



 Pacific Islands Water Science Center

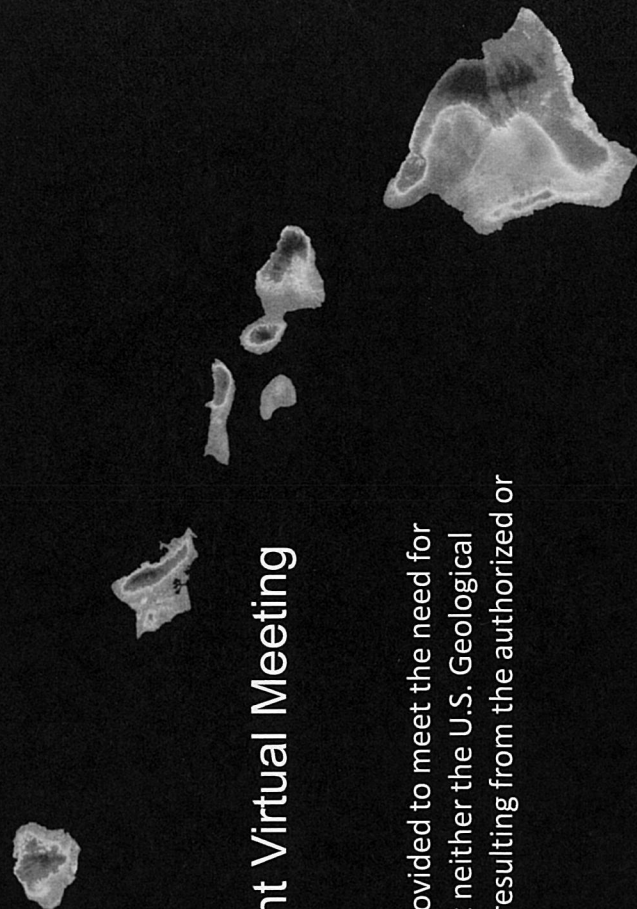
Estimated Groundwater Recharge for Mid-Century and End-of-Century, Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, and Hawai'i

Heidi Kāne and Alan Mair
Pacific Islands Water Science Center

State of Hawai'i
Commission on Water Resource Management Virtual Meeting
January 18, 2022

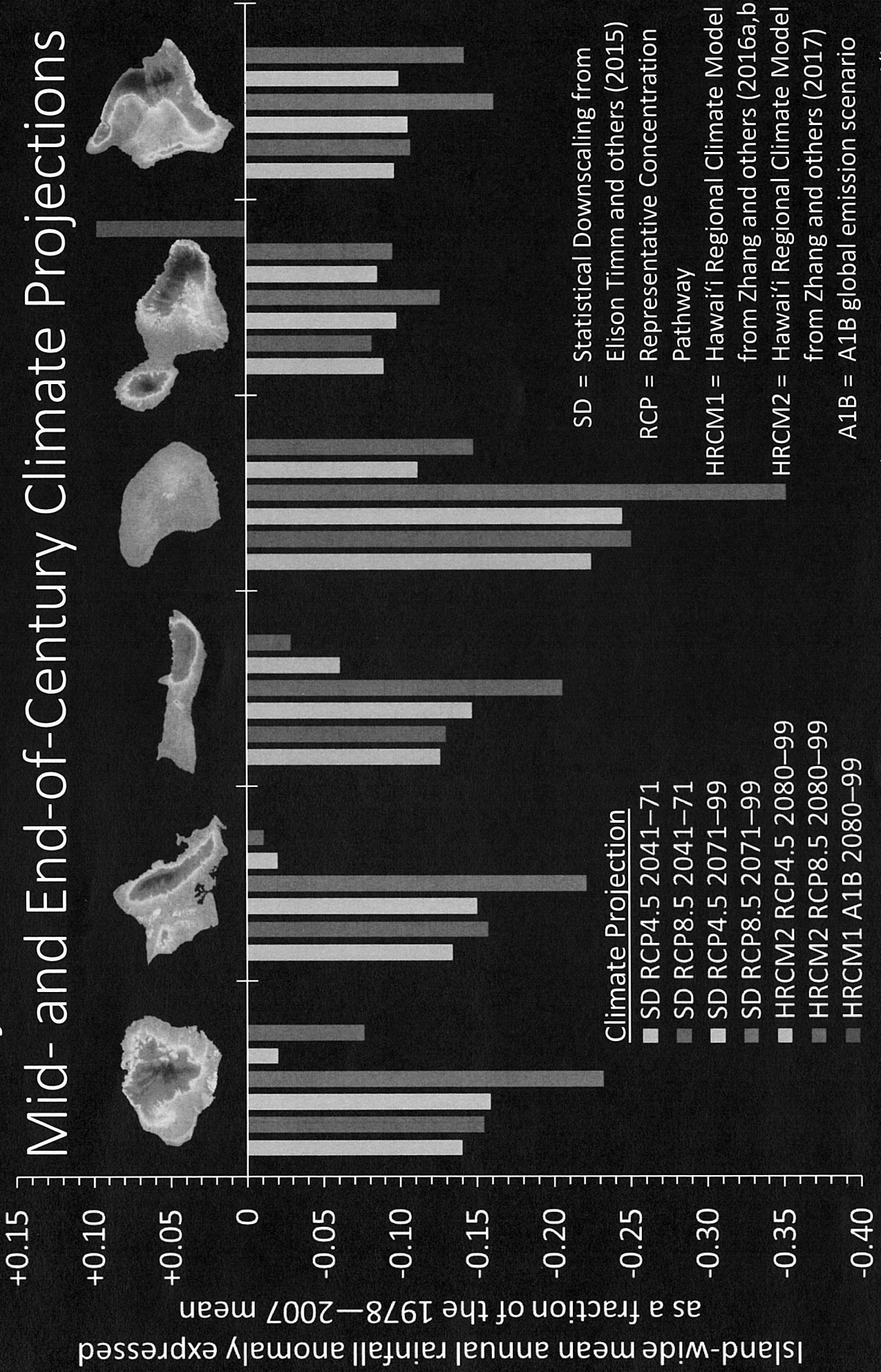
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U.S. Department of the Interior
U.S. Geological Survey



