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Constraining the dynamics of the present-day Alps with 3D geodynamic inverse models - model version 0.1

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Understanding the orogeny of the Alps is one of the main goals of the AlpArray geophysical project, and it's German contribution 4D-MB. Whereas many sub-projects within AlpArray focus on geophysical observations, the mountain building process is a dynamic process and understanding it requires linking observations with dynamic models of lithospheric deformation. We focus on the large scale geodynamic processes that drive this complex system of multiple subduction zones, ranging from the surface to the mantle and including Eurasia, Africa and the Atlantic.

For this purpose we employ 3D thermomechanical deformation models to simulate the geodynamic behaviour of this area. In our models, the deeper structure is based on different recent seismological studies, which are tested as different end-member scenarios on their influence on the present-day geodynamics of the Alps. As a result, we can quantify the impact of a subduction polarity switch, the depth of the subduction zones or the thickness of the lithosphere on mantle and lithospheric flow.

Here, we present the first inversion results, which are largely based on already published data. We use gravity anomalies and surface elevation data to invert for the 3D density structure beneath the Alps. However, isostatic and gravity data give non-unique results in terms of the geometry of the system. Earlier studies (e.g. Baumann et al. 2014) showed that inversion results can be improved by incorporating GPS velocity data into the inversion framework.

Our inversion approach is based on the computation of the adjoint gradients of the material parameters, which are implemented in a gradient based inverse approach. We take velocity data into account and efficiently invert for a large amount of material parameters that control the rheology of crust and mantle rocks. We will test various hypothesis and explore their impact on the dynamics of the mountain building process. We will analyse which additional geophysical data could potentially improve the quality of the inversion result.

Baumann, T. S., Kaus, B. J., and Popov, A. A. (2014). Constraining effective rheology through parallel joint geodynamic inversion. Tectonophysics, 631, 197-211.