

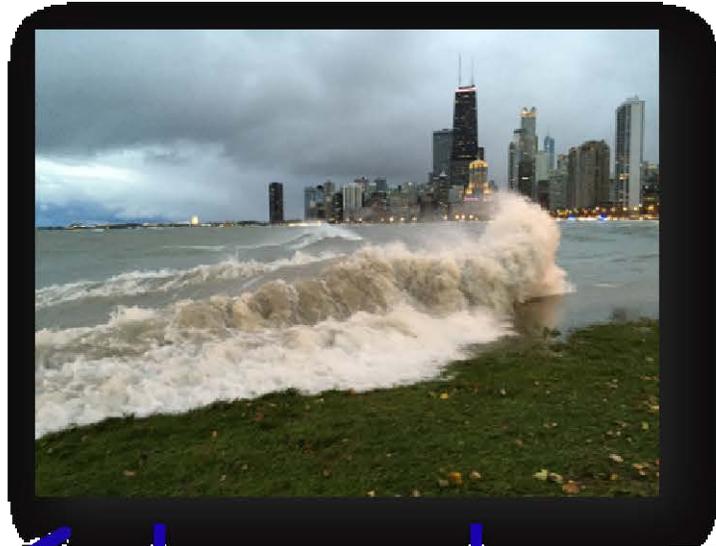


Freak Waves and Meteo-tsunamis

Eric J. Anderson, Ph.D.
Civil and Environmental Engineering
Hydrologic Science and Engineering
Department of Geophysics
Colorado School of Mines

