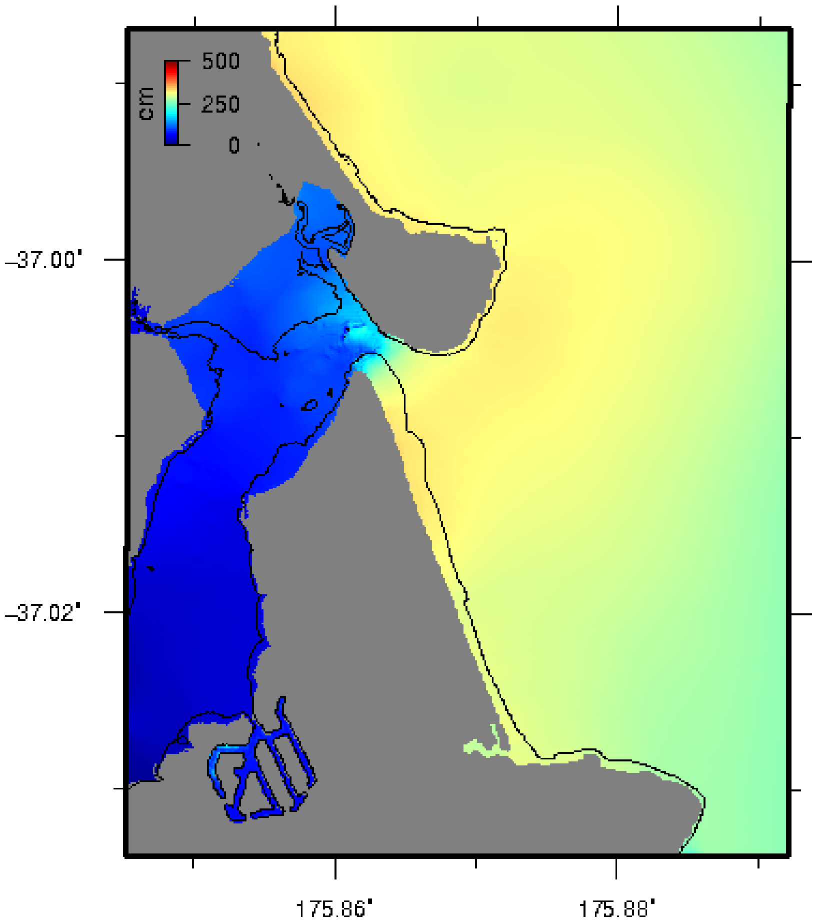
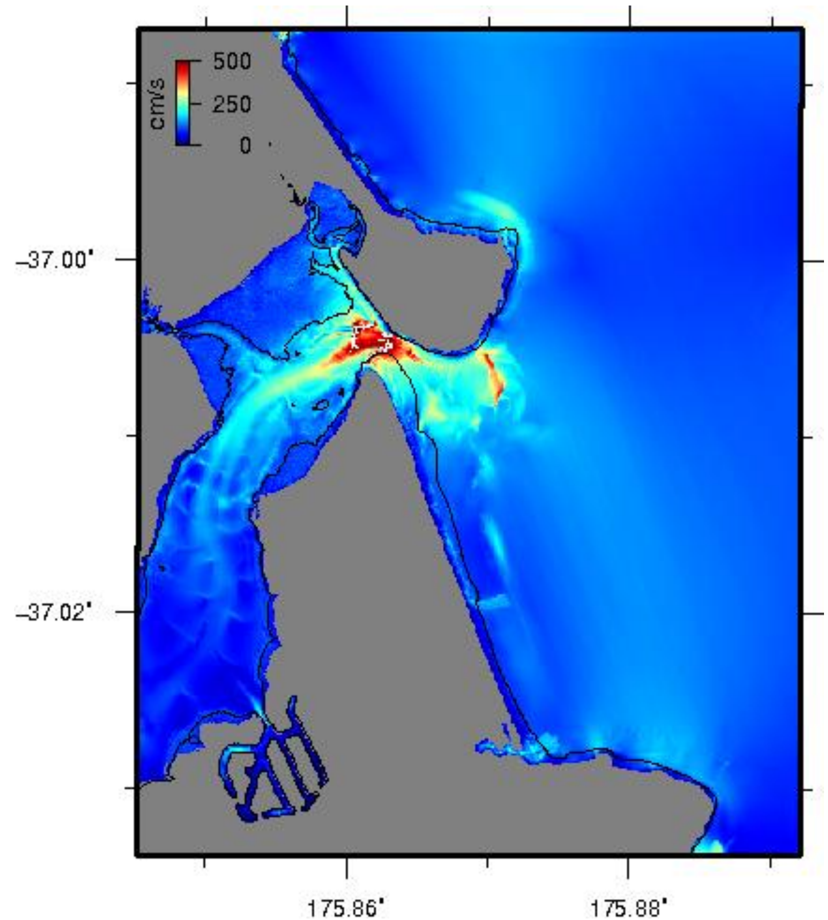
Tsunami Inundation Modelling for Tairua & Pauanui





Jose C. Borrero, Ph.D.

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Study Objectives

- Review previous studies
- Compile updated relevant scientific literature
- Assess tsunami inundation in Whitianga from the 1960 Chile tsunami
- Assess tsunami inundation in Tairua/Pauanui for a South American and Kermadec trench earthquake scenarios.

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Previous Studies

- Prasetya et al. (2008) - Univ. of Waikato report
- Prasetya and Wang (2011) – GNS report
- Bell et al. (2004) – NIWA/GNS

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Modelling Approach

- Need to update model
  - 3DD modelling by Prasetya was not repeatable
- Specialized and more easily expandable modelling tools are available
  - The ComMIT modeling system

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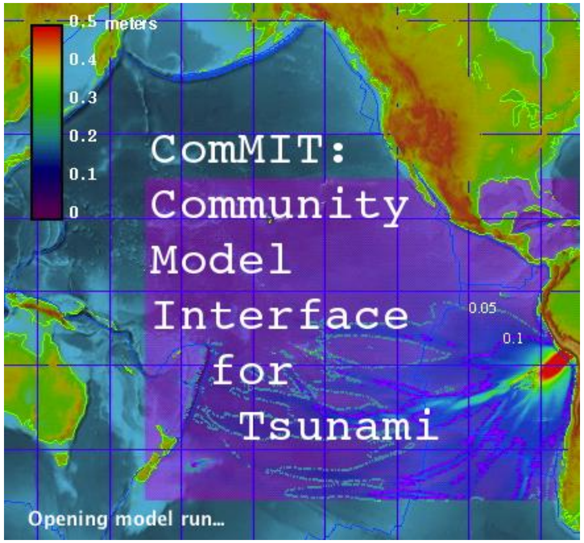
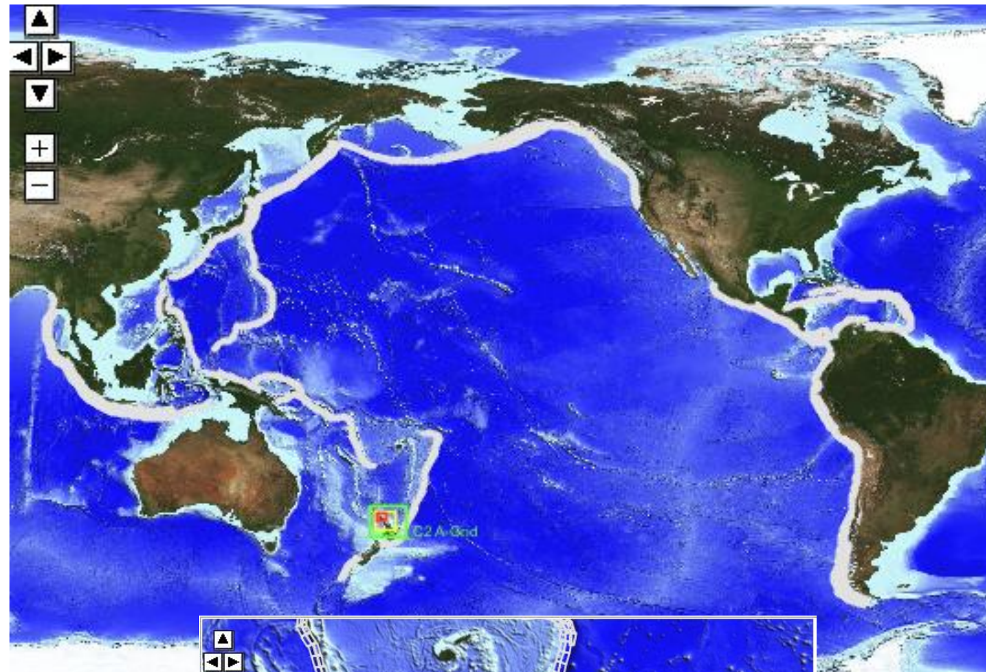
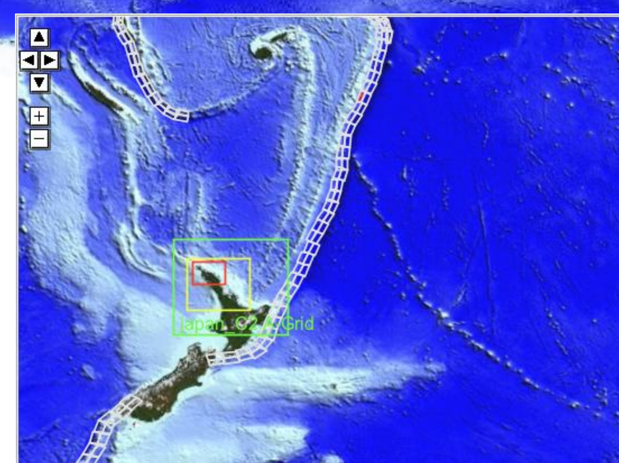
ComMIT

- **Com**munity **M**odel **I**nterface for **T**sunamis







•Database driven
•Unit source approach
•Propagations results downloaded from web
•Inundation run locally on user controlled bathymetry

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Earthquake Source Models

- Explored the effect of uniform vs. distributed slip at the source on tsunami in Whitianga.
- Updated information regarding the 1960 earthquake: Fujii and Satake (2012).

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Model Calibration and Sensitivity

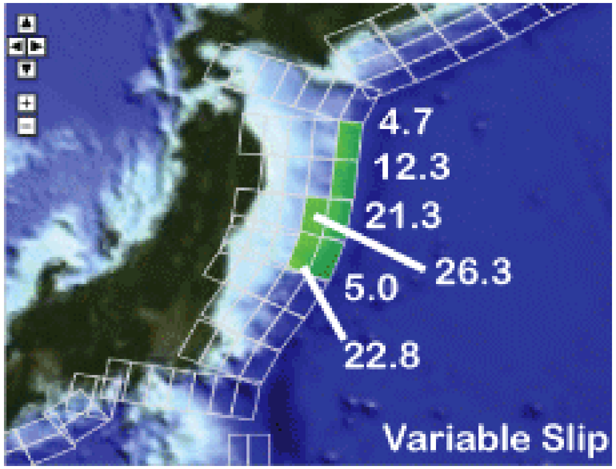
Instrumental Calibration:

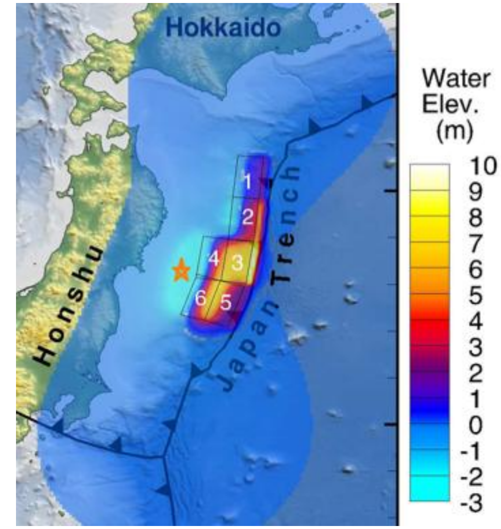
- Tohoku 2011
- Chile 2010

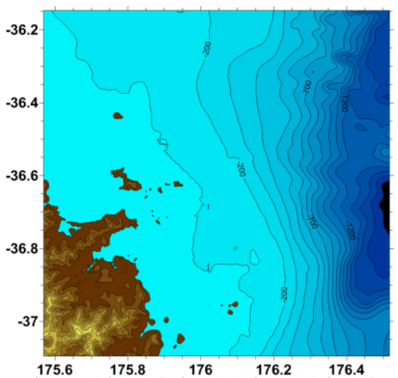
Qualitative Calibration

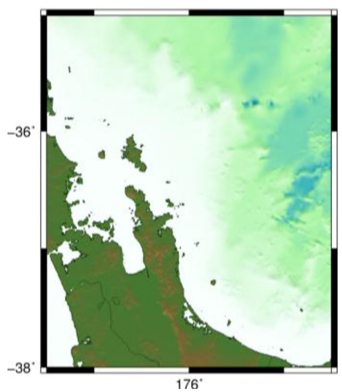
- Chile 1960

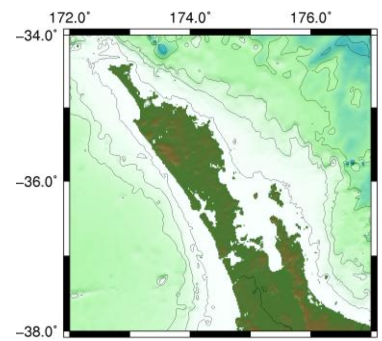
Tohoku 2011

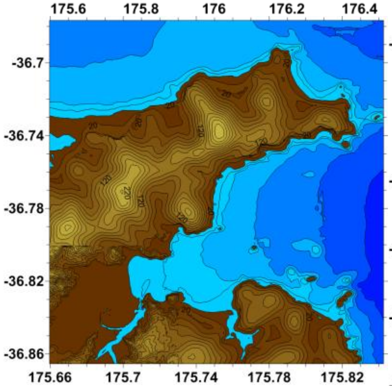

4.7
12.3
21.3
26.3
5.0
22.8
Variable Slip

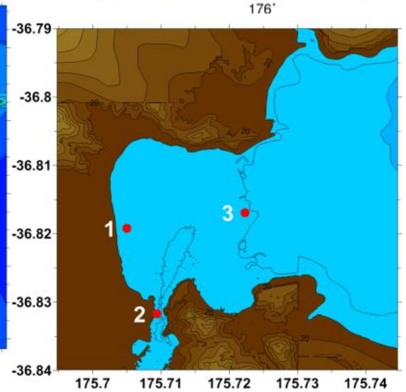

Hokkaido
Honshu
Japan Trench
1
2
3
4
5
6
Water Elev. (m)
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3

