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# TSUNAMI PROPAGATION AROUND OFFSHORE ISLANDS

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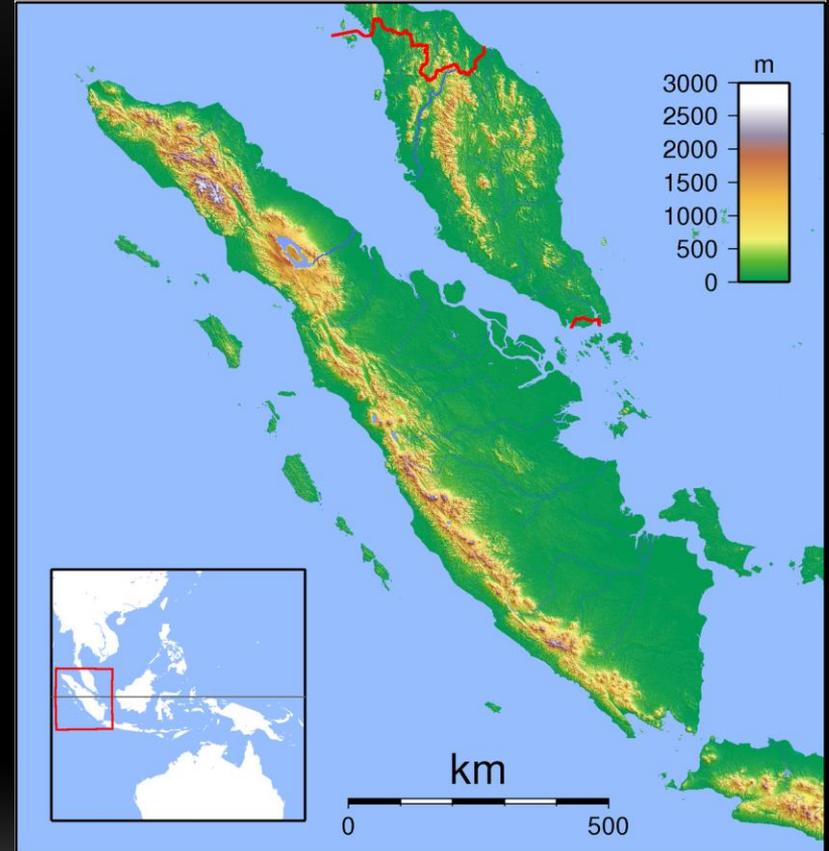


# OUTLINE

- 2010 Mentawai Tsunami
  - Stefankis et al. (2014)
  - Questions
  - Oregon State University Directional Wave Basin
  - Islands
  - Instruments
  - Wave conditions
  - Maximum runup
  - Very preliminary conclusions
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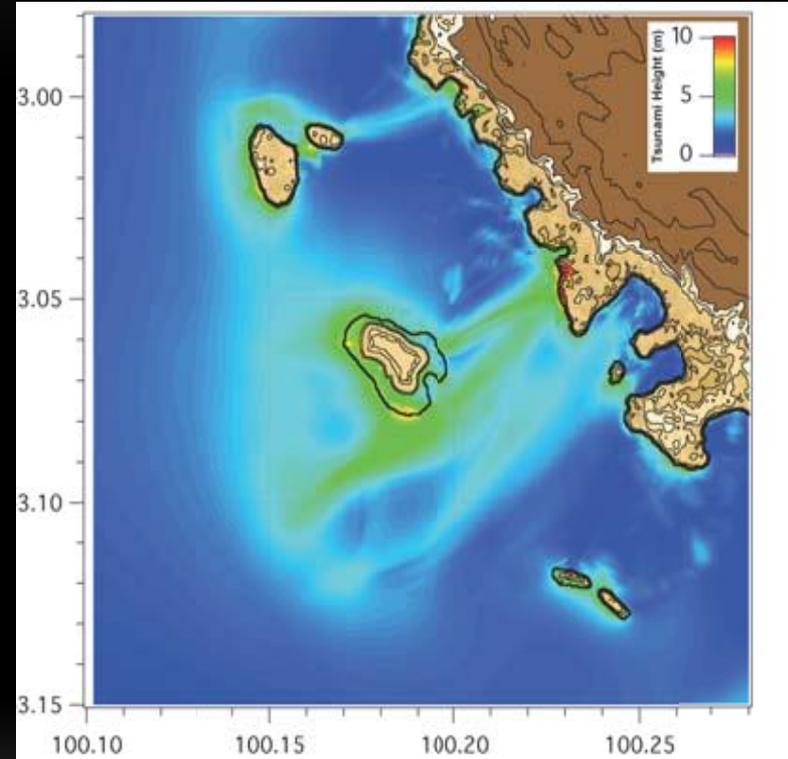
# 2010 MENTAWAI TSUNAMI

- October 25, 2010, 14:00 UTC
- 7.7 Moment magnitude (~7.0 Richter Scale)
- Part of same fault system as 2004 event
- 408 killed, 303 missing



# 2010 MENTAWAI TSUNAMI

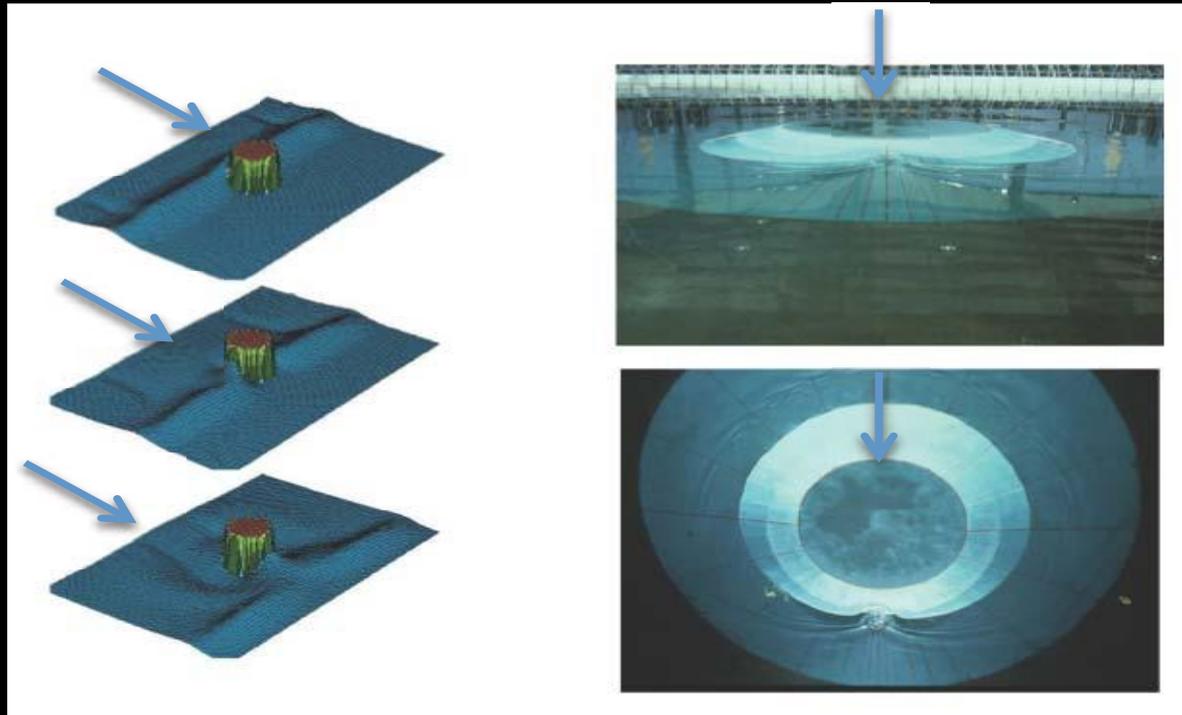
- Post-tsunami survey on Mentawai Islands
  - Evidence of higher inundation behind islands than elsewhere
- Local folklore: islands and reefs provide sheltering from tsunamis
  - Villages often located directly behind islands
- Prior work focused on inundation on lee side of island, not on beach



