Processes and repercussions of slab detachment

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The European Alps are a result of the convergence between the European and the Adriatic plate, where the oceanic part of the European plate subducted beneath the Adriatic plate until continental collision occurred and slowed down subduction. This stalling of subduction then resulted in strong extensional stresses in the subducting slab and ultimately in slab detachment. Based on geological and seismological arguments different slab detachment/lithosphere delamination events have been proposed to have occurred in the last 40 Ma. These delamination events have severe effects on surface processes, such as rapid rock uplift, potentially enhanced magmatic activity and significant changes in erosion/deposition processes.

However, the direct link between slab detachment and its surface expression has still not been sufficiently quantified. On the one hand, the processes governing the detachment and in particular its time scale are still incompletely understood while on the other hand quantitative links between the detachment and shallow processes are still missing. Next to the uncertain geometry and configuration of slabs beneath the European Alps, our incomplete understanding of the detachment process is one of the reasons why timing, duration and number of detachment events beneath the European Alps are still debated.

Here, I summarize the results of different studies within the framework of MB4D that have addressed these issues from a numerical perspective. I show how numerical modelling has increased our quantitative understanding of the slab detachment process and the physical mechanisms governing its temporal evolution. With the increased computational capabilities, high resolution three-dimensional models of slab detachment have also increasingly become feasible, thus enabling us to study three-dimensional effects such as convergence obliquity and slab curvature to an unprecedented degree. By coupling these models of deep detachment processes with stratigraphic modelling, it has also become possible to create synthetic datasets that can then be compared to observed data. In addition to these more generic models, large-scale models of the European Alps have shown that to properly model the evolution of the European Alps, effects of neighbouring slabs have to be taken into account.

Finally, creating present-day models of the Alps has been complicated by the fact that the exact slab configuration and geometry is still debated. Depending on interpretations of seismic tomographies, uplift velocities and overall dynamics may change considerably. This has led to technical developments such as the GeophysicalModelGenerator (https://github.com/JuliaGeodynamics/GeophysicalModelGenerator.jl) and the accompanying graphical user interface GeoDataPicker.jl (https://github.com/JuliaGeodynamics/GeoDataPicker.jl) that are designed to significantly facilitate the process of data interpretation and geodynamic model generation.