Seismicity and Stress Field Changes in the Afar and its surroundings

Mona Abdelazim, Mohamed N. ElGabry and Hesham M. Hussein

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National Research Institute of Astronomy and Geophysics (NRIAG).

10 Sept 2025

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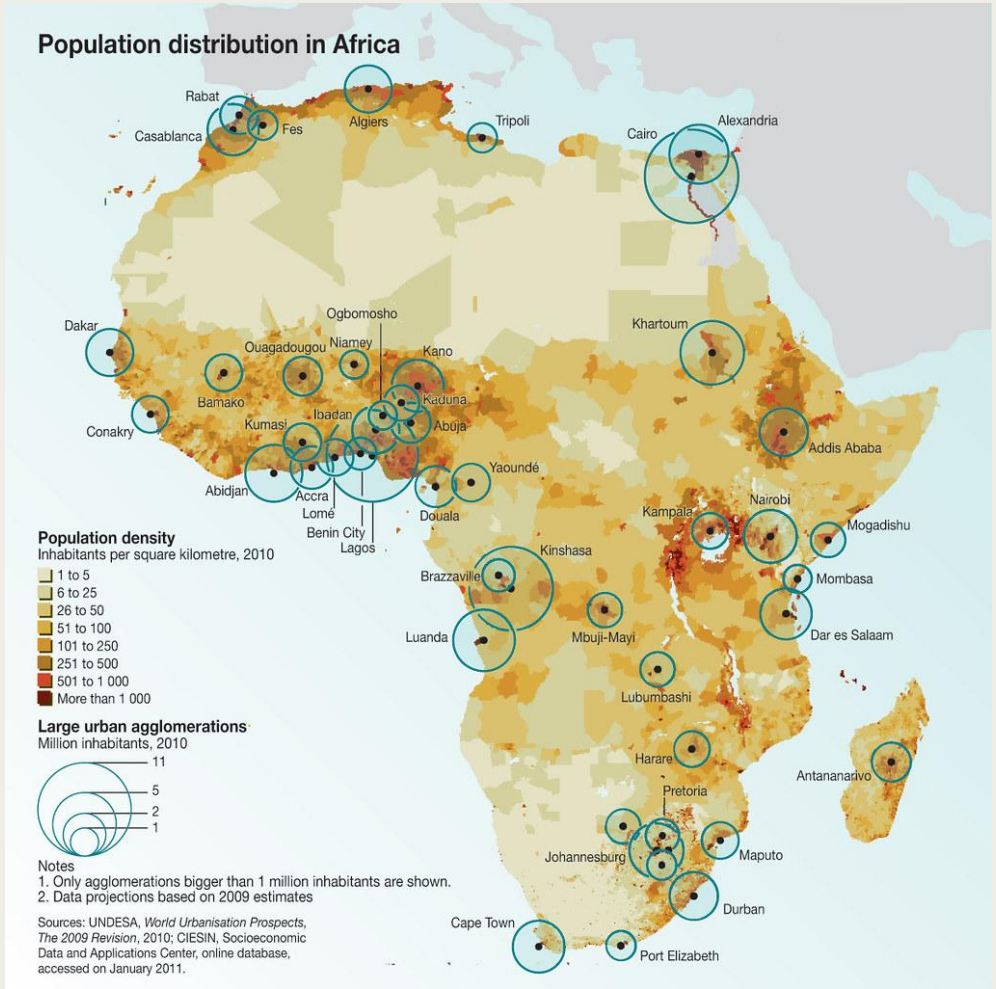
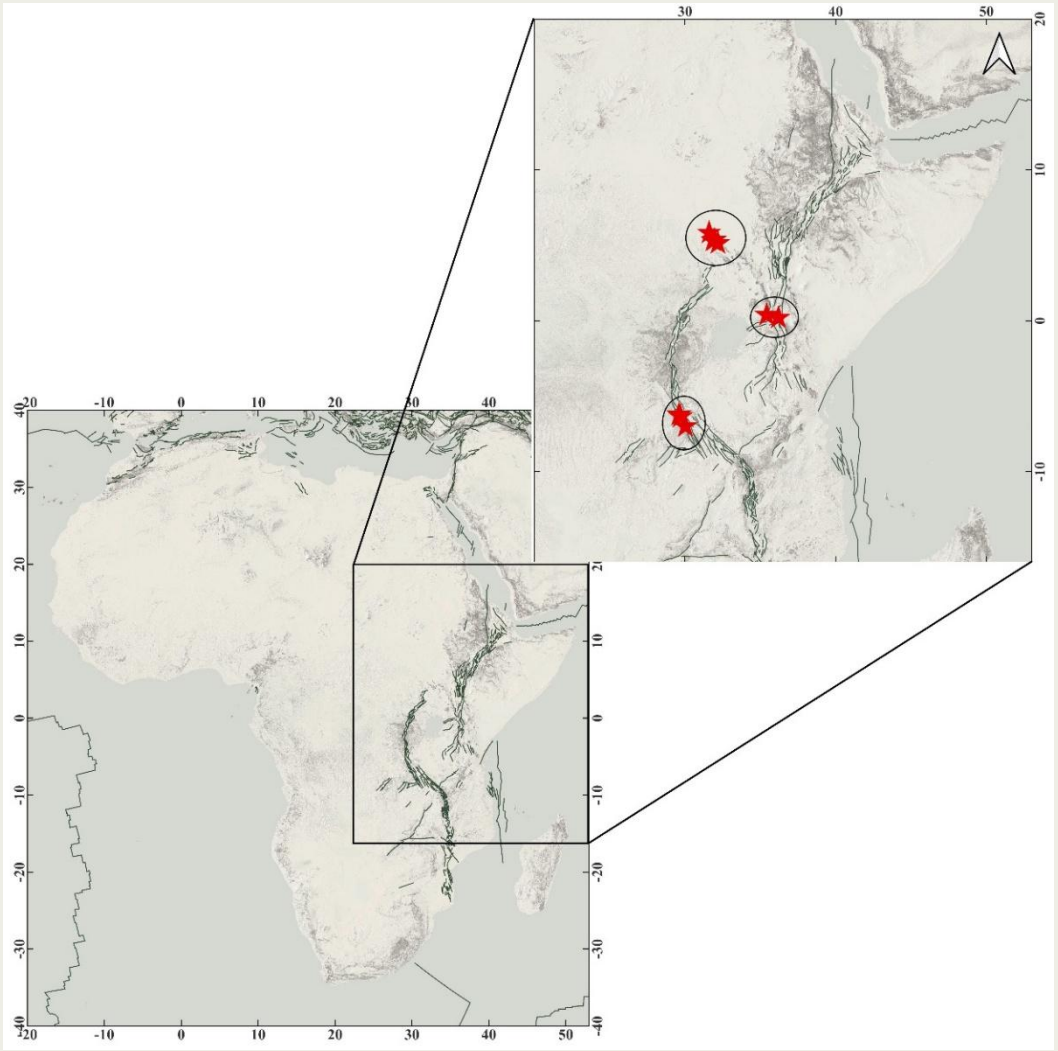
The problem





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Contents

- Tectonic setting of Africa and Afar region
- Coulomb stress change for the interested events in afar zone and its surrounding
- Seismicity and b-value
- Results
- Conclusions and recommendations

