Wave-driven extreme water levels on coral and rocky reef coastlines

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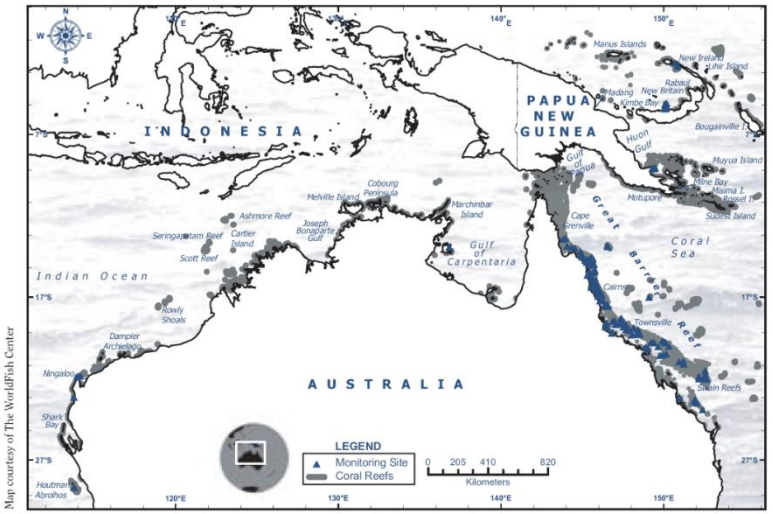
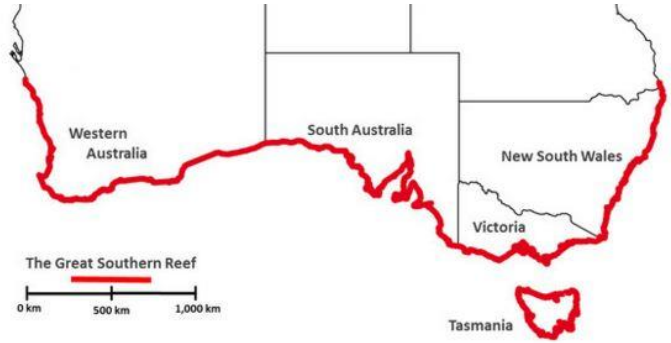
Australia's diverse coastline: both coral and rocky (temperate) reefs

- Knowledge foundation of nearshore processes has been historically based on open coast sandy beaches
- Up to ~80% of the world's coastline is reefs (Emery and Kuhn 1982); ~30-50% of Australia's coast is reefs (Short 2009)

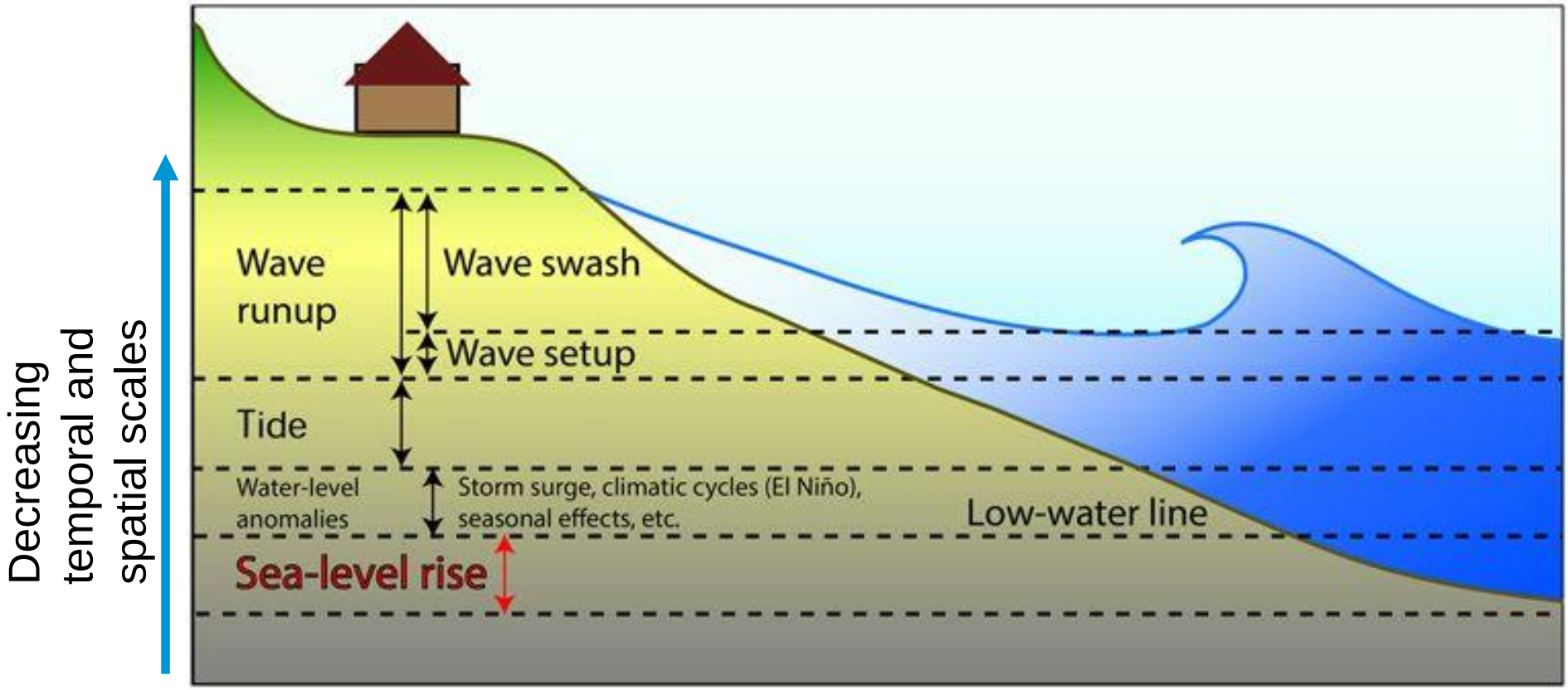
Coral reefs



Rocky reefs



Temporal and spatial scales of coastal extreme water levels



Vitousek et al. 2017

Challenges to predicting wave runup along coral and rocky reef coastlines

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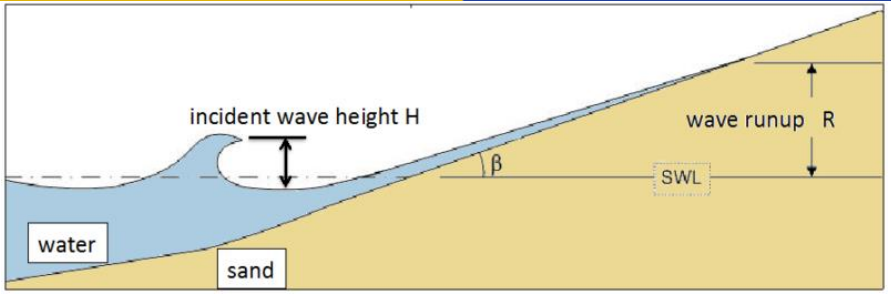
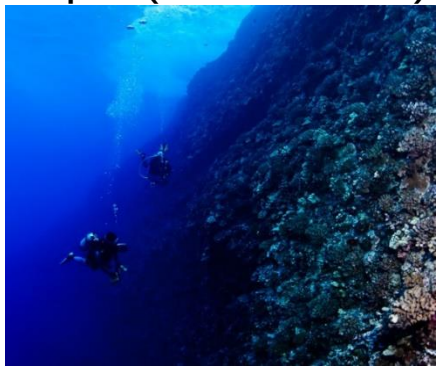
Beaches

- Extensive literature on predicting runup on sandy beaches
- Numerical and empirical models



Wave breaking on steep slopes(~1:20 to 1:1)