Projected Island-Wide Rainfall Anomalies

Mid- and End-of-Century Climate Projections



Kaua'i

O'ahu

Moloka'i

Lāna'i

Maui

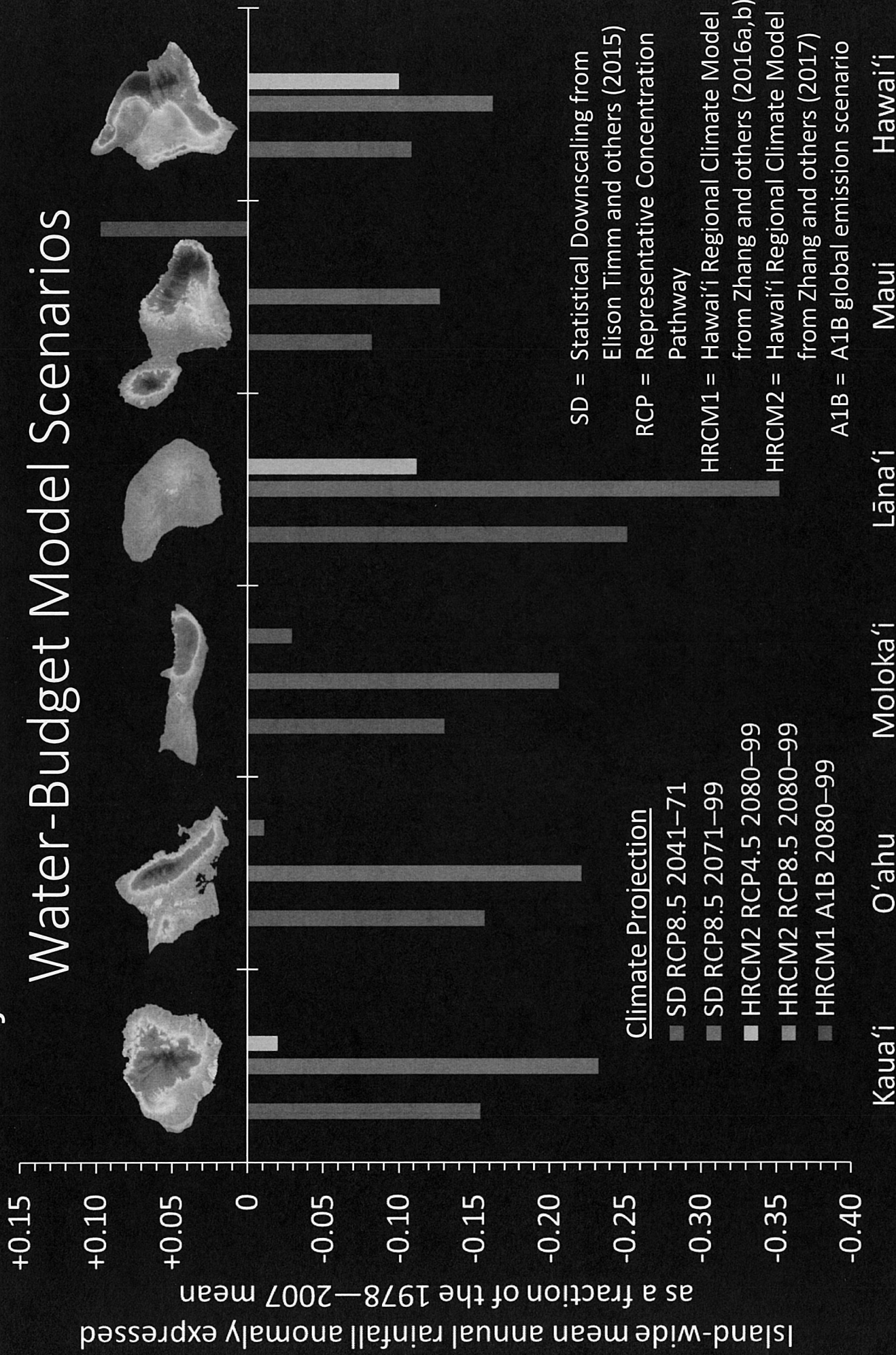
Hawai'i



Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Projected Island-Wide Rainfall Anomalies

Water-Budget Model Scenarios



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Water-Budget Model Scenarios

Study-defined climate scenario ^a	Selected climate condition or projection	Kaua'i	O'ahu	Moloka'i	Lāna'i	Maui	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	1998–2002	-	-	-	✓	-	-