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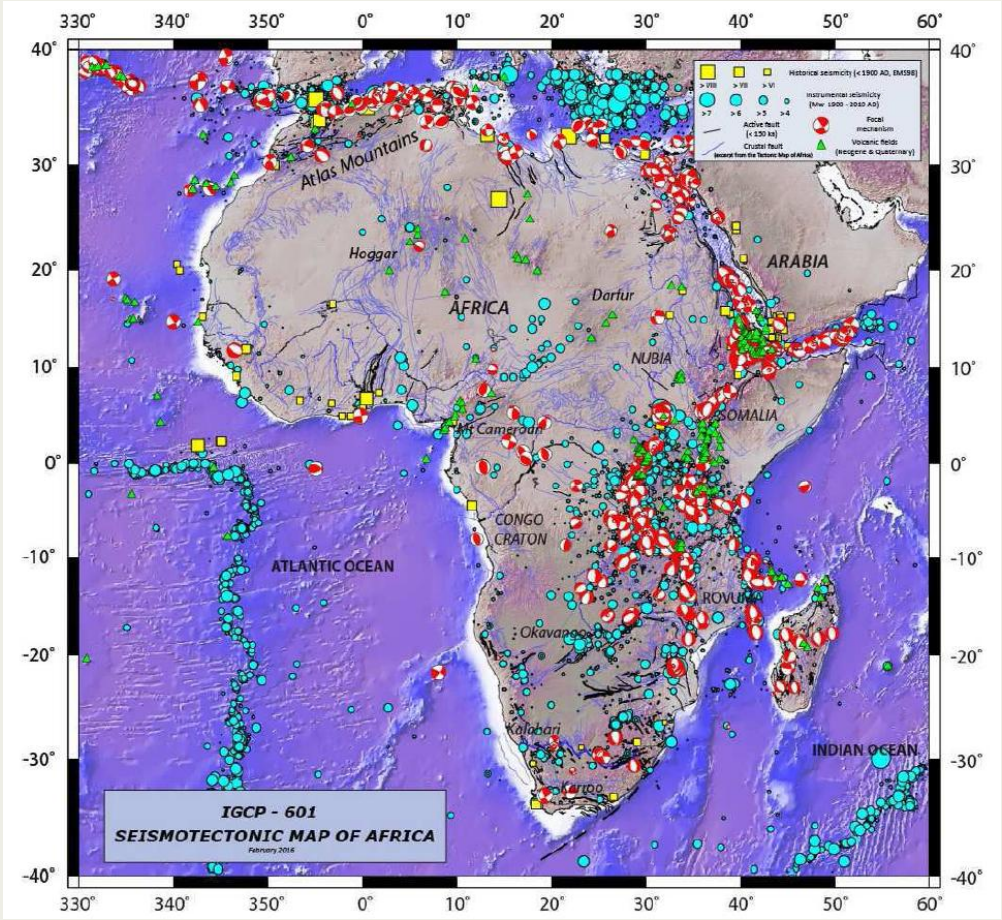
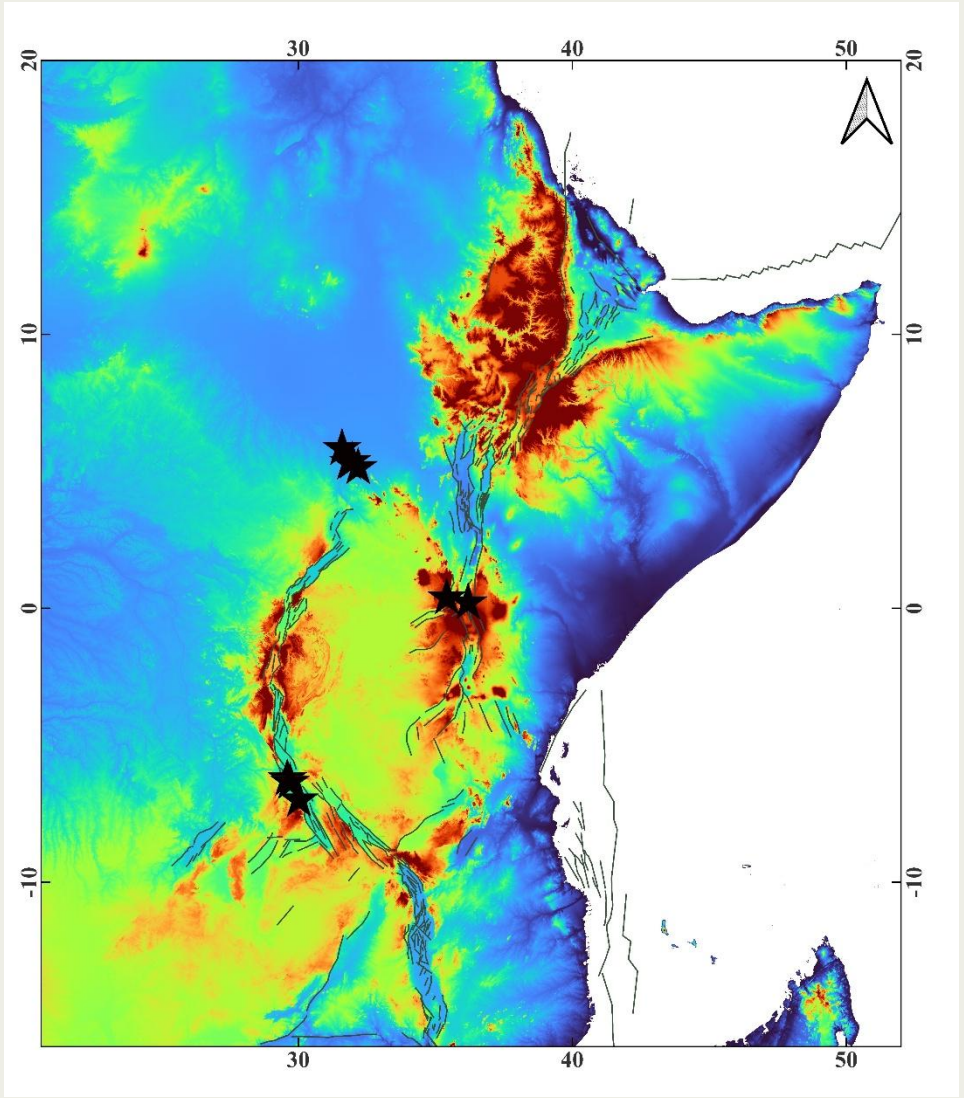
O1.2-305

Tectonic setting of Africa and Afar region and its surroundings (area of study)



Seismotectonic map of Africa.
Meghraoui, M., & IGCP-601 Working Group. (2016).



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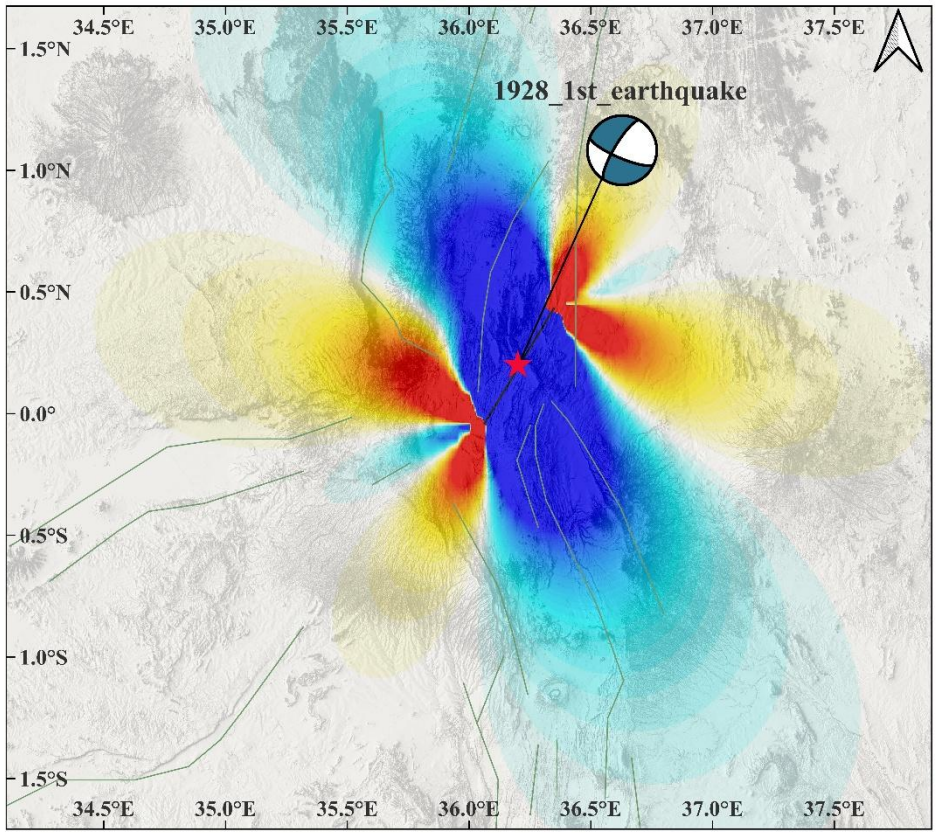
Coulomb's stress change (Δσf)

Also can be written as ΔCFS or ΔCFF. Based on the assumption of the half-space homogeneous isotropic elastic medium theory proposed by Okada (1992) and developed by King et al. (1994) and the simplest formula:

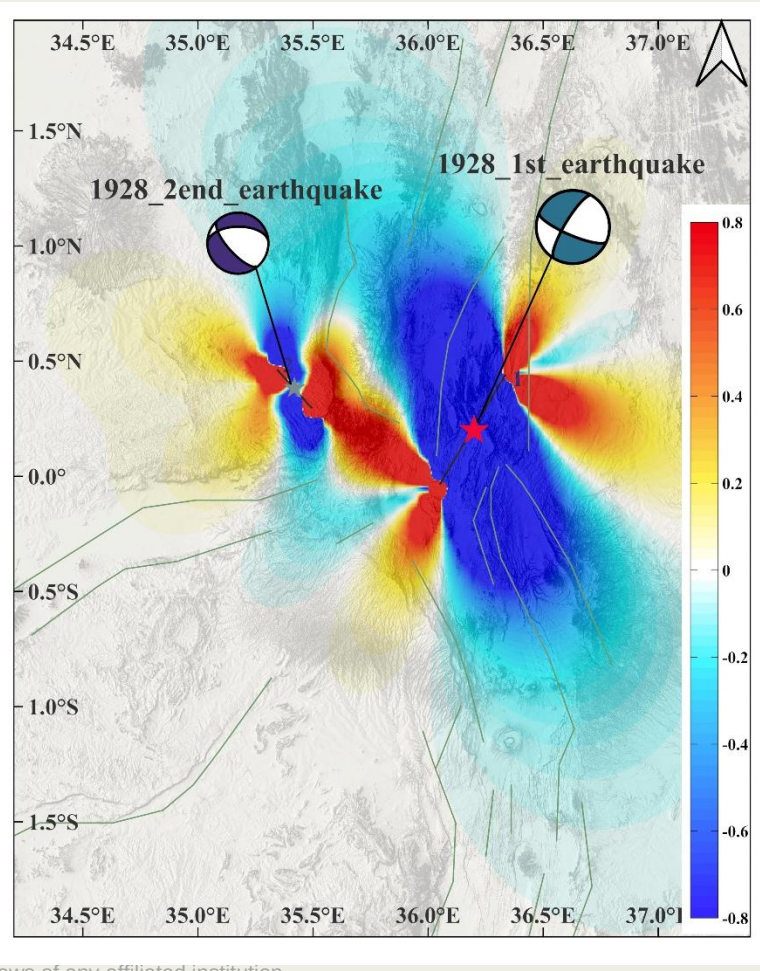
$$\Delta\sigma f = \Delta\tau s + \mu' (\Delta\sigma n + \Delta P)$$

