Stakeholder Advisory Group

Board of Water Supply
City & County of Honolulu

Thursday April 25, 2019

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CLIMATE CHANGE PANEL DISCUSSION

Hawai‘i Climate Change and Water

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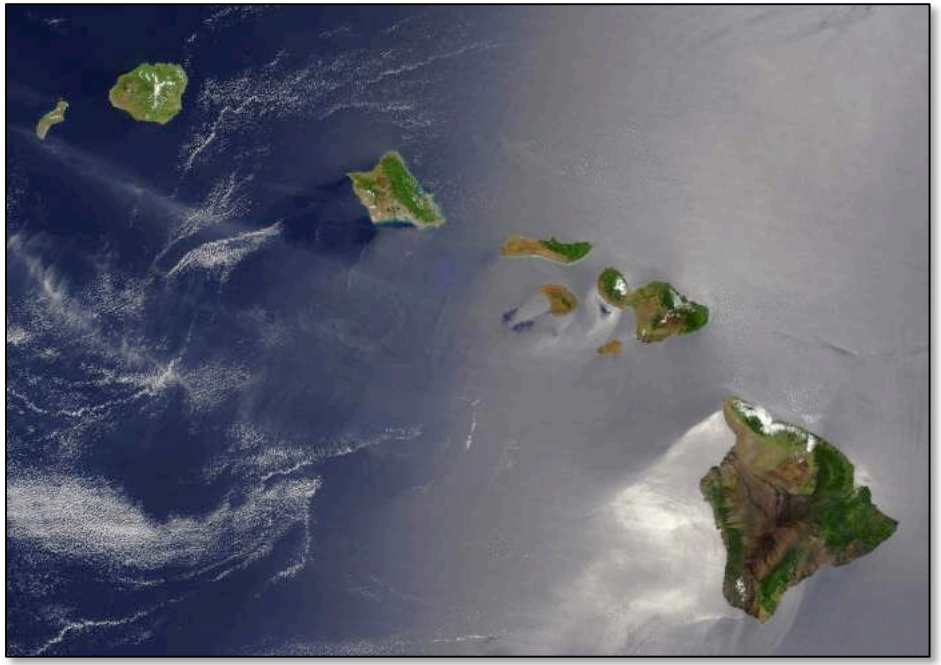
Board of Water Supply
Stakeholder Advisory Group – Workshop 30
Neal S. Blaisdell Center
25 April 2019

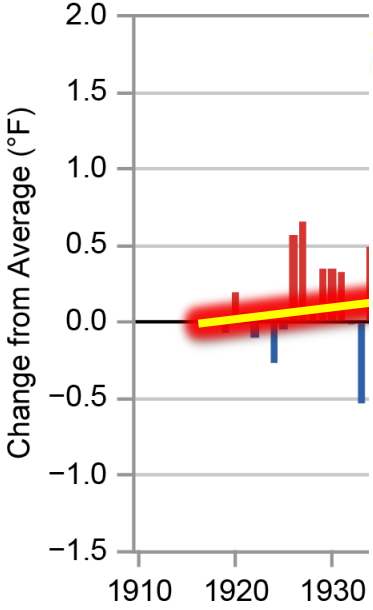
Board of Water Supply

Climate Change in Hawai‘i

How much change have we already seen?



How much more should we expect?



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RESEARCH ARTICLE

Temperature trends in Hawai'i: A century of change, 1917–2016

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Based on a revised and extended multi-station Hawai'i Temperature Index (HTI), the mean air temperature in the Hawaiian Islands has warmed significantly at 0.052°C/decade ($p < 0.01$) over the past 100 years (1917–2016). The year 2016 was the warmest year on record at 0.924°C above the 100-year mean (0.202°C). During each of the last four decades, mean state-wide positive air temperature anomalies were greater than those of any of the previous decades. Significant warming trends for the last 100 years are evident at low (0.056°C/decade, $p < 0.001$) and high elevations (0.047°C/decade, $p < 0.01$). Warming in Hawai'i is largely attributed to significant increases in minimum temperature (0.072°C/decade, $p < 0.001$) resulting in a corresponding downward trend in diurnal temperature range (−0.055°C/decade, $p < 0.001$) over the 100-year period. Significant positive correlations were found between HTI, the Pacific Decadal Oscillation, and the Multivariate ENSO Index, indicating that natural climate variability has a significant impact on temperature in Hawai'i. Analysis of surface air temperatures from NCEP/NCAR reanalysis data for the region of Hawai'i over the last 69 years (1948–2016) and a mean atmospheric layer temperature time series calculated from radiosonde-measured thickness (distance between constant pressure surfaces) data over the last 40 years (1977–2016) give results consistent with the HTI. Finally, we compare temperature trends for Hawaii's highest elevation station, Mauna Loa Observatory (3,397 m), to those on another mountainous subtropical island station in the Atlantic, Mt. Izaña Observatory (2,373 m), Tenerife, Canary Islands. Both stations sit above the local temperature inversion layer and have virtually identical significant warming trends of 0.19°C/decade ($p < 0.001$) between 1955 and 2016.

KEYWORDS
climate change, El Niño-southern oscillation, Hawai'i, Pacific decadal oscillation, radiosonde observations, temperature trends

r change = +0.52°C (+0.94°F)

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temperature t
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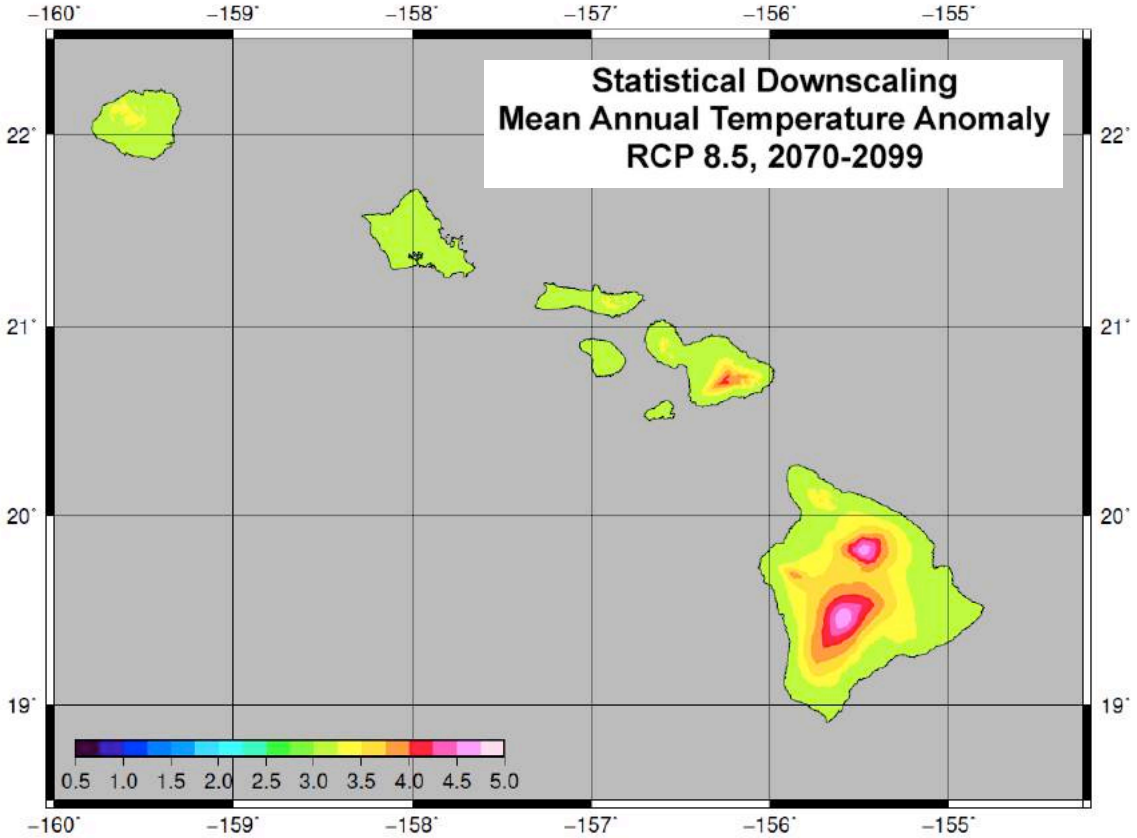
1 | INTRODUCTION