Complex morphology

Large bottom roughness

Fringing coral reefs

Along-shore uniform

No net mass flux
Mean bottom stress directed seaward

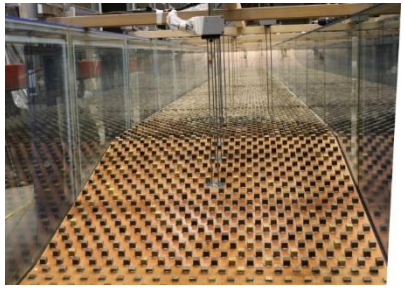
Open channels

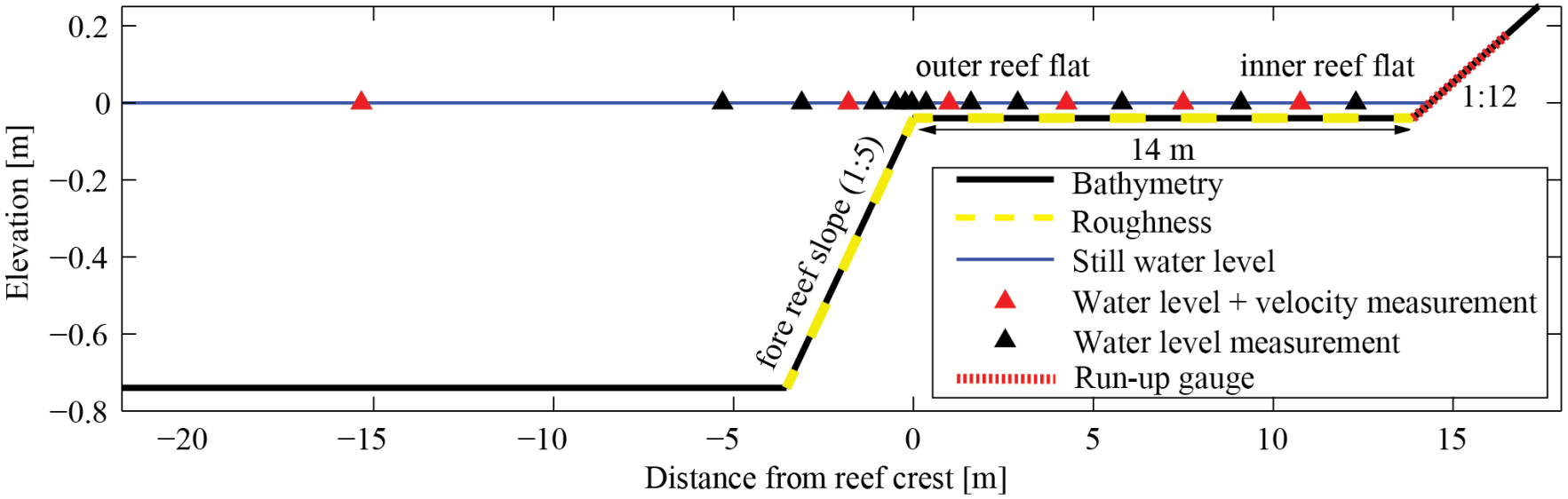
Shoreward net mass flux
Mean bottom stress directed shoreward

UWA Fringing Reef Experiment
(alongshore uniform fringing reef)

- 55-m long flume (Deltares)
- 1:36 geometry scaling
- 14 m long reef flat (500 m in prototype)
- 1:5 fore reef slope
- 1:12 beach slope

- Smooth and rough bed
- 16 wave and water level cases
- 18 wave gauges + 6 velocimeters
- Runup gauge





UWA Fringing Reef Experiment

(alongshore uniform fringing reef)

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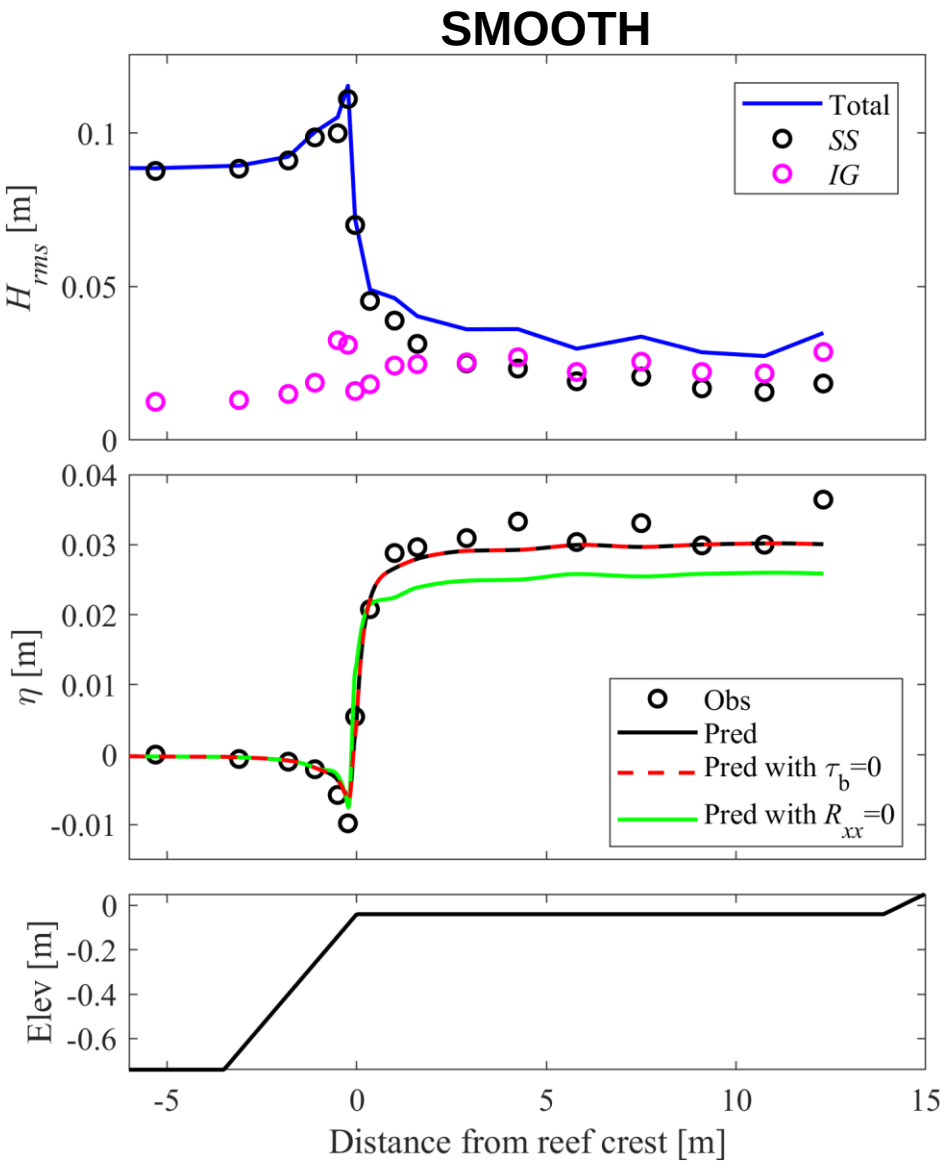
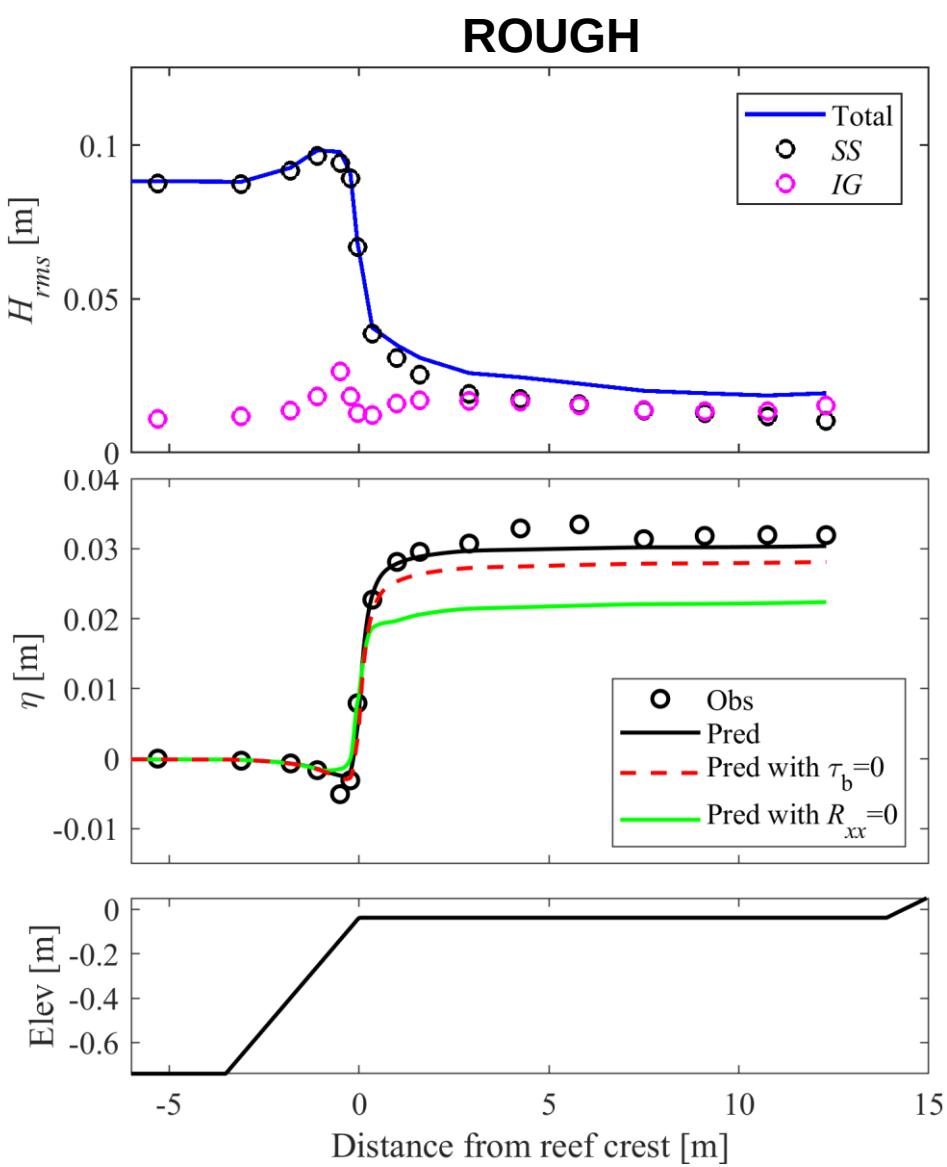


