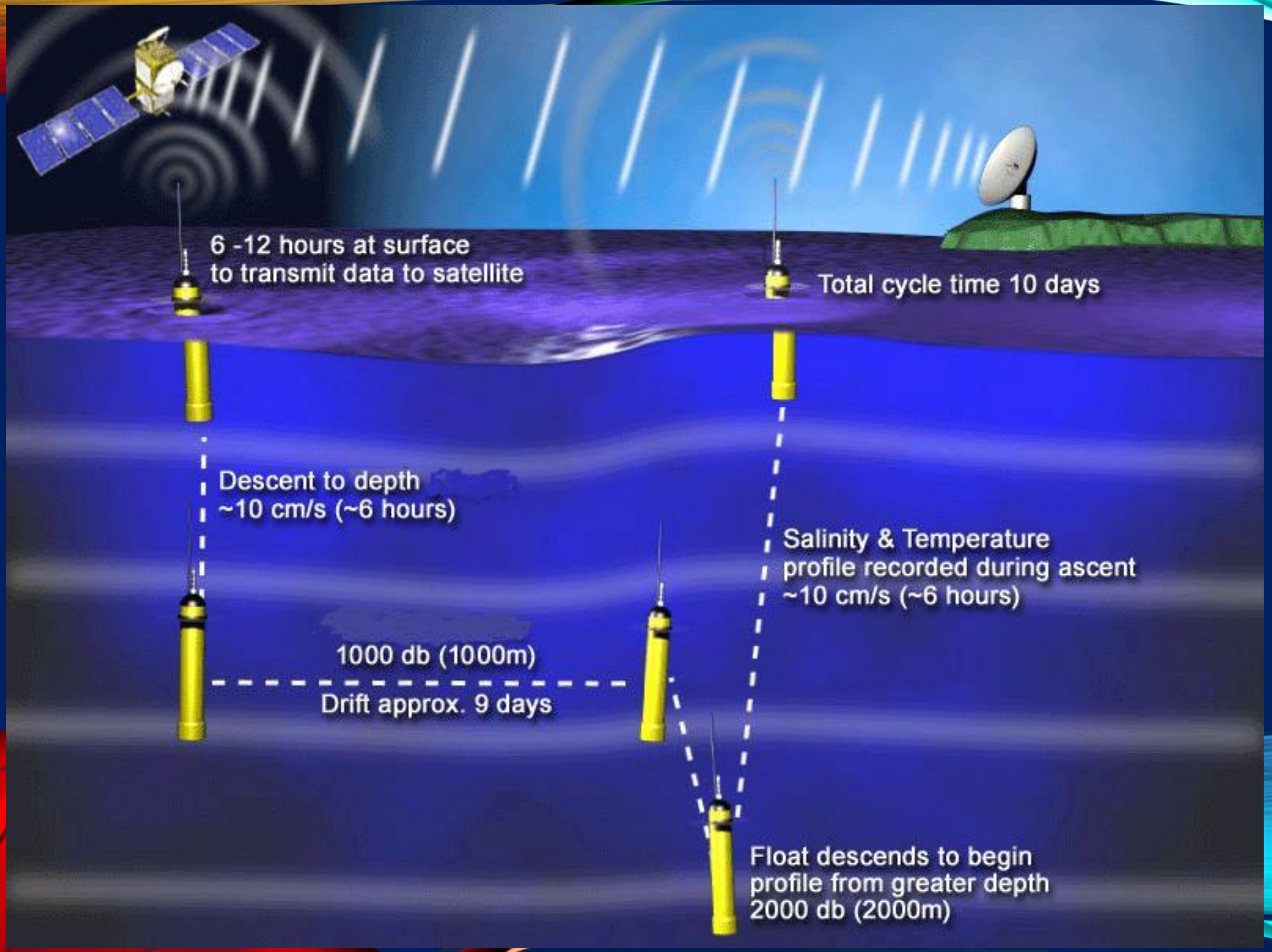
A network of moored buoys was established from the 1980s across the Pacific Ocean to study and help predict El Nino/La Nina events. This was the Tropical Atmosphere Ocean (TAO) array – due mainly to the US Pacific Marine Environmental Laboratory.

Other networks have since been established covering the Western Pacific, Indian and Atlantic Oceans. E.g. Prediction and Research Moored Array in the Tropical Atlantic (PIRATA).

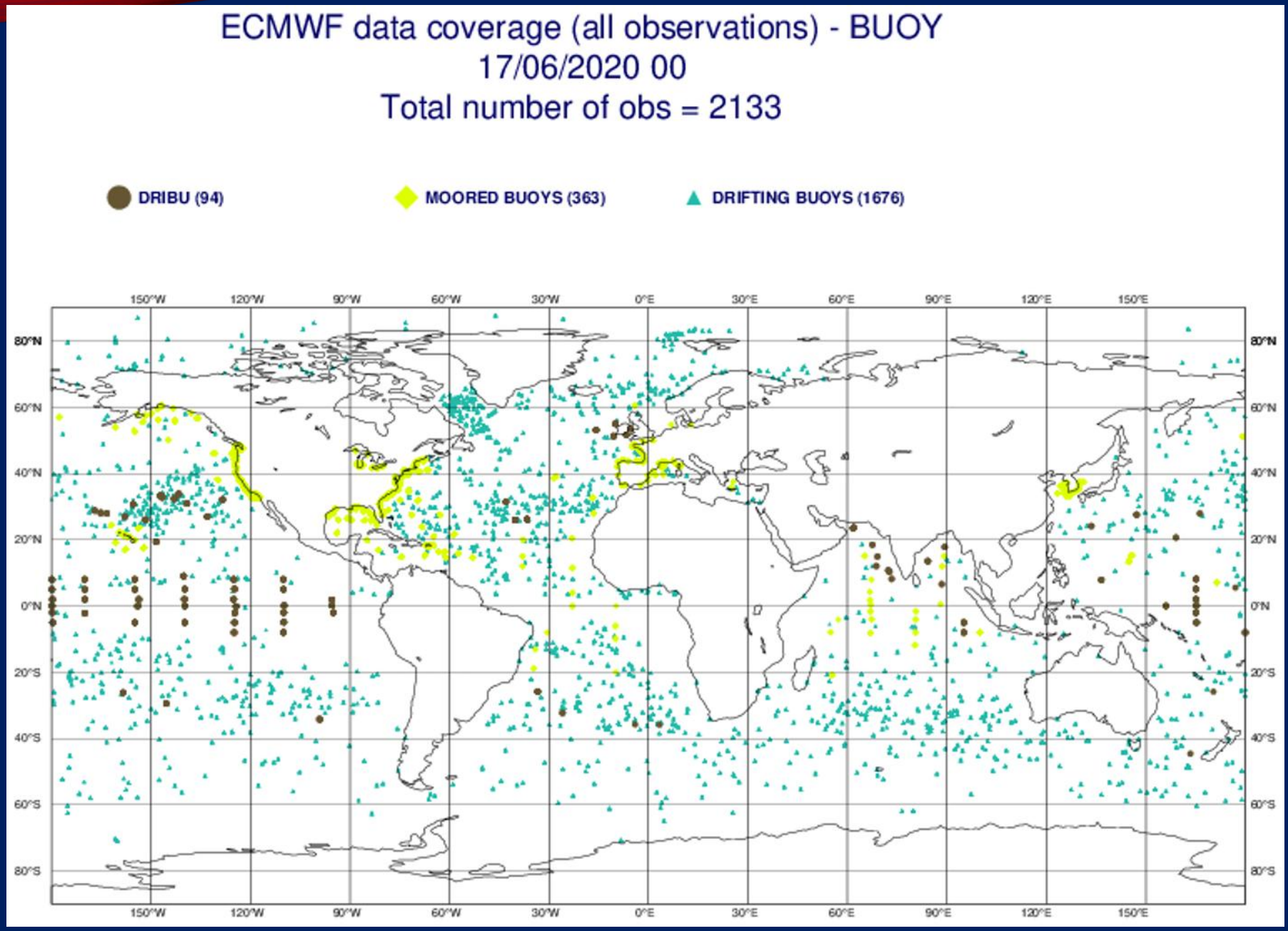
https://www.pmel.noaa.gov/gtmba/pmel-theme/pacific-ocean-tao

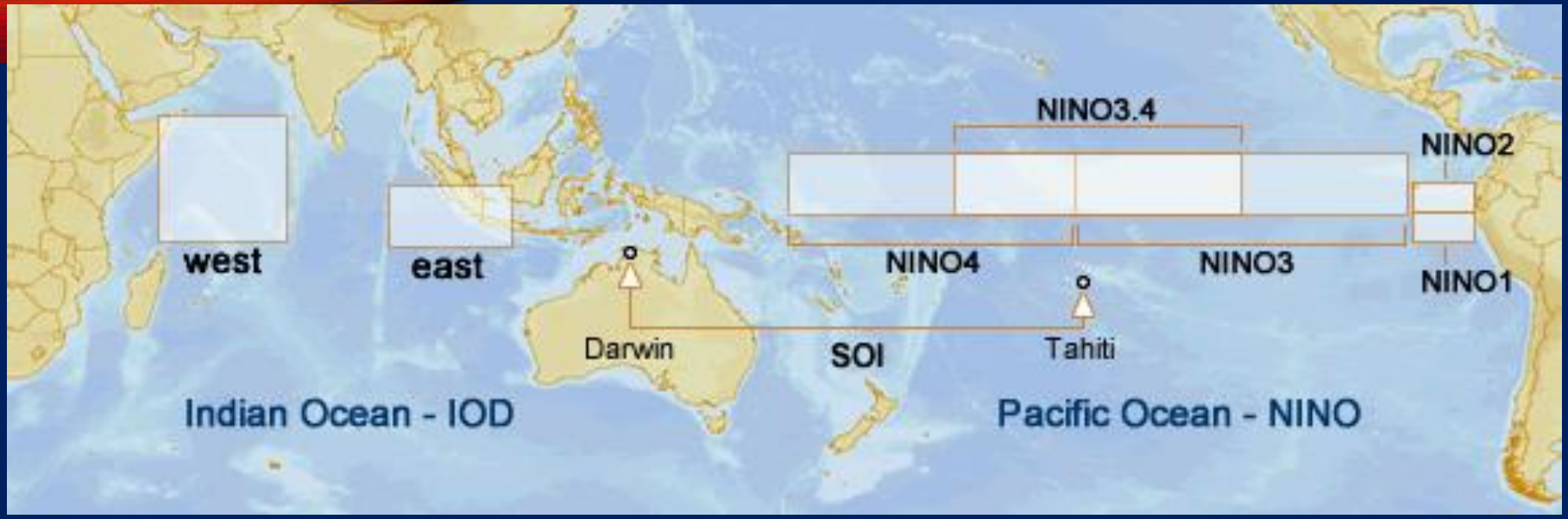


What was happening below the surface was also important.


6 -12 hours at surface
to transmit data to satellite
Total cycle time 10 days
Descent to depth
~10 cm/s (~6 hours)
Salinity & Temperature
profile recorded during ascent
~10 cm/s (~6 hours)
1000 db (1000m)
Drift approx. 9 days
Float descends to begin
profile from greater depth
2000 db (2000m)

Data coverage - buoys





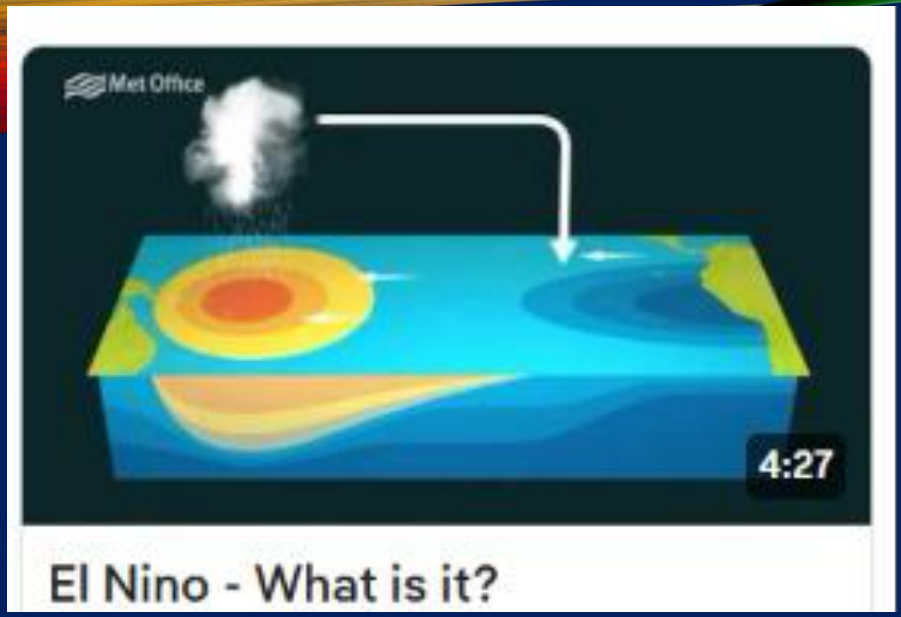
Southern Oscillation Index:

Tahiti (Papa'ete): 17°40' S 149° 25' W

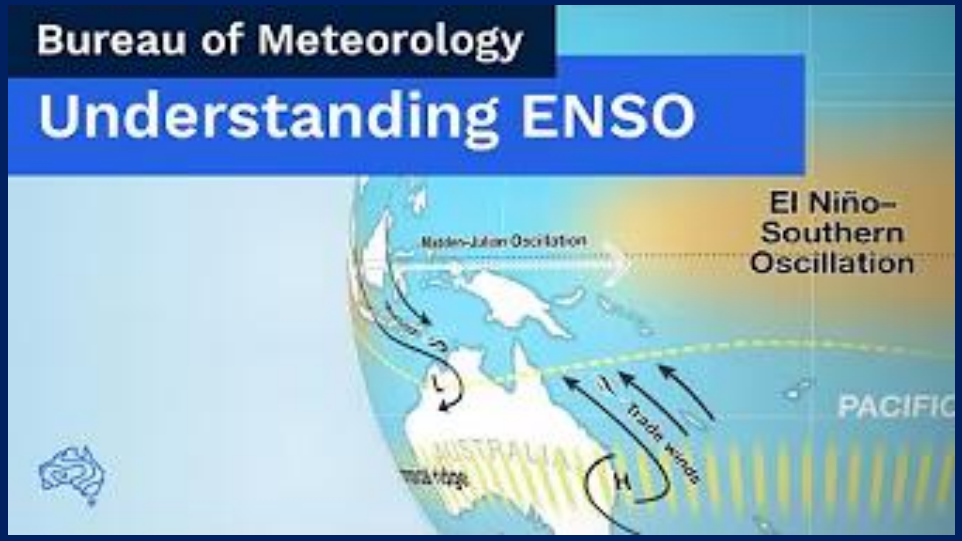
Darwin: 12° 28' S 130° 51' W

Sea Surface Temperature Indices:

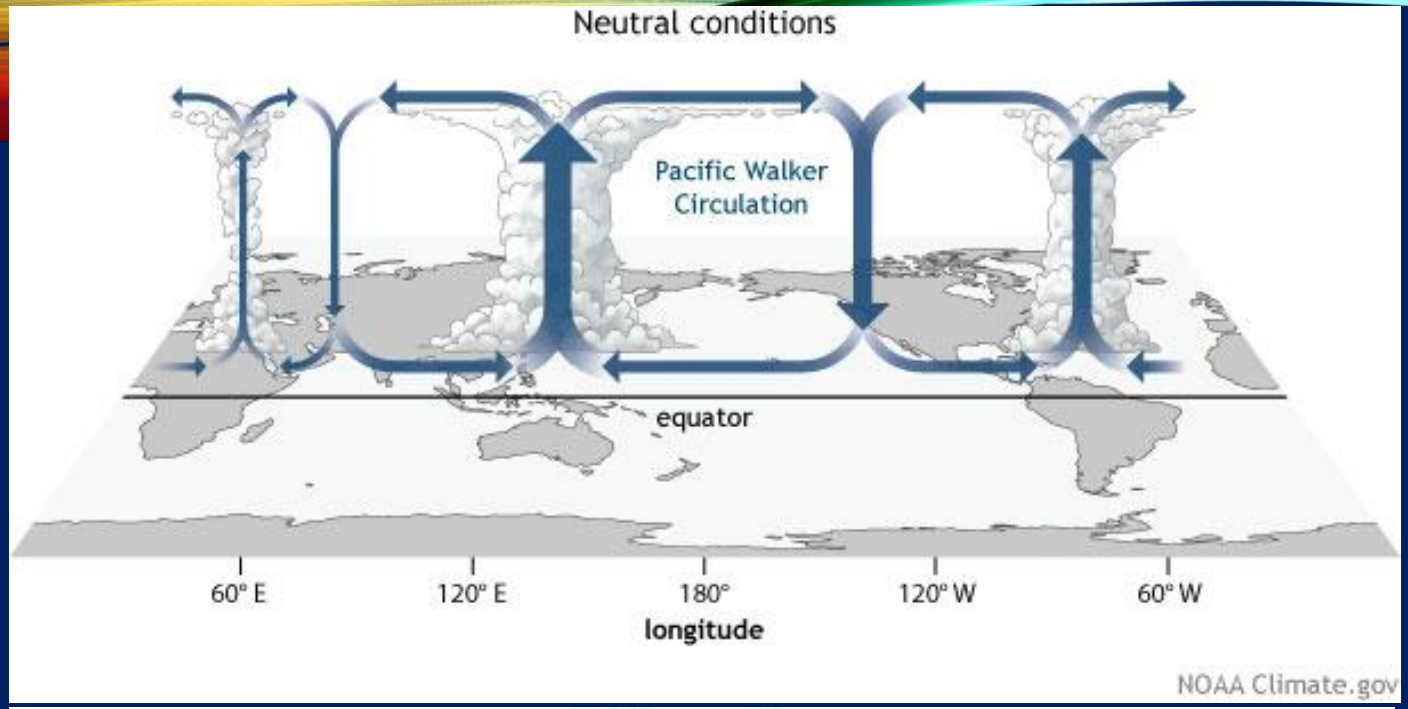
The Bureau cites sustained monthly Niño3 or Niño3.4 values above +0.8 °C as being associated with El Niño, and values below –0.8 °C being associated with La Niña.

