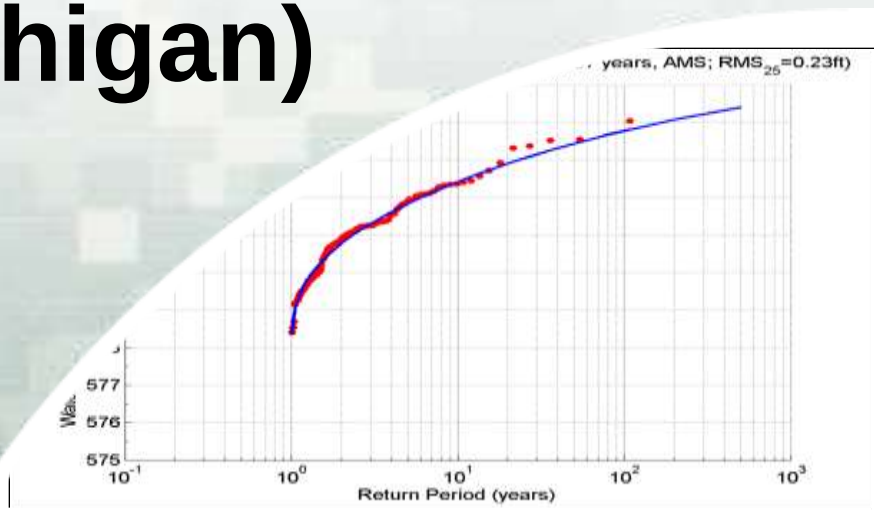
Great Lakes Flood Hazard Mapping Project - Data Development (Lake Michigan)

Bruce Ebersole

USACE Engineer Research and Development Center

Coastal and Hydraulics Lab



FEMA

US Army Corps of Engineers
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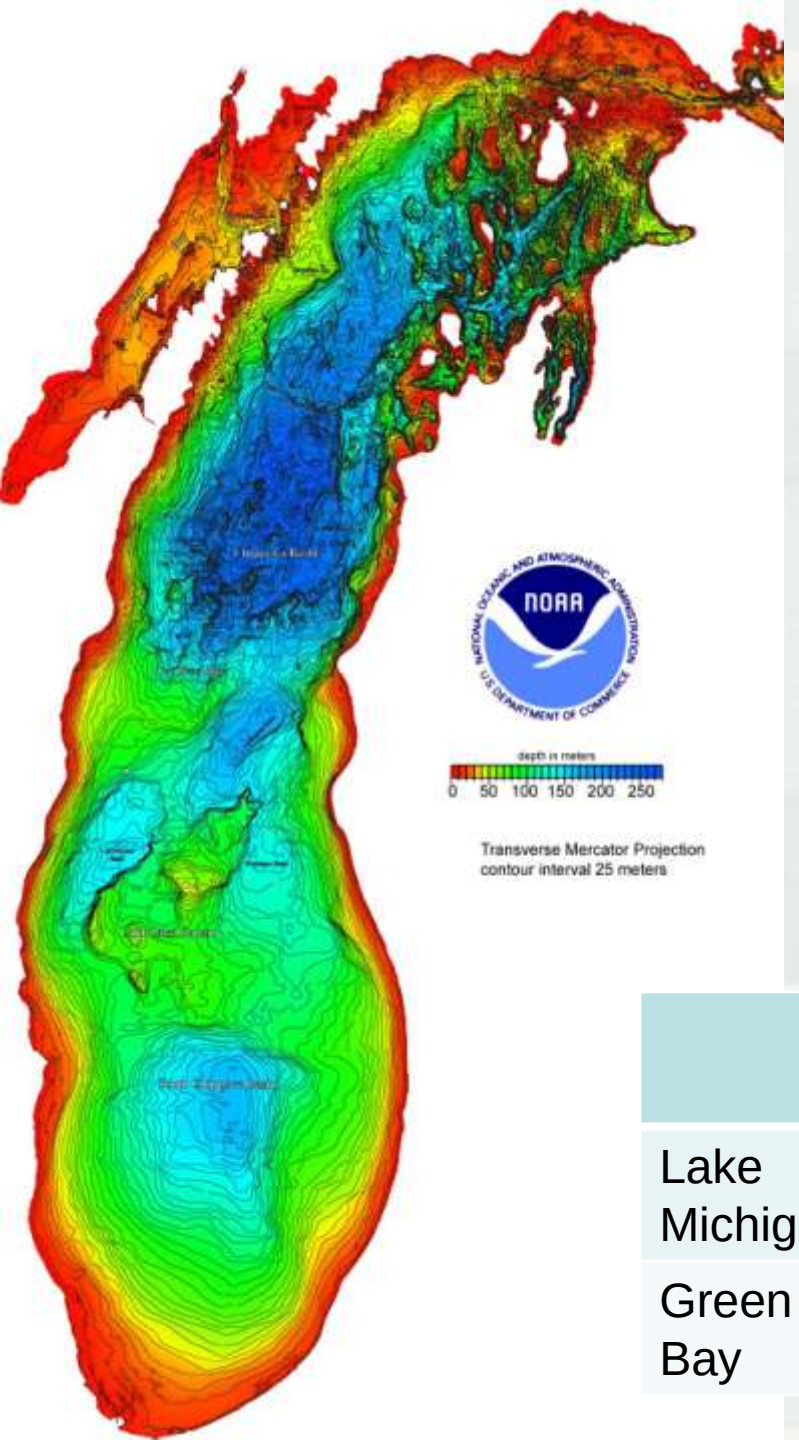
Outline

- 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

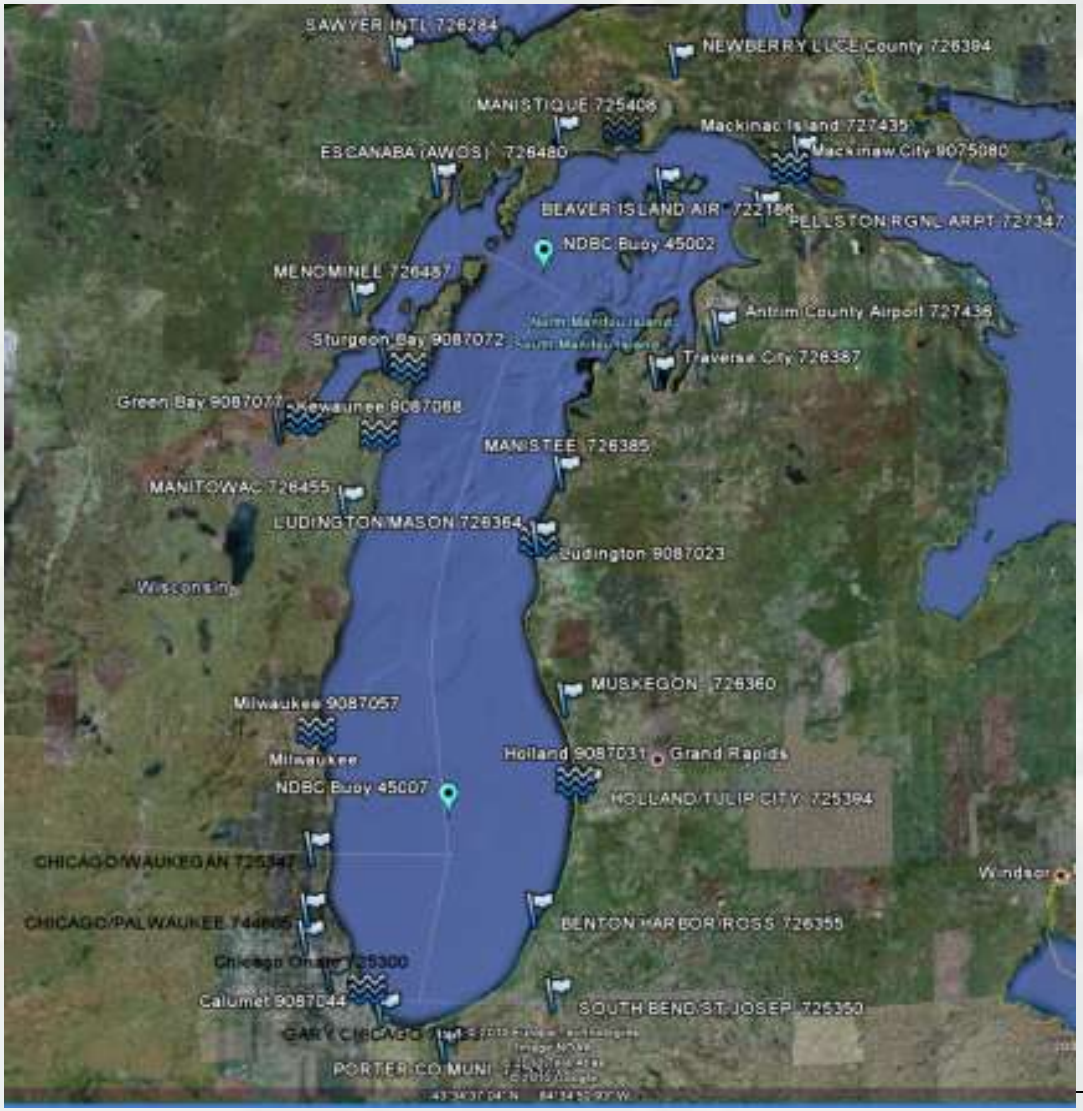


Contributors to BFEs Approximate Magnitudes

- 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

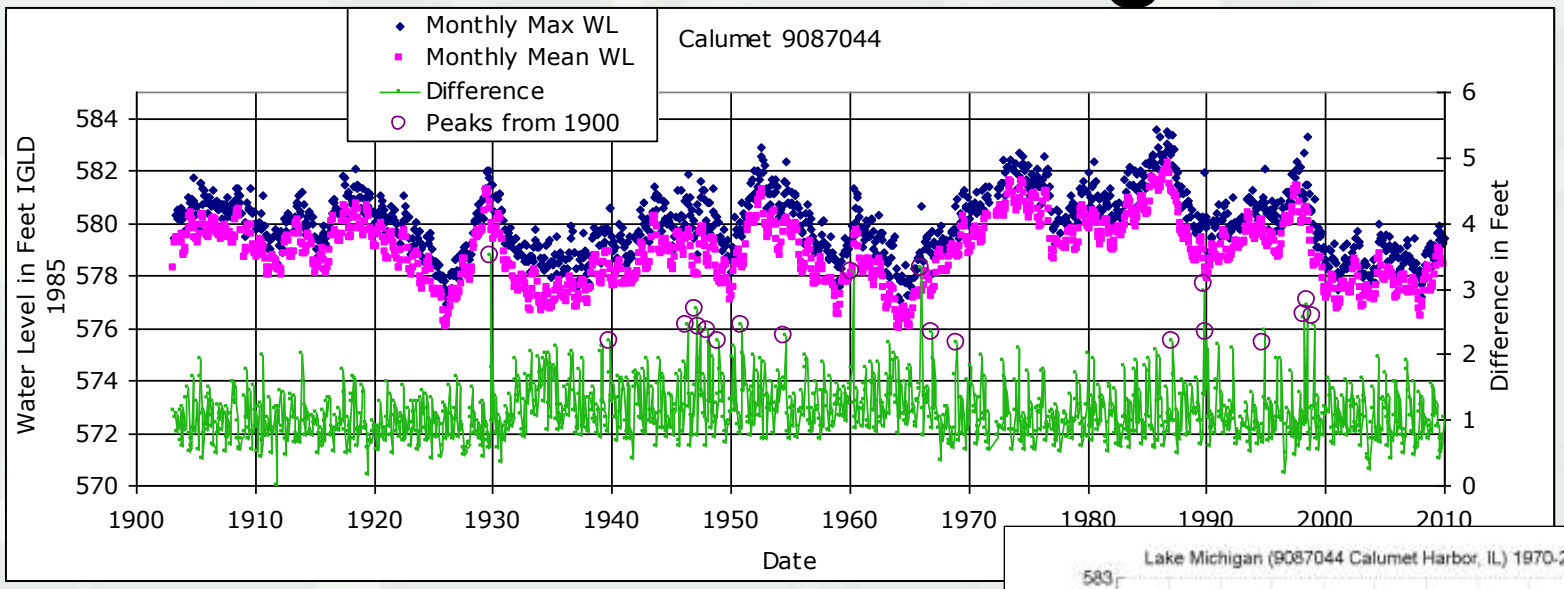
Measured Data Sources



- NOAA NDBC wave and met buoys (removed in winter)
- NOAA NWS land based weather stations
- NOAA NOS water level gages

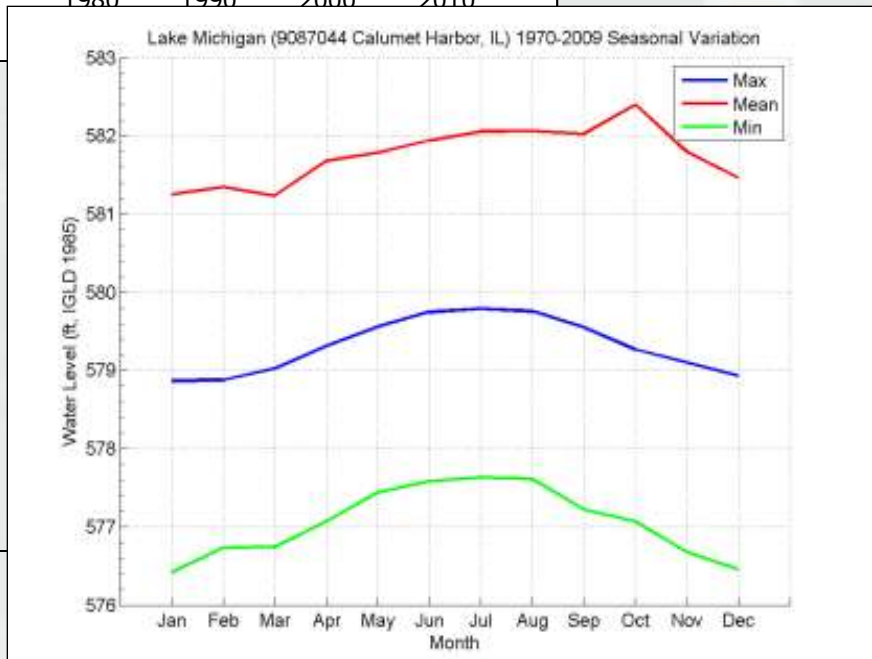
- 100+ years of data at some locations to evaluate statistical approach to water levels and storm sampling issues

