How Good are Next-Day Earthquake Forecasts? A Comprehensive Evaluation of Clustered Seismicity Models in California

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[6] Statewide California Earthquake Center, U.S.A.

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European Seismological Commission

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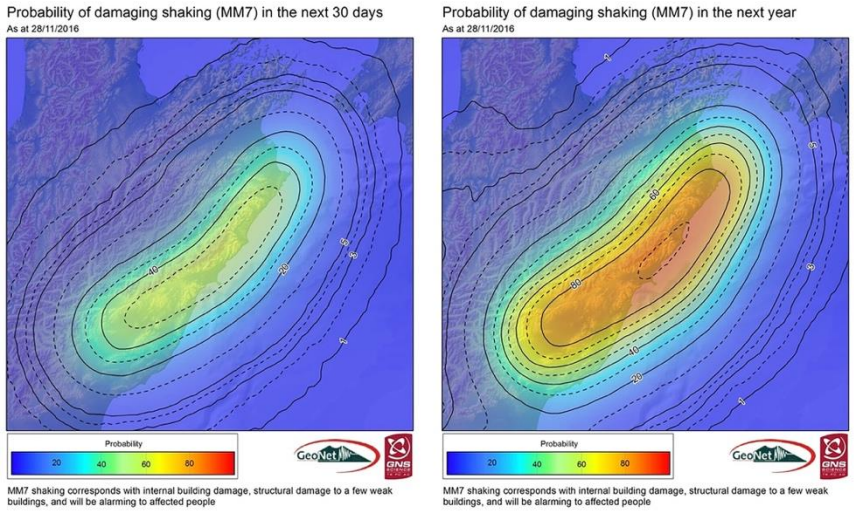
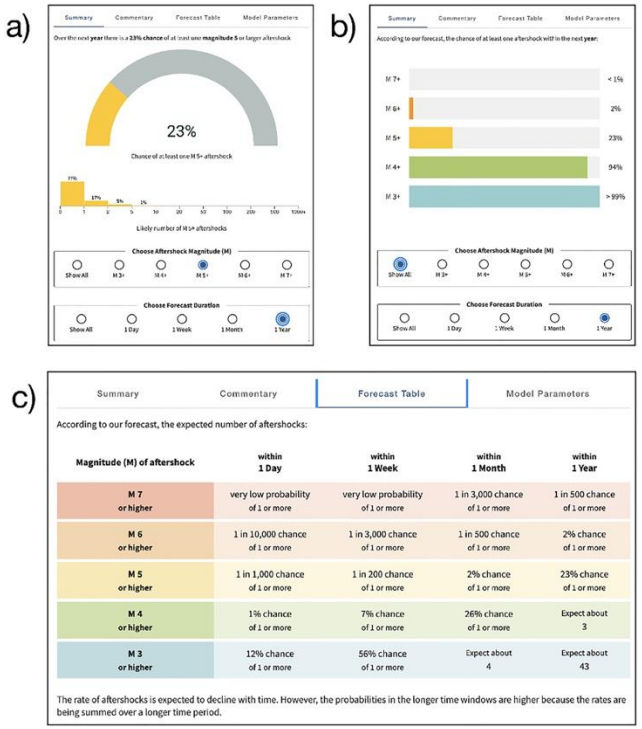
Motivation

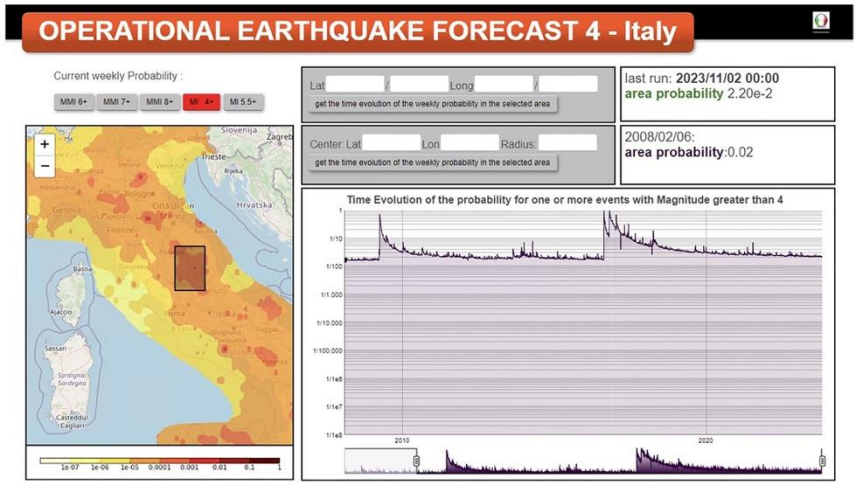
New Zealand



United States



Italy



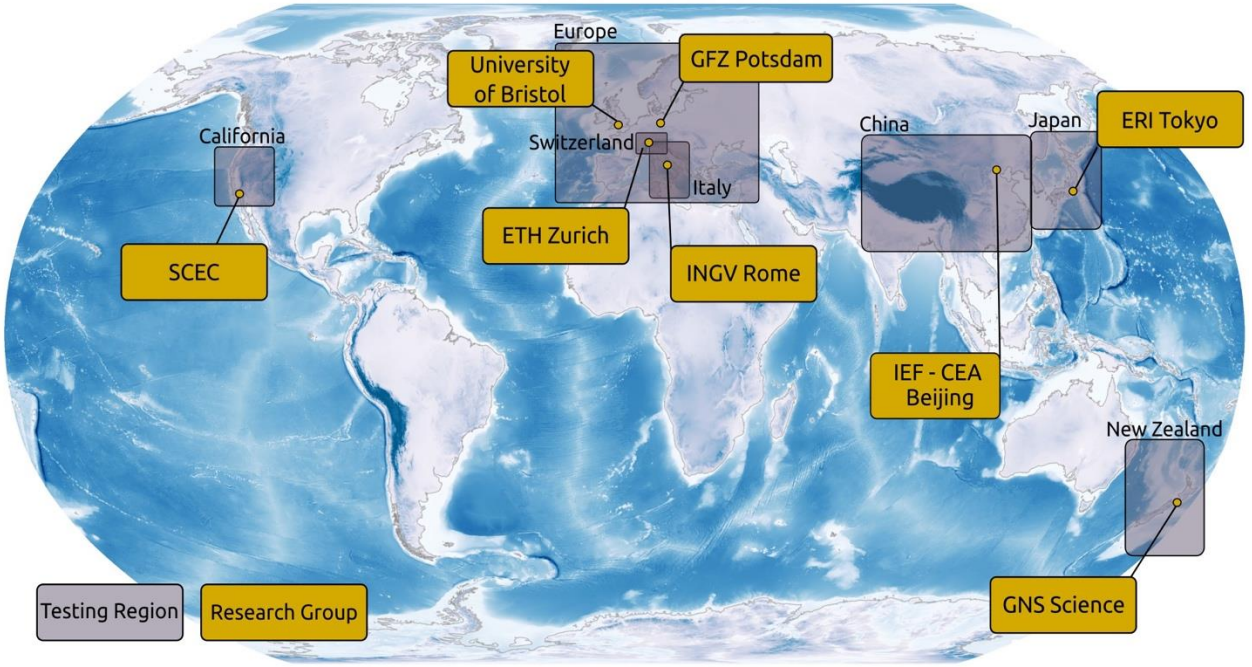
Mizrahi et al. (2024)

