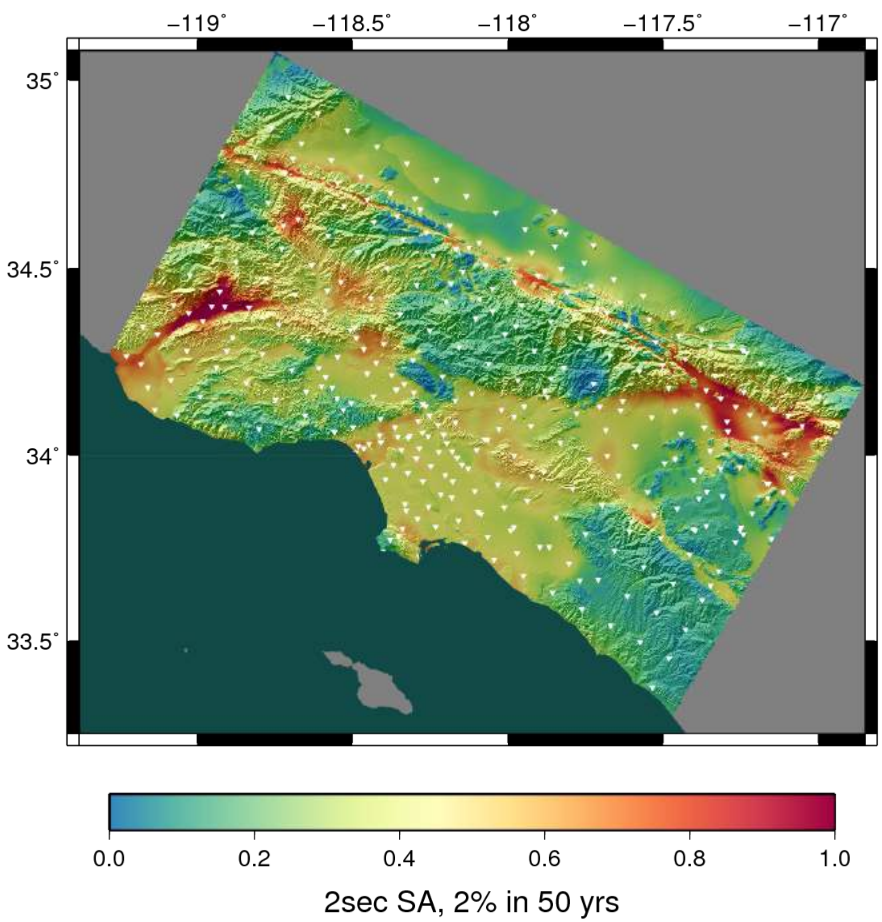
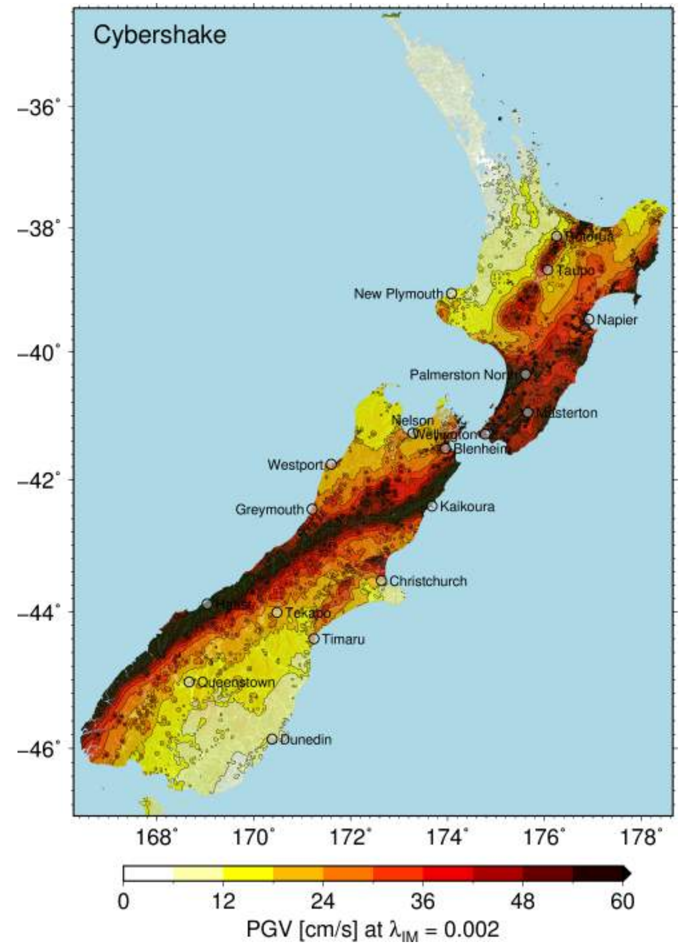
Summary of 2019 SCEC Posters and reflection on QuakeCoRE GMSV





Brendon Bradley, Sept 2019

Aim

- Provide a synopsis of the 29 posters (and CVM workshop) at the 2019 SCEC Annual meeting related to ground motion prediction/simulation
- Reflect on the priorities and progress of QuakeCoRE's efforts in FP1