Long wave model result, courtesy of  
Dr. Jose Borrero

# 2010 MENTAWAI TSUNAMI

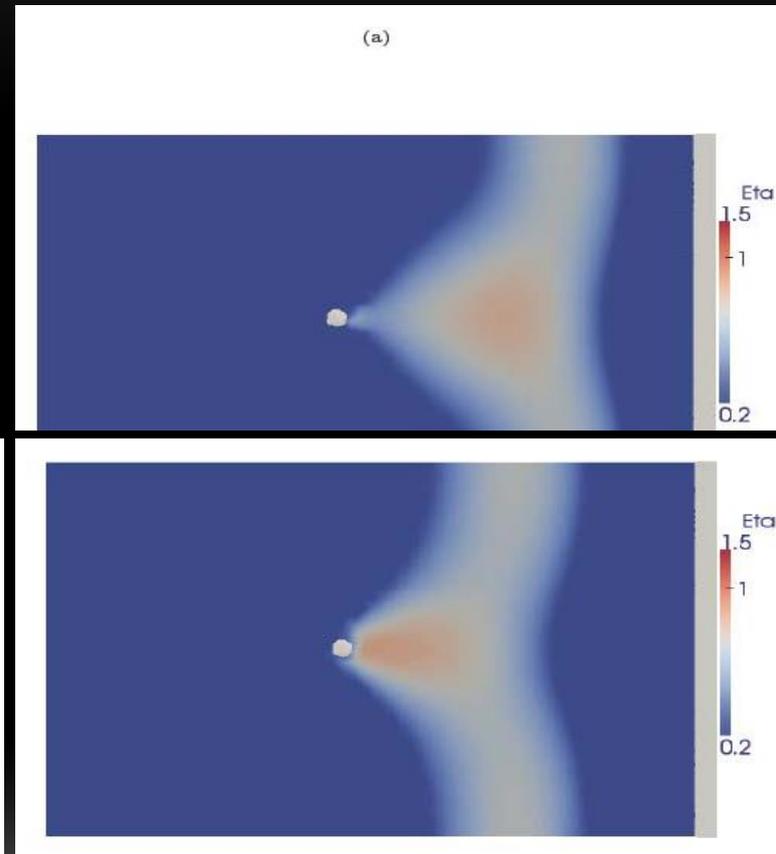
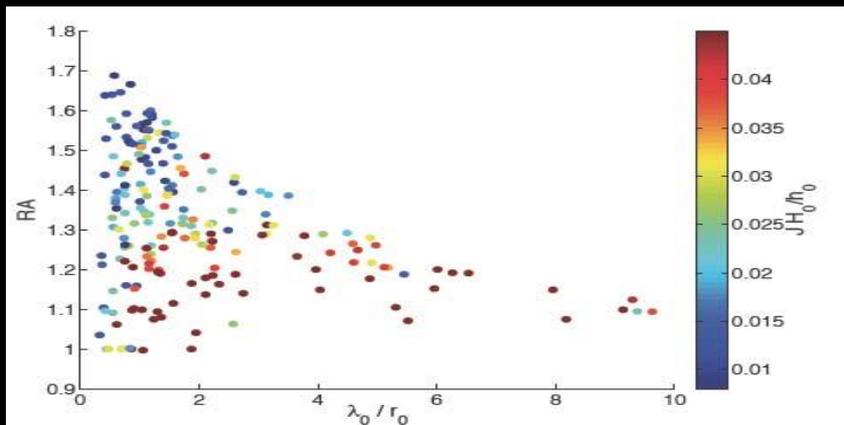
Prior work: more focus on lee side of island



Titov and Synolakis (1995): Briggs et al. (1995)

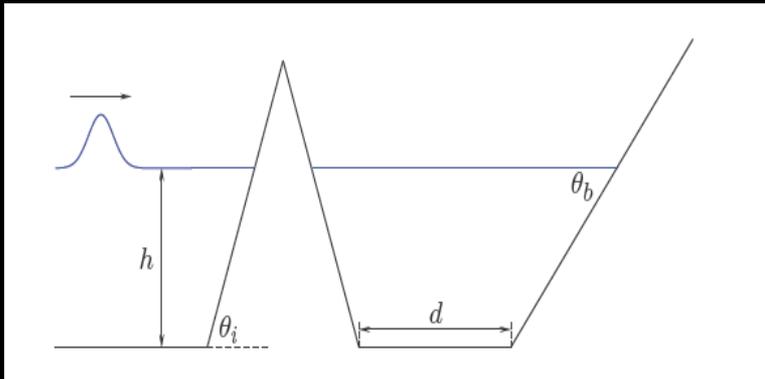
# STEFANAKIS ET AL. (2014)

- Determined maximum runup possible on shoreline behind conical island over range of tsunami conditions
- Used “emulators” in machine learning approach
- Determined that runup was generally amplified on shoreline behind islands



