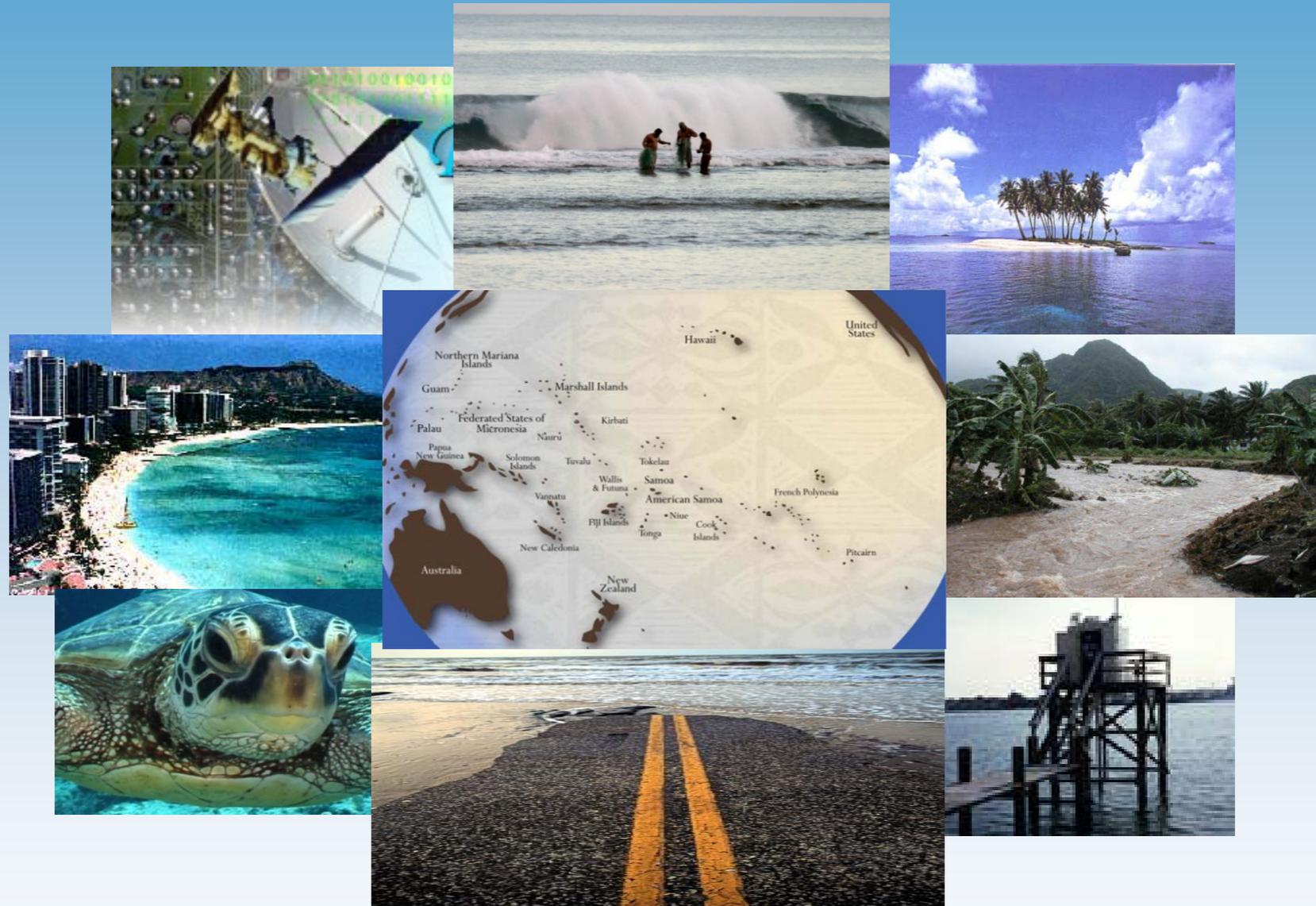


# Climate Change Impacts in Hawaii and US-affiliated Pacific Islands



COASTAL PEOPLES ADDRESS CLIMATE CHANGE  
**FIRST STEWARDS**

17 – 20 July 2012

National Museum of the American Indian

Washington, DC



# Pacific Islands Regional Climate Assessment (PIRCA)

The PIRCA is a **collaborative effort** aimed at assessing **the state of climate knowledge, impacts, and adaptive capacity** in Hawai'i and the US-Affiliated Pacific Islands.

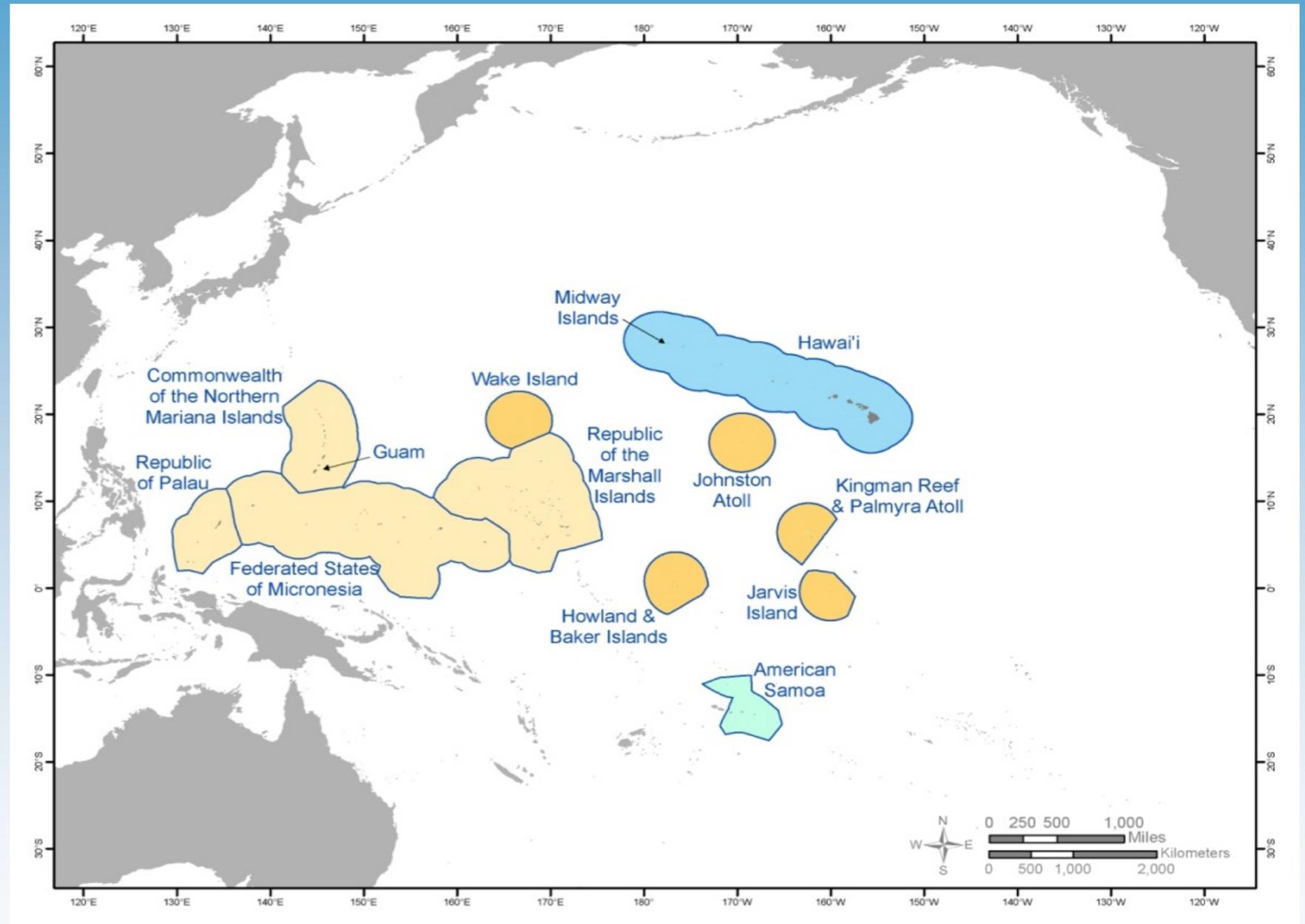
PIRCA activities include dialogs, workshops, and other forums to facilitate sharing, analyzing, and reporting on scientific consensus, knowledge gaps, sectoral needs, and adaptive capacity for addressing the changing climate.

