

An Integrated Nowcasting and Forecasting Operation System (INFOS) for the Apostle Islands, Lake Superior



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Site Significance

Tourism

- Apostle Islands National Lakeshore
- Big Bay State Park
- Kayaking, Sailing, Scuba



Annual reports of loss of life

- Kayakers



StarTribune.com | MINNEAPOLIS - ST. PAUL, MINNESOTA

Duluth News Tribune

Minn. man found dead after kayaking in N. Wi

Published June 09, 2011, 12:00 AM

Associated Press

September 11, 2010

BAYFIELD, Wis. - Authorities say a Minnesota man has died after the Apostle Islands area off northern Wisconsin.

Kayaker dies after spill into Lake Superior

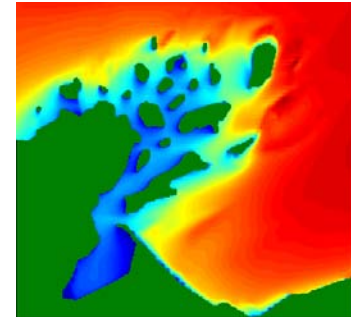
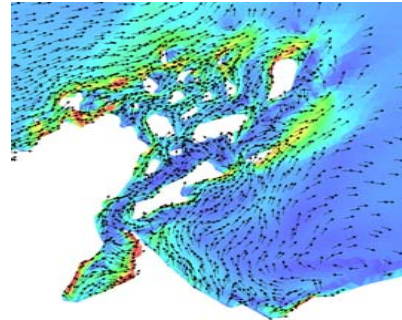
An afternoon kayaking trip by four college friends in the Apostle Islands turned tragic Austin, Minn., died.

By: **Steve Kuchera**, Duluth News Tribune

Objectives

1.) Develop high resolution models for the water environment of the Apostle Islands

2.) Design a website that
A.) Provides model results
B.) Combines real-time data



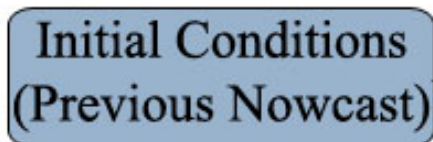
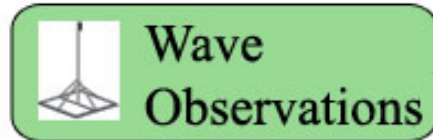
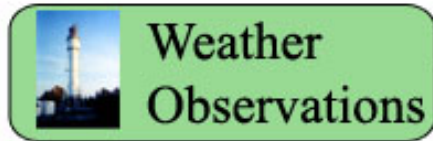
3.) Examine characteristics of the water environment in Apostles.

- Freak Waves
- Circulation patterns



INFOS - Apostles

REAL-TIME DATA

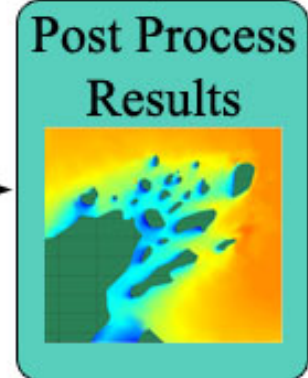
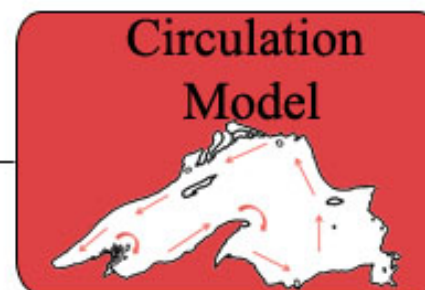
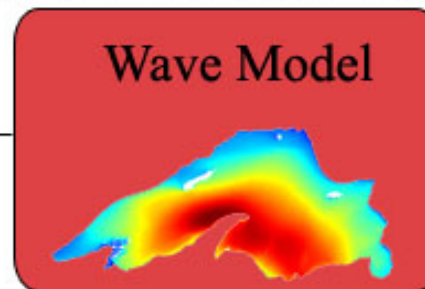


INFOS - Apostles

Update HTML files
Upload to Webserver



NOWCAST & FORECAST Models



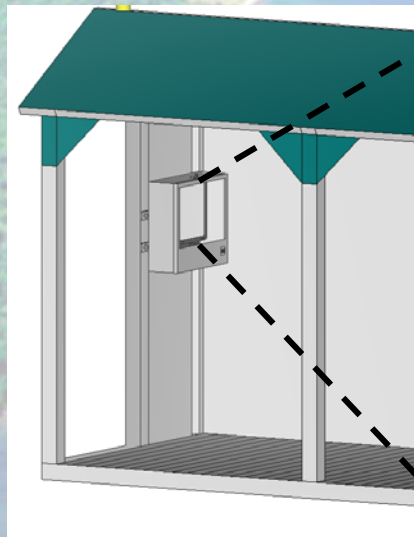
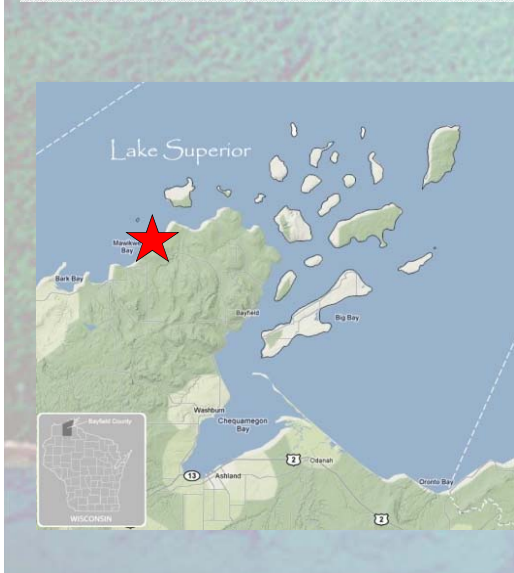
Real-Time Data

