Coastal and Tsunami Research within RNC at the University of Auckland

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

ENGINEERING

RESILIENCE TO NATURE'S CHALLENGES
Kia manawaroa – Ngā Ākina o Te Ao Tūroa

National SCIENCE Challenges

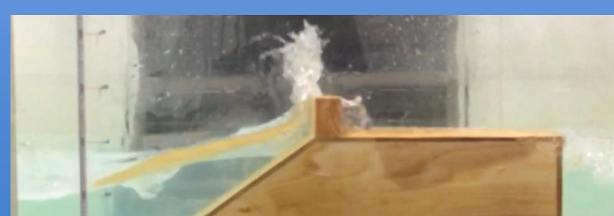
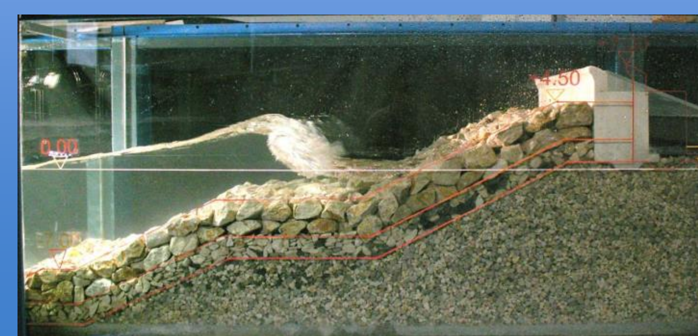
THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

ENGINEERING

Outline

- Adaptation of coastal structures
- Tsunami impacts on horizontal infrastructure
- Tsunami impacts on vertical infrastructure
- Aligned work
    - Tsunami impacts on composite breakwaters and bridges
    - Tsunami generation by volcanic eruptions
    - Tsunami inundation and evacuation
    - Beach/seawall interactions under rising sea levels

Adaptation of coastal structures

Stage	A. Overtopping	B. Structure stability
1. Structure degradation and what happens with no intervention – when is a trigger point reached ***'what is happening now?'***		
2. What are the adaptation options - Repair/retrofit/upgrade? ***'what can we do about it?'***		

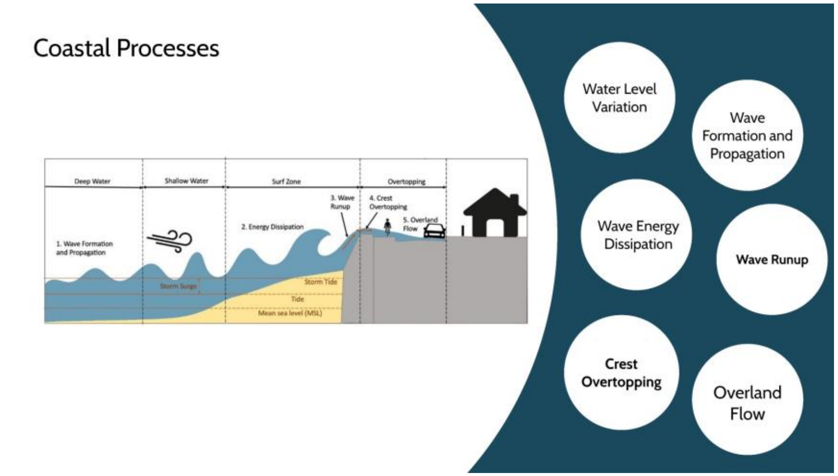
Tom Shand, Colin Whittaker, Pete Quilter, Maddy Witney, Holly Blakely

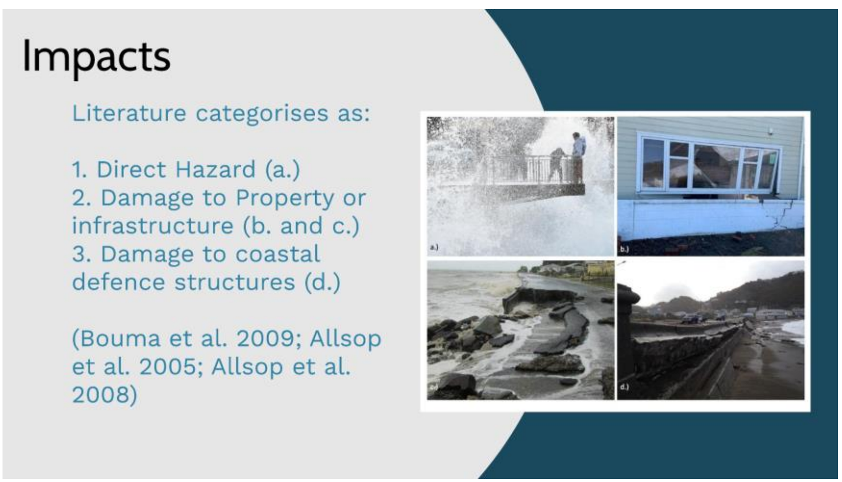
Adaptation of coastal structures

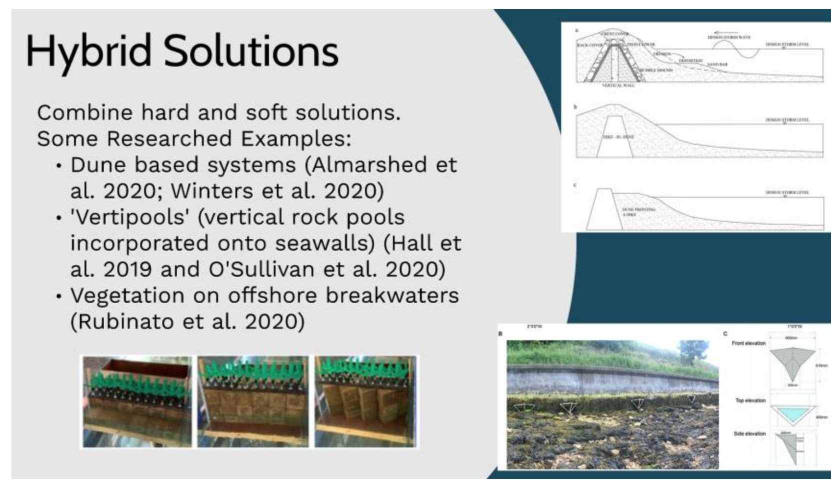
Rarer extreme overtopping events typically draw a great deal of attention. Arguably the effects are more easily tolerated as a 'one-off' than smaller events that may become more consequential due to their comparatively higher frequency?