Great Lakes Waves | Wave spectrum

Wind Waves



1 sec

30 sec

Seiche

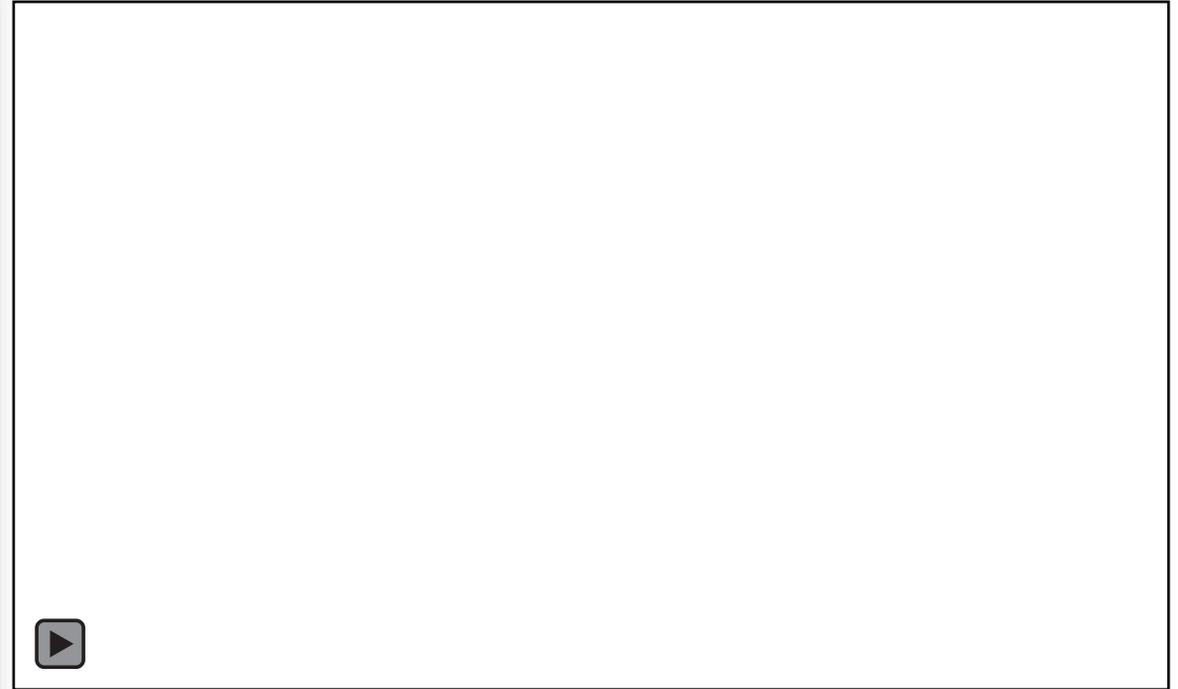


2 hr

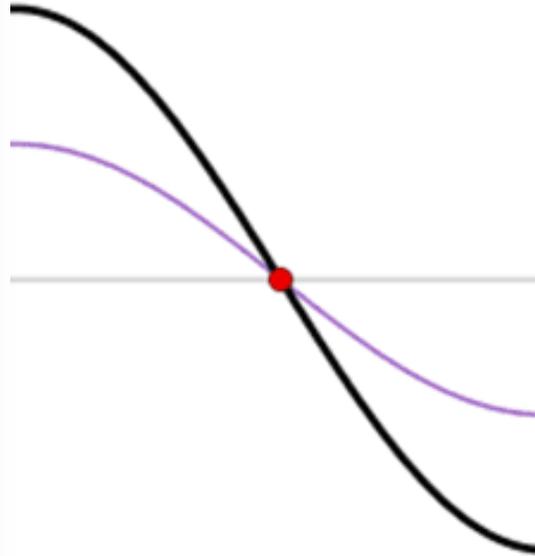
24 hr

Wave Period

Great Lakes Waves | wind waves



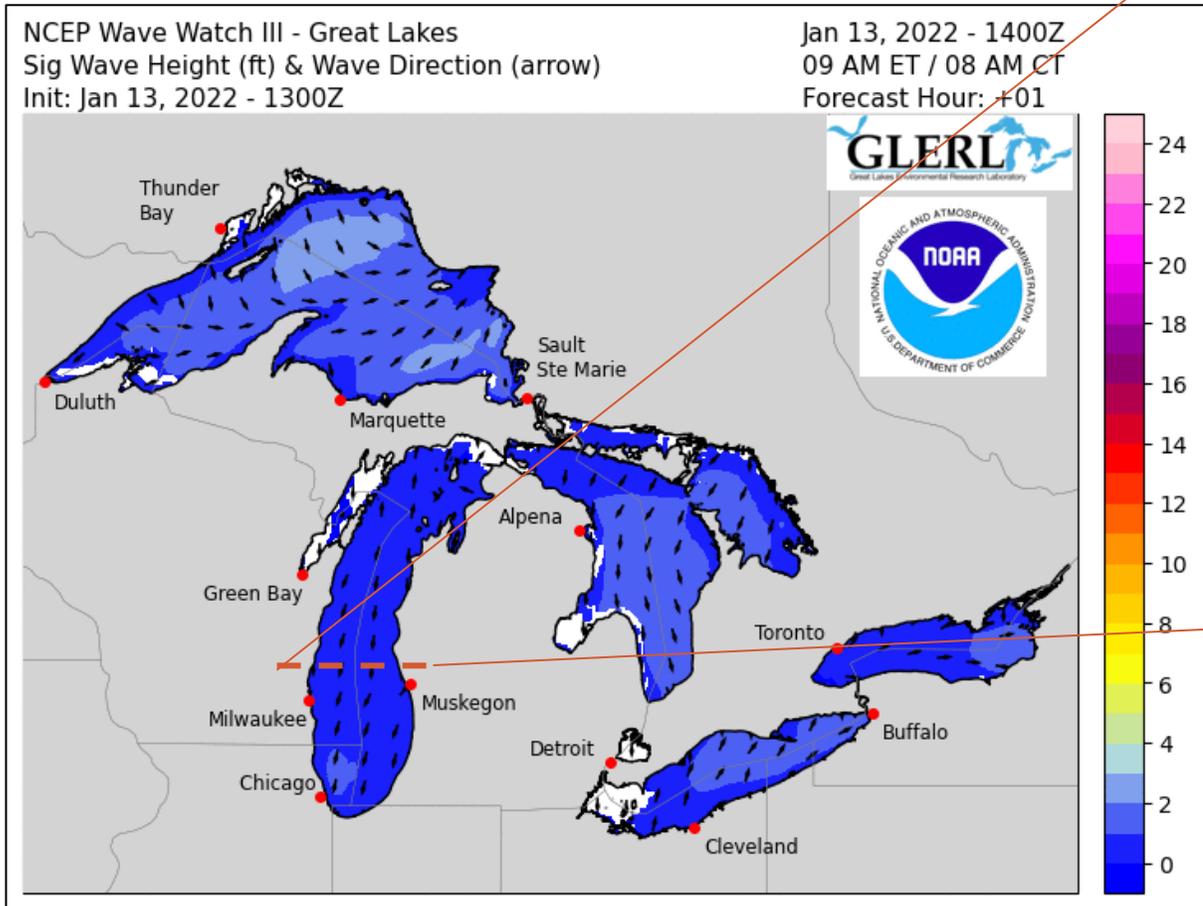
Great Lakes Waves | seiche



“bathtub sloshing” standing wave

Great Lakes Waves | Waves we know

Wind Waves

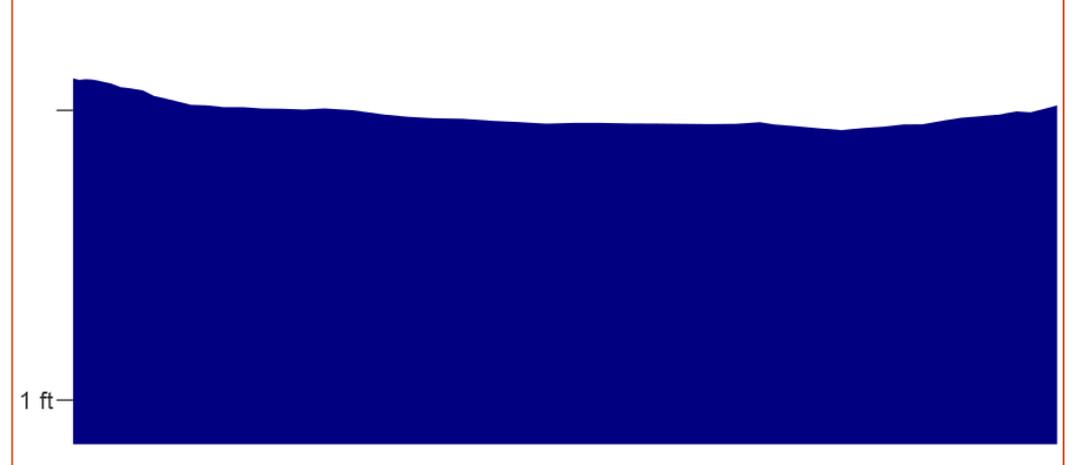


Seiche

1 minutes

1 ft—

1 ft—



Great Lakes Waves | Wave forecasting

Wave Watch III Significant WaveHeight (ft) & Direction
 Valid Time: 2022-03-07 0100 UTC
 Init Time: 2022-03-07 0100 UTC
 Sun Mar 06 08 PM EST
 Sun Mar 06 07 PM CST
 Hour: 60

