Will there be an ice bridge this winter?

Predicting spatio-temporal freeze-up patterns along the Yukon River, Canada

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Outline

1. Challenge and objectives
2. Theoretical background
3. Research area in Canada
4. Methodology
5. Results
6. Discussion

1. Challenges and objectives

- No ice cover in 2014 and from 2016 to 2018
- Long term objective: Sustainable mitigation (find a way to ensure safe winter crossing at Dawson)
- <u>Short term objective</u>: Improve our understanding (explain freeze-up dynamics)

2. Some theory about river ice formation

In large, low-gradient rivers:

- Cold weather
- Water cooling down to 0°C
- Ice production
  - Border ice
  - Frazil
- Drifting ice chocking by border ice
- Congestion and bridging
- Full ice cover formation
  - Local thickening by submergence
  - Upstream progression by interception
- Resilient open-water leads immediately downstream of bridging locations (nothing to intercept)

3. Research area

Some facts:

- Dawson: 2,000 people
- Tr'ondek Hwech'in Traditional Land
- Average annual T_{air} = - 4°C
- Winter intensity = 3500 CDDF
- Yukon R. watershed = 264,000 km^2
- Late winter flow = 400 m^3/s

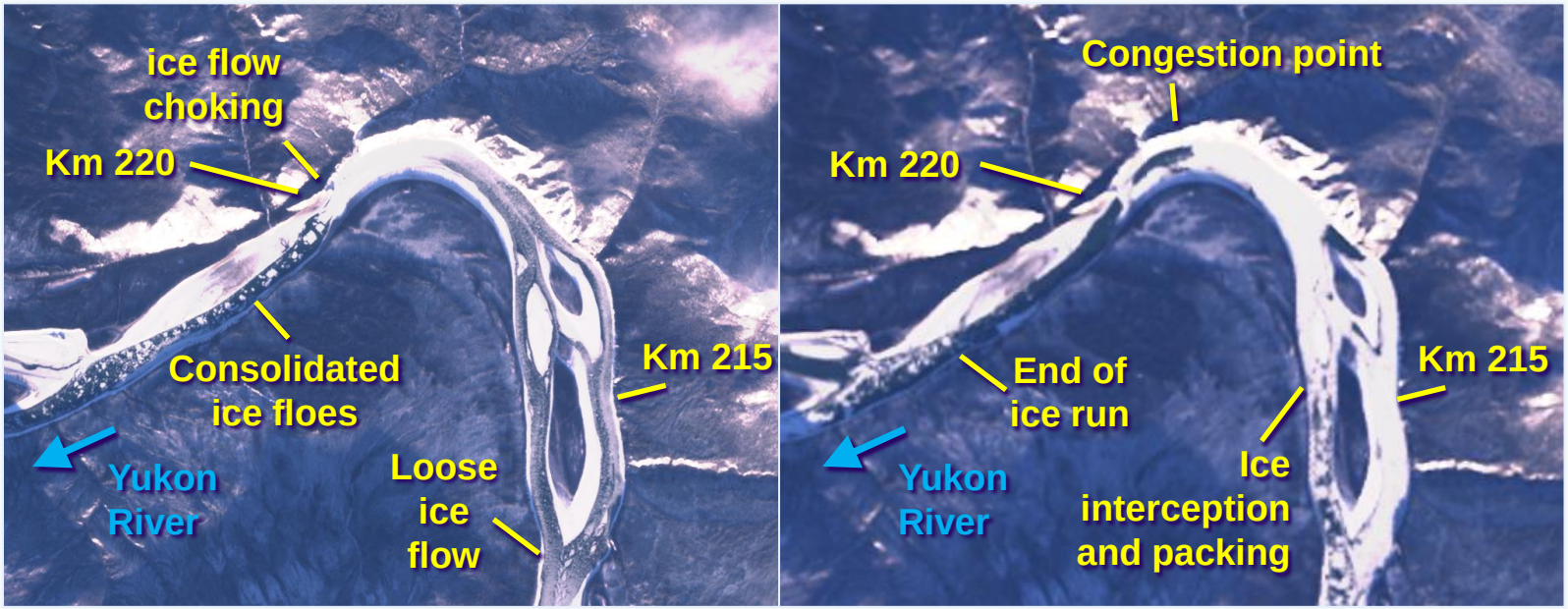
4. Methodology

- Use satellite (S1, S2, RadarSAT2, L8) observations to document freeze-up along 300 km of the Yukon River
- Identify dominant ice congestion locations
- Relate freeze-up dynamics to simple hydrometeorological indicators
- Create a simple model that predicts freeze-up timing and patterns

5. Results

Dominant ice congestion locations from 2013 to 2018:

- Km 220 (channel bend + constriction)
- Km 124 (just downstream of Dawson)
- Km 120 (Klondike River delta, just upstream of Dawson)
- Km 0 (White River delta)

