Investigating the role of an upstream watershed on ice-jam flood regimes at the Peace-Athabasca Delta

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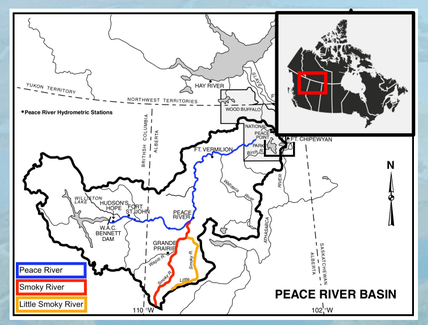
Introduction

Peace-Athabasca Delta (PAD) is the world's largest freshwater boreal delta.

- Located within Wood Buffalo National Park, a UNESCO World Heritage Site
- Has been a focus of concern for decades because of declining ice-jam flood frequency associated with river regulation and climate change



(Modified from Prowse & Conly, 2002)[1]

Ice-Jam Floods formed on the Peace River are essential for recharging perched basins downstream at the PAD.

- River ice break-up on the Peace River is dependent on high spring discharge[2]

Smoky River is an unregulated tributary upstream of the PAD.

- Contributes a large portion of spring flow to the Peace River when ice-jams occur[2]

What has been the role of the Smoky River in driving flood frequency at the PAD in the decades prior to available hydrometric data?

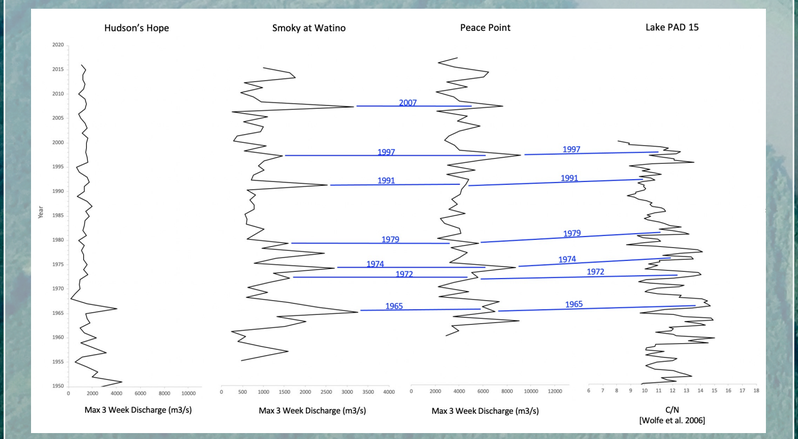


Figure 1. Maximum daily discharge within the 3-week ice-jam flood period at a) Hudson's Hope, the station just below the W.A.C Bennett Dam, b) Smoky at Watino, the station at the outflow of the Smoky River, and c) Peace Point, the station just above the PAD. Flood record from the PAD using d) carbon to nitrogen ratio at PAD15.[3]

Results

- There is a decadal-scale correspondence in flood frequency between lakes in the Smoky River Watershed (Figure 3b,c) and lakes in the PAD (Figure 3d) in the past 160 years.
- A decline in flood frequency beginning in the late 1800s, decades before river regulation began in 1968, is seen in both the Smoky watershed and the PAD.
- Similar trends observed in both the unregulated Smoky watershed and the PAD in the past two centuries suggests the strong role of climate in driving declining flood frequency.