Long Term and Seasonal Lake Level Changes



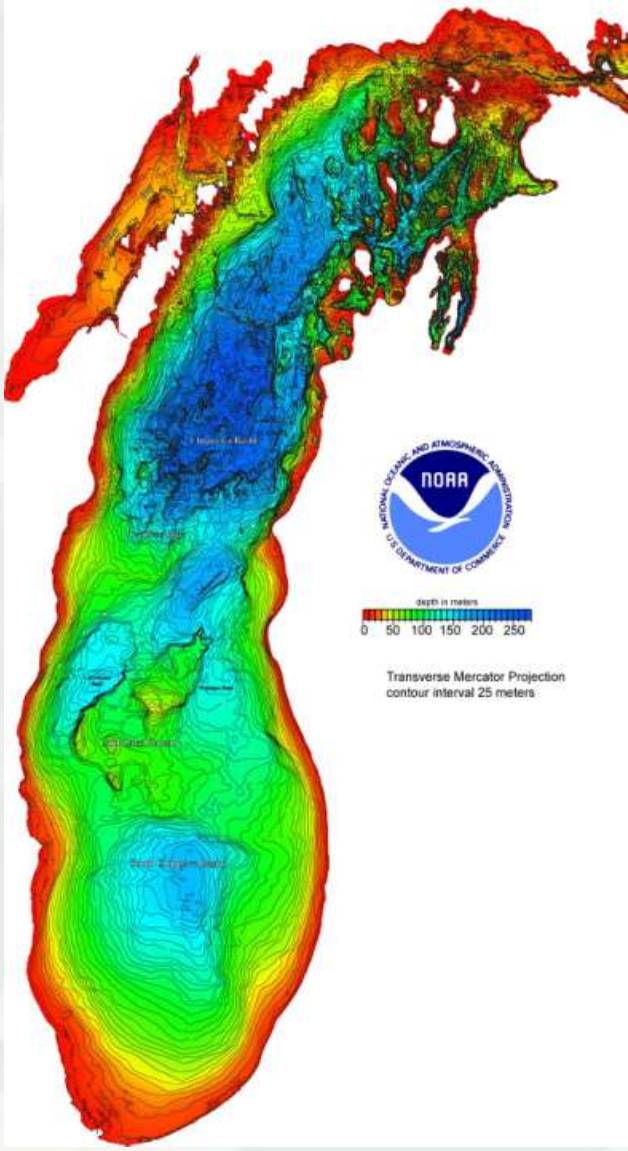
- Using Basis of Comparison corrected water levels to define lake levels

