Modeling Stream Plumes in Conesus Lake

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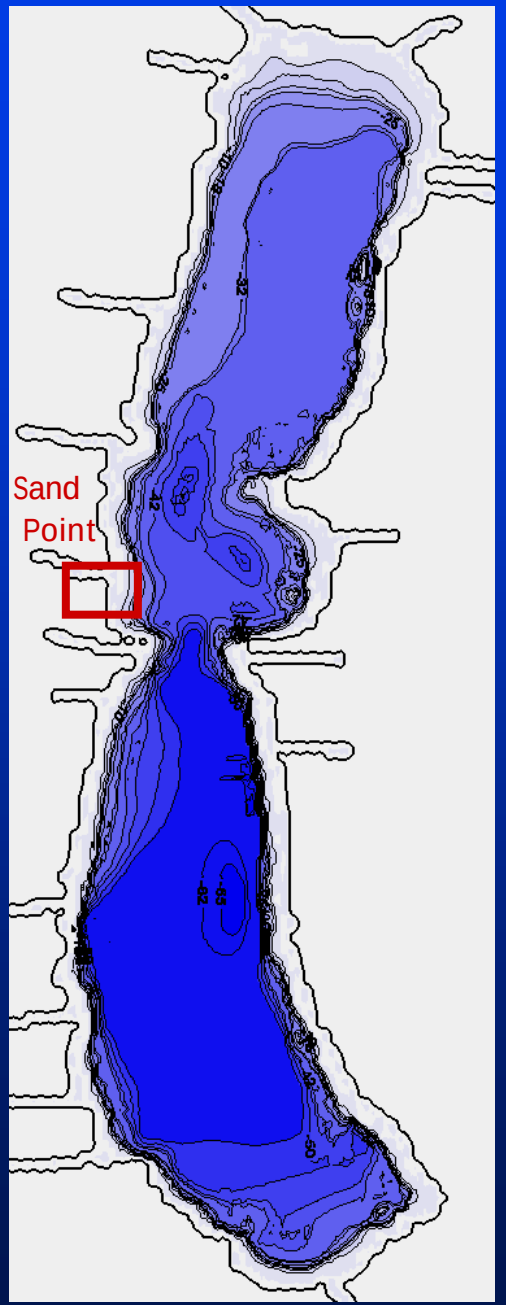
Project Goal



- Simulate water circulation and nutrient transport in individual stream plumes

Plume: A region within a body of water that has measurable different surface characteristics (temperature and/or particle concentration) from the rest of that body of water ■

- Compare the ALGE model output predictions of the movement of thermal plume and nutrients to known ground truth and airborne imagery
- Study site: Sand Point (Experimental watershed)

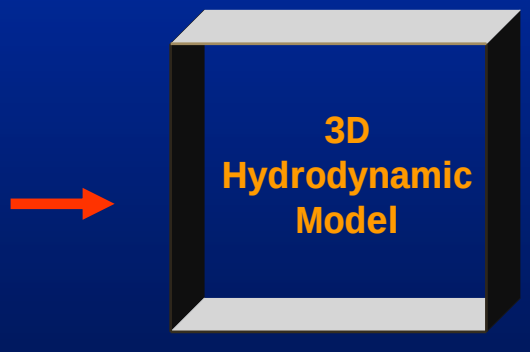
ALGE 3D Hydrodynamic Model

- 3D finite differencing hydrodynamic model solving momentum, mass and energy conservation equations
- Realistic predictions of movement and dissipation of thermal plumes, sediments, and dye tracing discharged into big, cooling lakes
- Produce high resolution simulations for node-to-node matching with satellite thermal imagery or airborne imagery