CSEP experiments

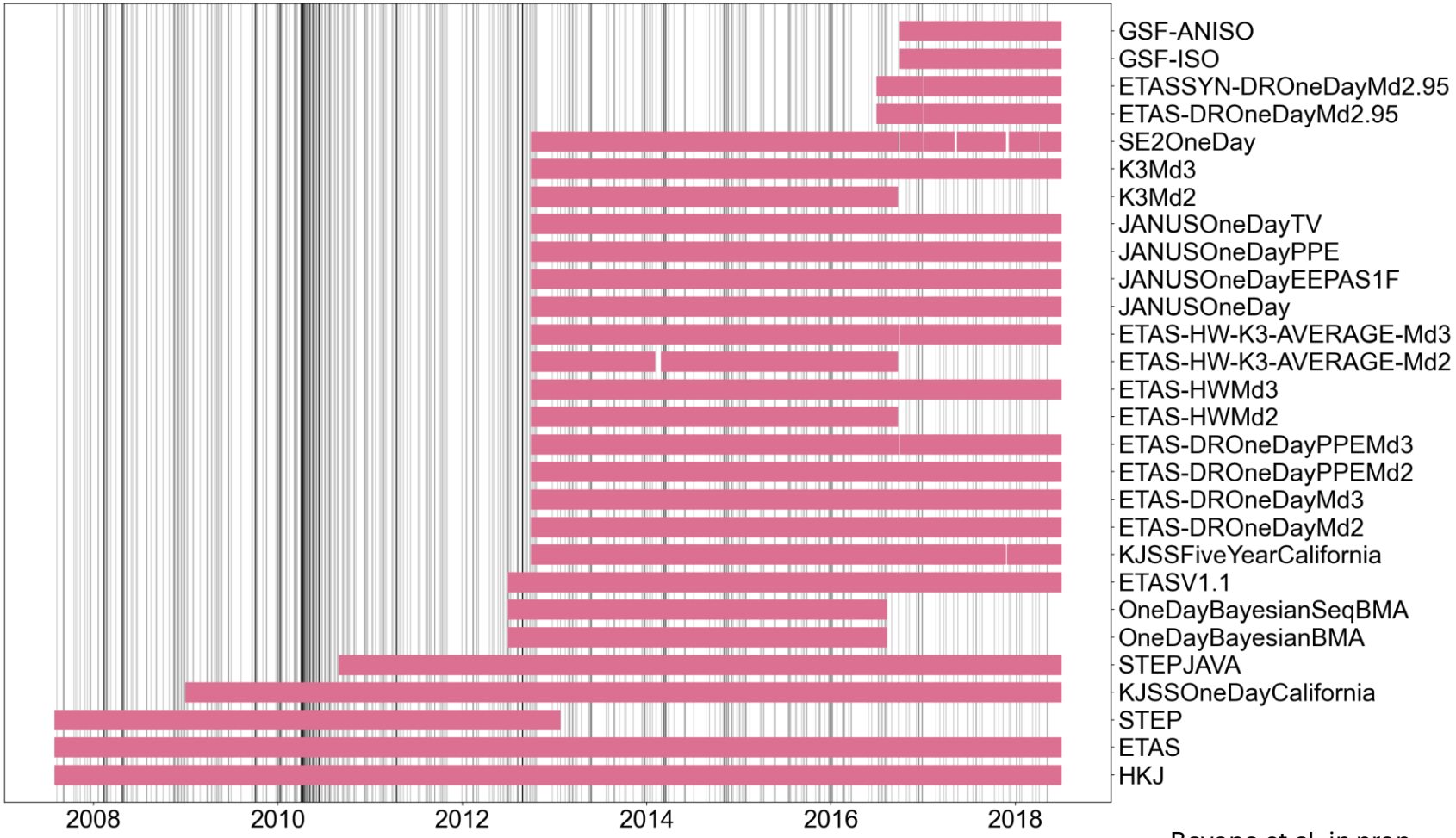
- Testing region
- Evaluation period
- Magnitude range
- Target earthquakes
- Testing methods

The main pillar of CSEP's approach is the prospective evaluation of seismicity models in fully reproducible and transparent forecasting experiments.

Starting in 2007, CSEP has managed testing centres in California, Japan, Italy, New Zealand, and China, hosting more than 440 models.

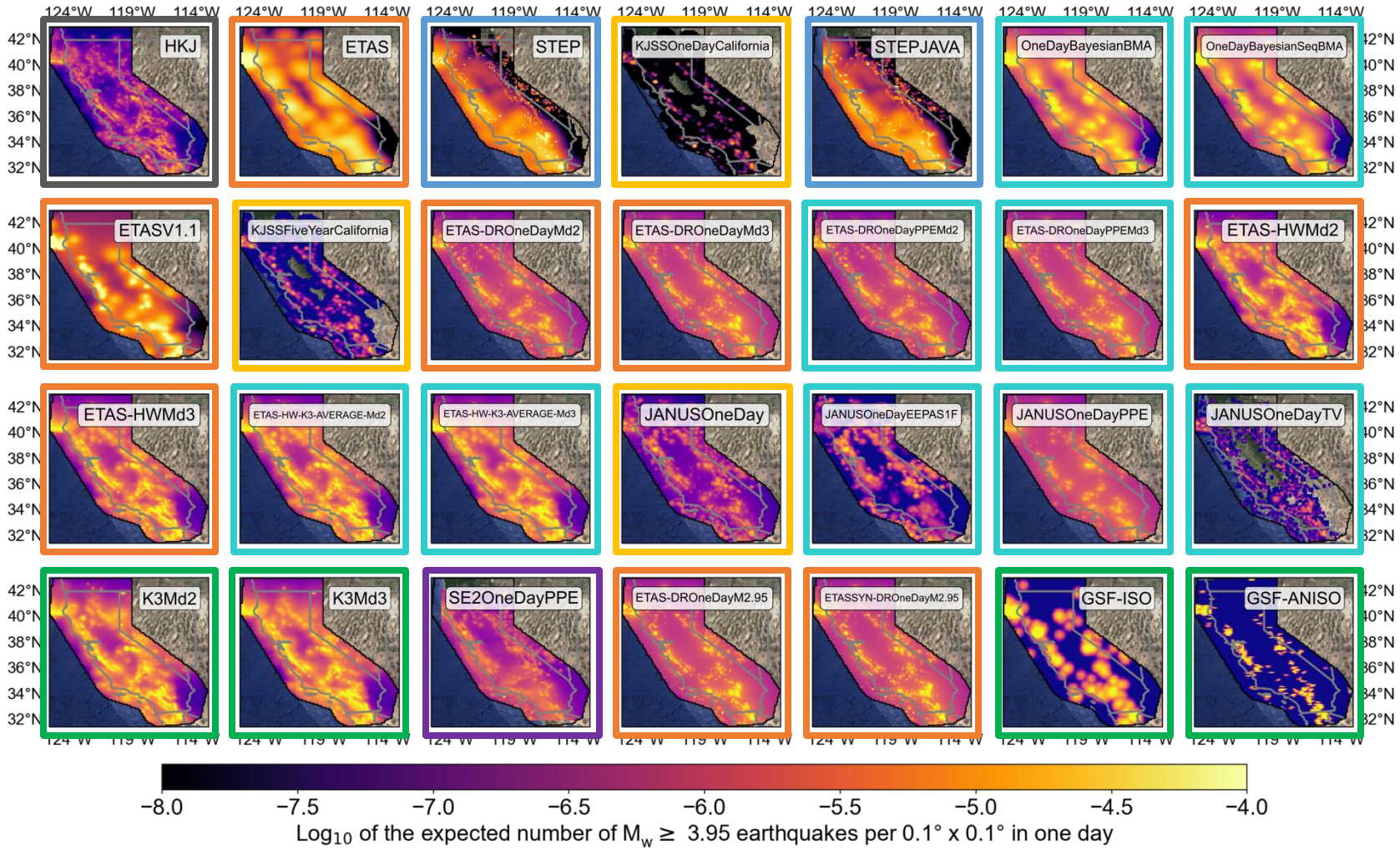


Can we improve OEF?

