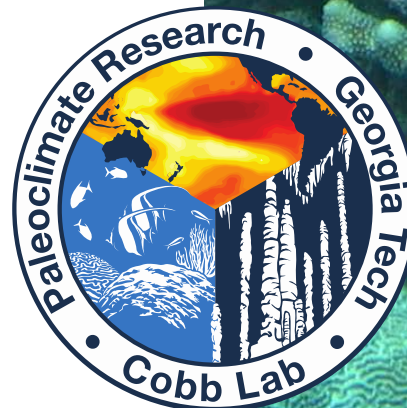
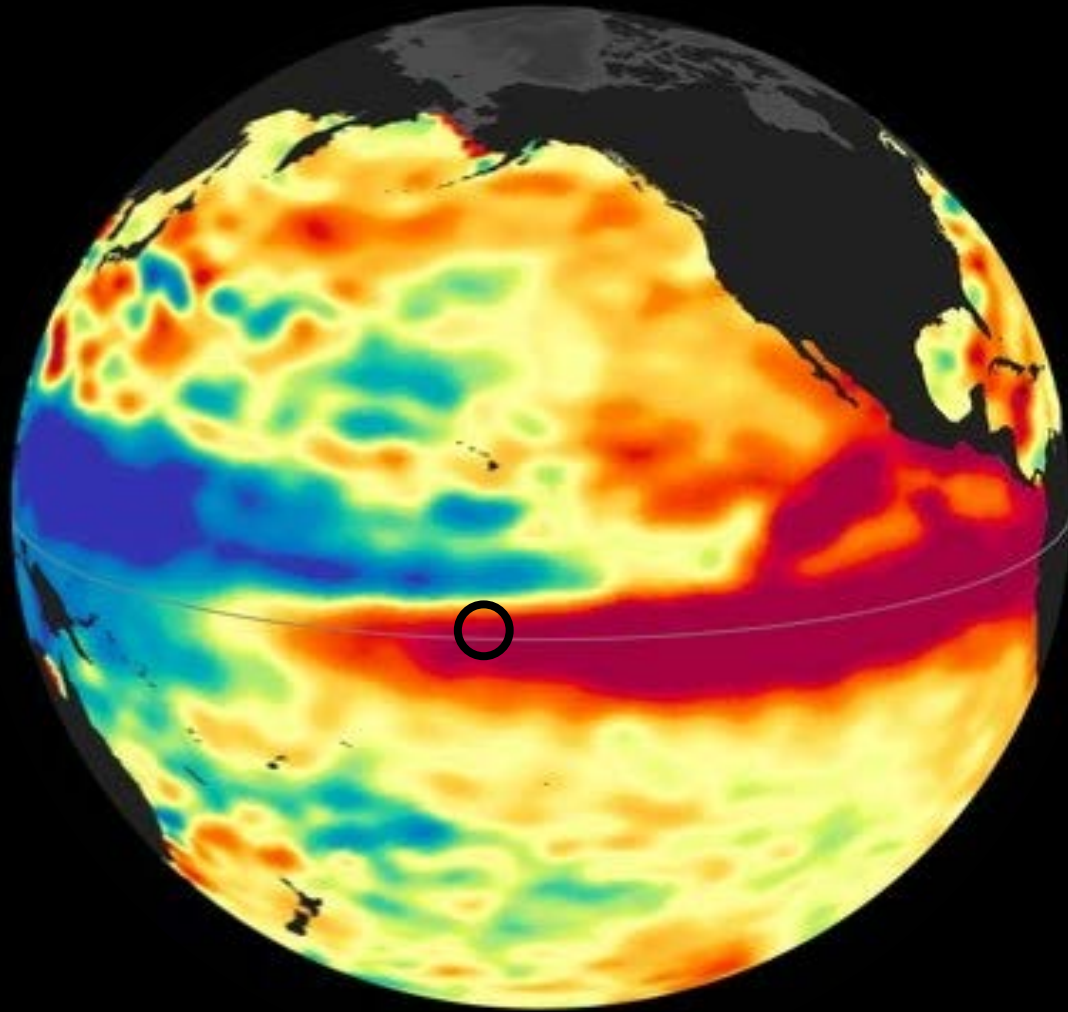


# CORALS & CLIMATE CHANGE: A SHIFTING LANDSCAPE OF RISK

Kim M. Cobb  
@coralsncaves

Pamela Grothe, Hussein Sayani,  
Alyssa Atwood, Tianran Chen,  
Intan Nurhati, Gemma O'Connor





