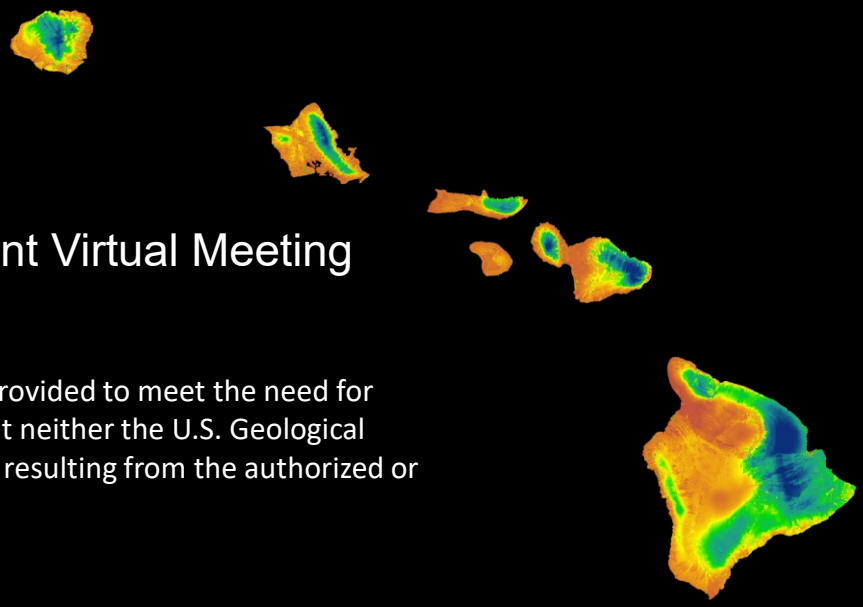
USGS
science for a changing world

Pacific Islands Water Science Center

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

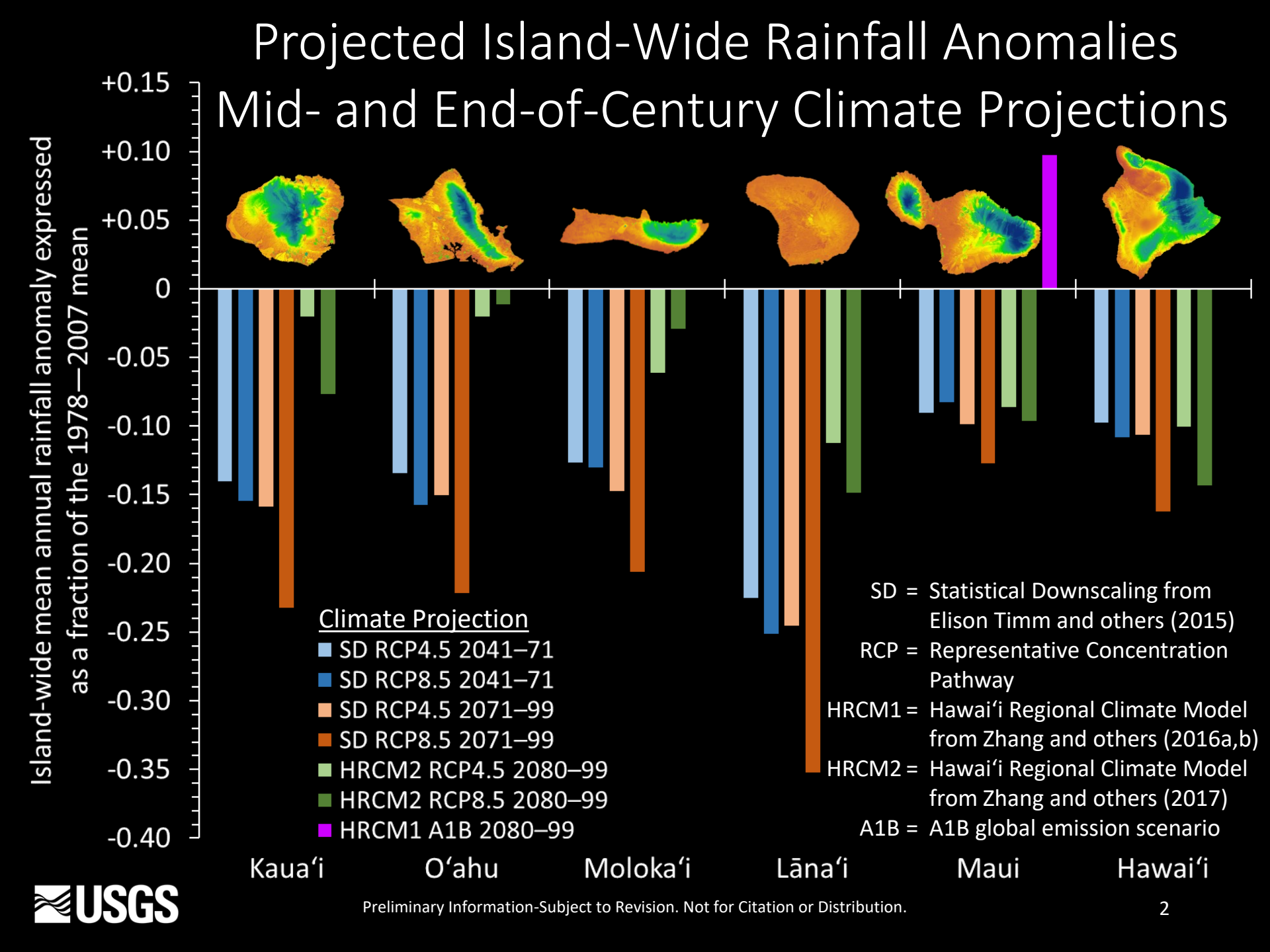
Heidi Kāne and Alan Mair
Pacific Islands Water Science Center

State of Hawaiʻi
Commission on Water Resource Management Virtual Meeting
January 18, 2022



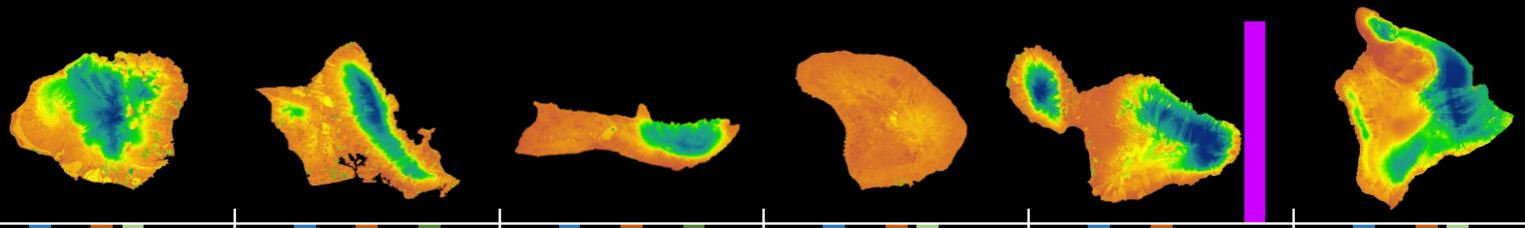
U.S. Department of the Interior
U.S. Geological Survey

Projected Island-Wide Rainfall Anomalies
Mid- and End-of-Century Climate Projections



USGS

Projected Island-Wide Rainfall Anomalies
Water-Budget Model Scenarios



Island-wide mean annual rainfall anomaly expressed as a fraction of the 1978—2007 mean

+0.15
+0.10
+0.05
0
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40

Climate Projection
- SD RCP8.5 2041–71
- SD RCP8.5 2071–99
- HRCM2 RCP4.5 2080–99
- HRCM2 RCP8.5 2080–99
- HRCM1 A1B 2080–99