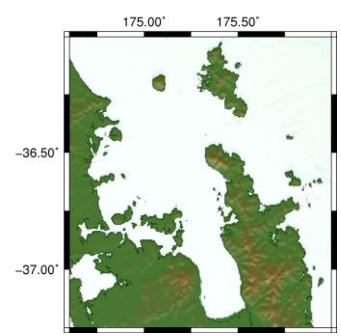

-36.2
-36.4
-36.6
-36.8
-37
175.6
175.8
176
176.2
176.4

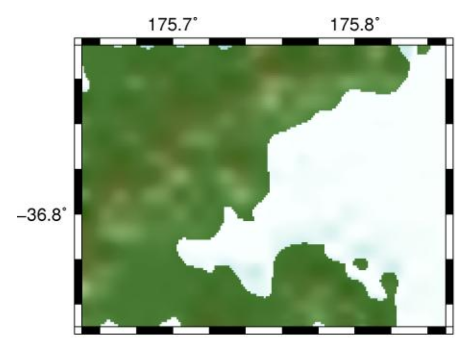

−36˚
−38˚
176˚


172.0˚
174.0˚
176.0˚
−34.0˚
−36.0˚
−38.0˚

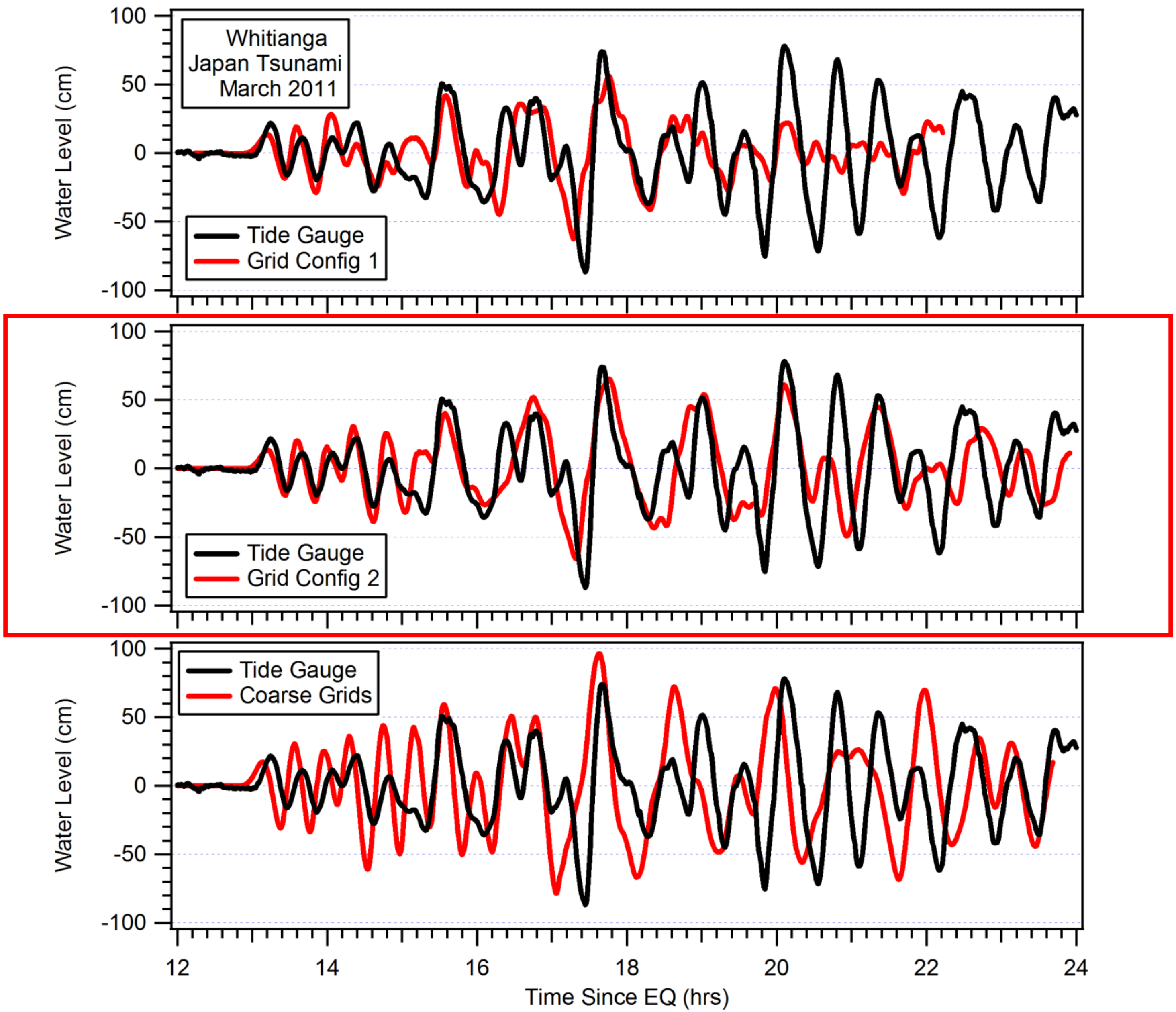

-36.7
-36.74
-36.78
-36.82
-36.86
175.66
175.7
175.74
175.78
175.82


-36.79
-36.8
-36.81
-36.82
-36.83
-36.84
1
2
3
175.7
175.71
175.72
175.73
175.74

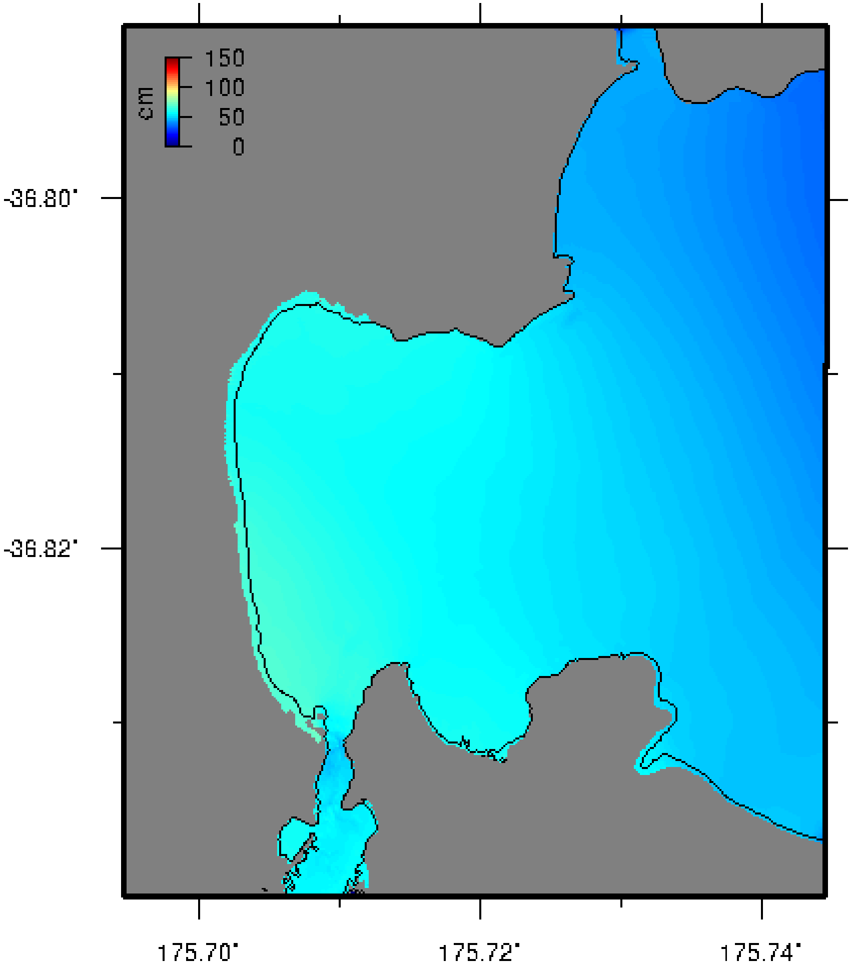

175.00˚
175.50˚
−36.50˚
−37.00˚

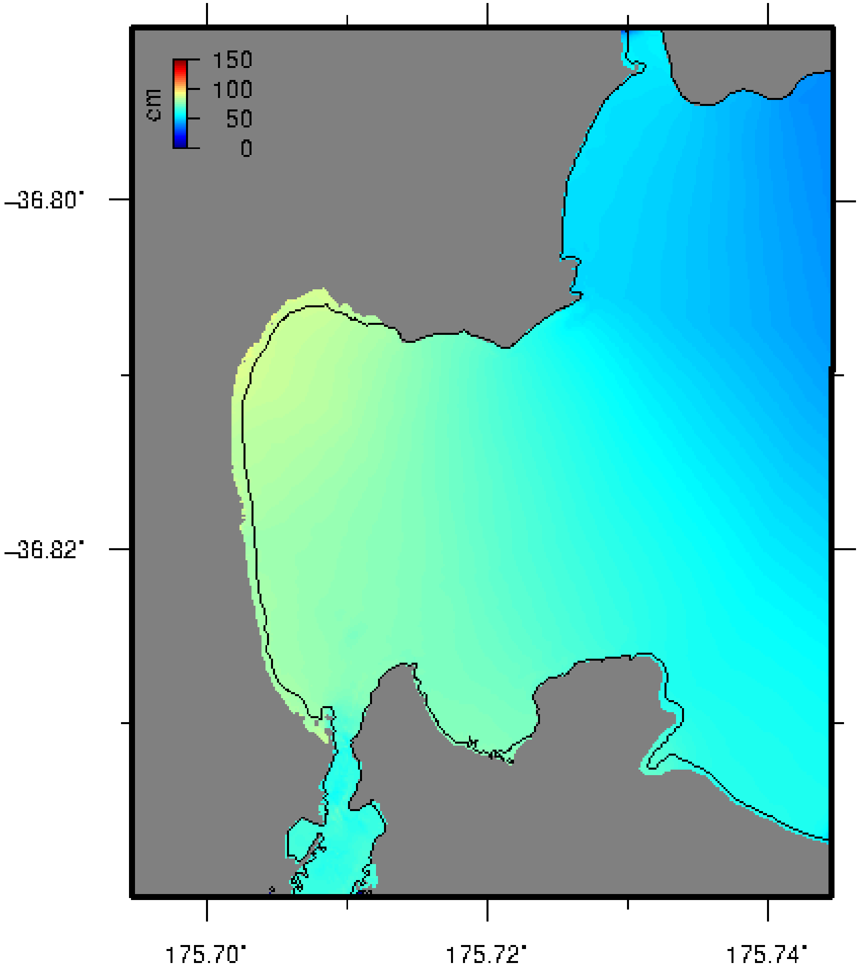

175.7˚
175.8˚
−36.8˚

Comparison to Tide Gauge

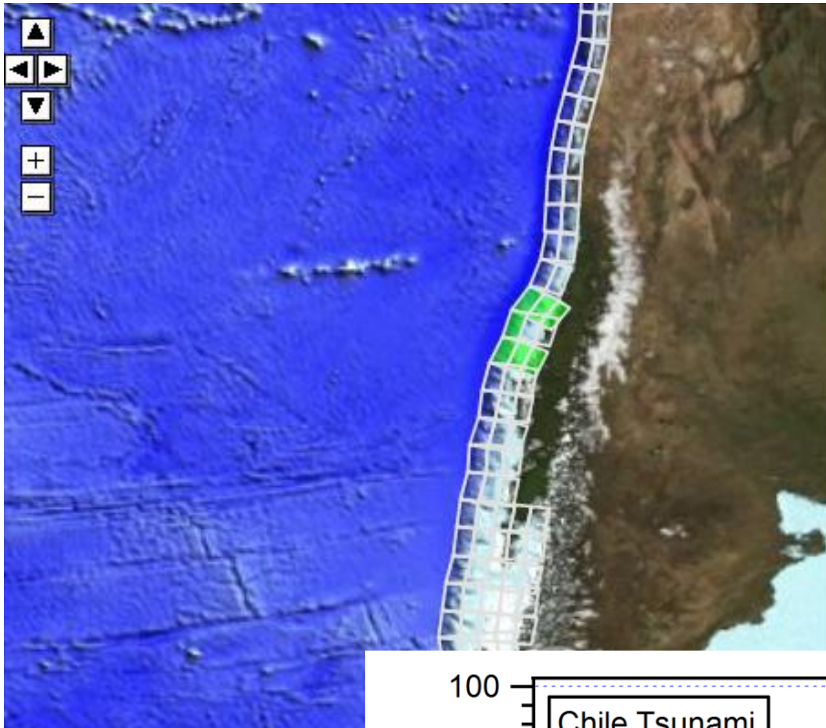


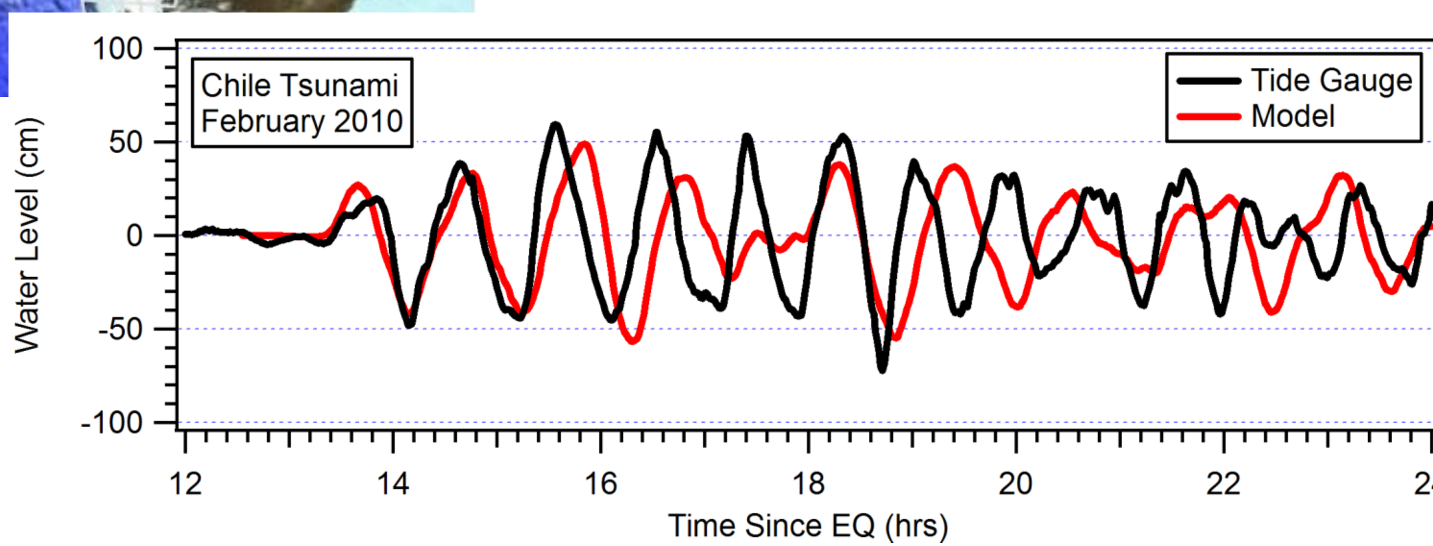
Max Water Level





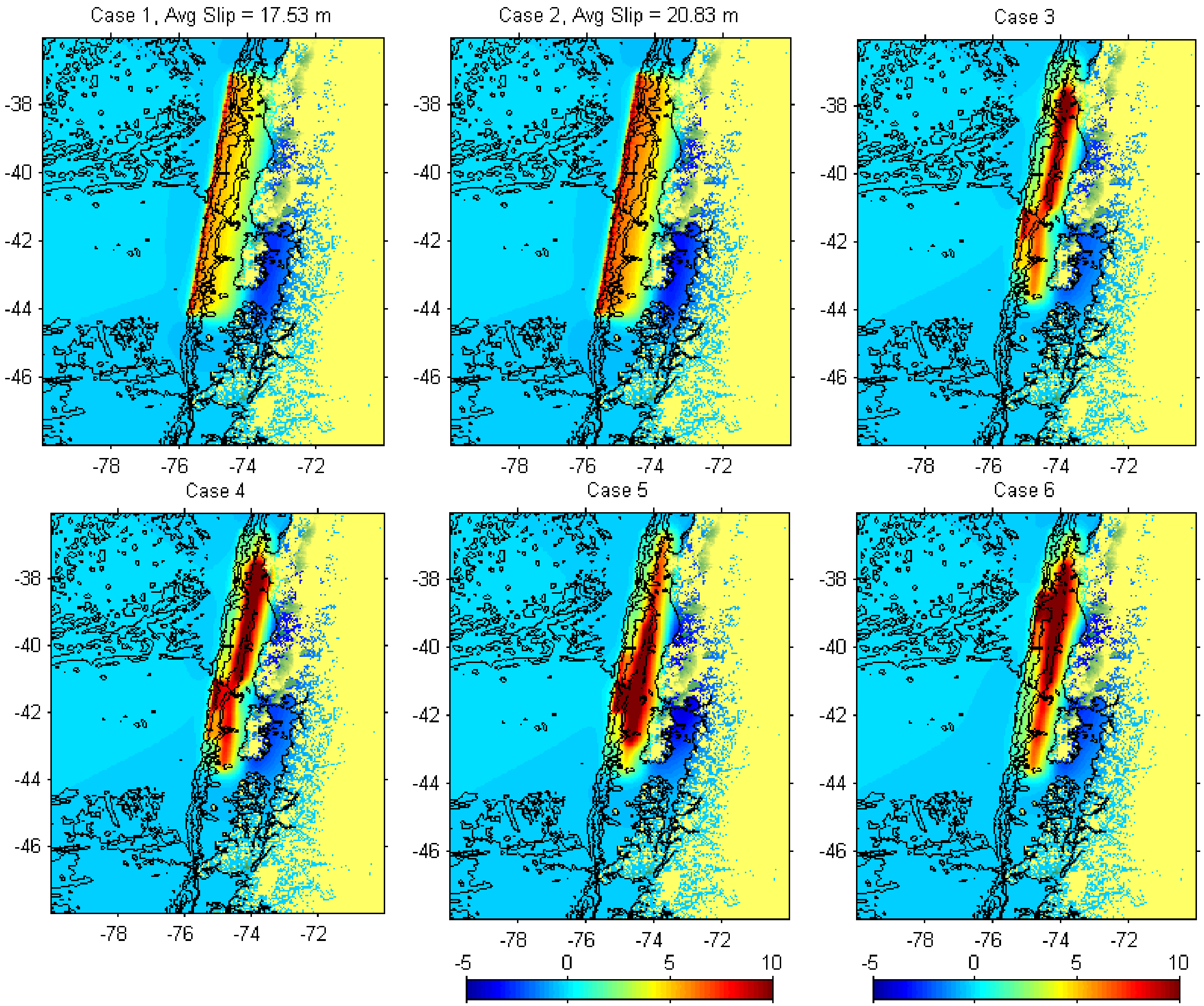
Chile 2010





Chile Tsunami
February 2010
Tide Gauge
Model
Water Level (cm)
100
50
0
-50
-100
12
14
16
18
20
22
24
Time Since EQ (hrs)

Earthquake Source Models – Chile 1960



Case 1 – average slip 17.5 m

Case 2 – average slip 20.8 m

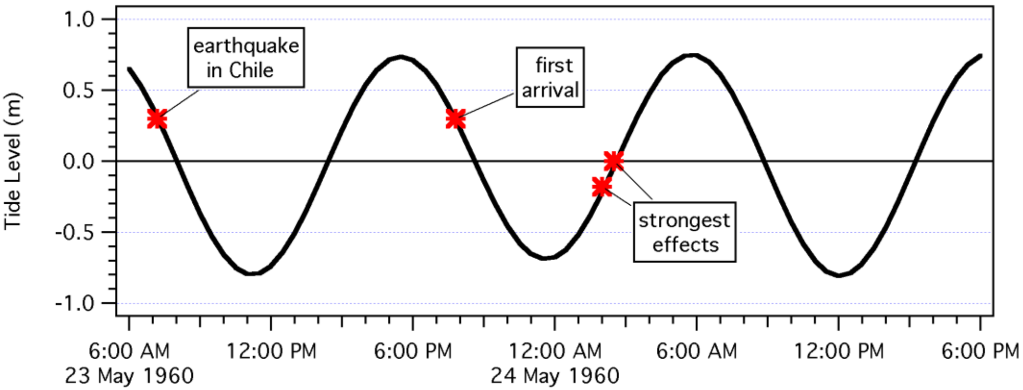
Case 3 – Fujii and Satake (2012) source.

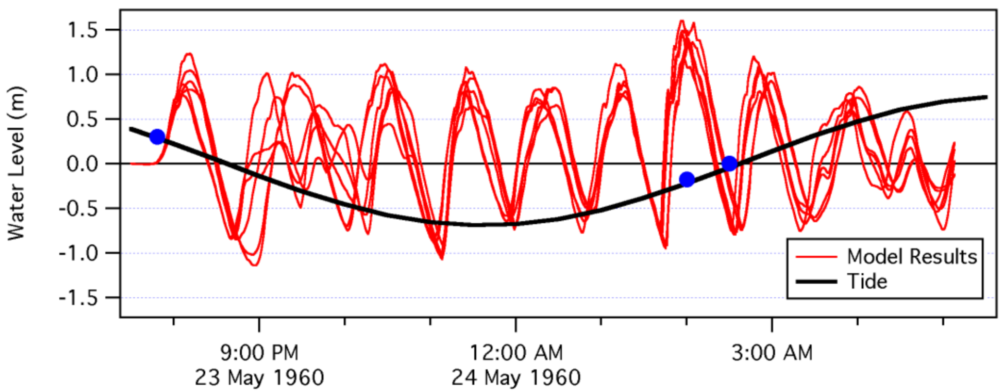
Case 4 – Fujii and Satake (2012) slip distribution increased by 20%.

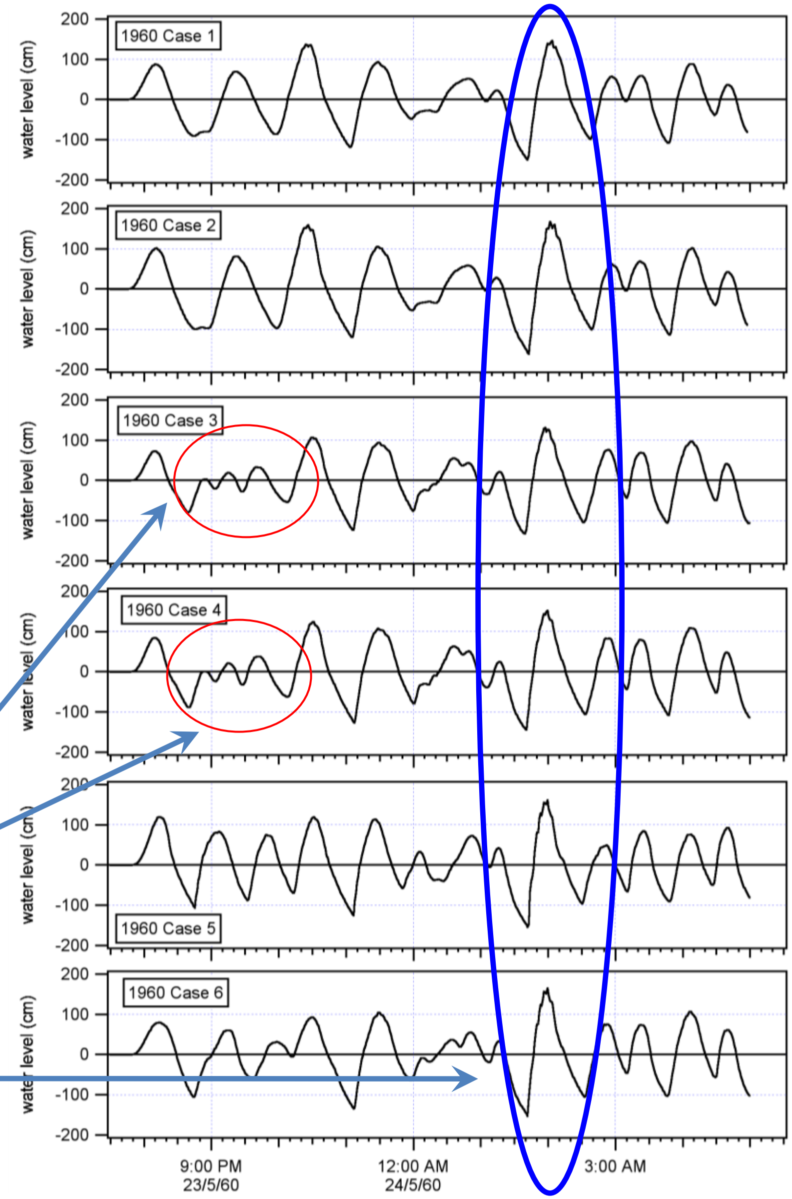
Case 5 - Fujii and Satake (2012) slip distribution increased by 20%, concentrated to south.

