Assessing Coastal Hazards through a Mauka (Mountain) to Makai (Sea) Modeling Approach

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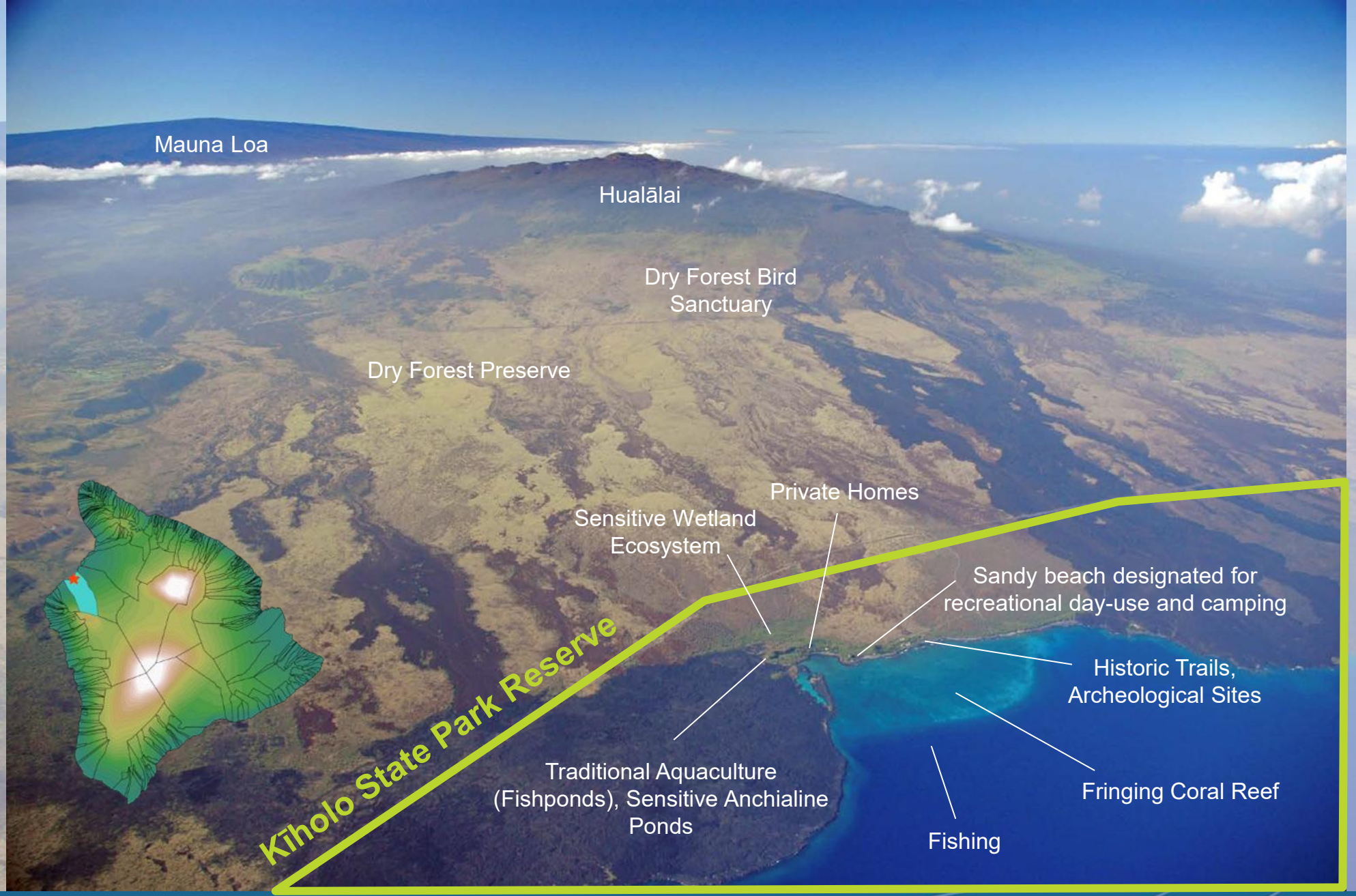

Mauna Loa
Hualālai
Dry Forest Bird Sanctuary
Dry Forest Preserve
Private Homes
Sensitive Wetland Ecosystem
Sandy beach designated for recreational day-use and camping
Historic Trails, Archeological Sites
Kīholo State Park Reserve
Traditional Aquaculture (Fishponds), Sensitive Anchialine Ponds
Fringing Coral Reef
Fishing

Motivation

Goal: Probabilistic assessment of Kīholo hazard exposure under different future scenarios to support management planning across diverse environmental systems and socio-cultural needs.

How can we better adapt hazard model frameworks to suit cultural philosophies and decision processes?

Community Focus Groups, Interviews, & Participatory Mapping

"In my mind I'm thinking about preserving functionality– because there's so many different ways– like what is the functionality of a [loko] fishpond? It is a massive amount of habitat *and* it is a feeding ground. In my mind, it's thinking about– What is the functionality that we want to see in the future? That is healthy for place and that is healthy for people? and that is what I would prioritize."

