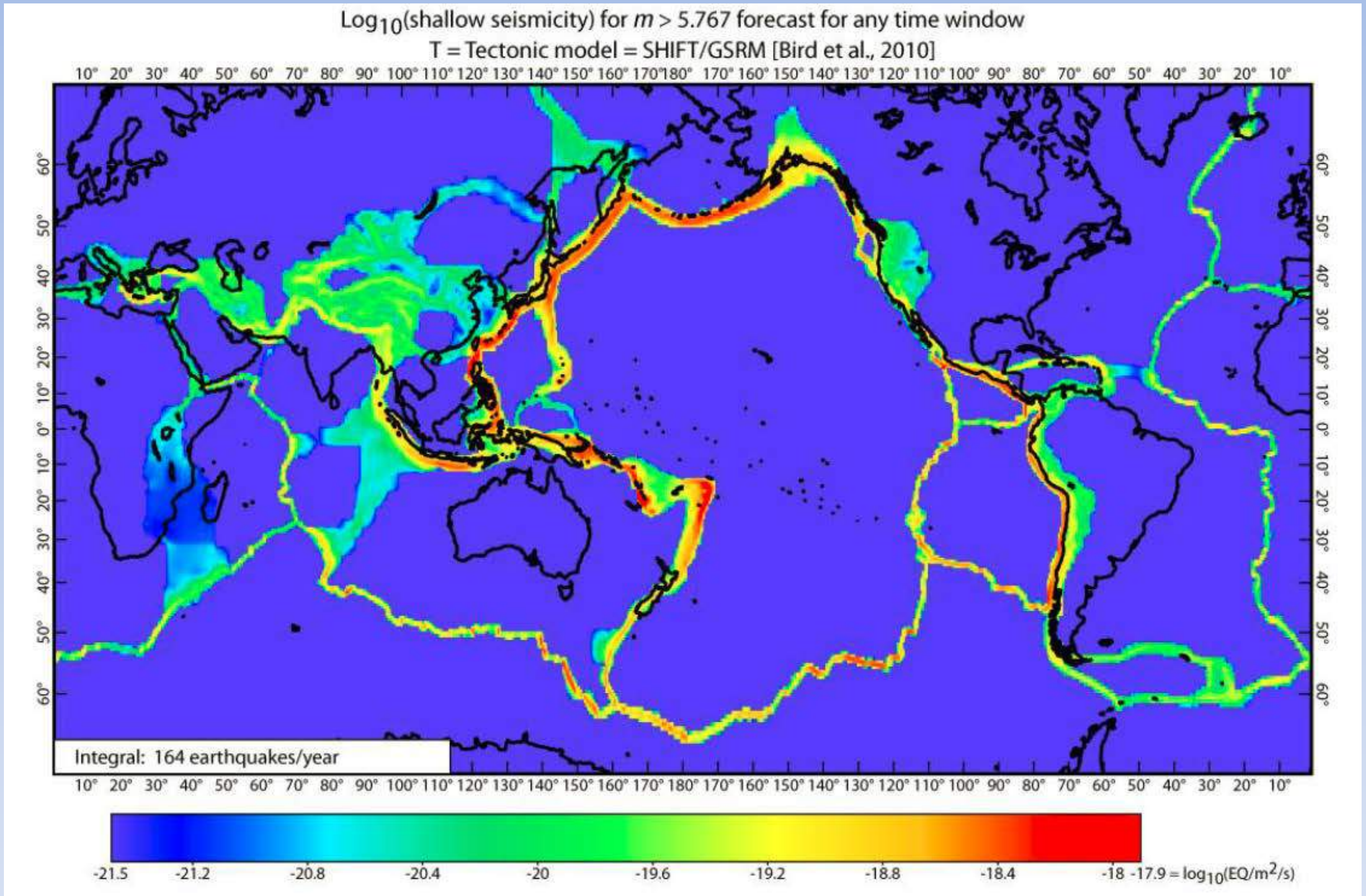
Dynamic Ensemble Model Testing and Global Earthquake Forecast Evaluation



