Climate change in the Pacific region: The physical setting

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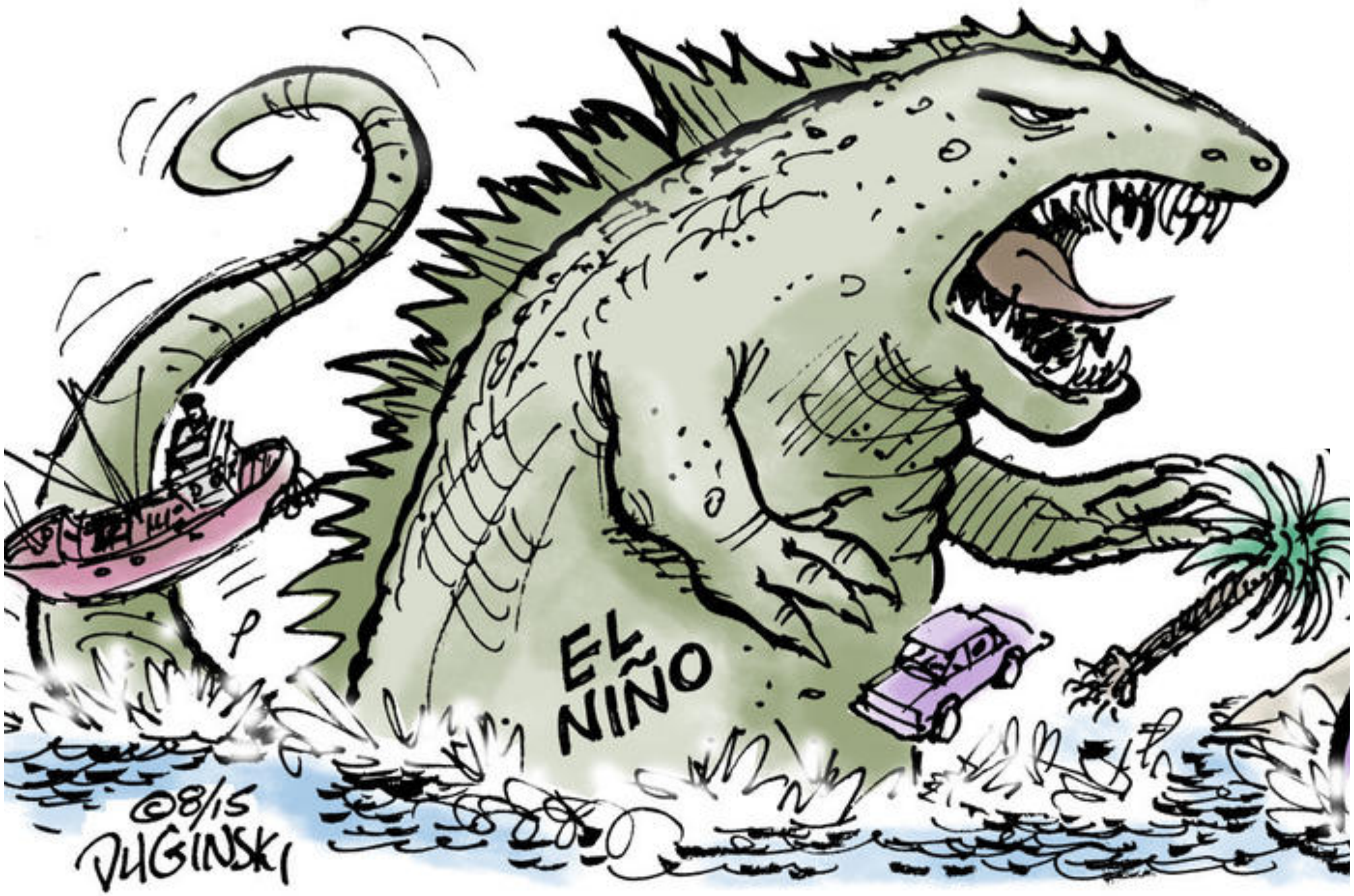
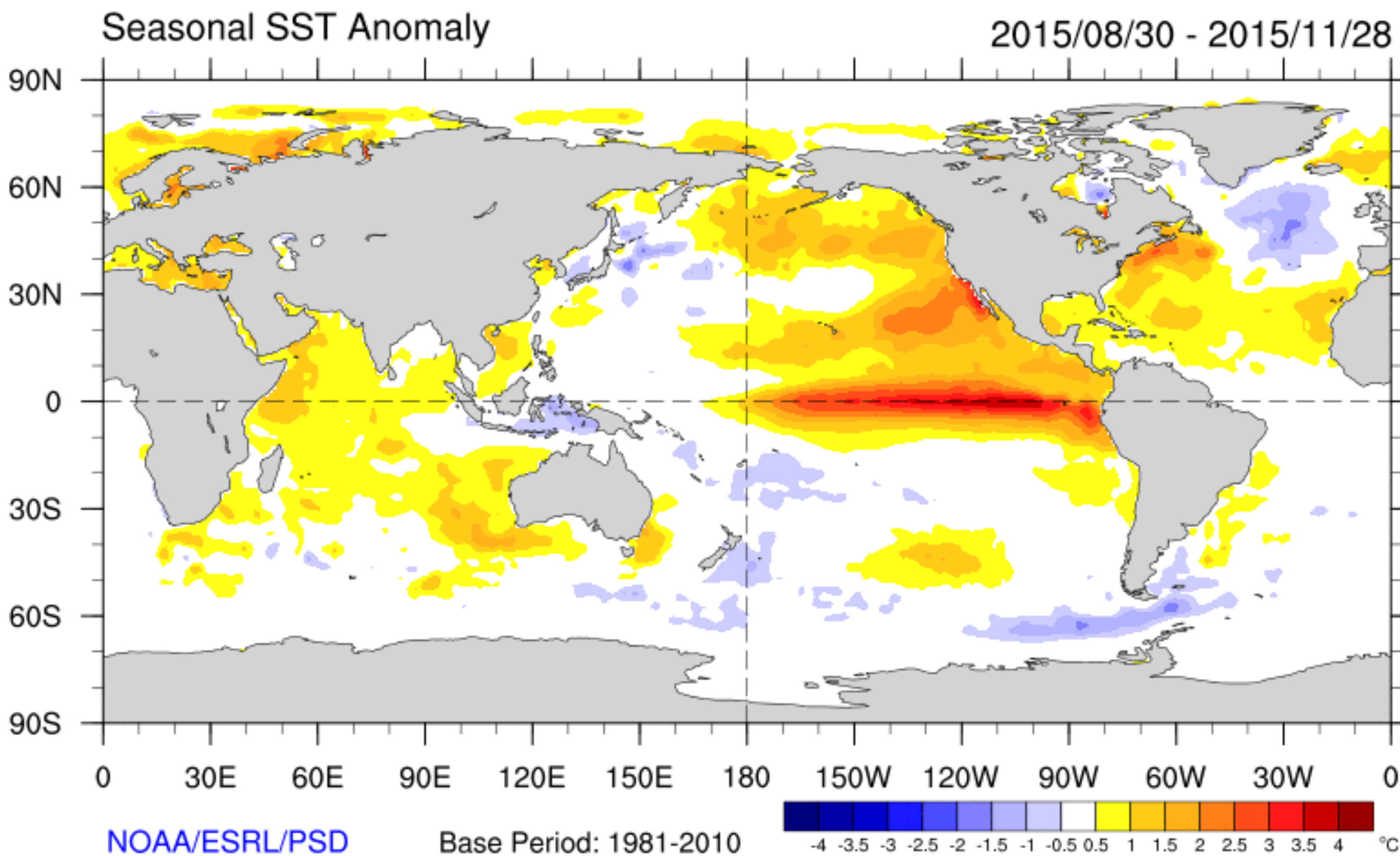
Regional and Global Climate Modeling Program

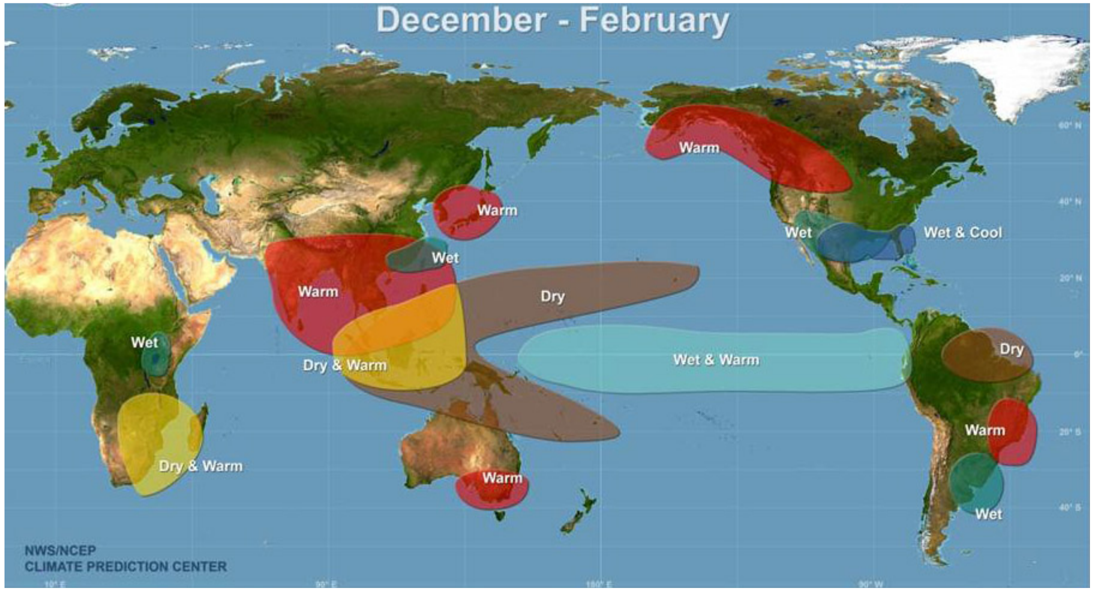
When you say "Pacific climate" to most people, they often think "El Niño"