Real-Time Wave Observation System (RTWOS)

- Cellular Modem Transmission
- Significant Wave Height (Hs)
 - $H_s = 4\sigma$
- Webcam (ice pics)

2013 Plans

- Kiosk at Meyers Beach



Time	Wave Height (ft)	Max Wave (ft)	Wind Speed (mph)	Wind Gust (mph)	Wind Direction	Water Temp (°F)	Pictures
1:00 PM	2.5	++5.3	30.4	38.9	N	68.0	picture
12:30 PM	2.4	4.7	29.2	---	N	67.0	picture
12:00 PM	2.4	4.5	27.9	35.8	N	67.0	picture
11:30 AM	2.3	4.1	24.2	---	NW	66.0	picture
11:00 AM	1.8	3.6	22.6	30.0	NW	65.0	picture
10:30 AM	1.9	++4.3	21.3	---	NW	65.0	picture
10:00 AM	1.7	3.3	18.0	28.0	NW	65.0	picture
9:30 AM	1.7	3.3	16.0	---	NW	65.0	picture
9:00 AM	1.6	3.5	17.0	30.0	NW	65.0	picture
8:30 AM	1.7	2.0	14	---	NW	65.0	picture
8:00 AM	1.0	1.7	11.0	20.0	NW	65.0	picture
7:30 AM	0.8	1.4	9.0	---	NW	66.0	picture
7:00 AM	0.6	1.0	7.0	12.0	NW	65.0	picture

** Indicates a break wave
 ** Waves traveling from the East or Northeast may be underestimated by the sensor due to the sensor location. Use caution.
 N/A stands for Not Available. Wind Data is taken from NOAA's weather station at Devils Island and will often lag wave data.

Wave Model

SWAN –

- Simulating WAVes Nearshore

Phase averaged Spectral model

- Conservation of Wave Energy

Sources & Sinks (Calibration):

- Wind Growth
- Whitecap Dissipation

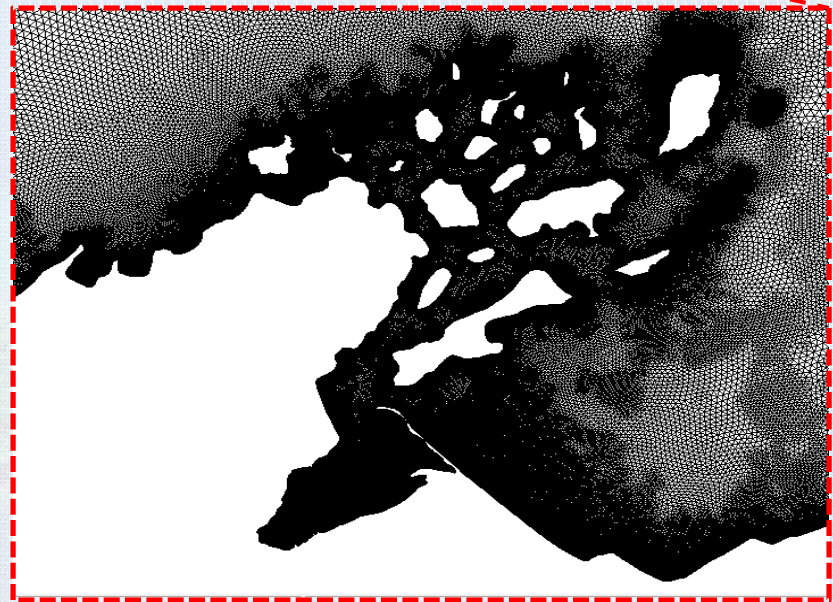
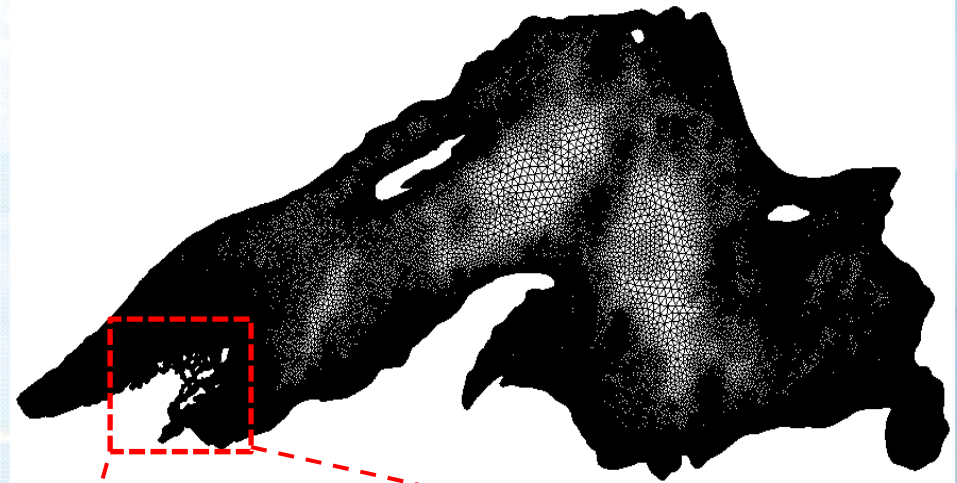
Grid

