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Postglacial rebound promotes glacial re-advances - a case study from the European Alps

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Although deglaciation after the Last Glacial Maximum (LGM) caused considerable isostatic rebound of orogens worldwide the effect of this uplift on the mass balance of glaciers has never been quantified. Here we show that postglacial rebound may promote the re-advance of glaciers by enlarging their accumulation areas (Norton & Hampel, Terra Nova, 2010). As a case study, we selected the European Alps, which were covered by up to 2000 m of ice during the LGM. Based on the spatial distribution of moraines and the elevation of trimlines, we first reconstructed the LGM ice surface and determine its volume (∼54700 km3). We then show – using a three-dimensional numerical model with a rheologically layered lithosphere and the LGM ice distribution – that deglaciation caused up to ∼128 m of rebound between 21 and 13 ka. Finally, we quantified the rebound-induced increase in the total glacier accumulation area to be ∼3000 km2 or 50% at the onset of the Younger Dryas. This shows that postglacial rebound results in a positive glacier mass balance. Also, it provides a feasible mechanism to explain why from 18 to 13 ka the equilibrium line altitude (ELA) derived from moraines in the central Alps is consistently lower than the ELA inferred from temperature and/or precipitation conditions. With respect to the present uplift rate of the European Alps, our numerical model shows that - owing to the presence of viscous layers in the model lithosphere - the rebound-induced uplift continues at a rate of 0.36 mm/yr until the end of the model run, i.e. today.ay.