BAMS
 Bulletin of the American Meteorological Society

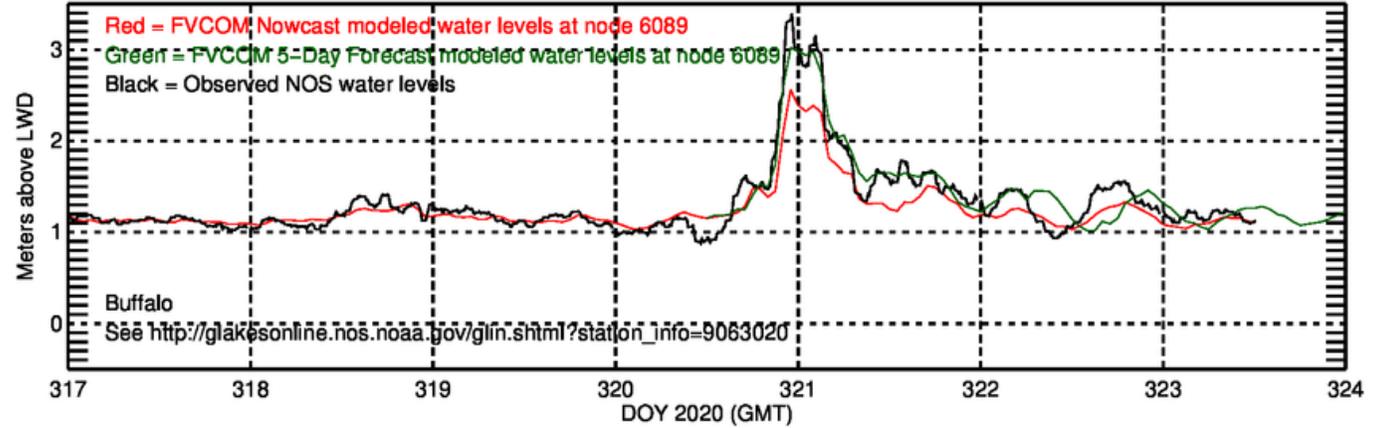
Volume 87 Number 5 May 2006

MJO PREDICTIONS ON-LINE
 HURRICANE IVAN'S BIG WAVES
 EVEREST'S DEADLY WEATHER

THE WEATHER OF THE EDMUND FITZGERALD TRAGEDY

NOAA
 NATIONAL OCEANOGRAPHIC AND ATMOSPHERIC ADMINISTRATION
 U.S. DEPARTMENT OF COMMERCE

Seiche Forecast



Great Lakes Waves | Historic events

'Great Lakes tidal wave' causes 5-foot immediate rise in water on Lake Superior shoreline



The New York Times MAY 6, 1952
SMALL 'TIDAL' WAVE SWEEPS LAKE HURON

TIDAL WAVE SWEEPS ERIE.
Steamer Wrenched from Moorings on Lake Rams Large Freighter.

EXTRAORDINARY.
A HUGE TIDAL WAVE IN LAKE ERIE.
Damage to Shipping and Other Property—Loss of Life—Details of the Wonderful Phenomena
—A Great Cloud Precedes It With Some Drops of Rain.

FREAK TIDAL WAVE.
50ft Wall of Water.
NEW YORK, June 1.—A freak tidal wave churned up by high winds swept a 50ft wall of water along the shore of the Lake Erie resort area of North-East Cleveland on Saturday night, drowning at least 6, injuring others and smashing scores of small boats.

BIG TIDAL WAVE HERE!



Many Swept Into Lake; Fear 10 Killed

Three Bodies Already Found
Mother of 11 Among Victims
3 Divers, Boats Hunt Others

Three persons were drowned and several more were feared lost Saturday when a 25-mile-wide tidal wave smashed the Lake Michigan shore here. The freak wave, estimated from 3 to 10 feet high, struck at about 9 a.m. from Jackson Park north to Wilmette. An undetermined number of persons were swept into the lake.

