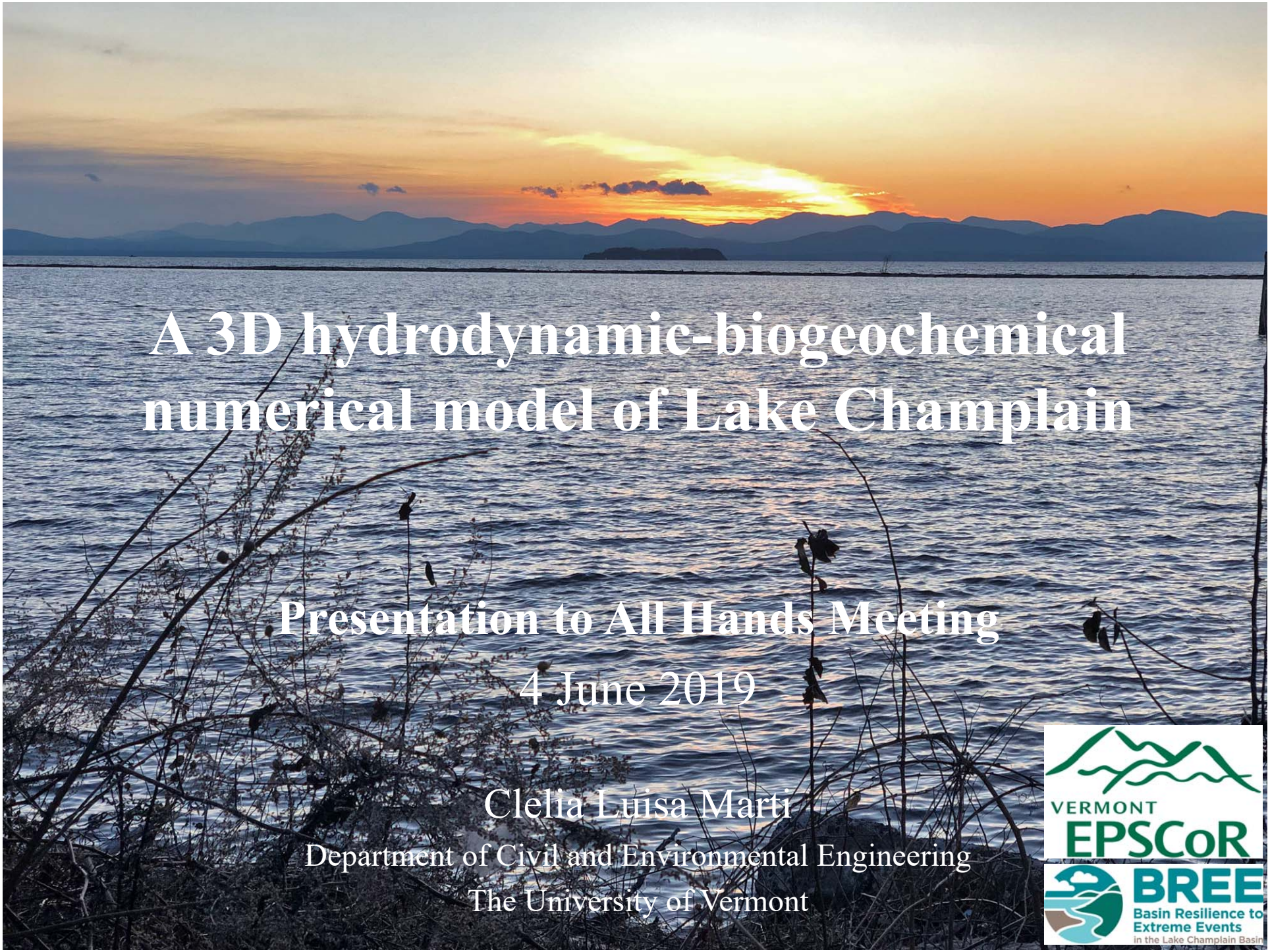


A 3D hydrodynamic-biogeochemical numerical model of Lake Champlain

Presentation to All Hands Meeting

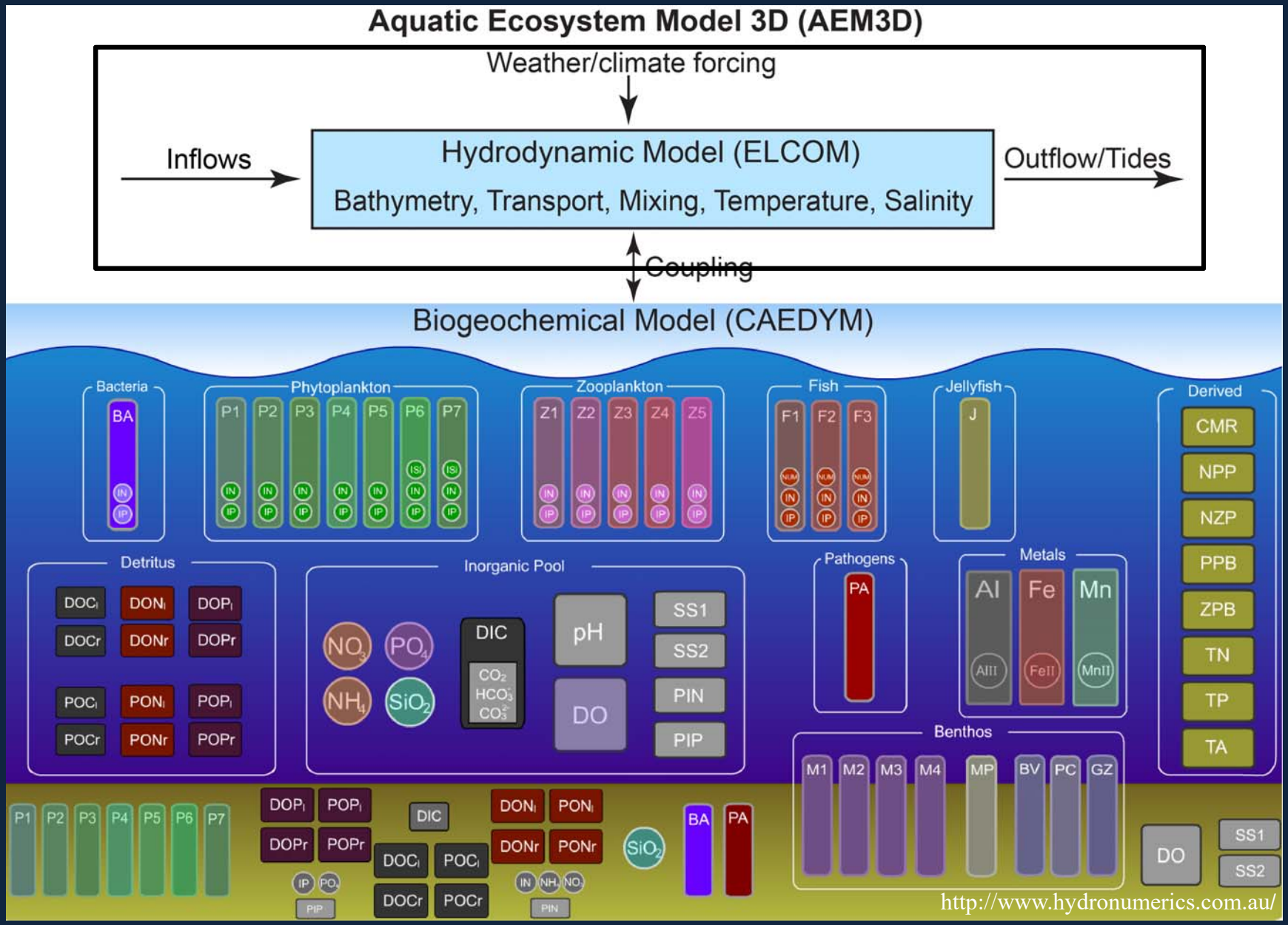
4 June 2019

Clelia Luisa Marti
Department of Civil and Environmental Engineering
The University of Vermont

