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Quantification of short-term dynamic of debris flows at the high-Arctic environment, Ebbabreen and Ragnarbreen, Svalbard

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Extensive ice-cored moraines complexes are common elements marking last advance of many of Svalbard glaciers. Sediment gravity flows are the most dynamic parts of these landsystem components, leading to the serious transformations of postglacial landforms. Short-term dynamic of debris flows activity was studied in cm-scale using repetitive topographic surveys. We monitored several debris flows on the forelands of two glaciers: Ebbabreen and Ragnarbreen located near to the Petuniabukta, at the north end of the Billefiorden, Spitsbergen. Reflectorless, robotic scanning was used to obtain accurate and detail topographic data. Six measurement sessions were carried out: three during summer 2012 and three during summer 2013, which enables us to assess seasonal and short-term (weekly) variations. Photographic monitoring was also carried out along with the survey sessions. Digital elevation models (DEMs) generated from each measurement session were subsequently subtracted from each other, providing a spatial picture of the erosion or deposition of material in each cell of the model between survey sessions. By subtracting DEMs from subsequent time periods we created DEMs of Differences – DoDs, which enables us to calculate the amount of material which was moved within the test sites and also to investigate the spatial patterns of transformations.

The surveys indicate high dynamic rates of debris flows. Total yearly changes of the volume of sediments and dead-ice for the most active part of the debris flows was around -0.3 m^3/m^2. However, most of the transformation occurred during summer, with the short term values as high as -0.1 m^3/m^2 per week. In comparison, dynamic of the other parts of the ice-cored moraines was 10-times lower. Total change in elevation (attributed mainly to dead-ice downwasting) during one year was -0.03 m^3/m^2, whereas lowering during summer was about 0.01 m^3/m^2 per week. The results of our study indicate that in case of studied glaciers backwasting was much more effective than downwasting in terms of landscape transformation on the glaciers' forelands. Despite high activity of debris flows, overall short term dynamic of ice-cored moraines for studied sites was relatively low. We suggest that as long as debris cover is sufficiently thick – thicker than the active layer depths – the debris flow activity occur only due to specific topographic conditions and/or occurrence of external meltwater sources. In other areas ice cored moraines remain stable landsystem component in short term (yearly to decadal) time-scale.