

Combined Earthquake & Tsunami Losses for Wellington

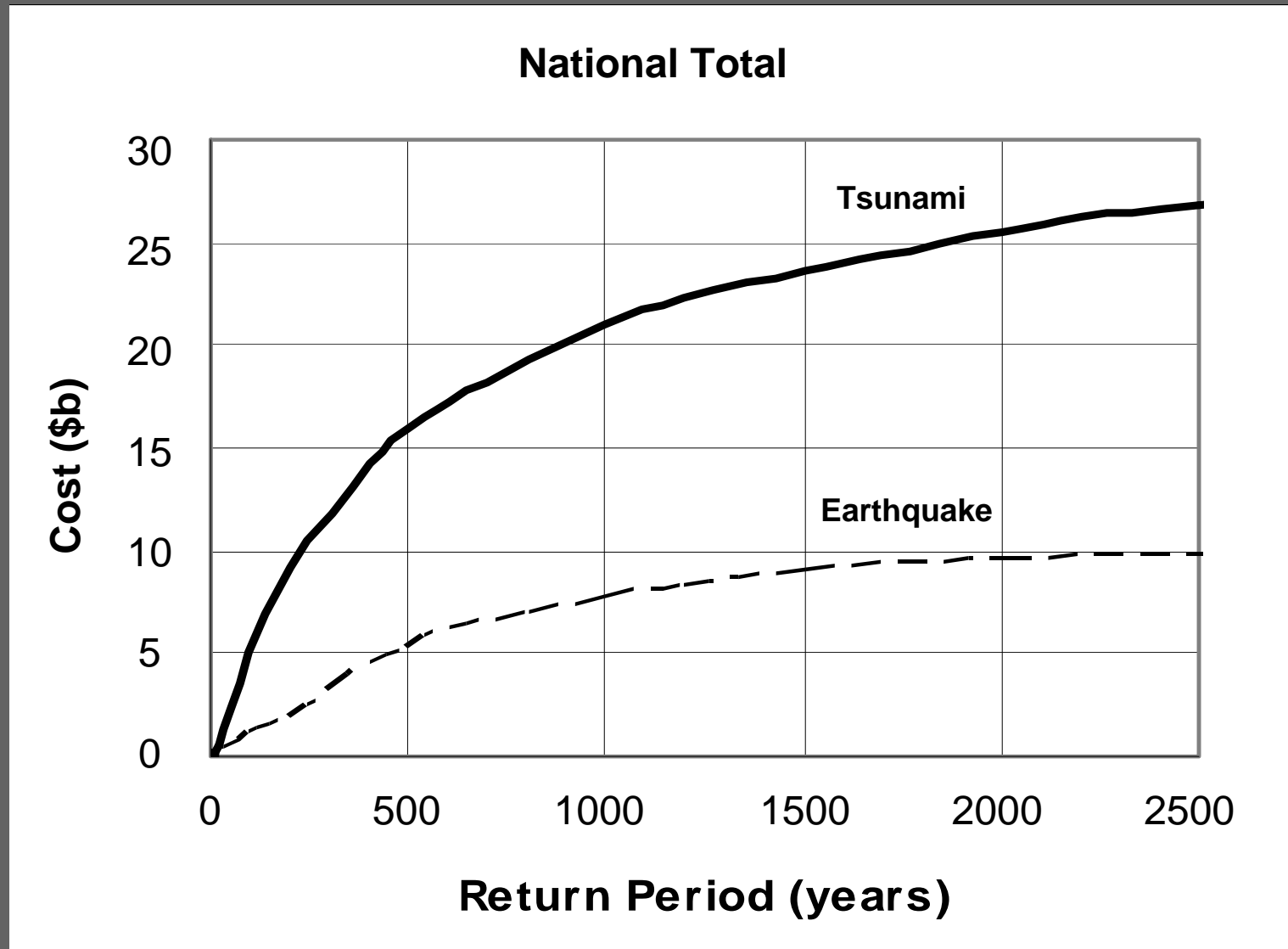
Jim Cousins, William Power, Umut Destegul, Andrew King



BENFIELD



Question from the Prime Minister (in 2005): ... what about NZ ?