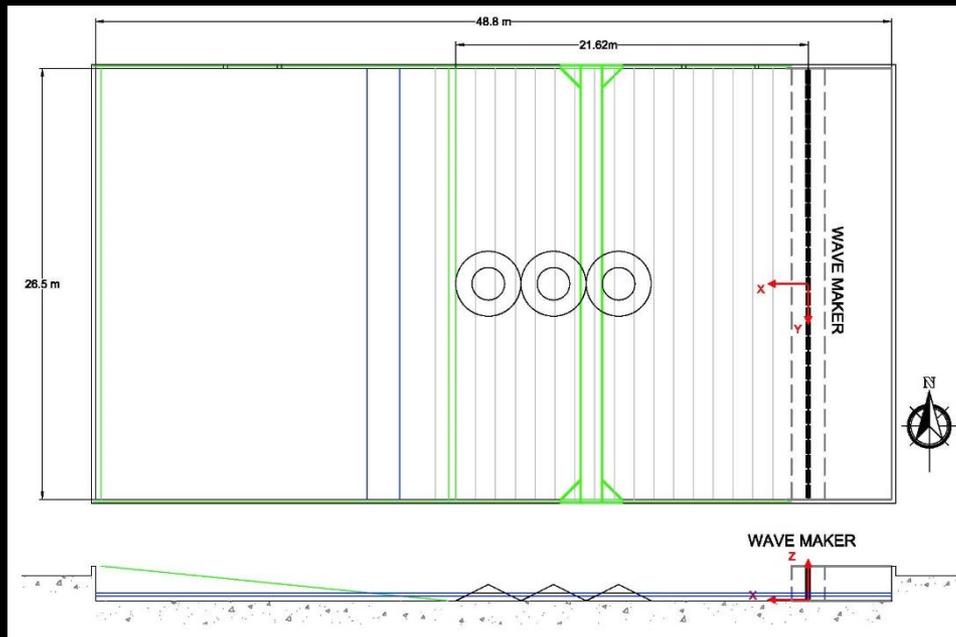
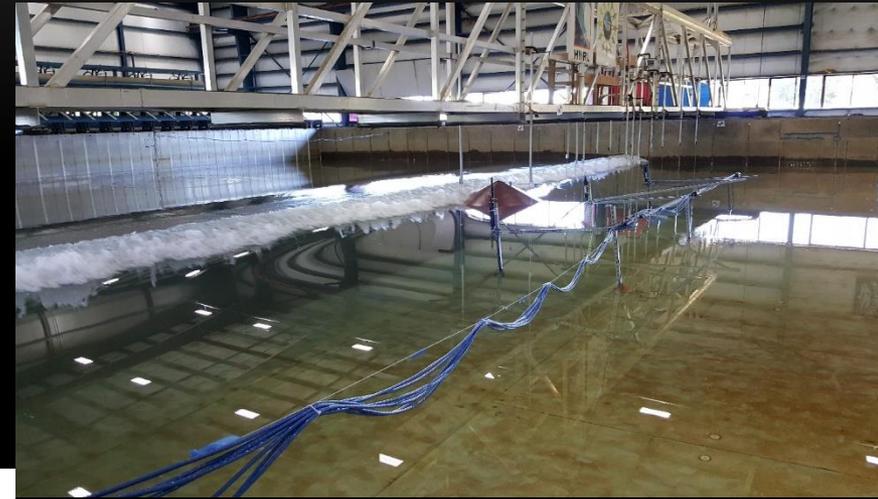
# QUESTIONS

- Can the presence of offshore islands actually *increase* inundation on shoreline behind them?
- What is the dependence of inundation on island distance and configuration?



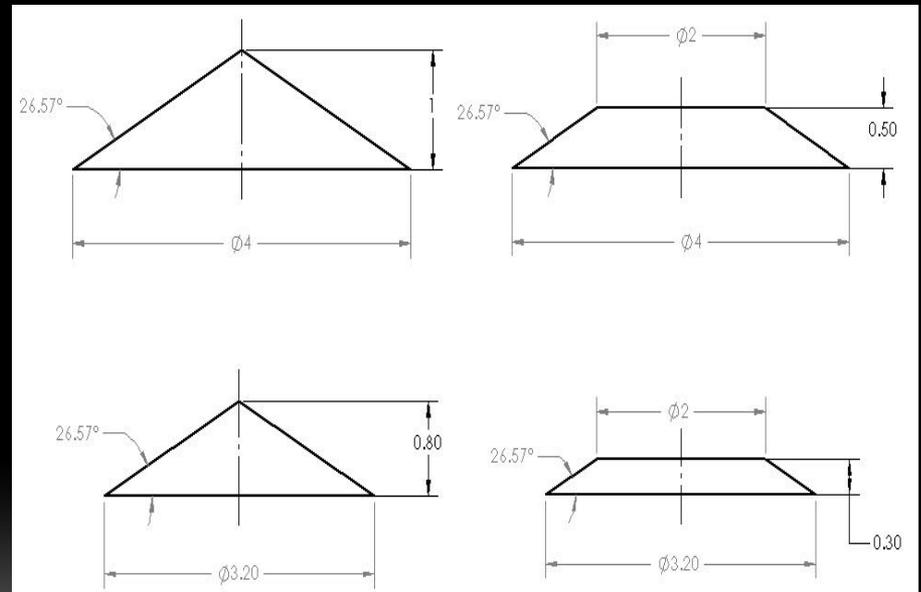
# OREGON STATE DIRECTIONAL WAVE BASIN

- 48.8 m long
- 26.5 m wide
- 2.1 m deep
- 1/10 steel beach



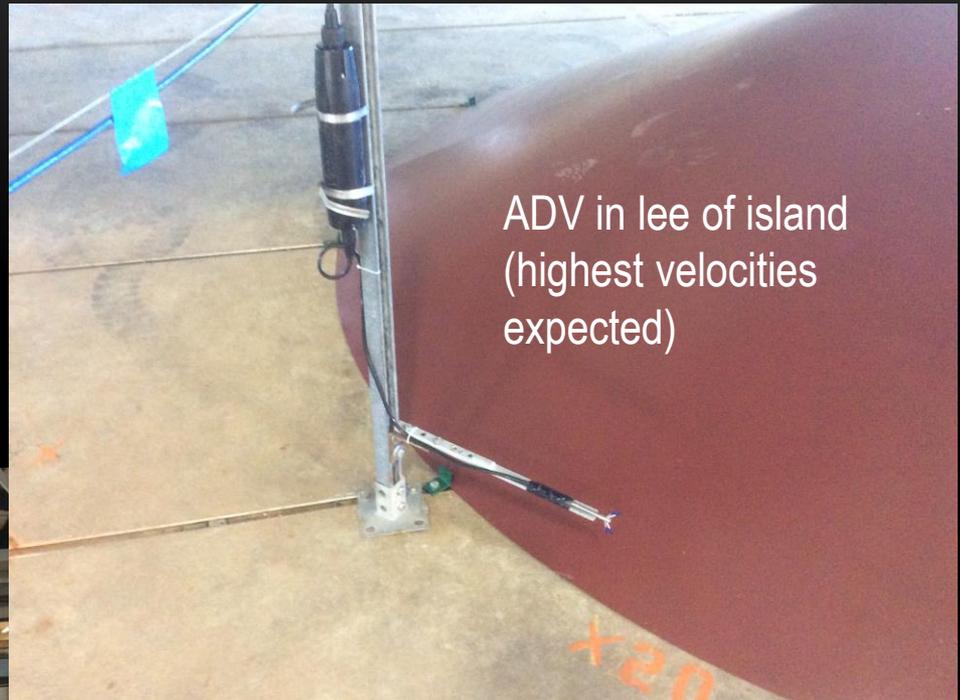
# ISLANDS

- Fabricated from sheet metal
- Full conical shape (e.g. Stefanakis et al. (2014)) and truncated at waterline (reef-like structure)
- Two water depths: 0.5m and 0.3m
- Islands to be 2m diameter at waterline
- Positioned zero, one, and two diameters from toe of slope

