SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Variability of ETAS Parameters and Their Relationship with Physical Processes for Earthquake Forecasting in Africa

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Thystere M. Bantidi[1], Takeshi Nishimura[2], Takeo Ishibe[1], Bogdan Enescu[3,4], Georges MavongaTuluka[5]

(1) Association for the Development of Earthquake Prediction (ADEP), Tokyo, Japan
(2) Tohoku University, Sendai, Japan
(3) Kyoto University, Kyoto, Japan
(4) National Institute for Earth Physics (NIEP), Magurele-Bucharest, Romania
(5) Goma Volcano Observatory, Goma, Democratic Republic of the Congo

ADEP 公益財団法人 地震予知総合研究振興会
ASSOCIATION FOR THE DEVELOPMENT OF EARTHQUAKE PREDICTION

INTRODUCTION AND MAIN RESULTS

Seismicity of Africa is moderate by global standards, but M ≥ 6.0 earthquakes often occur along poorly understood fault lines. ETAS models, which account for seismic clustering and variability in crustal properties, offer the most effective approach for forecasting this seismicity. But region-specific ETAS estimates for Africa are currently lacking.

In this study, we divided Africa into subregions and fitted ETAS models to earthquakes in each one. Parameters were compared across subregions and correlated with crustal properties. Our results revealed significant regional variability in ETAS parameters. We also found positive correlations between the aftershock decay parameter *p*, heat flow, and the Vp/Vs ratio, whereas a negative correlation was observed with Curie depth. An extreme value distribution analysis indicates a relatively high probability of an M ≥ 7.0 earthquake occurring in Northwest Africa and the western East African Rift System within the next decade, underscoring the need for measures that enhance public preparedness.

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Research Background

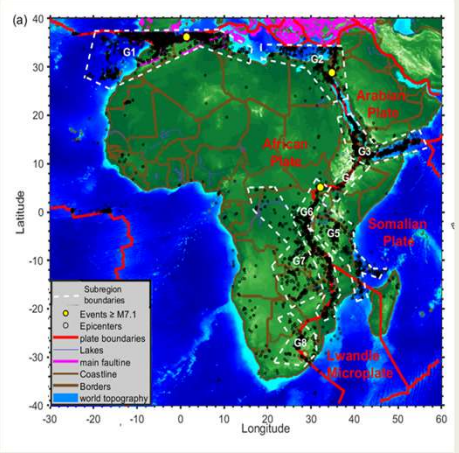
This study estimates and compares the variation of ETAS parameters, across Africa and discuss their causative relation with various physical properties of the crust as an attempt to understand regional seismotectonics, and the sub-crustal configuration.

Method: ETAS model (Ogata 1998; Zhuang et al., 2006),

$$\lambda(t,x,y|\mathcal{H}_t) = r(x,y) + \sum_{t_i<t} Ae^{\alpha(M-M_c)}\left(\frac{p-1}{c}\right)\left(1+\frac{t}{c}\right)^{-p}\left[\frac{q-1}{\pi d^2 e^{\gamma(M-M_c)}}\left(1+\frac{x^2+y^2}{d^2 e^{\gamma(M-M_c)}}\right)^{-q}\right]$$

r: background seismicity,
A : earthquake productivity,
c *and* p : parameters of the modified Omori's law;

d characteristic triggering distance;
α: efficiency of events in triggering offspring
q: describes how triggered events decay in space.



Data: USGS

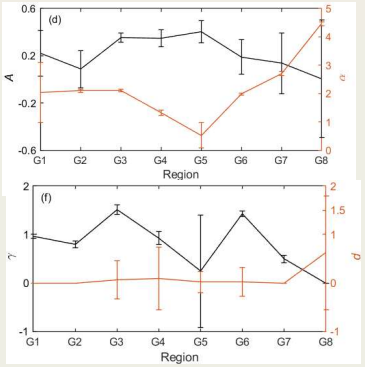
- 1970 – 2023
- Magnitude Mw≥2.0

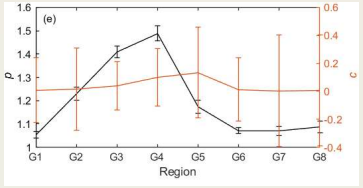
Completeness magnitude, Mc

- Group 1 (Mc=3.2);
- Group 2 (Mc=4.3);
- Group 3 (Mc=4.7);
- Group 4 (Mc=4.7);
- Group 5 (Mc=4.7);
- Group 6 (Mc=4.6);
- Group 7 (Mc=4.6);
- Goup 8 (Mc=4.6).

Results

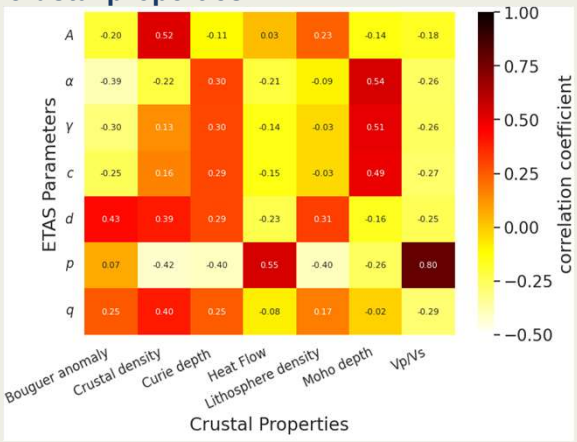
Result 1: Variability of ETAS parameters





α, *c*, *d*, and *γ* are the most widely dispersed, probably due to missing events in the catalog caused by sparse seismic networks.

Result 2: Correlations between ETAS parameters and crustal properties



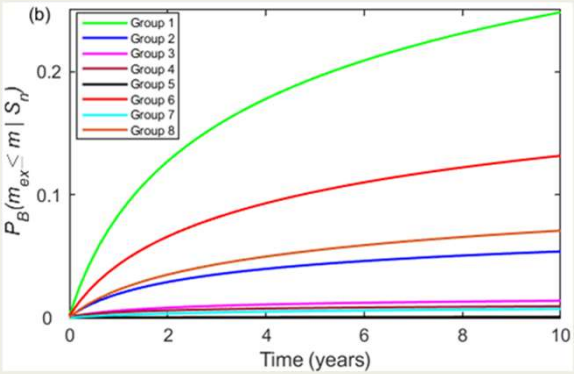
Positive correlations between *p*, heat flow, and the Vp/Vs ratio, and a negative correlation with Curie depth.

Discussion and conclusion

We assess the probability distribution of the M ≥ 7.0 earthquake within a specified space–time window from our ETAS estimates using the extreme value theory (e.g., Shcherbakov et al. 2019)

$$P_{EV}(m_{ex} > m|\theta,\omega,\Delta T) = 1 - \exp\{(-\Lambda_\omega(\Delta T)\exp[-\beta(m-m_c)]\}$$

Λ_ω (ΔT): productivity
ΔT: Forecasting interval time



High probability of an M ≥ 7.0 event occurring in NW Africa and the western East African Rift System.

Our results provide a complete set of ETAS parameters for Africa, which can serve as a valuable reference for implementing operational earthquake forecasting across the continent.

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