



A Comprehensive Earthquake Catalog in Central Asia

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The Lawrence Livermore National Laboratory (LLNL), Michigan State University (MSU), and national data centers in Central Asia (Kazakhstan, Kyrgyzstan and Tajikistan) digitized analog seismic bulletins in order to produce a new, unified seismic catalog. The main objective of the project is to provide a reliable seismicity map for new probabilistic seismic hazard analysis of Central Asia. The national network bulletin data are supplemented by data from the International Seismological Centre (ISC) bulletin.

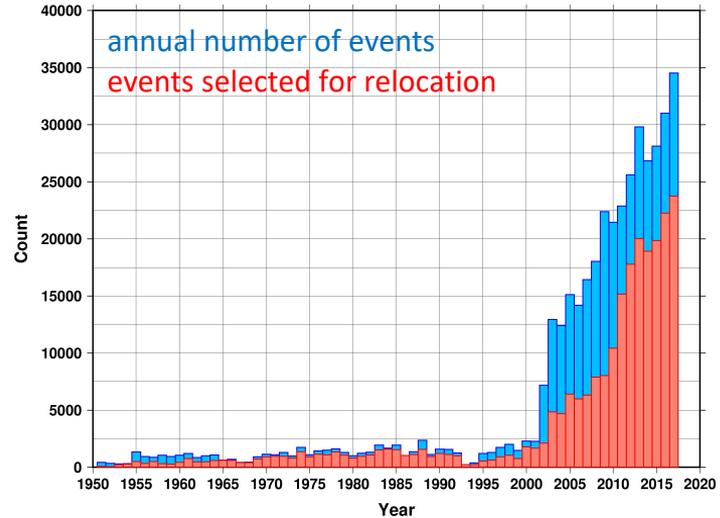
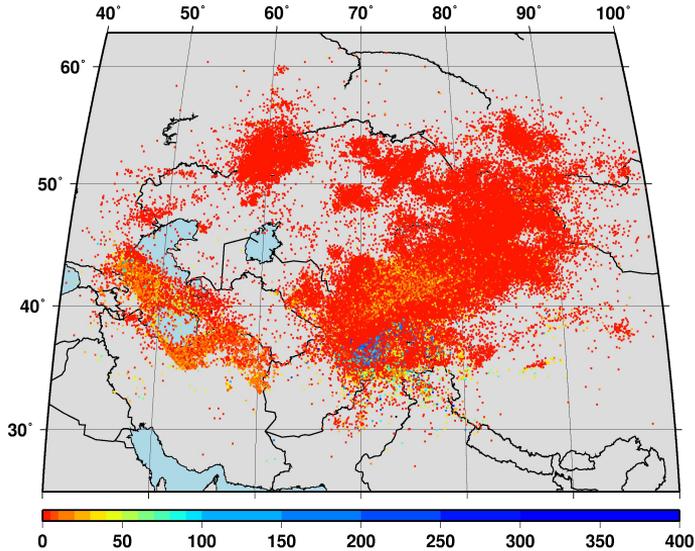
We present the preliminary relocation results of more than 350,000 events recorded by hundreds of seismic stations in the region. Digitized bulletins extend to the early 1950s, providing millions of amplitude and phase arrival data. We relocated each event with iLoc, a single event location algorithm, using both ak135 and Regional Seismic Travel Time (RSTT) predictions to improve locations and to measure the performance of the RSTT model. The results show significant improvements in the understanding of regional seismicity in Central Asia. When data ingestion and relocation are finalized, the result will provide a basis for many other studies (e.g., travel-time tomography, seismicity) that have not been previously possible.

- The Lawrence Livermore National Laboratory (LLNL) and Michigan State University supported National Data Centers in Central Asia (Kazakhstan, Kyrgyzstan and Tajikistan) to compile analog and digital seismic bulletins in order to produce a new, unified seismic catalog.
- The objective of the project is to provide a new probabilistic seismic hazard analysis of Central Asia using the new PSHA-ready catalog.
- In order to improve the catalog for the PSHA, we relocate the compiled bulletin with iLoc using the global 3D RSTT velocity model.