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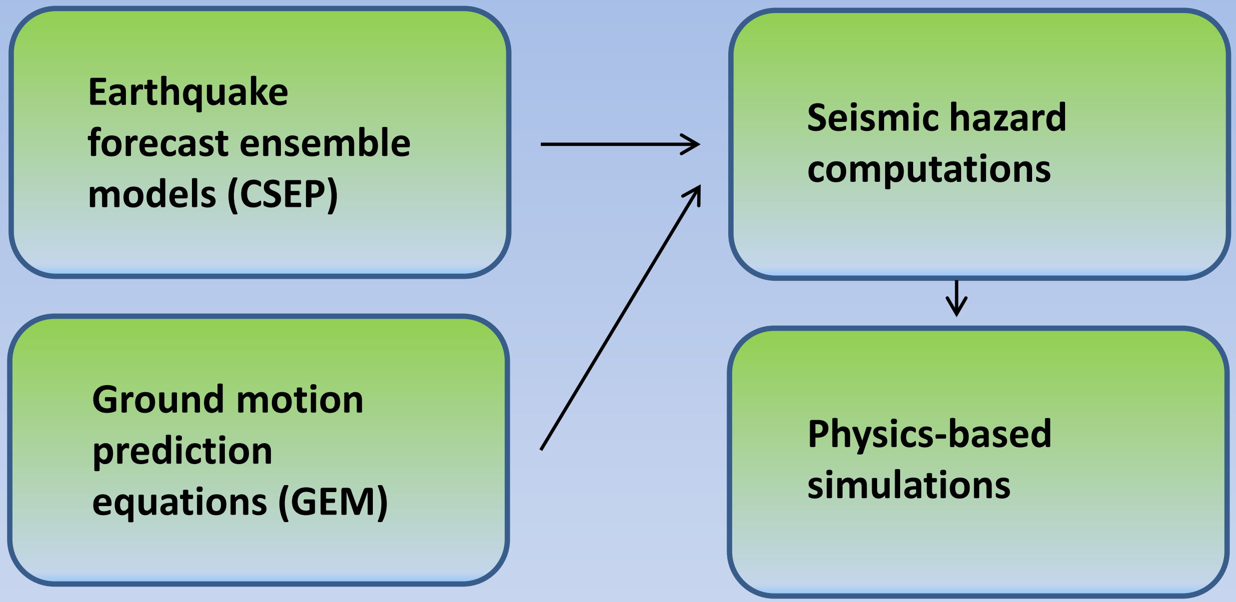
Dynamic Risk Quantification



- Connects existing earthquake forecast, ground motion prediction, and seismic hazard testing centers to forecast seismic risk
- Expert-opinion-based decision making replaced by algorithmically driven, data-informed framework

Ensemble Models

- Earthquake forecasts currently evaluated according to number (N-test), spatial distribution (S-test), and magnitude (M-test) through CSEP
- Forecast performance may vary for CSEP test components (for example, the number of earthquakes may be correctly forecasted but not the spatial distribution)
- DRQ ensemble forecasts are a combination of weighted individual forecasts according to their information gain with respect to number, magnitude, and spatial distribution

Ensemble Models (continued)

