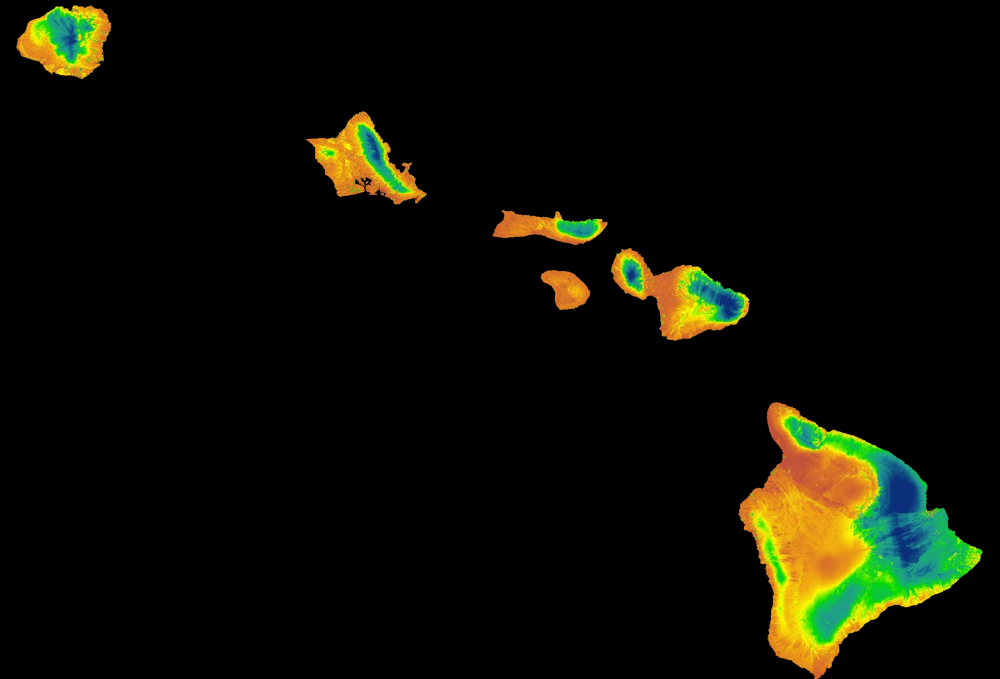


Estimated Mid- and End-of-Century Groundwater Recharge, Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Maui, and the Island of Hawaiʻi

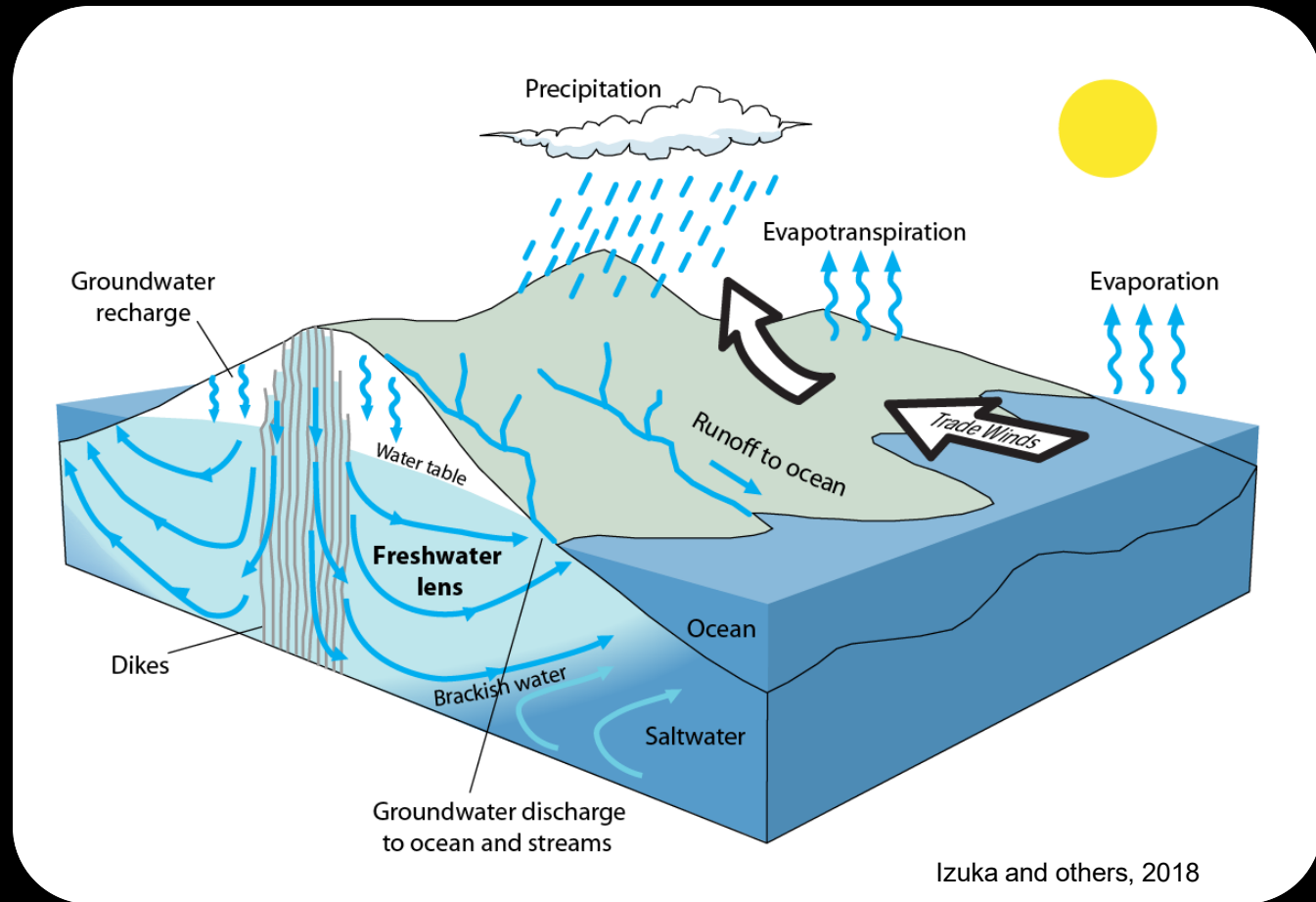
Heidi Kāne
Pacific Islands Water Science Center

State of Hawaiʻi
Commission on Water Resource Management – Virtual Meeting
August 20, 2024

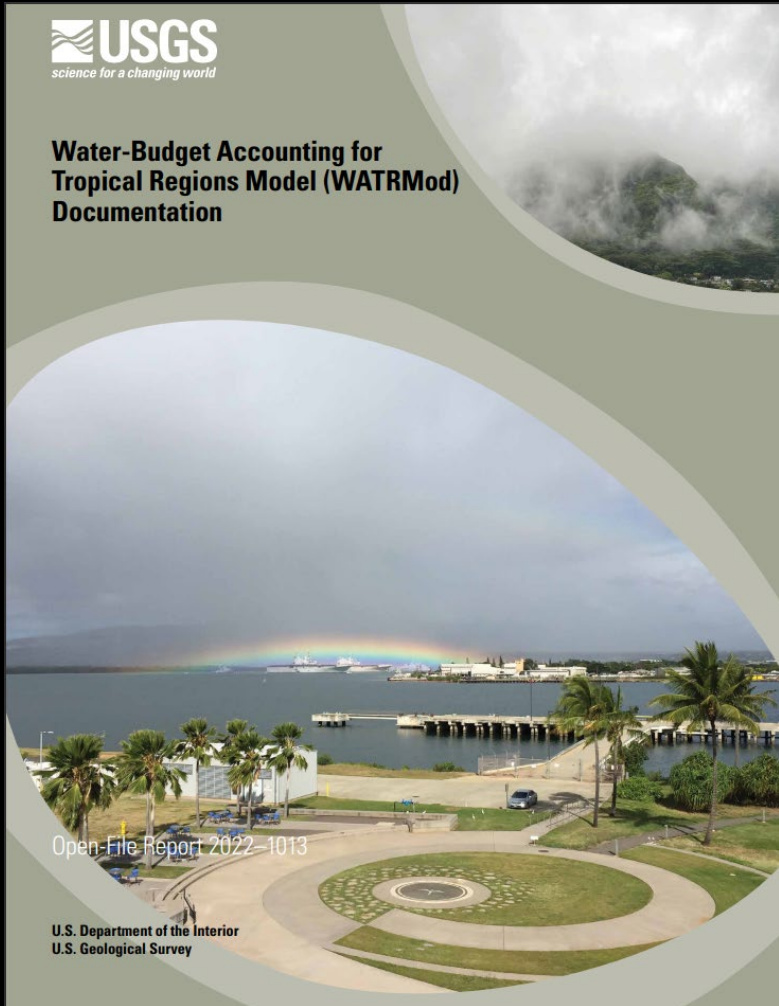


Study Background

- Groundwater recharge is water derived from precipitation and other sources, such as irrigation and leakage from surface reservoirs, that moves through or bypasses the plant-soil system and replenishes aquifers.
- Groundwater provides 99 percent of Hawai'i's drinking water and about 50 percent of all freshwater used in the State (Gingerich and Oki, 2000; Izuka and others, 2018).
- Reliable estimates of groundwater recharge are critical for evaluating the availability of groundwater in the Hawaiian Islands now and in the future.