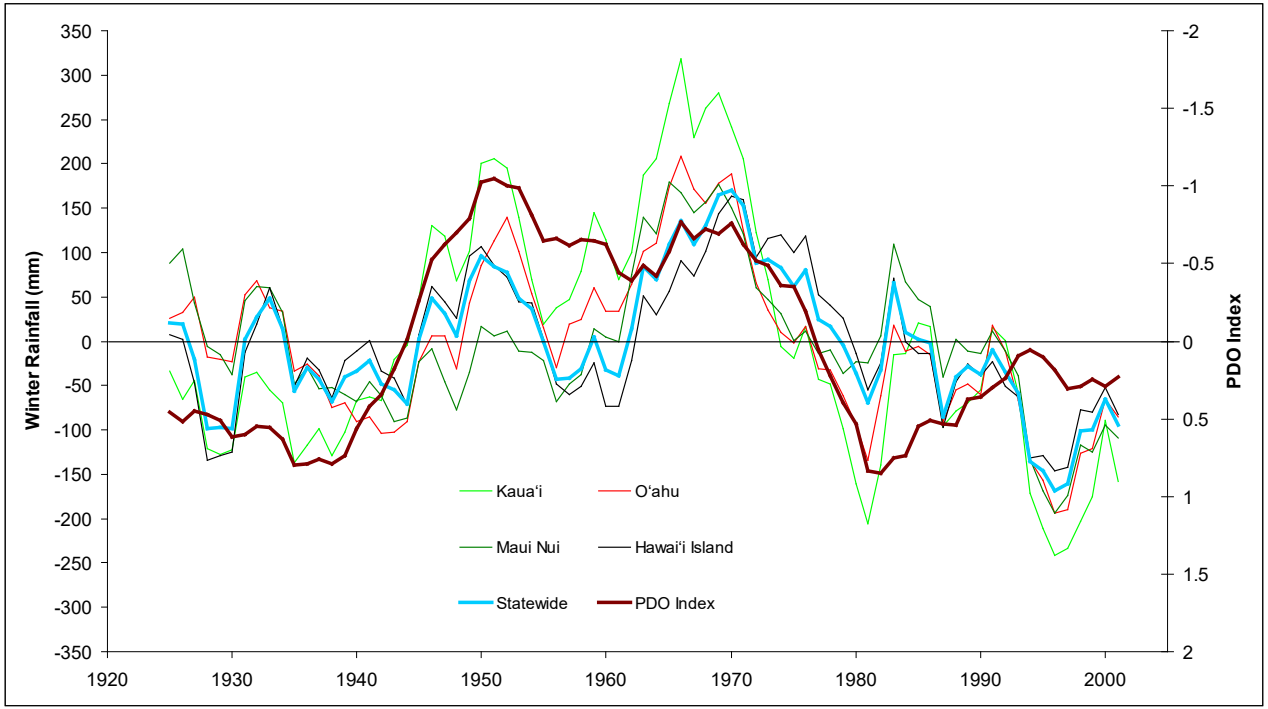
trends, both at the surface and higher elevations in the atmo-

Model Projections

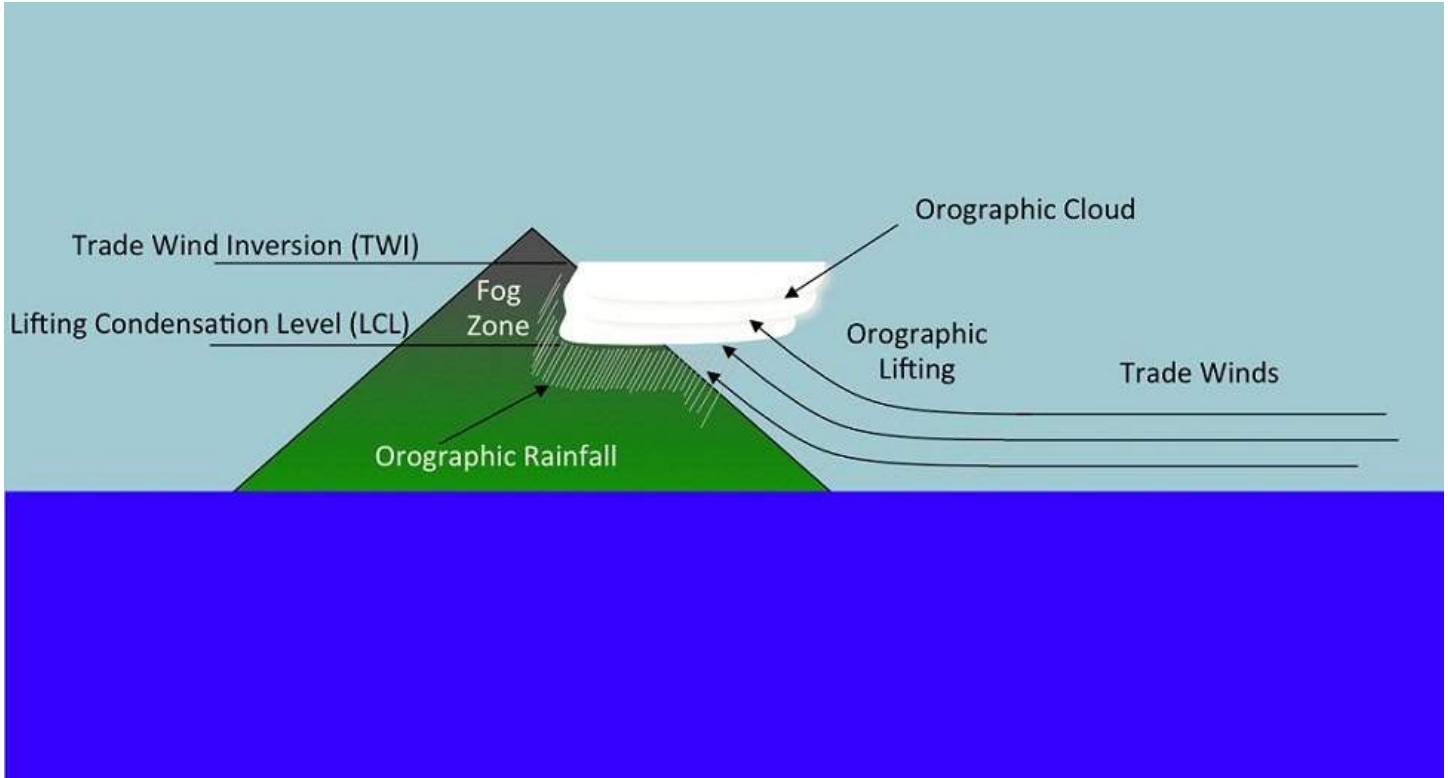


How About Rainfall Change in Hawai‘i?