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Compiled bulletin and event selection

METHODS

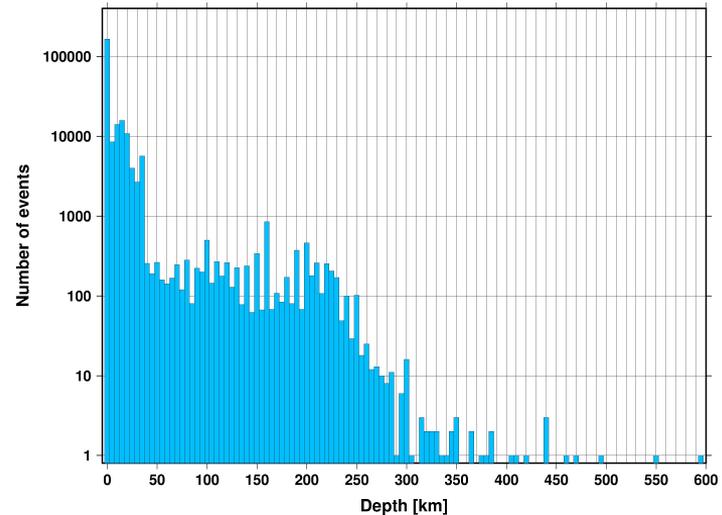
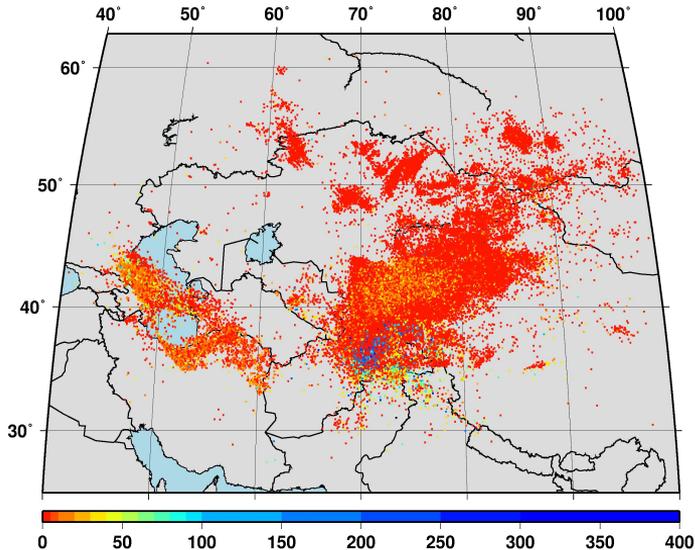


The compiled bulletin consists of **398,728** events. We converted K-class magnitude to M_w using the regression $M_w = 0.474 K\text{-class} - 0.774$ to produce the input data set for the PSHA. To ensure the maximum achievable completeness, we selected events with *magnitude* > 3 and *secondary azimuthal gap* $< 355^\circ$.

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Events selected for relocation

