Experience with OEF in New Zealand

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Outline

- Recent New Zealand Earthquake Activity
- Response and modelling for the Canterbury Sequence
- Response to recent Wellington sequences response (2013-14)
- A few issues...
- And a few thoughts

OEF in New Zealand

Prior to the Canterbury Sequence:

- No regular forecasts were issued.
- STEP internal email list (probs & numbers)
- "OEF-style" NZ-wide STEP hazard maps were running within GeoNet, but were not used internally or externally
- EEPAS forecasts used internally and in published client reports

Post Canterbury:

- We have been issuing seqeuence-response forecasts only (i.e., not continuous in space or time).
- Such forecasts have been issued around the world; we can still do a lot better

GNS response: ***post-Christchurch***

Canterbury region long-term probabilities

	One month: May 28 2012 - June 27 2012			One year: May 28 2012 - May 27 2013		
Magnitude range	Expected range	Expected average	Probability	Expected range	Expected average	Probability
5.0 - 5.4	0 - 1	0.19	17%	0 - 4	1.4	75%
5.5 - 5.9	0 - 1	0.05	5%	0 - 2	0.4	33%
6.0 - 6.4	0 - 1	0.014	1%	0 - 1	0.1	10%
6.5 - 6.9	0 - 1	0.004	<1%	0 - 1	0.03	3%
7.0 - 7.9	0 - 1	0.0015	<1%	0 - 1	0.01	1%

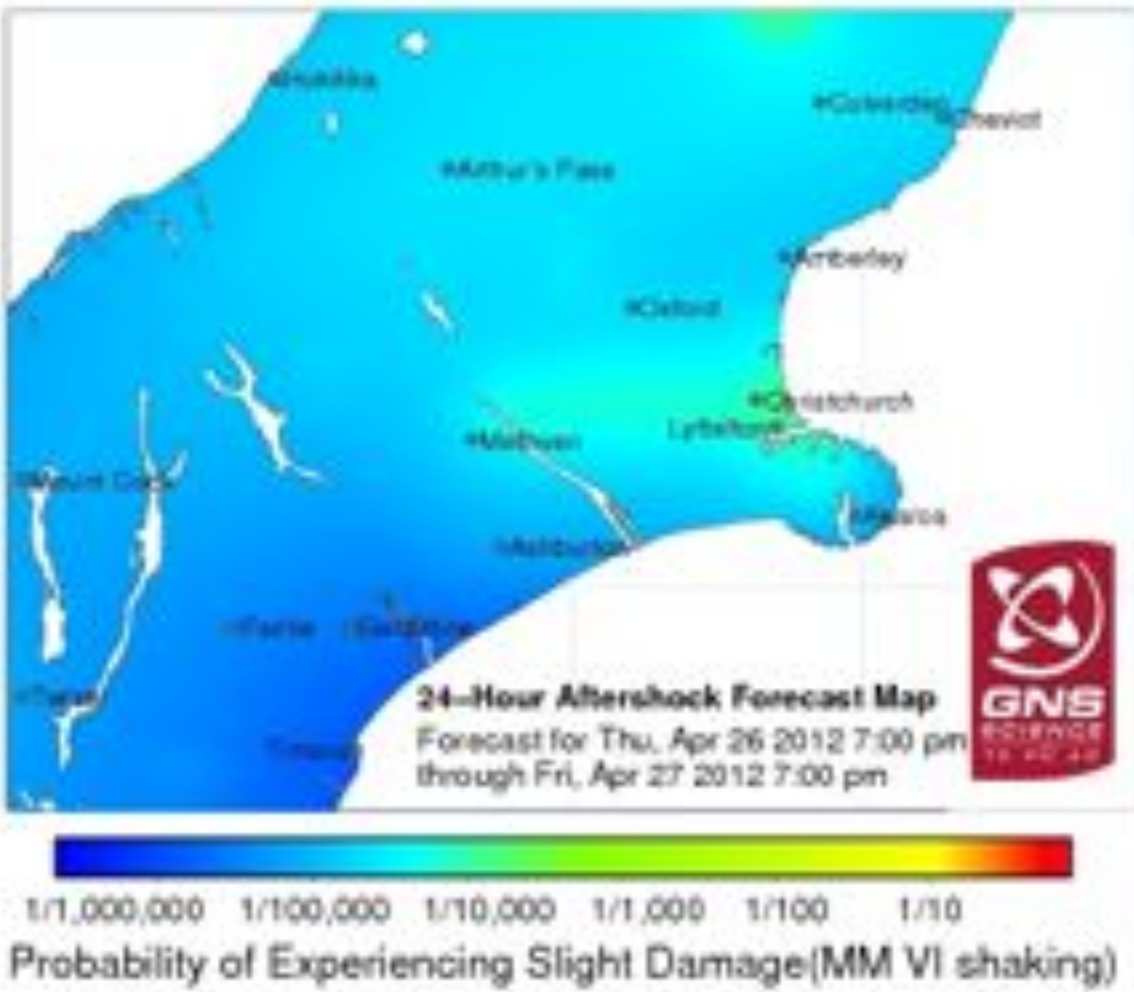
This table was last updated on May 28 2012

