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REGIONAL-SCALE EARTHQUAKE **GROUND MOTION PREDICTIONS** THROUGH PYHSICS-BASED AND EMPIRICAL APPROACHES: **A CASE STUDY CENTRAL ITALY**

New methods for the evaluation of the Ground Motion Models

Matteo Taroni, Aybige Akinci, Paolo Zimmaro , Gianluca Regina,
and many others

Rome, March 11-12 2026

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Overview

- Earthquake size distribution vs rake and heat flow
- From a log-likelihood score to a weighted log-likelihood score
- Statistical test of a Ground Motion Model vs observations

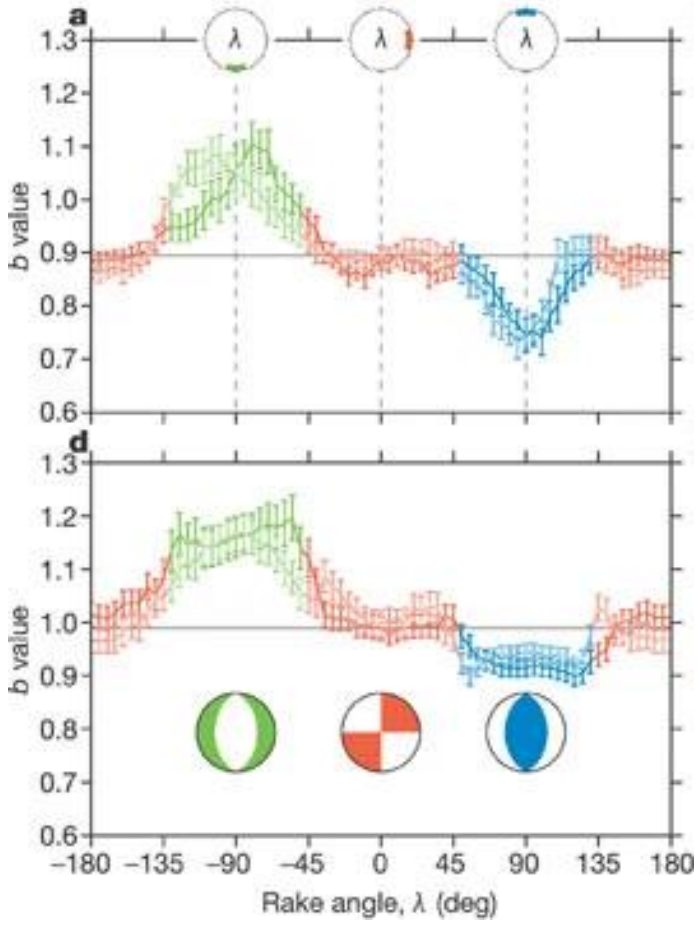