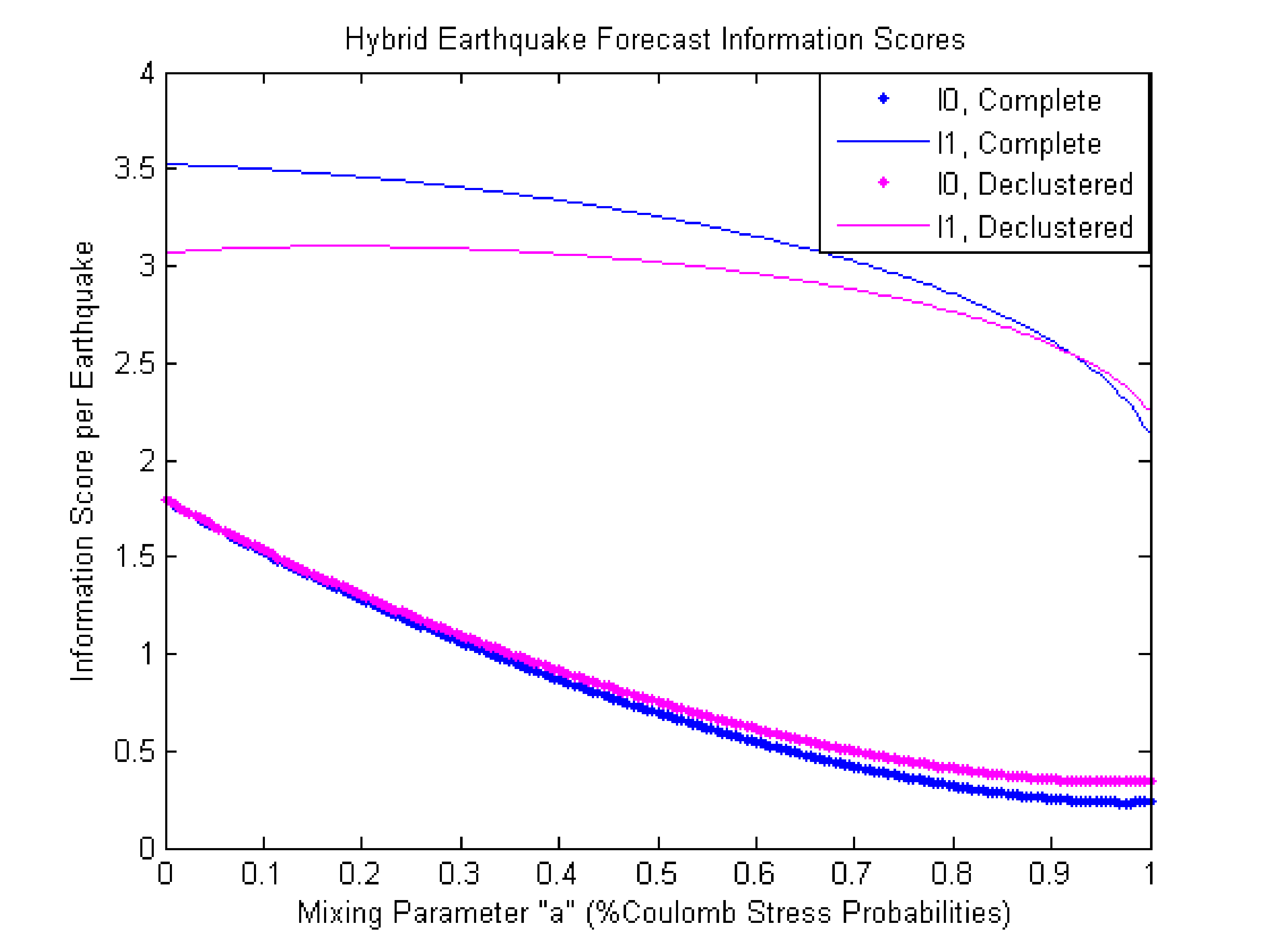
- Forecasts may be evaluated against a Poissonian null hypothesis through measuring their information scores:

$$I_1 = \frac{1}{n_j} \sum_{i=1}^{n_j} \log_2 \frac{\lambda_i}{\xi}$$

$$I_0 = \sum_{i=1}^{N} \nu_i \log_2 \left(\frac{\nu_i}{\tau_i} \right)$$

- I_1 measures the average information gain per earthquake
- I_0 measures the information gain over multiple regions (long-term I_1 score)

Information Score Example



Dynamic Forecast Evaluation

- For a forecast to be included in the ensemble model, it must first not be rejected in favor of a “null” forecast (such as a Poissonian earthquake forecast) at the 95% confidence level
- Forecasts are then weighted according to their ability to forecast earthquake numbers, magnitudes, and spatial distribution
  - Weights are allowed to vary spatially, possibly temporally following a large mainshock (log likelihood residuals)

Dynamic Forecast Evaluation (continued)

- Prior to the beginning of the "learning period", weights are assigned for each forecasting component (N, M, S) according to correlations between forecasted seismicity distributions
  - Similar types of forecasts may have similar seismicity rate distributions, and overwhelm forecasting classes with fewer submitted models
- During a series of time intervals during the "testing period", the mixing parameter is repeatedly optimized to maximize the information gain per earthquake (the information gain may be modified to focus solely on magnitude, number, or spatial earthquake distribution)
  - Within each cell of the study area, the mixing parameter is adjusted to reflect each forecast's median information gain, as well as its stability (variance in information gain over the first set of time intervals)
  - The mixing parameter is increased for greater median information scores and lower information score variance

Log Likelihood Residuals