Yukon University

# Towards improved winter discharge estimates

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# Outline

1. Current status and objectives
2. User needs in winter
3. Winter complexity
4. Classic approaches
5. Proposed project philosophy
6. Site documentation, station optimization, tools
7. Example
8. Summary

# 1. Current status

- Estimating river / stream discharge in the presence of ice = challenging
- New technology = accessible
- Computational power = increasing
- Some northern agencies attempt to provide:
  - Continuous 12-month stage & discharge data
  - Real-time discharge estimates during winter
- Are historical records “accurate”?
- Can we do “better” for current and future users?

Objectives

# 2. Winter data user needs

| | Real-Time | Post-Winter |
|---|---|---|
| ➢ Water availability | X | |
| ➢ Accurate discharge (Q) or water level (Y) forecasts (e.g., management) | X | |
| ➢ Accurate river ice breakup forecast (e.g., safety) | X | |
| ➢ Accurate ice-induced hydrodynamic simulations (e.g., design) | X | X |
| ➢ Continuous & reliable cold regions flow records (e.g., environmental research) | | X |
| ➢ Simulation of the impact of climate change on cold regions hydrology | | X |

# 3. Complexity of winter hydrological processes

- Most complex periods:
  - Freeze-up (1 day to entire winter)
  - Mid-winter runoff events (1 to +5 / winter)
  - Spring breakup (1 day to 1 month)
- Other factors impacting ice processes complexity:
  - Climate: Temperate and arctic
  - Upstream morphology: steep or heterogeneous
  - Local geometry: diffused hydraulic control, low floodplain
- Y varies: is this a Q or an ice effect (IE) fluctuation?