Earthquake size distribution

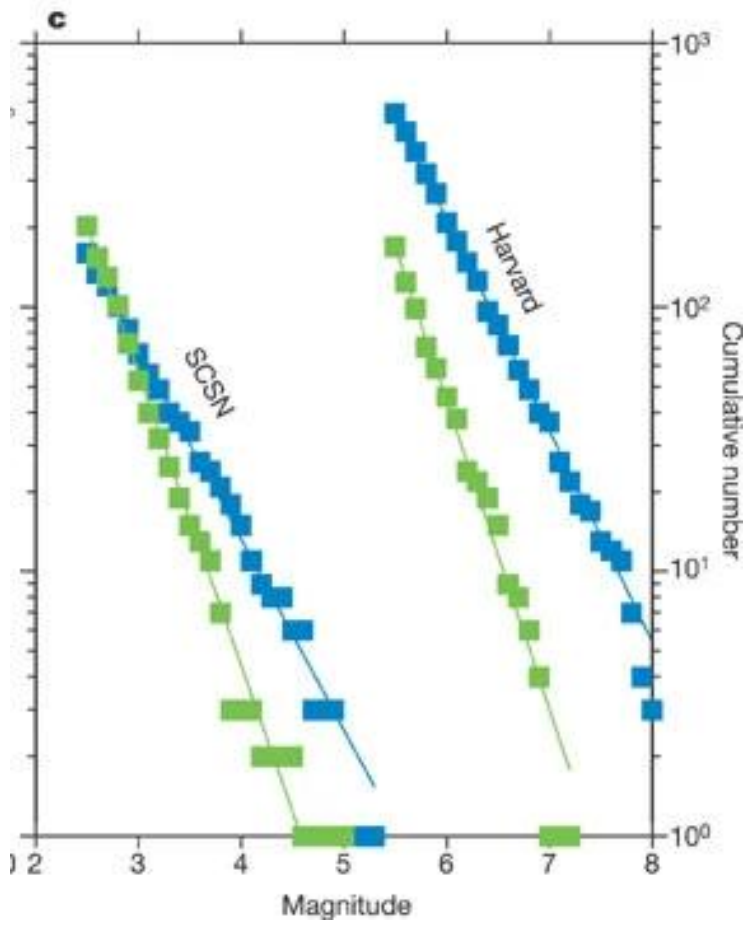
Letter | Published: 22 September 2005

Variations in earthquake-size distribution across different stress regimes

Danijel Schorlemmer, Stefan Wiemer & Max Wyss

Nature **437**, 539–542 (2005) | Cite this article





Earthquake size distribution

Geophysical Research Letters

RESEARCH LETTER
10.1029/2025GL120494

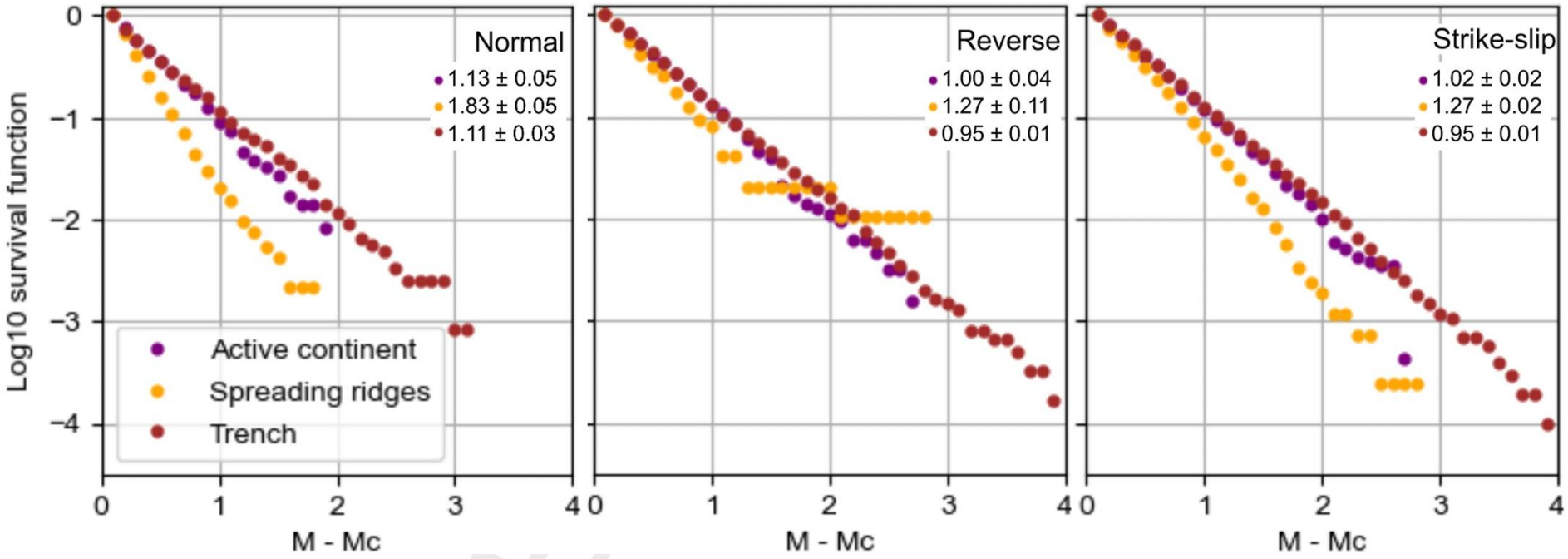
Key Points:

- The *b*-value increases with the increase of the heat flow
- The correlation between *b*-value and heat flow is generally consistent across tectonic environments and the fault kinematics