SD = Statistical Downscaling from Elison Timm and others (2015)
RCP = Representative Concentration Pathway
HRCM1 = Hawai‘i Regional Climate Model from Zhang and others (2016a,b)
HRCM2 = Hawai‘i Regional Climate Model from Zhang and others (2017)
A1B = A1B global emission scenario

Kaua‘i | O‘ahu | Moloka‘i | Lāna‘i | Maui | Hawai‘i

USGS

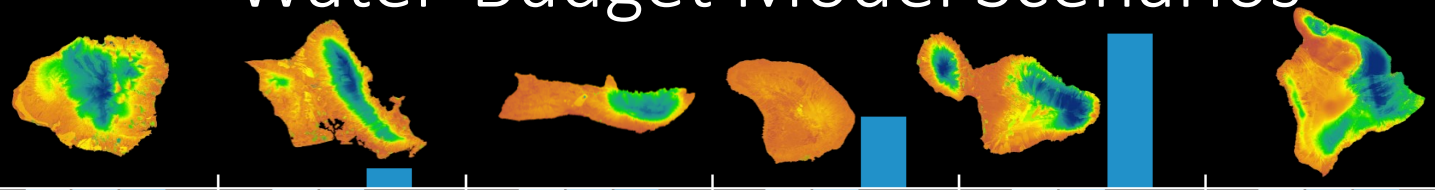
Water-Budget Model Scenarios

Study-defined climate scenario[a]	Selected climate condition or projection	Kauaʻi	Oʻahu	Molokaʻi	Lānaʻi	Maui	Hawaiʻi
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

USGS

Projected Island-Wide Recharge Anomalies Water-Budget Model Scenarios



Island-wide mean annual groundwaer recharge anomaly expressed as a fraction of the 1978–2007 mean

+0.20
+0.10
0
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60

Kaua‘i
O‘ahu
Moloka‘i
Lāna‘i
Maui
Hawai‘i

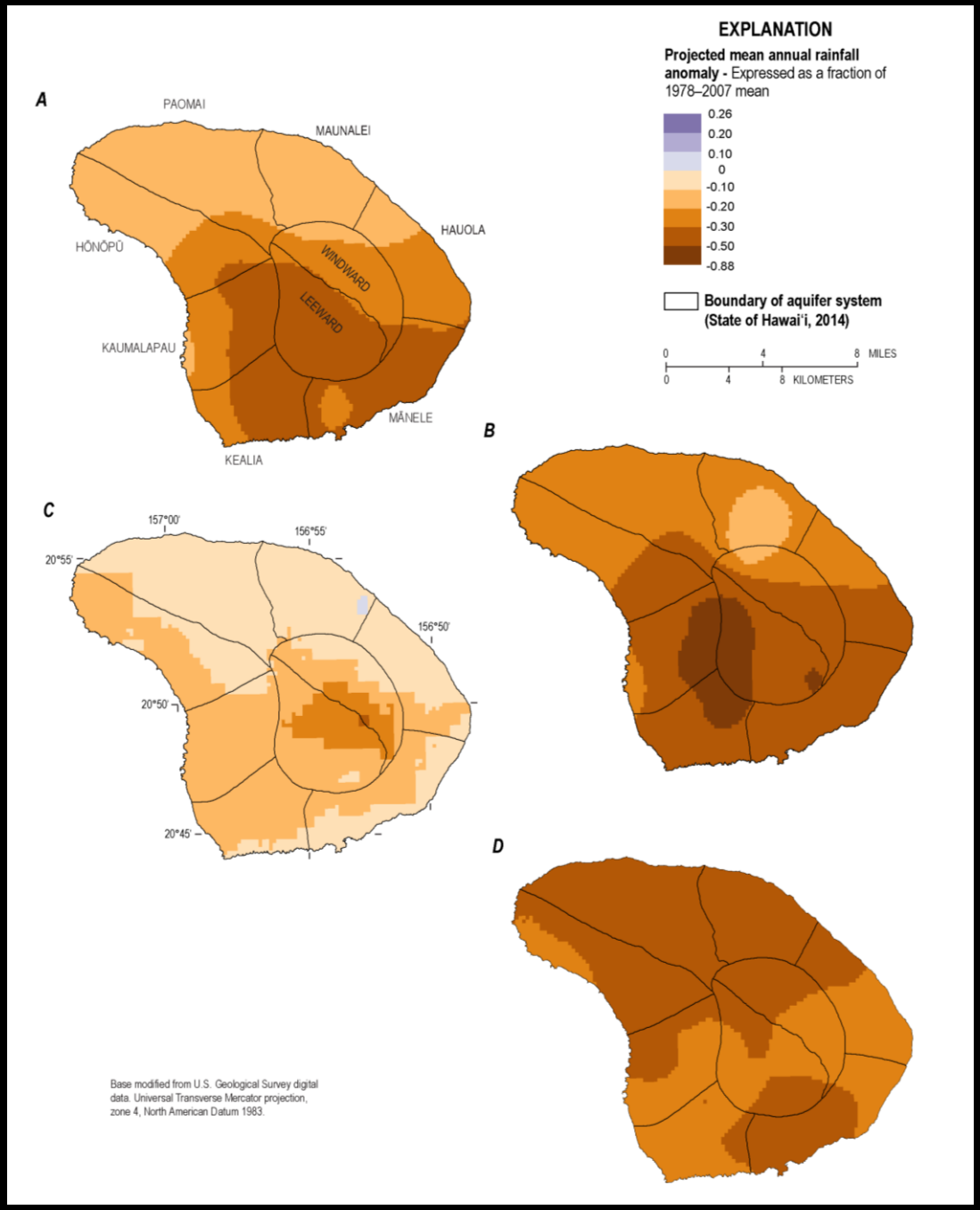
Study-defined climate scenario
- Mid-century climate
- Dry climate
- Wet climate

