Accounting for uncertain fault geometry in earthquake source inversion problems

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Abstract

Imagery of slip history on a fault can be biased by uncertainties of the forward model. These uncertainties will always persist to some level as we will never have a perfect knowledge of the Earth interior. This makes the choice of the forward physics ambiguous, with the requirement to fix the value of several parameters such as crustal properties or fault geometry. The impact of this choice is rarely dealt with. Here, we explore the impact of uncertainties related to the choice of a fault geometry. To do so, we account for an augmented data covariance matrix which encapsulates the uncertainty related to the choice of a given fault geometry. We validate this approach with the simplified case of a fault that extends infinitely along strike, investigating fault dip and position uncertainty. We then apply our methodology to the 2016 Mw6.2 Amatrice earthquake, Central Italy. We show that introducing uncertainties in fault geometry in static inversions helps inferring more realistic and robust slip models. Epistemic uncertainties can be many orders of magnitude larger than observational errors for great earthquakes (Mw> 8). Not accounting for uncertainties in fault geometry may partly explain observed shallow slip deficits for continental earthquakes. Similarly, ignoring the impact of epistemic errors may bias predictions of tsunamis induced by megathrust earthquakes, particularly if near field observations are used. Finally, for most continental earthquakes and events with near fault observations, accounting for uncertainties in both fault geometry and crustal structure will be of significant impact.

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