The **most recent activity** was bringing together scientific experts and practitioners to generate **an integrated report** that constitutes a regional contribution to the National Climate Assessment (NCA).



# The Pacific Islands Region

- The Pacific Islands **region is vast**.
- **Land is scarce**. The ocean encompasses hundreds of times more area than the total square miles of land.
- The **islands are isolated**, with hundreds of miles of ocean between individual islands and thousands between island chains.
- The **islands are highly diverse** in terms of geography, climate, ecology, and culture.
- The **ocean and its resources play a vital role** in the lives and livelihoods of the peoples of the region.

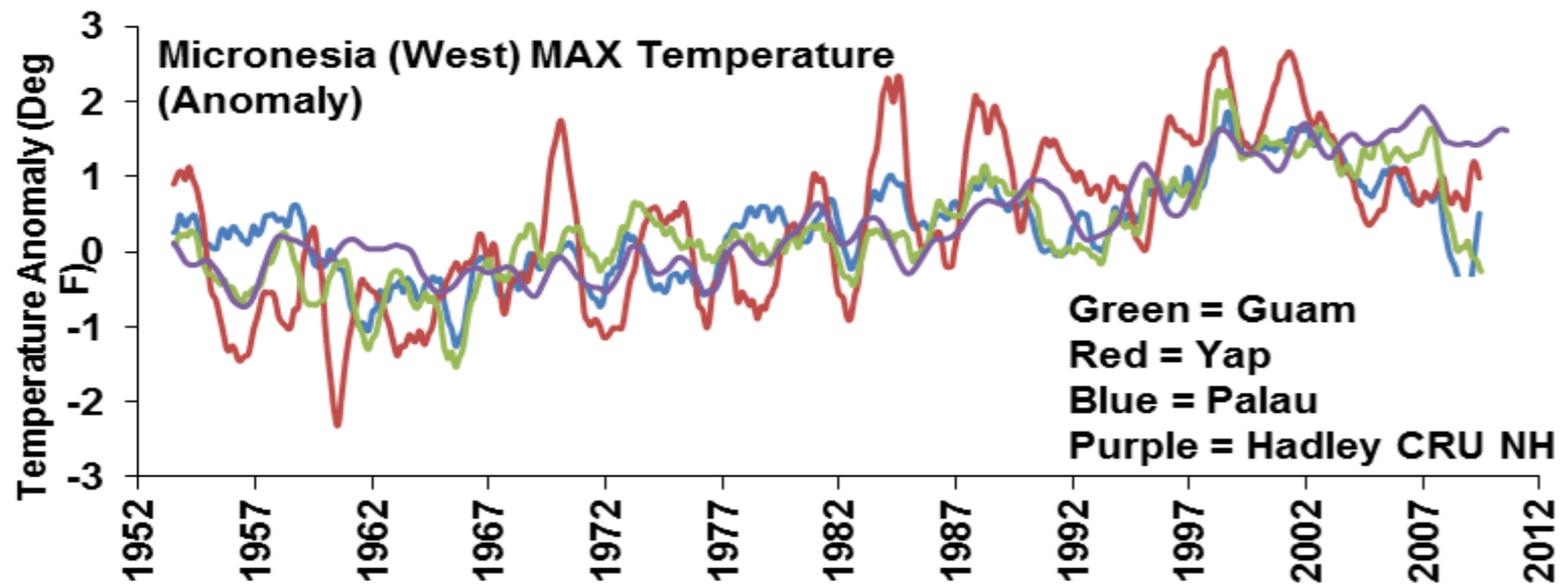


*PIRCA Map courtesy of Miguel Castrence/East-West Center.*

- The **region is home to some of the most pristine habitat in the world** and possesses tremendous biodiversity.

# Climate Variability versus Change

- Weather versus Climate  
*...what is like today versus what it is normally like today.*
- There is normally a lot of natural variability.
- What we mean by climate change is a new normal.



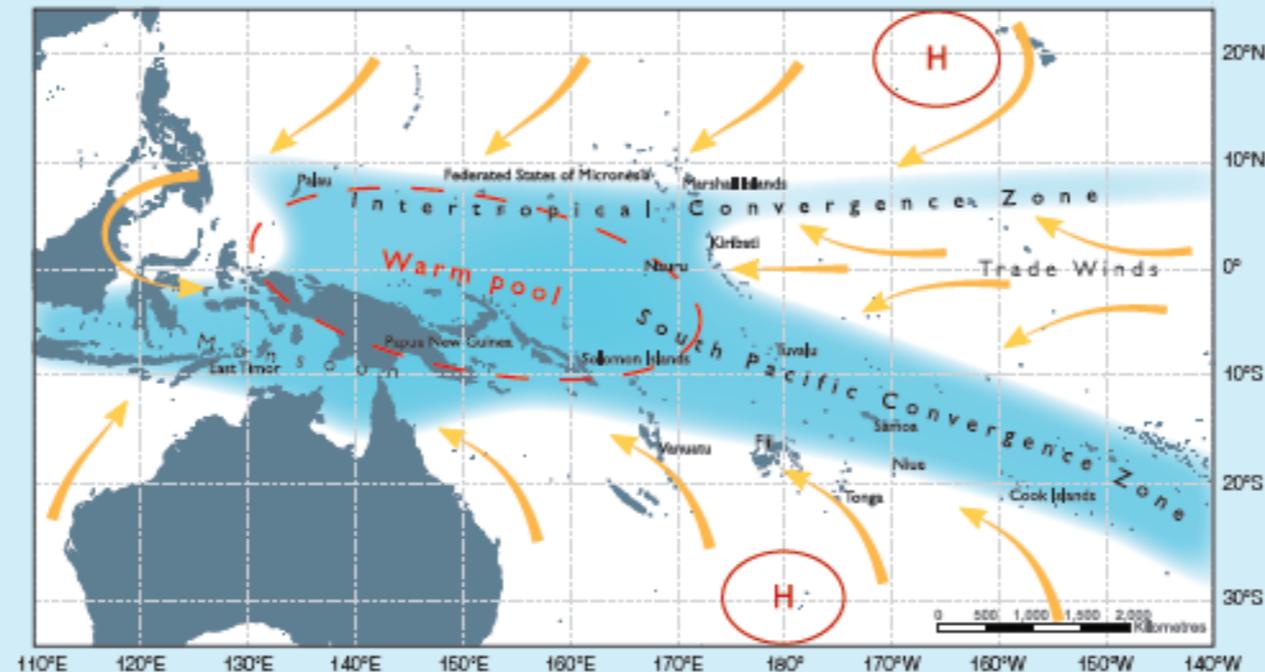
⑩ Maximum monthly temperature anomaly time series from 1952 to 2012 for single monitoring stations. The Northern Hemisphere temperature time series (purple line) is superimposed for comparison. Adapted from Lander & Guard (2003).

