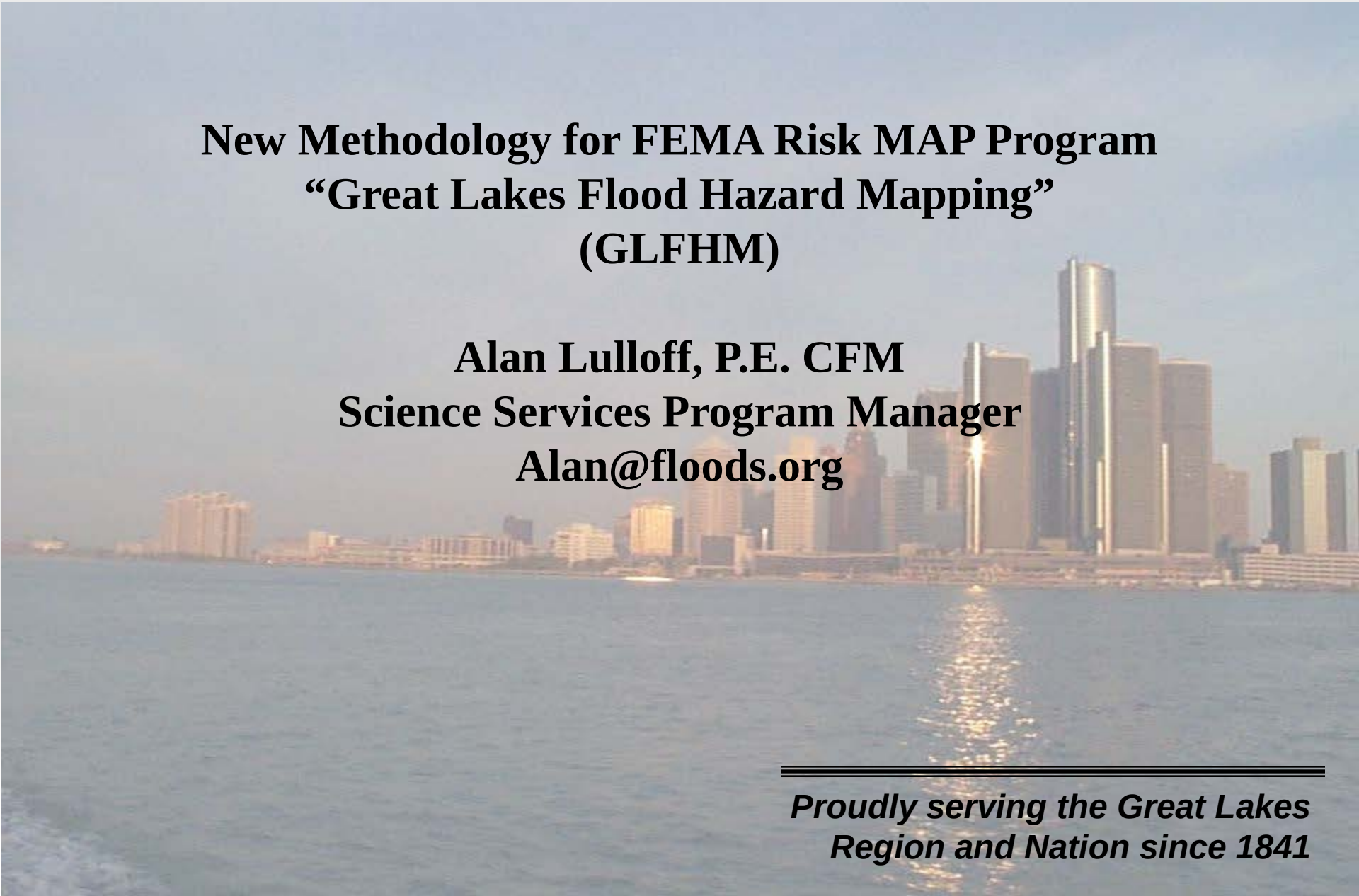


New Methodology for FEMA Risk MAP Program "Great Lakes Flood Hazard Mapping" (GLFHM)

Alan Lulloff, P.E. CFM
Science Services Program Manager
Alan@floods.org

Proudly serving the Great Lakes Region and Nation since 1841

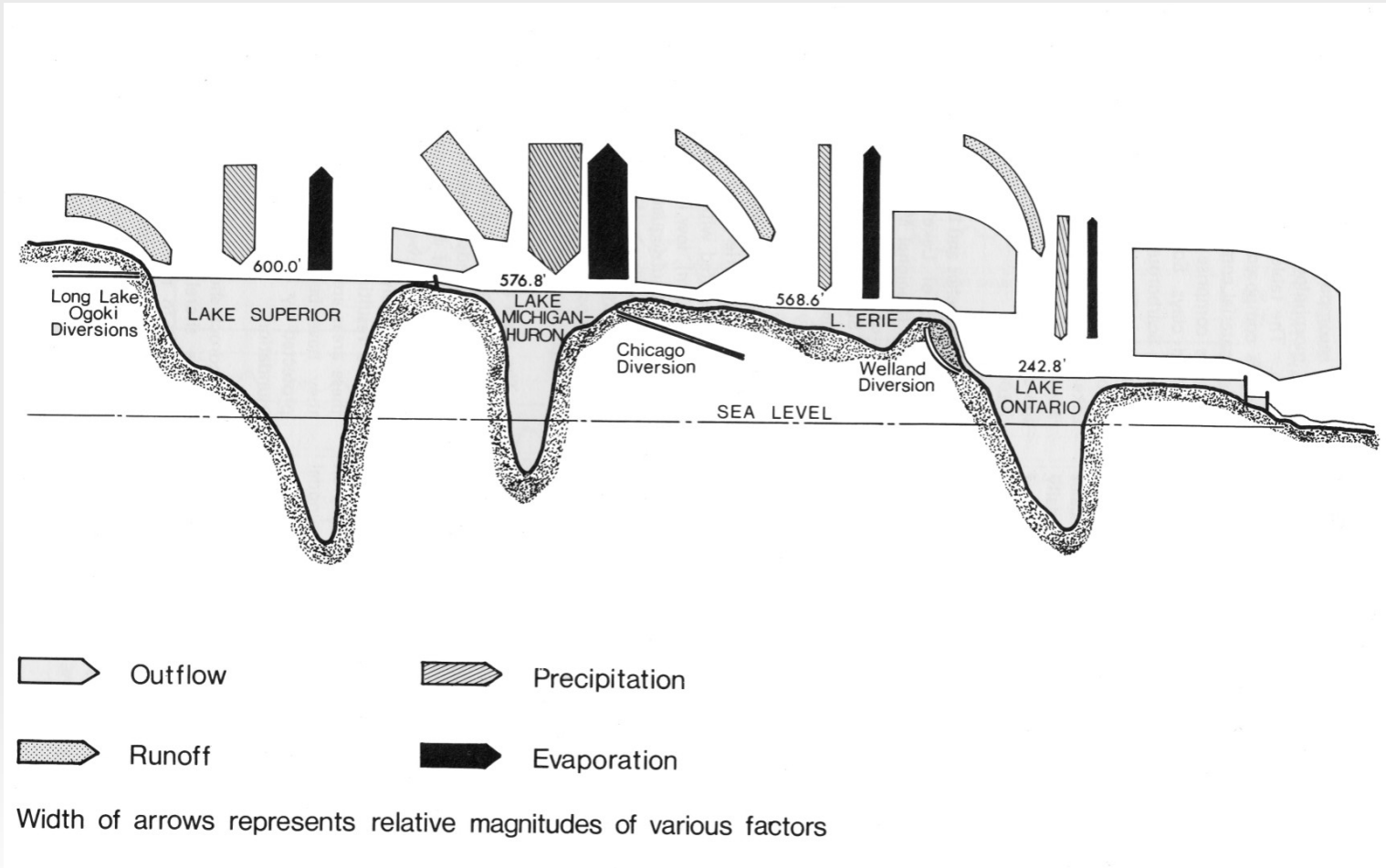
Outline

- 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

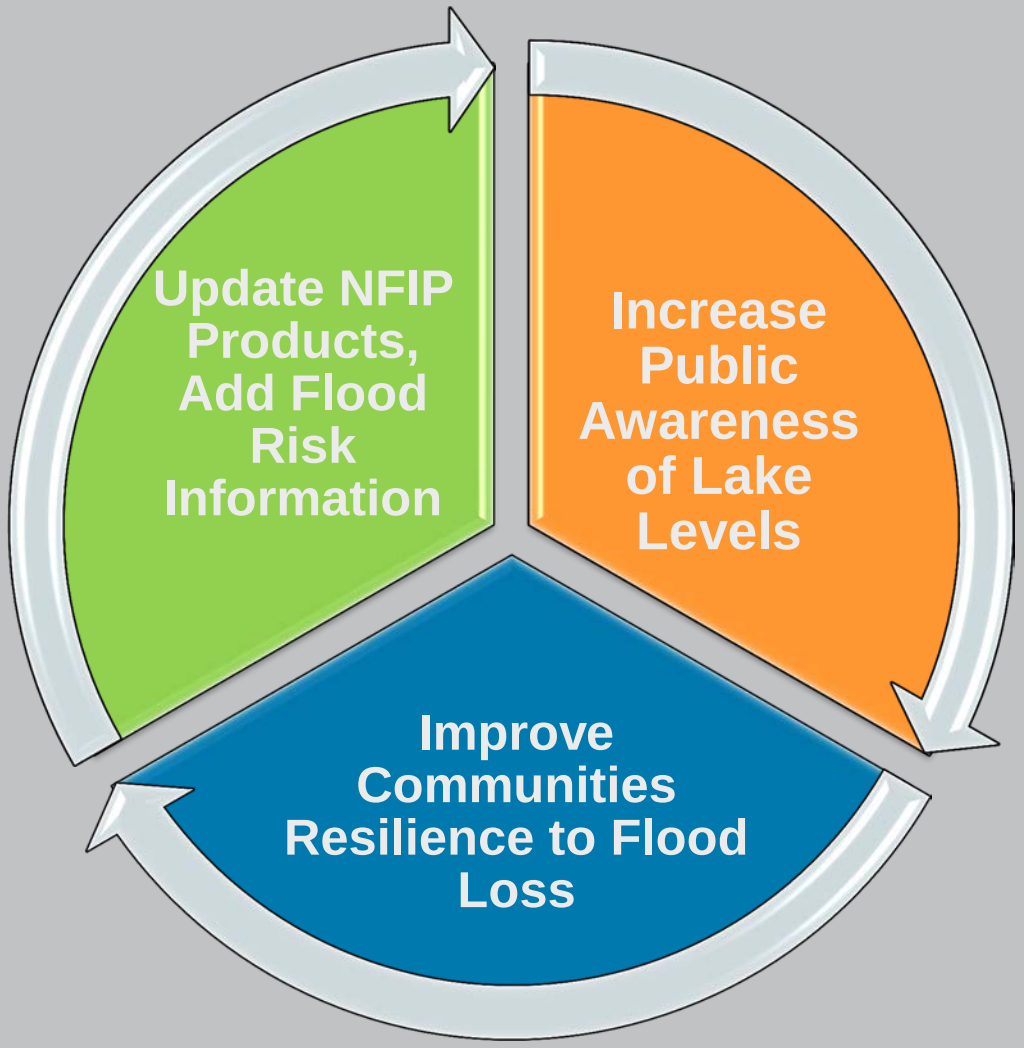
Great Lakes Flood Hazard Mapping Program

The initiative is a system-wide solution that provides a comprehensive analysis of storm and high water events within the Great Lakes Basin