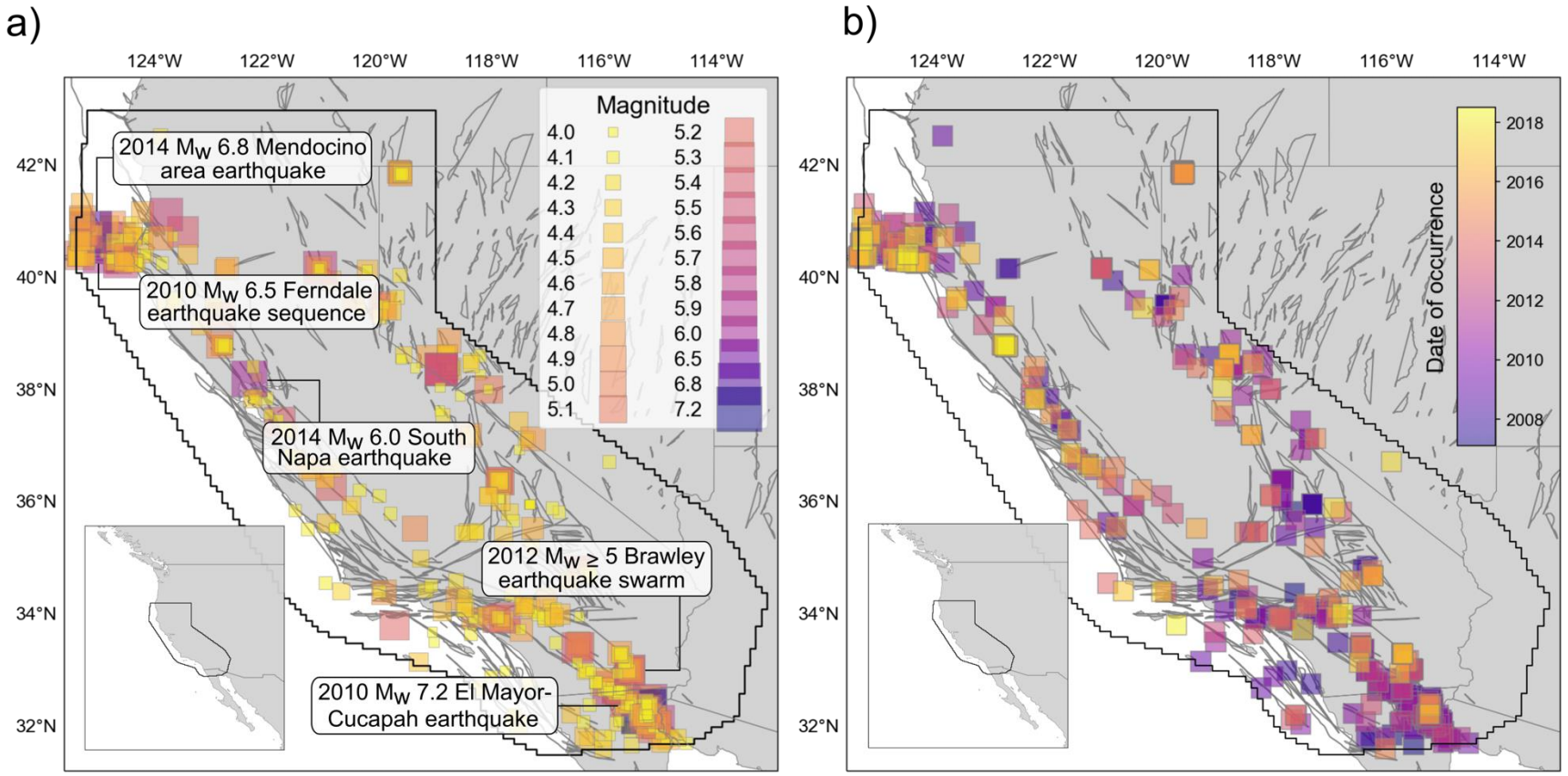


Bayona et al. in prep.