Spatial data

Geo-referenced site specific

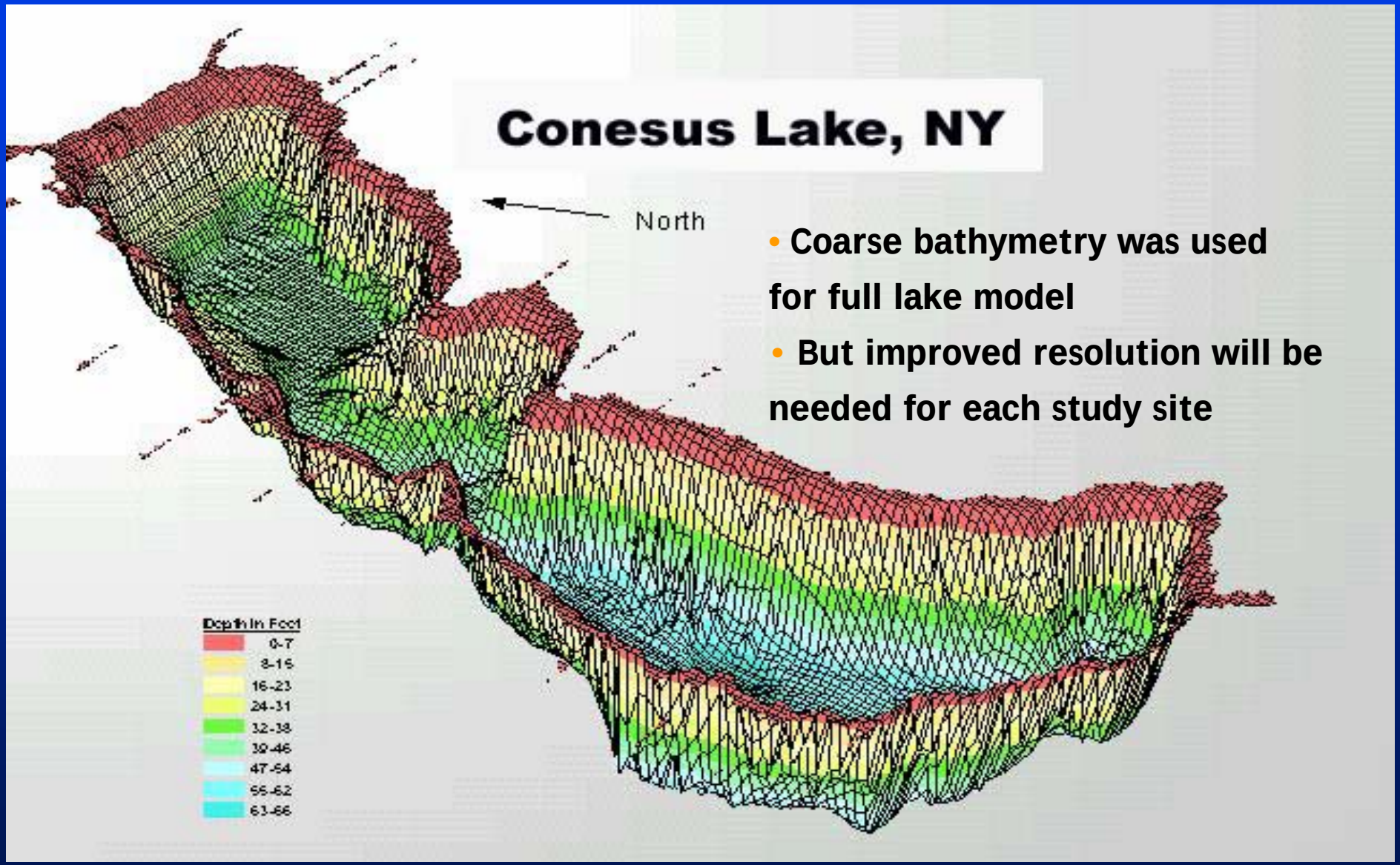
- Bathymetry
- Weather data
- Inflow and outflow



Model Output

Ground truth **and** remote imagery

Bathymetry Grid for Conesus Lake



- Coarse bathymetry was used for full lake model
- But improved resolution will be needed for each study site

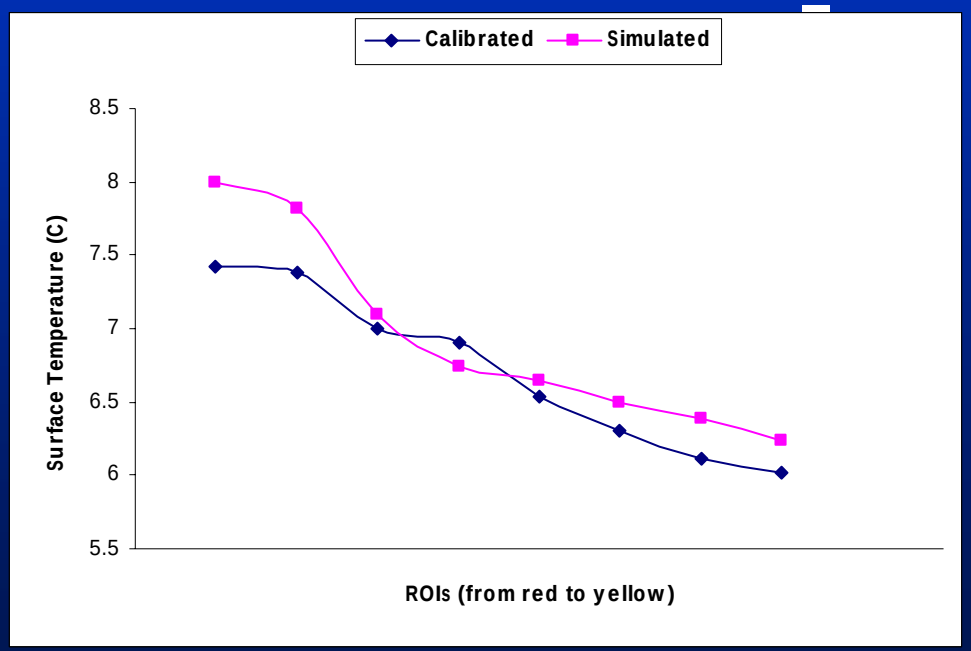
ALGE Hydrodynamic Simulation for Entire Lake

