CLIMATE RESILIENCE COLLABORATIVE

UNIVERSITY OF HAWAIʻI AT MĀNOA

2024 REPORT

MAHALO FOR YOUR SUPPORT

Climate Resilient Development means taking actions to prepare for and recover from climate-related hazards to improve the safety of under-served communities.

2024 had unprecedented challenges and remarkable opportunities in the face of a changing climate. Here in Hawai'i, and across the Pacific, we are on the front lines of these impacts, from rising sea levels to more intense storms. But amidst these challenges, we also find hope and resilience – a spirit of innovation and collaboration that fuels our determination to build a sustainable future.

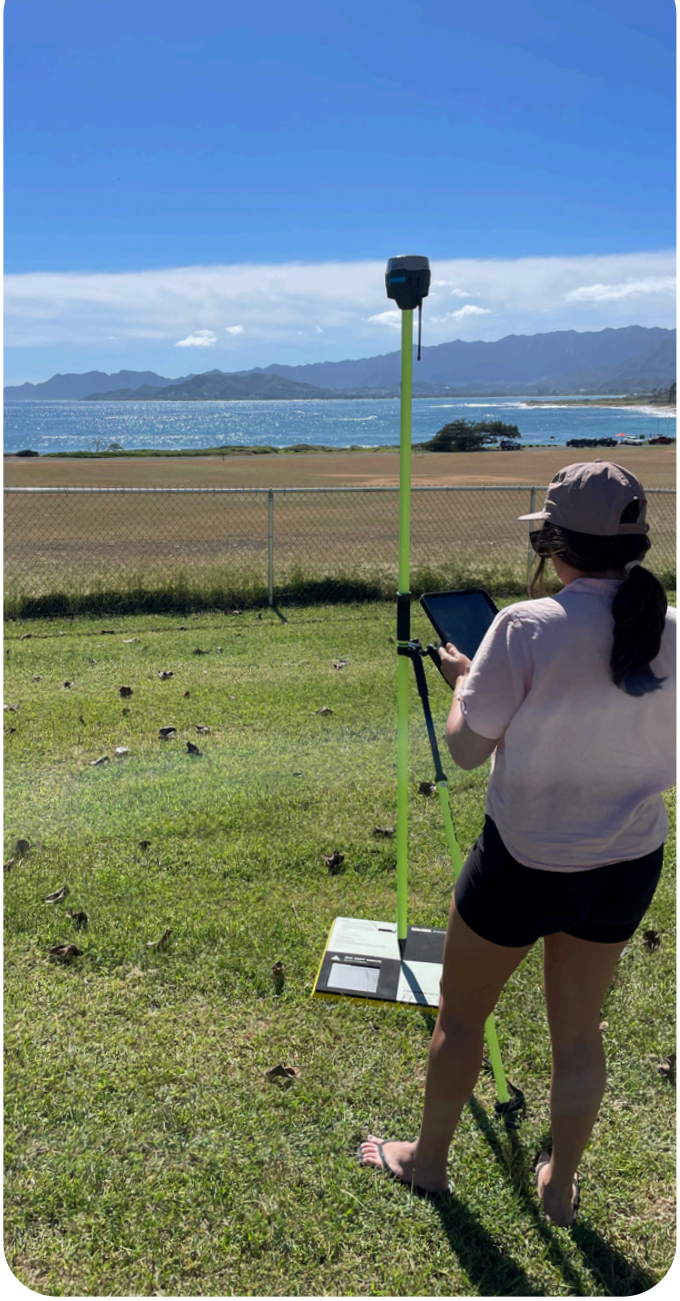
This report highlights the critical work of the University of Hawai'i at Mānoa's Climate Resilience Collaborative (CRC). Our mission is to provide communities and government agencies with research that informs effective management decisions leading to *climate resilient development*.

A cornerstone of our approach is seeking equity through the incorporation of stakeholder perspectives and engagement, including community and government stakeholders to develop social, cultural, policy, and economic perspectives on climate change issues that threaten Hawaii's communities.

We are thrilled to share the progress and impact the CRC has achieved over the past year. This includes advancements in research projects, enhancements in numerical modeling, successful integration of our guidance into government policies, and strengthened partnerships with communities across the state.

Mahalo,

Dr. Chip Fletcher



A beach survey being conducted at MCBH.

Our team's work is made possible entirely through the generosity of donations and grant funding.