Tom Shand, Colin Whittaker, Pete Quilter, Maddy Witney, Holly Blakely

Adaptation of coastal structures







Tom Shand, Colin Whittaker, Pete Quilter, Maddy Witney, Holly Blakely

Tsunami impacts on horizontal infrastructure

PhD student progress:

- Reviewing literature on tsunami loadings, fragility functions
- Preparing for tsunami flume tests over the summer period

Pablo Higuera, Liam Wotherspoon, Colin Whittaker, Tate Kimpton

Tsunami impacts on vertical infrastructure

PhD student progress:

- Reviewing tsunami loading standards (ASCE 7, MBIE, MLIT)
- Using case-study building in Wellington to compare demands from these standards
- Comparing different inundation predictions at specific sites
- Evaluating the practicality of developing multi-fidelity analysis procedures for tsunami loading on structures using seismic analysis techniques as a baseline
- Scoping flume testing that (1) can capture flexibility of the structure and (2) provides 'serviceability' tsunami loading case

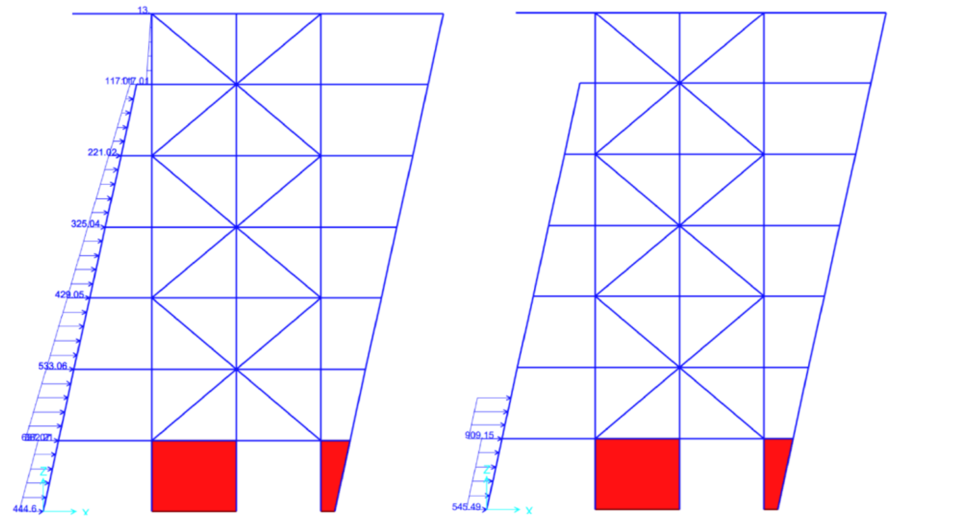


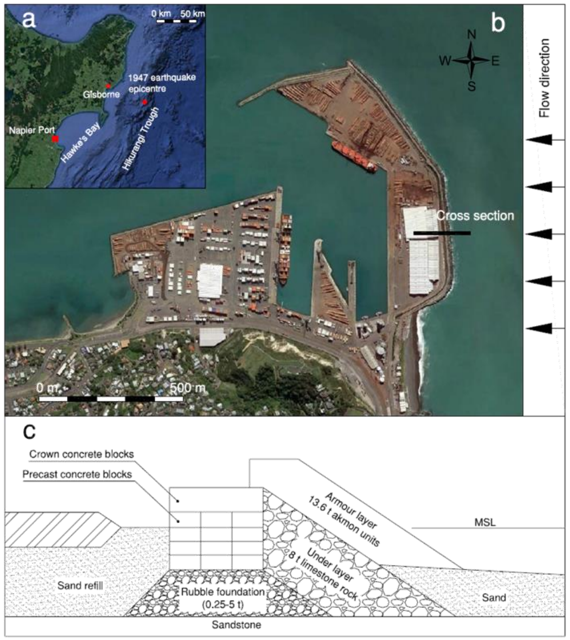
Figure 4: Hydrostatic Pressure Distribution for MLIT (left) and ASCE/MBIE (right)

Aligned research (Stephens, FRDF):

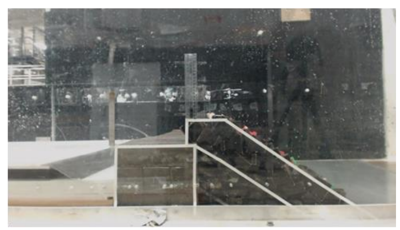
- Determined inundation of all base-isolated buildings in central Wellington
- Currently developing detailed numerical model of building on the waterfront - will subject to loading from the various standards and from CFD

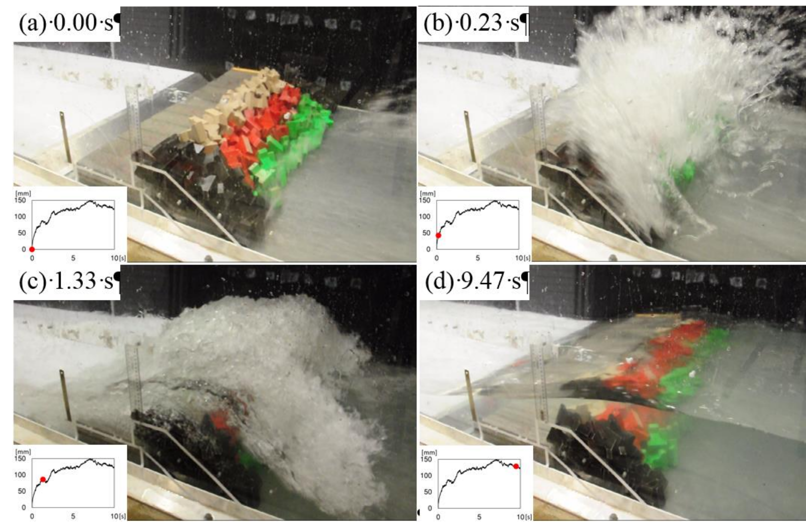
Max Stephens, Charlotte Toma, Henry Till

