



Collaboratory for the Study of
Earthquake Predictability



Evaluation of global high-resolution 1-yr forecast models

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Introduction

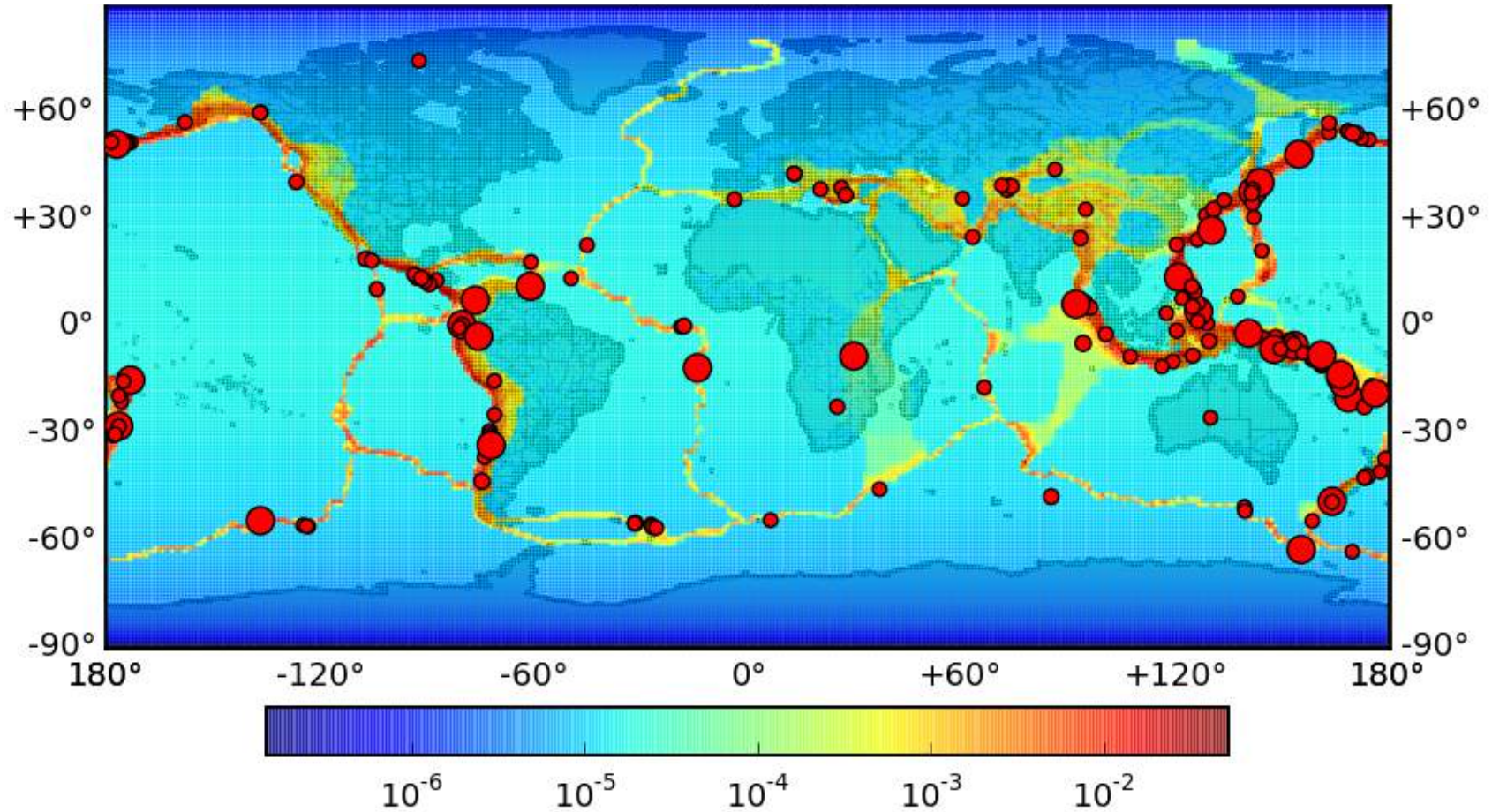
- **Many scientific questions about earthquakes concern the large ones.**
- **Number M6+ in CSEP California 2011/1-2017/8: 2**
- **Number M6+ globally (PDE) 2011/1-2017/8: 986**
- **SCEC: go global or go home!**
- **Challenge: generalizing the models/hypotheses/data**
- **Current global CSEP experiments:**
 - **Lower resolution [1 deg] to 30 km depth**
 - **1-year: 3 models, DBM, KJSS, TripleS since 2009**
 - **1-day: 1 model, KJSS**
 - **Higher resolution [0.1 deg] to 70 km depth**
 - **1-year: 3 models, SHIFT_GSRM, SHIFT_GSRM2f, GEAR1**
 - **Higher resolution [0.1 deg] to 30 km depth**
 - **1-year: 1 model, KJSS**
 - **1-day: 1 model, KJSS**