Case 6 - Fujii and Satake (2012) slip distribution increased by 20%, concentrated to north.

Comparison to Historical Accounts - 1960





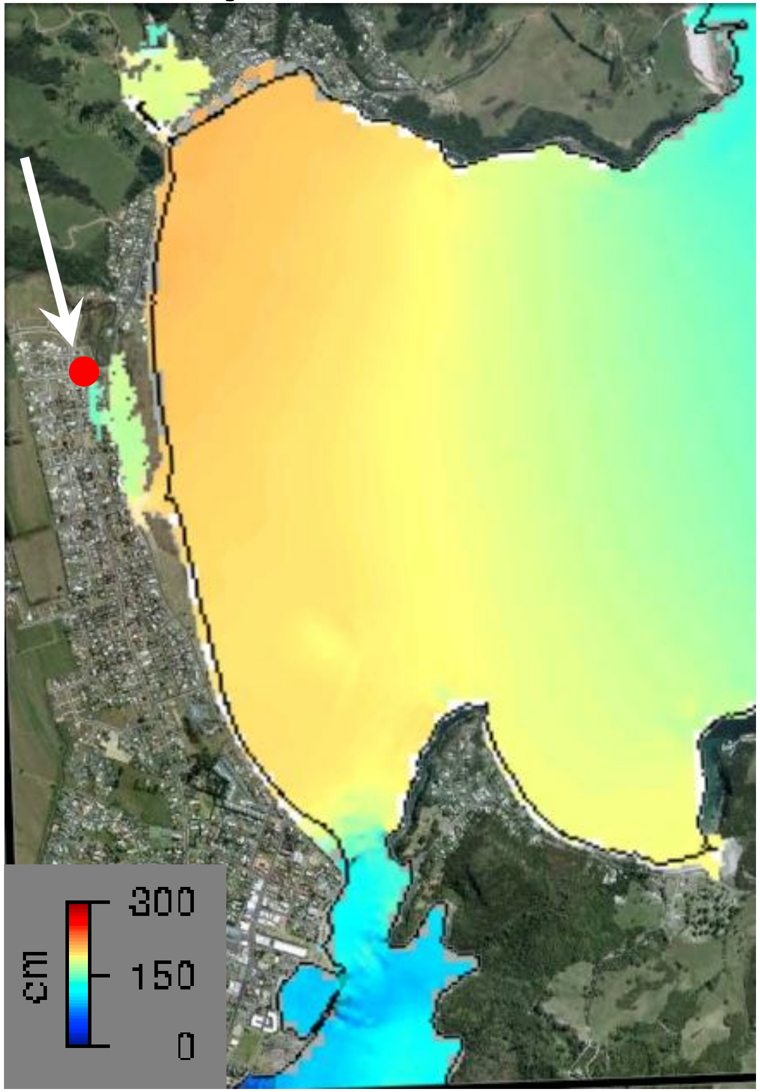


Eyewitness accounts report:

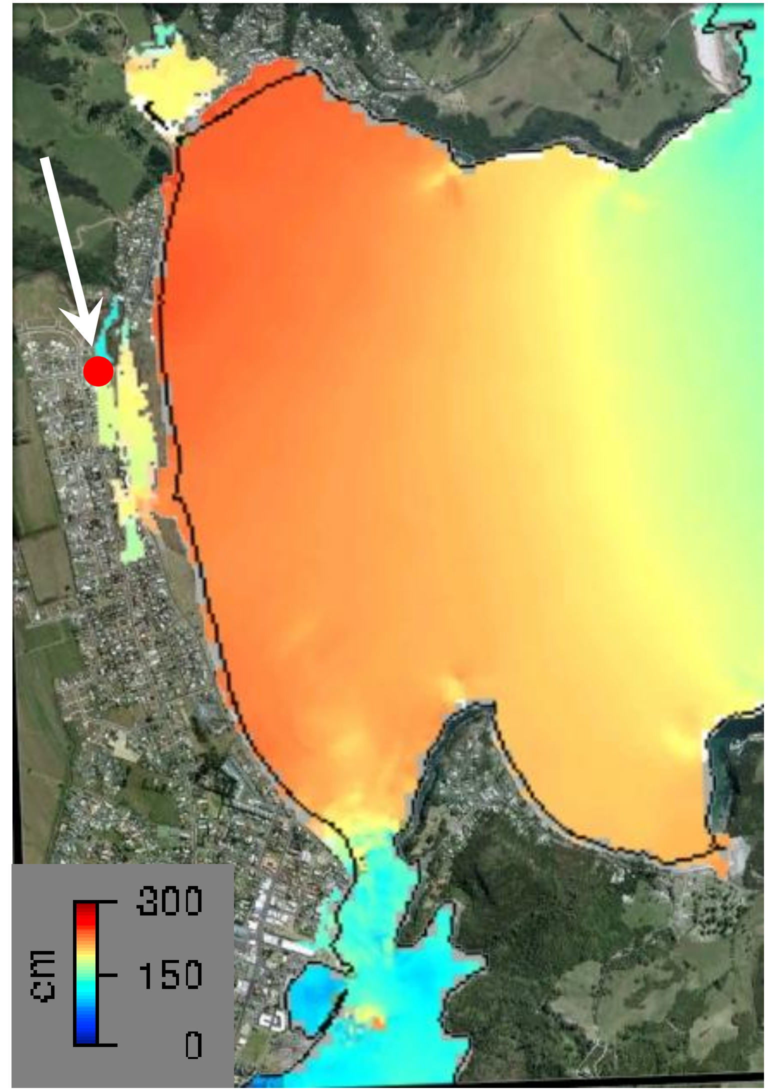
…around 9:30 pm on May 23: ***'the tide came in and out at a fast rate'***

'about 2 am on Tuesday morning […] seemed to be the worst time'

Comparison to Historical Account - 1960



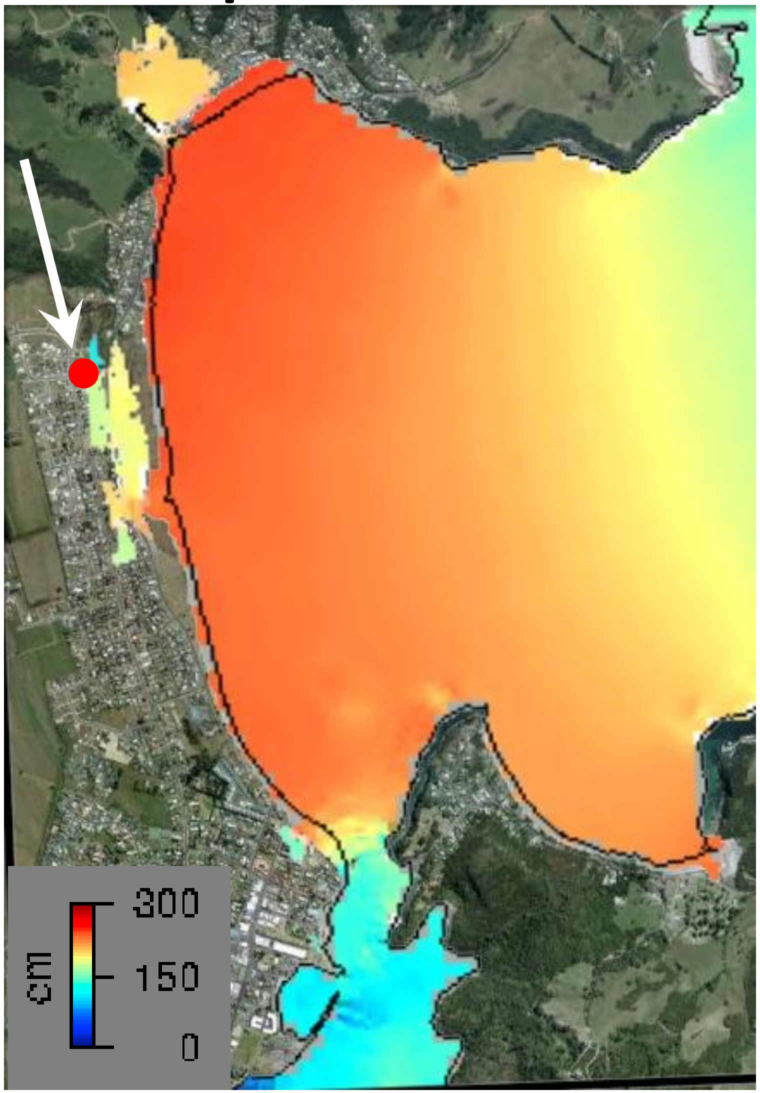
Case 3 (n = 0.03)



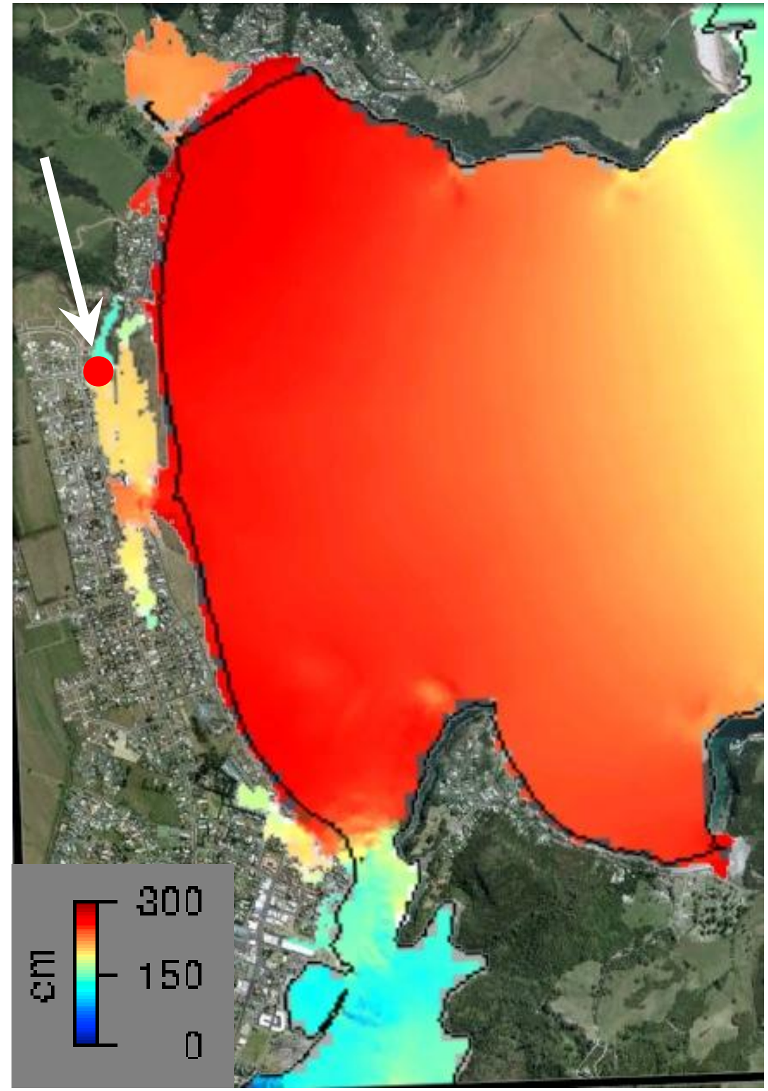
Case 3 (n = 0.021)

inundation ***‘into the old aerodrome hangar along the northern end of Buffalo Beach, where it wet crates of corrugated iron stored on the floor damaging them’***

Comparison to Historical Account - 1960



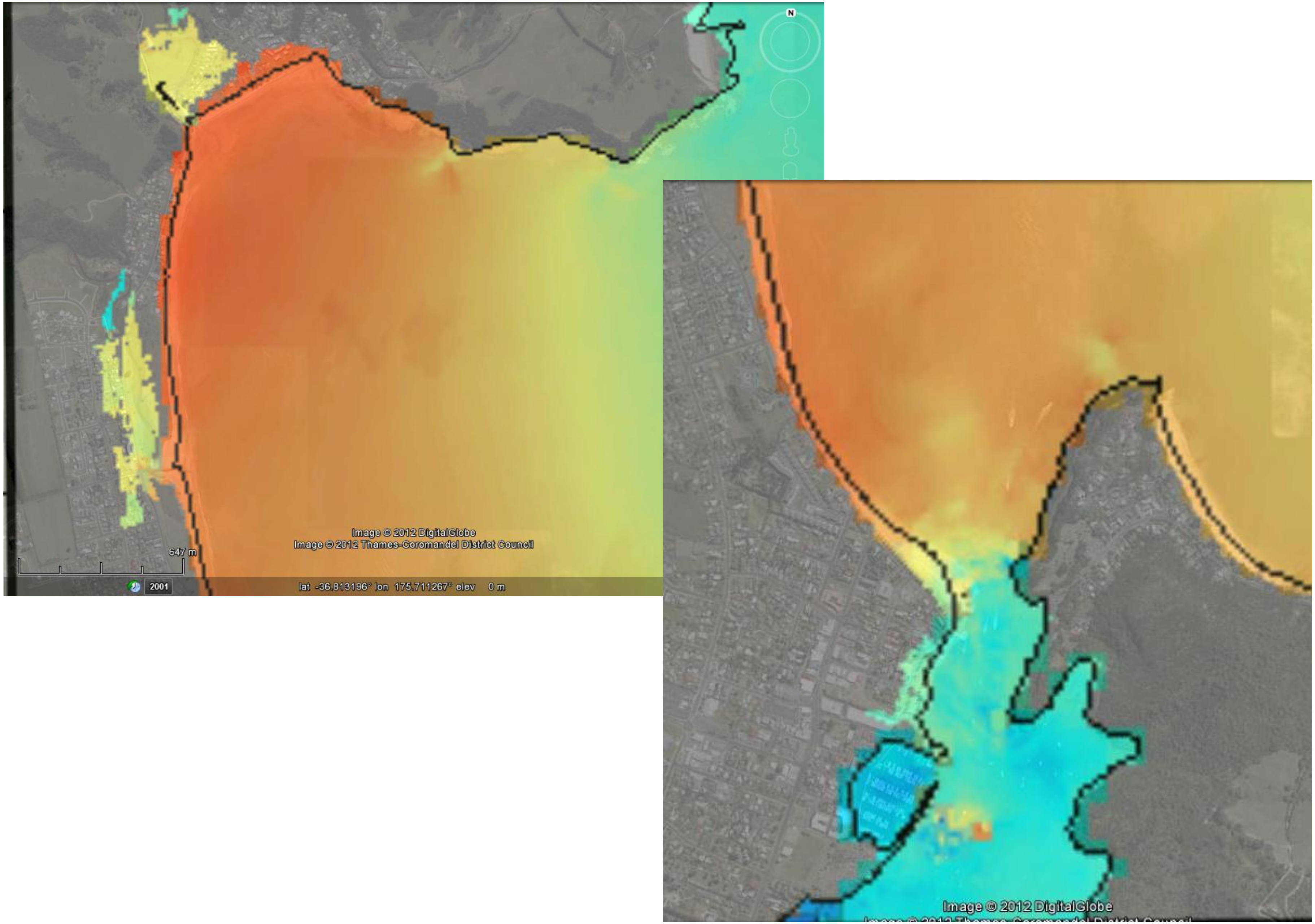
Case 4 (n = 0.03)



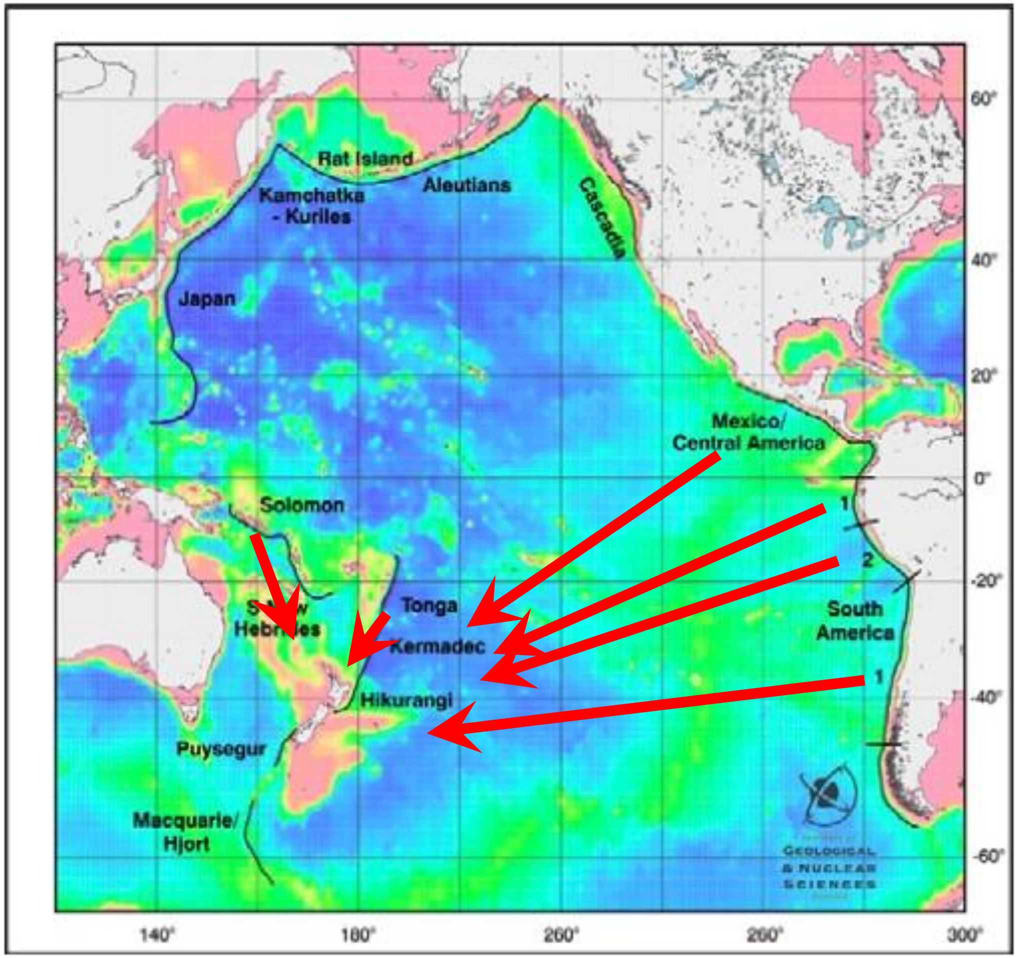
Case 6 (n = 0.03)

inundation ***'into the old aerodrome hangar along the northern end of Buffalo Beach, where it wet crates of corrugated iron stored on the floor damaging them'***

