Glacial and erosional contributions to Late Quaternary uplift of the European Alps (GEOLQUEA)

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Isostatic adjustments of the Earth's surface to changes in water, ice, and sediment loading are important contributions to present-day uplift/subsidence rates in many regions on Earth. In the absence of significant horizontal tectonic shortening in the central and western parts of the European Alps, uplift rates larger than 2 mm/yr are difficult to explain by geodynamic processes and have been a matter of debate for many decades. Here we examine the likely contribution of glacial isostatic adjustment in the European Alps in response to changes in ice loading using state of the art ice flow and lithospheric numerical modeling. In contrast to a similar previous approach (Mey et al., 2016), we employ a transient ice sheet model over the last glacial cycle (100 kyr) in combination with a spherical viscoelastic solid earth model. We present ice model results using the Instructed Glacier Model (Jouvet et al., 2021), in which we tested the effect of spatial resolution on the growth and extent of the European ice cap. We found significant differences using a model resolution of 200 m compared to a resolution of 2000 m, which is commonly used in large-scale glacier modeling studies. These differences result in near-steady state volumetric differences at the maximum ice extent of +13% for the high compared to the low-resolution model. In addition, we observed periods of marked ice growth that initiated at significantly different times for the different resolution models. Therefore, we conclude that a realistic ice loading history requires a sufficiently high spatial resolution, which is significantly higher than used in previous models. Based on the modeled ice loading histories, we used the lithosphere and mantle model VILMA (Klemann et al., 2008, J. Geodyn.) to predict the vertical land motion. These estimates are based on a global 60 km thick elastic lithosphere, followed by a 200 km thick viscous layer with a viscosity of 10^{20} Pa s, which increases to 5 x 10^{20} Pa s down to 670 km depth, and 3.16 x 10^{21} Pa s to the core mantle boundary. Preliminary results indicate similar first-order lithospheric responses, with spatiotemporal differences in the magnitude of postglacial response. We hope to present more results based on further ice models that are forced by a more realistic climate history.

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