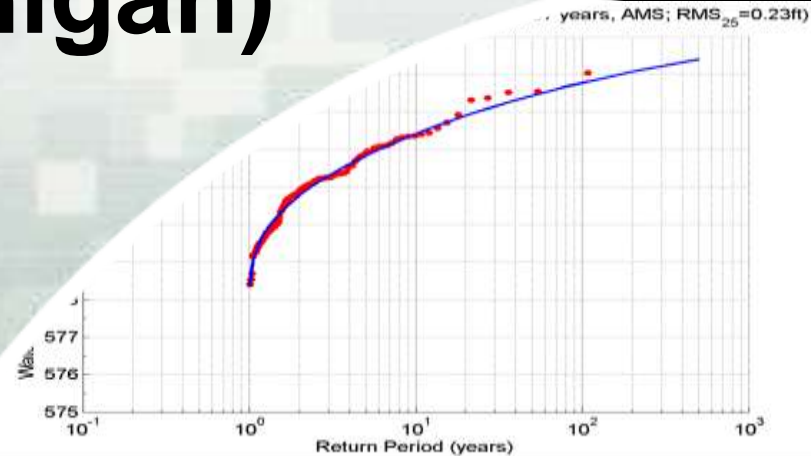


Great Lakes Flood Hazard Mapping Project - Data Development (Lake Michigan)

Bruce Ebersole

USACE Engineer Research
and Development Center

Coastal and Hydraulics Lab



US Army Corps of Engineers
BUILDING STRONG[®]

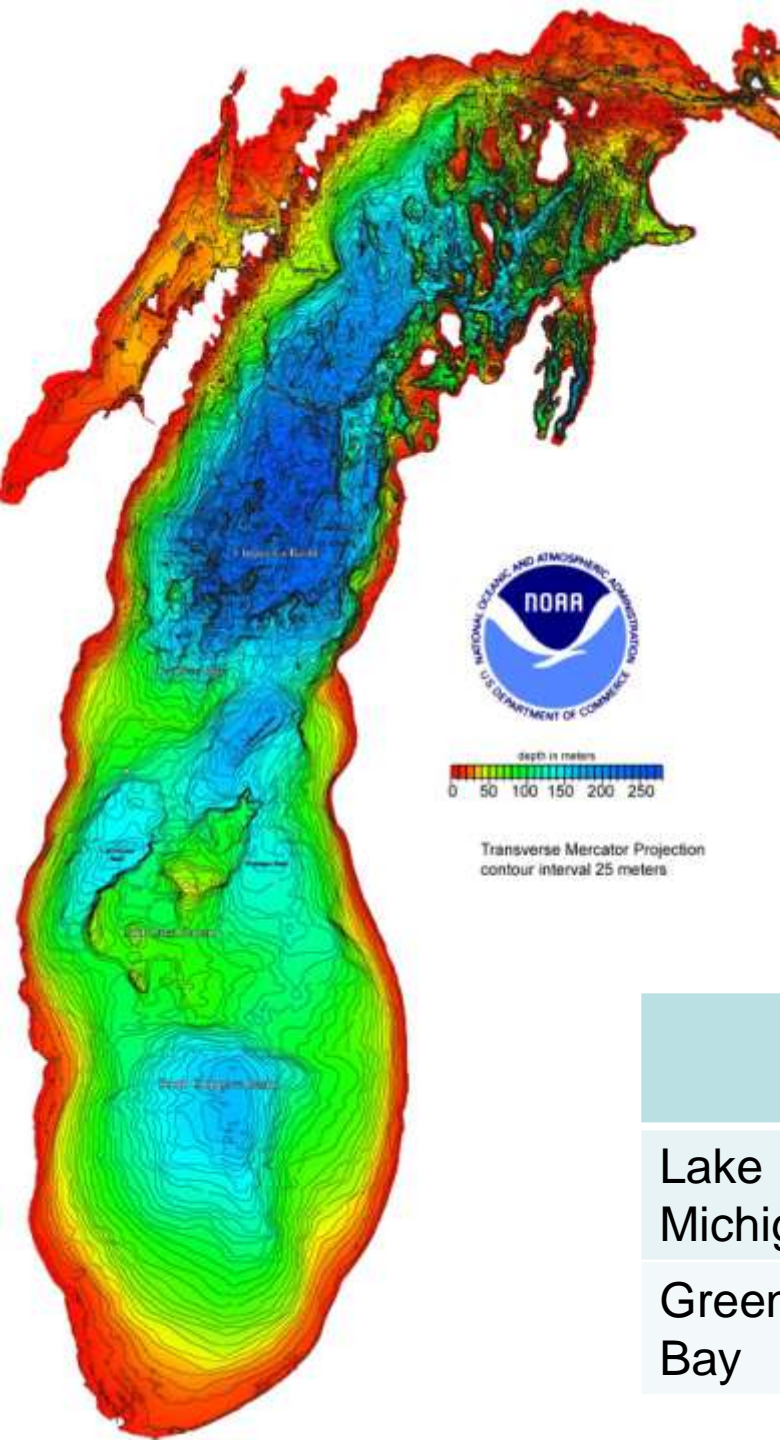
Outline

- Water Level and Wave Contributors to BFEs
- Lake Level Changes
- Modeling Approach for Storms
- Wind, Atmospheric Pressure and Ice Input
- Storm Surge Modeling
- Wave Modeling
- Nearshore Dynamics and Run-up Modeling
- Statistics of Water Levels
- Archival/Delivery of the Storm Data for FIRM Preparation



Contributors to BFEs

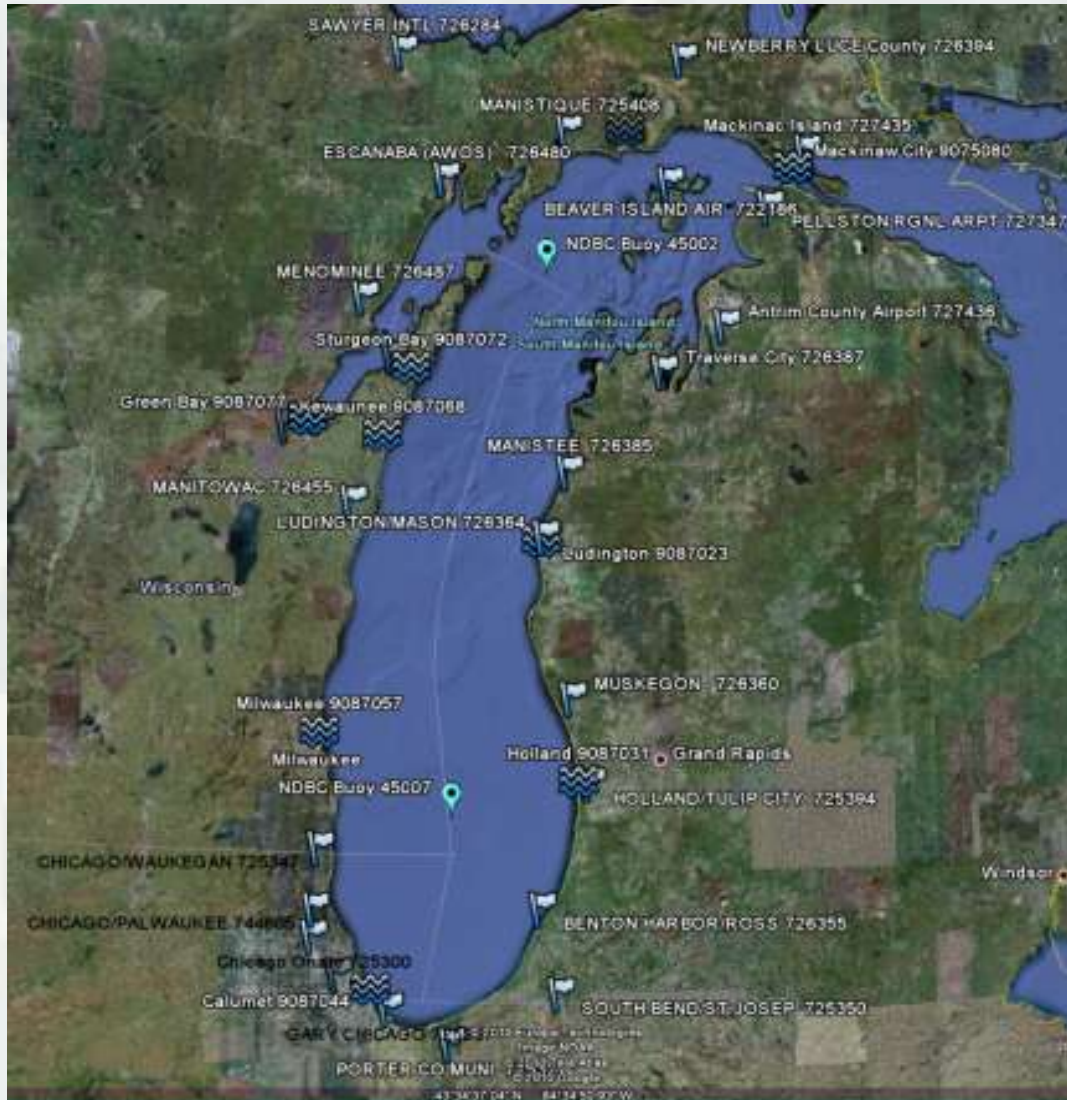
Approximate Magnitudes



- Long-term lake level changes
- Seasonal lake level changes
- Storm waves and surge

	Lake Level	Storm Surge	Waves	Beach Run-up
Lake Michigan	+/- 3 ft	3 ft	H = 20 ft T = 8 sec	4 to 7 ft
Green Bay	+/- 3 ft	5 ft	H = 9 ft T = 6 sec	2 to 3 ft

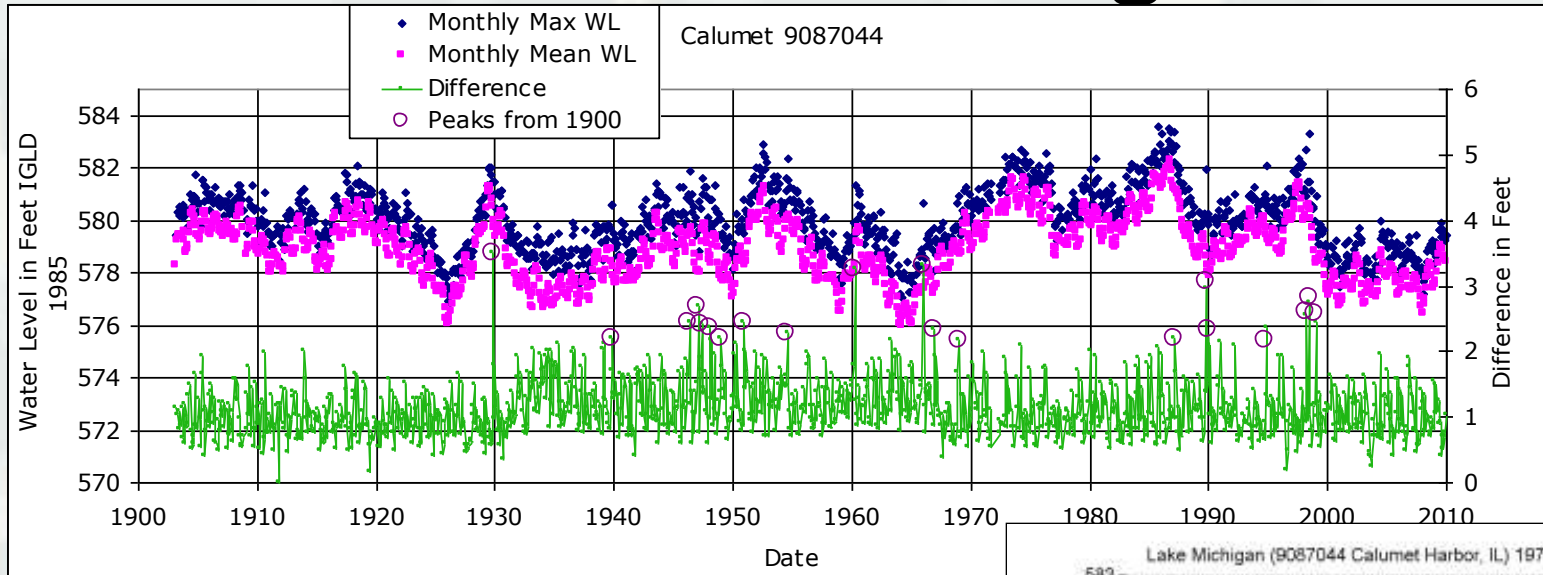
Measured Data Sources



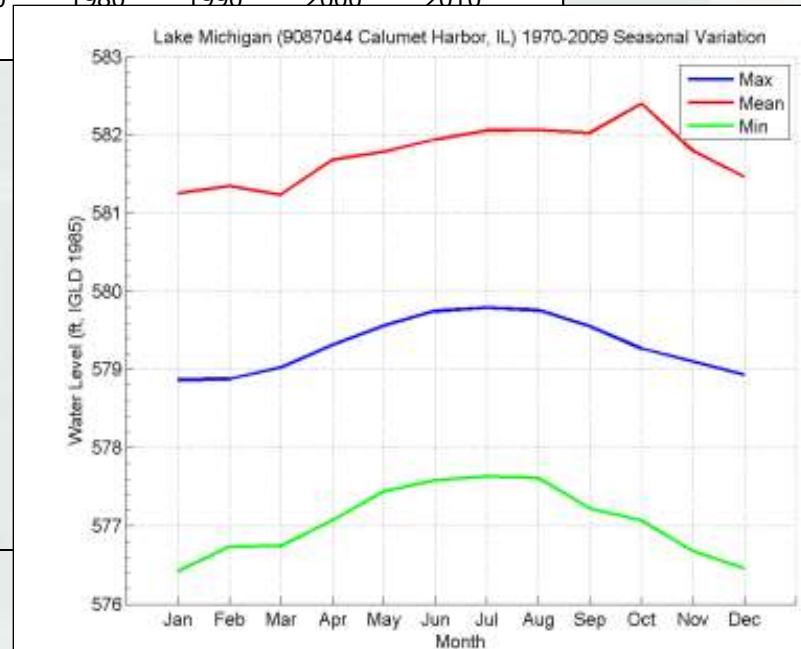
- NOAA NDBC wave and met buoys (removed in winter)
 - NOAA NWS land based weather stations
 - NOAA NOS water level gages
-
- 100+ years of data at some locations to evaluate statistical approach to water levels and storm sampling issues



