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Glacier response to climatic change along the Southern Patagonia Icefield: Insights from in-situ observations and a climate model

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Heterogeneous ice loss has been observed in the Southern Patagonia Icefield (SPI), however, the understanding of how glaciers are responding to changes in climate over this region is extremely limited. Empirical studies of the on-glacier conditions that drive glacier response and its spatial variability are extremely limited on the SPI. This precludes a robust assessment of the response of the glaciers to current and projected climate change. In this work, the analysis of nine months of meteorological observations (October 2015 to June 2016) and of a regional climate model (RegCM4.6) during the period 1980-2015, reveals spatial differences of the meteorological and glacier boundary layer characteristics as well as in the rates and long-term changes of the snow accumulation. In-situ observations suggest that conditions on the east side are drier, less cloudy and colder than on the west. There is considerable spatial and temporal variability in the air temperature lapse rates (LRs) which, overall, are steeper in the east (mean value of -0.0072 °C m-1) compared to the west (-0.0055 °C m-1). Also, the glacier cooling effect is higher on the east when comparing with west conditions. Results of a point-scale energy balance during the period November 2015-March 2016, suggest that the main source of energy in the west is the incoming longwave radiation, while in the east, incoming longwave and shortwave radiation are of similar magnitude. These conditions lead to a higher amount of melt in the west when comparing with the east side and a higher amount of sublimation on the east compared to the west side. In a long-term perspective, RegCM4.6 simulations show that snow accumulation rates are higher on the west side relative to the east side and significant positive trends are mainly present in the autumn season on the west side, while on the east side, significant negative trends in autumn were determined. Over annual timescales, glaciers previously observed to be exhibiting positive and/or stable elevation and frontal changes, are related to areas with snow accumulation increase during the period 2000-2015. This suggests that the snow accumulation increase attenuates the response of the glaciers in a context of overall glacier retreat due to climate warming in Patagonia. We propose that the spatial differences in glacier surface mass balance responses are controlled by the interplay between the local scale given by the spatial differences in the meteorological conditions (e.g. lapse rates, cooling effect, cloud cover) that defines the notable gradient between the west and east side of the SPI and by large-scale and long-term atmospheric conditions as for example the influence of the positive polarity of the Southern Annular Mode (SAM) in the snow accumulation trend. These results introduce insights into the recent behaviour of some of the major glaciers in the region and the calculation of the surface mass balance on these glaciers could be improved by considering such spatial variability. This work is financed by CONICYT, Chile, Doctoral Fellowship (CB).