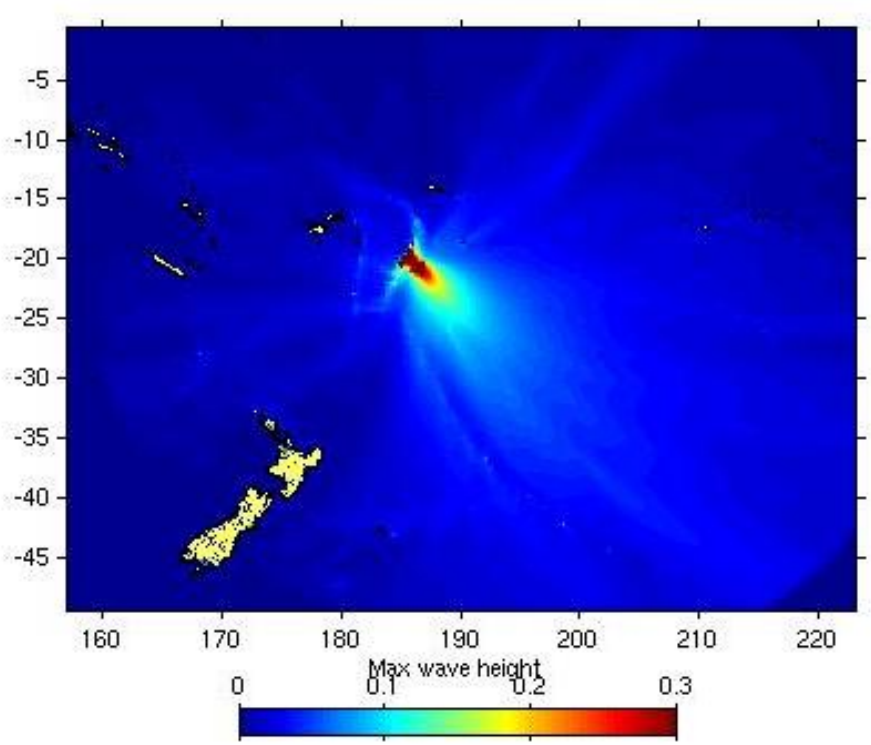
Comparison to Historical Account - 1960



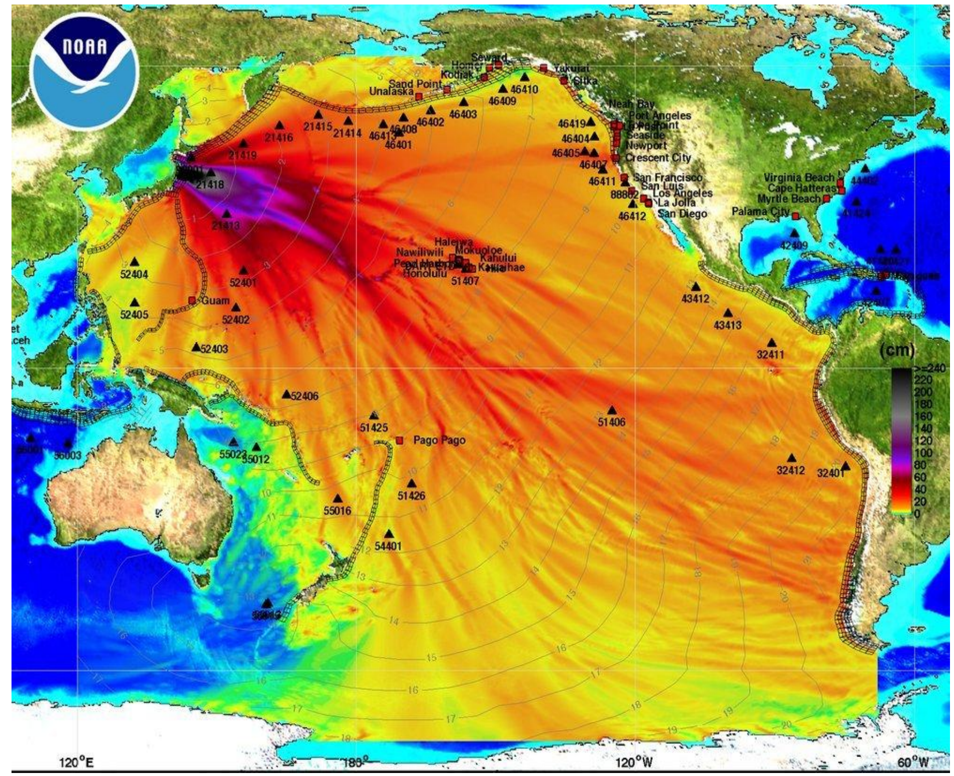
SO WHERE IS TAIRUA'S NEXT TSUNAMI COMING FROM?



Trans-Oceanic?

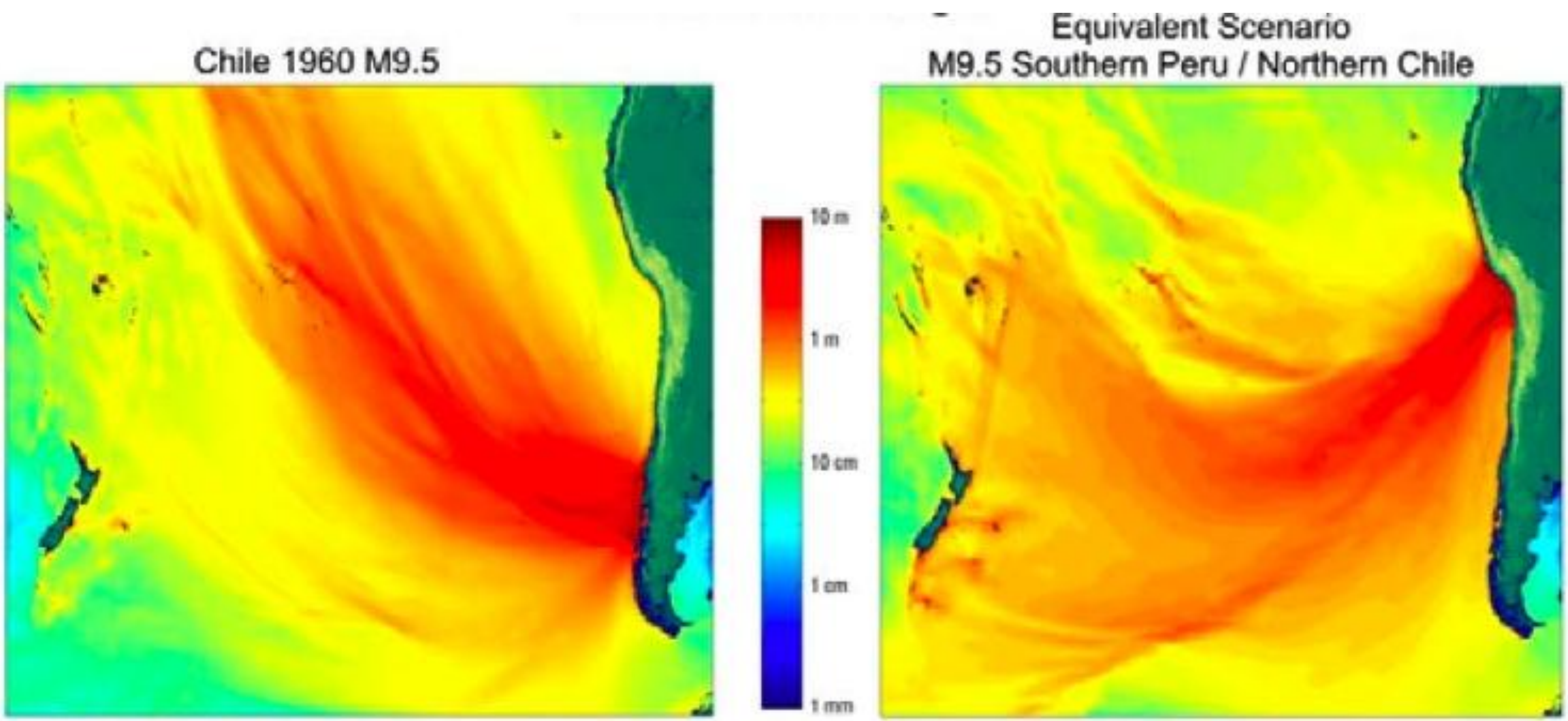


Samoa/Tonga Region



Japan Region

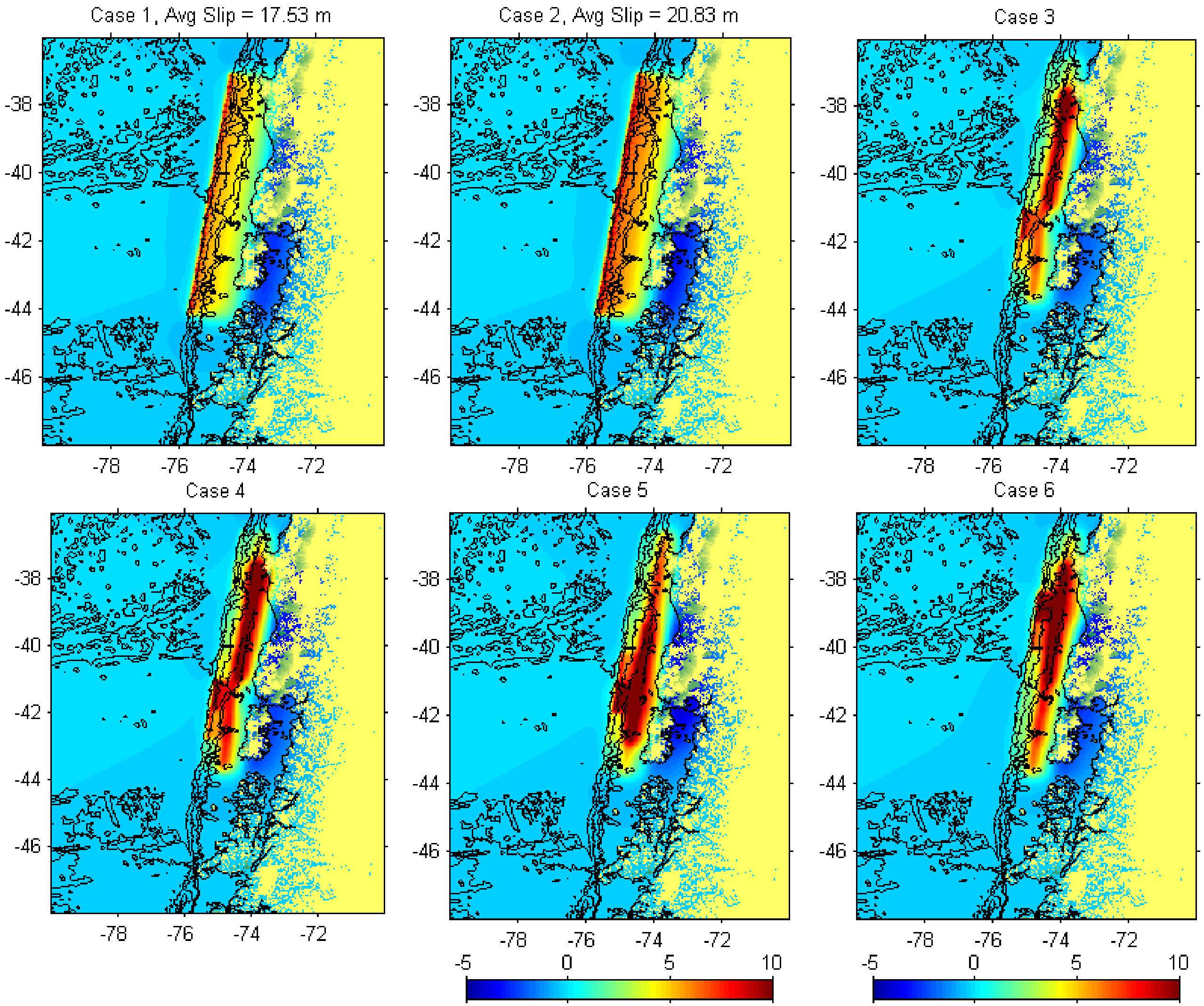
Worst Case For NZ – Far Field



The greatest far-field hazard for NZ comes from sources in northern Chile and Southern Peru

1868: Quake near Arica, (Chile/Peru border), same size as Japan quake, caused a 7 m tsunami in Lyttelton

Earthquake Source Models – Chile 1960



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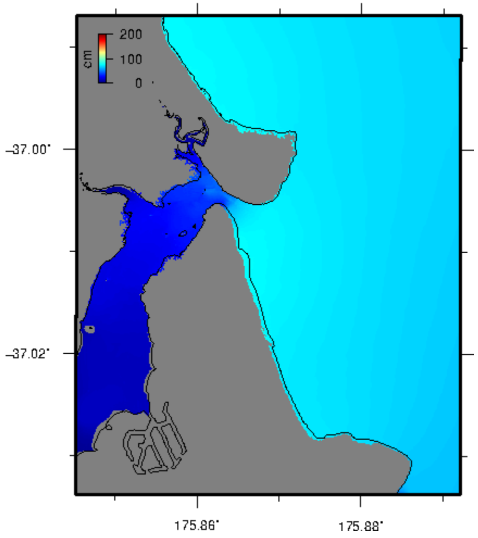
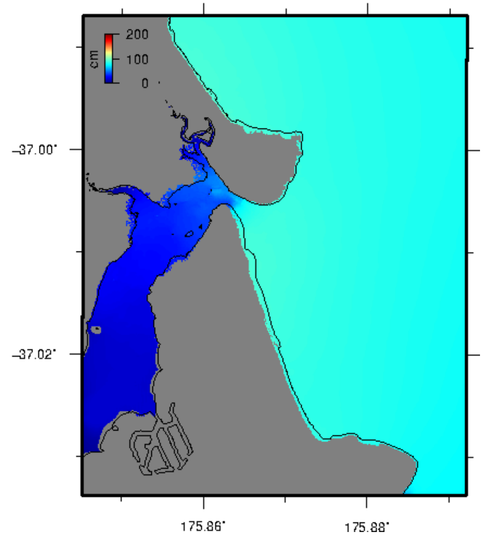
Tairua 1960 Cases