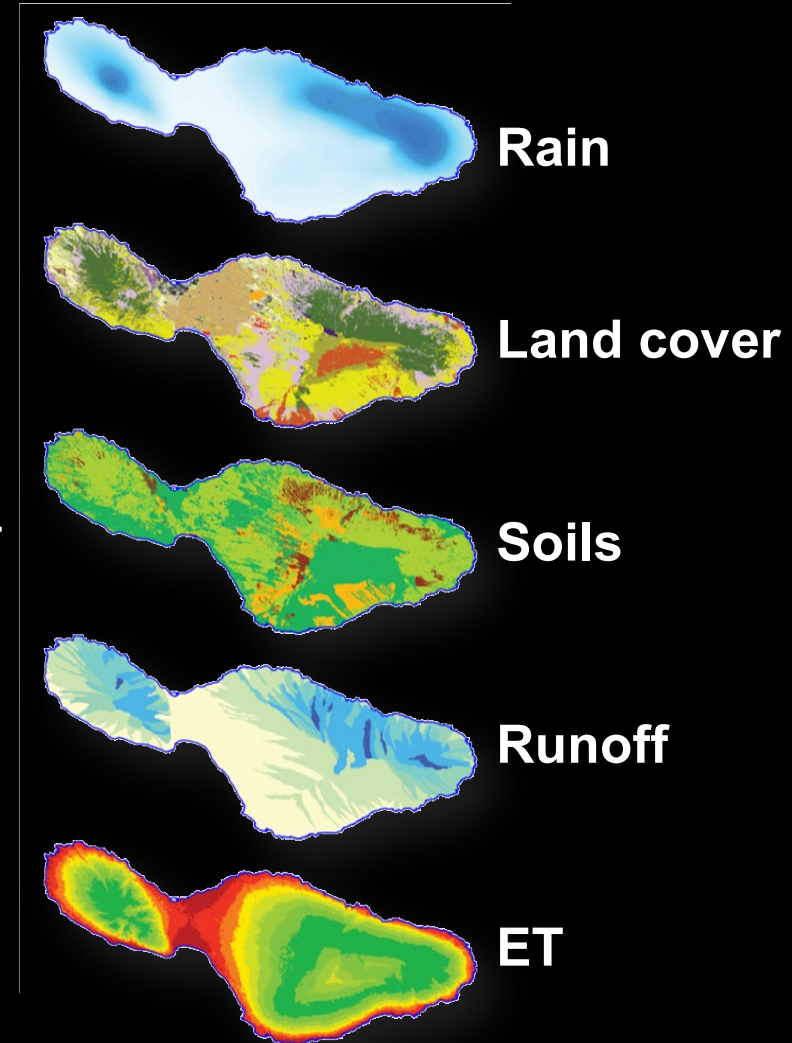


Water-Budget Accounting for Tropical Regions Model (WATRMMod)



- Incorporates available information
- Provides spatially distributed estimates of recharge, soil moisture, and actual evapotranspiration (ET)
- Quantifies effects of land-cover and climate changes on recharge, soil moisture, and actual ET
- Recharge estimates can be refined as better information becomes available

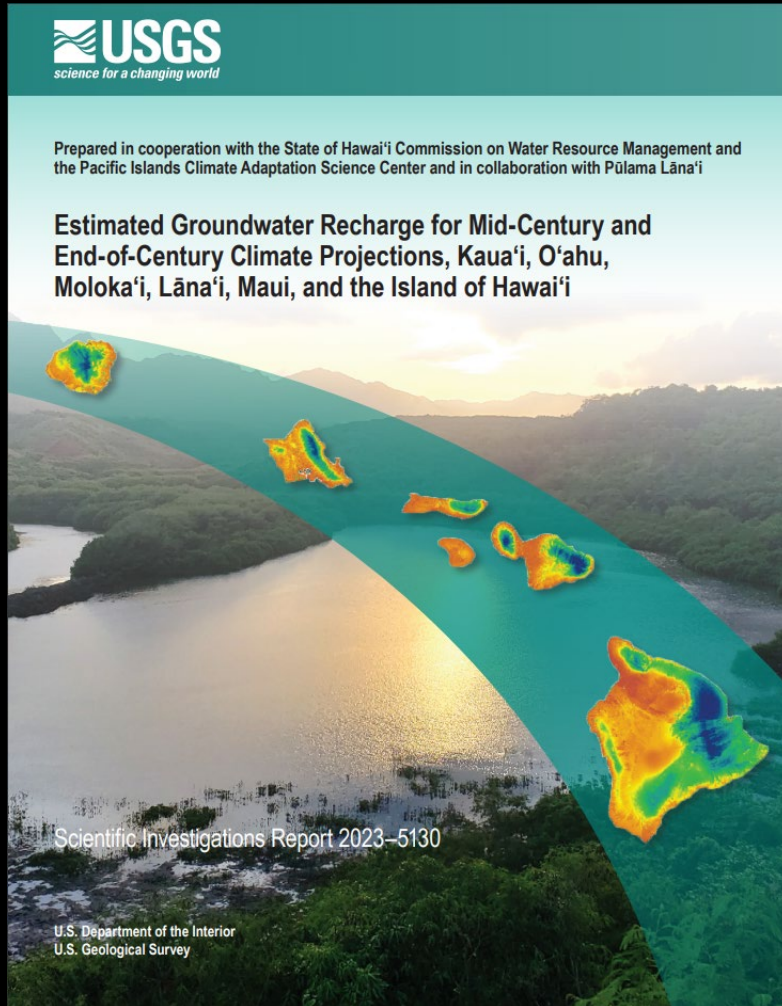
Model Inputs



Johnson and others, 2018

Oki, 2022

Improvements to Modeling Approach and Updates to Input Datasets

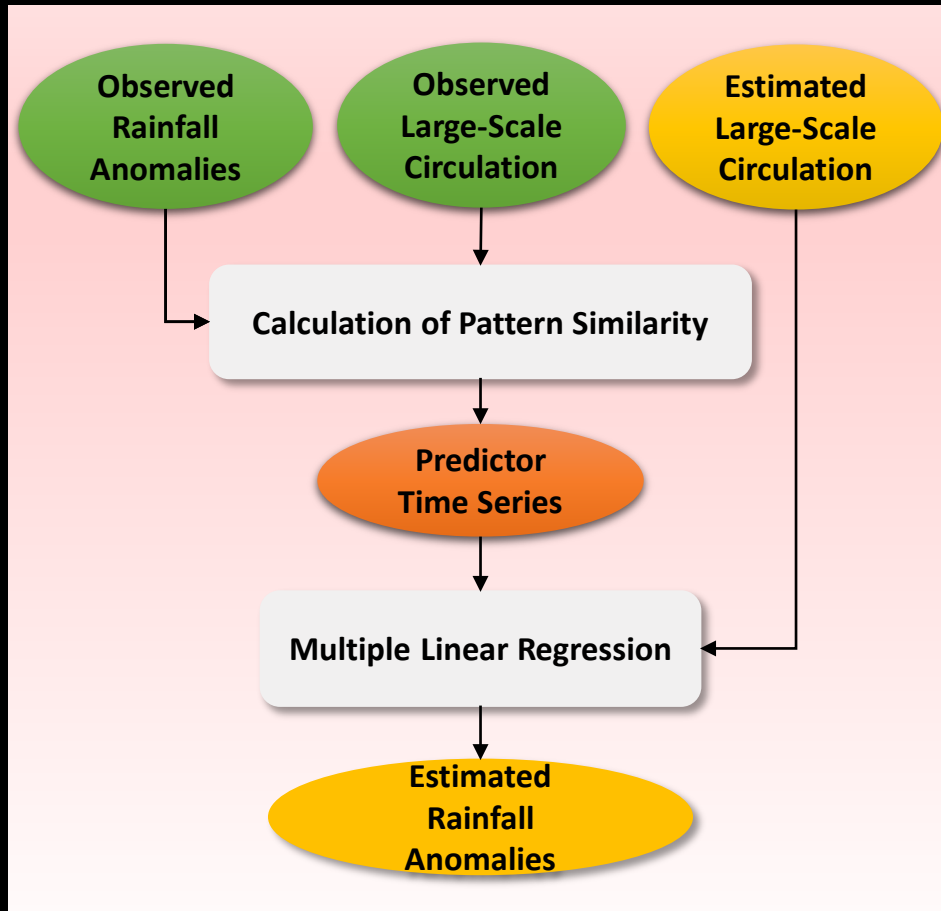


Kāne and others, 2024

- Updated water-budget model code
- Updated land-cover maps
- New gridded daily rainfall dataset
- Updated cloud zones for Maui and the Island of Hawai'i
- Updated soils maps
- Updated runoff-to-rainfall ratios
- Updated reservoir classification and seepage rates
- Estimated taro cultivation rates
- Quantified groundwater use by kiawe

