Why resolution matters when using WRF to drive hydrology and hydrodynamic models

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The Jefferson Project at Lake George

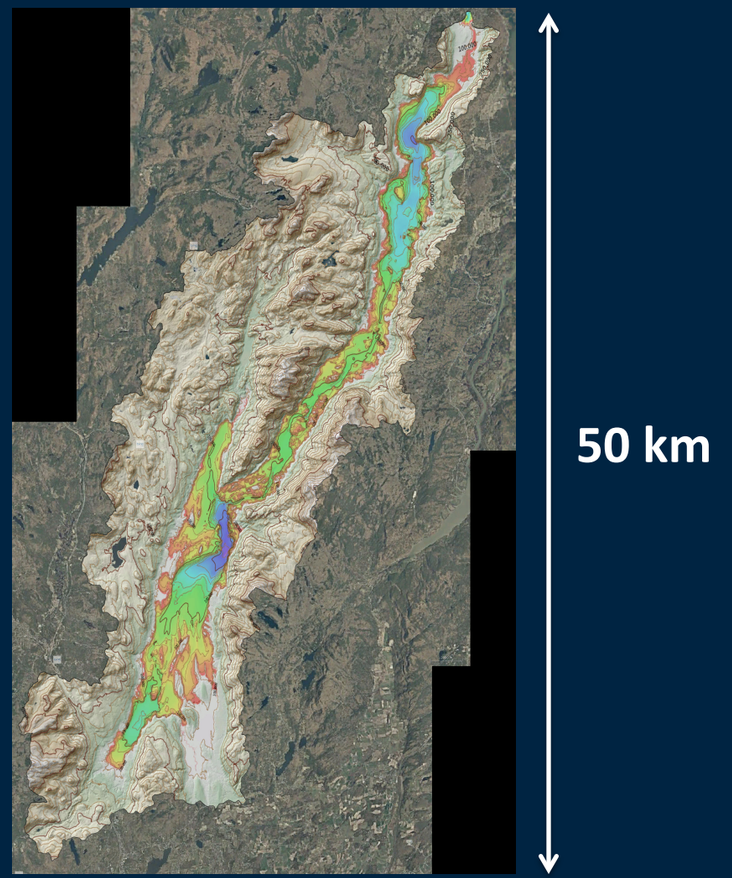
The Jefferson Project at Lake George

A multi-year partnership initiated in June 2013

Understand and manage the complex factors threatening Lake George, NY

Monitor, model, predict and experiment

60+ scientists and engineers



DEEP THUNDER

WEATHER

LAND and HYDROLOGY

LAKE CIRCULATION

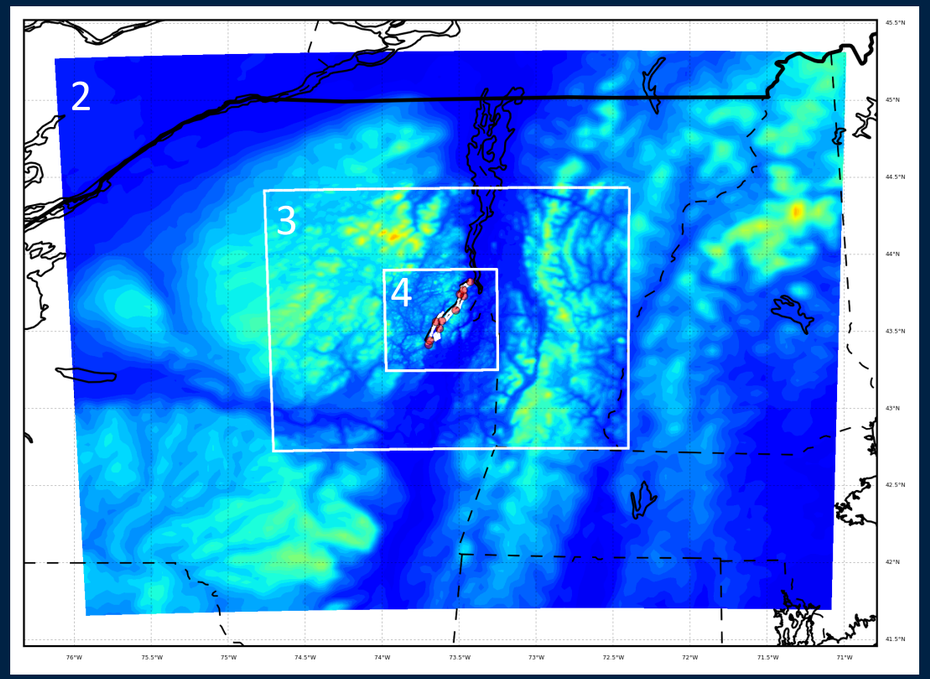
Particle tracking

Ecosystem Model

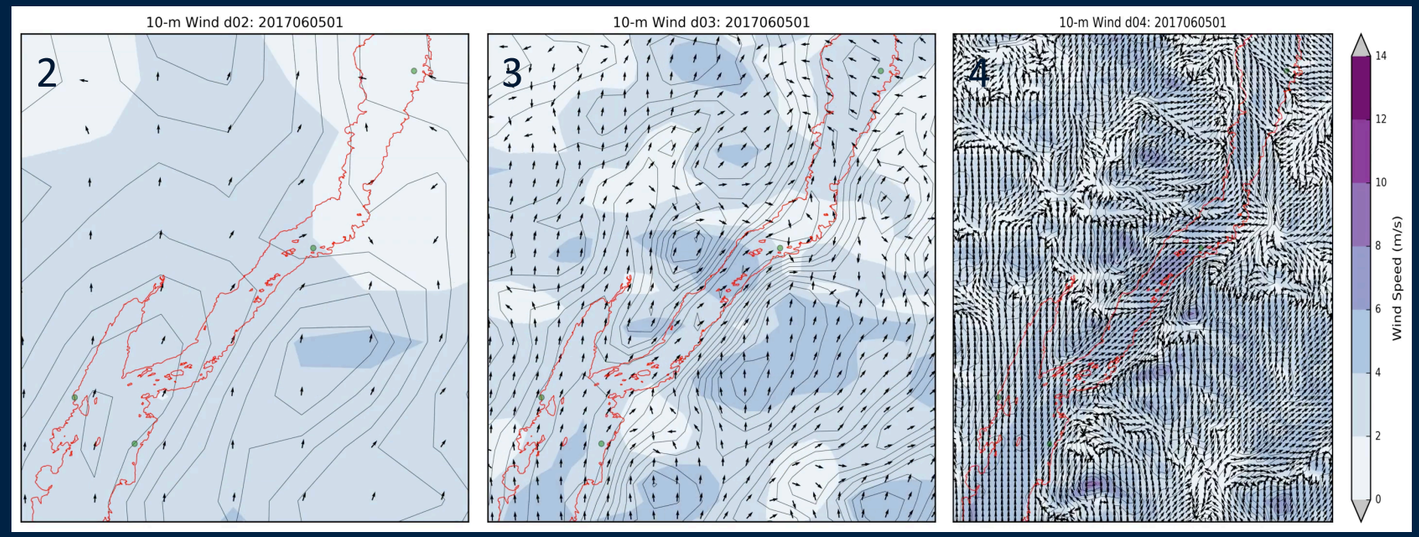
Salt Model

WRF v3.8.1 – Weather

Nested domains over Lake George



10-m winds at Lake George



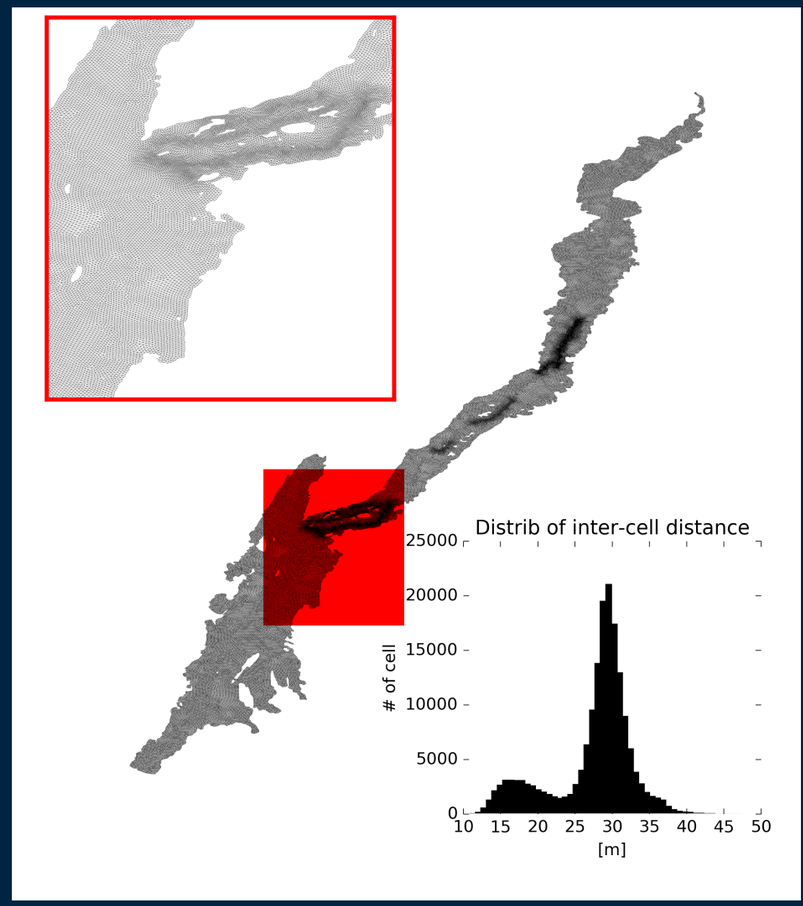
△ 3 km △ 1 km △ 0.33 km

-We have run daily, 36-hr operational forecasts at 0.33 km for over 1.5 years
