

The Pacific Drought Knowledge Exchange (PDKE)

Ryan J. Longman, Ph.D.

Fellow East-West Center, Pacific Islands Development Program
Research Faculty, Water Resources Research Center Hawai'i at Mānoa

Rlongman@hawaii.edu

East-West Center Insights

June 15, 2022



Road Map

- How we got here.
- What we are up to now.
- Where we are headed.

Extreme drought on Maui, June 2010



Dr. Abby Frazier
Clark University



Dr. Christian Giardina
US Forest Service



Derek Ford
East-West Center



Cherrylle Hue
UHM SOEST



Emily Sesno
PI-CASC



Dr. Alyssa Anderson
UHM SOEST



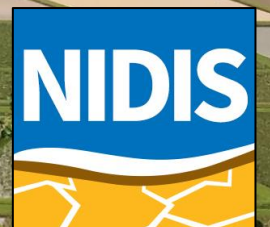
Melissa Kunz
UHM NREM



Dr. Katie Kamelamela
Akaka Foundation



Patrick Grady
UHM Sea Grant
PI-CASC



- a

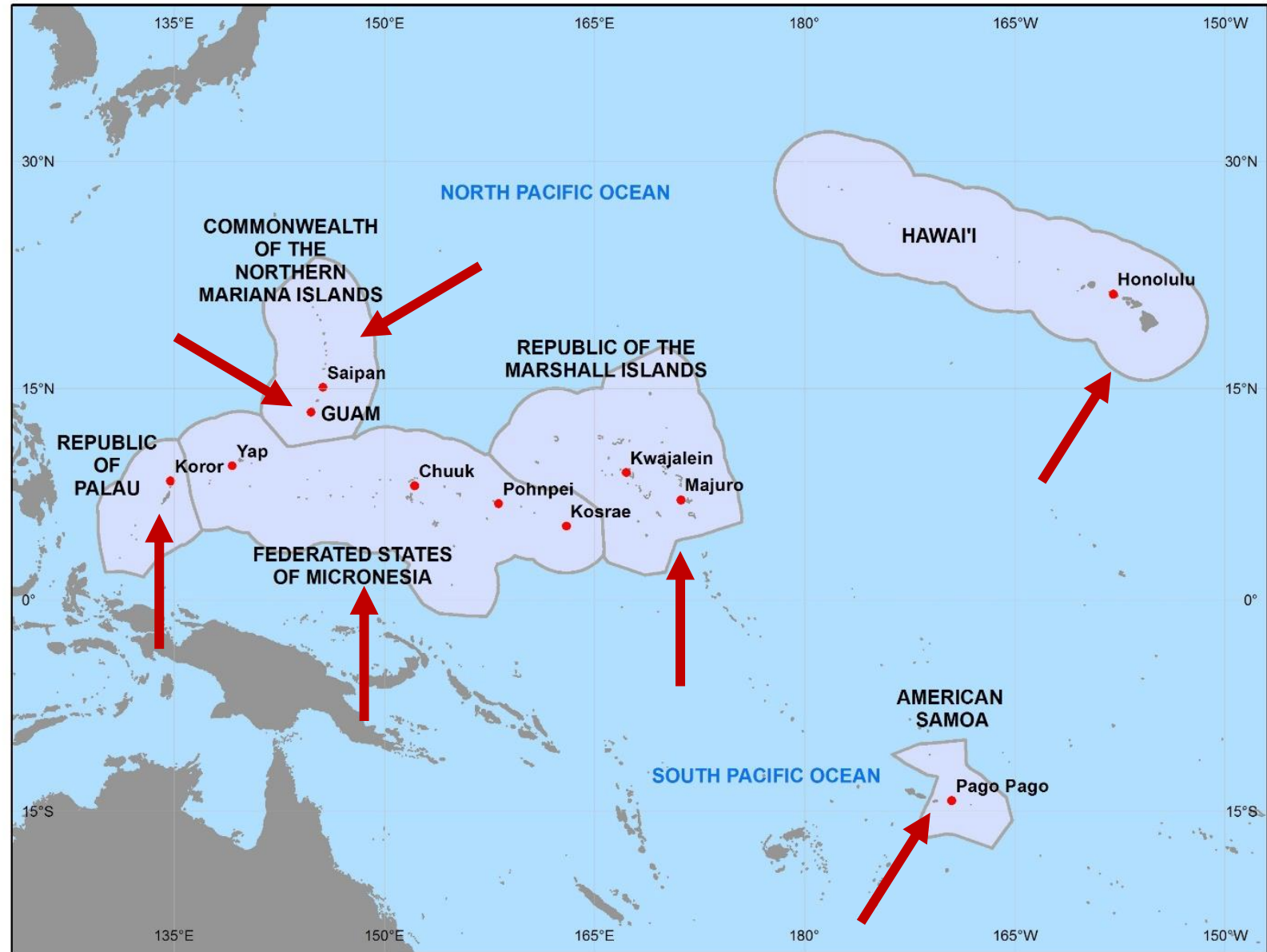
Part 1

How we got here?



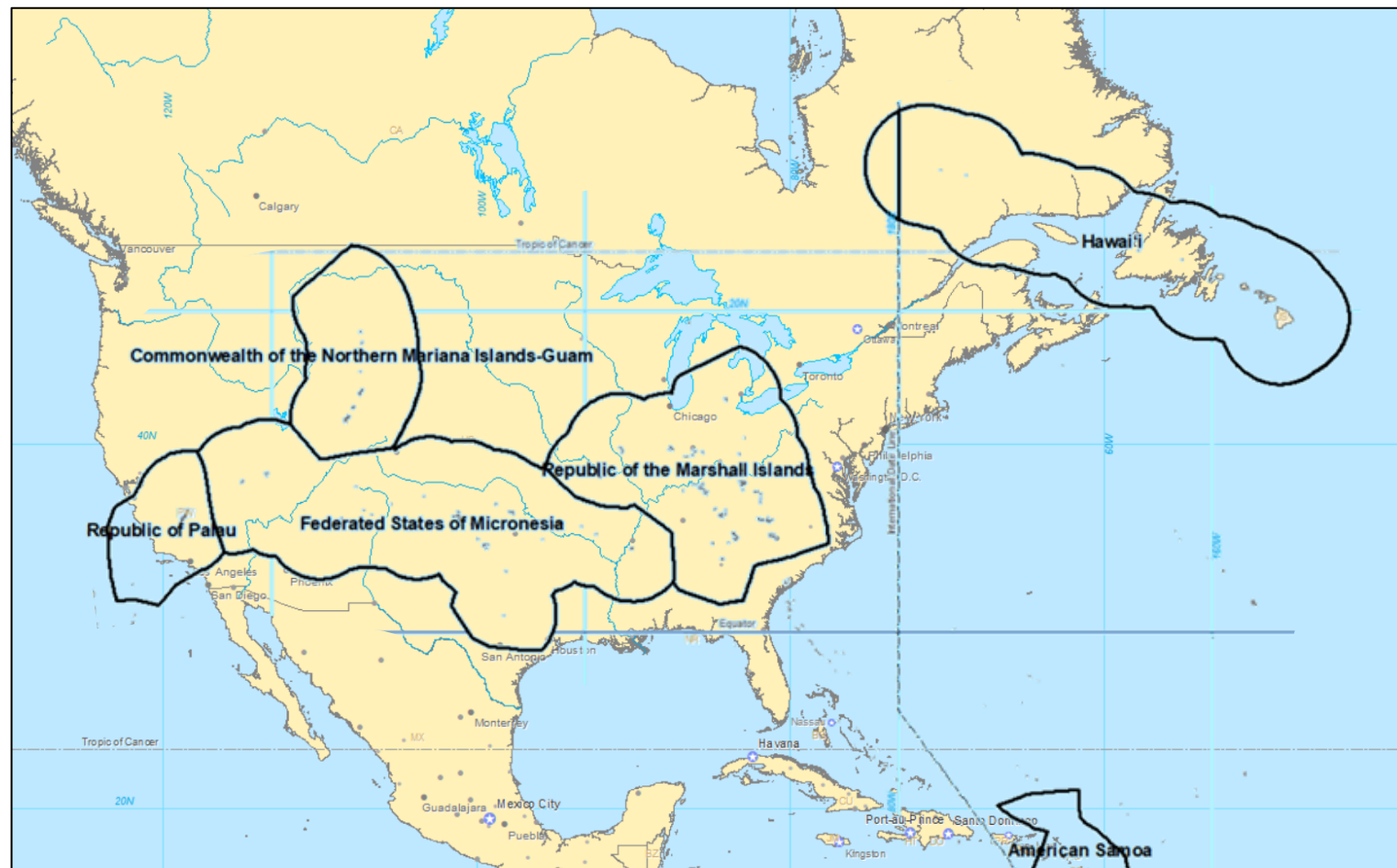
Geographic Scope: Hawai'i & the U.S.- Affiliated Pacific Islands (USAPI)

- 1 state: Hawai'i
- 2 territories: Guam, American Samoa
- 1 commonwealth: Commonwealth of the Northern Mariana Islands (CNMI)
- 3 independent nations: Republic of Palau
Federated States of Micronesia (FSM)
Republic of the Marshall Islands (RMI)



Geographic Scope: Hawai'i & the U.S.- Affiliated Pacific Islands (USAPI)

- Large Spatial Extent
(greater width than
continental US!)
- Isolated small islands
(**High** & **Low** islands)



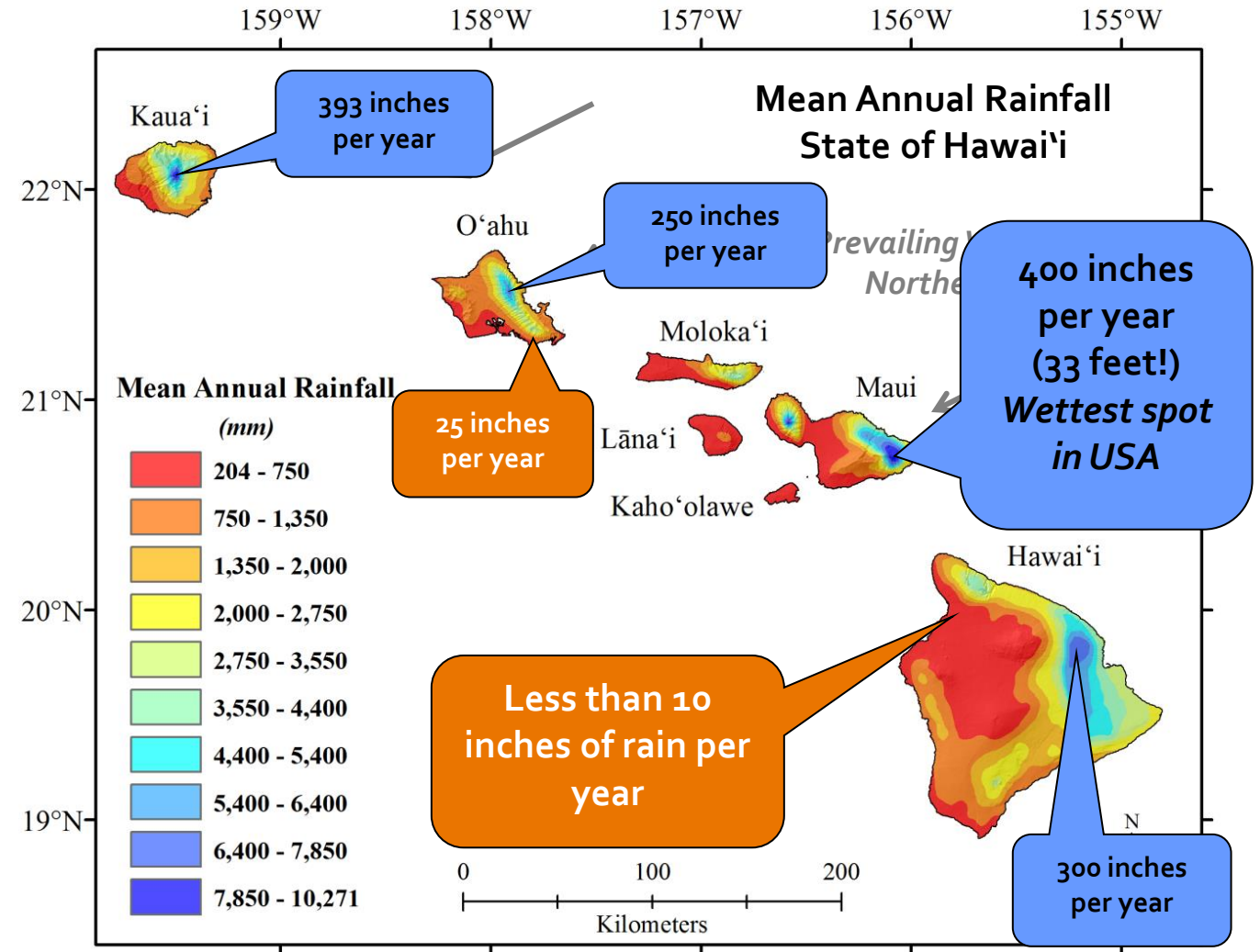
Alamagan, CNMI. Photo: Curt Kessler, USFWS



Majuro Atoll, RMI.
Photo: Christopher Michel/flickr

Spatial Patterns of Rainfall in Hawai'i

- Complex patterns, steep gradients
- Wet windward slopes
- Dry leeward areas
- Greater range than some continents...



<http://rainfall.geography.hawaii.edu/>

"Online Rainfall Atlas of Hawai'i" Giambelluca, Chen, Frazier et al. 2013

Pacific Islands

- Pacific Islands are on the front lines of global climate change
- Already experiencing changes & impacts:
 - Sea level rise
 - High tide flooding
 - Climate-induced migration
 - Wildfires
 - **Drought**



Beaches & waterfront development threatened by sea level rise, O'ahu



Majuro Atoll, Republic of the Marshall Islands



Wildfire on Hawai'i Island



High tide flooding in Majuro, 2014

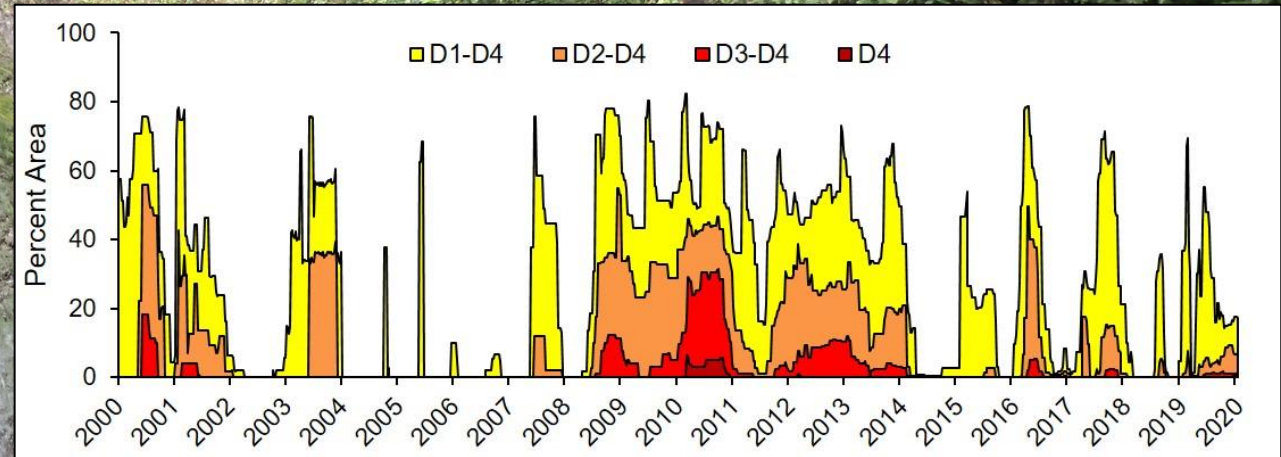


Water tanks arriving on Fais during drought, Federated States of Micronesia



Dying pandanus trees during drought on Mejit Atoll, RMI (important agroforestry species)

How important is drought in tropical Pacific Islands?

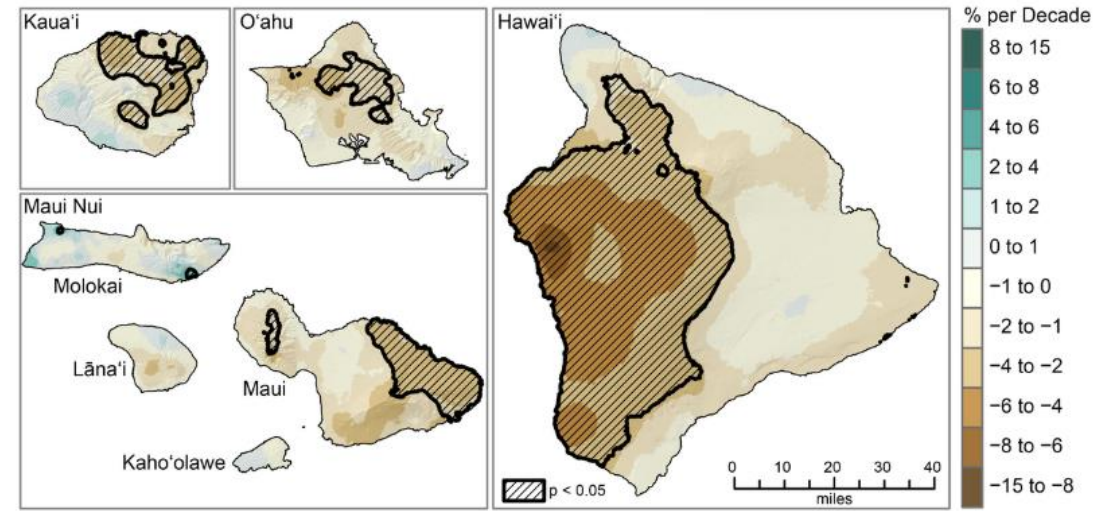


U.S. Drought Monitor for Hawai'i (2000-2019)

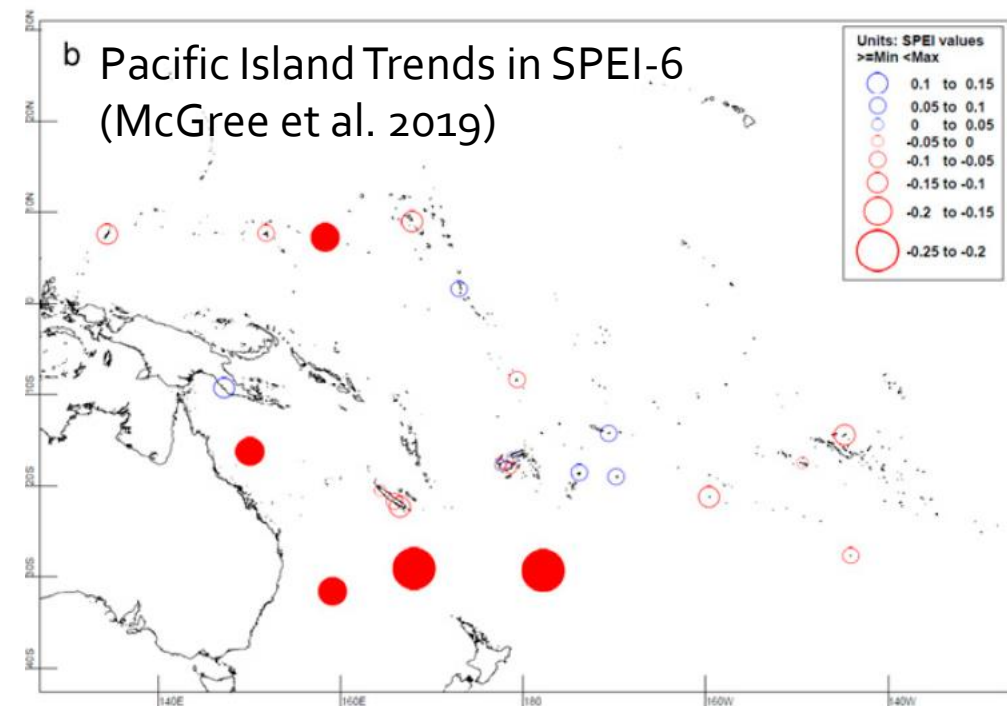
<https://droughtmonitor.unl.edu/>

Motivations

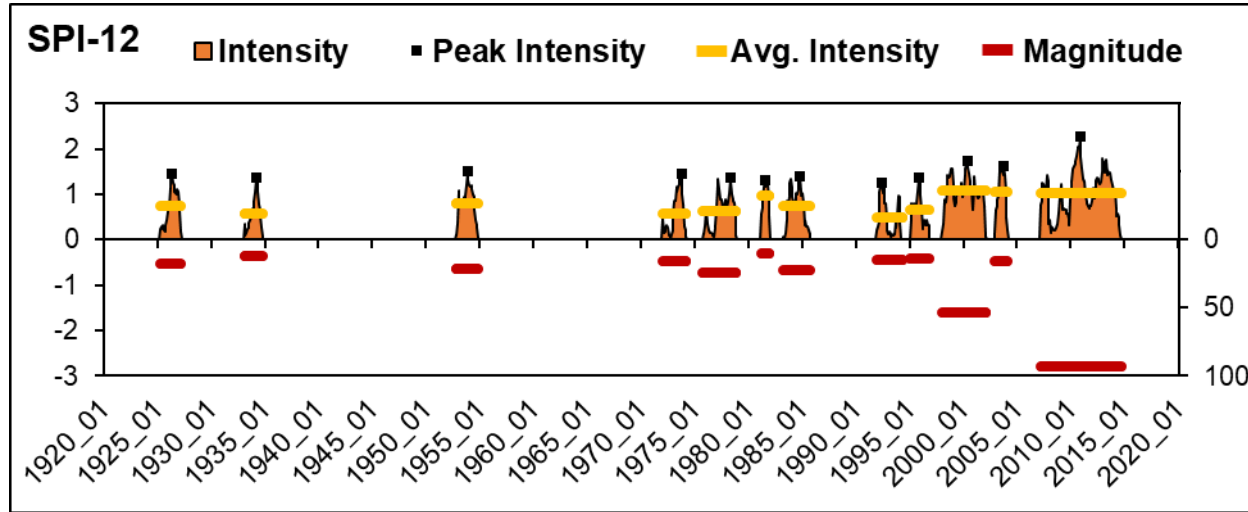
- Strong drying & warming trends have been found in Hawai'i (Frazier & Giambelluca 2017; McKenzie et al. 2019)
- Drying trends & increasing drought have been documented in other Pacific Islands (McGree et al. 2016; 2019)
- **How is drought changing?**
- **How does drought impact Pacific Islands?**
- **How can science better inform drought management?**



Rainfall Trend Map 1920-2012 (Frazier & Giambelluca 2017)



Droughts More Frequent, Lasting Longer, & More Severe in Hawai'i

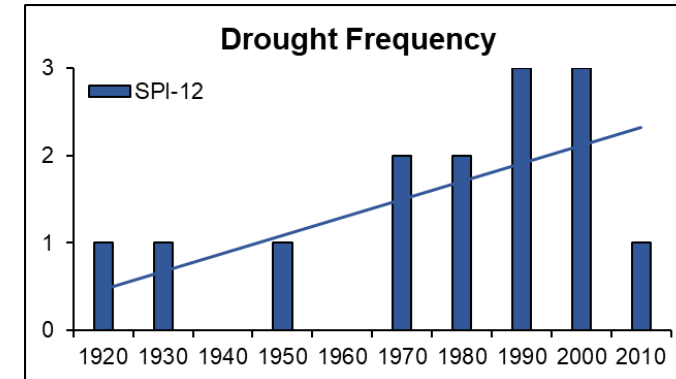


Statewide droughts from **1920-2019**

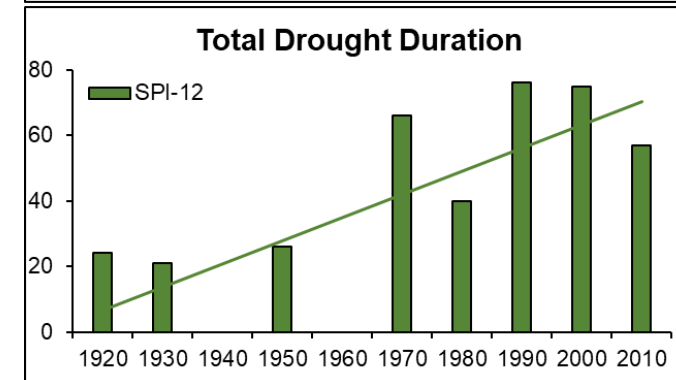
(based on 12-month gridded Standardized Precipitation Index, SPI – Lucas et al. 2020)

**Worst droughts in last century were
1998-2002 and 2007-2014**

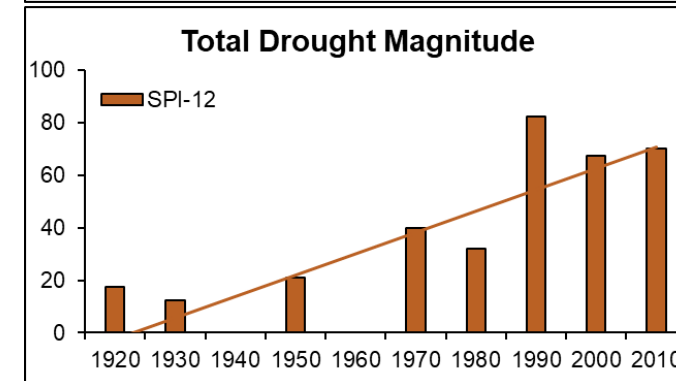
Statewide Per
Decade Drought
Frequency (DF),



Total Drought
Duration (TDD), &



Total Drought
Magnitude (TDM)
have **all increased
significantly since
1920**



1920 - 2019

What actions do resource managers take to prepare for & cope with drought?

Frazier et al. *USDA Forest Service Report (2019)*

CHAPTER 5



Managing Effects of Drought in Hawai'i and U.S.-Affiliated Pacific Islands

Abby G. Frazier, Jonathan L. Deenik, Neal D. Fujii, Greg R. Funderburk, Thomas W. Giambelluca, Christian P. Giardina, David A. Helweg, Victoria W. Keener, Alan Mair, John J. Marra, Sierra McDaniel, Lenore N. Ohye, Delwyn S. Oki, Elliott W. Parsons, Ayron M. Strauch, and Clay Trauernicht



Water Resources



Agriculture



Wildfire Prevention



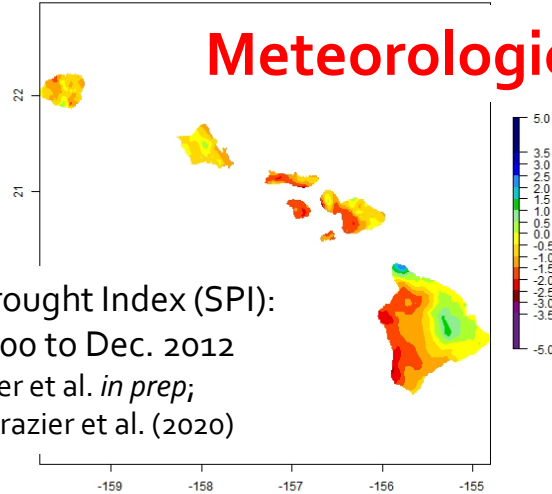
Endangered Species

Drought has severe impacts across multiple sectors

SPI 12 Jan 2000

Meteorological

Hawaii Drought Index (SPI):
Jan. 2000 to Dec. 2012
Frazier et al. *in prep*;
Lucas, Frazier et al. (2020)

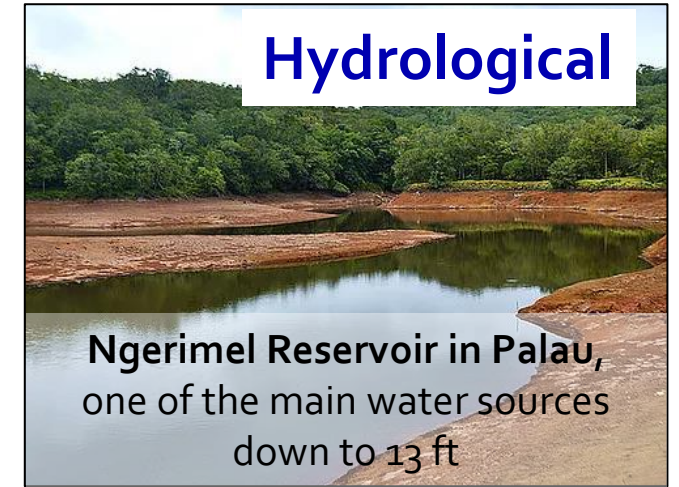


Agricultural



Kona coffee under drought

Hydrological



Ngerimel Reservoir in Palau,
one of the main water sources
down to 13 ft

Lava-ignited fire burned
over 3,000 acres of rain
forest in Hawai'i
**Volcanoes National
Park** during 2002-2003
drought



Ecological

Socioeconomic



Public Works in **Majuro,
Marshall Islands**,
established fresh water
“filling stations” during the
2015-2016 drought

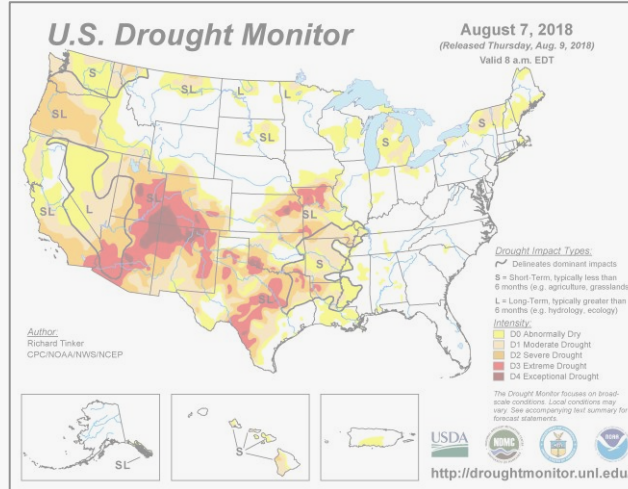
Drought Decision Making

What data resources are used?
How do you get info?

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What types of
decisions are made?



Hawaii Drought Plan

2017 UPDATE



May, 2017

Is drought
considered in
planning of
new
activities?



What kinds of products are useful
for diff. sectors?

El Niño and Long-Lead Fire Weather Prediction for Hawaii and US-affiliated Pacific Islands

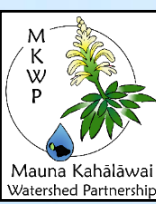
Clay Trauernicht

PFX Fact Sheet 2015_1

Need for a Knowledge Exchange:

- Resource managers seek to be more actively engaged in research
- Limited time/training to access info
- No centralized data clearinghouse
- Need formal communication mechs.
- Easier access to comprehensive data & technical assistance
- A model exists for Fire: PFX

Pacific Drought Knowledge Exchange (PDKE) Pilot



- Work with 3 partners in Hawai'i



Mauna Kahālāwai
Watershed Partnership
(MKWP)

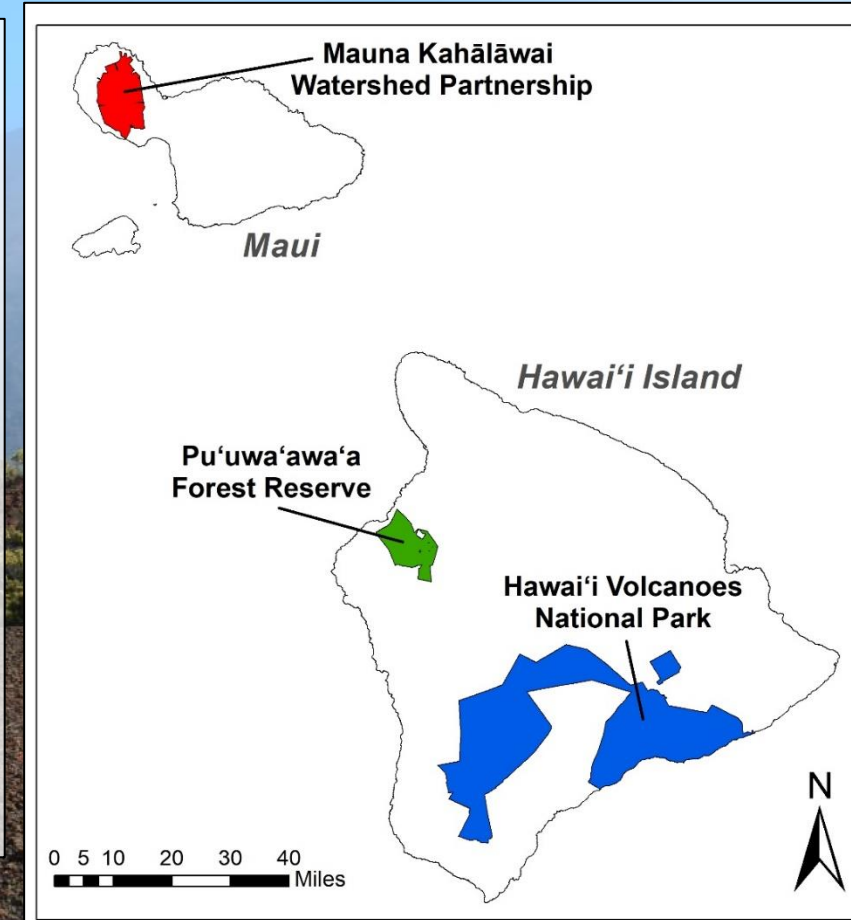


Pu'uwa'awa'a
Forest Reserve
(PWW)



Hawai'i Volcanoes
National Park
(HAVO)

- Partnered at the beginning: co-wrote proposal



All threatened by drought, wildfire, &
invasive plants & animals

Knowledge Exchange



- Demonstrate four aspects of a knowledge exchange:

1. Easier Access to Drought & Climate Information and Data Sources:

customized results for each mgmt. area

2. Better & More Comprehensive Information:

synthesize existing information from multiple sources

3. Improved Technical Assistance:

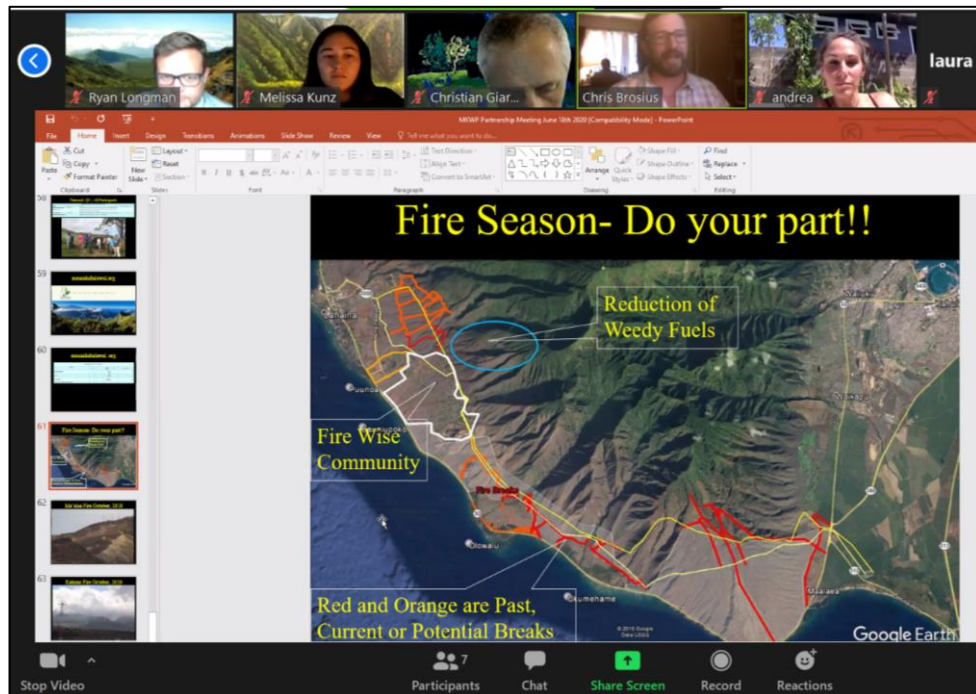
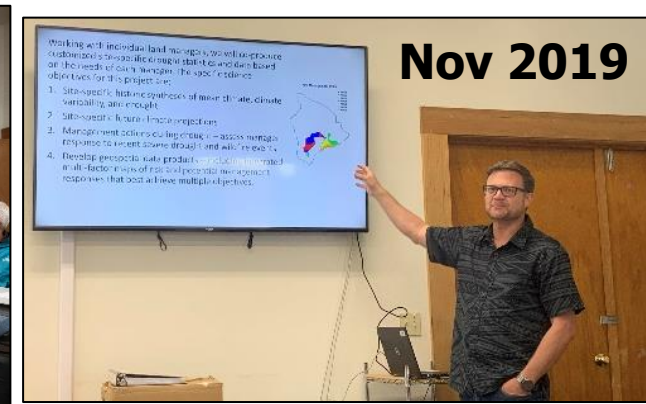
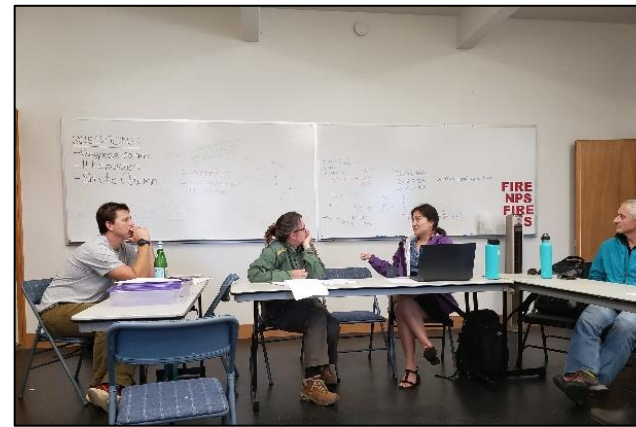
translated science summaries, offer hands-on training opportunities, develop decision support tools

4. More Collaborative Information Transfer Environment:

improve communication mechanisms, develop a feedback process between scientists & managers (regular meetings, facilitated information transfer, etc...)