The **high interannual and interdecadal variability** of the climate in the Pacific Islands region (e.g., ENSO, PDO/IPO) makes it difficult to discern long-term trends.

This means that **over the near term** (next 25-30 years) **impacts are more about variability than change**. This will be manifest as a greater likelihood, and increased intensity, and duration of extreme events.

# Climate drivers of the Pacific Region

Box 2.2: Main features influencing the climate of the PCCSP region



The average positions of the climate features in November to April. The yellow arrows show near-surface winds, the blue shading represents the bands of rainfall (convergence zones with relatively low pressure), and the red dashed oval indicates the West Pacific Warm Pool. H represents the typical positions of moving high pressure systems.

#### *West Pacific Monsoon*

This moves north to mainland Asia during the Northern Hemisphere summer and south to Australia in the Southern Hemisphere summer. The seasonal arrival of the monsoon usually brings a switch from very dry to very wet conditions. It affects countries in the far western Pacific and the Maritime Continent.

#### *Intertropical Convergence Zone*

This band of high rainfall stretches across the Pacific just north of the equator and is strongest in the Northern Hemisphere summer. It affects most countries on, or north of, the equator.

#### *South Pacific Convergence Zone*

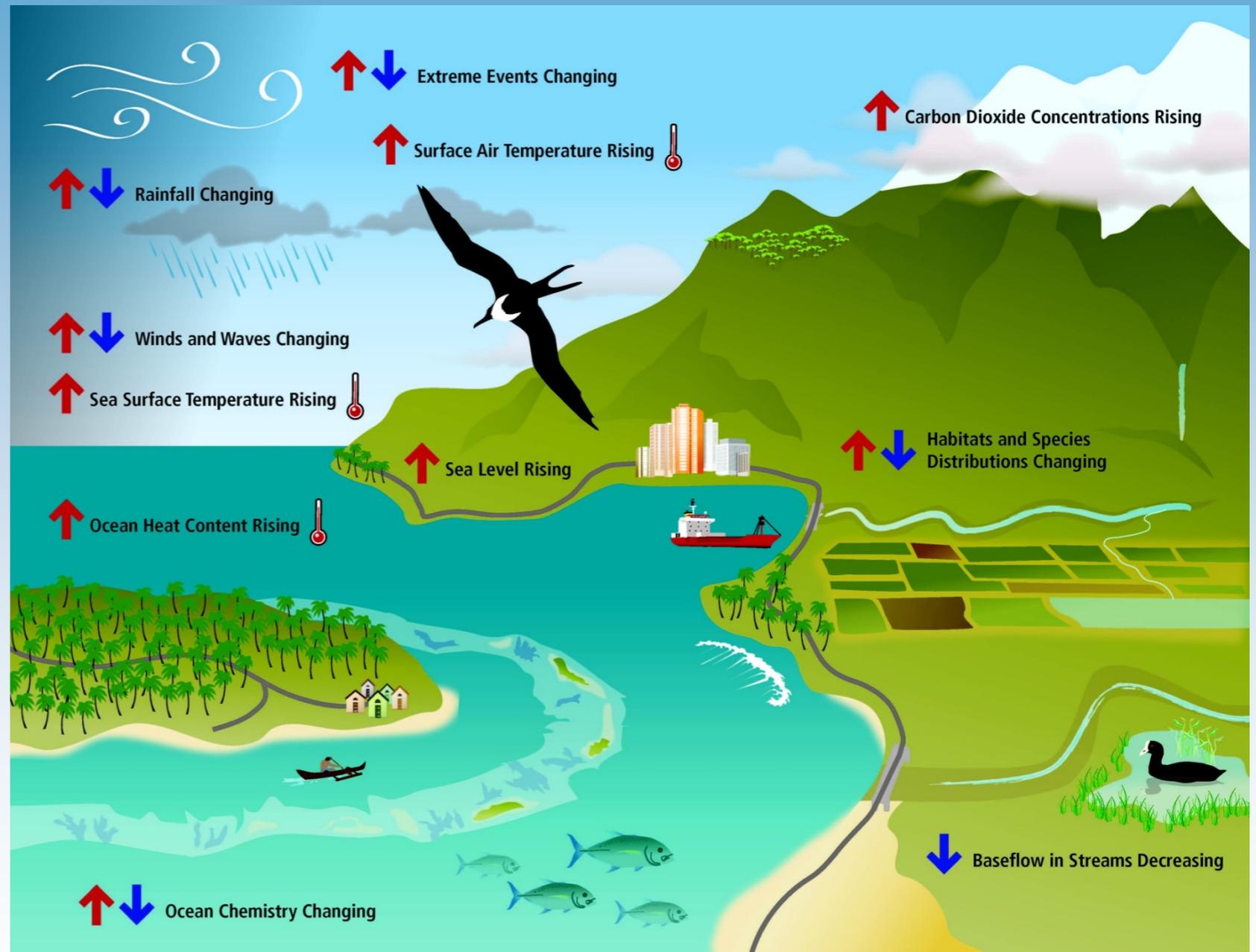
This band of high rainfall stretches approximately from the Solomon Islands to east of the Cook Islands. It is strongest in the Southern Hemisphere summer and affects most countries in the South Pacific.

#### *Sub-Tropical and High Latitude Influences*

These include sub-tropical high pressure systems and associated south-east and north-east trade winds, and cold fronts.

# Indicators of Climate Change in the Pacific Islands

- Carbon dioxide (CO<sub>2</sub>) concentrations are rising.
- Ocean chemistry is changing (ocean acidity is increasing).
- Sea-surface temperature is rising.
- Upper-ocean heat content is rising (stratification is changing).
- Surface air temperature is rising.
- Rainfall amount and distribution is changing
- Stream “base flow” is decreasing.
- Sea level is rising.
- Winds and waves are changing.
- Extremes are changing (e.g., drought, rainfall, coastal inundation).