USGS

Lānaʻi

Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99



Mean Annual Rainfall Anomalies

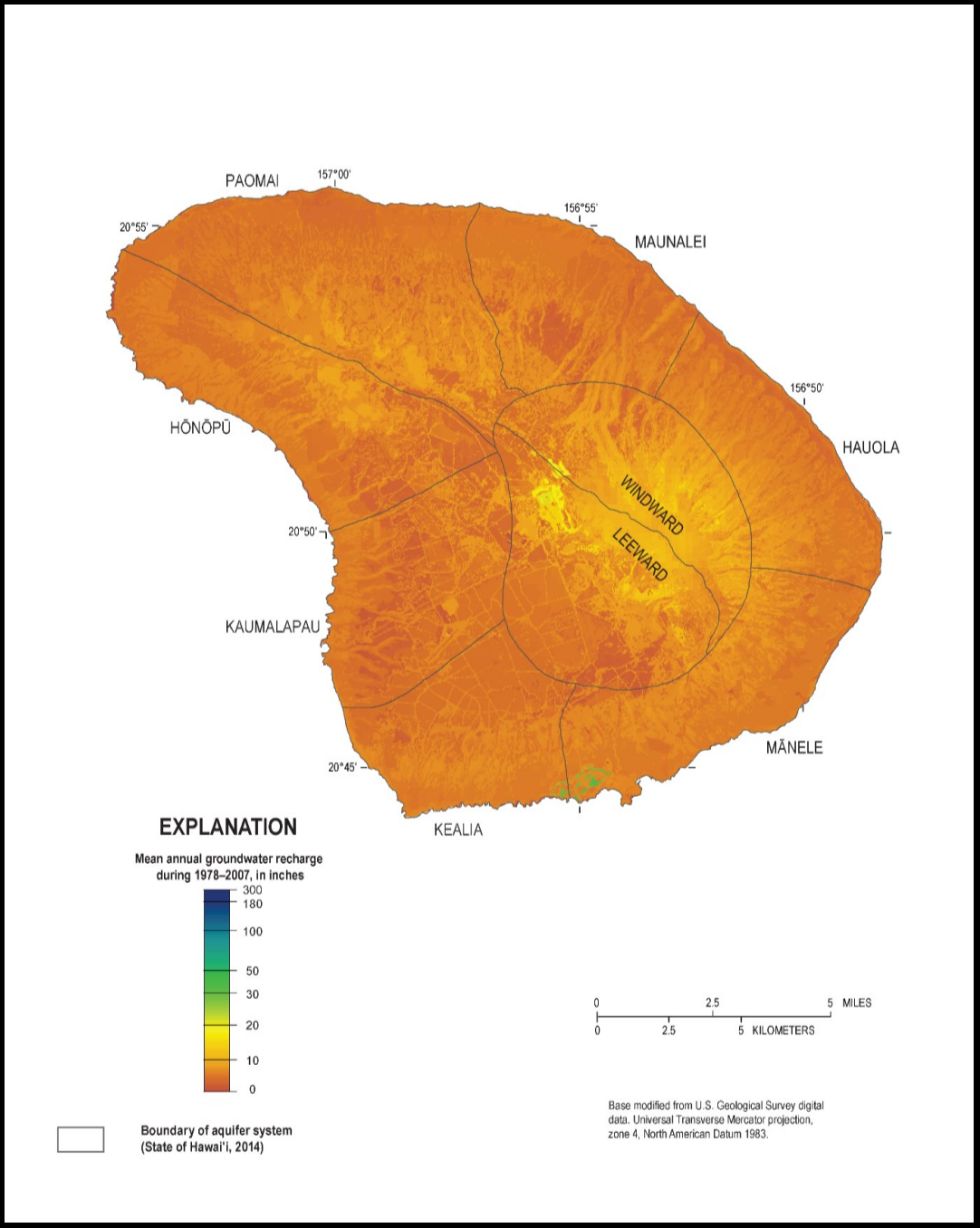
Dry climate
SD RCP8.5 2071–99

Drought
1998–2002

USGS

Lānaʻi

Reference climate
1978–2007



Mean Annual Groundwater Recharge

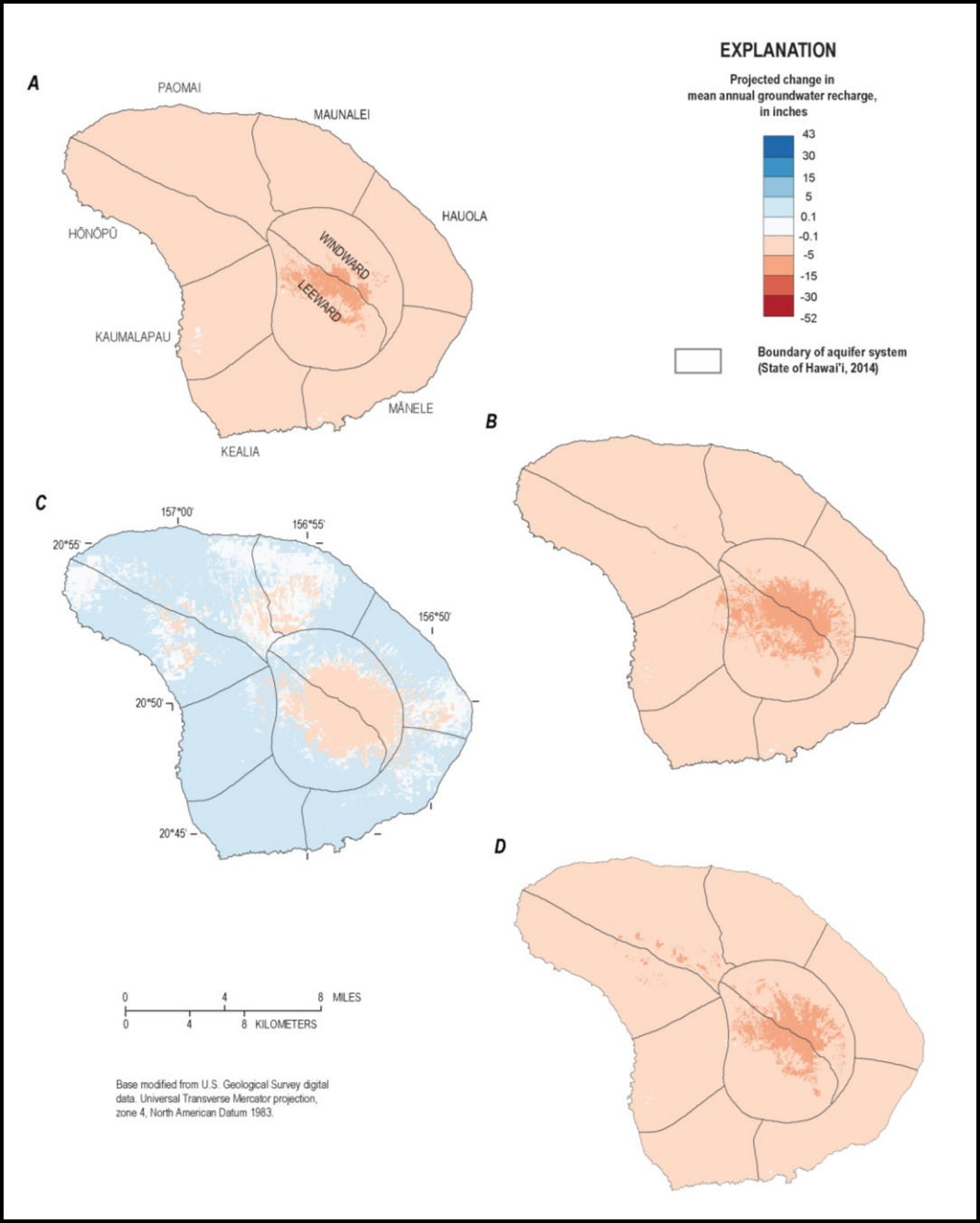
USGS

Lānaʻi

Change in Groundwater Recharge

Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99



Dry climate
SD RCP8.5 2071–99

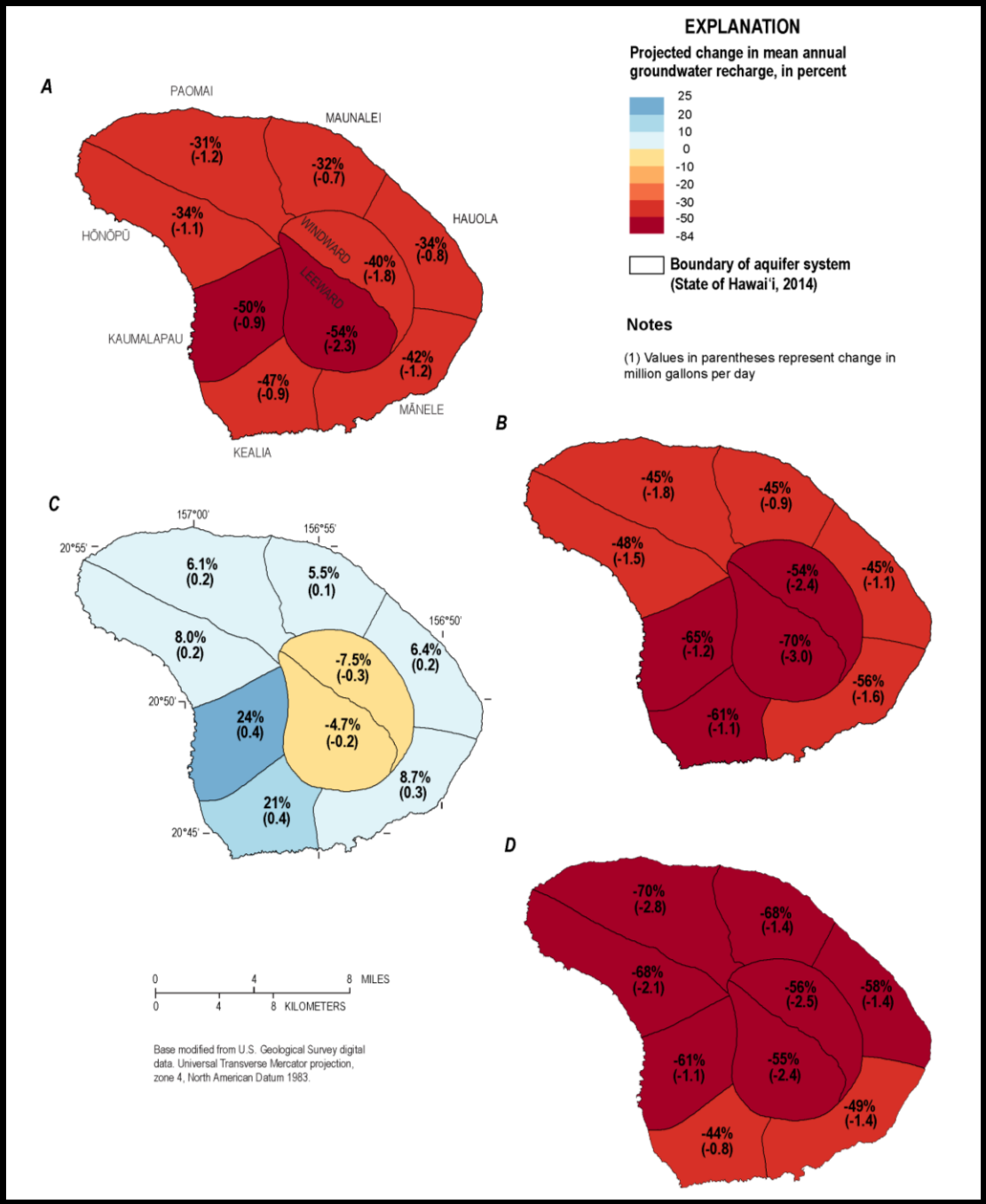
Drought
1998–2002

USGS

Lānaʻi

Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99



Change in Aquifer-System Recharge

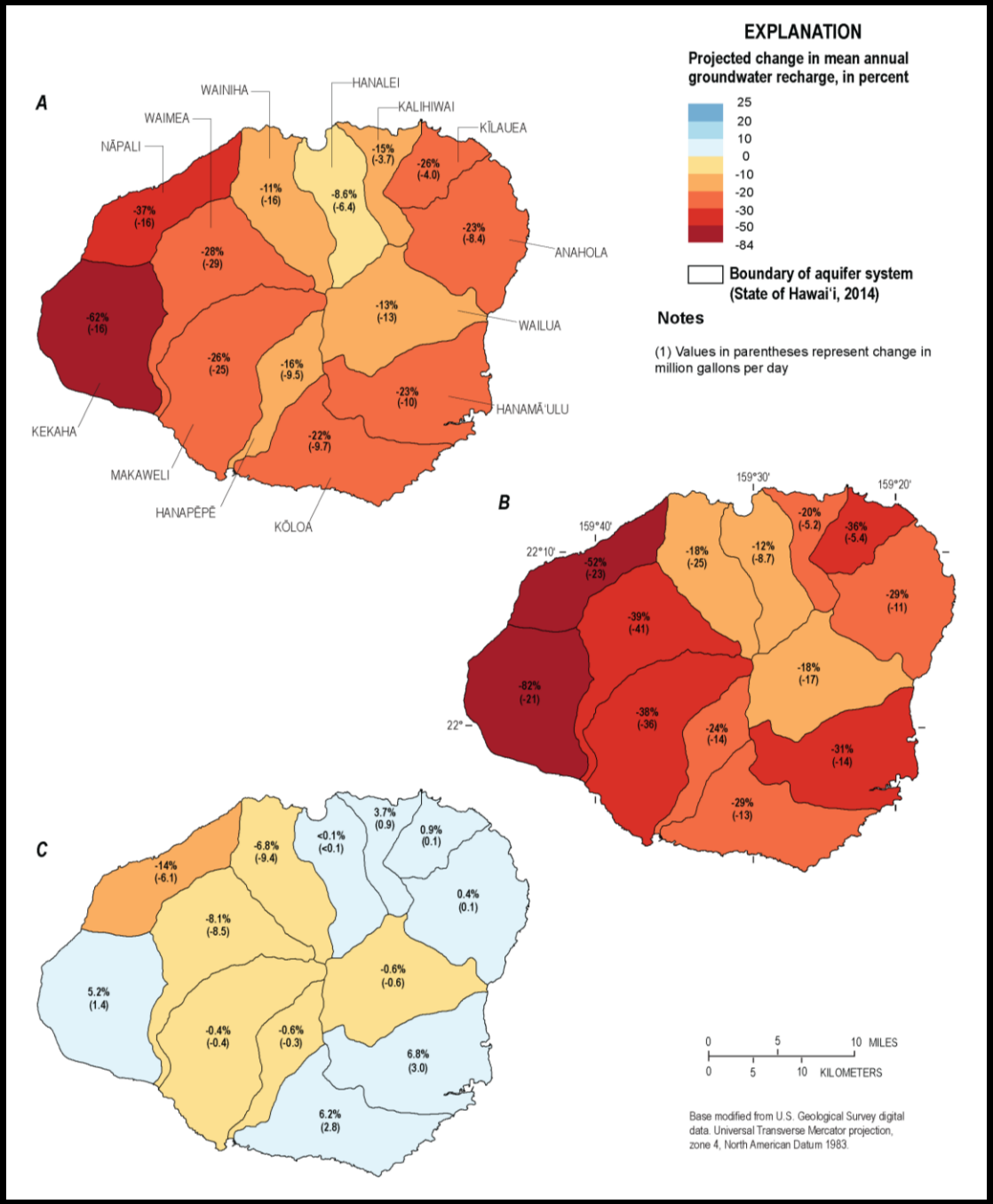
Dry climate
SD RCP8.5 2071–99

Drought
1998–2002

USGS

Kaua‘i

Mid-century climate
SD RCP8.5 2041–71