^a All scenarios use 2020 land-cover conditions

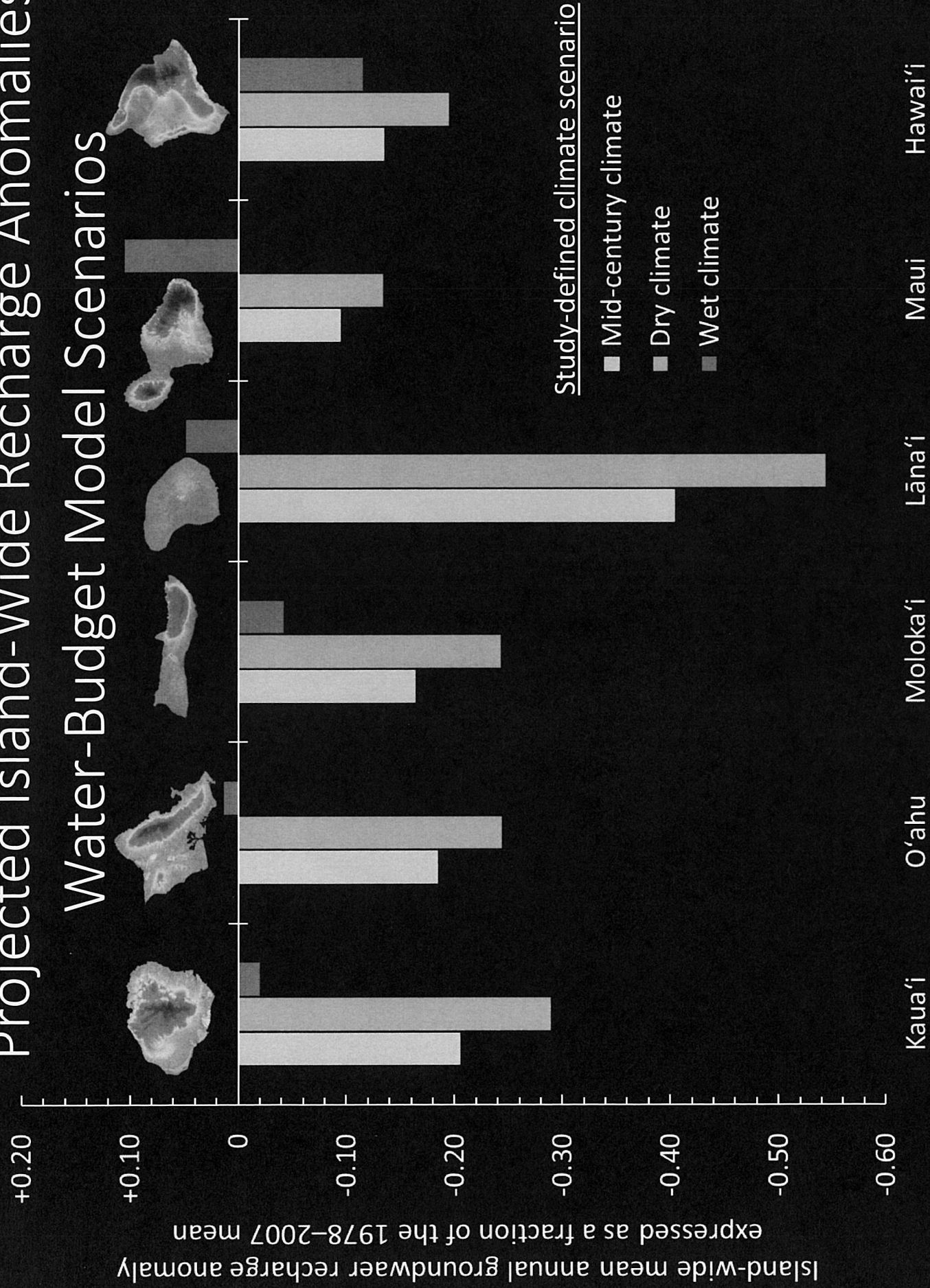
^b Driest scenario relative to available set of projections

^c Wettest scenario relative to available set of projections



Projected Island-Wide Recharge Anomalies

Water-Budget Model Scenarios



Lānaʻi

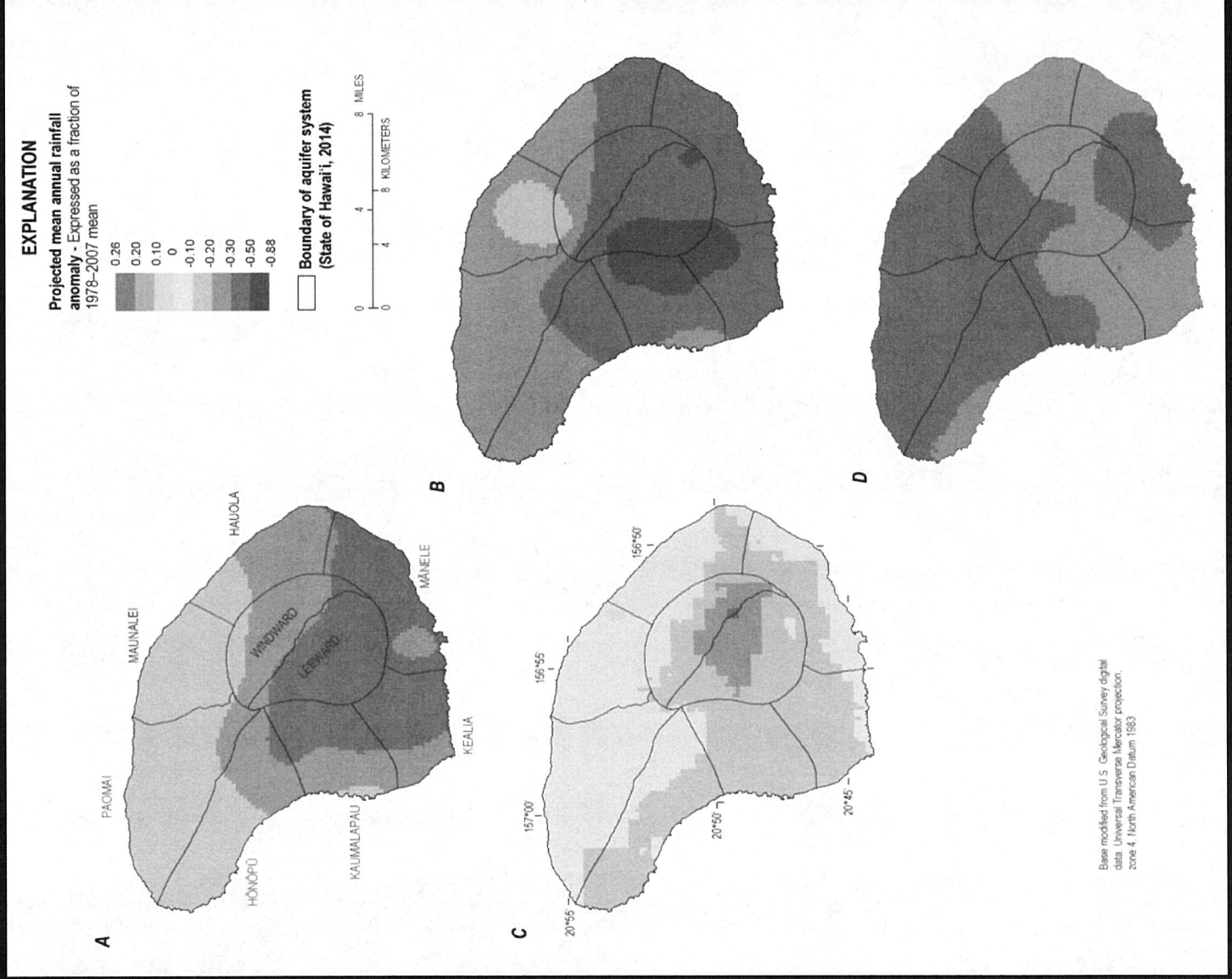
Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99

