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The influence of obliquity on subduction zones and related topography: inferences from 3D numerical and analogue modelling

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We aim to contribute to the understanding of 3D surface topography and sedimentary basin evolution in the geodynamic context of oblique subduction systems. Surface topography is governed by the joint effects of crustal thinning or thickening via isostasy, stresses imposed at the base of the lithosphere controlled by asthenospheric flow and lithospheric flexure. In this study we present a series of numerical experiments to analyze the evolution of oceanic and subsequent continental subduction prior to continental collision along an oblique continental margin. Numerical modelling is compared with analogue subduction experiments.
We applied the thermo-mechanically coupled 3D finite-difference code I3ELVIS (Gerya, 2013). Simplified surface processes and phase changes are implemented in the simulations. Oceanic subduction is forced by an initial boundary velocity imposed on one model side for the first few million years. Subsequent subduction velocity varies in time as a function of the dynamics of the system, i.e. gradually increases during free-fall subduction and then starts to decrease at the onset of continental subduction. Oblique subduction creates a specific mantle flow pattern. Orientation of the convective cell beneath the downgoing plate is parallel with the subduction velocity direction, while the poloidal return flow is near perpendicular to the trench. The obliquity between the two convective cells creates an overall asymmetrical mantle flow pattern leading to the along-strike variation of slab roll-back and upper-plate deformation. Furthermore, vertical axis rotation is recorded in the upper plate.
We model the formation of the accretionary wedge behind a 4-6 km deep trench. 1-3 km accommodation space is created in the forearc basin area recording repeated extensional and contractional deformation. A 2-3 km deep dynamic sag basin forms at ca. 350 km distance behind the trench, during the main phase of slab roll-back. Furthermore, back-arc extensional deformation is distributed or localized at heterogeneities in the upper plate. Onset of continental subduction is diachronous due to the oblique margin geometry. The transition from oceanic to continental subduction is manifested in the gradual decrease of the accommodation space in the basins and the extensional stress regime changes to compression. Following a few million years of soft collision and continental subduction a high topography orogen is gradually built up during hard collision before subduction ultimately slows down.