

Playing Hide and Seek With El Niño

***Mike McPhaden
NOAA/Pacific Marine Environmental Laboratory
Seattle, Washington, USA***

Nature Climate Change, in press (17 August 2015).

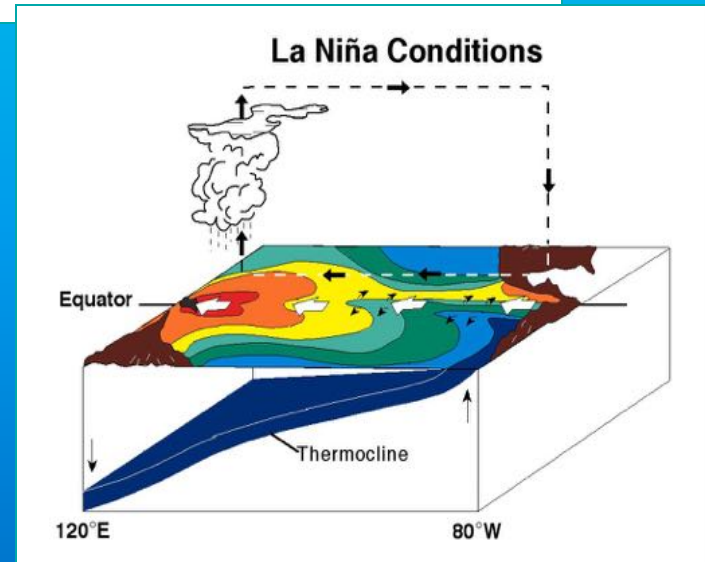
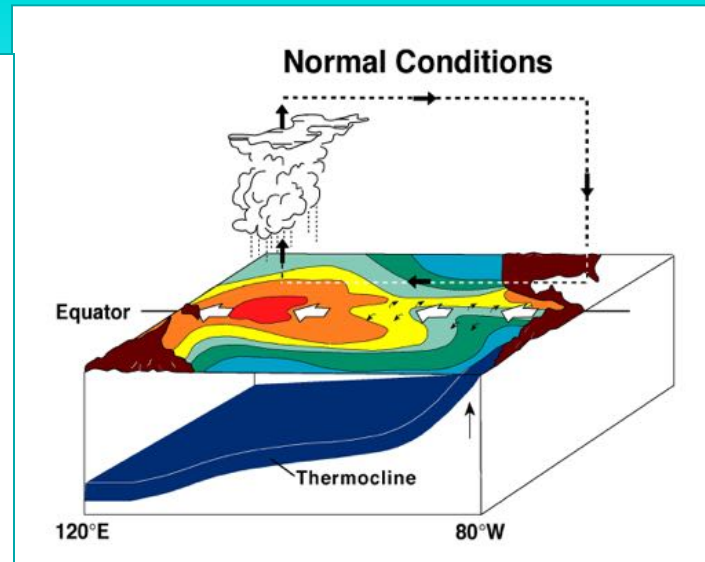
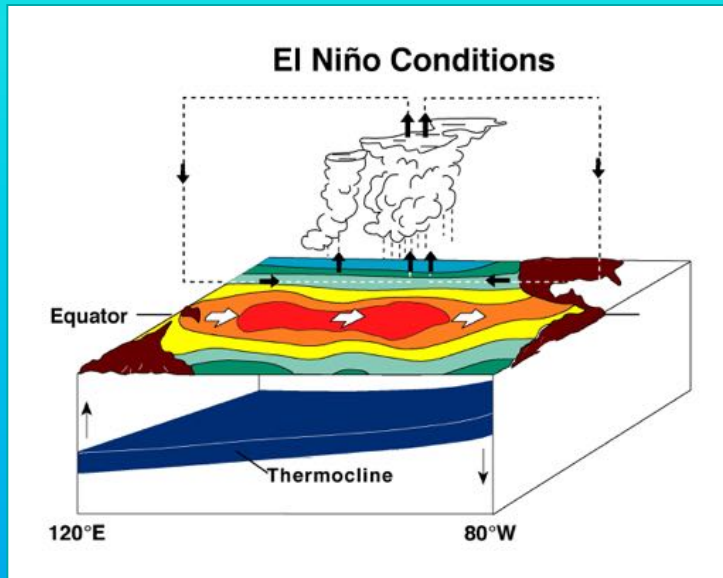
***U.S. CLIVAR Summit
Tucson, AZ
4 August 2015***

A tropical beach scene with several palm trees leaning over a sandy shore. The ocean is visible in the background under a blue sky with light clouds. Two people are sitting on the beach near some driftwood.

Outline

- 1. Observations vs Predictions in 2014-15**
- 2. Understanding What Transpired**
- 3. Research imperatives**

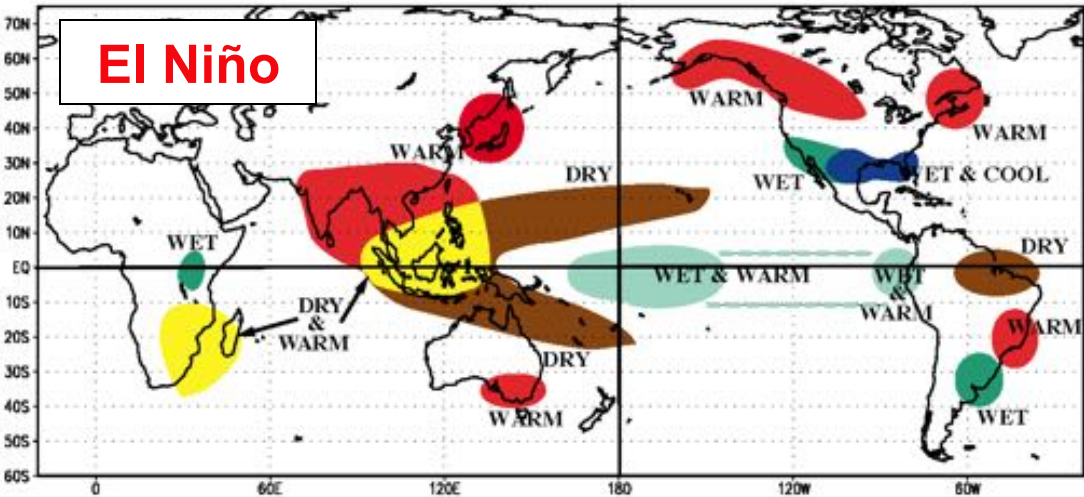
El Niño and the Southern Oscillation (ENSO)



El Niño—Warm phase of ENSO
La Niña—Cold phase of ENSO

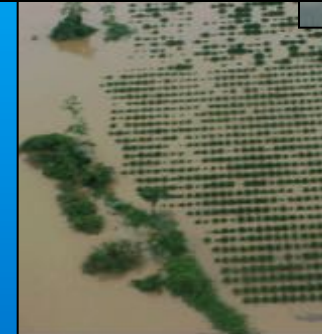
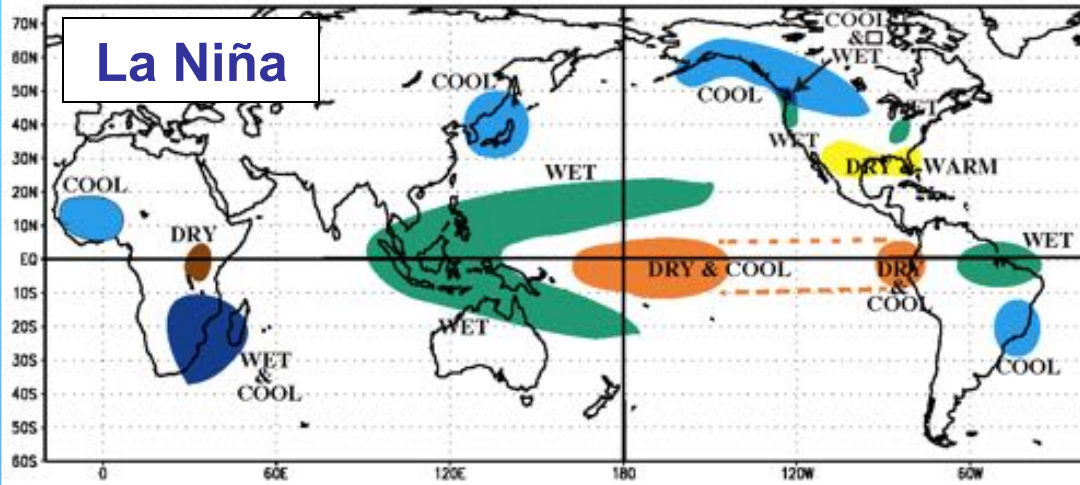
El Niño & La Niña Impacts on Patterns of Weather Variability

WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



El Niño and La Niña shift the probability for droughts, floods, heat waves, extreme weather events around the globe

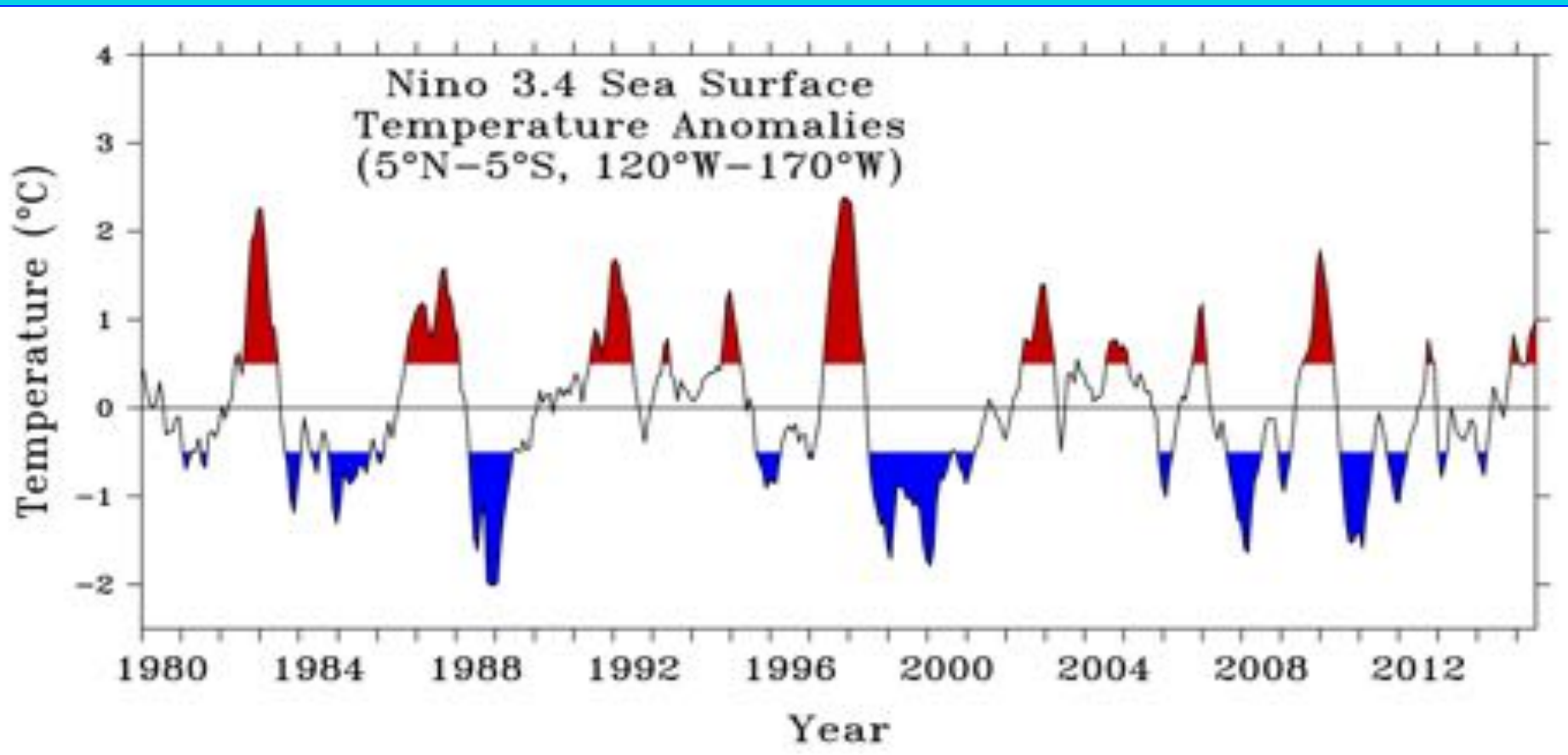
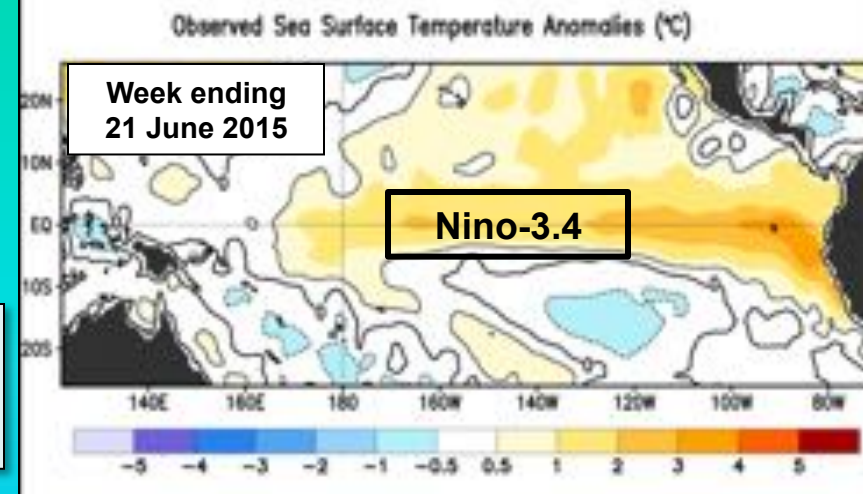
COLD EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



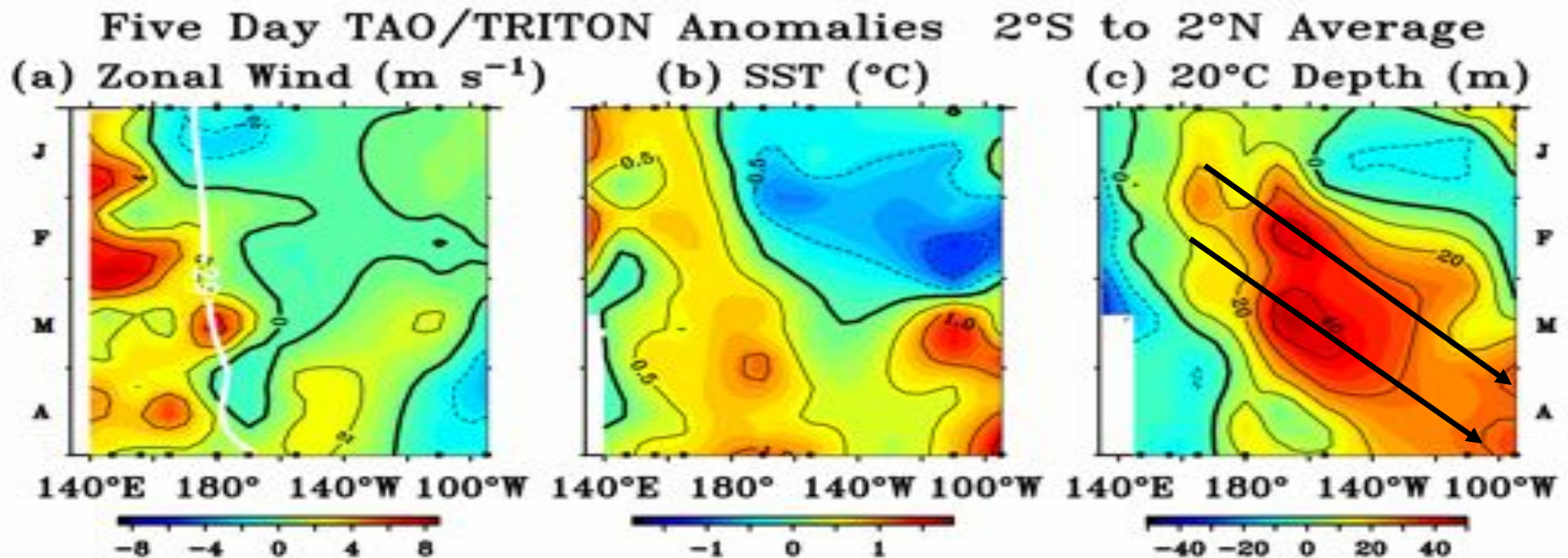
An ENSO Index

El Niño=NINO3.4 $\geq 0.5^{\circ}\text{C}$ for 5 months

La Niña=NINO3.4 $\leq -0.5^{\circ}\text{C}$ for 5 months



Birth of the Big 2014 El Niño?