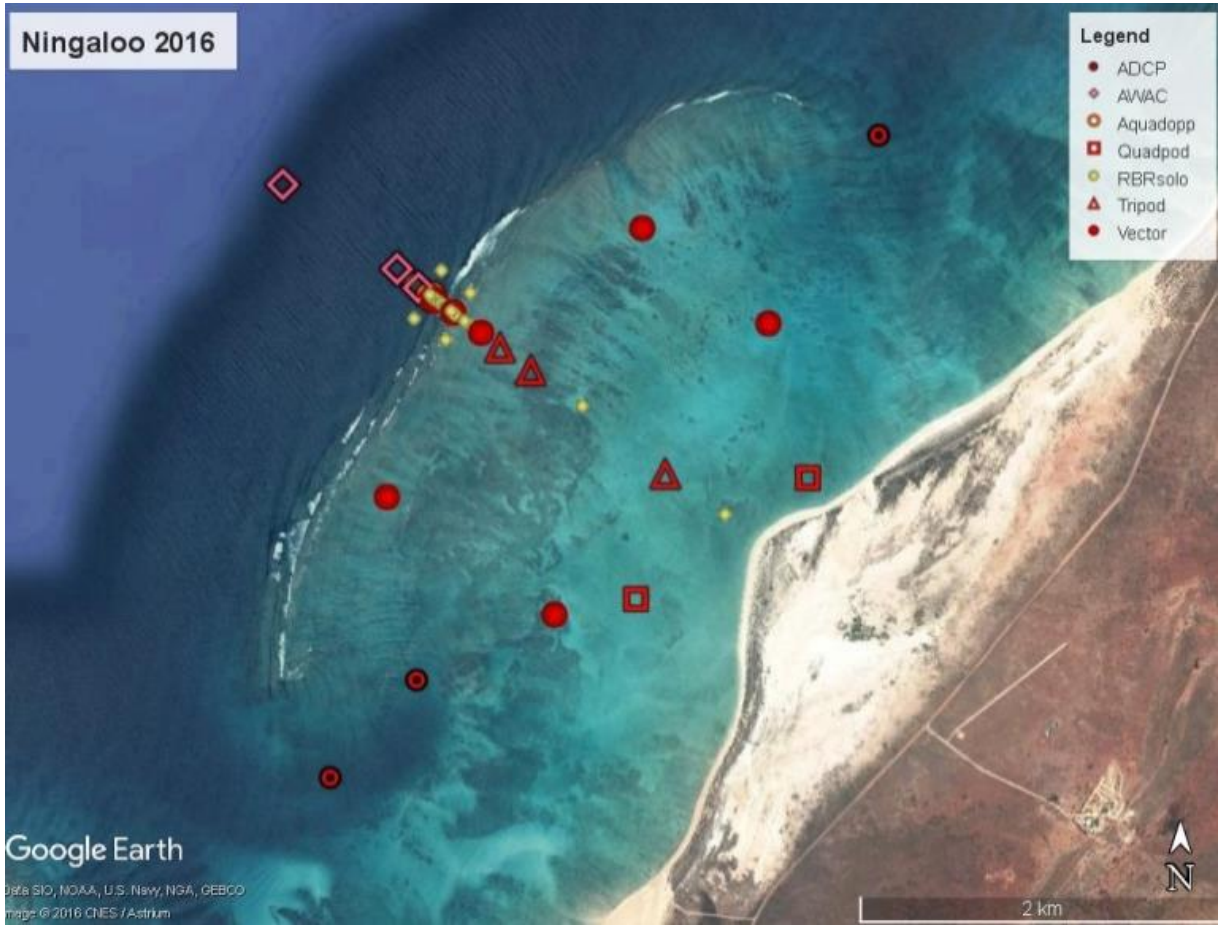


Ningaloo Reef, WA
(fringing reefs with open channels)

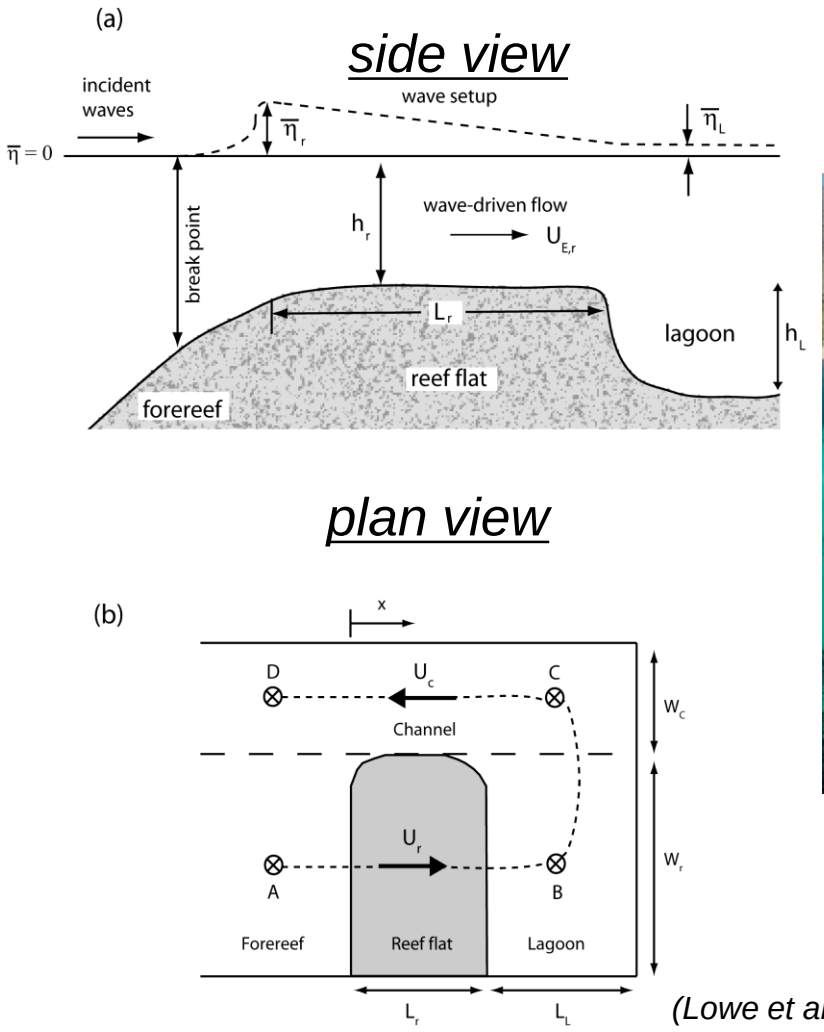
May to June 2016 deployment
Continuous sampling at 1-2 Hz
Processed in 1 hour bursts