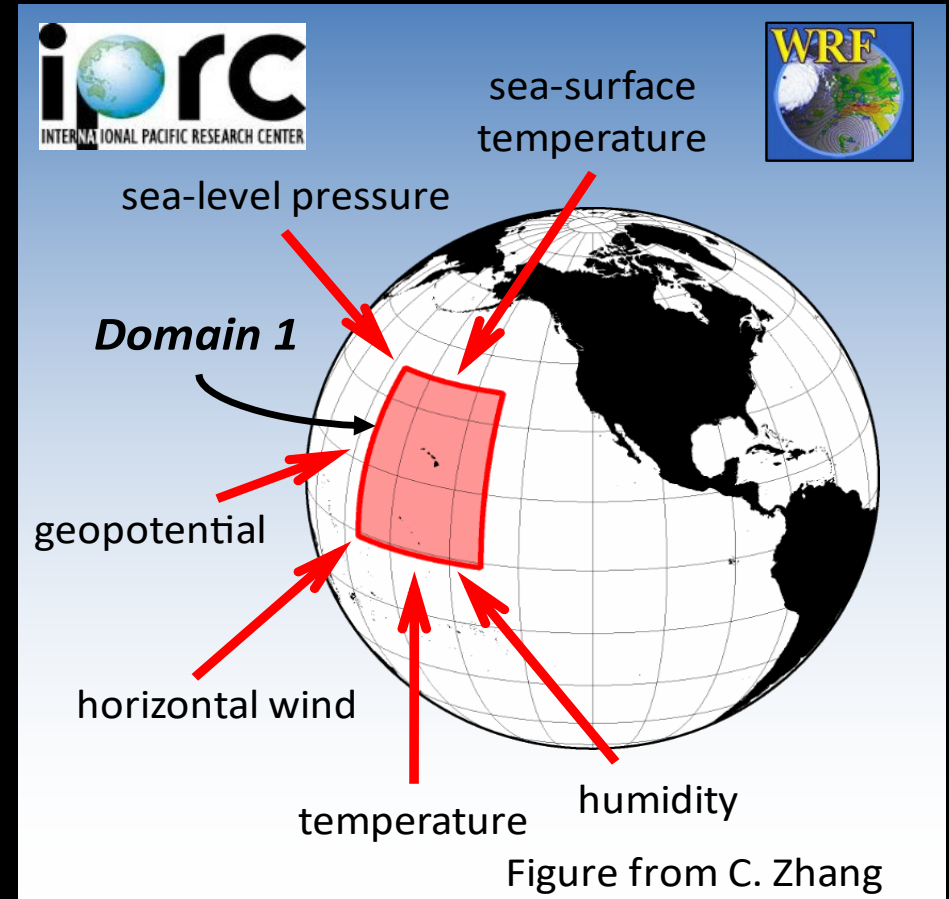
High-Resolution Downscaled Climate Projections

Statistical Downscaling (SD)



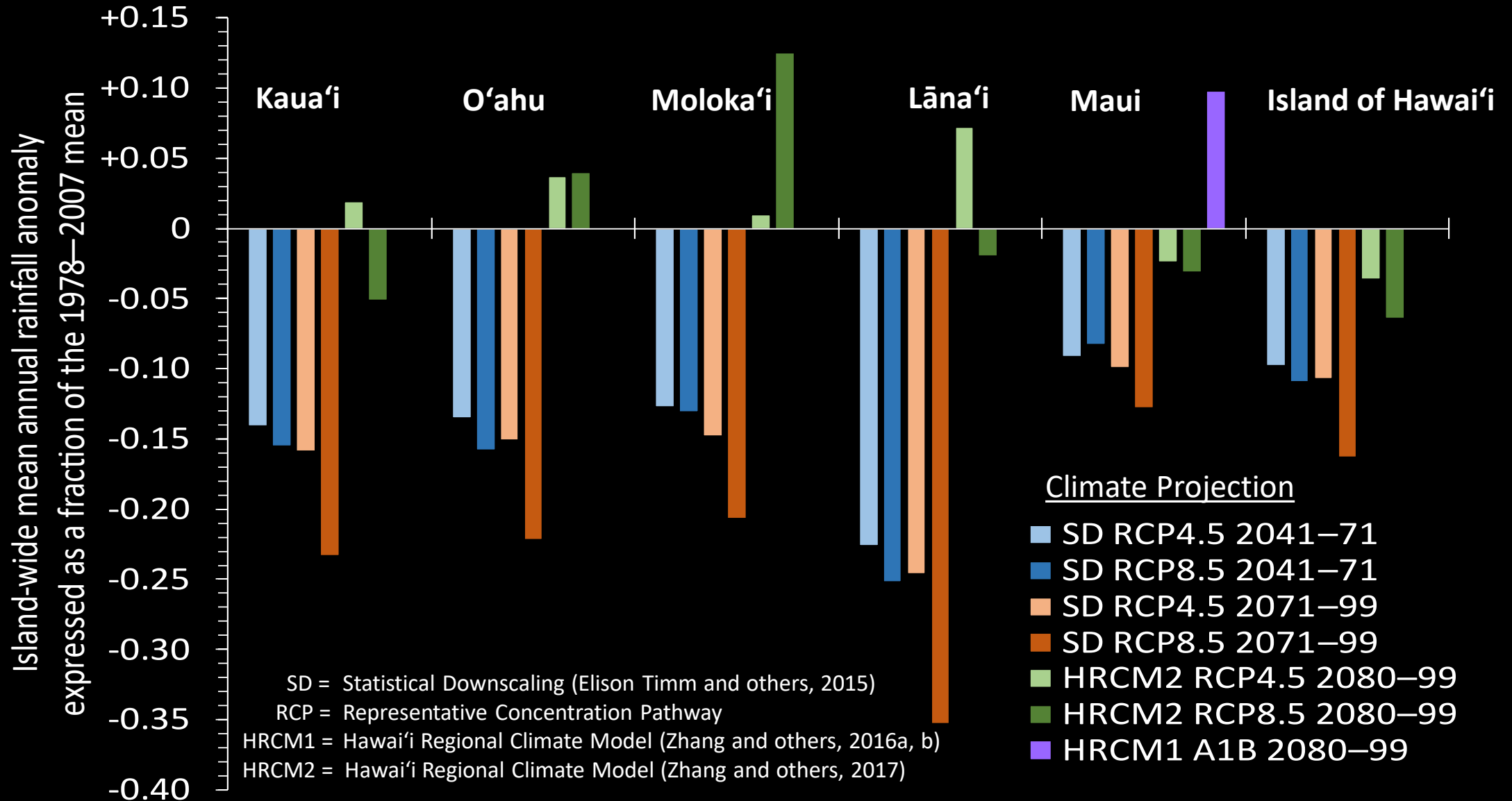
Elison Timm and others, 2015

Dynamical Downscaling (HRCM)