Long Term and Seasonal Lake Level Changes

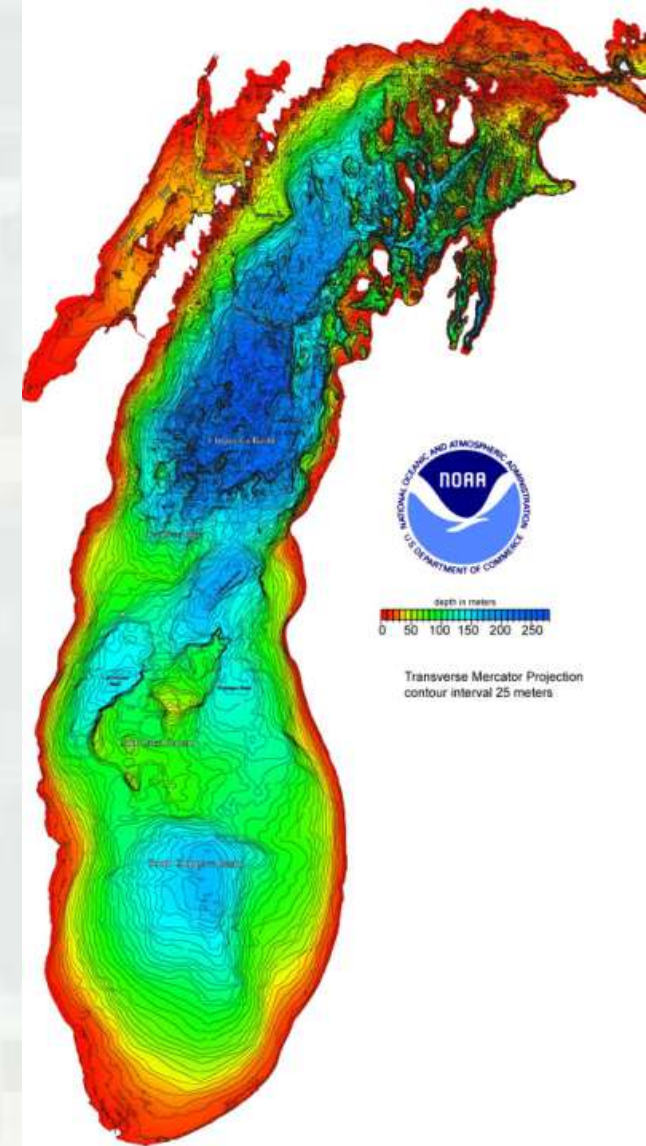


- Using Basis of Comparison corrected water levels to define lake levels
- Focus is on 1960 to 2010 period



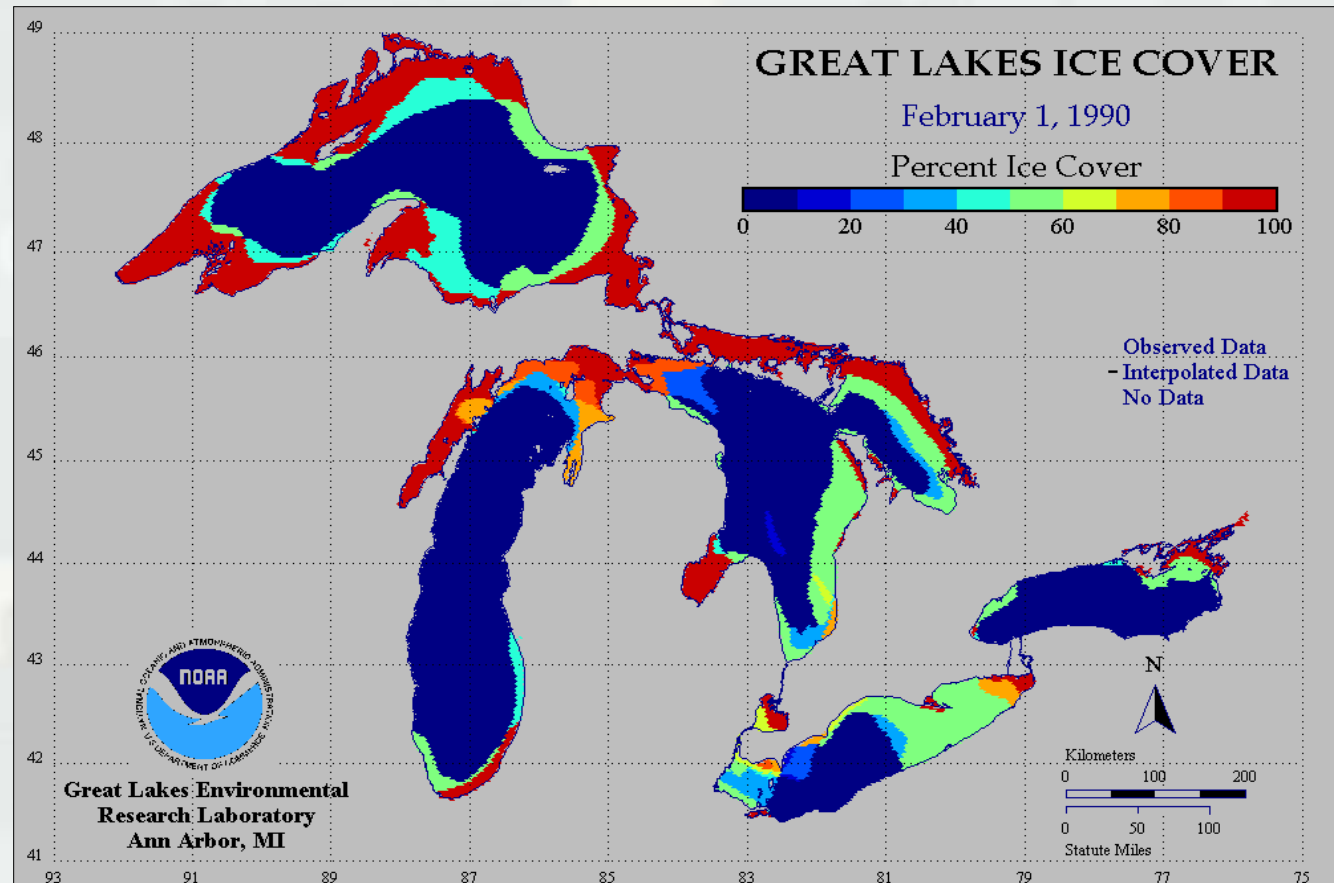
Modeling Approach

- Desire for unbiased and defensible wave and water level estimates for BFE determination—rigorously validate all models
- Models forced with wind, atmospheric pressure, ice fields from NOAA
- Lake-scale storm surge modeling using ADCIRC
- Lake-scale wave modeling using WAM
- Higher resolution shallow water wave modeling using STWAVE in some areas
- Coupled shallow-water wave and surge modeling in southern Green Bay
- Nearshore dynamics incl run-up using CSHORE
- Simulate historic storms at synoptic lake level
- Considering storms during 1960-2009 period



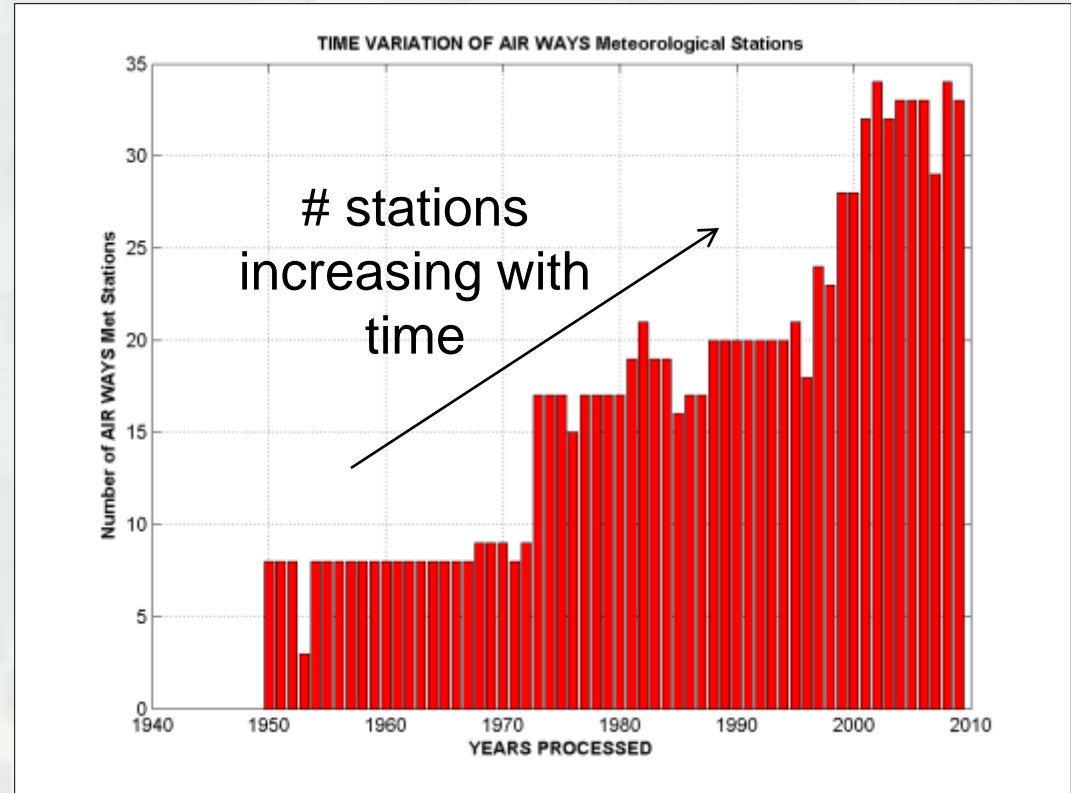
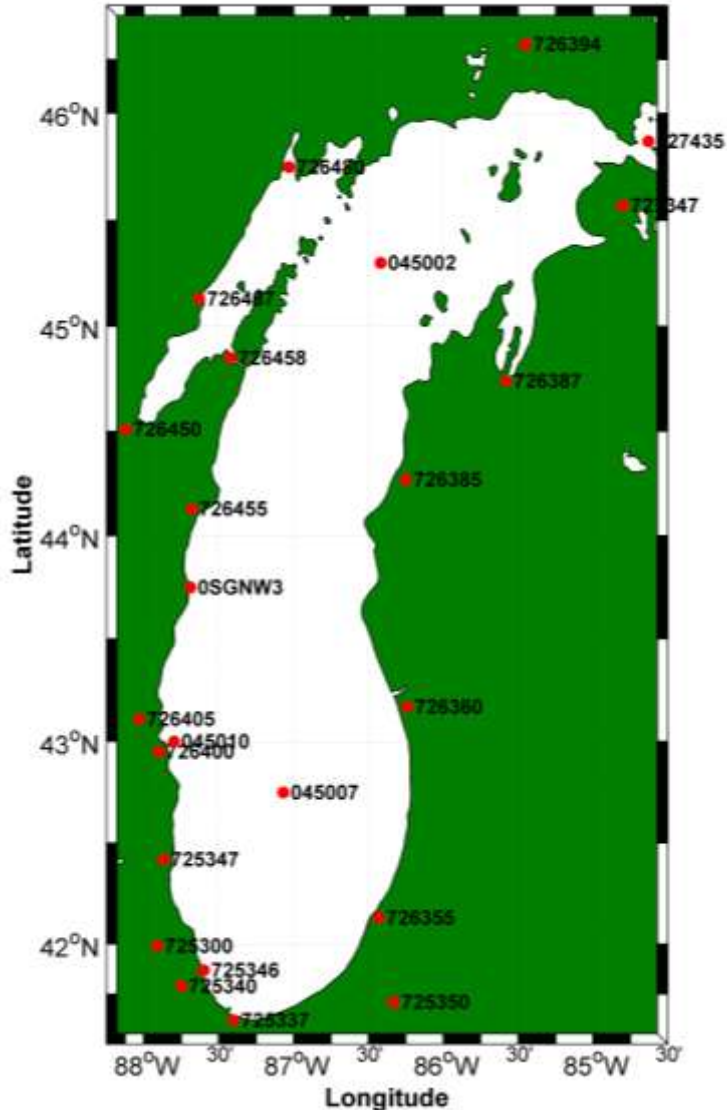
NOAA GLERL Ice Cover Data

- Ice Concentration Data Base (1960-1979)
- Digital Ice Atlas (1973-2002)
- Recent Digital Data (2003-2009)
- Data only available since 1960



