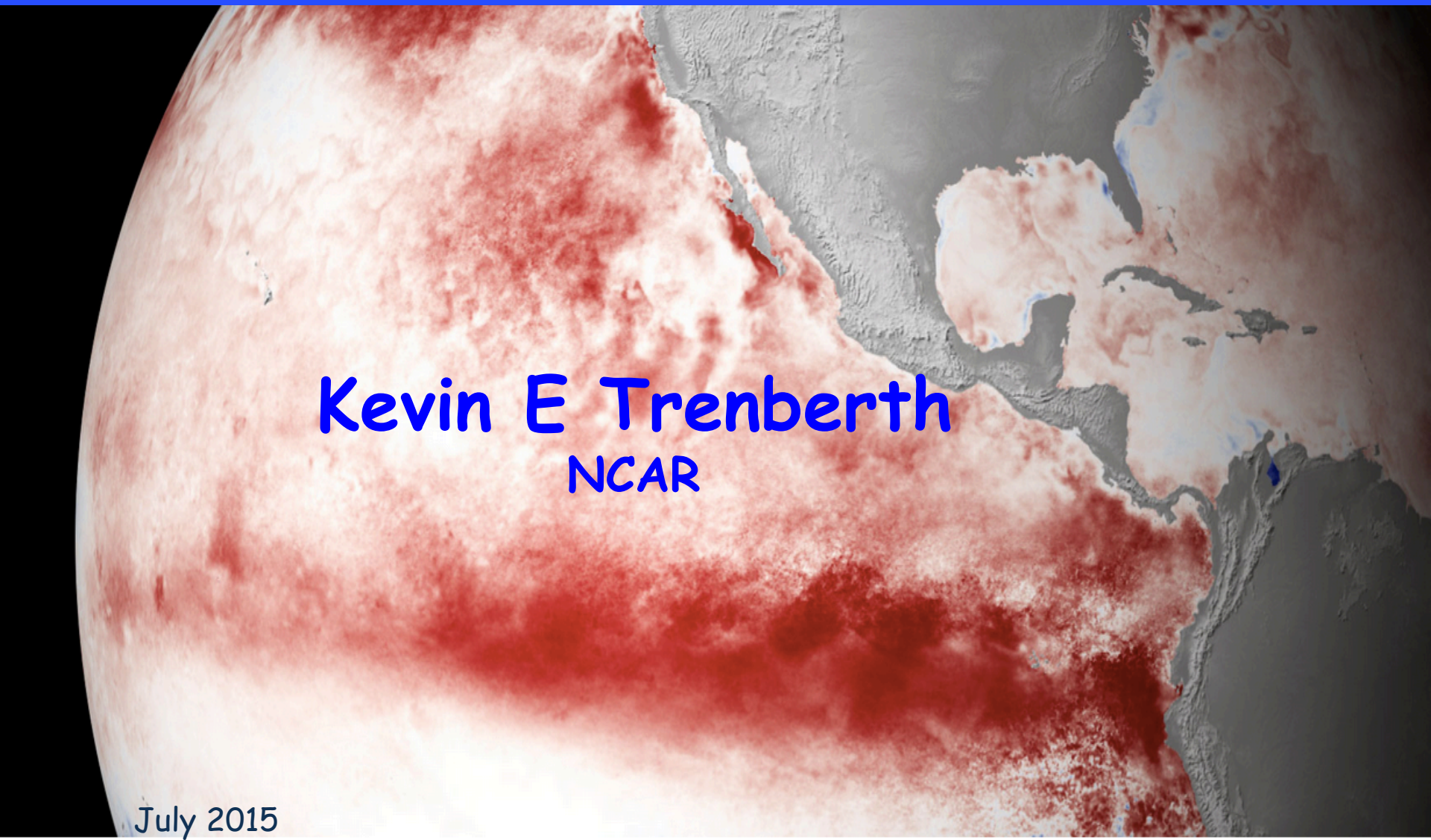
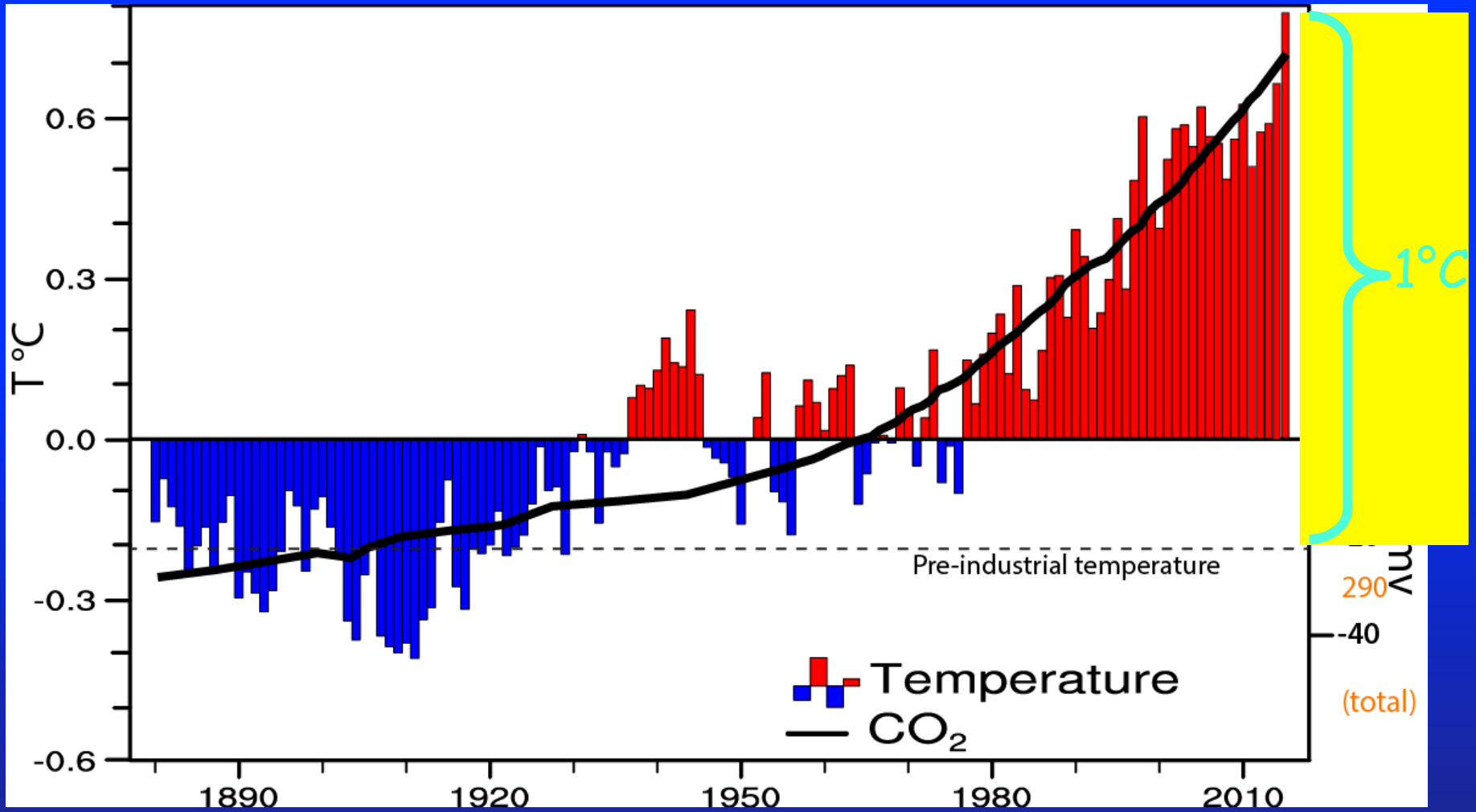
What's going on with El Niño and climate change?



