## Estimating the magnitude of completion based on data recorded between February 01, 2022 and February 01, 2023

We assume the magnitude $m$ of an earthquake is exponentially distributed with parameter $\beta$. The frequency of earthquakes at a particular magnitude $m$, denoted $N(m)$, will then be proportional to the exponential probability density function, that is:

$$N(m) \propto \beta e^{-\beta m}. \tag{1}$$

Taking logs, we get

$$\log N(m) = \underbrace{\alpha\beta}_{a} - \underbrace{\beta}_{b} \cdot m, \tag{2}$$

which is a linear model with an intercept and linear term: $\log N(m) = a - bm$, where $a$ and $b$ are unknown coefficients.

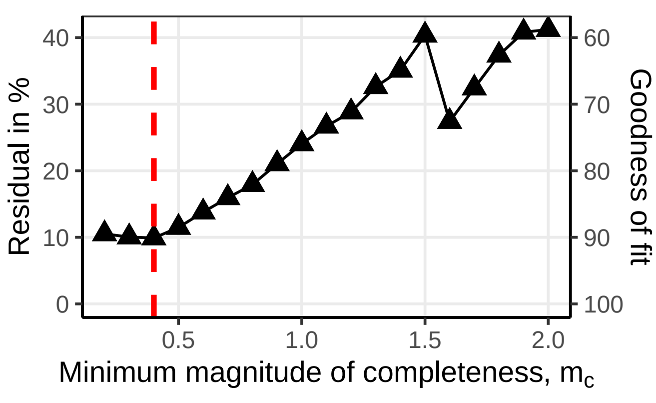
To estimate $m_c$, we use a method proposed by Wiemer and Wyss [2000]. First, the magnitudes are binned, where $N(m)$ denotes the frequency counts for the bin with lower limit $m$. The bin-width is set to 0.1. The candidate values $M_1, \dots, M_{max}$ for $m_c$ are then iterated, and the linear model in eq. (2) is fitted to the subset of data with magnitudes equal to or greater than $M_j$. The goodness of fit of a candidate $M_j$, with corresponding parameter estimates $(\hat{a}, \hat{b})$, is given by

$$R(\hat{a}, \hat{b}, M_j) = 100 - 100 \left( \frac{\sum_{M_i = M_j}^{M_{max}} |B_i - S_i|}{\sum_{M_i = M_j}^{M_{max}} B_i} \right), \tag{3}$$

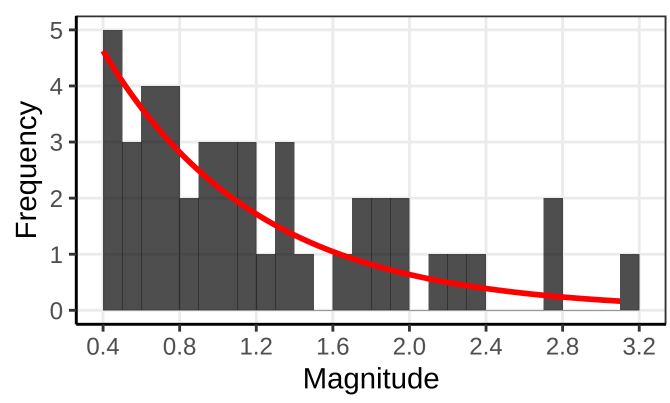
where $B_i$ is the cumulative count of bins with magnitude $M_i$ or lower, and $S_i$ is the corresponding cumulative count predicted by the fitted linear model. The results are shown in fig. 1a, and we pick the smallest $m_c$ candidate that achieves a goodness of fit above 90%. This gives

$$\widehat{m_c} = 0.4, \tag{4}$$

when only using data from the last 12 months. The corresponding model fit parameters are $\hat{a} = 2.0268$ and $\hat{b} = -1.2386$, for which the data for the past 12 months is plotted in a histogram in fig. 1b along with the predictions. We see that above $m_c = 0.4$, the magnitudes are approximately exponentially distributed, although there are only 45 earthquakes with magnitudes above this level, so there is uncertainty involved.




(a) The goodness of fit for each candidate value $M_j$ for $m_c$, according to eq. (3), with the selected value highlighted.




(b) Earthquake frequencies for magnitudes $m \geq m_c = 0.4$ in the past 12 months. The histogram bin width is 0.1.

Figure 1: Goodness of fit metrics for different magnitudes of completeness, along with an exponential fit to the data above the selected value.

