Present-day crustal deformation of Georgia (Caucasus)

Giorgi Sokhadze[1], Galaktion Hahubia[2], Manana Kachakhidze[3], Giorgi Khazaradze[4]*

[1] Geosciences and Technology Development Institute, Tbilisi, Georgia

[2] National Agency of Public Registry, Ministry of Justice of Georgia, Tbilisi, Georgia

[3] Saint Andrew the First-Called Georgian University of the Patriarchate of Georgia, Tbilisi, Georgia

[4] Grup RISKNAT, Institut Geomodels, University of Barcelona, Faculty of Earth Sciences, Department of Earth and Ocean Dynamics, Barcelona, Spain

*Corresponding author: gkhazar@ub.edu

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Giorgi Sokhadze, Galaktion Hahubia,
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EGU2020-8100
Session: **Active Tectonics and Geodynamics of Eastern Mediterranean**
TS5.5/GD7.6/NH4.14/SM2.12

Thu, 07 May, 14:00–15:45 | D1237

Abstract

The republic of Georgia is located in the Caucasus, between the Black and Caspian seas from the west and the east, and Greater and Lesser Caucasus mountains from the north and the south. Tectonically, the region belongs to the Alpine-Himalayan collisional zone, formed during the late Cenozoic period as a result of a collision between the Arabian and Eurasian plates. The deformation zone due to this collision is broad and extends from Zagros mountains in southern Iran to the Greater Caucasus in the north. The GPS studies conducted during the last decade suggest a convergence rate of 18 mm/yr between the Arabia and Eurasia plates. Although majority of this convergence occurs in the southern part of the deformation zone, important part of this convergence takes place in Georgia, implying an elevated seismic risk in the region. This is corroborated by a presence of significant historical and instrumental earthquakes in the country.

As part of the project dealing with the detection of possible low frequency electromagnetic emissions proceeding earthquakes, in summer of 2016 we have installed a continuous GNSS station MTSK between Mtskheta and Tbilisi. The station consists of Leica GRX1200 GNSS receiver with an AS10 antenna. It is mounted on top of the building, anchored to the existing brick wall. In contrast, principal convergence between the Lesser and Greater Caucasus across the Tbilisi segment, occurs along the northern boundary of the Lesser Caucasus. To constrain the velocity gradient to the northern boundary of the lesser Caucasus, in 2019 an additional continuous GNSS station MKRN was installed in this deformation zone by the GTDI near the settlement of Mukhrani. It consists of Trimble 5700 receiver with a Zephyr Geodetic antenna.

The analysis of the data is performed using the Gamit/Globk software package from MIT and it is processed in conjunction with 26 continuous GNSS stations of the GEO-CORS network operated by National Agency of Public Registry of Georgia (*geocors.napr.gov.ge*). In addition, we analyze data form the stations located on Eurasia, Arabia and Africa plates. The principle objective of the given work is to monitor millimeter level deformation of the crust due to the collision of Arabia and Eurasia tectonic plates and identify the regions of higher deformation and relate them to individual faults.

Objectives

Derive and update the 3D GPS velocity field of the Caucasus, with a special emphasis on Georgia, using GPS continuous data from 2011 to 2019.

➢ Identify areas with active deformation

➢ Correlate the results with geological and anthropogenic processes

➢ Establish new CGPS stations

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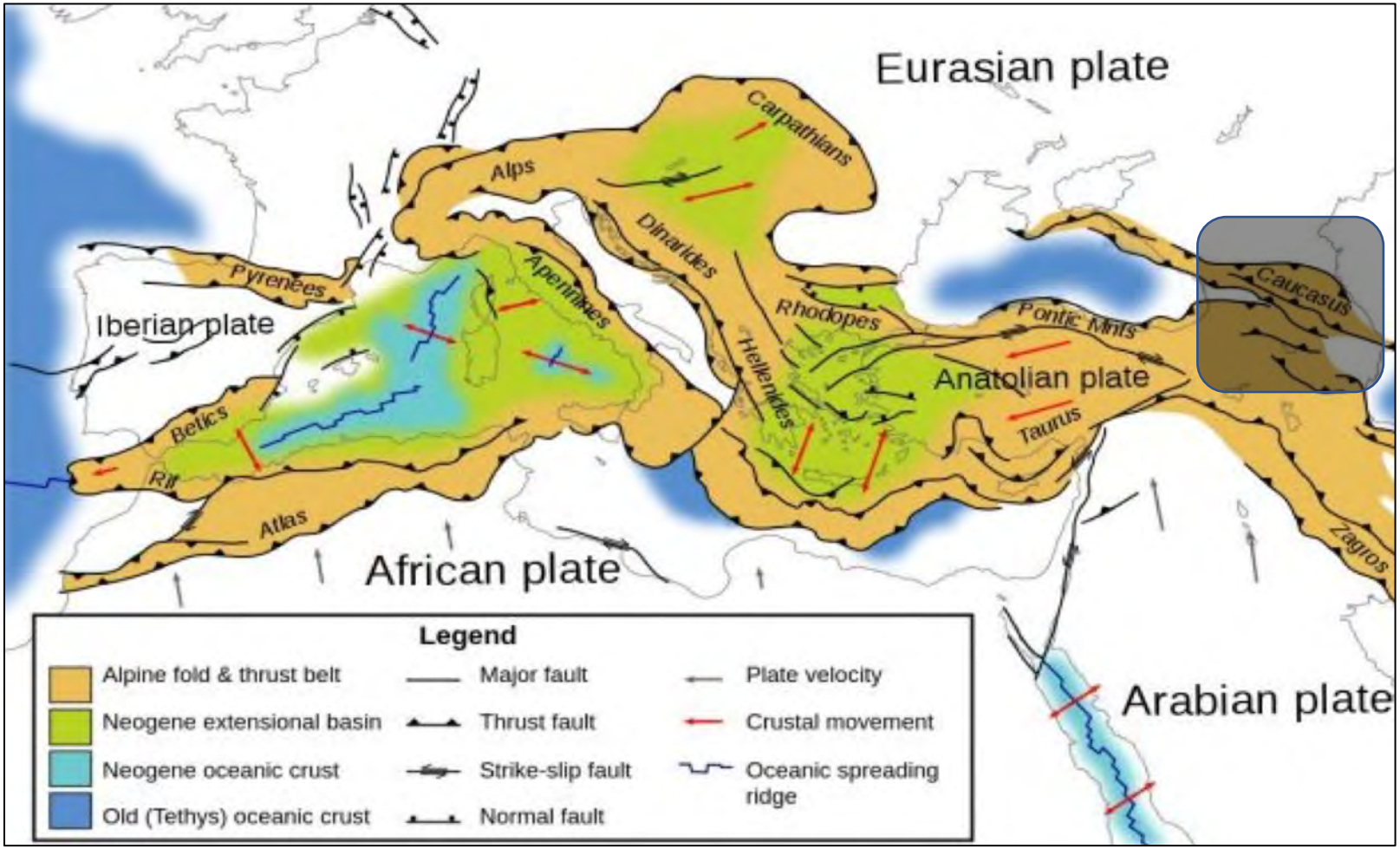
The study area: Caucasus