VERMONT EPSCoR

BREE Basin Resilience to Extreme Events in the Lake Champlain Basin

The Numerical Model

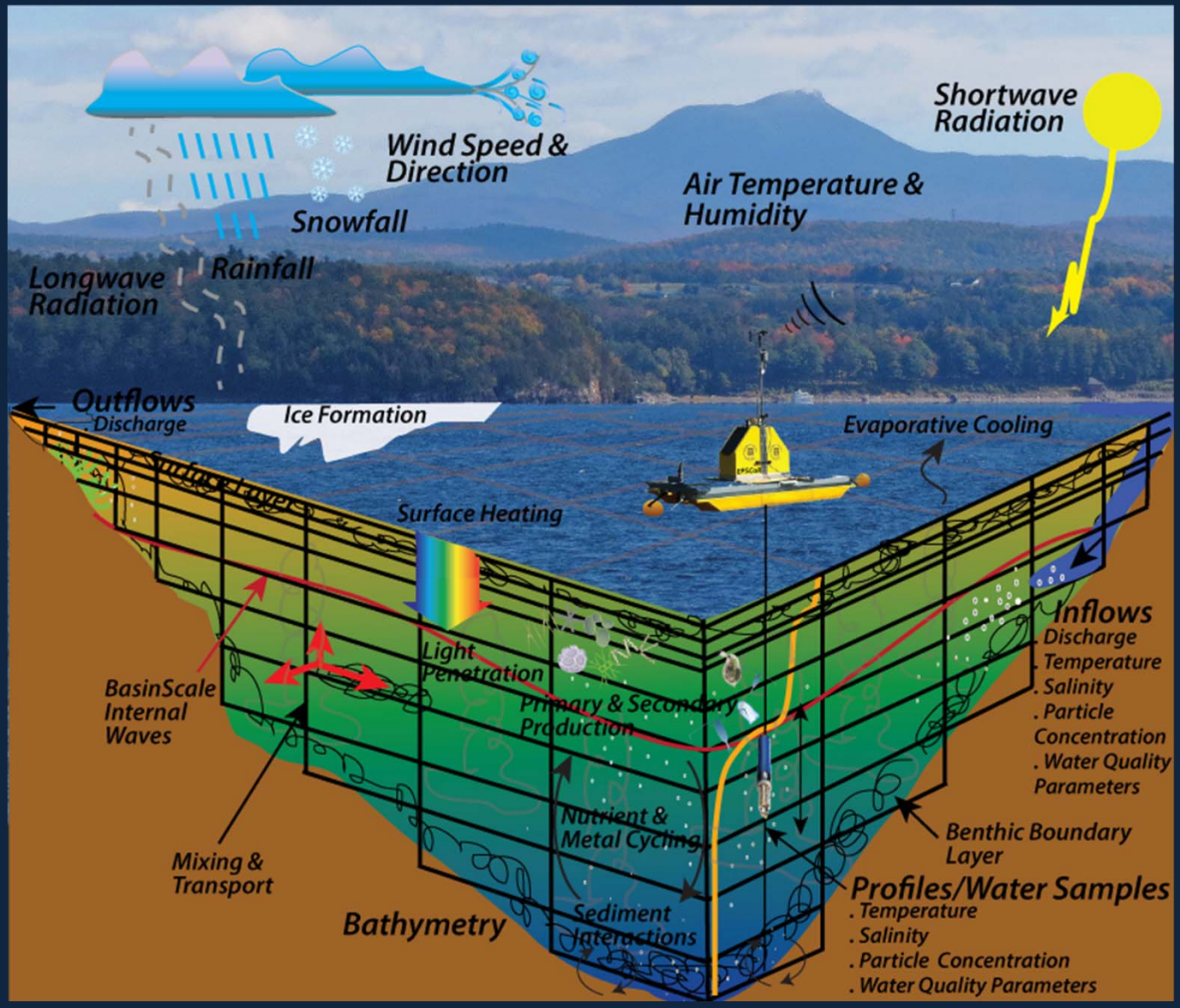


Hodges et al. (2000) Limnology and Oceanography, Romero et al. (2003) Ecological Modelling, Trolle et al. (2012) Hydrobiologia

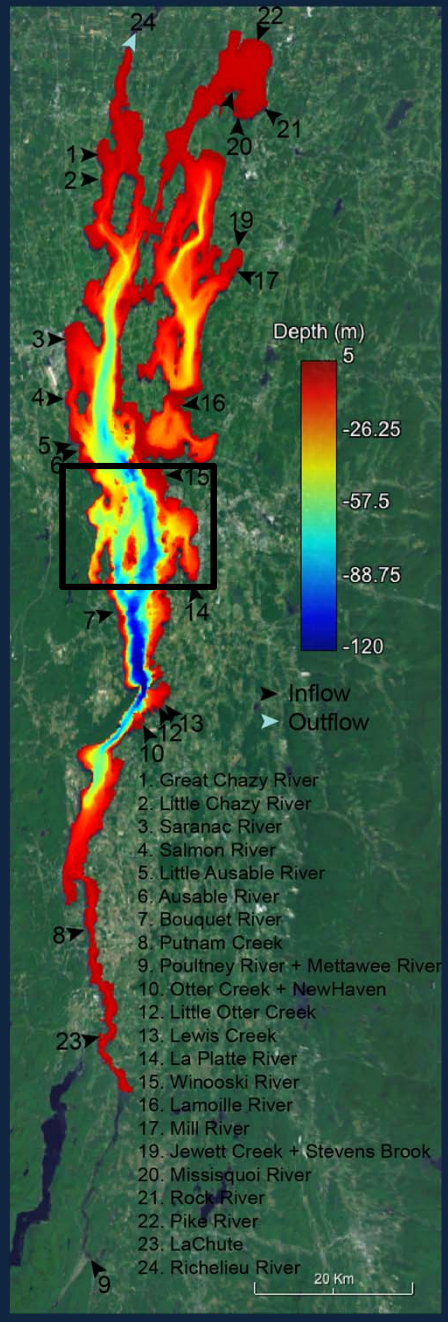
Numerical Models - Philosophy

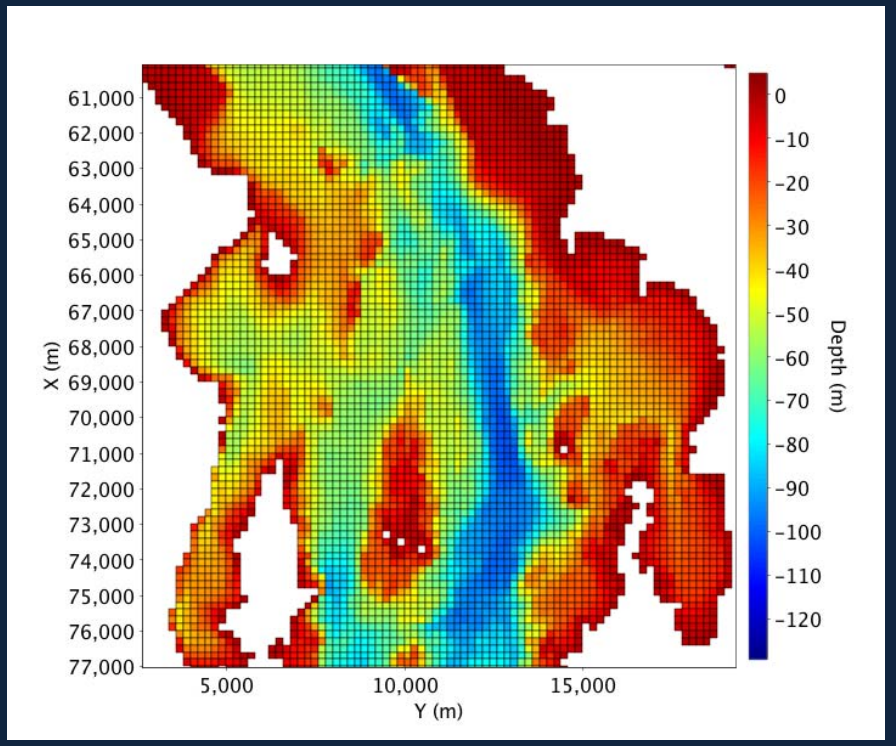
- *Process-based models.*
- *Models are under active and continuous developments, i.e., science and run time.*
- *The science in the models must be able to capture processes in the water column at the scale of interest according to the objective.*
- *Models must be open source so the science in the models can be peer reviewed.*
- *Accessing the best possible forcing data.*
- *Validation data must be collected in regions where signal to noise is the highest and in an adaptive way.*