$$Q_{estimated} = Q_{rating\ curve} (1 - IE)$$

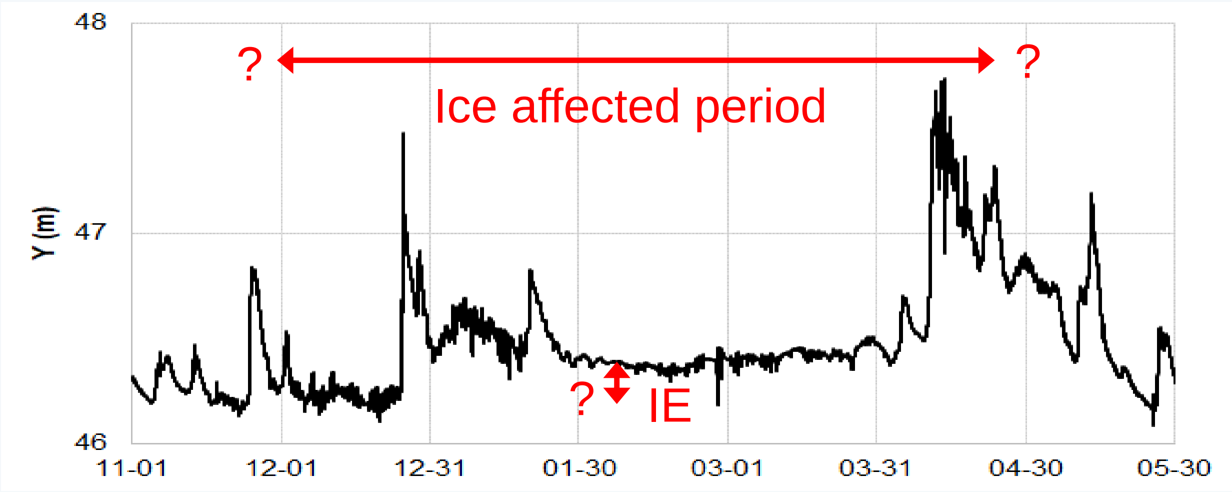
# 4. Classic approaches

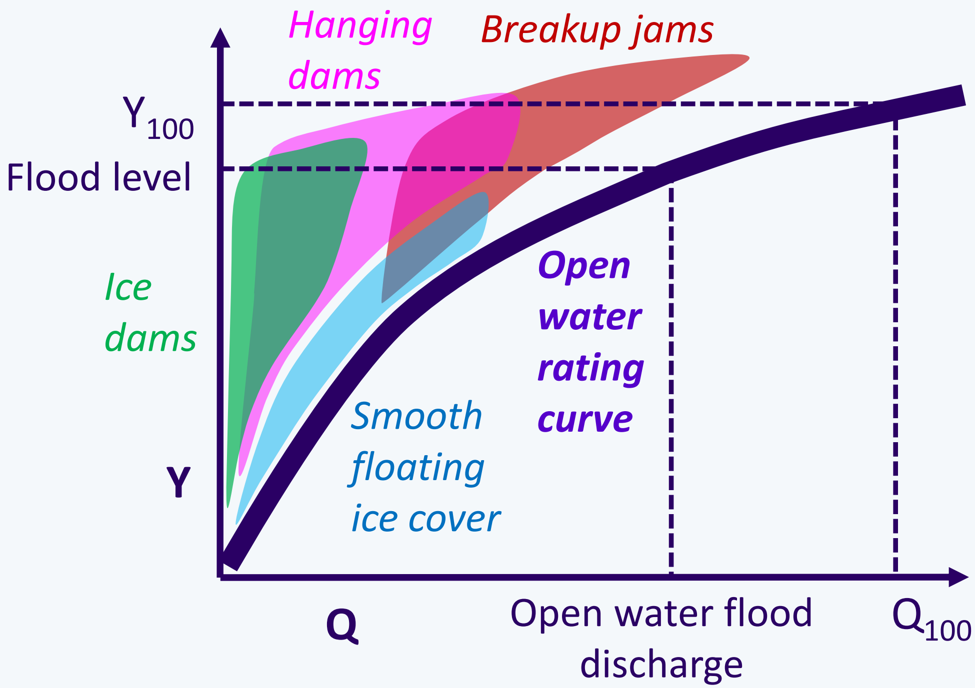
| | RT | PW |
|---|---|---|
| ➢ 1-3 Under-ice Q measurements | X | X |
| ➢ Best guess, judgment and experience | X | X |
| ➢ Comparison with historical data | X | X |
| ➢ Comparison with sister stations | X | X |
| ➢ Recession extrapolation | X | X |
| ➢ Recession interpolation | | X |
| ➢ Hydrological simulation | X | X |

# 5. Project philosophy

- Recognize current weaknesses:
  - Long Q recessions = exception
  - Dynamic ice processes = dominance
  - Experience = judgement & subjectivity
- Embrace Nature’s complexity: Be curious
- Station documentation: What ice process explains this?
- Classify station sites by winter behaviour:
  - Optimal instrumentation strategy
  - Appropriate tools
  - Q data production protocols
- Be confident: “River, I see what you are doing…”
- Vision: Reduce cost and Q estimation uncertainty (U)