Mean Annual Rainfall Anomalies

Dry climate
SD RCP8.5 2071–99

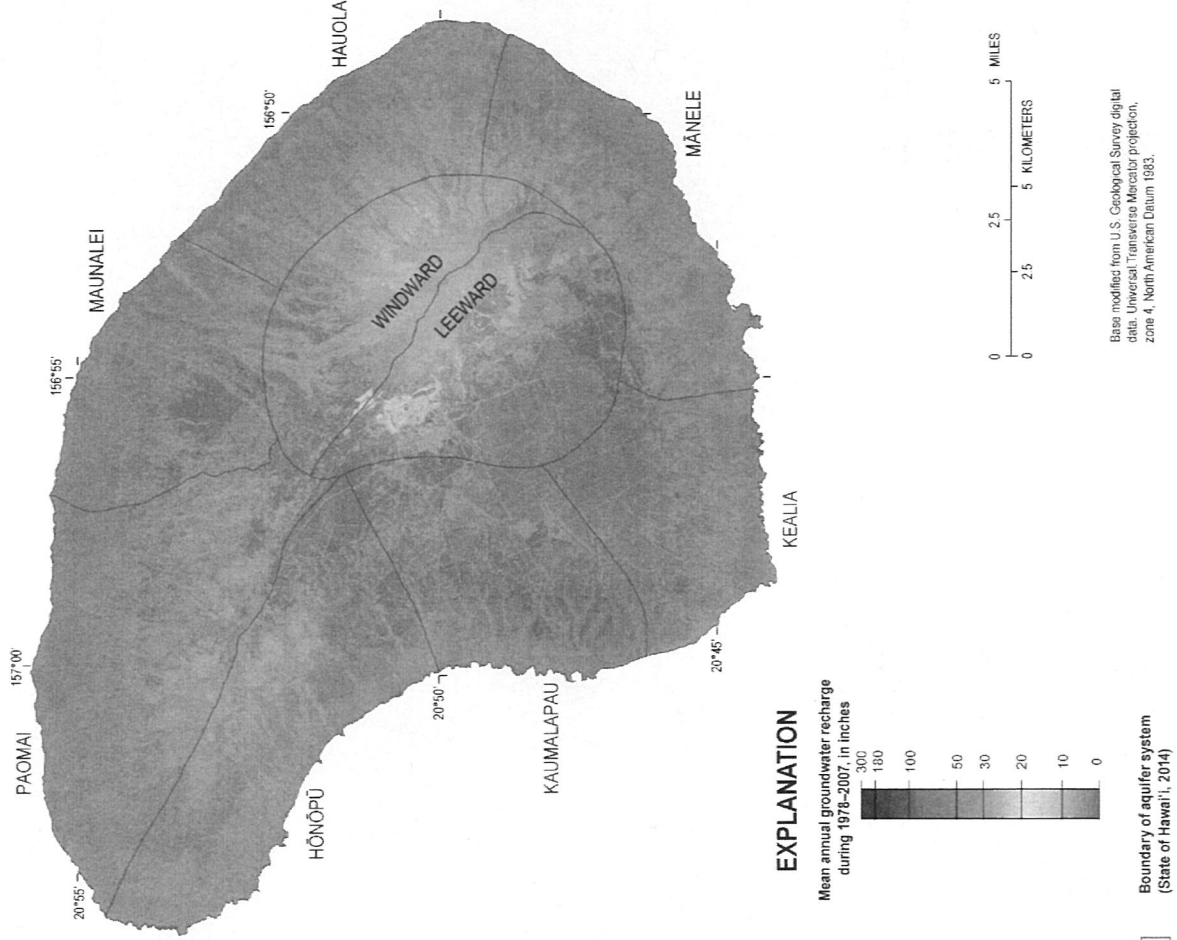
Drought
1998–2002



Lānaʻi

Reference climate
1978–2007

Mean Annual Groundwater Recharge



Lānaʻi

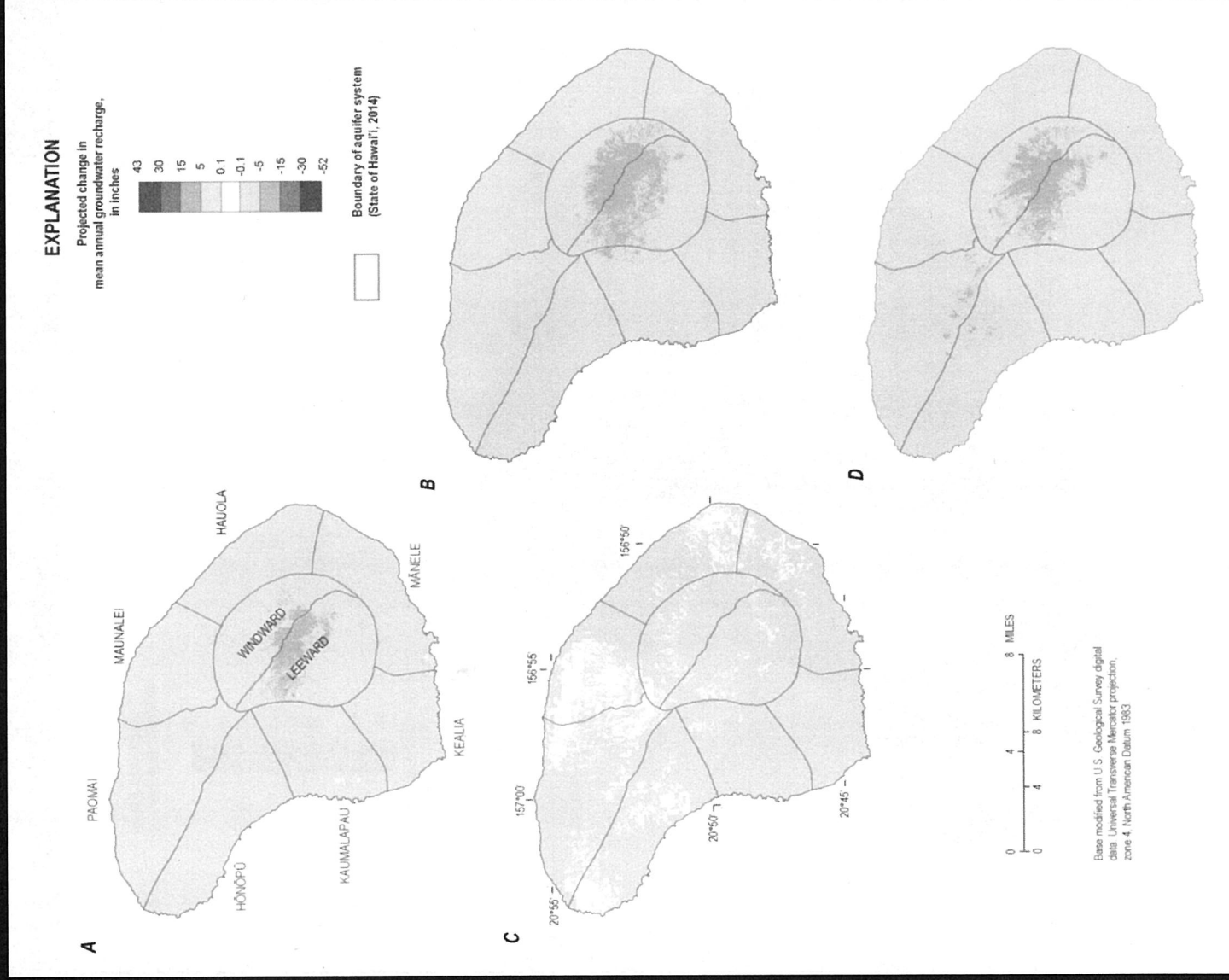
Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99