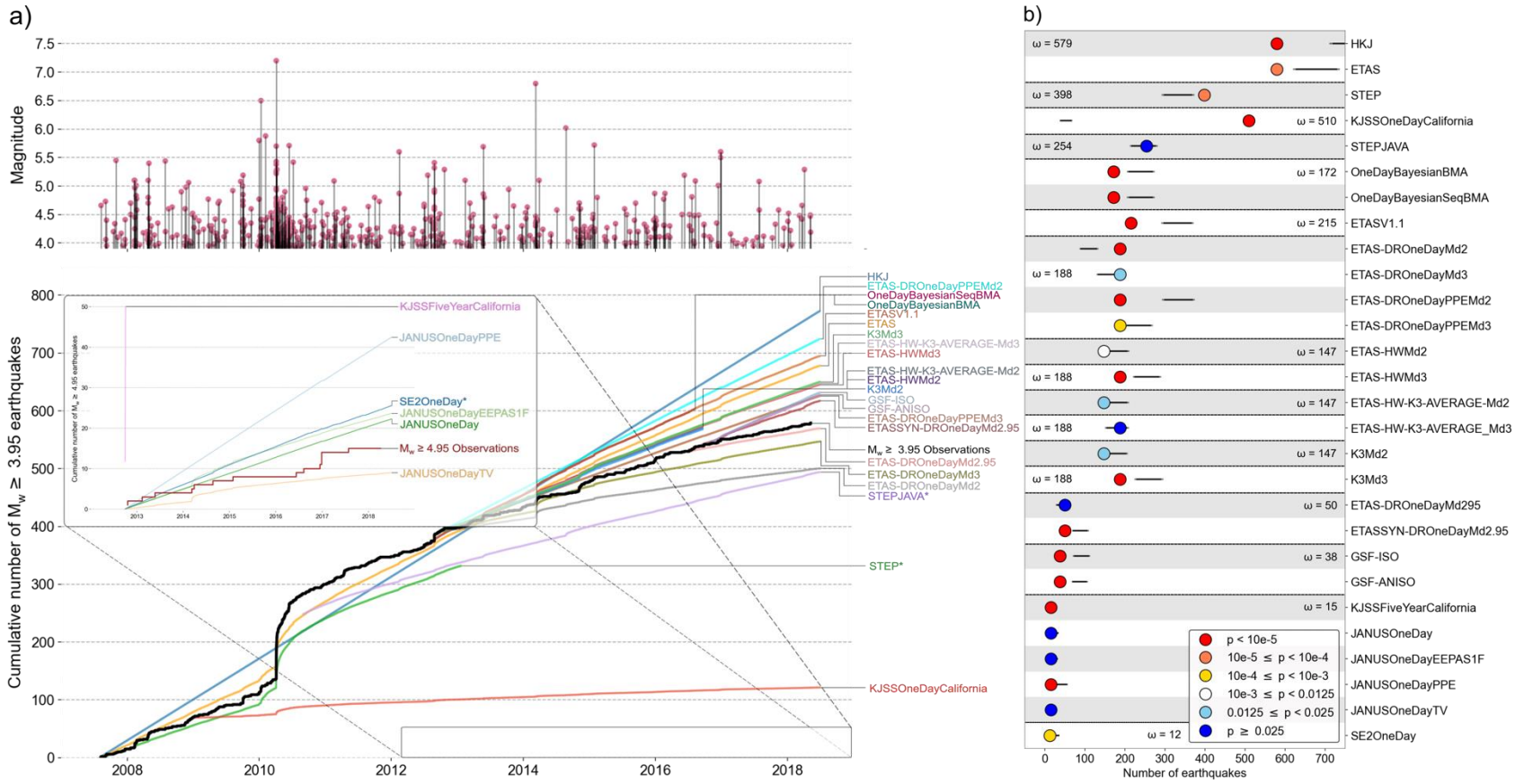
Predictive pool of models



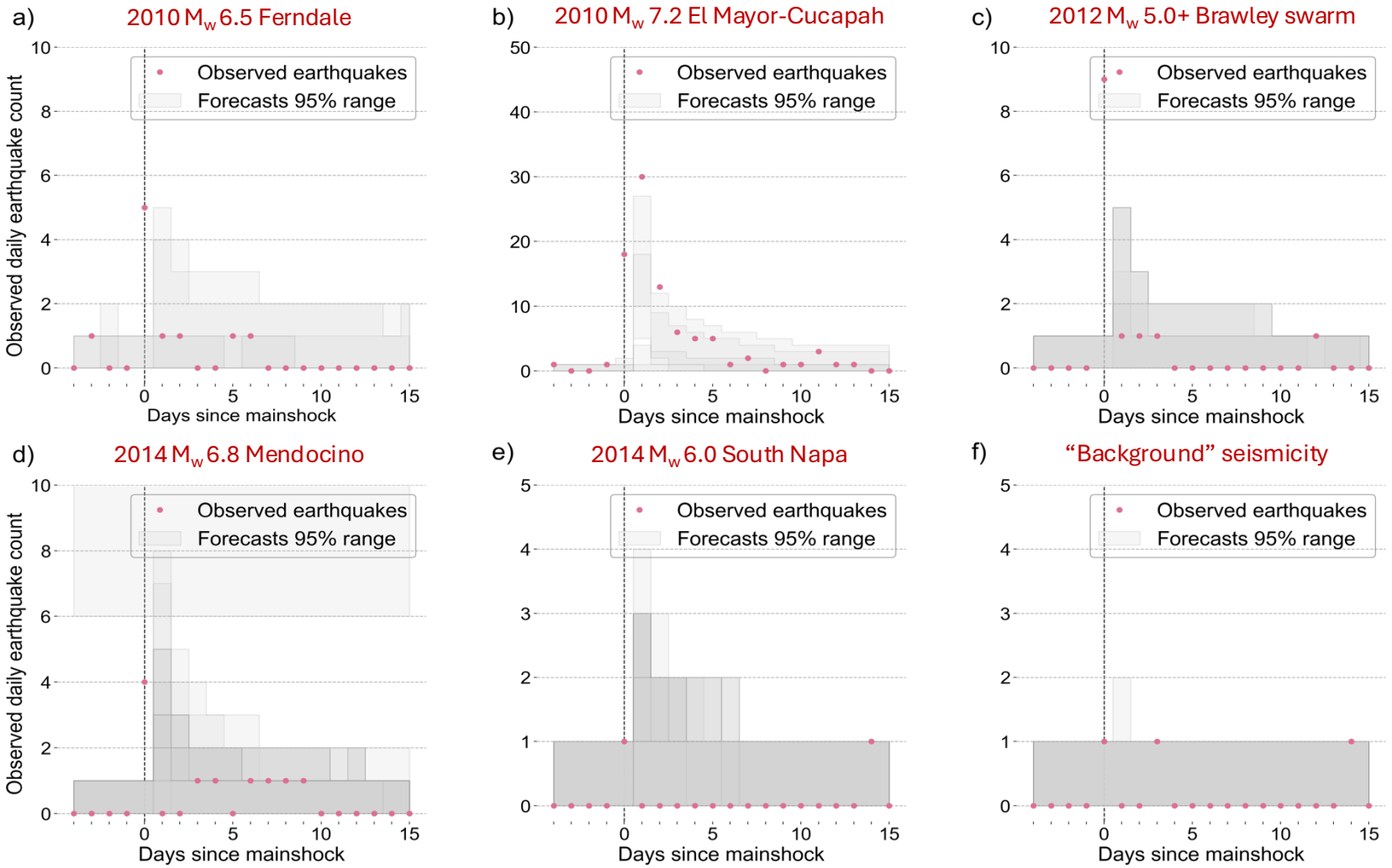
Prospective dataset