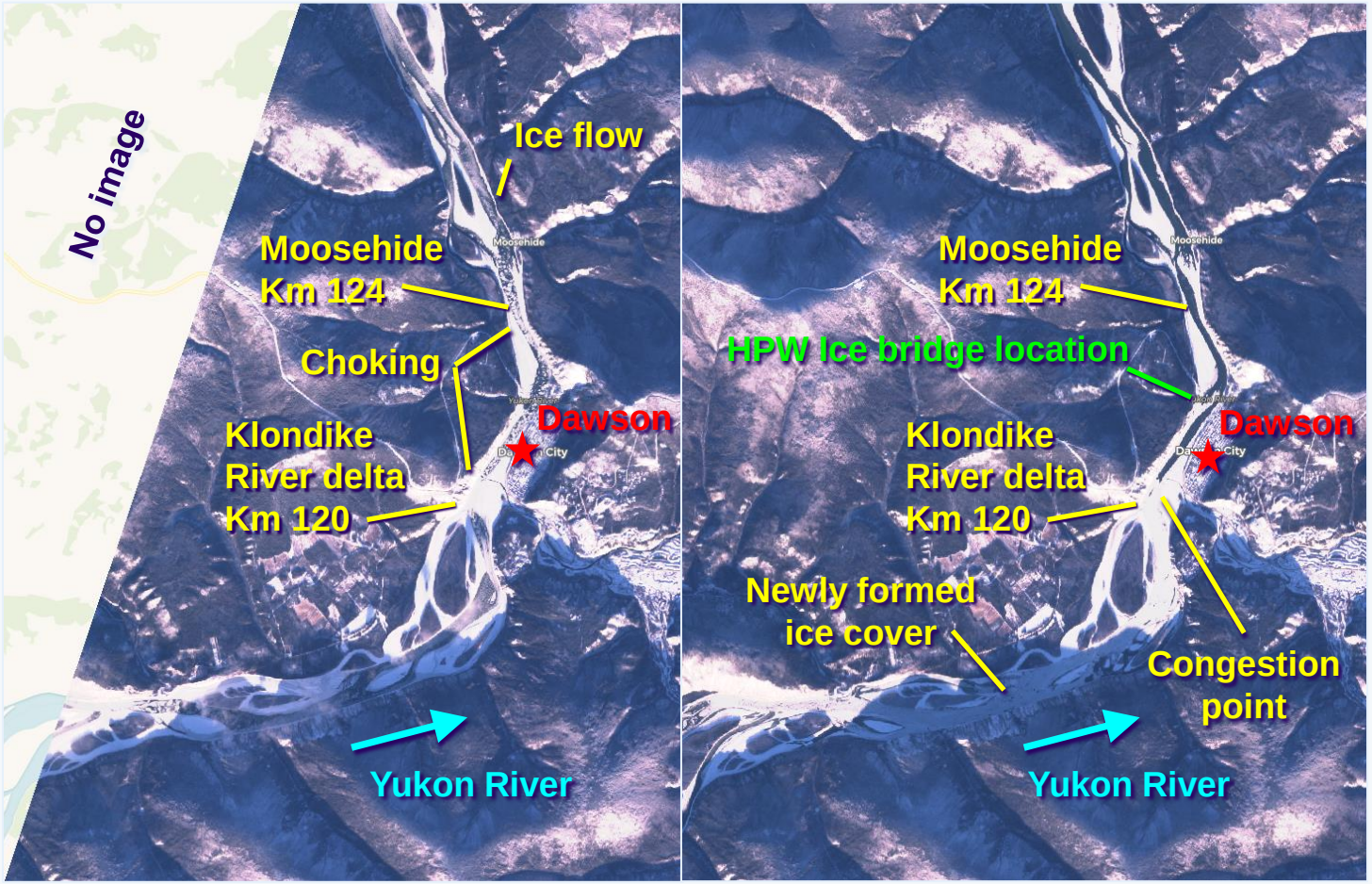


Nov 2, 2018

Nov 4, 2018

5. Results

Cause of open water