Wet climate
HRCM2 RCP4.5
2080–99

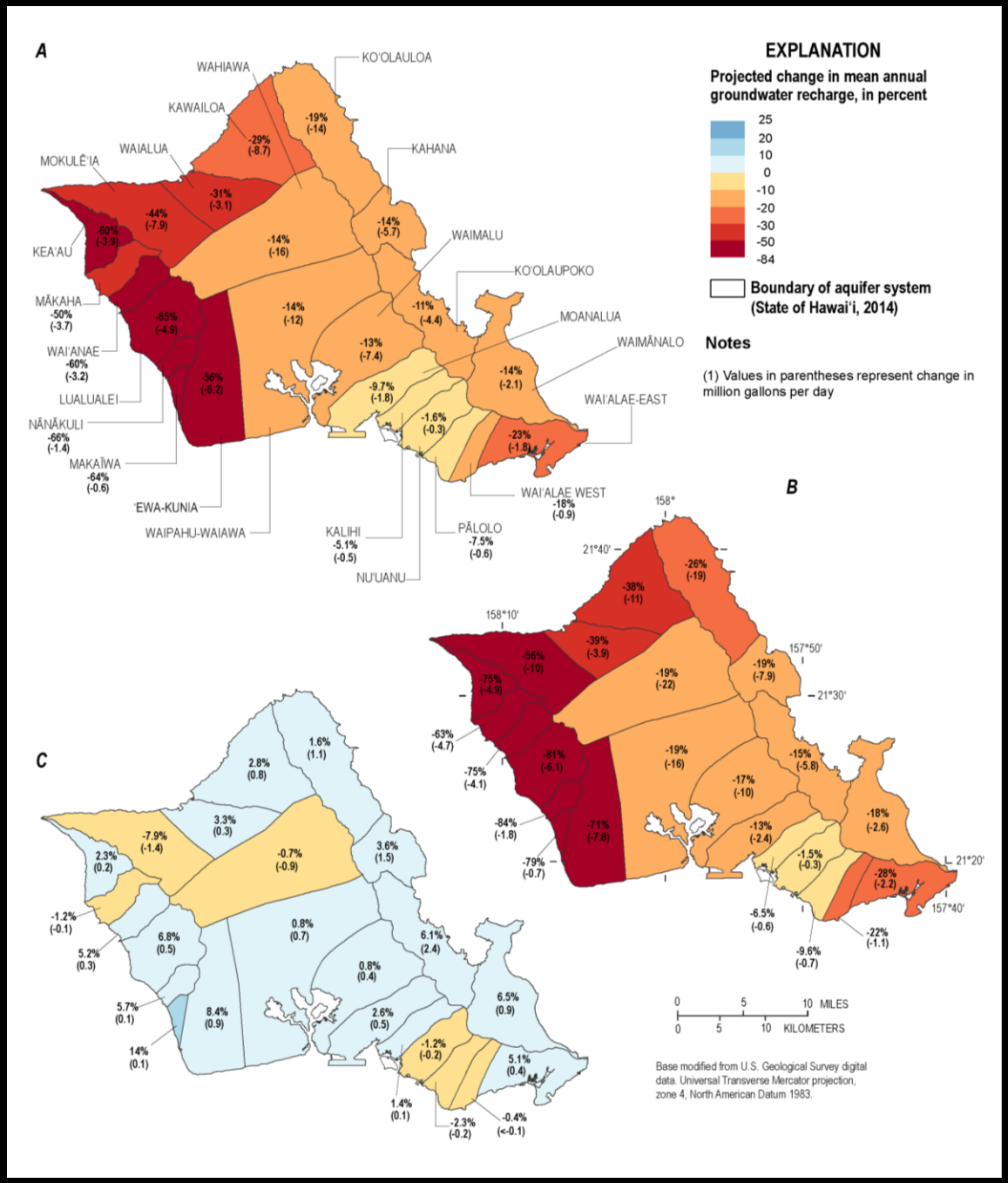
Change in Aquifer-System Recharge

Dry climate
SD RCP8.5 2071–99

USGS

O‘ahu

Mid-century climate
SD RCP8.5 2041–71



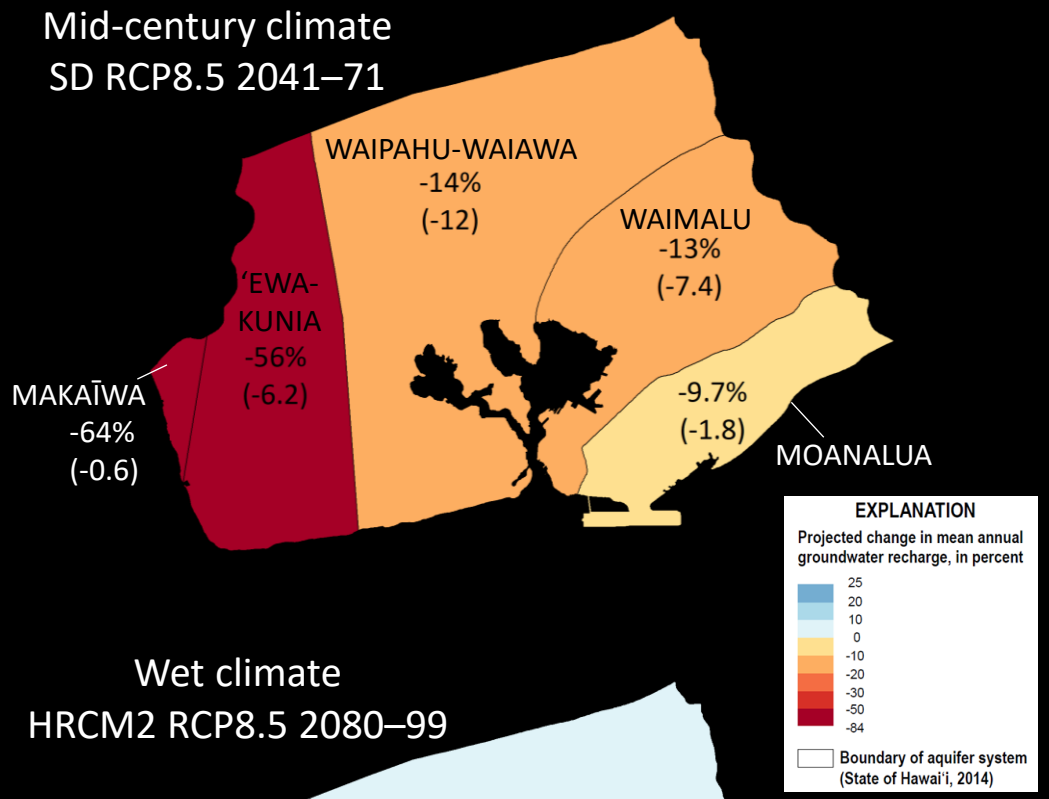
Change in Aquifer-System Recharge

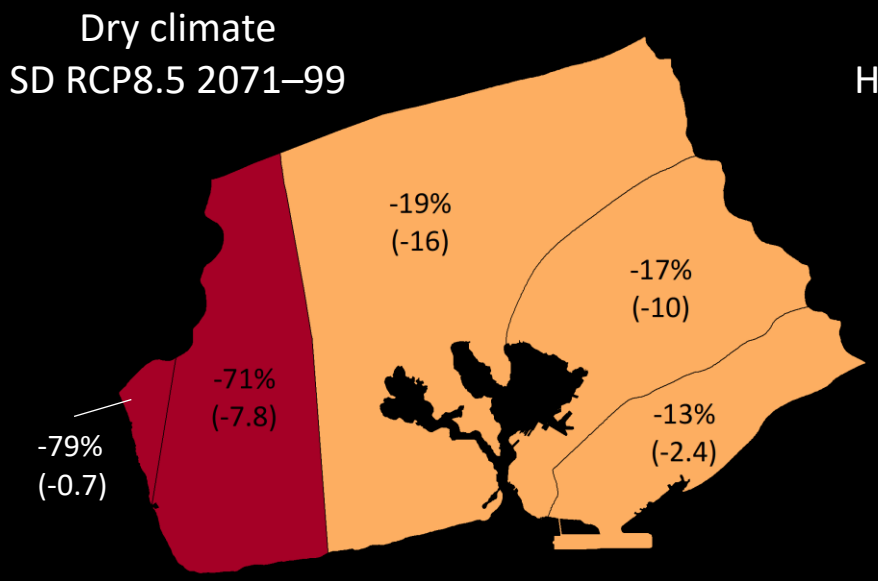
Dry climate
SD RCP8.5 2071–99

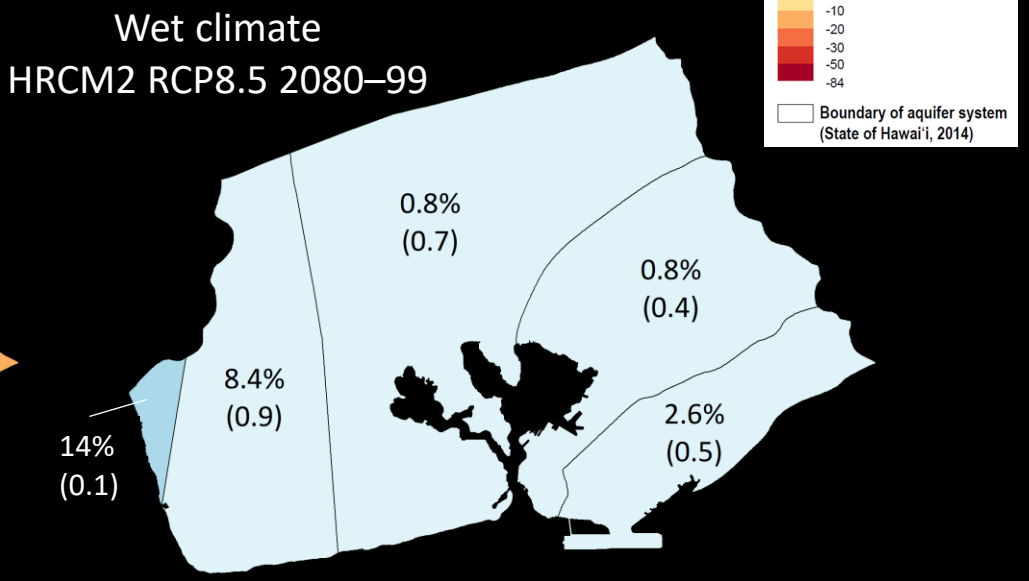