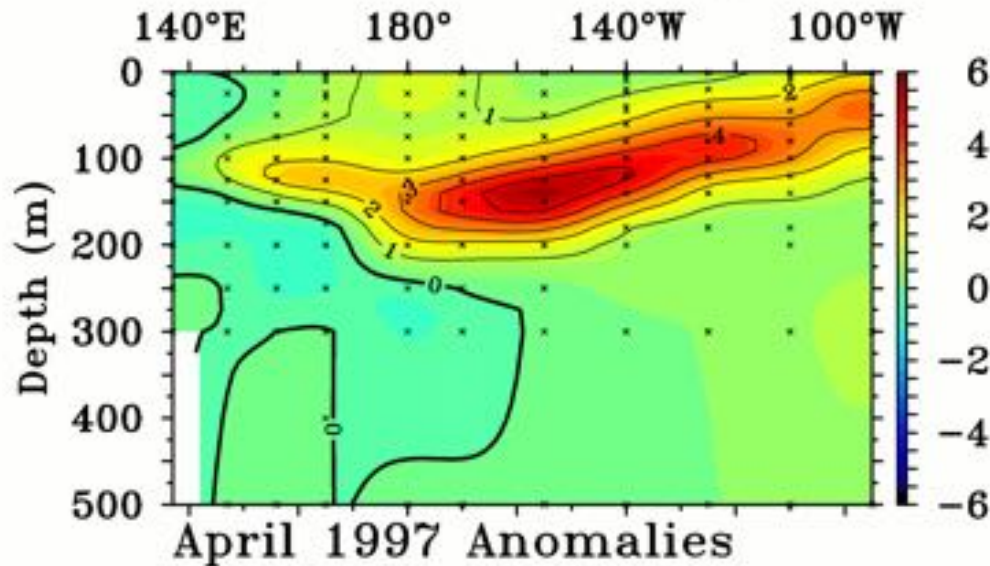
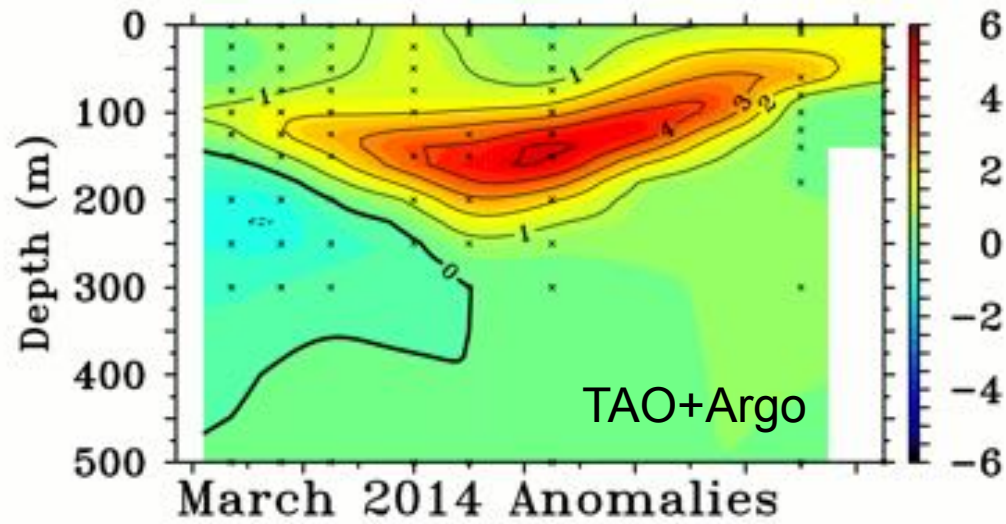


Westerly
Wind Bursts

Warming
by Zonal
Advection

Warming by
Downwelling
Kelvin Waves

Monthly TAO/TRITON Temperatures ($^{\circ}\text{C}$)
2 $^{\circ}\text{S}$ to 2 $^{\circ}\text{N}$ Average

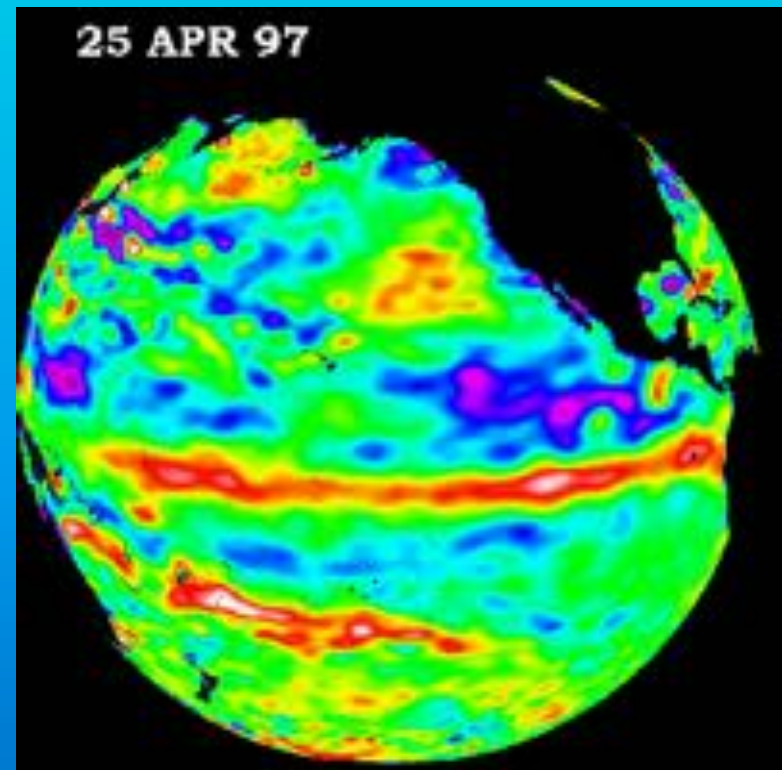
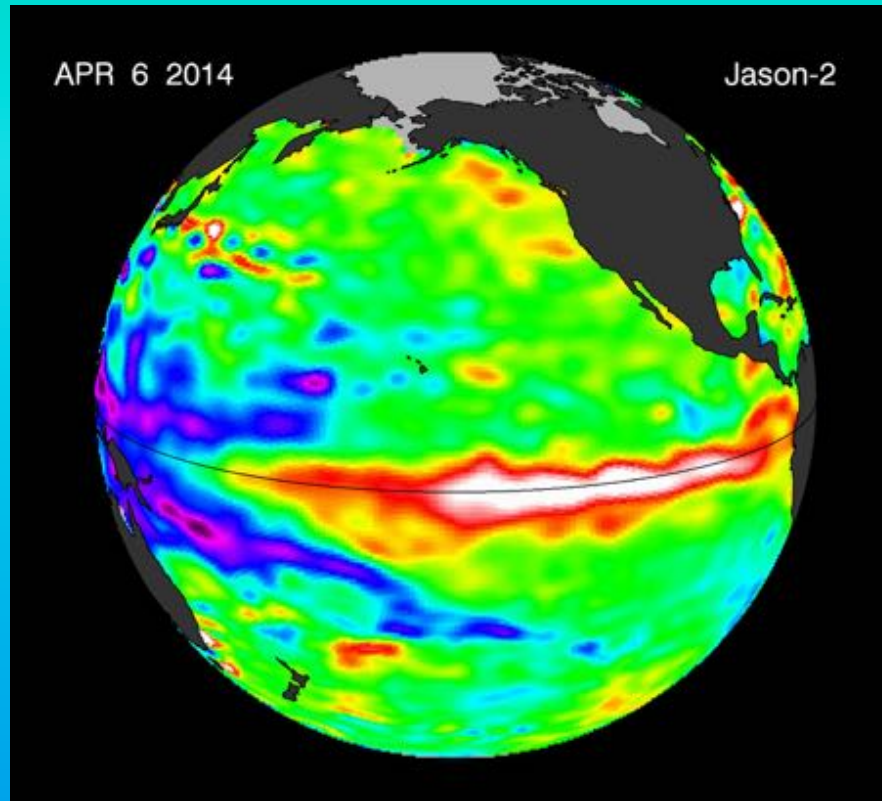


***Early 1997 vs
Early 2014***

***Subsurface
Temperature
Anomalies***

Early 1997 and Early 2014

Surface Height Anomalies





The BIG One!



Unusually Intense El Nino May Lie Ahead, Scientists Say
Mashable 19 March 2014

“The present event is actually bigger than it was in 1997...”

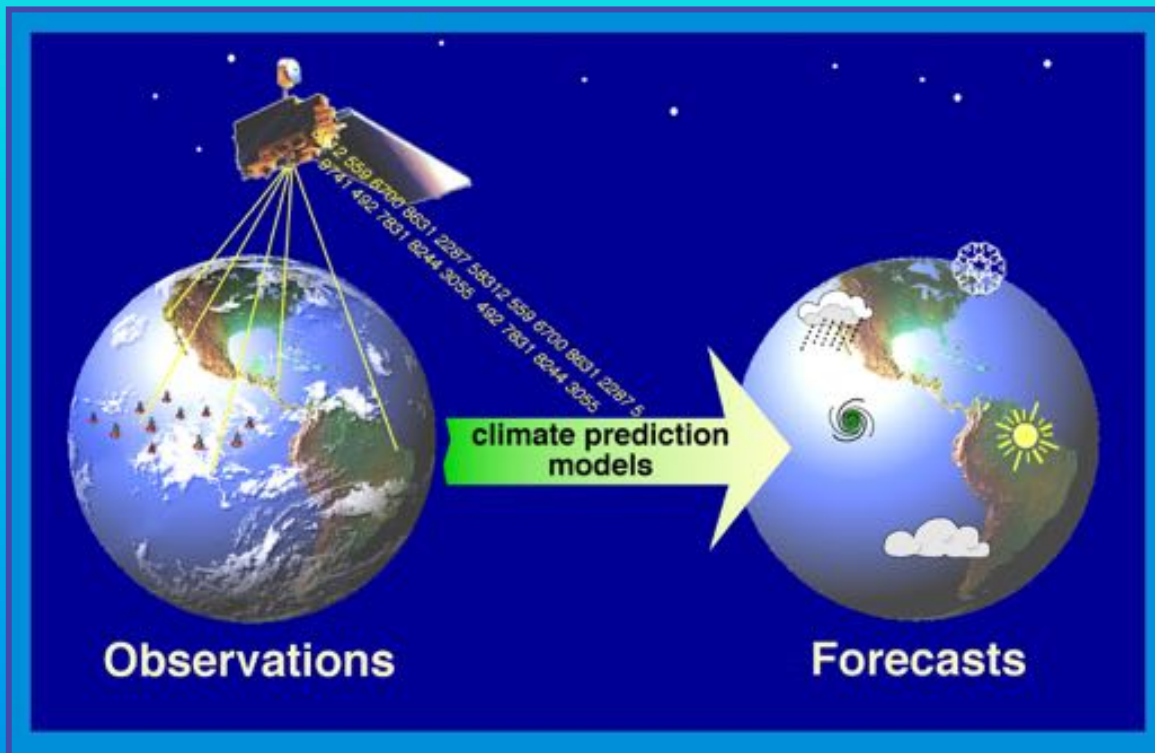
El Niño Could Grow Into a Monster, New Data Show
Slate 7 April 2014

“It might be a big one...”

World is unprepared for major El Niño later this year
New Scientist 7 May 2014

"The tropical climate system is primed for a big El Niño..."
“It looks like a big one...”

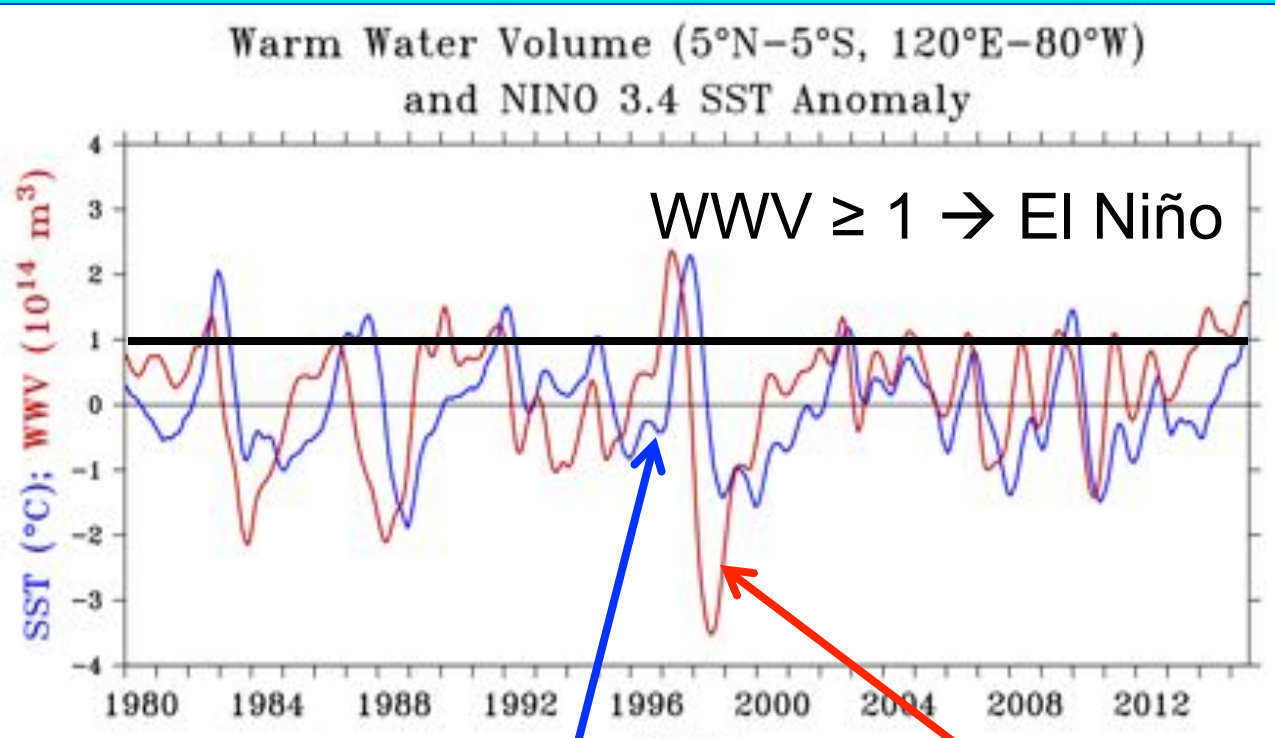
El Niño and La Niña are Predictable



- ***First successful El Niño prediction in 1986***
- ***Forecast models are reasonably skillful at up to 6-9 month lead times***
- ***Predictability based on slow evolution of upper ocean heat content***

Upper Ocean Heat Content as ENSO Predictor

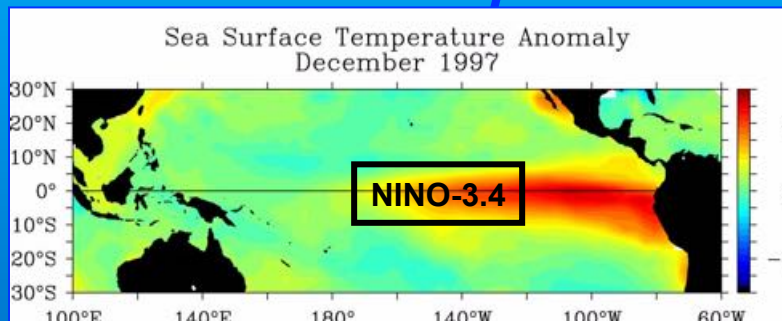
Recharge Oscillator Theory (Jin, 1997)



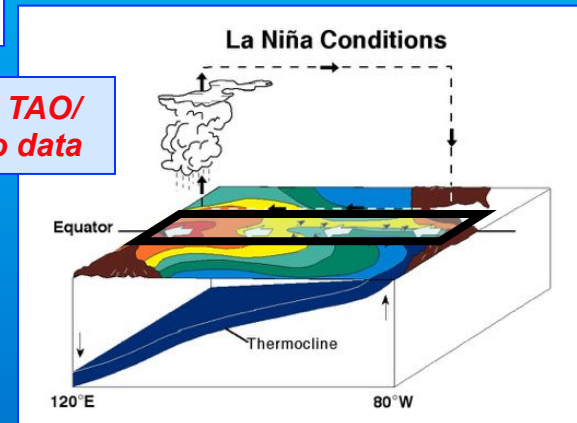
- Build up of excess heat content along equator is a necessary precondition for El Niño to occur.

