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Extending near fault earthquakes catalogs using convolutional neural network and single-station waveforms

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The machine learning (ML) algorithms have already found their application in standard seismological procedures, such as earthquake detection and localization, phase picking, earthquake early warning system, etc. They are progressively becoming superior methods since one can rapidly scan voluminous data and detect earthquakes, even if buried in highly noisy time series.

We here make use of ML algorithms to obtain more complete near fault seismic catalogs and thus better understand the long-term (decades) evolution of seismicity before large earthquakes occurrence. We focus on data recorded before the devastating L'Aquila earthquake (6 April 2009 01:32 UTC, Mw6.3) right beneath the city of L'Aquila in the Abruzzo region (Central Italy). Before this event sparse stations were available, reducing the magnitude completeness of standard catalogs.

We adapted existing convolutional neural networks (CNN) for earthquake detection, localisation and characterization using a single-station waveforms. The CNN is applied to 29 years of data (1990 to 2019) recorded at the AQU station, located near the city of L'Aquila (Italy). The pre-existing catalog maintained by Istituto nazionale di geofisica e vulcanologia is used to define labels and train and test the CNN. We are here interested in classifying the continuous three-component waveforms into four categories, noise/earthquakes, distance (location), magnitude and depth, where each category consists of several nodes. Existing seismic catalogs are used to label earthquakes, while the noise events are randomly selected between the catalog events, evenly represented by daytime and night-time periods.

We prefer CNN over other methods, since we can use seismograms directly with very minor pre-processing (e.g. filtering) and we do not need any prior knowledge of the region.