Global temperature and carbon dioxide: anomalies through 2015 (projected)



Base period 1900-99; data from NOAA

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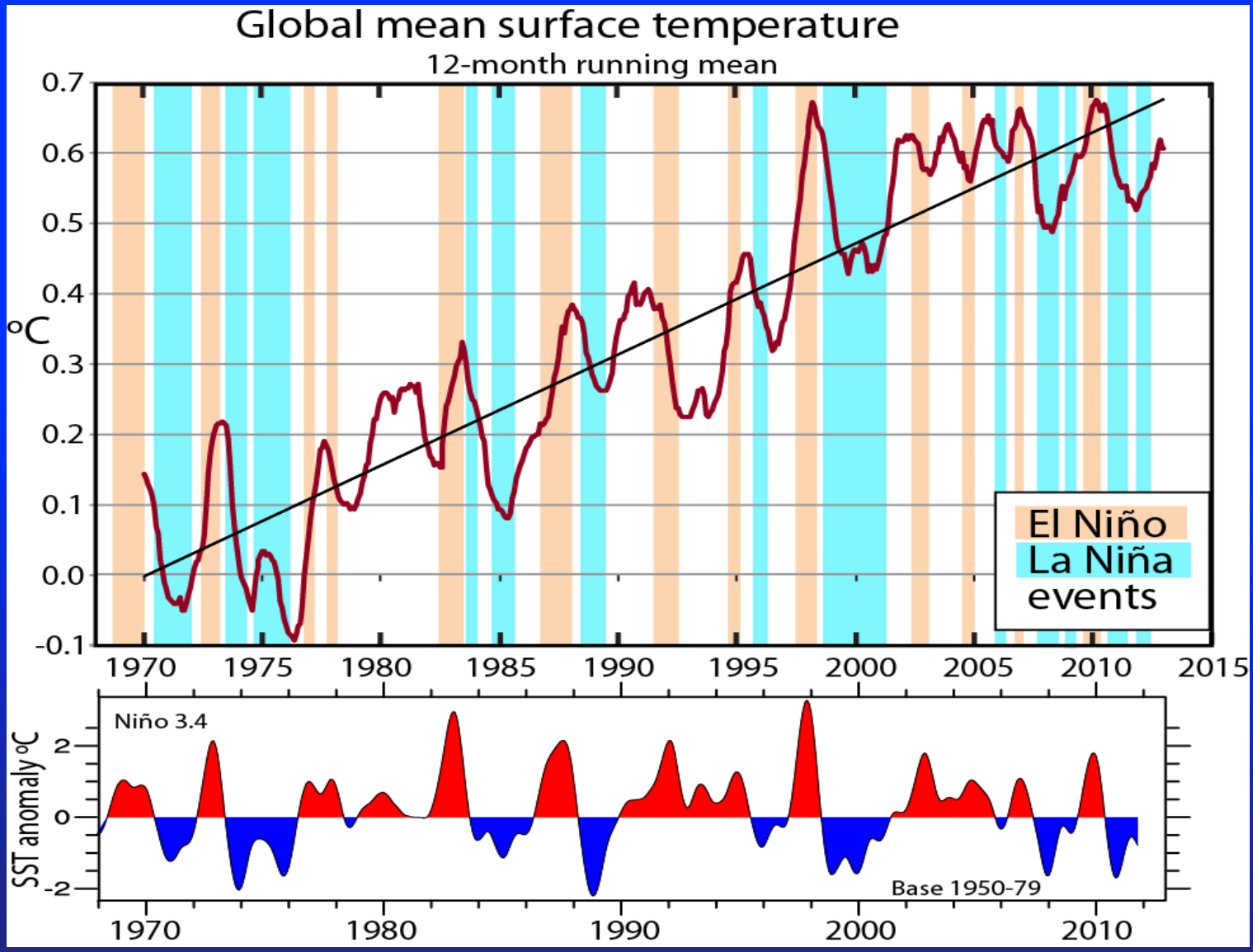
ENSO is the main source of interannual variability



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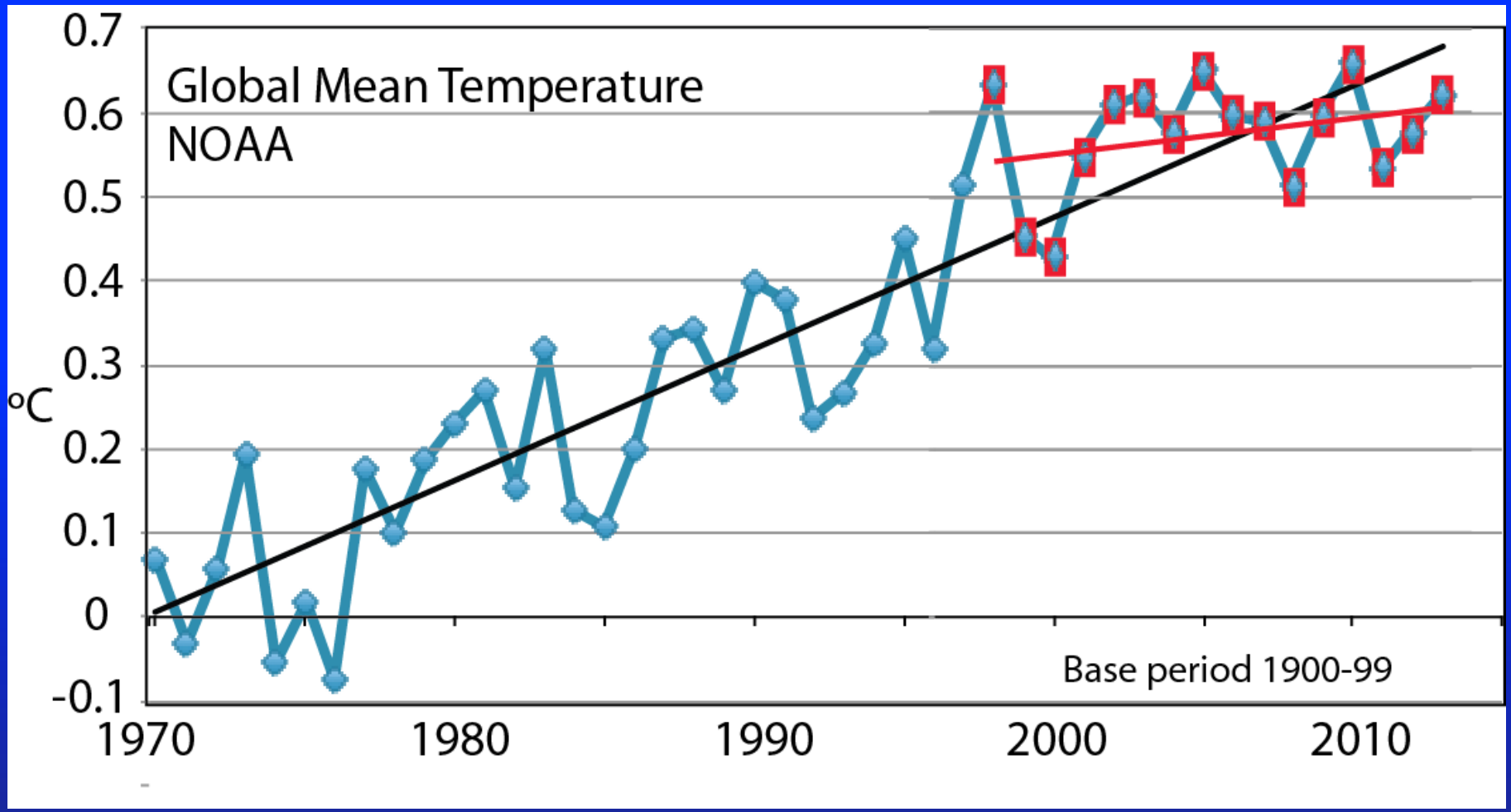
Global mean T