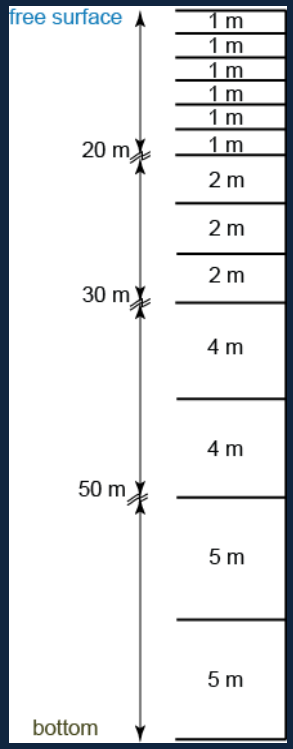
Model Schematic of Lake Champlain



Lake Champlain Model Domain







⊗X=⊗Y=200 m ⊗Z variable

734 × 146 × 45 cells

Source: Tom and Pat Manley, Middlebury College

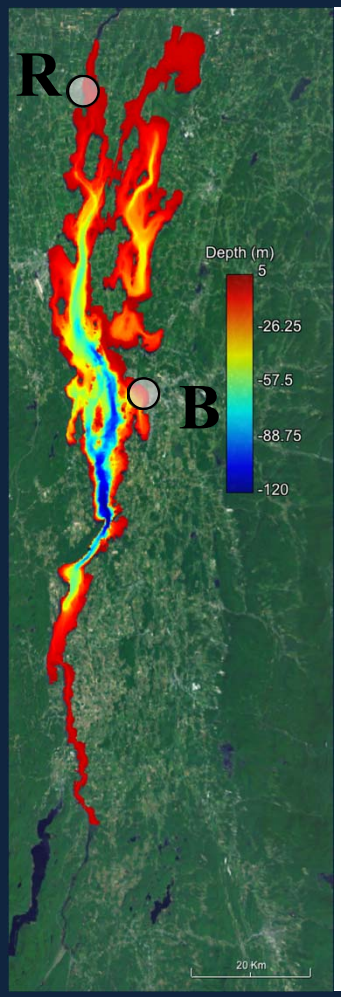
Model Forcing Data and Initial Conditions

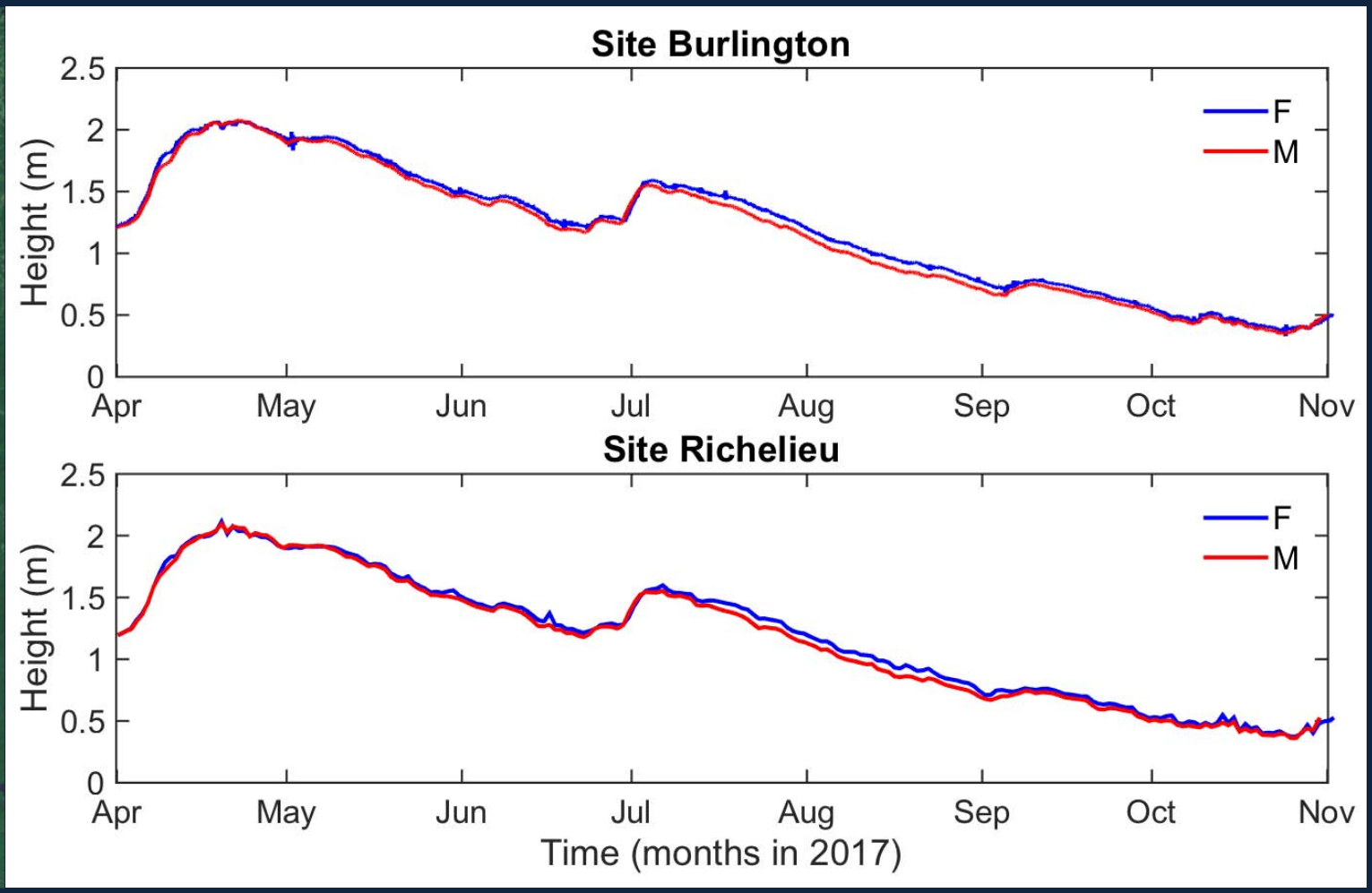
Forcing Data/Initial Conditions	Data	Time Interval	Source
Meteorological Forcing	Air temperature, Relative humidity, Solar radiation, Cloud cover, Wind speed and direction, Precipitation	15 min/Hourly/Daily	NOAA, UVM, VT EPSCoR BREE, GOV OF CANADA
Inflow	Flow rate	15 min/Daily	USGS, MELCC (QUEBEC)
	Water temperature and Salinity	Daily/Weekly/Biweekly/Monthly	DEC, Running averages of air temperature data
Outflow	Flow rate	Hourly/Daily	GOV OF CANADA
Initial Conditions	Water level	15 min	USGS
	Water temperature and Salinity	15 min/30 min/Hourly/ Biweekly/Monthly	VT EPSCoR BREE, USGS, DEC
	Extinction coefficient	Weekly/Biweekly/Monthly	DEC

Field Data Availability for Model Validation

Instrument	Source	Time Period	Sampling Frequency
A) In-situ Data Streams			
Pontoon Vertical Profiling System	VT EPSCoR BREE	Late May through October	Hourly
Water temperature Moorings and Water level gauges	VT EPSCoR BREE, NOAA, USGS, SUNY Plattsburgh	Late May through October/ ~ Year round	5 min/15 min/ 30 min
ADCP	VT EPSCoR BREE	~ Year round	30 min
B) Monitoring Programmes			
Profiler	DEC	Late May through October	Weekly/Biweekly/ Monthly

