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Constraints on Seismic and Aseismic Slip on the Cascadia Megathrust from geodesy and seismicity

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Our understanding of the dynamics governing aseismic and seismic slip hinges on our ability to image the time evolution of fault slip during and in between earthquakes and transients. Such kinematic descriptions are also pivotal to assess seismic hazard as, on the long term, elastic strain accumulating around a fault should be balanced by elastic strain released by seismic slip and aseismic transients. In this presentation, we will discuss how such kinematic descriptions can be obtained from the analysis and modelling of geodetic time series. We will use inversion methods based on a variational Bayesian Independent Component Analysis (ICA) decomposition of the time series to extract and model the aseismic slip (afterslip and slow slip events). We will show that this approach is very effective to identify, and filter out, non-tectonic sources of geodetic strain such as the strain due to surface loads, which can be estimated using gravimetric measurements from GRACE, and thermal strain. We will focus on the Cascadia subduction zone. The analysis shows a clear along-dip segmentation. A shallow section (depth between 0-10 km) which is locked in the interseismic period and where slip is probably mostly seismic; a transition zone (10-20 km) where slip is mostly aseismic and results from both interseismic stable creep and afterslip of large subduction earthquakes; a deeper section (20-50 km) where slip is aseismic but non-stationary in the interseismic period resulting in recurring slow slip events and tremors. Based on kinematic model, we are able to estimate the contribution of aseismic slow slip events and seismic slip to the moment budget. By combining this analysis with seismicity and paleo-turbidite observations we constrain the magnitude and frequency of the largest megathrust earthquake needed to balance the moment budget and estimate the associated uncertainties.