UNIVERSITY OF HAWAI'I
SEA LEVEL CENTER

Operations and Research

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Global Ocean Monitoring and Observing
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

CIMAR
COOPERATIVE INSTITUTE FOR MARINE AND ATMOSPHERIC RESEARCH
UH • NOAA

History

Using sea level to understand El Niño

- **Klaus Wyrtki**
  - Created a network of tide gauges across the Pacific.
  - Used sea level observations to make **fundamental advancements** in the modern understanding of El Niño.
- The **Pacific tide-gauge network** and **sea-level database** expanded under large international climate research efforts.
  - North Pacific Experiment (NORPAX, 1971–1980)
  - Tropical Ocean Global Atmosphere program (TOGA, 1985–1994)
- The **University of Hawaii Sea Level Center** (UHSLC) became an operational NOAA-funded entity in 1993.

Global tide-gauge network

Global Sea Level Observing system (GLOSS)

What are tide-gauge observations use for?

- Coastal sea-level trends and climate impacts
- Tsunami warning and modeling
- Storm surge monitoring and research
- Tide predictions and vertical datums
- Calibration and validation of satellite altimetry
- Any many others …

Global tide-gauge network

Global Sea Level Observing system (GLOSS)

What is GLOSS?

- Established by UNESCO-IOC in 1985
- Part of GOOS; reports to IOC; coordinates with the Joint WMO-IOC Collaborative Board (JCB)
- Goal is to establish and maintain a well-designed, high-quality **in situ sea-level observing network** to support a broad user base
- Provides oversight, coordination, and capacity development

★ **The UHSLC is the primary U.S. partner in GLOSS.**

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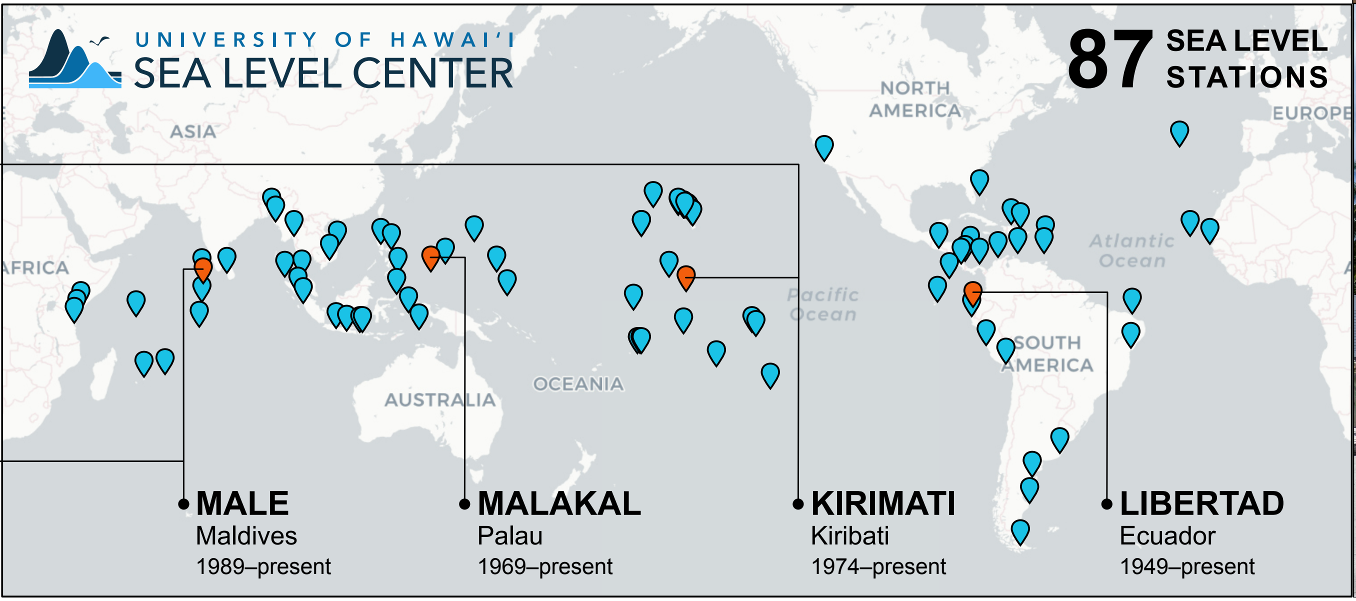
Role in GLOSS and NOAA

1. Operate a global network of 87 tide gauges

- Including about 20% of operational gauges in the GLOSS Core Network.



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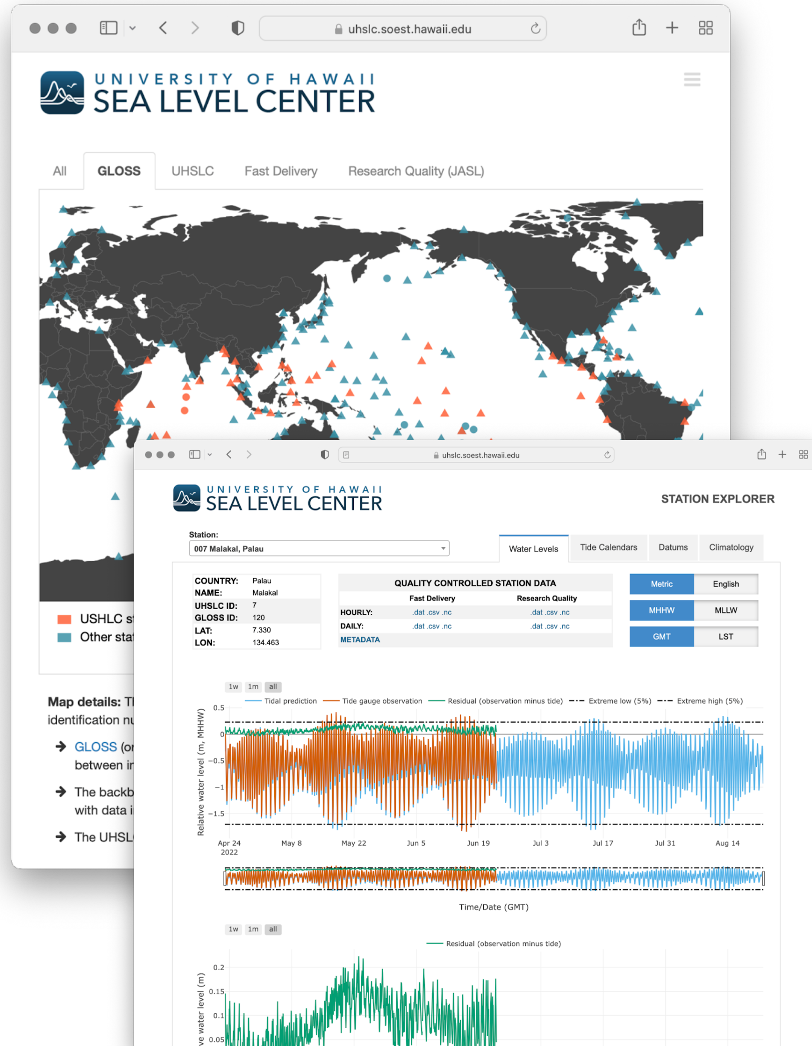
Role in GLOSS and NOAA

