Great Lakes Research Center: Hydrodynamic Modeling of Lake Superior

Lake Superior Environmental Monitoring Collaborative
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Houghton, MI

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Integrated Observing System

http://celebrating200years.noaa.gov/visions/ioos/obs_system.html

observing system

Monitoring Network

Numerical Modeling

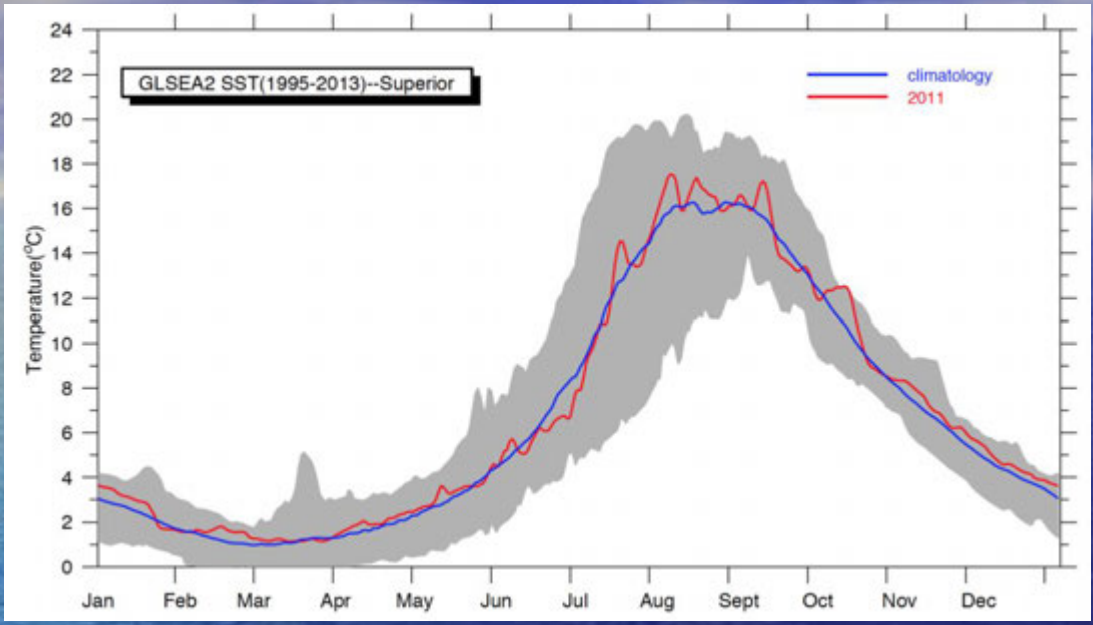
Data Analysis

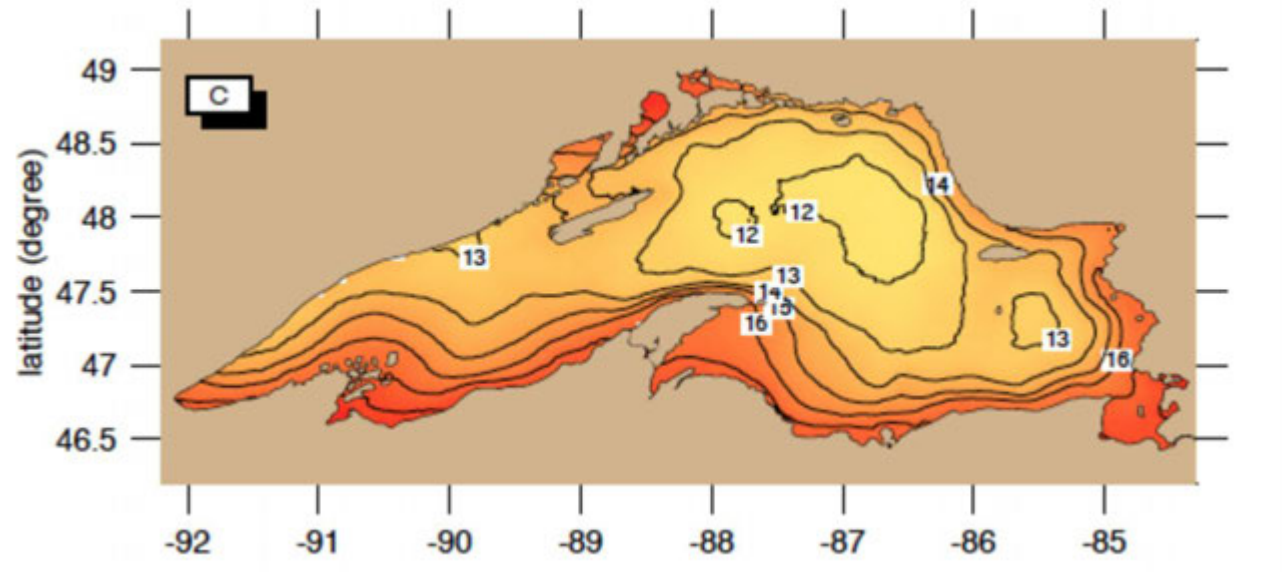
Data Management

Monitoring and Predicting

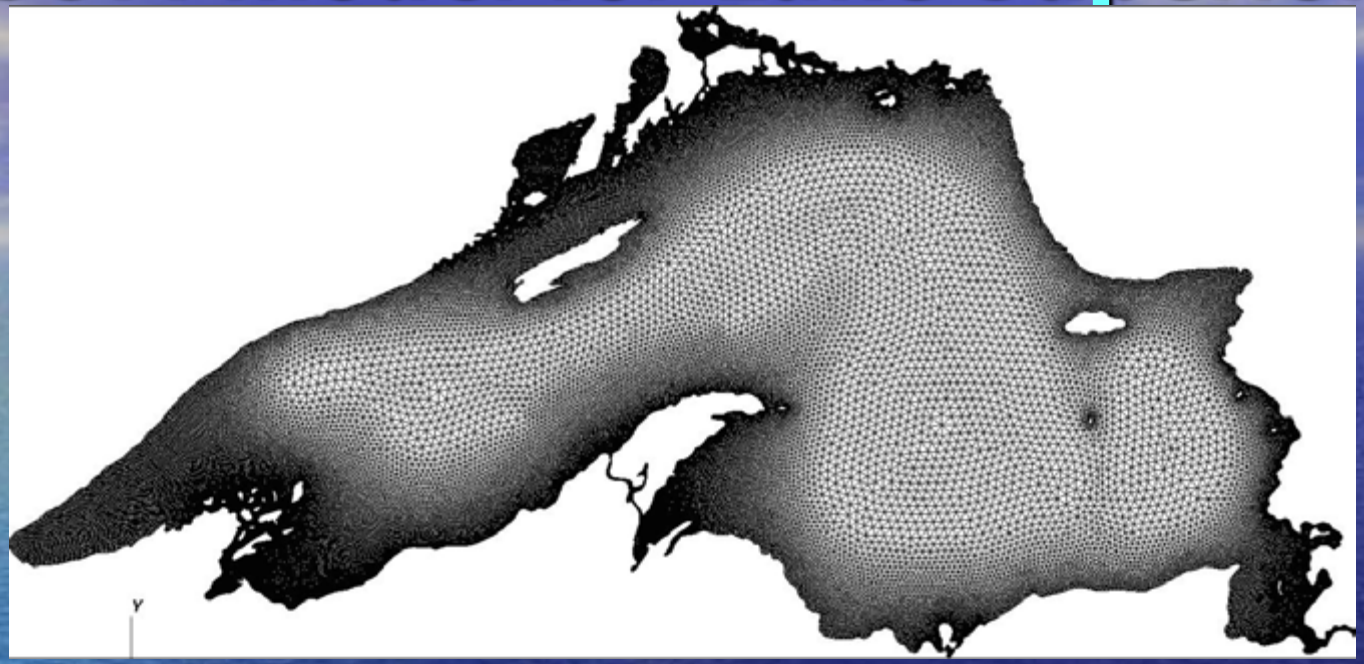
Spatial and temporal variability

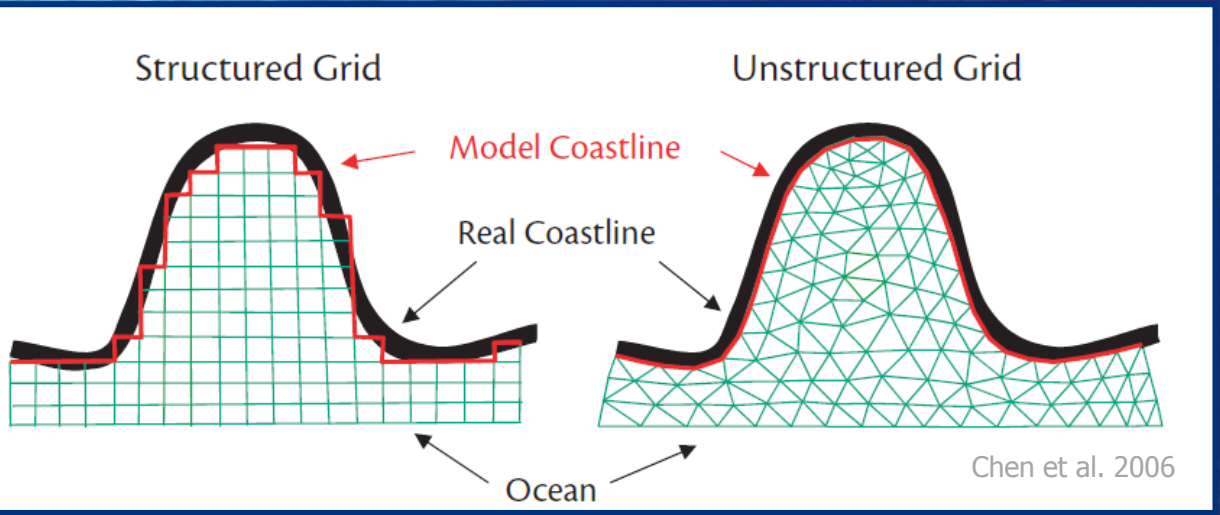
Great Lakes Surface Environmental Analysis (GLSEA)