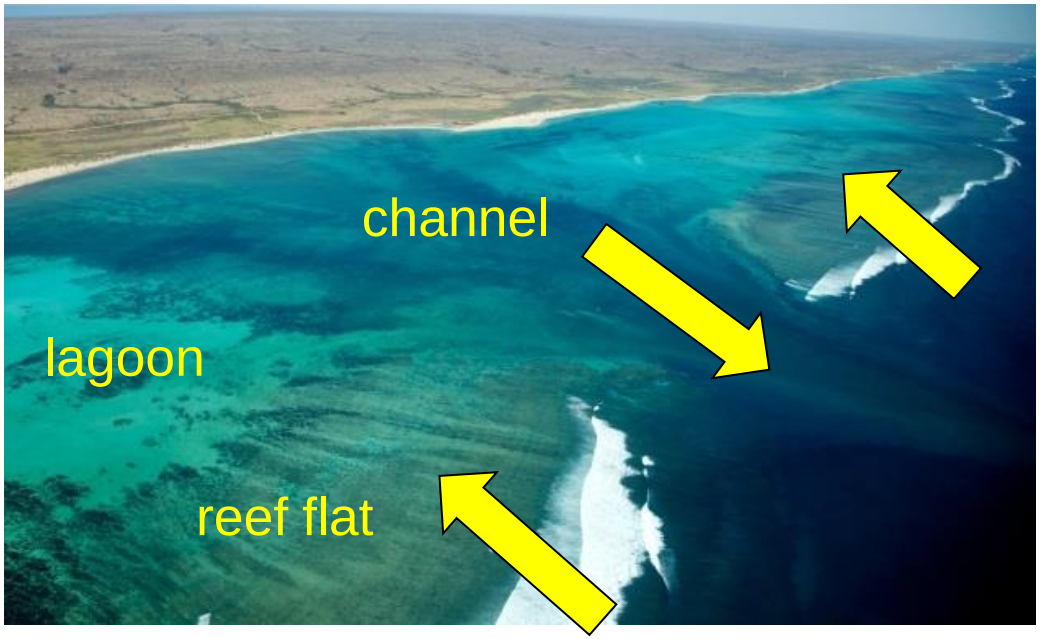
- 3 AWACs
- 9 ADCPs
- 12 Vectors
- 33 RBR pressure sensors

Collaboration with USGS



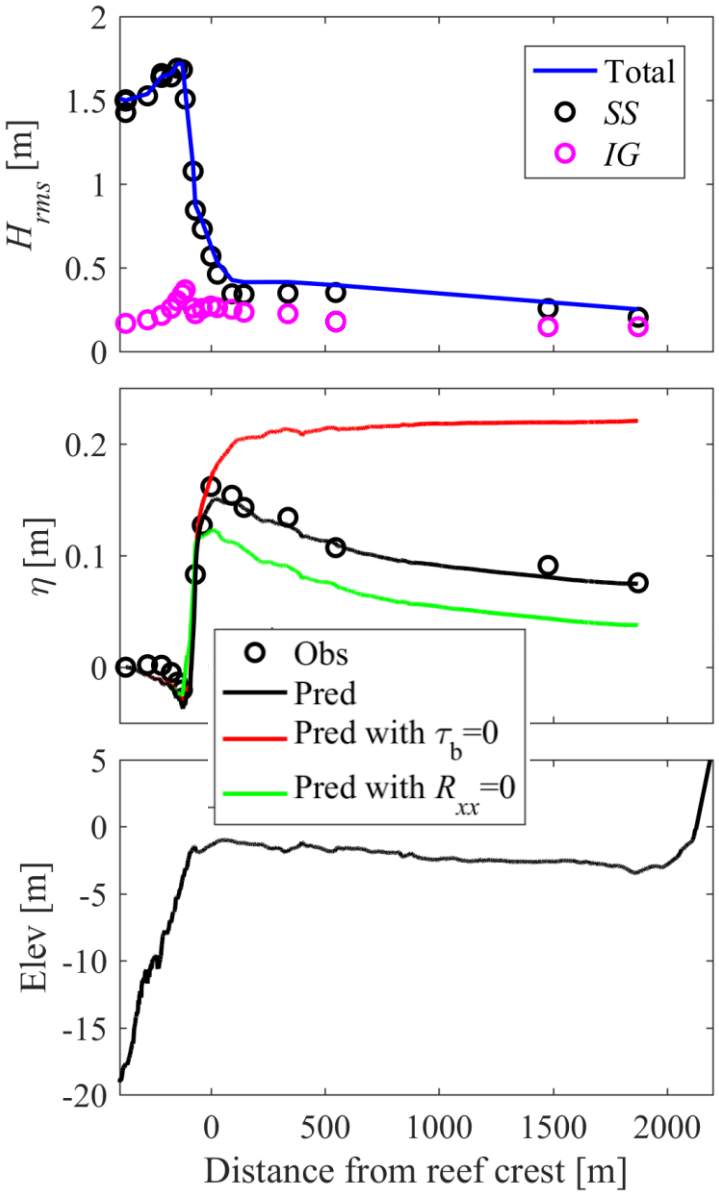
Wave-driven circulation on reefs (fringing reefs with open channels)





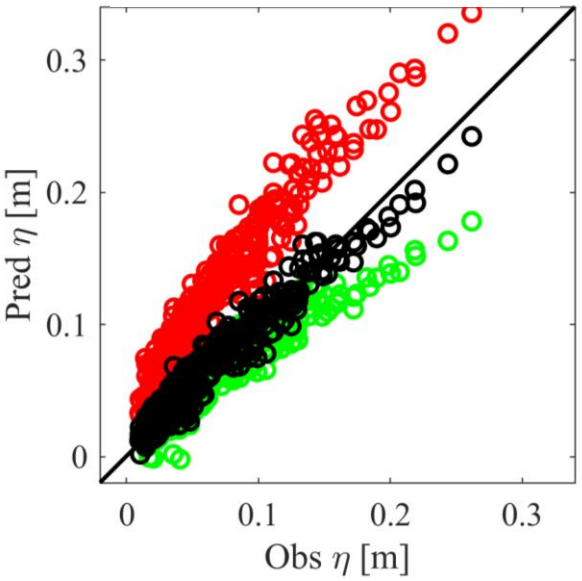
(Lowe et al. 2009)

Ningaloo Reef, WA
(fringing reefs with open channels)