-Over 2000 observations assimilated every forecast (3D-var), including seven from Lake George
-42 vertical levels with 14 below 1 km

SUNTANS – Hydrodynamics

Lake hydrodynamics from SUNTANS

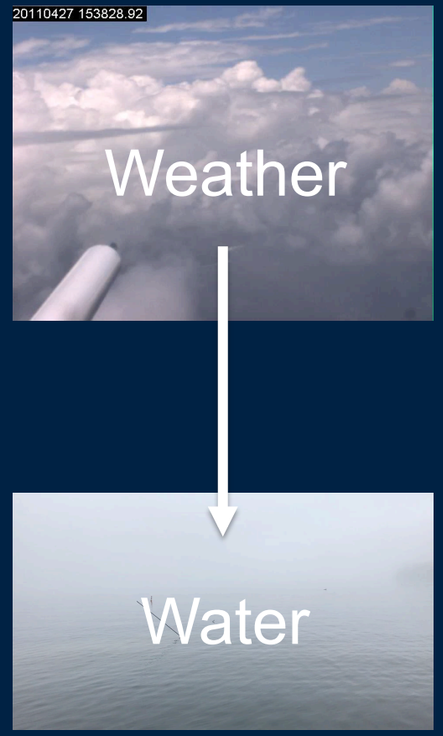
- The Stanford unstructured-grid coastal ocean model
- Run in hydrostatic mode
- Triangular mesh with variable-resolution (10-30 m)
- 57 *z*-layers and approx. 110,000 grid cells



Hypothesis:

Weather forecasts at higher horizontal resolution provide more accurate surface winds which improves the simulation of lake hydrodynamics

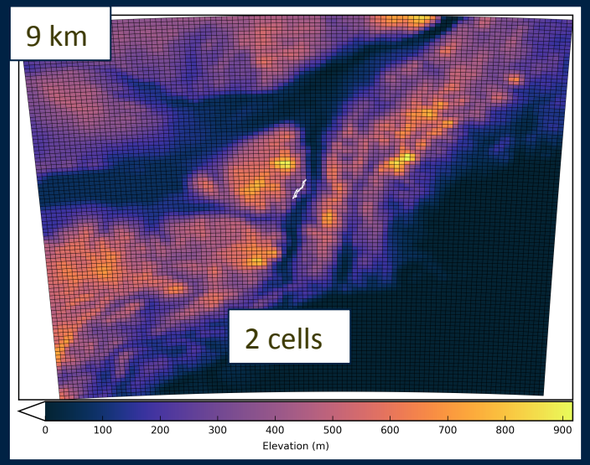
Case study: A sudden downwelling event on June 15 2017

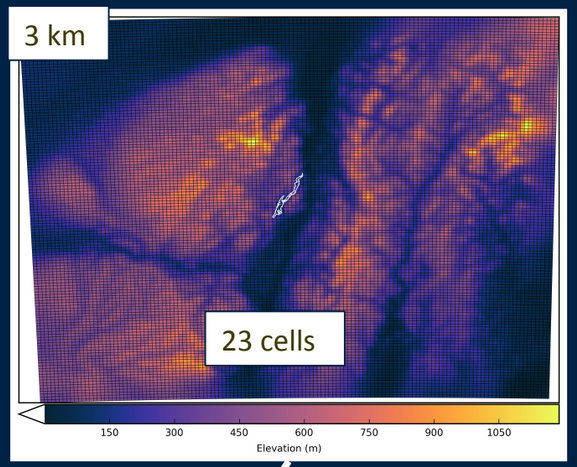


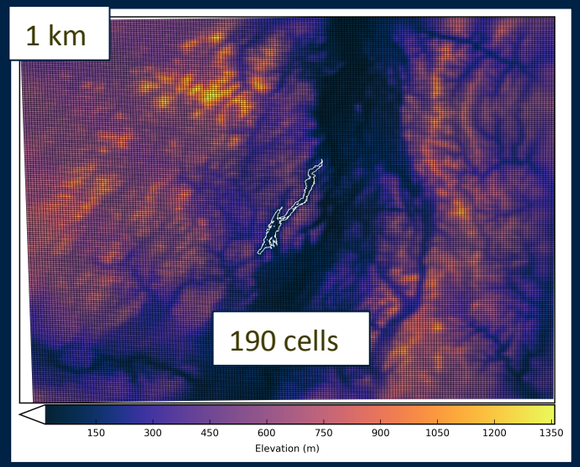
One month of daily WRF forecasts
at 3 km, 1 km, 0.33 km

