THE INTERNATIONAL CONFERENCE ON THE 120TH ANNIVERSARY OF THE BULNAY EARTHQUAKE:
ADVANCES IN ASTRONOMY AND GEOPHYSICS

Aftershocks of the 2021 Khankh earthquake: analysis of temporal variation of the Omori law p-value

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Content

Introduction

Temporal variation of aftershock decay following the 2021 Khankh earthquake using the Modified Omori Law, with a focus on the variation of the p-value over different time periods.

Tectonic structure: Located in the active Western Mongolian Rift System, influenced by the India–Eurasia plate collision

Mainshock: Mw 6.5 earthquake on January 11, 2021, near Khankh soum – one of the largest in Mongolia in recent decades

Macroseismic : Widely felt across northern Mongolia

- IV–VIII in Khuvsgul (based on 1,324 macroseismic responses)
- III–V in Ulaanbaatar, Darkhan, Erdenet

Fault Mechanism: Combination of normal and right-lateral strike-slip faulting

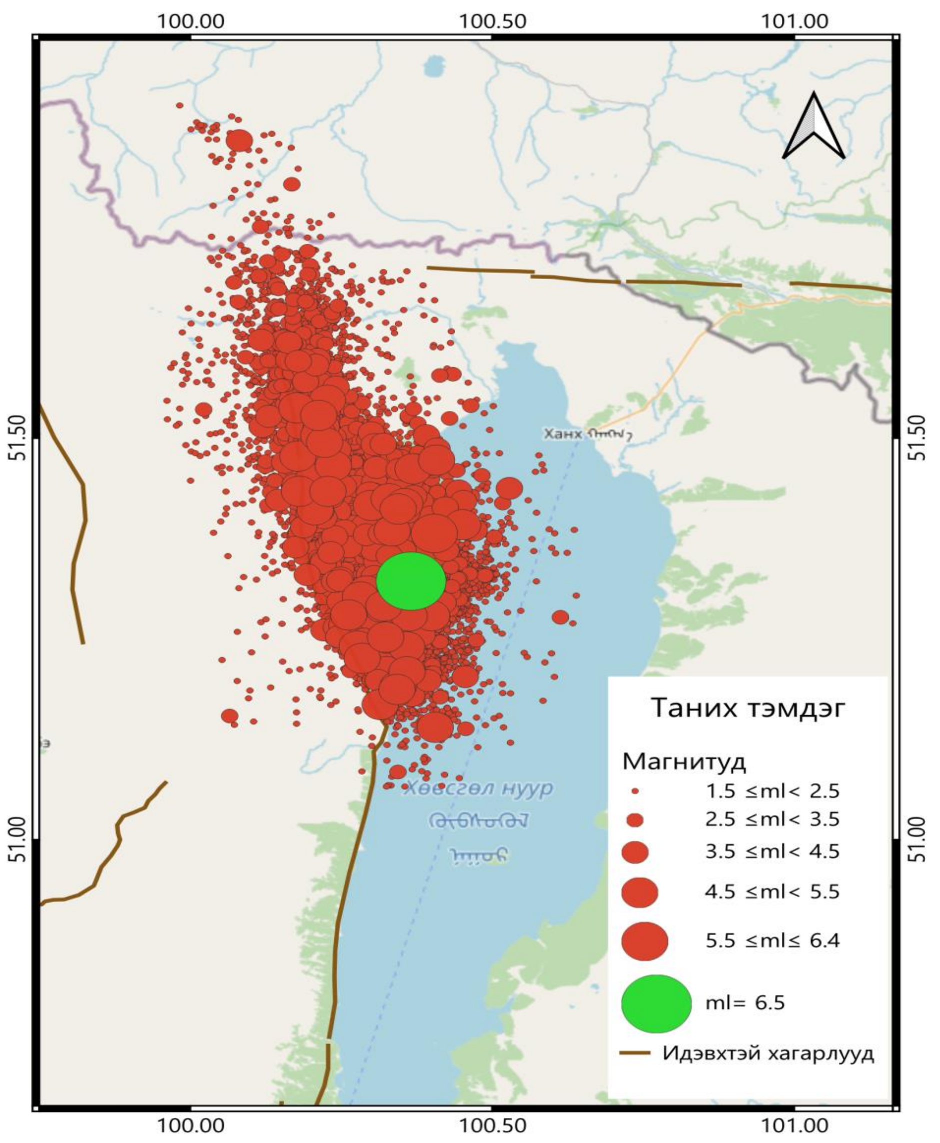


Figure 1: Map of epicenter distribution of Khankh earthquake (2021-2025)