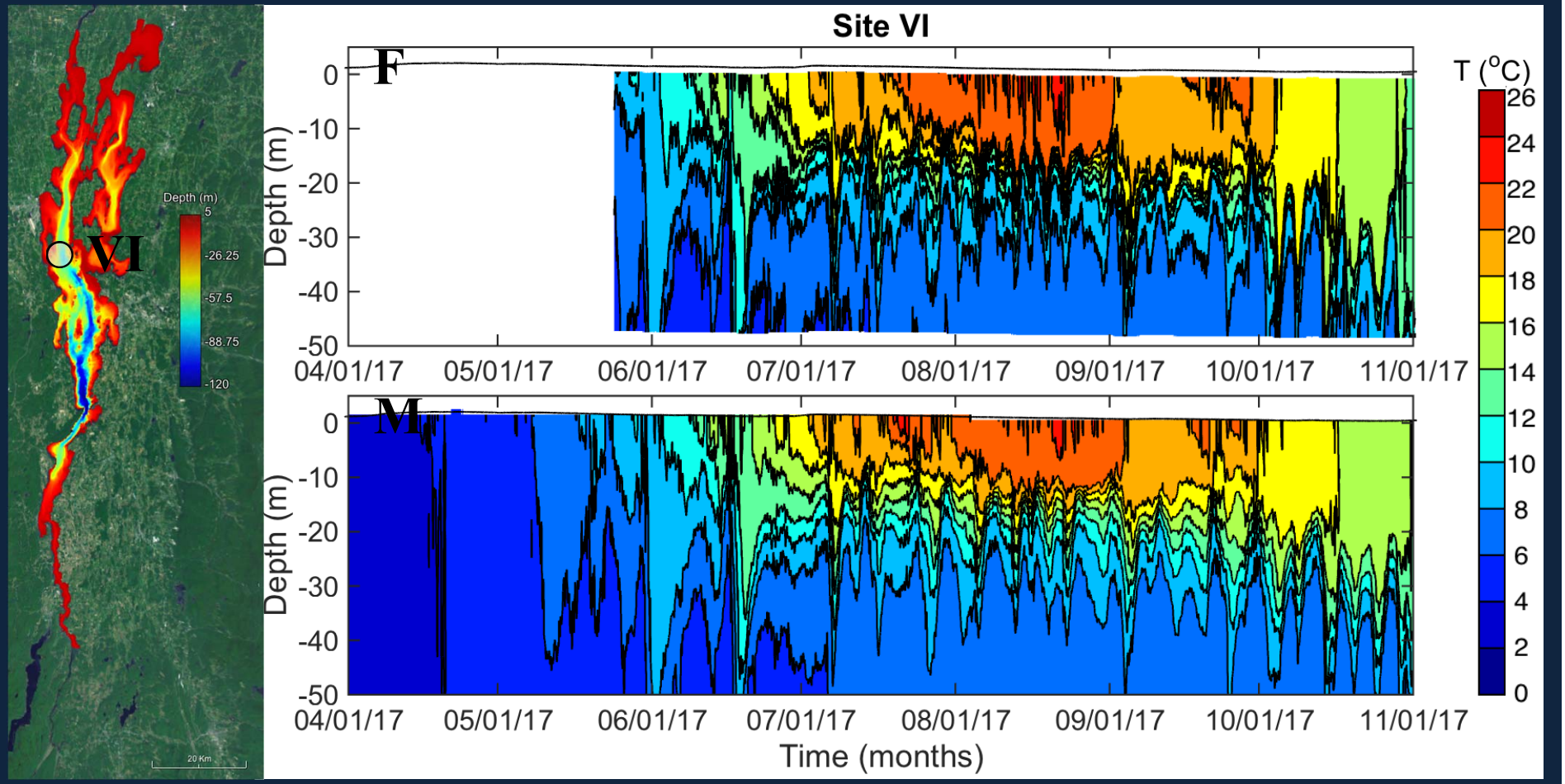
Model Validation - Water Height





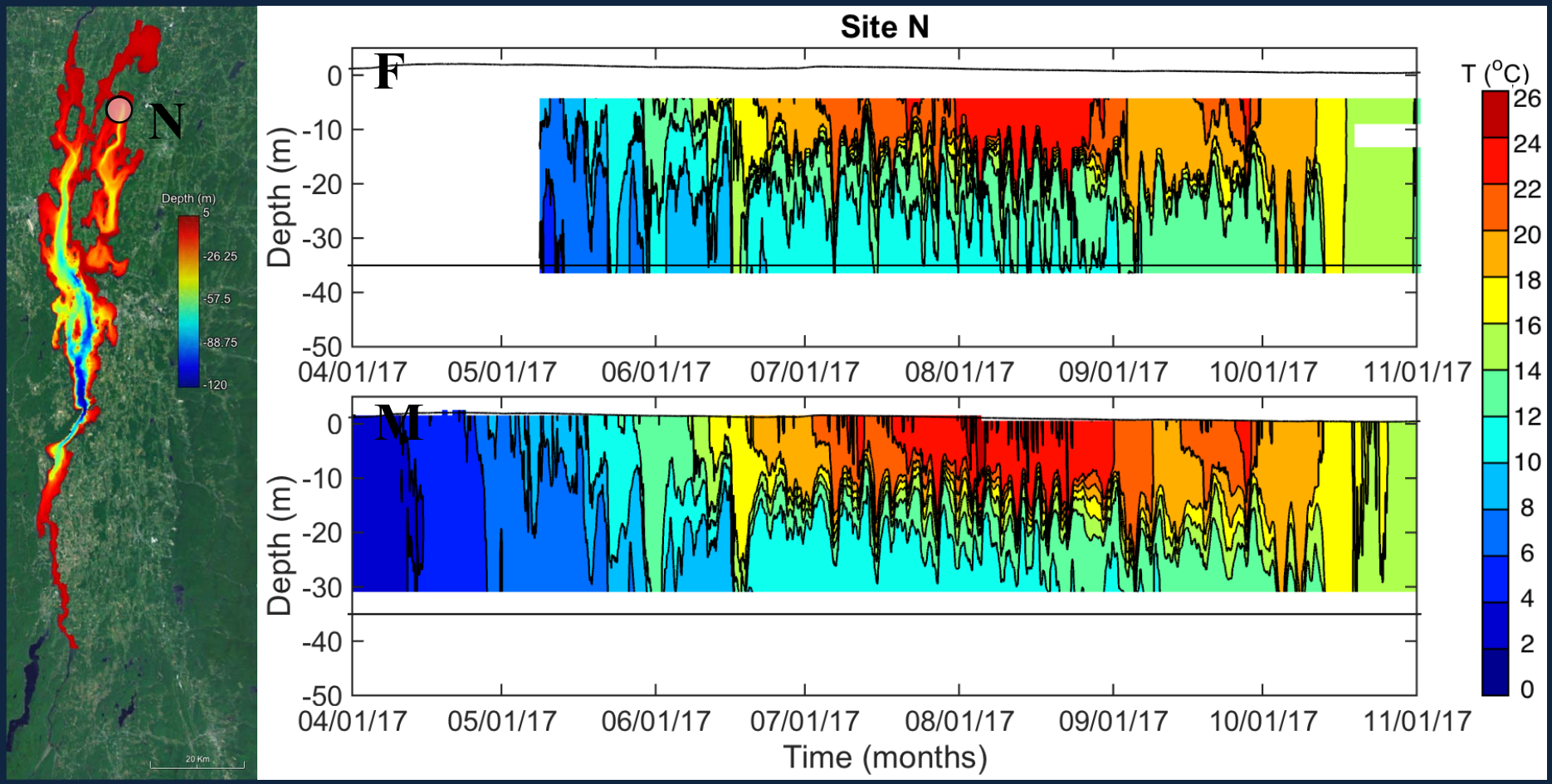
Source: USGS (Water level gauges)

Model Validation - Water Temperature



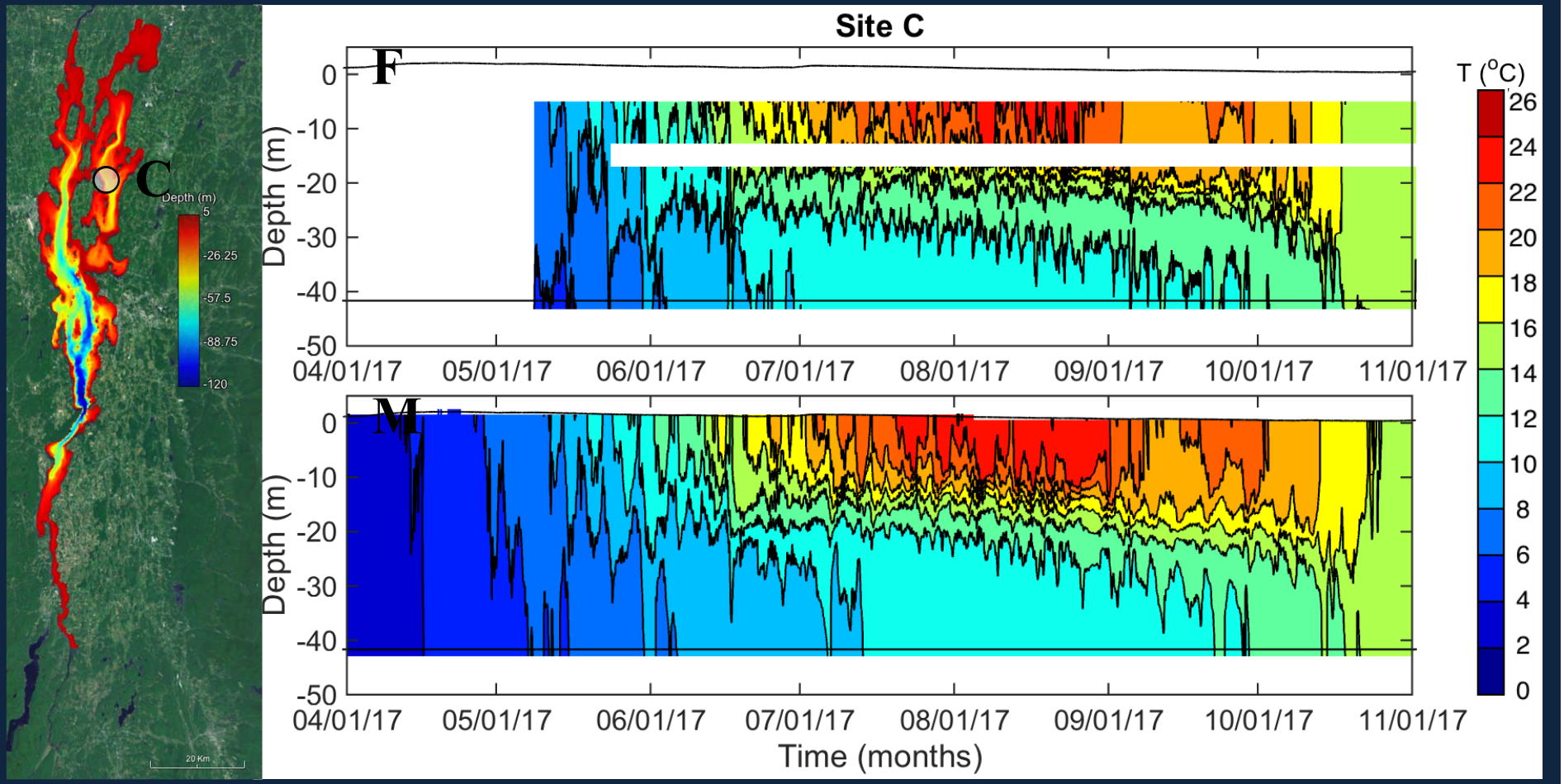
Source: Eric Leibensperger, SUNY Plattsburgh (Water temperature moorings)