Introduction

- **Taroni et al. (2013) analysed 4 years of the 1-yr low-resolution experiment results.**
 - All models were smoothed seismicity models.
 - Conclusions mostly concerned testing methodology.
- **The high-resolution experiment offers the chance to compare two different *types* of models:**
 - Strain-rate based: SHIFT_GSRMx
 - Hybrid strain-rate/smoothed seismicity based: GEAR1
- **CSEP required modifications to handle high-resolution demand:**
 - New binary hdf5 format for forecasts
 - Improved sorting/finding algorithm
 - [Magic indexing: lat/lon/mag information determines bin index]

SHIFT_GSRM

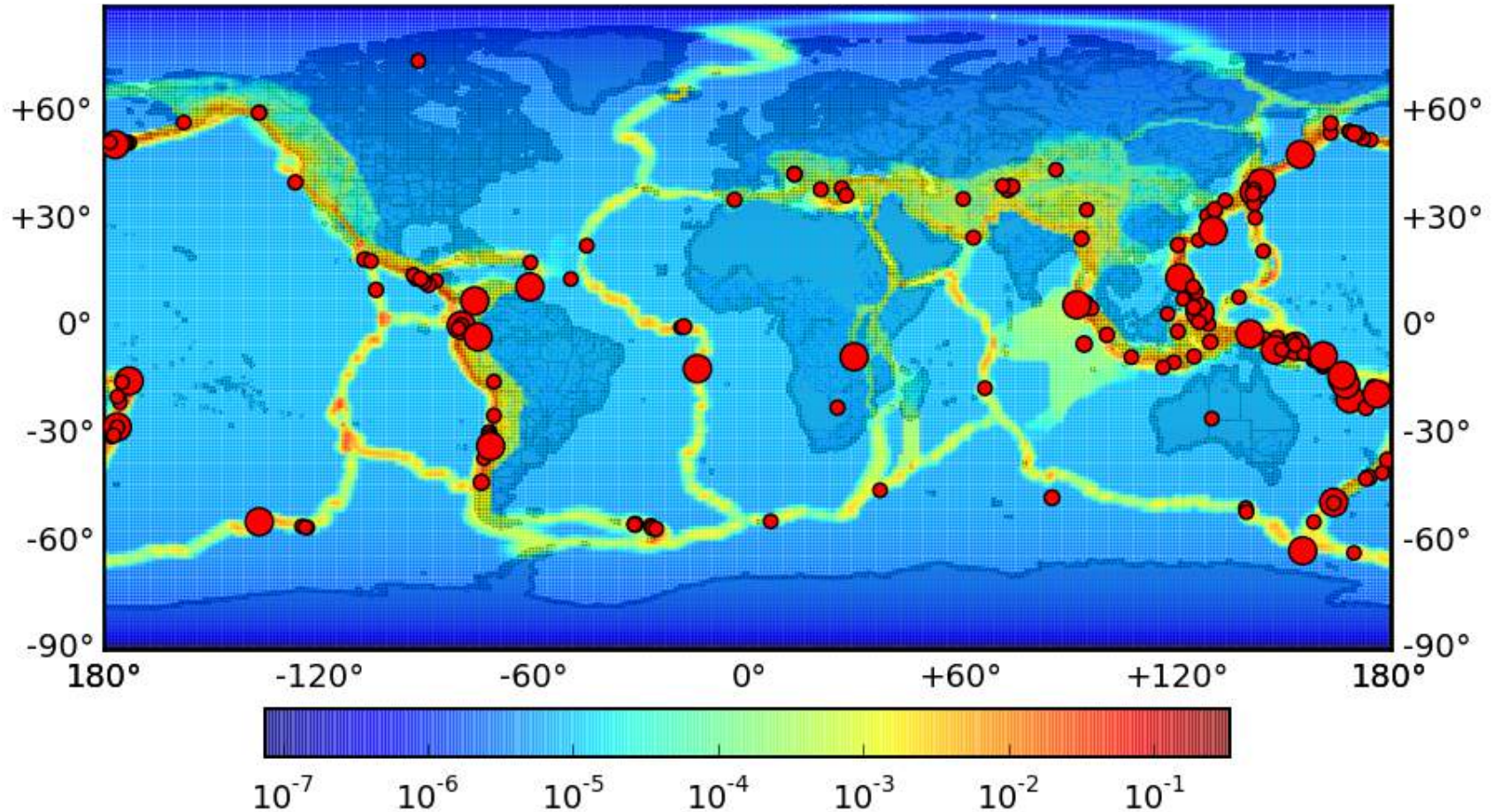
200 eqks M5.95+ in gCMT between 2015-10-01 and 2017-08-07