at Dawson: Dominance of congestion at Km 120 over Km 124



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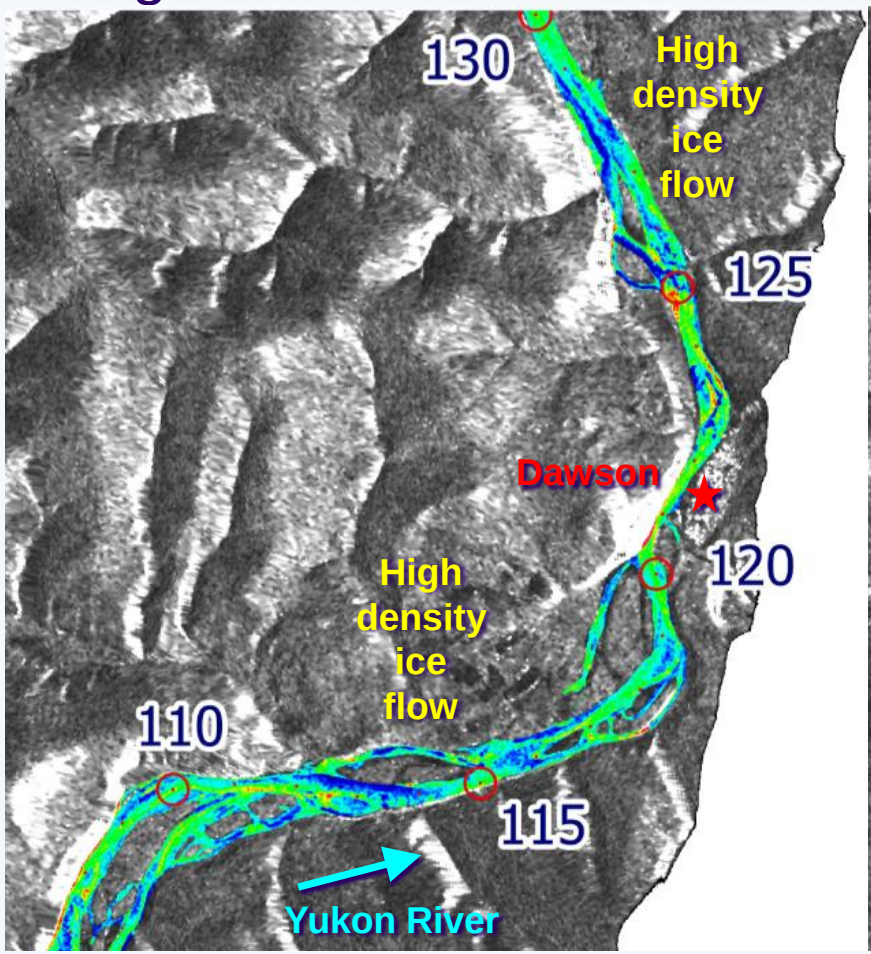
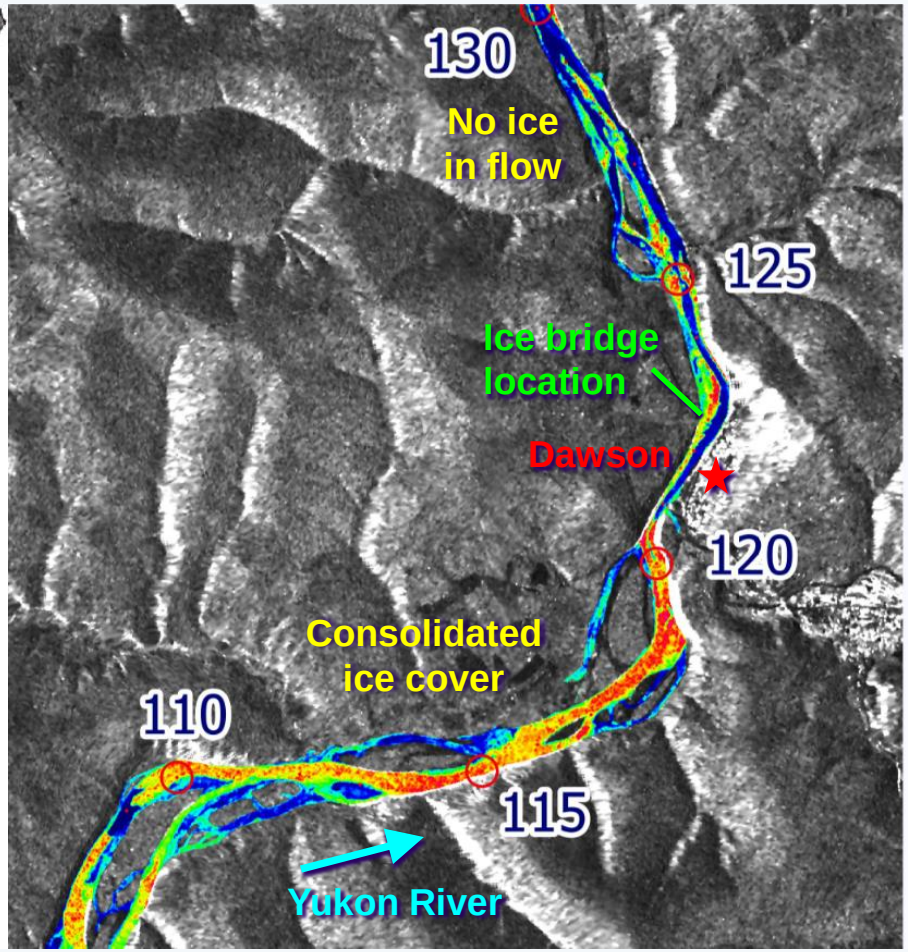