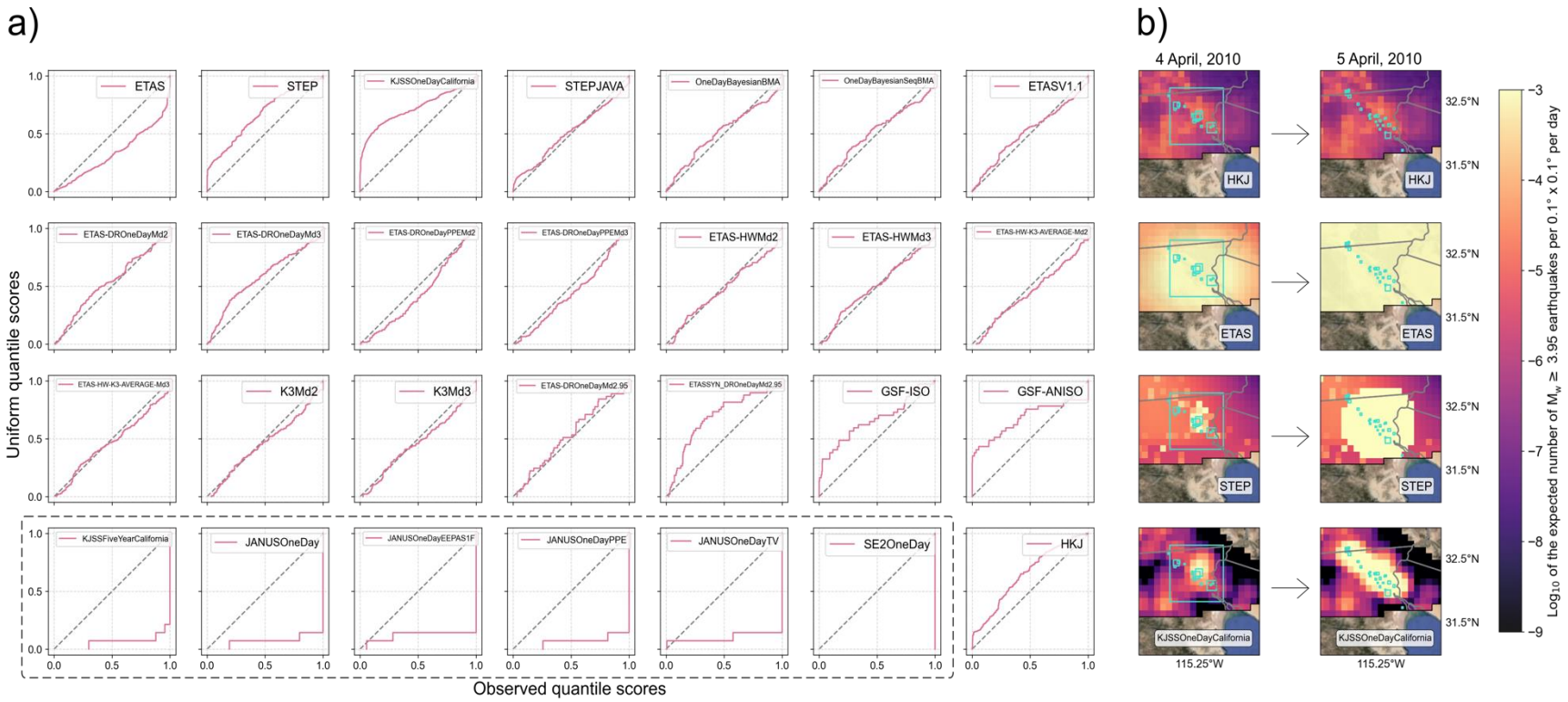
Number test results



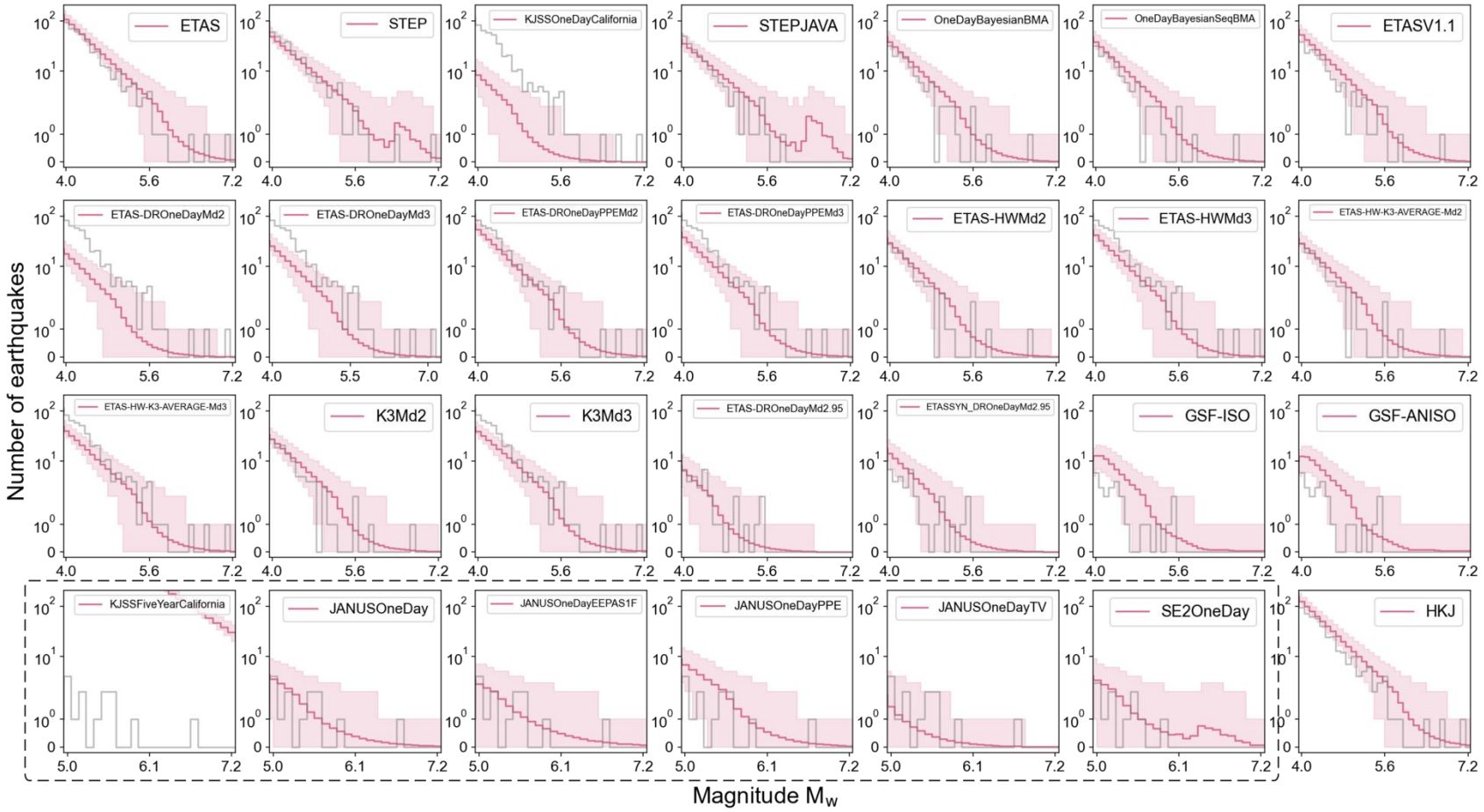
How did the models perform daily?



