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Climate, Freshwater & Ocean Science

17 June 2019

BGUM 2019 Paris, France


Photo Credit: Putu Sayoga/Bloomberg via Getty

A two-layer model for submarine landslide generated tsunamis

Emily Lane, Kendall Mollison

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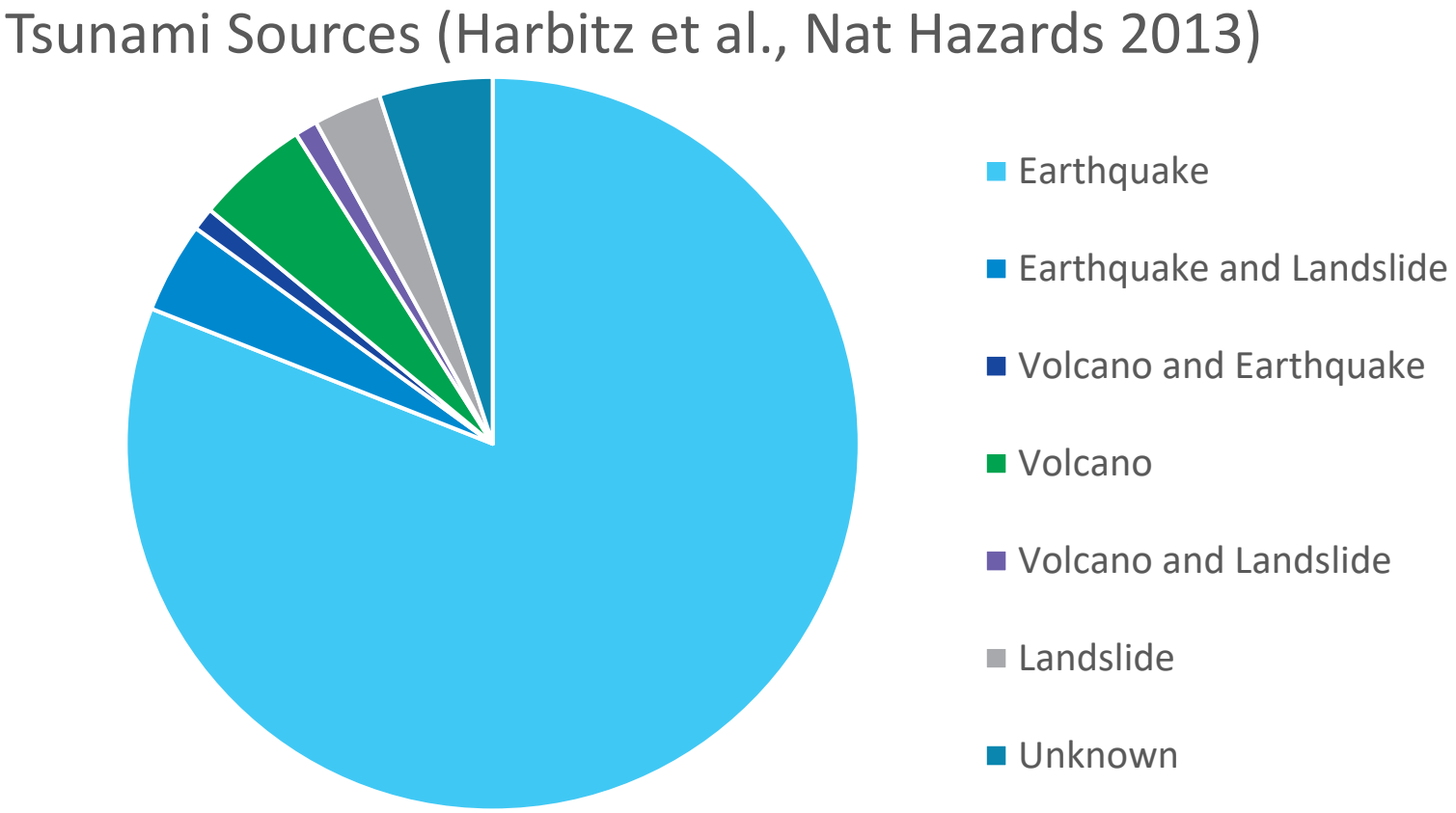
Earthquakes are not the only way to create a tsunami…

While earthquakes are the most common cause of tsunamis, 8% of tsunamis are caused by landslides.



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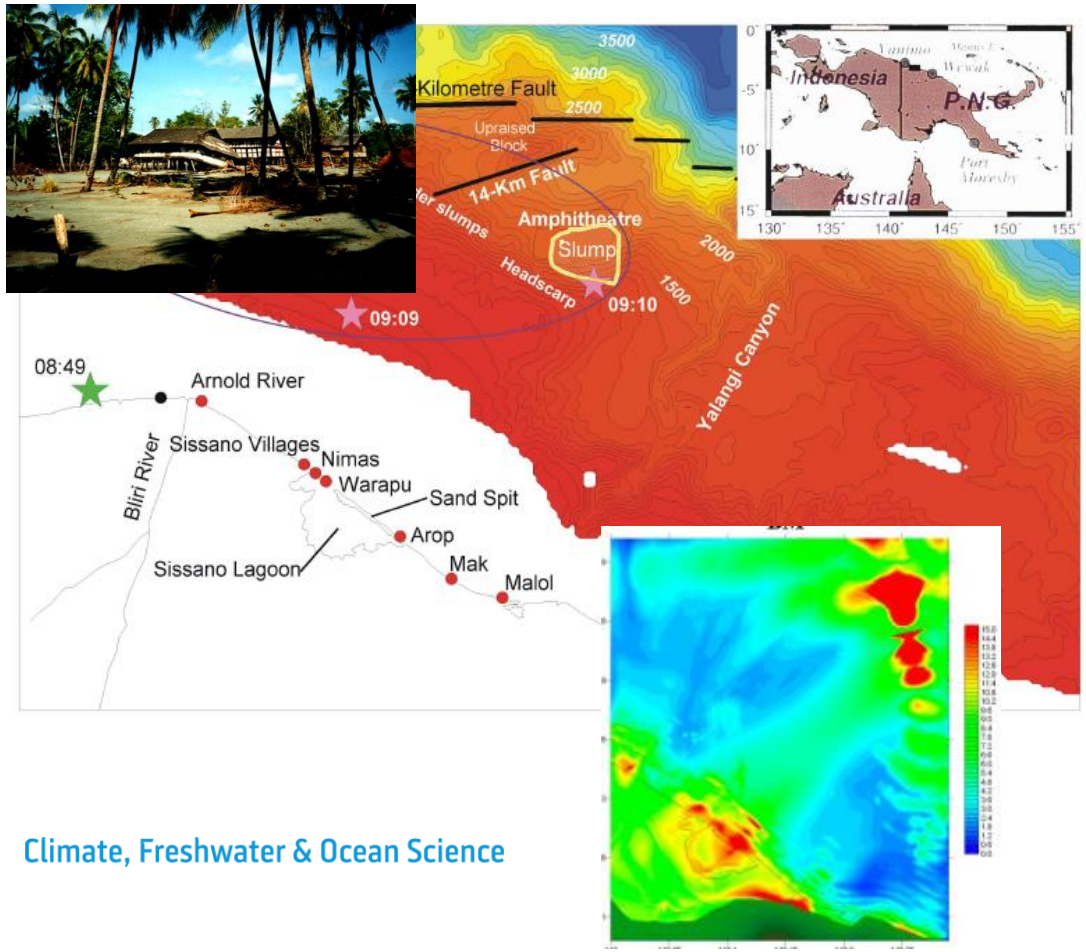
Sissano Lagoon, Papua New Guinea, 1998

- Earthquake caused submarine slump
- Wave heights up to 15 metres
- More than 2,100 people killed and 2,700 people injured



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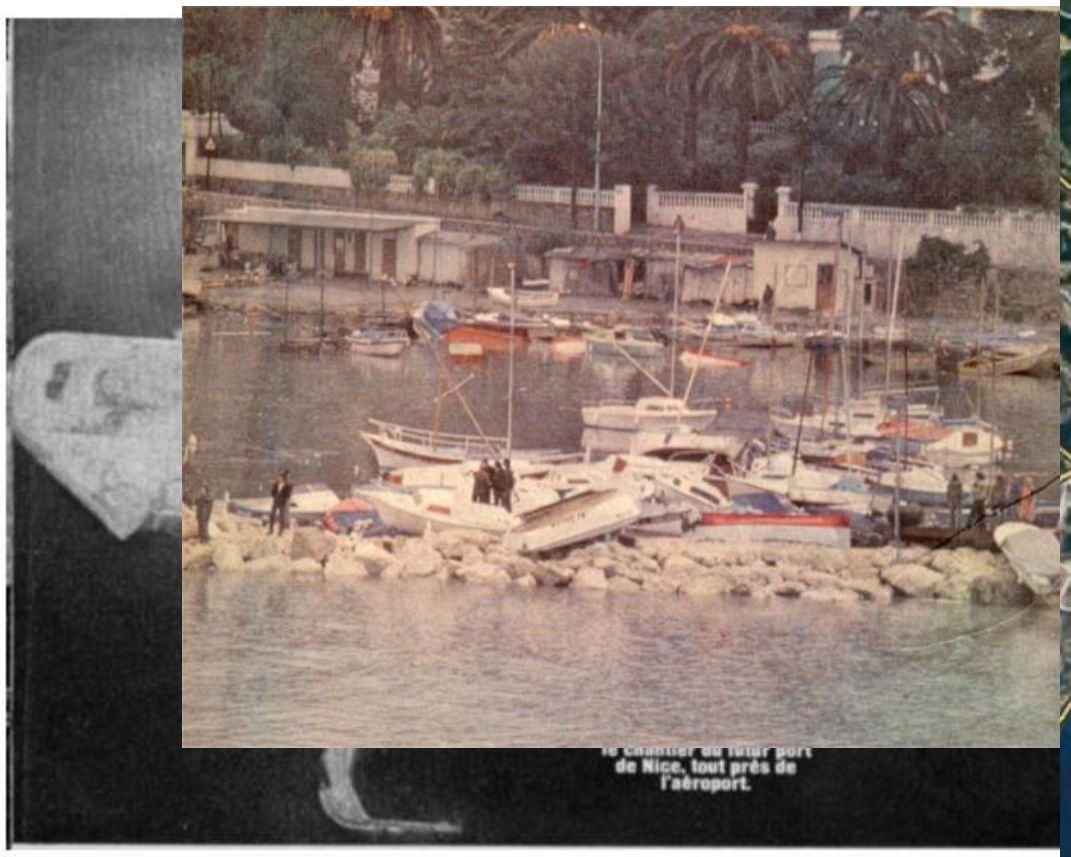
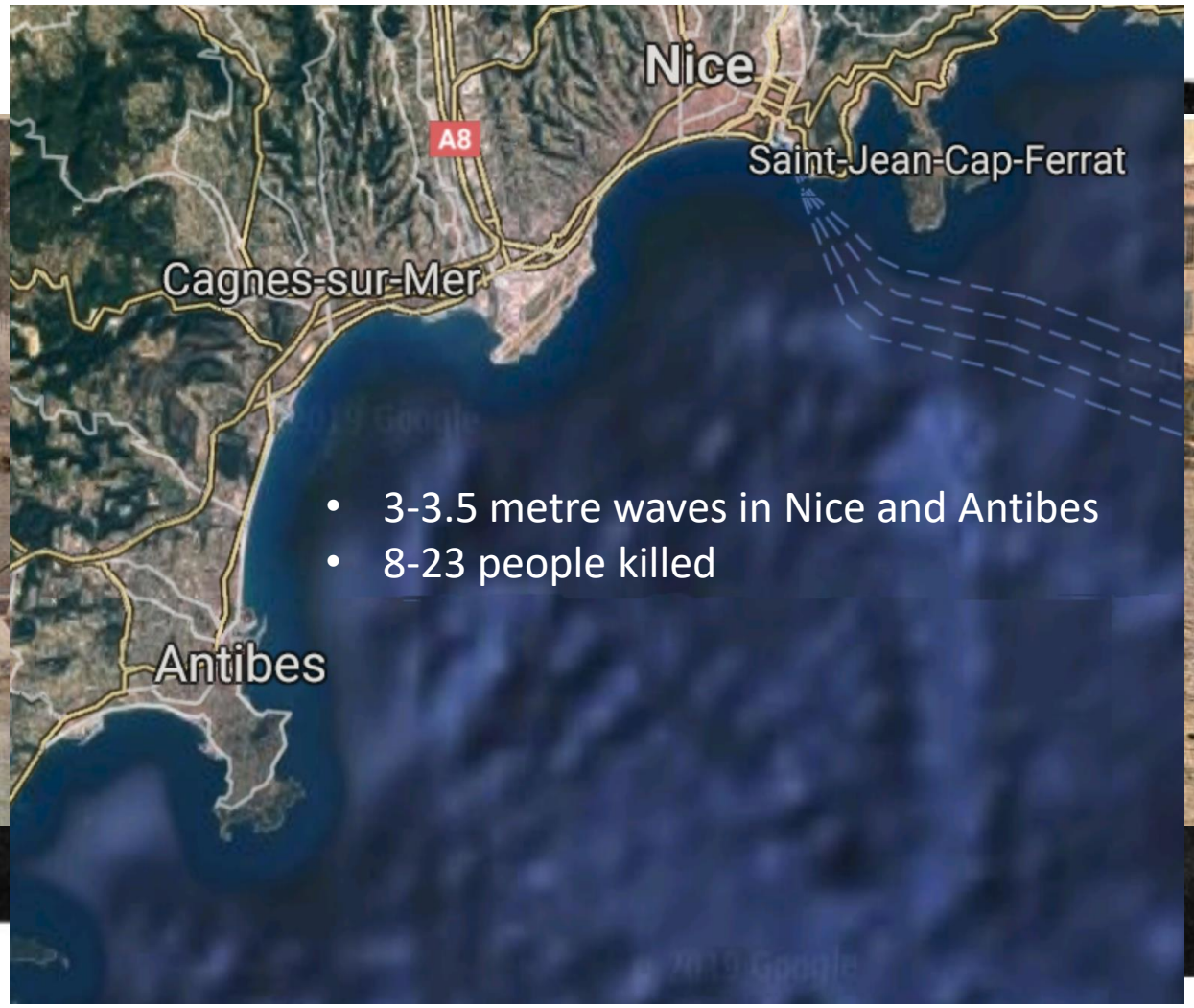
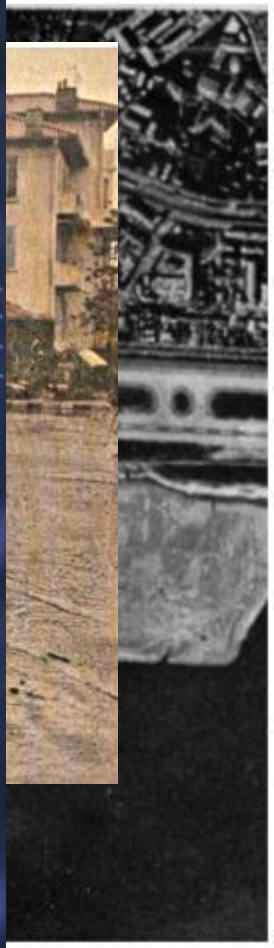
Nice Airport 1979

