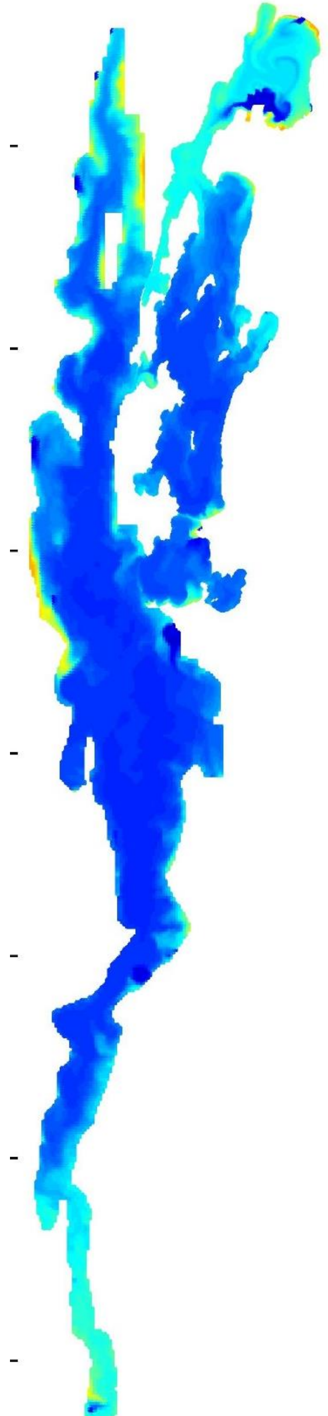
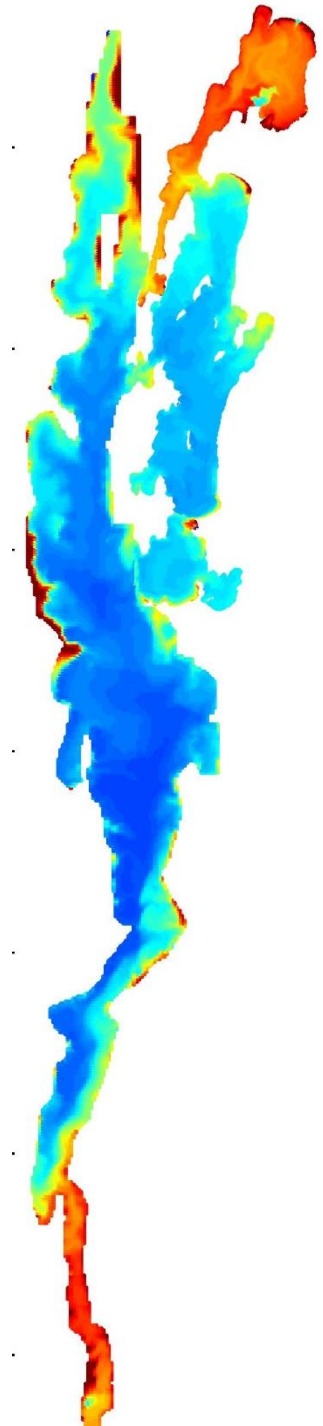


Hydrodynamic Model of Lake Champlain

Liv Herdman and Tom Manley

Undergraduates: Tina Chen and Jing He

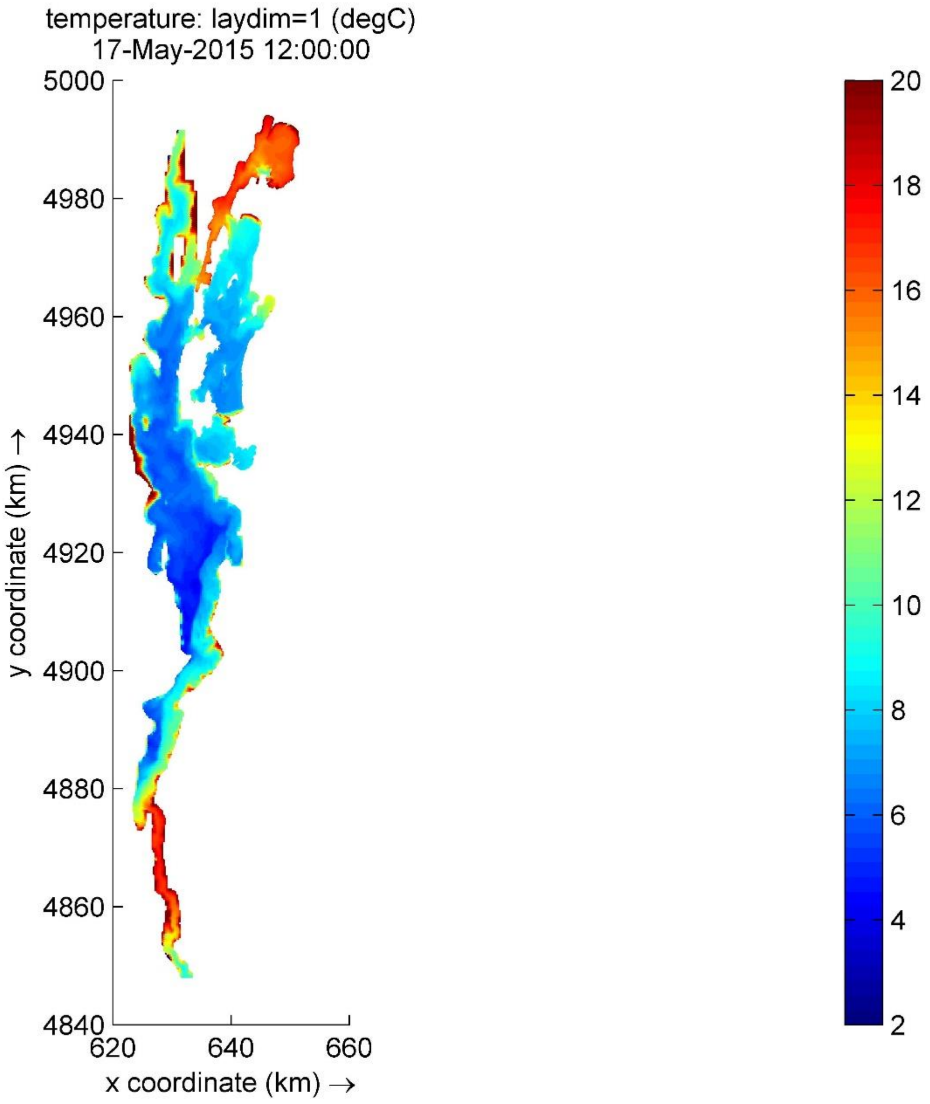


Overview

- What can we learn from a hydrodynamic model?
- How we model the lake
- Preliminary results for St Albans and Missisquoi Bay

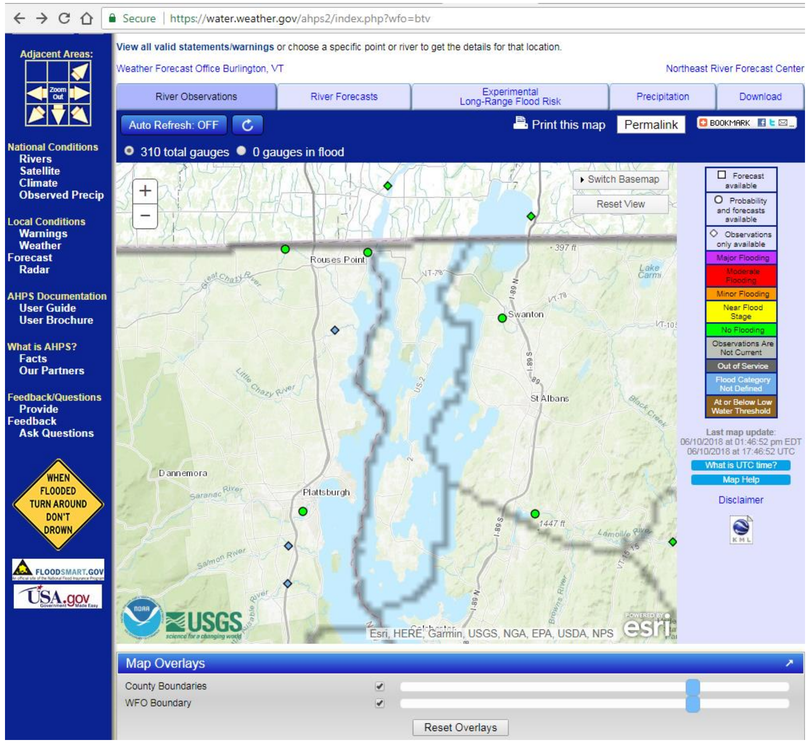
What can we learn from a hydrodynamic model?

- Water Level
- Velocity
- Temperature

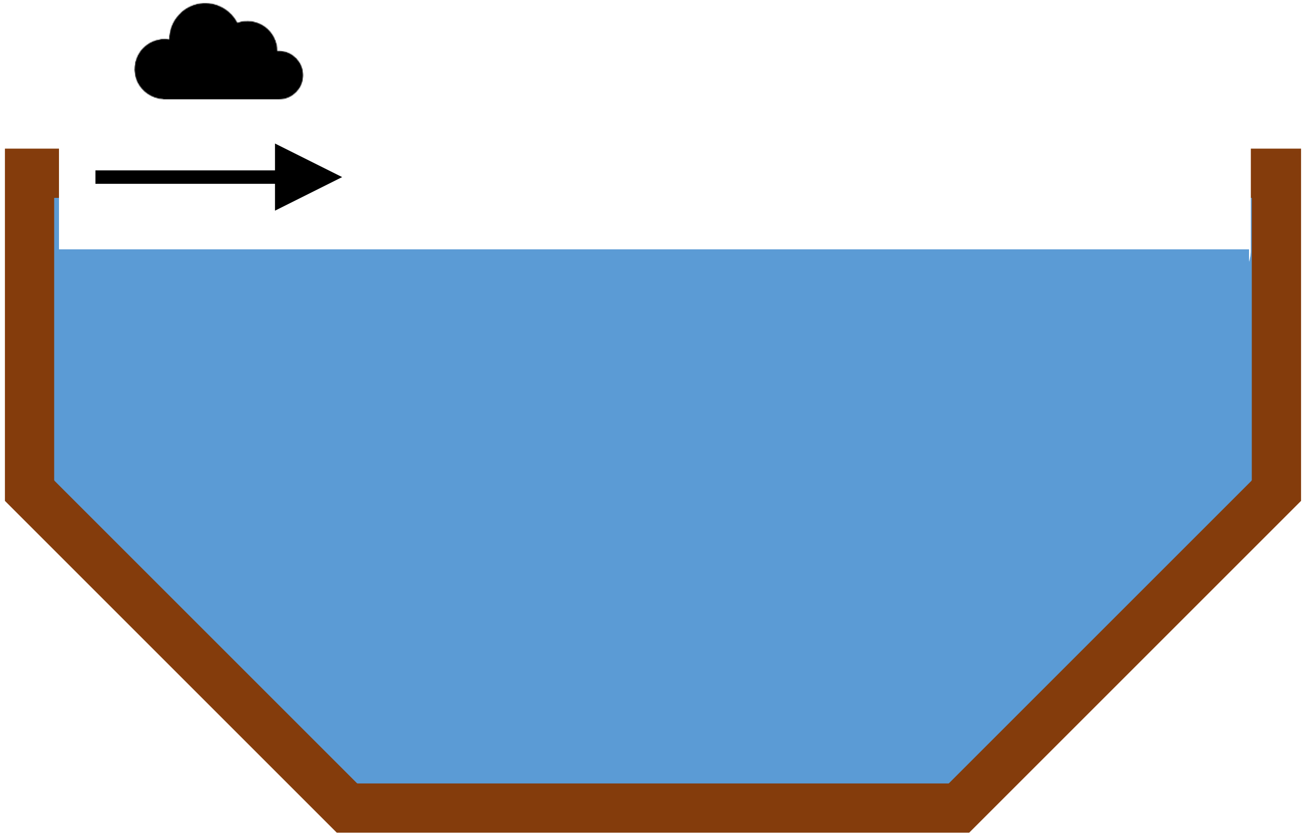


What can we learn from a hydrodynamic model? Water Level

How much water is in the lake?

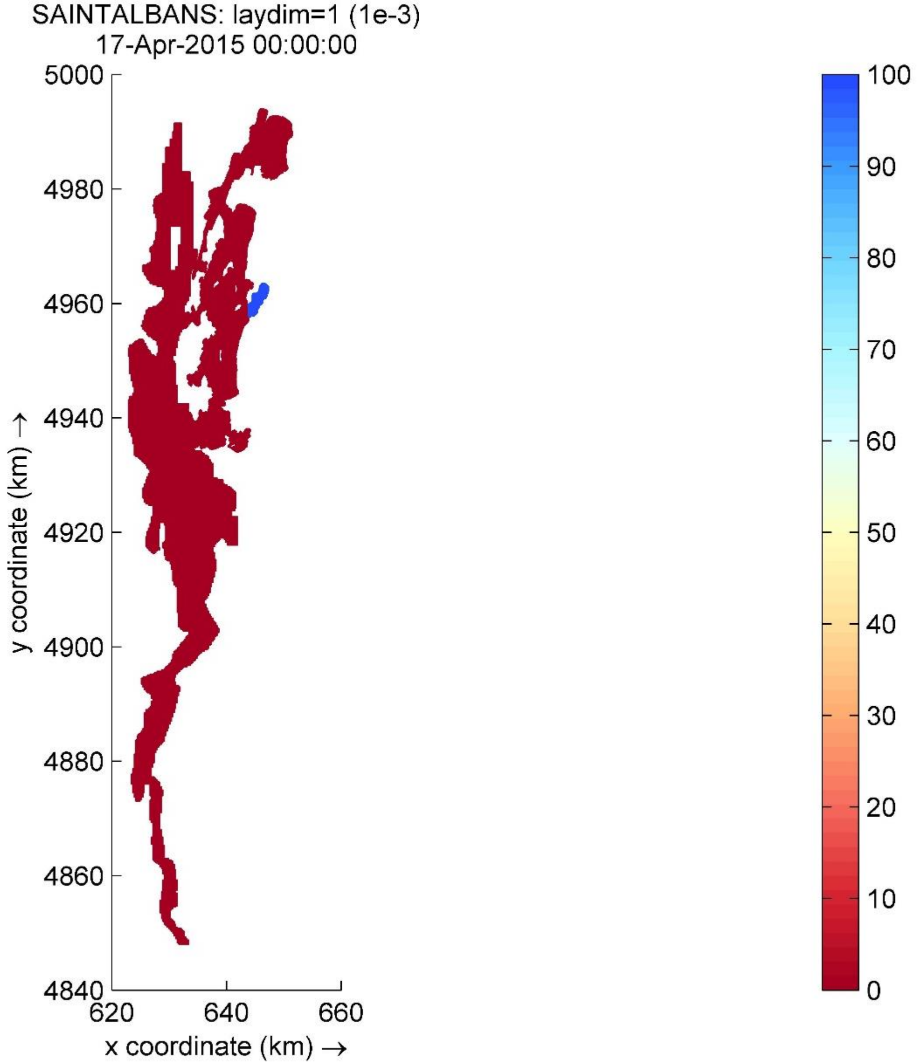


What are the surface seiche dynamics?