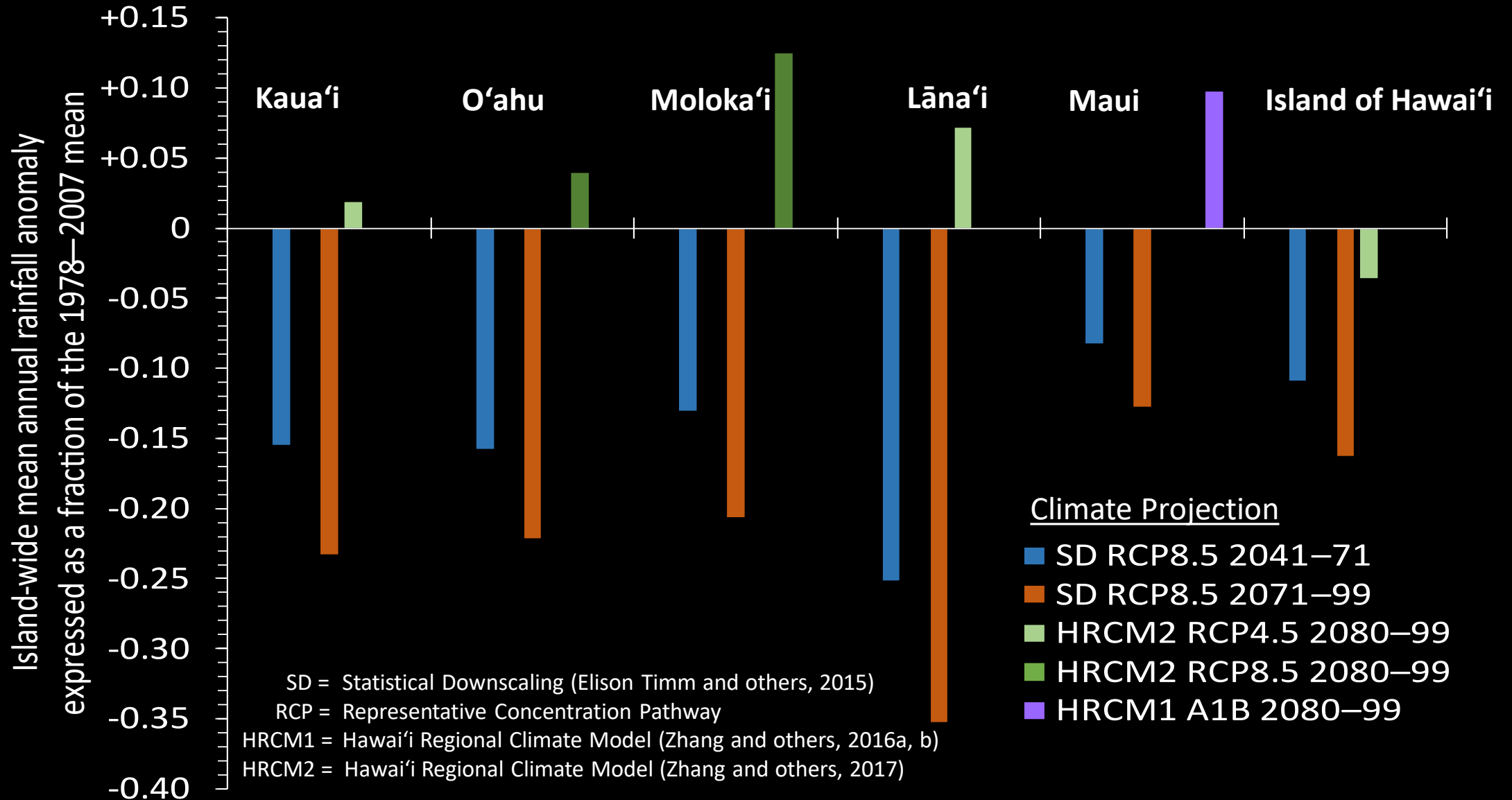


Zhang and others, 2016a,b; Zhang and Wang, 2017

Estimated Mid- and End-of-Century Island-Wide Rainfall Anomalies



Estimated Mid- and End-of-Century Island-Wide Rainfall Anomalies



Water-Budget Model Scenarios

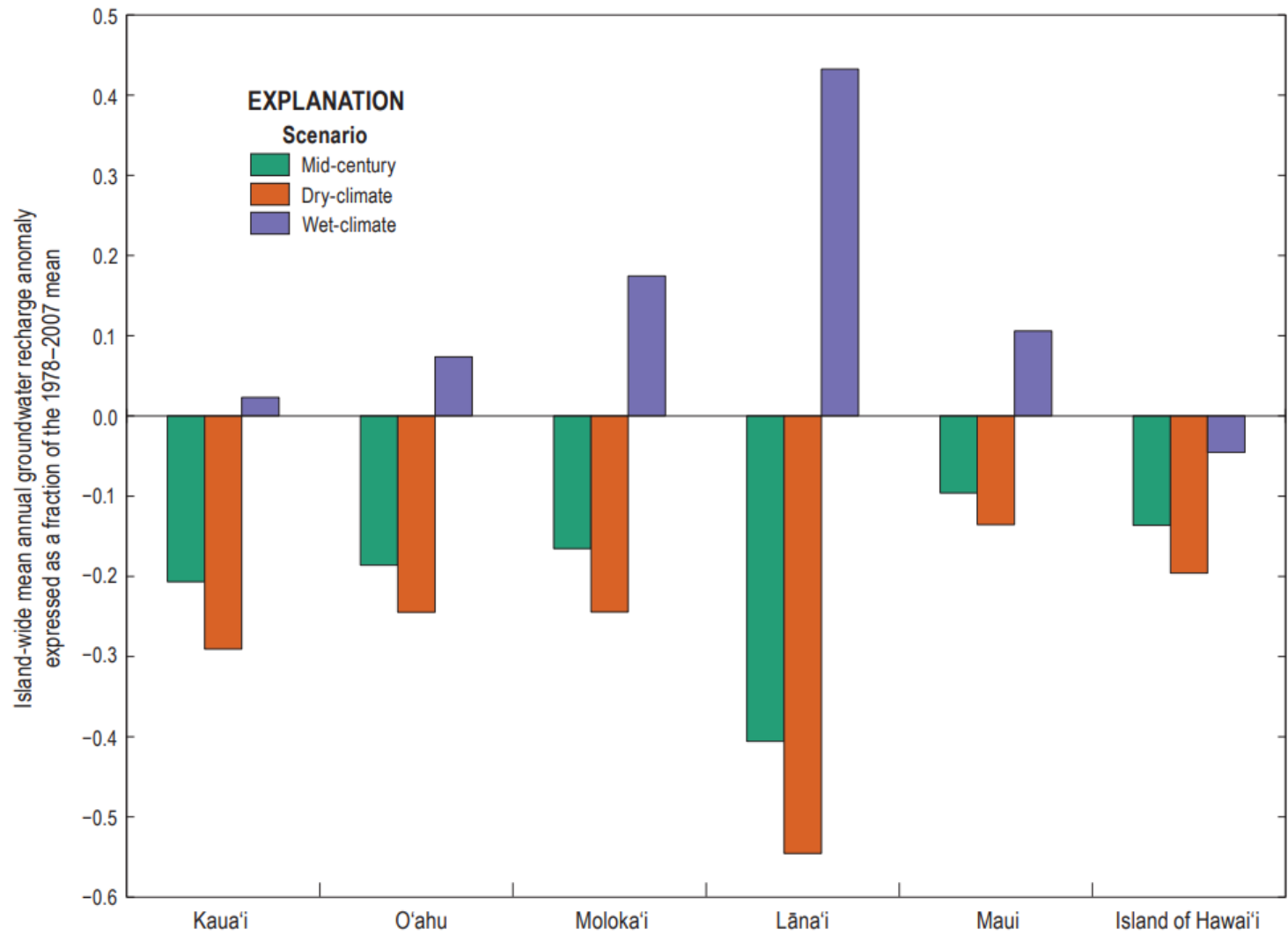
| Study-defined climate scenario ^a | Selected climate condition or projection | Kaua'i | O'ahu | Moloka'i | Lāna'i | Maui | Island of Hawai'i |
|---|--|--------|-------|----------|--------|------|-------------------|
| Reference climate | 1978–2007 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Mid-century climate | SD RCP8.5 2041–71 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Dry-climate ^b | SD RCP8.5 2071–99 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Wet-climate ^c | HRCM1 A1B 2080–99 | - | - | - | - | ✓ | - |
| Wet-climate ^c | HRCM2 RCP4.5 2080–99 | ✓ | - | - | ✓ | - | ✓ |
| Wet-climate ^c | HRCM2 RCP8.5 2080–99 | - | ✓ | ✓ | - | - | - |
| Drought | 2008–2012 | - | - | - | ✓ | - | - |

^a All scenarios use 2020 land-cover conditions

^b Driest scenario relative to available set of projections

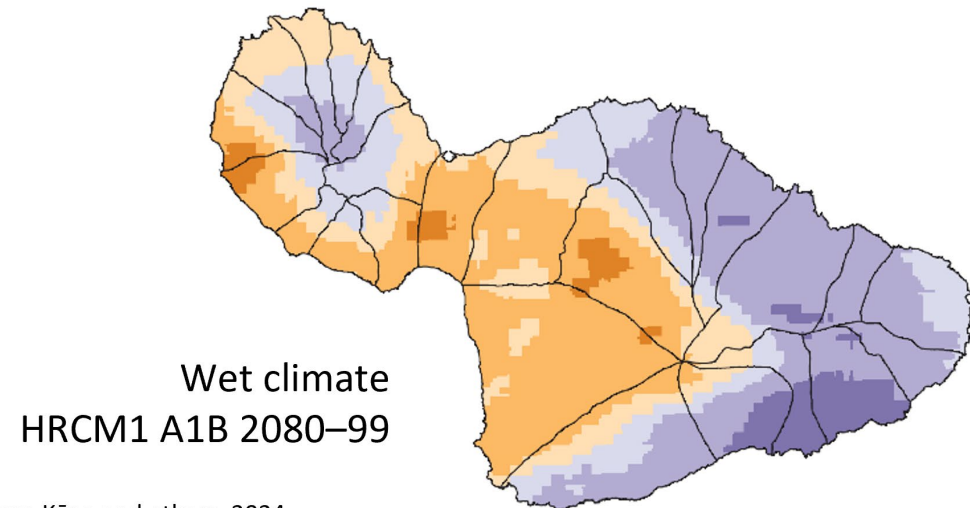
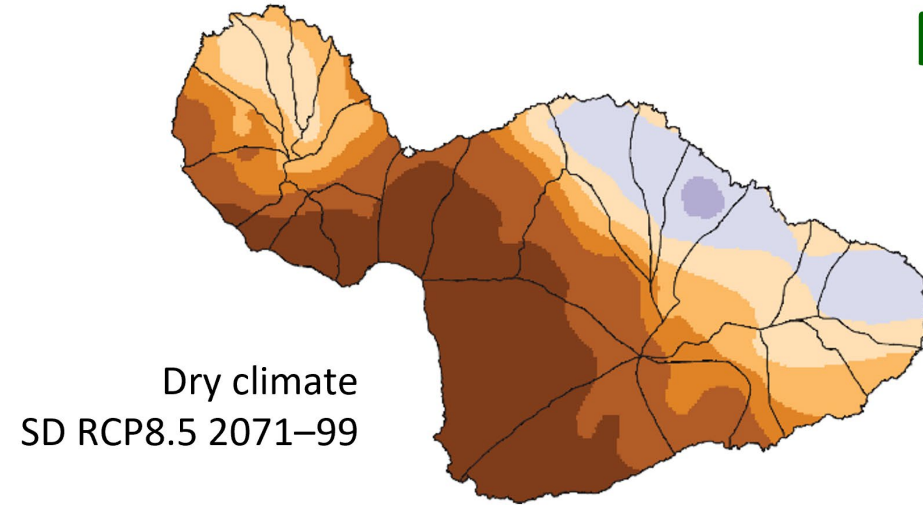
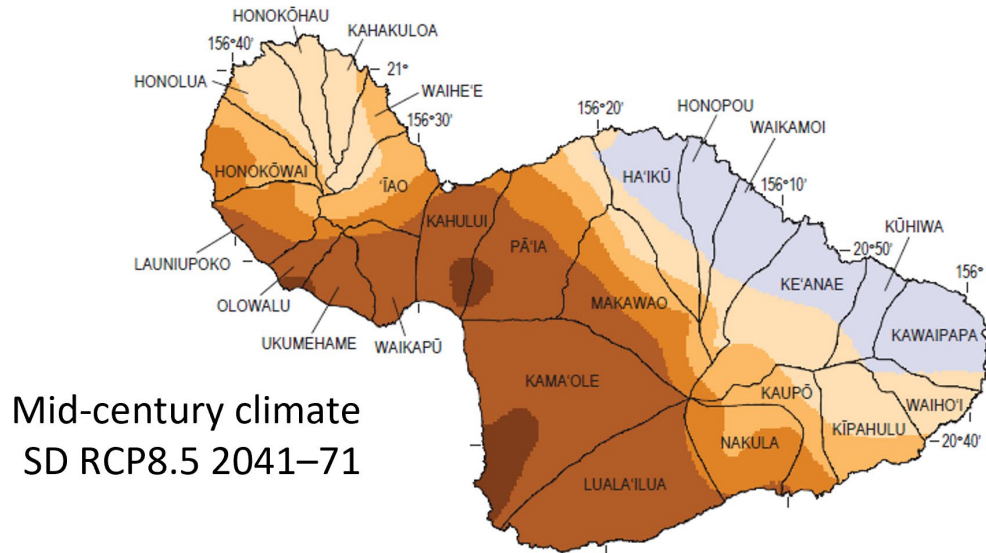
^c Wettest scenario relative to available set of projections