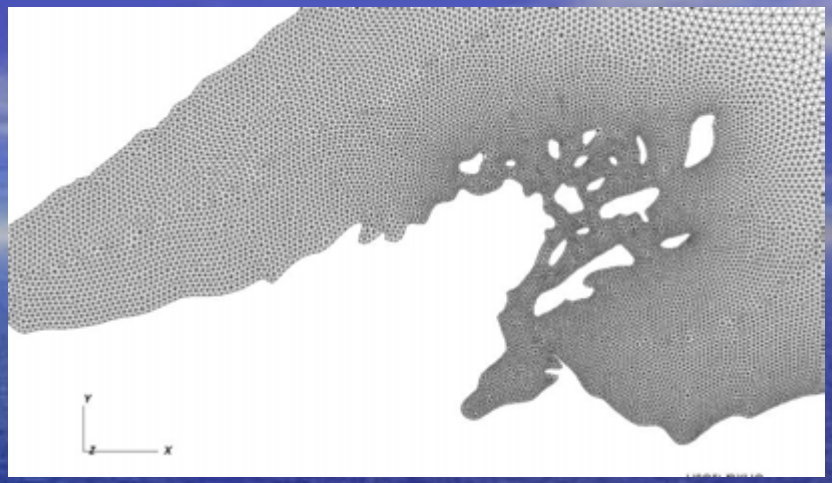
FVCOM model for Lake Superior

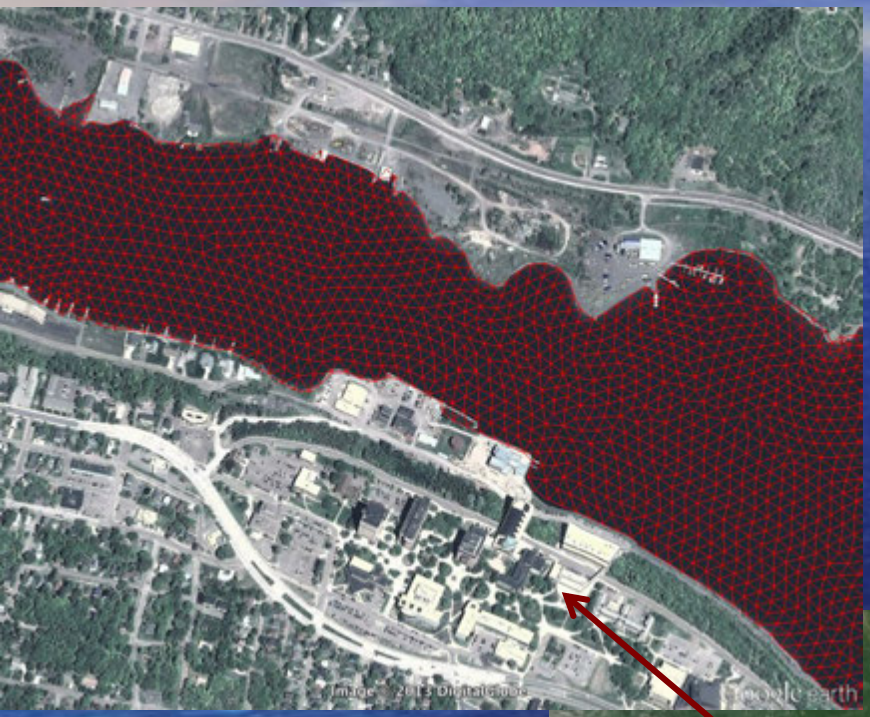




FVCOM model is currently also being used by NOAA for operational forecasting in several coastal regions and is scheduled to replace the Princeton Ocean Model in NOAA's GLCFS.

Unstructured Model Grids





Discretization: Break the domain into numerous components

Approximate solution at each model grid

higher-resolution (finer grids), better approximation

Unstructured grid models have much more flexibility in varied grid resolution (~ 2km -- ~30m)

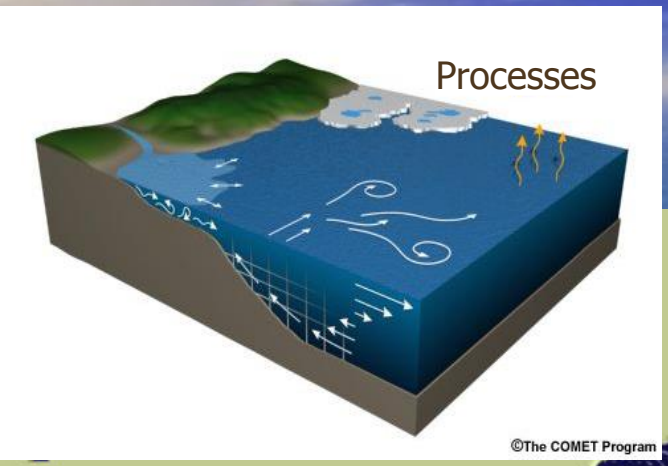
~120,000 model elements for each vertical layer. Lake Superior-FVCOM contains 40 vertical sigma coordinate layers

HPC "Cluster Superior"

One front end, two login nodes, three 48 TB RAID60 NAS node, **Total (1376 CPU cores):** 86 CPU compute nodes [each having 16 CPU cores (Intel Sandy Bridge E5-2670 2.60 GHz) and 64 GB RAM] and five GPU compute nodes [each having 16 CPU cores (Intel Sandy Bridge E5-2670 2.60 GHz), 64 GB RAM and 4 NVIDIA Tesla M2090 GPUs].
FVCOM run in parallel configuration using O(100) CPU cores.

