Phase-Resolving Wave Runup for Storm Inundation Assessment

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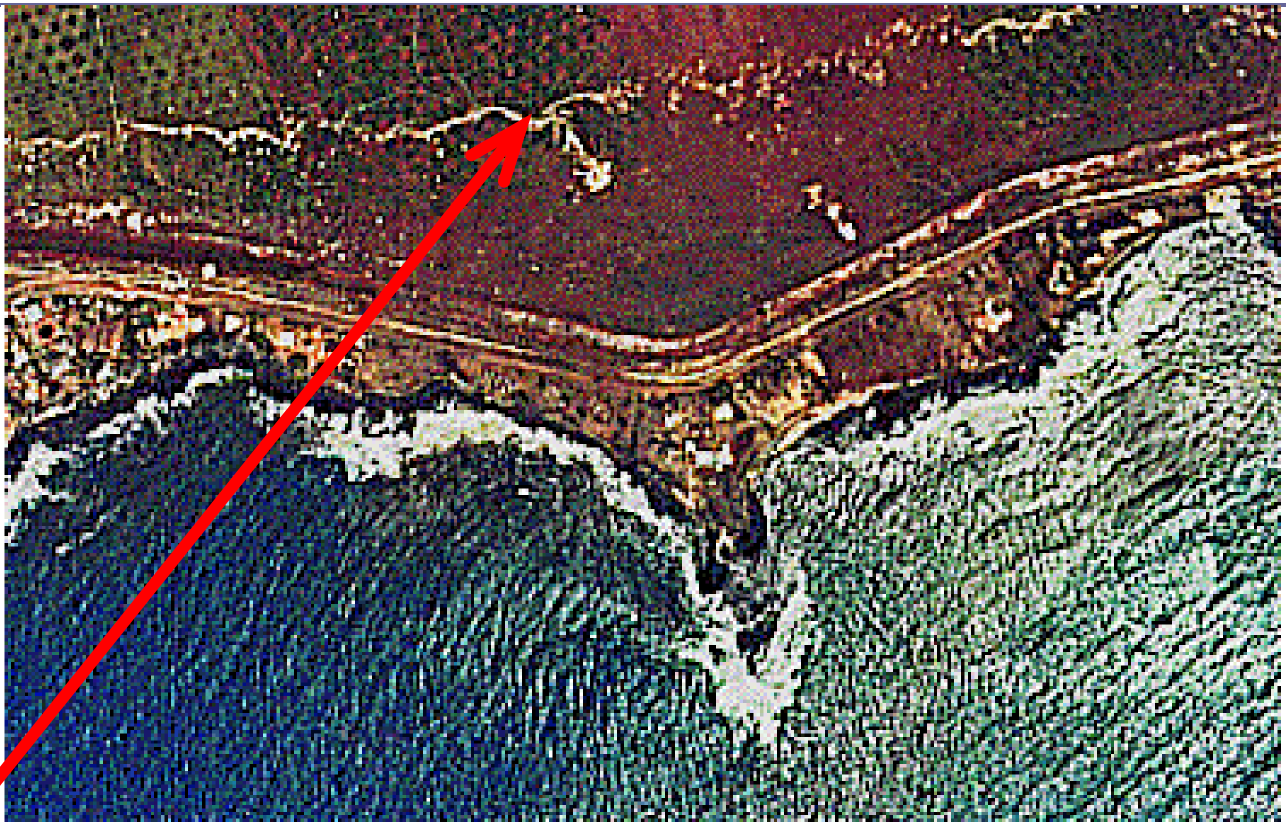
Motivation



Hurricane Iniki (1992) debris line is much further inland and higher elevation (~7m) than the 2-3 m surge.

Motivation

- On steep coastlines, particularly with little or no continental shelf, wave runup can dominate storm inundation
- Parameterized runup predictions exist for beaches and breakwaters, but these are not general enough for arbitrary topographies

Runup Modeling Approach

- Phase-resolving Boussinesq model
- Nonlinear processes on arbitrary topographies, including runup
- Applied on 1D transects to develop lookup table of response

Conclusions

- One-dimensional Boussinesq computations give reasonable estimates of runup over complex topographies
  - Limited by one dimensionality, bare earth assumption
  - Results are conservative, especially in built up areas
  - Runup can dominate over surge on steep topographies
- When combined with large scale wave/water level simulations, can give estimates of worst case inundations
- Significant areas of Honolulu would be underwater with a direct hurricane strike

Outline

- One-dimensional Boussinesq Modeling for Hawaiian Islands
  - Runup for a single wave height/water level
  - Storm matrix to cover range of possible conditions
  - Hurricane Iniki runup comparisons
- Maximum Potential Runup for Oahu
  - Wave+Surge+Runup inundation for suite of storms, separated by central pressure