Model Validation - Water Temperature



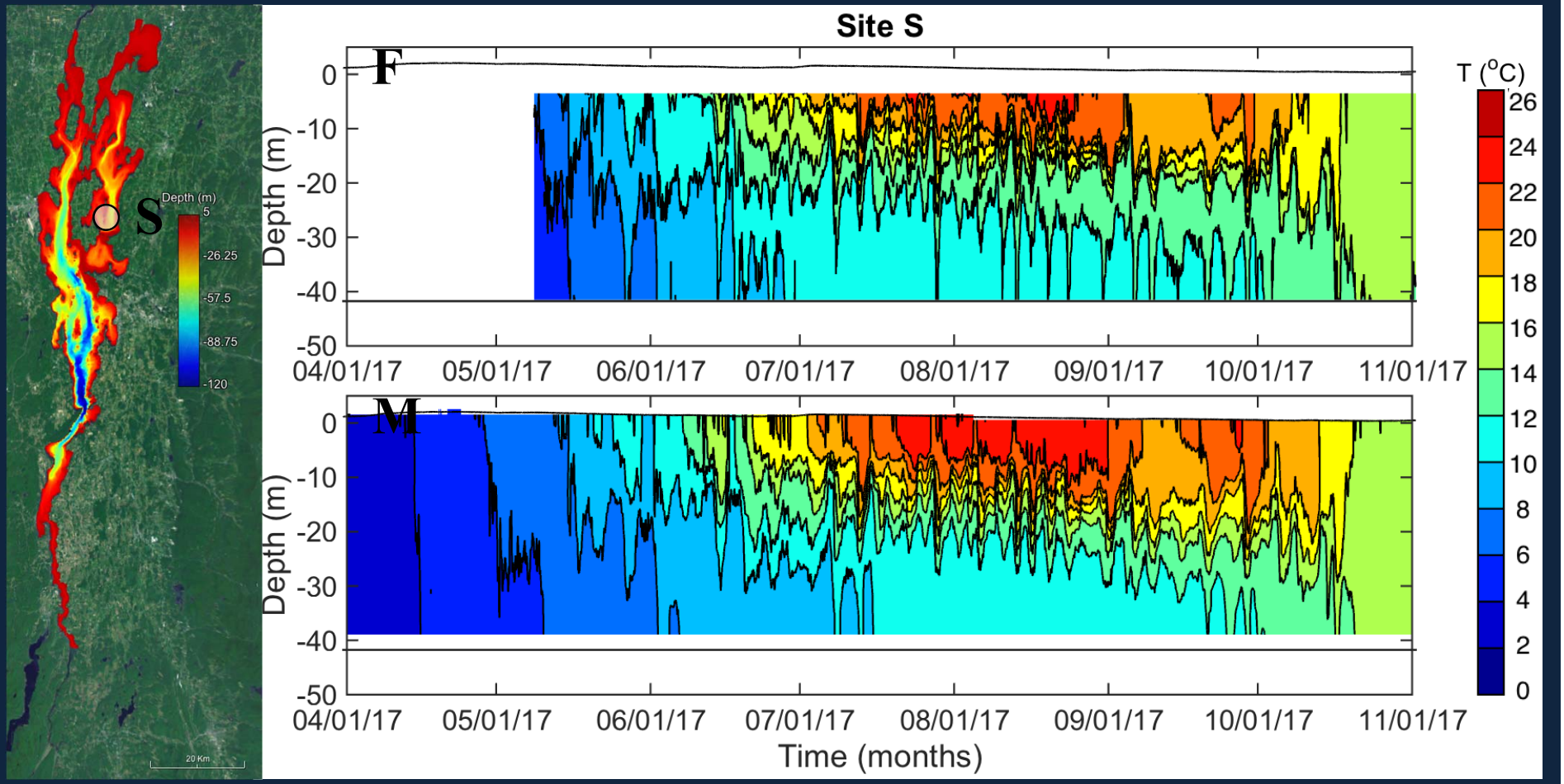
Source: VT EPSCoR BREE (Water temperature moorings)

Model Validation - Water Temperature



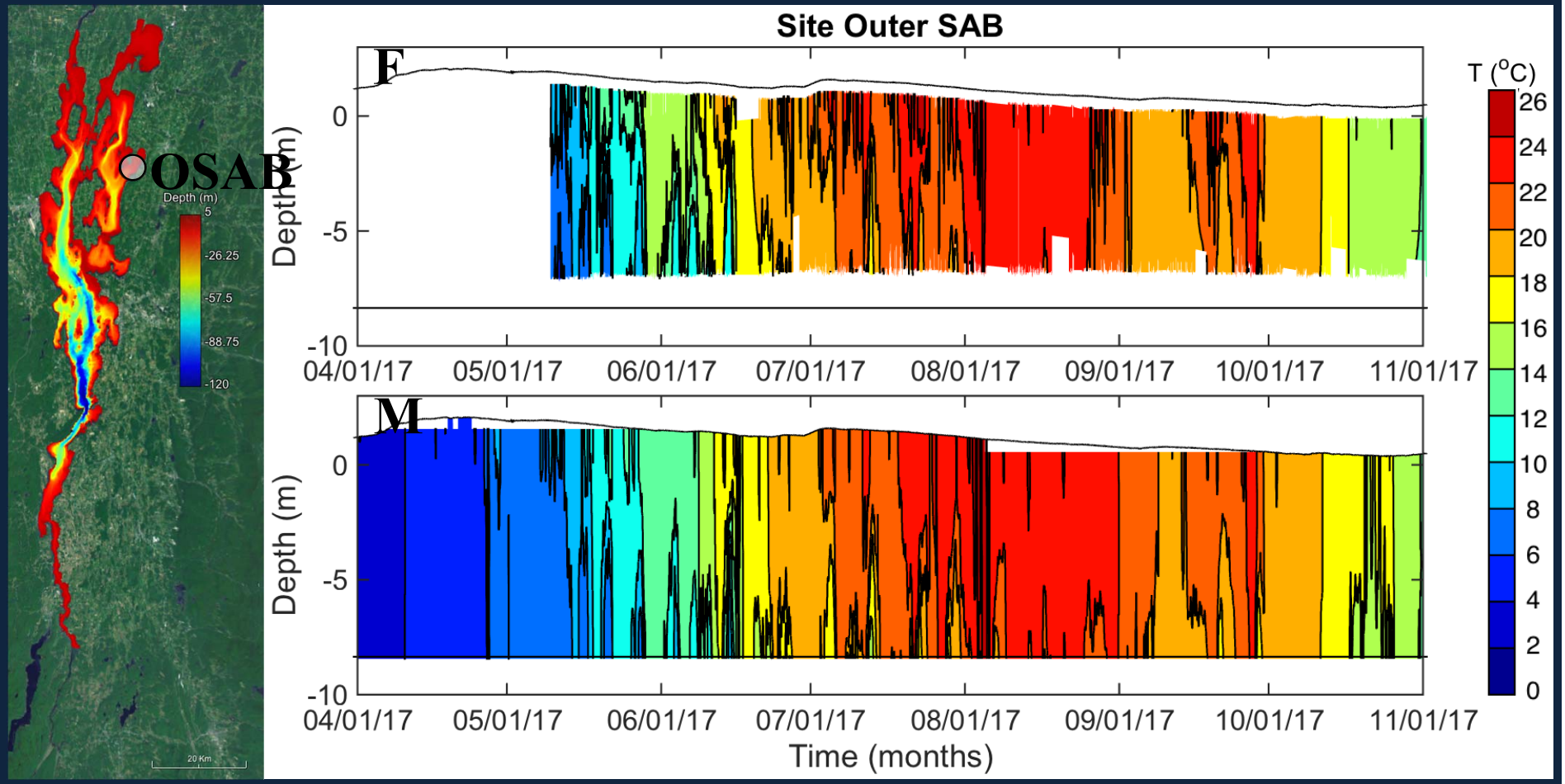
Source: VT EPSCoR BREE (Water temperature moorings)