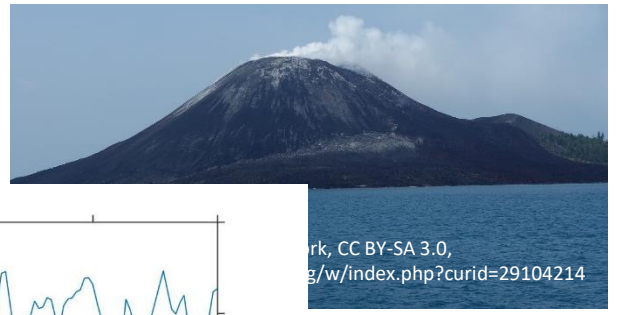


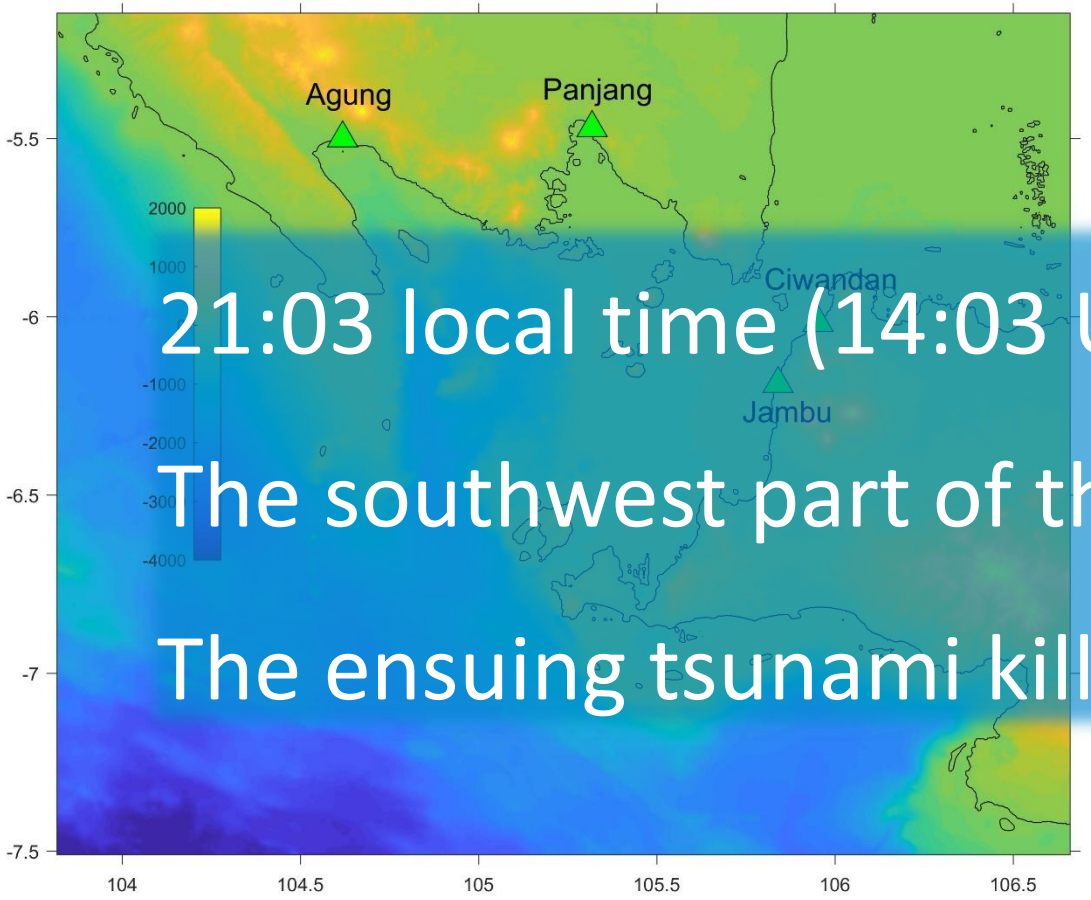


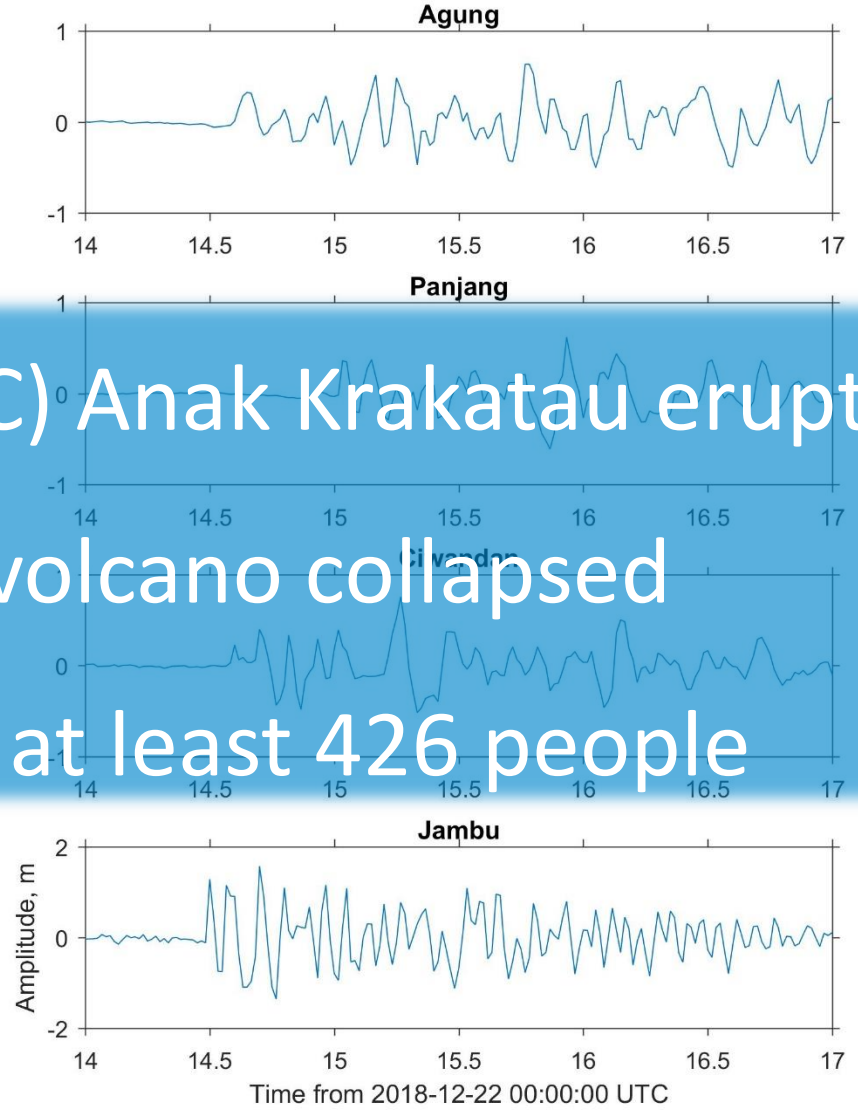
- 3-3.5 metre waves in Nice and Antibes
- 8-23 people killed



Anak-Krakatau Tsunami 22 December 2018







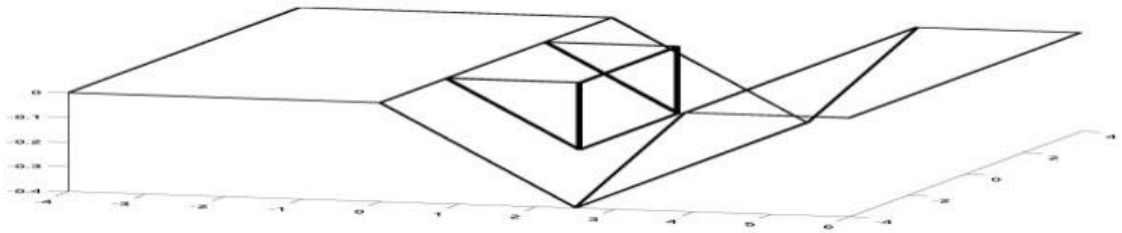
21:03 local time (14:03 UTC) Anak Krakatau erupted