- El Niño purges excess heat to higher latitudes, which terminates the event.

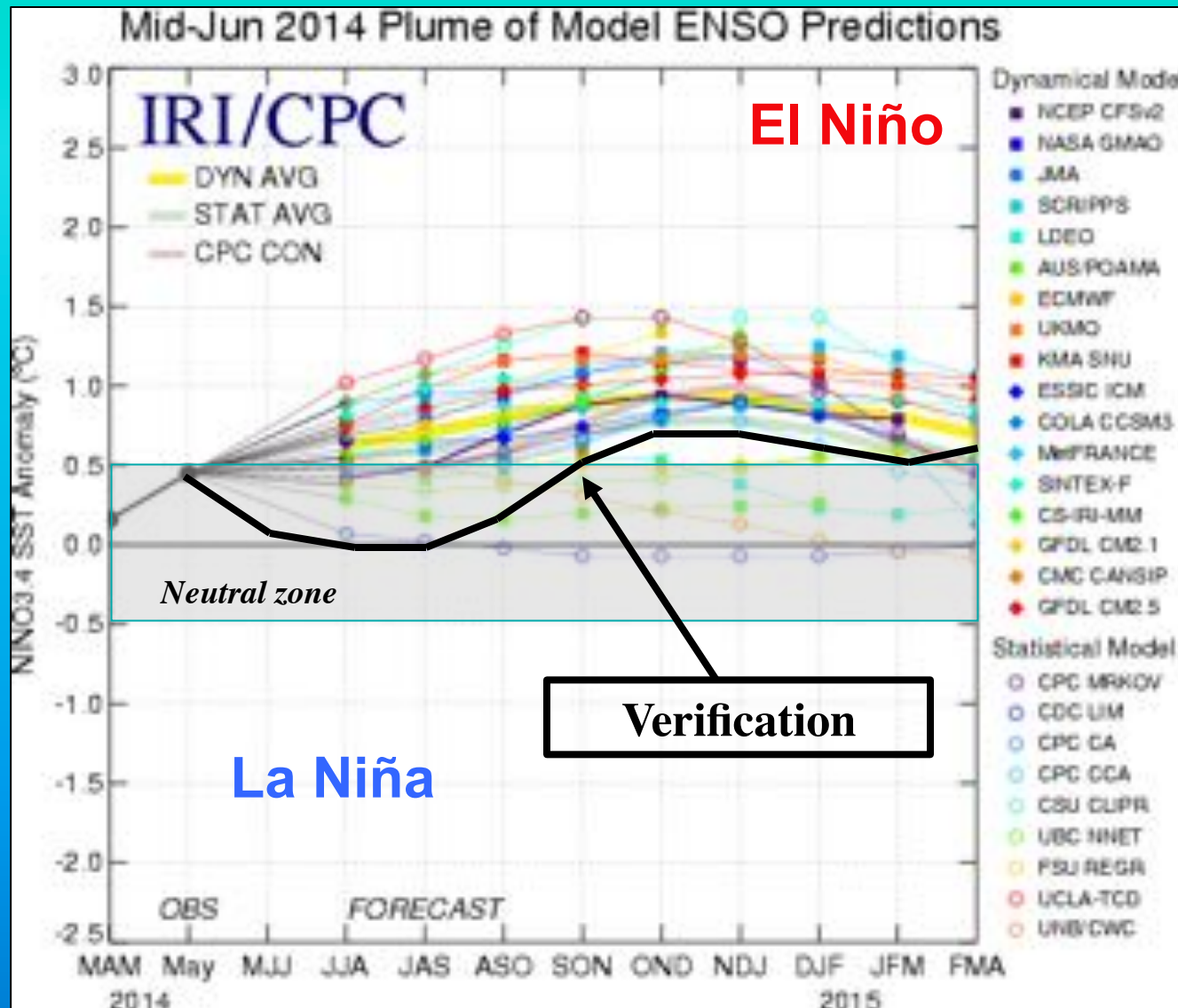
- The time between El Niños is determined by the time to recharge.



Heat content based on TAO/
TRITON, XBT, and Argo data



Niño-3.4 Predictions From June 2014



“The chance of El Niño is about 70% during the Northern Hemisphere summer and is close to 80% during the fall and early winter.”

NOAA/NCEP
10 July 2014

NOAA El Niño Watch Advisories

10 July 2014: “The chance of El Niño is about 70% during the Northern Hemisphere summer and is close to 80% during the fall and early winter.”

7 Aug 2014: “The chance of El Niño has decreased to about 65% during the Northern Hemisphere fall and early winter.”

4 Sept 2014: “The chance of El Niño is 60-65% during the Northern Hemisphere fall and winter.”

6 Nov 2014: “There is a 58% chance of El Niño during the Northern Hemisphere winter, which is favored to last into the Northern Hemisphere spring 2015”

8 Jan 2015: “There is an ~50-60% chance of El Niño conditions during the next two months...the consensus favors a weak event that ends in early Northern Hemisphere spring”



The ^{big} One?



El Niño Fizzle: No Relief Likely for California Drought

KQED Science Network 7 Aug 2014

Chances for El Niño this winter ‘sputtering’

Reno Daily Gazette 8 Aug 2014

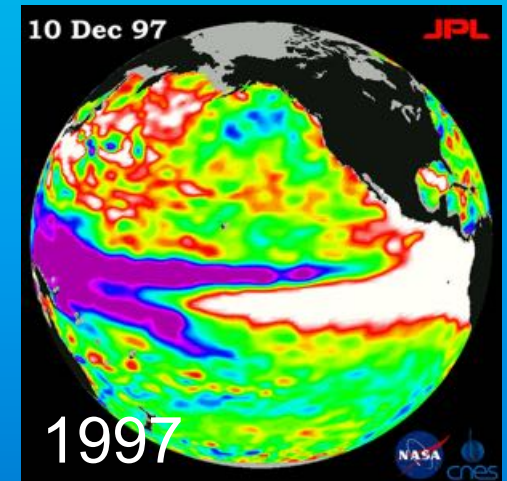
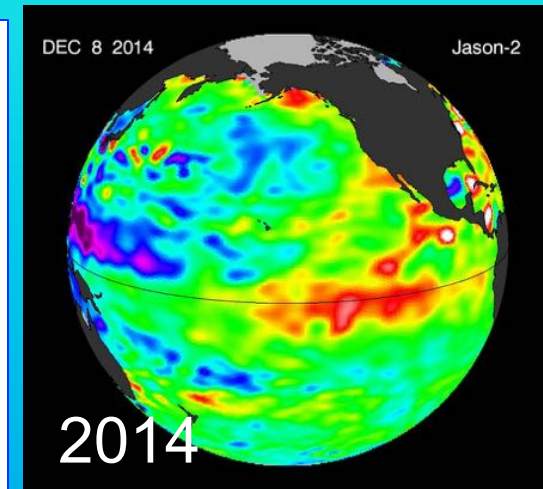
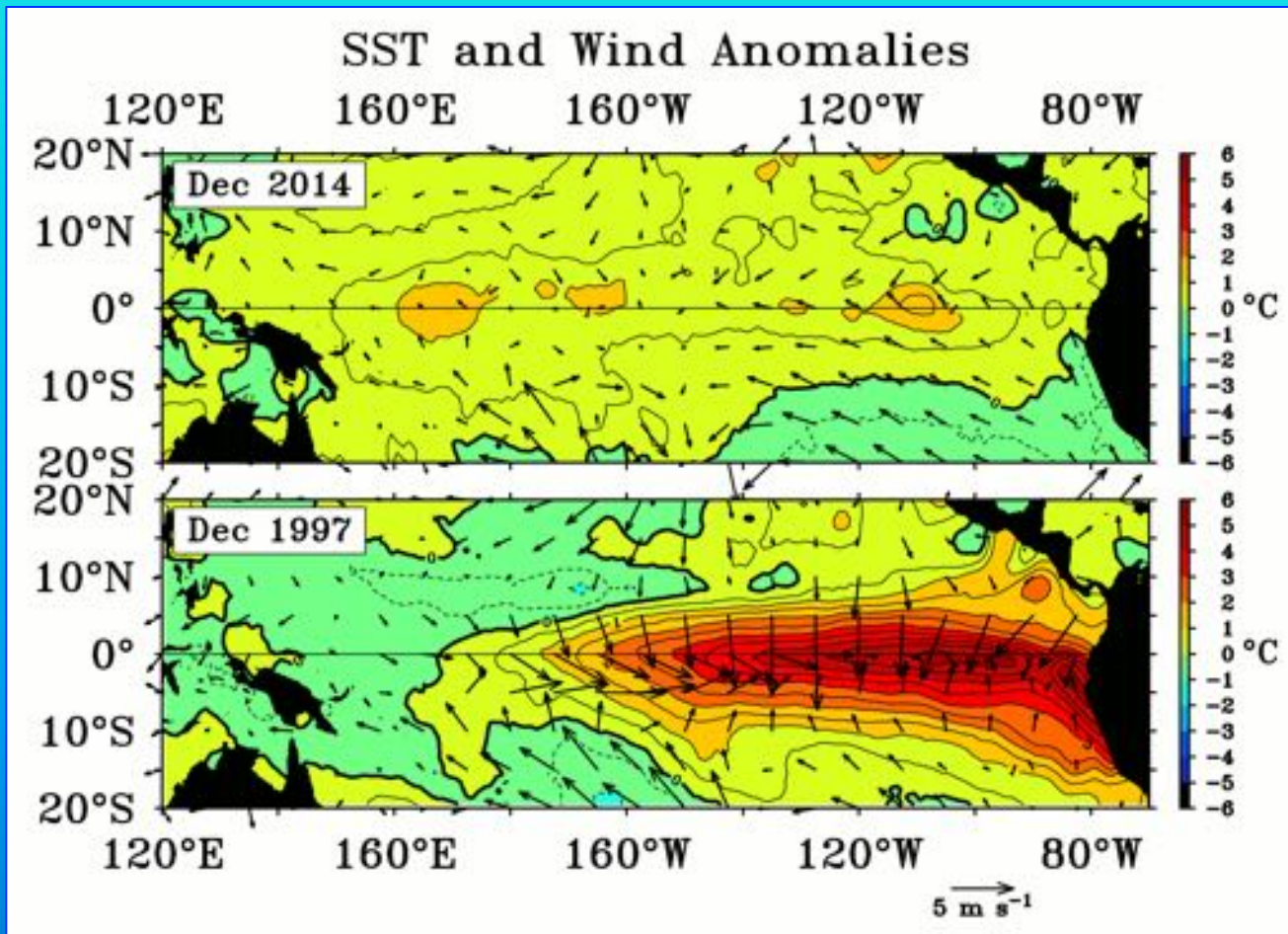
To El Niño or not to El Niño, that is the question

Deep Sea News 13 Sept 2014

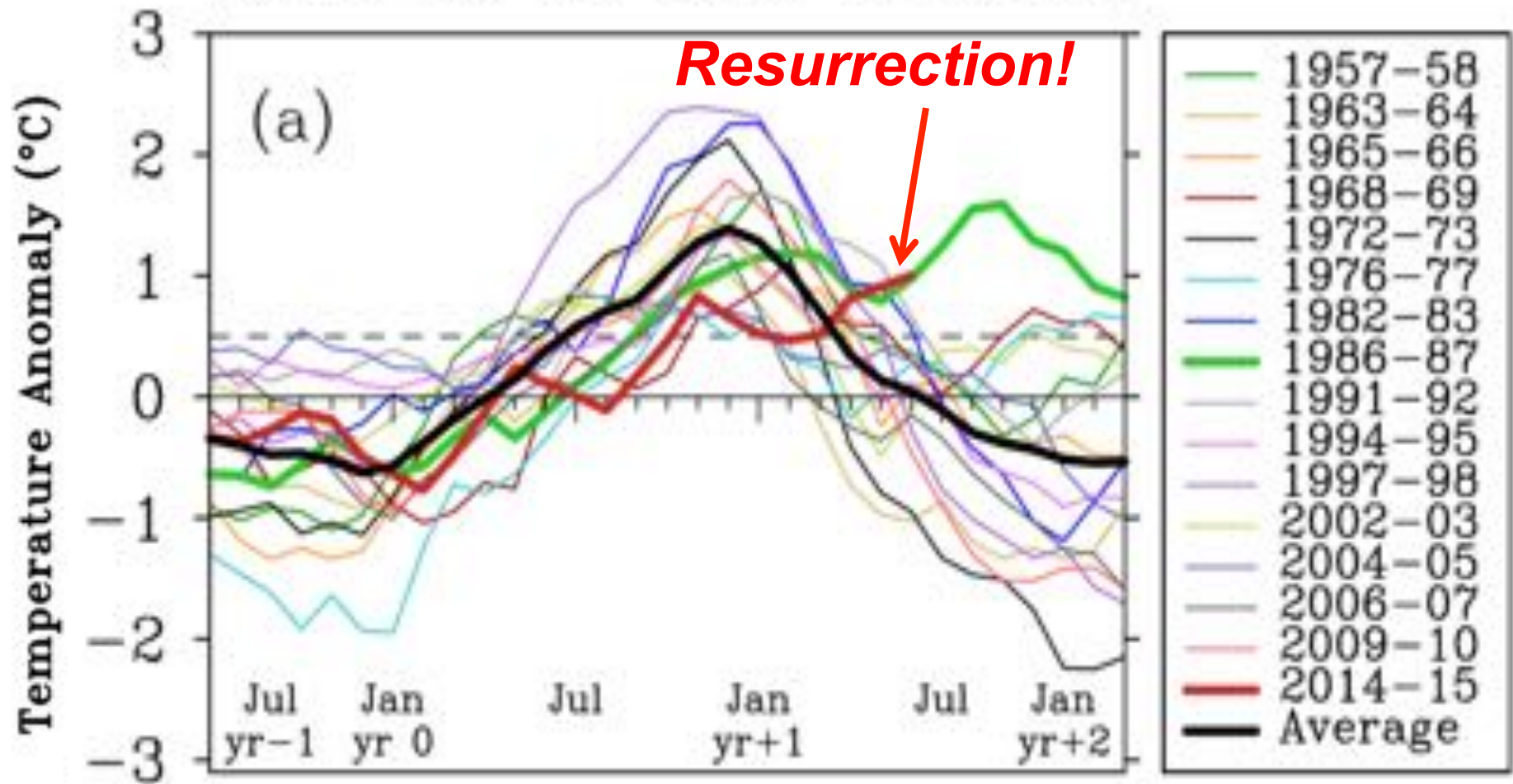
**Scientists were expecting a big El Niño this year. So
where did it go?**

