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Shear-tensile source model: West Bohemia/Vogtland swarm 1997

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Earthquake swarm in West Bohemia/Vogtland in 1997 comprised of events with prevailingly two types of the mechanism: (A) shear-slip events of normal faulting mechanism and (B) thrust faulting events with notable non-double-couple (non-DC) component describing an extension in their foci. They were interpreted as activation of two fault systems differing in the orientation to the acting tectonic stress, which originates differing predispositions to shear/non-shear faulting. Regardless a detailed testing of their confidence taking into account the data quality and the knowledge on the velocity modelling, and also evaluating the mechanism in moment tensor (MT) description by both absolute and relative methods, additional check is worth of the effort. We performed it by applying an alternative source description to the traditional MT, namely the shear-tensile crack (STC) model.
The STC is the simplest extension of the traditional pure shear-slip model consisting in complementing it with a phenomenon describing an opening or closing within the focal zone just by allowing a deviation of the slip off the fault plane causing either an opening or closing the fault. As extreme cases of the oblique slip, the model involves both the pure shear and the tensile crack. Contrary to the MT which is a body force equivalent of the rupture, the STC is described straight by the parameters of the slip and, as such, it can be considered as a physical model. Technically, its advantage is a smaller number of parameters needed for its description: there are 5 parameters only, i.e. one parameter less than for an unconstrained MT. Smaller number of parameters is an advantage in the inverse process, expressed in its greater robustness. This is important especially in sparse monitoring configurations. The extreme case is single-borehole monitoring of seismicity induced by hydrofracturing of oil or gas wells. This configuration is unable to determine the complete MT (from far-field seismic phases), while the STC can be estimated fairly well, depending of the quality of the data, accuracy of the location and velocity model, and also of the geometry of the source.
We evaluated the STC parameters for a set of events of the 1997 swarm and confirmed the feature of extension in their foci, which suggests the opening of the fault during its thrust shear slipping. The amount of the opening is not large – no more that few degrees of the slope angle, it however generates a notable percentage of the non-DC component in the mechanism. Based on a realistic estimate of the error in the input data, we constructed confidence regions of the STC parameters both concerning the orientation and the slope angle. The results indicate that the non-shear character of the events may be real. Thanks to its physical concept, the STC allows to include additional parameters to be optimized during the inversion. We considered the Poisson ratio as the additional variable and tested its resolvability in the monitoring configuration of the 1997 West Bohemia earthquake swarm.