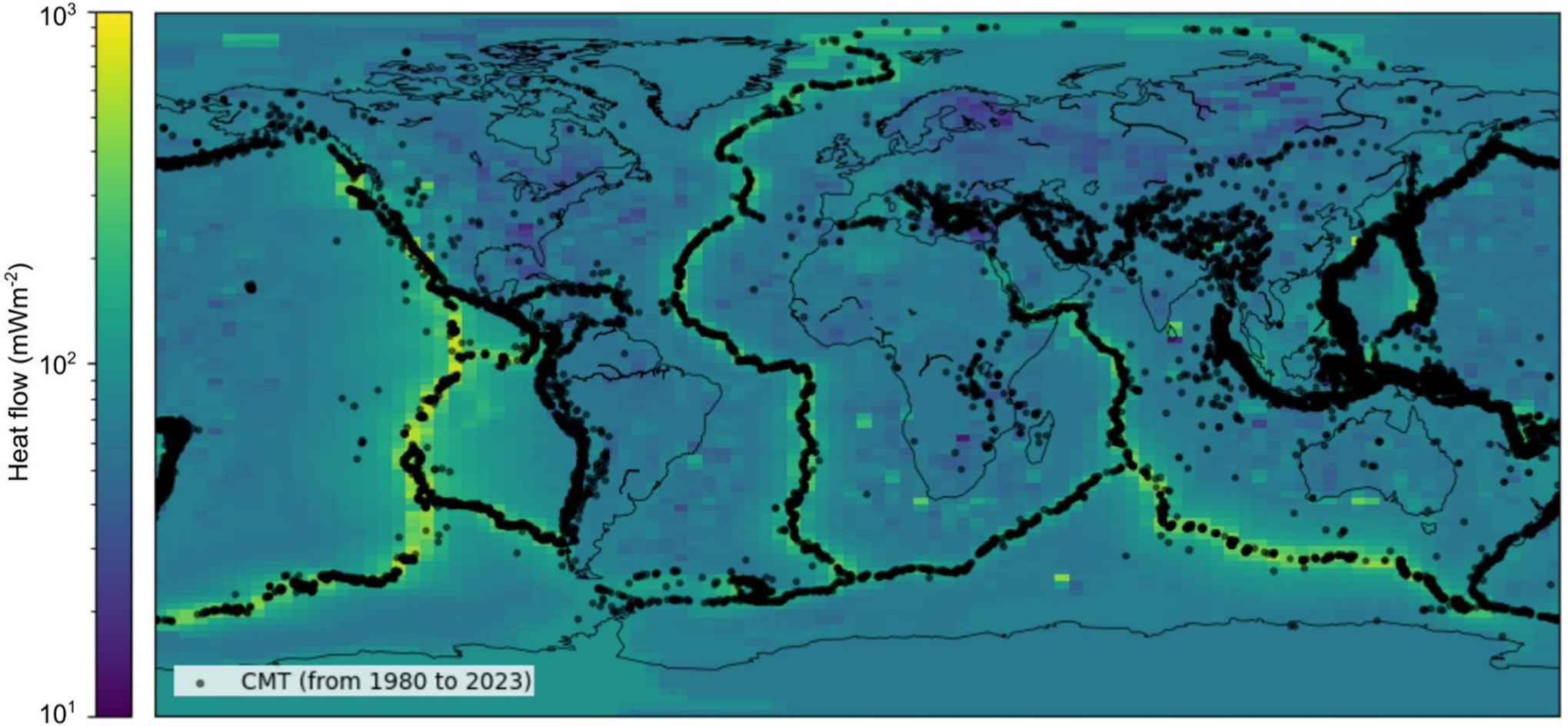
Crustal Heat Flow Drives the Earthquake Magnitude Distribution

