GNSS measurements in Ulaanbaatar and its vicinity

Erdenezul Danzansan
Institute of Astronomy and Geophysics MAS, Ulaanbaatar, Mongolia
erdenezul@iag.ac.mn

Andrei Miroshnichenko
Institute of the Earth's Crust SB RAS, Irkutsk, Russia

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Outline

- A brief introduction seismicity of Mongolia
- Recent seismic activity around Ulaanbaatar area, capital of Mongolia
- The active faults related to this activity
- The research that are currently going on
- Analysis and preliminary result of GNSS measurement
- Summary

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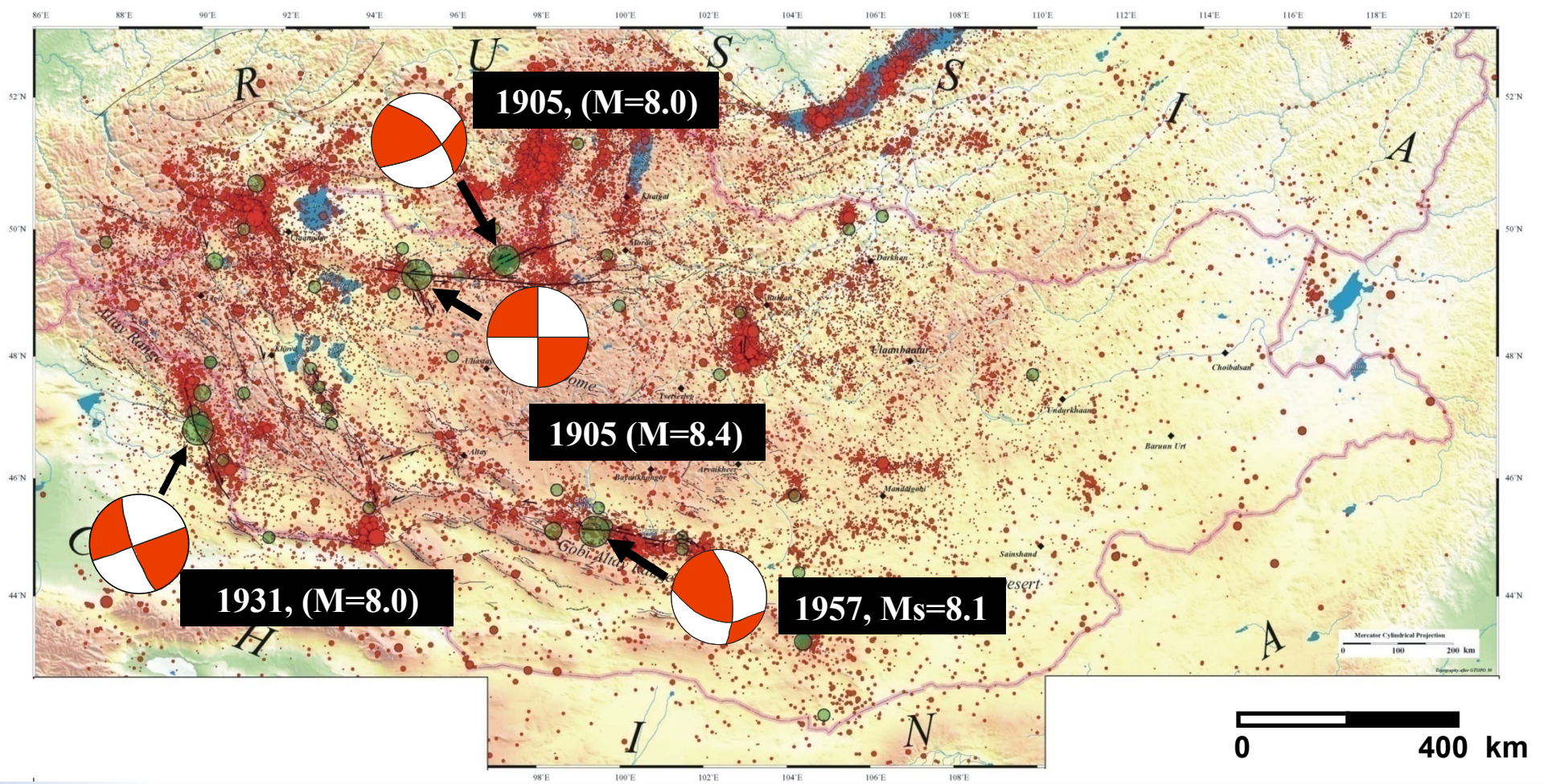
Seismicity of Mongolia



30 earthquakes with M≥7 including 4 with M ≥8
rate of occurrence of earthquakes per one day ~ 50

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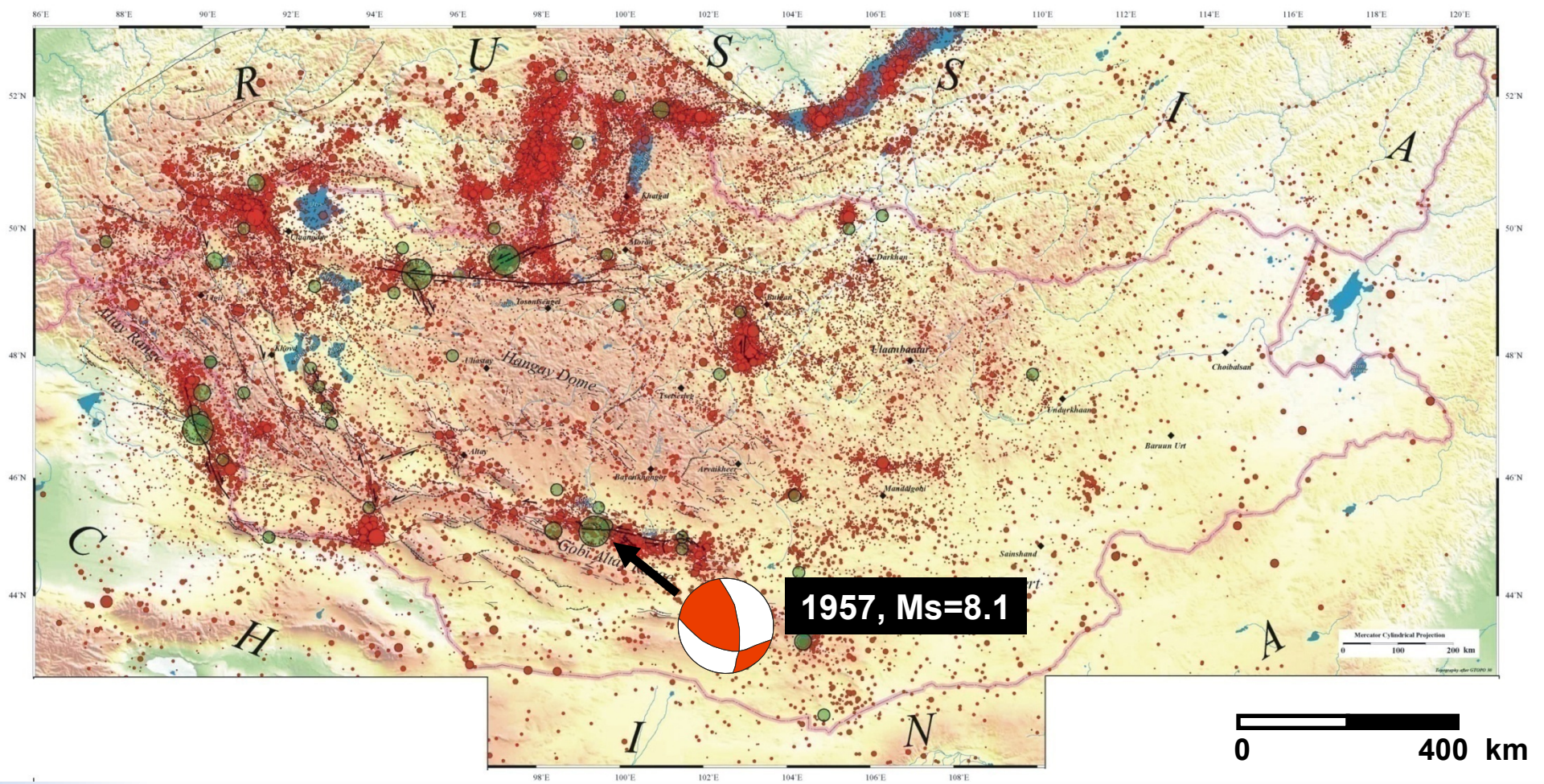
The Gobi-Altay earthquake



In 1957, Gobi_Altay earthquake (M~8.1) occurred in south Mongolia, and produced a 250 km long surface rupture along the left-lateral, strike-slip, trending Gobi-Altay Fault. The largest displacement was around 8-10 m of horizontal and 3-4 m vertical of offset

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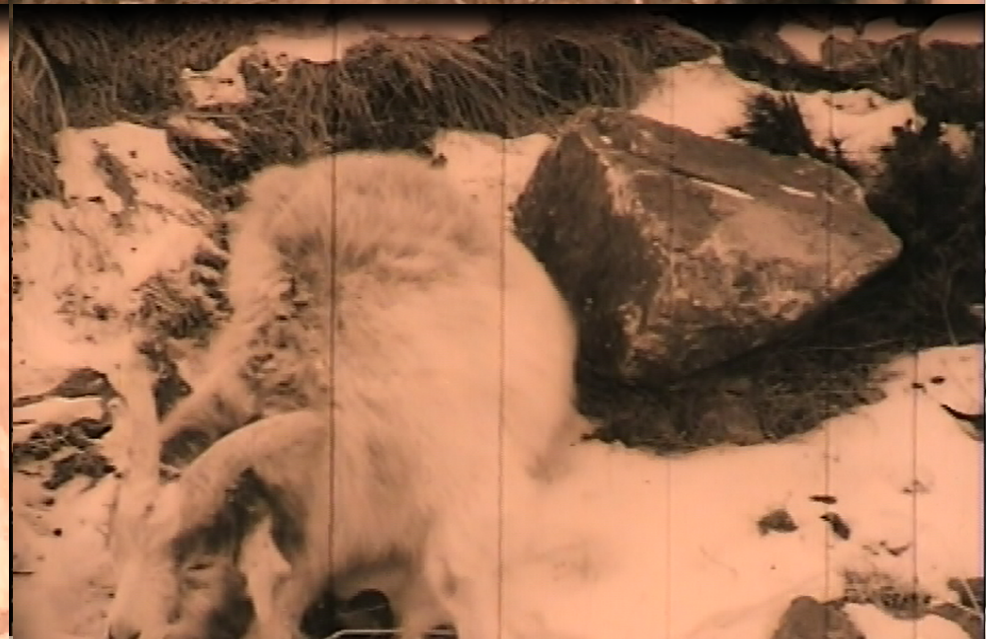
Casualties