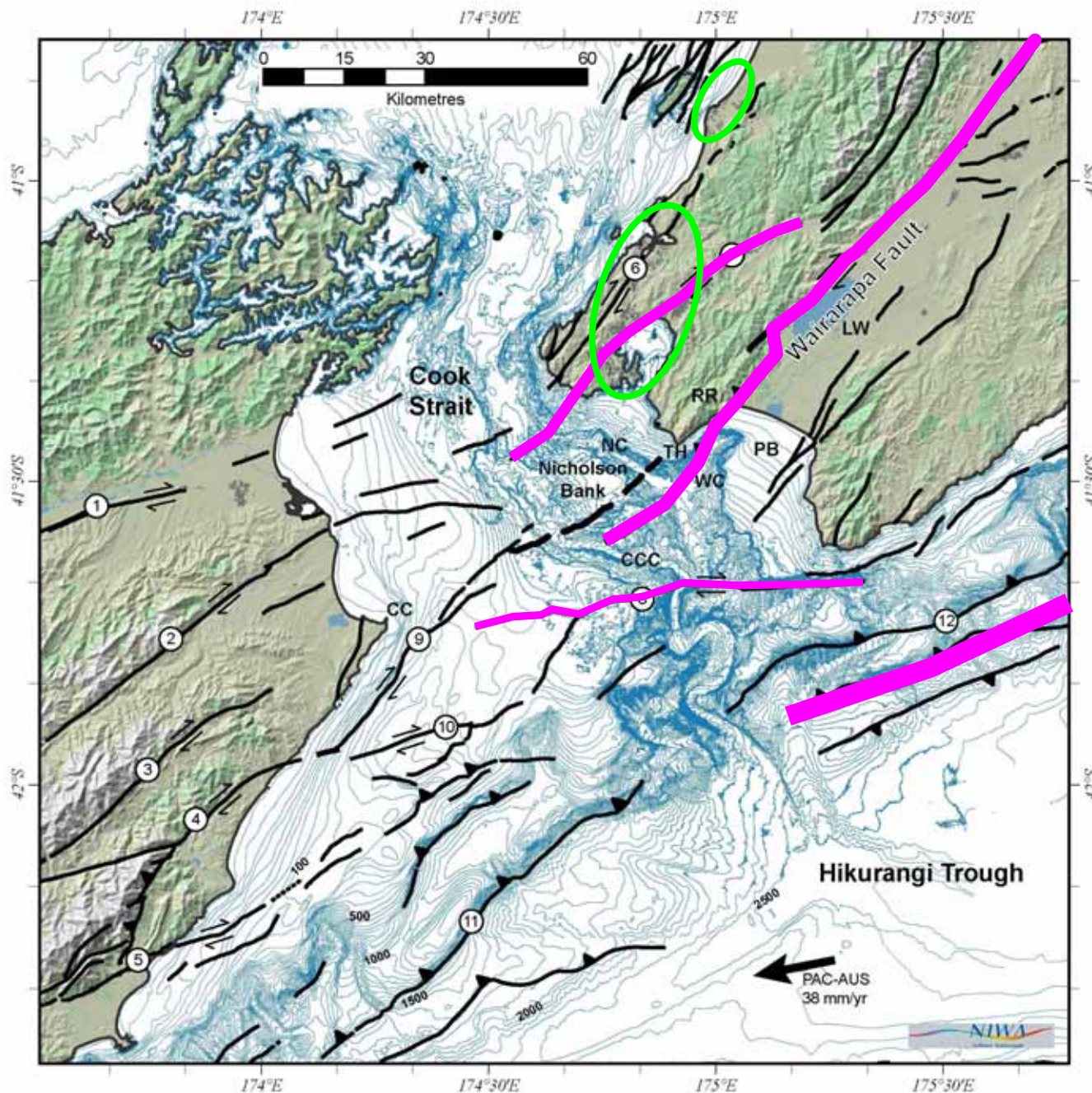
Question from Benfield (in 2006):

.... do we need to rethink our old favourite PML
for New Zealand – the Wellington Fault
Earthquake ?

(c. \$10-15 b event)

... most costly sources – earthquake shaking alone

| Source | Loss (\$ billion) |
|-------------------------------------|-------------------|
| Wellington Fault (magnitude 7.5) | 12 ± 5 |
| Wairarapa Fault (8.2) | 8 ± 5 |
| Ohariu Fault (7.5) | 6 ± 4 |
| <i>Subduction Zone (8+ ?)</i> | <i>5+ (?)</i> |
| Pukerua-Shepherds Gully Fault (7.5) | 5 ± 2 |
| Napier 1931 Fault (7.8) | 4 ± 2 |



... add tsunami to the scenarios

- Wellington Fault
- Wairarapa Fault
- BooBoo Fault
- Plate interface
- ~~Landslides~~

Note: Booboo Fault was embellished a bit !