Runup Computations

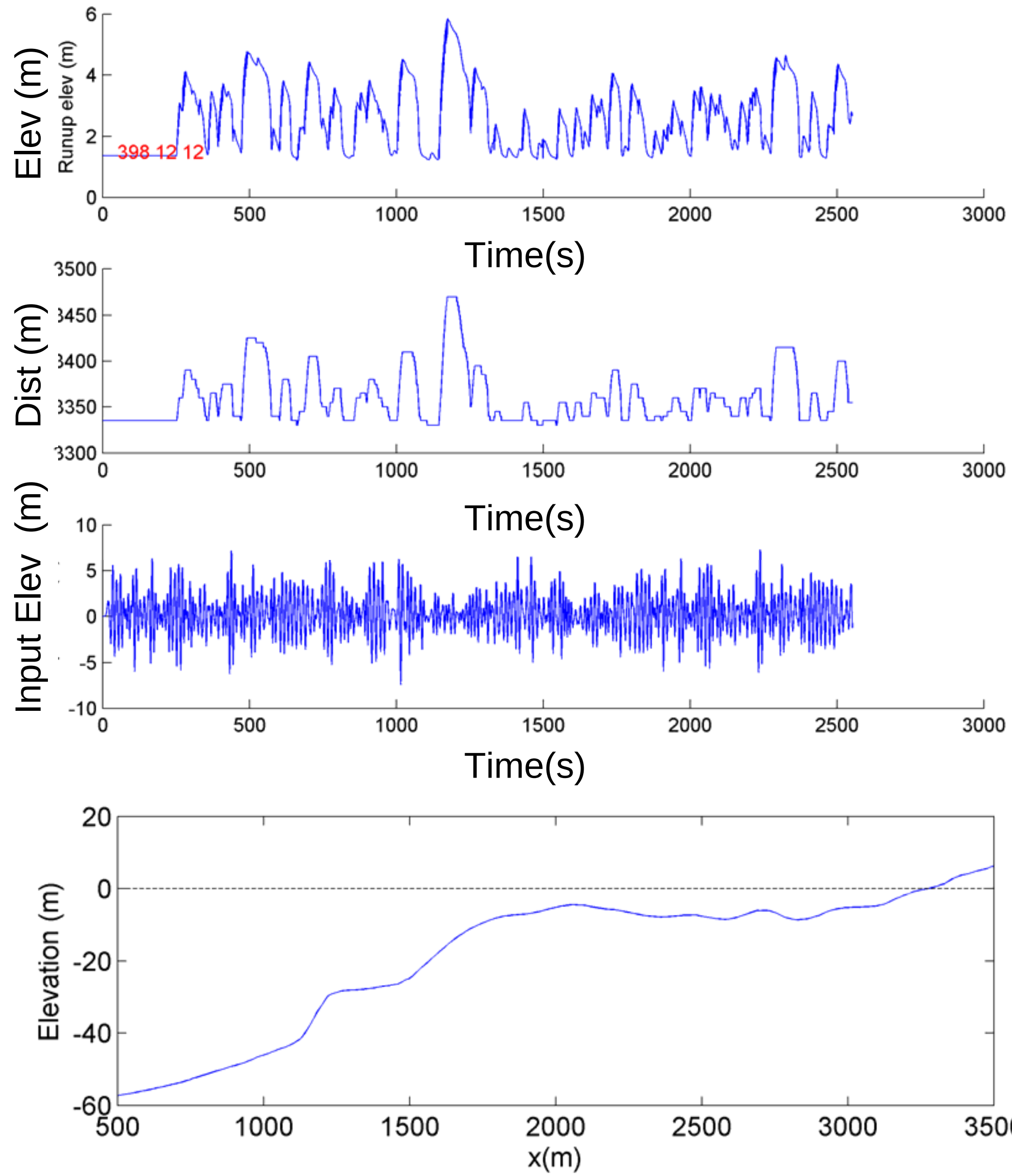
- As part of SWIMS project, compute runup along one-dimensional transects for the major Hawaiian Islands
  - Wave conditions, water levels at transect starting points determined from range of wave heights/water levels from large-scale SWAN+ADCIRC simulations
  - Use Bouss1D model (Nwogu and Demirbilek)
  - On each transect, run 169 combinations of waves/water levels, find max runup from each
  - 300-800 transects for each island
  - Hundreds of thousands of total runs
- Would like to perform 3D inundation, but computing power is not sufficient for large number of runs