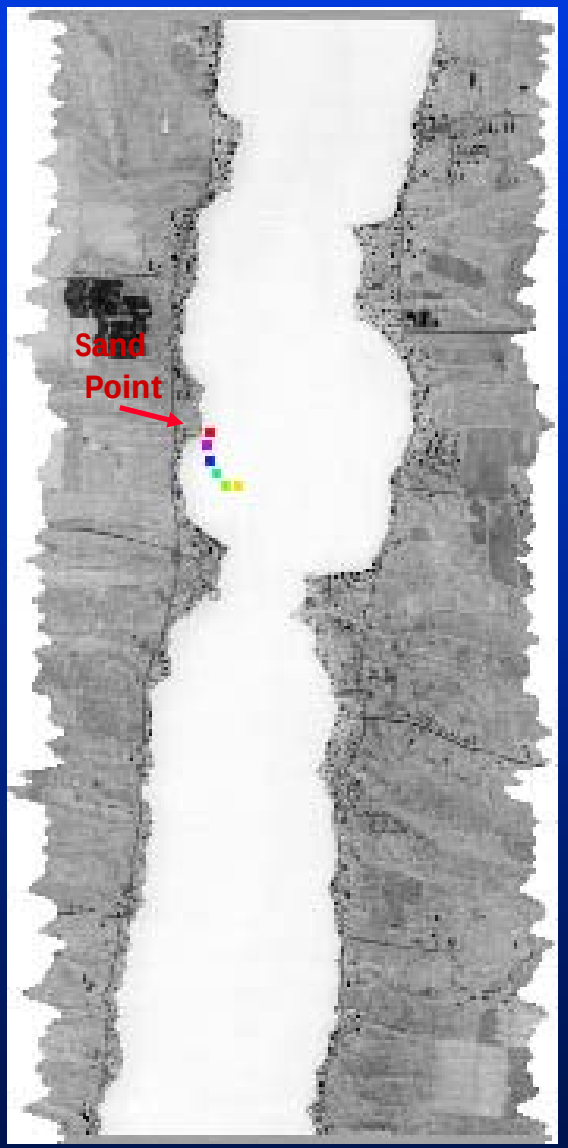
- Case 1: Late spring (May, 2001)
- Case 2: Early spring (April, 2004)
  - Computational domain
    - » Horizontal resolution: 46.9 m (269x100)
    - » Vertical resolution: 3.1 m (max of uniform 6 levels)
  - Water temperature
    - » Case 1: Uniform temperature of 6 ^{o}C by the airborne imagery
    - » Case 2: Uniform temperature of 4.5 ^{o}C by the ground truth
  - Meteorological data
    - » Case 1: Dansville airport (winds, temperatures, humidity, clouds)
    - » Case 2: Geneseo station
  - Simulation time
    - » Case 1: 72 hrs (noon at 04/28/2001 – noon at 05/01/2001)
    - » Case 2: 600 hrs (03/31/2004 – 04/30/2004) Ensure the initial guess for the lake temperature had no effect on the final computed temperature distribution

Case 1: Simulated Surface Temperature and Calibrated Temperature Derived from MISI Image

- Thermal image of central Conesus lake (right) taken by MISI (Modular Imaging Spectrometer Instrument) on May 1, 2001

