Calibration of a degree day-model and estimation of the mass balance until 2100 for the Martial Este Glacier in Tierra del Fuego, Argentina

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The Martial Este Glacier is situated north of Ushuaia at the southernmost tip of South America. It was studied in order to estimate the mass balance from 1960 until 2006. For this reason a degree-day model was calibrated. Temperature and precipitation data obtained from the weather station Ushuaia (20 m a.s.l) as well as temperature data recorded by the automatic weather station Martial Este (990 m a.s.l) were available. To find out which degree-day factors (DDF) represent the glacier behaviour best, glaciological measurements were adducted. The model was driven using a vertical temperature gradient of 0.69/100 m, different DDFs and different precipitation gradients. By comparing the modelled results with the measured accumulation and ablation a DDF_{Snow} of 4.7 mm/K*day and a DDF_{Ice} of 9.4 mm/K*day could be determined.

In order to reconstruct the surface mass balance for the Martial Este Glacier for the time period 1960-2006 a winter vertical temperature gradient of 0.57 K/100 m and a summer vertical temperature gradient of 0.71 K/100 m were applied as well as a digital terrain model. The key finding is an almost continuous negative mass balance that averages 772 mm w.e. y⁻¹. The strong ice loss concerning the whole period is mainly caused by remarkable temperature increase and precipitation decrease since the end of the 1970s. The mean annual loss in the last six years (2000-2006) is about 533 mm w.e. y⁻¹. Overall, the analysis shows that the glacier reacts stronger to temperature variation than to changes in precipitation. The calculated sensitivity index (SI) for the Martial Este Glacier is 0.57 at an annual precipitation of 1590 mm. This high SI is caused by a relatively dry climatic setting implying sensitivity to temperature change restricted to the summer months. Moreover, the mass balance for the years 2007-2100 was estimated. In order to accomplish this prognosis, the dataset of the global climate model HadCM3 was statistically downscaled to fit local conditions at Martial Este Glacier. It is based on the SRES A2-scenario. Subsequently, the downscaled temperature and precipitation were applied to a model presented for the first time by OERLEMANS & REICHERT (2000) making use of the sensitivity characteristics. By means of the obtained results a continuous deglaciation could be determined. The mean annual mass balance will be at about -600 mm weq throughout the 21st Century, which implicates that Martial Este Glacier might be disappeared by the beginning of the 22nd Century.
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