Example Runup Computation

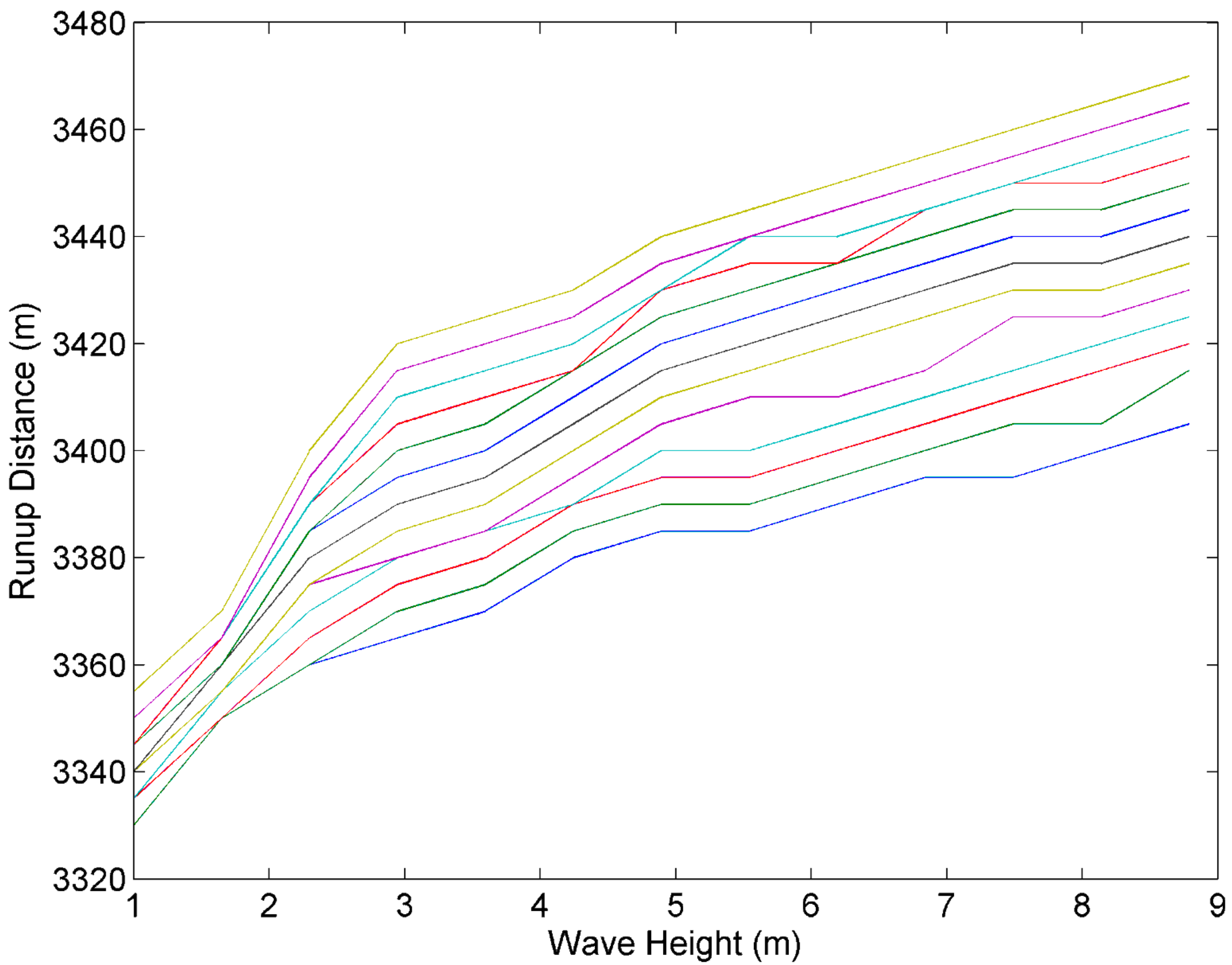
- Runup along one transect
  - 60 m depth to breaking on shallow reef, then runup
  - Incident waves H_s ~ 8.8 m
  - Still water level ~ 1.4 m

- Runup elevation and inundation are both wave group dominated
  - Up to 6 m maximum runup
  - Up to 130 m max inland penetration