Vox 3 Oct 2014

Demise of the Big El Niño

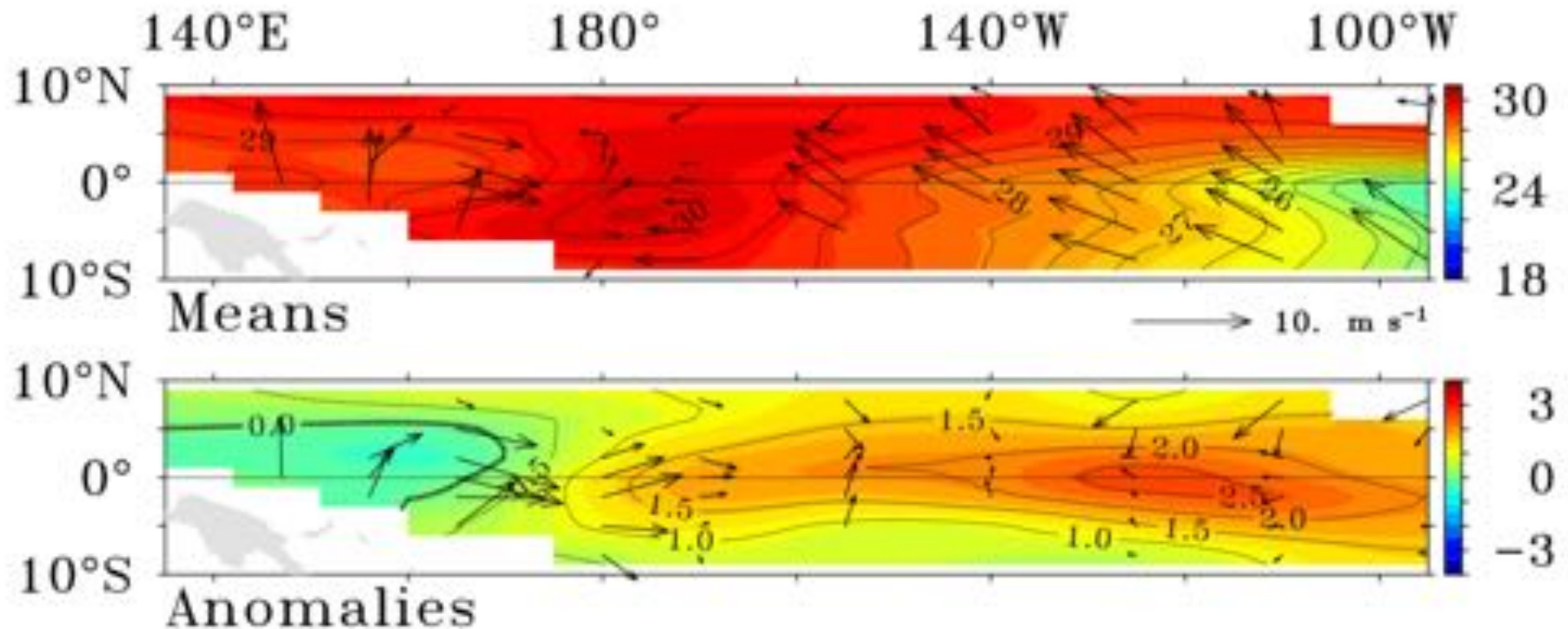


2014-15 vs. Past El Niños



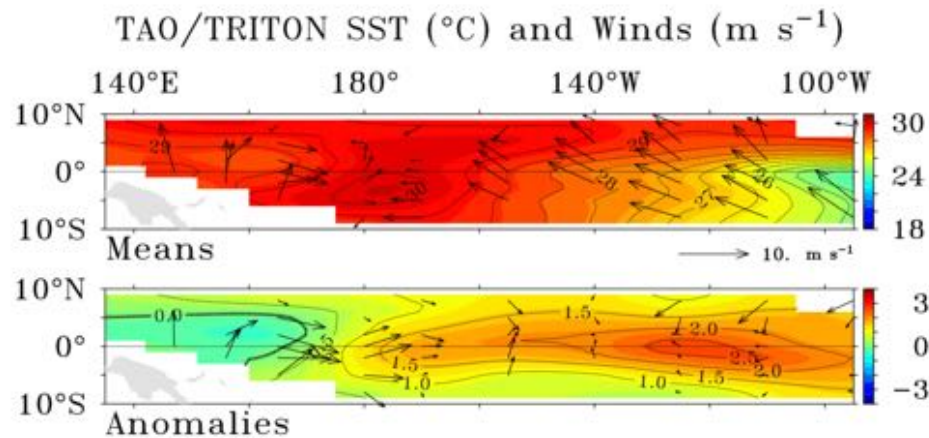
Current Conditions

TAO/TRITON SST ($^{\circ}\text{C}$) and Winds (m s^{-1})



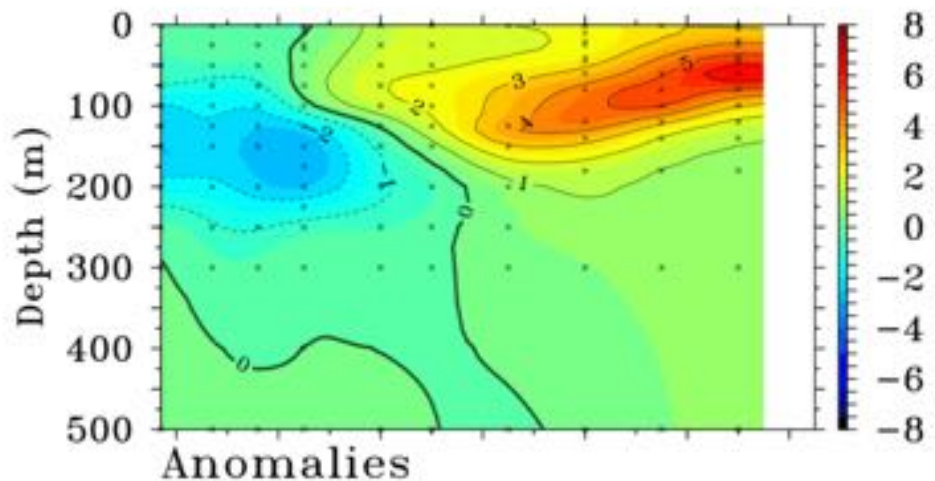
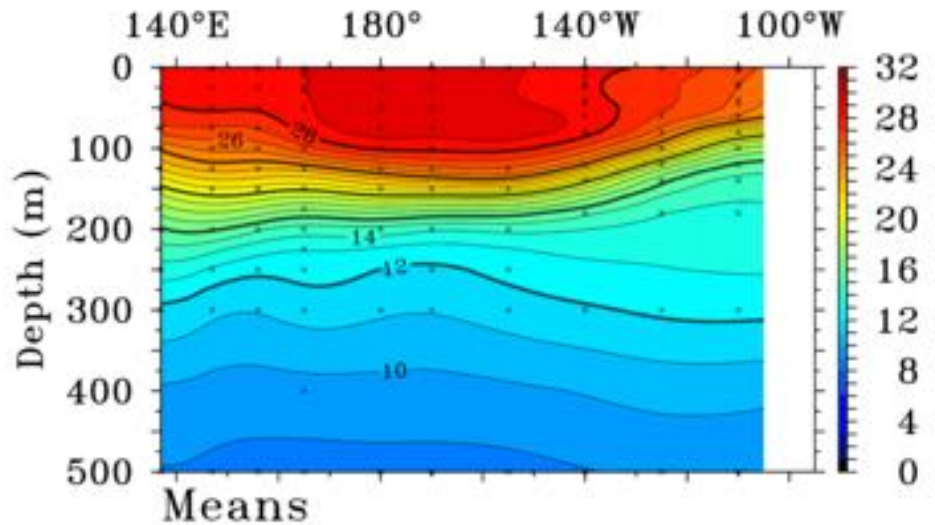
Five-Day Analysis Ending on August 3 2015

Current Conditions

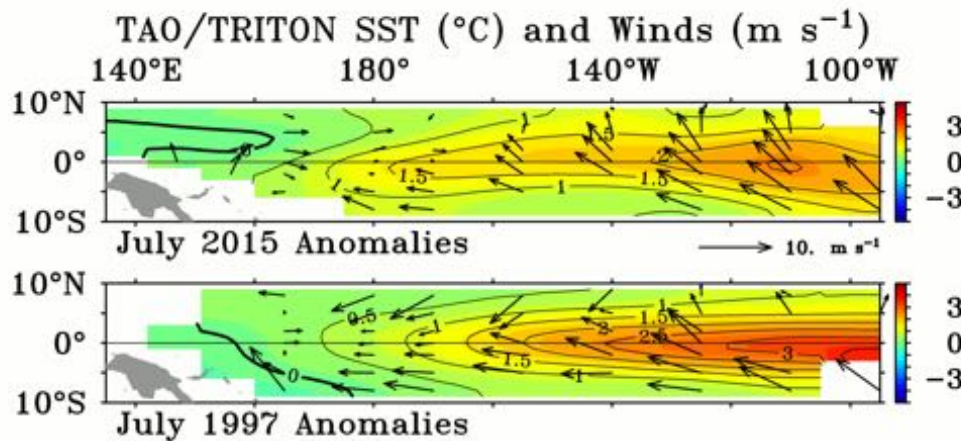


Five-Day Analysis Ending on August 3 2015

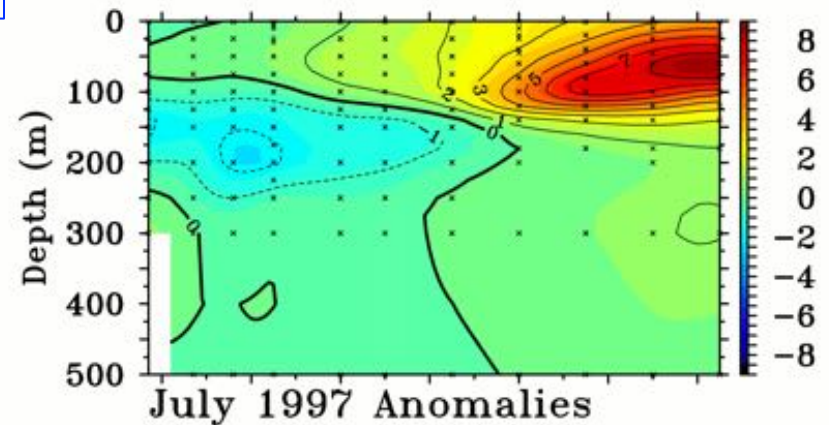
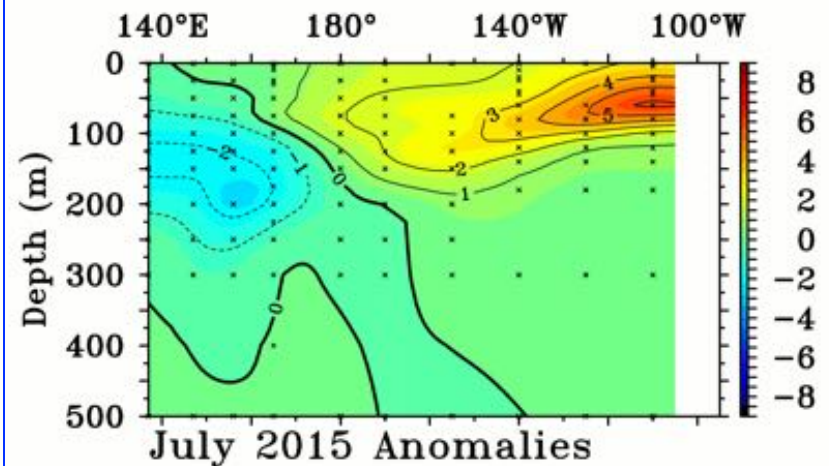
TAO/TRITON 5-Day Temperature ($^{\circ}\text{C}$)
End Date: August 3 2015 2°S to 2°N Average



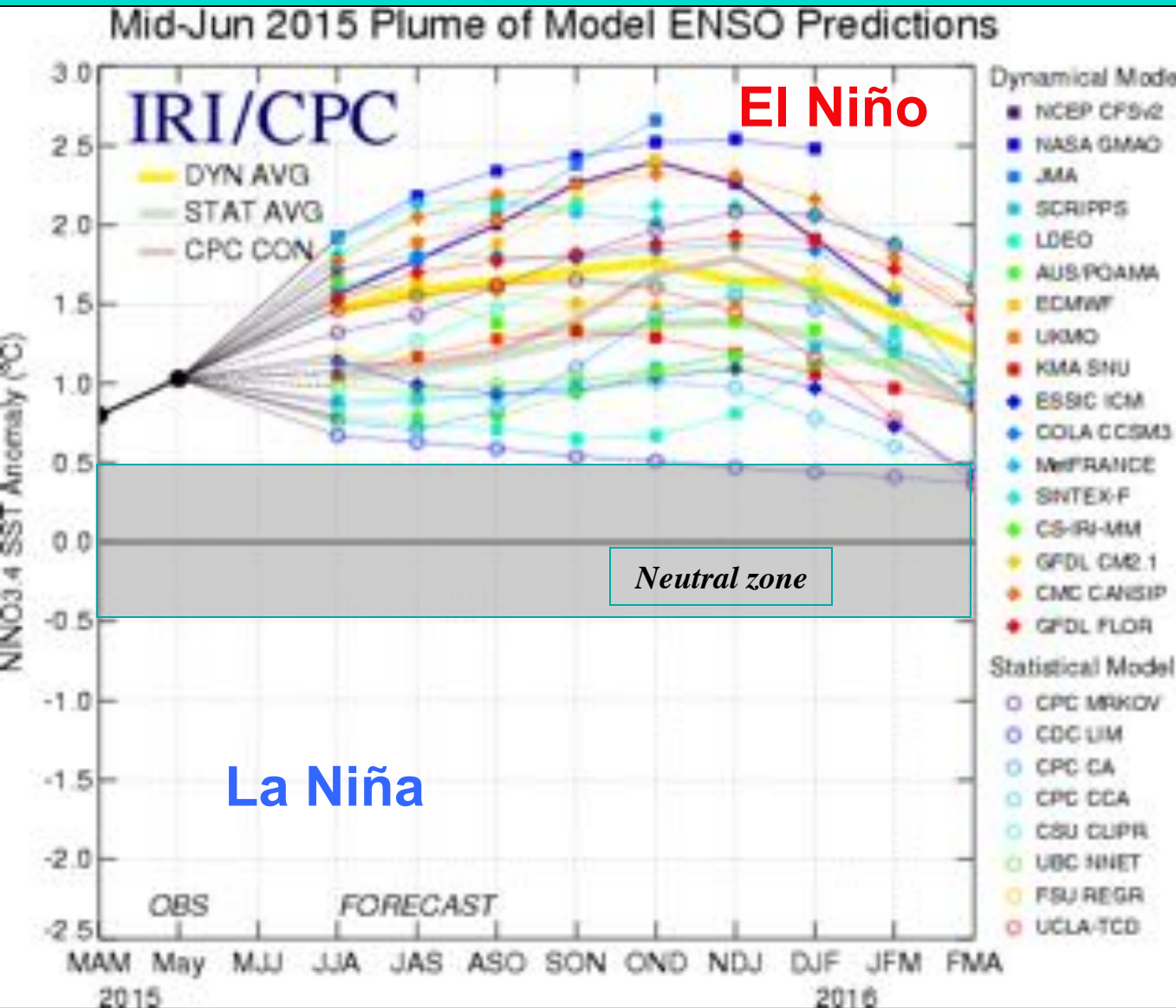
July 2015 vs July 1997



Monthly TAO/TRITON Temperatures ($^{\circ}\text{C}$)
2°S to 2°N Average



Niño-3.4 Predictions: May 2015 Initial Conditions



“There is a greater than 90% chance that El Niño will continue through Northern Hemisphere fall 2015...the consensus of forecasters...favors a strong event.”