Stakeholder Engagements

Feb 2020






CCVD Portfolios

- Climate Change, Climate Variability & Drought (CCVD) Portfolio
- Automated tool to extract site-specific climate data and information from available datasets.
- Only input is spatial information
- PDF/PPT ~30 pages
- Figures, tables, explanations, statistics summaries and links.

 Pacific Drought Knowledge Exchange

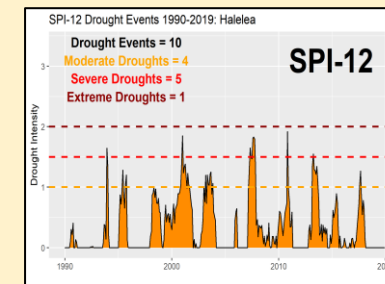
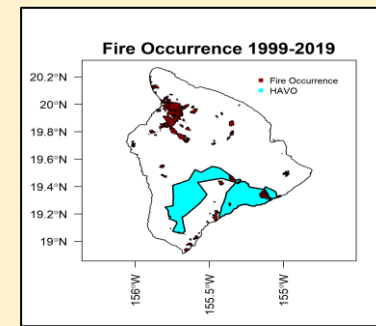
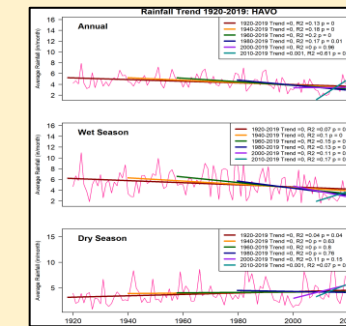
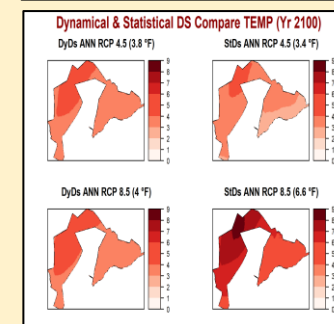
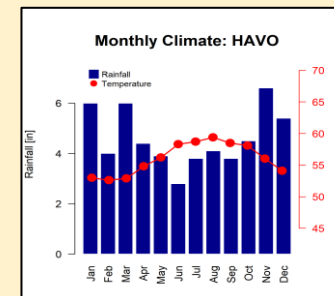
Climate Change, Climate Variability, & Drought Portfolio

Hawai'i Volcanoes National Park

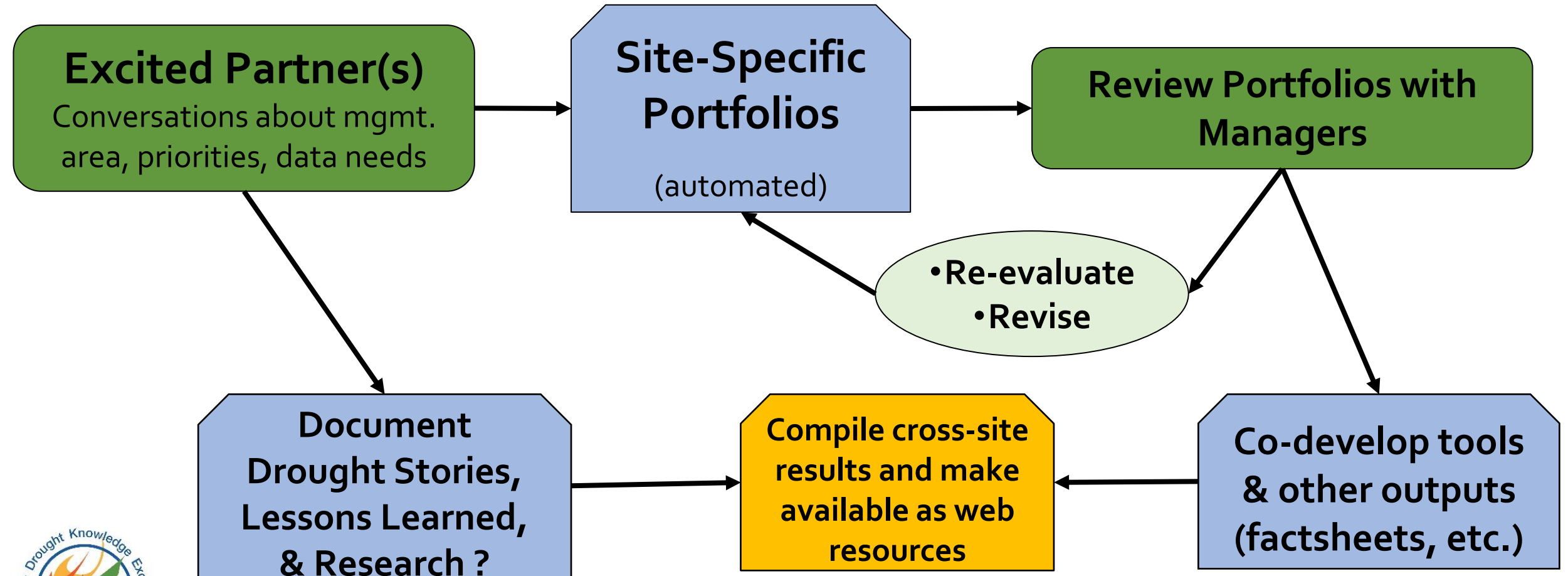
2021-03-25

- **Climate Characteristics**
- **Monthly Rainfall Trends and Variability**
- **Ecological Characteristics**
- **Future Climate Projections**
- **Historical Drought**
- **Analysis and summaries**



| Start Date | End Date | Duration (months) | Average Intensity | Peak Intensity | Magnitude |
|------------|----------|-------------------|-------------------|----------------|-----------|
| 1922-01 | 1927-04 | 48 | 1.0 | 2.8 | 47.6 |
| 1929-04 | 1932-01 | 21 | 0.4 | 1.2 | 8.9 |
| 1933-11 | 1934-11 | 12 | 1.2 | 2.4 | 13.9 |
| 1935-06 | 1942-04 | 30 | 0.5 | 1.2 | 15.1 |
| 1942-10 | 1946-02 | 28 | 1.1 | 2.2 | 31.6 |
| 1946-04 | 1950-09 | 24 | 0.5 | 1.4 | 12.0 |
| 1951-08 | 1954-08 | 26 | 1.2 | 2.4 | 31.7 |
| 1957-05 | 1958-09 | 16 | 0.6 | 1.1 | 8.9 |
| 1958-12 | 1960-05 | 13 | 0.6 | 1.2 | 7.7 |
| 1960-08 | 1963-05 | 20 | 0.6 | 1.0 | 12.7 |
| 1964-08 | 1974-04 | 63 | 0.7 | 2.1 | 38.7 |
| 1975-05 | 1978-11 | 42 | 1.1 | 2.0 | 48.9 |
| 1979-07 | 1980-07 | 12 | 0.7 | 1.8 | 8.3 |
| 1981-03 | 1981-12 | 9 | 0.6 | 1.1 | 5.5 |
| 1983-07 | 1986-12 | 41 | 1.3 | 3.1 | 54.9 |
| 1987-03 | 1994-03 | 25 | 0.3 | 1.6 | 7.9 |
| 1995-02 | 1996-01 | 10 | 0.8 | 1.3 | 8.3 |
| 1998-01 | 1999-03 | 14 | 0.6 | 1.0 | 8.8 |
| 1999-04 | 2002-01 | 33 | 0.8 | 1.8 | 26.7 |
| 2002-02 | 2004-03 | 20 | 0.7 | 1.2 | 14.2 |
| 2005-12 | 2009-04 | 28 | 0.7 | 1.8 | 19.2 |
| 2009-05 | 2011-05 | 23 | 0.5 | 1.9 | 10.8 |
| 2012-11 | 2014-08 | 21 | 0.6 | 1.6 | 13.5 |
| 2014-11 | 2018-03 | 31 | 0.4 | 1.3 | 12.8 |

Pacific Drought Knowledge Exchange (PDKE) Approach:



Factsheets

Impacts of El Niño



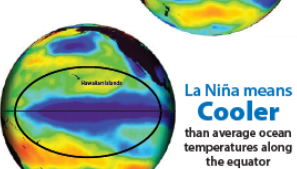
Impacts of El Niño on Climate in Hawai'i Volcanoes National Park

Understanding and anticipating climate variations during El Niño events allows us to protect park resources

El Niño vs. La Niña

The **El Niño-Southern Oscillation (ENSO)** is a naturally recurring feature in the Earth's climate system that involves a change in sea surface temperatures in the eastern and central tropical Pacific Ocean. This change in temperature is brought on by changes in surface winds that move water from east to west across the Pacific basin. During the **La Niña** (cool) phase of ENSO, strong winds move cool water quickly from east to west across the basin, resulting in cooler water temperatures around Hawai'i. During the **El Niño** (warm) phase winds are weaker, so the slower moving water has the ability to absorb more heat energy, resulting in warmer sea surface temperatures.

El Niño means Warmer
than average ocean temperatures along the equator



See Surface Temperature (°C) difference from normal

Wet season climate characteristics during the ENSO phases

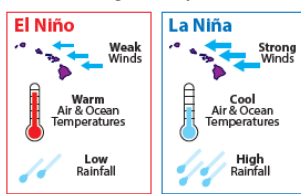


Figure 2 (above): Average wet season climate conditions during El Niño and La Niña phases of ENSO.

Figure 1 (left): Ocean temperatures during the El Niño and La Niña phases of ENSO. Credit: Steve Albers, NOAA

The Effects of El Niño at HAVO

Average monthly wet season rainfall is about 5 inches per month at Hawai'i Volcanoes National Park (HAVO), but during an El Niño event, average rainfall typically declines by 2 inches per month. During a strong El Niño in January 2010, rainfall was 5.9 inches (94%) drier than the long-term average for that month and maximum temperatures (measured at the park headquarters) were 3.1°F warmer than normal.

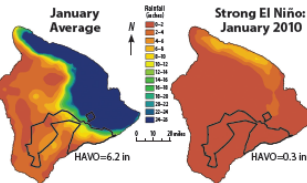


Figure 3: January average rainfall (left) and January 2010 rainfall (right).

Why is This Important?

A Range of Impacts in the Park

Some of the most intense droughts observed in the park have been associated with El Niño events that have occurred during the wet season. These extreme changes in seasonal rainfall can result in a range of direct and indirect impacts on natural resources including survival of native plants (seedlings and adults), invasive plant expansion, and survival of endangered animals. In addition, decreases in rainfall accompanied by decreases in relative humidity are conducive to wildland fires (with an ignition source). In May 2003, following a moderately strong El Niño, the Lohi Fire burned approximately 4,900 acres in the Kilauea unit of the Park. This fire was ignited by lava and spread during a period of extremely low relative humidity and strong winds. In addition, the rainfall leading up to the fire event was extremely low.

Authors: Ryan J. Longman (East-West Center), Sierra McDaniel (Hawai'i Volcanoes National Park), Abby G. Frazier (East-West Center), and Christian P. Giardina (USDA Forest Service).

Design and layout: Brooks Bays (DOEST Publication Services)
February 2011

In fact, during the consecutive 6-month period leading up to the fire, total rainfall was 66% drier than normal and maximum temperatures were 1.7°F warmer. The resulting dry conditions allowed the fire to spread in uluhe wet forest and 'ohia/swordfern mesic forest. Fire risk in this area of the park is generally low due to high frequency of rainfall, but fire can occur after short dry periods.

Understanding the timing, intensity, and duration of an El Niño event is critical to an effective management response, which can include securing resources (equipment and staff), growing seedlings for restoration, invasive species control, and saving seeds of rare species. The phase of ENSO and the strength of the event can usually be identified several months in advance, therefore, resource managers can make the necessary adjustments in restoration schedules or take the necessary precautions in fire management activities.



Figure 4: 2003 Lohi Fire. Inset shows location of the fire relative to Park Headquarters. Credit: NPS

This work was funded by the Pacific Islands Climate Adaptation Science Center.



Future Climates



Future Climate Projections at Hawai'i Volcanoes National Park

The park is expected to become drier and hotter by the end of the century

What is Climate Downscaling?

Future projections of both rainfall and temperature are available for most of the Earth's surface from a wide variety of global climate models. These models use mathematical equations to describe how energy and matter interact in different parts of the ocean and atmosphere over time. Climate downscaling is a technique used to translate the global model projections at a finer resolution. A range of future climate projections that use different downscaling methods for both rainfall and temperature are available for Hawai'i for two distinct future climate scenarios. These scenarios include:

1) Future rainfall scenarios were used together to estimate the amount of greenhouse gases (GHGs) in the atmosphere (low emissions scenario, and 2) future rainfall scenarios were used to estimate the amount of greenhouse gases (GHGs) in the atmosphere (high emissions scenario).

Information on climate projections is critical to an effective management response that incorporates a wide range of adaptation options, for example, ecosystem-based adaptation, ecosystem restoration to avoid degradation and

deformation, biodiversity management, and incorporating local and indigenous knowledge into decision making. Adopting a changing climate helps to reduce the risk to both natural and managed ecosystems.

The primary threat to native Hawaiian forest birds is avian malaria, which is transmitted by the bite of non-native mosquitoes. In the past, low temperatures of high elevations allowed forest birds to avoid malaria. However, atmospheric warming allows the mosquitoes to move to higher elevations, increasing the risk of avian malaria to native Hawaiian forest birds.

Further projections that indicate the area of safe habitat and resulting in population decline. Current climate-based population models predict most species of Hawaiian forest birds will experience a decline in their current range by 2050. The future 'low' (Figure 3) shows only a small range of safe habitat, while the future 'high' (Figure 4) shows a much larger range of safe habitat. The future 'high' scenario shows a much larger range of safe habitat, but it also shows a much larger range of high-risk areas, indicating a much larger range of high-risk areas.

Understanding how climate is projected to change is critical to an effective management response that incorporates a wide range of adaptation options to provide healthy ecosystems. Land managers are seeking to build climate resilient native ecosystems by excluding invasive species, partnering with researchers to

understand how climate is projected to change in the future, and how climate change is expected to affect native Hawaiian forest birds.

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Design and layout: Brooks Bays (DOEST Publication Services)
June 2011



A 100-Year History of Drought at Pu'u Wa'awa'a

Extended dry periods can be a deadly situation for many native species across Pu'u Wa'awa'a

What is Drought?

Low rainfall over a long period of time can lead to a prolonged period with less-than-average amounts of water in a particular area. A lack of rainfall can reduce soil moisture or groundwater, reduce stream flow, and cause drought. Low rainfall can also lead to higher-than-average temperatures and reduced cloud cover. An individual drought event can last for several months, or even years, and the severity of a drought will depend on how long the dry conditions last.

Low temperatures can make drought worse by preventing moisture from the soil. Drought also can create environmental conditions that lead to wildfires.

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Future Climate Projections at Hawai'i Volcanoes National Park

The park is expected to become drier and hotter by the end of the century

Future projections of both rainfall and temperature are available for most of the Earth's surface from a wide variety of global climate models. These models use mathematical equations to describe how energy and matter interact in different parts of the ocean and atmosphere over time. Climate downscaling is a technique used to translate the global model projections at a finer resolution. A range of future climate projections that use different downscaling methods for both rainfall and temperature are available for Hawai'i for two distinct future climate scenarios. These scenarios include:

1) Future rainfall scenarios were used together to estimate the amount of greenhouse gases (GHGs) in the atmosphere (low emissions scenario, and 2) future rainfall scenarios were used to estimate the amount of greenhouse gases (GHGs) in the atmosphere (high emissions scenario).

Information on climate projections is critical to an effective management response that incorporates a wide range of adaptation options, for example, ecosystem-based adaptation, ecosystem restoration to avoid degradation and

deformation, biodiversity management, and incorporating local and indigenous knowledge into decision making. Adopting a changing climate helps to reduce the risk to both natural and managed ecosystems.

The primary threat to native Hawaiian forest birds is avian malaria, which is transmitted by the bite of non-native mosquitoes. In the past, low temperatures of high elevations allowed forest birds to avoid malaria. However, atmospheric warming allows the mosquitoes to move to higher elevations, increasing the risk of avian malaria to native Hawaiian forest birds.

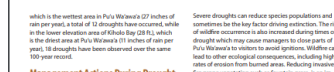
Further projections that indicate the area of safe habitat and resulting in population decline. Current climate-based population models predict most species of Hawaiian forest birds will experience a decline in their current range by 2050. The future 'low' (Figure 3) shows only a small range of safe habitat, while the future 'high' (Figure 4) shows a much larger range of safe habitat. The future 'high' scenario shows a much larger range of safe habitat, but it also shows a much larger range of high-risk areas, indicating a much larger range of high-risk areas.

Understanding how climate is projected to change is critical to an effective management response that incorporates a wide range of adaptation options to provide healthy ecosystems. Land managers are seeking to build climate resilient native ecosystems by excluding invasive species, partnering with researchers to

understand how climate is projected to change in the future, and how climate change is expected to affect native Hawaiian forest birds.

Authors: Ryan J. Longman (East-West Center), Sierra McDaniel (Hawai'i Volcanoes National Park), Abby G. Frazier (East-West Center), and Christian P. Giardina (USDA Forest Service).

Design and layout: Brooks Bays (DOEST Publication Services)
June 2011



A 100-Year History of Drought at Pu'u Wa'awa'a

Extended dry periods can be a deadly situation for many native species across Pu'u Wa'awa'a

Low rainfall over a long period of time can lead to a prolonged period with less-than-average amounts of water in a particular area. A lack of rainfall can reduce soil moisture or groundwater, reduce stream flow, and cause drought. Low rainfall can also lead to higher-than-average temperatures and reduced cloud cover. An individual drought event can last for several months, or even years, and the severity of a drought will depend on how long the dry conditions last.

Low temperatures can make drought worse by preventing moisture from the soil. Drought also can create environmental conditions that lead to wildfires.

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Hawai'i Drought Needs Assessment

- Literature Review & Synthesis
- Meetings with Resource Managers
- Workshops & Trainings
- 1-on-1 Manager Interviews
- Statewide Drought Information Survey
- Indigenous Drought Knowledge Assessment

development
managers specific strategies
future information weather
management climate land
knowledge or dry
drought
based water hawaii areas
impacts conditions indigenous
cultural actions traditional change



Melissa Kunz
UHM NREM



Dr. Katie Kamelamela
Akaka Foundation

Adaptation Planning & Practices Course

- 8 week course: Jan-Mar 2021
 - Hands-on training to identify adaptation actions for natural resource management professionals
- 42 participants from 19 different organizations
- Project-based approach, flexible

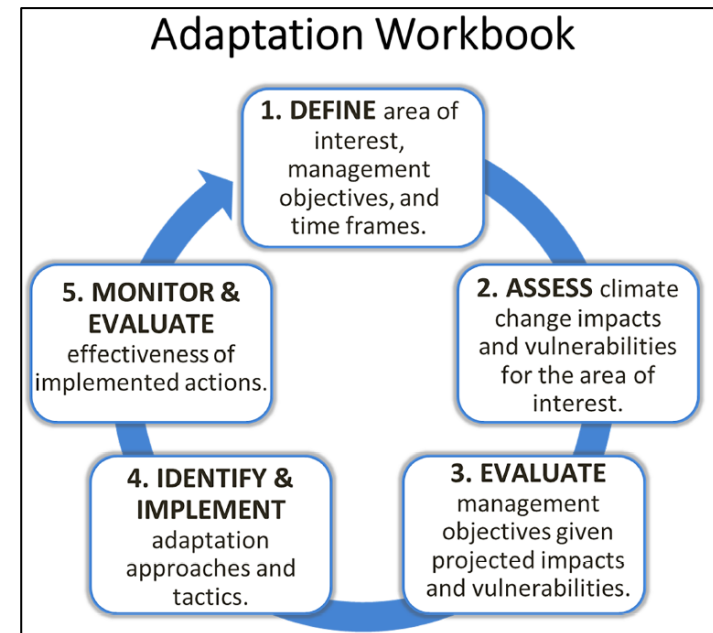
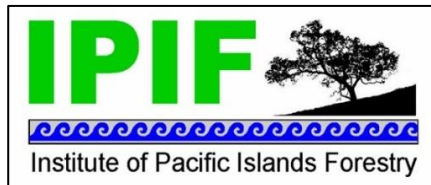
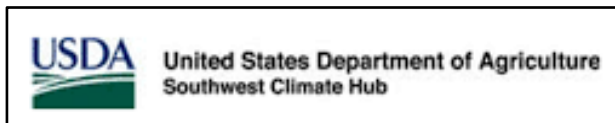
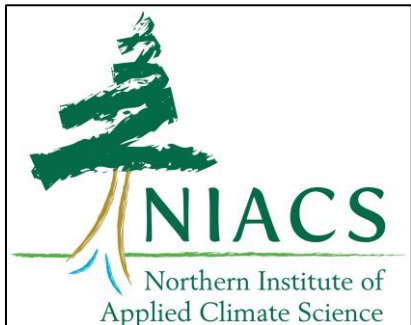
Longman et al. 2022, BAMS

BAMS
Meeting Summary

Climate Adaptation for Tropical Island Land Stewardship

Adapting a Workshop Planning Process to Hawai'i

Ryan J. Longman, Courtney L. Peterson, Madeline Baroli, Abby G. Frazier, Zachary Cook, Elliott W. Parsons, Maude Dinan, Katie L. Kamelamela, Caitriana Steele, Reanna Burnett, Chris Swanston, and Christian P. Giardina



<https://adaptationworkbook.org/>

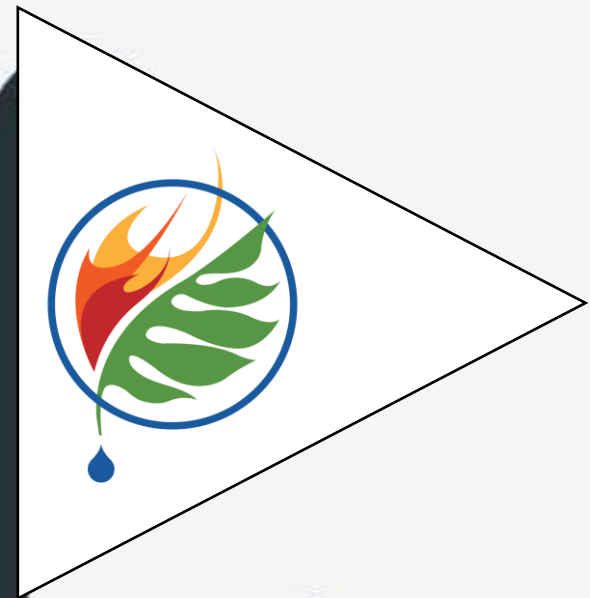
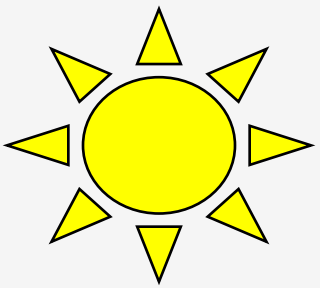


Part 2

Where are we now?

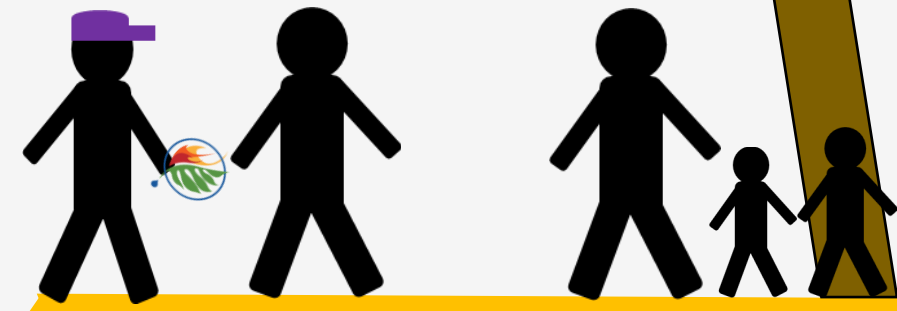
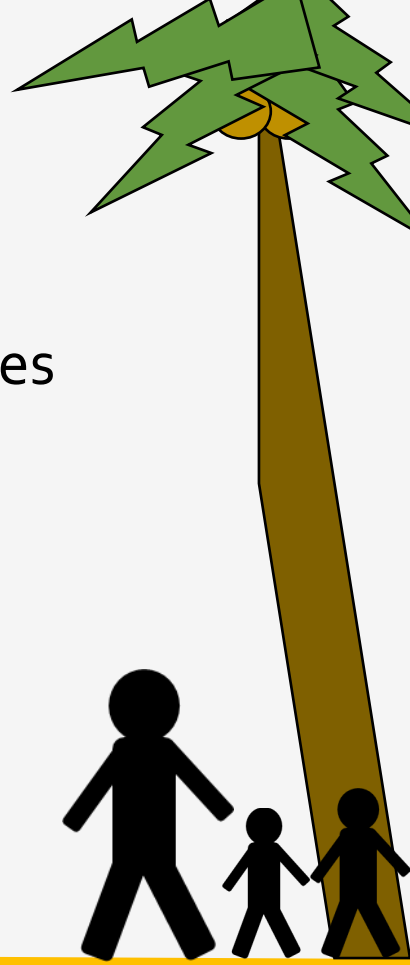






PDKE

- Access new places
- Work with new resource managers
- Engage with new communities
- Program new activities



Drought Decision Support Tool for Ranchers

- Co-developing a new **tool** to help ranchers proactively plan for drought

Hawai'i Rangeland Information Portal (H-RIP)

- 3-month projections of rainfall & forage growth based on historical climate during ENSO (El Niño) phases
- Site-specific near-real time historical climate information
- Decision support:
 - Quarterly Forage Production
 - Site Stability
 - Grazing Days



Cherrylle Hue
UHM SOEST

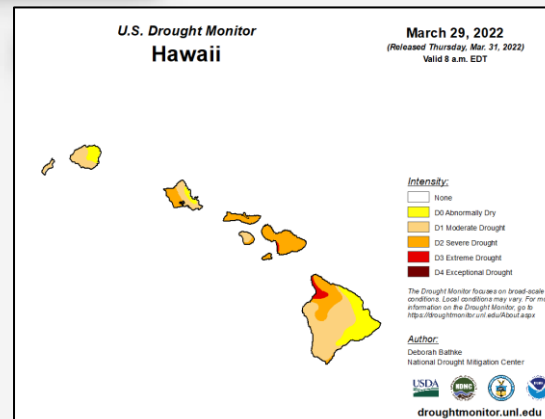
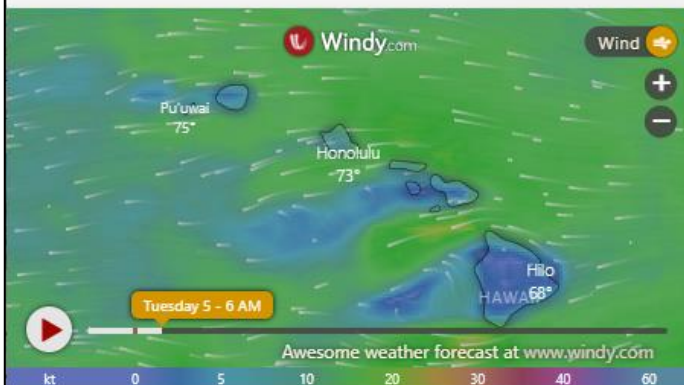
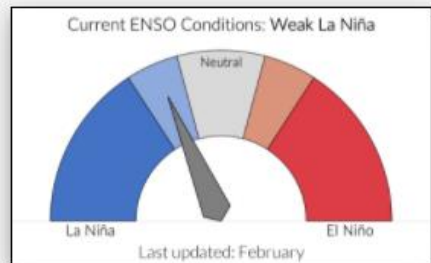




Welcome to H-RIP

[Learn more](#)

Statewide Conditions - April, 2022

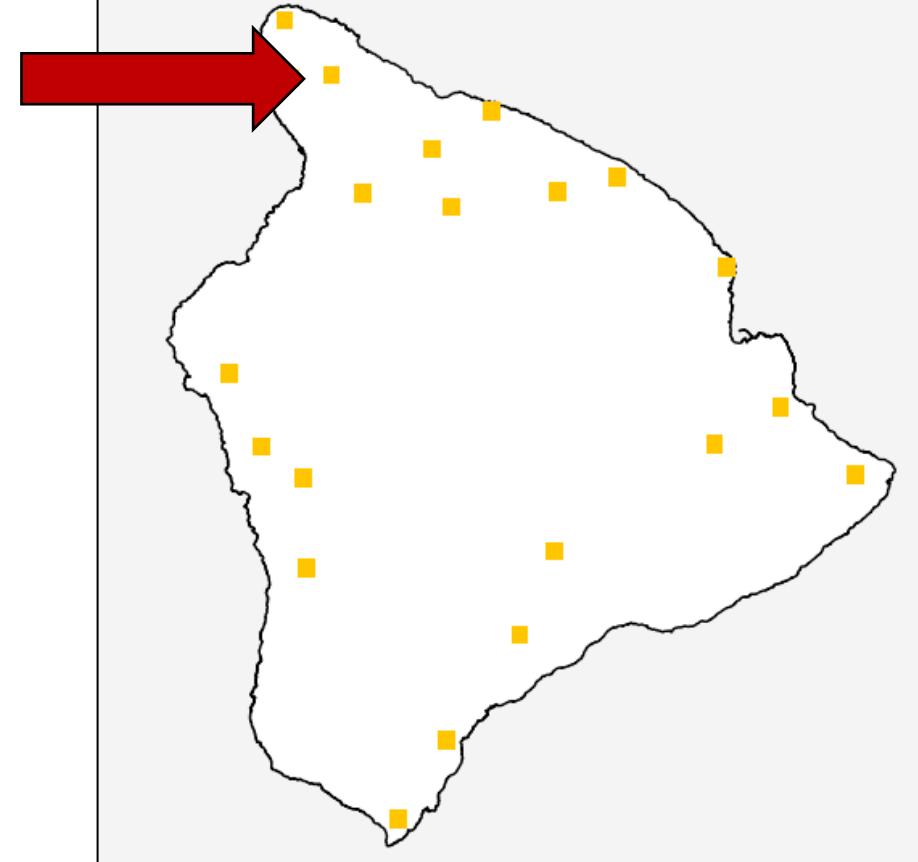


Select an island from the dropdown below.

Hawai'i Island ▾

Click on an area of interest to view site-specific data.

