Analysis of Retrospective Probabilistic Storm Surge Forecasts for Hurricane Iniki (1992)

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The Probabilistic Tropical Storm Surge model (P-Surge) is used operationally at the National Hurricane Center (NHC) to help forecasters issue storm surge watches and warnings. The recent incorporation of a parametric wave model has allowed P-Surge to provide more reliable inundation forecasts for islands where wave setup typically contributes to a higher fraction of the total water level. Upcoming improvements to the P-Surge model for the 2025 hurricane season will include the expansion to areas in the Pacific Ocean, including the Hawaiian Islands, American Samoa, and Guam.

Hurricane Iniki (1992)

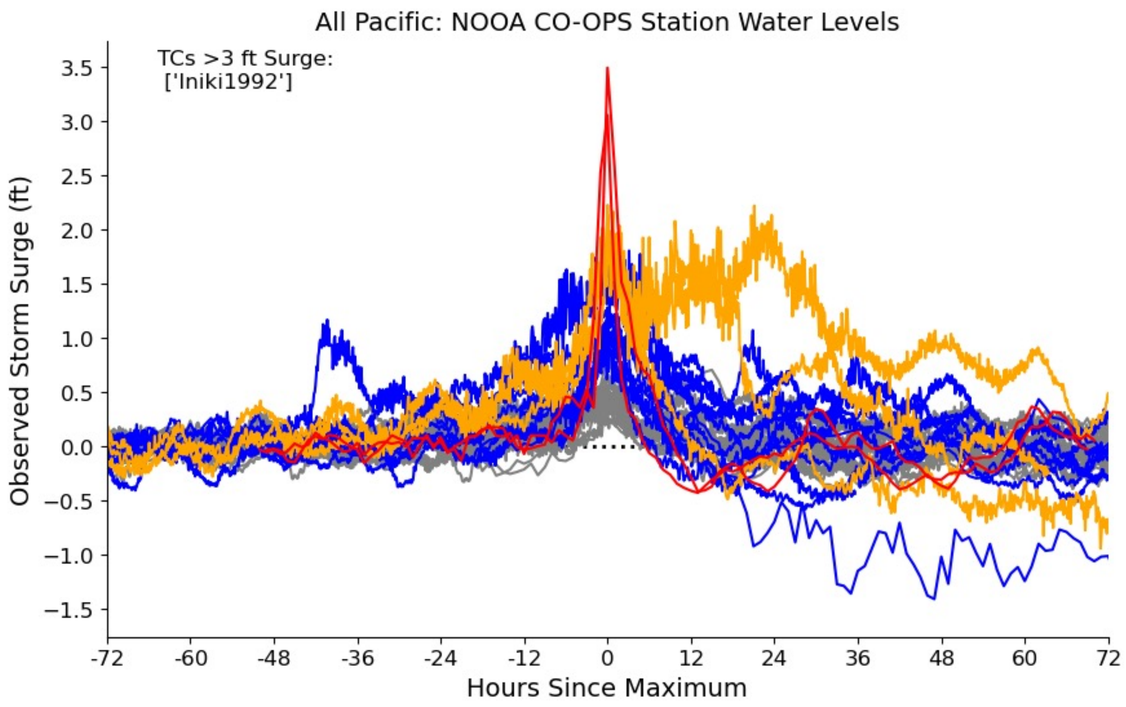


Figure 1: Storm surge observations from multiple NOAA CO-OPS stations during 19 tropical cyclones impacting Hawaii, American Samoa, and Guam. Surge is taken as the water level change relative to the average 1-3 day water levels prior to maximum water level. Lines are colored by the maximum storm surge: red=>3ft, orange=>2ft, blue=>1ft.

