Roles of Short-term Water Level Fluctuations in the Lower Green Bay and Fox River Area of Concern

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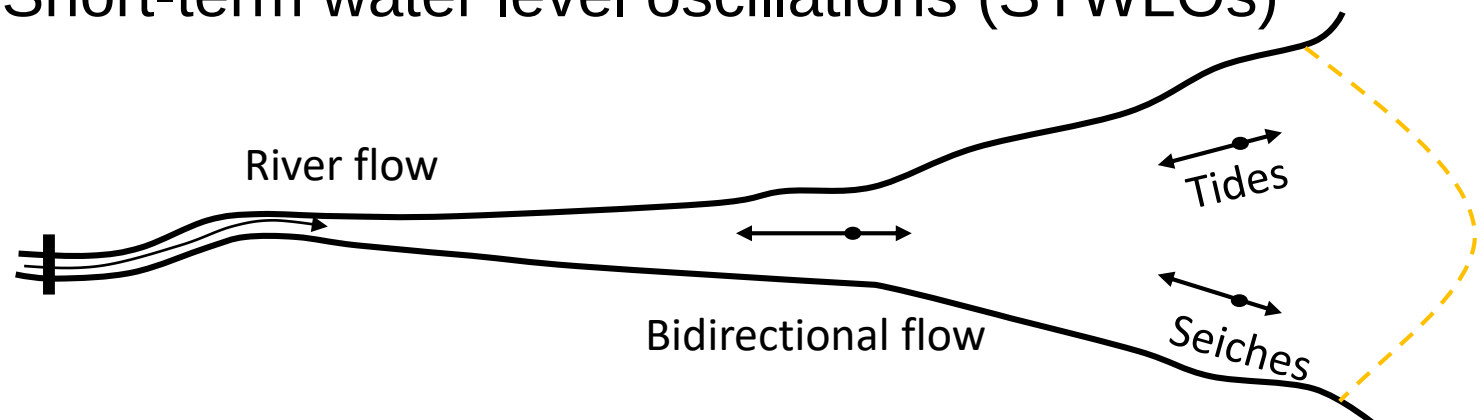
Motivation

- Sediment-associated contaminants (e.g. PCB)
- Explosive algae growth due to nutrient loading

Map of Great Lakes Areas of Concern [*WDNR*, 2013]

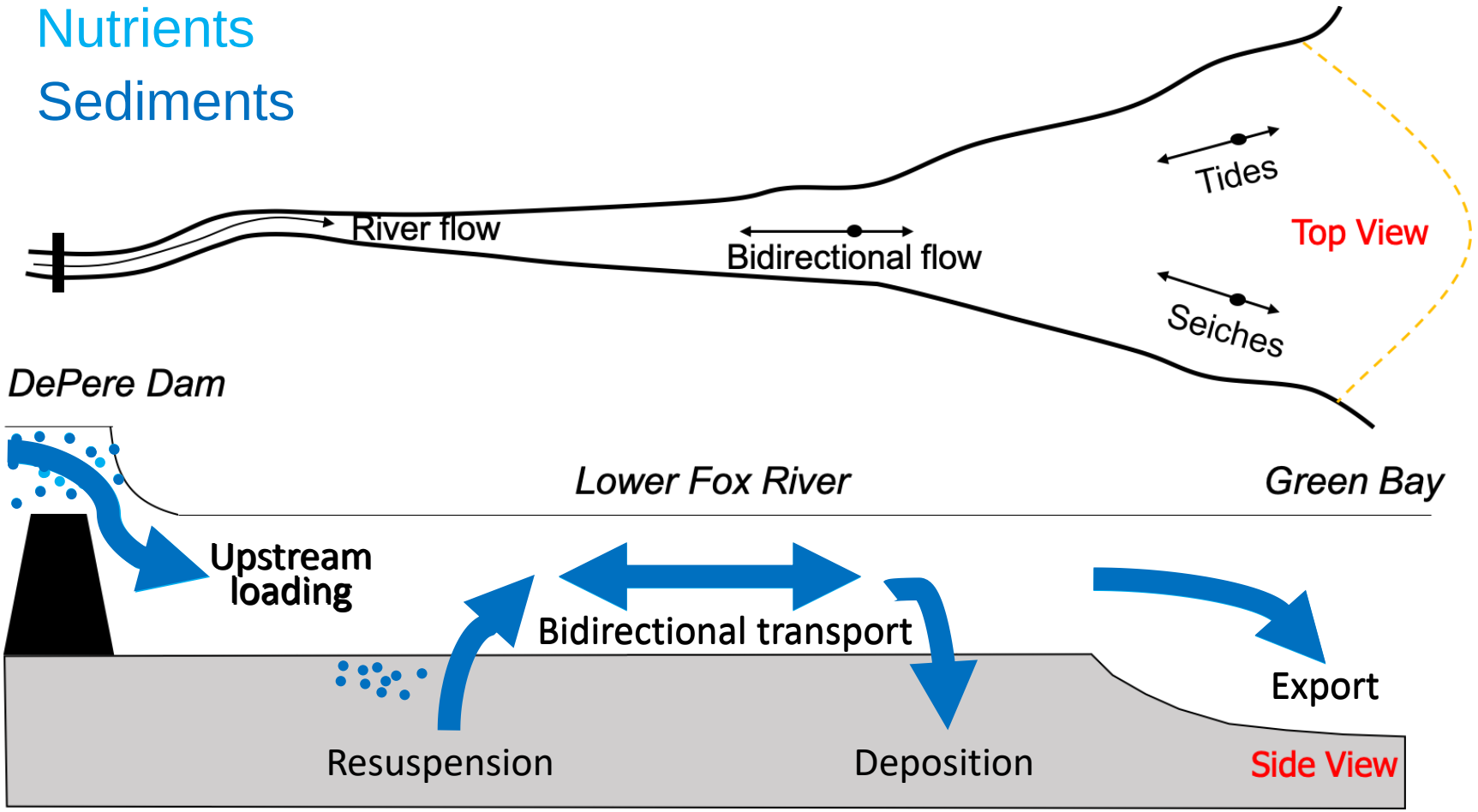
Algal bloom in Green Bay [*SSEC*, 1999]

