

# OUR CHANGING OCEANS: THE CHALLENGES AHEAD

Margaret Leinen

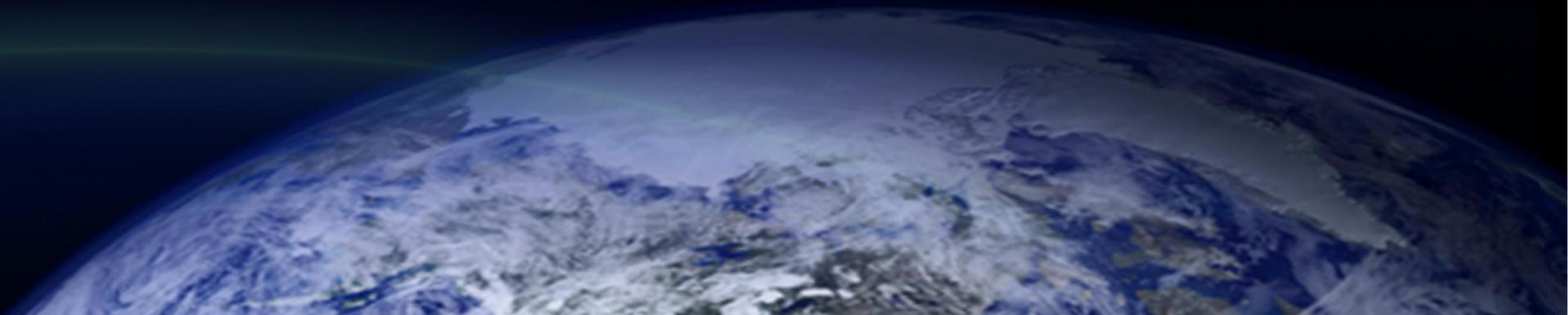
US Department of State Science Envoy

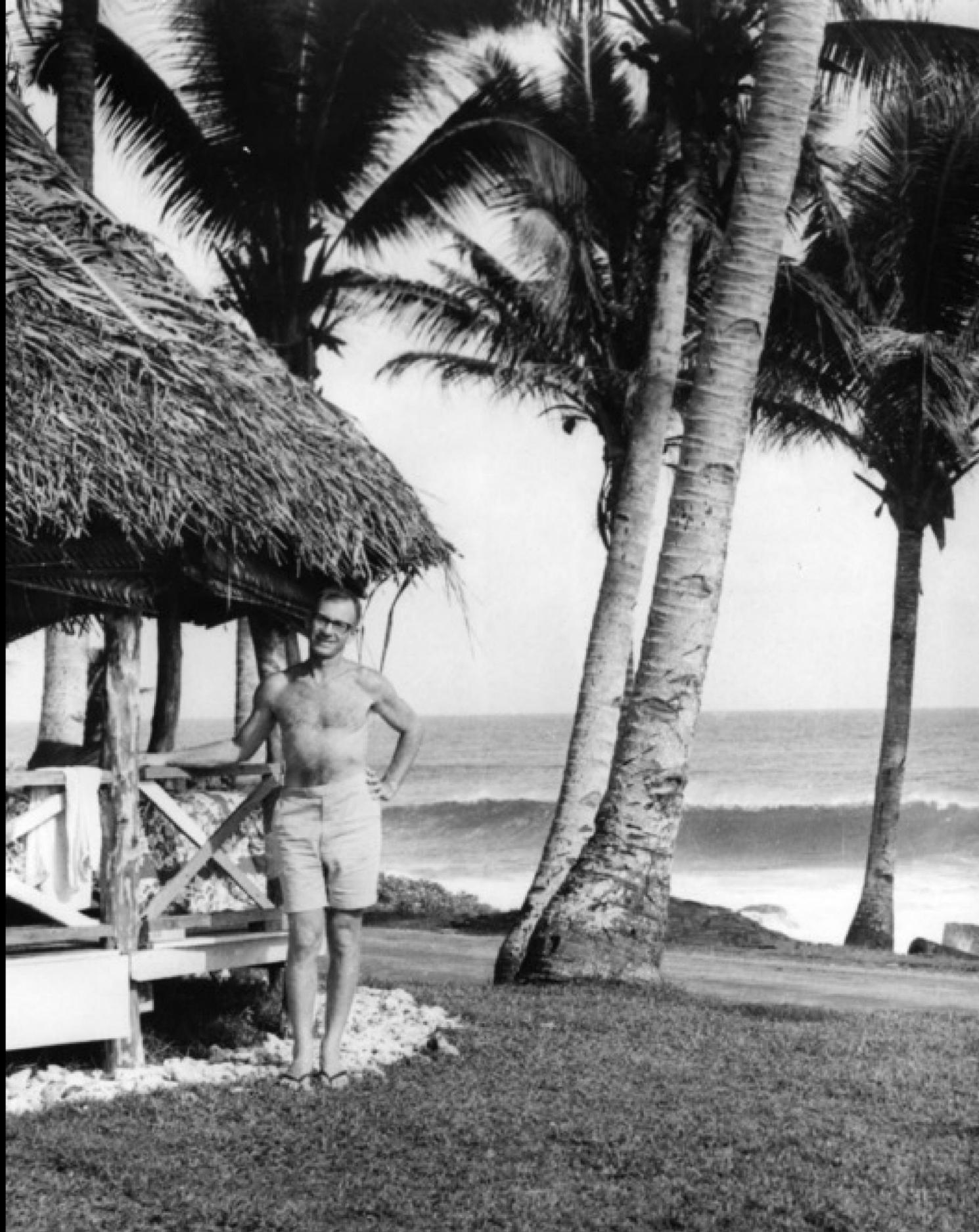
Director, Scripps Institution of Oceanography

Vice Chancellor, UC San Diego

Apia, Samoa

July, 2016





World renowned Scripps oceanographer Walter Munk spent much of 1963 in Samoa

Munk was engaged in an experiment that has become world famous called 'Waves Across the Pacific'

He measured waves and their decay at sites across the Pacific and showed that there was little decay in energy as the waves moved from New Zealand to Alaska



Oceans are one of the most dynamic environments on  
Earth

The oceans have been far different in the past,  
but they are now changing rapidly

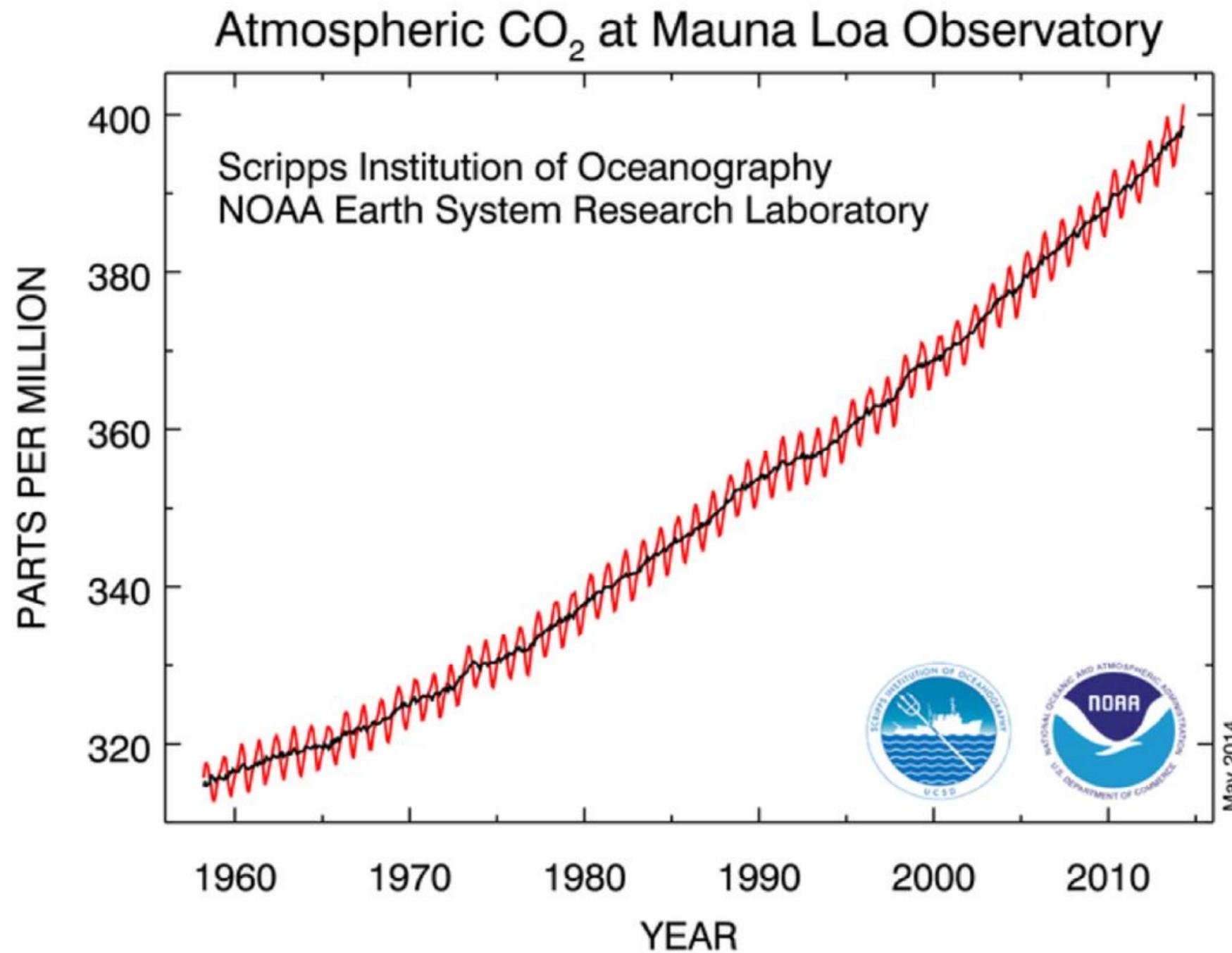
Ocean research is focused on understanding these  
changes  
and developing ways to adapt to change if possible

