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Seismicity of the Caucasus region: a comprehensive, revised catalog for 1951-2019

Barbara Czecze[1], István Bondár[2], Tea Godoladze[3], Gurban Yetirmishli[4], Rengin Gök[5]

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[1] Roland Eötvös University, Budapest, Hungary
[2] Research Centre for Astronomy and Earth Sciences, Budapest, Hungary
[3] Ilia State University, Tbilisi, Georgia
[4] Republic Seismic Survey Center of ANAS, Baku, Azerbaijan
[5] Lawrence Livermore National Laboratory, Livermore, CA, USA

POSTER

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Motivation

- The Lawrence Livermore National Laboratory (LLNL) and the Institute of Earth Sciences (IES), Ilia State University developed a project to generate a new seismic catalog for Georgia.
- The main objective of the project was to provide **a reliable seismicity map that can be effectively used in a new probabilistic seismic hazard analysis for Georgia**. Monitoring centers in Armenia, and Turkey have also contributed bulletins from their own archives and provided picks for selected events. A subset of events from the IES bulletin was used as an input for the seismic hazard analysis (Onur et al., 2020). This data set is combined with the seismological bulletins of the Republic Seismic Survey Center (RSSC) and the International Seismological Centre (ISC) bulletin.
- **We present the relocation results of more than 20,000 events in the bulletin.** We relocated each event with **iLoc**, a single event location algorithm, using Regional Seismic Travel Time (**RSTT**) predictions to improve locations. Using the iLoc results as initial locations, we then applied **Bayesloc**, a multiple event location algorithm, to simultaneously relocate the entire seismicity of the Caucasus region.

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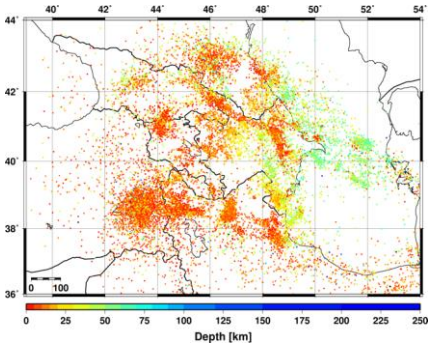
Data sources, initial bulletins

- To create a comprehensive event bulletin for the Caucasus region, we combined the RSSC IES and ISC bulletins:
  - We selected events from the ISC bulletin that have at least four phase arrivals. The IES bulletin consisted of 11,234 events between 1955/01/06 and 2017/11/17, the RSSC bulletin had 20,021 events between 2003/03/31 and 2019/03/19, and the ISC bulletin had 10,550 events between 1951/11/02 and 2018/12/30.

a)



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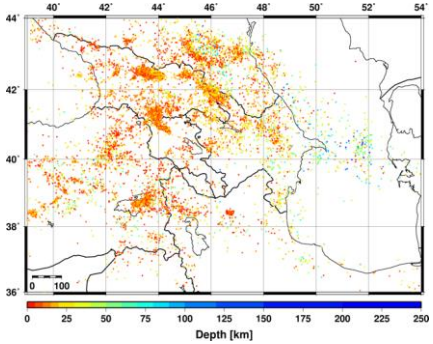

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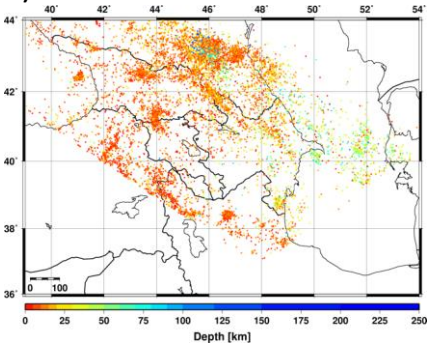

The original a) RSSC, b) IES and c) ISC hypocenters in the Caucasus region

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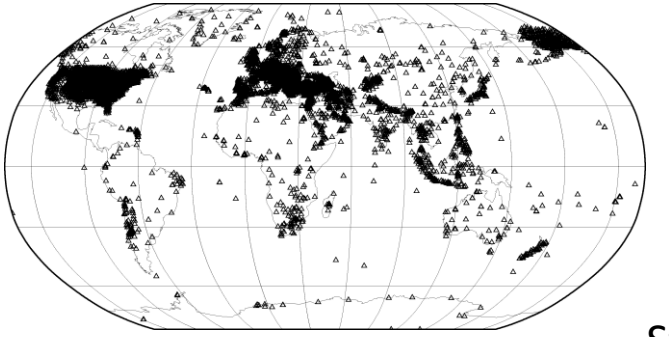
Station coverage

a)