- Short-term water level oscillations (STWLOs)



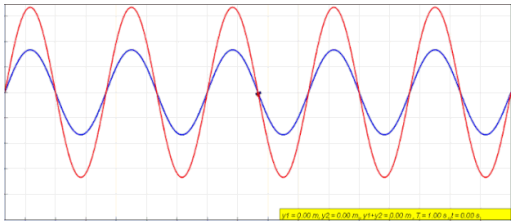
Transport processes

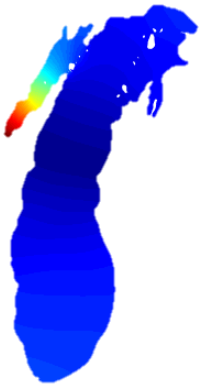
- Bidirectional flow will reverse river flow and transport nutrients and sediments to upstream



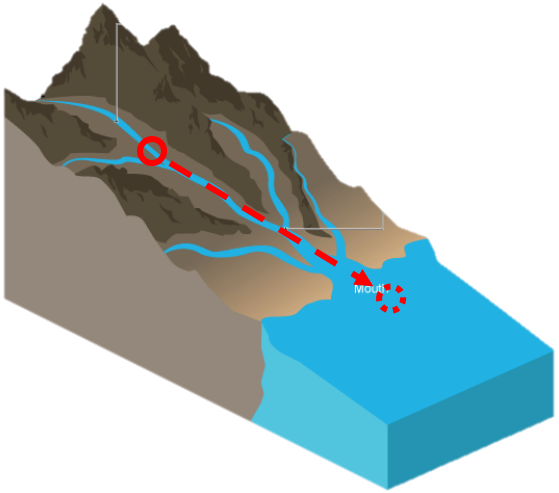
Objectives

➢ Characterize the temporal and spatial patterns for short-term water level oscillations.



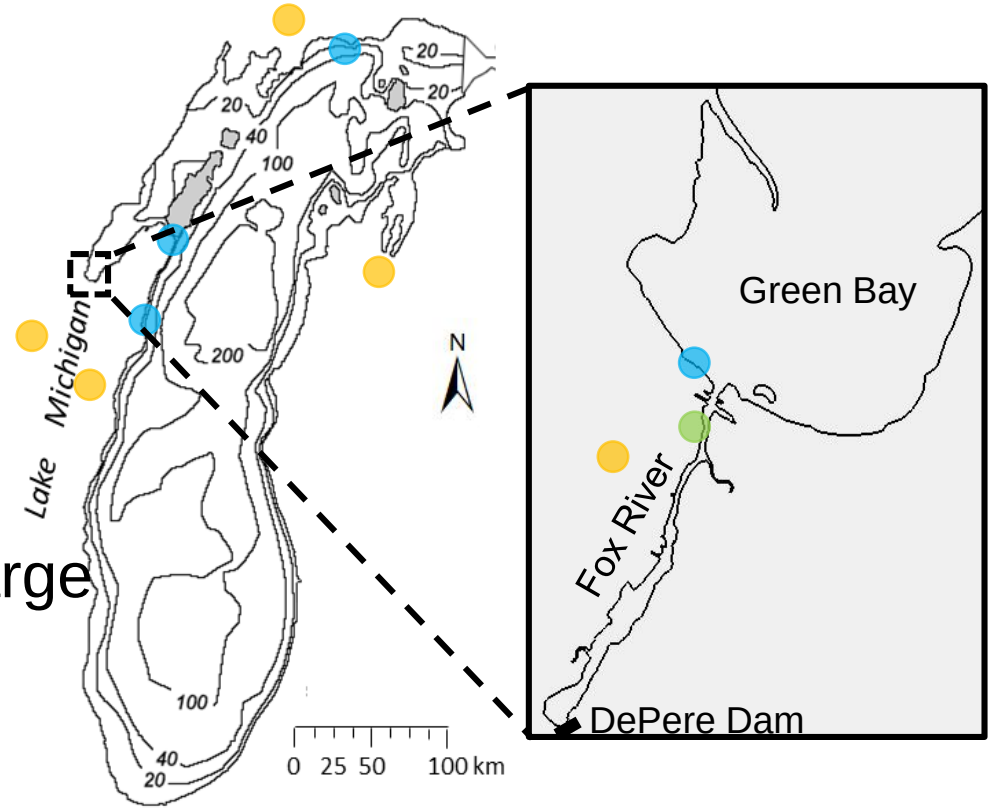


➢ Reveal the role of the short-term water level oscillations on velocity and residence time for sediment transport.