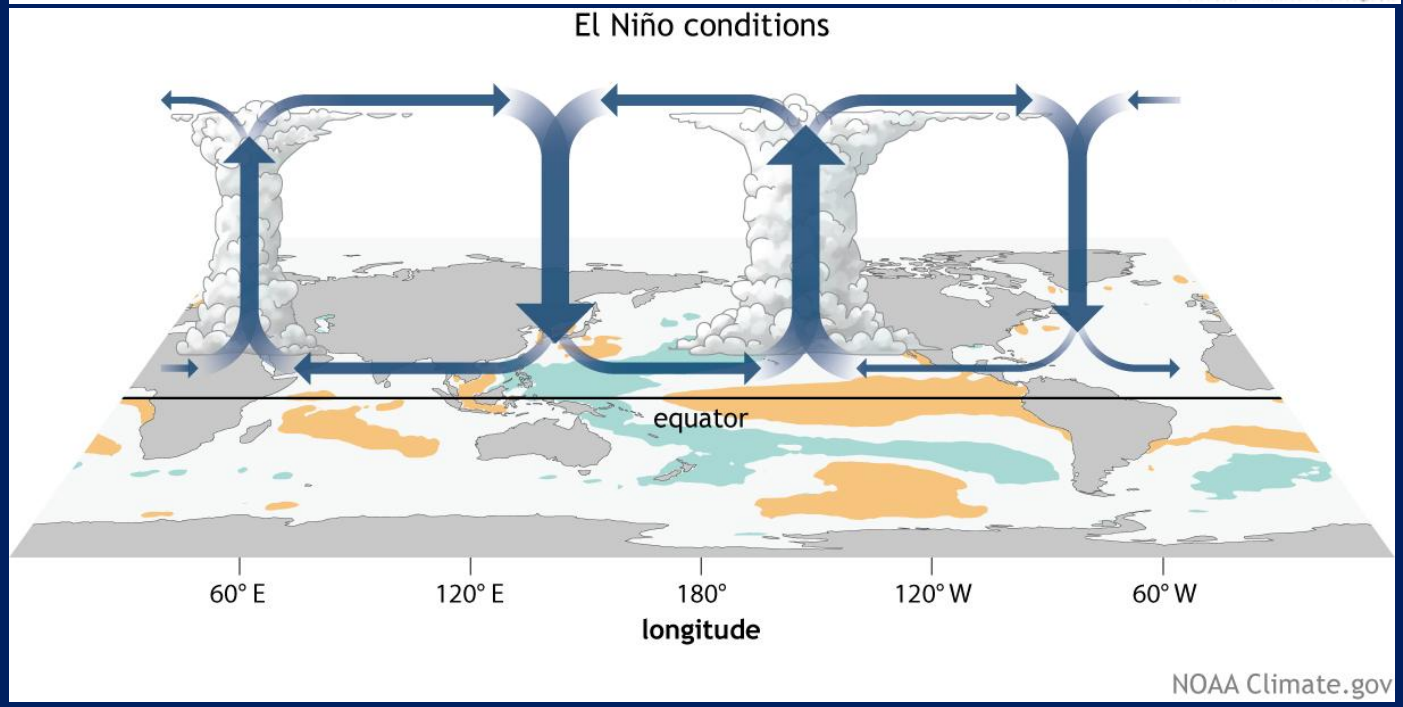


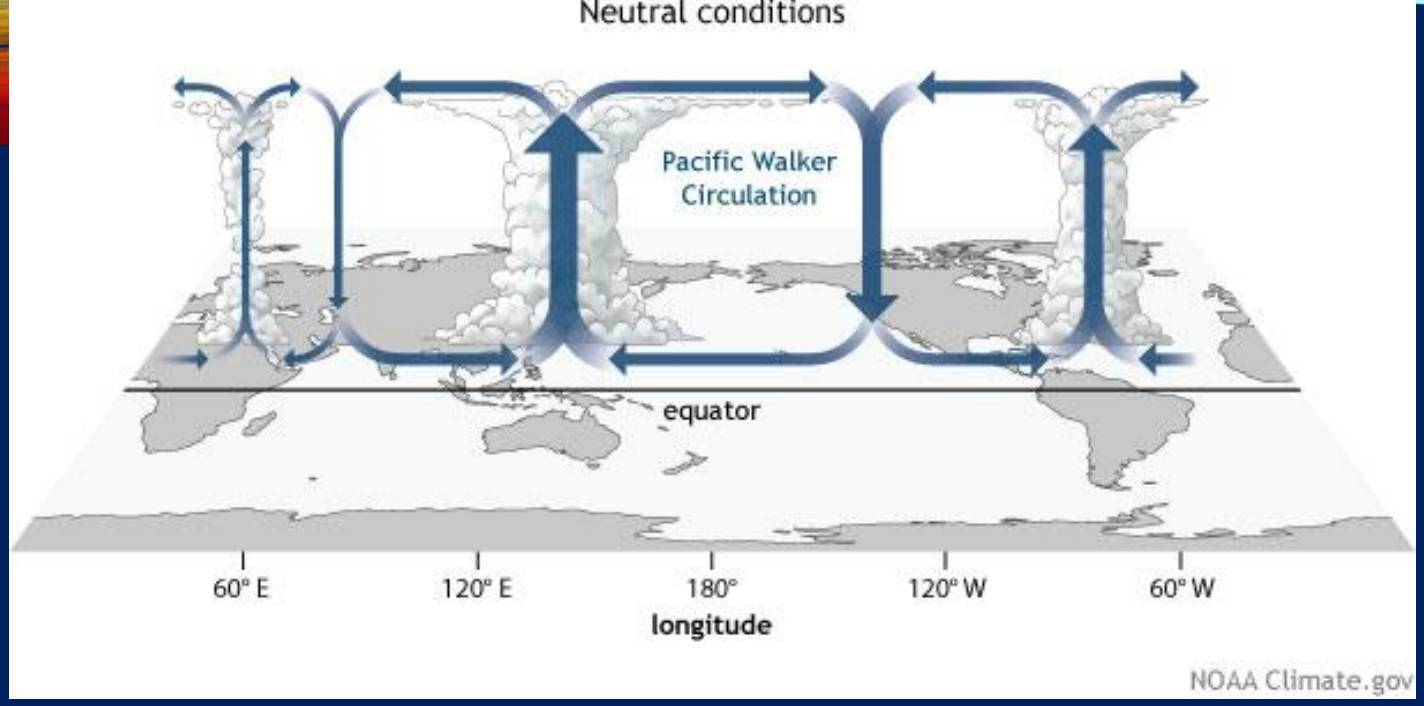
https://www.youtube.com/watch?v=WPA-KpldDVc

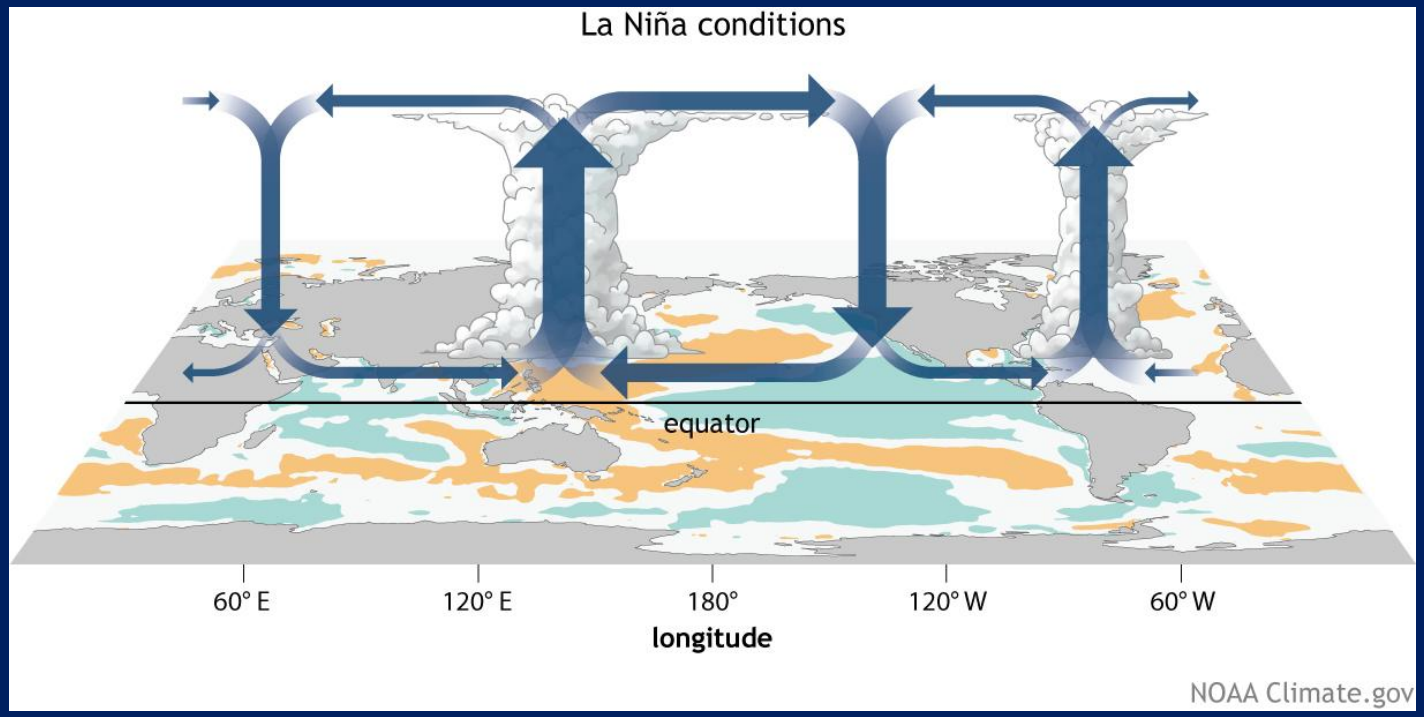


https://www.youtube.com/watch?v=dzat16LMtQk


Neutral conditions
Pacific Walker Circulation
equator
60° E
120° E
180°
120° W
60° W
longitude
NOAA Climate.gov


El Niño conditions
equator
60° E
120° E
180°
120° W
60° W
longitude
NOAA Climate.gov


Neutral conditions
Pacific Walker Circulation
equator
60° E
120° E
180°
120° W
60° W
longitude
NOAA Climate.gov


La Niña conditions
equator
60° E
120° E
180°
120° W
60° W
longitude
NOAA Climate.gov

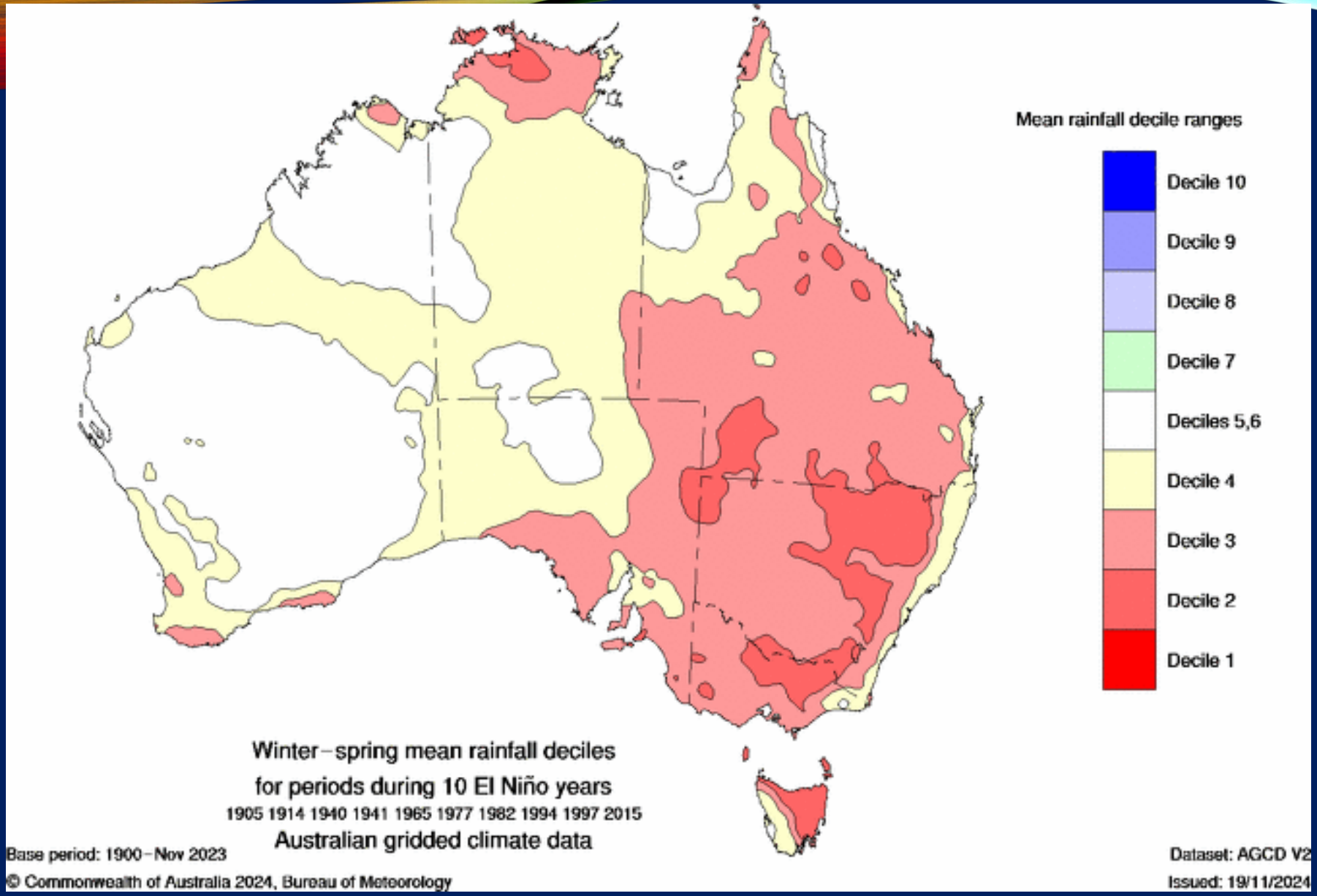
El Niño – Southern Oscillation - ENSO

So what? How does it affect Australia's climate?

Potential effects of El Niño on Australia include:

- Reduced rainfall
- Warmer temperatures
- Increased frost risk
- Reduced tropical cyclone numbers
- Later monsoon onset
- Increased fire danger in southeast Australia
- Decreased alpine snow depths

The impact may vary and is more along the lines of increasing the chances of these effects (like playing with loaded dice)

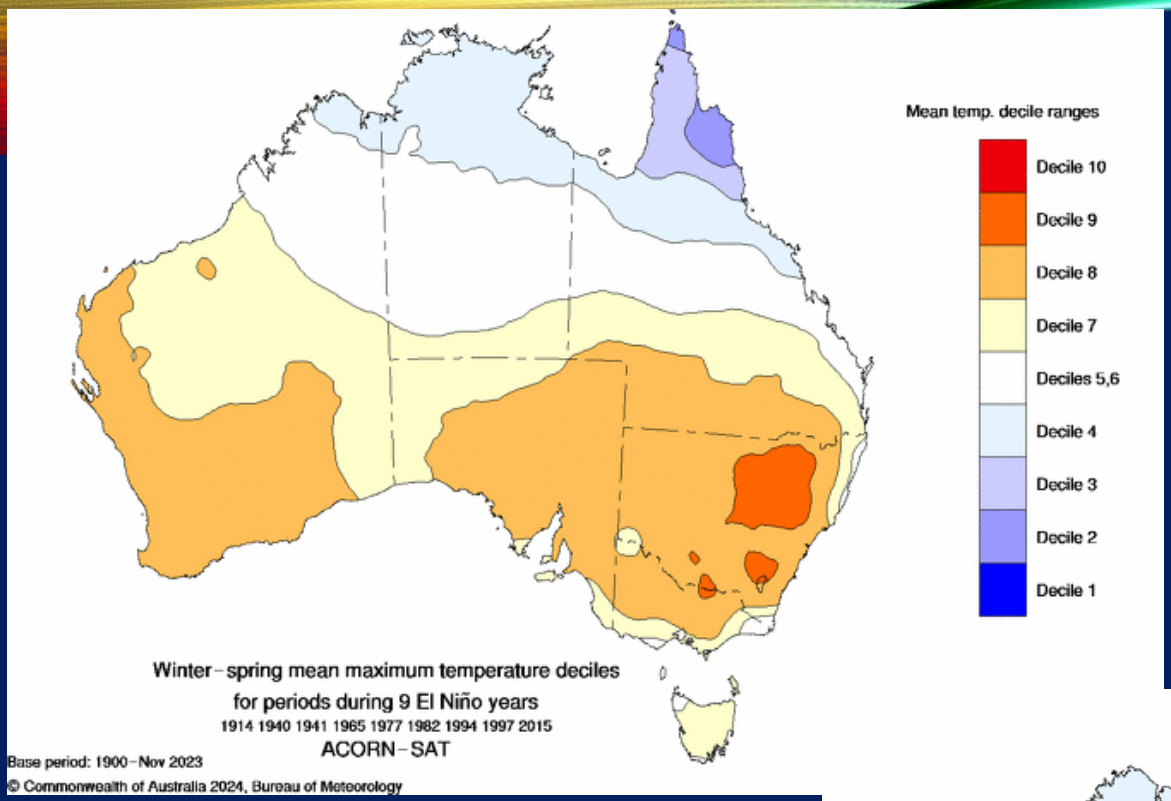


Winter-spring rainfall deciles during 10 El Niño years.