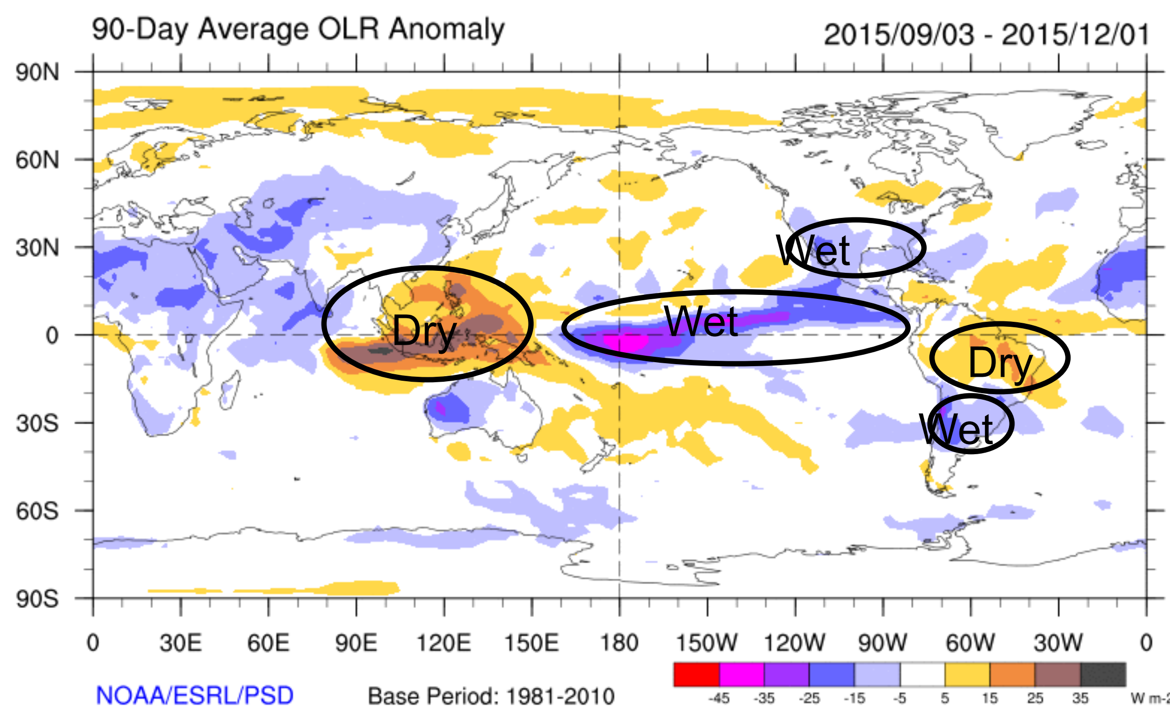
El Niño of 2015-2016—largest on record



El Niño impacts

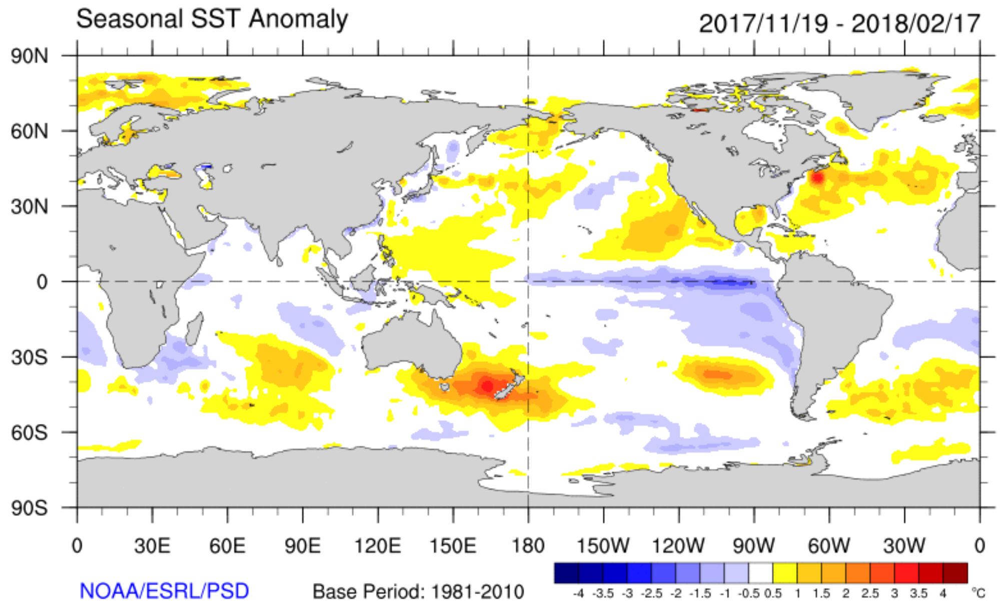


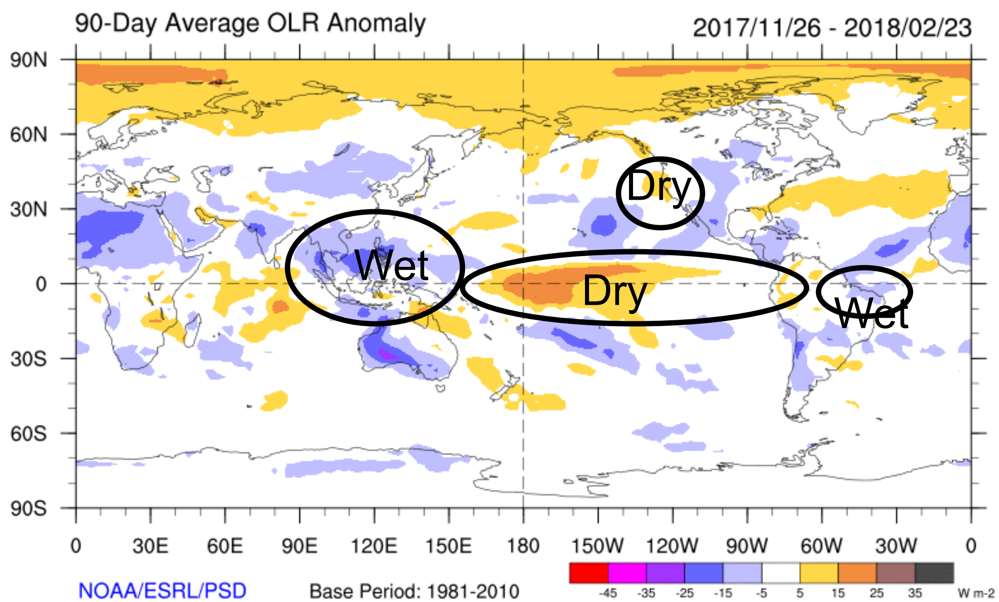
Observed precipitation anomalies Sept.-Nov., 2015



The flip side of El Niño is "La Niña"

The weak La Niña of 2017-2018 with nearly opposite impacts to El Niño





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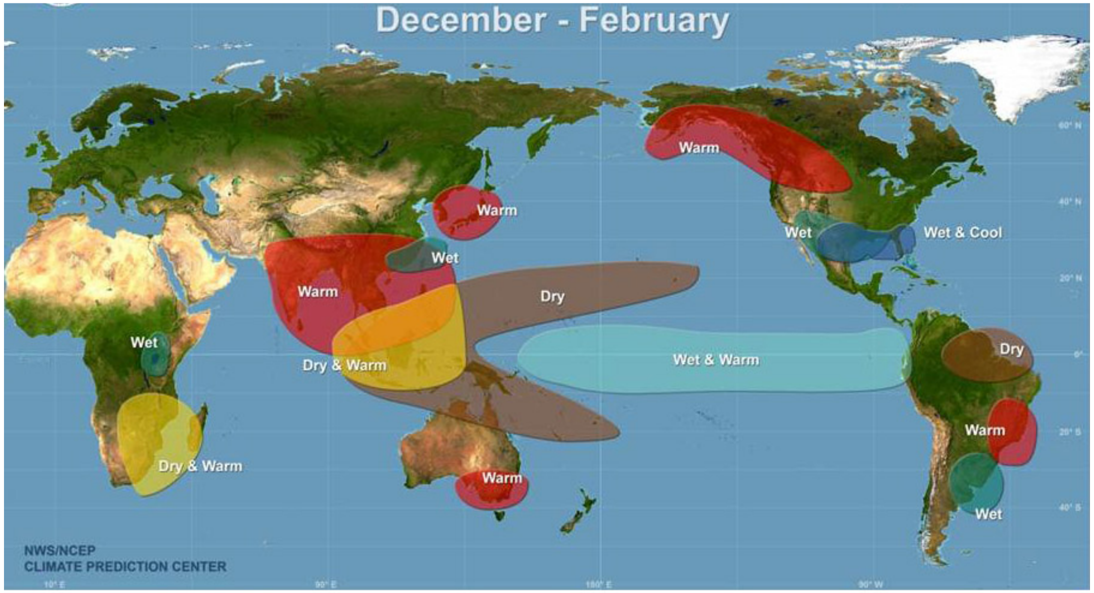