Wet climate
HRCM2 RCP8.5
2080–99

USGS

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







Values in parentheses represent change in million gallons per day

USGS

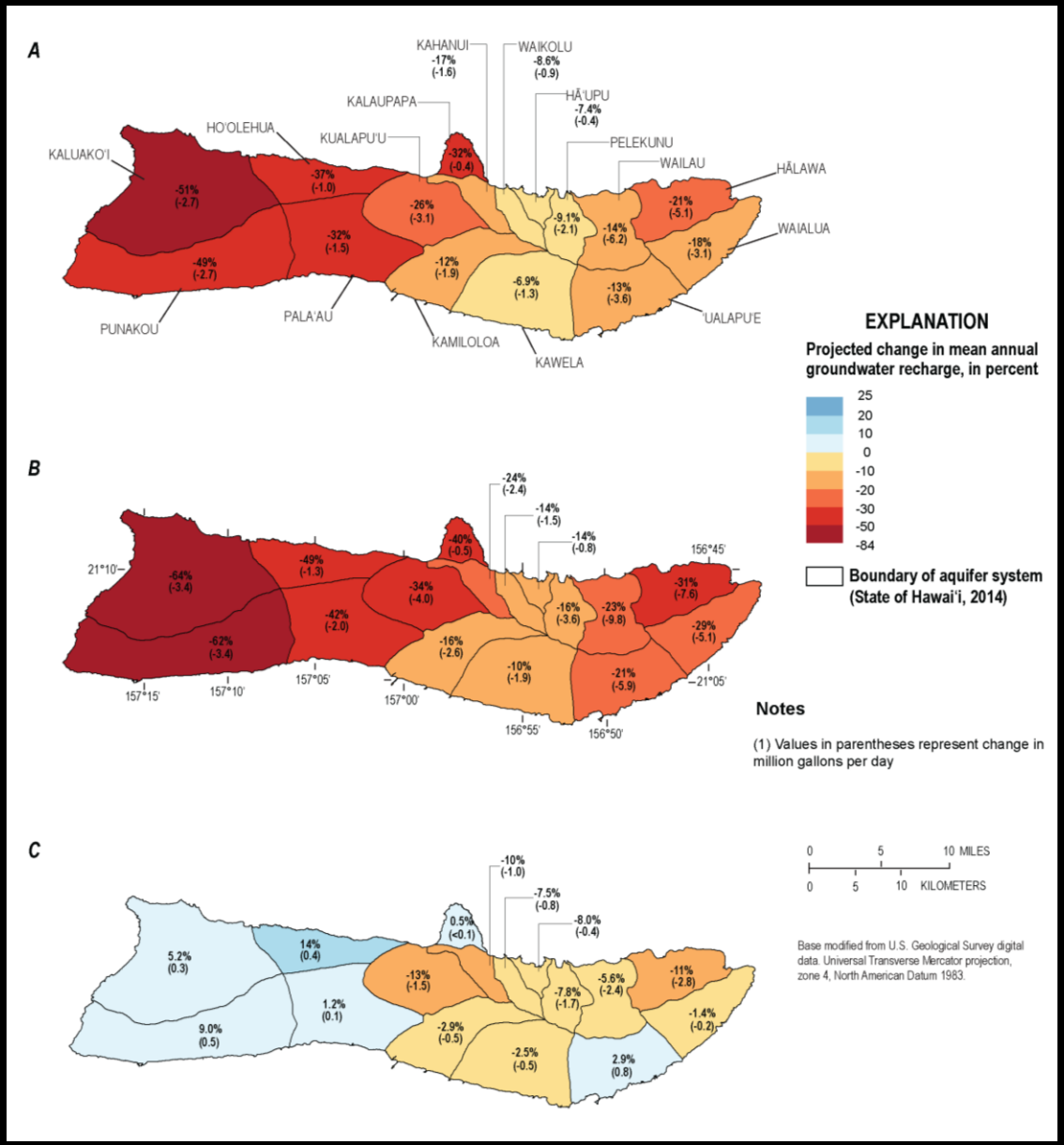
Moloka‘i

Change in Aquifer-System Recharge

Mid-century climate
SD RCP8.5 2041–71

Dry climate
SD RCP8.5 2071–99

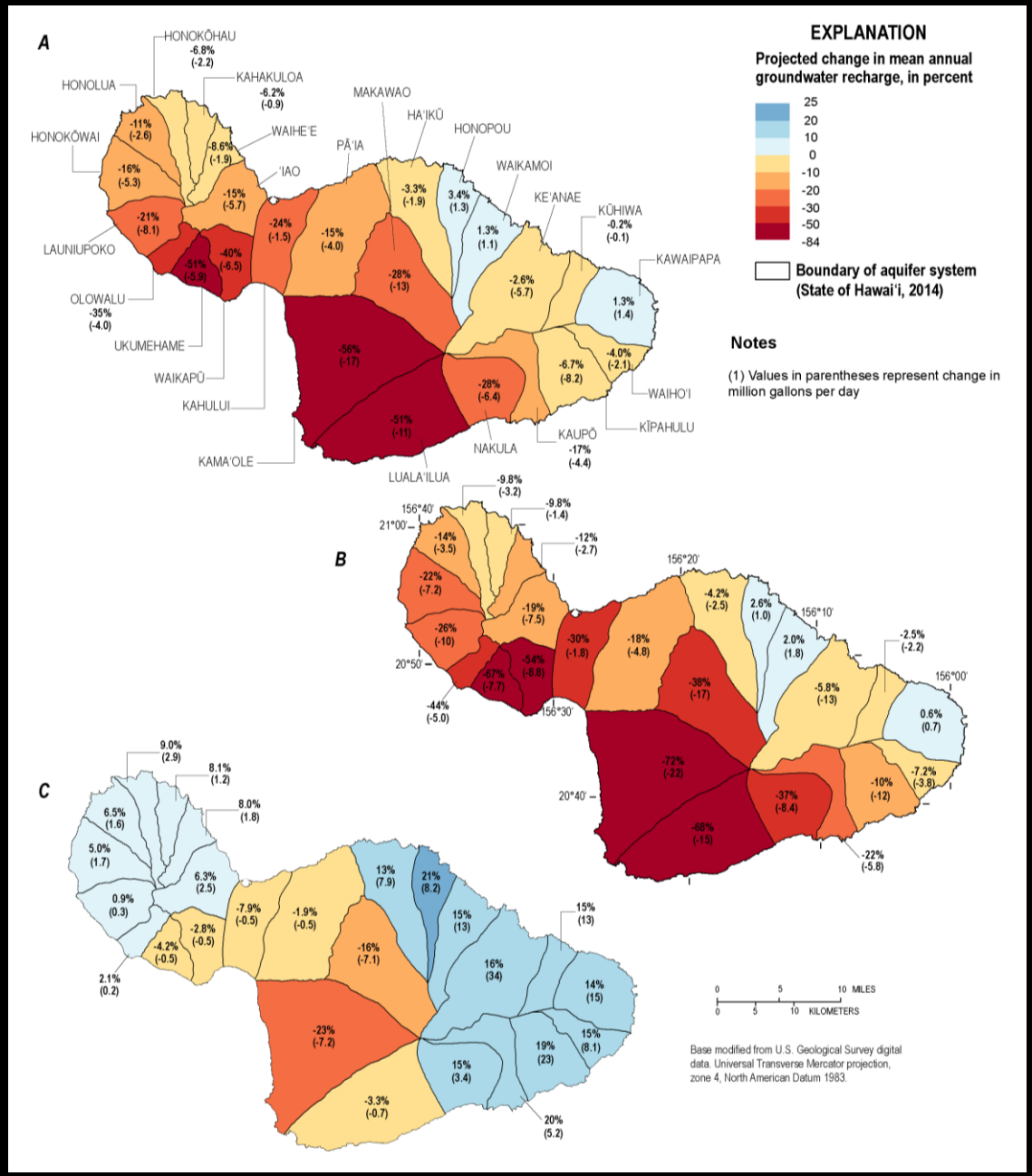