Freak or Rogue Wave



Meteotsunami Wave

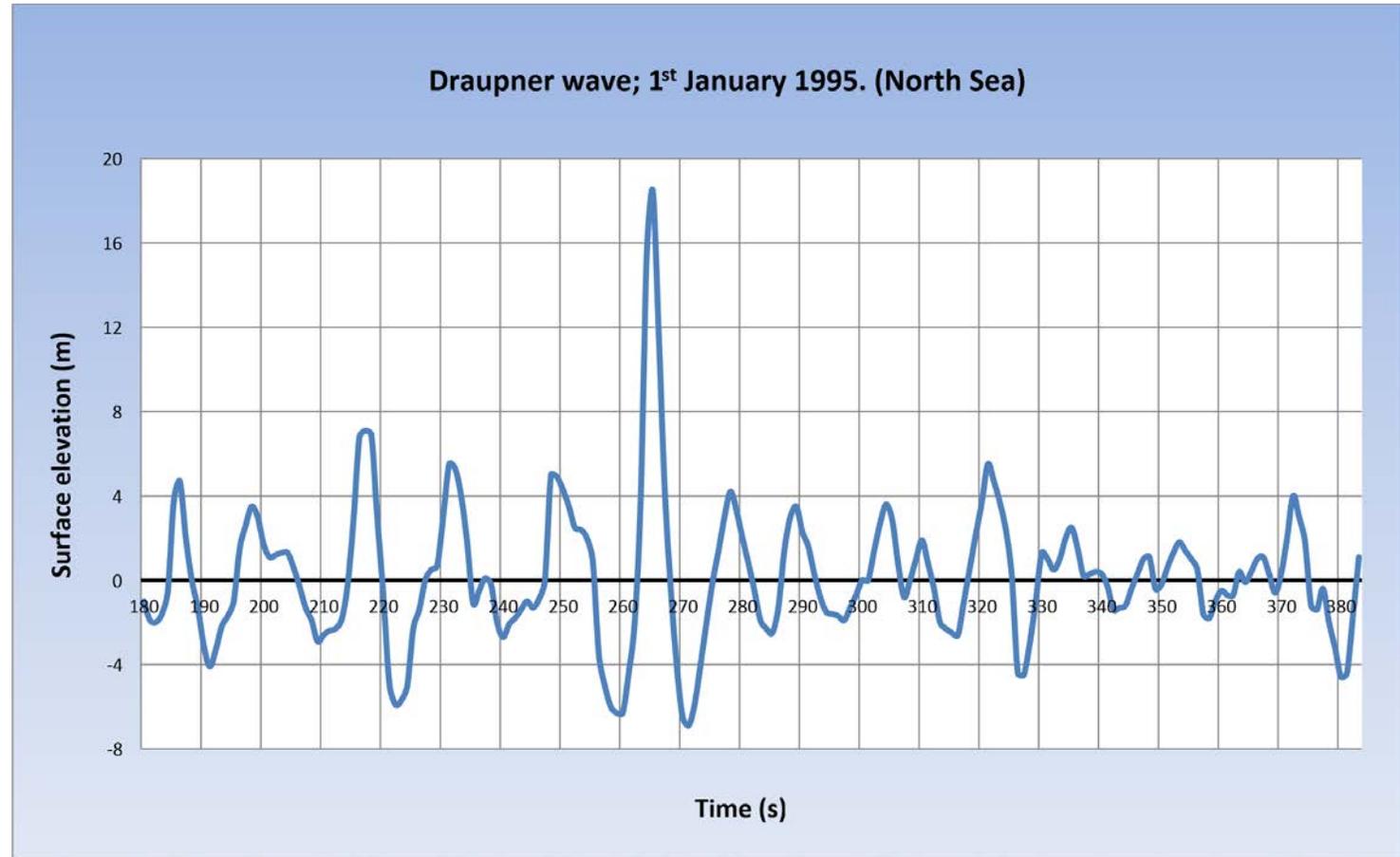


Debbie Maglothin

Great Lakes Waves | Freak Waves

- A form of wind wave
- Unusually large and unpredictable
- Height > 2x significant wave height
- Unclear mechanisms
 - Wave field meets opposing currents, strong winds
 - Nonlinear combination of waves
- "a wall of water" usually steeper than surrounding waves
- Statistically outside of wave expectations
- Sailor's lore
 - Most don't live to report them
- *...until 1995*

Great Lakes Waves | Freak Waves

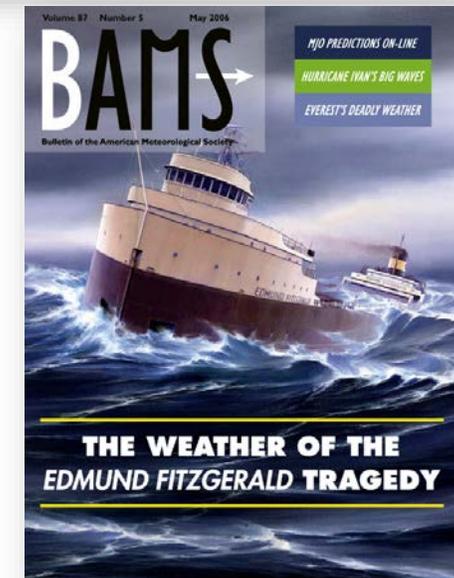


Great Lakes | Freak Wave Chronology (by Paul Liu, NOAA)

1916: Lake Erie. October 29, 1916. Although it was designed for heavy weather, the *Colgate*, a whaleback steamer, couldn't take the waves during the notorious Black Friday, 1916. Three men managed to make it to the life-raft when the ship plunged nose first, but only the skipper would make it ashore. Today the wreck is upside down in 24 m of water in the middle of Lake Erie.

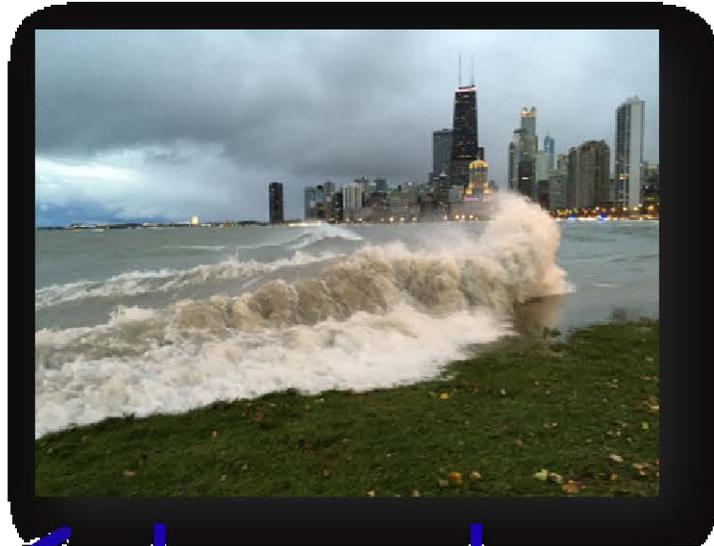
1929: Lake Michigan. September 9, 1929. The *Andaste* carried a load of gravel from Grand Haven heading southwest toward Chicago but never arrived. Small craft warnings were posted after her departure. The bodies of 14 of the 25 crew members ultimately floated to shore, 11 of them wearing life jackets.

1975: Lake Superior. On November 10, 1975 the *SS Edmund Fitzgerald* sank. A freak wave was suspected. All 29 crew members were lost.