Map view: ☒ No Data ☐ Rainfall ☐ Evapotranspiration



The Decision support tool asks for four inputs: Grass type, dry matter per animal unit, number of an

* required field

Grass Type:

Kikuyu Grass

Dry matter per animal units:

26

Number of animal units: *

150

Number of acres grazed: *

42

Submit

Historical characteristics under Neutral Conditions

Quarterly Forage Production

Historical Average -0.4%↓ → Less than average production expected

Historical Low

-70.9%↓ → Less than average production expected,
potential to request funds

March Production Ratio

Historical Average 0.95 → Site is stable

Historical Low 1 → Site is stable

March Grazing Days

Historical Average 5.89 → De-Stock or supplement feeding

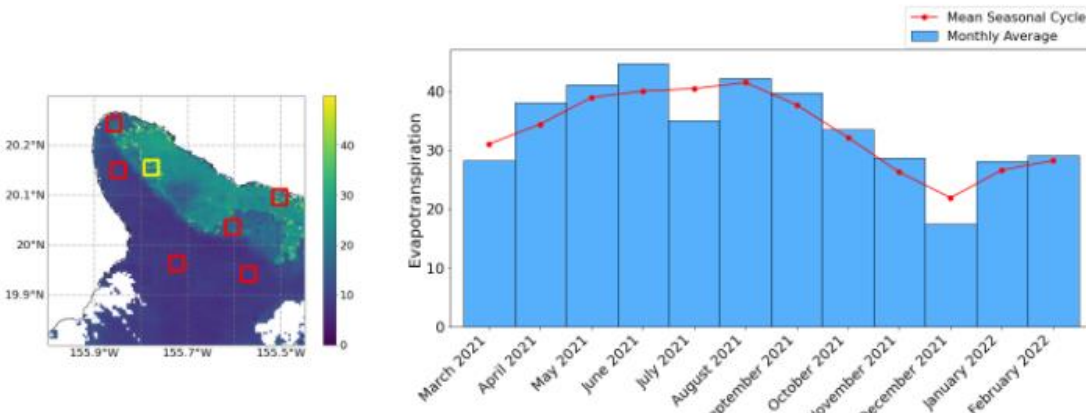
Historical Low 0.7 → De-Stock or supplement feeding



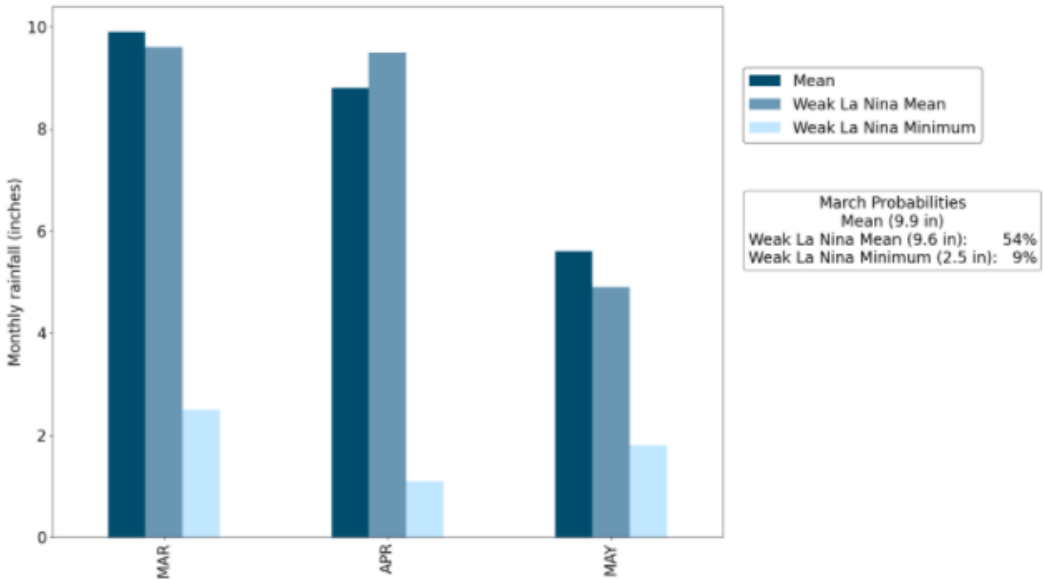
Average Climate Conditions

☐ Rainfall ☐ Temperature ☒ Evapotranspiration ☐ NDVI

Evapotranspiration (mm/8 days) ①



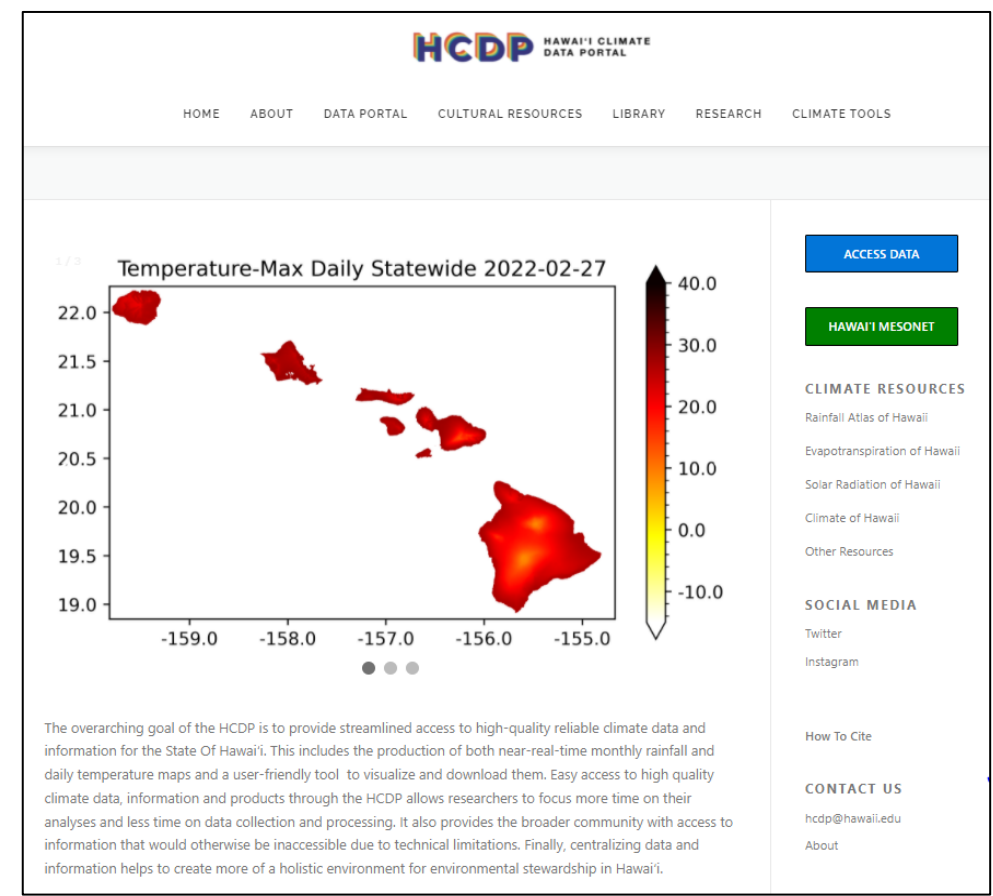
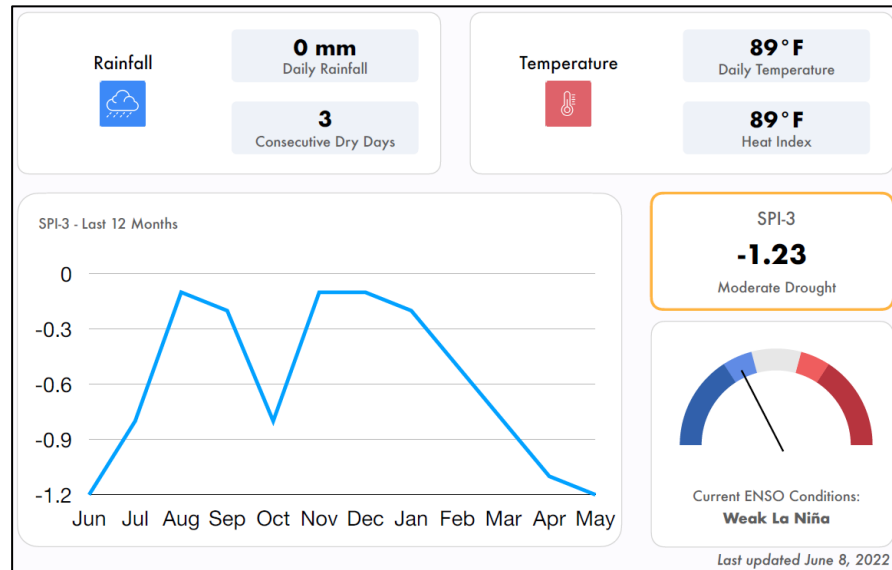
3-Month Rainfall Projections



Hawai'i Climate Data Portal

- Pulling in real time data to support the H-RIP tool.
- Calculate Drought conditions in near-real-time
- **Working with USDA Dept of Ag. Risk Management Agency (RMA), to bring insurance options to ranchers in Hawai'i.**

Mobil App
Real-time
site specific
data



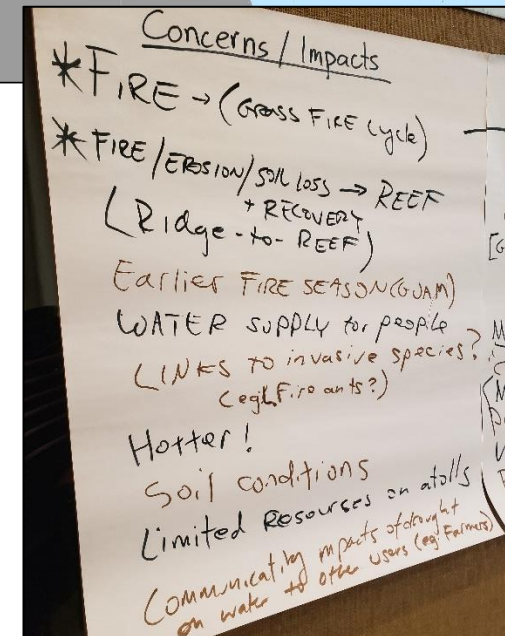
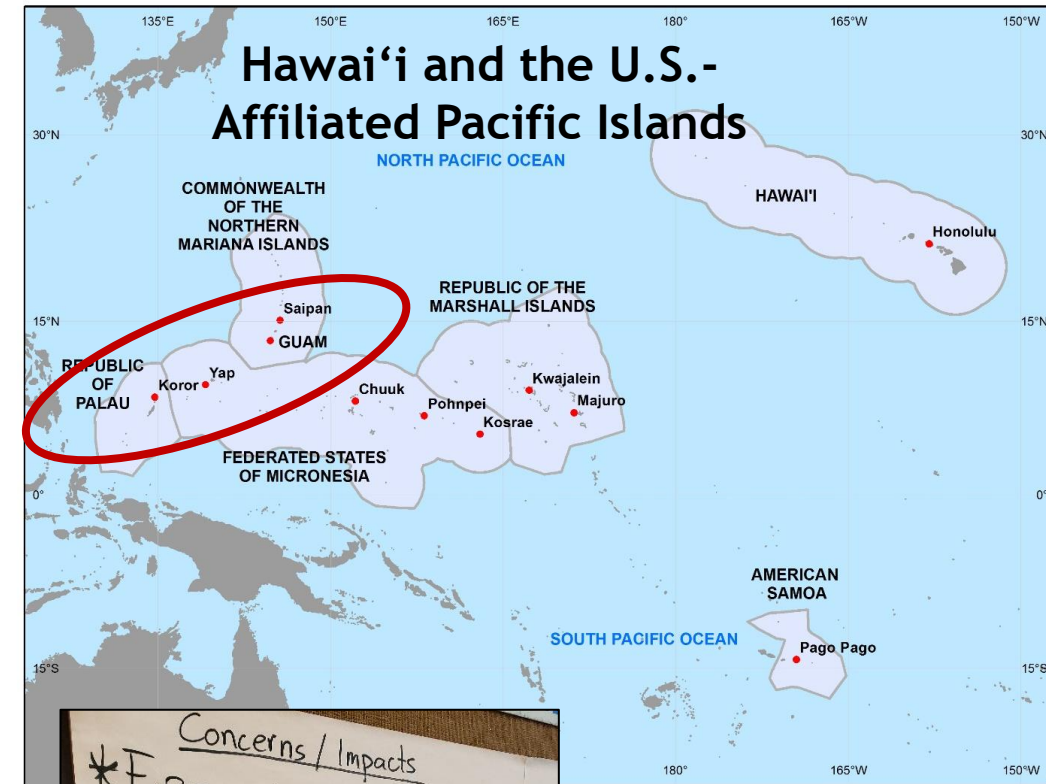
HCDP HAWAI'I CLIMATE
DATA PORTAL

<https://www.hawaii.edu/climate-data-portal/>

Project

PDKE in the USAPI

- Guam, Palau, & Yap (FSM)
- Fire activity is very high in Western Pacific
- Partnering with UoG, Guam Dept. of Ag., Yap Division of Ag., & Ebiil Society Palau



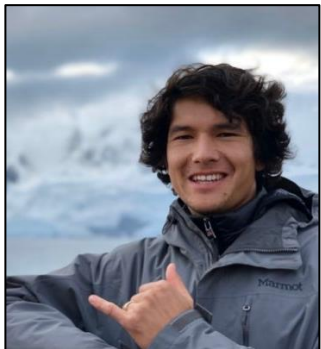
***Builds off 2019
Pacific Islands
Forestry
Professionals
Workshop***



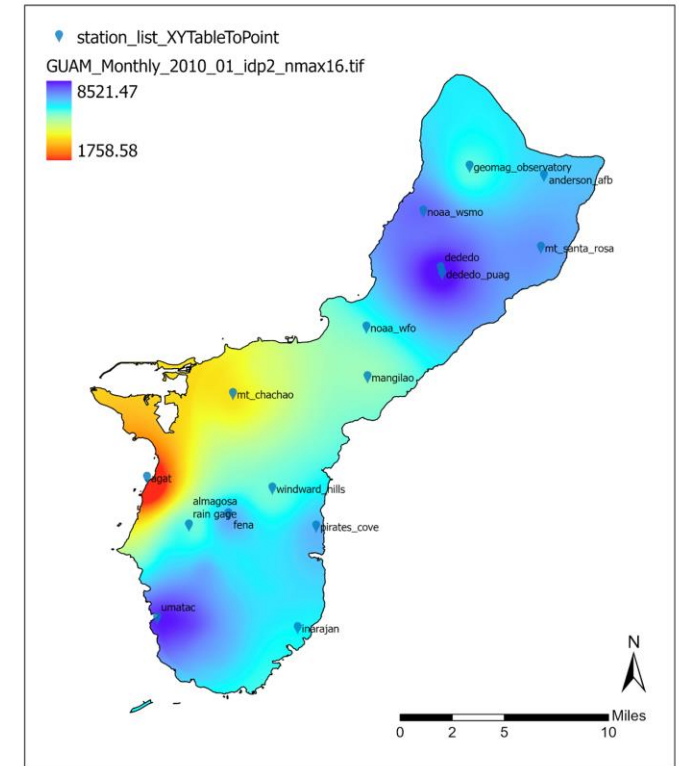
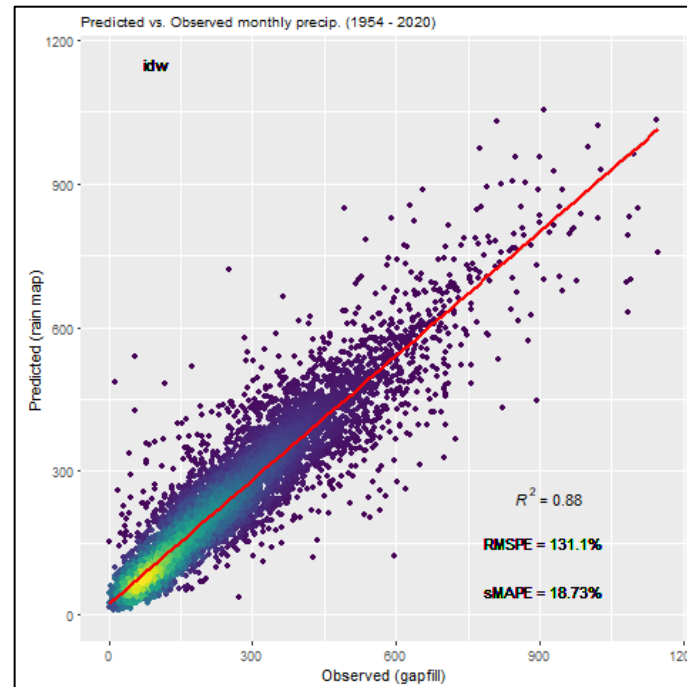
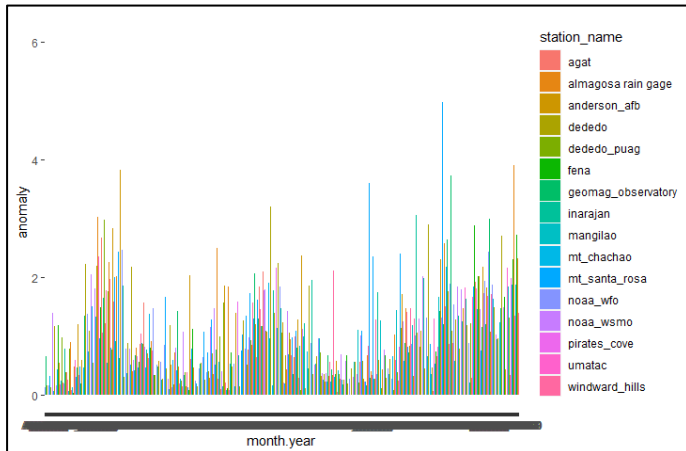
Rainfall Mapping in Guam (~70-years)



- Gridded Rainfall Timeseries (1953-2021)
 - Quality Control
 - Gap-filling
 - Method comparisons
- Opens the door
 - Guam CCVD portfolio?
 - Maps in HCDP for vis. & download
 - Answer more research questions

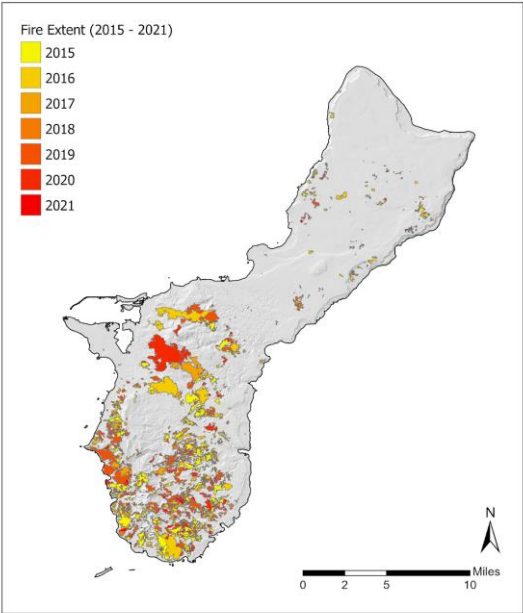
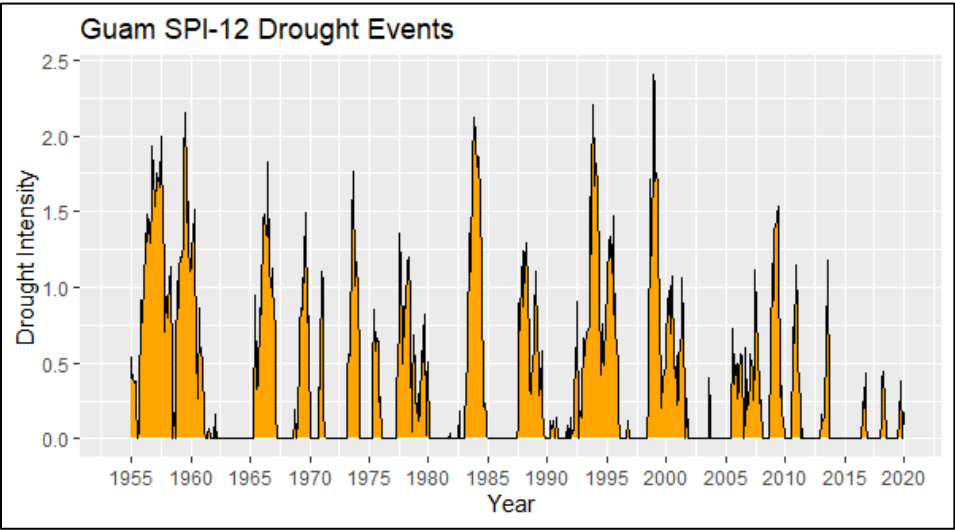


Derek Ford
East-West Center

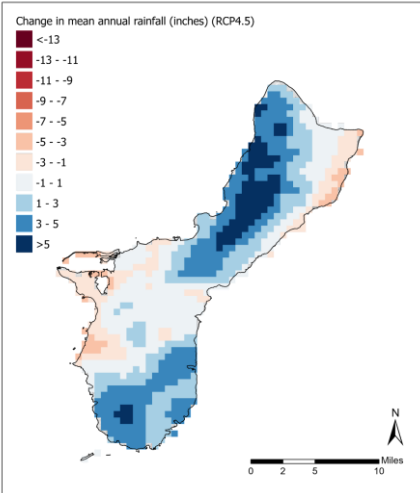


PDKE Products in Guam

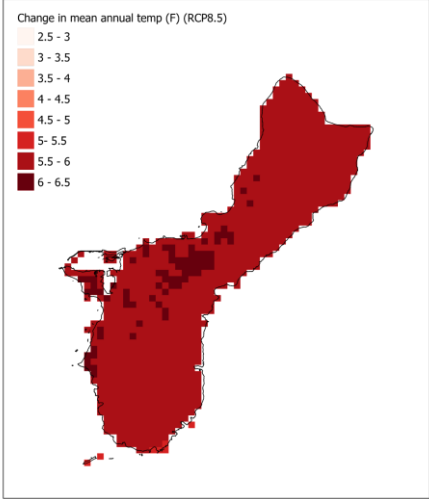
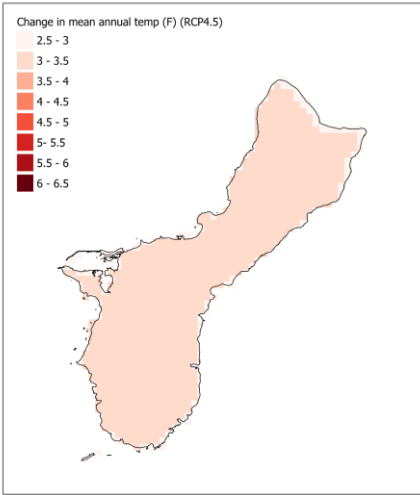
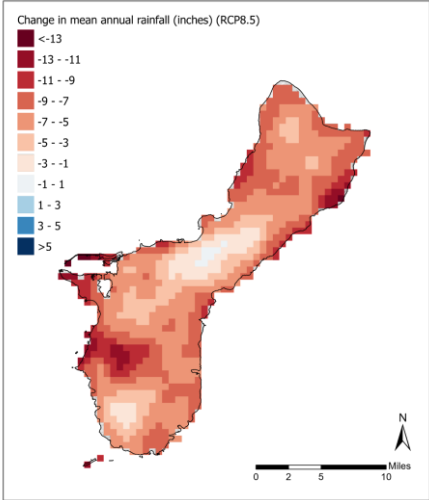
- Future **Rainfall** and **Temperature** projections
- Under two future scenarios
- Historical drought
- Fire occurrence



Low Emissions



High Emissions

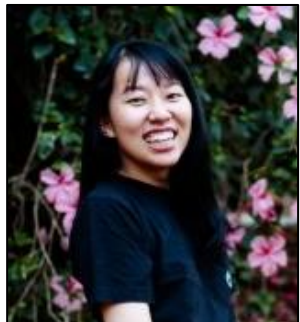


Project 3

Developing Educational Materials



- Educational resources
 - Create K-12 educational resources from PDKE products
 - Teacher workshops & trainings
 - Portfolios for schools
 - Drought story-maps
 - Tutorials



Cherryle Hue
UHM SOEST



Emily Sesno
PI-CASC



<https://picasc-education-usgs.hub.arcgis.com/>

ʻŌlelo Hawaiian Translation

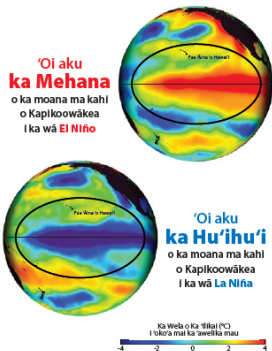


Ka Wā El Niño ma ka Pāka Aupuni 'o Kilauea

E ho'omalua 'ia nā kumuwaiwai o ka pāka i ka ho'omaopopo 'ana i ke aniau i ka wā El Niño

Ka Wā El Niño a La Niña

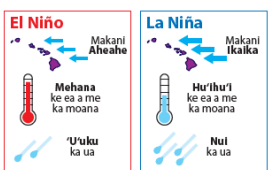
O ka **El Niño-Southern Oscillation** (ENSO), 'o ia nō kekahi hana kōloheho o ke aniau o ka honua, pili i ka loli o ka wela o ka 'ilikai ma ka hikiina a ma waena o ka Moana Pākīpika kopikala. 'O ke kumu o ia loli 'ana o ka wela, 'o ia nō ka loli 'ana o ka makani e ho'one'e ana i ke kai mai ka hikiina a hiki i ke komohana o ka Pākīpika. I ka wā **La Niña** (anu) o ka ENSO, pā ka makani ikaika e ho'one'e 'āwāwā anu i ke kai hūhū i ke kai ma kahi o Hawai'i. I ka wā **El Niño** (mehana), pā ahehe ka makani, a no laila, hiki ke omo 'ia ka ikehu wela ma muli o ka 'ene ikeho 'ana o ke kai, a 'o ka 'ilikai mehana ka hopena.



Ke Anilā i ka Wā El Niño ma Hawai'i

Ma Hawai'i, loli ka nui o ka ua a me ka wela o ke ea i ka wā El Niño a me La Niña pō. I ka wā El Niño, 'ūku ka ua, a pili 'a'e ka wela o ke ea i ke kau ho'olo (Nowemapa a hiki i 'Apelila), a i ka wā La Niña, nui ka ua a hūhū i ke ea. I ke kau wela (Mā i hiki i 'Okakopa) loli ke 'ano o ke anilā: 'o ka mea ma' mau, nui ka ua i ke kau wela i ka wā El Niño, a malo'o ke kau wela i ka wā La Niña. 'Okō ka ikaika o nā wā pākahi o El Niño a me La Niña. Inā wela loa a i 'ole hūhū i loa ka 'ilikai, he wā ikaika loa ia. Inā 'ano mehana a i 'ole 'ano hūhū i ka 'ilikai, he wā 'ano ikaika ia. I ka hapanui o ka manawa, 'o ikaika ma'alo'o o ke kau ho'olo i ka wā El Niño ikaika loa. I ka wā El Niño 'ano ikaika, 'ike 'ia nā anilā like 'ole (ka malo'o a me ka ua).

Ke 'Āno Aniau o ke Kau Ho'olo i nā Wā o ka ENSO



KI'Ī 2 (ua kumu): Ka 'āweliika 'ano aniau o ke kau ho'olo (Nowemapa-'Apelila) i nā wā El Niño a La Niña o ka ENSO.

KI'Ī 1 (ma ka hema): Ke kōlana wela o ka moana i ka wā El Niño a La Niña o ka ENSO. Na: Steve Alberson, NOAA

O ka wā El Niño ikaika, ua pau i ke ahi he 4,900 'eka ma ka 'āpana 'o Kilauea ma ka pāka. Ua ho'ā 'ia kēia ahi e ka pele, a hōkupu aku ma muli o ka malo'o o ka 'āina ka pā kawāwae ha'aha'a loa a me ka ikaika o ka makani. 'Uuku loa ka ua i loko o nā mahina ma mua o ke ahi.

I loko o nā mahina 'eono ma mua o kēia ahi, ua emi iho ka nui o ka ua he 66 pakeneka ma lalo o ka ua mau, a ua 'oi aku ka nui o ka wela he 1.7°F ma luna o ka wela mau. No ka malo'o loa, ua laha aku ka 'ā 'ana a kēia ahi i ka ululā'au

'Apelila 2022

uluhe, a me ka ululā'au 'ohi'a a kupukupu. 'O ka mea ma'ama, 'ole pō'ino nui kēia wahi o ka pāka i ke ahi ma muli o ka ua pinepine 'ana, aka hiki ke 'ā koke ke ahi ma hope o ka wā malo'o pokole.

He mea kō'iko'i ka ho'omaopopo 'ana i ka manawa, ka nui, a me ka loli o ka hanana El Niño no ka ho'olā 'ana i nā hana ho'omalua kopono, e like me ka ho'olā 'ana i nā kumuwaiwai (nā lako a me ka po'e koku), ka ho'oulu hou 'ana i ke kawowō, ke kachī 'ana i nā mea ola malihini, a me ka mālama 'ana i nā 'ano'ano kakahikā'. Hō'ike 'ia ka manawa a me ka nui o ka ENSO i kekahi mau mahina ma mua o la hanana, no laila, hiki i nā luna mālama 'āina ke ho'omākauau a no'ono'o mua e pale i ka pō'ino i ke ahi.



KI'Ī 4: Ke ahi 'o Luhī i ka makahiki 2003. Hō'ike 'ia kahi o ke ahi ma ka Pāka Aupuni. Na: NPS

Uku 'ia nō kēia papahana a ka hui 'o Pacific Islands Climate Adaptation Science Center



No Ke Ahi Lalapa Wale ma Pu'u Wa'awa'a

'O kōnaka ke kumu o ka 98 pakeneka o ke ahi lalapa wale ma Hawai'i, a he ulia ka 75 pakeneka o ia ahi, no laila, hiki ke 'alo a'e.

Ke Ahi ma Hawai'i

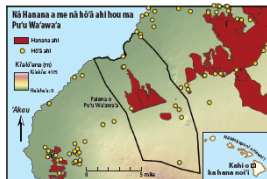
He mea pō'ino loa ke ahi lalapa wale ma Hawai'i i nā kumuwaiwai kōloheho, nā kumuwaiwai mo'omeheu, a me nā kalaula ma nā 'āina e 'ā koke i ke ahi. Ua pūhi ke ahi lalapa wale no ka makahiki holo'oko'a ma nā mau' malihini a me nā lā'au 'ē a'ē i hiki ke ulu hou ma hope o ka meo'o o ke ahi. Ua 'ā pinepine ke ahi ma nā wahi 'olenehana, aka, ala ka nui o nā pau ahi nui ma nā kula mau' malo'o, a 'o kēia mau pau ahi kekahi kumu o ka pō'ino o ke kalano'o a me ka 'emi 'ana o nā mea ola 'ōwi'. Ma mua o ka hiki 'ana mai o kōnaka, ua mana'o 'ia, 'o ka hana a Pele a me ka 'āpana kōkō'āhi o ka ulu nā mea wale nō i hō'i i ke ahi, a no laila, 'ole i hiki i ka hapanui o nā lā'au 'ōwi ke ulu hou ma hope o ke ahi. Nā nā kōnaka i hō'i i ka heluna hanana o ke ahi ma ka pae 'āina ma o ka lawelawē 'ana mai i nā lā'au i hiki ke ulu hou ma hope o ke ahi, a me ka ho'oulu 'ana i nā hō'a 'ana. I loko o ka 'umi makahiki i hala (2002–2012), ma ka heluna 'āweliika he 1,100 o nā ahi lalapa wale, ua pau ma kahi o 17,000 'eka ma ka pae 'āina'.

Ka Mo'olelo a me Ka Pō'ino o Ke Ahi Lalapa Wale e Hiki mai ana ma Pu'u Wa'awa'a

Ma Pu'u Wa'awa'a, ua laulā nā ululā'au 'ōwi o ka 'āina i ka wā kōkō, a wahi a nā kōnaka kōkō'āhi nāhele kōkō, 'o kēia kahi o nā ululā'au mo'onoa nui loa ma ka pae 'āina 'o Hawai'i. 'O ka mea 'āpiki, i loko o nā makahiki 100 i hala, ua lawelawe aku nei nā lā'au 'ōwi o ia wahi ma muli o ke ahi lalapa wale a me ka 'āi 'ana o nā holoholona hānā'. 'O ka uluwahewa 'ana o nā mau' malihini 'o fountain a me Kikuyu ke kumu o ka nui 'ana o nā mea ulu i 'ā koke i ke ahi, a ua lilo ke ahi lalapa wale i mea ho'one'o i nā ululā'au 'ōwi ma Pu'u Wa'awa'a. Ma waena o ka makahiki 2004 a me ka makahiki 2011, ua palapala 'ia he 'ewalu hō'a 'o ke ahi, a ma waena o ka makahiki 1999 a me ka makahiki 2018, he 'elima ahi nui i 'oi aku 50 'eka) ma Pu'u Wa'awa'a, e 'ā 'ia ana ma kahi o 6,000 'eka (KI'Ī 1). 'O kekahi o nā pau ahi nui, i ke ahi Ahi Ula o ka makahiki 2016, ua 'ā ke ahi ma lalo iho o ke Alanui 190, a ua pau he 1,600 'eka. Ma mua o ka makahiki 2000, ua palapala 'ia

kekahi mau ahi nui 'ē a'e ma Pu'u Wa'awa'a. I ka makahiki 1995, ua pau he 1,300 'eka i ke ahi lalapa wale. Ua ho'olilo 'ia he \$369,000 e ka 'Olhana Ululā'au a me Holoholona Lōhiu (Division of Forestry and Wildlife, DOFAW) no ke kina' 'ana i ke ahi, a ma kahi o \$1,755,000 ke pōho o nā kumuwaiwai kōloheho. I ka makahiki 1999, ua pau he 3,800 'eka i ke ahi lalapa wale nui loa i palapala 'ia ma Pu'u Wa'awa'a. Ua ho'olilo 'ia he \$109,000 e ka hui 'o DOFAW no ke kina' 'ana i ke ahi, a ma kahi o \$20,500,000 ke pōho o nā kumuwaiwai kōloheho.

I kēia mau lā, 'o nā wahi ha'aha'a o ka honua (ma lalo o 200 kapua'i), kahi e uluwahewa ai nā mau' malihini, 'o kēia mau wahi ke pō'ino nui i ke ahi. Aka, i ka wā e hiki mai ana, e nui ana paha ka heluna o nā ahi lalapa wale ma ka 'āina (o la ho'i, ka hikiwale o ka 'ā 'ana) ma muli o ka loli 'ana o ke aniau'. I ka 'emi 'ana o ka ua a me ka pili 'ana o ka wela, e pō'ino paha nā wahi kī'eki'e o ka honua i loko o ka hapalua o kēia kenekulia ma muli o ke ahi (KI'Ī 2). Ua kōho 'ia, e nui ana ka 'āweliika o ka hiki ke pō'ino i ke ahi ma Pu'u Wa'awa'a, ma kahi o 'ekua pakeneka. Aka, e pili ana ka hiki ke pō'ino ma kahi o 10 pakeneka ma nā wahi kī'eki'e (ma luna o 200 kapua'i) a ma ka 'ao'ao hikiina o ke Alaioa 190, i ka makahiki 2050.



KI'Ī 1: Nā ahi i pūhi he 50 'eka a 'oi aku mai ka makahiki 1999 a hiki i ka makahiki 2019 (ula'ula), a me nā hō'a ahi mai ka makahiki 2004 a hiki i ka makahiki 2011 (nā kiko melemele).

ka hui 'o DOFAW. Aka ke kalaula o DOFAW ma kōkō'āhi, kahi e mālama 'ia ai nā lako kina'āhi, ala ma kahi o 22 mīle (30 minuke ke kalaula 'ana) mai Pu'u Wa'awa'a aku, a mākaukau lakou e kōkua aku. 'A pinepine ke ahi ma nā palena like 'ole, a hana pō nā hui kina'āhi like 'ole (HFD, DOFAW, NPS, a me PTA) e kina' i ke ahi ma ka mokupuni 'o Hawai'i. Malama ka hui 'o Hawai'i Wildlife Management Organization (hawaiiwildfire.org) i ka pale 'ana i ke ahi ma ke kalaula, a me ka ho'olā 'ana i nā hō'i'ohi'ona 'āina ma ka mokupuni 'o Hawai'i a me ka pae 'āina Hawai'i.

Papa Hua 'ōlelo
Ahi lalapa wale = wildfire
Wahi pale ahi = firebreak

'Apelila 2022

He Mea Nui Kēia, No Ke Aha?

Ka Pale 'Āina i Ke Ahi

Inā 'ole i waele 'ia nā mea ulu malihini, e mau ana nā pau ahi nui ma Hawai'i nei. Me ka 'ole o nā hana pale ahi a me nā hana ho'omākauau kina'āhi, 'o ia hō'i ka hō'emi 'ana i ka wahi, ka ho'omākauau 'ana i nā wahi pale ahi, a me ka mālama 'ana i nā lako kina'āhi, hiki i ke ahi lalapa wale ke laha aku i 'o i 'āne! Ma Pu'u Wa'awa'a, a pau he mau kaukani 'eka i ke ahi (KI'Ī 3). Hiki i ka lehulehu ke kōkua i ka pale 'āina aku i ke ahi, no ka mea, hō'a nā kōnaka i ke 98 pakeneka o nā ahi ma ka pae 'āina 'o Hawai'i. Ala ka pono 'o ka ho'omaopopo o ka lehulehu i ka pō'ino a me ka hopena o ke ahi lalapa wale. A he pono nō hō'i ka hāwāi 'ia 'ana o nā lako a me ka 'ike e pale aku ai i ke ahi ma nā kalaula.



KI'Ī 3: He imahana o ka Papahana Ho'omalua Nāpū'u e nānā ana i ke ahi pōhaku ma kahi i 'ā 'ia e ke ahi 'ōlapa ulu o ka makahiki 2016 ma Pu'u Wa'awa'a.

- 1. LaRoza et al., 2008 <https://www.fs.fed.us/research/pubs/13678>
- 2. Trauernicht 2014 Wildfire in Hawaii Pacific Fire Exchange Factsheet
- 3. Blackmore and Vitousek 2000 <https://doi.org/10.1111/j.1744-7429.2000.tb00594.x>
- 4. PWW Management Plan (2003) <https://dnr.hawaii.gov/forestry/files/2014/06/PWW-Management-Plan.pdf>
- 5. Wada et al., 2017 <https://doi.org/10.2984/711.42>
- 6. Trauernicht et al., 2019 <https://doi.org/10.1016/j.scitotenv.2018.08.347>

This work was funded by the Pacific Islands Climate Adaptation Science Center.