ADVANCING INTERDISCIPLINARY RESEARCH

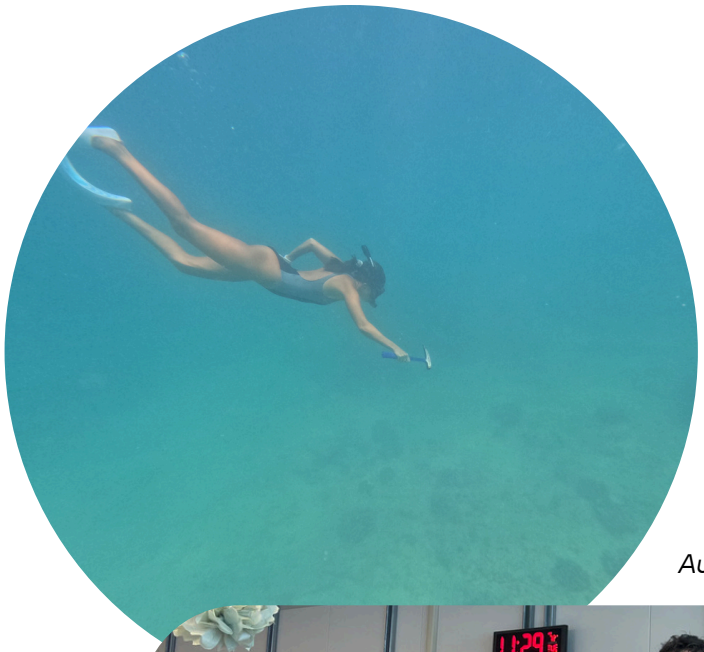
Our core work focuses on advanced physical modeling of seasonal and interannual wave flooding, coastal erosion and land-loss, hydrostatic flooding, groundwater inundation and drainage network failure, compound flooding related to extreme tides and precipitation scenarios, and run-off flood modeling. Model products developed in these areas are published in the peer-reviewed scientific literature and intended to be used as decision-support tools, and to be incorporated in law to guide policies and best practices.

- **Climate impact models**
  - We continue to upgrade all modeling products and expand hazard monitoring programs to include erosion zones, groundwater inundation, highwave exposure, heat and wildfire ignition,
- **Groundwater monitoring**
  - Testing salinity in tidally influenced floodwaters and analyzing the varying salinities to assess their corrosion potential.
  - Monitoring groundwater levels in Waikīkī.
- **Innovations in AI**
  - We've developed machine learning models that accurately extract shoreline position and beach area from satellite and aerial imagery.
  - We have created data management tools to help organize large internal data sets.
- **Exploring new funding partnerships**
  - Applied for grants from the Department of Energy, the National Science Foundation, the Office of Naval Research, and the Environmental Protection Agency to expand the functional ways our research is applied.

Dr. Shellie Habel, Dr. Chip Fletcher, Colin Lee and Dr. Juliette Budge in St. Louis for a conference.

BUILDING CAPACITY TO MODEL CLIMATE IMPACTS

- **Grant Funding**
  - Successfully secured $3 million in external grant funding from federal agencies to support CRC research and programs.
- **Philanthropic Support**
  - Cultivated relationships with individual donors and foundations interested in supporting climate resilience initiatives, resulting in new philanthropic gifts.



- **CRC Activities**
  - CRC scientists build an expanding network through public engagement and participation in various boards and advisory councils to further the goal of climate resilient development.
  - CRC researchers, technicians, and modelers, along with undergraduate and graduate students, explore modeling solutions to climate change impacts, including:
    - Sea level rise
    - Compound flooding
    - Urban flooding
    - Coastal erosion
    - Groundwater inundation
    - Wave flooding
    - Drainage failure
    - Heat
    - Pluvial flooding
    - Wildfire-prone landscapes

Left: Helena Andrade dives to a sample site for her research on sea level rise

Below: A portion of the CRC team at a gathering in August.

EDUCATING COMMUNITIES AND GUIDING POLICIES

- **Partnership Development**
  - The CRC builds partnerships with key state and local agencies, including the Department of Land and Natural Resources, the Office of Planning and Sustainable Development, the Hawai'i Climate Change Mitigation and Adaptation Commission, Maui, Kaua'i, and Honolulu counties, and others.
  - We collaborate with researchers across the UH campus on climate change and adaptation.
- **Indigenous Knowledge Integration**
  - Team members participated in an intensive training series to enhance the university as a Native Hawaiian Place of Learning.
  - We supported research projects that incorporate Indigenous methodologies and perspectives on climate change.