2. Curate global tide-gauge data sets

- Datasets contain approximately **20k years of data** from almost 700 sites across 97 countries.
- UHSLC aggregates, quality controls, and distributes the tide-gauge data.
- Data curation is performed in partnership with a Hawai‘i-based NCEI liaison (Ayesha Genz).
- UHSLC datasets are **cited 50–100 times per year** in peer-reviewed literature.



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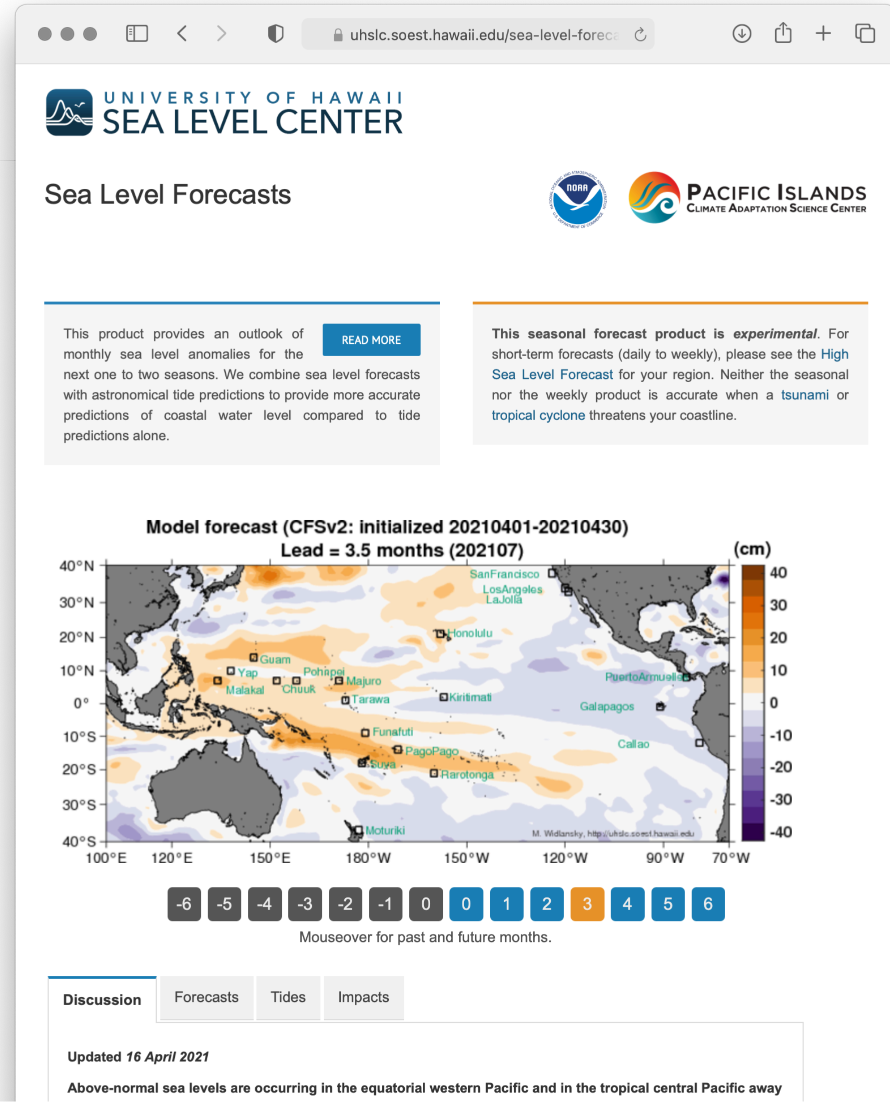
Role in GLOSS and NOAA

3. Research and product development

- Diverse portfolio of extramural research leveraging UHSLC resources and expertise
- Current projects funded by **multiple NOAA Programs** (MAPP, Pacific RISA, CO-OPS)
- Additional projects funded by NASA, USGS, DoD, and ONR
- Topics include:
  - Seasonal sea-level forecasts
  - 21st century projections of high-tide and compound flooding.
  - Assessing NOAA's 40-year reanalysis of hourly coastal water levels



