Constituent transport in river

Concept, implementation, and test run

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Data courtesy: Michael Rawlins (UMass Amherst)

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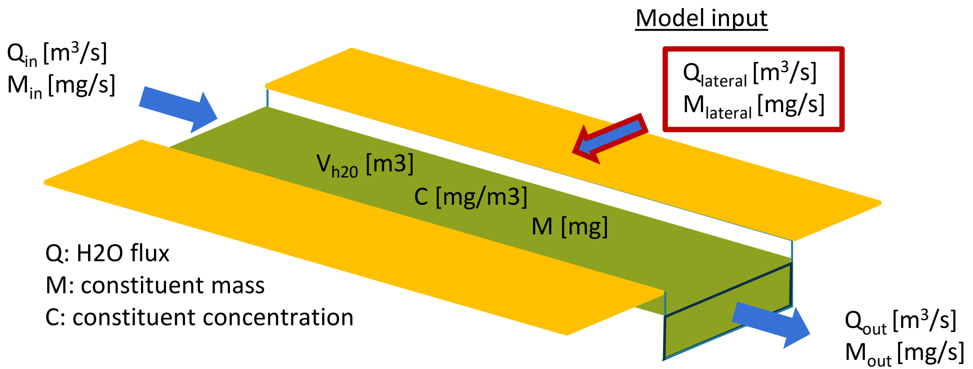
Introduction

- A river model has been focusing on fresh water transport in rivers.
- Interest in the transport of constituents in rivers (e.g., DOC, isotopes, heat).
- Initial implementation and test run of H2O and DOC (Dissolved Organic Carbon) transport in river systems.

Model implementation

One river reach



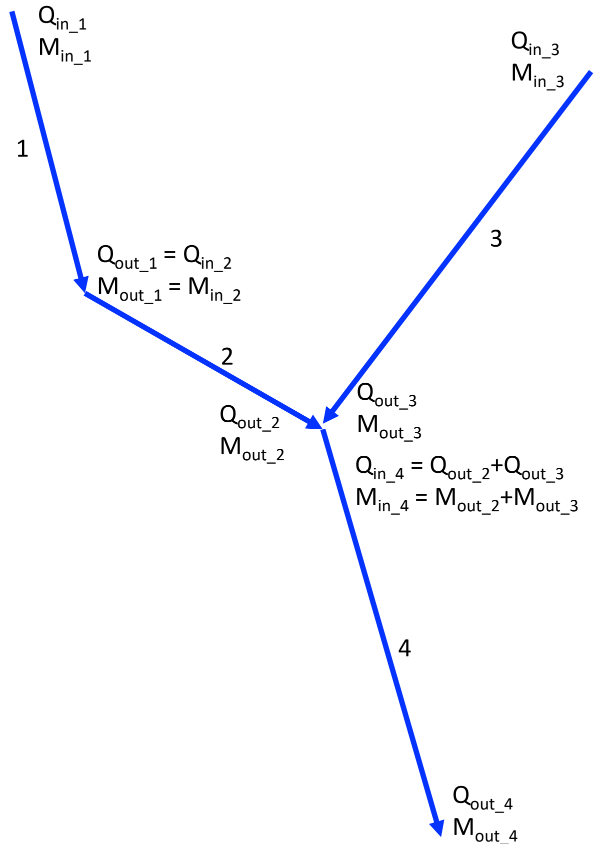
Assumption:

- Constant concentration in a reach
- No sink (bioreactivity, etc.)

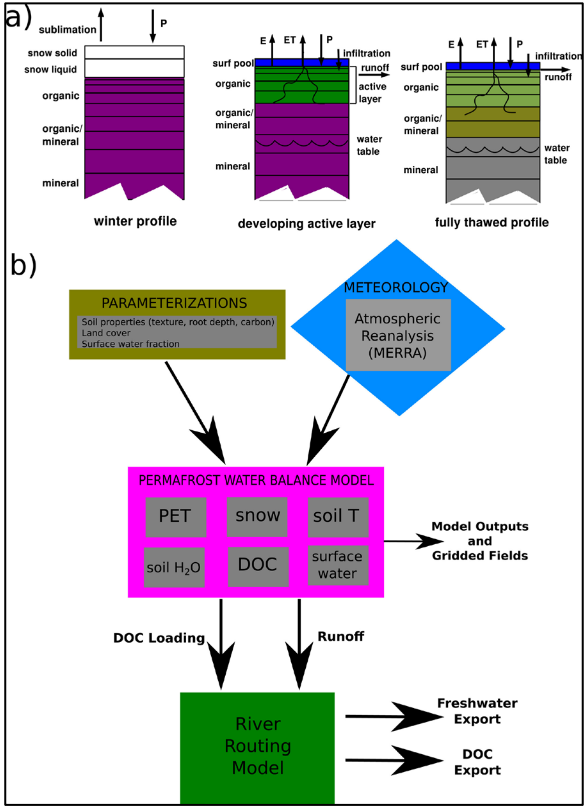
Each time step:

1. $C\ [mg/m^3] = (M_{in}\ \Delta t + M_{lateral}\ \Delta t + M(t\text{-}1))/(Q_{in}\ \Delta t + Q_{lateral}\ \Delta t + V_{h2o}(t-1))$
2. $M_{out}\ [mg/s] = C \times Q_{out}$
3. $M(t)\ [mg] = M_{in} - M_{out} + M_{lateral} + M(t\text{-}1)$

River network



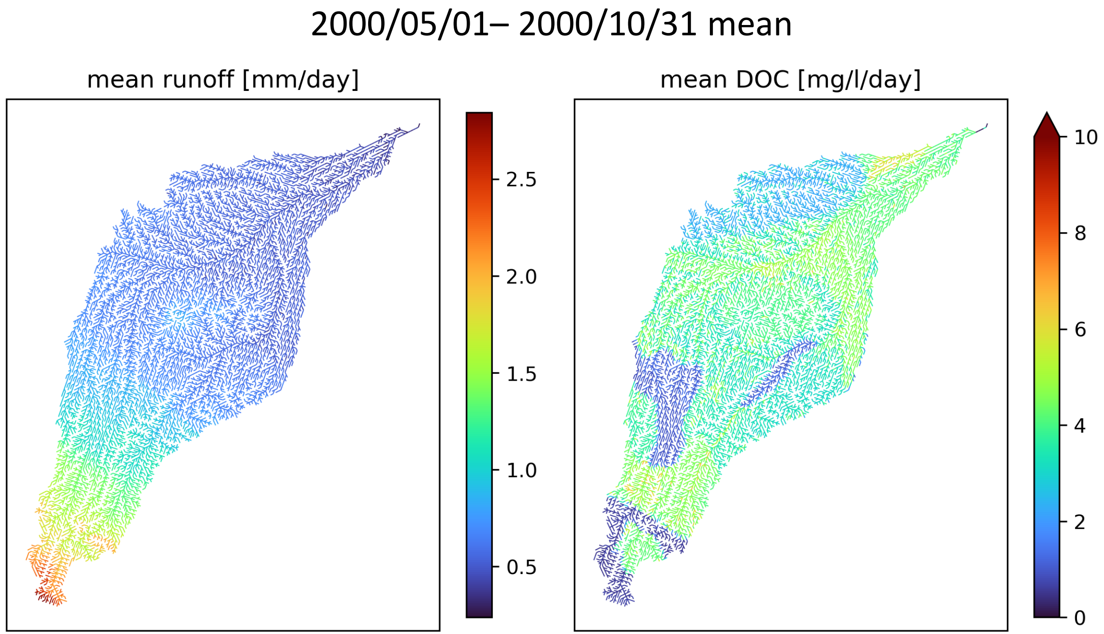
Testing water-DOC routing – Alaska North slope

