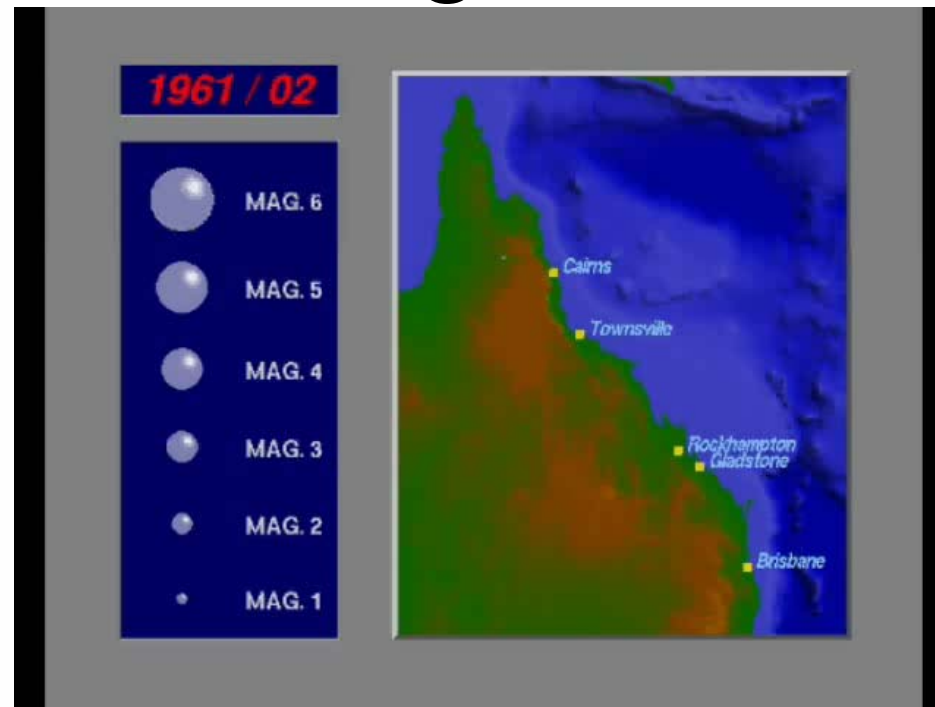


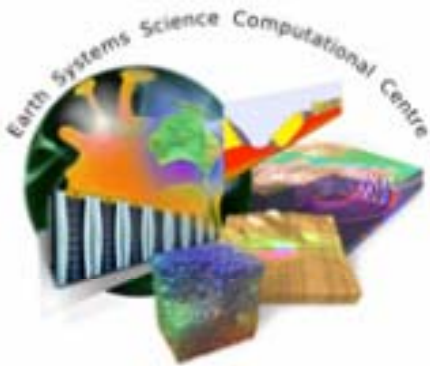
Ensemble Earthquake Forecasting on the Grid



D. Weatherley

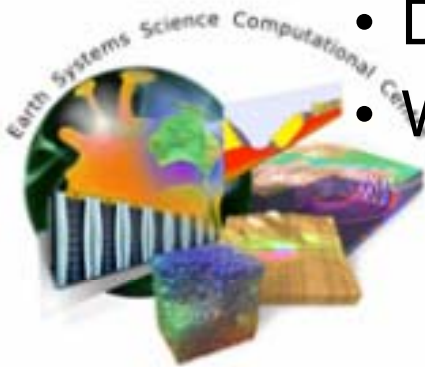
Earth Systems Science Computational
Centre,

University of Queensland.



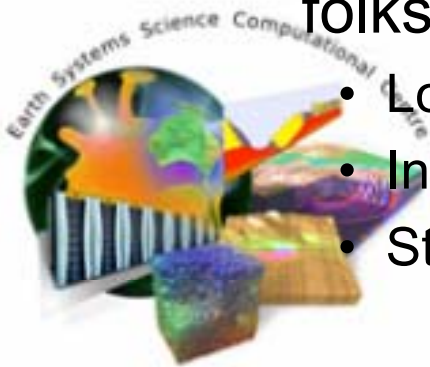
Outline

- Earthquake Forecasting, are you kidding?
 - Success stories and the lessons learnt
 - Current status in Australia (unlikely $\pm \infty$)
- Down-to-Earth and Pie-in-Sky
 - Strong ground motion prediction
 - Brisbane, you're next!
- Grid me up
 - Data constraints
 - Workflows



Earthquake Forecasting, are you kidding?

- No, forecasting \neq prediction
 - The Weather analogy:
 - Weather forecasting utilises numerous models based upon available data to forecast weather 1-3 days out with $>70\%$ accuracy
 - Weather inherently has a short time-constant of a few days but earthquakes have a time-constant of a few years to decades
 - 70% accuracy over 1-10 years is achievable
 - Forecasting means different things to different folks:

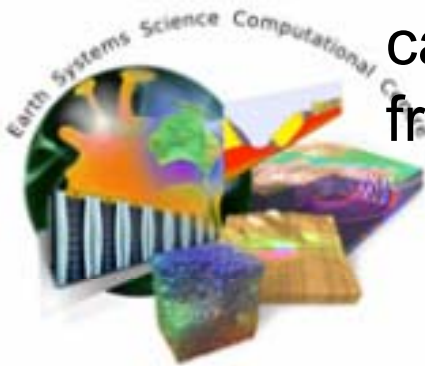


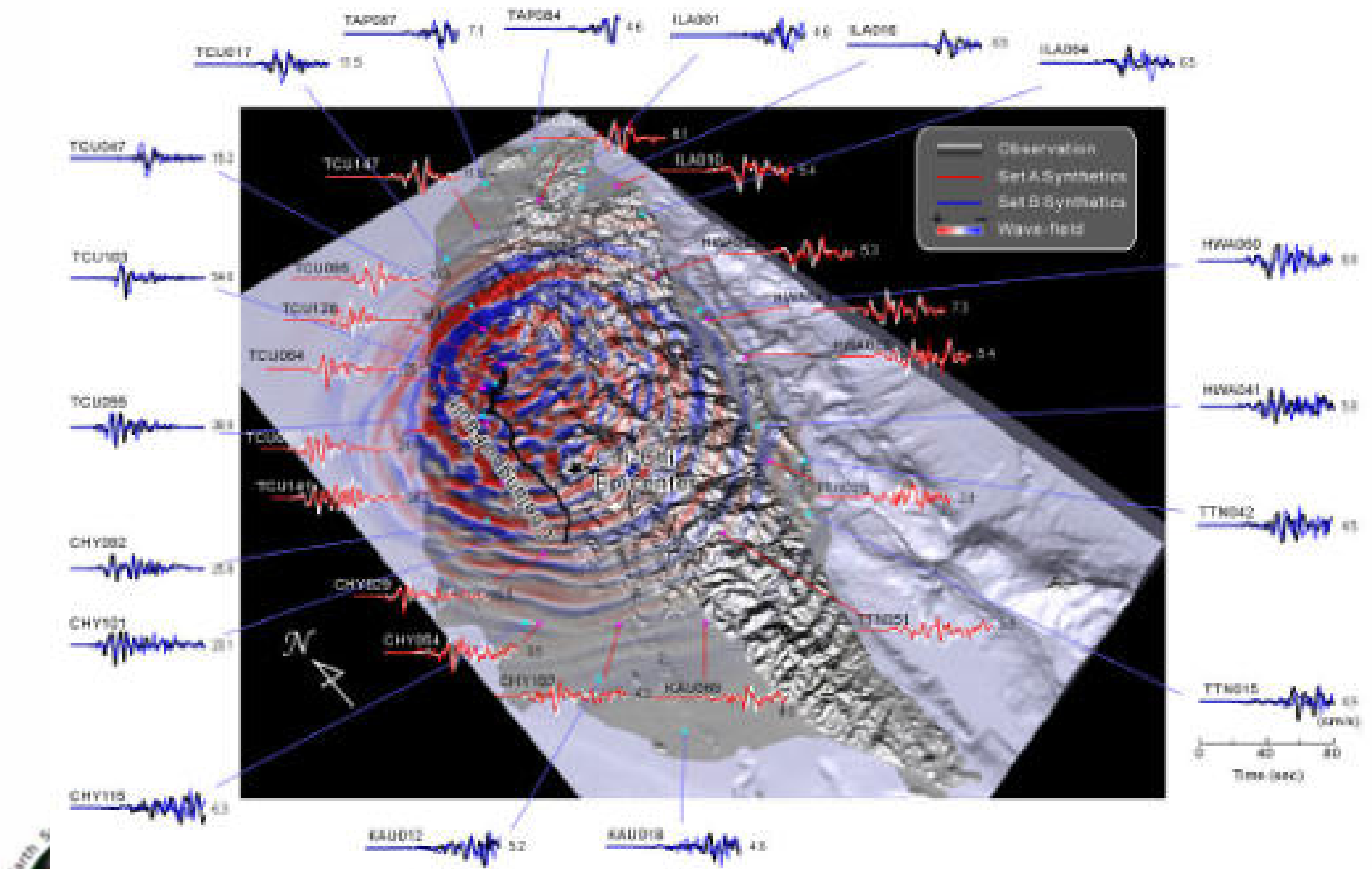
- Long-term seismic potential
- Intermediate-term warnings and aftershock prediction
- Strong ground motion

Success Stories

- Local Site Effects

- Largest damage not always close to the rupture zone
- Sedimentary basins trap seismic waves
- Amplitude and duration of ground-shaking strongly site-dependant
- ‘quake location and magnitude not the only consideration
- Numerical simulations of strong ground motion can “predict” the site-specific ground-shaking from scenario earthquakes