Why are the Pacific Islands so important?

sea level rise faster than most regions  
biodiversity great than most regions  
and being threatened faster than most regions

effective as a group in influencing international agreements

Atmospheric CO<sub>2</sub>  
at Mauna Loa  
since the  
beginning of the  
Scripps  
Oceanography  
measurement  
program in 1957



Scripps  
Oceanography  
and NOAA

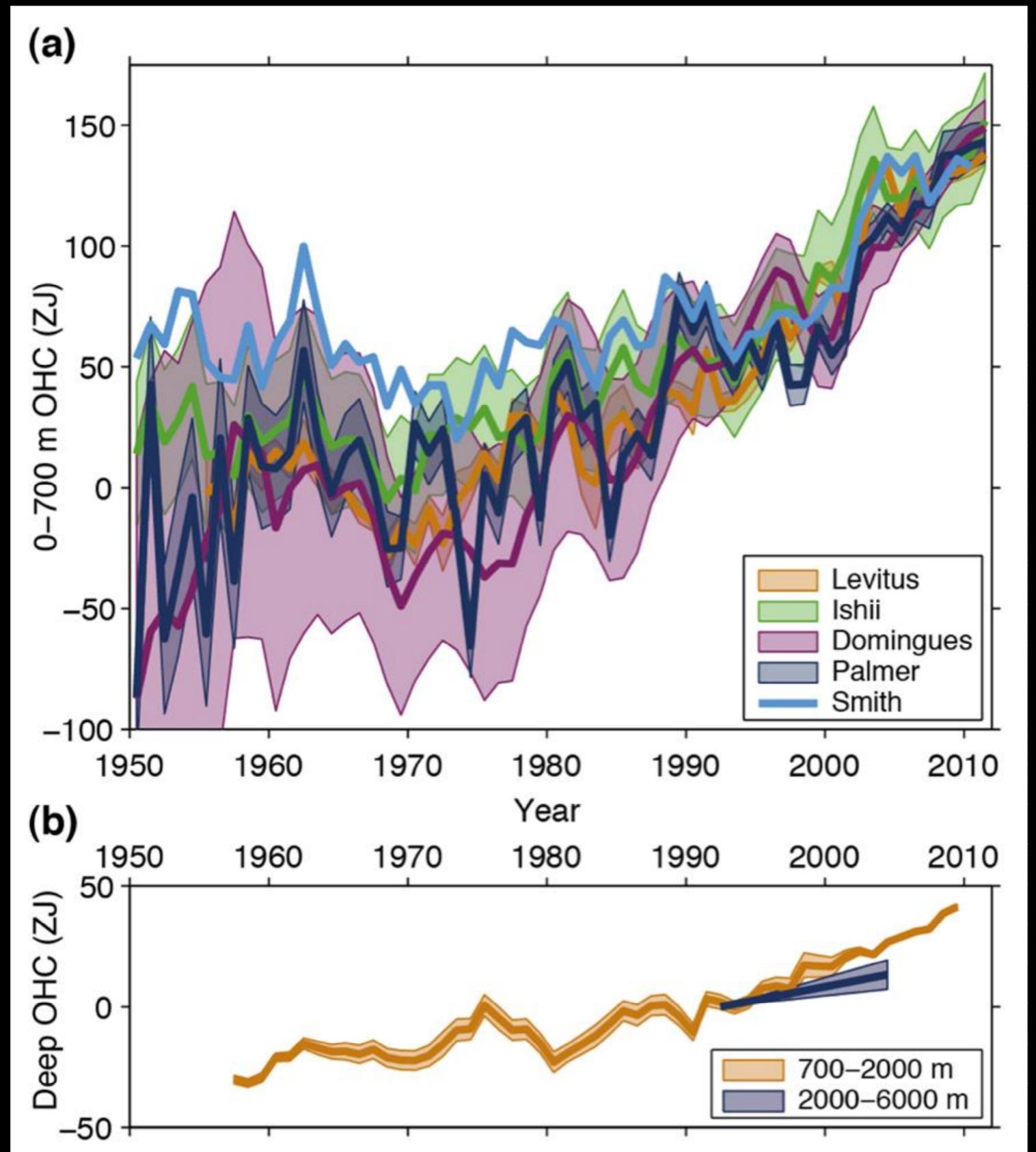
An underwater scene with sunlight rays filtering through the water, creating a serene and slightly hazy atmosphere. The water is a deep blue-green color, and the light rays are visible as bright, diagonal streaks. The overall mood is calm and contemplative.

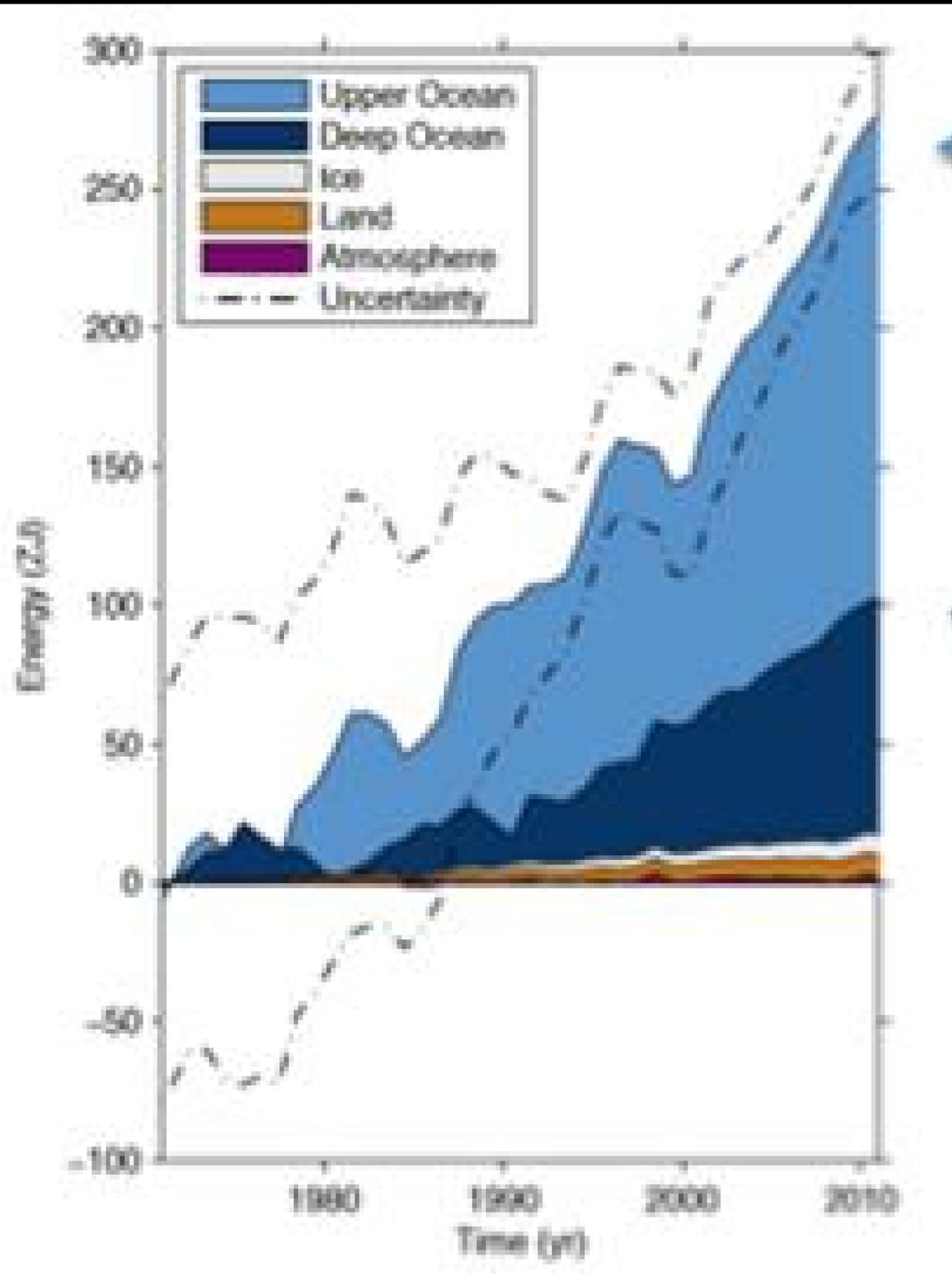
# The warming ocean



The ocean has been warming since we started measuring its heat content about 40 years ago.