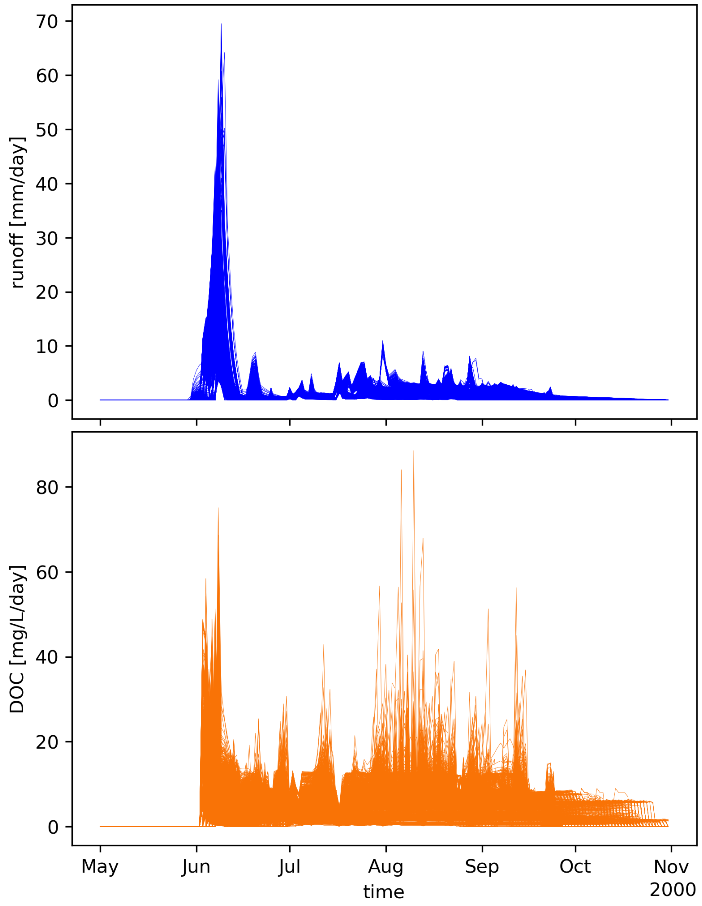


Rawlins et al., 2021, JGR Biogeosciences

Simulated runoff and DOC 1km data

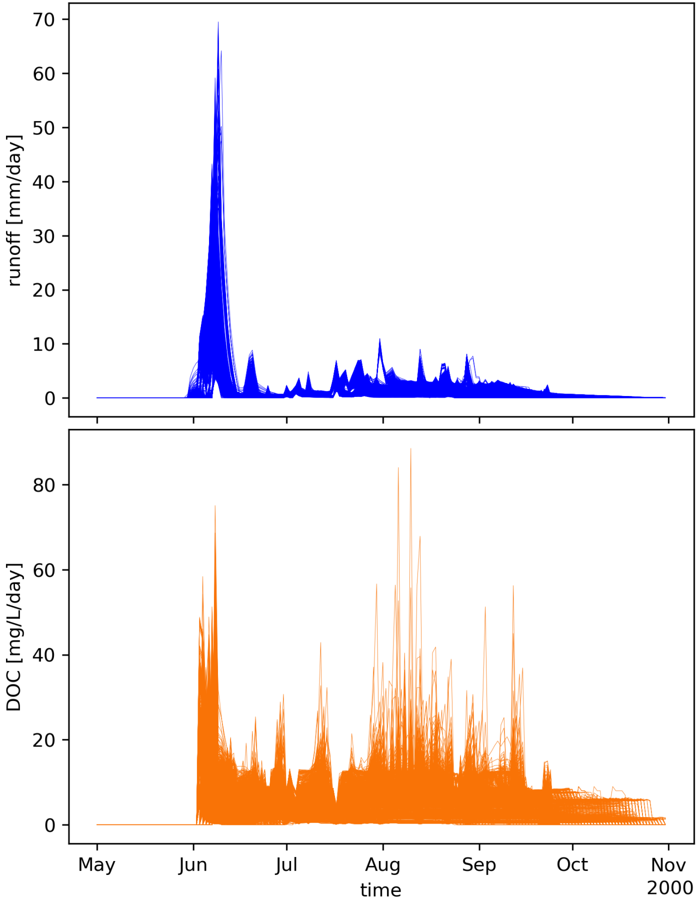
River model inputs: runoff & DOC load (2000/05-2000/10)