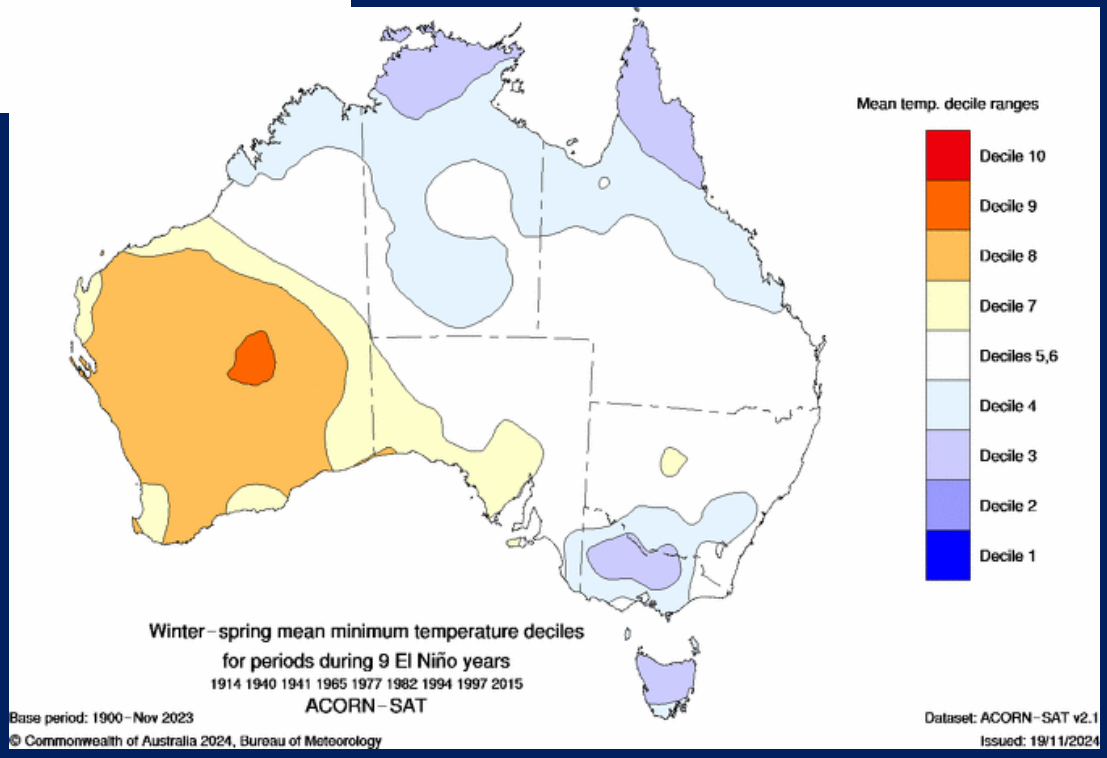
https://www.bom.gov.au/climate/enso

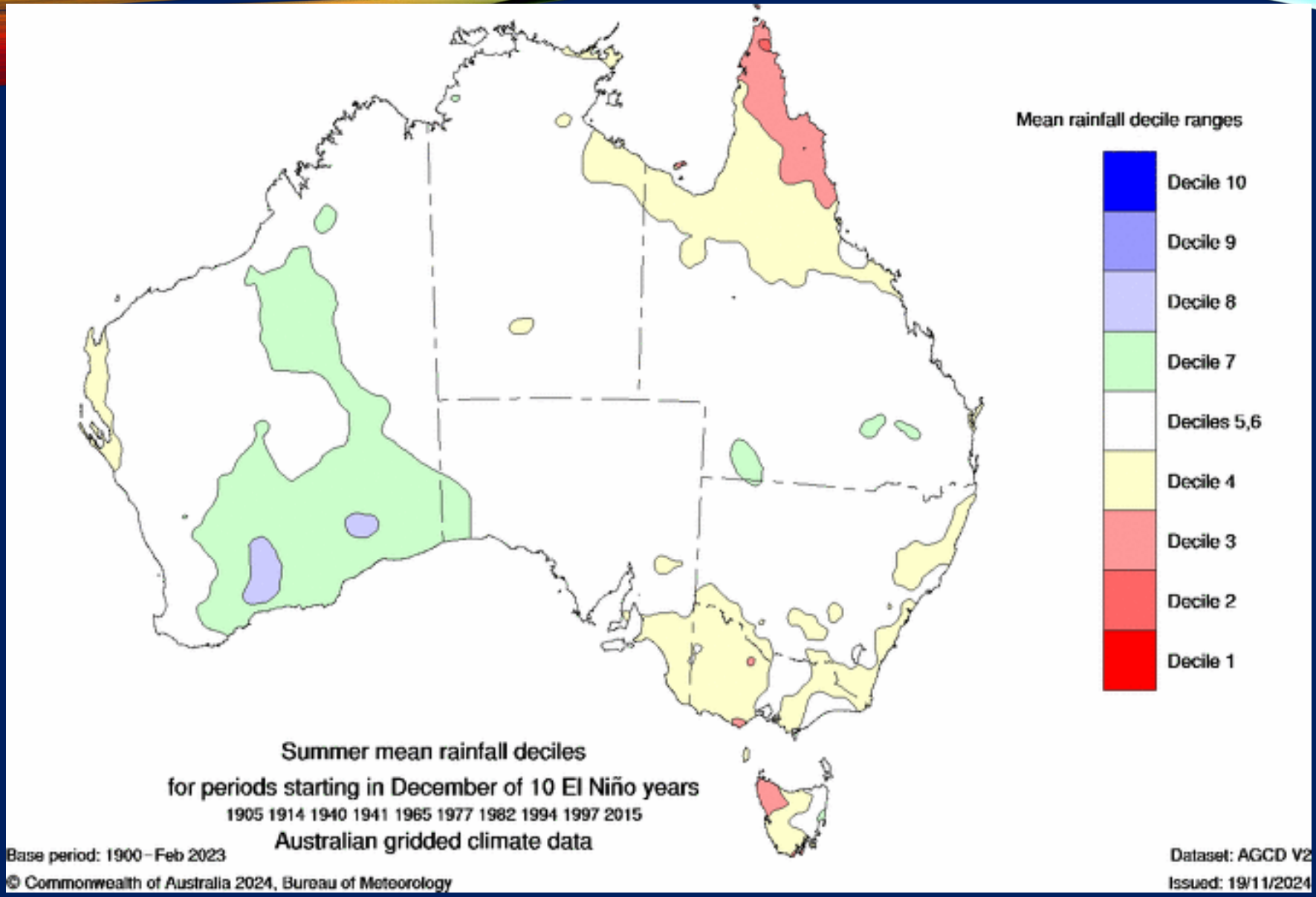
El Niño Years

Winter-spring Maximum Temperature



Winter-spring Minimum Temperature

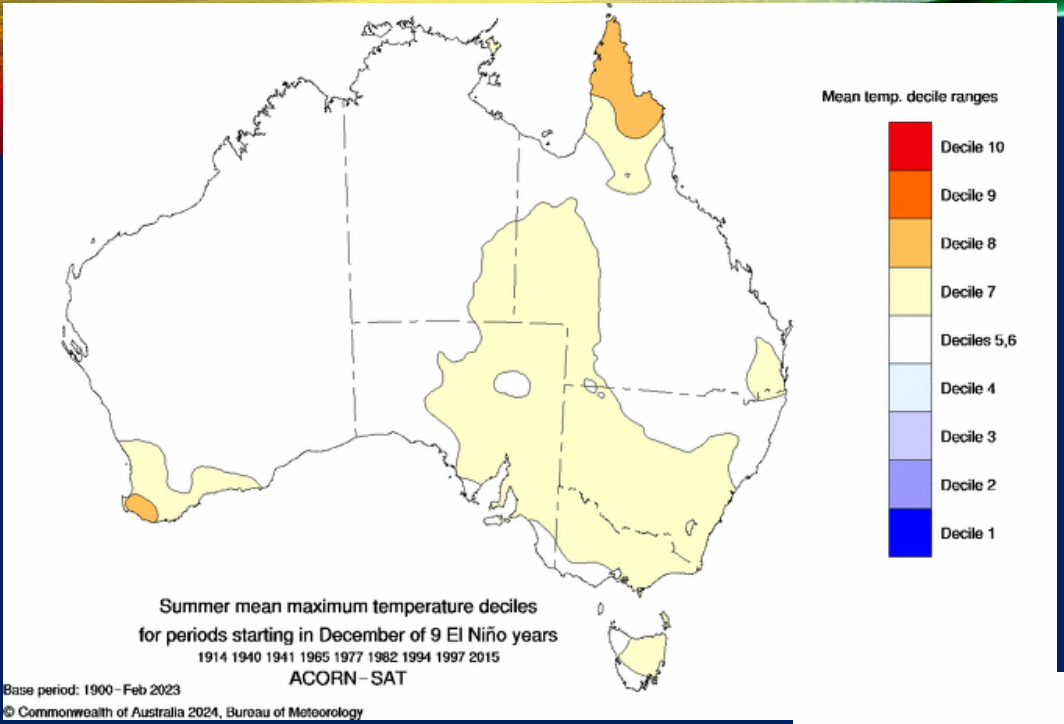




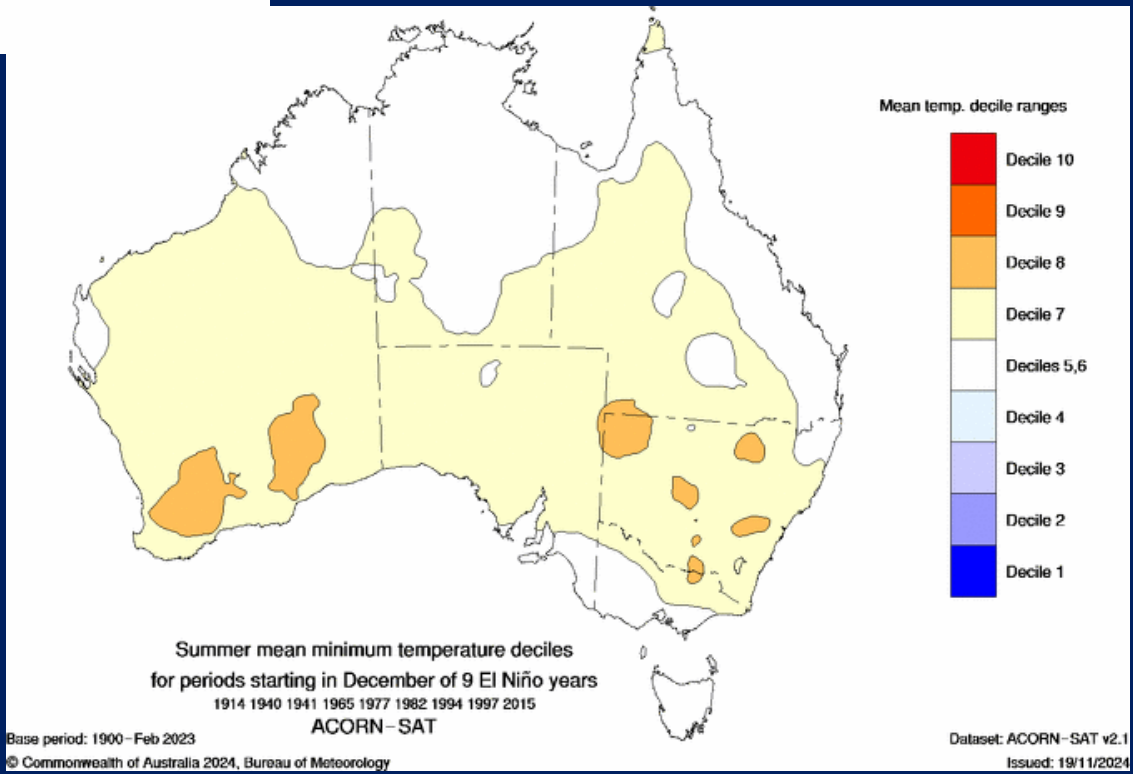
Summer rainfall deciles during 10 El Niño years.

