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Structural inversion of sedimentary basins: insights from 3D coupled thermo-mechanical and surface processes models and observations from the Mediterranean

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A common observation in plate tectonics is the successive stages of rifting and associated crustal and lithospheric thinning, and subsequent convergence and inversion of sedimentary basins. Rates and style of inversion often vary across the sedimentary basins, influenced by changing stress and thermal fields, different convergence directions, and also controlled by inherited structures, all of which determine the localization and style of the resulting deformation. However, the dynamic feedbacks between lithospheric tectonics and surface processes, and their 3D expressions have not been studied in details by previous models, even though erosion and sediment distribution exerts a significant control on differential vertical movements and thermal evolution.

In this study, we investigate strain partitioning during extension and subsequent structural inversion, and tackle the coupling between tectonics, mantle melting and surface processes. To do so, we apply the 3D thermo-mechanical code I3ELVIS (Gerya 2015; Munch et al. 2020), which is based on staggered finite differences and marker-in-cell techniques to solve the mass, momentum and energy conservation equations for incompressible media. The models also take into account simplified melting processes, as well as erosion and sedimentation by diffusion.

We compare the modeling results with seismic and well data from the Mediterranean back-arc basins, such as the Alboran, Tyrrhenian and Pannonian Basins. The temporal variation of different plate convergence and slab retreat velocities lead to the extensional formation, recent structural inversion and related differential vertical motions of these basins. In fossil extensional basins, plate convergence has ultimately overprinted the former basin structure, and lead to the rise of young orogens, i.e. the Pyrenees or Great Caucasus.