Short-term probabilistic earthquake risk assessment considering time-dependent b-value
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Abstract
Short-term forecast models currently consider only the generic probability that an event can trigger subsequent seismicity in the near field. Laboratory experiments highlight a systematic b-value decrease during the stress increase period before failure and some large natural events are known to show a precursory decrease in the b-value, together with an increasing of the seismicity rates; we here show the probability increase offered by considering both observations (changes in the seismicity rates and temporal changes in the b-value) through the temporal analysis of the 2009 L’Aquila sequence.

The seismicity map on the right shows the time and space migration of the seismicity towards the future epicenter: background events (2005-2009, black circles), foreshocks (color-coded in time, see scale) and the epicenter (red star) in the 20 km radius study area. Circles’ sizes are proportional to Mw, spanning from 1.3 to 4.3. Black open circles: events outside the study area; red box: surface projection of the Paganica fault plane according to Serpelloni et al. (2012).

The time signal (b-value decrease and rate increase) is also evident comprising the frequency-magnitude distribution (FMD) of the following periods: Background: April 2005-end of 2008 (black circles)
Foreshocks: last week of foreshocks (red circles)
Aftershocks: first 3 months (APT1, grey circles) and the period January 2010-May 2012 (APT2, grey squares)

The continuous time series below (a-c) show the evolution of the whole sequence for both a-value and b-value (window length of 100 events, moving event by event).

The probability increase from the GR3 model exceed predefined CBA action thresholds even before the mainshock, suggesting evacuation of people living in vulnerable buildings. Specifically, three days before the mainshock, foreshocks (color-coded in time, see scale) and the epicenter (red star) in the 20 km radius study area. Circles’ sizes are proportional to Mw, spanning from 1.3 to 4.3. Black open circles: events outside the study area; red box: surface projection of the Paganica fault plane according to Serpelloni et al. (2012).

We investigate whether the above probability increases over the long-term background, might, in retrospect, justify mitigation actions (e.g., evacuations) during the L’Aquila seismic sequence.

The daily probability for an Mw6.3+ event for the daily a-value and b-value (window length of 100 events, moving event by event).

References
Gulia, E., Gulia, L., (2015), submitted to GRL

b-value dependent foreshock probabilities and risk assessment using cost-benefit-analysis

Aforeshock sequence started three months before the mainshock, activating a region of about 10 km length.

We compare the daily probability of a Mw6.3+ event for 3 models based on the Gutenberg-Richter model and 2 realizations of ETAS models:
GR1-time-independent a-value and b-value, fixed to the background values
GR2-background b-value combined with a time-dependent a-value.
GR3-background a-value and time-dependent b-value.


We investigate whether the above probability increases over the long-term background, might, in retrospect, justify mitigation actions (e.g., evacuations) during the L’Aquila seismic sequence.

Analogue to van Stiphout et al. (2010), we translate theseforeshock probabilities into time-varying seismic risk.

By combining the short-term hazard (Bindi 2011 + Faenza and Michelini 2010, Pacioci 2006, and Allen 2012) with the long-term estimations, we calculate the temporal evolution of risk throughout the sequence.

The probability increase from the GR3 model exceed predefined CBA action thresholds even before the mainshock, suggesting evacuation of people living in vulnerable buildings. Specifically, three days before the mainshock, foreshocks (color-coded in time, see scale) and the epicenter (red star) in the 20 km radius study area. Circles’ sizes are proportional to Mw, spanning from 1.3 to 4.3. Black open circles: events outside the study area; red box: surface projection of the Paganica fault plane according to Serpelloni et al. (2012).