Several tens thousand cattle's died



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Surface rupture of the Gobi-Altay earthquake

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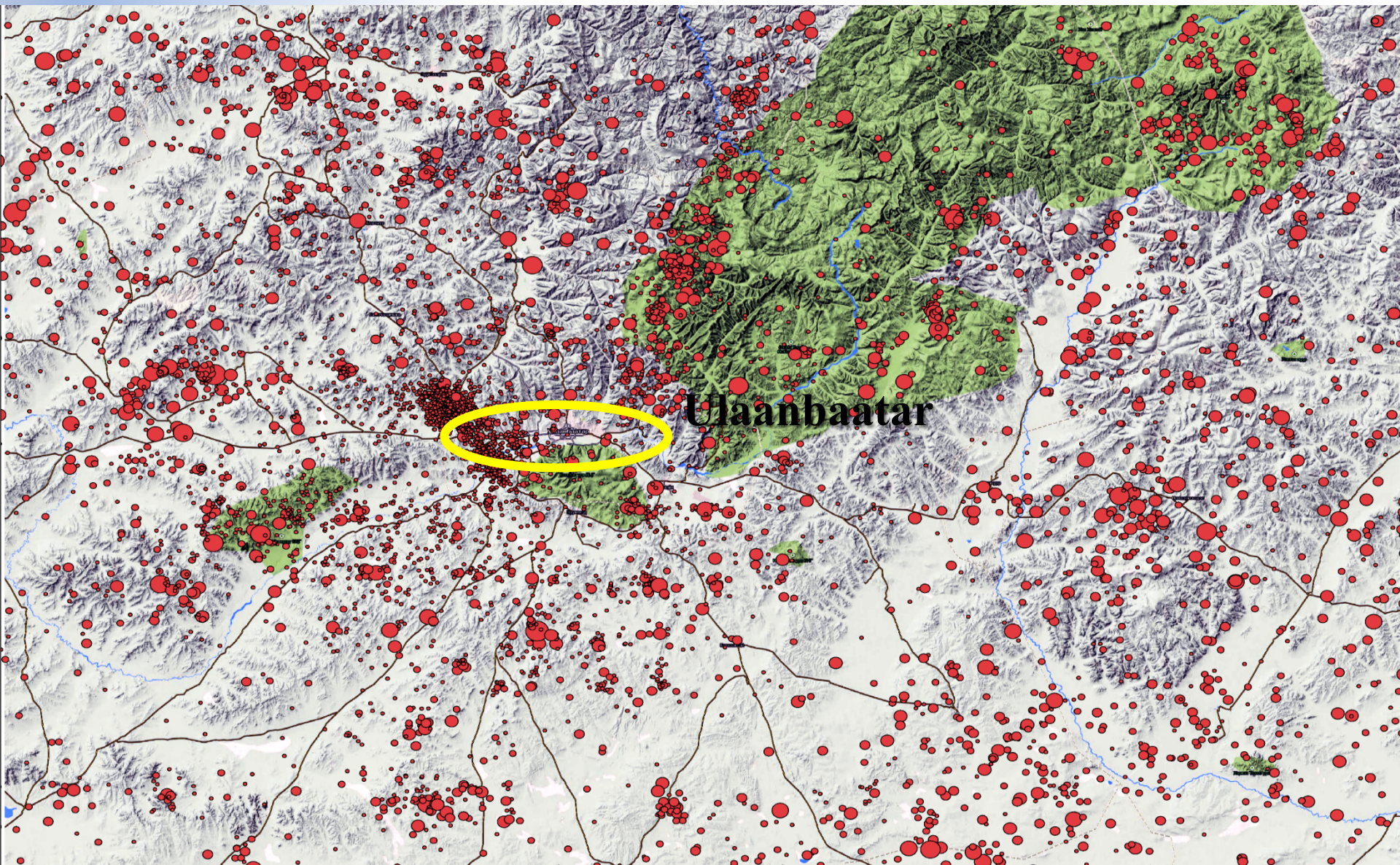
Recent seismic activity of Ulaanbaatar



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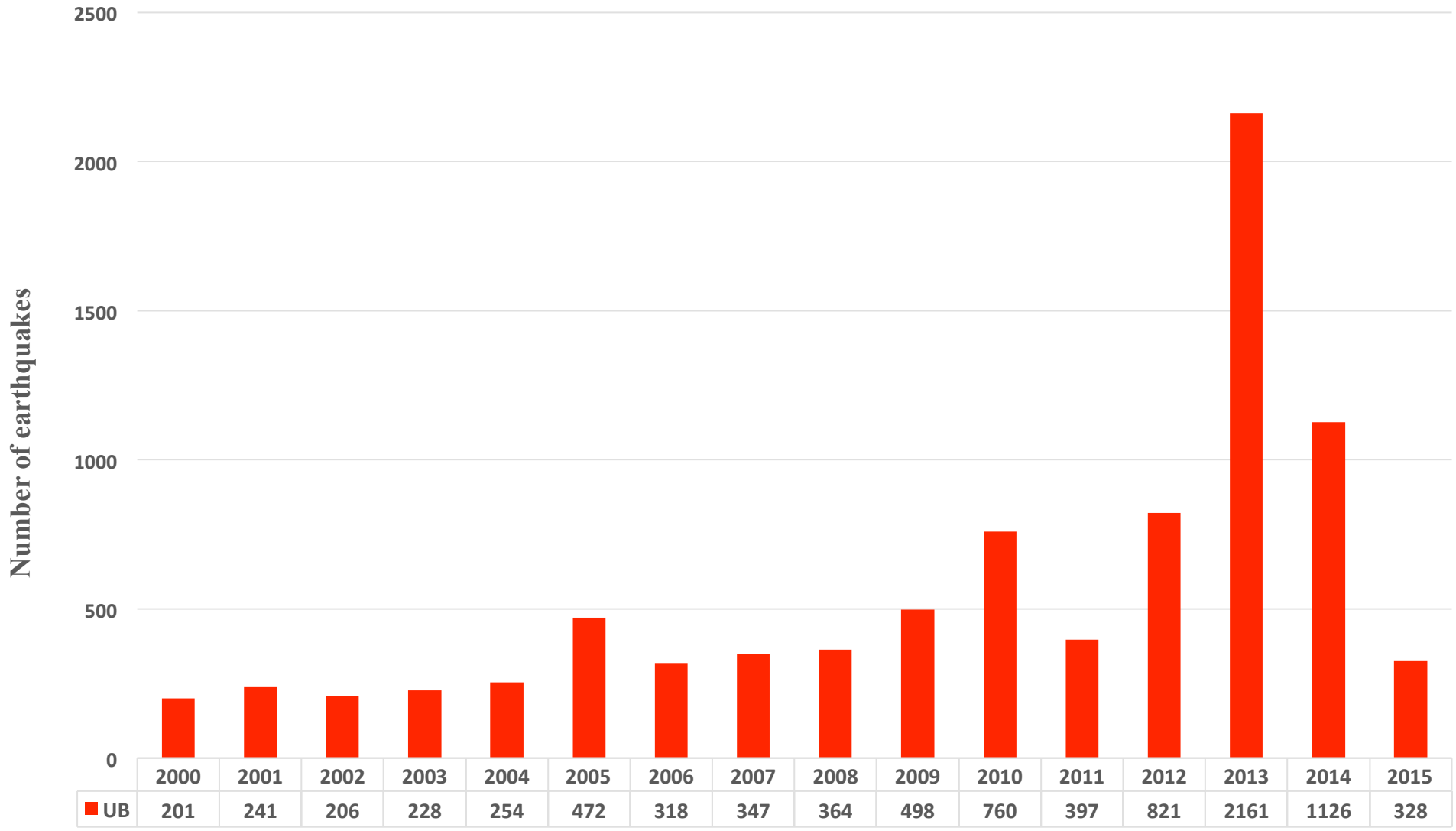
Cumulative number of earthquakes occurred between 2000 and 2015



