Expert Elicitation Workshop: November 7-9, 2011. New Zealand National Seismic Hazard Model Update for Canterbury

Presentations will have limited questioning time (5min).
Elicitation sessions are divided into two parts beginning with an open discussion on the specific elicitation topic and with the final 20 minutes reserved for filling in the requested weights with minimal discussion.

Day 1 (Monday November 7):

9:00 – 9:10 Kelvin Berryman: Welcome
9:10 – 9:35 Matt Gerstenberger: Intro & Overview
9:35 - 11:00 Training and Seed Question Introduction
11:00 – 11:30 Morning Tea
11:30 – 11:55 Terry Webb: Royal Commission Hearing and Reviews Summary
11:55 – 12:15 Mark Stirling: 2011 NSHM intro (&Mmax, etc)

12:15 – 13:30 Lunch

13:30 – 14:00 Bill Fry: Ground Motion Observations
14:00 – 14:40 Graeme McVerry: McVerry GMPE and implications of Canterbury
14:40 – 15:00 Afternoon Tea
15:00 – 17:00 Elicitation S8 (GMPE)

Day 2 (Tuesday November 8):

9:00 – 9:30 Seed Questions Analysis
9:30 – 10:30 Elicitation S5 (Mmin)
10:30 – 10:50 Morning Tea
10:50 – 11:20 David Rhoades AVMAX Model. EEPAS, Rhoades-ETAS, PPE
11:20 – 11:40 Matt Gerstenberger: STEP, Helmstetter, NSHMBG
11:40 - 12:05 Charles Williams: Coulomb & Rate&State+Coulomb
12:05 – 12: 20 Sandy Steacy: STEP+Coulomb: 10mins
12:20 – 12:45 David Rhoades: Retrospective test results

12:45 – 13:45 Lunch

13:45 – 15:15 Elicitation S1 (Time-Dep Models – 50yrs)
15:15 – 15:35 Afternoon Tea
15:35 – 16:00 Elicitation S1 continued
16:00 – 17:00 Elicitation S3 (Time-Dep Models – 1yr)

18:00+ BBQ At Mark's House

Day 3 (Wednesday, November 9)

9:00 – 10:30 Elicitation S2 (Time-Indep Models)
10:30 – 10:50 Morning Tea
10:50 – 11:10 Elicitation S2 continued
11:10 – 11:40 Kelvin Berryman: Late and Large Triggered events & fault model
11:40 – 12:00 Jarg Pettinga: Canterbury Faults
12:00 – 12:20 Mark Stirling Mmax, Source depth, Fault Model
12:20 – 12:40 Andy Nicol Fault Data Completeness

12:40 – 13:40 Lunch

13:40 – 14:40 Elicitation S4 (Faults)
14:40 - 15:00 Martin Reyners: Relocated Canterbury Earthquake Catalogues
15:00 – 15:40 Elicitation S6 (Maximum Magnitude)
15:40 – 16:00 Afternoon Tea
16:00 – 16:20 Elicitation S6 continued
16:20 – 17:00 Elicitation S7 (Source Depths)

We will be using an expert elicitation methodology which has at its core the methodology of Cooke (1991). A key aim of the workshop is to explore the range of uncertainties in the update of the New Zealand National Seismic Hazard Model (NSHM) for Canterbury.

Using the methodology of Cooke, we will be trialing the use of expert calibration which provides a weight to the input of each expert. Based on responses to 15 calibration questions, a weight is calculated for each expert that measures the calibration (how well, statistically, the expert's values match the true values) and the information (a statistical measure of the width of the expert's confidence bounds). The scoring is designed so that an expert receives his or her optimal score by giving the best estimate of the mean and confidence bounds. An additional benefit of calibration questions is in helping the experts to understand the elicitation process they will be undertaking. Any expert weighting calculated will be kept confidential to the facilitator & analyst. Presentation of analysis of calibration question results to the workshop will be kept anonymous, and no individual weights will be shown.