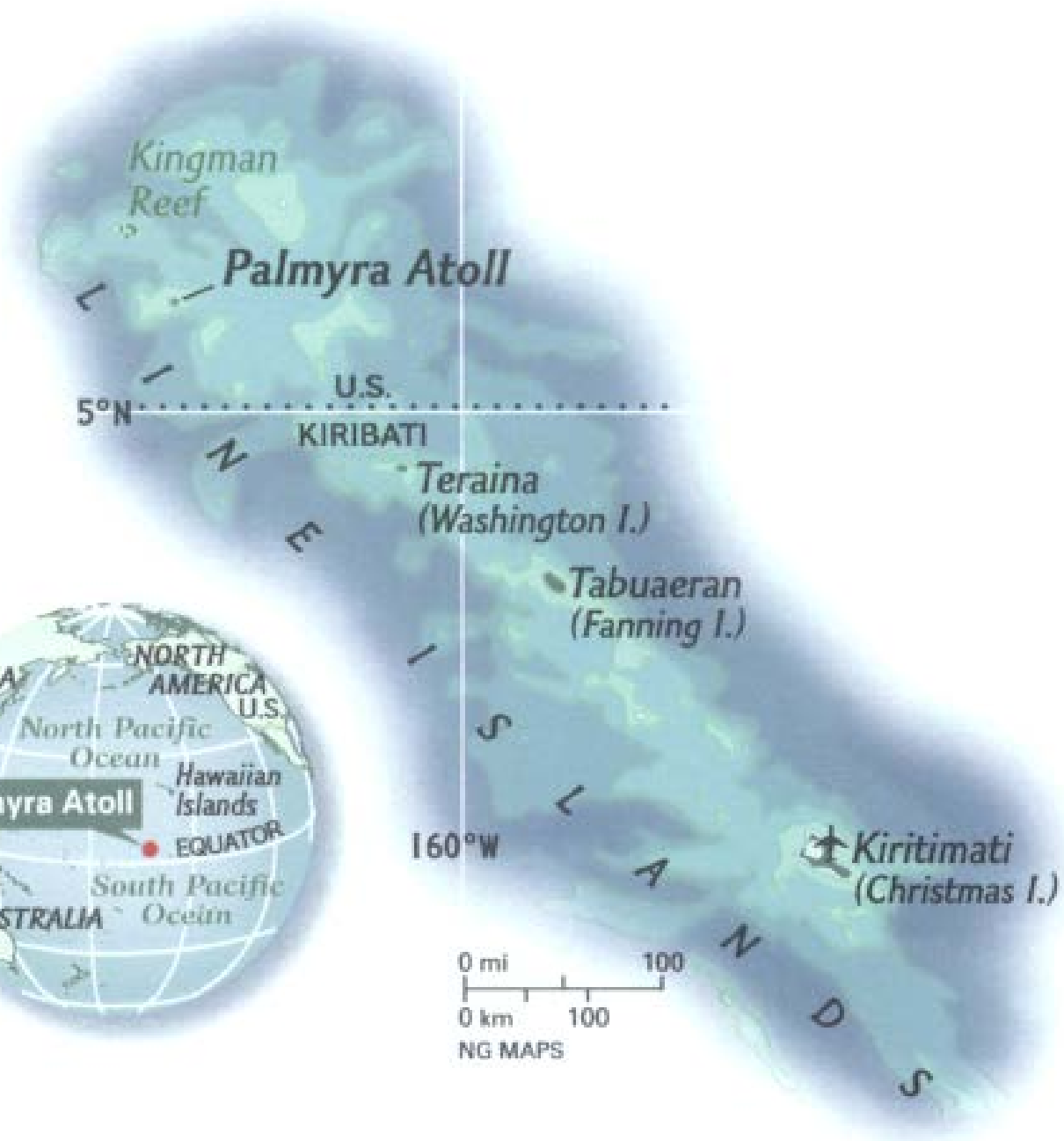
Nov 2015

2015/2016 El Niño

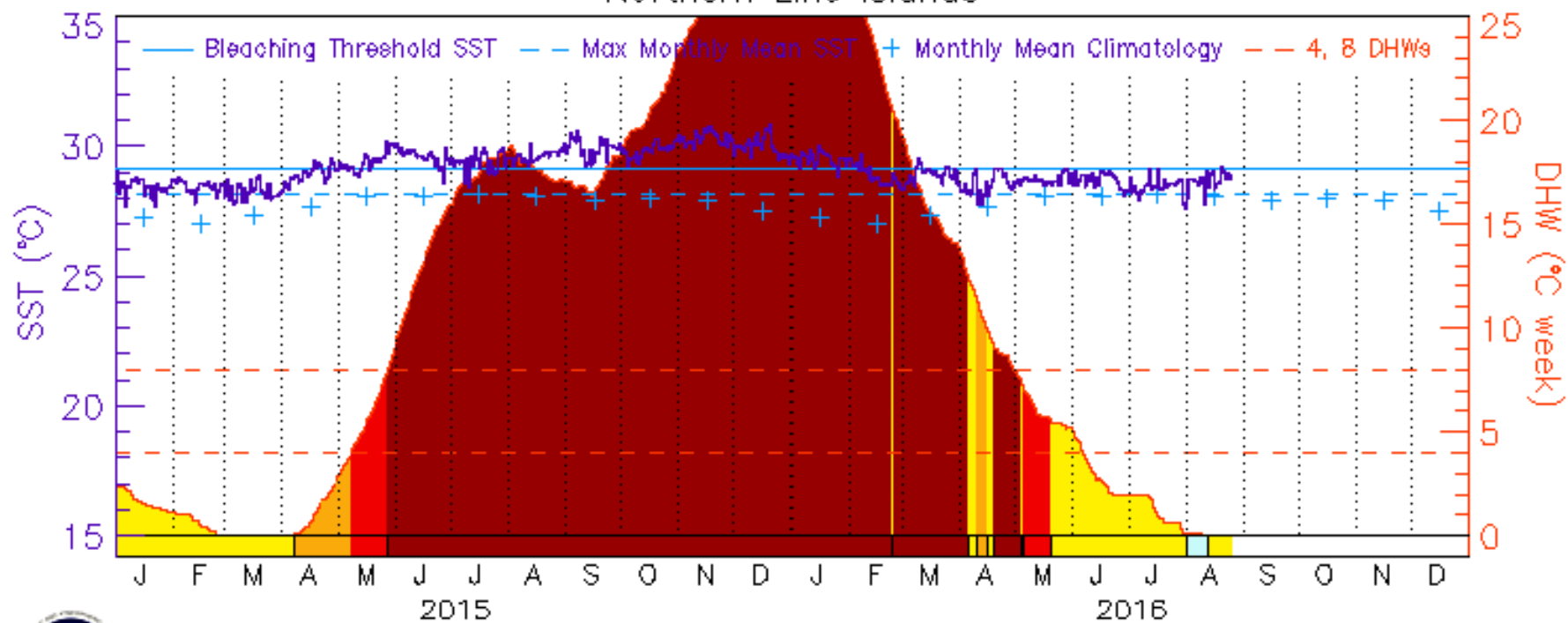
A composite image featuring the monster Godzilla on the left, standing against a dark blue background. To the right, a large, glowing red and white map of the Earth is shown, representing the El Niño climate phenomenon. The text "GODZILLA" is written in large, white, blocky letters with a black outline, and "El Niño" is written below it in blue, bold letters with a white outline.

# GODZILLA

## El Niño



## Northern Line Islands



No Stress
  Bleaching Watch
  Bleaching Warning
  Alert Level 1
  Alert Level 2

<http://coralreefwatch.noaa.gov>


August, 2014





November, 2015

30-90% bleached  
0-90% dead  
depending on site

An underwater photograph of a coral reef. The reef is heavily degraded, with most of the coral appearing dead or bleached. The water is clear and blue, with several small fish swimming around. A text box in the upper left corner provides statistics on the reef's health: 85% dead, 10% bleached, and 5% healthy. The date 'April, 2016' is written in the upper right corner.