480,000 elements

- $\Delta x, \Delta y = 10\text{m} - 5\text{ km}$

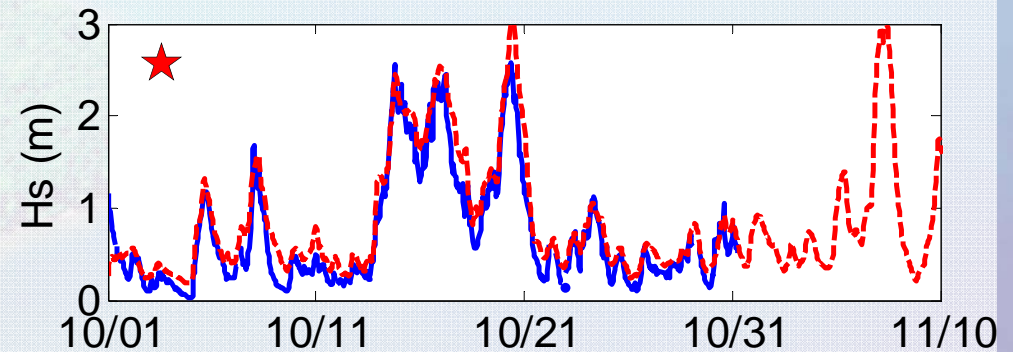
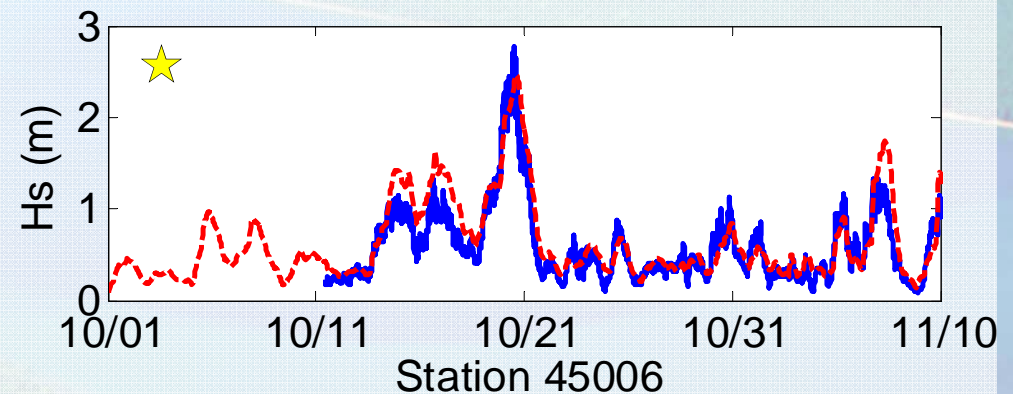
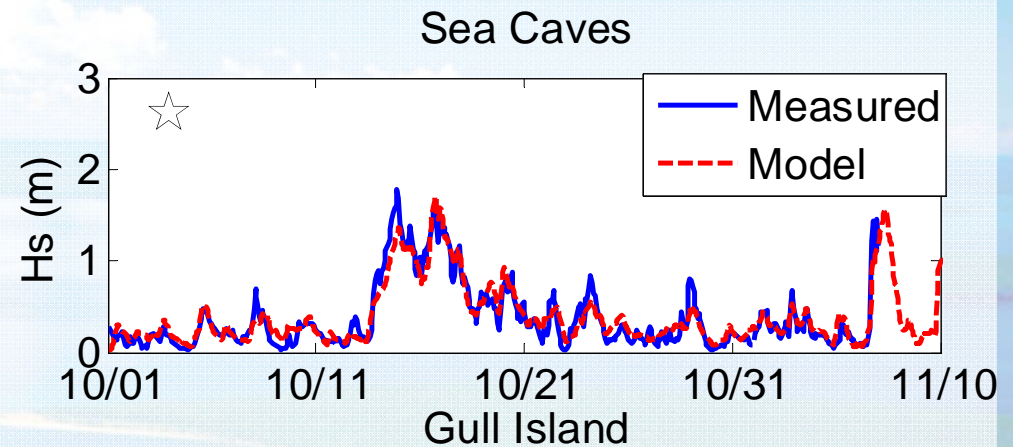
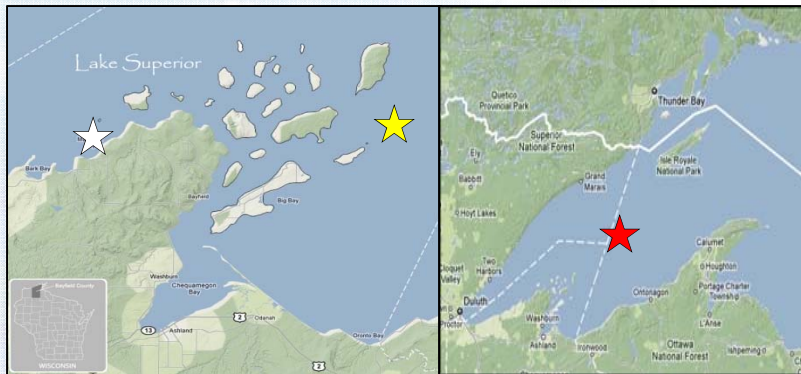
Parallel – 12 cores