Nov 7, 2017



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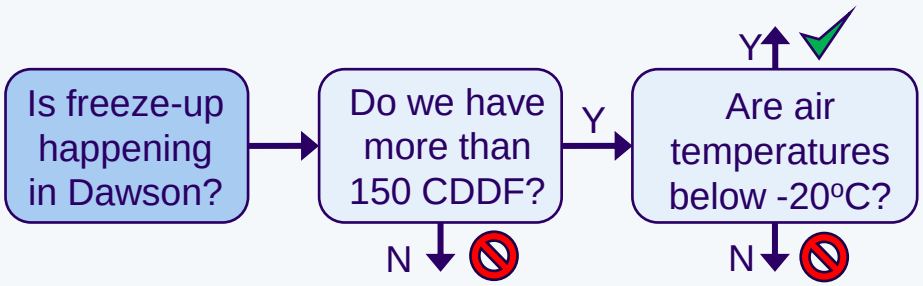
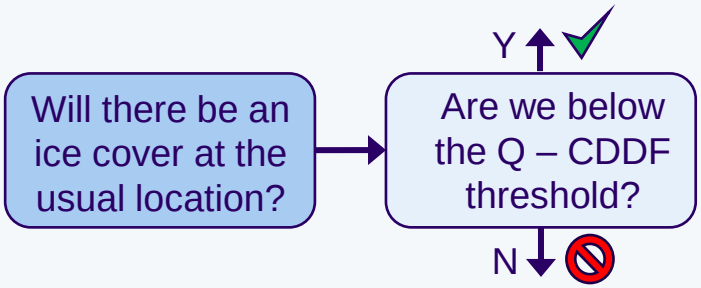
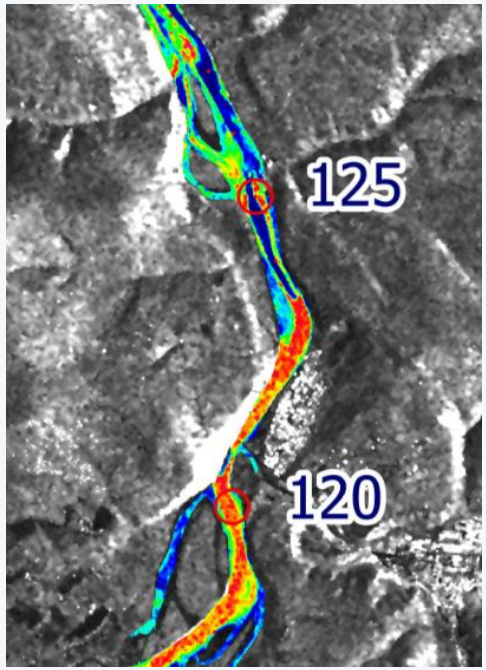
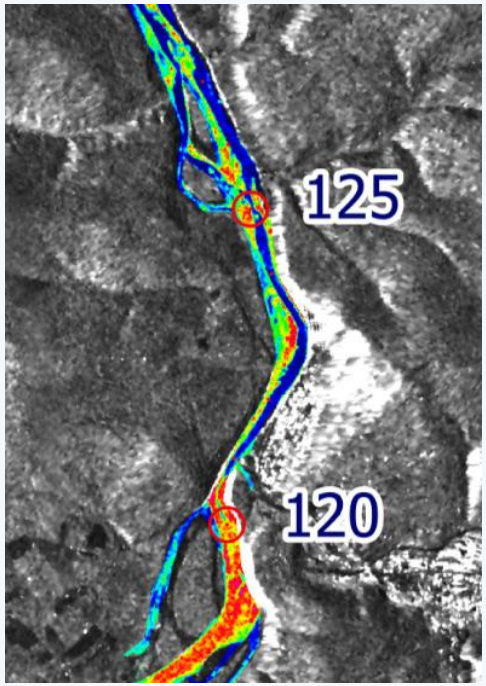
5. Model