P. Corrado[1], M. Taroni[2], L. Cordrie[3], R. Basili[2], W. Marzocchi[1,4], and J. Selva[1]

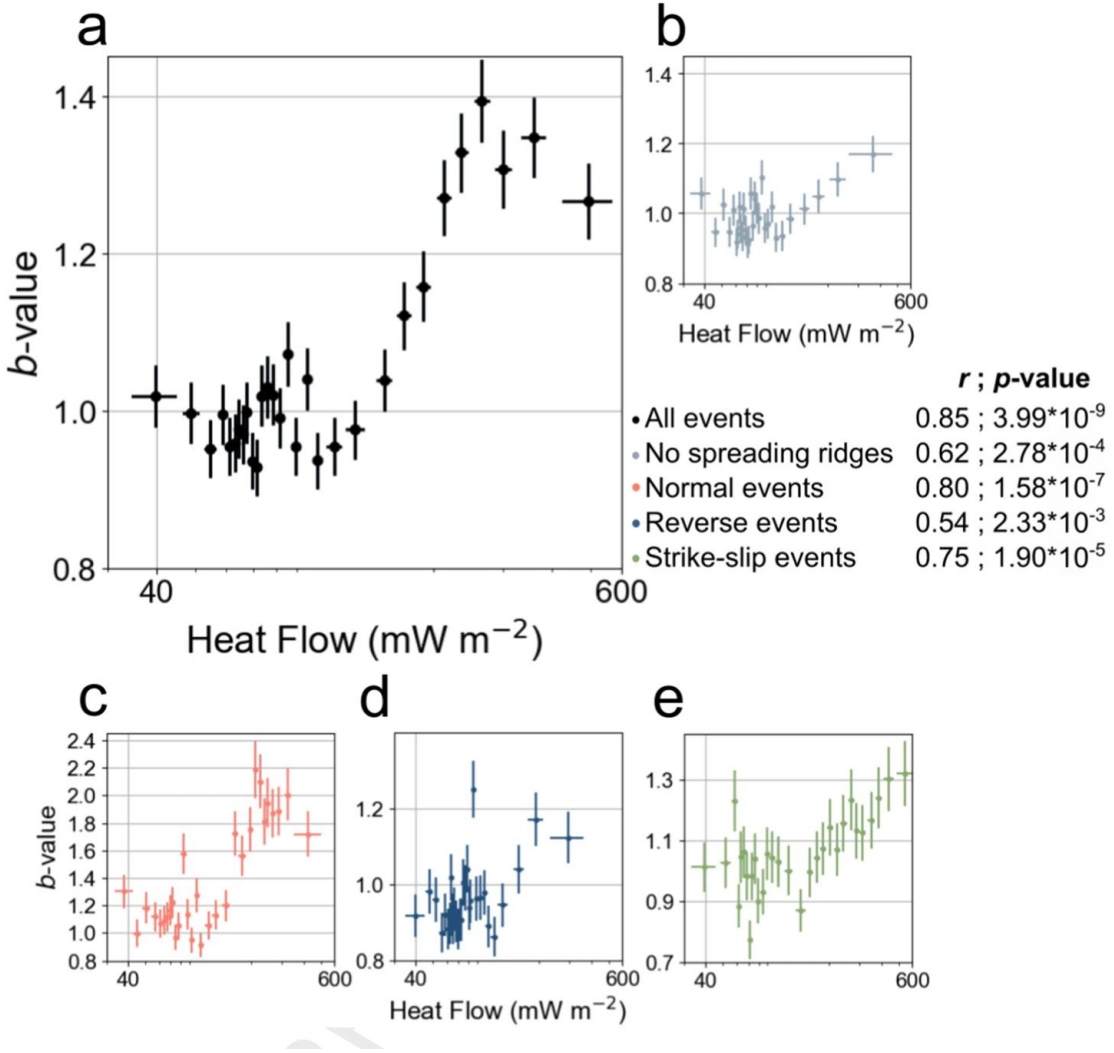
[1]Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli Federico II, Napoli, Italy, [2]Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy, [3]CINECA, Bologna, Italy, [4]Scuola Superiore Meridionale, Naples, Italy



Earthquake size distribution



Earthquake size distribution



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Scoring ground motion models

RESEARCH ARTICLE | DECEMBER 01, 2009

Model Selection in Seismic Hazard Analysis: An Information-Theoretic Perspective

Frank Scherbaum; Elise Delavaud; Carsten Riggelsen

+ Author and Article Information

Bulletin of the Seismological Society of America (2009) 99 (6): 3234–3247.
https://doi.org/10.1785/0120080347 | Article history

Previous work

Research Paper

EARTHQUAKE SPECTRA

Earthquake Spectra
1–19
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DOI: 10.1177/87552930221141724
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Peculiar characteristics of ground motions in Southern Italy: Insights from global and regional ground motion models

Gianluca Regina[1], Paolo Zimmaro[2,3], Matteo Taroni[4], and Aybige Akinci[4]