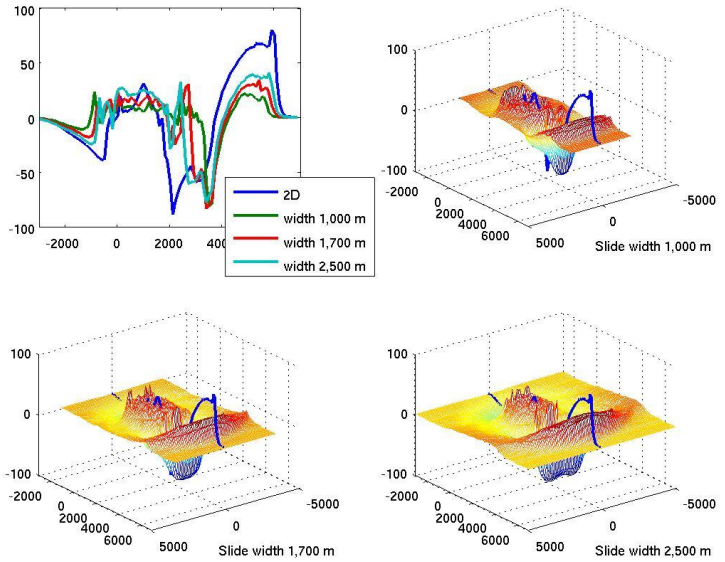
The southwest part of the volcano collapsed

The ensuing tsunami killed at least 426 people

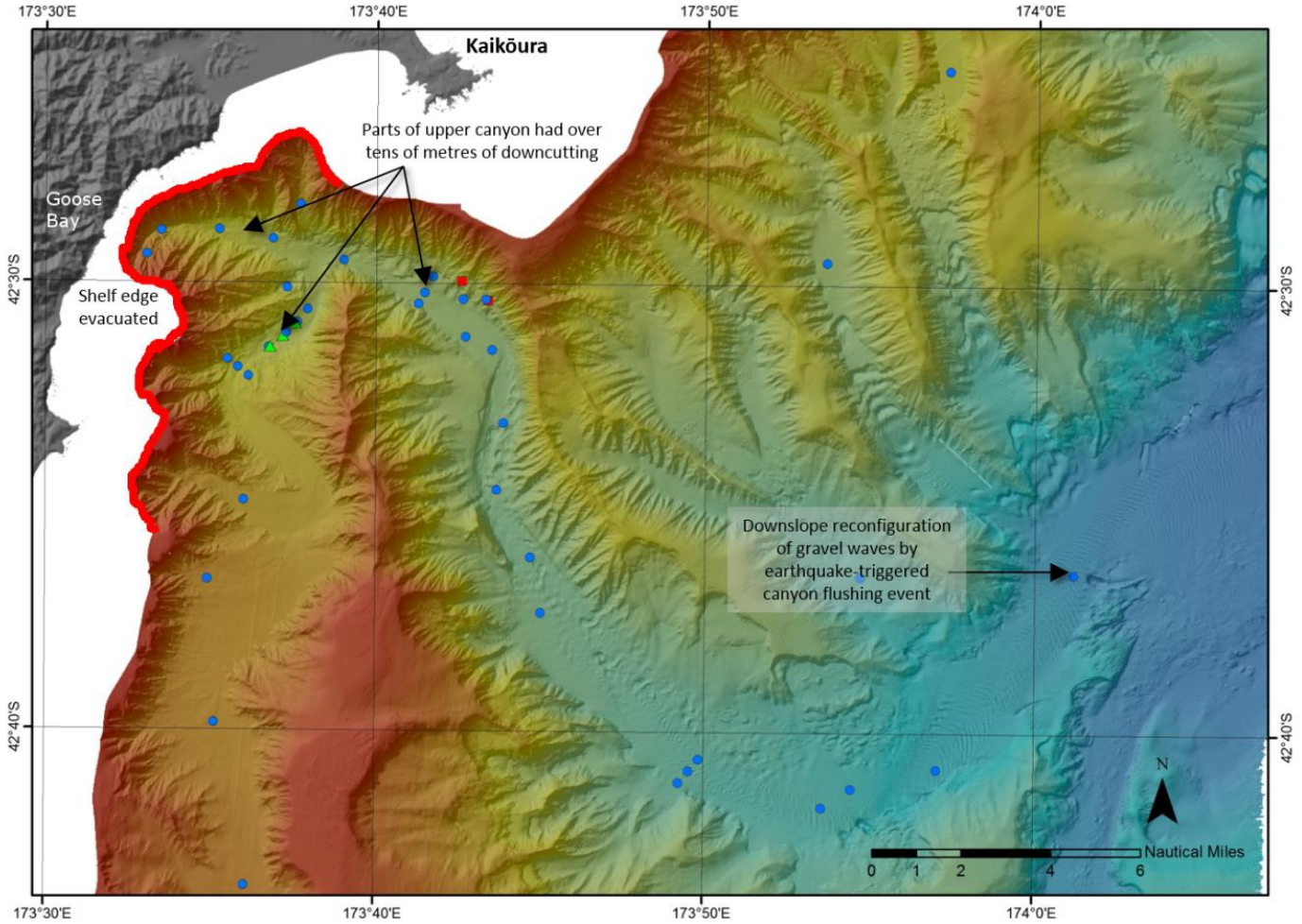
How to model these submarine landslides?

- Previously modelled simplified geometry using Gerris VoF
- Used water elevation and depth-integrated velocity as initialisation for Saint-Venant equations
- Not ideal – especially in regions with complex domains and close shorelines





Kaikōura, 12:04 am November 14, 2016 M_w 7.8



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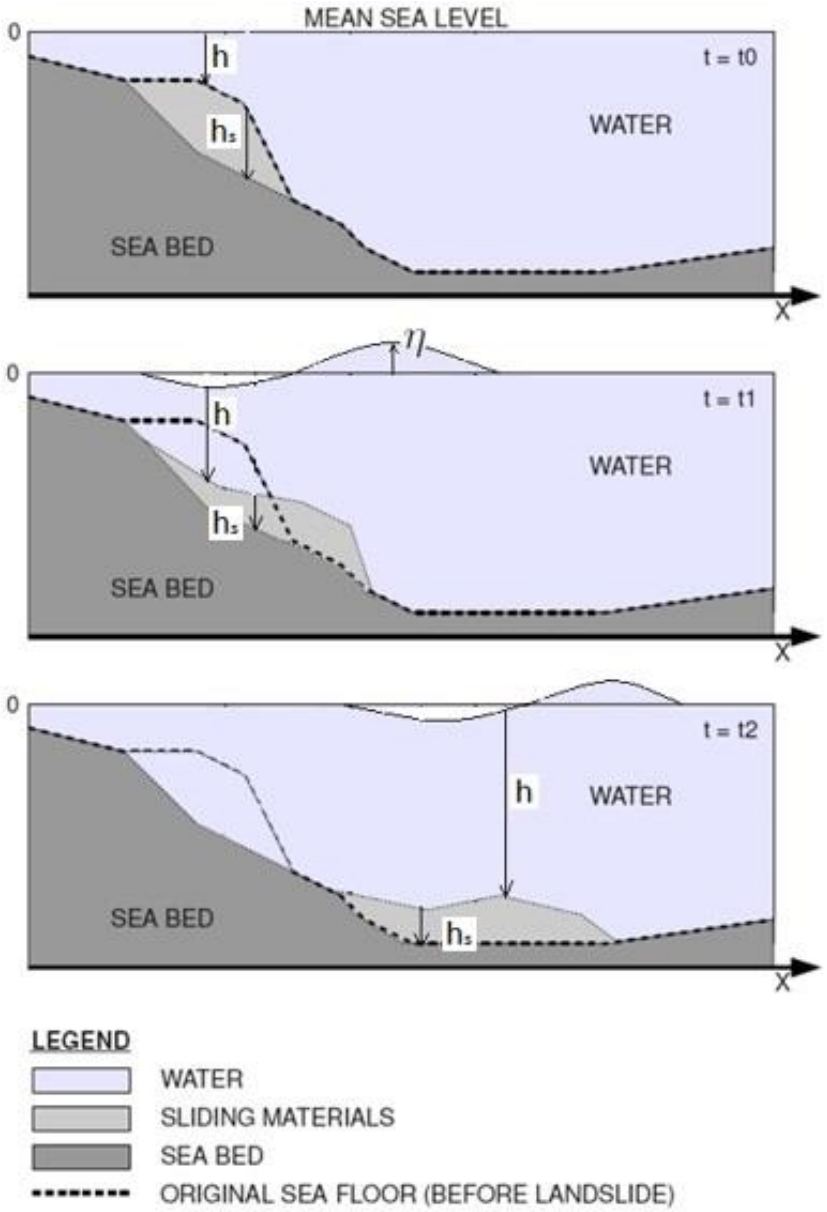
2-layer model

- Assumption: landslide behaves like fluid.
- Model water and landslide as two immiscible layers of fluid.
- Landslide denser and more viscous
- (Rabinovich et al.; Savage and Hutter; Heinrich et al.; Kelfoun and Druit; Sorensen et al.;…);



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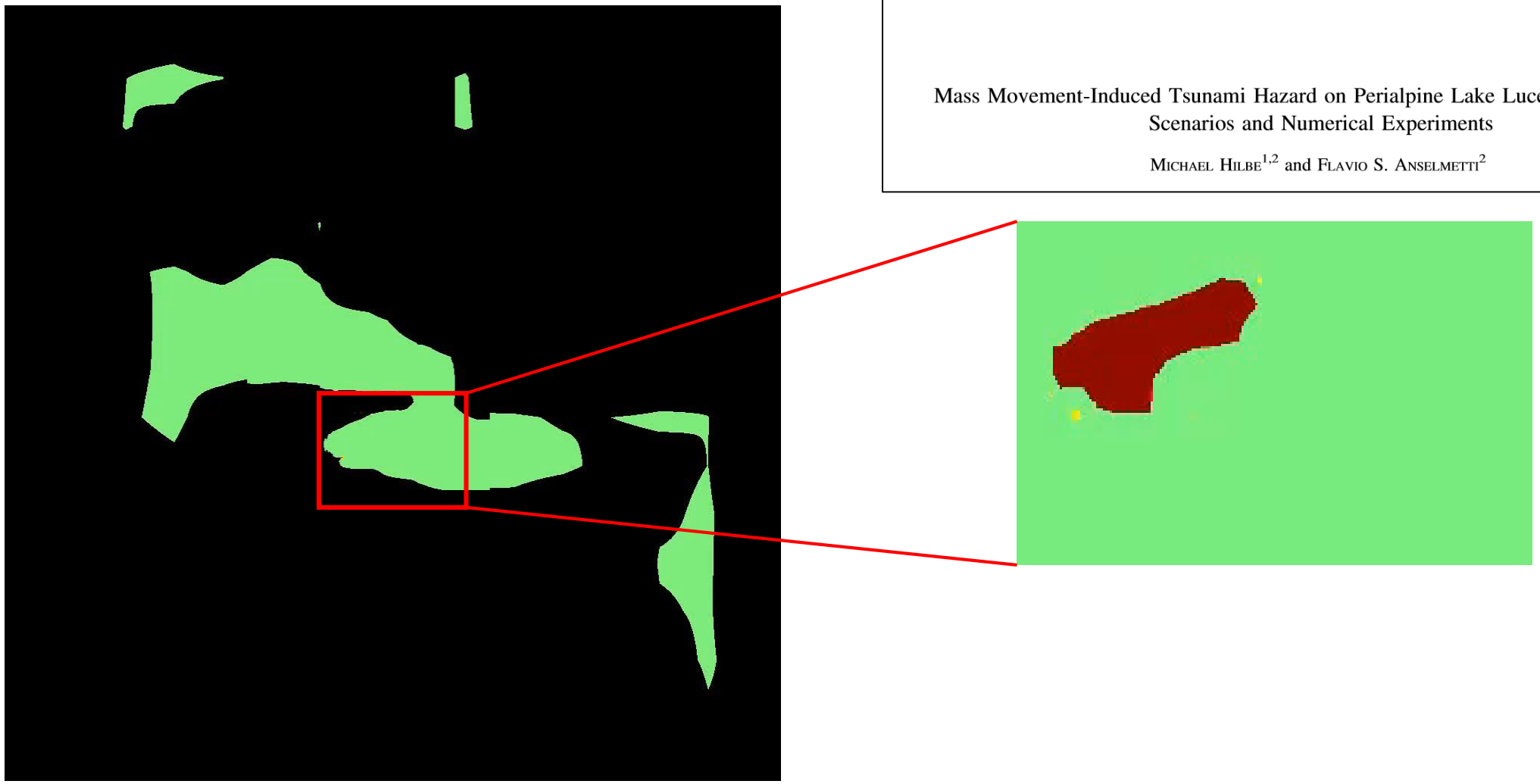
Lake Lucerne – Gersau slide