- Focus is on 1960 to 2010 period



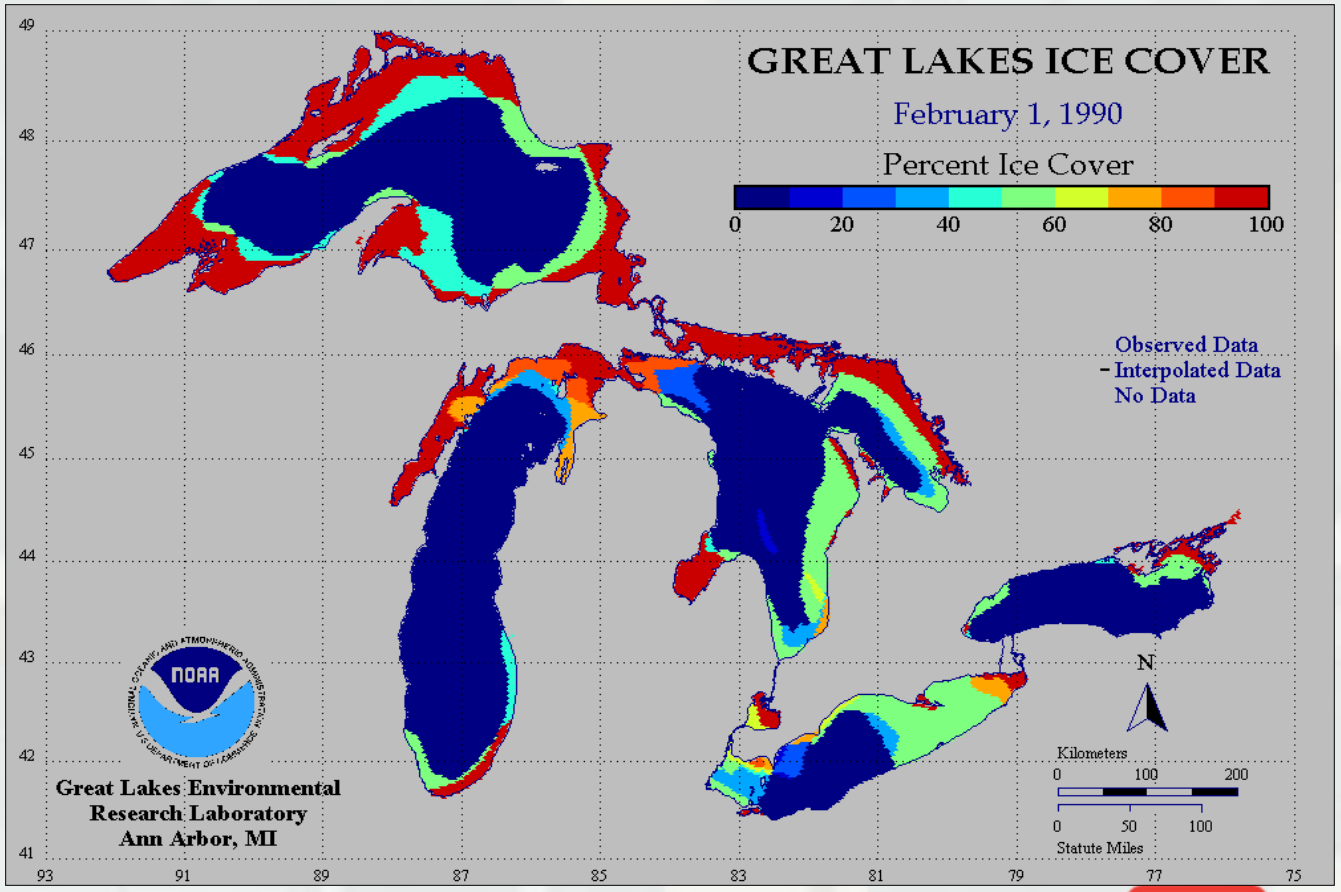
Modeling Approach

- 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

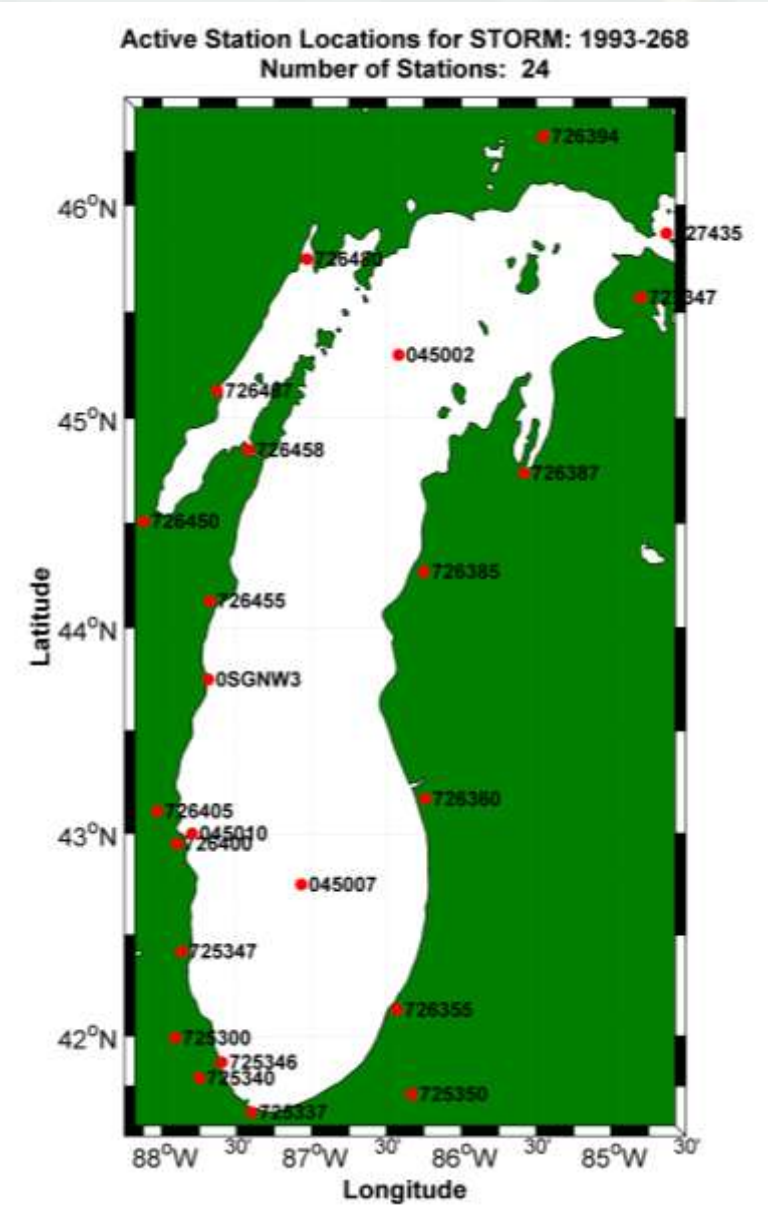


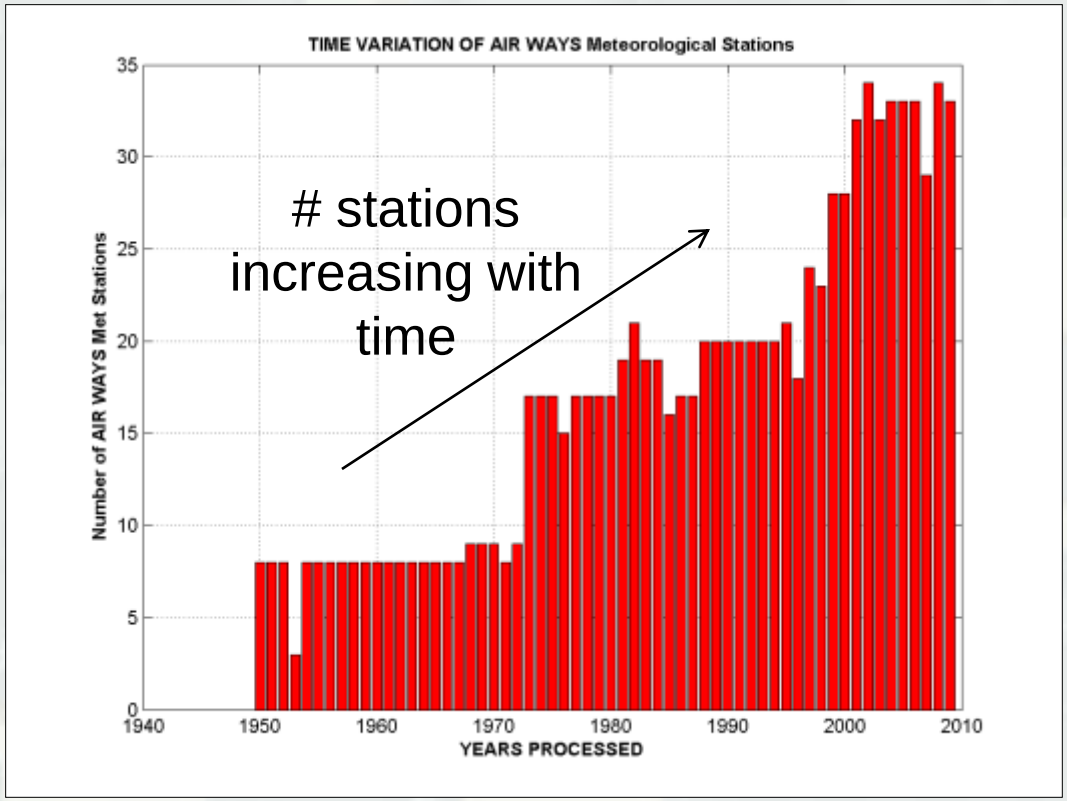
NOAA GLERL Ice Cover Data

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

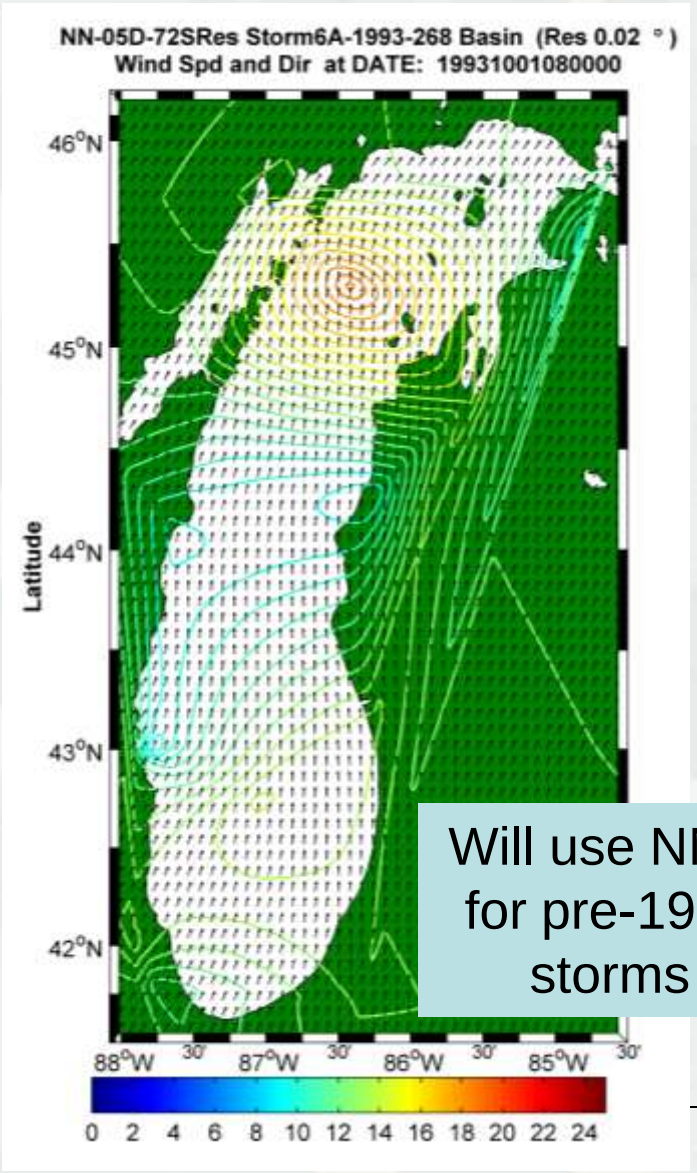


Measured Met Data Availability



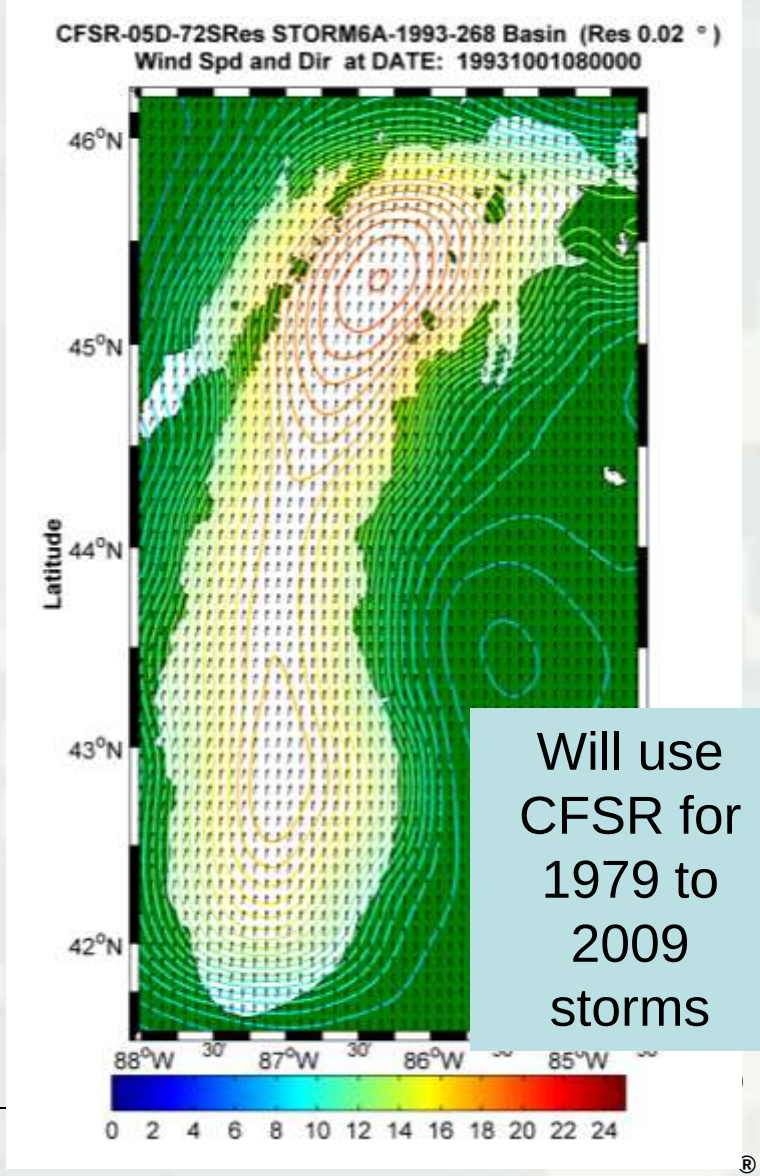


Options for Specifying Wind Fields



Wind Speed Contours

Will use NNM for pre-1979 storms

