

Climate Trends, Future Projections, and Impacts on Land Use in Hawai'i

Hawai'i Land Use Commission Meeting

August 26, 2015

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Pacific Regional Integrated Sciences & Assessments (Pacific RISA)

Pacific RISA

Pacific Regional Integrated Sciences and Assessments



EAST-WEST CENTER
COLLABORATION • EXPERTISE • LEADERSHIP



- US Global Change Research Act of 1990
- Helps federal government prioritize science investments
- Third US National Climate Assessment
 - PIRCA, December 2012
 - NCA released by White House, May 2014
- <http://nca2014.globalchange.gov/>
 - **Chapter 23: Hawaii and the US Affiliated Pacific Islands**



Climate Change Impacts in the United States

CHAPTER 23 HAWAII AND U.S. AFFILIATED PACIFIC ISLANDS

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On the Web: <http://nca2014.globalchange.gov/report/regions/hawaii-and-pacific-islands>

Products

- **DOWNLOAD:**
www.eastwestcenter.org/PIRCA
- Climate Change and Pacific Islands: Indicators and Impacts
- Case Studies
- Executive Summary
- NCA Pacific Islands chapter (2013)



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CLIMATE CHANGE AND PACIFIC ISLANDS: INDICATORS AND IMPACTS

*Executive Summary of the 2012
Pacific Islands Regional Climate Assessment (PIRCA)*

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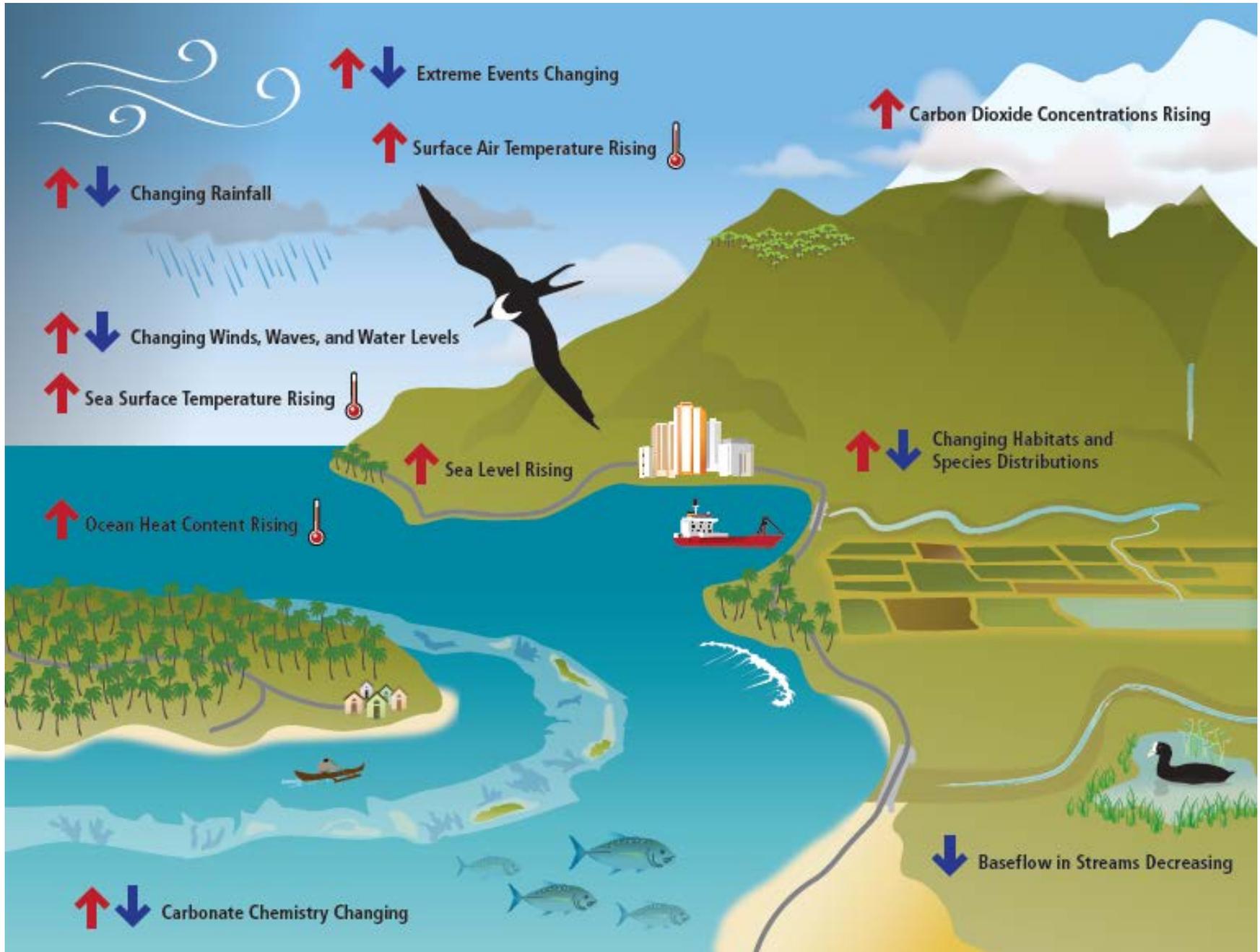
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Climate /

This executive summary has
been adapted from the full-
length report, which can be
accessed at
www.EastWestCenter.org/PIRCA.

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Climate Assessment (PIRCA)