... assets at risk

... elevation & bathymetry

Kapiti Coast

Porirua

Lower Hutt

Petone

Eastbourne

Wellington

CBD

Evans Bay

Seatoun

Lyall Bay

Island Bay

Owhiro Bay

Rock ledge, seaside cliffs



Low-lying, flat



Wellington – CBD – waterfront



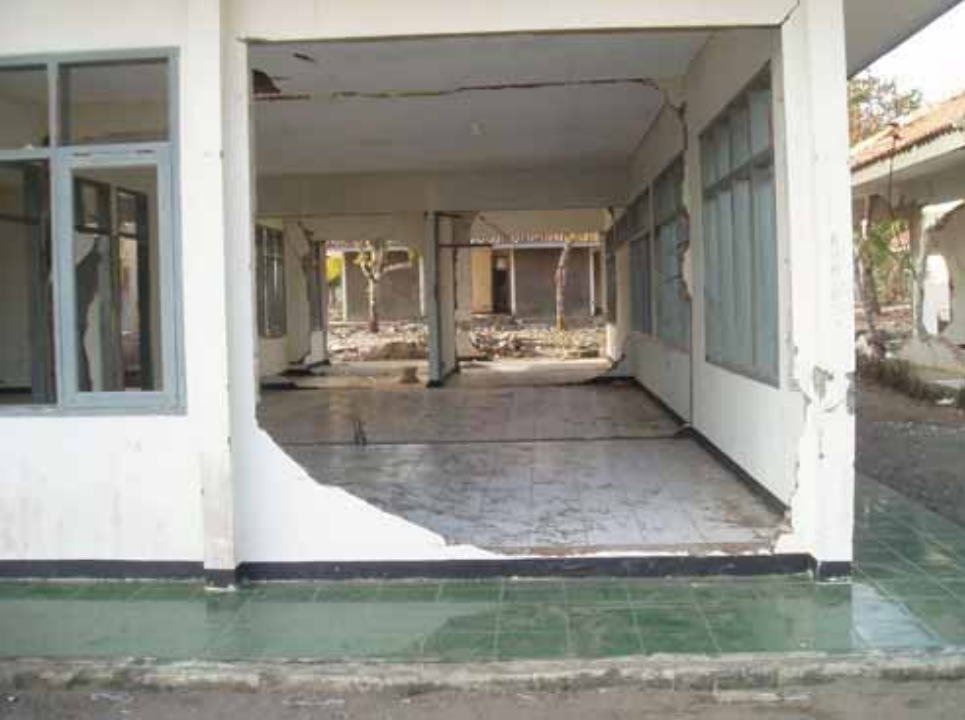
Wellington – expensive stuff

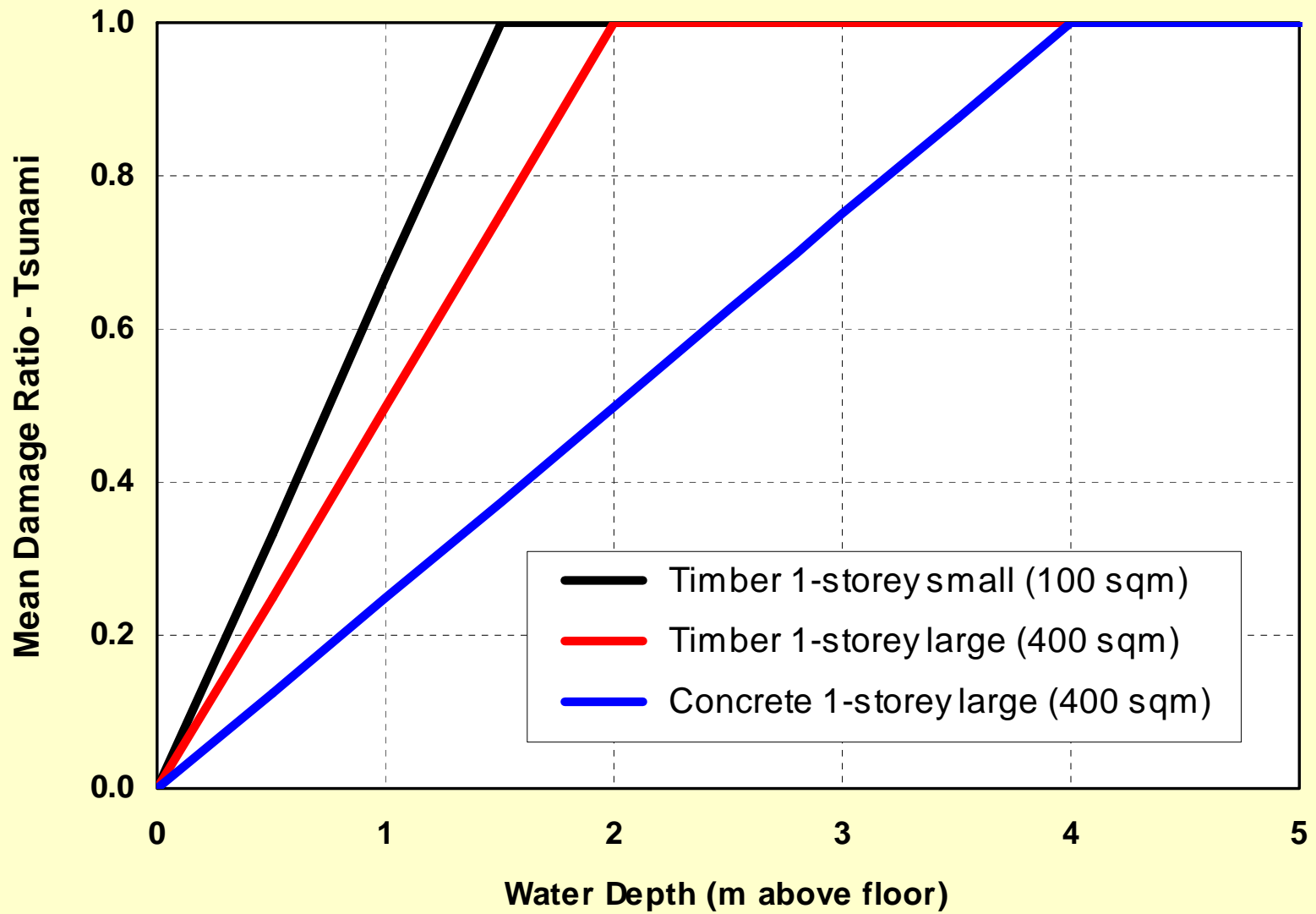


Assets Model