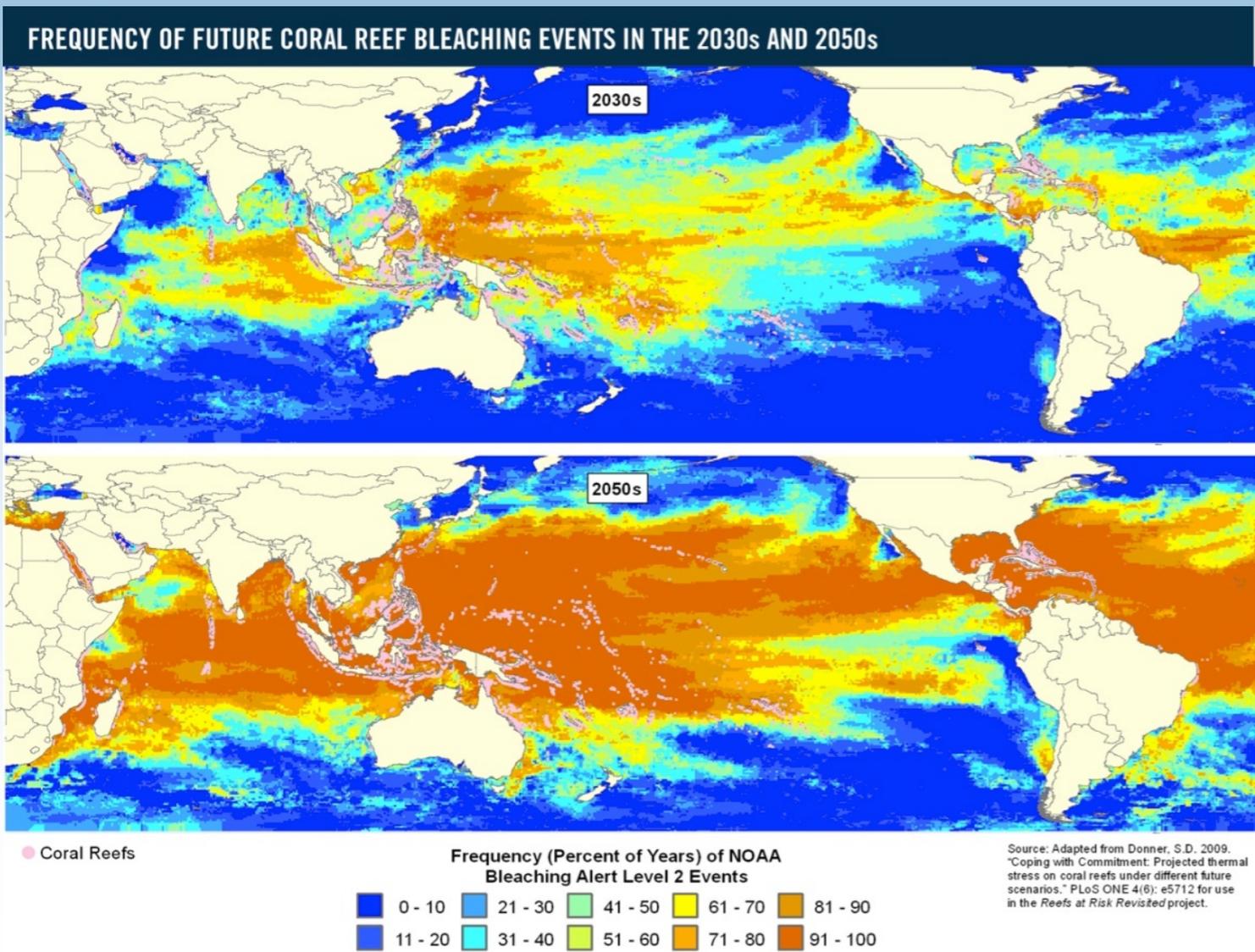
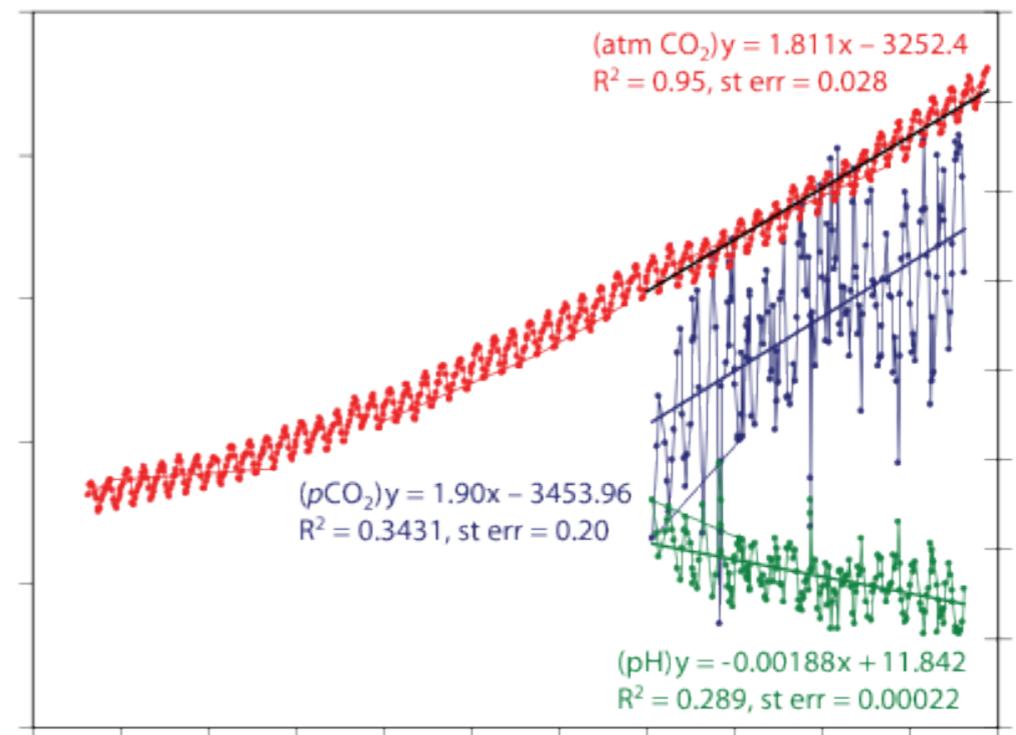


- Habitats (and species distributions) are changing.

Carbon dioxide (CO<sub>2</sub>) concentrations are rising.

Ocean chemistry is changing (ocean acidity is increasing).

Time series of atmospheric CO<sub>2</sub> at Mauna Loa à (ppmv) and surface ocean pH and pCO<sub>2</sub> (µatm) at ocean Station Aloha. *Feely et al. 2009*



Sea-surface temperature is rising.