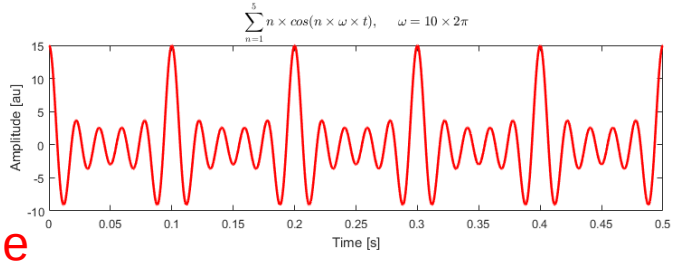
Approach

- Observational data
  - 6-min water level
  - 1-min wind & pressure
  - 5-min water level & discharge

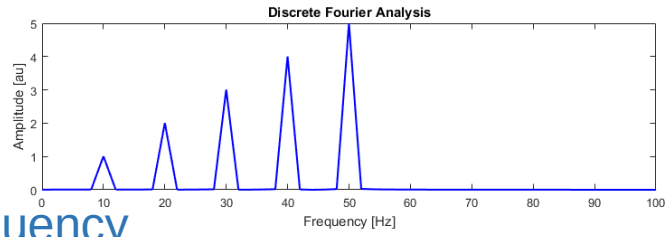


- Time series analysis

Fast Fourier Transform and Harmonic Analysis

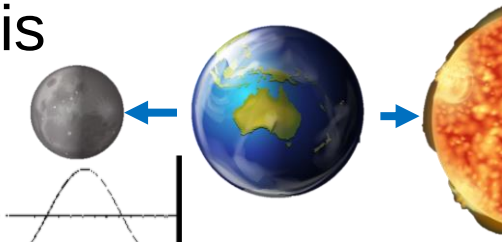