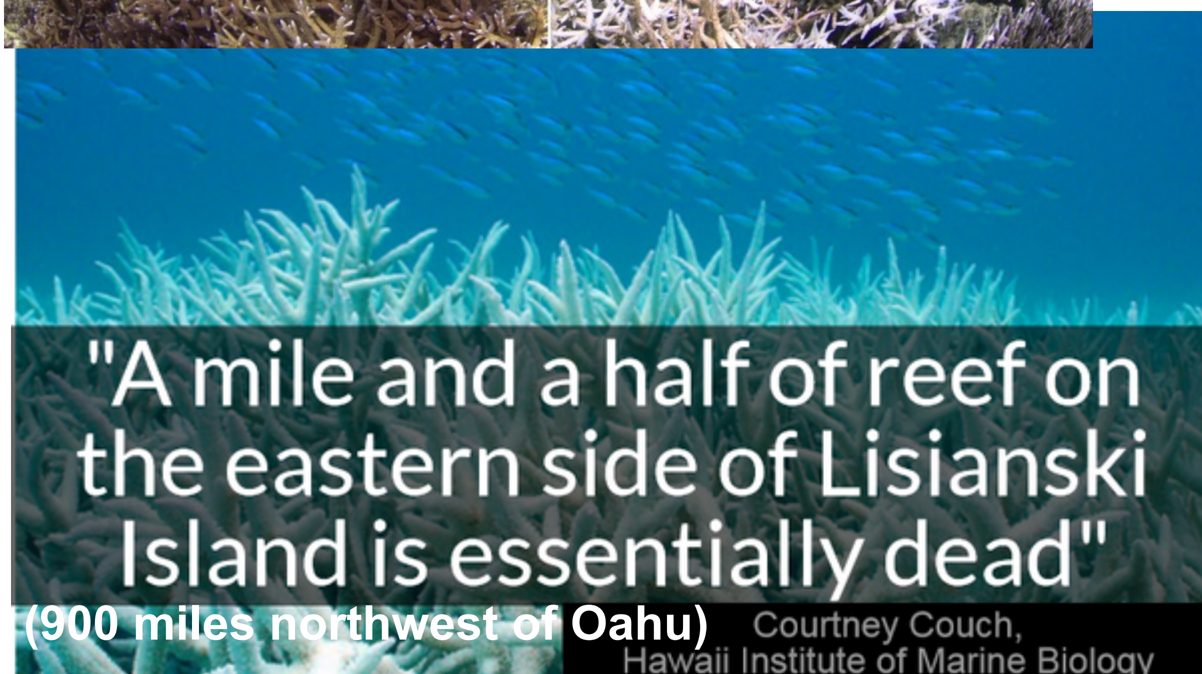
The future: As average ocean temperatures continue to warm, the impacts from El Niño events will worsen

Coral Bleaching

corals expel symbiotic algae that live and photosynthesize within their tissues

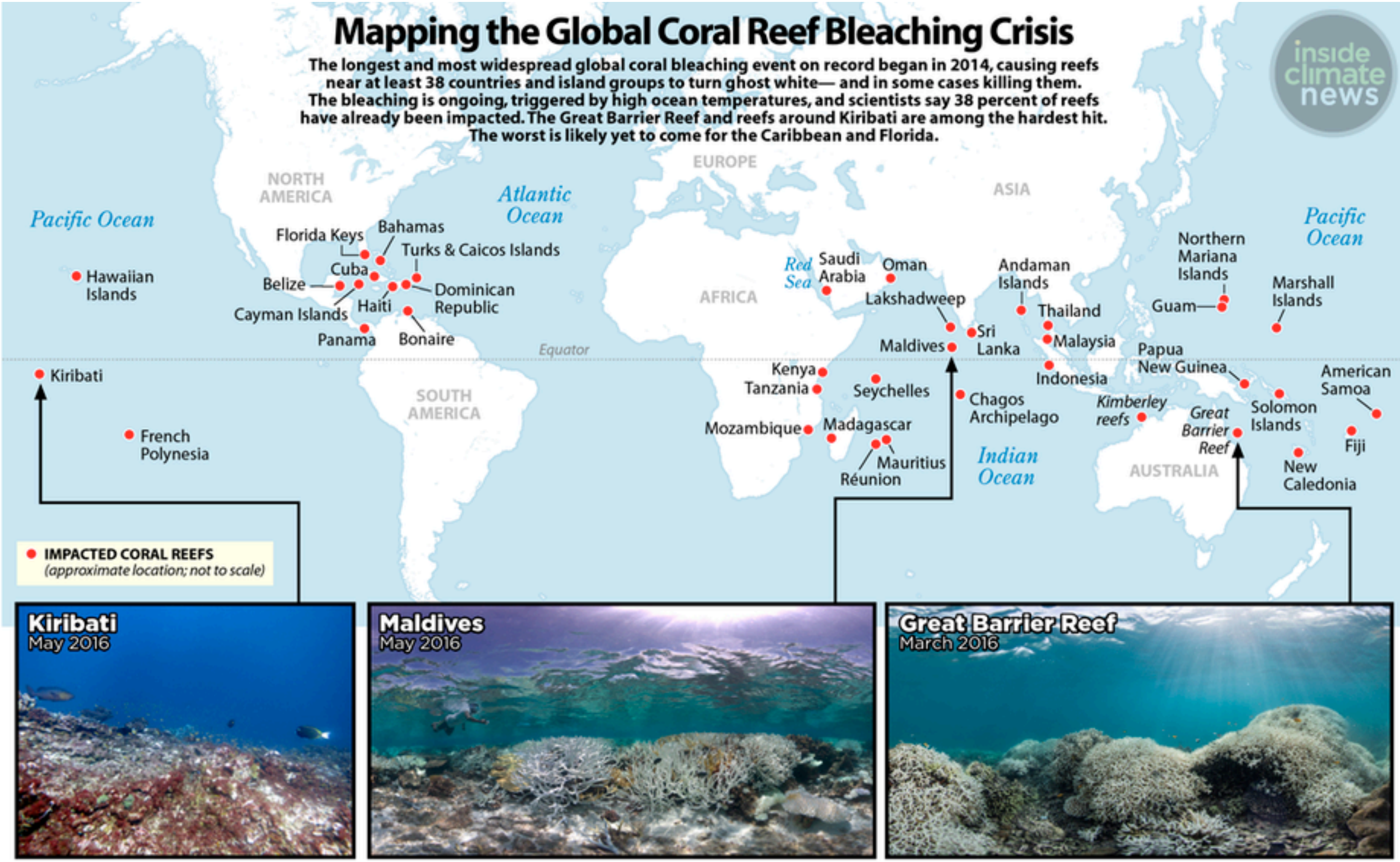
Coral bleaching in progress in 2015 at Pago Pago, American Samoa

In Hawaii, bleaching occurred in Kaneohe Bay, Waimanalo on Oahu and Olowalu on Maui. On the Big Island, bleaching was reported from Kawaihae to South Kona on the leeward side and Kapoho in the southeast



Not all reefs that bleach die, but mortality of bleached reefs can be 50% or more

A reef in American Samoa



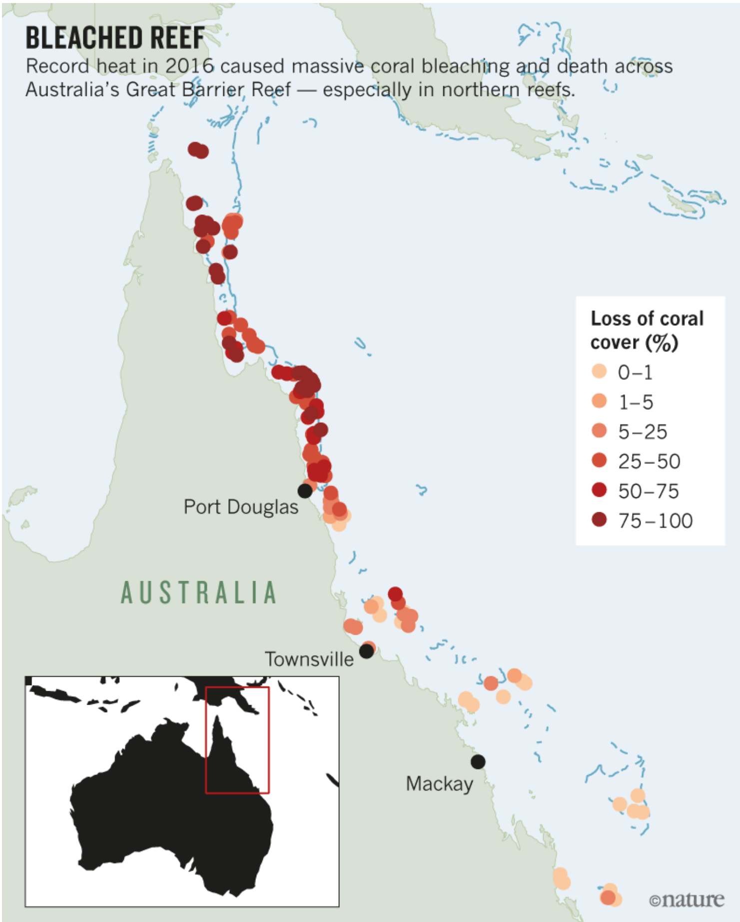
SOURCES: "Global Coral Bleaching 2014-2017" report by C.M. Eakin et al.; NOAA/Bernardo Vargas-Ángel; XL Catlin Seaview Survey; InsideClimate News research

PAUL HORN / InsideClimate News

In 2015-2017, the Great Barrier Reef experienced its worst bleaching event on record

Bleaching during the 2015-2016 El Niño was severe and, for the first time, continued into the non-El Niño year of 2017