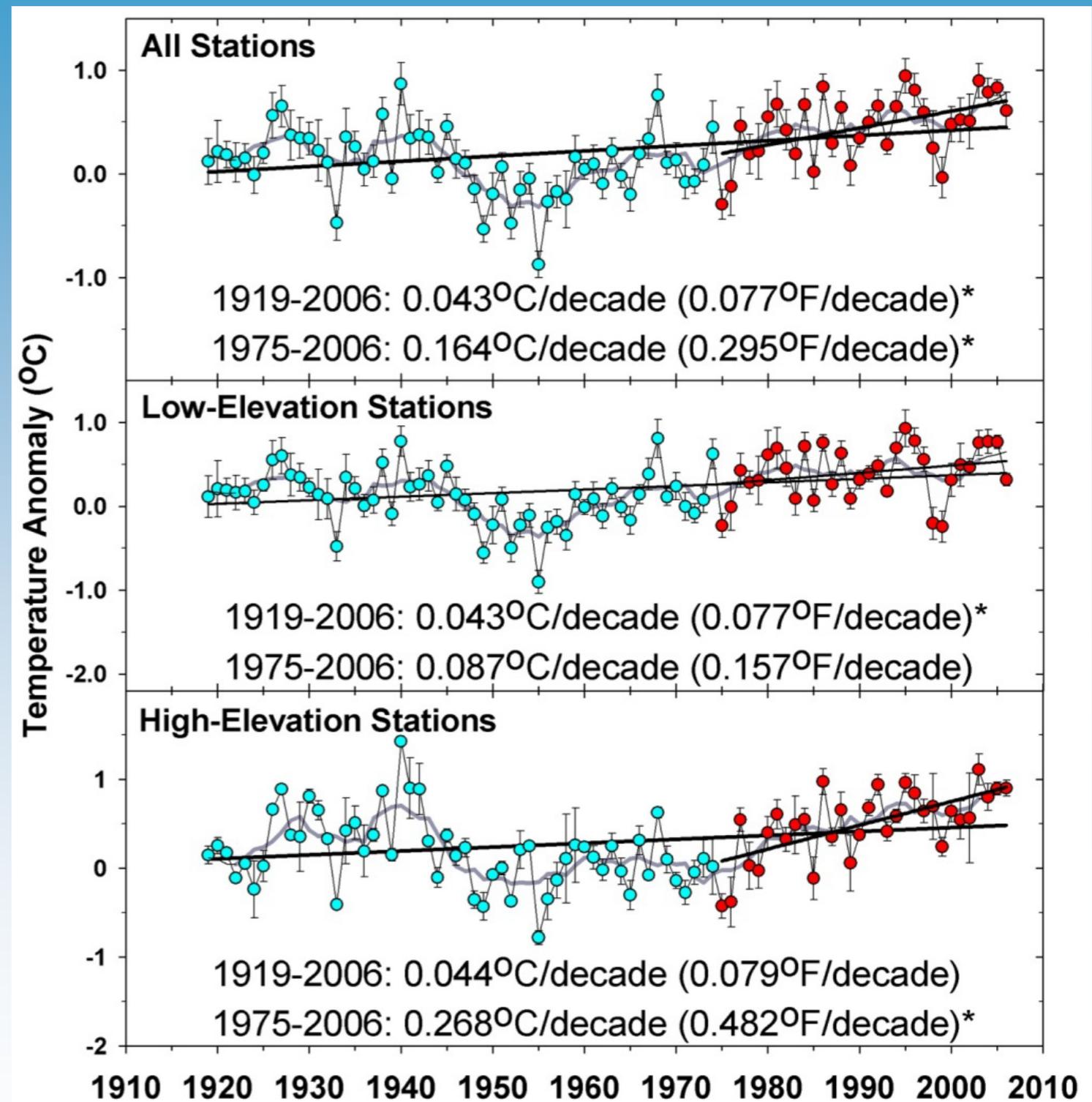
β Frequency of future bleaching events in the 2030s and 2050s, as represented by the percentage of years in each decade where a NOAA Bleaching Alert Level 2 is predicted to occur. Predictions are based on an IPCC A1B (business-as-usual) emissions scenario and adjusted to account for historical temperature variability, but not adjusted by any other resistance or resilience factors.

*Donner, S.D. 2009; Burke et al. 2011*

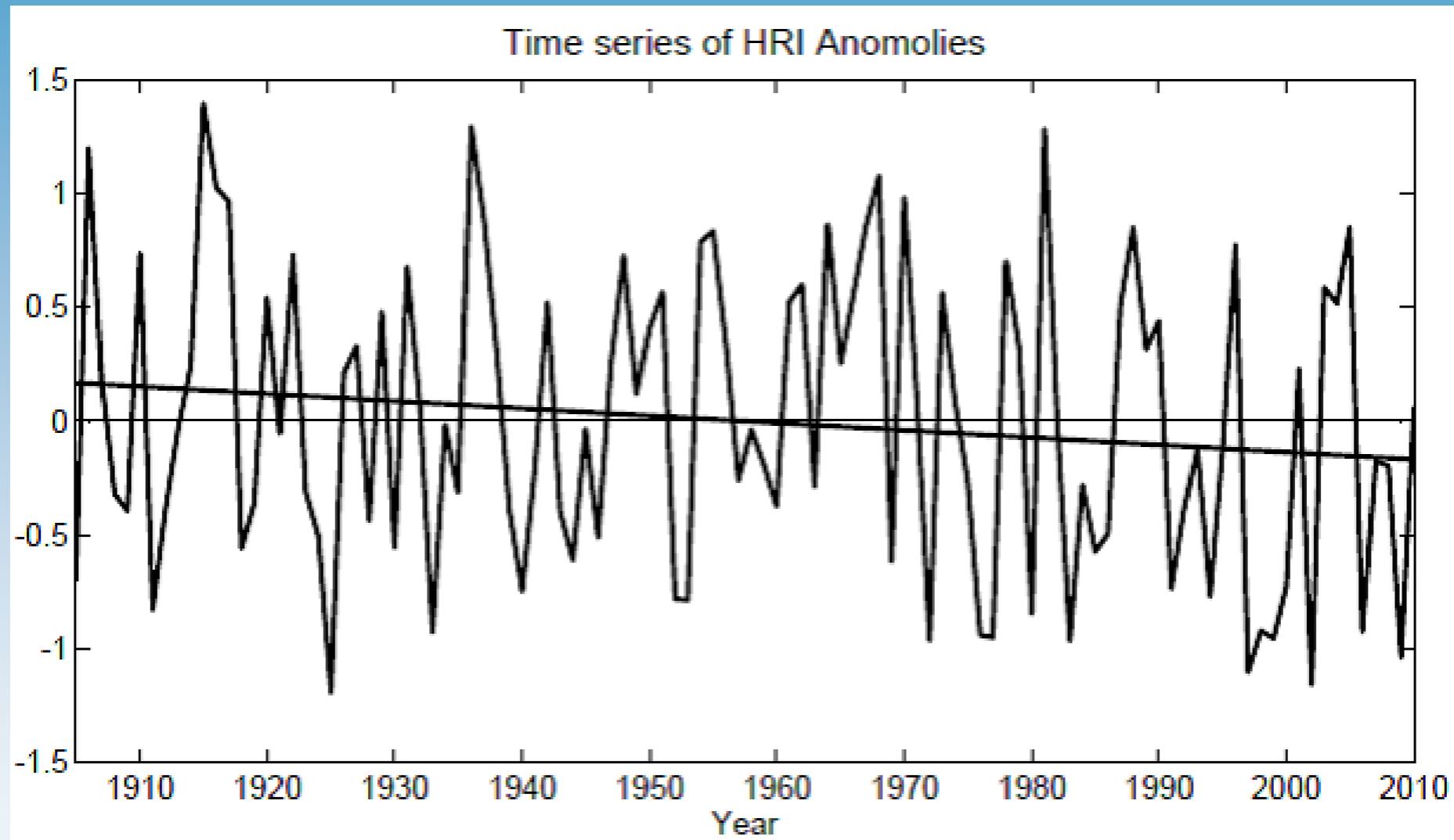
# Surface air temperature trends.