85% dead  
10% bleached  
5% healthy

April, 2016



# A bittersweet victory for an El Niño chaser

Author: Kim Cobb

May 27, 2016

*BEFORE*



*AFTER*



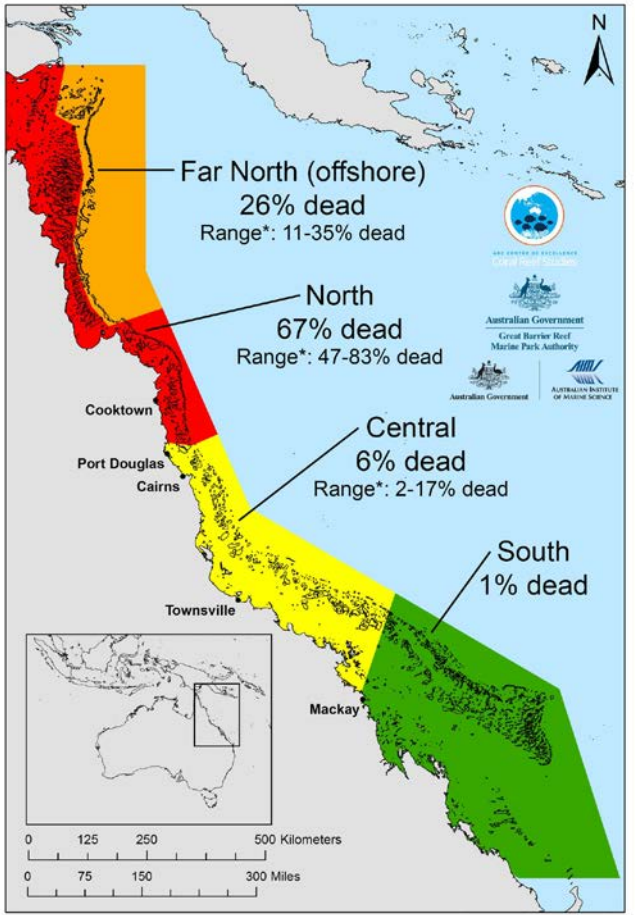
[link](#)

# Great Barrier Reef Hit by Worst Coral Die-Off on Record, Scientists Say

By MICHELLE INNIS NOV. 29, 2016



A field of staghorn coral this month killed by bleaching on Bourke Reef, a part of the 430-mile northern section of the Great Barrier Reef. Greg Torda/ARC Center of Excellence for Coral Reef Studies



\*upper and lower quartiles

What's next for the world's reefs?

What will global reefs look like in 2030? 2050?

How will they function ecologically?

How will these changes impact

global food supply?

ocean health & adaptive capacity?

size of ocean carbon sink?

coastal vulnerability to sea level rise?

## Research Goal:

Document short- and long-term effects of 2015/16 El Niño on Line Islands reefs

## The Dream Team:

Kim Cobb, Mark Hay (Georgia Tech)

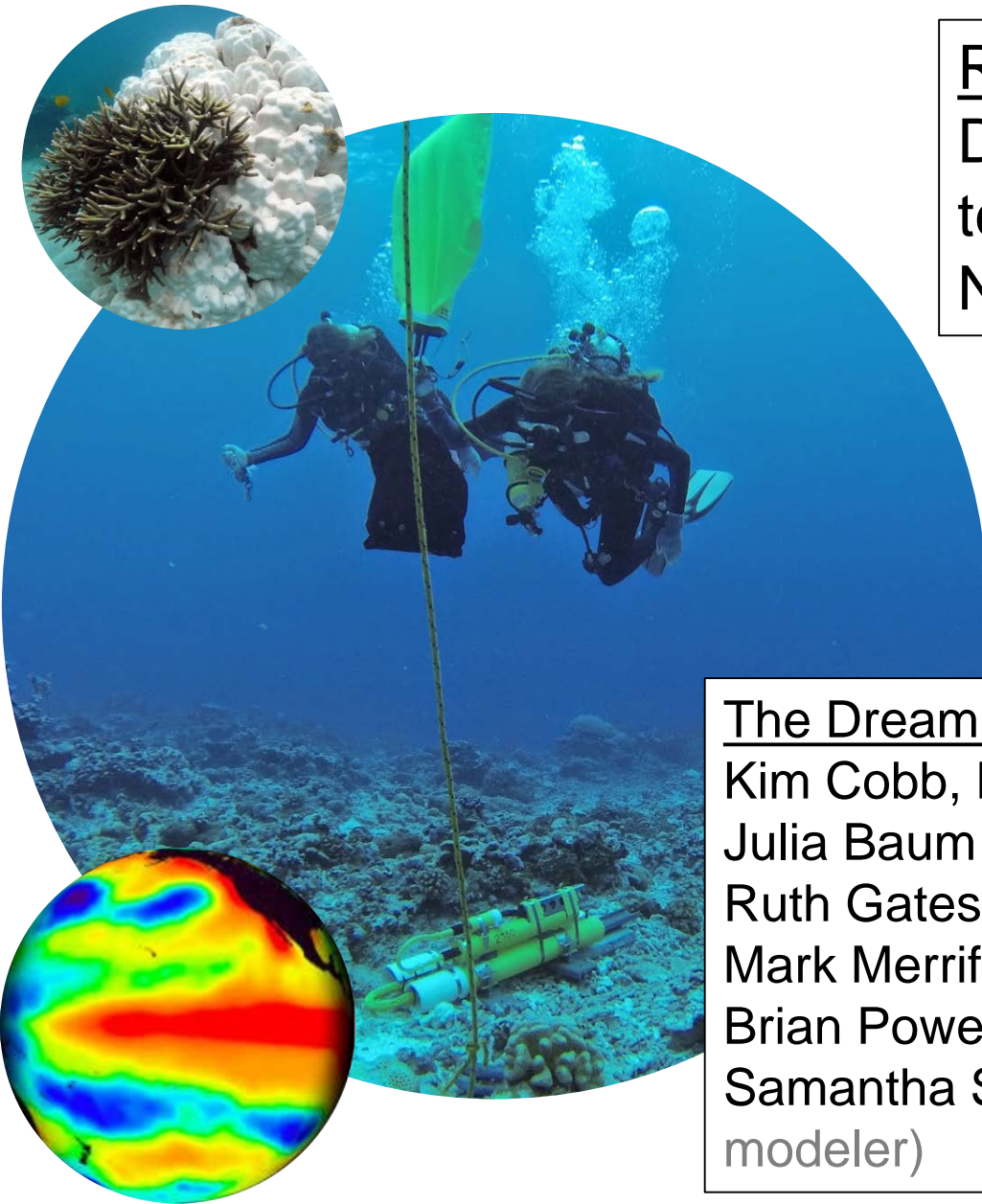
Julia Baum (U. Victoria, ecologist)

Ruth Gates (UH, coral ecologist & genomicist)