Expected Eqks M5.95+

SHIFT_GSRM2f

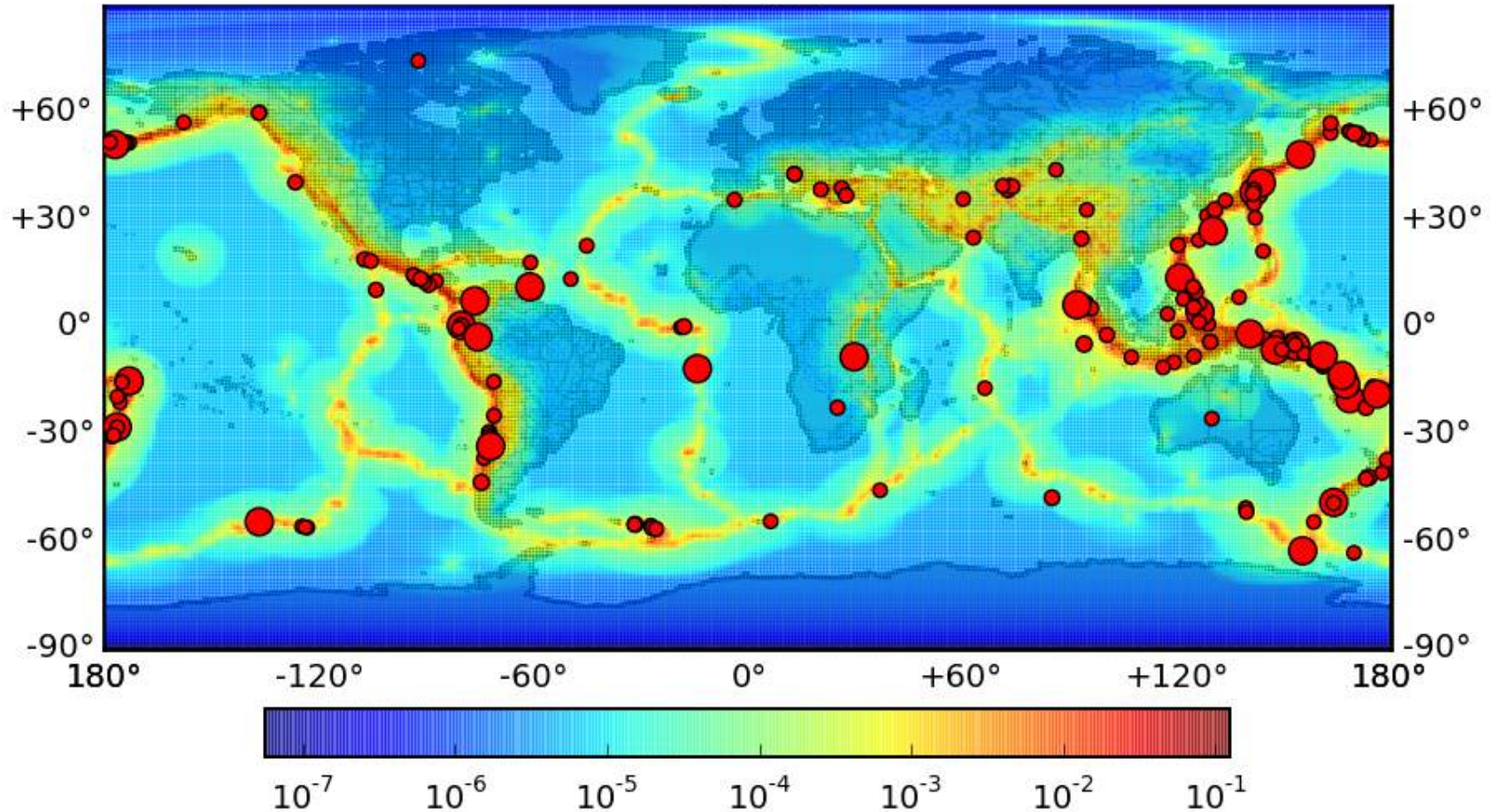
200 eqks M5.95+ in gCMT between 2015-10-01 and 2017-08-07