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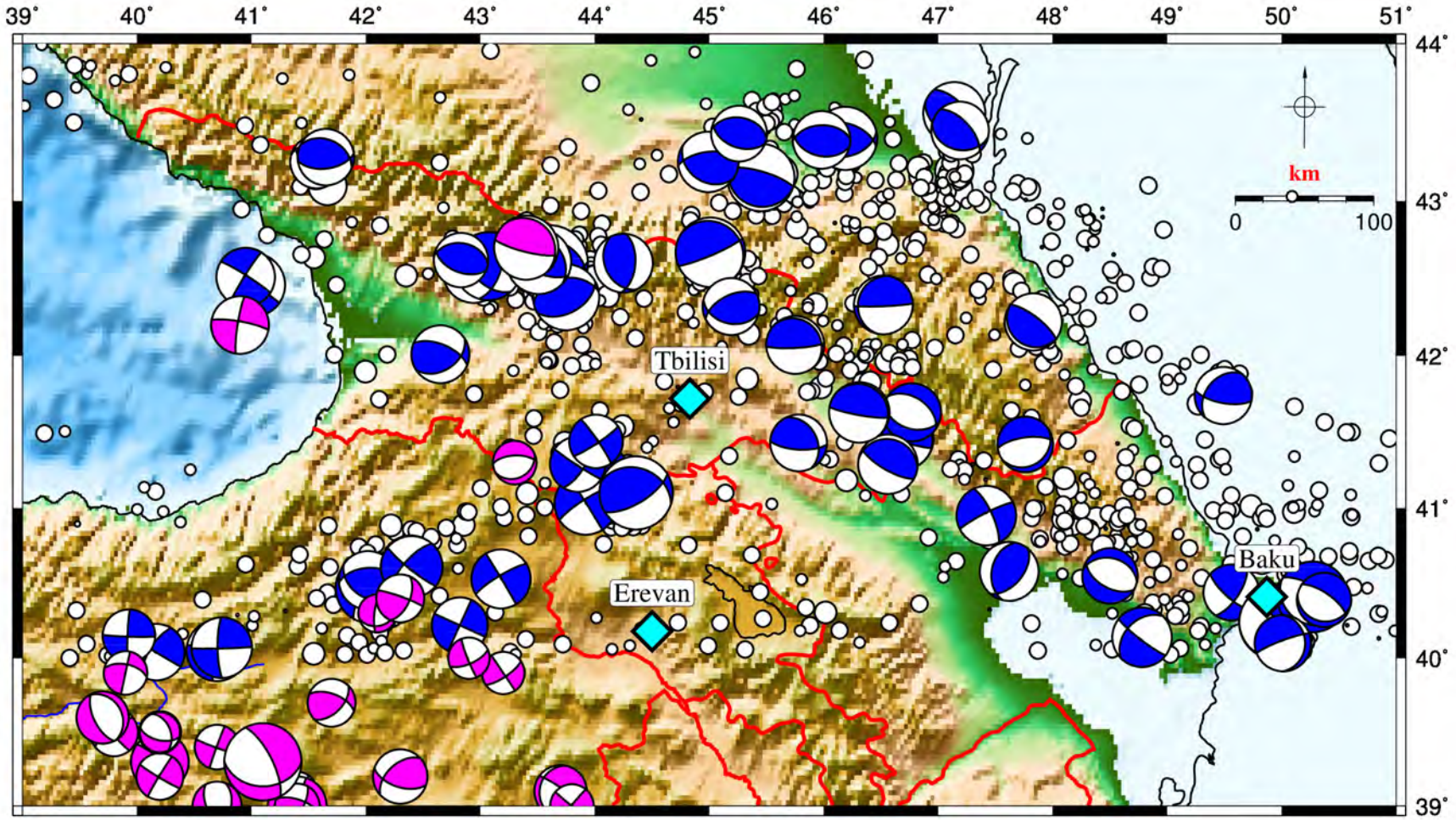
Caucasus: seismicity



The focal mechanisms come from the SesimQuery of IRIS (http://ds.iris.edu/SeismiQuery/sq-eventsmag.htm) (blue) and the Turkish DDA catalog (magenta) (see Tuba Kadirioğlu et al., 2016).

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Previous geodetic studies

Reilinger, R., McClusky, S., Souter, B.J., Hamburger, M.W., Prilepin, M.T., Mishin, A.A., Guseva, T., Balassanian, S., **1997**. Preliminary estimates of plate convergence in the Caucasus collision zone from Global Positioning System measurements. Geophys. Res. Lett. 24, 1815–1818.