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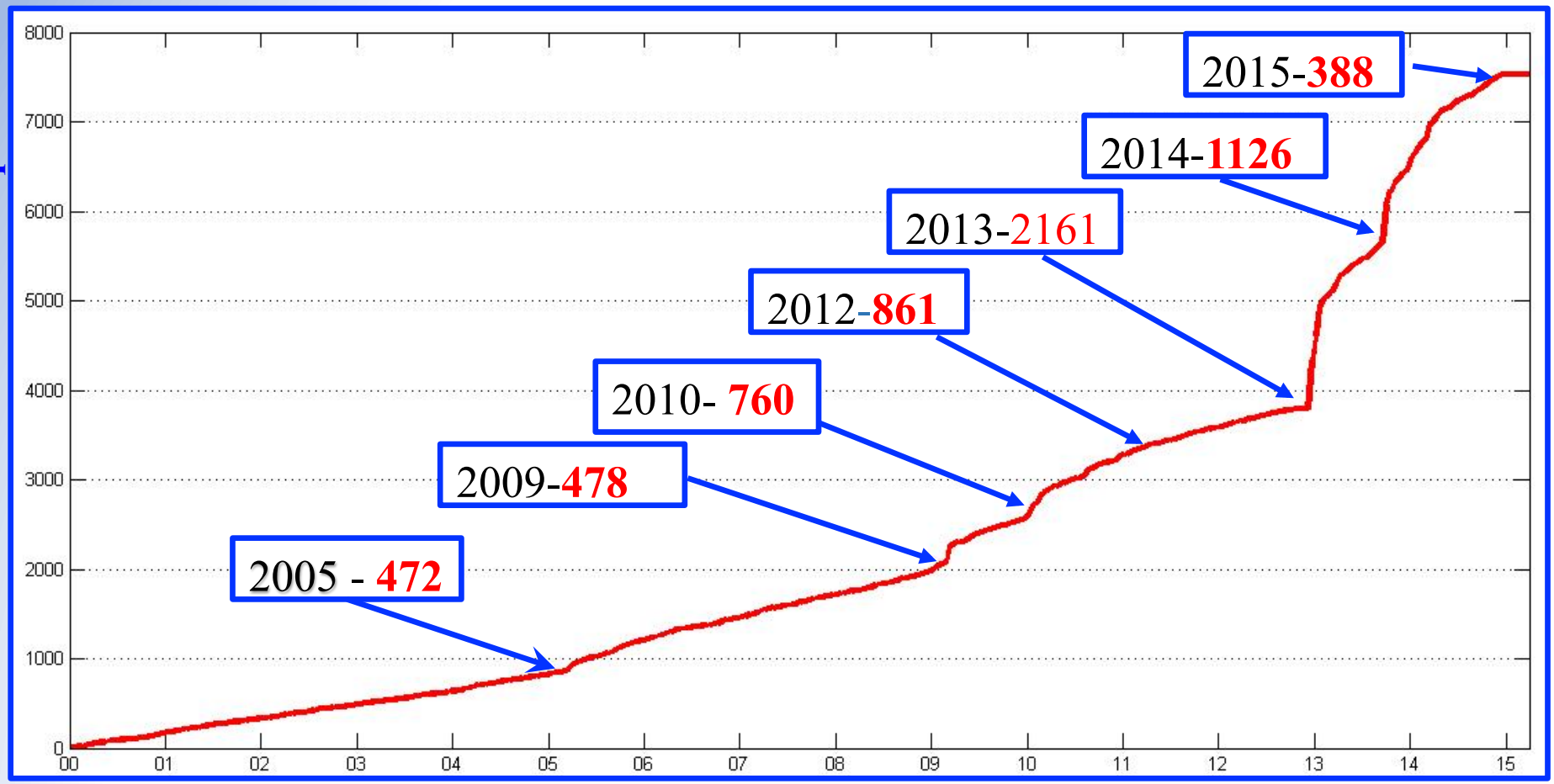
Seismic storm starts -2005



Seismic activity around Ulaanbaatar city increasing in last years and rate is changing several times during that period.

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The active faults related to this activity

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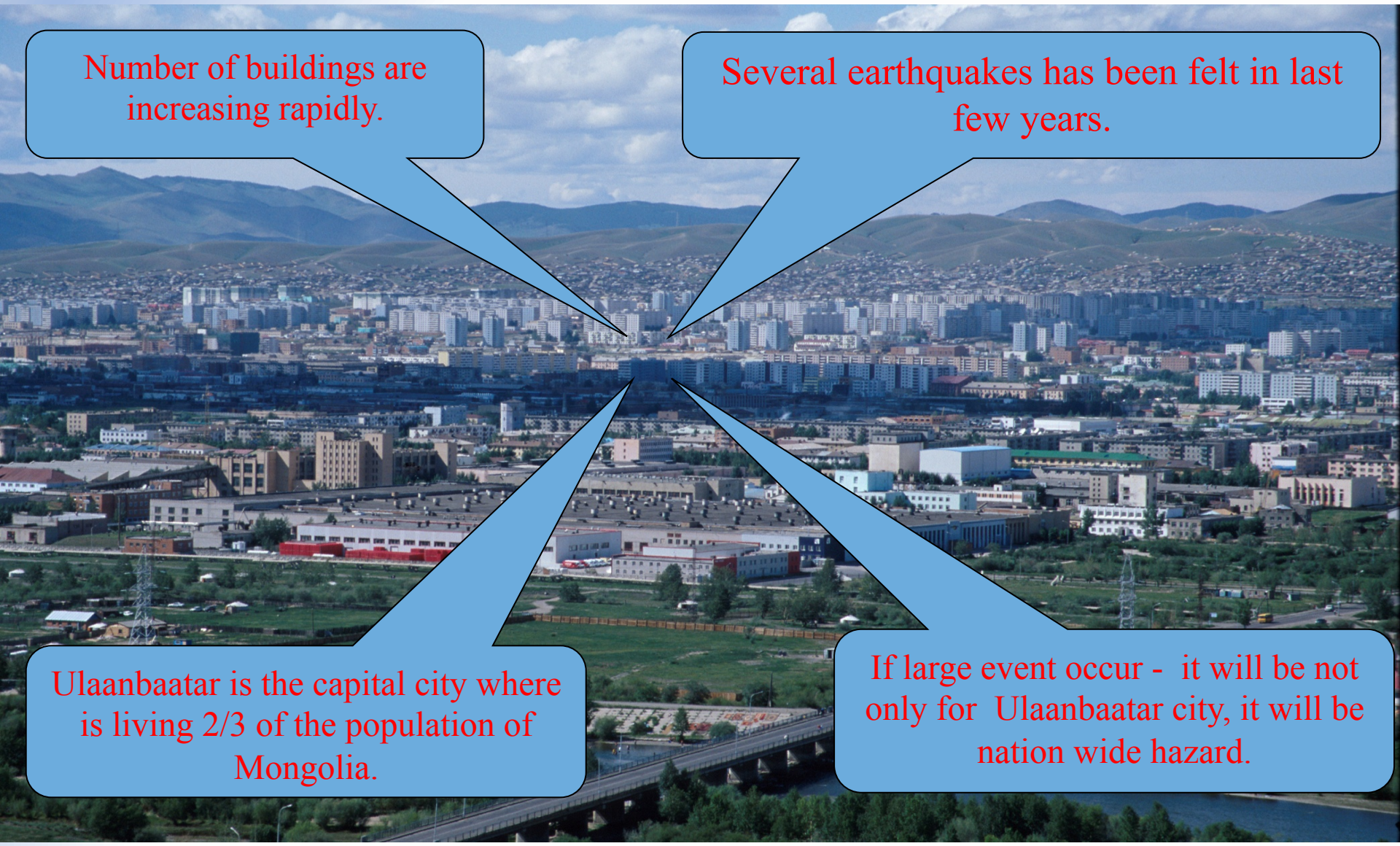
Seismic hazard of Ulaanbaatar city



GPS derived velocities with respect to Eurasia

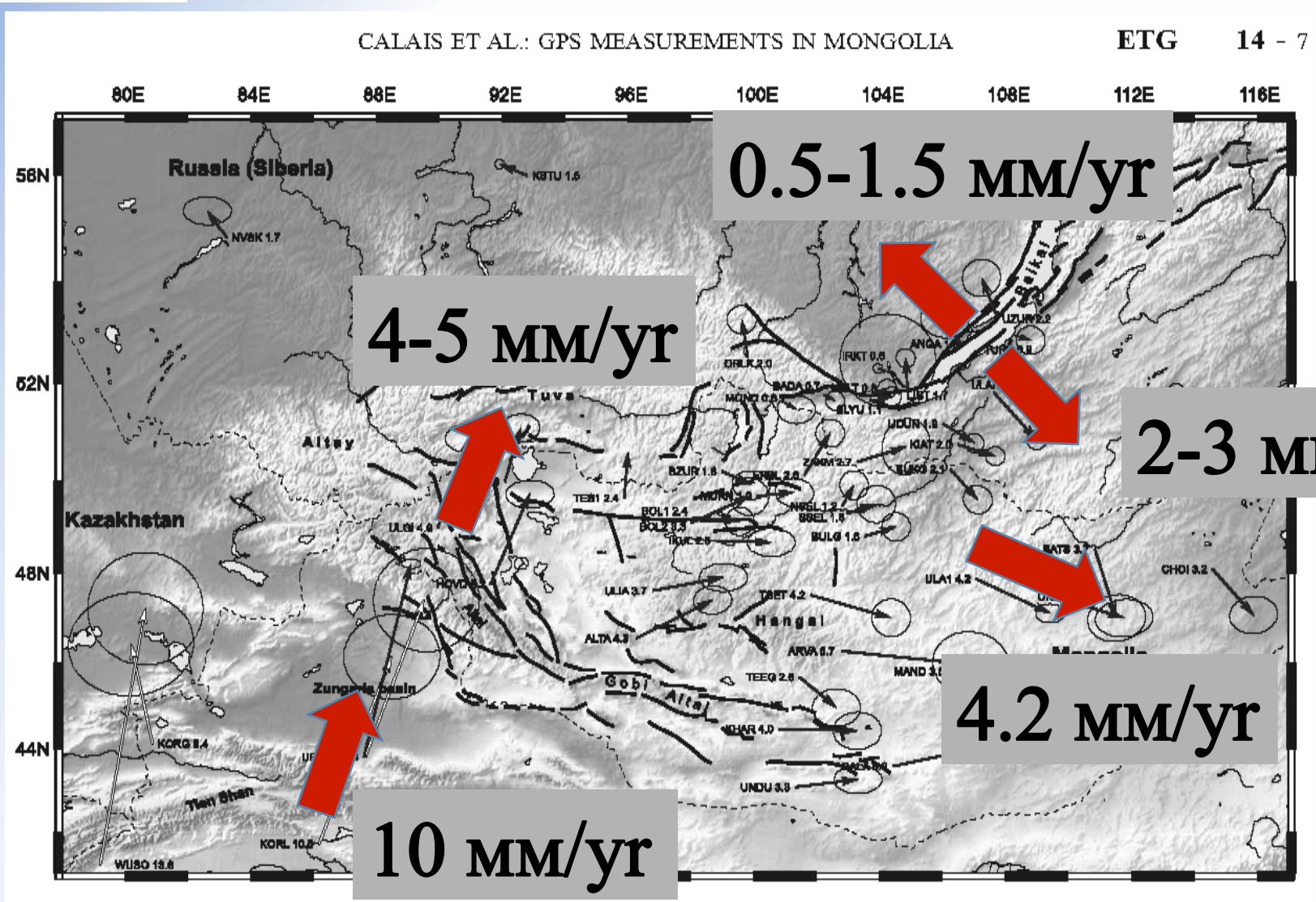


Figure 4. GPS-derived velocities with respect to Eurasia. Ellipses are 95% confidence. Numbers by the site names are velocities with respect to Eurasia in mm yr ^{1}.