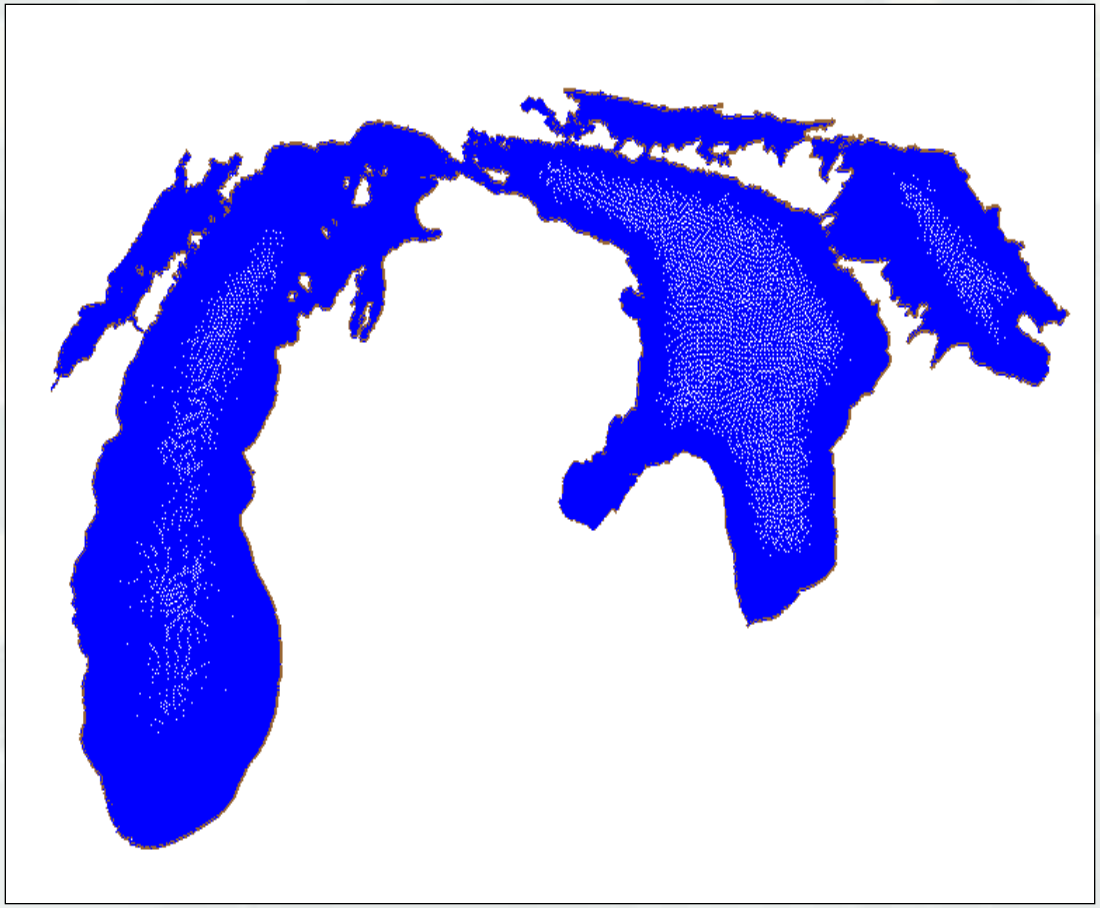


Will use CFSR for 1979 to 2009 storms

NOAA GLERL Natural Neighbor Method

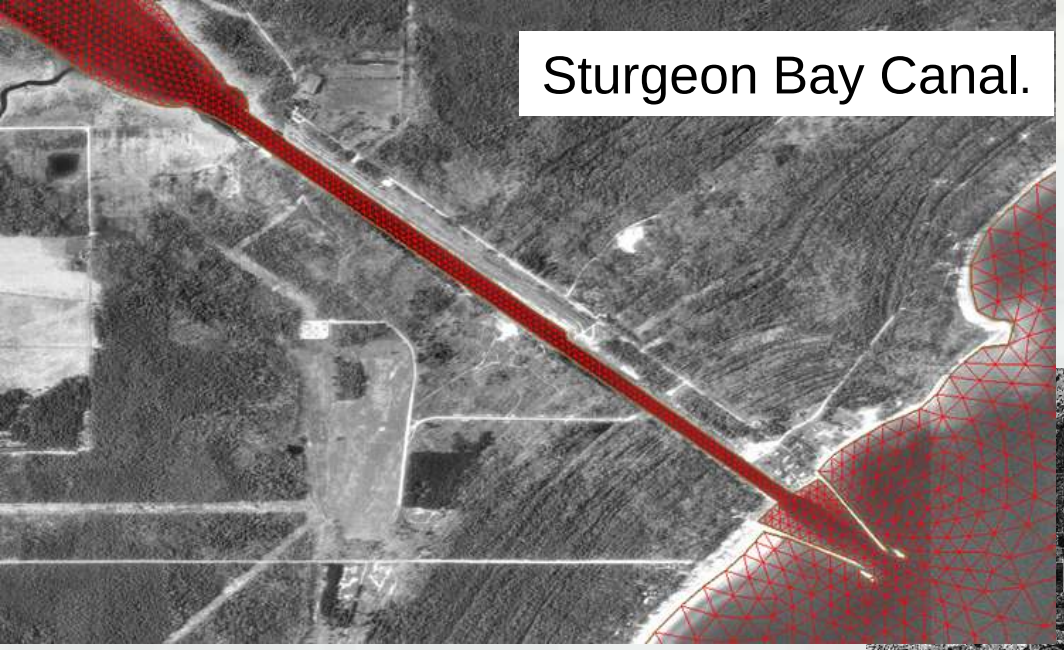
NOAA CFSR Reanalysis

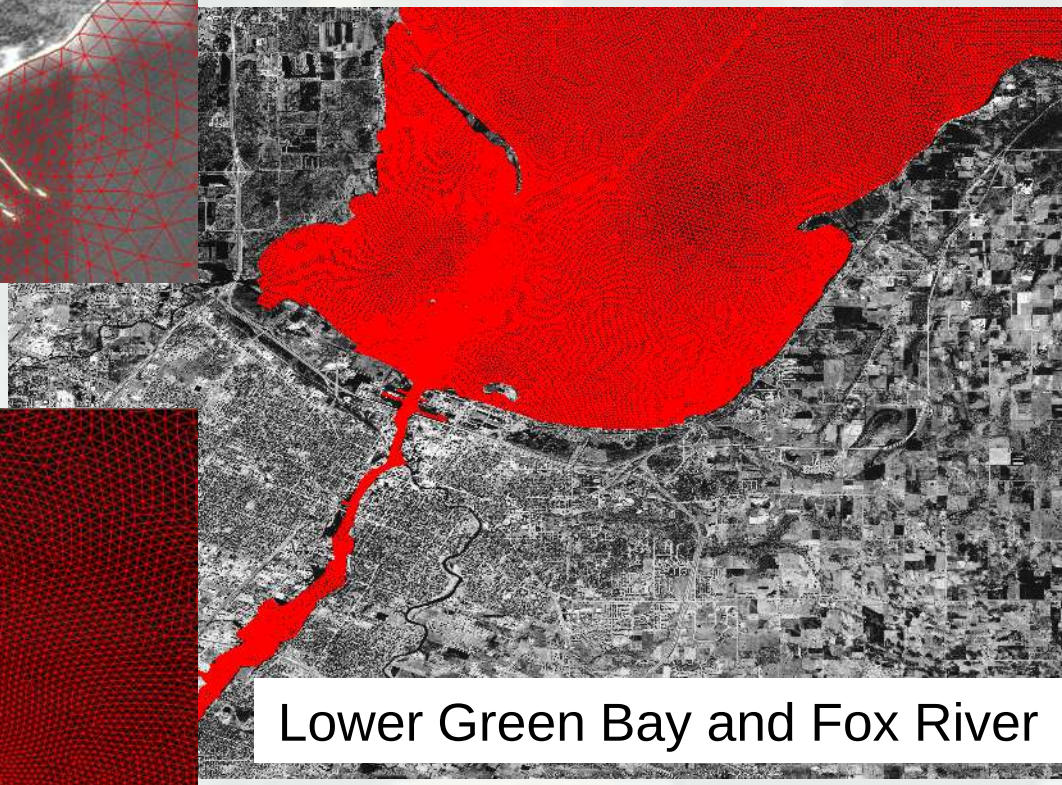
Storm Surge Modeling with ADCIRC



•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





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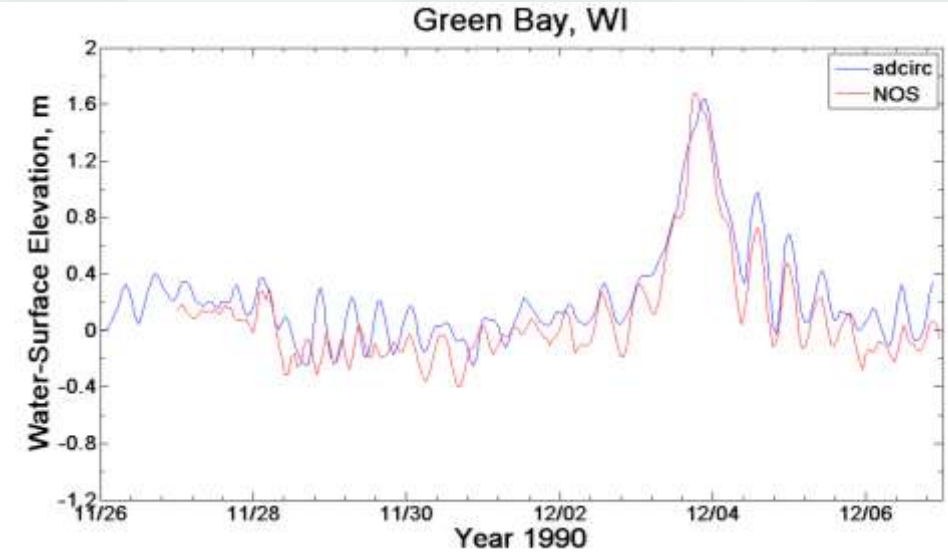
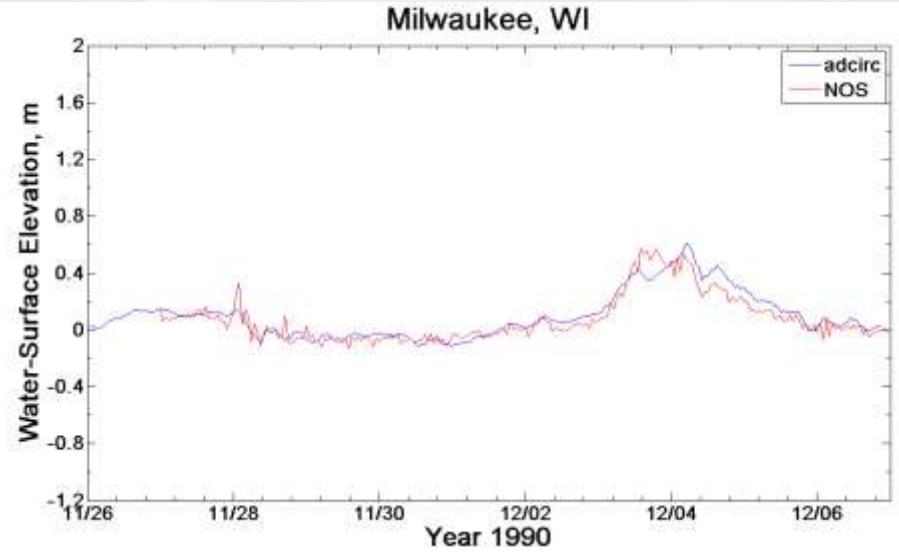
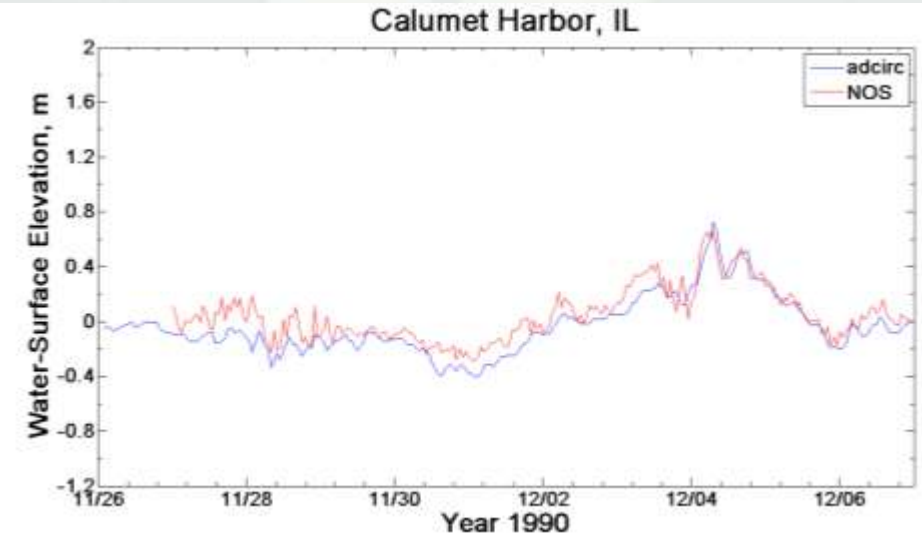
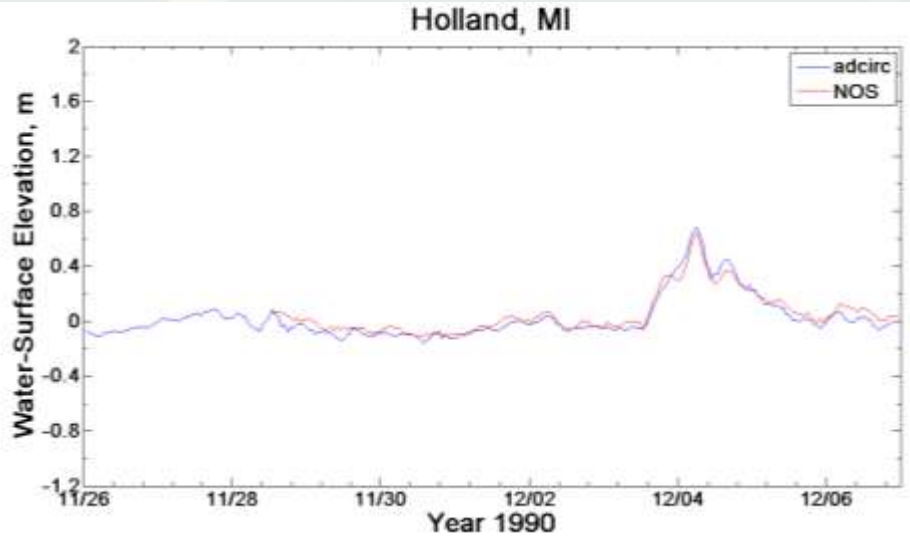
Water Level Measurement Locations