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Kadirov, F., Floyd, M., Alizadeh, A., Guliev, I., Reilinger, R., Kuleli, S., King, R., Nafi Toksoz, M., **2012**. Kinematics of the eastern Caucasus near Baku, Azerbaijan. Nat. Hazards 63, 997–1006. https://doi.org/10.1007/s11069-012-0199-0

Karakhanyan, A., Vernant, P., Doerflinger, E., Avagyan, A., Philip, H., Aslanyan, R., Champollion, C., Arakelyan, S., Collard, P., Baghdasaryan, H., Peyret, M., Davtyan, V., Calais, E., Masson, F., **2013**. GPS constraints on continental deformation in the Armenian region and Lesser Caucasus. Tectonophysics 592, 39–45. https://doi.org/10.1016/j.tecto.2013.02.002

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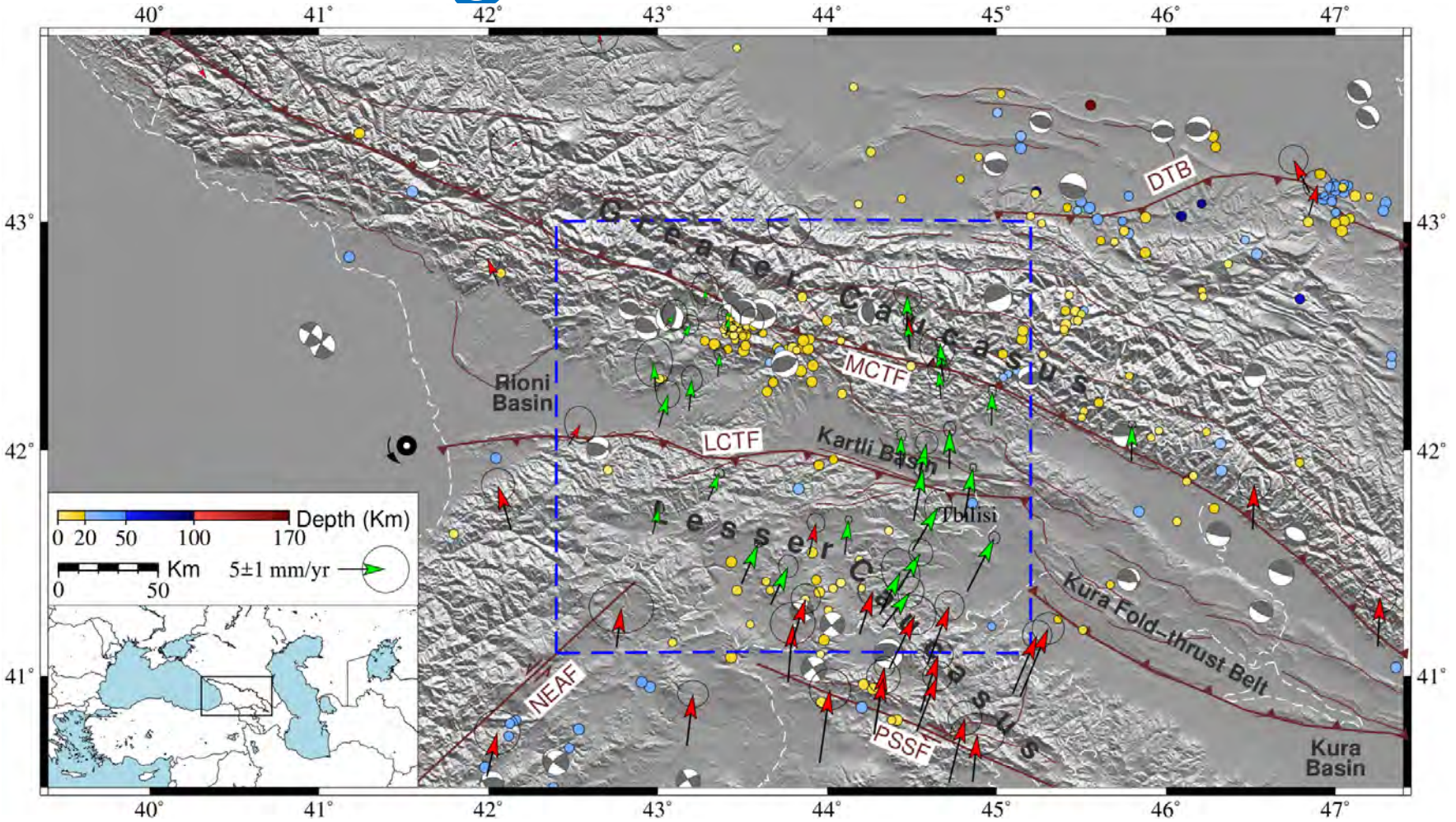
Sokhadze, G., Floyd, M., Godoladze, T., King, R., Cowgill, E.S., Javakhishvili, Z., Hahubia, G., Reilinger, R., **2018**. Active convergence between the Lesser and Greater Caucasus in Georgia: Constraints on the tectonic evolution of the Lesser–Greater Caucasus continental collision. Earth Planet. Sci. Lett. 481, 154–161. https://doi.org/https://doi.org/10.1016/j.epsl.2017.10.007

Previous geodetic studies



Map showing GPS velocities relative to Eurasia with 95% confidence ellipses, where **red** vectors are from Reilinger et al., [2006] and Karakhanian et al. [2013] and **green** vectors are from Sokhadze et al., [2018].

From Sokhadze et al., Earth Planet. Sci. Lett., 2018.