What can we learn from a hydrodynamic model? Velocity

Where is the water going? (TRANSPORT)



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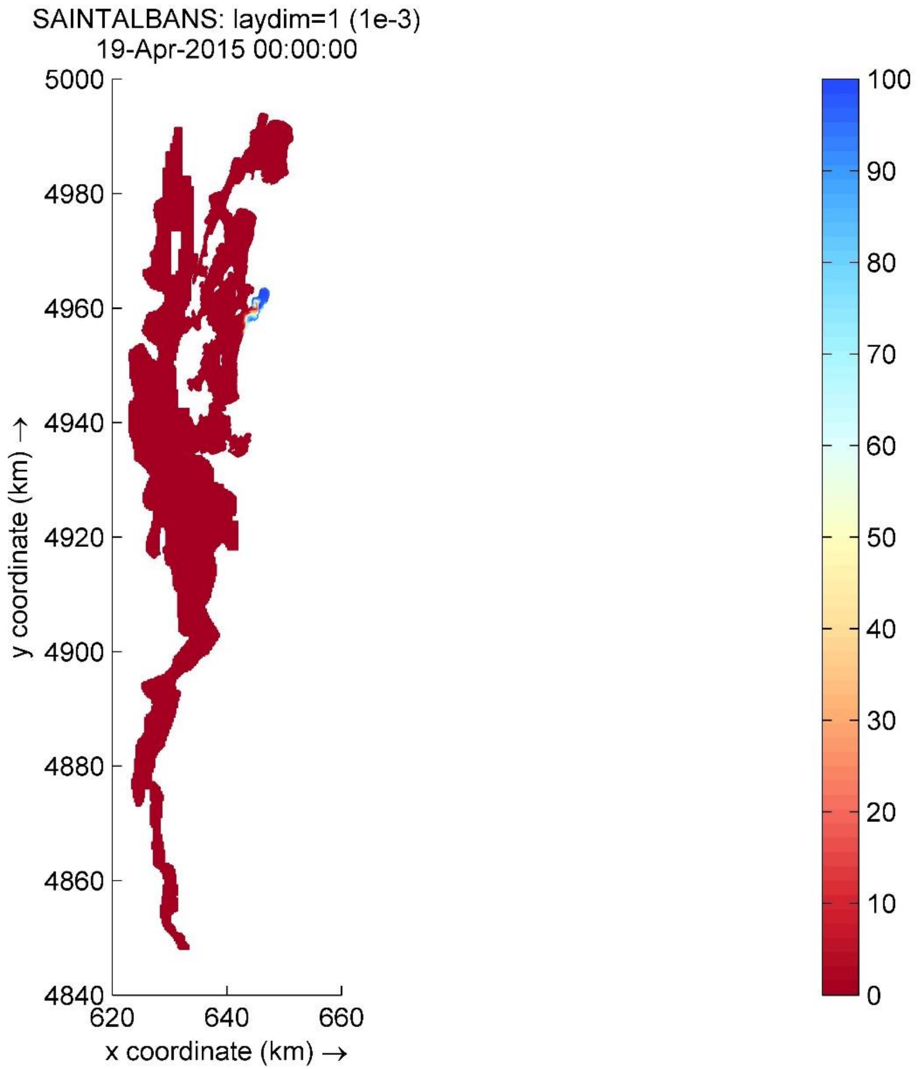

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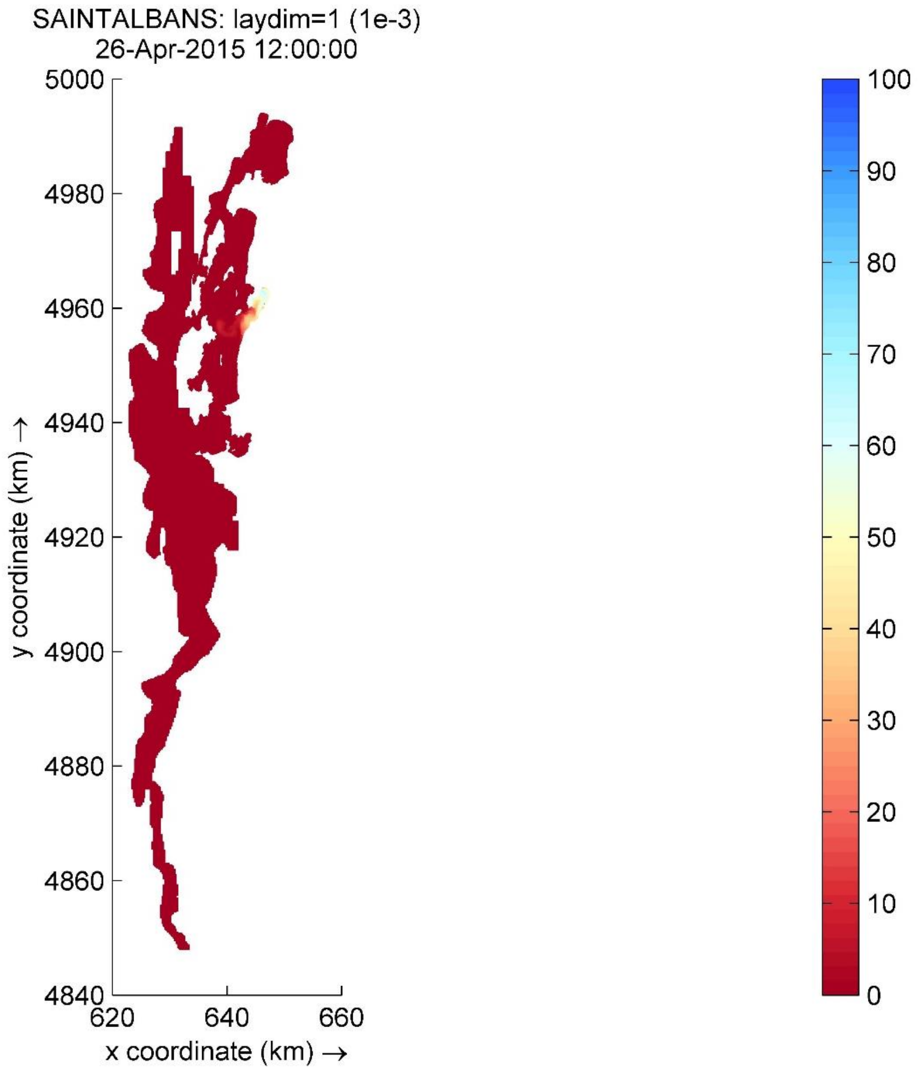
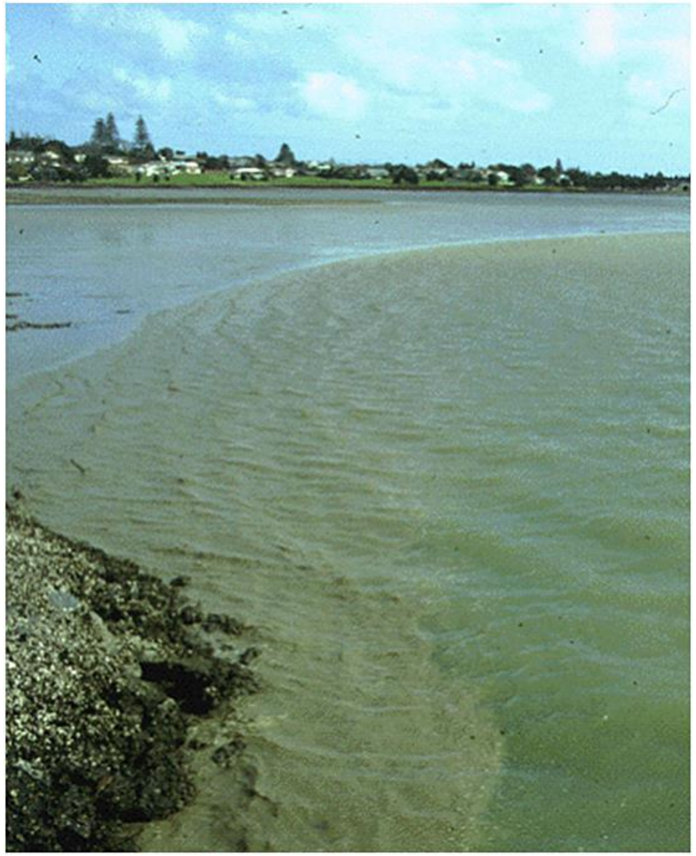
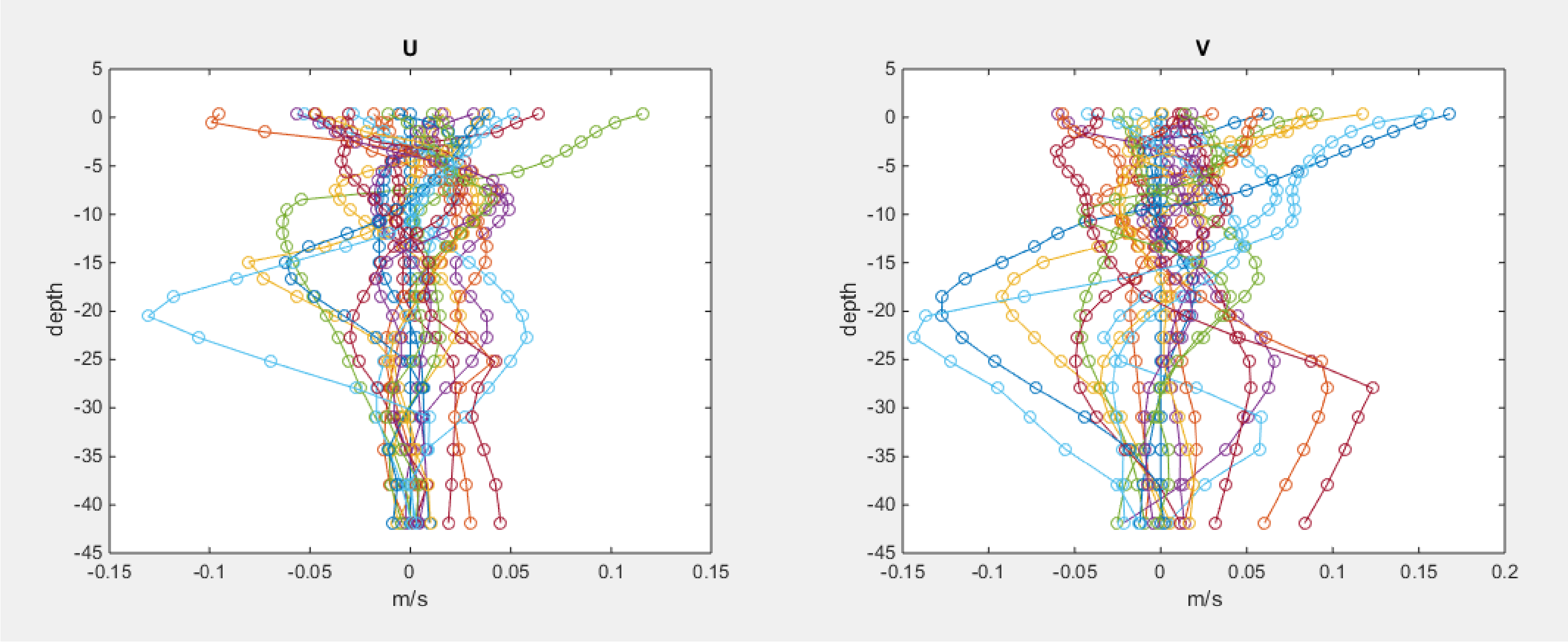


What can we learn from a hydrodynamic model? Velocity

Is the water moving quickly enough to resuspend sediment?