The end result of the procedure will be two time-dependent ensemble models: 1) a 50 year forecast for the next 50 years starting July 1st 2012; and 2) a one-year forecast starting sometime between January 1st 2012 and June 1st 2012. For each possible component model, 50 subsequent one-year forecasts are created. The ensemble model will be created using a linear combination of the weighted component models; however we are using what we have termed the AVMAX model. In this model we separate the weighting of the time-dependent models from the weighting of the time-independent models. The final ensemble is created by the maximum of either the time-dependent or the time-independent weighted model in each one-year period. This is further broken down by using the maximum at each grid node (.05 degree grids). In all cases the standard NSHM fault model is added independently, and in full, to the ensemble model and is excluded from the weighting process.

Preliminary weights based on all questions are expected to be submitted at the end of the workshop. Final weights are expected two weeks later on Thursday, November 24th, 2011.

Some important details for the three-day workshop are:

1. We are eliciting seismicity models separately for a one-year forecast and a 50-year forecast.
2. We have eight *independent question sets* for which we will be eliciting model weights.
3. Each question set contains and refers to multiple models
4. Weights (mean) are relative to all models within a single set
5. Lower Bounds (10th-Percentile) and Upper Bounds (90th-Percentile) are also required.
6. Mean weights must sum to one, except for the seismicity model sets (S1 & S2) which must sum to either one or zero, where zero means that the model set does not contribute to the overall seismicity. Only one seismicity set can be weighted to zero.

7. An individual model weight within a set can be 0.
8. Lower and Upper Bound weights are only relative to the median weight and are independent of other models within a set; therefore these weights do not need to sum to one.
9. The weights have no time dependence, that is, they are constant throughout the time period.

The Elicitation Question Sets

1. Set S1: time-dependent models – 50 years
2. Set S2: time-independent models – 50 years
3. Set S3: time-dependent models – 1 year
4. Set S4: Fault models
5. Set S5: Mmin in time dependent and time independent seismicity models (independent of faults)
6. Set S6: Mmax in time dependent and time independent seismicity models (independent of faults)
7. Set S7: Minimum depth layer in time dependent and time independent seismicity models
8. Set S8 Ground motion variability

Model Definitions

Time-dependent Models

STEP: Short-term earthquake probability model. Ad-hoc superimposed Omori sequences. Spatially adaptable.

Rhoades-ETAS: David Rhoades' implementation of the ETAS model.

STEP+Coulomb: Scaling of the final STEP forecast using the Coulomb stress lobes as a binary spatial filter. 93% of the forecast rates are placed in red lobes, 7% into blue (based on analysis of a few historical sequences).

Rate&State+Coulomb: Applies rate and state scaling to the predicted Coulomb stress changes

EEPAS: Every Earthquake a Precursor According to Scale. Medium-term cluster model based on three precusory scaling relationships (magnitude, area and time)

EEPAS-low-aftershocks: down-weighting of influence of aftershocks in EEPAS

Time-independent Models

PPE1950+Darfied: Proximity to Past Earthquake model using M≥4 since 1950 and including all events from Darfield until the calculation of the forecast. Non-declusted.

PPE1950-NoDarfield: PPE model using M≥4 since 1950 up until September 3, 2010 (i.e., no Darfield aftershocks included). Non-declustered.

PPE1840+Darfield: PPE model using M≥4 since 1950 and M≥6 since 1840 and including all events from Darfield until the calculation of the forecast. Non-declustered.

PPE1840-NoDarfield: PPE model using M≥4 since 1950 and M≥6 since 1840 and up until September 3, 2010 (i.e., no Darfield aftershocks included). Non-declustered.

NSHMBG: The 2011 NZ NSHM smoothed background seismicity model based on a Reasenberg declustered catalogue using events from 1840-2009.5. It uses a 50km Gaussian smoother.

NSHMBG+Darfield: The 2011 NZ NSHM smoothed background seismicity model based on a Reasenberg declustered catalogue and updated to use events from 1840 until the time of calculation of the forecast (i.e., it will include the time-

period of Darfield, but will be declustered). It uses a 50km Gaussian smoother.

Helm-NoDarfield: The Helmstetter, Kagan & Jackson density based adaptive kernel using all events M≥3.0 since 1964 up until September 3rd, 2010. Non-declustered. An implementation of the currently best performing model in CSEP-California (1st 5yr period is complete).

Helm+Darfield: The Helmstetter, Kagan & Jackson density based adaptive kernel using all events M≥3.0 since 1964 up until the time of calculation of the forecast (i.e., it will include Darfield aftershocks). Non-declustered. An implementation of the currently best performing model in CSEP-California (1st 5yr period is complete).