Media pressure for finer and finer information

Reluctance to publishing M≥6 & M≥7

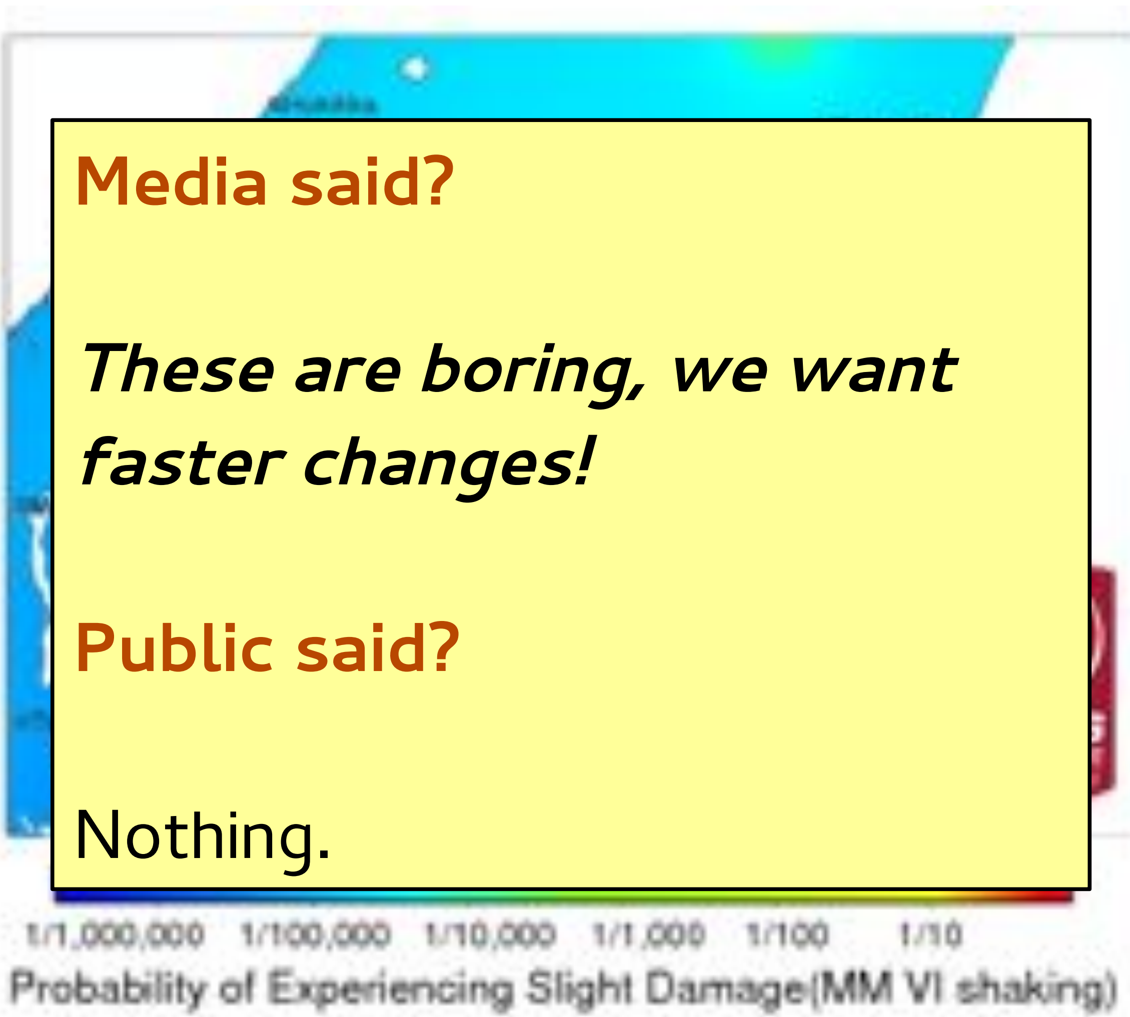
- Not published on GeoNet (for some months)
- Presented and discussed in public forums