Review of wave-driven sediment resuspension and transport in estuaries, Volume: 52, Issue: 1, Pages: 77-117, First published: 11 December 2013, DOI: (10.1002/2013RG000437)

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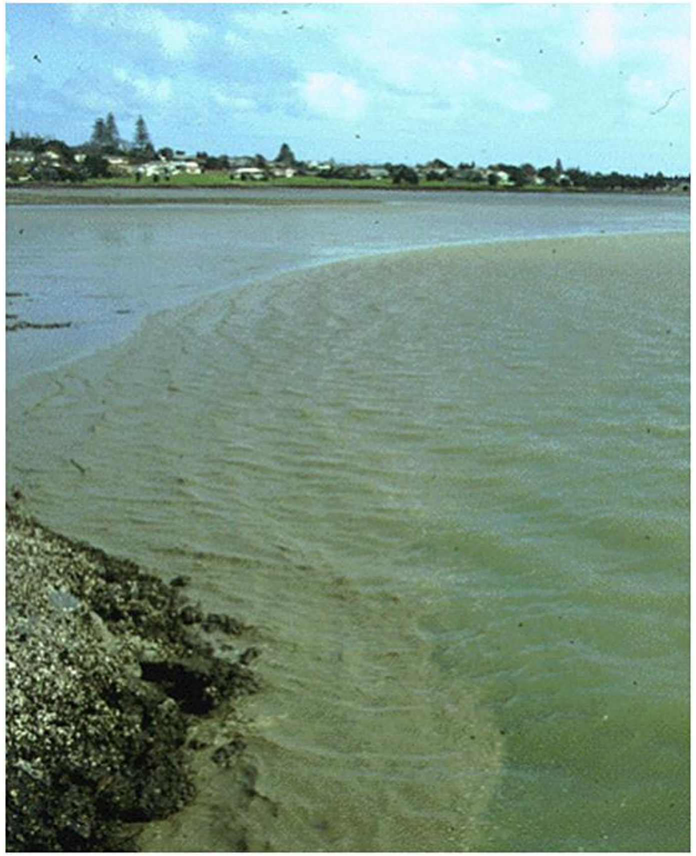
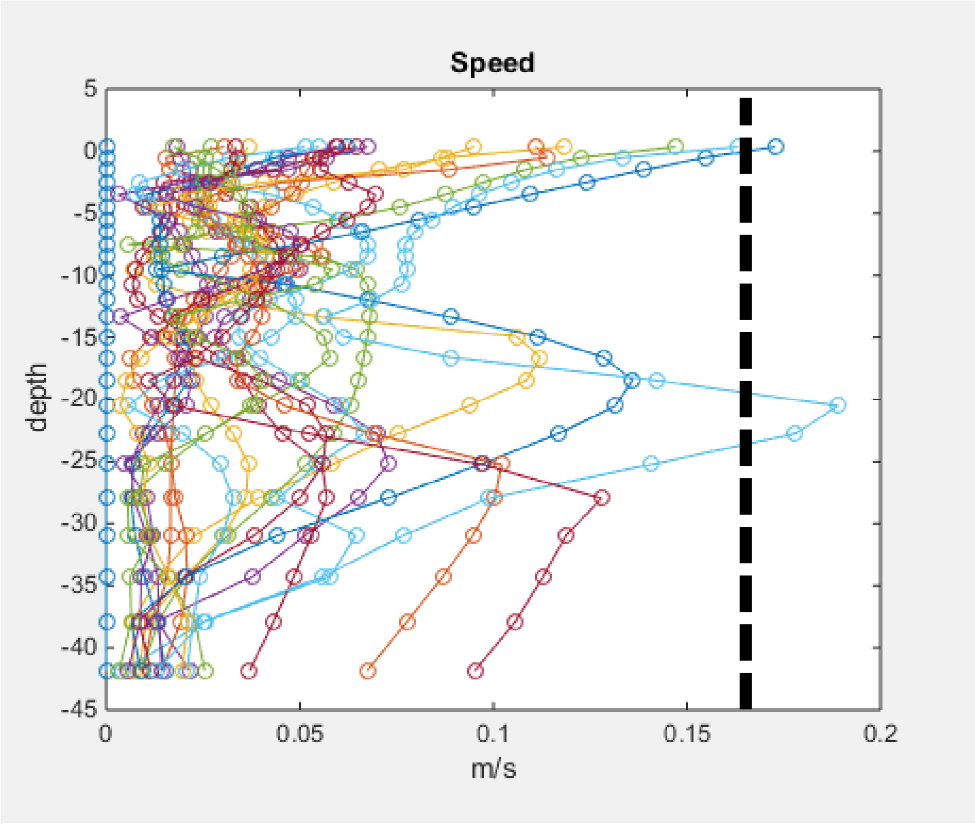




16 cm/s to resuspend sediment (P. Manley pers. Comm)

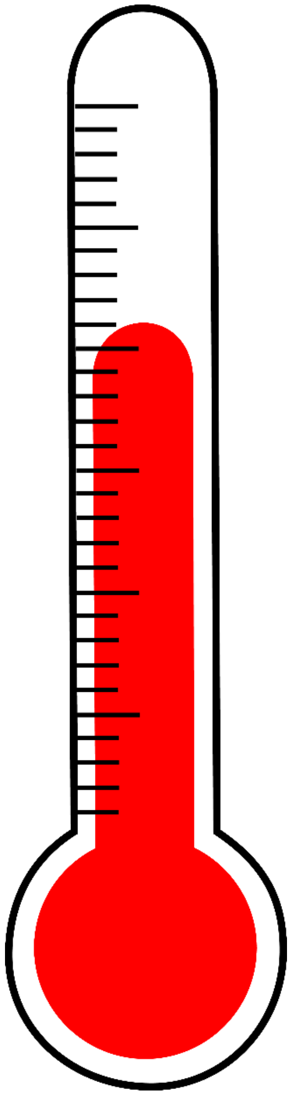
Review of wave-driven sediment resuspension and transport in estuaries, Volume: 52, Issue: 1, Pages: 77-117, First published: 11 December 2013, DOI: (10.1002/2013RG000437)

What can we learn from a hydrodynamic model? Temperature

- How warm is the water?

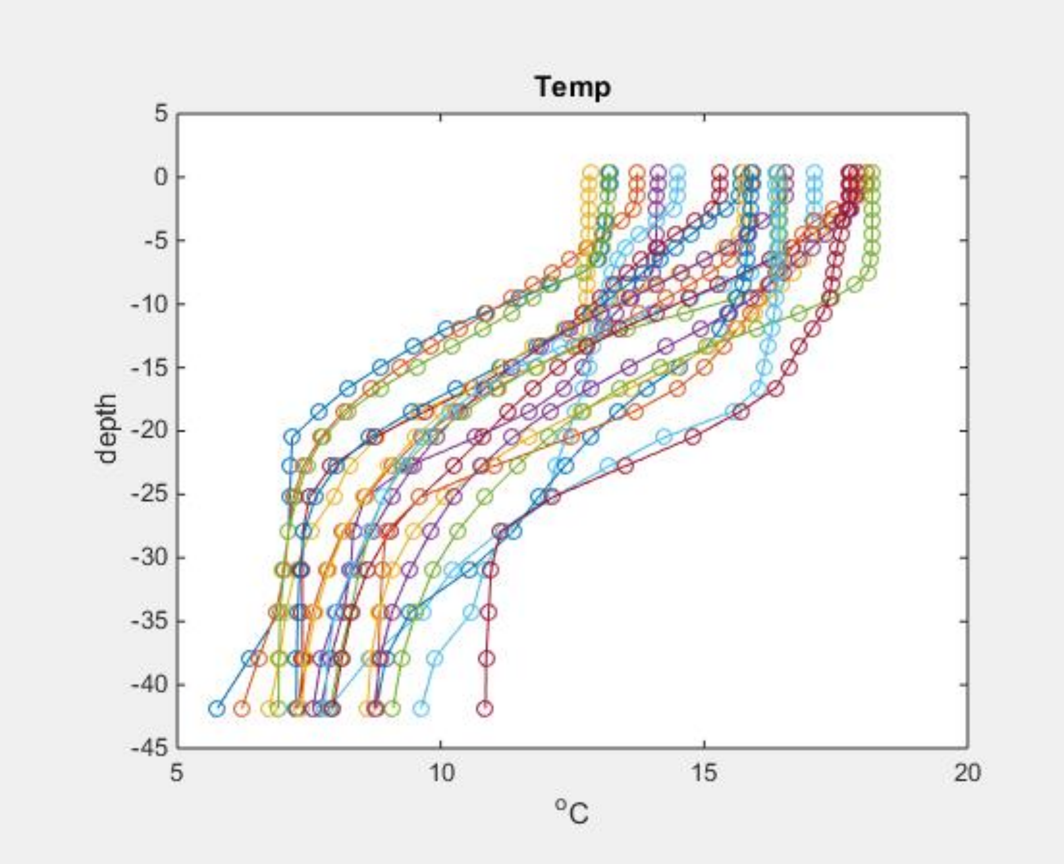
Important for geochemistry: chemical reaction rates and oxygen solubility.

Controls ecological processes: metabolism, growth, and reproduction of organisms

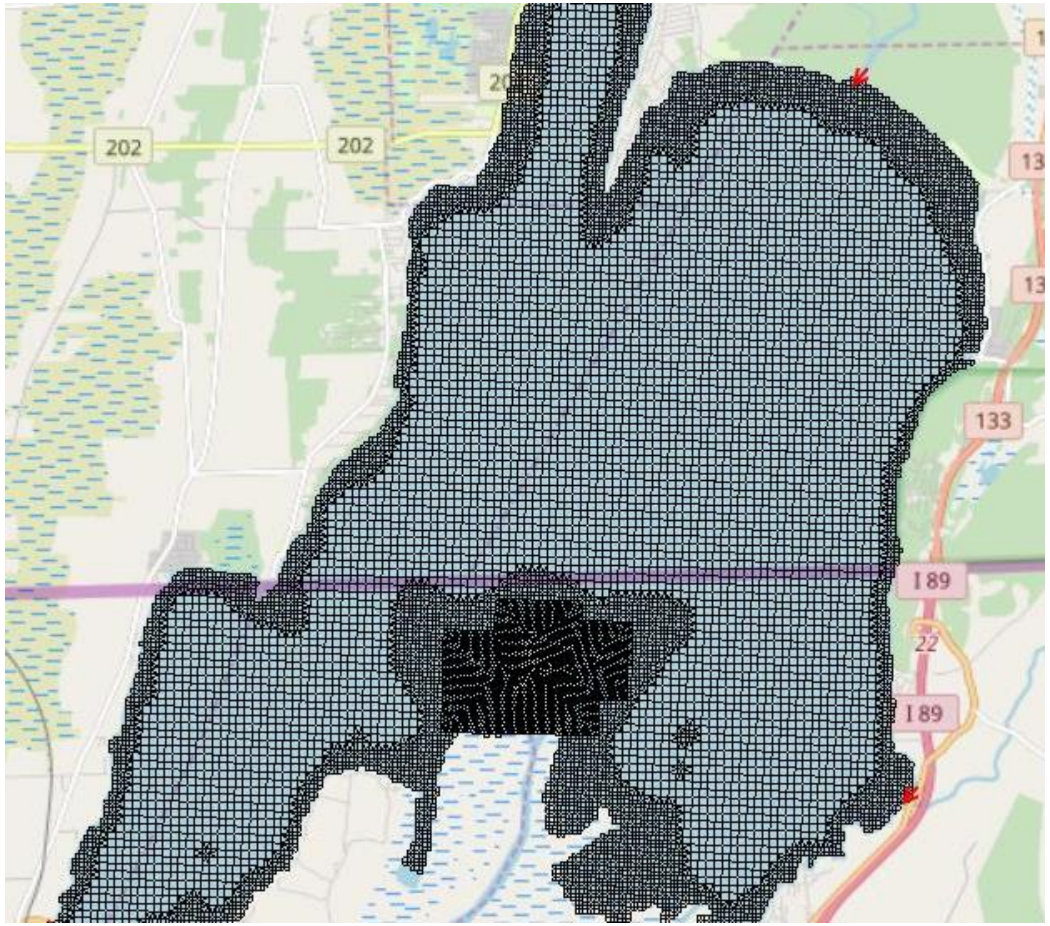


What can we learn from a hydrodynamic model? Temperature

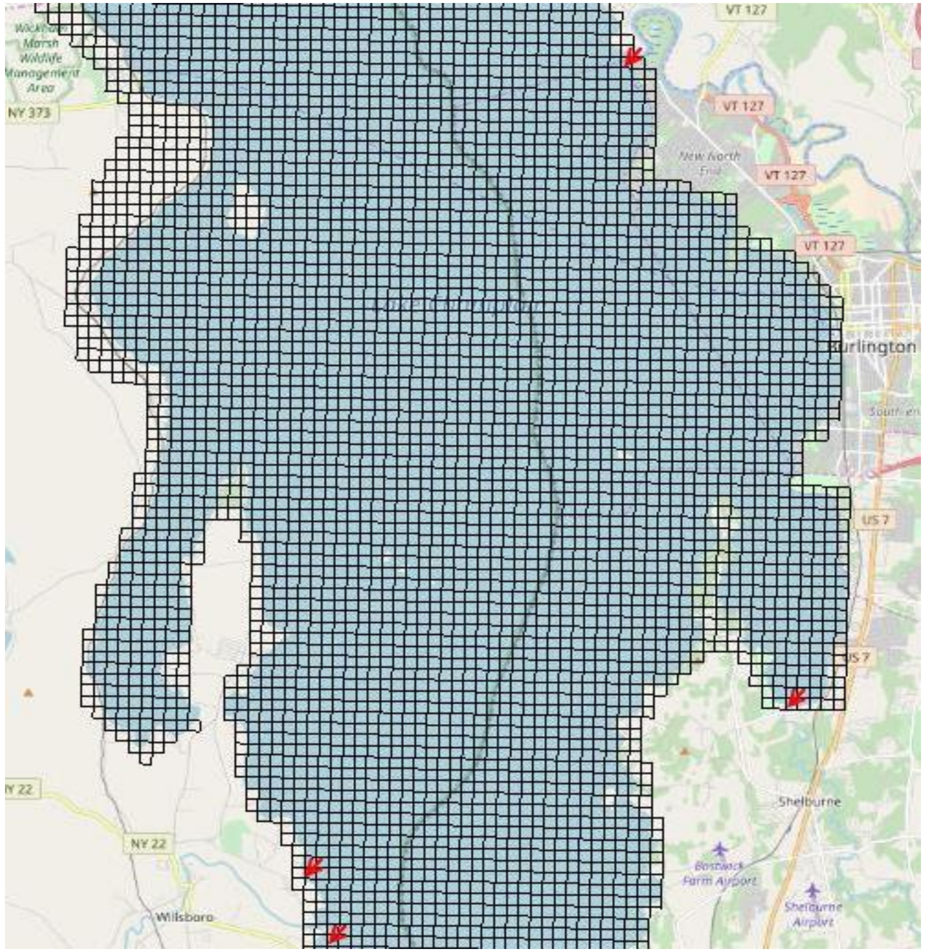
How strong is the stratification? (A control on the development of internal waves and on the vertical transport within the water column)



How do we model the lake? Deltares Flexible Mesh Code solves the equations of motion



Areas of Interest have horizontal resolution down to 50 meters, with vertical resolution of 0.5 m