Set 1 Time-Dependent Models: 50-year forecast

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

All questions are with respect to the AVMAX combined seismicity model.

The Canterbury region in consideration extends [-43,-44;171, to the coastline]

S1Q1: When comparing all models in S1, what relative weight would you give **STEP** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S1Q2: When comparing all models in S1, what relative weight would you give **Rhoades-ETAS** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S1Q3: When comparing all models in S1, what relative weight would you give **STEP+Coulomb** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S1Q4: When comparing all models in S1, what relative weight would you give **Rate&State+Coulomb** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S1Q5: When comparing all models in S1, what relative weight would you give **EEPAS (EEPAS0)** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S1Q6: When comparing all models in S1, what relative weight would you give **EEPAS-low-aftershocks (EEPAS1)** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S1Q7: When comparing all models in S1 what relative weight would you give to a model not presented in S1 for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

Set 2 Time-*In*dependent Models: 50-year forecast

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

All questions are with respect to the AVMAX combined seismicity model.

The Canterbury region in consideration extends [-43,-44;171, to the coastline]

S2Q1: When comparing all models in S2, what relative weight would you give **PPE1950+Darfield** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S2Q2: When comparing all models in S2, what relative weight would you give **PPE1950-NoDarfield** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S2Q3: When comparing all models in S2, what relative weight would you give **PPE1840+Darfield** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S2Q4: When comparing all models in S2, what relative weight would you give **PPE1840-NoDarfield** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S2Q5: When comparing all models in S2, what relative weight would you give **NSHMBG+Darfield** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S2Q6: When comparing all models in S2, what relative weight would you give **NSHMBG-NoDarfield** for representing the seismicity in Canterbury for the next

50 years?

10%_____50%_____90%_____

S2Q7: When comparing all models in S2, what relative weight would you give **Helm+Darfield** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S2Q8: When comparing all models in S2, what relative weight would you give **Helm-NoDarfield** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

S2Q9: When comparing all models in S2, what relative weight would you give to a **model not presented in S2** for representing the seismicity in Canterbury for the next 50 years?

10%_____50%_____90%_____

Set 3 Time-Dependent Models: 1-year forecast

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

All questions are with respected to a weighted-average model. Considered start times for the forecast will be between January 1st, 2012 and June 1st, 2012

The Canterbury region in consideration extends [-43,-44;171, to the coastline]

S3Q1: When comparing all models in S3, what relative weight would you give **STEP** for representing the seismicity in Canterbury for the next year?

10%_____50%_____90%_____

S3Q2: When comparing all models in S3, what relative weight would you give **Rhoades-ETAS** for representing the seismicity in Canterbury for the next year?

10%_____50%_____90%_____

S3Q3: When comparing all models in S3, what relative weight would you give **STEP+Coulomb** for representing the seismicity in Canterbury for the next year?

10%_____50%_____90%_____

S3Q4: When comparing all models in S3, what relative weight would you give **Rate&State+Coulomb** for representing the seismicity in Canterbury for the next year?

10%_____50%_____90%_____

S3Q5: When comparing all models in S3 what relative weight would you give **EEPAS (EEPAS0)** for representing the seismicity in Canterbury for the next year?

10%_____50%_____90%_____

S3Q6: When comparing all models in S3 what relative weight would you give **EEPAS-low-aftershocks (EEPAS1)** for representing the seismicity in Canterbury for the next year?

10%_____50%_____90%_____

S3Q7: When comparing all models in S3 what relative weight would you give to

a model not presented in S1 for representing the seismicity in Canterbury for the next year?

10%_____50%_____90%_____

Set 4 Scaling the model to include fault location data

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

Questions S4Q1, S4Q2 & S4Q3 Must sum to 100%.

S4Q1: What relative weight would you give to a final ensemble model that uses **the Fault-Scaled Model where total forecast rates are conserved** (ie, the rates in non-fault grids will decrease)?

10%_____50%_____90%_____

S4Q2: What relative weight would you give to a final ensemble model that **uses the Fault-Scaled Model where total forecast rates are NOT conserved** (ie, the rates in the non-fault grids are unchanged and the total regional rate may increase)?