Great Lakes Waves | Wave spectrum

Wind Waves



Meteo-tsunami



Seiche

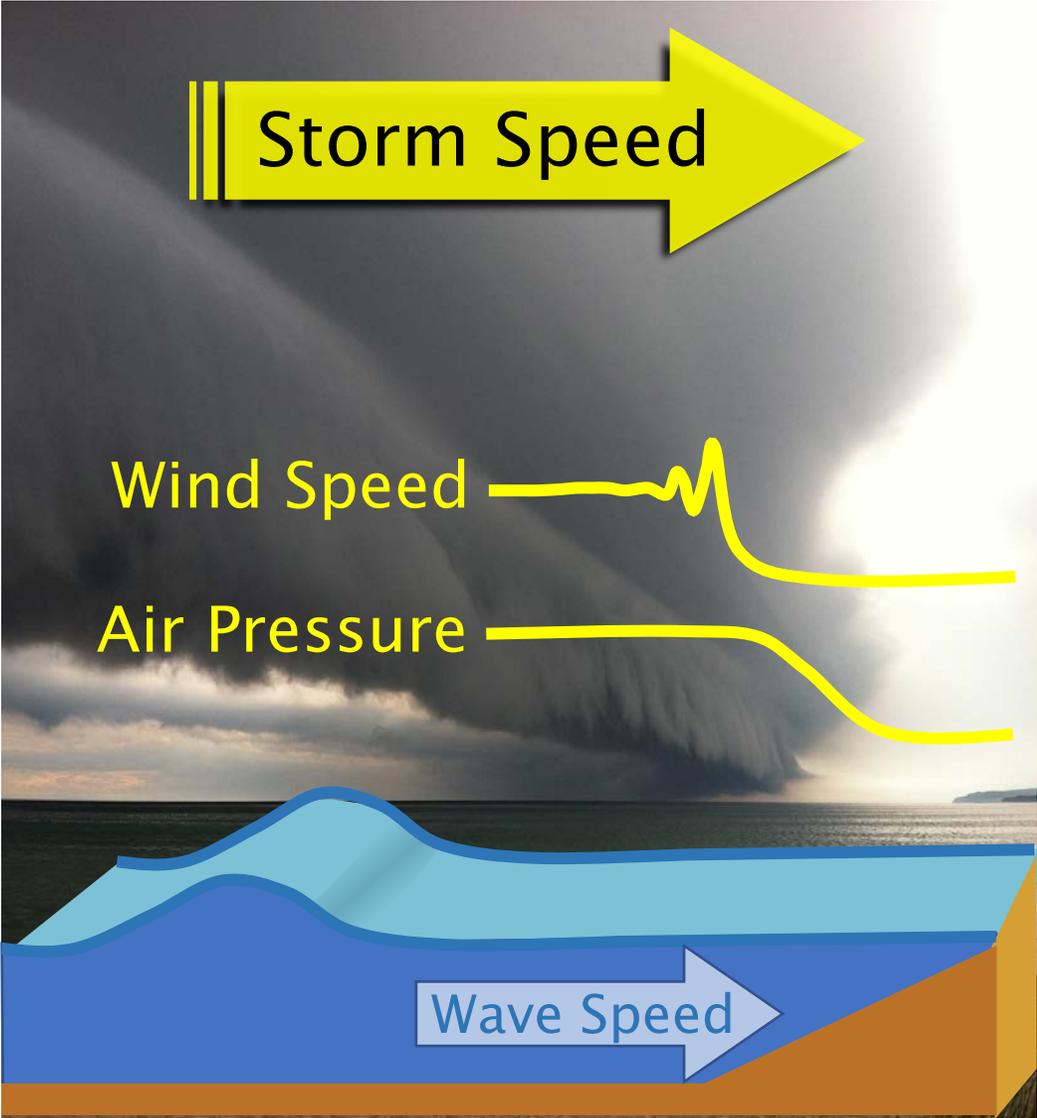
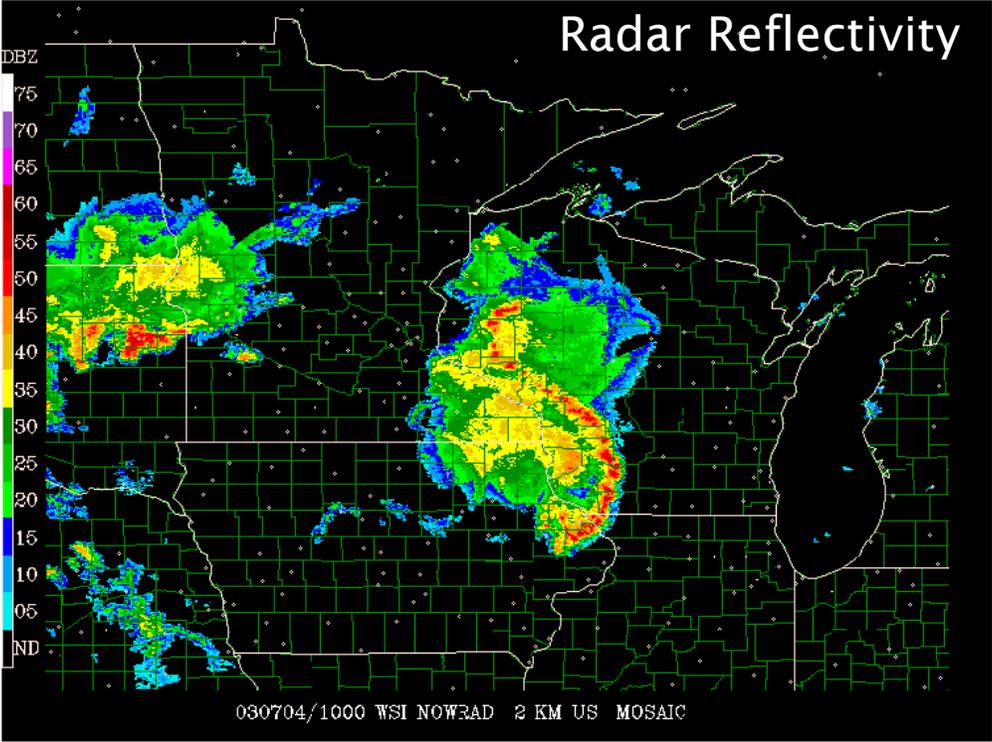