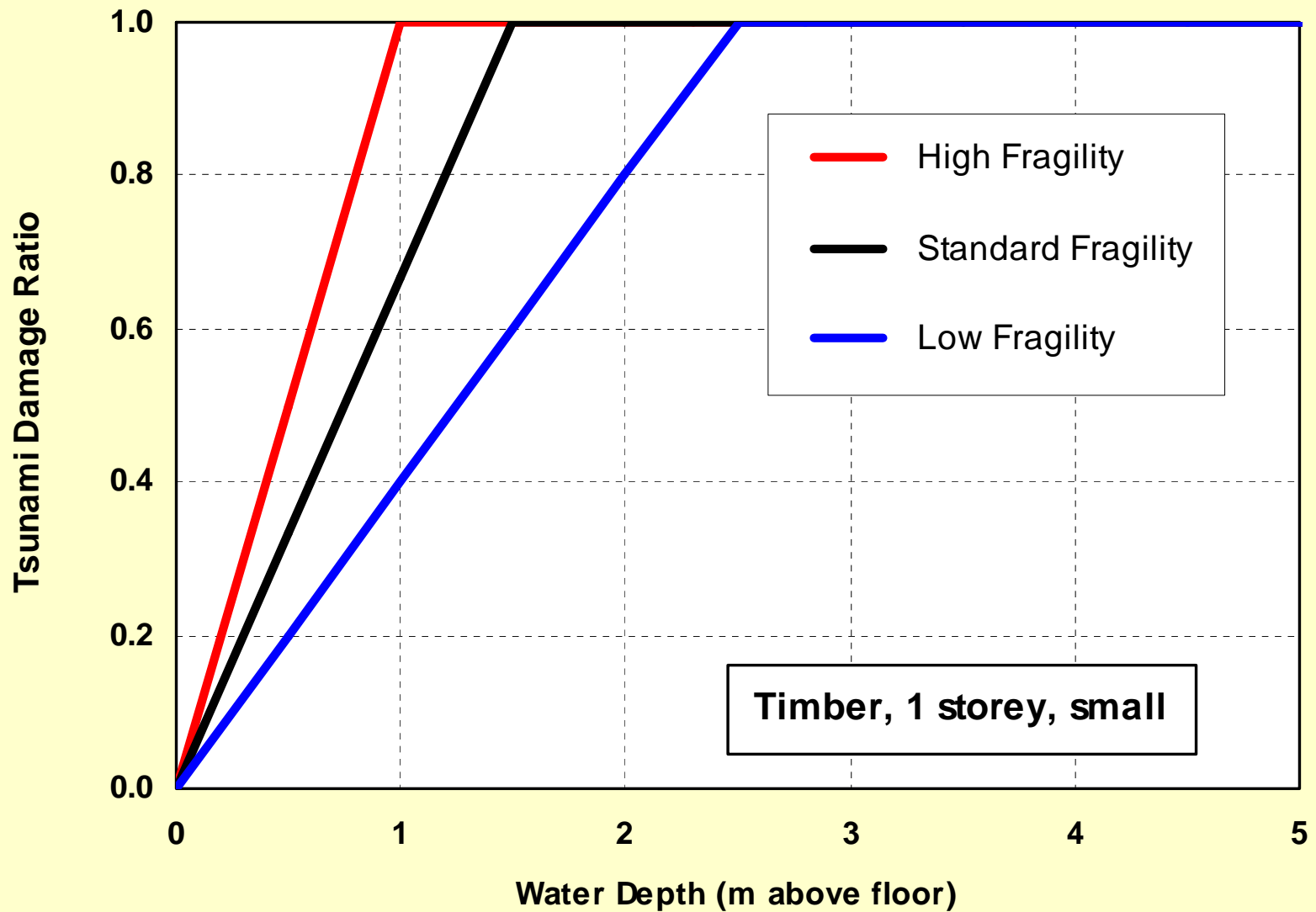
- 160,000 residential
20,000 non-residential
- data sources
 - ... councils (footprints, earthquake-risk buildings)
 - ... QV property
 - individual for 12,000 large (300 m²) properties
 - aggregated by meshblock for all of NZ
 - ... site visits & personal knowledge
- composite model
 - ... footprint, property, meshblock aggregate