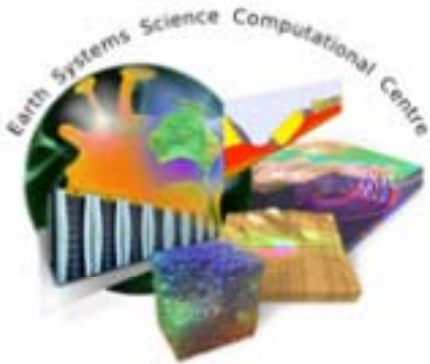


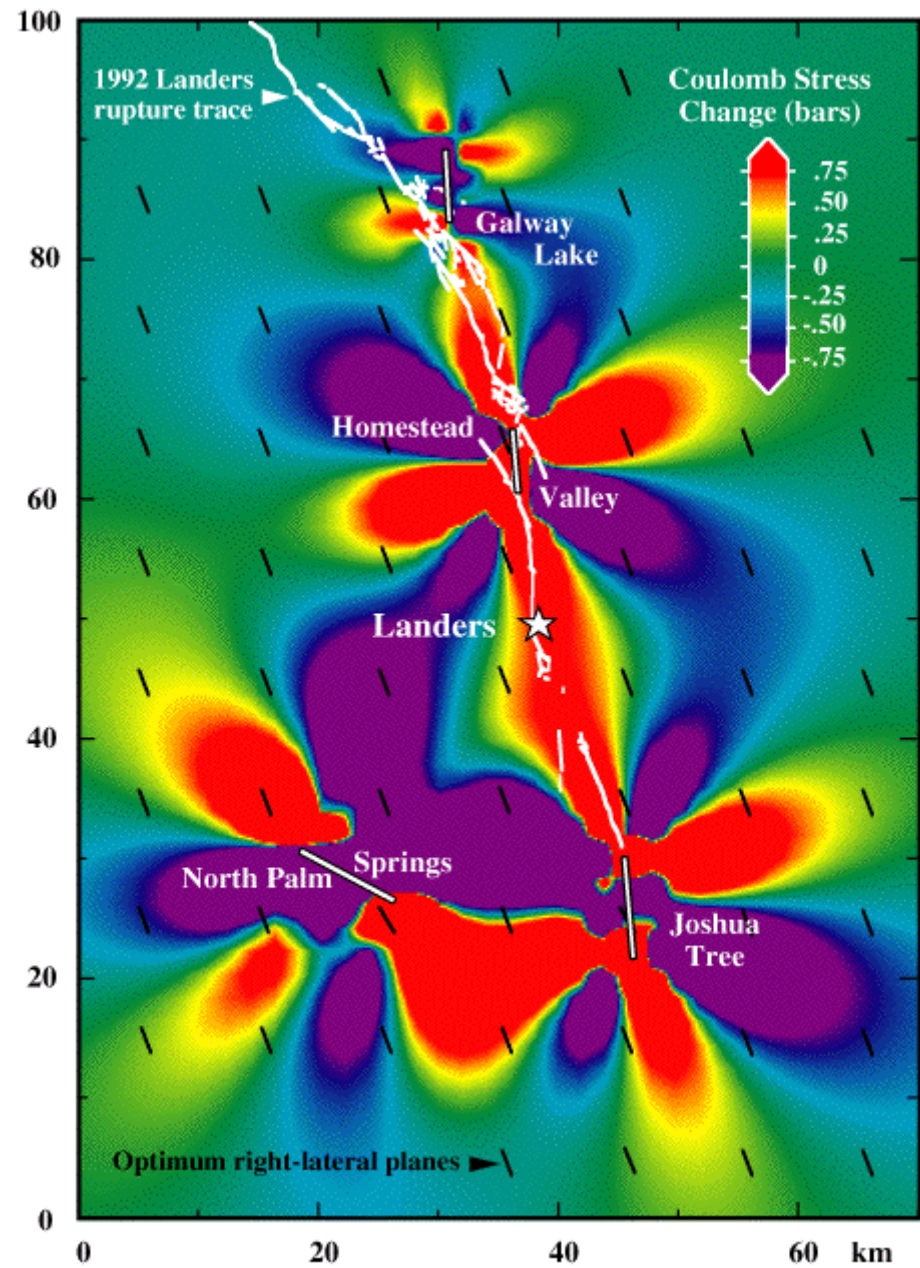
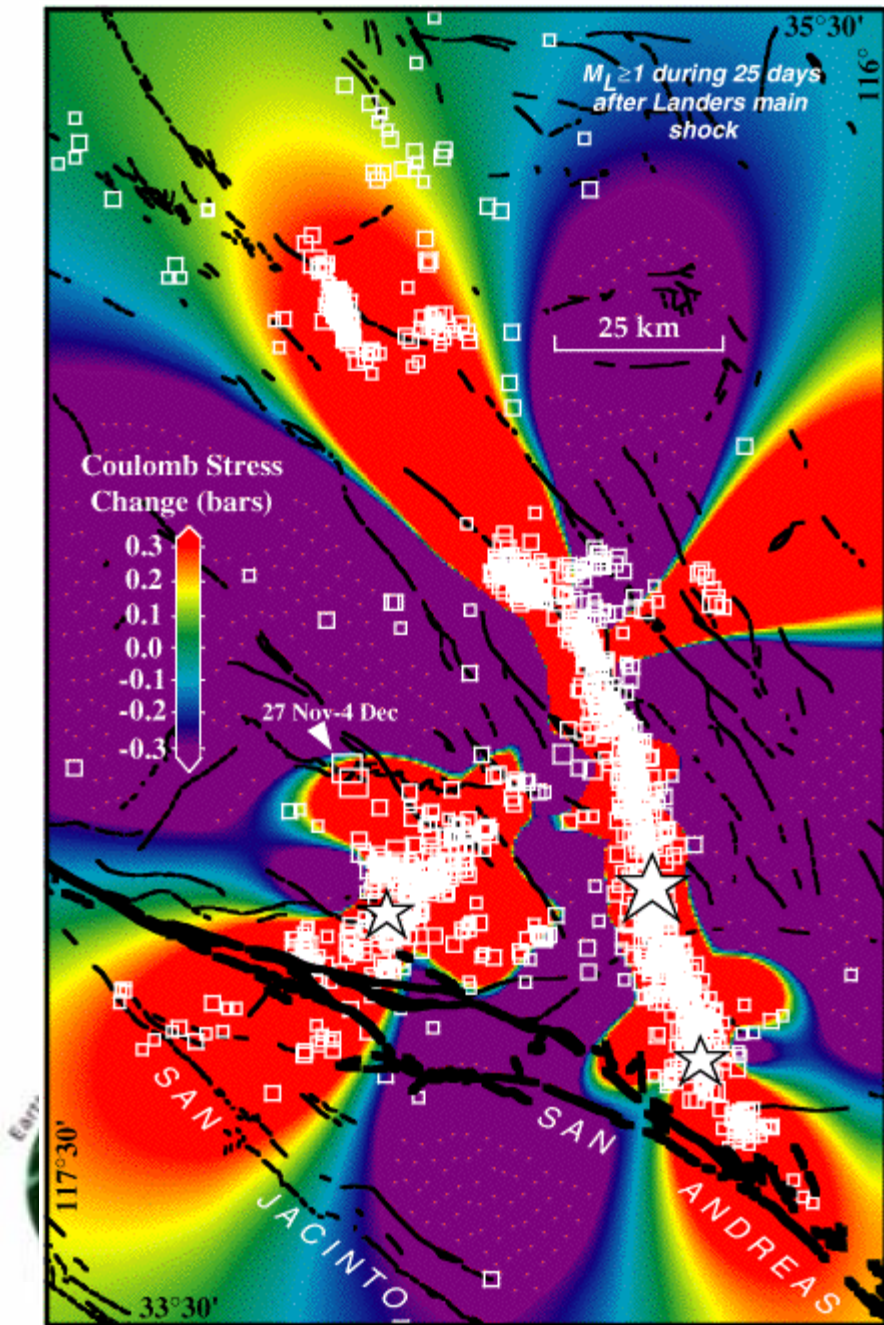