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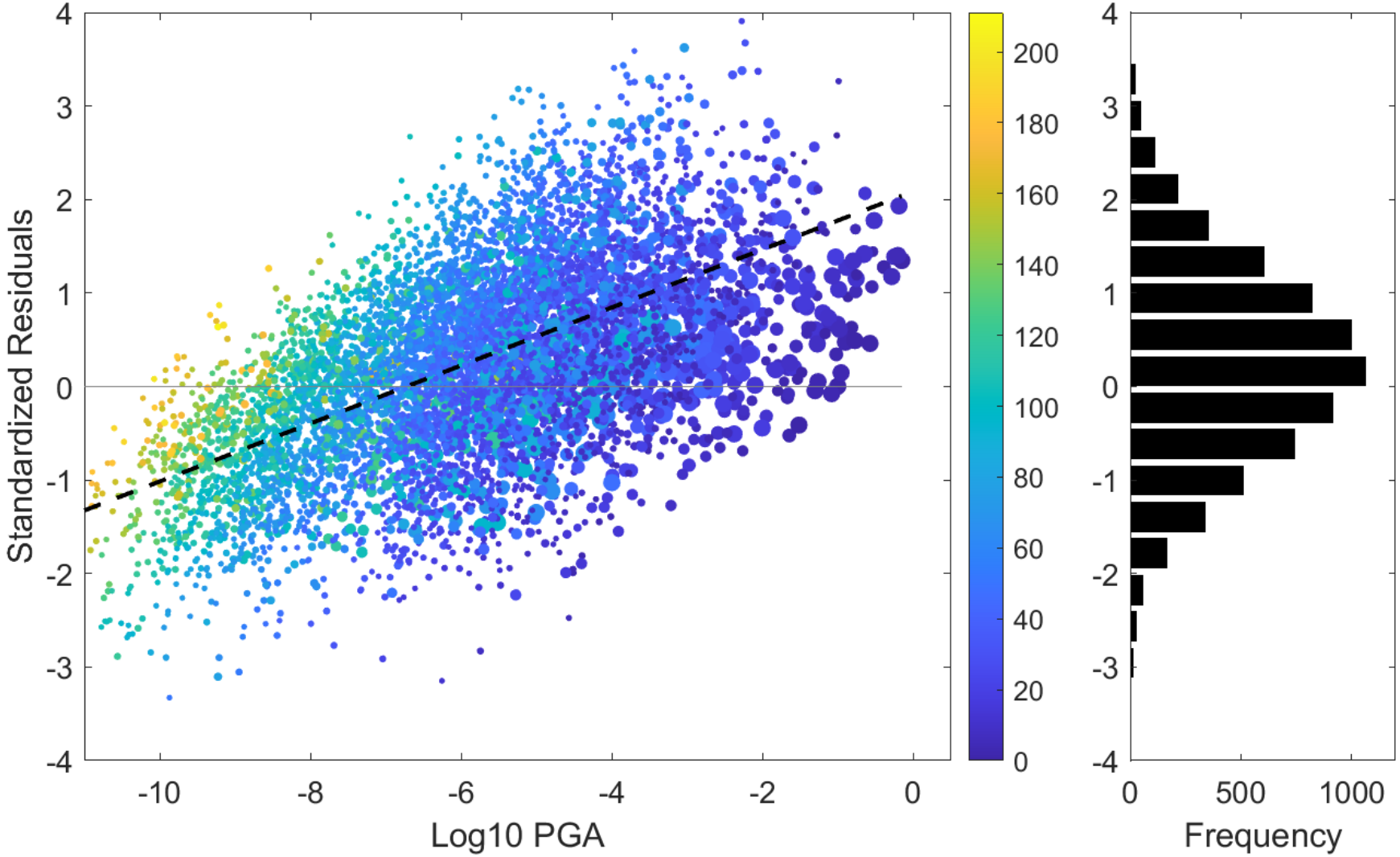

Performance of the Models

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Classical Approach (**LLH**):
Scherbaum et al. 2009 BSSA

$$\langle \log_b(\mathcal{L}(g|\mathbf{x})) \rangle = \frac{1}{N} \sum_{i=1}^{N} \log_b(g(x_i)).$$

Performance of the Models

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Weighted Likelihood Approach: inspired by Zhuang 2015 Spatial Statistics

$$\langle \log_b(\mathcal{L}(g|\mathbf{x})) \rangle = \frac{1}{N} \sum_{i=1}^{N} \log_b(g(x_i)).$$

$$\langle \log_b(\mathcal{L}(g|\mathbf{x})) \rangle = \sum_{i=1}^{N} w_i \log_b(g(x_i))$$