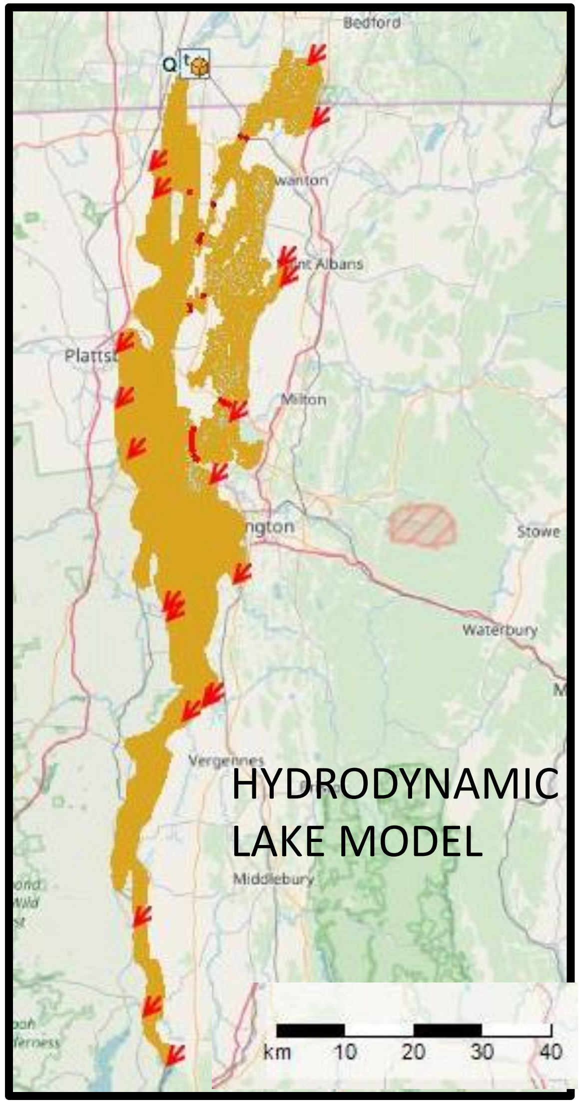


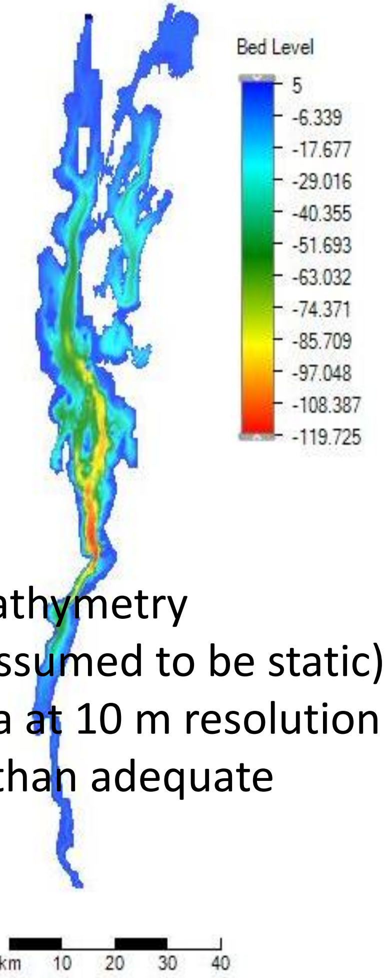
Most of Lake is covered by ~500 m grid in horizontal with vertical resolution of 1 to 0.5 meters

Need information at the boundaries of the model

Atmospheric Forcing (hourly over pictured Domain):
Wind Speed and Direction
Air Temperature
Air Humidity
Cloudiness or Direct Solar Radiation

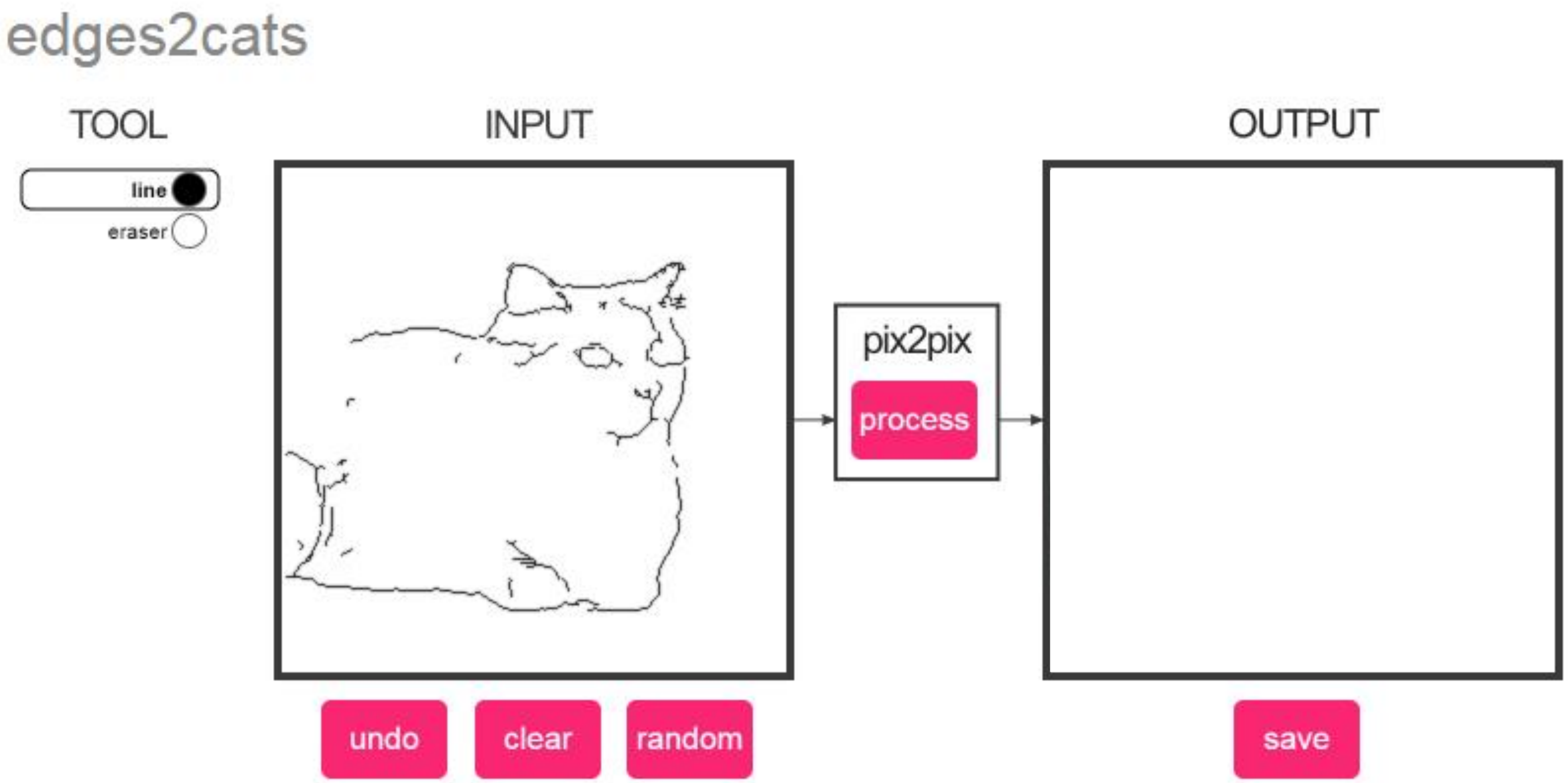
Currently including 19 Major Rivers (Daily at each Red Arrow):
Volume Flow Rate
Water Temperature
Water Quality Parameters(future)





Bathymetry
(Currently assumed to be static)
Existing data at 10 m resolution more than adequate

The better information you provide the model, the better the model performs



https://affinelayer.com/pixsrv/

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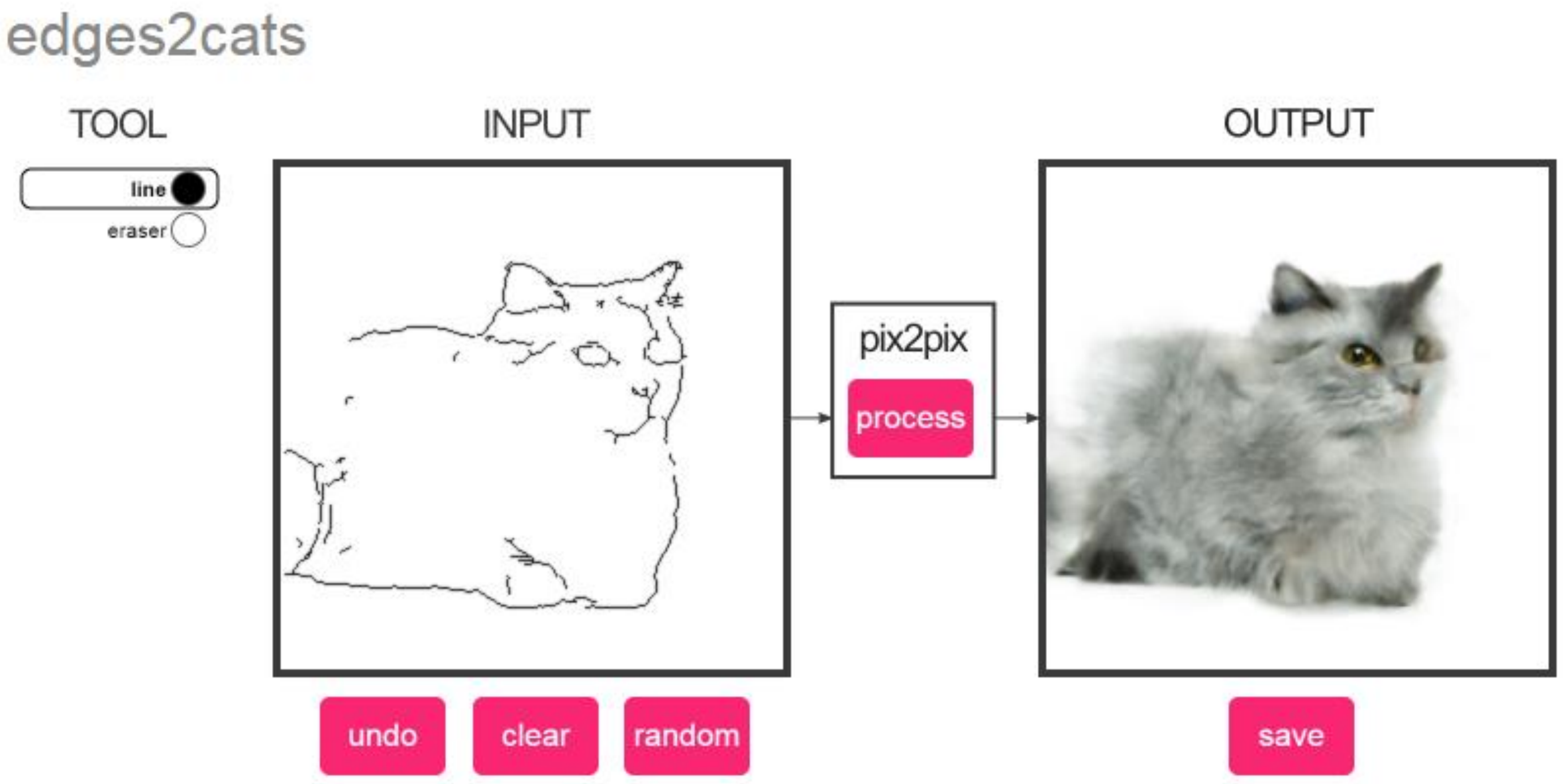

This is like a hindcast!

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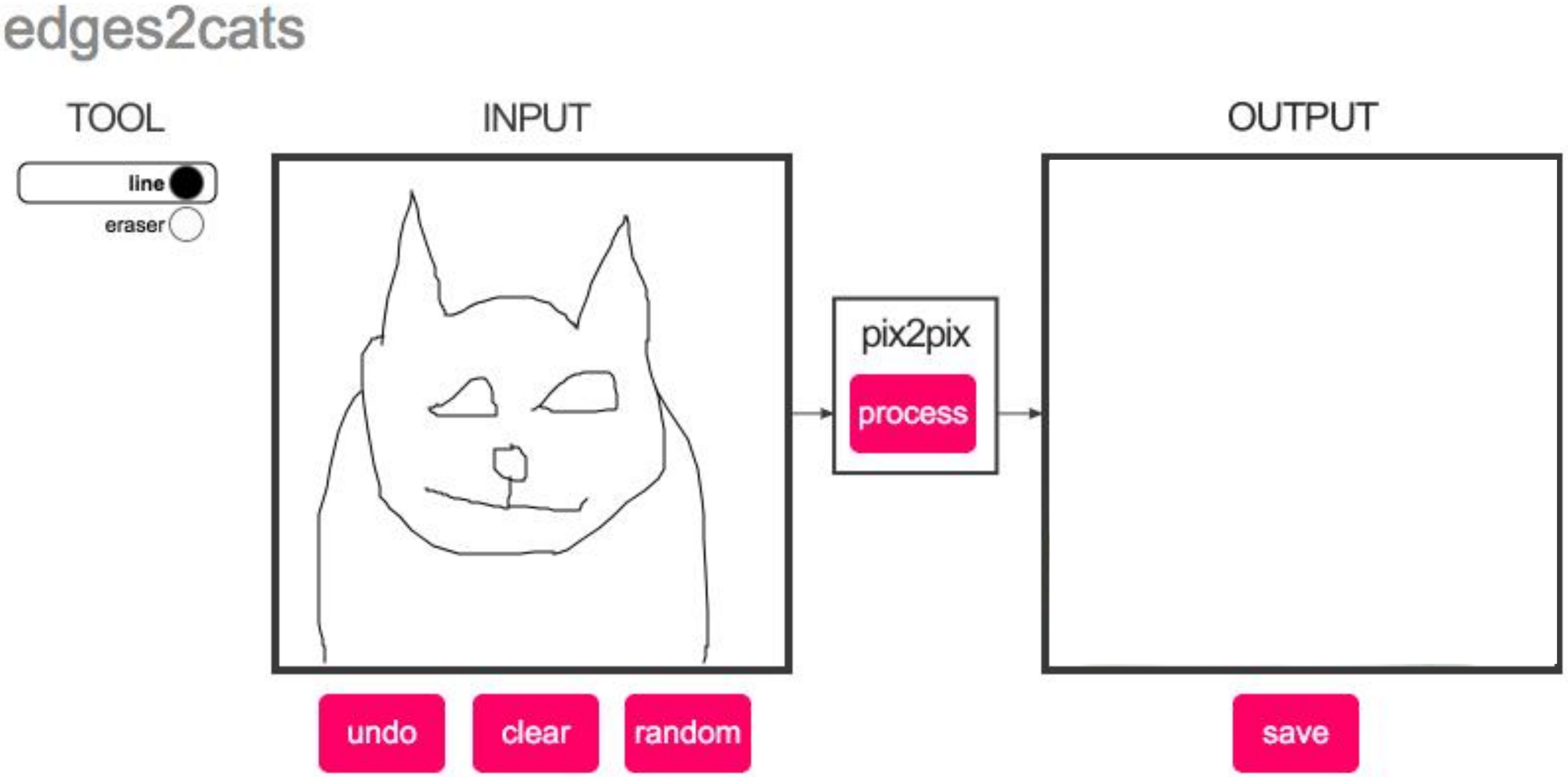