Changing Rainfall



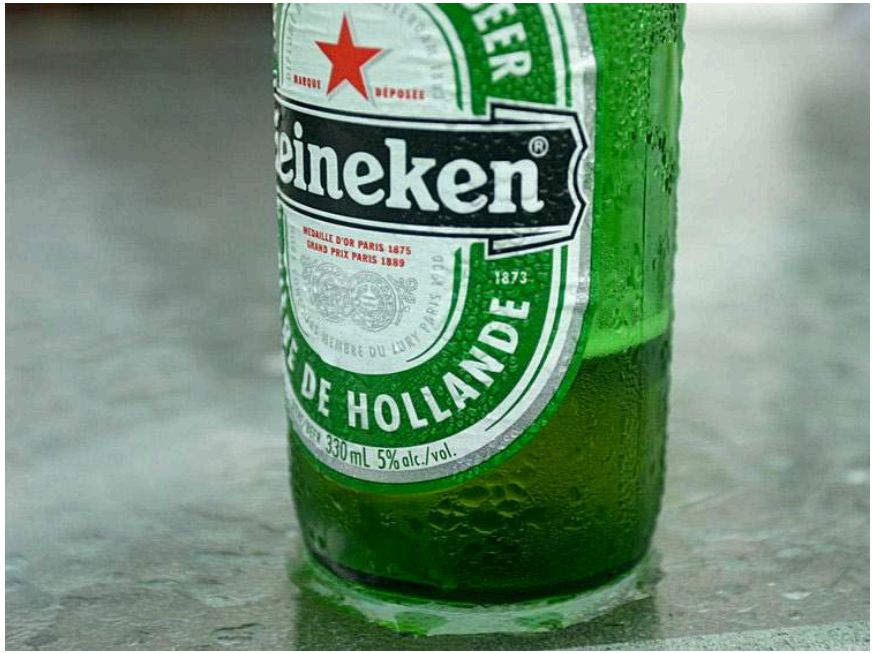
The Orographic Cloud




Two Ingredients Needed to Produce Rainfall
1. Moist air
2. Rising Air

Cloud Formation

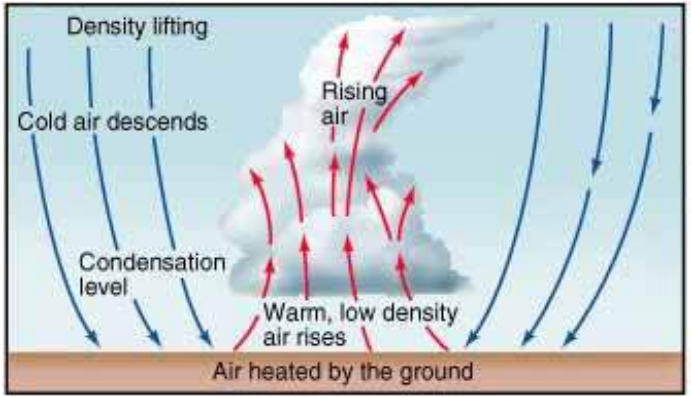
- Clouds in Hawai‘i are made up of tiny liquid drops
- The drops form through condensation

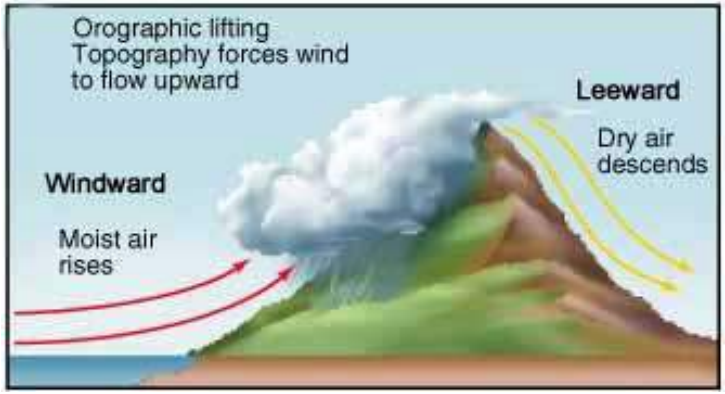


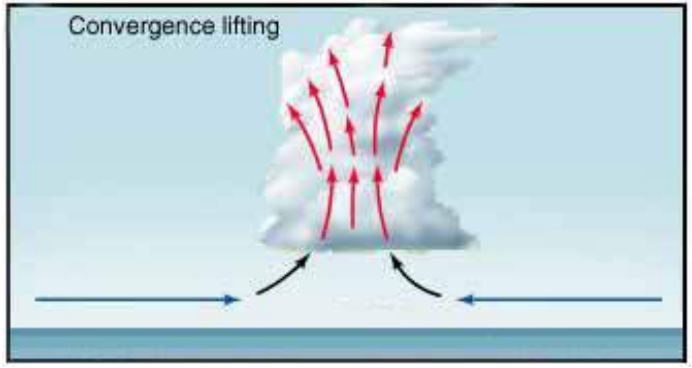
CONDENSATION

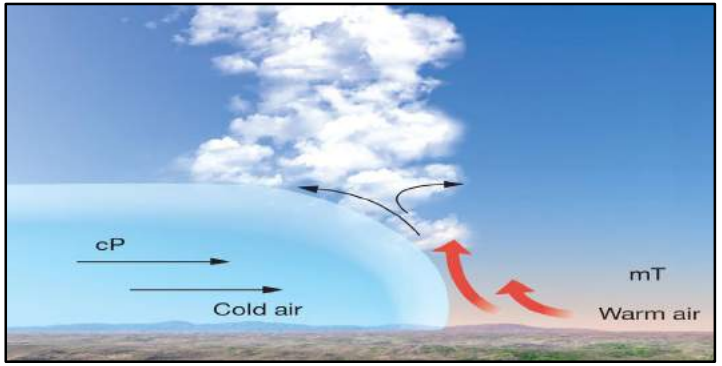
- Air with water vapor has to be cooled to cause condensation
  - –Cold Heineken
  - –Cool windshield
- How does moist air get cooled to form a cloud?
  - –By being forced to rise
  - –Rising air cools by expanding