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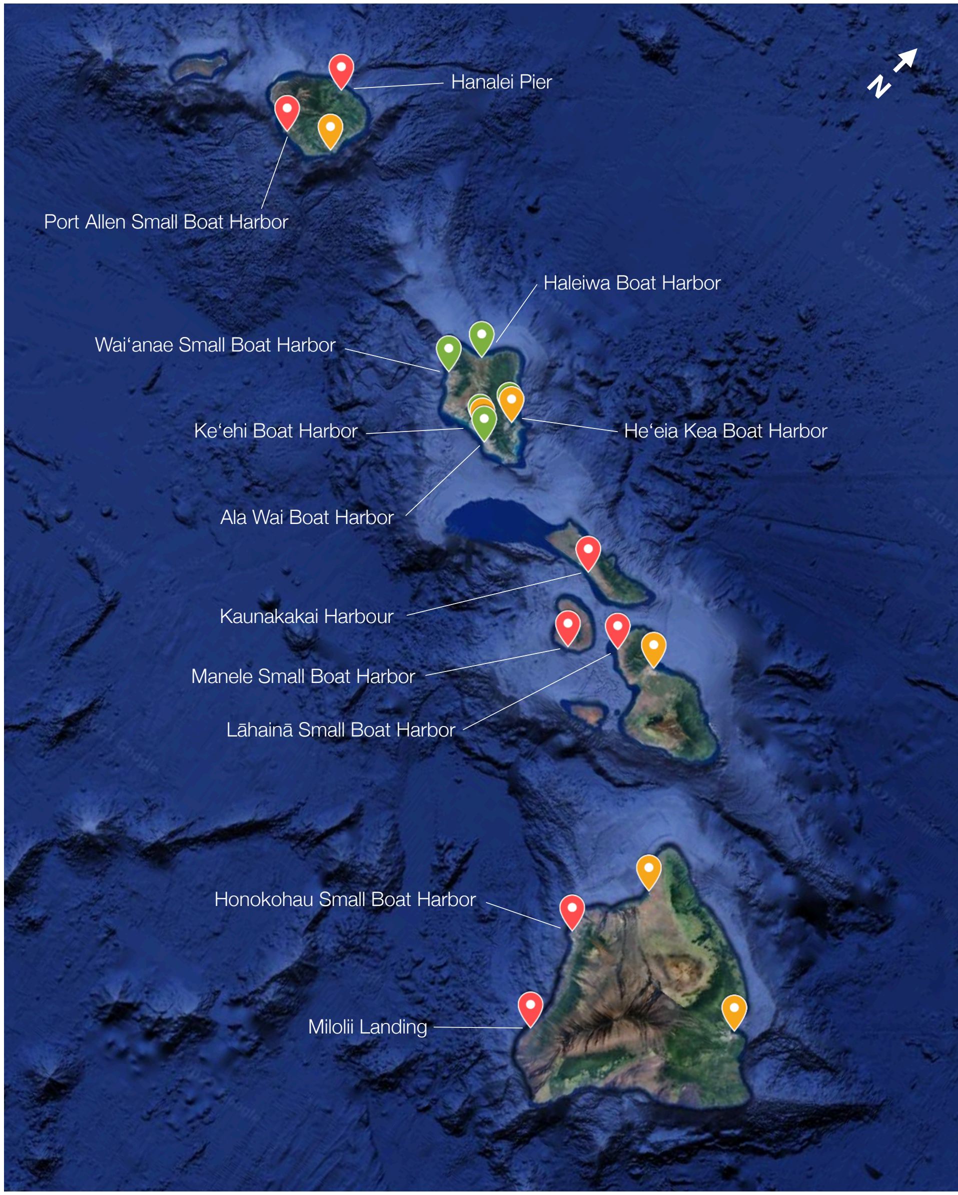
Current priorities

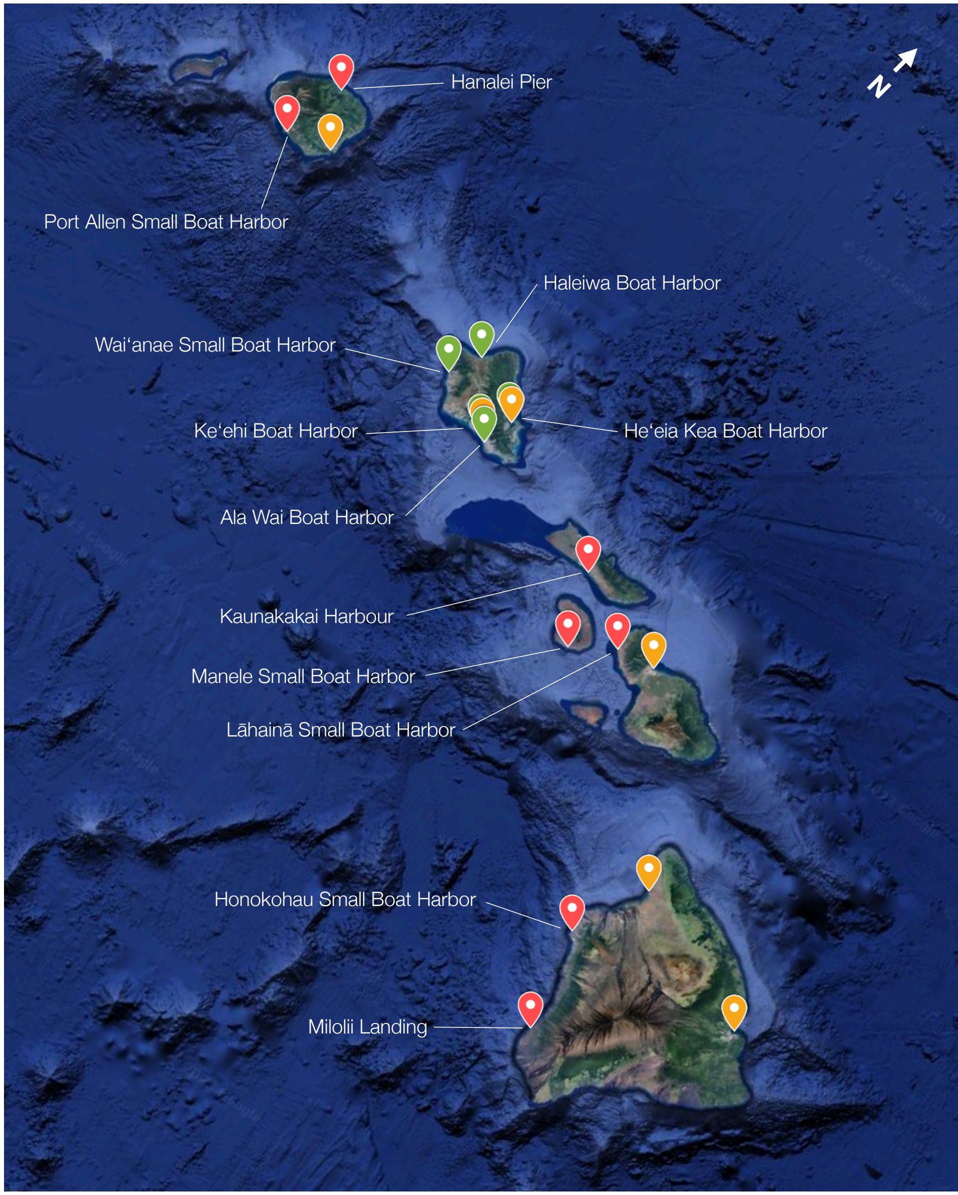
- Transition the UHSLC tide-gauge network to **Iridium** communications
  - Minimize data loss
  - Improve efficiency of maintenance operations
- Expand sea-level observing networks in **island regions** for climate and tsunami applications
  - Recently expanded in Hawai‘i, American Samoa, and Palau
- Increase online data **interactivity** and value-added calculations
  - 10– and 100–year flood levels; sea-level trends; etc.