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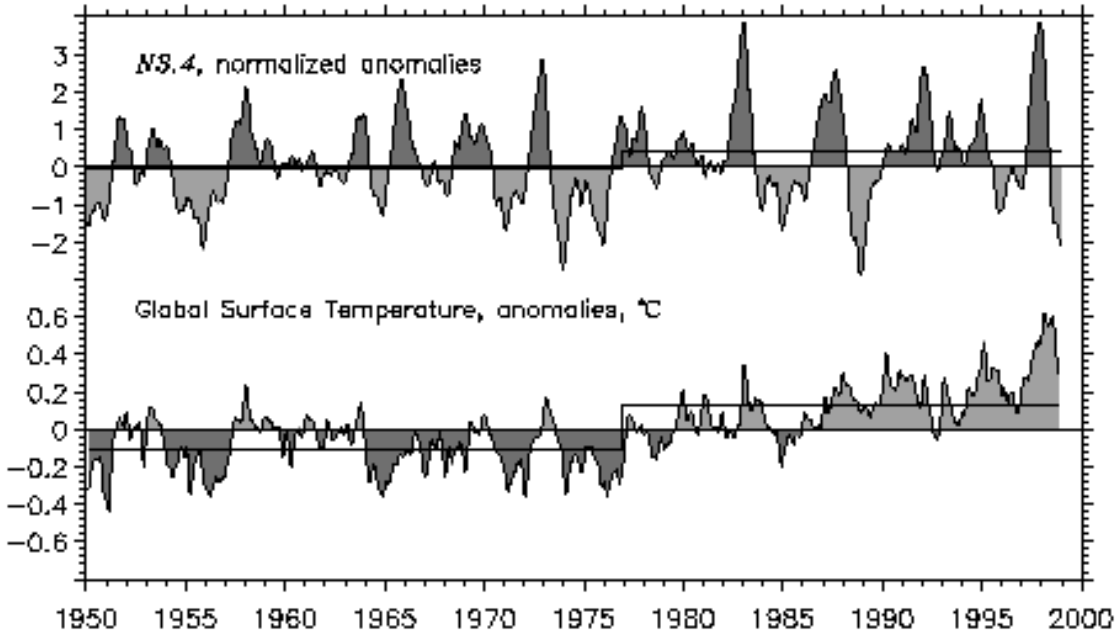
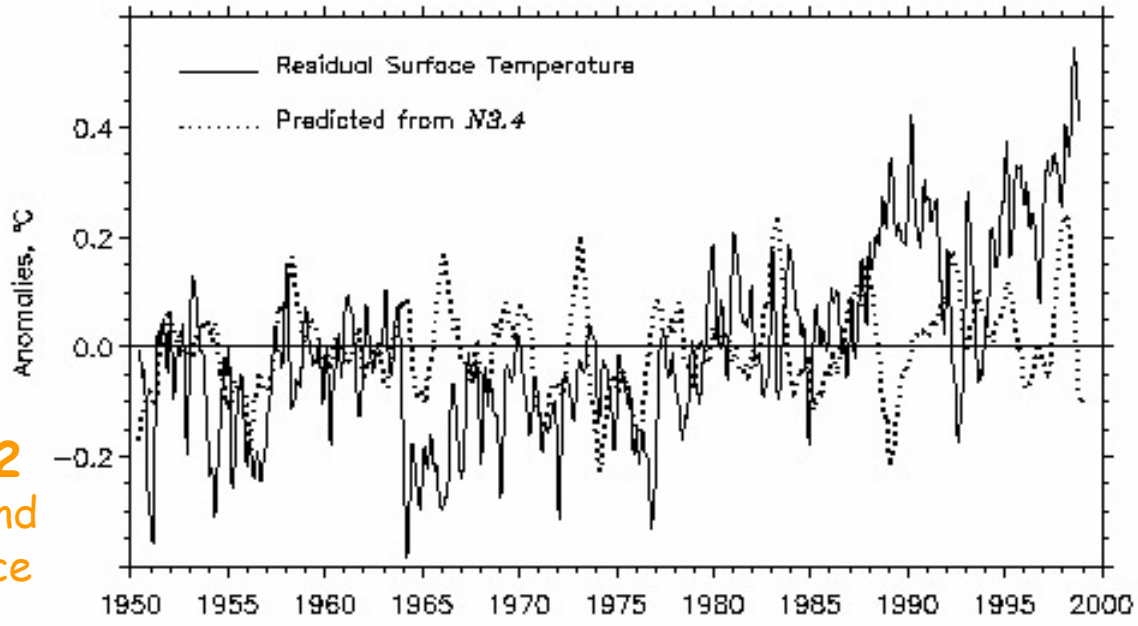
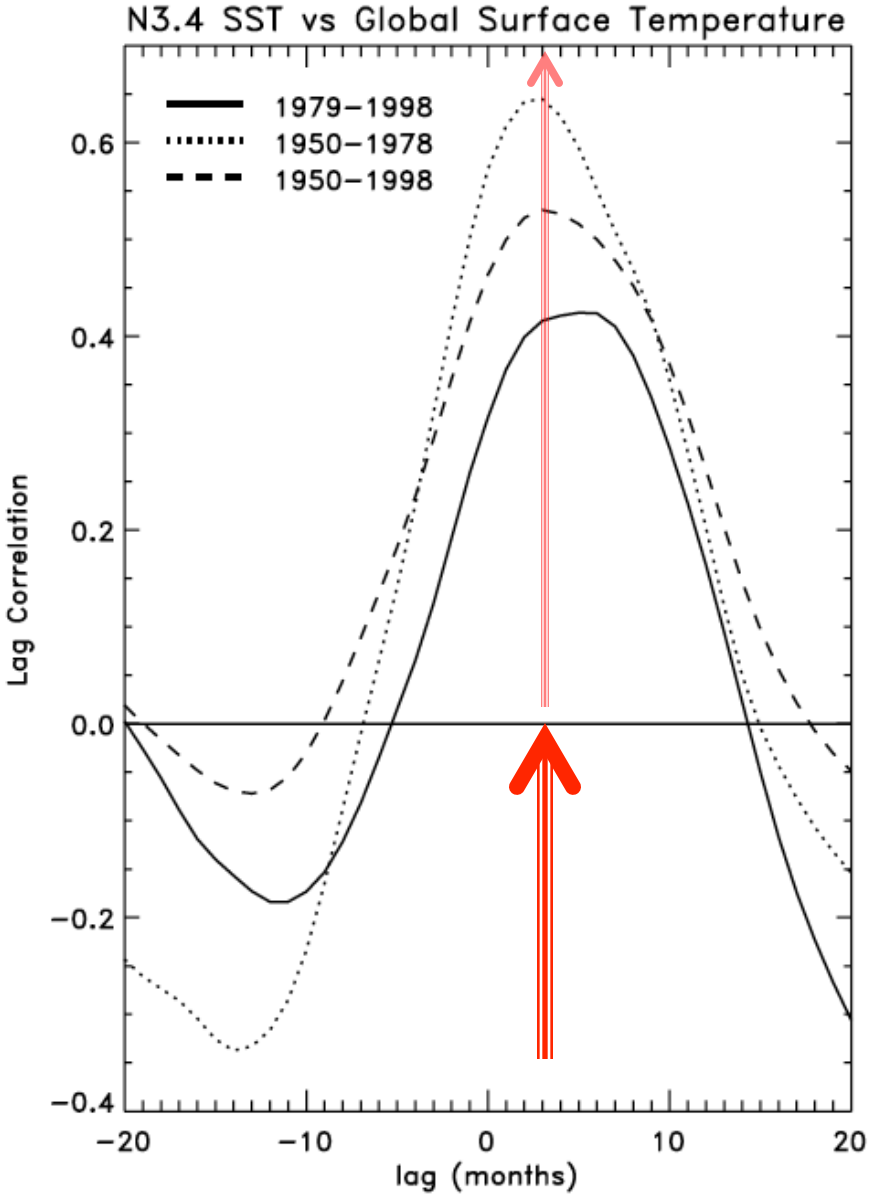
There is a mini global warming with El Niño:
0.24°C peak in 1998,
0.17°C for year