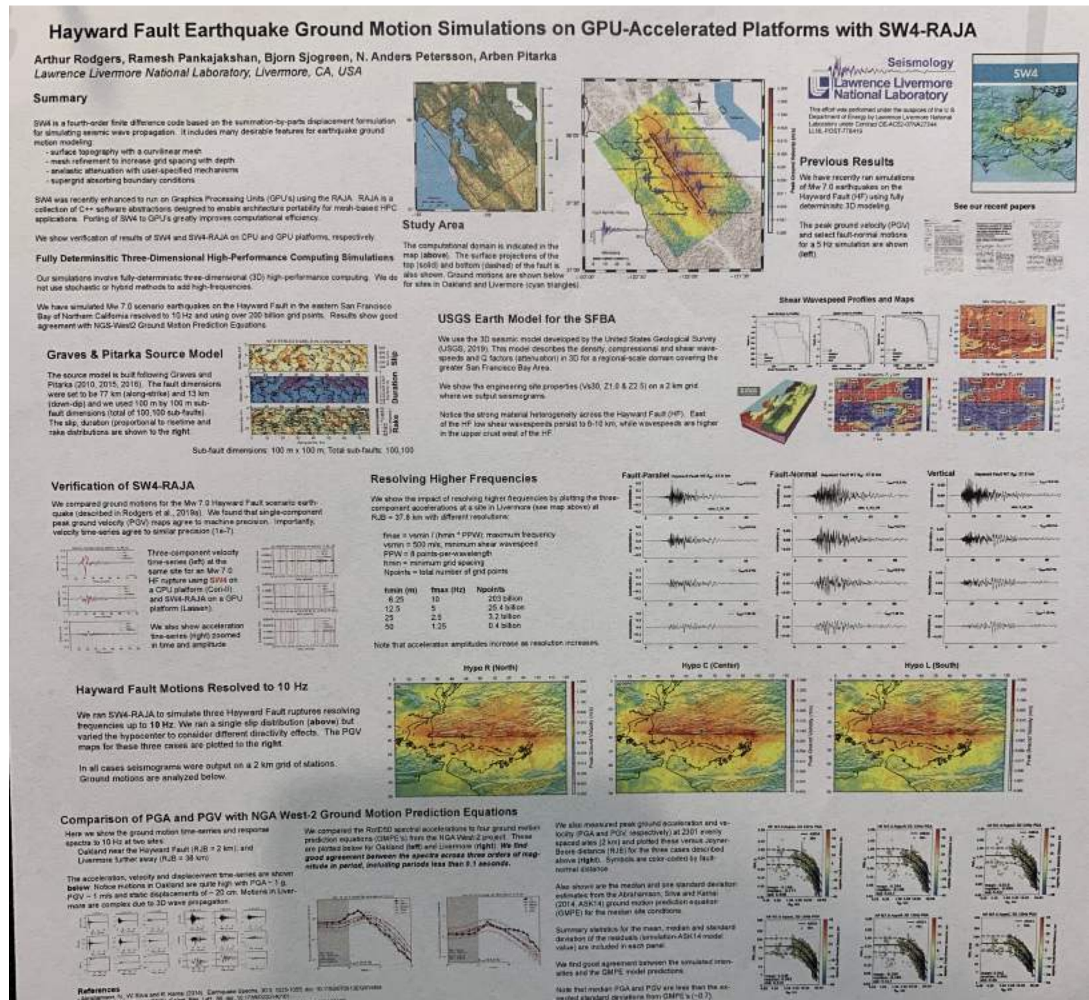
- Note:
  - Program at: https://www.scec.org/meetings
  - PDF of posters usually available ~1 month after meeting

Poster Summary

- 5 of the 29 Presented by QC researchers! (Sarah, Anna, Robin, Andrei, Brendon)
- Of the remaining 24:
  - 2 adding new ‘enhancements’ to codes:
  - 4 Gm Simulation applications
  - 2 Gm Sim validation
  - 4 on shallow (geotechnical) site response
  - 2 Flagship SCEC projects (BBP and Cybershake)
  - 3 Machine learning approaches using simulated ground motions or hybrid empirical/simulated
  - Remainder misc. topics