NOAA/NCEP
9 July 2015

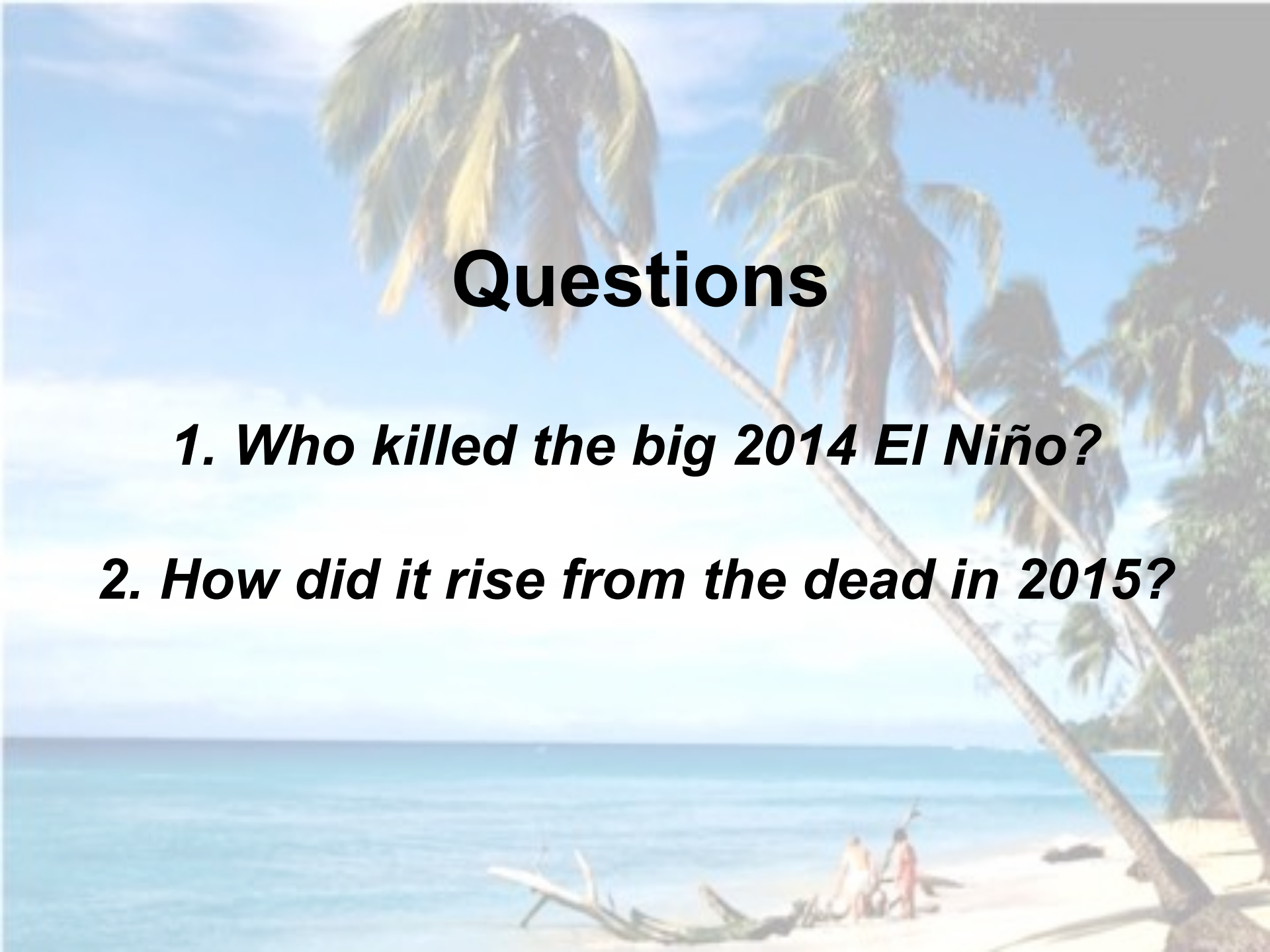
“There is an ~50-60% chance of El Niño conditions during the next two months...the consensus favors a weak event that ends in early Northern Hemisphere spring.”

NOAA/NCEP
8 Jan 2015

Questions

1. Who killed the big 2014 El Niño?

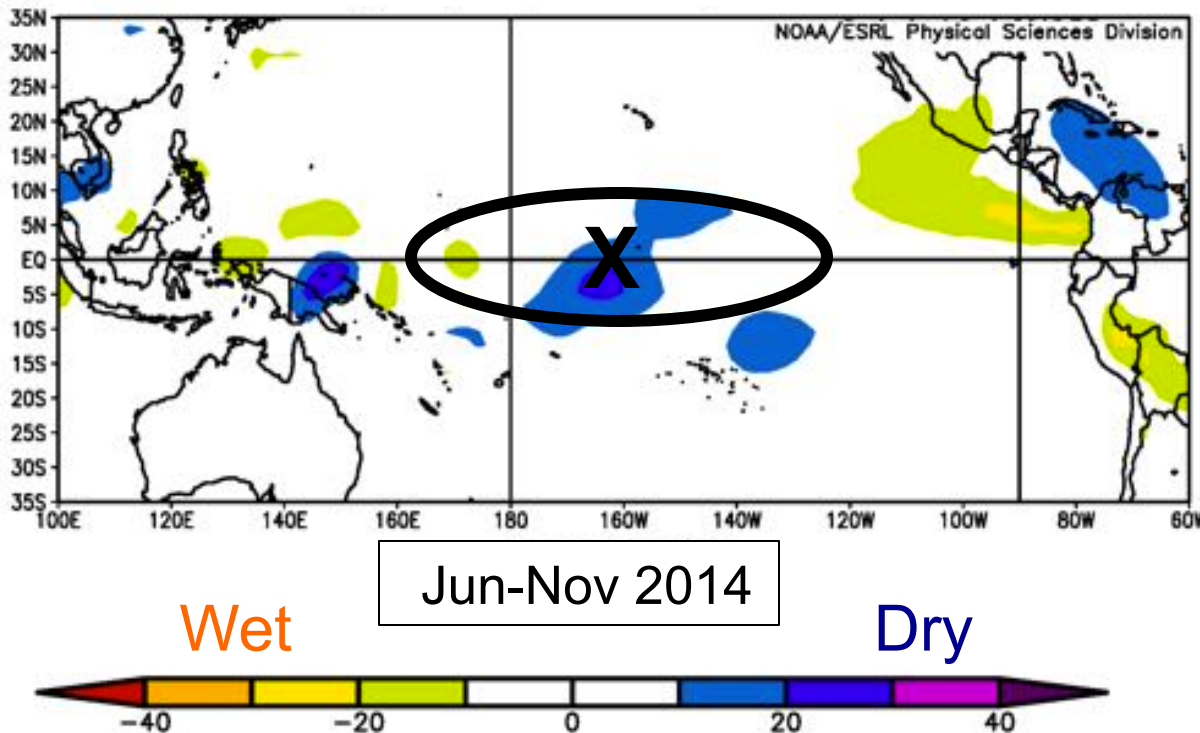
2. How did it rise from the dead in 2015?



Atmosphere is not Engaged!

No Organized Persistent Deep Convection Near Dateline

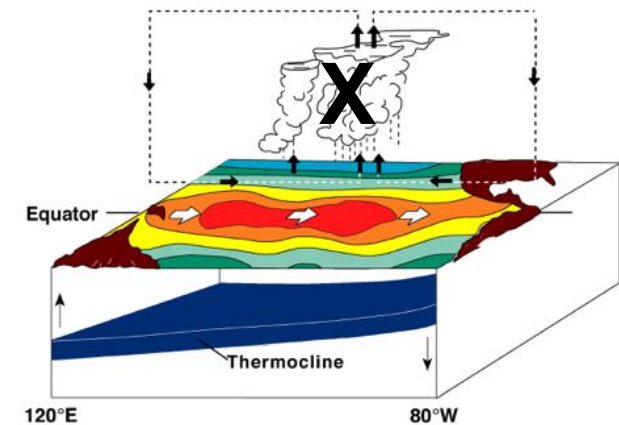
Outgoing Longwave Radiation



“...rainfall continued to be below average near the Date Line...and near average east of the Date Line.”