Trenberth et al. 2002
The evolution of ENSO and global atmospheric surface temperatures. JGR



Regression of GMST on N3.4

3 month lag:
0.11°C per Nino 3.4 SST change

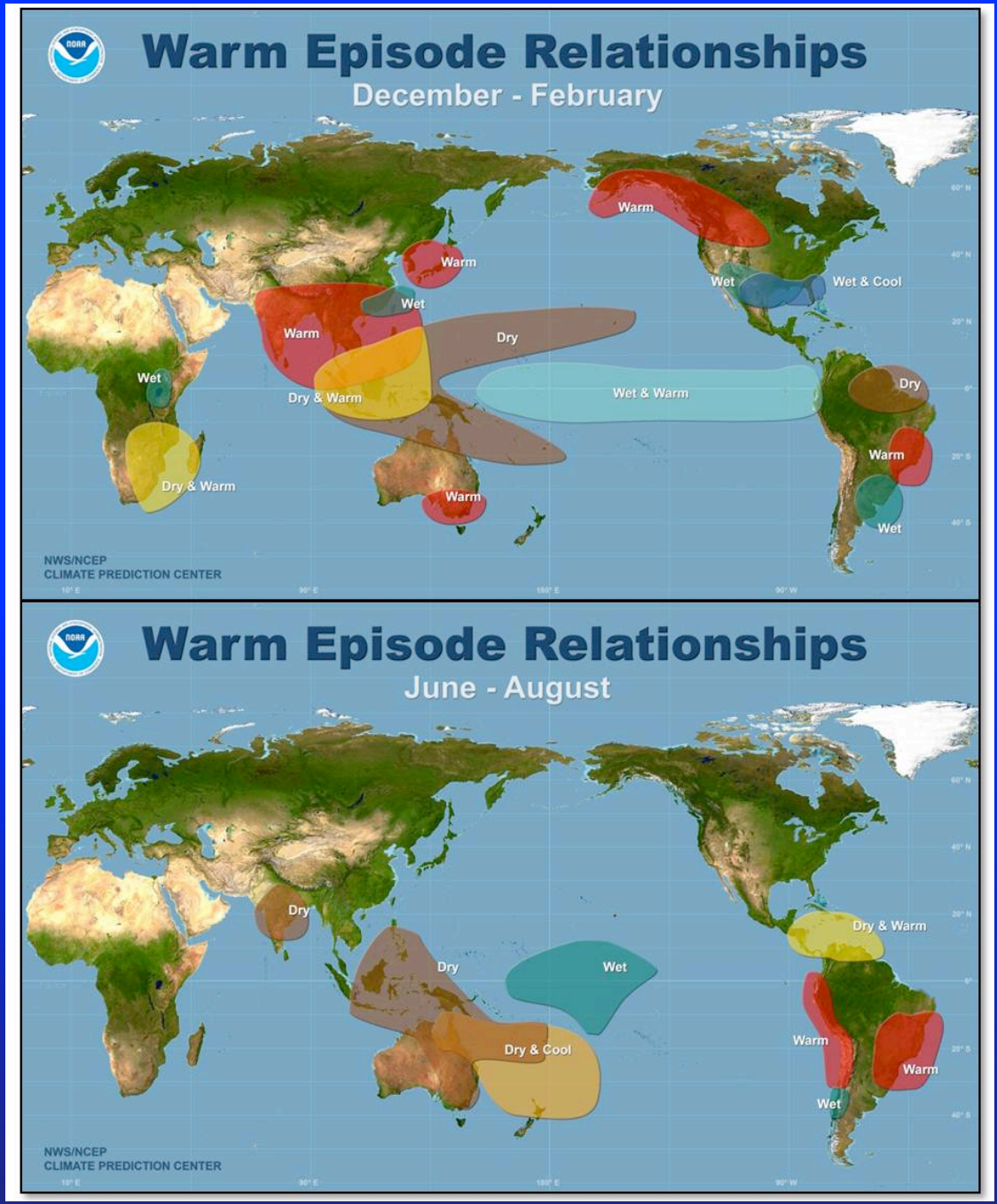
In 1998 peak N3.4 2.5°C =>
order 0.25°C in GMST or 0.17°C
for annual mean 1998.

Also for
2015: ~0.25°C GMST rise

T et al JGR 2002

The biggest source of drought and floods around the world is ENSO

During El Nino, drought besets: Australia, Indonesia, India, the Philippines, Brazil, parts of east and south Africa, the western Pacific basin islands (incl. Hawaii), Central America, and parts of the U.S.



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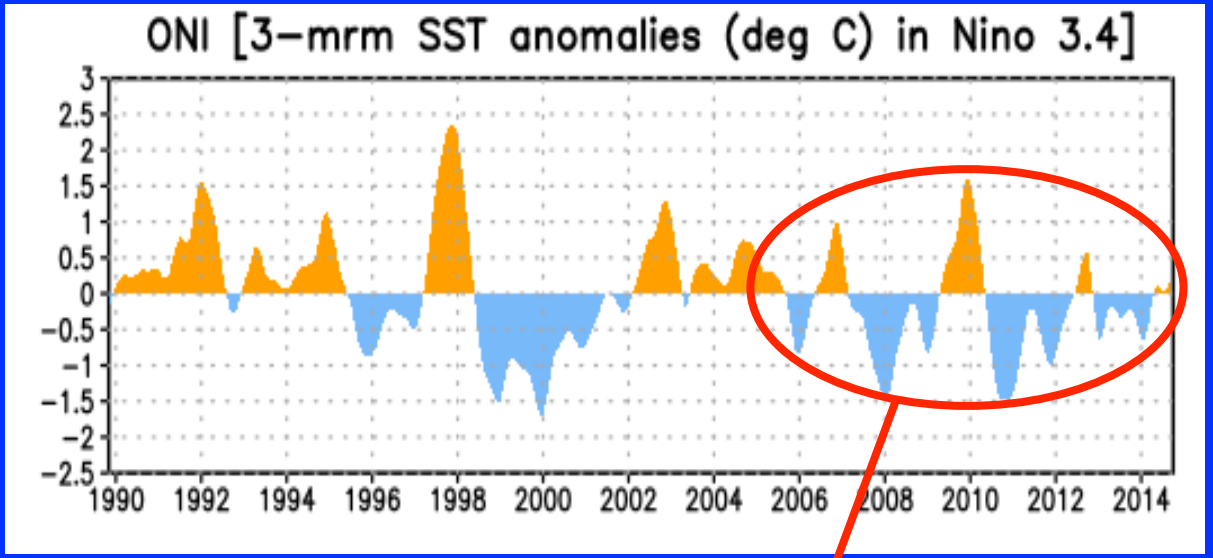


During El Niño, drought besets: Australia, Indonesia, India, the Philippines, Brazil, parts of east and south Africa, the western Pacific basin islands (incl. Hawaii), Central America, and parts of the U.S.