Annual average surface air temperature anomalies are increasing at both high and low-elevation stations in Hawaii.

*Giambelluca et al. (2008)*



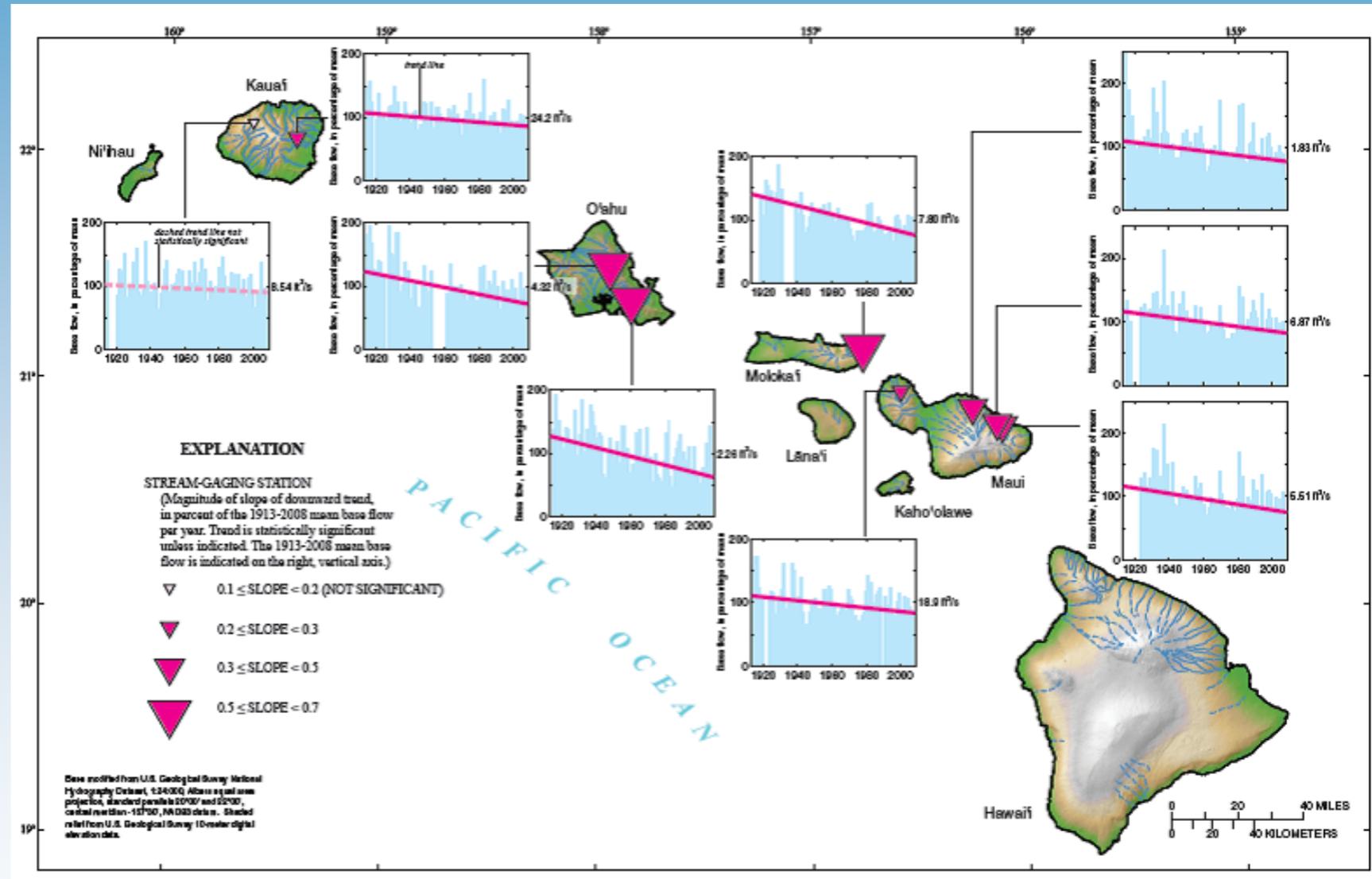
# Rainfall amount and distribution is changing.



Annual time series of the Hawai'i Rainfall Index (HRI) from 1905 to 2010 shows a long-term downward (drying) trend over the last century. *Chu & Chen (2005)*

# Stream “base flow” is decreasing.

Base flow at eight out of the nine long-term stream flow gauges in Hawai'i show significant decreases of 20 to 70 percent over the past 100 years  
*Oki, 2004;*  
*Bassiouni & Oki, 2012*

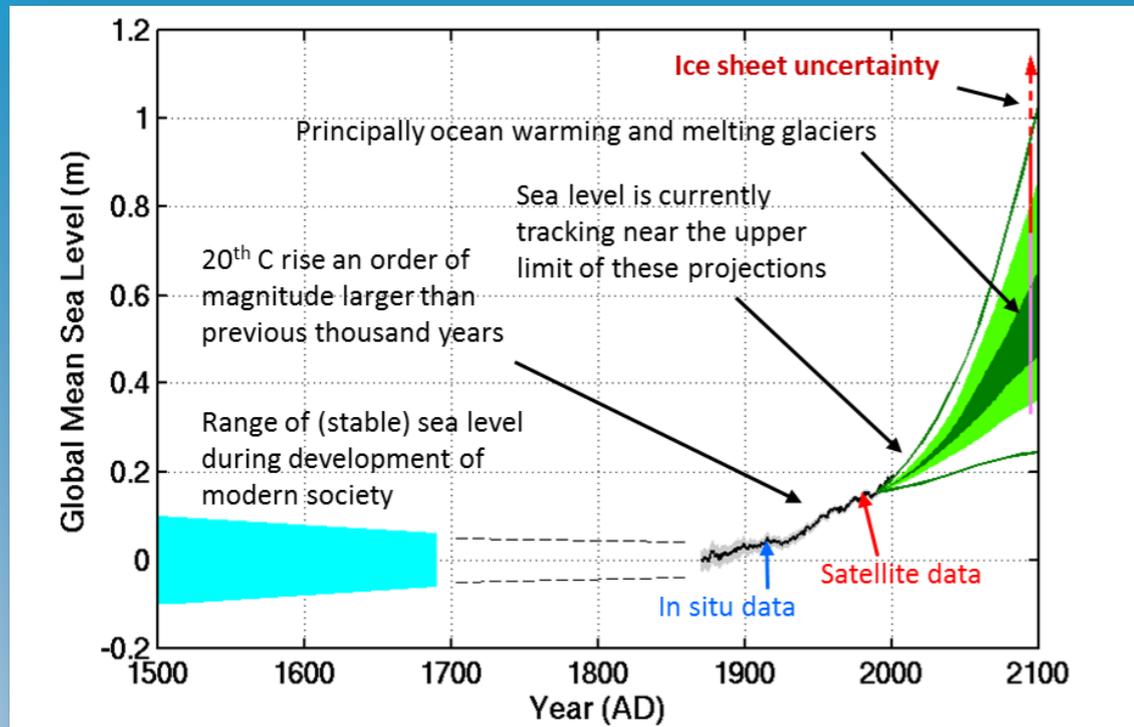


# Sea level is rising.

β Since the early 1990s, the rate of globally averaged sea-level rise has been estimated to be  $3.4 \pm 0.4$  mm per year based on satellite altimeter measurements. This is twice the estimated rate for the 20th century as a whole based on tide gauge measurements.