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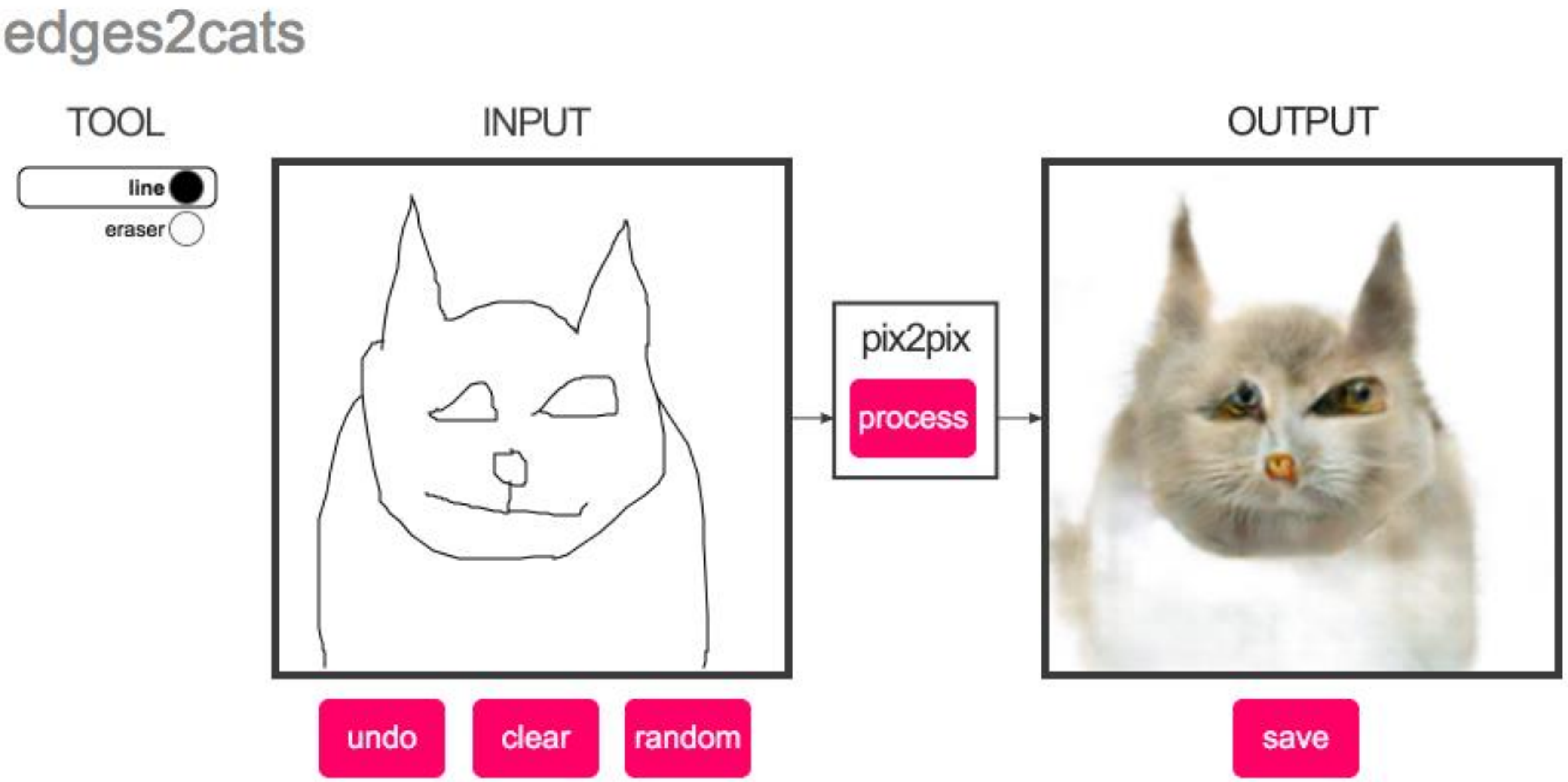
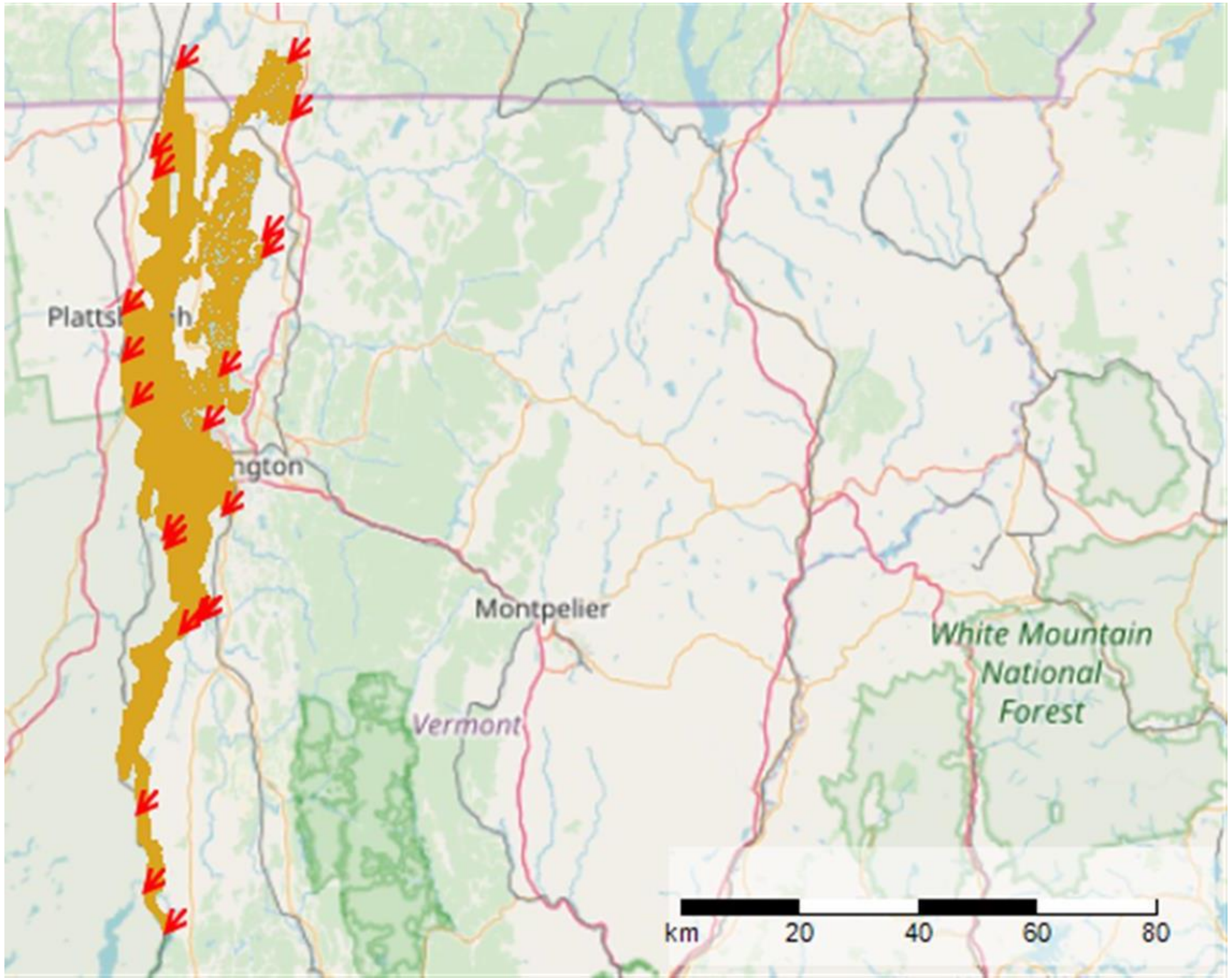


This is like a forecast!

https://affinelayer.com/pixsrv/

What we need to know all inputs and outputs at boundaries



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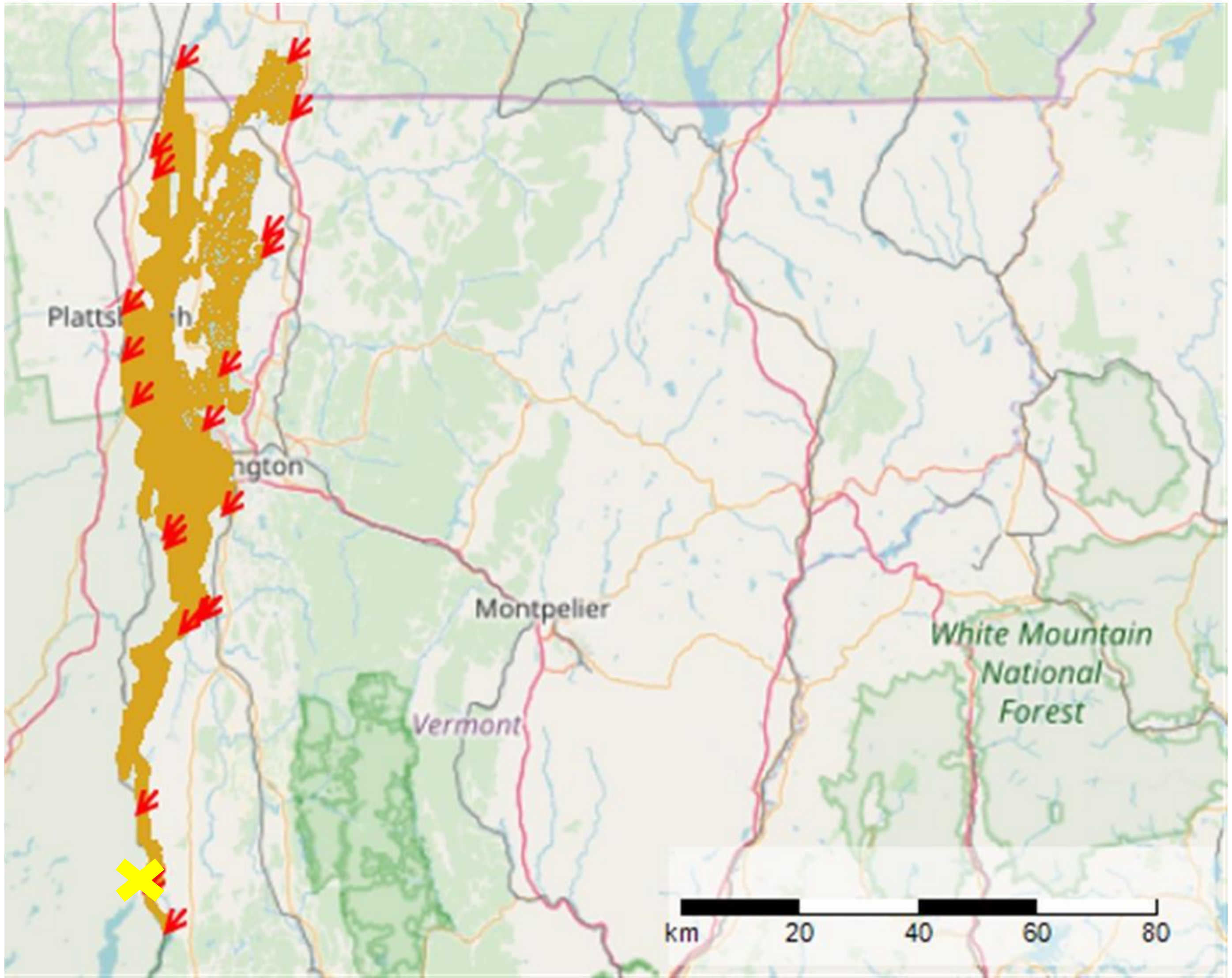
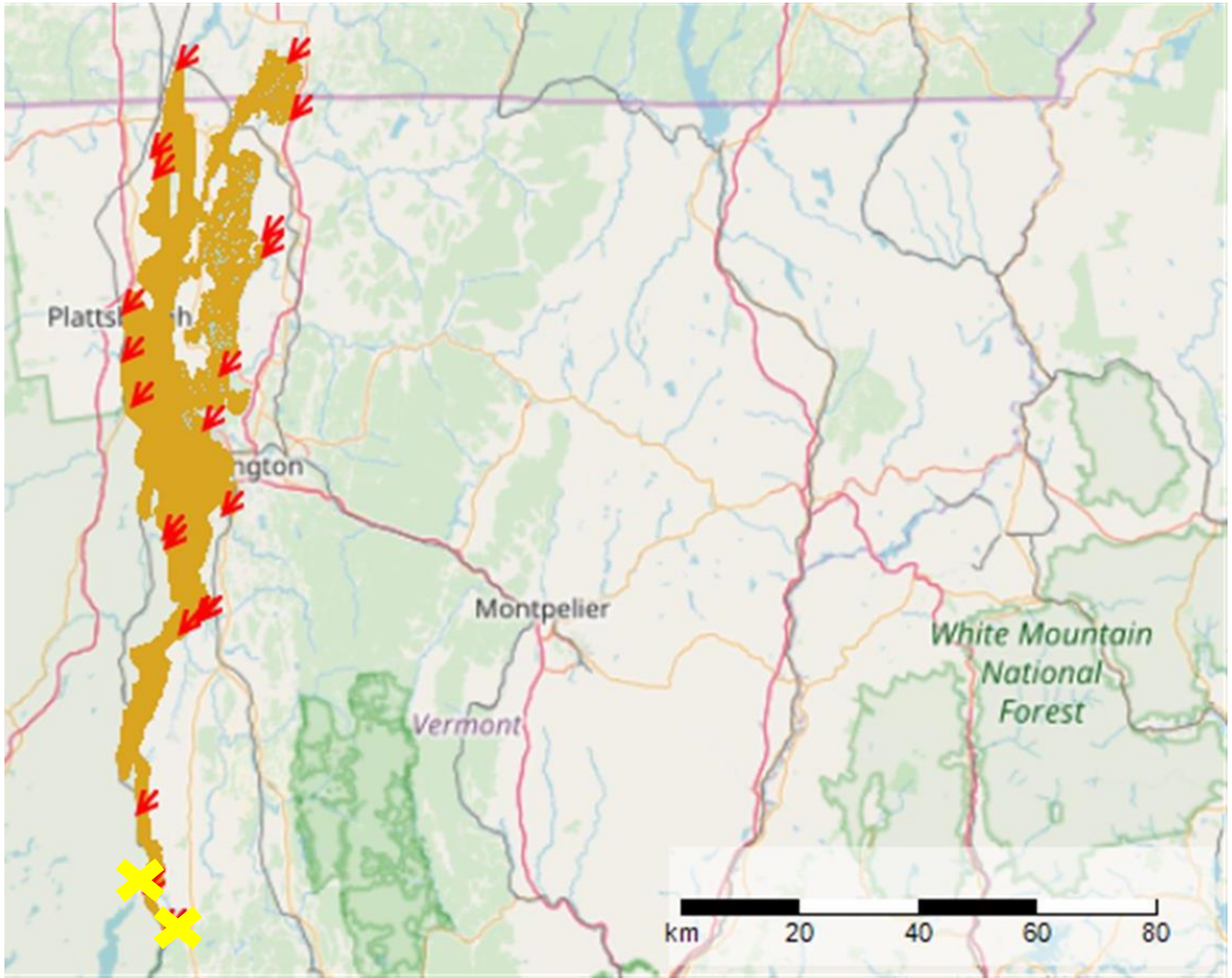