$w_i \rightarrow$ *this weight can be used to adapt the score*

Performance of the Models

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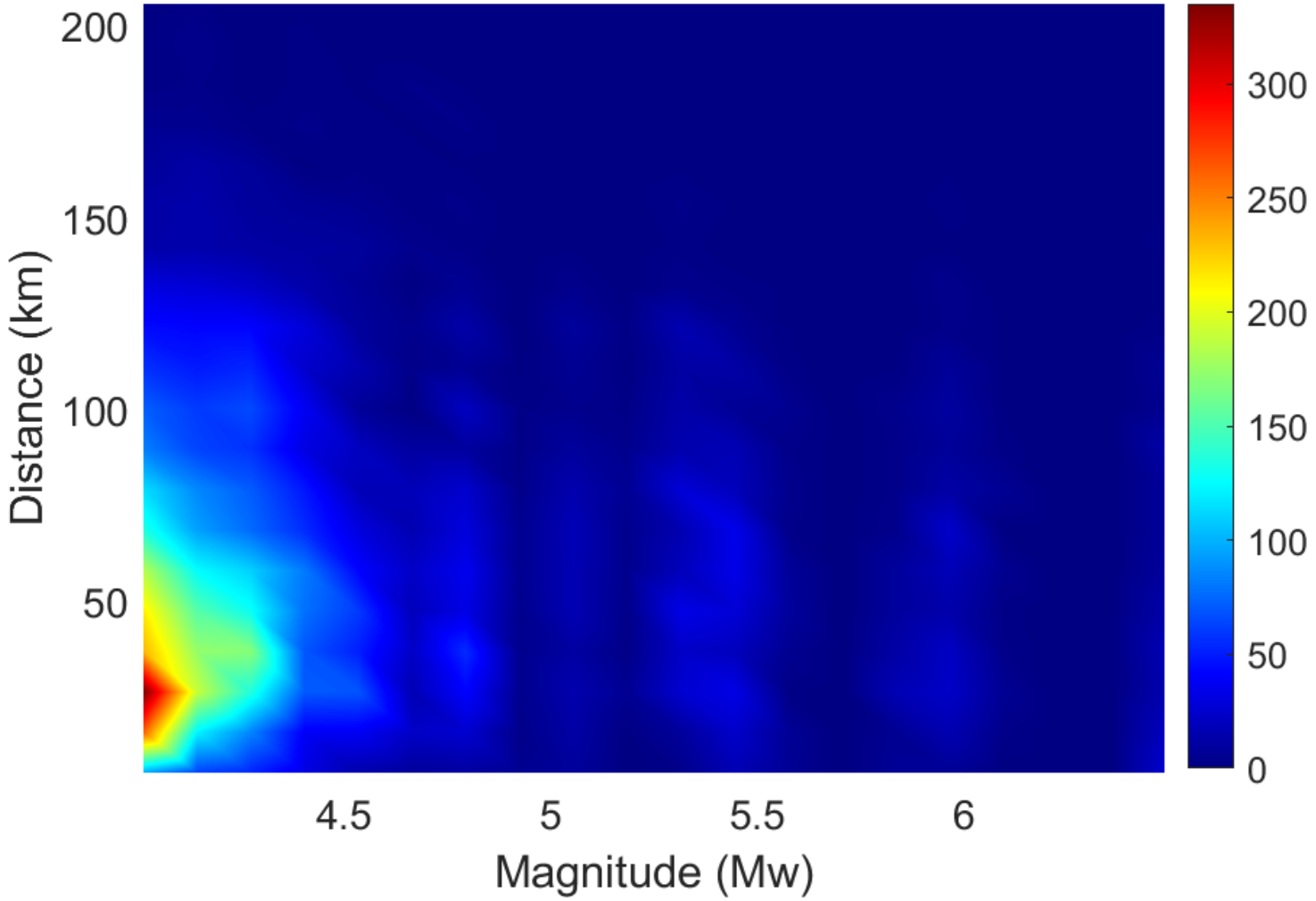
Central Italy 2014-2020 Mw 4.0+ heatmap