El Niño Years

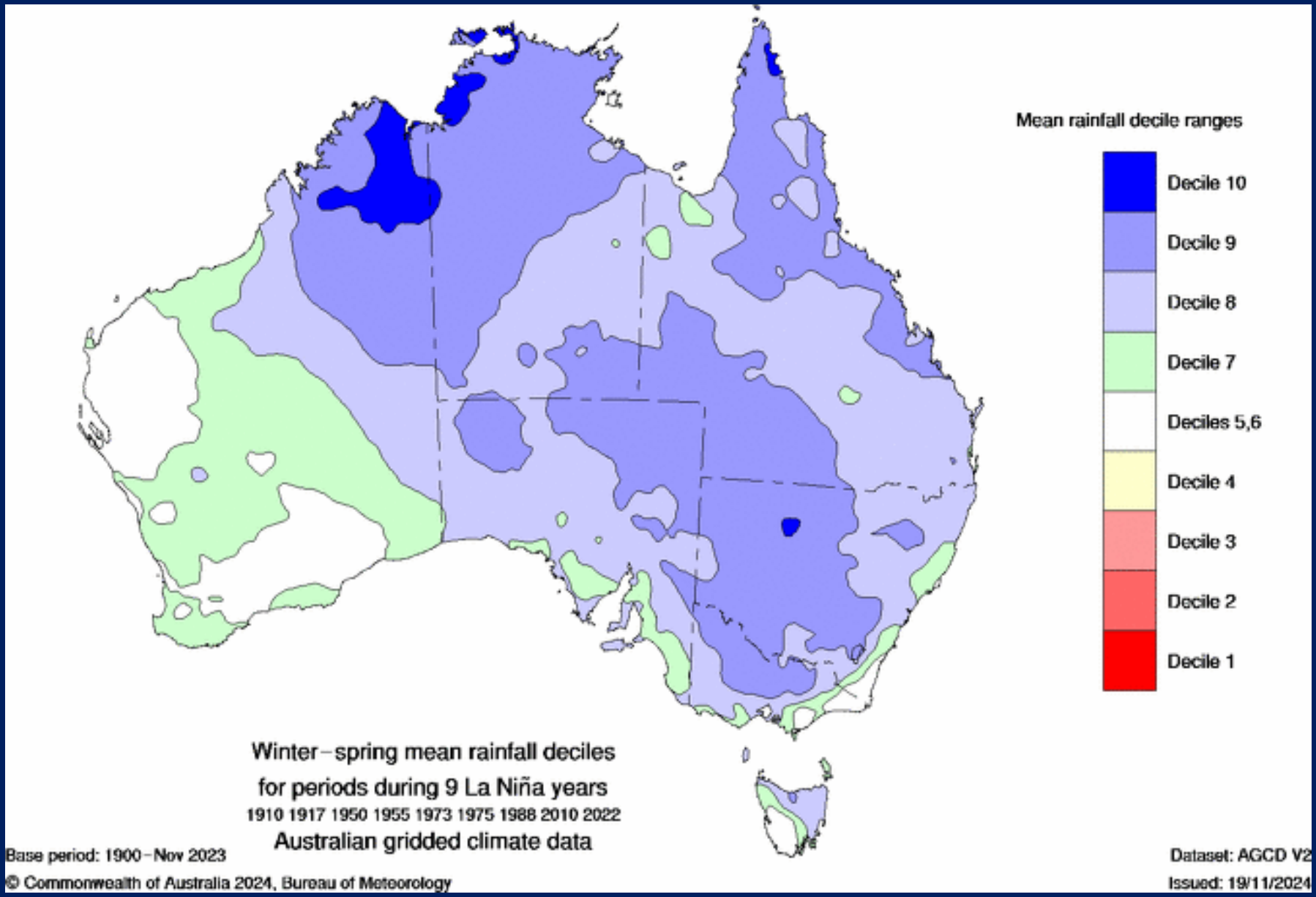
Summer Maximum Temperature



Summer Minimum Temperature

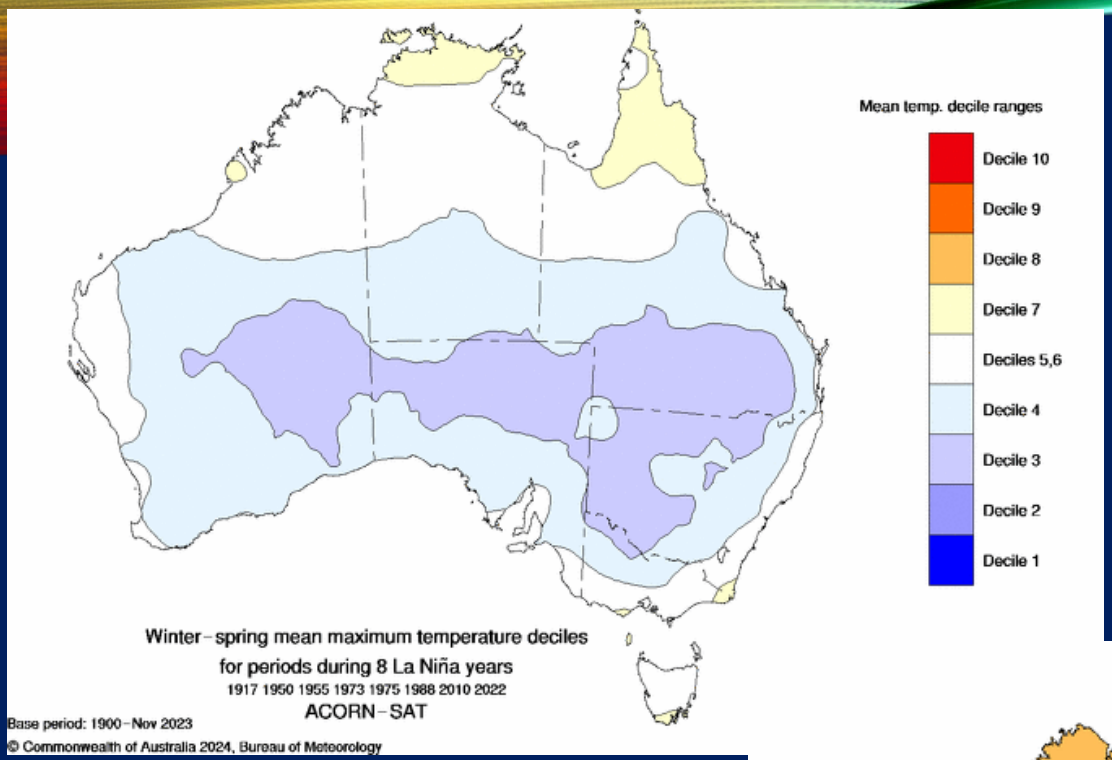


La Niña - typical rainfall patterns for Winter-Spring

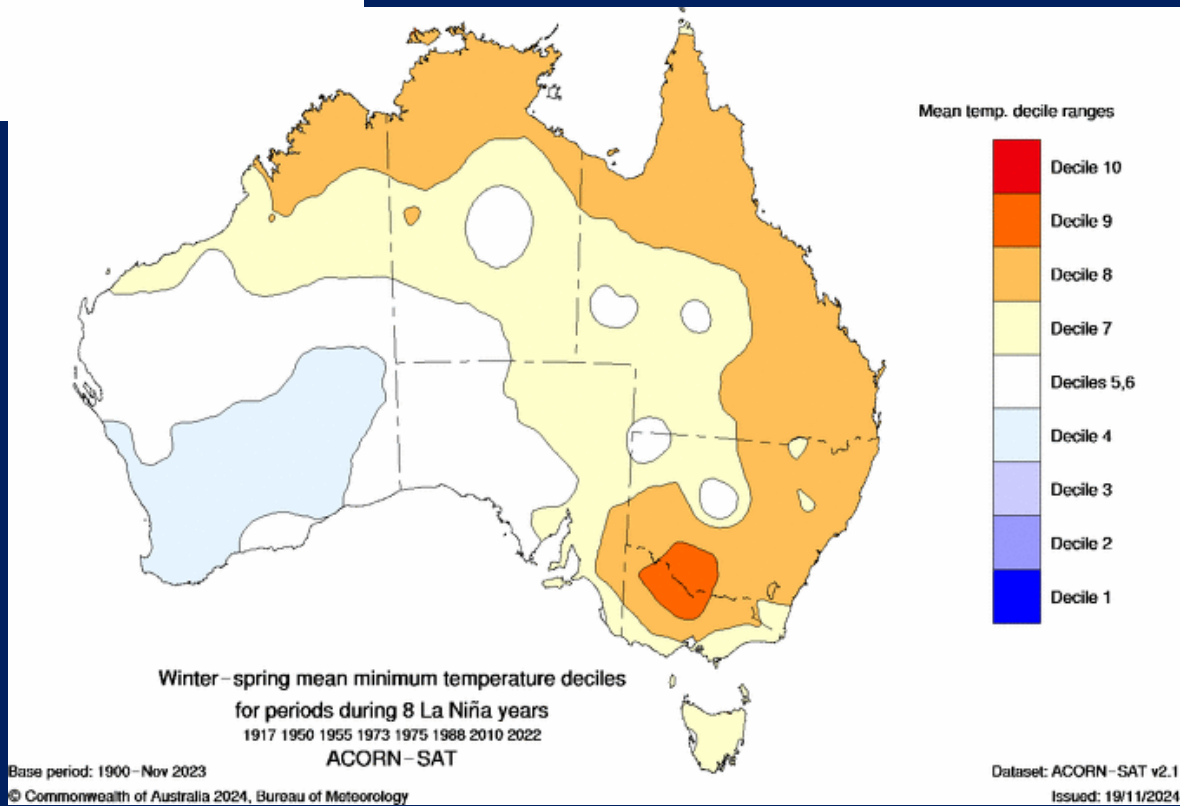


La Niña Years

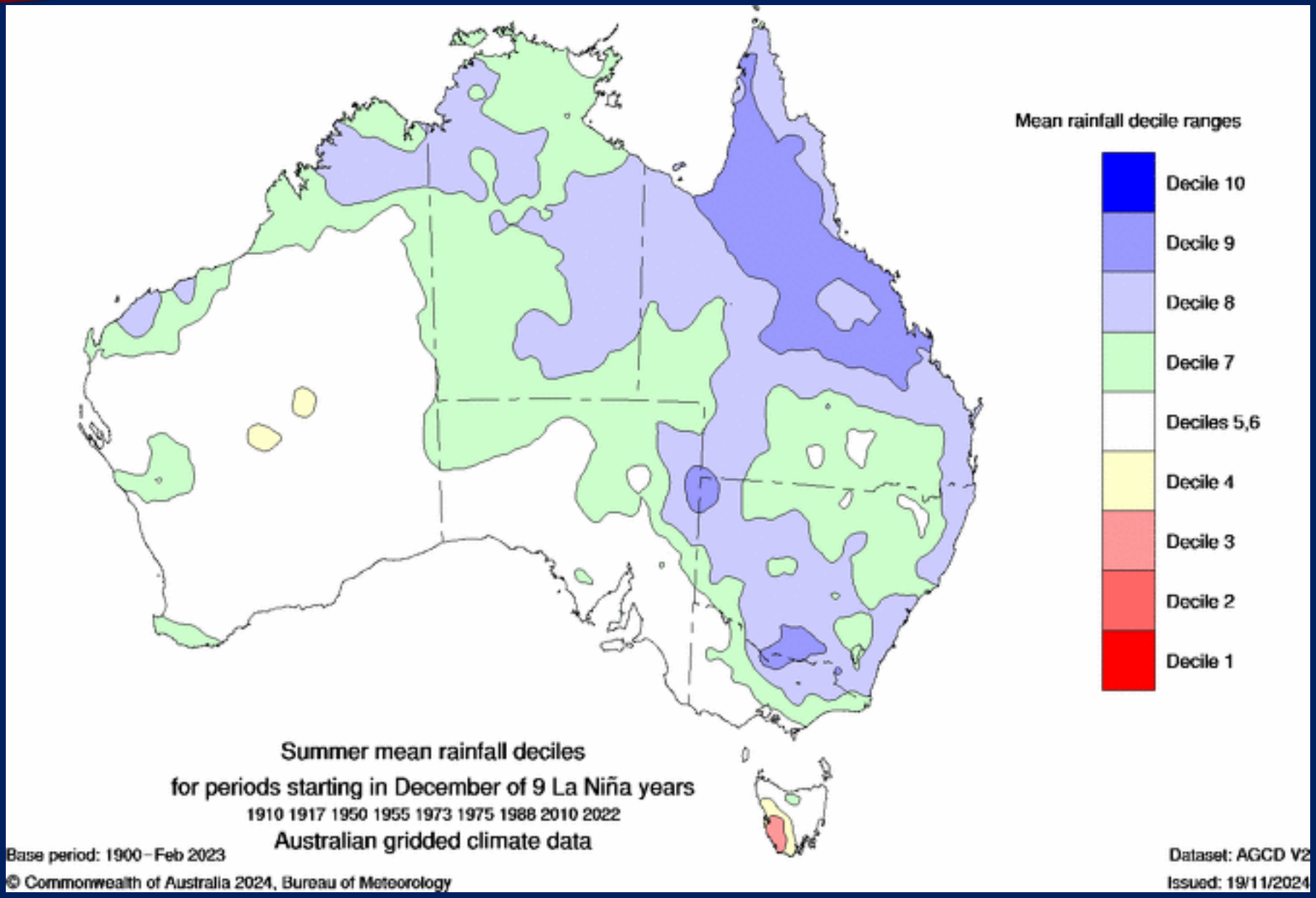
Winter-spring Maximum Temperature



Winter-spring Minimum Temperature

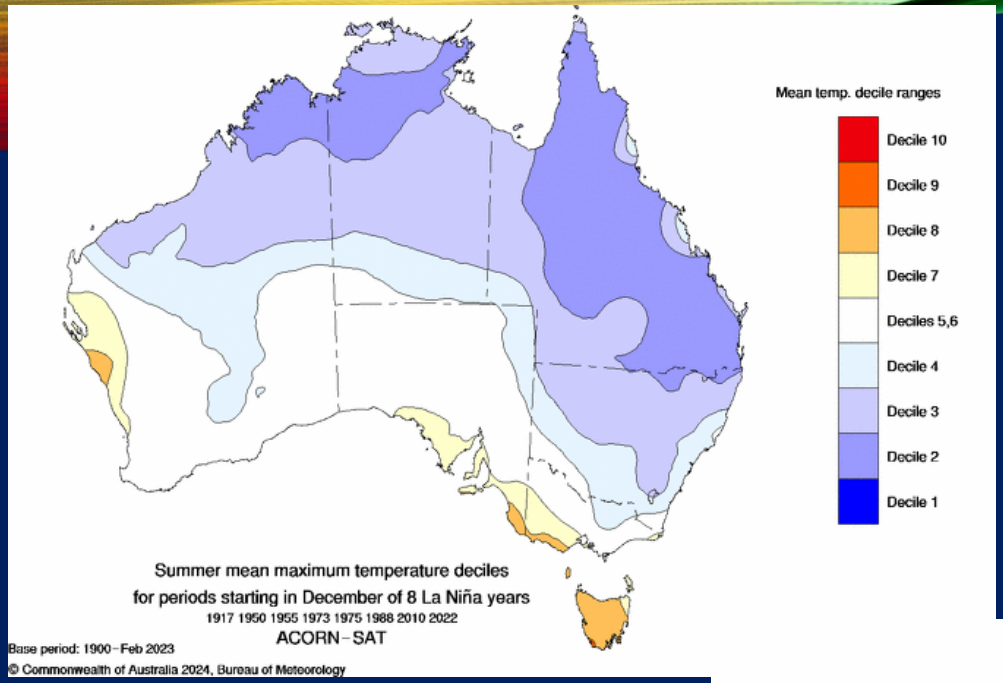


La Niña - typical rainfall patterns for Summer

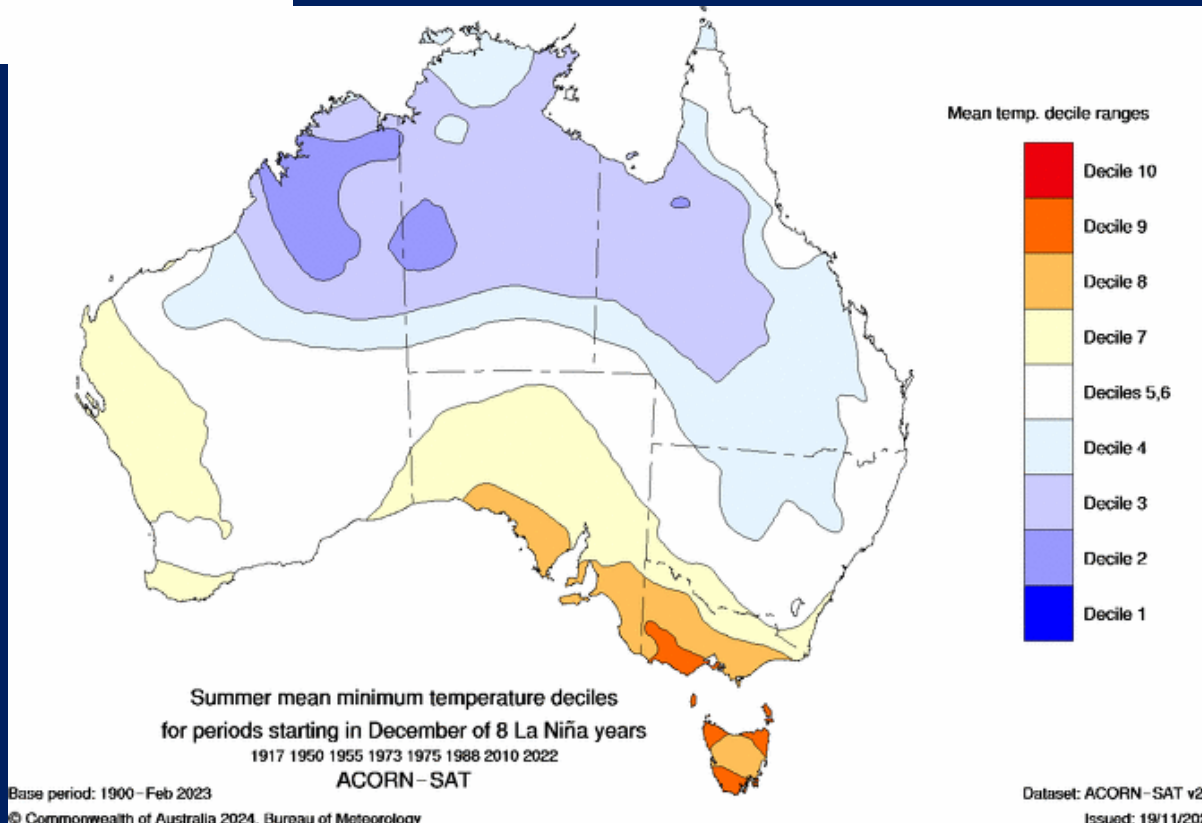


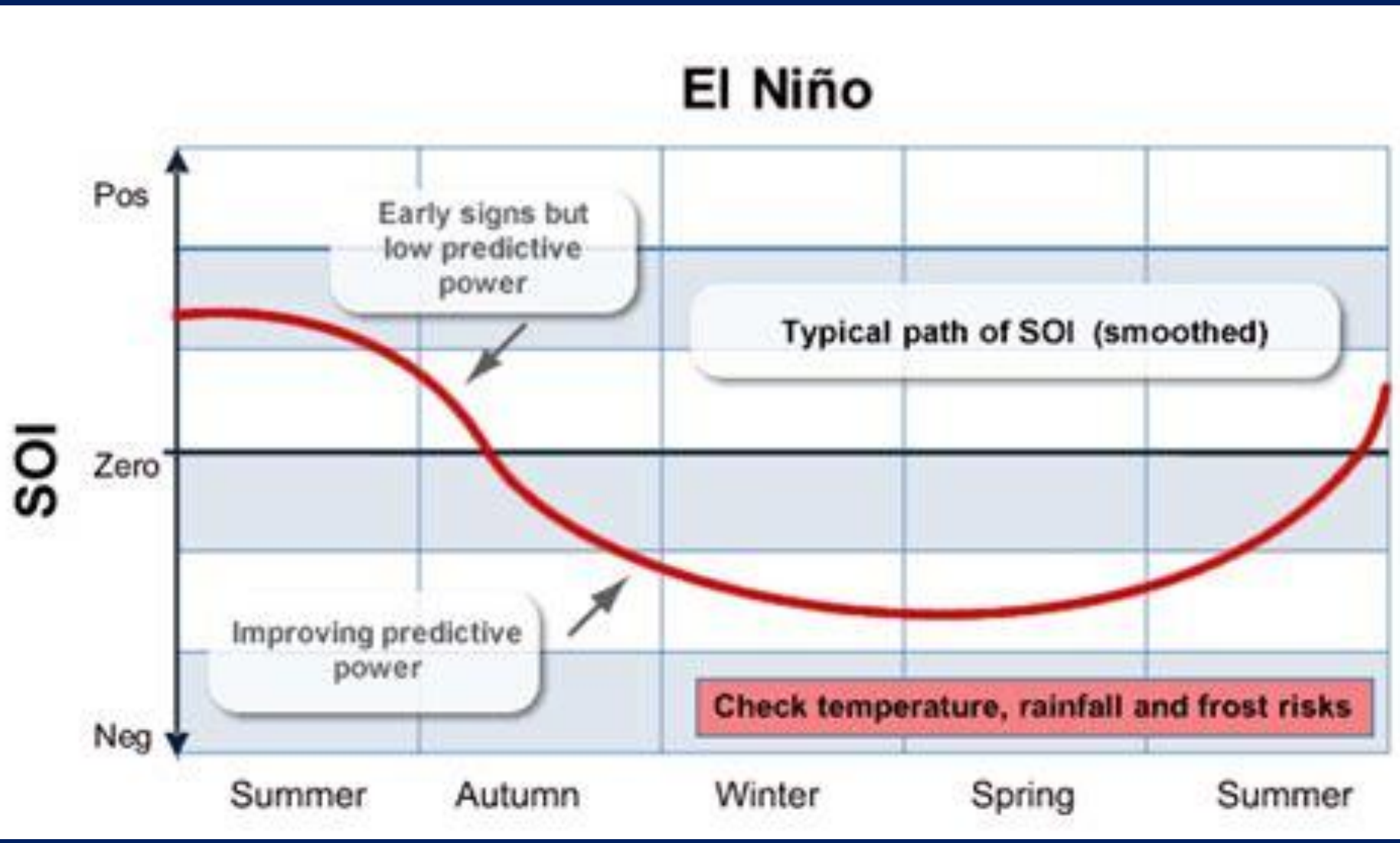
La Niña Years

Summer Maximum Temperature



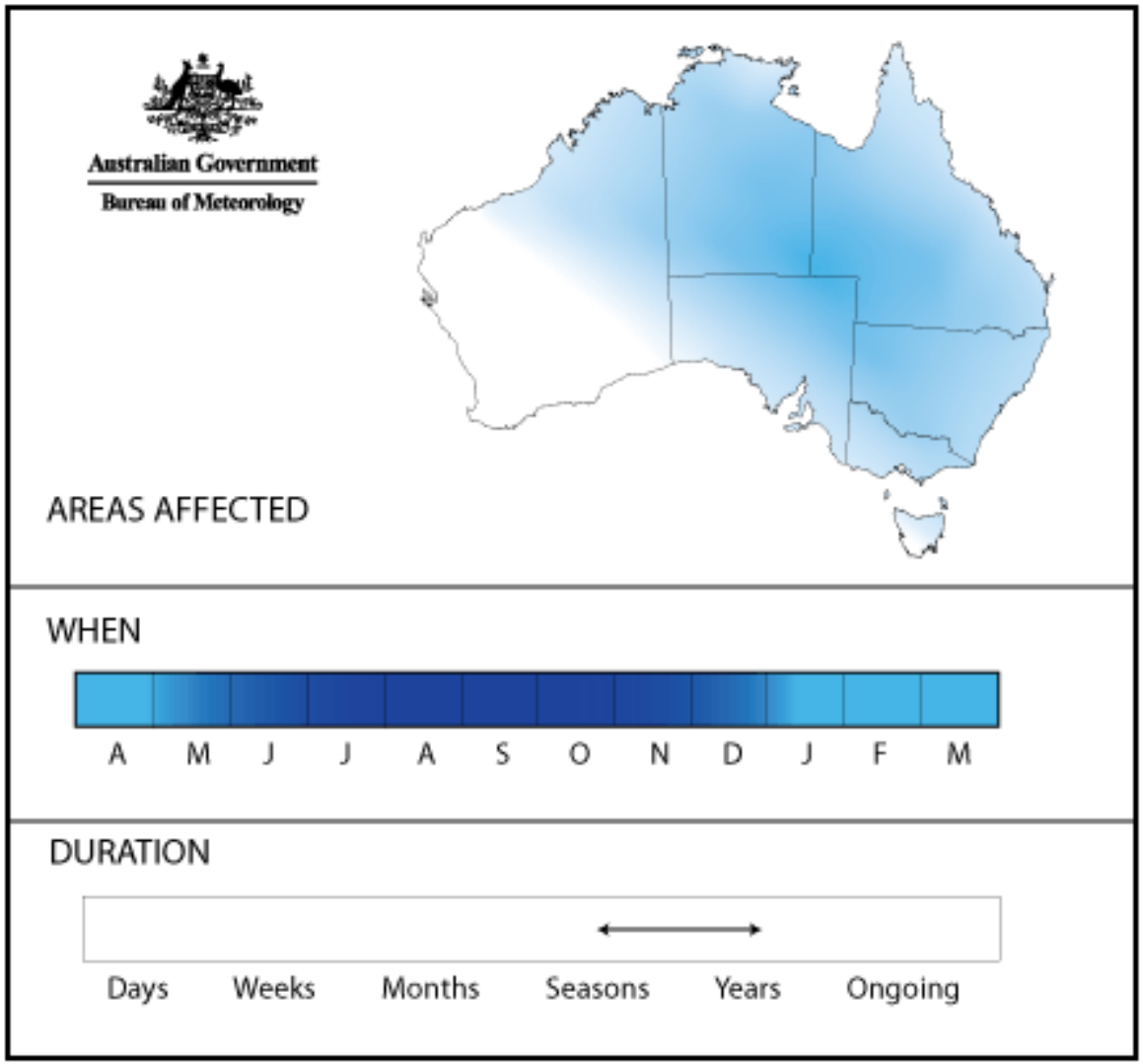
Summer Minimum Temperature



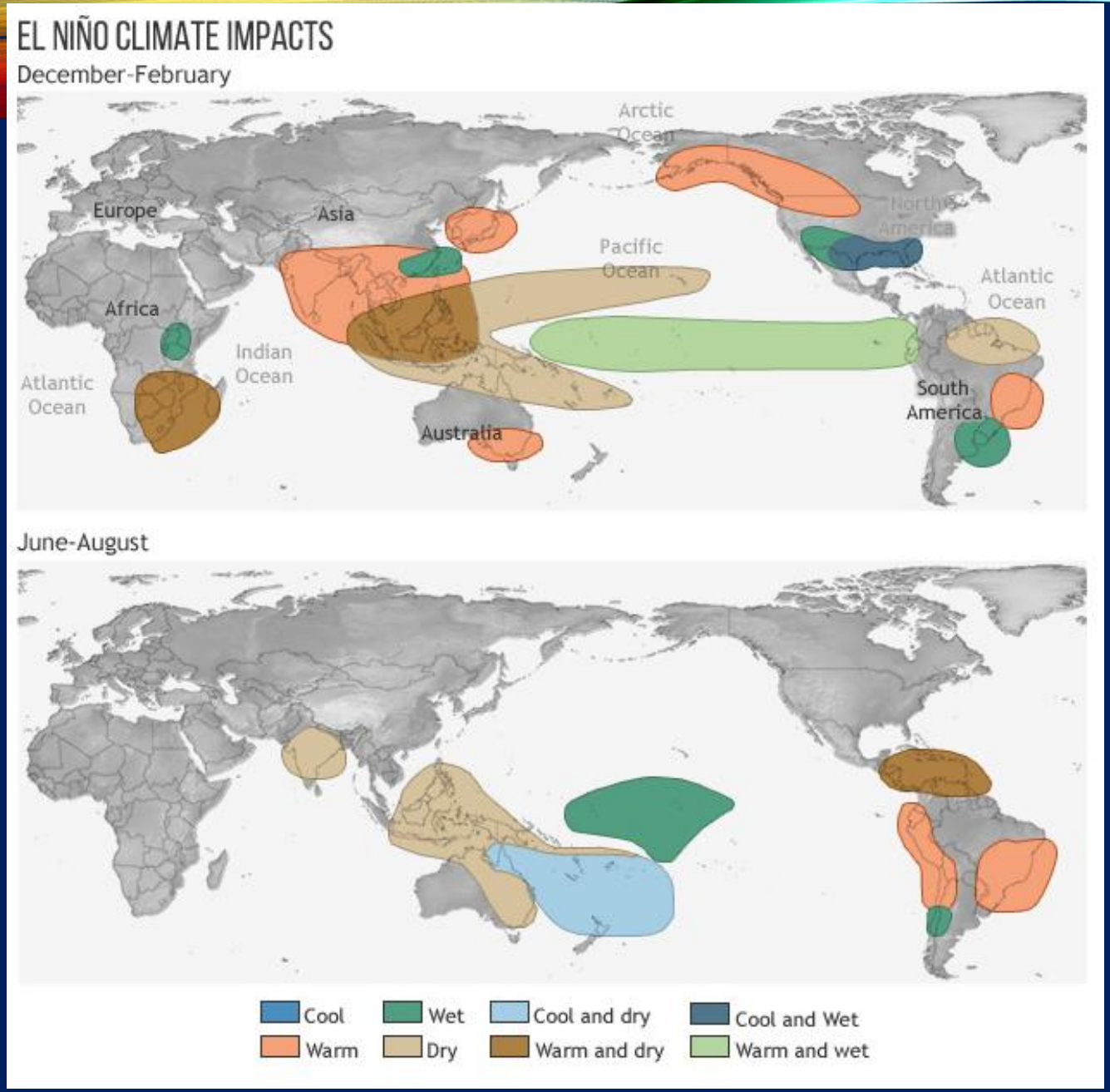

El Niño
SOI
Pos
Zero
Neg
Early signs but low predictive power
Typical path of SOI (smoothed)
Improving predictive power
Check temperature, rainfall and frost risks
Summer
Autumn
Winter
Spring
Summer

La Niña

Where, when and for how long does it occur?

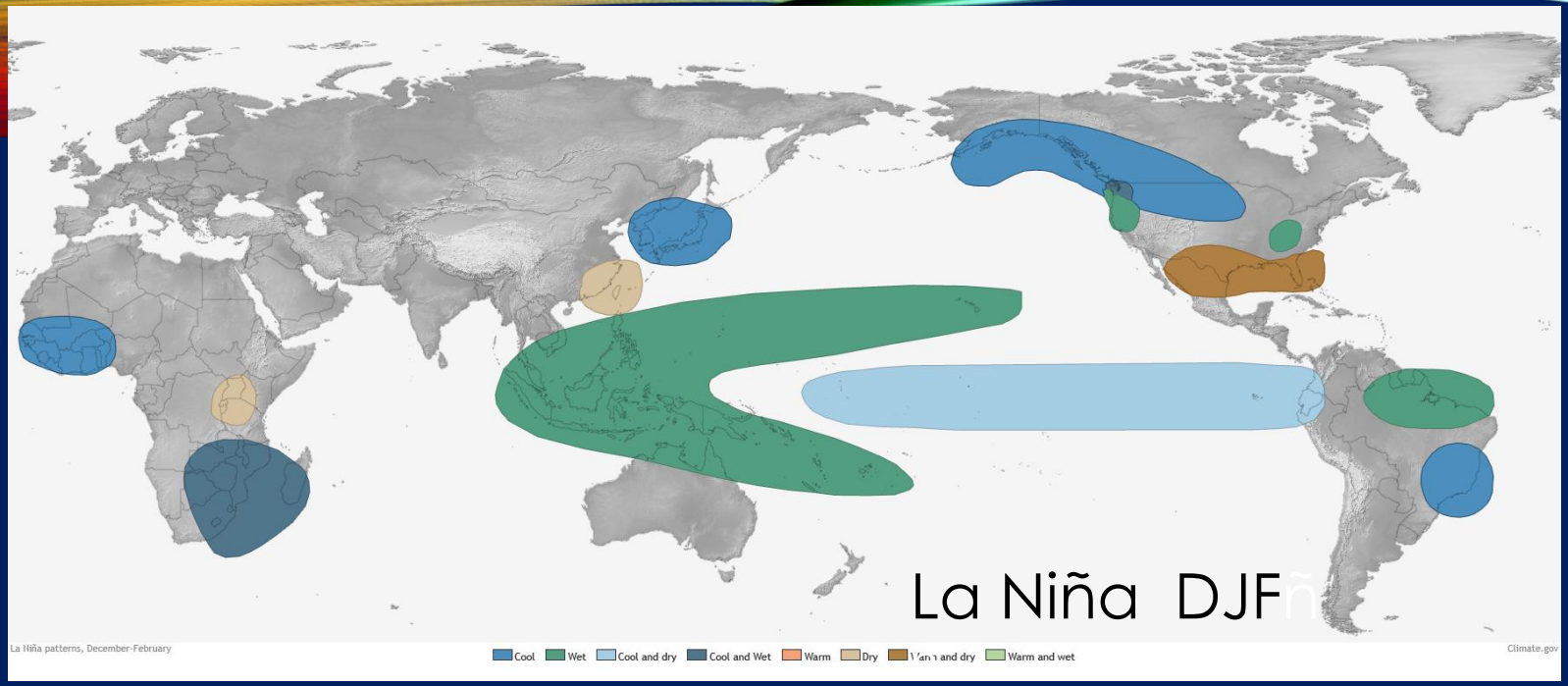


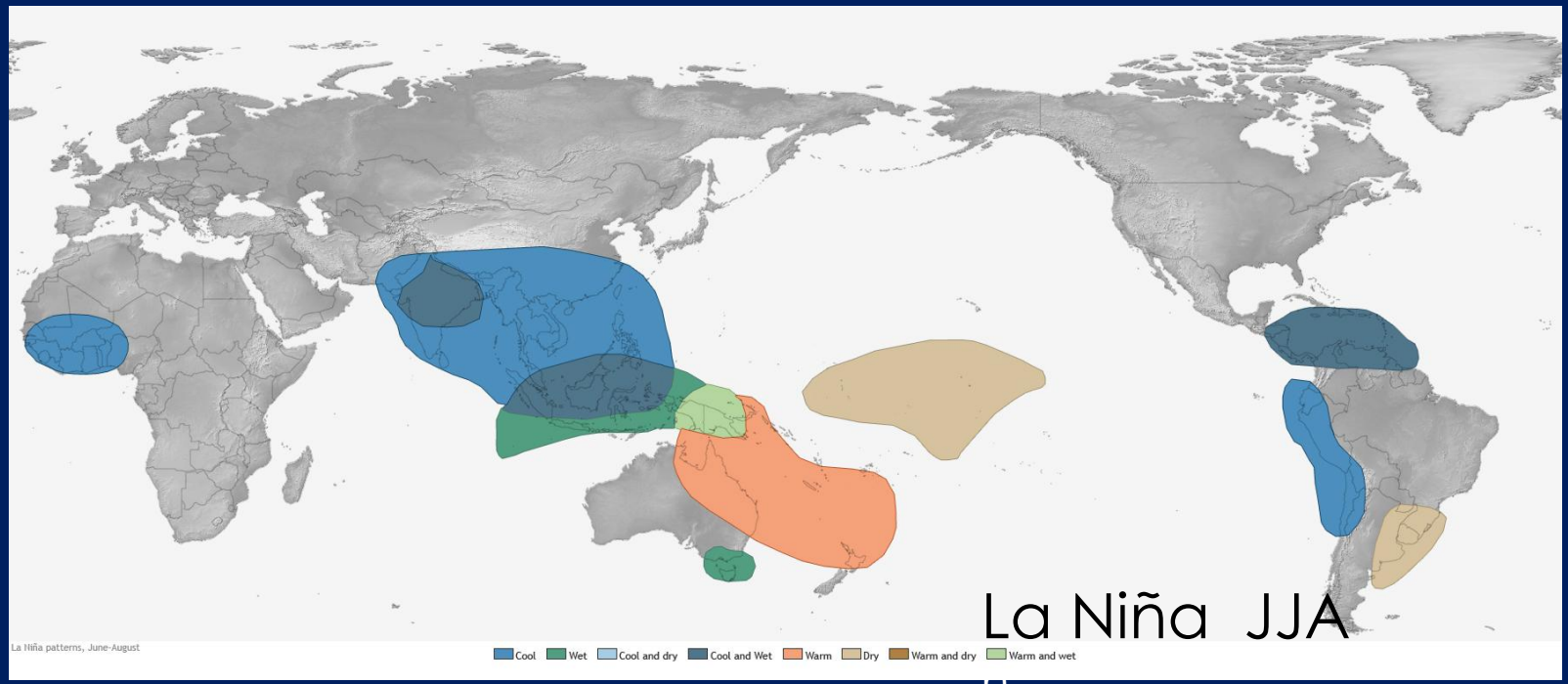
The diagram above shows the area affected by La Niña, when it occurs and how long it may last.

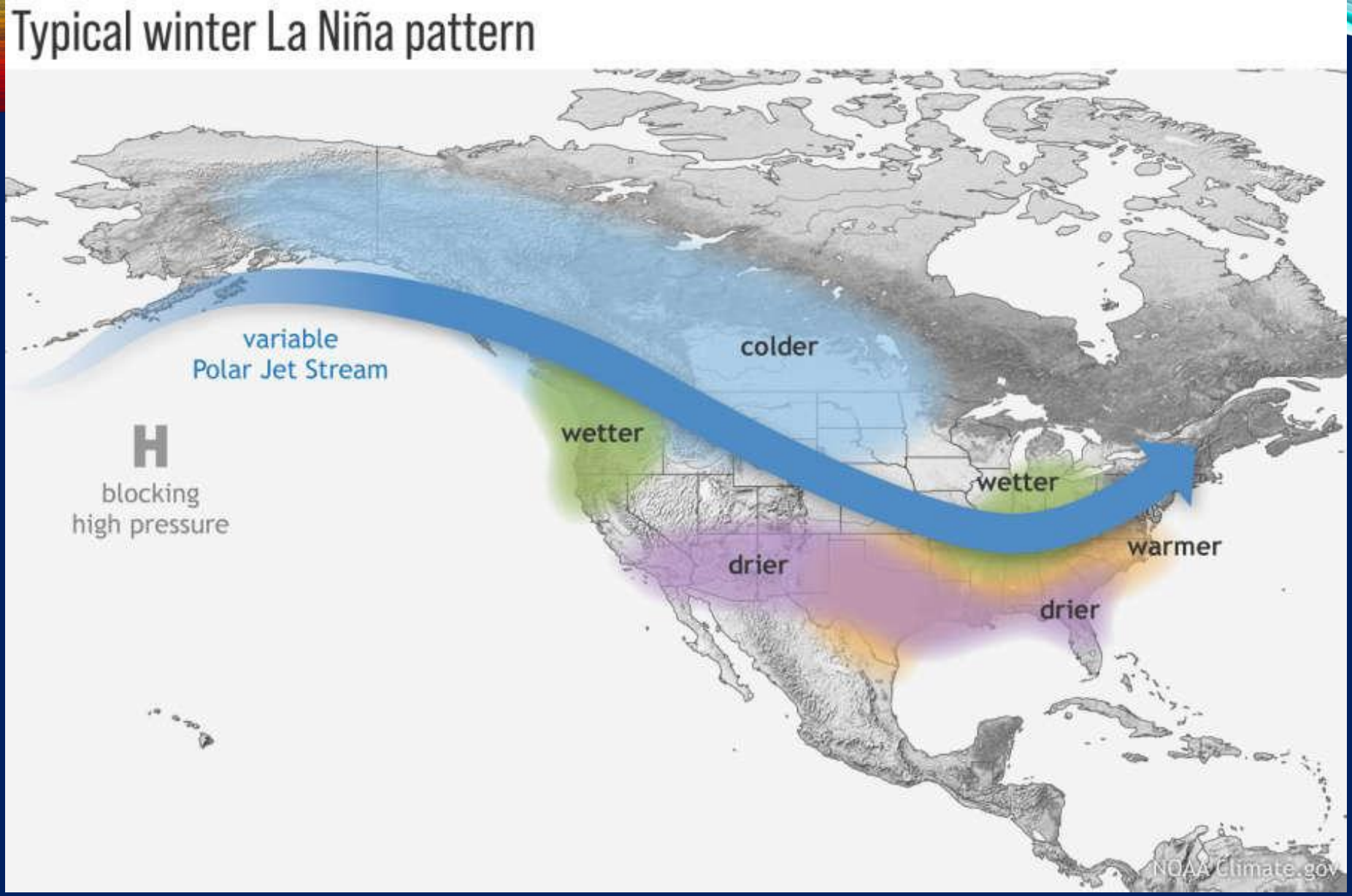


Note: India and eastern Australia – and Indonesia.

https://www.climate.gov/news-features/featured-images/global-impacts-el-niño-and-la-niña


La Niña DJFñ
La Niña patterns, December-February
Cool
Wet
Cool and dry
Cool and Wet
Warm
Dry
