SERA
Seismology and Earthquake Engineering
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WP 28: Real-time earthquake shaking

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Keywords

Real-Time Earthquake shaking, Rupture kinematics, shake-maps, qualitative impact assessment

Figure

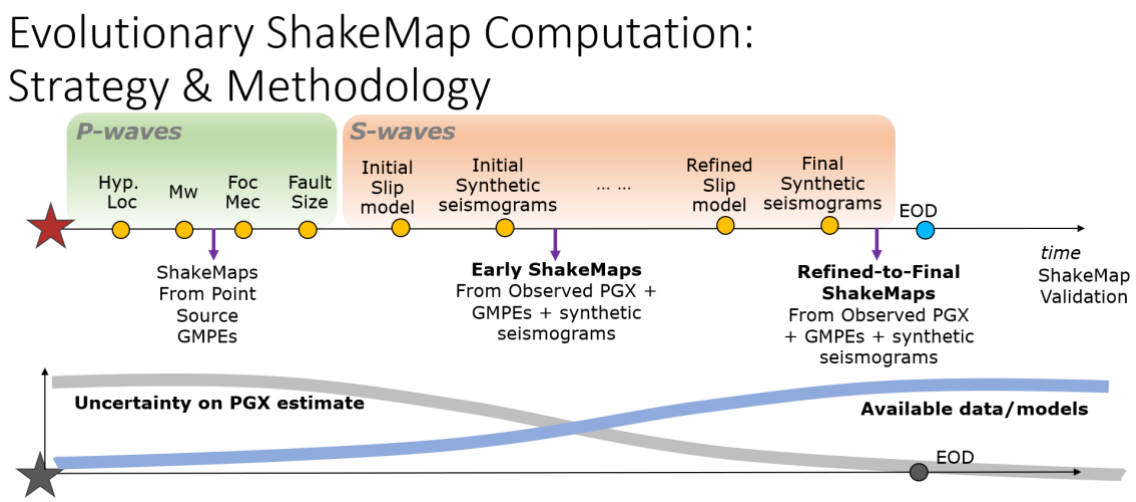

Figure 1. Schematic description WP 28 objectives. (top) At the occurrence of an event, moving on the timeline in the P-waves time window fast estimates of the hypocenter, magnitude and fault geometry are computed. During the recording of the S-wave phase, the closest real PGx estimates become available. The S-waves recording, along with the previous estimates, are hence used to compute refined source models with complementary approaches. Finally, these models are to compute refined synthetic seismograms and the final Shake Maps. (bottom) The definition of a refined source model is expected to reduce the uncertainty on the PGx estimates a few minutes after the end of the event.

Main Results

In the past decade, real-time seismology has moved from providing post-event information within minutes from earthquake occurrence, to issuing event information during or shortly after the rupture.

We compare the performance of four independent algorithms in the calculation of finite-fault models, through their application to the 2016-2017 Central Italy earthquake sequence and a dataset of 19 large global earthquakes. We show that two algorithms (developed at ETH Zurich (ETHZ) and Università degli Studi di Napoli Federico II (UNINA) using near-source accelerometric stations) can provide robust finite-fault models within 10 to 15 seconds from the event occurrence, for earthquake early warning applications. Other two algorithms (developed at GFZ Potsdam and Instituto Nazionale di Geofisica e Vulcanologia (INGV), using regional/global broadband waveforms) can provide more detailed finite-fault models within 10-20 minutes from event origin, for rapid response applications.

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The testing attenuation models from earthquakes recorded in Central Italy confirmed the strong frequency dependence of ground motion residuals and variability, and the complementarity of the magnitude scales considered in the Ground Motion Prediction Equation (GMPE). Since the source parameter stress drop is observed to improve the ground shaking prediction, a procedure is proposed by GFZ for the rapid assessment of the shaking potential which uses the seismic moment and the radiated energy measured over the seismograms. The development of numerical Green function databases was integrated into a python based simulation toolbox, in order to simulate ground motion parameter for different earthquake scenarios rapidly. The feasibility of a European ShakeMap system has been further tested and realized by prototype implementations at ETHZ, INGV and the National Observatory of Athens (NOA).
The Swiss Seismological Service (SED) at ETHZ finalised the upgrade of the Earthquake Early Warning Display (EEWD) to integrate source information from Real-time Finite Fault Rupture Detector (FinDer) and to include ground shaking estimates consistent with the FinDer rapid simplified finite fault representation as a line segment.
We explored two different strategies (SLIPNEAR CNRS and Back-Projection UNINA) for the rapid estimation of the earthquake source models. The final goal is to use these refined, kinematic source models for the computation of synthetic seismograms and shake maps, with the aim of reducing the uncertainties on the ground shaking prediction. The SLIPNEAR and Back-Projection are shown to provide complementary images of the source. These projections allow constraining the main patches of low-frequency slip and the high-frequency asperities (such as the arrest phase) respectively.

To compute evolutionary updated ground shaking prediction, the rapid estimates of the magnitude, location and fault geometry allow updating the point-source shaking prediction by applying Joyner & Boore distance-based GMPEs. Meanwhile, this early geometrical description and, at a later stage, the source inversions is used by UNINA to compute shaking prediction through sets of forward source modelling. The final aim is to integrate over different time scales (from EW to Rapid Response) real data, attenuation law and simulated PGx by using a ShakeMap-based interpolation scheme.

The final main outcome of this WP is the provision of rapid estimates of exposure and qualitative assessments of impact deriving for an earthquake and its strong ground shaking. The partners have developed independently procedures for rapid assessments using very diverse approaches:

- to detect earthquake damage from the lack of crowdsourced data, make very fast location and magnitude estimate of felt earthquakes (EMSC)
- Rapid calculation of exposure qualitative assessment of impact using the tools provided by SesDARO (the near real-time system for estimating the seismic damage in Romania, NIEP) and the ARISTOTLE project (INGV)

Within the framework of SERA, WP 28 has developed various services to ease the access to public databases of main infrastructures potentially affected by relevant ground shaking. We are expecting that those services will provide more complete descriptions of exposure and impact assessment.

Both INGV and the SED have started the migration their institutional ShakeMap systems to the new USGS version 4.0 that features the improved interpolation method described by Worden et al. (2018) and makes use of the ground motion models as implemented in OpenQuake (Pagani et al., 2014). The transition of the European prototype system to v4.0 is planned along with further community building activities.

List of Publications

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