Subseasonal Predictability of Sea Level in the Hawaiian Islands

Hyang Yoon[1], Philip Thompson[1], Mark Merrifield[2], James Potemra[1], and Bo Qiu[1]

[1]University of Hawaii at Manoa
[2]University of California San Diego

November 21, 2022

Abstract

The Hawaiian Islands experienced record-high sea levels during 2017, which caused nuisance flooding in vulnerable coastal communities and exacerbate beach erosion, especially when positive sea level anomalies coincided with high tides. To build toward solutions for mitigating inundation risk, the predictability of daily-averaged sea level anomalies is investigated. Background sea level around the Hawaiian Islands was elevated during most of 2017 due to an oceanic Rossby-type planetary wave, which propagated slowly westward across the tropical North Pacific over the course of a year. The investigation focused on leveraging observed westward propagation that sea level anomalies exhibit over a range of timescales to make subseasonal predictions. Daily near-real-time gridded altimetry (CMEMS/AVISO) was used to specify upstream sea level at each site with propagation speeds based on mode-one baroclinic Rossby wave speeds. The skill of the predictions exceeds persistence at most locations around the archipelago out to a month or more lead time, but the skill is highly dependent on location even over the short distances spanned by the Hawaiian Ridge. Here, hindcast results are presented that establish where skillful subseasonal predictions can be made in Hawaii, as well as the barriers to predictability in locations where they cannot. These results inform the oceanographic and modelling communities about what processes need to be resolved in order to provide island communities with useful short-term sea level forecasts as the frequency of flooding events increases.

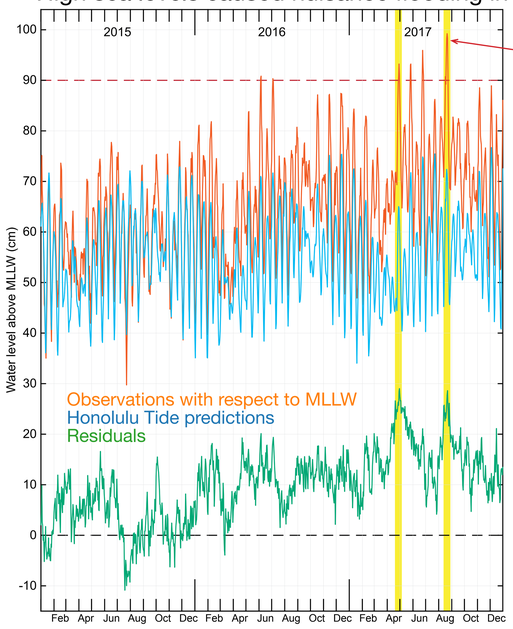
SUBSEASONAL PREDICTABILITY OF SEA LEVEL IN THE HAWAIʻIAN ISLANDS

Hyang Yoon[1] (hyangy@hawaii.edu), Philip R Thompson[1], Mark A Merrifield[2], James T Potemra[1], Bo Qiu[1]
[1] University of Hawaii at Manoa, Honolulu, HI [2] University of California San Diego, La Jolla, CA

PURPOSE **To investigate the predictability of daily-averaged sea level anomalies to build toward solutions for mitigating inundation risks.**

1. RECORD BREAKING SUMMER IN 2017

- Hawaii experienced record-high sea levels during 2017
- High sea levels caused nuisance flooding in vulnerable coastal areas



Anomalous Events

- Hourly value > 90 cm
  - Entire record: 58
  - Summer 2017: 25
- Daily max value > 90 cm
  - Entire record: 40
  - Summer 2017: 15

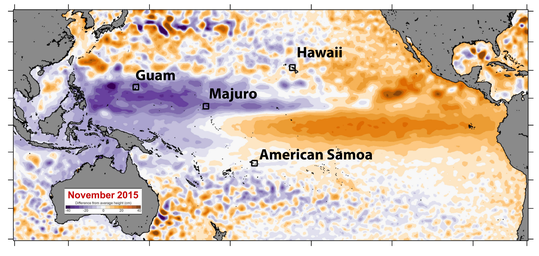
← Figure of daily max sea levels

2. BARRIERS WITH CURRENT FORWARD DYNAMICAL MODELS

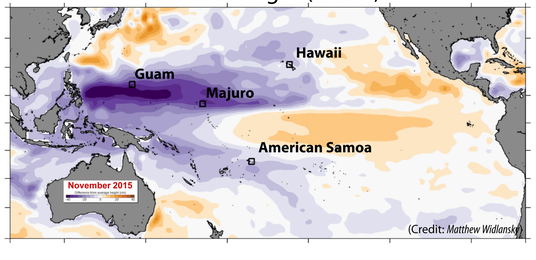
Sea level prediction at mid-latitudes (e.g., Hawaii) have low skill, likely due to mesoscale variability

- Low latitudes show high skill (e.g. Majuro)
- High latitudes show low skill (e.g. Hawaii)

Observed sea surface height (CMEMS, trend removed)