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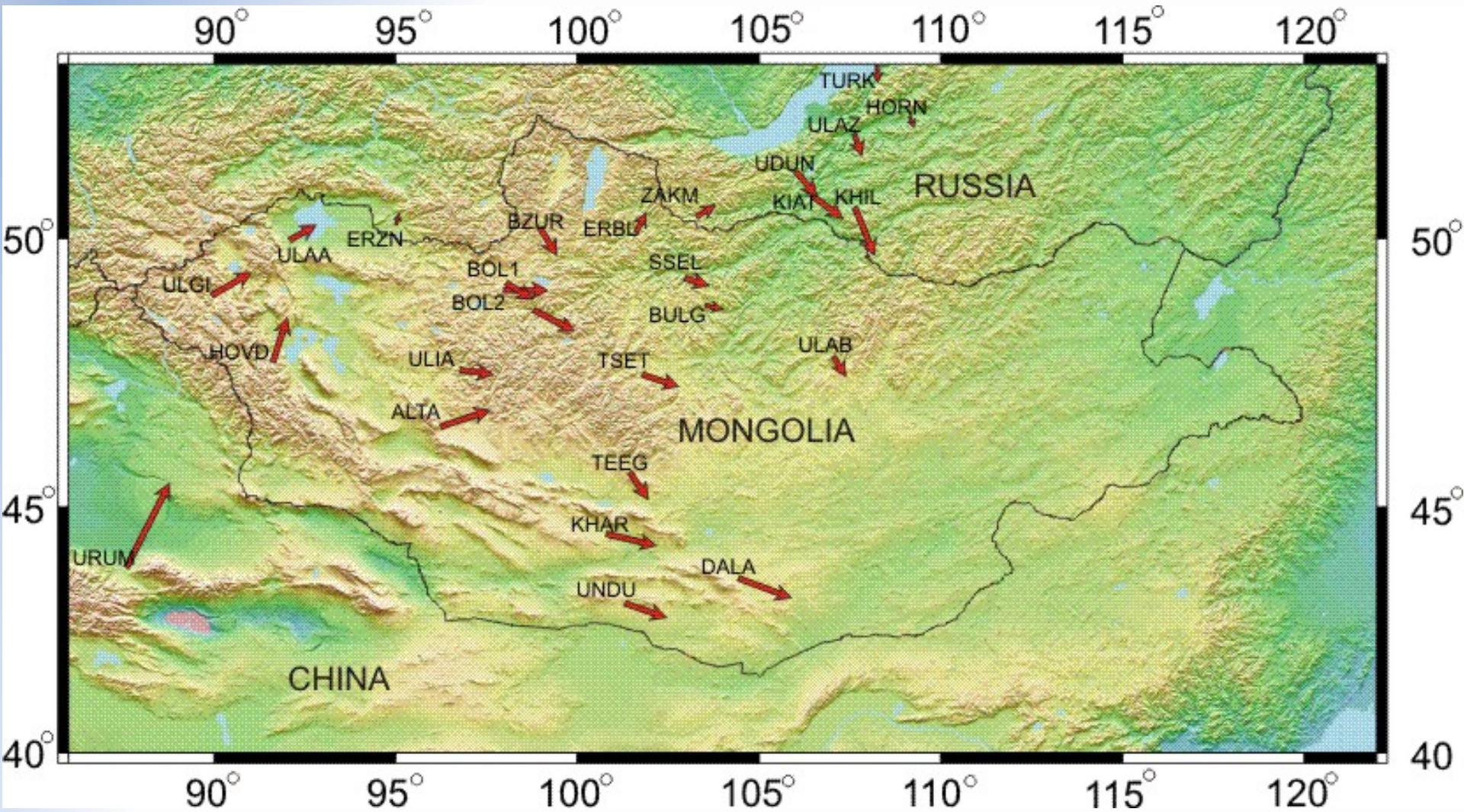
Previous study



GPS-derived velocities with respect to Eurasia (Lukhnev A. et al, 2010).

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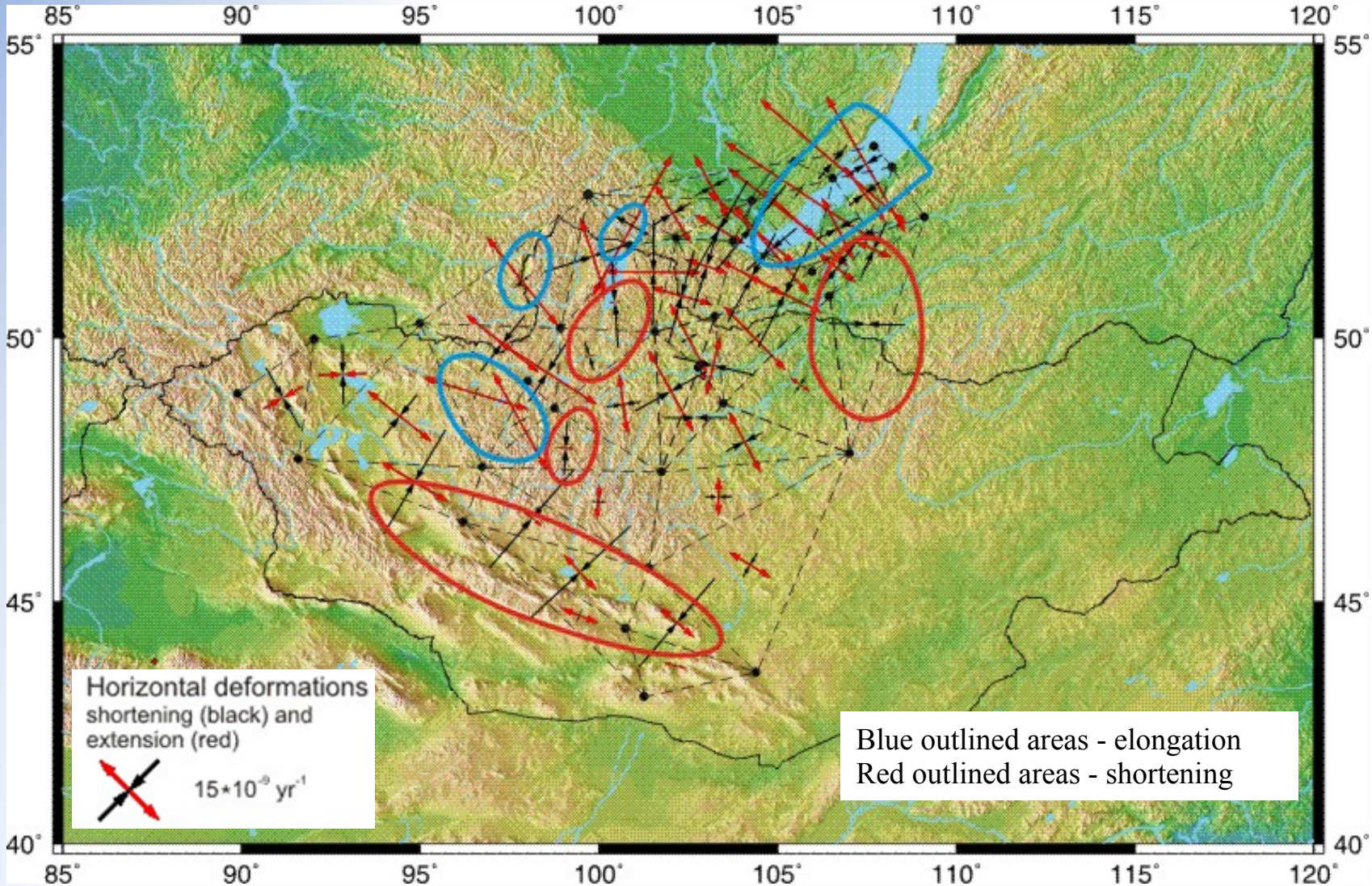
Strain rates derived within the Baikal-Mongolian GPS network



(Lukhnev A. et al, 2010)

The research that are currently going on:

The aim of this study is to estimate the surface velocity field and strain rate in the vicinity of Ulaanbaatar and eastern part of Mongolia.

Stage 1.

To install regional and local GNSS networks around Ulaanbaatar as well as in the eastern part of Mongolia.

Stage 2.

To carry out GNSS campaigns at the testing areas.

Stage 3.

To process the measurements.

Stage 4.

