The New Normal: The Impact of a Warming Climate on Hawaii's Environment

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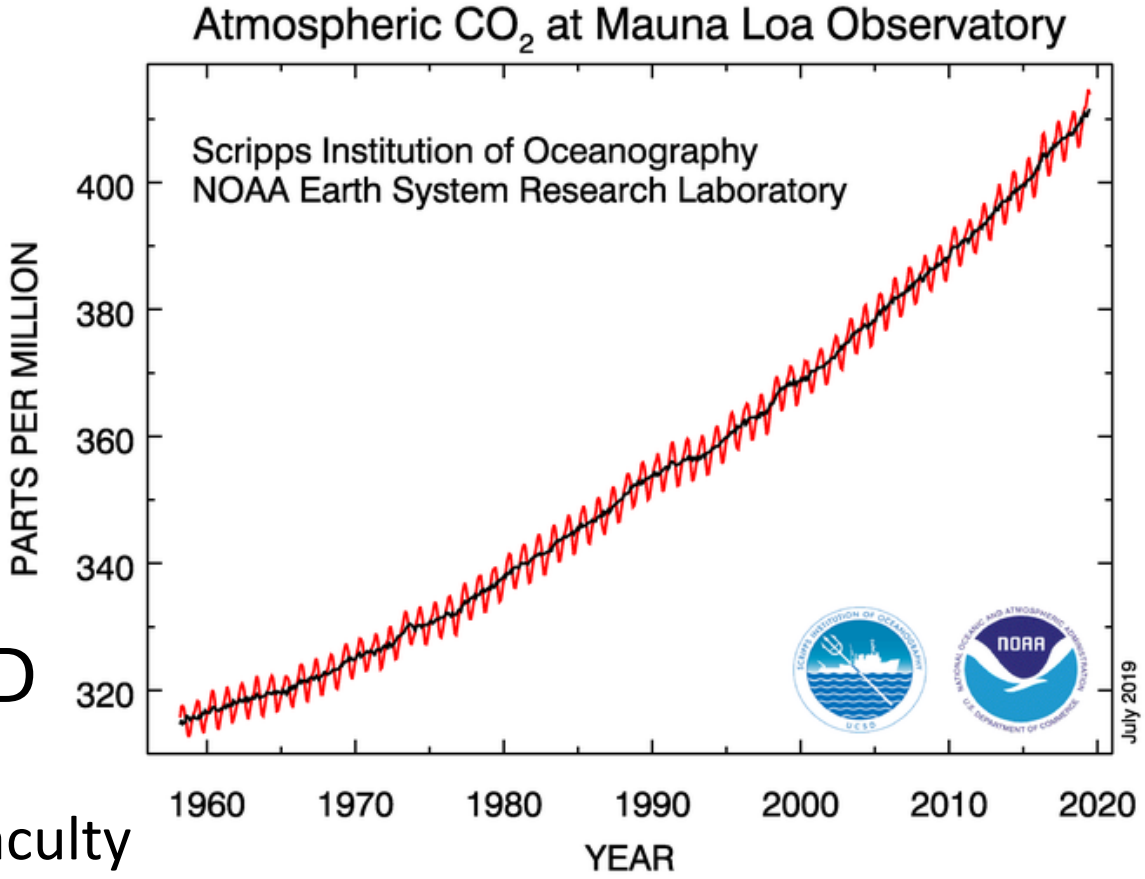


Hawai‘i-Pacific Islands Chapter Stats

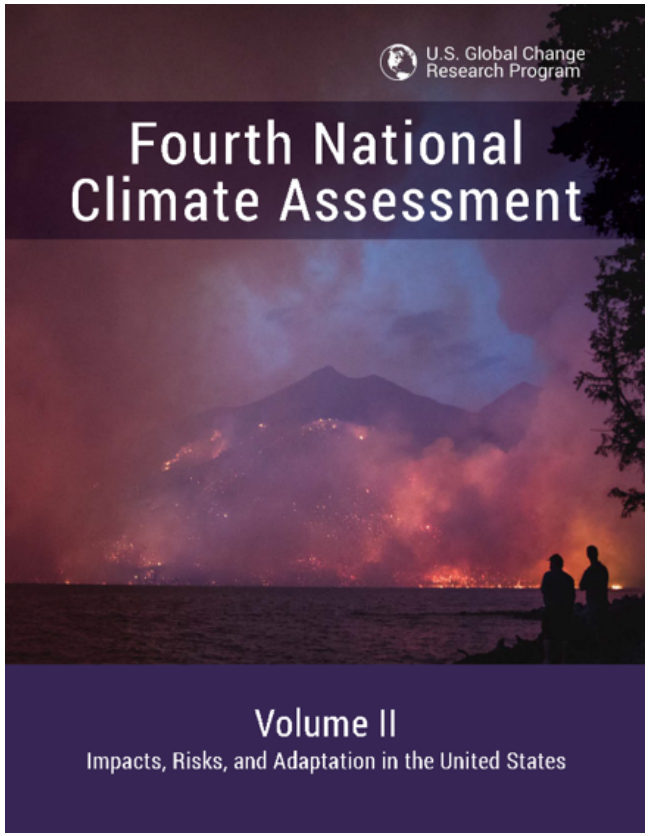
11 authors

77 technical contributors

250+ cited references from articles, reports, books (peer review and “grey” literature)

~350 people engaged in chapter development

8 rounds of review (Federal, Public, Nat. Academy of Sciences)



https://nca2018.globalchange.gov/chapter/27/

Key Messages for Hawai‘i and Pacific Islands

1. Water Supplies

2. Ecosystems and Biodiversity

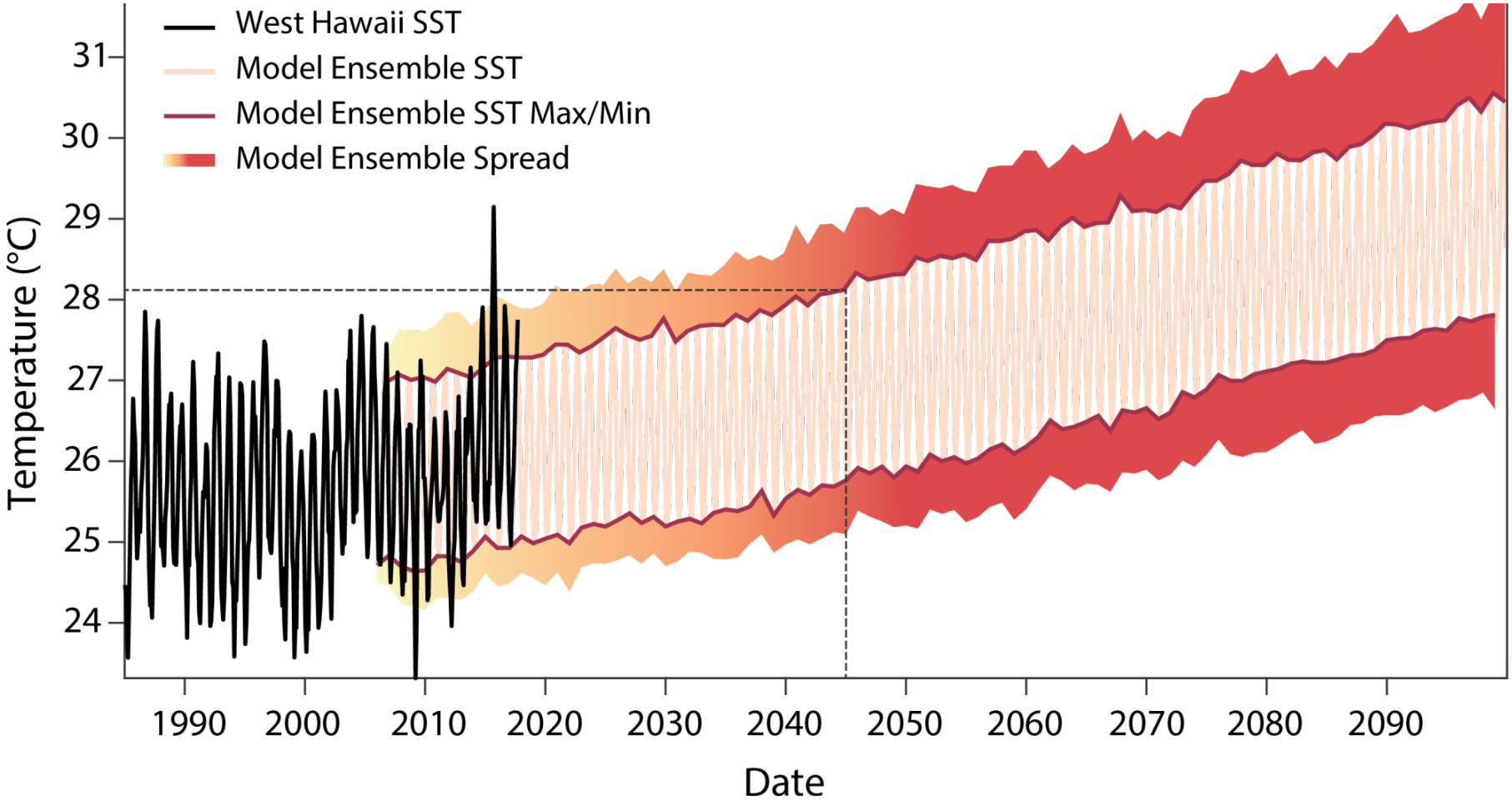
3. Coastal Systems

4. Oceans and Marine Resources

5. Indigenous Communities

6. Cumulative Impacts and Adaptation

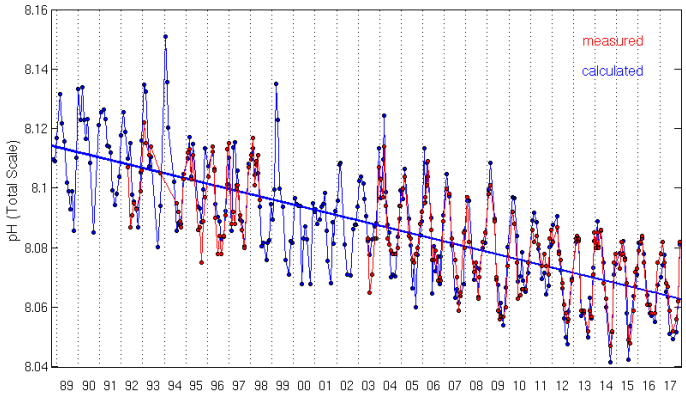
Data and Models (climate and earth system)