- Time Ratio – 15:1



Calibration - Wave Model

Oct.-Nov. 2011



$$SI = \frac{RMSE \text{ of } H_s}{\text{mean observed } H_s}$$

Location	SI
Sea Caves	0.32
Gull Island	0.32
St45006	0.33
Gulf of Mexico*	0.30
Lake Erie**	0.20

* Siadatmousavi et al. 2010

** Moeini and Etemad-Shahidi 2007

Circulation Model

SELFE

Semi-Implicit Eulerian Lagrangian Finite-Element model

Solves 3-D Navier Stokes Equations

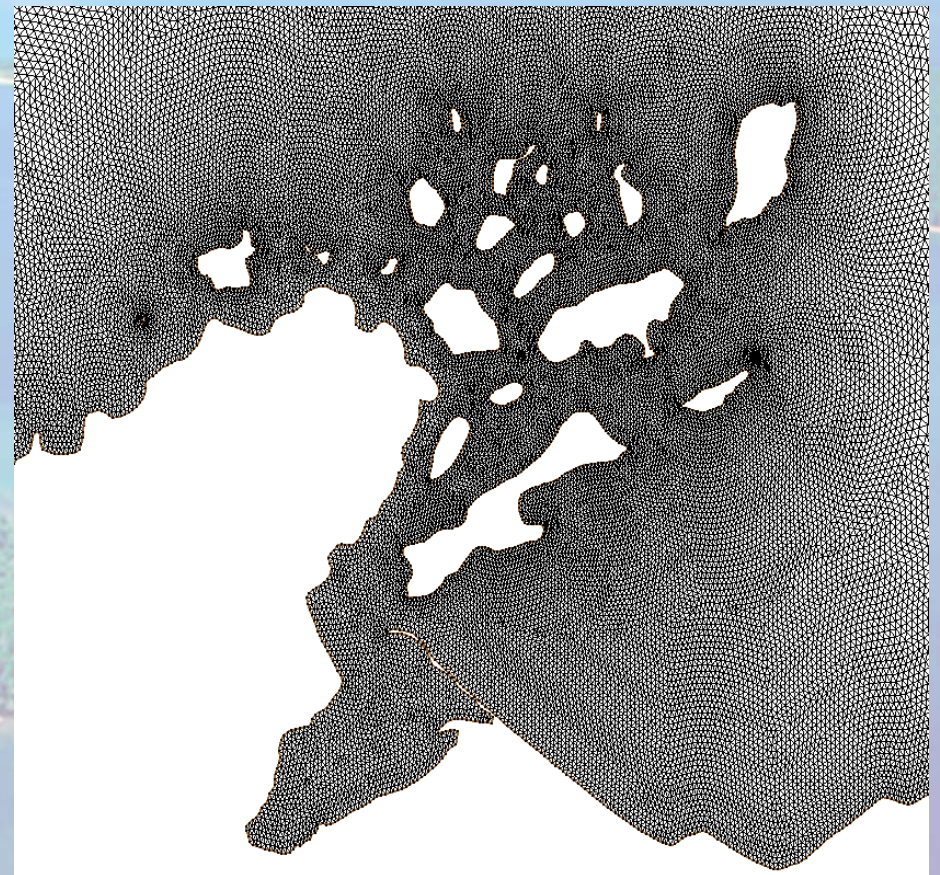
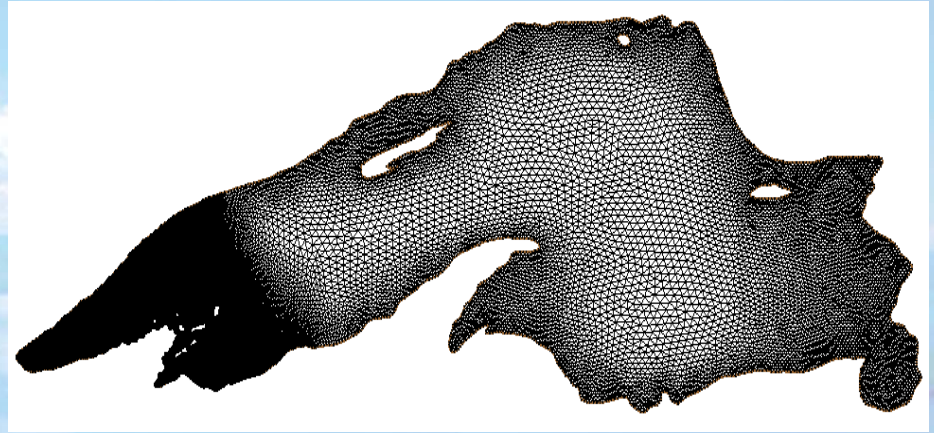
- Hydrostatic assumption
- Baroclinic

