Environment and Climate Change Canada Environnement et Changement climatique Canada

Estuarine Tides and Discharge Reconstruction from SWOT

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SWOT ST Meeting
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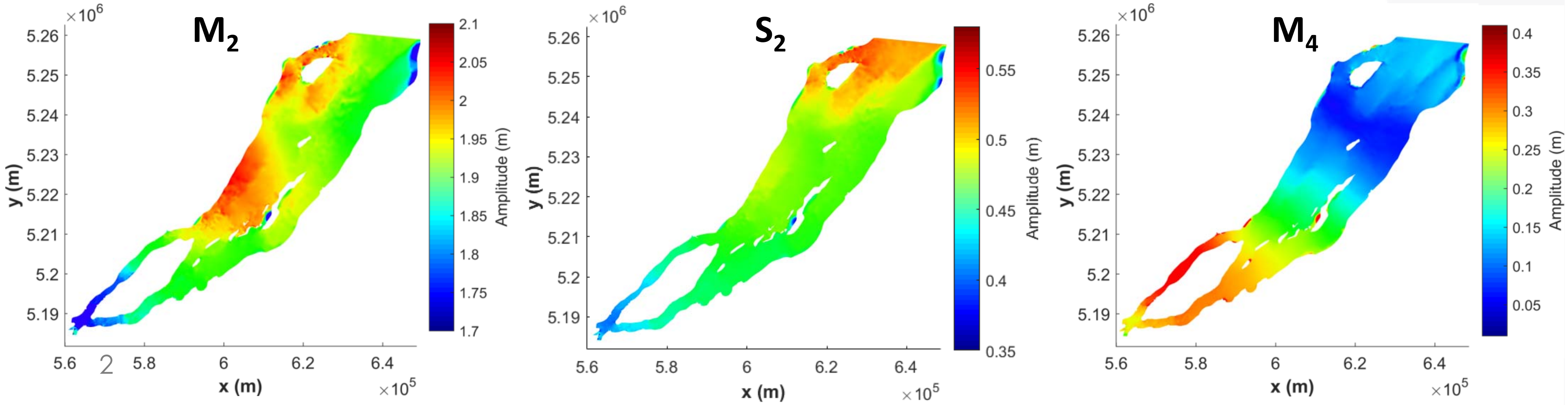
Canada

Mapping surface tides from SWOT

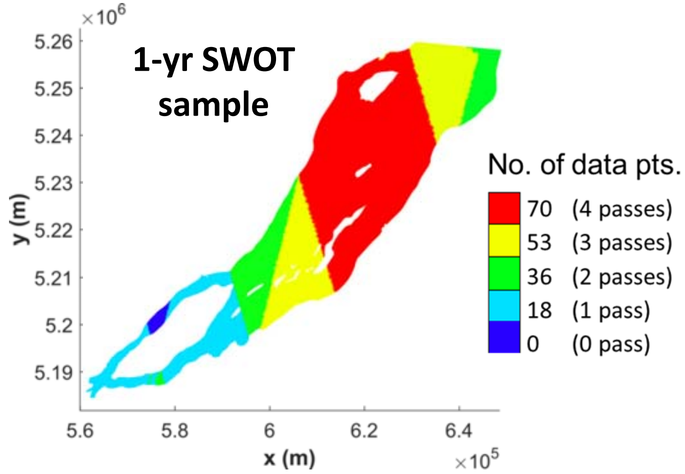
- St. Lawrence Upper Estuary
    - Macro-tidal (tidal range <7m)
    - 2D variability in tides
    - Increasing influence of river discharge upstream