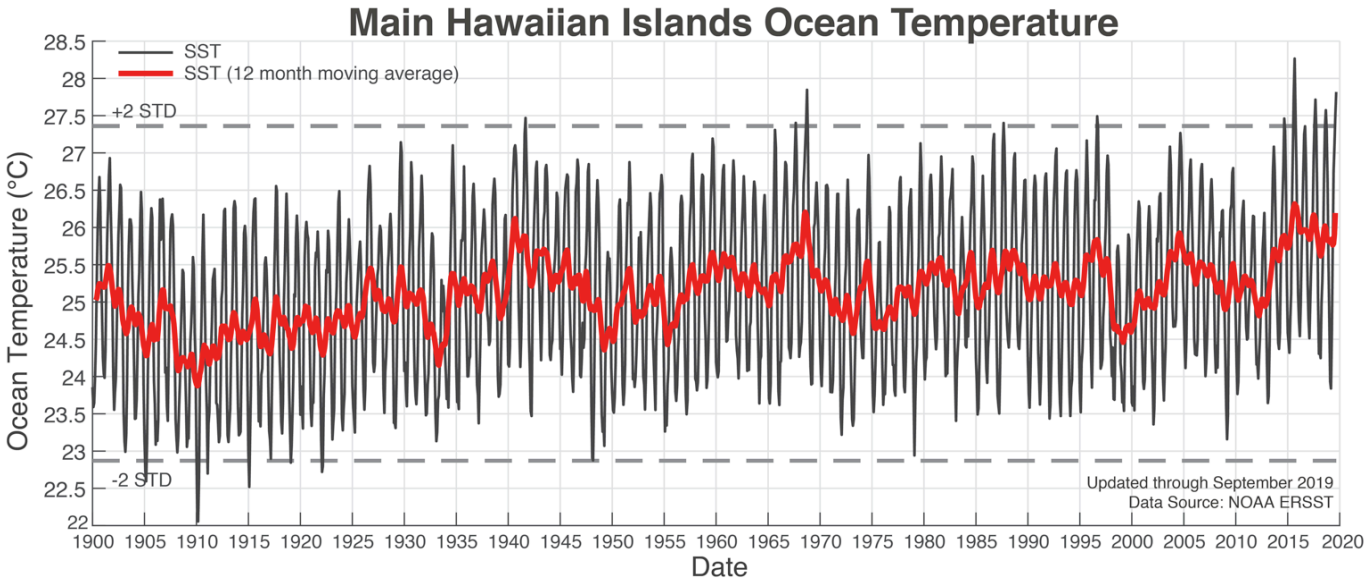
Emission scenario: Business as usual

We're already beyond historical levels

1. Station Aloha pH



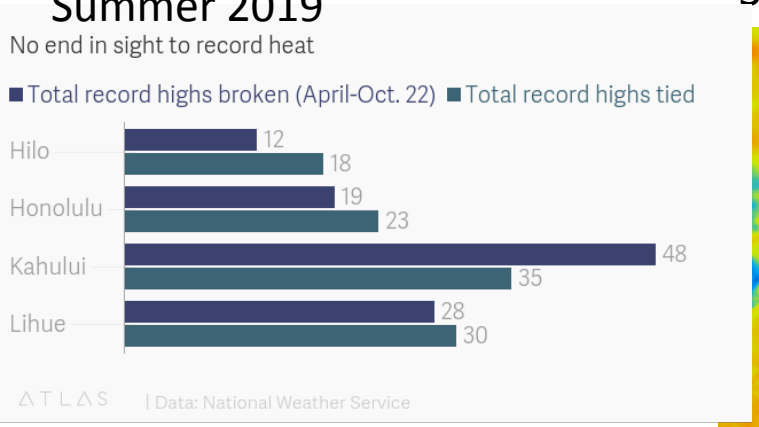
2. Rising SST



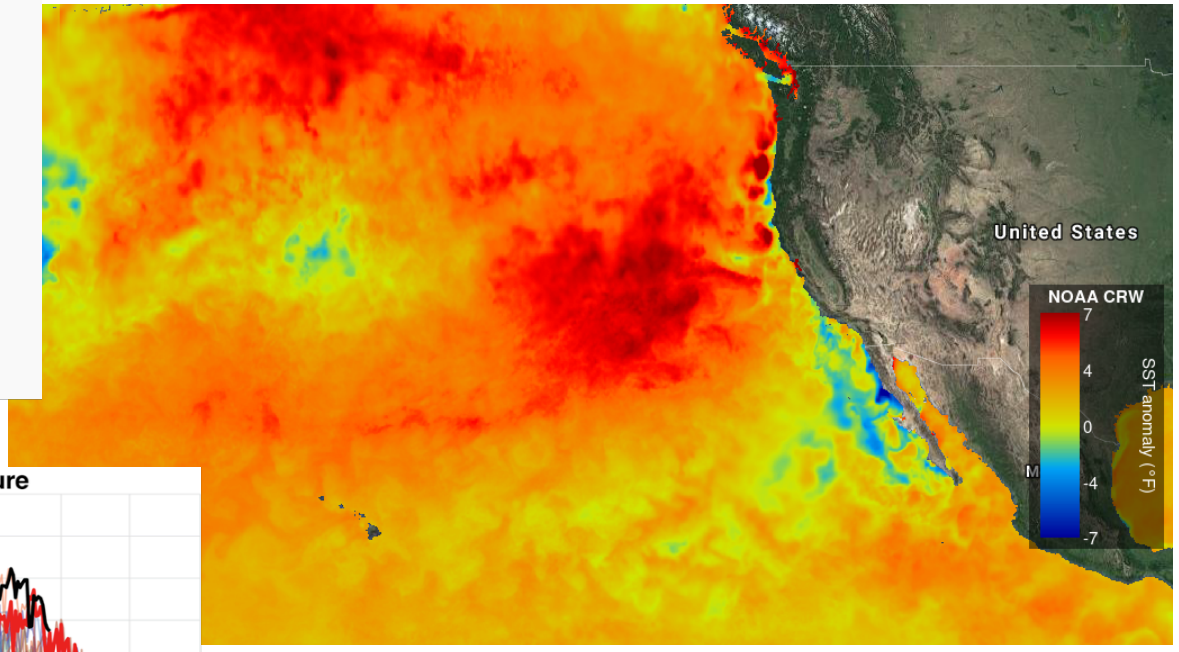
3. 2014-2016, 2019 coral reef bleaching

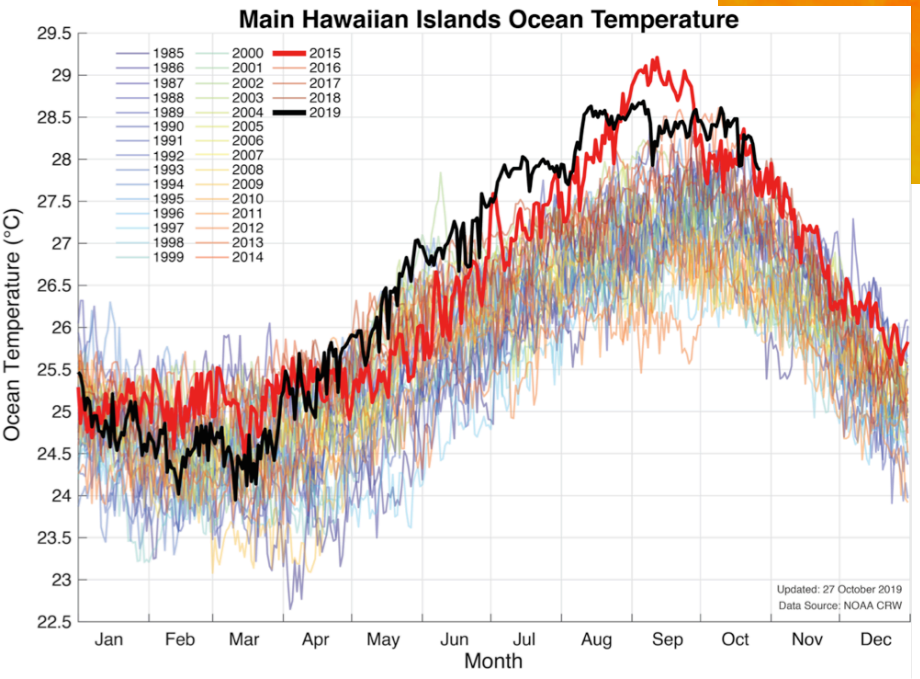
Why were Hawaii's 2015 and 2019 summer ocean and air temperatures so hot?