$$\Delta\sigma f = \Delta\tau s + \mu' \Delta\sigma n$$



Draw stress distribution

Study the field interaction between earthquakes



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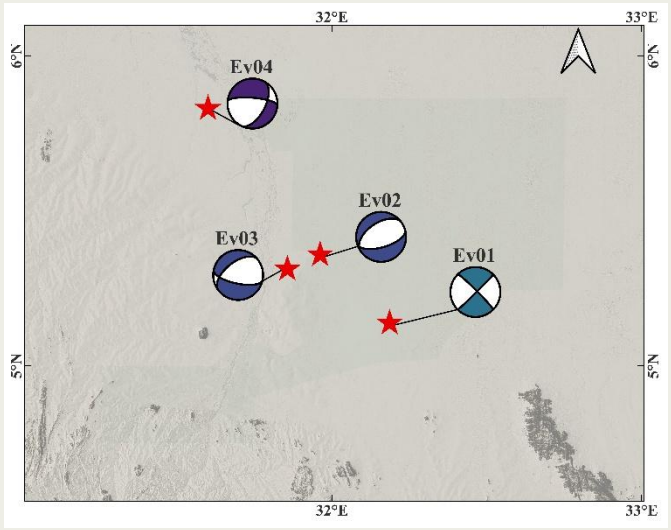
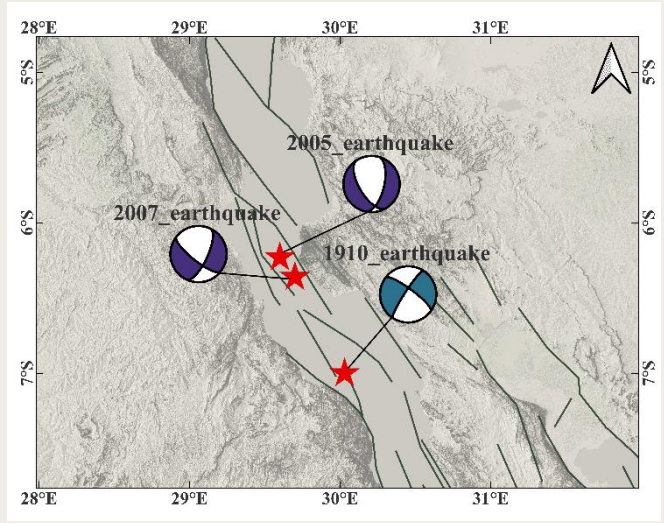
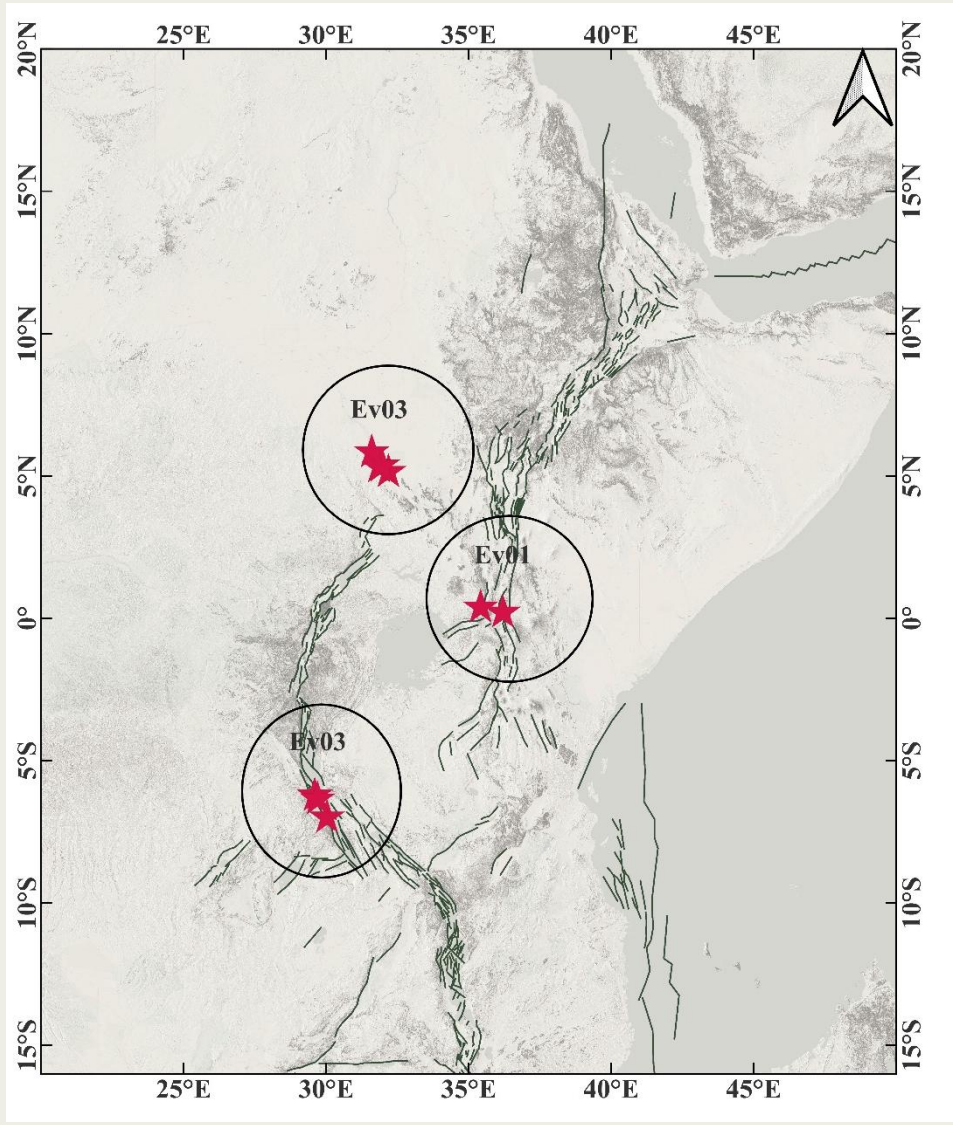
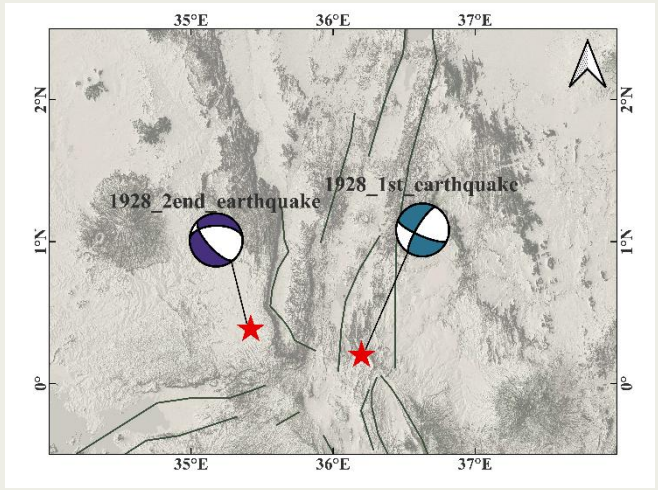
Location maps for the interested earthquakes in the area of study









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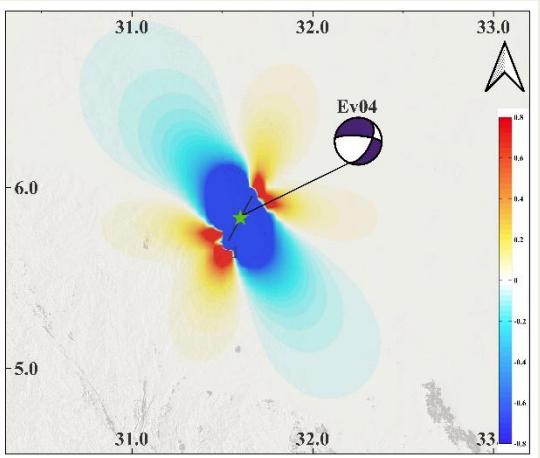
Coulomb's stress change (Δσf) for South Sudan earthquakes