Mechanisms for Cloud Formation





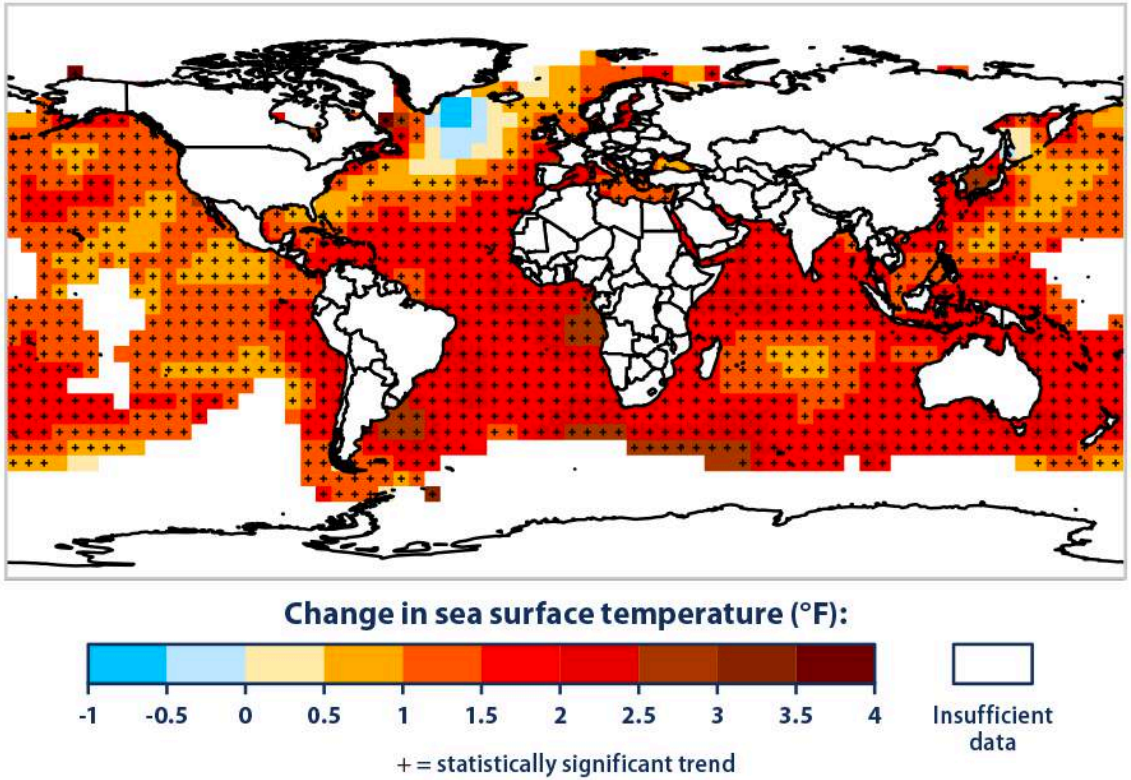




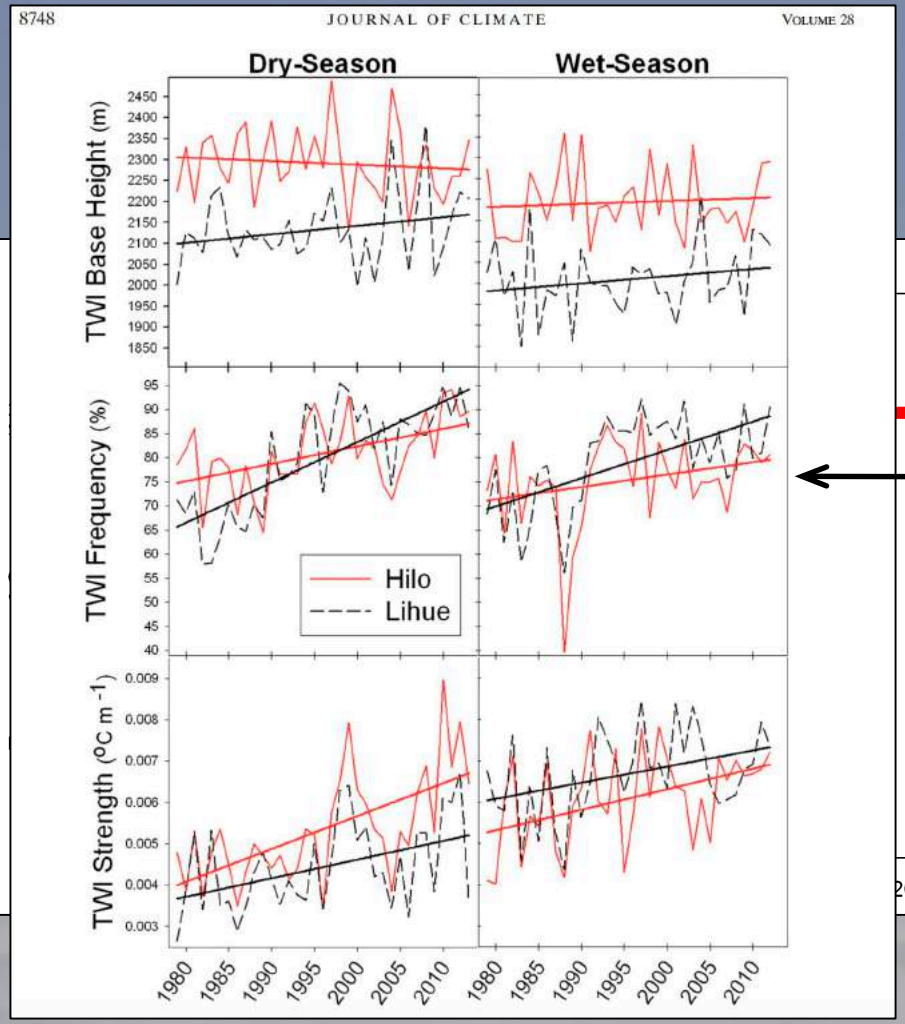
Climate Change Can Affect Our Rainfall by:

- Making the air more or less moist
- Making it easier or harder for air to rise

As Climate Warms:
Air Becomes More Moist



Trade Wind Inversion



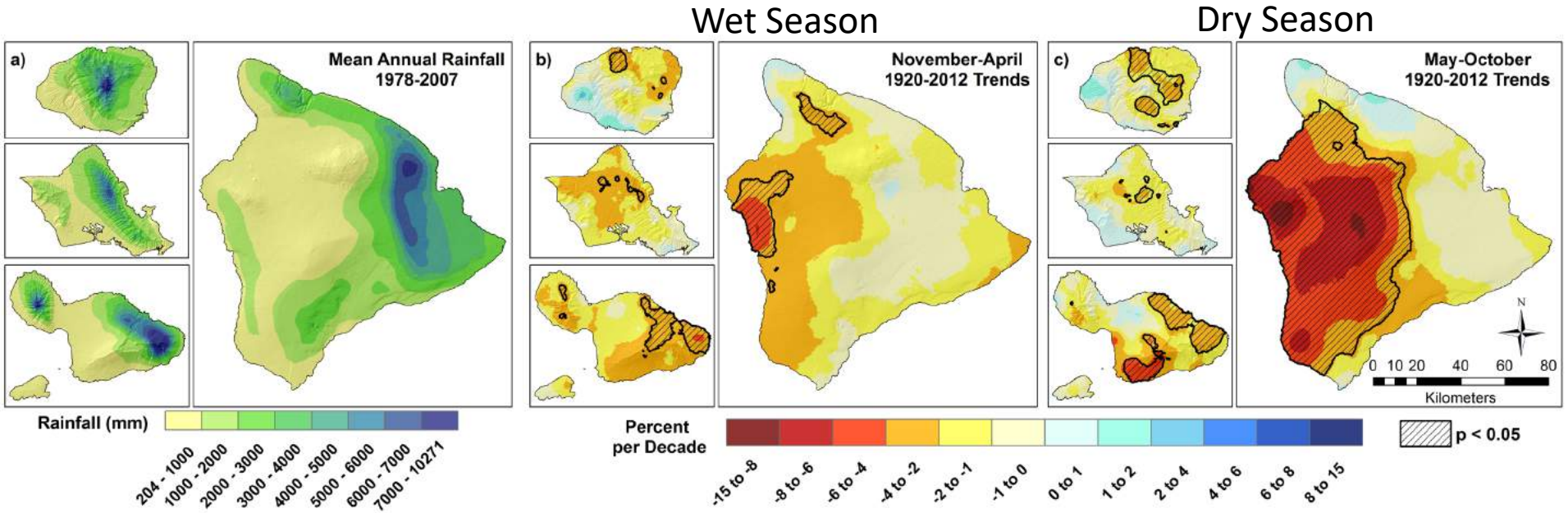
The pattern of more TWI days per year has continued.

Longman et al. (2015)