# 6. Station site documention



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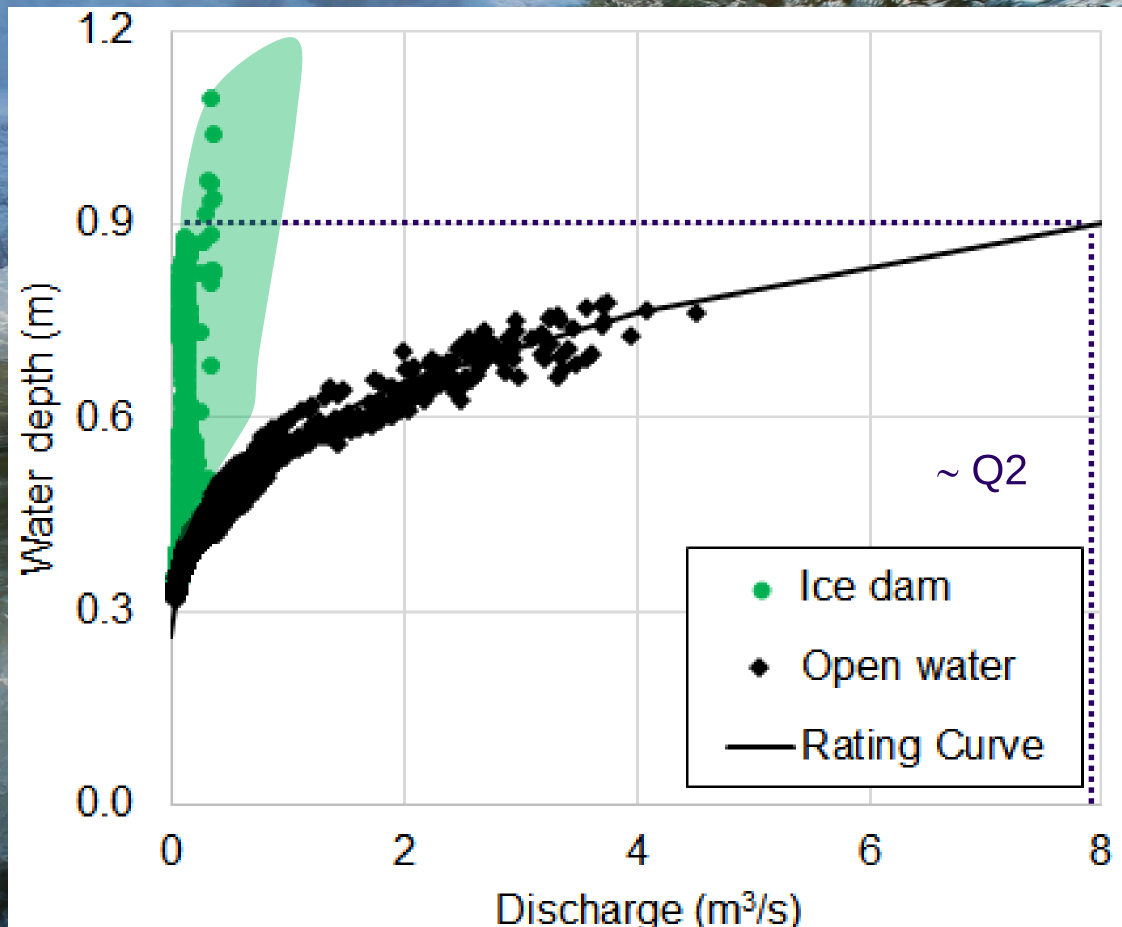
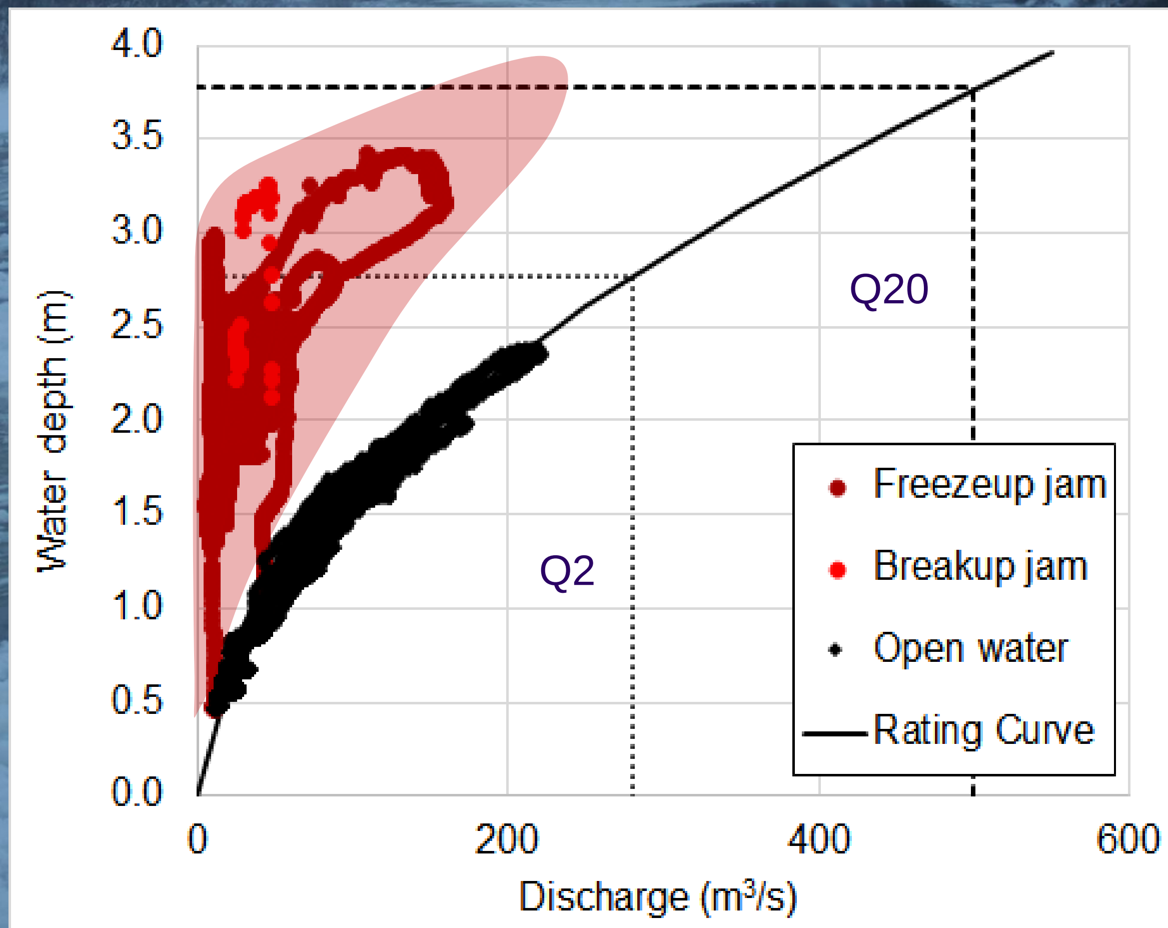