Fewer El Niño's in recent years means fewer droughts

Warmer air holds more moisture

7% per °C

Global warming=

More heat

⇓

More drying

⇓

More evaporation

⇓

More moisture

More rain

More drought

Global warming

⇓

Heating ↑

⇓

Temperature ↑ & Evaporation ↑

⇓

water holding capacity ↑

⇓

atmospheric moisture ↑

⇓ ⇓

greenhouse effect ↑ & rain intensity ↑

⇓

Floods & Droughts

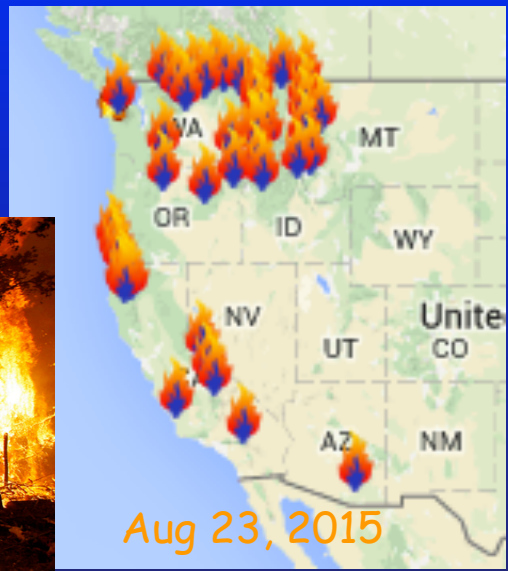
Drought

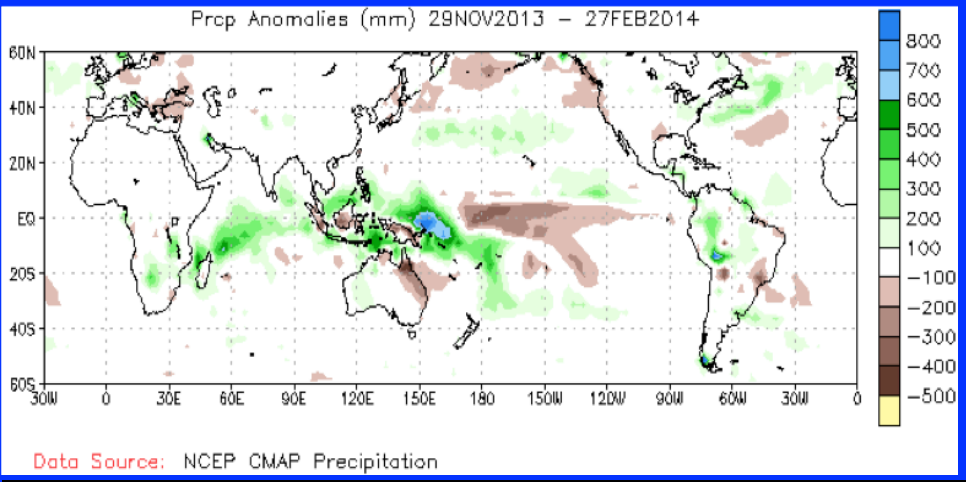
Whether and when a drought occurs is largely natural variability, dominated by ENSO.

But given a drought, global warming makes it more intense and longer lasting.

Extra heat builds up: has nowhere to go.

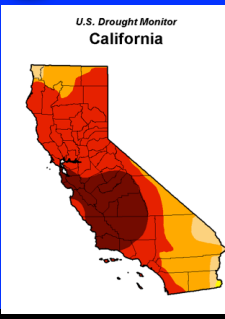
- **Increased drying**
- **Increased heating and heat waves**
- **Increased wildfire risk**