Expected Eqks M5.95+

GEAR1

200 eqks M5.95+ in gCMT between 2015-10-01 and 2017-08-07

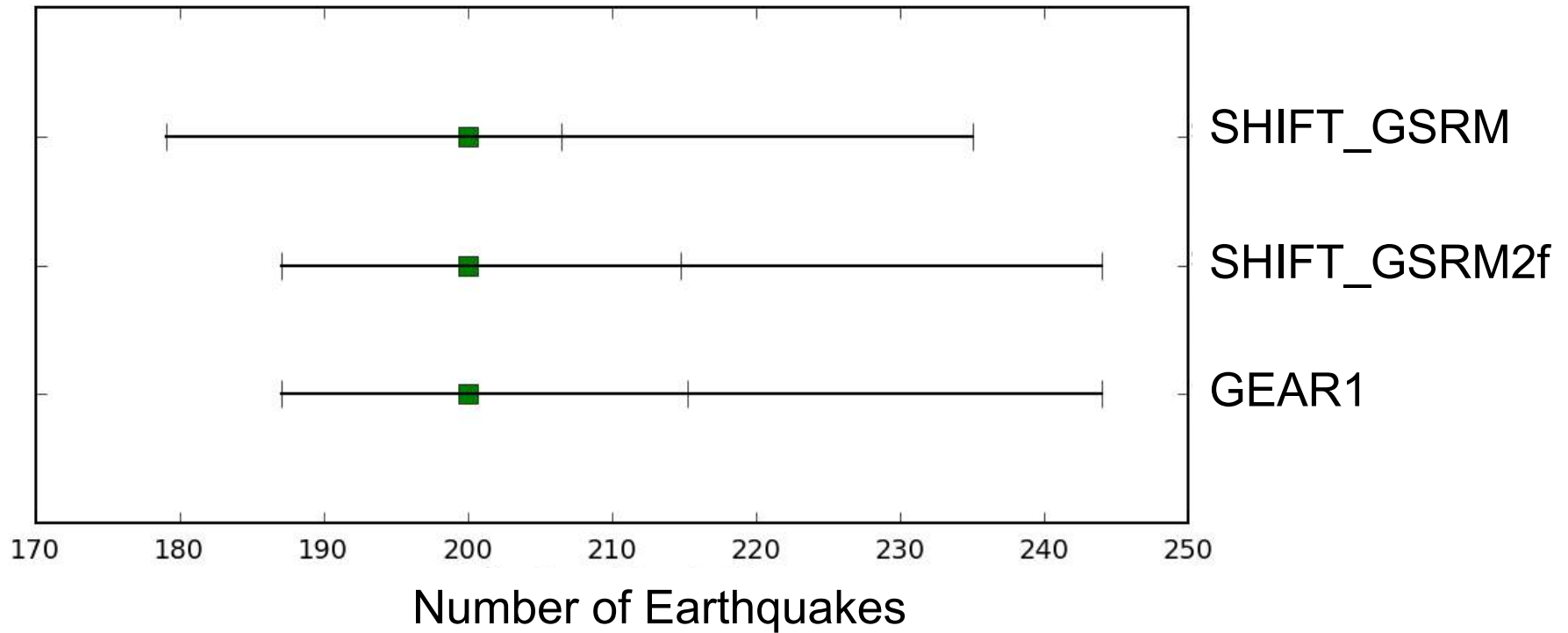


Expected Eqks M5.95+

Methods

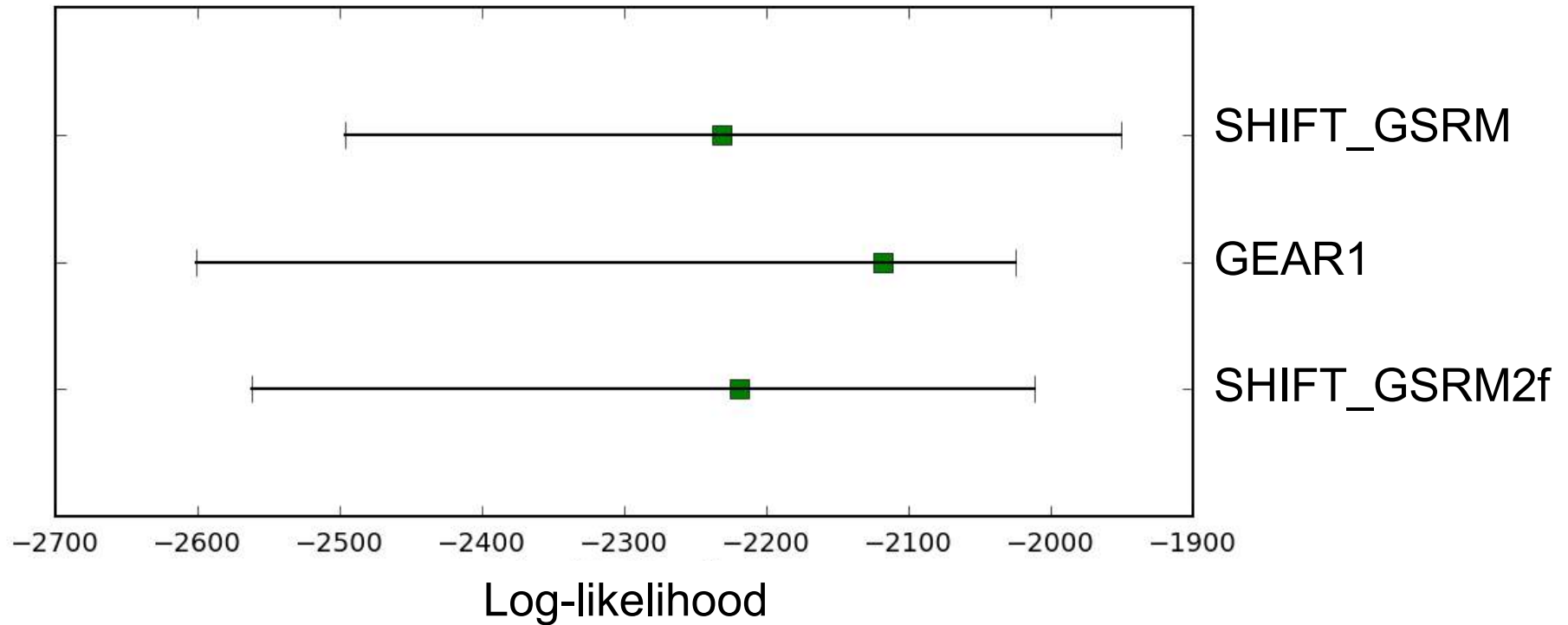
- **RELM tests (Schorlemmer et al., 2007, Zechar et al. 2010, Werner et al., 2010)**
 - Number test
 - Likelihood test