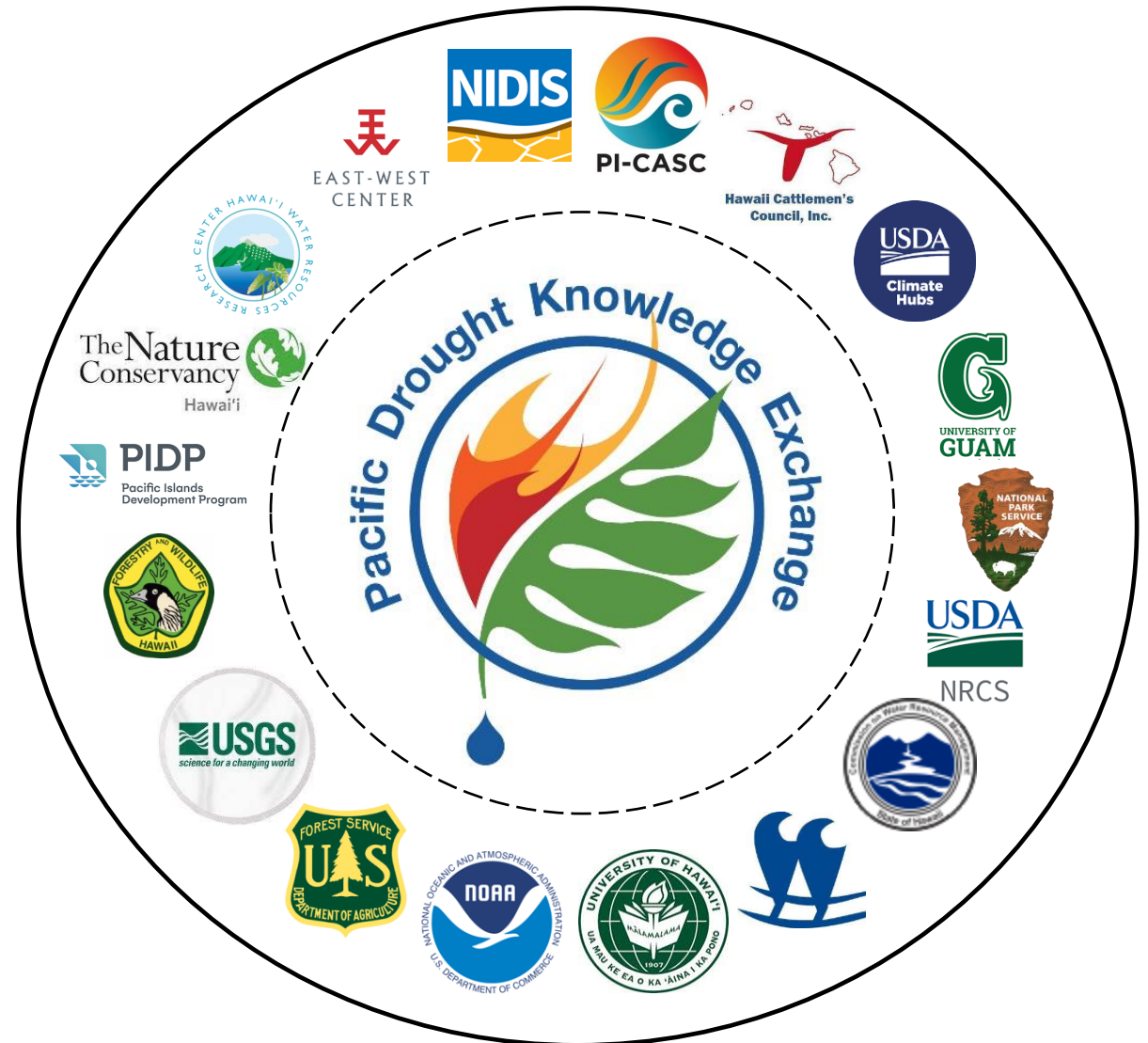


Dr. Alyssa Anderson
UHM SOEST

10 factsheets

Sustaining the PDKE: Alliance Model

- Synergize efforts among partner organizations
- Kickoff Meeting: Dec 2, 2021
- Formalize governance structure
 - Roles & Responsibilities
 - Personnel
 - Core Team (Weekly)
 - Leadership Team (Quarterly)
 - Advisory Council (Annual)
 - Funding
 - Code of Conduct



Part 3

Where we are headed?

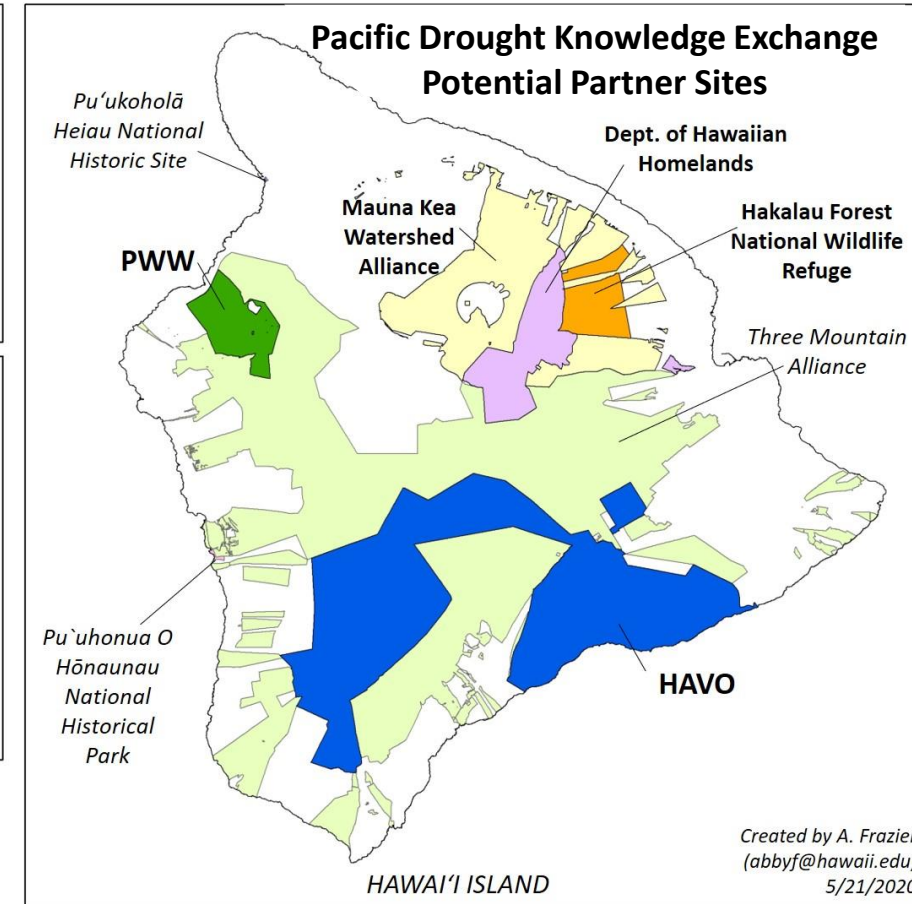
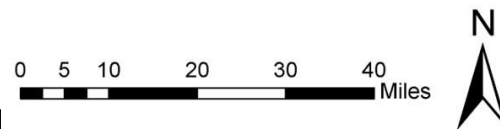
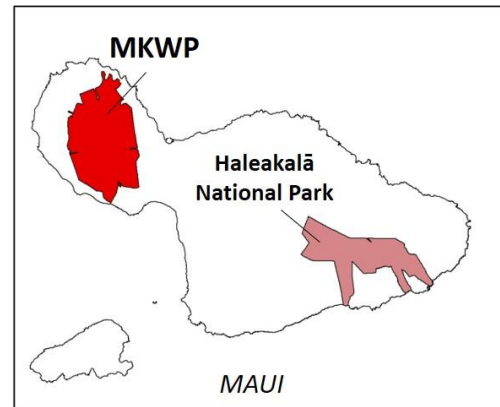
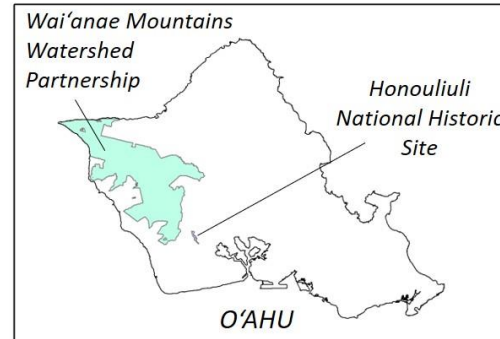


Scaling Up the PDKE

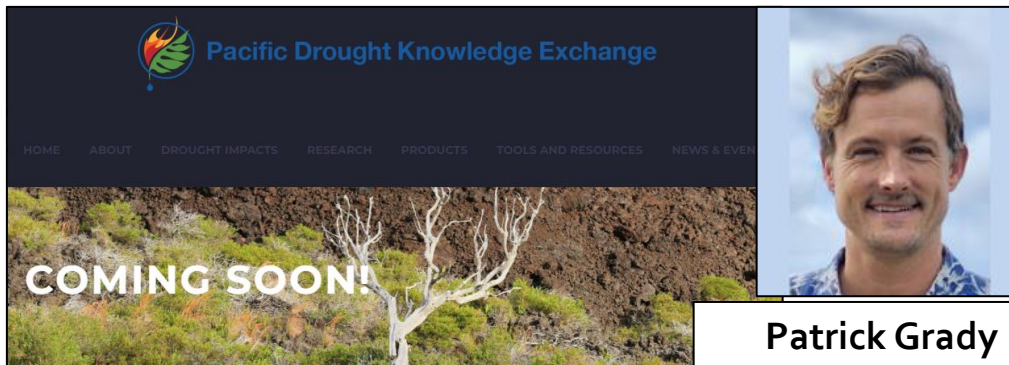
- Include new partners
- Streamline co-production process
- Hire new team member
- Build centralized website for drought resources



PACIFIC ISLANDS
CLIMATE ADAPTATION SCIENCE CENTER



Created by A. Frazier
(abbyf@hawaii.edu)
5/21/2020



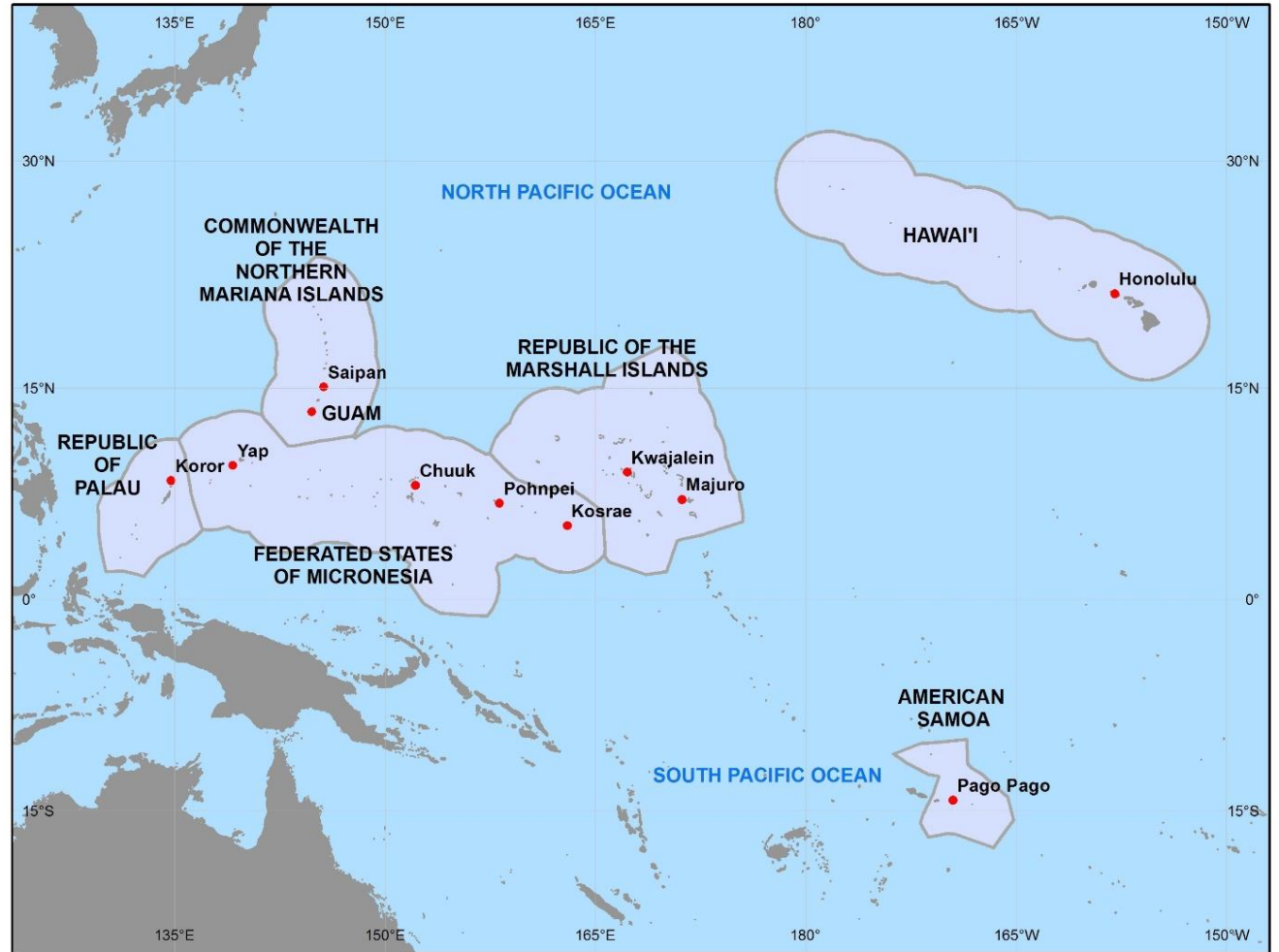
Patrick Grady
UHM Sea Grant
PI-CASC

Expand Efforts in the USAPI

- Existing funding streams
- Access additional funding
- Some ideas
 - Chamorro translated factsheets
 - CCVD Portfolio for Guam
 - Rainfall Maps for America Samoa
 - Factsheets in other countries
 - HCDP Pacific Data Portal

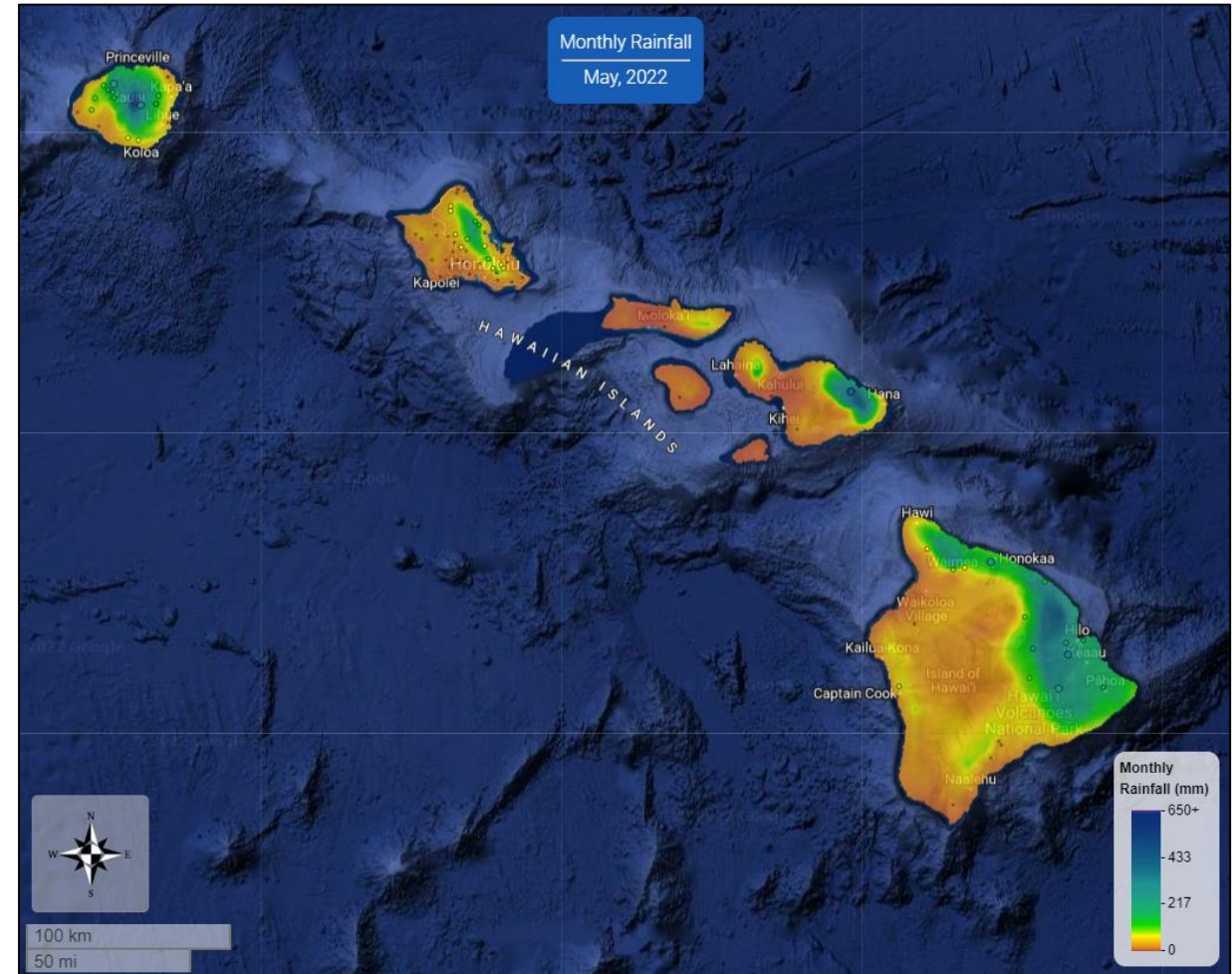


**Pacific
Islands
Development
Program**



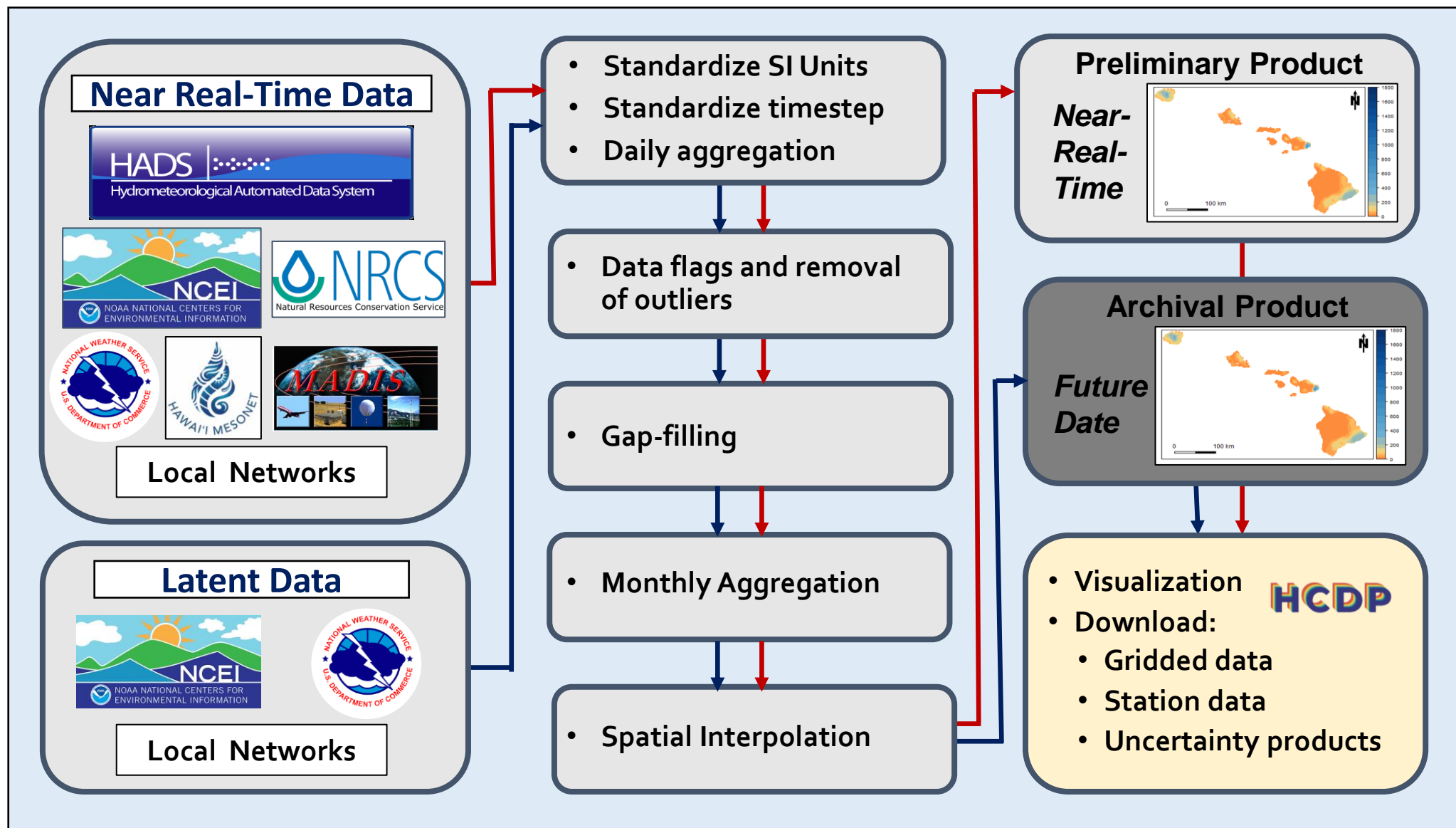
Linkages with the HCDP

- What is the HCDP?
- NRT information for Ranchers
- Building in cyber infrastructure to completely automate CCVD
- Near-real-time portfolios with a click.
- New products coming online.
 - Fire Risk Maps
 - Land cover maps
 - Vegetation maps
 - Daily rainfall
 - Much more



<https://www.hawaii.edu/climate-data-portal/>

Monthly Rainfall Workflow

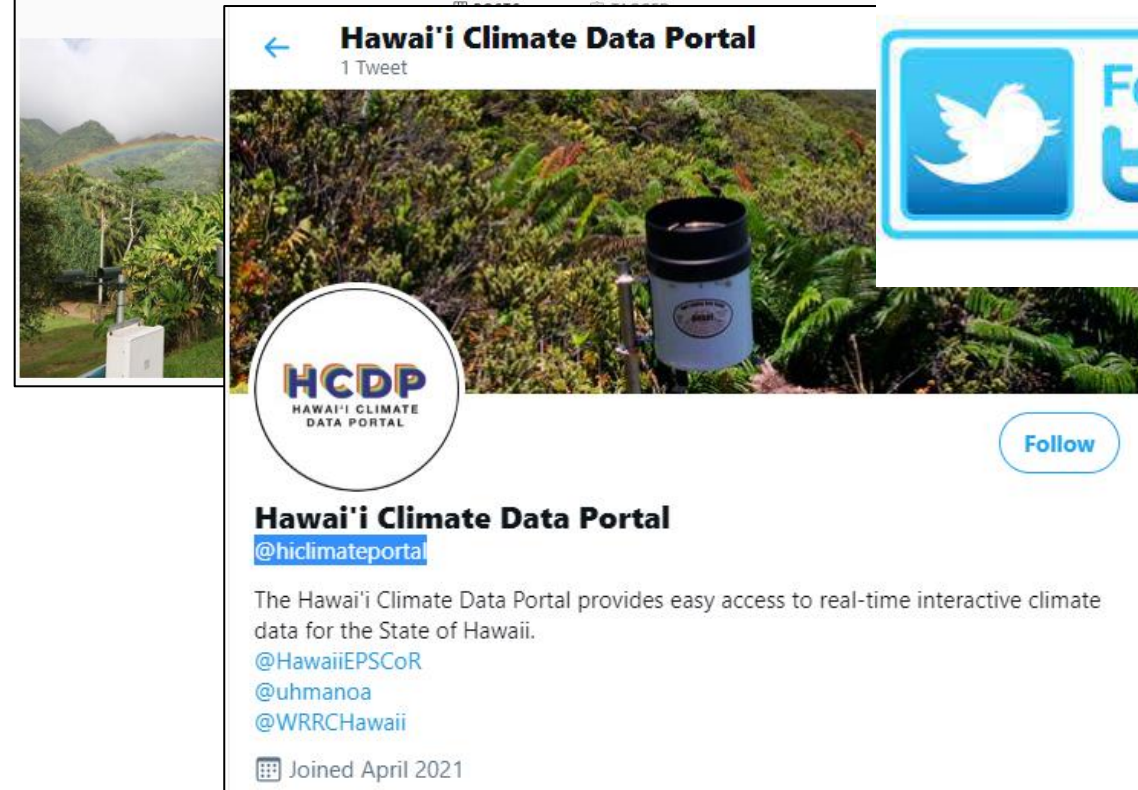
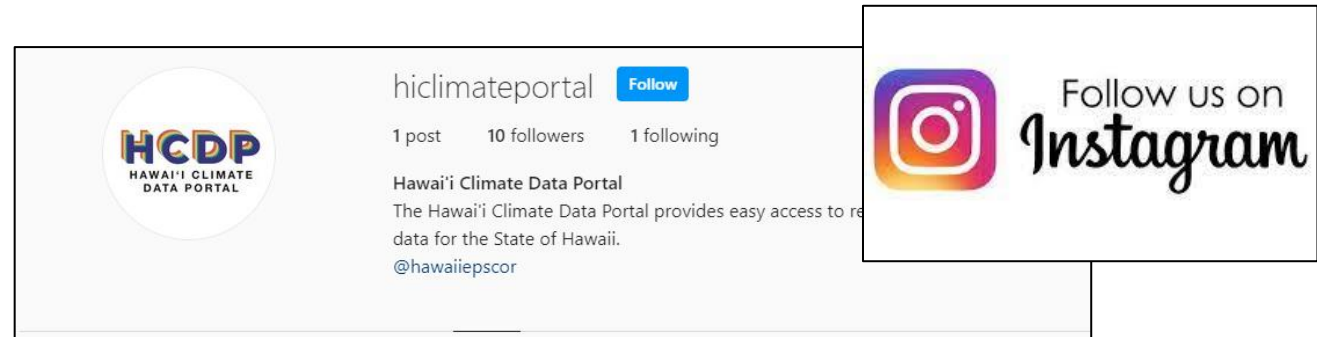


Social Media

hiclimateportal

Weekly Post (Thursday)

- Current Weather
- Future Projections
- Historical trends
- New Research
- Cultural Knowledge
- Ongoing projects



Aimee Schriber
UHM WRRC

Conclusions

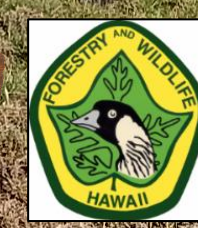
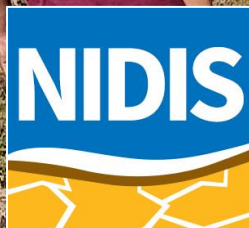


- Pilot project demonstrated success of this co-production model
- We have expanded the PDKE to work with a diverse group of partners across Hawaii & Pacific
- We are continuing to grow our team! Building an Alliance!
- The future looks bright!

Mahalo!

Huge thanks to" Abby Frazier, Christian Giardina, Elliott Parsons, Sierra McDaniel, Melissa Kunz, Romina King, Christine Fejeran, Farron Taijeron, Derek Ford, Cherryle Heu, Jim Potemra, John Marra, Carolyn Auwelo, Nicole Galase, Clay Trauernicht, Susan Cordell, Alyssa Anderson, Neil Fujii, Kevin Kodama, David Helweg, Katie Kamelamela, Emily Sesno, Courtney Peterson, Emile Elias, SW Climate Hub, NIDIS, Darren Learner, Viki Keener, Laura Brewington, Mari-Vaughn Johnson, Heather Kerkering, Rachel Lentz, Patrick Grady, and Darcy Yogi, Sean Cleveland, Jared Mclean, Michael Dodge, Keri Kodama, Matt Lucas, Aimee Schriber, and Tom Giambeluca, Tammy Tabe, and Mary Hattori.

LongmanR@EastWestCenter.org



The Hawai'i Rangeland Information Portal

Cherryle Heu

Natural Resources and Environmental Management Department

University of Hawai'i at Mānoa

cherryle@hawaii.edu

EWC Legislative Lunch Briefing

April 14, 2023





Pacific Drought Knowledge Exchange

- Demonstrate four aspects of a knowledge exchange:

1. Sector- and geography- specific climate information
2. Improved Technical Assistance
3. Better and more comprehensive information
4. More collaborative information transfer (co-production)

Stewardship Team



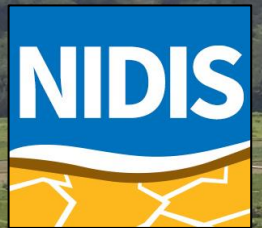
Dr. Ryan Longman
East-West Center



Dr. Abby Frazier
Clark University



Dr. Christian Giardina
US Forest Service



Dr. Alyssa Anderson
UHM Sea Grant
PI-CASC



Derek Ford
East-West Center



Cherryle Heu
UHM NREM

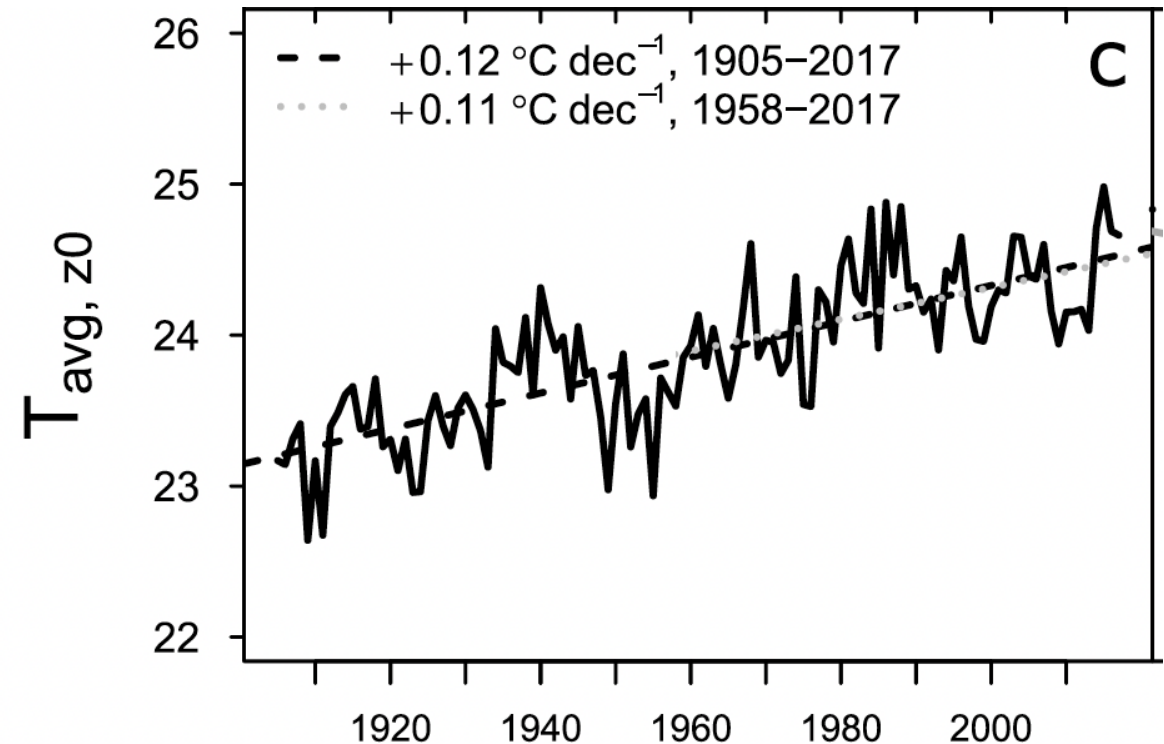


Patrick Grady
UHM Sea Grant
PI-CASC

Hawai'i Historical Trends: **Temperature**

- Globally: 0.08°C (0.14°F) per decade since 1880
- In Hawai'i: 0.12°C (0.22°F) per decade since 1905
- Warming at sea-level and high elevations

Sea Level Temperature

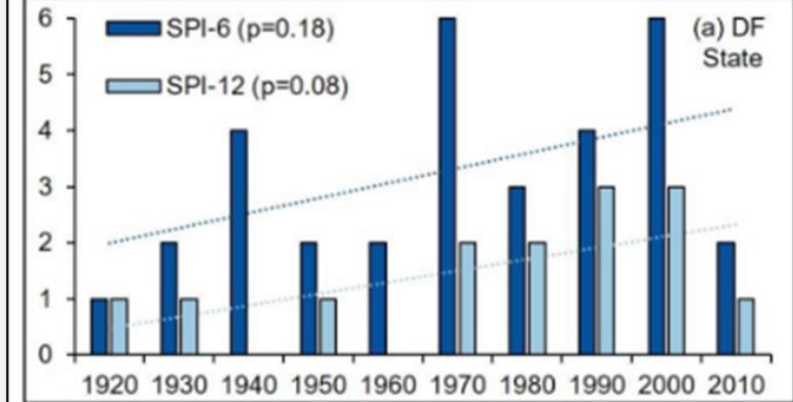


Kagawa-Viviani and Giambelluca (2020)

Hawai'i Extremes: Drought

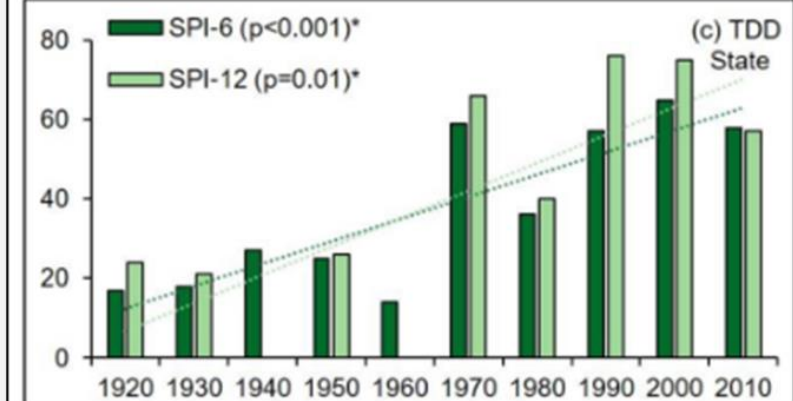
- Drought Frequency: Increasing
- Drought Duration: Increasing
 - Statistically Significant
- Drought Magnitude: Increasing
 - Statistically Significant

Drought
Frequency



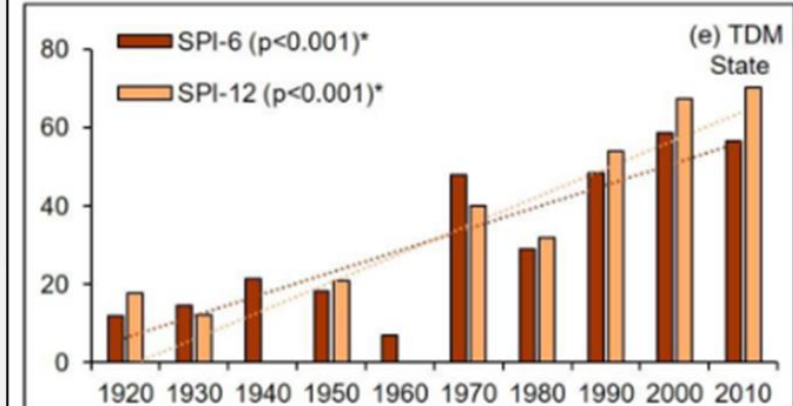
↑
Increasing

Drought
Duration



↑
Increasing
Significant

Drought
Magnitude



↑
Increasing
Significant

Frazier et al.
2022

The Hawai'i Range Land Information Portal H-RIP



Drought Decision Support Tool for Ranchers

Hawai'i Rangeland Information Portal (H-RIP)

- Tool to help ranchers:
 - Gain easy access to data
 - Proactively plan for drought
 - Understand the climate better



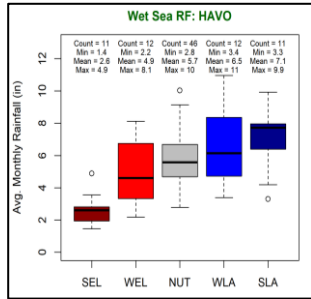
5-Functions of the H-RIP Tool

1. Real-time information on Hawai'i climate
Site Specific
2. Near-real-time climate from the HCDP
3. Three-month projection of rainfall & forage growth
4. Decision support metrics
5. Historical trends and climatology's

Three-Month Forecast

1

Classify Historical Rainfall
by ENSO Phase

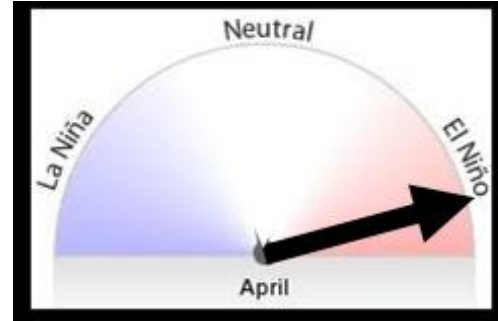


| | |
|-----|----------------|
| SEL | Strong El Nino |
| WEL | Weak El Nino |
| NUT | Neutral |
| WLN | Weak La Nina |
| SLN | Strong La Nina |

- Almanac perspective
- Average & worst case scenarios.