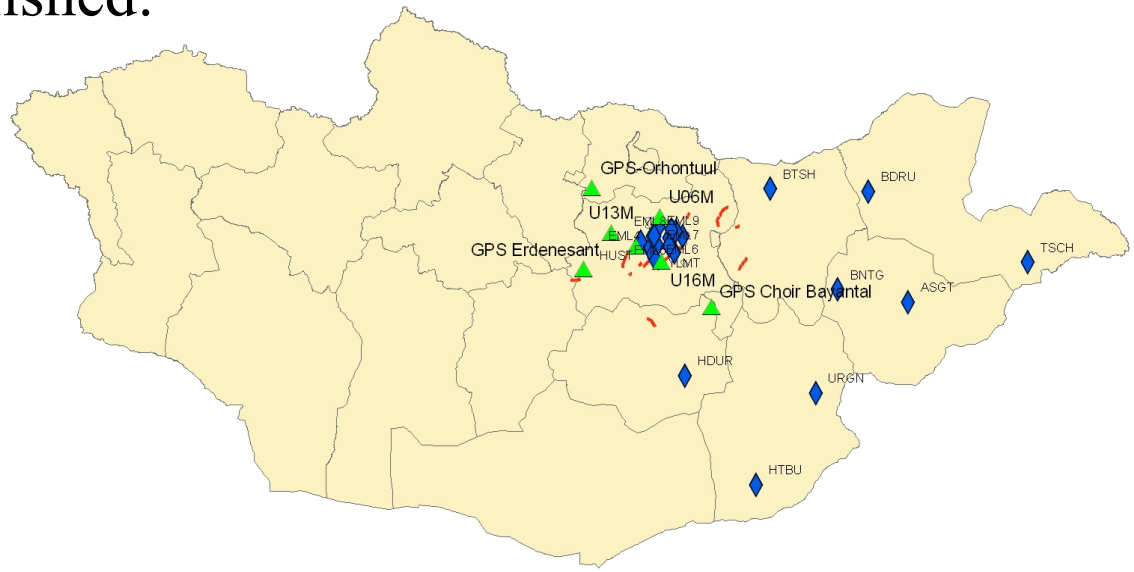
To implement the results for geodynamic models.

The research that are currently going on:

Configurations of GNSS polygons and quantities of permanent and temporary sites are determined with regard to the geological and geomorphological structure of the areas, locations and orientations of active faults, and paleo-and-recent seismicity indicators.

Three polygons are established:

- East (8 sites)
- Ulaanbaatar (12 sites)
- Emeelt (10 sites)



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GNSS equipments

Measurements were taken by dual-frequency Trimble 5700 GPS receivers with Zephyr TRM antennas and starting from 2012, measurements at all the sites are taken by Trimble NetR9 multi-channel GNSS-receivers with ChokeRing antennas.

Analysis and preliminary result of GNSS measurement

Measurement recording cycles lasted for 72 hours as minimum at East and Ulaanbaatar polygons, and for at least two (2) hours at Emeelt polygon.

Software:

- GAMIT (King & Bock, 2000),
- GLOBK (Herring et al., 1990),
- FONDA (Dong et al., 1998),

Calculated with:

- ITRF2008
- IGS stations (ARTU, BADG, BJFS, CHUM, FAIR, GRAZ, IISC, IRKT, KHAJ, KIT3, KOKB, KUNM, LHAZ, MAG0, NRIL, NVSK, ONSA, PETP, PETS, POL2, SELE, SHAO, TIDB, TIXI, TSKB, ULAB, URUM, USUD, WUHN, XIAN, YAKT)

Analyses of the measurement data yielded preliminary results for Ulaanbaatar polygon.

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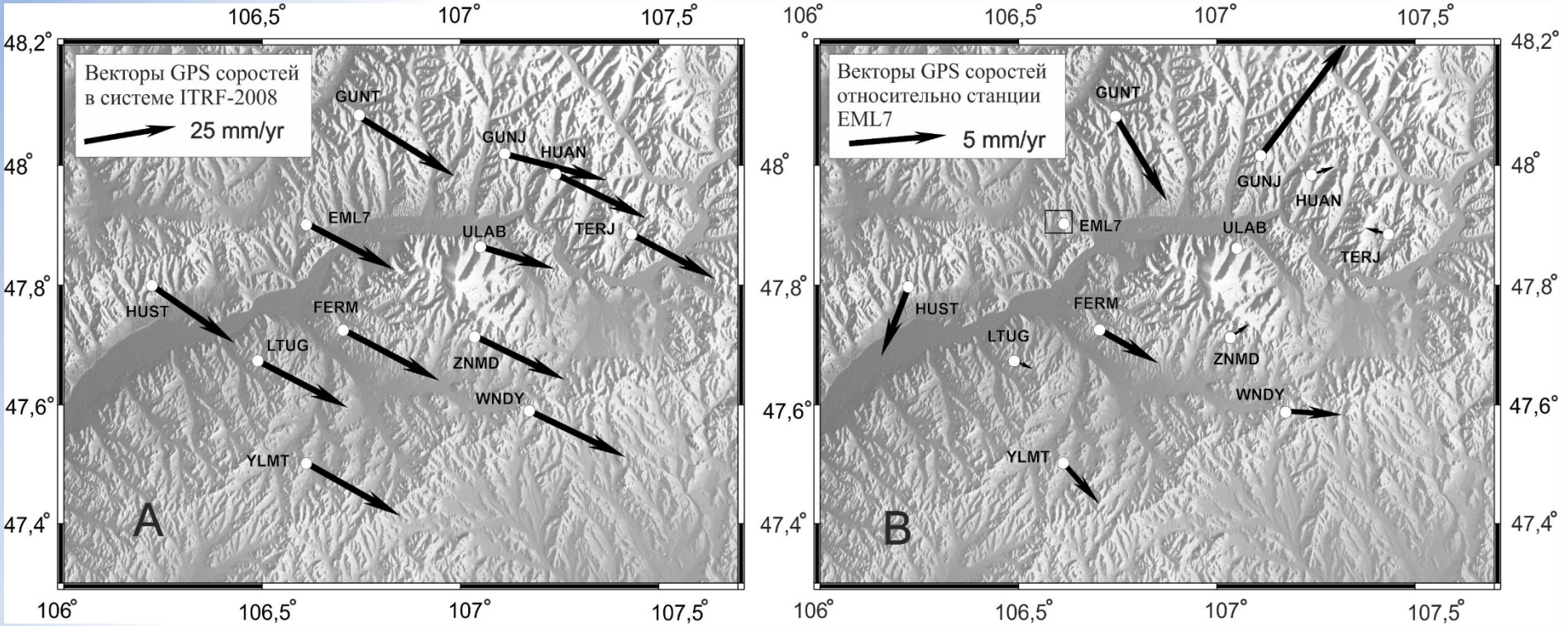
Horizontal velocity of the GNSS network "East", "Ulaanbaatar" and "Emeelt" in ITRF2008 system and the accuracy of the measurements

SITE	Long. (deg)	Lat. (deg)	Rate E (mm/yr)	Rate N (mm/yr)	± dE	± dN
ULAB	107.052	47.865	23.47	–6.97	0.18	0.17
ASGT	113.651	46.331	26.06	–6.66	0.36	0.3
BDRU	112.865	48.503	24.23	–9.08	0.38	0.34
BNTG	111.733	46.698	27.37	–10.3	0.33	0.32
HDUR	107.373	45.232	26.32	–8.86	0.35	0.33
HTBU	109.172	43.091	29.88	–11.25	0.36	0.32
BTSH	109.329	46.218	25.81	–7.18	0.34	0.33
BORU	109.173	43.091	27.95	–7.38	0.39	0.35
TSCH	107.374	45.232	27.53	–7.14	0.33	0.3
URGN	117.100	46.777	28.16	–11	0.42	0.36
TERJ	107.430	47.886	26.62	–14.03	0.49	0.52
HUAN	107.240	47.986	29.02	–13.97	0.53	0.58
WNDY	107.173	47.590	30.79	–14.55	0.34	0.36
GUNJ	107.111	48.019	32.53	–8.26	0.50	0.53
ZNMD	107.035	47.715	28.77	–13.72	0.36	0.38
GUNT	106.744	48.082	30.57	–18.79	0.35	0.38
FERM	106.702	47.727	30.96	–16.11	0.37	0.39
YLMT	106.613	47.502	29.70	–16.44	0.34	0.36
LTUG	106.487	47.674	28.83	–14.77	0.36	0.37
HUST	106.222	47.800	26.38	–18.02	0.61	0.65
EML0	106.607	47.905	16.92	–20.02	4.05	4.50
EML4	106.601	47.911	32.04	–11.89	3.77	4.09
EML5	106.611	47.908	31.06	–7.30	3.90	4.21
EML6	106.600	47.902	23.24	–15.65	3.96	4.62
EML7	106.612	47.903	27.85	–14.36	0.36	0.37
EML8	106.573	47.909	22.69	–6.45	3.57	3.95
EML9	106.612	47.919	17.49	–0.54	4.09	4.87

Preliminary results of the “Ulaanbaatar” polygon



The sites at the polygons under study were shifted at velocities from 30 mm/yr (TERJ) to 36 mm/yr (GUNT), and strain rates were variable within the range from $3*10^{-8}$ to $6.5*10^{-7}$ yr^{-1}.