Regional networks

Expansion in Hawai‘i

- NOAA CO-OPS operates **five** tide gauges
    - Long-term (35–120 year records)
    - Vertically controlled
- New UHSLC TG stations
    - **Five** new gauges on O‘ahu
    - **Seven** new gauges on other islands
    - All are operational and currently transmitting data
    - Vertically tied to NGS/DOT benchmarks



Regional networks

Expansion in Hawai‘i

- Designed for technicians, not consumers
  - Robust components; modular and serviceable
- Vertically controlled
  - Steel mast bolted into concrete
  - Surveyed into the NGS/HDOT statewide benchmark network, i.e., we know water levels relative to roads
- Near-real-time data transmission onto GTS
  - 1-minute water levels transmitted every 15 minutes
- Internal data storage
  - No data loss if cell service goes down

Ke‘ehi Boat Harbor

Haleiwa Boat Harbor

Regional networks

Expansion in Hawai‘i

- Industrial-grade components at low cost
  - Telemetry (Sutron Xlink 100 w/ cell modem): $1,250
  - Radar sensor (Vegapuls C22): $1,200
  - Mounting (custom stainless steel): $1,100
  - Instrument enclosure: $200
  - Power supply (5W solar panel & regulator): $100
  - Battery (7Ah): $50
  - Hardware (attachments & markers): $50
  - **Total: ~$4000**
- Components chosen based on decades of installation and maintenance experience

Ke‘ehi Boat Harbor

Haleiwa Boat Harbor

Regional networks

Expansion in American Samoa

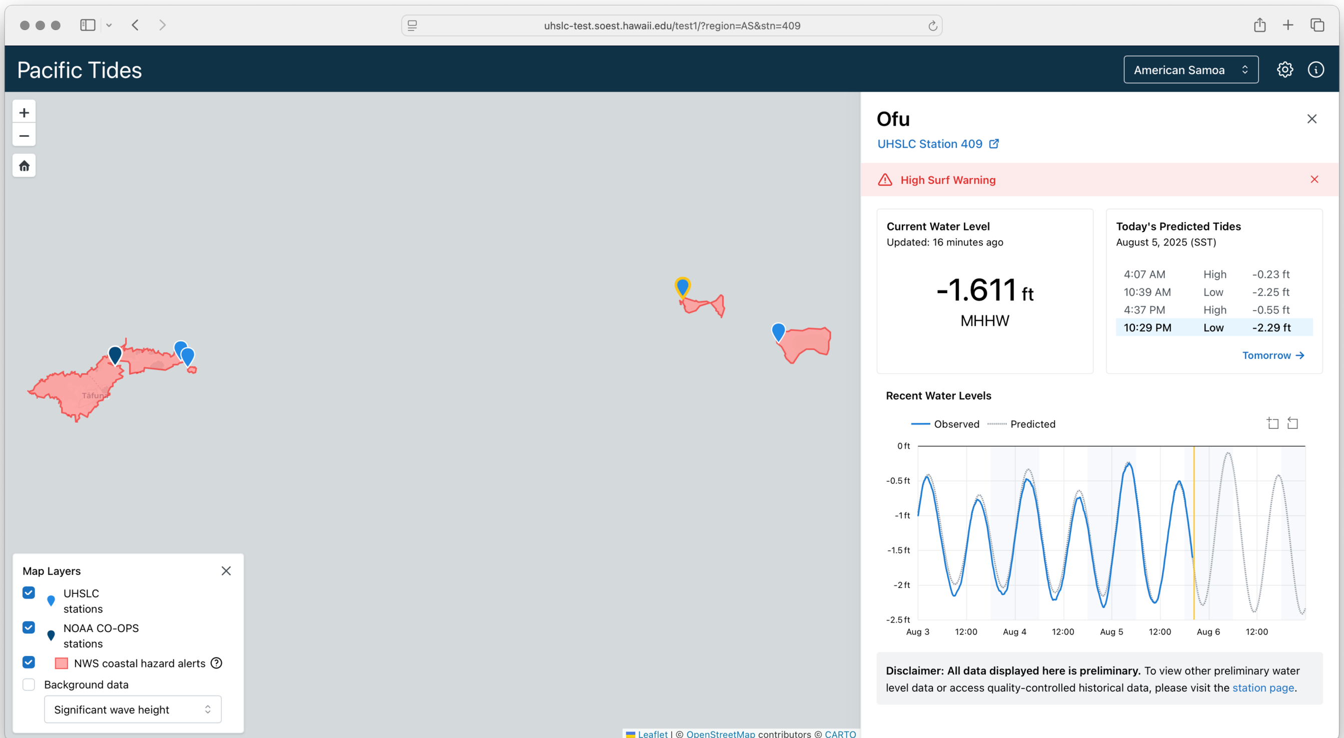
- Aunuʻu, American Samoa
  - Subsidence + SLR causes frequent disturbances from high-tide flooding.
- Tongan eruption
  - Could something similar happen in American Samoa?
  - Seismic activity detected in Mānua Islands.

Interactive tools

Pacific Tides real-time viewer

Coming soon …

- Current water level
- Timing of high/low tides
- NWS watches warnings
- Links to download data
- Current wave forecast
- Satellite altimetry