Summer 2019



Sea surface temperature Aug 2019

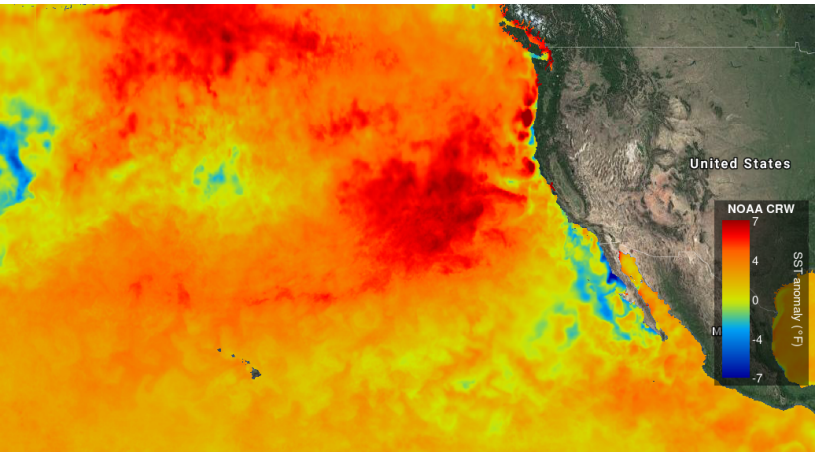




Summer 2015 very warm Hawaii ocean and air temp were primarily the result of weak Trades linked to warming in subtropical north eastern Pacific (Zhu and Li 2017)

What produced the warm NE Pacific SST?

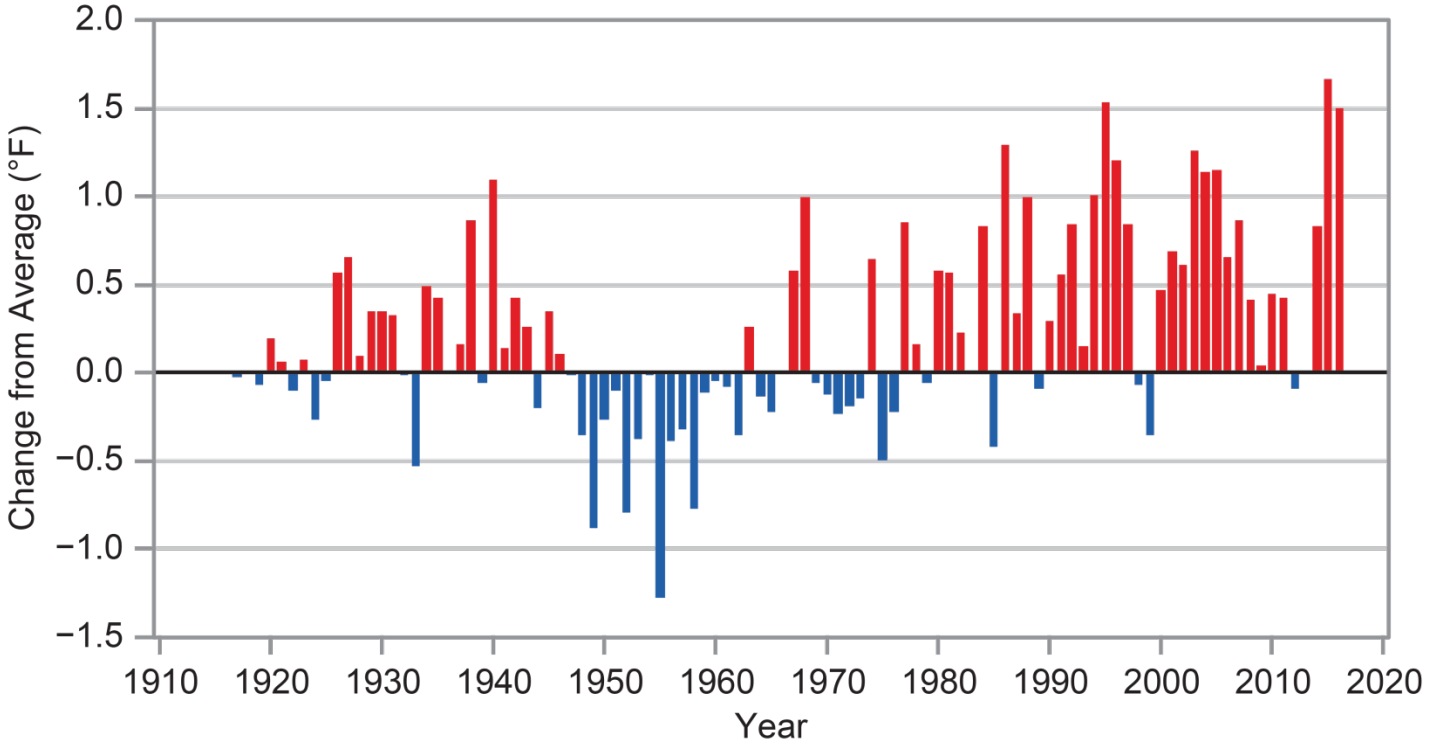
A sustained high pressure ridge in NE Pacific resulted in weak winds and clear skies warming the NE Pacific waters



Are these 2015 and 2019 Hawaii and NE Pacific heat waves just extreme weather events or are they a new climate mode linked to global warming?

Under a moderate emissions scenario by the end of this century, maximum daily temperatures of 90 F or higher are projected for half the year in Honolulu and 20% of the year in Hilo (Zang et al. 2016 J. *Climate*).

KM1: Freshwater supplies for communities and ecosystems are threatened



- Rising air temperatures
- Statewide decline in rainfall
- Saltwater contamination

Rainfall Trends in Hawai‘i (1920 to 2012)