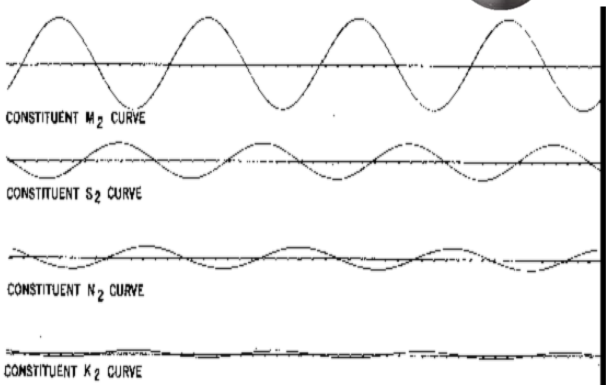
Time



Frequency

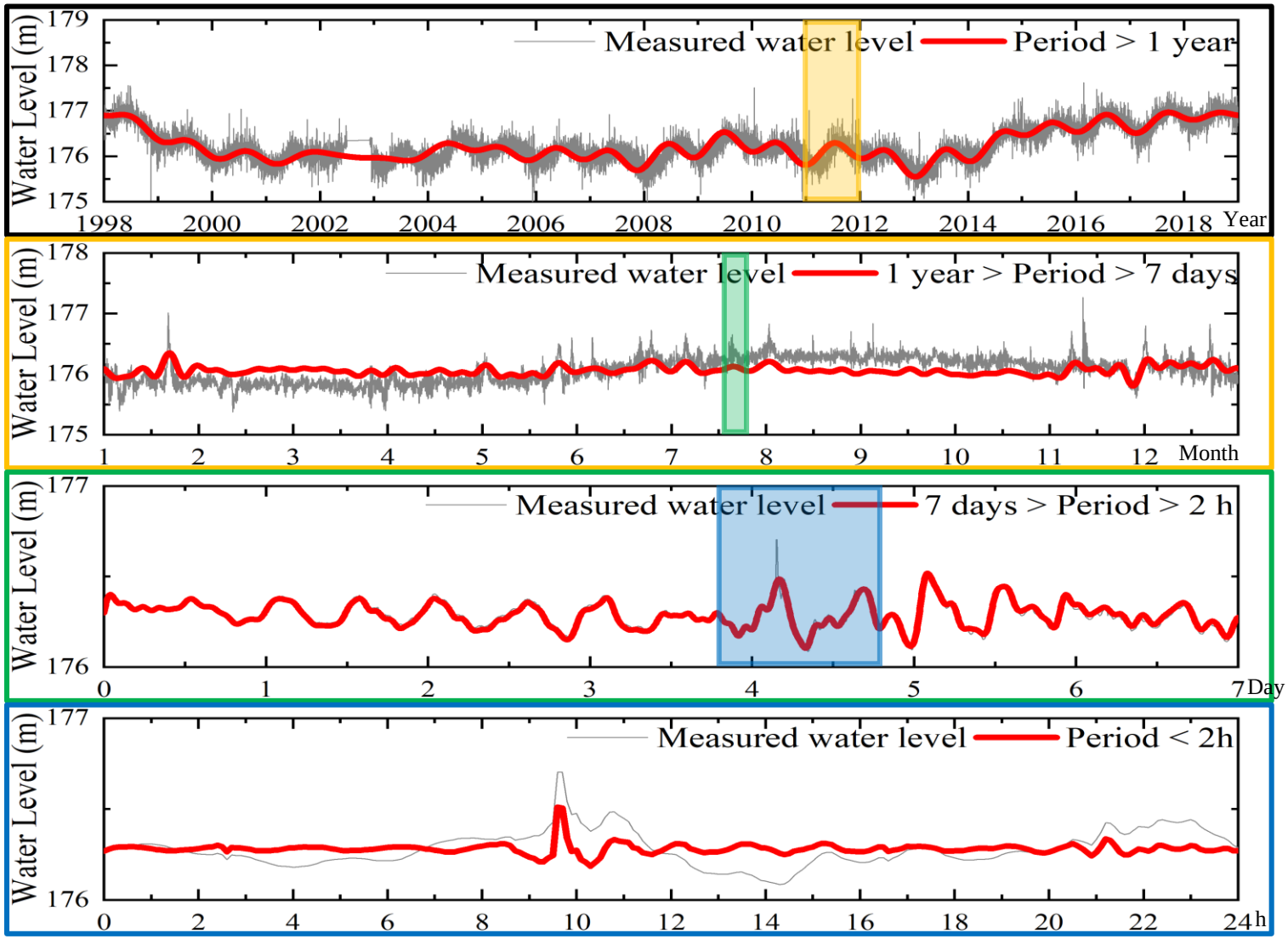
Tidal constituents





Multi-time scale water level oscillations

Fox River Estuary



Long-term

Annual

Climate

Seasonal

River flow

Density-driven

Short-term

Daily

Tides

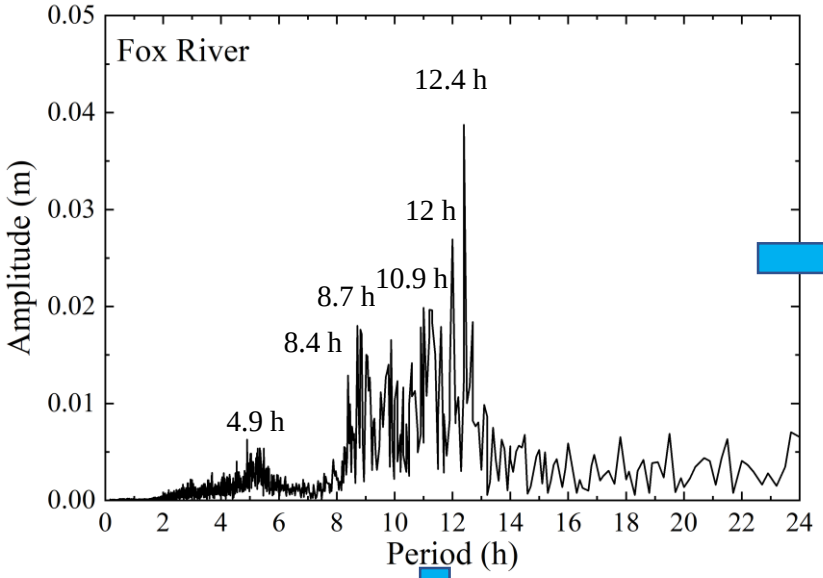
Seiches