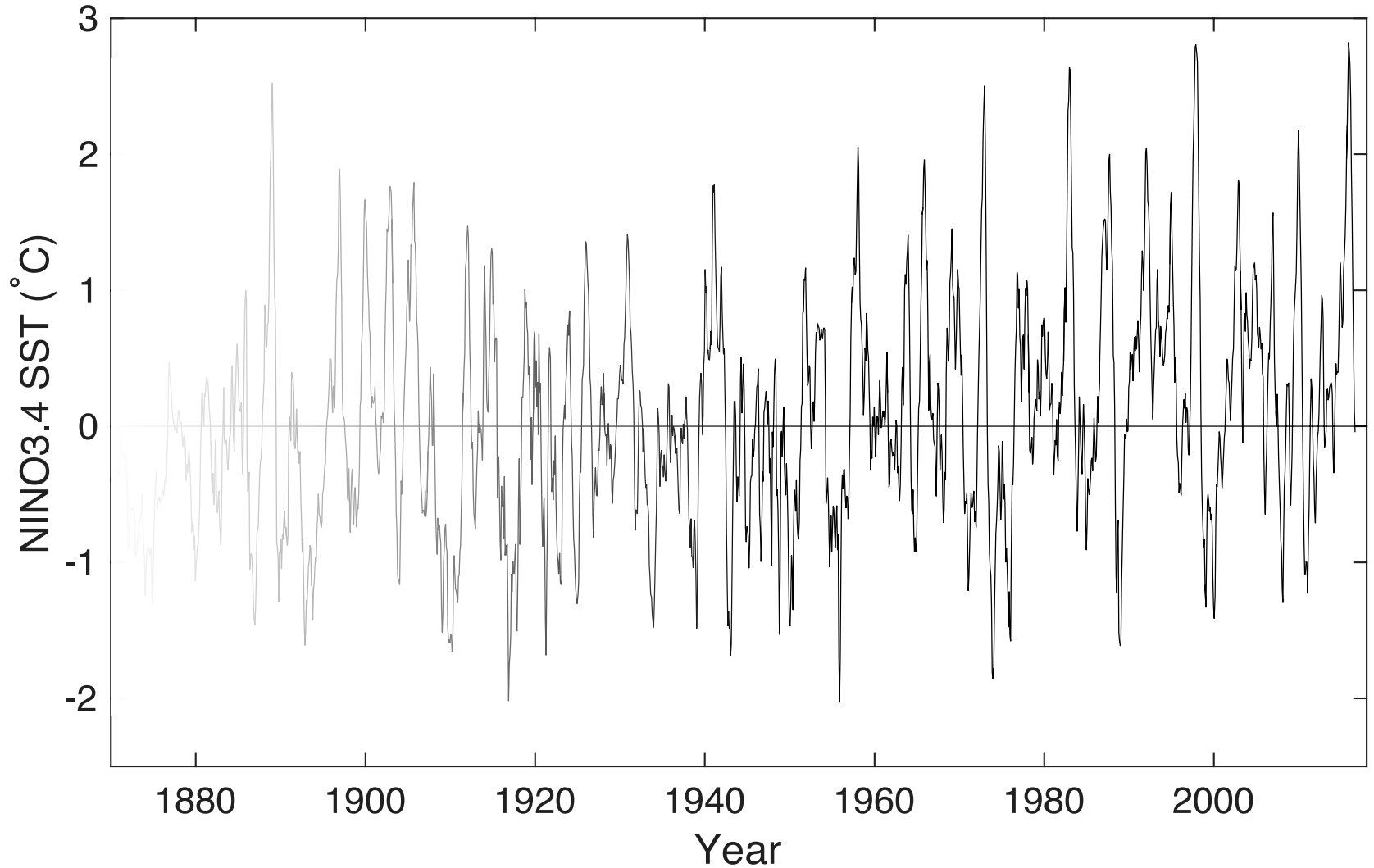
Mark Merrifield (UH, phys. oceanography)

Brian Powell (UH, phys. oceanography)

Samantha Stevenson (NOAA, climate modeler)