- Air temp. (CDDF) and estimated discharge (Q) to define empirical thresholds









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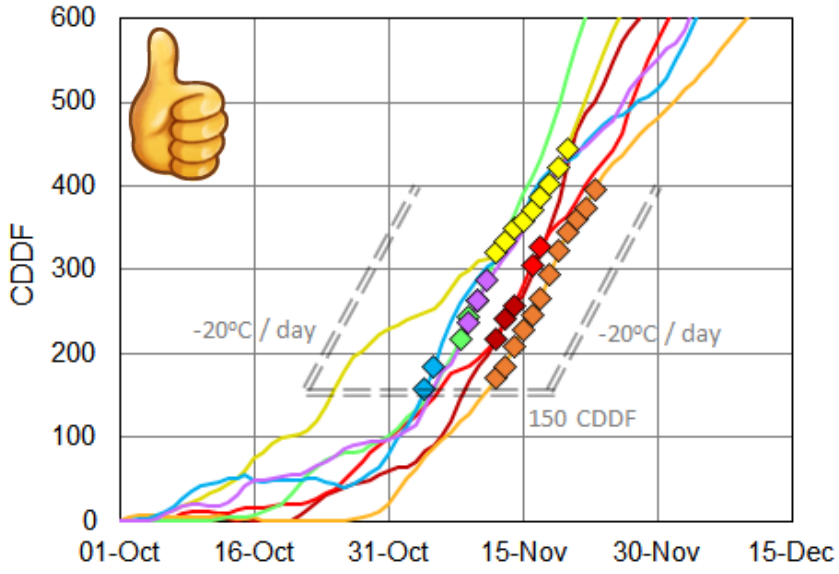

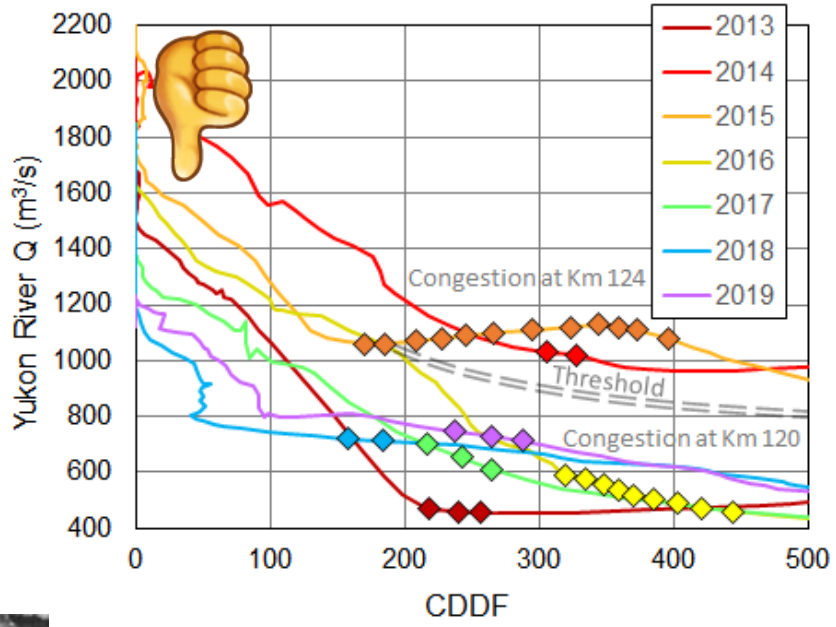

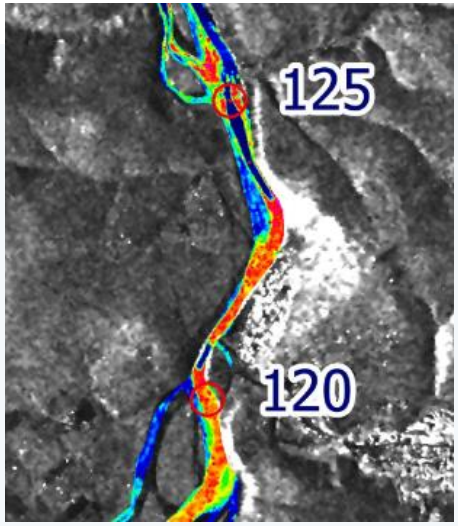

Nov 2019

6. Discussion

- Improved understanding of freeze-up processes 👍
- Still some uncertainty about initial congestion pattern 👉
- Covid19 bonus: High Q in Nov 2020 and the ice cover did form at Dawson, but it was the freeze-up front migrating all the way up from Km 220 👍👉
- Needs:
  - Longitudinal profile (slope vs. km)
  - Other heat budget parameters (e.g., wind)
  - Hydraulic conditions monitoring or simulation
- A parallel discussion about mitigation can happen

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Thank you

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