Model Validation - Water Temperature



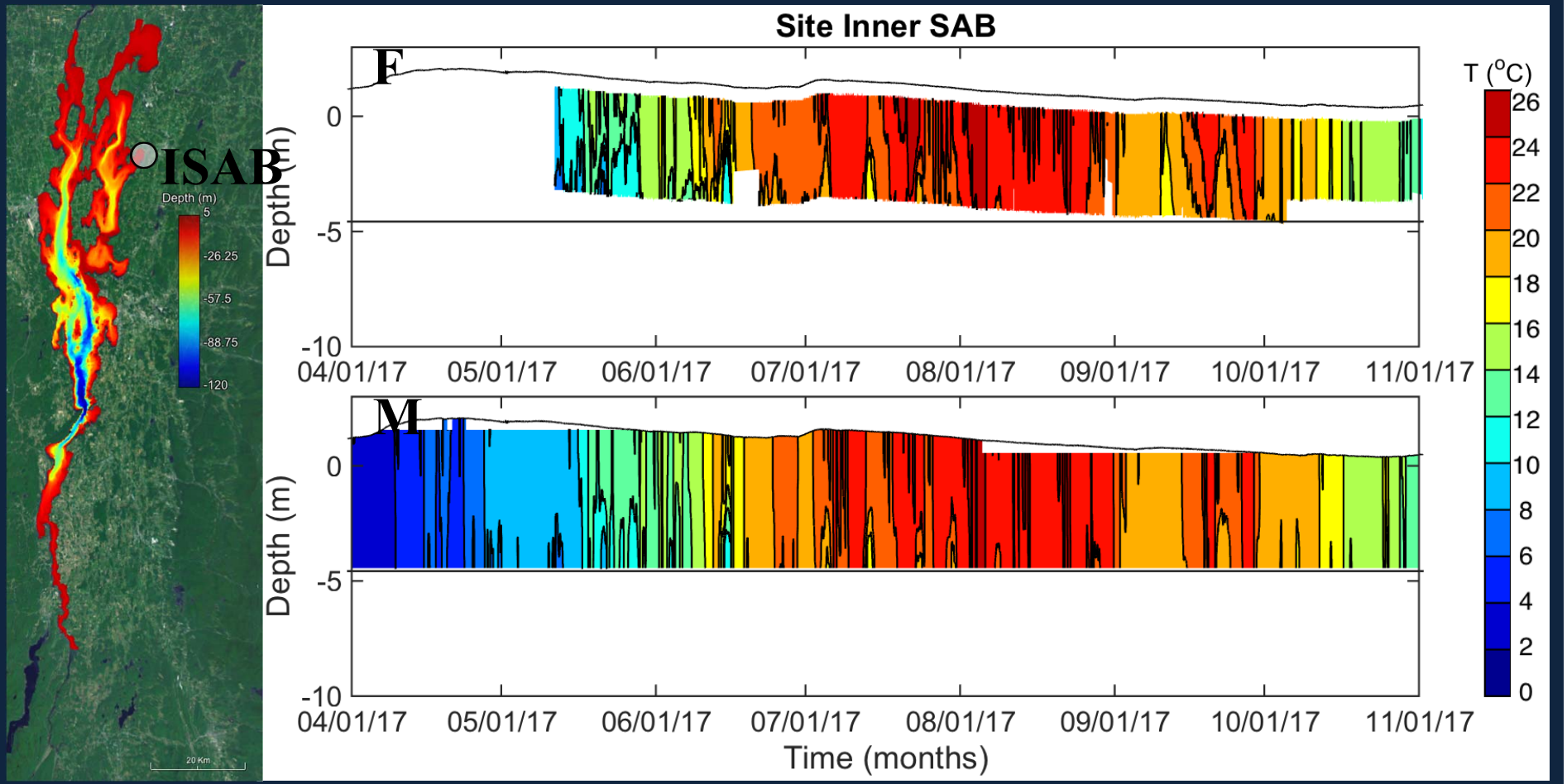
Source: VT EPSCoR BREE (Water temperature moorings)

Model Validation - Water Temperature



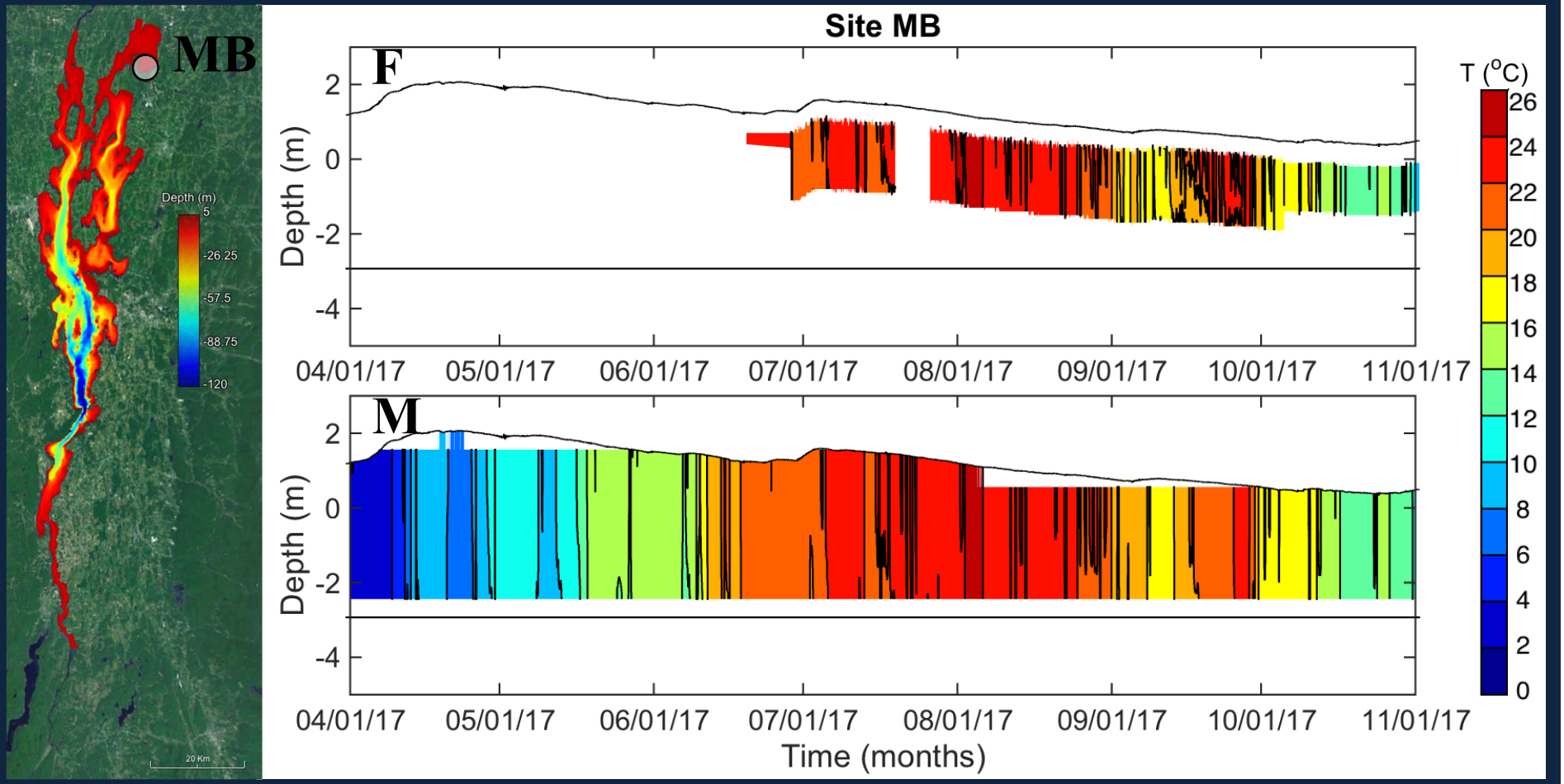
Source: VT EPSCoR BREE (Pontoon System)