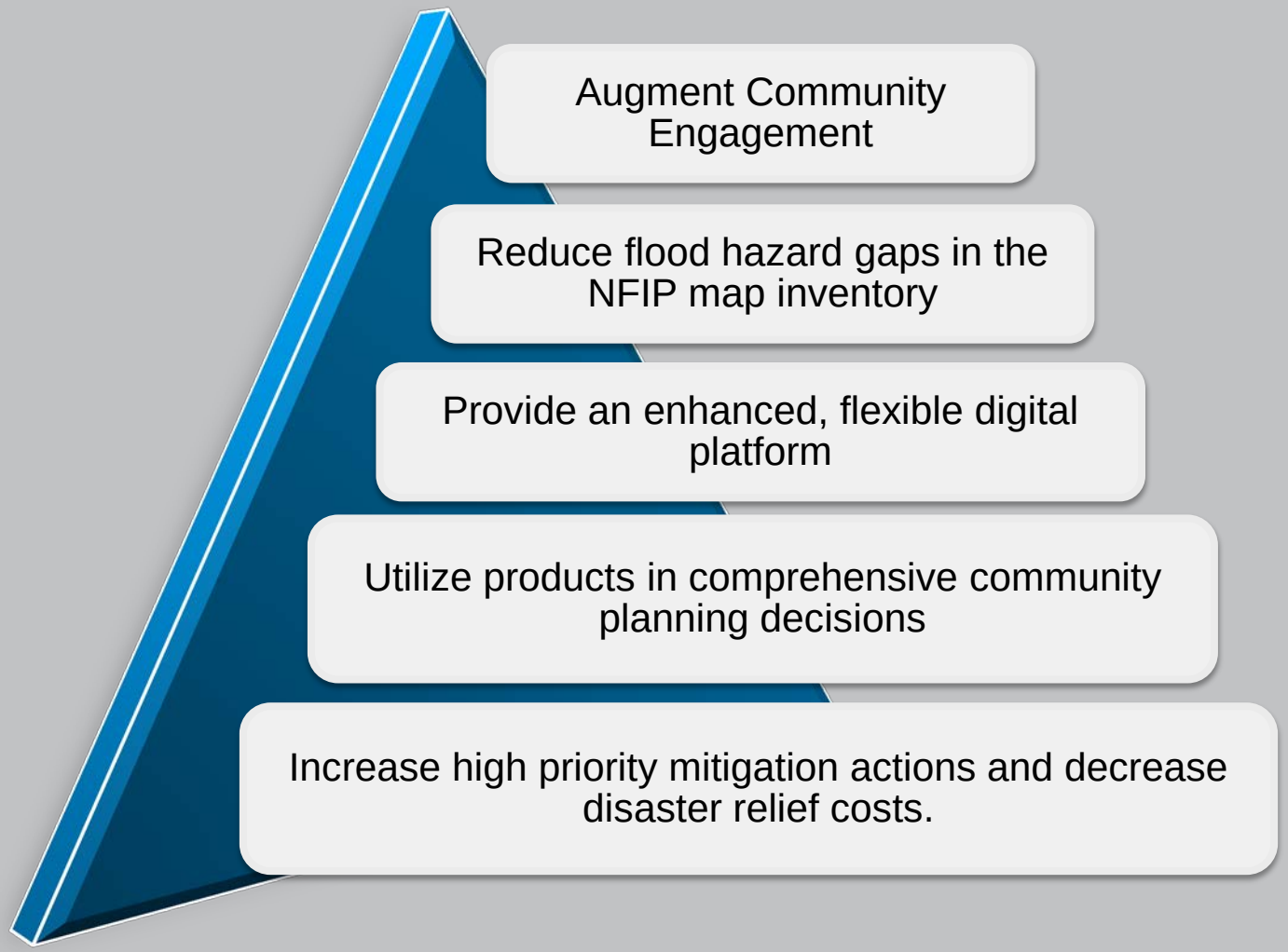
Great Lakes Watershed



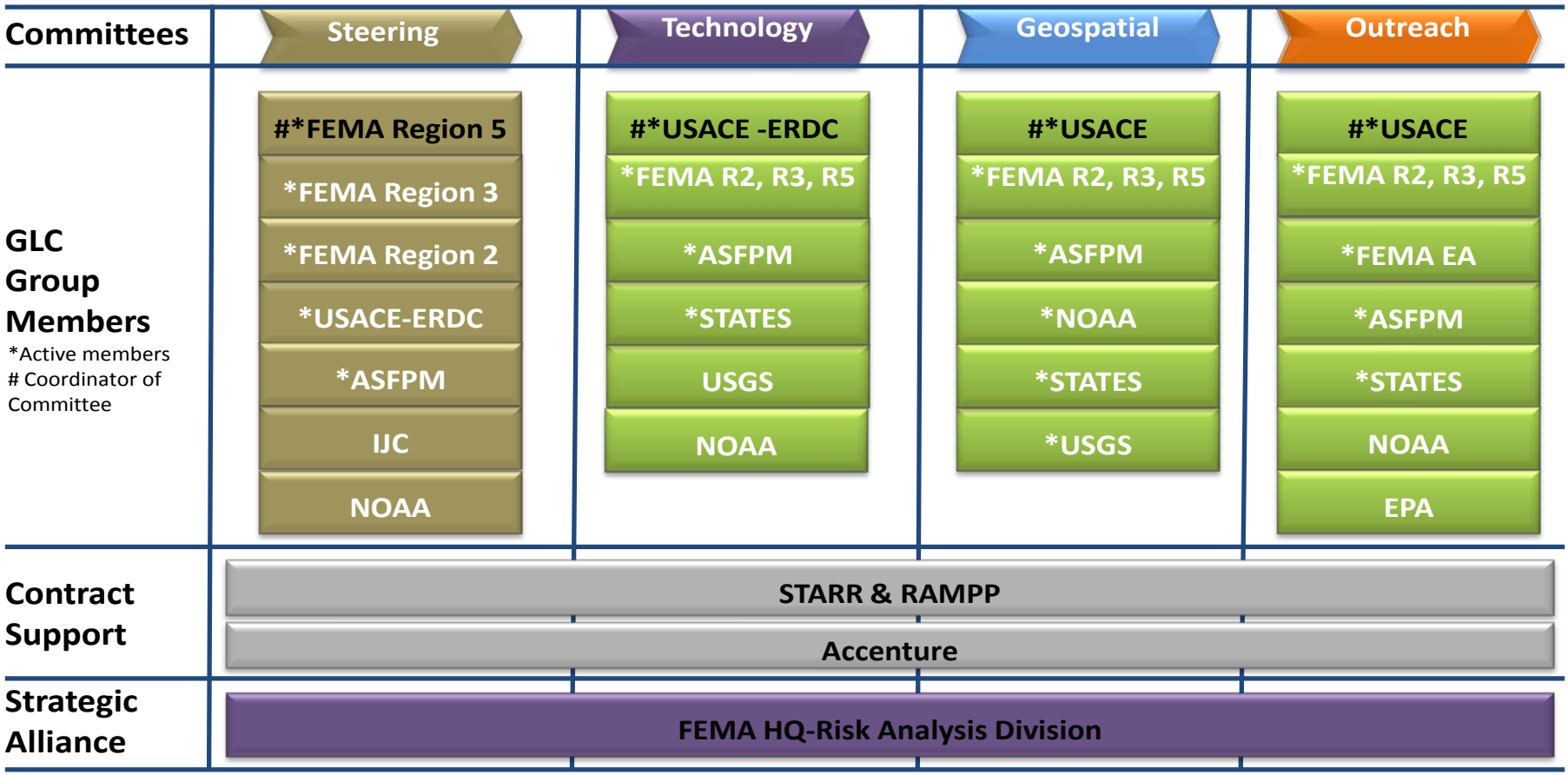
Vision


Update NFIP Products, Add Flood Risk Information
Increase Public Awareness of Lake Levels
Improve Communities Resilience to Flood Loss

Strategic Objectives



Great Lakes Program Governance



Legend

= Execute program decisions

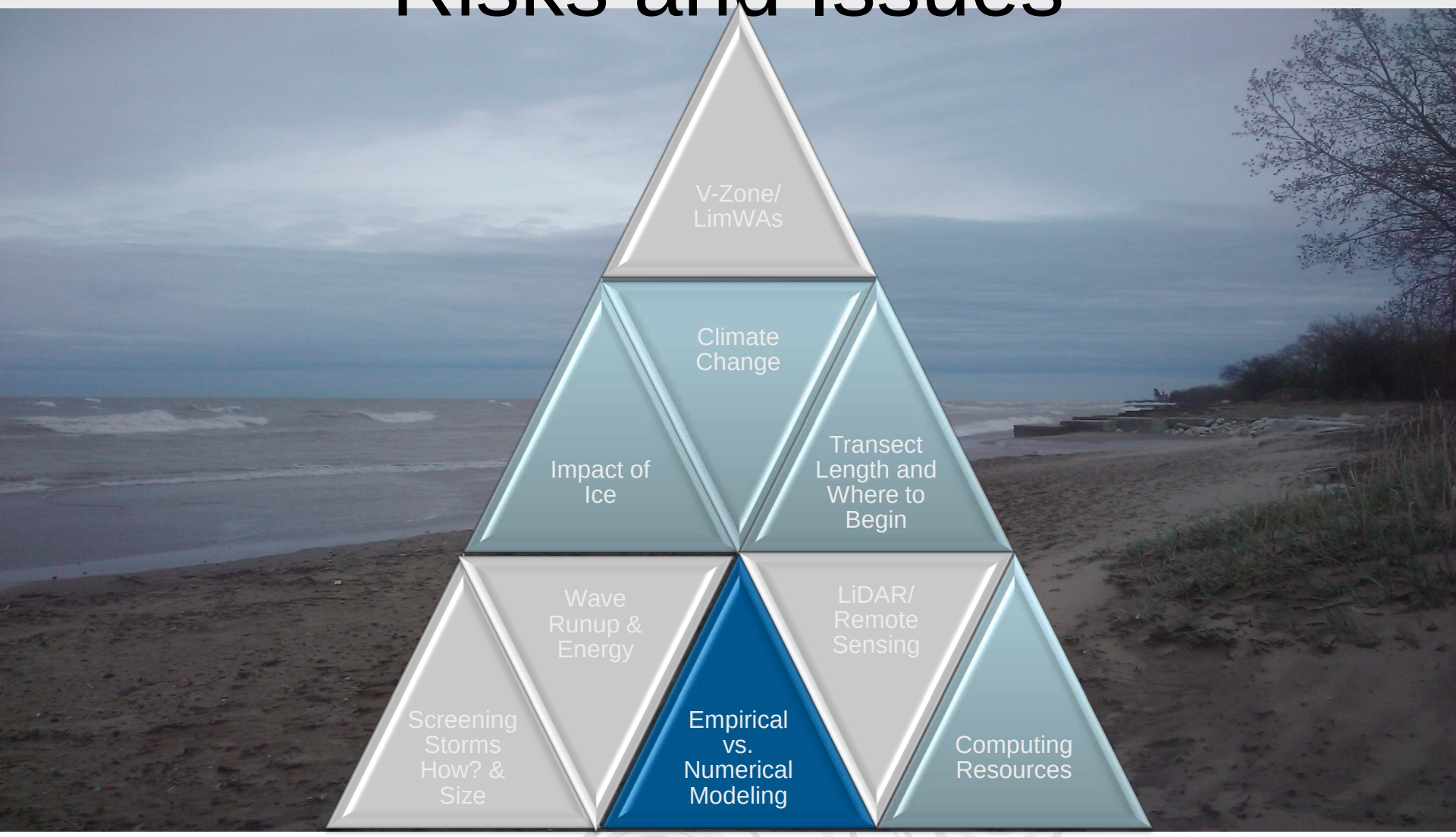
= Expedite subprojects initiated by the Steering Committee

= Observe, provide feasibility assessment as needed, develop work products

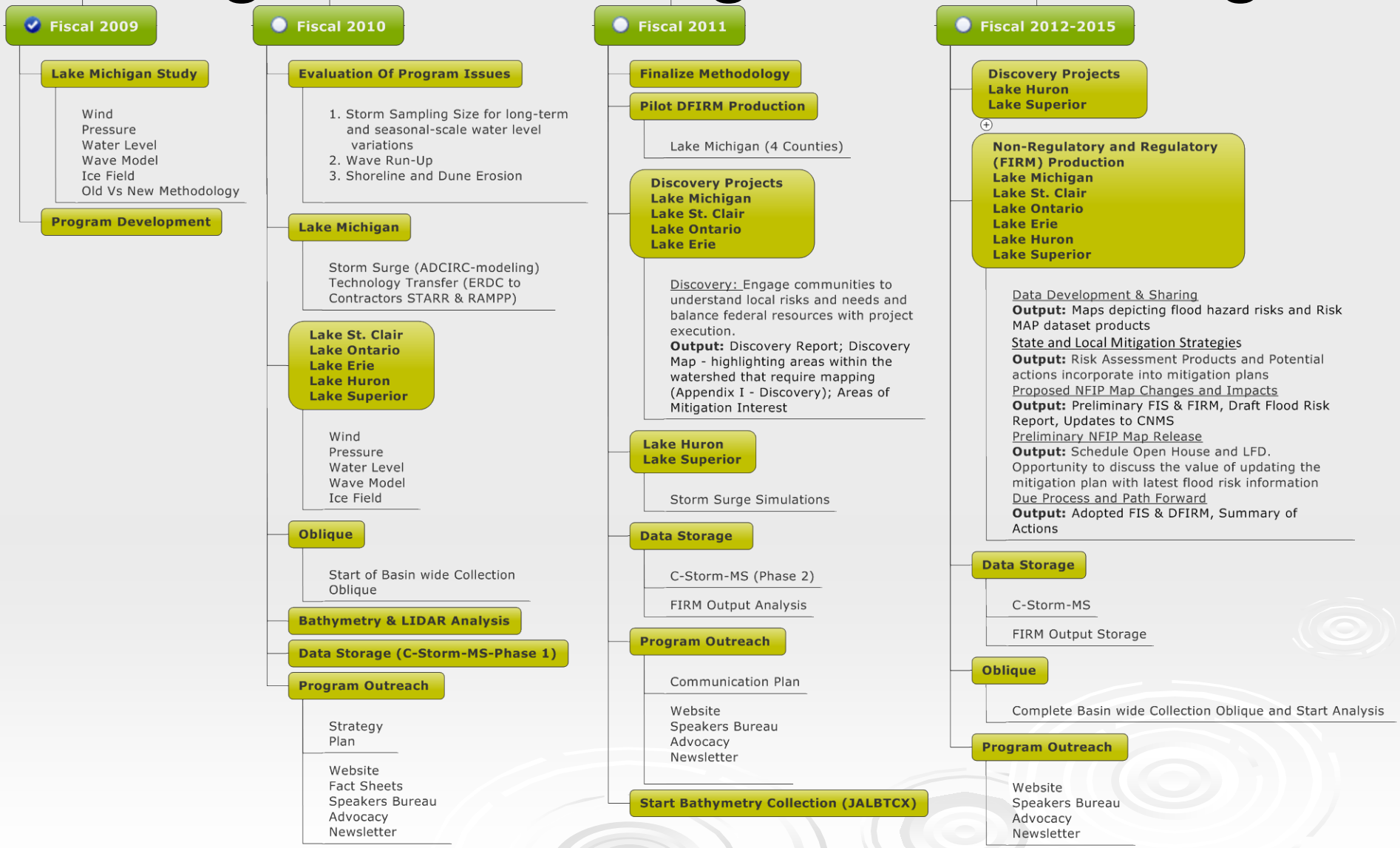
= Maintain strategically the Risk MAP related endeavors and objectives

ASFPM= Association of State Floodplain Managers
EA= External Affairs
ERDC= Engineer Research and Development Center
FEMA= Federal Emergency Management
IJC= International Joint Committee Canada & US
NOAA= National Oceanic and Atmospheric Administration
USACE= US Army Corps of Engineers
USGS= U.S. Geological Survey
EPA= Environmental Protection Agency

Program High Level Risks and Issues



High Level Program Planning



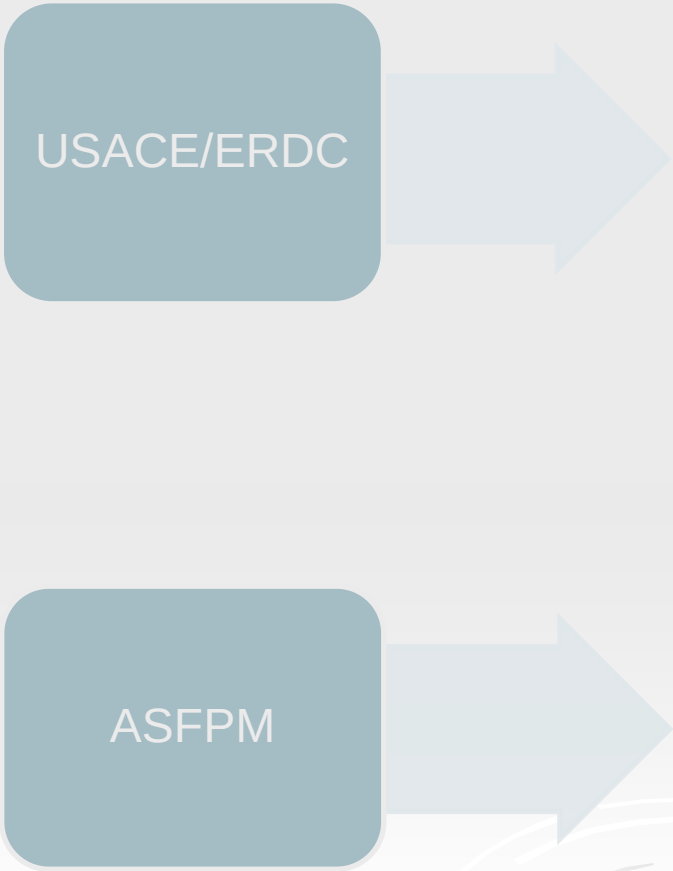
2010 Project Outputs

USACE/ERDC

ASFPM

- Oblique Partial Collection (Lake Michigan) & Viewer
- Oblique Analysis
- Lake Michigan & Lake St. Clair Basinwide model (Data Analysis, Model Set Up, Wave & Water Level Production Modeling)
- Web Interface to Access supporting data “CSTORM-MS” (Coastal Storm Modeling System)
- Focus Studies (Wave Run-up, Beach Erosion, Storm Sampling)
- Program Outreach Strategy
- Technology Transfer Group

2010 Project Outputs



- **Fact Sheets**
- **Website**
- **Speakers Bureau**
- **Advocacy**
- **Pilot Newsletter**

2010 Project Outputs

STARR Contractors

- Lake Superior & Lake Huron Basinwide model (Data Analysis, Model Set Up)

RAMPP Contractors

- Lake Ontario and Lake Erie Basinwide model: (Data Analysis, Model Set Up, Wave & Water Level Production Modeling)

Great Lakes Flood Hazard Mapping (GLFHM)

Collaborative Project Between:

FEMA Region 5 (Lead)

FEMA Region 2

FEMA Region 3

Detroit District USACE

Chronology of Project Events

August 1996 – FEMA HQ publishes draft guidance "Wave Elevation Determination and V-Zone Mapping for the Great Lakes"

January 2005 – Corps hosts a 2-day workshop for the FEMA-Corps update of Appendix D.3 which was attended by State NFIP and CZM leads

November 2008 – FEMA HQ and Baker completes a third version of Appendix D.3 update and asks Corps and FEMA Region 5 to provide for review and comment

August 2009 – Corps holds a Stakeholder Workshop with FEMA Regions 2 / 3 / 5, State govt. officials, ASFPM, FEMA contractors and other interested parties

February 2010 – USACE ERDC holds an Executive Committee meeting with FEMA Region 5, Corps, ASFPM, and FEMA contractors

Key Changes to the Methodology

1. Run-up Computations

- **Old method used the 100-year S.W.L. with a 3-year wave height**
- **New method uses a response-based analysis approach to run-up computations**
- **100-year water levels will be updated from the 1988 Open Coast Report.**

Photo: *Timaru Herald*

Key Changes to the Methodology

2. New Run-up Methods Available for Structures and Revetments

- **Updated methodology provides for the TAW run-up method at the structures and revetments**
- **Mean overtopping rates from Owen & Goda may be used**

Photo: *Timaru Herald*

Key Changes to the Methodology

3. New Methods for Overland Wave Propagation

- Available for Embayments and Sheltered Shoreline Areas
- Discarding the use of ACES ✡ Transitioning to CHAMP
- WHAFIS and STWAVE together can be better utilized

Key Changes to the Methodology

4. Ice Cover

- **Currently examining multiple methods to include ice cover in wave height determination, run-up, and overland wave propagation calculations**

Photo: Lori Niedenfuer

Photo: *Michigan Travel Bureau*

GLFHM "Technical" Sub-Committee

Goal

- Address V-Zone feasibility within the new Great Lakes Coastal Flood Hazard Mapping methodology

Objectives

- Incorporate the methodology both timely & seamlessly
- Prioritize the mapping to account for population density and potential risks
- Collect and organize spatial and tabular data to populate analysis for the GIS Enterprise System Subcommittee