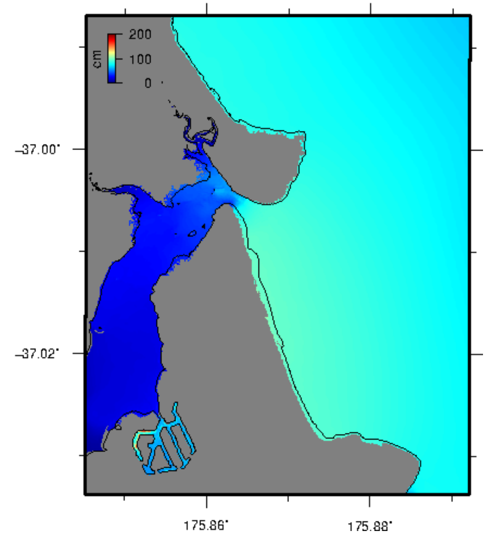
water level



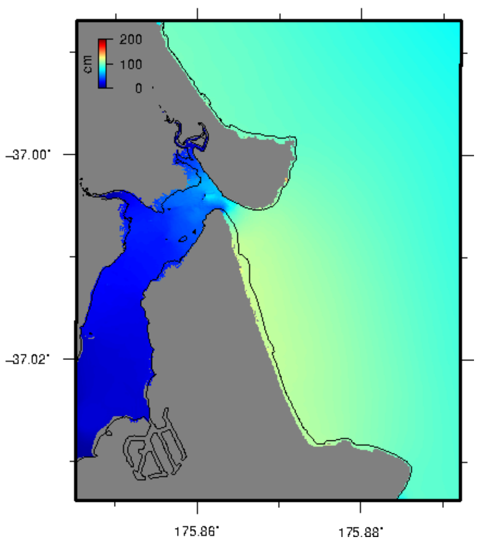
Case 1



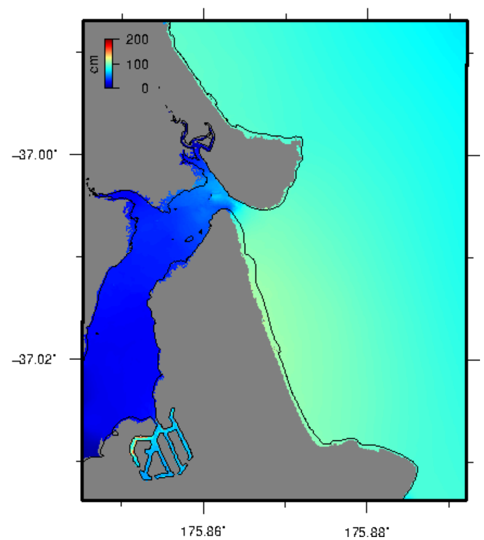
Case 2



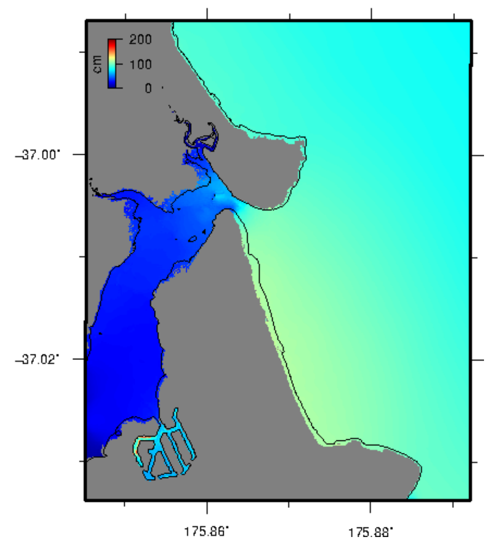
Case 3



Case 4



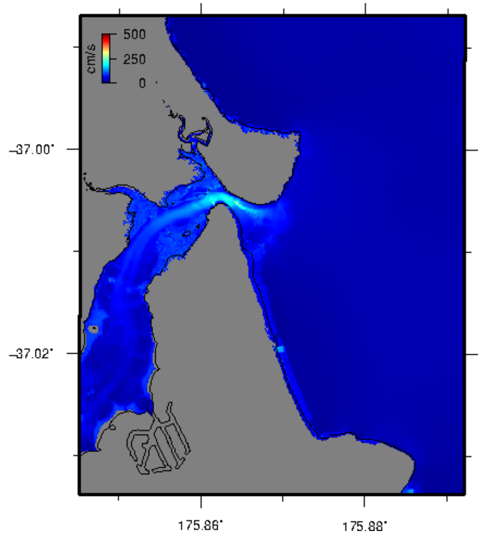
Case 5



Case 6

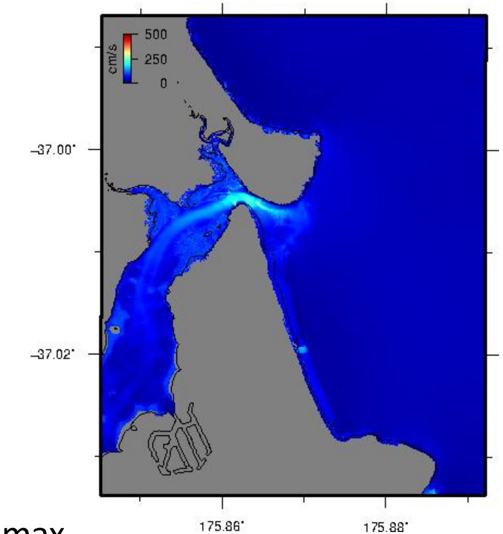
Tairua 1960 Cases

current speed

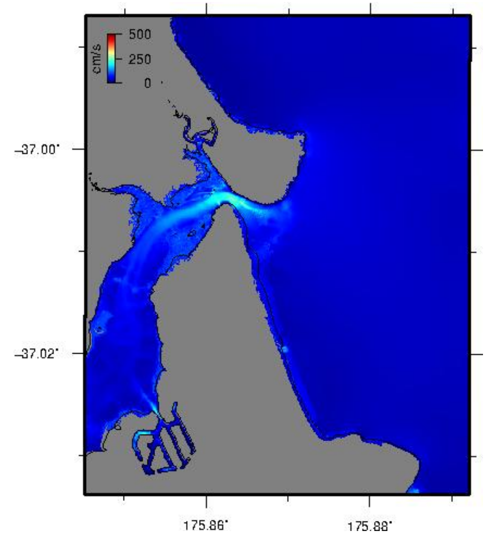


Case 1

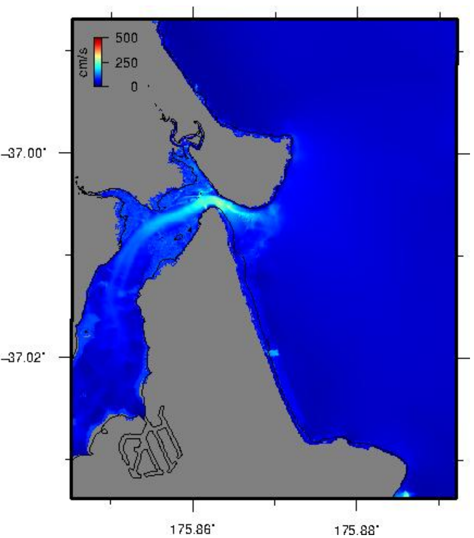
~5 knot max
above tidal current



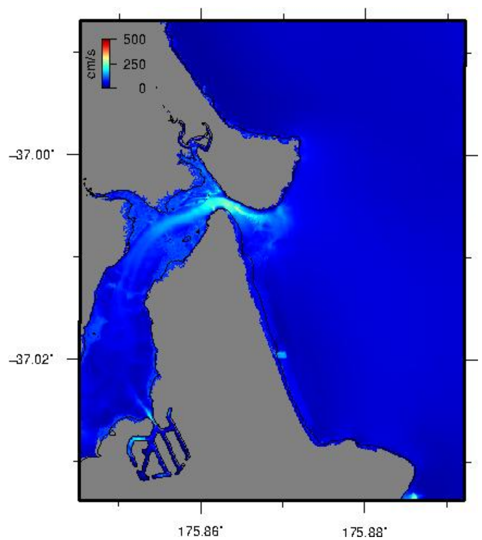
Case 2



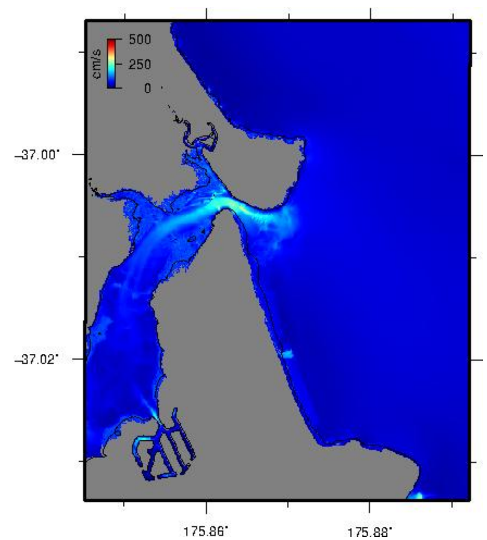
Case 3



Case 4

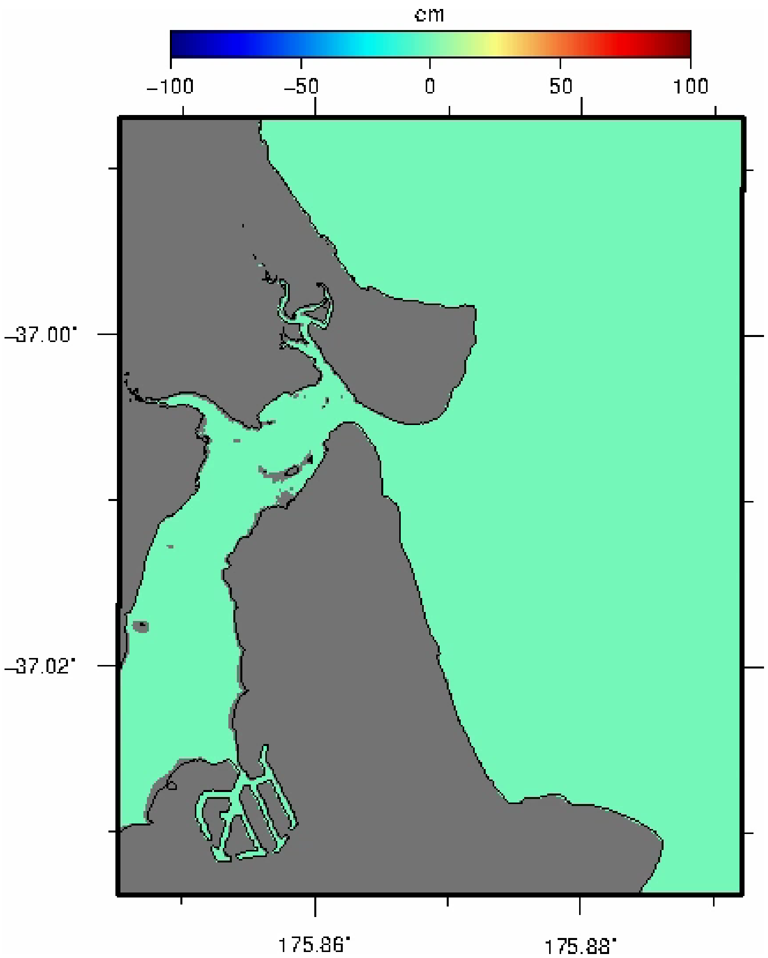


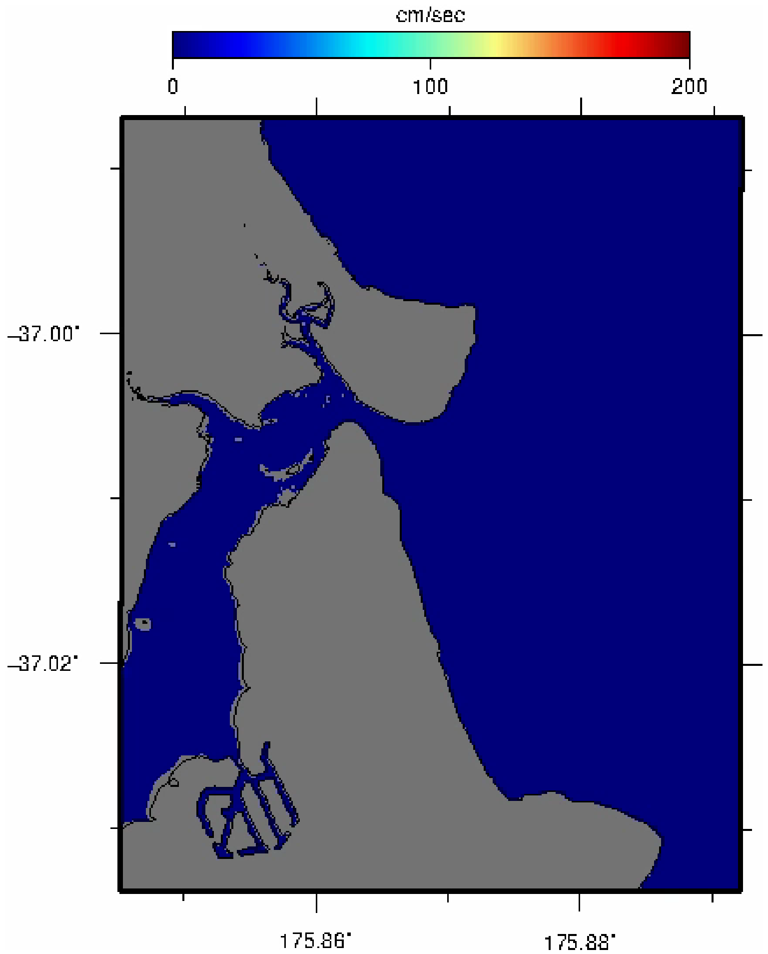