- **Policies That Rely on CRC Data and Modeling**
  - Kaua'i, Maui, and C&C of Honolulu
    - Coastal setbacks determined by CRC historial erosion data
  - SB474 State-wide Real Estate Disclosure Law for Sea Level Rise based on CRC mapping
  - Act 16 SLH 2020
    - State-wide setback increased based on CRC historic erosion rates.
    - Sea level rise is assessed in all shoreline and special management area (SMA) permitting, even for parcels that aren't oceanfront.
    - Use of seawalls and revetments on sites with beaches is prohibited unless clearly in the public interest.
  - HB243 requires state agencies to identify facilities exposed to sea level rise and publish plans for adaptation to flooding.

A drone image taken by the CRC of the extreme beach loss and shoreline hardening on the North Shore of O'ahu.

Dr. Shellie Habel secures the anchor in Kailua Bay at the site of a research dive to gather sediment samples.

CRC 2024 PUBLICATIONS

- Meguro, W., C.H. Fletcher, J. Briones, E. Teeples, and G. Casey. 2024. **A visionary approach to advancing sea level rise adaptation in an urban coastal community, Waikīkī, Hawai'i**. Oceanography 37(1):122–123, https://doi.org/10.5670/oceanog.2024.223.
- Rozell, D. J. (2024) **Don't underestimate the rising threat of groundwater to coastal cities**. Nature 627, 735 doi: https://doi.org/10.1038/d41586-024-00917-9
- Mikkelsen, A.B., McDonald, K.K., Kalksma, J. et al. **Three years of weekly DEMs, aerial orthomosaics and surveyed shoreline positions at Waikīkī Beach, Hawai'i.** Nature Sci Data 11, 324 (2024). https://doi.org/10.1038/s41597-024-03160-z
- Fletcher, C.H.; Ripple, W.; Newsome, T.; Barnard, P.; Beamer, K.; Behl, A.; Bowen, J.; Cooney, M.; Crist, E.; Field, C.; Hiser, K.; Karl, D.; King, D.A.; Mann, M.E.; McGregor, D.P.; Mora, C.; Oreskes, N.; Wilson, M., **Earth at risk: An urgent call to end the age of destruction and forge a just and sustainable future**, PNAS Nexus, Volume 3, Issue 4, April 2024, pgae106, https://doi.org/10.1093/pnasnexus/pgae106
- Meguro, W.; Briones, J.; Failano, G.; Fletcher, C.H. **A Science and Community-Driven Approach to Illustrating Urban Adaptation to Coastal Flooding to Inform Management Plans**. Sustainability 2024, 16, 2849. https://doi.org/10.3390/su16072849
- Andrade, H.A.A.; Rodrigues, F.C.G.; Fletcher, C.H.; Casey, G., and Giannini, P.C.F., 2024. **Winter sedimentology and morphology of the Maçambaba beach–foredune system, SE Brazil**. Journal of Coastal Research, 40(2), 338–352. Charlotte (North Carolina), ISSN 0749-0208.
- Shellie Habel, Charles H. Fletcher, Matthew M. Barbee, Kyrstin L. Fornace, **Hidden Threat: The Influence of Sea-Level Rise on Coastal Groundwater and the Convergence of Impacts on Municipal Infrastructure**. Annual Review of Marine Science 2024 16:1. https://www.annualreviews.org/doi/10.1146/annurev-marine-020923-120737
- Tarui, N., Urbanski, S., Lam, Q.L. et al. **Sea level rise risk interactions with coastal property values: a case study of O'ahu, Hawai'i**. Climatic Change 176, 130 (2023). https://doi.org/10.1007/s10584-023-03602-4
- Wendy Meguro, Elliot J. Glassman Josephine Briones. **Estimating Thermal Comfort and Energy Use with Future Warmer Weather**, ARCC Conference Proceedings, 391-398 (2023).
- Setter, R.O., Han, R.X., Tavares, KD. et al. **Managing retreat for sandy beach areas under sea level rise**. Nature Sci Rep 13, 11920 (2023). https://doi.org/10.1038/s41598-023-38939-4
- Paoa, N., Fletcher, C.H., Anderson, T.R. et al. **Probabilistic sea level rise flood projections using a localized ocean reference surface**. Nature Sci Rep 13, 2257 (2023). https://doi.org/10.1038/s41598-023-29297-2
- Murray, K.D., Thompson, P.R., Barbee, M., Fletcher, CH. (under review). **Coastal land subsidence accelerates timelines for future flood exposure in Hawai'i**. Communications Earth & Environment.
- Joel Nicolow, **CoastVision Python Framework** publicly available on GitHub at https://github.com/Climate-Resilience-Collaborative/CoastVision.