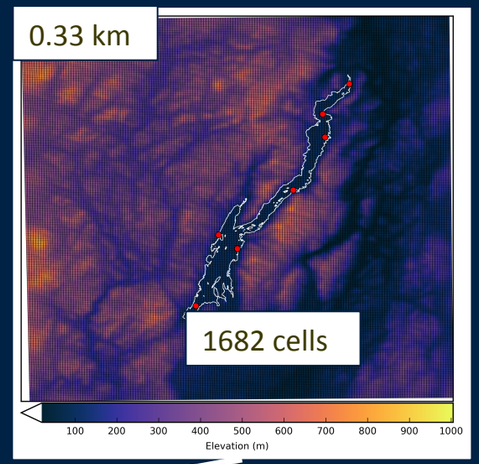
Three independent
SUNTANS forecasts

How Deep Thunder Represents Lake George at Different Resolutions

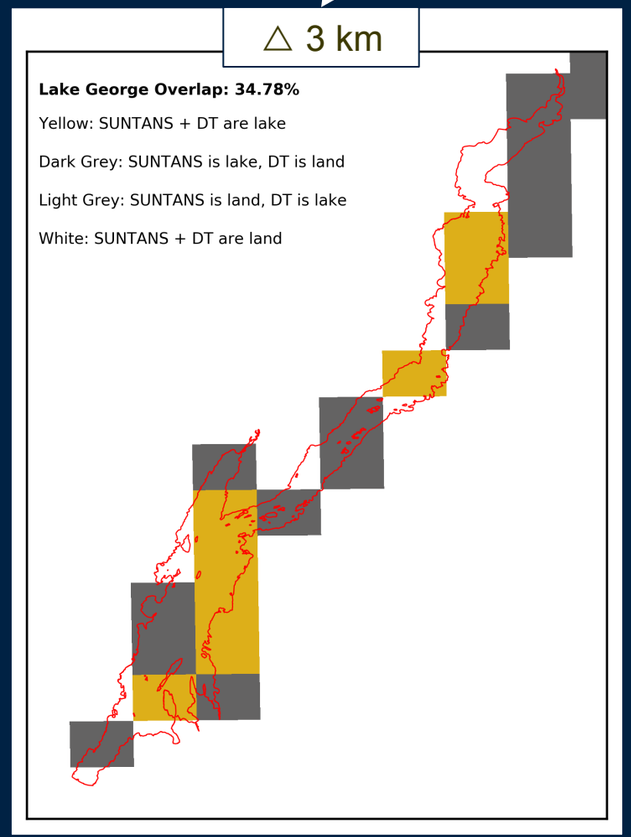


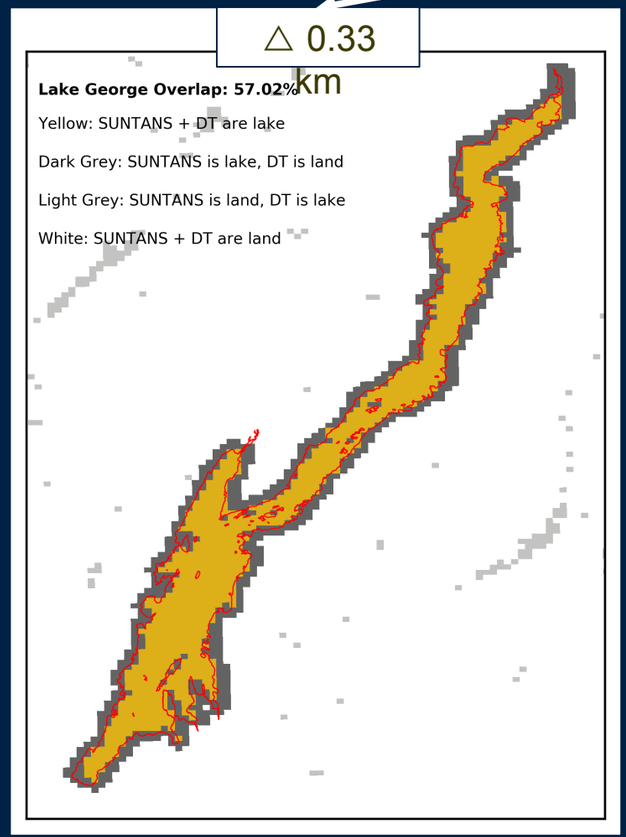