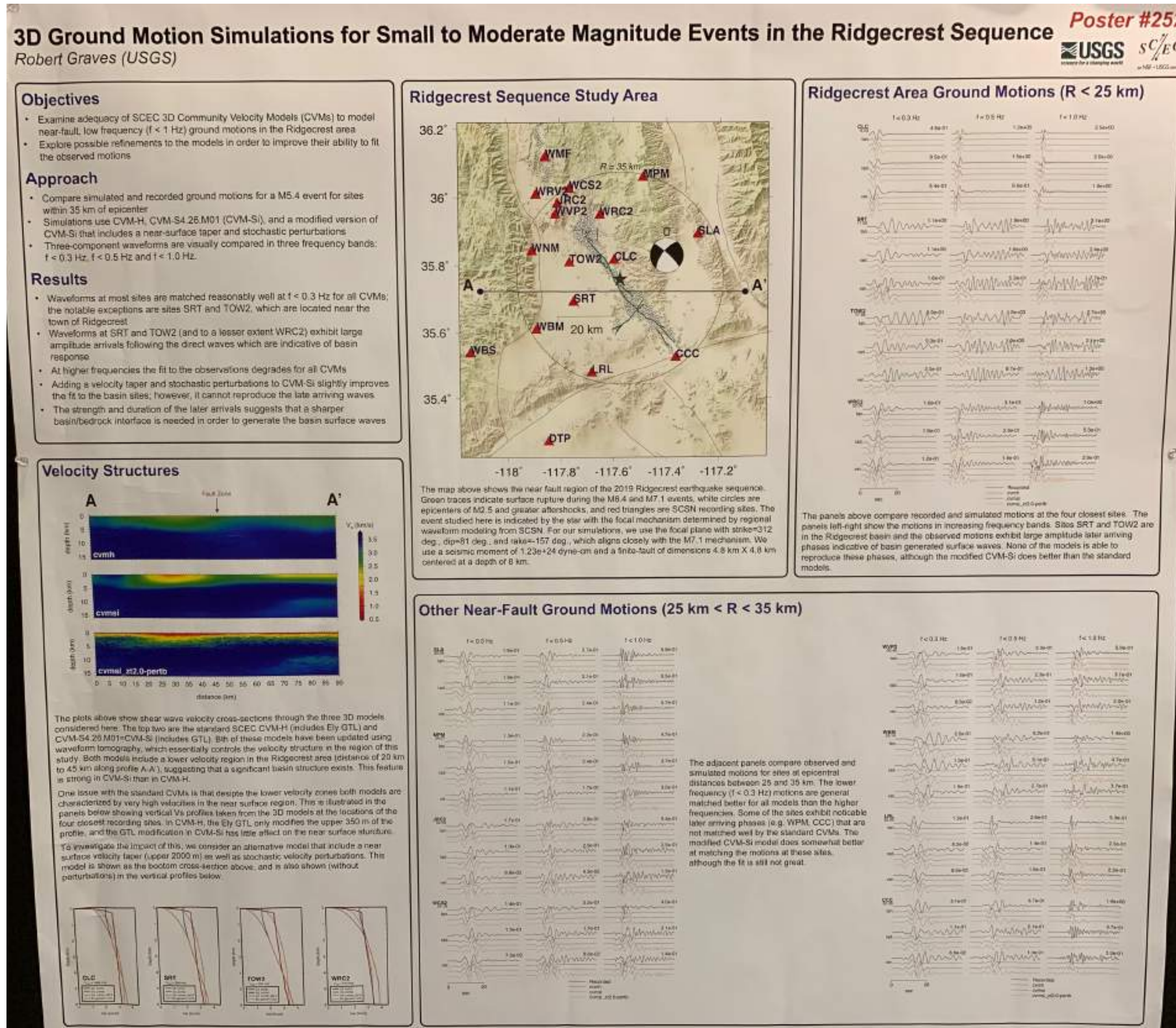
Gm sim applications

- Rodgers et al. Hayward Fault sim on SW4 up to 10Hz via 3D calculation (no ‘HF’ method) [200B grid points]
- Results broadly consistent with NGA-W2 methods (minimum Vs=500m/s, no nonlinear soil response)
- This LLNL project is focused on pushing calculations to Exa-scale – Art openly mentions that they don’t realistically believe that they can resolve the fault or crustal structure at the length scale of 10Hz (yet)



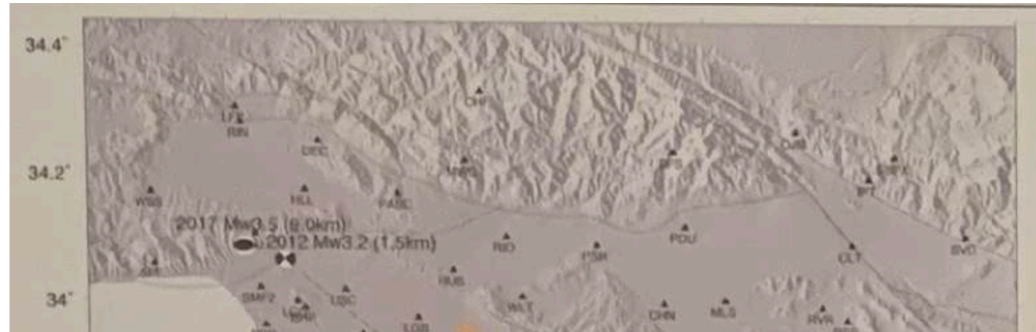
Gm sim validation (1 of 2)