 - Conditional Likelihood test
 - Space test
 - Magnitude test
- **Comparison tests (Rhoades et al., 2011)**
 - Information gain per earthquake
 - Confidence bounds from T-test by Rhoades et al. (2011)

Results: N-test



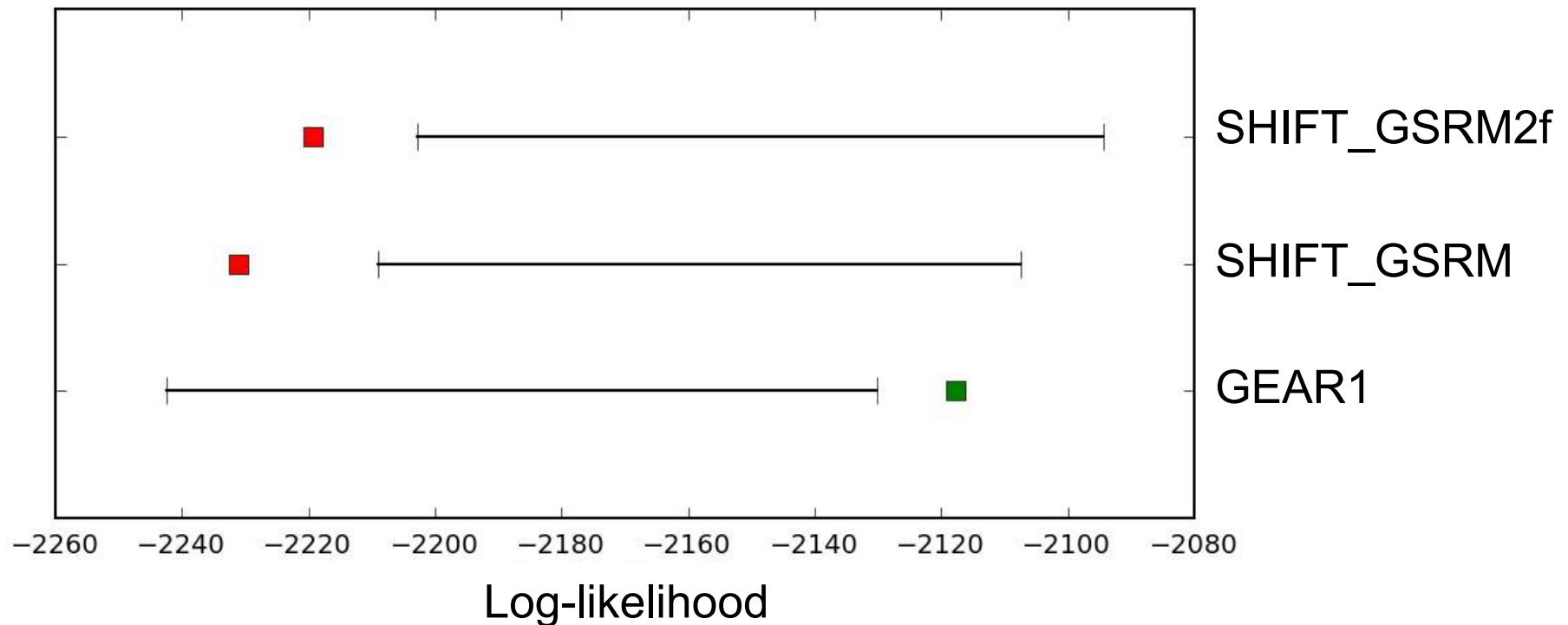
- **All models forecast the number of earthquakes well.**