# Are El Niño events becoming stronger?



*ERSSTv4*





last 100+ yrs

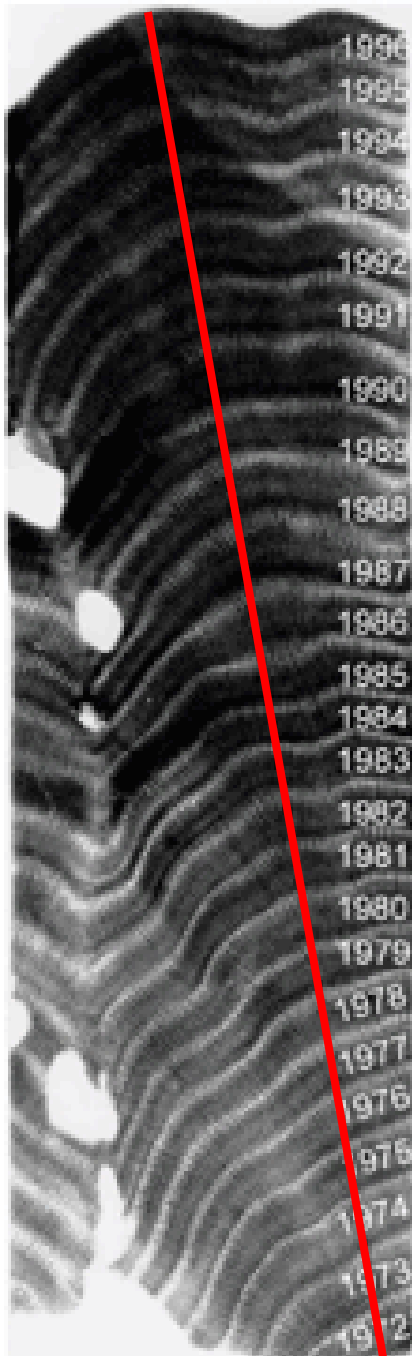
drilled via SCUBA



last 7000 yrs  
U/Th dated

storm/tsunami deposits  
scattered on beaches  
across the tropics

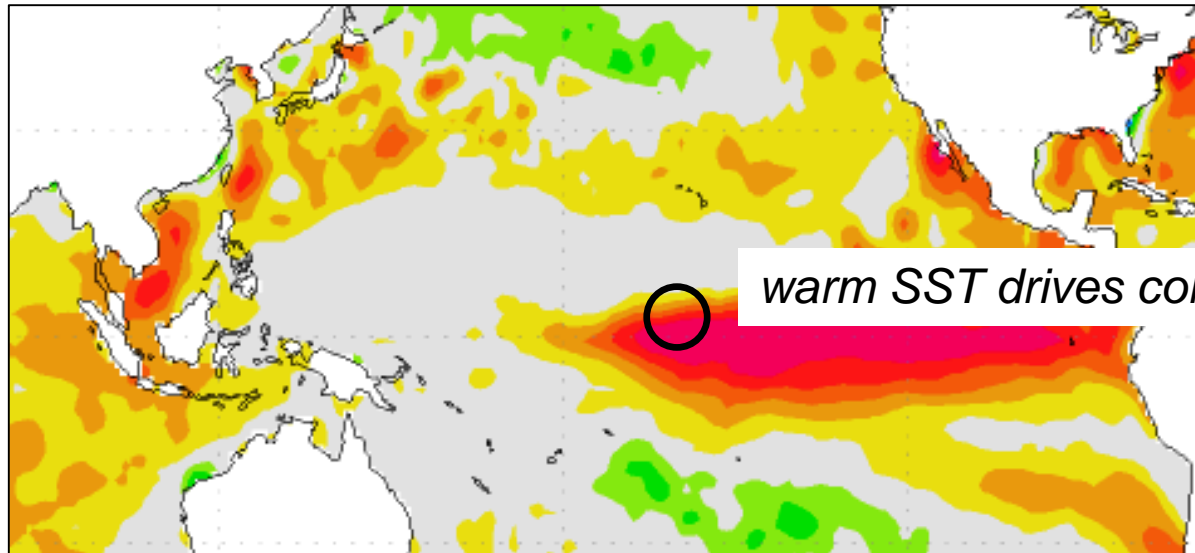




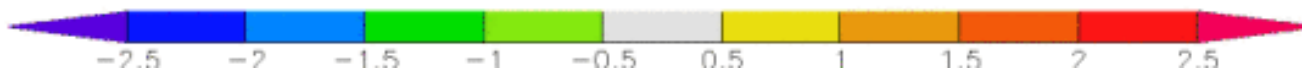
1mm sampling transect for coral oxygen isotopes ( $\delta^{18}\text{O}$ ) affords monthly resolution

$$\text{Coral } \delta^{18}\text{O} = \text{SST} + \delta^{18}\text{O}_{\text{seawater}}$$

Feb 2016  
OISST

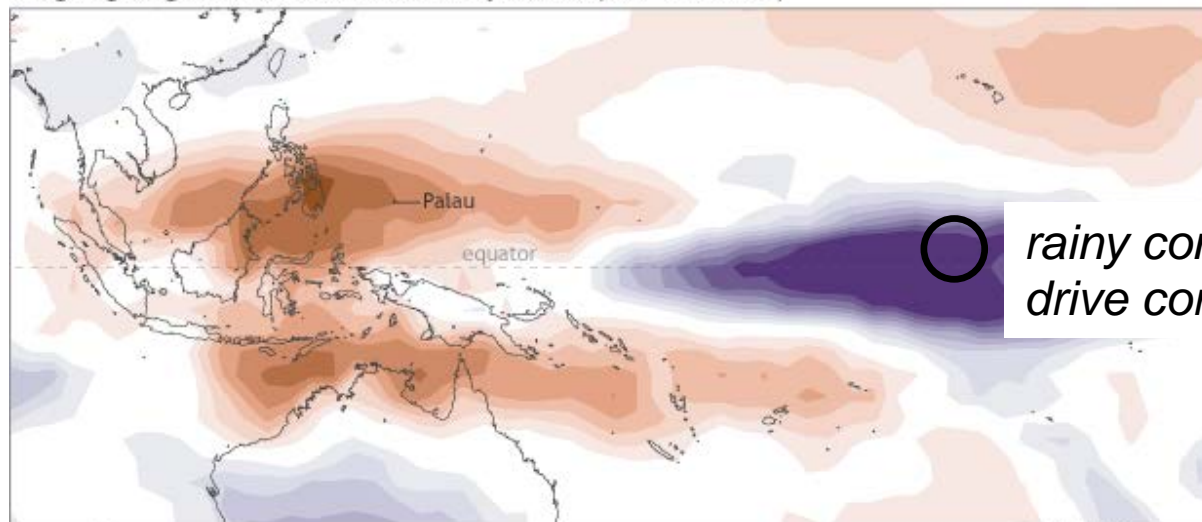


warm SST drives coral  $\delta^{18}\text{O}$  down



Outgoing longwave radiation blocked by clouds (Jan-Mar 2016)

Jan-Mar 2016  
OLR

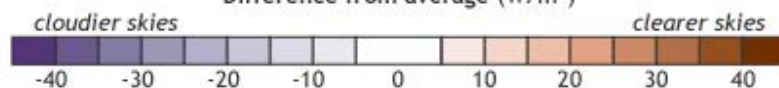


rainy conditions drive coral  $\delta^{18}\text{O}$  down

compared to  
1981-2010

Difference from average ( $\text{W}/\text{m}^2$ )