ISLANDPRESS

Indicators of a Changing Climate in the Pacific Islands Region



Key Messages



Average, max, and min air temperatures rising



Fresh water supplies more limited



Increased coastal flooding and erosion



Changes in marine ecosystems



Native plant & animal stress



Increasing human migration



Threats to agriculture & indigenous cultures



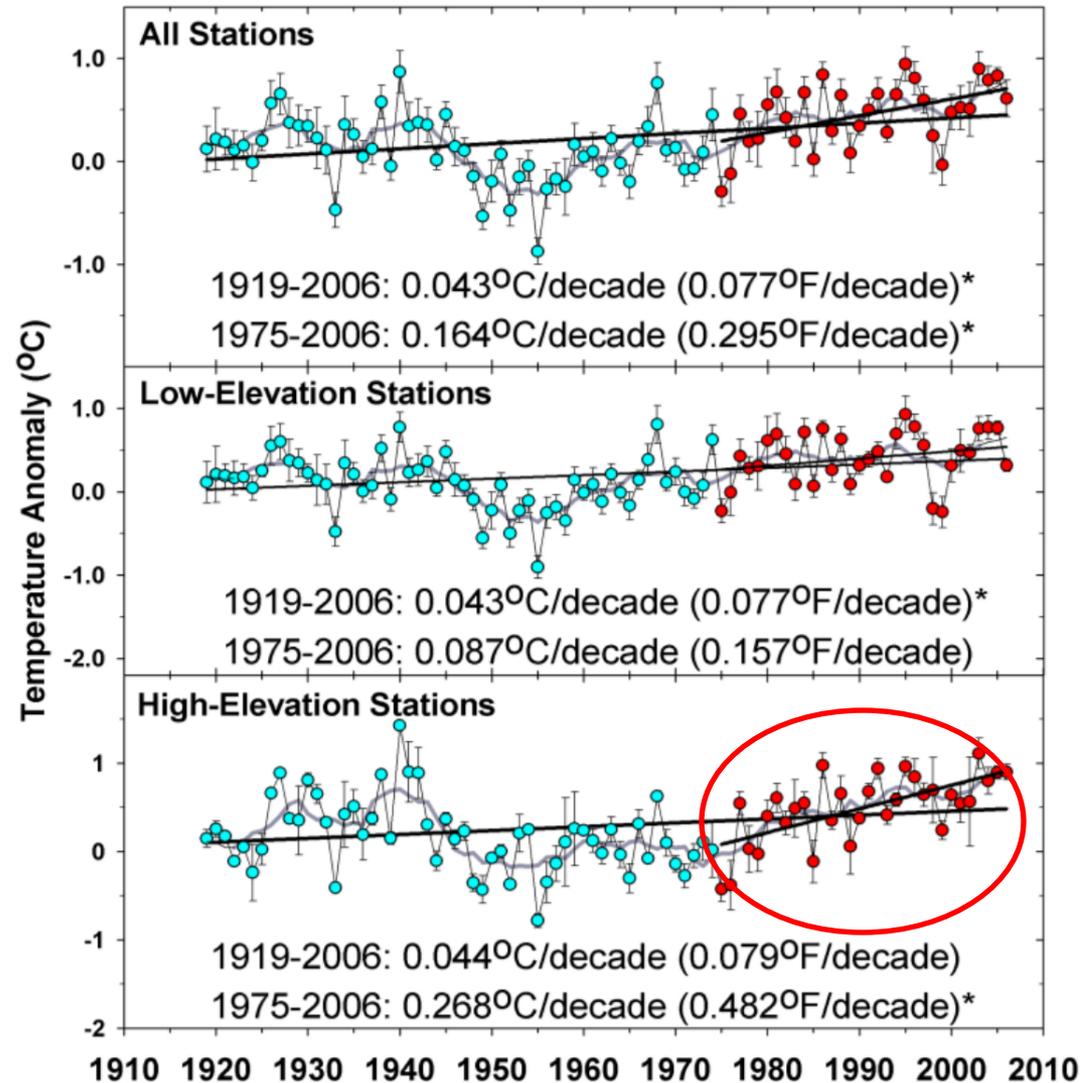
Changing rainfall amounts and patterns



Changing frequency/intensity of wind, waves, and storms

Air Temperature is Rising

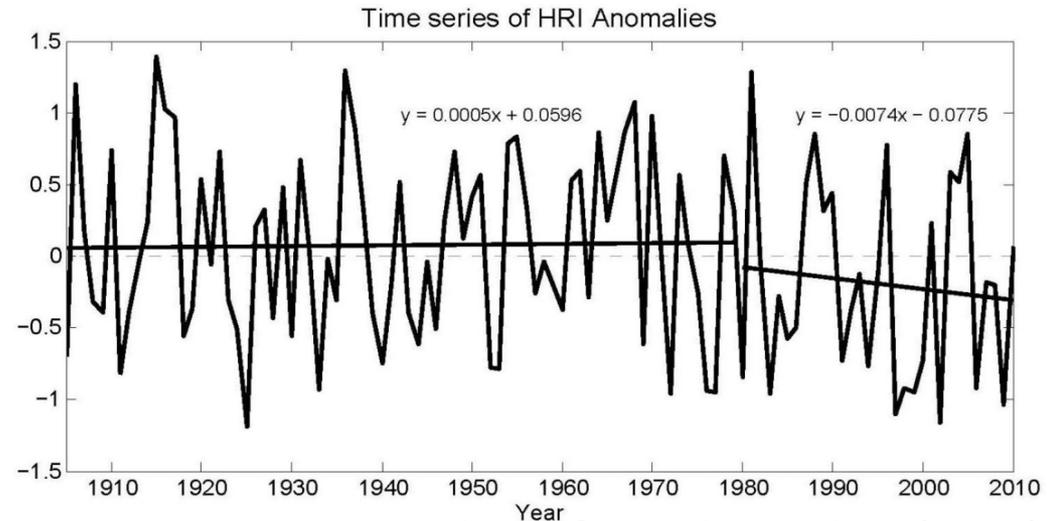
- Average, min, and max air temperature has risen **significantly** in Hawai'i in the past 100 years
- This has accelerated in the past 30 years
- Increasing air temperature is **more rapid at high-elevations** (>0.5 mile above sea level)