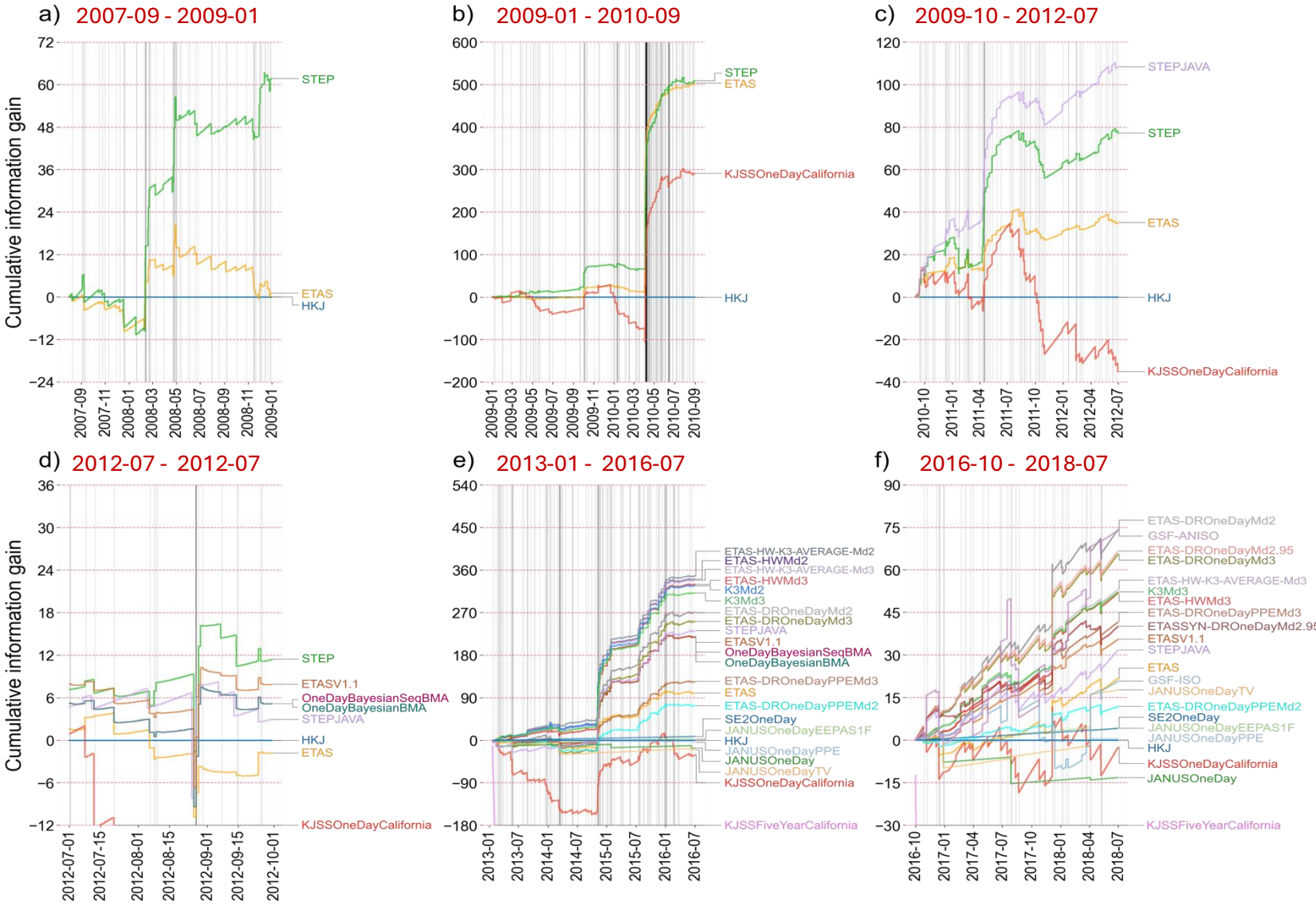
Spatial test results



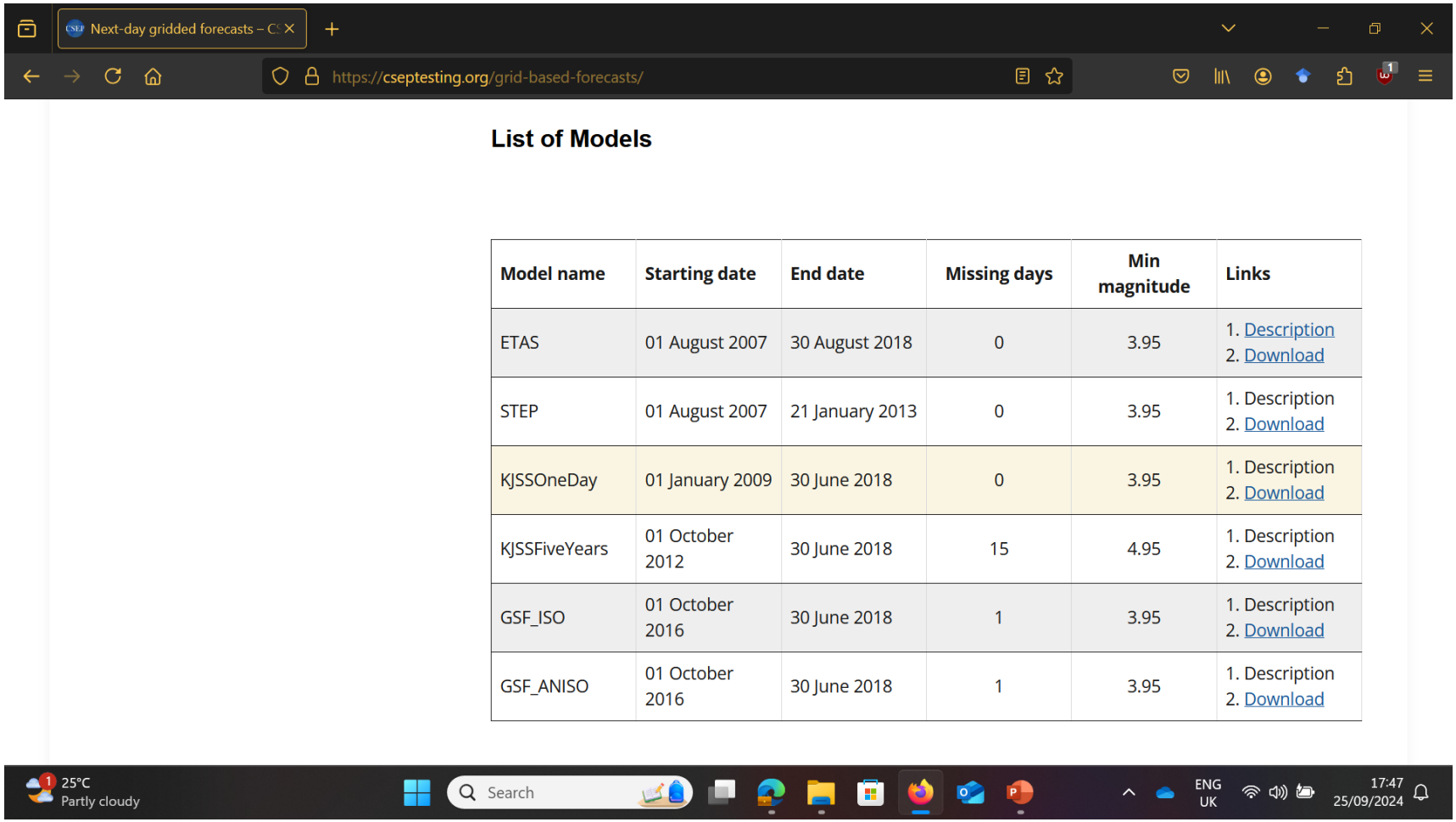
Magnitude test results



Comparative test results



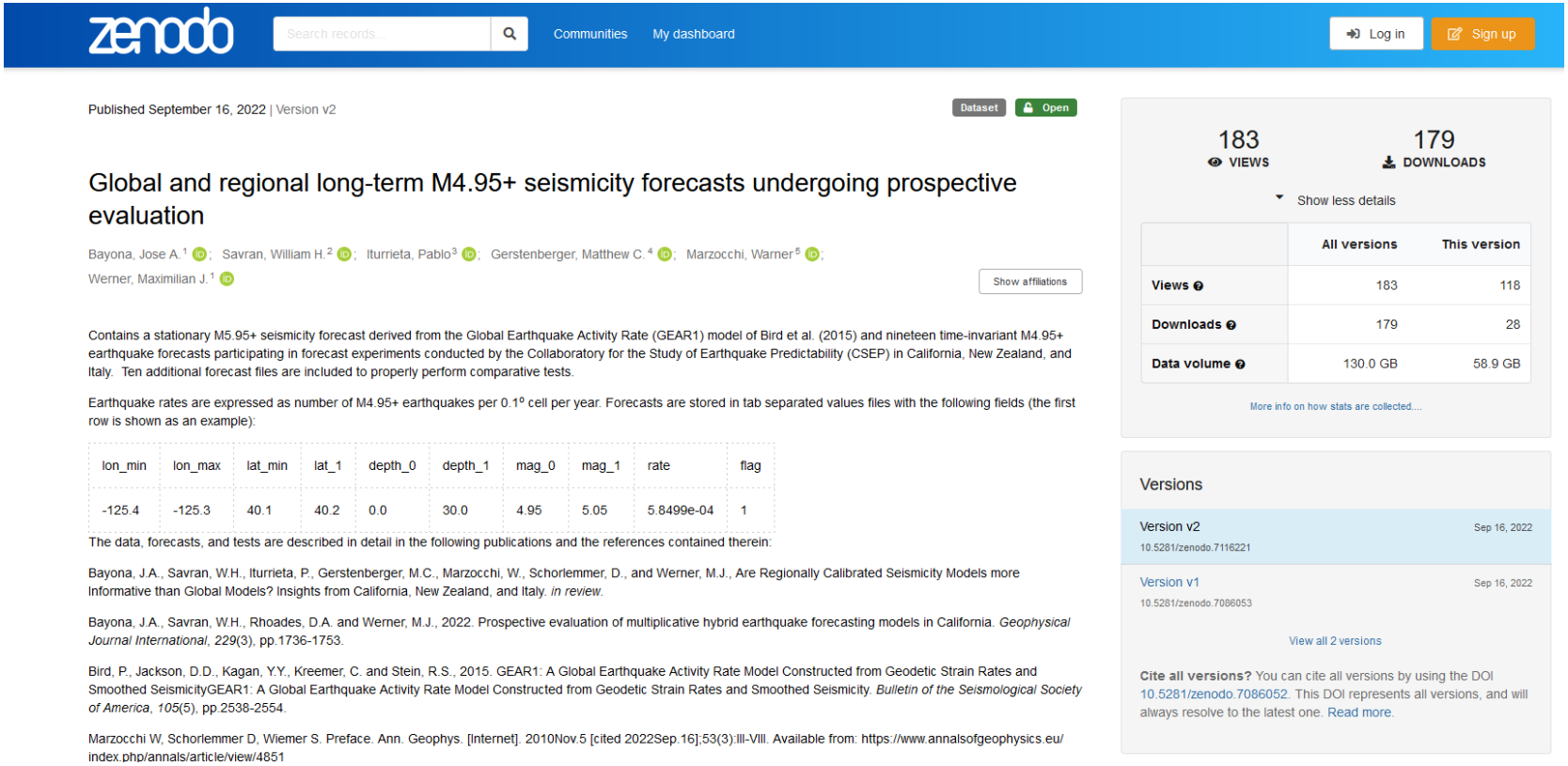
Data availability: cseptesting.org



List of Models

Model name	Starting date	End date	Missing days	Min magnitude	Links
ETAS	01 August 2007	30 August 2018	0	3.95	1. Description 2. Download
STEP	01 August 2007	21 January 2013	0	3.95	1. Description 2. Download
KJSSOneDay	01 January 2009	30 June 2018	0	3.95	1. Description 2. Download
KJSSFiveYears	01 October 2012	30 June 2018	15	4.95	1. Description 2. Download
GSF_ISO	01 October 2016	30 June 2018	1	3.95	1. Description 2. Download
GSF_ANISO	01 October 2016	30 June 2018	1	3.95	1. Description 2. Download

Reproducibility package



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Published September 16, 2022 | Version v2

Dataset Open

Global and regional long-term M4.95+ seismicity forecasts undergoing prospective evaluation

Bayona, Jose A.[1]; Savran, William H.[2]; Iturrieta, Pablo[3]; Gerstenberger, Matthew C.[4]; Marzocchi, Warner[5]; Werner, Maximilian J.[1]

Show affiliations

Contains a stationary M5.95+ seismicity forecast derived from the Global Earthquake Activity Rate (GEAR1) model of Bird et al. (2015) and nineteen time-invariant M4.95+ earthquake forecasts participating in forecast experiments conducted by the Collaboratory for the Study of Earthquake Predictability (CSEP) in California, New Zealand, and Italy. Ten additional forecast files are included to properly perform comparative tests.

Earthquake rates are expressed as number of M4.95+ earthquakes per 0.1° cell per year. Forecasts are stored in tab separated values files with the following fields (the first row is shown as an example):

lon_min	lon_max	lat_min	lat_1	depth_0	depth_1	mag_0	mag_1	rate	flag
