**Supplementary material  
Status of Earthquake Early Warning in Switzerland**Frédérick Massin1, John Clinton1, Maren Böse1

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## Maximum predicted intensity

The difference (*PGΔ*) between the peak ground motions of reference (*PGr*) recorded by seismic instruments, and modelled from EEW event parameter estimates (*PGm*) provides an indication of the reliability of the EEW event parameter estimates.

Recorded and modelled ground motion terms are 2-dimensional matrices with lateral complexities from source and site effects, but prominently featuring an amplitude decay from the fault rupture line. In absence of a method to model all these effects as it is the case in a EEW context, any attempt to compare *PGm* to ground truth *PGr* is prone to significant bias. For the purpose of comparing performances between several EEW methods, we can assume that *PGr* is provided by a generic Ground Motion Prediction Equation, or Intensity Prediction Equation for meaningfulness. For consistency, the same IPE should then be used for evaluating *PGr* using final event magnitude, and *PGm* using EEW parameter estimates. We use the IPE from Allen et al. (2012) as it is appropriate for generic applications to crustal earthquakes.

In addition, since we inspect the results from EEW methods based on an incomplete time-evolving dataset, the ground motions being compared should be limited to the same geographical range (*RPG*), where *PGr* should be available. At a given delay after origin time, we assume *RPG* as the area where S-waves have propagated, which we infer using the iasp91 velocity model and the final event location. For simplification, we focus performance analysis on the edge of *RPG*, or its radius (*r*), where *PGr* reaches its mode value, which also is the limit of the maximum ground motion being predictable at the considered time.

Thus we define the *maximum predicted intensity (MPI)* as our term for comparing *PGm* to *PGr* at the edge of *RPG*, using the generic Allen et al. (2012) IPE, the distance to the fault-line provided by EEW, and the iasp91 velocity model. We note that, although *MPI* is only relevant to EEW methods performance comparison, it might also present consistency with recorded ground motion.

## Captions for supplementary table and figures

**Table A1.** The 100 largest earthquakes, over magnitude 2.7, within Switzerland since 2009.

**Figure A1.** Delays from seismic stations in the Switzerland region in 2021. a: Packet reception delays are the differences between packet receptions and end times with a median of 0.4691s (+/-1.237192 / 0.116 s). b: Packet reception intervals are the differences in the reception times of consecutive packets, with a median of 1.648s (+/-0.412 / 0.184 s). c: Data delays is a proxy for the delays of the individual data sample, assumed as the sum of packet delays and half of the packet reception interval, with a median of 1.4619 s (+/-1.171696 / 0.2952 s).

**Figure A2.** Seismic stations in the Switzerland region in 2021. SM: strong-motion accelerograph. BB: broadband seismograph. SP: short-period seismograph. a: Station map with channel type distribution and map of the distance to the closest station. b: Station map with channel type distribution and P-wave delays for triggering the 1rst station (considering hypocentres at 5 km depth and seismic data delays).

**Figure A3.** Temporal (a, c) and geographical (b, d) overview of the VS (green, 56 earthquakes online and 92 playbacks), FinDer (orange, 10 earthquakes online and 37 playbacks) performances for the 100 largest earthquakes over magnitude 2.7 in Switzerland since 2009. The plotting conventions are the same as in Figure 11. Further details on errors are provided in Supplemental Material Figure A4.

**Figure A4.** Error (δ) cumulated distributions for the results from VS (green, 56 earthquakes online and 92 playbacks), and FinDer (orange, 10 earthquakes online and 37 playbacks) for the 100 largest earthquakes over magnitude 2.7 in Switzerland since 2009. We use the same plotting conventions as in Figure 12.

**Figure A5.** Delays of the fourth travel time (blue), first VS magnitude (green), and first FinDer magnitudes for the 100 largest earthquakes over magnitude 2.7 (solid lines), and the 8 largest earthquakes over magnitude 3.9 (dashed lines), in Switzerland since 2009. a: Delays for the online real-time ESE system. b: Delays for the playback ESE system. c: Hodochron plot for the 100 largest earthquakes showing all P and S travel times as a function of Epicentral distance and depth. Delay percentiles can be compared to the S-wave hodochrones in order to estimate the related minimum radius of the area with positive EEW.

**Figure A6.** Delays of the fourth travel time (blue), first VS magnitude (green), and first FinDer magnitudes for the earthquakes with both VS and FinDer magnitudes (solid lines), and those over magnitude 3.9 (dashed lines), in Switzerland since 2017 (since ESE is configured for 4-stations location and FinDer). a: Delays for the online real-time ESE system (9 earthquakes). b: Delays for the playback ESE system (21 earthquakes). See supplementary material Figure A5 for complete results.