Change in Groundwater Recharge

Dry climate
SD RCP8.5 2071–99

Drought
1998–2002



Lāna'i

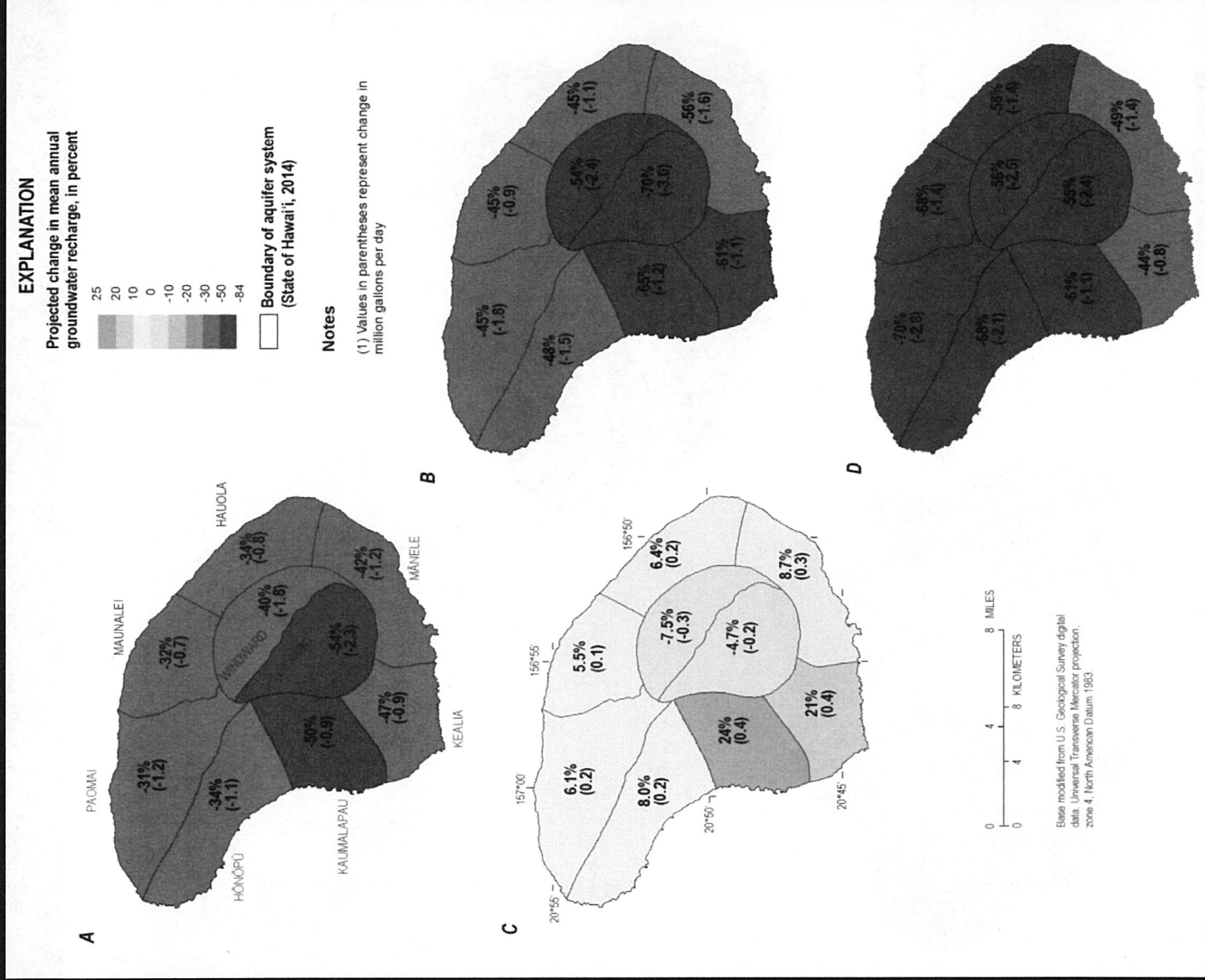
Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99