-125.4	-125.3	40.1	40.2	0.0	30.0	4.95	5.05	5.8499e-04	1

The data, forecasts, and tests are described in detail in the following publications and the references contained therein:

Bayona, J.A., Savran, W.H., Iturrieta, P., Gerstenberger, M.C., Marzocchi, W., Schorlemmer, D., and Werner, M.J., Are Regionally Calibrated Seismicity Models more Informative than Global Models? Insights from California, New Zealand, and Italy. *in review*.

Bayona, J.A., Savran, W.H., Rhoades, D.A. and Werner, M.J., 2022. Prospective evaluation of multiplicative hybrid earthquake forecasting models in California. *Geophysical Journal International*, *229*(3), pp.1736-1753.

Bird, P., Jackson, D.D., Kagan, Y.Y., Kreemer, C. and Stein, R.S., 2015. GEAR1: A Global Earthquake Activity Rate Model Constructed from Geodetic Strain Rates and Smoothed SeismicityGEAR1: A Global Earthquake Activity Rate Model Constructed from Geodetic Strain Rates and Smoothed Seismicity. *Bulletin of the Seismological Society of America*, *105*(5), pp.2538-2554.

Marzocchi W, Schorlemmer D, Wiemer S. Preface. Ann. Geophys. [Internet]. 2010Nov.5 [cited 2022Sep.16];53(3):III-VIII. Available from: https://www.annalsofgeophysics.eu/index.php/annals/article/view/4851

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Take-home messages

Most models provide cumulative earthquake counts that are nearly consistent with the observations.

Most models provide spatial forecasts that are consistent with the spatial distribution of epicenters.

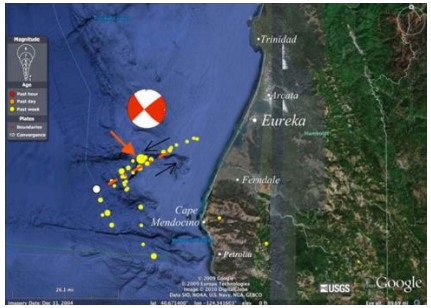
Most models provide frequency-magnitude distributions that are nearly consistent with the observations.

Models that use more small earthquakes are more informative.

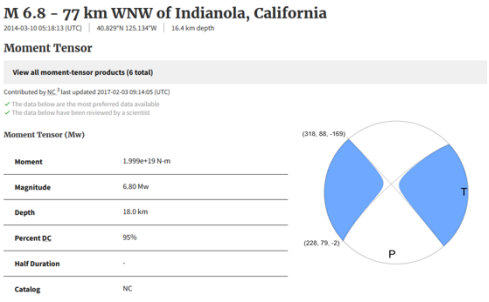
Newer models display better performance with time.