Aligned: Damage to composite breakwaters



Sources: Google earth, GeoNet, Opus (2018)

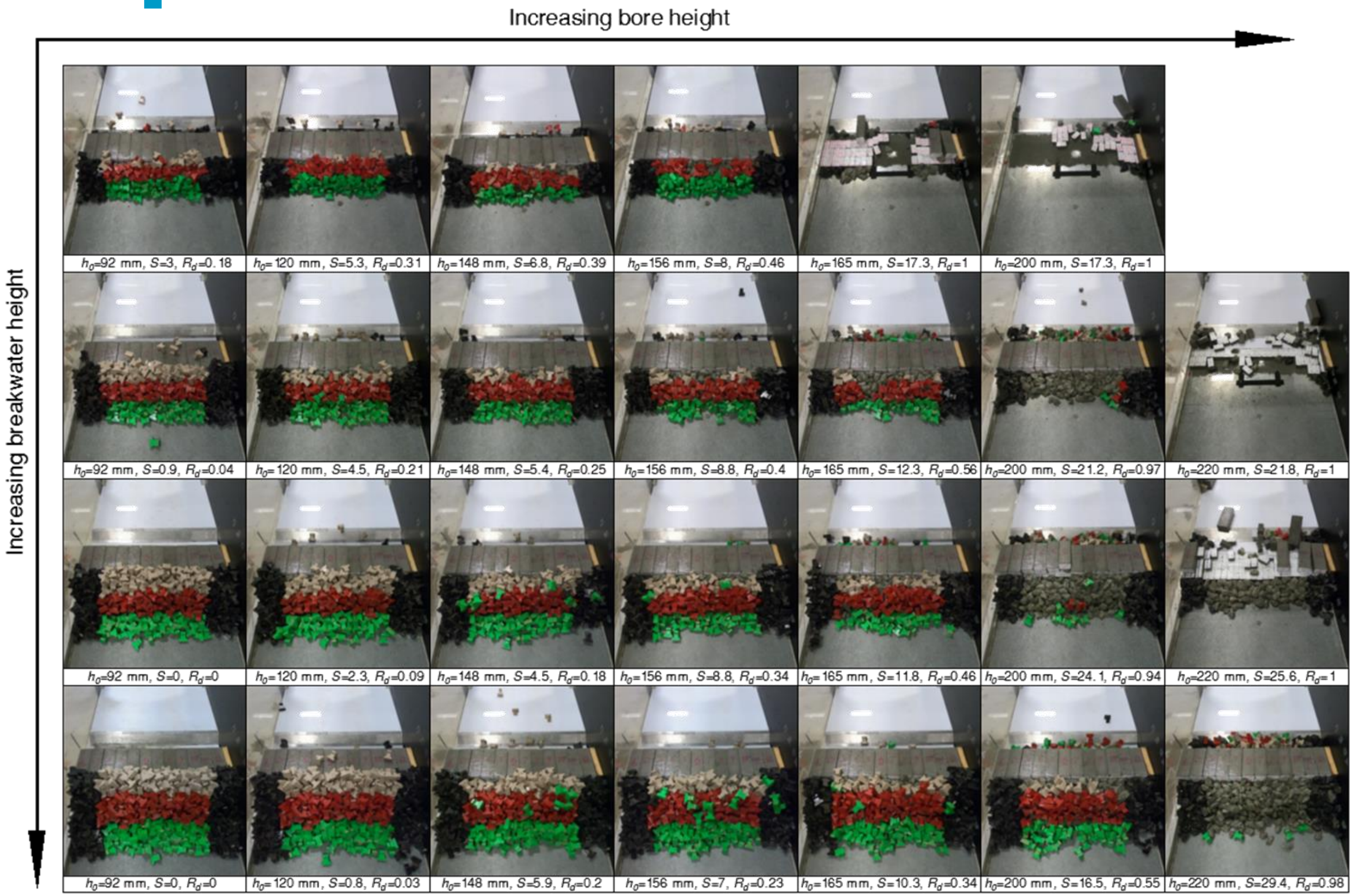




Case ID	Reservoir water depth H (mm)	Gate opening height GO (mm)	Gate opening time (s)	Maximum bore depth h_0 (mm)	Bore tip propagation speed U (m/s)	Average Fr in the quasi-steady period
a	300	200	10	92	1.91	1.05
b	400	200	10	120	2.41	1.49
c	500	200	10	148	2.75	1.47
d	600	200	10	156	2.92	1.49
e	700	200	10	165	3.28	1.67
f	700	300	10	200	3.31	1.39
g	900	300	10	220	4.01	1.60

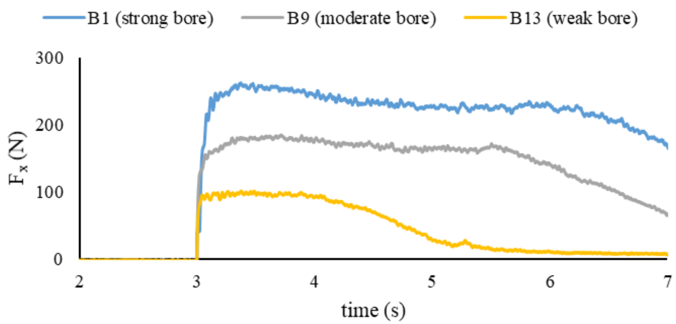
Bruce Melville, Liam Wotherspoon, NAK Nandasena, Zhonghou Xu

