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Toward a Reliable Detection and Early Warning System for Meteotsunami Events in an Operational Environment

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Abstract

Meteotsunamis are similar to earthquake-generated seismic tsunami waves, but are induced by perturbations in barometric pressure and wind associated with meteorological events such as mesoscale convective storms (MCS) or cyclonic-type storms. Meteotsunamis in the Great Lakes are very fast moving (>20 m/s) and are often unexpected, adding to their danger. To date, the forecast of such perturbations remains a challenging task due to their rapid formation, and thus, unlike seiches or storm surges, an early warning system for meteotsunamis is lacking.

Need for a weather-ready nation:

NOAA's National Weather Service (NWS) goal is to build a weather-ready nation to protect residents from hazardous weather events and property damages. There's a strong need to develop operational capabilities to detect, monitor and predict meteotsunamis.

Recent efforts:

First worldwide meteotsunami workshop (June 2017)

Who? Thirty experts in meteorology, oceanography, social sciences and big data analytics.

Objectives: 1) Identify knowledge gaps; 2) Determine instrumentation and modeling requirements; 3) Consider social science aspects.

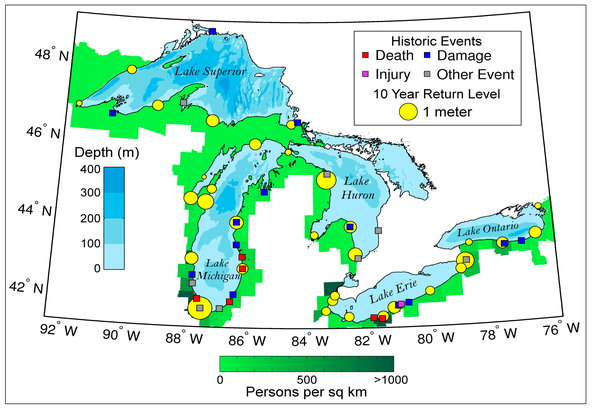
NWS hosted workshop (September 2017)

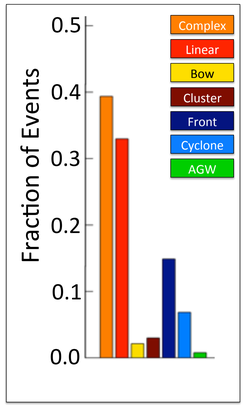
Who? NWS Tsunami program office, National Center for Tsunami Research (NTRC), and local Weather Forecast Offices (WFO).

Objectives: 1) Identify detection methods and algorithms, 2) Evaluate existing tools; 3) Identify gaps and resources required to develop a reliable meteotsunami warning system.

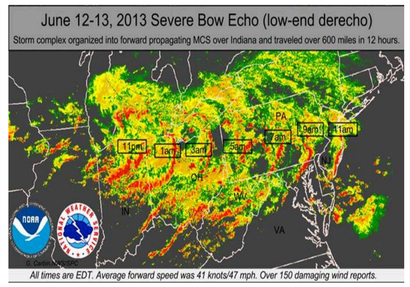
Meteotsunamis: Where do they occur and how often?

Meteotsunamis are known to occur in coastal regions, marginal seas, inland lakes and harbors around the world. Meteorotsunami events have been identified, documented and reported in the Great Lakes, Atlantic Coast, Gulf of Mexico, Mediterranean, Adriatic Sea, and Pacific Coast. Research has shown that on average more than 100 meteotsunami events occurred per year in the Great Lakes and 24 events per year in the Atlantic coast. Large meteotsunamis with wave height greater than 3 feet (1m) were found to occur once every three to four years and meteotsunami waves can reach as high as 10 feet, devastating costal communities. The primary storm structure associated with meteotsunami events in the Great Lakes are linear convection and convective complexes; Cyclonic storms are also associated with a number of meteotsunami events. Meteotsunami activity in the Great Lakes is most frequent in the months of April, May, June, and July.