IPCC AR5, 2014





Upper Ocean

Deep ocean

90% of the heat from global warming is in the ocean

ARGO - taking the temperature and pulse of the planet





Argo

### National contributions - 3839 Operational Floats

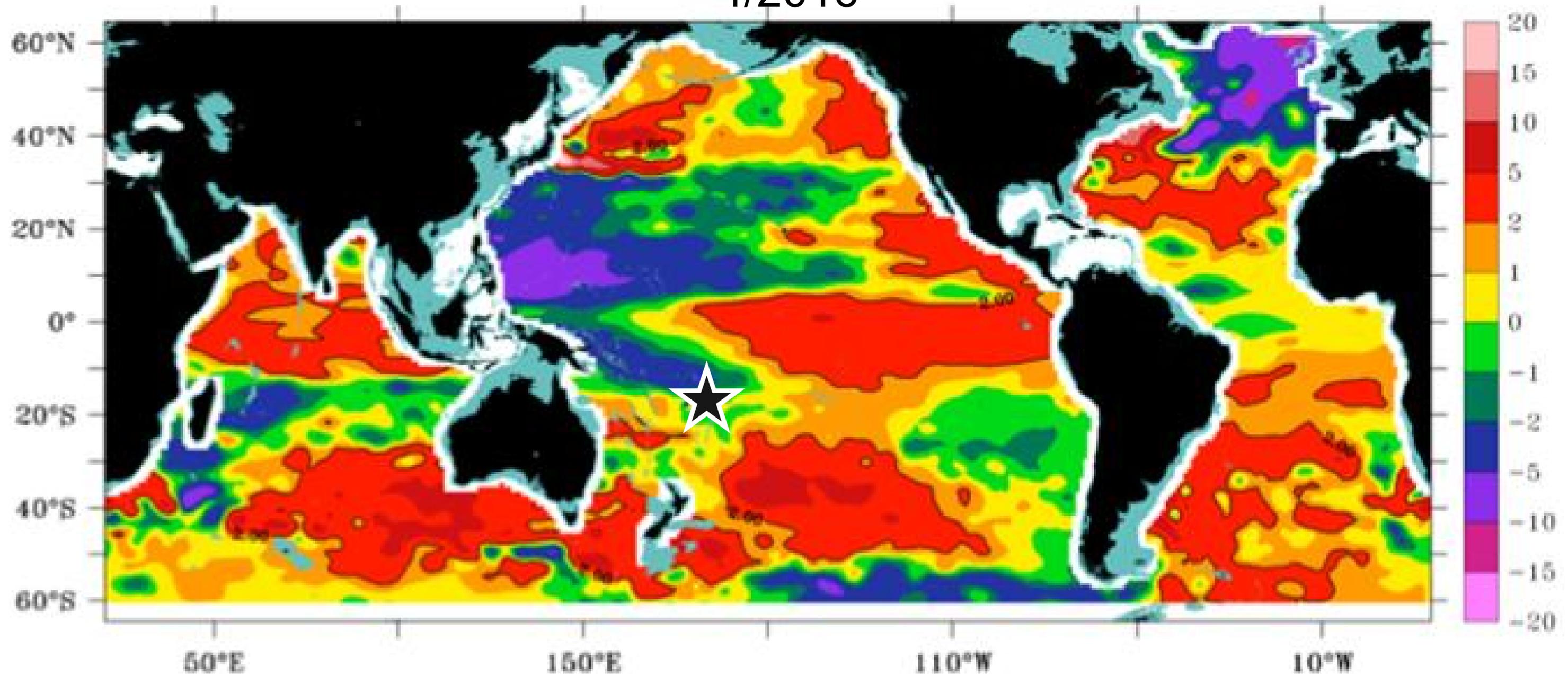
March 2016

Latest location of operational floats (data distributed within the last 30 days)

• ARGENTINA (2)	• CHINA (196)	• GERMANY (123)	• JAPAN (169)	• NEW ZEALAND (12)	• SPAIN (9)
• AUSTRALIA (378)	• ECUADOR (2)	• GREECE (7)	• KENYA (1)	• NORWAY (18)	• TURKEY (3)
• BRAZIL (11)	• EUROPE (6)	• INDIA (125)	• MAURITIUS (3)	• POLAND (3)	• UK (134)
• BULGARIA (2)	• FINLAND (5)	• IRELAND (7)	• MEXICO (2)	• SOUTH AFRICA (1)	• USA (2136)
• CANADA (55)	• FRANCE (332)	• ITALY (47)	• NETHERLANDS (12)	• SOUTH KOREA (56)	



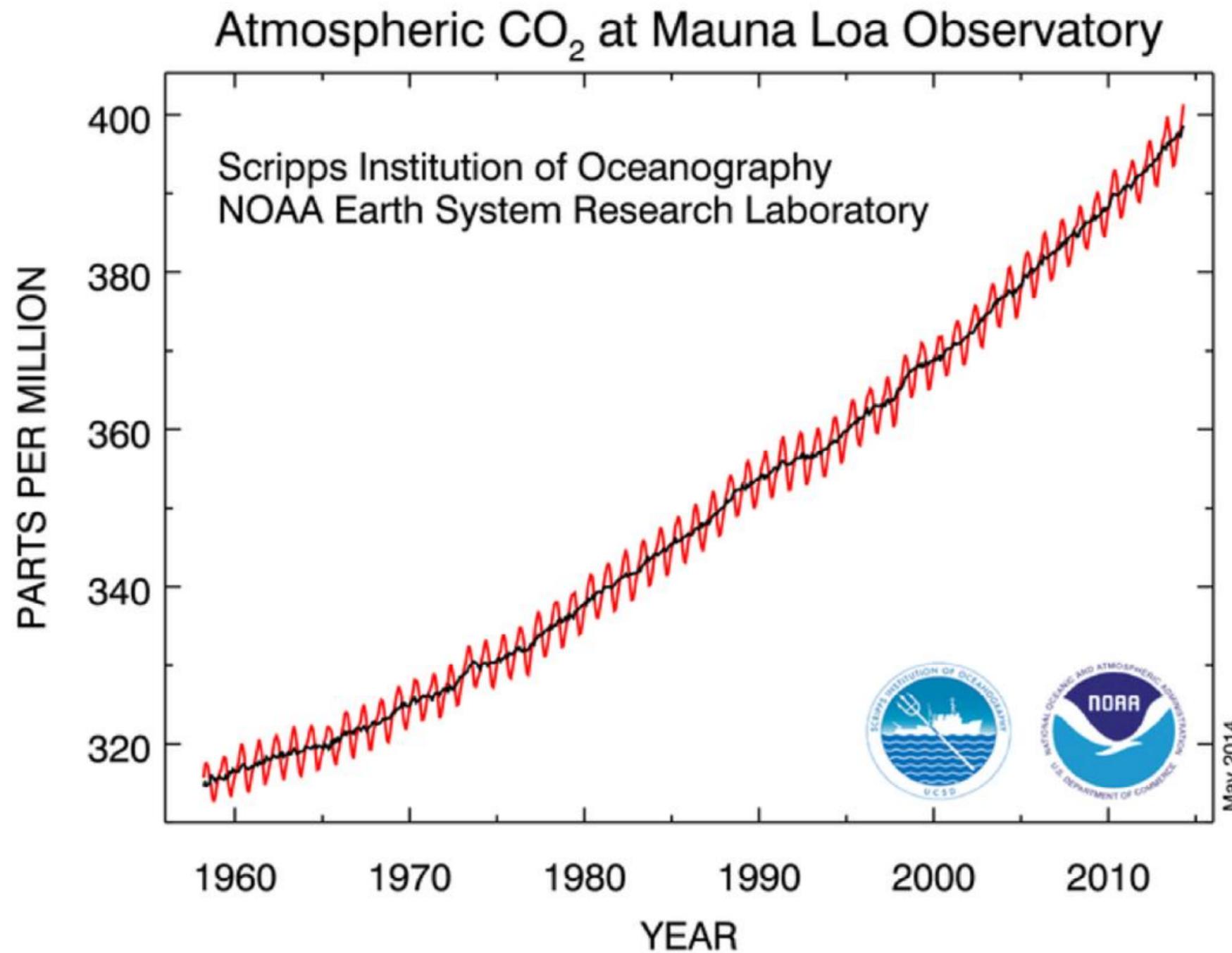
# 0-2000m depth heat gain ( $\text{W}/\text{m}^2$ ), based on linear regression, 2006 – 4/2016