# 6. Site documentation



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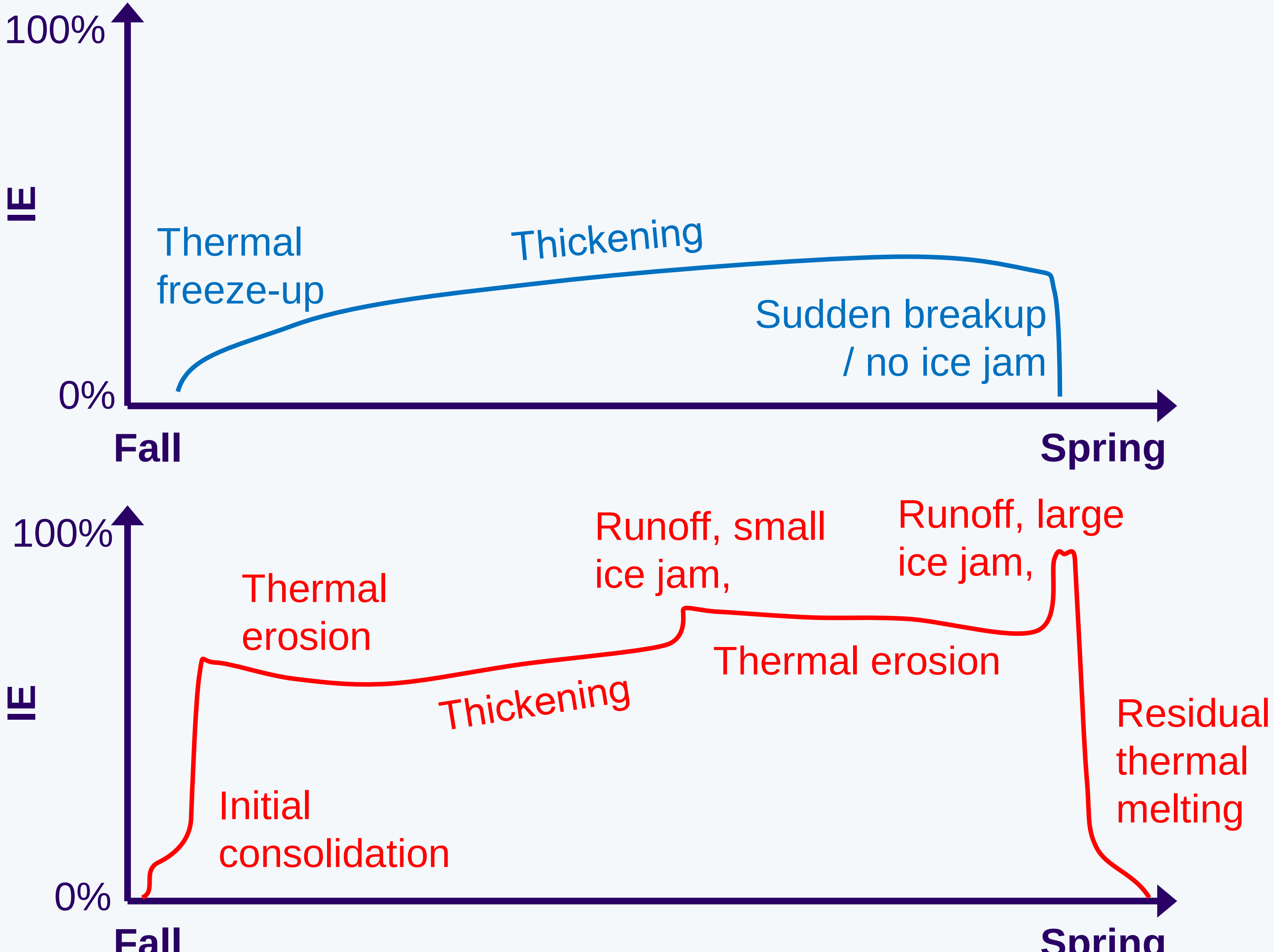
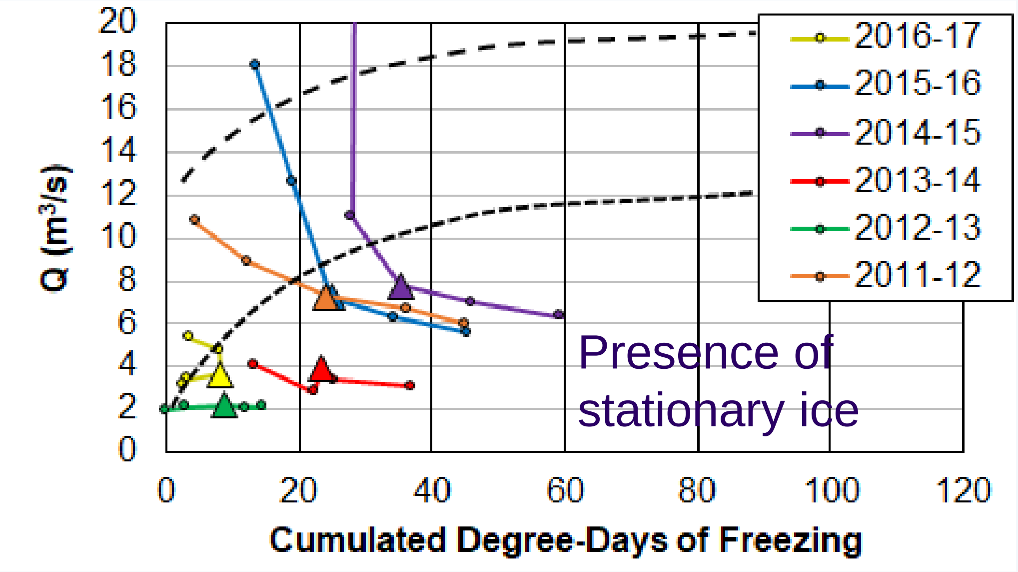