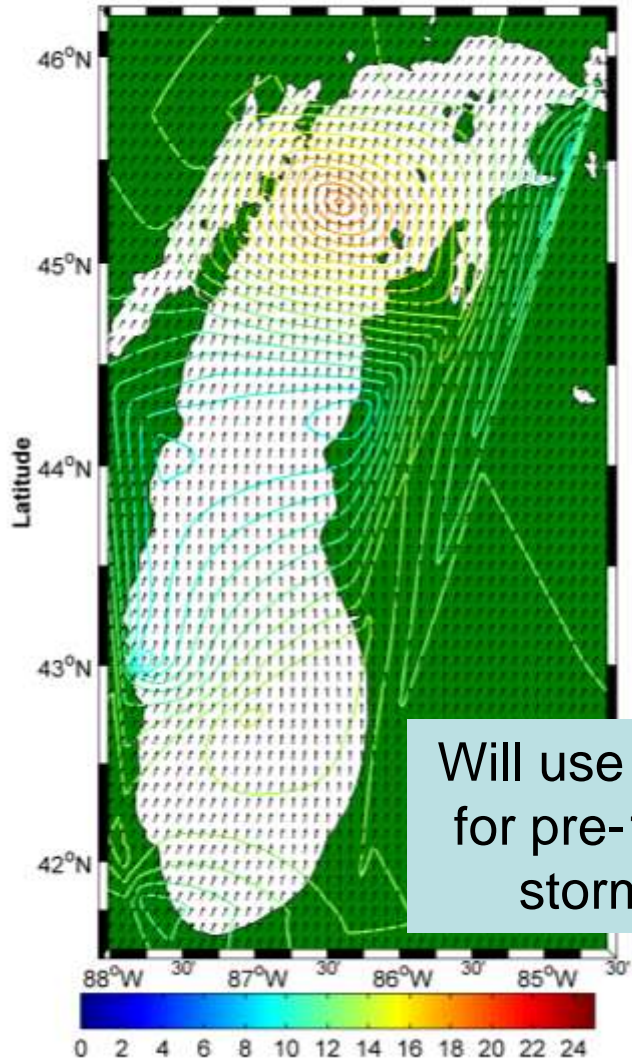
Measured Met Data Availability

Active Station Locations for STORM: 1993-268
Number of Stations: 24



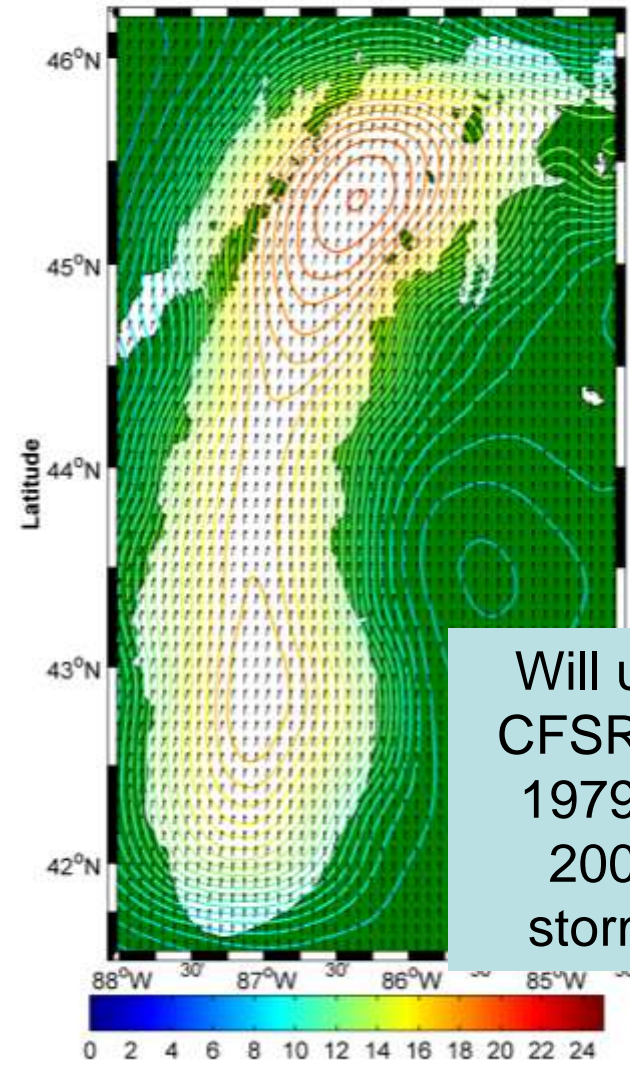
Options for Specifying Wind Fields

NN-05D-72SRes Storm6A-1993-268 Basin (Res 0.02 °)
Wind Spd and Dir at DATE: 19931001080000

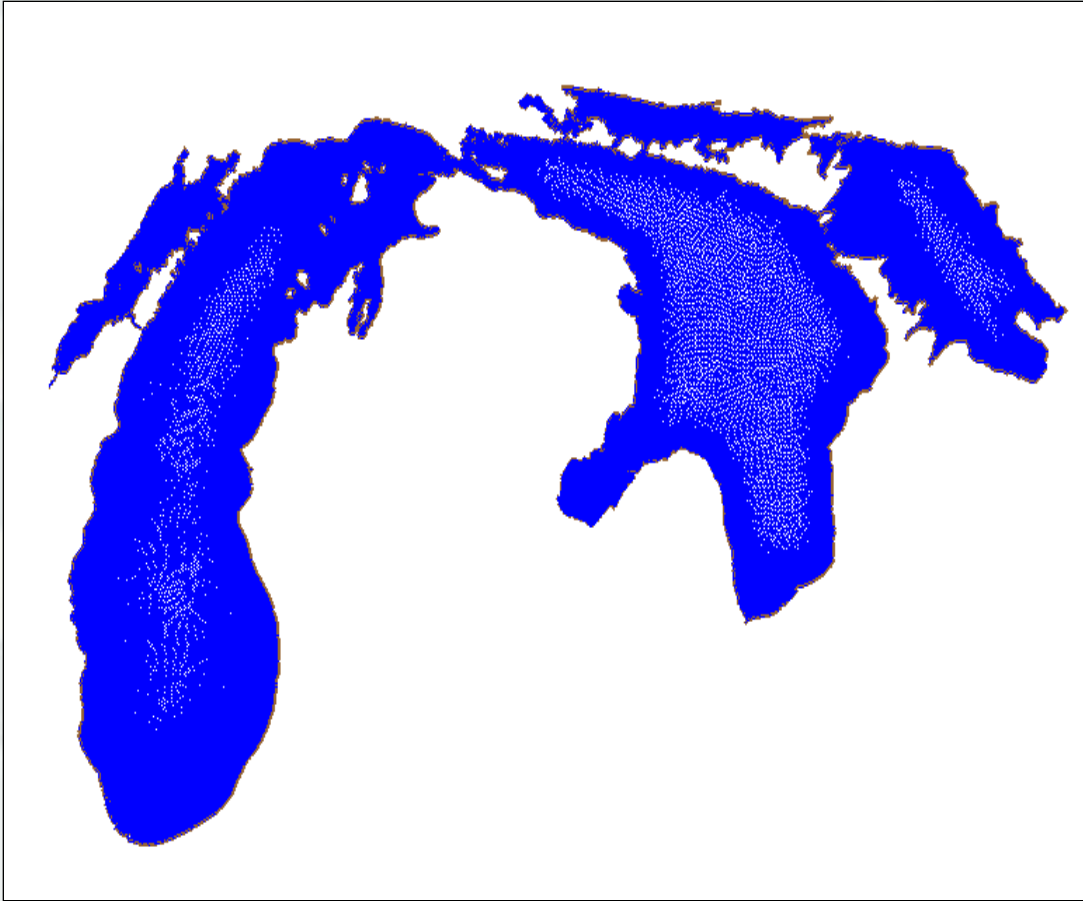


Wind Speed Contours

CFSR-05D-72SRes STORM6A-1993-268 Basin (Res 0.02 °)
Wind Spd and Dir at DATE: 19931001080000



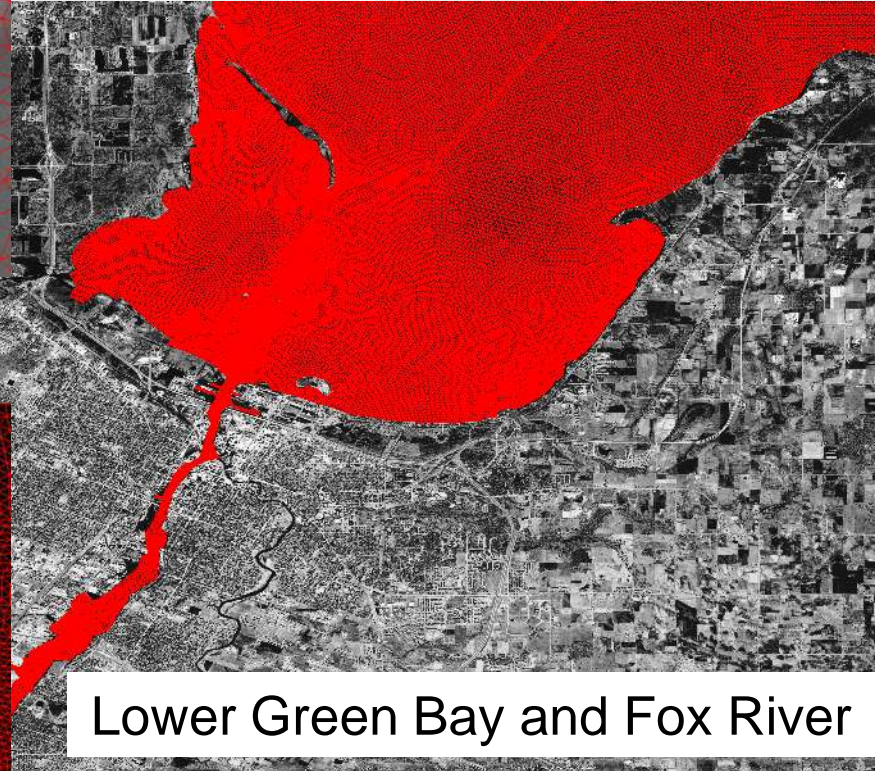
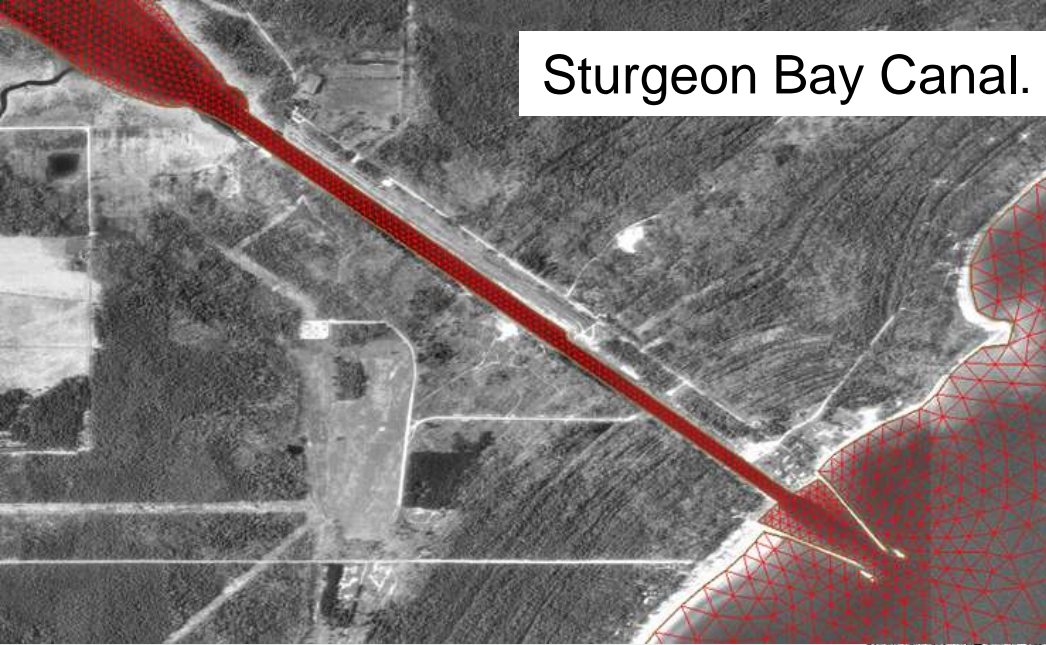
Storm Surge Modeling with ADCIRC



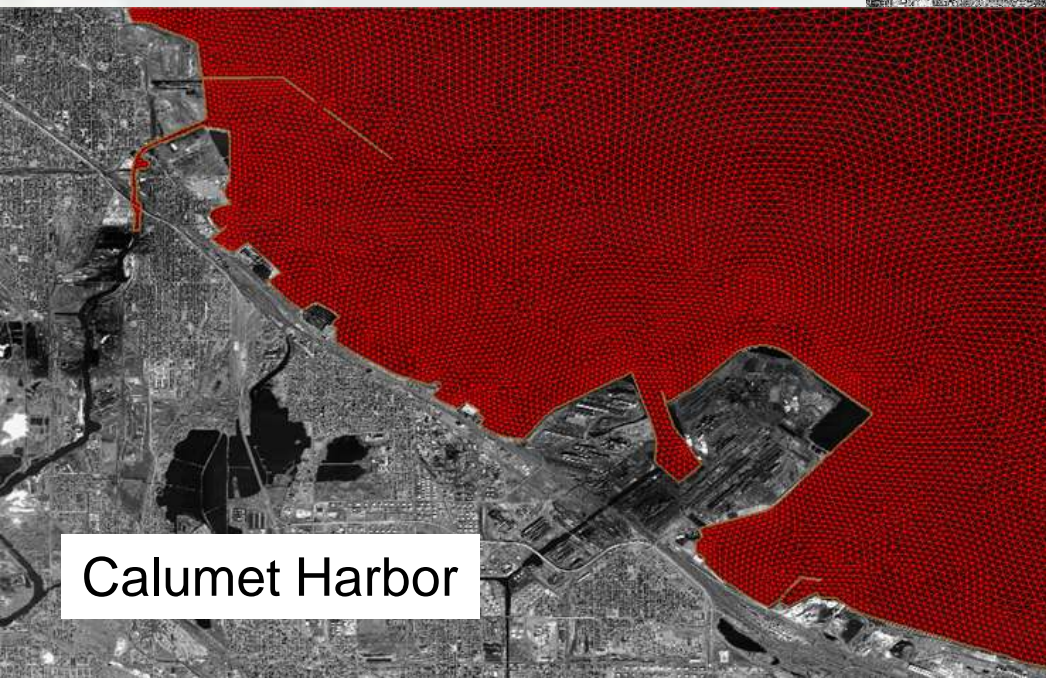
- Coupling of lakes required to accurately model water exchange between lakes associated with moving low pressure systems
- Can increase water level throughout Lake Michigan and Green Bay by as much as 1.5 ft



Sturgeon Bay Canal.