Methodology

Omori Law (1894):

$$n(t) = \frac{K}{t}$$

$n(t)$- aftershocks per time unit

K-constant

Issue: becomes **infinite** when t=0

Modified by Utsu (1961):

More realistic for real earthquake sequences

$$n(t) = \frac{K}{(t+c)^p}$$

C- time delay P-decay rate

Utsu and his collaborators, based on over 200 earthquake data sets collected over 33 years, found that the value of c typically ranges from 0.01 to 1.00 in time units, and the value of p fluctuates between 0.6 and 2.5

Decay Rate (p):

If p>1 : aftershocks decay quickly

If p<1 : aftershocks persist longer

Total Number of Aftershocks N(t):

Integrate over time:

$$N(t) = \int_0^t n(\tau)d\tau = \int_0^t \frac{K}{(\tau+c)^p} d\tau$$

$$N(t) = \frac{K}{p-1}\left[\frac{1}{c^{p-1}} - \frac{1}{(t+c)^{p-1}}\right]$$

Accumulated aftershocks increase as time goes on, depending on p. To determine **p**, take logarithms:

$$log n(t) = log K - p log(t+c)$$

Solve for **p**:

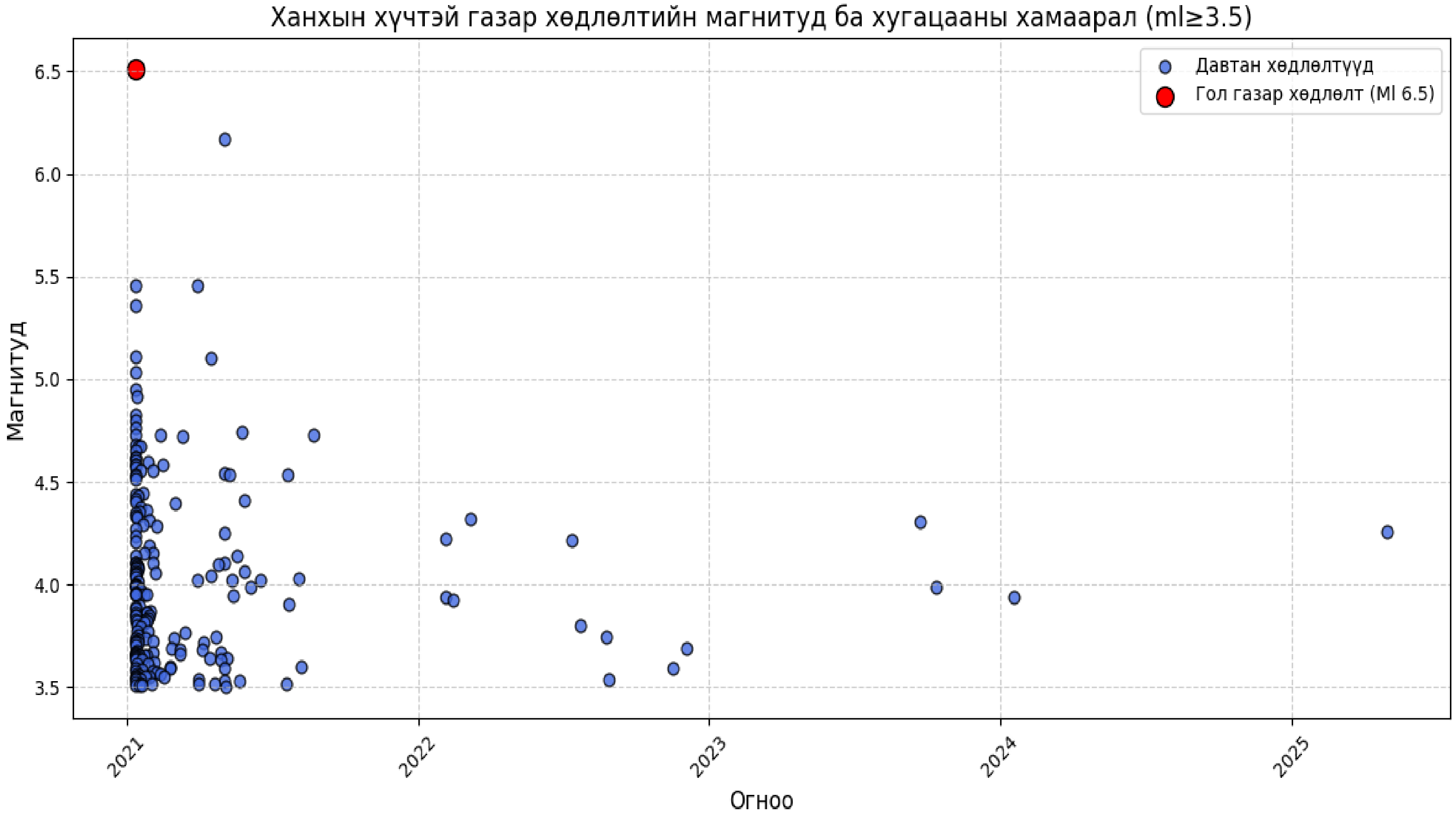
$$p = \frac{log K - log n(t)}{\log(t+c)}$$