# 5. Station instrumentation strategy

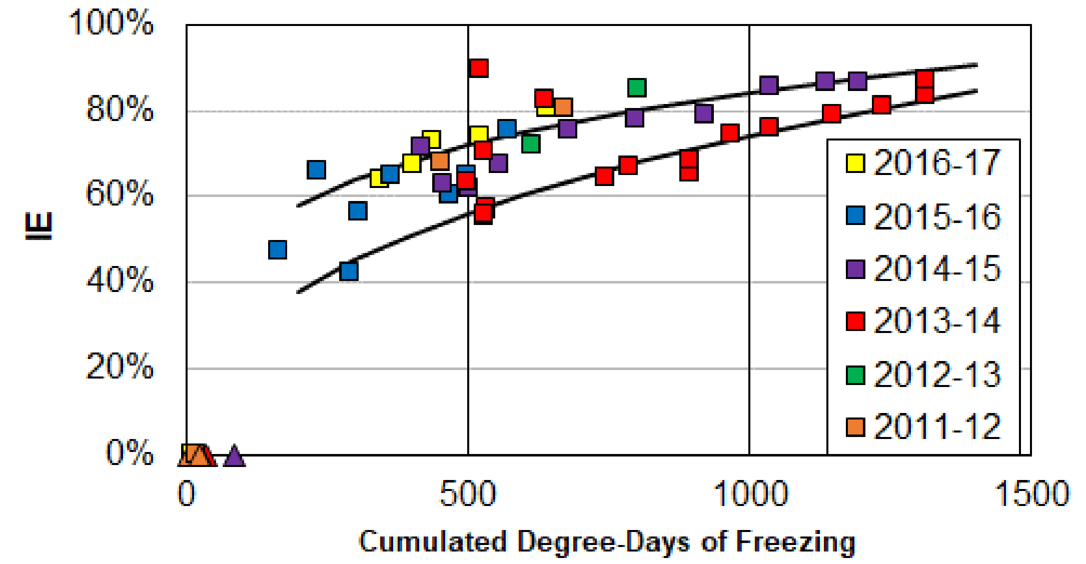
- Ensure continuous Y record
- Move the station where ice processes are "simple"
- Choose the right instrumentation for the site:
  - ADCP
  - Remote camera
  - Water temperature logger
  - Spaced Y sensors
  - Secondary Y sensor
  - Water – ice surface elevation sensor
  - Automated salt-dilution
  - Etc.