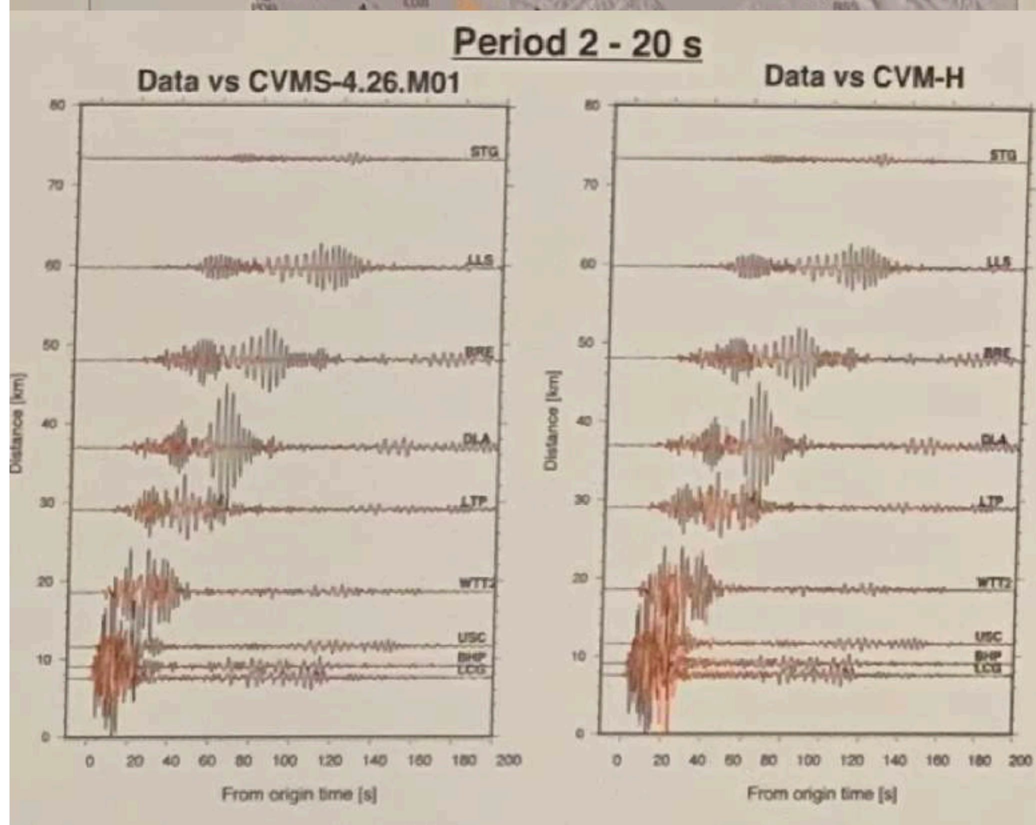
- Graves, 3D sims vs. obs in Ridgecrest
- Match to obs. ok for f<0.3Hz, but cant match f>0.3Hz
- Considered perturbing VM and introducing softer Vs near surface
- Latter leads to increasing compatibility, suggesting that the current VMs are too stiff in the near surface



Gm sim validation (2 of 2)

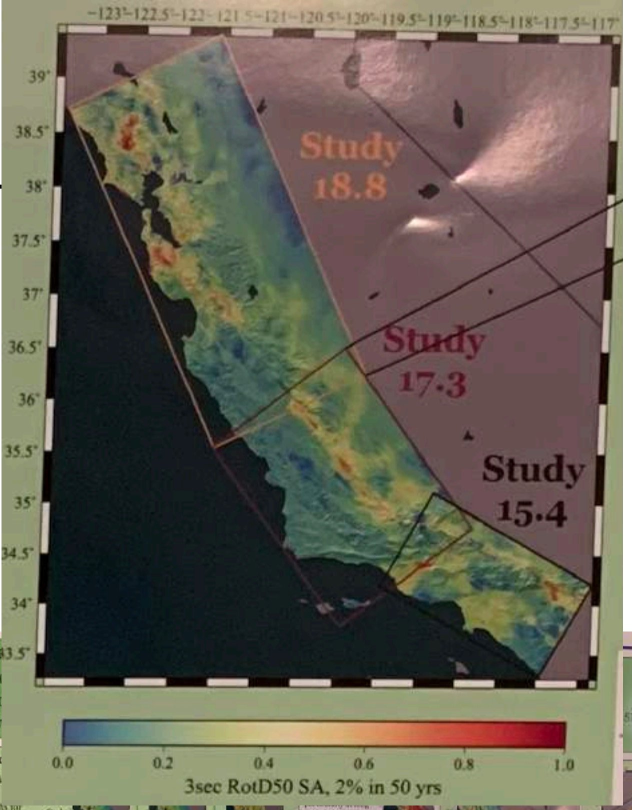
- Lai et al. Sim vs. Obs for two events in LA Basin
- Mw3 events in Westwood and Beverly Hills
- Considered CVM-S and CVM-H velocity models (base)
- CVM-S: Does not lead to basin wave reverberation (‘basin-edge’ is too smooth)
  CVM-H: Amplitudes of direct arrivals too large, but basin-edge waves too small also.
- Highlight the issues with these models at freq. greater than they were developed for

