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

Improvements in the Detection Capability of the Mongolian Seismic Network Over the Last 10 Years

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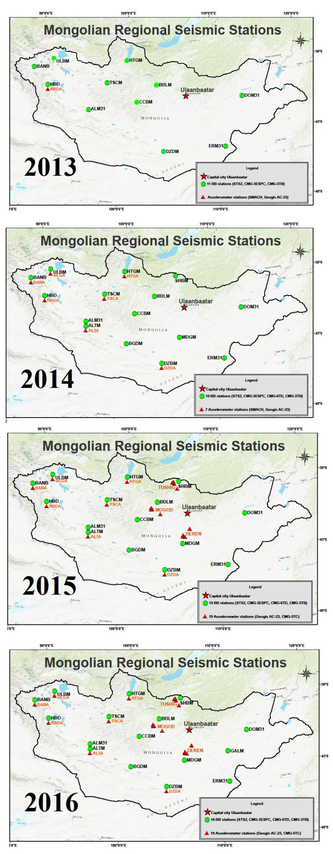
Brief history of seismic stations of Mongolia

In 1957, the international geophysical year, the very first seismic station was installed in Mongolia and seismic monitoring started from then on. The Mongolian Seismic station number of IAG of MAS has been increasing year by year, especially in the last 10 years totally 49 seismic stations were installed and upgraded. From 2013, regional short period stations were updated to broadband station, 16 broadband stations were installed near Ulaanbaatar city, early warning system included 12 accelerometer stations installed on three active faults near Ulaanbaatar city, 5 short period stations were installed in west site of Mongolia, 6 broadband stations were installed in east and north side of Mongolia. In 2024 10 broadband stations were installed center and east side of Mongolia with Earthquake Administration of China. The detection capability and location accuracy of Mongolian seismic network has been increasing noticeably. A sparse network at present and determining and improving detection capability and location accuracy of the Mongolian Seismic Network is important for seismic event detection in Mongolia. The detection capability of seismic network of Mongolia is increased from Ml 2 to Ml 1.6 in whole territory of Mongolia in last 10 years. We will present detection capability improvement in last 10 years of MNDC in this poster.



1957- The first analog seismic station “Ulaanbaatar”, with electro-magnetic seismometer was installed on July 6th /3 components short period SKM-3(2 sec) and 3 components long period SK(12sec)/

1958- Altai, 1964 – Tsetserleg, 1965 – Khovd, 1969 – Dalanzadgad, 1973 – Bulgan, 1975- Khatgal, 1987 – Ulaangom, 1988 - Bayan-Ulgii /3 components SP SKM-3(2 sec)

1994 – First digital telemetric seismic network (6 stations) were installed within range of 25 to 75 km from Ulaanbaatar. ZM500(1 sec) seismometer,USGS named ULN /STS-1, GS-13 and FBA23

2002- PS25 IMS CTBTO 9 element vertical SP ZM400 (2 sec), 1 element 3 component long period LPZ&H12 (12 sec)

2004 ALM31 and ERM31 stations

2008- Built-up Mongolian National Data Center (MNDC) and DOM31

2013- 16 broadband Ulaanbaatar Monitoring Geophysical stations

2014- 3 new regional stations have been established Selenge, Bogd and Mandalgovi CMG-3ESPC CMG-DM24S3EAM/

2015- Earthquake Early warning system was built with 12 stations

2017- 4 broadband stations have been installed in east side of Mongolia.