# 6. New tools

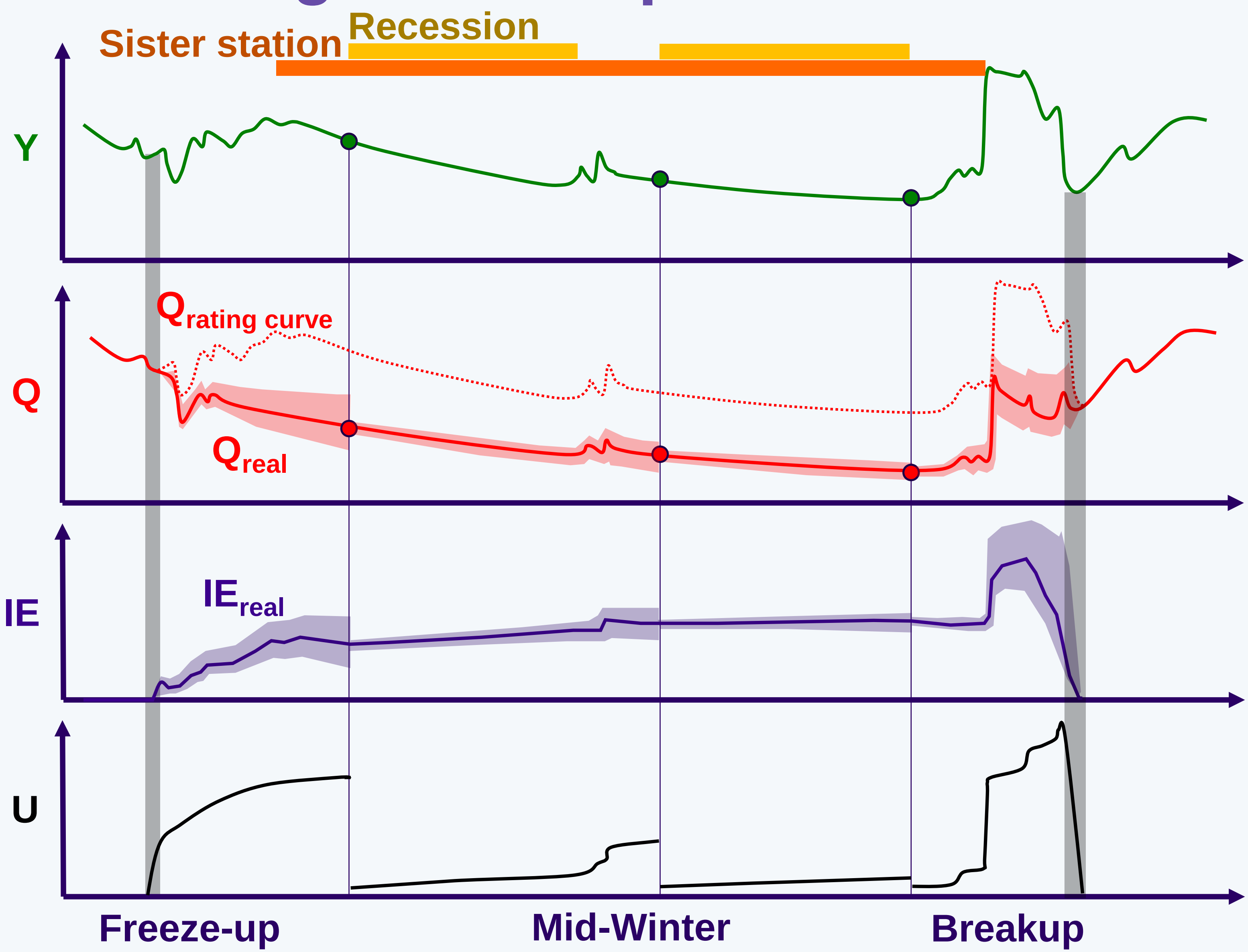
Empirical freeze-up threshold