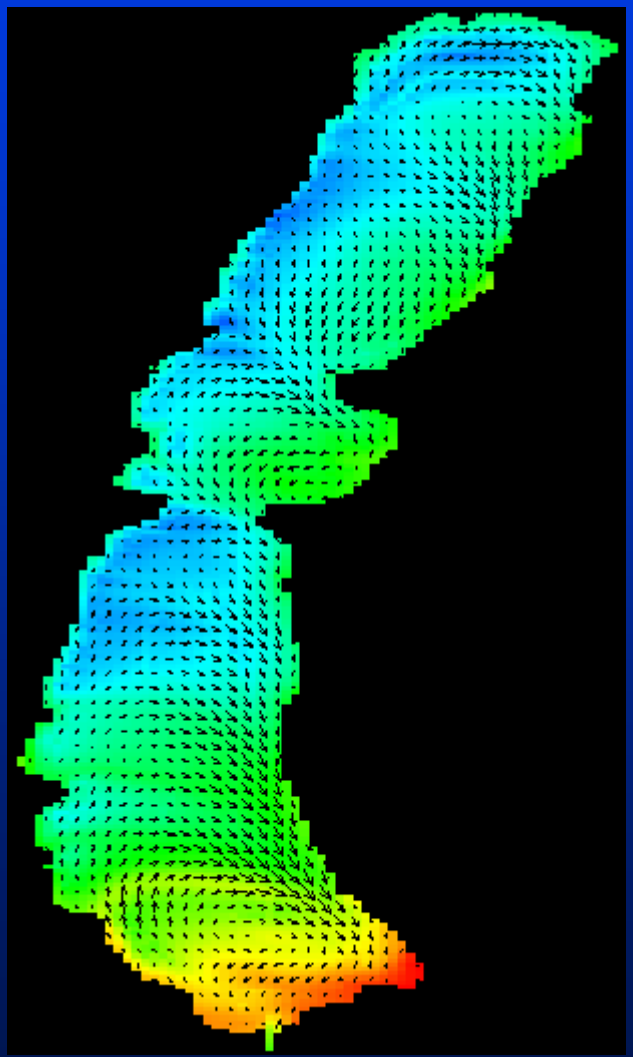
- Measured thermal radiance converted to surface temperature at different locations around sand point plume