COMMUNITY ENGAGEMENT - DR. FLETCHER

Op-Eds 2024

- Sea Level Rise Is A Science Issue, Not Just An Environmental Concern
- The Post-Trump Climate Crisis: Our Last Stand For A Livable Future
- Hawai'i's Climate Call: Lead On Adaptation, Mitigation

Service 2024

- Special Advisor on Climate Change and Resilience to Governor Josh Green, M.D.
- Member of 6 person Climate Advisory Team (CAT)
- Governor's Office, Carbon Reduction Working Group

Keynote Speeches 2024

- *Humanity's converging crises: climate change, ecological destruction, disease, pollution, and socioeconomic inequality*, Cooperative Institute for Marine and Atmospheric Research, Mānoa
- *Earth at Risk*, Climate and Health Conference, HI Dept. of Health, Waikīkī
- *Climate Impacts in Hawai'i,* Legislative Briefing, Joint committees on Energy and Environmental Protection, Water and Land, Honolulu
- *Drainage Losses Related to SLR*, Pacific Water Conference, Honolulu
- *Converging global crises: pollution, climate change, disease, biodiversity loss, and social inequality*, Office of National Intelligence, Officers Education Conference 2024, Waikīkī
- *Climate Impacts and Hawai'i Resiliency*, Shar Poe, Wai'anae Wai Panel
- *Sea level rise in Hawai'i: Realities and Prospects*, DoD Sustainability Panel 2024, Waikīkī
- *The Unexpected Realities of Sea Level Rise*, American Waterways Association Annual Meeting, Honolulu
- *A Global Polycrisis*, Blue Planet Alliance Fellows, East-West Center
- *Climate Change & Sea Level Rise Are Reshaping Our Communities*, Annual Conference, Urban Land Institute, Honolulu

The Ala Wai overflowing its banks on a high tide.

Media 2024

- Exploring Climate Change Through a Legal Lens with Dr. Chip Fletcher and Colin Lee - PodCast Episode, Hawaii Law
- Spotlight Now: Dr. Chip Fletcher discusses climate science — and resilience - Spotlight Now, Hawai'i News Now
- New Report Led By UH Scientist Is A Call To Action On Climate Change - Hawai'i Public Radio, The Conversation

SELECT 2024 SPEAKING ENGAGEMENTS

- Dr. Habel, ORMP Coordinated Working Group February meeting – Invited presentation with CRC colleagues - **Modeling from the CRC**
- Dr. Habel, Caltech Linde Center for Global Environmental Science workshop on Innovations in the Science & Policy of Water Quality Measurement - Invited Presentation -**Navigating the Depths: Unveiling Coastal Groundwater Inundation in Honolulu, HI – Understanding Infrastructure Impacts and Contaminant Exposure in the Face of Sea Level Rise.**
- Dr. Habel, SSFM resilience-related Lunch and Learn seminar – Invited Seminar - **Unveiling Coastal Vulnerabilities: Sea-Level Rise's Hidden Impact on Infrastructure.**
- Dr. Habel, Project Hōkūlani presentation – provided a series of three talks on the **topic of drones and their use by research groups as part of coastal erosion studies.**
- Dr. Habel, co-convened a technical session entitled **"Coastal Hydrology in an Age of Rising Seas"** at the Annual Geological Society of America meeting.
- Dr. Fletcher, Public Lecture, **Climate Change and the Global Polycrisis**, Maui, Mayors Resilience Series
- Dr. Fletcher, Keynote, **Climate Change and Resiliency in Koʻolau Poko**, OLDCC Kick-Off Meeting, Koʻolau Poko Risk and Vulnerability Project
- Dr. Fletcher, Keynote, **Climate Change Trajectories**, 13th Festival of Pacific Arts and Culture (FestPAC)
- Dr. Fletcher, Panelist, **Ocean Health in Hawai'i**, Federal Ocean Research Advisory Panel (ORAP) (Sept. 2024).
- Dr. Fletcher, Savannah Harriman-Pote, Climate scientist says **North Shore house collapse gives glimpse of future sea level rise,** Hawai'i Public Radio.
- Dr. Fletcher, PBS Insights, Community Discussion: **Climate Change: Our Disappearing Beaches,** Public Broadcasting Service Hawai'i.