Results: likelihood-test



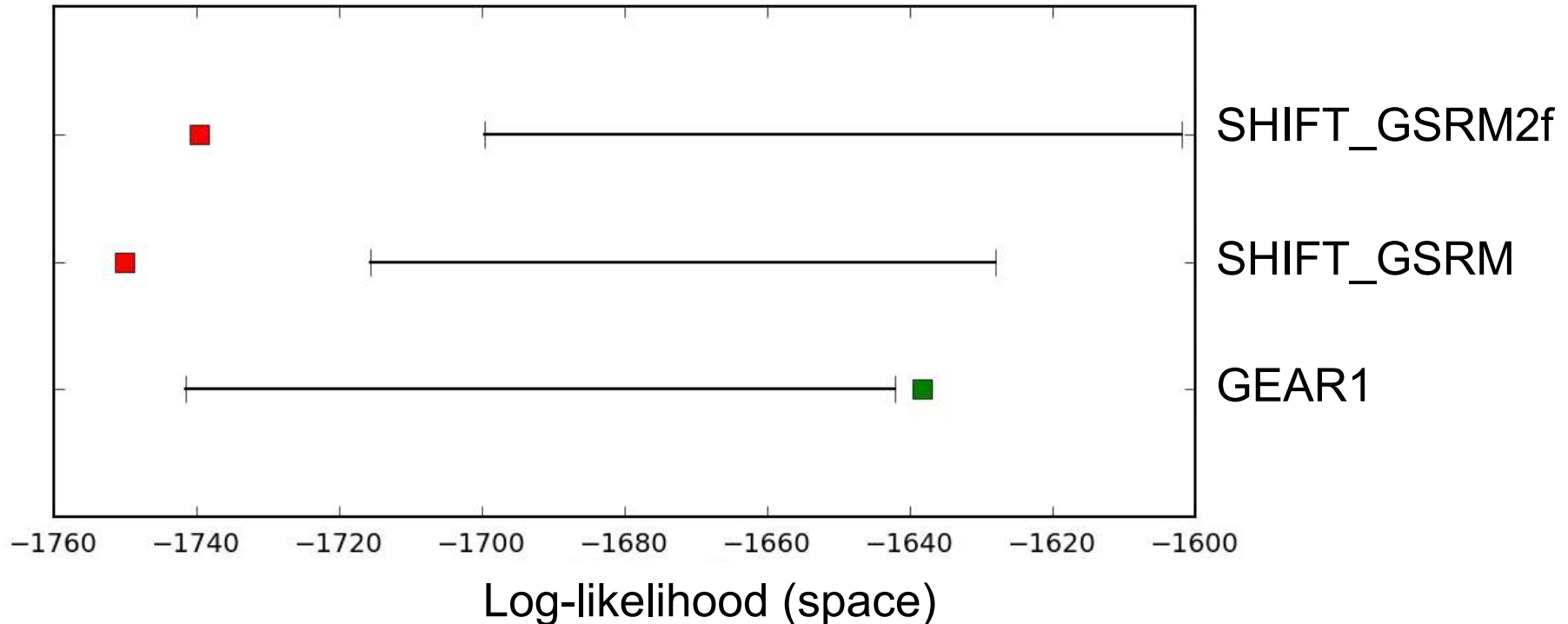
- **GEAR1 leads LL-score – can explain data best.**
- **L-test isn't very powerful...**

