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Measuring changes in snowpack SWE continuously on a landscape scale using lake water pressure

Hamish Pritchard^{1,2}, Daniel Farinotti^{2,3}, and Steven Colwell¹

¹British Antarctic Survey, Cambridge, United Kingdom of Great Britain – England, Scotland, Wales (hprit@bas.ac.uk)

²Swiss Federal Institute for Forest, Snow and Landscape Research WSL, CH-8903 Birmensdorf, Switzerland

³Laboratory of Hydraulics, Hydrology and Glaciology (VAW), ETH Zurich, CH-8093 Zürich, Switzerland

The seasonal snowpack is a globally important water resource that is notoriously difficult to measure. Existing instruments make measurements of falling or accumulating snow water equivalent (SWE) that are susceptible to bias, and most can represent only a point in the landscape. Furthermore the global array of SWE sensors is too sparse and too poorly distributed to be an adequate constraint on snow in weather and climate models. We present a new approach to monitoring snowpack SWE from time series of lake water pressure. We tested our method in the lowland Finnish Arctic and in an alpine valley and high-mountain cirque in Switzerland, and found that we could measure changes in SWE and their uncertainty through snowfalls with little bias and with an uncertainty comparable to or better than that achievable by other instruments. More importantly, our method inherently senses change over the whole lake surface which can be several square kilometres, or hundreds of million of times larger than the aperture of a pluviometer. This large scale makes our measurements directly comparable to the grid cells of weather and climate models. We find, for example, snowfall biases of up to 100% in operational forecast models AROME-Arctic and COSMO-1. Seasonally-frozen lakes are widely distributed at high latitudes and are particularly common in mountain ranges, hence our new method is particularly well suited to the widespread, autonomous monitoring of snow-water resources in remote areas that are largely unmonitored today. This is potentially transformative in reducing uncertainty in regional precipitation and runoff in seasonally-cold climates.