Warm and dry
Warm and wet
Climate.gov


La Niña JJA
La Niña patterns, June-August
Cool
Wet
Cool and dry
Cool and Wet
Warm
Dry
Warm and dry
Warm and wet



NOAA Climate Prediction Centre

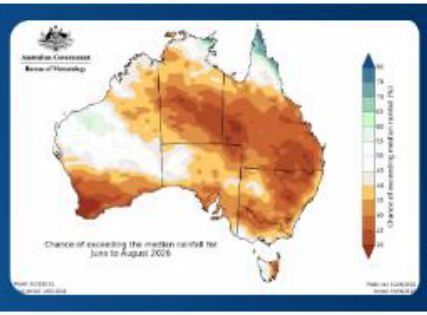
Claire's question

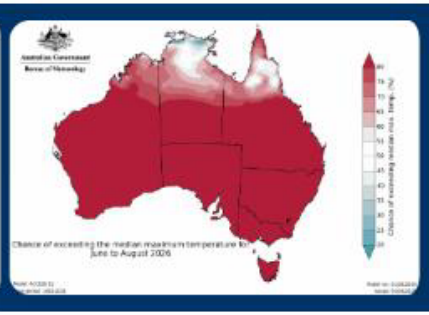
Most of our weather comes from the west. How does El Niño/ La Niña affect that?

It is like a background effect superimposed on how the weather systems passing through our area.
e.g. In an El Niño high pressure systems are "encouraged" over eastern Australia while fronts tend to be weaker.

It doesn't mean we can't have floods even in an El Niño (e.g. 1987).

For long-range forecasts of rainfall and temperature for Australia, please see our long-range forecast page. It provides the best guidance on likely conditions in the coming months, using the Bureau's climate model to take into account all influences from the oceans and atmosphere.





The Southern Hemisphere Monitoring page contains information on the broader hemispheric climate state, including the current status of the El Niño–Southern Oscillation and the Indian Ocean Dipole. This information is useful because:

- it can be a source of longer-term predictability, which can provide intelligence that extends beyond the long-range forecast period.
- understanding the long-range forecast is improved through the assessment of its consistency within the broader climate system.

