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Determination of the hypsometric variation of glacier surface mass balance sensitivity

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The sensitivity of glacier surface mass balance on climate change is a key issue for any estimation of future glacier change as induced by global climate warming. It varies with geographical setting and forms typical characteristics for specific climatic conditions. The well-established method of Oerlemans and Reichert (2000) displays glacier mass balance sensitivity on changes in air temperature and precipitation regimes as monthly values forming a so-called 'seasonal sensitivity matrix'. The derived matrices represent glaciers as a whole and thus depend on individual glacier topography. However, with oncoming climate warming glaciers will retreat and change their hypsometry. As surface mass balance depends on altitude it seems likely that also its variability does. This would imply that glacier surface mass balance sensitivity might change according to changing glacier surface topography in the course of their recession. Therefore, with regard to the estimation of future glacier change it can be concluded that there is a need to distribute glacier surface mass balance sensitivity over altitude. This would provide valuable information for the modelling of future glacier evolution.
We present a method for altitudinal distribution of the seasonal sensitivity matrix. It was developed using meteorological and glaciological data from Gran Campo Nevado Ice Cap (southernmost Chilean Patagonia). To demonstrate the wider applicability of this method it is transferred to Glacier No.1 (Chinese Tian Shan Mountains) and Martial Este Glacier (Tierra del Fuego).
Results for Gran Campo Nevado Ice Cap indicate a general increase of the surface mass balance sensitivity on air temperature changes during the summer months and a year-round overall decrease of the sensitivity with altitude. Regarding the sensitivity on precipitation changes a temporally unstructured pattern was obtained. However, a general increase of surface mass balance sensitivity on precipitation with altitude is derived. Moreover, we observe a distinctly higher sensitivity on both, variations of air temperature and precipitation, around the transient snowline altitude.