## Earthquake activity in January 2023

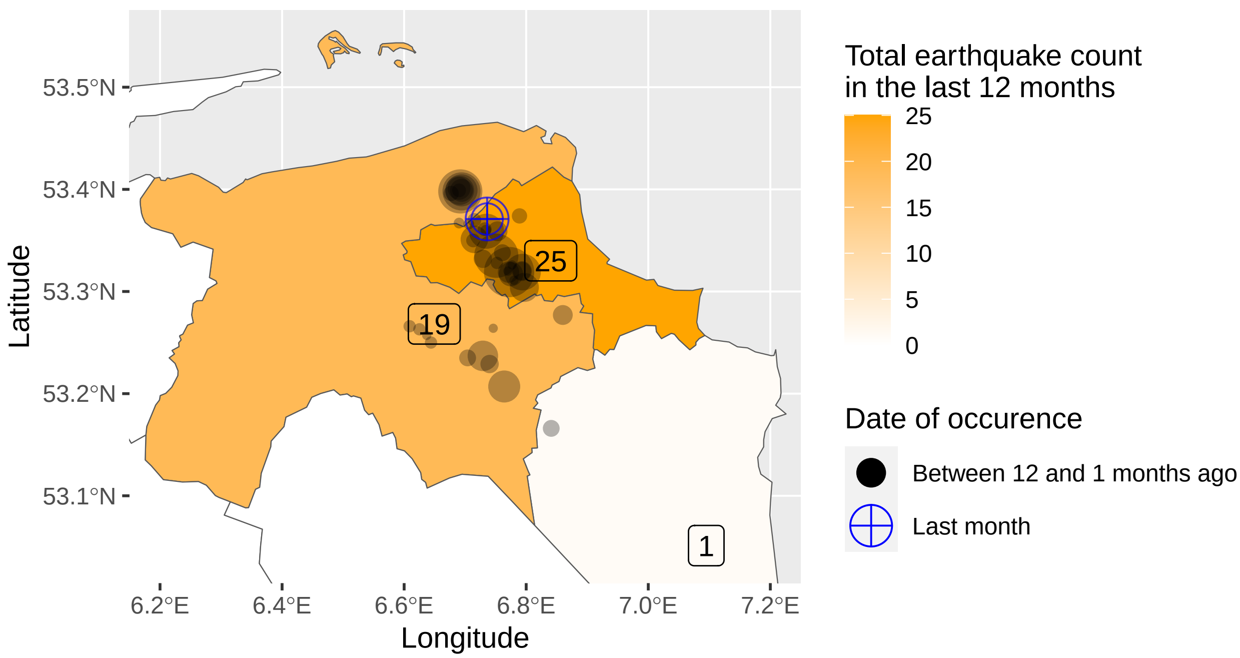



Figure 2: Map of Northern Netherland, overlayed with the epicentres of the earthquakes recorded in the past 12 months with a magnitude above $m_c = 0.4$. The size of the circles correspond to the earthquakes' magnitude.

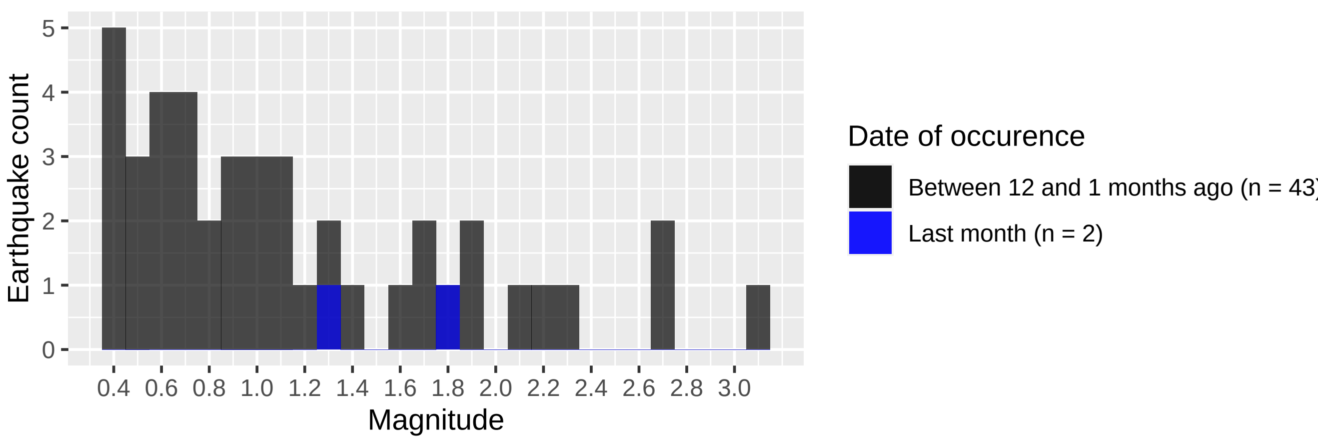



Figure 3: Histogram of the magnitudes of the earthquakes recorded in the past 12 months.

In January 2023, there were 2 earthquakes recorded above magnitude $m_c = 0.4$. In the 11 preceding months, there were 43, with an average monthly count of 3.91, meaning there was less earthquakes than expected last month. The largest magnitude was 1.8, compared to a magnitude 3.1 earthquake that happened in the 11 months prior. The distribution of the earthquakes is shown in fig. 3, with the average magnitude being 1.55 in the last month and 1.17 in the preceding 11 months. The location of all the earthquakes in the past 12 months is shown in fig. 2. We see that both of the earthquakes last month happened in the same location, close to where most of the earthquakes in the 11 months preceding happened as well.

## References

Stefan Wiemer and Max Wyss. Minimum magnitude of completeness in earthquake catalogs: Examples from alaska, the western united states, and japan. *Bulletin of the Seismological Society of America*, 90:859–869, 09 2000. doi: 10.1785/0119990114.