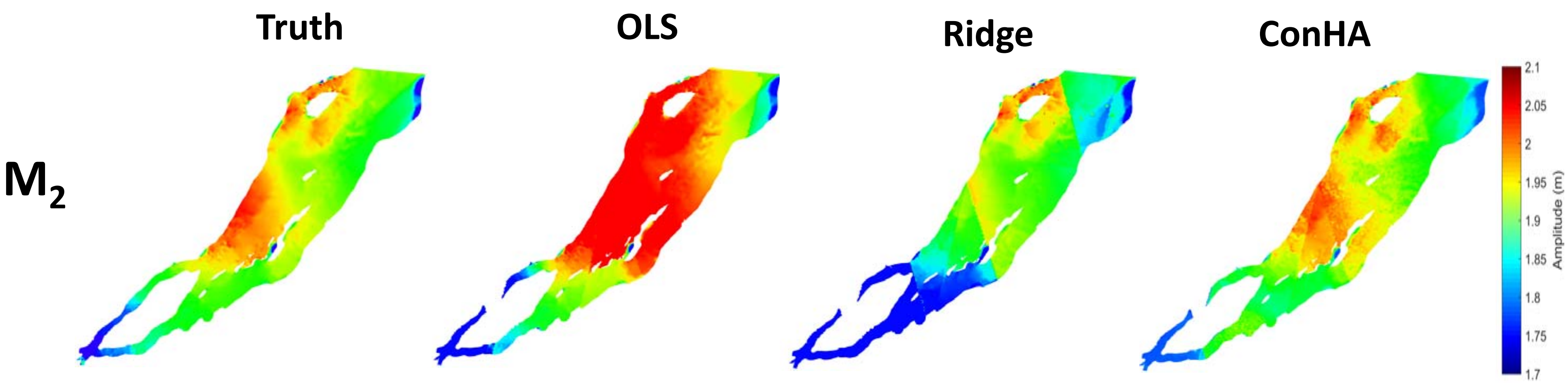
Will SWOT capture this variability?



Mapping surface tides from SWOT

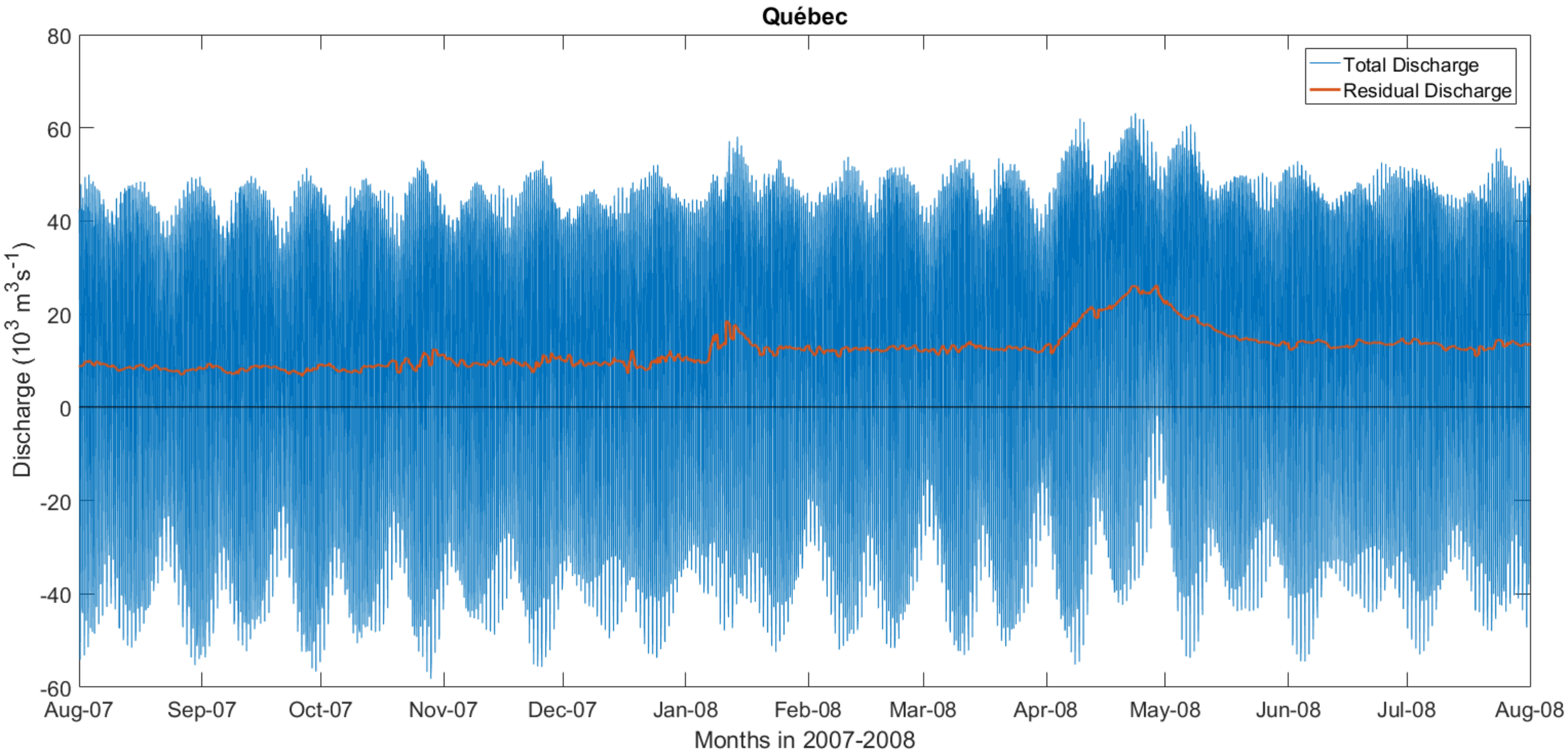
- Methods
  - Ordinary Least-Squares (OLS)
  - Regularized Least-Squares (e.g. ridge)
  - Constrained Harmonic Analysis (ConHA)