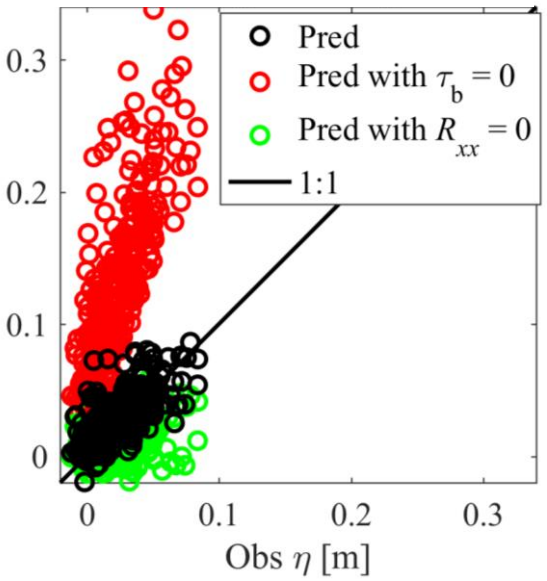


Wave setup

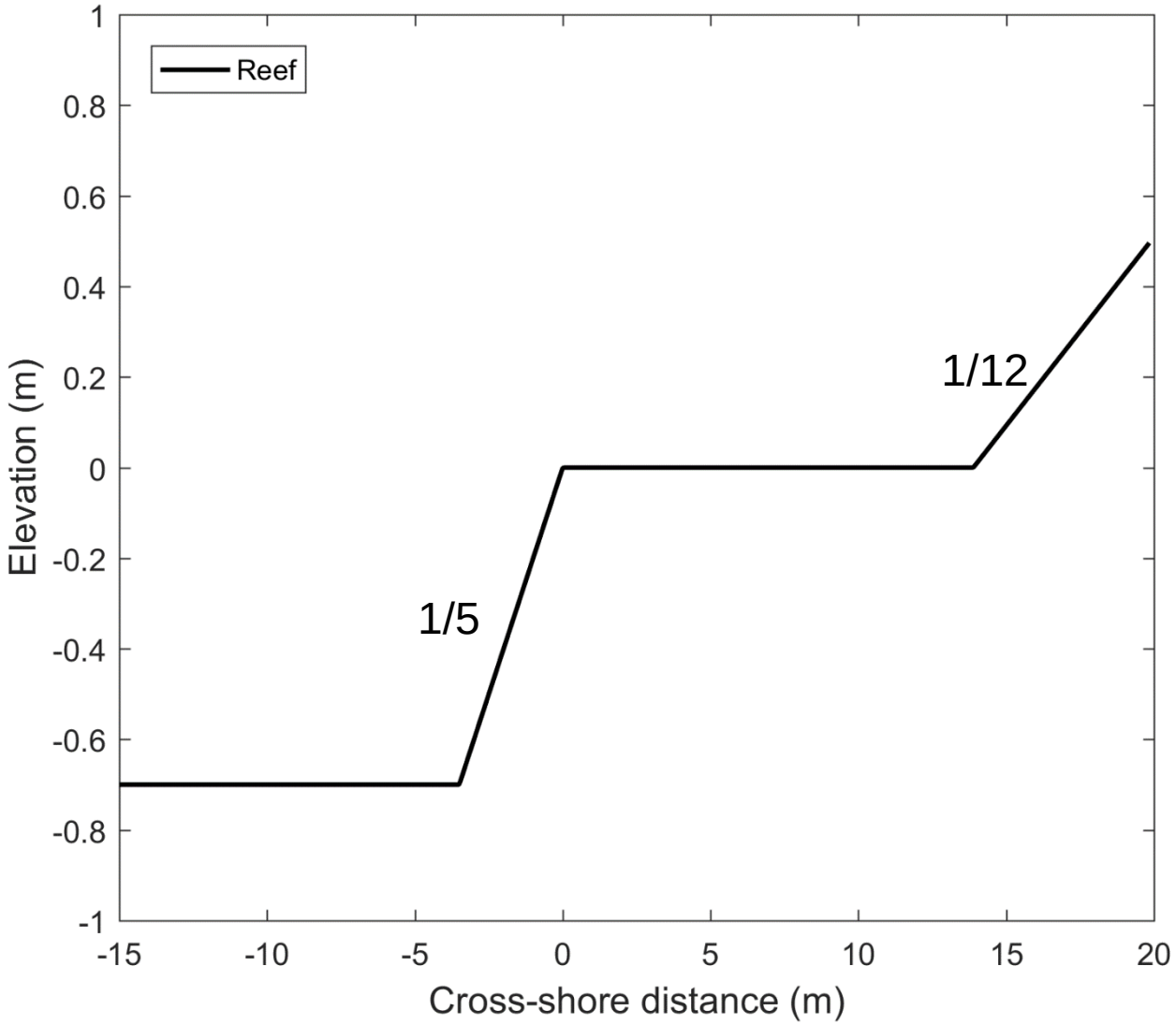
Reef crest (max) setup



Lagoon (x = 1800 m) setup



Runup on coral reefs vs plane beaches



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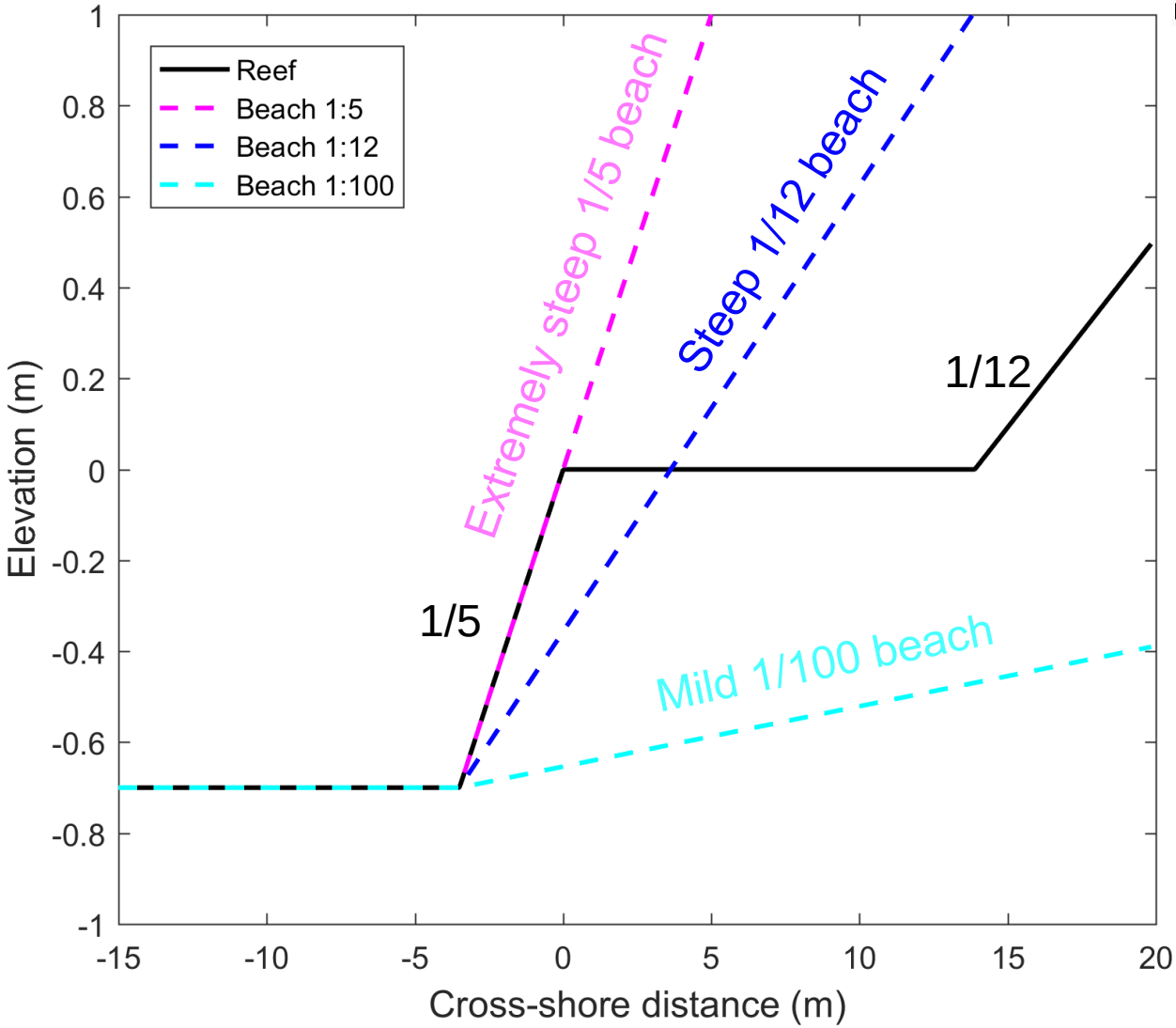