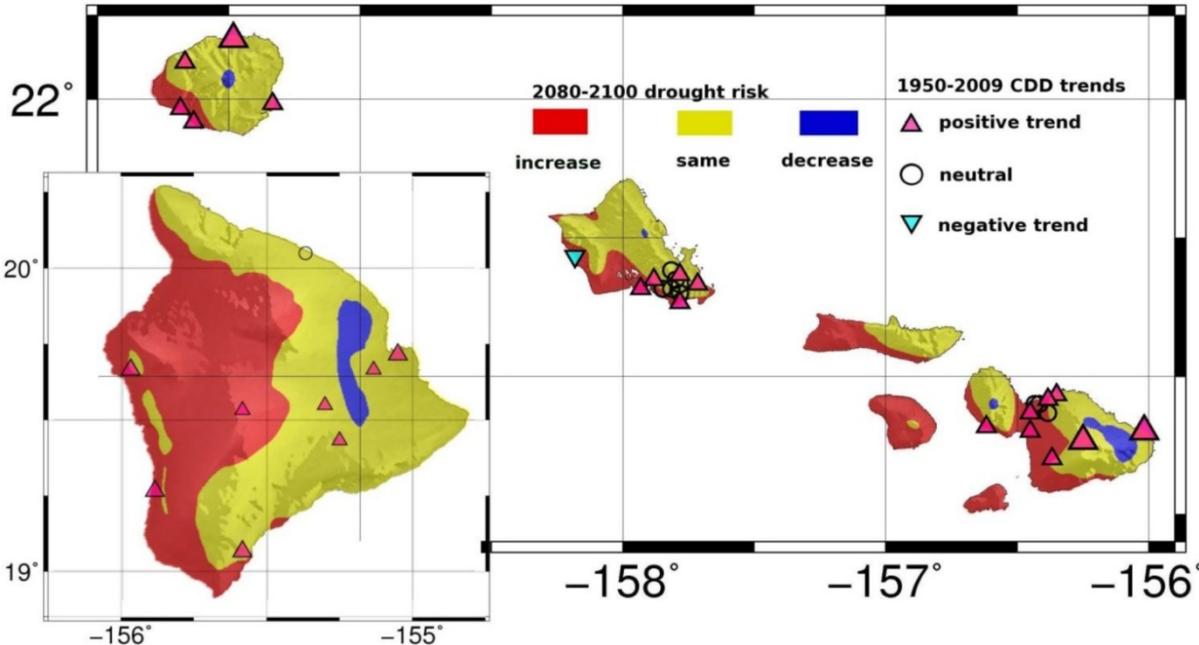
Giambelluca et al, 2008

Precipitation & Drought Patterns are Changing

Annual precipitation has decreased significantly in the past 30 years in Hawai'i

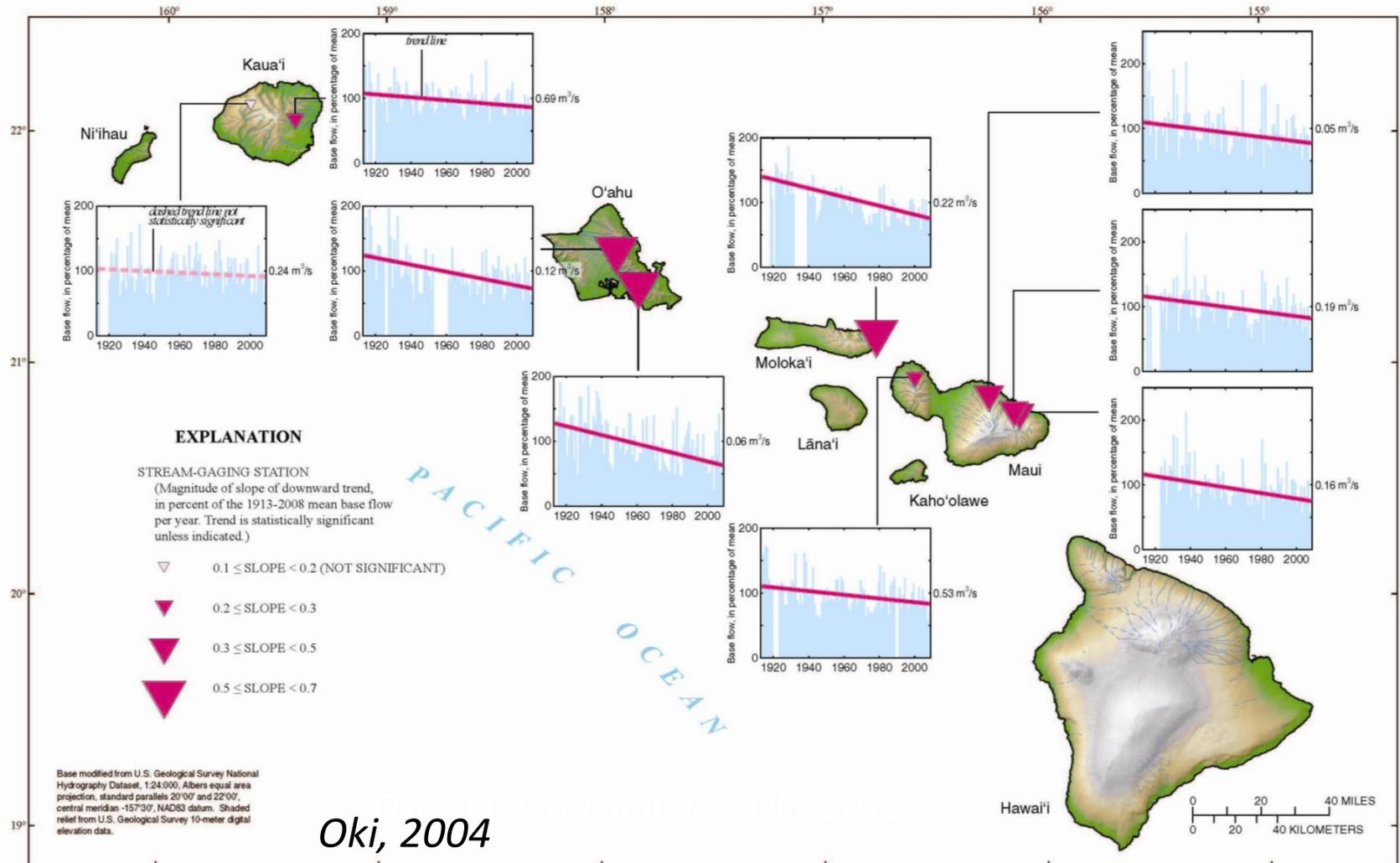


updated from Chu & Chen (2005)



In the past 30 years, all Hawaiian Islands have experienced greater numbers of consecutive dry days, and fewer days of intense rainfall

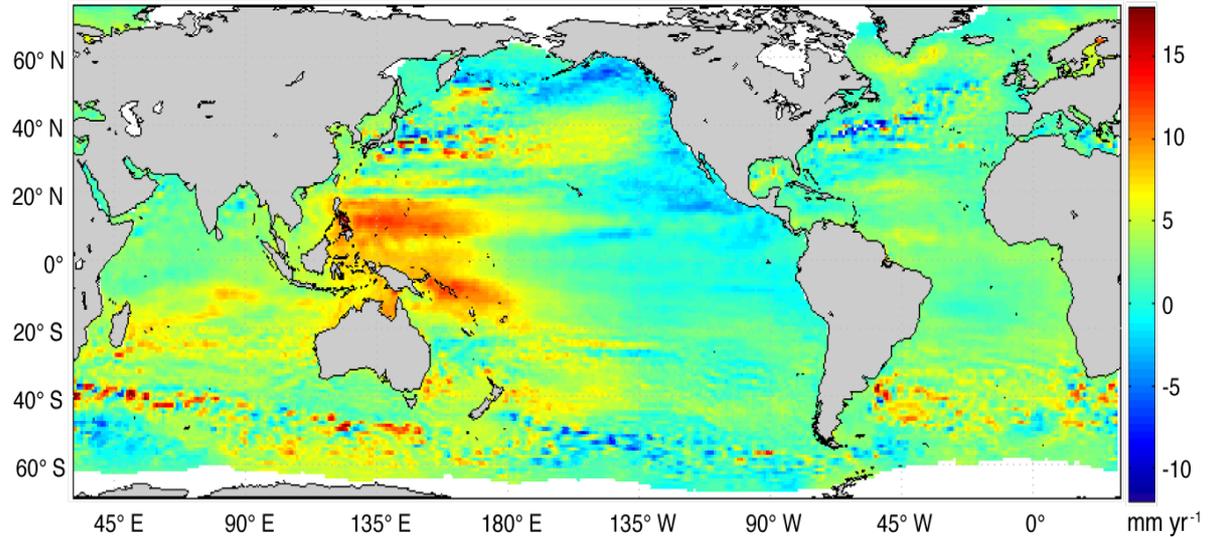
Base Flow in Streams is Decreasing



In Hawai'i, base flow, the groundwater component of streamflow, has shown significant downward trends of 20-70% in the past 100 years

Sea Level is Rising

- Since the 1990s, the rate of **globally averaged sea-level rise** has been **~0.13 inches per year**
- This is **twice the estimated rate** for the 20th century as a whole
- Climate **model projections** (that do not include ice-sheet contributions) are for an **6 to 24 inch rise in global sea level** by 2100



Sea-level trend for 1993-2010 from Aviso altimeter.
Merrifield 2011

Increased Flooding and Erosion Threaten Natural and Built Environments

- Coastal structures
- Airports
- Groundwater supply
- Harbor operations
- Agricultural productivity
- Waste water systems
- Sandy beaches
- Coral reef ecosystems
- Cultural resources
- Nesting habitat



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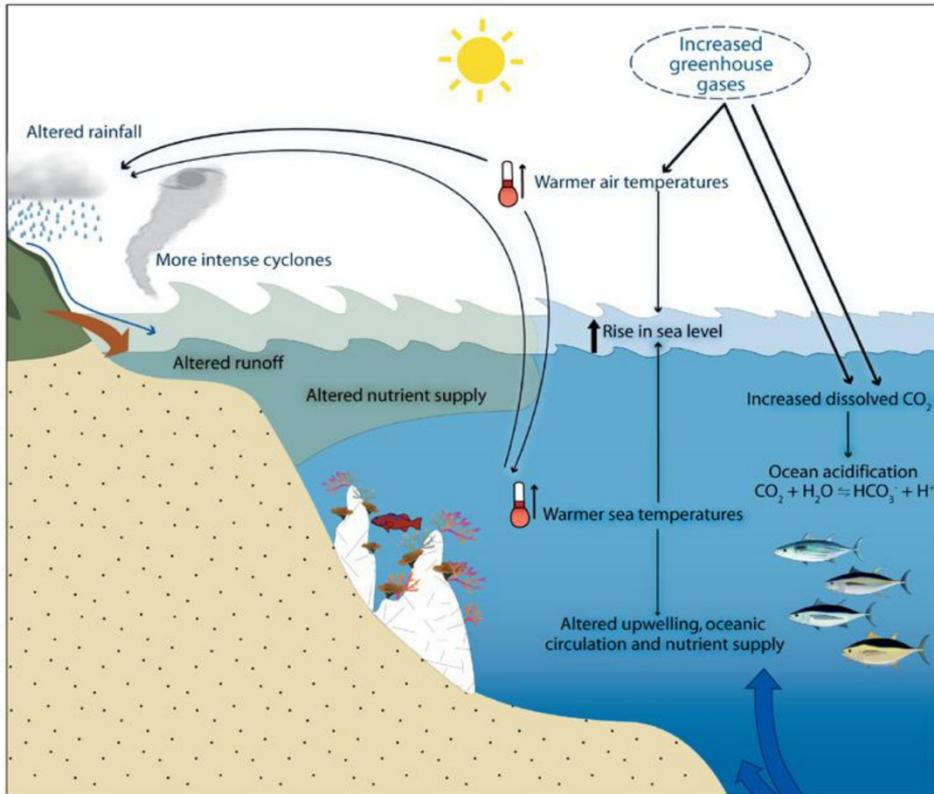


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Native plant and animal populations will be increasingly stressed



- Different **impacts** are **interconnected** and will combine to alter ecosystem function
- Rising air temperatures, especially at high elevations, could **exacerbate invasive species** problems

Generalized effects of increased greenhouse gases on oceanic and coastal ecosystems in the tropical Pacific, *Bell et al., 2011*

Climate and Land Use in Hawaii

- A changing climate will impact what areas are best suited for development, conservation, and cultural uses
- Freshwater quality and quantity, economics of potable water
- Citing new infrastructure, changing capacities
 - Intense rainfall: 10” in 24-hours shut down the Waimanolo Gulch landfill in 2010 (La Niña...)
 - Drought: Food security, sustainable development, cultural resources
- Impacts tend to hit the most vulnerable populations first



The million dollar question:

Given the uncertainties, how do we take the climate research and data that we DO have and make the results most useful and useable for policy and management of natural resources right now?

