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Automatic detection and machine learning-based discrimination of earthquakes in northwestern intraplate Europe using SeisComP3 and the AlpArray network

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Northeastern France and surrounding areas, like other intraplate zones, are vulnerable to earthquakes because of their population density, intense industrialization and fragile constructions. Most of the seismicity is distributed over the region; it expresses as low-to-moderate events (M<3), but episodic large earthquakes (M>5) also occur. The region's weak loading rates and poorly constrained active seismic structures lead to uncertain hazard models that influence risk mitigation policies.
Available seismic catalogs, necessary for any seismic hazard estimate, suffer from common weaknesses: they are incomplete, due to past in-homogeneous station coverage, and they contain many non-earthquake events, due to high anthropogenic activity and poor systematic discrimination.
Focusing in this intracontinental region, our goal is to build a new reliable catalog by improving both detection and discrimination of microseismicity. We have benefited from the recent development of European seismic networks, spearheaded by the AlpArray project and the concurrent growth of permanent national networks, to develop a method adapted to low detection thresholds and large data volumes.
Our approach is a fully automatic procedure that integrates machine learning tools. After refining the detection protocol by optimizing SeisComP3's standard parameters, we have built two new real-time SeisComP modules. The first one enhances the SeisComP3 procedure that selects the best fitting origin for each event. The second one discriminates between well-locatable earthquakes, events outside the network, fake events, quarry blasts, and other events such as landslides. The discrimination is carried out by a Random Forest algorithm and labels each event automatically. Our methodology can be incorporated into real-time routine procedures of earthquake detection.
Using these new modules, we have built a new discriminated regional seismic catalog for 2016-2018. The resulting decrease of the completeness magnitude and the improved estimates of hypocentral locations and magnitudes will allow us to conduct a reliable and detailed analysis of the seismicity in the region.