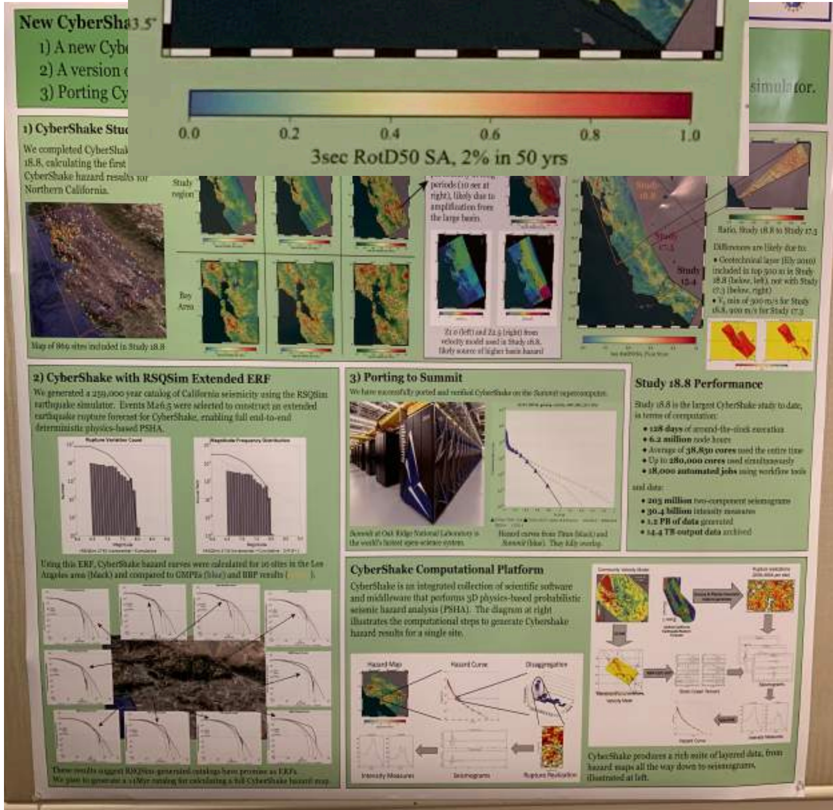




SCEC Cybershake

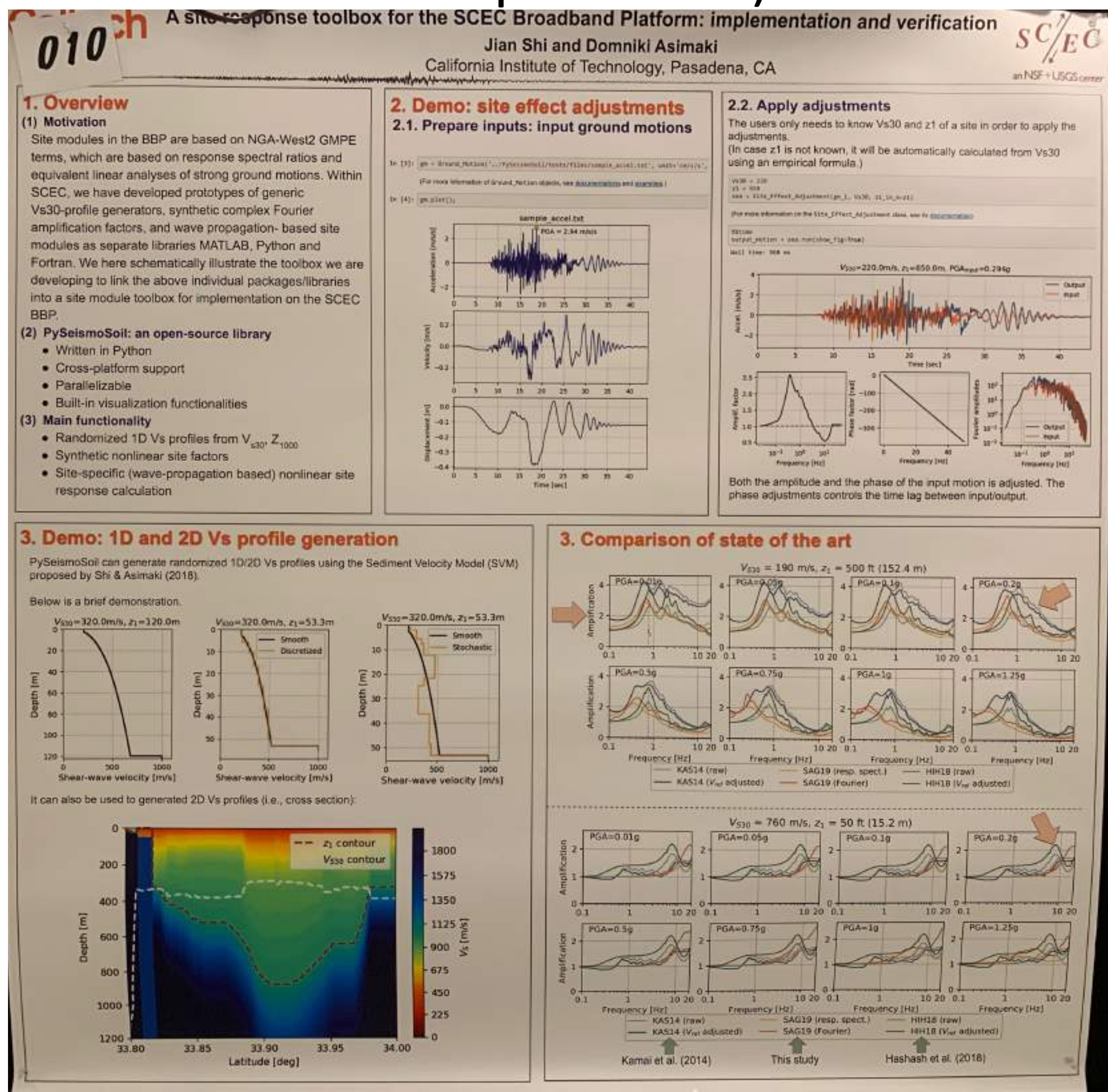
- Callaghan et al.
- CS v18.8 in Northern California, essentially run the GP10 hybrid method at f_max=1Hz.
- ~400k ruptures, ~800 sites
- Largest to date (~250M core-hours; n.b. QC has access to ~2 Million core-hours/year)
- See May 2018 GMSV call for technical comparison of QC vs. SCEC Cybershake efforts