GLFHM "GIS" Sub-Committee

Goal

- Obtain and manage all Great Lakes Coastal Flood Hazard Mapping GIS data

Objectives

- Establish a database architecture to ensure long-term utility for an array of datasets
- Create and implement a quality control protocol for the datasets
- Enable an innovative data sharing solution with federal/state partners and regional organizations

GLFHM "Education and Public Outreach" Sub-Committee

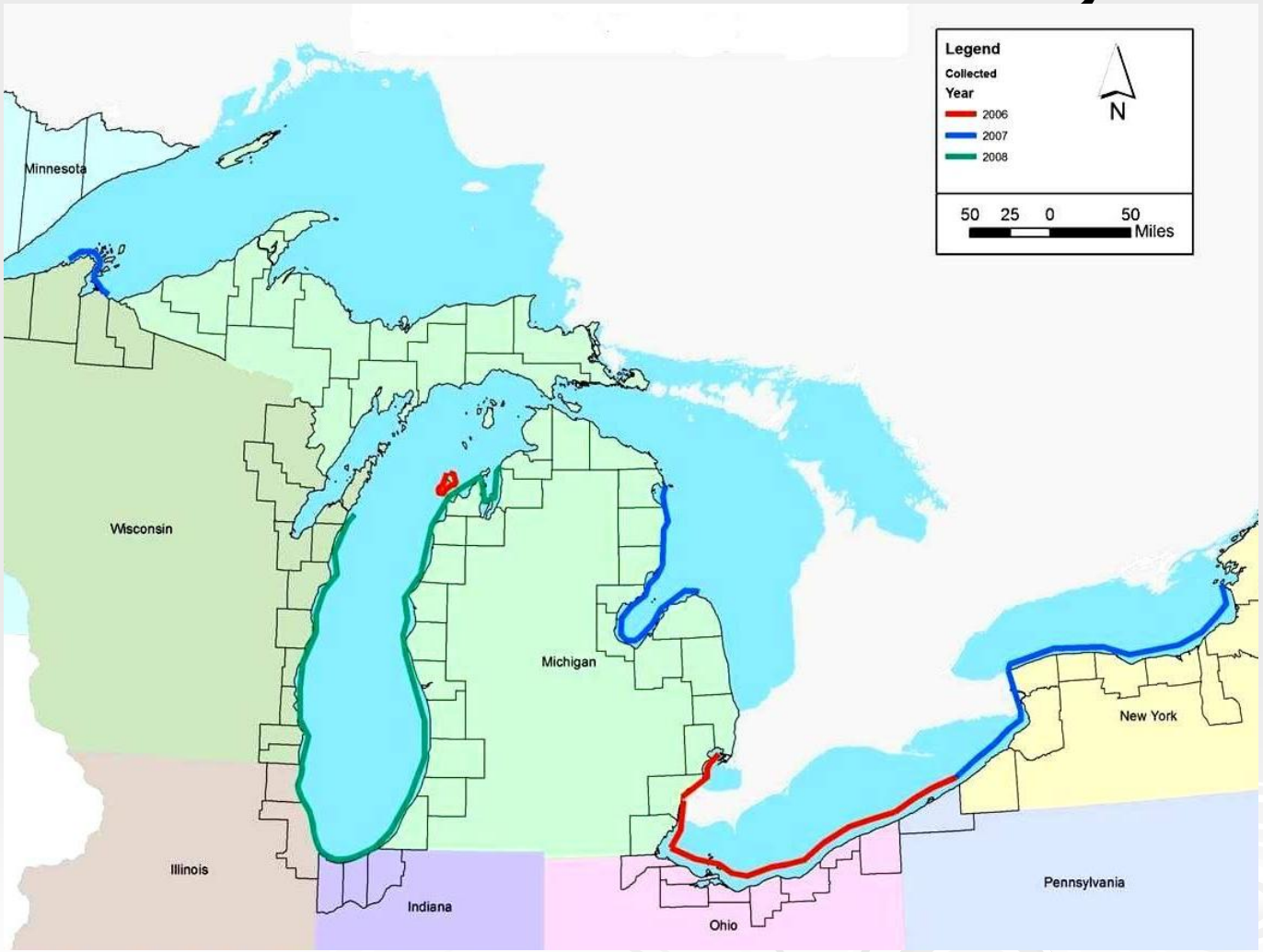
Goal

- Identify the target audiences and tools in order to communicate the new Great Lakes Coastal Flood Hazard Mapping methodology

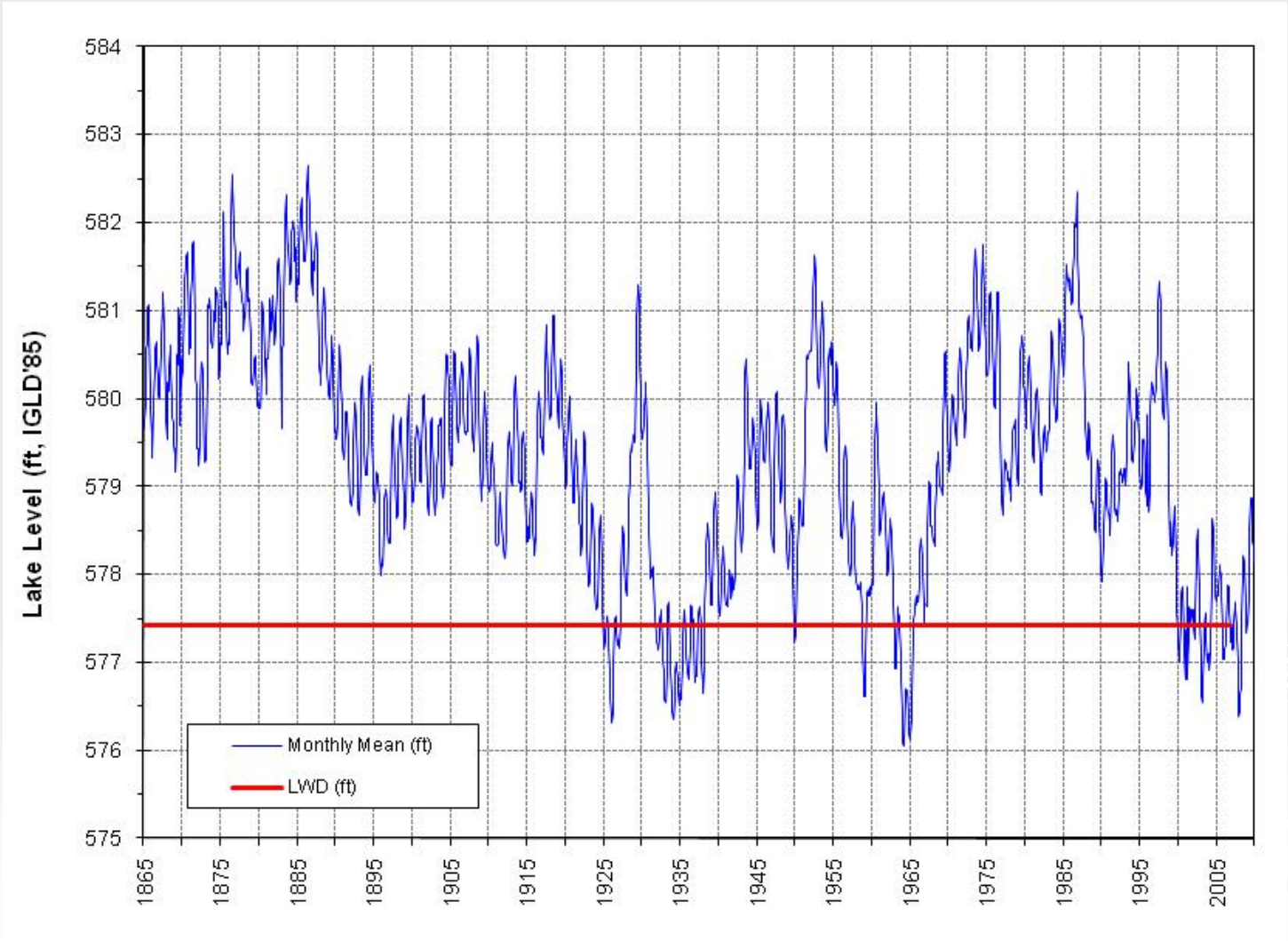
Objectives

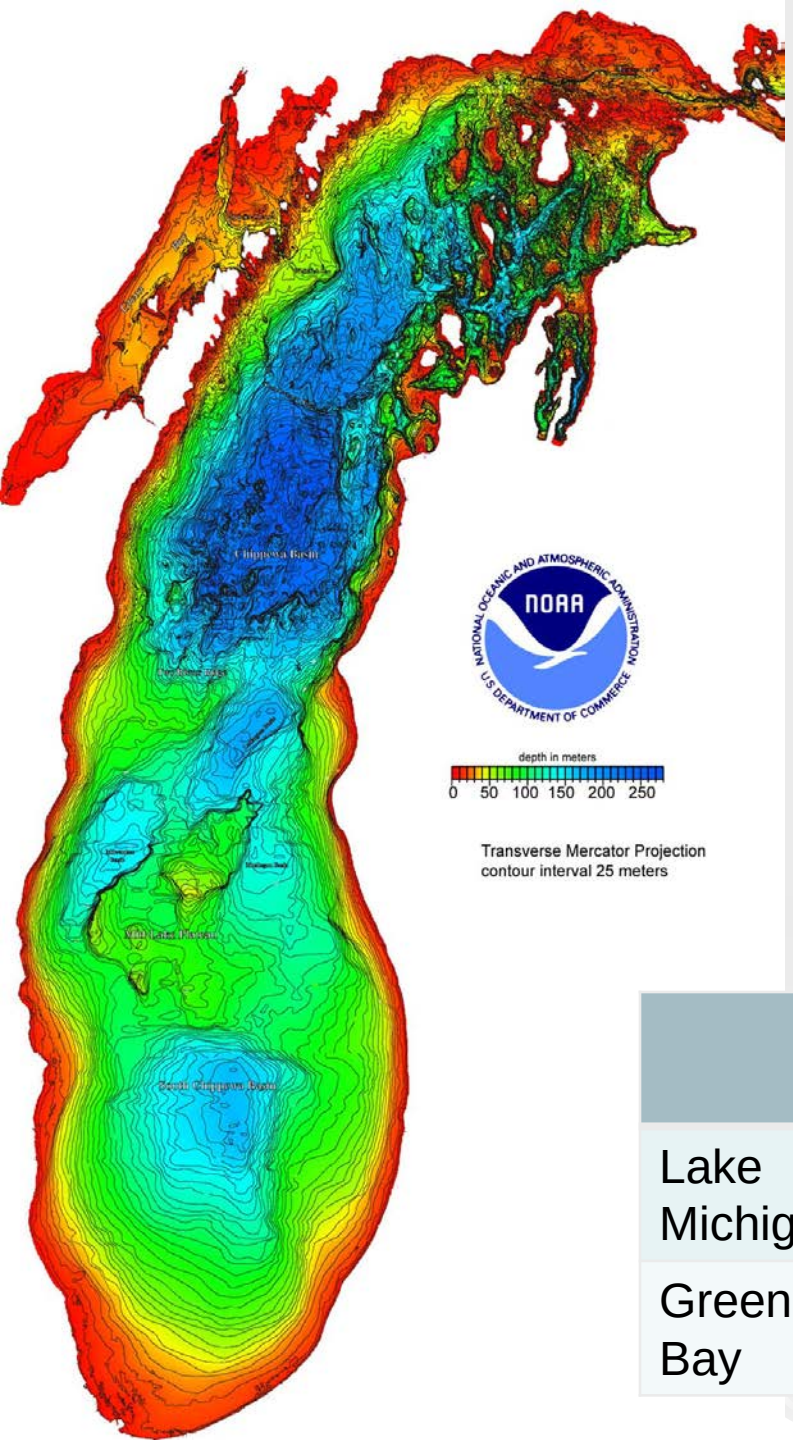
- Establish both a process and framework that will be able to communicate the GLFHM process to both technical and non-technical audiences
- Enable proactive tools to educate both the public and stakeholders
- Utilize existing conferences and/or workshops to facilitate speakers

Status of Shoreline Bathymetry



Lake Michigan Water Levels



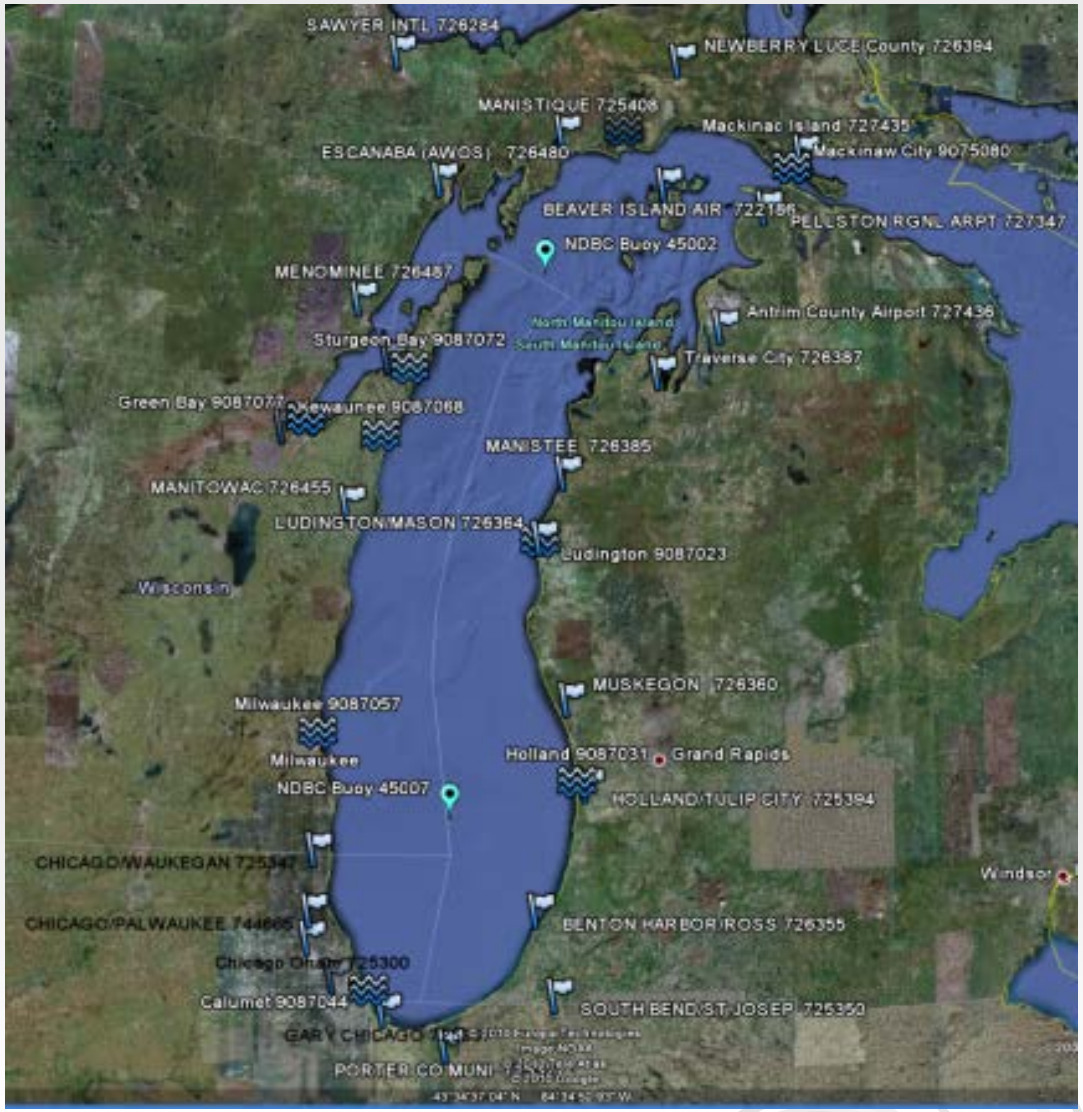


Contributors to BFEs Approximate Magnitudes

- 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

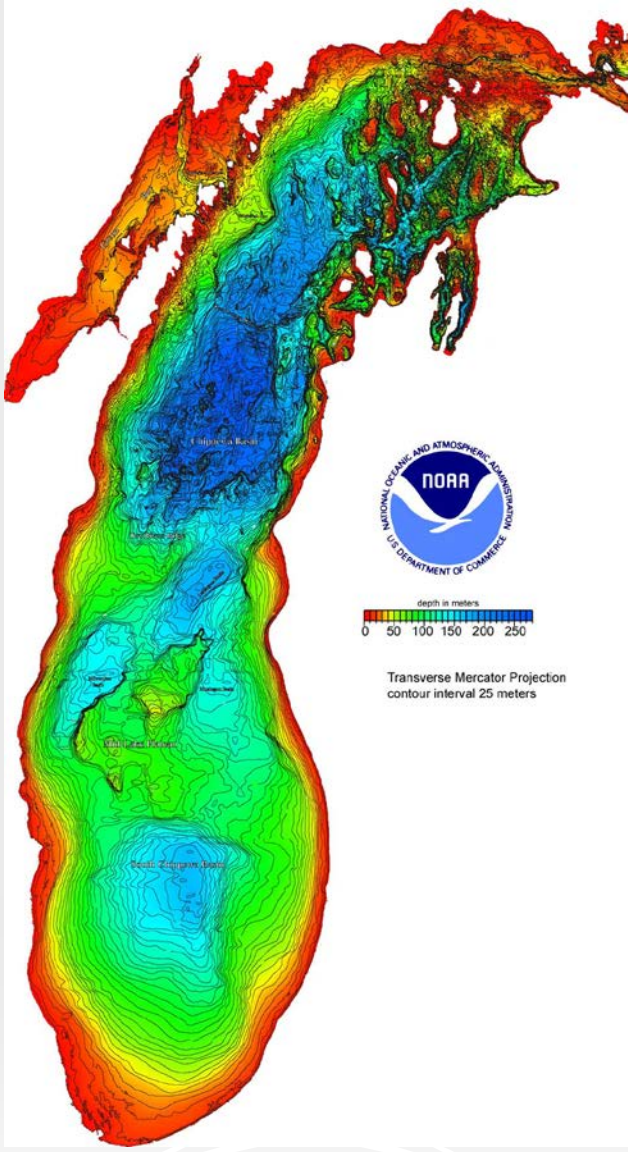


- NOAA NDBC wave and met buoys (removed in winter)
- NOAA NWS land based weather stations
- NOAA NOS water level gages