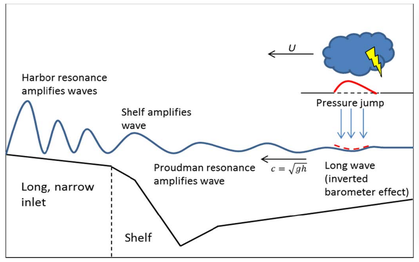


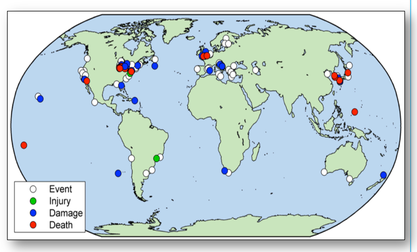


About 30 miles offshore, east of Tom's River, NJ, June 13, 2013. Photo credit: Buddy Denham



All times are EDT. Average forward speed was 41 knots/47 mph. Over 150 damaging wind reports.

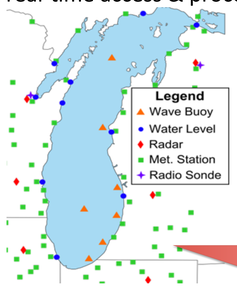




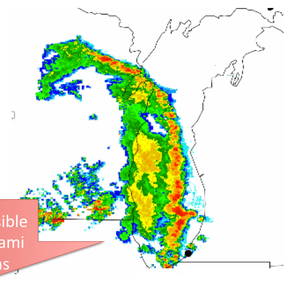
Warning System Requirements

Real Time Observations

Expand Existing Sensor Network with real-time access & processing



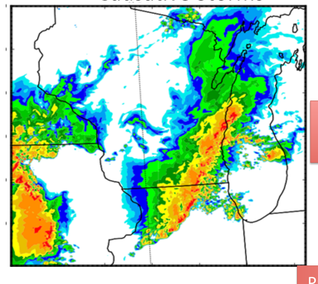
Process Radar Reflectivity & Radial Velocities



Detect possible meteotsunami conditions

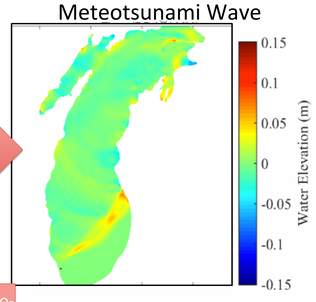
High Resolution Modeling

Weather Forecast Model of Causative Storms



Forecasted Storm Path & Intensity

Hydrodynamic Simulation of Meteotsunami Wave



Predicted meteo-tsunami location, arrival & height

Decision making framework and warning protocol

References

Anderson et al., 2015. Reconstruction of a meteotsunami in Lake Erie on 27 May 2012: Roles of atmospheric conditions on hydrodynamic response in enclosed basins. *J. Geophys. Res. Oceans*, 120(12)

Bechle et al., 2015. Meteotsunami occurrences and causes in Lake Michigan. *J. Geophys. Res. Oceans*, 120(12)

Bechle et al., 2016. Meteotsunamis in the Laurentian Great Lakes, *Scientific Reports*, 6, doi:10.1038/srep37832

Sepic´ and Rabinovich, 2014. Meteotsunami in the Great Lakes, Chesapeake Bay and on the Atlantic coast of the United States generated by the propagating ''derecho'' of 29–30 June 2012, *Nat. Hazards*, 74

Can we detect & predict meteotsunamis? It requires:

- Real-time meteorological, pressure, and water level sensor network infrastructure.
- Accurate weather forecast model that predict the path and intensity of storms.
- High-resolution hydrodynamic model to predict meteotsunami heights.
- Data & model processing methods to reliably identify meteotsunami risk.

Progress made so far:

- Researching meteotsunamis cause and process.
- Established a Great Lakes Meteotsunamis database and climatology.
- Improving weather and hydrodynamic model accuracy.
- Building sensor network for detection.
- Coordinating with NOAA tsunami program office, Tsunamis Warning Center, and local forecast office on warning protocols.
- Planning to organize international symposium on meteotsunamis research, development, forecasting and warning system.

What's next? To build a reliable warning system.

- International collaboration.
- Real-time meteorological, pressure, and water level sensor network.
- Accurate weather forecast and hydrodynamic model.
- Establish warning protocols and coordinate with NOAA tsunami warning center and line offices to issue advisories and warnings.
- Educate the public on meteotsunami risks and the appropriate response to warnings.