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Constraining the Alpine rheological structure using 3D numerical modelling

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From both a geological and geophysical point of view, the Alps represent one of the most thoroughly studied orogens on Earth, and as such is possibly one of the best examples to constrain orogenic processes. The result of the subduction-collision orogeny is a strongly non-cylindrical structure at all lithosphere levels even within the more linear eastern Alps. Whilst first studies using two-dimensional, thermo-mechanical numerical models have been performed, performing full three-dimensional models of the entire Alpine region remains a technical challenge. Overcoming this computational barrier is paramount to furthering our understanding of the formation of the Alps and to mountain building in general as such processes are inherently three-dimensional in nature if we consider the forces and geometries of the plates, and that they lead to specific features such as the western Alpine arc that may not be adequately modelled by 2D methods.

Here we report on both the numerical details of the software and some preliminary results obtained. Specifically we will (1) describe the ongoing development of a scalable, parallel 3D ALE finite element code which is suited to performing sufficiently well resolved three-dimensional, thermo-mechanical numerical models of the Alps with an emphasis on the linear algebra techniques used to solve the resulting discrete problem. In a second part (2) w discuss the preliminary results of a case study designed to constrain the present-day rheological structure of the Alps. We examine the present day deformation field, using as input recent surface topography measurements combined with a gravitational consistent density structure and with geometrical constraints on Moho topography and lithosphere mantle slabs. The quality of the models is determined by comparing the numerically computed surface velocities with GPS velocities.