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

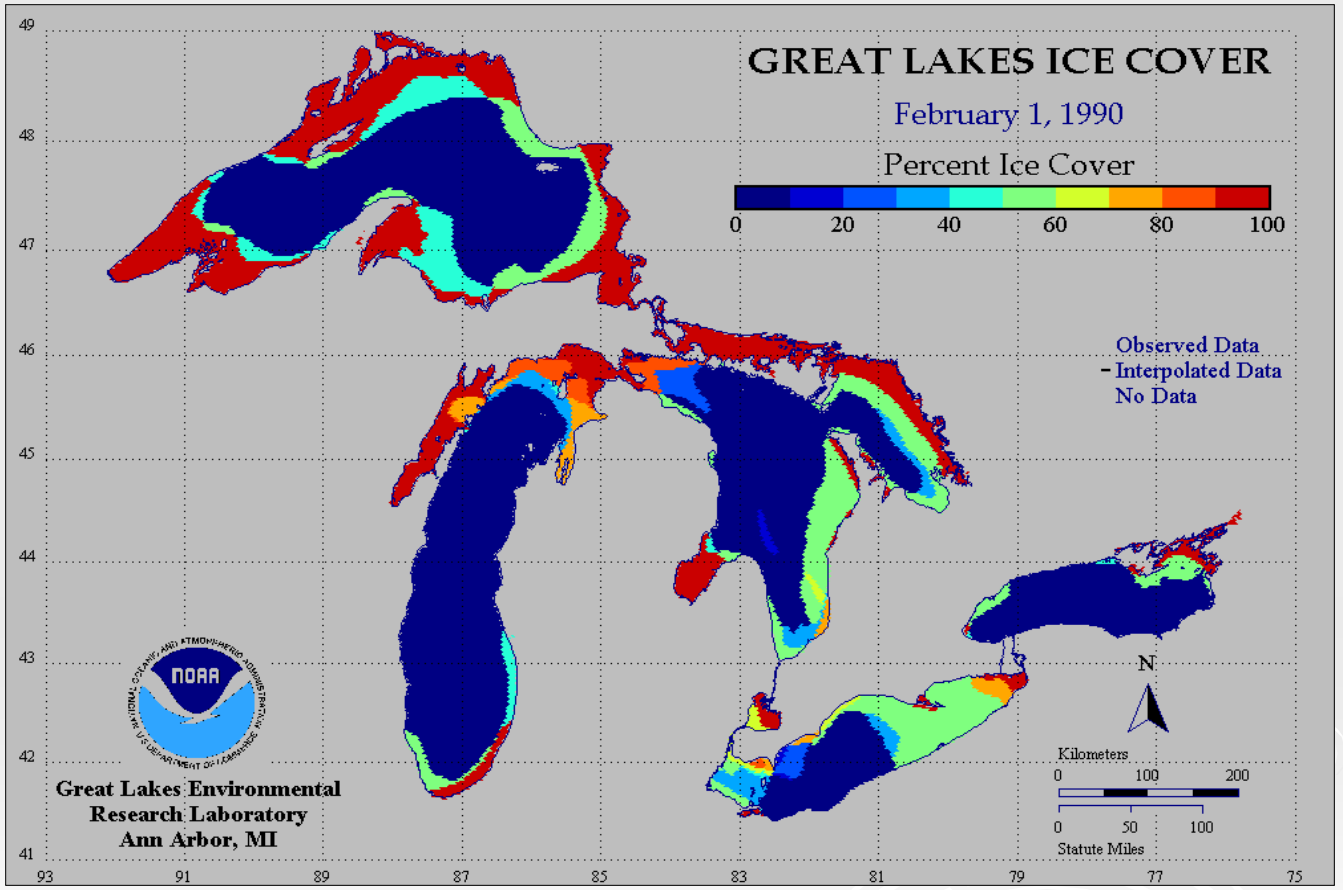
Modeling Approach

- 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

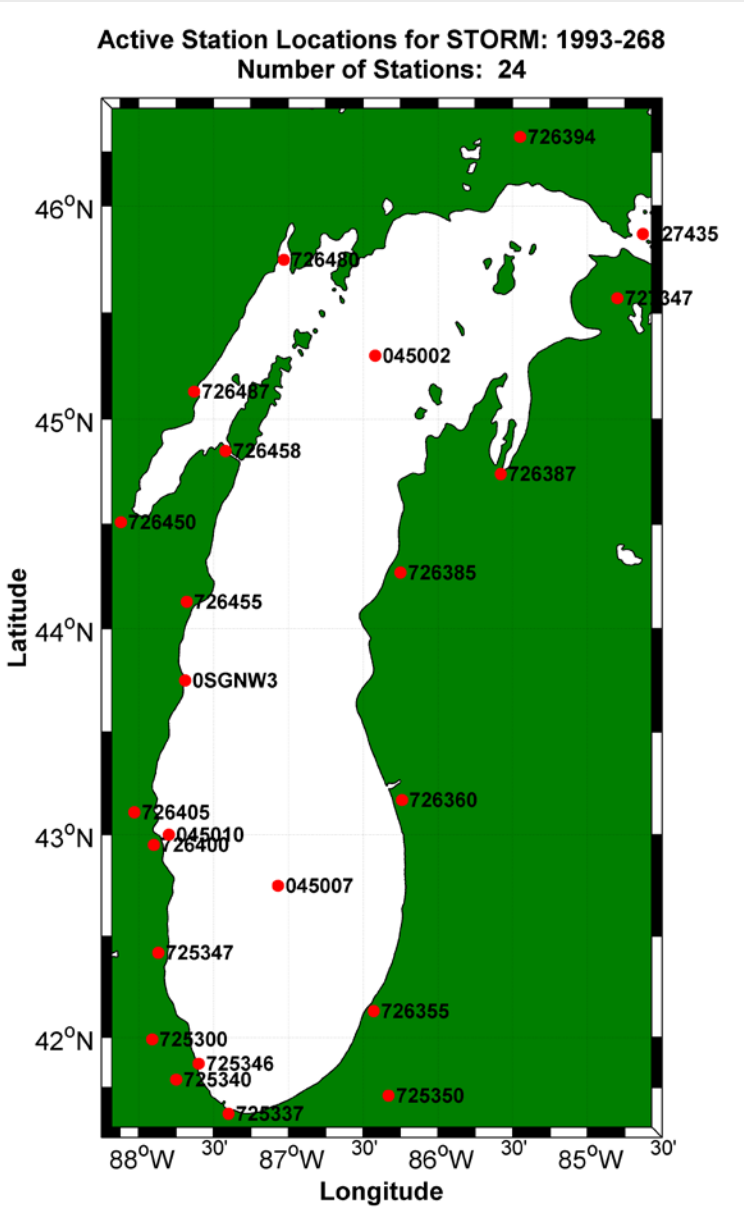


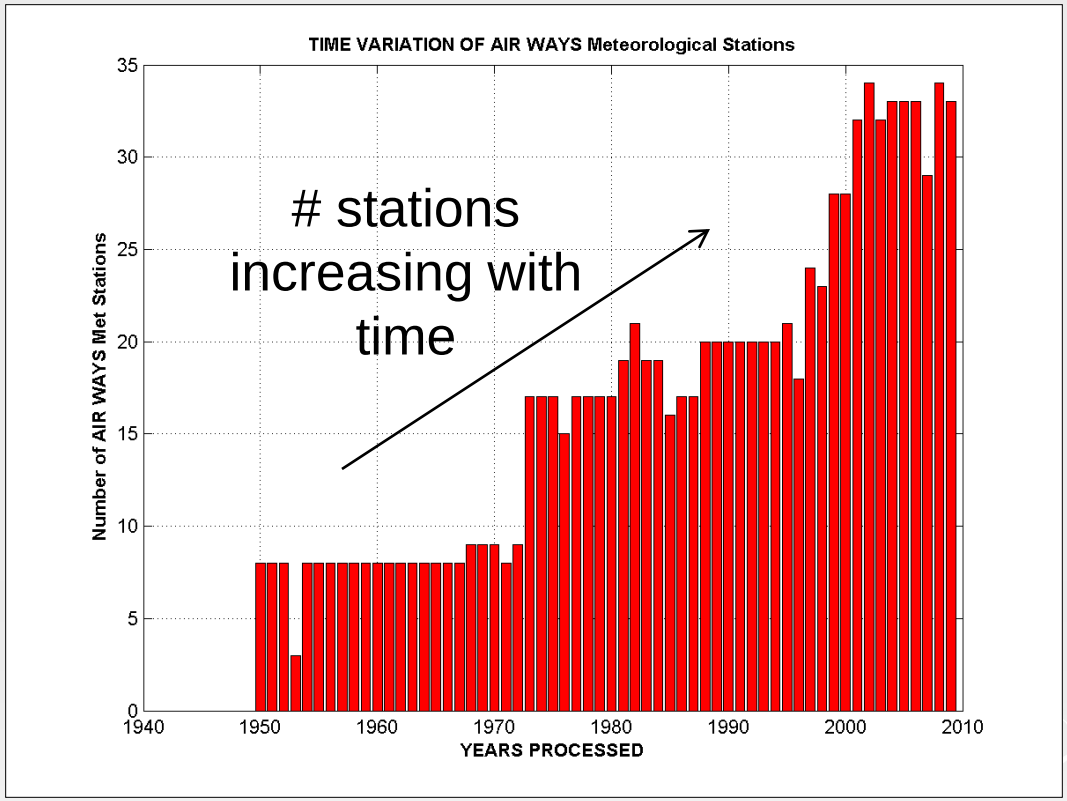
NOAA GLERL Ice Cover Data

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

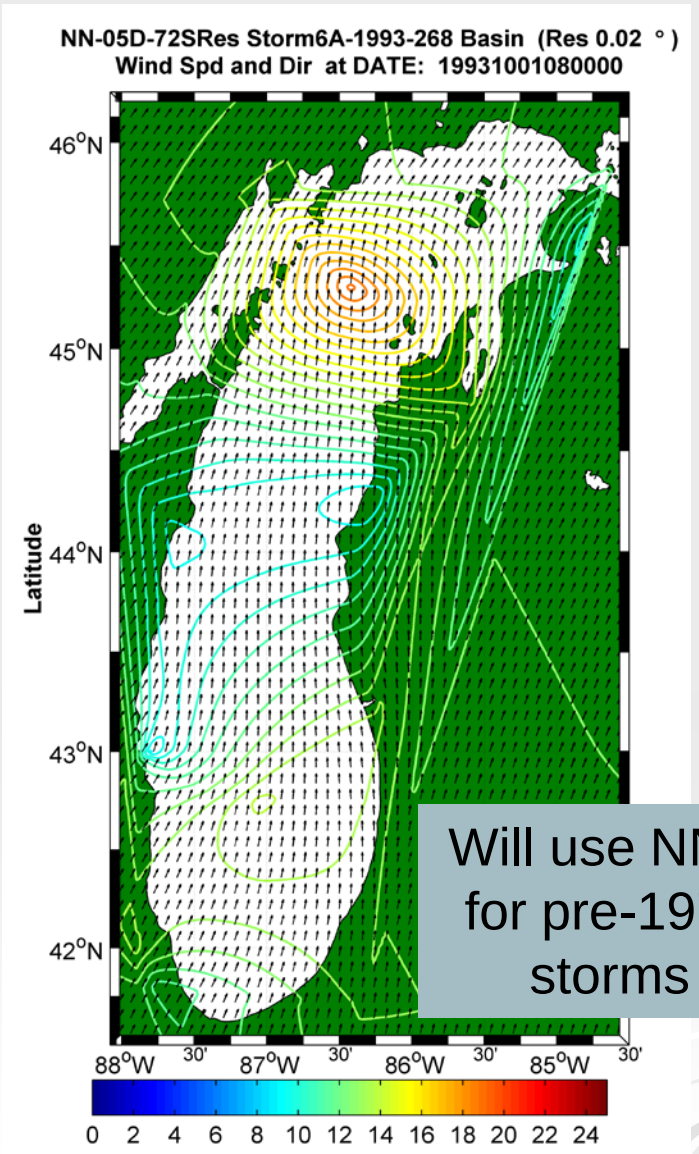


Measured Met Data Availability





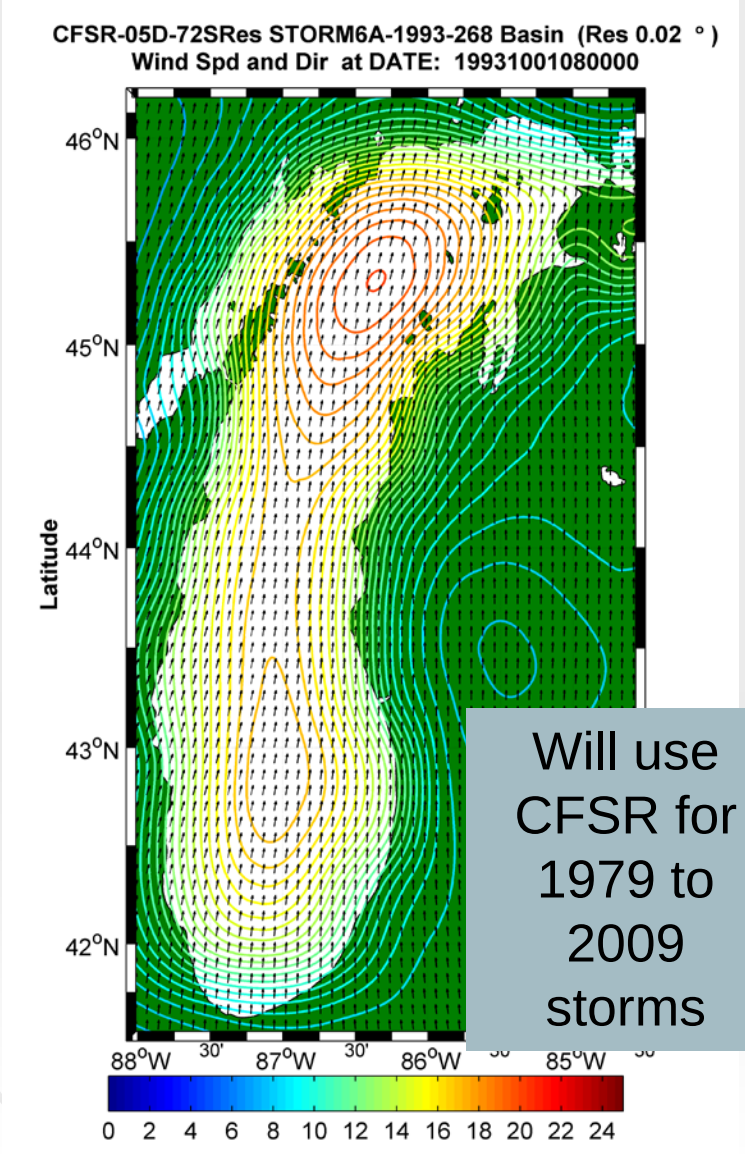
Options for Specifying Wind Fields



Wind Speed Contours

Will use NNM for pre-1979 storms

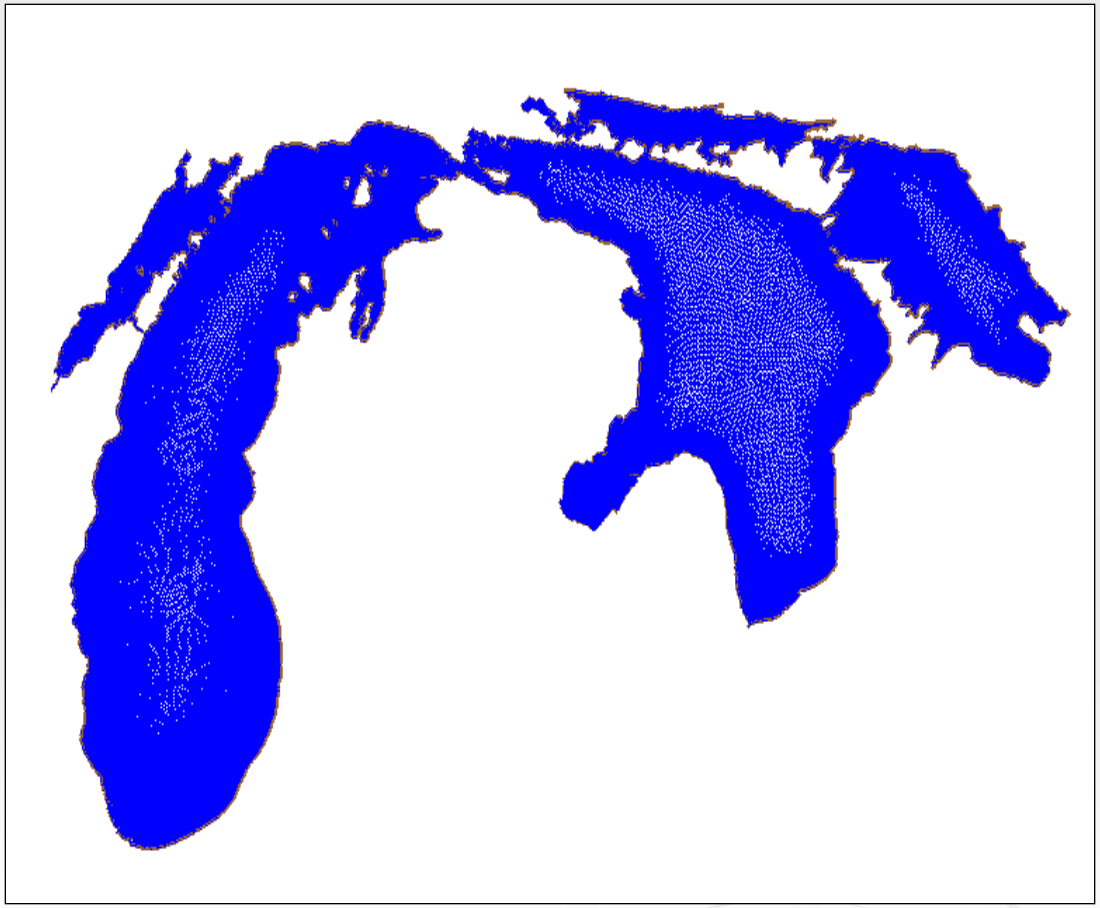
