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On the use of prior information in the Virtual Seismologist real-time implementations

Yannik Behr, John Clinton, Carlo Cauzzi, Jochen Wössner, Georgia Cua, and Men-Andrin Meier
ETH Zurich, Swiss Seismological Service, Department of Earth Sciences, Zürich, Switzerland

The Virtual Seismologist (VS) method is a Bayesian approach to regional network-based earthquake early warning (EEW) originally formulated by Cua and Heaton (2007). Implementation of VS into real-time EEW codes has been an on-going effort of the Swiss Seismological Service at ETH Zurich since 2006. VS is one of three EEW algorithms — the other two being the ElarmS [Allen and Kanamori, 2003] and On-Site [Wu and Kanamori, 2005; Boese et al, 2008] algorithms — that form the basis of the California Integrated Seismic Network (CISN) ShakeAlert system, a USGS-funded prototype end-to-end EEW system that could potentially be implemented in California. Recently, VS has also been integrated into the SeisComp3 system which is now used to run VS in real-time in Switzerland, Greece and Turkey.

Both real-time implementations make use of external associator modules to infer the hypocenter location from P-wave detections. Though this strategy leads to stable locations as standard, widely tested locator algorithms are used, there are some negative consequences: 1) the original 3D likelihood function in VS that relates ground motion envelope values to magnitude and epicentral location is reduced to a simple 1D likelihood function for magnitude only. Further, the prior distribution of magnitude is assumed to be uniform which turns VS effectively into a maximum likelihood algorithm. 2) the requirement of at least four P-wave detections to obtain a first hypocenter estimate (the lower limit for travel-time based location algorithms) has a major impact on the warning time.

In this test-case study we evaluate the potential improvement of warning time and source parameter estimate uncertainties by exploring as much of the available information as possible during an event. This involves characterizing the shape of the 3D *a posteriori* probability density function that includes hypocentral information as well as including non-uniform *a priori* information such as the seismic network geometry or smoothed seismicity maps. We use playbacks of over 400 events with magnitude ≥ 2.0 registered by the Swiss Seismological Service since January 2009 which also includes 20 events falsely identified as local earthquakes by the existing automatic system.