GNS response: ***post-Christchurch***



24 hour forecast. Updated hourly

GNS response: ***post-Christchurch***



Media said?

These are boring, we want faster changes!

Public said?

Nothing.

24 hour forecast. Updated hourly

Time-dependent hazard modelling

For revision of building design standards & rebuild planning

Short-term clustering

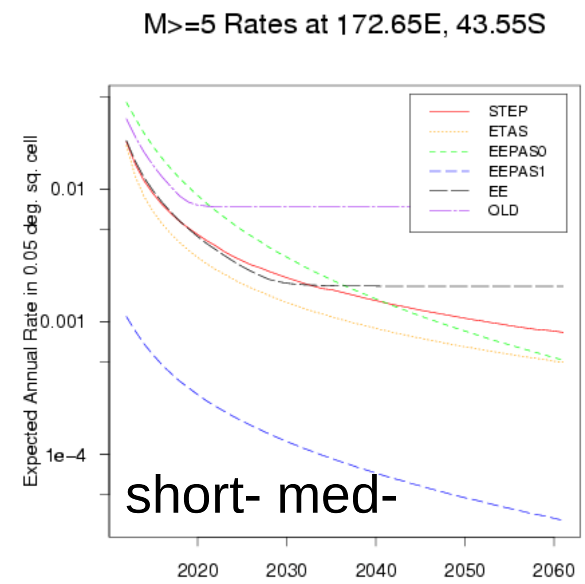
- **STEP & ETAS (aftershocks)**

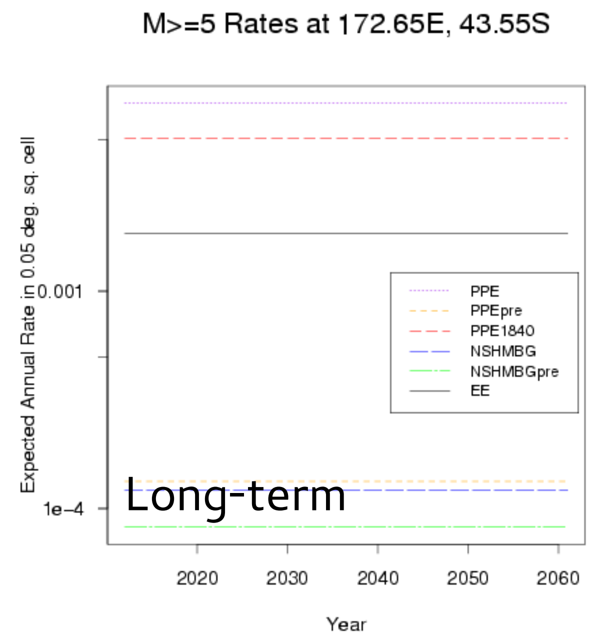
Medium-term clustering

- **EEPAS 1&2 (decadal scale)**

Long-term smoothed seismicity

- **PPE, NSHM (Gaussian), Helmstetter**





- All models were implemented in CSEP testing centres prior to their use in the ensemble
- Retrospective testing shows that the ensemble out performs any of the individual models

Communication: a few key issues

Inexperience with time-dependent models:

- When is a 475-year return period really a 475-year return period, and when is it an uncertainty on the next 50-years? Critical for risk
- How to communicate the temporal decay in useful terms to decision makers?
- How to efficiently provide all of the information that everyone requires when under time-pressure?