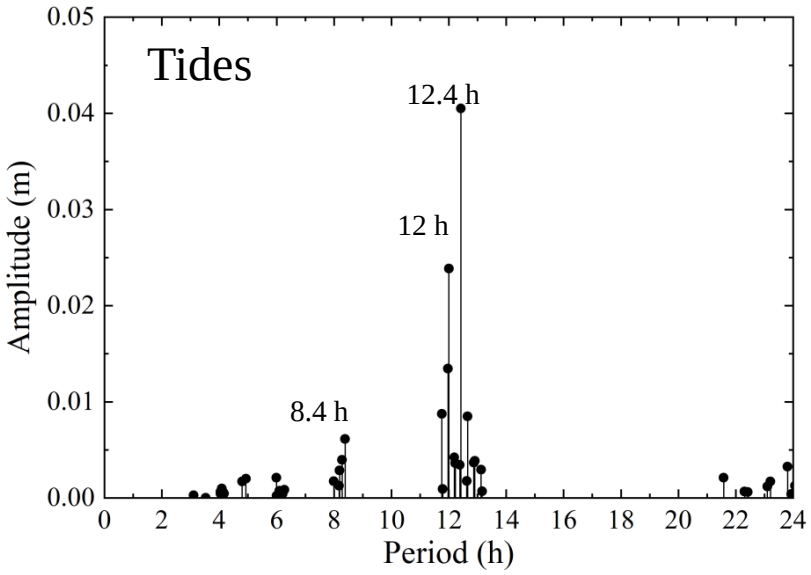
Hourly

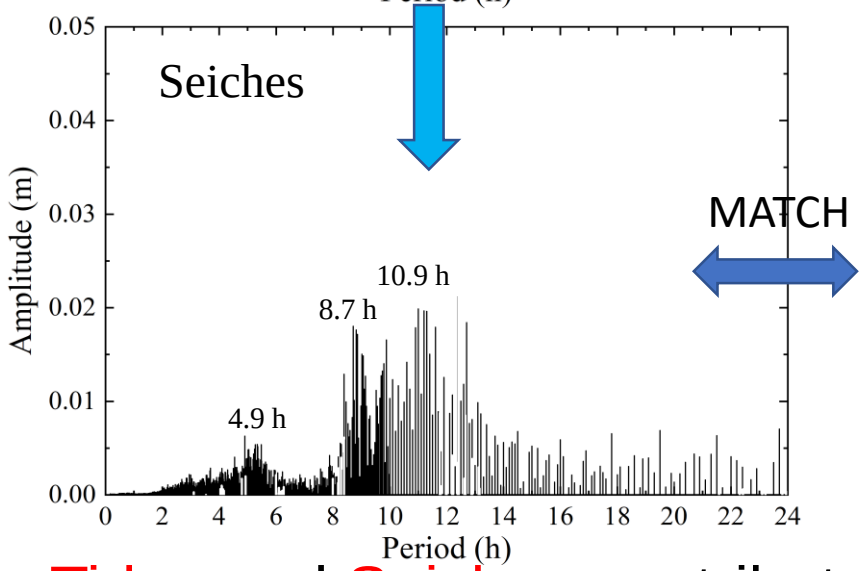
Meteorology

forcing

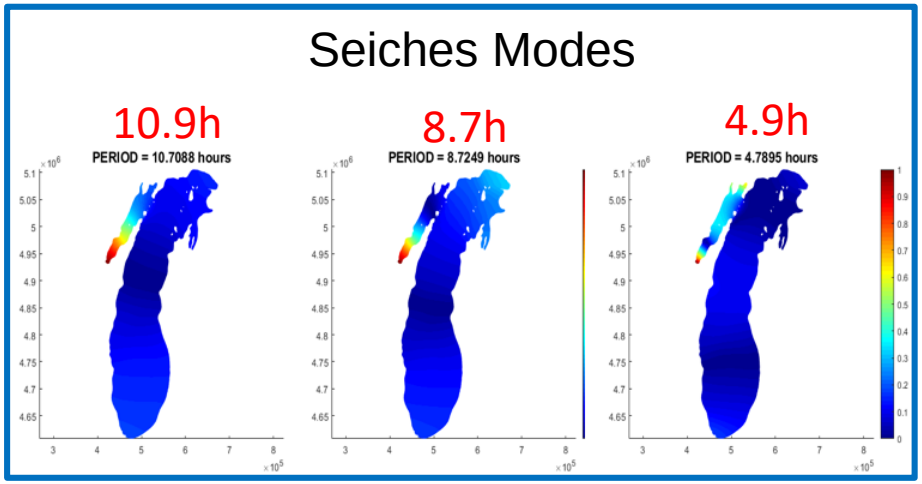
Short-term water level oscillations







MATCH

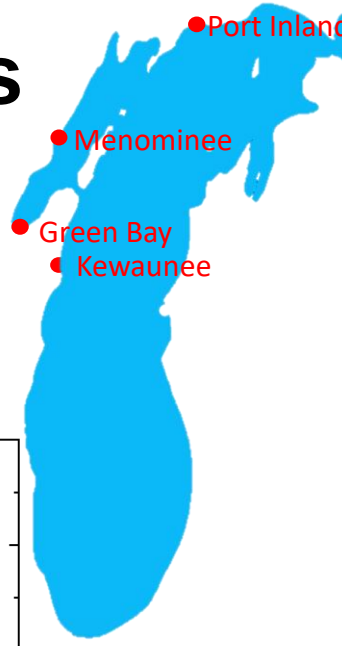


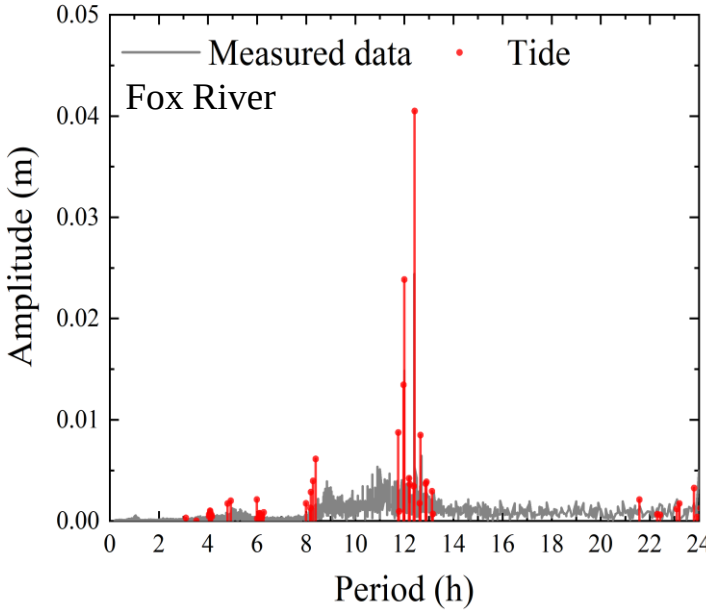
Tides and Seiches contribute to short-term oscillations

