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Surface-to-base transfer and subglacial hydrology controls on subglacial erosion evidenced from 7 years of hydro-sedimentary observations within Bossons glacier catchment (Mont-Blanc massif, France)

Hervé Guillon (1,2), Jean-Louis Mugnier (1,2), Jean-François Buoncristiani (3,4)

(1) Université de Savoie, ISTerre, Le Bourget du Lac, France, (2) CNRS, ISTerre, Le Bourget du Lac, France, (3) Université de Bourgogne, Biogéosciences, Dijon, France, (4) CNRS, Biogéosciences, Dijon, France

Continuous monitoring of sediment load in proglacial rivers allows to quantify the mass of sediment exported from a glaciated catchment toward the fluvial system. However, supraglacial, subglacial and proglacial sources contribute to this export and their specific roles are poorly understood. Our general intent in this study is to understand their respective contribution to the total exported load of suspended sediment. The catchment of the rapidly retreating Bossons glacier (Mont-Blanc massif, France) provides an ideal field laboratory to infer about the intensity of present-day erosion processes. On this glacier, two proglacial rivers were monitored : Crosette stream and Bossons stream. For Bossons stream, completing the initial 2009-2010 data, discharge and sediment load have been measured from 2011 to 2015 at a high time resolution (timestep from 15 to 2 min). Two stations acquired these data, upstream and downstream, respectively, from a valley sandur located at $\sim$1 km from the glacial tongue. Crosette stream was monitored directly at the exit of the subglacial system during 2013 and 2014. The combined dataset currently available from these 3 stations spans 7 years from 2009 to 2015, is not only limited to the melt season duration and is appreciably rich (4.3 millions raw data points). This tremendous data profusion allowed developping statistical methods. Multi-linear models were used to investigate sediment transfer processes in the proglacial area during the 2013 melt season. An original probabilistic approach provided critical information for every other years. Uncertainties on sediment masses were assessed by a careful propagation and by a Monte-Carlo method. Additionnaly, sediment transfer from supraglacial to subglacial position has been estimated for Crosette and Bossons streams. Applying the conclusions of these previous works on the 7 years dataset, we provide erosion rates for the supraglacial rockwalls, subglacial bedrock and proglacial area. Finally, we focus on subglacial erosion processes by comparing Bossons and Crosette catchments, and analyzing export distribution throughout each melt season. Excluding the case of extreme event, the mean proglacial erosion rate is significantly lower, 0.12 ± 0.10 mm.yr^{-1}, than the mean supraglacial and subglacial erosion rates, 0.86 ± 0.42 and 0.51 ± 0.39 mm.yr^{-1}, respectively. Our results show peaks of sediment export in the middle of the ablation season. Additionnally, uncommon export peaks took place during the late 2010 and 2012 melt season and are not correlated with increase in temperature, melt water runoff or precipitations. These results could indicate the presence of an heterogeneous sediment storage beneath Bossons glacier and abrupt exports related to the evolution of the subglacial drainage system. Furthermore, the calculated glacial erosion rates are 0.41 ± 0.44 and 0.61 ± 0.35 mm.yr^{-1} for Crosette and Bossons streams, respectively. Such difference could be explained by moulins and bédières efficiently transferring surface sediment and melt water towards glacier base in the lower ablation area drained by Bossons stream but not present in the thickest and steepest parts of glacier drained by Crosette stream. Surface-to-base sediment and water transfer as well as subglacial drainage development may thus significantly control subglacial erosion.