Collaboration with NOAA

Schwab (retired) and Anderson



Hindcast/ Forecast,/Nowcast
Scientific/operational

Model Output (3D in space, time evolution)

- **Currents**
- **Temperature**
- **Water Level**
- **Mixing**
- **Evaporation**
- **…**

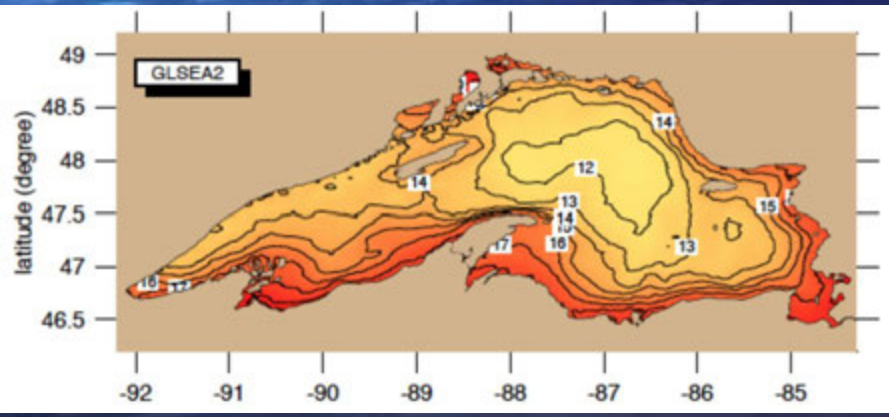
Model Calibration and Validation

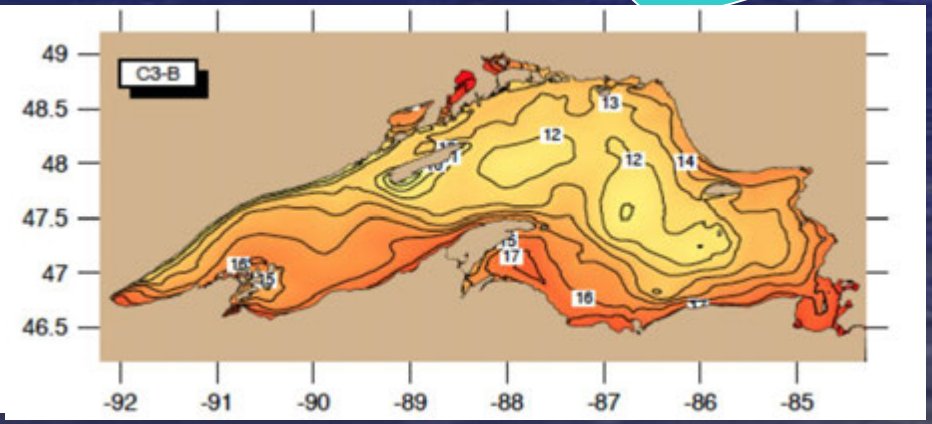
JGR-Oceans 2015 Xue et al. in revision

Model-data comparison

Model Development **Accuracy of forcing** **Model configuration**

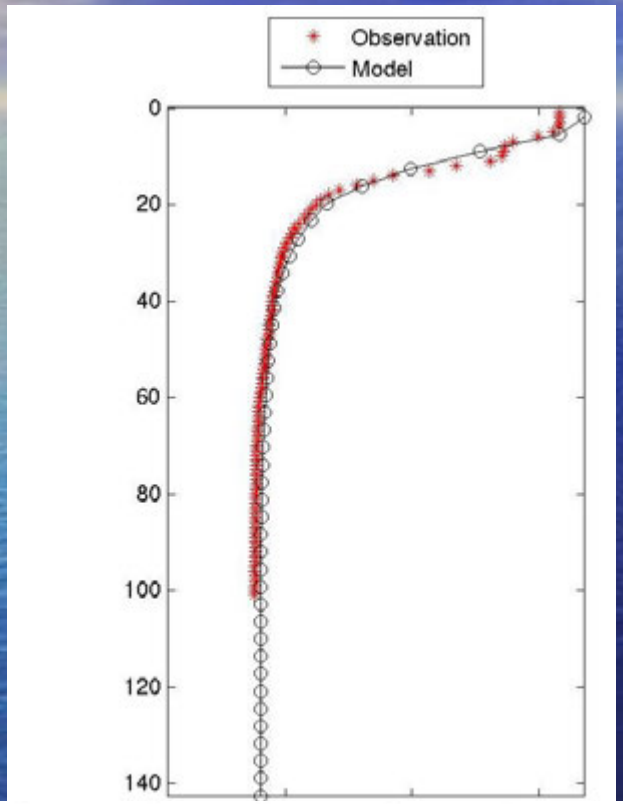
"one trusts a model except the man who wrote it; Everyone trusts an observation except the man who made it." -Harlow Shapley