- 169 runs for this transect covering envelope of wave heights, water levels

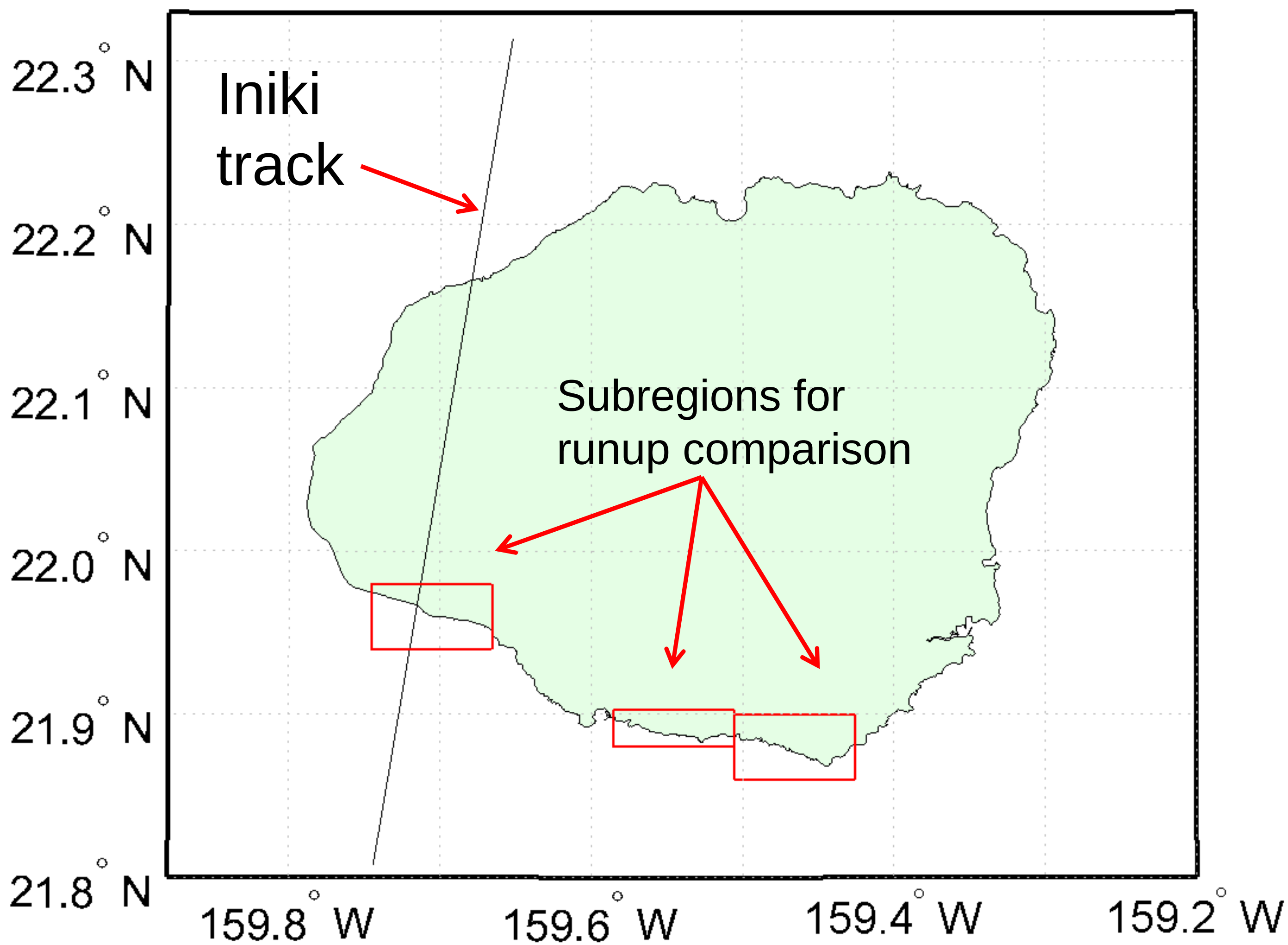


Matrix of Runup from 13 Wave Heights×13 Water Levels

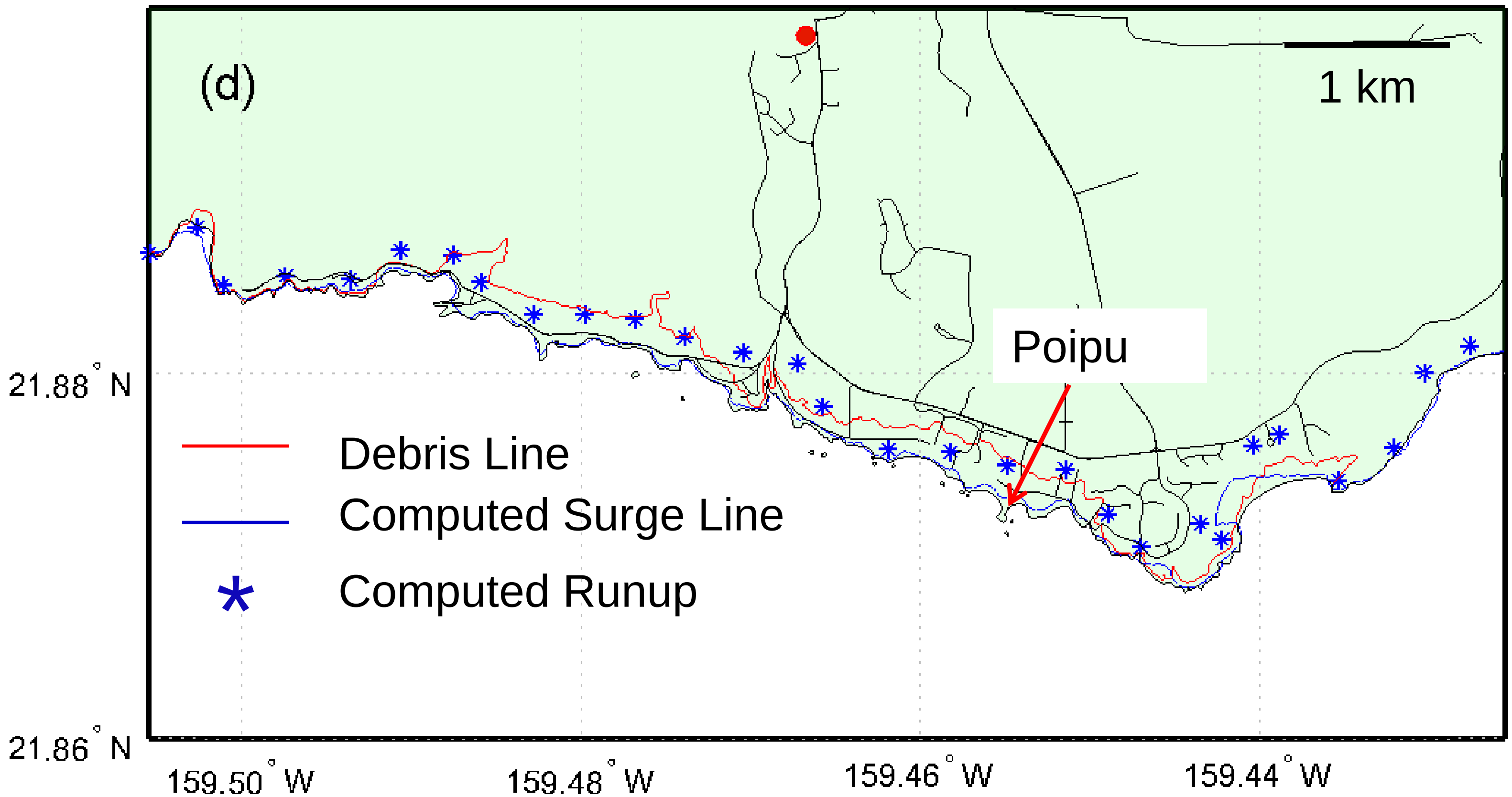


- **Lines represent different initial water levels**
- **Wave height/water level matrix covers range of conditions**
- **Interpolate within this range**