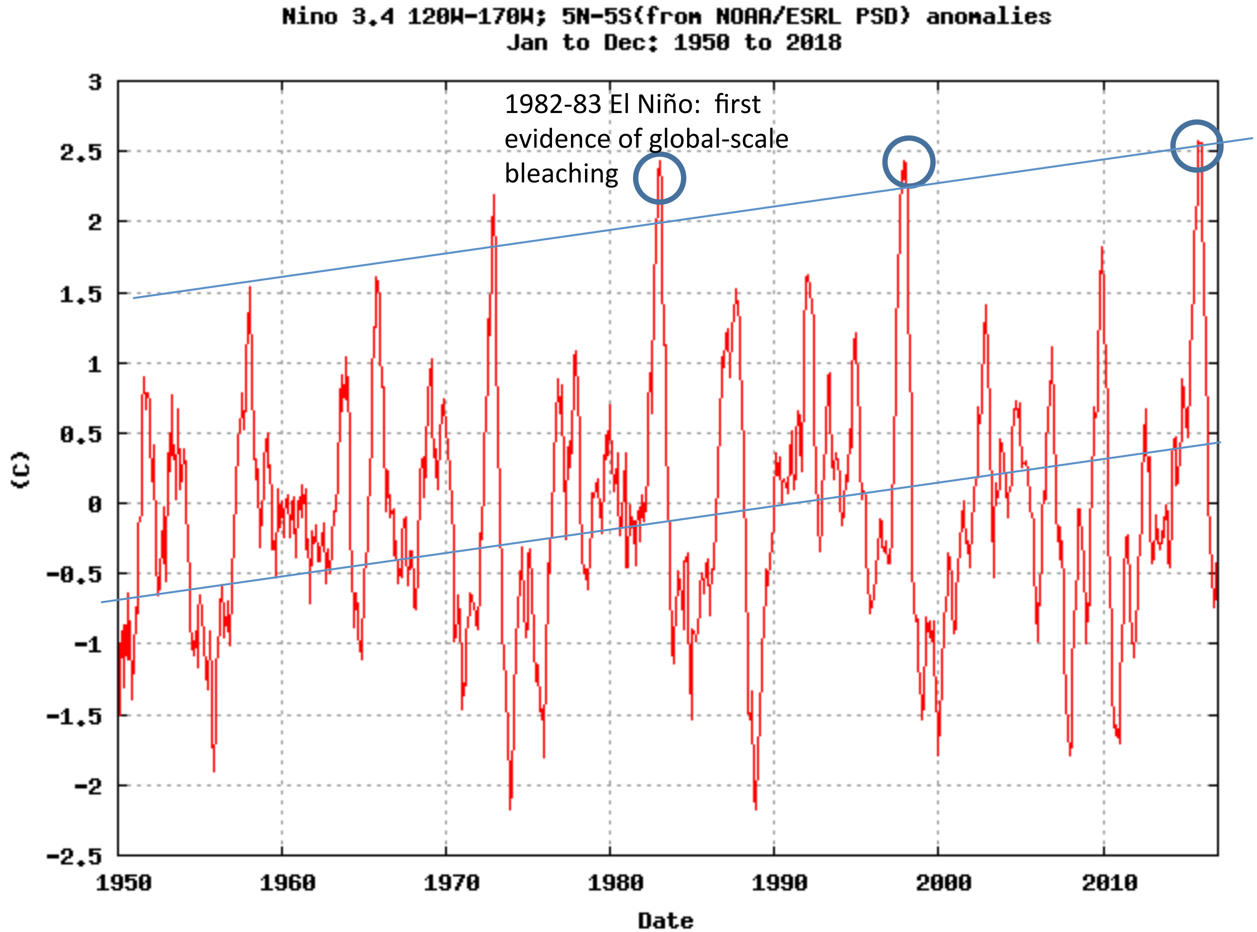
https://www.facebook.com/chasingcoral/videos/1776577129313083/



High ocean temperatures killed roughly 30% of the Great Barrier Reef corals in 2016 alone (Hughes et al., 2018, Nature)

"the interval between recurrent bouts of coral bleaching is too short for a full recovery…tropical sea surface temperatures are warmer now during current La Niña conditions than they were during El Niño events three decades ago. Consequently, as we transition to the Anthropocene, coral bleaching is occurring more frequently in all El Niño–Southern Oscillation phases, increasing the likelihood of annual bleaching in the coming decades." (Hughes et al., 2018, Science)

The El Niño connection: as average ocean temperatures warm, El Niño events are superimposed on those warmer temperatures and impacts become more severe



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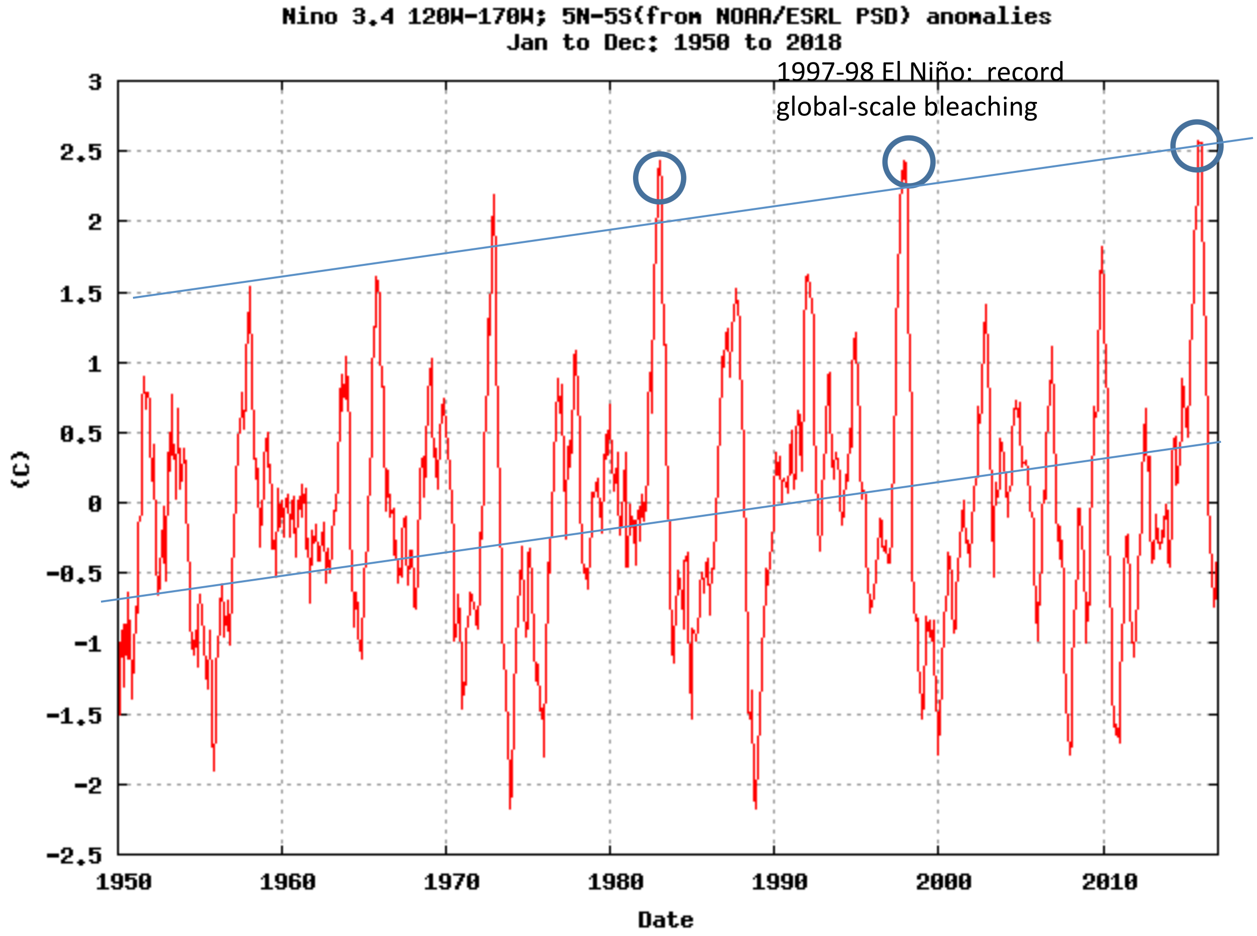