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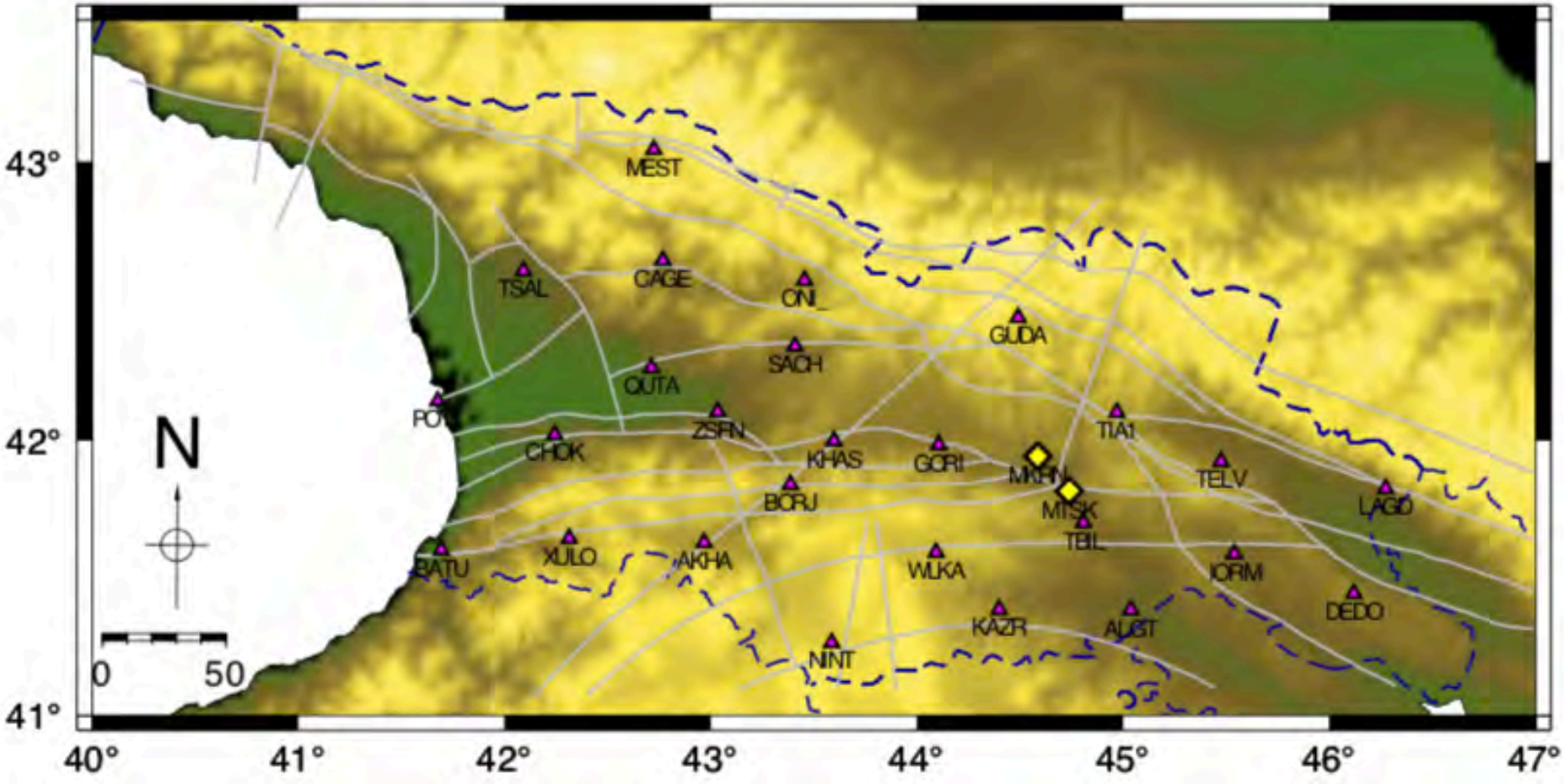
Methods: analyzed CGPS Data



Faults based on: Gamkrelidze, et al., Bull. Georg. Natl. Acad. Sci., 2015

Magenta triangles denote Geo-CORS stations
Yellow diamonds show stations installed by the authors

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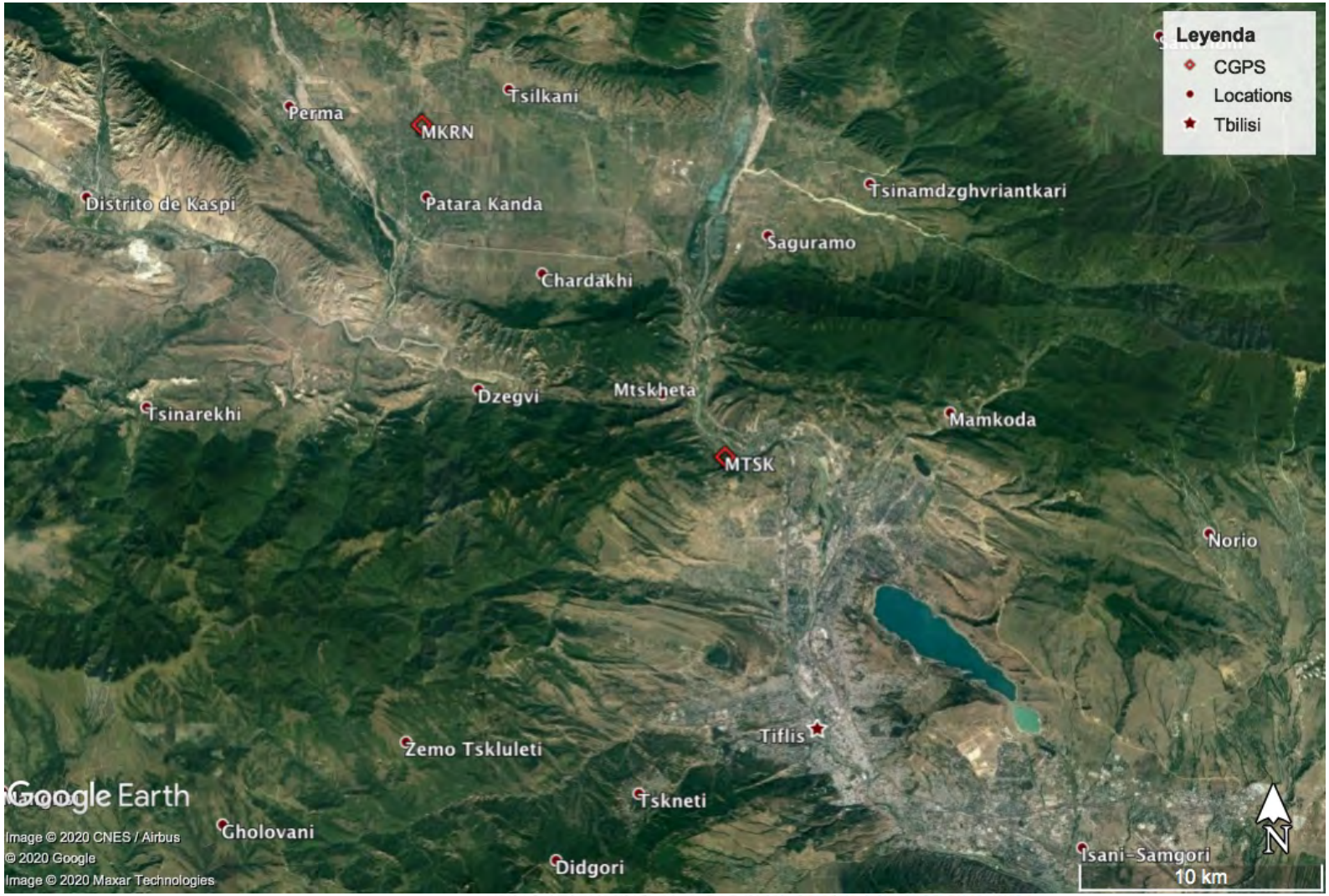
Newly established CGPS stations: MTSK and MKRN