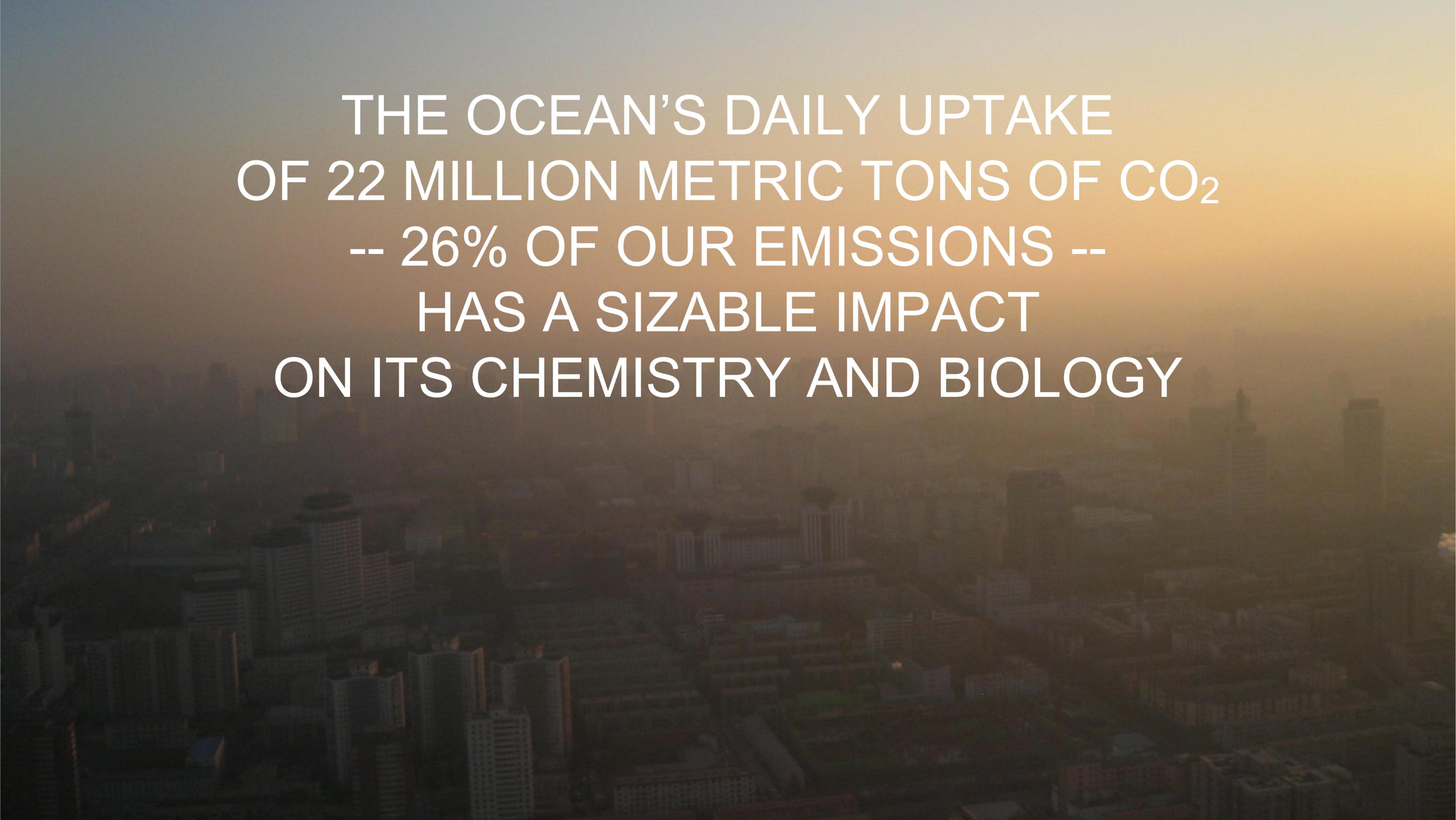
The red colors indicate regions with greater than 2  $\text{W}/\text{m}^2$  heat gain.  
Note the strong warming in the mid-latitude Southern Hemisphere  
Trends over the 10-year record are influenced by interannual variability

Roemmich, 2016

Atmospheric CO<sub>2</sub>  
at Mauna Loa  
since the  
beginning of the  
Scripps  
Oceanography  
measurement  
program in 1957



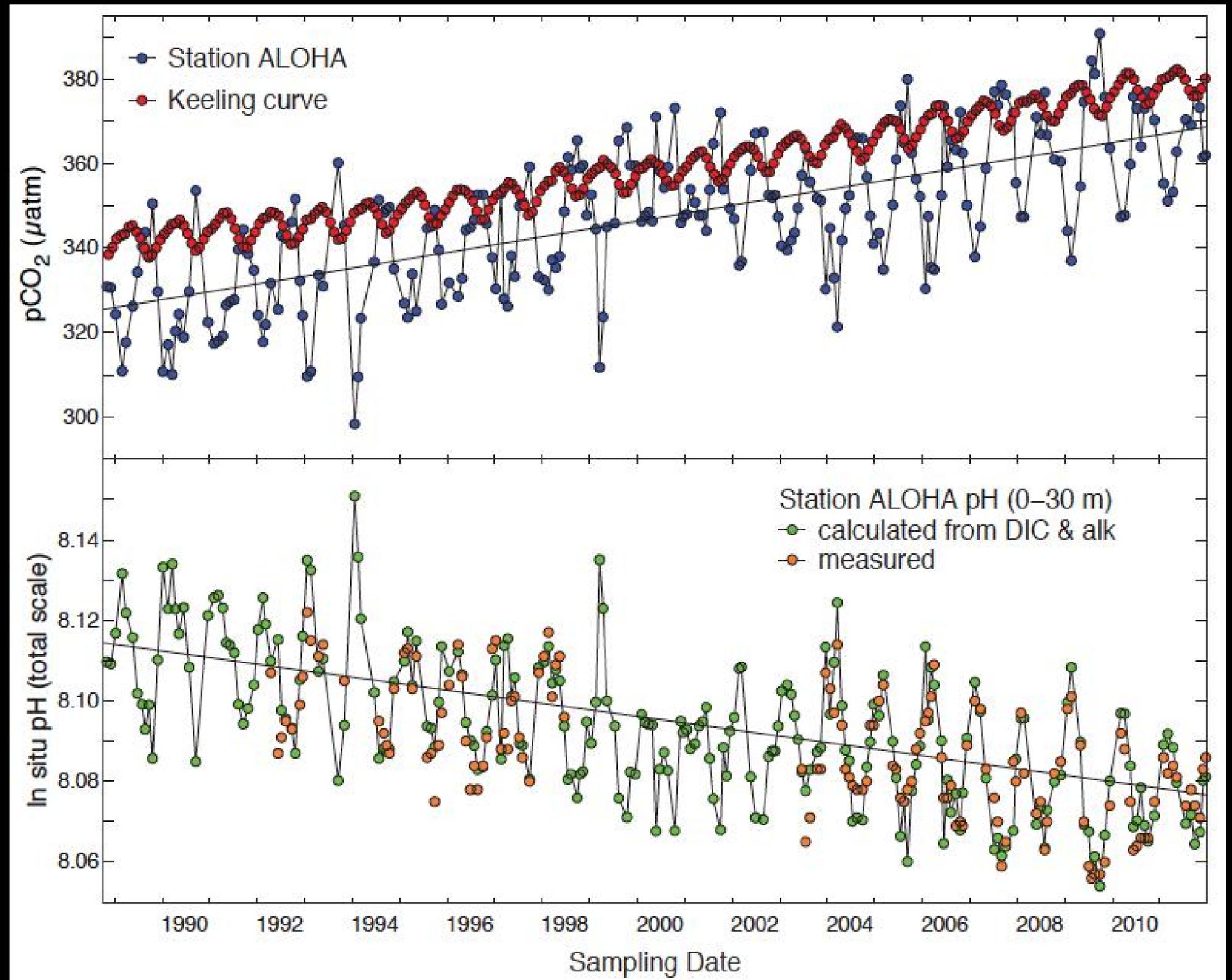
Scripps  
Oceanography  
and NOAA

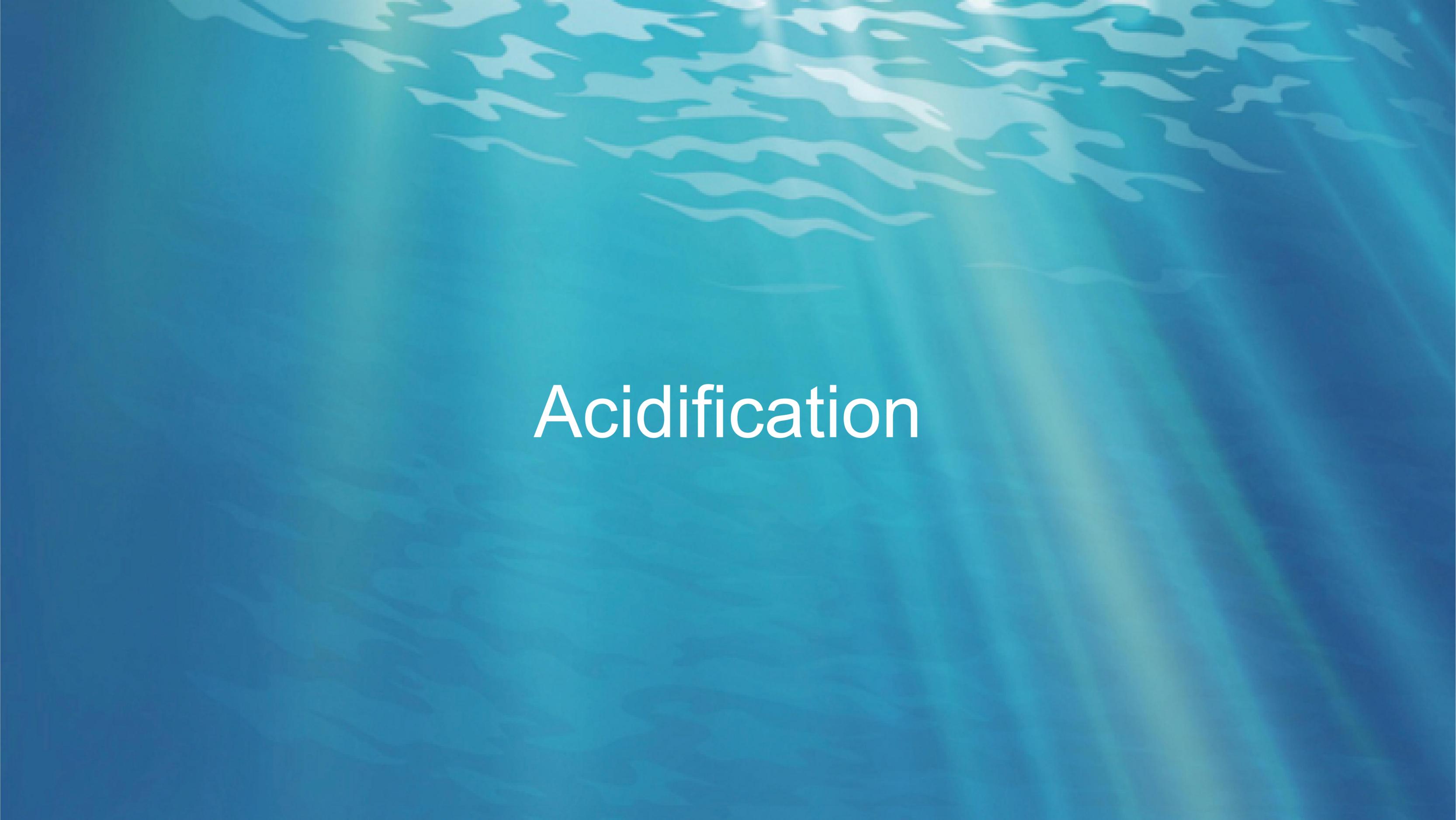
An aerial photograph of a city skyline at sunset. The sky is a gradient of orange and yellow, with the sun low on the horizon. The city buildings are silhouetted against the bright sky. The text is overlaid in white, bold, sans-serif font.