NOAA GLERL Natural Neighbor Method



Will use CFSR for 1979 to 2009 storms

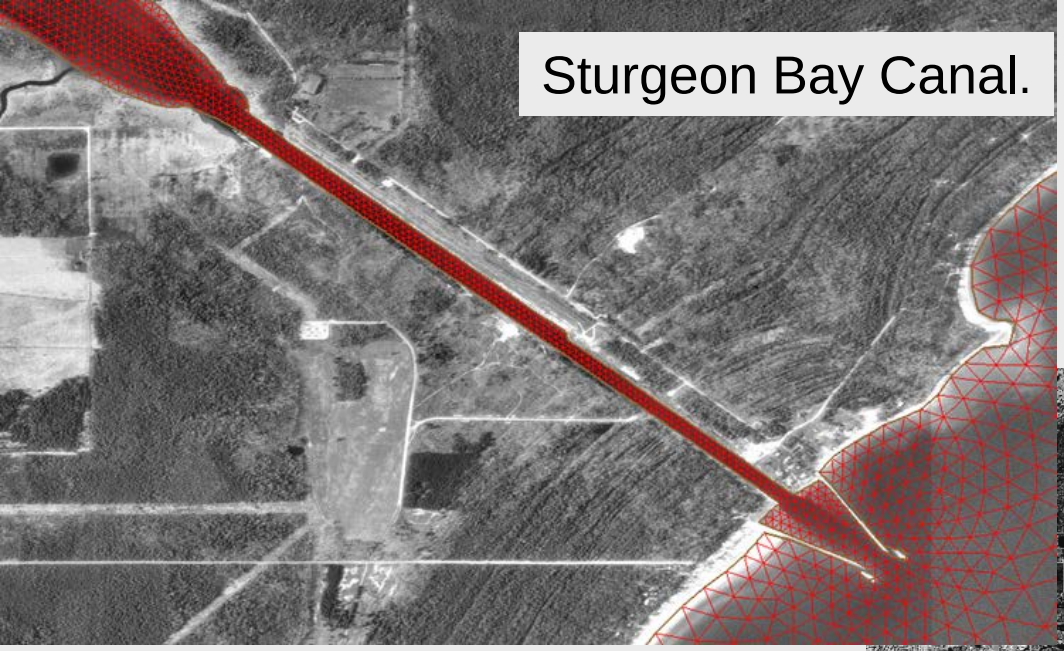
NOAA CFSR Reanalysis

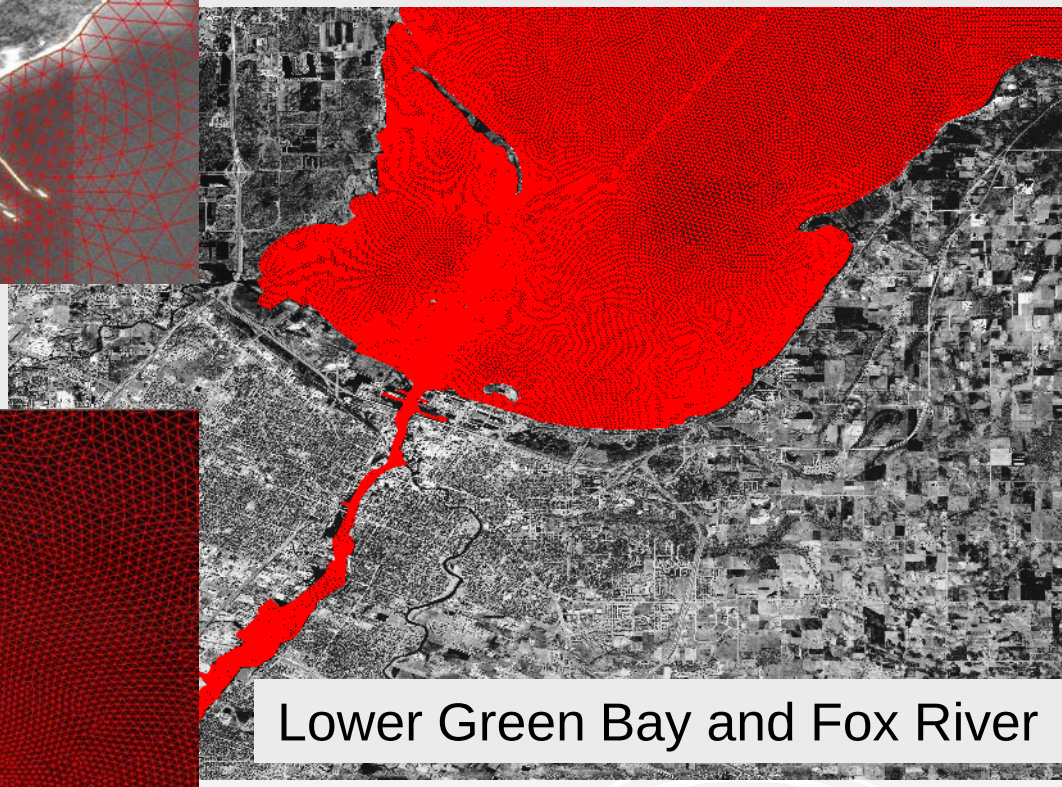
Storm Surge Modeling with ADCIRC



•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

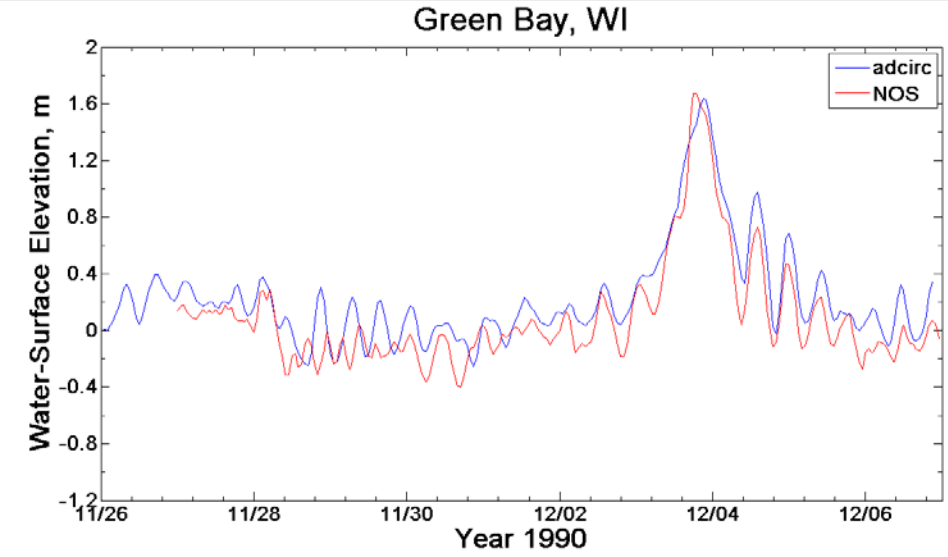

Sturgeon Bay Canal.

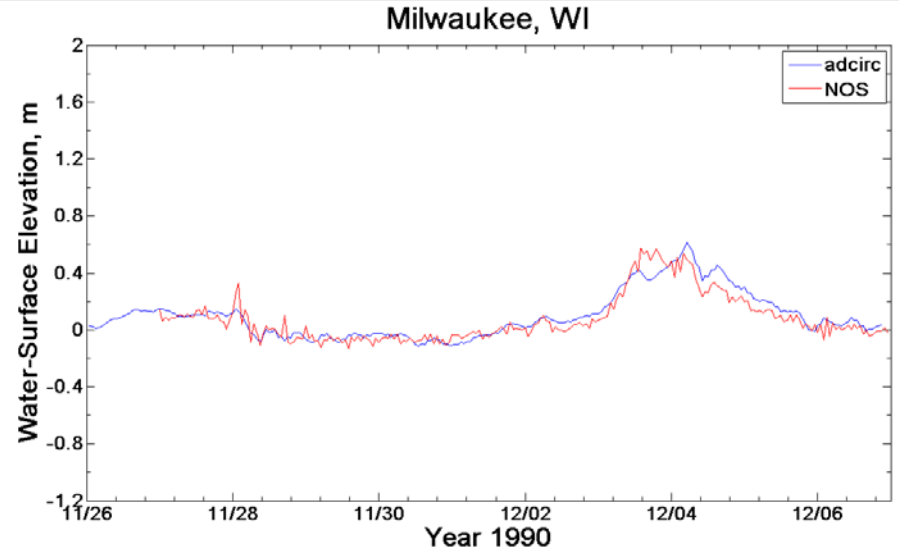

Lower Green Bay and Fox River

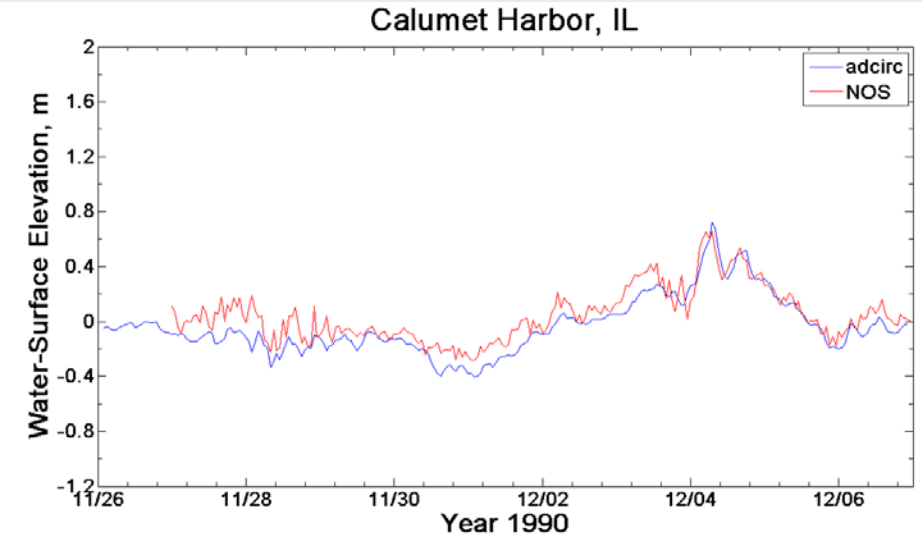

Calumet Harbor

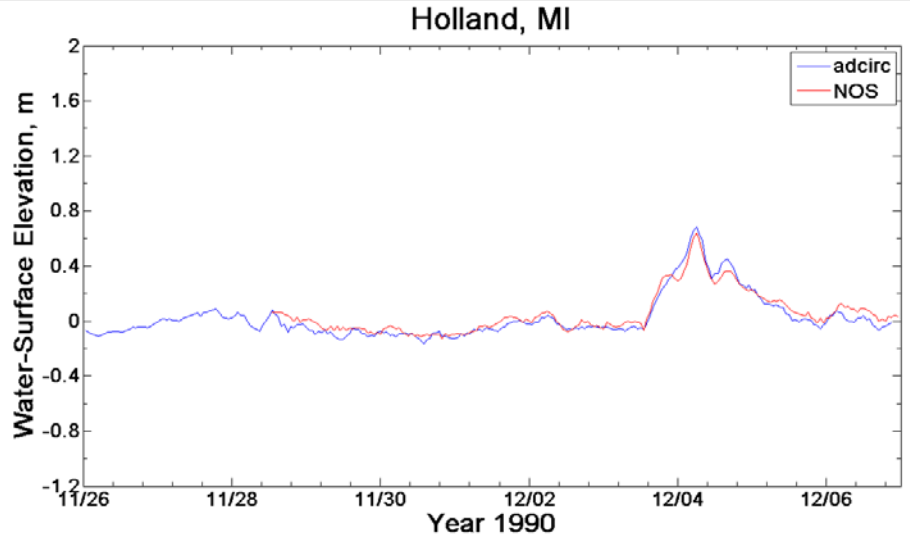
Water Level Measurement Locations

ADCIRC Model Comparisons to Measurements (Dec 1990 Storm)

