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Gravity effect of glacial ablation in the Eastern Alps - observation and modeling

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For the first time, this paper proves glacier ablation due to atmosphere warming by absolute gravity observation results and its quantitative modeling. Absolute gravity observations performed twice a year in Obergurgl (Austria) indicate a gravity increase of about 308 nms^{-2} since 1987 until present. Obergurgl is located at 1950 m close to the main crest of the Eastern Alps and is surrounded by glaciers. The main approach to explain the gravity increase is modeling of the mass deficit caused by glacial ablation. Temporal elevation changes in glacial areas are provided by successive glacier inventories of the Ötztal Alps (Abermann et al. 2009, 2011). Modeling is based on high resolution DEMs (spacing varying from 5 to 8 m depending on the specific inventory).

For glaciers in the Ötztal Alps, gravity effects of 81 nms^{-2} (1997-2006) and 122 nms^{-2} (1969-1997) were determined. The major contribution stems from the range up to 10 km around Obergurgl. A gravity effect of about 22 nms^{-2} has been estimated for ice thinning between 1969 and 2006 in the Stubai Alps.

After correcting the observed gravity time series for the total glacial ablation effect of 225 nms^{-2}, a positive gravity trend is still visible. However, it shows weak statistical significance. Its origin remains still open. Geodynamical processes like the uplift of the Alps or postglacial deformation would contribute to a gravity decrease. Consequently, its correction would increase the remaining trend.

The ablation impact on gravity explains about 2/3 of the observed gravity change. The remaining trend observed in Obergurgl can be regarded as due to a mixture of hydrological and geodynamical processes and instrumental uncertainties. In this context further glacier inventories with high spatial resolution would be helpful as well as improved absolute gravimeter technology.