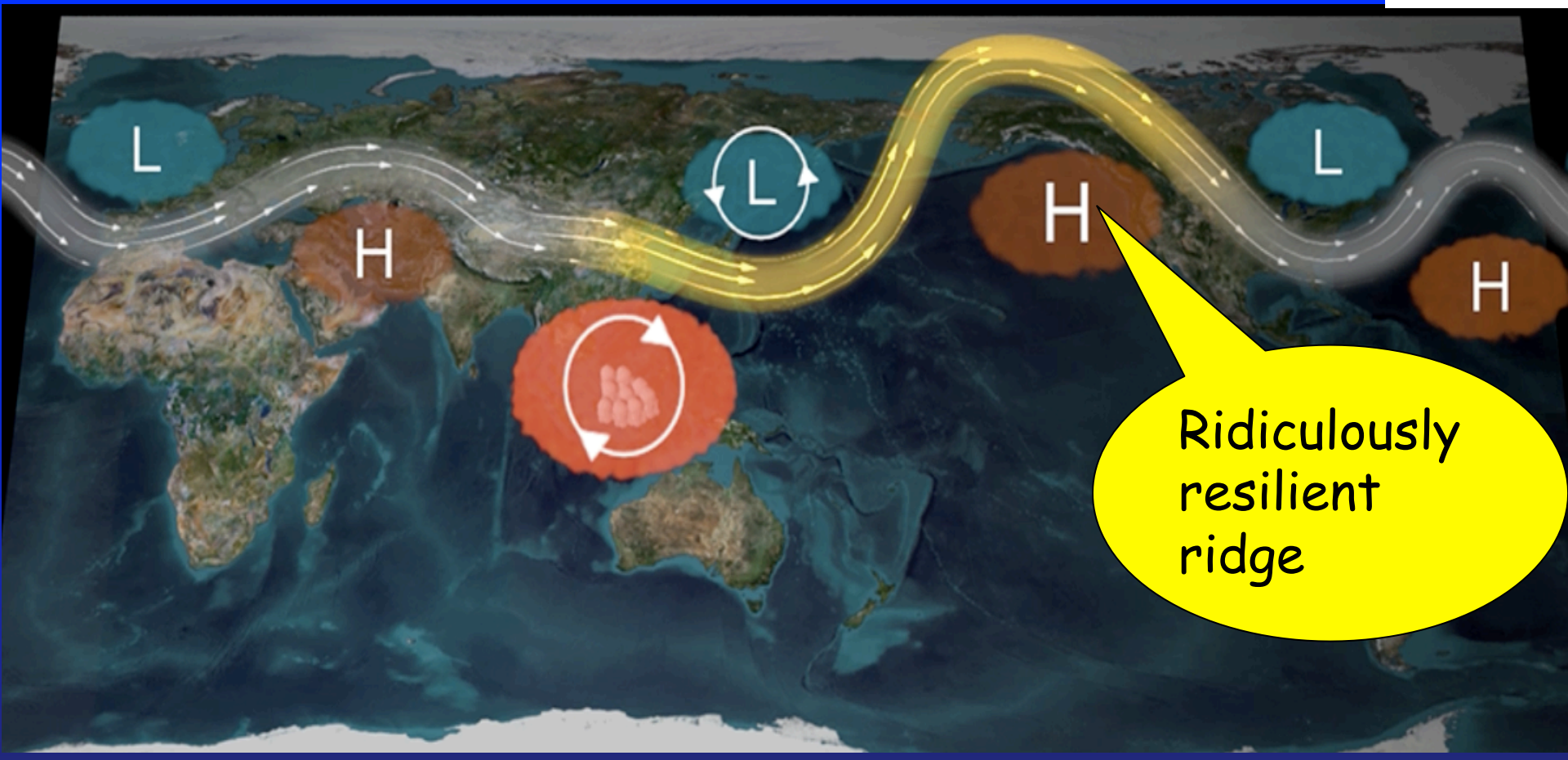




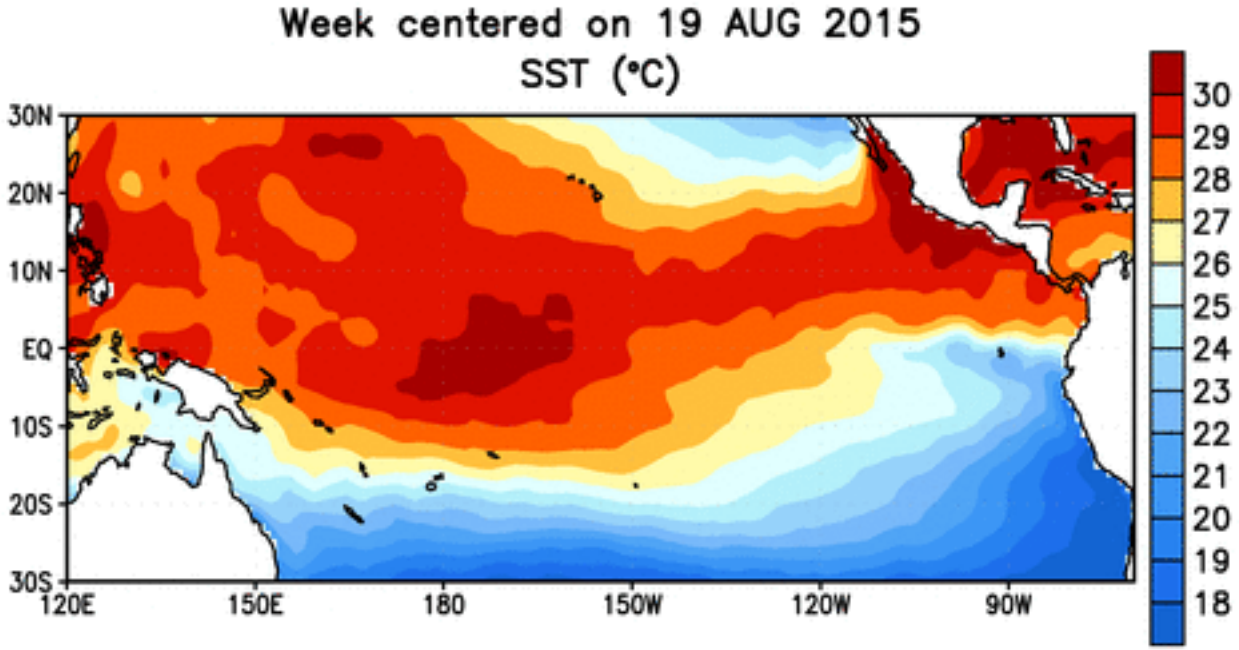
California drought

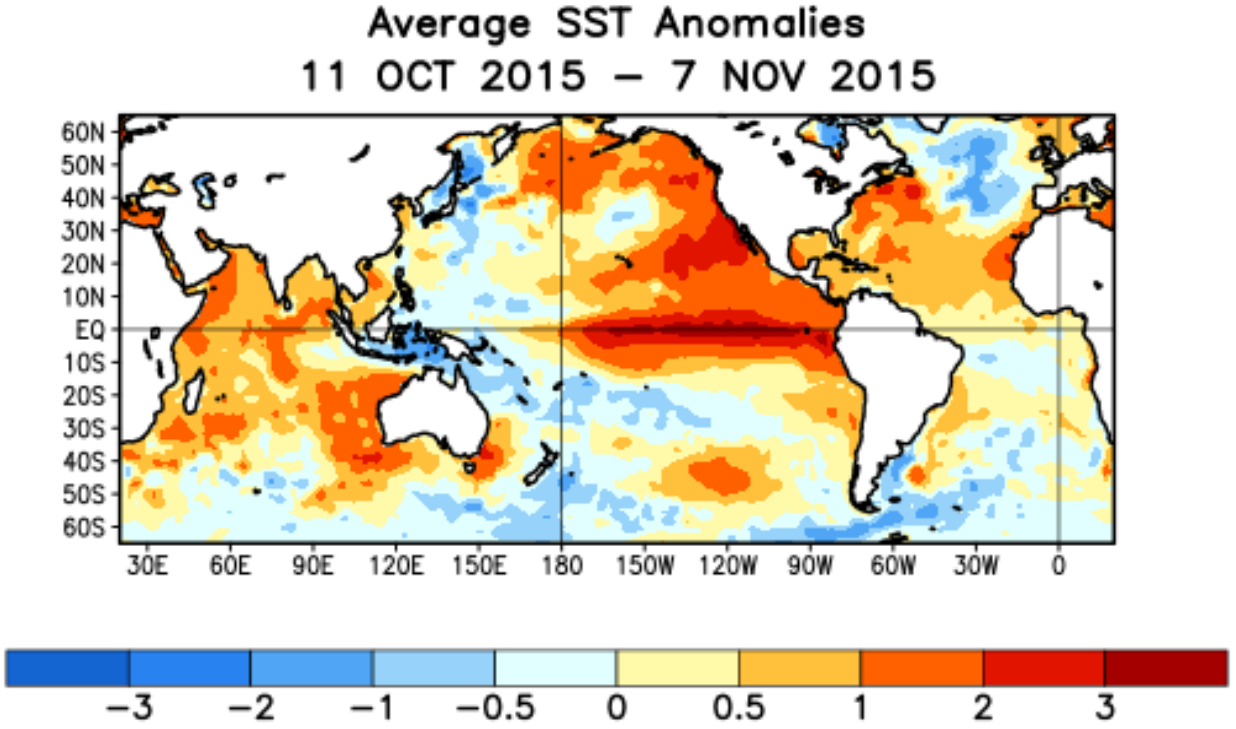
Winter 2013-14





NH winter EN





We have a strong El Niño.

But the focus should be more on total SST as that controls where low level convergence occurs and thus upper level outflow and Rossby wave forcing.

It is not linear!

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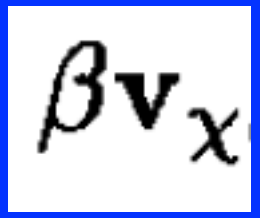
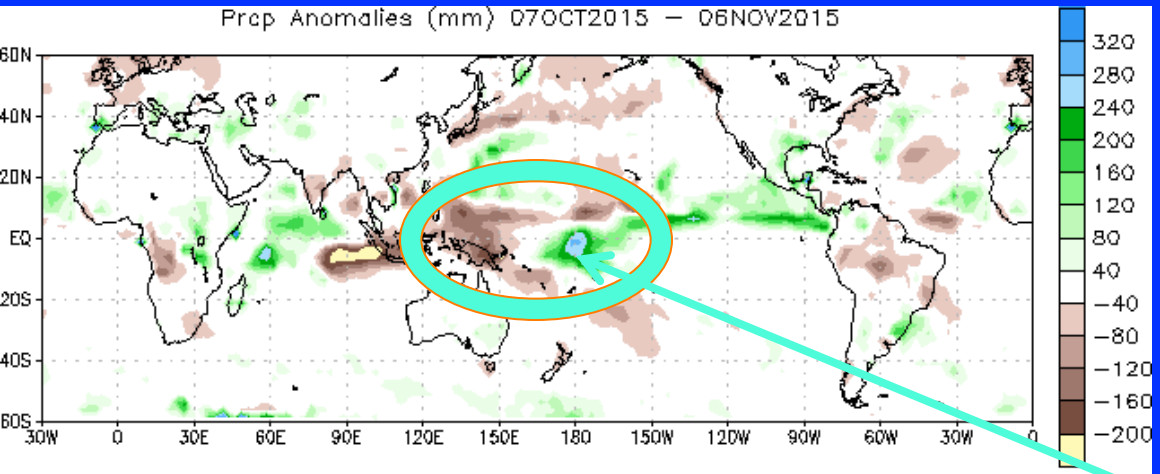
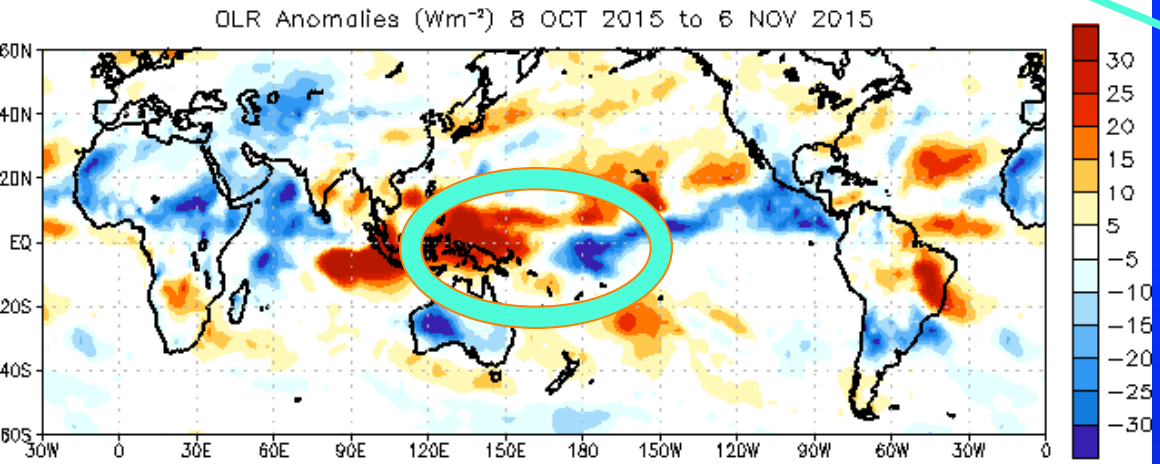
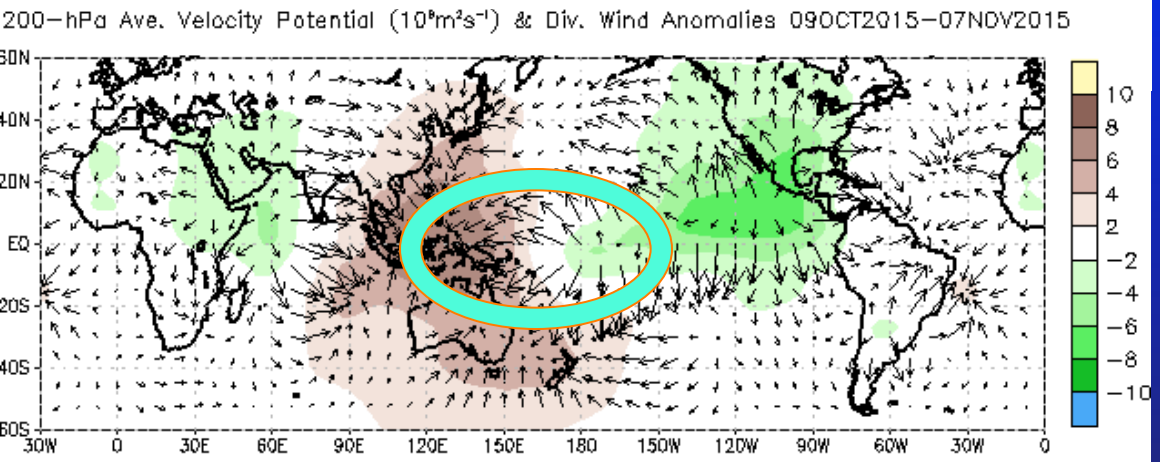
Main source term for Rossby waves
Vorticity tendency

