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Earthquake source parameters determined from InSAR and seismic data: The 2003 Bam earthquake

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The 26 December 2003 M_w 6.5 Bam (Iran) earthquake killed more than 26'000 people and destroyed about 80% of the building stock in the city, including large parts of the Bam citadel, which is more than 2000 years old. No large earthquakes are known to have happened in Bam prior to the 2003 event. Moment-tensor solutions indicate that the earthquake occurred on a near-vertical, north-south oriented strike-slip fault with primarily right-lateral displacement. Field investigations and aftershock locations clearly show that the earthquake did not occur on a previously mapped thrust fault (the Bam fault), but rather on a strike-slip fault system located only 5 km to the west. Recent studies on the detailed source mechanism have not yet been able to conclusively answer to what extent the pre-existing Bam fault has contributed or influenced the rupture process of this devastating earthquake.

In this study we combine Envisat-1 InSAR data and broadband teleseismic recordings to determine the source parameters for the Bam earthquake. We also include strong-motion records to constrain the spatio-temporal details of the rupture process and will address the question why the previously mapped Bam thrust fault did not slip in this event. The Envisat-1 radar interferograms provide almost a complete picture of the coseismic surface deformation in this earthquake, both the pattern in areas away from the fault and the fine details near the fault rupture. The only gaps in the InSAR data exist in the cities of Bam and Baravat that are due to vegetation and collapsed structures. We use radar data acquired from both ascending and descending orbits, which is important for reducing trade-offs between estimated model parameters. The teleseismic

P- and SH-waveform data come from 16 broadband seismic stations of the IRIS and GEOSCOPE worldwide seismic networks, filtered in the passband of 0.01-1Hz (P-waves) and 0.01-0.4 Hz (SH-waves). Our fault parameter estimation comprises two main steps. During the first step we estimate the fault location and geometry using the InSAR data and teleseismic data independently, resulting in two sets of similar fault parameters. In the second step we use these fault parameters, expand the dimensions of the fault, and divide the fault plane into many fault patches. We then solve for variable slip on the fault plane using all the data, while the teleseismic data are additionally used to invert for time-dependent slip and rupture time. In addition, we use strong-motion data to further constrain the slip and rupture time distribution.

Our inversion results show that the slip is spatially variable with two distinct slip maxima on the fault. Both the rupture time and the on-fault rake angles show large degree of variability. The effective fault length and width are about 15 and 10 km, respectively, suggesting a rather compact, high-stress drop event. Furthermore, there is indication for fast rupture propagation from the hypocenter in an up-dip direction towards to the city of Bam (where an accelerograph recorded a PGA of $\sim$1g on the vertical component) that could be related to the devastating consequences of this earthquake.