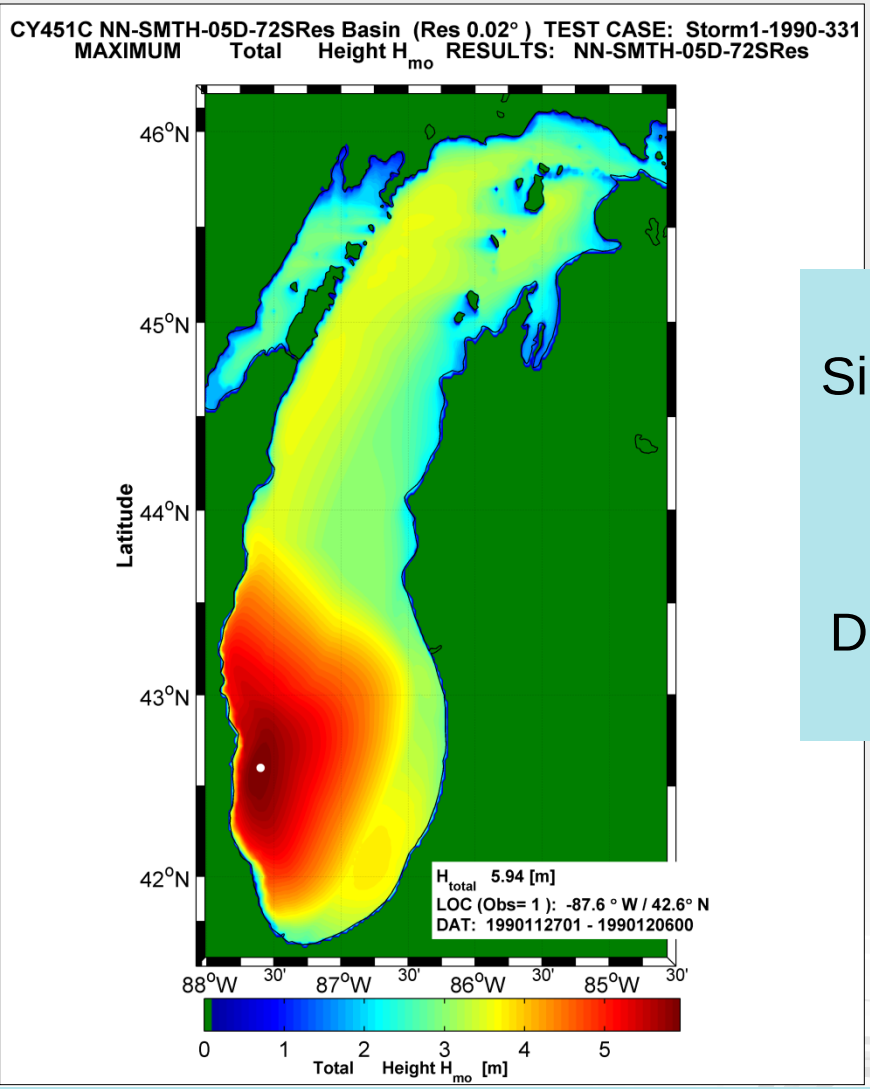






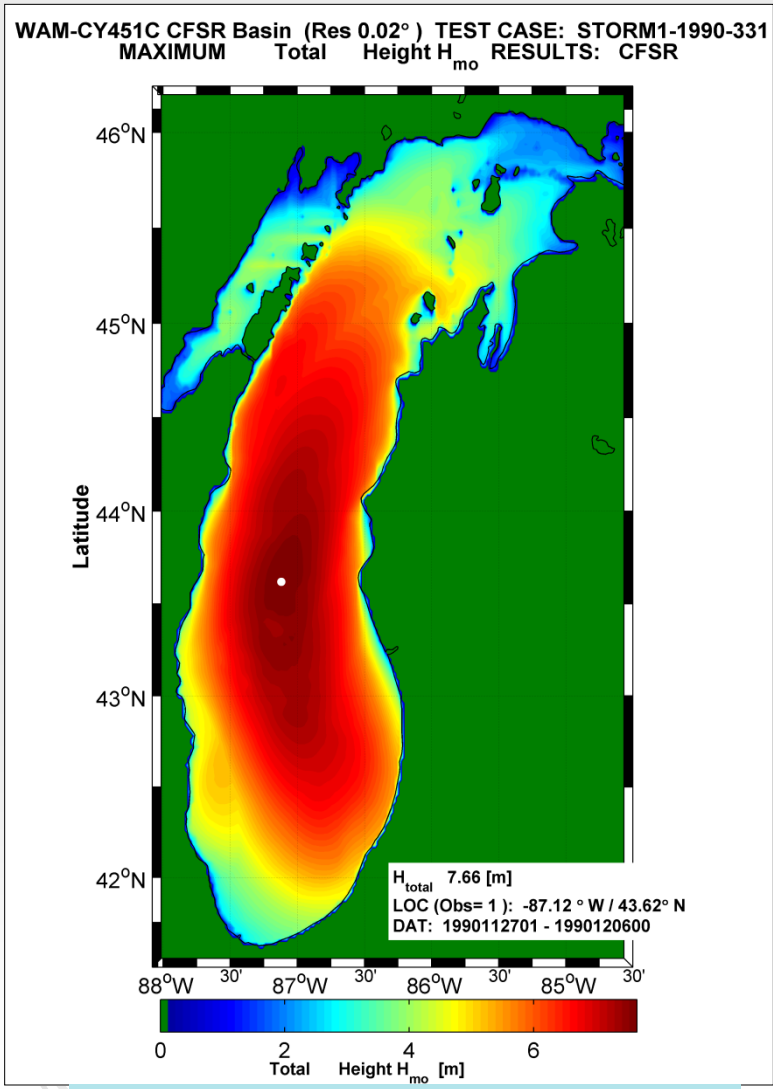


Lake-Scale Wave Modeling Using WAM



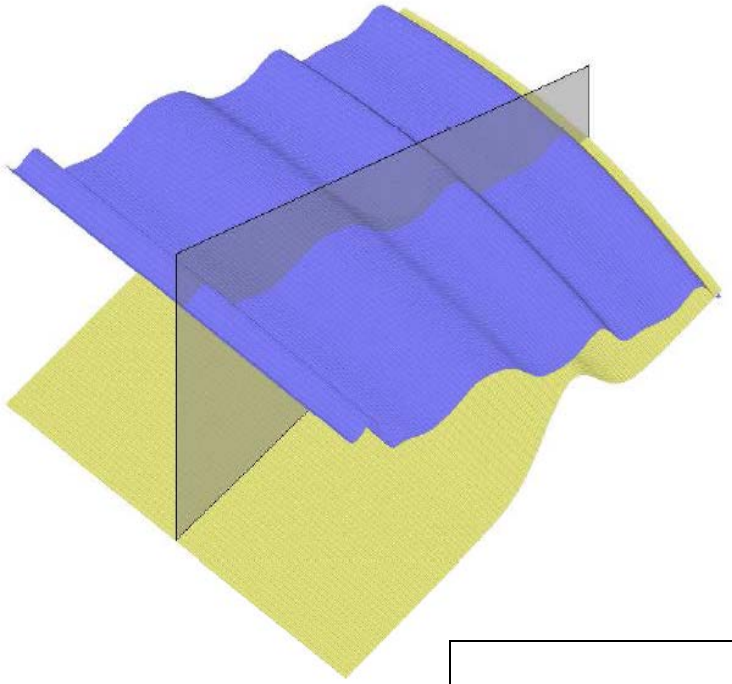
Max Significant Wave Height

Dec 1990 Storm

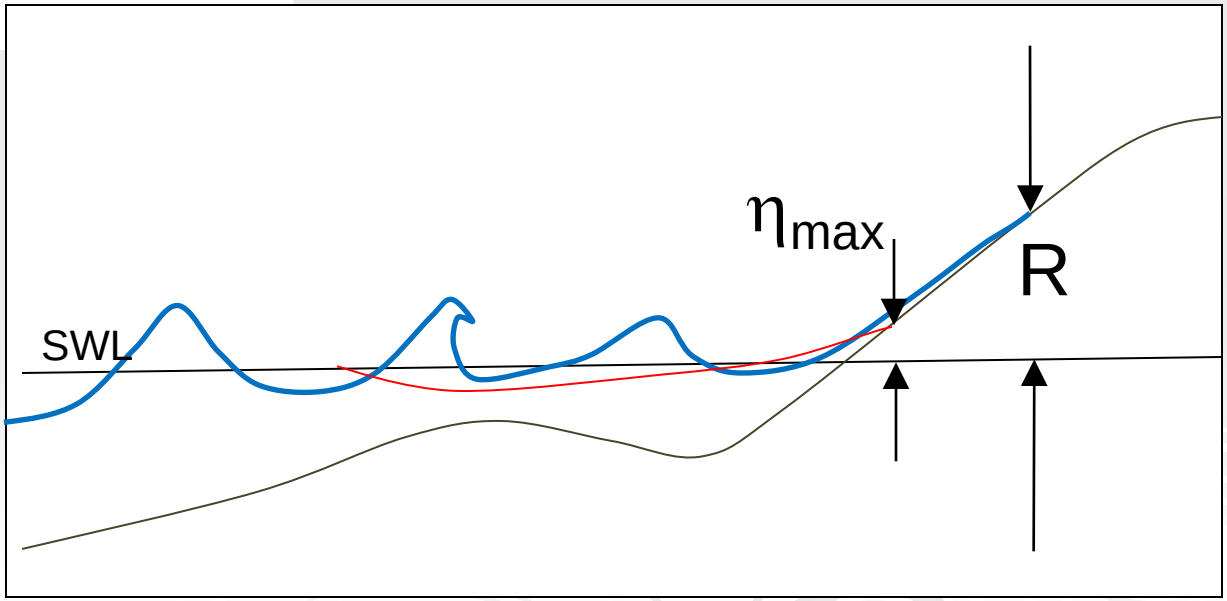


Natural Neighbor Method Winds

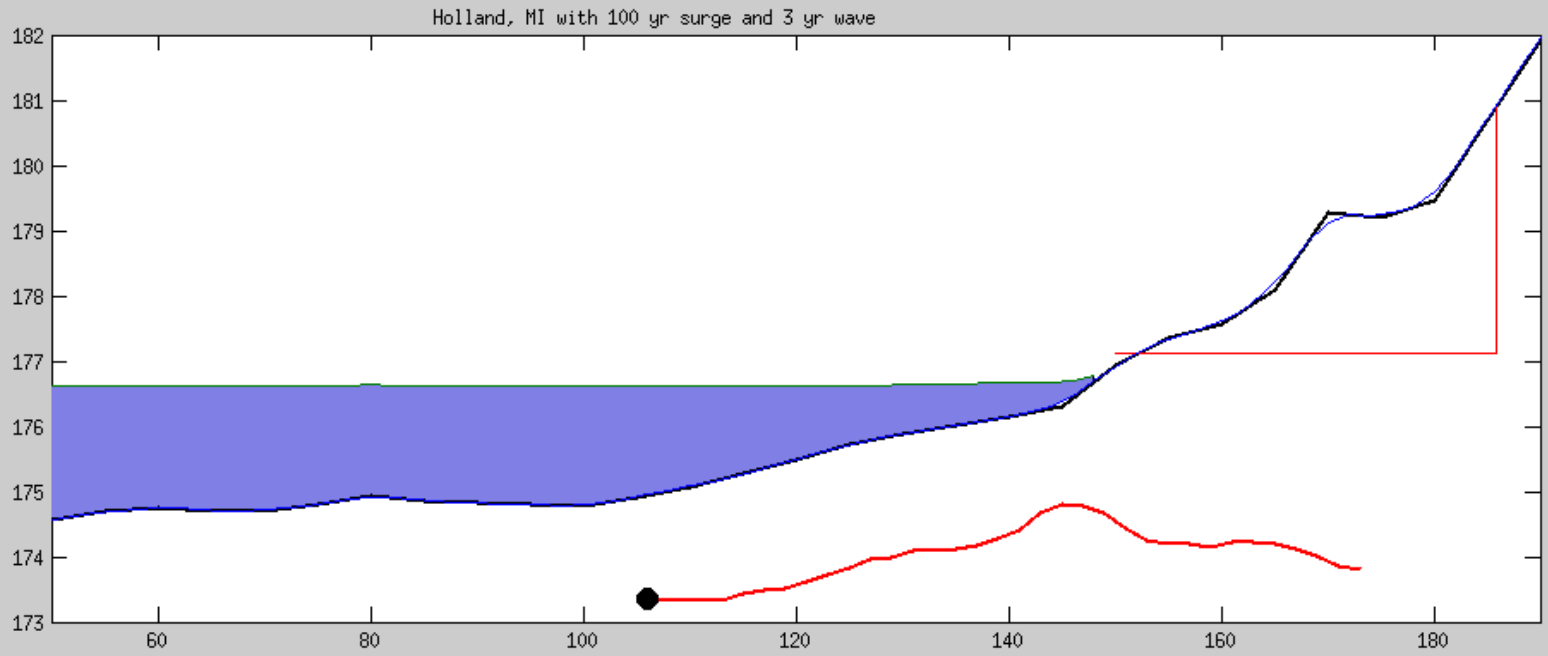
CFSR Reanalysis Winds



Nearshore Dynamics and Wave Run-up Modeling with CSHORE



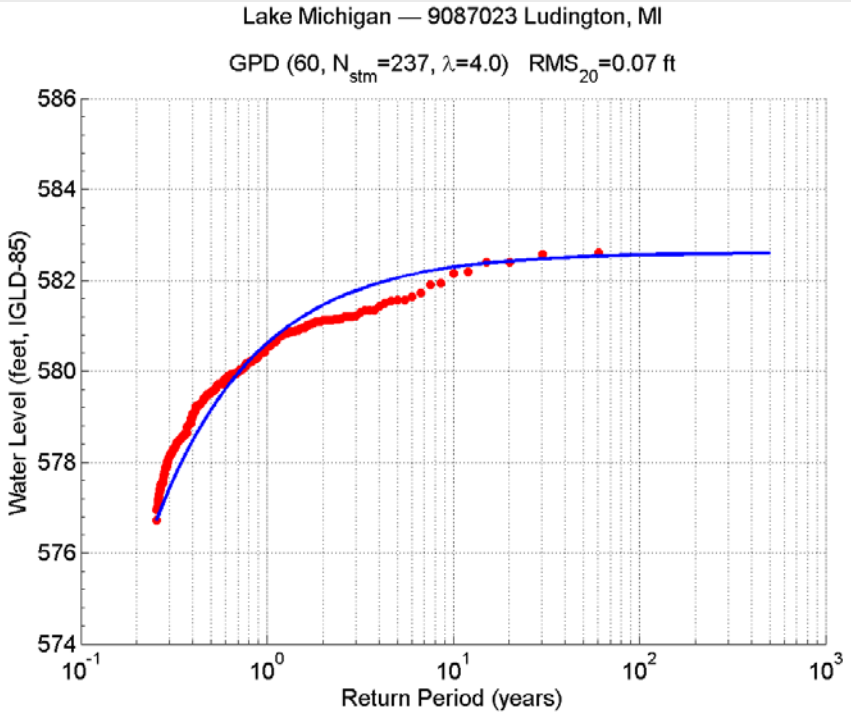
Beach Erosion Simulations

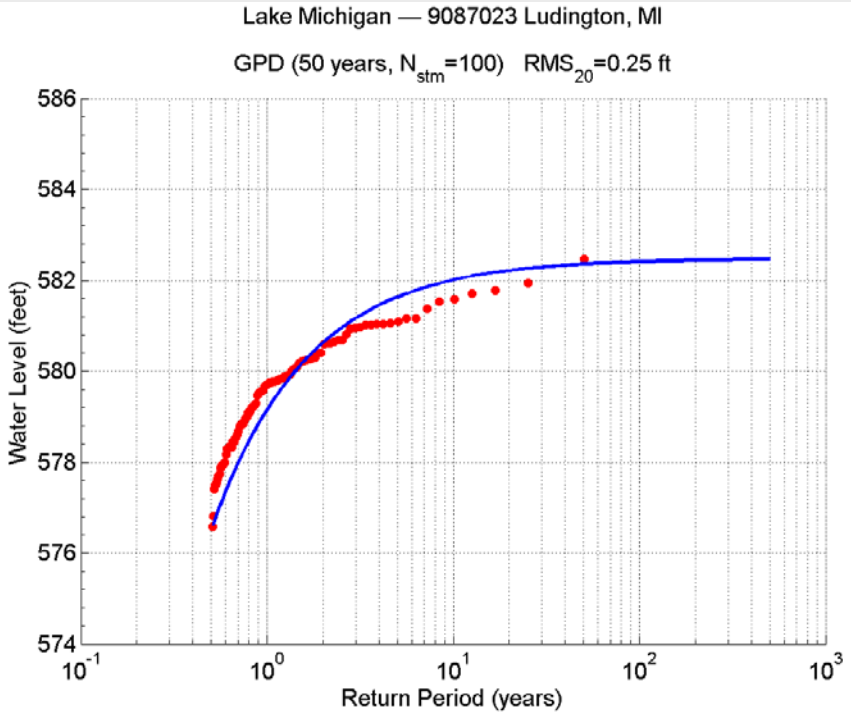


Holland, MI morphology change using CSHORE

Storm Sample Size

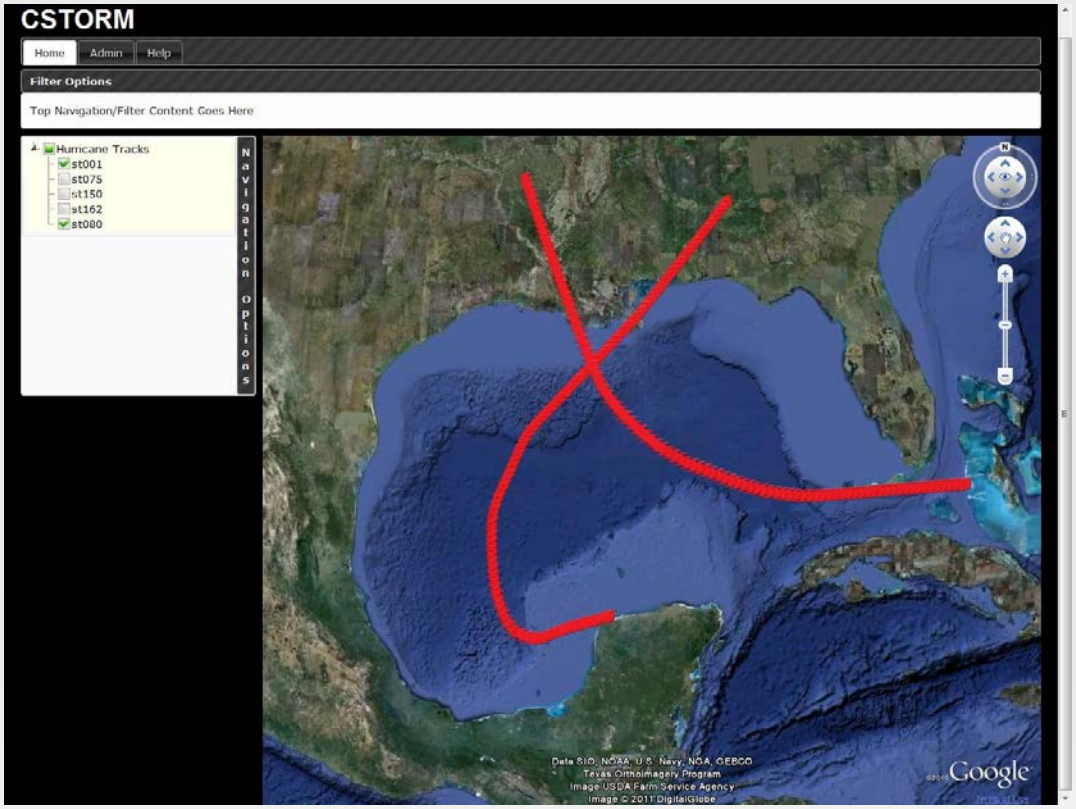
- Challenge – Produce reliable statistics in the extreme tail of distribution, throughout the lake system, with minimum number of storms
- Verification of Statistical Approach
  - *Full set vs. 100-storms Composite set – Water Level*
  - *100 storms minimum – will simulate 150*



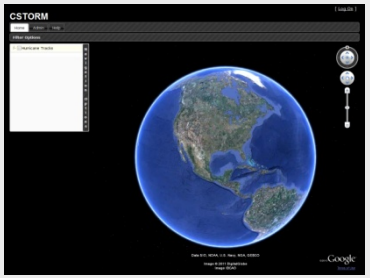


CSTORM-DB/VS

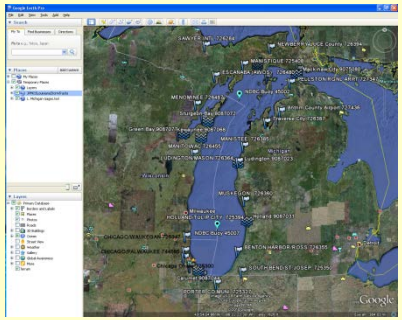