Hawai‘i Climate Change

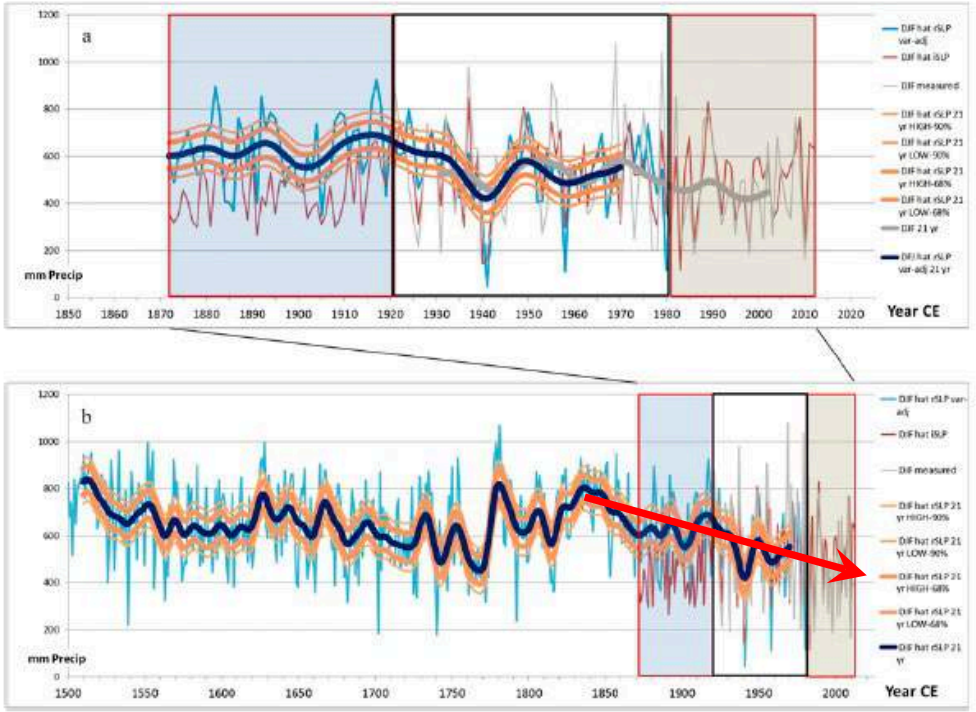
It’s getting drier, especially in Kona

Decreases statewide — including most of O‘ahu



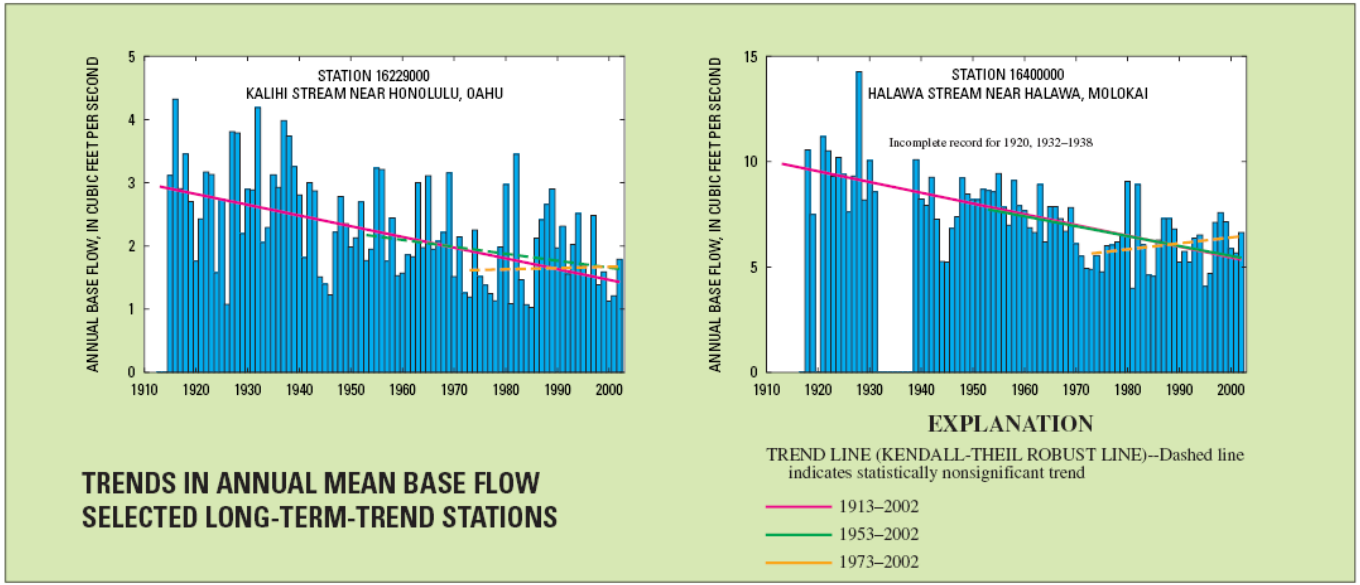
Frazier et al. (2018)

500-yr Hawaiian Winter Rainfall Reconstruction



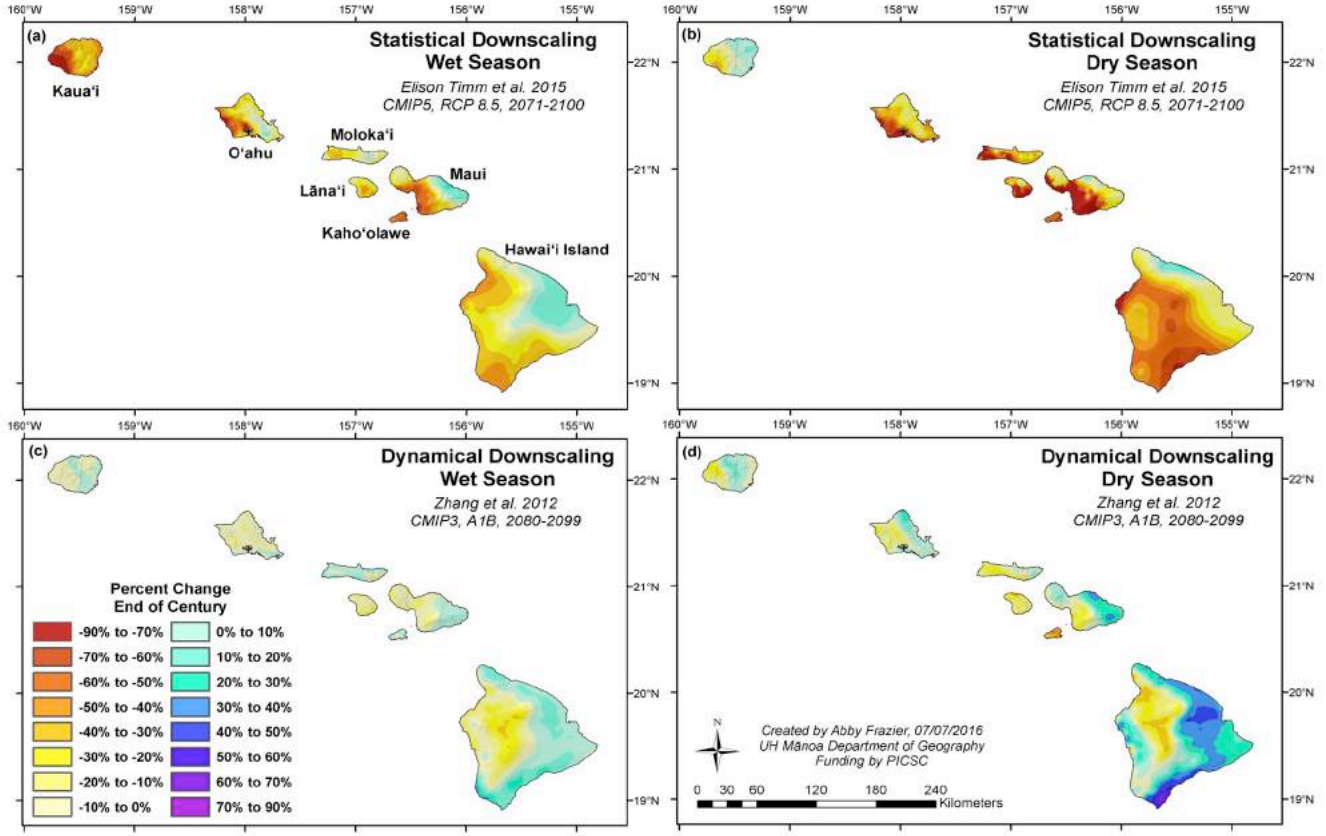
Diaz et al. (2016)

Stream Base Flow Also in Decline



Oki, D.S., 2004, Trends in Streamflow Characteristics in Hawaii, 1913-2003: U.S. Geological Survey Fact Sheet 2004-3104, 4 p.