Model Validation - Water Temperature



Source: VT EPSCoR BREE (Pontoon System)

Model Validation - Water Temperature



Source: VT EPSCoR BREE (Pontoon System)

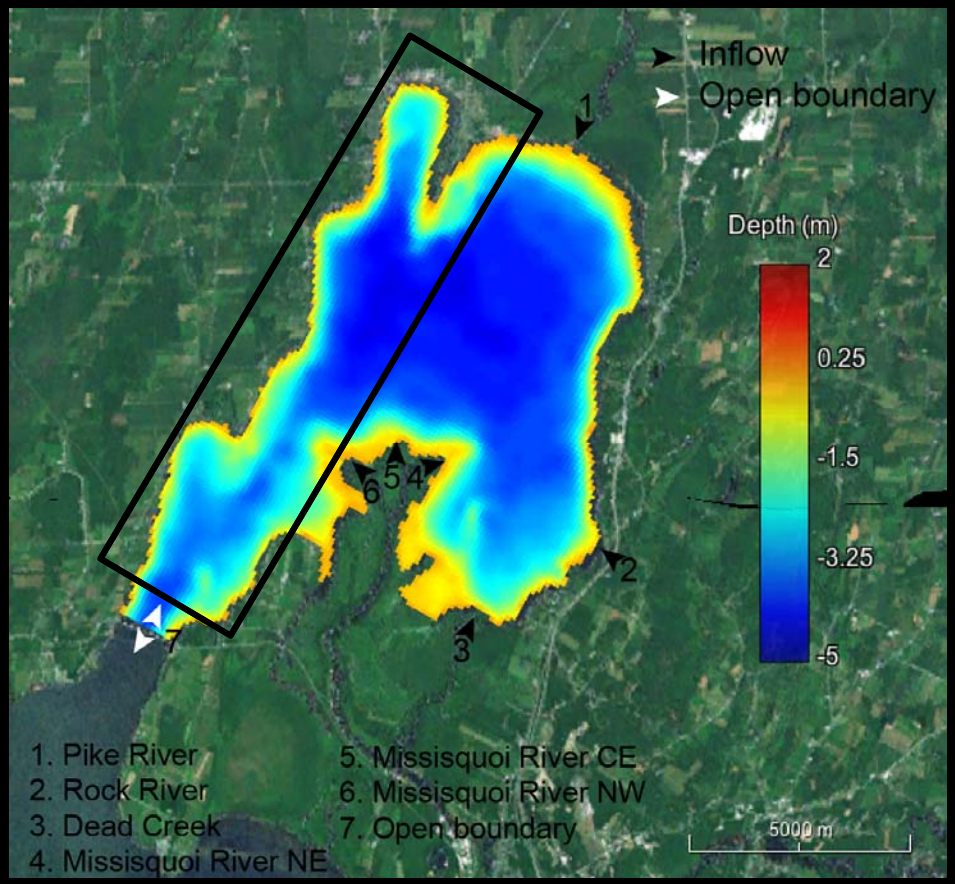
Comparison of field and modeled in-lake variables

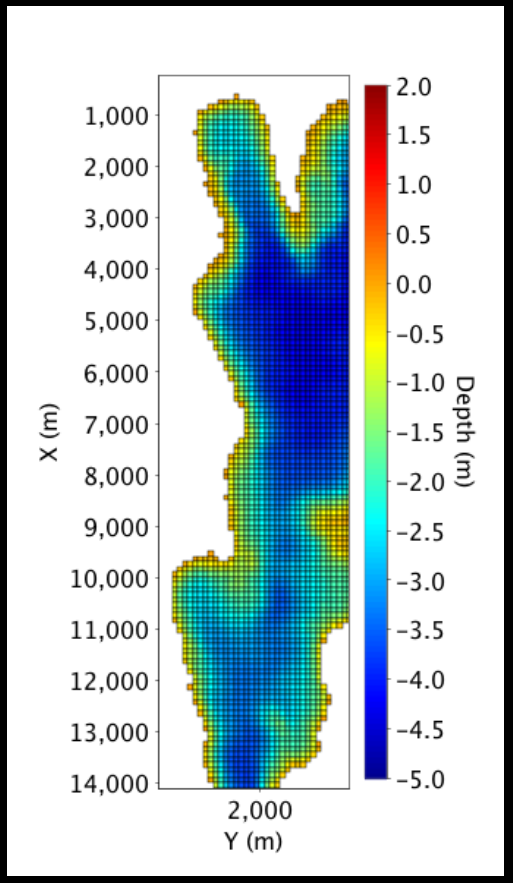
Variable	Station	RMSE
Water level	Burlington	0.047 m
	Richelieu	0.049 m
Water temperature	VI	0.91 °C
	N	0.89 °C
	C	0.90 °C
	S	0.68 °C
	OSAB	0.74 °C
	ISAB	0.83 °C
	MB	0.69 °C

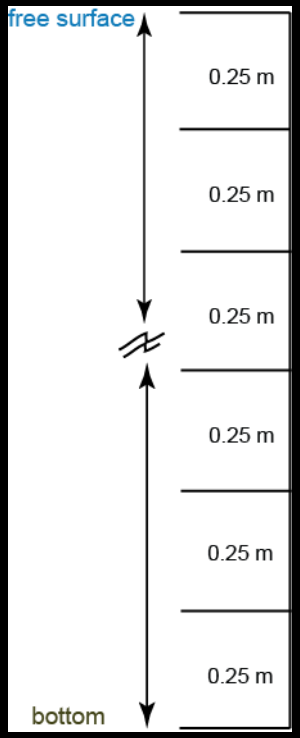
Similar to those reported in other 3-D modeling studies

Oveisy et al. (2014) Journal of Great Lakes Research, Marti et al. (2016) Water Resources Research, Tranmer et al. (2018) Ecological Modelling

