Defrosting sedimentary systems: the impacts on the evolution and material transport of high-latitude rivers

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Summary of the project

The current understanding of seasonally variable fluvial and subaerial processes, and their interlinkages is insufficient for high-latitude rivers. Therefore, it is needed: 1) To determine how river ice may affect seasonal hydrodynamics and sediment transport within high-latitude rivers. 2) To define the seasonal interlinkages and combined effects of sub-aerial and fluvial processes on seasonal sediment transport and its origins in high-latitude rivers. 3) To define the feedbacks between defrosting watersheds and total sediment load transported to the high-latitude oceans. 4) To analyze the role of hydro-climatic factors and their seasonal variation, including shortened ice-covered flow period and increased zero-crossings, in long-term river dynamics. Technological advances in remotely sensed flow characteristics, river ice, sediment transport and topography data acquisition enable greater spatial and temporal detail than before. New field data is also necessary for verifying the development of a model (Delft3D) to include ice-cover formation and ice-covered flow and sediment fluxes/channel erosion.

BSG granted funding for measuring seasonal (including ice-covered) hydro- and morphodynamics at a meandering subarctic Pulmanki River (Northern Finland). The data acquisition took place in 4.-10. February 2019. This would not have been possible to perform without the funding from BSG. In addition to scientific publications, this field data will be applied as pilot data for larger future project proposals, which will be written in autumn 2019 (e.g. the Academy of Finland and ERC).

Summary of the methods and outcomes

Mid-winter ice, flow, snow and topography characteristics were detected. Also installations for continuous hydrological observations were done. The ice-thickness was measured with ground-penetrating radar, and manually as reference from cross-sectional drill holes. The drill holes (92 in total), which covered different water depths, were also applied for measuring spatial flow and topography characteristics with Acoustic Doppler Current Profiler (ADCP) (Figure 1). Stationary method was used for gaining discharge, and moving boat mode was used for 5-10 minutes long eddy flow measurements. The flow at the bed and ice-water interface were measured with Acoustic Doppler Velocitymeter. The bed load was sampled with the Helley-Smith sampler simultaneously with the velocity measurements, so that bed movement will be also possible to define from the ADCP data. The transported grain sizes were defined with dry sieving. Water quality was analysed (turbidity, total suspended solids and color) from gathered water samples. The time-lapse cameras were installed for monitoring ice cover development and ice break-up processes. These were installed next to a radar based discharge station (RQ-30), so that the remotely sensed discharge and flow velocity could be also analysed photogrammetrically from the camera's data. RTK-GPS measurements of control points enable the georeferencing of these data. Also time-lapse cameras were installed to detect the bank erosion and ground water impacts. In addition to these cameras and RQ-30 sensor, weather station (air temperature and pressure) and moisture sensors were installed for continuous hydrological measurements. Drones were used for gaining RGB photos and calculating snow volume and land surface topography based on structure from motion method. Reference measurements were made with RTK-GPS for this purpose. Due to the harsh conditions (-30 degrees), laser scanning and seismic sensor installations were not yet possible.

Figure 1. Drilling (left), ADCP setup of flow measurements (middle), GPS and ADV measurements (right).

The data set of mid-winter hydro- and morphodynamics enabled the detection of differences in their spatial and temporal characteristics, when compared to the theories of open-channel flow situation. These pilot data, and the initiated continuous long-term measurements, will now enable writing of the larger project applications. Publications related to aims 1 and 2 are have also already been planned and initiated, and will be possible to finish after the sensors, which were left logging, are read and corresponding measurements have been done in open-channel conditions. The gathered data was applied as part of a presentation held by Lotsari in EGU2019 conference. In addition to the direct analyses based on field data, the pilot data enables the initiation of the Delft3D's code refinement during 2019.