Estimated Island-Wide Recharge Anomalies

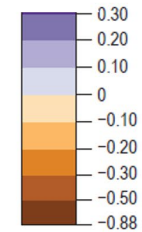


Mean Annual Rainfall Anomalies

Maui



EXPLANATION
Projected mean annual rainfall
anomaly—Expressed as a fraction
of 1978–2007 mean

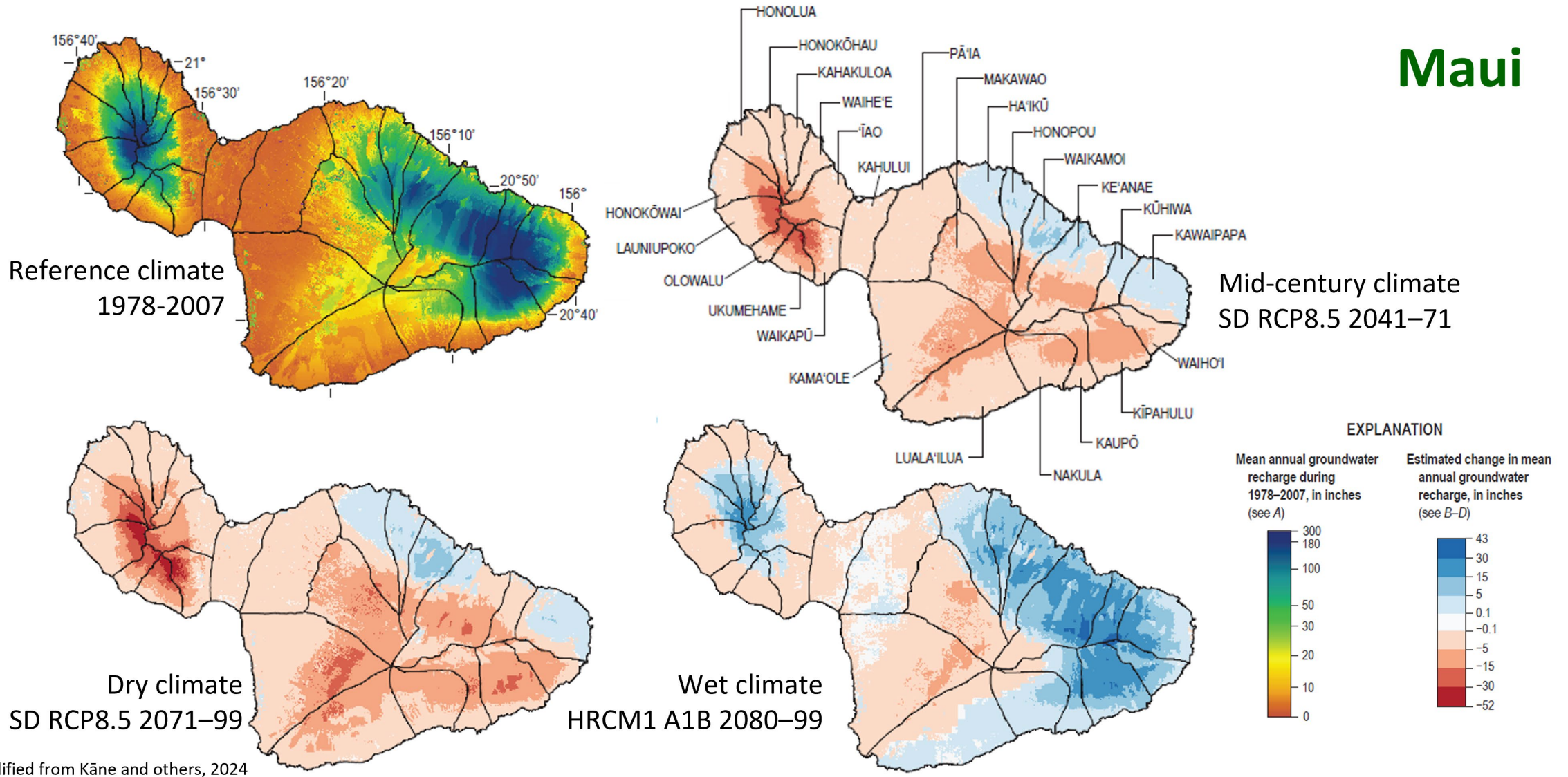


— Boundary of aquifer system

Modified from Kāne and others, 2024

Change in Mean Annual Groundwater Recharge

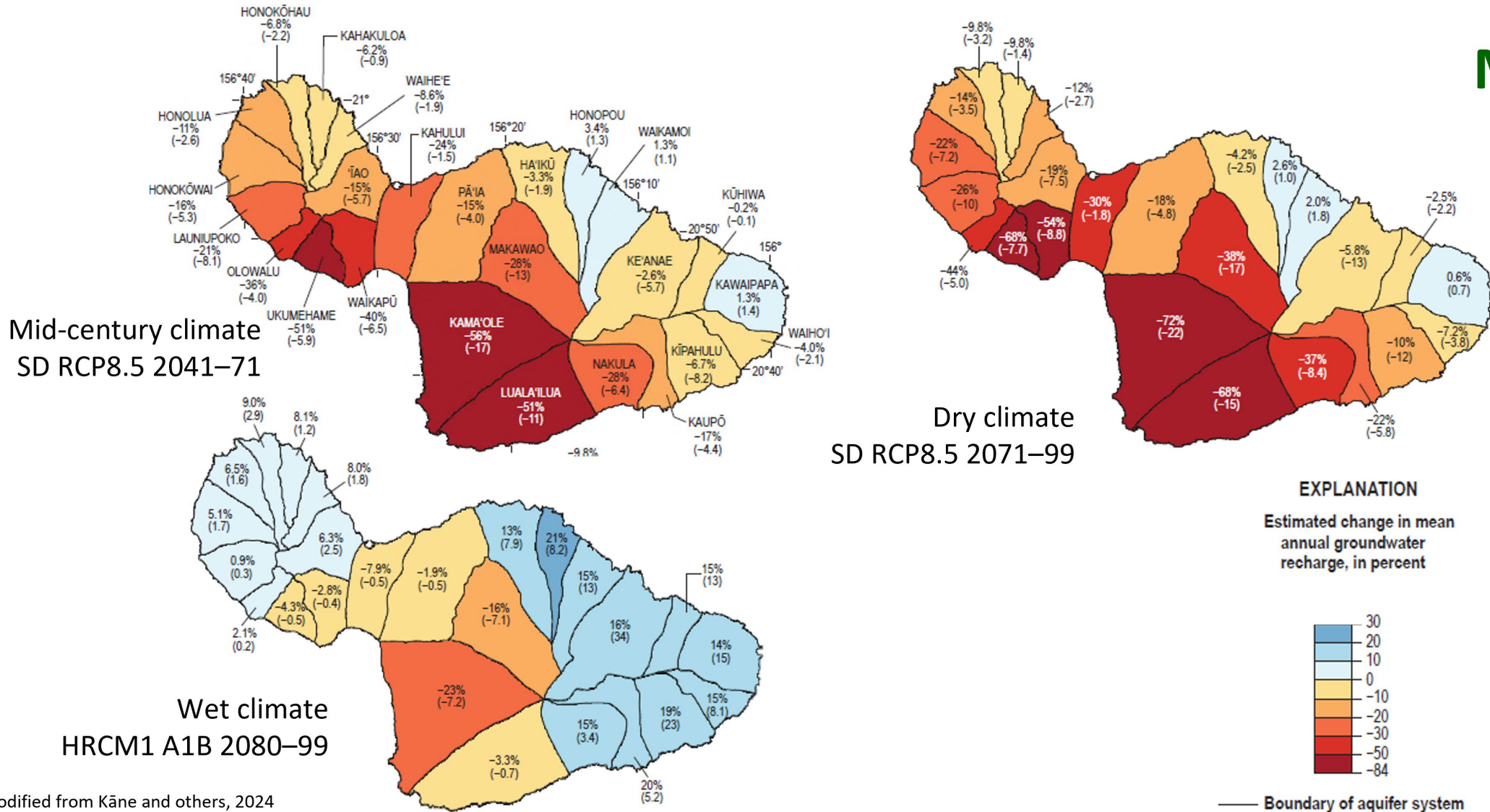
Maui



Modified from Kāne and others, 2024

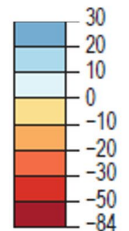
Change in Aquifer System Recharge

Maui



EXPLANATION

Estimated change in mean annual groundwater recharge, in percent