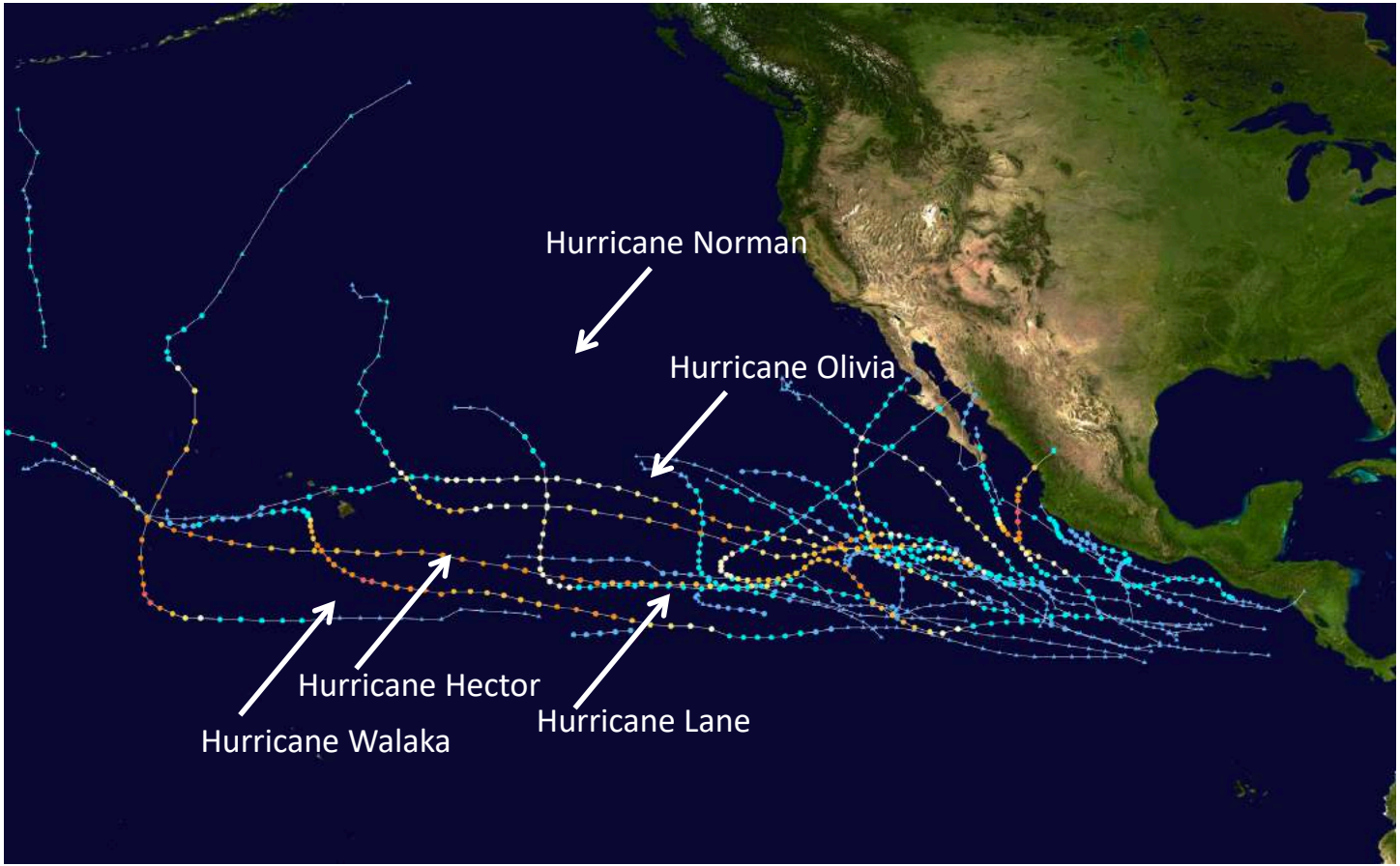
Model Projections



Rainfall Extremes

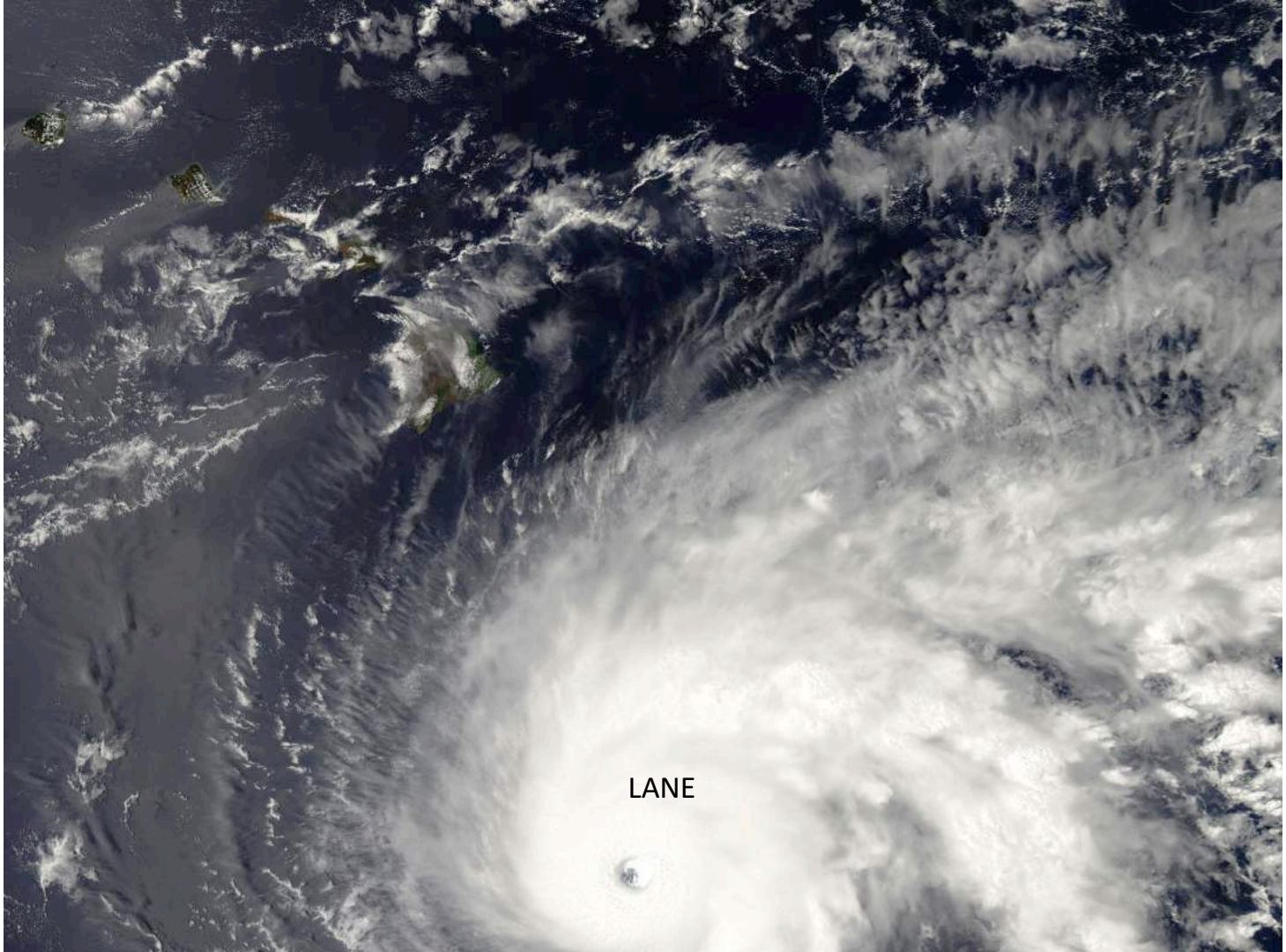
Kaua‘i: April 2018 – 49.69 inches – A new US record for 24-hr rainfall

2018 Eastern and Central North Pacific Tropical Storm/Hurricane Season

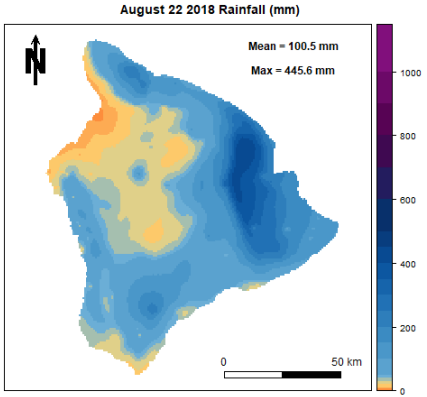


- Change in number of storms uncertain.
- Storms becoming stronger.
- Storms to produce more intense rainfall.

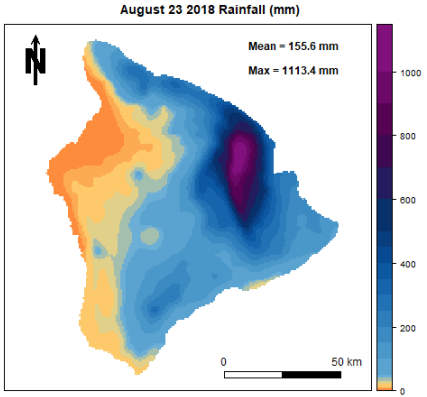
Five <u>hurricanes</u> passed near or though the islands last season


LANE

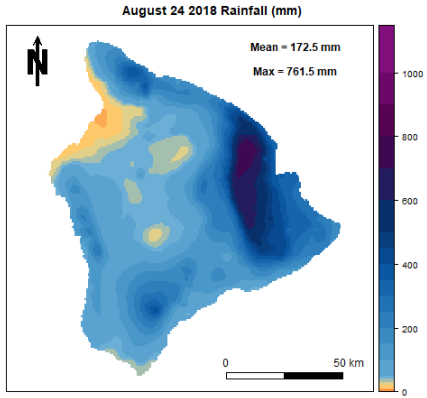
Hurricane Lane Rainfall



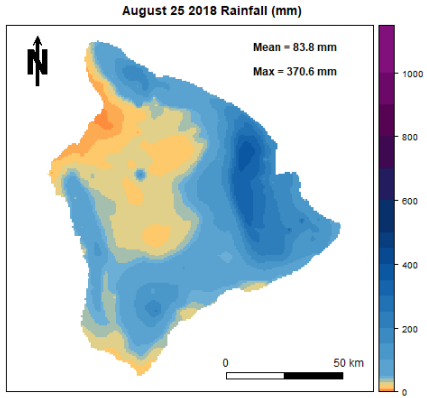
Observed
Max = 401 mm (16 in)



