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Breakup 2014 on the Montmorency River

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Abstract
This paper addresses the Montmorency River 2014 breakup. The River is well known for its regular flooding events. The winter of 2013-2014 was very cold with 1350 cumulated degree-days of frost. The ice thickened until the end of March. From the 14 to the 16 of April, the flow rate rose from 35 to 570 m^3/s. HOBO U20 sensors recorded water depths at various locations during this breakup event and a LiDAR survey was performed on the following days. The data analysis revealed that different javes, originating from various longitudinal locations, occurred. An ice jam formed at km 9.7, but finally broke with the larger jave. The LIDAR survey was used to investigate the maximum water elevation during breakup based on shear wall deposits elevation. An analysis showed that the water level was superior to an open water discharge of 850 m^3/s (a flow with a return period of 100 years). This poster highlights the usefulness of water level sensors to capture javes and LiDAR data to provide comprehensive spatial documentation of a breakup event.

1. Introduction

The Montmorency River is located just north of Quebec City. It's a gravel bed river composed of three different geomorphological reaches in the area interest. In the higher reach (km 34.0 to km 19.5), there are rapids with a river gradient over 1%. In the middle reach (km 19.5 to km 11.5), there are riffles and pools and the river gradient is 0.6%. In the lower reach, there is an anastomosed section (km 11.5 to km 8.0) with a river gradient of about 0.2%. The River is known for its regular flooding events. During the winter of 2014, Quebec City Public Security was worried about potential flooding and mandated the University Laval to observe and describe the breakup. The research team had already instrumented the river and was prepared for this task.

2. Instrumentation

HOBO U20 sensors were anchored on the channel bed in a PVC protective case at different locations. They monitored the River from November to April at a sampling rate of 10 minutes. A total of 9 sensors were used from km 34.4 to 9.5 and several others were installed in tributaries to identify the source of potential breakup events (Figure 1). Two air temperature sensors were installed in the watershed. In complement of the instruments, the water flow was measured by the Centre d'Expertise Hydrique du Québec (CEHQ) at km 2.2. A LiDAR survey was performed just after breakup to measure the elevations of the shear walls and other features. The nature of the surface (ice, water, ground) was determined based on return signal strength (Leclerc, 2014).

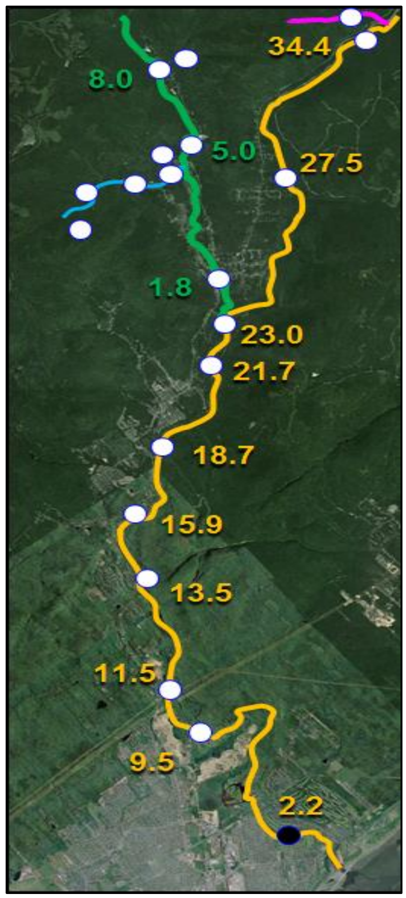

Figure 1. Position of the HOBO sensors in the River (yellow) and in its tributaries

3. Conditions at breakup

The winter of 2013-2014 was very cold with 1350 cumulated degree-days of frost (CDDF) at Québec (Turcotte and Morse, 2014). The ice thickened until the end of March and only 100 degree-days of thaw above -5°C had been cumulated at the time of breakup. The ice cover was still competent on April 8th, 2014 when 25 mm of rain fell on the Montmorency watershed followed, from April 13th to 15th, by an additional 50 mm. At that time, combined with an air temperature above 10°C, there was enough runoff to trigger breakup.

4. Analysis

From April 14th to April 16th, the flow rate rose from 35 m³/s to 570 m³/s (Figure 2). Seven different javes were detected on the 15th and 16th and they originated from different locations (Figure 2).