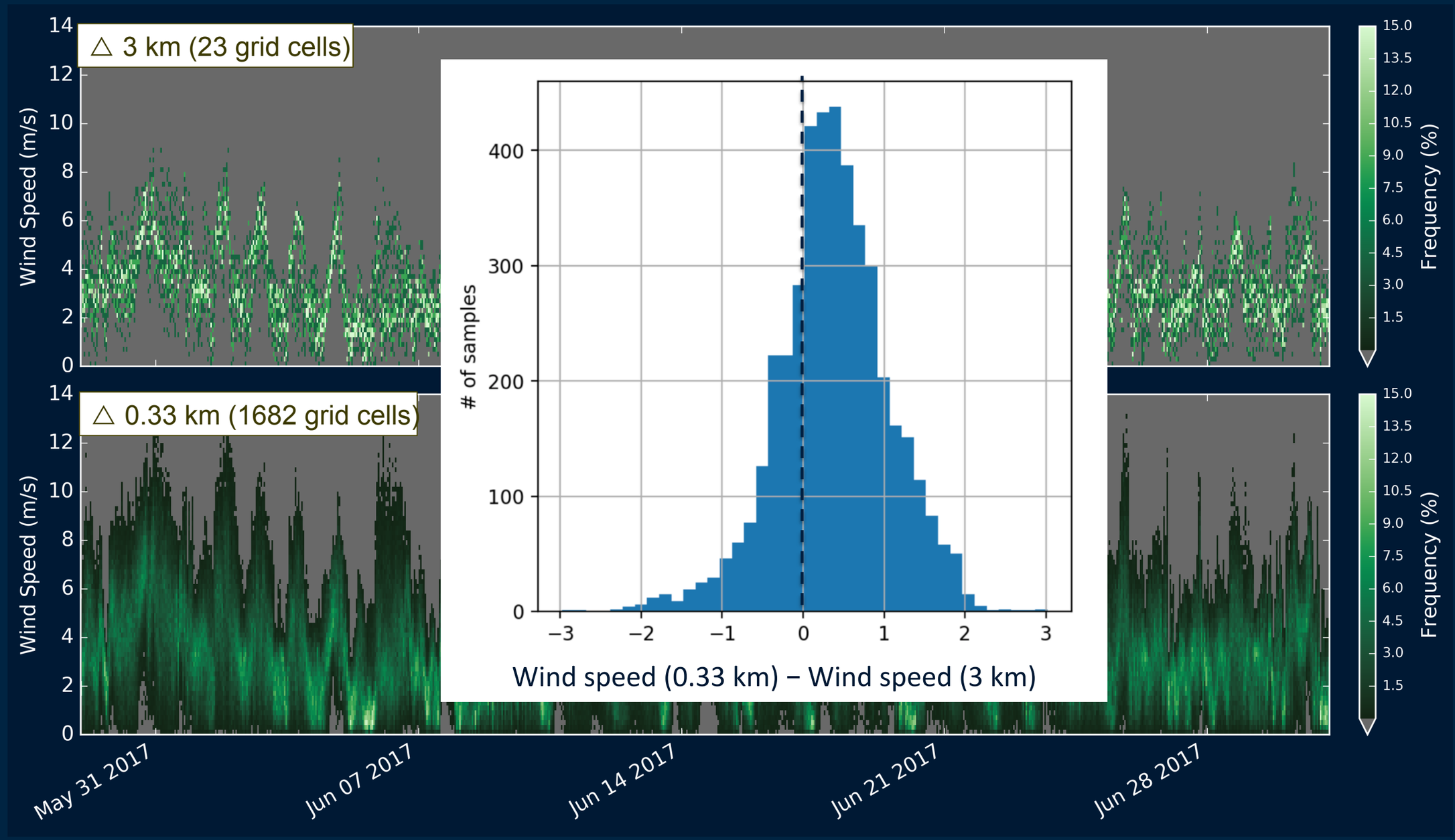
Terrain height and grid cells





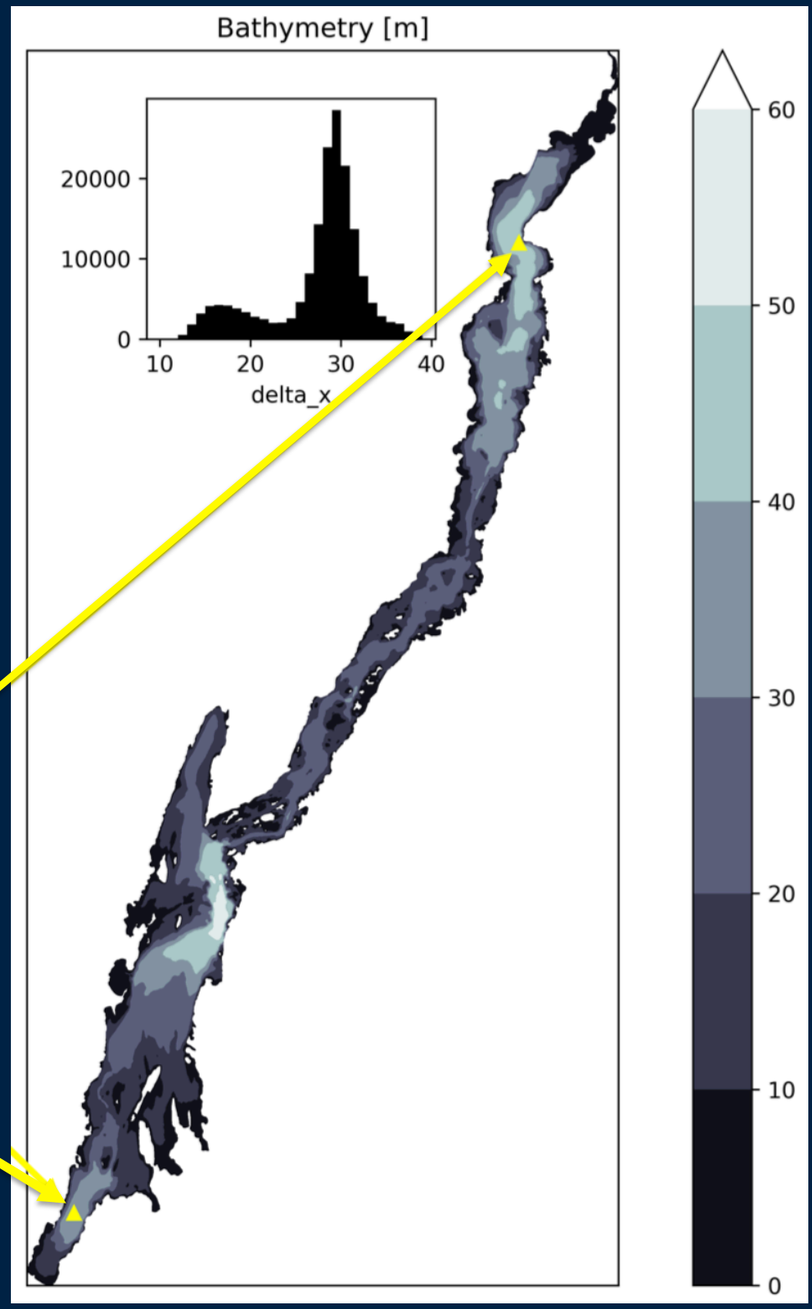
Landmask

Histogram of wind speed over Lake George through June 2017

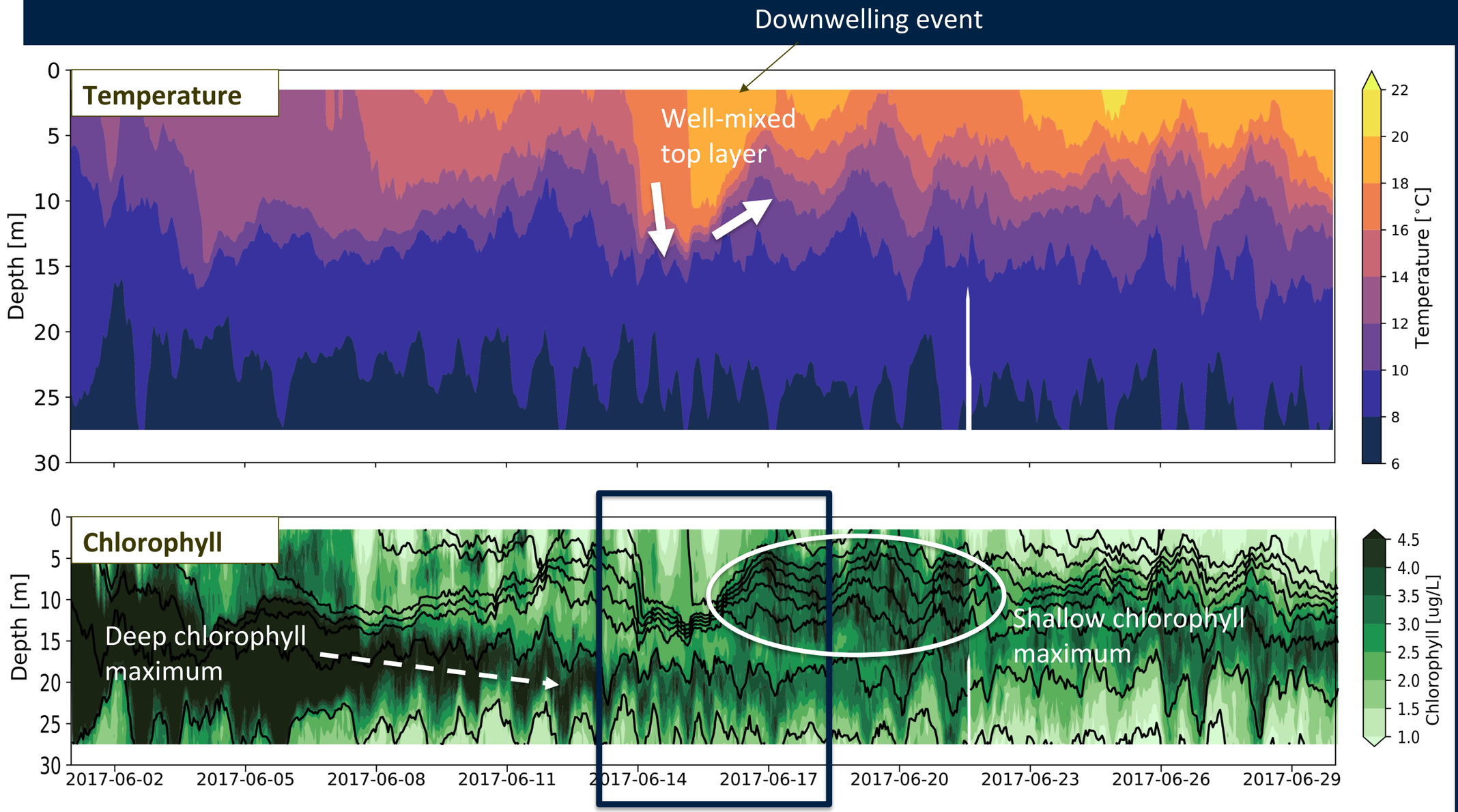


OBSERVATIONS

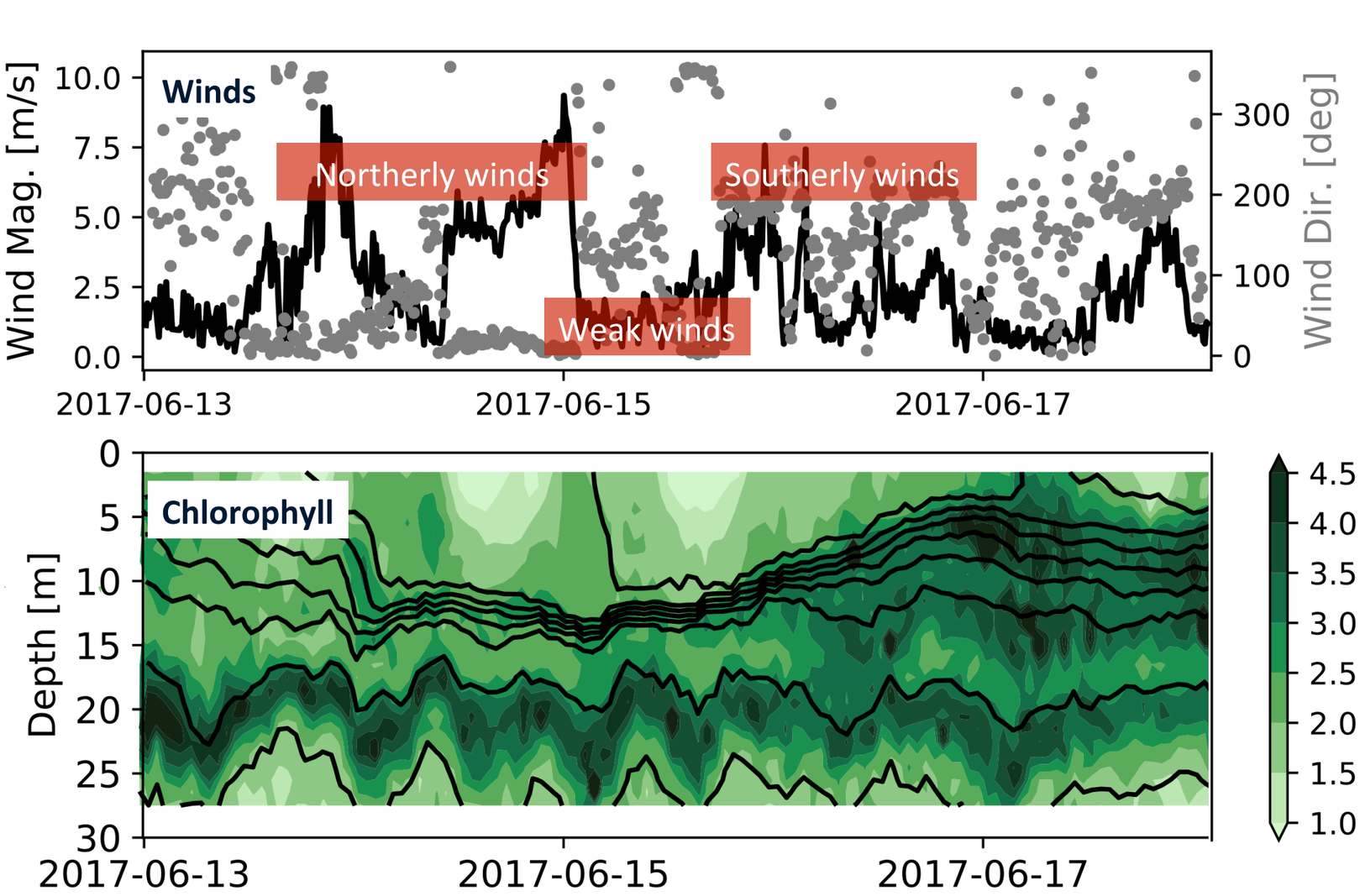