Case 5



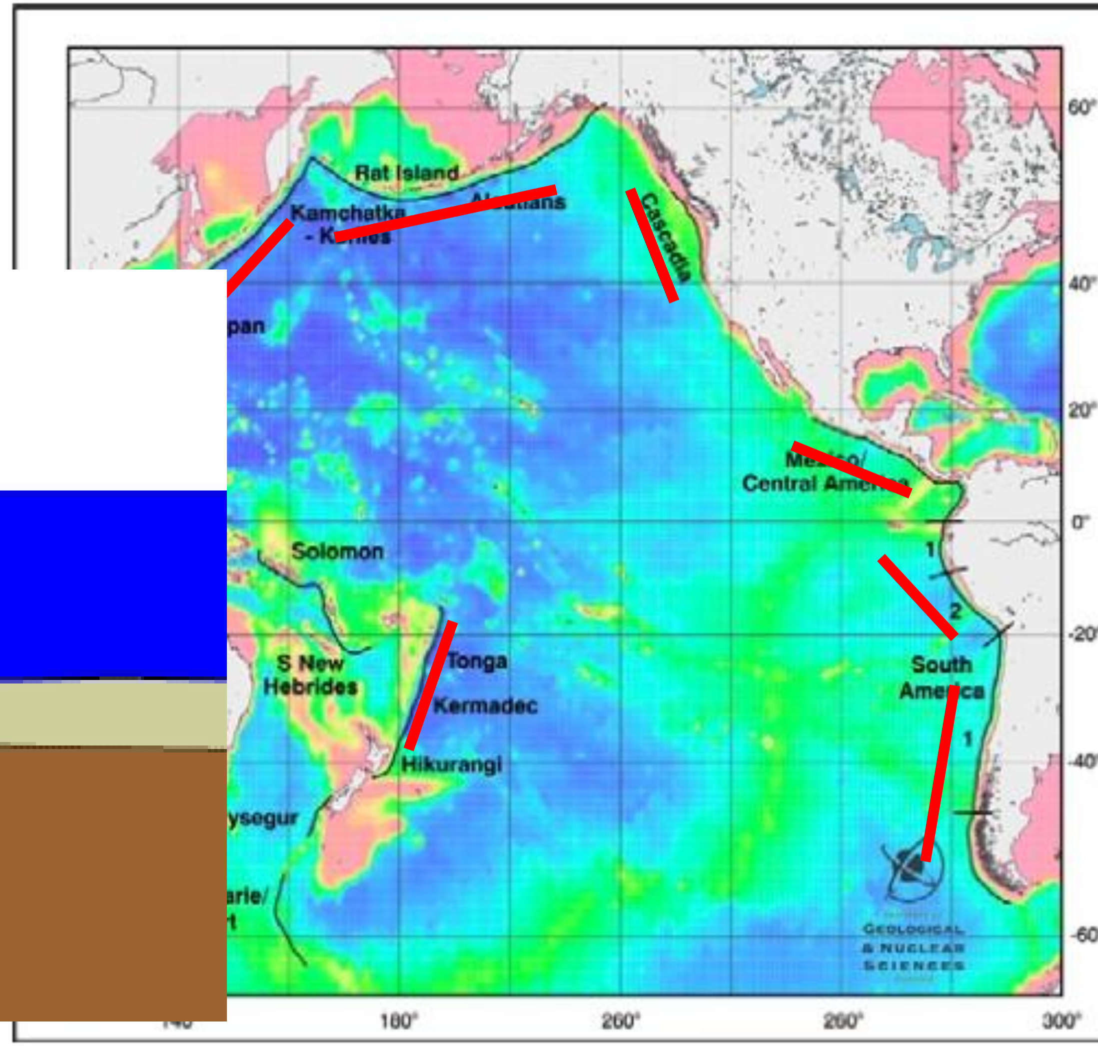
Case 6

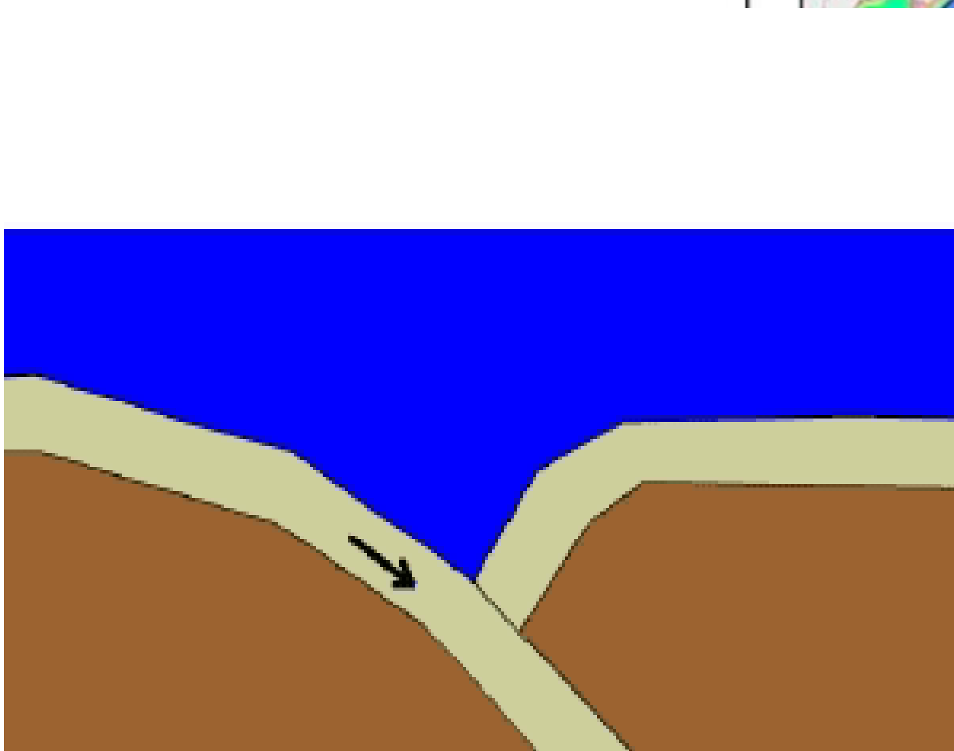
1960 Case 5


cm
–100
–50
0
50
100
–37.00°
–37.02°
175.86°
175.88°

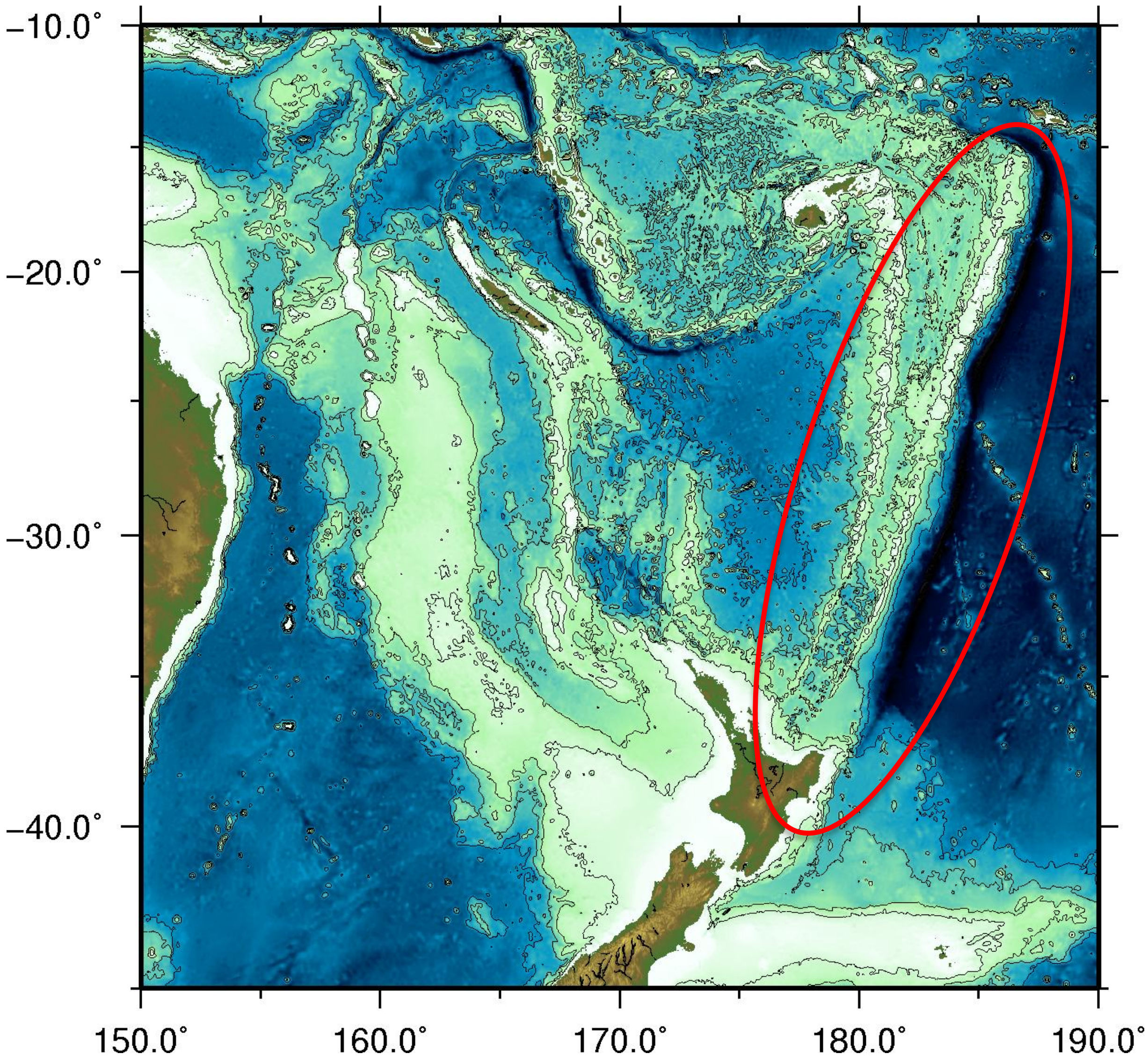

cm/sec
0
100
200
–37.00°
–37.02°
175.86°
175.88°

Subduction Zone

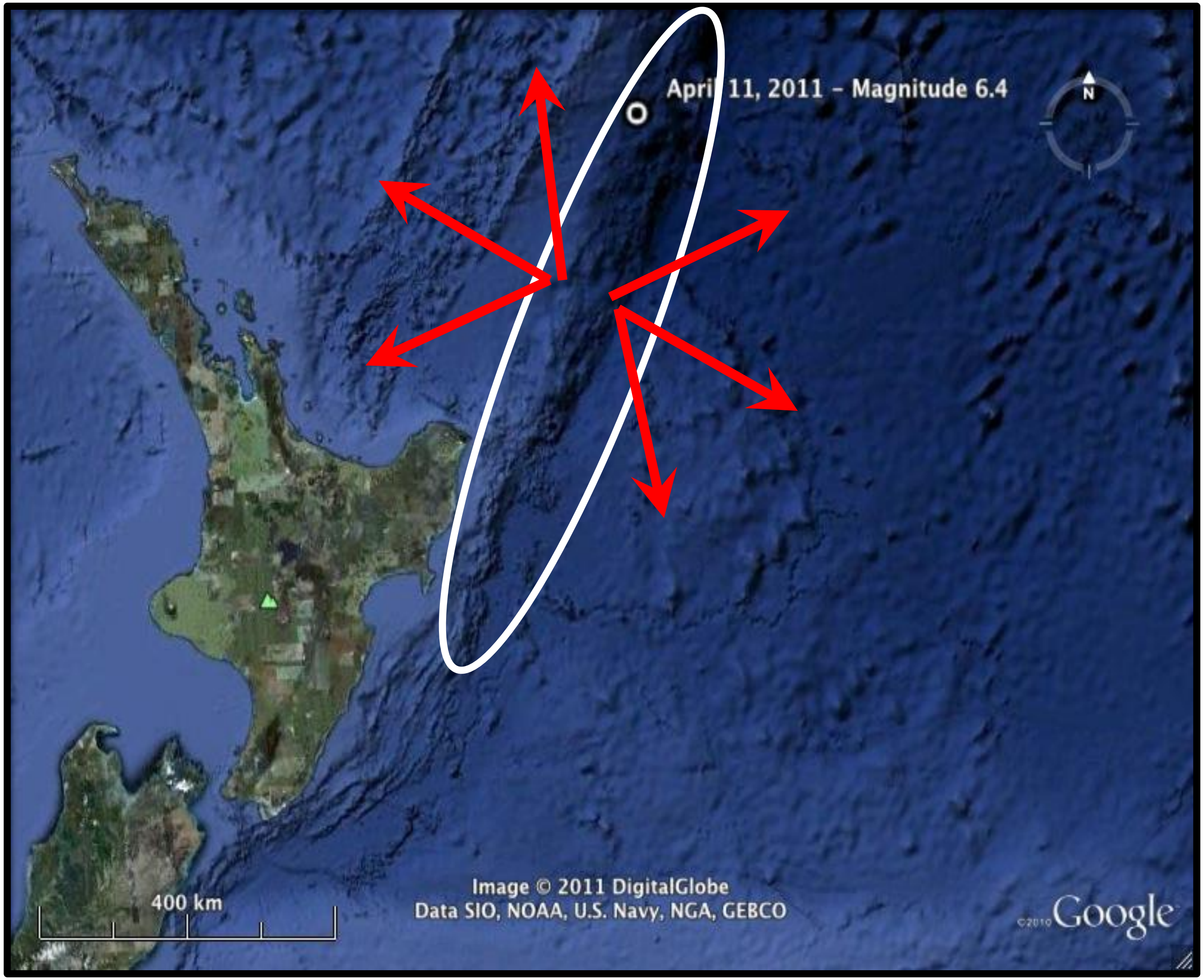




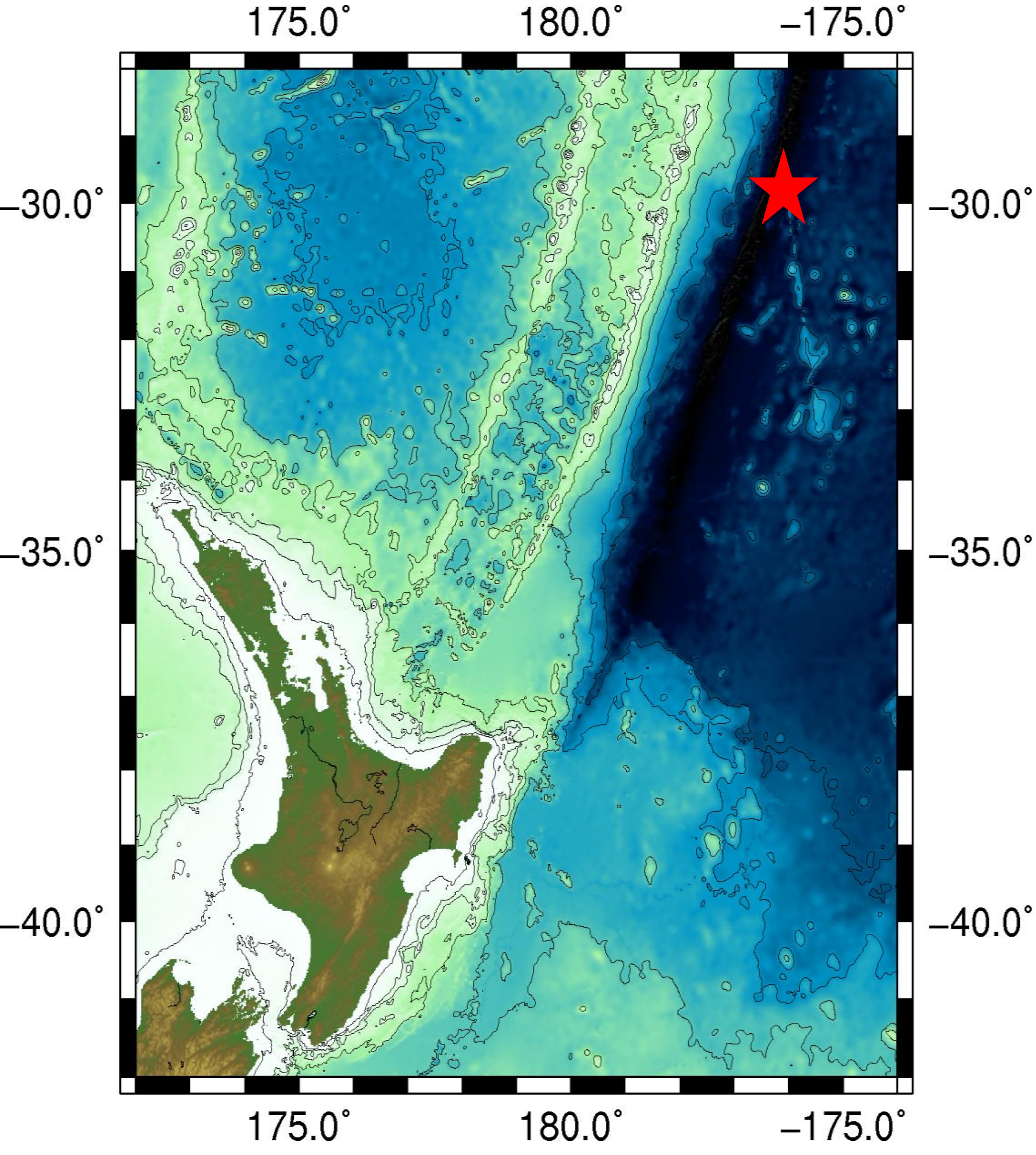
Tairua – Pauanui

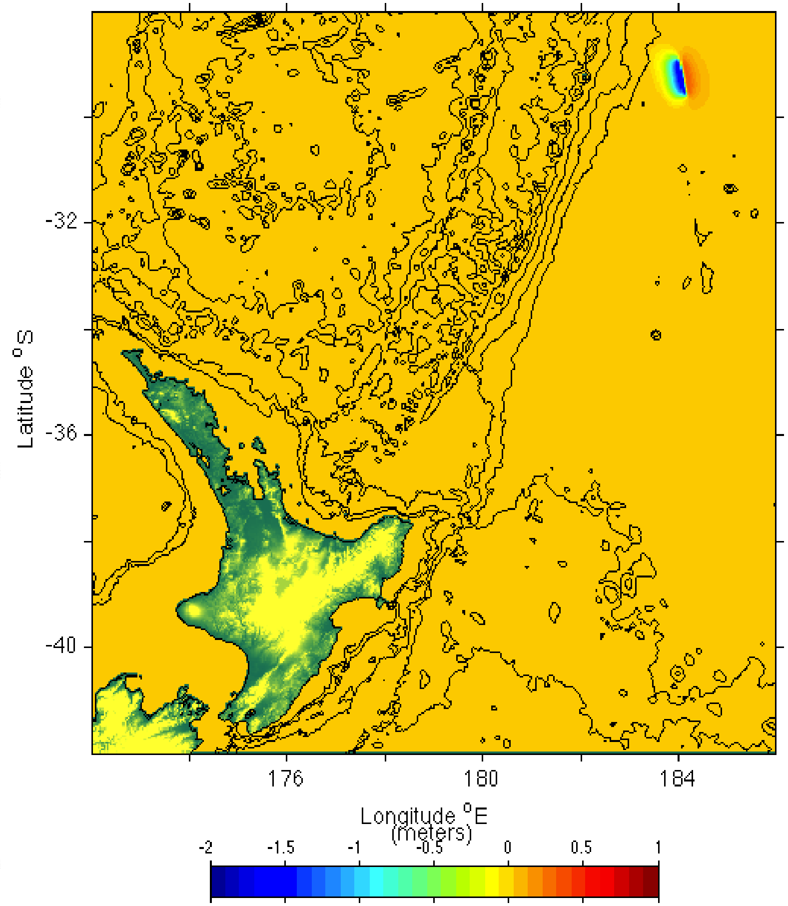


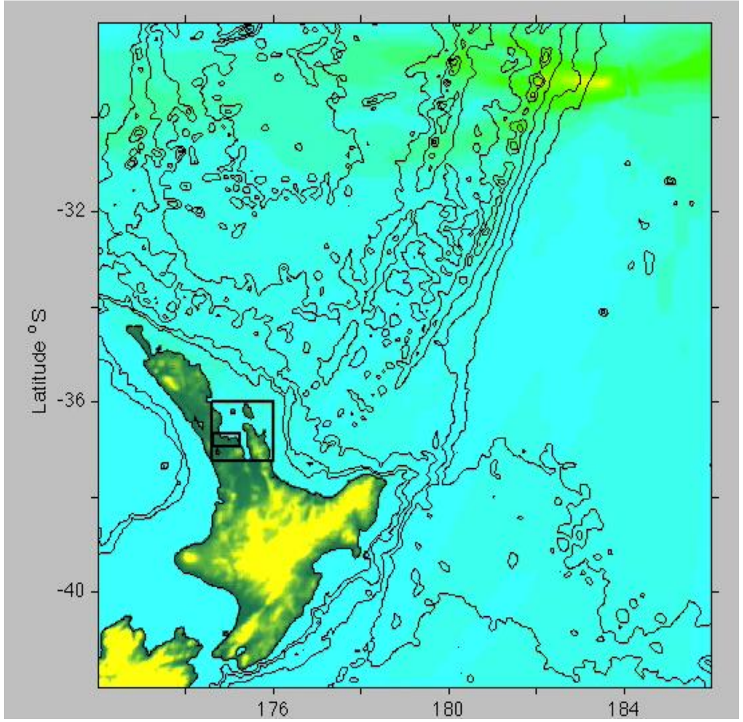
Tonga-Kermadec



July 7, 2011: Mw = 7.8 Kermadec Trench

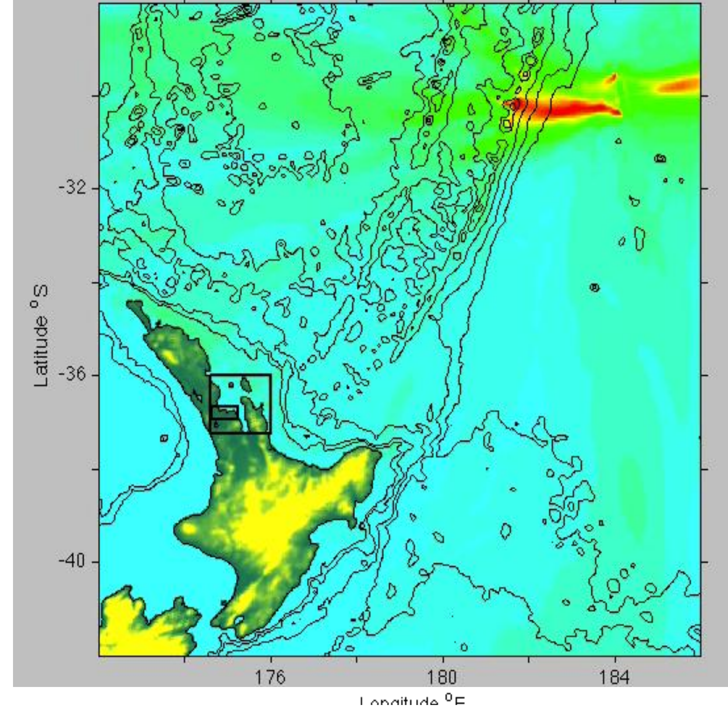


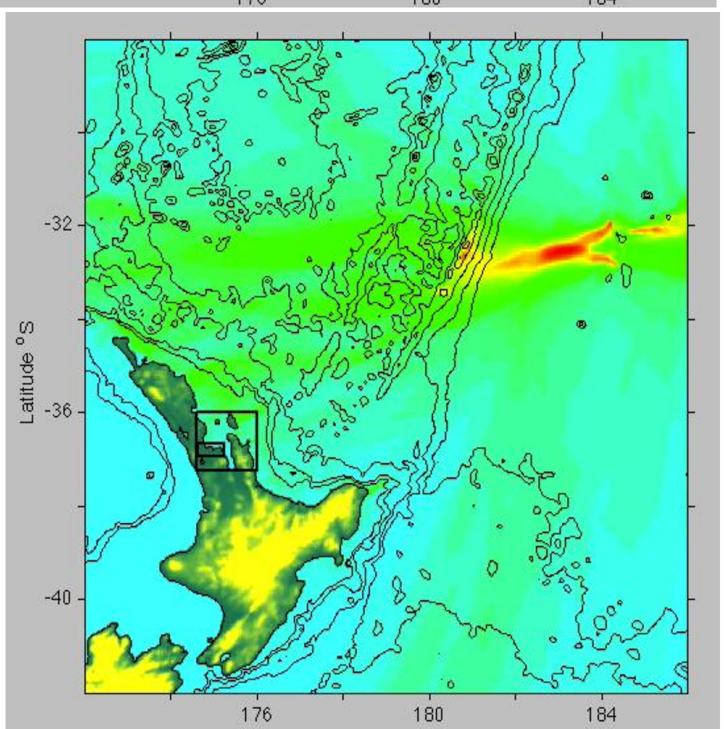




Original

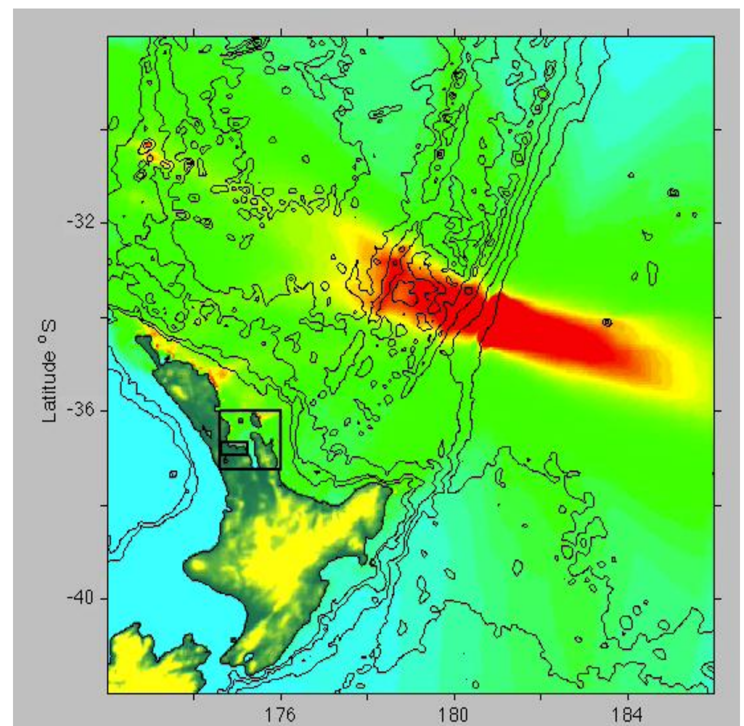
'Samoa Size'