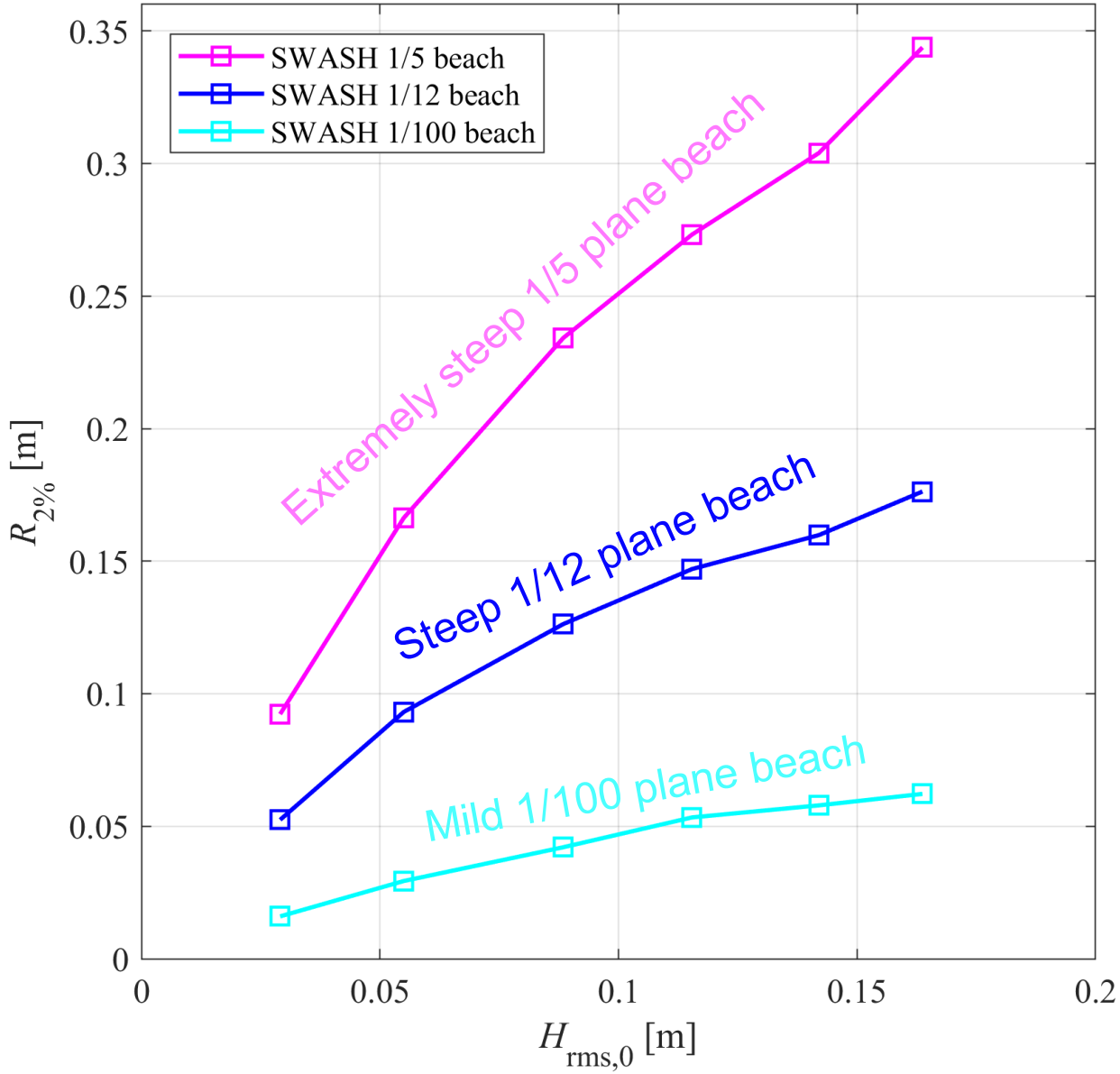


SWASH

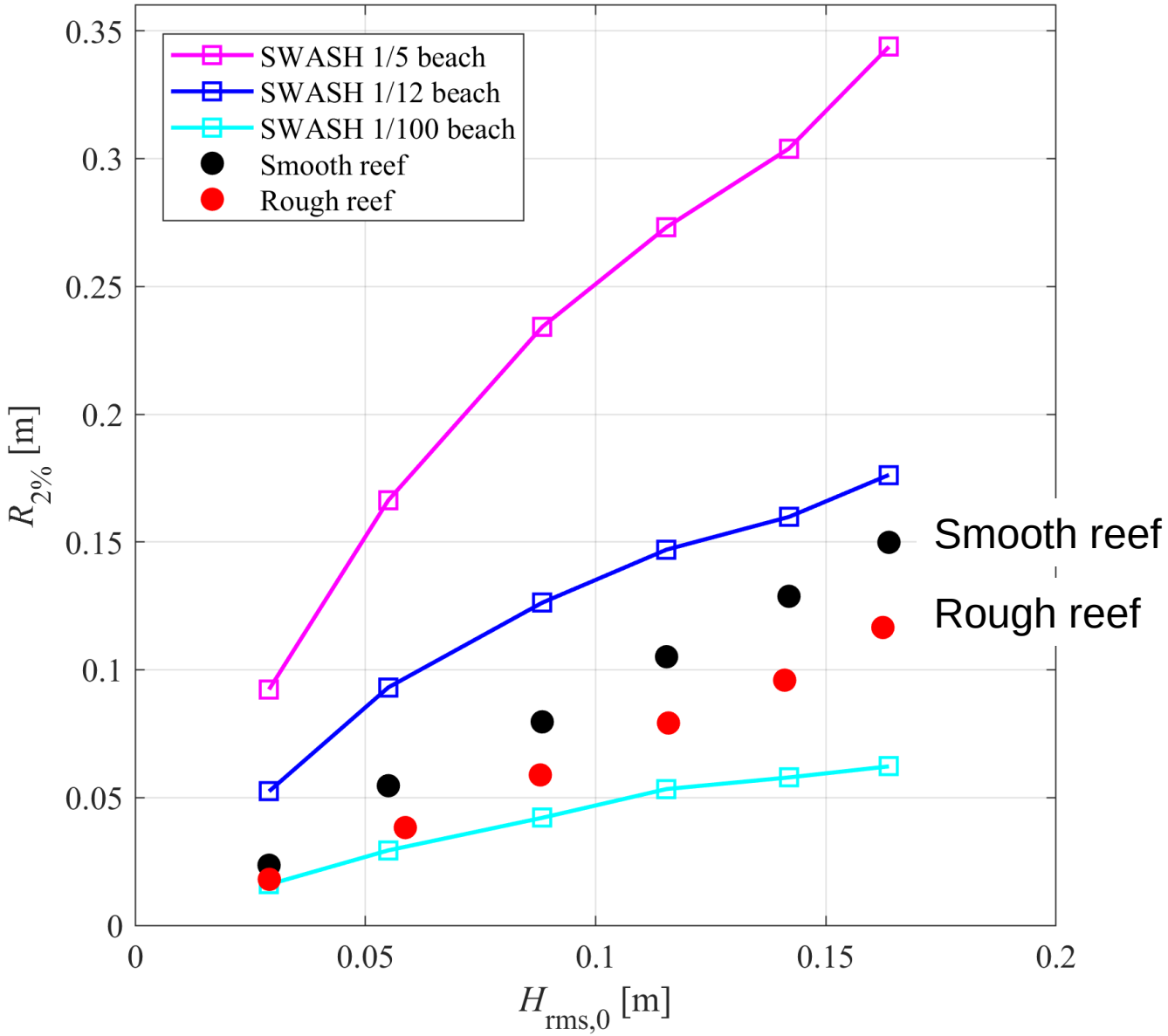
Simulating WAves till SHore

- Non-hydrostatic wave-flow model
- 5 cm grid
- 20 vertical layers
- forced with flume data for runs, only varying $H_{rms,0}$