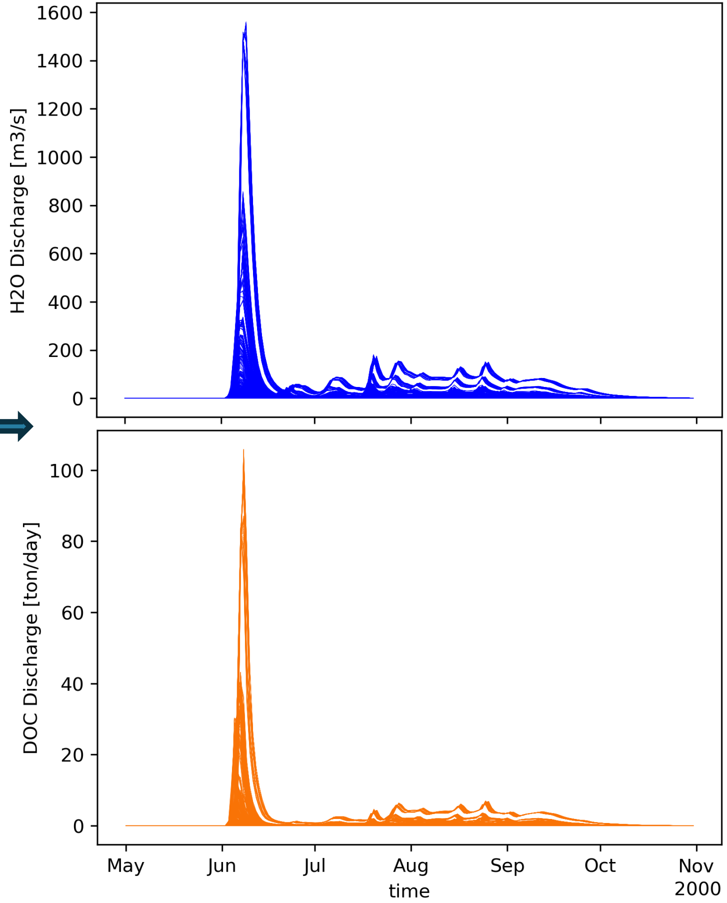
River model output: H2O & DOC discharge

River model inputs

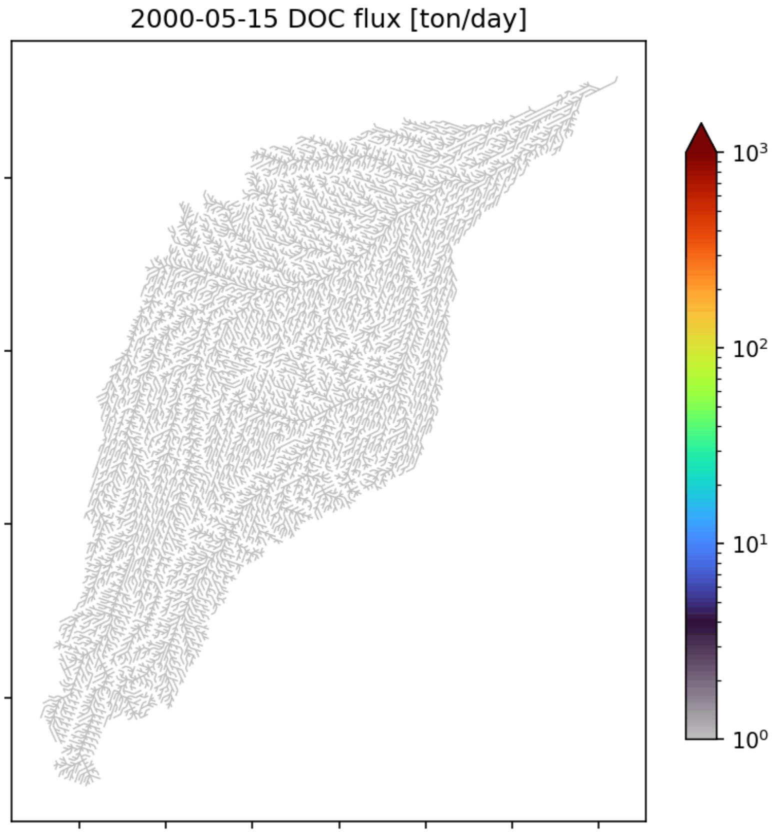


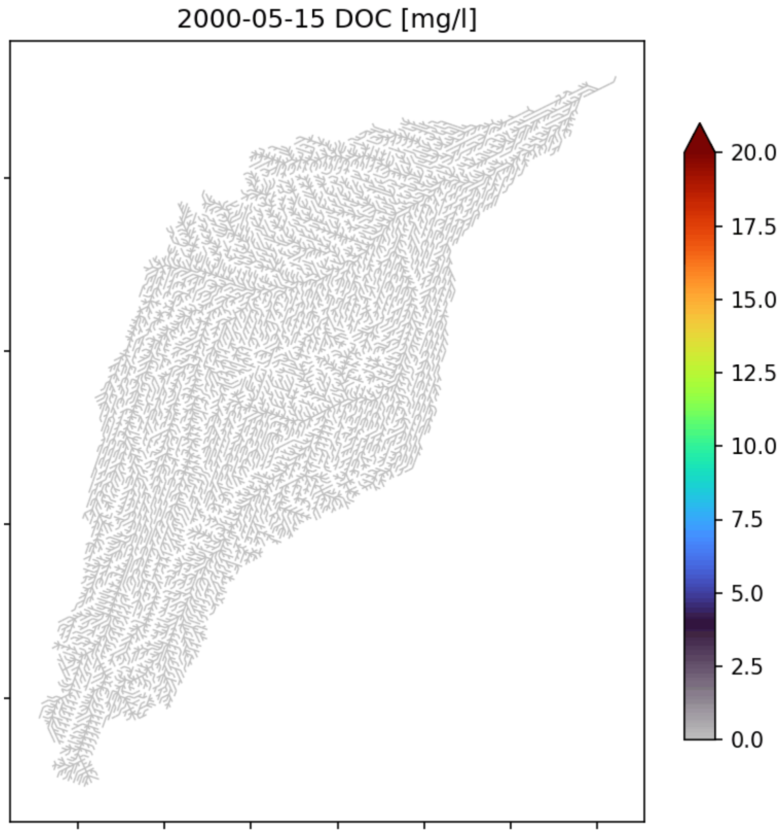