2018- 5 short period automatic station have been installed west side of Mongolia

2021- Guralp Minimus+ installed in north side of Mongolia

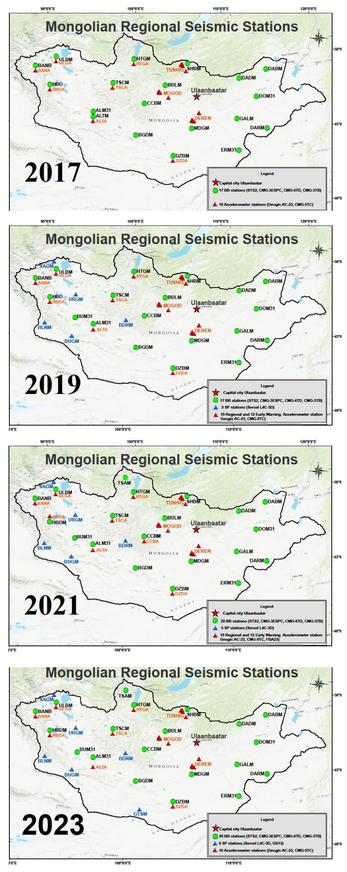
2023- Reftek 130 and GS-13 short period station in south side of Mongolia

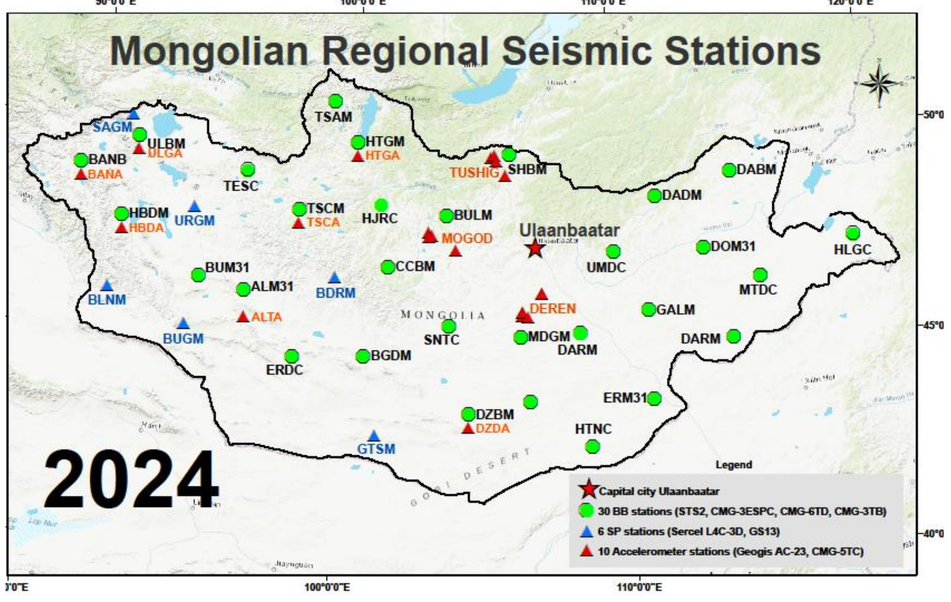
2024- 10 broadband JS120 stations were installed with Institute of Geophysics, China Earthquake Administration

1957 - The first analog seismic station “Ulaanbaatar”, with electro-magnetic, photopaper, seismometer was installed on July 6th, 1957.

In 2005-2007, 12 regional photopaper stations were replaced with digital stations **/Aorai digitizer and 3 component SP Sercel L4-3D/** Data of it was transferred by flash disk via post firstly, then ADSL modem trough phone line.

In 2010-2011, regional short period stations were swapped with BB Guralp-3ESPC with Guralp digitizer in new seismic vault. Data transportation was used 3G modem till 2015 connected through fiber optic cable with 1mbps.