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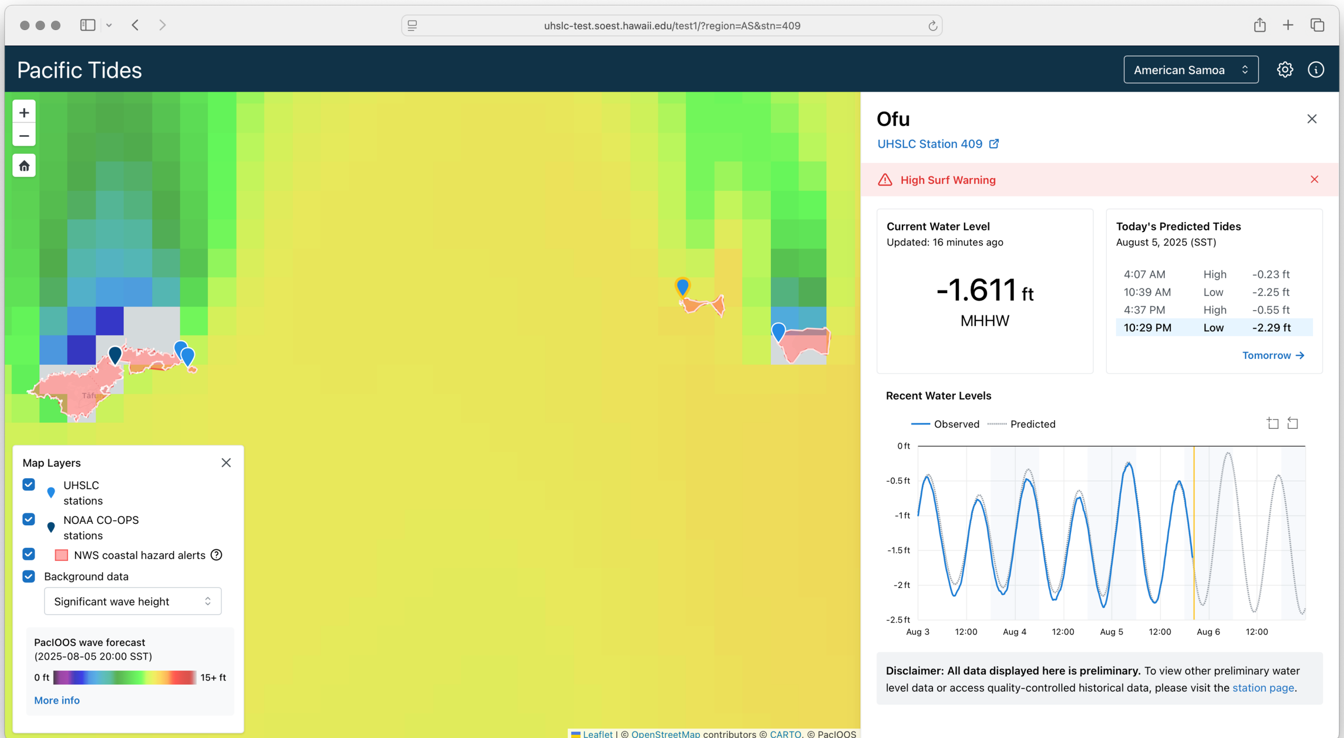


High-tide flooding (HTF)

“A window into the future”

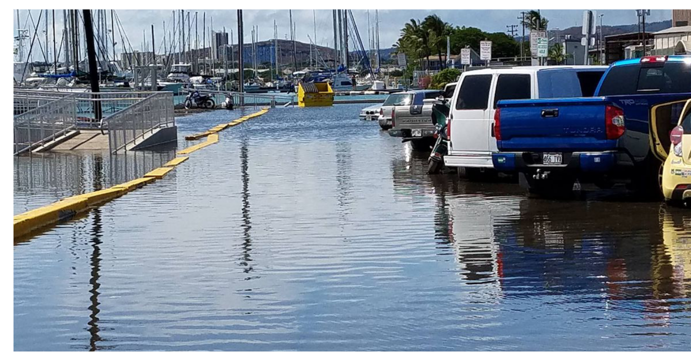
But how far into the future?

- Only **occasional** impacts now.
- When will these become **chronic** problems?

For transitions from occasional to chronic flooding, we determined …

- The amount of sea-level rise needed in different locations.
- The duration of such transitions.

We assessed whether **material resources** for adaption aligns (or not) with **vulnerability to rapid increases.**

Transition timelines

From occasional to chronic HTF

Defining frequency transitions

- **Occasional** → 1 day/year on average
- **Chronic** → 26 days/year on average (Dahl et al., 2017)

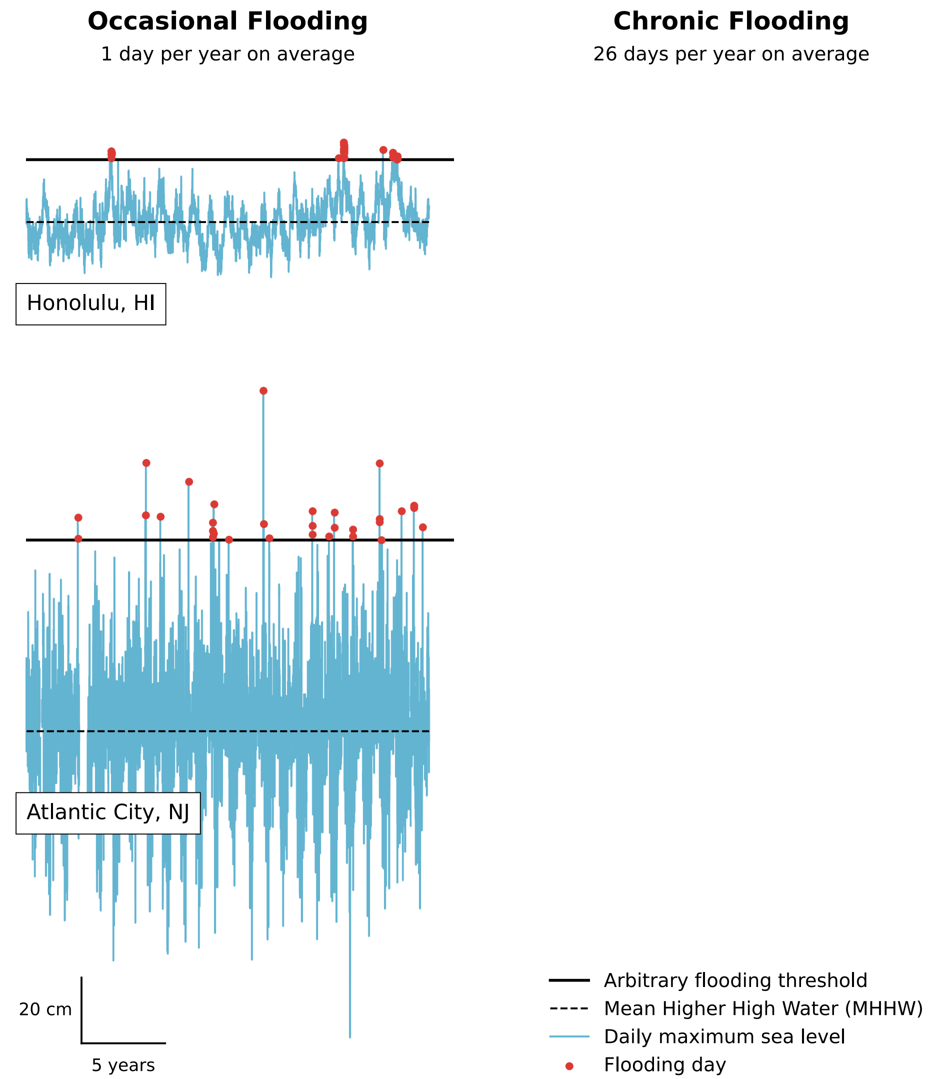
How much SLR is needed for the transition?