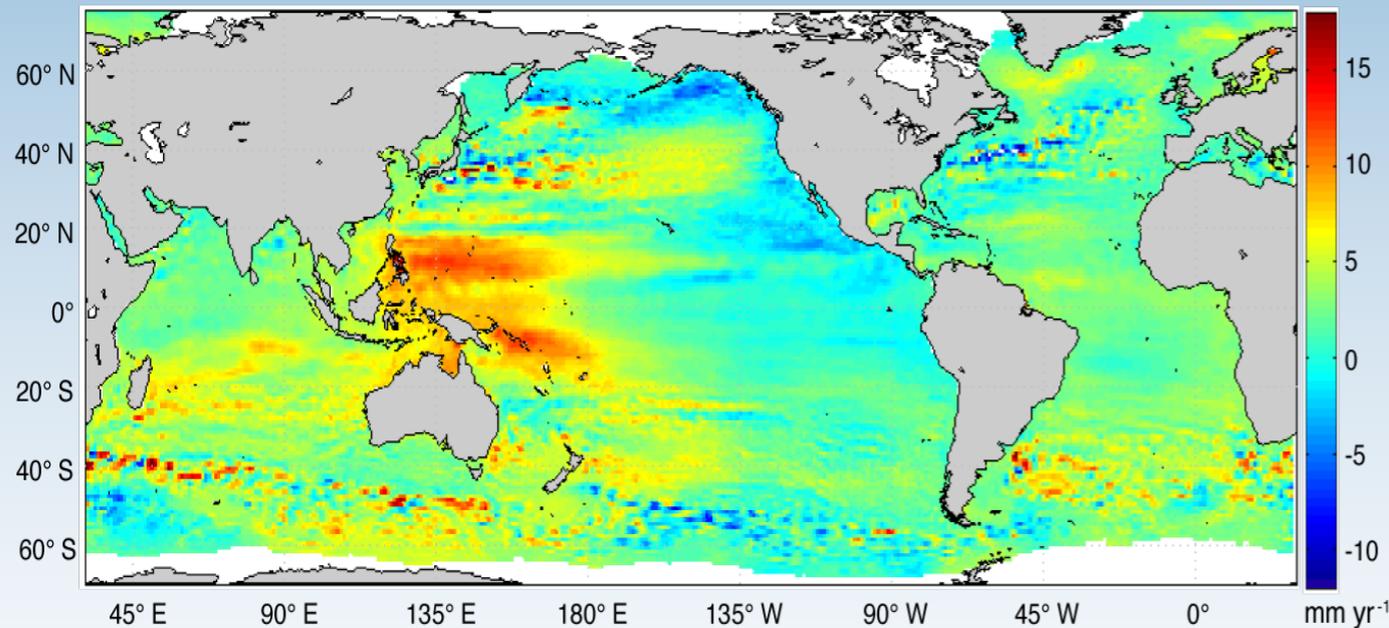
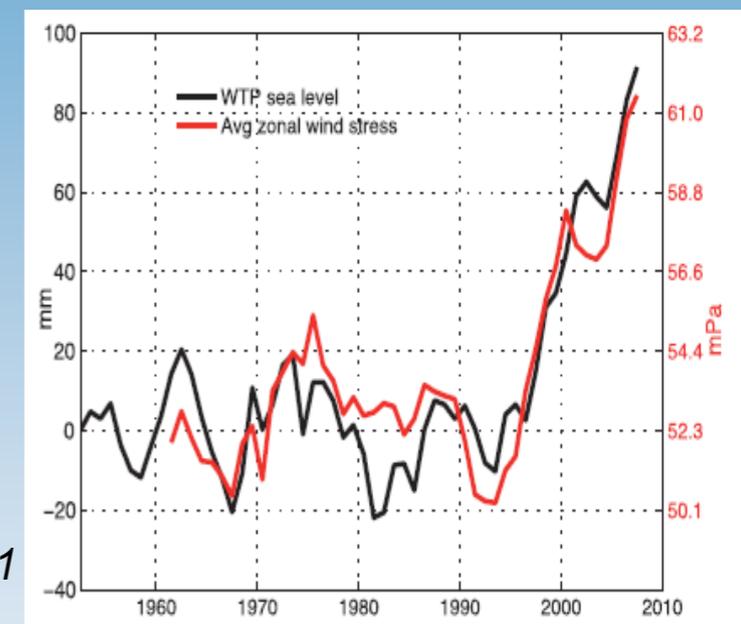
IPCC, 2007

# Winds and waves are changing.



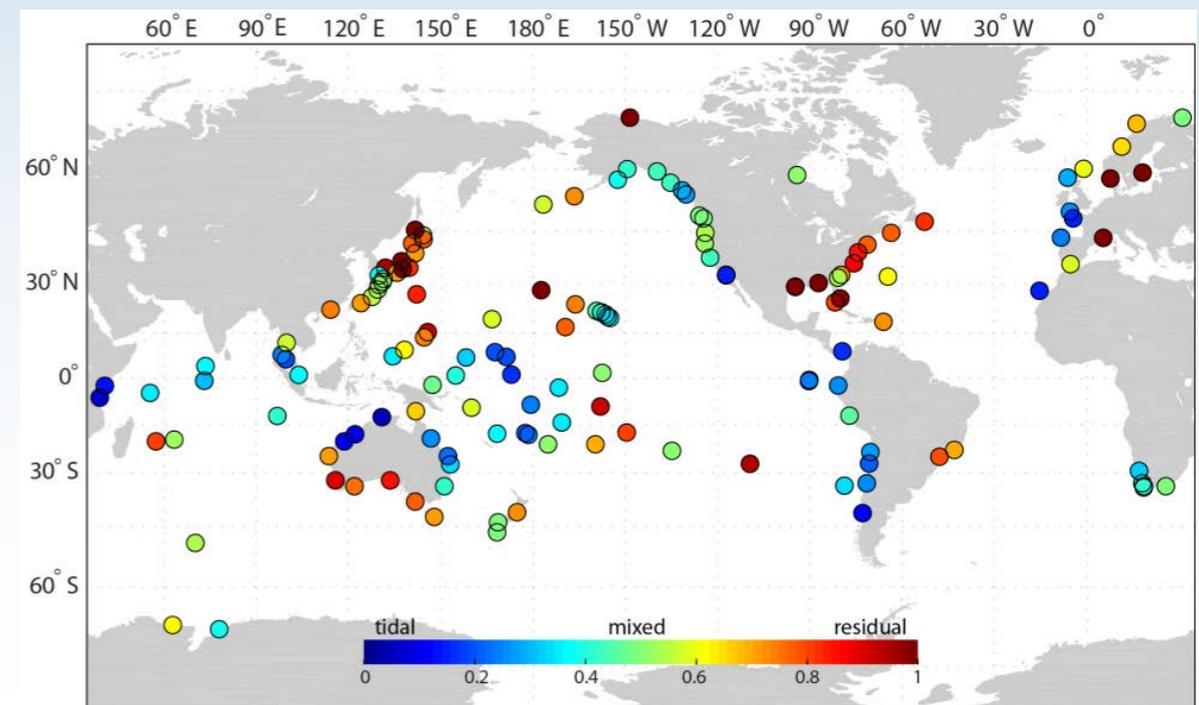
Comparison of à average western tropical Pacific sea level and the amplitude of zonal wind stress averaged across the Pacific.