Communication: a few key issues

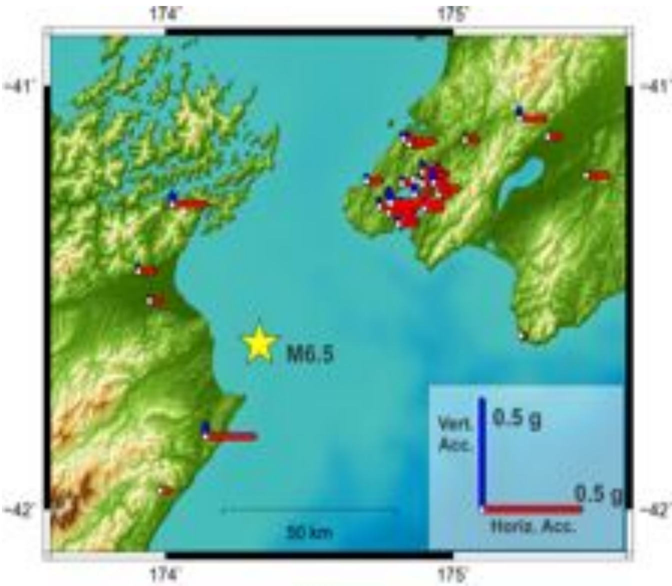
Disbelief of the forecasts:

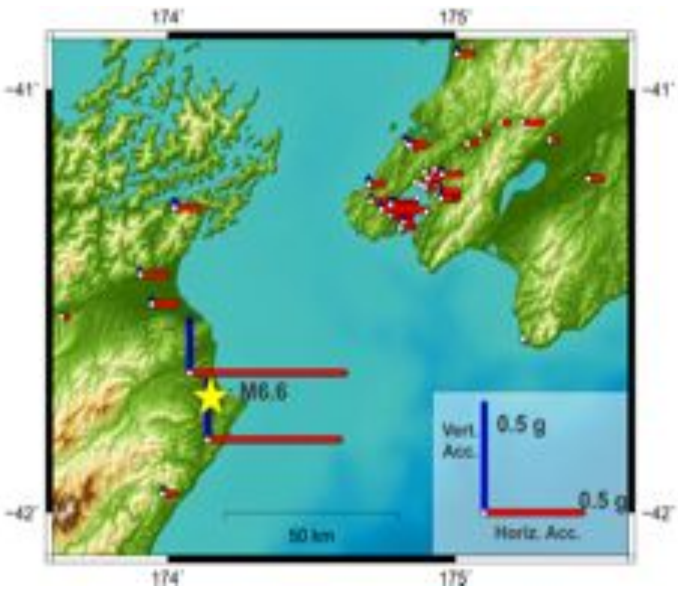
- Your models have the highest probabilities where earthquakes have already happened: that ***can't*** be right! *not said by *Ned Field*
- The sequence sure seems quiet, shouldn't you adjust your models down?
- Perceived lack of relevance/importance of CSEP style testing results

July – August 2013 Cook Strait M6.5; Grassmere M6.6

- Probabilities of M>4, 5, 6 & 7 on GeoNet
- Still! initial reluctance for forecasts of larger events
- Added context of relativity to long-term NSHM expectation

- Probabilitistic Scenarios presented publically, provided to Civil Defense
-





Scenario One – Very Likely (over 98% within 30 days)

Aftershocks will continue to decrease in frequency as expected (and in line with forecasts), remaining relatively deep (i.e. deeper than 25 km) in the Pacific plate.

Scenario Two – Very Unlikely (1% within 30 days)

Another earthquake occurs, with a similar size - magnitude 6 to 7 - to the Eketahuna quake. The earthquake could be at the same depth as the current aftershocks, in a nearby part of the Pacific plate. Or the quake could be centred at a shallower depth (i.e. less than 25 km) in the overlying Australian plate. If a shallower earthquake happens, there may be stronger shaking at the surface than the Eketahuna earthquake.