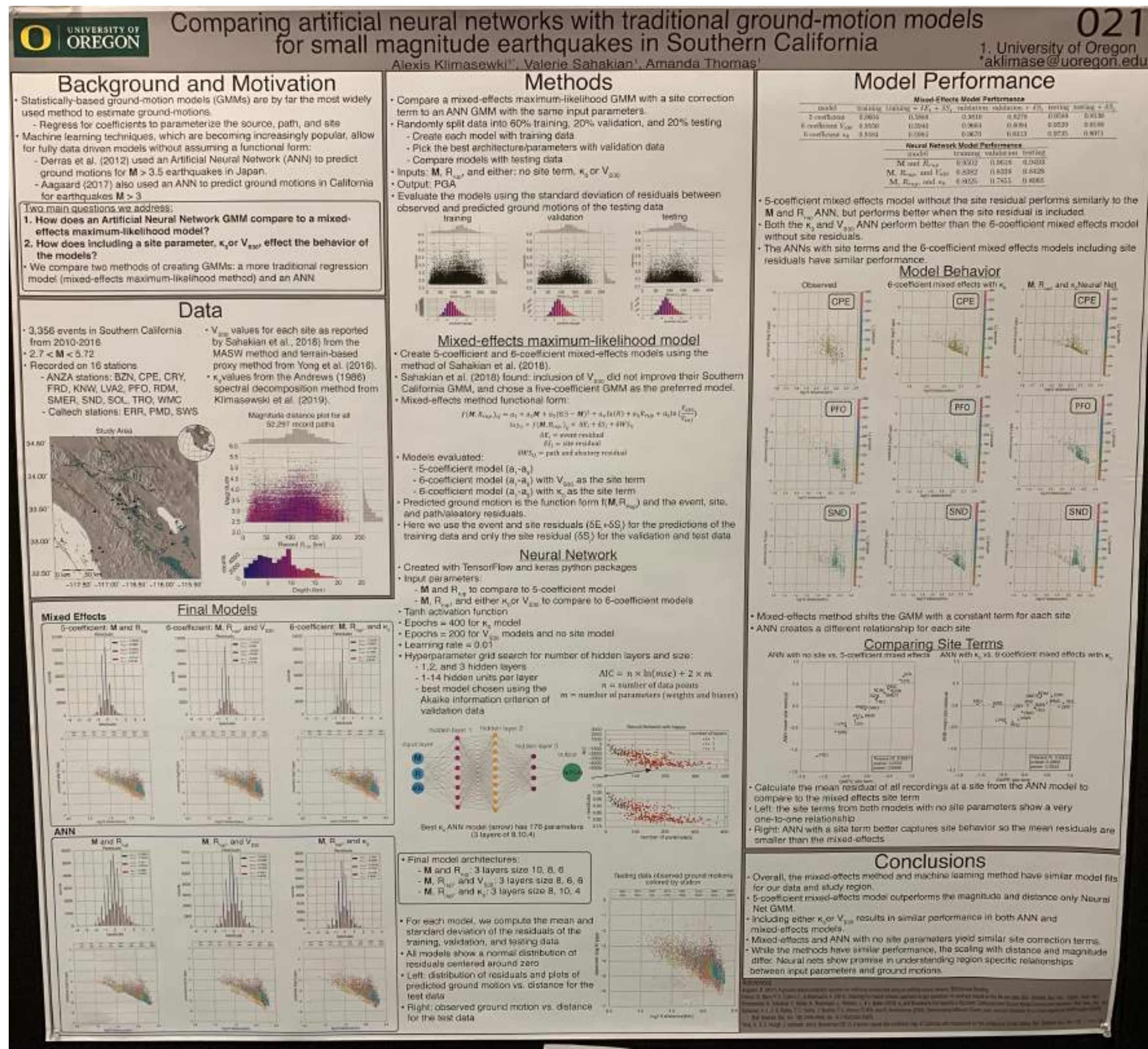
Shallow geotechnical response

- Shi and Asimaki site response method for BB simulations based on Vs30 / Z1.0 (vs. GMM-based Vs30 amplification)
- They present the theoretical benefits. Time domain, so can include site response effects on duration etc also.
- Has not been used in validation studies to date
- Obvious thing to consider for NZ-based GM sim work