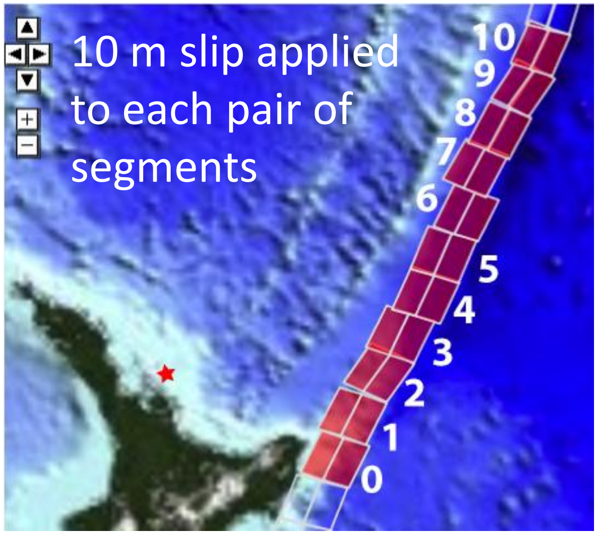


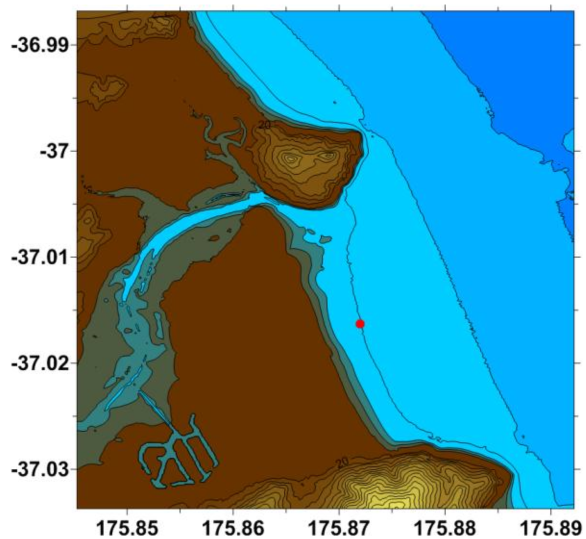
'Samoa Size'
South

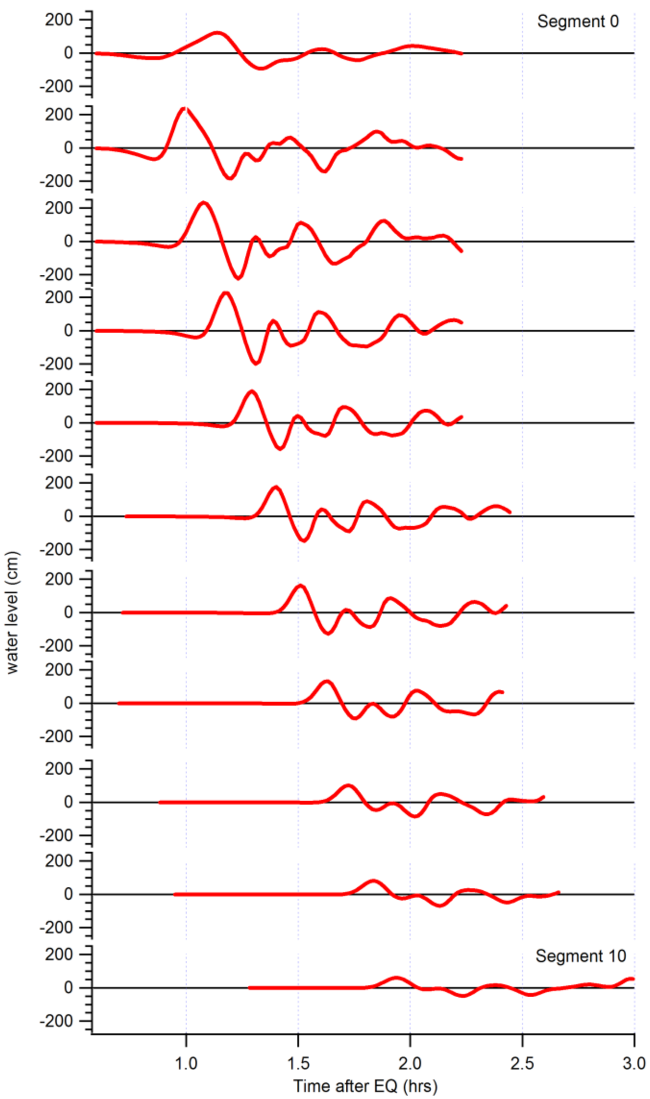
Thrust

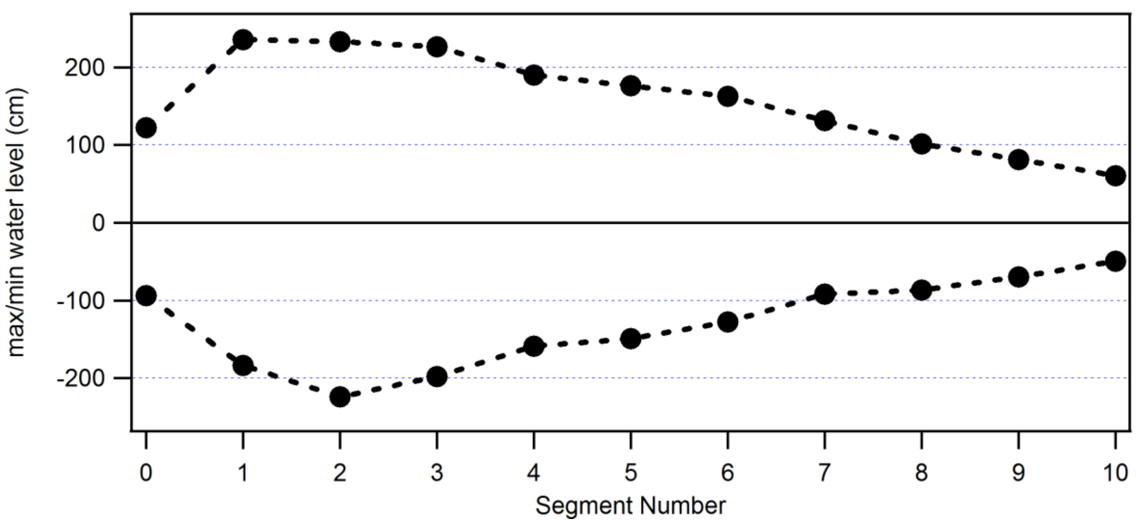


Sensitivity to Source Segment: Kermadec Trench

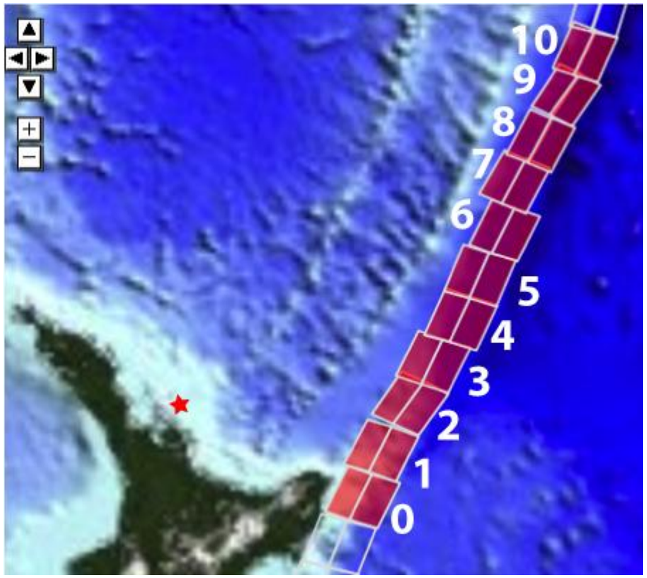




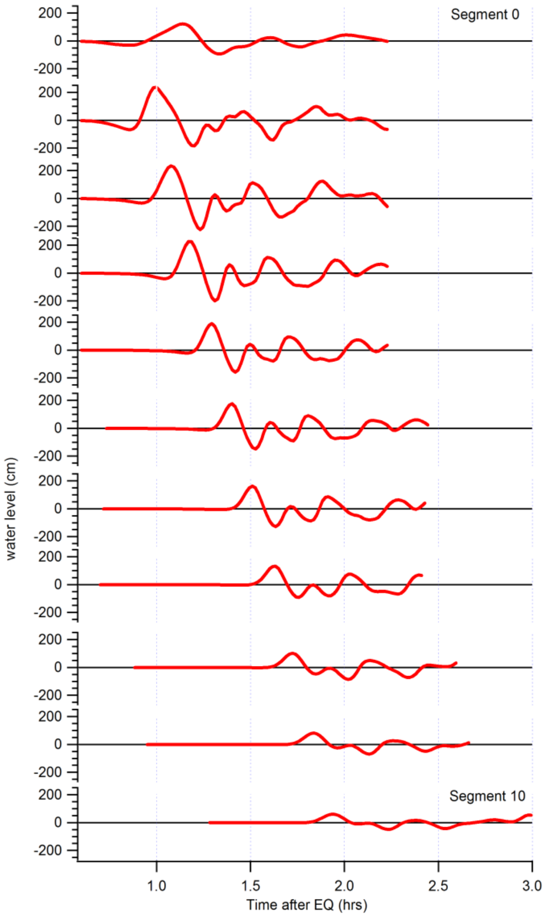




Arrival Times



Segment number	max Drawdown (m)	Time (mins)	max Positive (m)	Time (mins)	Lag (mins)
0	-0.31	51.5	1.23	68.4	17
1	-0.67	51.5	2.36	59.9	8
2	-0.33	55.3	2.33	64.8	10
3	-0.40	62.7	2.27	70.2	7
4	-0.21	70.2	1.9	77.4	7
5	-0.12	75.7	1.76	84.0	8
6	-0.06	80.3	1.63	90.6	10
7	-0.03	86.8	1.32	97.8	11
8	-0.02	92.2	1.01	103.2	11
9	-0.02	99.0	0.81	110.4	11
10	-0.01	94.7	0.61	116.4	22



	Whitianga		Tairua		Time Difference (mins)
	Max Drawdown (m)	Time (mins)	Max Drawdown (m)	Time (mins)	
Case 3	-0.89	74.5	-0.80	62.6	12.1
Case 8	-2.18	66.1	-1.95	52.3	13.8

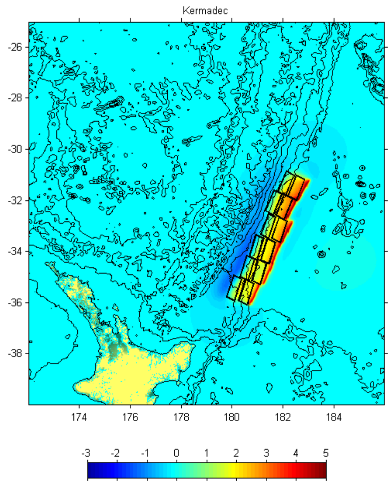
Earthquake Magnitude:

Magnitude = strength of the rock x Slip x Length x Width

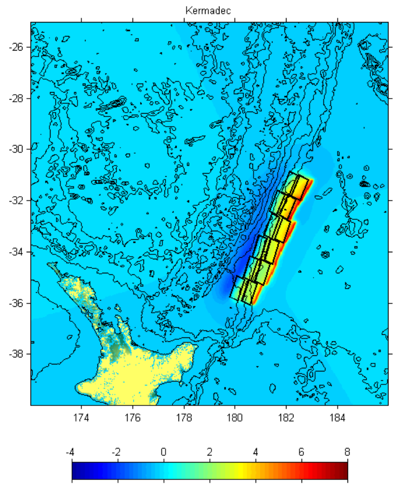
$$M = \mu\ u\ (L \times W)$$

To get a bigger earthquake:
make fault **LONGER**
or
add more **SLIP**

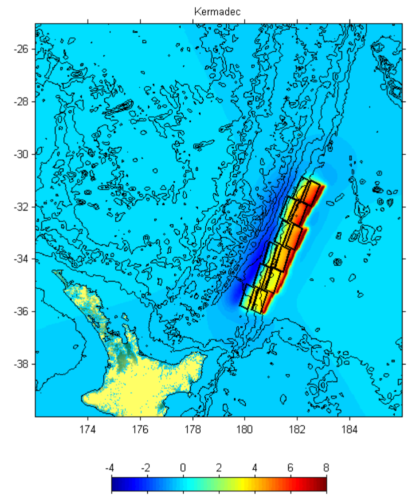
Earthquake Source Models – Kermadec Trench



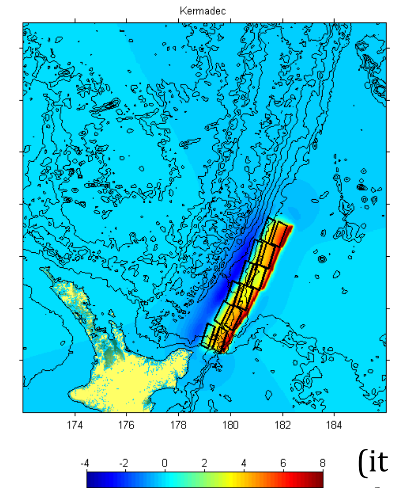
Case 1: 10.5 m - North



Case 3: 14.7 m - North

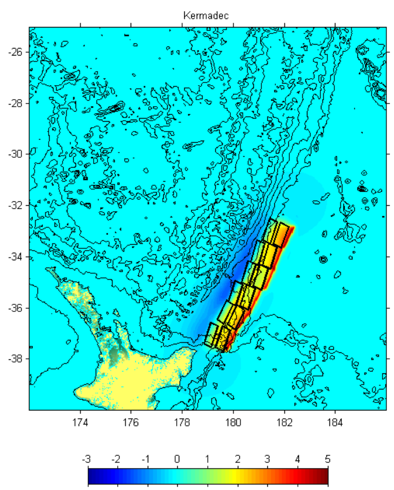


Case 6: 21 m - North

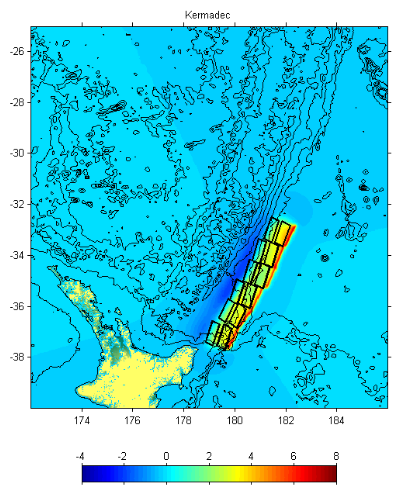


Case : 35 m - South

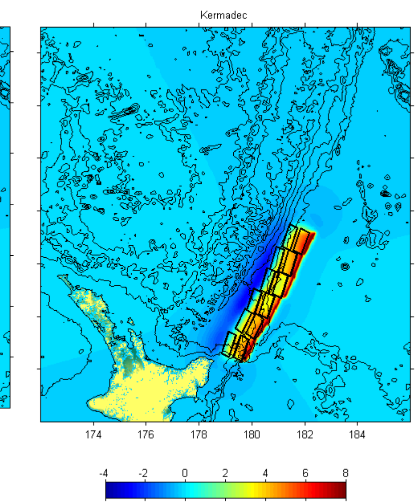
(it happened in Chile 1960…)



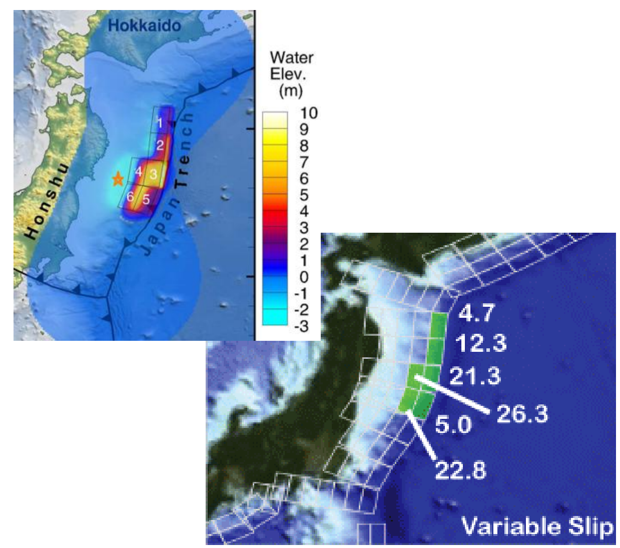
Case 2: 10.5 m - South



Case 4: 14.7 m - South.



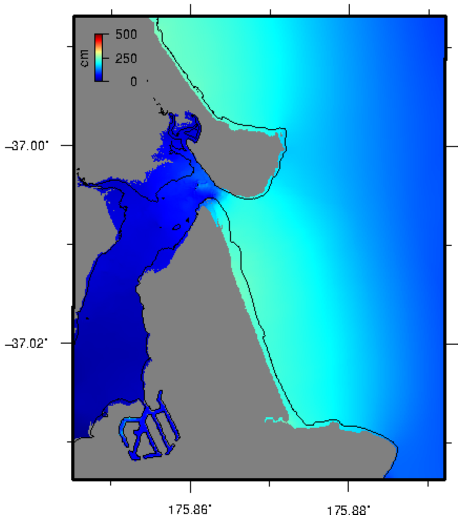
Case 5: 21 m - South



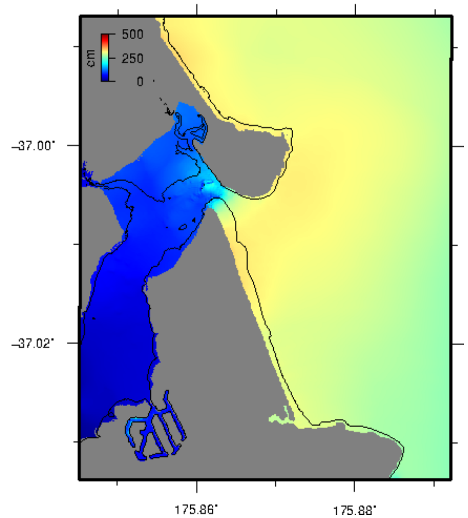
Case 8 – What if Japan 2011 happened in our backyard?