There are two examples in the east of the North Island where a large earthquake was followed by an earthquake(s) of similar or greater magnitude. In the first example, a magnitude 6.5 earthquake in June 1942 near Masterton was followed by two subsequent events, a magnitude 6.8 in August and a magnitude 6.0 in December the same year.

In the second example, a magnitude 5.9 earthquake in February 1990 near Weber and Porangahau was followed by a magnitude 6.2 earthquake in May 1990 in the same area, which damaged buildings near Weber.

Scenario Three – Extremely Unlikely (less than 1% within 30 days)

A larger magnitude quake - greater than magnitude 7 - on the 'plate interface' (the transition between the Pacific and Australian plates) is extremely unlikely, however, as with many places in New Zealand an earthquake of this size can occur at any time. The chances of one occurring are temporarily increased by the Eketahuna earthquake, in the area outlined in the box in the map below. The expected intensity of shaking from these earthquakes has already been built into the New Zealand Seismic Hazard Model, which is used by the engineering community to design buildings that can withstand intense shaking in New Zealand.

Note: These probabilities will be updated as new forecasts are produced.

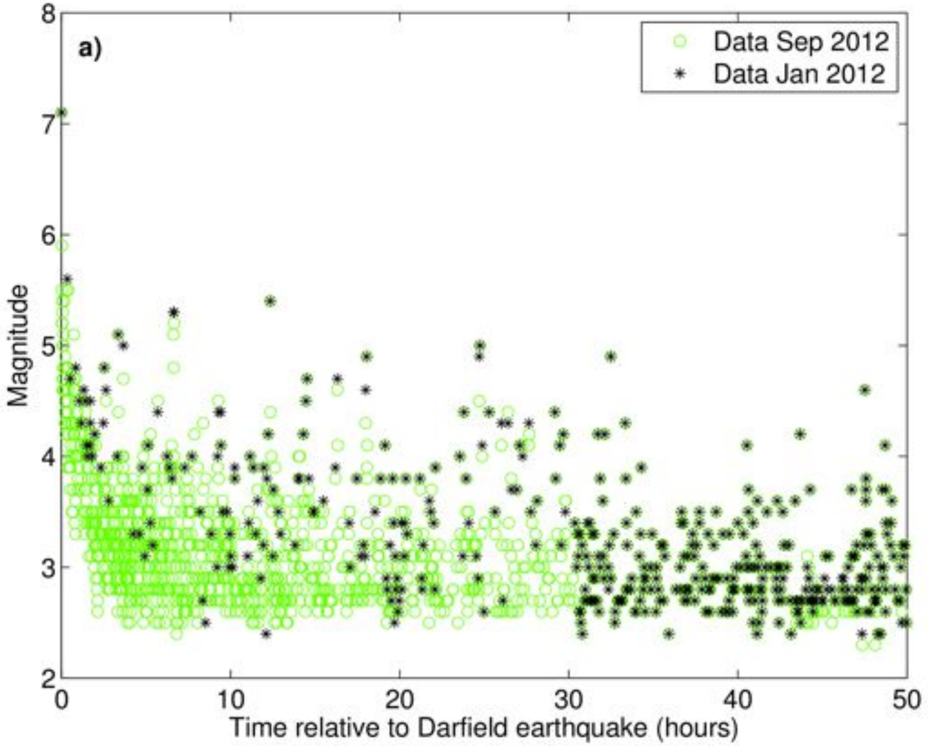
Scenarios

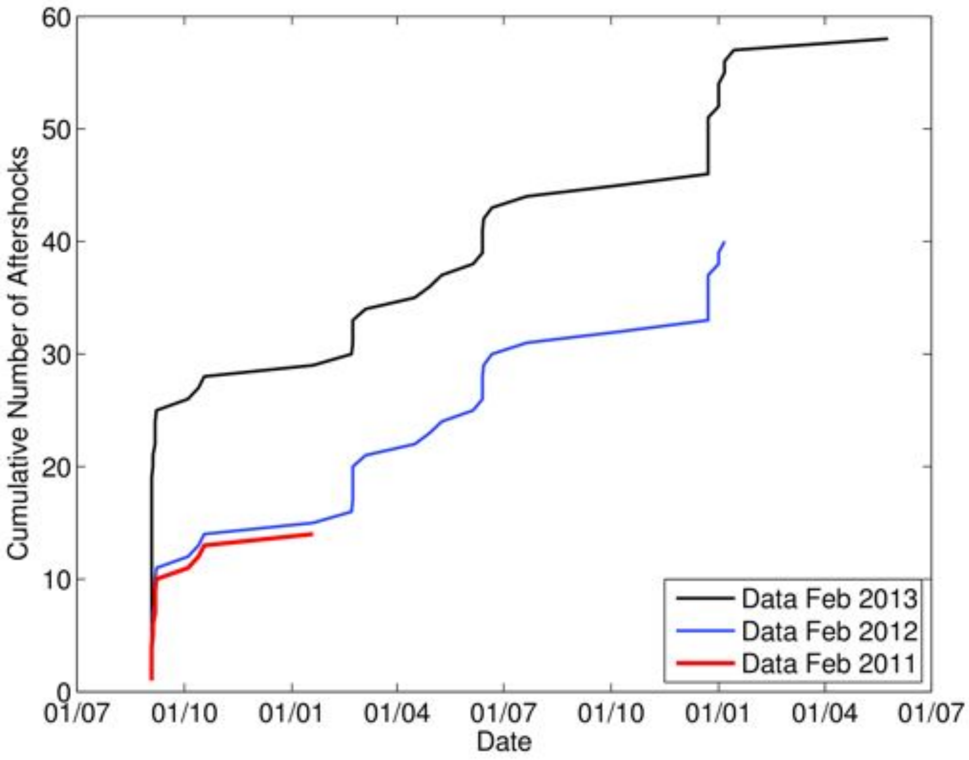
- Informal committee consensus: geologist, geodesists, seismologists
- Must be consistent with forecast probabilities

- Very positive feedback from Government and public (with a little negativity…). Requested by Government