Lower Green Bay and Fox River



Calumet Harbor



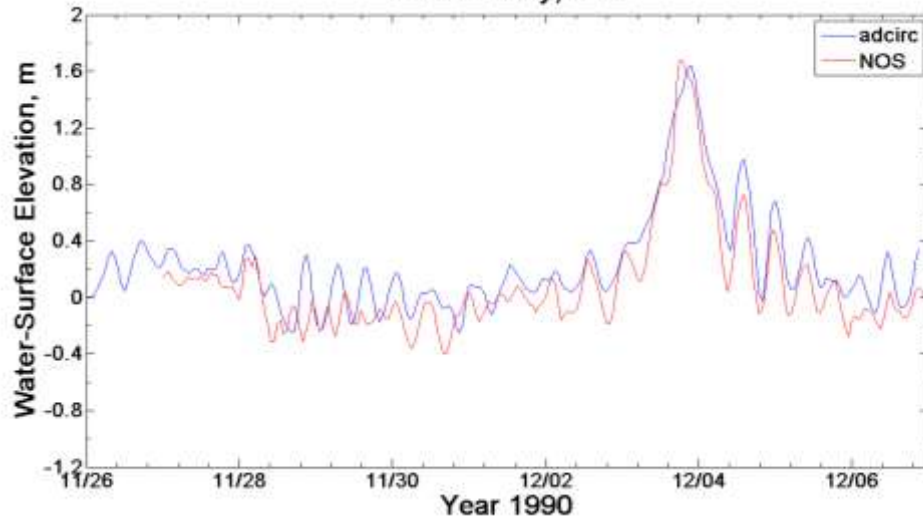
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Water Level Measurement Locations



ADCIRC Model Comparisons to Measurements (Dec 1990 Storm)

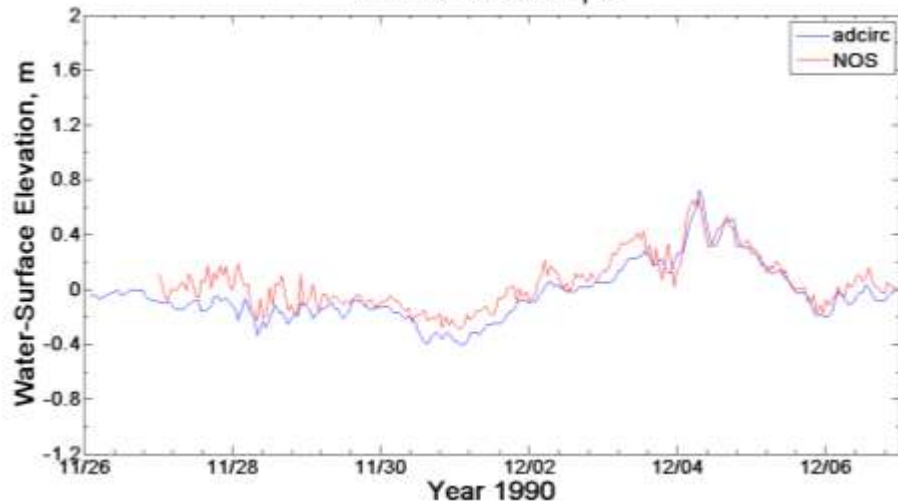
Green Bay, WI



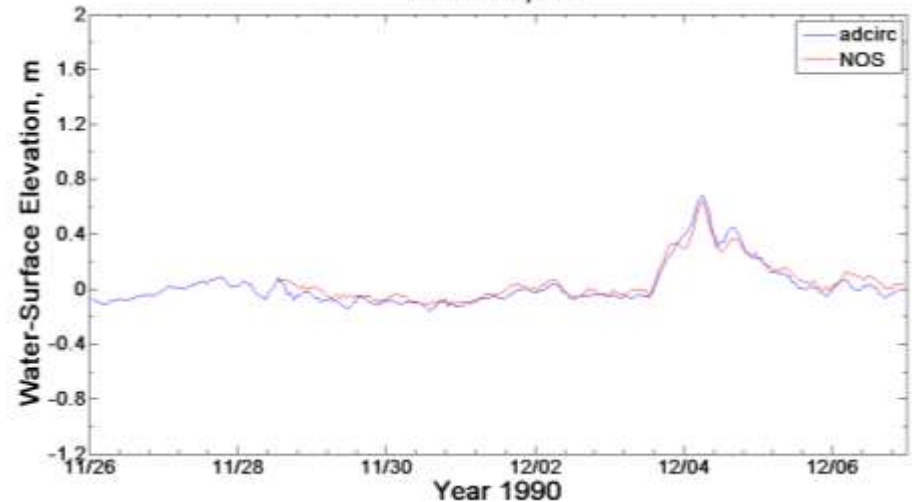
Milwaukee, WI



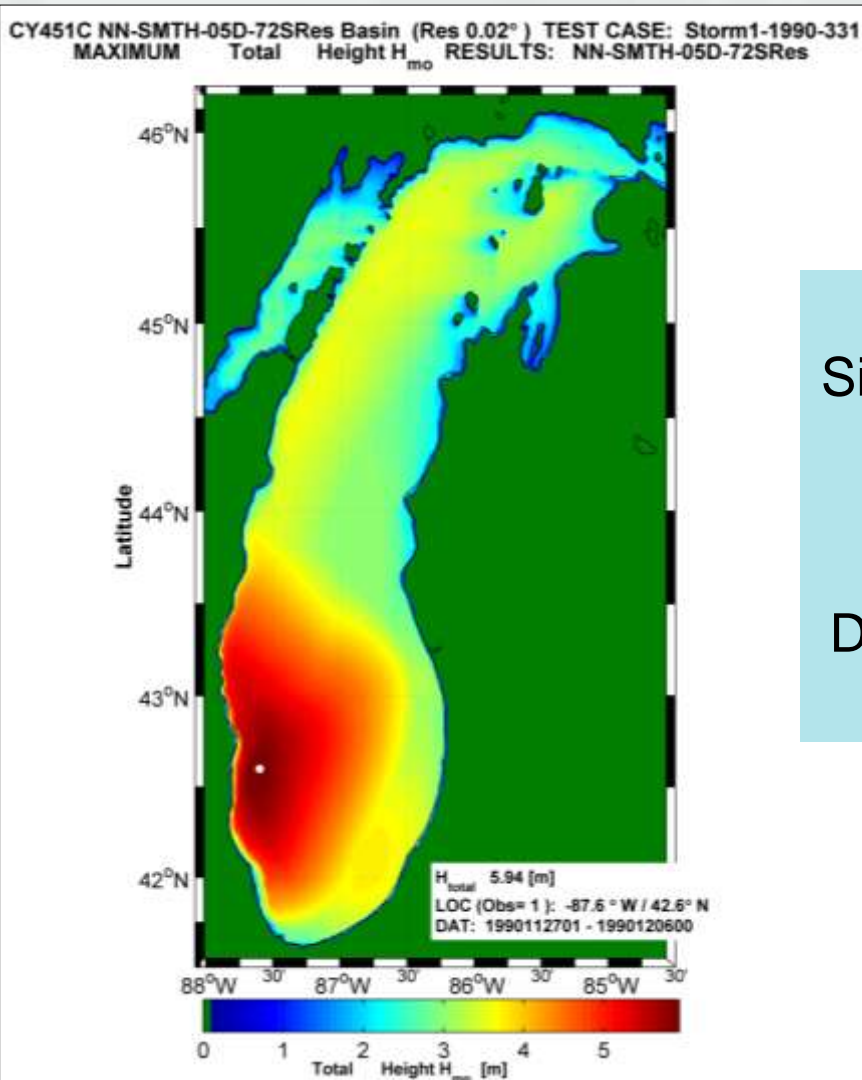
Calumet Harbor, IL



Holland, MI

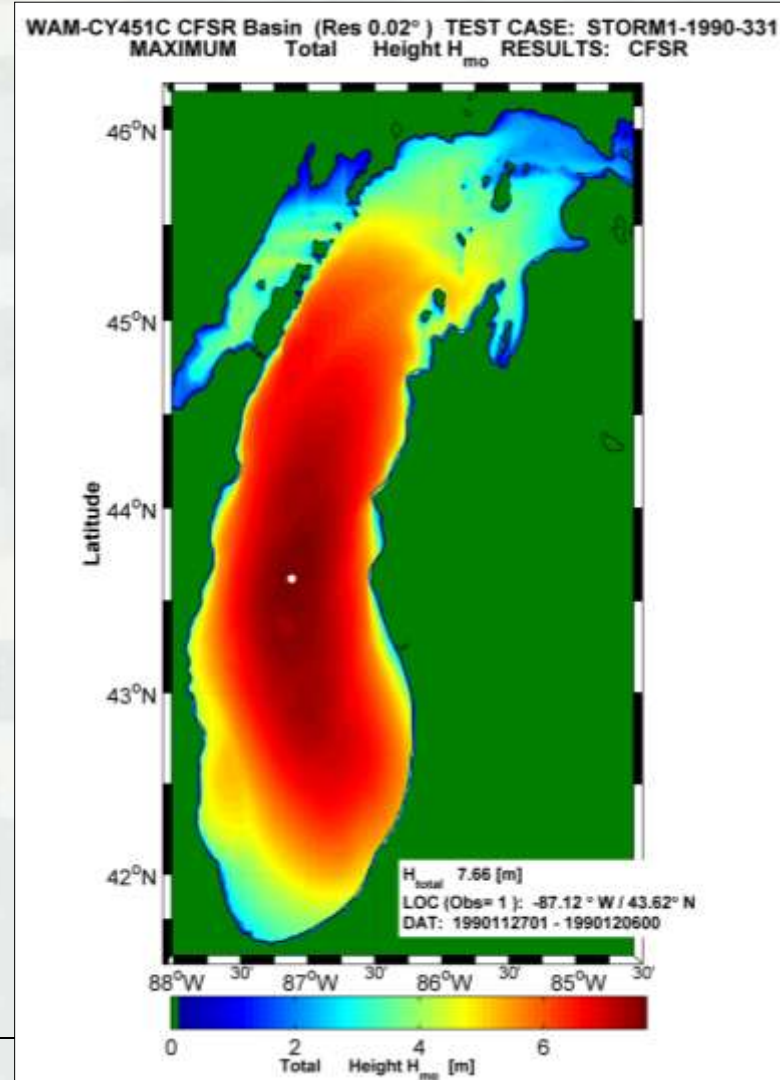


Lake-Scale Wave Modeling Using WAM



Max
Significant
Wave
Height

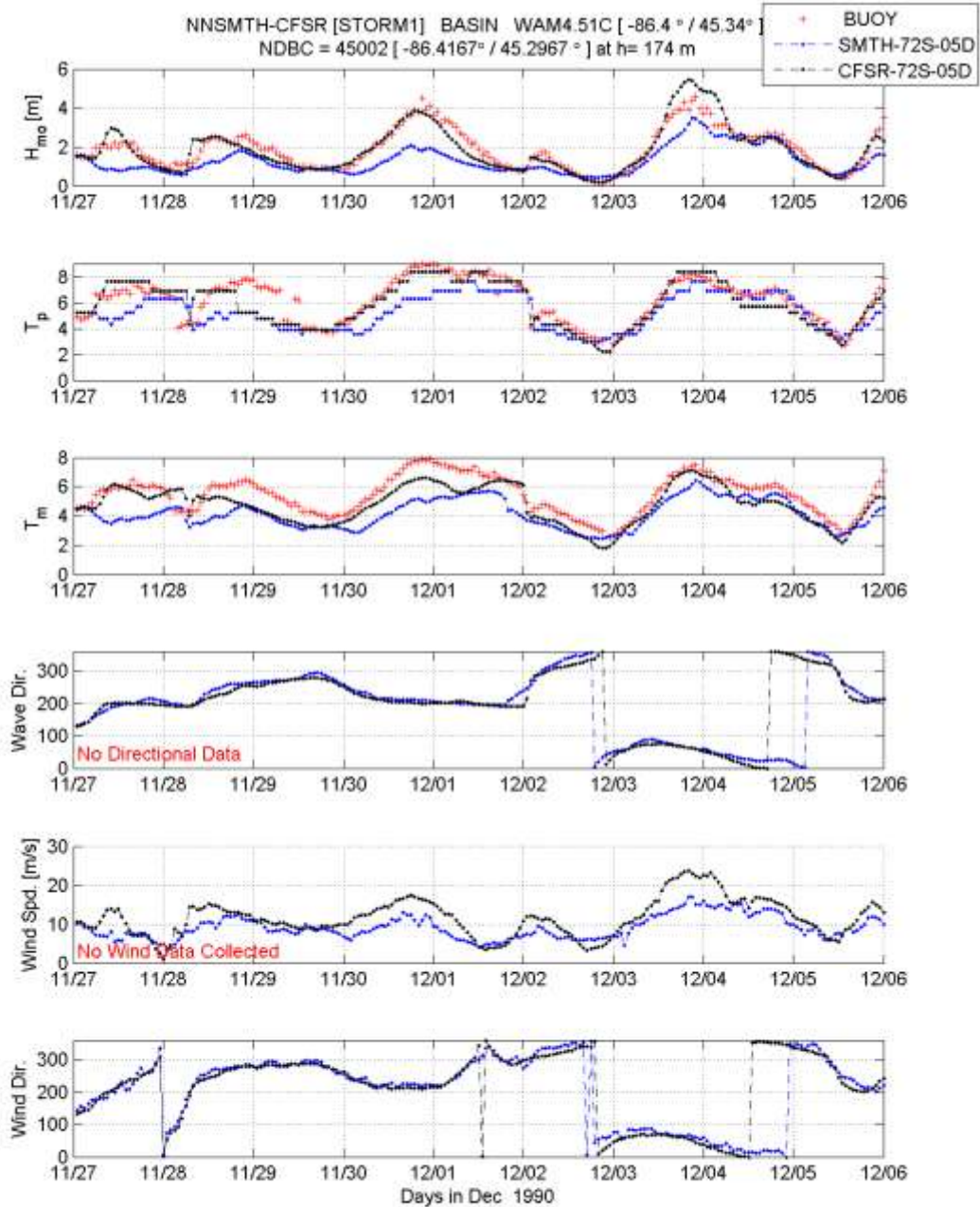
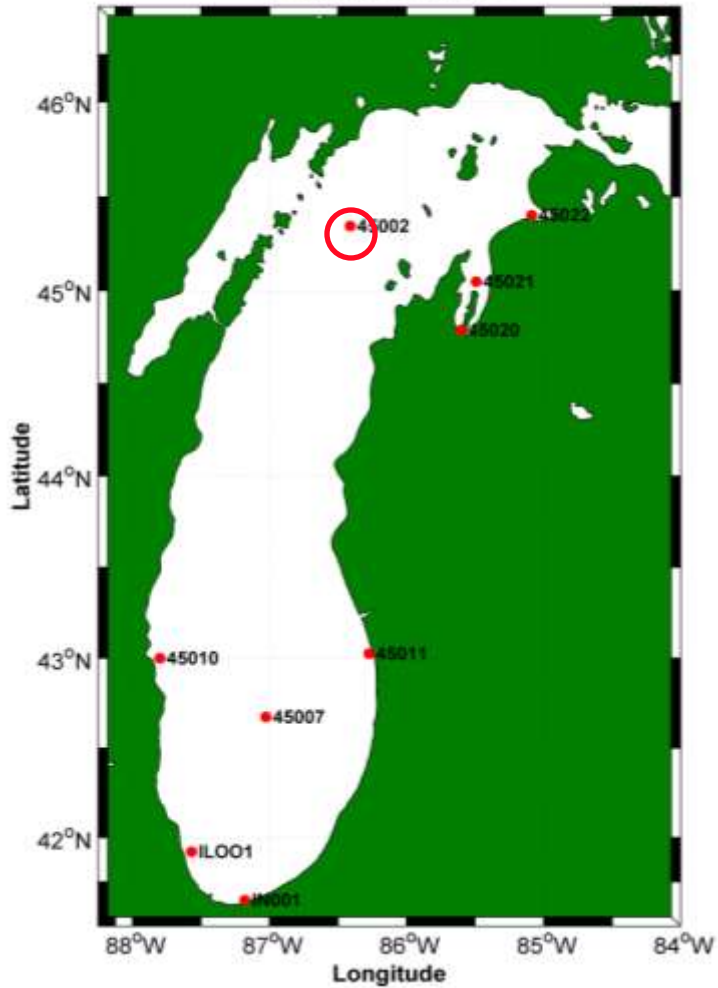
Dec 1990
Storm



