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

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Minn. man found dead after kayaking in N. Wi

Associated Press
September 11, 2010

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

Kayaker dies after spill into Lake Superior

Published June 09, 2011, 12:00 AM

An afternoon kayaking trip by four college friends in the Apostle Islands turned tragic. A kayaker from 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
- Weather Observations
- RADAR
- Wave Observations
- Webcams
- External Forcing
- Initial Conditions (Previous Nowcast)

INFOS - Apostles
Update HTML files
Upload to Webserver

NOWCAST & FORECAST Models
- Wave Model
- Circulation Model

Post Process Results
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
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
- $\Delta x, \Delta y = 10m - 5 km$

**Parallel** – 12 cores
- **Time Ratio** – 15:1
Calibration - Wave Model

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

<table>
<thead>
<tr>
<th>Location</th>
<th>SI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Caves</td>
<td>0.32</td>
</tr>
<tr>
<td>Gull Island</td>
<td>0.32</td>
</tr>
<tr>
<td>St45006</td>
<td>0.33</td>
</tr>
<tr>
<td>Gulf of Mexico*</td>
<td>0.30</td>
</tr>
<tr>
<td>Lake Erie**</td>
<td>0.20</td>
</tr>
</tbody>
</table>

* Siadatmousavi et al. 2010
** Moeini and Etemad-Shahidi 2007
SELFE
Semi-Implicit Eulerian Lagrangian Finite-Element model

Solves 3-D Navier Stokes Equations
  • Hydrostatic assumption
  • Baroclinic

Grid
  • 100,000 elements
  • \( \Delta x, \Delta y = 100m - 5 km \)
  • 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/

Model Results
Use Google Maps

24 Forecast
**Freak Waves**

**Definition:** A single wave that is > 2Hs

**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