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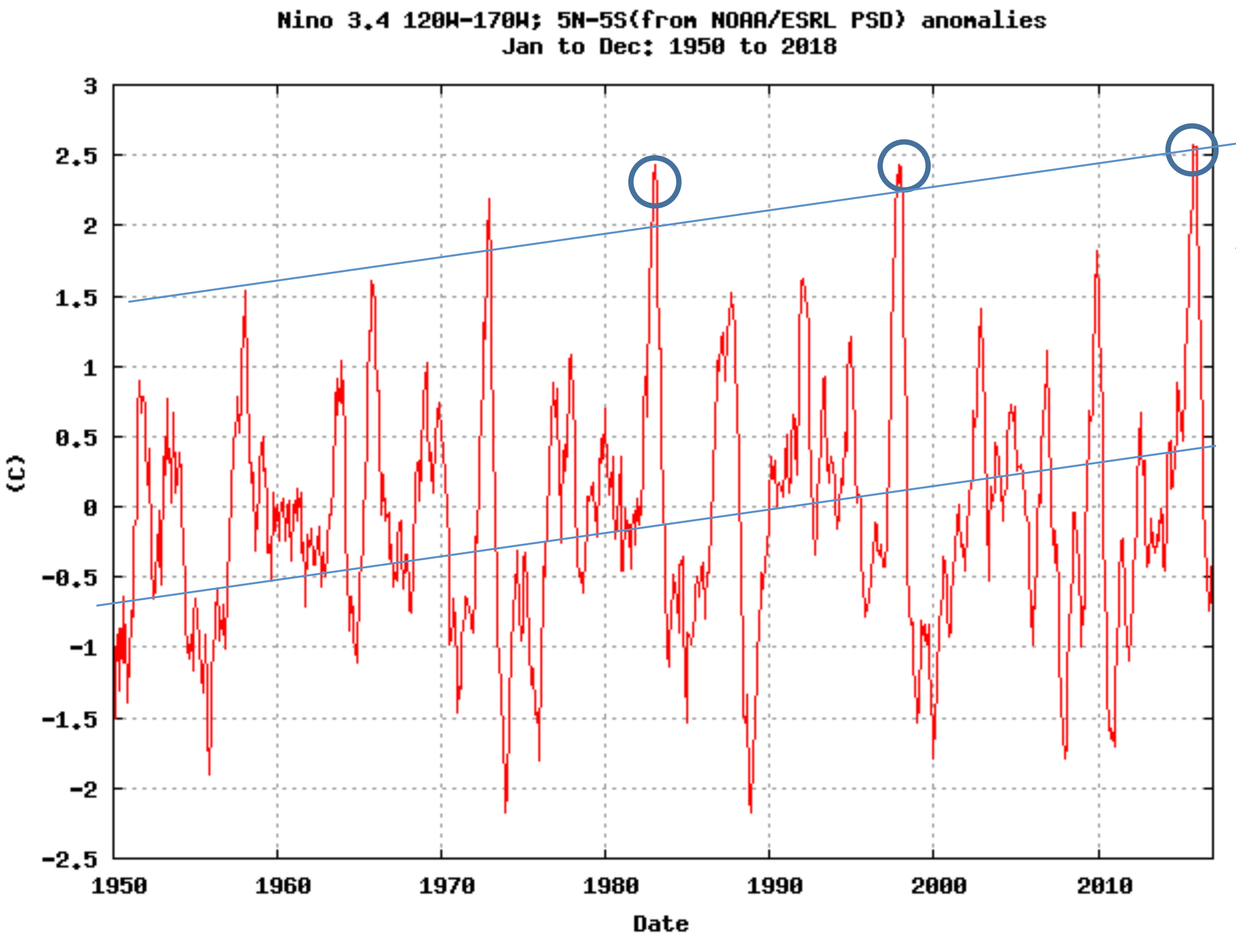
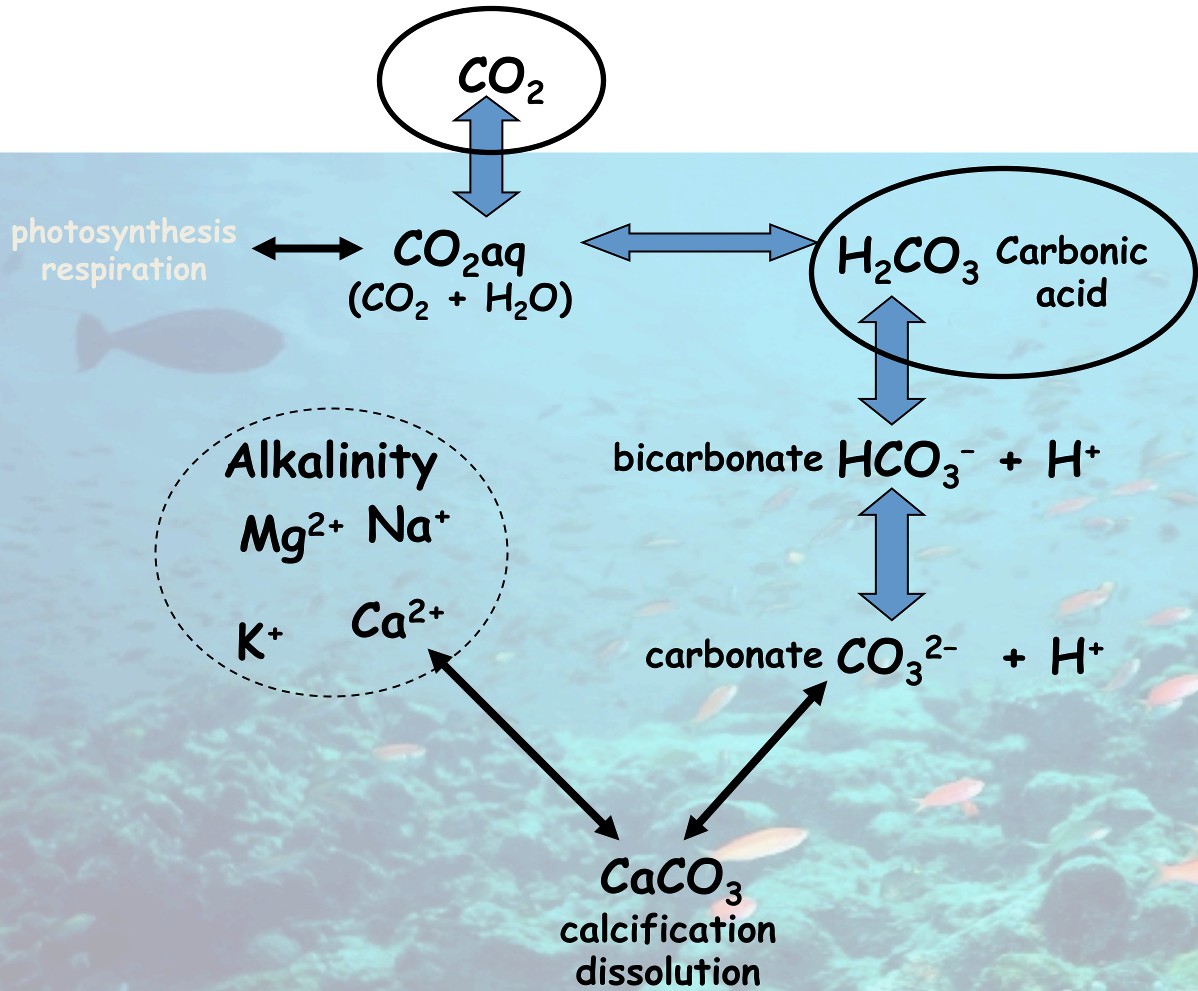


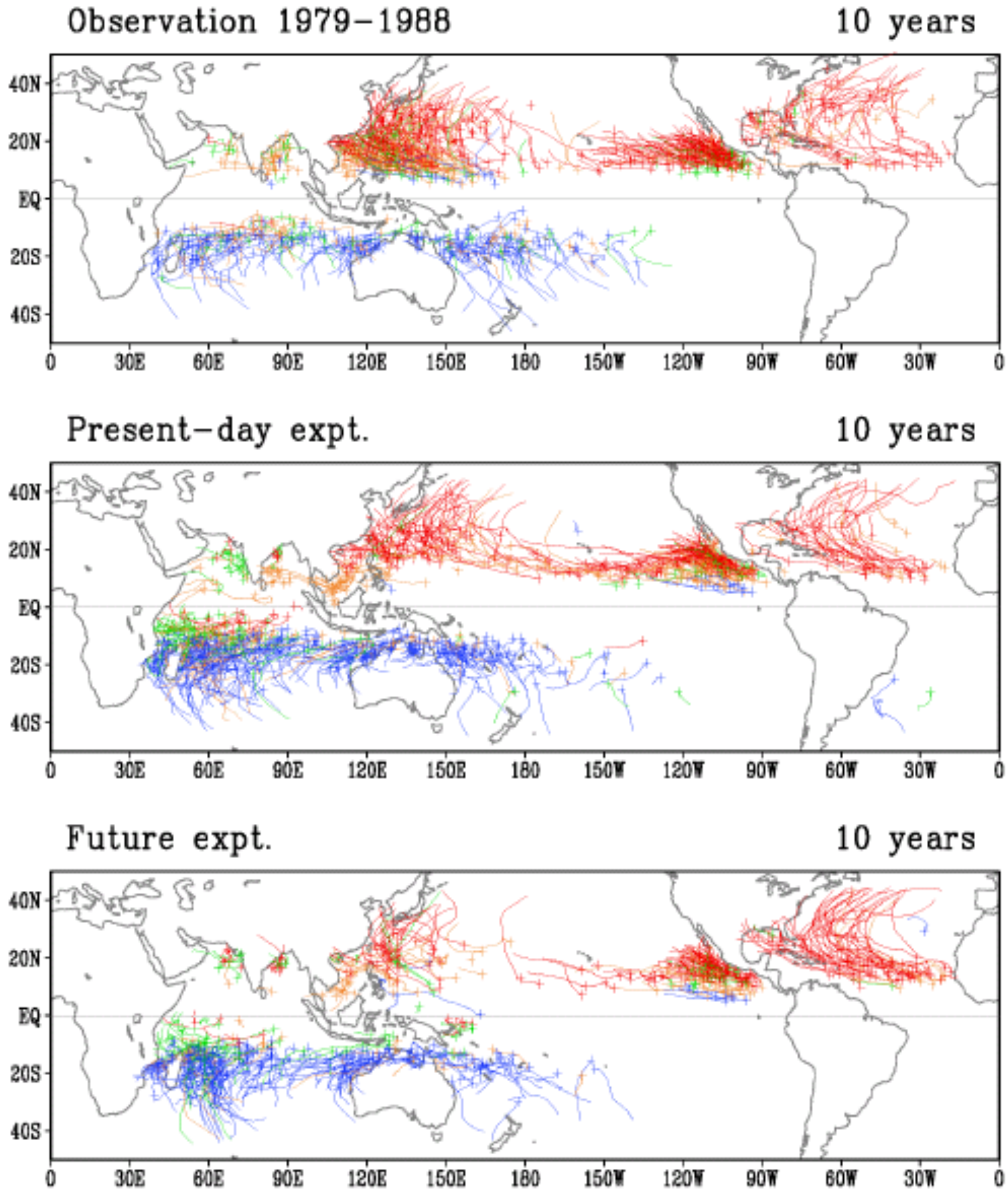
2015-16 El Niño: new record global-scale bleaching, extends into non- El Niño year 2017 for first time

Ocean Acidification and Carbonate Chemistry

Causes skeletal loss in corals and other marine organisms



As CO_2 in the atmosphere increases from the burning of fossil fuels, the oceans become more acidic



Tropical cyclones/ typhoons (hurricanes)

Hurricane tracks from a global climate model

Future: less hurricanes but the ones that form will likely be more intense

What about sea level rise?

Two factors can cause sea level to rise:

1. thermal expansion of warmer water
2. additional water added to the oceans from melting land ice (glaciers and ice sheets);

(sea ice is shrinking but that doesn't add to sea level rise)

What if you live on an atoll like this one? (Tetiaroa, highest point above sea level: 6 feet)
You'd better worry about land glaciers, Greenland and Antarctica!