Grid

- 100,000 elements
- $\Delta x, \Delta y = 100\text{m} - 5 \text{ km}$
- 30 sigma layers

Parallel – 12 cores

- Time Ratio – 50:1



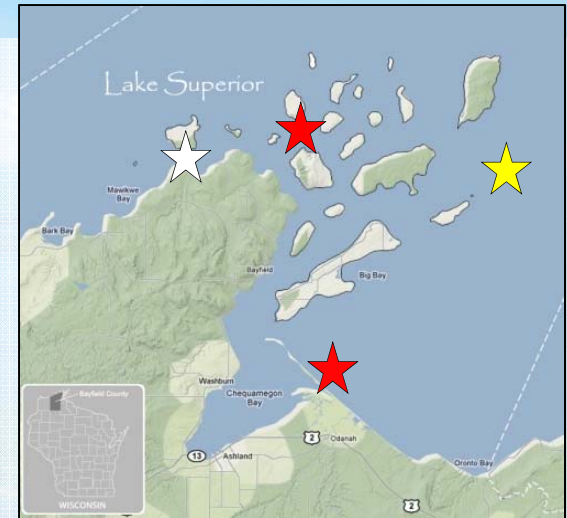
Circulation Model - State of Calibration

Surface Currents

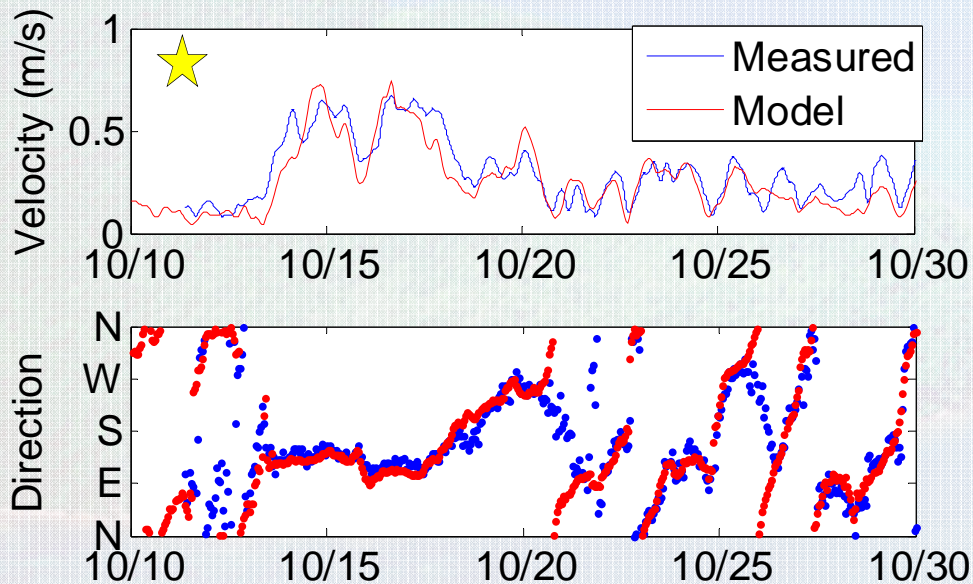
- Calibration
Windfactor – 1.3

Future Work

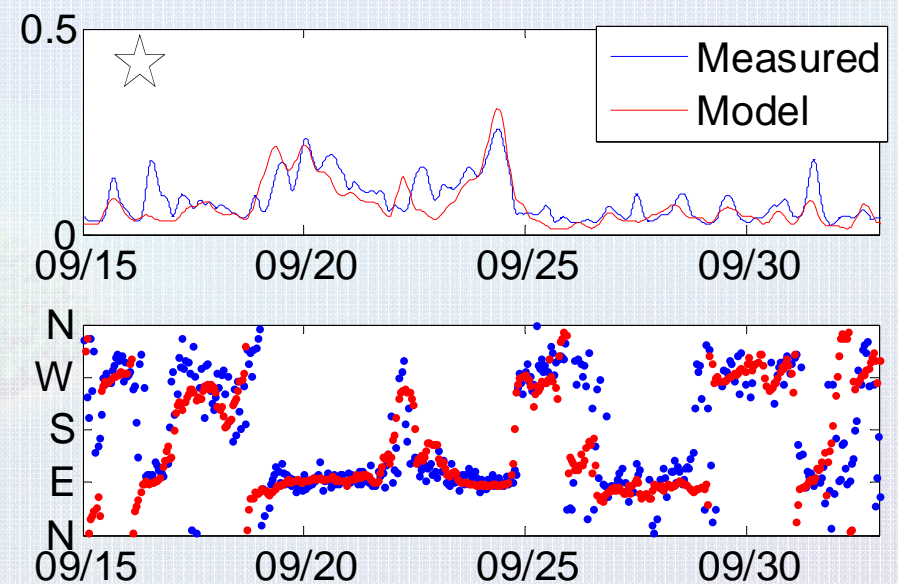
- Two instruments currently deployed
- Currents with depth



