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Orogenic wedge formation starting from hyper-extended passive margins: a self-consistent modelling study with application to the Western Alps

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The concept of orogenic wedges has been applied to explain the geodynamic evolution of many orogens worldwide. Recent numerical modelling studies have investigated orogenic wedge formation in a shortening lithosphere which was initially homogeneous, that is, having initially a constant crustal thickness. However, many orogens, such as the Western Alps, are characterised by the collision of hyper-extended passive margins which exhibited a significant variation of crustal thickness from the onset of orogenic wedge formation. Also, the pre-Alpine Piemonte-Liguria basin likely lacked significant amounts of embryonic oceanic crust and consisted of inherited and refertilised exhumed subcontinental mantle.

To study the impact of hyper-extended passive margins and exhumed subcontinental mantle on subsequent orogenic wedge formation we perform 2D thermo-mechanical numerical simulations. We model first the formation of a hyper-extended margin with exhumed subcontinental mantle during lithospheric extension and then subsequently shorten the evolved basin to model orogenic wedge formation. Hence, the starting configuration for orogenic wedge formation has been modelled in a self-consistent way by a prior extension model. We investigate the effect of (i) immediate shortening after exhumation of the subcontinental lithospheric mantle as well as (ii) the impact of a non-deforming and cooling period prior to the compression. We also study the impact of various density structures on the modelling results. The densities are thereby either calculated by simplified equations of state, where density is a simple function of temperature and pressure, or by petrological phase diagrams for specific mantle compositions. Potential applications of the model results to the Western Alpine orogeny are discussed.