includes especially 

= northward divergent wind component







Last 30 days: 8 Oct-6 Nov Anomalies

Precipitation

10 inches!

OLR

Divergent wind

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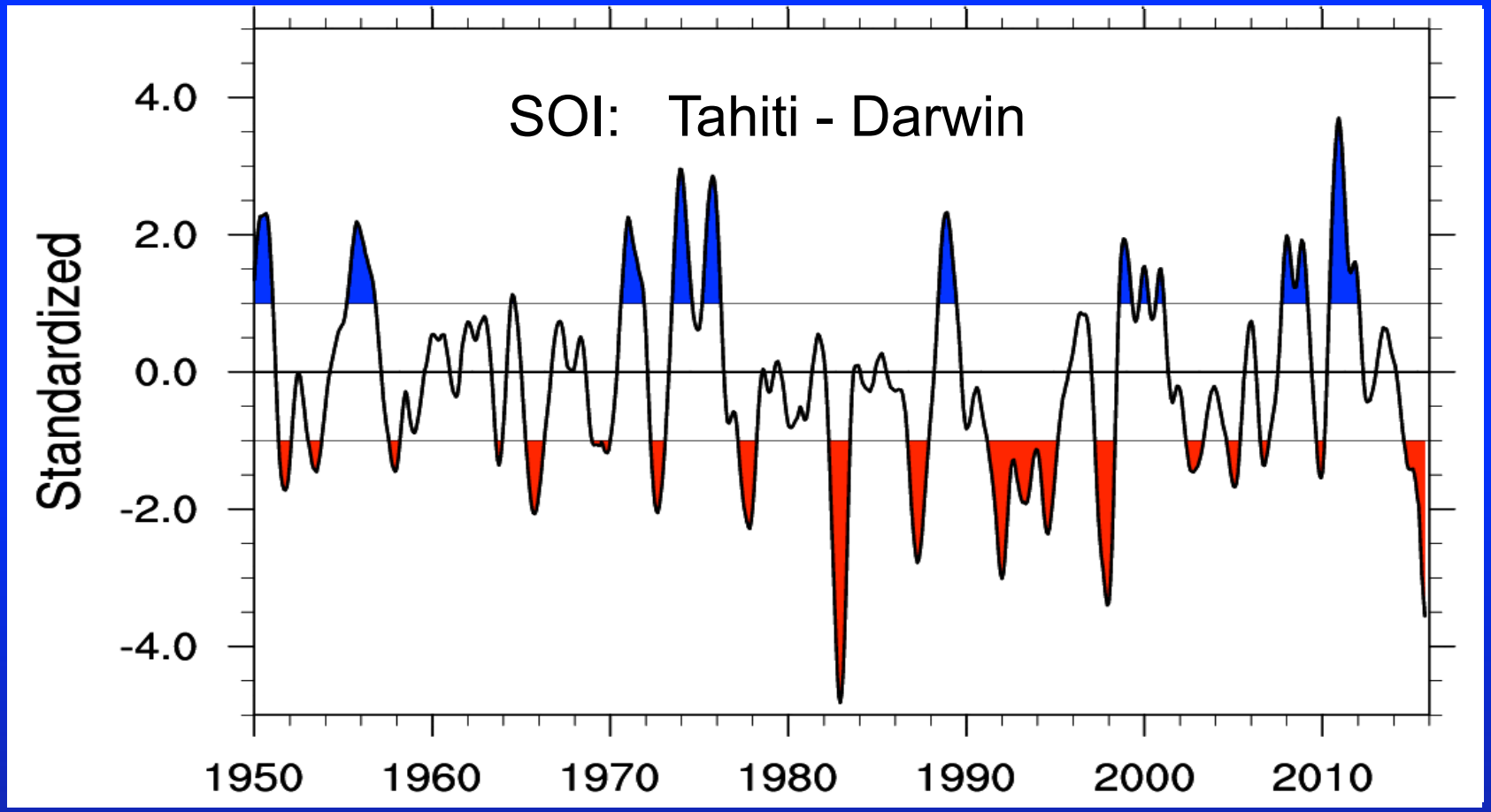
Decadal variability



El Niños are red, La Niñas are blue
They follow in sequence every year or two.