Related: Southern Hemisphere Outlooks

Southern hemisphere monitoring

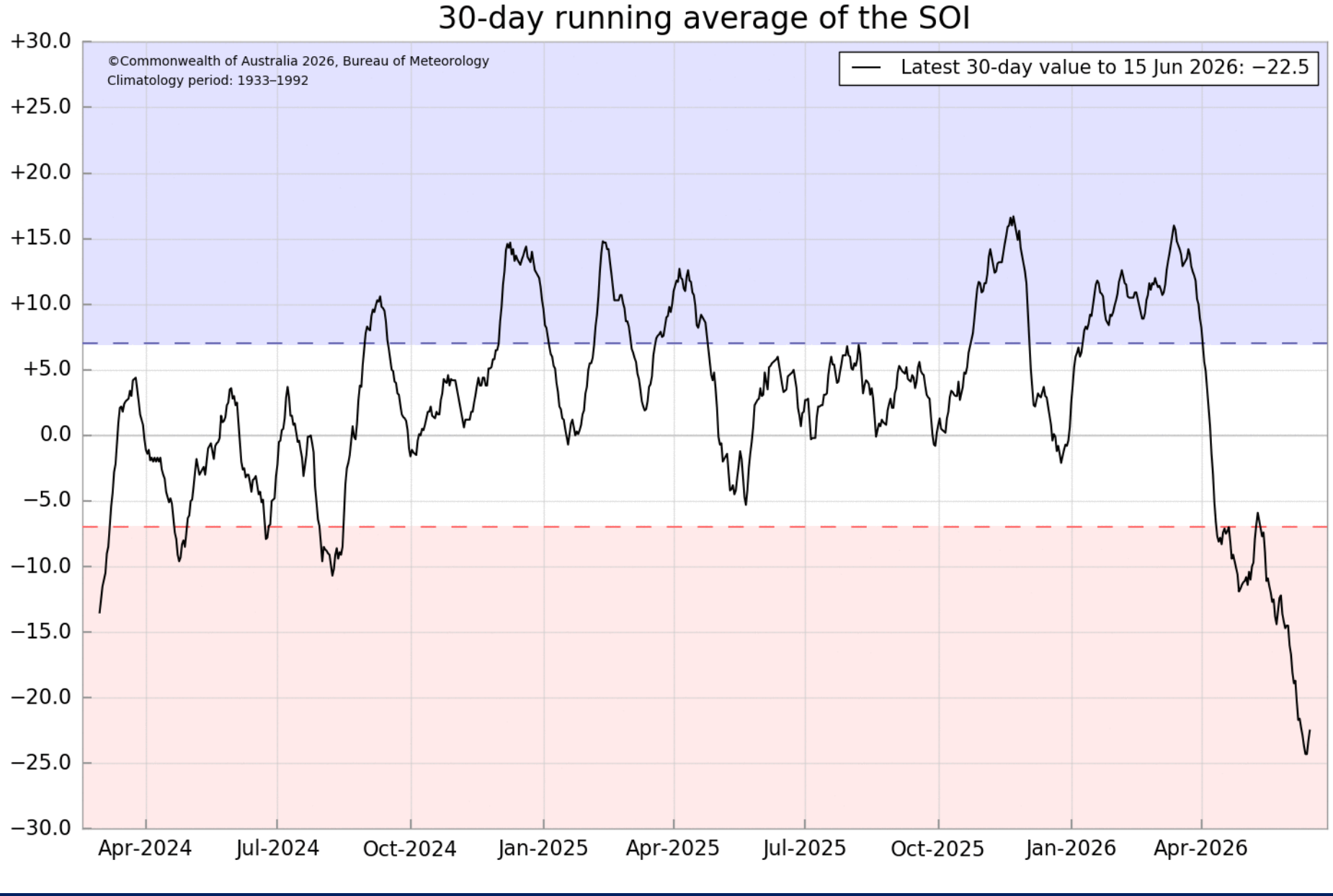
Pacific, Indian and Southern ocean regions

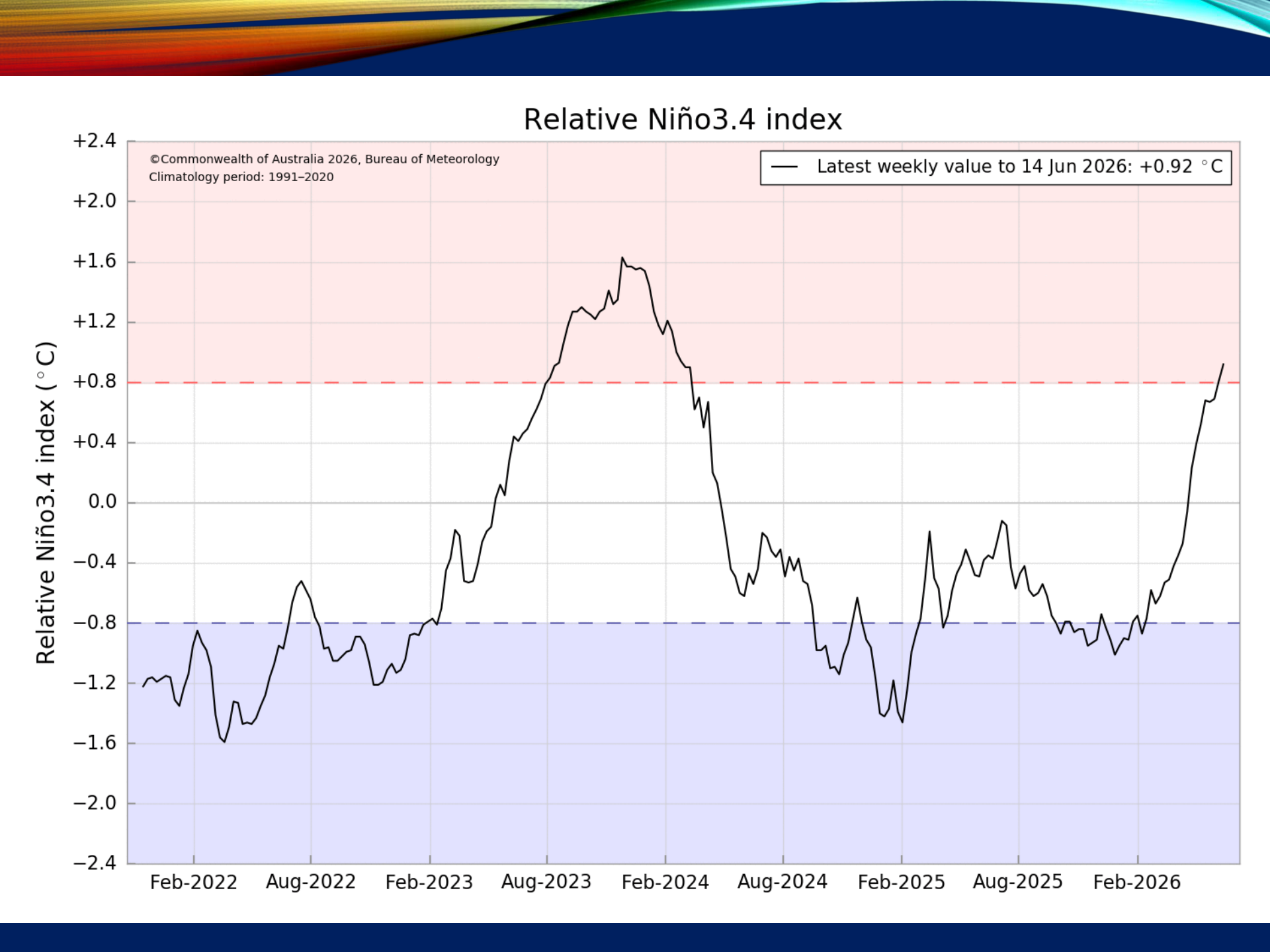
Issued **9 June 2026**

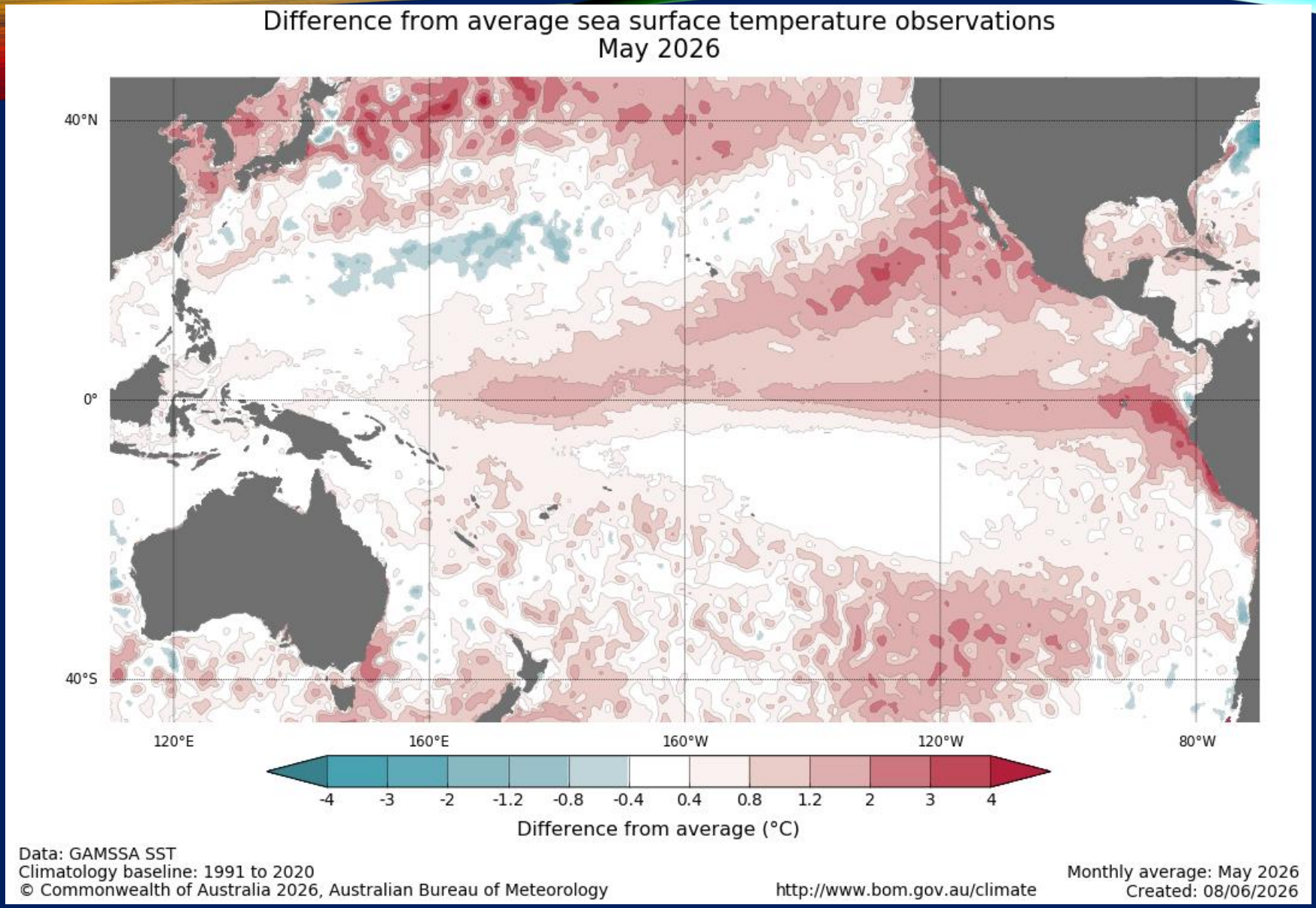
Overview | Pacific Ocean | Indian Ocean | Southern Ocean | About

Summary | Sea surface temperature maps | Monitoring graphs

http://www.bom.gov.au/climate/enso/

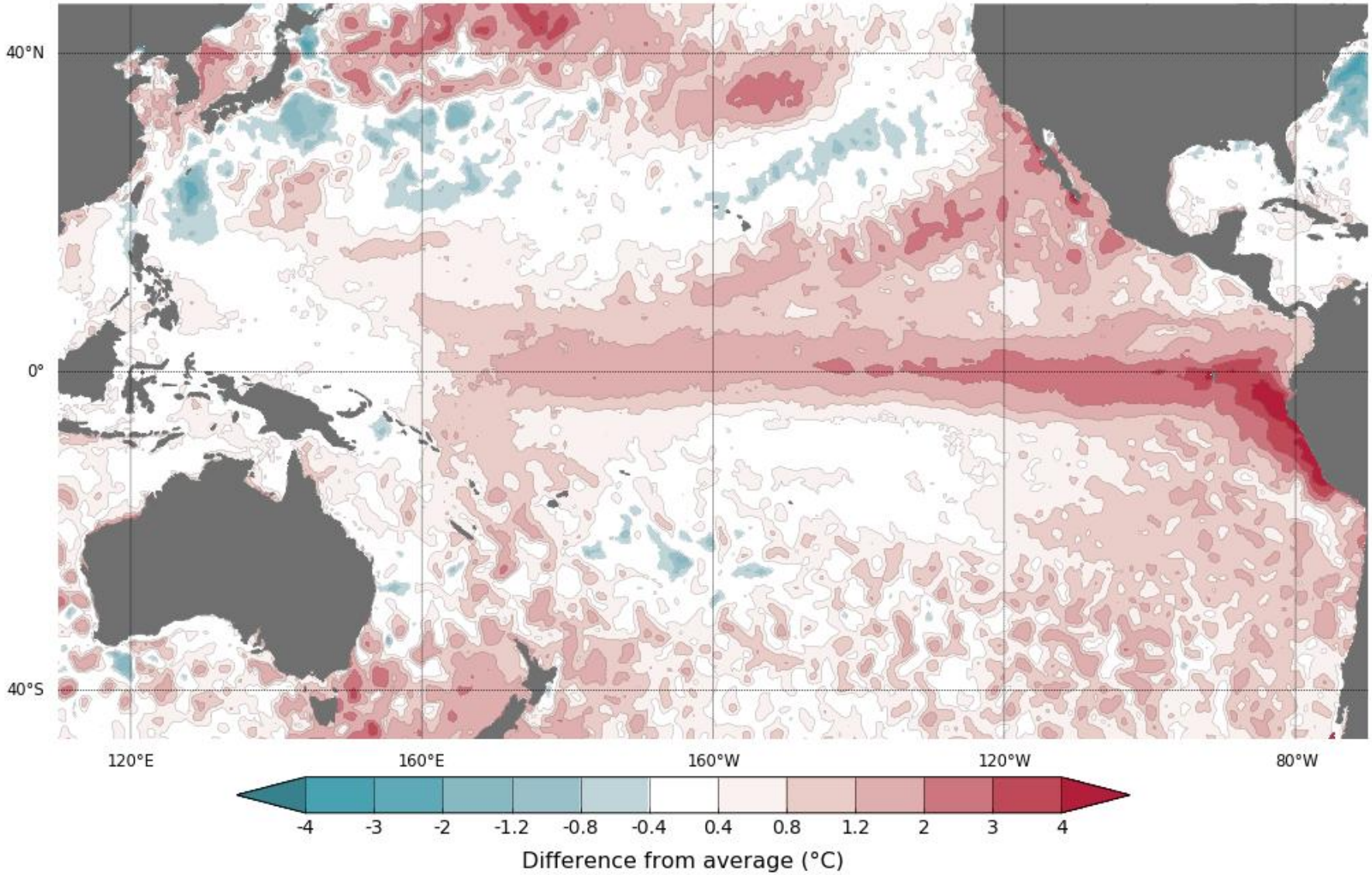

30-day running average of the SOI
©Commonwealth of Australia 2026, Bureau of Meteorology
Climatology period: 1933–1992
Latest 30-day value to 15 Jun 2026: −22.5
+30.0
+25.0
+20.0
+15.0
+10.0
+5.0
0.0
−5.0
−10.0
−15.0
−20.0
−25.0
−30.0
Apr-2024
Jul-2024
Oct-2024
Jan-2025
Apr-2025
Jul-2025
Oct-2025
Jan-2026
Apr-2026


Relative Niño3.4 index
©Commonwealth of Australia 2026, Bureau of Meteorology
Climatology period: 1991–2020
Latest weekly value to 14 Jun 2026: +0.92 °C
Relative Niño3.4 index (°C)
+2.4
+2.0
+1.6
+1.2
+0.8
+0.4
0.0
−0.4
−0.8
−1.2
−1.6
−2.0
−2.4
Feb-2022
Aug-2022
Feb-2023
Aug-2023
Feb-2024
Aug-2024
Feb-2025
Aug-2025
Feb-2026



Animation of last 3 months: https://www.bom.gov.au/climate/enso/wrap-up/archive/20260609.ssta_pacific_weekly_anim.gif?popup