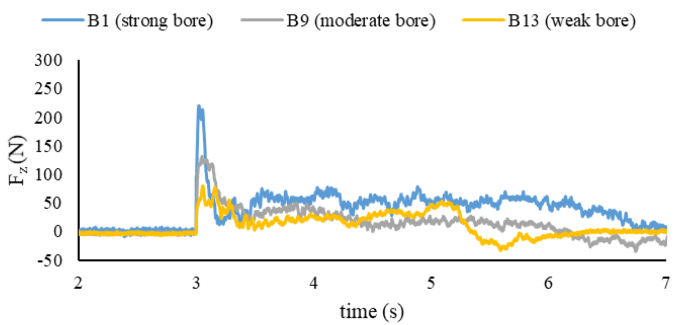
Aligned: Damage to composite breakwaters

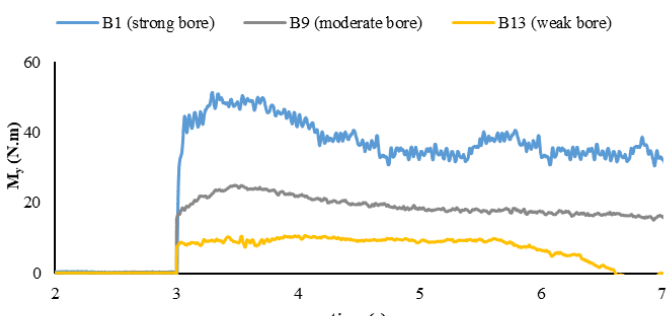


Bruce Melville, Liam Wotherspoon, NAK Nandasena, Zhonghou Xu

Aligned: Tsunami impacts on bridges



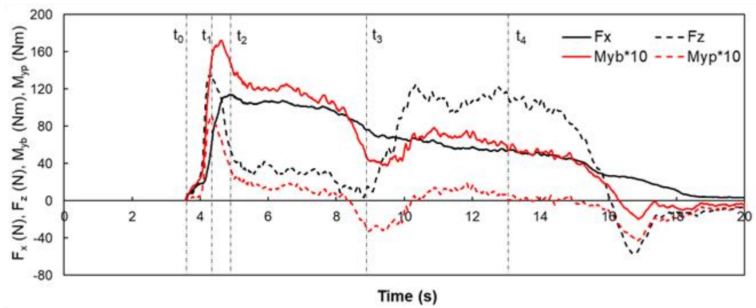




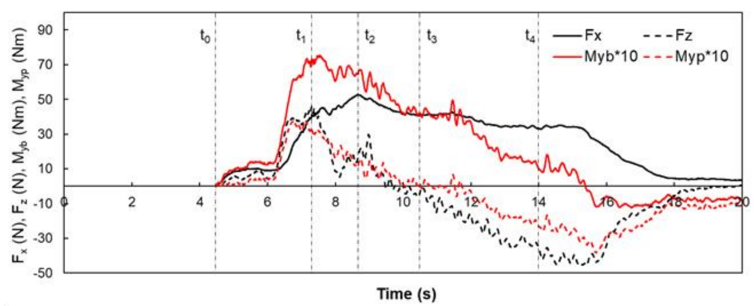
Bruce Melville, Asaad Shamseldin, Farzad Farvizi