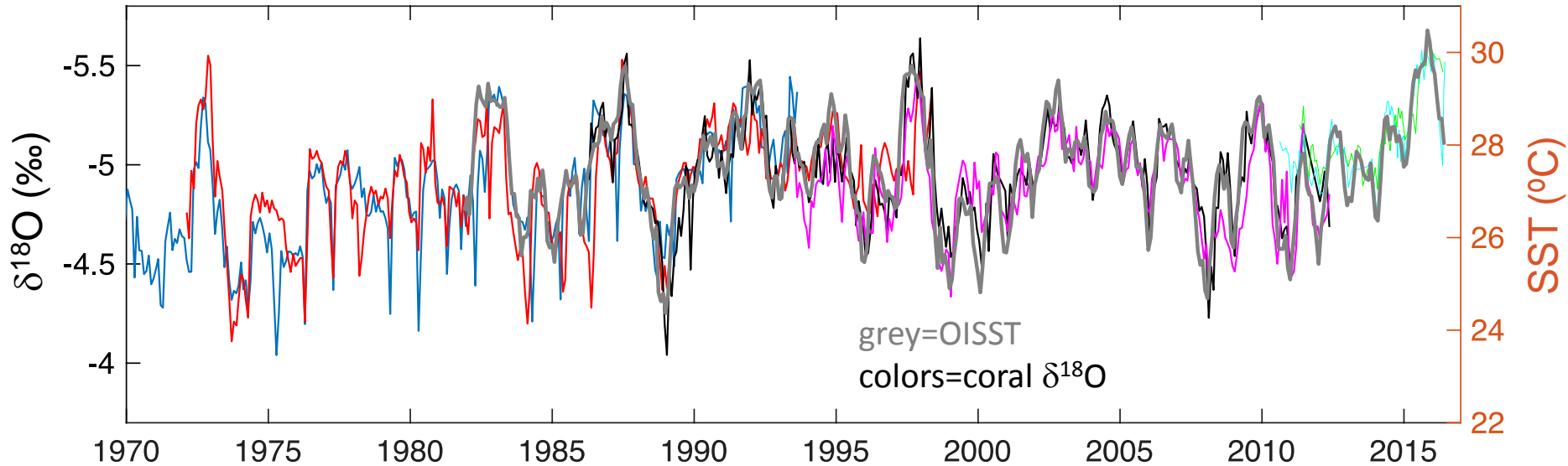
NOAA Climate.gov  
Data: NCEP/NCAR



cloudier skies

clearer skies

# Christmas coral oxygen isotopes vs. SST

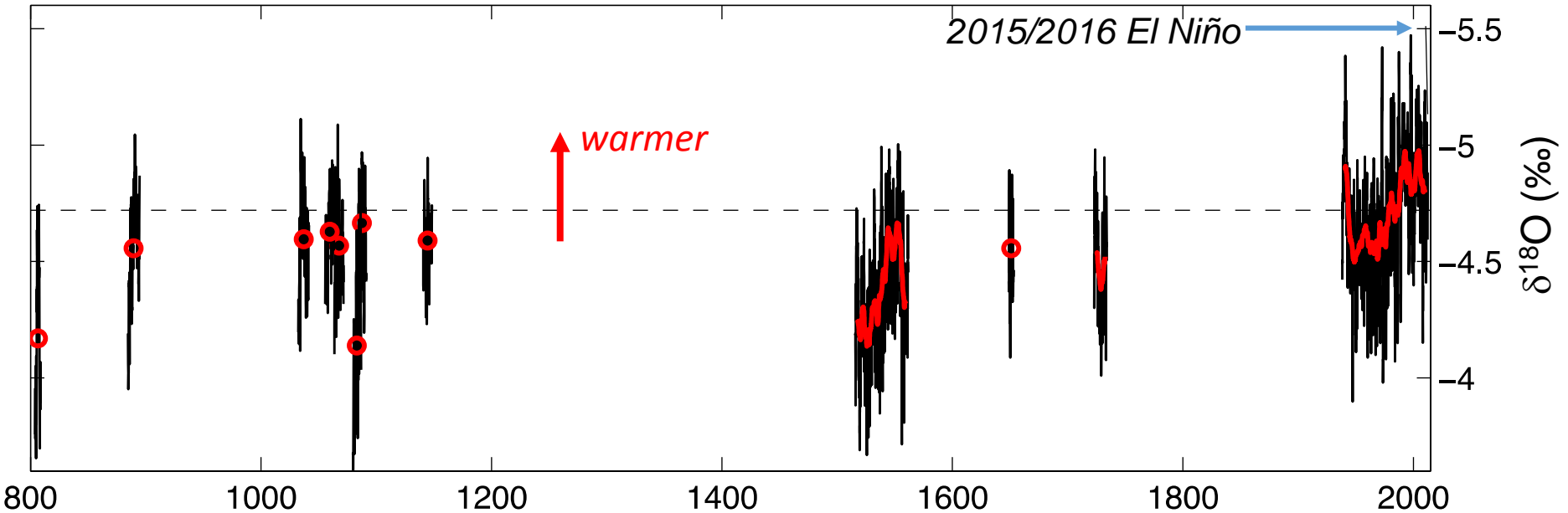


*Evans et al., 1999*  
*Nurhati et al., 2009*  
*Grothe et al., in prep*  
*O'Connor et al., in prep*

Coral  $\delta^{18}\text{O}$  records are interchangeable with SST.

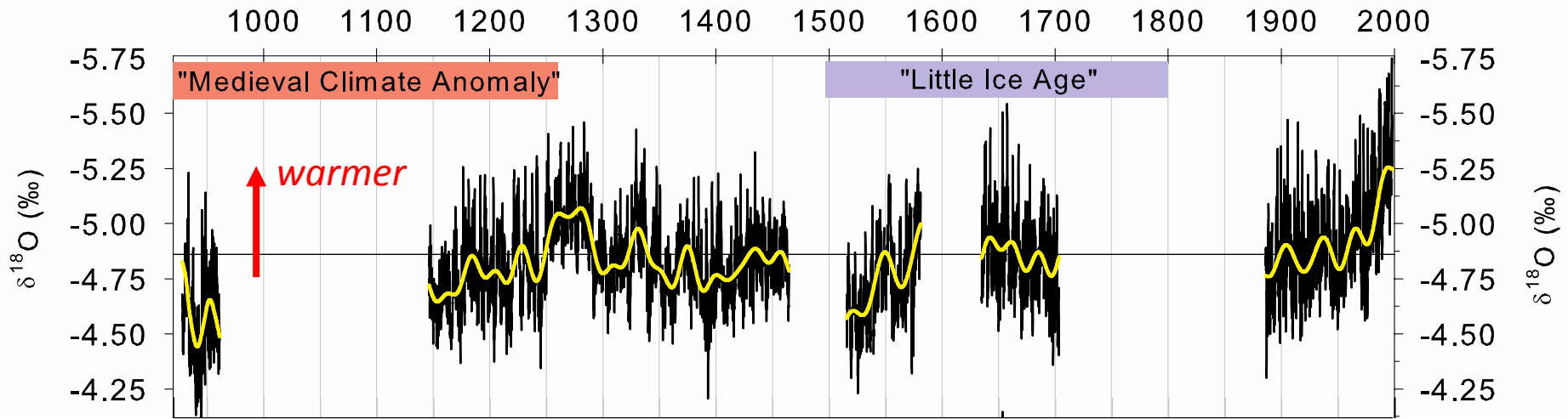
Replication yields better reconstruction.