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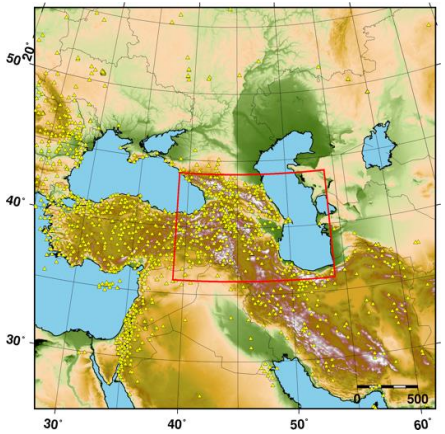

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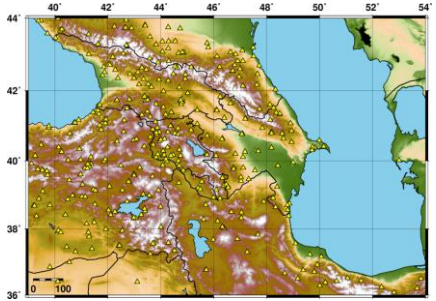

Station coverage in the comprehensive Caucasus bulletin. Triangles show the stations used in the relocations in **a)** teleseismic and **b**) regional distances. The red rectangle denotes the region of interest for the relocation. **c)** Stations within the region of interest.

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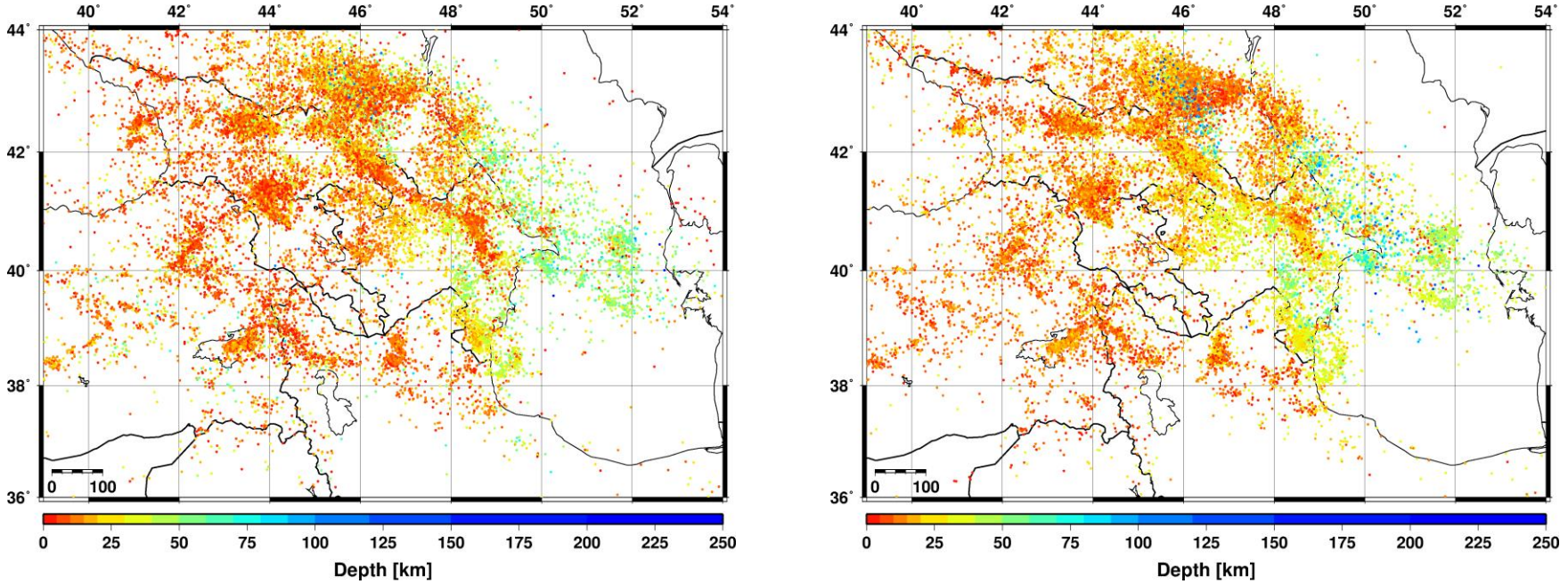
iLoc relocations using RSTT I.



Seismicity map from a) the initial Caucasus bulletin and b) the *iLoc* relocations with RSTT.