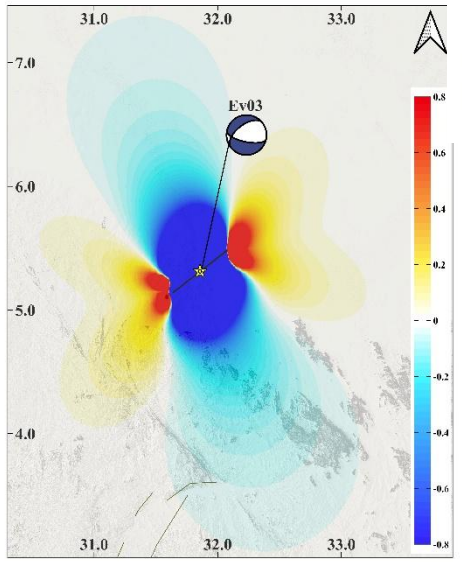


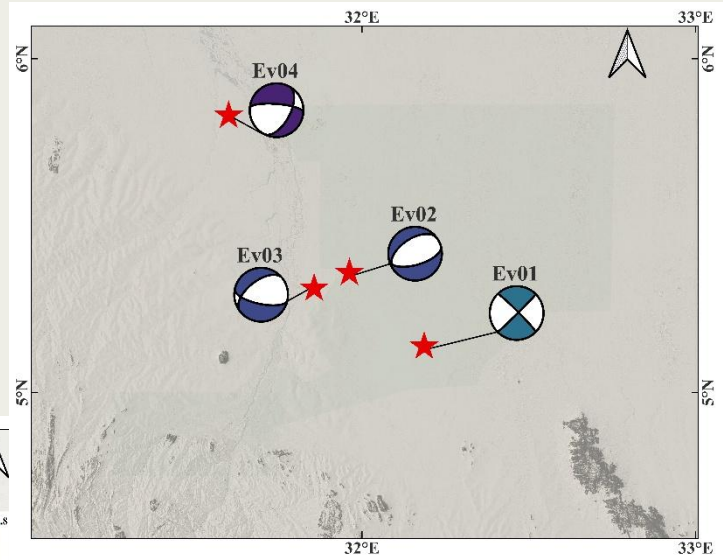
Date: 1990-07-09

Time:15:11:28

Mw: 6.3

- (28/44/-149) model of (Harvard CMT) at depth 15 km





Date: 1990-05-24

Time:20:00:11.35

Mw: 7.1

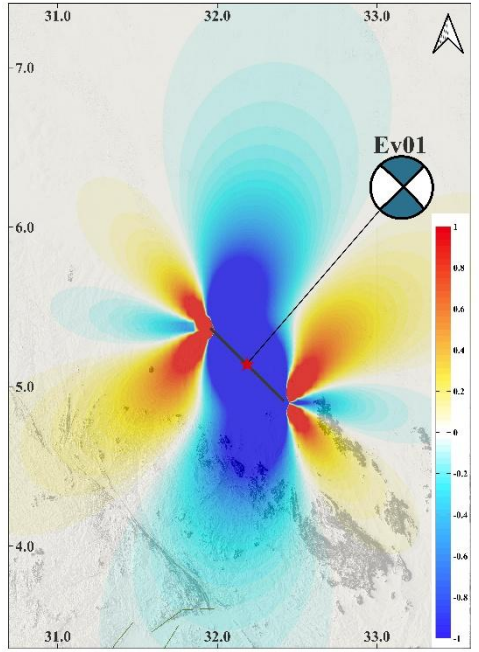
- (232/43/-131) model of (Harvard CMT) at depth 25.5 km

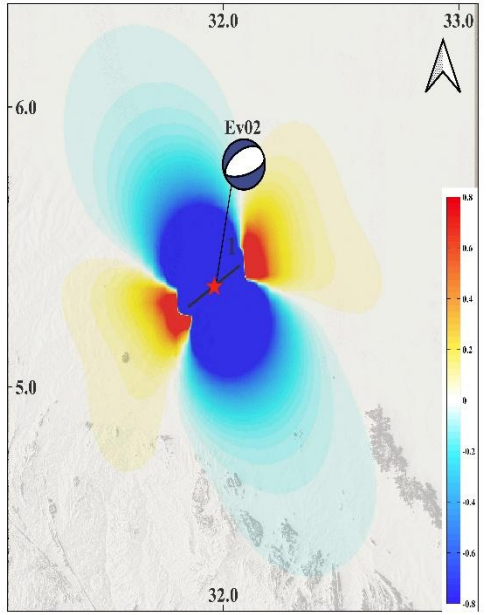
Date: 1990-05-20

Time:02:22:03.5

Mw: 7.2

- (315/84/-3) model of (Mulwa, J. K., & Kimata (2014)) at depth 13.8 km





Date: 1900-05-24

Time:19:34:48.16

Mw: 6.5

- (236/39/-104)the model of (Harvard CMT) at depth 25.8 km

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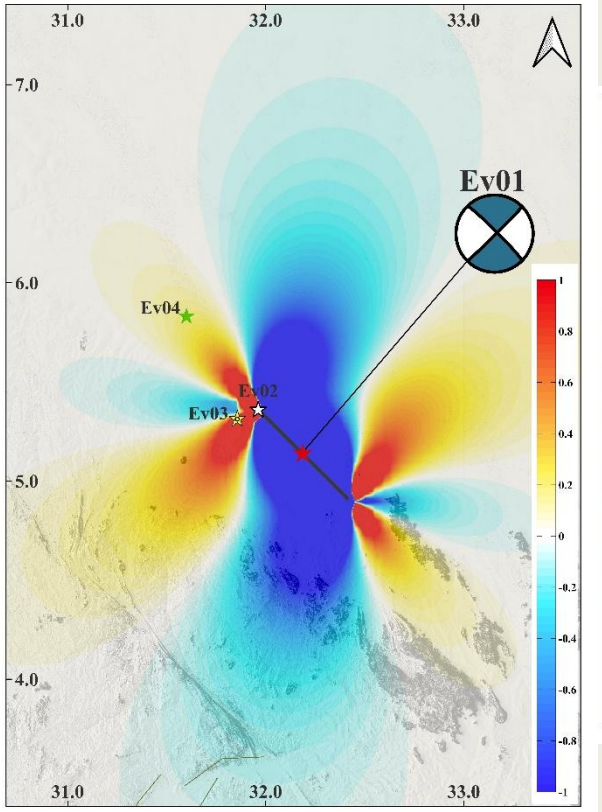
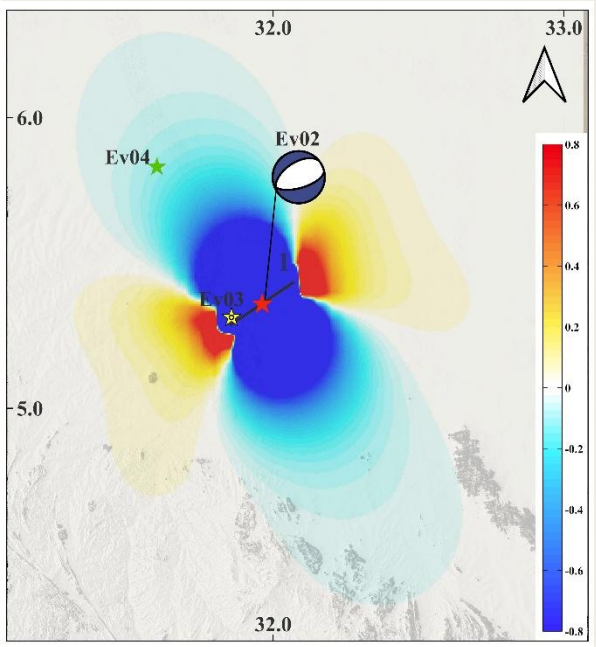
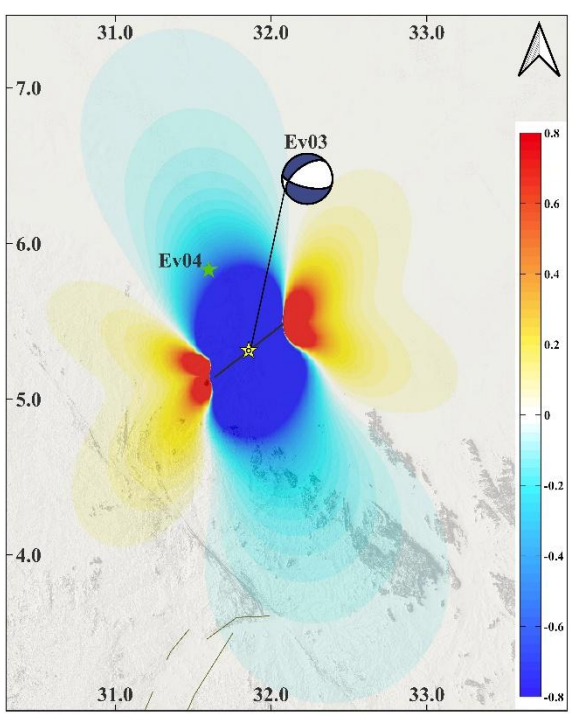
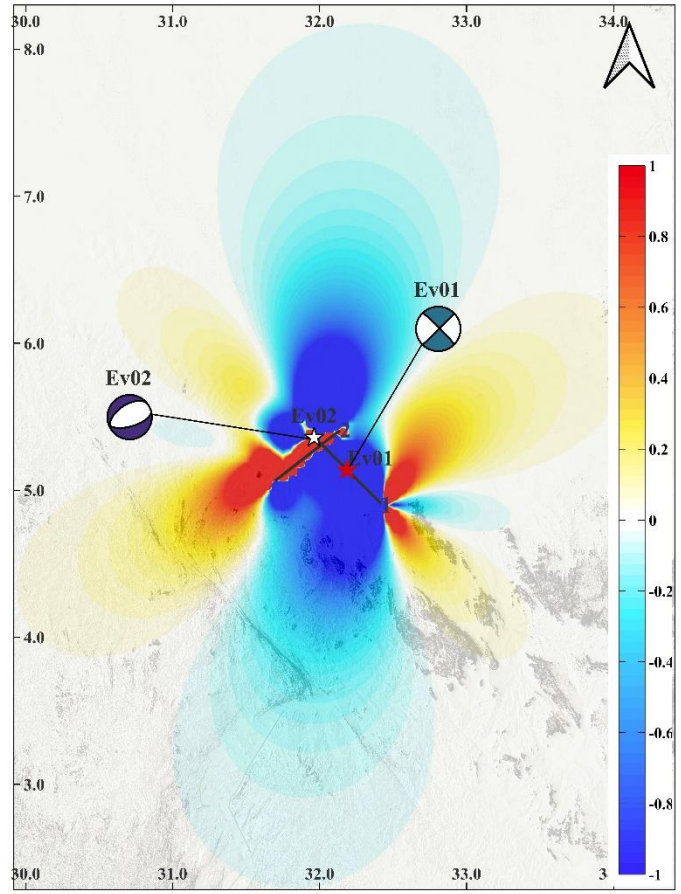
O1.2-305