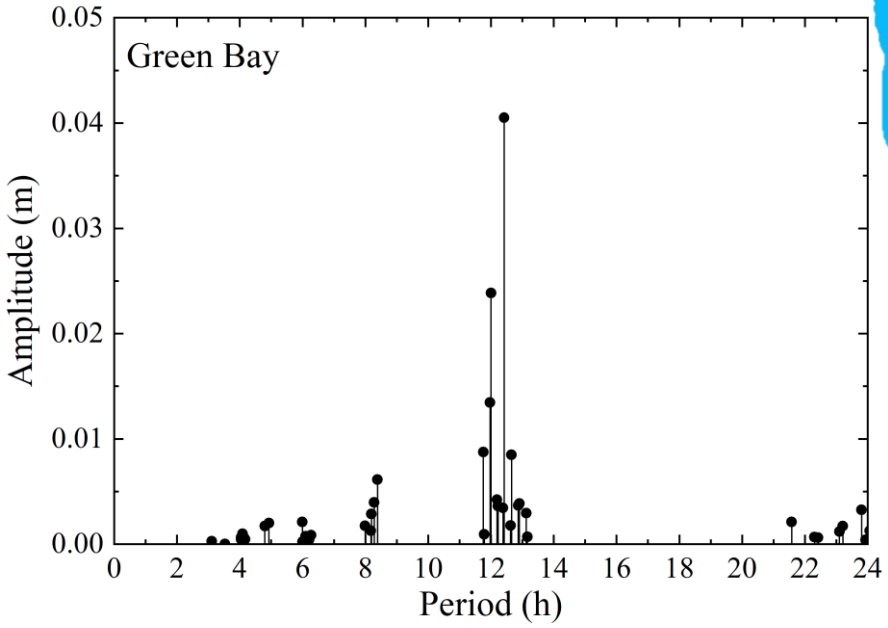
Tide induced water level oscillations

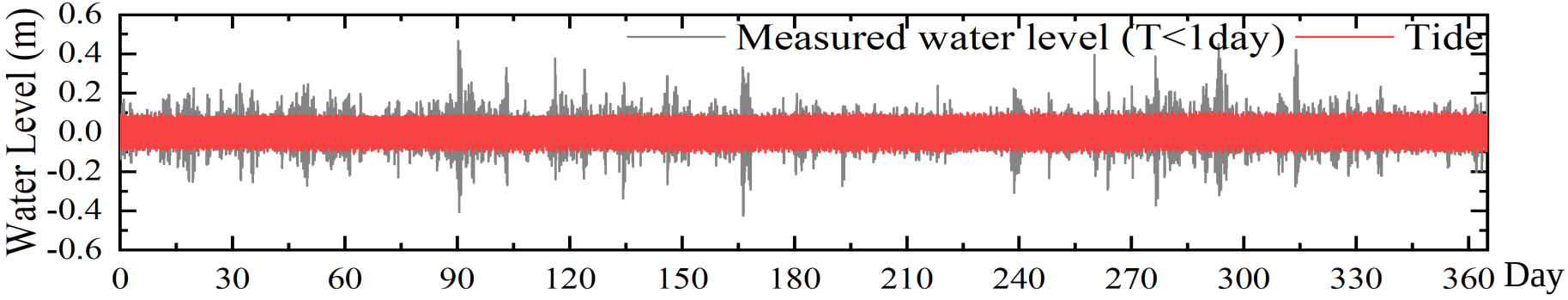
Tide is significant inside Green Bay

47.7% of total short-term water level oscillations

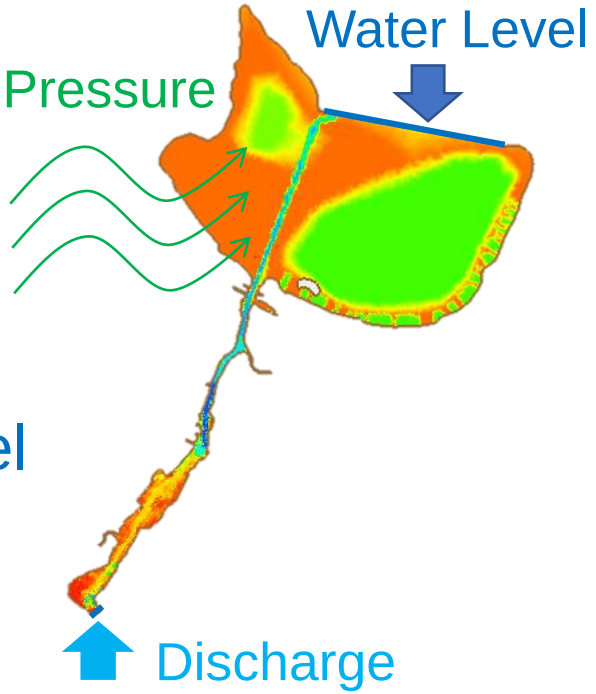








Hydrodynamic model

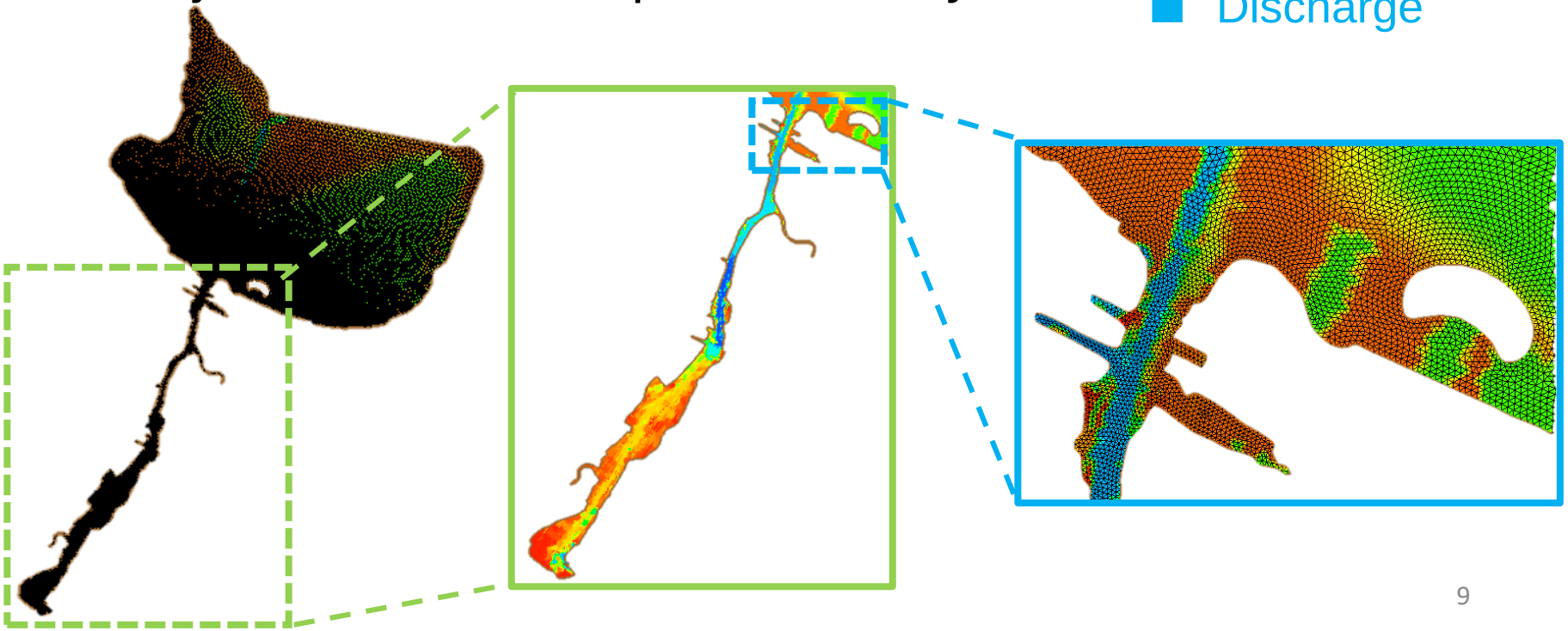


- 3D Hydrodynamic Model - SCHISM

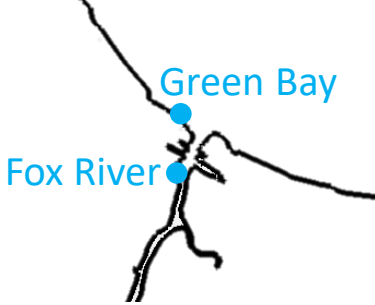