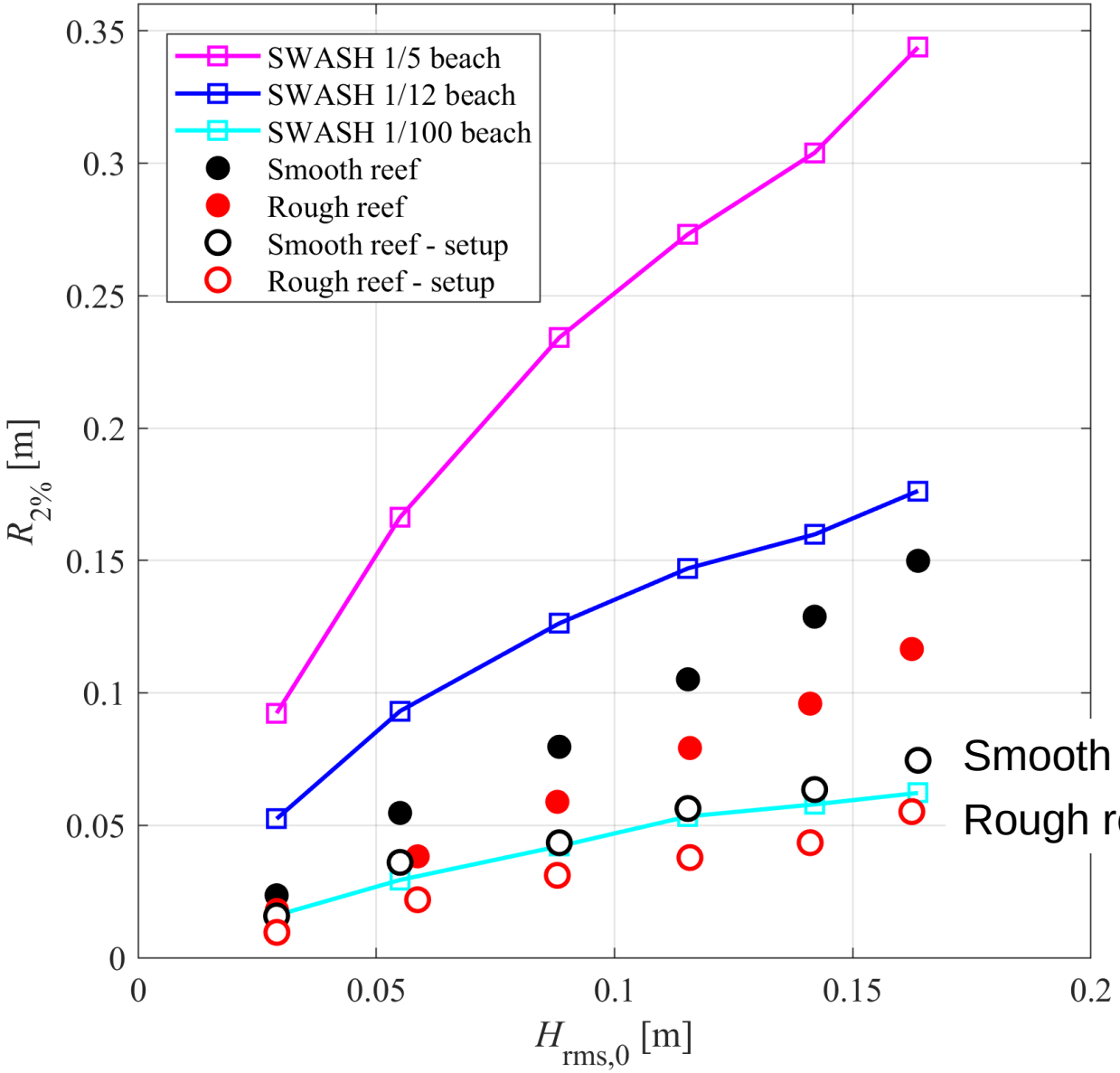
Runup on coral reefs vs plane beaches



Runup on coral reefs vs plane beaches



Runup on coral reefs vs plane beaches

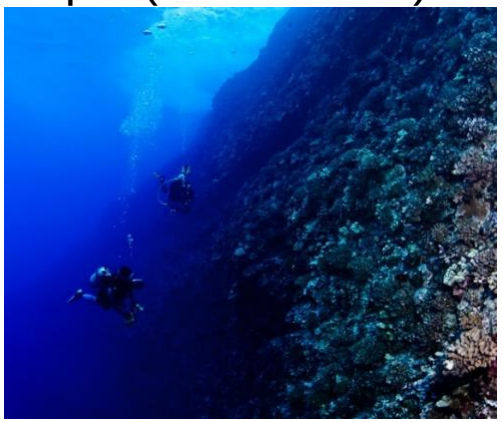


Smooth reef - setup

Rough reef - setup

Transitioning from coral to rocky reefs

Wave breaking on steep slopes(~1:20 to 1:1)

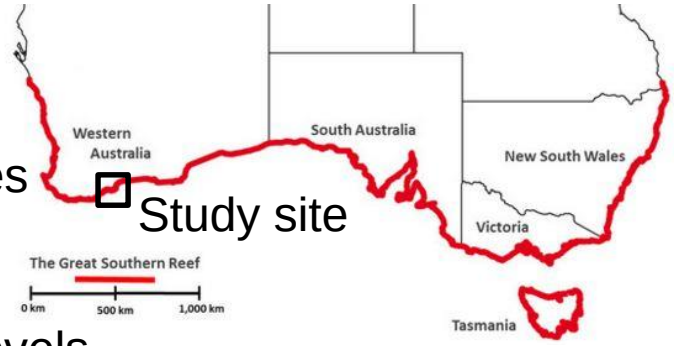


Complex morphology

Large bottom roughness

Rocky reef study site: Albany, WA

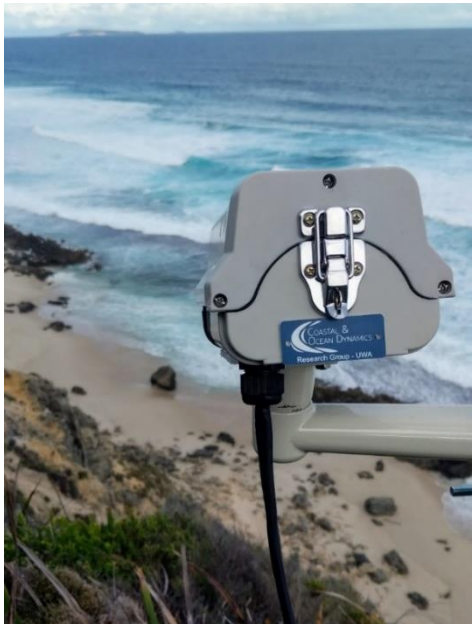
- Part of the Great Southern Reef system
- Small tidal range (~1 m)
- Large waves (mean ~2.5 m, storms >5 m)
- Water levels and currents vary at a range of time scales