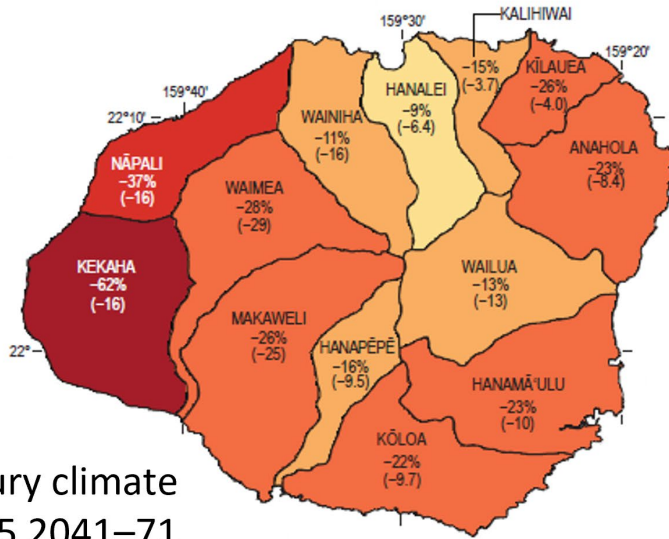


— Boundary of aquifer system

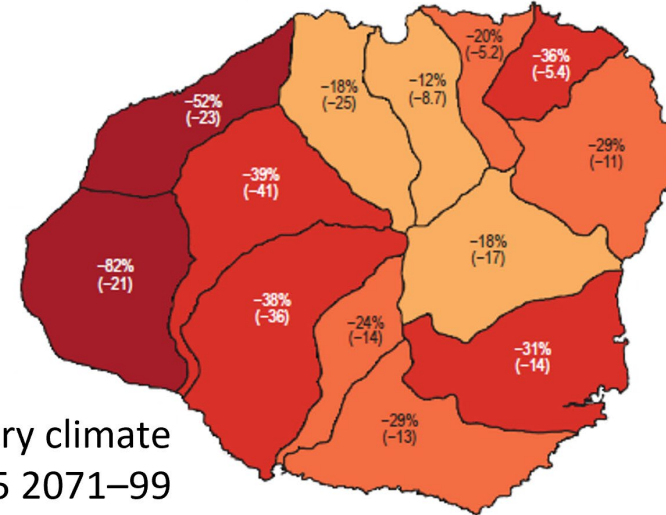
Modified from Kāne and others, 2024

Change in Aquifer System Recharge

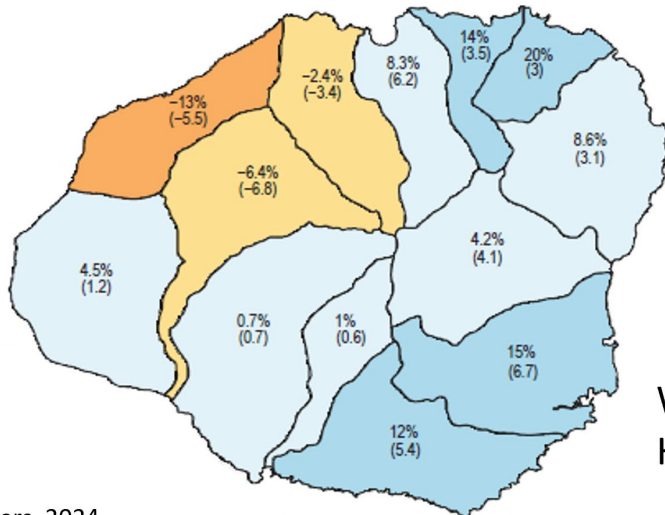
Kaua'i



Mid-century climate
SD RCP8.5 2041–71

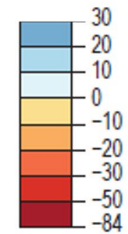


Dry climate
SD RCP8.5 2071–99



Wet climate
HRCM2 RCP4.5 2080–99

EXPLANATION
Estimated change in mean
annual groundwater
recharge, in percent



— Boundary of aquifer system

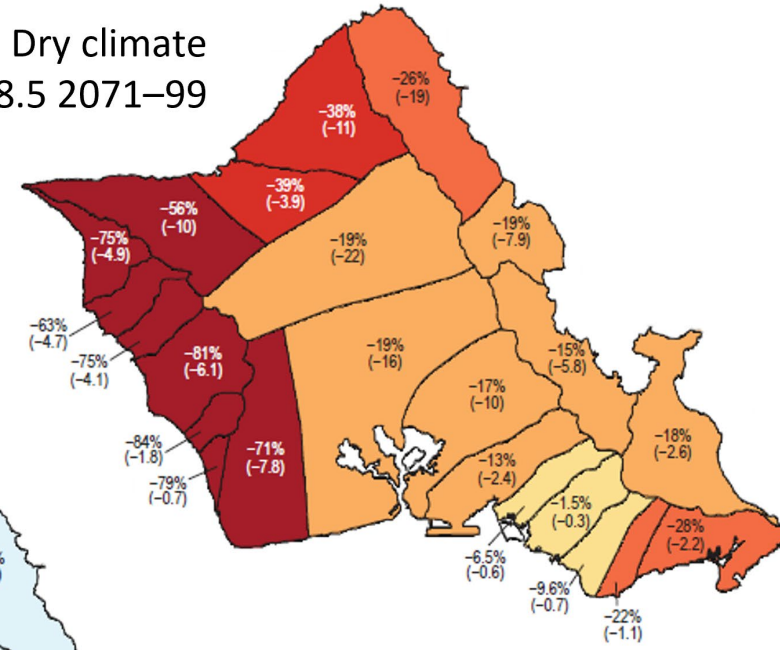
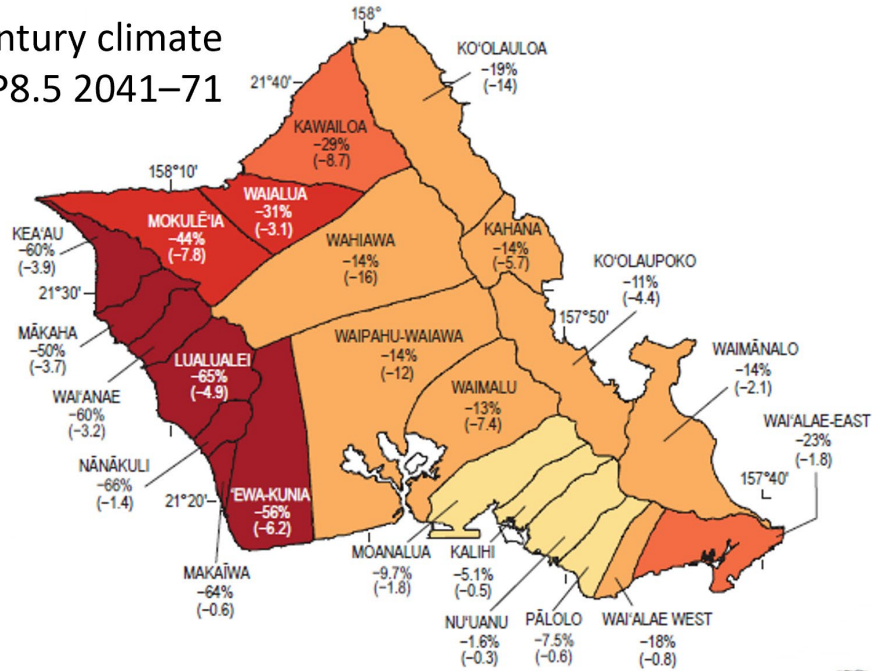
Modified from Kāne and others, 2024