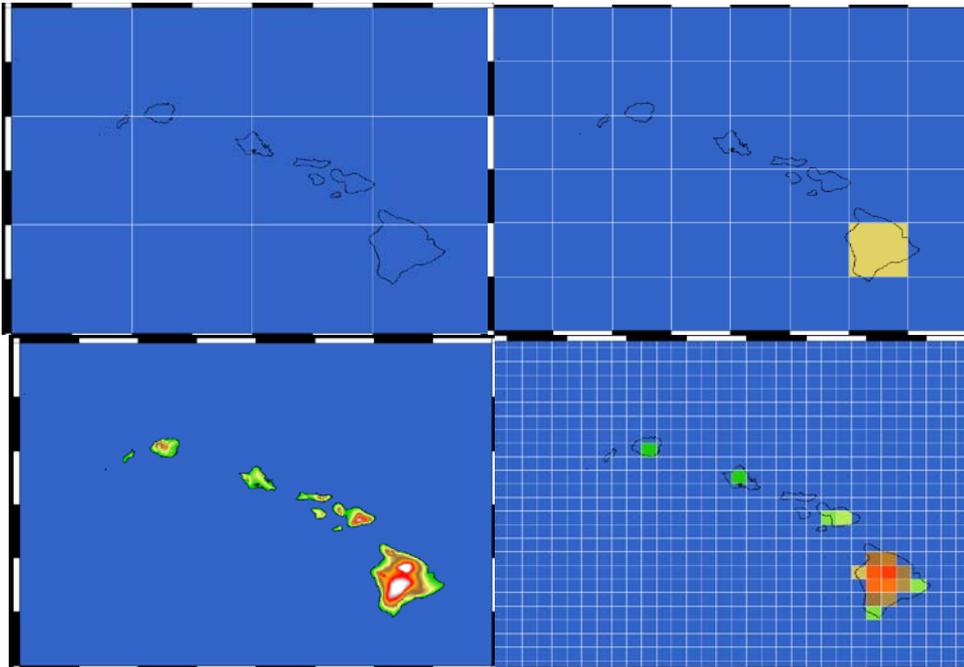
How can climate projections at the island or state scale be used to guide planning and investments?

(the most “bang” for your buck)

1. Seasonal planning
2. Long term scenario planning

Climate Variability in the Pacific

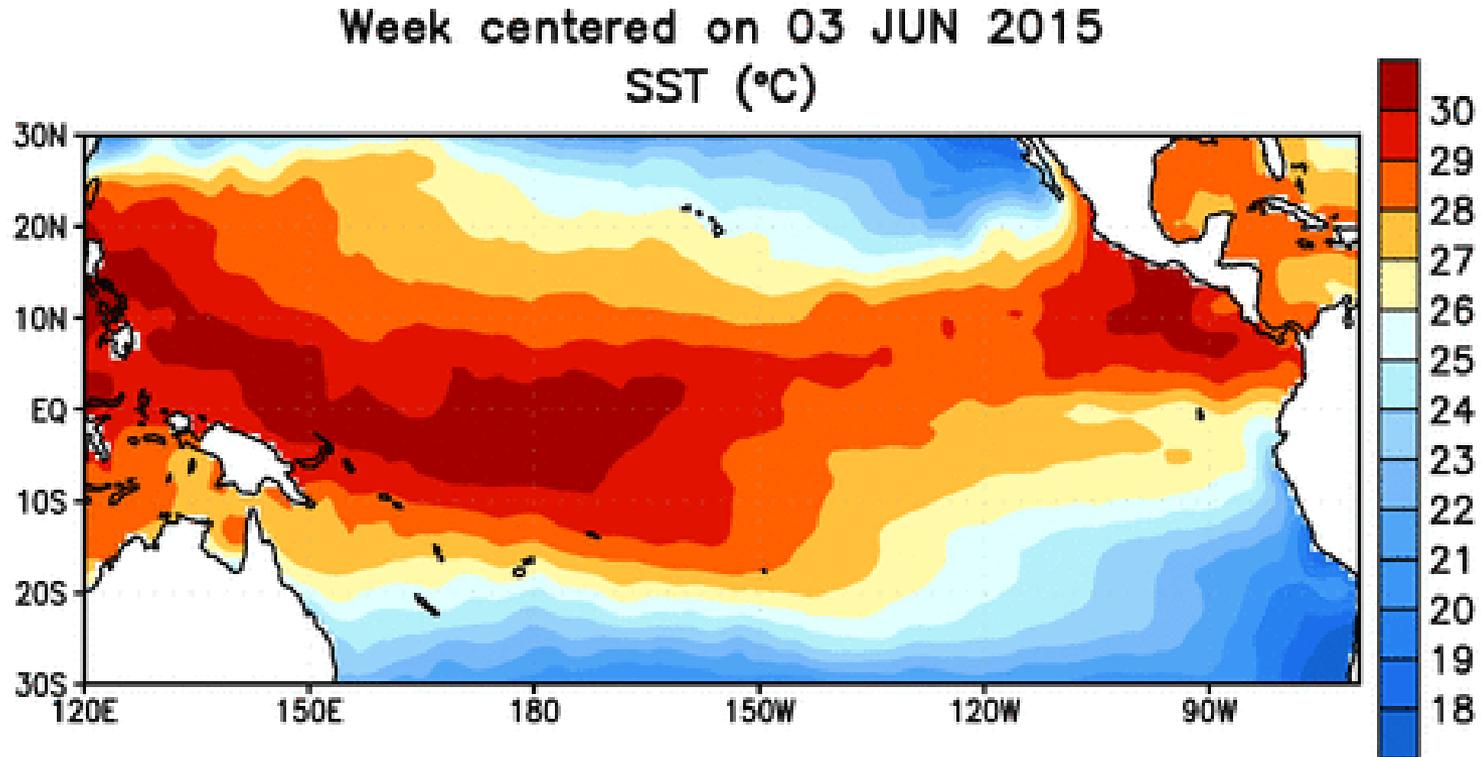
- Hawai'i and the greater Pacific Islands region has difficulties in relation to regional climate downscaling



- Small size
- Extreme topography
- Tradewind dynamics
- High natural regional climate variability

Clockwise from left: The Hawaiian Islands as seen (or not seen) in two global models, a regional model and a downscaled climate model (Courtesy of Axel Lauer, IPRC, UH)