- Long-term archive/database of measured and modeled coastal storm data
- Easily accessible data; search, browse, visualize, process, analyze for FIRM preparation
- Contextual data products and tools that support decision making
  - Risk management, assessment, communication
  - Project design and evaluation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

CSTORM Data Processing and Visualization System

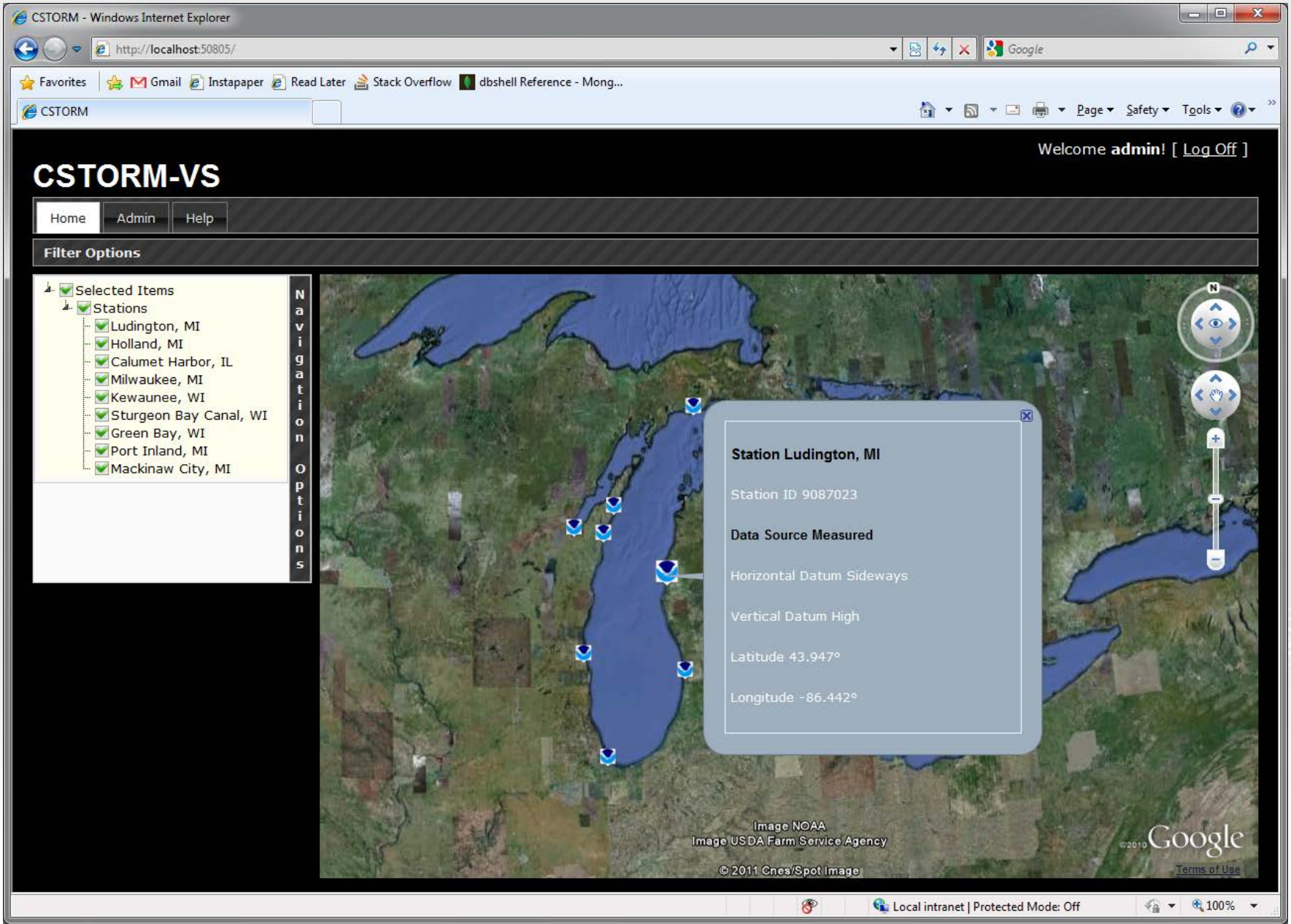
Desktop PC
Personal Google Earth App

CSTORM-DB Storm Server

Coastal Storm Database

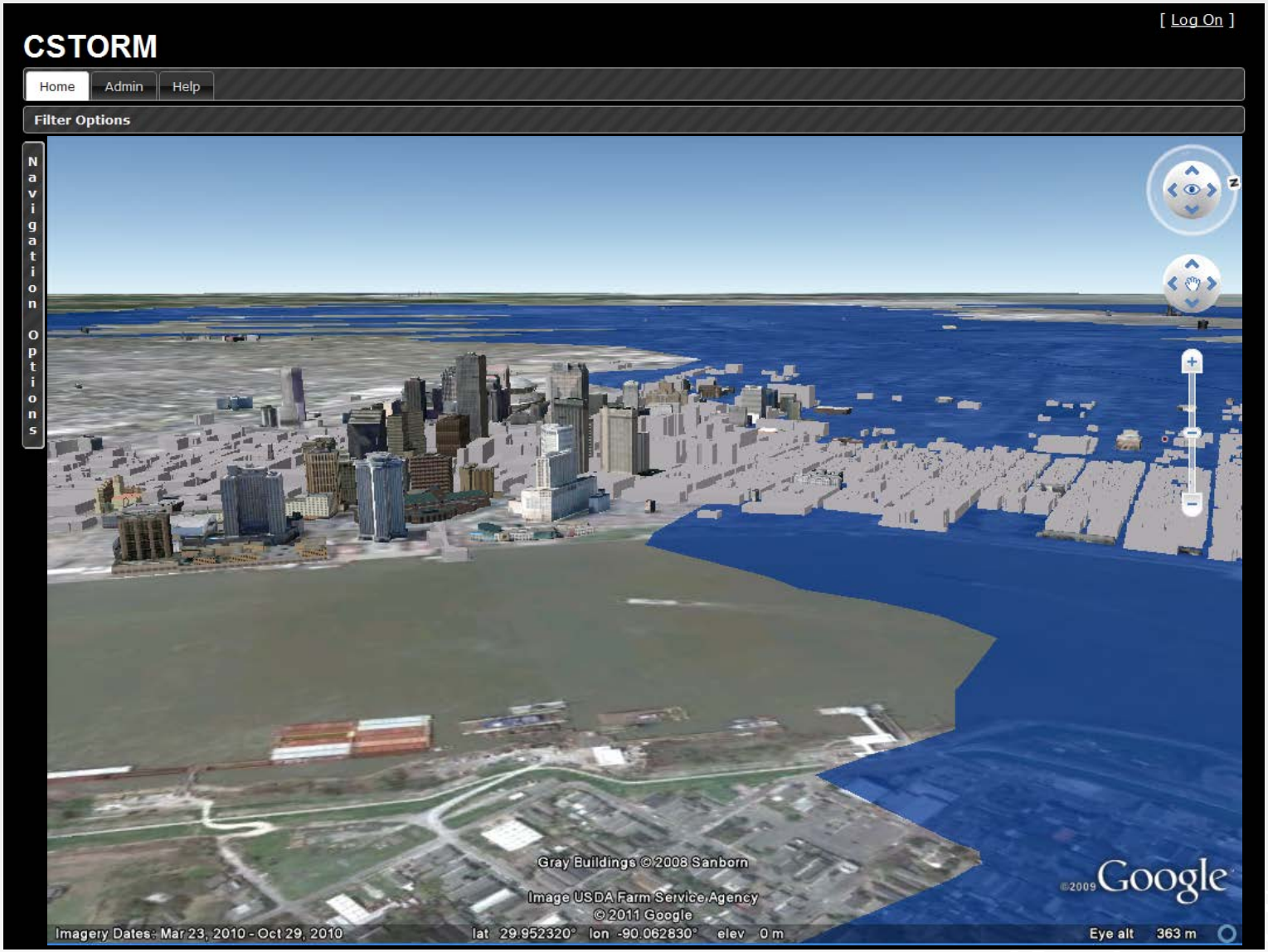
Coastal Storm HDF5 Archive

Station Information

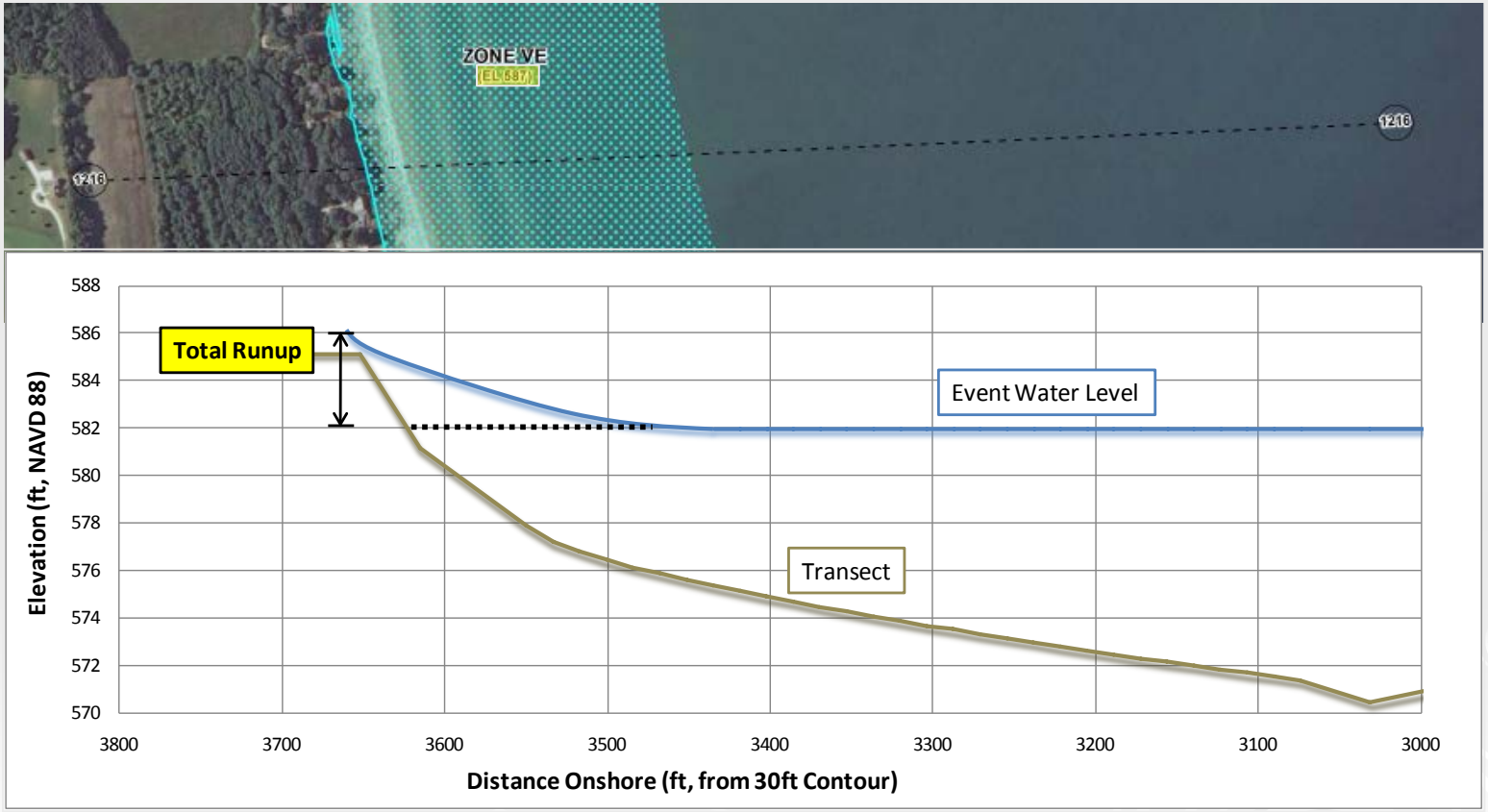


Data for Lake Michigan

- 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


[Log On]
CSTORM
Home
Admin
Help
Filter Options
Navigation Options
Gray Buildings © 2008 Sanborn
Image USDA Farm Service Agency
© 2011 Google
©2009 Google
Imagery Dates: Mar 23, 2010 - Oct 29, 2010
lat 29.952320° lon -90.062830° elev 0 m
Eye alt 363 m