Change in Aquifer System Recharge

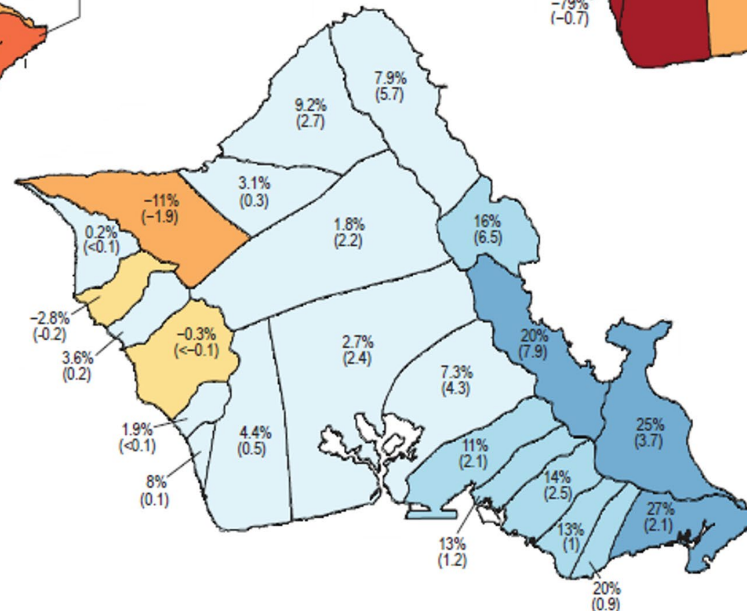
O'ahu

Mid-century climate
SD RCP8.5 2041–71

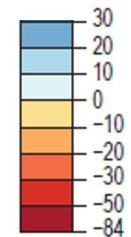
Dry climate
SD RCP8.5 2071–99



Wet climate
HRCM2 RCP8.5 2080–99



EXPLANATION
Estimated change in mean annual groundwater recharge, in percent

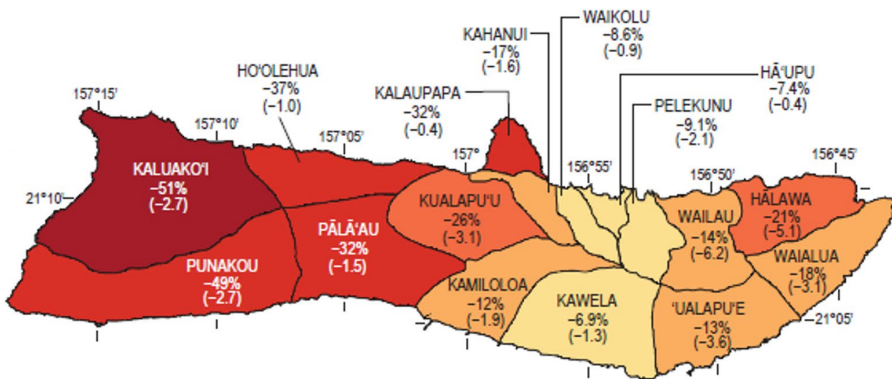


— Boundary of aquifer system

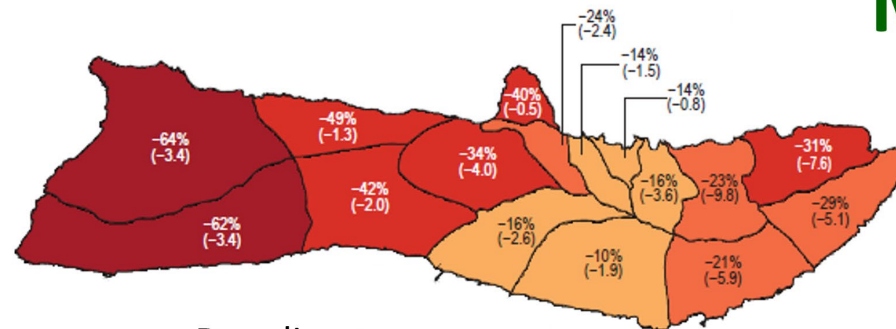
Modified from Kāne and others, 2024

Change in Aquifer System Recharge

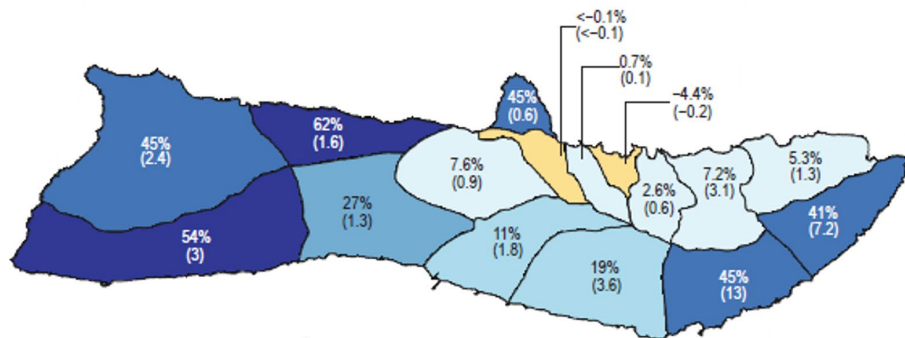
Moloka'i



Mid-century climate
SD RCP8.5 2041-71



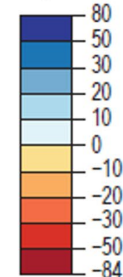
Dry climate
SD RCP8.5 2071-99



Wet climate
HRCM2 RCP8.5 2080-99

EXPLANATION

Estimated change in mean annual groundwater recharge, in percent



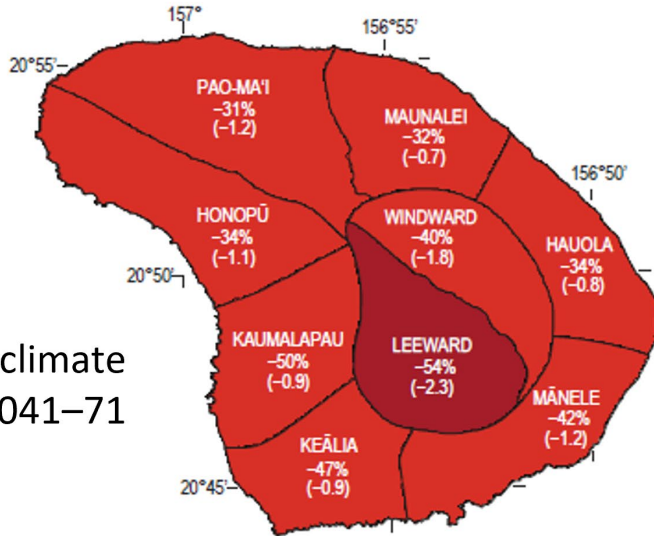
— Boundary of aquifer system

Modified from Kāne and others, 2024

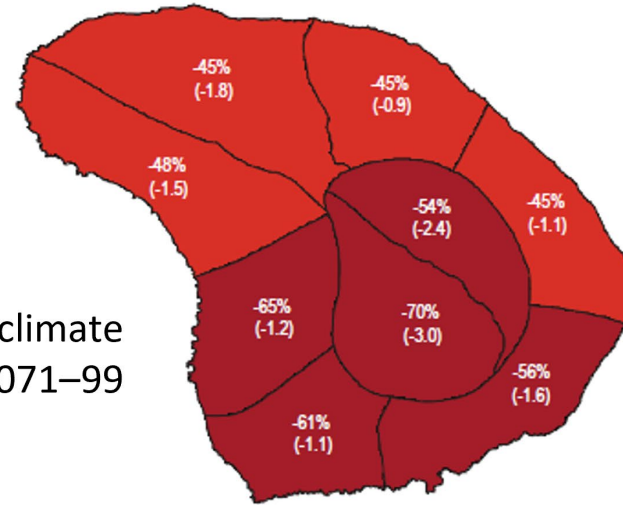
Change in Aquifer System Recharge

Lānaʻi

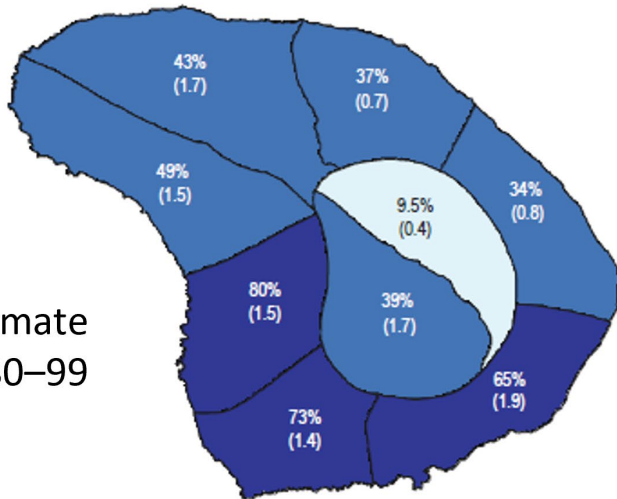
Mid-century climate
SD RCP8.5 2041–71



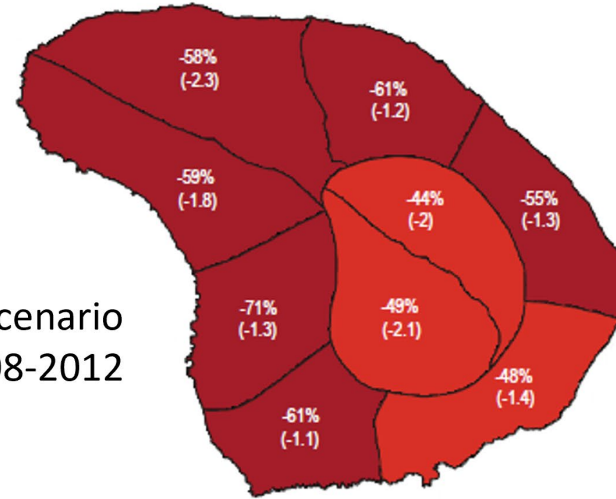
Dry climate
SD RCP8.5 2071–99



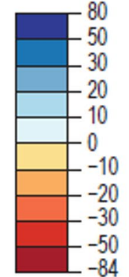
Wet climate
HRCM2 RCP4.5 2080–99



Drought scenario
2008–2012



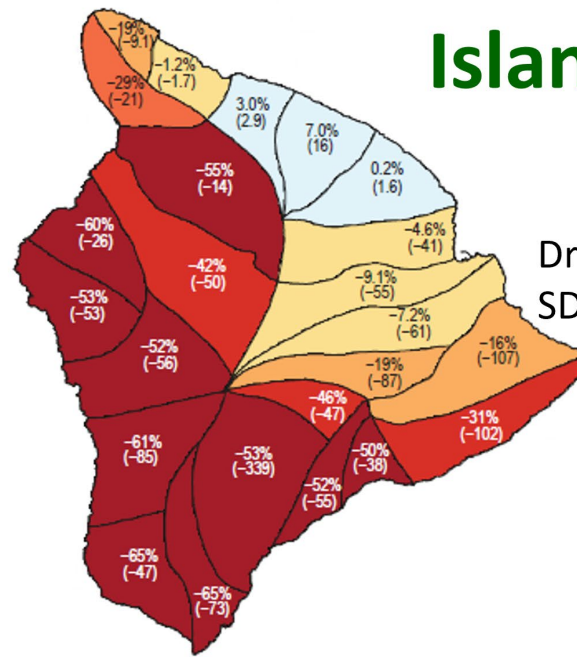
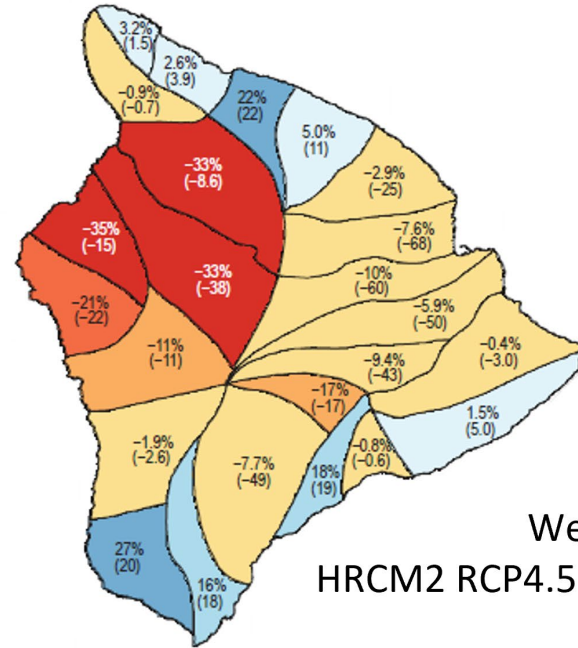
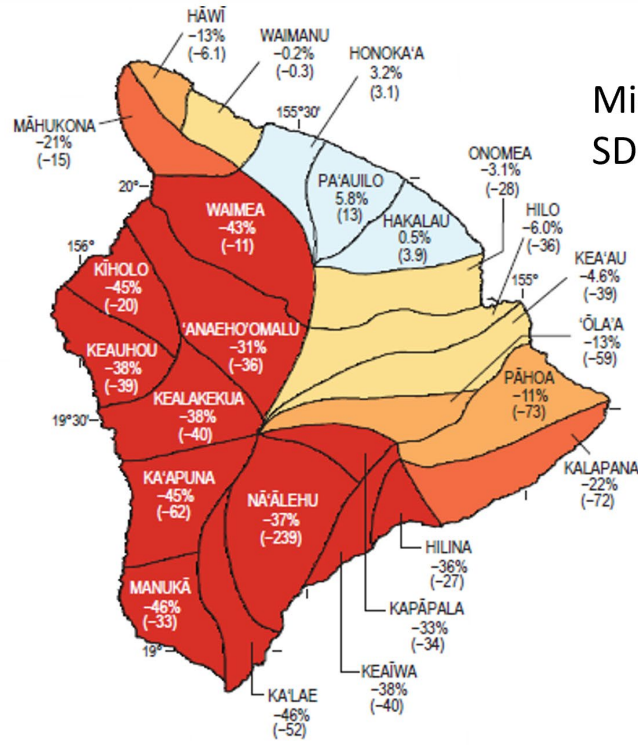
EXPLANATION
Estimated change in mean annual groundwater recharge, in percent



— Boundary of aquifer system

Modified from Kāne and others, 2024

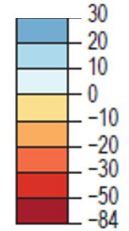
Change in Aquifer System Recharge



Island of Hawai'i

Dry climate
SD RCP8.5 2071-99

EXPLANATION
Estimated change in mean annual groundwater recharge, in percent



— Boundary of aquifer system

Modified from Käne and others, 2024

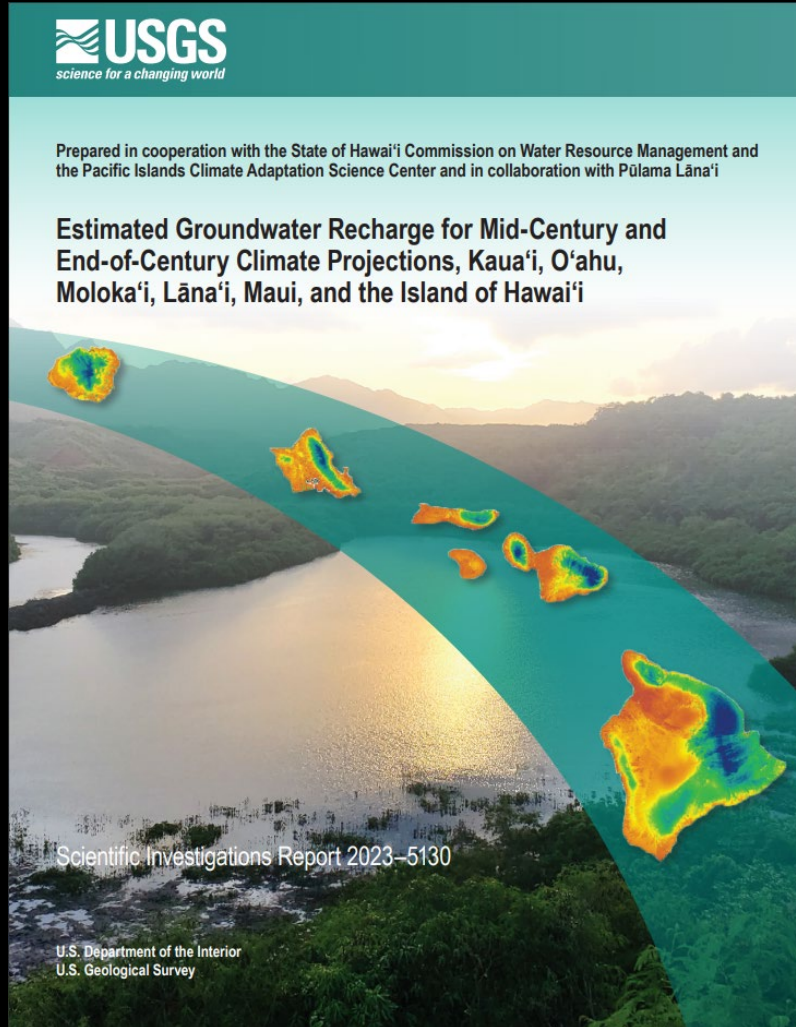
Study Limitations

- Dissimilar simulation periods between the climate projections
- Greater uncertainty in recharge estimates in areas with low rain-gage and stream-gage densities
- Limited information on projected changes to cloud-water interception rates, cloud-zone altitudes, and evapotranspiration rates
- Differences in the evapotranspiration rates of native and non-native forests are not well known for all important species and settings
- Limited information on recharge rates from reservoirs
- Limited information on taro irrigation & cultivation

Summary

- Estimated decreases in island-wide recharge for the mid-century and dry-climate scenarios on all 6 islands
- Estimated increases in island-wide recharge for the wet-climate scenario on all islands except the Island of Hawai‘i