NOAA is Predicting a Strong El Niño

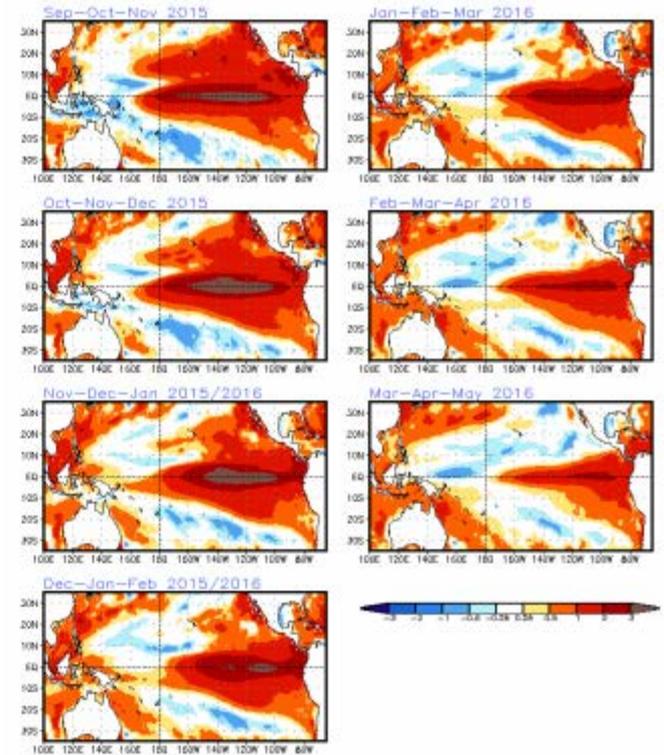
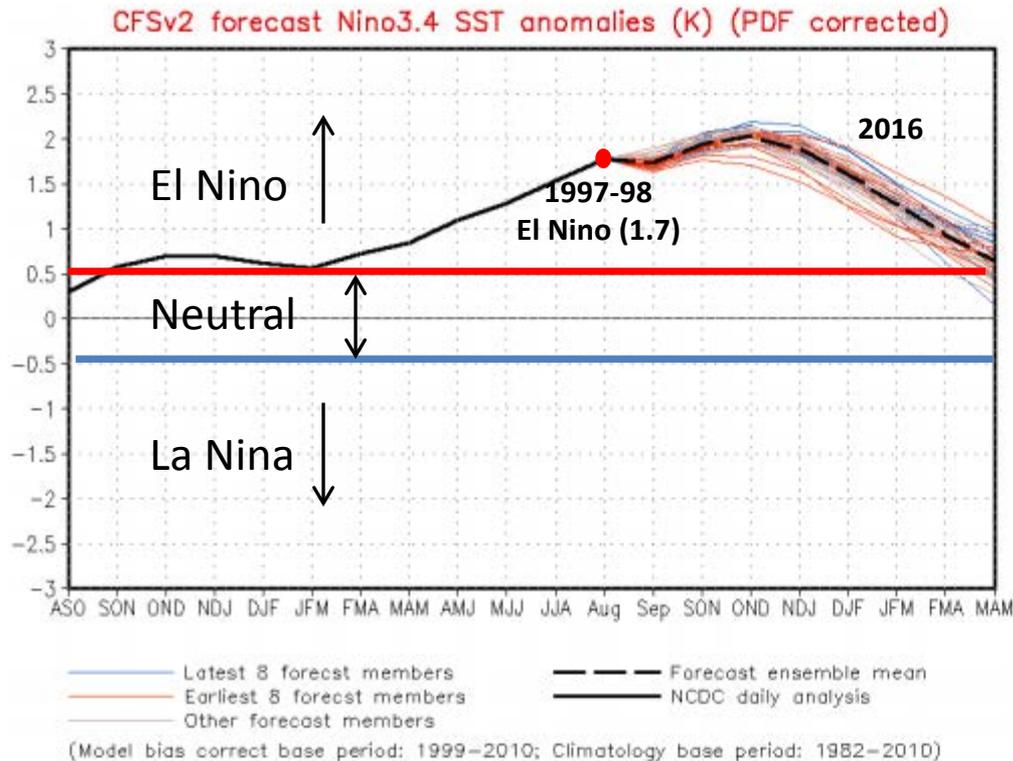


El Niño Impacts in Hawaii

- Strong events have better predictability
 - 1997-1998 was the strongest El Niño on record
- Slightly wetter than average Sept/Oct/Nov
- **VERY DRY winter and spring** (Dec/Jan/Feb/Mar)
- Implications for terrestrial and aquatic ecosystems, nearshore reef ecosystems, irrigation needs, agriculture & ranching, stream diversions, potable water supply, groundwater pumping, cultural uses...

Seasonal Impacts: The El Niño-Southern Oscillation (ENSO)

The CFS.v2 ensemble mean (black dashed line) predicts El Niño through MAM 2016.



Future Land and Climate Scenario Development

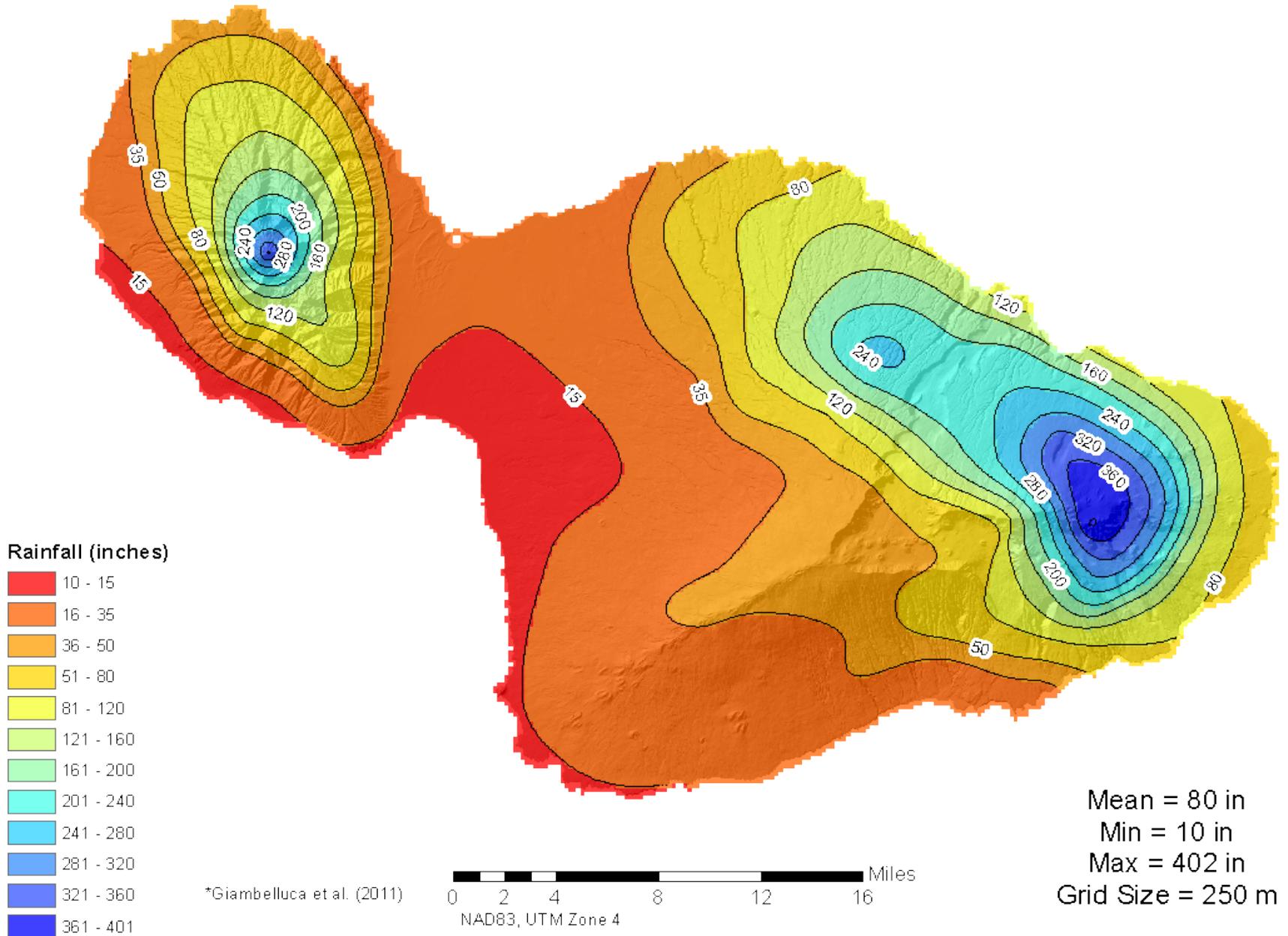
- Quantify groundwater recharge under **current** versus **future** climate conditions on Maui
- Compare past and future groundwater recharge under different land-use and development scenarios
 - Create plausible future land use scenarios with stakeholder input to feed the water budget model;
 - Identify vulnerable “hot-spots” of interest between scenarios where groundwater recharge changes the most.