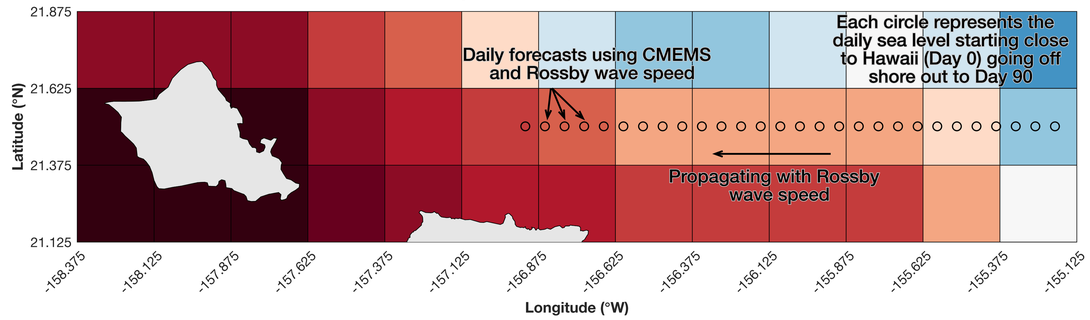


Forecasted sea surface height (CFSv2, 2.5 month lead)



3. SUBSEASONAL SEA LEVEL FORECAST USING OBSERVATIONS

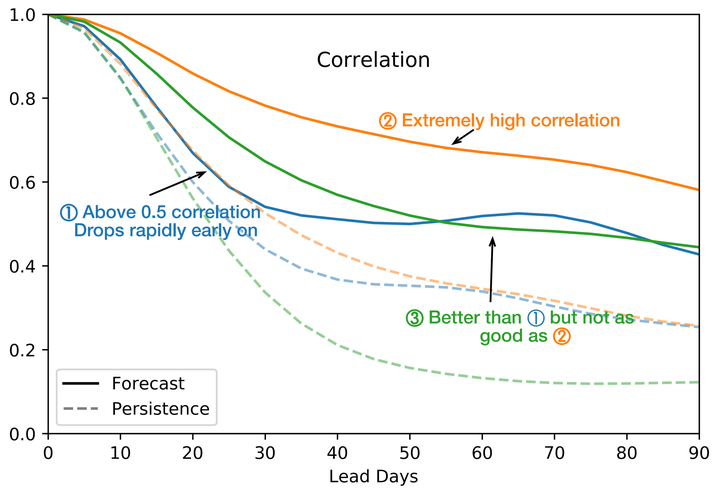
- Focused on leveraging observed westward propagation that sea level anomalies exhibit over a range of timescales
- Daily near-real-time gridded altimetry (CMEMS) was used to specify upstream sea level at each site with propagation speeds based on first baroclinic mode Rossby wave speeds

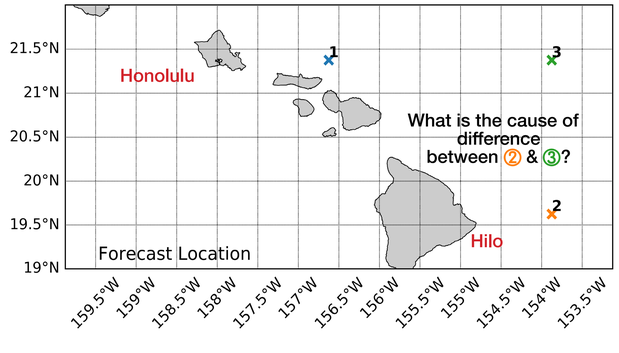


- Forecasts with 90-day lead time
- Propagate sea level to Hawaii using Rossby wave speed
- Daily forecast for entire CMEMS record (~20 years)

4. WHERE CAN THE CMEMS FORECAST BE USED?

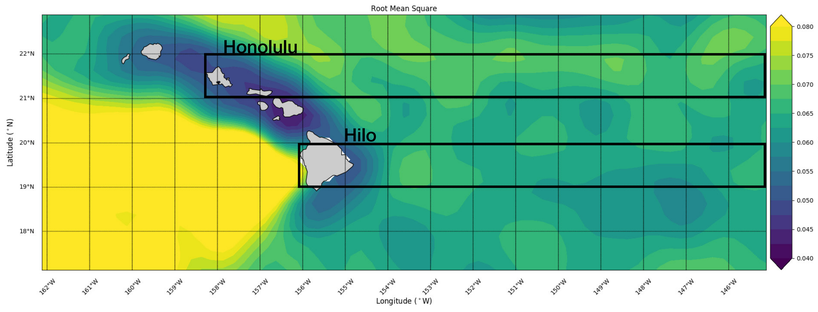
- Skill of the predictions exceeds persistence at most locations
- Skill is highly dependent on location





5. RMS OF SSH TO CHARACTERIZE MESOSCALE VARIABILITY

More variability at the latitude of Honolulu vs latitude of Hilo



6. SUMMARY AND FUTURE WORK

- Subseasonal numerical sea level predictions are not skillful at higher latitudes - including the latitudes of the Hawaiian Islands
- Hypothesis was using Rossby wave speeds and CMEMS will generate high skills
- Study revealed barriers that we do not fully understand
- Sea level predictions at Hilo are better than Honolulu
- Going to look into dynamical explanations of revealed barriers
- At Hilo we may be able to make useful predictions