  Mesh resolution: 20 to 150 m

  Forcing: Inflow Discharge & Water Level
  Wind & Pressure

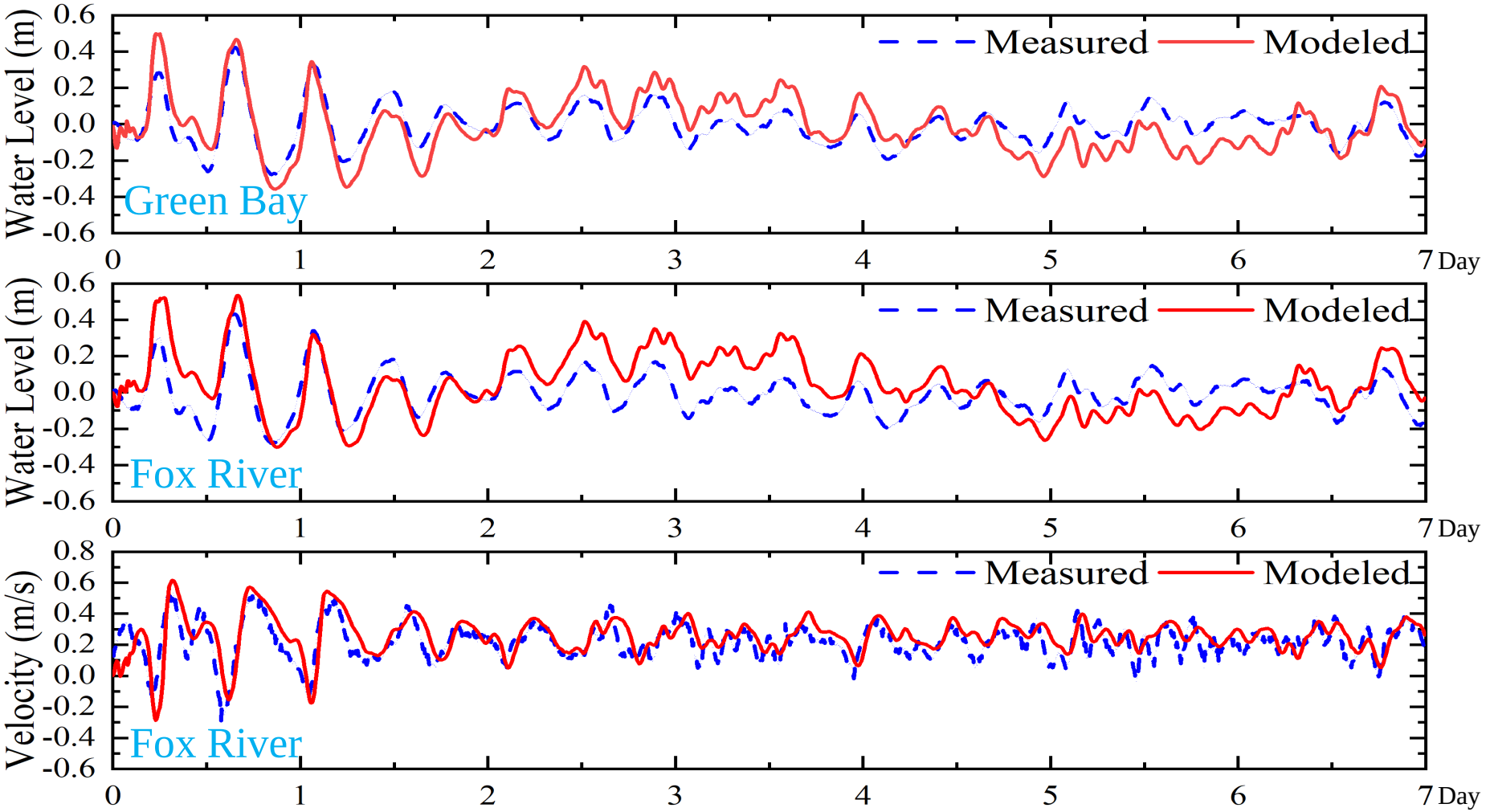
  Adjoint method for Open Boundary



Hydrodynamic model



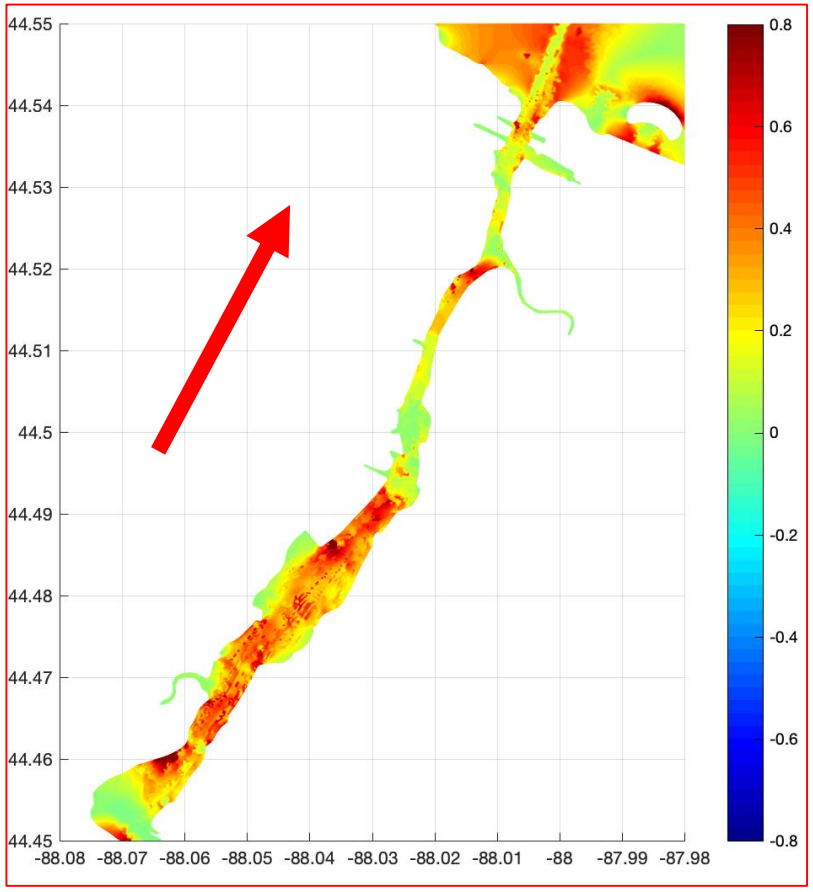
- Model validation



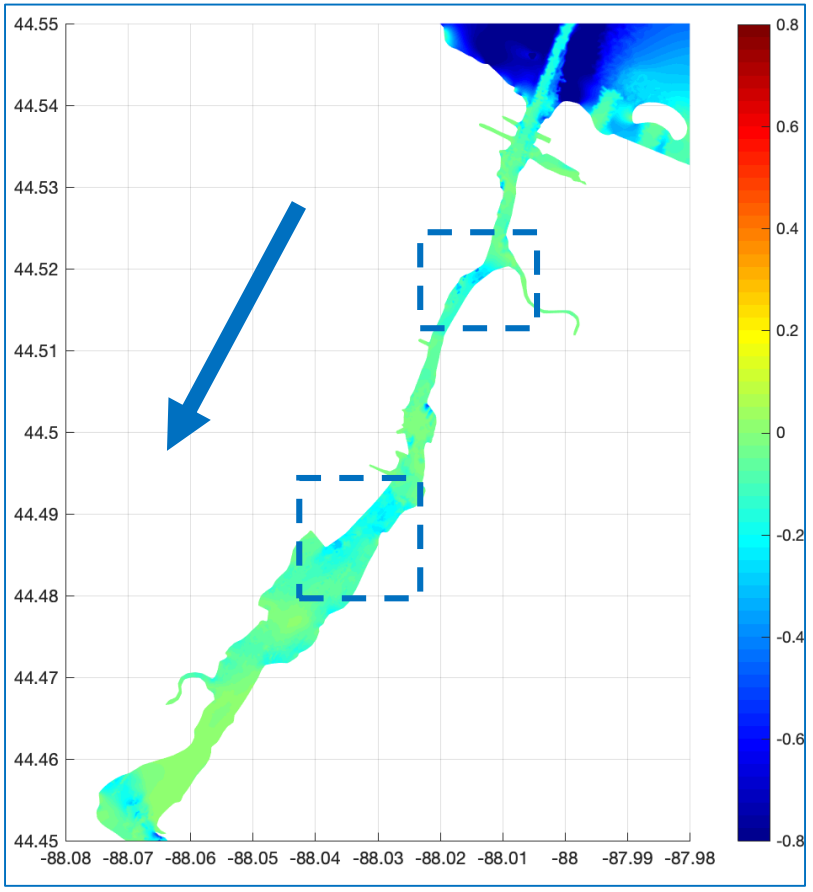
Velocity map

Large upward velocity (~0.5m/s) is caused by STWLOs

Max. Downward Velocity

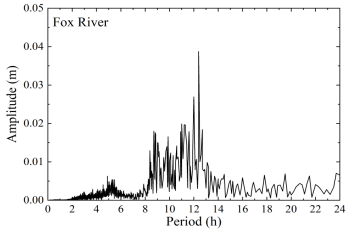