THE OCEAN'S DAILY UPTAKE  
OF 22 MILLION METRIC TONS OF CO<sub>2</sub>  
-- 26% OF OUR EMISSIONS --  
HAS A SIZABLE IMPACT  
ON ITS CHEMISTRY AND BIOLOGY

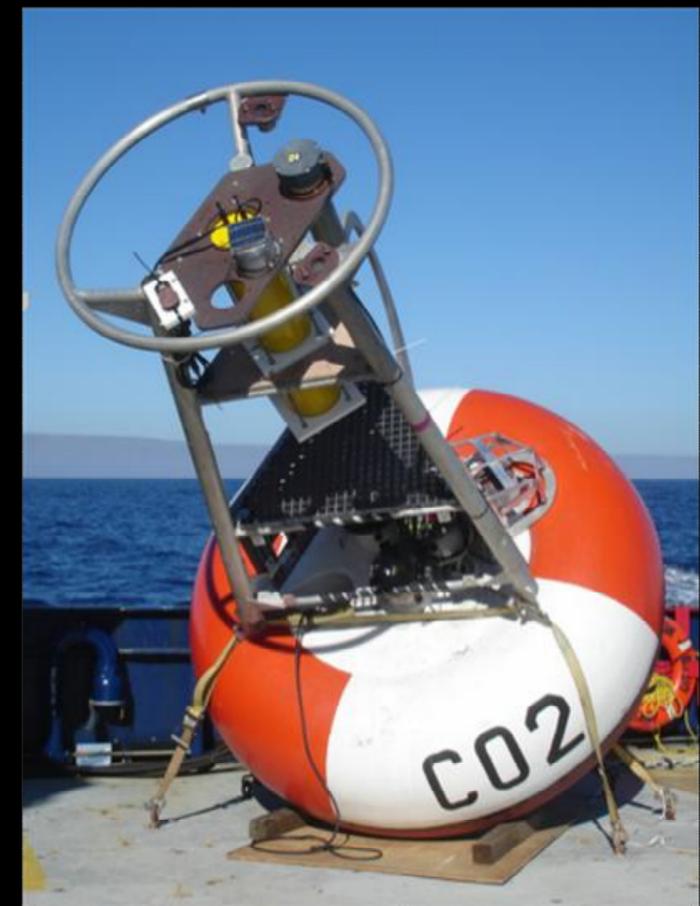
Increase in  $\text{CO}_2$  in the surface ocean - and decrease in pH - accompanies atmospheric  $\text{CO}_2$  growth

The oceans are 30% more acidic than in 1850



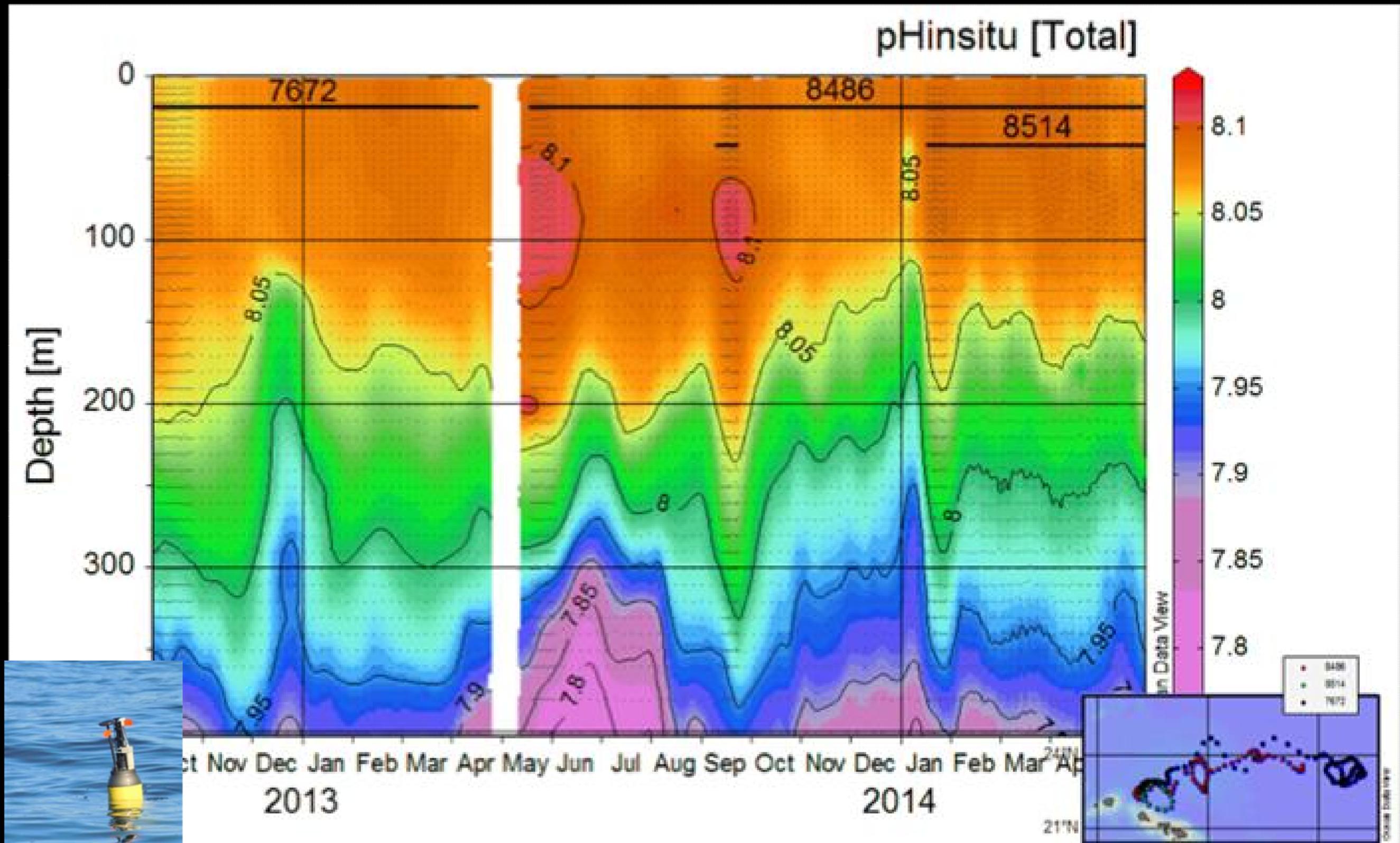
An underwater scene with sunlight rays filtering through the water, creating a serene and slightly dim atmosphere. The water is a deep blue-green color, and the light rays are visible as bright, diagonal streaks. The surface of the water is visible at the top, with gentle ripples and reflections of light.