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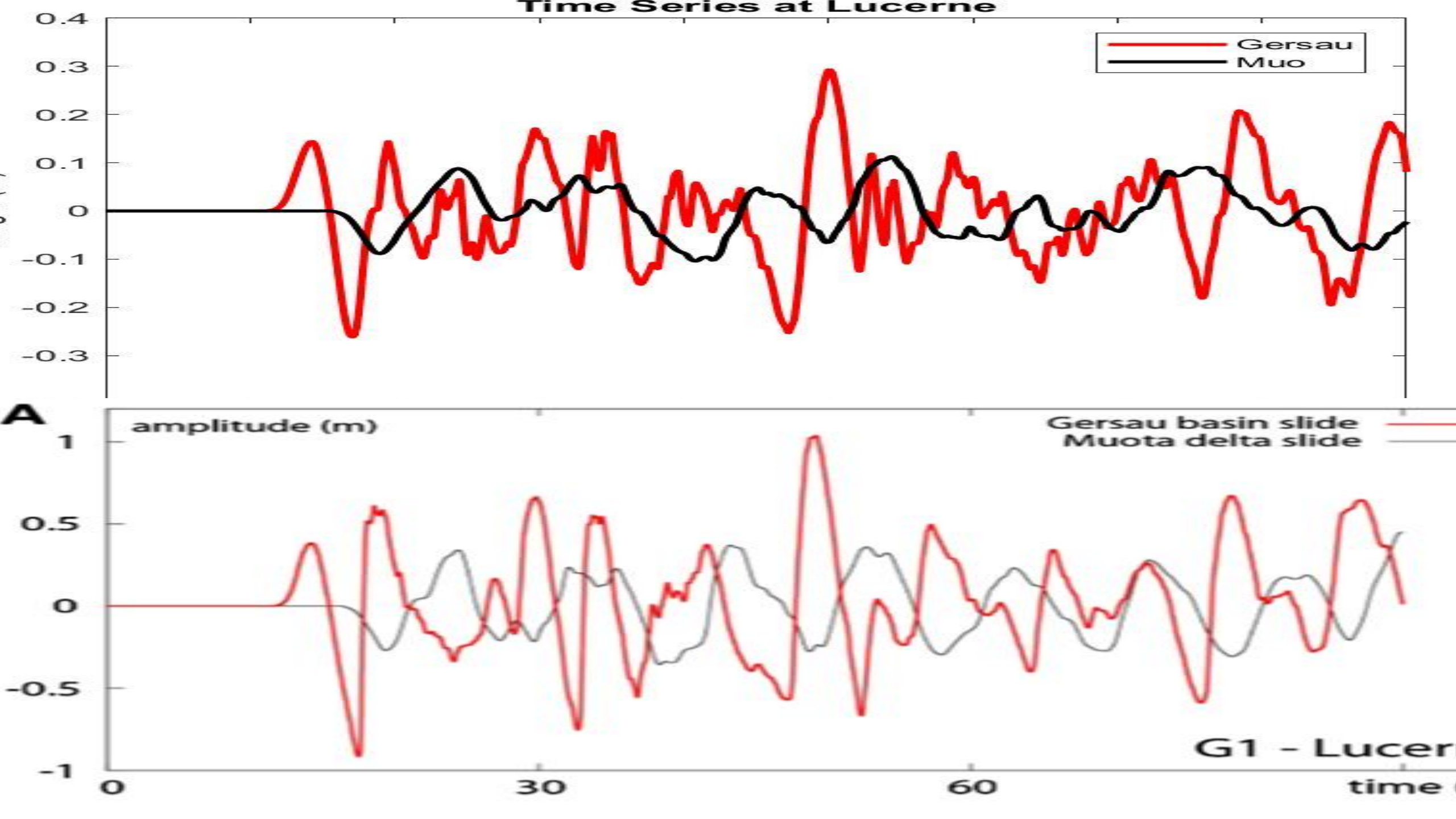
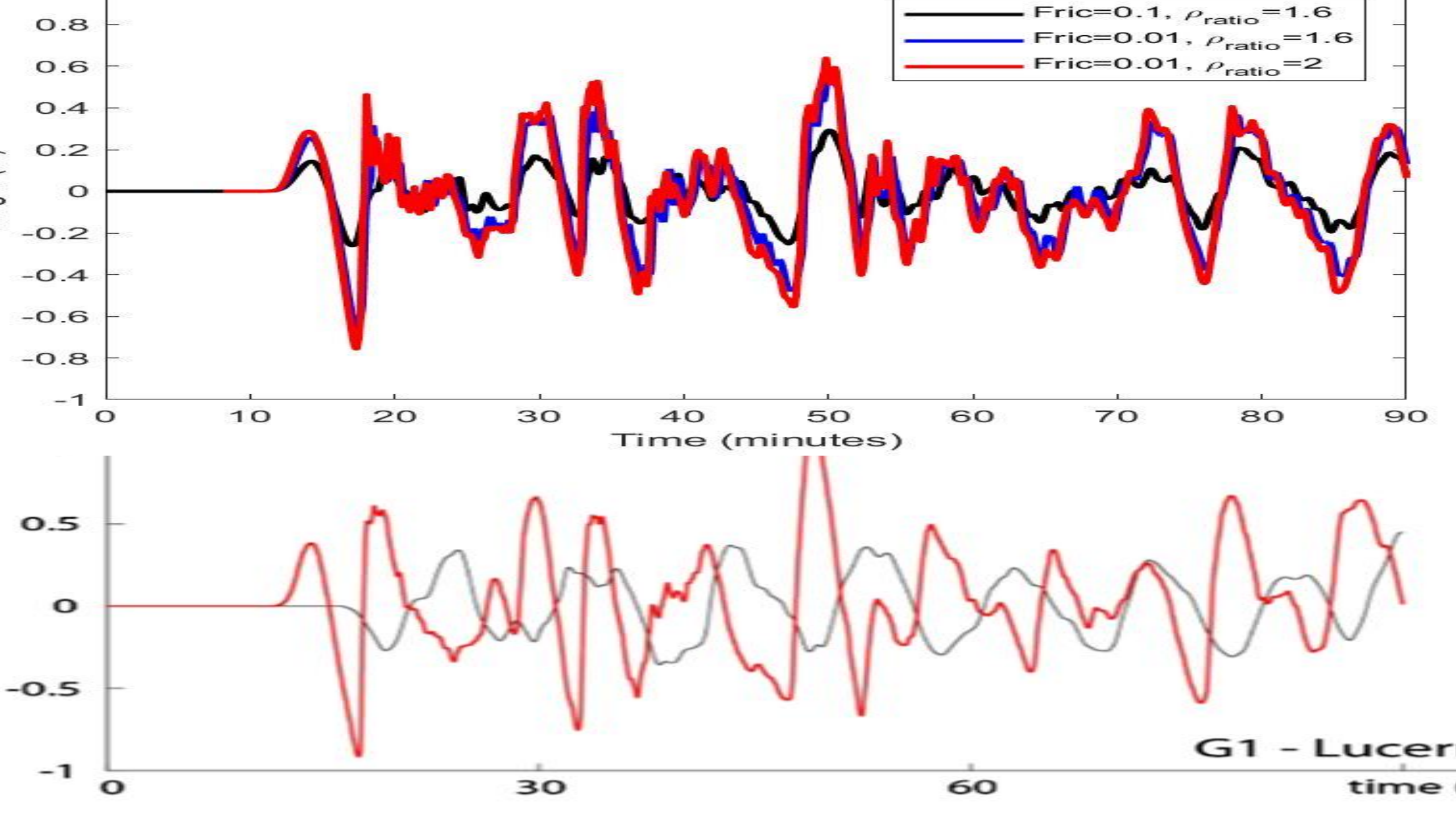
Pure and Applied Geophysics

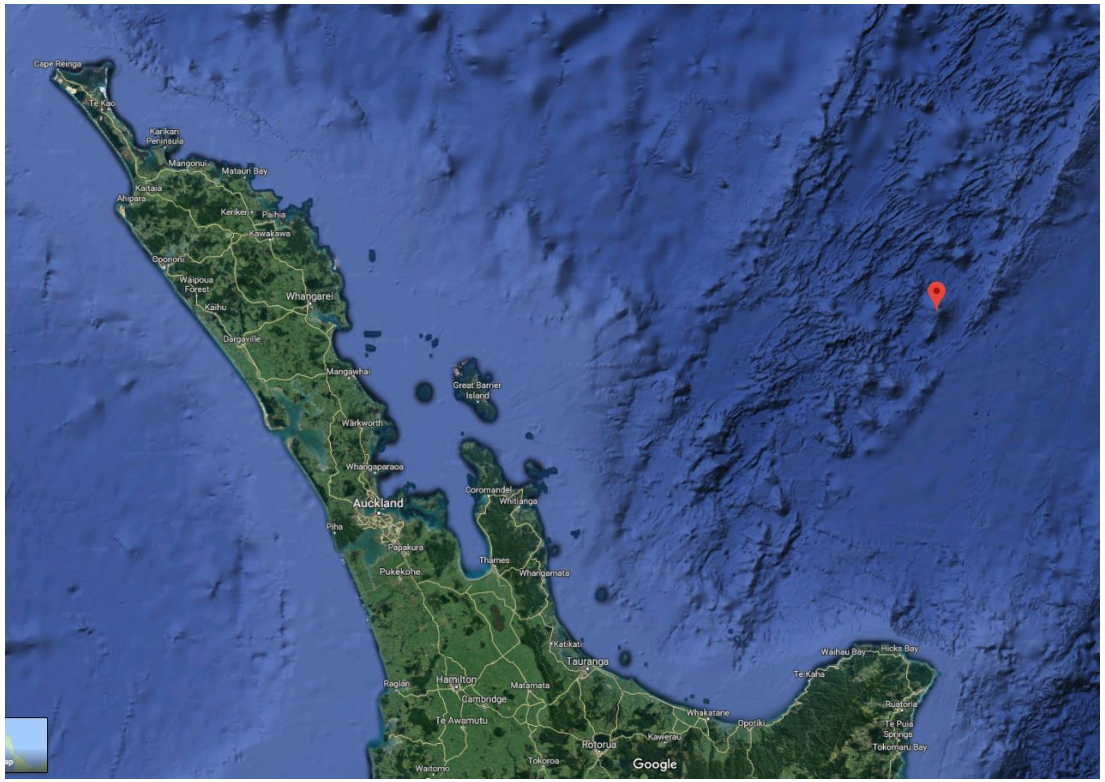
Mass Movement-Induced Tsunami Hazard on Perialpine Lake Lucerne (Switzerland): Scenarios and Numerical Experiments

Michael Hilbe[1,2] and Flavio S. Anselmetti[2]