eCoast

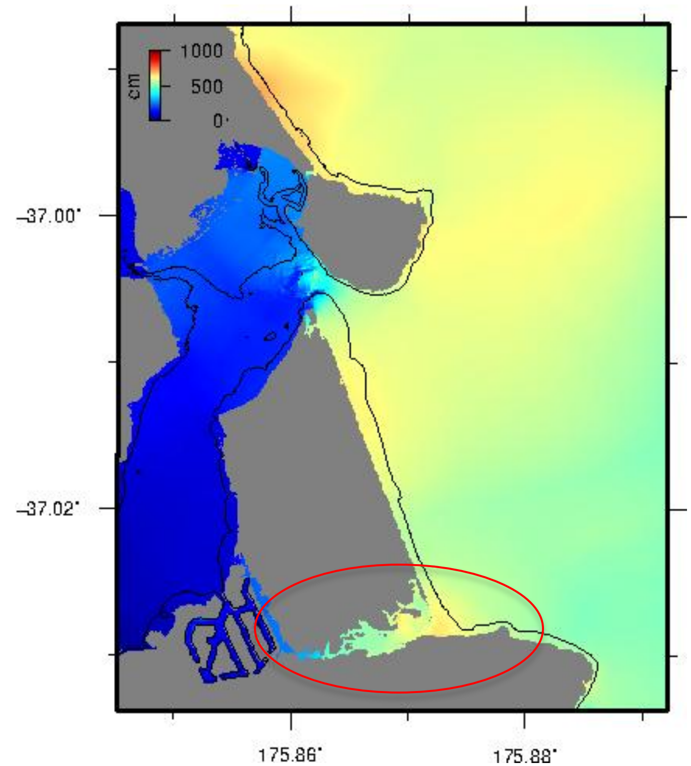
Tairua – Pauanui Results



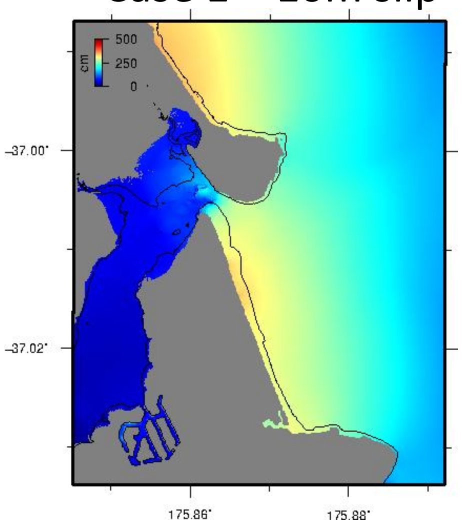
Case 1 – 10m slip



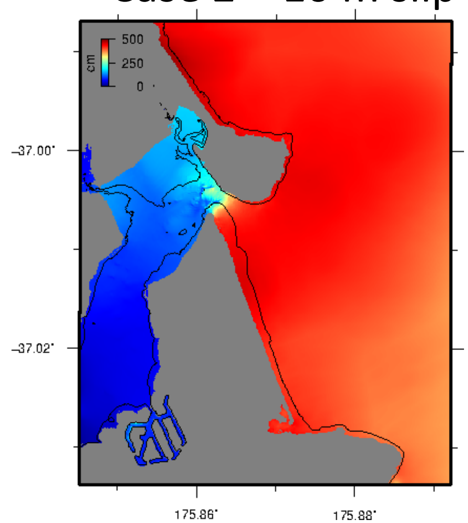
Case 2 – 10 m slip



Case 5 – 21 m slip



Case 3 – 15 m slip



Case 4 – 15 m slip

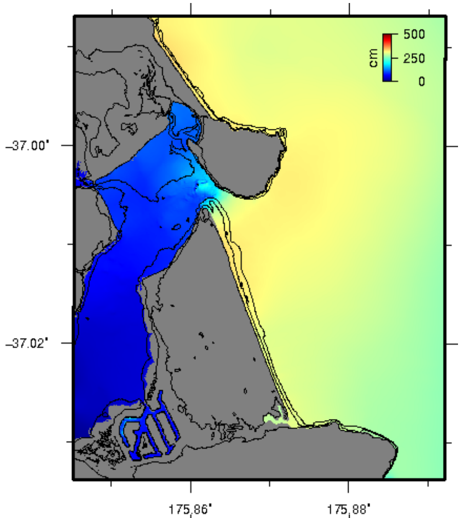
Kermadec Trench Scenarios

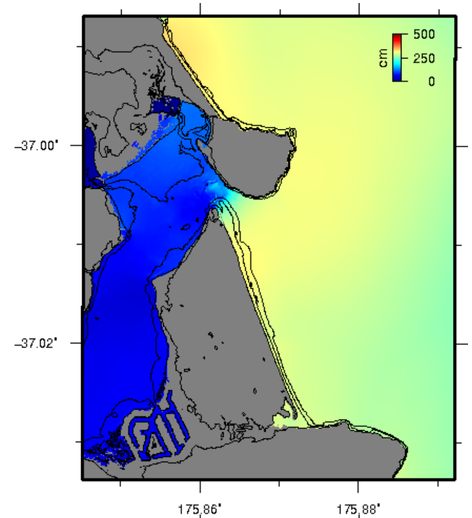
Tairua – Pauanui Results

Mid-Tide

HIGH-Tide

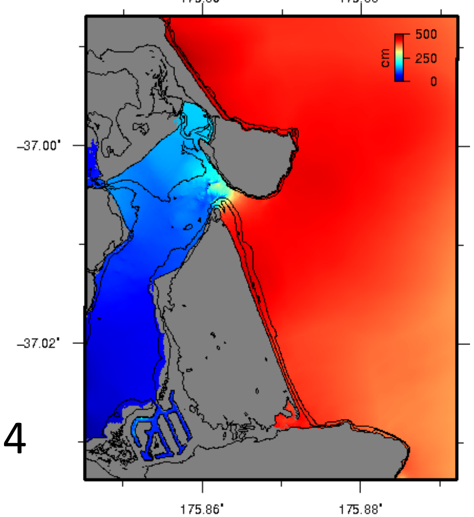
Case 2

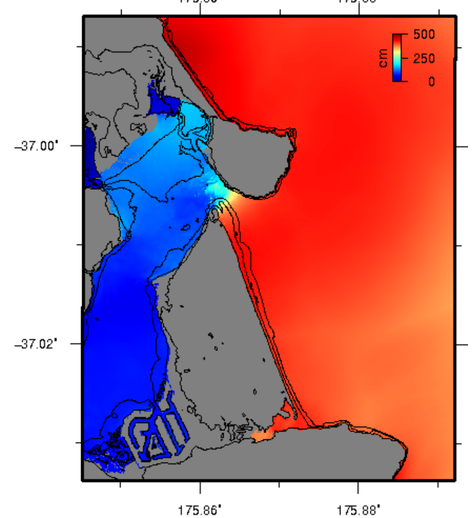




Case 2

Case 4



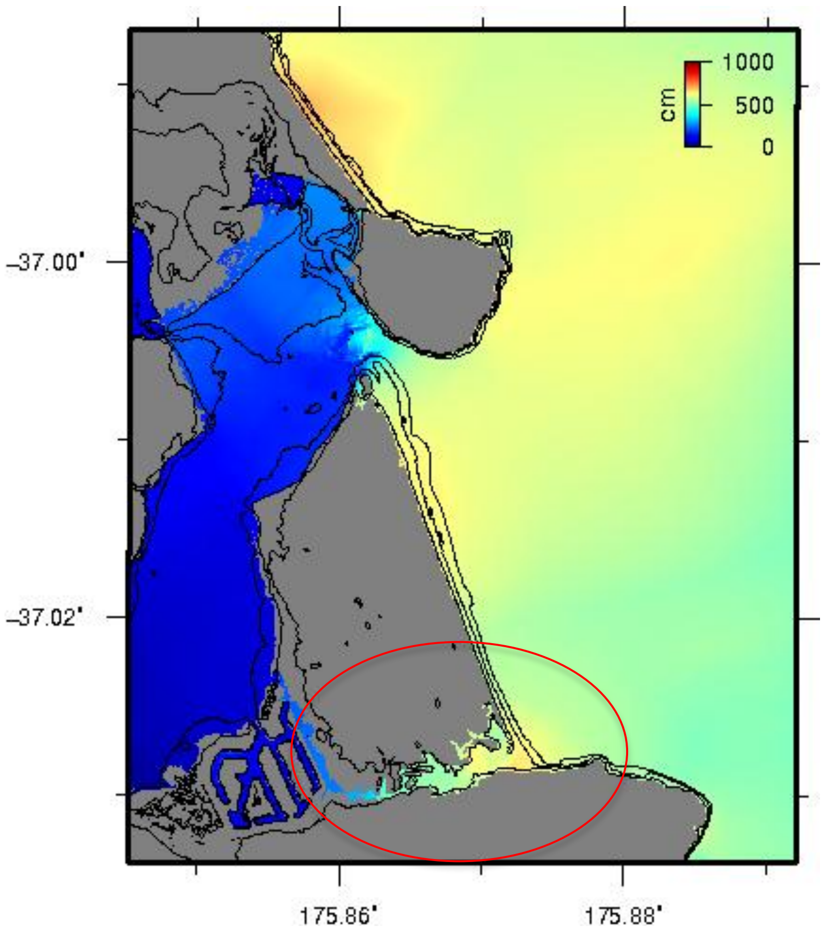


Case 4

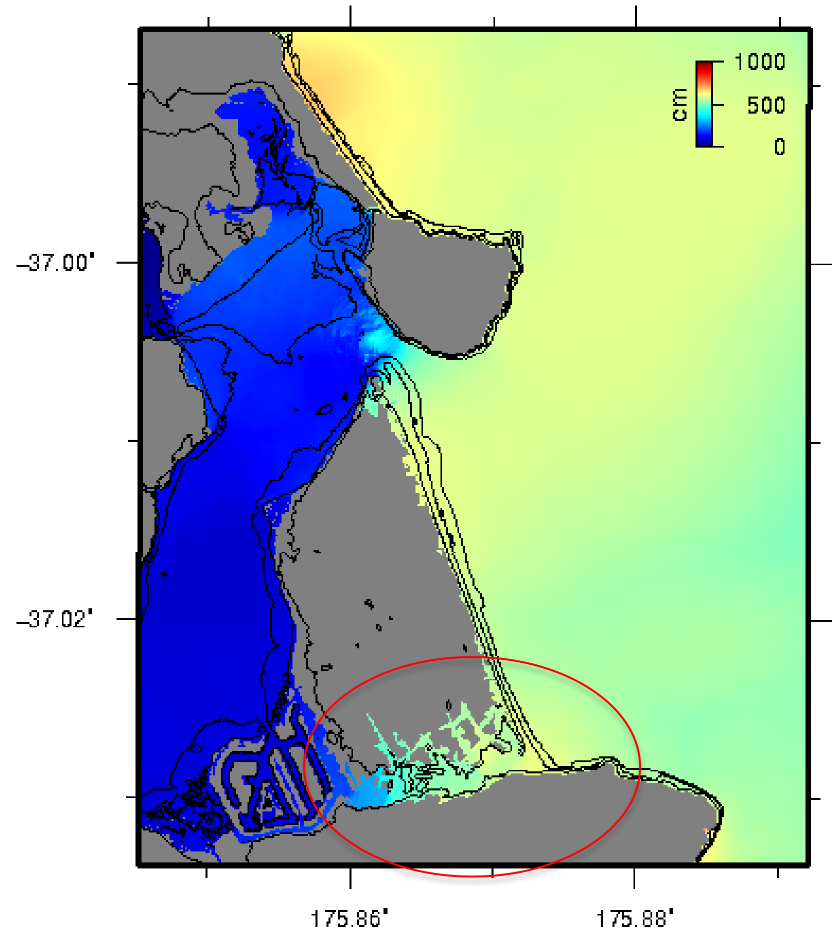
Kermadec Trench Scenarios

Tairua – Pauanui Results

Mid-Tide



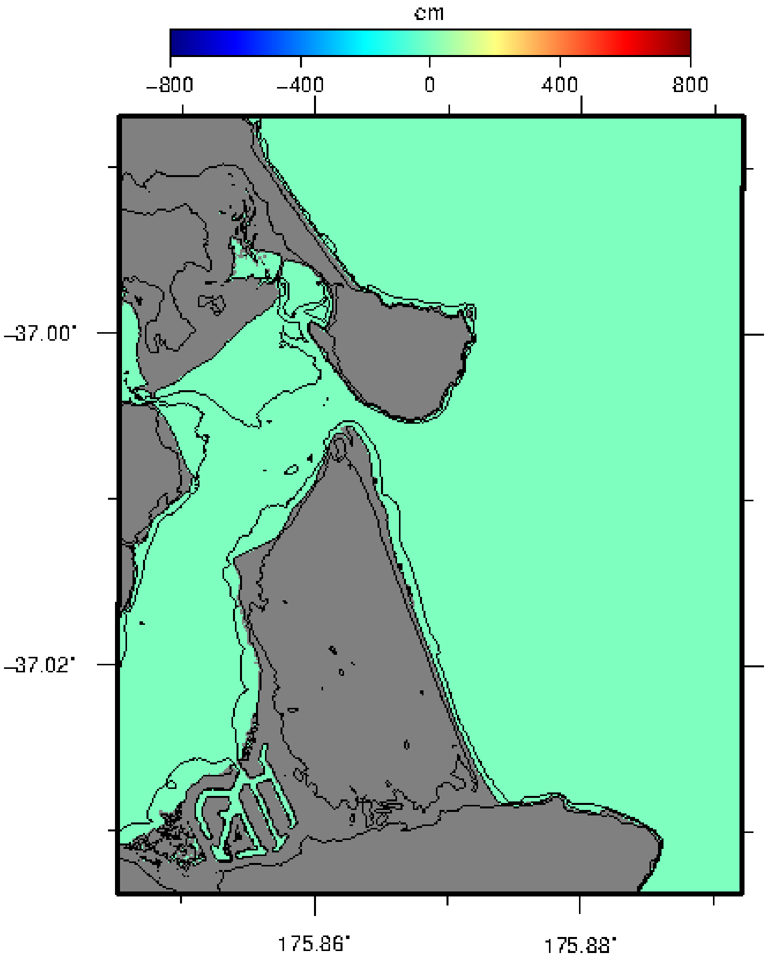
HIGH-Tide

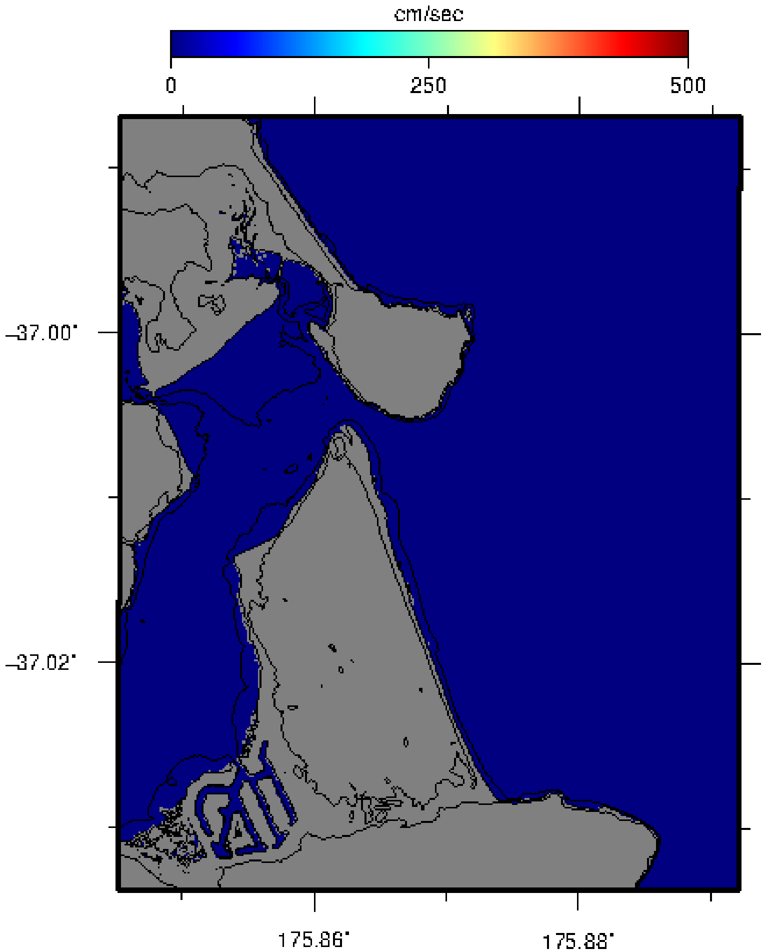


Case 5

Kermadec Trench Scenario

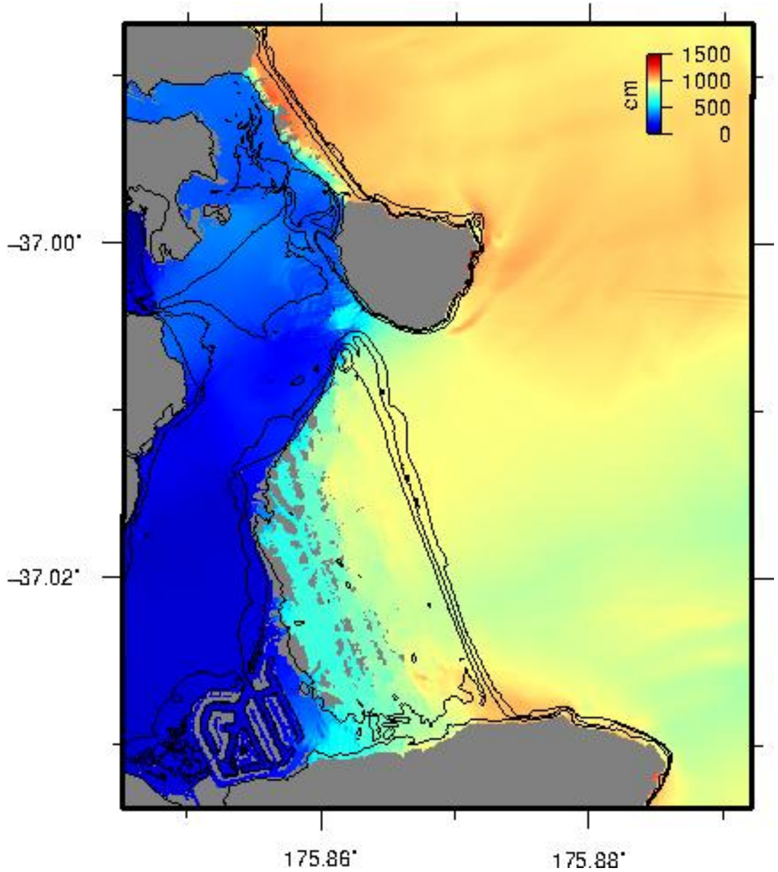
Case 5 – High Tide



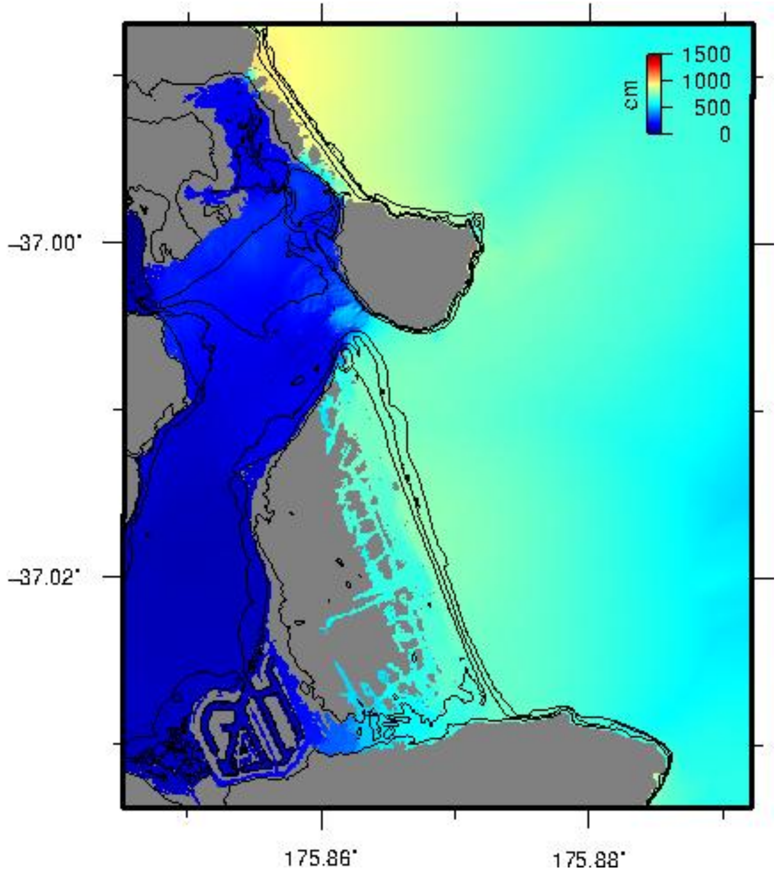


Case 5

Two Additional [EXTREME] Cases

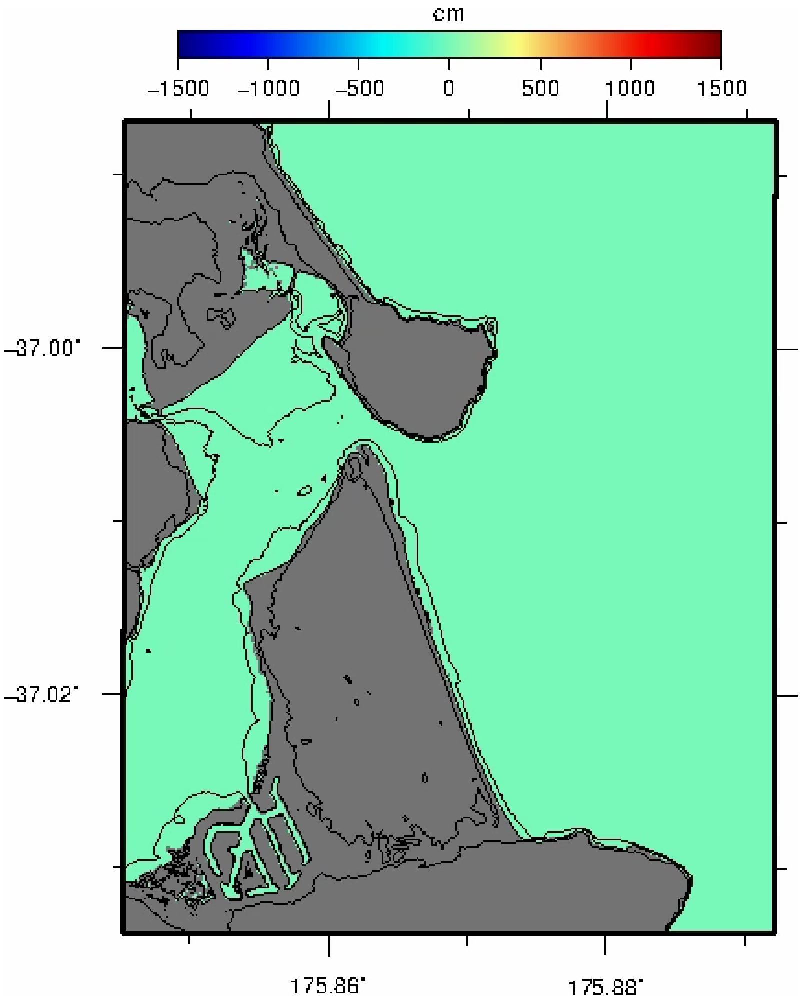


Case 7 High Tide

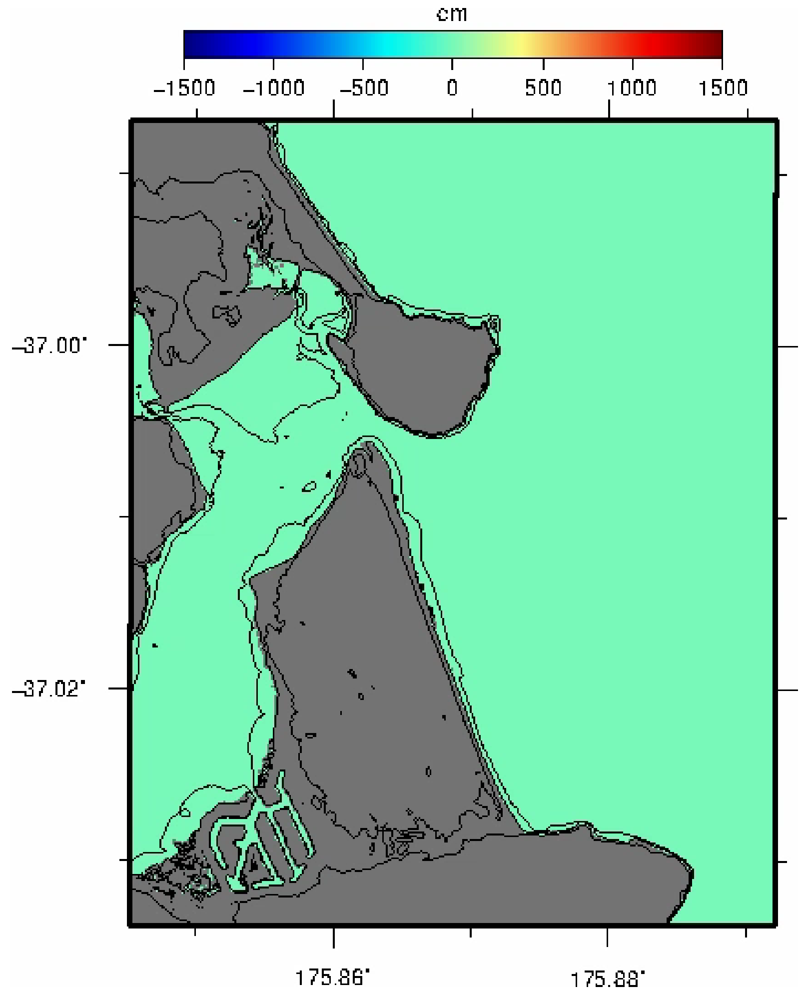


Case 8 High Tide

Tairua – Pauanui Results



Case 7 – 35 m slip



Case 8 – 'Japan on the TK-Trench'
26 m slip

Worst Cases

Case 5

Case 7

Case 8

Conclusions

- Model reproduces instrumental record of historical tsunamis well (2010, 2011)
- Good qualitative match to historical accounts in Whitianga.
- Far field sources do not represent a large scale inundation hazard for Tairua-Pauanui. An extreme event arriving at high tide and currents in the harbour are a concern.
- Worst case scenario is the Kermadec Trench Scenario. The further south, the worse it is.