Fragility Model





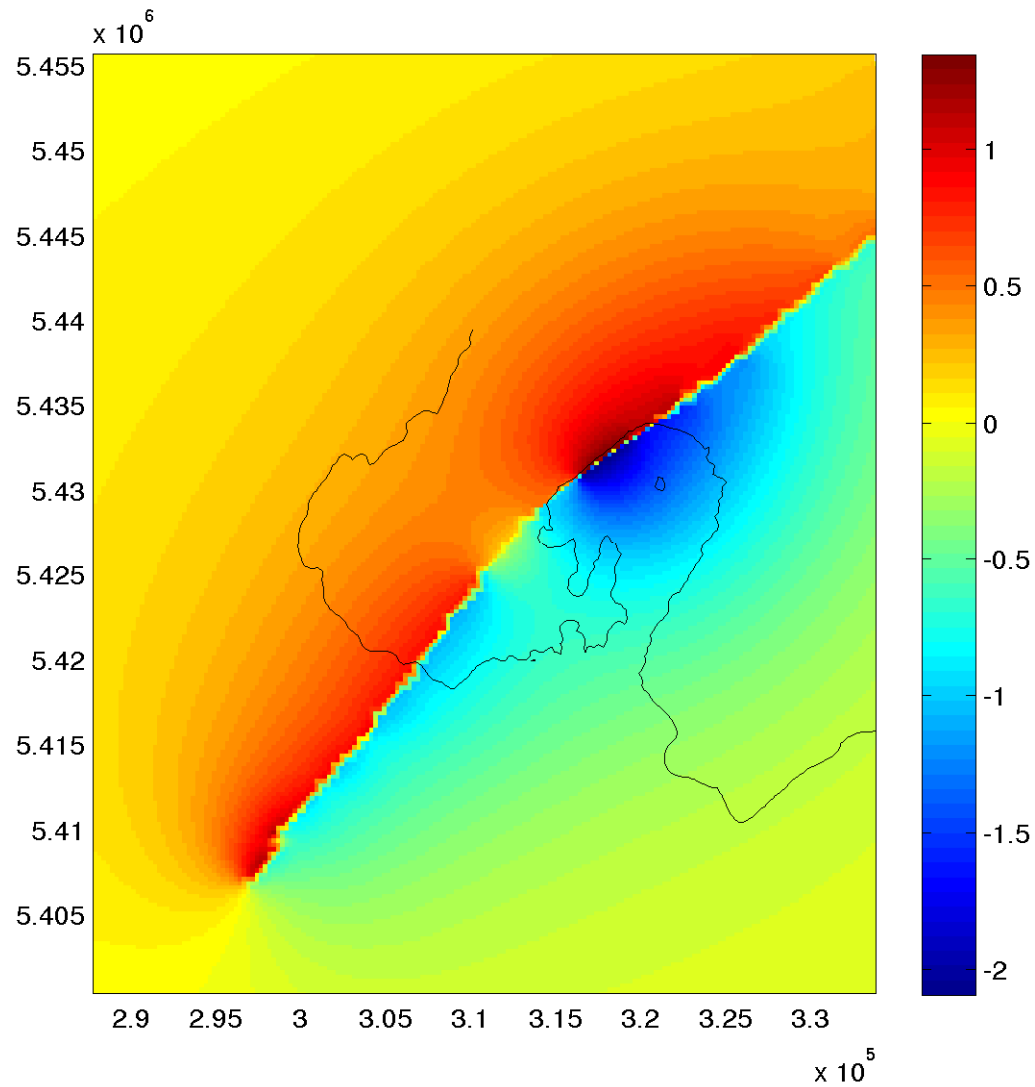
Uncertainty in fragility function



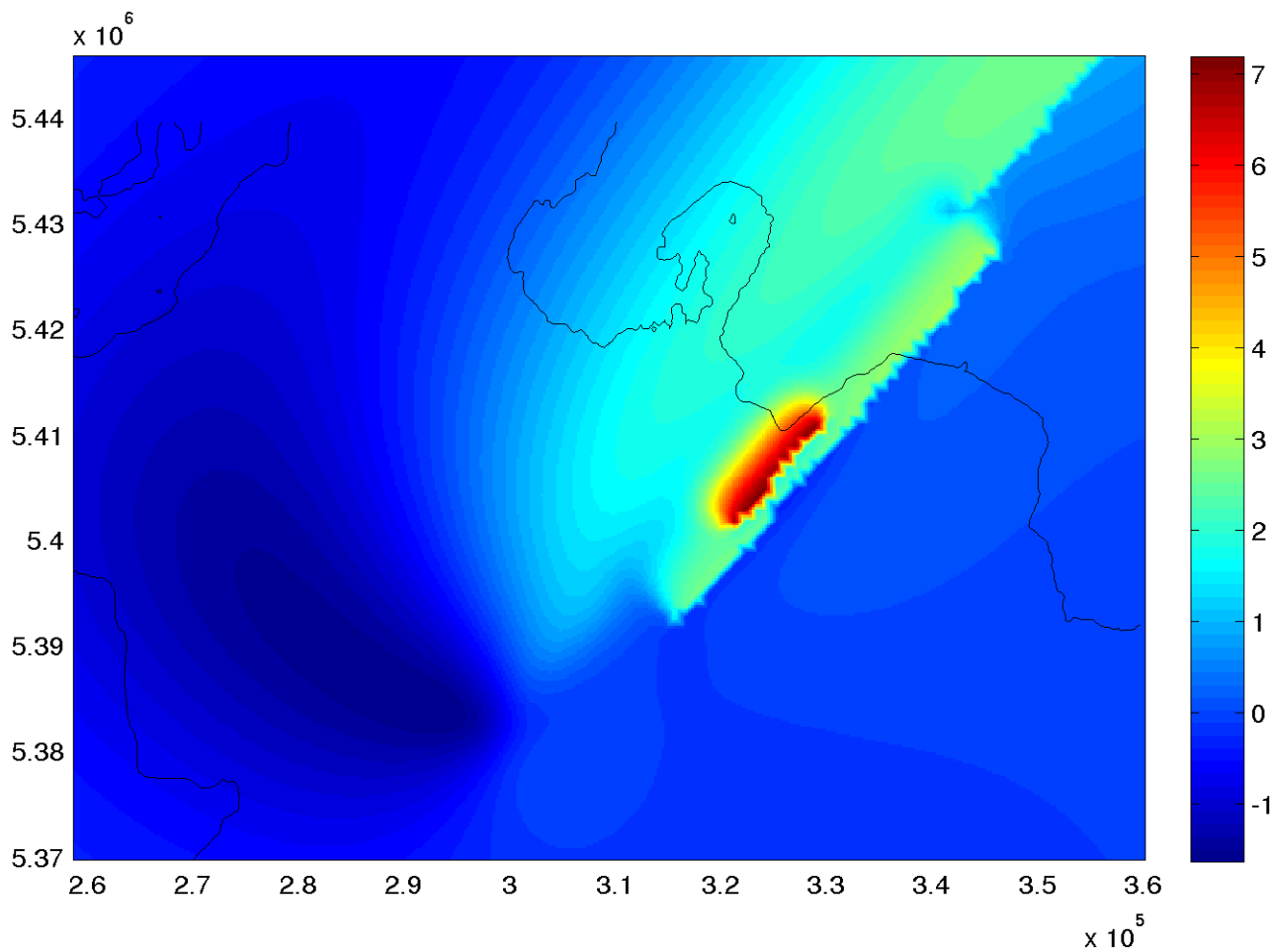
Inundation Modelling – ANUGA

- Developed by scientists at Geoscience Australia and ANU
- Solves non-linear shallow water equations, and models wetting-drying of land
- Finite element method allows modelling to take place on an unstructured mesh