Shiann-Jong Lee, How-Wei Chen and Kuo-Fong Ma
http://www.earth.sinica.edu.tw/~sjlee/921_forward.htm

Success Stories

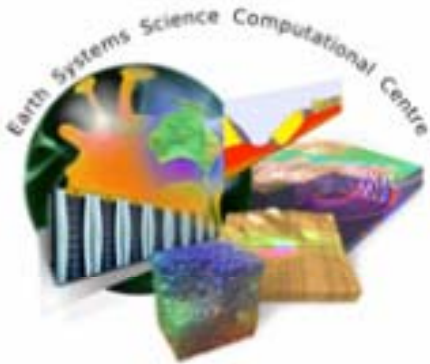
- Coulomb Stress Change
 - Earthquakes decrease stress regionally but increase stress locally, in some places
 - Aftershocks occur where the mainshock increases stress
 - Moderate 'quakes cooperate and future epicentres often in residual stress "islands" of past earthquakes



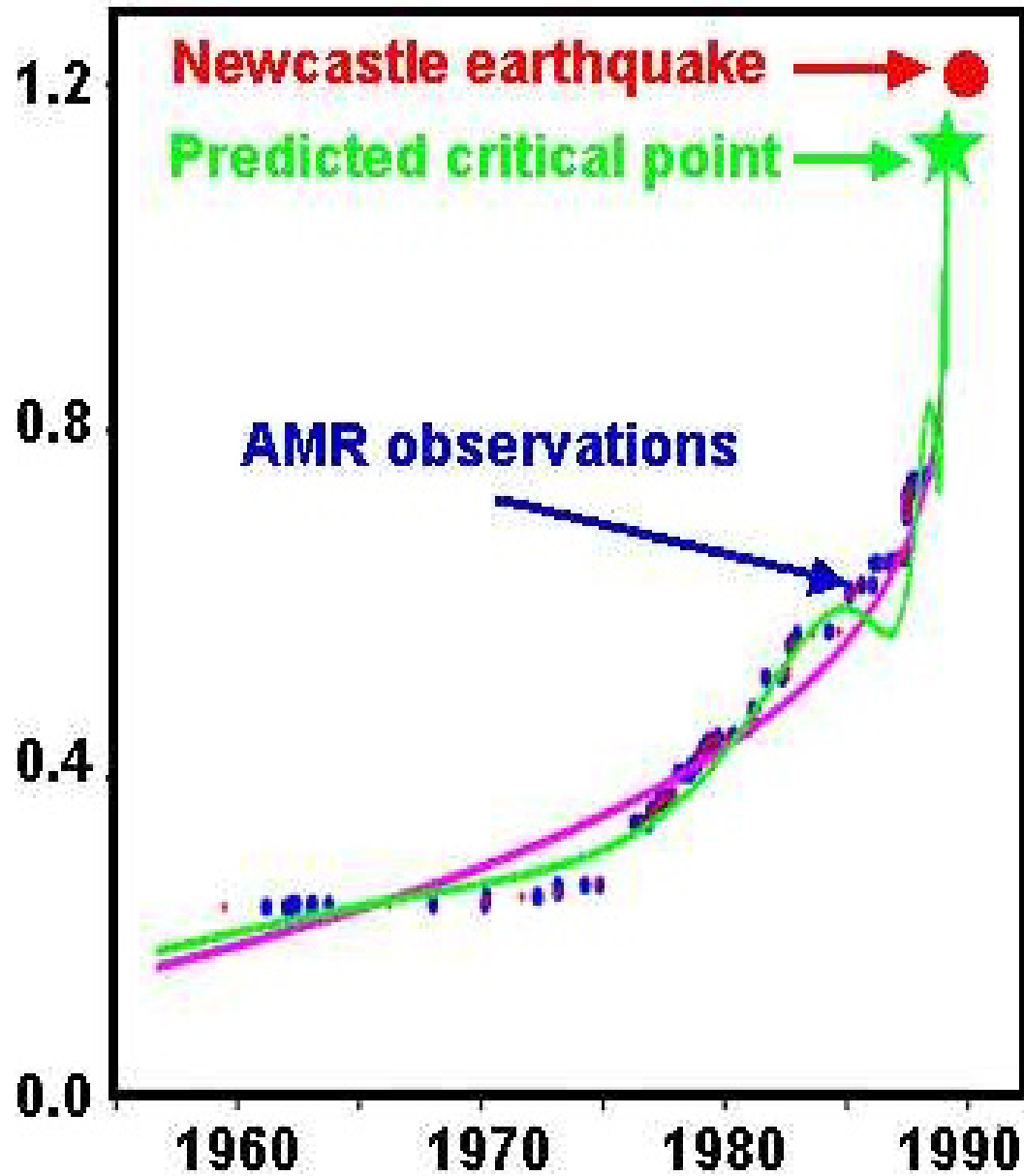


Success Stories

- Accelerating Moment Release
 - Rate of energy release accelerates in the decades preceding large earthquakes
 - Regional fault systems are cooperative
 - smaller earthquakes prepare the way for larger ‘quakes
 - Large ‘quakes hit the reset button
 - Seismicity is not a Poisson process,
 - Earthquakes cluster spatially and temporally
 - Fault systems have “signature” seismicity patterns