Fault interaction between South Sudan earthquakes









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

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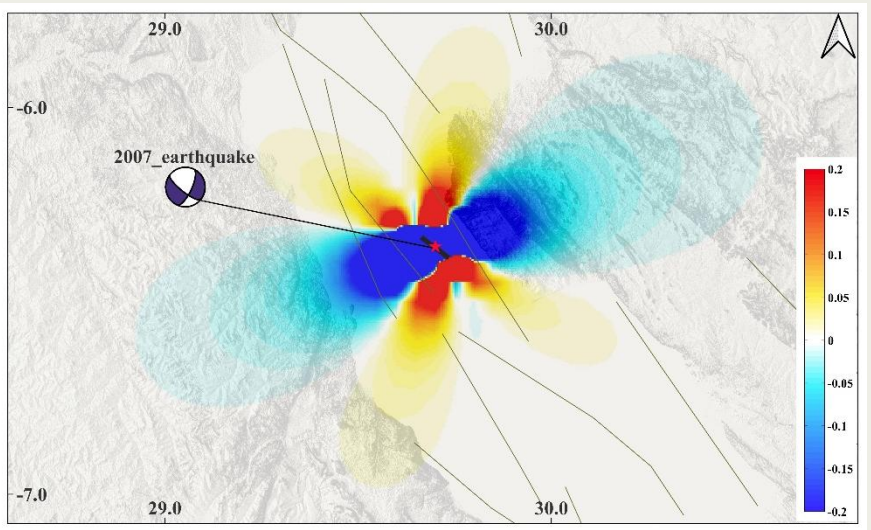
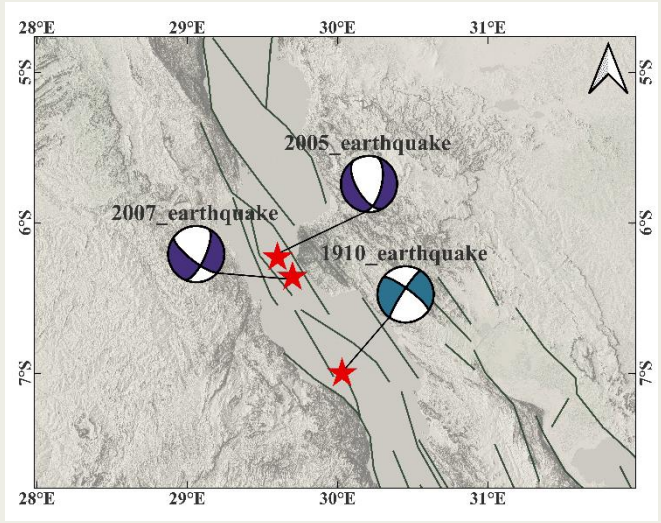
O1.2-305

Coulomb's stress change (Δσf) for Tanganyika earthquakes



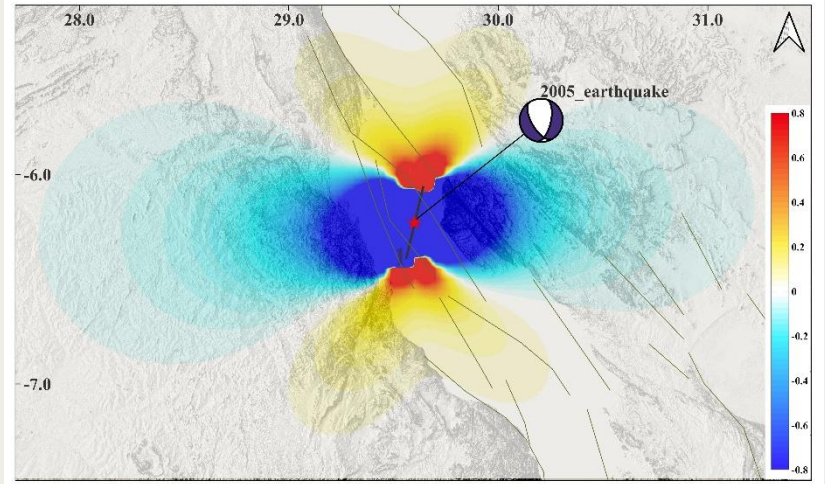
Date: 2007-03-28
Time:21:17:14
Mw: 5.8

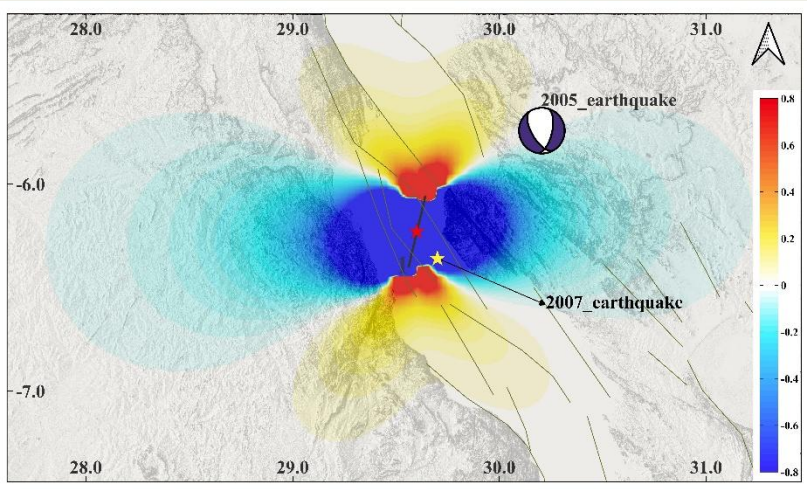
- **(128.3/67.46/-148) model of (Harvard CMT) at depth 14 km**

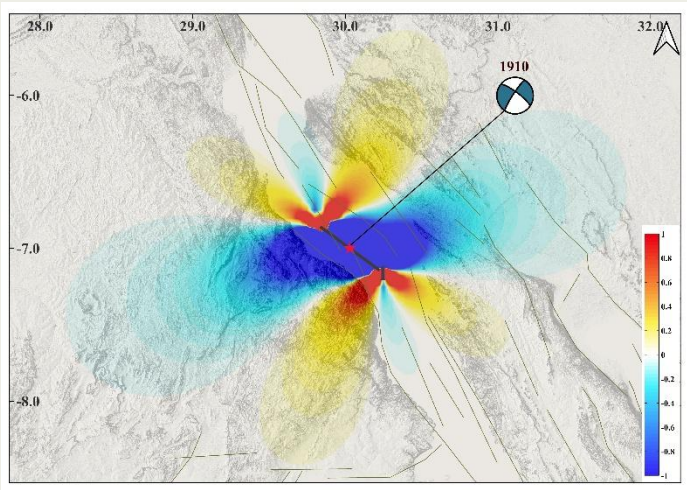


Date: 1910-12-13
Time:11:37:30
Mw: 6.9

- **(306.55/72.34/-168.45) model of (Ayele & Kulhánek, 2000)) at depth 16 km**







Date: 2005-12-05
Time:12:20:04
Mw: 6.8

- **(13.19/49.49/-57.73) model of (Moussa, H. (2008)) at depth 18 km**

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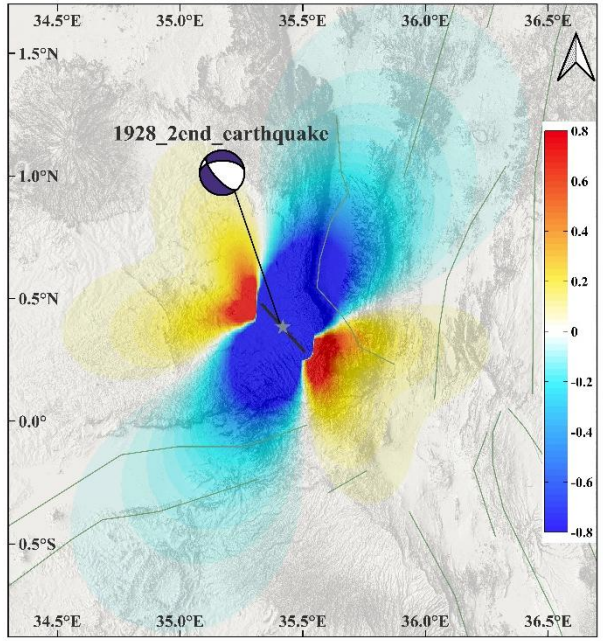
O1.2-305