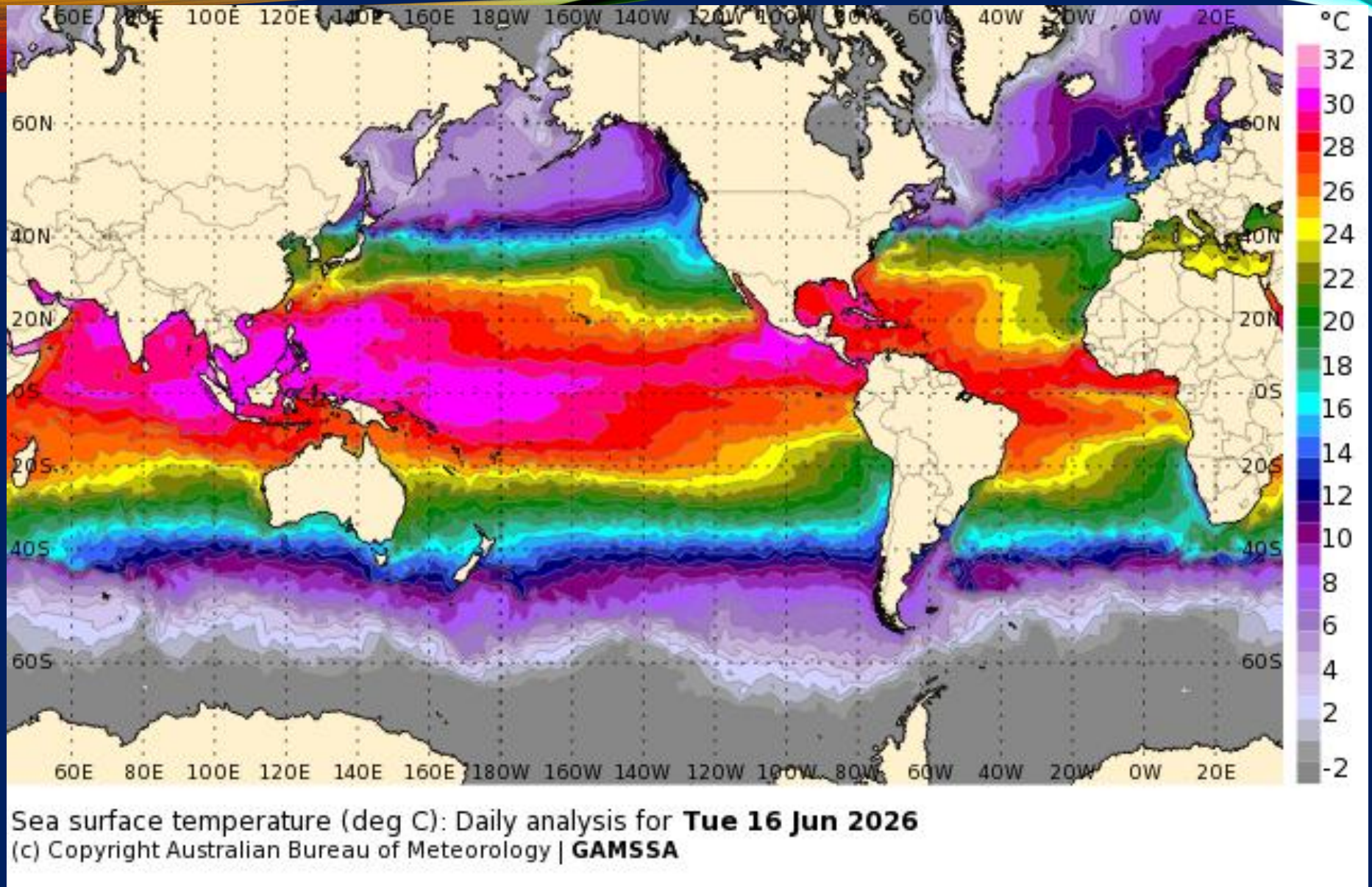
Difference from average sea surface temperature observations
8 June to 14 June 2026



Data: GAMSSA SST
Climatology baseline: 1991 to 2020

http://www.bom.gov.au/climate

Weekly average: 14 June 2026
Created: 15/06/2026



Sea surface temperature (deg C): Daily analysis for **Tue 16 Jun 2026**

http://www.bom.gov.au/products/IDYOC053.Global.SSTAnalysis.shtml

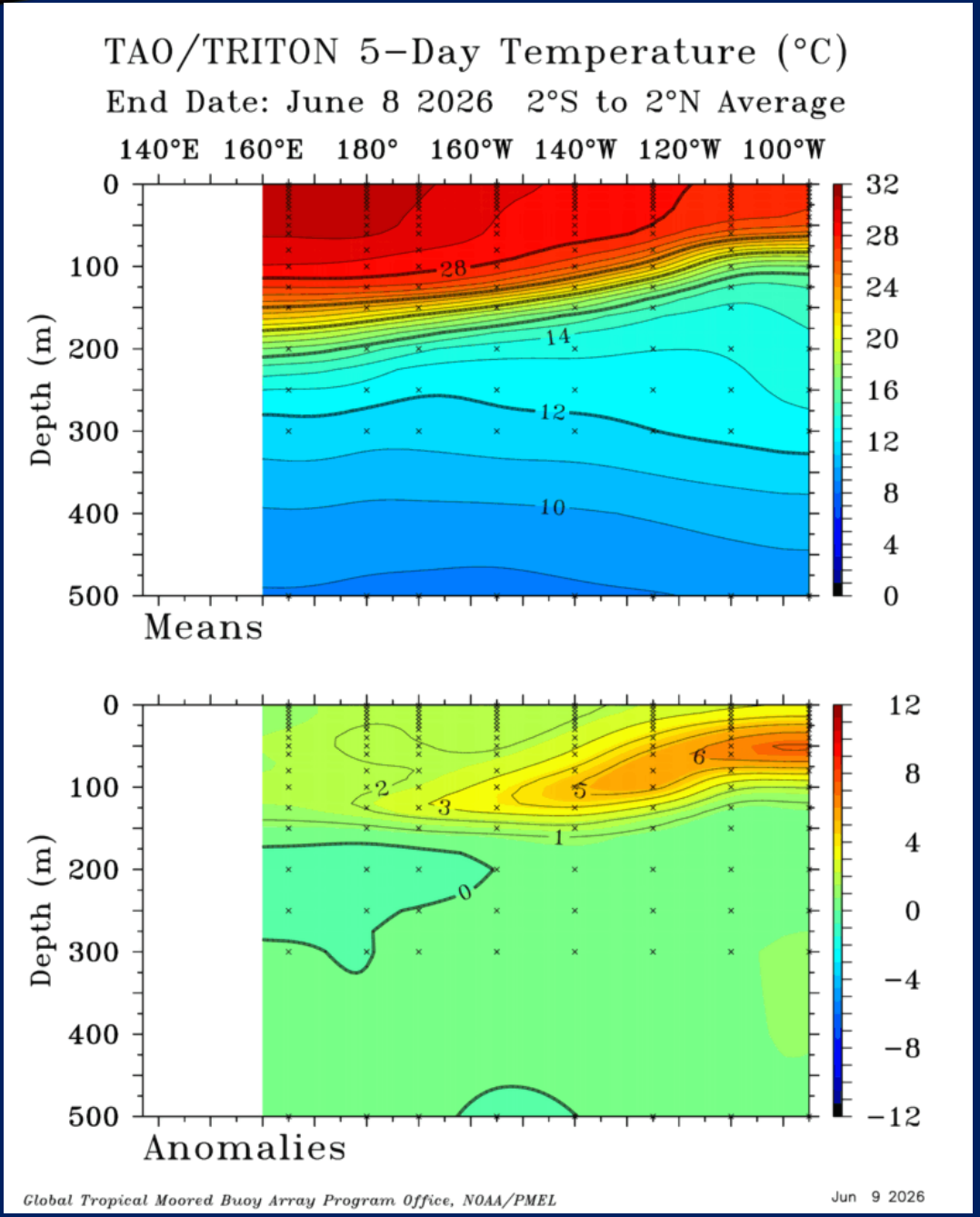
Sub-surface:

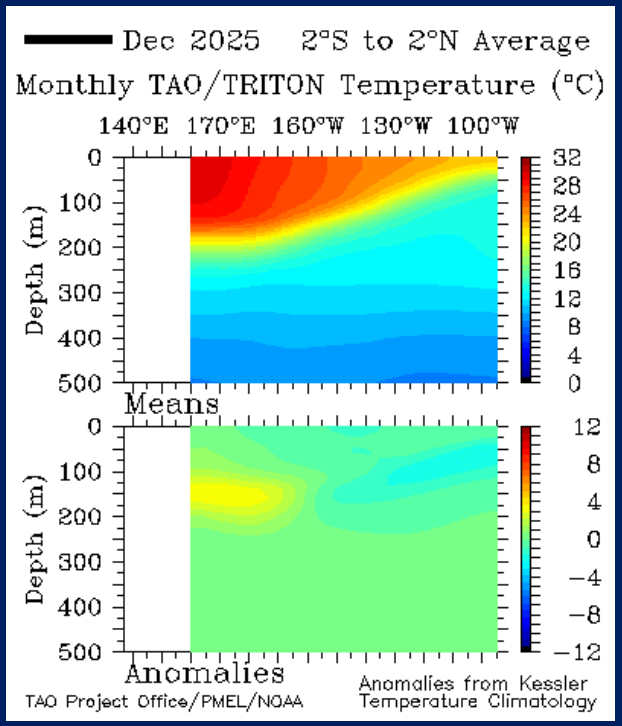
What happens below the surface is important.

https://www.pmel.noaa.gov/tao/drupal/assorted_plots/images/TAO_5Day_EQ_xz.gif

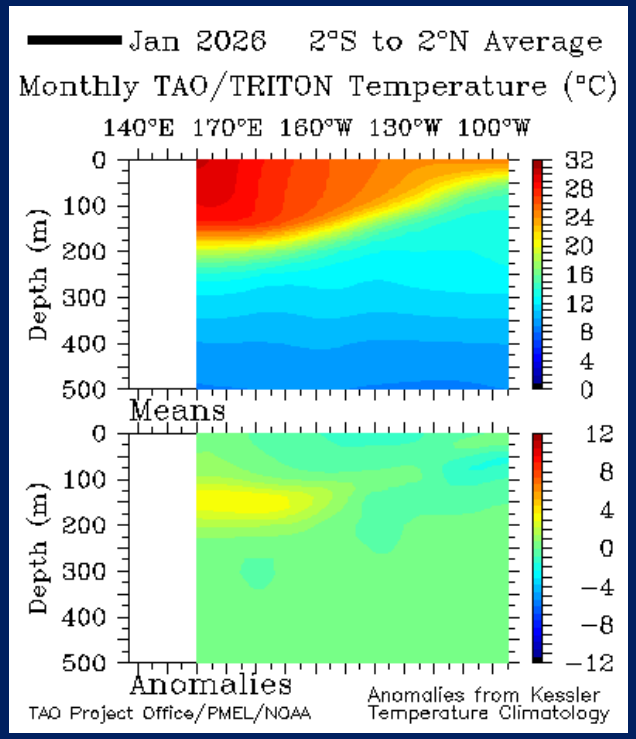
Animation:

https://www.pmel.noaa.gov/cgi-tao/cover.cgi?P1=TAO_EQ_DEP&P2=big&P3=5yr&script=disdel/ani-drupal.csh

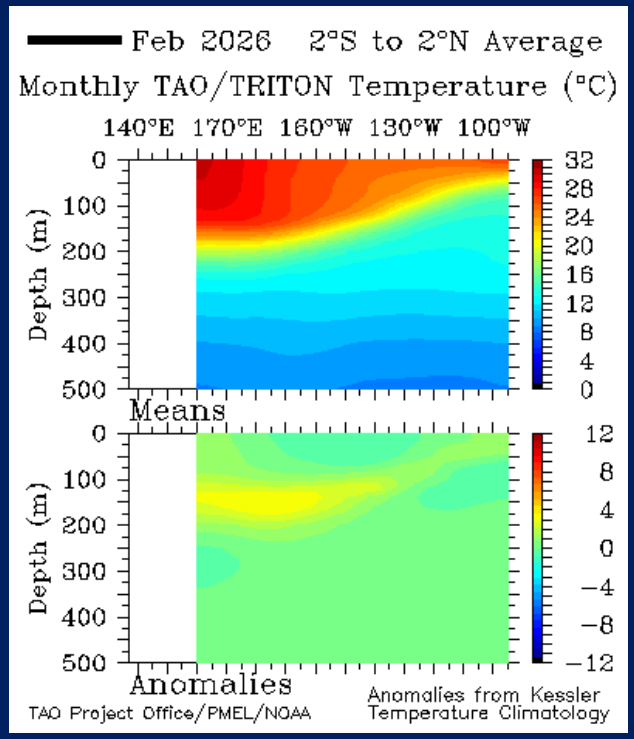




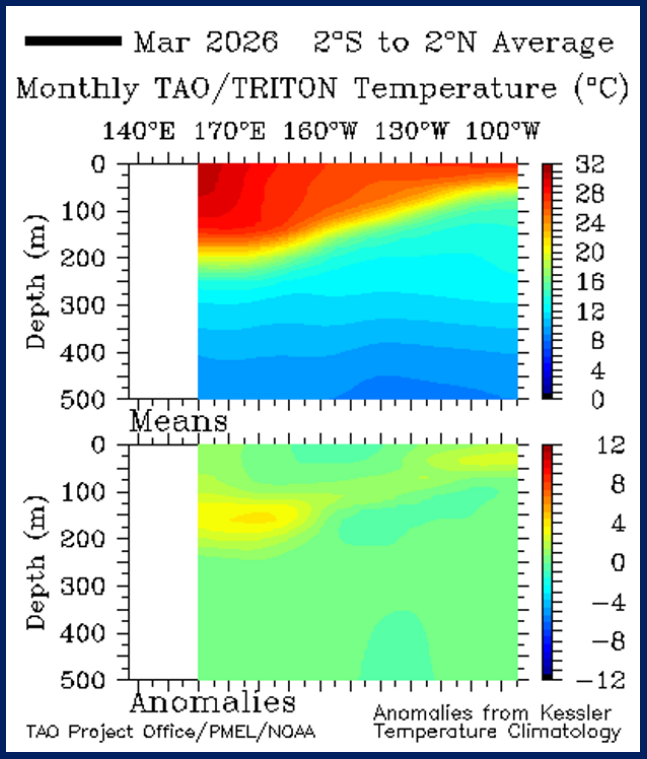
December 2025



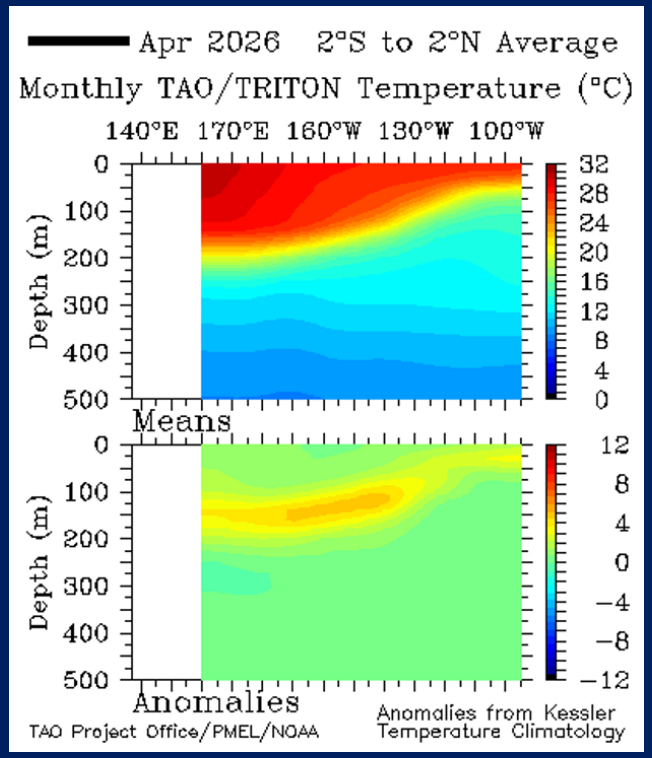
January 2026



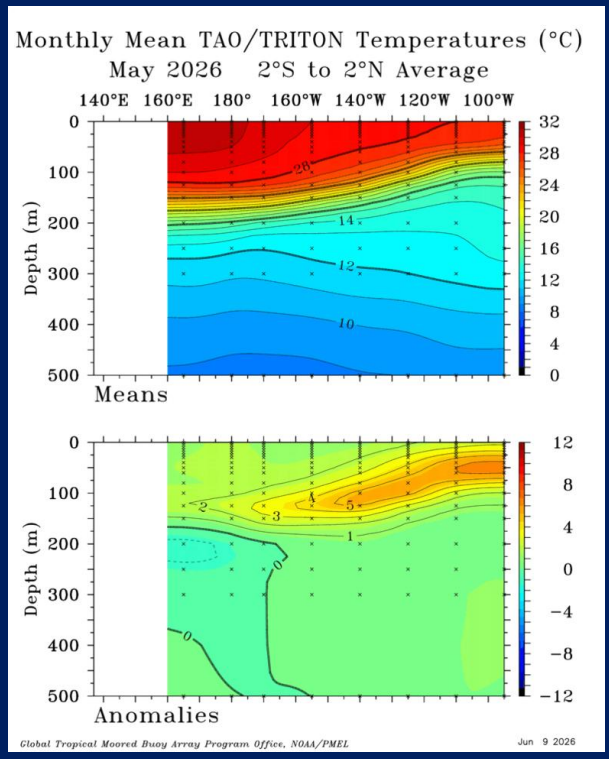
February 2026



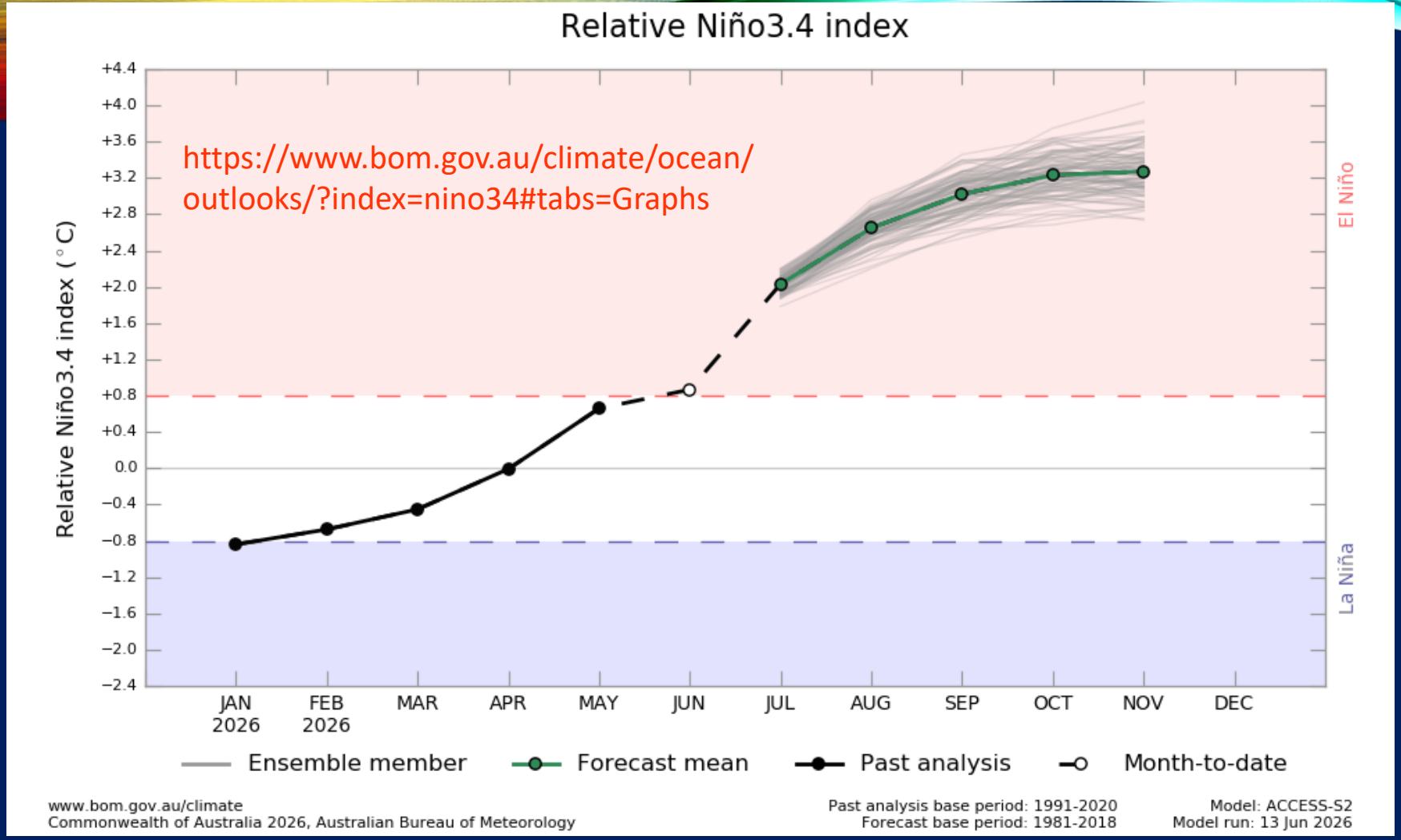
March 2026



April 2026



May 2026



Relative Niño3.4 probabilities

Month	Jul 2026	Aug 2026	Sep 2026	Oct 2026	Nov 2026
R-Niño3.4	**2.0 °C**	**2.6 °C**	**3.0 °C**	**3.2 °C**	**3.3 °C**
below −0.8 °C	0%	0%	0%	0%	0%
neutral	0%	0%	0%	0%	0%
above 0.8 °C	100%	100%	100%	100%	100%