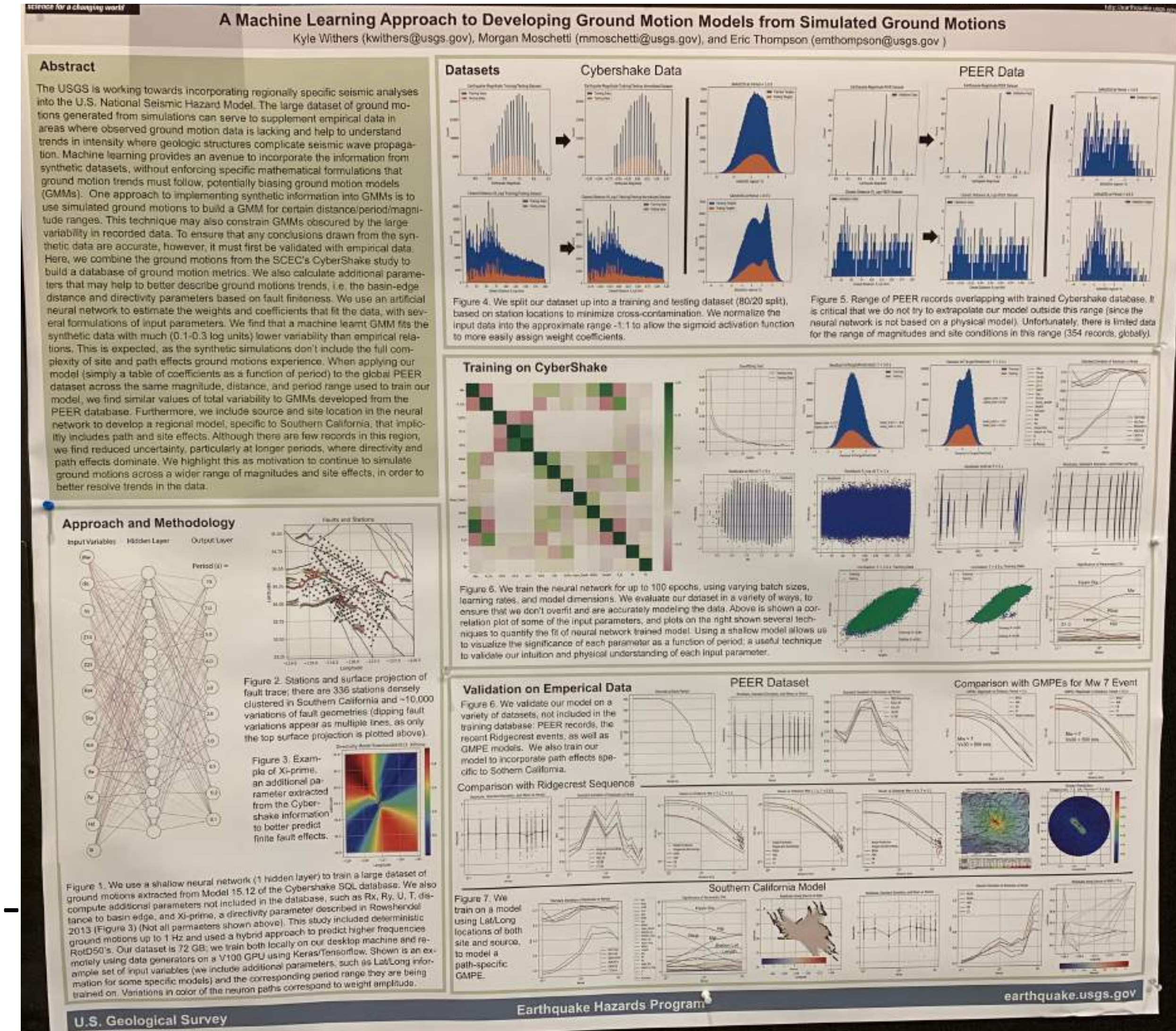
Machine Learning applications

- Klimasewki et al. compared traditional GMM (parametric) with Neural Net for fitting to empirical data
- Find similar standard deviation in residuals
- i.e. NNet does not lead to lower residuals
- Also, Nnet will not extrapolate beyond the data as well (as compared to traditional model were functional form can be 'set' based on theoretical guidance)
- Conclusion: ML directly with empirical data not fruitful (until several orders of magnitude more data)