Natural Neighbor Method Winds

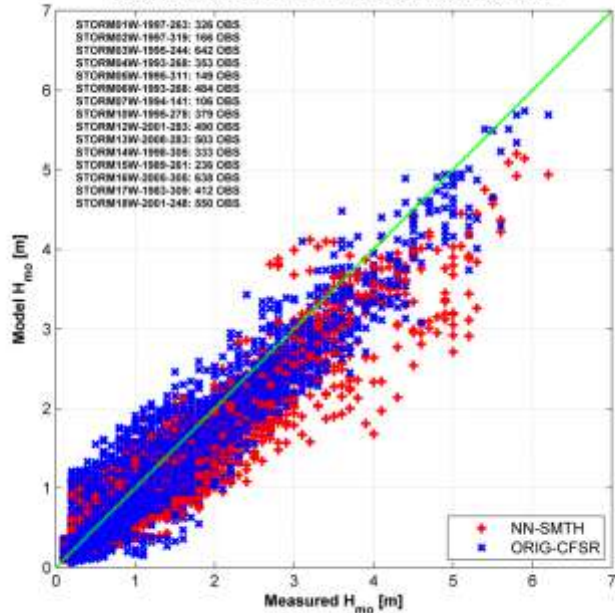
CFSR Reanalysis Winds

Active Point Source Wave Measurements 1979-2009
Number of Stations: 9

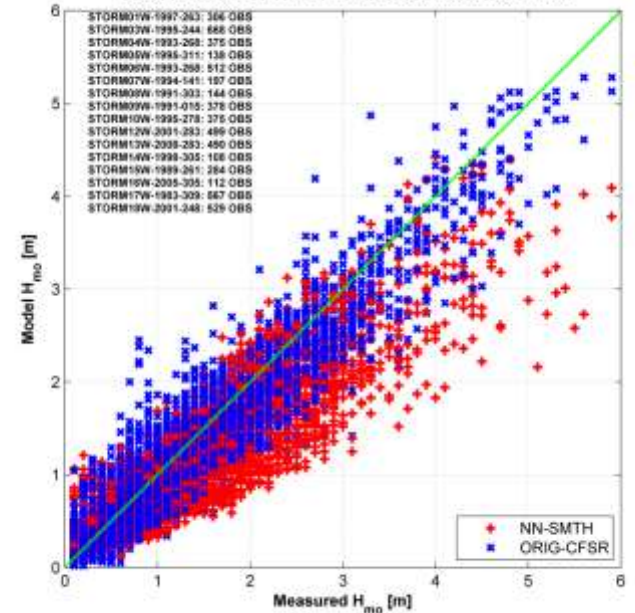


Dec 1990 Storm

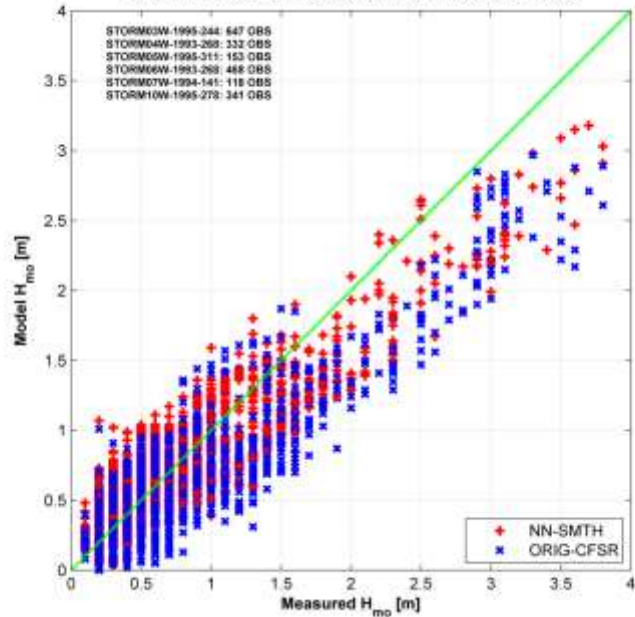
Time Paired Comparisons NDBC 45007
Total Number of Time Paired Observations: 5767



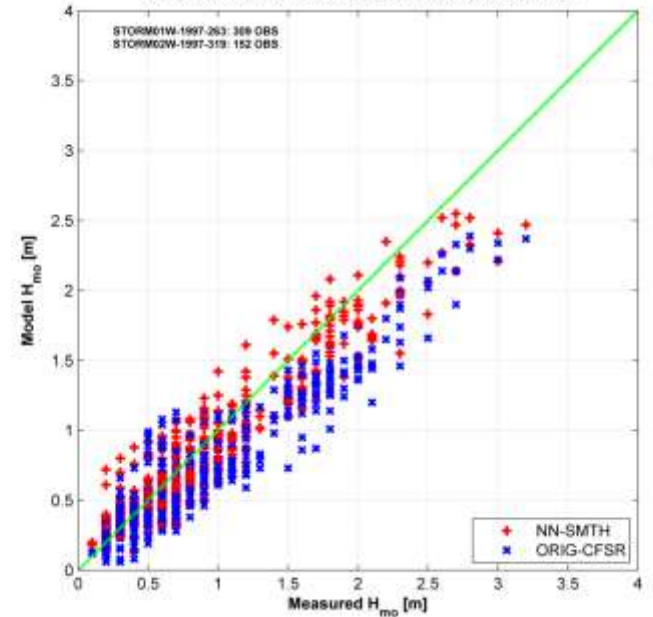
Time Paired Comparisons NDBC 45002
Total Number of Time Paired Observations: 5682

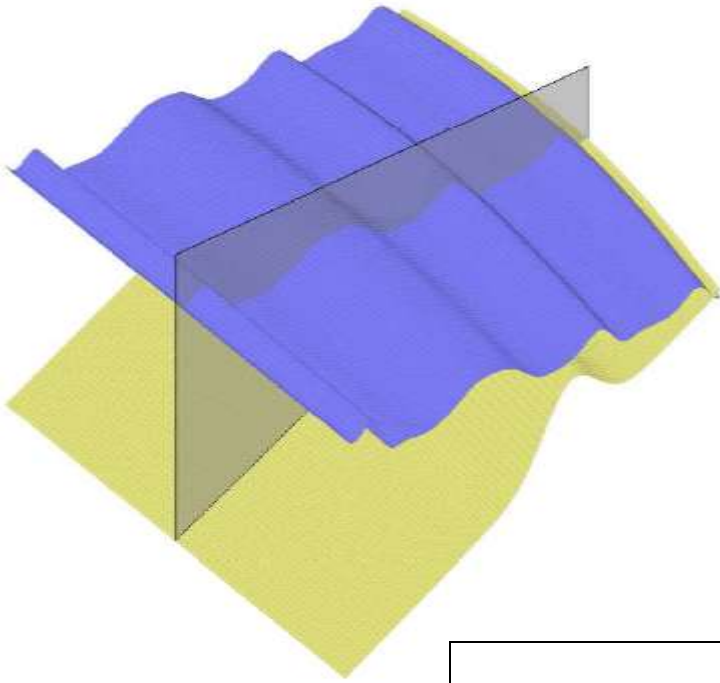


Time Paired Comparisons NDBC 45010
Total Number of Time Paired Observations: 2059

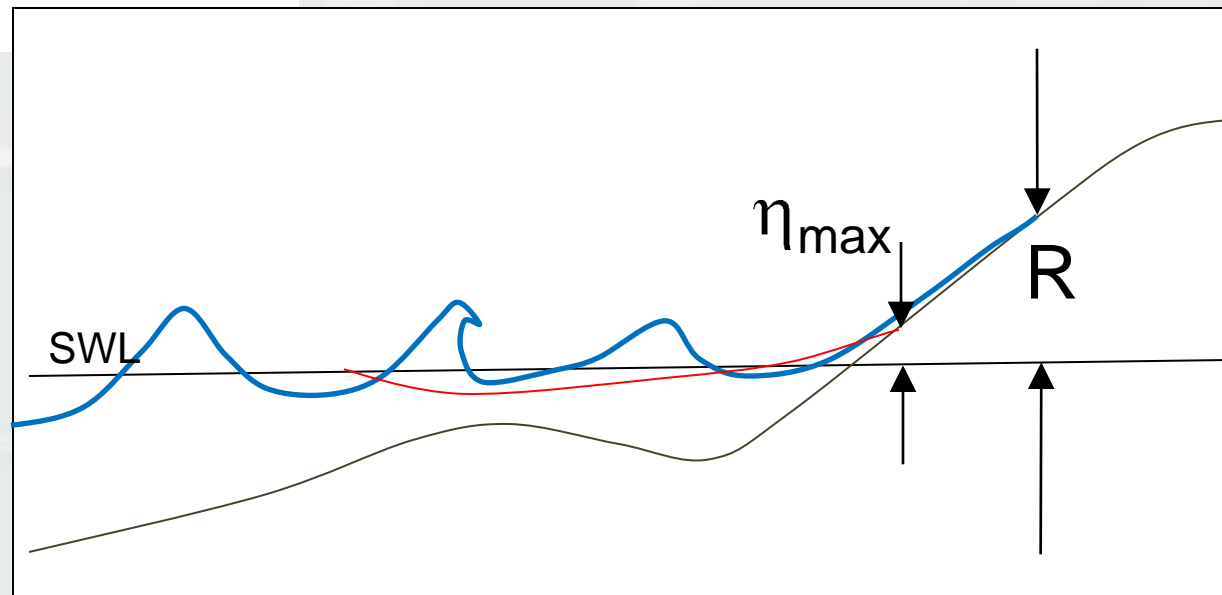


Time Paired Comparisons NDBC 45011
Total Number of Time Paired Observations: 461





Nearshore Dynamics and Wave Run-up Modeling with CSHORE

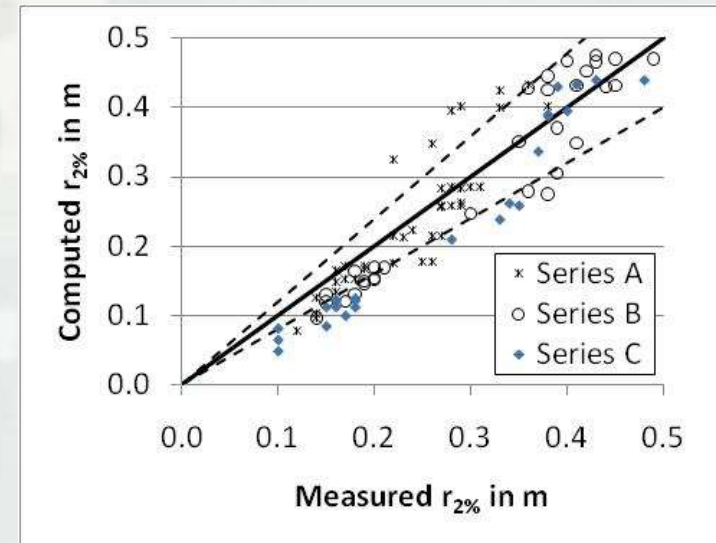
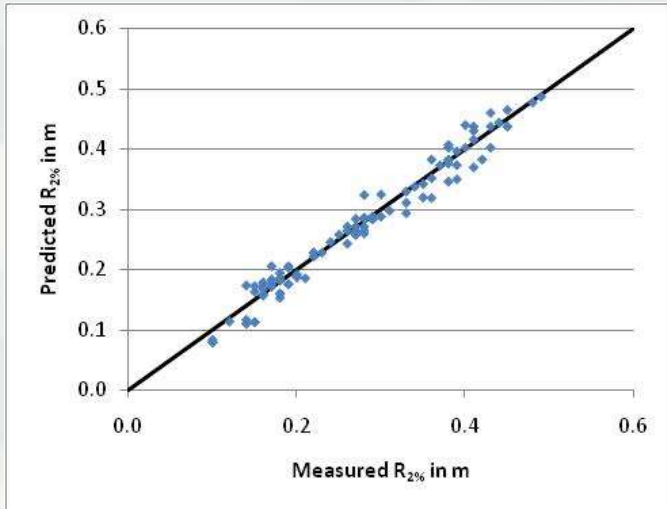


Run-up Validation Data Sets

- Ahrens (1975, 1985) (ACES) (older monochromatic data)
- Mase (1989) (uniform plane impermeable slopes, small-scale lab)
- De Wall and Van der Meer (1992) (TAW)
- Van Gent (1999a, 1999b) (4 model and prototype levee experiments)
- Stockdon et al. (2004) (9 beach experiments, all video runup meas.)

