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Complexities in Active Fault Characterisation and their Implications for Probabilistic Seismic Hazard Assessment

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The role of geology in probabilistic seismic hazard assessment (PSHA) has become prominent within the last two decades, with more countries incorporating active faults directly into local and national earthquake hazard models. In parallel to this trend, modern ground motion prediction models require increasingly detailed source and site parameterisations in order to capture the effects of observed amplification phenomena, particularly in the near-field of the faults. Yet, whilst both geologists and ground motion modellers seek characterisations of the faults and their corresponding ruptures that represent their understanding of the physics of the process, there is an increasing divergence between the two representations that hazard modellers are more and more often faced with reconciling.

The OpenQuake-engine software for probabilistic seismic hazard and risk analysis is designed to provide a flexible and comprehensive range of possible options for characterising the active fault geometry and the rupture behaviour in seismic hazard analysis. It also incorporates many state of the art ground motion prediction equations, in addition to functionalities to model directivity in PSHA. Utilizing the OpenQuake-engine software we perform a set of PSHA calculations using active fault sources, incorporating both examples from current national and regional PSHA models as well as idealised faults of varying complexity, which are representative of those commonly encountered in different tectonic regimes (extensional, transform and compressional). Through this exploration, we demonstrate not only the challenges facing the modeller in characterising rupture behaviour, but also the potential impacts of the resulting modelling decisions on the seismic hazard analysis, for which the hazard modeller may not always be aware. These may include the spatial pattern of hazard in regions where hanging wall effects may be complex, as is the case where the fault is changing strike or dip along the rupture, whose effects may be highly sensitive to the uncertainties in the geological model, especially when directivity is incorporated into the calculation. These analyses illustrate the care that hazard modellers should take in the selection of appropriate ground motion models, especially in the near field of the source if there is sparse strong motion data from which to assess the suitability of the ground motion model for the application in question.