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Spatial differences of air temperature, lapse rates and ablation sensitivity on the South Patagonian Icefield

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It has been widely recognized that glaciers in Patagonia are shrinking rapidly and hence concern exists about the sea level rise contribution of these glaciers due to recent climate change and projected regional warming. To investigate the response of the glaciers to climate change, mass balance models depend on an accurate spatial representation of inputs, such as the air temperature. Observed lapse rates are the most common method of distributing air temperature in modelling studies. This has not been possible for the Patagonian Icefields due to the scarcity of measured on-glacier values from which to extrapolate or validate the lapsed air temperature, hence mass balance modelling and temperature sensitivity analyses of this area often distribute the air temperature by using the environmental lapse rate as a spatially and temporally constant value. This is a major simplification, as it has been widely recognized that air temperature lapse rates are both spatially and temporally variable in mountainous regions. This work presents air temperature variations across the South Patagonia Icefield (SPI) along a longitudinal transect at approximately 48° 45’ S. We analyse nine months of observations from a network of five complete automatic weather stations (AWSs) installed close to glacier fronts and on nunataks, supplemented by three air temperature sensors installed directly over the glacier surface. The sensor network was established by the Centro de Estudios Científicos (CECs) within a project of the National Water Office of Chile (DGA) enabling a novel, robust assessment of air temperature variability on the SPI. By analysing time series of observed air temperature and distributed values modelled with the observed lapse rates, including a bias-correction over glacier surfaces, we are able to identify spatial differences in the air temperature structure between the east and the west sides of the icefield. Specifically, we find that on-glacier conditions are warmer in the west side, obtaining a 200 m higher 0°C isotherm compared to the east. While observed lapse rates are generally steeper on the east side. Investigating the sensitivity of ablation to modelled air temperatures shows that important differences exist depending on the method used for air temperature distribution. Distributed temperature-index modelling and point-scale energy balance analysis reveal that melt is overestimated and sublimation is underestimated if the glacier cooling effect is not included in the distributed temperature data. Data from these weather stations will allow validation and downscaling of climate models for modelling of current and future mass balance of the South Patagonia Icefield. This work is financed by FONDECYT (AR) and CONICYT, Doctoral Fellowship (CB).