10%_____50%_____90%_____

S4Q3: What relative weight would you give to a final ensemble model that **does not use the Fault-Scaled Model?**

10%_____50%_____90%_____

Questions S4Q3-S4Q5 must sum to 100%

S4Q4: In the Fault-Scaled Model, what weight would you give to a model that uses **M6.5** as the minimum magnitude?

10%_____50%_____90%_____

S4Q5: In the Fault-Scaled Model, what weight would you give to a model that uses **M7.2** as the minimum magnitude?

10%_____50%_____90%_____

S4Q6: In the Fault-Scaled Model, what weight would you give to a model that uses a minimum magnitude that is **not presented in S4?**

10%_____50%_____90%_____

S4Q7 & S4Q8 are independent of other questions. All entries may be 0.

S4Q7: In **the rate-conserved Fault-Scaled Model (S4Q1), what scalar**, in percent, would you apply to alter the rates of the ensemble seismicity model at locations of known faults?

10%_____50%_____90%_____

S4Q8: In the **rate-non-conserved Fault-Scaled Model (S4Q2),** what **scalar**, in percent, would you apply to alter the rates of the ensemble seismicity model at locations of known faults?

10%_____50%_____90%_____

Set 5 Minimum Magnitude in Seismicity Models

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

S5Q1: What relative weight would you give to a seismicity model that uses **M5.0** for its minimum forecast magnitude when combined with the McVerry (2006) GMPE for hazard calculations?

10%_____50%_____90%_____

S5Q2: What relative weight would you give to a seismicity model that uses **M5.25** for its minimum forecast magnitude when combined with the McVerry (2006) GMPE for hazard calculations?

10%_____50%_____90%_____

S5Q3: What relative weight would you give to a seismicity model that uses **M5.5** for its minimum forecast magnitude when combined with the McVerry (2006) GMPE for hazard calculations?

10%_____50%_____90%_____

S5Q4: What relative weight would you give to a seismicity model that uses **M6.0** for its minimum forecast magnitude when combined with the McVerry (2006) GMPE for hazard calculations?

10%_____50%_____90%_____

S5Q5: What relative weight would you give to a seismicity model that uses a **magnitude not presented in S5** for its minimum forecast magnitude when combined with the McVerry (2006) GMPE for hazard calculations?

10%_____50%_____90%_____

Set 6 Maximum Magnitude in Seismicity Models

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

S6Q1: What relative weight would you give to a seismicity model, for Canterbury, that uses **M7.2** for its maximum forecast magnitude for a forecast for the next 50 years?

10%_____50%_____90%_____

S6Q2: What relative weight would you give to a seismicity model, for Canterbury, that uses **M7.5** for its maximum forecast magnitude for a forecast for the next 50 years?

10%_____50%_____90%_____

S6Q3: What relative weight would you give to a seismicity model, for Canterbury, that uses **M8.0** for its maximum forecast magnitude for a forecast for the next 50 years?

10%_____50%_____90%_____

S6Q4: What relative weight would you give to a seismicity model, for Canterbury, that uses a **magnitude not presented in S6** for its maximum forecast magnitude for a forecast for the next 50 years?

10%_____50%_____90%_____

Set 7 Minimum depth layer in Seismicity Models

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

The 50% value over all questions must sum to 100%

S7Q1: What relative weight would you give to a depth layer of **1km** in a seismicity model, for Canterbury?

10%_____50%_____90%_____

S7Q2: What relative weight would you give to a depth layer of **2km** in a seismicity model, for Canterbury?

10%_____50%_____90%_____

S7Q3: What relative weight would you give to a depth layer of **5km** in a seismicity model, for Canterbury?

10%_____50%_____90%_____

S7Q4: What relative weight would you give to a depth layer of **10km** in a seismicity model, for Canterbury?

10%_____50%_____90%_____

S7Q5: What relative weight would you give to a depth layer of **20km** in a seismicity model, for Canterbury?

10%_____50%_____90%_____

S7Q6: What relative weight would you give to a depth layer of **30km** in a seismicity model, for Canterbury?