Wet climate
HRCM2 RCP8.5
2080–99



USGS

Maui

Mid-century climate
SD RCP8.5 2041–71



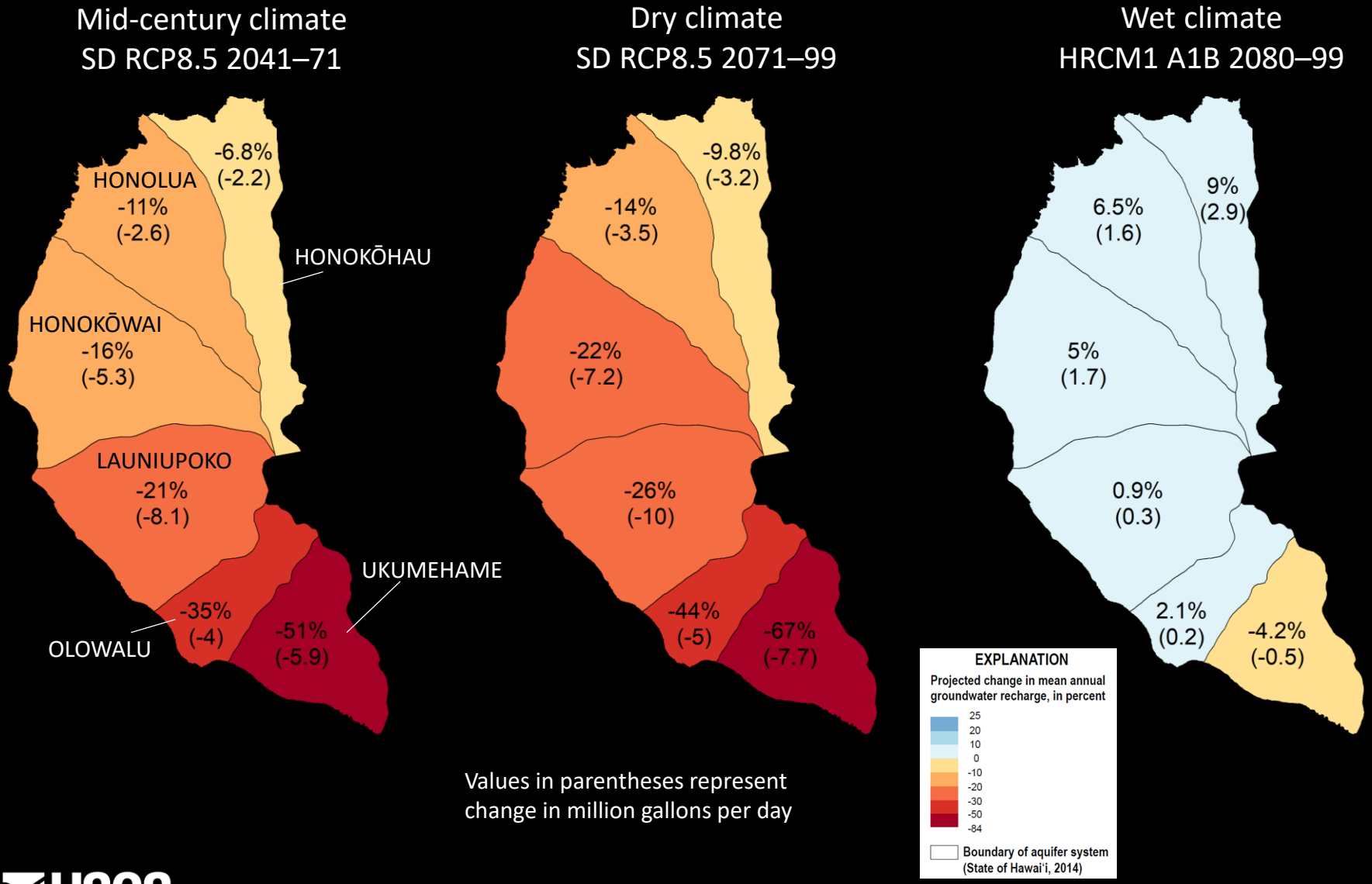
Change in Aquifer-System Recharge

Wet climate
HRCM1 A1B
2080–99

Dry climate
SD RCP8.5 2071–99

USGS

Lahaina Aquifer Sector, Maui



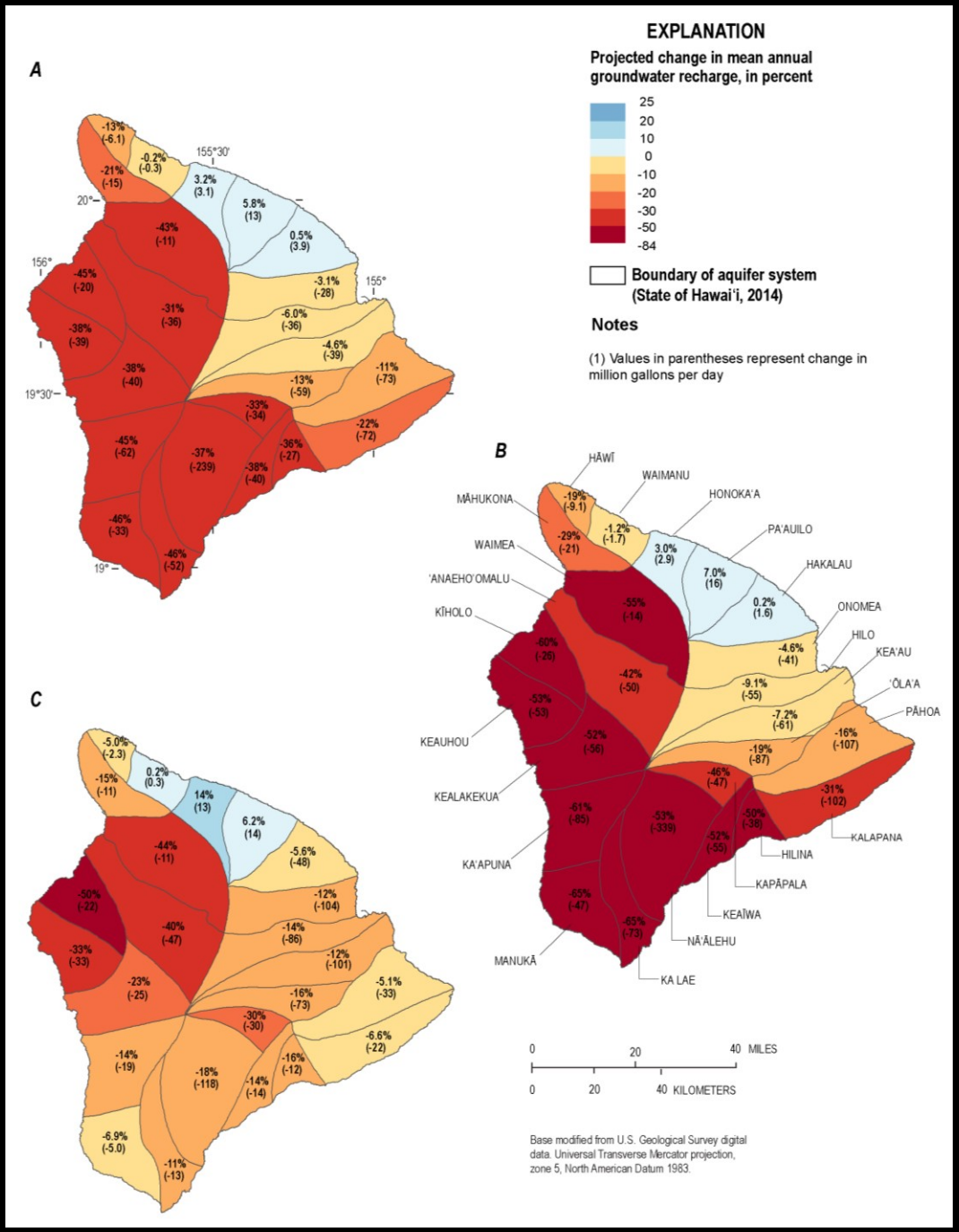
Values in parentheses represent change in million gallons per day