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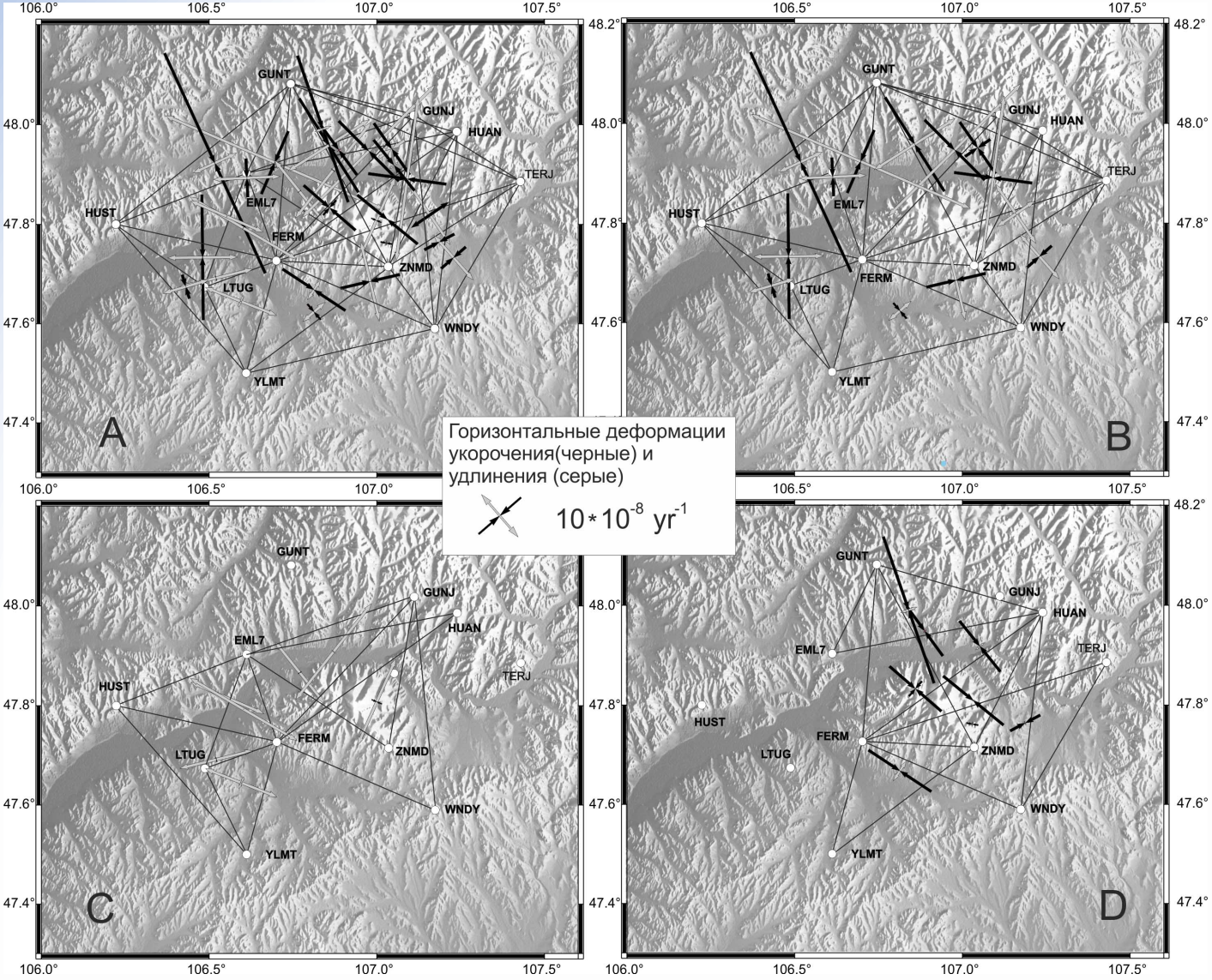
Horizontal deformation on “Ulaanbaatar” GNSS network



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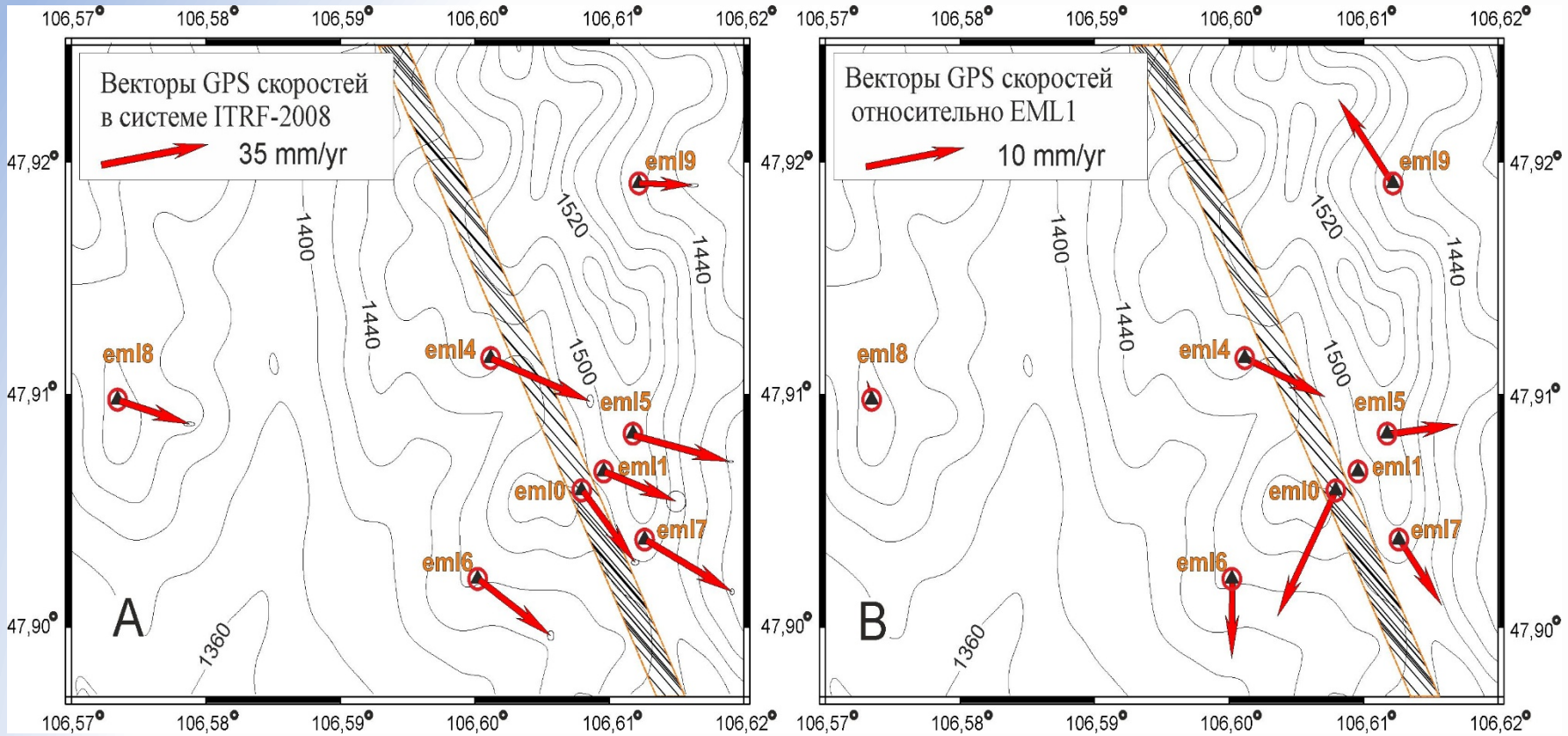
Preliminary results of the “Emeelt” polygon



The sites at the polygons were shifted at velocities from 17.5 mm/yr (EML9) to 32 mm/yr (EML5) and direction of the vectors varies from 92 to 140 degrees. Such variations associated that points in the polygon "Emeelt" substantially disposed within the seismogenic structure. Accordingly, the relative deformation, manifested at the site, are characterized by considerable variation both in strain rate and types.

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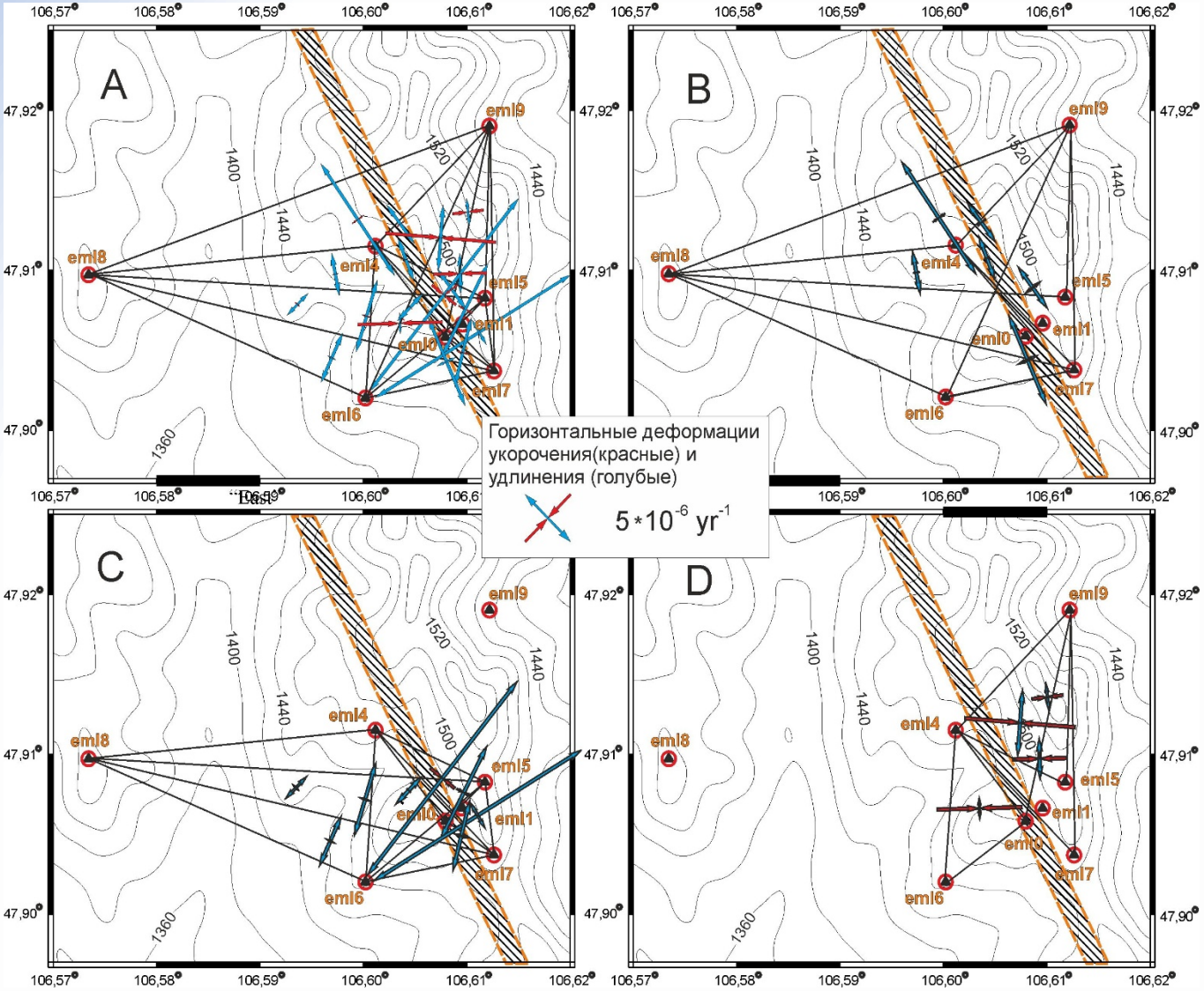
Horizontal deformation on “Emeelt” network