I – Event vs. Response for Runup

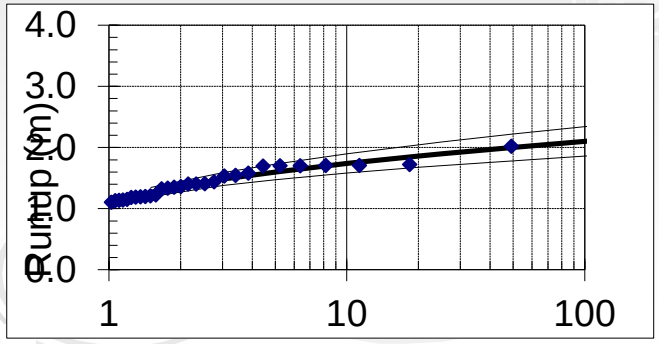


Event Based (G&S, 2003)

- 1% SWEL and 3-yr wave height
  - Extreme value analysis (EVA) required for hourly wave data
- Single run-up calculation per transect
- $R_{2\%}$ defines spatial extent of floodplain
- VE/AE transition based on where runup profile is less than 3 ft above terrain

Modified Response (2010)

- Runup calculated for actual storms and hourly lake levels
- One event per year selected that produced the highest runup elevation
- EVA on annual maximum to determine the 1% Flood Elevation (BFE)



Sample Response Calculation

Combined waves (from hindcast) & WLs (NOAA) to create stormlisting

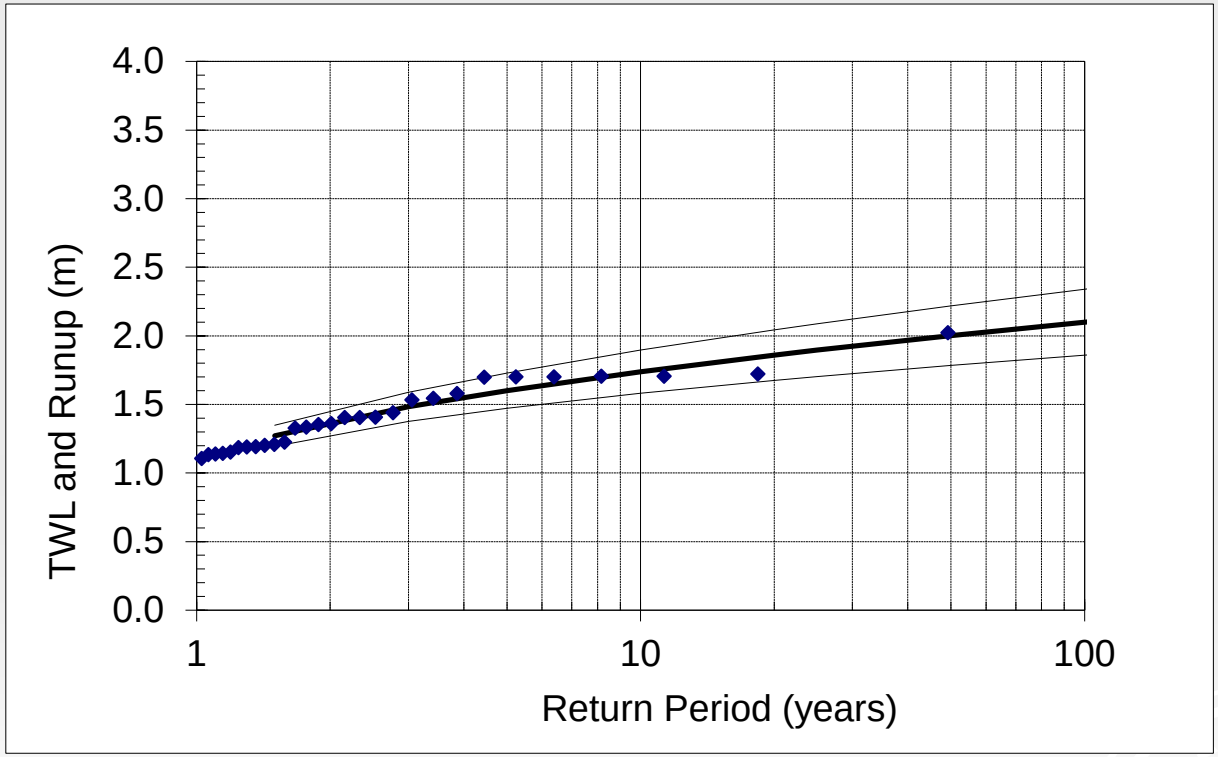
Year	Duration	Hs (m)	Tp (s)	Dir	Surge (m)
1998	15	2.92	8.61	22	0.22
1998	13	3.27	8.24	22	0.17
1998	23	3.65	9.44	22	0.16
1998	37	3.92	8.88	22	0.53
1998	23	2.96	7.07	112	0.25
1998	14	3.01	8.87	22	0.2
1998	49	4.24	9.74	22	0.35
1997	21	2.95	7.67	45	0.28
1997	7	2.55	7.16	22	0.33
1997	14	2.64	7.78	45	0.25
1997	3	2.5	7.82	135	0.21
1997	8	2.4	7.53	90	0.15
1996	2	2.47	7.23	158	0.1
1996	1	2.35	6.8	112	0.11
1996	5	2.68	7.67	135	0.15

Calculate $R_{2\%}$

$R_{2\%}$ (m)
0.914
0.875
1.002
0.943
0.751
0.942
1.034
0.814
0.760
0.826
0.830
0.799
0.768
0.722
0.814

Add $R_{2\%}$ to TWL from each storm

Extreme Value Analysis for ‘TWL plus Runup’



Event vs Modified Response

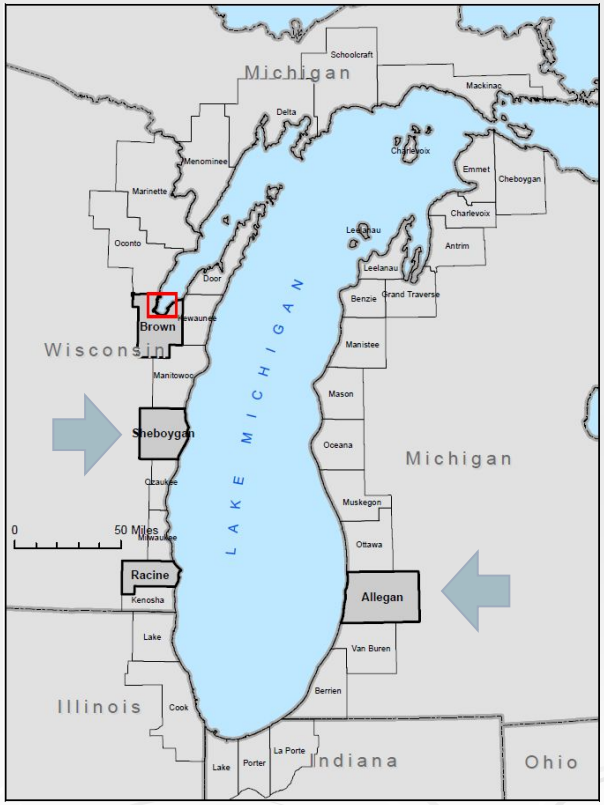
- Old Event
  - = $SWEL_{1\%} + R_{2\%}$
  - = Transect 1224 BFE = 587 ft

- Modified Response
  - = TWL (actual storms) + $R_{2\%}$
  - Fit probability distribution to all runups
  - = Transect 1224 BFE = 588 ft

Summary

- Modified Response produces results ~1 ft higher than the Old Event Method
- Technically superior approach
- Detailed wave and surge modeling under way for ~150 storms per lake
- Results will be used for the Modified Response approach

III – Data Sensitivity Analysis



Bathy/Topo Resolution

- High Resolution
- $R_{2\%}$ = 589 ft

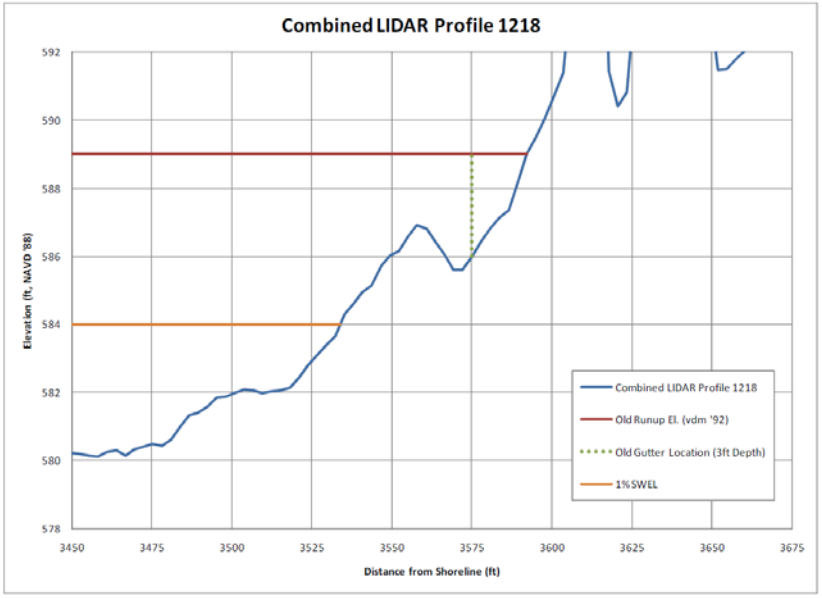


Figure 3.1 Combined High Resolution LIDAR Transect for 1218 in Sheboygan County with Runup

- Low Resolution
- $R_{2\%}$ = 587 ft

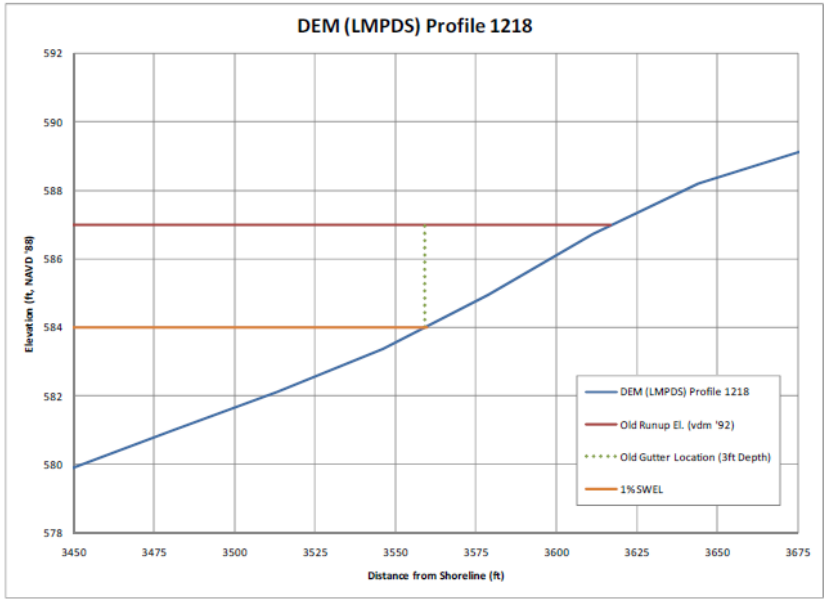
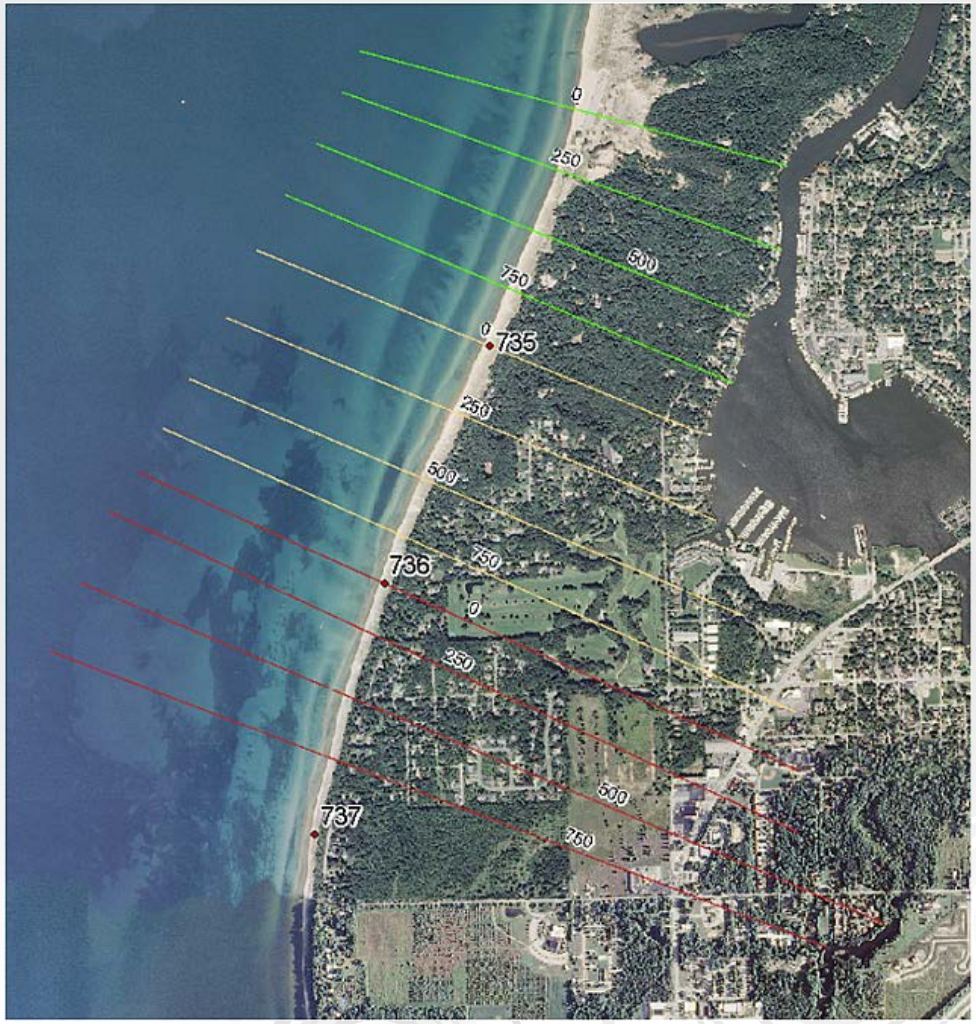


Figure 3.2 DEM/LMPDS Coarse Resolution Transect for 1218 in Sheboygan County with Runup

Impact of Lake Level Trends on Beaches

- New LIDAR collected during low phase
- Flood events happen during high wls
- X

Spacing Resolution (Allegan)



734	589
735	588
736	588

GLFHM Pilot Studies

Old Methodology vs. the New Methodology

1. Review Old Methodology
2. Revise the Old Methodology Study
3. Conduct New Methodology Analysis Using Old Datasets
4. Perform a Comparison of Old and New Methodology Using the Old Datasets and Assumptions
5. Re-create Historical Flood Event

GLFHM Pilot Studies

Data Sensitivity Analysis

1. Identify & Compare Datasets that should be used for Sensitivity Analysis Comparing Data Resolution

2. Develop Matrix of Comparison

3. Conduct Flooding, Run-up & Overland Propagation Elevation Analysis

GLFHM Pilot Studies

Structure Sensitivity

1. Coastal Protection Structures will be examined by modeling the structures parcel by parcel and increased spacing in order to determine whether or not the high resolution mapping of structures has a large impact on the final results

2. Comparison of structure stability
   - Total Loss
   - Partial Loss
   - No Loss - Total Stability

GLFHM Pilot Studies

Coastal Erosion

1. **The topic of Coastal Erosion as it is explained in the new methodology will be examined by the contractor**

2. **This topic is discussed in flood mapping arenas, so the results from the pilot studies for bluff erosion, dune erosion etc will be helpful in finalizing the methodology**

3. **Perform a sensitivity analysis using SBEACH to determine the effects coastal erosion may have on the results.**

Opportunities for Stakeholder Involvement

Members of Sub-Committees

- **Technical**
- **GIS**
- **Education & Public Outreach**


Thank you for your time!
Questions???