Data collection and results

A total of **40,769 aftershocks** (M ≥ 1.0) were recorded. For statistical analysis, only **208 events** with **M ≥ 3.5** were selected to ensure data completeness

- **Magnitude timeline**

•Most aftershocks occurred within the first 3 months.
•A major aftershock (M6.1) happened on May 3, 2021.
•Aftershock activity declined significantly after mid-2021.



Data collection and results

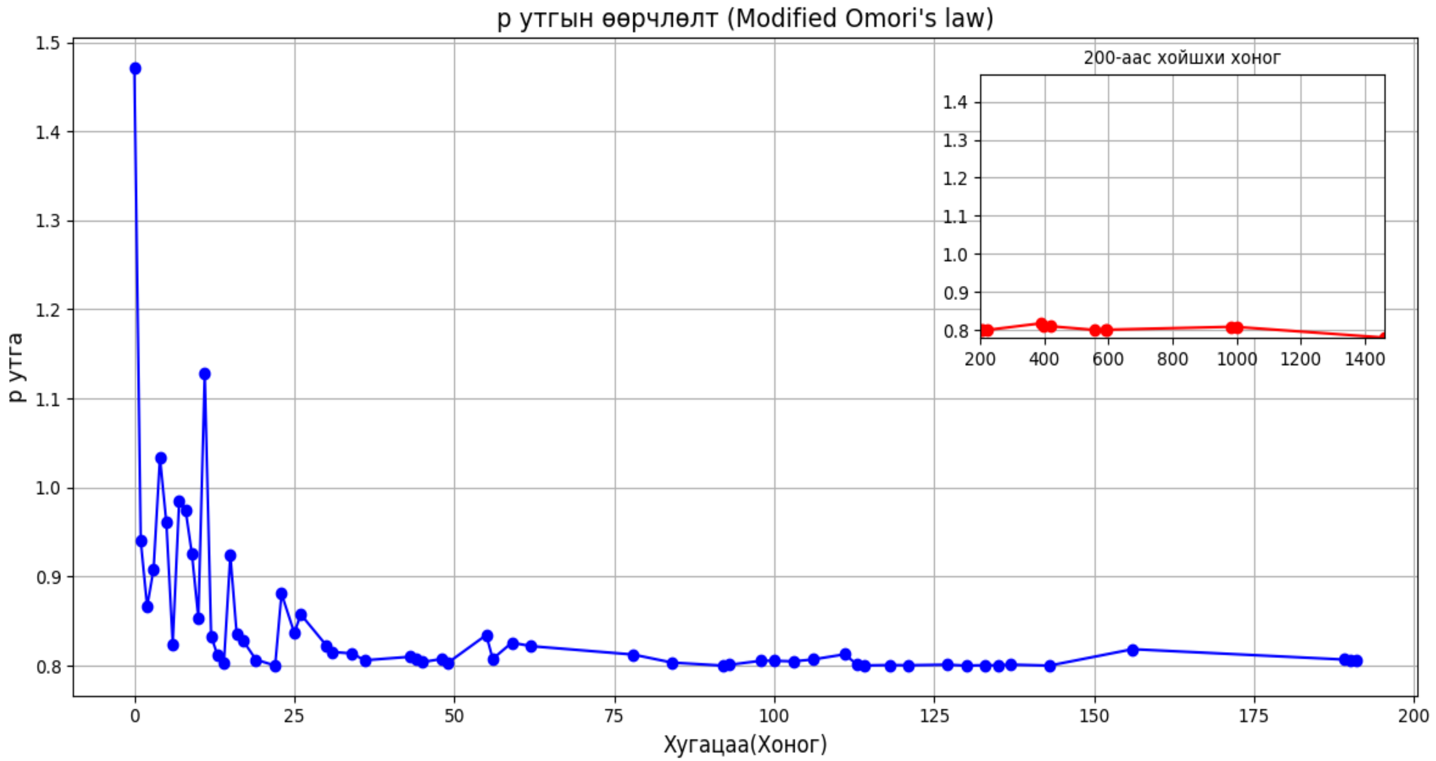
➢ Temporal variation of p-value

•Aftershocks started with high intensity, indicated by p = 1.47 on Day 1.

•A sharp drop in activity occurred on Day 2, where p decreased to 0.94.

•From Days 2 to 5, p-values stabilized between 0.86 and 1.03.

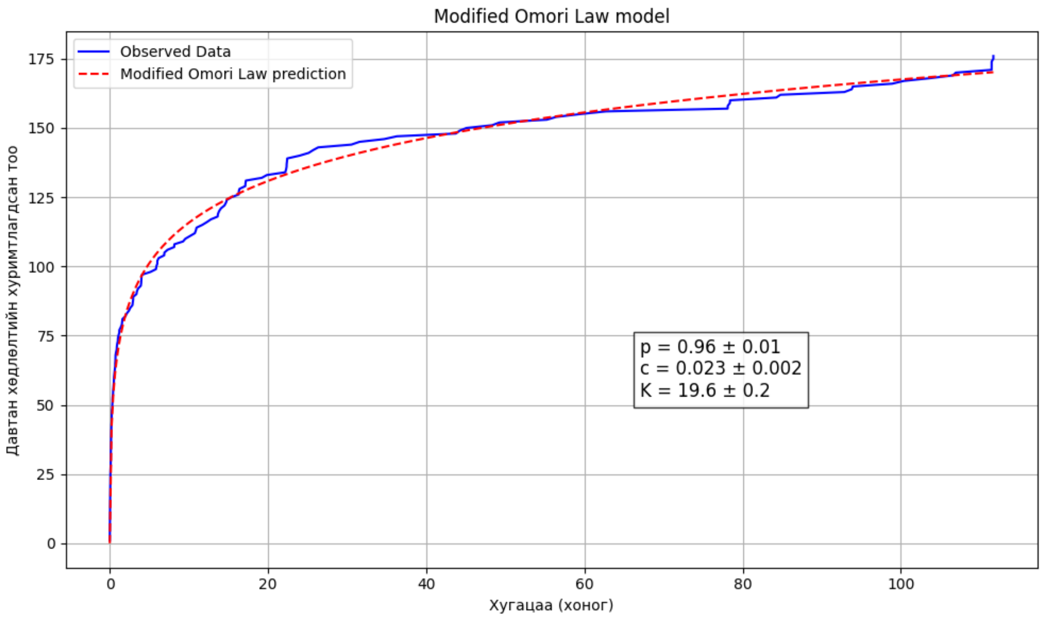
•After Day 10, a slow and steady decline was observed, indicating long-term decay in aftershock activity.