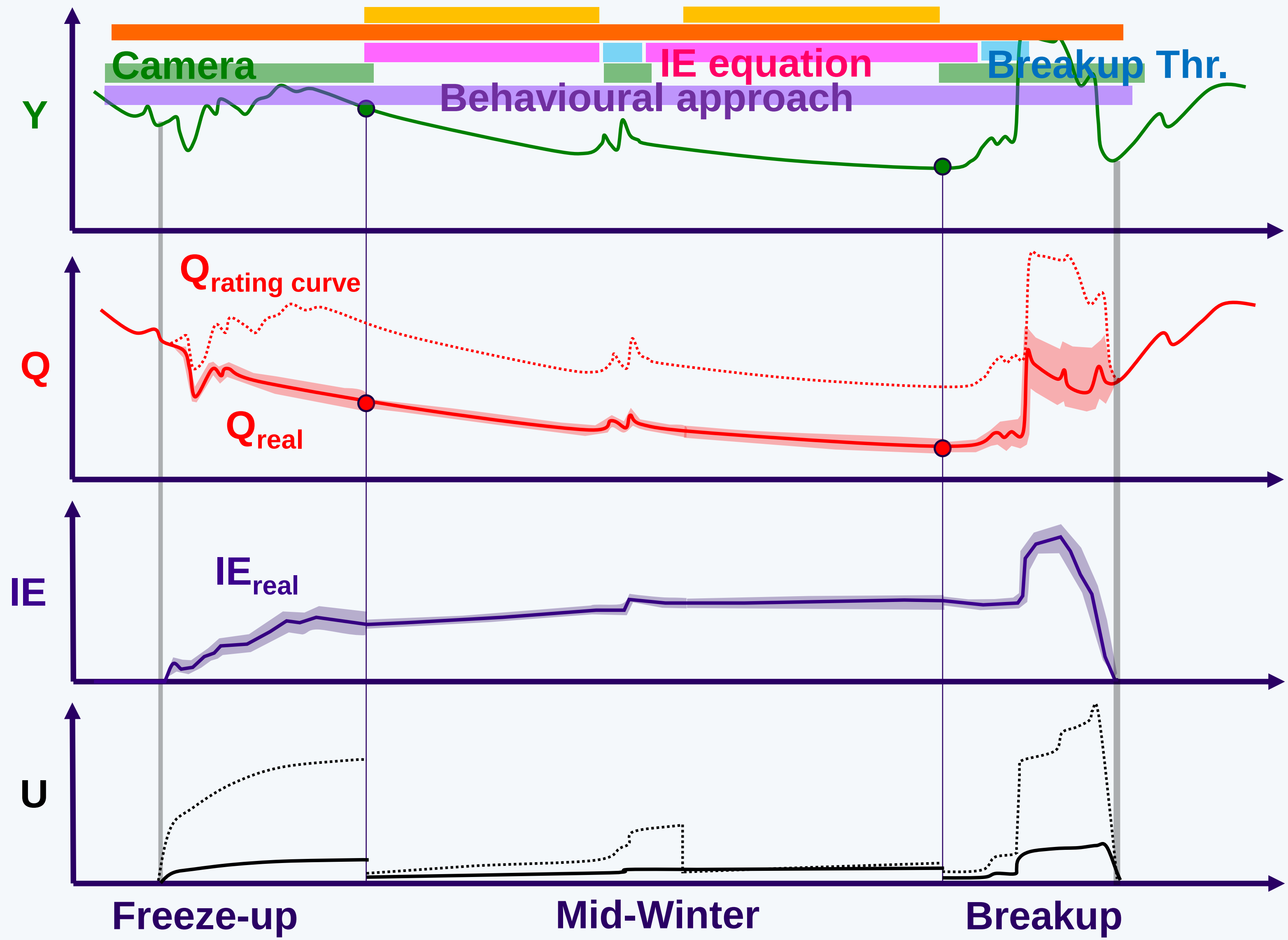

Empirical estimation of ice effect (IE)