Reconstructing discharge from SWOT

- Measuring or estimating tidal discharges is challenging
  - Affected by multi-scale non-stationary signals
  - Traditional rating-curve approaches fail under these conditions



Reconstructing discharge from SWOT

- New method for instantaneous discharges (Bourgault & Matte)
  - Physically-based, nonlinear and unsteady (semi-empirical)
  - 1D momentum equation
    - Nonlinear advection neglected
    - $R \approx h_0 + h$
    - $A \approx B(h_0 + h)$

$$\frac{\partial Q}{\partial t} = -g[B(h_0+h)]\left(\frac{\Delta h + \Delta a_0}{\Delta x}\right) - \frac{gn^2}{B(h_0+h)^{7/3}}Q|Q|$$

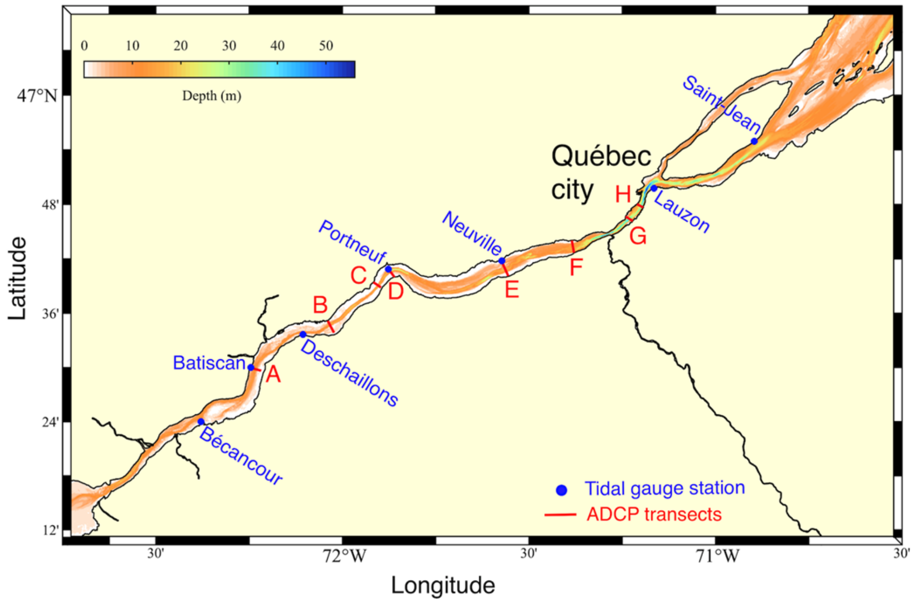
$$\frac{\partial Q}{\partial t} = -g[C_1(C_2+h)]\left(\frac{\Delta h + C_3}{\Delta x}\right) - \frac{gC_4^2}{C_1(C_2+h)^{7/3}}Q|Q|$$