Wave Period

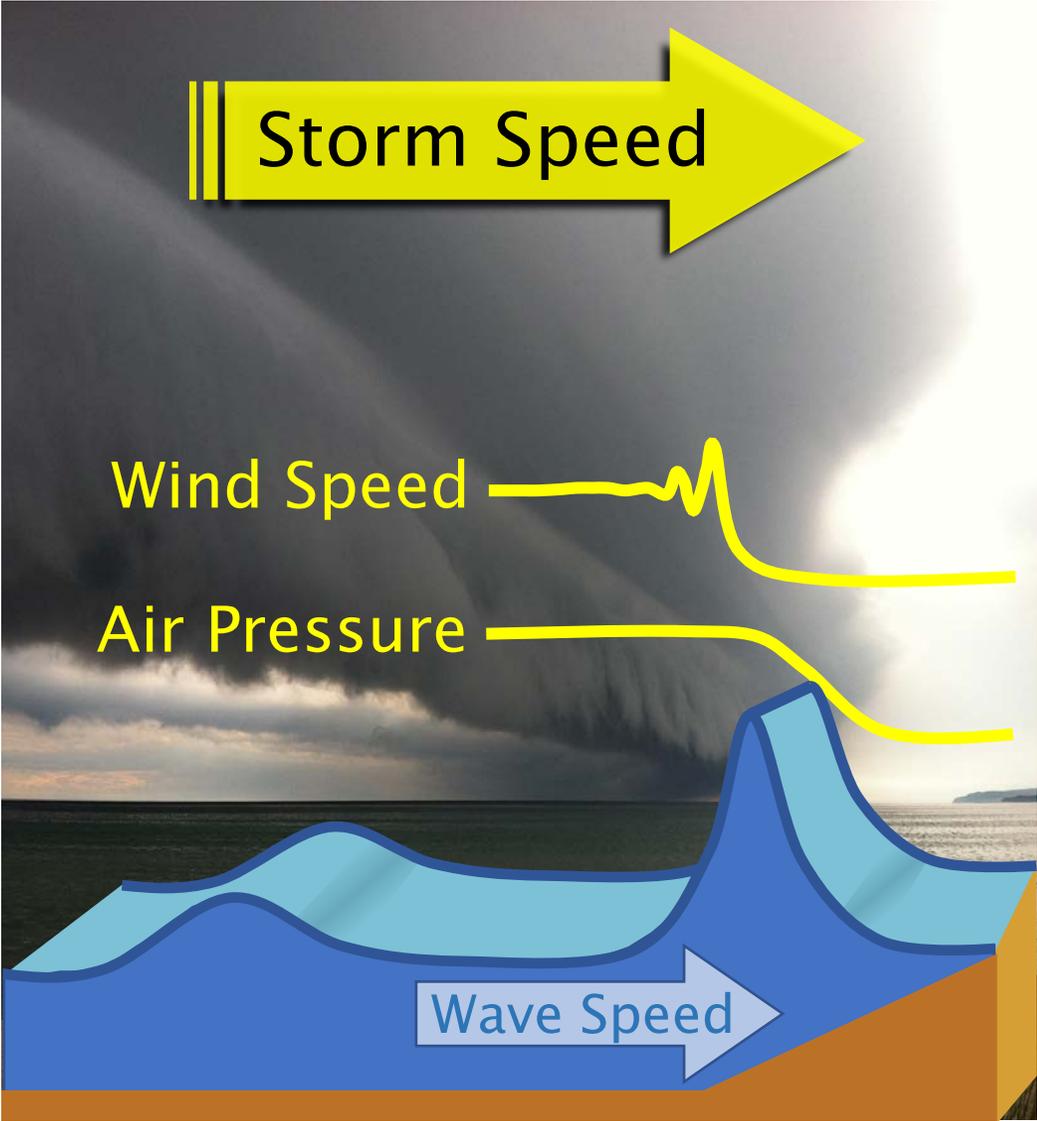
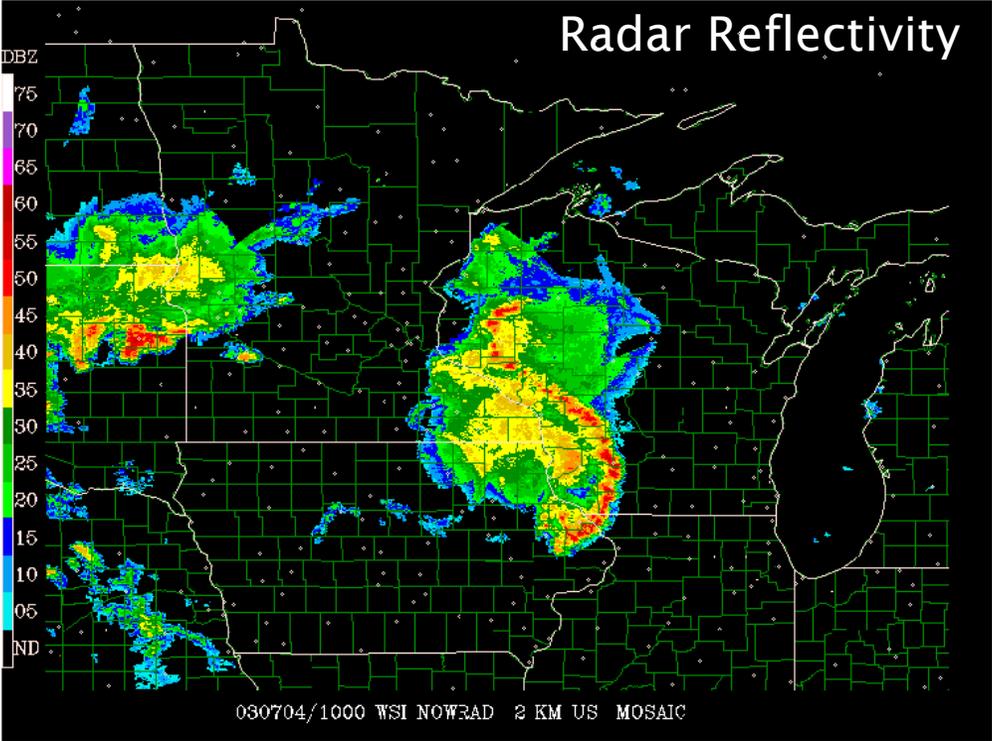
Great Lakes Waves | Tsunami waves

- Tsunami = big/harbor wave
- Tsunami waves characteristics:
 - Propagate from the source
 - Wave periods between 2 minutes and 2 hours
 - Long wavelength relative to other wind waves
 - Often appear as rapid rise/decline in water level rather than a breaking wave
 - Can be a single wave or a series of waves
- Most common form is “seismic tsunami” (about 80%)
 - Earthquake in ocean floor
- Meteorological induced = ***meteotsunami*** (about 10%)
 - Driven by atmospheric disturbance rather than seismic
 - *e.g.* squall line or derecho