2

Identifying the
Current ENSO phase



3

Using Avg. & Min.
RF to calculate
forage growth



Metrics

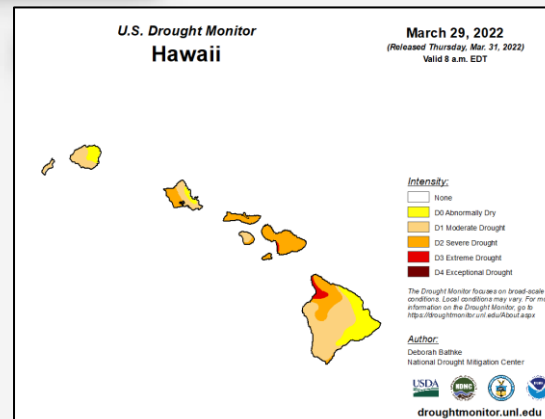
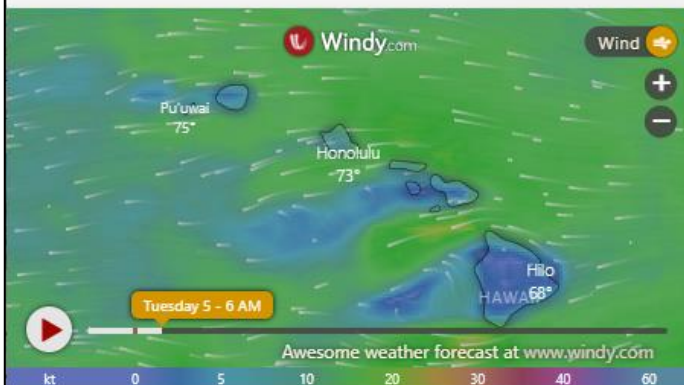
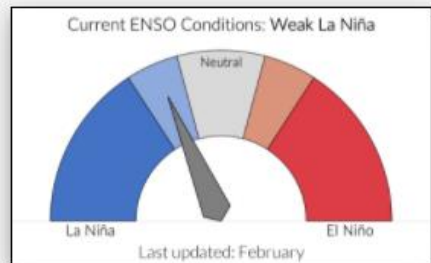
- Quarterly Forage Production
- Site Stability
- Number of grazing days



Welcome to H-RIP

[Learn more](#)

Statewide Conditions - April, 2022

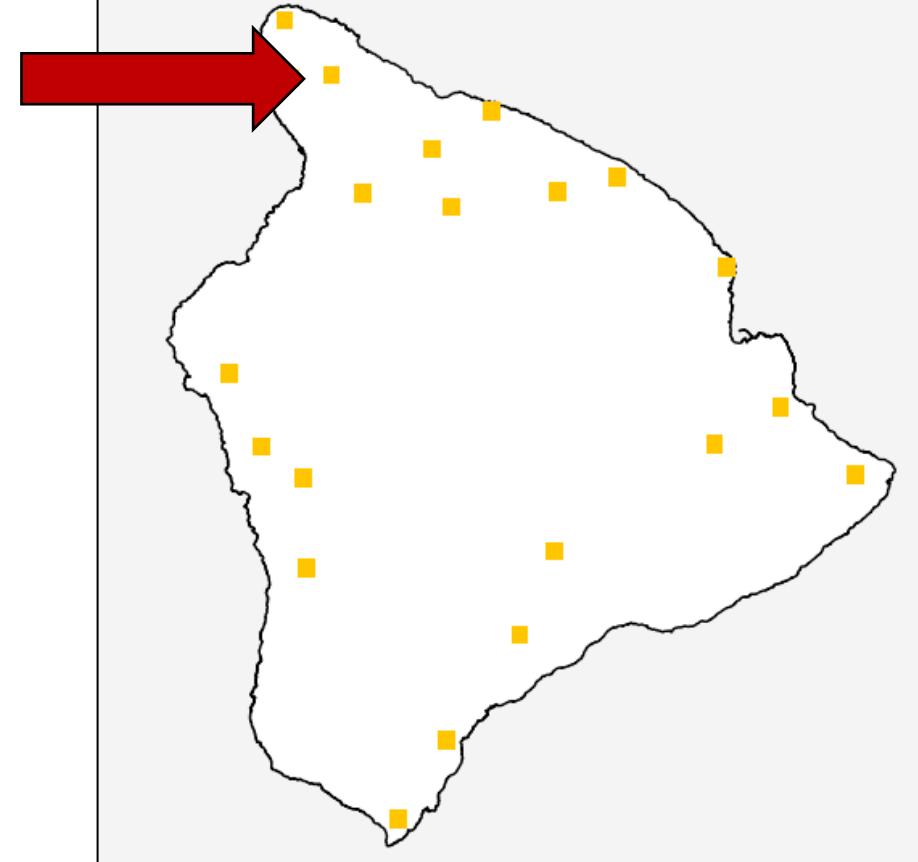


Select an island from the dropdown below.

Hawai'i Island ▼

Click on an area of interest to view site-specific data.

Map view: ☒ No Data ☐ Rainfall ☐ Evapotranspiration



The Decision support tool asks for four inputs: Grass type, dry matter per animal unit, number of an

* required field

Grass Type:

Kikuyu Grass

Dry matter per animal units:

26

Number of animal units: *

150

Number of acres grazed: *

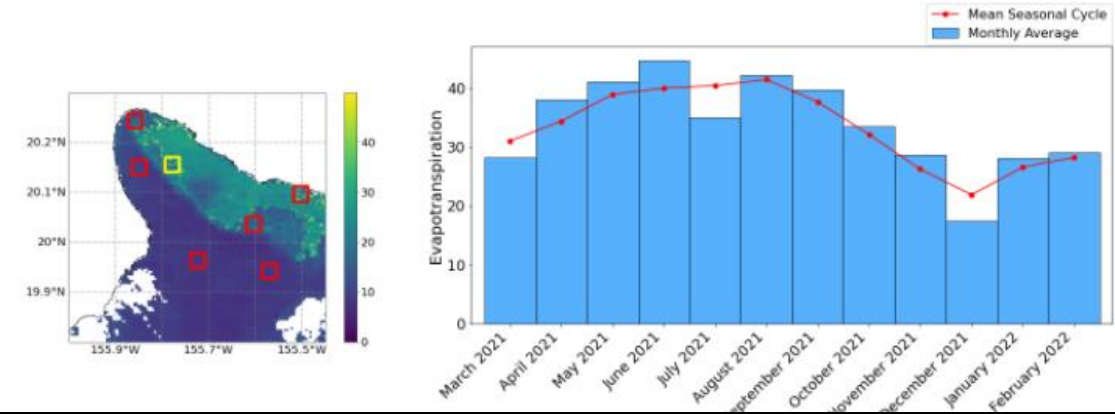
42

Submit

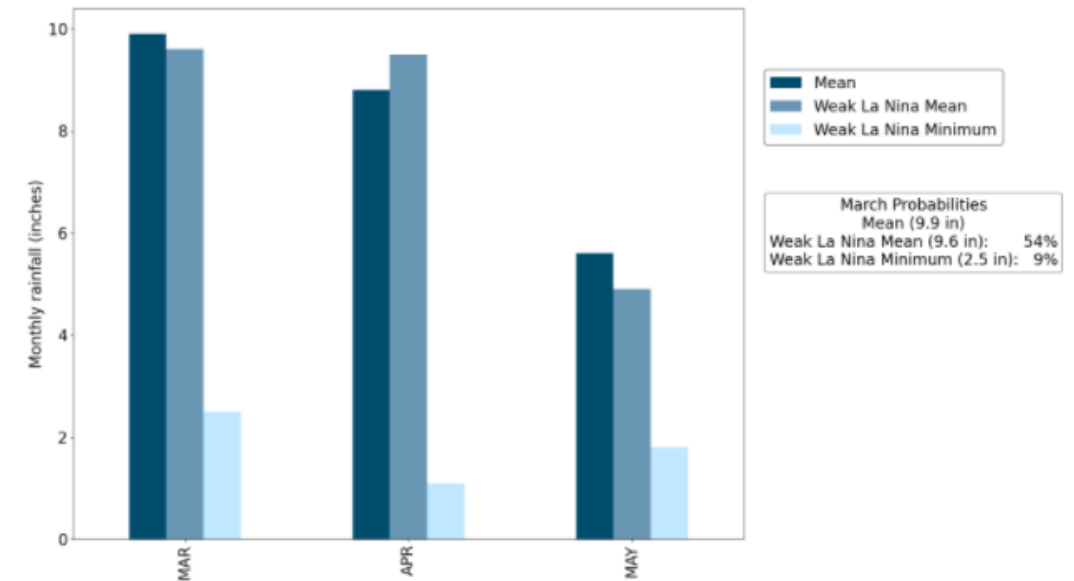
Average Climate Conditions

☐ Rainfall ☐ Temperature ☒ Evapotranspiration ☐ NDVI

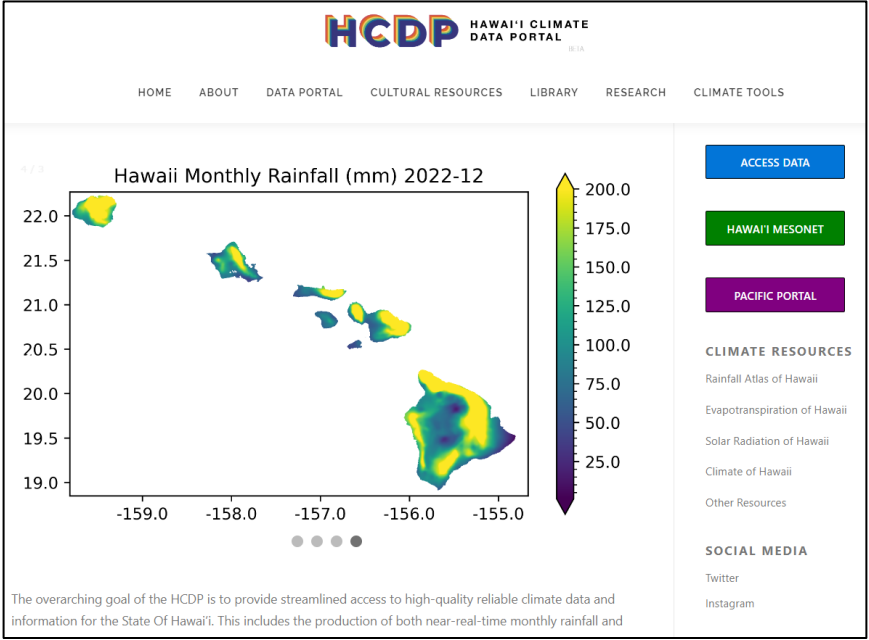
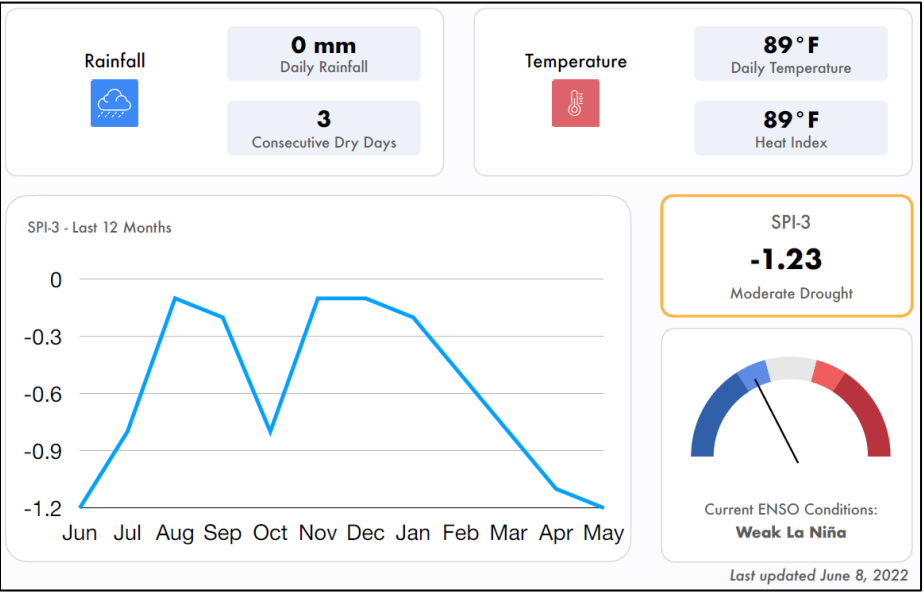
Evapotranspiration (mm/8 days) ①



3-Month Rainfall Projections



Site-specific Climate Dashboards



Where we are headed?

- Working with USDA Dept of Ag. Risk Management Agency (RMA), to bring insurance options to ranchers in Hawai'i.





The Hawai'i Rangeland Information Portal

Cherryle Heu

Natural Resources and Environmental Management Program
University of Hawai'i at Mānoa





Pacific Drought Knowledge Exchange

- 1 Sector- and geography- specific climate information
- 2 Improved technical assistance
- 3 Better and more comprehensive information
- 4 More collaborative information transfer (co-production)

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PI-CASC



Derek Ford
East West Center



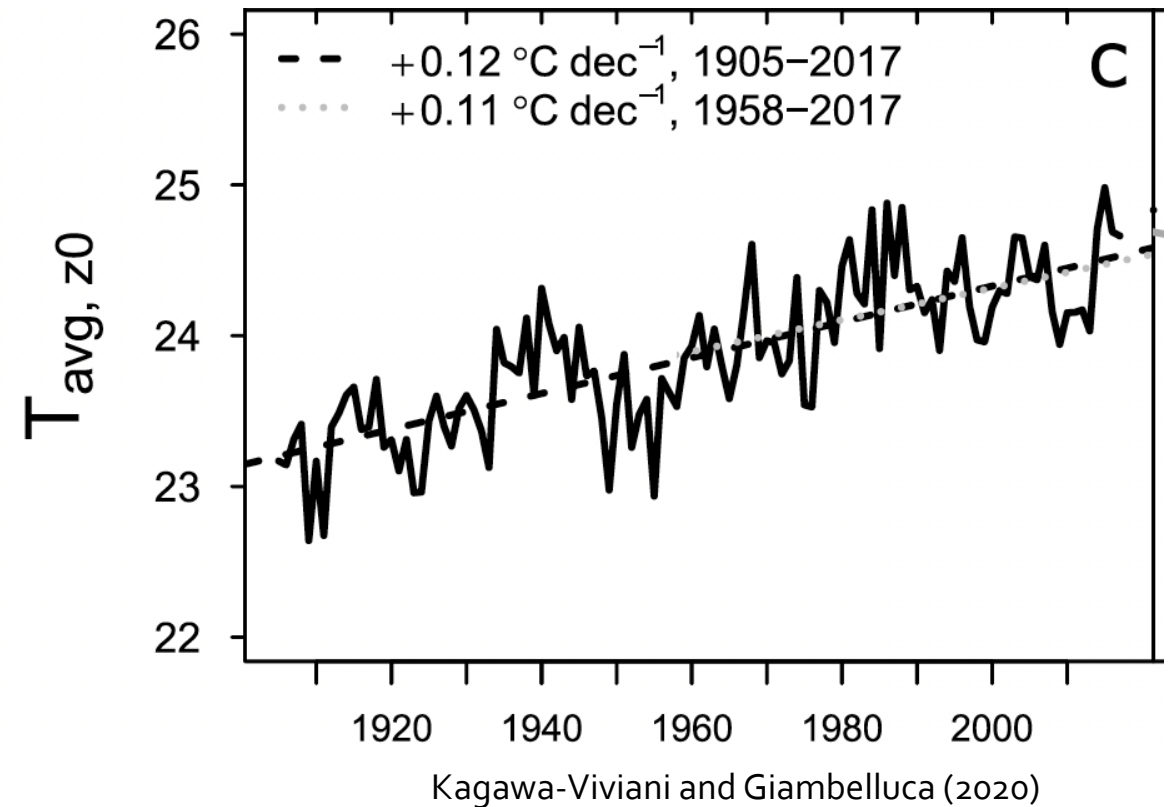
Cherryle Heu
UHM NREM



Patrick Grady
UHM Sea Grant
PI-CASC

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- Warming at sea-level and high elevations



Hawai'i Extremes: Drought



Drought Frequency



Drought Duration

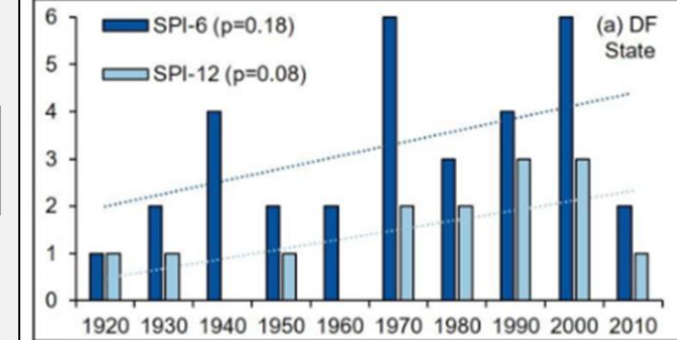
*statistically significant



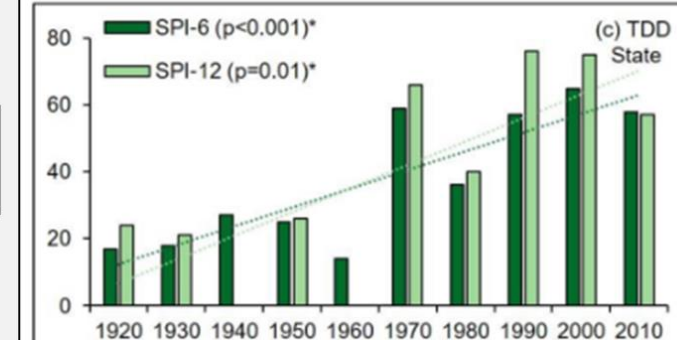
Drought Magnitude

*statistically significant

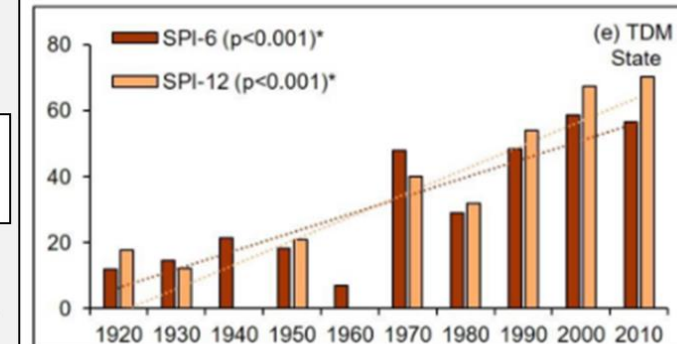
Drought
Frequency



Drought
Duration

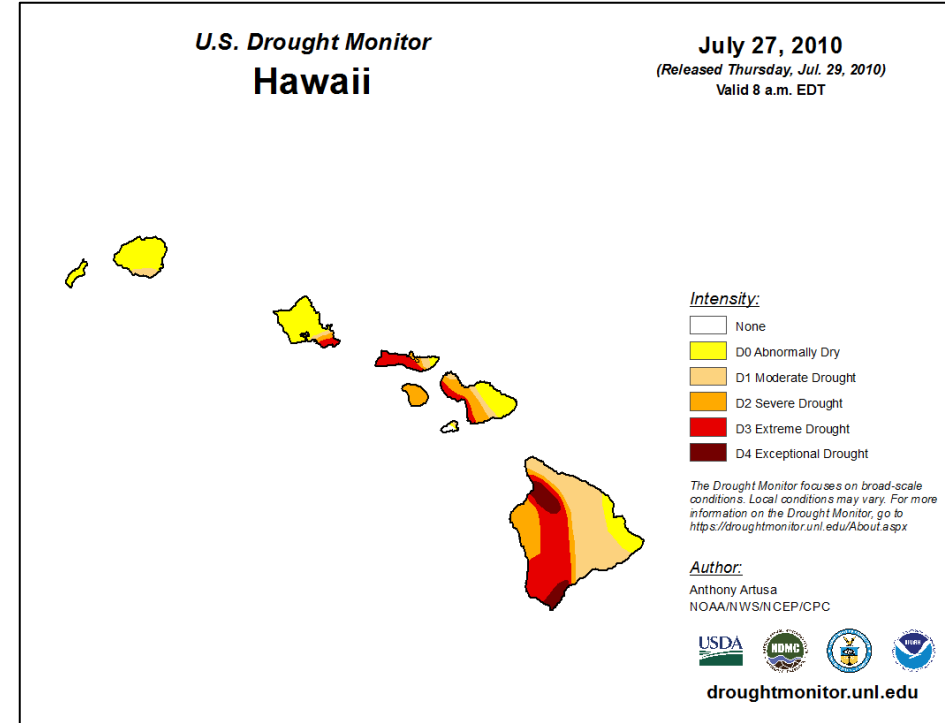


Drought
Magnitude



Frazier et al.
2022

Cattle Industry Impacts: 2008-2016 Drought



\$44.5 million **20,000+ cattle**
lost in cattle production

\$50 million+
in payout by insurance
programs

Hawai'i Rangeland Information Portal (H-RIP)

Drought Decision Support Tool for Ranchers

A tool to help ranchers:

Gain easy access to data

Proactively plan for drought

Understand the climate better



Four Site-Specific Functions of H-RIP



Near-real-time
Climate
Information



Rainfall and Forage
Growth Outlook



Ranching
Decision Support
Tool



Historical Trends
and Climatology

The background image is a wide-angle landscape photograph. It shows a lush green valley with rolling hills. In the foreground, a group of about six riders on horseback are moving across the grass. The middle ground is filled with dense, green trees and shrubs. In the background, there are large, rugged mountains with steep, forested slopes. The sky is overcast with soft, grey clouds. The overall tone is natural and serene.

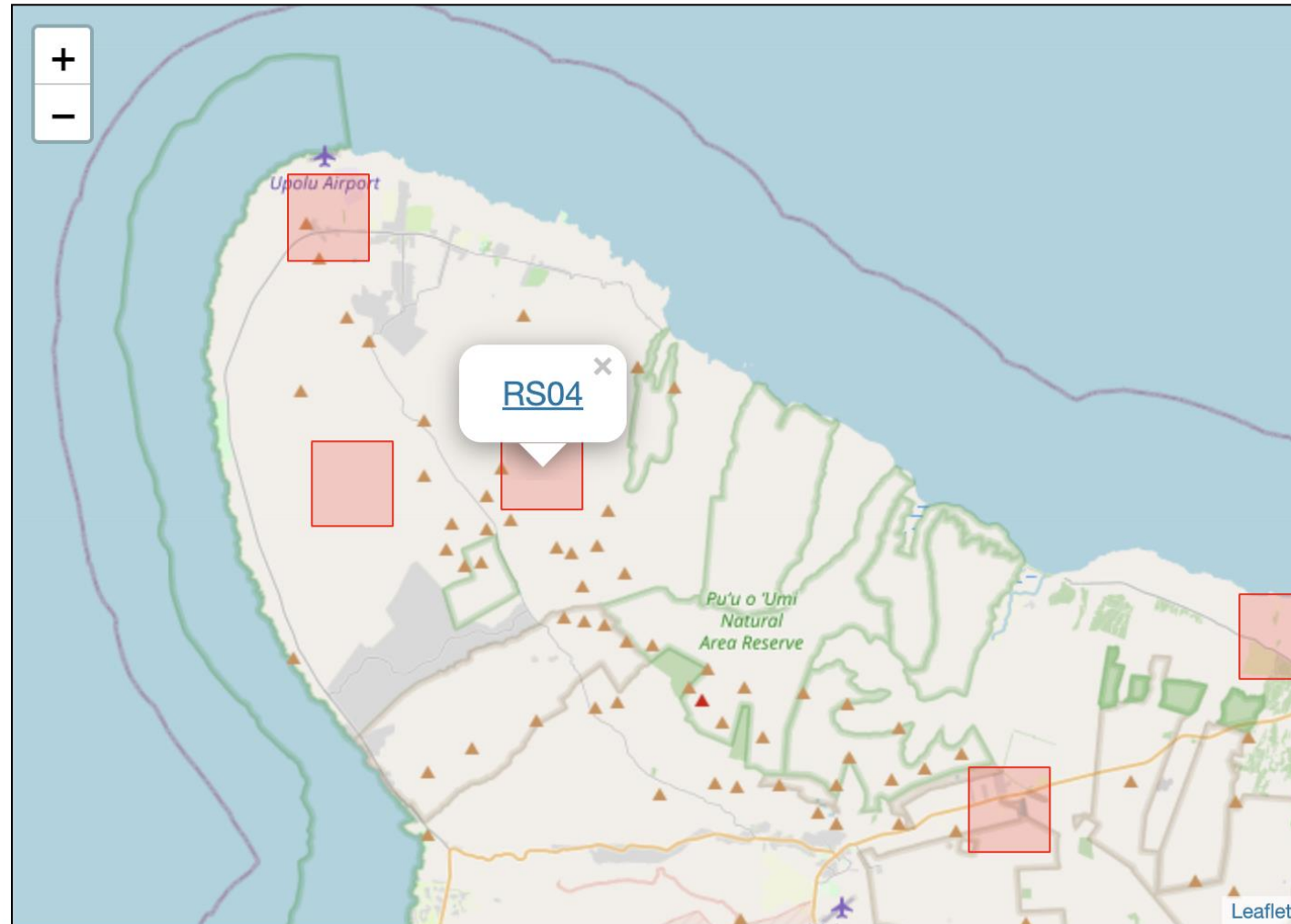
Welcome to the Hawai'i Rangeland Information Portal (H-RIP)

[Learn more](#)

Site-specific Conditions

Select an island from the dropdown below.

Hawai'i ▾





Near-real-time Climate Information

RS04 - Ranch Page

Rainfall



Daily

Monthly

March, 2023

13.14 in ^{+29%}

Total Rainfall

✓ Above Average

X total dry days

Temperature



Daily

Monthly

April 9, 2023

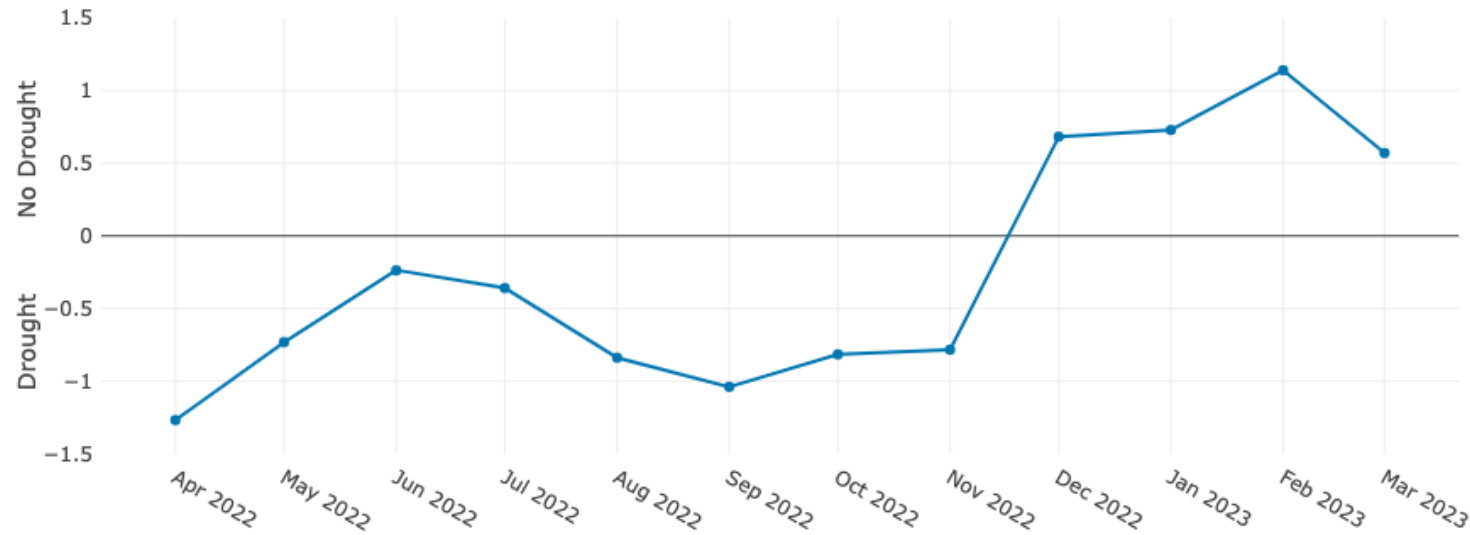
65°F

Mean Temperature 65°F

Min: 56°F Max: 74°F

12-Month Drought History

8 out of 12 months in drought



Current Drought Severity

✓ No Drought

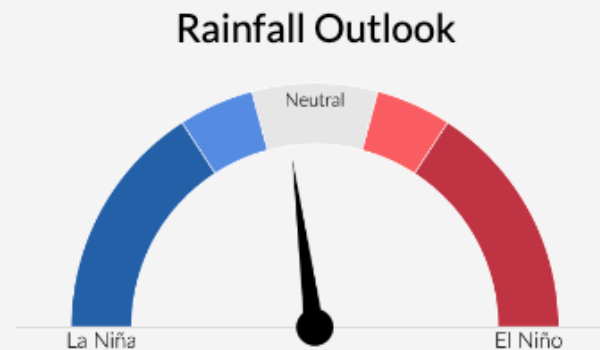


April ENSO Conditions:
Neutral

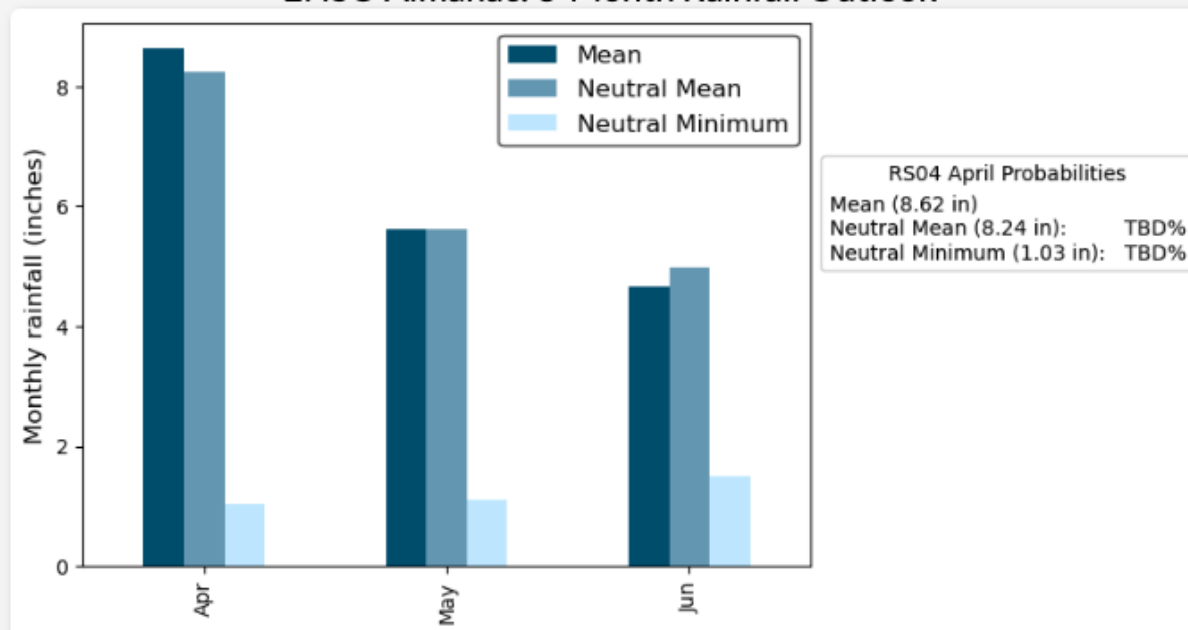
Rainfall

| | |
|----------------|----------|
| Historical Avg | 8.62 in. |
| WLA Avg | 8.96 in. |
| WLA Min | 1.06 in. |

Rainfall and Forage Growth Outlook



ENSO Almanac: 3-Month Rainfall Outlook





Ranching Decision Support Tool

Animal Management and Decision Support Tool

* required field

Grass Type:

Kikuyu Grass

Dry matter per animal units:

26

Number of animal units: *

400

Number of acres grazed: *

1000

Submit



Historical characteristics under **Neutral** Conditions

Change in Quarterly Forage Production

| | | |
|--------------------|---------|---|
| Historical Average | -0.4%↓ | → Less than average production expected |
| Historical Low | -70.9%↓ | → Less than average production expected, potential to request funds |

April Site Stability

| | | |
|--------------------|------|--------------------|
| Historical Average | 0.95 | → Site is stable |
| Historical Low | 0.11 | → Site is unstable |

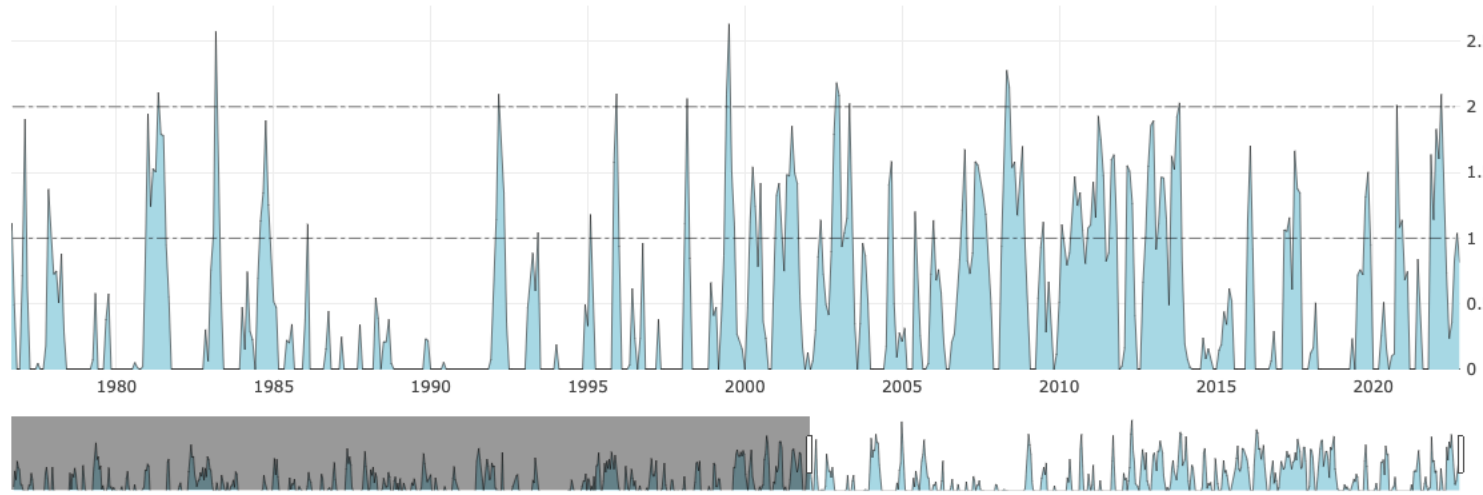
April Grazing Days

| | | |
|--------------------|---------|----------------------------------|
| Historical Average | 53 days | → Stock or do nothing |
| Historical Low | 6 days | → De-Stock or supplement feeding |

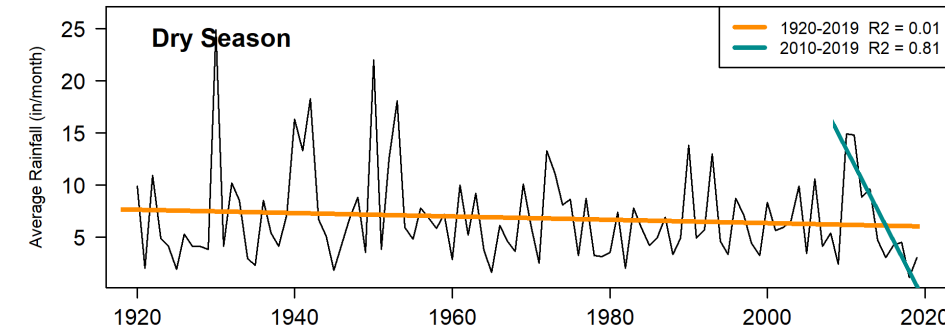
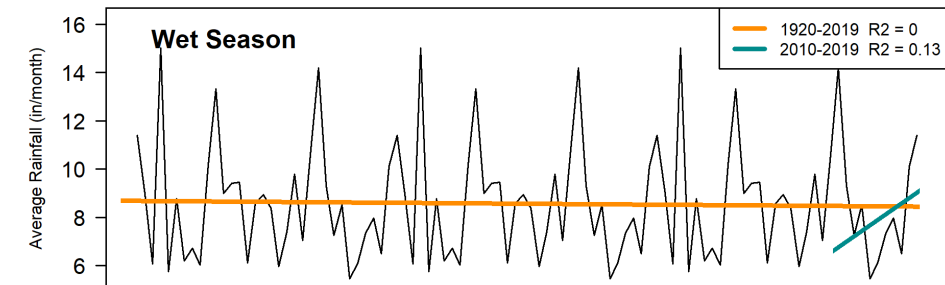
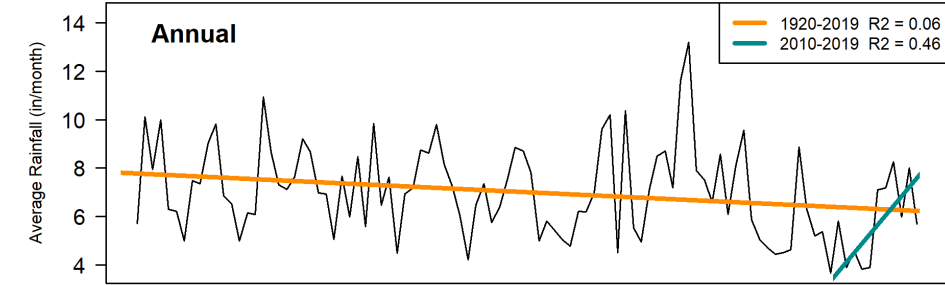


Historical Trends and Climatology

1m 6m YTD 1y all



Rainfall Trend 1920-2019: RS04_BI



A Co-Production Approach

Hawai'i Cattlemen's Council Convention, November 2022



Where are we headed?