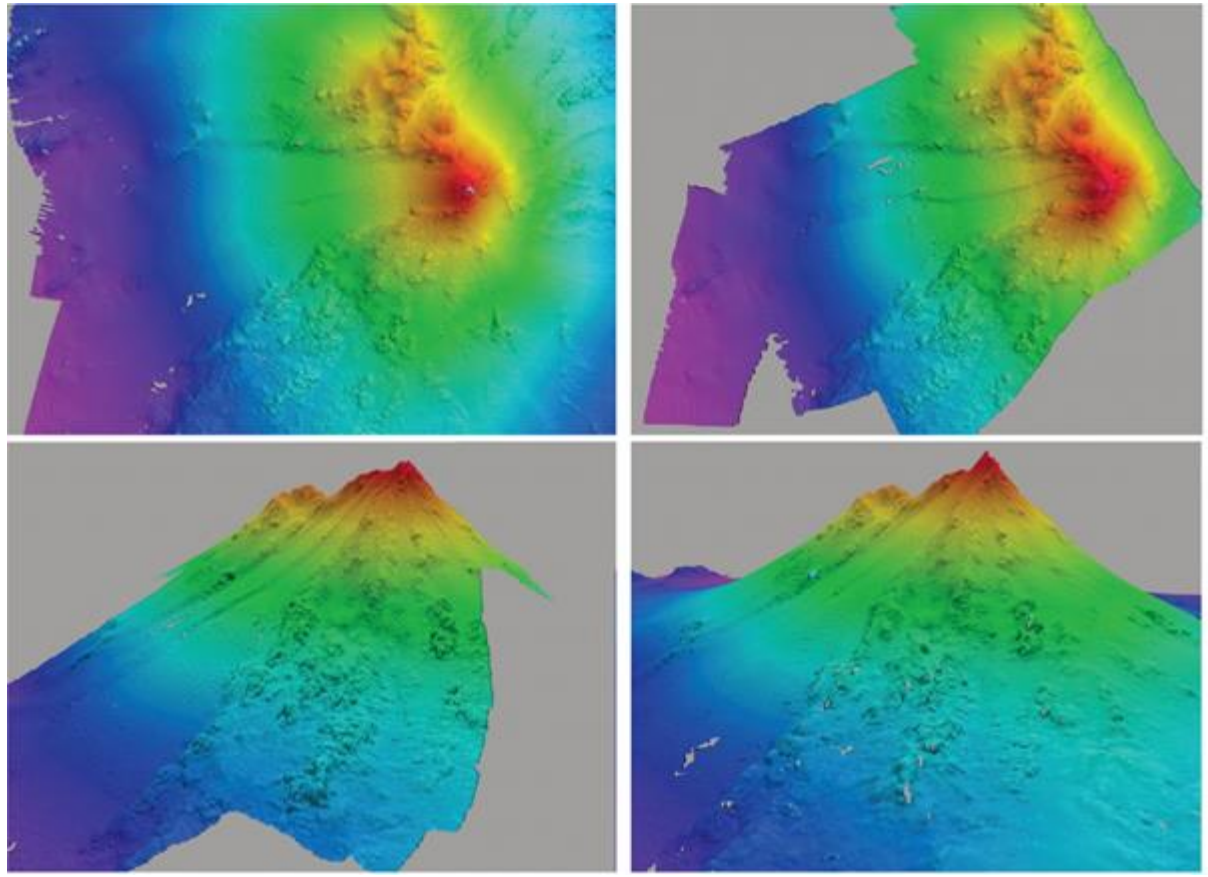

Time Series at Lucerne
Gersau
Muo
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
A
amplitude (m)
Gersau basin slide
Muota delta slide
1
0.5
0
-0.5
-1
G1 - Lucer
0
30
60
time


Fric=0.1, ρ_{ratio}=1.6
Fric=0.01, ρ_{ratio}=1.6
Fric=0.01, ρ_{ratio}=2
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
10
20
30
40
50
60
70
80
90
Time (minutes)
0.5
0
-0.5
-1
0
30
60
G1 - Lucer
time