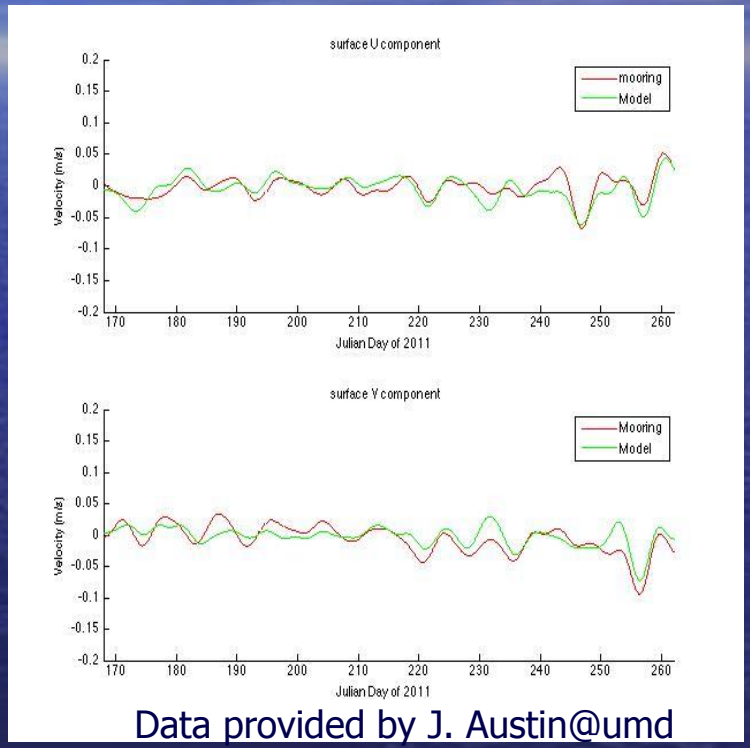


Model Calibration and Validation

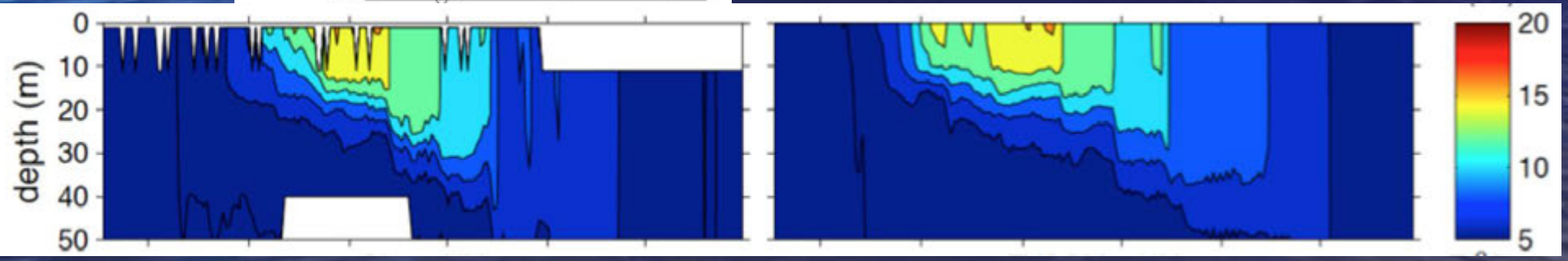
Temperature profile



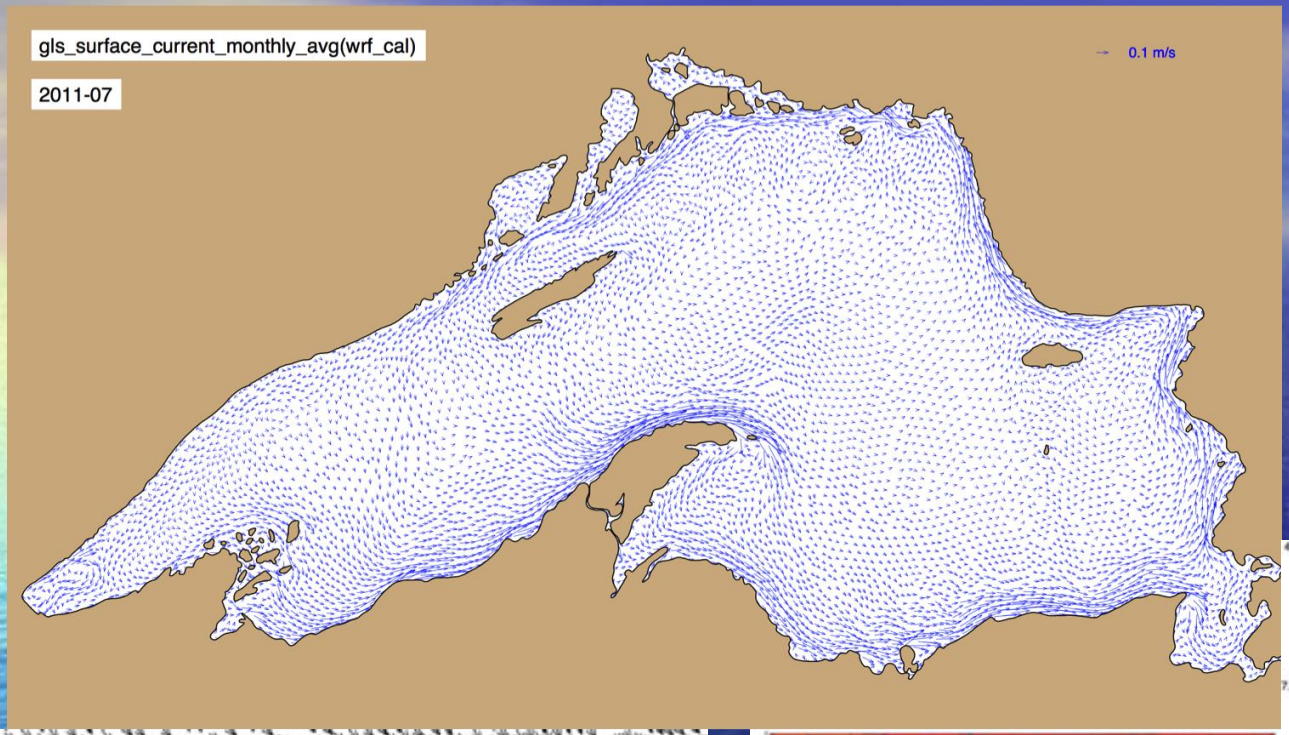
Surface Current from ADCP

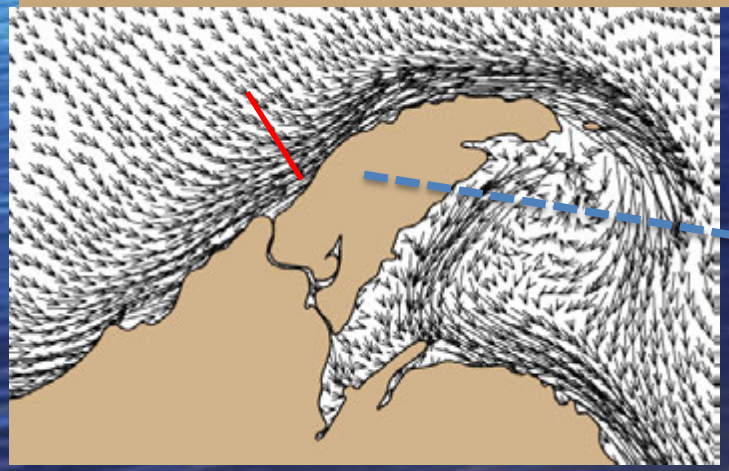


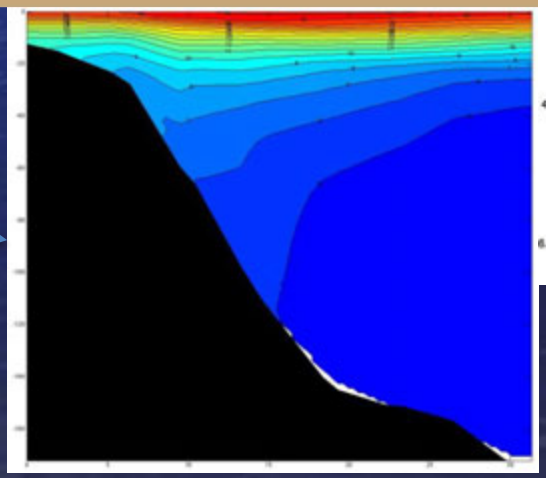