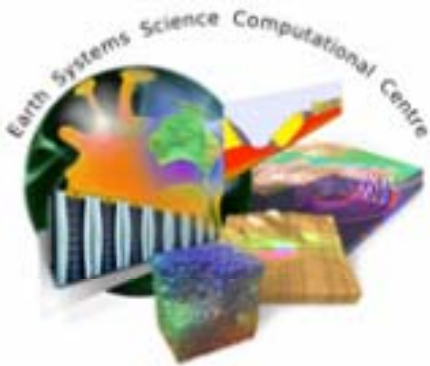


AMR versus time



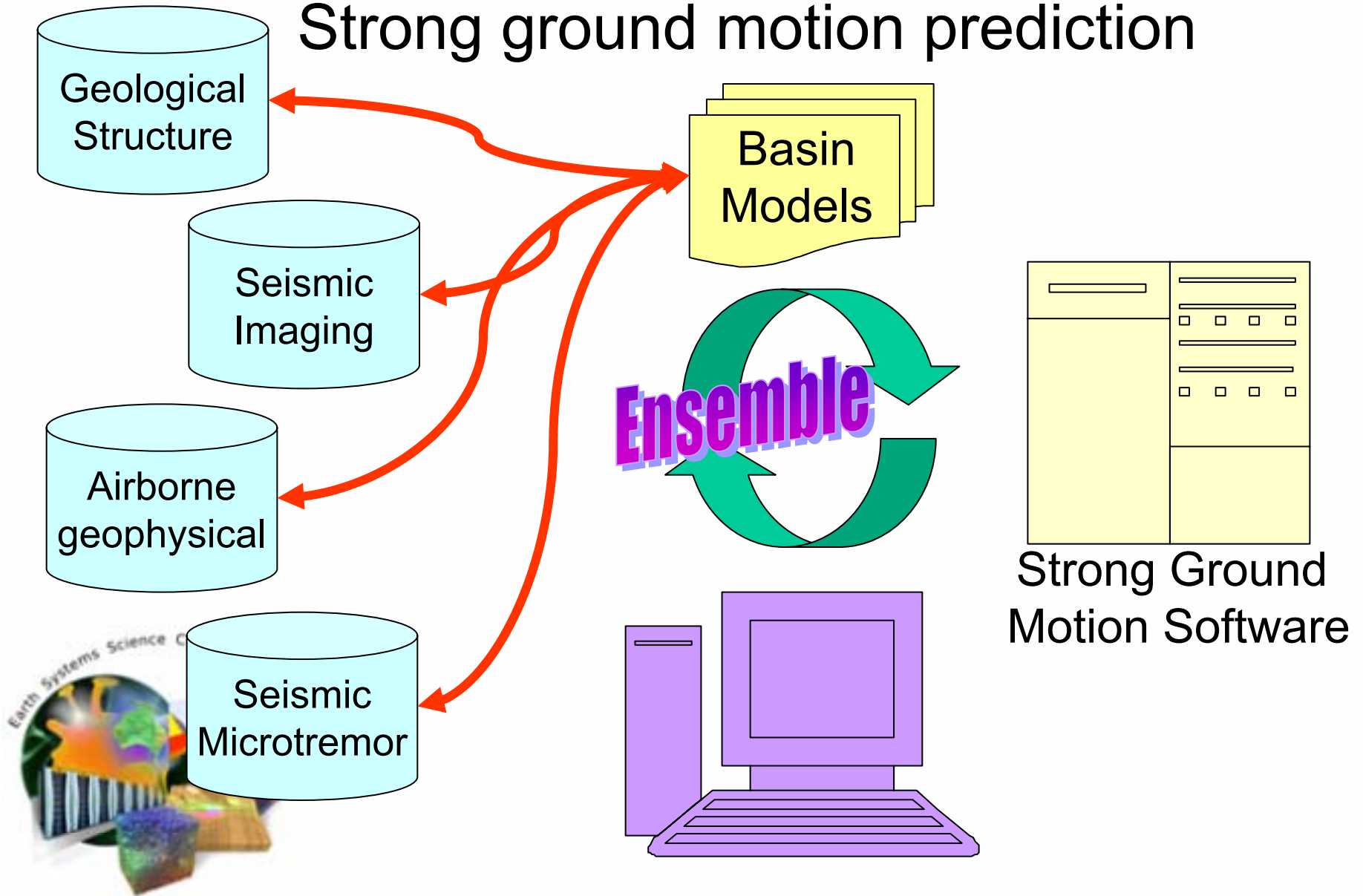
Current Status in Australia

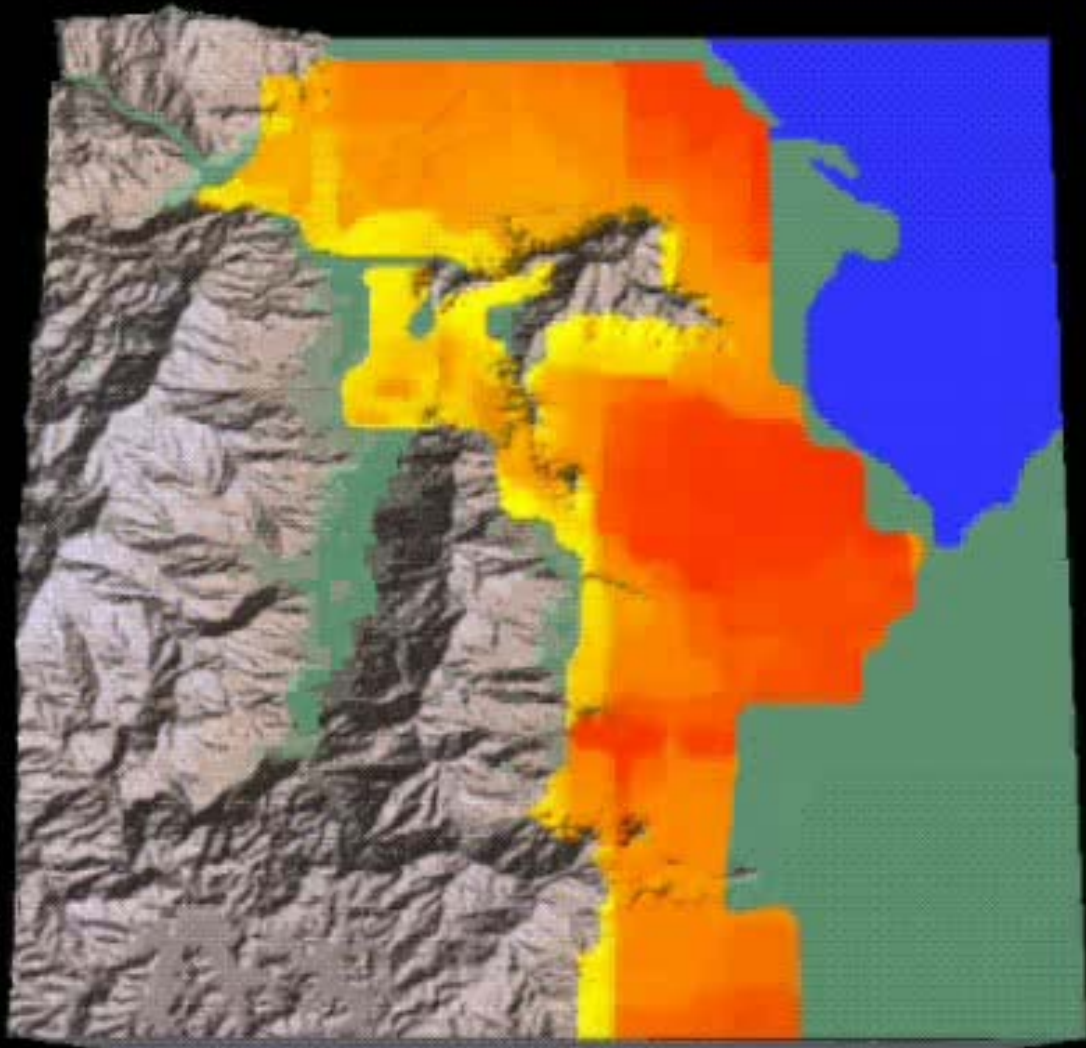
- “Past is key to future” paradigm
 - <100yrs of reliable seismic records
 - >100Kyr recurrence times
 - “hotspots”: 3xM6+ in 1988 implies high seismic hazard at Tennant Creek, NT
- Attenuation of ground-motion
 - Insufficient data for probabilistic model of attenuation in Australia
 - Eastern US attenuation good enough?
 - Local site effects covered by blanket “amplification factors”
 - What about basin geology or edge-effects?