ADCIRC Model Comparisons to Measurements (Dec 1990 Storm)

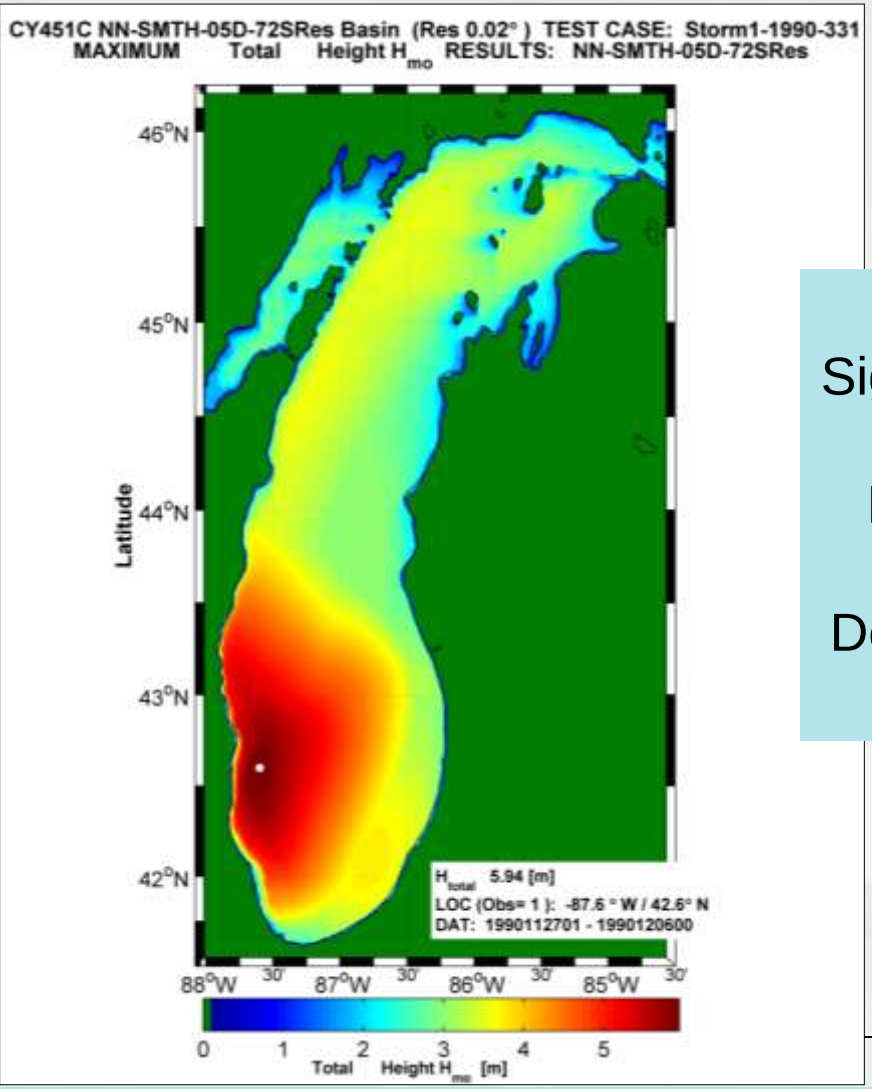








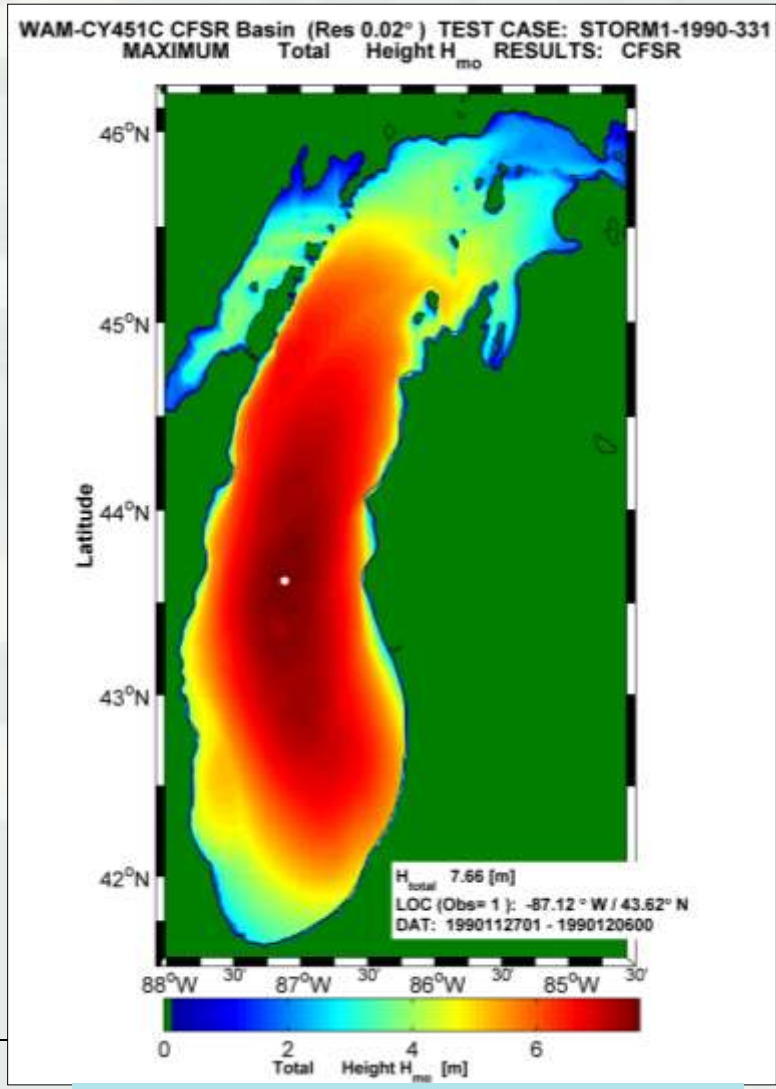
Lake-Scale Wave Modeling Using WAM



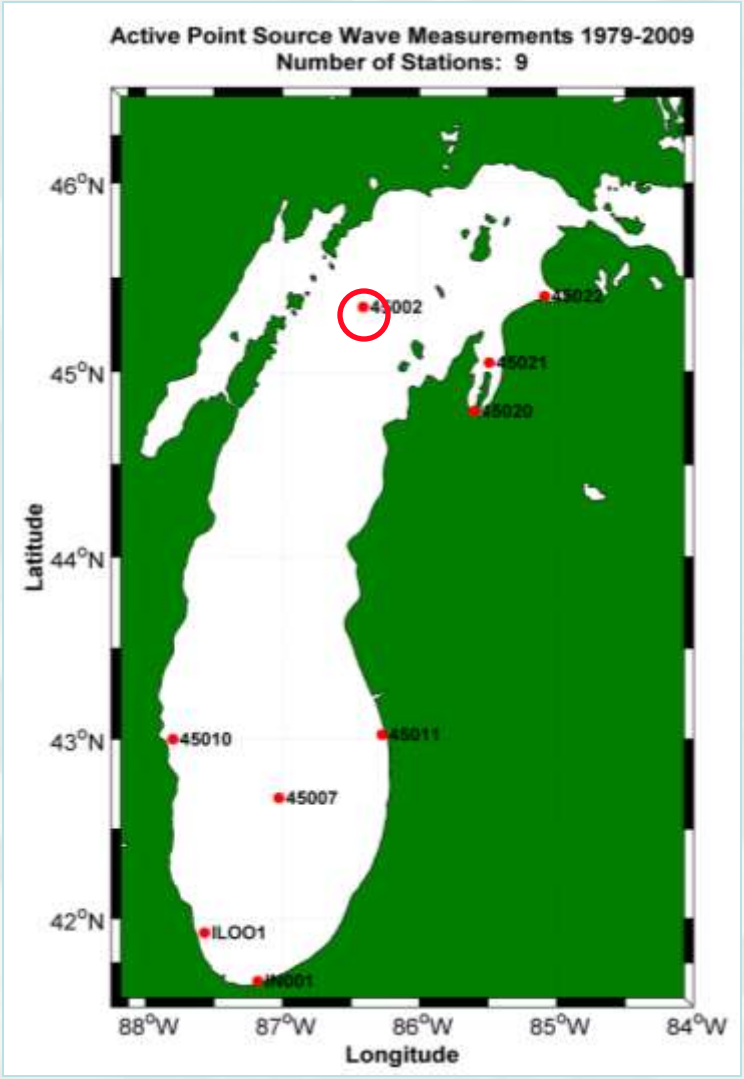
Natural Neighbor Method Winds

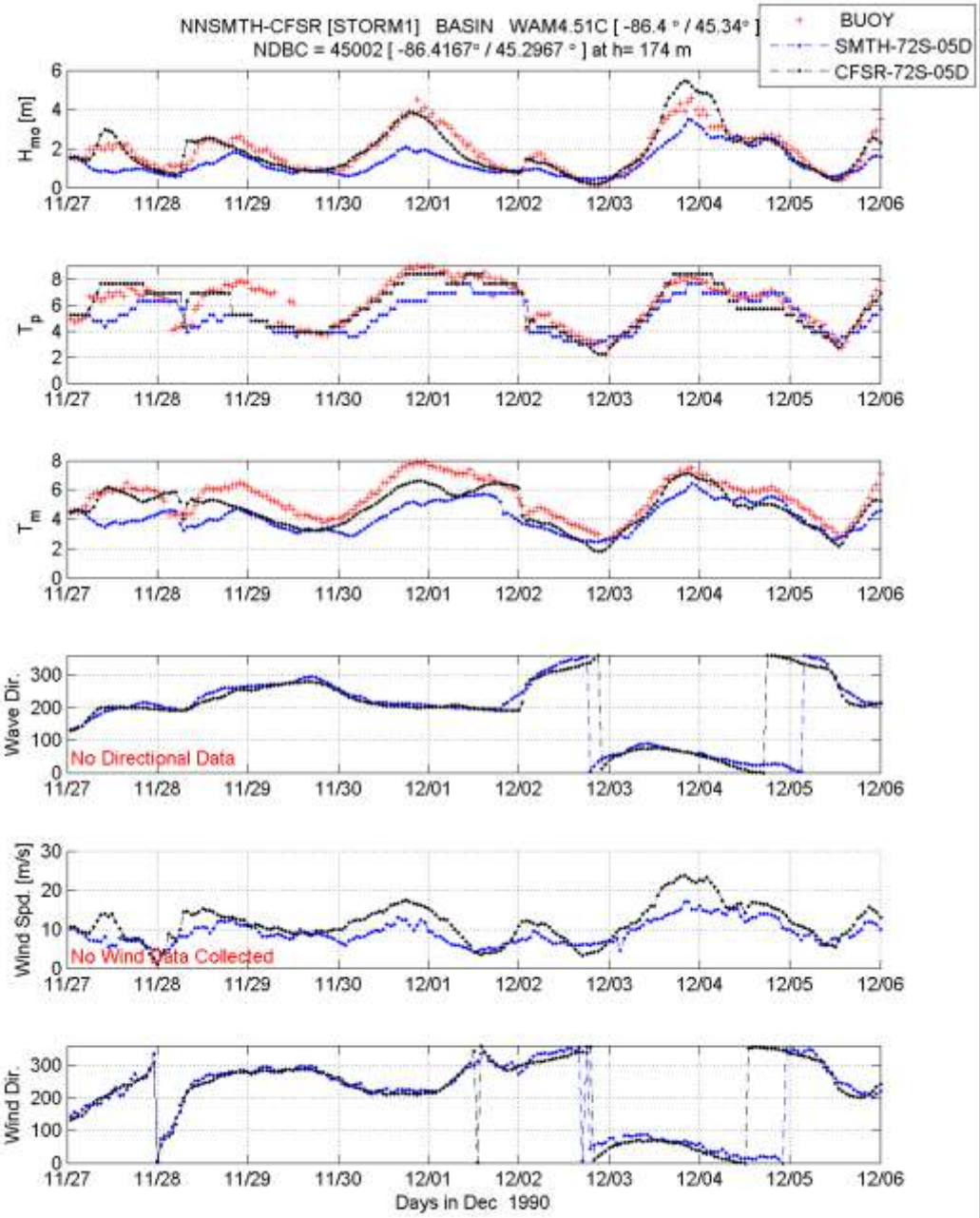
Max Significant Wave Height

Dec 1990 Storm

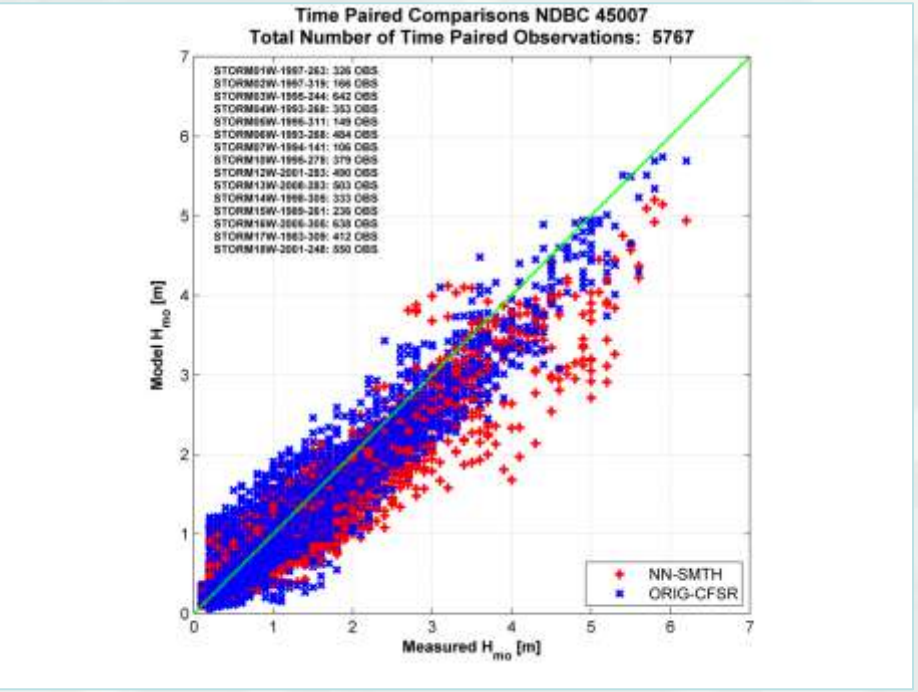


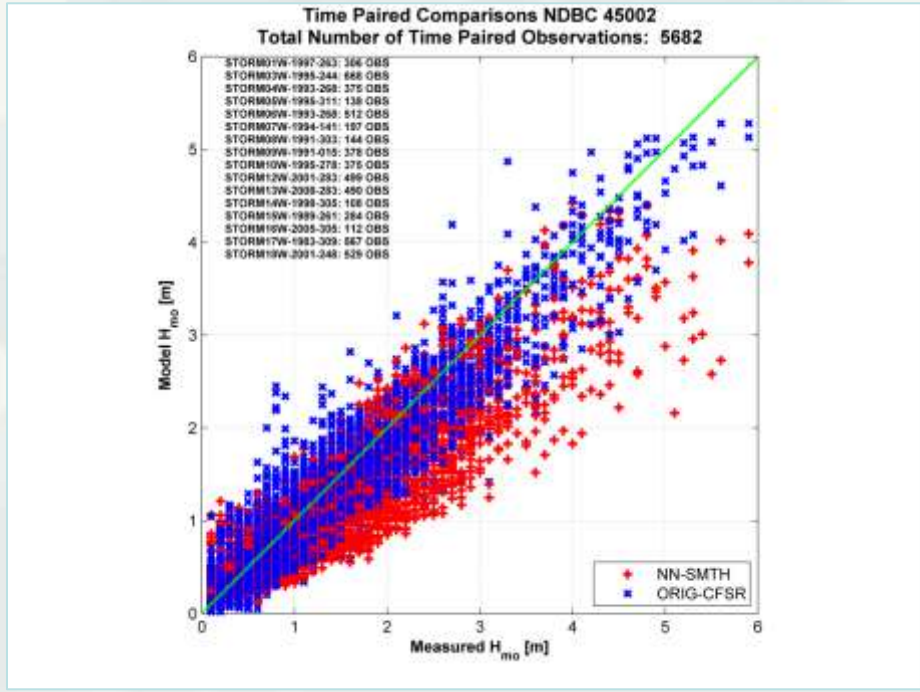
CFSR Reanalysis Winds

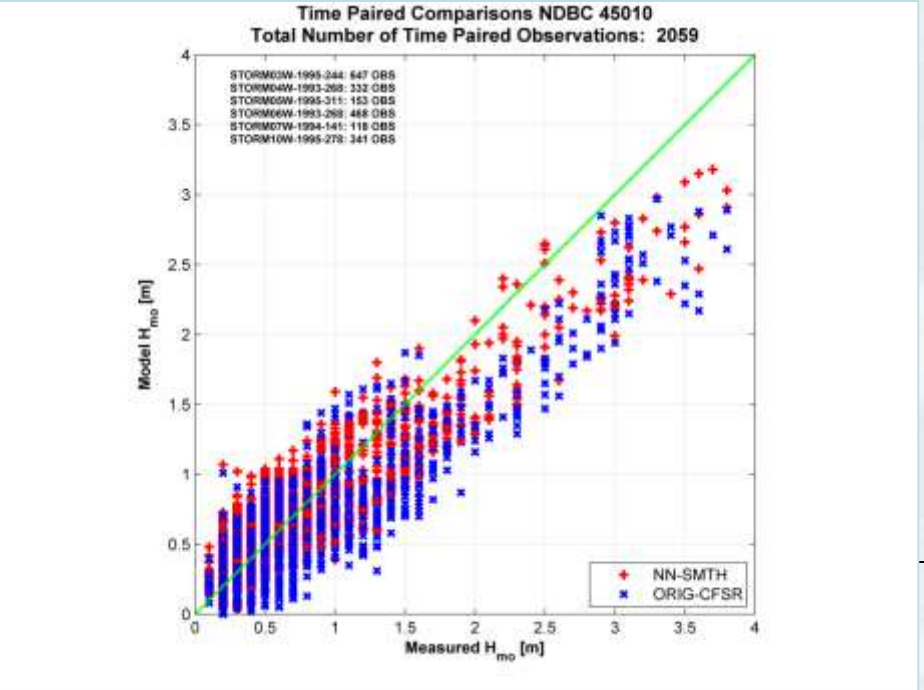


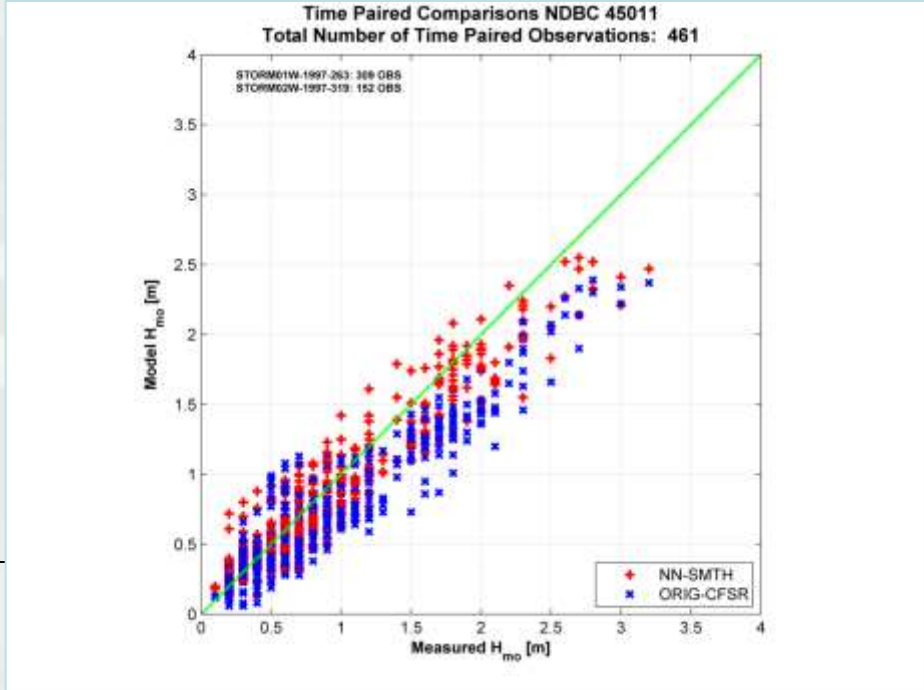


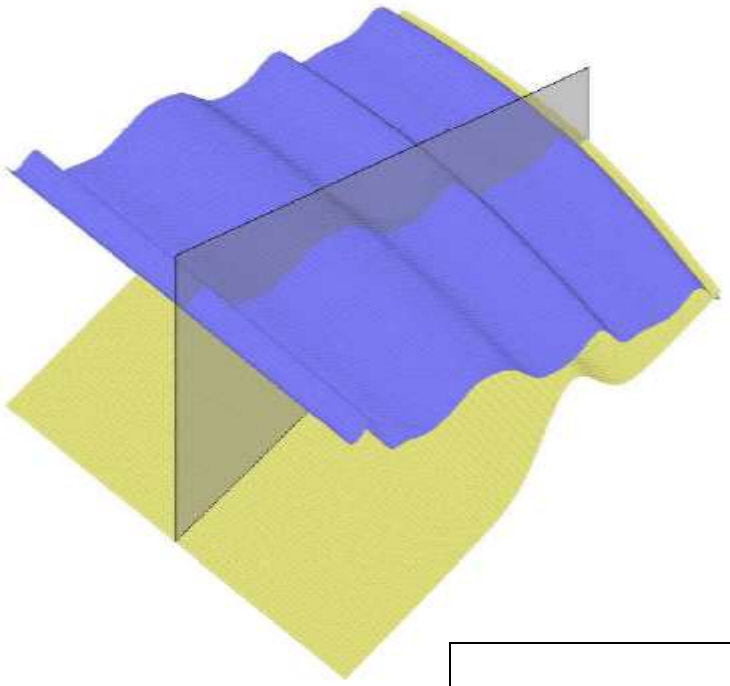
Dec 1990 Storm


Time Paired Comparisons NDBC 45007
Total Number of Time Paired Observations: 5767
STORM01W-1997-263: 326 OBS
STORM02W-1997-319: 166 OBS
STORM03W-1995-244: 642 OBS
STORM04W-1993-268: 353 OBS
STORM05W-1995-311: 149 OBS
STORM06W-1993-268: 484 OBS
STORM07W-1994-141: 106 OBS
STORM10W-1995-278: 379 OBS
STORM12W-2001-283: 490 OBS
STORM13W-2008-283: 503 OBS
STORM14W-1998-305: 333 OBS
STORM15W-1989-261: 236 OBS
STORM16W-2005-305: 638 OBS
STORM17W-1983-309: 412 OBS
STORM18W-2001-248: 550 OBS
NN-SMTH
ORIG-CFSR
Model H_mo [m]
Measured H_mo [m]

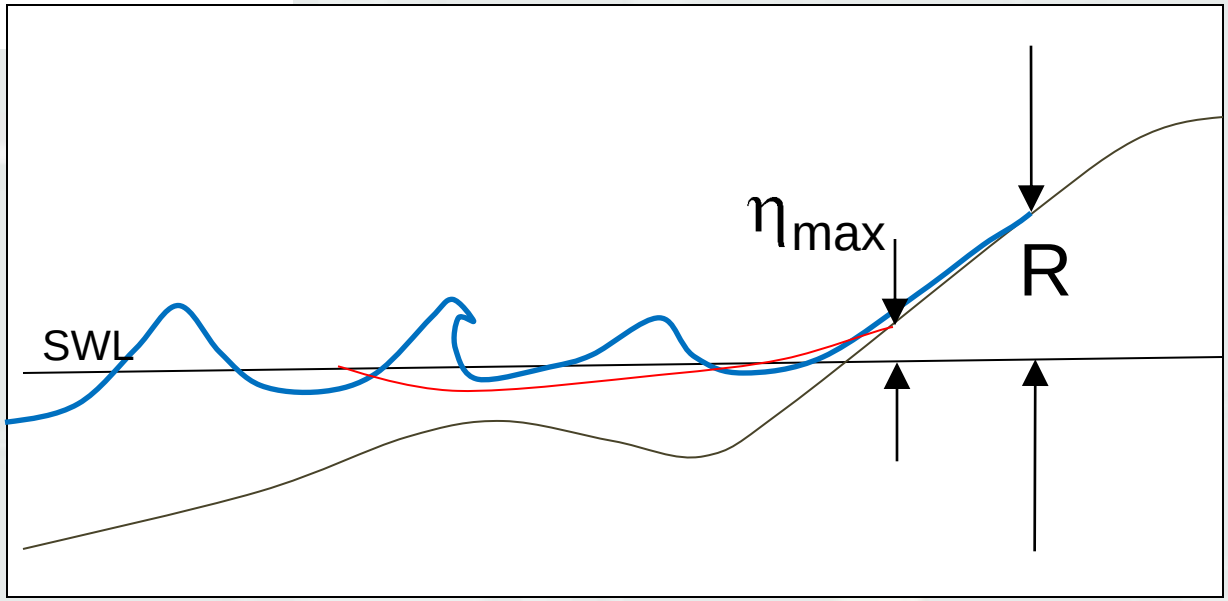

Time Paired Comparisons NDBC 45002
Total Number of Time Paired Observations: 5682
STORM01W-1997-263: 366 OBS
STORM03W-1995-244: 668 OBS
STORM04W-1993-268: 375 OBS
STORM05W-1995-311: 138 OBS
STORM06W-1993-268: 512 OBS
STORM07W-1994-141: 107 OBS
STORM09W-1991-303: 144 OBS
STORM09W-1991-015: 378 OBS
STORM10W-1995-278: 375 OBS
STORM12W-2001-283: 499 OBS
STORM13W-2008-283: 490 OBS
STORM14W-1998-305: 108 OBS
STORM15W-1989-261: 264 OBS
STORM16W-2005-305: 112 OBS
STORM17W-1983-309: 867 OBS
STORM18W-2001-248: 529 OBS
NN-SMTH
ORIG-CFSR
Model H_mo [m]
Measured H_mo [m]


Time Paired Comparisons NDBC 45010
Total Number of Time Paired Observations: 2059
STORM03W-1995-244: 647 OBS
STORM04W-1993-268: 332 OBS
STORM05W-1995-311: 153 OBS
STORM06W-1993-268: 468 OBS
STORM07W-1994-141: 118 OBS
STORM10W-1995-278: 341 OBS
NN-SMTH
ORIG-CFSR
Model H_mo [m]
Measured H_mo [m]


Time Paired Comparisons NDBC 45011
Total Number of Time Paired Observations: 461
STORM01W-1997-263: 309 OBS
STORM02W-1997-319: 152 OBS
NN-SMTH
ORIG-CFSR
Model H_mo [m]
Measured H_mo [m]