Great Lakes Waves | Meteotsunami waves



Great Lakes Waves | Meteotsunami waves



meteotsunami: 1 minutes

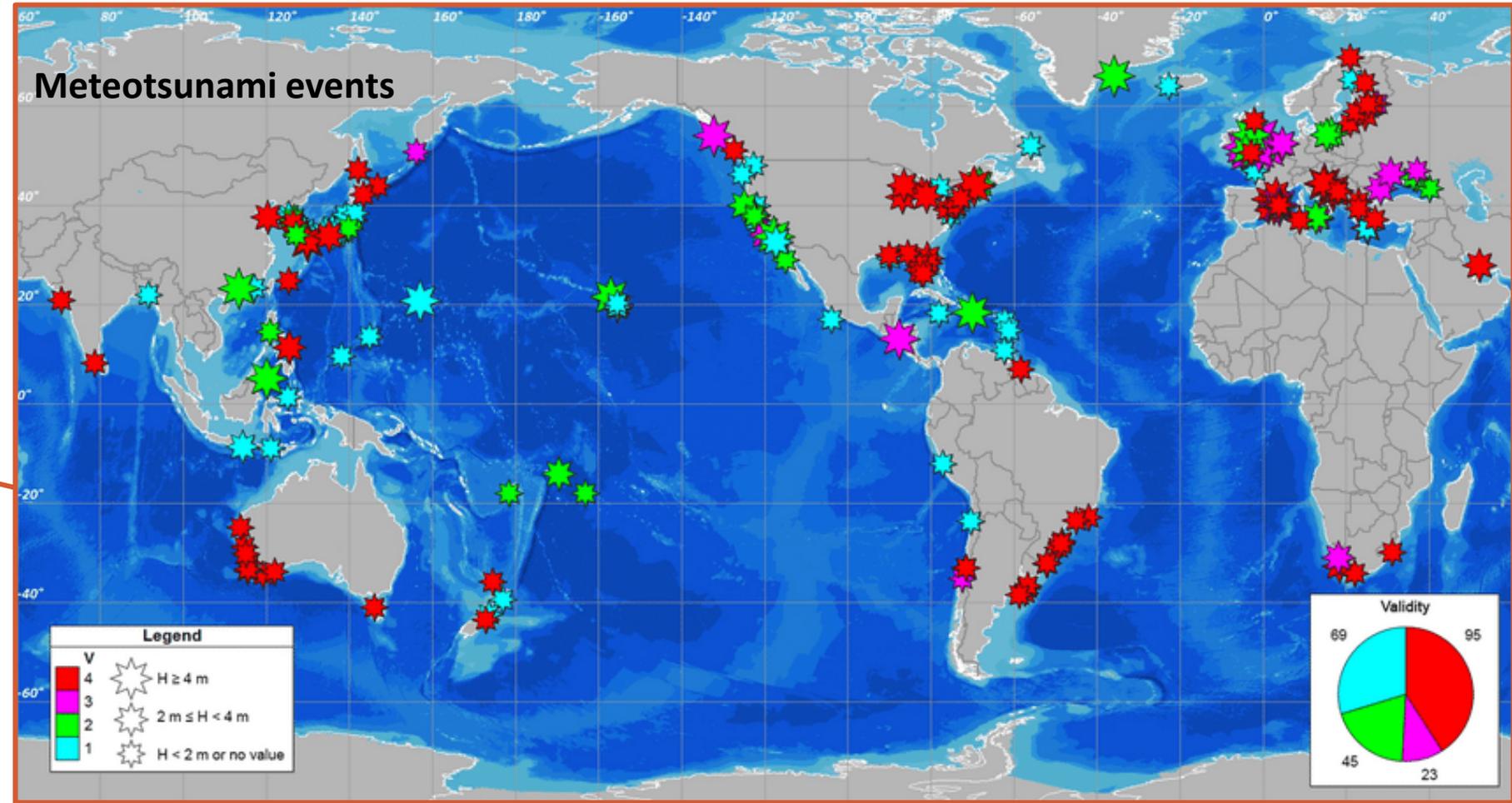
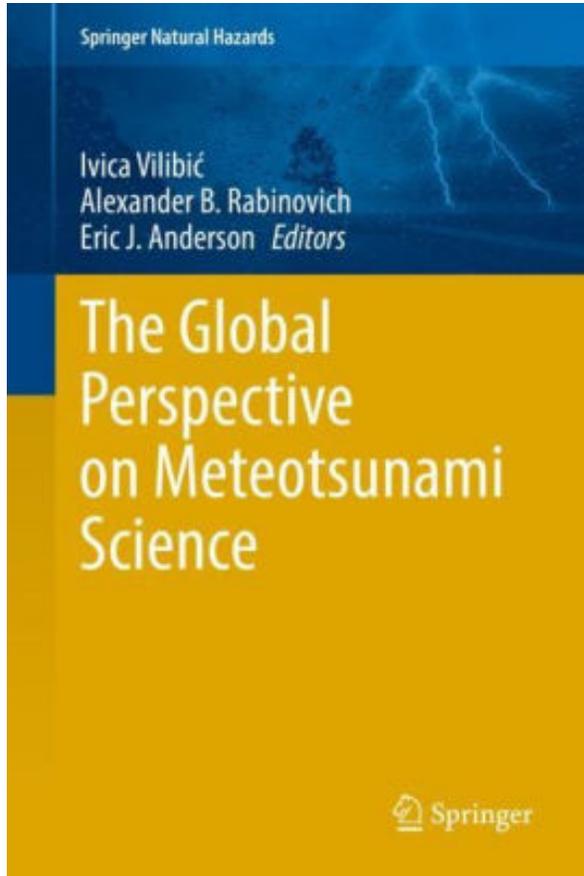
seiche: 1 minutes