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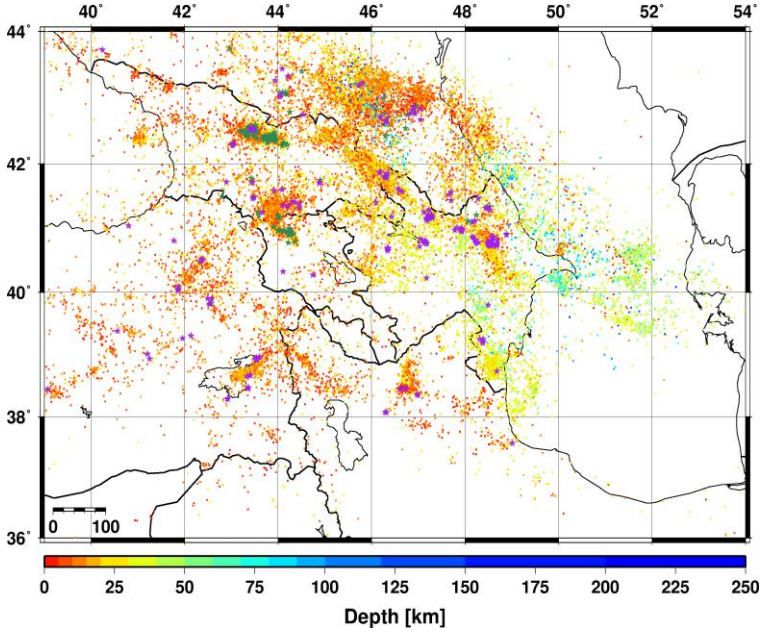
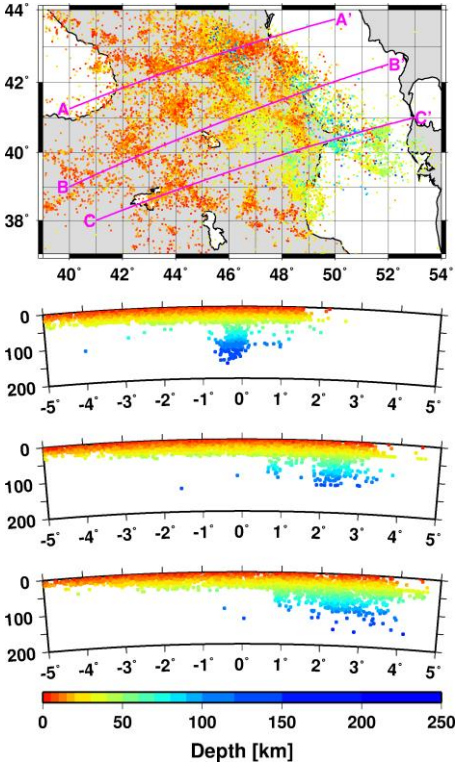
iLoc relocations using RSTT II. (reviewed)



Seismicity map of the Caucasus region obtained with iLoc using RSTT travel time predictions for crustal and mantle phases after manual reviewing process. Green stars denote the ground truth events listed in the IASPEI Reference Event List maintained at the ISC; magenta stars indicate the new GT5 events identified in this project.



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Bayesloc relocations - Quality control

- We used the *iLoc* relocations as initial locations for *Bayesloc*
- The reviewed *iLoc* bulletin has **26,326** events, but not all of the events are suitable for Bayesloc.
- Removed events or stations:
  - First order selection: **only events with secondary azimuthal gap < 270°** → ~ 18,700 events
  - Second order selection: After an auto Bayesloc test run, events with poor Gelman-Rubin statistics have been removed
  - Stations with poor connectedness are also removed from the data set
- The total number of events that can be determined with Bayesloc is about 14,000

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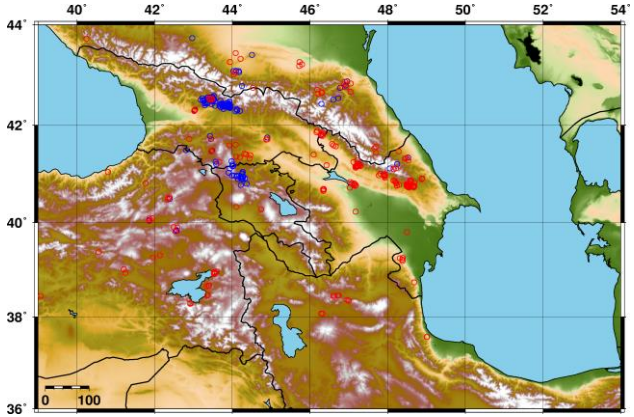
Prior constraints

- *Bayesloc* can use *a priori* information during the relocations to help tighten the *a posteriori* distribution on all parameters and estimating the travel-time corrections.
- In case of ground truth events, we used the **GT hypocenter parameters as priors with relatively tight uncertainties**, otherwise we took **the *iLoc* locations with varying uncertainty** depending on the size of the error ellipse . **Table 1** shows the constraints applied to the different event types.