Coulomb's stress change (Δσf) for Gregory Rift and The Rukwa Rift earthquakes

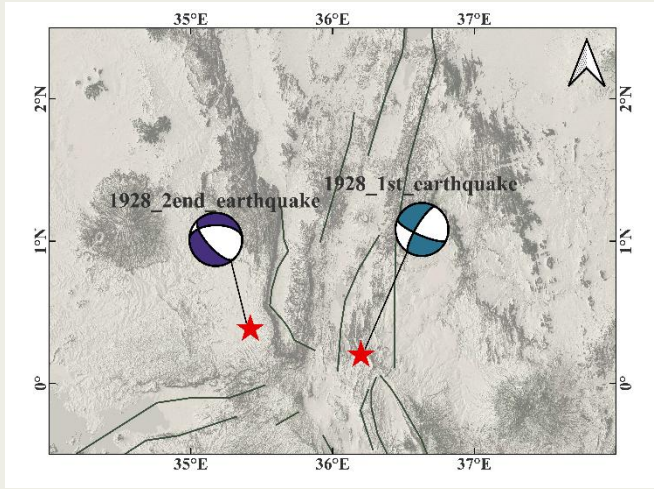


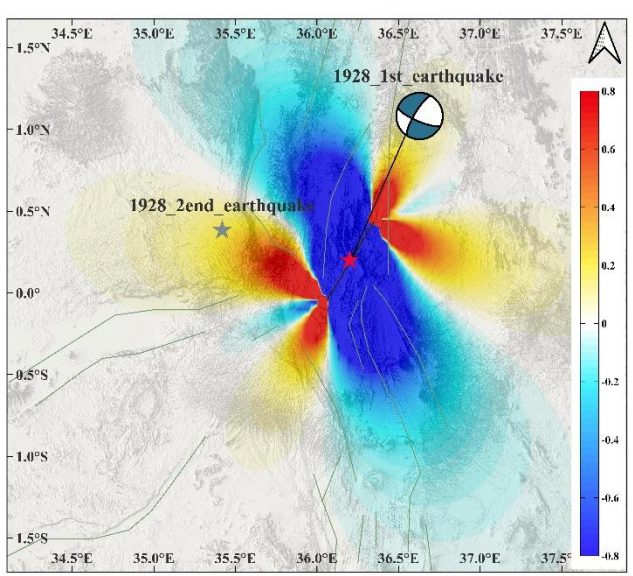
Date: 1920-01-10

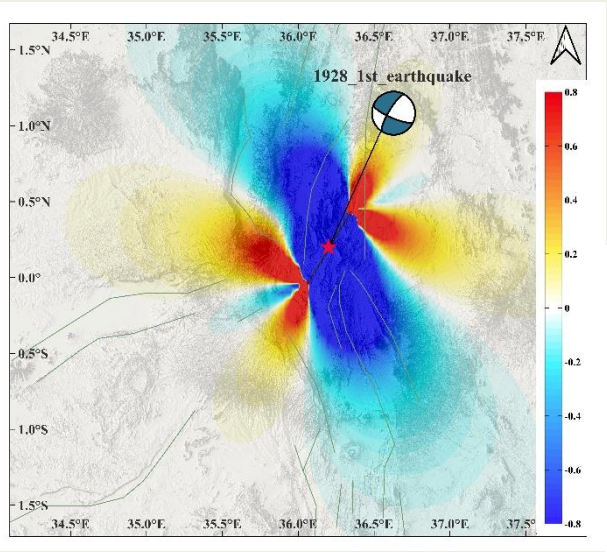
Time:02:25:37

Mw: 6.2

- **(138/60/-6) model of (CMT) at depth 10 km**





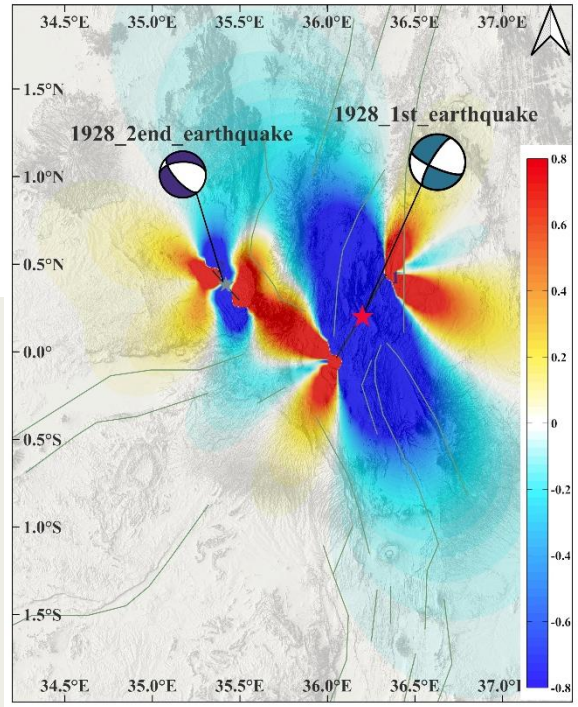


Date: 1928-01-06

Time:19:31:58

Mw: 6.6

- **(211/70/-158) model of (Ayele & Kulhánek, 2000)) at depth 8 km**



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Seismicity and b-value in the area of interest

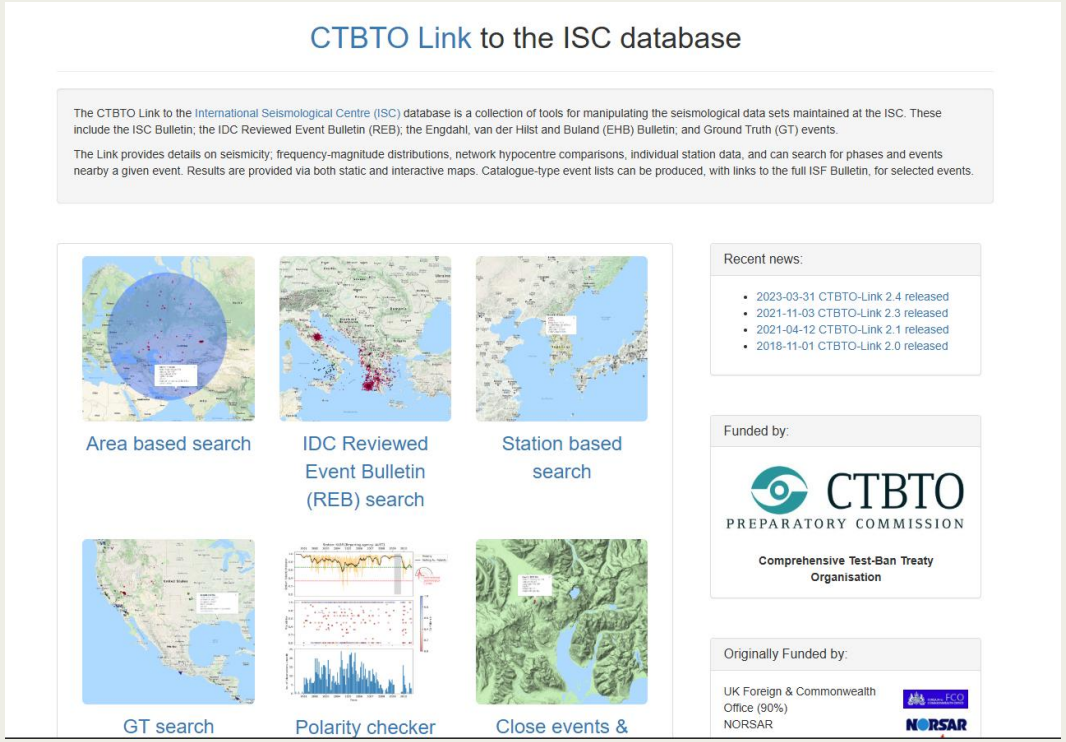
Collection
From different sources and the main source is iscx.ctbto.org

Duplications
We used Compicat software to remove duplicated events
0.1°
30 sec
0.2

Uniform
Mb, Ms, Ml, and Md uniformed to Mw
According to the Lamessa, et al., (2019)