# Acidification





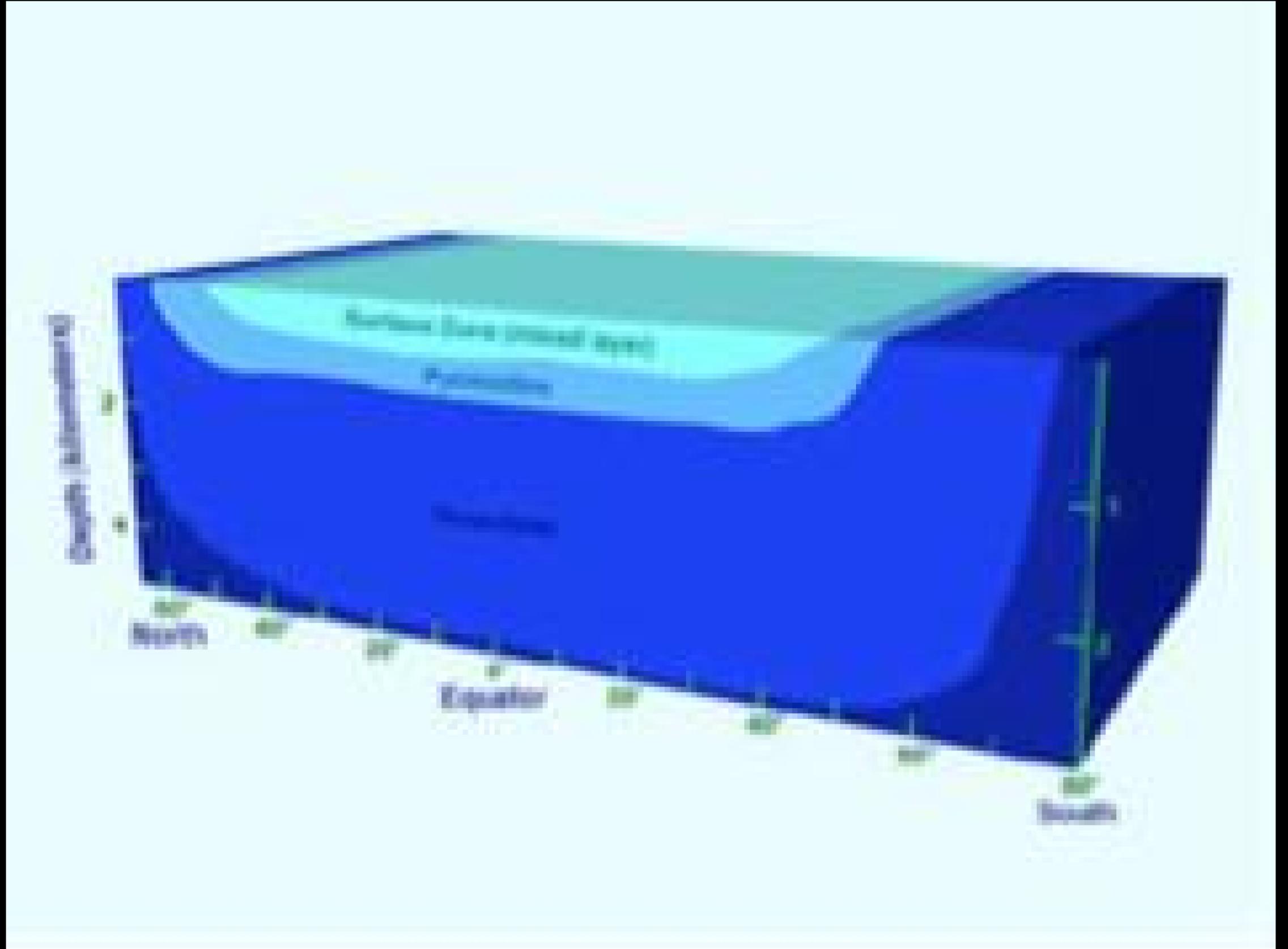
Three profiling floats deployed near Station ALOHA have now captured depth-resolved



# Deoxygenation

Because of the deep cold interior and bottom water, a warmer surface ocean results in a more stratified ocean:

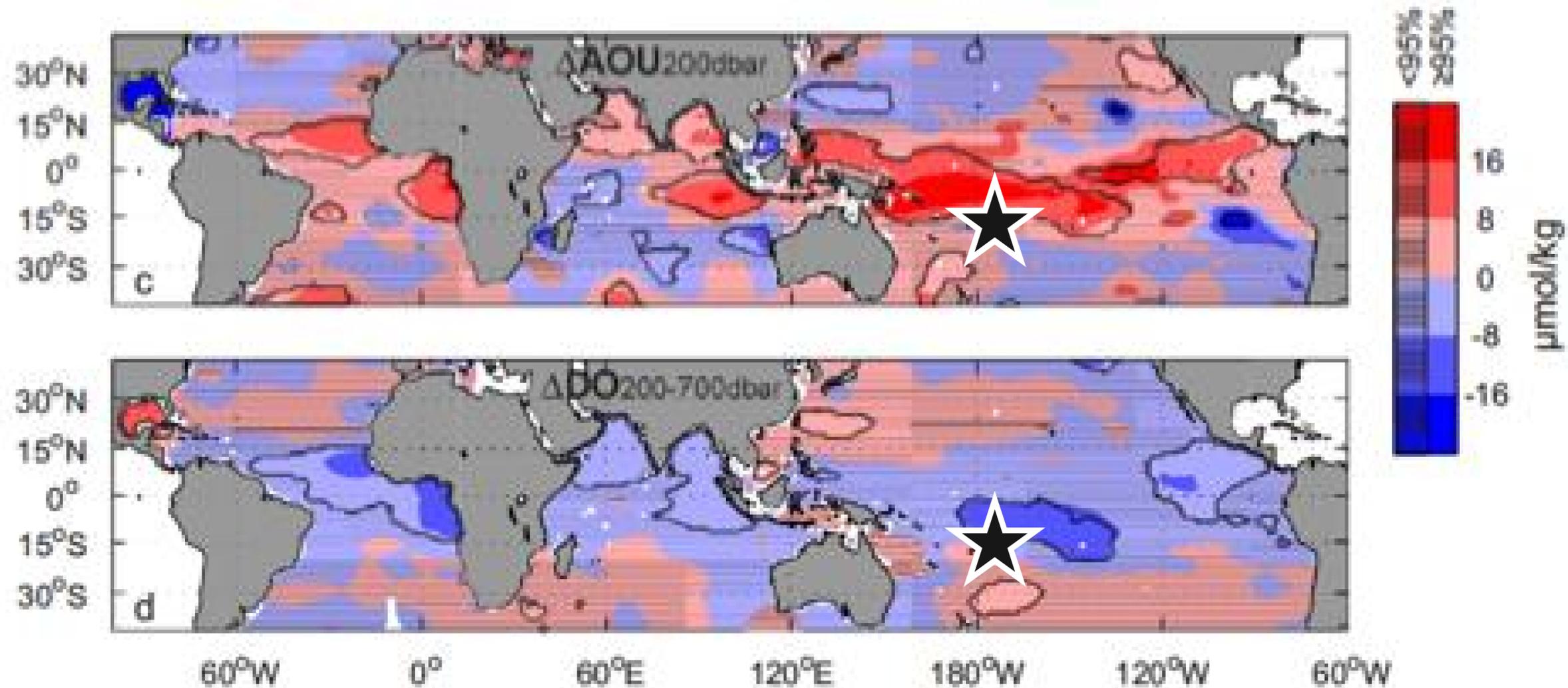
less exchange between layers



# Low oxygen areas are expanding

In the last 50 years, there has been a rise in AOU and massive oxygen loss in the tropical and subtropical ocean

At 200 meters, the area with  $< 70 \text{ mM O}_2$  has increased by 4.5 million  $\text{km}^2$  area



Changes from 1960-74 to 1990-2008

Stramma et al. 2010  
DSR I

- Warming reduces organism tolerance to hypoxia
- Warming narrows ecological niches in a stratified ocean
- Through their effects on metabolism, warming and hypoxia are projected to result in 20% body size decrease in fishes by 2050