No Gauge On La Chute River which is draining Lake George and it is not a natural system (dammed for hydropower)

What we need to know all inputs and outputs at boundaries



No gauge On La Chute River which is draining Lake George and it is not a natural system (dammed for hydropower)

No gauge On South Lake, but we do know water level

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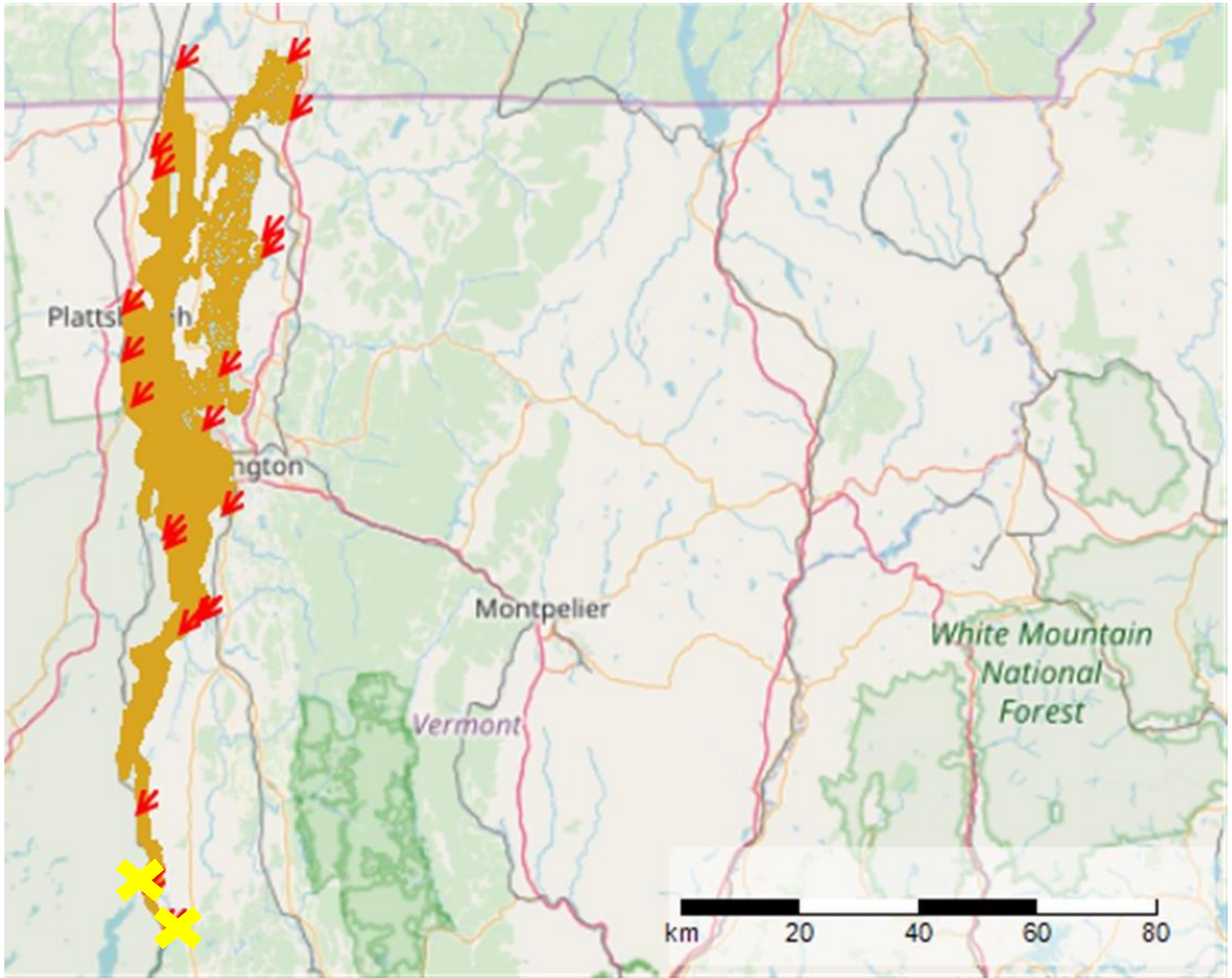
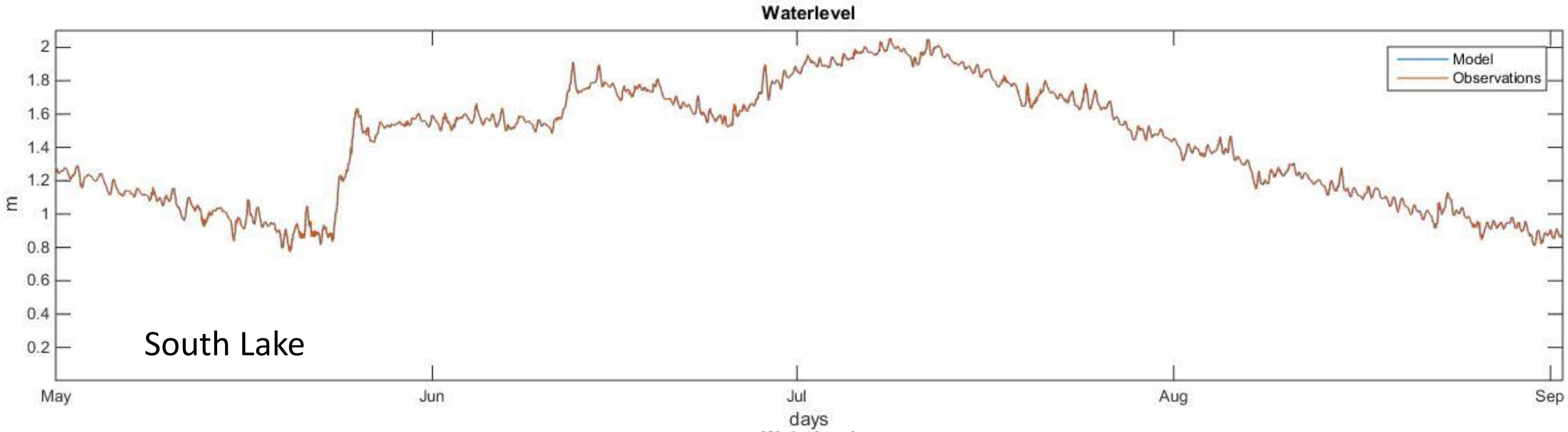


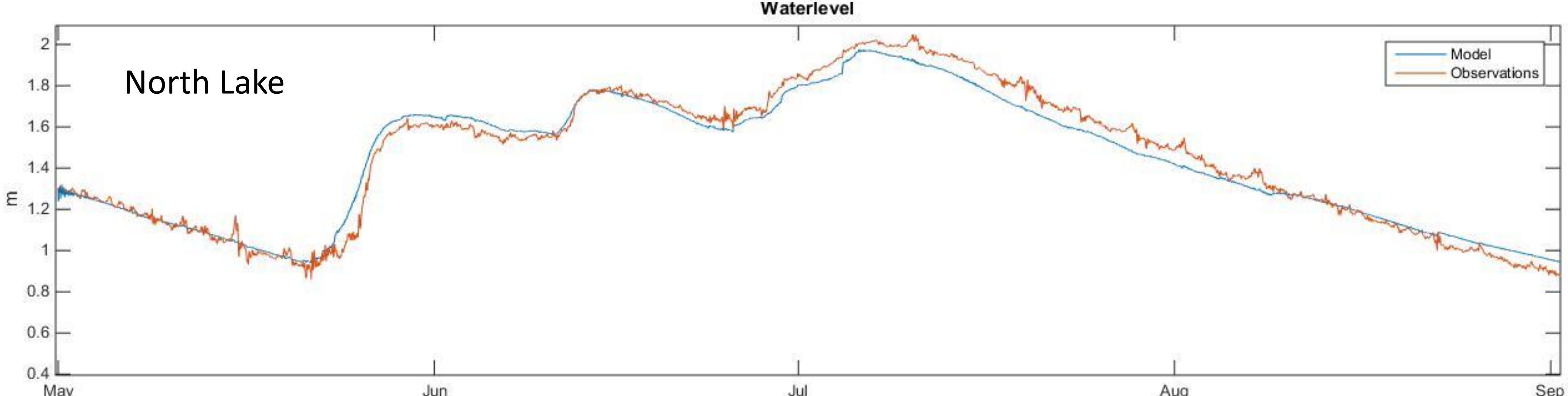
No gauge On La Chute River which is draining Lake George and it is not a natural system (dammed for hydropower)

No gauge On South Lake, but we do know water level

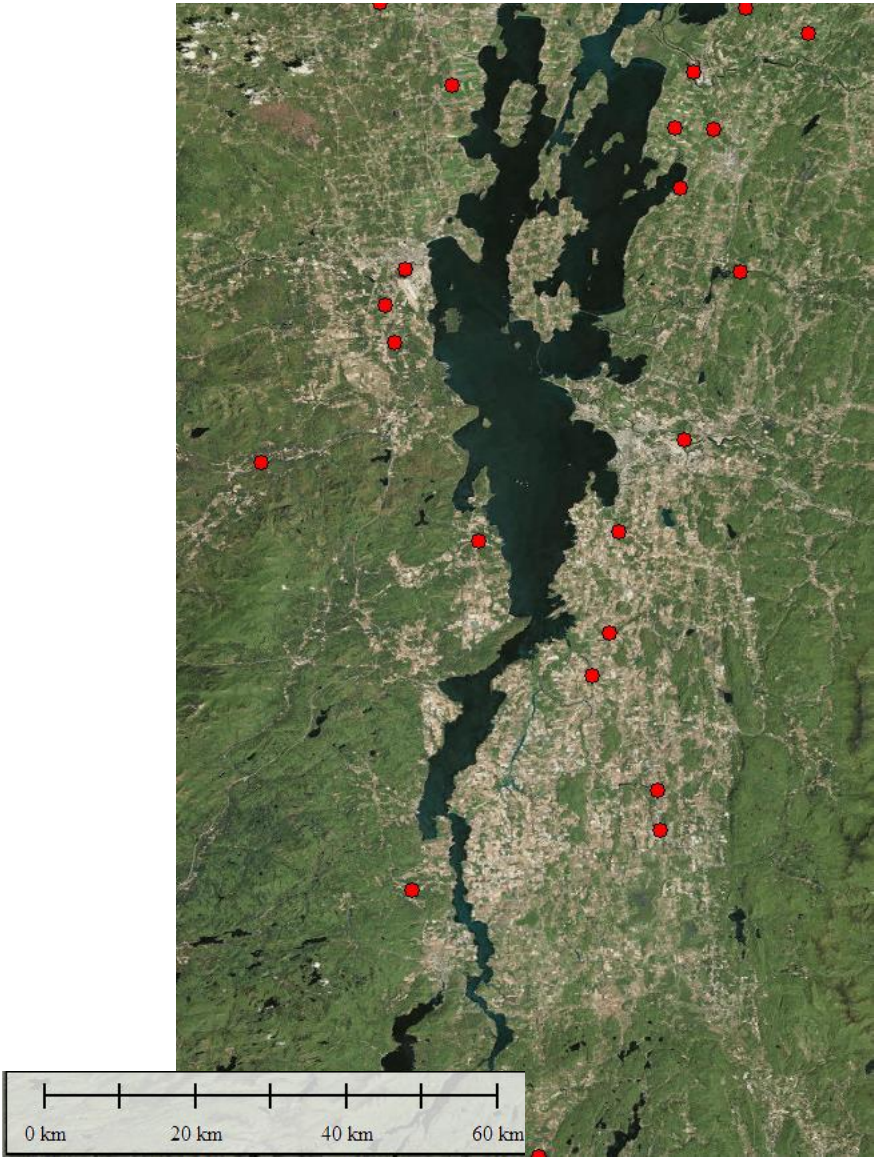
No long term temperature measurements on any rivers