Change in Aquifer- System Recharge

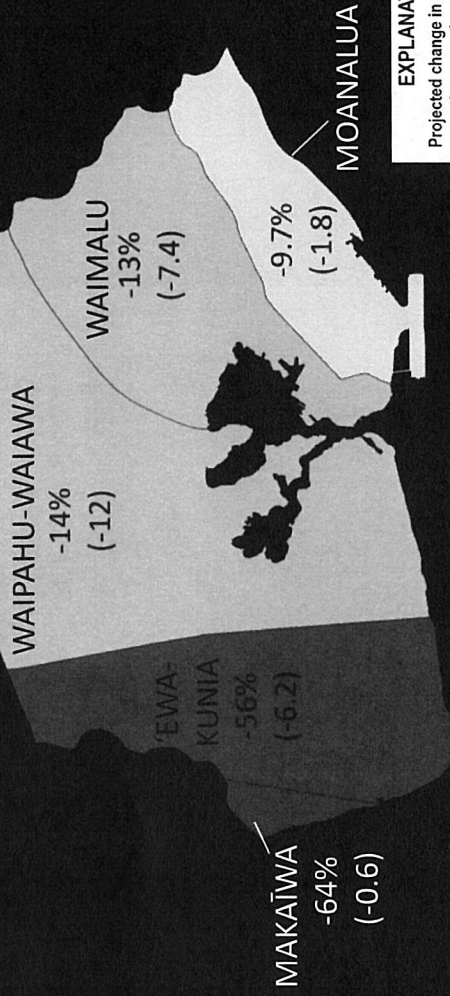
Dry climate
SD RCP8.5 2071–99

Drought
1998–2002

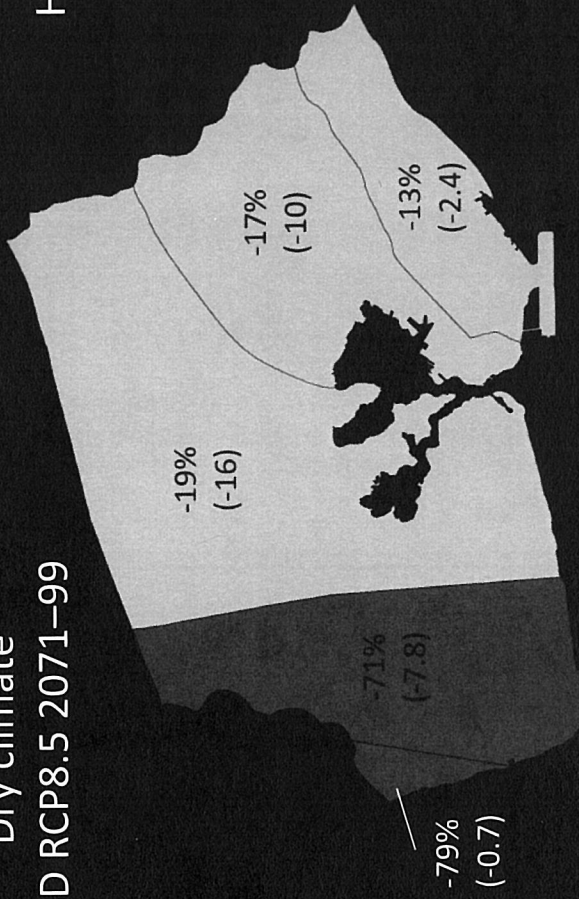


Pearl Harbor Aquifer Sector and Moanalua Aquifer System, O'ahu

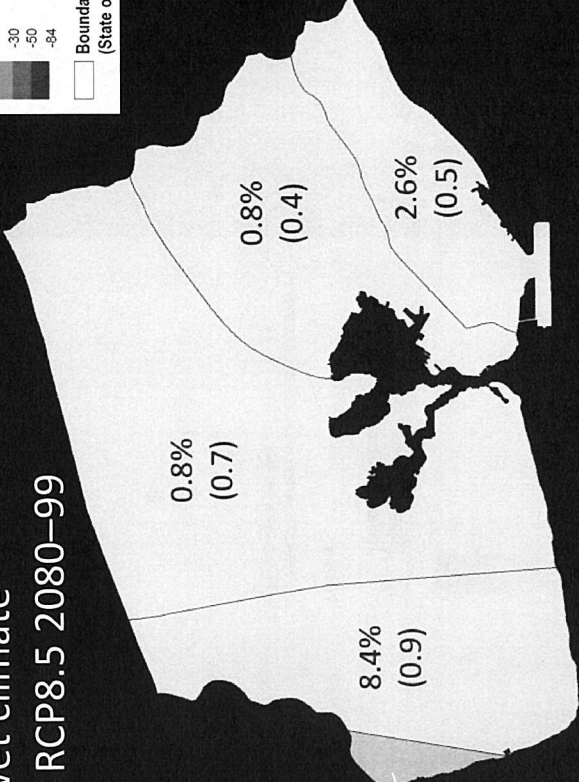
Mid-century climate
SD RCP8.5 2041-71



Dry climate
SD RCP8.5 2071-99



Wet climate
HRCM2 RCP8.5 2080-99



EXPLANATION

Projected change in mean annual groundwater recharge, in percent

25
20
10
0
-10
-20
-30
-50
-84

□ Boundary of aquifer system (State of Hawaii, 2014)