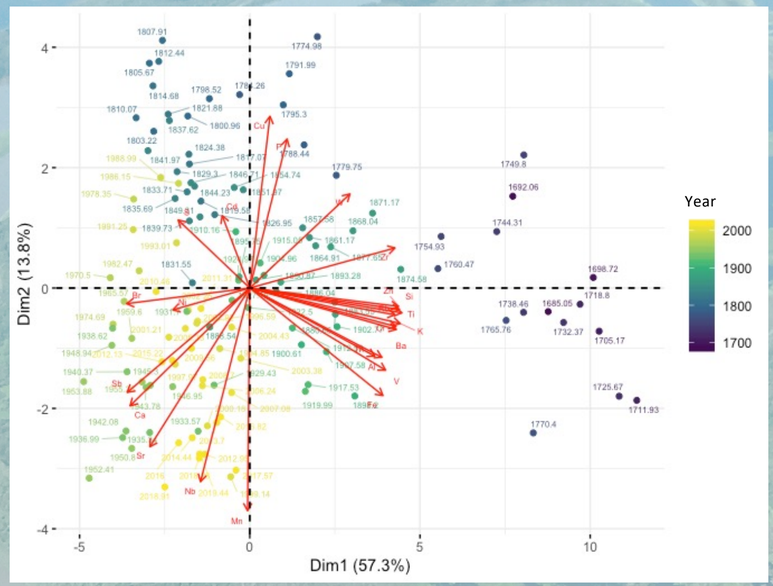


Figure 2. Principal component analysis (PCA) of X-Ray fluorescence (XRF) data from Smoky 4. XRF analysis provided count data of the elements within each 0.5 cm sediment layer. 24 elements were selected for the PCA based on a priori information. The elements plotting positively on the first axis are associated with allochthonous input introduced to lakes via flood waters. Consequently, Axis 1 was interpreted as being representative of flooding and described 57.3% of the signal in Smoky 4. Individual sediment samples are denoted by year and coloured on a gradient from oldest (purple) to youngest (yellow).

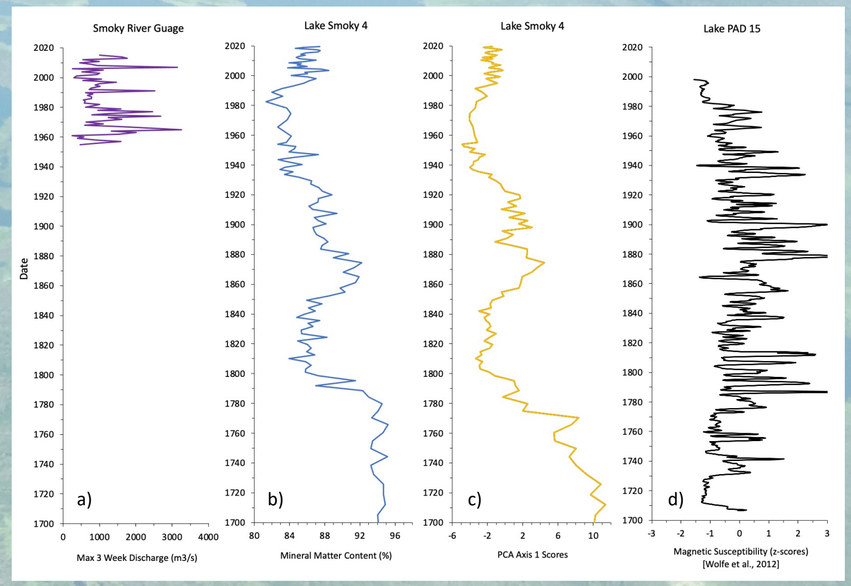


Figure 3. Flood records from the Smoky River Watershed and the Peace-Athabasca Delta. A) Maximum daily discharge within the 3-week ice-jam flood period at the gauging station located at the outflow of the Smoky River. B) Mineral matter content measured at Smoky 4. High mineral matter is interpreted as periods of flooding as mineral-rich sediment is introduced to lakes by river floodwaters. C) PCA axis 1 scores derived from X-Ray Fluorescence at Smoky 4. High positive values are interpreted as periods of flooding since the elements plotting positively along axis 1 are associated with allochthonous flood input. D) Magnetic susceptibility z-scores at PAD 15. High z-scores are interpreted as periods of flooding since minerogenic sediment in river floodwaters have higher magnetic susceptibility.

Implications

The findings from this study demonstrate:

- the relationship between upstream tributaries and ice-jam flood frequency at the PAD, and
- the role of climate on the hydrology of the PAD

This knowledge will be used to inform a federal Action Plan aimed to improve stewardship of the delta and anticipate future water availability.

References

1. Prowse, T. D. & Conly, F. M. (2002). A review of hydroecological results of the Northern River Basins Study, Canada, Part 2. Peace-Athabasca Delta. *River Research and Applications, 18,* 447–460.
2. Prowse, T. D. & Conly, F. M. (1998). Impacts of climatic variability and flow regulation on ice-jam flooding of a northern delta. *Hydrological Processes, 12,* 1589–1610.
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