Accounting for uncertain fault geometry in earthquake source inversions

Sladen, A.[1], Ragon, T. [1], Simons, M.[2]

1 *Université Côte d'Azur, CNRS, Observatoire de la Côte d'Azur, IRD, Géoazur, France*

2. *Seismological Laboratory, California Institute of Technology, USA.*

Earthquake source estimations are primarily constrained by available observations and the physics of the forward model. Yet, the forward model is potentially unknown and its uncertainties bias our inferences of fault slip. These uncertainties will always persist to some level as we will never have a perfect knowledge of the Earth interior. The choice of the forward physics is thus ambiguous, with the requirement to fix the value of several parameters such as crustal properties or fault geometry. Here, we explore the impact of uncertainties related to the choice of a fault geometry, and compare its influence to uncertainties on the elastic structure. To do so, we account for an augmented data covariance matrix which encapsulates the uncertainty related to the choice of forward model parameters. The results include a synthetic tests on a toy model as well as an application to a real case: the 2016 Mw 6.2 Amatrice earthquake, Central Italy. This event, well instrumented and characterized by a relatively simple fault morphology, allows to emphasize the role of basic fault parameters, such as fault dip and position.

We show that introducing uncertainties in fault geometry in the static inversion helps inferring more realistic and robust slip models. For most continental earthquakes and events with near fault observations, accounting for uncertainties in both fault geometry and crustal structure will have a significant influence on the solution. Yet, we also show that accounting for these two major sources of uncertainties might limit the need to account for additional types of epistemic uncertainties.

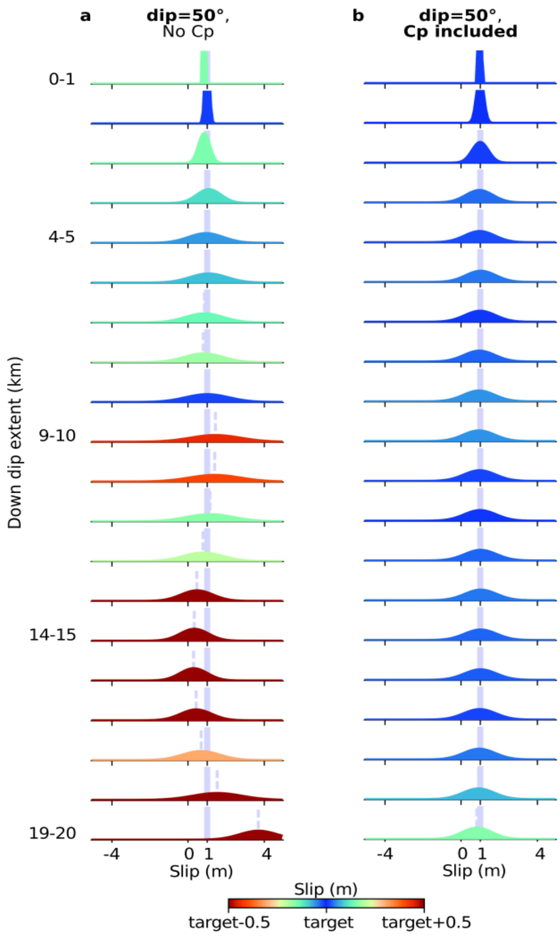

Figure 1. Comparison of full Bayesian inversion of surface displacement measurements to infer the slip on a 50° dipping fault, infinite along strike. The synthetic observations were computed on a 55° dipping fault for a slip distribution of 1 m (vertical grey bar). On the left, the inversion doesn't acknowledge epistemic uncertainties, contrary to the figure on the right. The later case shows much smaller deviation from the true model (blue PDF).