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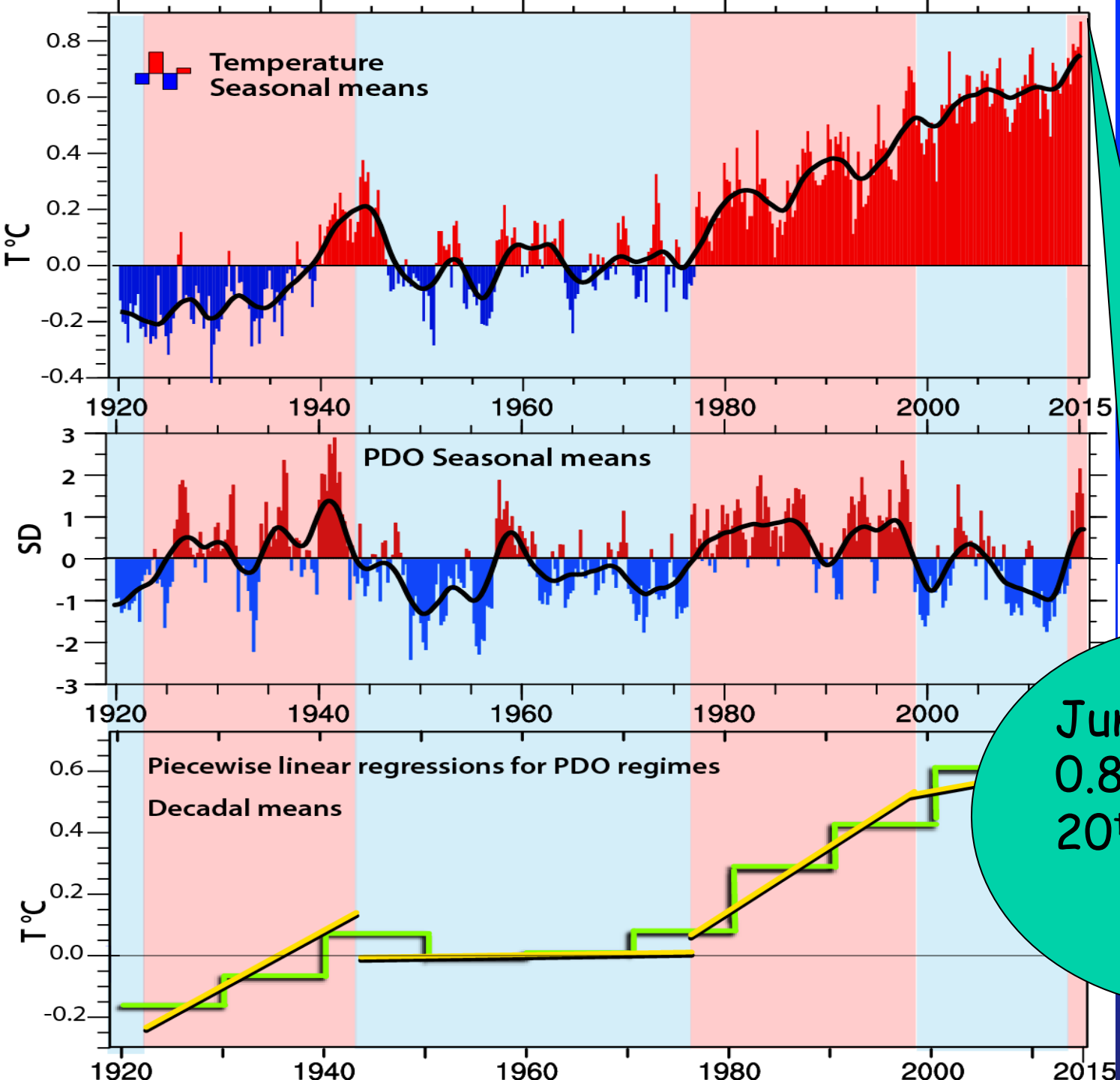
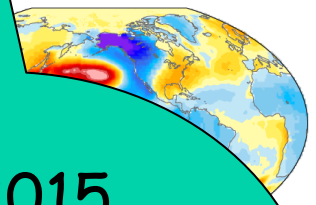


Global T and PDO



June 2015
0.88C above
20th C mean

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Energy budget of Earth:

- The OHC data strongly suggest that the ocean loses heat during latter stages of El Niño.
- Largely through evaporative cooling of ocean.
- Moistens atmosphere and invigorates storms and raises risk of floods.
- **Leads to mini-global warming.**

- Then there is a recharge of heat during La Niña.
- Models do not do this discharge-recharge correctly: they tend to slosh heat around (delayed oscillator).
- In PDO –ve, more heat goes deeper and is less accessible to atmosphere.

Increasing frequency of extreme El Niño events due to increased greenhouse warming

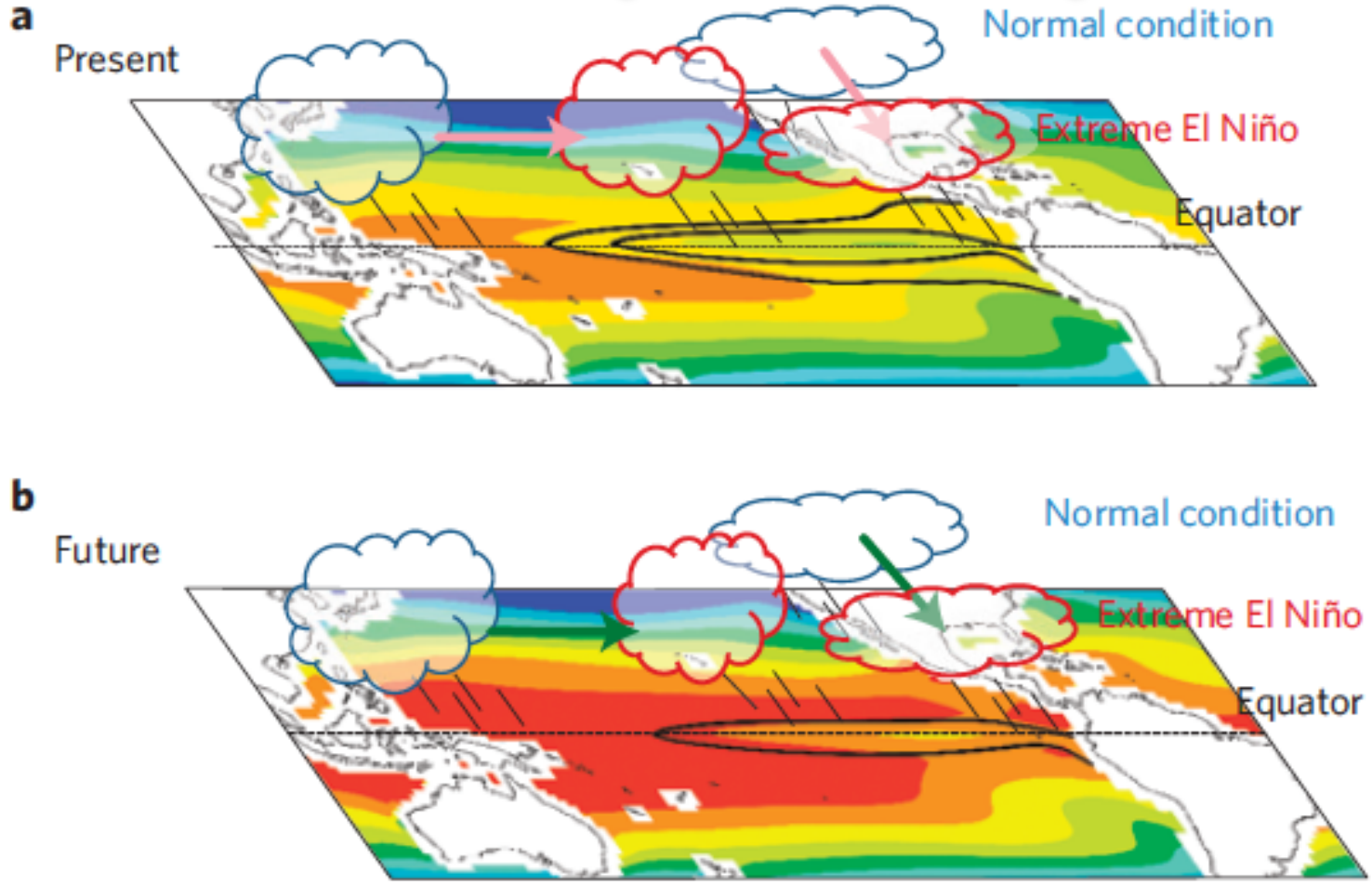

Figure 4 | Schematic depicting the mechanism for increased occurrences of extreme El Niño under greenhouse warming. a,b, In both present-day climate (**a**) and future climate (**b**), convection zones in the western Pacific

Relies on CMIP models: reduced SST gradients

Cai et al NCC 2014

How ENSO itself changes with climate change is not very clear.

But it is clear that the consequences become greater (in terms of droughts and floods).

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