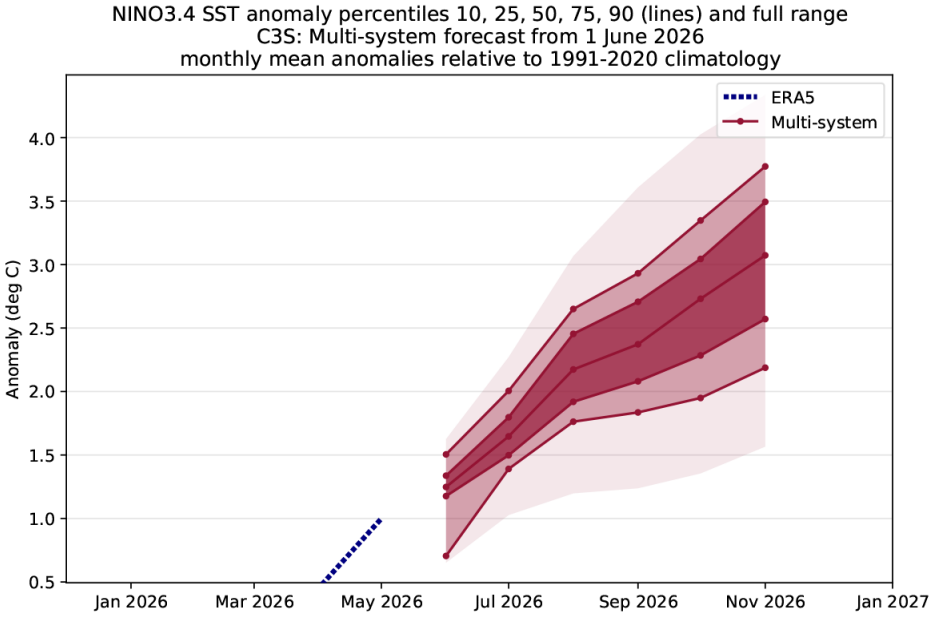
Highlights of the latest seasonal forecasts

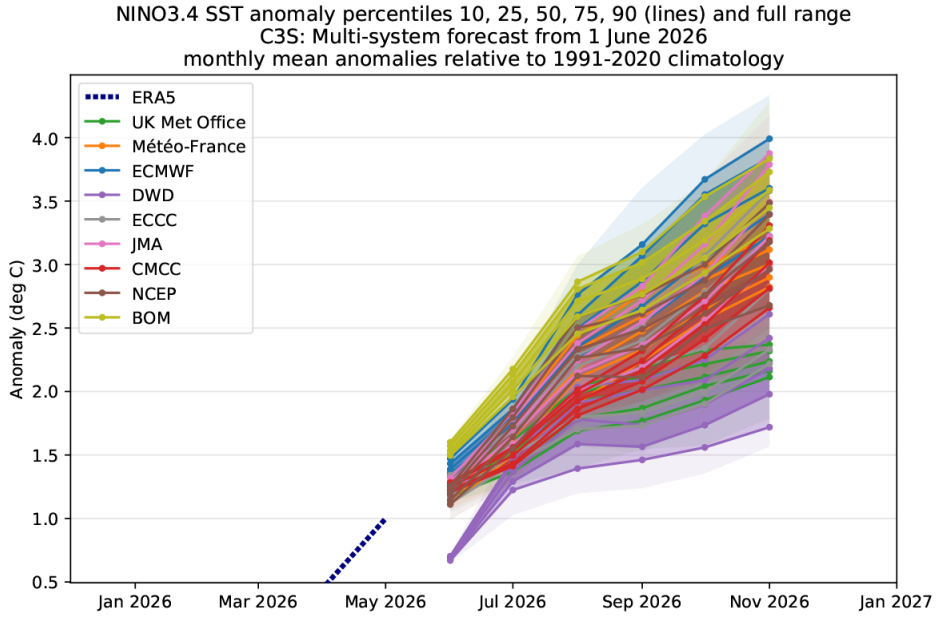
Copernicus Climate Change Service (C3S)

10 June 2026

The C3S June forecast further strengthens the likelihood of a large El Nino event developing through the latter part of the year. 75% of members of the grand ensemble exceed 2.5°C amplitude in the Nino3.4 index at the end of the forecast period (November).

The individual models are not unanimous in the support for a very strong event; however, statistics of past performance suggest that the models with lowest amplitude in this forecast are likely to underestimate the amplitude.





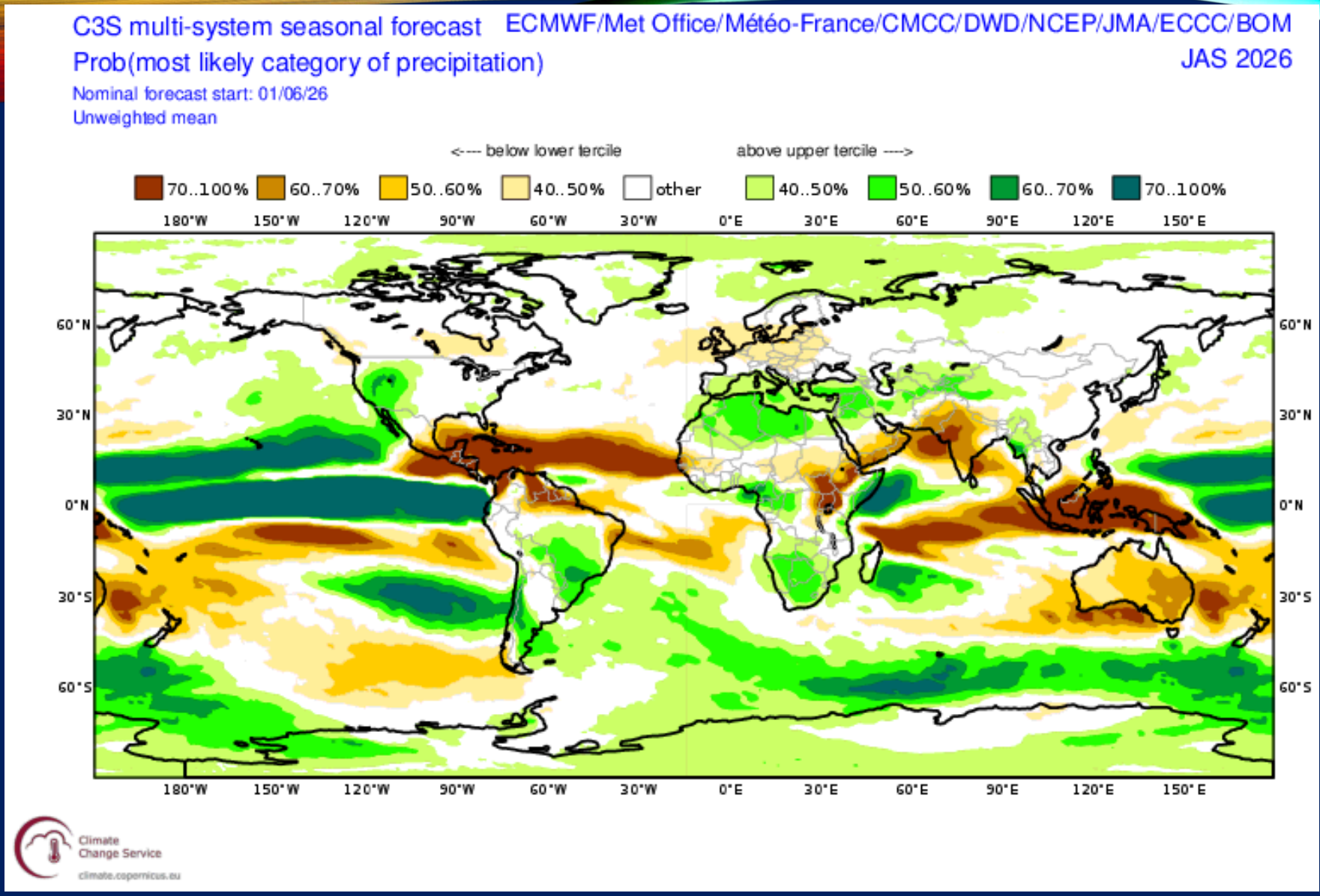
PROGRAMME OF THE EUROPEAN UNION

copernicus Europe's eyes on Earth

Climate Change Service climate.copernicus.eu

IMPLEMENTED BY ECMWF

https://climate.copernicus.eu/seasonal-forecasts



Forecast Rainfall for July-September 2026

Probability of being in the lowest third of rainfall amounts (brown) or highest third of rainfall amounts (green).

US forecasters say potentially record-breaking El Niño underway

Weather

8h ago

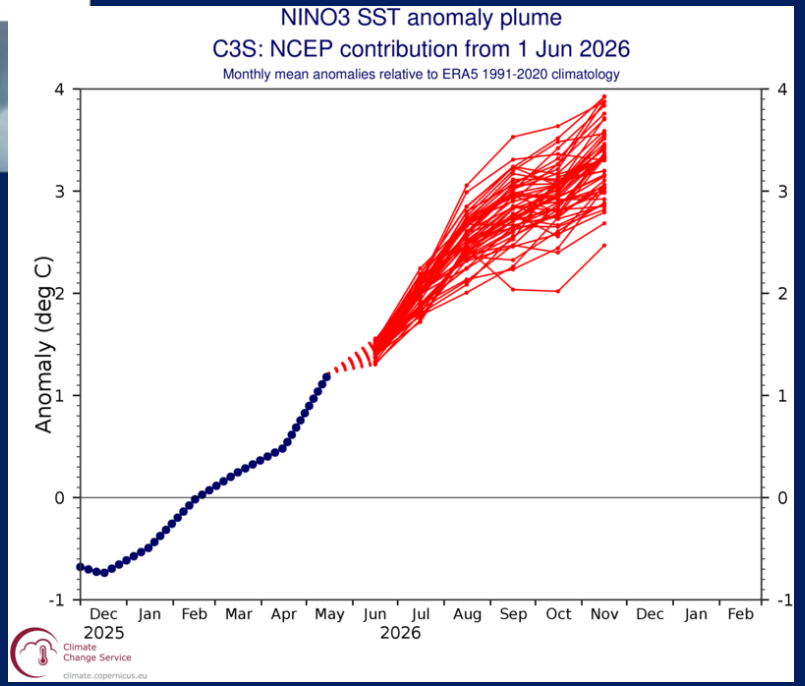
https://www.abc.net.au/news/2026-06-12/el-nino-underway-says-us-noaa/10678859**8**

What's next?

There is a 63 per cent chance this year's El Niño could be one of the largest events since records began in 1950.

The US meteorological agency says an El Niño has now formed in the Pacific Ocean that could reach record-breaking intensity in coming months.

The NOAA's announcement said there was a 63 per cent chance the El Niño would get so intense over the Southern Hemisphere's spring and early summer that it "would rank among the largest El Niño events in the historical record going back to 1950".



https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml

https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf

EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

issued by

CLIMATE PREDICTION CENTER/NCEP/NWS
11 June 2026

ENSO Alert System Status: El Niño Advisory

Synopsis: El Niño conditions are present and expected to strengthen into the Northern Hemisphere winter 2026-27.

"There is a 63% chance of a very strong El Niño during November-January that would rank among the largest El Niño events in the historical record going back to 1950.
Even very strong El Niño events do not lead to the expected impact everywhere, but stronger events can more significantly tilt the odds in favor of expected outcomes.
In summary, El Niño conditions are present and expected to strengthen into the Northern Hemisphere winter 2026-27."

https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.pdf

Monitoring ENSO

One of the measures we use to track ENSO is the difference between current and average sea surface temperatures.

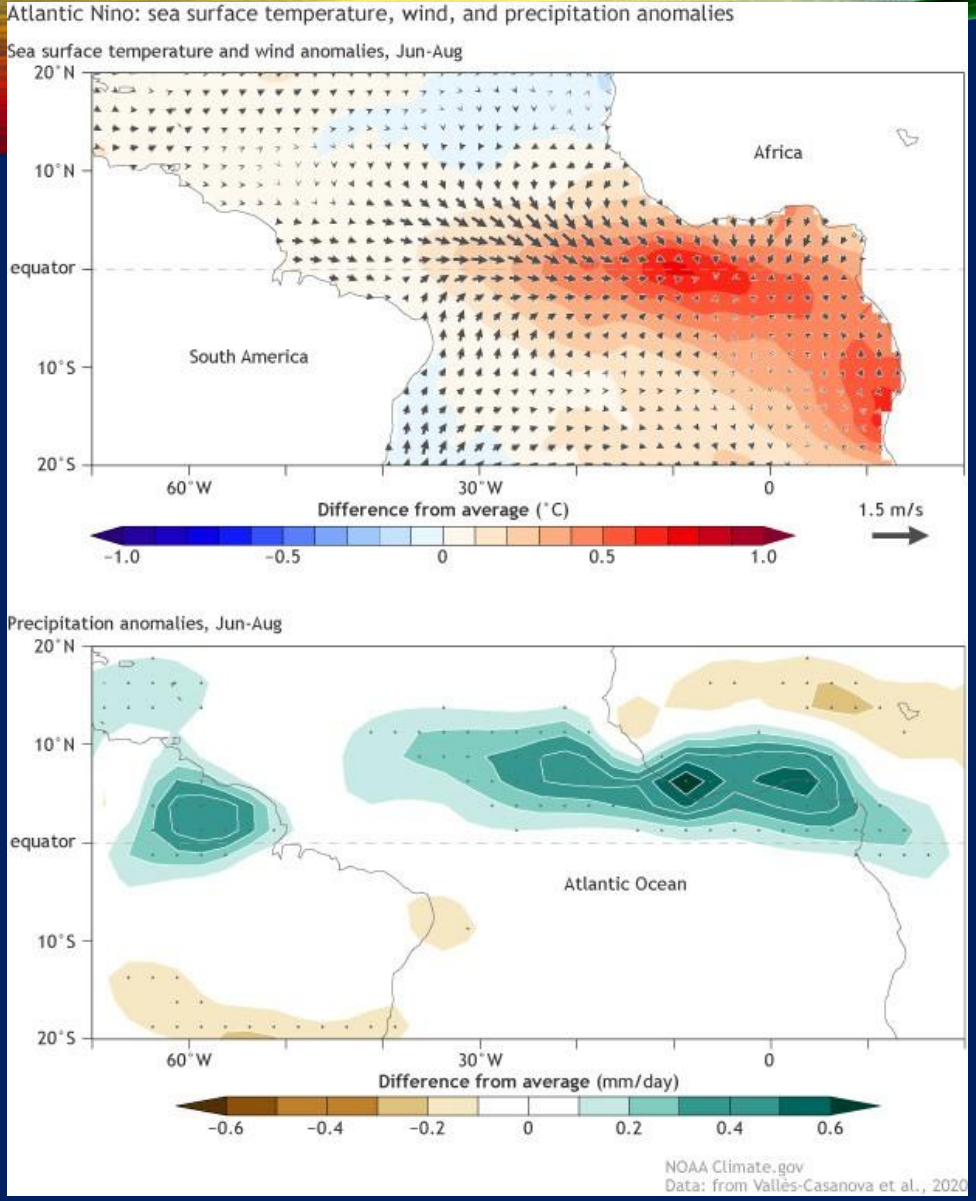
We monitor sea surface temperatures in the tropical Pacific Ocean and use a 'Niño index' to track ENSO conditions.

Until August 2025 the Bureau used a traditional Niño index to check for signs of El Niño or La Niña. This compared the difference in temperatures against a baseline period.

From early September 2025 the Bureau started using a relative index to check for signs of El Niño or La Niña. The relative Niño index measures how unusually cool or warm the ocean is in areas of the Pacific Ocean. Temperature differences are compared to the averaged sea surface temperature for the broader global tropical region.

This makes it clearer when temperature differences in the Pacific Ocean are a sign of ENSO activity, rather than part of the long-term warming trend.

For more information on the relative index and how we track ENSO phases, view Relative Niño – a new way to measure El Niño–Southern Oscillation.



The Atlantic Niño: El Niño's Little Brother

https://www.aoml.noaa.gov/news/the-atlantic-nino-el-ninos-little-brother/

El Nino Met Office

https://www.youtube.com/watch?v=WPA-KpldDVc

BoM

http://youtu.be/dzat16LMtQk

US NOAA

https://oceanservice.noaa.gov/facts/elninolanina/otkn_721_elninolanina_lg.mp4

Some useful references:

https://phys.org/news/2014-06-el-nino-la-nina.html

Queensland Government – service to agriculture

https://www.longpaddock.qld.gov.au/about/resources/

Look for “Will it rain?”

Bureau of Meteorology Seasonal Outlook

http://www.bom.gov.au/climate/enso/