NRCS

Further develop decision support tool for accurate real-time forage production outlook



USDA RMA

Bring insurance options to ranchers in Hawai'i.



Stakeholder Consultation



Official Launch

Fall 2023



A person with a backpack is seen from behind, walking on a dirt trail through a dense forest of ferns and trees. In the background, a valley is visible, partially obscured by a thick layer of white clouds. The sky is a clear, bright blue.

Mahalo!

Cherryle Heu
cherryle@hawaii.edu

Data at your fingertips: The frontier of climate science in Hawai'i

2023 Pacific Water Conference

February 7th, 2023

Ryan Longman, PhD
Fellow, East-West Center
Pacific Islands Development Program
Water Resources Research Center UH Manoa



Road Map

1. What we know about climate so far
2. Future climate projections
3. Advances in climate science in Hawai'i
4. Hawai'i Climate Data Portal (HCDP)
5. Future opportunities

Extreme drought on Maui, June 2010

A landscape photograph showing a lush green rice paddy field in the foreground, with rows of rice plants growing in water. The field is bordered by a grassy area. In the background, there are rolling green hills and mountains, some of which are partially covered by white clouds. The sky is overcast with grey clouds.

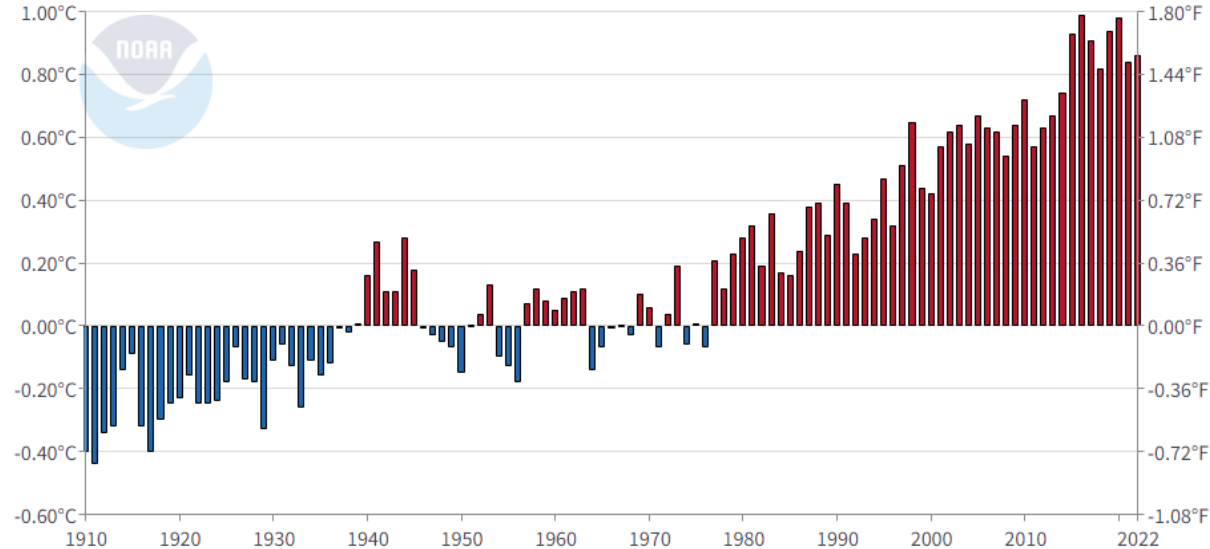
Part 1

What do we Know so far?

Temperatures are rising!

Global Land and Ocean

January-December Temperature Anomalies



How hot was 2022?

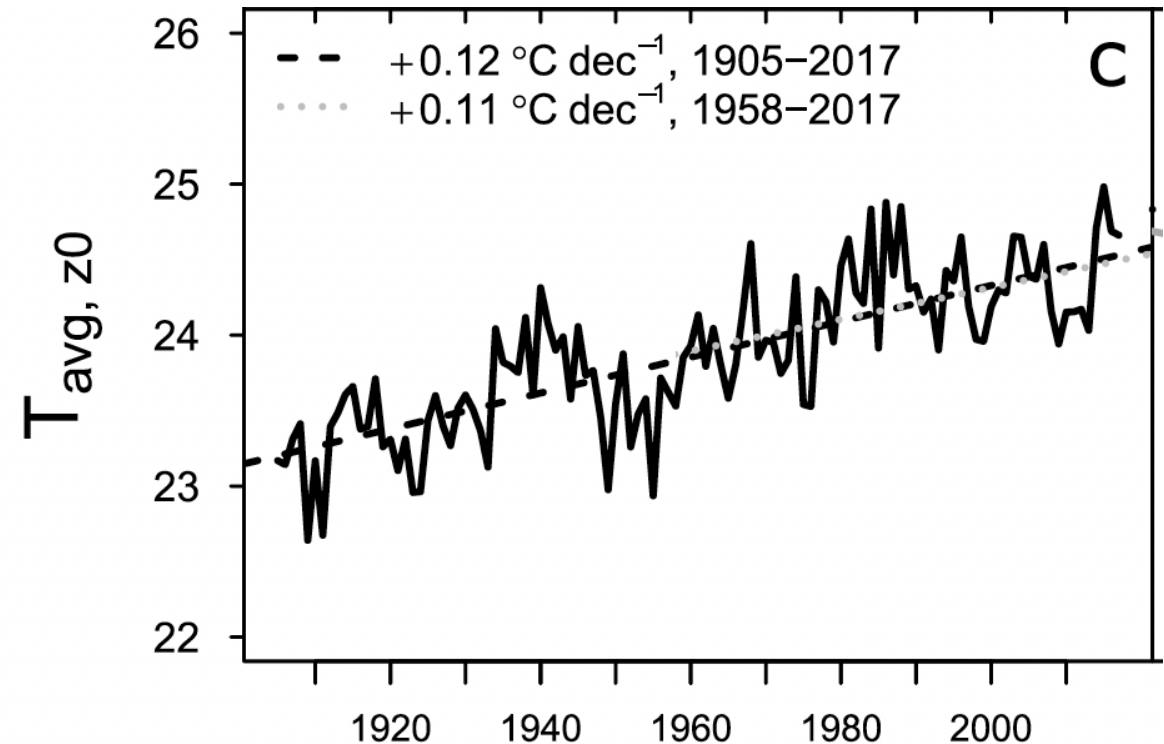
| Year | Anomaly | Rank | ENSO |
|------|---------|------|---------|
| 2016 | 0.99 | 1 | El Niño |
| 2020 | 0.98 | 2 | |
| 2019 | 0.94 | 3 | El Niño |
| 2015 | 0.93 | 4 | El Niño |
| 2017 | 0.91 | 5 | El Niño |
| 2022 | 0.86 | 6 | |
| 2021 | 0.84 | 7 | |
| 2018 | 0.82 | 8 | El Niño |

- The past 8-years have been the hottest in 143 year record.
- 46th Consecutive “warmer than average” year.
- 18 of the 19 warmest years have occurred since 2002.
- The rate of increase has been 0.08°C (0.14°F) per decade since 1880
- The rate since 1981 is 0.18°C (0.32°F). (Twice the long-term rate)

Hawai'i Historical Trends: **Temperature**

- Globally: 0.08°C (0.14°F) per decade since 1880
- In Hawai'i: 0.12°C (0.22°F) per decade since 1905
- Warming at sea-level and high elevations

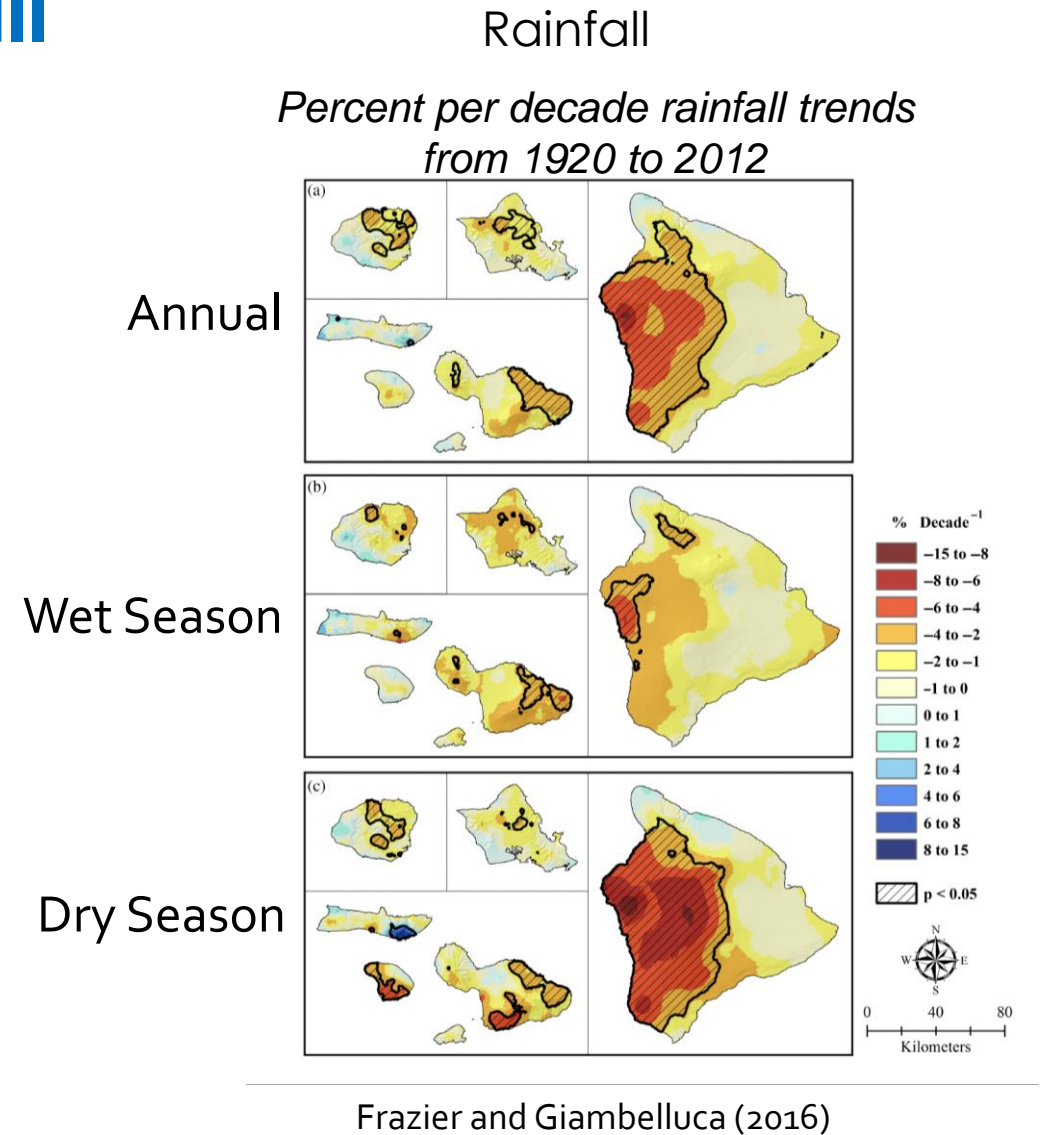
Sea Level Temperature



Kagawa-Viviani and Giambelluca (2020)

Hawai'i Historical Trends: Rainfall

- A number of studies in Hawai'i that report long-term decreases in rainfall.
- Also a study that demonstrated that the significance of the trend is determined on where you start your trend ([Frazier and Giambelluca, 2017](#)).
- Large interannual variability in rainfall ([Frazier et al. 2018](#))
- The difference between wet and dry years may dependent on the frequency and intensity of disturbance events (Kona Lows cold fronts etc.; [Longman et al., 2020](#))

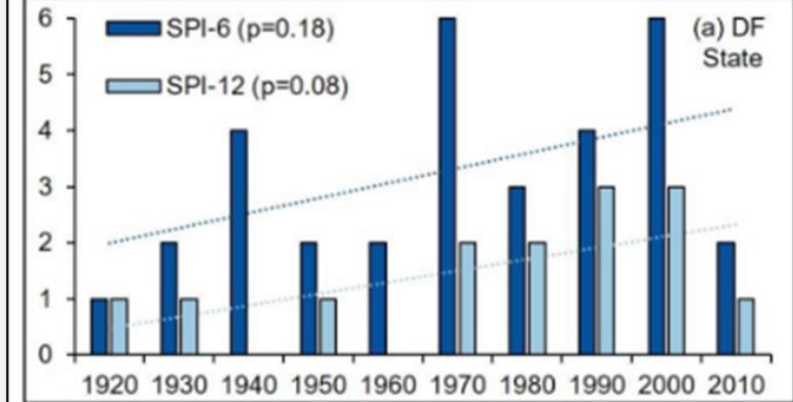


- Long-term rainfall decline in most areas

Hawai'i Extremes: Drought

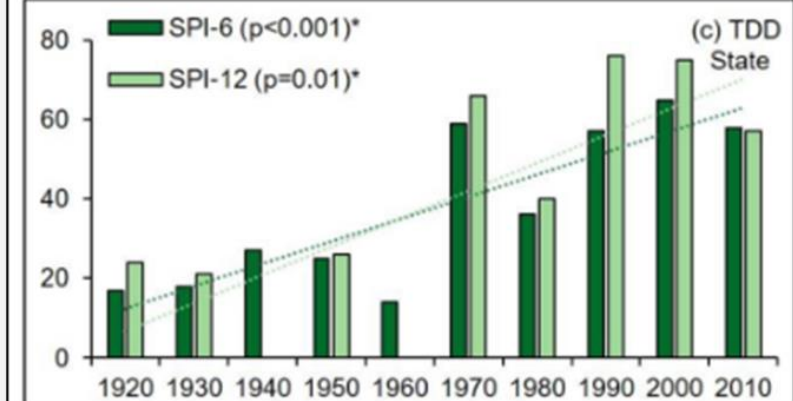
- Drought Frequency: Increasing
- Drought Duration: Increasing
 - Statistically Significant
- Drought Magnitude: Increasing
 - Statistically Significant

Drought
Frequency



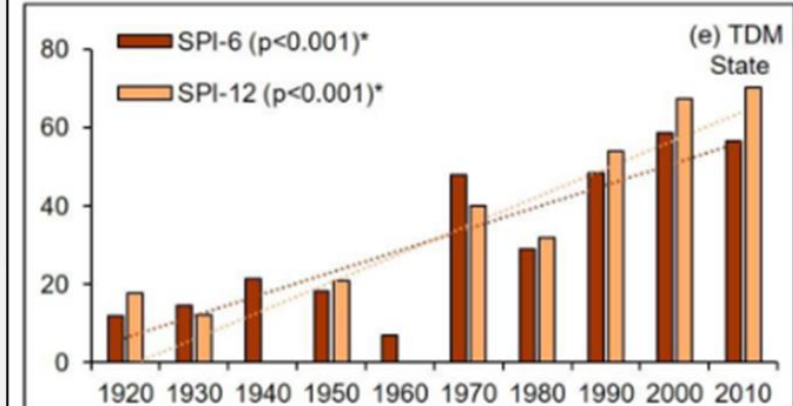
↑
Increasing

Drought
Duration



↑
Increasing
Significant

Drought
Magnitude



↑
Increasing
Significant

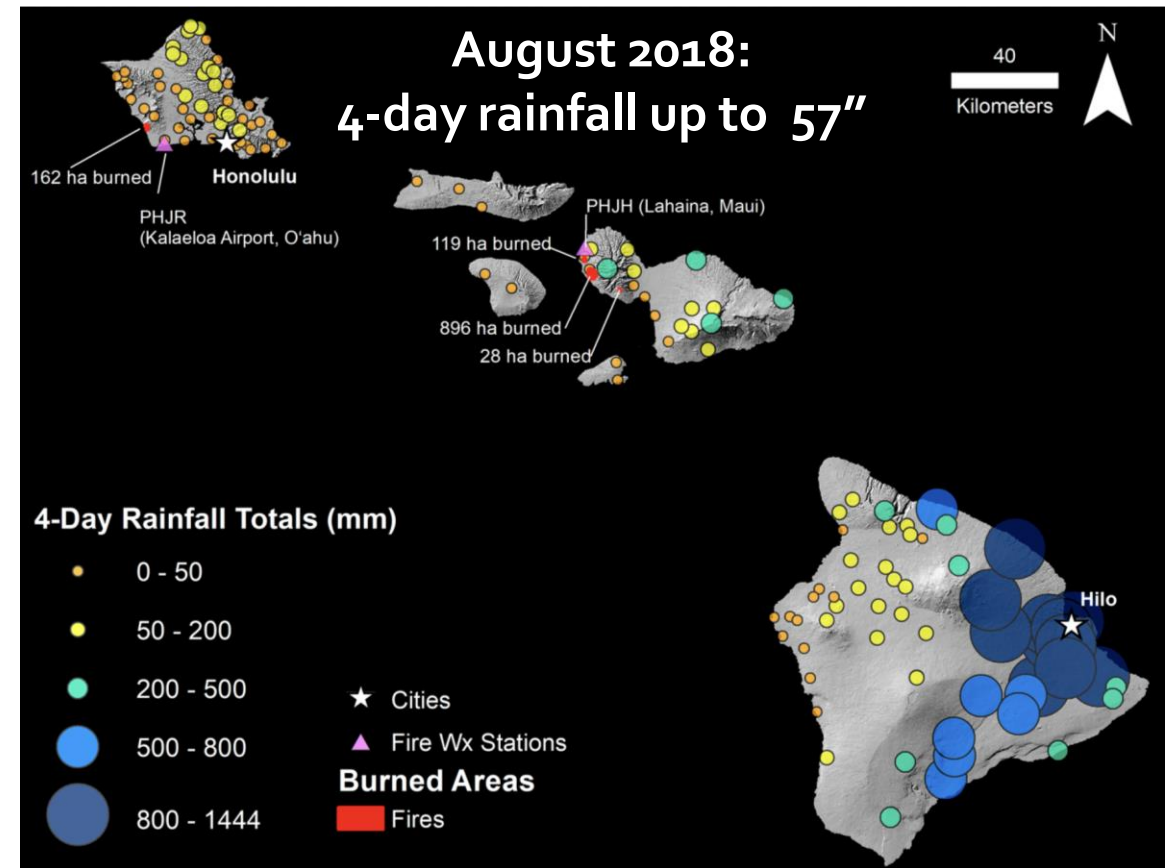
Frazier et al.
2022

Hawai'i Rainfall Extremes: Flooding

Hawai'i has recently seen unprecedented extreme rainfall and flooding



Halele'a, Kaua'i, April 2018 (Photo: Civil Beat)



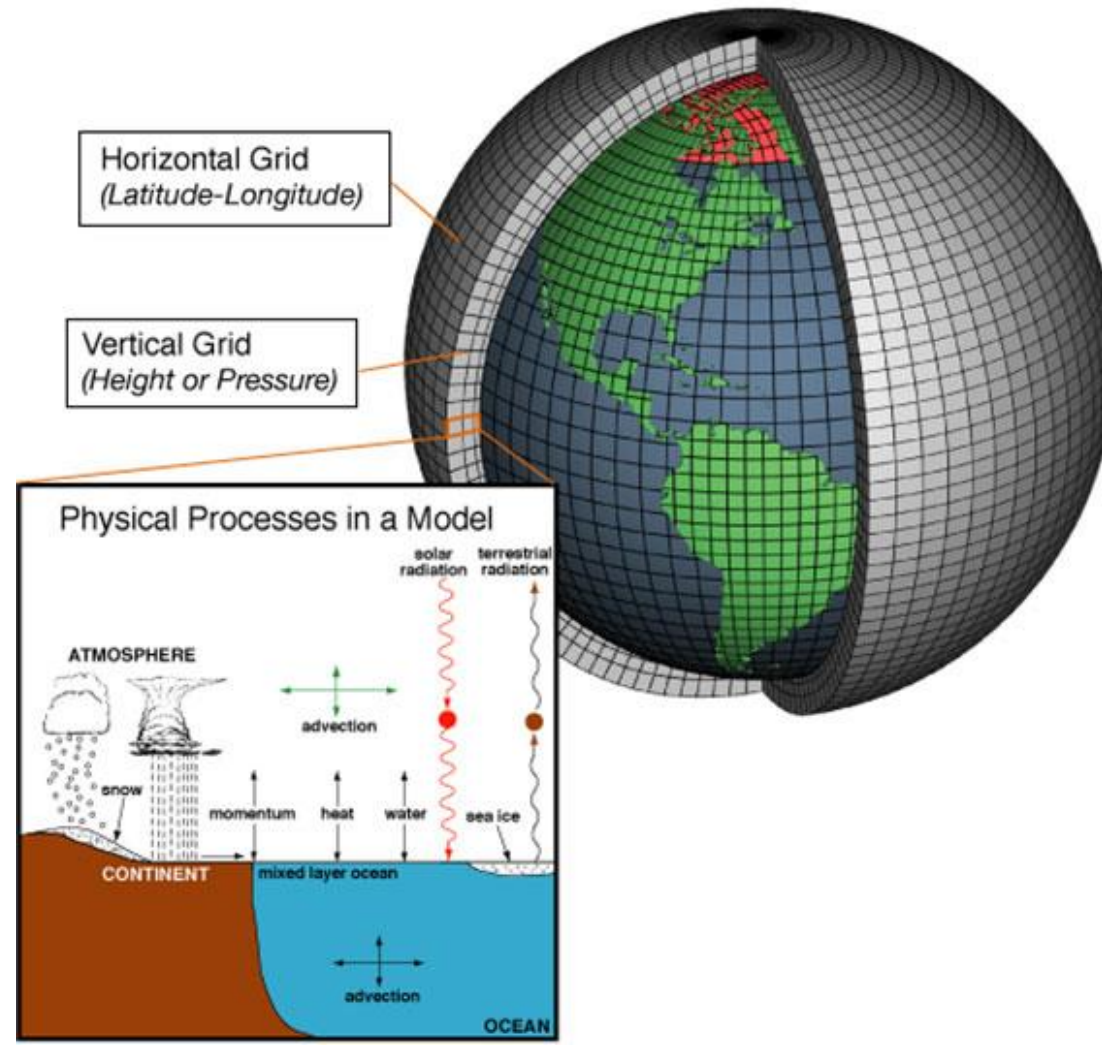
Hurricane Lane, August 2018 (Nugent et al. 2020)

A scenic landscape photograph showing a dense, green forest covering rolling hills. In the foreground, there's a small, dark pond surrounded by thick vegetation, including some flowering shrubs. The background features more forested hills under a bright, slightly hazy sky. The overall tone is natural and serene.

Part 2

What do models tell us about the future?

The best tool for projecting future climate changes – Global Earth System Models



Why use a climate model?

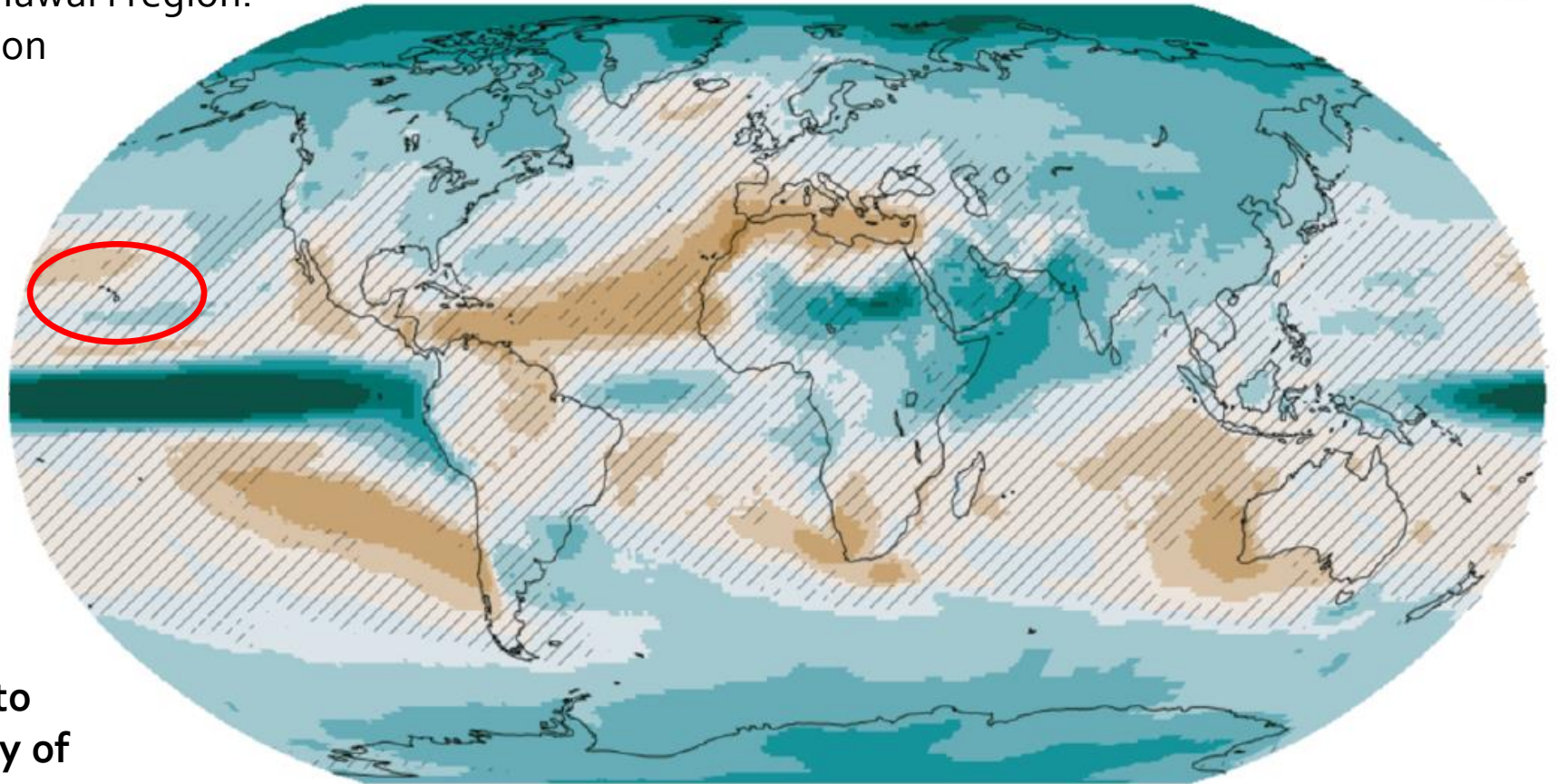
- No observations from the future
- No other planet earth to experiment with
- Models help predict future changes
- Models help understand the processes related to change
- Models can be tested by simulating past climate and comparing results with observations

(a) Precipitation

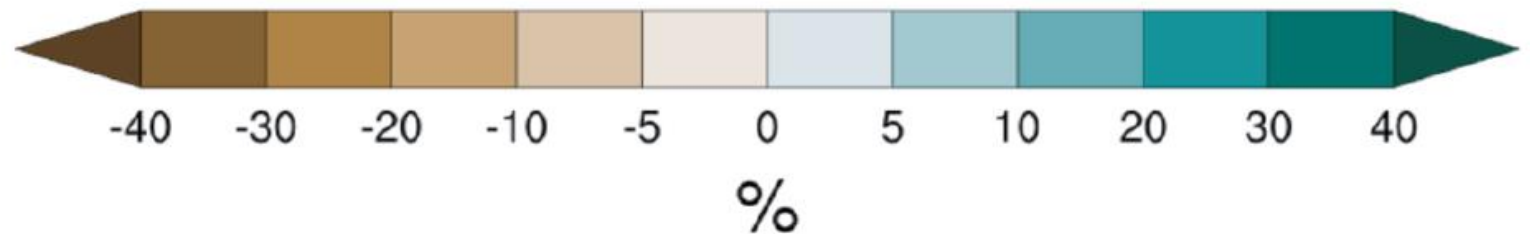
38

Global model projections for the Hawai'i region:

- Near zero change in precipitation
- Low model agreement

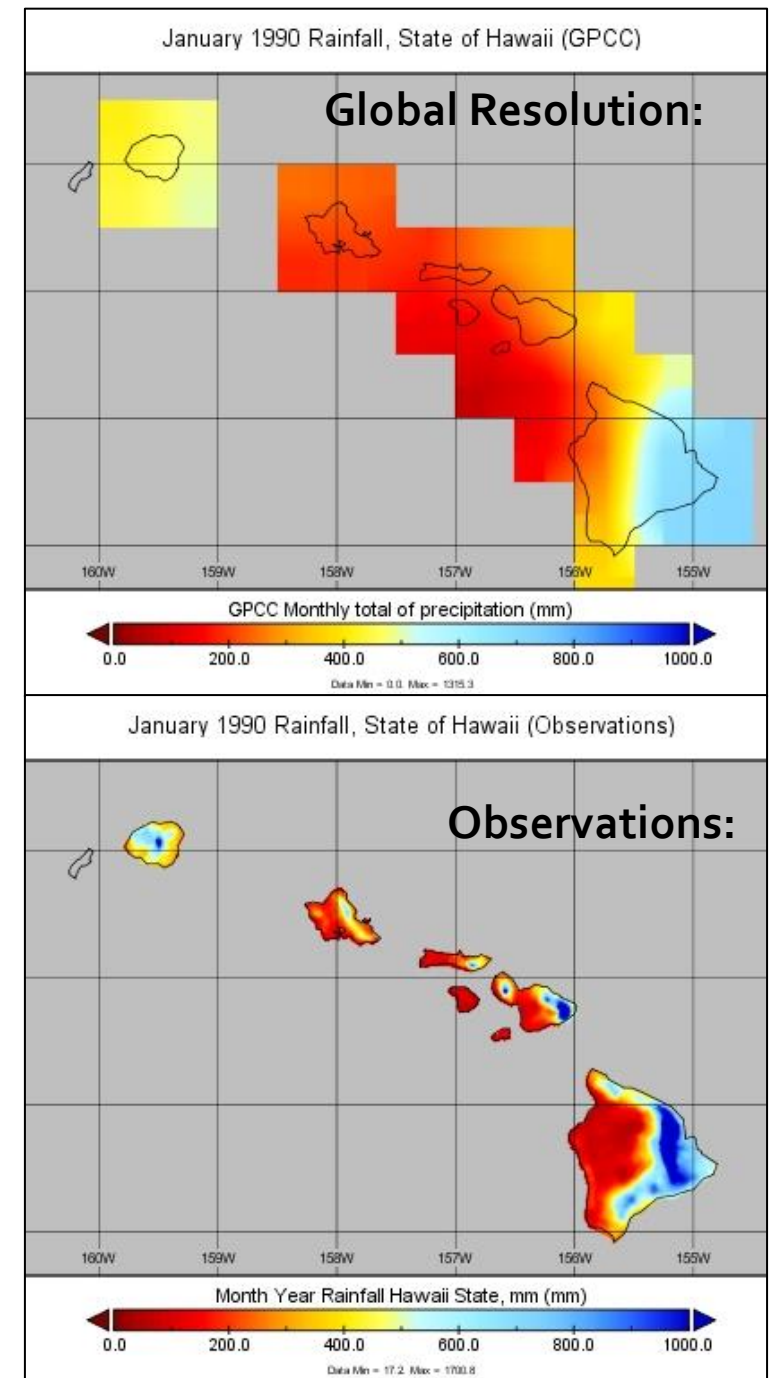


But global models are too coarse to represent the complex topography of the islands.