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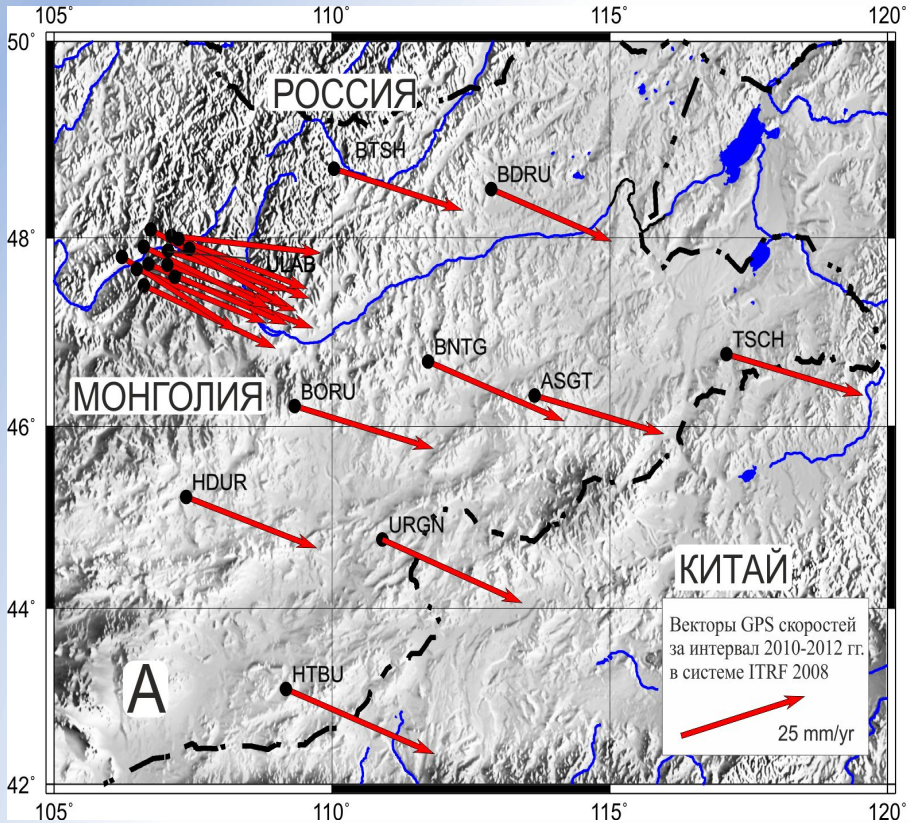
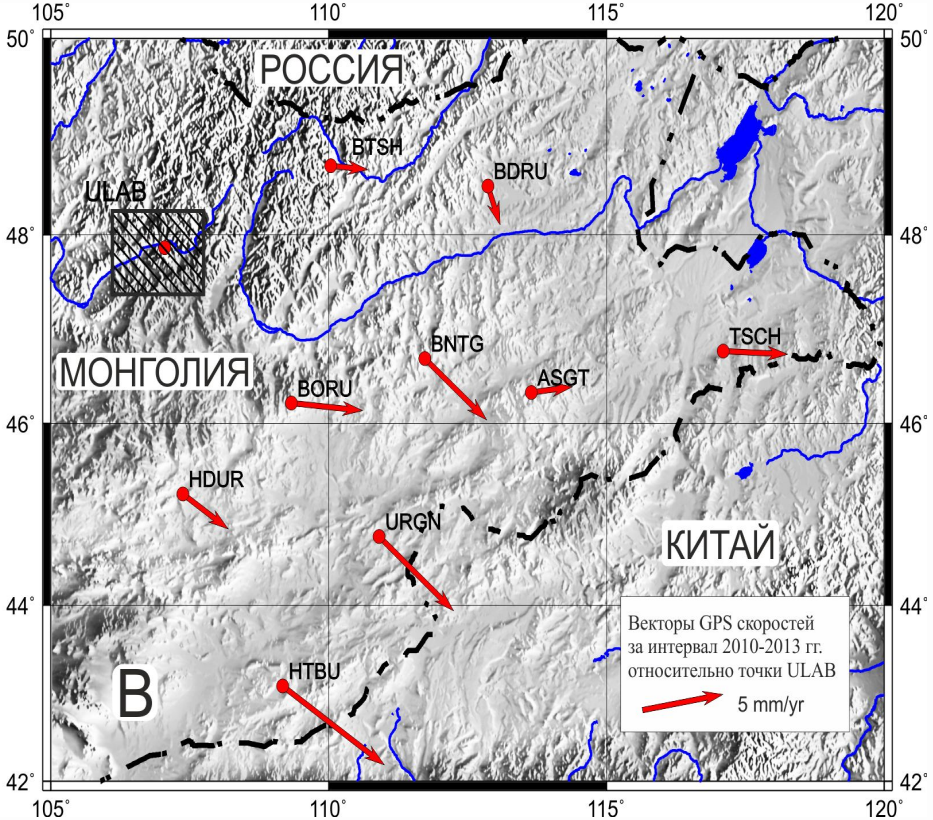
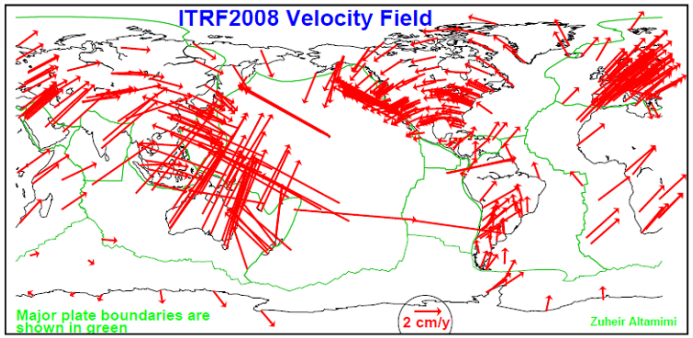
Horizontal velocities of the networks







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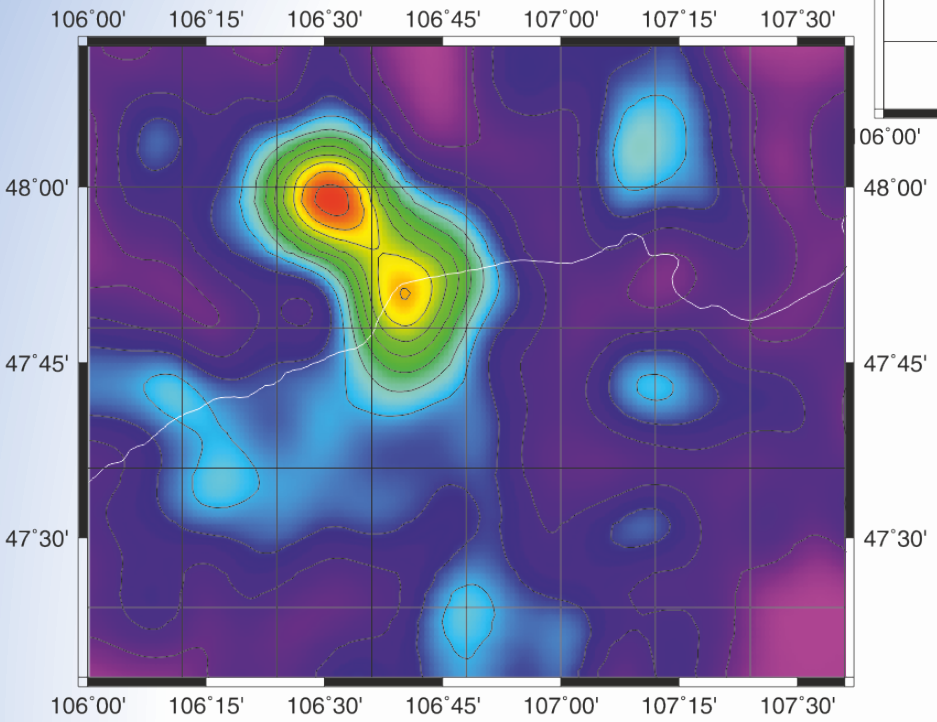
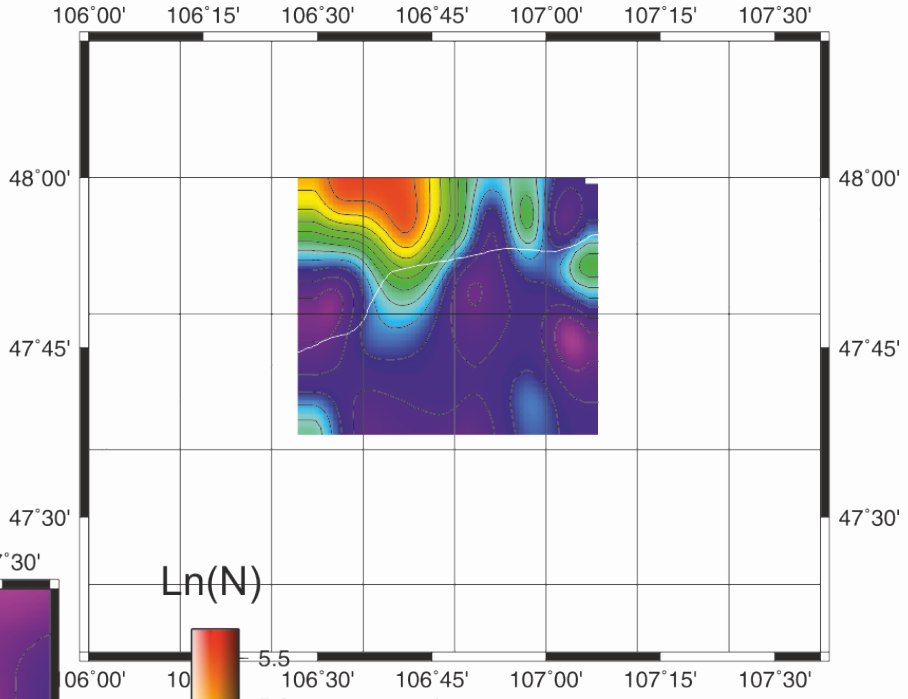
By seismic data