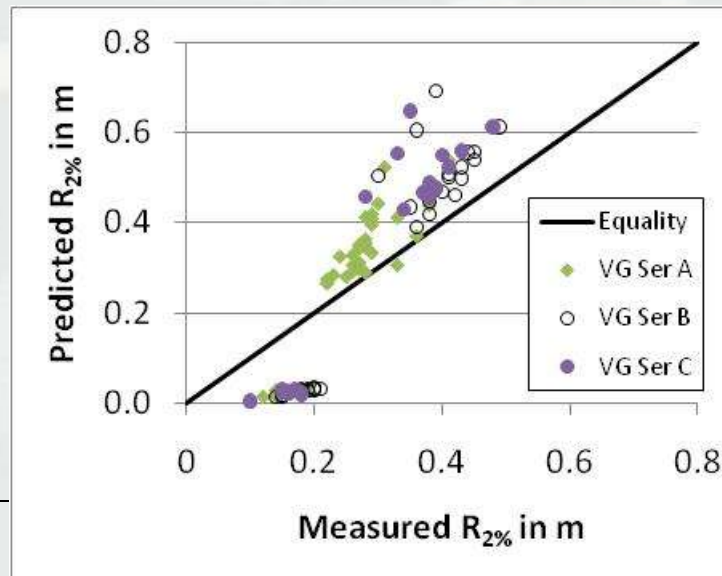


Van Gent Series A, B, C



Van Gent
Empirical
Equation

Runup 2.0

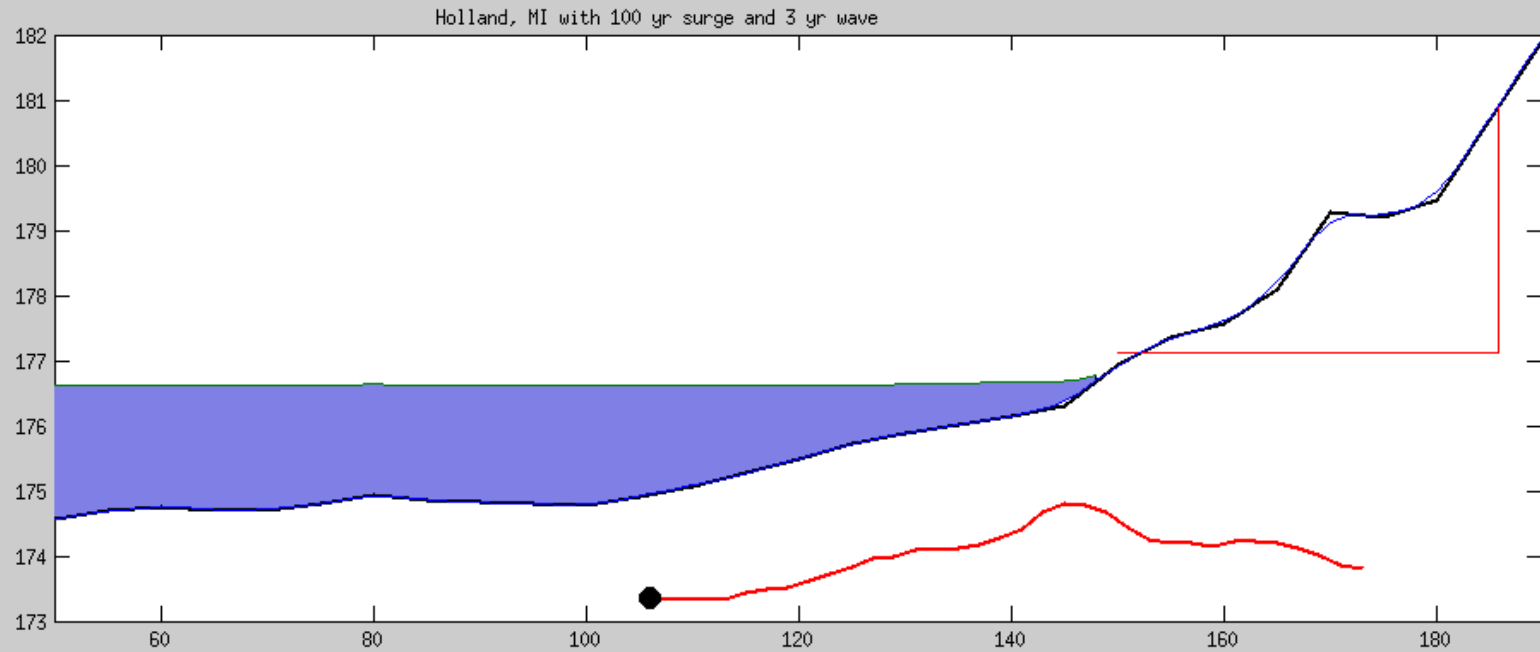


CSHORE



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Beach Erosion Simulations



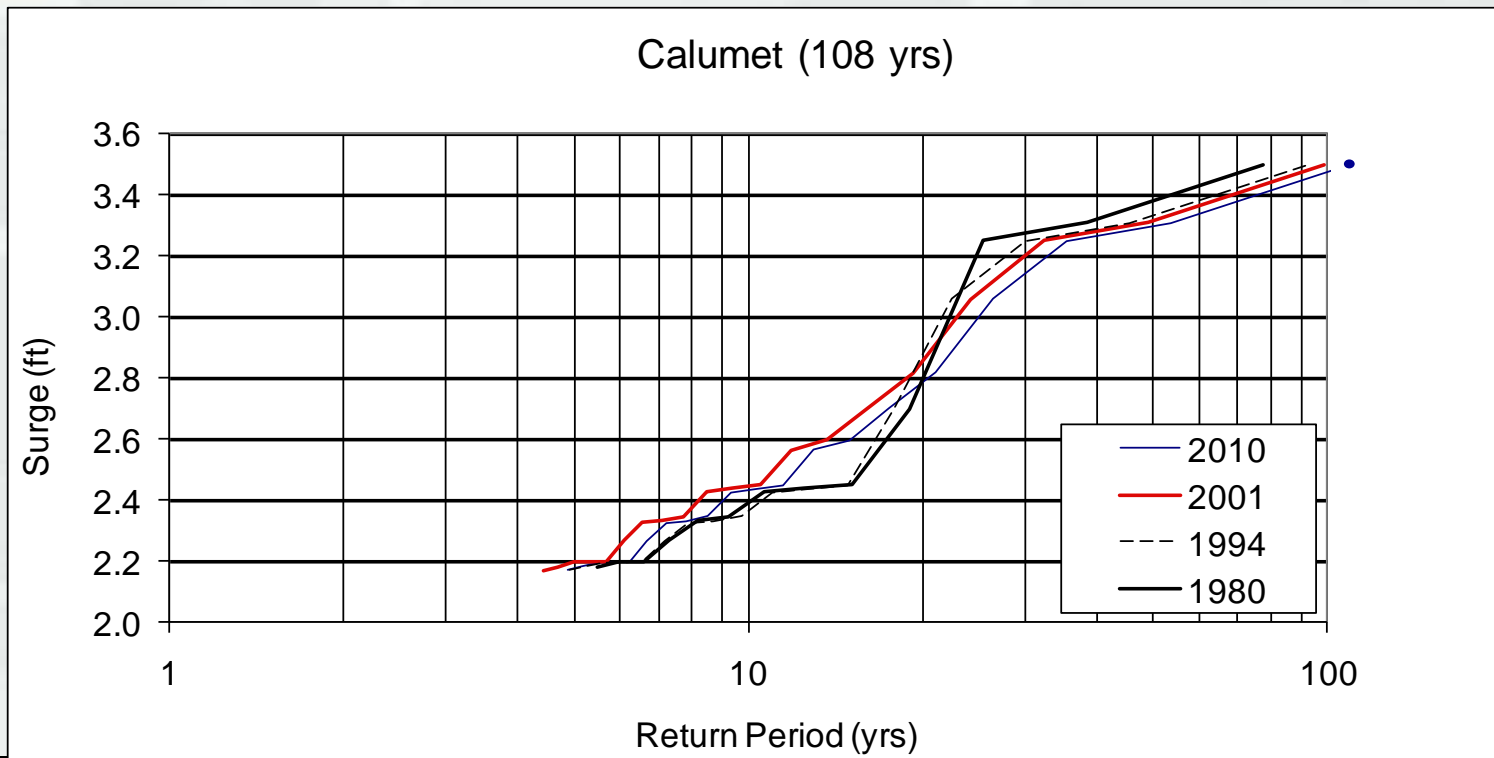
Holland, MI morphology change using CSHORE



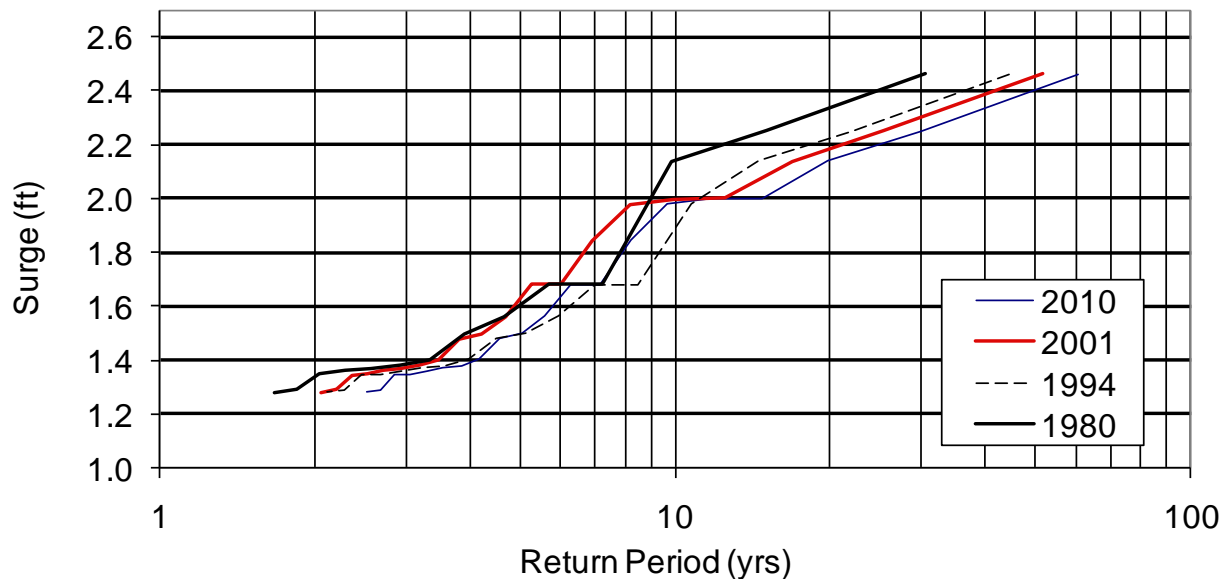
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Water Level Statistics

- Points-over-threshold approach to selecting storms, versus annual maximum series
- Adequacy of the storm record length

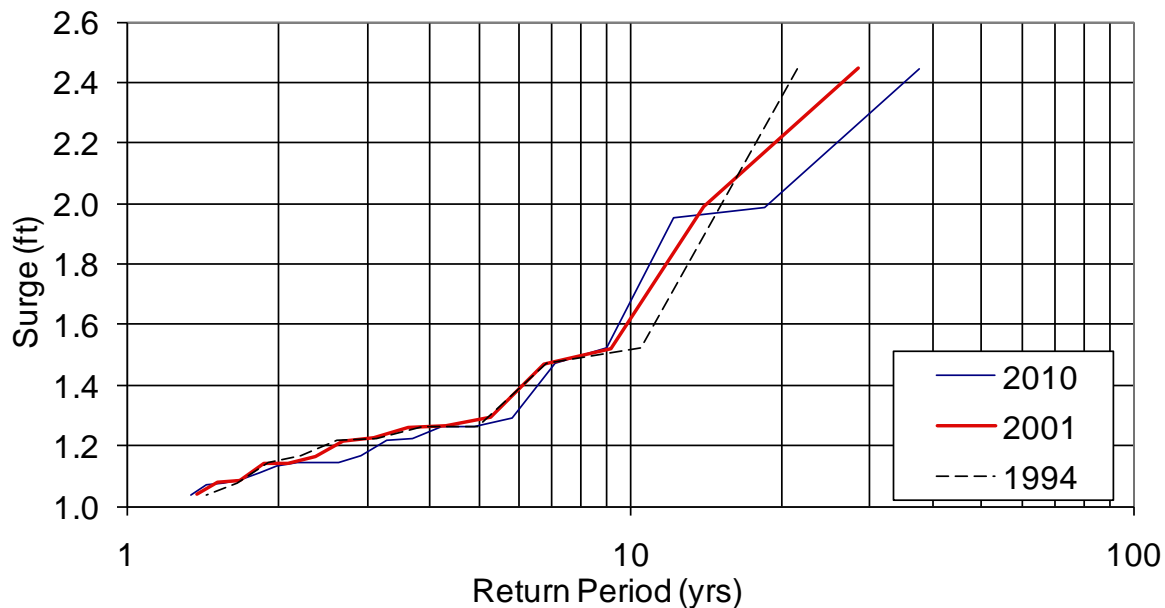


Sturgeon Bay (61 yrs)