 - Arbitrary boundary shapes
 - Various boundary conditions available
 - Variable triangle density
 - One unstructured mesh - no need for nested grids – easy to incorporate co-seismic uplift
- Python scripting permits great flexibility
- Open source software – quick feedback

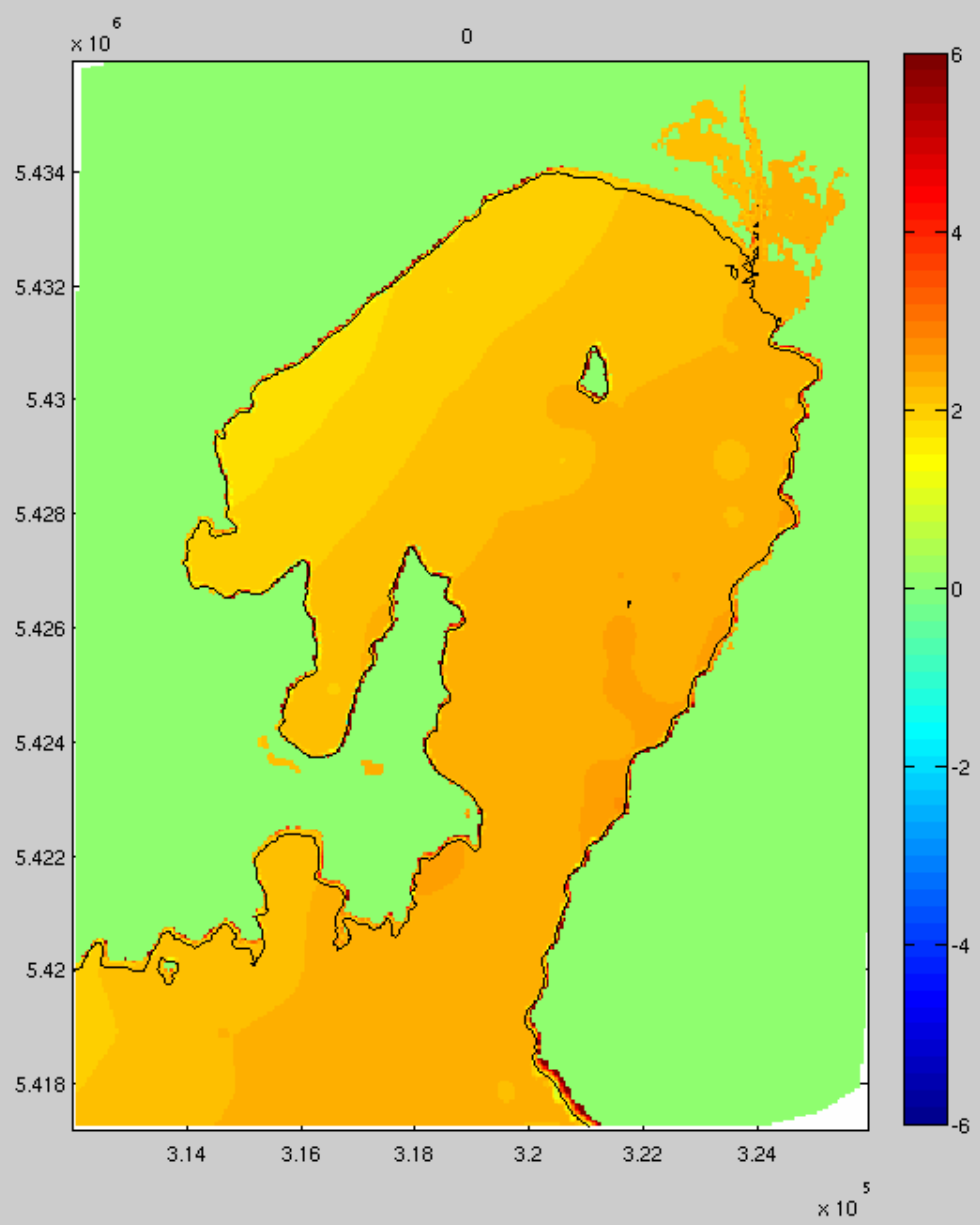
Wellington Fault - vertical deformation in metres