Sea level rise

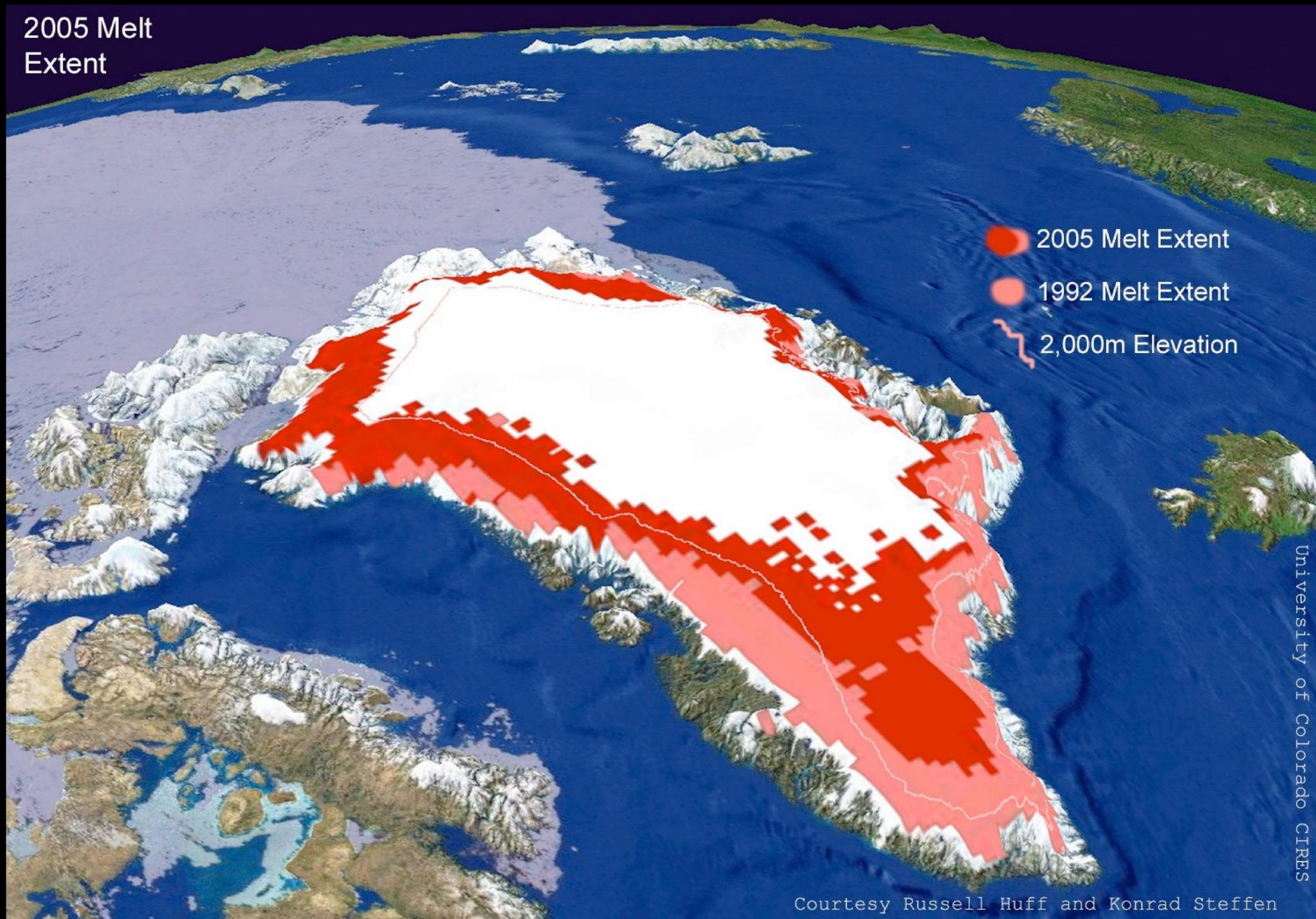


Muir Glacier at Glacier Bay National Park and Preserve in Alaska is among the many worldwide that are disappearing. Muir, left, as seen in August 1941, and photographed in August 2004.