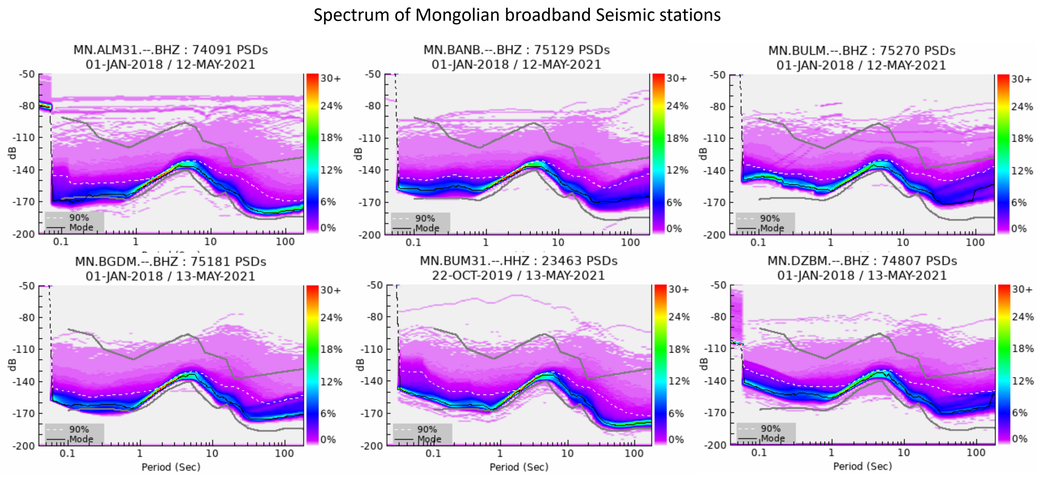




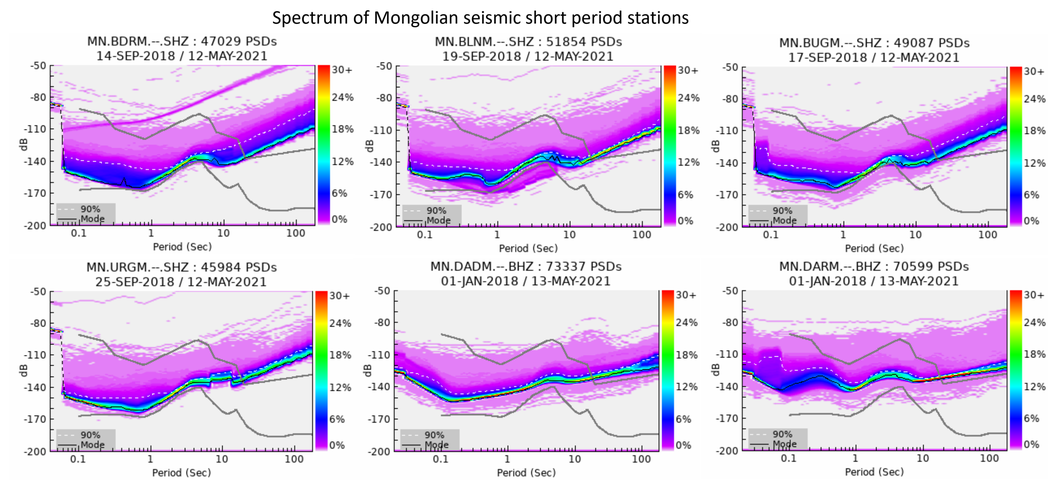
Calculation method of the detection capability

1. Calculation of noise amplitude in displacements *d* at each station from the corresponding PDF using PQLX (McNamara and Boaz 2011)
2. Ground displacement amplitude attenuation expression of Dr. Ulziibat calculates minimum earthquake detection threshold of stations.