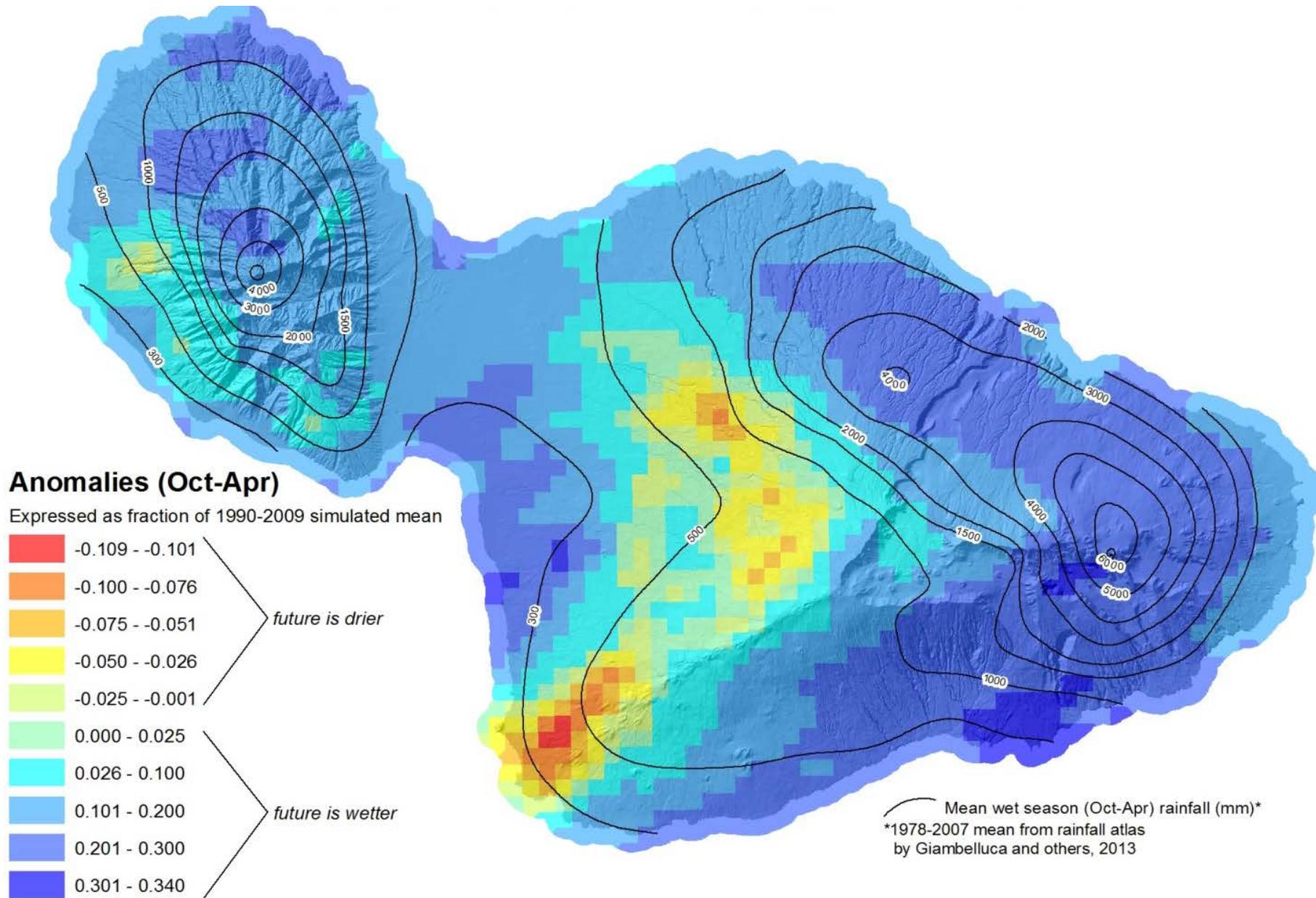
UH IPRC Future Climate Projections

- Temperature increases at all elevations
- Wet areas get wetter
- Dry regions are mixed (some wetter, some drier)
- Mean annual rainfall increases
 - Seasonal patterns show May-September drying in central Maui
- Mean annual reference evapotranspiration increases
- Little change in cloud-base elevation and trade-wind inversion height