Results: conditional likelihood-test



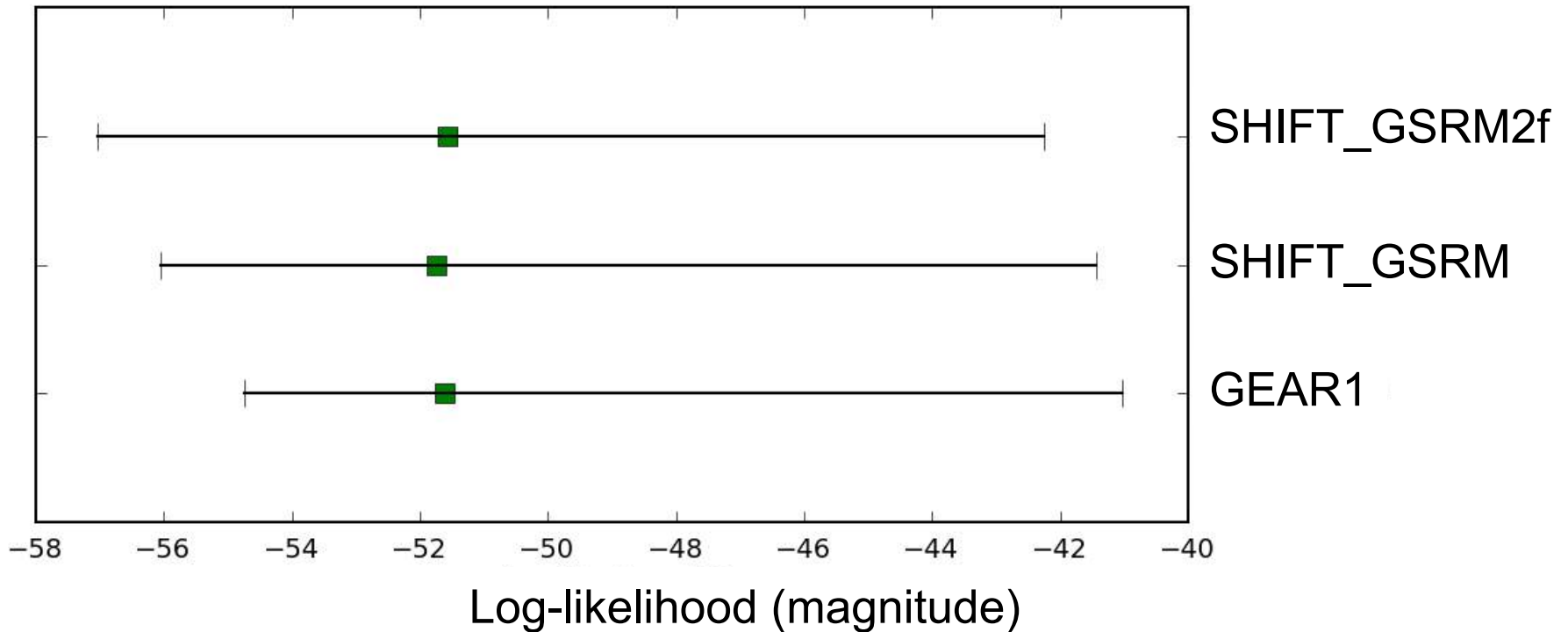
- **Conditional on number, much narrower range of LLs.**
- **Conditional L-test much more powerful.**
- **GEAR1 has greater entropy but is under-confident.**
- **SHIFT_GSRMx have lower entropy but are overconfident.**