Aligned: Tsunami impacts on bridges

h_0=0.215 m

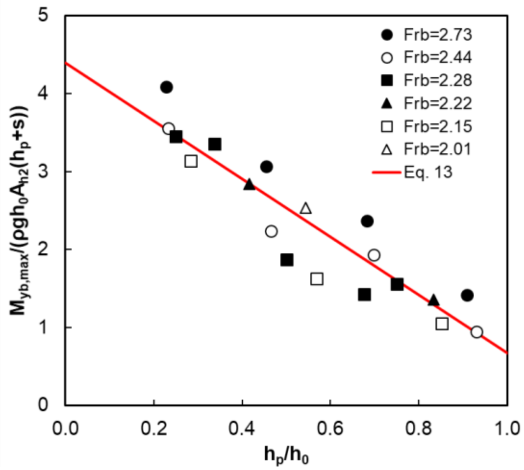


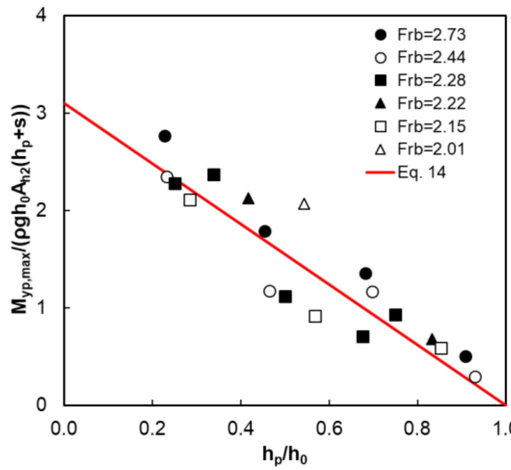
h_0=0.148 m



Bruce Melville, Asaad Shamseldin, Colin Whittaker, Zhonghou Xu

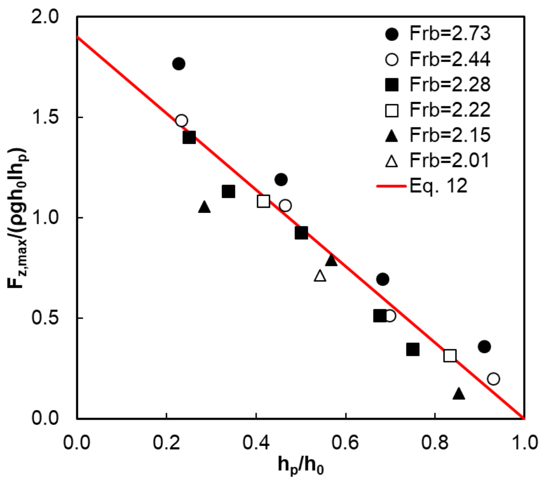
Aligned: Tsunami impacts on bridges



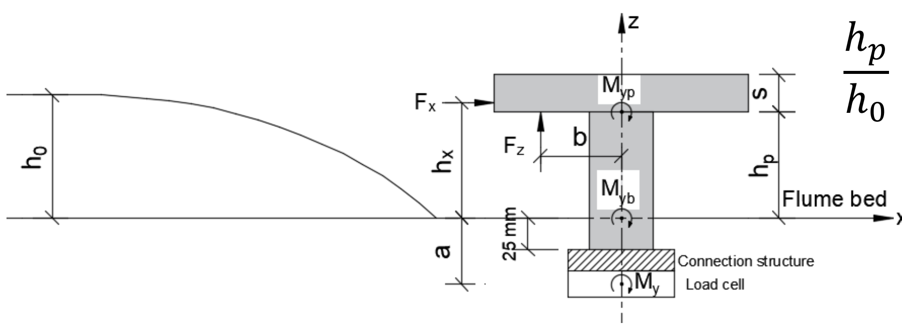


$$\frac{M_{yb,\max}}{\rho g h_0 A_{h2}(h_p + s)} = 4.4 - 3.7\frac{h_p}{h_0}$$

$$\frac{M_{yp,\max}}{\rho g h_0 A_{h2}(h_p + s)} = 3.1 - 3\frac{h_p}{h_0}$$



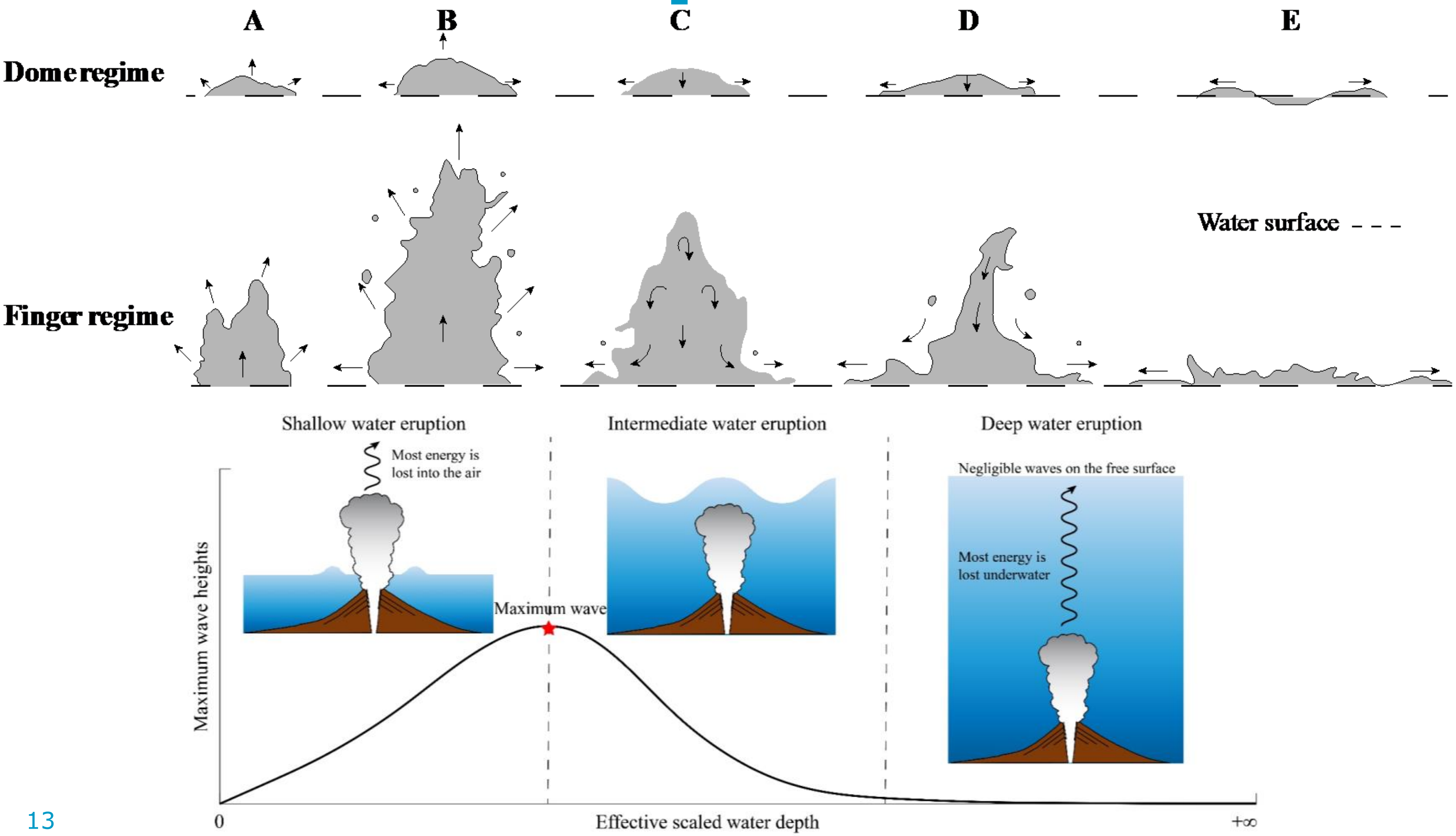
$$\frac{F_{z,\max}}{\rho g h_0 l h_p} = 1.9 - 1.9\frac{h_p}{h_0}$$