Two vertical profilers measure the water column at Anthony's Nose and Tea Island

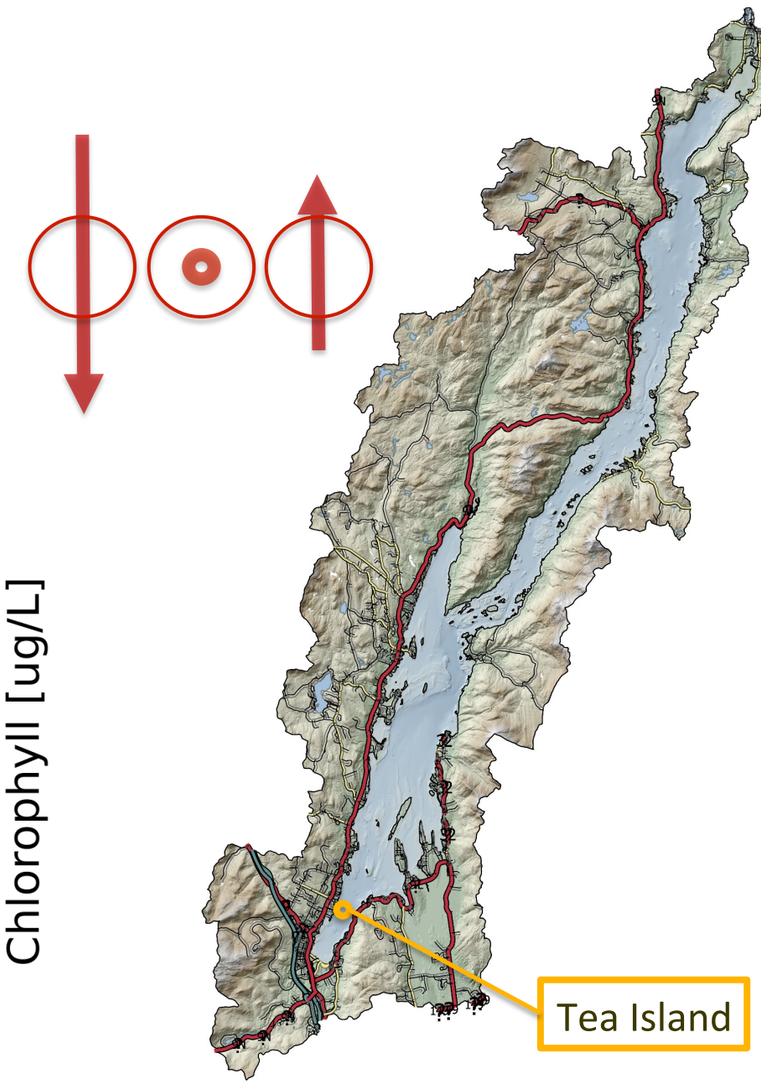


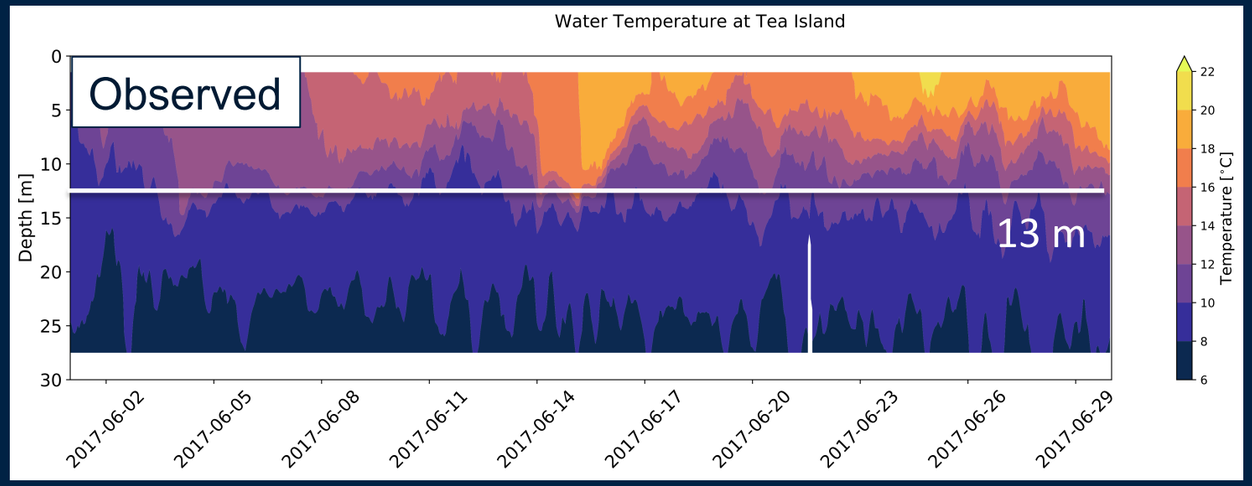
Observed Water Temperature and Chlorophyll at Tea Island, June 2017