Results: S-test



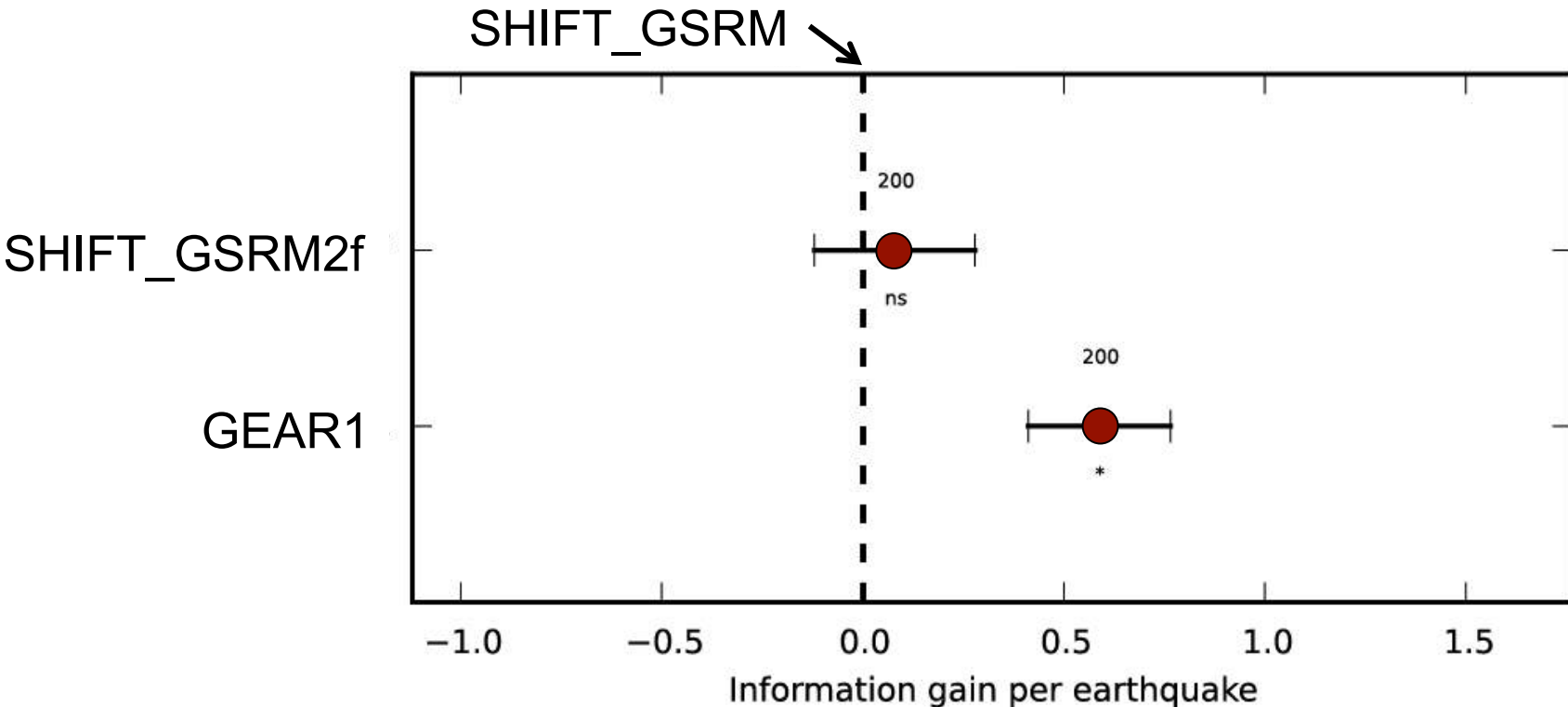
- **S-test isolates spatial component (no magnitude information).**
- **If models have same/similar magnitude distributions, this test is most powerful (no variability in magnitudes) than cL.**

Results: M-test



- **Compares observed magnitude distribution with forecast.**
- **Slight differences in entropy – identical scores.**
- **Slight differences in magnitude distributions.**
- **M-test could be replaced by a more powerful KS test.**

Information gains per earthquake



- 200 earthquakes M5.95+ ...
- GEAR1 is more informative: probabilities of observed quakes ~4 times higher than SHIFT_GSRMx.

Conclusions and next steps

- **Observed number of eqks is consistent with the SHIFT approach, which converts tectonic moment to seismic rates.**
- **The SHIFT_GSRMx models are overconfident in their spatial forecasts. Why?**
 - Strain-rate too concentrated around plate boundaries?
 - Lack of data or lack of signal elsewhere?
 - Limitations of strain-rate forecasts?
- **GEAR1 is under-confident (probably too smooth) in its spatial forecast**
 - presumably due to the smoothed seismicity model.
 - Is this robust or are more earthquakes needed?
- **Past epicentroids provide additional predictive skill to the strain-rate map. Where?**
 - Along plate boundaries? additional localisation due to eqk triggering/ clustering?
 - In plate interiors? where strain-rate is too small or not available?

On information gain scores

- **Rhoades' information gain per earthquake is “the” information gain per event ($=\Delta LL/N$):**
 - **Assesses full forecast.**
 - **No simulations needed.**
 - **Uncertainty estimates exist [but need deeper probing].**
- **Kagan's information scores are useful additions:**
 - **Assesses spatial forecast only, normalised to one.**
 - **No simulations needed.**
 - **No uncertainty estimates (yet).**
 - **I_0 : expected information gain if model were data-generator.**
 - **I_1 : information gain with observed locations approximated by cell centers. (Good for smooth Gaussians, bad for steep power-laws?)**
 - **I_2 : information gain at actual locations. (trickier).**