$$\frac{h_p}{h_0} = 0.23 \sim 0.93$$

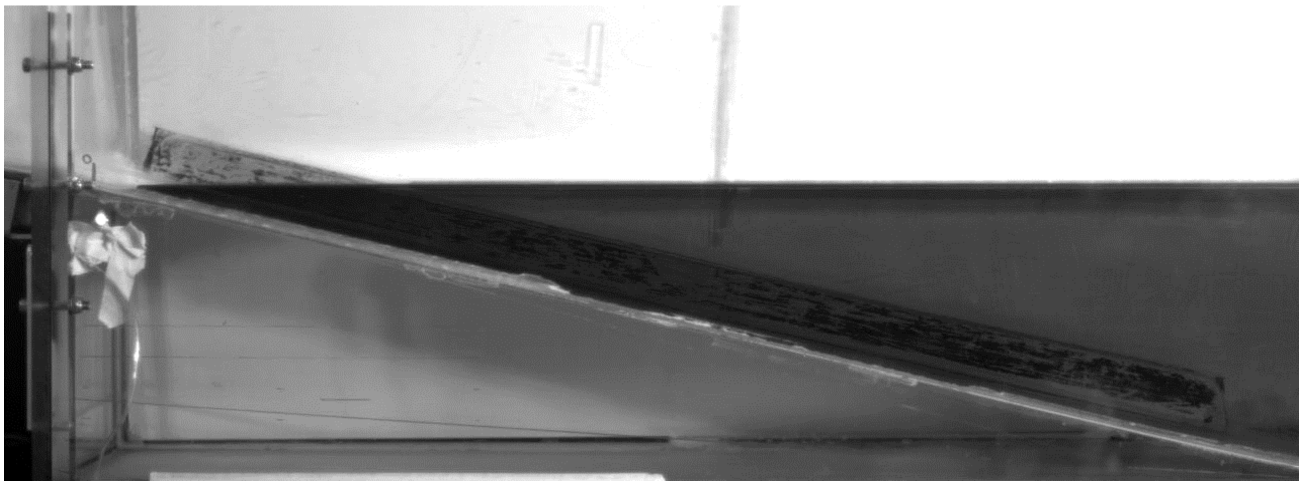
Bruce Melville, Asaad Shamseldin, Colin Whittaker, Zhonghou Xu

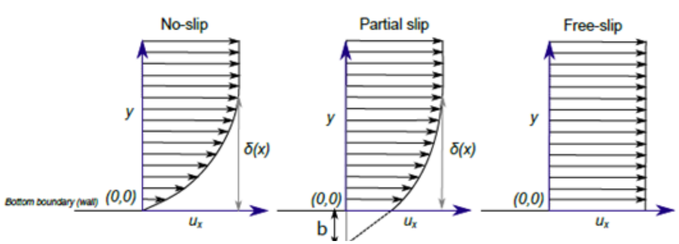
Aligned: Tsunami generation by volcanic eruptions

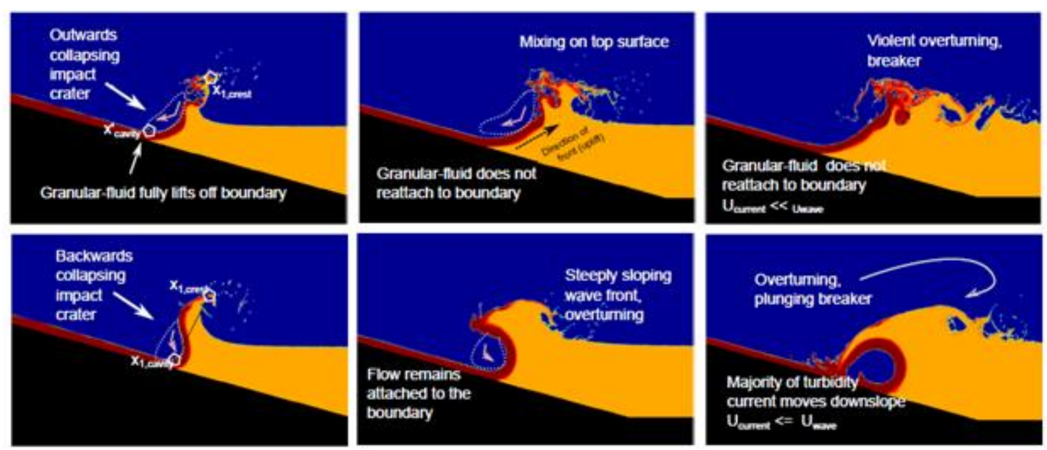


Colin Whittaker, Emily Lane, William Power, James White, Yaxiong Shen, Natalia Lipiejko, Lily Battershill, Matty Hayward