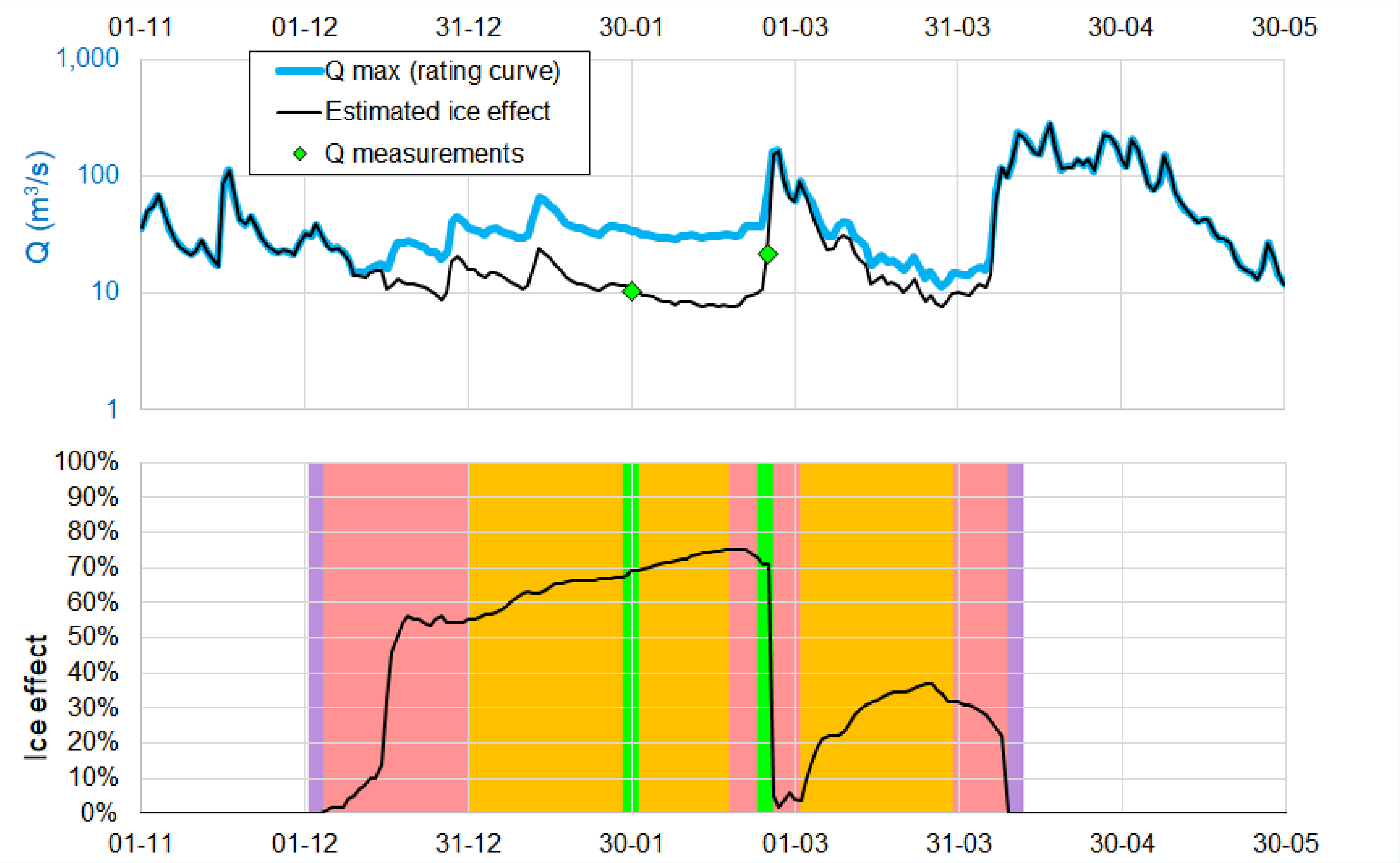
# 7. Working RT example



# 7. Working RT example: New approach

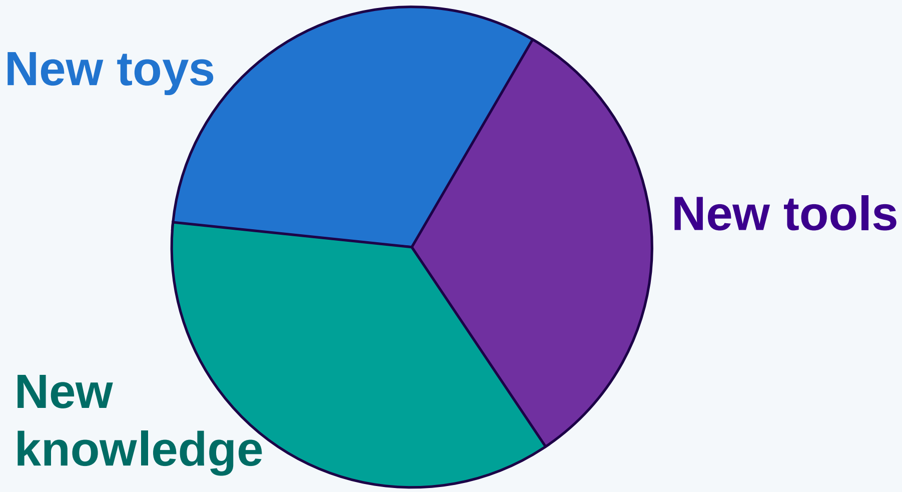


# Real example



# 8. Summary

- Station resilience = crucial
- Gain in winter discharge estimation accuracy =




- Make the right decisions about station locations, measured parameters, instrument types, training, etc.
- Q and IE graphs should make sense

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