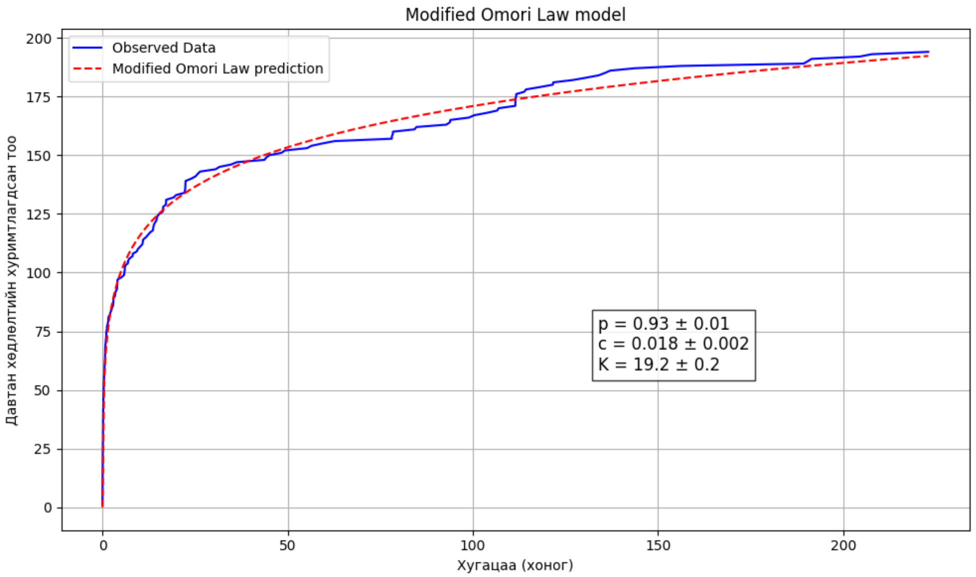
- The p-value reflects how quickly aftershock activity decays over time -higher p-values mean faster decay, while lower values indicate slower decay.

Omori Law Analysis (p, c, K)

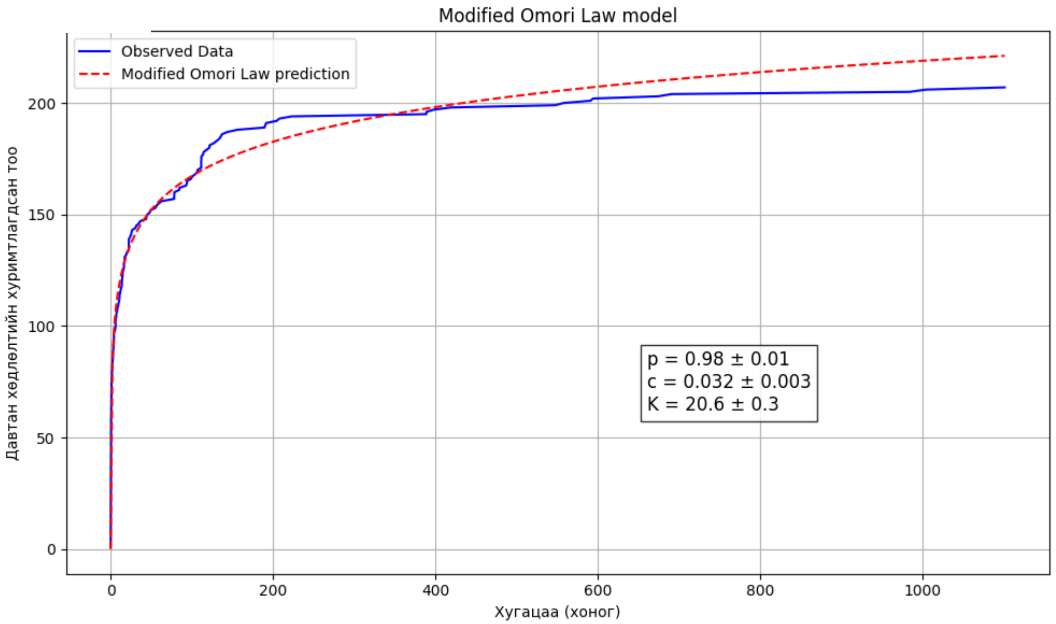
➢Comparison of observed and predicted cumulative number of aftershocks using the Modified Omori Law.



112 days



365 days



1460 days

- Short-term (112 days): Fast decay after mainshock.
- 1 year: Decay slightly slows, indicating extended activity.
- 4 years: The system stabilizes, p rises again, and the model predicts long-term decay with higher K.

Conclusion

- The 2021 Khankh aftershock sequence showed clear temporal changes in the p-value from the Modified Omori Law:

  In 112 days: rapid decay (p = 0.96)
  In 1 year: slower decay (p = 0.93)
  In 4 years: increased p (p = 0.98), indicating stabilization

- Although seismicity is stabilizing, low-magnitude aftershocks may still occur for several more years.→ Long-term monitoring is important for better risk assessment.

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Thank you for your attention!

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