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Temporal variation of river bank dynamics and their driving processes during open-channel flow period of a sub-arctic meandering river

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River bank dynamics have not been studied in such a detail in sub-arctic environments, as in warmer areas. In addition to fluvial processes and sedimentological characteristics of river banks, temporal variation of soil moisture and temperature (e.g. freeze-thaw and ground water), snow-melt and rainfall affect bank erosion during open-channel flow periods of sub-arctic rivers. Understanding of these complex and interacting processes are needed, as bank erosion can cause substantial amount of the total sediment yield in rivers, which are also under changing climatic conditions.

The aim is to analyze the causing processes of the river bank dynamics during the whole open-channel flow period, i.e. from the rise of a spring snow-melt flood until the autumn low flow period, in a sub-arctic river. In detail, it is detected (1) how the variation of soil temperature and moisture affect the bank erosion, (2) how the bank collapses relate to the fluvial processes, e.g. temporal water level fluctuations, and (3) whether there are diurnal and seasonal variations and interlinkages between the different driving processes of river bank dynamics. Thus, the bank dynamics occurring during the rising flood are compared to the changes during the receding phases of discharge events, the low flow periods and the whole open-channel flow period. The study is done in a circa 20 m high bank of meandering Pulmanki River (Northern Finland). The bank consists of material from clay to gravel, and does not have vegetation. The analyses are based on the forward looking infrared (FLIR) camera and normal color camera images, in addition to water level, discharge, soil moisture, soil temperature, and topographical (i.e. terrestrial laser scanning, TLS) data. Also Acoustic Doppler Current Profiler (ADCP) data enables the shear stress analyses along the bank. In addition to measurements at the beginning and in the end of the open-channel flow period, the data includes also daily/diurnal measurements from snow-melt flood and low flow periods.

The FLIR images revealed the spatial and temporal variation of the thermal and moisture characteristics of the river bank. The ground water areas were cooler during the day and warmer during the night than the surrounding bank areas. The loose sand layers were also easy to recognize as the warmest areas. These two distinct areas were the most prone ones for the erosion. The erosion was greatest during the summer secondary discharge events, especially during their receding phases. The mass failures caused more volumetric change, than the direct effect of the flowing water, as the bank surface slid down progressively at the same pace with the water level, i.e. after the flow had carved the toe area. Thus, the rising phase of the spring snow-melt flood did not affect the river bank as much as its peak or receding phases, the summer discharge events, or the total open-channel flow period. This is explained with the still frozen and drier nature of the river bank during the initial stages of the spring flood.