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A comparison of three methods for estimating pro-glacial suspended sediment loads: an example from Castle Creek, Cariboo Mountains, British Columbia

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In terms of landscape dynamics, the widespread retreat of mountain glaciers is revealing new expanses of fresh glacial debris, the stability, dynamics and potential fluvial transport of which is little understood. Robust estimates of suspended sediment loads (SSL) are therefore essential in order to assess changes in sediment flux across pro-glacial zones and to assess changes over time.

This study, based in the pro-glacial zone of the Castle Creek glacier in the Cariboo Mountains of northern British Columbia, estimated suspended sediment flux at three stations, 0, 0.5 and 1.0 km from the glacier snout, over 34-days in July-August 2008. ISCO automatic pumping samplers, a pressure transducer and turbidity sensors were deployed and 459 water samples were retrieved from the three stations and analysed gravimetrically for their suspended sediment concentration (SSC). A stage-discharge (Q) rating relationship was established at the distal end of the pro-glacial zone and an hourly Q record was maintained from 9 July – 12 August 2008.

Three methods of calculating SSLs were compared for 214 hours for the 9-18 July phase of the study: (1) SSC v Q rating relationships were developed using 116 synchronous samples collected at each of the three stations and these were applied to the 1-h Q record to estimate SSL, (2) SSC v Q rating relationships were developed using all samples collected at each of the stations: n = 160, 151 and 148 at the proximal, middle and distal stations respectively, and these rating curves were applied to the 1-h Q record to estimate SSL, (3) an unbroken record of 3-hr samples at each of the three locations was obtained from 9-18 July and the product of each 3-hr SSC and Q value was used to represent each 3-hr time period and these were summed. Method 1 (n = 214) estimated SSLs of 213.969 $\pm$ 0.019 t, 272.284 $\pm$ 0.026 t and 411.605 $\pm$ 0.033 t respectively at the proximal, middle and distal stations. Method 2 (n = 214) estimated SSLs of 221.110 $\pm$ 0.020 t, 279.020 $\pm$ 0.031 t and 377.579$\pm$0.028 t respectively at the proximal, middle and distal stations while method 3, using the 3-hr samples, estimated SSLs of 218.694 $\pm$ 0.111 t, 322.361 $\pm$ 0.400 t and 468.392 $\pm$ 0.033 t respectively at the proximal, middle and distal stations. Comparing the SSL estimates with the mean of the three methods, method 1 was 98, 93 and 98% of the mean at the three stations, method 2 was 101, 96 and 90% and method 3 was 100, 111 and 112% of the mean estimates. The degree of scatter in the SSC v Q rating relationships increases across the pro-glacial zone from proximal to distal station. These results raise interesting questions as to which is the best method to choose. Also in this study, two Partech infrared (IR15C) 0-10 000 mg/L range turbidity (Tu) sensors were later deployed at the middle and distal stations. The SSC v Tu rating relationships are slightly stronger than those between SSC and Q which is promising for the future use of Tu sensors as a surrogate for SSC in this environment. Synchronous SSC traces for the Middle and Distal stations reveal some interesting observations which suggest that the system here is transport limited for the duration of the study and that there is no evidence to suggest a sediment supply limitation.

KEYWORDS: estimation of suspended sediment loads; pro-glacial; British Columbia; turbidity