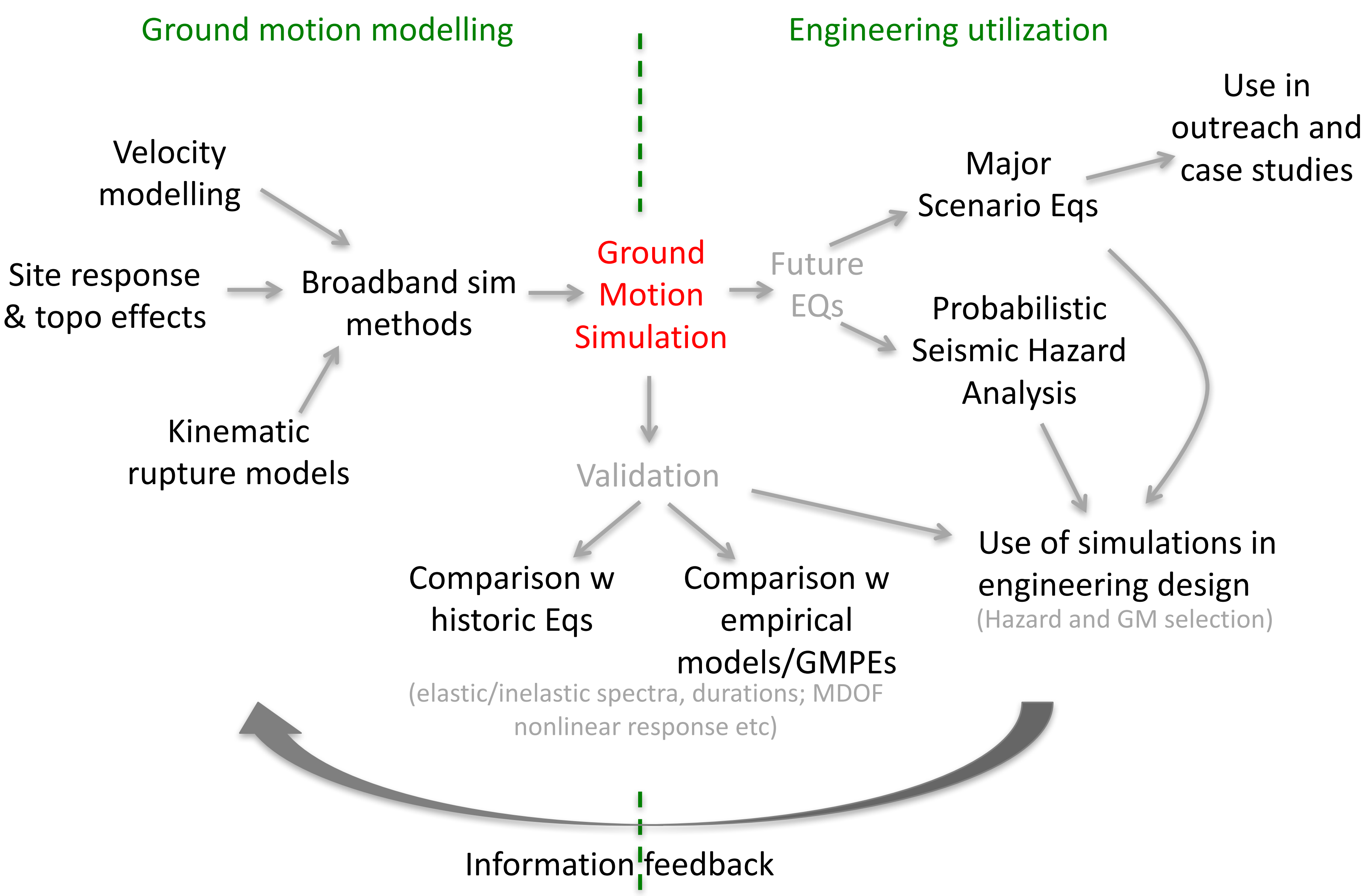
Machine Learning applications

- Withers et al. Single hidden layer NN to develop an empirical model based on simulated data.
- Relative to the previous example, more promise here because you can have ~unlimited simulation data
- Can develop surrogate model for us in real-time applications, or consideration of distributed seismicity in hazard calculations (too many sources to simulate all via physics-based sims)



Reflections on QuakeCoRE GMSV activities

Spectrum of research



Take-away sentiments (my own biased views)

- Access to computing
  - More than 50x greater capacity in US – no point trying to undertake bleeding-edge sims at high f.
  - Advances in theory will generalise to global application, so we can reap benefits from intl. colleagues.
- Validation ('formal', not simply GMM comp.)
  - QC's thinking is significantly more advanced wrt validation (considering ~600 events in NZ so far, vs. a handful of events in California). Many comments of 'yeah, we should be doing this'
  - This is a strategic advantage to continue to focus on, and also the principal hurdle for demonstration of practical utility to enable widespread adoption
  - Validation also suggests that for f>1Hz, 3D-based calculations can still not yet reliably outperform 1D-based simplified approaches
- Shallow site response
  - SCEC emphasis on this increasing. Several 'simplified' approaches (Shi and Asimaki) useful to consider for NZ applications.
- Machine Learning
  - Main benefit to be gained based on training using simulation data and then using as a surrogate model for a multitude of applications