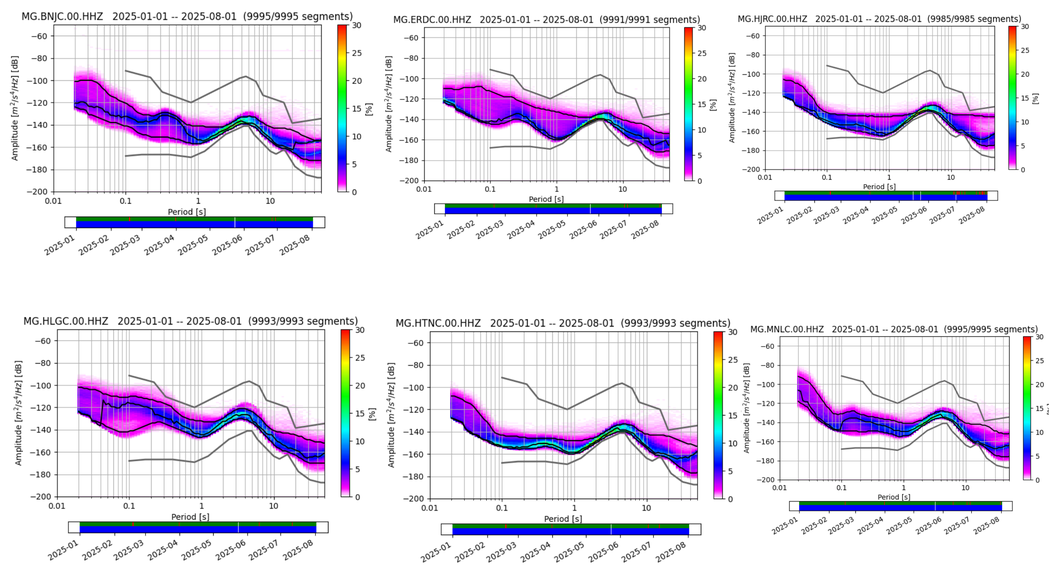
Spectrum of Mongolian broadband Seismic stations



Spectrum of Mongolian seismic short period stations



Spectrum of some stations of Seismology Administrator of China



For example, calculation of BANB станц

$$dB = 10log_{10}\frac{Pa}{\left(\frac{m}{s^2}\right)^2/Hz} \qquad Pd = \frac{Pa}{(2\pi F_0)^4}$$

$$d_{ap} = 1.25\sqrt{P_d \cdot (f_2 - f_1)}$$

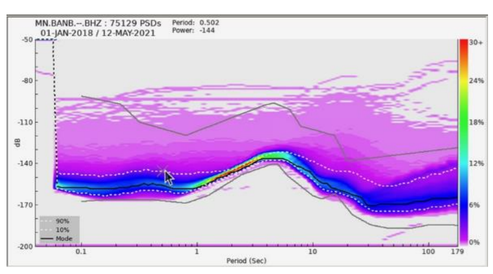
(Havskov and Alguacil 2006)

$$d \approx 3 \cdot d_{ap} = \frac{3.75}{(2\pi f_0)^2} \cdot \sqrt{P_a \cdot (f_2 - f_1)}$$

(Marthin Mollhoff 2019)

Center frequency is f_0 =2Hz and half octave frequency band
Upper and lower frequency is f_1 and f_2

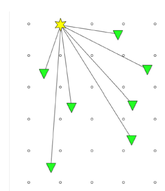
$$f_1 = f_0 2^{-n/2} \qquad f_2 = f_0 2^{n/2}$$



Calculation from PDF 90% at 2HZ to displacement

$$d(mn) \approx \frac{3.75}{(2 * pi * 2)^2}\sqrt{10^{\frac{-144}{10}} * \left(2 * 2^{\frac{0.5}{2}} - 2 * 2^{\frac{-0.5}{2}}\right)} * 10^9 = 1.25058nm$$

Calculation of the attenuation from epicenter to station using Dr. Ulziibat’s Ml scale equation.