GT events

Event type	Distance SD	Depth SD	Time SD
Earthquake	semi-major axis of the iLoc error ellipse	-	-
GT (explosion)	5 km	0.1 km	-
GT (earthquake)	5 km	5 km	-

Table 1. Prior Constraints

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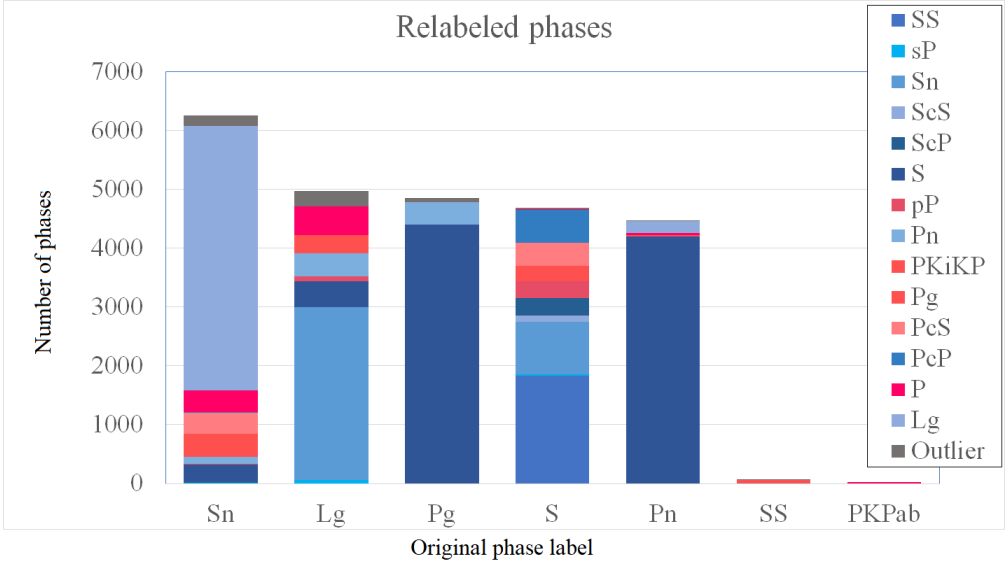
Relabeled phases by Bayesloc



Relabeled phases by *Bayesloc*. The horizontal axis shows the original phase labels; colors indicate the most probable phase label.

Bayesloc can also quantify the probability that an input phase pick was correct or not depending on how well it fits into the model. If the label is deemed incorrect, it relabels the phase or marks it as an outlier There were 25,525 out of 1,387,531 phases reidentified by *Bayesloc*. **Figure** shows the distribution of how the initial phases were relabeled during the *Bayesloc* run.

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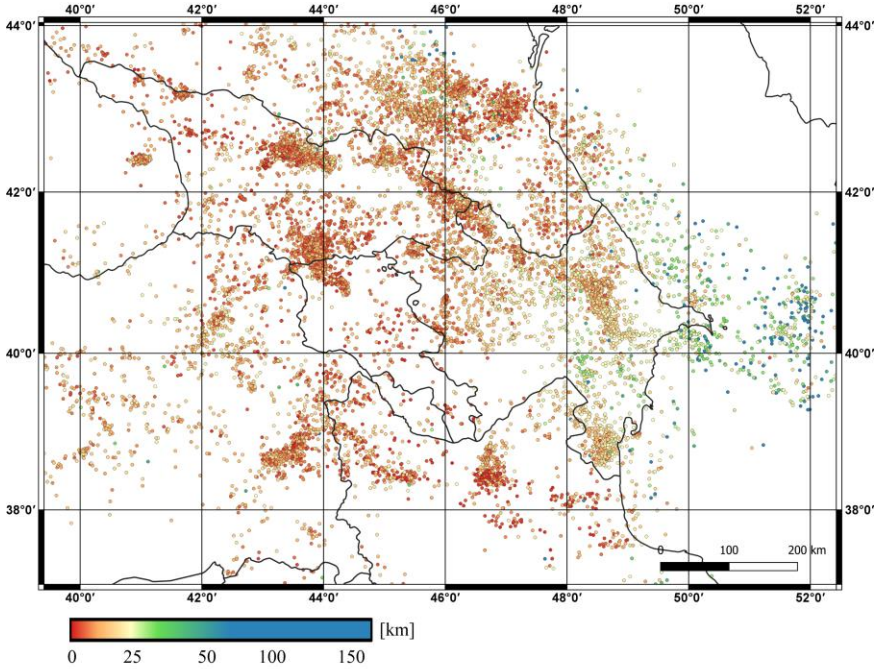
Results

- We performed 15,000 iterations with Bayesloc, using both travel-time and arrival-time corrections
- Bayesloc improves the locations by making the seismicity tighter inside the seismic network.
- The improvements are marginal outside the network.
- Bayesloc requires strict quality control procedures and reasonably well-tuned prior constraints to get the best results.



Bayesloc solutions