Observed
Max = 646 mm (25 in)



Observed
Max = 655 mm (26 in)



Observed
Max = 434 mm (17 in)

Climate Change in Hawai‘i

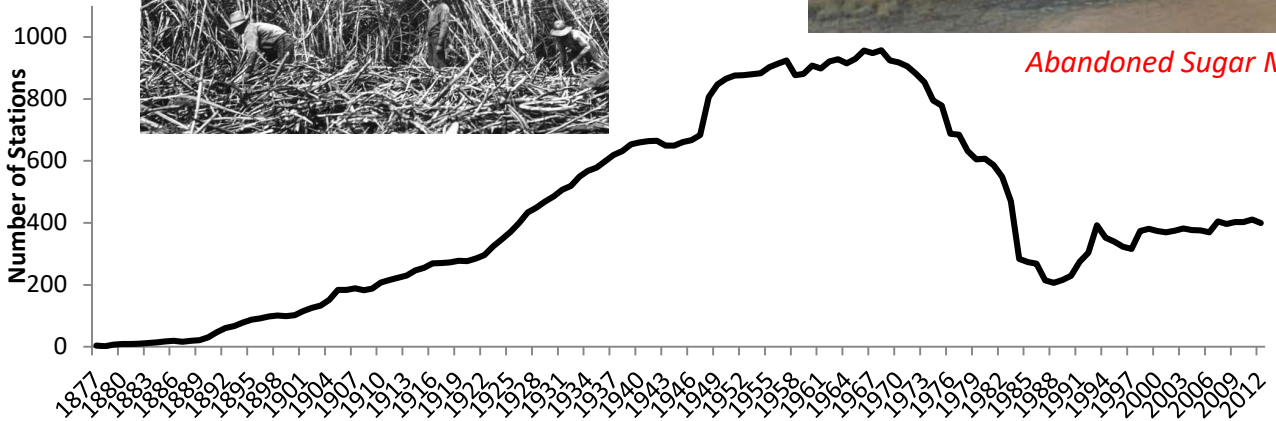
- Warming at a faster rate — ET Increase, More heat waves
- Air becoming more moist: — RF Increase
- Lifting becoming more difficult: — RF Decrease
- Windward areas become wetter
- Leeward and high elevation areas become drier
- Storms become less frequent but more intense
  - More droughts — More wildfires
  - More floods — Higher proportion of rainfall running off
- Sea level rise — Coastal flooding

Hawai‘i’s Rain Gauge Network

- Number of stations operating at any given time
  - Peaked in 1968 (over 950 stations)
  - Large declines since the 1980s

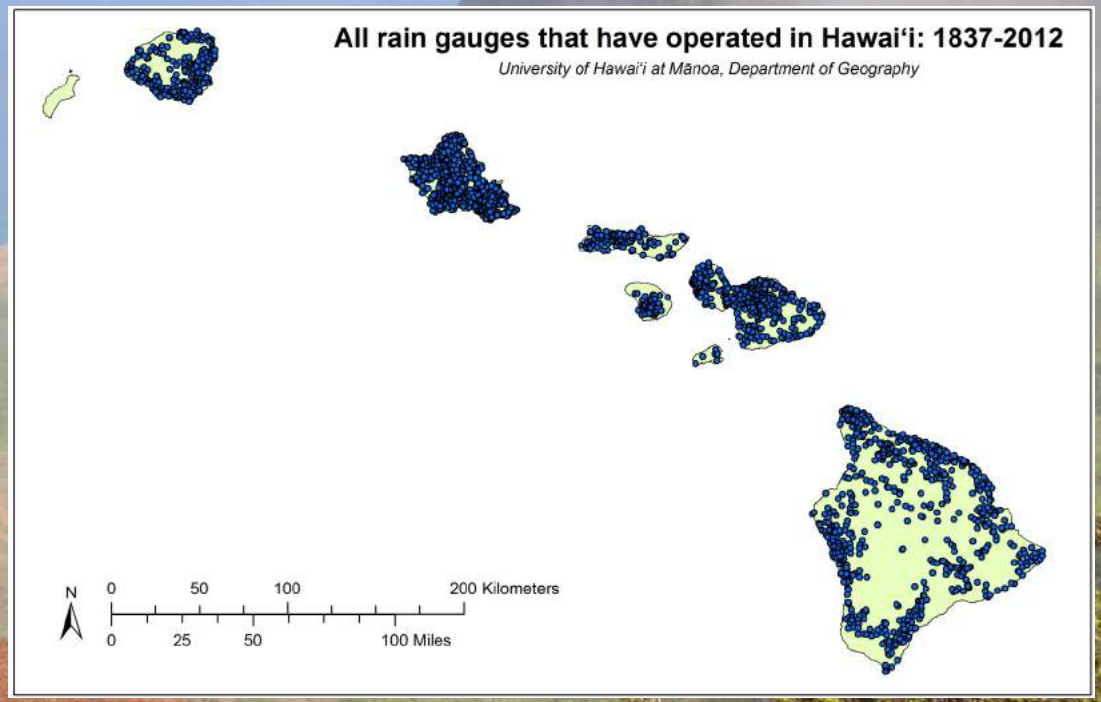
Plantation Agriculture

Abandoned Sugar Mill



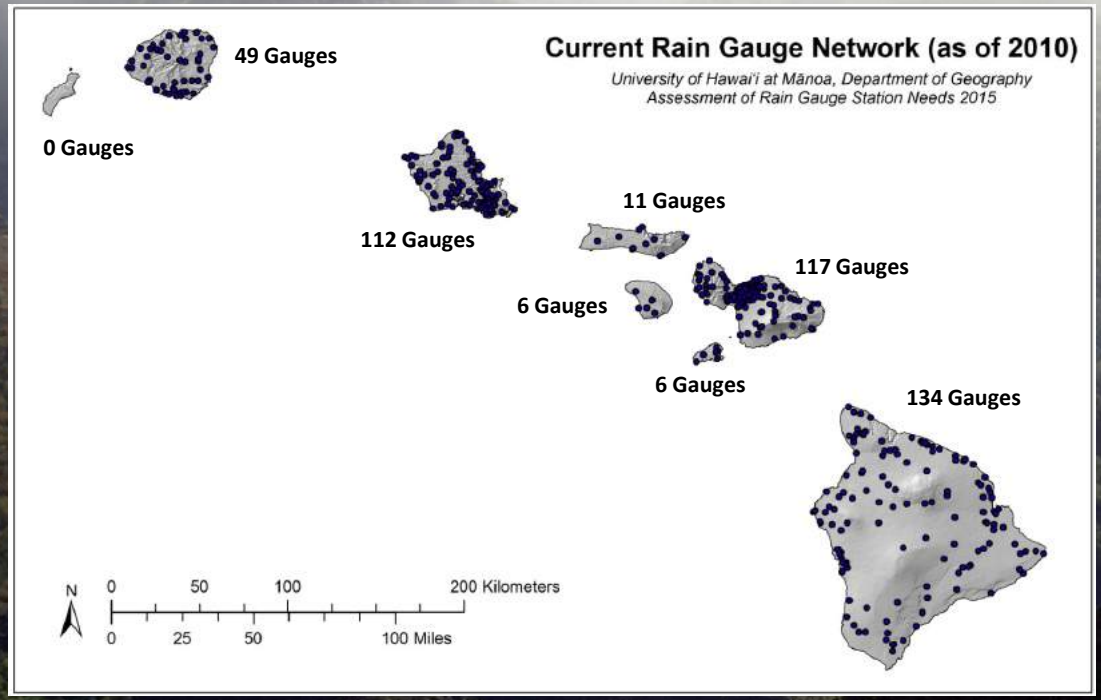
The Rain Gauge Network

- Monthly RF database of 2,224 rain gauge sites (1837-2012)
- Average length of record: 24 years