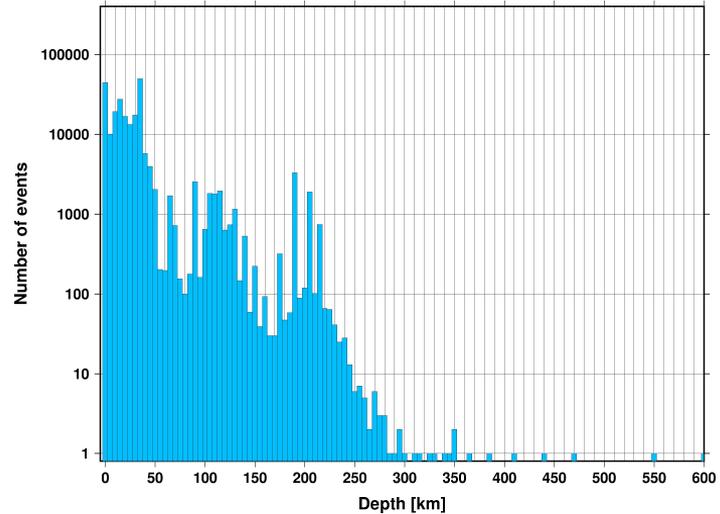
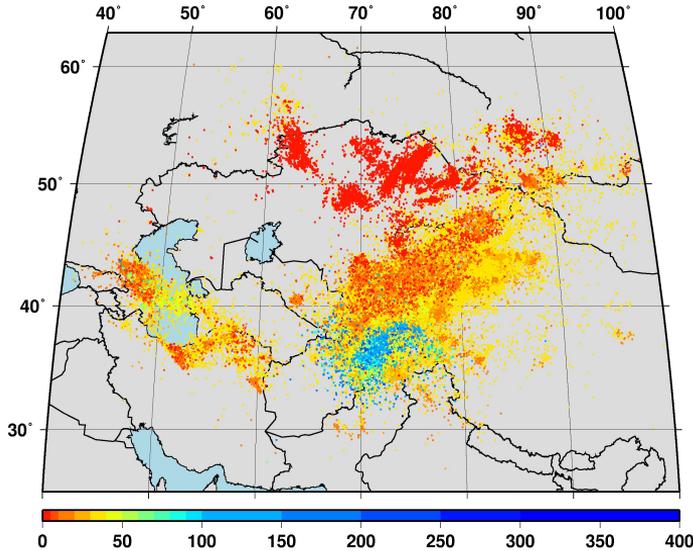
METHODS



The selection procedures kept about two-third of the events, **235,877** for relocation.
 The distribution of intermediate-depth events is quite flat.

