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A precision based regularization scheme for slip inversion: Application to the Central Andean Subduction Zone

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Imaging subsurface slip behavior from surface observations is essential to increase our level of understanding of the kinematics and physical processes controlling earthquake and tsunami occurrence. As the estimation procedure is an inherently ill-posed problem, the adopted inverse methodology to obtain such estimates, particularly the form of the a priori information, plays a key role in this learning process. There are two general end member approaches to estimate the distribution of slip on a fault that deals with the inherent instability of the inverse problem: An unregularized, computationally expensive, fully Bayesian MCMC approach and a much more expedient but biased optimization approach using some form of regularized least squares. We focus our efforts in the latter approach. On the regularized inversion, the chosen form of a priori information, or regularization scheme, will introduce a bias on fault slip estimates that needs to be well understood to be able to achieve rigorous interpretation of the obtained slip values.

Here we discuss the effects that the a priori information implied by commonly used regularization schemes has on slip estimates of fault behavior. Also, we propose a novel regularization scheme, based on the precision of the model parameters in the unregularized problem, that accounts for the spatial variability of the constraints provided by the observations (typically onland). The proposed regularization scheme improves the stability and resolution of the inferred slip distributions of fault behavior.

We illustrate our findings by analyzing synthetic cases in the Central Andean subduction megathrust, and apply the methodology to perform an analysis of the seismic cycle in the region.