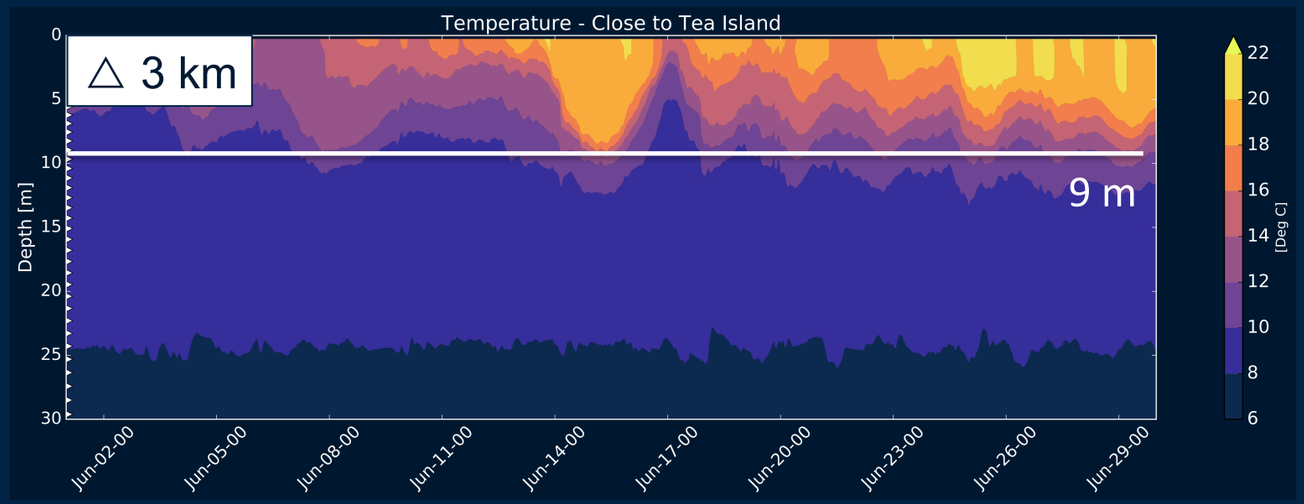


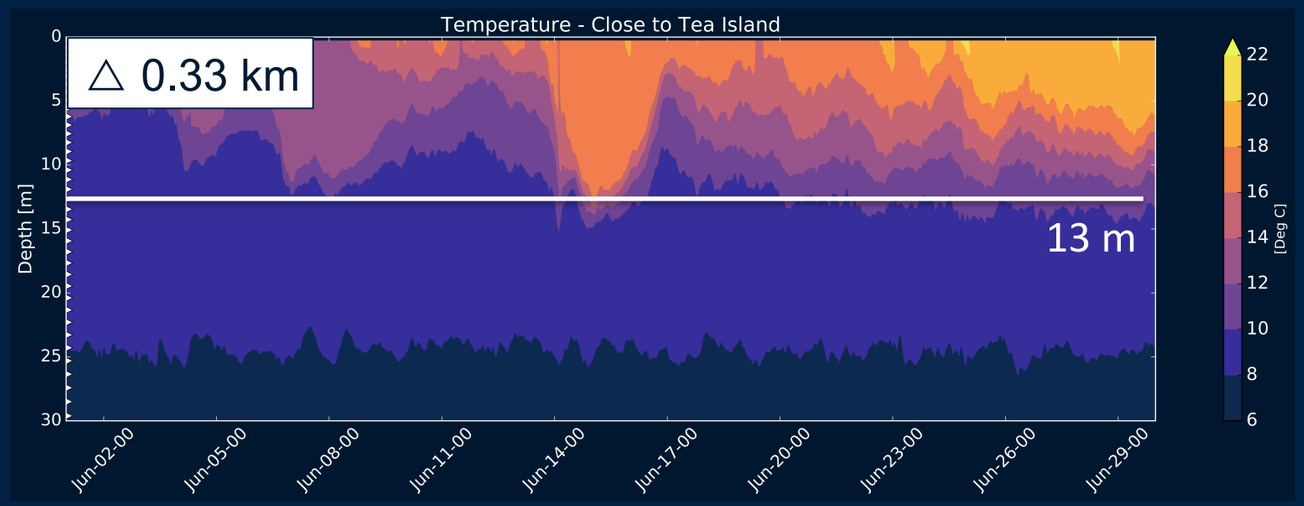
Observed Winds and Chlorophyll at Tea Island, June 2017



