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Potentials and limitation of interpreting sediment availability and connectivity using hysteresis patterns

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Both suspended and bedload transport during flood events often reveals hysteretic patterns. Hysteresis can be clockwise (when flow discharge peaks after the peak of bedload) or counterclockwise (when flow discharge peaks before the peak of bedload), and recent indexes have been developed in order to quantify the degree of hysteretic patterns. Hysteresis patterns and degree can be used to infer the dynamics of sediment availability, as counterclockwise and clockwise hysteresis have been interpreted as representative of limited and unlimited sediment supply conditions, respectively. This work focuses on interpreting the temporal and spatial variability of coarse and fine sediment sources using hysteresis patterns measured in two monitoring station in a glacierized basin. The study site is the Estero Morales, a 27 km2 Andean catchment located in central Chile. The elevations range from 1850 m a.s.l to 3815 m a.s.l., and the basin host glaciers with a current extent of 1.8 km2. Runoff is dominated by snowmelt in late spring, and glacier melt from December to March. Liquid discharge, turbidity, bedload transport rates and grain size (using a calibrated bedload acoustic pipe) have been measured continuously from 2013 to 2016. The hysteresis patterns of suspended sediment transport show that during snowmelt, unlimited supply conditions for fine sediments caused the loops to be mostly clockwise. Instead, during glacier melting the source of fine sediments is progressively the proglacial area, producing counterclockwise hysteresis. As to bedload, coarse sediment transport yield peaks in early glacier melting, then bedload rate reduces during the glacier ablation season, and hysteresis loops switch from clockwise to counterclockwise from earlier to late glaciermelting. It is suggested that the analysis of hysteretic patterns over time provides a useful framework for interpreting variability of location and activity of sediment sources at the basin scale. These evidences indicate that suspended and bedload transport in glacierized basins is affected by complex interactions among runoff generation, and sediment availability, and that the analysis of temporal hysteresis can help inferring the activity of sediment sources at the basin scale. However, issues related to the interpretation of the hysteretic loops are discussed, with special emphasis on the changes in loops due to the relative activity of different sources in the proglacial area, the possibility of discriminating the role of the channel as a sediment sink-release system, and the role of changes in hydro and sediment connectivity overtime.