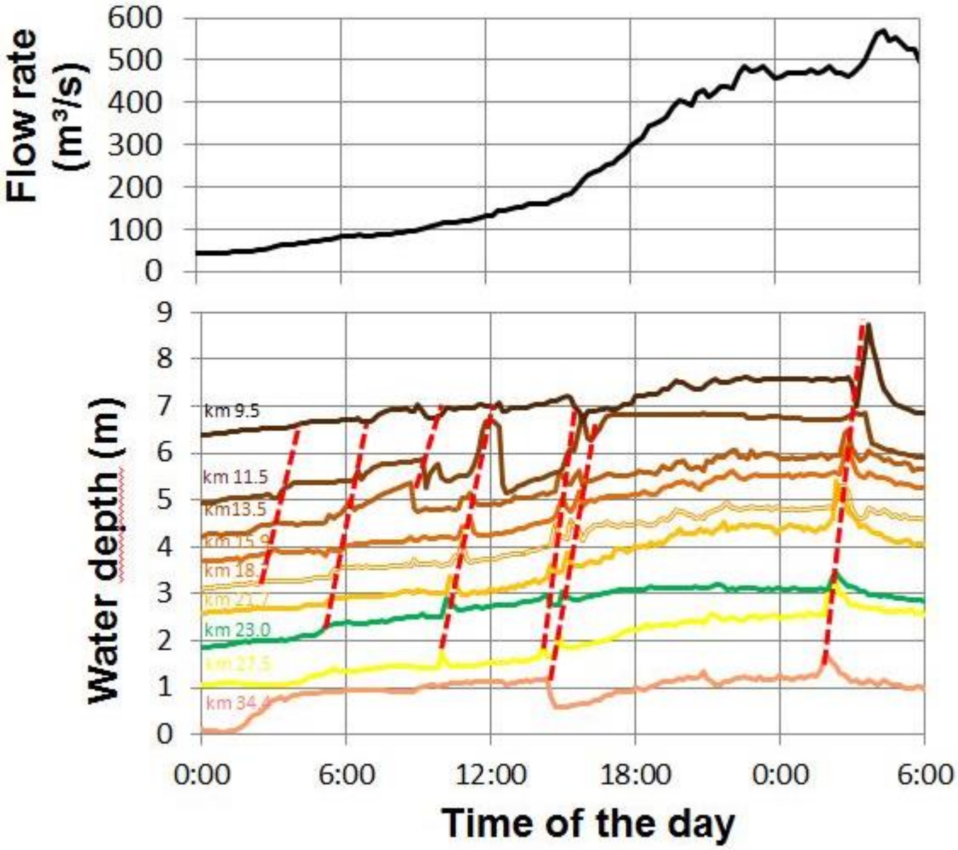

Figure 2. Flow rate, water levels (various colours) and javes (red lines) measured at breakup from April 15th to April 16th, 2014

The first jave was a local displacement of the ice cover around km 21.5. The second jave was created by breakup in the De l'Île River (Green in Figure 1). The third jave moved the ice jam formed at km 13.5. The fourth jave originated between km 27.5 and km 34.4. Its amplitude was 0.4 m to 0.5 m and it travelled at a celerity of 5 m/s in the rapids and 2 m/s in the riffle-pool reach. The ice run stopped at km 11.5 and formed a new ice jam. This is jam was slowly mobilized in the following hours. At about 3 p.m. on April 15th, two subsequent javes occurred (originating from downstream and upstream of km 34.4). These javes travelled at a celerity of 4.8 m/s to 5.3 m/s, and 3.5 m/s to 5.0 m/s, respectively. They were responsible for the formation of the ice jam at km 10. The ice jam stayed in place for many hours despite the fact that the flow rate increased over 450 m^3/s. Some areas were already flooded. The last jave occurred before 3 a.m. of the 16th of April. In the rapids, this jave's celerity was 8 m/s. Its amplitude at km 34.4 was 0.4 m and grew to 1.0 m until it reached and destabilized the ice jam at km 10. A major jave ensued (more than 1.5-m high) and additional flooding occurred. The subsequent ice run jammed once more at km 5 in a reach of very small gradient known as 'Lac du Délaissé' and flooding occurred there as well.

LiDAR was used to investigate maximum water level inferred by the maximum elevation of the shear walls (Figure 3). From km 11.5 to km 10.0 (within the jammed section), an analysis (Leclerc and Secretan, 2012) showed that the water level was superior to that expected for open water discharge of 850 m³/s. The jave (below km 10.0) generated a water level comparable to this open water discharge, which is associated with a return period of 100 years (even though the actual flow rate measured at km 2.2 was only 570 m^3/s). This event caused a lot of damages to residential areas and private properties near the River. Three small bridges were damaged or washed out.

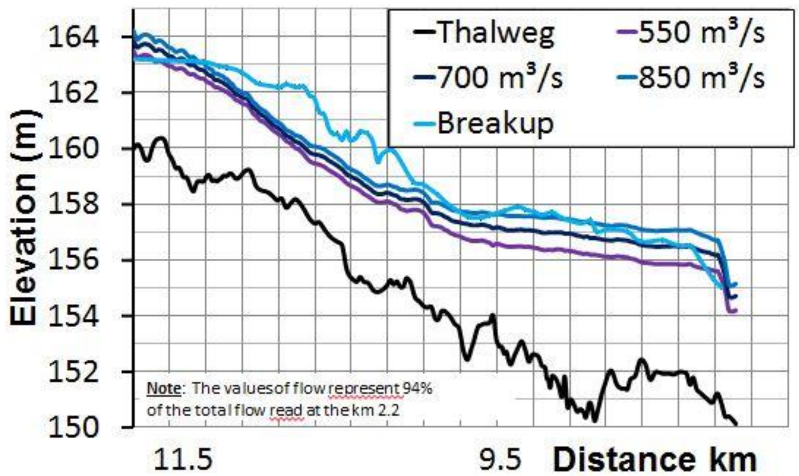

Figure 3. Water level estimated by LiDAR (light blue) at breakup compared to simulated values under open water conditions.

5. Summary and Future Plans

The breakup event of April 2014 had important consequences on the morphology, the riparian and flood plain vegetation, and on the local population. The combination of a cold winter and a sudden spring runoff event generated important ice jams. Their release led to the formation of major javes that either worsen or released downstream ice jams.

The pressure sensors used for this research revealed useful information such as the amplitude and celerity of javes under different ice conditions, discharges, and reach morphologies. The LiDAR data was very comprehensive and revealed exactly where overbank ice was stored. This enabled the estimation of maximum water levels. This research shows once more that the frequency of ice-induced floods can be higher than the frequency of open water floods, especially in a dynamic reach with secondary channels.

References

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