# Christmas coral $\delta^{18}\text{O}$ records through the last millennium



2015/2016 El Niño reached unprecedented values;  
extreme event + background warming

# Palmyra coral $\delta^{18}\text{O}$ records through the last millennium



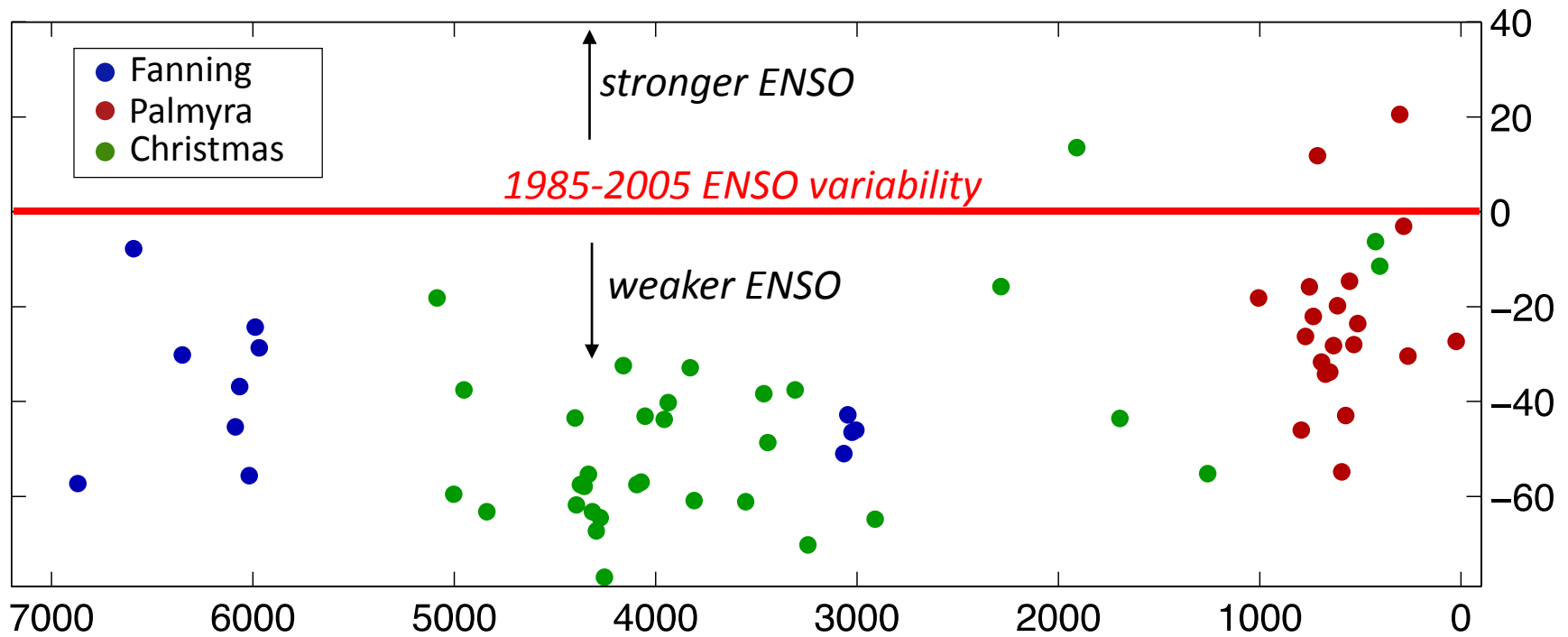
Has ENSO variance changed?

Now combining corals from all Line islands  
over last 7,000 years

# of yrs covered: 2055

plotting ENSO variance only

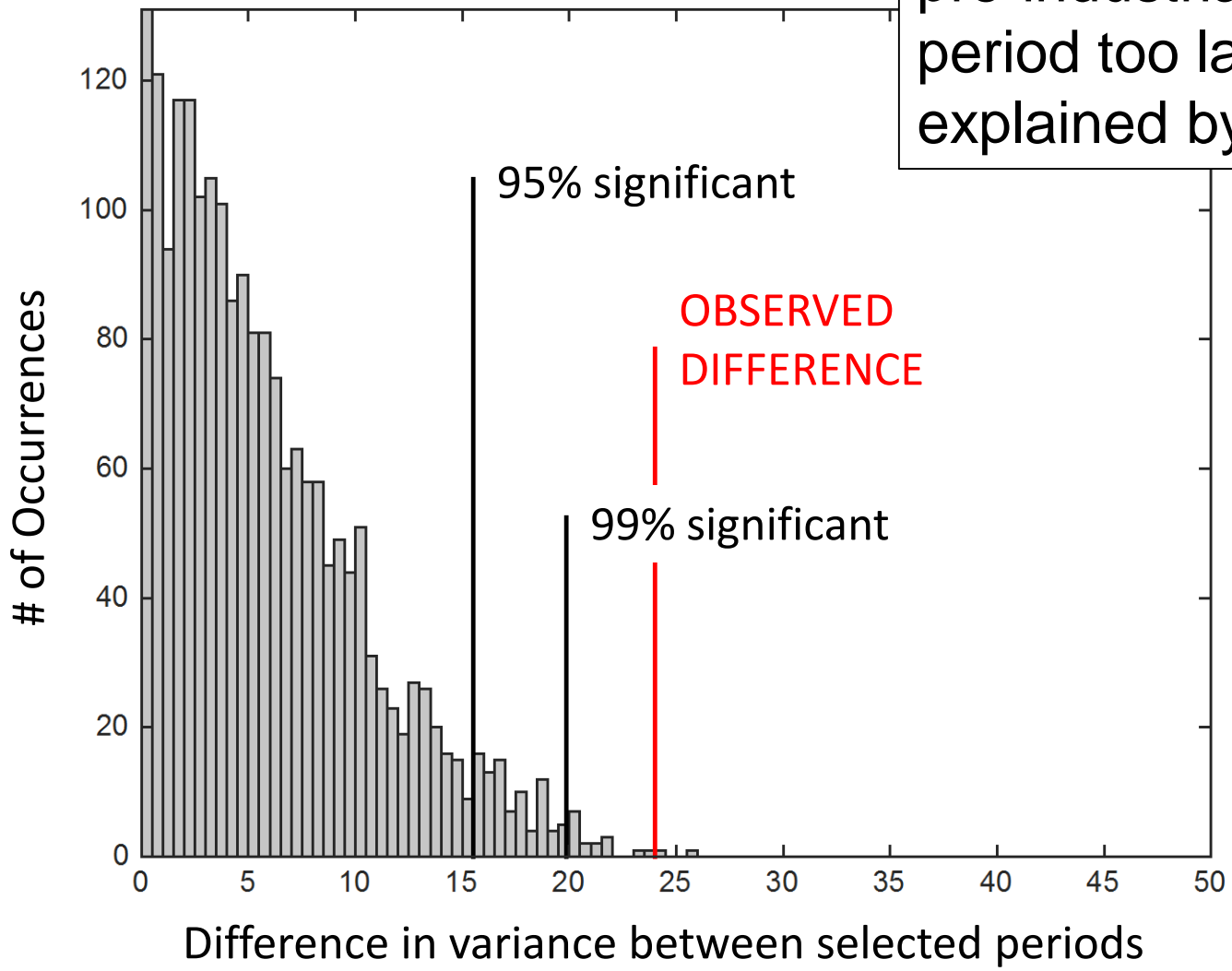
# ENSO variance over the last 7,000yrs



Most pre-industrial data reflect much weaker ENSO than present.