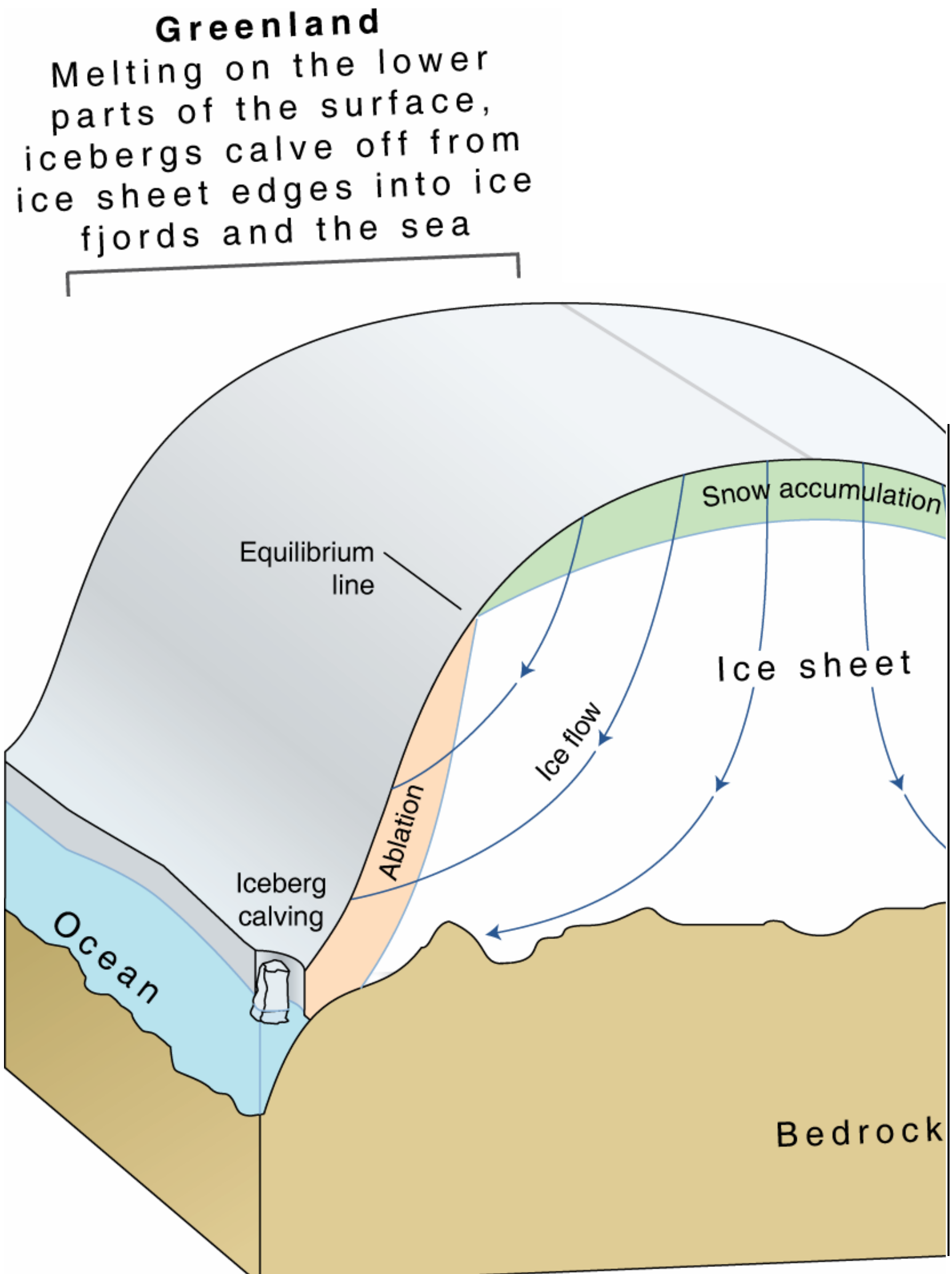
Sea level rise over the past 50 years or so (about 8”) is already causing coastal and beach erosion, increased tidal flooding, and more severe storm surge flooding; in the future sea level rise could submerge entire atolls making them uninhabitable

Coastal flooding on Funafuti Atoll (top) and Tarawa Atoll (bottom)

Melting all of the current Greenland ice sheet would result in a sea-level rise of about 6.5 meters (about 20 feet); melting all of the West Antarctic ice sheet would result in a sea-level rise of about 8 meters (about 25 feet)

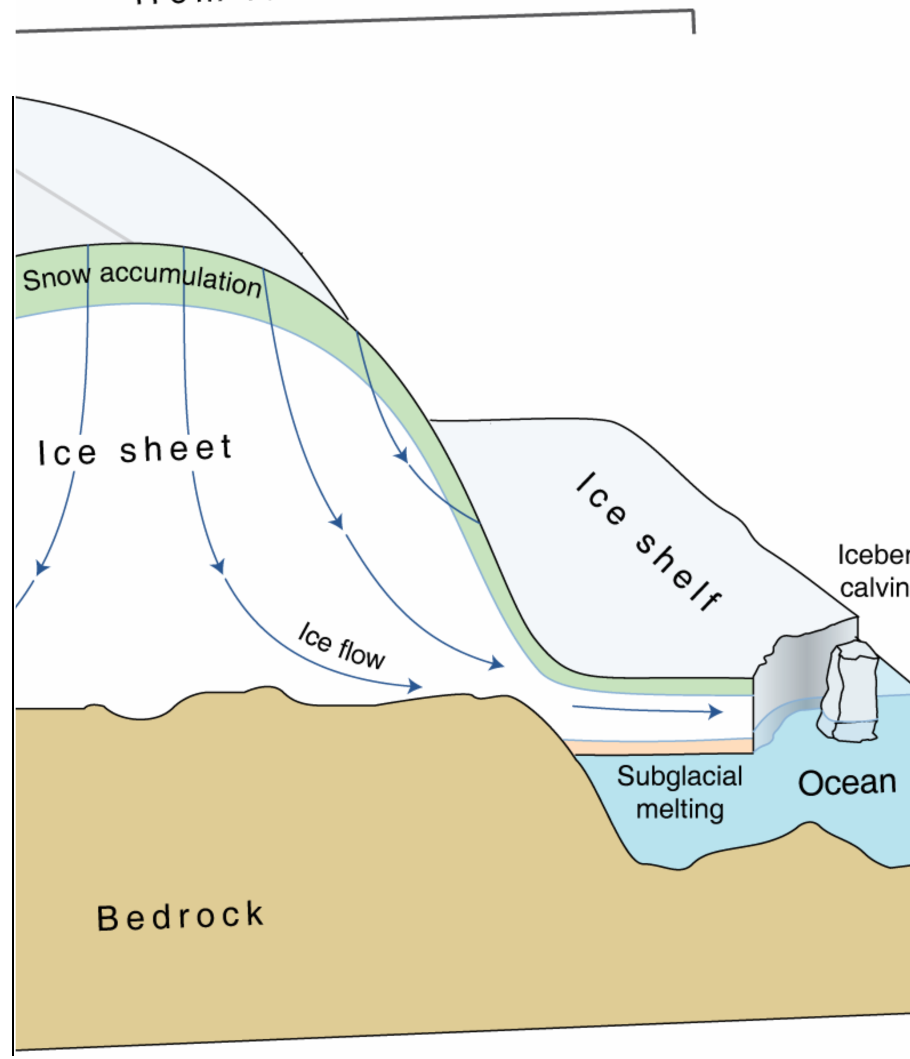
This is not likely to happen, but accelerated melting of the Greenland ice sheet has already been observed

how much will melt and how fast?