Data provided by J. Austin@umd



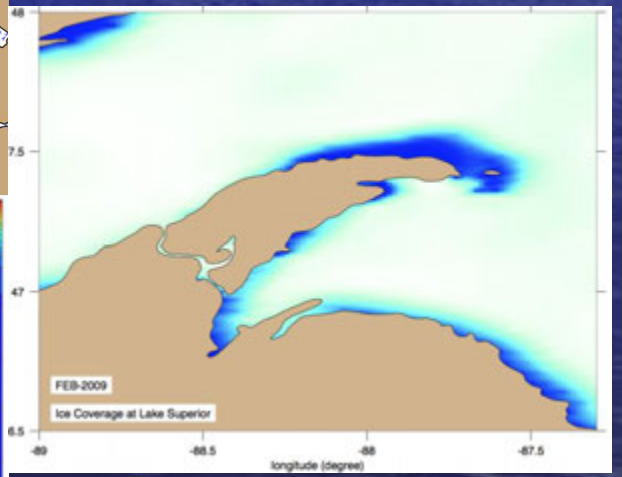
Model produced various datasets



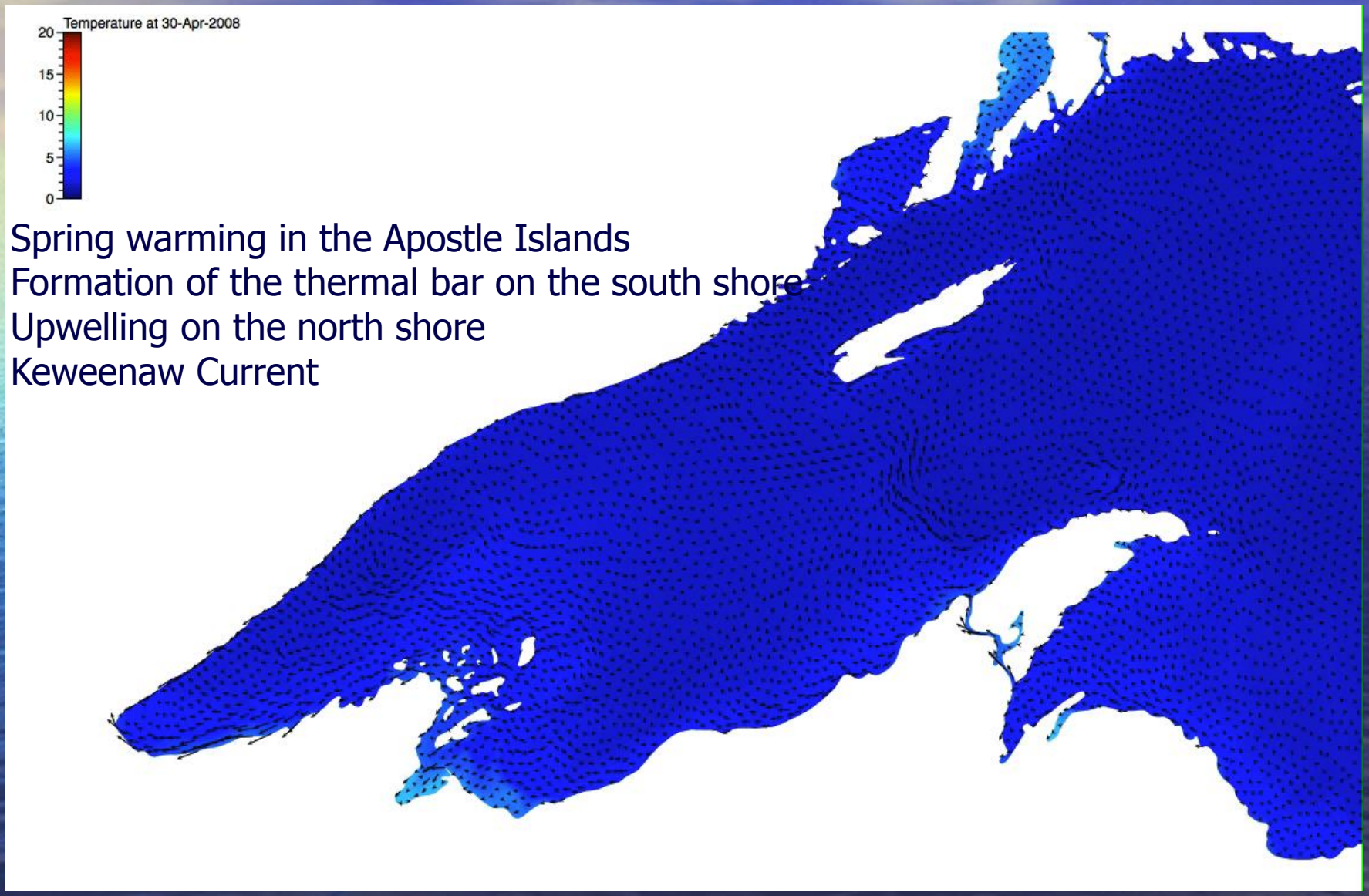




Winter Simulation

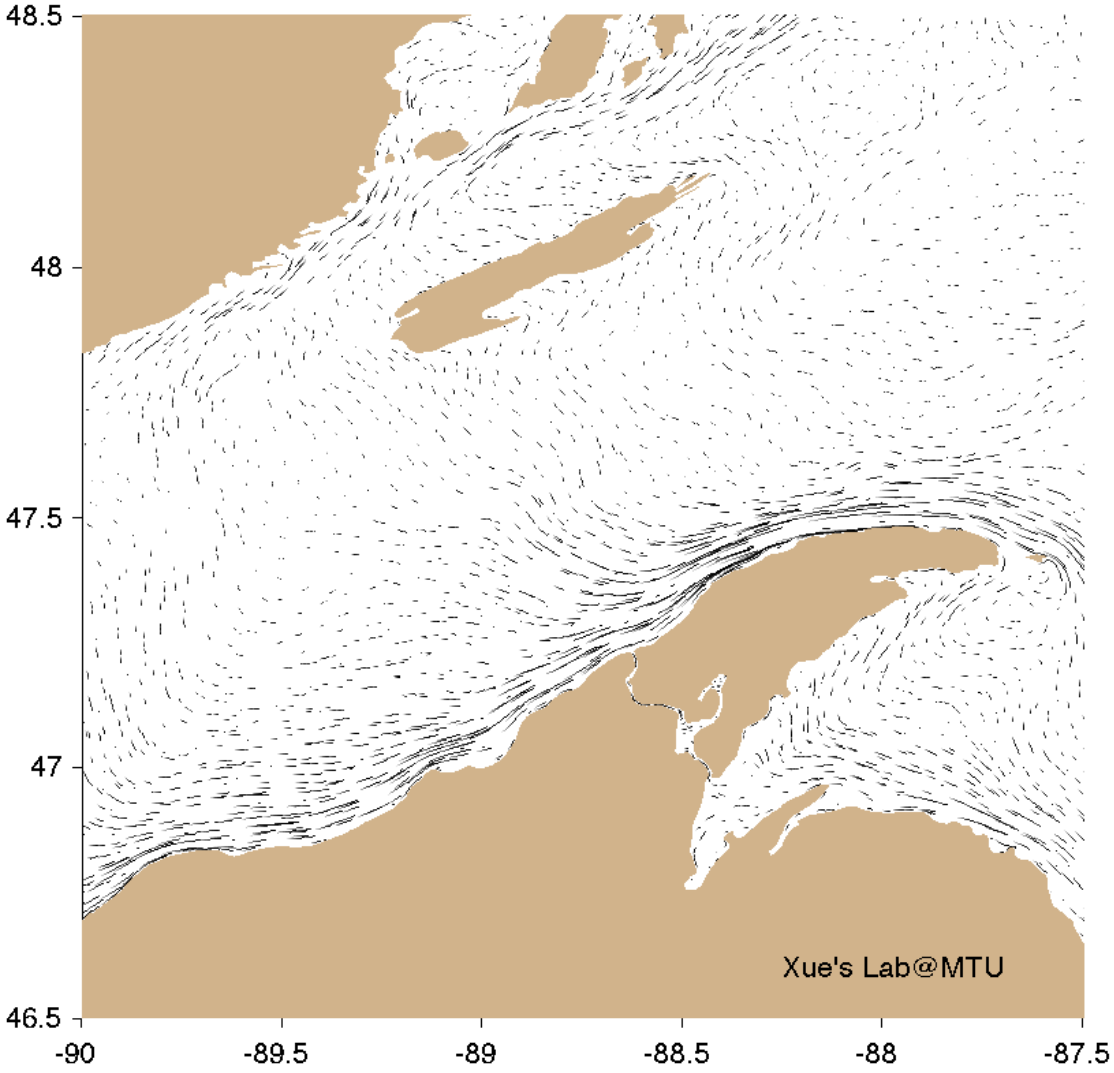


Visualization of Processes Modeled

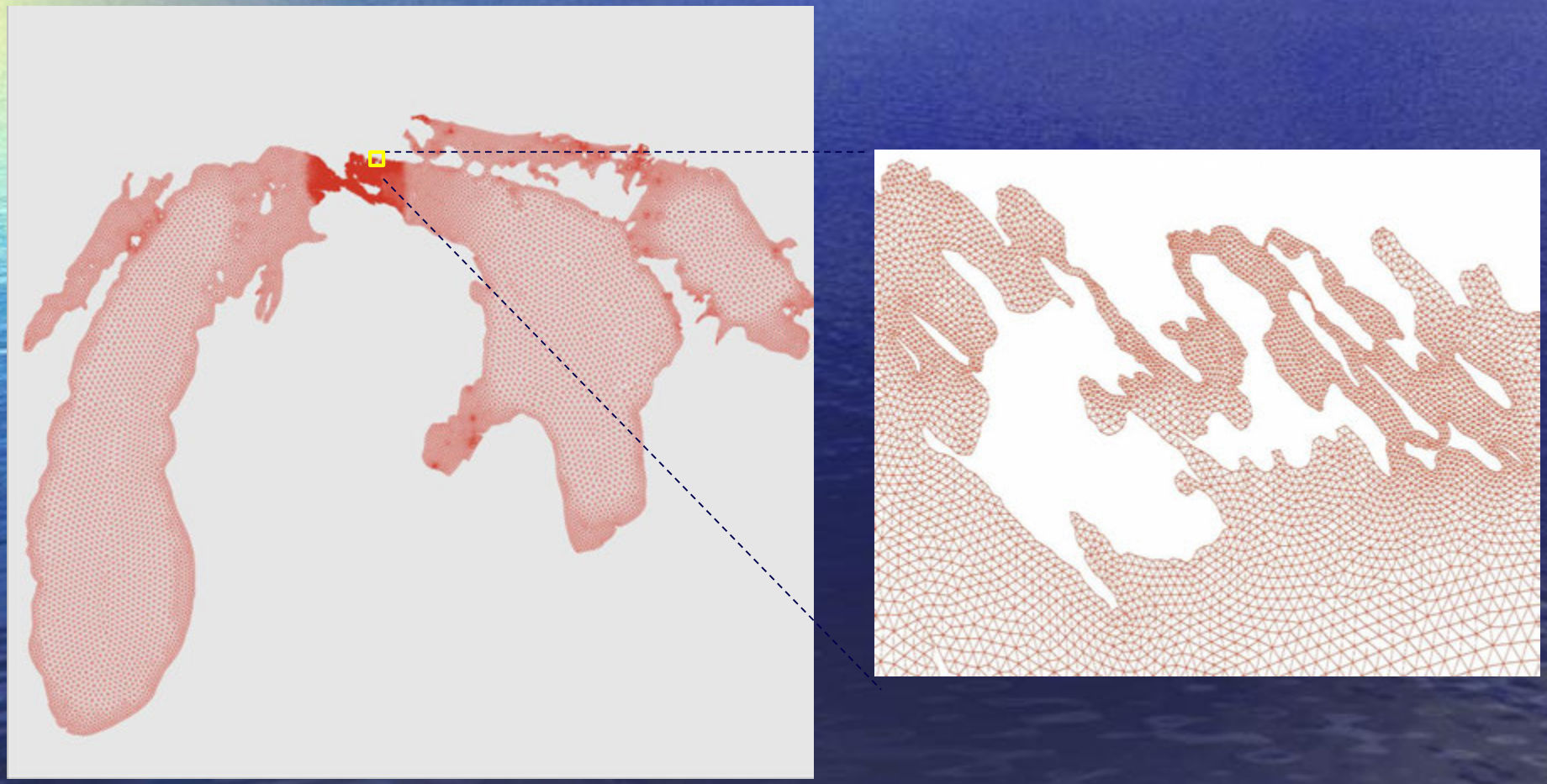


- Spring warming in the Apostle Islands
- Formation of the thermal bar on the south shore
- Upwelling on the north shore
- Keweenaw Current

Application of simulation results



Modeling of Great Lakes



Summary

- **Continue model development**
  - **End-to-end model coupling as done in other regions** (Xue et al. 2015 J. climate, Xue et al. 2014 JGR)
  - **Plan for long-term (decadal) simulations as done in other regions** (Xue et al. 2014 JMS)
- **Establish "reliable" numerical source of advanced capability to generate new data on circulation and forcing**

Thanks!