- Diverse range of estimated increases and decreases in aquifer-system recharge among all three future climate scenarios

Available Publications



<https://doi.org/10.3133/sir20145168>

Analysis and results documented in Scientific Investigations Report 2023-5130 and associated data release

The screenshot shows a ScienceBase Catalog page. The breadcrumb trail is 'ScienceBase Catalog → USGS Pacific Islands Water ... → Groundwater Recharge → Mean annual water-budget c...'. The title is 'Mean annual water-budget components for Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, and the Island of Hawai'i for a set of recent and future climate conditions, and 2020 land cover'. There are buttons for 'Add', 'View', and 'Manage Item'. Under 'Citation', it lists 'Kāne, H.L., Mair, A., and Mifflin, J., 2024, Mean annual water-budget components for Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, and the Island of Hawai'i, for a set of recent and future climate conditions, and 2020 land cover: U.S. Geological Survey data release, https://doi.org/10.5066/P972KMSL'. The 'Summary' section describes the data files and scenarios. A map shows the Hawaiian Islands with a color-coded overlay. Under 'Child Items', there are four entries for different island groups and climate scenarios. At the bottom, there are 'Spatial Services' and a 'ScienceBase WMS' link: 'https://www.sciencebase.gov/catalog/10.5066/P972KMSL'.

<https://doi.org/10.5066/F7K64H14>

Mahalo to Our Partners!



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- Johnson, A.G., Engott, J.A., Bassiouni, M., and Rotzoll, K., 2018, Spatially distributed groundwater recharge estimated using a water-budget model for the Island of Maui, Hawai'i, 1978–2007 (ver. 2.0, February 2018): U.S. Geological Survey Scientific Investigations Report 2014–5168, 53 p., <https://doi.org/10.3133/sir20145168>.
- Kāne, H.L., Mair, A., Johnson, A.G., Rotzoll, K., Mifflin, J., and Oki, D.S., 2024, Estimated groundwater recharge for mid-century and end-of-century climate projections, Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, and the Island of Hawai'i: U.S. Geological Survey Scientific Investigations Report 2023–5130, 133 p., <https://doi.org/10.3133/sir20235130>.
- Kāne, H.L., Mair, A., and Mifflin, J., 2024, Mean annual water-budget components for Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, and the Island of Hawai'i, for a set of recent and future climate conditions, and 2020 land cover: U.S. Geological Survey data release, <https://doi.org/10.5066/P972KMSL>.
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