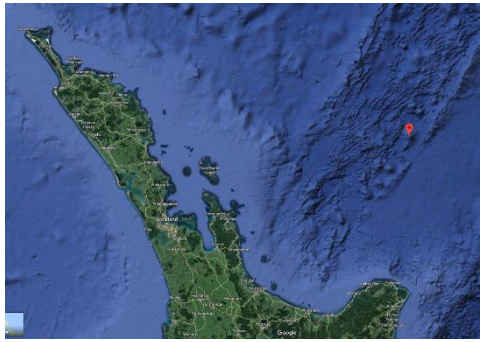
Rumble III



2008 **2010**

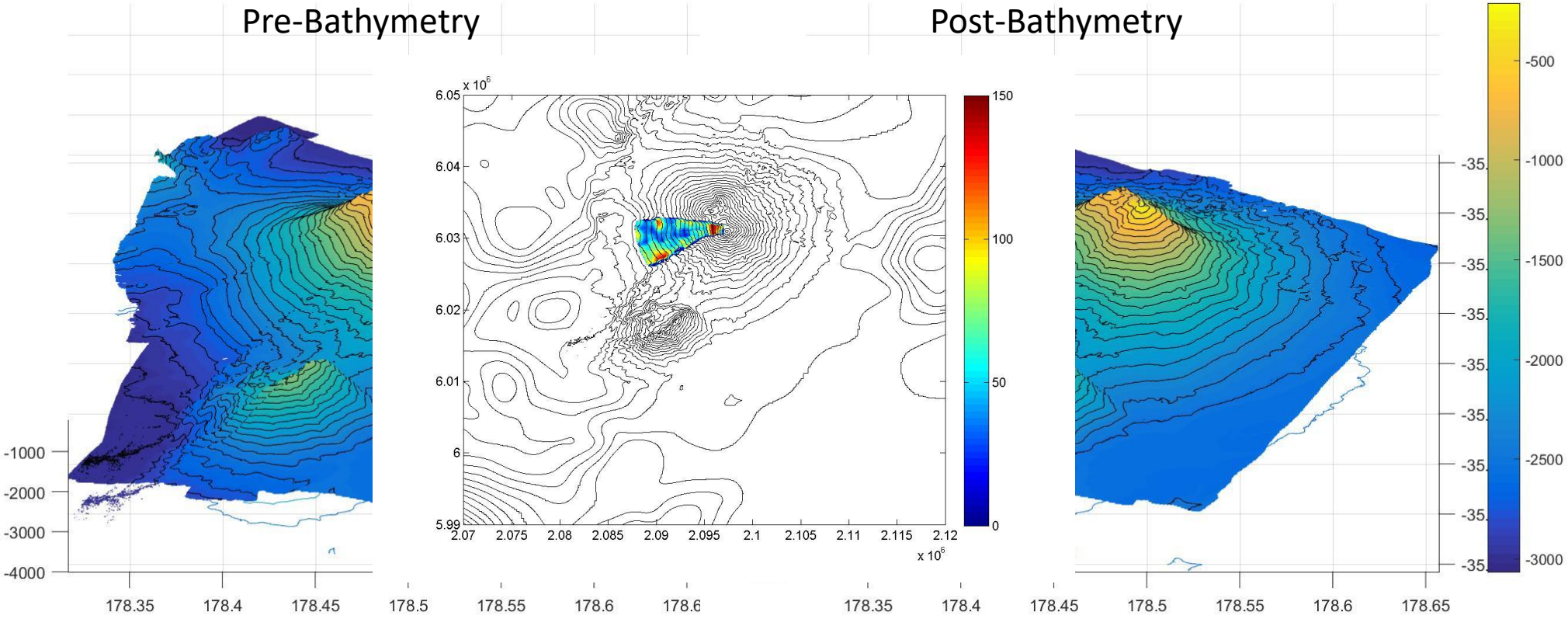


Rumble III

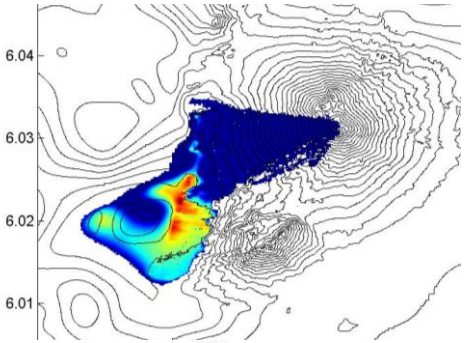


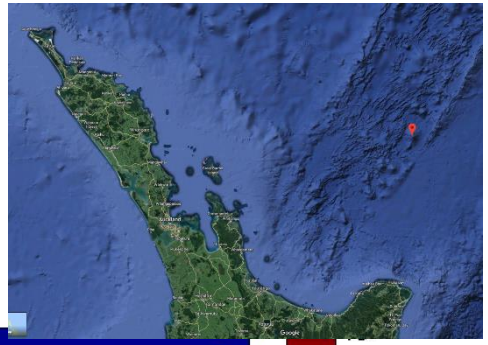
Pre-Bathymetry

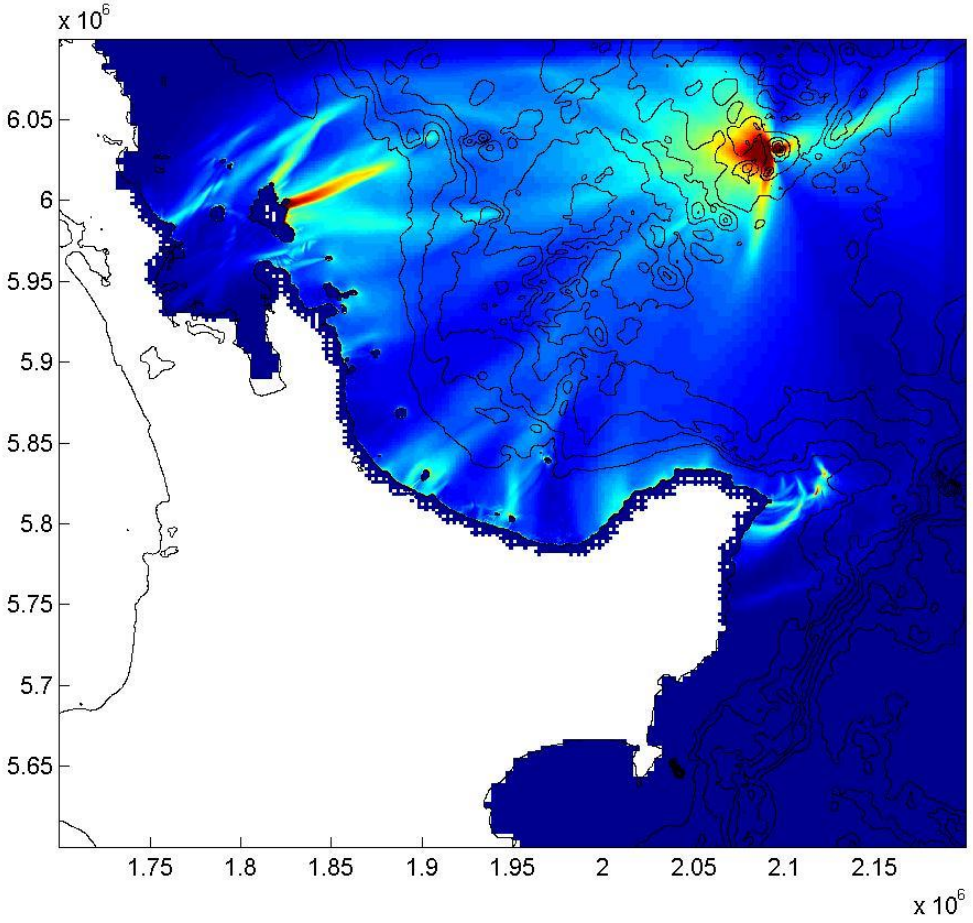
Post-Bathymetry

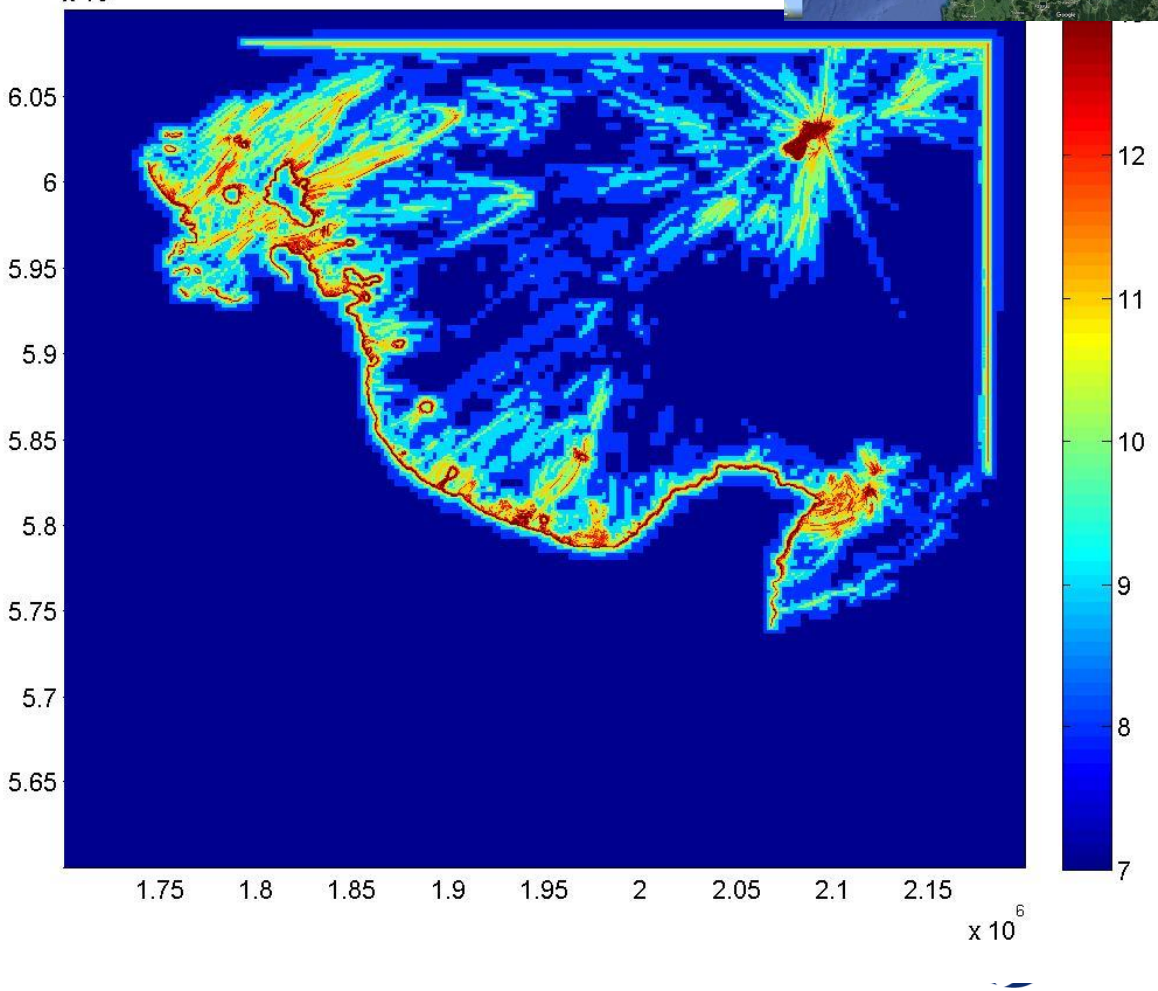


Rumble III

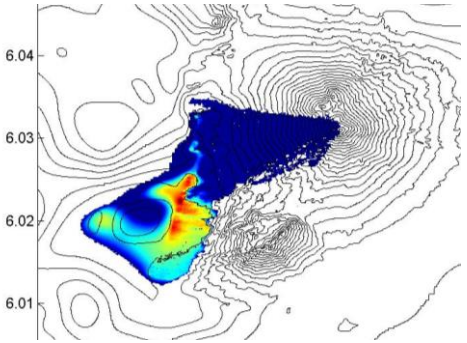

6.04
6.03
6.02
6.01
x 10

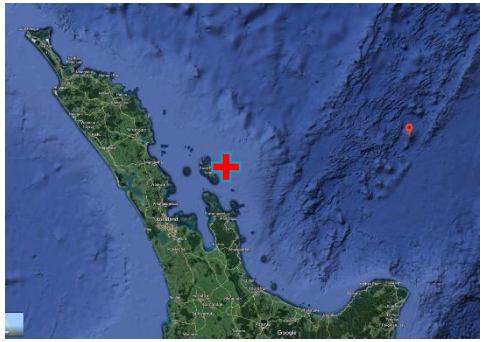


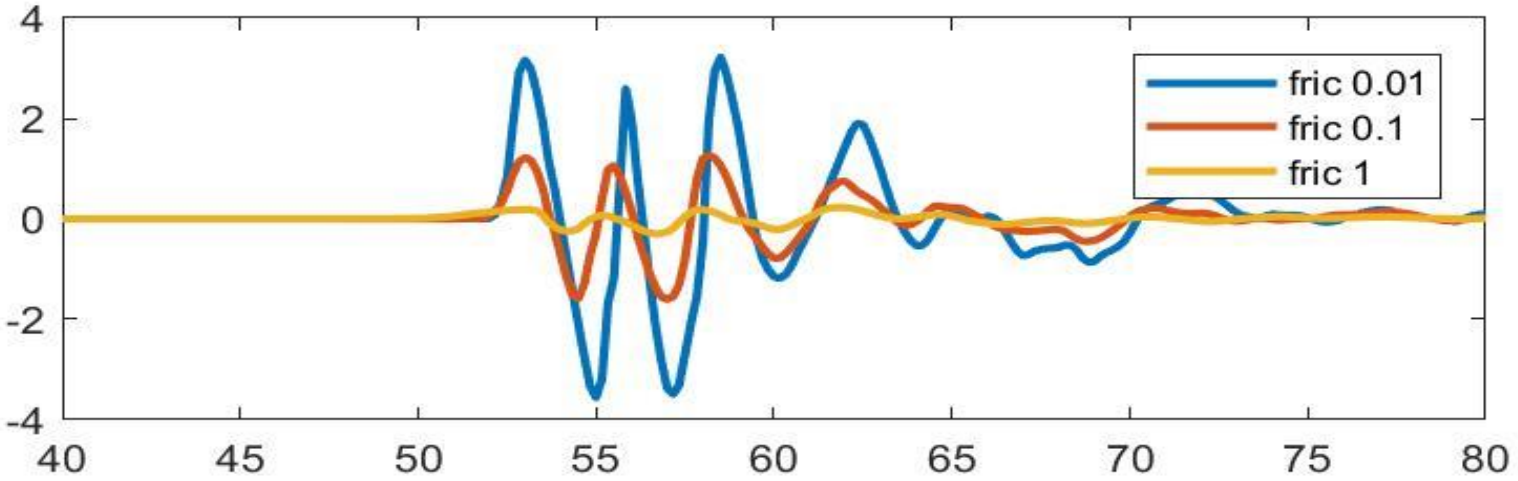

x 10^6
6.05
6
5.95
5.9
5.85
5.8
5.75
5.7
5.65
1.75
1.8
1.85
1.9
1.95
2
2.05
2.1
2.15
x 10^6

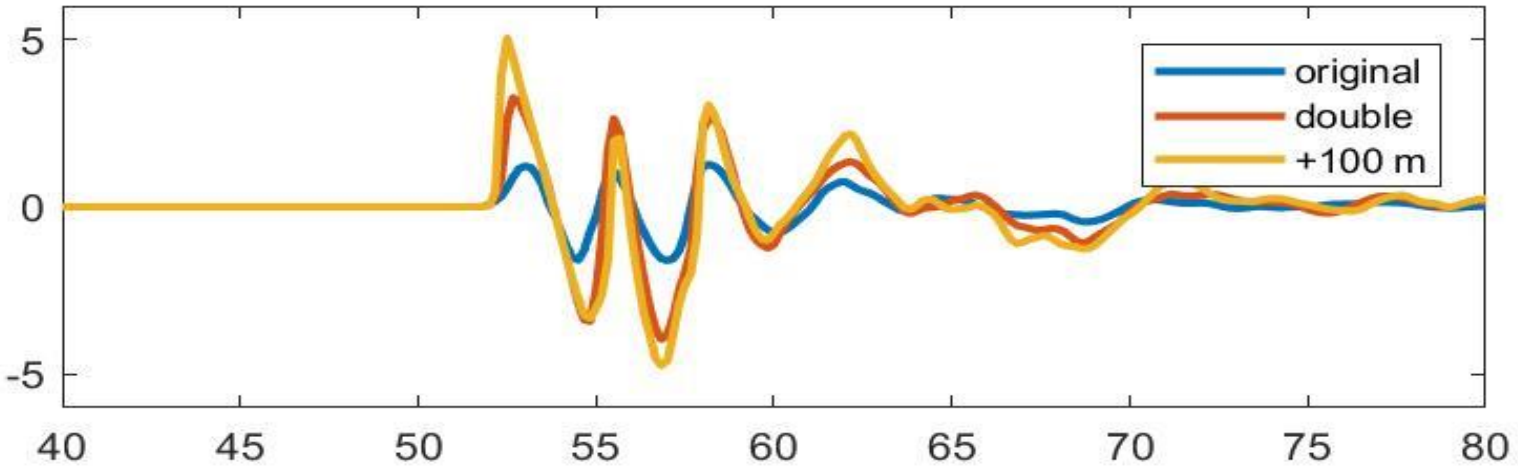

6.05
6
5.95
5.9
5.85
5.8
5.75
5.7
5.65
1.75
1.8
1.85
1.9
1.95
2
2.05
2.1
2.15
x 10^6
12
11
10
9
8
7