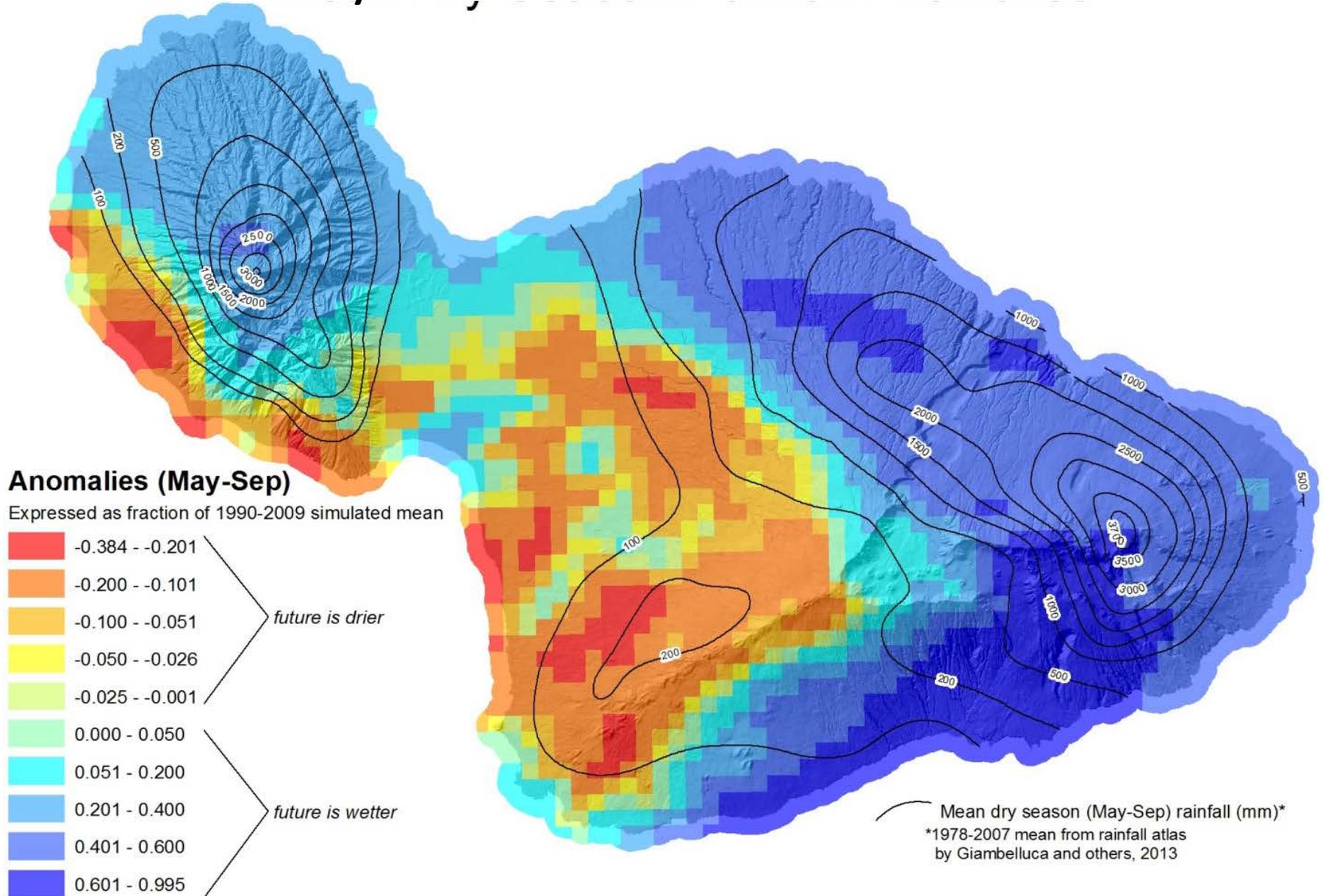
Mean Annual Rainfall 1978-2007



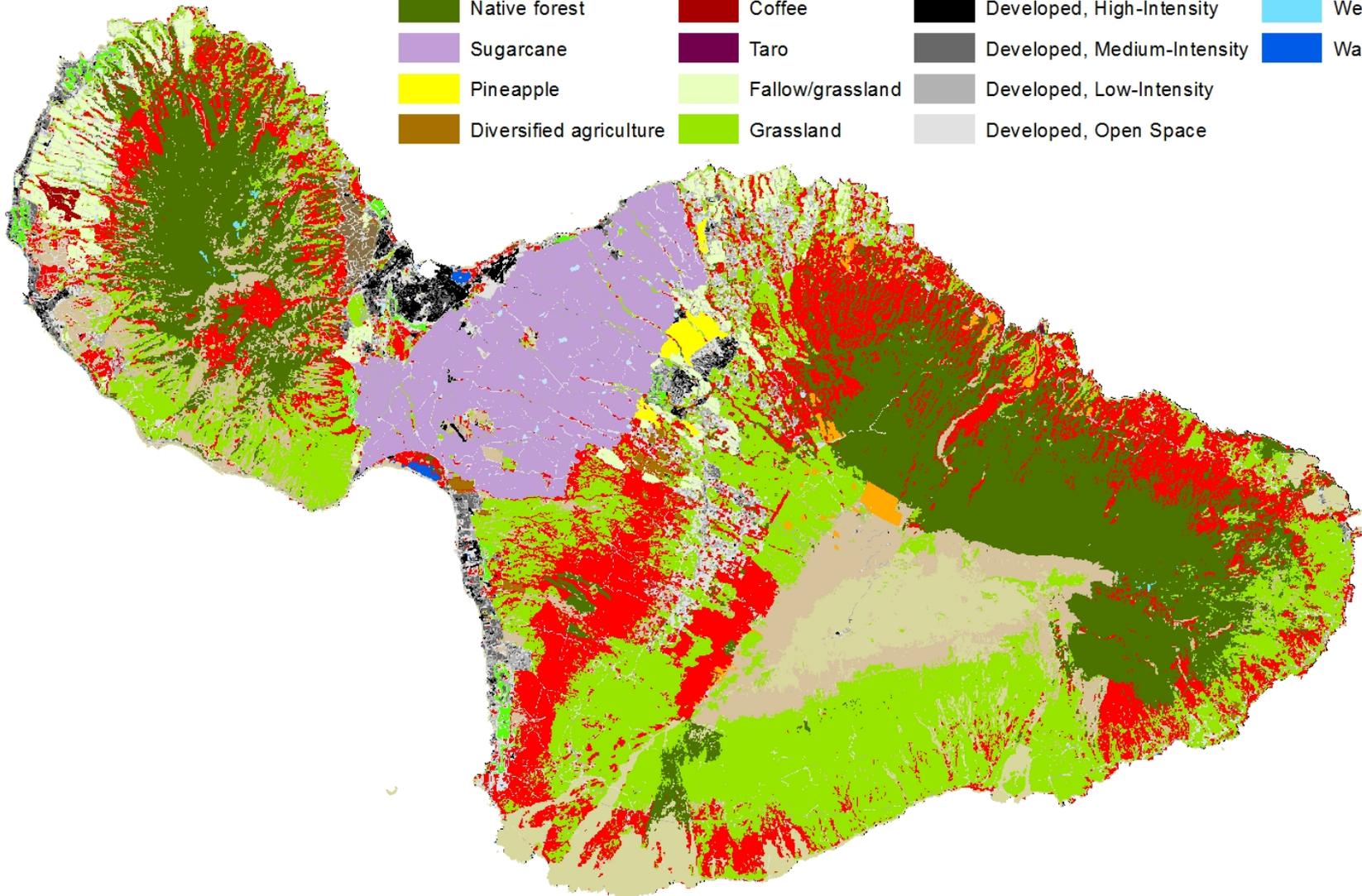
Mean Wet Season Future Rainfall Anomalies



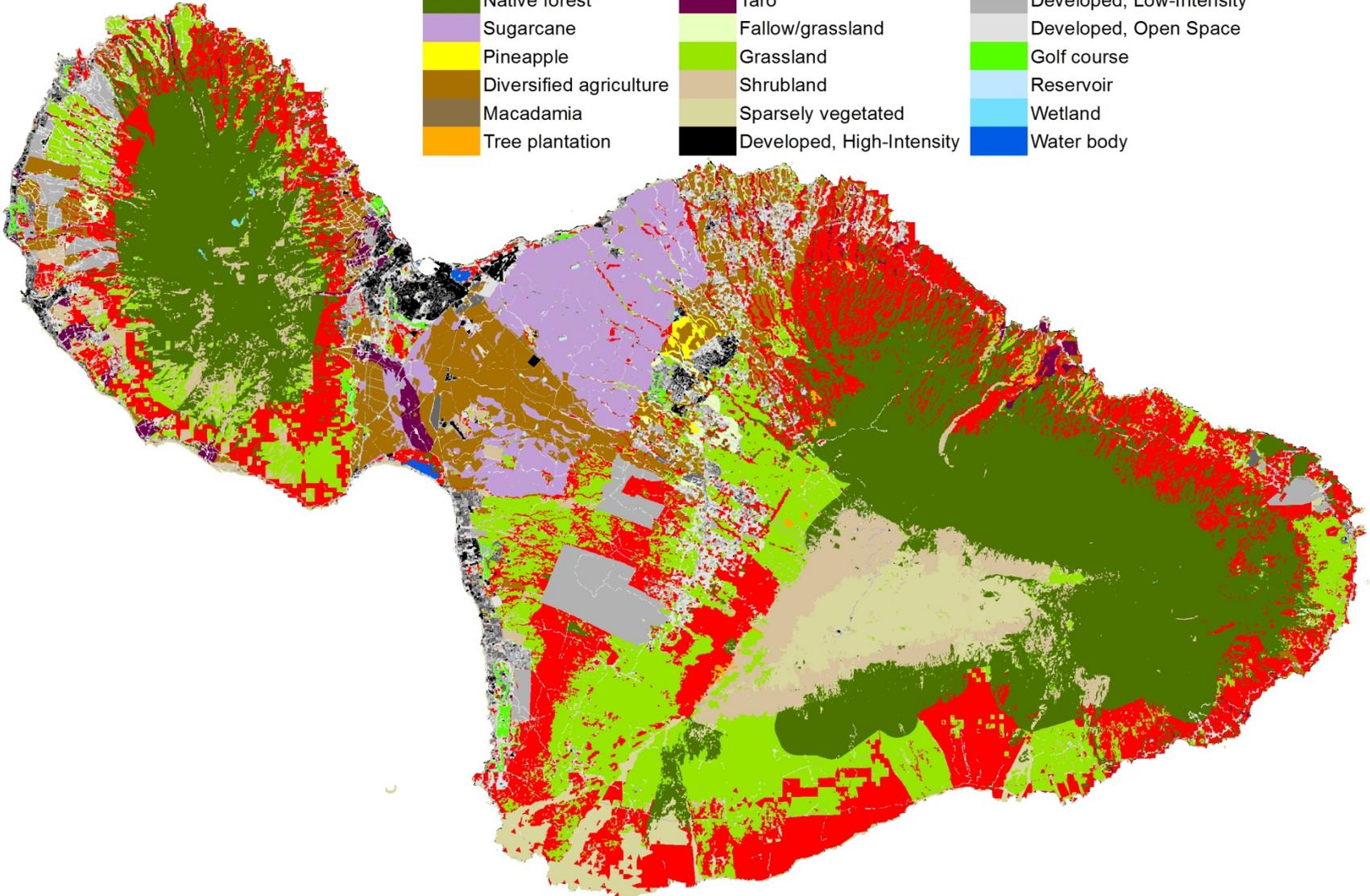
Mean Dry Season Future Rainfall Anomalies