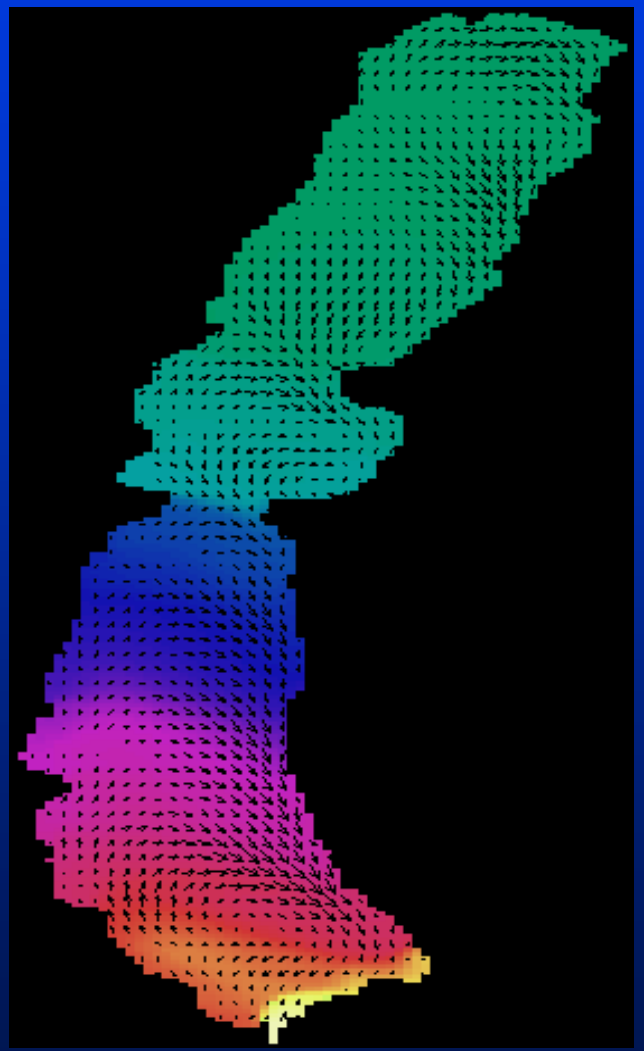
Case 2: Simulated Surface Circulation

Surface temperatures and velocities



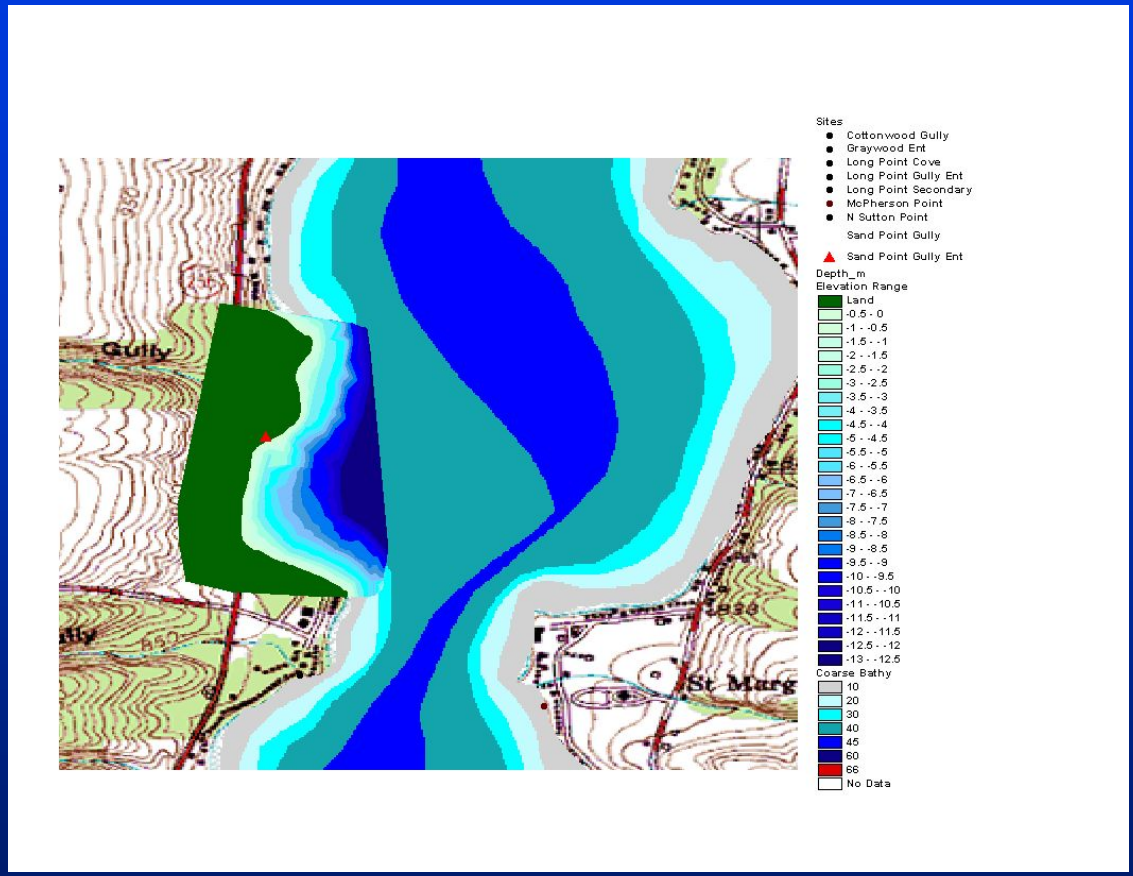
- Highest surface velocity is 0.07m/s
- Wind-driven flow pattern is complex
- Surface temperature variation is about 1 ^{o}C
- Dye tracer is equivalent to dissolved nutrients

Dye tracer and velocities



Case 3: Sand Point

- Interpolated near shore bathymetry contours
- Inflow location
- Bathymetry mapper
  - GPS
  - FishFinder
  - RIT Datalogger