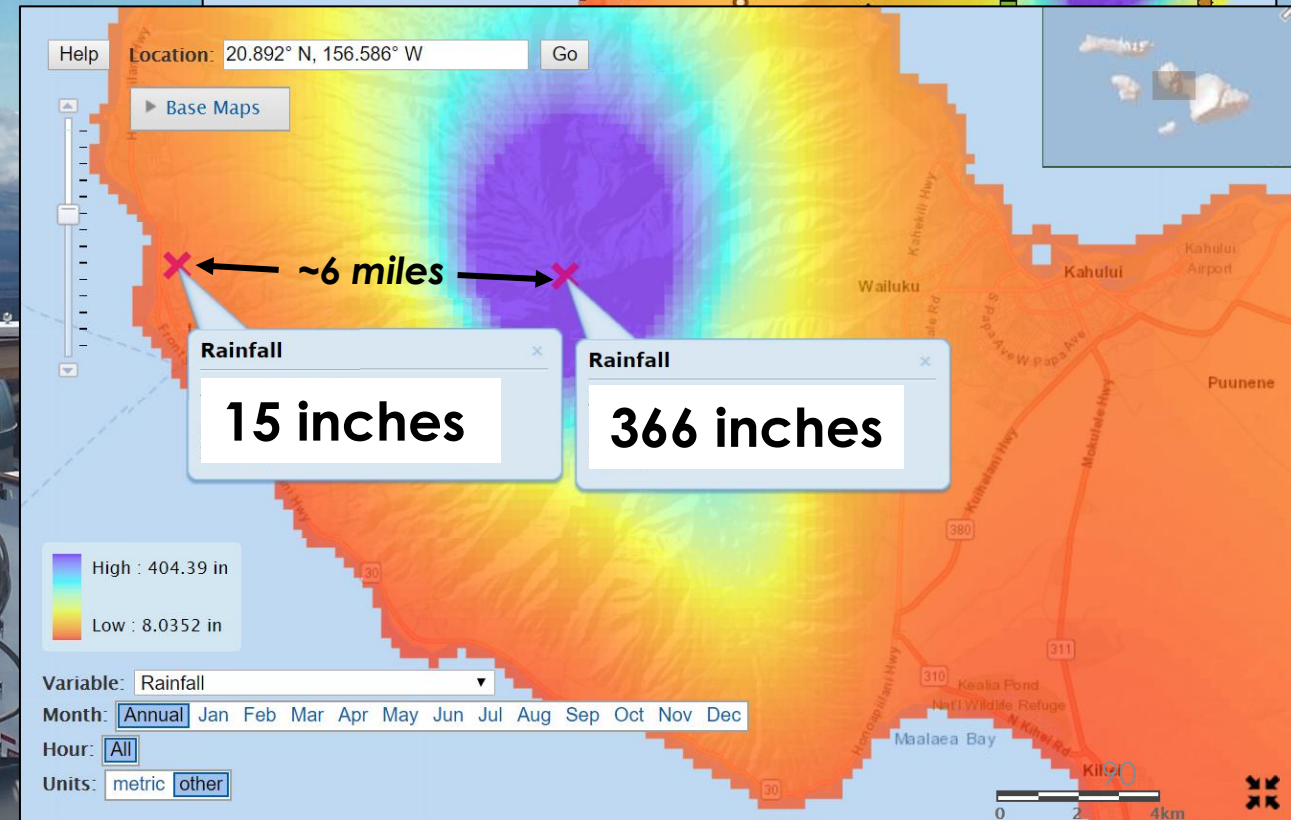
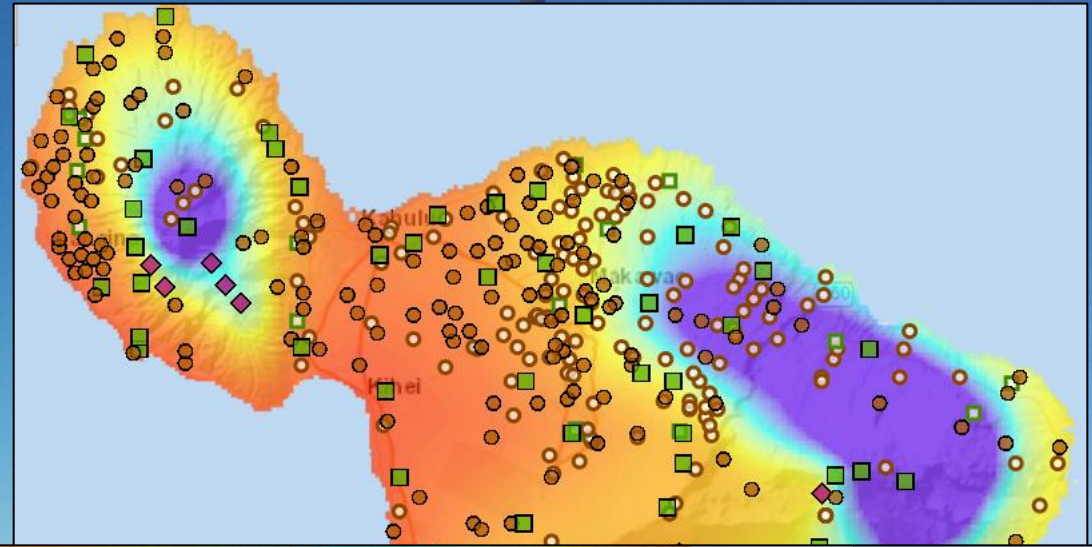


Model Projections are too course for Hawai'i

- Global Earth System Models are used to simulate Earth's future climate under various scenarios
- Cannot capture Hawai'i's **complex small-scale processes/topography**
 - Entire state may fit in 3 or 4 grid cells

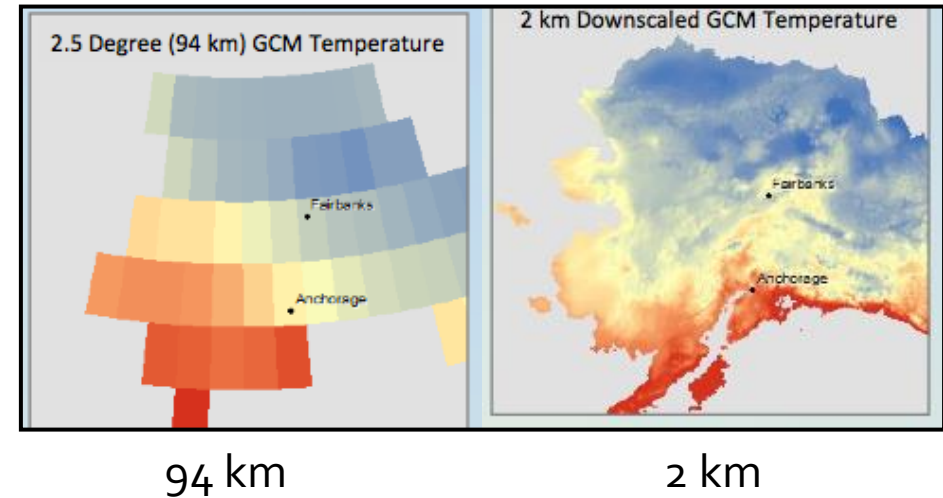


Need high resolution data to capture steep gradients and complex local patterns...



Downscaling

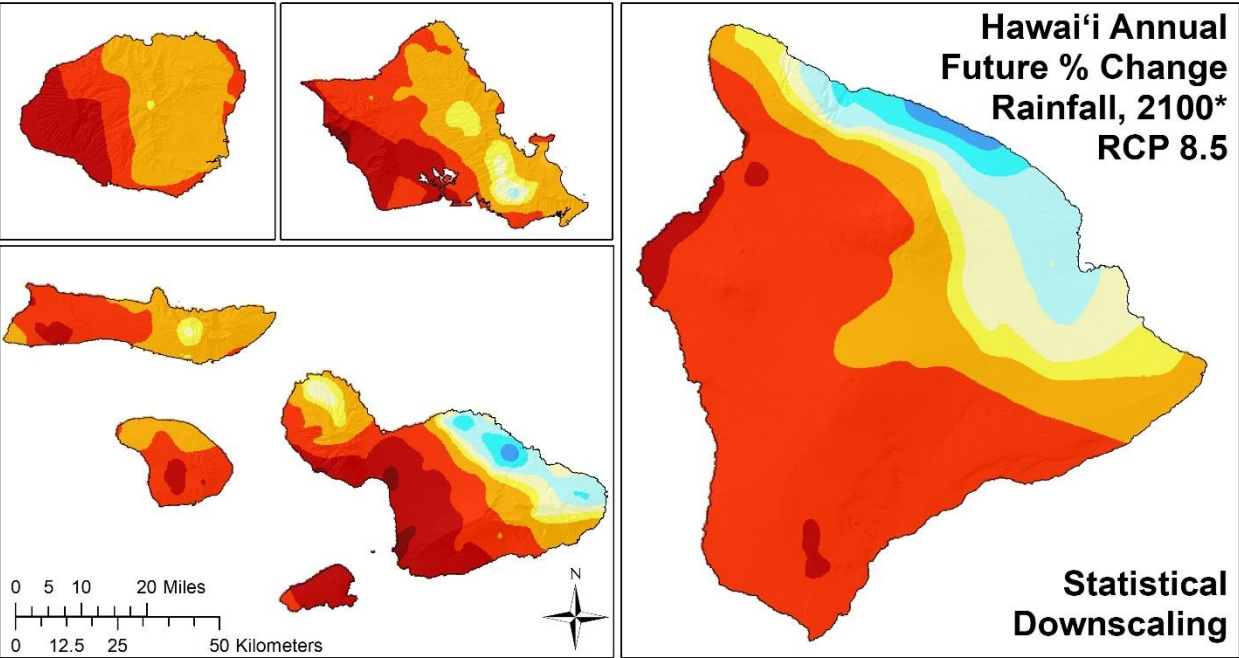
- “**Downscaling**” used to relate global model results to local-scale
- 2 main types of Downscaling:
 - **Statistical**
 - **Dynamical**



- Downscaled climate projections have been produced for Hawai'i
 - We currently have several different sets of projections
 - Difficult to access and use

Future % Change Annual Rainfall, RCP8.5

Statistical Downscaling

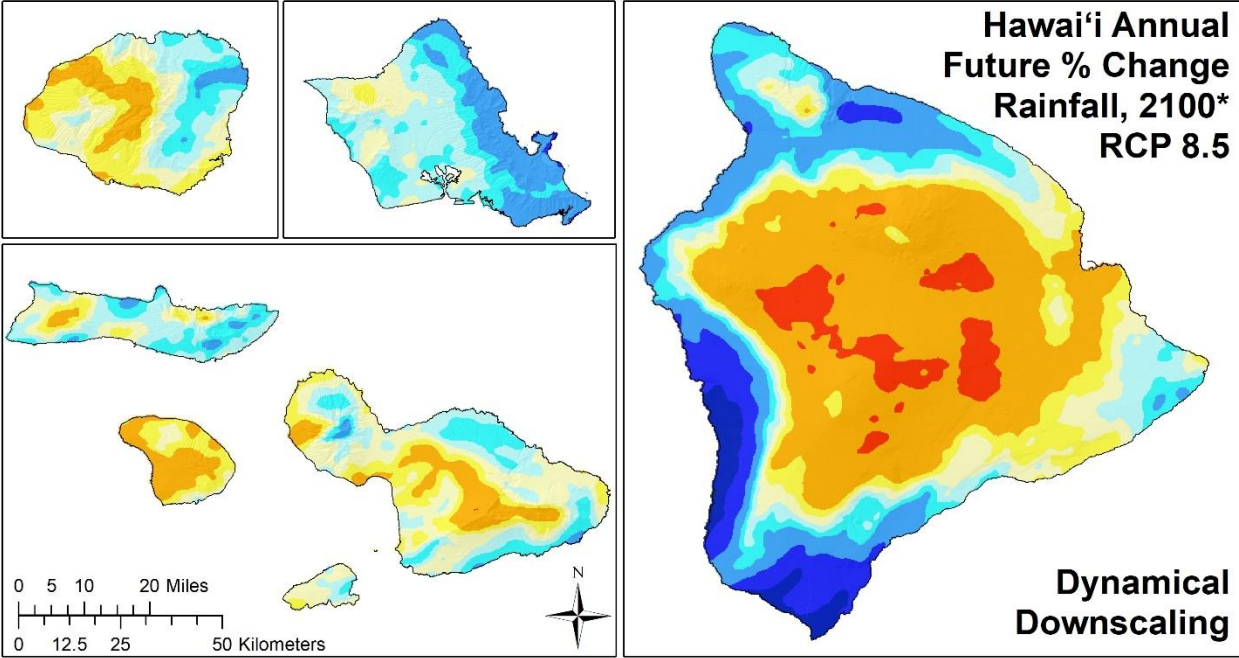


Data Sources:
Oliver Elison Timm. See Elison Timm et al. 2015, Journal of Geophysical Research: Atmospheres

Processing and Map by Abby Frazier (abbyf@hawaii.edu), East-West Center. 5/31/2019

*Future Percent Change in Rainfall, 2070-2099

Dynamical Downscaling



Data Sources:
Chunxi Zhang. See Zhang et al. 2016, Journal of Climate

Processing and Map by Abby Frazier (abbyf@hawaii.edu), East-West Center. 5/31/2019

*Future Percent Change in Rainfall, 2080-2099

Annual Rainfall,
RCP 8.5

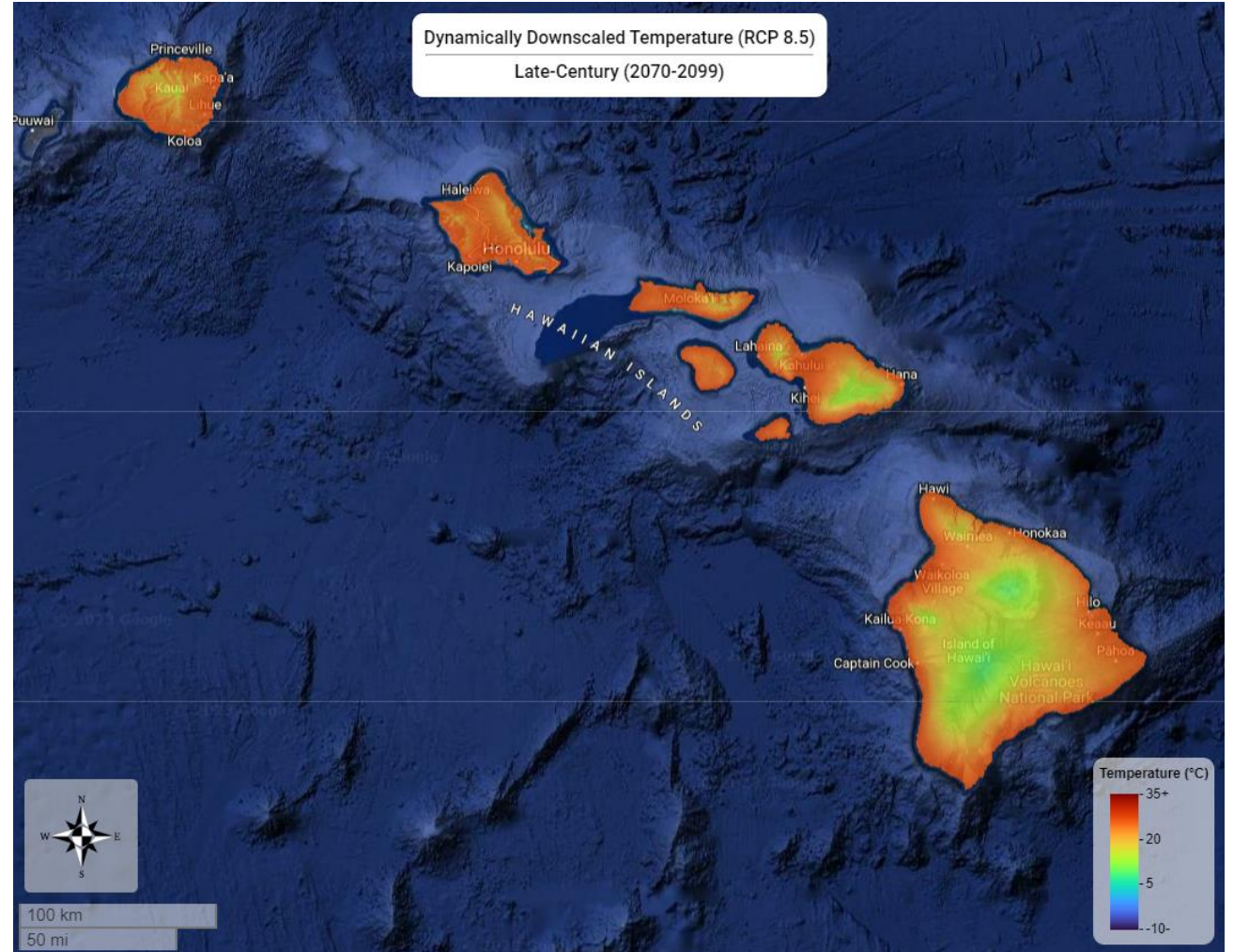
Frazier et al., *in prep.*

General Patterns:

- Leeward areas drier, High Elevations drier
- Windward areas slightly wetter

Future Temperature

- Models are in fairly good agreement.
- They all say hotter!!
- End Century 3°F to 7°F
- Largest warming occurring at high elevations.



Part 3

The Advances in Climate Science in Hawai'i



The Data Lifecycle



Data
Monitoring



Data
Processing



Data
Storage

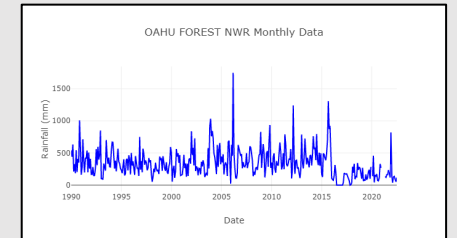
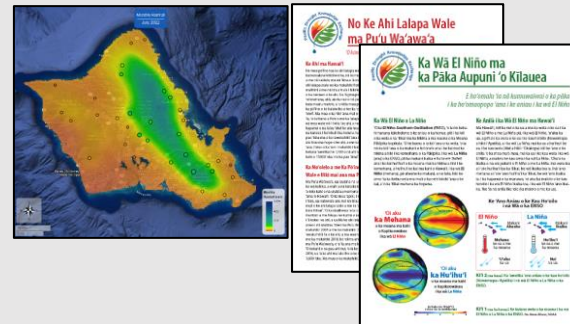
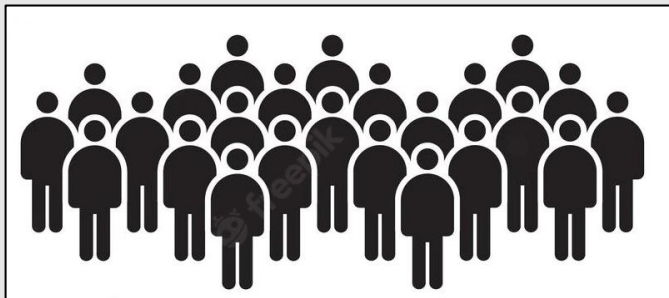


Data
Access

Data
Analysis

Data
Products

Data
Dissemination

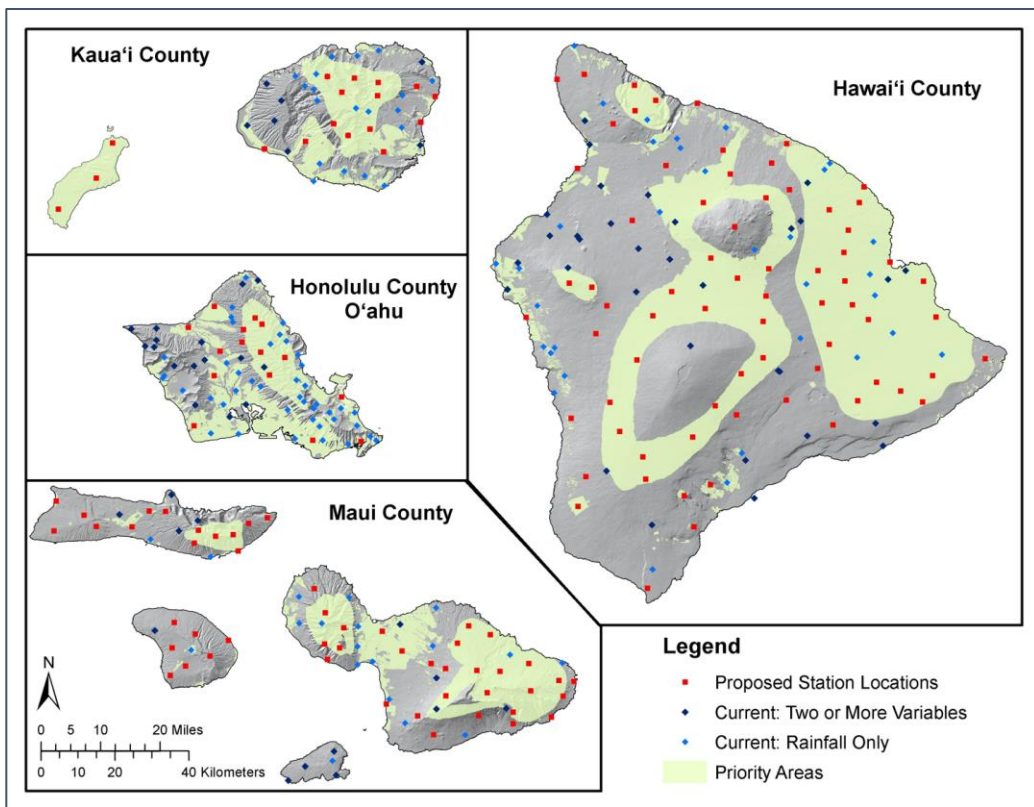




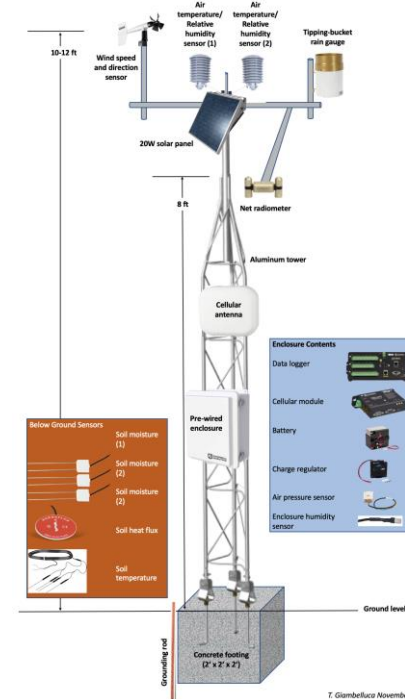
Data Monitoring



HAWAI'I MESONET



~ 95 New Stations

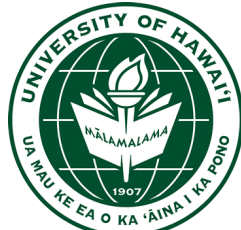




Data Processing

What do we do with raw data?

- This is a huge component that is hard to address and often overlooked.
- Quality Control and Quality Assurance (Qa/Qc)
- The ChangeHI project supports the development of HCDP cyber-infrastructure to support the QaQc of MesoNet and other data.

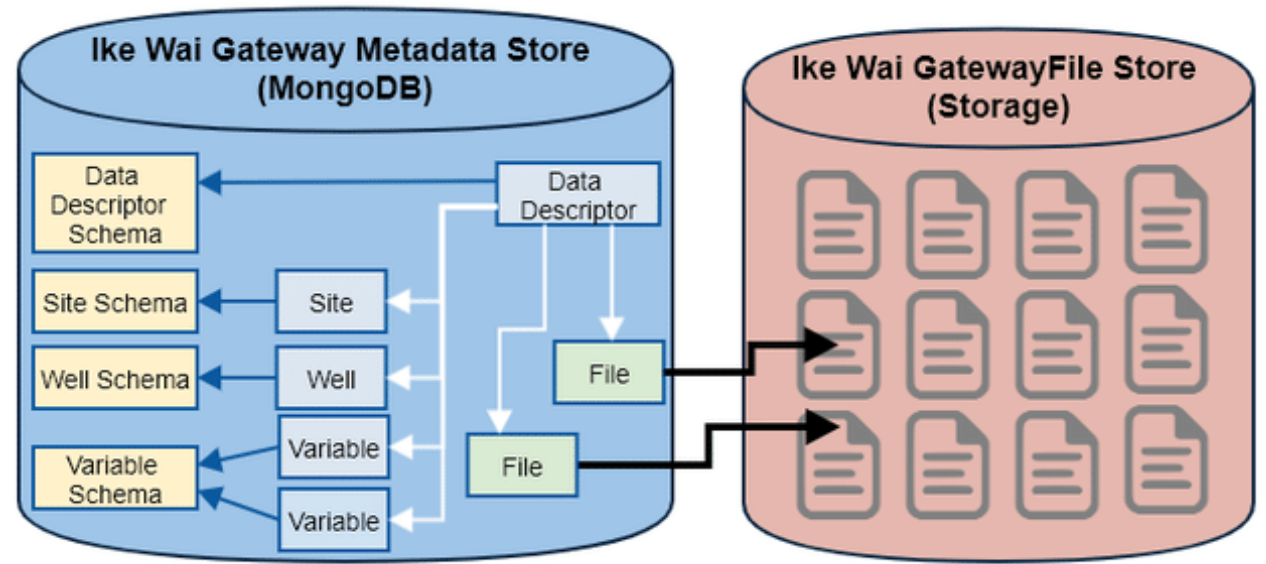
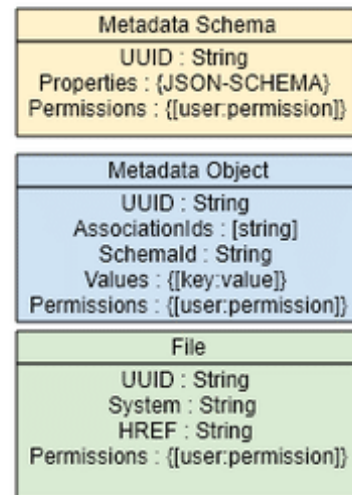




Data Storage

First class storage opportunities on the 'Ike Wai Gateway Server

- Allows UH Researchers to effectively store and manage data.





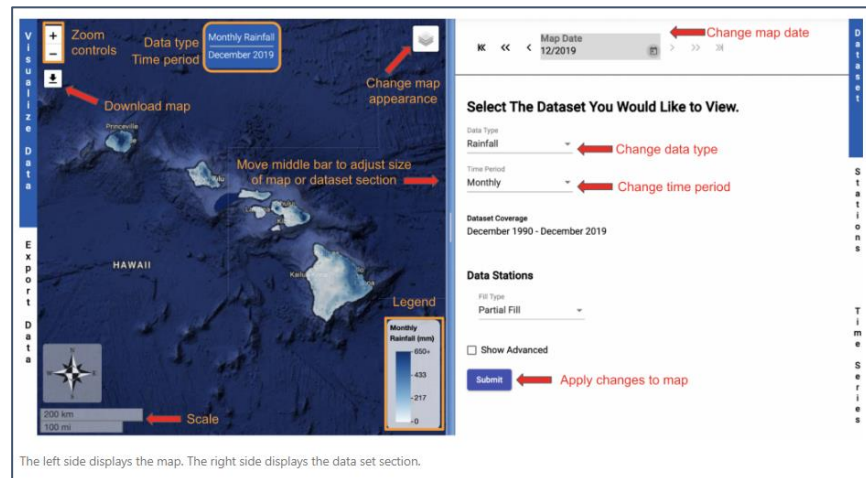
Data
Access

HCDP



Accessing Hawai'i climate data Has never been easier!

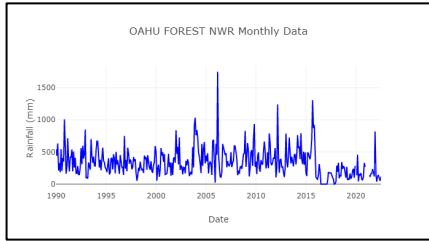
- Data is being centralized
- Easy to download manually
- Advanced Programming Interface (API) for modeling applications



HOW AN API WORKS



Data Analysis



The fruit is ripening and ready for the picking.....

- Over 100-years of rainfall data
- Over 30-years of temperature data

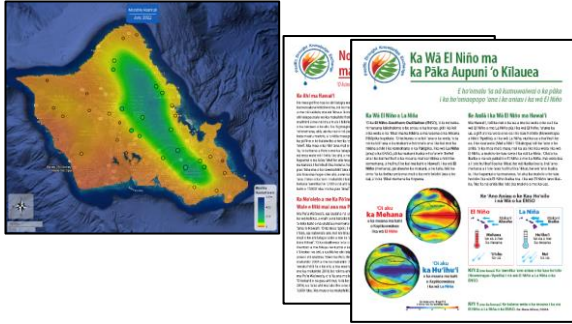


Frazier et al. 2022

- A Century of Drought in Hawai'i: Geospatial Analysis and Synthesis across Hydrological, Ecological, and Socioeconomic Scales

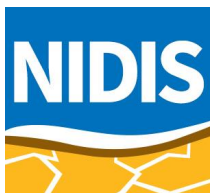


Data Products

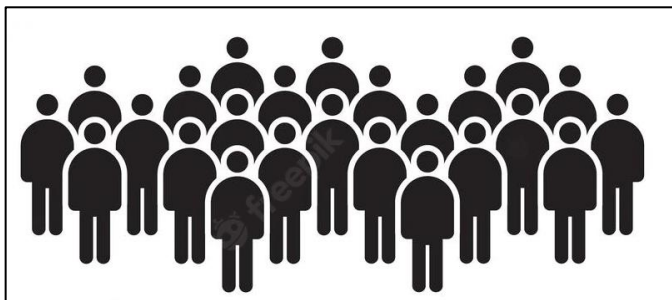


An Infinite number of opportunities!

- Gridded products
 - Many more in development
- Decision support tools
 - Hawai'i Rangeland Information Portal (HRIP)
- Climate Change Climate Variability and Drought (CCVD) portfolios
 - Pacific Drought Knowledge Exchange (PDKE)
- Early-warning systems
 - HI-EMA Fire Risk and Fire Warning (Gridded product)
- Hydrologic modeling
 - Flood Risk and Warning
 - Improvements to the National Water Model



Data Dissemination



Getting the data and information out there.

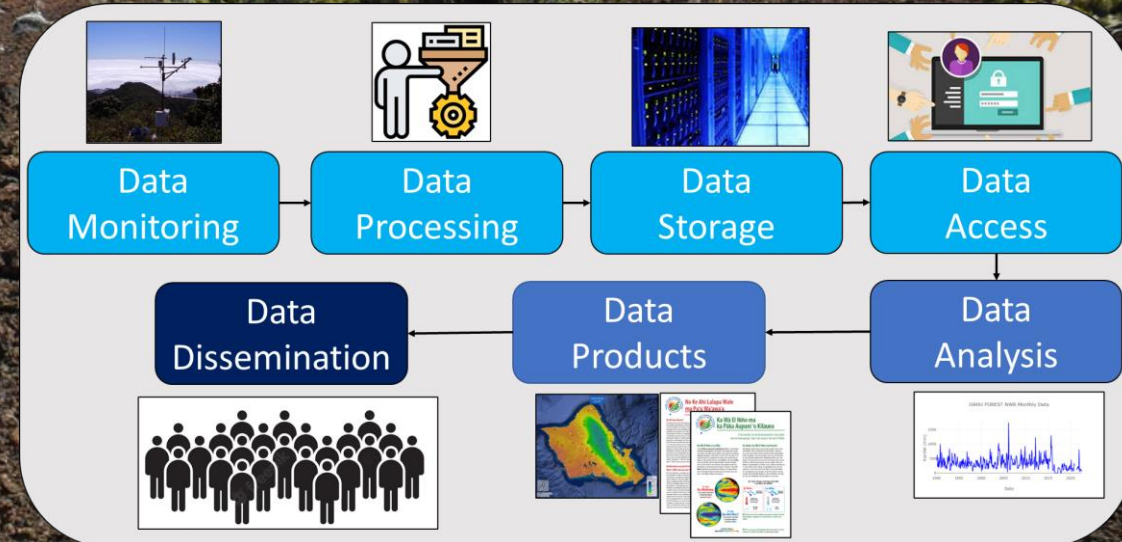
- **Pacific Drought Knowledge Exchange**
 - Co-Production
- **Educational Materials and Resources**
 - Story boards, social media, and interactive tools
- **HCDP User Group (HUG)**
 - Feedback and advice from sector and industry experts.
- **Social Media**
 - Weekly post on the climate data & Information in Hawaii



Part 4

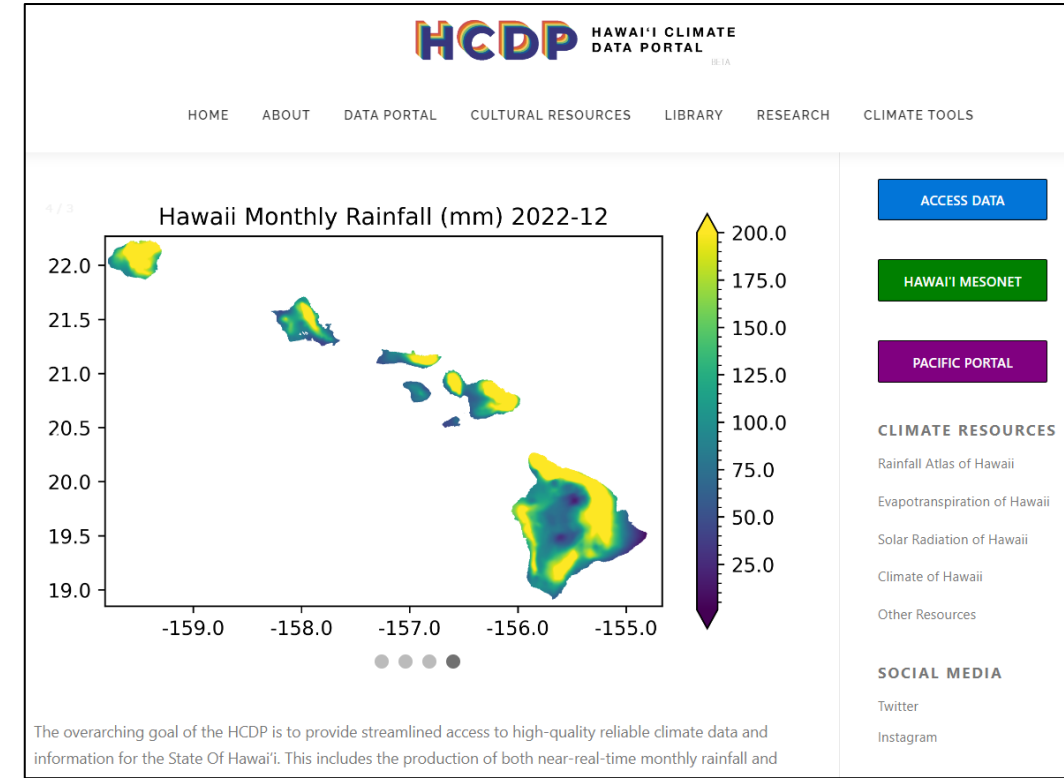
Hawai'i Climate Data Portal

HCDP

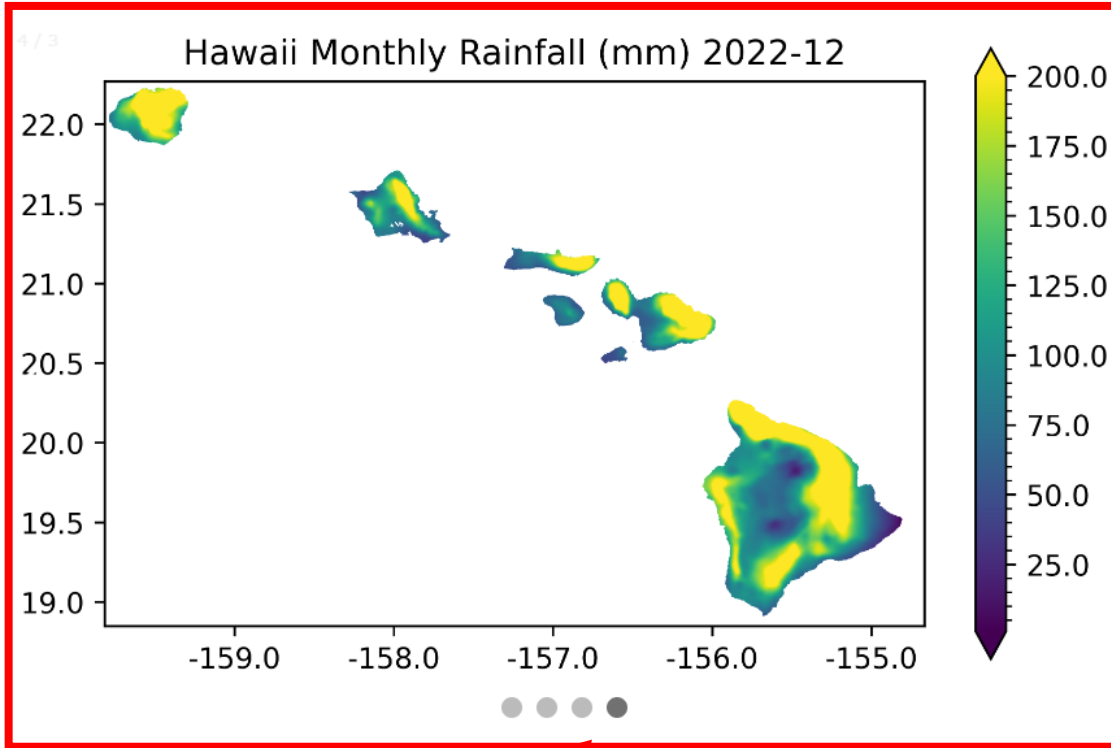


What is the HCDP

- **A Place** to get climate data
- **A Tool** that allows us to explore the past, monitor the present, and project the future
- **A Portal** to other places and data sources
- **An Opportunity** to learn, to education, to network, and to share



HOME ABOUT DATA PORTAL CULTURAL RESOURCES LIBRARY RESEARCH CLIMATE TOOLS



The overarching goal of the HCDP is to provide streamlined access to high-quality reliable climate data and information for the State Of Hawai'i. This includes the production of both near-real-time monthly rainfall and

ACCESS DATA

HAWAII MESONET

PACIFIC PORTAL

CLIMATE RESOURCES

Rainfall Atlas of Hawaii

Evapotranspiration of Hawaii

Solar Radiation of Hawaii

Climate of Hawaii

Other Resources

SOCIAL MEDIA

Twitter

Instagram

Download maps & data

Mesonet Site

Pacific Portal

Easy access to other
climate resources

hiclimateportal

Latest Rainfall &
Temperature maps



PUBLICATIONS SEARCH

BROWSE PUBLICATIONS

Rainfall

SEARCH BY: ☒ ITEM ☐ TAG

Bai, X. (2017). *Hawaiian Winter Rainfall Variability During Central Pacific (CP) and Eastern Pacific (EP) El Niño Events* [MS Thesis]. University of Hawai'i at Mānoa. (CITE) (DOWNLOAD)

Barbosa, J. M., & Asner, G. P. (2017). Effects of long-term rainfall decline on the structure and functioning of Hawaiian forests. *Environmental Research Letters*, 12(9), 094002. <https://doi.org/10.1088/1748-9326/aa7ee4> (CITE) (DOWNLOAD)

Bassiouni, M., Vogel, R. M., & Archfield, S. A. (2016). Panel regressions to estimate low-flow response to rainfall variability in ungaged basins. *Water Resources Research*, 52(12), 9470–9494. <https://doi.org/10.1002/2016WR018718> (CITE) (DOWNLOAD)

Chu, P.-S. (1995). Hawaii Rainfall Anomalies and El Niño. *Journal of Climate*, 8(6), 1697–1703. [https://doi.org/10.1175/1520-0442\(1995\)008<1697:HRAAEN>2.0.CO;2](https://doi.org/10.1175/1520-0442(1995)008<1697:HRAAEN>2.0.CO;2) (CITE) (DOWNLOAD)

Chu, P.-S., & Chen, H. (2005). Interannual and Interdecadal Rainfall Variations in the Hawaiian Islands. *Journal of Climate*, 18(22), 4796–4813. <https://doi.org/10.1175/JCLI3578.1> (CITE) (DOWNLOAD)

Chu, P.-S., Zhao, X., Ruan, Y., & Grubbs, M. (2009). Extreme Rainfall Events in the Hawaiian Islands. *Journal of Applied Meteorology and Climatology*, 48(3), 502–516. <https://doi.org/10.1175/2008JAMC1829.1> (CITE) (DOWNLOAD)

- Over 400 peer-reviewed journal articles and technical reports (climate & ecology of Hawai'i)
- 31-years of National Weather Service monthly rainfall summaries
- Searchable index, Author last name or key words.
- Open-source PDFs available for download.
- Our you can email us.
 - HCDP@hawaii.edu



HAWAI'I CLIMATE
DATA PORTAL

HOME

ABOUT

DATA PORTAL

CULTURAL RESOURCES

LIBRARY

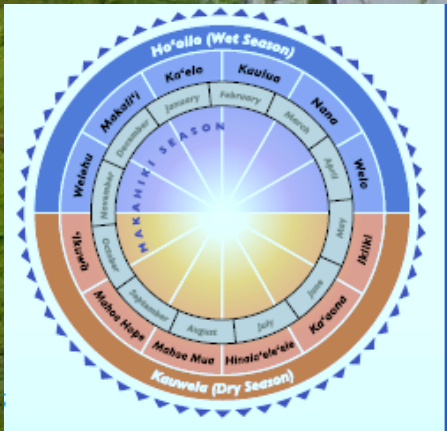
RESEARCH

CLIMATE TOOLS

Nā Kaulana Mahina



- Indigenous Perspectives
- Contemporary Research
- Climate glossary
- Archival Newspaper
- Moon calendar
- Publications
- Education Resources



*Nā Kaulana Mahina
Calendar 2017*

Photo Credit: John Delay



HAWAI'I CLIMATE DATA PORTAL

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LIBRARY

RESEARCH

CLIMATE TOOLS

- *Highlighting past and ongoing research projects*
- *Providing links to external resources*

RESEARCH HIGHLIGHTS

Search

Search

Is your research missing? Email hcdp@hawaii.edu



Developing a real time tool to identify the likelihood of avian malaria insitu development to help the targeting of mosquito control efforts

Avian malaria poses the threat of extinction to multiple unique Hawaiian forest bird species. With mosquito vector control as one of the likely tools needed to prevent such extinctions, a ...