River model

River model outputs

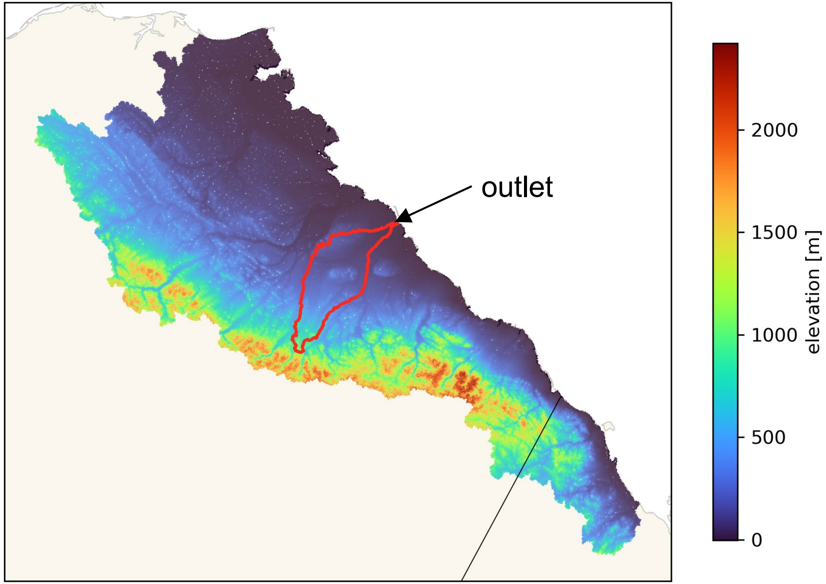


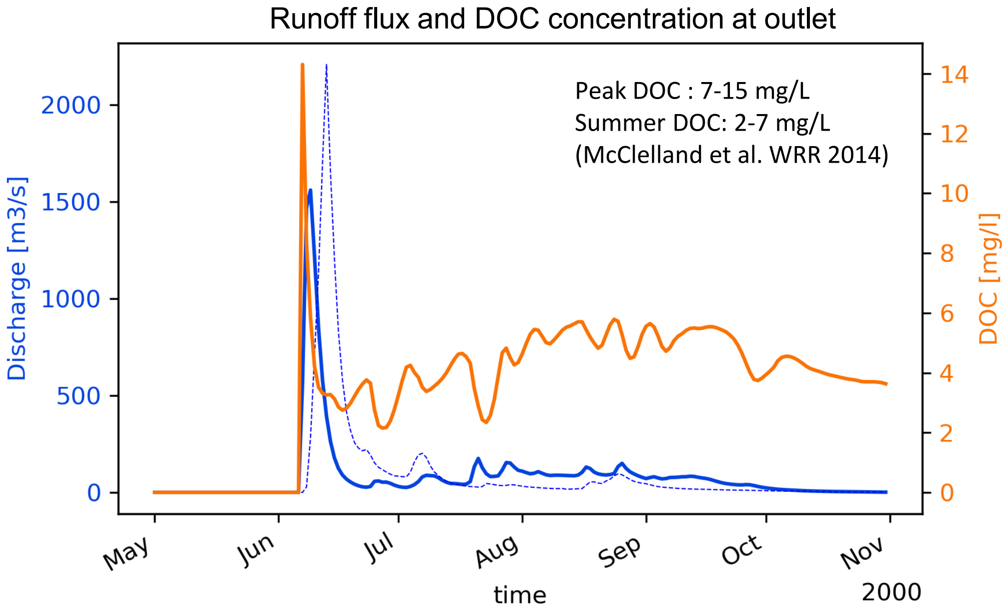
How water & DOC move through river network