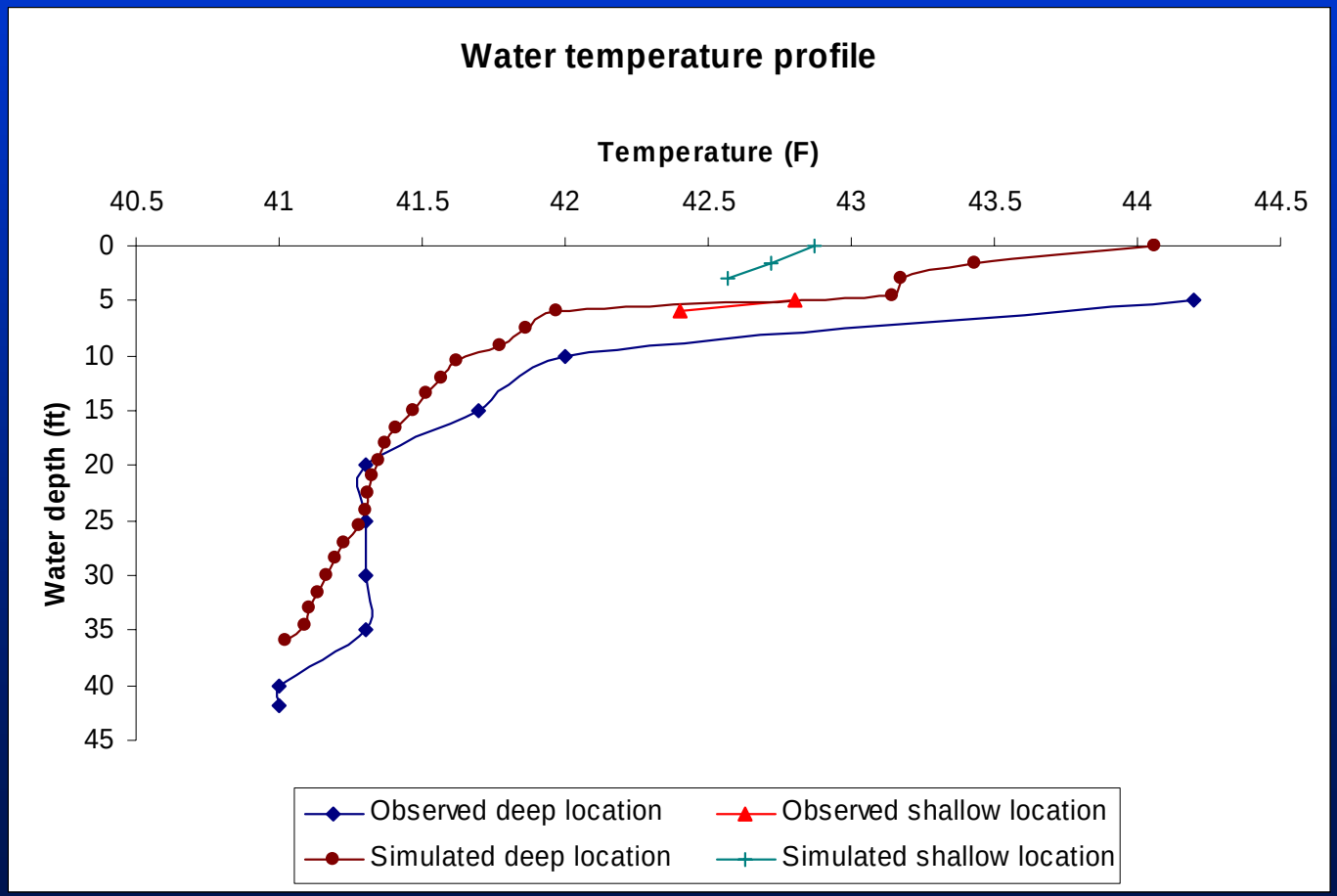


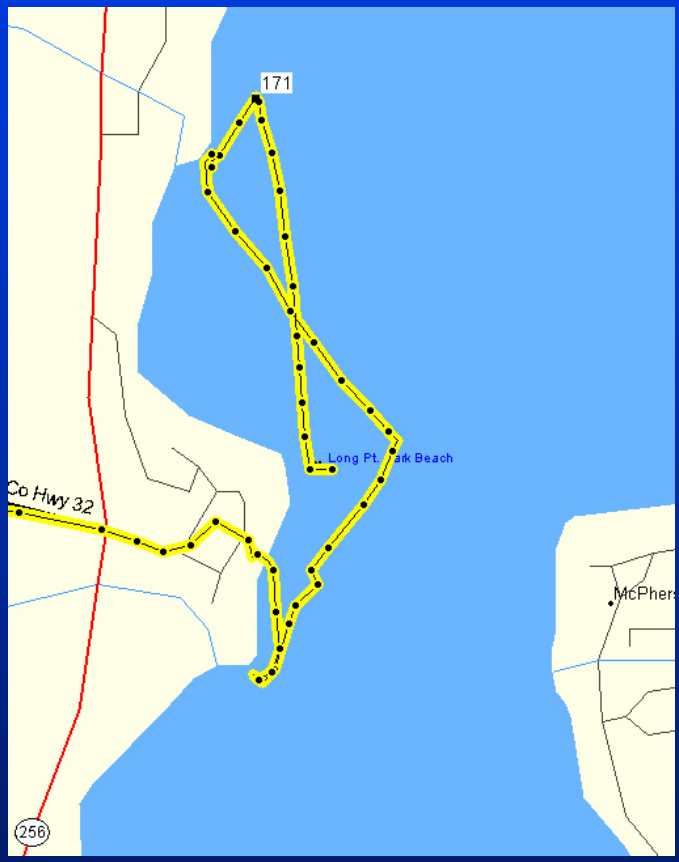
Nudging: Entire Lake -> Sand Point (Case 3)