Missisquoi Bay Model Domain







⊗X=⊗Y=100 m

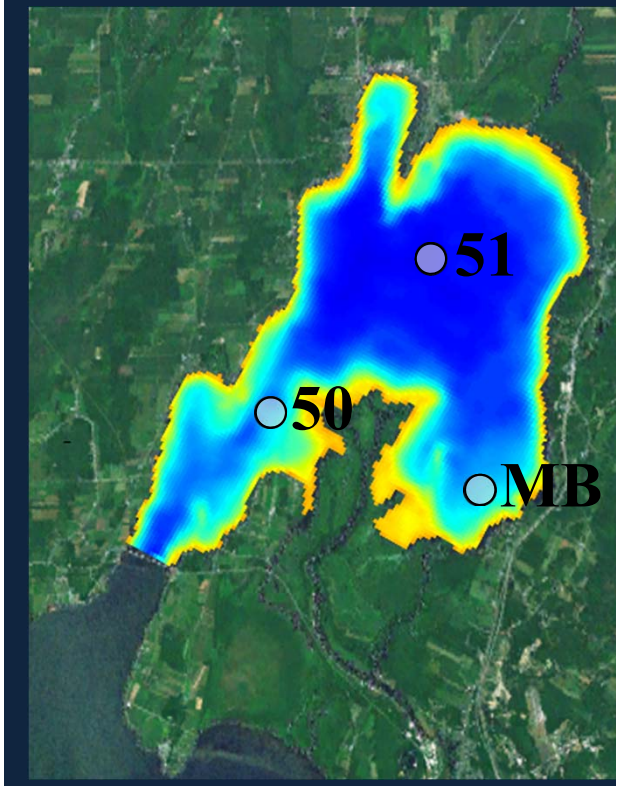
152 × 100

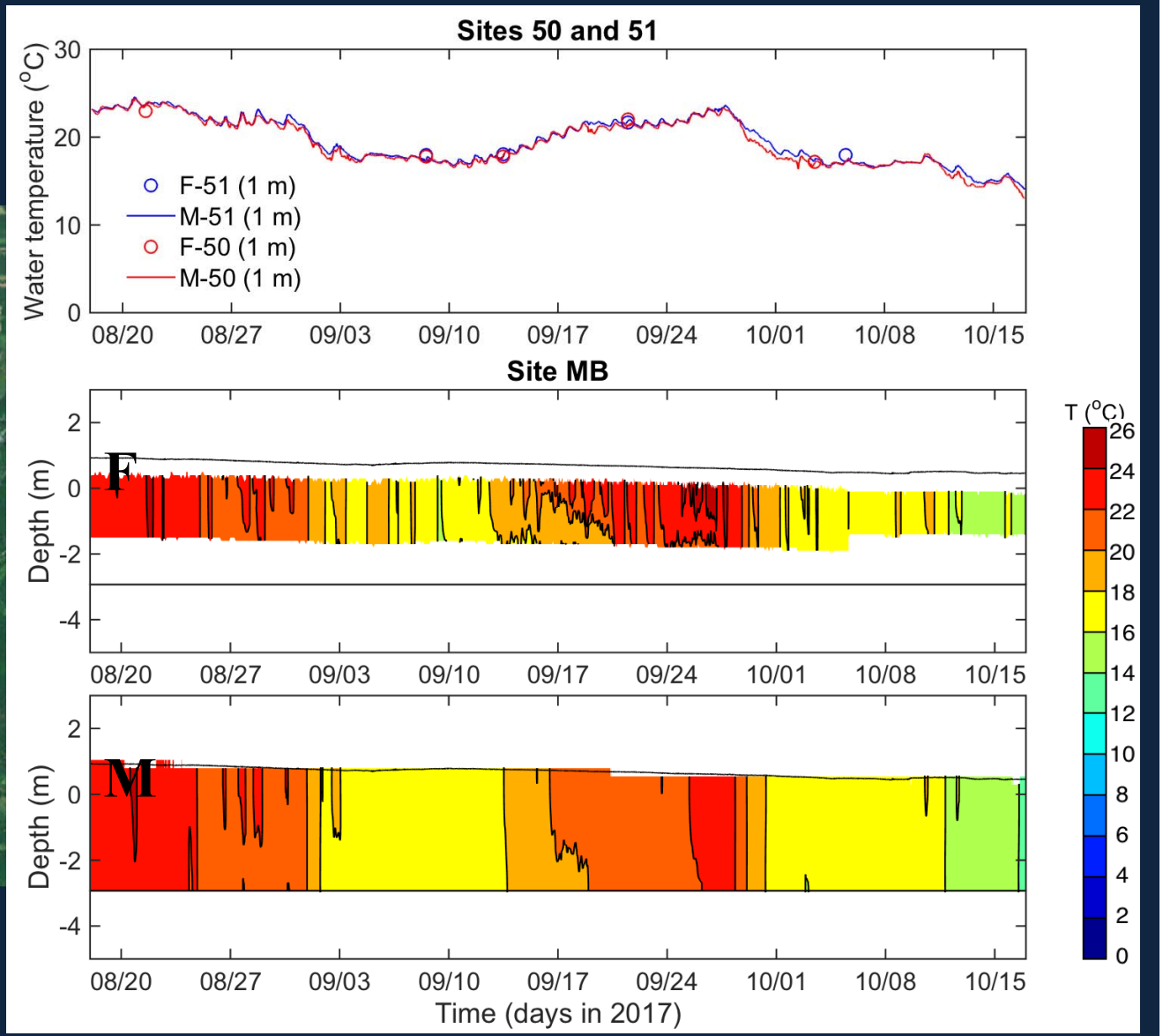
⊗Z cte

× 34 cells

Source: Tom and Pat Manley, Middlebury College

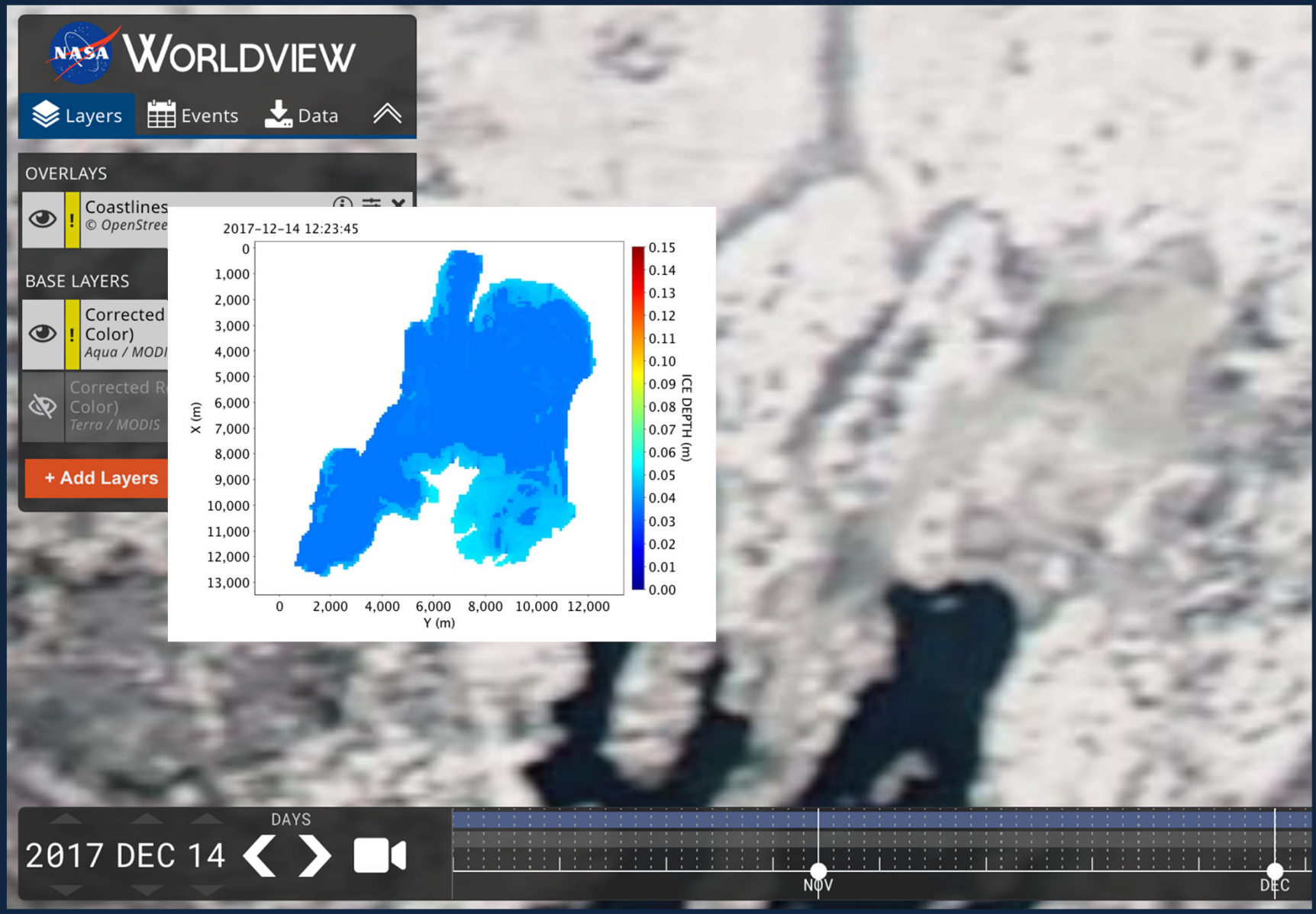
Model Validation - Water Temperature





Source: DEC (Profiler) and VT EPSCoR BREE (Pontoon System)

Model Validation - Ice cover



Source: NASA (https://worldview.earthdata.nasa.gov/)

Summary

- *Collected, processed and analysed most of the relevant data (2017 and 2018) required for the implementation of a 3D hydrodynamic-biogeochemical model for Lake Champlain.*

- *Implemented and validated a 3D hydrodynamic model for Lake Champlain.*

- *Implemented and validated a 3D hydrodynamic model for Missisquoi Bay.*

- *Both models ability to simulate temporal and spatial hydrodynamics is good.*

Summary

Work in progress …

- *Setting up a 3D hydrodynamic model for Saint Albans Bay (expected completion September 2019)*
- *Coupling the biogeochemical model for Missisquoi Bay (expected completion December 2019)*

Thank you for your attention!
Any questions?