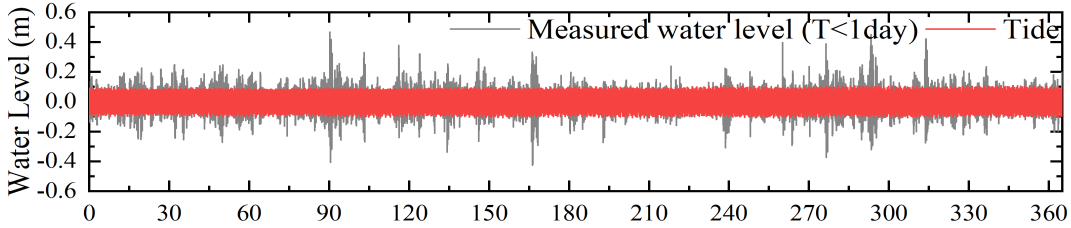
Max. Upward Velocity



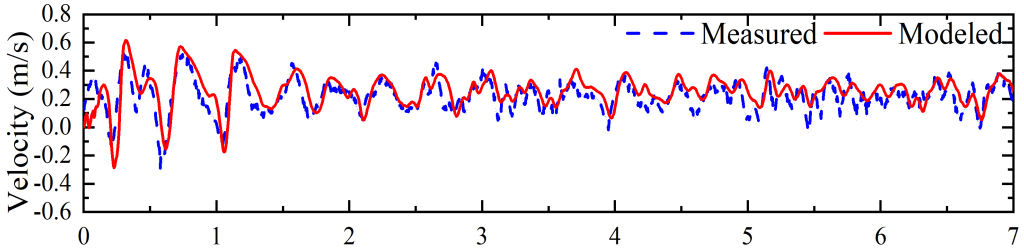
Summary

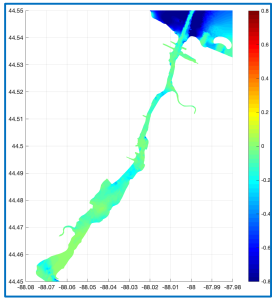
Tides and Seiches are the main causes of STWLOs





STWLOs cause large upward velocity





Ongoing works: modeling sediment and nutrients transport and residence time with particle tracking model


Q&A
Photo by Chris Rand, 2014