Aligned: Tsunami generation by volcanic eruptions

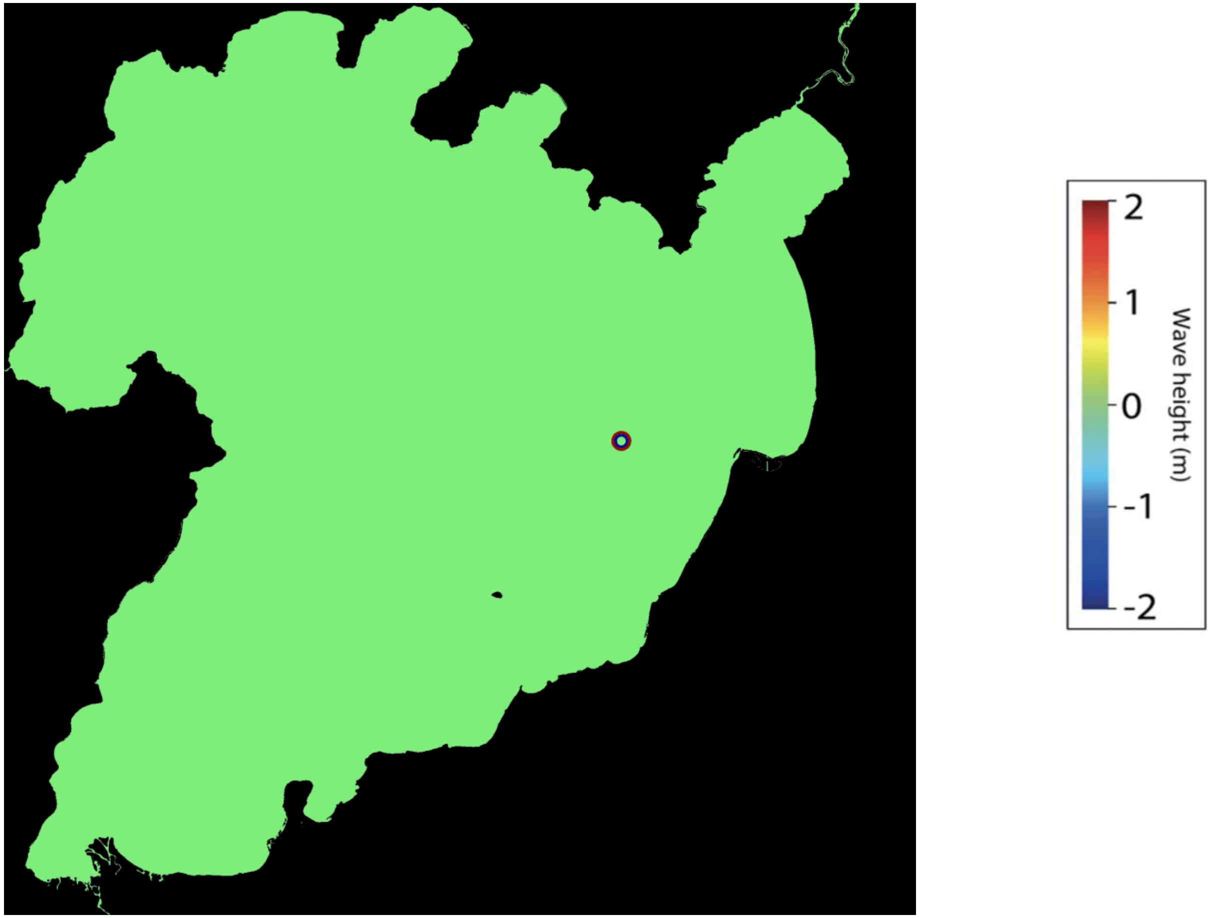






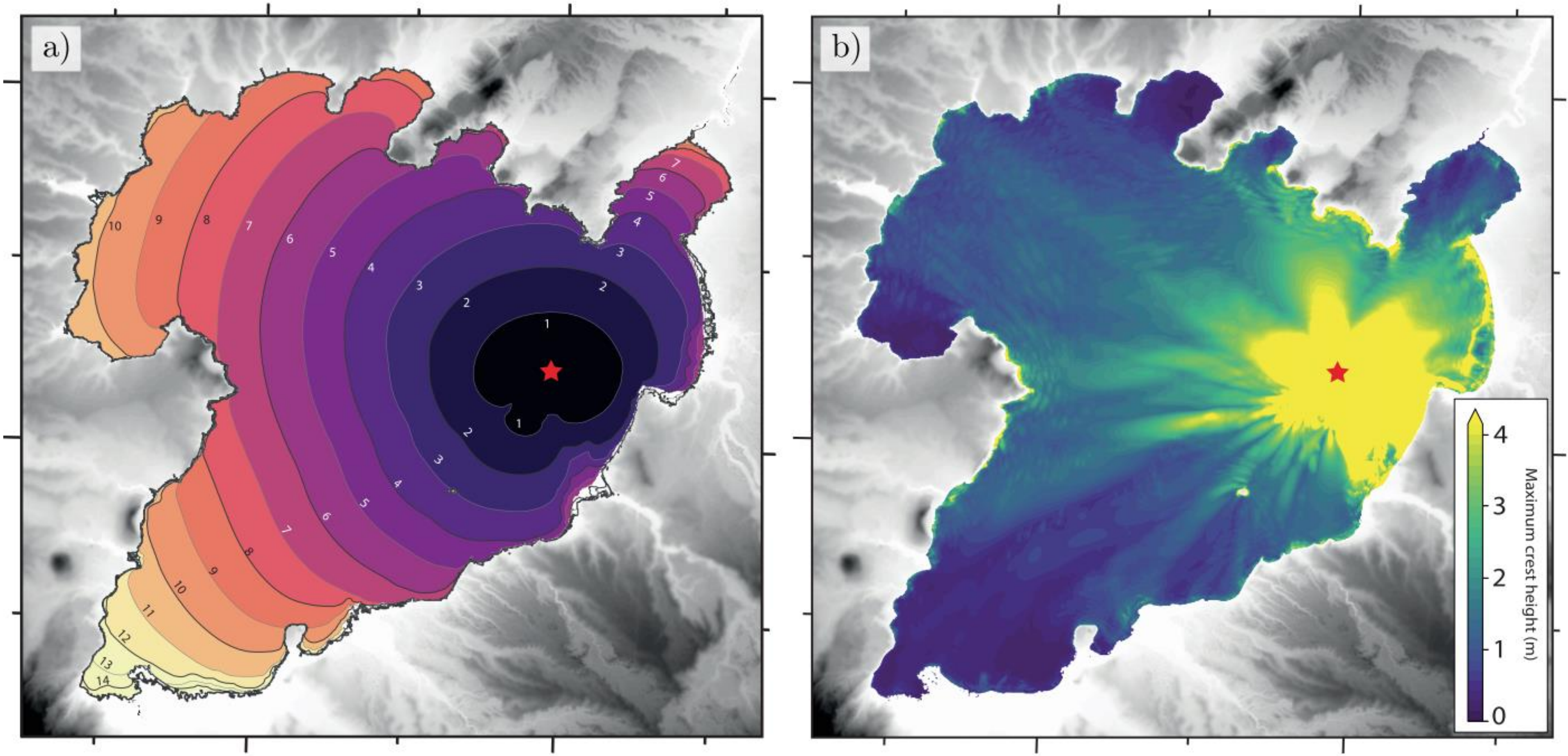
Colin Whittaker, Emily Lane, William Power, James White, Yaxiong Shen, Natalia Lipiejko, Lily Battershill, Matty Hayward