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Methods: newly established CGPS stations: MTSK

On August 17ht of 2016, we have installed a new continuously operating GNSS station between Tbilisi and Mtskheta. It was installed in Mukhatgverdi (მუხათგვერდი), located 10 km to the north from Tbilsisi. We were given permission from the Andronikashvili Institute of Physics (www.aiphysics.tsu.ge), that currently forms part of the Ivane Javakhishvili, Tbilsii State University (www.tsu.ge) to install the station on the territory of their laboratories, that have a 24 hour security.

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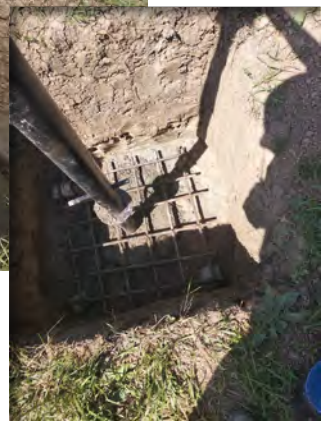
Methods: newly established CGPS stations: MKRN



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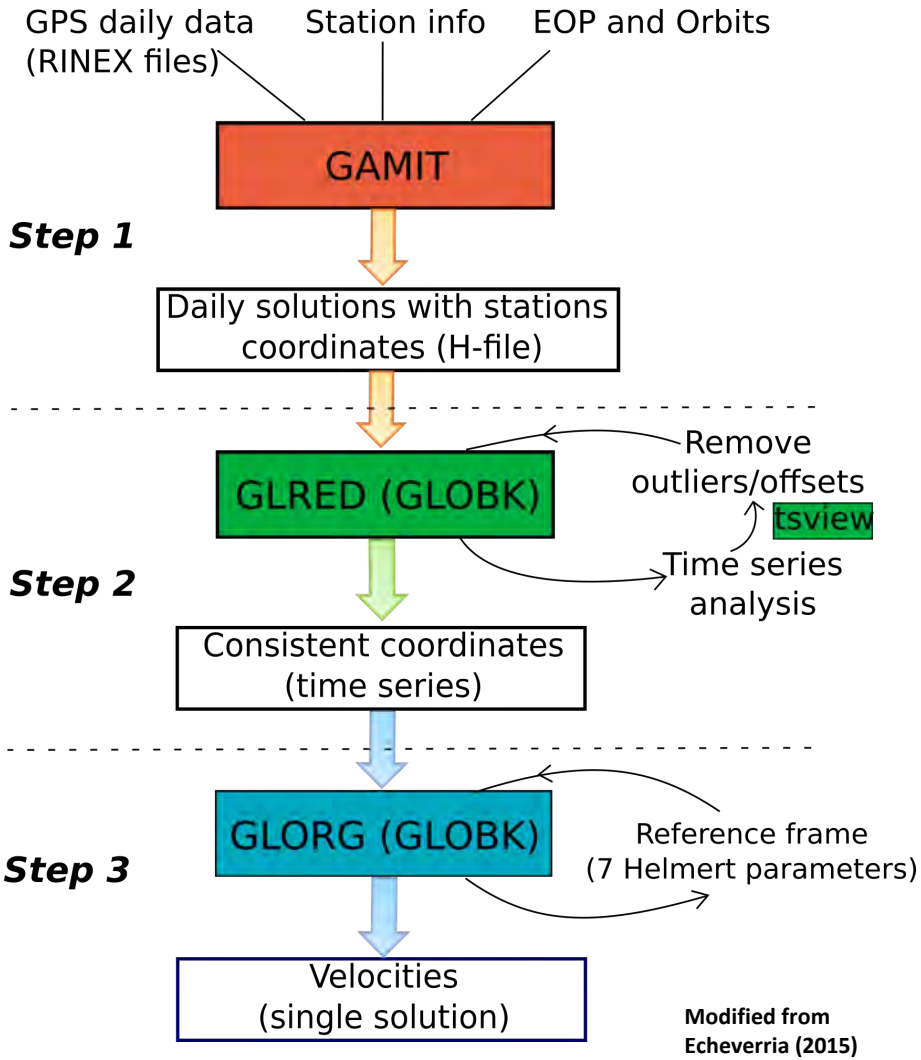
Methods: data analysis

- GAMIT/GLOBK software from MIT
- Three-step approach
- All the steps are performed using several **C-shell** scripts specifically designed for the tasks at the UB



Modified from Echeverria (2015)