Wairarapa Fault Vertical deformation in metres

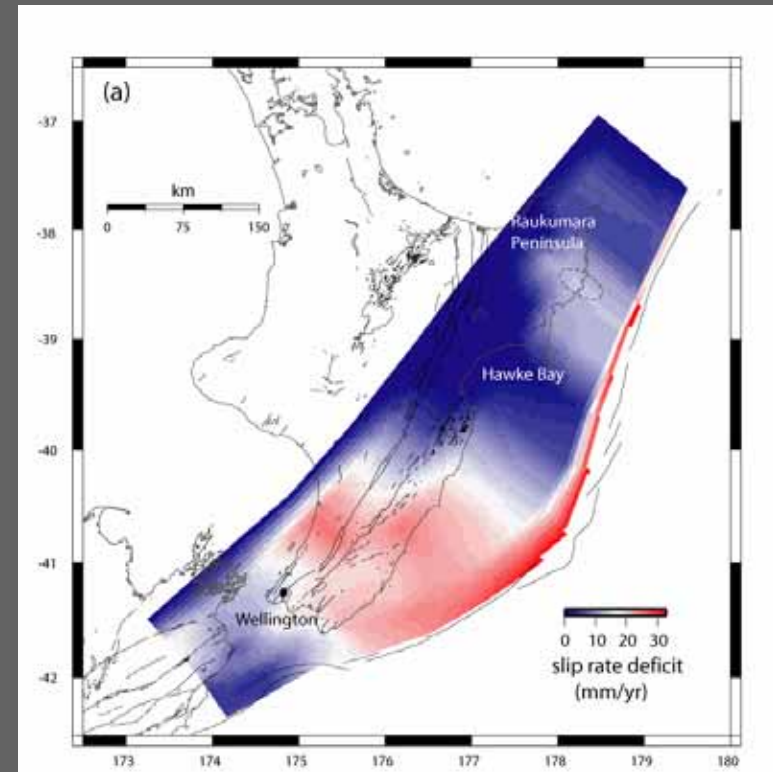


1855 reconstruction



Subduction zone

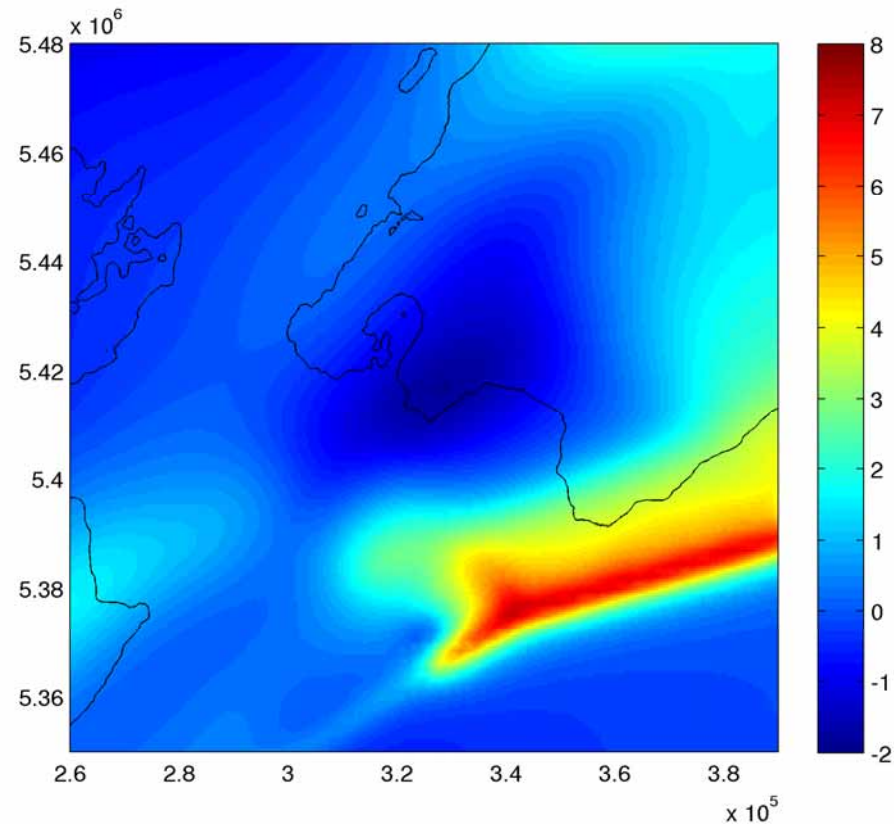
- Variation of near surface rupture
 - Termination at 'seismic front'
 - Splay fault rupture
 - Rupture to trench
- Return time
 - 400 to 1200 years
- Southern termination
 - Limit of GPS confirmed locking ~ Cape Palliser
 - Extending into Cook Strait