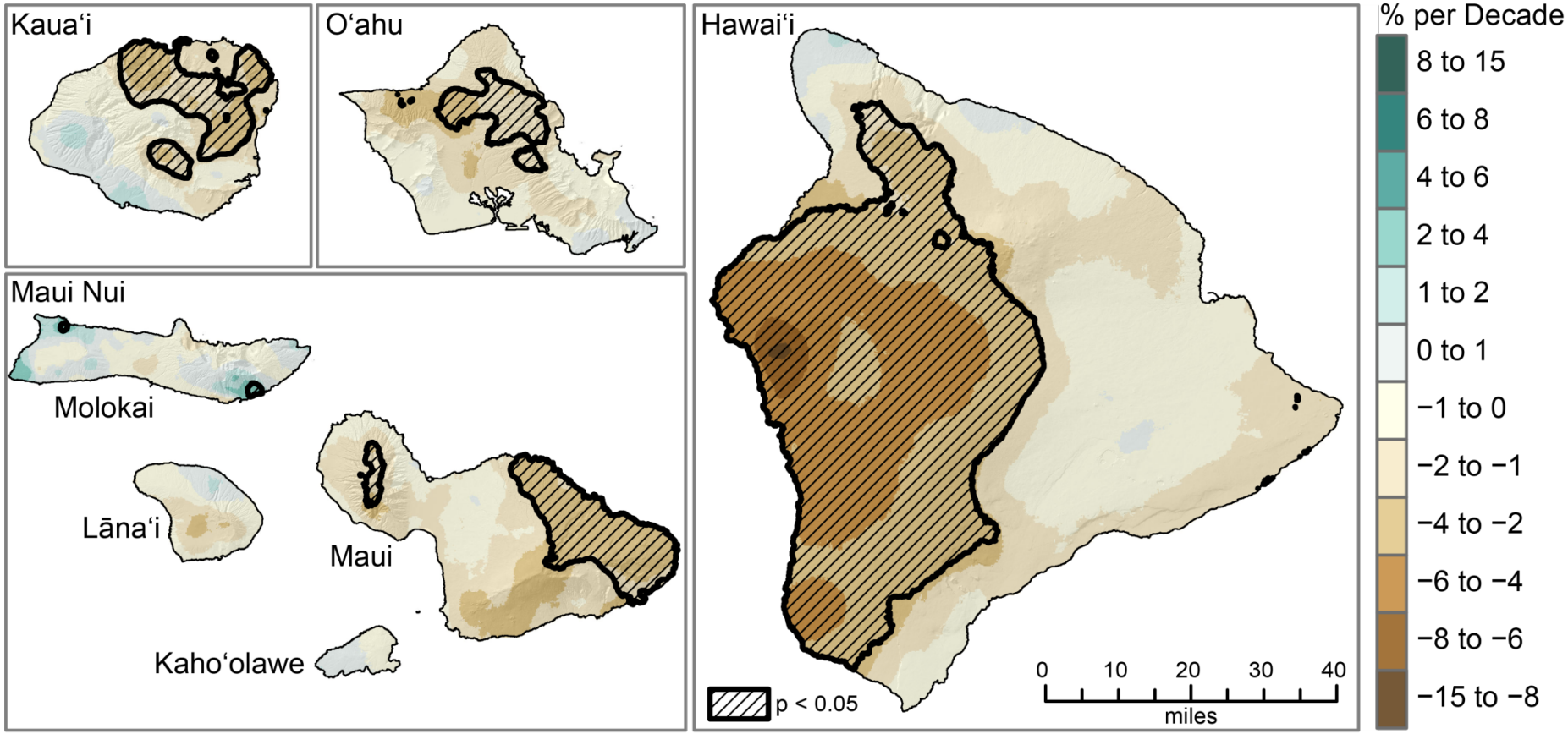
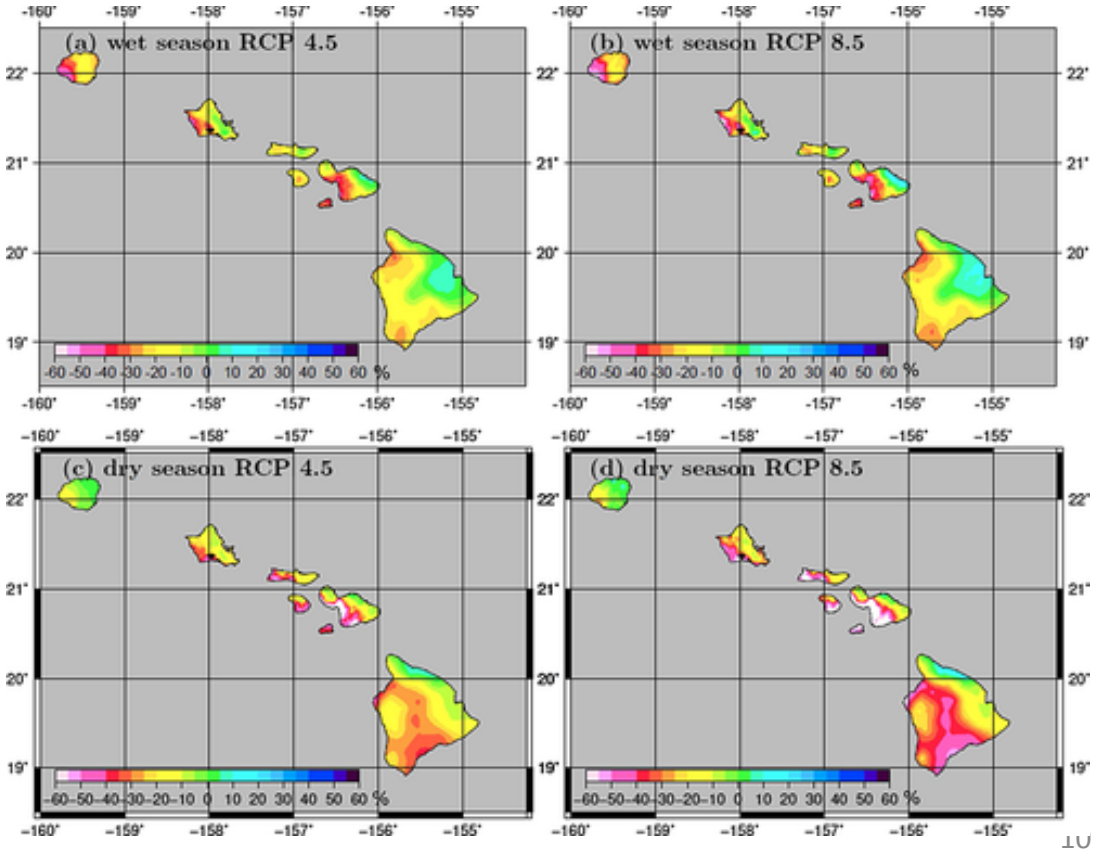


Fig. 27.6

- Statewide drying trend with more consecutive dry days AND wet days
- Increased extreme rainfall events (1940-2010)

Future Rain Projections

- End-of-century rainfall projections for Hawaii under a higher emissions scenario (RCP8.5) range from small increases to increases of up to 30% in wet areas, and from small decreases to decreases of up to 60% in dry areas



Rainfall % change for the period 2041–2071 (Timm et al. 2014)

KM2: Climate change threatens terrestrial ecosystems, species, and services

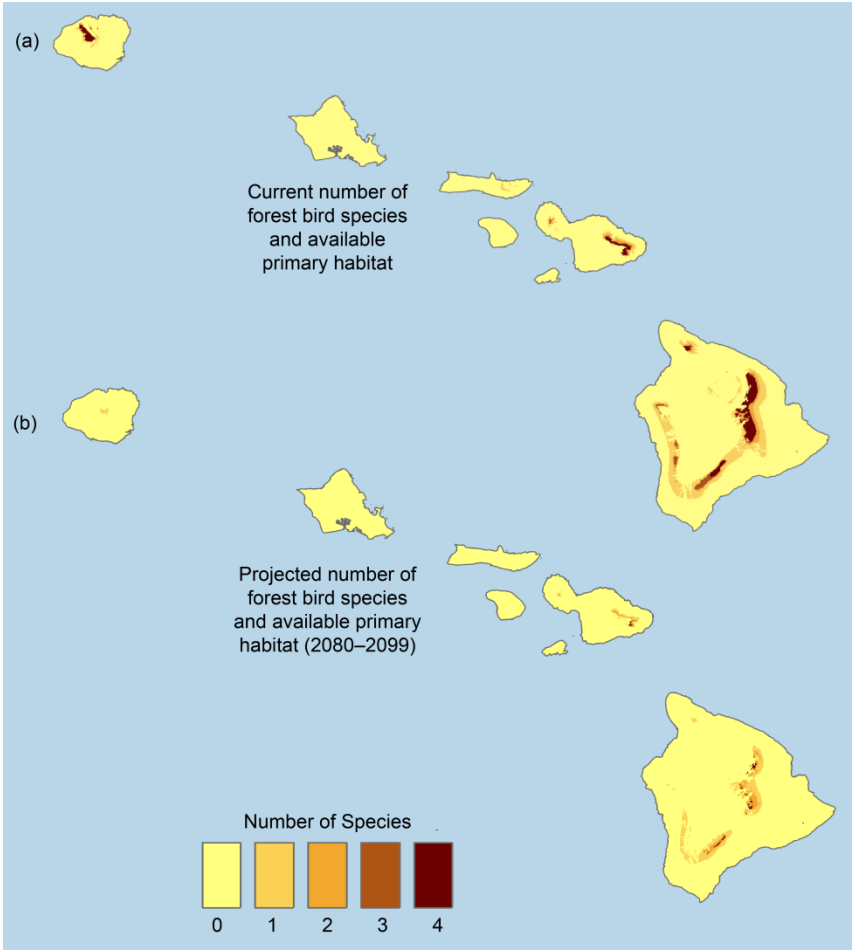


Fig. 27.7 - Modeled number of native Hawaiian forest bird species for (a) current and (b) 2100 climate conditions.

- 90% of Hawaii'a terrestrial species are endemic
- As temperatures rise, high-elevation sites will become more suitable for avian malaria impacting birds
- The main HI islands have >1,000 native plant species
  - By 2100, >350 will no longer be in their optimal growing range

Impacts to Northwestern Hawaiian Island Species

East Island, May 2018

East Island, Oct 2018

SLR and decline in coral reefs will result in loss of seabirds, turtles, and monk seal nesting and pupping habitat

KM3: Sea level rise will increasingly impact coastal infrastructure, transportation, ecosystems, and communities

- The rate of global SLR has accelerated, but the ultimate timing and magnitude of the increase is uncertain
  - Coastal erosion; Flooding, storm surge; Inundation; Saltwater intrusion
- In 2017, the State of Hawai'i adopted SLR planning projections of 3.2 feet by 2100
  - Regular plan updates needed