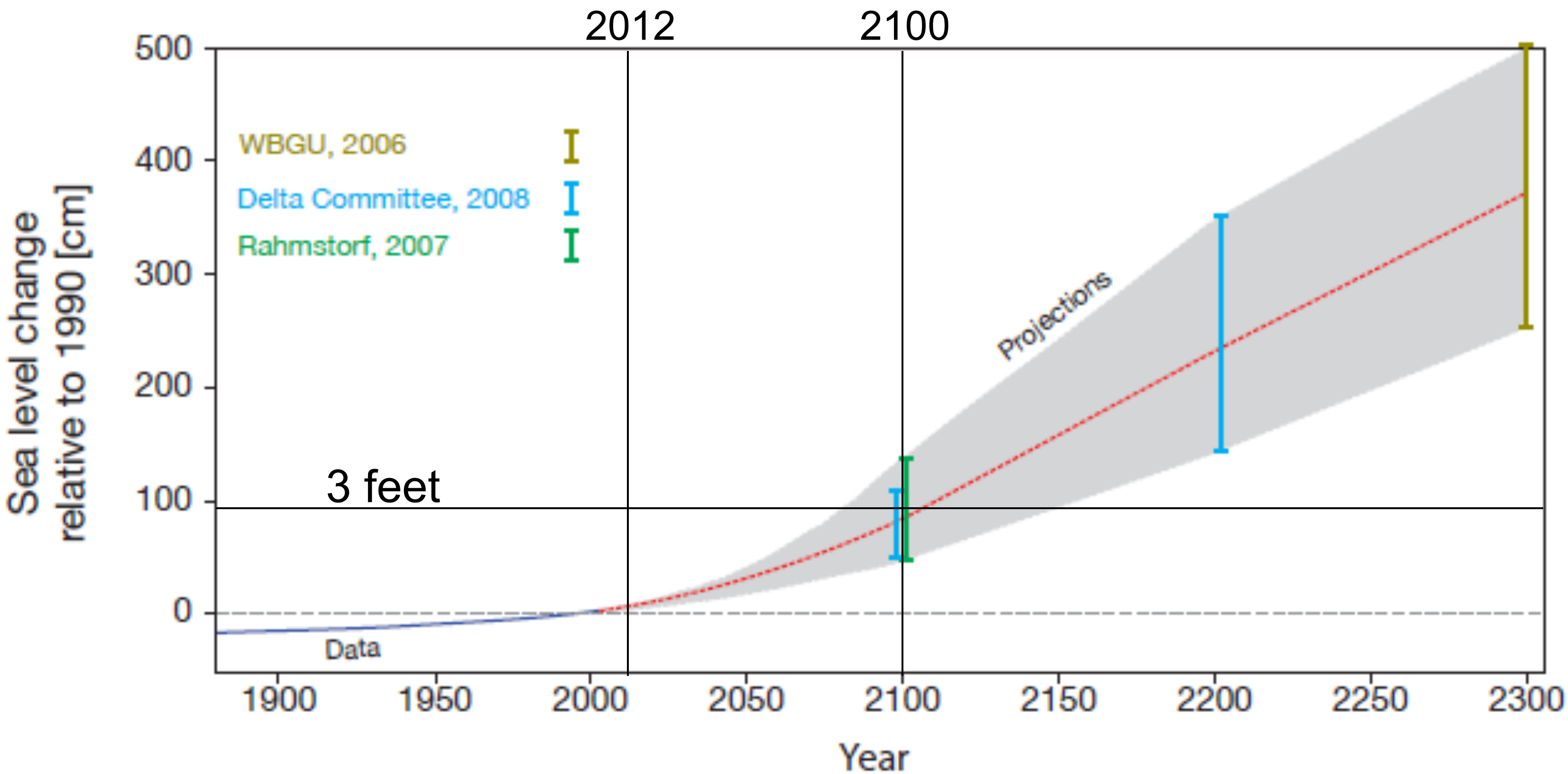

Greenland
Melting on the lower parts of the surface, icebergs calve off from ice sheet edges into ice fjords and the sea
Equilibrium line
Snow accumulation
Ice sheet
Ice flow
Ablation
Iceberg calving
Ocean
Bedrock

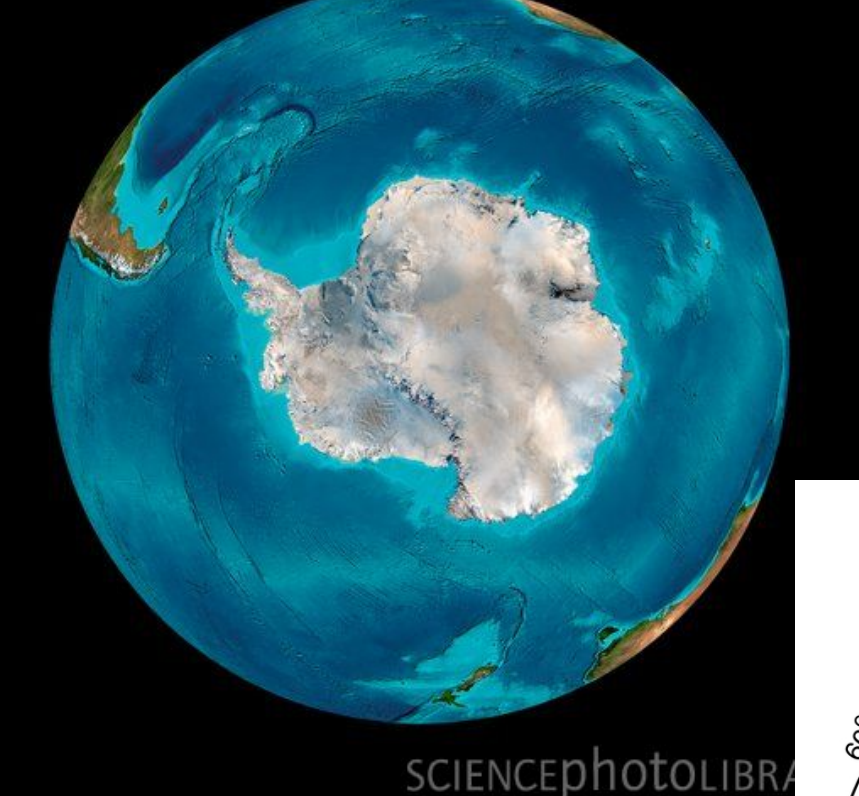
Antarctica

Ice shelves, with subglacial melting. Icebergs calve off from ice shelves

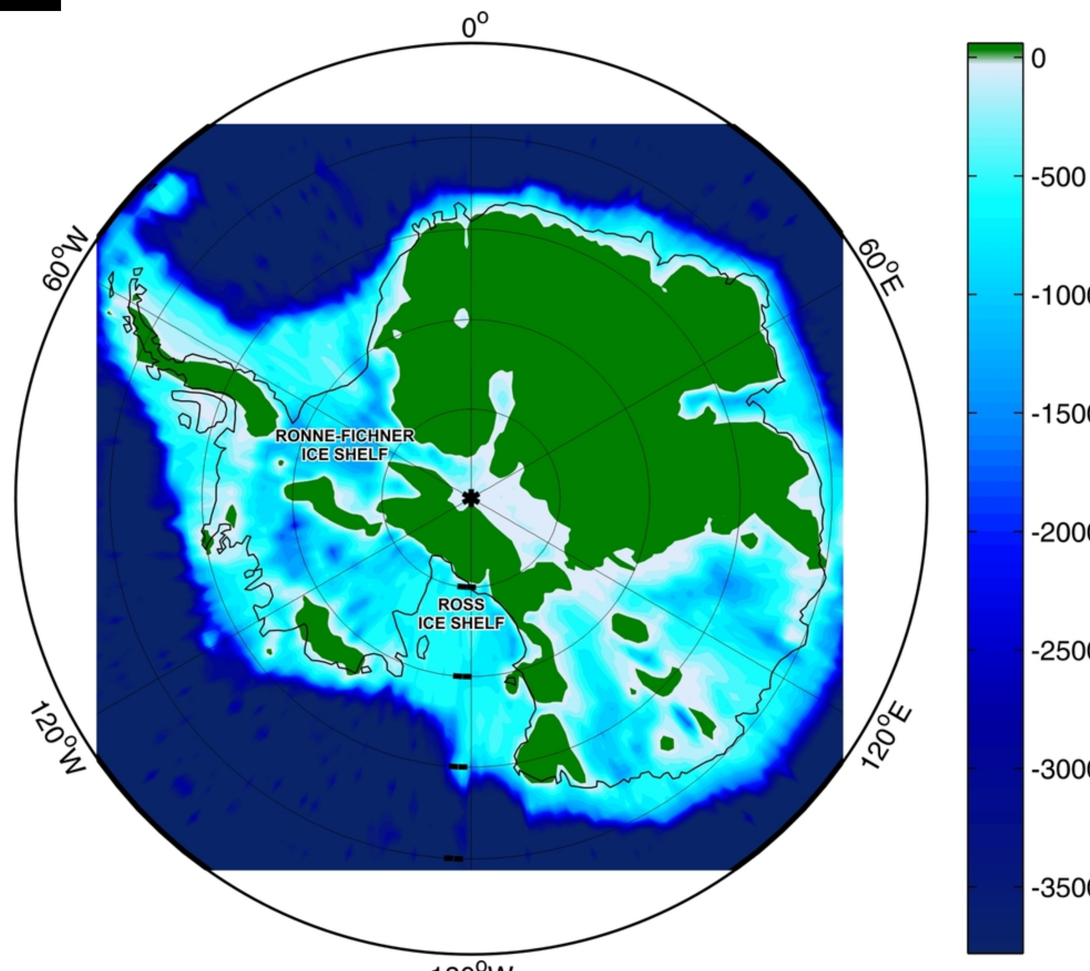


Due to our lack of knowledge of ice sheet disintegration processes, we still cannot definitively answer the questions "how much and how fast?" Some estimates go as high as 3 feet of sea level rise or more by 2100



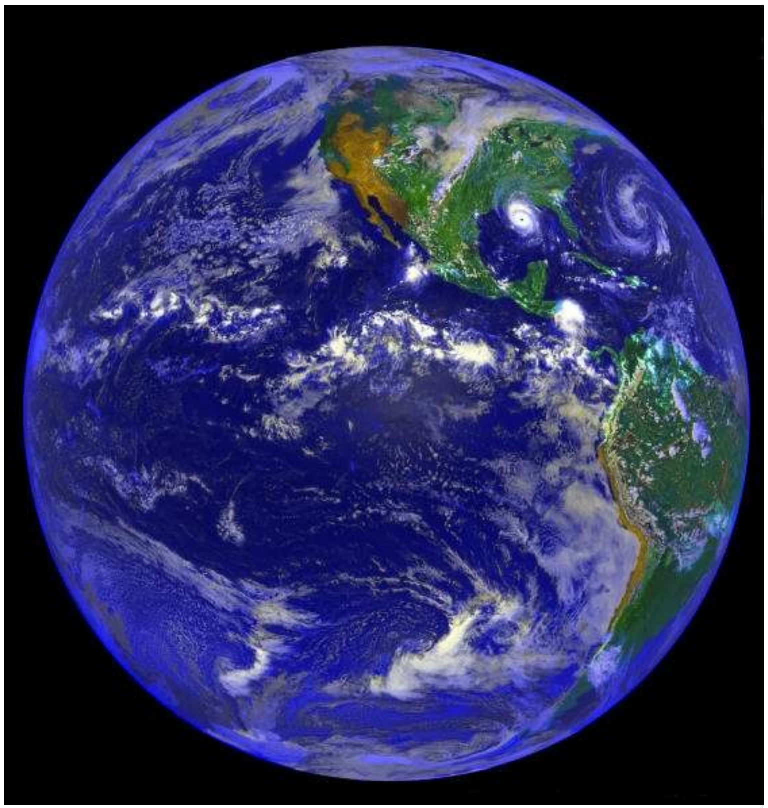


Much of West Antarctica is below sea level; if warming ocean water penetrates under the ice and starts melting it, the West Antarctic Ice Sheet could become unstable and disintegrate more rapidly—we have very little information on whether that has occurred before or could occur now