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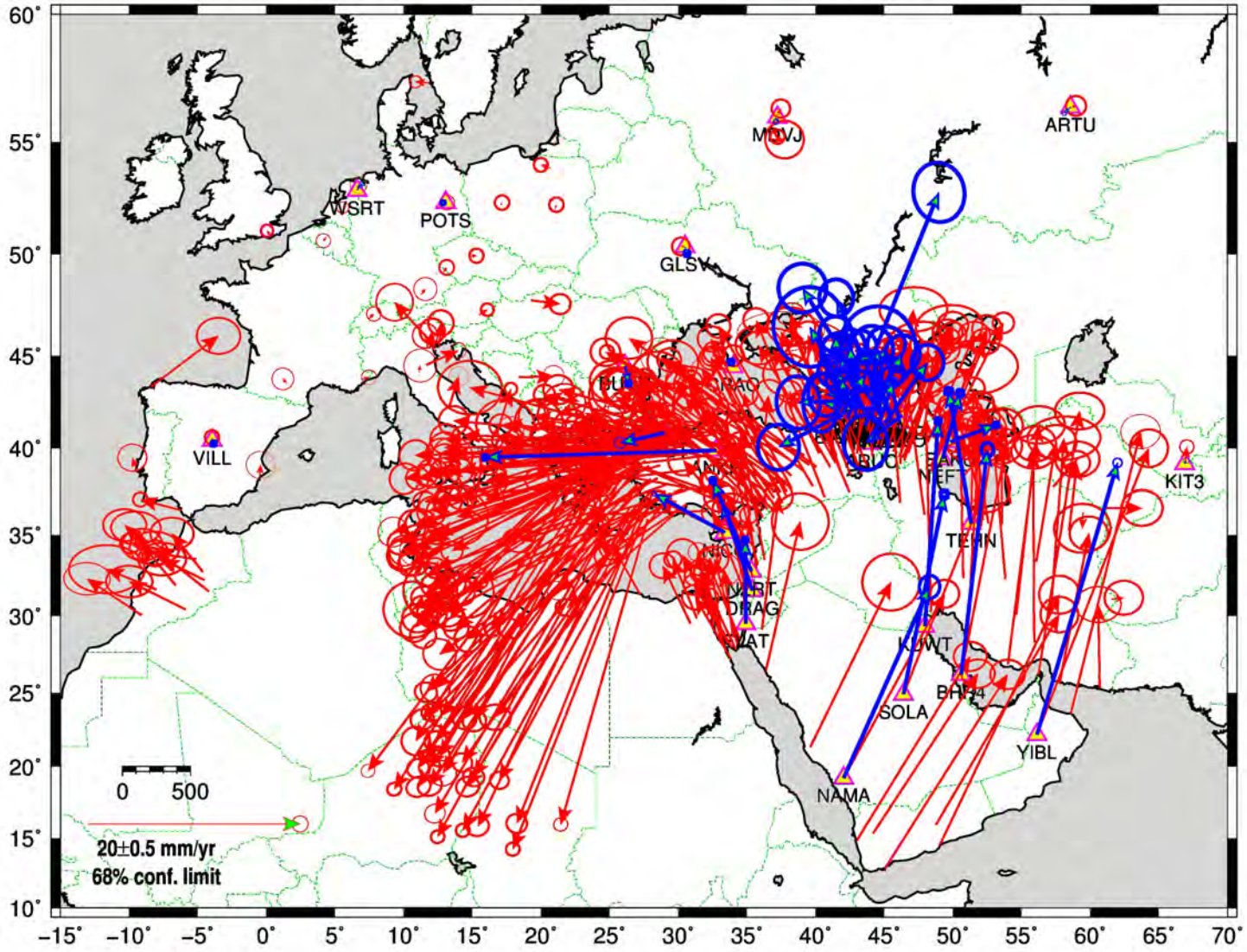
Methods: data analysis



Stations used to define **Eurasia** fixed reference frame

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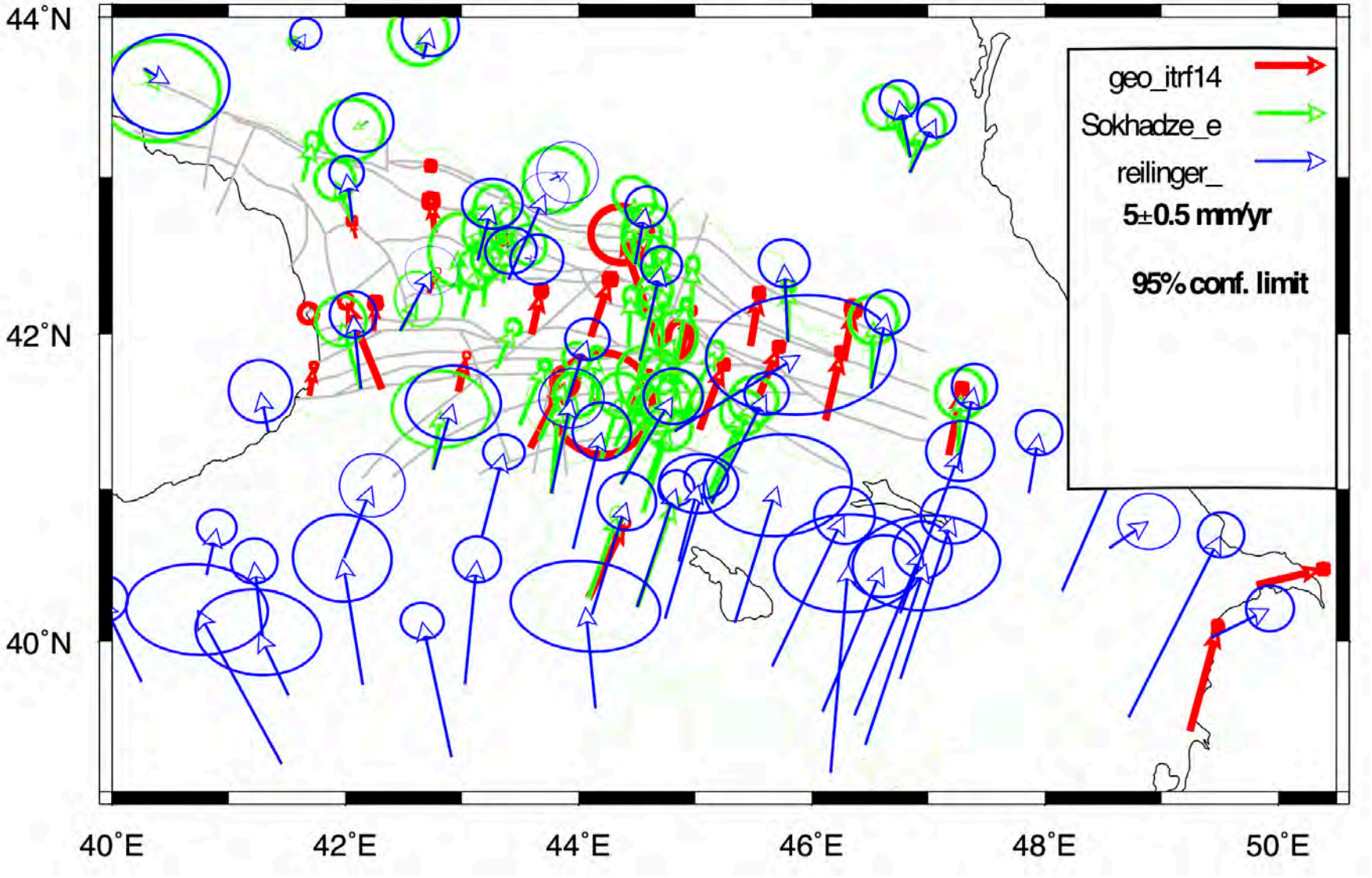
Results: Horizontal Velocities