2011



2012



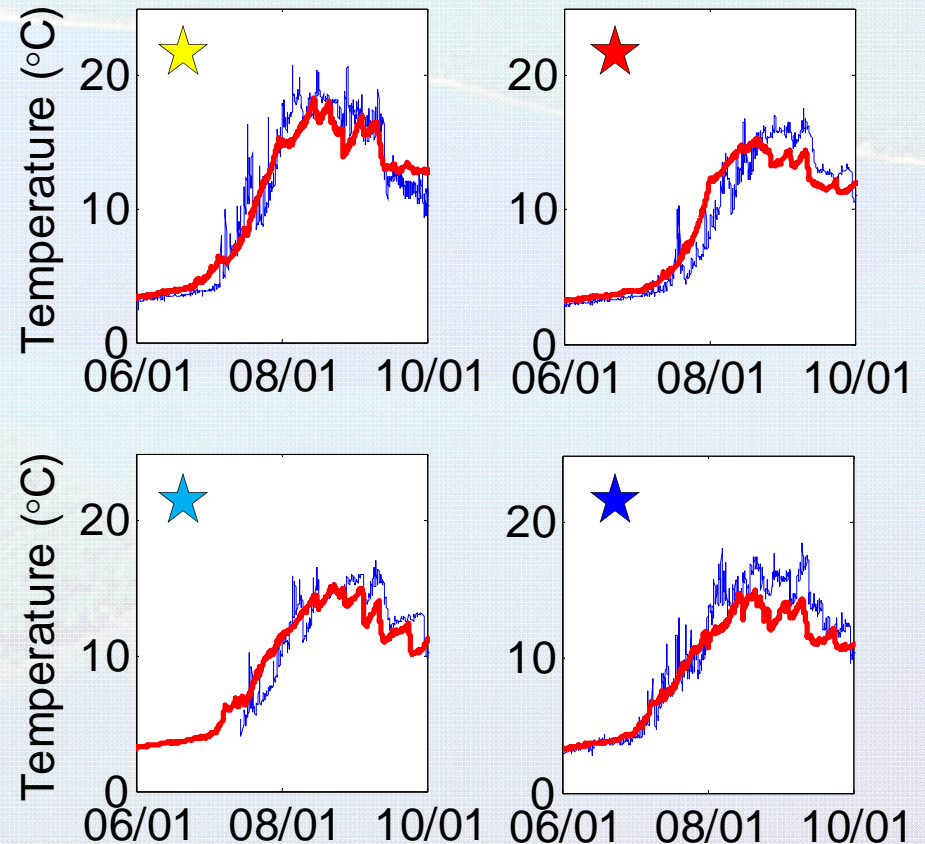
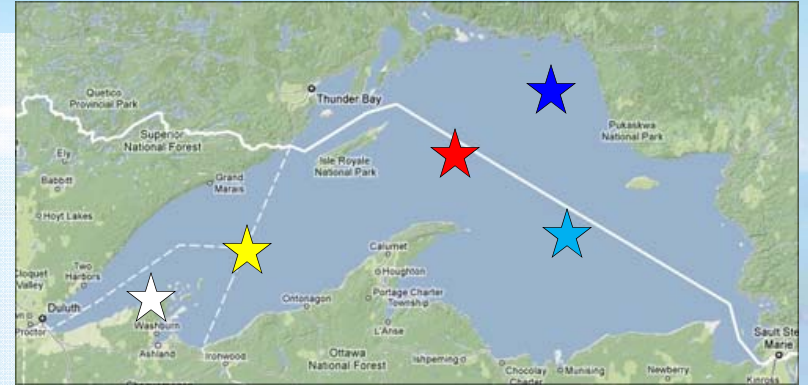
Circulation Model - State of Calibration

Surface Temperature

- Calibration
 - Albedo (reflectivity)
 - Water clarity

Future Work

- Temperature with depth



Website

<http://infosapostles.cee.wisc.edu/>

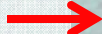
Real-Time Data



Model Results



Webcams



INFOS *Apostles*

Integrated Nowcast/Forecast Operation System for the Apostle Islands

[Home](#) [About INFOS](#)

Observations

- Weather
- Radar
- Waves
- Streamflow

Hydrodynamic

- Waves
- Currents
- Water Temperatures
- Water Level

Webcams

- Mainland Sea Caves
- Bayfield Harbor
- Seagull Bay
- Chequamegon Bay

History

- Fishing
- LightHouses
- Shipwrecks
- Islands

More Information

- Links

Weather Observations



[Display Interactive Map](#)