Values in parentheses represent change in million gallons per day

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Moloka'i

Mid-century climate
SD RCP8.5 2041-71

Dry climate
SD RCP8.5 2071-99

Wet climate
HRCM2 RCP8.5
2080-99

Change in Aquifer- System Recharge

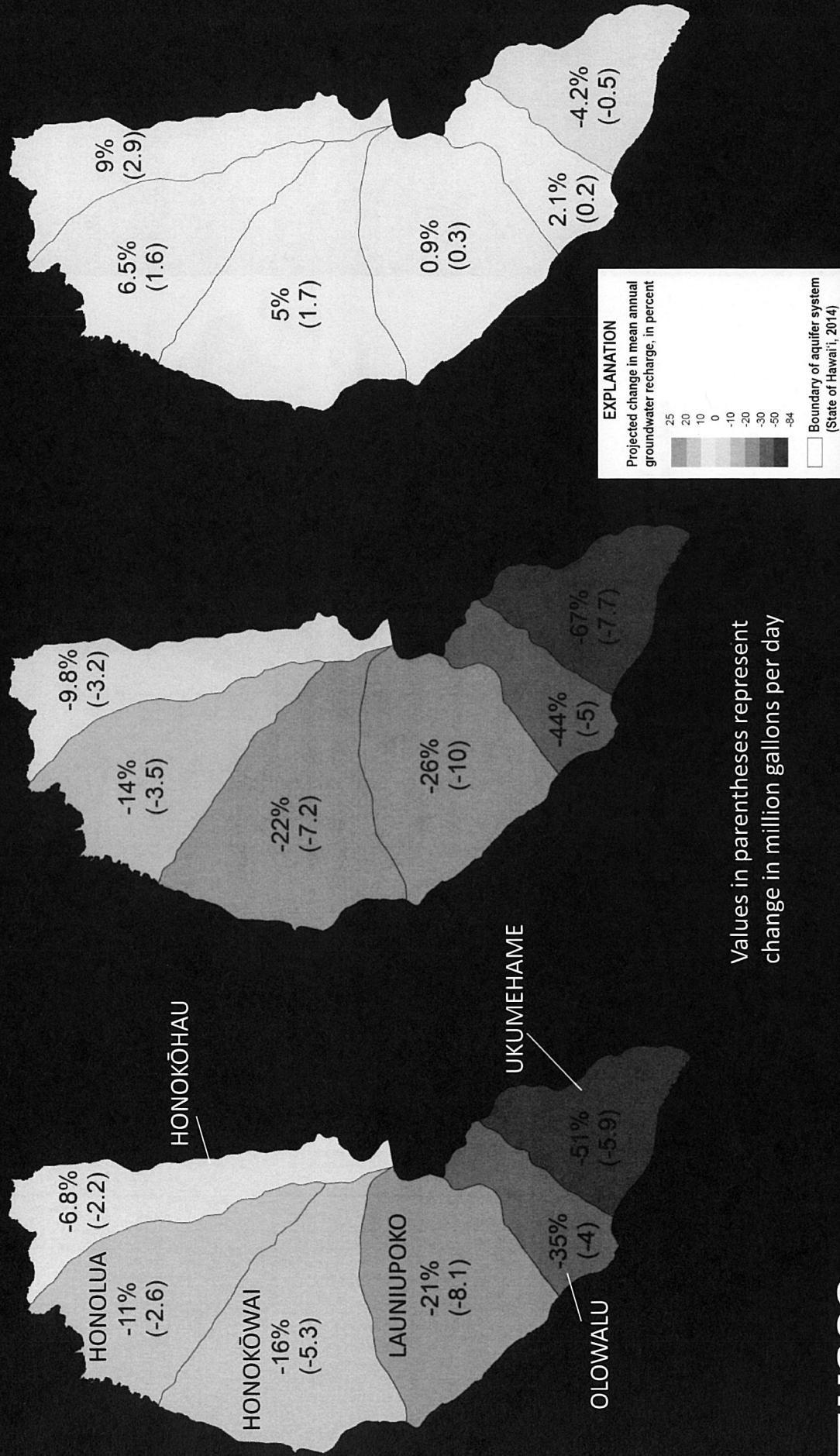


Lahaina Aquifer Sector, Maui

Mid-century climate
SD RCP8.5 2041-71

Dry climate
SD RCP8.5 2071-99

Wet climate
HRCM1 A1B 2080-99



Values in parentheses represent change in million gallons per day

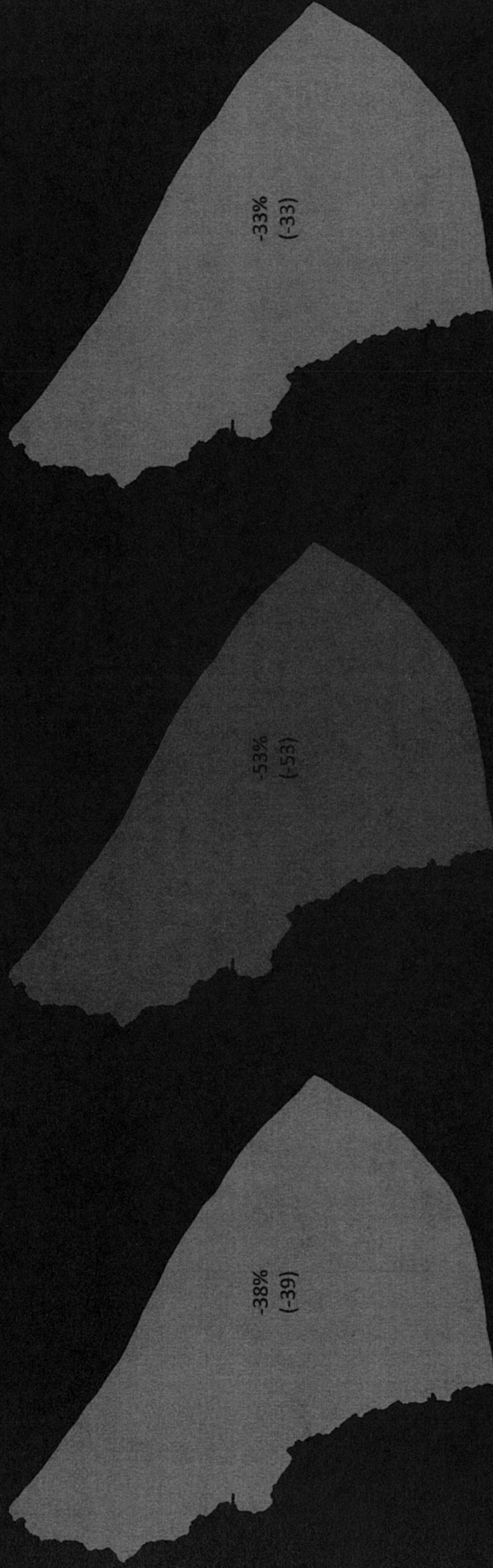


Keauhou Aquifer System, Hawai'i

Mid-century climate
SD RCP8.5 2041–71

Dry climate
SD RCP8.5 2071–99

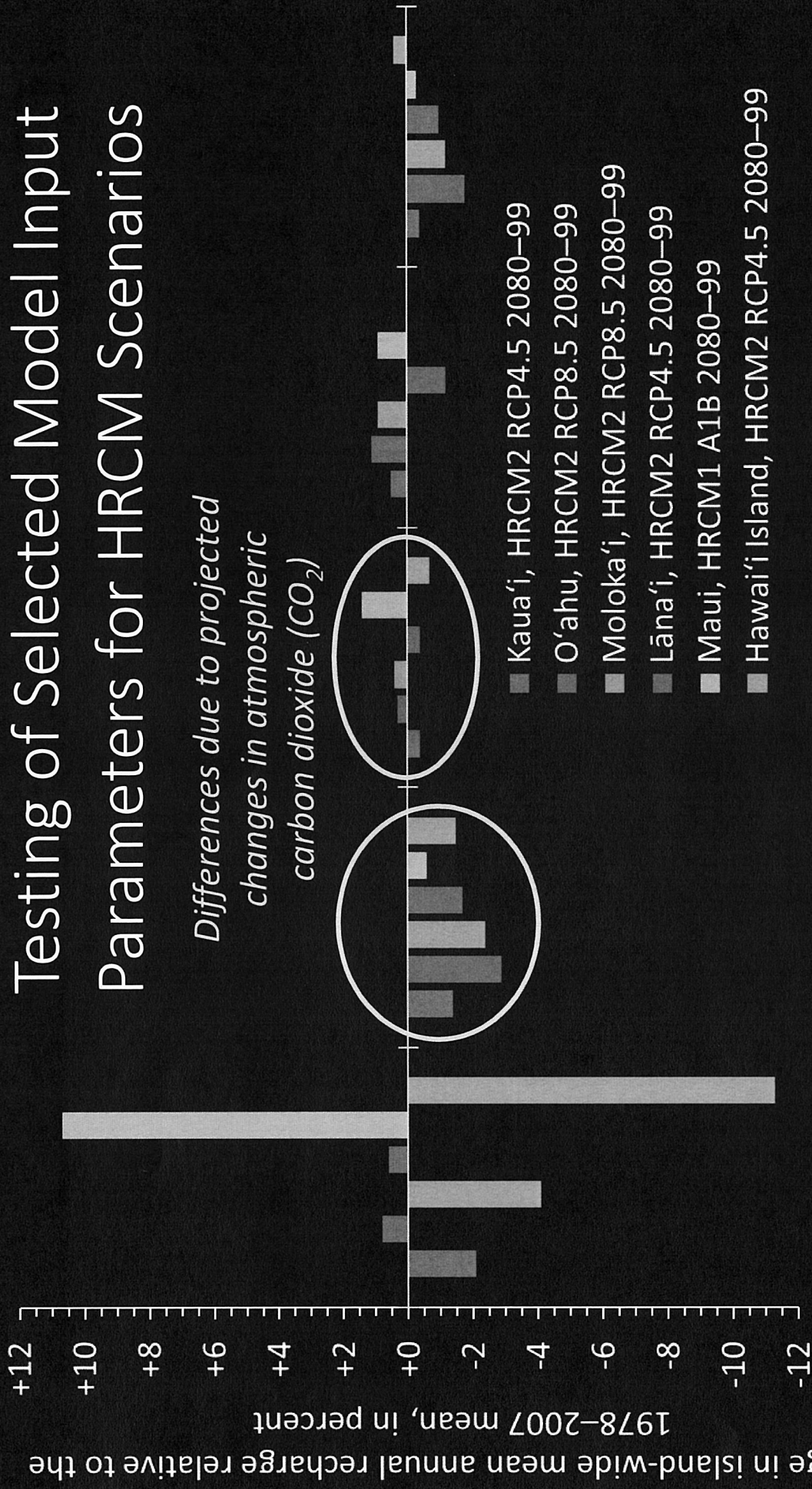
Wet climate
HRCM2 RCP4.5 2080–99



Values in parentheses represent change in million gallons per day



Testing of Selected Model Input Parameters for HRCM Scenarios



Monthly rainfall, seasonal runoff-to-rainfall ratios

Mean monthly reference ET, adjusted for projected warming and increased atmospheric CO₂ concentrations

Ratio of the mean evaporation rate to mean precipitation rate during saturated conditions, V

Daily rainfall fragments

Summary

- Projected decreases in island-wide recharge for the mid-century and dry-climate scenarios on all 6 islands
- Mixture of decreases and increases in aquifer-system recharge projected for the wet-climate scenario on all 6 islands
- Projected decreases in island-wide recharge due to projected warming are largely offset by enhanced recharge due to projected increases in mean atmospheric CO₂ concentrations

Limitations

- Dissimilar simulation periods between the climate projections requires adjustment to a common reference period
- 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