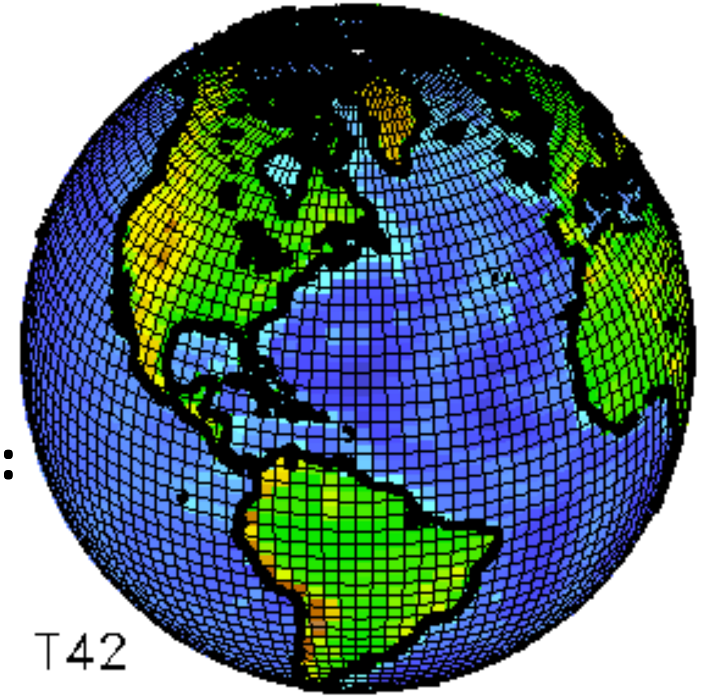


Earth System models

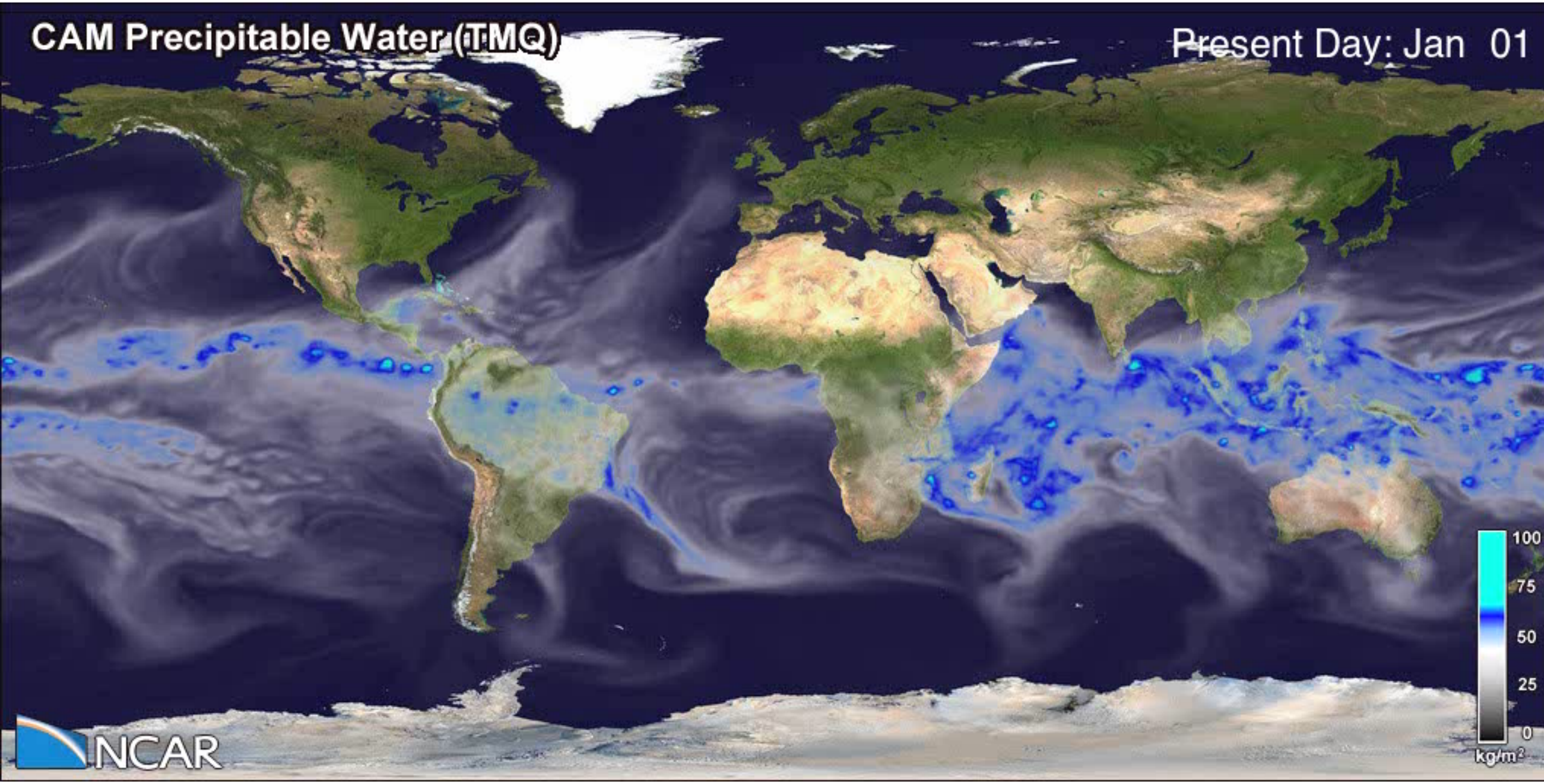
simulate this:



with this:



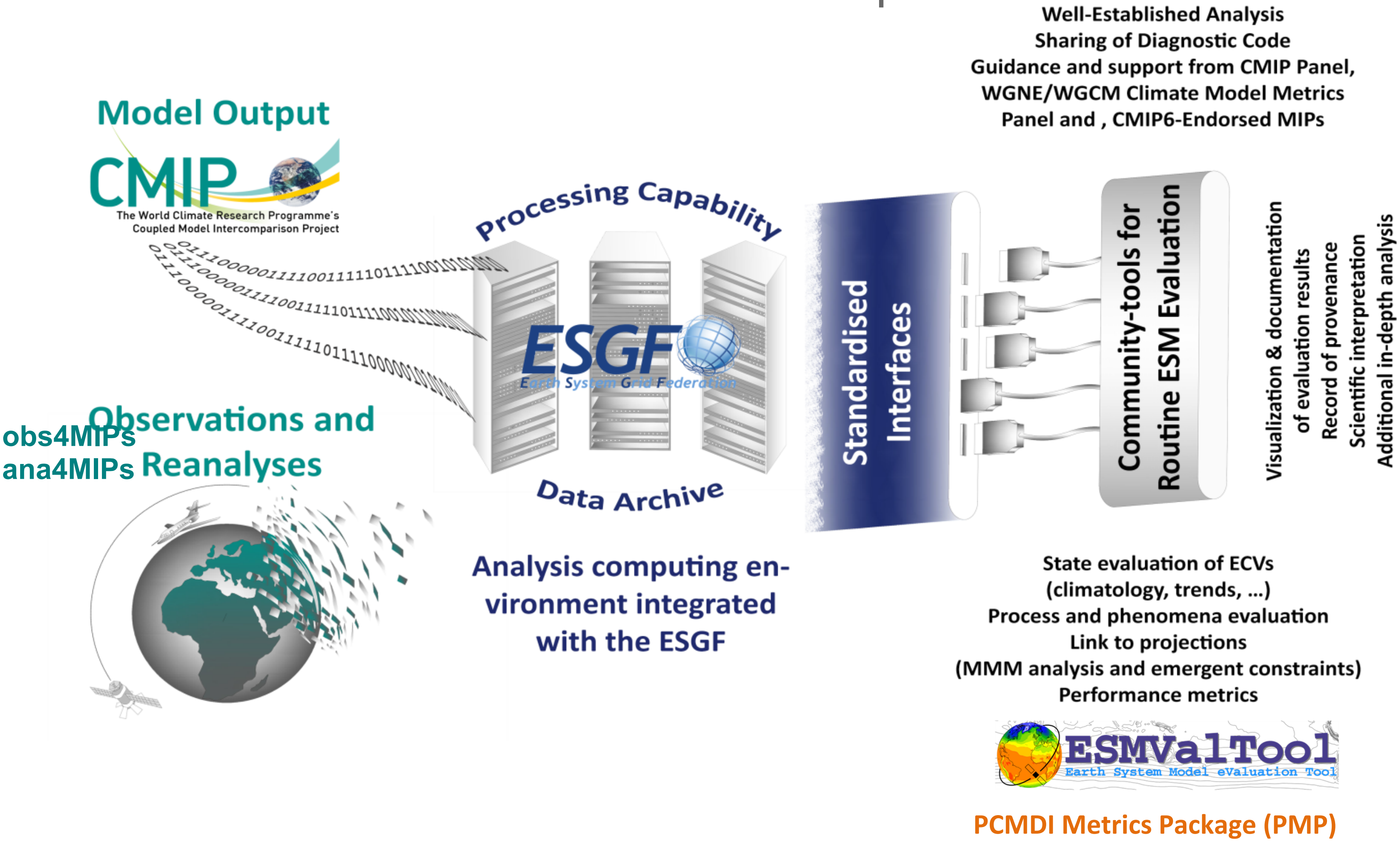
Components of atmosphere, ocean, land surface processes, sea ice, ice sheets (sea level rise), ocean biogeochemistry (ocean acidification), atmospheric chemistry (air pollution)



¼ degree (grid points every 25 km) time slice simulation representative of present-day climate run with an INCITE allocation at Argonne

Access and Analysis of Earth System Model output current phase of CMIP6 expected to produce 10 petabytes of model data; 33 modeling groups from 16 countries

data access via web portals



Summary:

Future threats to physical system in Pacific region related to increasing CO_2 from burning of fossil fuels:

1. Warming ocean temperatures produce more intense El Niño impacts (droughts, floods, extreme heat, coral bleaching)
2. Ocean acidification
3. Fewer total tropical cyclones/typhoons but more intense
4. Sea level rise
5. Earth System Models are tools to quantify possible future risks; large data volumes and distributed analysis via the Earth System Grid Federation