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Numerical two-wedge model applied to the Alpine orogeny

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Two prominent phases of deformation characterize the structure and current geometry of the western-central Alps: (1) nappe emplacement and stacking associated with single-vergent, NW-directed thrusting, and (2) backfolding associated with doubly-vergent, SE-directed movement. For the Monte Rosa region, early subduction and delamination of crustal units has been proposed to explain the nappe stack sequences that emplace ophiolite units onto continental crustal units, associated with areas of high-pressure metamorphism. However, the reasons for switching to late-stage backfolding associated with major uplift to lower grade metamorphic conditions is still ambiguous. This change in deformation style of the Alpine orogeny could potentially be explained by the relative weakening of the orogenic, wedge-shaped, lid with respect to the lower wedge in which nappe stacking took place. In this study, we present simple two-dimensional numerical simulations of two-wedge viscous corner-flow in order to quantitatively understand the mechanisms that control the large-scale geometries of the Alpine orogeny. Our initial model configuration consists of a lower wedge (representative of the orogenic wedge above the subducting European plate) and an upper wedge (representative of the overriding Adriatic orogenic lid).

Our model utilizes the M2Di routines (Räss et al., 2017) which employ a direct-iterative approach to solve the system of partial differential equation for 2D viscous Stokes flow. The solver relies on a MATLAB based finite difference method to solve incompressible viscous flow adapted for both linear and power-law viscous rheology. We employ a semi-Lagrangian backward characteristic advection scheme in order to advect material phases; and define material boundaries using the level-surface approach that enables tracking of interfaces over large strains and limits numerical diffusion. We aim to: (1) benchmark numerical solutions against analytical corner-flow solutions valid for simple geometries and linear viscous flow, (2) quantify the impact of variable viscosity contrasts between the two wedges, (3) quantify the impact of an evolving deformable interface between the two wedges, and (4) quantify the impact of linear and power-law viscous flow on the results. Moreover, we compare our model results with the current geometry and tectono-metamorphic history of the Monte Rosa region in the Western Alps.