- Landfalling hurricanes on the Hawaiian Islands are rare which limits the verification dataset for P-Surge
- Hurricane Iniki (1992) is the most recent and strongest major hurricane to make landfall in the state of Hawaii
- Hurricane Iniki is the only tropical cyclone with verifiable observations of storm surge > 3 ft
- Analysis using perfect-prog approach and best-track analysis (no forecast errors)

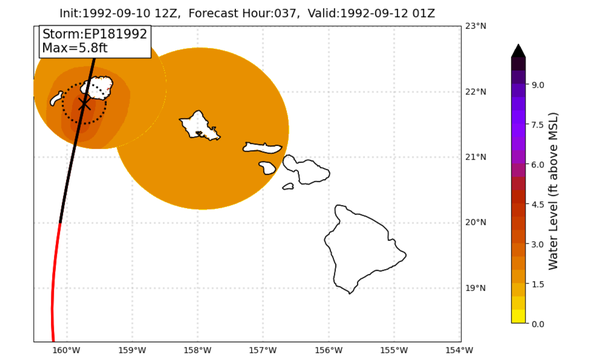
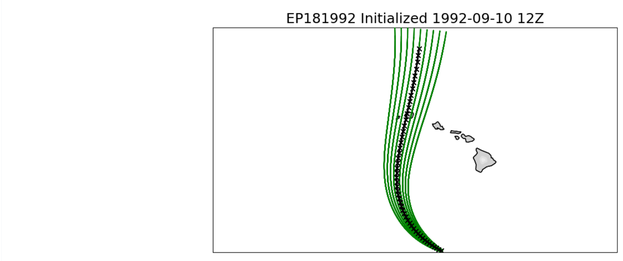


Figure 2: SLOSH water level above mean sea level (MSL) hindcast for Hurricane Iniki with the track line overlaid. 'X' denotes the center of the tropical cyclone at valid time with dashed circle highlighting the radius of maximum wind.

SLOSH + Waves

- Sea, Lake, and Overland Surge from Hurricane (SLOSH) model
  - Computational efficient hydrodynamical model
  - Models water flow through barriers, gaps, and passes
  - Models overtopping of barrier systems, levees, and roads
  - Models inland inundation
  - Requires meteorological forcing as input
- SLOSH does not include breaking waves, river flow, or rainfall
  - Has been coupled to a parametric wave model to include wave setup

Probabilistic Storm Surge Model



- Cross track spread is variable, contains 90% of uncertainty
- Along track (7 members)
- Intensity (3 members)
- Storm size (3 members)

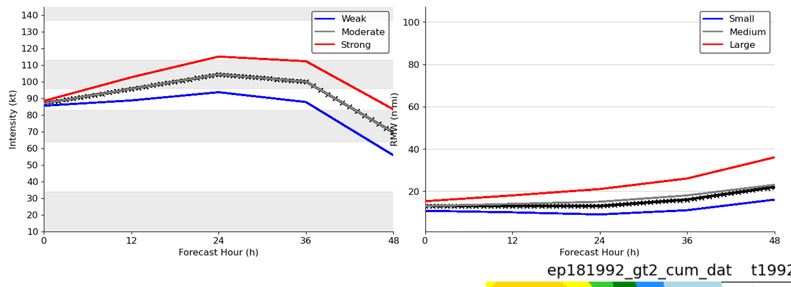


Figure 3: (Top) track forecasts, (left) intensity forecasts, and (right) RMW forecasts for the P-Surge ensemble that SLOSH is run for.