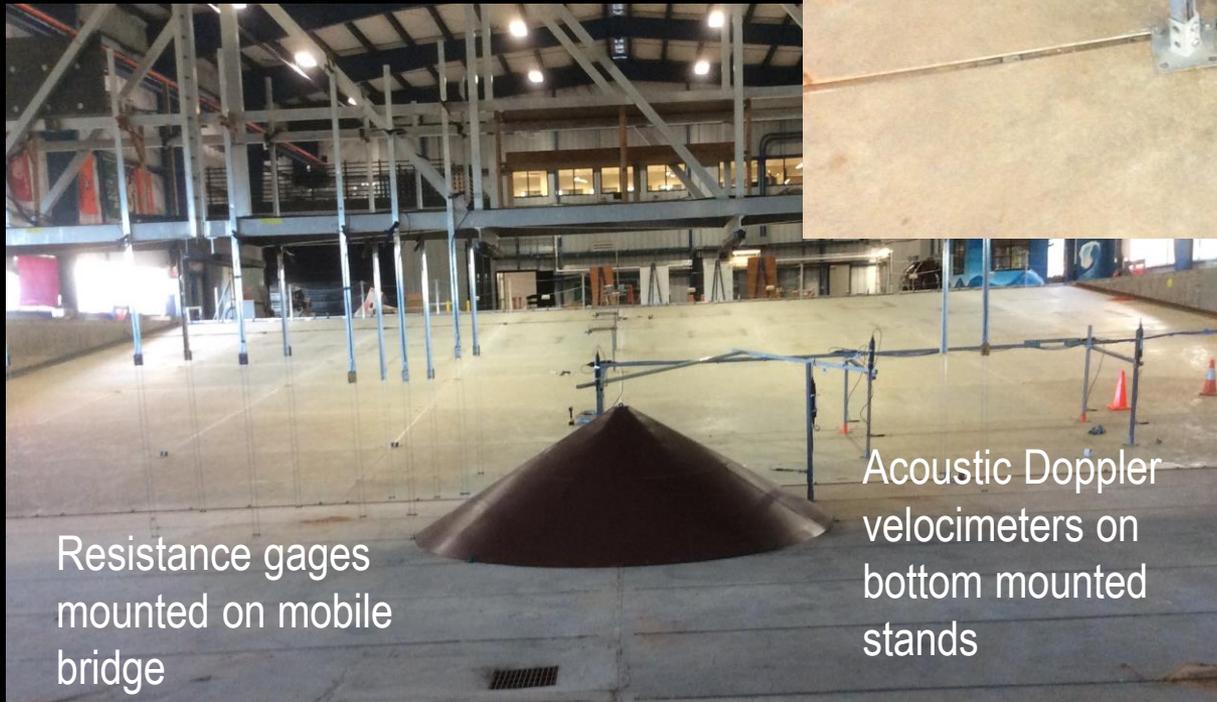


# INSTRUMENTS

## Wave and Current Measurements



ADV in lee of island  
(highest velocities  
expected)

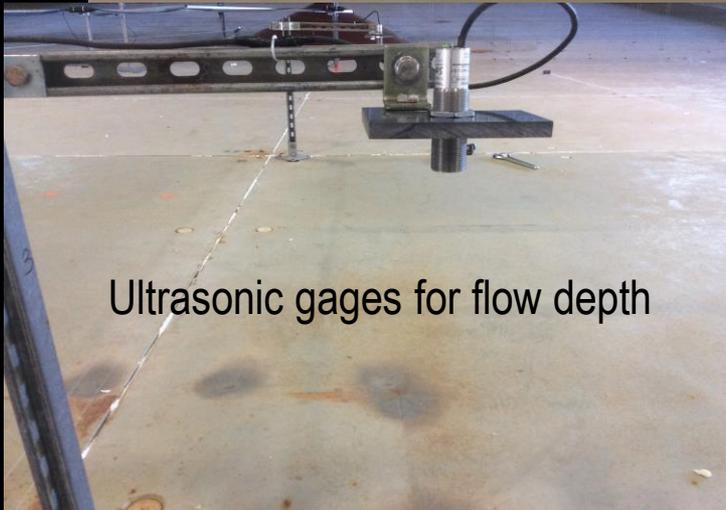


Resistance gages  
mounted on mobile  
bridge

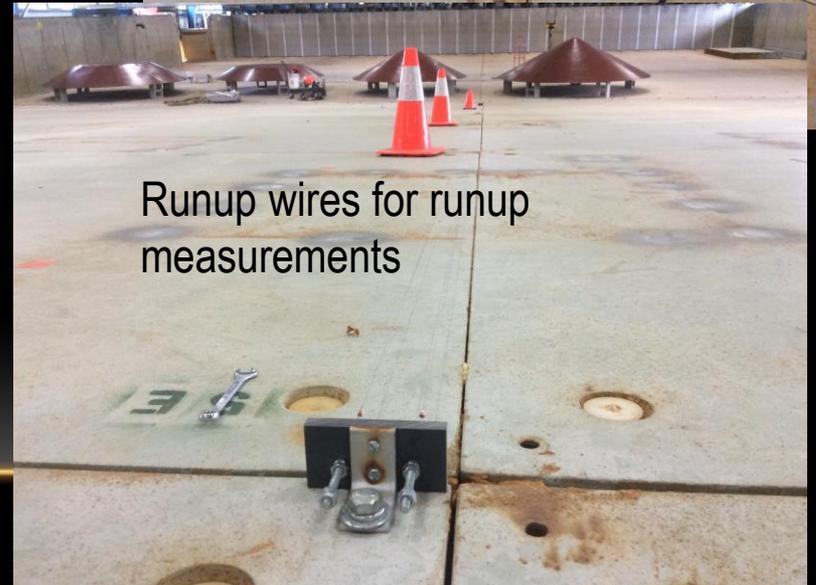
Acoustic Doppler  
velocimeters on  
bottom mounted  
stands

# INSTRUMENTS

## Runup and Flow Depth Measurements



Ultrasonic gages for flow depth



Runup wires for runup measurements

Video measurements of runup also collected

# WAVE CONDITIONS

h (m)	Wavelength (m)	l (m)	Amplitude (m)
0.5	3	1.5	0.25
	4	2	0.14
	5	2.5	0.09
	6	3	0.06

Stroke Time (s)
5
8
10
12

- Solitary waves: allow for scaling between island geometry and wave characteristics
- Dam break waves: maximize runup