10%_____50%_____90%_____

Set 8 McVerry Ground Motion Prediction Equation (GMPE) Variability

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

S8Q1: What relative weight would you give to a McVerry GMPE, for Canterbury, with **increased uncertainty** to match the epistemic uncertainty of the NGA models for California? (logic tree method; scaled medians)

10%_____50%_____90%_____

S8Q2: What relative weight would you give to a McVerry GMPE, for Canterbury, that scales predicted ground motions using the **Boore & Atkinson (2006**) Stress Drop Scaling Relationship using a target stress drop of 150 bars and a reference stress drop of 100 bars?

10%_____50%_____90%_____

S8Q3: What relative weight would you give to a McVerry GMPE, for Canterbury, that uses the standard prediction with **no additional scaling?**

10%_____50%_____90%_____

S8Q4: What relative weight would you give to other GMPE models, for Canterbury, that are **not presented in S8?**

10%_____50%_____90%_____

GMPE Expert Elicitation Workshop

9:30-9:45 Introduction
9:45-10:05 Intro to Combining Expert Judgement
10:05-10:30 Seed Questions

10.30-10.50 Morning Tea

10.50-11.20 Brendon Bradley: B10 Model
11.25-11.55 Graeme McVerry: McVerry Model
12.00-13.00: Bill Fry & Discussion

13.00-14.00: Lunch

14.00- 15.00: Discussion
15.00-15.30: Individual Weighting

GMPE Expert Elicitation Workshop Question Set

Set 1 Ground Motion Prediction Equations & Variability

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

Questions S1Q1 through S1Q6 must sum to 1.

S1Q1: What relative weight would you give to a McVerry GMPE, for Canterbury, with **increased uncertainty** to match the epistemic uncertainty of the NGA models for California?

10%_____ 50%_____ 90%_____

S1Q2: What relative weight would you give to a McVerry GMPE, for Canterbury, that scales predicted ground motions using the **Boore & Atkinson (2006) Stress Drop Scaling Relationship** using a target stress drop of 150 bars and a reference stress drop of 100 bars?

10%_____ 50%_____ 90%_____

S1Q3: What relative weight would you give to a McVerry GMPE, for Canterbury, that uses the standard prediction with **no additional scaling?**

10%_____ 50%_____ 90%_____

S1Q4: What relative weight would you give to a Bradley (2010) GMPE, for Canterbury, with **increased uncertainty** to match the epistemic uncertainty of the NGA models for California?

10%_____ 50%_____ 90%_____

S1Q5: What relative weight would you give to a Bradley (2010) GMPE, for Canterbury, that scales predicted ground motions using the **Boore & Atkinson (2006) Stress Drop Scaling Relationship** using a target stress drop of 150 bars and a reference stress drop of 100 bars?

10%_____50%_____90%_____

S1Q6: What relative weight would you give to a Bradley (2010) GMPE, for Canterbury, that uses the standard prediction with **no additional scaling?**

10%_____50%_____90%_____

S1Q7: What relative weight would you give to other GMPE models, for Canterbury, that are **not presented in S8?**

10%_____50%_____90%_____

Set 2 Minimum Magnitude in Seismicity Models

10% is your lower bounds (10th-Percentile) on the weighting.
50% is your preferred (median) bounds on the weighting.
90% is your upper bound (90th-Percentile) on the weighting.

Questions S2Q1 through S2Q4 must sum to 1.

S2Q1: What relative weight would you give to a seismicity model that uses **M5.0** for its minimum forecast magnitude when combined with the ensemble GMPE for hazard calculations?

10%_____50%_____90%_____

S2Q2: What relative weight would you give to a seismicity model that uses **M5.25** for its minimum forecast magnitude when combined with the ensemble GMPE for hazard calculations?

10%_____50%_____90%_____

S2Q3: What relative weight would you give to a seismicity model that uses **M5.5** for its minimum forecast magnitude when combined with the ensemble GMPE for hazard calculations?

10%_____50%_____90%_____

S2Q4: What relative weight would you give to a seismicity model that uses **M6.0** for its minimum forecast magnitude when combined with the ensemble GMPE for hazard calculations?

10%_____50%_____90%_____

S2Q5: What relative weight would you give to a seismicity model that uses a **magnitude not presented in S5** for its minimum forecast magnitude when combined with the ensemble GMPE for hazard calculations?

10%_____50%_____90%_____