USGS

Hawai‘i

Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99



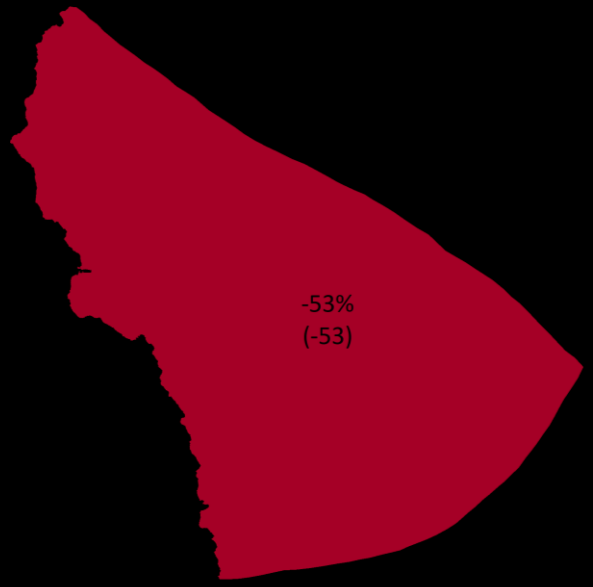
Change in Aquifer-System Recharge

Dry climate
SD RCP8.5 2071–99

Keauhou Aquifer System, Hawai‘i

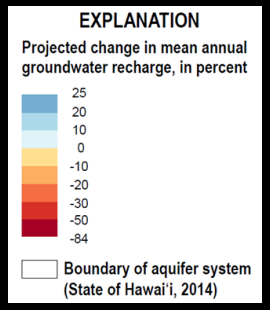
Mid-century climate
SD RCP8.5 2041–71

Dry climate
SD RCP8.5 2071–99



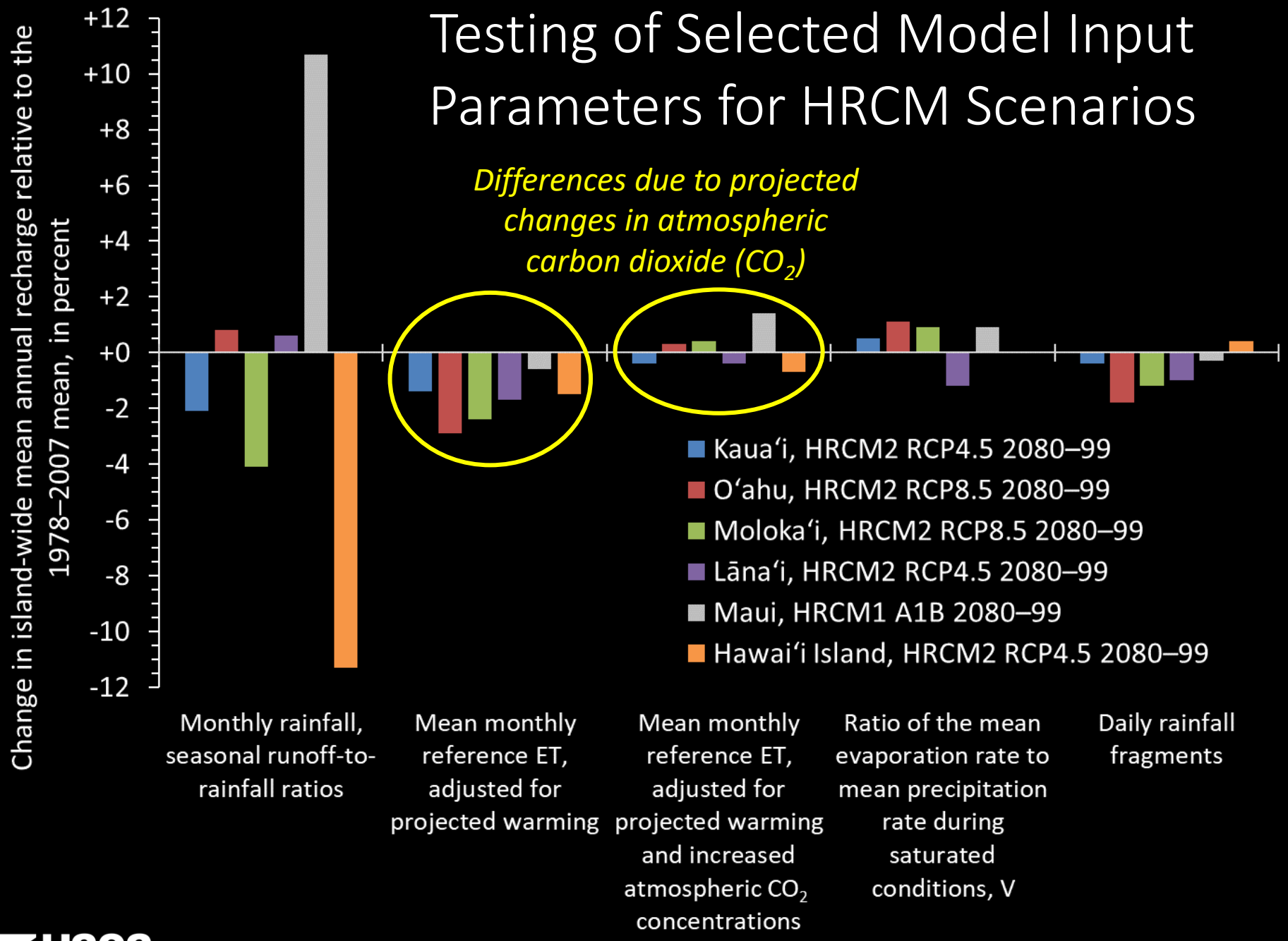
Wet climate
HRCM2 RCP4.5 2080–99

Values in parentheses represent change in million gallons per day



USGS

Testing of Selected Model Input Parameters for HRCM Scenarios



USGS

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 CO_2 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