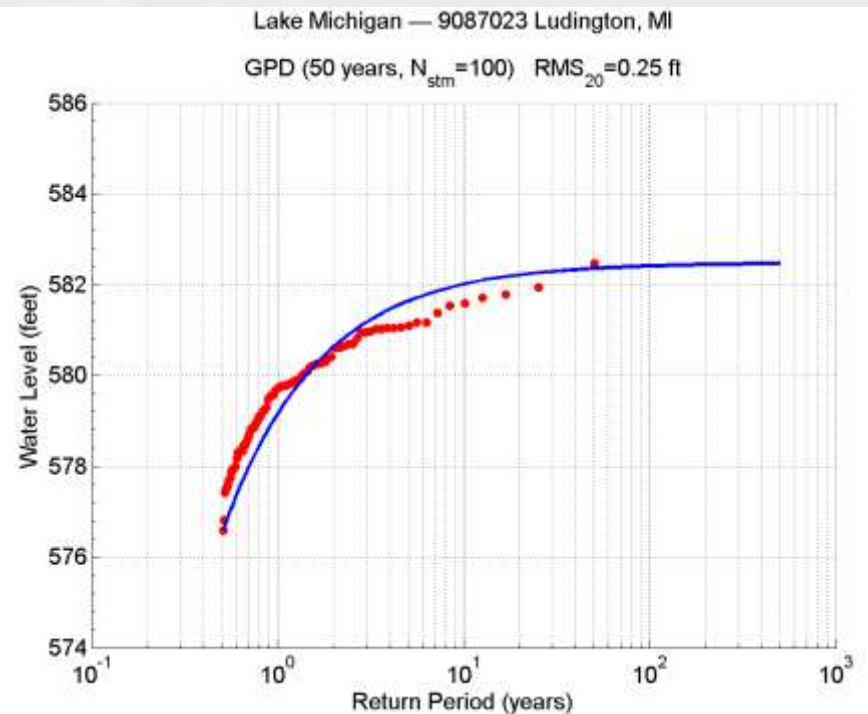
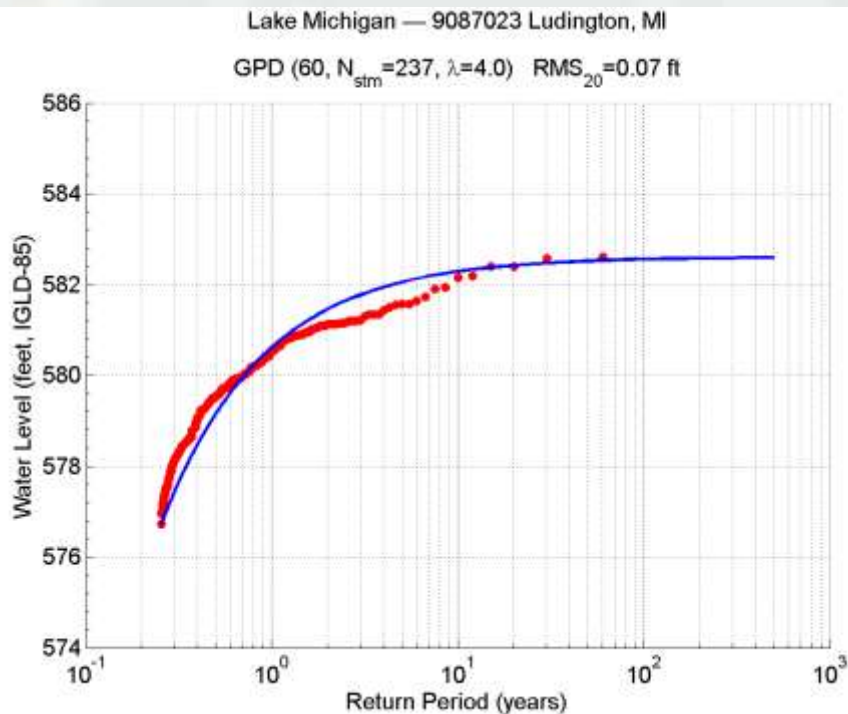
- Maximize record length for storms
- Minimum of 50 years; 50 years dictated in large part by met data availability for storm modeling

Kewaunee (38 yrs)



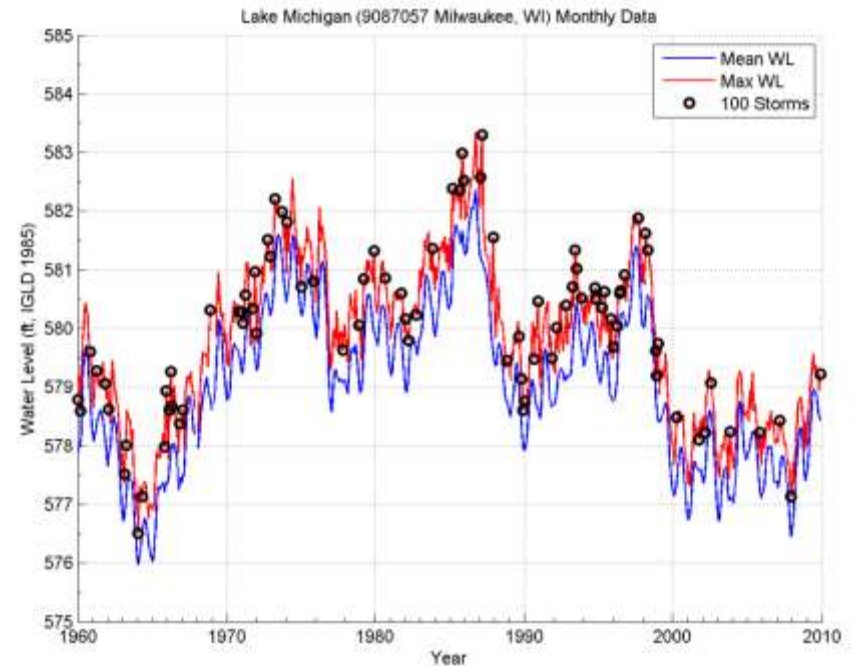
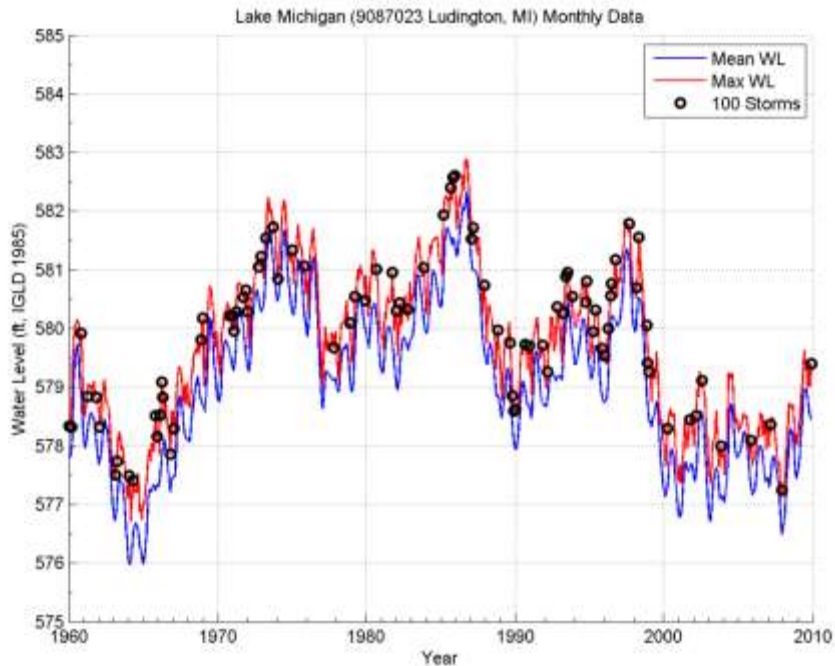
Storm Sample Size

- Challenge – Produce reliable statistics in the extreme tail of distribution, throughout the lake system, with minimum number of storms
- Verification of Statistical Approach
 - *Full set vs. 100-storms Composite set – Water Level*
 - *100 storms minimum – will simulate 150*



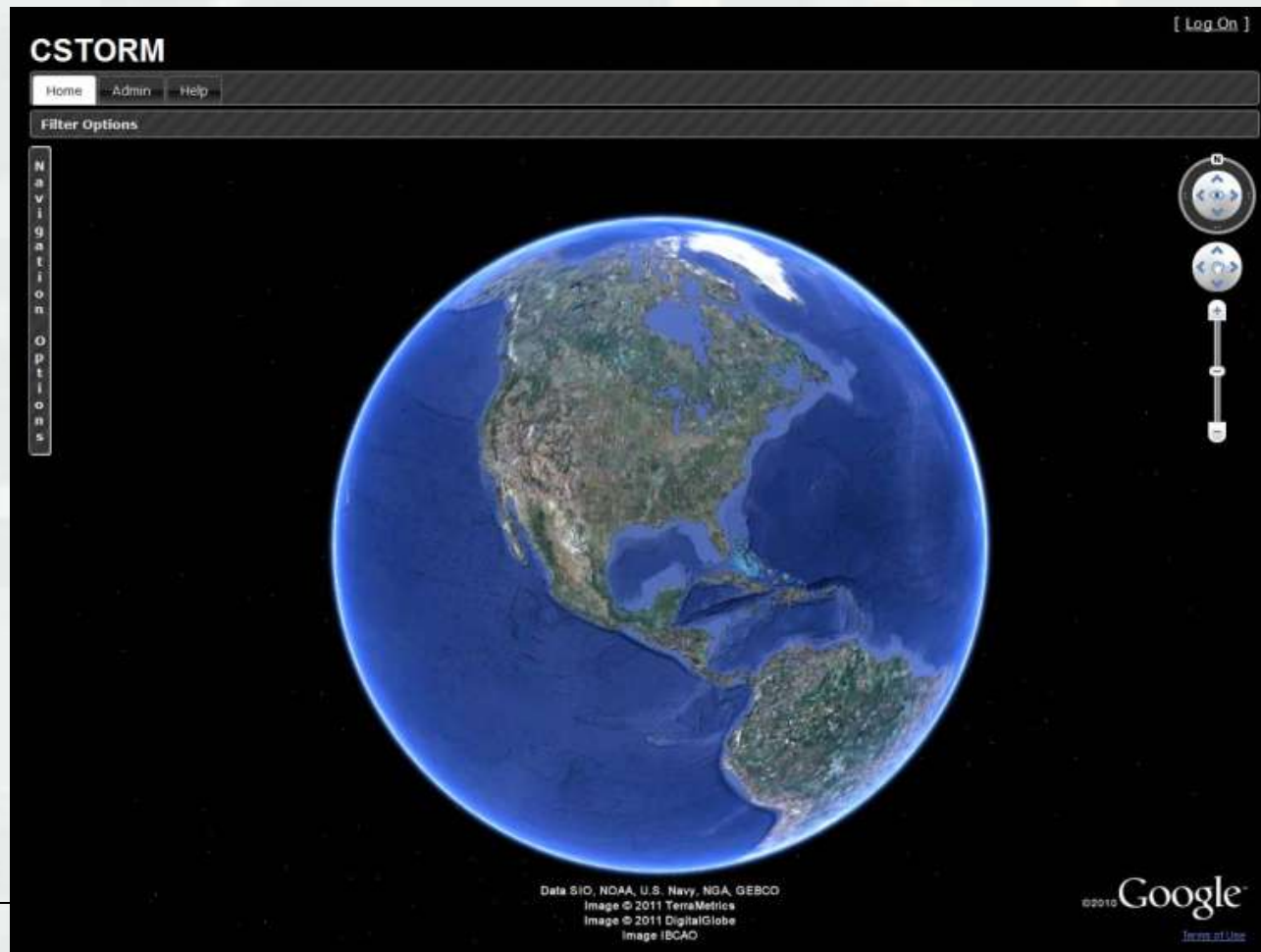
Storm Sample Size

- Sample-Size Adequacy
 - Sampling during **High** and **Low** lake water levels...