Understanding the environmental factors determining the spatial patterns of malaria prevalence in native forest birds across Hawaii

The clearly identified link between temperature and avian malaria across the landscape threatens several unique native Hawaiian birds with extinction as the climate warms. With the new climatic datasets provided ...

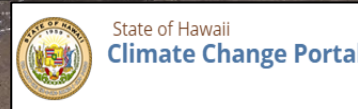
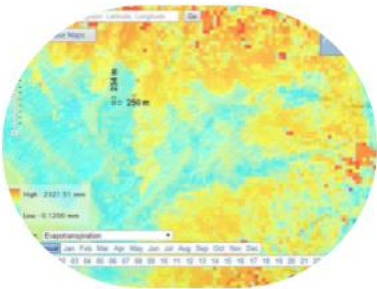


Photo Credit: John Delay



CLIMATE TOOLS

Climate of Hawaii



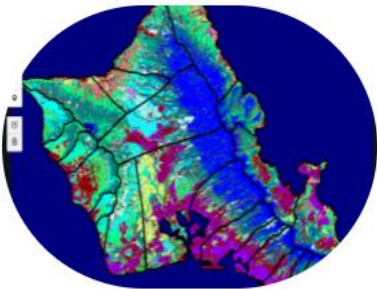
Rainfall Atlas of Hawaii



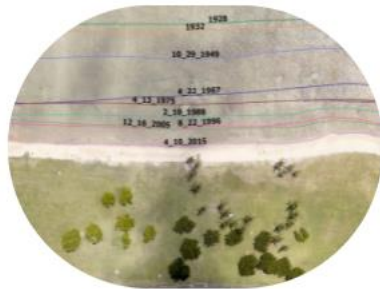
Sea Level Rise Viewer



Hawaii Groundwater Recharge Tool



Coastal Erosion



Avian Malaria-Risk & Warning
(Coming soon)



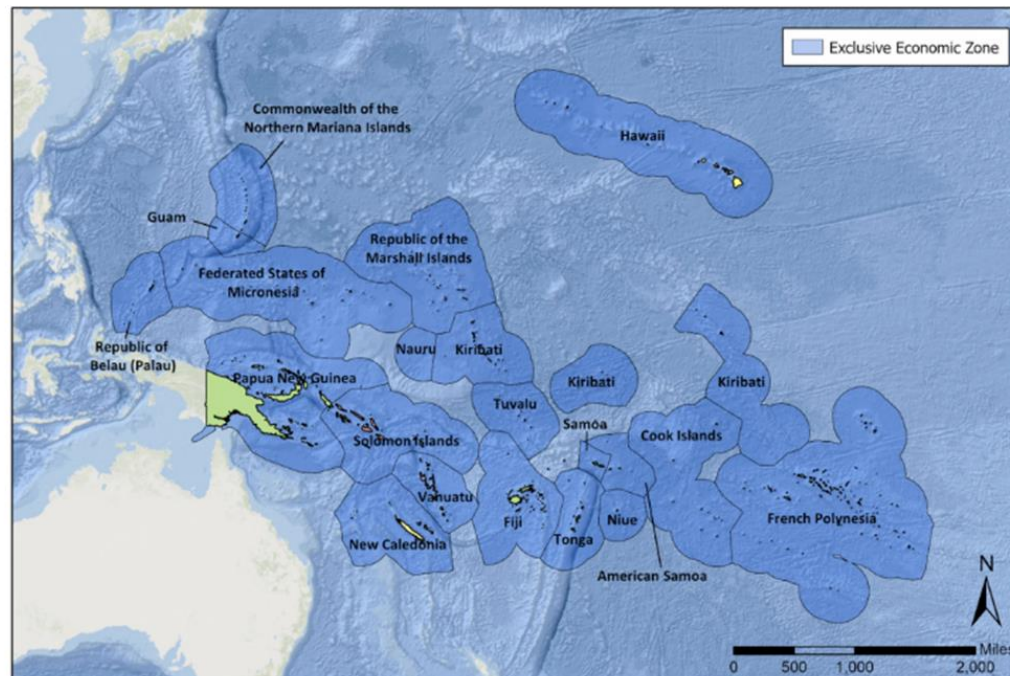
- *Rainfall Atlas of Hawai'i*
- *Climate of Hawai'i*
- *Sea-Level Rise Viewer*
- *Coastal Erosion*
- *USGS Groundwater Recharge Tool*
- *Fire Waring and Risk*
- *Flood Warning and Risk*
- *Drought Warning and Risk*
- *Avian Malaria Warning and Risk*

Pacific Islands Portal



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[DATA](#)

[REGIONAL PARTNERS](#)


[COUNTRY PAGES](#)

[TOOLS & RESOURCES](#)




Pacific Portal

Data Portals


**HAWAII CLIMATE DATA PORTAL**
BETA

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PACIFIC PORTAL DATA

**PCCP**
PACIFIC CLIMATE CHANGE PORTAL


The Pacific Climate Change Portal is for accessing climate resources, news, events and more in the Pacific Islands region.

**SPREP**
PROE

The Pacific Environment Portal provides an easy way to find, access and reuse regional and national data.




The PNW-RIA Pacific Islands Database conducts and provides resource inventories for islands in the Pacific.

**PRDR**
PACIFIC REGIONAL DATA REPOSITORY
for SE4ALL
Sustainable Development Goals


The Pacific Regional Data Repository is a Data and Information Revolution for the Pacific Island Countries and Territories (PICTs)

Regional Partners


**HAWAII CLIMATE DATA PORTAL**
BETA

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PACIFIC PORTAL REGIONAL PARTNERS

**SPREP**
Secretariat of the Pacific Regional Environment Programme


SPREP is the regional organisation established by the Governments and Administrations of the Pacific charged with protecting and managing the environment and natural resources of the Pacific.

**Pacific Community**
Communauté du Pacifique


The Pacific Community (SPC) is the principal scientific and technical organisation in the Pacific region, proudly supporting development since 1947.

**Australian Government**
Department of Foreign Affairs and Trade


The Australian Government Department of Foreign Affairs and Trade


**FFA**

The Pacific Islands Forum Fisheries Agency (FFA) strengthens national capacity and regional solidarity so its 17 members can manage, control and develop their tuna fisheries now and in the future.


**SAO**
PACIFIC TOURISM ORGANISATION

Established in 1983 as the Tourism

**USP**
THE UNIVERSITY OF THE SOUTH PACIFIC


**PASO**
PACIFIC AVIATION SAFETY ORGANISATION

The Pacific Aviation Safety

**PPA**
PACIFIC PORTAL PARTNERSHIP


The PPA is an inter-

Tools & Resources


**HAWAII CLIMATE DATA PORTAL**
BETA

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PACIFIC ISLANDS TOOLS AND RESOURCES




USAID Climate Ready Small Grants Guide




USAID Climate Ready Knowledge Products



Pacific Islands Climate Change Monitor: 2021



State of Environment and Conservation in the Pacific Islands



Framework for Resilient Development in the Pacific

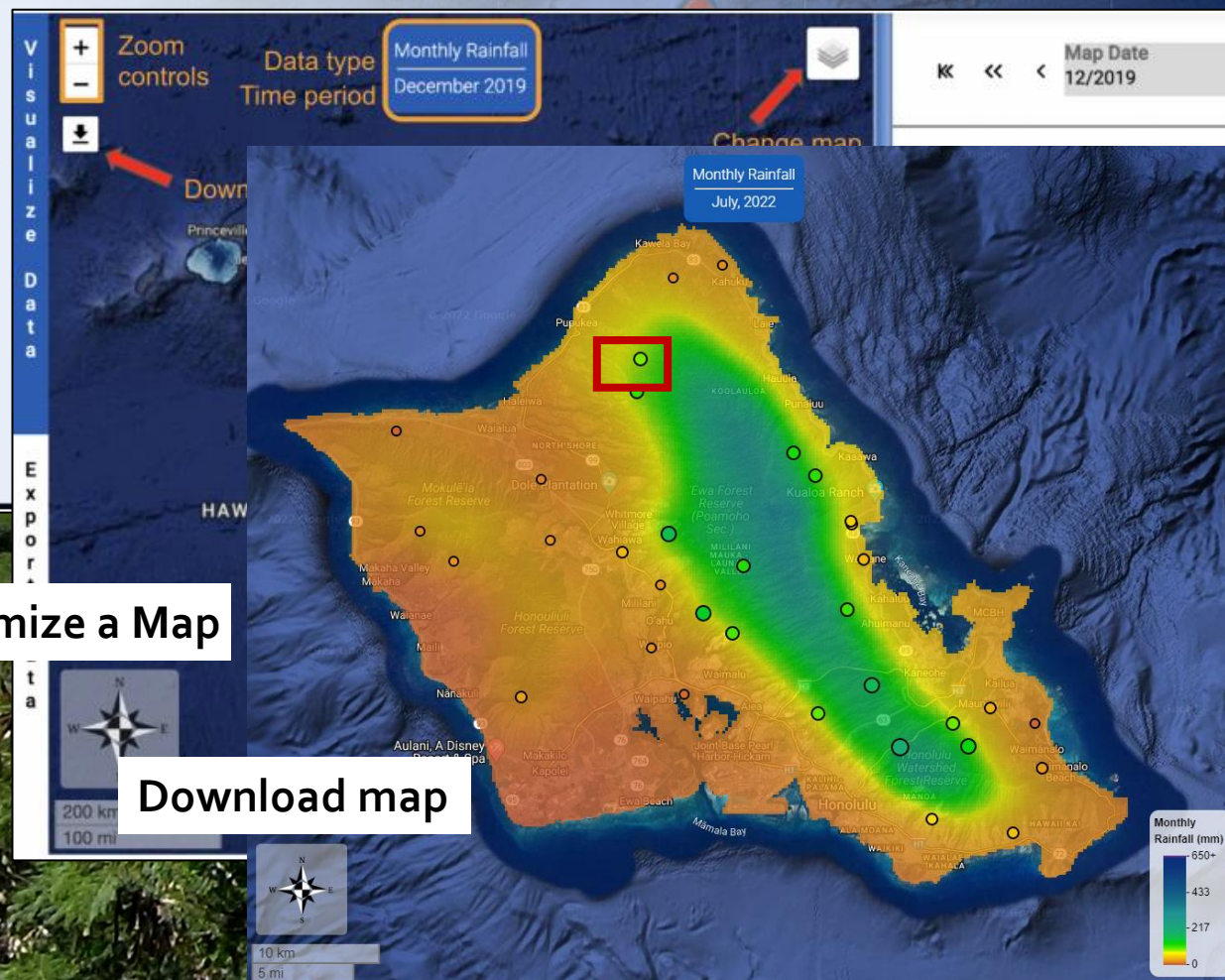


HAWAI'I CLIMATE DATA PORTAL

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Visualize Data

Visualize available climate data in the portal.

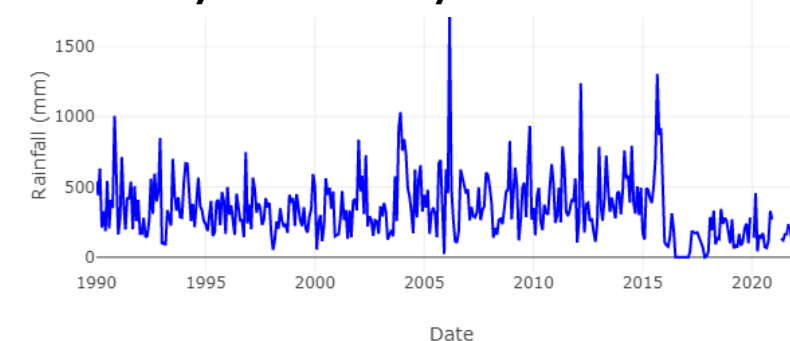


| Name | Station ID | Island |
|---------------------------------|------------|--------|
| PunaluuRainGagealt | 884.4 | O'ahu |
| SCHOFIELD BARRACKS | 858 | O'ahu |
| Poamoho Exp Farm | 855.3 | O'ahu |
| DILLINGHAM | 843.7 | O'ahu |
| MakahaRainGage | 842.1 | O'ahu |
| Waihee Pump | 839.8 | O'ahu |
| WAIHAOLE STREAM NEAR KAHALUU 2N | 837.12 | O'ahu |
| Palisades | 835.2 | O'ahu |
| Waiawa CF | 834.13 | O'ahu |
| SCHOFIELD EAST | 828 | O'ahu |
| Waipio | 824.2 | O'ahu |
| Milliani | 820.6 | O'ahu |
| WHEELER ARMY AIR FIELD 810.1 | 810.1 | O'ahu |
| WAIANA VALLEY | 803.2 | O'ahu |
| Waimanalo Nonokio | 795.3 | O'ahu |
| BELLOWS AFS AT WAIMANALO | 793.2 | O'ahu |

| Station Metadata | |
|------------------|--------------------|
| SKN (Station ID) | 884.4 |
| Name | PunaluuRainGagealt |
| Observer | USGS |
| Network | USGS |
| Island | O'ahu |
| Elevation (m) | 73.15 |
| Latitude | 21.56 |
| Longitude | -157.9 |
| NWS ID | PNSH1 |
| NESDIS ID | DD989652 |
| Value | 120.39 |

Get Station Meta Data

Adjustable time series plots Daily or monthly





HAWAI'I CLIMATE DATA PORTAL

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Select the type of data you would like to export from the options below then click "Add Files"

Dataset

Rainfall

Select dataset

Time Period

Monthly

Select time period

Date Range

Start Date

01/1990

End Date

03/2022

Select date range

Files

☐ Rainfall Map

Check boxes to select files

Filetype: tif

☐ Standard Error Map

Filetype: tif

☐ Anomaly Map

Filetype: tif

Add Files

Data are also
Available
through Near
Real Time API
Access

Gridded Products (250 m)

Available Now

- *103-Years of Monthly Rainfall Maps (1920 – NOW) – 1,226 maps*
- *33-Years of Monthly & Daily Temperature (Max, Mean, Min) Maps (1990 – NOW) – < 35,000 maps*
- *Future Climate Projections of Rainfall and Temperature (2-Methods)*

Coming Soon

- *Daily Rainfall maps*
- *Bi-Monthly NDVI (Vegetation) – maps*

In the works

- *Relative humidity, winds speed, solar radiation maps*
- *Fractional land cover maps*

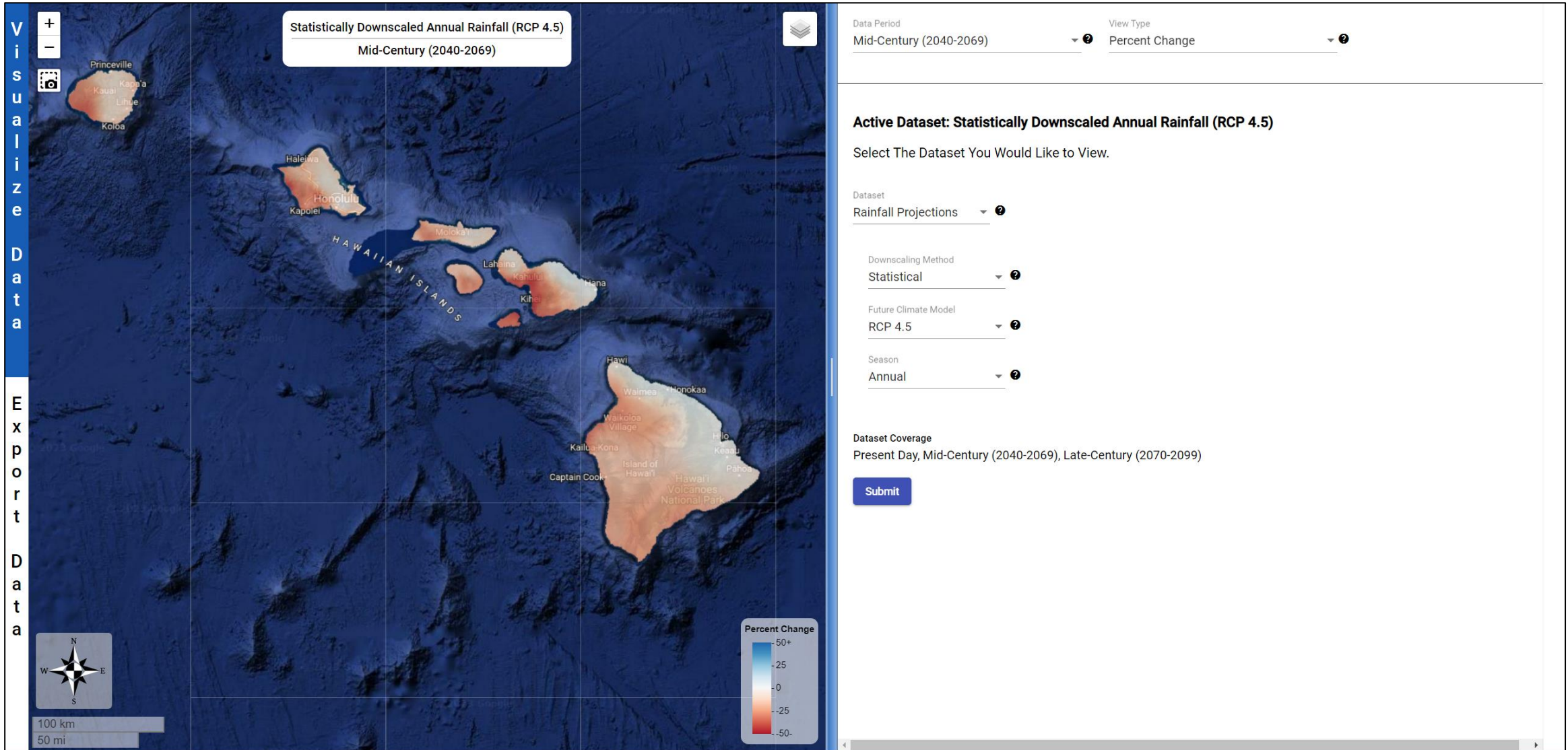
Derived Products

- Fire risk & Warning
- Fire forecasts
- Drought risk
- Flood risk
- Energy balance
- Water balance



HAWAI'I CLIMATE DATA PORTAL

BETA



Hawai'i Climate Data Portal: <https://www.hawaii.edu/climate-data-portal/>

January 2023 Rainfall Map

Produced on February 1st

What would this take.....

1. Need to get the data

- Only 2-people in the state who know what data sources are available.
- Only 1-person who knows how to access them all.

2. Process the data (QaQc)

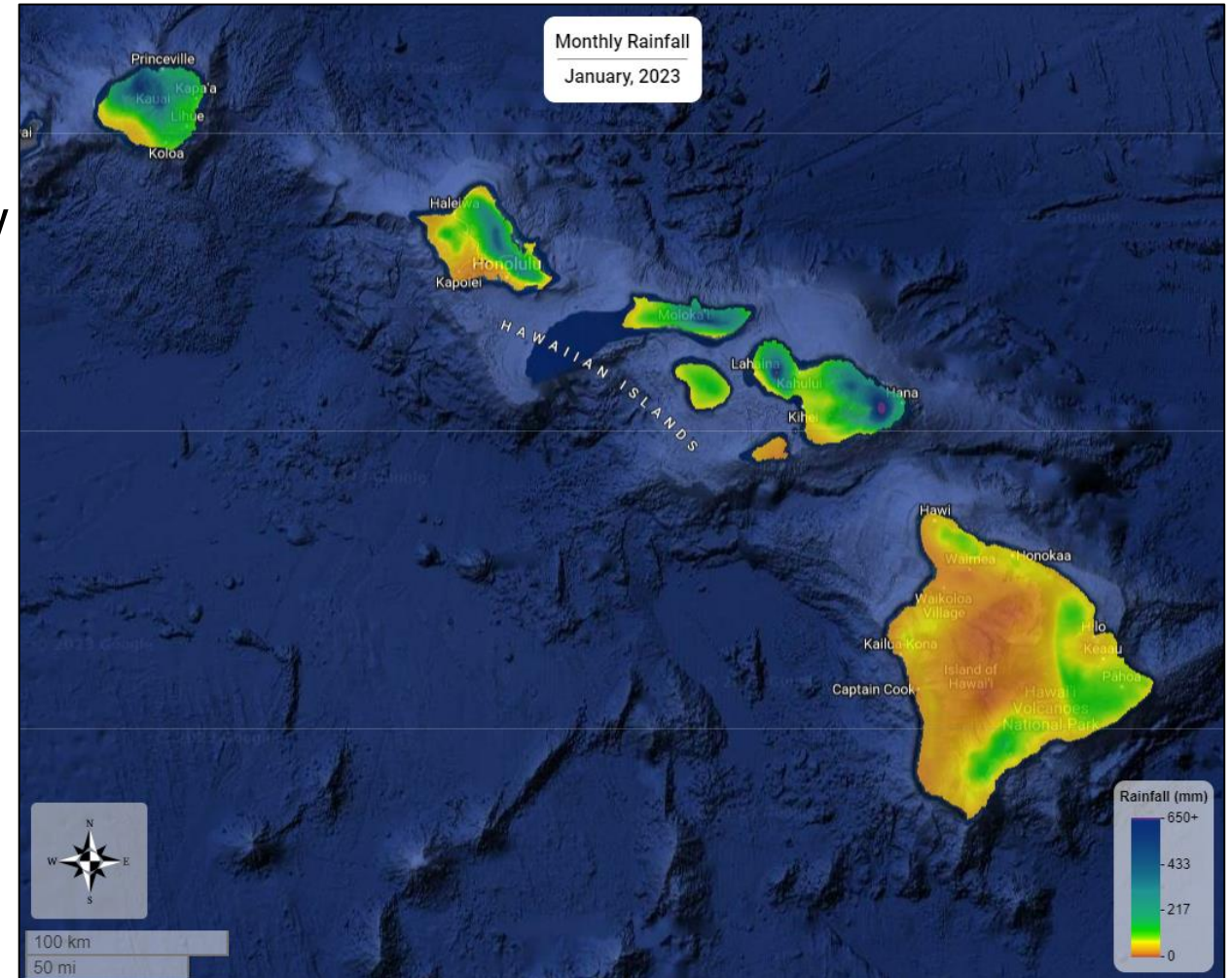
- Handful of people

3. Interpolate the data

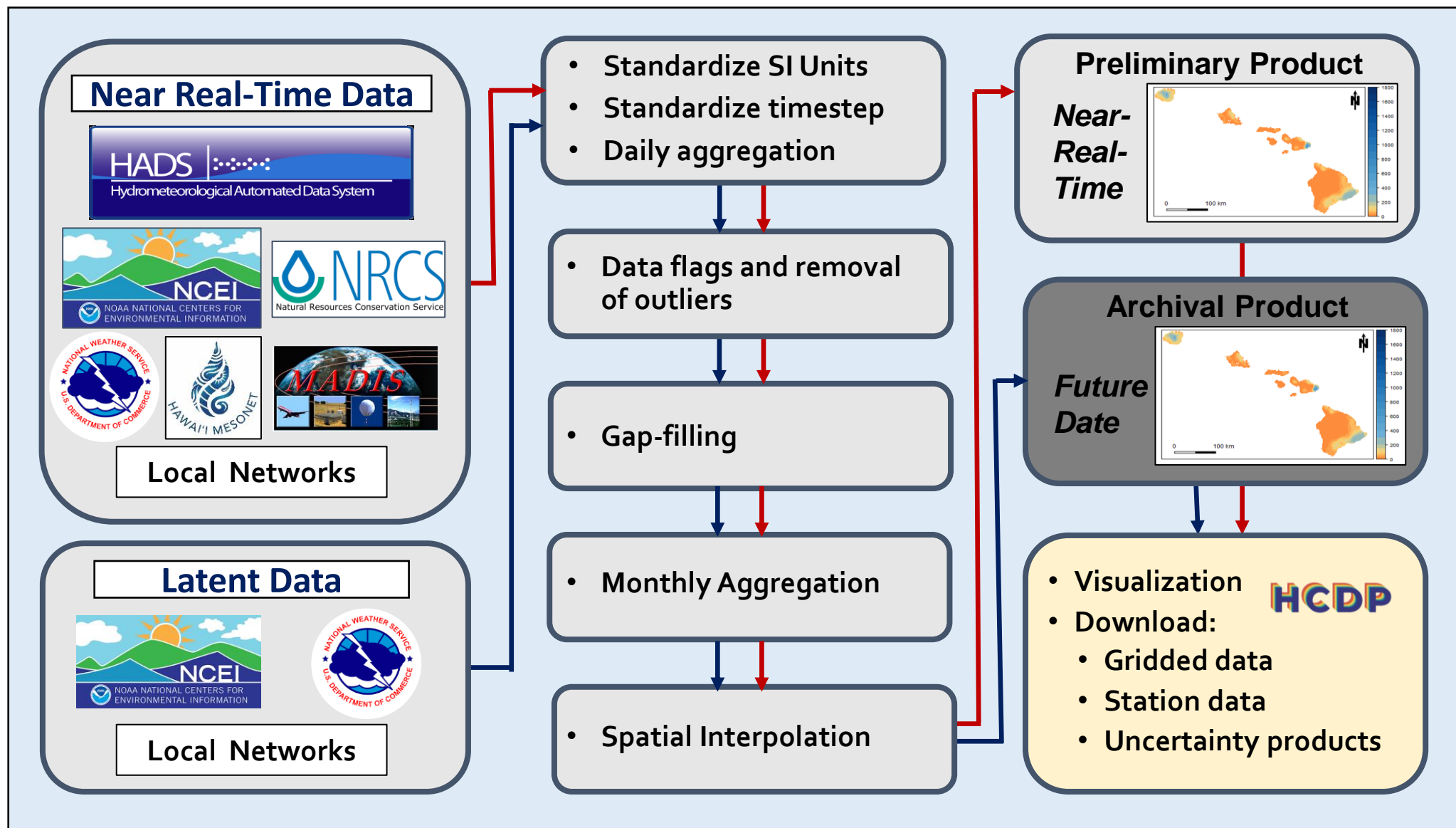
- A handful of people could to do this

4. Make a map

- Need Skills (GIS or related)



Monthly Rainfall Workflow





**HAWAI'I CLIMATE
DATA PORTAL**

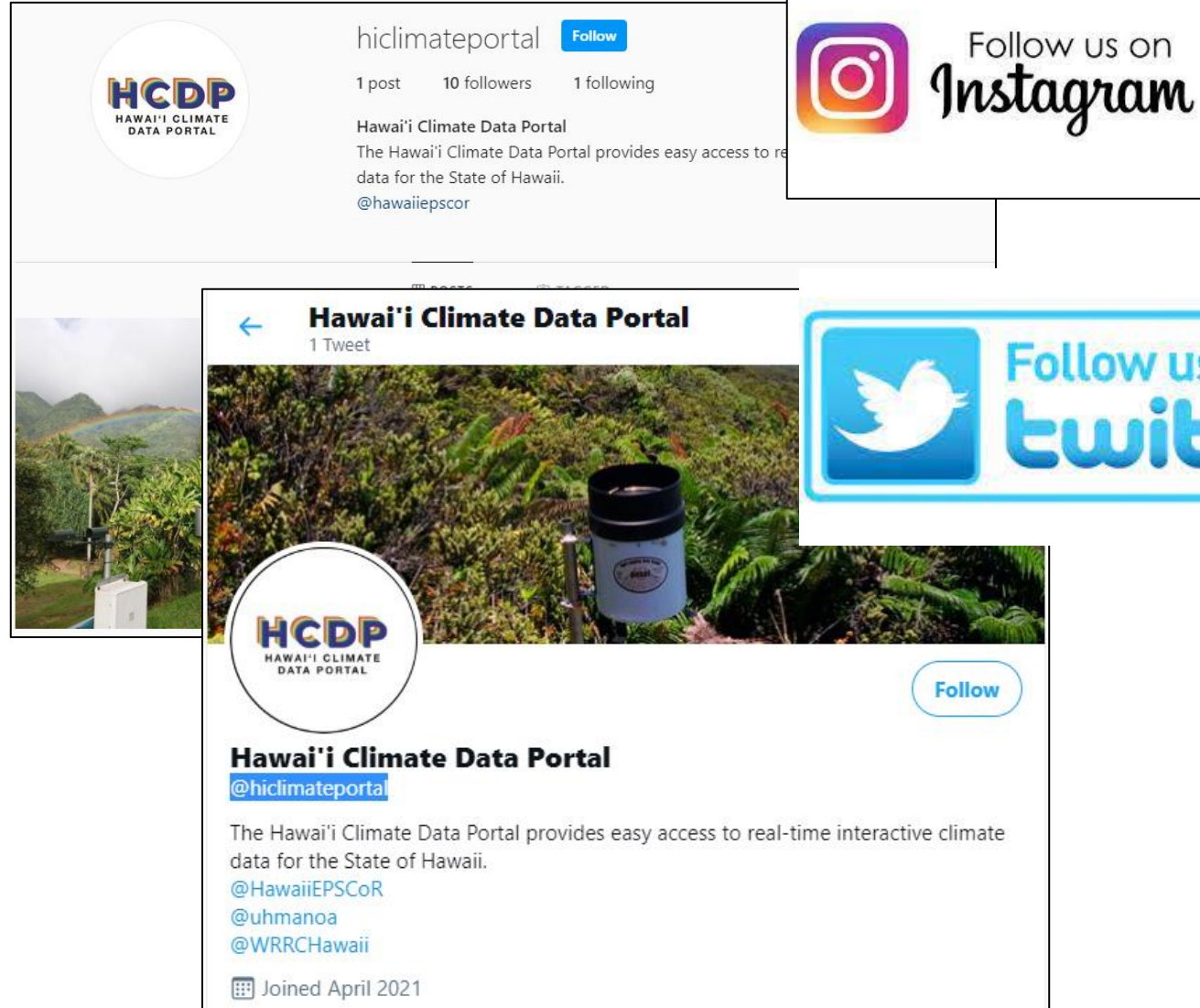
- On March 3rd 2022, the HCDP was officially launched.
- To date, the HCDP has had ~20,000 unique visitors (~35,000 visits)
- Visitors from 115 different countries around the world.
- There have been ~1,000 unique downloads and ~1.6 million files downloaded.

Social Media

hiclimateportal

Weekly Post (Thursday)

- New Products
- Current Weather
- Future Projections
- Historical trends
- New Research
- Cultural Knowledge
- Ongoing projects



Part 5

Future Opportunities



The Future Looks Bright

- The MesoNet providing high quality, island-wide data
- More products and improved products are in development
- A synergy of projects
- Geographic expansion into the USAPI
- Less time for data collection and more time for research
- Decision support
- Buy in from a range of stakeholders
- Adaption to changing environmental conditions



**Tom
Giambelluca**



**Matt
Lucas**



**Keri
Kodama**



**Ryan
Longman**



**Abby
Frazier**



**Han
Tseng**



**Cherrylle
Heu**



**Patrick
Grady**



**Jared
Mclean**



**Michael
Dodge II**



**Jason
Leigh**



**Peter
Sadowski**



**Sean
Cleveland**



**Gwen
Jacobs**



**Derek
Ford**



**Amy
Schriber**



**Christian
Giardina**



**Lucas
Berio Fortini**



**John
Delay**



**Sayed
Bateni**



**Hamid
Vosoughifar**



**Yu-fen
Huang**



**Chris
Shuler**



**Yinphan
Tsang**



**Elliot
Parsons**



**Clay
Trauernicht**



**Alyssa
Anderson**



**Melissa
Kunz**



**Katie
Kamelamela**



**Emily
Senso**



**Giuseppe
Torri**



**Allison
Nugent**

Mahalo!

• a