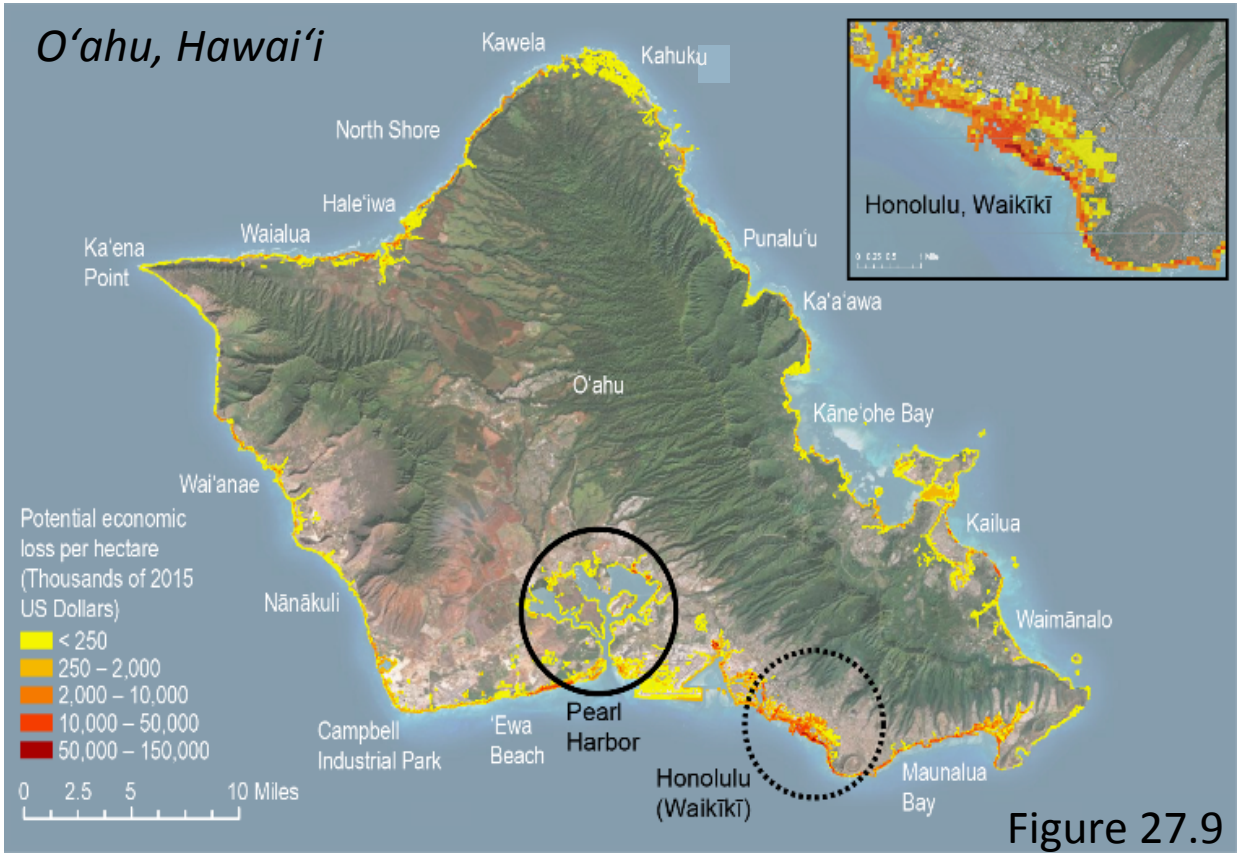


Figure 27.9

SLR=ocean expansion + ice melt

POTENTIAL IMPACTS
STATE-WIDE SUMMARY

Hazard | **Sea Level Rise Exposure Area**

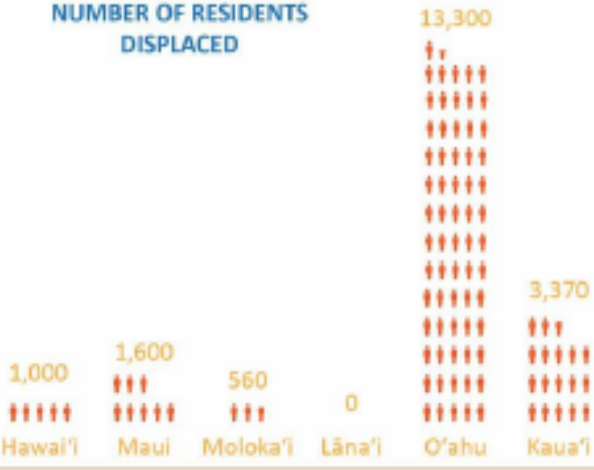
Impact | **Chronic Flooding**

Scenario | **3.2 feet of Sea Level Rise**

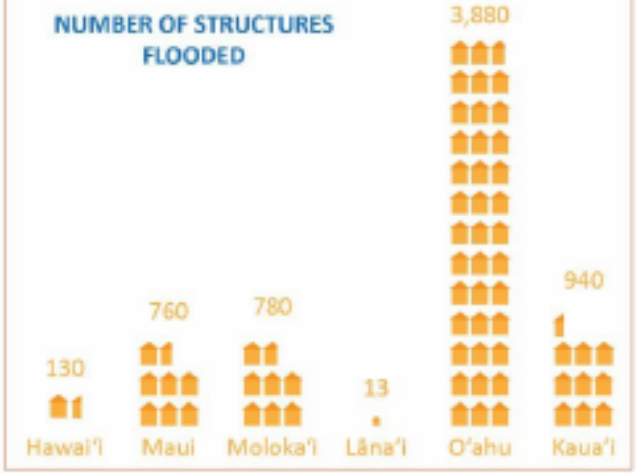
ACRES OF LAND FLOODED IN SLR-XA

ECONOMIC LOSS due to structure and land loss

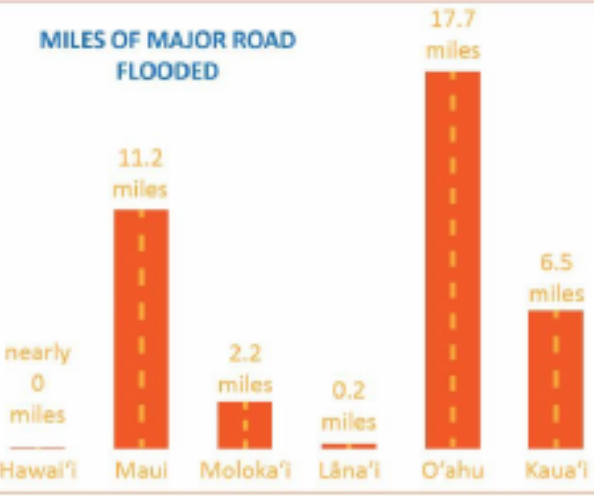
NUMBER OF RESIDENTS DISPLACED

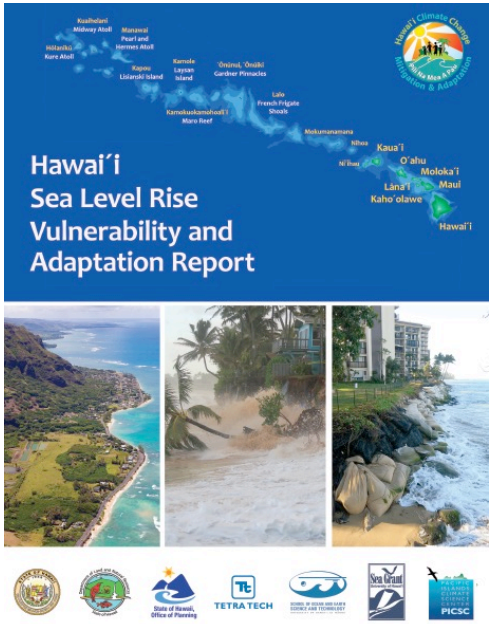


NUMBER OF STRUCTURES FLOODED



MILES OF MAJOR ROAD FLOODED





HI Sea Level Rise Report (2017)

KM4: Rising ocean temperatures and acidification threaten fisheries, coral reefs, and the livelihoods they support