Hurricane Iniki Runup Comparisons on Kauai

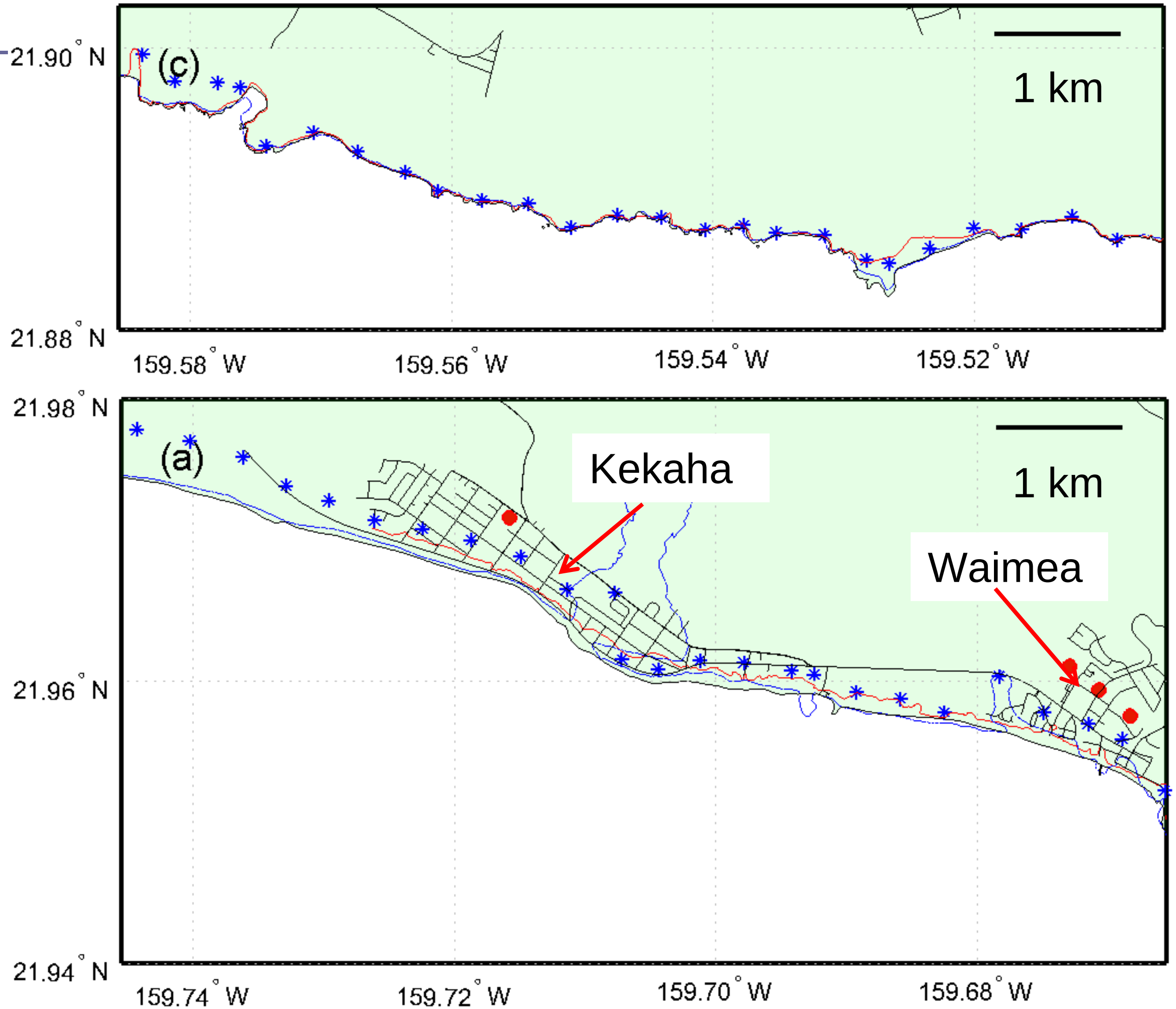


Hurricane Iniki Runup



- Iniki is worst hurricane to hit Hawaiian Islands in the past century
- Runup comparisons give reasonable results for most cases
- Computed runup is much more important than computed surge