- Island-radius to wavelength ratios from 1.5 to 6
- Full stroke “error function” waves to create dam break

h (m)
0.3

Wavelength (m)	l (m)	Amplitude (m)
1.5	0.75	0.22
2	1	0.12
3	1.5	0.05
4	2	0.03

Stroke Time (s)
5
8
10
12

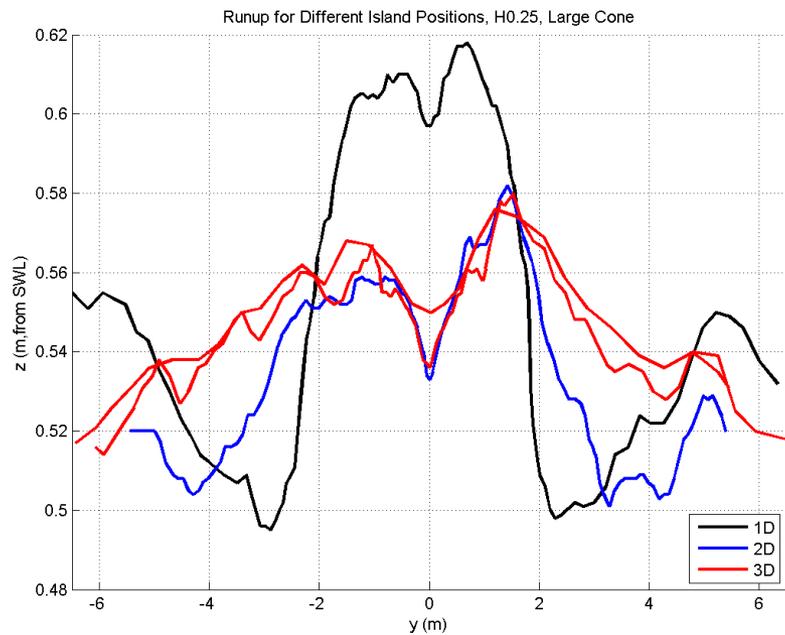
# SOLITARY WAVE



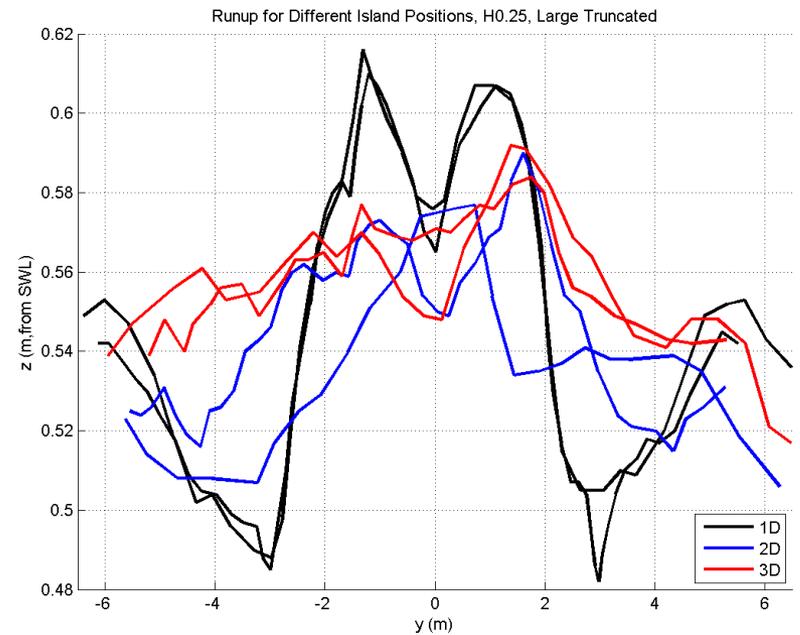
# “FULL STROKE” WAVE



# MAXIMUM RUNUP: SOLITARY WAVE $H=0.25\text{M}$ DEPTH= $0.5\text{M}$

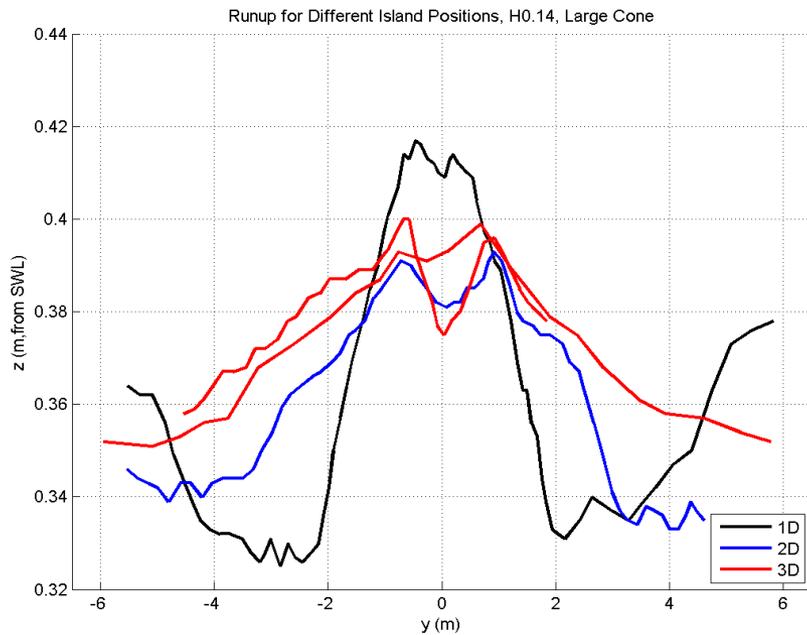