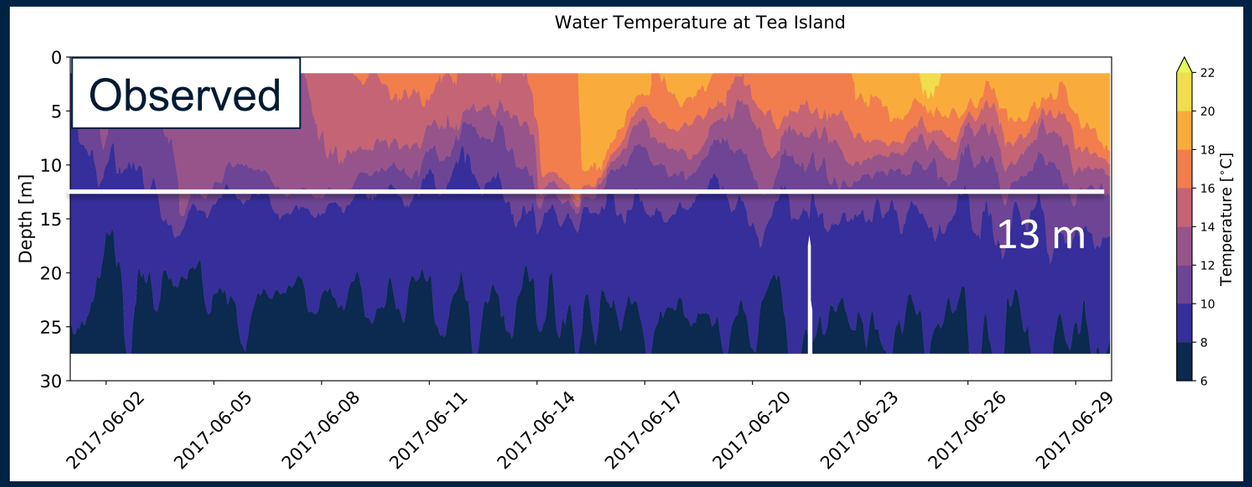


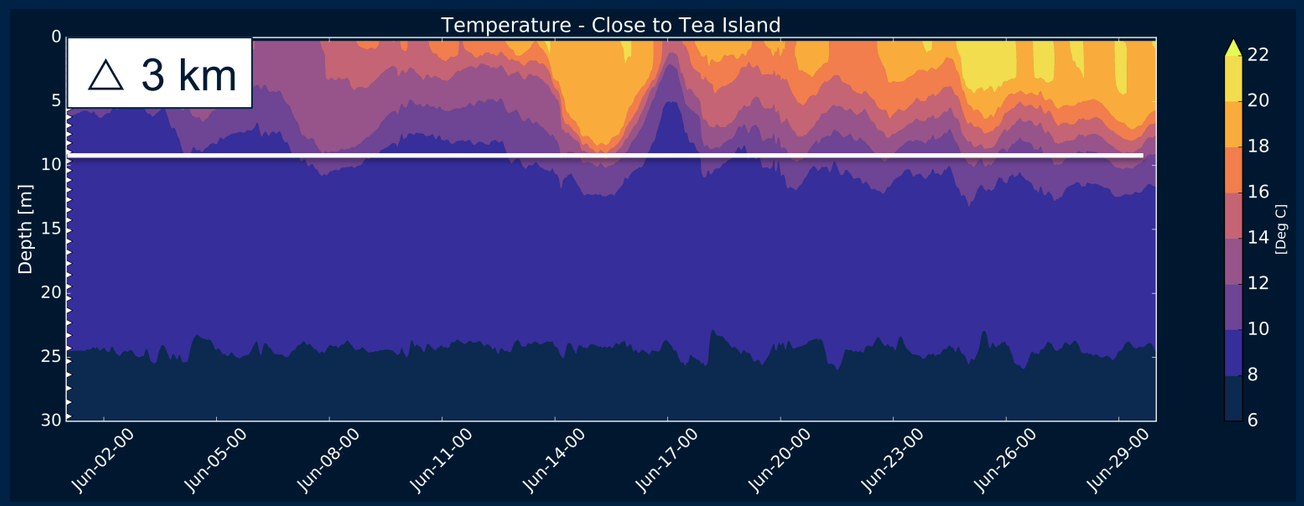


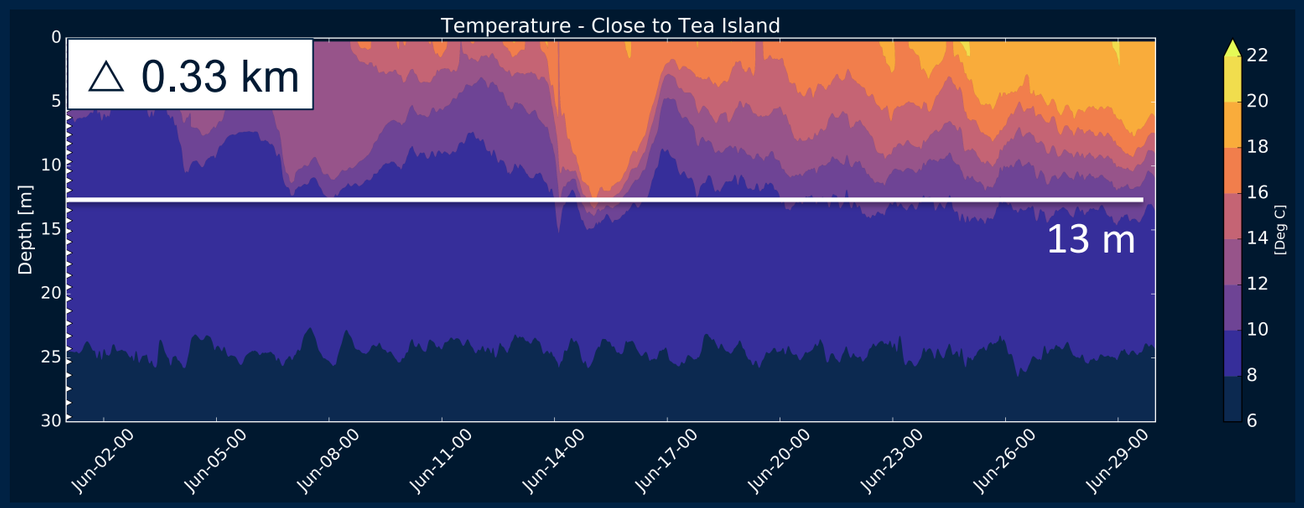


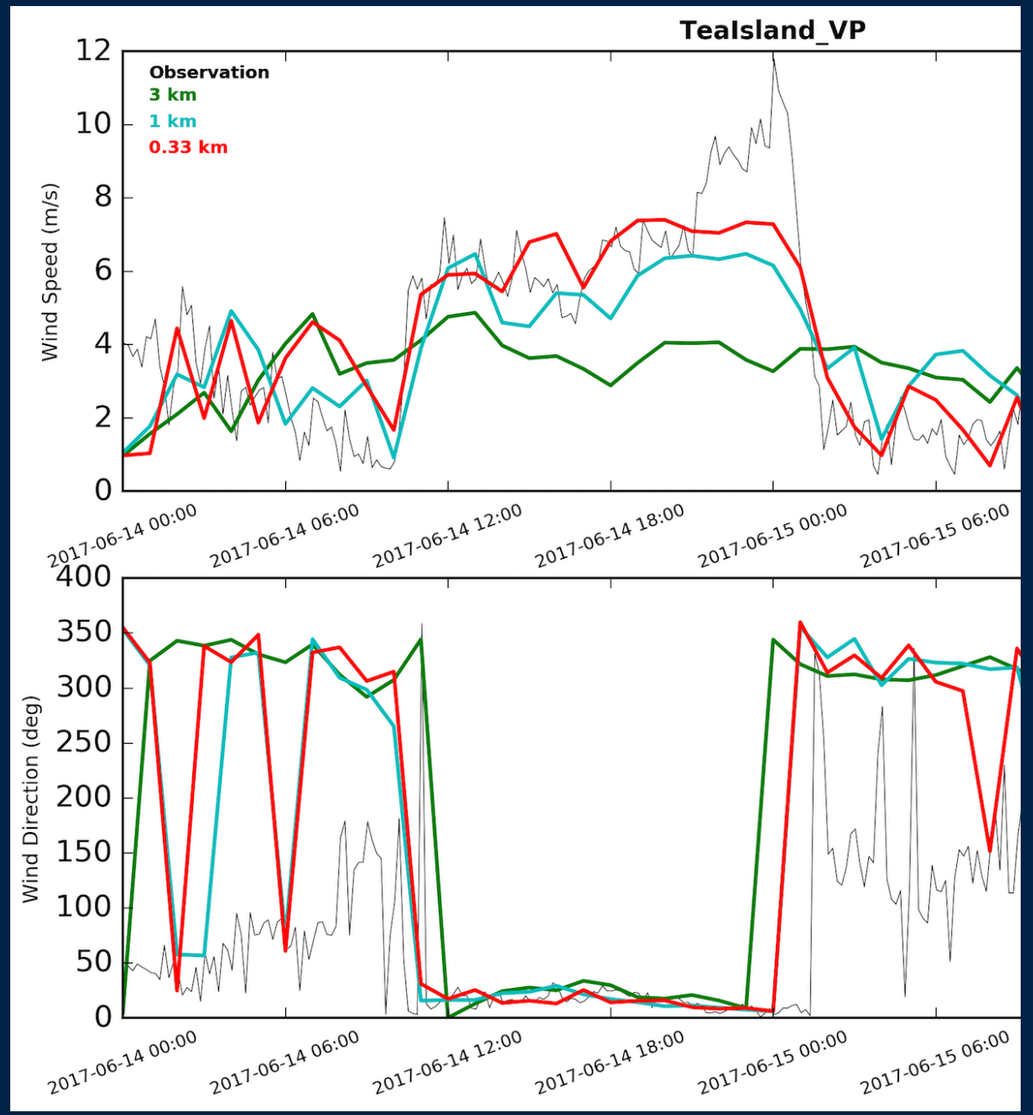


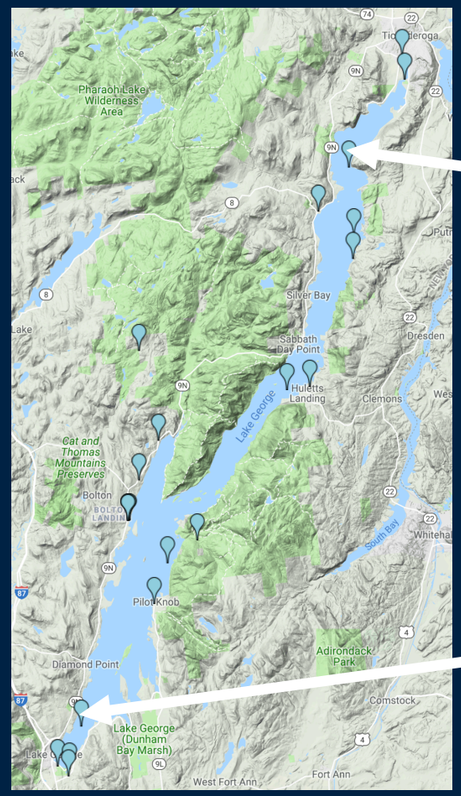
Maximum depth of downwelling is underestimated using coarser weather forcing