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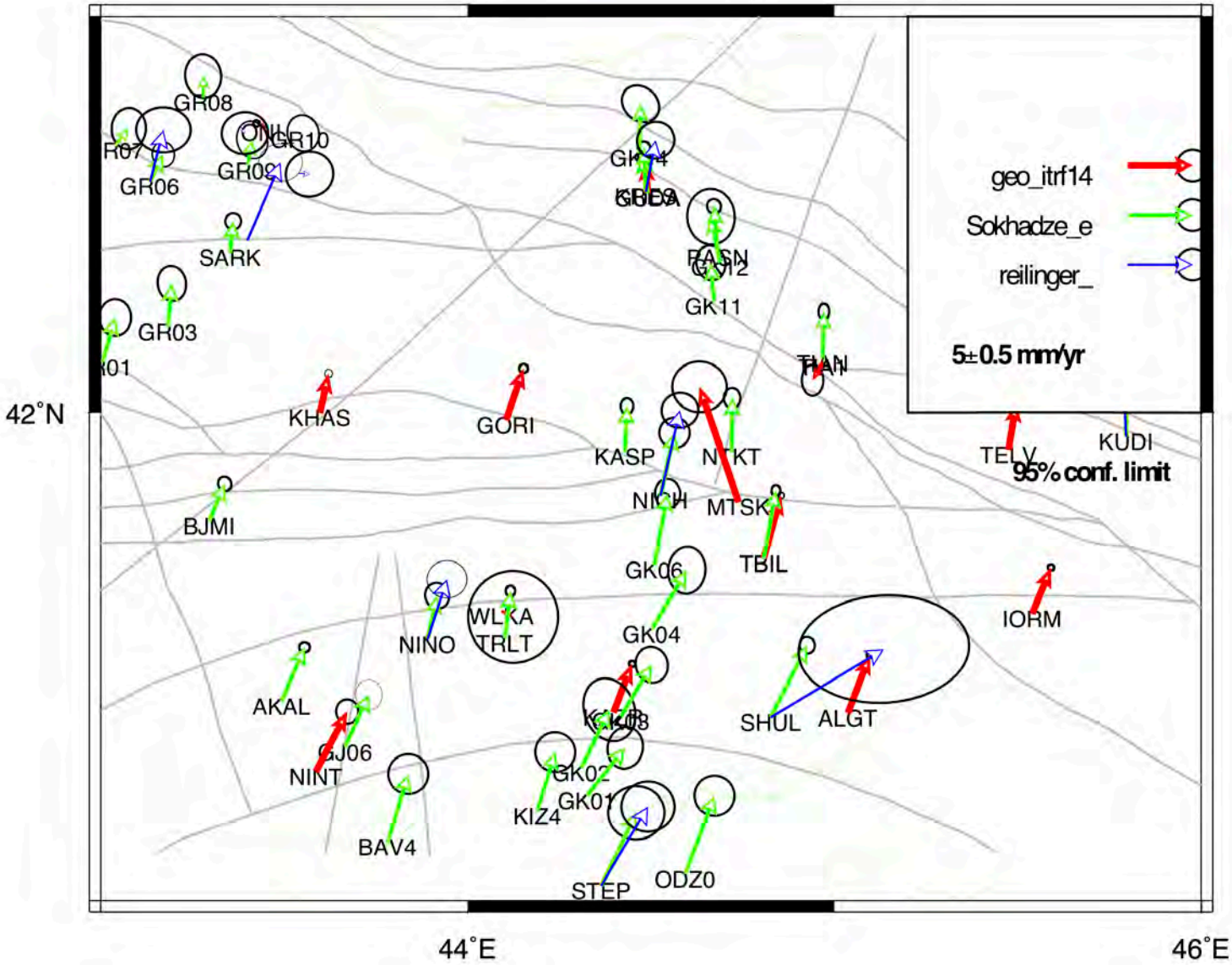