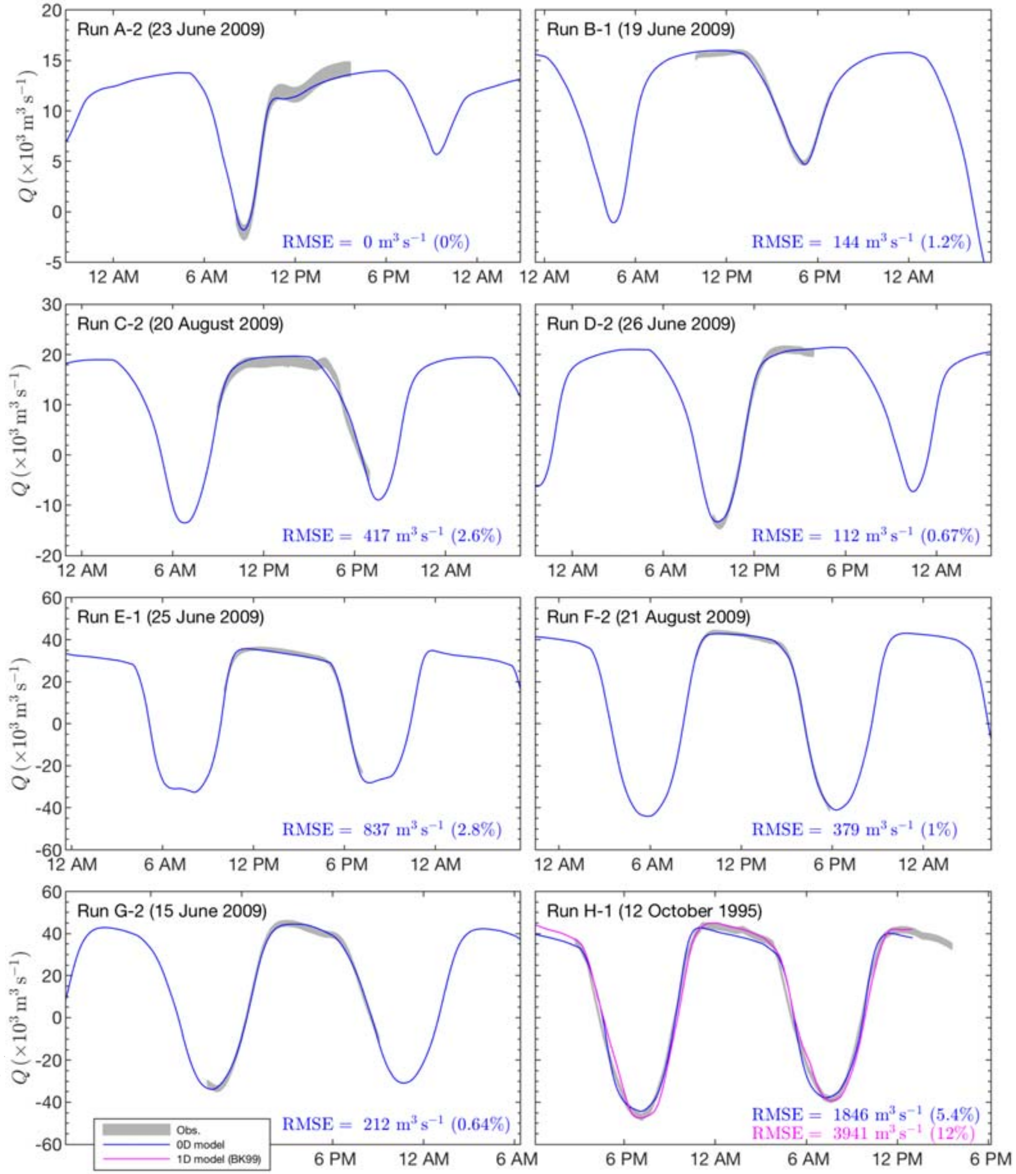
where $(C_1, C_2, C_3, C_4) = (B, h_0, \Delta a_0, n)$.

- Δh is the water level difference between two successive tide gauges
- Discretized using Adams-Bashfort 2nd order scheme
- Iteratively solved by minimizing the difference between Q_{mod} and Q_{obs}

Reconstructing discharge from SWOT

- Application to the St. Lawrence fluvial estuary
  - RMSE <5%
  - Once parameters are optimized, predictions can be made for any period





Reconstructing discharge from SWOT

- Ungauged estuaries
  - Forward model
    - h and Δh from SWOT
    - Estimated parameters
      - B estimated from SWOT water extent
      - h_0 estimated from wave celerity: $c \approx \sqrt{gh_0}$
      - Δa_0 estimated from mean slope
      - n estimated from tidal damping/channel convergence properties?
    - Q error estimation by perturbing the parameters

$$\frac{\partial Q}{\partial t} = -g[C_1(C_2+h)]\left(\frac{\Delta h + C_3}{\Delta x}\right) - \frac{gC_4^2}{C_1(C_2+h)^{7/3}}Q|Q|$$

$$(C_1, C_2, C_3, C_4) = (B, h_0, \Delta a_0, n)$$

  - Remains to be tested…