- Currently formalising the procedure
- How should this best be done?

Real-time data quality can be abysmal





Forecast models: timelines, utility and uptake

Forecast	Based On	Used for What
24 hr	STEP	Not used – little new info compared with today
1 week	STEP (EEPAS)	Health & Safety – entry to damaged buildings, USAR, Civil Defence
1 month	STEP (EEPAS, ETAS)	Public decision to relocate**, H&S, Public preparedness actions
1 year	STEP + EEPAS + ETAS	Insurer/banking confidence for rebuild Insurer rebuild risk models, building code changes ready for rebuild, insurance premiums, recovery planning, public seek psychological help
5 year	EEPAS, STEP (PPE)	Land zoning decisions, CBD rebuild decisions “new city” needs - e.g. schools + 1 yr decisions
20 years	EEPAS + PPE + faults	As for 5 year

** Public and policy makers response to aftershock forecasts research is still being completed,

How has CSEP contributed and what else do we need?

- Forecast format: numerous models are already available to are in a consistent format, etc.
- Test results provided:
  - quantitative information to inform expert judgement in building a long-term model
  - Global testing provided some level of confidence in building a model that has significant financial consequences

What else do we need?

- Tests of models of all classes using:
  - Longer forecast time periods
  - Longer lag-times (e.g., a 1-year forecast 20 years from now)

  - More retrospective testing
  - Better results communication strategies

Thank you.