Rumble III









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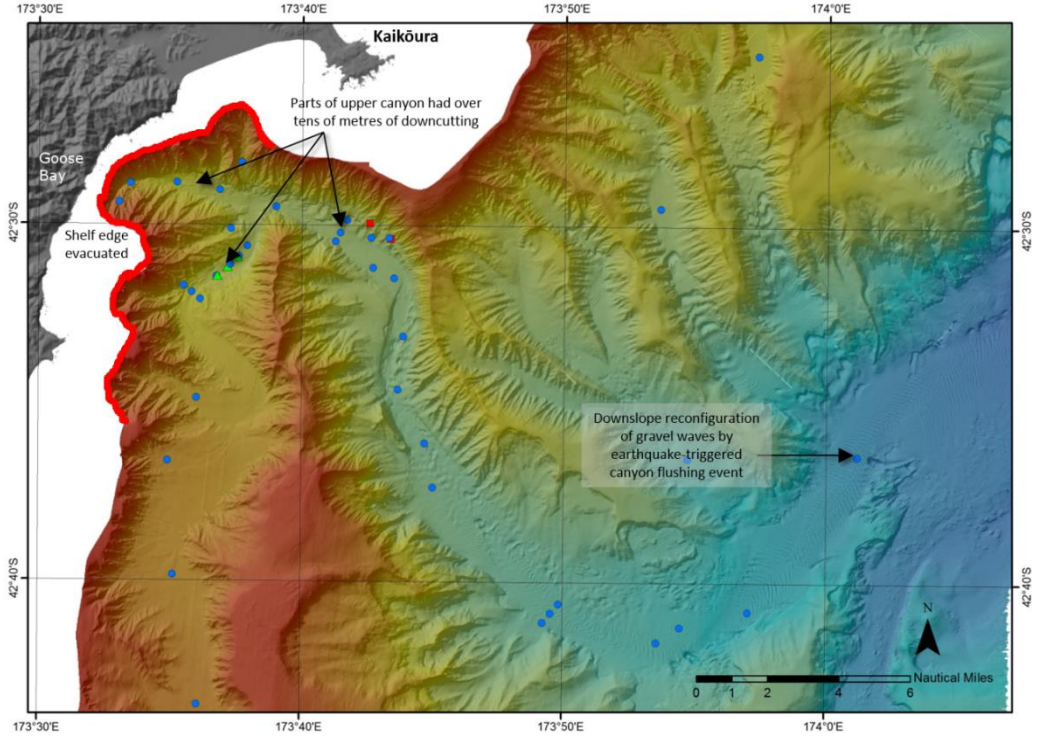
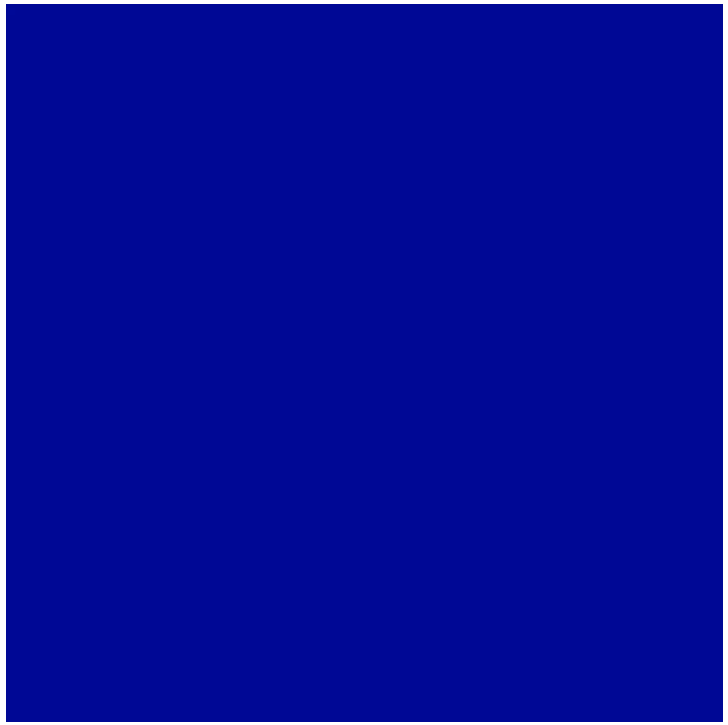
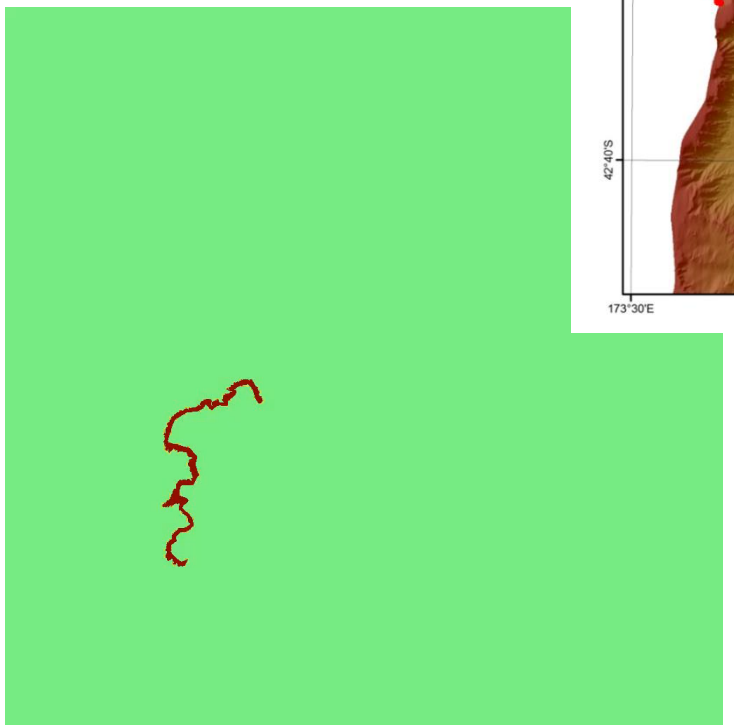
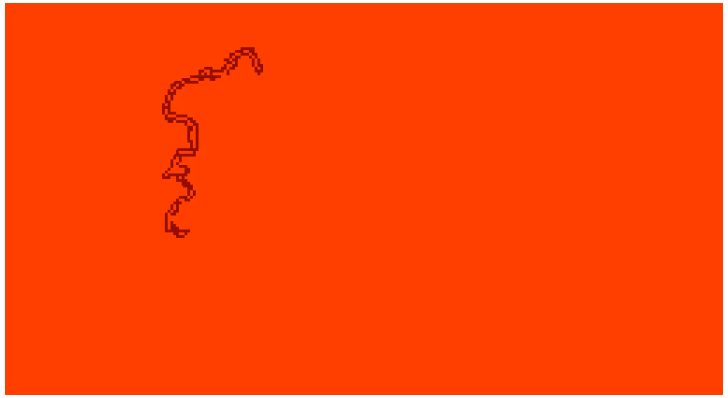
Kaikōura, November 14, 2016

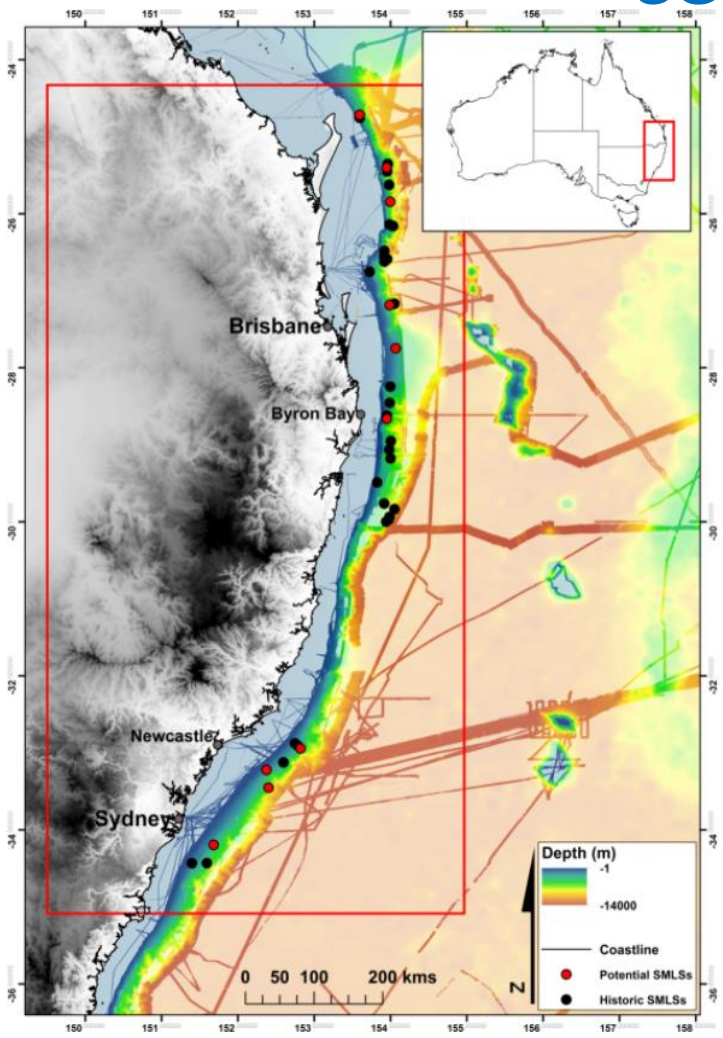








Submarine landslides along the east Australian continental margin



Kendall Mollison

Supervised by:
Dr. Hannah Power
Professor Kevin Hall

- 250 individual historic submarine landslide (SMLS) scars identified along the East Australian continental margin (EACM)
- 36 suggested by previous 2D empirical modelling to have tsunamigenic potential
- 13 potential SMLS identified through analysis of bathymetry

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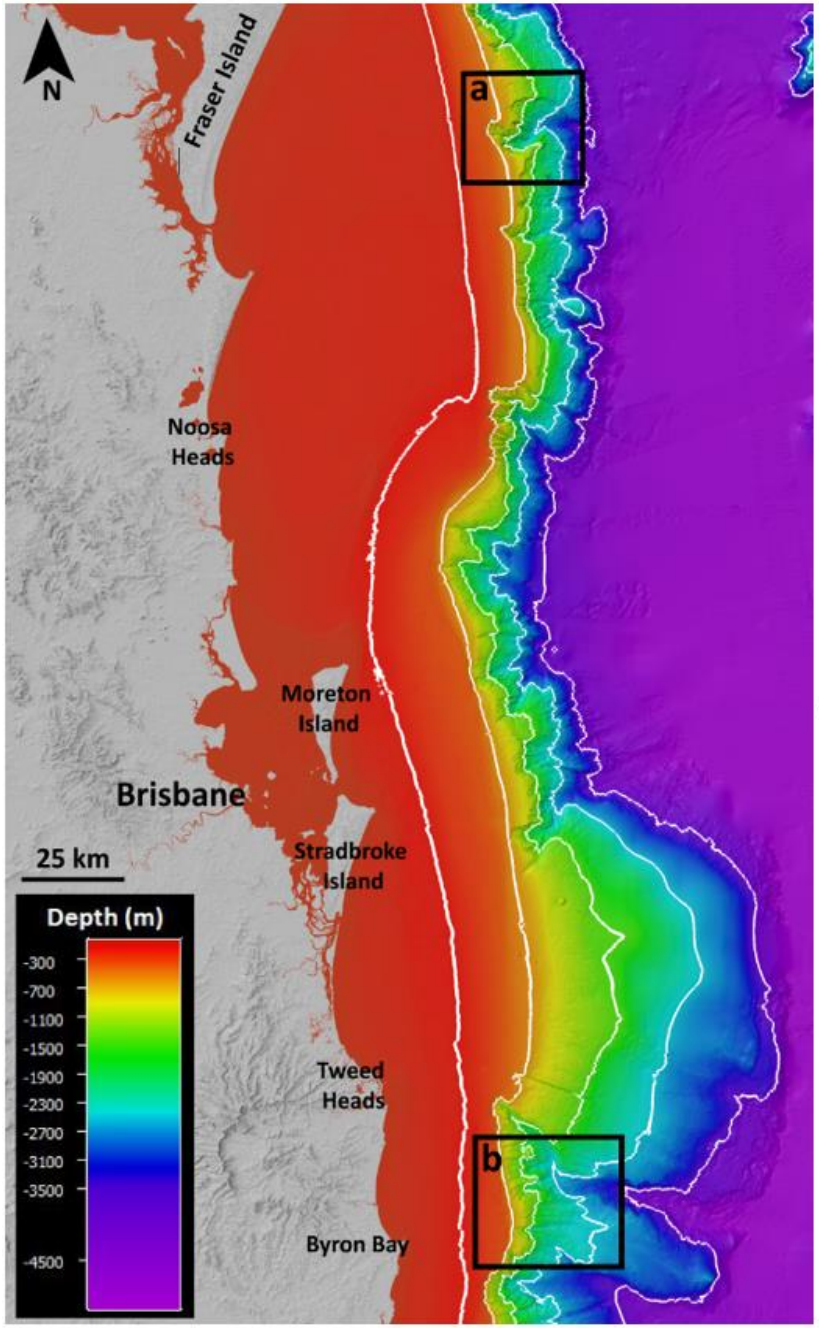