- Case 3: Sand Point
  - Long flow-through boundary close to the shore
  - High resolution
    - » Horizontal: 4.8m
    - » Vertical: 0.1m
    - » Primary mass source: 2.2 ^{o}C gradient between mass source and whole lake
- The large scale solution is used to drive a high resolution, limited area simulation of the thermal plume
  - A time series of surface currents velocities from the entire lake simulation
  - Weighting function
    - » Compensating for a flow-through boundary
    - » Zero close to shore , increase to 1.0 about halfway between the shoreline and the offshore boundary

Case 3: Observed and Simulated Vertical Temperature

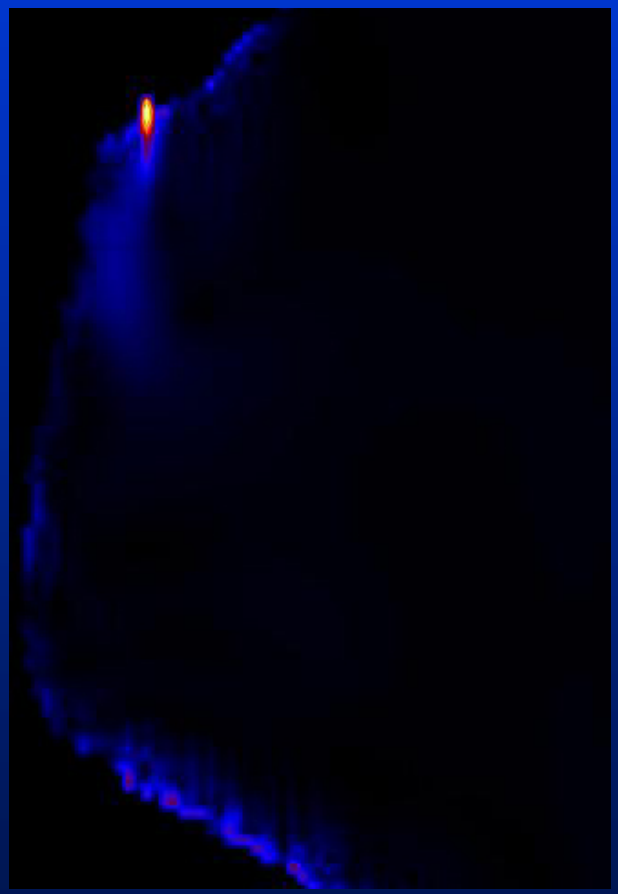
- Validate the model in the vertical dimension by two locations