$$w_i \approx {}^{1}/_{N_k}$$

Performance of the Models

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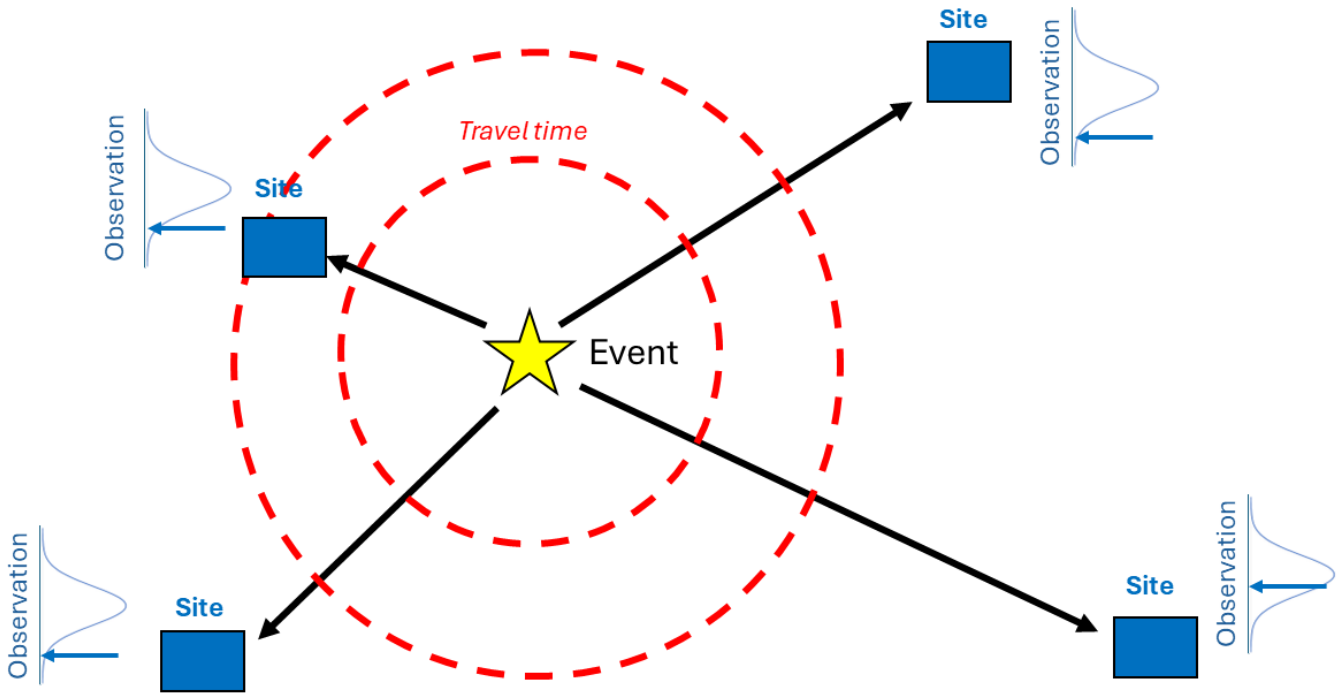
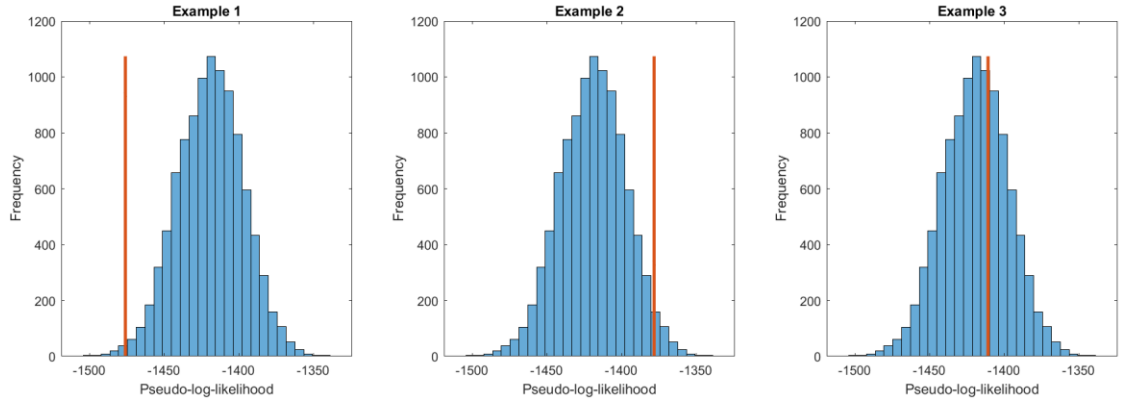
$$w_i \approx {}^{1}/_{N_k}$$

Model	LLH	WLL	Rank LLH	Rank WLL
ITA10	-1.852	-1.582	1) KOT22	1) ITA18
Bindi14	-1.994	-1.984	2) ITA18	2) KOT22
ITA18	-1.786	-1.500	3) ITA10	3) ITA10
BSSA14	-1.905	-1.679	4) BSSA14	4) BSSA14
KOT22	-1.762	-1.524	5) Bindi14	5) Bindi14