MS student Chloe Obara discussing her research on the failure of gravity-based drainage in Waikīkī.

STUDENTS SUPPORTED

Noah Paoa
- PhD candidate, Dept. Earth Sciences, University of Hawai'i, "Wave- and tide- driven sea level flooding in Pacific Island Communities"

Helena Andrade
- PhD candidate, Dept. Earth Sciences, University of Hawai'i, "Holocene sea level change and controls exerted on modern carbonate coastal systems"

Chloe Obara
- MS candidate, Dept. Earth Sciences, University of Hawai'i, "Failure of gravity-based drainage in coastal urban Waikīkī due to sea level rise", **Graduated Dec. 2024**

Kammie Tavares
- PhD candidate, Dept. Urban and regional Planning, University of Hawai'i "Sea level rise flooding and erosion in underserved coastal communities and cultural Indigenous impacts"

Joel Nicolow
- PhD Candidate, Dept. of Computer Sciences, University of Hawai'i, "Development of artificial intelligence tools for interpreting coastal satellite imagery"

Skyler Kimura
- MS Candidate, Dept. of Computer Sciences, University of Hawai'i, "Programming and structure of an online web mapping service to depict multiple complex sea level rise impacts"

Sarah Blichfeldt
- BS Candidate, Dept. of Oceanography, University of Hawai'i, "Risk and Vulnerabiity assessment of sea level rise scenarios and Indigenous cultural assets in Ko'olau Poko, Moku, O'ahu", **Graduated Dec. 2024**

CRC team prepares to fly the Wingtra drone, which is made in the U.S.A and approved for flight over military installations.

CRC RESEARCHERS

- **Dr. Chip Fletcher**
  - Director of CRC and the Interim Dean of SOEST at UHM
- **Dr. Shellie Habel**
  - Coastal hydrologist and geologist at CRC and the Hawai'i Sea Grant College Program. Her research focuses primarily on how rising groundwater affects the built environment.
- **Dr. Juliette Budge**
  - Operations project manager at CRC. Juliette's research focuses on community response to climate change and stakeholder-driven resilience.
- **Dr. Kyle Murray**
  - A geophysicist, his research focuses on how vertical land motion will impact relative sea level rise and integrating dynamic land elevations into digital elevation models.
- **Dr. Tiffany Anderson**
  - A coastal geologist. Tiffany's research centers on sea level rise driven coastal erosion and passive flooding.
- **Dr. Assaf Azouri**
  - A physical oceanographer with PacIOOS and CRC, he conducts coastal wave modeling and validation to create and maintain harbor surge, wave run-up, and inundation forecasts under future sea level projections.
- **Dr. Hariharasubramanian Annamalai**
  - A professor of oceanography at SOEST International Pacific Research Center. He researches changing climate systems and weather patterns.
- **Colin A. Lee, Esq.**
  - An attorney, he leads CRC's adaptation policy and project-specific community outreach. His research focuses on coastal policy and the convergence of the public trust doctrine and private property rights.
- **Kayla Yamamoto**
  - A meteorologist and climate modeler, her research focuses on pluvial flooding and compound flooding using advanced modeling techniques.
- **Matthew Barbee**
  - A GIS data scientists, he manages CRC's team of geospatial analysts. His work focuses on remote sensing and shoreline change.
- **Aloha Dye**
  - A geospatial analyst at CRC, her work primarily focuses on CRC's Hawai'i Shoreline Study Web Application.
- **Anna Mikkelsen**
  - A geospatial analyst responsible for analyzing geospatial datasets, creating maps and visualizations for our user platform, she also conducts in field data collection.
- **Richelle Moskvichev**
  - A geospatial analysis in support of coastal erosion monitoring and modeling including sea level rise research, and calculating uncertainty in various types of geodatasets using observational and modeling data.
- **Thanh Van Tran**
  - Administrative officer who ensures that the lights stay on and that the entire CRC team has what they need to complete their work.

View of the Ala Wai during high-tide.

Keep in touch, sign up for our quarterly newsletter by emailing **crcinfo@apps.soest.hawaii.edu**

The CRC is located in the School of Ocean and Earth Science and Technology, at the University of Hawai'i at Mānoa