- Δh depends on the positive tail of the SL distribution.

How quickly do transitions happen?

- Δt depends on variations in Δh and the rate of SLR.

See Hunter et al. (2013), Vitousek et al. (2017), and Stephens et al. (2018) for similar ideas in the context of SL extremes.



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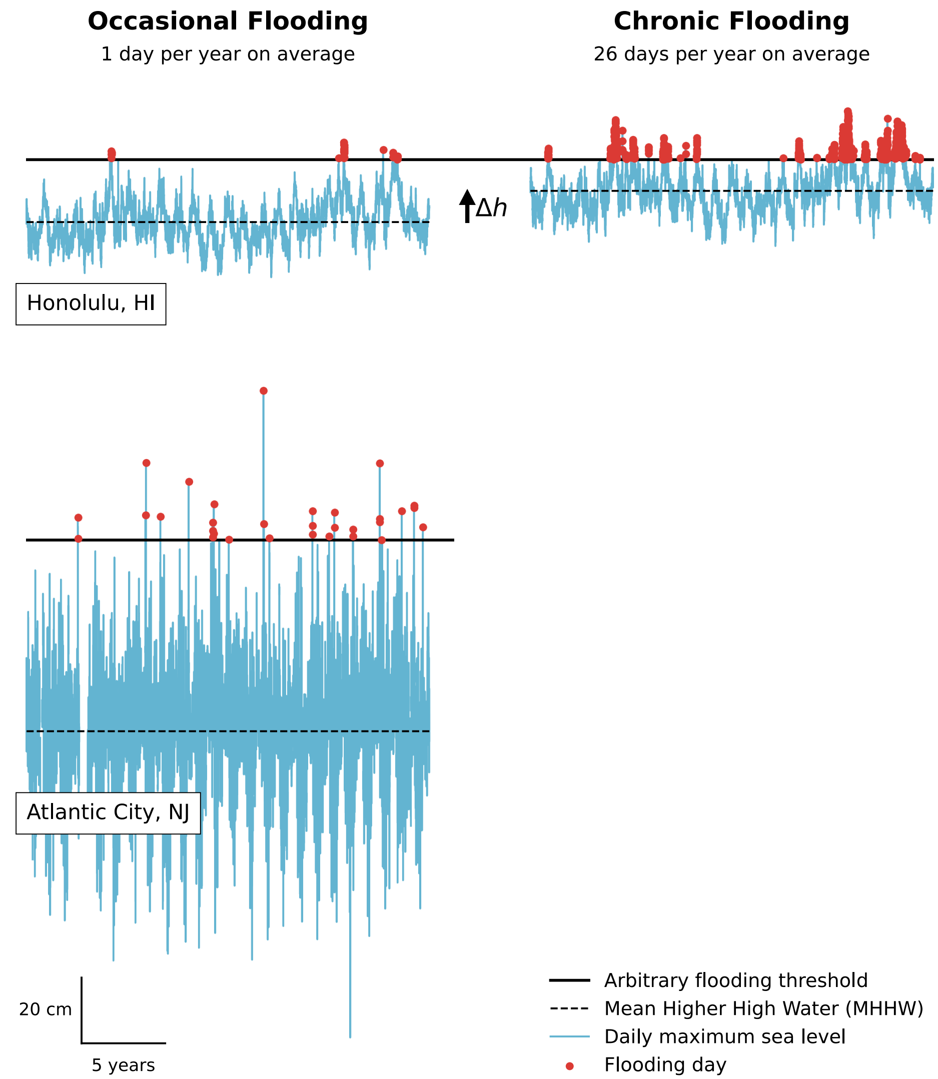