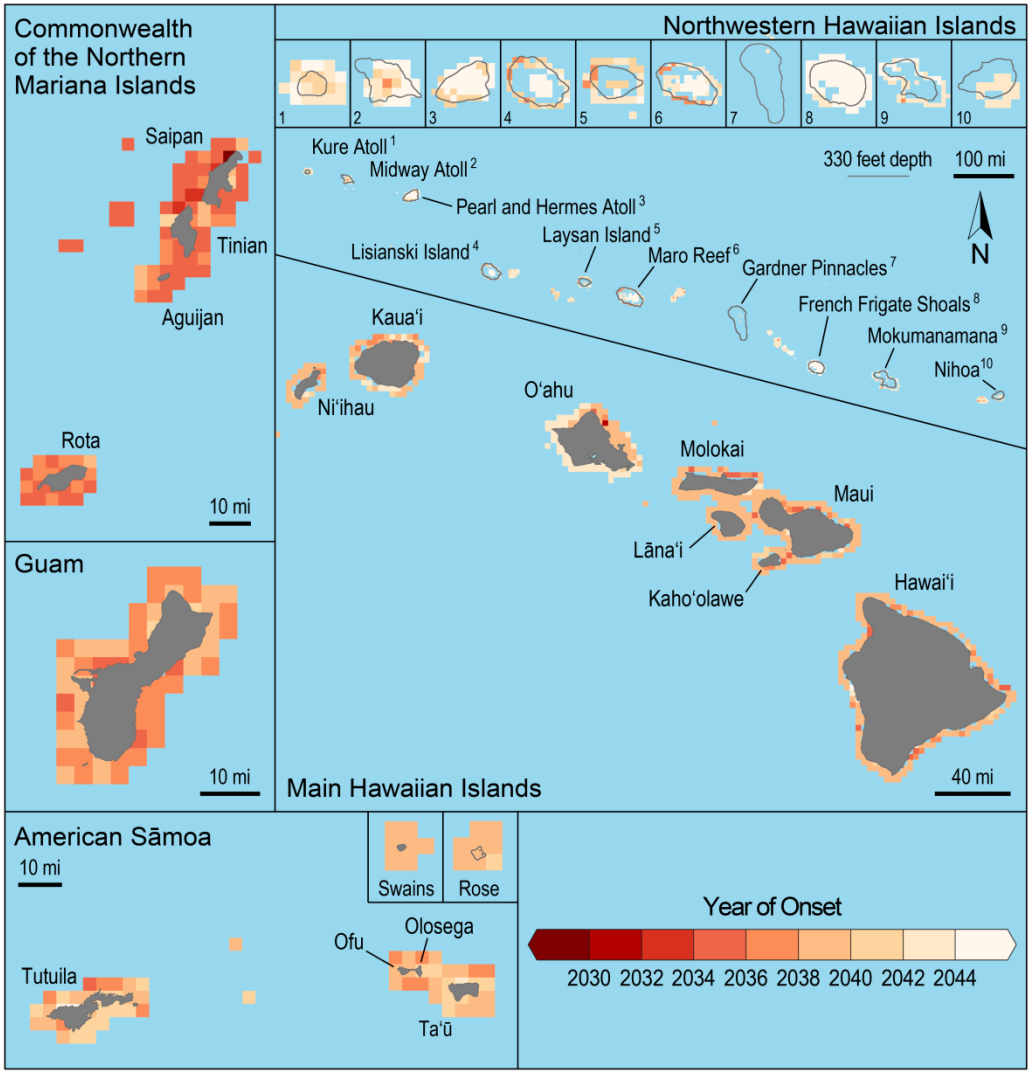
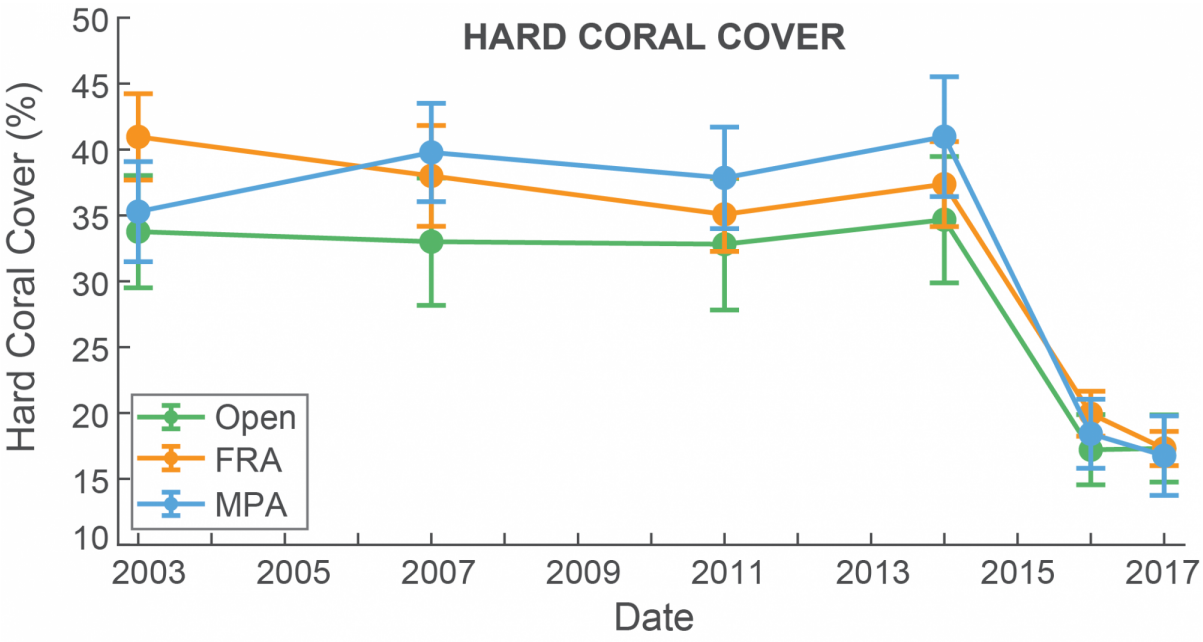


Fig. 27.10

- Coral reefs add ~$364 million in goods and services annually
  - 2015 bleaching resulted in 50% mortality in western HI
- Reefs are projected to bleach annually by 2040
- Landings from the pelagic longline fisheries add over $100 million annually
  - Projected declines in tuna and billfish yields by ~2-5%/decade

West Hawaii % coral cover



(Dan Dennison)

Projected Climate Changes in the Central Pacific Over the 21st Century

Basin-wide warming

Tropical easterlies weaken

Westerlies and polar easterlies weaken and shift poleward

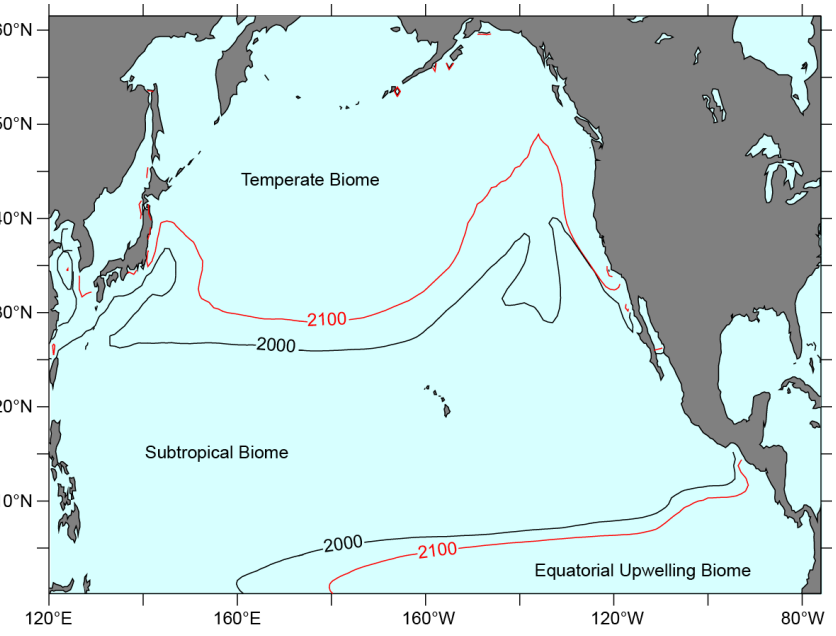
Reduced wind-stress curl

Weakened vertical velocities and increased stratification

Nutrient redistribution

Rykaczewski and Dunne 2010, Sarmiento *et al*. 2004, Vecchi *et al*. 2006, Yin 2005

Expansion of the subtropical gyre between the beginning and end of the 21st Century (GFDL ESM2.1)

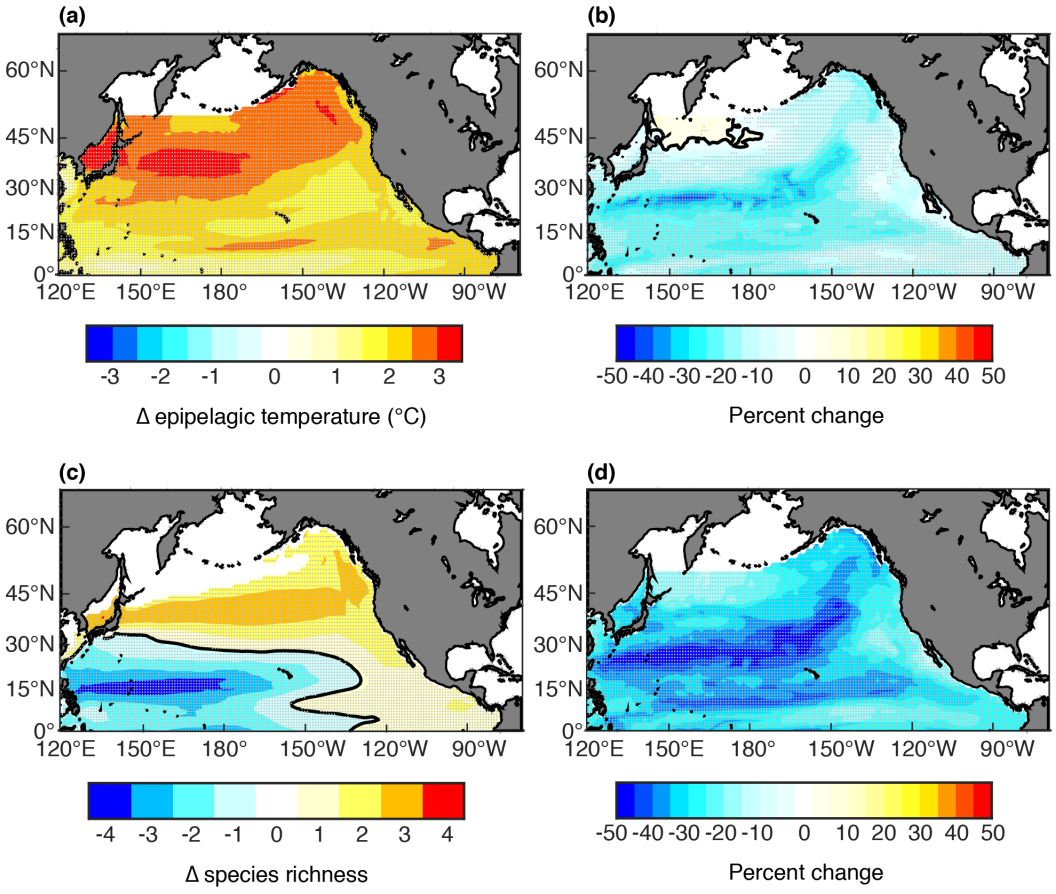


Polovina et al. 2011

Changes in physical and ecological variables over the 21st Century from 11 Earth System Models

Epipelagic Temp

zooplankton



Tuna and Billfish species

Carrying Capacity

Woodworth-Jefcoats et al. 2017

KM5: Climate change affects the health, well-being, and modern livelihoods of Indigenous peoples of the Pacific

- Cultural heritage of interconnectedness with the environment
  - SLR impacts agriculture, coastal communities, food security, livelihoods, disaster mgmt, cultural practices (salt cultivation, fishpond maintenance)