station location

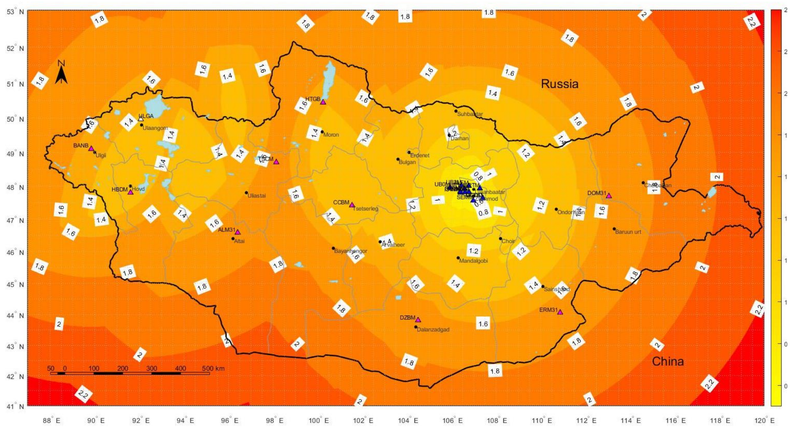
earthquake epicenter

$$ML = \log A + 0.816 \log \Delta + 0.00045\,\Delta - 1.22$$

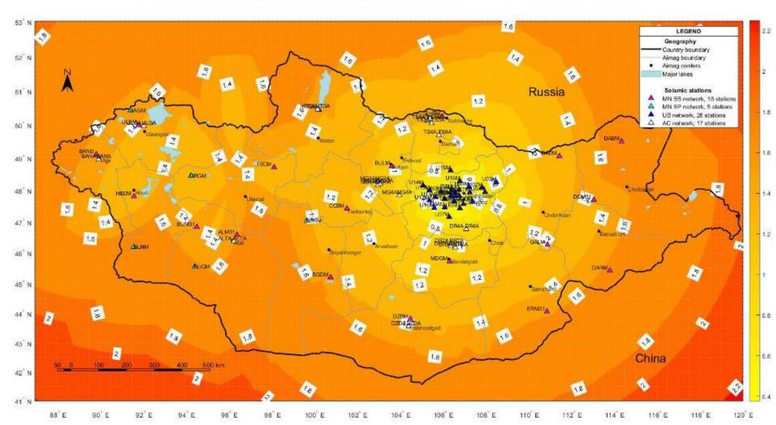
Δ distance between seismic station and epicenter
A Maximum ground displacement amplitude

1. Calculate the hypocentral distances *R* between the grid point and each station. Grid points distance is longitude around 1.5 km and latitude 2 km. For network capability estimation at regional scale epicentral distances can be used as an approximation for hypocentral distances.
2. For a range of values, calculate for each station the maximum ground displacement amplitude *A(nm)* from the equation for the M_L scale.
3. Find the smallest M_L value for which the condition $A > 3d$ is met for at least 5 stations.

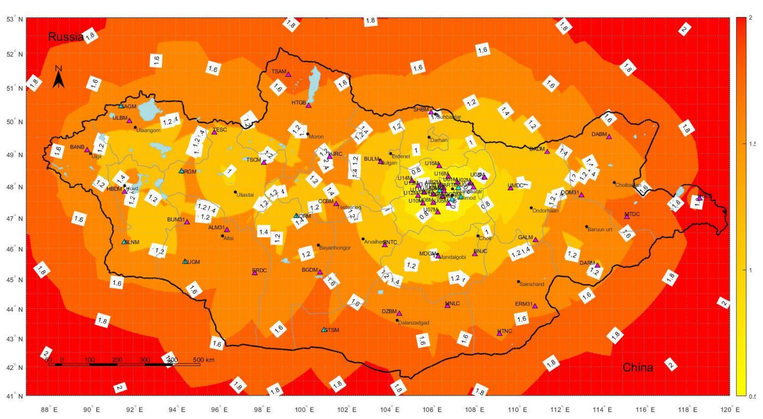
Detection Availability of Mongolian Seismic Network in 2011-2016



Detection Availability of Mongolian Seismic Network in 2016-2021



Minimum Earthquake Detection Capability Map of Mongolian Seismic Network in 2025



Based on the "Minimum Earthquake Detection Capability Map of Mongolian Seismic Network in 2025," it is evident that the network can detect earthquakes with magnitudes as low as approximately 1.6 ML across most of Mongolia. The detection capability of the seismic network has improved from Ml 2 to Ml 1.6 over the last 10 years, reflecting enhanced sensitivity, particularly in central regions where magnitudes as low as 0.8-1.0 are detectable due to a dense concentration of stations.
This map is useful for assessing seismic monitoring coverage and identifying areas that may need additional stations for improved detection.