Conical Island

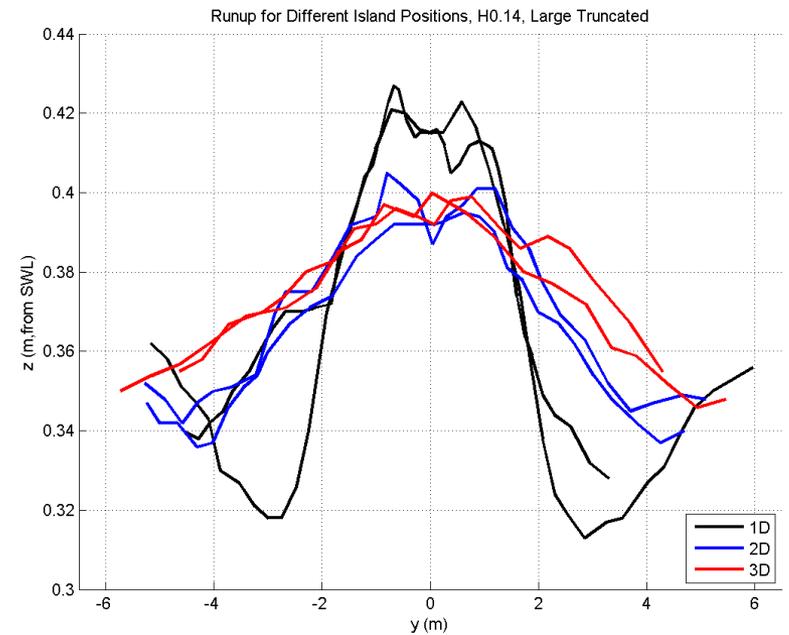


Truncated Island

# MAXIMUM RUNUP: SOLITARY WAVE $H=0.14\text{M}$ DEPTH= $0.5\text{M}$

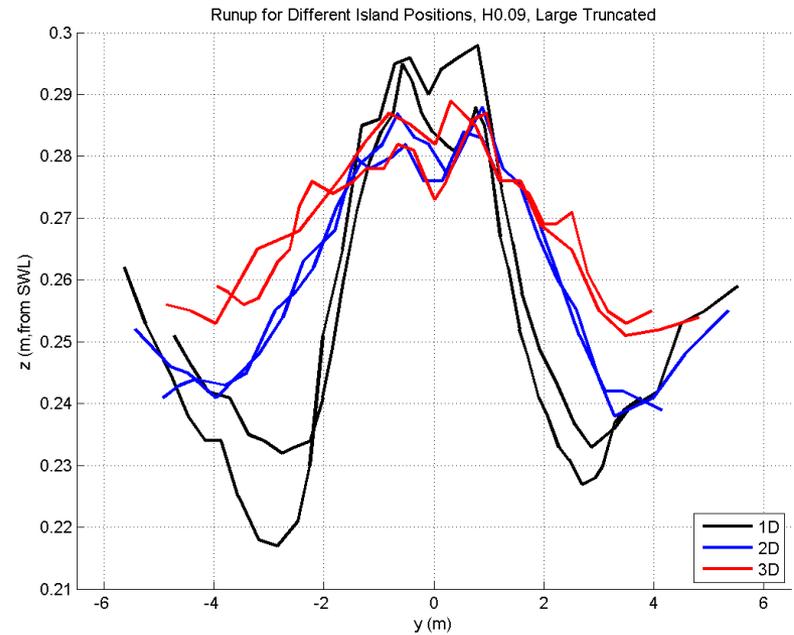
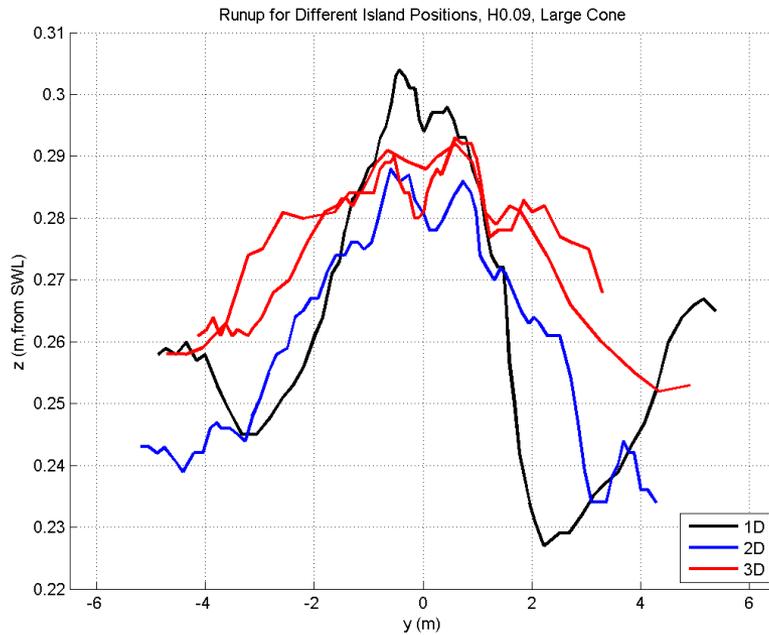


Conical Island



Truncated Island

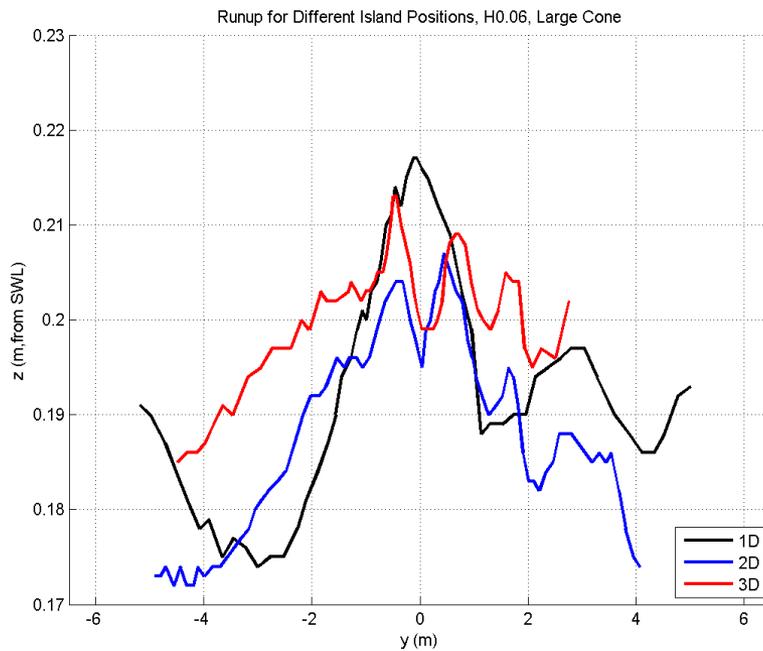
# MAXIMUM RUNUP: SOLITARY WAVE H=0.09M DEPTH=0.5M