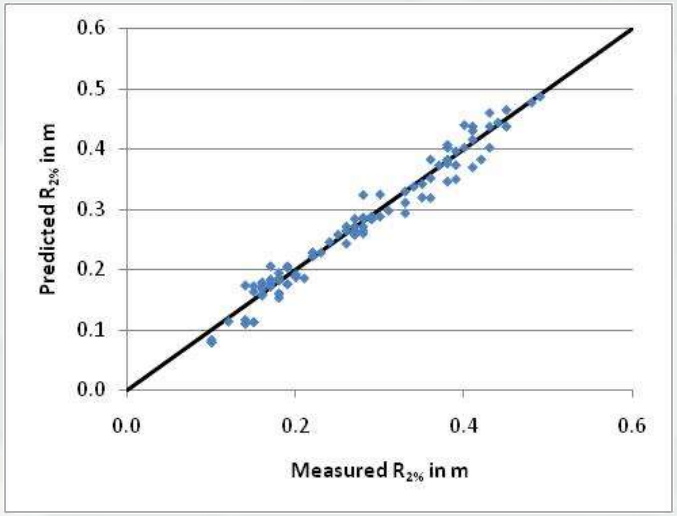
Nearshore Dynamics and Wave Run-up Modeling with CSHORE



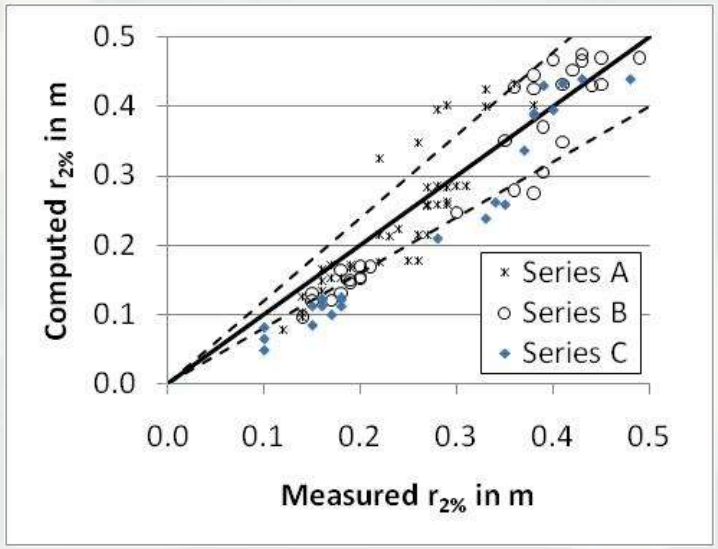
Run-up Validation Data Sets

- 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.)