Discharge to ocean during 2000/05 – 2000/10





Mass balance (2000/05/01 - 2000/10/31)

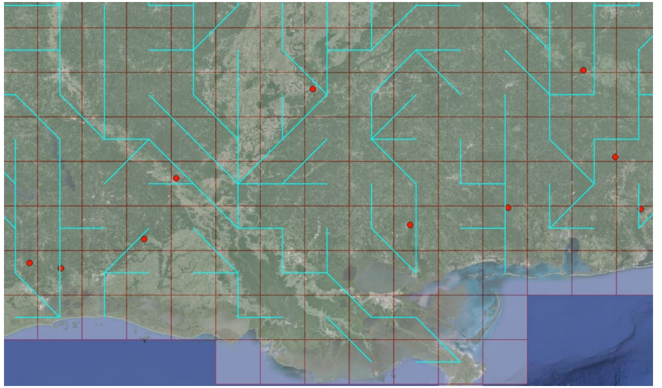
	Basin wide input	Basin discharge	Basin wide storage
Freshwater [km3]	1.34267	1.34200	0.00067 (672592 m^3)
DOC [metric tons]	6956.7	6954.9	1.8

McClelland et al. WRR (2014): 10,882 ± 748 tons/yr (2000-2007 mean)

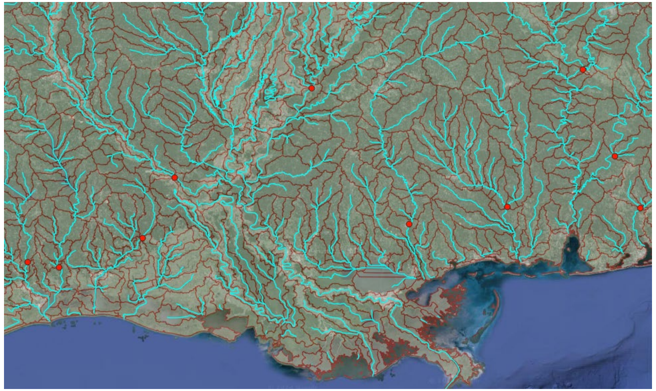
Summary

- Initial implementation of constituent transport
  - Ensure mass balance closure.
  - Maintain consistent concentrations with input.
  - Dilution and concentration by mixing flows and storage in a channel.
  - No in-stream sinks and sources; No dispersion.
- Next steps
  - Comparison with measured DOC
  - Test with global CTSM data.
  - Couple with CTSM and ocean.
  - Add other constituents tracking.
  - Add more physics.

gridded network (0.5 degree)



catchment network



Solution to diffusive wave routing

$$\frac{\partial Q}{\partial t} + C\frac{\partial Q}{\partial x} = D\frac{\partial^2 Q}{\partial x^2}$$

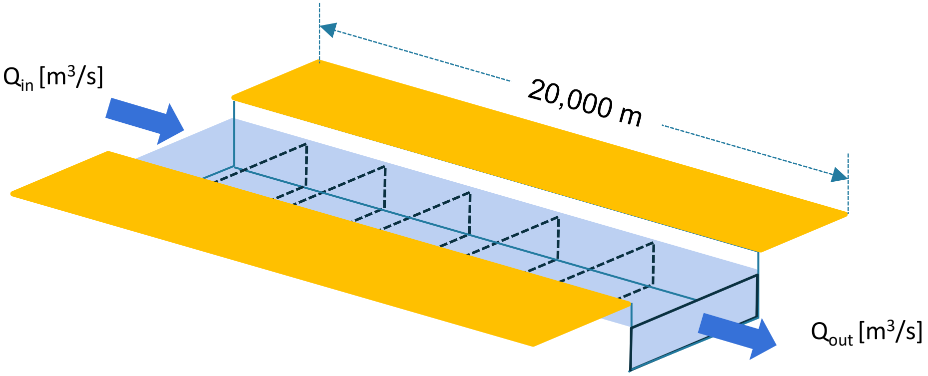
$$D = \frac{K^2}{2Qw}$$ Diffusivity[m2/s]

$$C = \frac{1}{K}\frac{\partial K}{\partial A}$$ Wave celerity [m/s]

$$K = \frac{A}{n}R^{\frac{2}{3}}$$ Channel conveyance

Routing synthetic inflow with one rectangular reach

- L=20,000 m
- W=100 m
- S_0=0.0001
- n=0.035



Solve fully implicitly or explicitly at multiple sub-reaches