Down-to-Earth

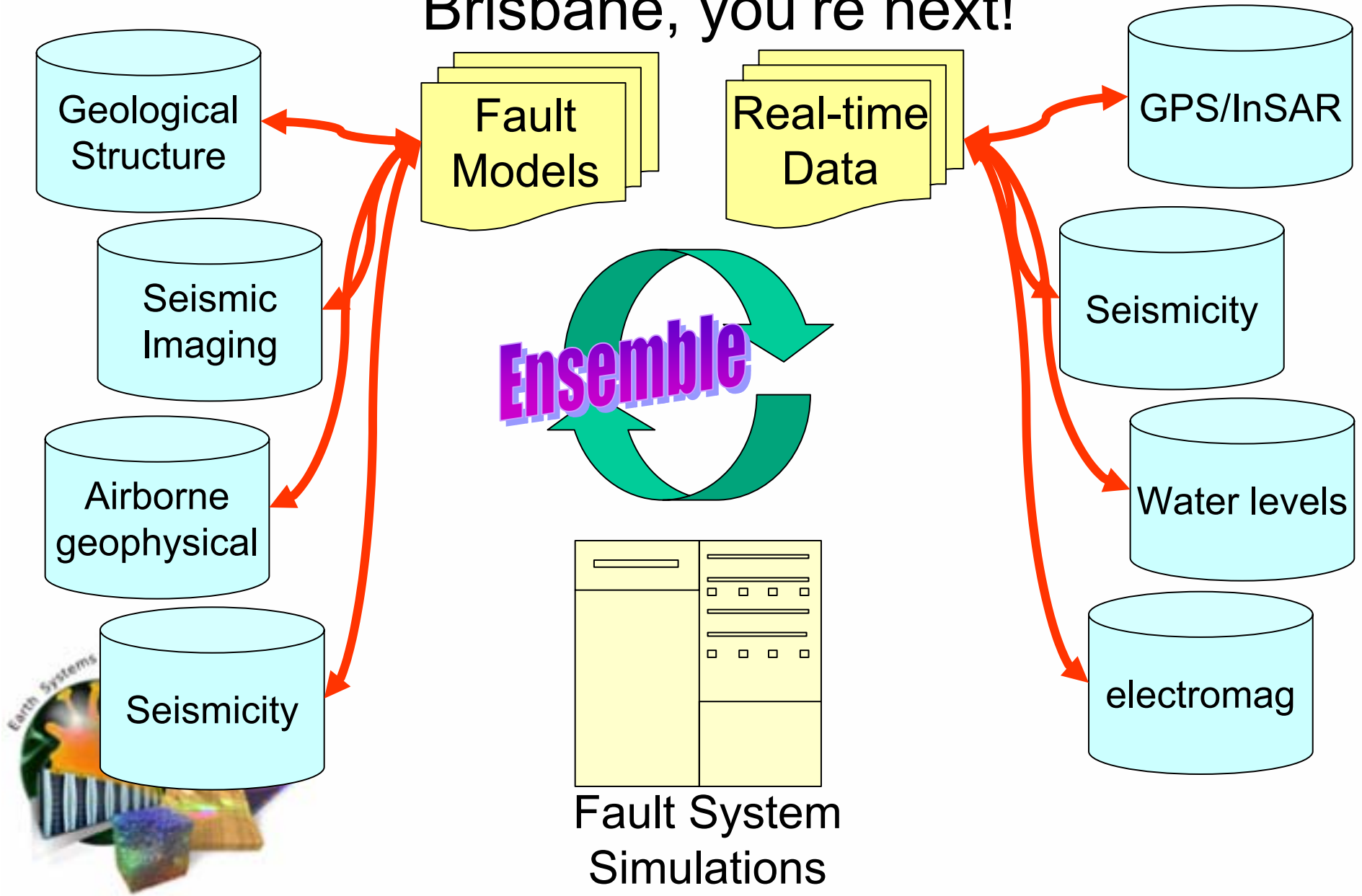
Strong ground motion prediction

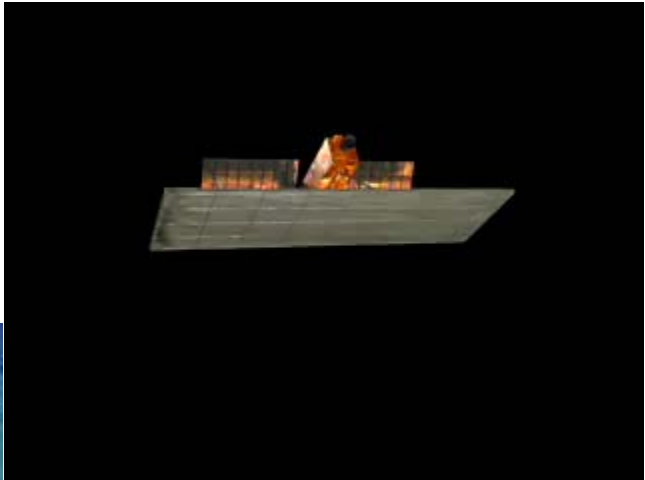
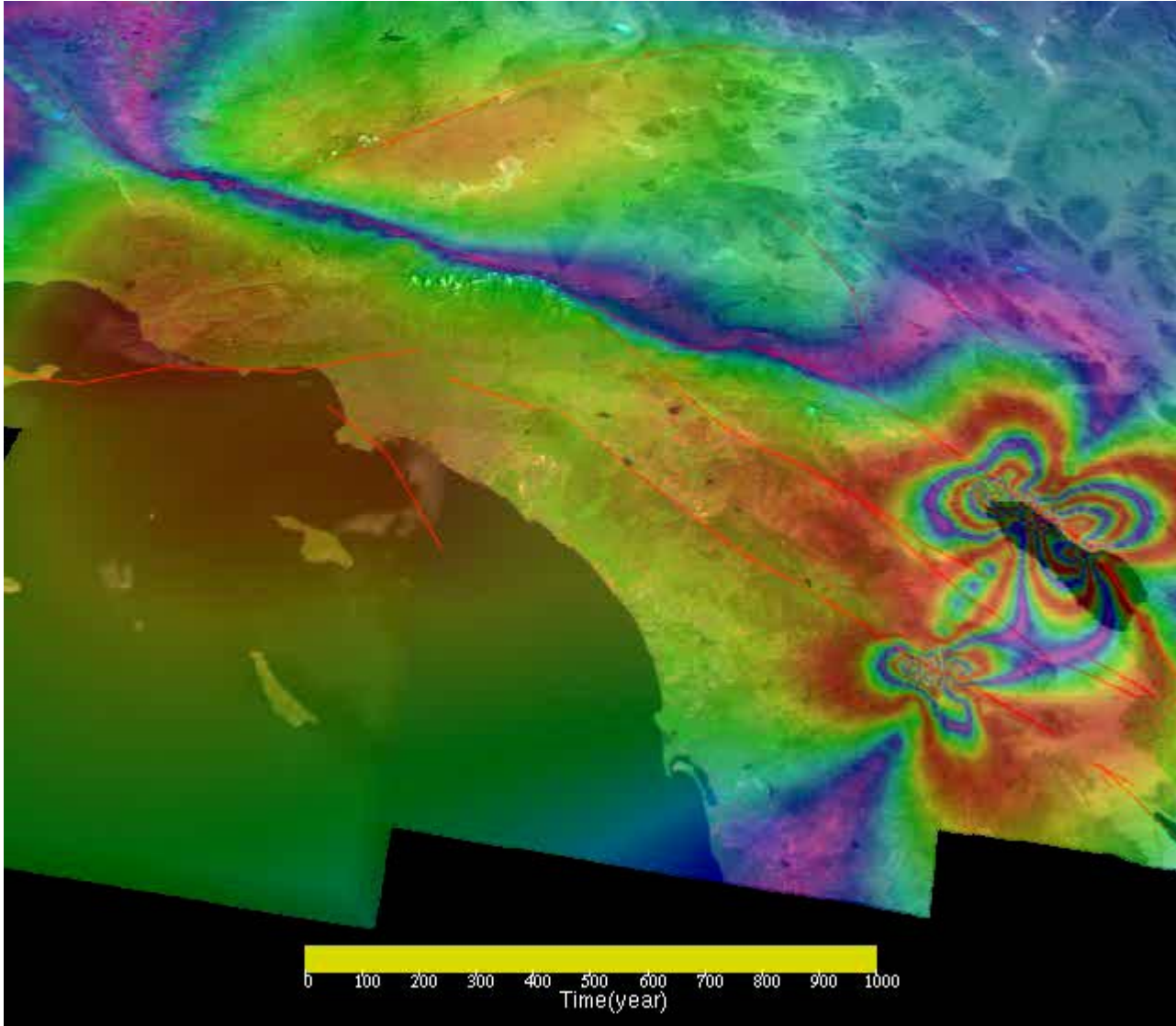




Pie-In-Sky

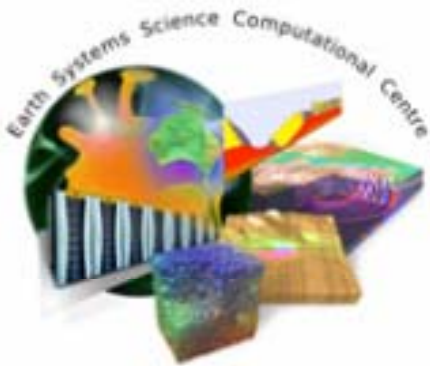
Brisbane, you're next!





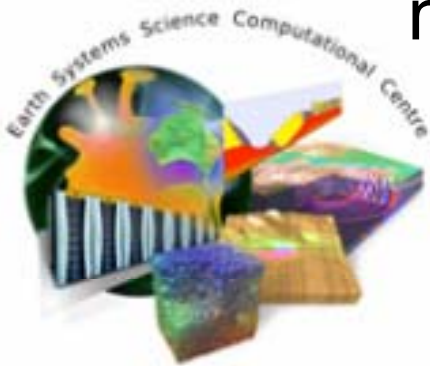
Grid me up

- Data constraints
 - Need access to all available data in “chewie” formats
 - Data must be uploaded in formats simulation models can digest without human intervention
 - Data must be used in multiple different regional seismicity simulation models
 - Interoperability of data and simulation models
 - Iterative refinement of forecasts mandatory
 - As new data arrives, the process needs to be repeated
 - Number of variables must be minimised
 - » Same data, different model
 - » Same model, different data



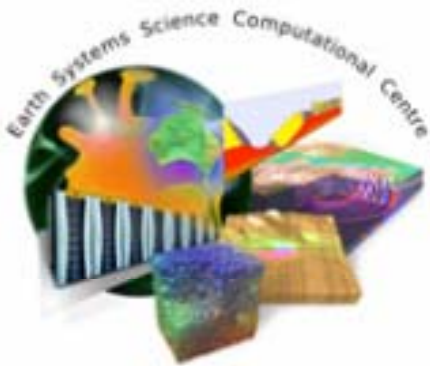
Grid me up

- Workflows
 - Ensemble simulations need to be “scriptable”
 - Post-sim analysis and reporting needs to be automated
 - Need the ability to store, modify, reuse workflows
 - Large amount of computational resources needed (4x APAC National Facility!)



Summary

- Earthquake forecasting is a challenge not a pipe-dream
- Inoperability of data, simulations and HPC facilities is critical
- GRID me up!



Acknowledgements

- Australian Research Council
- Main Roads, Queensland
- University of Queensland
- ACcESS MNRF
- APEC Cooperation for Earthquake Simulation
- Aust. Earthquake Engineering Society