By GNSS measurement data

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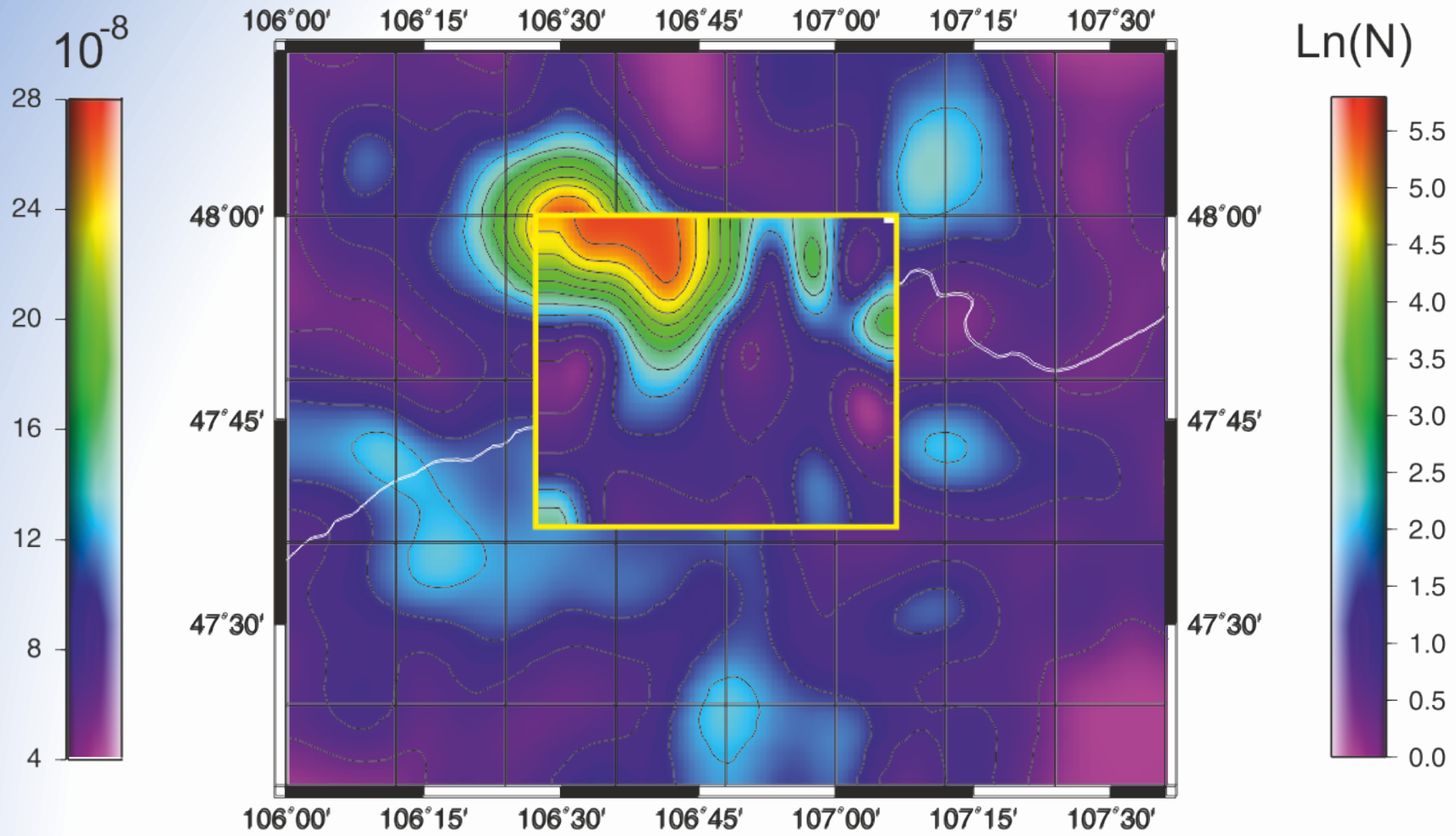
Seismic + GNSS data



Permanent GNSS stations– for geodynamic application

An assignment of the second stage of our program was designing and planning for network of permanent GNSS stations in Ulaanbaatar regions based on the results of first stage.

Now within the second stage, we did installation of permanent stations around Ulaanbaatar region. The structure of database was developed which received from GNSS monitoring. Software development of automatic calculation, monitoring the velocity of relative deformations for earthquake prediction is beginning.

Permanent GNSS station – UG05

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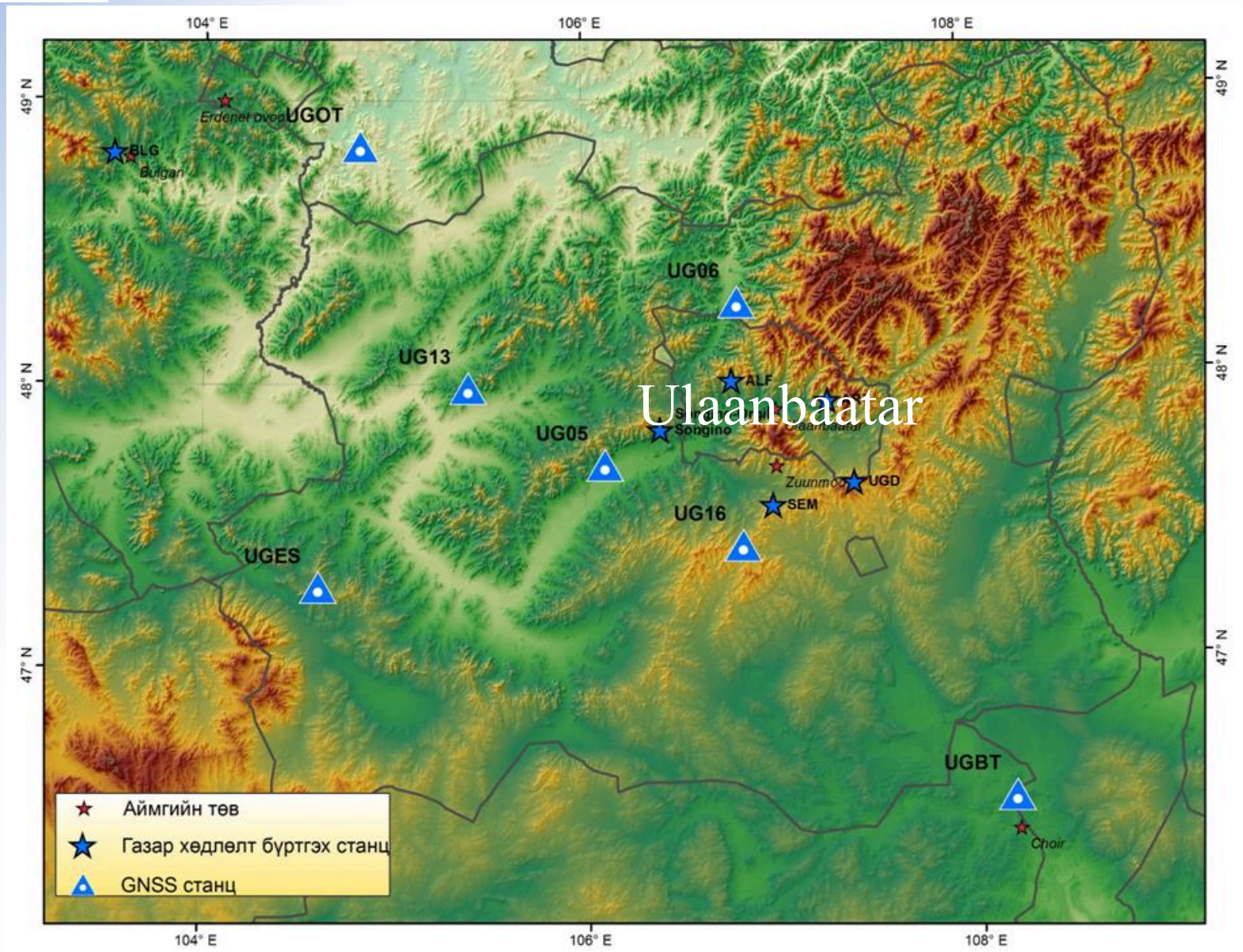
Permanent GNSS stations installed by IAG



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Summary

- ✓ The geodynamic networks have been designed and established in the territory of the eastern Mongolia and in the vicinity of Ulaanbaatar. Regular observations were conducted at 25 GNSS sites from 2010 to 2015.
- ✓ By results of measurements in 2010-2014, the preliminary sizes of modern horizontal velocities on points of the East, Ulaanbaatar and Emeelt polygons have been allowing to estimate that deformations of a terrestrial surface in the central and east regions of Mongolia.
- ✓ The method of research of geodynamic parameters fulfilled in tectonic active regions of Mongolia, and numerical values of modern deformations received by means from these methods. It will be used at an assessment of environmental, social and economic risks of development of Mongolia and Baikal regions.
- ✓ The results of measurements at the Ulaanbaatar testing area will be implemented for assessment of deformation of the Earth's surface in Ulaanbaatar and its vicinity.

Thank you for your attention