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Snowline observations to remotely derive glacier-wide mass balance on four Kyrgyz glaciers from 2003 to 2015

Martina Barandun (1), Matthias Huss (1,2), Leo Sold (1), Christian Kienholz (3), Ryskul Usubaliev (4), Tobias Bolch (5,6), and Martin Hoelzle (1)

(1) Department of Geoscience, University of Fribourg, Fribourg, Switzerland (martina.barandun@unifr.ch), (2) Laboratory of Hydraulics, Hydrology and Glaciology (VAW), ETH Zurich, Zurich, Switzerland, (3) Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK, USA, (4) Central Asian Institute of Applied Geosciences (CAIAG), Bishkek, Kyrgyzstan, (5) Department of Geography, University of Zurich, 8057 Zurich, Switzerland, (6) Institute for Cartography, Technische Universität Dresden, 01069 Dresden, Germany

The monitoring of glacier mass balance in remote regions is challenging but vital for understanding the response of glaciers to climate change. Direct mass balance observations are sparse and discontinuous in the Kyrgyz Tien Shan and Pamir. The under-sampling problem of glacier change assessments limits change predictions and impact projections. In this study, we elaborate on novel approaches to derive sub-seasonal glacier mass balance based on remote snowline monitoring on four Kyrgyz glaciers for a period from 2003 to 2015. The proposed methodology is based on the information content of short-term changes in snowline elevation detected with repeated remote sensing imagery for both the quantities of winter accumulation and summer ablation. By backward modelling the observed snowline position and the glacier geometry are related to the glacier-wide mass balance. Snowline position over the glacier area is detected with a semi-automatic procedure on remote sensing images (Landsat, ASTER) and automatically on terrestrial photographs. We apply the methodology to four glaciers on which direct mass balance measurements have been (re)-initiated recently and use reanalysed and partly reconstructed mass balance series as a first source to validate our approach to remotely determine the seasonal glacier mass budget. In a second step, the derived glacier-wide mass balance is compared to geodetic mass balance calculations for the first decade of the 21st century.