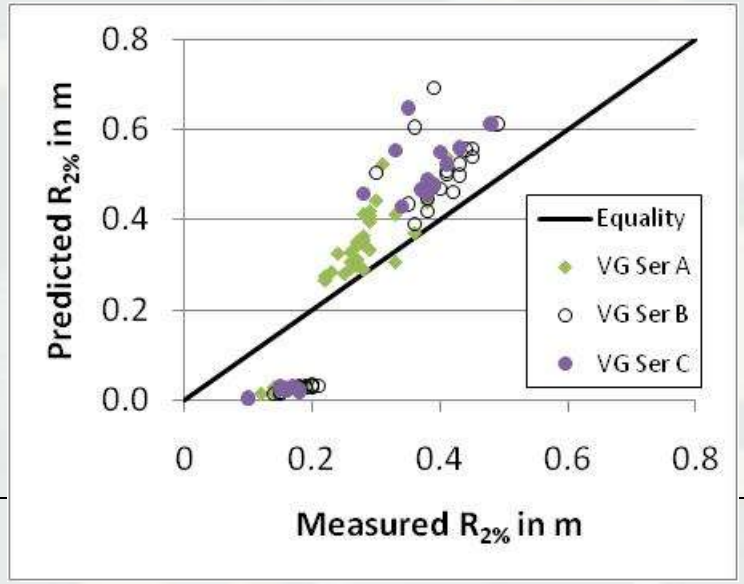
Van Gent Series A, B, C



Van Gent Empirical Equation

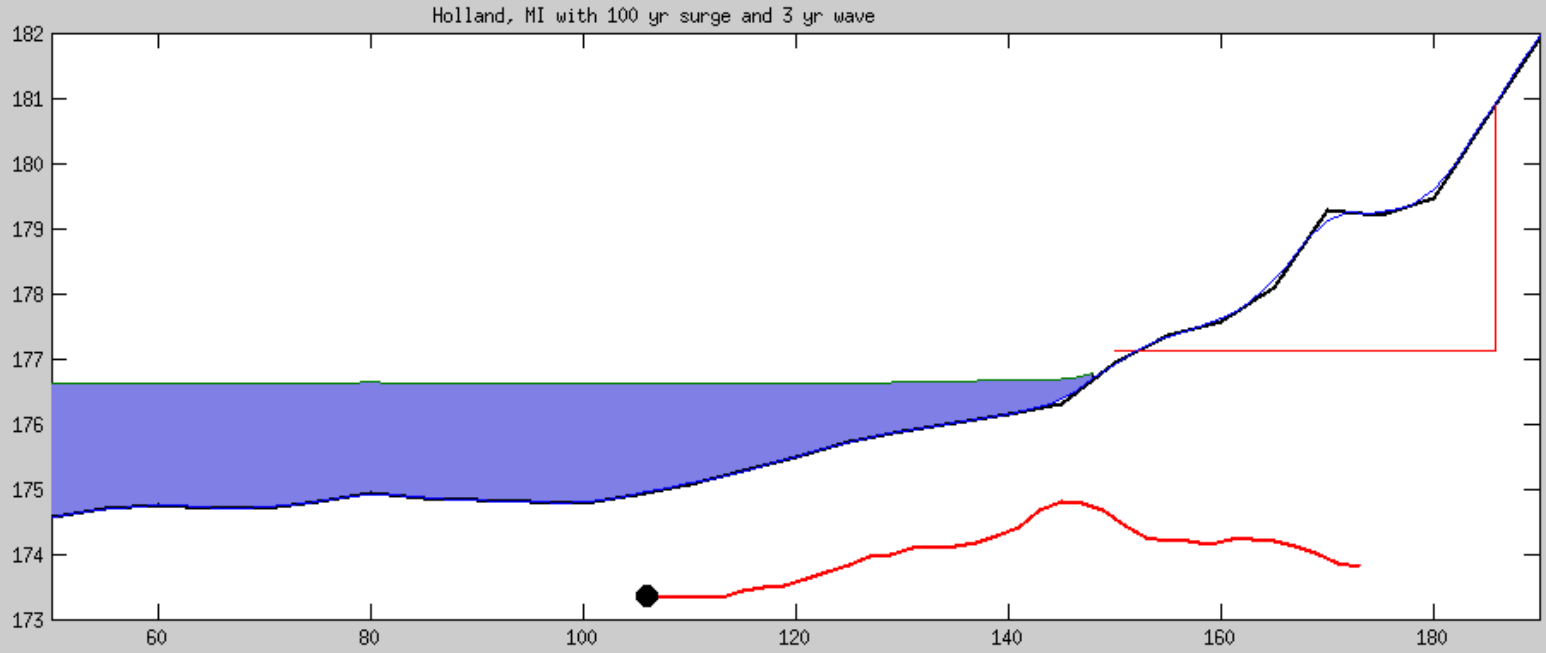


CSHORE



Runup 2.0

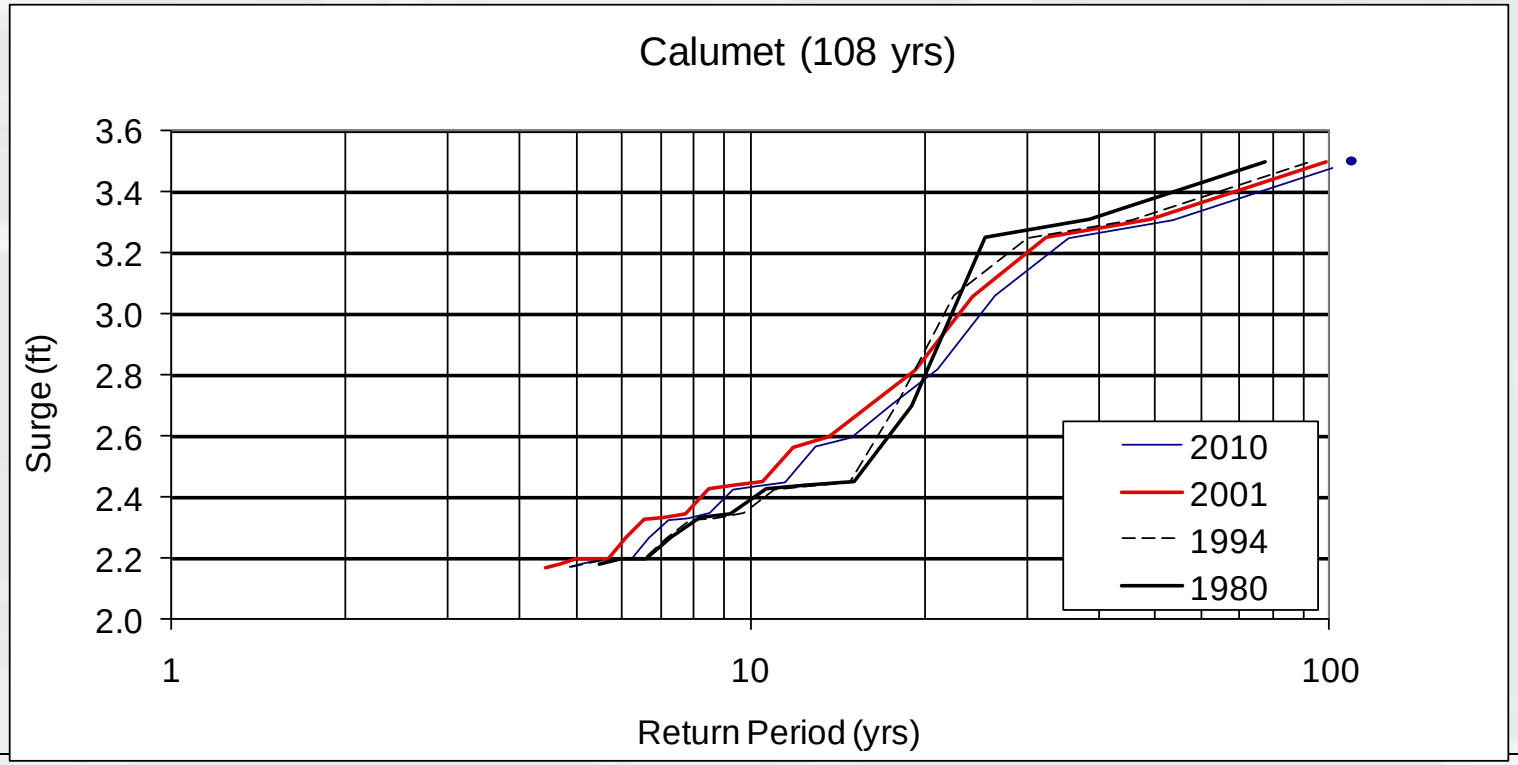
Beach Erosion Simulations

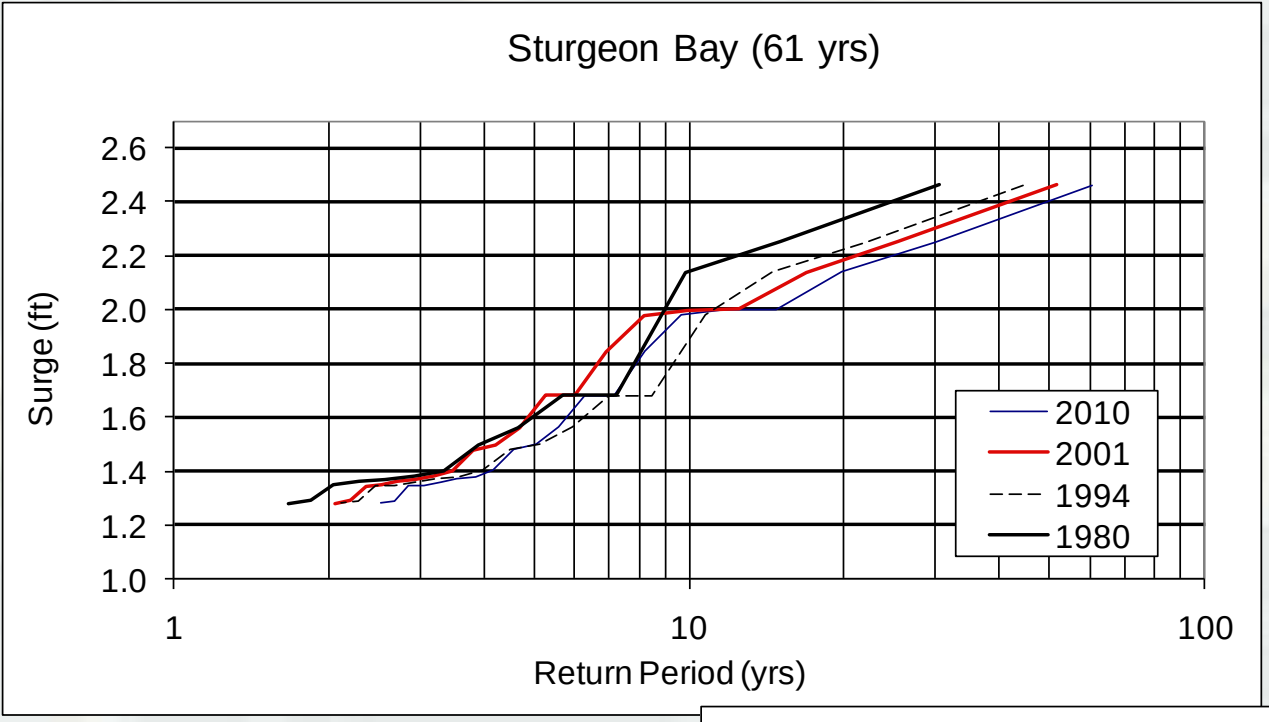


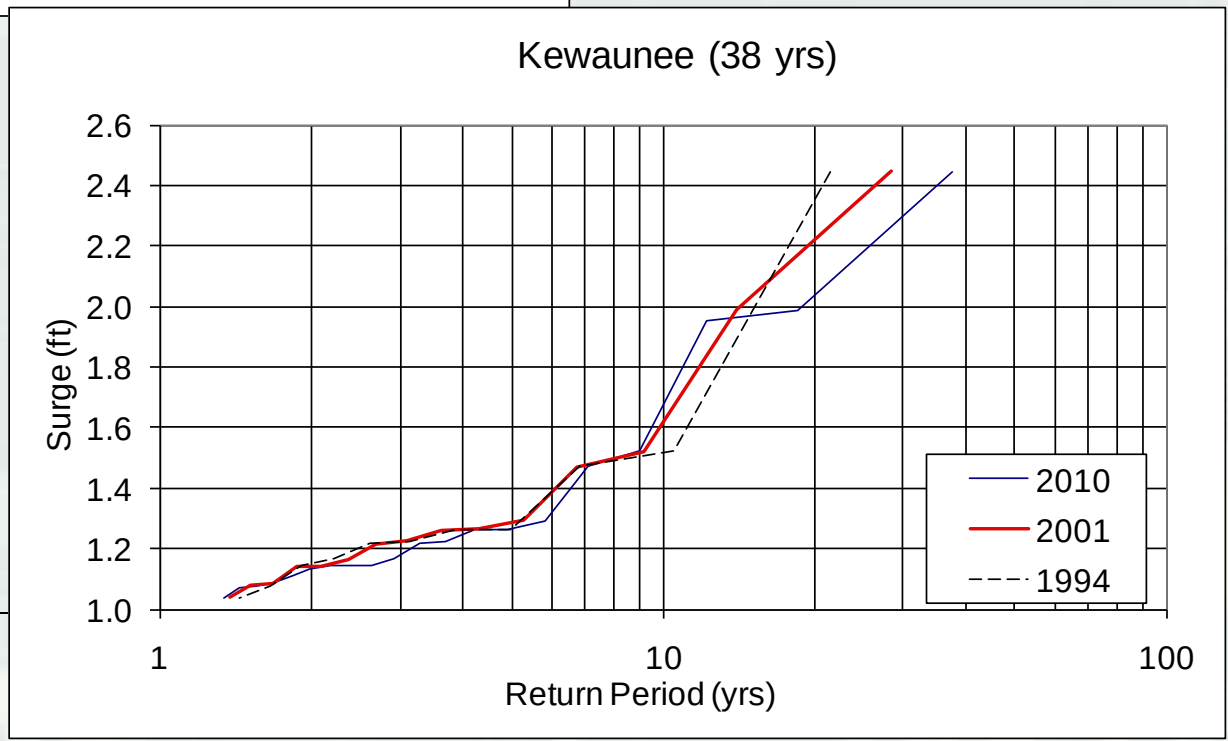
Holland, MI morphology change using CSHORE

Water Level Statistics

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



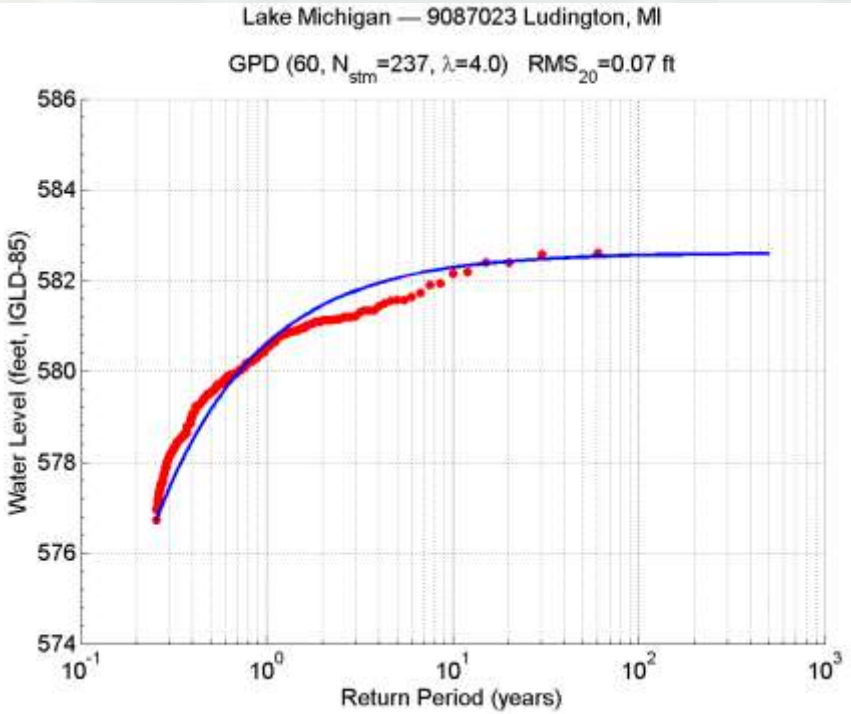


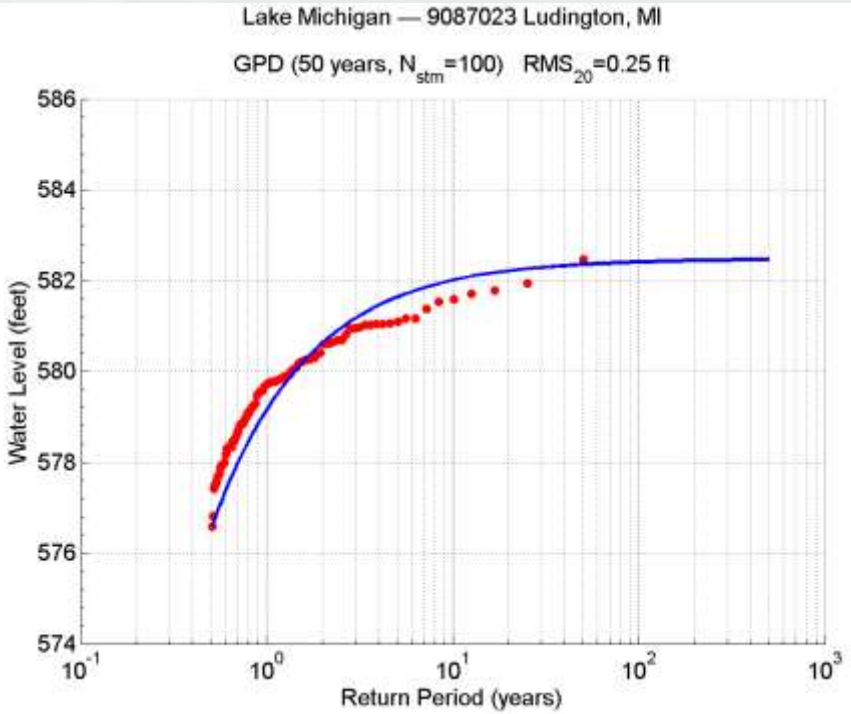


- Maximize record length for storms
- Minimum of 50 years; 50 years dictated in large part by met data availability for storm modeling

Storm Sample Size

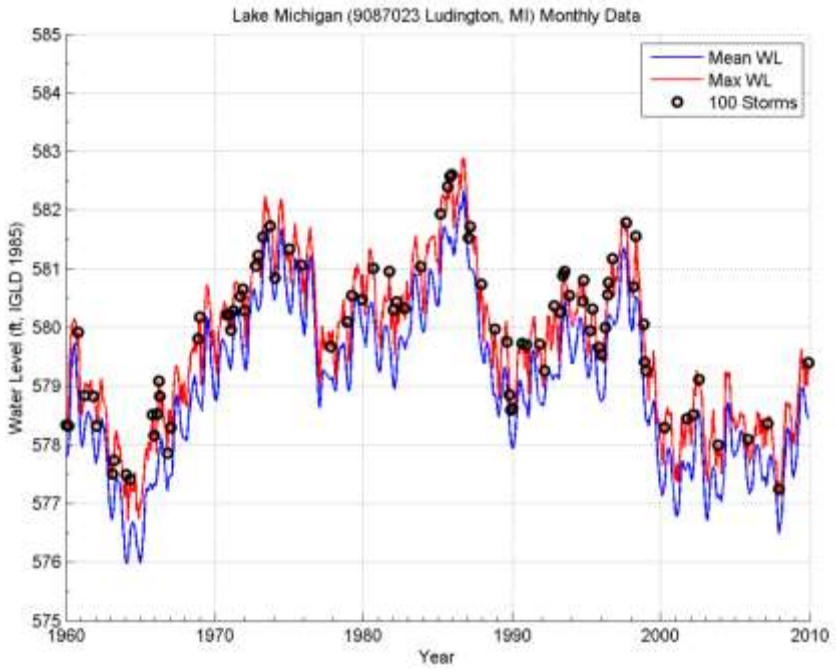
- Challenge – Produce reliable statistics in the extreme tail of distribution, throughout the lake system, with minimum number of storms
- Verification of Statistical Approach
  - *Full set vs. 100-storms Composite set – Water Level*
  - *100 storms minimum – will simulate 150*

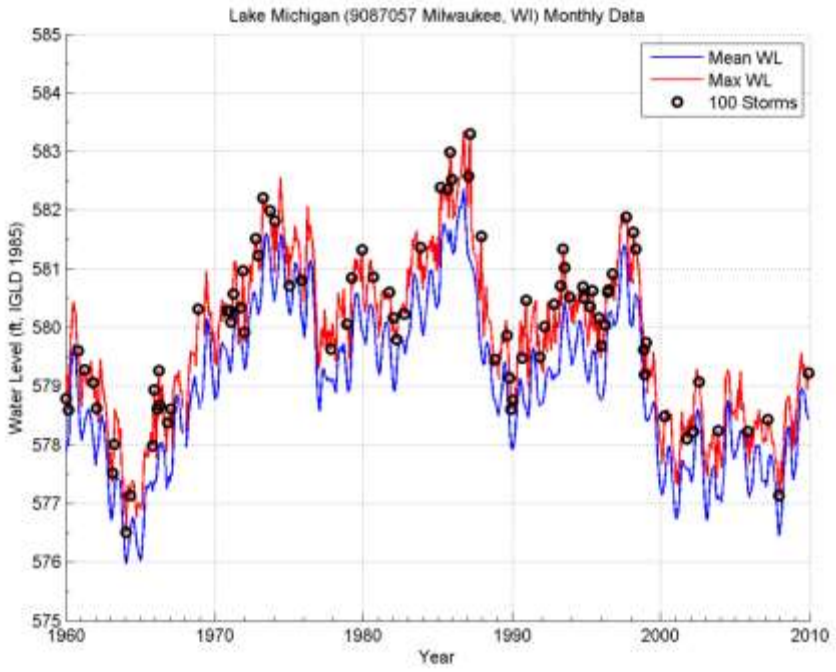




Storm Sample Size

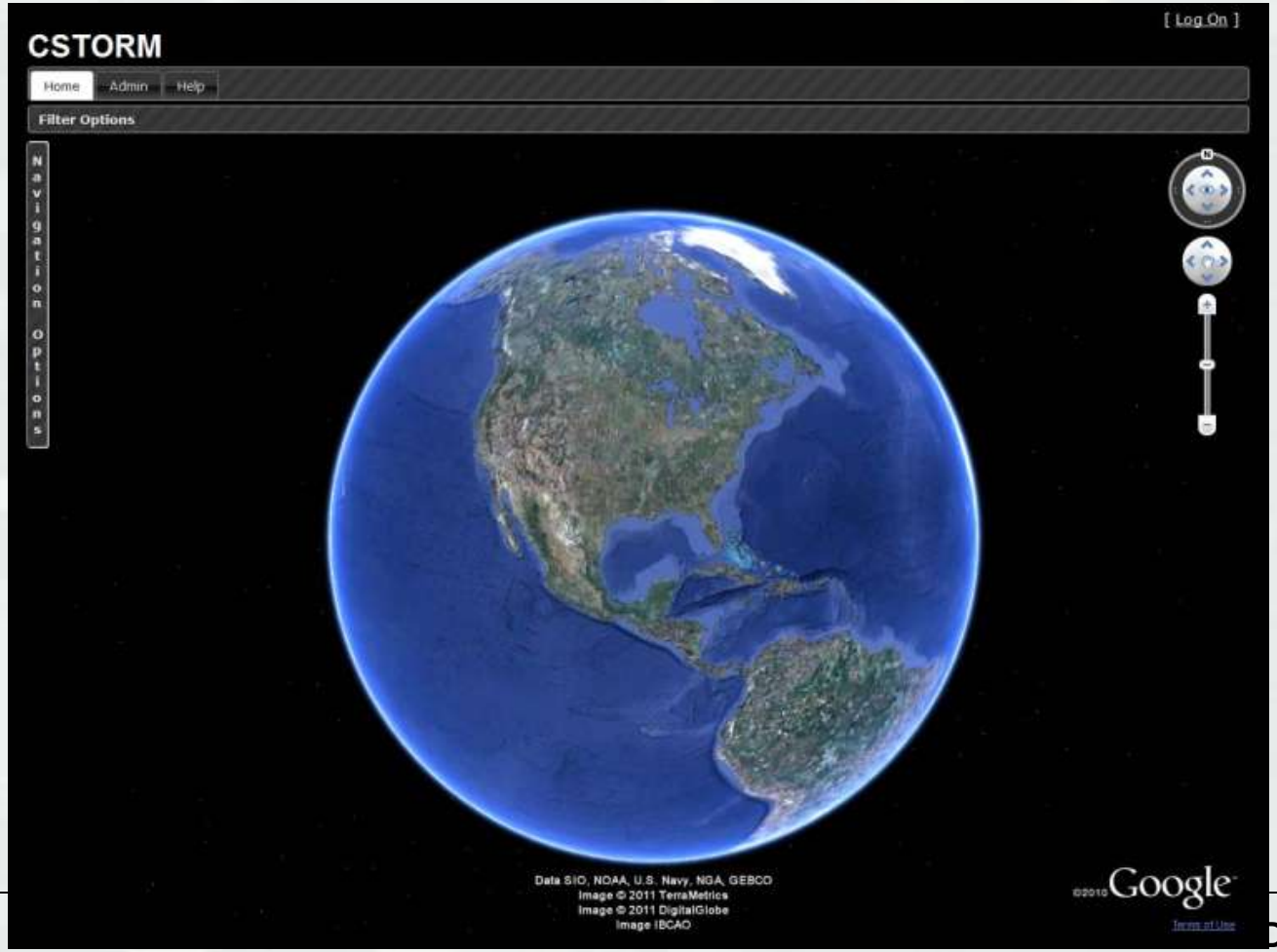
- Sample-Size Adequacy
  - *Sampling during **High** and **Low** lake water levels…*