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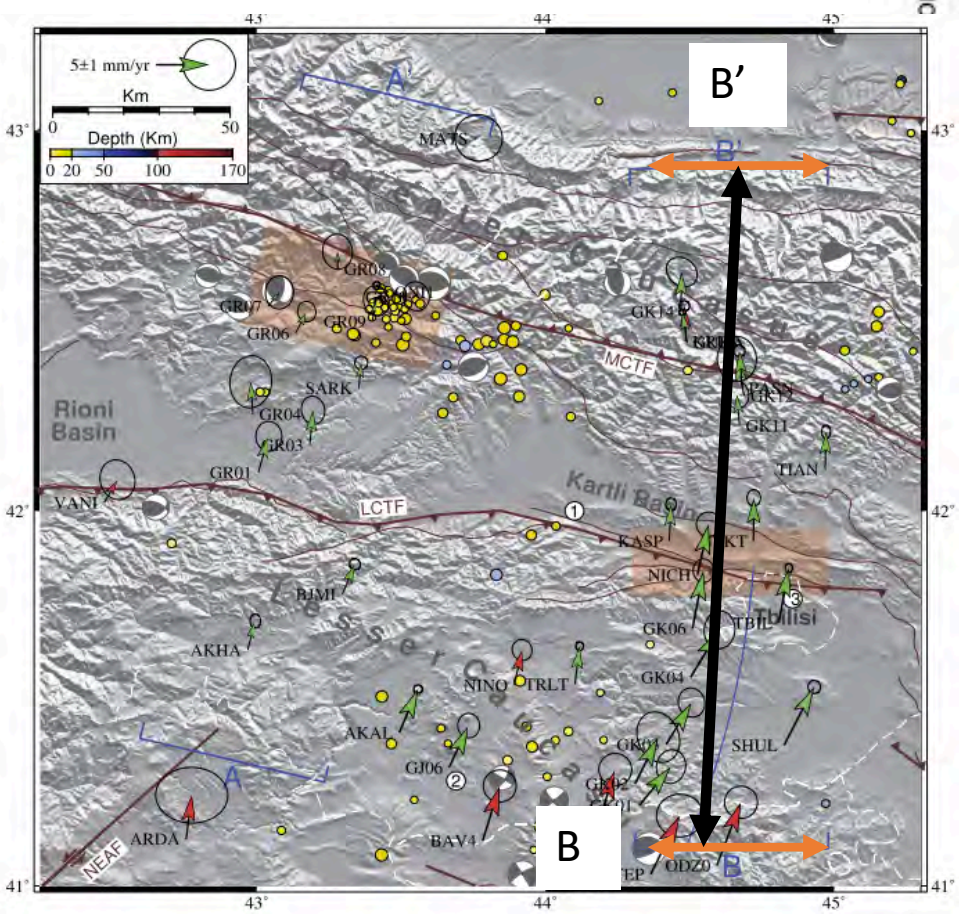
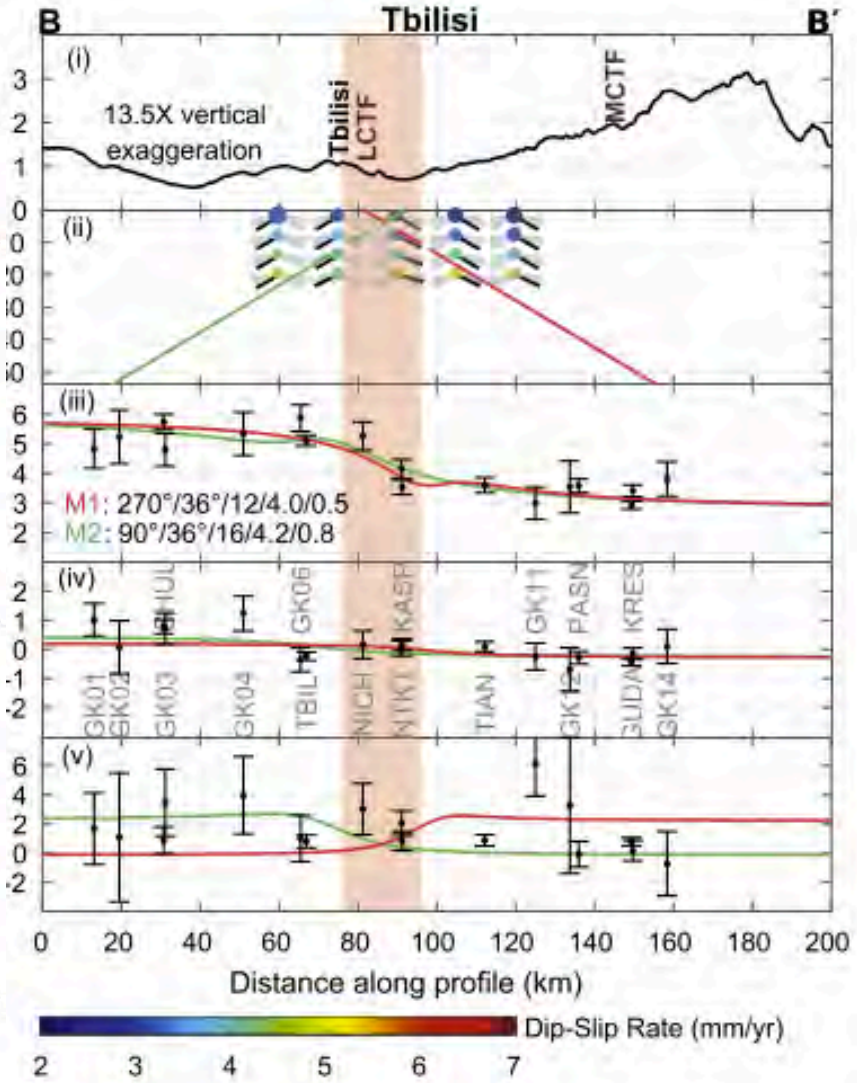
Discussion





GPS velocities with respect to Eurasia with 1-sigma uncertainties plotted versus distance along the profile B-B'.

From Sokhadze et al., Earth Planet. Sci. Lett., 2018.

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Conclusions

- The Caucasus region is presently tectonically active and deforming.
- The velocity field is relatively homogenous, although some anomalous motions can be detected.
- Convergence between the Lesser and Greater Caucasus along the eastern Rioni Basin is primarily accommodated on a north-dipping fault system along the southern margin of the Greater Caucasus, consistent with the location and fault parameters reported for the 1991, M_w6.9 Racha Earthquake [Triep et al., 1995].
- Towards the east, the deformation is concentrated north of Tbilisi, possibly related to the incipient collision between the Lesser and Greater Caucasus.
- Ongoing investigations promise to better characterize the source of observed strain, and accordingly, implications for seismic hazards and the tectonic evolution of the region.

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Triep, E.G., Abers, G.A., Lerner-Lam, A.L., Mishatkin, V., Zakharchenko, N., Starovoit, O., 1995. Active thrust front of the Greater Caucasus: The April 29, 1991, Racha earthquake sequence and its tectonic implications. J. Geophys. Res. 100, 4011. https://doi.org/10.1029/94JB02597

Acknowledgments

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We are grateful to the Andronikashvili Institute of Physics (*www.aiphysics.tsu.ge*) for letting us use their facility for the installation of the GNSS station.

Also, thanks to Rob Reilinger to initiate GPS work in this part of the world more than 20 years ago.

Thanks!

მადლობთ!

We surely are looking forward to present more definite results during the next EGU General assembly next year in Vienna.

Meanwhile, the best wishes to all during these hard times.

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