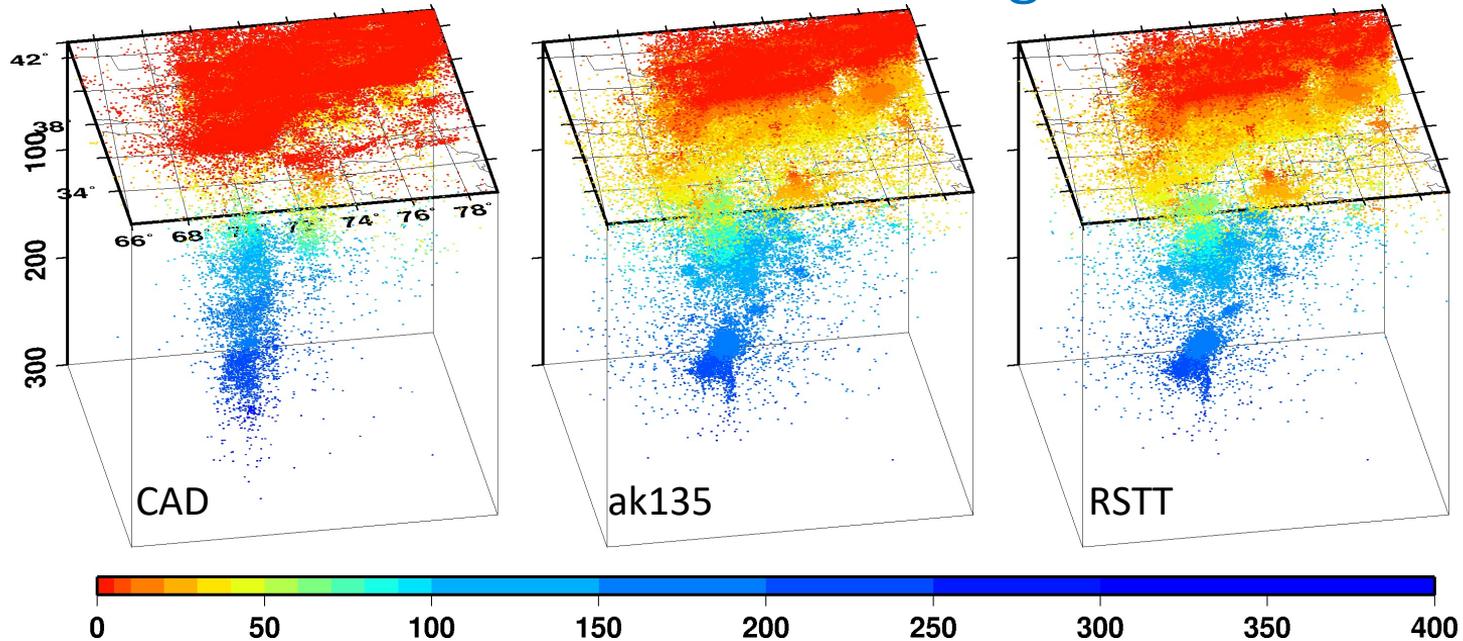
iLoc relocation with RSTT

RESULTS



iLoc dramatically improves both the seismicity map and the depth distribution. The depth distribution indicates two distinct source zones in intermediate depths in the Hindu Kush – Pamir region.

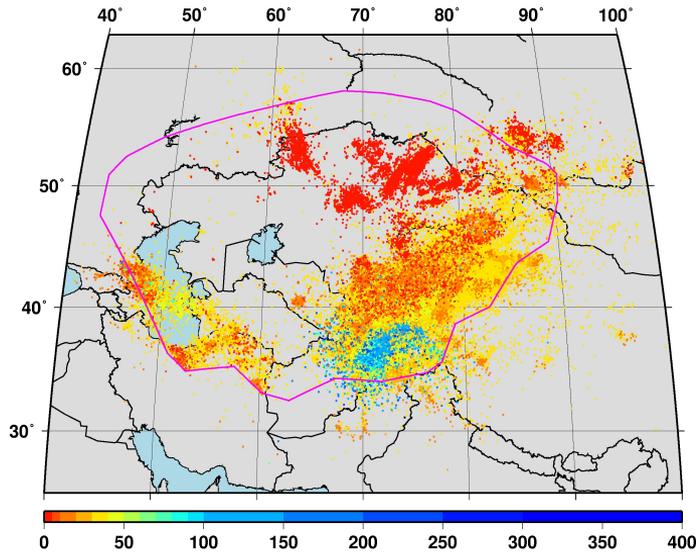
Hindu Kush – Pamir region



The initial Central Asia bulletin locations are dramatically improved by iLoc using ak135.
RSTT provides an even tighter image of seismicity.

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Manual review in the region of interest



The ROI is defined as the boundary of a 300 km wide zone around the Central Asian countries.

Automatic solutions may get stuck in a local minima, produced airquakes or the default depth value was not the best choice for depth. A manual review may also detect split/joined or fake events. No automatic procedure can deal with these issues.

However, it is unrealistic to perform a full manual review on such a large dataset. Even if only two minutes are spent on each event, it would take more than 800 work days to go through the entire bulletin.

