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Links between short and long term tectonics

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In the quest for understanding the rheology of the lithosphere a central question that can be addressed is the existence of a parameterisation of the rheology, which could reflect both the response of the lithosphere over the large time scale (10's Myr) and the time scale of earthquakes and faulting.

The gap existing between these observational time scales is mainly due to modelling approximations which in each separate fields permit to fit the data but which rely on simplification of the physics, the rheology and set of boundary conditions which are not always compatible one with each other.

The long-term community, i.e. the geodynamics community, tend to use Mohr-Coulomb non-associated plasticity to model self-consistent shear zone localisation. This type of rheology corresponds, in the limit of a discrete fault plan, to a slip weakening/hardening formulation in which weakening rate depends on fault plan orientation. The short term community, i.e. the earthquake community, has stopped using this kind of formulation and rather uses the rate and state formulation to model the activity of faults. Rate and State is limited because it cannot self-consistently generate an earthquake, the triggering, i.e. the initial slip acceleration must be imposed.

This contribution is a synthesis of several geological case studies at different length-scale, in which we suspects a strong link between long term geodynamic processes and current seismological and geodetic observations. We make use of these case studies together with quantitative numerical models to understand how the seismic and inter-seismic behaviour reflects the rather long-term geodynamic setting than the internal rheological properties of faults.

After briefly revisiting the different modelling approaches from geodynamic seismologic and geodetic communities, we show how modelling results obtained with the long term modelling approach brings new insights and alternative models for both the seismological and geodetic behaviour of active faults. The first example will concern the seismic activity on low angle normal faults focussing on the case of the Gulf of Corinth. Then focusing on strike slip tectonic, I will compare data from active and exhumed strike slip faults and discuss how a single model can explain their behaviour. The last example will focus on the creeping segment of the San Andreas Fault to discuss how heterogeneities in the long-term tectonic loading (in that instance flexure of the lithosphere) may influence the seismic behaviour of strike slip fault.