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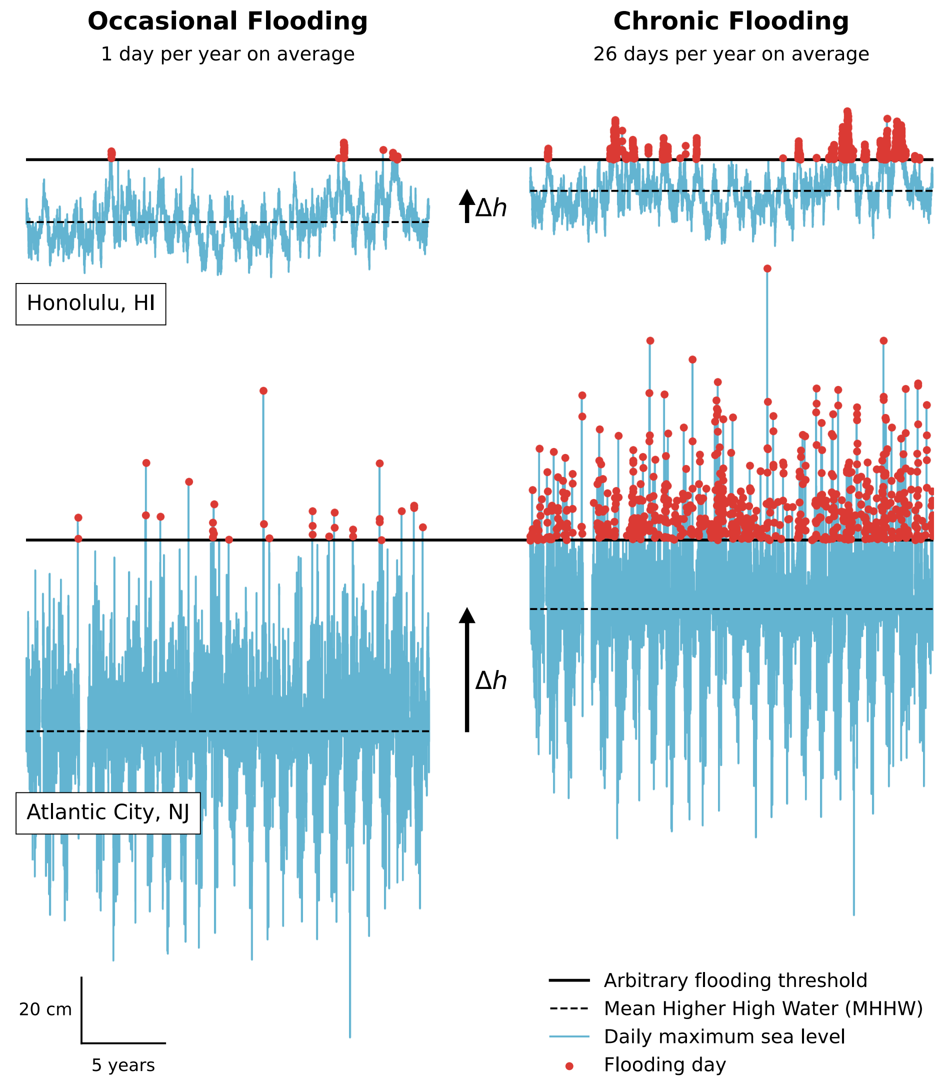
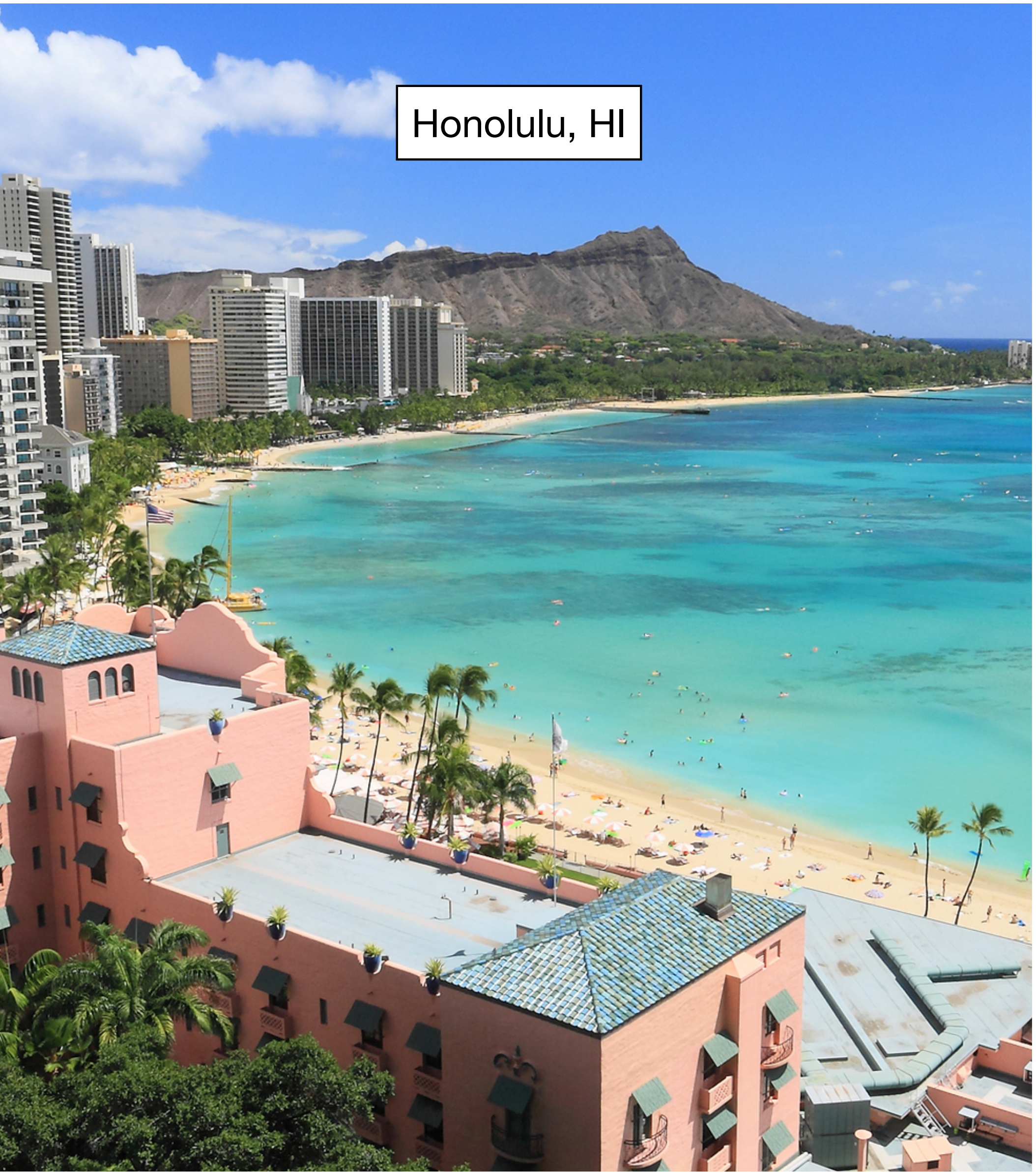
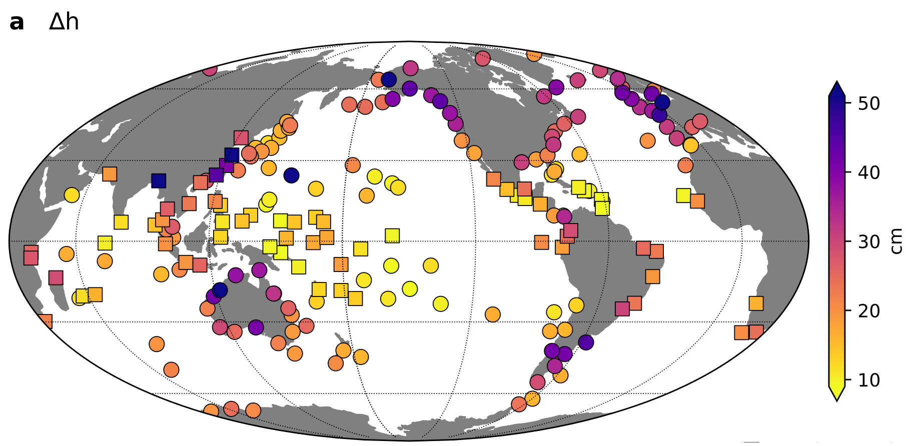