GNS response following Darfield: but before Christchurch

- Study for New Zealand Earthquake Commission (EQC: government earthquake insurance) looking ahead to inform risk model: February 2011
  - Based on previously published work using 3 models
    - Aftershock clustering: Omori-Utsu
    - Aftershock clustering: STEP
    - Longer-term clustering: EEPAS

    - A one-year forecast was requested
    - Model forecasts given independently
    - Effect of parameter uncertainty in Omori-Utsu

GNS response: ***post-Christchurch***

Canterbury region aftershock statistics and forecasts				
Dates	Expected number of aftershocks of magnitude 4.0-4.9	Observed	Expected number of aftershocks of magnitude 5.0 and above	Observed
Sep 4	43 - 73	34	2 - 12	6
Sep 5	11 - 29	18	0 - 5	1
Sep 6 - Sep 12	28 - 53	35	1 - 9	4
Sep 13 - Sep 19	8 - 23	20	0 - 5	0
Sep 20 - Sep 26	4 - 18	9	0 - 3	0
Sep 27 - Oct 3	2 - 13	3	0 - 3	0
Oct 4 - Oct 31	10 - 26	15	0 - 4	3
Nov 1 - Nov 28	5 - 17	11	0 - 4	0
Nov 29 - Dec 26	3 - 13	4	0 - 3	0
Dec 27 - Jan 23	2 - 11	8	0 - 3	1
Jan 24 - Feb 20	1 - 9	5	0 - 2	0
Feb 21 - Feb 22	0 - 2	0	0 - 1	0
February M6.3 sequence commences				
Feb 22 - Feb 28	12 - 29	67	0 - 5	5
Mar 1 - Mar 7	1 - 10	5	0 - 2	1
Mar 8 - Mar 14	0 - 6	8	0 - 2	0
Mar 15 - Mar 21	2 - 11	1	0 - 2	0
Mar 22 - Mar 28	0 - 7	2	0 - 2	0

Initial reluctance to specifically target M>6 & 7 remained

Still heavy reviewing of all outflowing information

Data quality issues in OEF

- The earthquake catalogue available in real-time is of variable and typically poor quality
- The ability of a model to forecast well in a real-time situation is not necessarily the same as its ability to forecast well in CSEP
- How important is this? Should modellers be paying more attention?

	Real-time data			Revised catalogue		
	STEPC1_pp	STEPC2_pp	C-RS_pp	STEPC1-r	STEPC2_r	C-RS_r
Darfield						
February						
June						
December						

Blue: ***worse*** than STEP Green: ***equivalent*** to STEP Red: ***better*** than STEP

Time-dependent hazard modelling

Within 6 weeks issues began to arise:

With heightened levels of seismicity what should the seismicity factor in the building code be?

When will seismicity reduce to a level such that further major damage is "acceptably" unlikely

Where & when should insurers/builders begin repairs

Land zoning – what areas could/should be repaired and what land should be retired

Time-dependent, 50-year, hazard estimate for the Canterbury region

Time-dependent hazard modelling

When combined with engineering information:

35% increase in building design standard for Christchurch

July – August 2013 Cook Strait M6.5; Grassmere M6.6

1. **Normal aftershock sequence of a M6.6 event**, with no further triggering taking place in the next few months. This is the most likely scenario, although currently the sequence is less productive than expected.

2. **Triggered rupture of nearby unidentified faults (M > 6)** – Possibly of similar size to the Cook Strait and Lake Grassmere earthquakes. This is most likely to happen to the south of the previous two events.

3. **Rupture of a major upper South Island fault**, for example the Clarence fault or Wairau fault. Although this has a low probability the GNS Science seismology team have begun kinematic modelling to examine the predicted ground motion that may be experienced in a Clarence Fault M7.7 earthquake, especially in relation to the effect on Wellington, Kaikoura and Hanmer Springs townships, considering directivity effects. An analogue event occurred in 1848 with reported intensities in Wellington as high as MM8. This could cause a tsunami in central New Zealand, if undersea land sliding was triggered.

4. **Triggered rupture of lower North Island faults**. Coulomb stress calculations for the M6.5 and M6.6 earthquakes (combined), when also combined with the stress effect from the ongoing M7+ slow slip event beneath Kapiti, show a slight increase in stress on the lower North Island faults, although this effect is much lower than the increased stress on the Awatere and Wairau faults. This has very low probability.

5. **Triggered rupture of the subduction thrust**, possibly influenced by the ongoing Kapiti slow slip. At the current time we consider this unlikely.