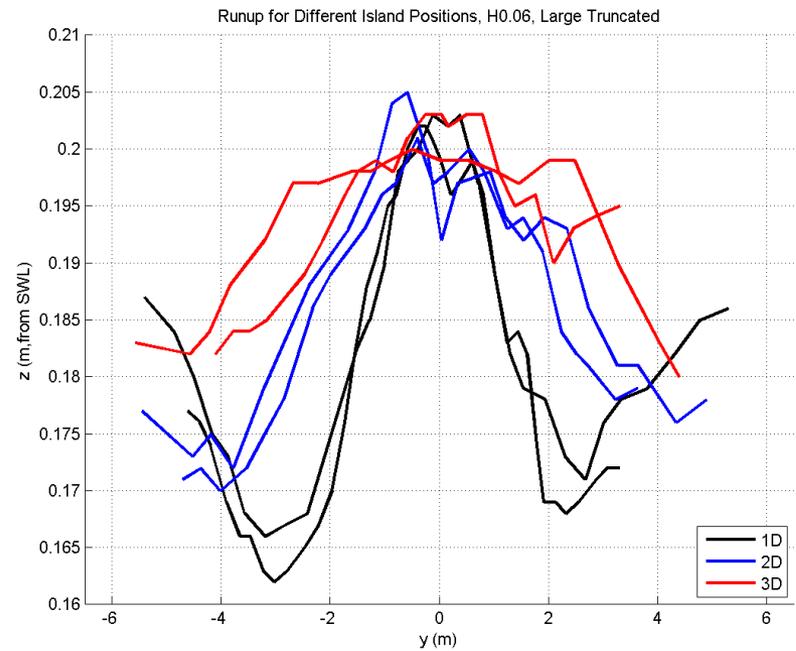
Conical Island

Truncated Island

# MAXIMUM RUNUP: SOLITARY WAVE $H=0.06\text{M}$ DEPTH= $0.5\text{M}$

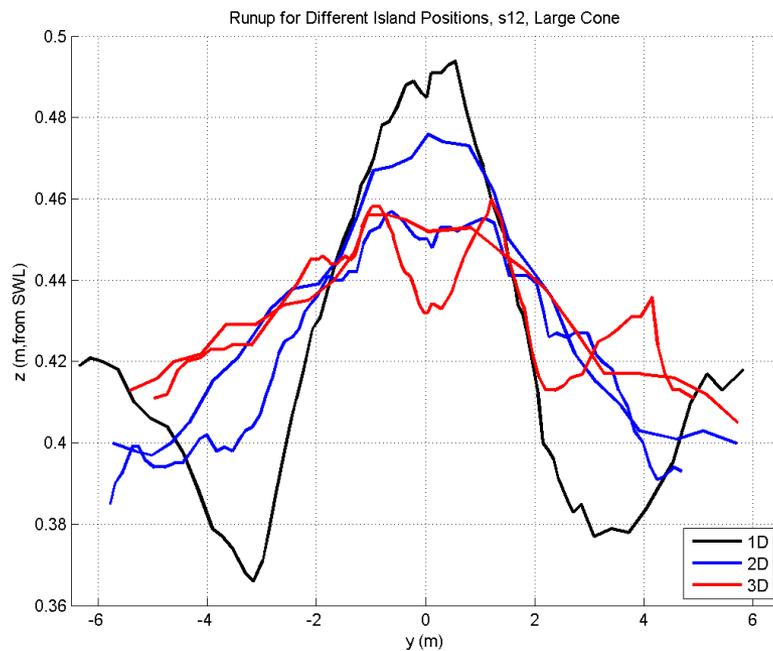


Conical Island

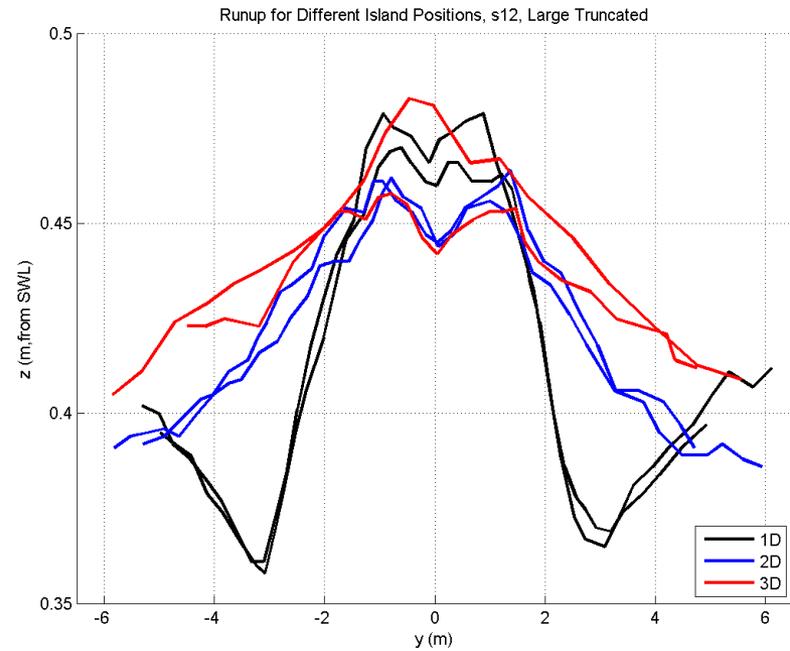


Truncated Island

# MAXIMUM RUNUP: 12 SEC FULL STROKE WAVE DEPTH=0.5M

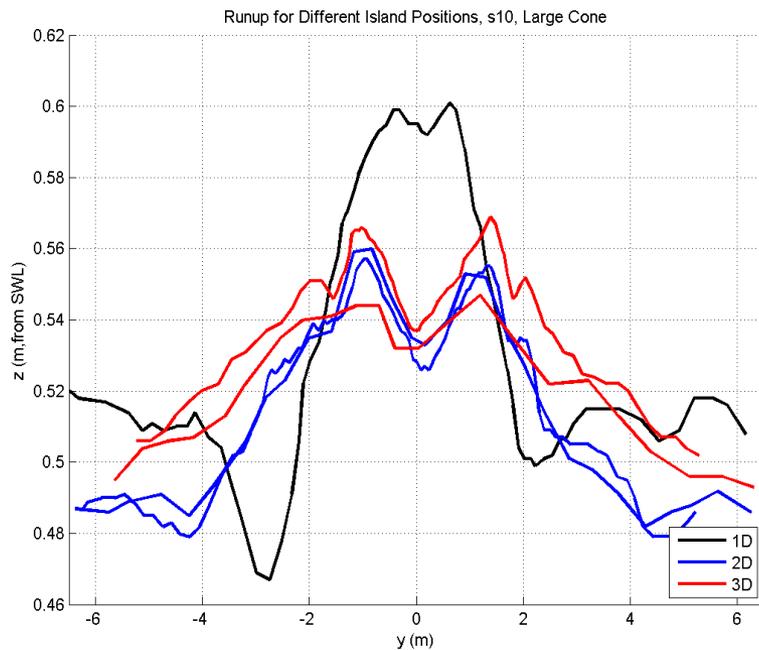


Conical Island

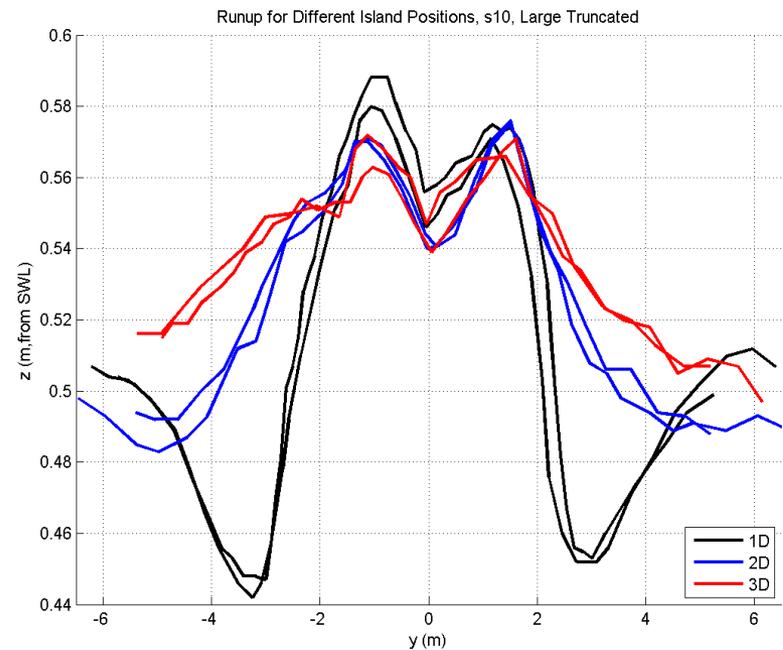


Truncated Island

# MAXIMUM RUNUP: 10 SEC FULL STROKE WAVE DEPTH=0.5M

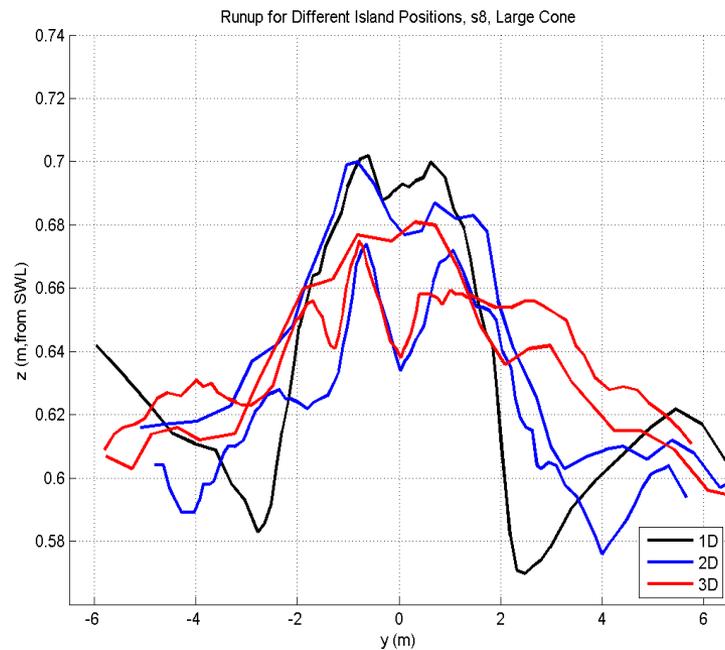


Conical Island

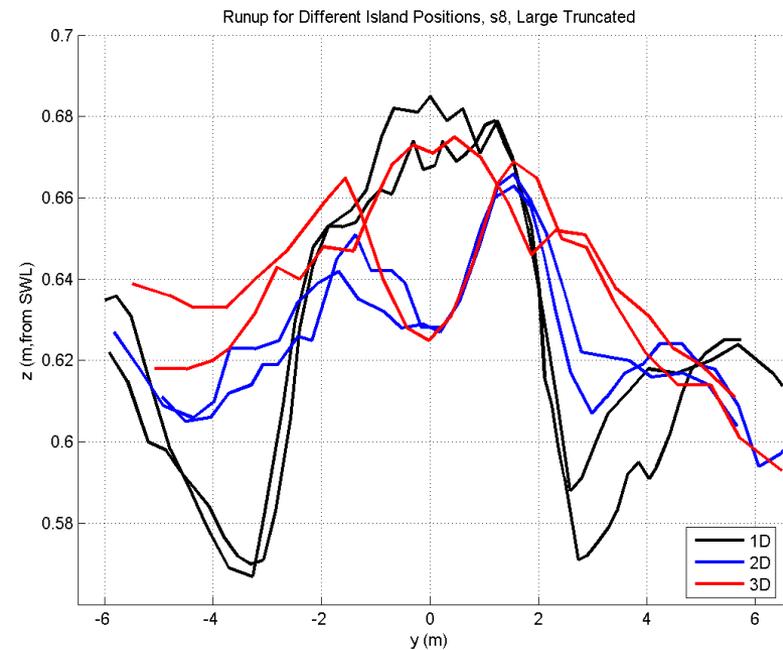


Truncated Island

# MAXIMUM RUNUP: 8 SEC FULL STROKE WAVE DEPTH=0.5M

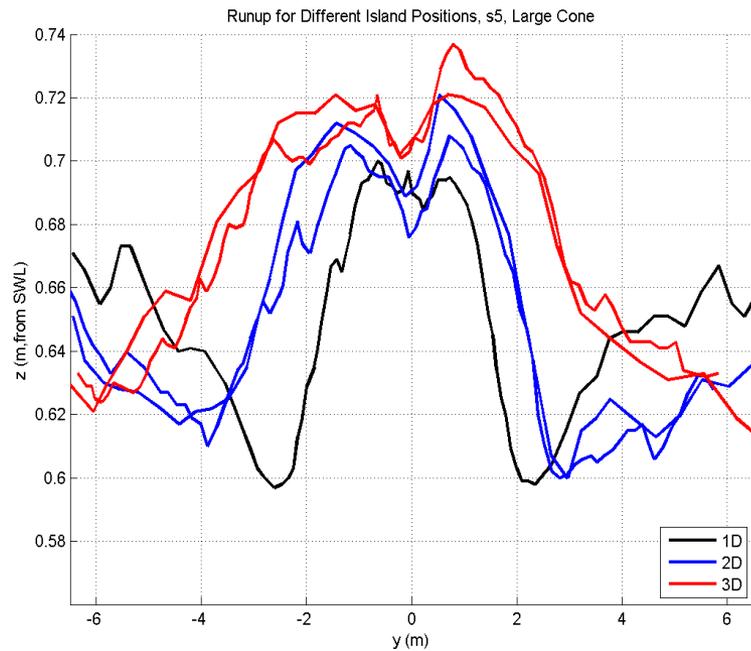


Conical Island

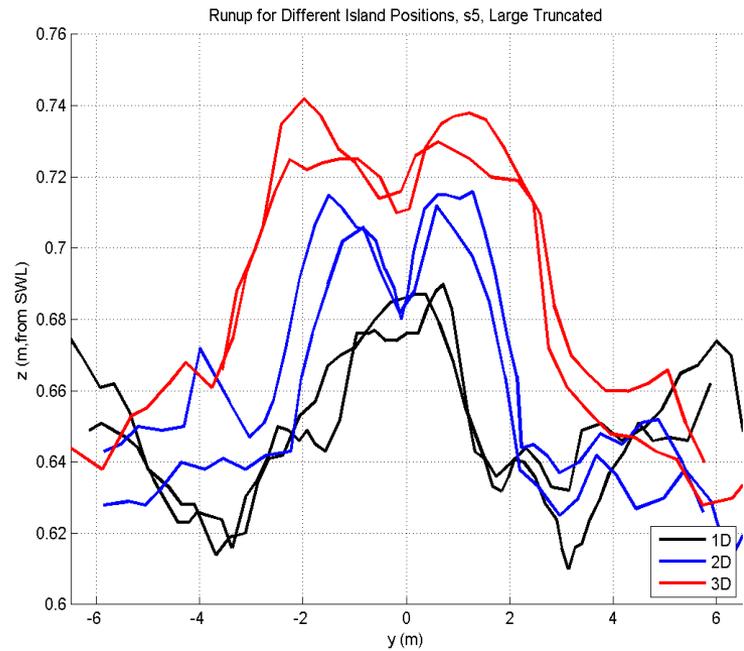


Truncated Island

# MAXIMUM RUNUP: 5 SEC FULL STROKE WAVE DEPTH=0.5M



Conical Island



Truncated Island

# VERY PRELIMINARY CONCLUSIONS

- Experiments on tsunami propagation past offshore islands were run to investigate effect on runup
  - Both solitary waves and full stroke “dam break” waves were used
  - Both full conical and truncated islands were used
  - Islands were placed at variable distances from toe of beach
-

# VERY PRELIMINARY CONCLUSIONS

- Solitary waves
    - Nearest island position: highest runup with highest wave
    - Less island position dependence for lower waves
    - Trends similar between full and truncated islands
  - Dam break waves
    - Slow paddle speed gives higher runup for nearest island position
    - Fast paddle speed gives higher runup for furthest island position
    - Little runup differences among truncated island positions, except for fastest paddle speed.
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THANKS!