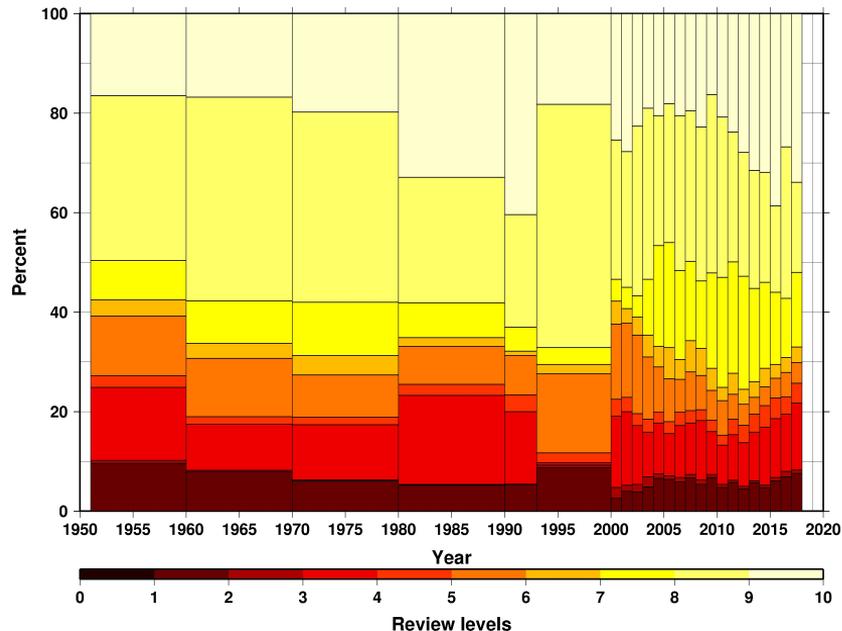
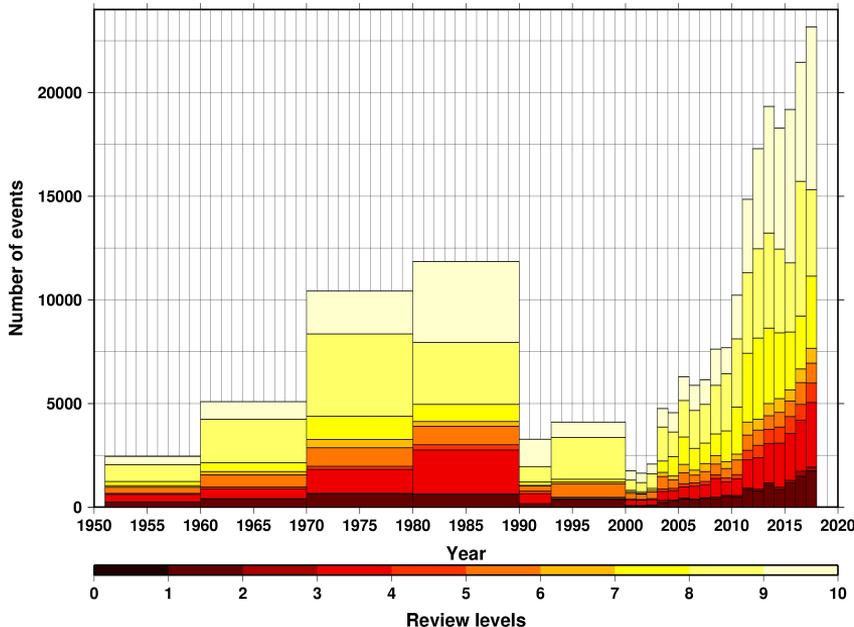
Strategy for manual review

We devised a strategy for the manual review that prioritizes the events by the potential severity of location problems:

1. Events that iLoc failed to locate or had secondary azimuthal gap $> 354^\circ$
2. Problematic solutions, abnormal exits from the iteration loop
3. Airquakes, discarded depth values due to large depth errors
4. Slow convergence
5. Events that moved by a large distance (> 100 km) from the initial guess
6. Large error ellipse (semi-major axis > 100 km)
7. Large secondary azimuthal gap ($> 320^\circ$) or RMS residual (> 4 s)
8. Events fixed to the default depth
9. The rest of the automatic locations are accepted without manual review.

Strategy for manual review

RESULTS



Number of events and percentages of the total annual number of events in the hierarchical manual review process, with the most severity level (potential location errors) at the bottom.

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Summary

- We relocated the events in the comprehensive bulletin for Central Asia with iLoc. RSTT, in conjunction with iLoc, is increasingly used to relocate the seismicity of larger regions. **RSTT almost invariably provides more accurate locations** and offers an improved view of the seismicity.
- Our strategy for hierarchical review offers an effective solution for identifying events that require manual review.
- The relocations provide reliable input for the PSHA in Central Asia.