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Spatiotemporal analysis of recent surface-elevation changes at Gran Campo Nevado ice cap (Patagonia): 1984-2000-2007

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The Gran Campo Nevado ice cap (GCN), southernmost Chilean Patagonia, is located at one of the most pronounced climate divides of the entire earth. At around 53°S the Andean mountain range forms the only continental barrier for the southern hemispheric westerlies. This makes annual precipitation sums increase to more than 10,000 mm at the summit regions due to strong orographic effects. As a result of this very high precipitation sums the existence of an almost 200 km^2 large ice cap is permitted at comparably low altitudes below 1,700 m asl although mean annual air temperature at sea level is as high as +5.7°C. Influenced by this highly maritime climatic setting the GCN showed a remarkable pattern of changes in surface elevation during recent decades.
This study presents a spatially distributed analysis of surface-elevation changes of GCN based on DEM data from 1984 (topographic maps), 2000 (SRTM4) and 2007 (ASTER). It compares the annual change-rate pattern of 1984-2000 to the one of 2000-2007. A comprehensive spatial correlation and GIS analysis identifies areas of highest and lowest change depending on altitude, aspect or drainage basin. It also reveals the temporal evolution of mean glacier changes across the entire ice cap.
Results indicate that the mean annual rate of surface lowering at GCN has increased by a factor of more than six when comparing the periods 1984-2000 and 2000-2007. The thinning throughout the lowermost parts of the outlet-glacier tongues increased considerably. The thickening that was evident throughout the central areas of the ice cap in 1984-2000 has slightly increased for the very uppermost parts. Consequently, GCN experienced a distinct steepening of the gradient of surface-elevation changes. However, the altitude where positive and negative change rates are balanced has moved to higher altitudes in the latter period.
It is concluded that in the near future the high precipitation sums may become insufficient to counteract the influences of rising air temperatures even at high altitude. Consequently, the area of glacier thinning will most probably show continuing expansion even into the highest areas of the ice cap.