Aligned: Tsunami generation by volcanic eruptions



Colin Whittaker, Emily Lane, William Power, James White, Yaxiong Shen, Natalia Lipiejko, Lily Battershill, Matty Hayward

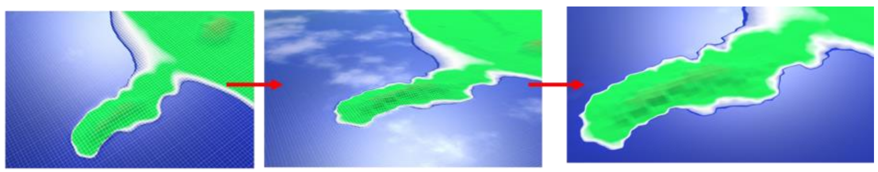
Aligned: Tsunami generation by volcanic eruptions



Colin Whittaker, Emily Lane, William Power, James White, Yaxiong Shen, Natalia Lipiejko, Lily Battershill, Matty Hayward

Aligned: Tsunami inundation and evacuation

1. Refining grid size
10m → 2m → 1m



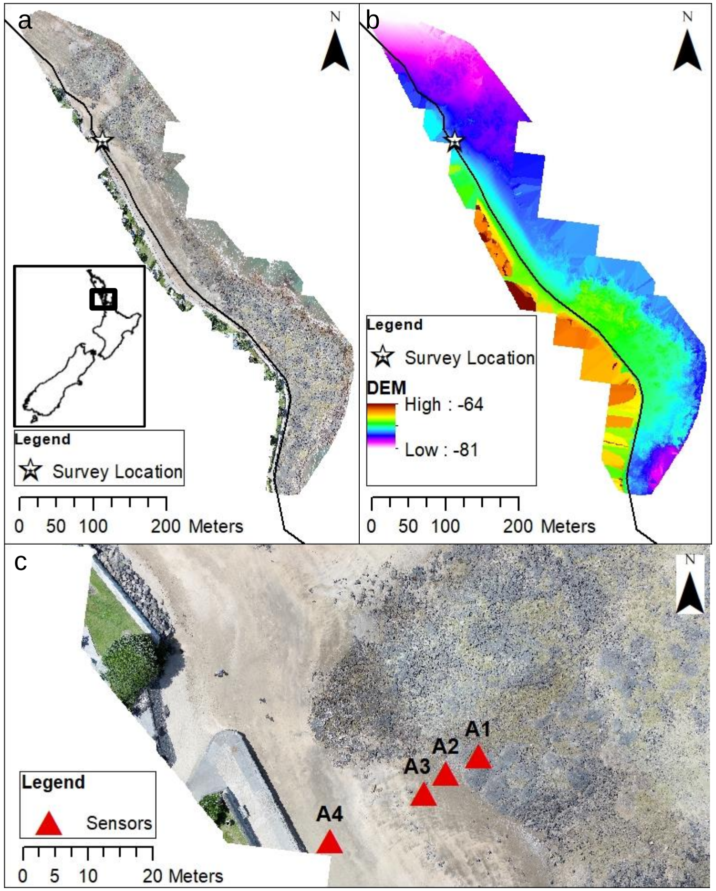
2. DEM vs modified DEM vs DSM

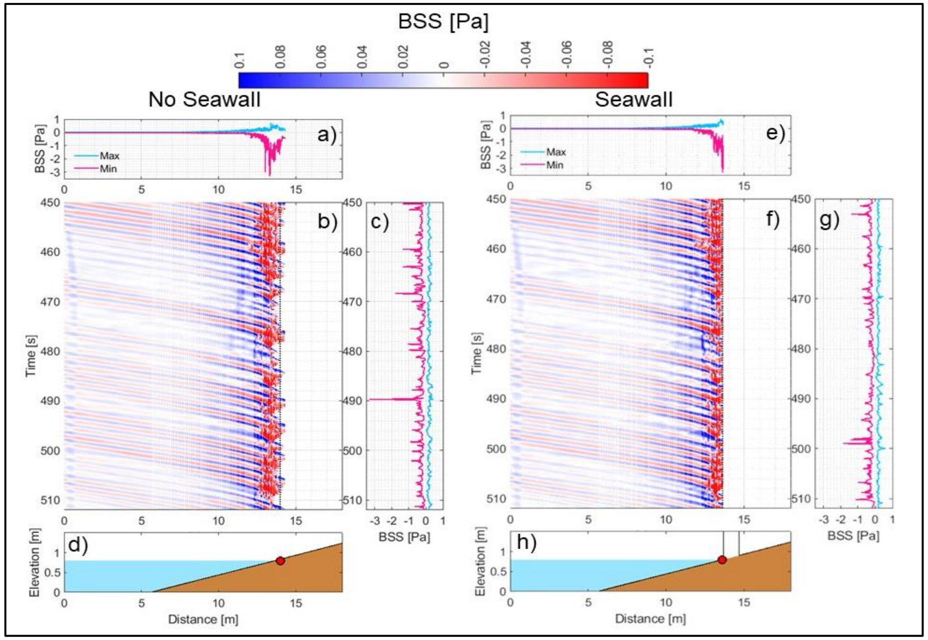
3. NLSW vs Boussinesq model

MIKE Powered by DHI → CELERIA.ORG

Tom Shand, Scott Murray

Aligned: Beach/seawall interactions





Colin Whittaker, Pablo Higuera, Tom Shand, Mark Dickson, Mark Battley, Giovanni Coco, Jennifer Montaño Muñoz, Catriona Thompson

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

ENGINEERING