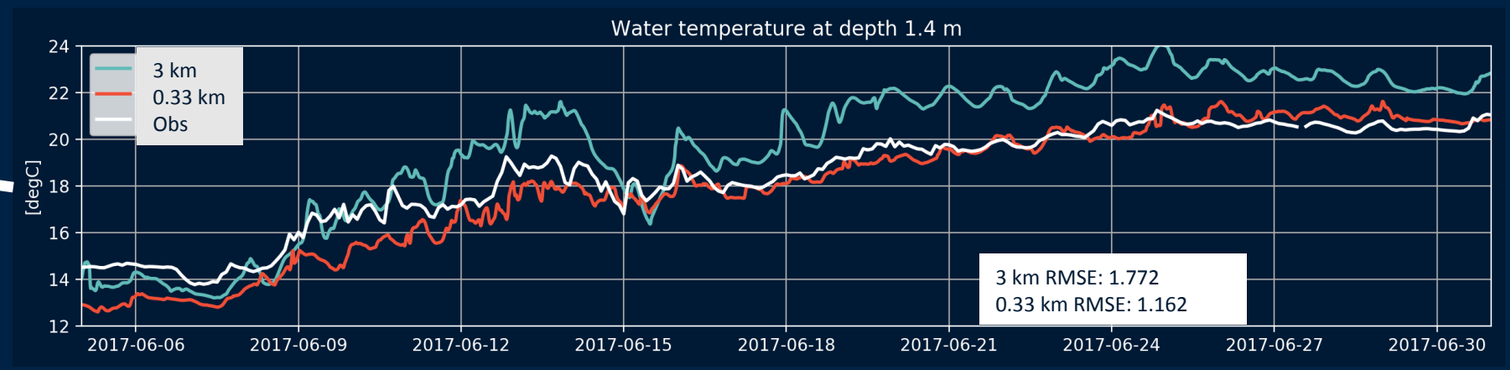

Water Temperature at Tea Island
Observed
13 m
Depth [m]
Temperature [°C]
2017-06-02
2017-06-05
2017-06-08
2017-06-11
2017-06-14
2017-06-17
2017-06-20
2017-06-23
2017-06-26
2017-06-29

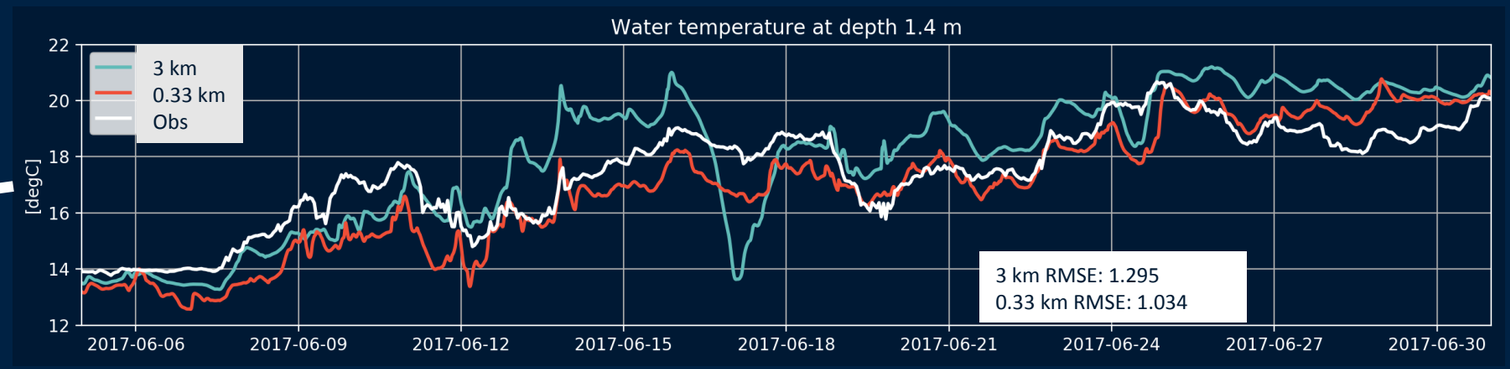

Temperature - Close to Tea Island
△ 3 km
Depth [m]
[Deg C]
Jun-02-00
Jun-05-00
Jun-08-00
Jun-11-00
Jun-14-00
Jun-17-00
Jun-20-00
Jun-23-00
Jun-26-00
Jun-29-00


Temperature - Close to Tea Island
△ 0.33 km
13 m
Depth [m]
[Deg C]
Jun-02-00
Jun-05-00
Jun-08-00
Jun-11-00
Jun-14-00
Jun-17-00
Jun-20-00
Jun-23-00
Jun-26-00
Jun-29-00


TeaIsland_VP
Observation
3 km
1 km
0.33 km
Wind Speed (m/s)
Wind Direction (deg)
2017-06-14 00:00
2017-06-14 06:00
2017-06-14 12:00
2017-06-14 18:00
2017-06-15 00:00
2017-06-15 06:00







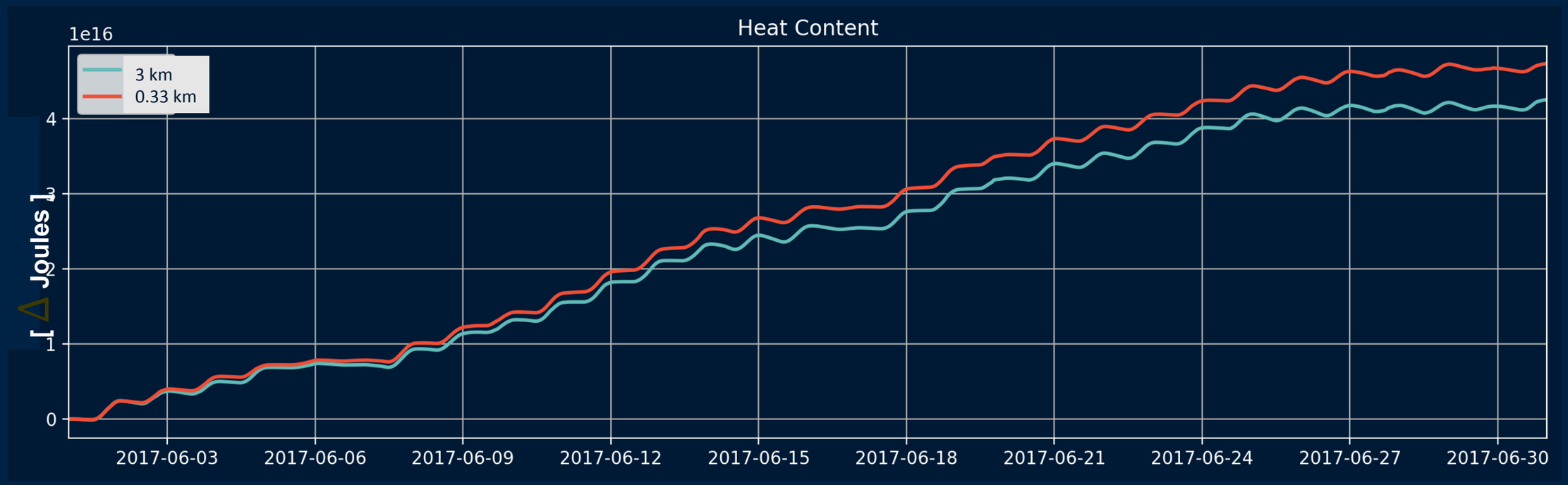
More accurate simulation when increasing weather resolution. (Dynamically and quantitatively)

The Jefferson Project at Lake George

Guillaume Auger

6 June 2018

Other differences ?



In using **0.33 km weather**, the **water stores more heat** than in using 3 km weather.

The Jefferson Project at Lake George

Guillaume Auger

6 June 2018

Conclusions

Consequence of driving the lake circulation model with winds from 0.33 km instead of 3 km Deep Thunder:

> Improved accuracy of temperature at Tea Island and Anthony's Nose
> A deeper metalimnion
> Cooler surface waters (reduced stratification)
> Higher overall heat content

Is the cause only wind speed? What about cloudiness, air temperature, humidity….

And what is the connection to Chlorophyll?

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Offline Ecosystem Model ($NPZDO_2$)