– Kīholo Steward

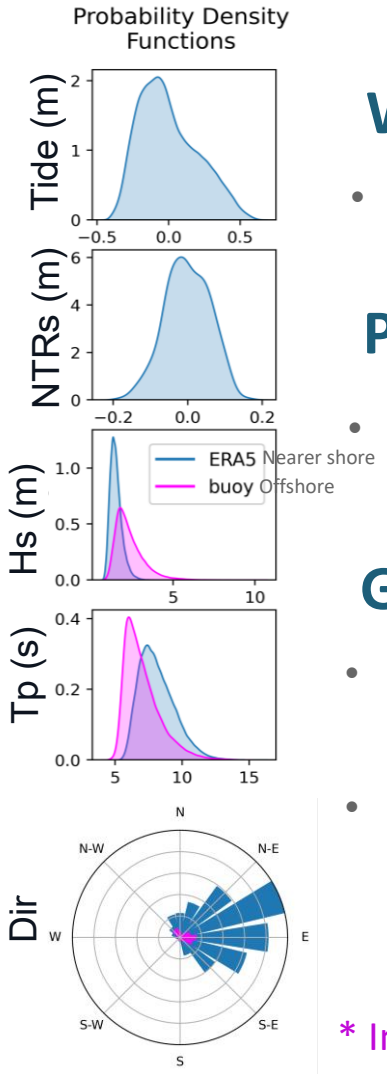
What makes Kīholo special?

How do you interact with Kīholo?

What changes have you seen?

Concerns for the future?

Hazard Drivers



Waves & Water Levels

- microtidal range, relatively sheltered from extreme waves and storms

Precipitation

- arid climate, major storms bring order ~10 cms of precipitation.

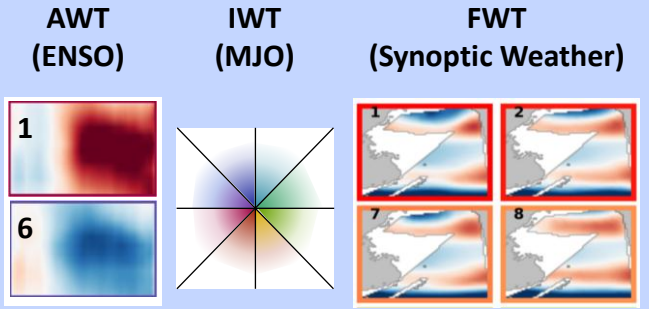
Groundwater

- critical role in anchialine pool, coral reef habitat, and cultural practice
- abundant flow in young and porous basalt coast, particularly high in fractures, faults, and lava tubes [2].

* Integrating complex systems, limited data

MUSCLE (Stochastic Weather Emulator)

MUSCLE is a climate and weather emulator that employs statistical and machine learning approaches to link long term environmental patterns to hazard forcings, and produce probabilistic timeseries of statistically feasible realizations of present day climate and hazard drivers.



Step 1: Weather Typing (WT) at multiple scales

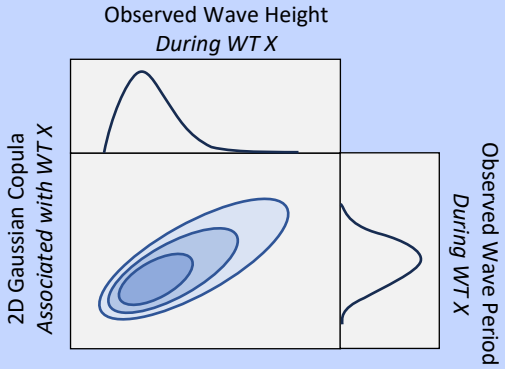
Techniques: *Principal Component Analysis, Hovmöller diagrams, K-means clustering*

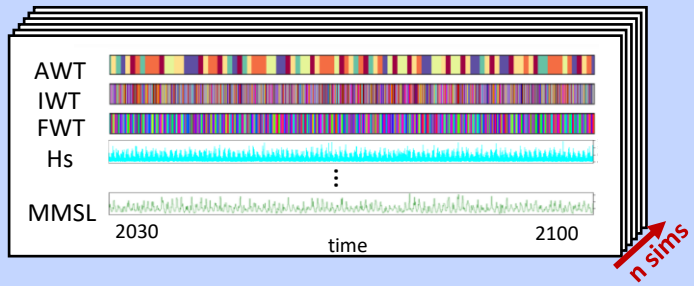
Input Datasets: *Sea Surface Temperature, Outgoing Longwave Radiation, Sea Level Pressure and Sea Level Pressure Gradients*

Step 2: Relate Weather Types and Observed Hydrodynamic Variables

Techniques: *N-Dimensional Copulas, Parameterized Wave Hydrographs, Linear Regression (MMSL)*

Input Datasets: *Kawaihae Tide Gauge (9439040), ERA5 Wave Hindcasts, Weather Types*





Step 3: Simulate New Chronologies

Techniques: *Auto Logistic Regression Model*

Input Datasets: *Weather Types, Copulas, MMSL Regression Model*

Key Takeaways

- **Community context matters:** Holistic, iterative approaches are needed to address community-specific needs.
- **Integrating qualitative knowledge, quantitative models, and local expertise:** supports a deeper understanding of hazard impacts and the development of relevant planning tools.
- **‘Mauka-Makai’ Modeling challenges:** Complex environments and limited data constrain interconnected ecosystem hazard analyses.