Currently at Bayfield

Air Temperature
23.9°F

Humidity
0%

Wind Direction
↓
N
360°

Wind Speed
9 mph

Pressure
30.38 in Hg

All Data Updated
03/07/2013

Partnership



BAYFIELD
and the apostle islands



Website

<http://infosapostles.cee.wisc.edu/>

Model Results
Use Google Maps

24 Forecast



INFOS *Apostles*

Integrated Nowcast/Forecast Operation System
for the Apostle Islands

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03/06 2 AM

All Times are CST

Observations

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Waves

Streamflow

Hydrodynamic

Waves

Currents

Water
Temperatures

Water Level

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Mainland Sea
Caves

Bayfield Harbor

Seagull Bay

Chequamegon
Bay

History

Fishing

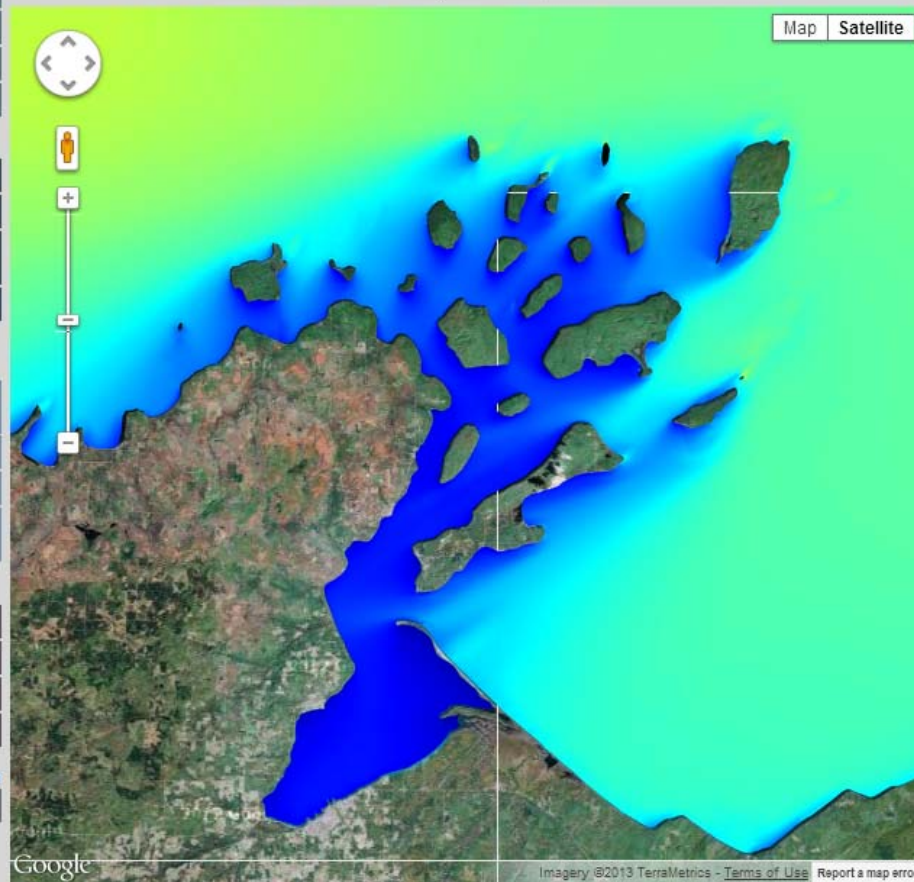
LightHouses

Shipwrecks

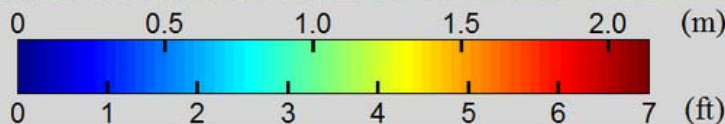
Islands

More Information

Links



03/06 2 AM	03/07 2 AM
03/06 3 AM	03/07 3 AM
03/06 4 AM	03/07 4 AM
03/06 5 AM	03/07 5 AM
03/06 6 AM	03/07 6 AM
03/06 7 AM	03/07 7 AM
03/06 8 AM	03/07 8 AM
03/06 9 AM	03/07 9 AM
03/06 10 AM	03/07 10 AM
03/06 11 AM	03/07 11 AM
03/06 12 PM	03/07 12 PM
03/06 1 PM	03/07 1 PM
03/06 2 PM	03/07 2 PM
03/06 3 PM	03/07 3 PM
03/06 4 PM	03/07 4 PM
03/06 5 PM	03/07 5 PM
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03/06 11 PM	
03/07 12 AM	
03/07 1 AM	