These test results may be useful to advance OEF in California and other seismically active regions.

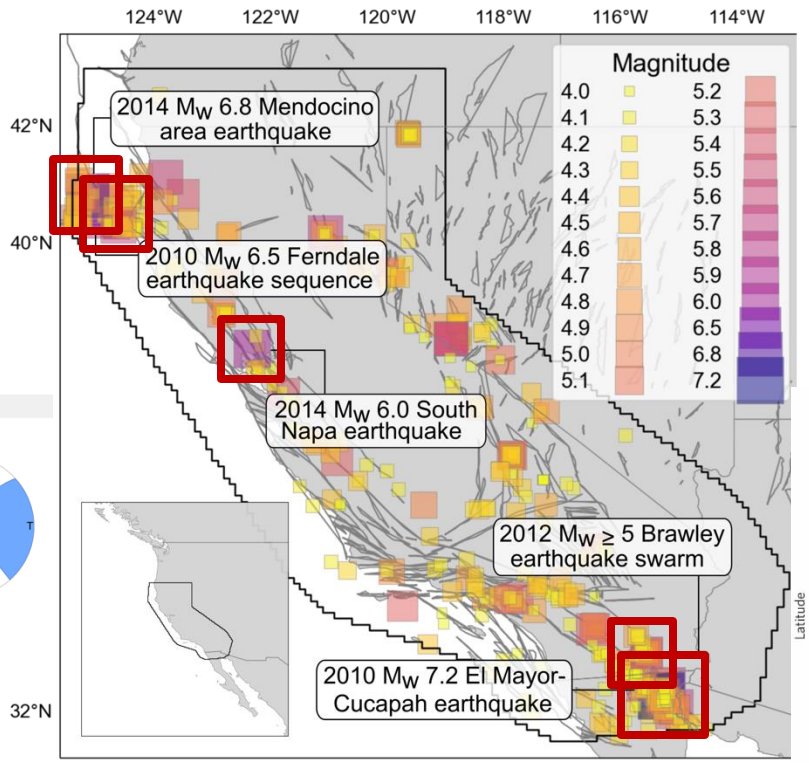
What did we learn about the earthquakes?

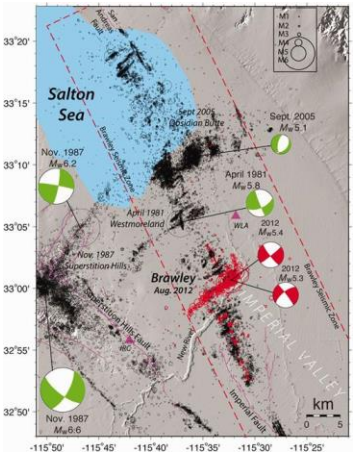


Storesund et al. (2011; GEER report)

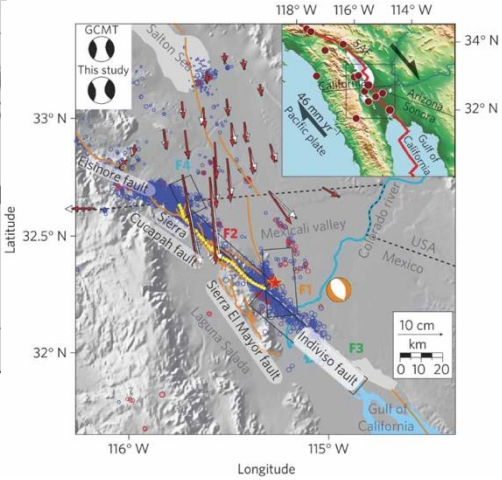


USGS



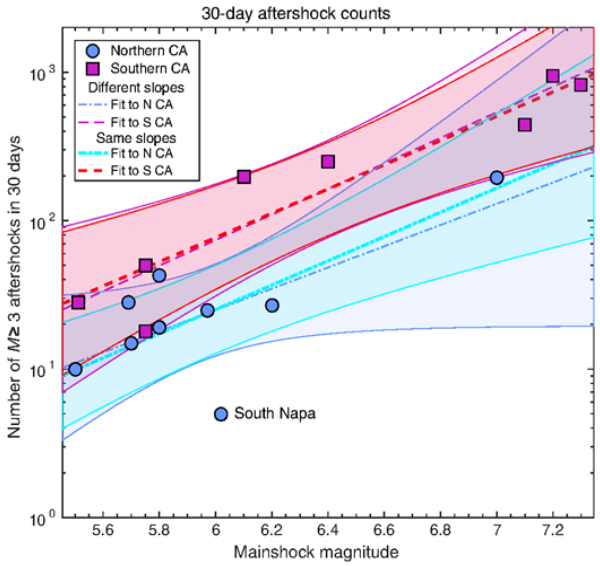


Hauksson et al. (2011; SRL)

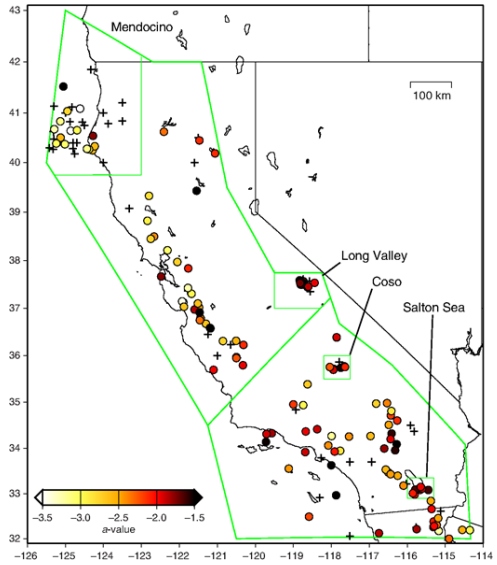


Wei et al. (2011; Nat .Geos.)

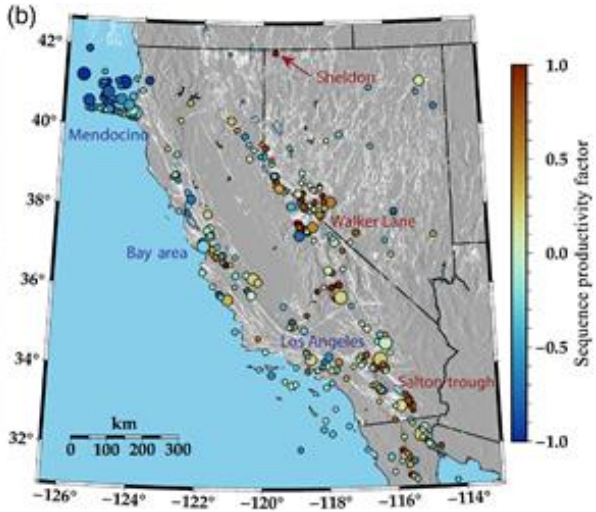
What did we learn about the earthquakes?



Llenos & Michael (2017; SRL)



Hardebeck et al. (2017; SRL)



Trugman & Ben-Zion (2023; TSR)

Testing methods

$\Lambda_1 = \{1,4,3,2\} \rightarrow \{0.1, 0.5, 0.8, 1.0\}$

$\Lambda_2 = \{2,1,3,4\} \rightarrow \{0.2, 0.3, 0.6, 1.0\}$