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First Author First Name / Last Name	Thomas E. (1) Shaw
Submitting Author First Name / Last Name	Thomas E. Shaw
Correspondence	thomas.shaw@wsl.ch
Co-Authors >> E-Mails will be not listed	Mccarthy, Michael (1); Buri, Pascal (1); Miles, Evan S. (1); Carturan, Luca (2); Shea, Joseph (3); Pellicciotti, Francesca (1,4)
Organisations	1: Swiss Federal Institute WSL, Switzerland 2: Department of Land, Environment, Agriculture and Forestry, University of Padova, Padova, Italy 3: University of Northern British Columbia, Prince George, British Columbia, Canada 4: Department of Geography, Northumbria University, Newcastle, UK
Country	Switzerland
Region	Western Europe

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Abstract

Glaciers can dramatically modify the ambient near surface air temperature in the presence of a developed katabatic boundary layer, thus producing a significant cooling and dampening effect relative to their surroundings. Moreover, the extent to which this relative cooling occurs is dependent upon several meteorological and topographical factors which can evolve in time and space, impacting the sensitivity of glaciers to climate change. Current glacier modelling efforts mostly neglect the energy feedback related to changes in the glacier boundary layer which likely results in an inaccurate estimation of glacier mass balance for more complex modelling frameworks. While past studies have explored this behaviour at a number of individual sites, the derived patterns have not been generalisable, leading to uncertainty in the extrapolation of off-glacier air temperatures for current and future modelling. We explore the patterns of air temperature modification utilising >1.5 million hourly air temperature measurements on >60 glaciers around the world. By combining detailed off- and on-glacier meteorological datasets with characteristics of glacier morphology and surface conditions, we are able to highlight the key controls of glacier-induced cooling and move toward a generalised pattern of glacier boundary layer response to regional meteorology. Our findings indicate that the size, elevation and climate setting of a glacier can all contribute to its relative cooling. We pay close attention to the interaction of valley and glacier wind fields through time in determining the strength of the air temperature modification and quantify the ability of existing methods to estimate its behaviour.