Grothe et al., in prep  
Cobb et al., 2013  
Cobb et al., 2003  
McGregor et al., 2013  
Grothe et al., in prep  
Woodroffe et al., 2003

Observed difference in variance between pre-industrial and modern period too large to be explained by chance





Evidence that 20<sup>th</sup> century interannual  
variance is stronger than pre-industrial:

Li et al., 2013 → tree rings from Java


McGregor et al., 2013 → Pacific multi-proxy

Liu et al., 2017 → Taiwan tree  $\delta^{18}\text{O}$

Cobb et al., 2013; Grothe et al., in prep →  
Line Islands coral  $\delta^{18}\text{O}$

What now?

**RESILIENCE** can only be quantified under stress

A woman with long brown hair, wearing a white lab coat over a black top, is speaking into a black microphone. She is looking slightly to her left. The background is a red brick wall. To the left, the head and shoulder of an older man with grey hair are visible. A white text box is overlaid on the right side of the image.

“For too long, we as scientists have relied on our data to do the talking for us. That strategy has failed, miserably.”

AGU rally, Dec 2016



FEARLESS  
FEMALE  
SCIENTIST



# OUR PLEDGE

~17,000 signatures  
from 109 countries

100+ "pods" in cities  
across the US

SIGN THE PLEDGE

## An open letter from women of science:

Science is foundational in a progressive society, fuels innovation, and touches the lives of every person on this planet. The anti-knowledge and anti-science sentiments expressed repeatedly during the U.S. presidential election threaten the very foundations of our society. Our work as scientists and our values as human beings are under attack. We fear that the scientific progress and momentum in tackling our biggest challenges, including staving off the worst impacts of climate change, will be severely hindered under this next U.S. administration. Our planet cannot afford to lose any time.



[500womenscientists.org](https://500womenscientists.org)



Kim Cobb  @coralsncaves · Mar 6

My [#biketowork](#) [#beforeandafter](#) photos from today. Thanks to [@DrShepherd2013](#) for photo w [@danielrochberg](#). [#navyblazersrock](#) [#GAclimate](#)



1



2

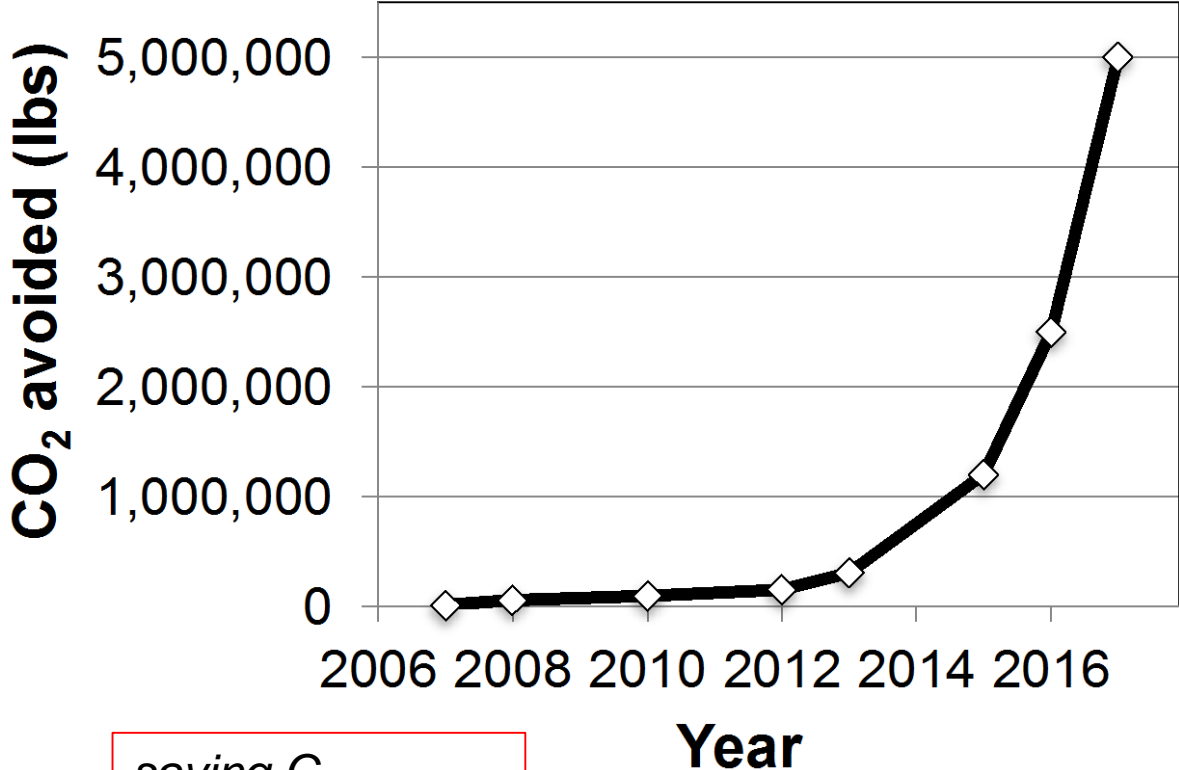


25



# Carbon Reduction Challenge

## EAS 3110, Georgia Tech



2017 CO<sub>2</sub> avoided:  
5 millions lbs

Annual class CO<sub>2</sub>  
footprint:  
1.2 million lbs

*saving C*  
*saving \$*  
*empowering the*  
*next generation*

- Partners:
- GT Facilities
  - IBM
  - BP
  - Delta
  - Home Depot
  - Chipotle
  - Trees Atlanta
  - Dept Veterans Affairs
  - 3M





## **Carbon Fee and Dividend**

- net gain for low-C emitters
- net loss for high-C emitters
- govt doesn't make 1 cent
- bipartisan appeal



**Citizens' Climate Lobby**

<https://citizensclimatelobby.org>

To be ensure a just, sustainable world,  
we need ALL hands on deck.



**BLACK LIVES  
MATTER**

[ShowingUpForRacialJustice.org](http://ShowingUpForRacialJustice.org)

2016 brought the magnitude of the climate problem into sharp focus.

The world needs solutions, and action.

Scientists must engage for change on individual, community, state, and federal levels.

“There are many ways of going forward,  
but only one way of standing still.”  
--*Franklin D. Roosevelt*