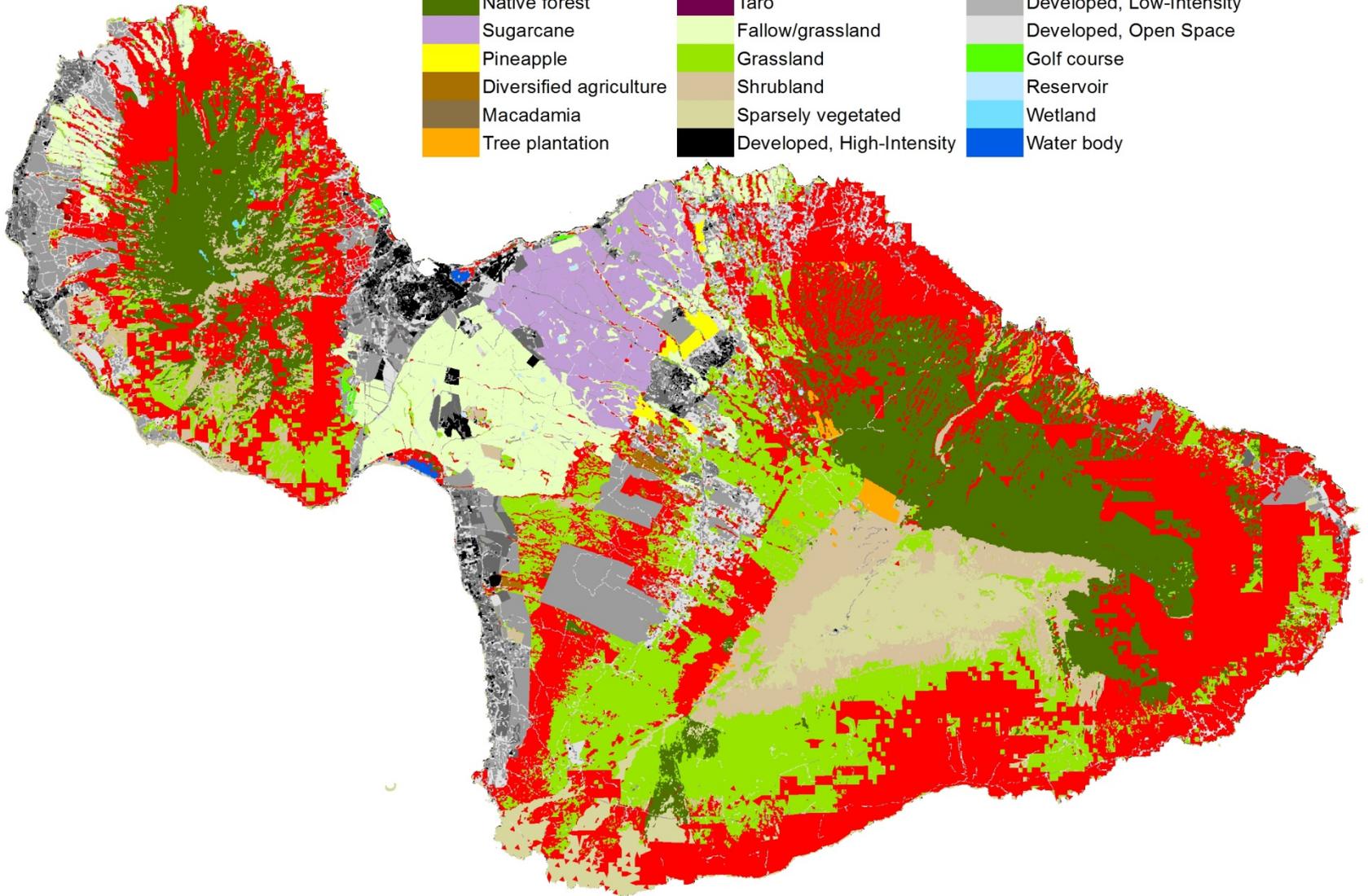
"Current" 2010 Land Cover



SCENARIO : CONSERVATION FOCUS



SCENARIO : DEVELOPMENT FOCUS



Policy Applications of Future Climate Scenarios

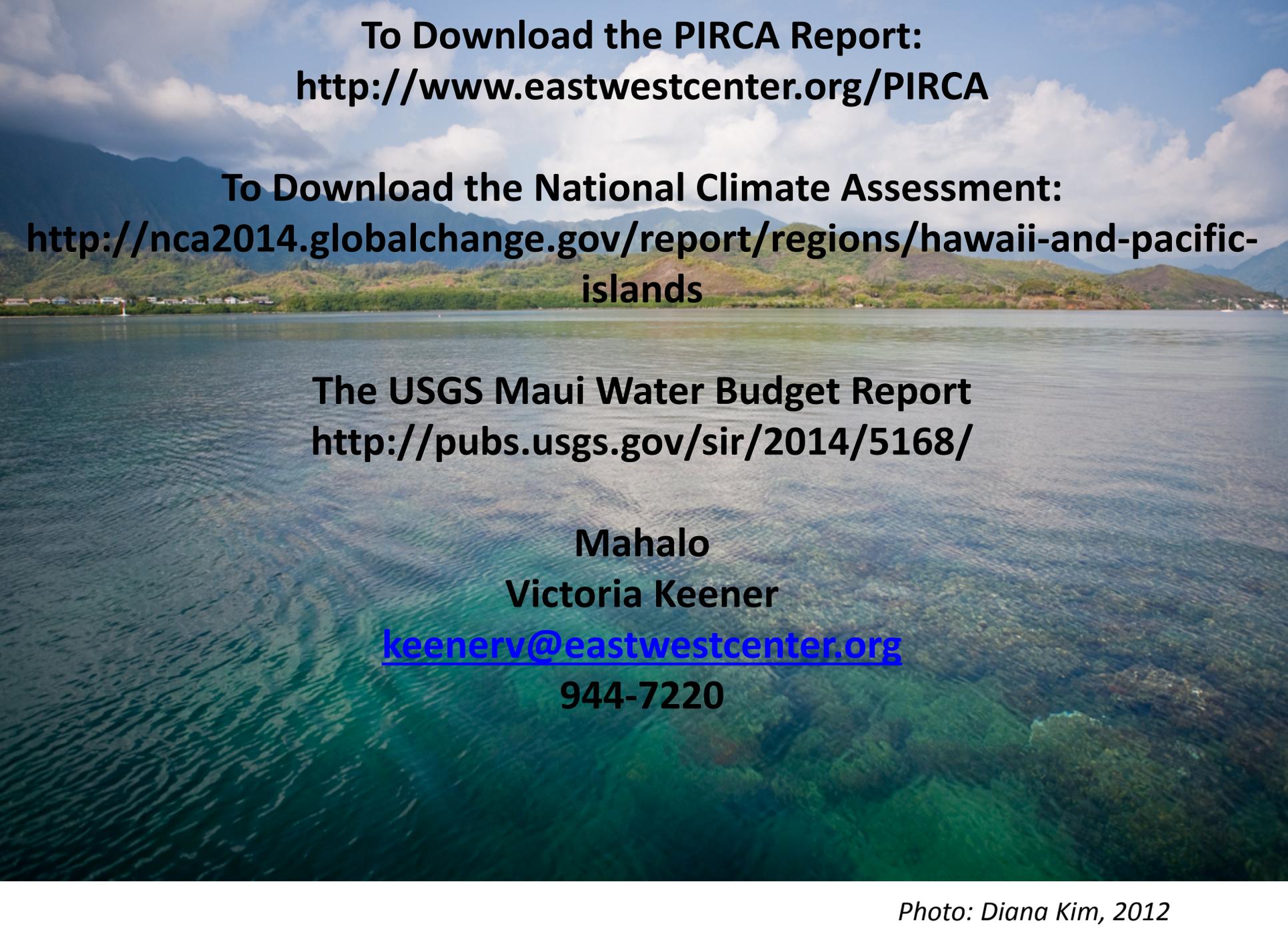
- Potential impact of **conservation and restoration** projects
- Modeled impacts of **native v. invasive forests**
 - increase reforestation efforts because it's an economic decision that might get a lot of return
 - No restoration is the way we currently build – contrast that with some conservation practices – what kind of difference would that make on recharge and what effect could that have on development policy?
- Common set of available GIS maps of future land use to compare between different sets of projects



Partnerships Between Research Scientists and Decision-Makers are Crucial

- Hawaii faces complex and **multidimensional problems**
- **Neither science nor management alone** can adequately address climate change impacts
- When scientists collaborate with planners and decision makers, information is practical and useable.





**To Download the PIRCA Report:
<http://www.eastwestcenter.org/PIRCA>**

**To Download the National Climate Assessment:
<http://nca2014.globalchange.gov/report/regions/hawaii-and-pacific-islands>**

**The USGS Maui Water Budget Report
<http://pubs.usgs.gov/sir/2014/5168/>**

**Mahalo
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