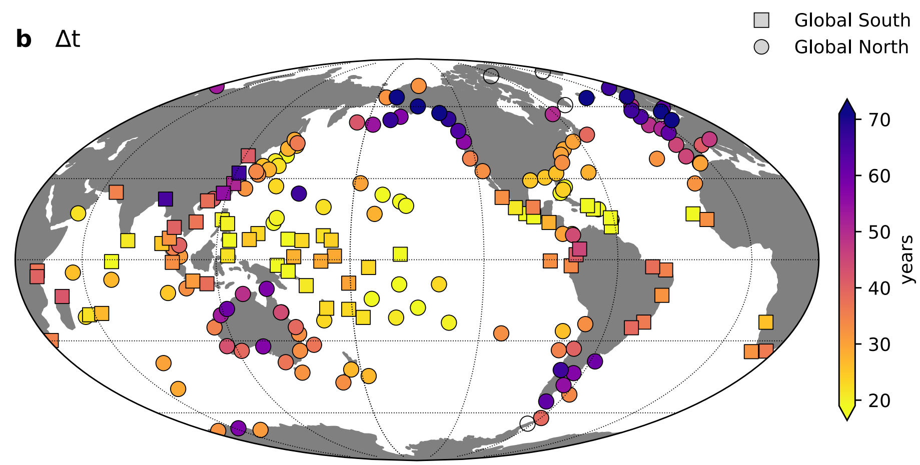

Honolulu, HI


Atlantic City, NJ

Occasional-to-chronic transitions

In a globally distributed set of long, high-quality tide-gauge records





- Note **latitudinal dependence** of Δh and Δt.
- How do these transitions map onto **availability of economic resources** needed for adaption?
- These values of Δt correspond to the US Interagency **Intermediate** SLR scenario beginning in 2020.

Results by group

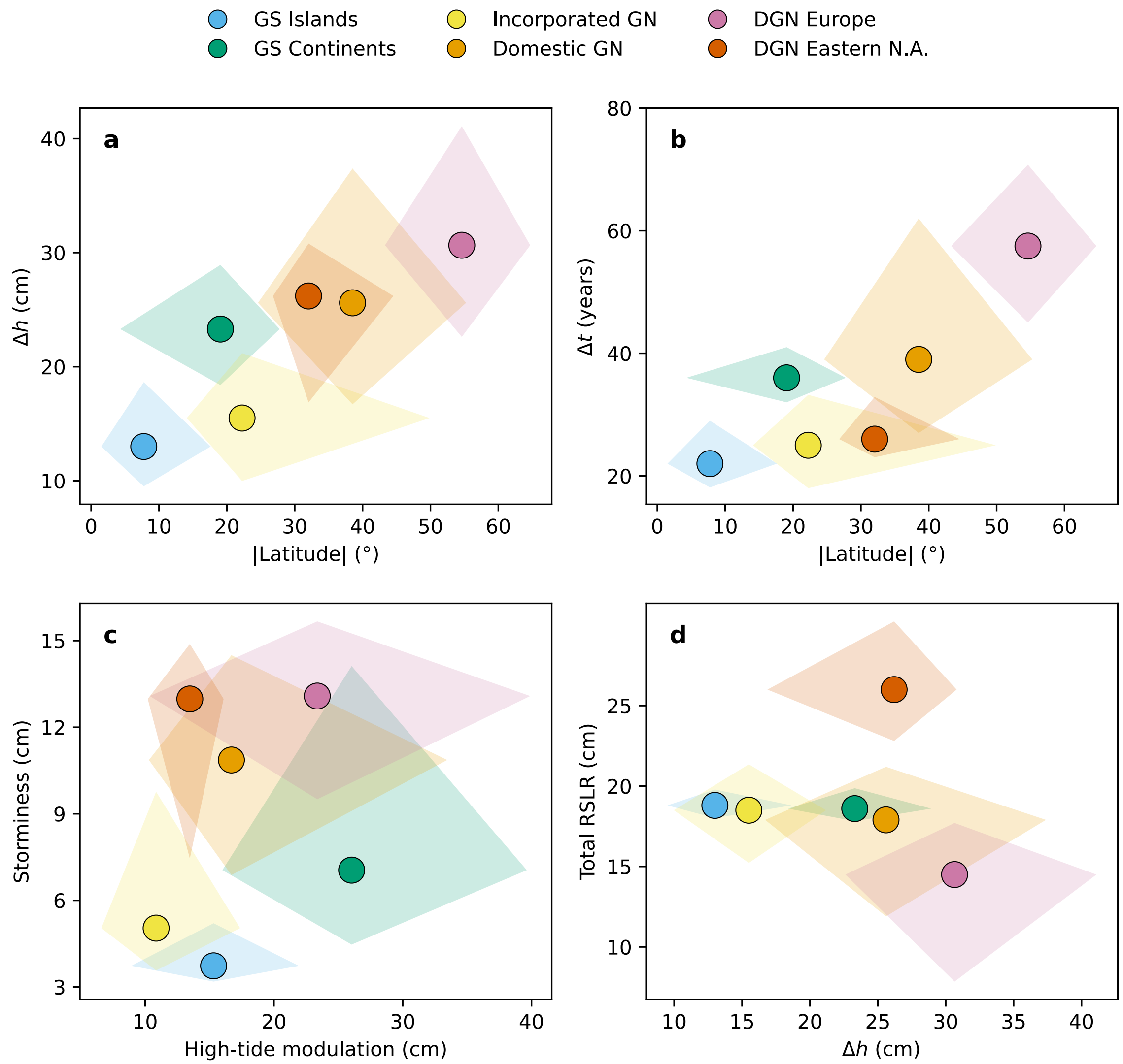
Geographic and socioeconomic

We examined the transition durations across various groups.

- **GS Islands → 22 years** [18, 29]
- GS Continents → 36 years [32, 41]
- GN Domestic → 39 years [27, 62]
- Domestic Europe → 58 years [45, 71]

GS Islands experience the most rapid transitions.

- SLR similar to continents.
- Least storminess and tidal modulation.



Thank you!

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