W. Field; B. Molnia/U.S.G.S., via Glacier Photograph Collection

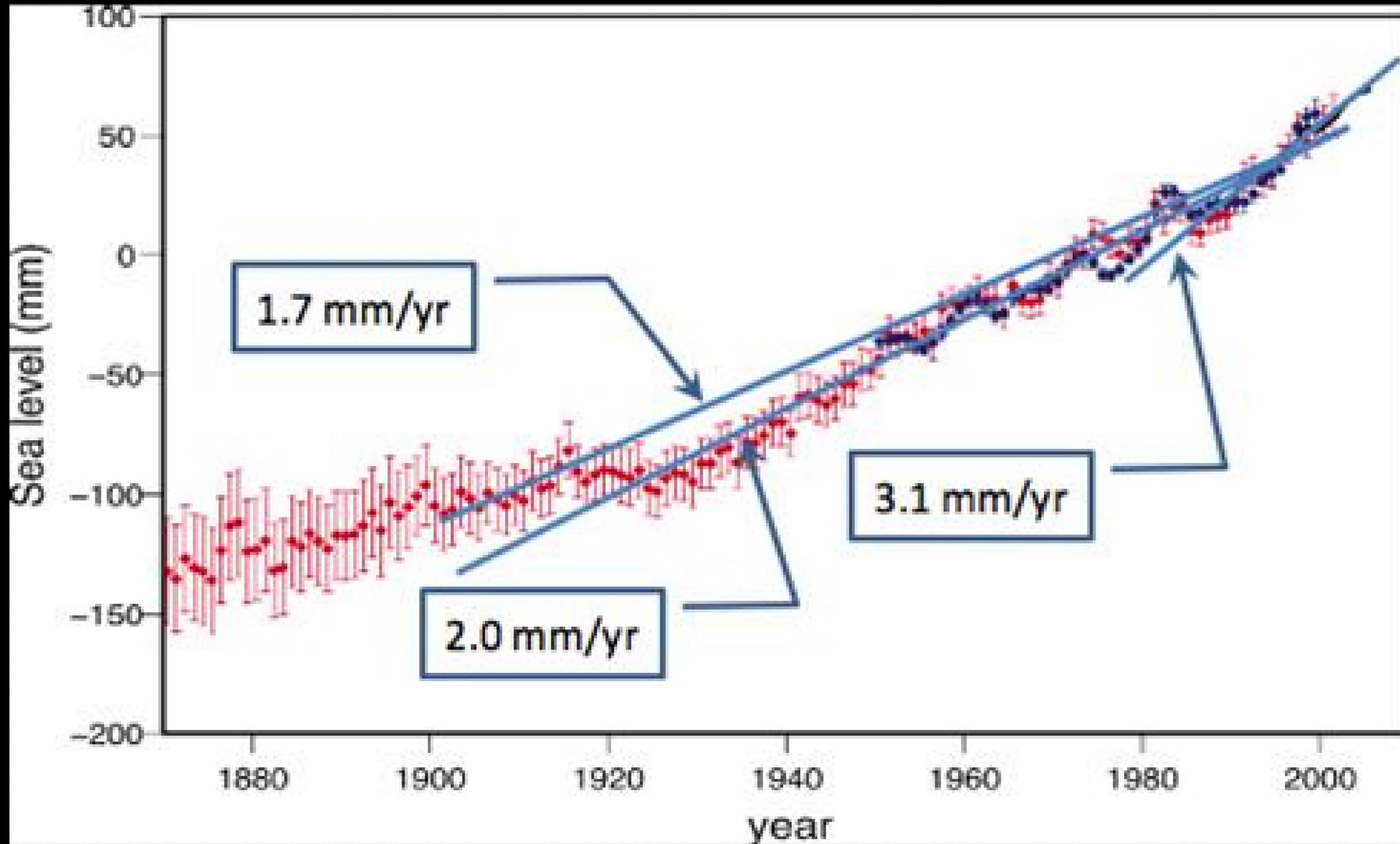
1941

2004

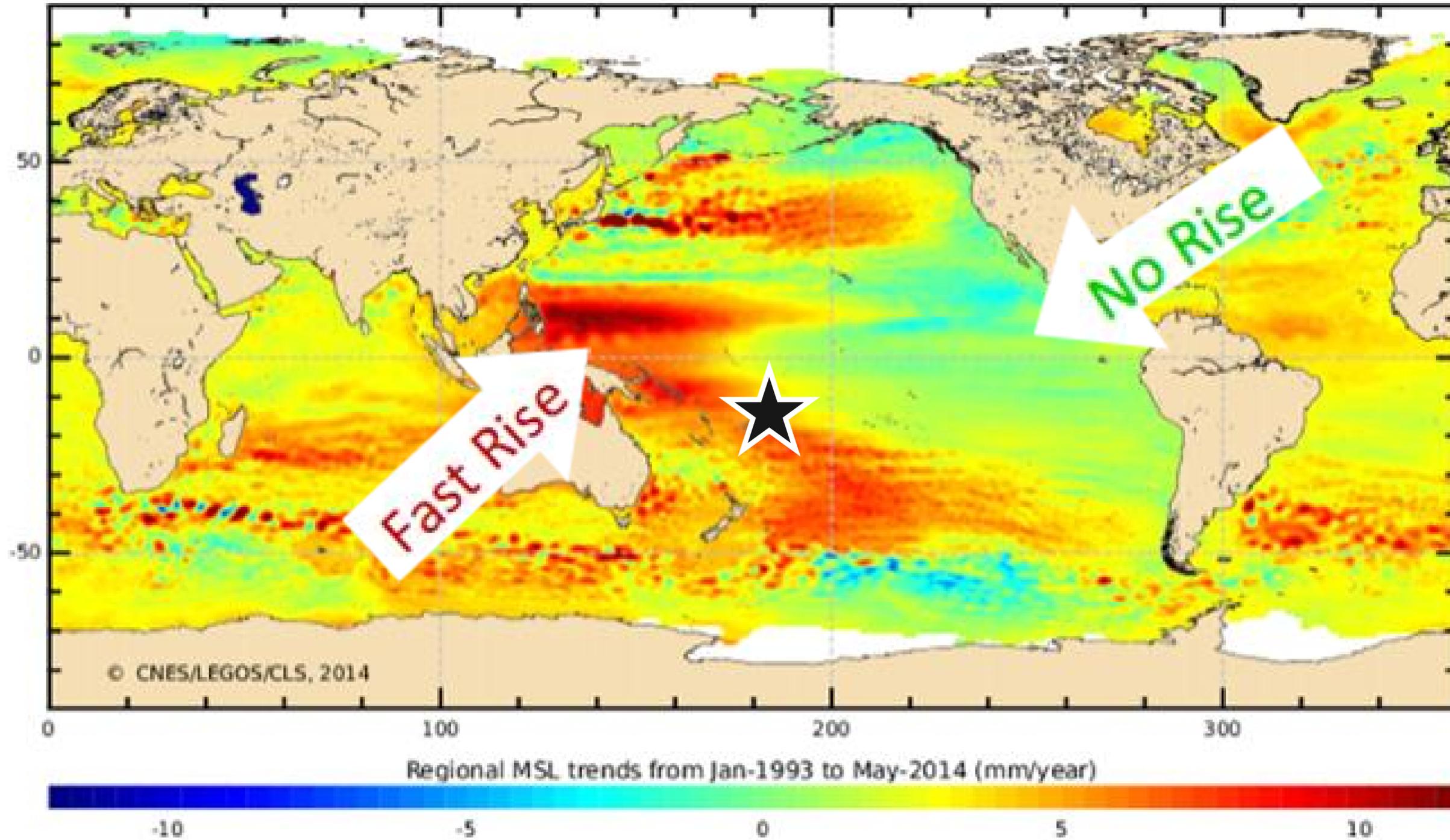


The maximum extent of summer ice melt in Greenland has been increasing

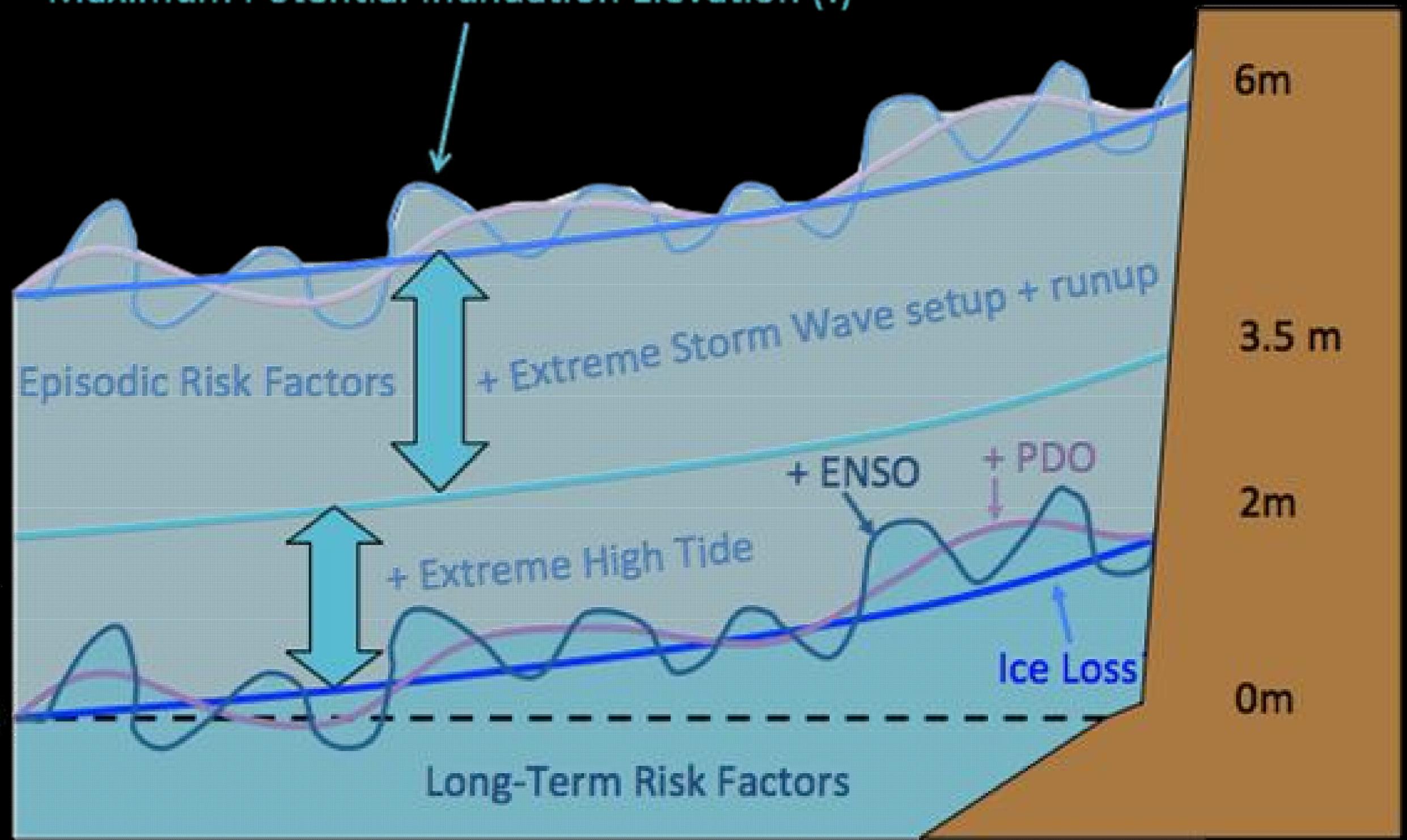
National Snow and Ice Data Center



# Regional context matters for sea level rise



# Maximum Potential Inundation Elevation (!)



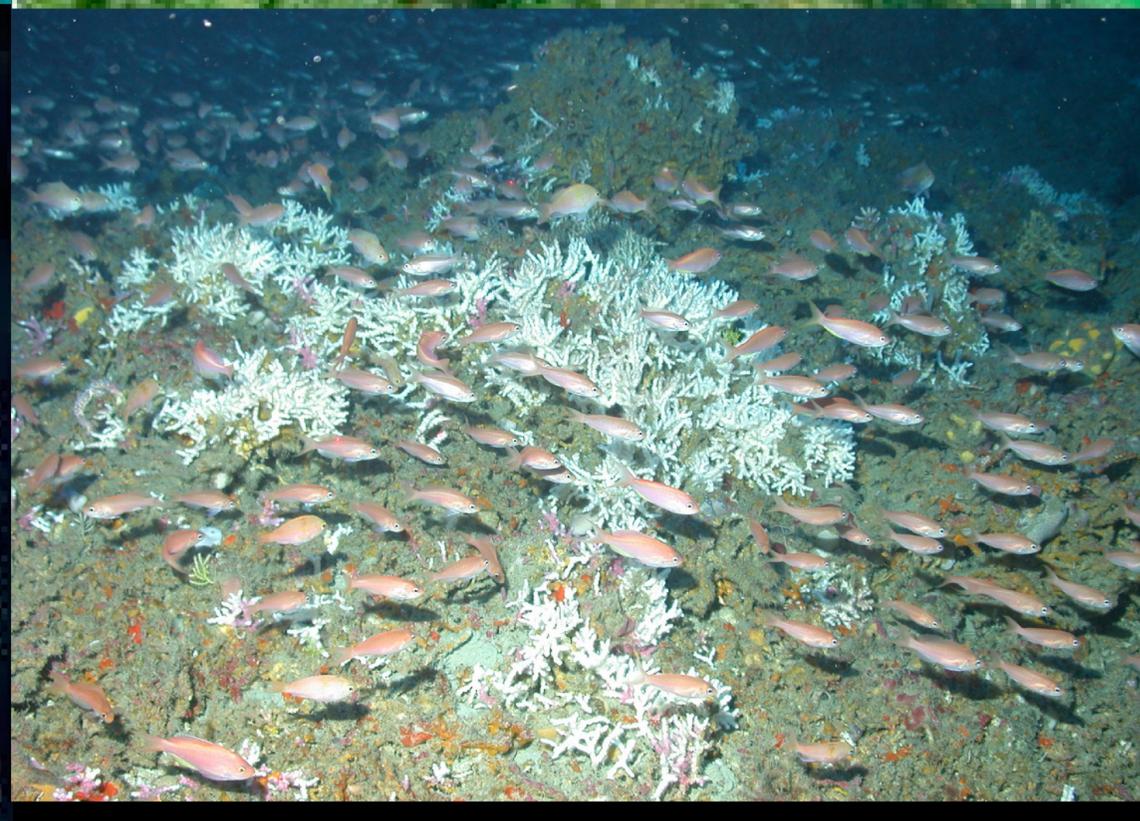
See Level Today

Today

2100

What are we optimistic about?

Coral  
research to  
understand  
vulnerability  
and ways to  
increase  
resilience





# SUSTAINABLE DEVELOPMENT GOALS

**1** NO POVERTY

**2** ZERO HUNGER

**3** GOOD HEALTH AND WELL-BEING

**4** QUALITY EDUCATION

**5** GENDER EQUALITY

**6** CLEAN WATER AND SANITATION

**7** AFFORDABLE AND CLEAN ENERGY

**8** DECENT WORK AND ECONOMIC GROWTH

**9** INDUSTRY, INNOVATION AND INFRASTRUCTURE

**10** REDUCED INEQUALITIES

**11** SUSTAINABLE CITIES AND COMMUNITIES

**12** RESPONSIBLE CONSUMPTION AND PRODUCTION

**13** CLIMATE ACTION

**14** LIFE BELOW WATER

**15** LIFE ON LAND

**16** PEACE, JUSTICE AND STRONG INSTITUTIONS

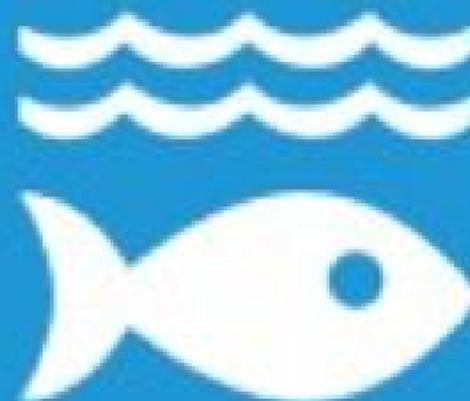
**17** PARTNERSHIPS FOR THE GOALS

  
SUSTAINABLE DEVELOPMENT GOALS

**13** CLIMATE  
ACTION



**14** LIFE  
BELOW WATER





Noting the importance of ensuring the integrity of all ecosystems, **including oceans**, and the protection of biodiversity, recognized by some cultures as Mother Earth, and noting the importance for some of the concept of “climate justice”, when taking action to address climate change,