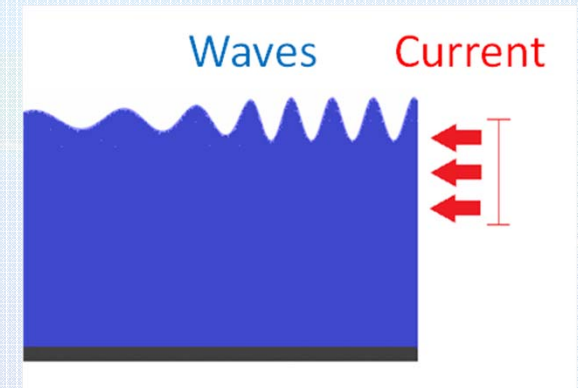
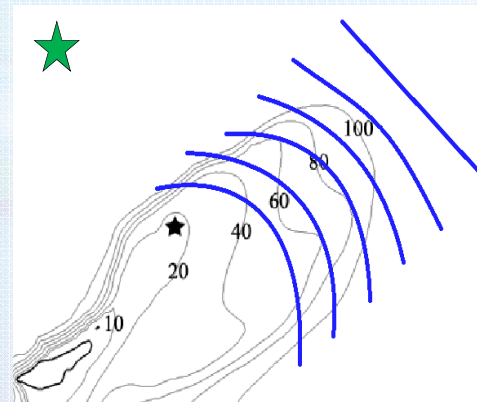
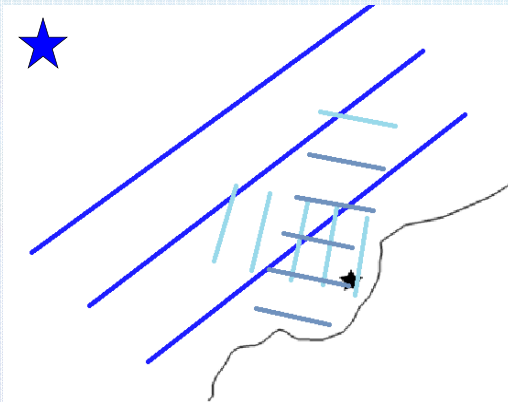


Significant Wave Height

Freak Waves

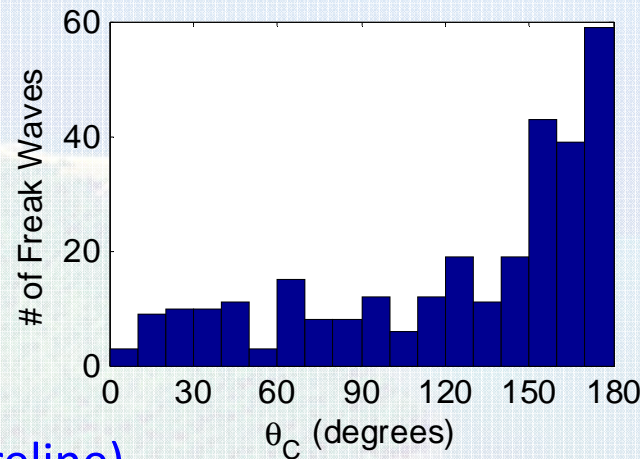
Definition: A single wave that is $> 2H_s$

Causes:



Gull Island Shoal

- 8 shoals
- Occur more frequently with opposing current
- 1:9,041 (~1:10 hrs)



Sea Caves (Reflecting shoreline)

- 1:2,273 (~1:2 hrs)
- Each Island has a portion of steep cliff shore



Summary

INFOS – Apostles

<http://infosapostles.cee.wisc.edu/>

RTWOS for Mainland Sea Caves

- Kiosk 2013

24 hr Model Forecast Results

- Significant wave height
- Surface current
- Surface temperature

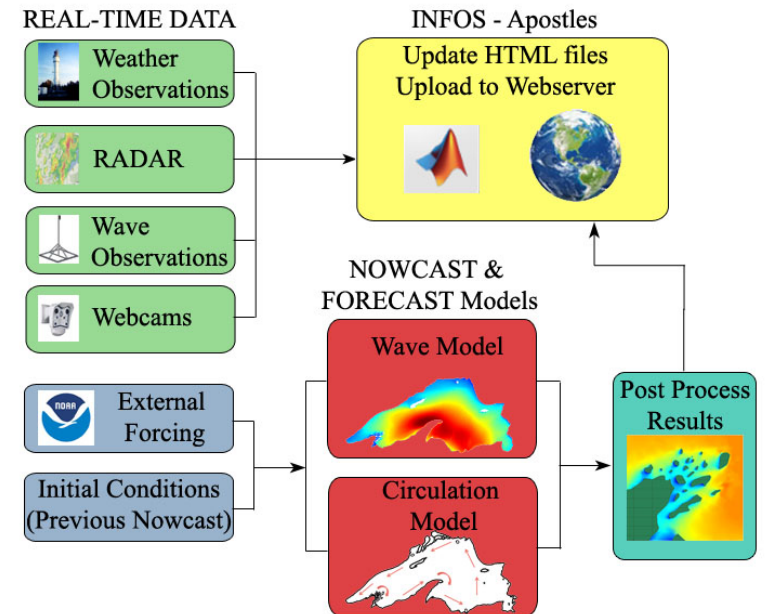
FREAK Waves

Gull Island Shoal

- Due Opposing Current
- 1:9,041 waves (~1:10hrs)

Sea Caves

- Reflecting Shoreline
- 1:2,273 wave (~1:2 hrs)



Acknowledgements



Questions?

Sources

Moeini, M. H. and A. Etemad-Shahid, 2007. Application of two numerical models for wave hindcasting in Lake Erie. *Applied Ocean Research*. 29: 137-145.

Siadatmousavi, S.M., F. Jose and G.W. Stone, 2011. Evaluation of two WAM white capping parameterizations using parallel unstructured SWAN with application to the Northern Gulf of Mexico, USA. *Applied Ocean Research*. 33: 23-30.