- Recharge rates from reservoirs are not well known and assigned constant values based on limited data
- Taro irrigation and cultivation rates on each island are not well known and assigned constant values based on limited data

Next Steps

- Publish results for recent conditions, and mid-century climate and end-of-century scenarios in a USGS report and data release
- Assess potential effects of drought on soil moisture and recharge for recent and future-climate conditions
- Assess capacity of cloud-water interception to mitigate the hydrologic effects of drought on recharge

References

- Elison Timm, O., Giambelluca, T.W., and Diaz, H.F., 2015, Statistical downscaling of rainfall changes in Hawai'i based on the CMIP5 global model projections, *J. Geophys. Res. Atmos.*, 120, 92–112, <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/2014JD022059>.
- Zhang, C., and Wang, Y., 2017, Projected Future Changes of Tropical Cyclone Activity over the Western North and South Pacific in a 20-km-Mesh Regional Climate Model: *Journal of Climate*, v. 30, no. 15, p. 5923–5941, <https://doi.org/10.1175/JCLI-D-16-0597.1>.
- Zhang, C., Wang, Y., Hamilton, K., and Lauer, A., 2016a, Dynamical Downscaling of the Climate for the Hawaiian Islands, Part I: Present Day: *Journal of Climate*, v. 29, no. 8, p. 3027–3048, <http://dx.doi.org/10.1175/JCLI-D-15-0432.1>.
- Zhang, C., Wang, Y., Hamilton, K., and Lauer, A., 2016b, Dynamical Downscaling of the Climate for the Hawaiian Islands. Part II: Projection for the Late Twenty-First Century: *Journal of Climate*, v. 29, no. 23, p. 8333–8354, <https://doi.org/10.1175/JCLI-D-16-0038.1>.

Mahalo to Our Cooperators!

Cooperators

- State of Hawai'i Commission on Water Resource Management
- USGS Pacific Islands Climate Adaptation Science Center
- Pūlama Lāna'i