For b-value

Declustering the uniformed catalogue



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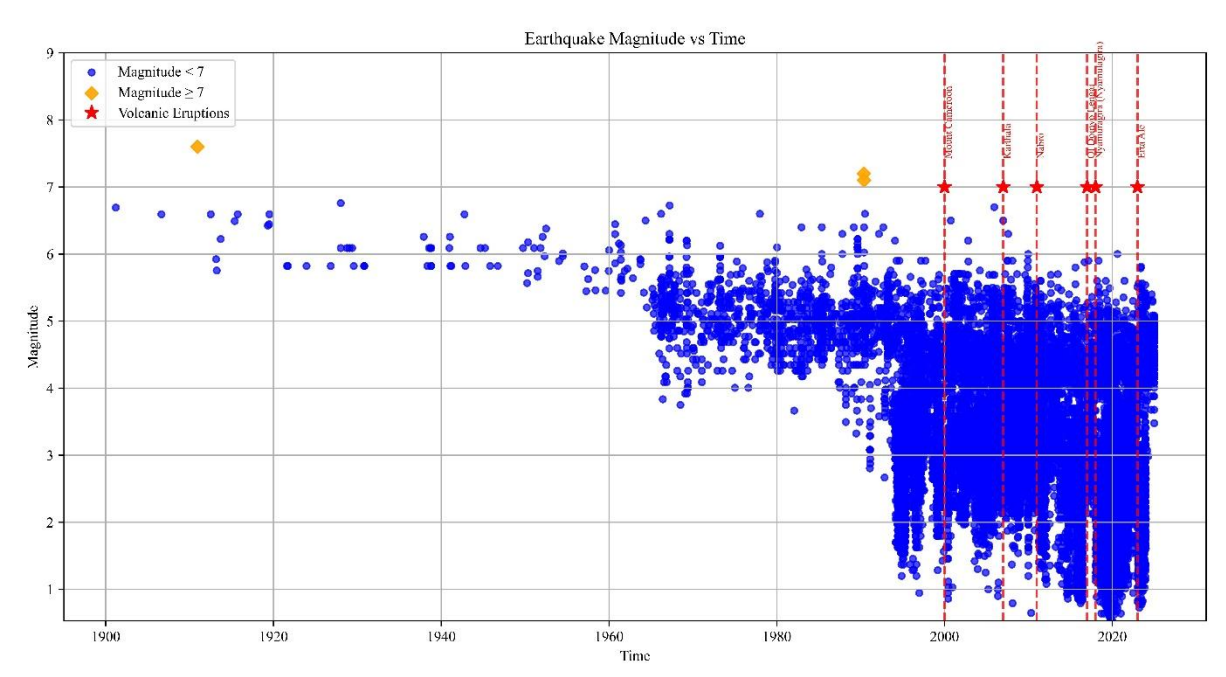
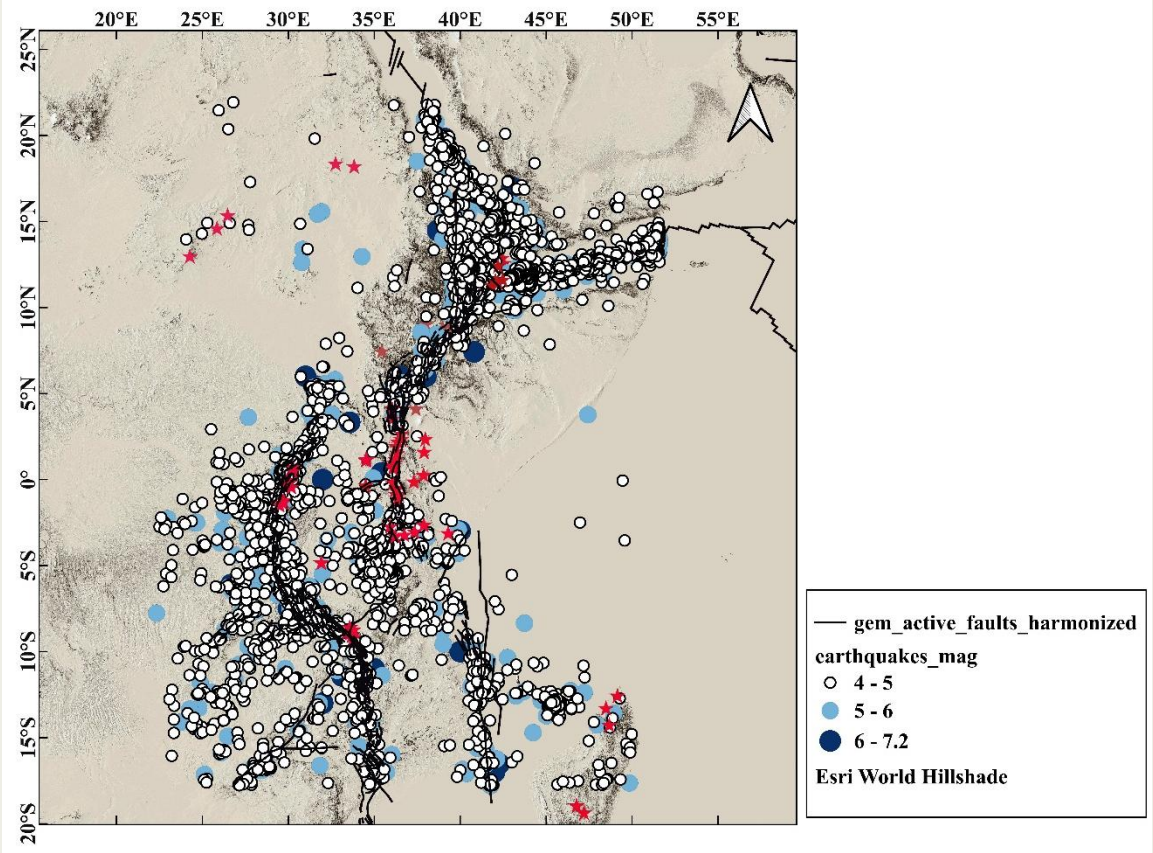
O1.2-305

Seismicity in the area of interest





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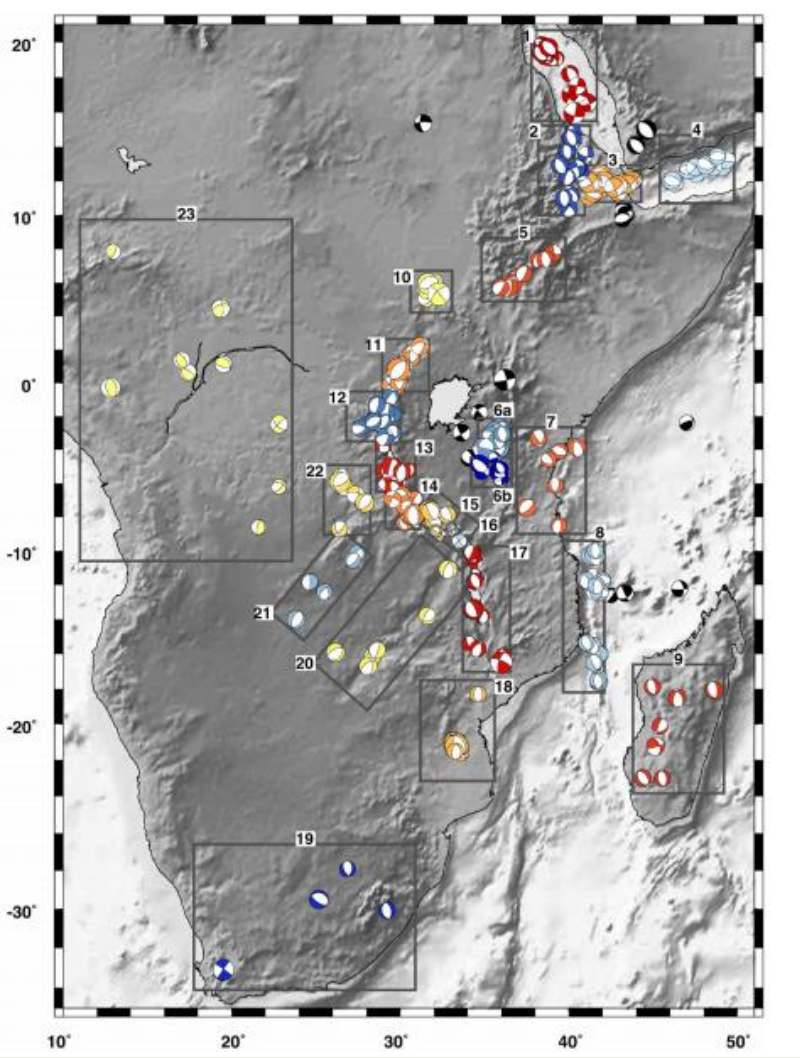
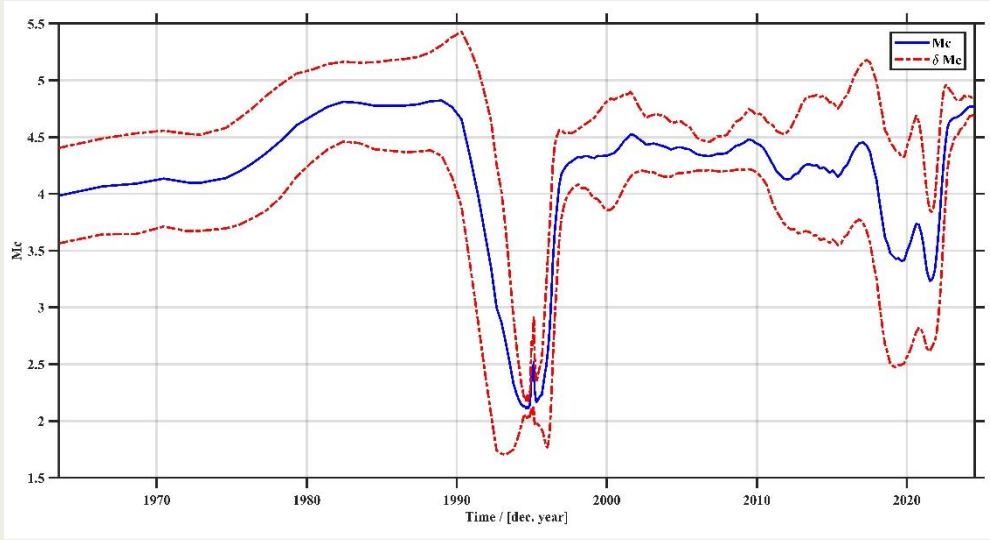
O1.2-305