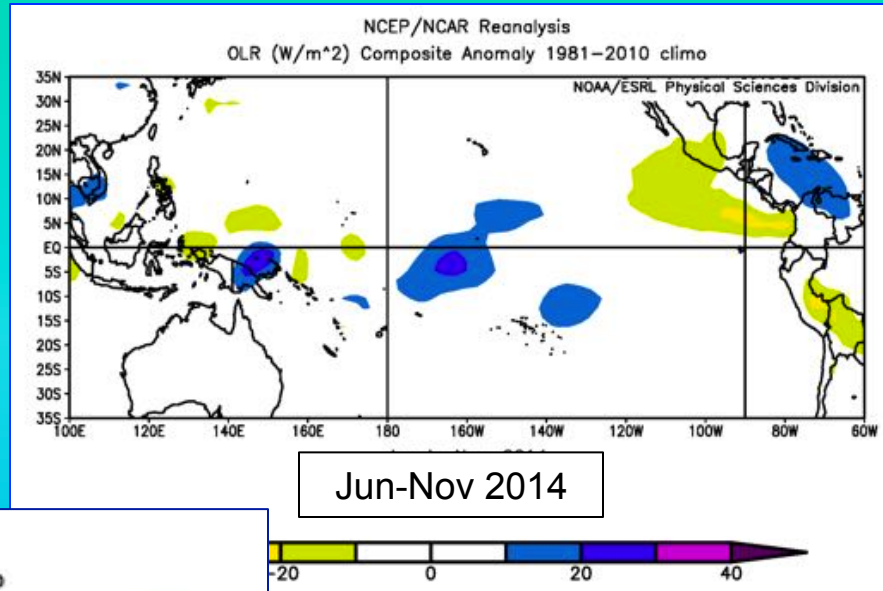
***NOAA El Niño Watch
4 Dec 2014***

El Niño Conditions

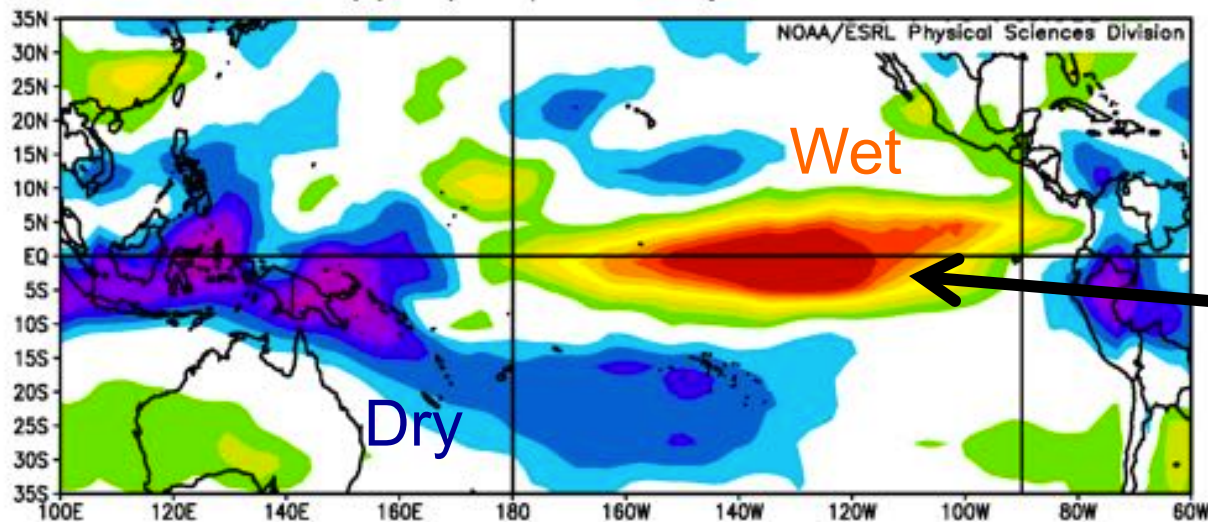


Outgoing Longwave Radiation: An indicator of deep convection and heavy rainfall

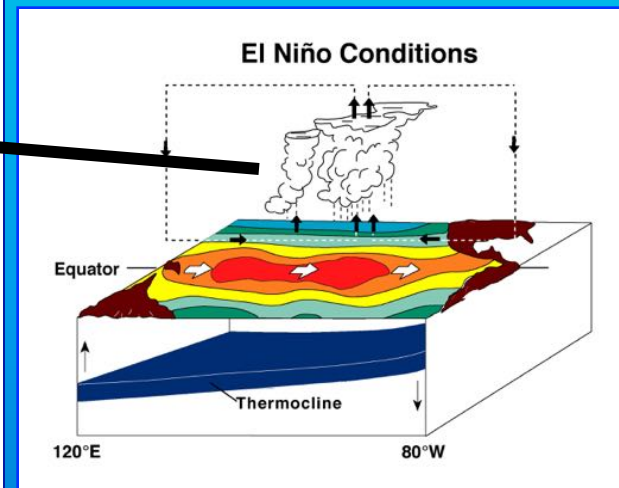
2014 vs 1997



NCEP/NCAR Reanalysis
OLR (W/m^2) Composite Anomaly 1981–2010 climo

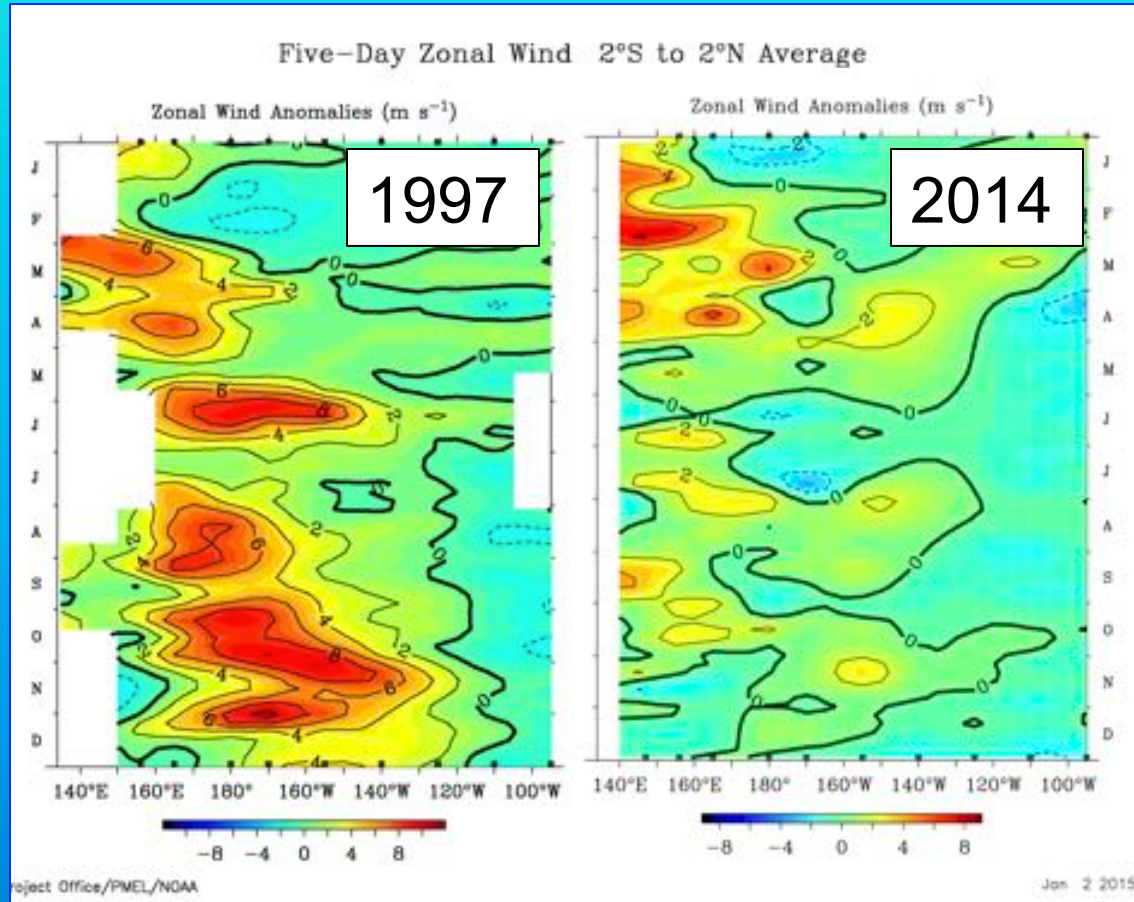


Jun-Nov 1997



Who Killed the Big 2014 El Niño?

Westerly Wind Bursts Too Weak?



Menkes et al, 2014, GRL

Who Killed the Big 2014 El Niño?

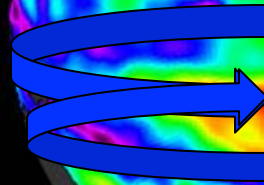
Early Onset Negative Feedbacks?

6 Apr 2014

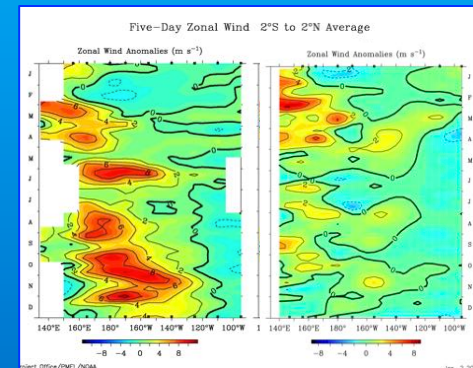
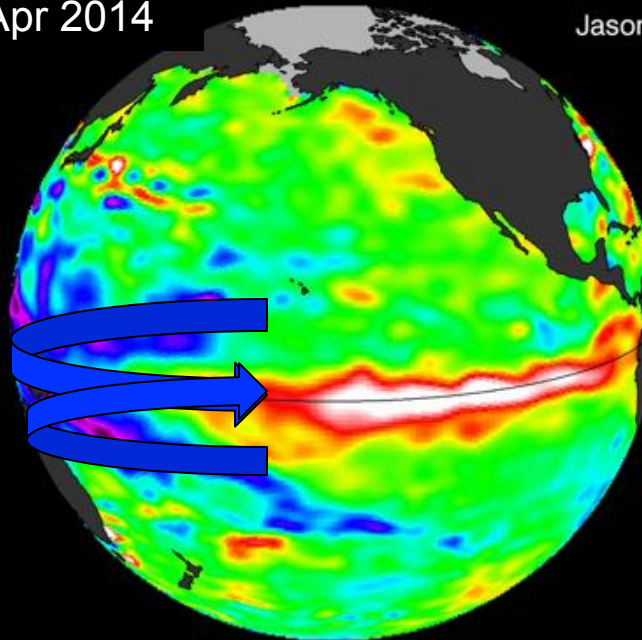
Jason-2

***Upwelling
Rossby Wave***

***→Upwelling
Kelvin Wave →
SST Cooling***

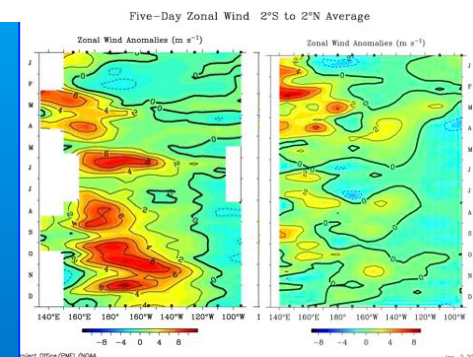
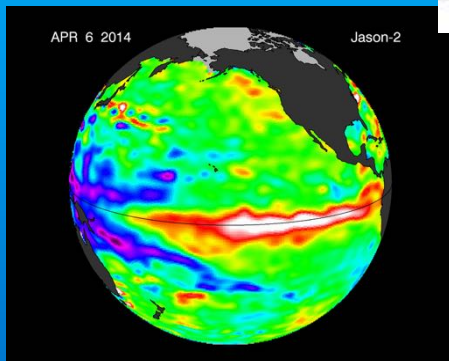
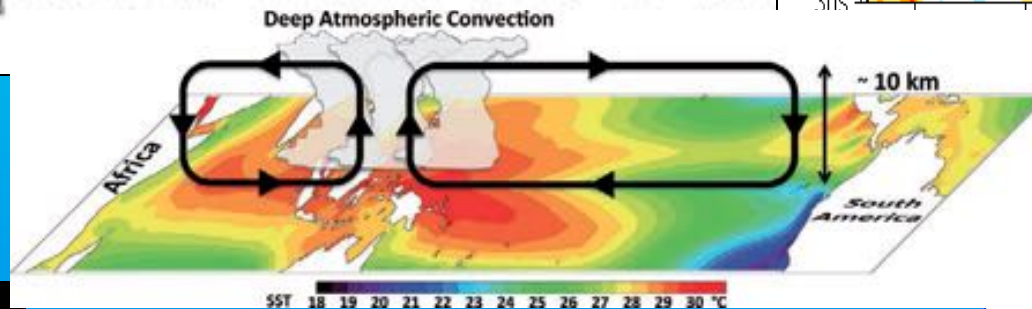
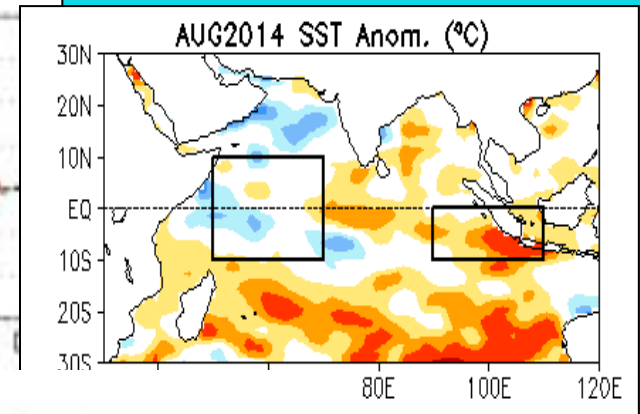
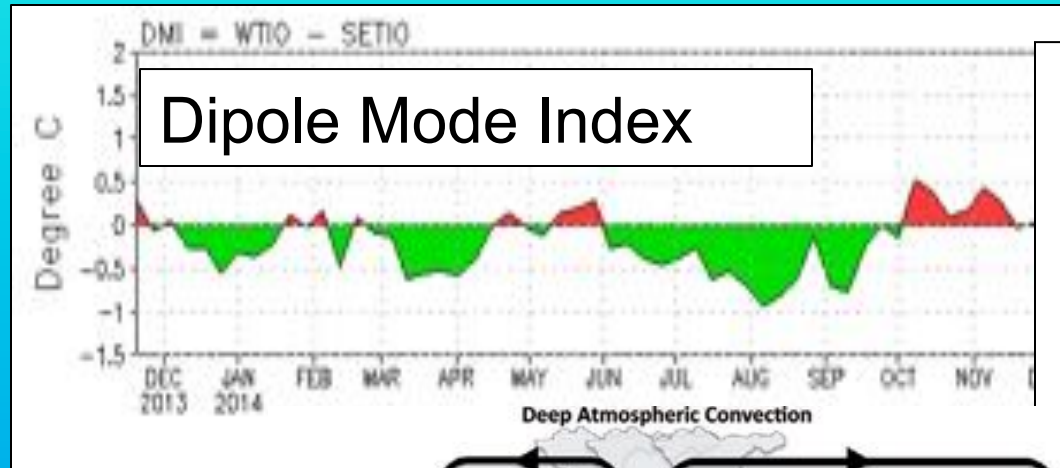


***Downwelling
Kelvin Wave
→SST Warming***



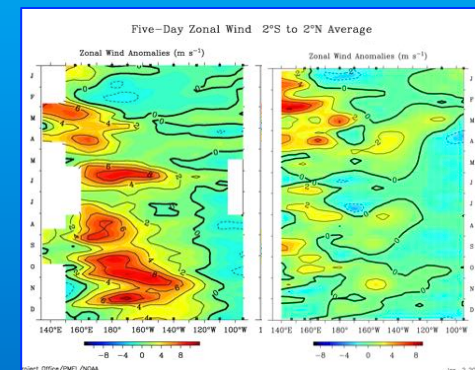
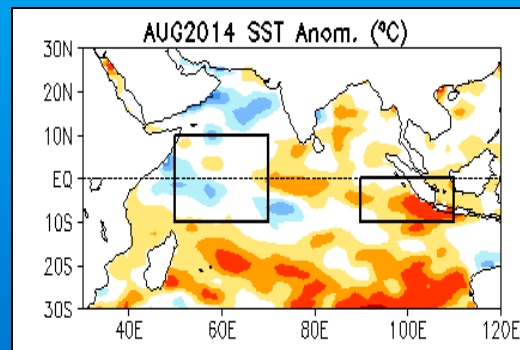
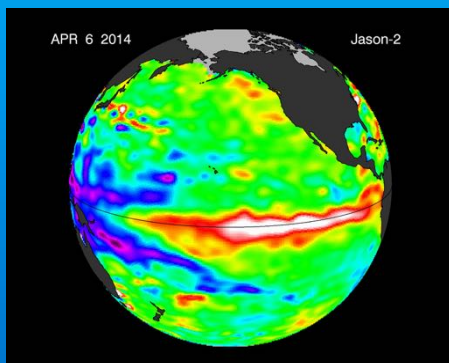
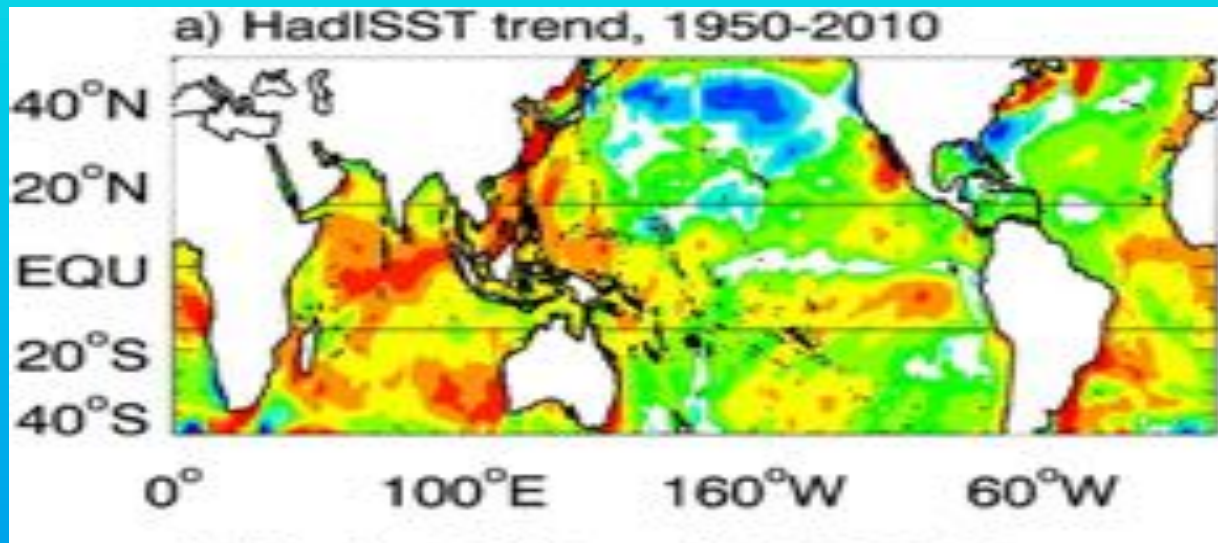
Who Killed the Big 2014 El Niño?

Negative Indian Ocean Dipole in 2014?



Who Killed the Big 2014 El Niño?