Using all this information: model performs well with respect to waterlevel

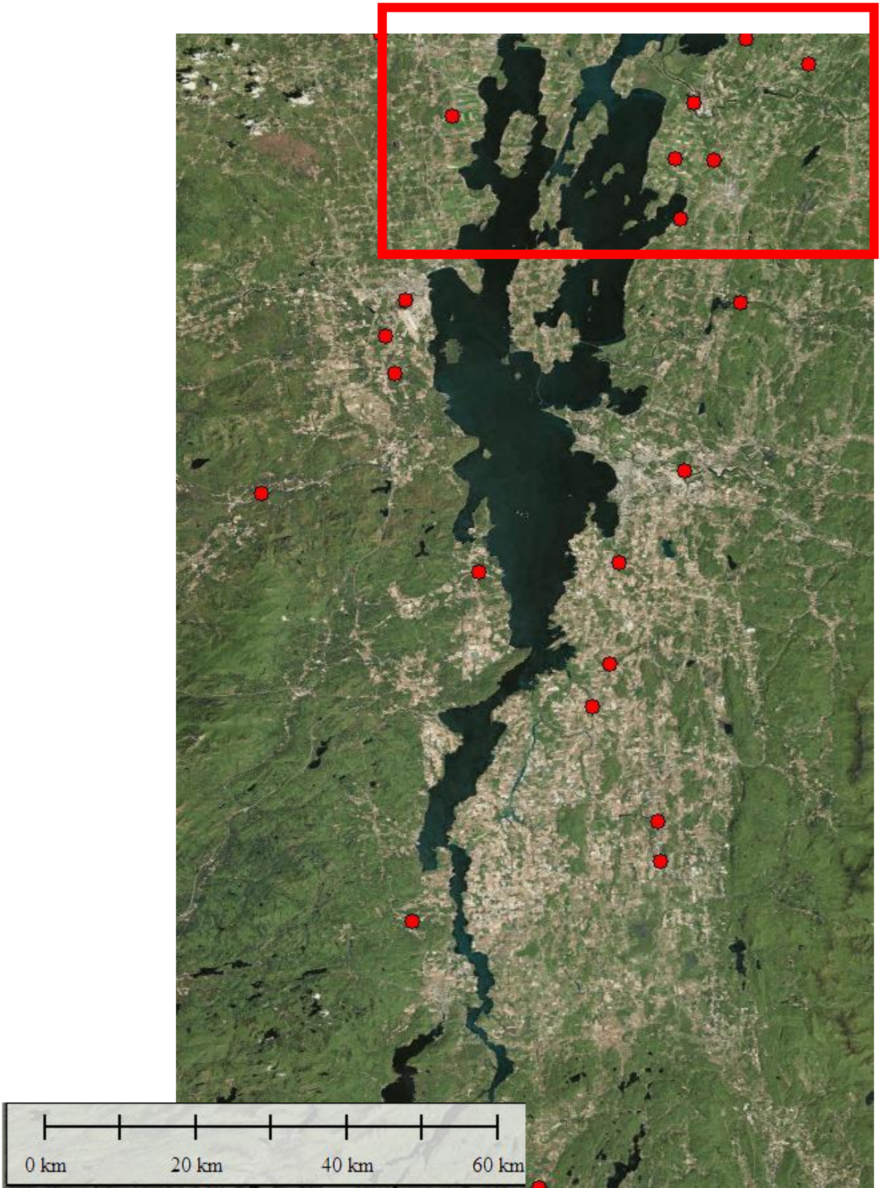


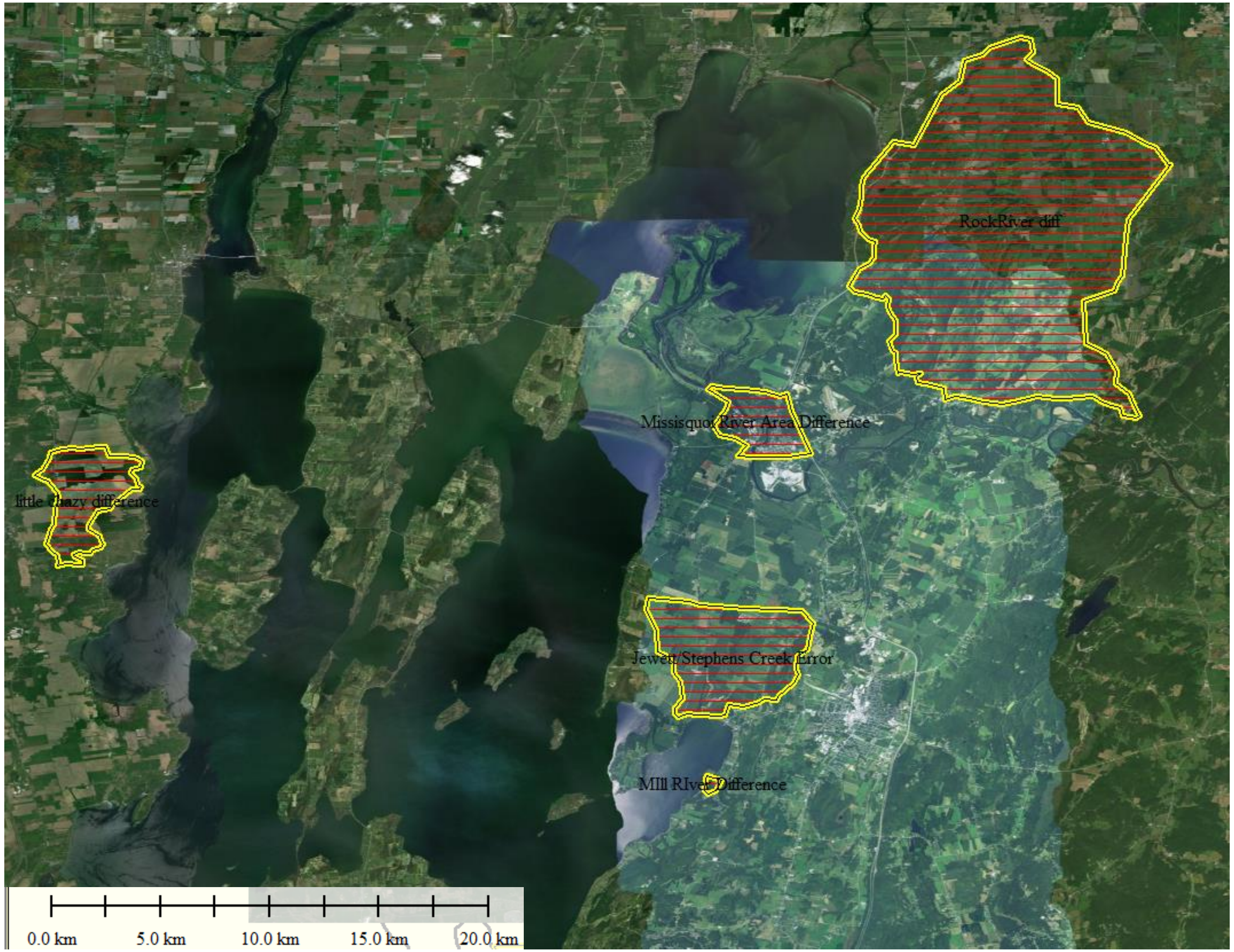


Location of River Gauges in the Champlain Basin



River Gauges are not located at model boundary!





Simple Hydrology Model

$$Q_{model} = F_{geo} \times Q_{measured}$$

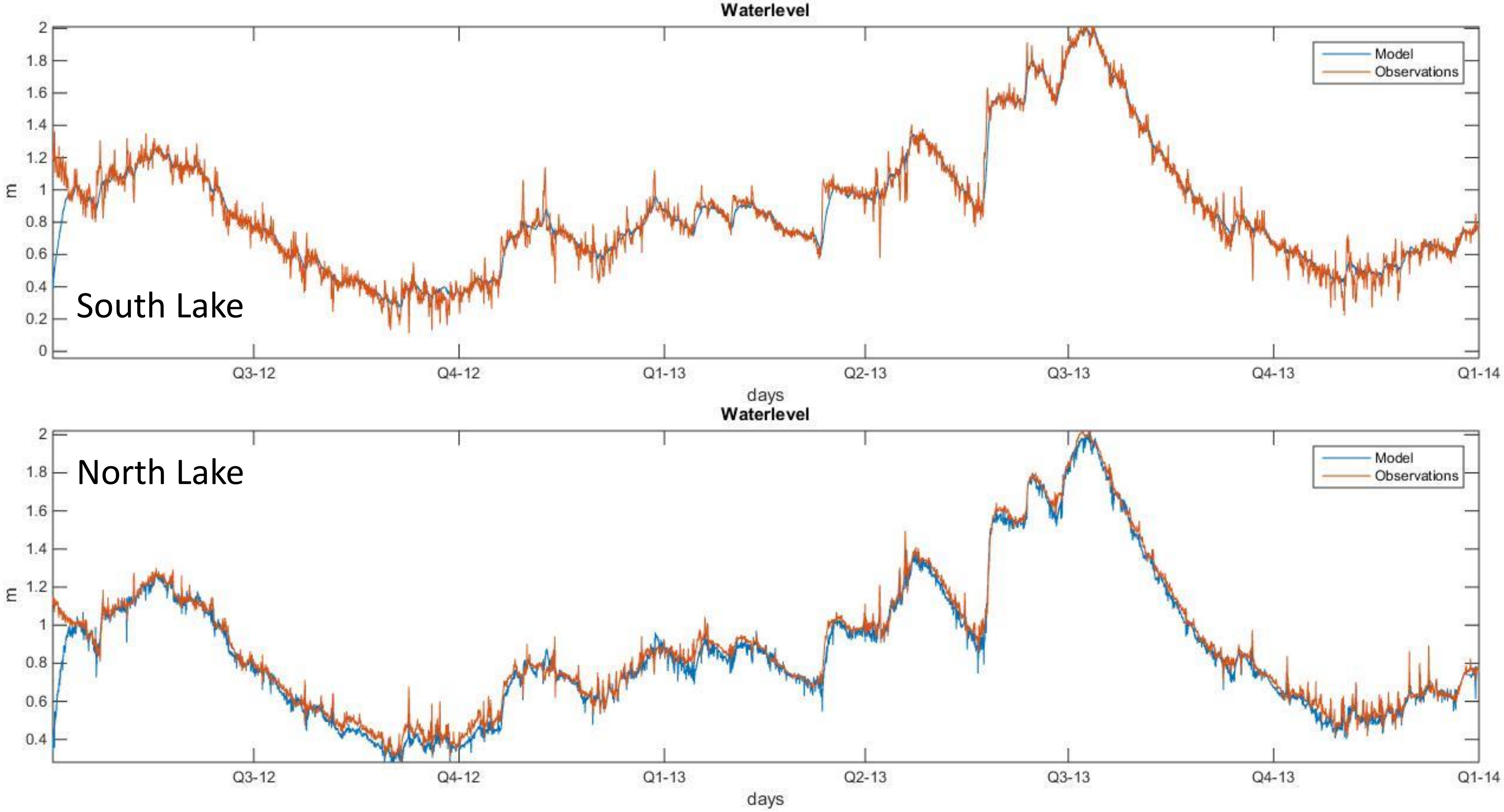
Discharge Point	Formula
Great Chazy River	1.2 * Great Chazy Discharge
Little Chazy	1.1 * Little Chazy Discharge
Saranac River	1.0*Saranac Discharge
Salmon River	1.1 * Salmon River Discharge
Little Ausable River	1.1 * Little Ausable River Discharge
Ausable River	1.2 * Ausable River Discharge
Bouquet River	1.0 * Bouquet River
Putnam Creek	1.2 * Putnam Creek Discharge
Poultney/Mettawee River	3.6* Poultney River Discharge
Otter Creek	1.3*Otter Creek Discharge +New Haven Discharge
Little Otter Creek	1.3*Little Otter Creek
Lewis Creek	1.0*Lewis Creek
La Platte	1.2* La Platte
Winooski	1.0*Winooski
Lamoille	1.1*Lamoille River
Mill River	1.0*Mill River
Stevens/Jewett	1.5*(Stevens+Jewett)
Missisquoi	1.0*Missisquoi
Rock River	4 * Rock River + Saxe Brook
Pike River	1.1 * Pike River
La Chute	0.68*Poultney +2.5* Putnam


Missisquoi River gauge (https:\\water.weather.gov)

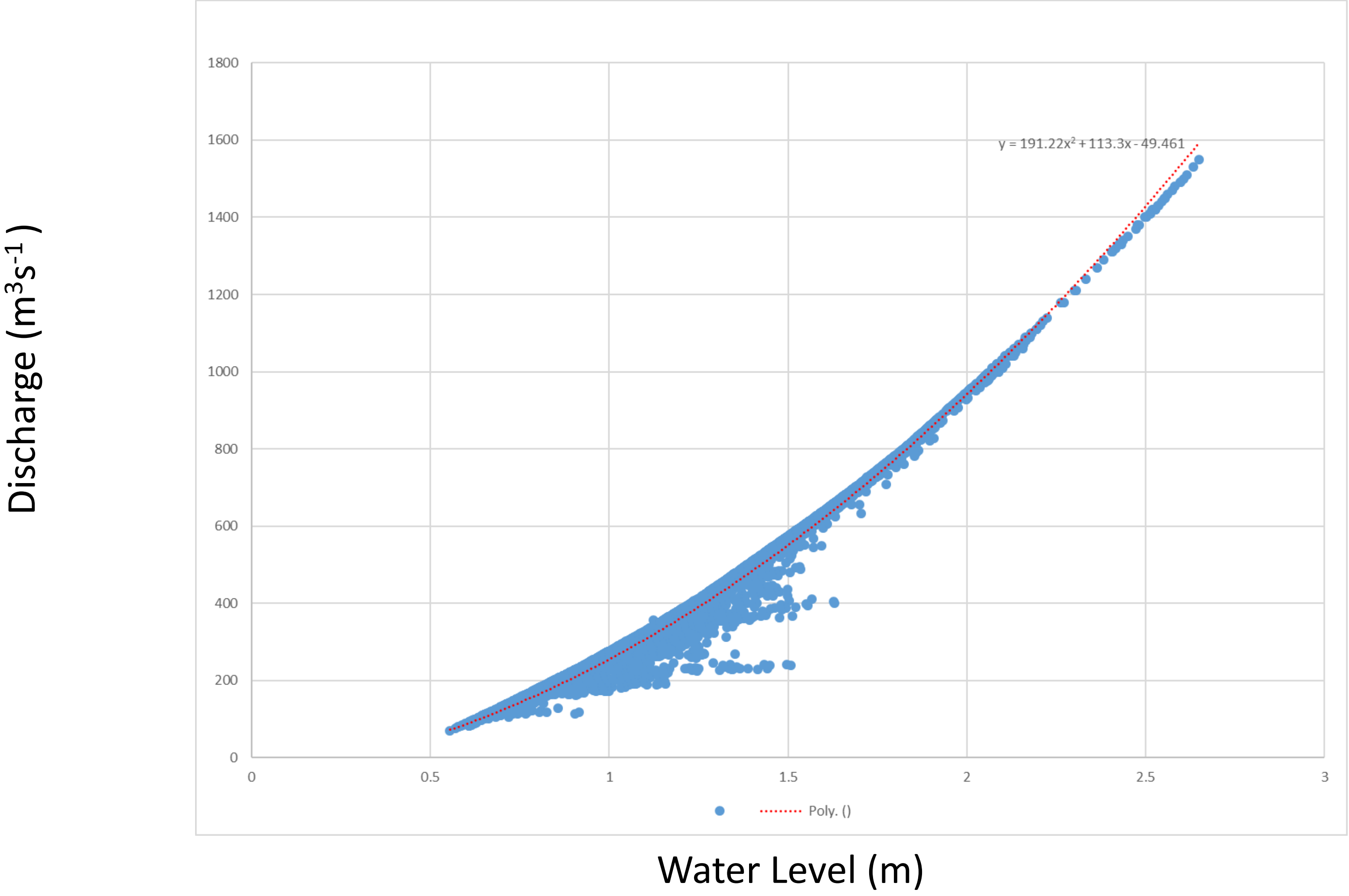
$$T_{river} = max\{0.6 \times T_{air}, 0\}$$