b-value of earthquakes



Delvaux & Barth (2010)



Mc versus time

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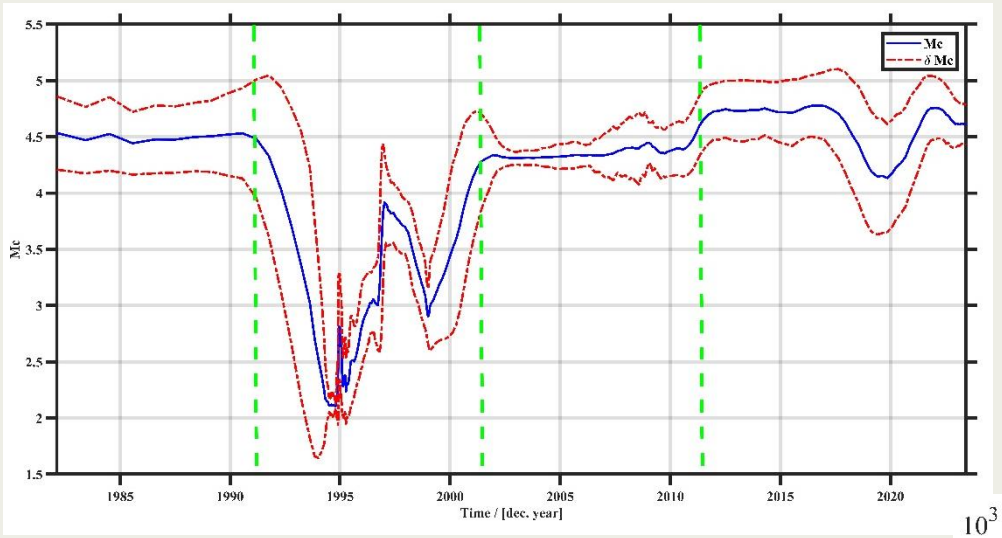
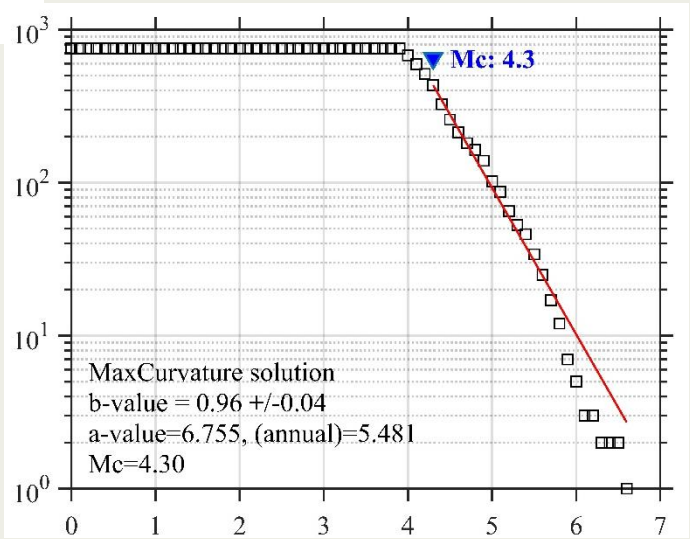
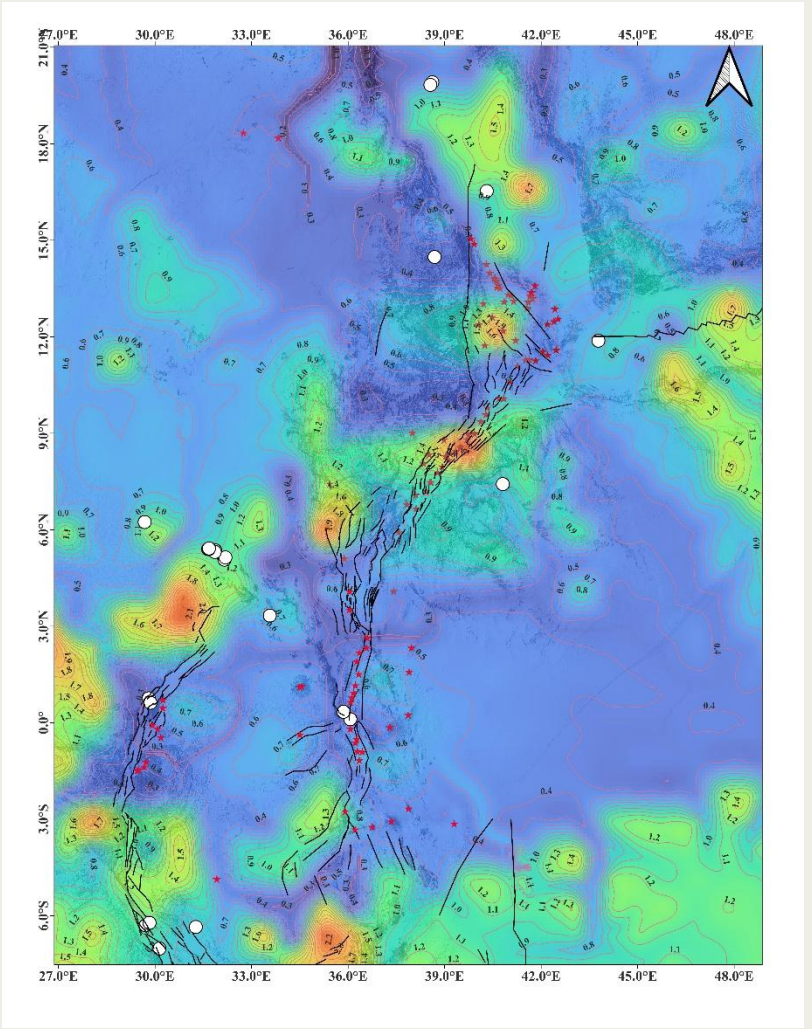
b-value of earthquakes



(Multi-scale seismicity model)
(Molchan et al., 1997)





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Results

According to Coulomb stress change analysis:

- The initial seismic event in South Sudan induced positive Coulomb stress perturbations that promoted the occurrence of the subsequent second, third, and fourth events.
- The 1928 earthquake in Kenya generated a stress redistribution that facilitated the triggering of the following seismic event.
- In contrast, the three Tanganyika earthquakes exhibited no significant Coulomb stress interaction, indicating that they were seismically independent and not dynamically or statically coupled.

According to the seismicity and b-value:

- The earthquakes were concentrated along the rift and in some volcanic regions.
- The b-value results showed variations over time, with some periods yielding small values such as 0.45±0.1, 0.52±0.04, and occasionally 0.60±0.1, while others produced values close to 1, such as 0.98±0.4, 0.95±0.01, 1.02±0.03, 1.07±0.01, and 1.2±0.2, as well as high values such as 1.9±0.04 and 2.1±0.01.

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Conclusions and recommendations

- The largest earthquakes in East Africa are spatially correlated with tectonic segmentation of the rift, reflecting fault geometry and regional stress orientation.
- Coulomb stress change analysis shows that strike-slip earthquakes redistribute stresses and can trigger subsequent ruptures on neighboring faults.
- 1990 The South Sudan sequence cannot be classified as a simple aftershock sequence; instead, the first event induced stress perturbations that contributed to later events.
- Tanganyika earthquakes evolved independently, with no significant Coulomb stress interaction detected between them.
- The tectonic setting of the South Sudan earthquakes remains questionable: they are often described as intraplate, but their proximity to the East African Rift suggests a possible rift-related origin.
- This uncertainty underscores the need to better define the southern and western limits of the rift system.
- Improved constraints on rift boundaries are essential for advancing seismotectonic models and for strengthening seismic hazard assessment across East Africa.
- CTBTO Link to the ISC database (https://iscx.ctbto.org/) is very useful tool.

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O1.2-305

Thank you

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