Fig. 27.11

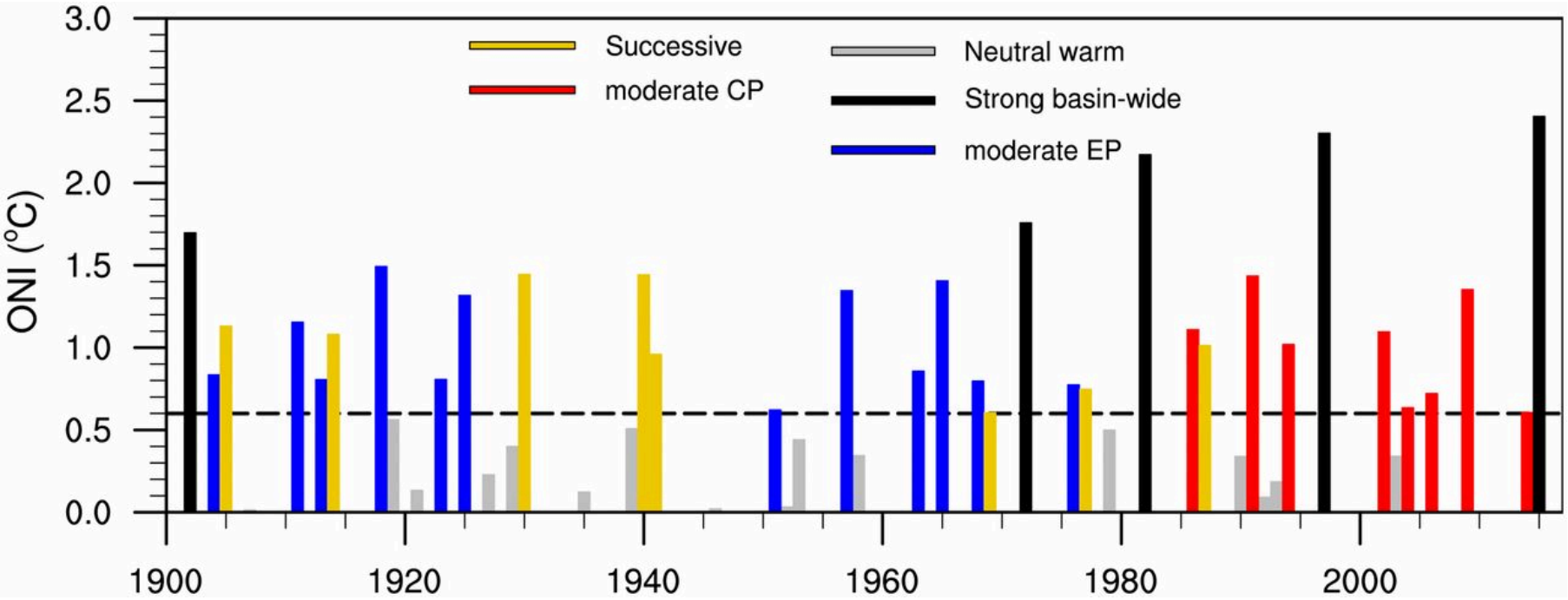
Fig. 27.12

Hurricanes

- Hurricanes are projected to become more intense in a warming world, with higher wind speeds and greater levels of precipitation.

French Frigate Shoals before and after Hurricane Walaka

Changing El Niño types from 1901 to 2017.



Bin Wang et al. PNAS doi:10.1073/pnas.1911130116

Recent climate model results suggest a doubling in frequency of both El Niño and La Niña extremes in the 21st century as compared to the 20th century under scenarios with more warming (NCA4)

PNAS

KM6: Compounding climate impacts mean that early interventions and adaptations will be more effective

- Recovery becomes increasingly difficult
- Repeated shocks amplify stressors
- Impacts with large uncertainty: public health, mental health, human migration, national security, conflict
- Early action and social cohesion will help increase climate resilience

New Normal

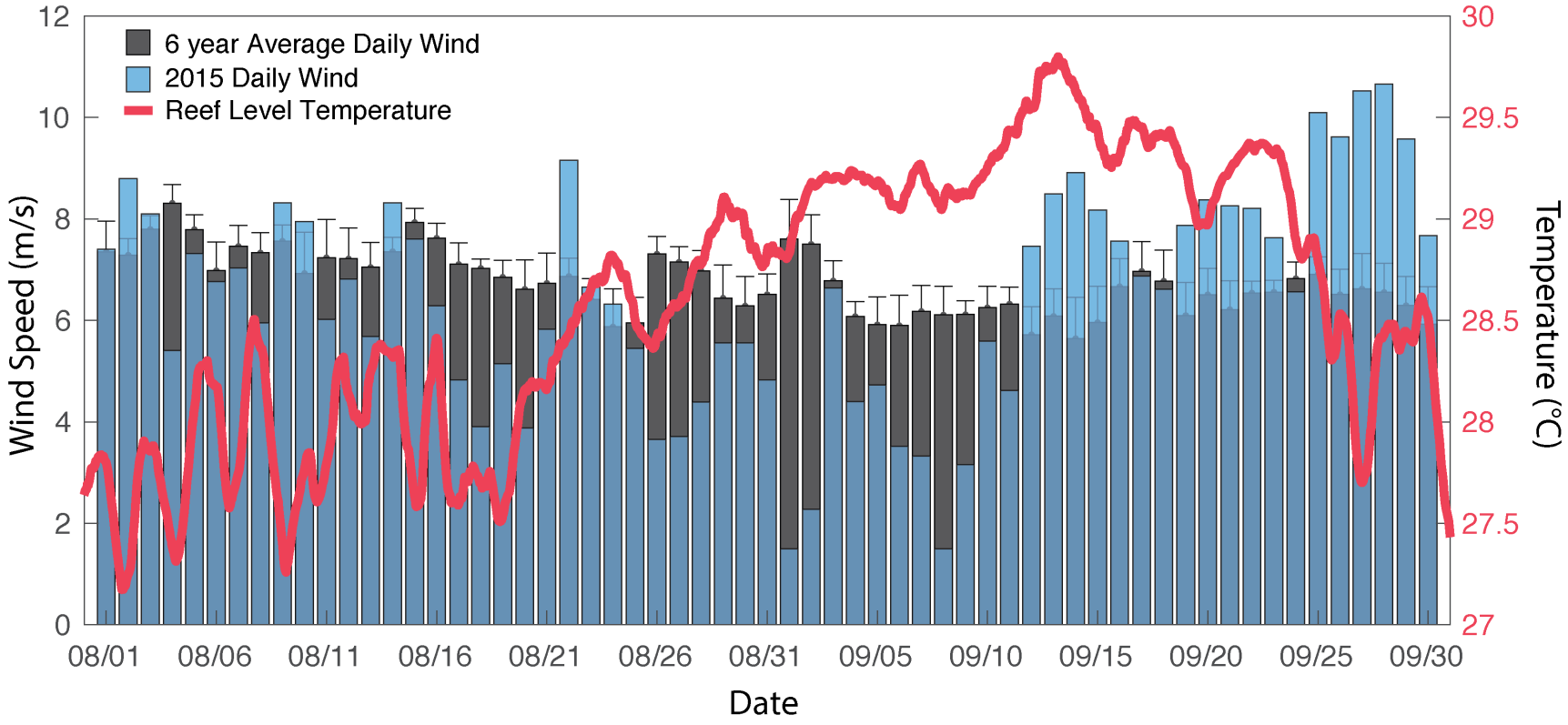
- More heat waves on land and in the ocean
- Storms with stronger winds and more rain
- More coastal flooding and erosion
- Fewer corals, reef fishes, and pelagic fishes
- Fewer endemic terrestrial species
- Any winners?
- Surprises?