Case 3: Plume Extension in Sand Point

0.5 hours

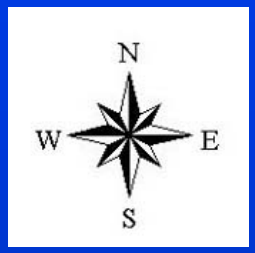


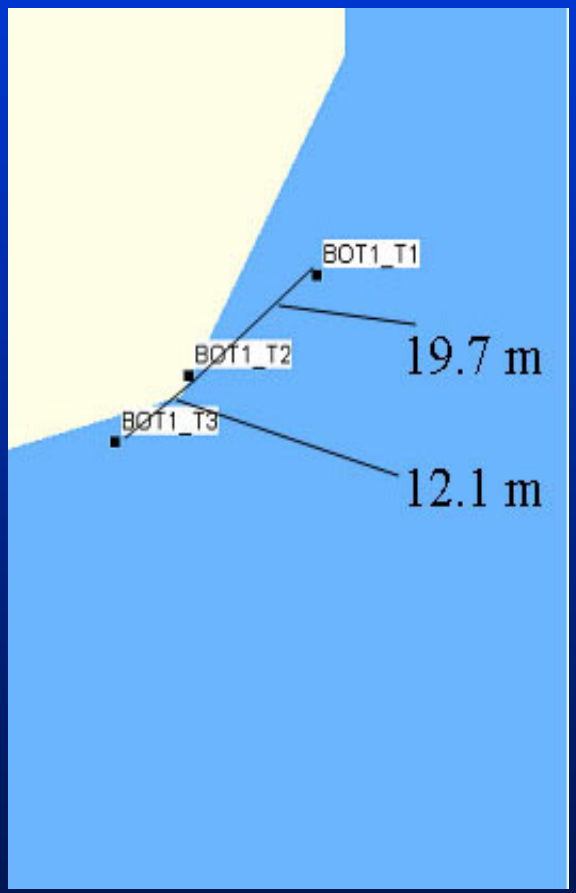
1.5 hours

18 hours

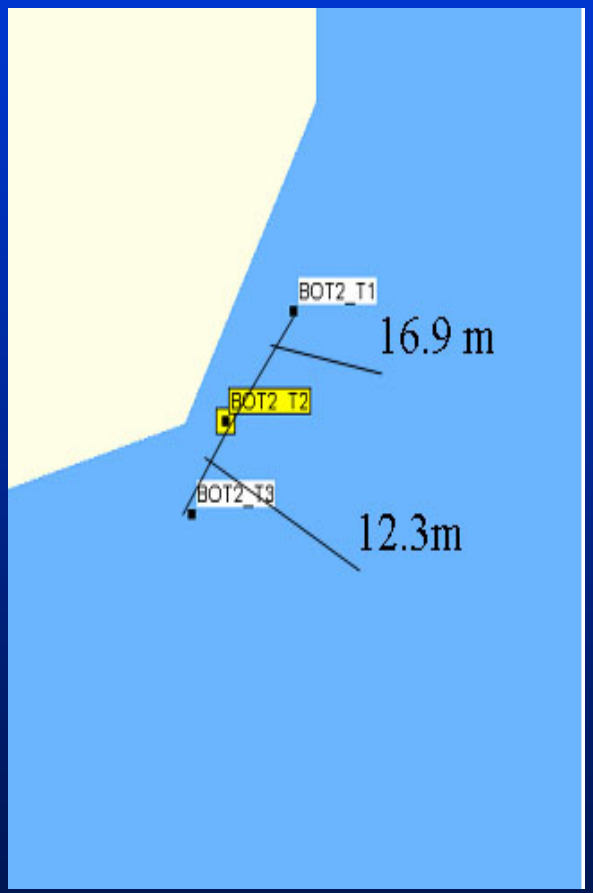
Case 3: Drifting Bottle Experiment

GPS locations and time for three drifting bottles put around Sand Point plume

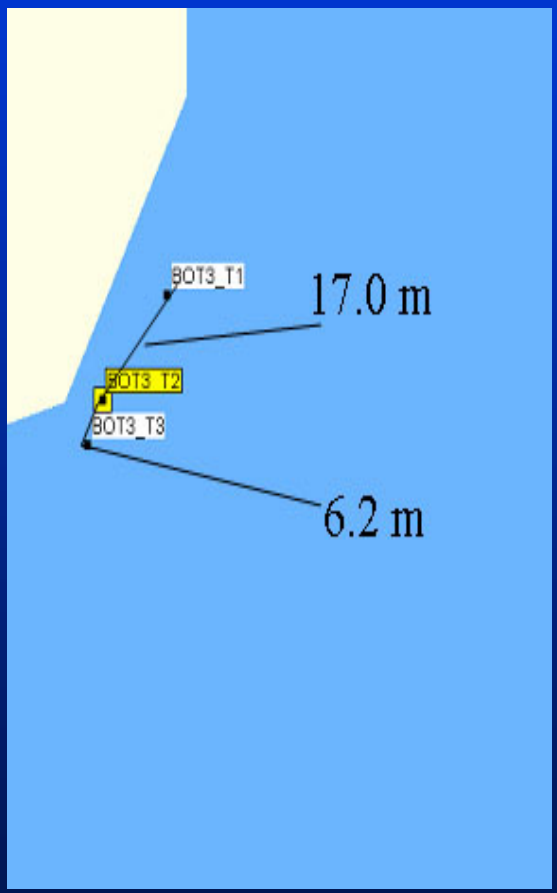




Bottle 1



Bottle 2



Bottle 3

Case 3: Comparison of Observed Drifting Bottle Velocities and Simulated Surface Current Velocities

Time	14:41:40 – 14:49:40		14:49:41 - 14:58:52	
	Observed	Simulated (m/s)	Observed	Simulated (m/s)
Bottle #1	0.04	0.058	0.02	0.052
Bottle #2	0.03	0.041	0.03	0.045
Bottle #3	0.03	0.045	0.01	0.02

Conclusions and Future Works

- Conclusions
  - Good agreement between simulations and observations
  - Calibrated thermal imagery and vertical temperature profile measurements are good verification of hydrodynamic model
  - Nudging is a good way to simulate from large scale simulation to a high resolution simulation

- Future Works
  - More accurate local weather data to drive the model
  - Vary the primary mass source
  - Request more satellite thermal imagery
  - Climatology