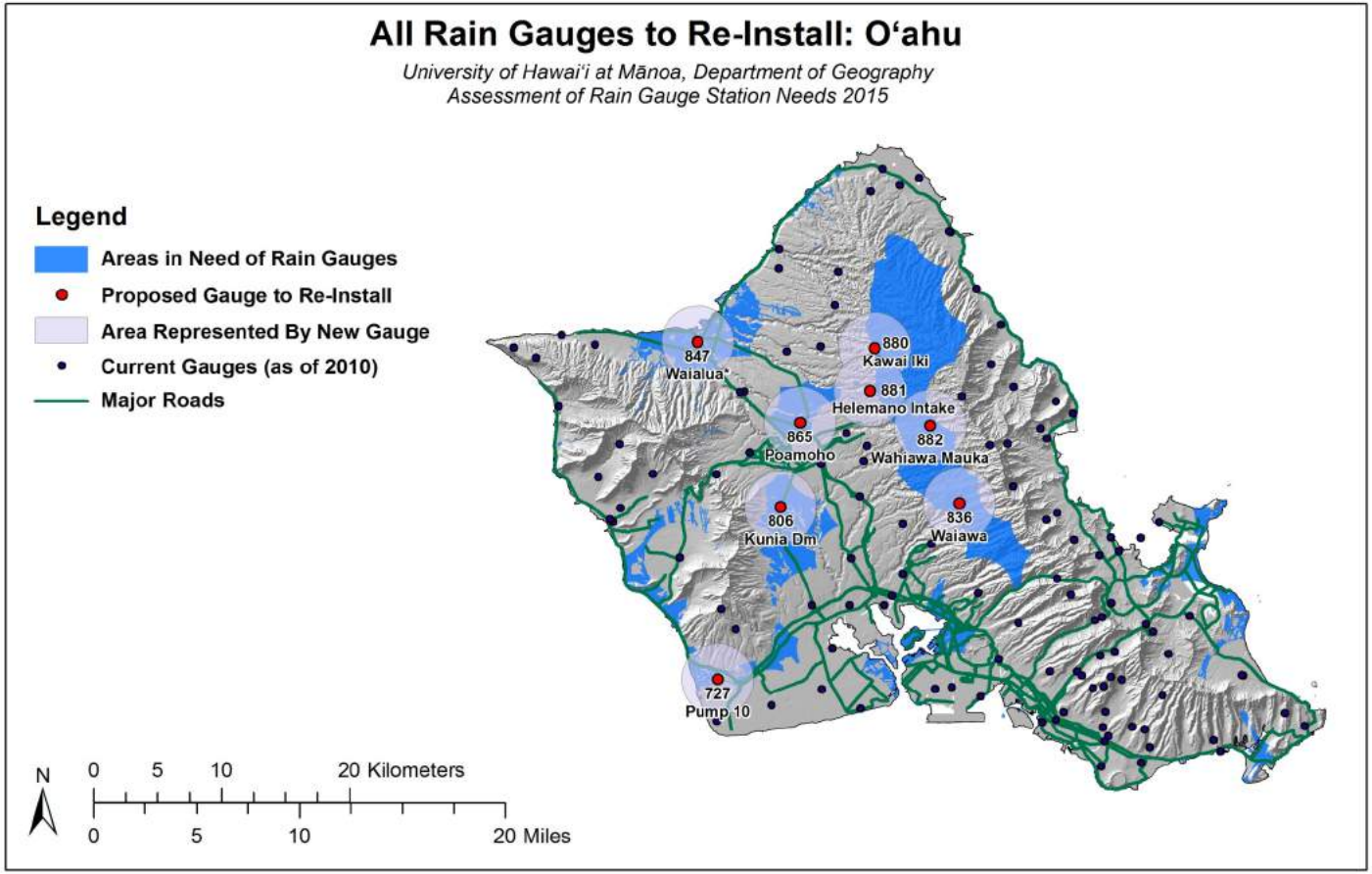


Current Rain Gauge Network

- # Current Stations (as of 2010): **435**
- # Current Stations with > 50 years of data: **130**
  - *Most of the current stations were installed within the last 30 years*

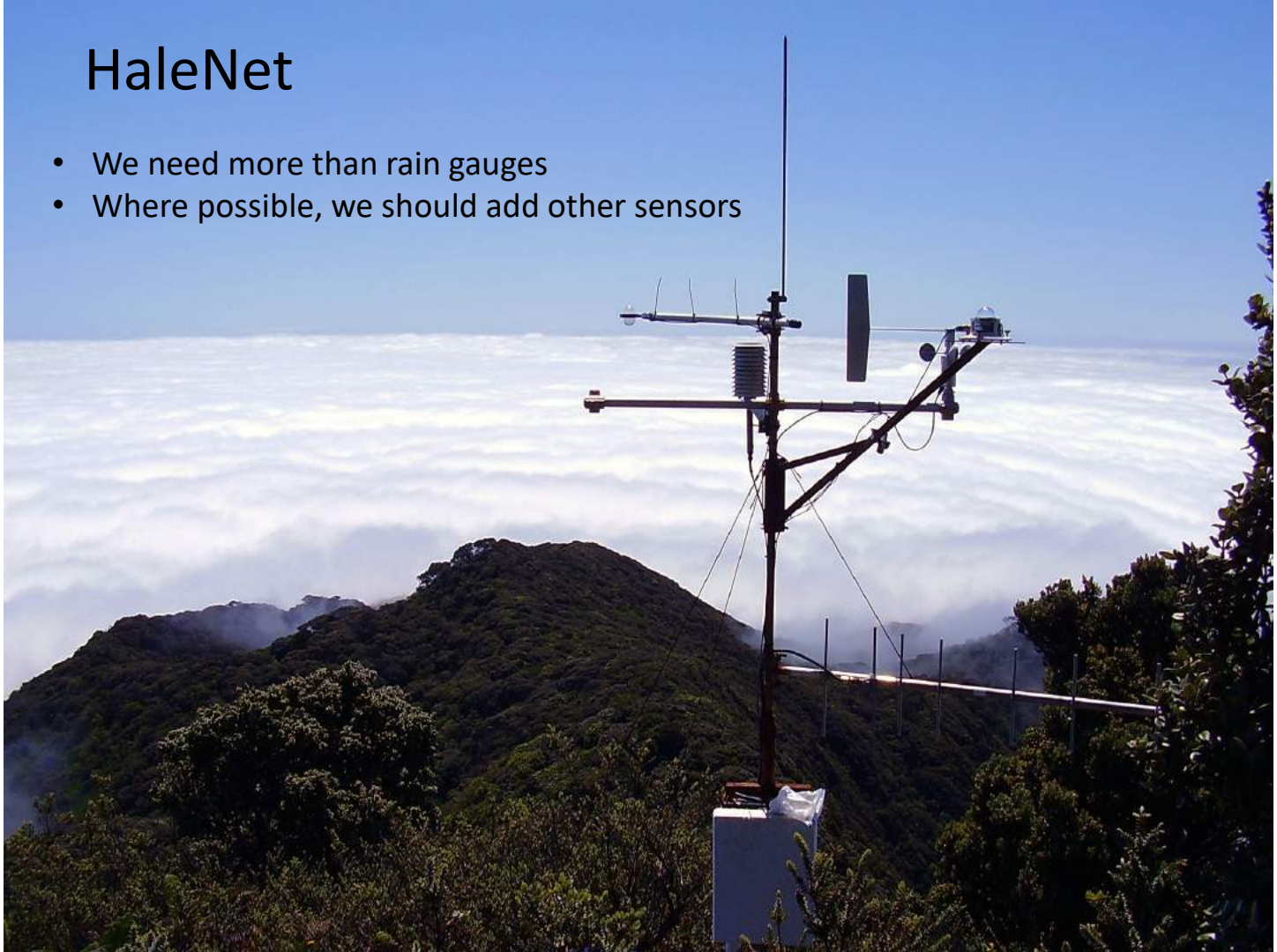


8 Gauges Proposed



HaleNet

- We need more than rain gauges
- Where possible, we should add other sensors



Mahalo!