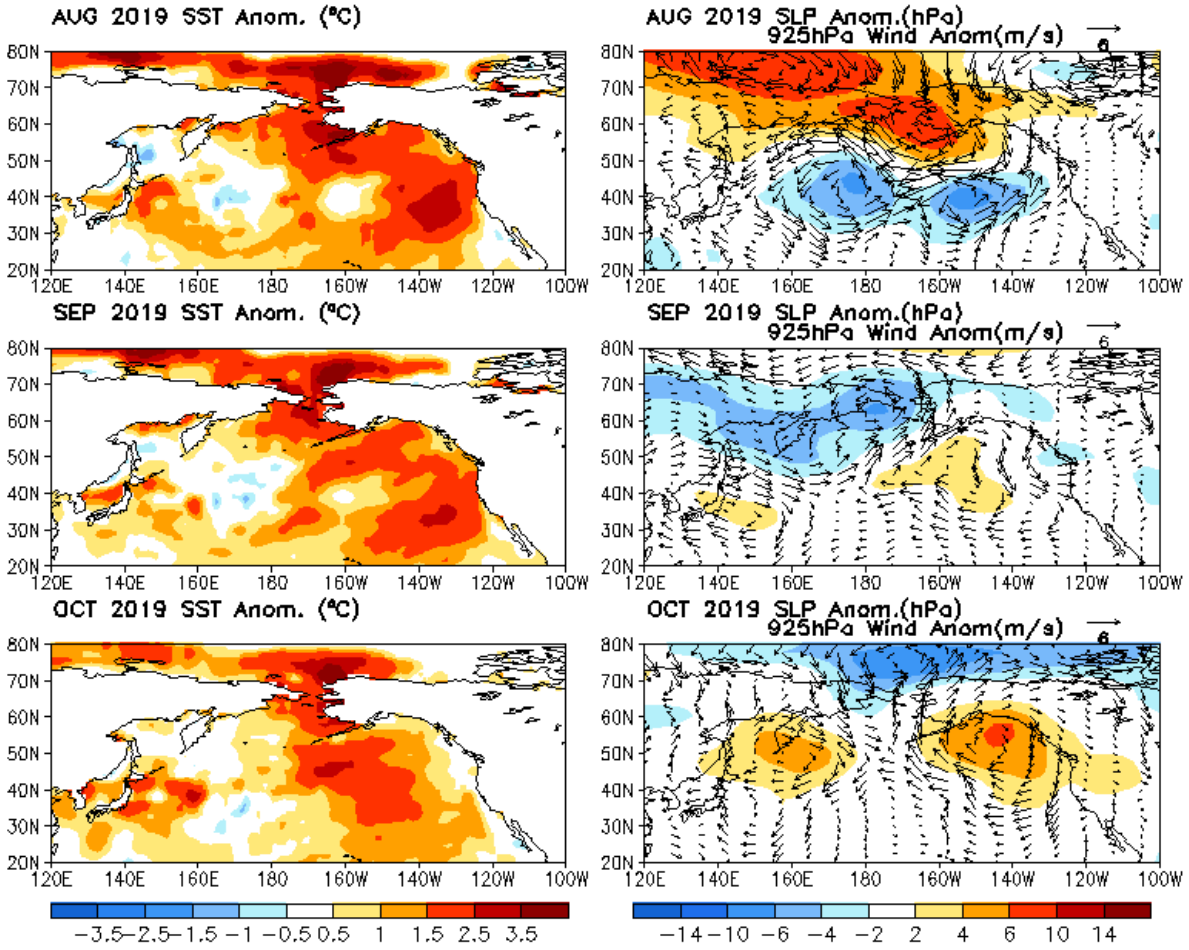
Acknowledgements

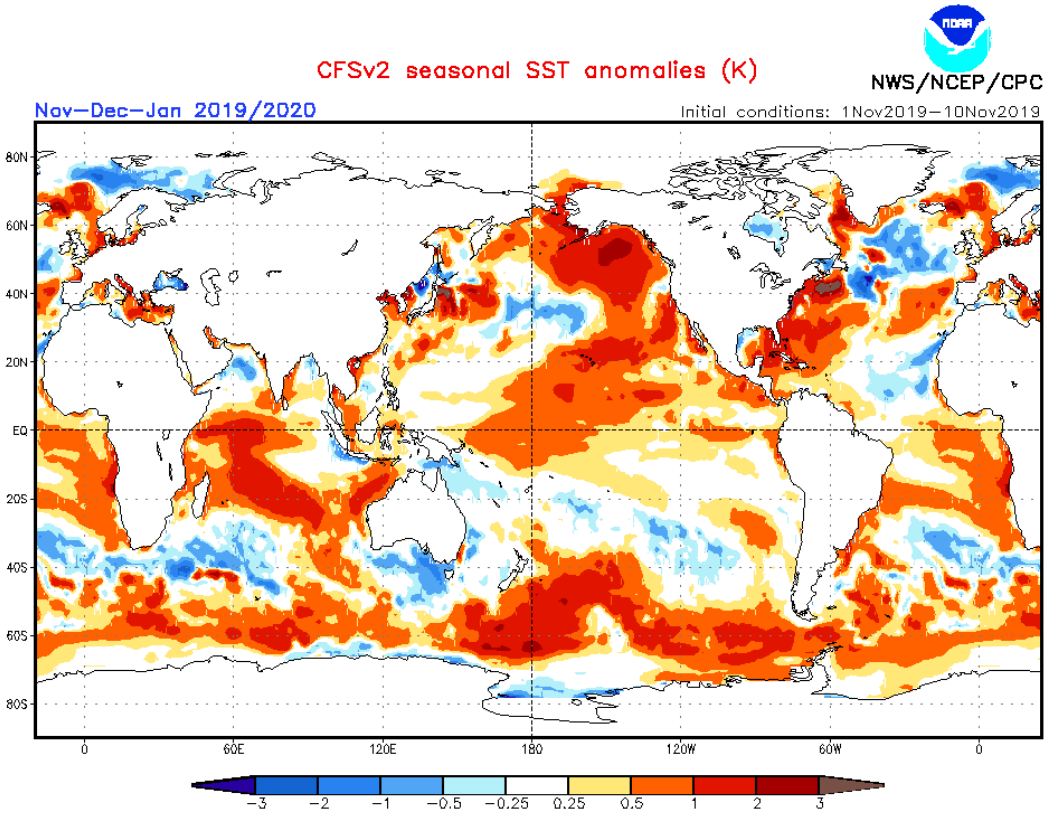
- Thanks to Victoria Keener, PhD, Research Fellow, East-West Center ,and Jamie Gove, Ph.D, NOAA Oceanographer, for several slides.

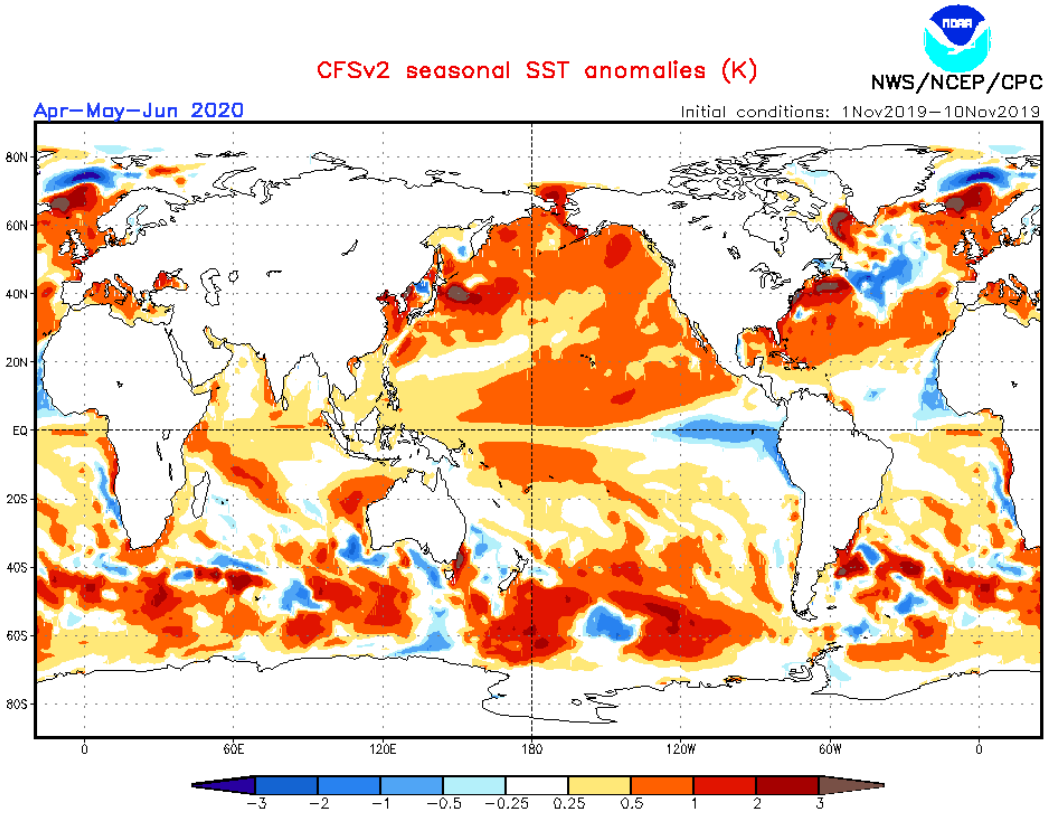
- E-mail: Polovinajeff@gmail.com

August and September 2015 wind and 10m temperature at Lapakahi with 6-yr average wind




AUG 2019 SST Anom. (°C)
AUG 2019 SLP Anom.(hPa)
925hPa Wind Anom(m/s)
SEP 2019 SST Anom. (°C)
SEP 2019 SLP Anom.(hPa)
925hPa Wind Anom(m/s)
OCT 2019 SST Anom. (°C)
OCT 2019 SLP Anom.(hPa)
925hPa Wind Anom(m/s)
80N
70N
60N
50N
40N
30N
20N
120E
140E
160E
180
160W
140W
120W
100W
−3.5 −2.5 −1.5 −1 −0.5 0.5 1 1.5 2.5 3.5
−14 −10 −6 −4 −2 2 4 6 10 14


CFSv2 seasonal SST anomalies (K)
NWS/NCEP/CPC
Nov–Dec–Jan 2019/2020
Initial conditions: 1Nov2019–10Nov2019
80N
60N
40N
20N
EQ
20S
40S
60S
80S
0
60E
120E
180
120W
60W
0
−3
−2
−1
−0.5
−0.25
0.25
0.5
1
2
3


CFSv2 seasonal SST anomalies (K)
NWS/NCEP/CPC
Apr–May–Jun 2020
Initial conditions: 1Nov2019–10Nov2019
80N
60N
40N
20N
EQ
20S
40S
60S
80S
0
60E
120E
180
120W
60W
0
−3
−2
−1
−0.5
−0.25
0.25
0.5
1
2
3