Merrifield, 2011



Sea-level trend for 1993-2010 from Aviso altimeter.

The ratio of mean non-tidal residual to mean extreme à amplitude for annual maxima. Merrifield et al., 2012



# Impacts - High versus Low Islands

The distinction between “high” volcanic islands and “low” atoll islands is essential to explain the many specialized terrestrial and marine ecosystems that have evolved, as well as forms of human communities they currently support.



*High alpine and subalpine ecosystems, low-lying atolls, nearshore and coastal areas, and coral reefs are most vulnerable to a changing climate.*

Inherent differences exist between these two settings in terms of exposure, sensitivity, and adaptive capacity.

*The atolls generally lack the freshwater and fertile soils and have limited terrestrial resources. They are especially prone to drought. High islands have more land and freshwater resources and therefore more long-term options for responding to climate change. The amount of land that is flat enough for large-scale settlement, development, and agriculture is limited, however, resulting in high concentrations of population, infrastructure, and commercial development in low-lying coastal areas. Thus, communities on high islands and low islands have somewhat similar short-term challenges associated with climate change, but they have different degrees of flexibility in how they can adapt.*

# Built versus Natural Environment

## Sectors ....social and economic impacts.

- Warmer and dryer conditions mean that **freshwater supplies will be reduced**. Atolls and low-lying islands are especially vulnerable. **Food security will be affected if prolonged drought threatens crop productivity** or storms damage infrastructure. In addition, sea-level rise will decrease the land area available for farming and may increase the salinity of ground-water resources.
- The **proximity of human settlements and major infrastructure to the ocean increases vulnerability**. Almost without exception, international airports are sited on or within 1-2 miles of the coast, and the main (and often only) road network runs along the coastline. Because Pacific Islands are almost entirely dependent on imported food, fuel, and material **the vulnerability of ports and airports to extreme events** is of great concern.
- In the fisheries sector, recent analyses suggest that under a high-emissions scenario **fish catches in the tropics may decrease** up to 40%. The Indo-Pacific region would be most highly affected, with up to a 50% decline in maximum fisheries catch potential by 2055.
- Pacific Island **tourism risks losing billions of dollars annually** if sea-level rise or storms threaten infrastructure, ocean bleaching threatens the recreational appeal of coral reefs, or freshwater supplies decrease.
- **Climate change may have serious effects on human health**, for instance by increasing the incidence of infectious diseases such as dengue. Sea-level rise and flooding may overcome sewer systems and threaten public sanitation. Psychosocial effects of stress from extreme weather events are likely to be gradual and cumulative. Increased incidences of resource conflicts may also affect mental and physical health, with a disproportionate impact on those of lower socioeconomic status.



# Built versus Natural Environment

## Ecosystem types ...environmental impacts.

- **In marine ecosystems, large-scale changes** in wind regimes, thermal stratification, and ocean chemistry affect phytoplankton distribution **will likely change the distribution of species all along the food chain.**

- **Rates of coral reef formation are declining**, presumably due to ocean acidification and coral bleaching due to extreme sea-surface temperatures is becoming more frequent and widespread.



- **Seagrass and mangrove ecosystems**, which serve as foraging areas and nursery habitat for many coastal species, **are expected to diminish** due to the combined effects of increased air and sea temperature, sea-level rise, drought, and increased runoff and sedimentation.

- **Coastal and atoll island ecosystems will be affected by high waves during storms**, which will reshape and move islets and beaches and increase salinity. **These changes will reduce or eliminate endemic terrestrial species, seabird colonies, sea turtle nests, and human presence on many small islands.**

- **Freshwater ecosystems face a gradual decline** of native aquatic species as rainfall and streamflow decline.



- **Invasive species** of plants and animals are established and expanding in **islands and forests and their response to climate change will interact with those of native species** to determine the composition of future ecosystems.

- **Existing climate zones are projected to shift**, generally upslope, **with some eventually disappearing.** Because many island species are endemic, the loss of a species from an island ecosystem often means global extinction.

# Cultural Resources

In the Pacific Islands there is a fundamental link between culture, the environment, and the economy.

*There is an emphasis on long-term connection with lands and resources, with multi-generational attachment to places.*

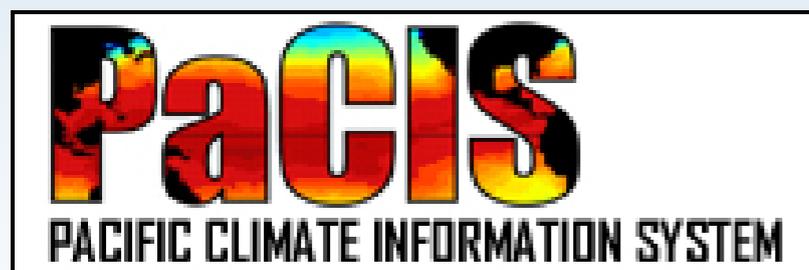


- The **changing climate poses serious consequences to the traditional lifestyles and cultures** of indigenous communities in the region.
- Inundation from sea-level rise may destroy coastal artifacts and structures or even the entire land base associated with cultural traditions.
- Drought threatens traditional food sources such as taro and breadfruit, and coral mortality from bleaching will likely threaten subsistence fisheries in island communities.
- **Climate-related environmental deterioration for communities at or near the coast, coupled with other socioeconomic or political motivations, may lead individuals, families, or communities to consider migrating to a new location.** Depending on the scale and distance of the migration, **a variety of challenges face the migrants and the communities receiving them.** Migrants need to establish themselves in their new community, find employment, and access services, while the receiving community's infrastructure, labor market, commerce, natural resources, and governance structures need to absorb a sudden burst of population growth.

# Building Partnerships to Support Climate Services

*“A mechanism to identify, produce, and deliver authoritative and timely information about climate variations and trends and their impacts on built, social-human, and natural systems on regional, national, and global scales to support decision making.” (NRC, 2009)*

**Partnerships are fundamental** for sustaining a regional climate assessment process and addressing the impacts of climate change across isolated and diverse islands. **The regional culture of communication and collaboration provides a strong foundation** for this effort and will be important for building resilience in the face of the changing climate.





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**For more on the PIRCA:**

<http://www.eastwestcenter.org/PIRCA>

**For more on the NCA:**

<http://www.globalchange.gov/what-we-do/assessment>

# Uncertainty

'uncertainty' [uhn-sur-tn-tee] \_

(noun)

1. doubt; hesitance; lack of assurance
2. instance of doubt, hesitance, uncertainty, etc.
3. unpredictability; indeterminacy; indefiniteness