Morrill, Bales and Conklin 2005

Without southern water levels the absolute error grows, but oscillations are more physical

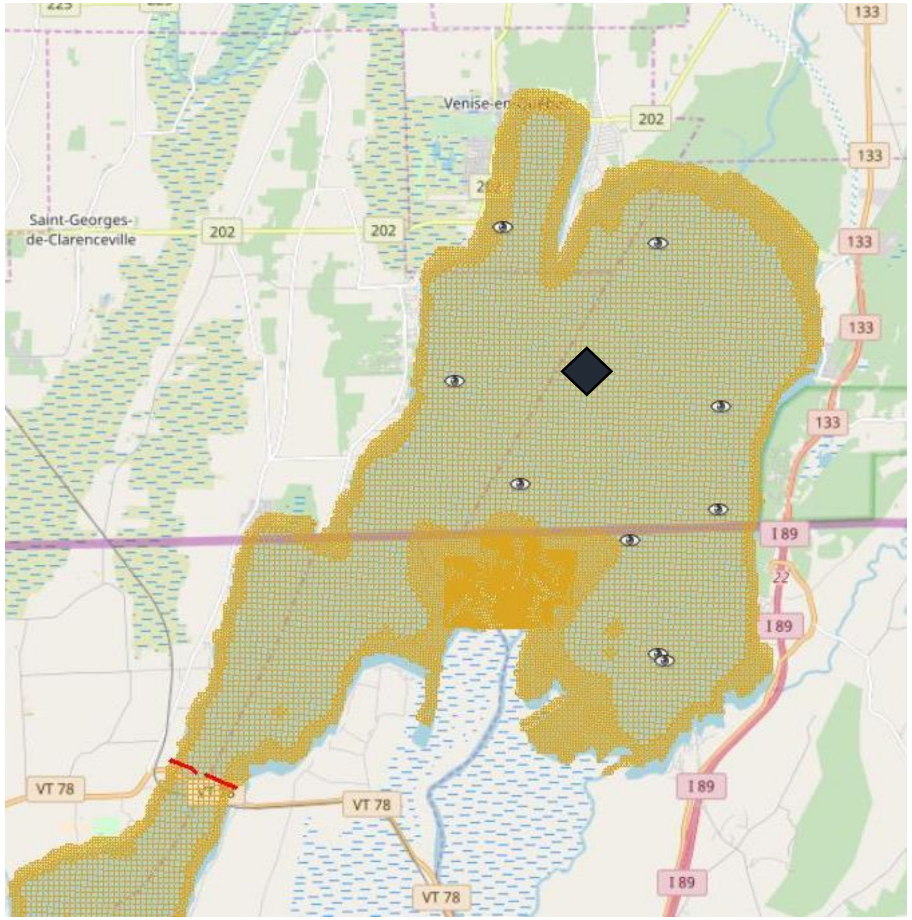


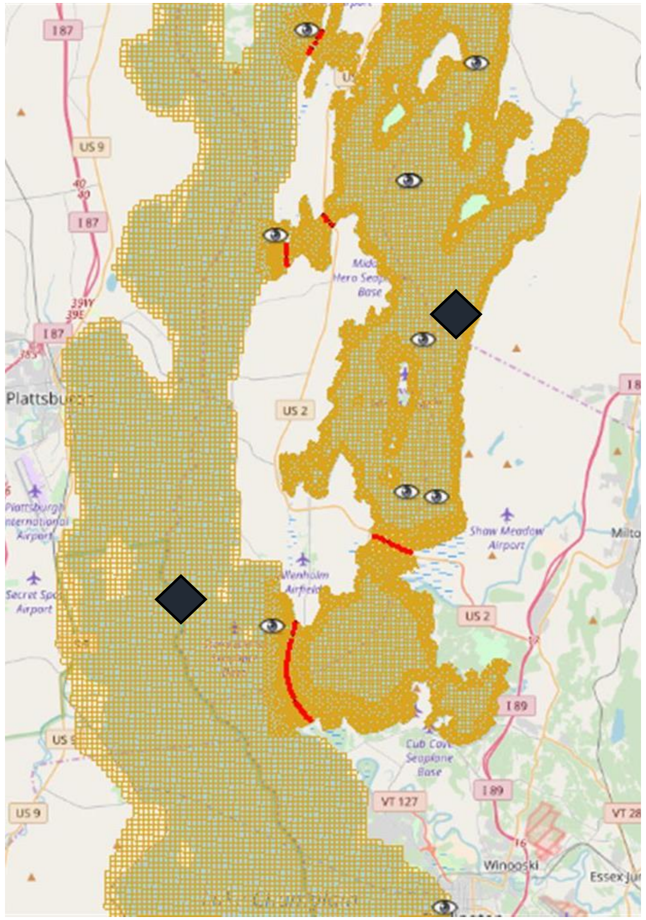
Next step: Extend grid to add Chambly Dam

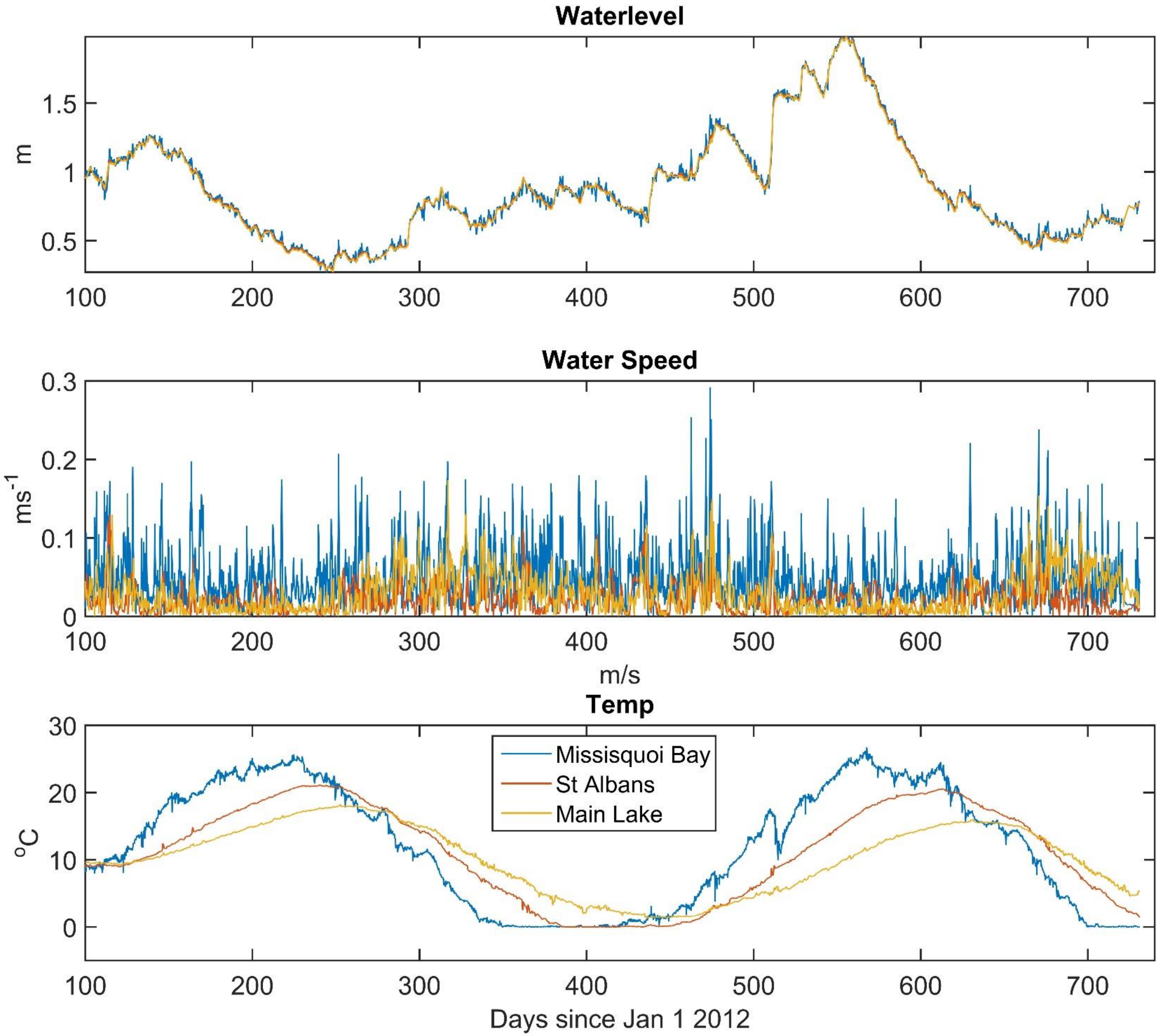


We can use the existing stage discharge relationship as a boundary on the Northern End

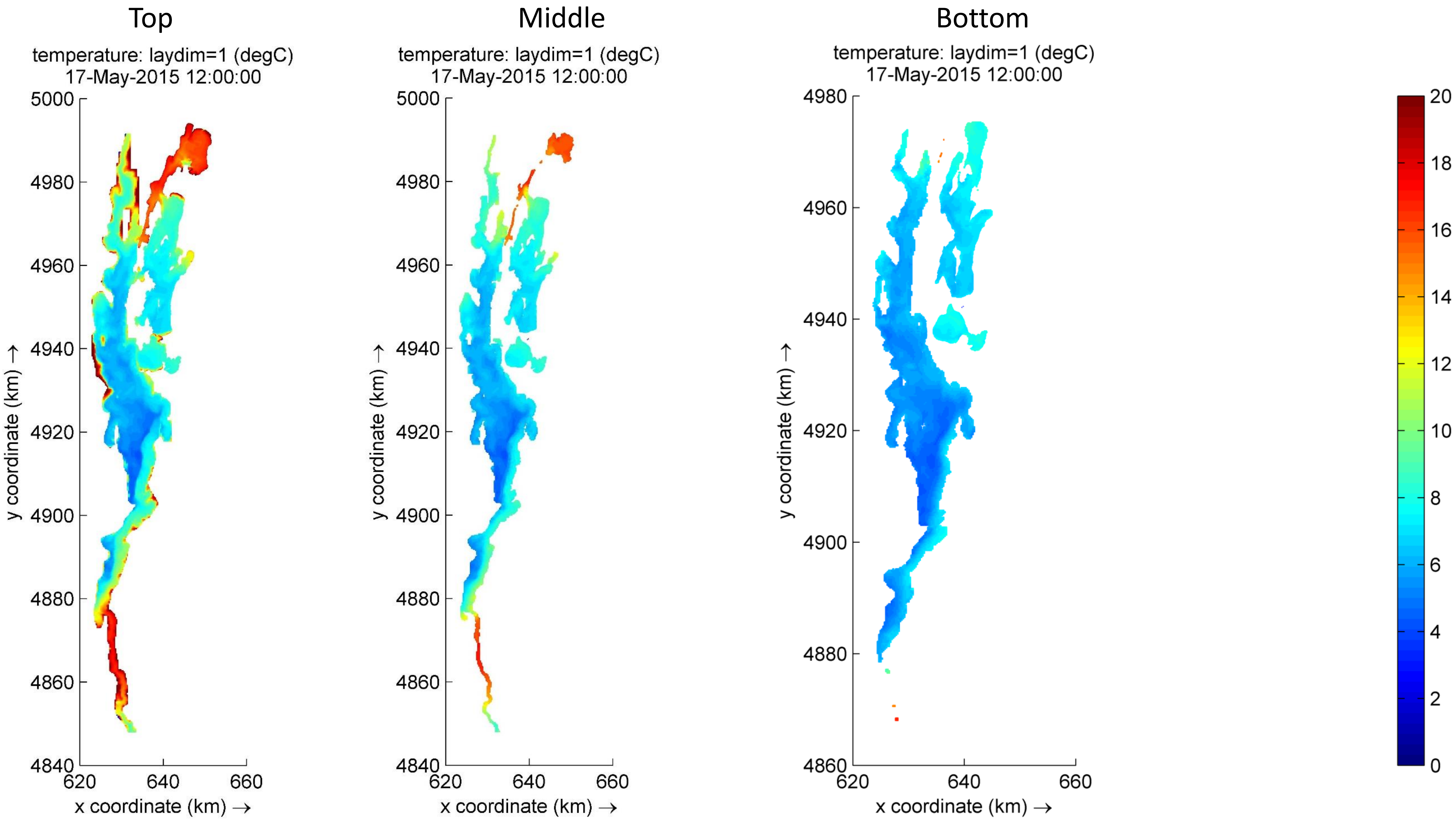
Preliminary Results from Lake Model: Seasonal Variability







April September April September



Top
temperature: laydim=1 (degC)
17-May-2015 12:00:00
Middle
temperature: laydim=1 (degC)
17-May-2015 12:00:00
Bottom
temperature: laydim=1 (degC)
17-May-2015 12:00:00
y coordinate (km) →
x coordinate (km) →
5000
4980
4960
4940
4920
4900
4880
4860
4840
620
640
660
0
2
4
6
8
10
12
14
16
18
20

Thanks!