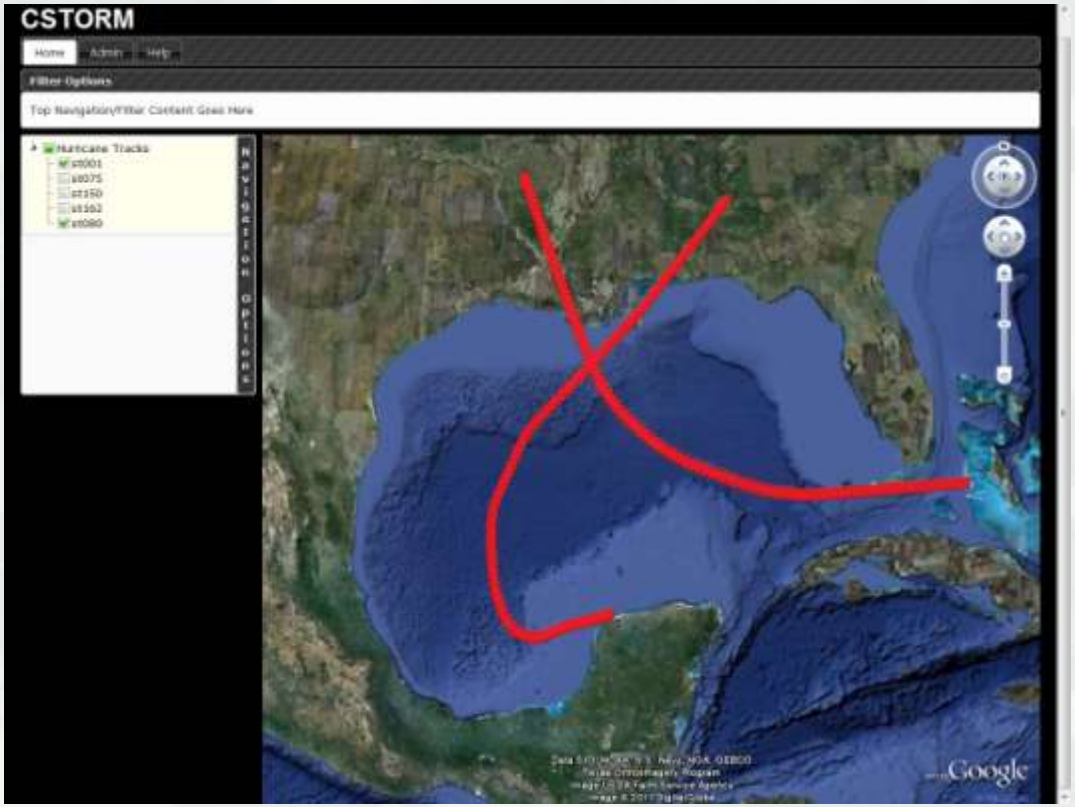
CSTORM-DB/VS

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



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

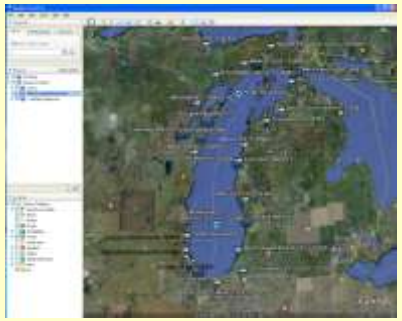


CSTORM-DB/VS

CSTORM-VS
Web App with
Google Earth
Plug-In

USACE KML and
Data Servers

External KML and
Data Servers



Desktop PC
Personal Google Earth App

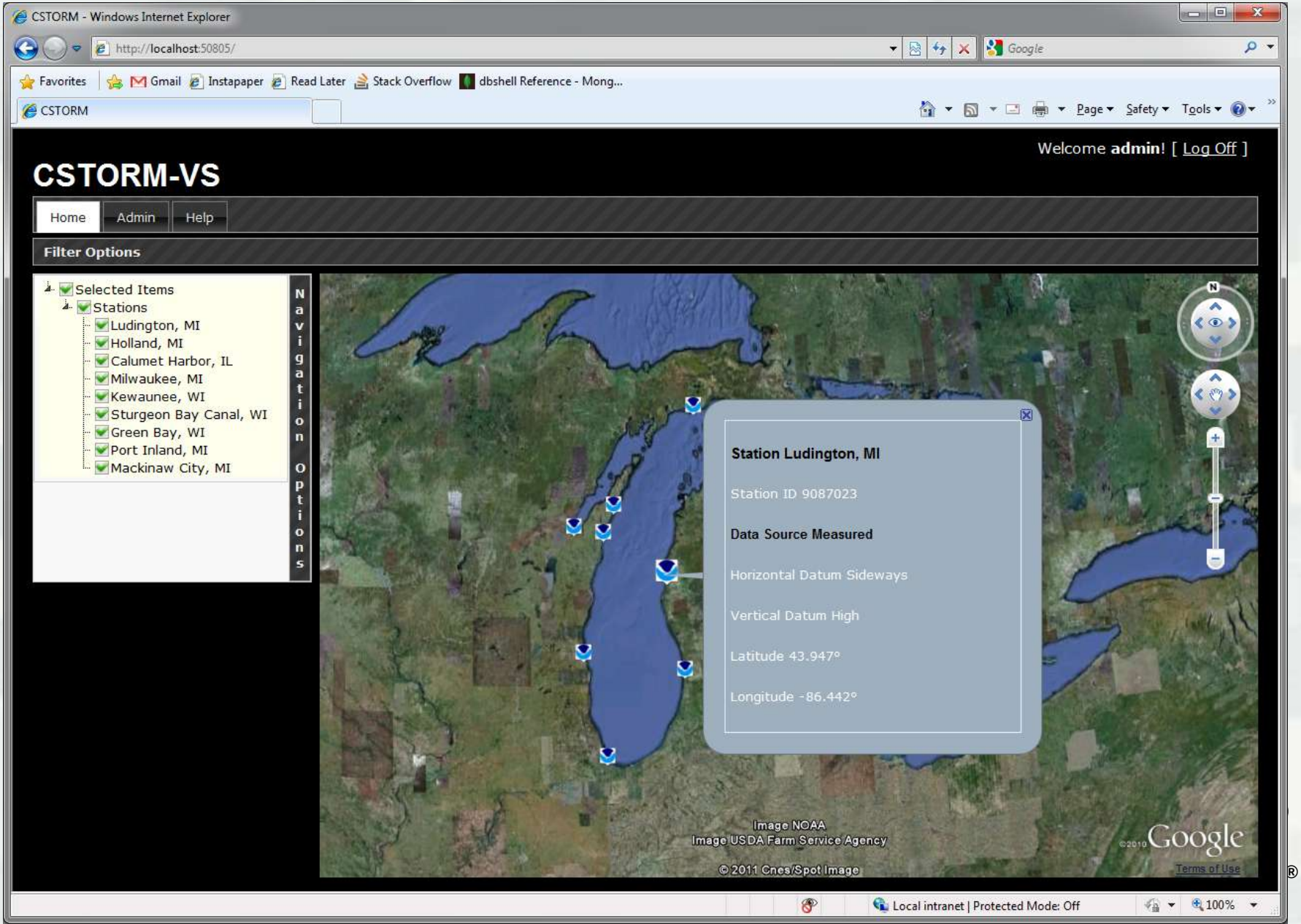
CSTORM Data
Processing and Visualization
System

CSTORM-DB Storm Server

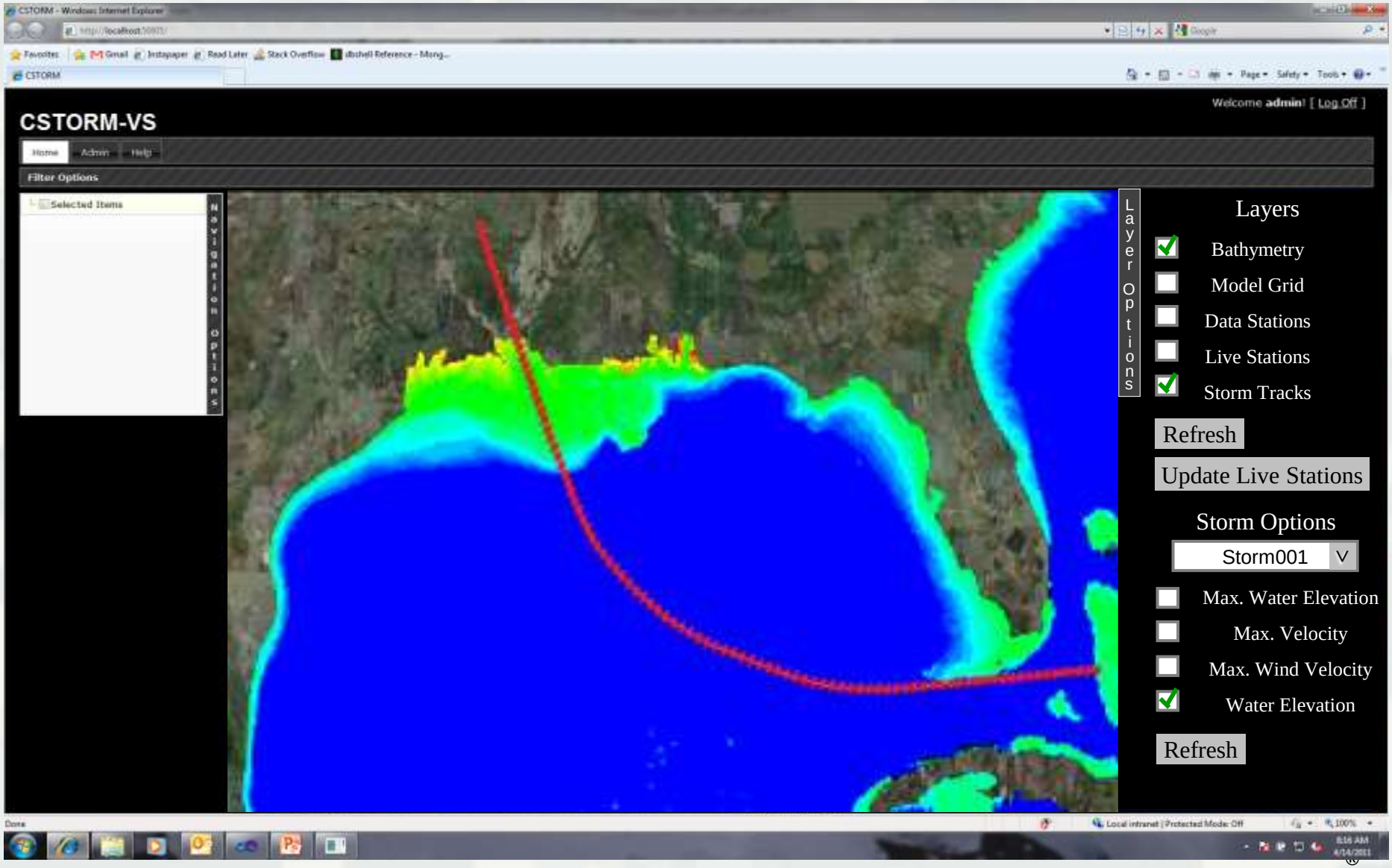
Coastal Storm
Database

Coastal Storm HDF5 Archive

Station Information

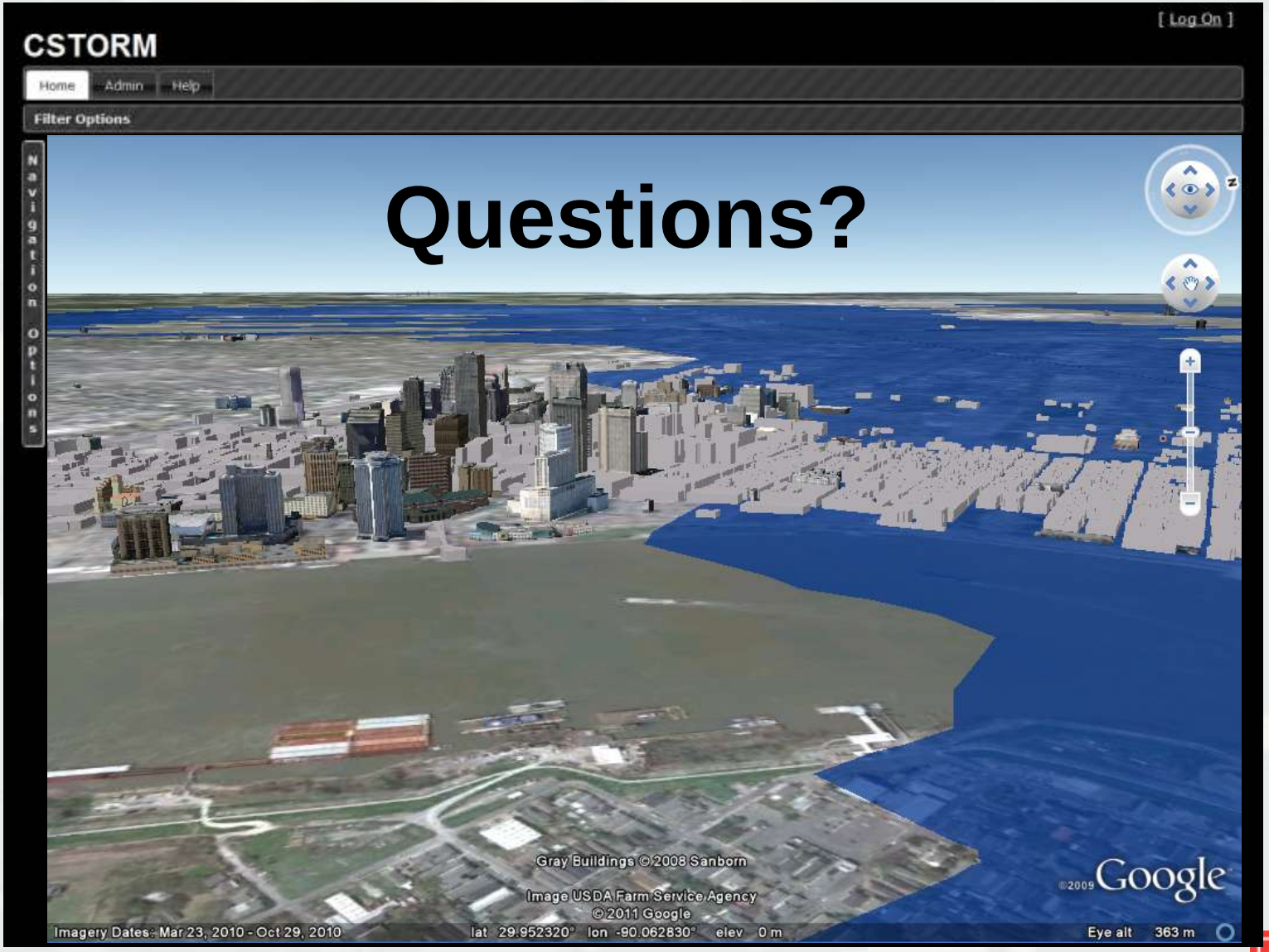


Contour Plots



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


CSTORM
[Log On]
Home
Admin
Help
Filter Options
Navigation Options
Questions?
Gray Buildings © 2008 Sanborn
Image USDA Farm Service Agency
© 2011 Google
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Imagery Dates: Mar 23, 2010 - Oct 29, 2010
lat 29.952320° lon -90.062830° elev 0 m
Eye alt 363 m