CSTORM-DB/VS

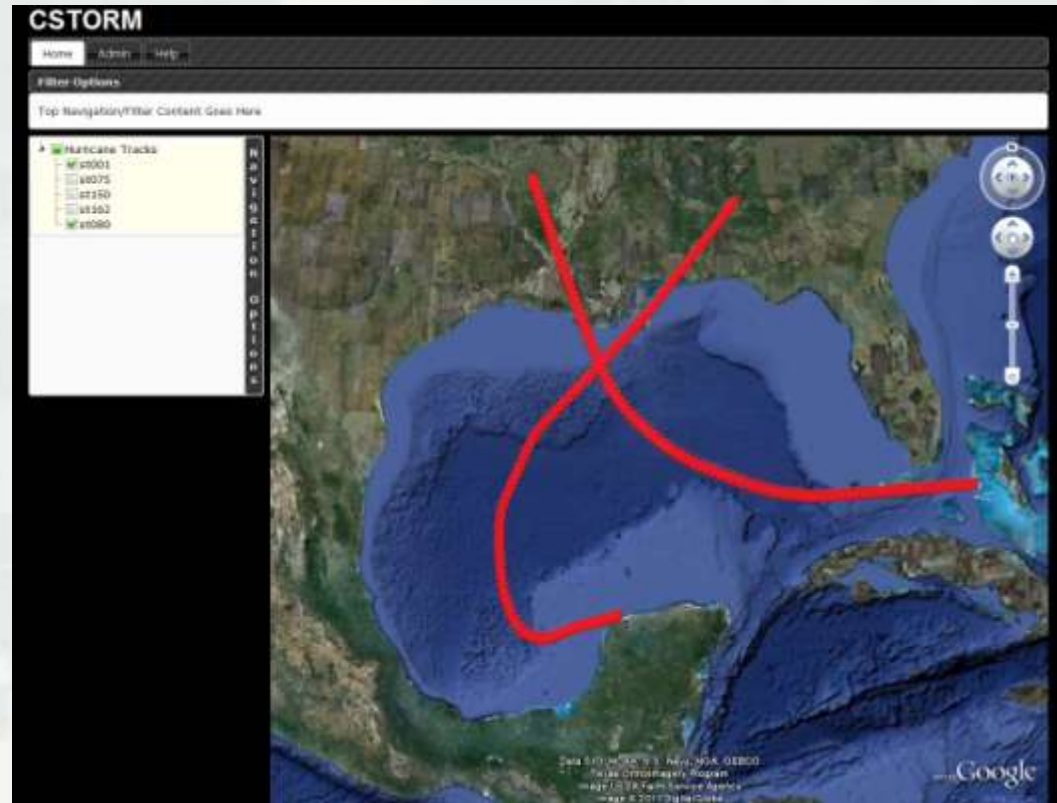
Web-Based Data Archive, Monitoring, and Mining
Tool for Coastal Storms



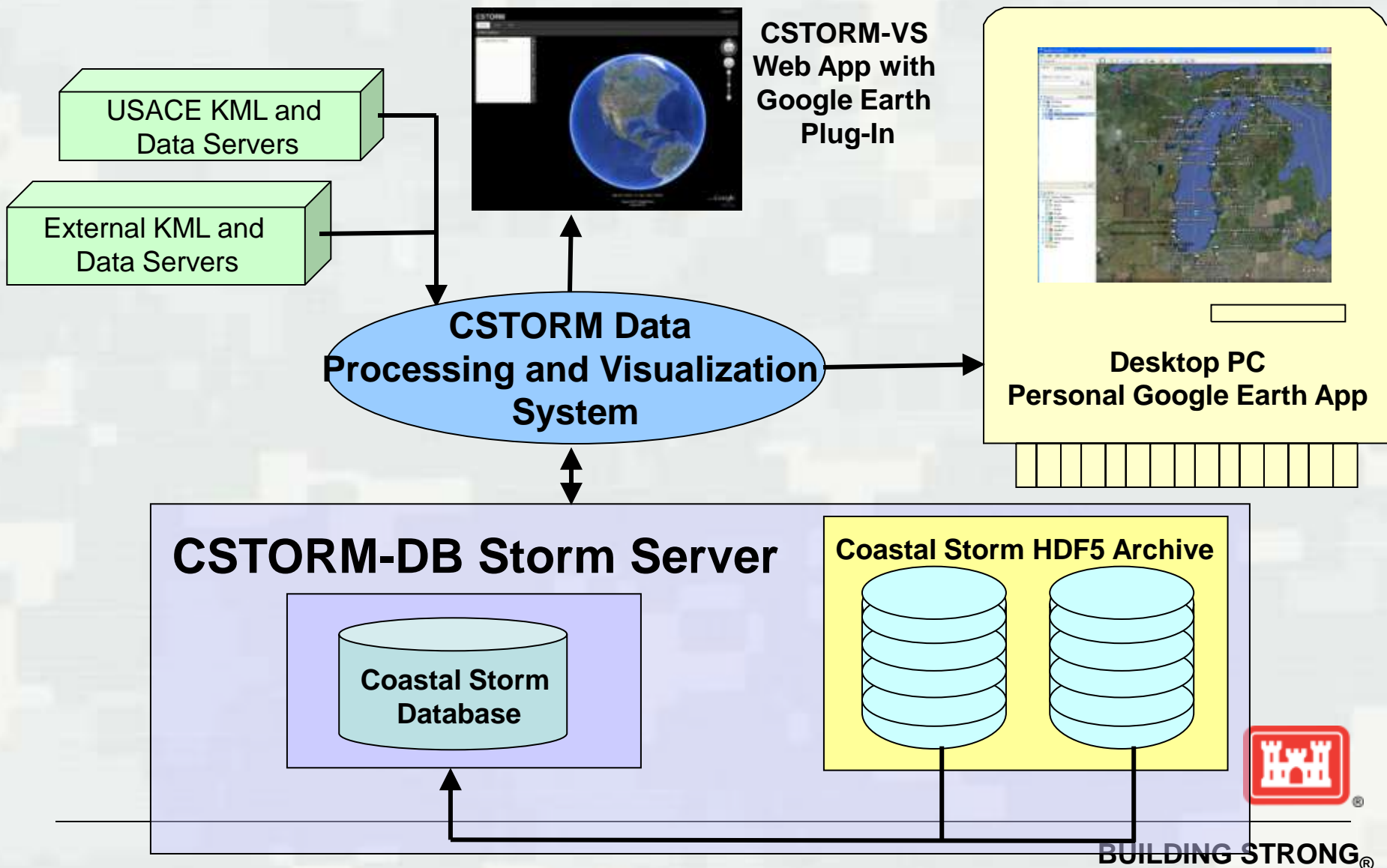
INDING STRONG®

CSTORM-DB/VS

- Long-term archive/database of measured and modeled coastal storm data
- Easily accessible data; search, browse, visualize, process, analyze for FIRM preparation
- Contextual data products and tools that support decision making
 - Risk management, assessment, communication
 - Project design and evaluation
 - Emergency management, operations



CSTORM-DB/VS



Station Information

CSTORM - Windows Internet Explorer
http://localhost:50805/

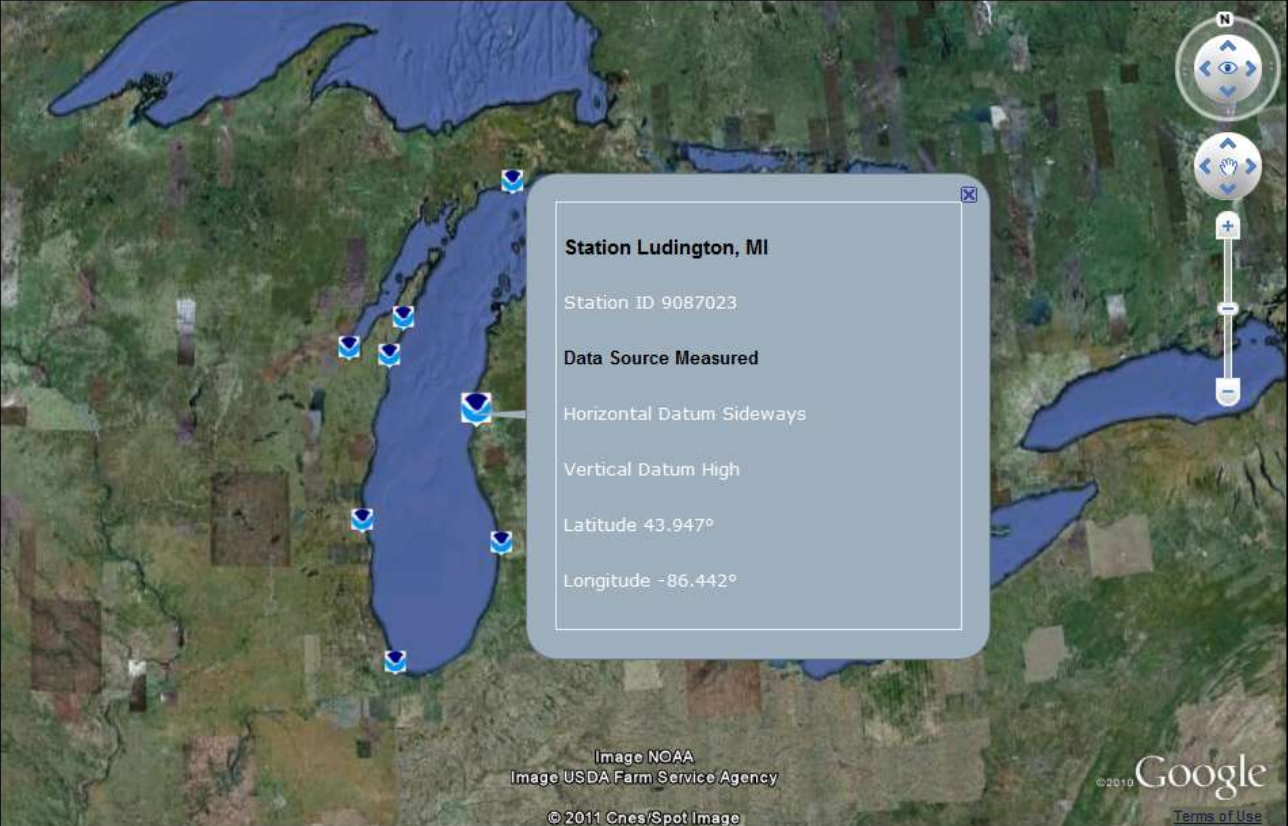
Home Admin Help

Filter Options

Selected Items

- Stations
 - Ludington, MI
 - Holland, MI
 - Calumet Harbor, IL
 - Milwaukee, MI
 - Kewaunee, WI
 - Sturgeon Bay Canal, WI
 - Green Bay, WI
 - Port Inland, MI
 - Mackinaw City, MI

Navigation Options

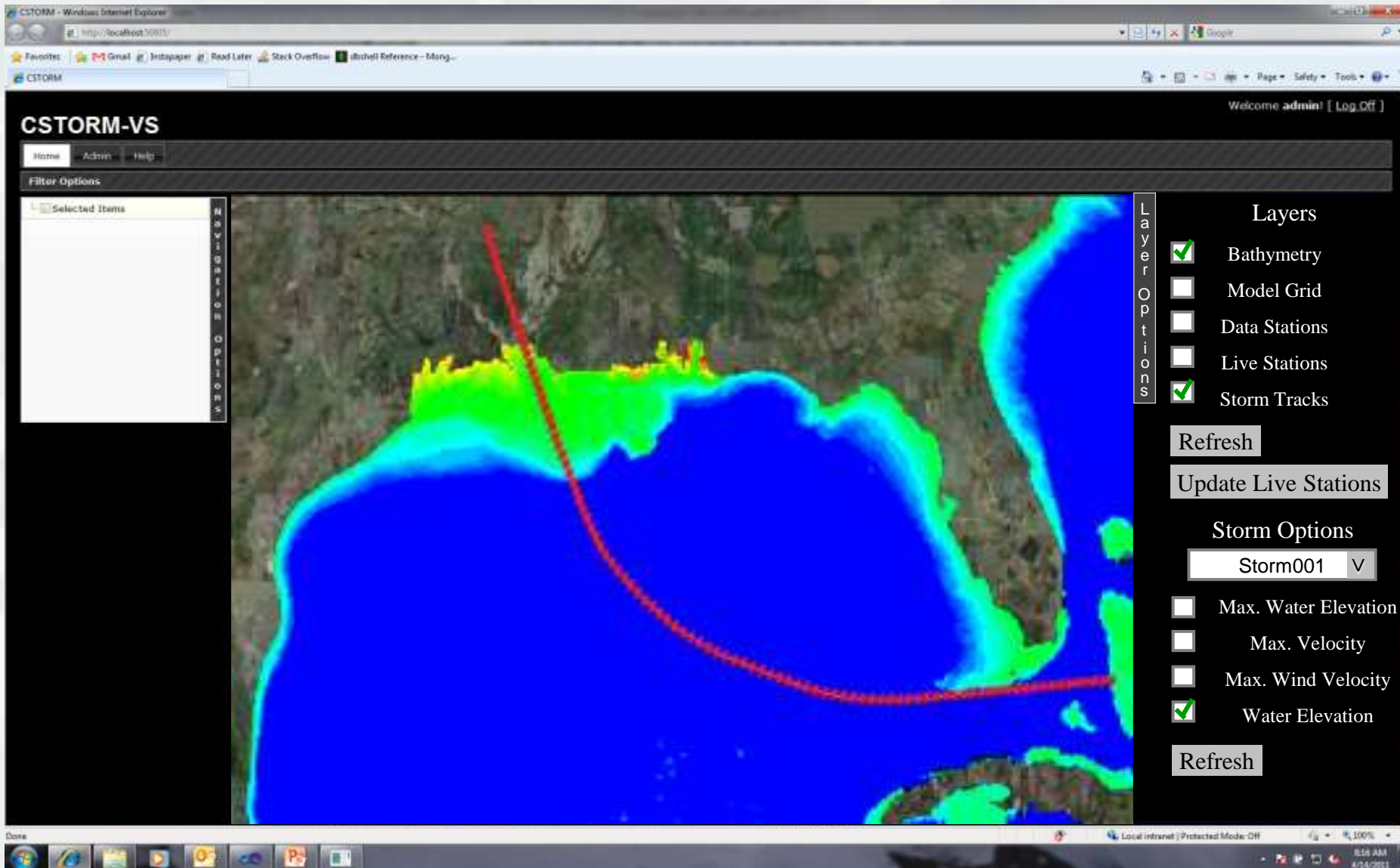


Station Ludington, MI
Station ID 9087023
Data Source Measured
Horizontal Datum Sideways
Vertical Datum High
Latitude 43.947°
Longitude -86.442°

Image NOAA
Image USDA Farm Service Agency
© 2011 Cnes/Spot Image
Google
© 2010
Terms of Use

Local intranet | Protected Mode: Off
100%

Contour Plots



Data for Lake Michigan

- For 12 day storm with peak WSE at day 9
 - ▶ ADCIRC time series at ~600 points at 15 minutes
 - WSE, water velocity, pressure, wind velocity, ice percentage
 - ▶ ADCIRC Field files at 30 minutes
 - WSE, water velocity, pressure, wind velocity, ice percentage
 - ▶ WAM at similar number of points
 - Bulk parameters, 2D spectra
 - ▶ STWAVE – same wave output
- Ice fields, wind fields, grids, bathymetry, Input files, metadata
- Historical measurements from water level, meteorological, wave gages
- Processed results such as lake level, statistics, etc



Questions?