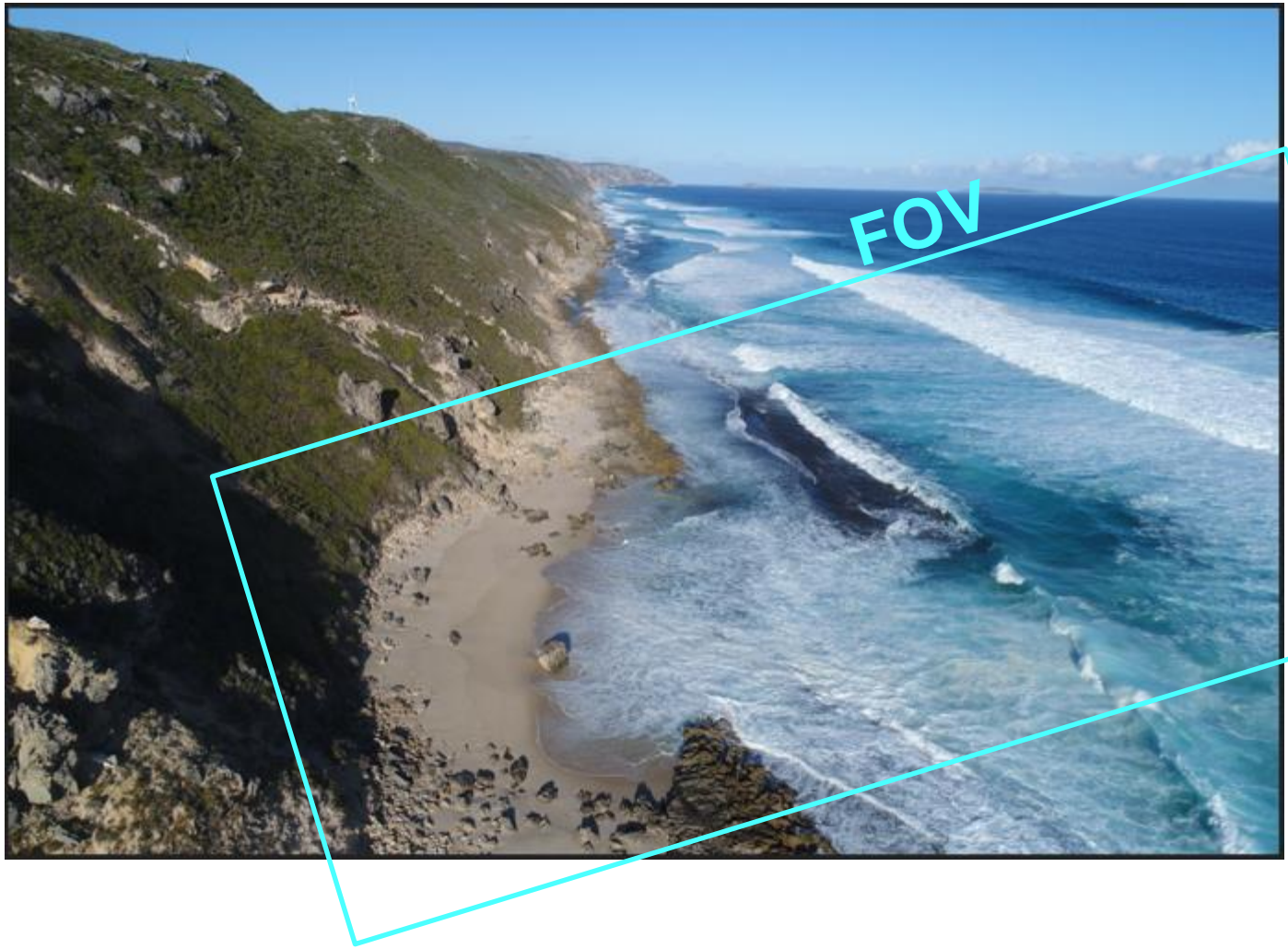


Research

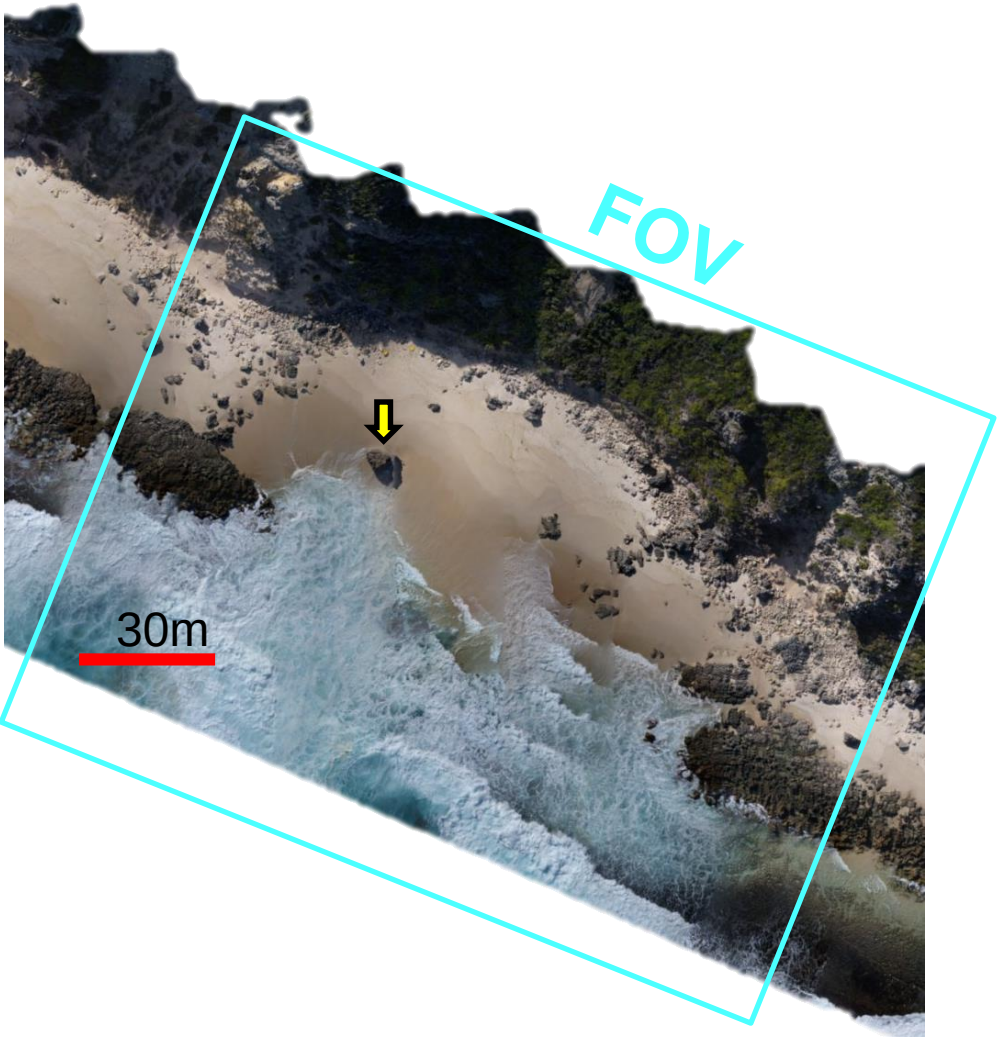
- COAWST: ROMS+SWAN for waves, currents, water levels
- Offshore wave buoys, nearshore sensors

Argus camera station





Argus camera station

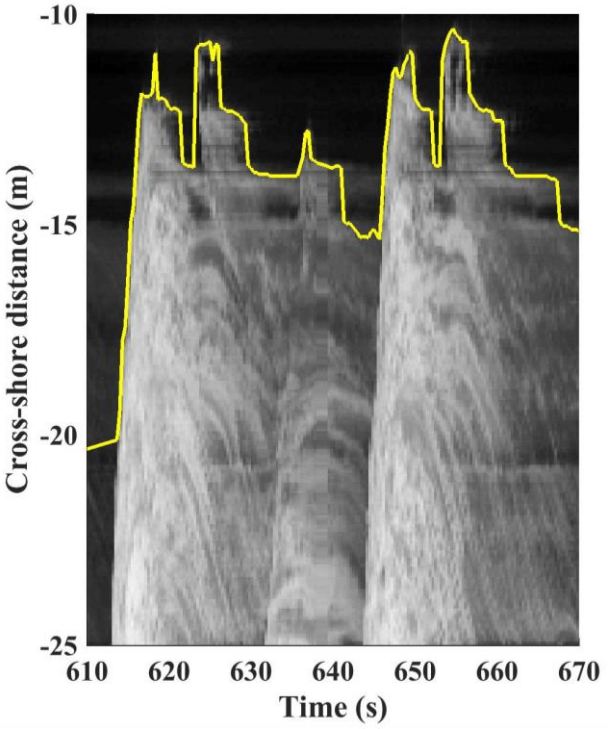


Summer

Winter

Argus camera station: automated runup measurements

Runup time series




Thank you!
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