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Towards 3D numerical modelling of Alpine-like continental collision

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The driving forces and the main deformation processes leading to the development and the evolution of a mountain belt have been matter of debate since the acceptance of plate tectonics. Most of the kinematic reconstructions of the 3D evolution of collision zones based on geological and geophysical data are generally not mechanically consistent. Since 20 years, reliable numerical models propose key parameters to rely the physical causes to the deformation observed, but, for technological reasons, they have been limited for long to two dimensions, inducing important limitations to understand the collision zones processes. For example, in 2D, it is impossible to take into account both the crustal thickening and micro-plate rotation and translation, which are two processes having a major role during collision, but which relative importance is debated.
The European Alps are an excellent example of a well accessible small-scale mountain belt, which has been thoroughly examined from a geological point of view. During the past decades, the geological information has been complemented with geophysical data on the deep crustal structure of the Alps. Much of this information highlights the three-dimensional structure of the region, in which an Adriatic micro-plate is wedged between the Adriatic and European crust. Recently, a change in subduction polarity has been found between the Western and Eastern Alps, which is thought to be related to the anticlockwise rotation of the Adriatic micro-plate during collision.

We recently developed a massively parallel 3D thermomechanical deformation code that is ideally suited to solve coupled mantle, lithosphere and surface processes and can model large deformations. Here, we employ this code to study several scenarios that might have resulted in the formation of the European Alps. The computations have been performed on Juqueen, FZ Jülich. Our model setup consists of an oceanic plate bearing a small rigid continent (Adria micro-plate) that moves northwards with an anticlockwise rotation component and subducts beneath a more viscous continental plate (Europe). We present initial results in which we vary the rheology of the continental and oceanic lithosphere.