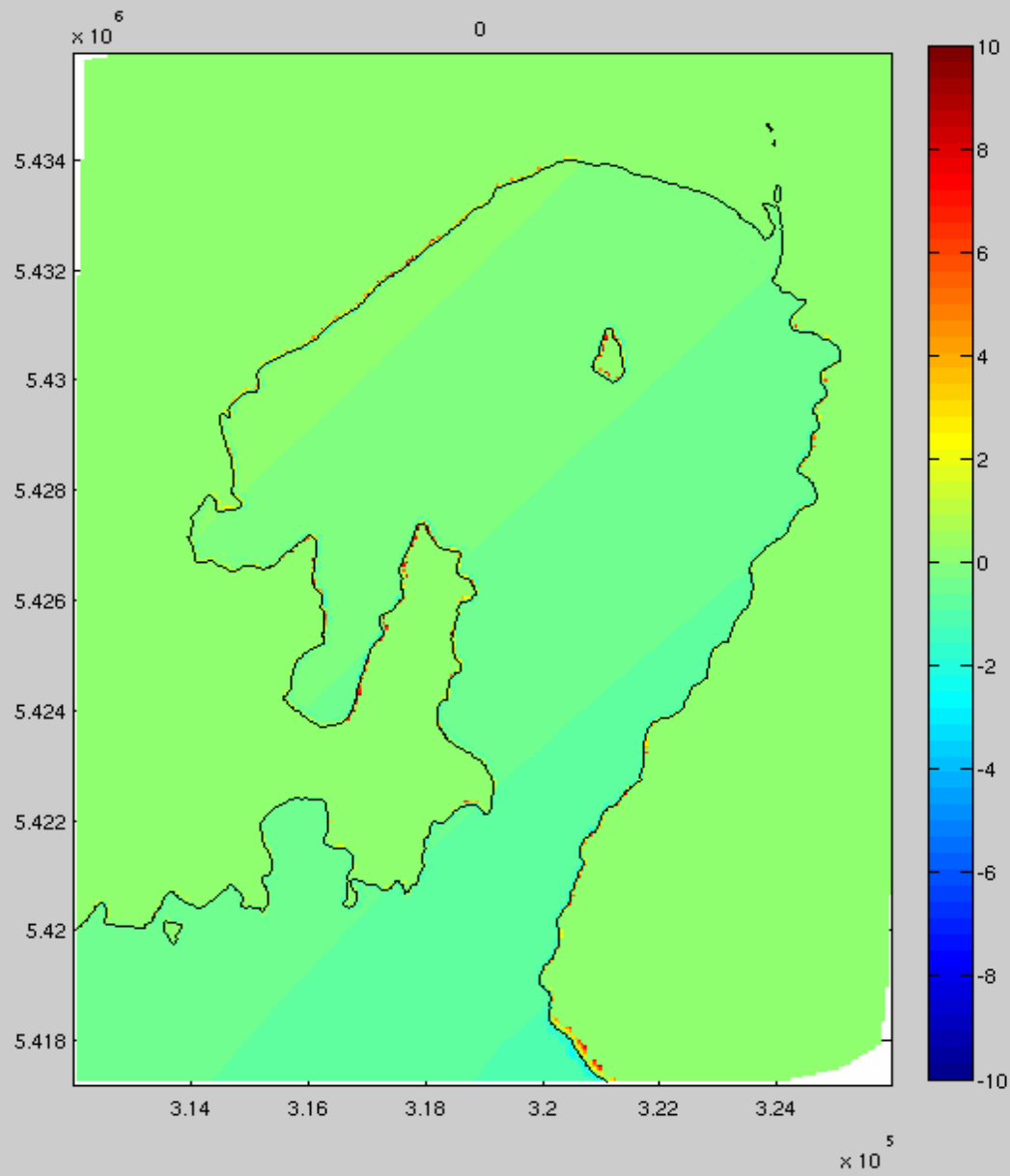
Distribution of slip rate deficit on the Hikurangi subduction interface, estimated from ~12 years of campaign Global Positioning System (GPS) site velocities (Wallace et al., 2004).

Subduction-interface rupture extending into Cook Strait

- 1200 year return time
- Rupture to seabed on interface
- 12-18m slip in this region
- Mw 8.9



Subduction into Cook Strait model



Estimated Losses

| Tsunami Source | Shaking Loss | | Tsunami Loss | |
|------------------------------------|--------------|-----|--------------|------|
| | (\$m) | (%) | (\$m) | (%) |
| Wellington, mag. 7.5 (base case) | 13,700 | 18 | 41 | 0.05 |
| Wairarapa, mag. 8.2 | 9,200 | 12 | 14 | 0.02 |
| BooBoo (embellished), mag. 7.4 | 800 | 1 | 1 | 0 |
| Subdn to Cook, mag. 8.9, 1200 y RI | 6,100 | 8 | 2,300 | 3 |

| | | | |
|------------------------------------|--------------------|-------|-----|
| Subdn to Cook, mag. 8.9, 1200 y RI | Worst-case tsunami | 3,500 | 4.5 |
| Subdn to Cook, mag. 8.9, 1200 y RI | Best-case tsunami | 1,200 | 1.5 |

- fragility function high / low
- floor height 0 / 1 m above ground
- prior quake damage increases / does not increase tsunami fragility



Kapiti Coast

Porirua

Lower Hutt

Petone

Eastbourne

CBD

Wellington

Evans Bay

Seatoun

Lyall Bay

Island Bay

Owhiro Bay



Scenario:

- Subduction to Cook
- Mag. 8.9
- 1200 yr recurrence interval

Main Findings

- tsunami does not add significantly to New Zealand's most costly earthquake
- or to the second most costly
- Porirua and Kapiti experience very little tsunami damage in the scenarios considered here
- a very large subduction zone earthquake is the worst local tsunami source
- losses from the most costly earthquake, magnitude 7.5 Wellington Fault, are greater than the combined losses from the worst tsunami-causing earthquake
- tsunami from very large South American earthquakes might be able to cause higher losses
- we haven't looked at casualties