Indo-Pacific Warm Pool Warming Trends? (Cravatte et al, 2009; Han et al 2014)

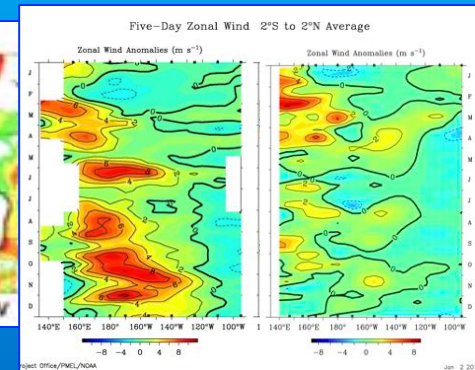
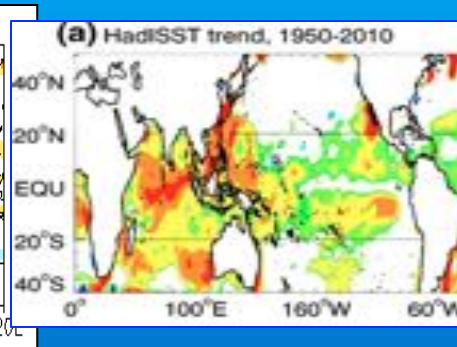
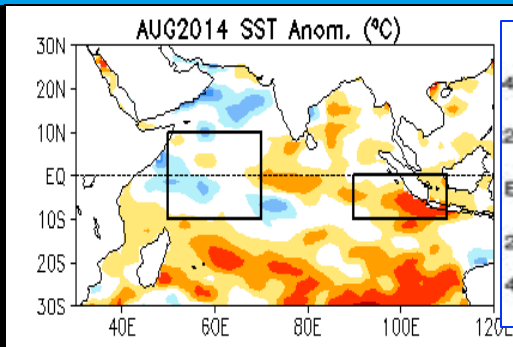
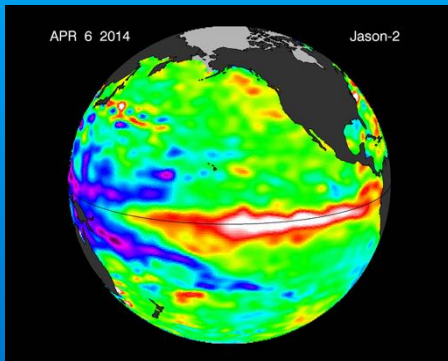
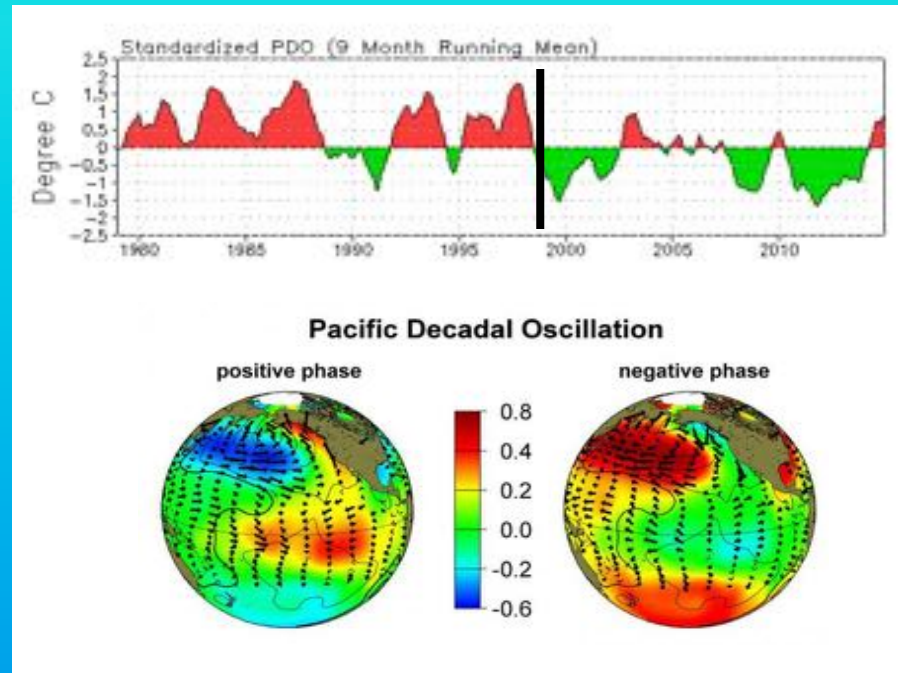


Who Killed the Big 2014 El Niño?

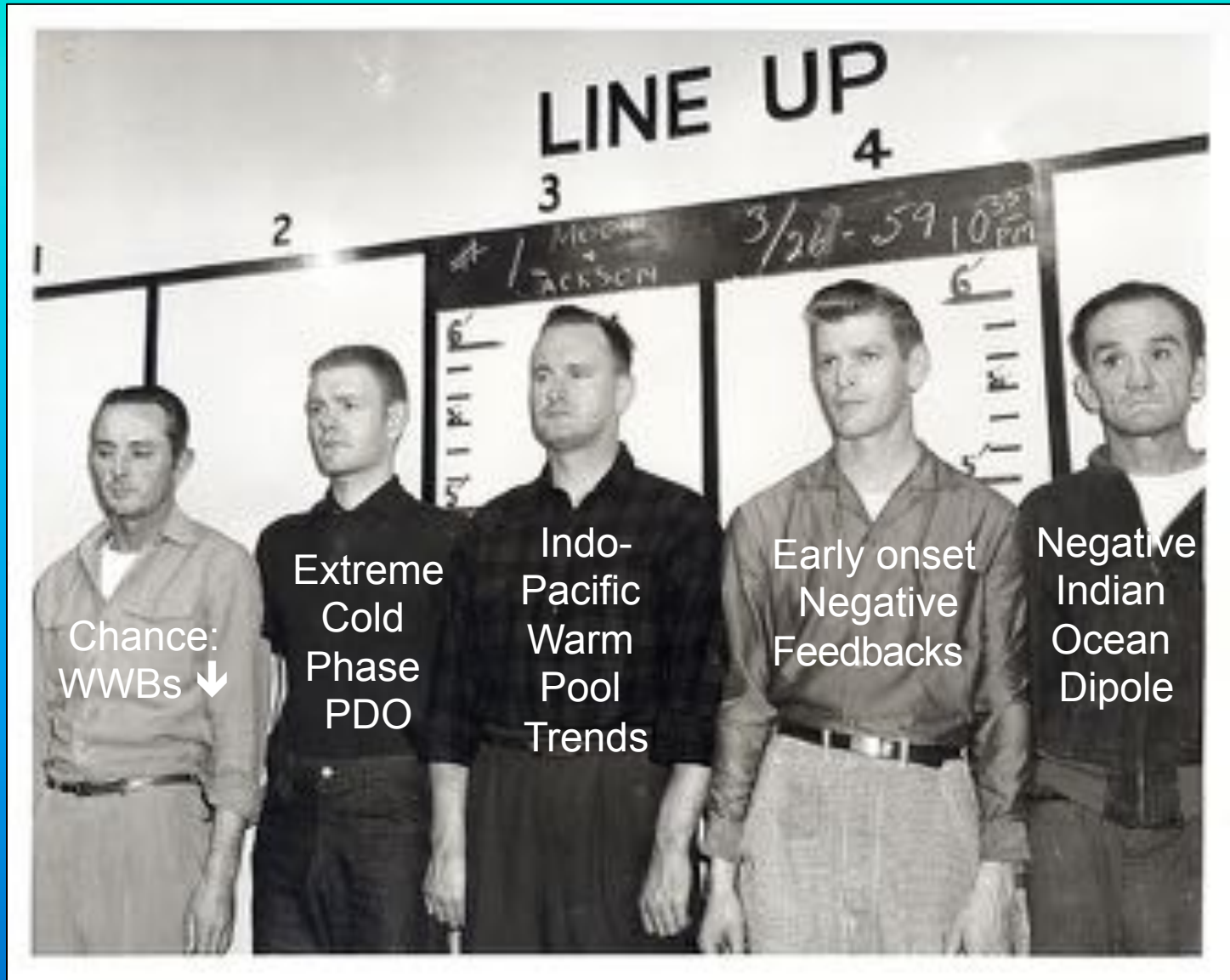
Cold Phase of PDO?

“...strengthening in Pacific trade winds over the past two decades—unprecedented in observations...”

England et al, 2014



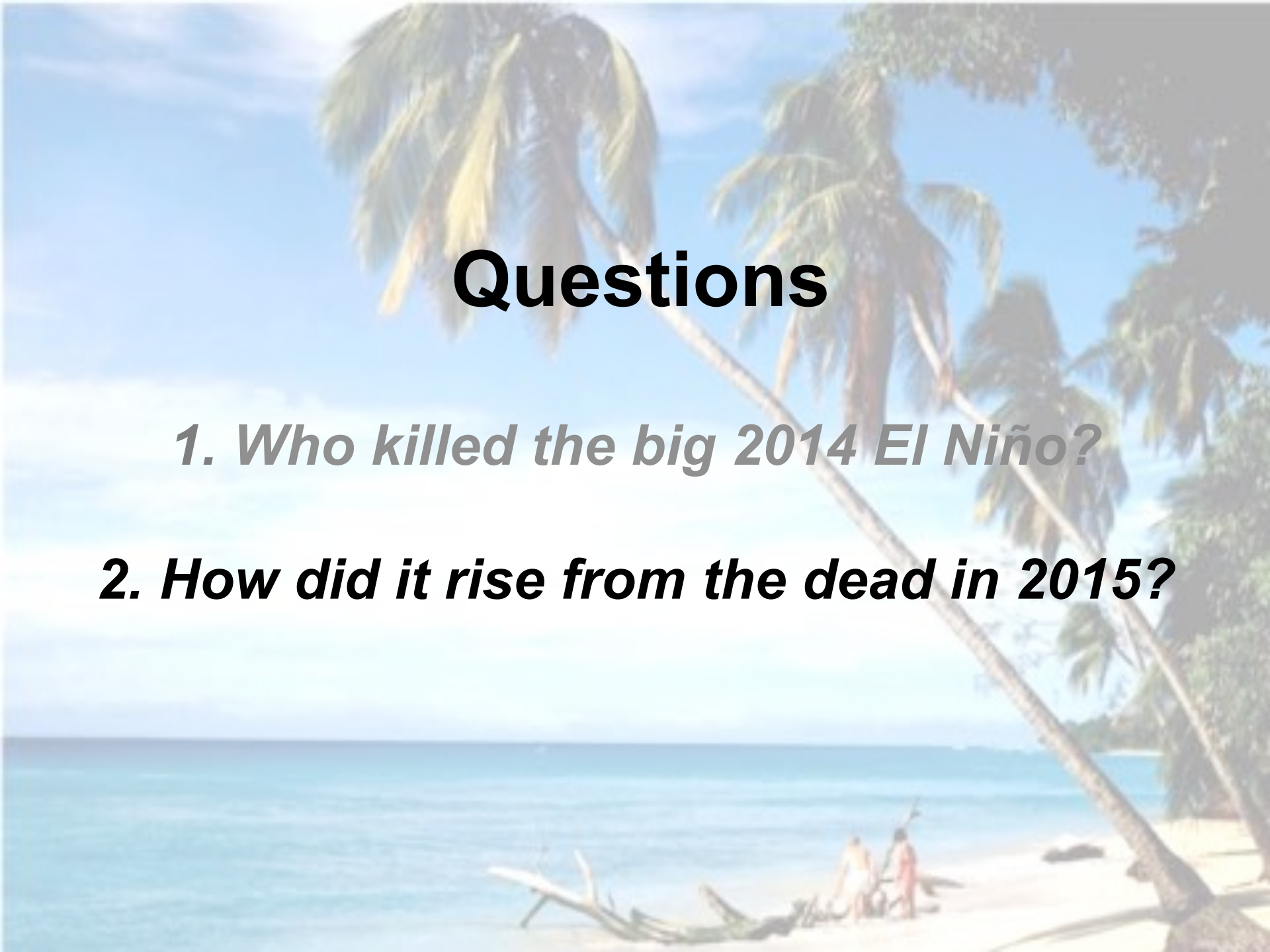
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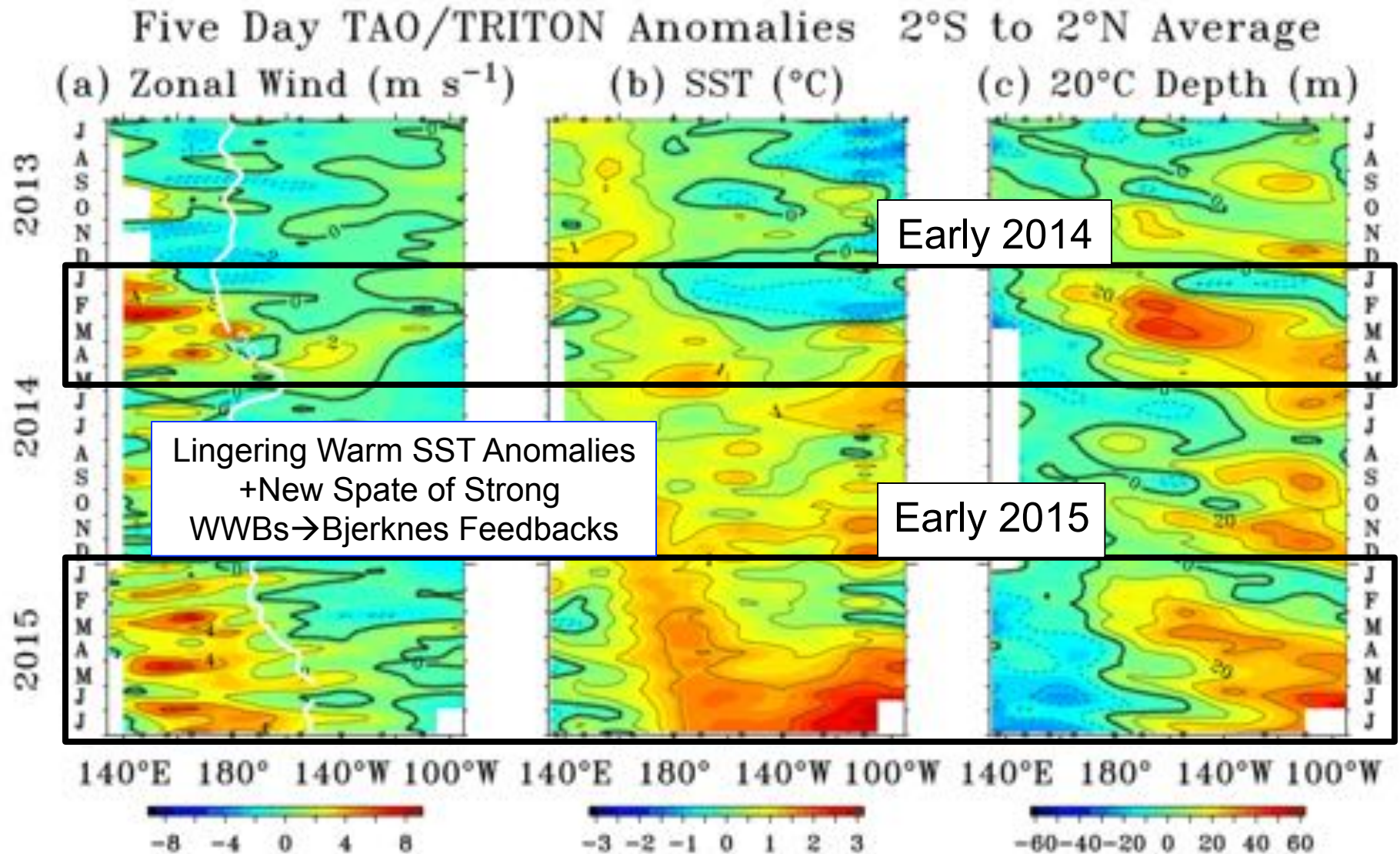
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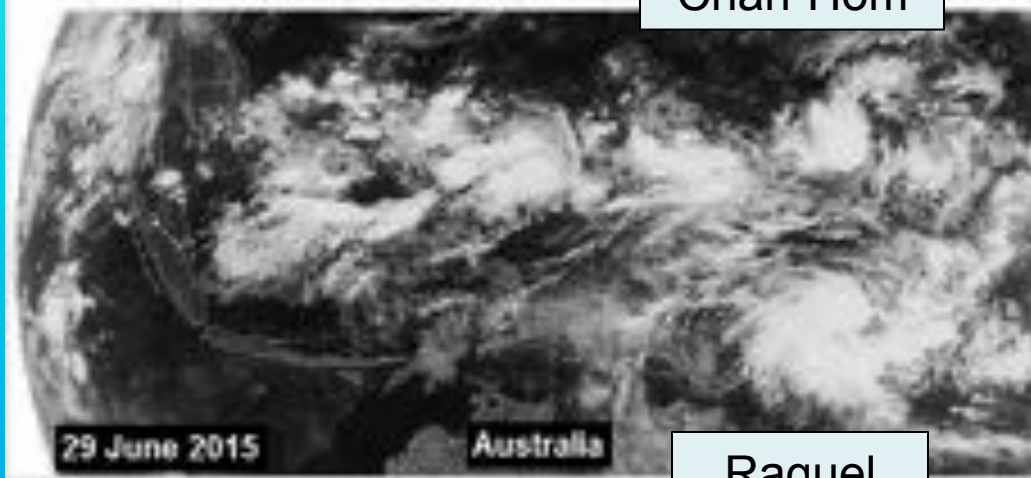