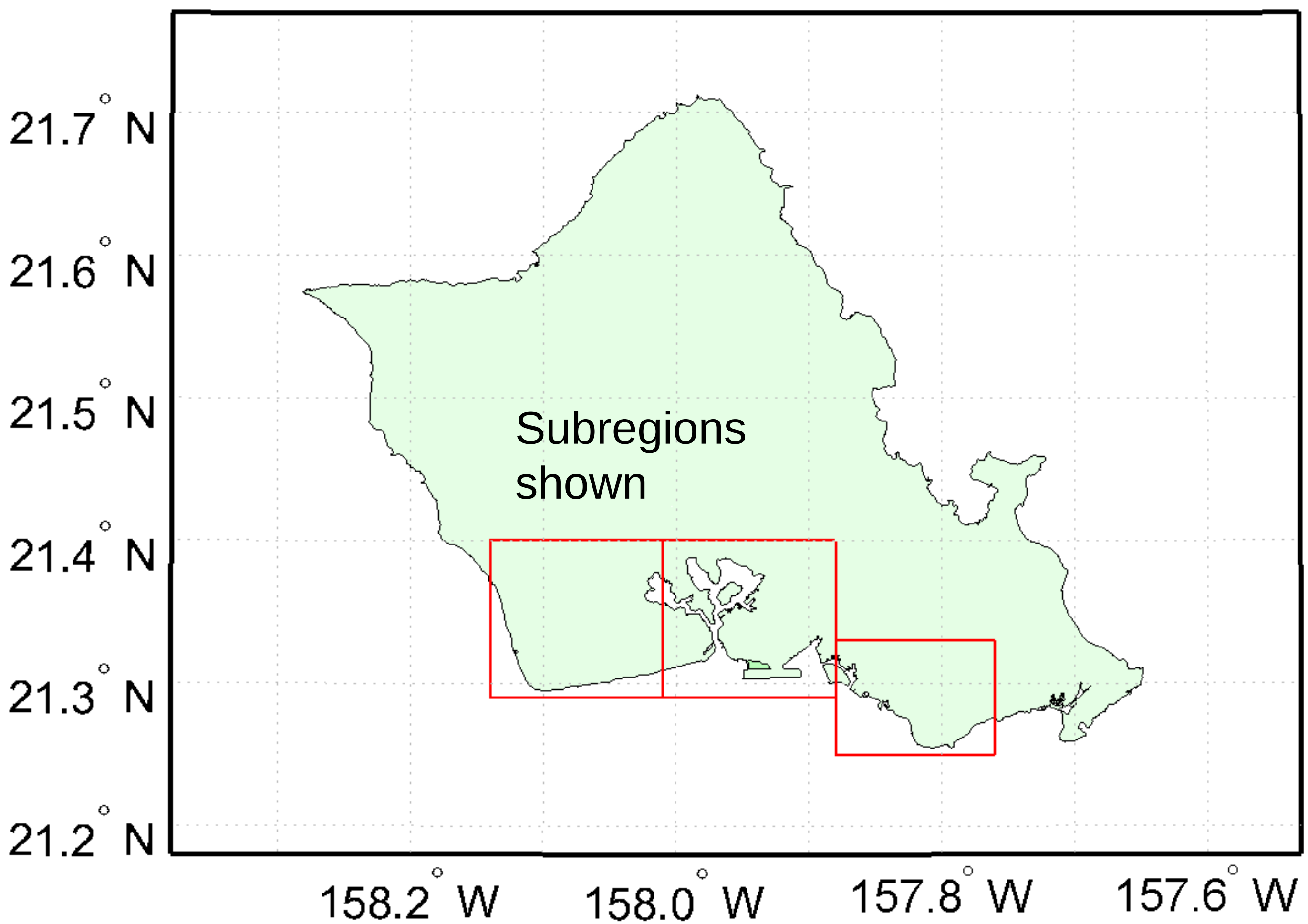
Iniki Runup Continued



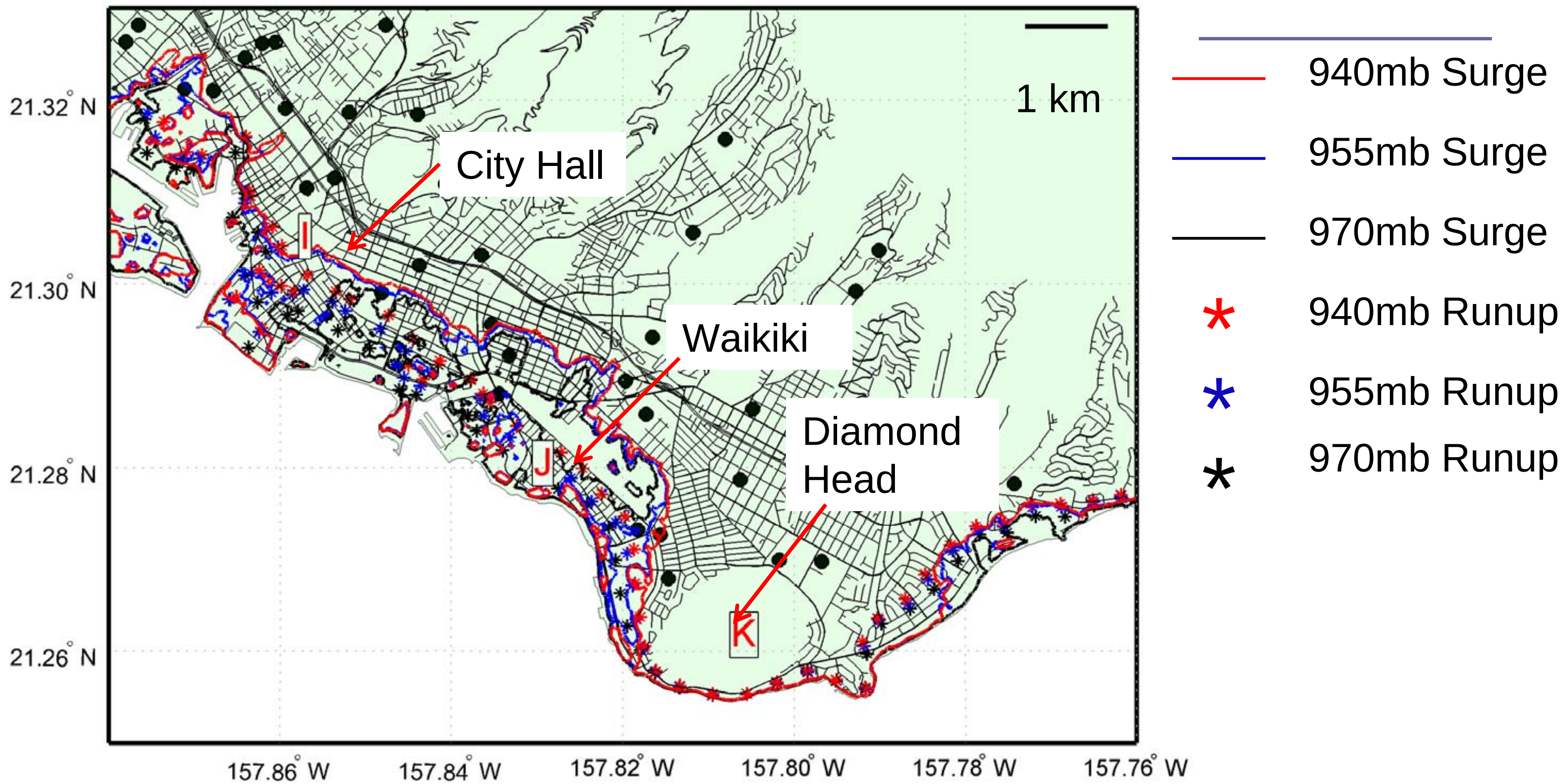
Maximum Potential Runup

- Hundreds of large scale SWAN+ADCIRC runs computed for different scenarios
- Use Boussinesq runup model to compute inundation for each run in Oahu and Kauai
- Group all storms by central pressure, find maximum runup/surge inundations
- Can be used to estimate worst case scenario for a given storm strength