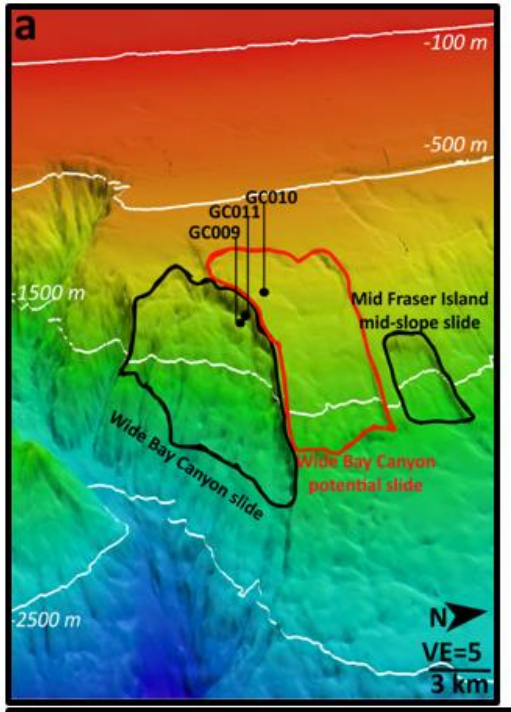

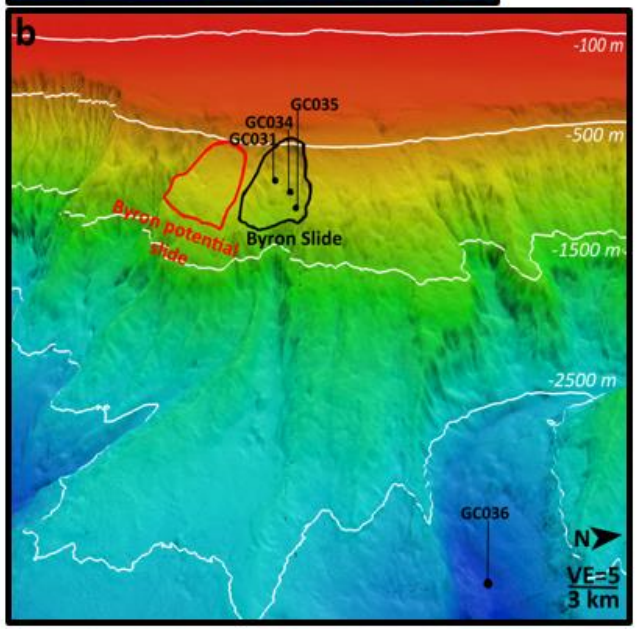

Research Aims:

- Analyse the SML sediments
- Rheology
- Ages
- **Model selected SMLS sites along East Australian Coastal Margin**
- Use Basilisk two-layer
- Quantify tsunami hazard of SMLS for EACM
- How rheology impacts tsunamigenic potential
- Coastal inundation maps
- Arrival times of SMLS events along the EACM

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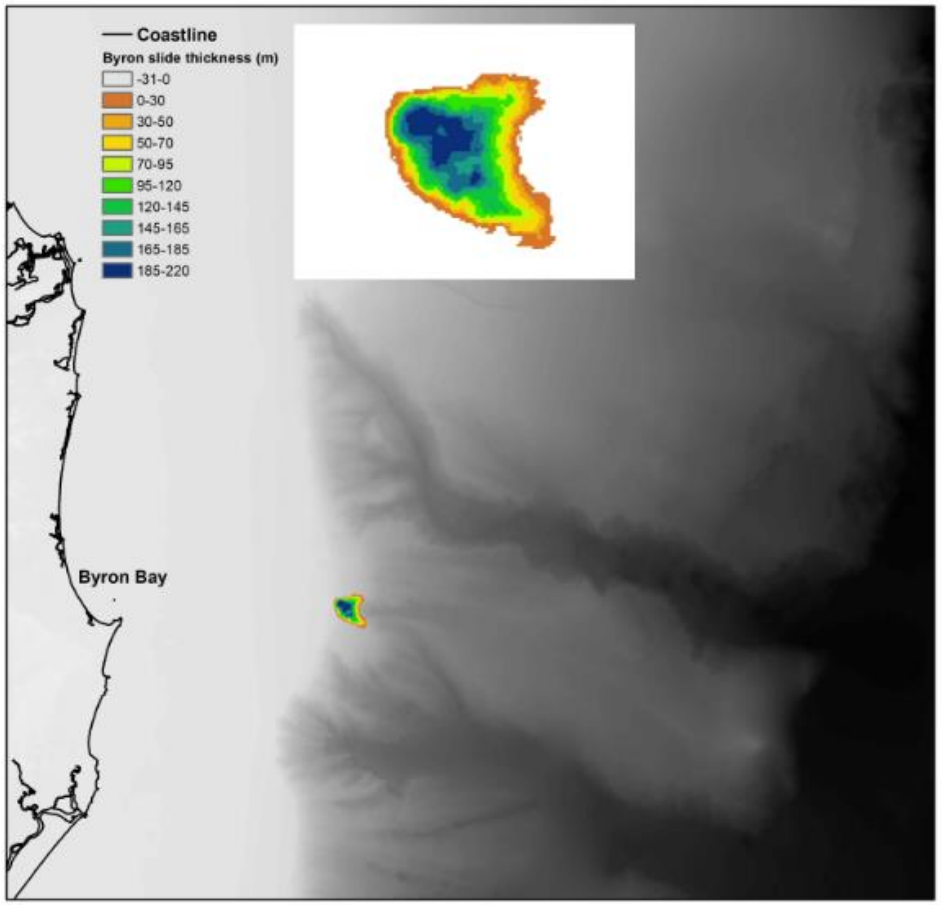
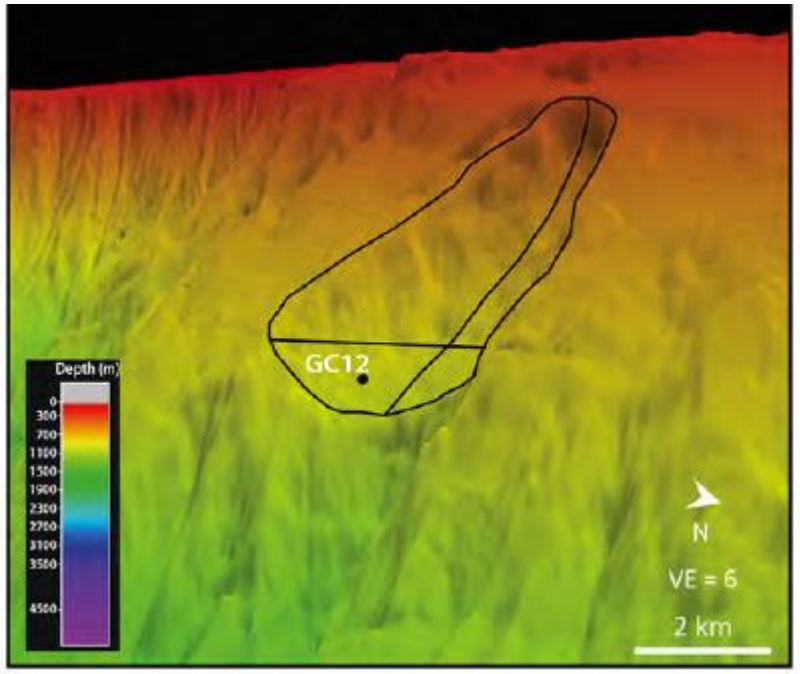
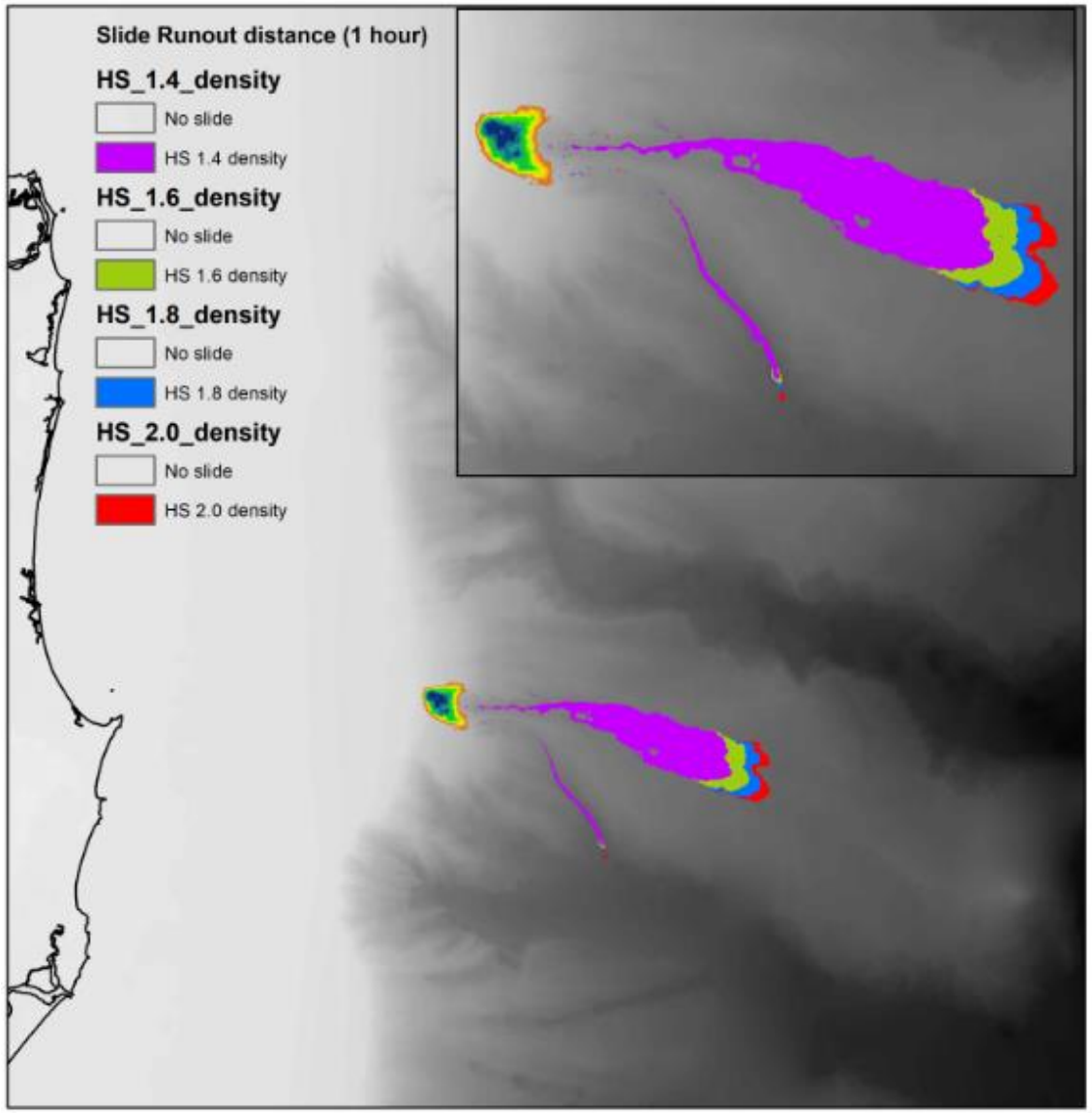
Byron Submarine Landslide Case Study



- 30 km offshore Byron Bay
- U-shaped
- Up to 220 m thick





- Sediment density for Byron region found from sediment cores → input into Basilisk
- Runout distance increases with density (over 1 hour)
- Pattern of runout shows good correlation with bathymetry

Issues and work to do

- Bug with refinement around h_s – spurious ripples
- Validation cases
- Better quantify rheology
- Dispersive Effects
- Very much a work in progress but happy for you to try it out/make improvements: - It's in my sandbox
- http://basilisk.fr/sandbox/Emily/two_layer.h

Thank you

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