Evolution: July 2013-July 2015



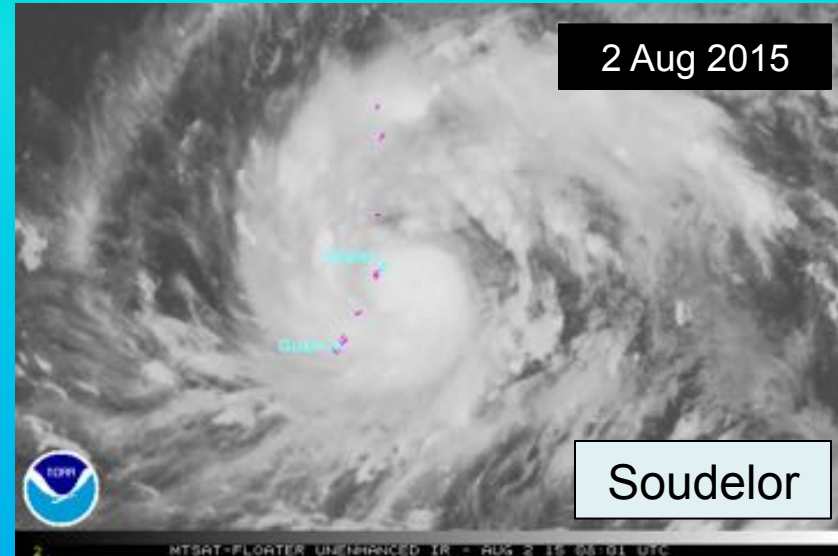
WWBs Related to Unusual Cyclone Activity in 2015

Chan-Hom



Raquel

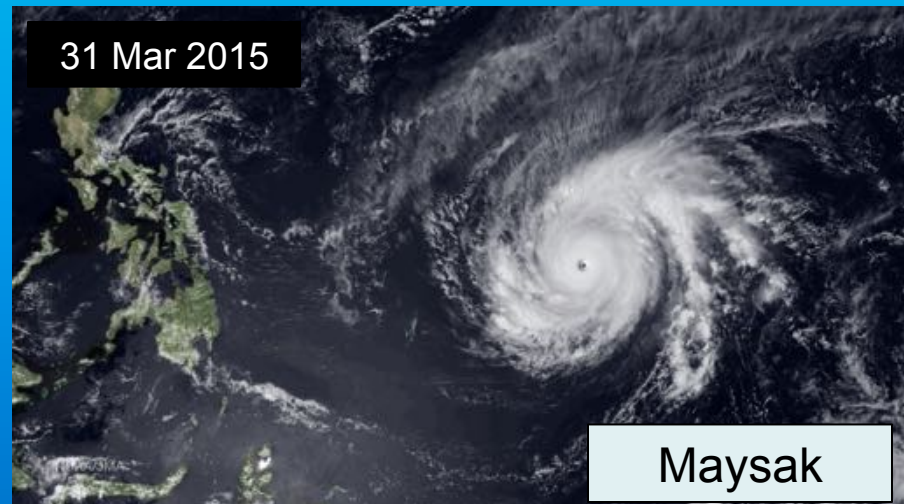
2 Aug 2015



Soudelor

Warm SSTs→
Cyclones→
WWBs→
Warm SSTs

31 Mar 2015



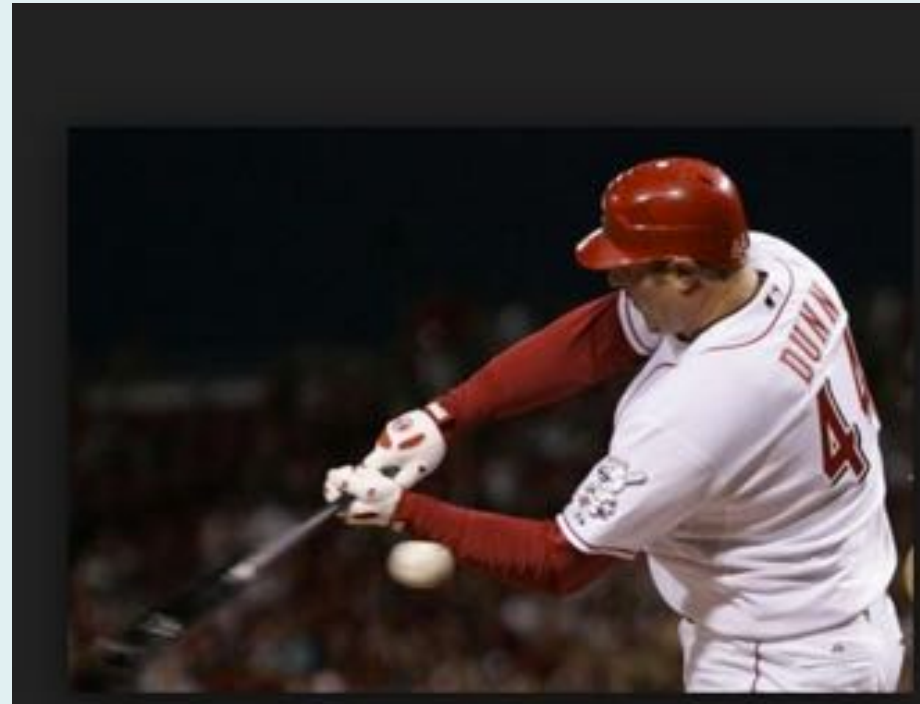
Maysak

Team El Niño

***Strike 1: Strong El Niño
→ Very Weak in 2014***

***Strike 2. Very Weak El Niño
→ Strong in 2015***

***Strike 3. Communications
morass***



“...collectively, the combined atmosphere and oceanic state remains ENSO-neutral.”

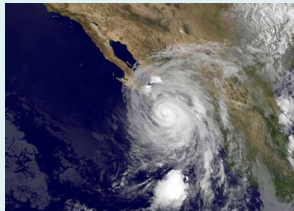
NOAA 4 Dec 2014

But there were impacts...



India's 2014 monsoon ends with double-digit rain deficit
Reuters 30 September 2014

“The four-month long monsoon season ended with 12 percent below average rainfall, making it the worst in five years”



A tale of two oceans: Pacific out-hurricanes Atlantic
USA Today 6 November 2014

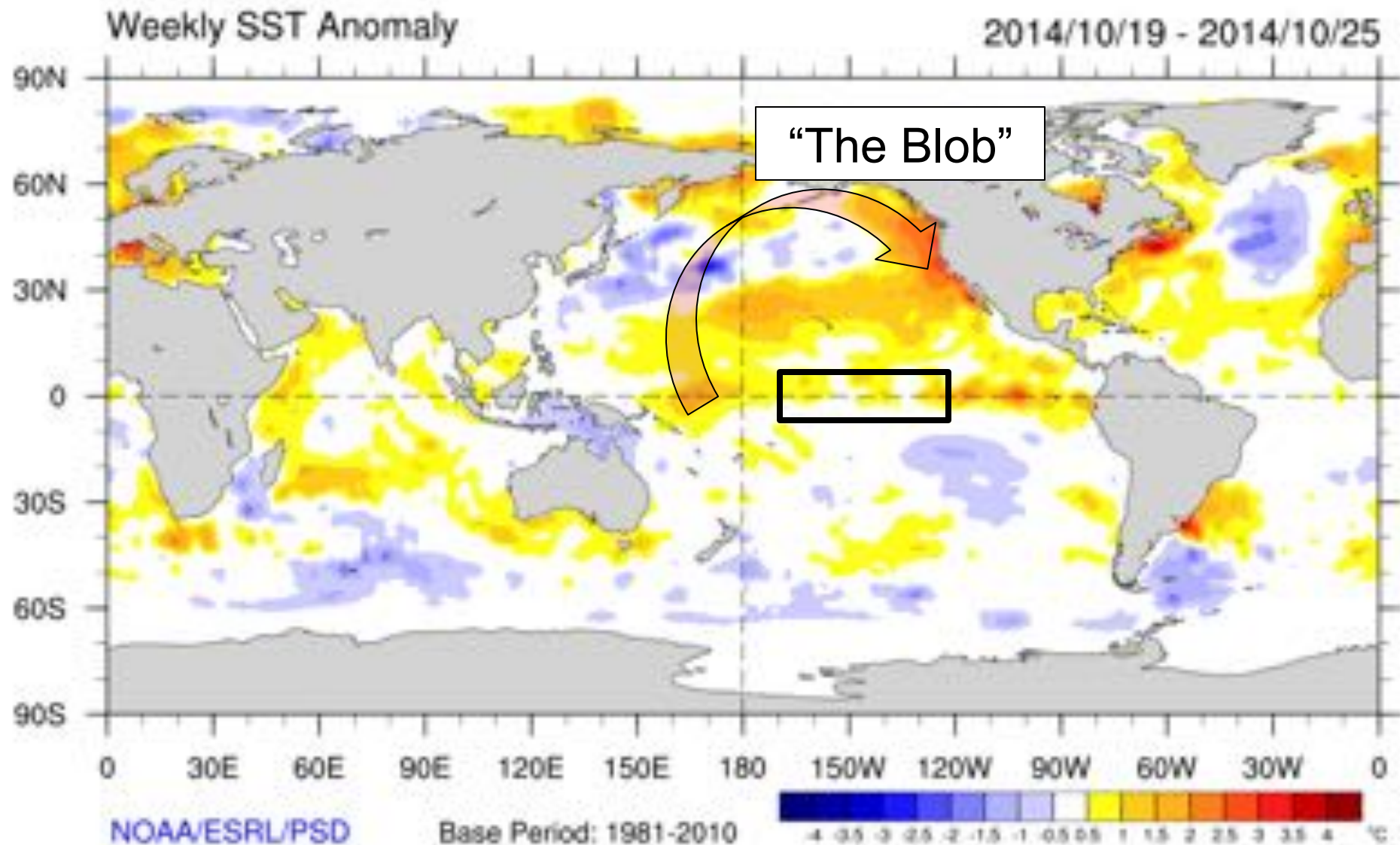
“...quiet Atlantic and active Pacific is typical of the El Niño-like pattern...”



Peru institute advises hold on fishing for second anchovy season
Undercurrent News 7 October 2014

“The advice also took into account the effect of the El Niño...This is still a shock to the industry”

Global SST Anomaly

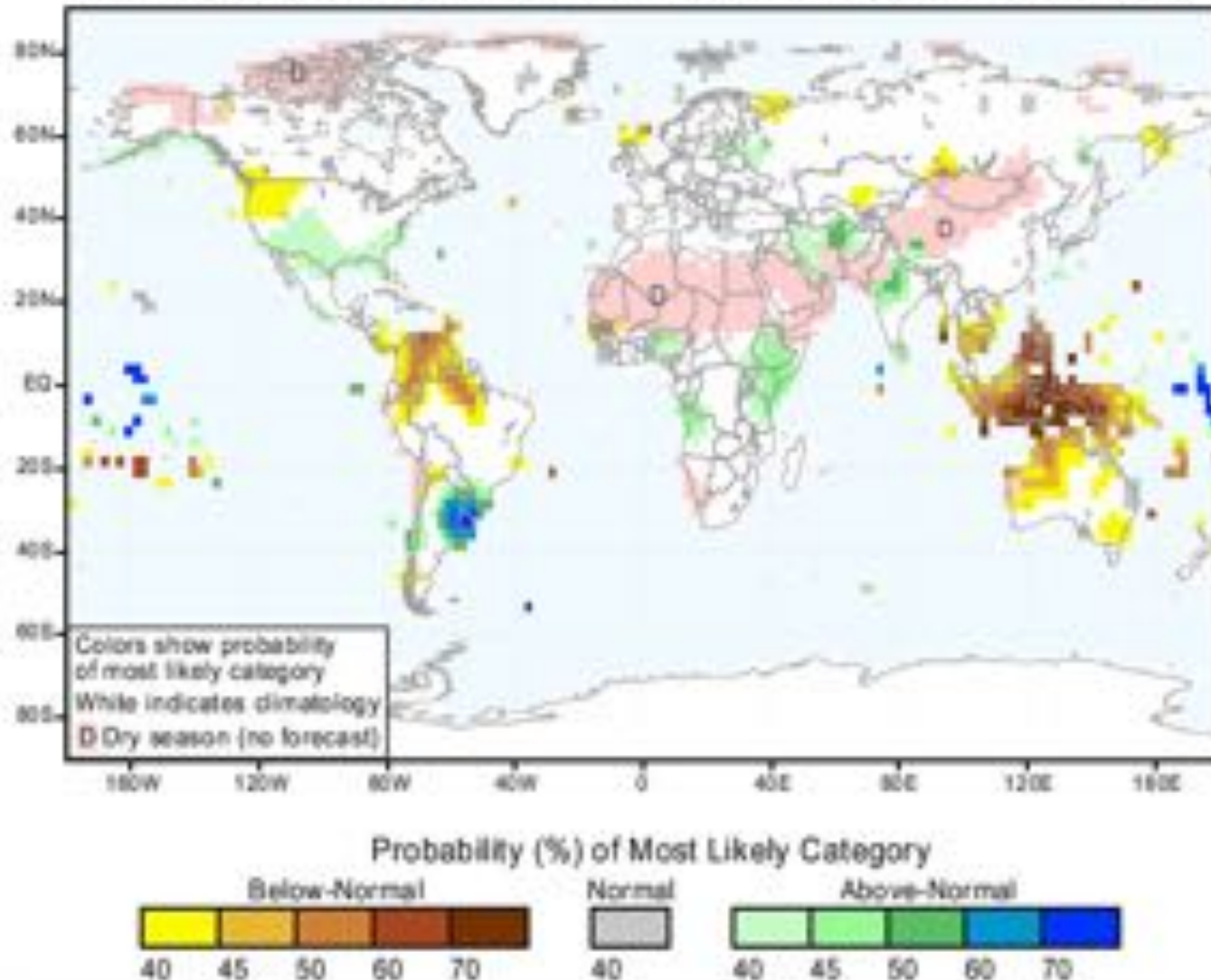


Issues

- 1. Understanding the physical processes accounted for the unusual evolution in 2014-15***
- 2. Determining why forecasts were so wide of the mark***
- 3. Characterizing ENSO in all its diversity***

Precipitation Forecast for OND 2015

IRI Multi-Model Probability Forecast for Precipitation
for October-November-December 2015, Issued June 2015



INFORMA

quil) a pesa
habla de
37 paíse
gro la vici

Global Impacts 1997-98 El Niño

Fatalities: 23,000

Economic Losses: US\$ 36 Billion

Landslides
could cost
\$1 billion
Lacking insurance,
Californians will pay

Prévisions des risques
«EL NIÑO» : LE TERRIBLE PRÉLUDÉ

Tropical fish move
north with El Niño

Early blooms
and a bushel of bugs

IN A RECENT CARTOON A LITTLE BOY
with a sheepish expression stands next to
a shattered vase. He offers the explanation,
"El Niño did it."

No relief
in sight for
Northern
California

Another strong
quake

Storms
pound
Gulf
Coast

California, already
in a drought, expects
floods

El Niño Did It

'Super typhoon' hits Saipan;
winds recorded to 225 mph

SAIPAN, Northern Mariana —
Super Typhoon Joan packed 225
mph winds as it swept through the
Northern Mariana Islands yesterday,
producing widespread damage but
no reported injuries.

Service meteorologist on Guam
said 60,000 residents on Saipan
evacuated concrete shelters to ride out
the storm.

Source: NOAA