Oahu Potential Inundation

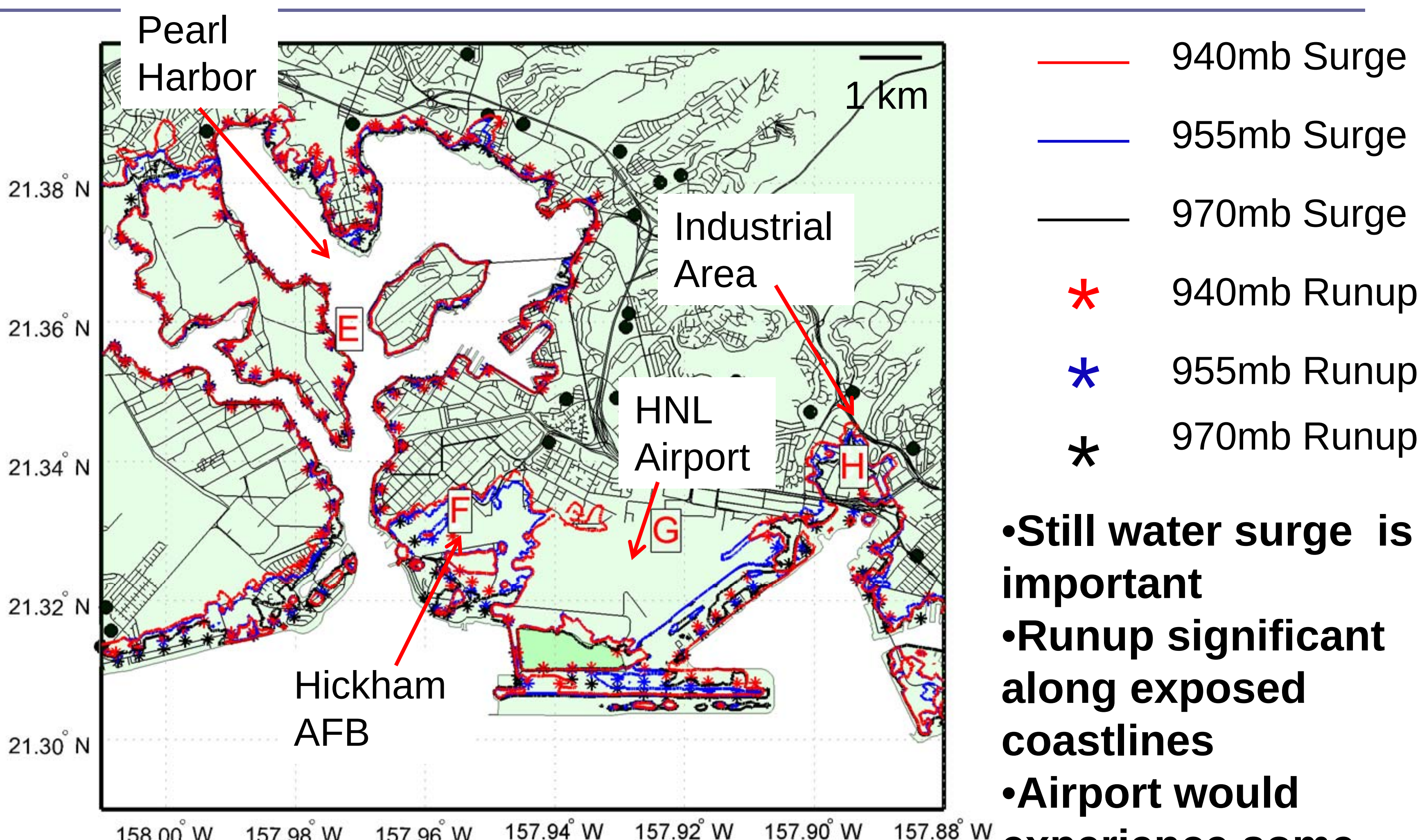


Waikiki/Diamond Head Potential Inundation



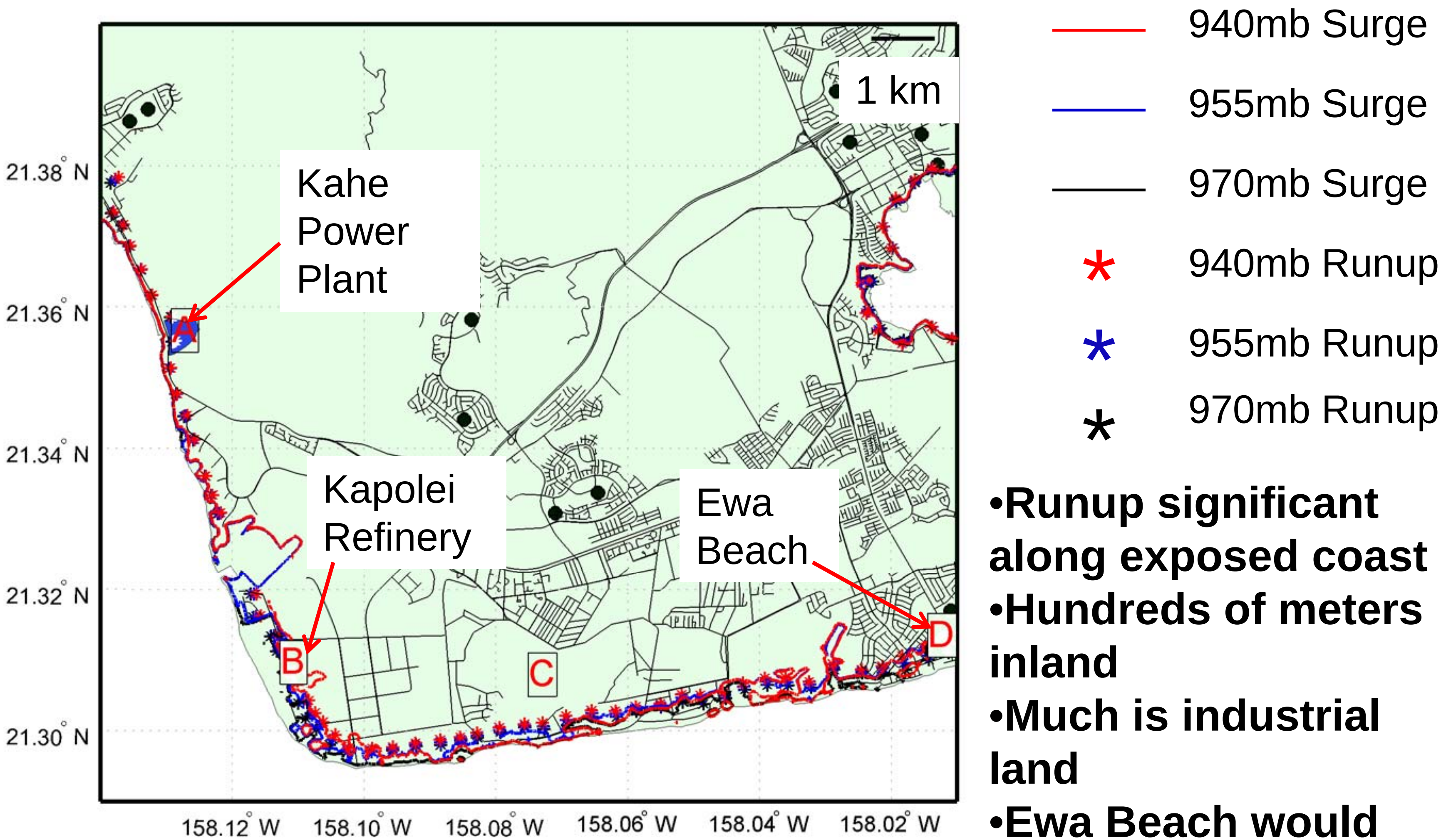
- Still water surge in particular is important in this region
- Low ground elevations mean that potential inundation is large
- Waikiki back side inundation through Ala Wai Canal

Pearl Harbor/Honolulu Potential Inundation



- **Still water surge is important**
- **Runup significant along exposed coastlines**
- **Airport would experience some inundation**

Southwest Oahu Potential Inundation



- **Runup significant along exposed coast**
- **Hundreds of meters inland**
- **Much is industrial land**
- **Ewa Beach would have inundation**

Conclusions

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