- Tracks are based on official forecast
- P-Surge creates probabilistic storm surge forecasts from SLOSH run on the ensemble of tracks

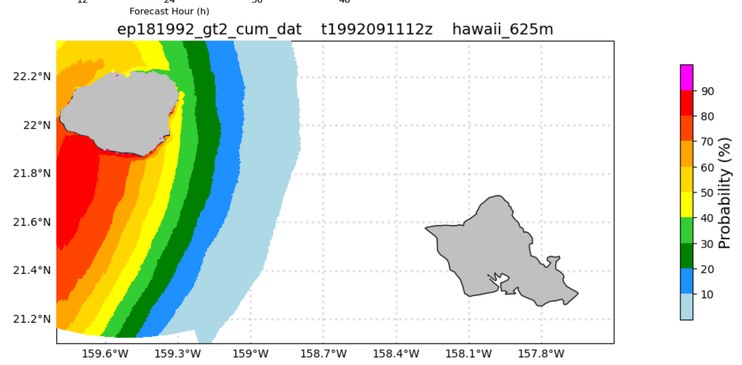


Figure 4: Cumulative probability forecast of storm surge exceeding 2 ft above MSL initialized 12UTC September 11, 1992.

Comparison with Observations

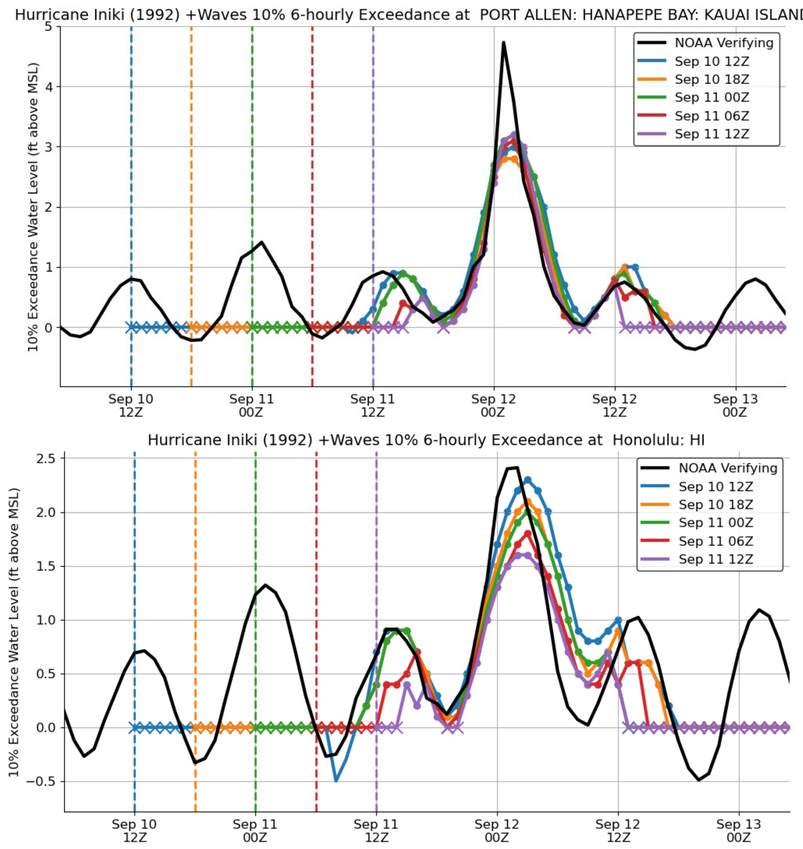


Figure 5: 10% Exceedance water level forecasts for 5 consecutive cycles (colors) valid at the location of the Port Allen (top) and Honolulu (bottom) tide station. Black lines are the observed water levels above MSL. 'X' denotes times where the basins were not running because the wind field was not interacting with the SLOSH domain.

- P-Surge captures peak water levels but under-represents peak surge in Port Allen
- Water level maximum is well captured in Honolulu, but slightly delayed in time
- 10% exceedance in Honolulu decreases with approaching landfall due to smaller spread and small wind field

Summary and Conclusions

Hindcast of Hurricane Iniki (1992) revealed a low bias in maximum water levels predicted by P-Surge at the Port Allen tide station. Complete retrospectives will be finished after finalizing operational SLOSH basins. This evaluation will be used to aid forecaster awareness and guide future improvements to the model. P-Surge will be expanded operationally to include Hawaii, Guam and American Samoa prior to 2025 hurricane season.

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