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Incorporating Complex Fault Geometry into PSHA

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Fault geometry is one of the key parameters used in a probabilistic seismic hazard assessment (PSHA) study. The mapped fault trace, width, and dip are often used to define the 3D geometry. However, as we know, fault geometry is incredibly complex. A single fault is often a complex network of multi-strand segments. Even if the complexities of the fault geometry are well mapped and documented, complex faults need to be simplified down for PSHA modelling purposes. Through this simplification process we lose location details of the fault geometry that remain unaccounted for in the site distance calculations for ground motion prediction equations. Depending on the fault geometry, these location discrepancies could easy extend a kilometer or more around a given fault. This has further implications when considering multi-fault ruptures. For example, if a 5km distance is used as a hard cut-off for multi-fault rupture, multi-fault rupture combinations could be excluded by underestimating the distance between faults.

It is standard practice to use simplified fault geometries to model rupture in PSHA studies. This is in part due to limitations on computer power and the often-unlimited possible rupture combinations and scenarios. However, even though we know we are working with a simplified realization of the fault, we don't account for these location uncertainties in the model. In some cases, like a mature well-defined strike-slip fault such as the San Andreas fault, these approximations may be small, and would not make a difference in the PSHA outcome. However, for less well-defined fault systems, or for dipping faults, these approximations can have larger impacts.

In this study I explore how to incorporate complex fault geometry into PSHA fault models. I examine modeling faults with an uncertainty distance buffer around the modeled fault plane, effectively turning the fault plane into a fault zone. This technique could incorporate both unknown fault splays and subsurface faults and could be used to account for known splays that are not explicitly modeled but incorporated onto a 'master' fault. The buffer zone would also include a distance-based decay that incorporates the likelihood of the rupture happening off the main modeled trace. Therefore, likelihood of ruptures on the main stranded would be weighted higher than on the farthest edge of the buffer. This is probability-based approach is especially helpful when considering multi-fault rupture possibilities for a given PSHA event set, so that faults located closer together could be weighted with a higher probability of rupturing together than faults further apart. The ultimate goal of this project is to find approaches to better incorporate realistic, and complex, geology into a PSHA model.