Statistical test of GMM



Statistical test of GMM



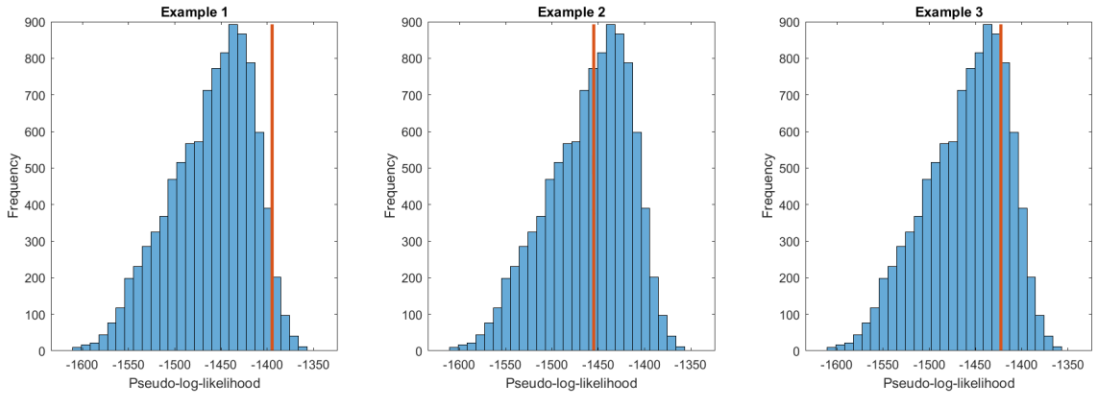
Case study: uncorrelated observations

Metric: log-likelihood

P-value distribution: Uniform

$$F_{OBS} = \prod_{i=1}^{n} F_i(h_{obs})$$

Statistical test of GMM



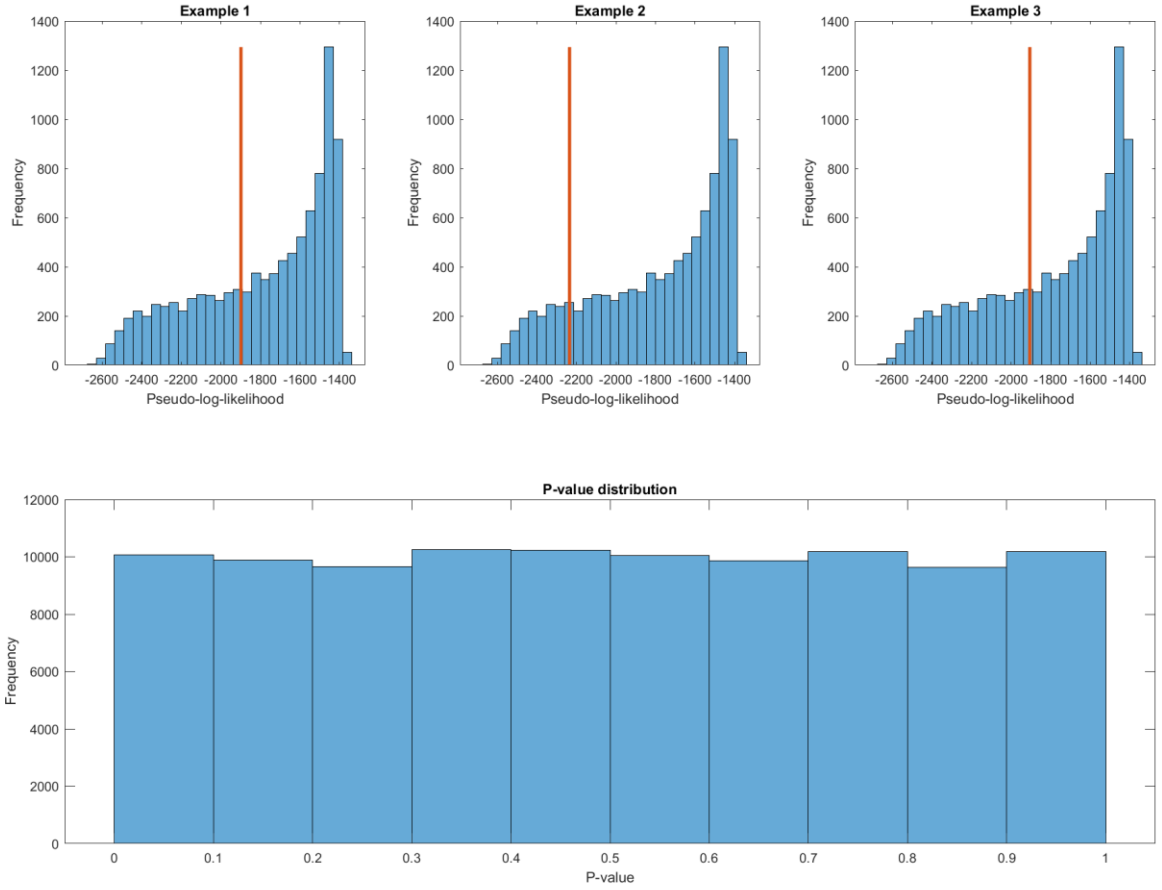
Case study: weakly correlated observations

Metric: pseudo-log-likelihood

P-value distribution: Uniform

$$F_{OBS} = \prod_{i=1}^{n} F_i(h_{obs})$$

Statistical test of GMM



Case study: highly correlated observations

Metric: pseudo-log-likelihood

P-value distribution: Uniform

$$F_{OBS} = \prod_{i=1}^{n} F_i(h_{obs})$$

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Thank you!