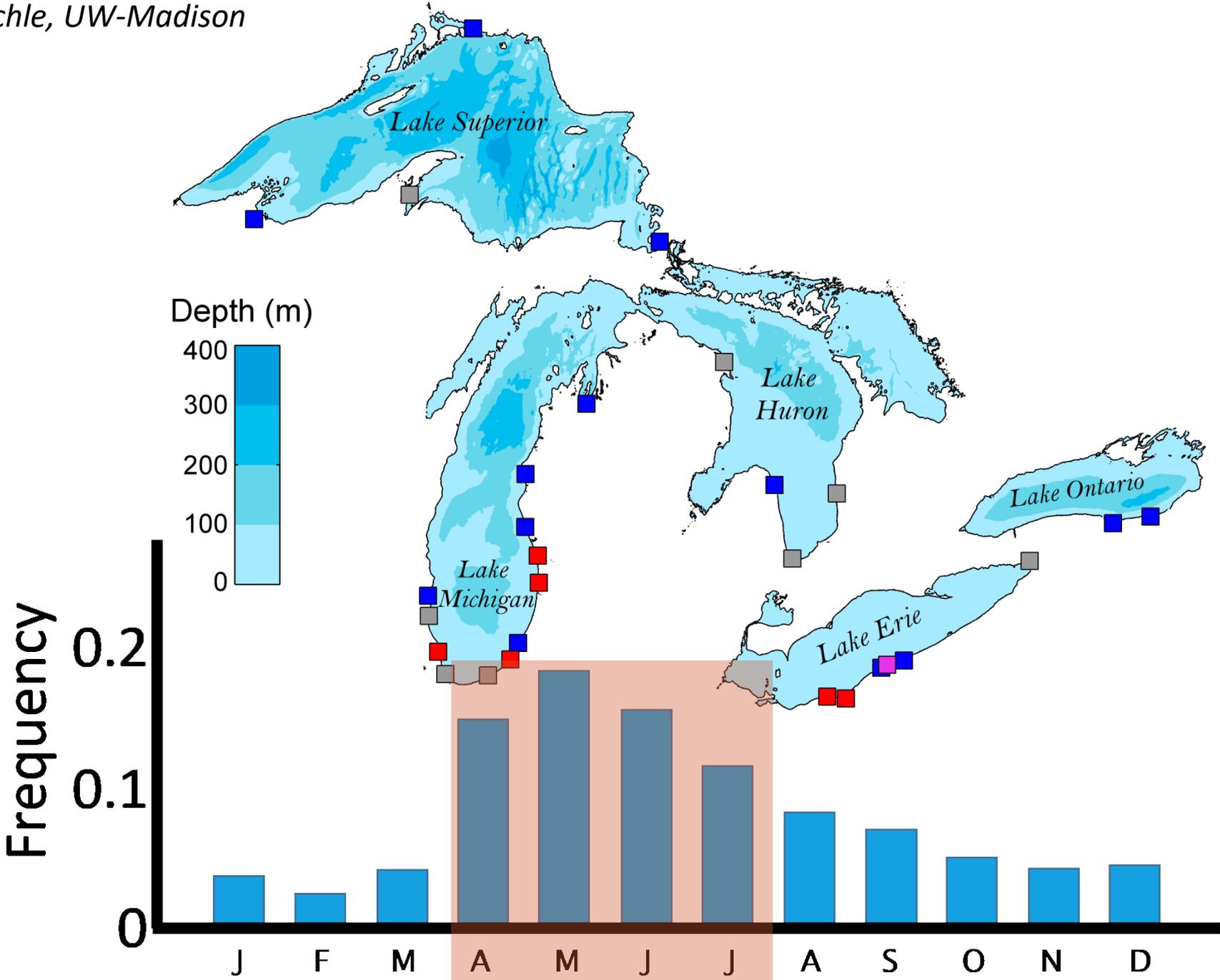
Great Lakes Waves | Meteotsunami waves

- ***Why are they dangerous?***
 - Like seismic tsunamis, they become decoupled from the source mechanism (e.g. convective thunderstorm)
 - Not as much lead time as ocean seismic tsunami
 - Reflected waves can appear “out of nowhere”
 - **No forecasts are available** for meteotsunami waves, and in Great Lakes no detection network exists
 - Can create rip currents, inundation, etc.

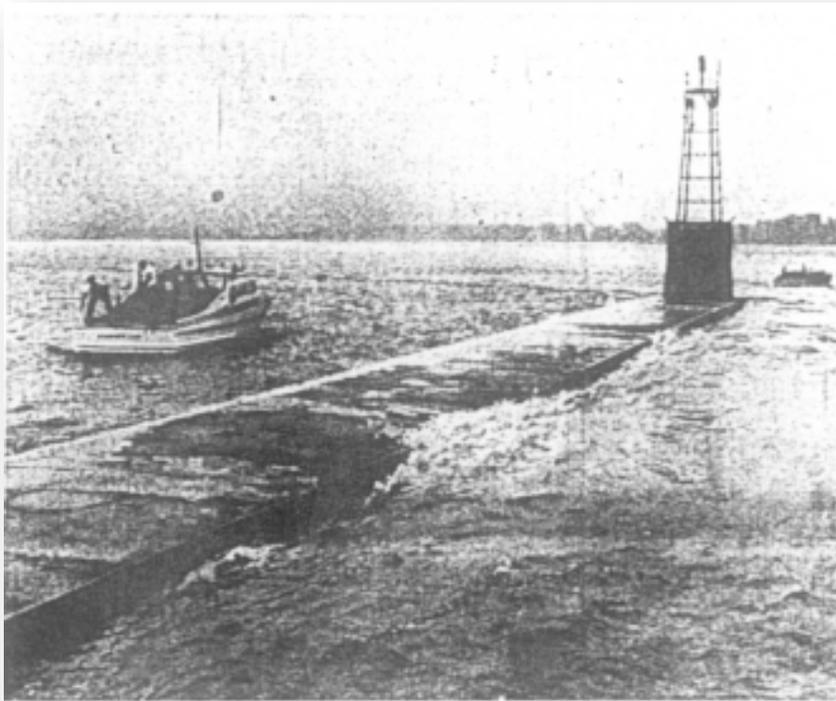
Global Meteotsunamis | Known Events



Credit: Adam Bechle, UW-Madison



Meteotsunami | Chicago 1954



Chicago, June 26, 1954

BIG TIDAL WAVE HERE!



Many Swept Into Lake; Fear 10 Killed

Three Bodies Already Found

*Mother of 11 Among Victims
3 Divers, Boats Hunt Others*

Three persons were drowned and several more were feared lost Saturday when a 25-mile-wide tidal wave smashed the Lake Michigan shore here. The freak wave, estimated from 3 to 10 feet high, struck at about 9 a.m. from Jackson Park north to Wilmette. An undetermined number of persons were swept into the lake.

Estimates of the death toll ran as high as 10, possibly including some children.

One of the victims was a mother of 11 children. Her husband also was feared drowned.

The wind-whipped water did its worst damage at Montrose Harbor, where about 15 or 20 fishermen were swept off a narrow, 175-foot pier.

Several of these struggled to safety or were rescued and at least two were known to be dead.

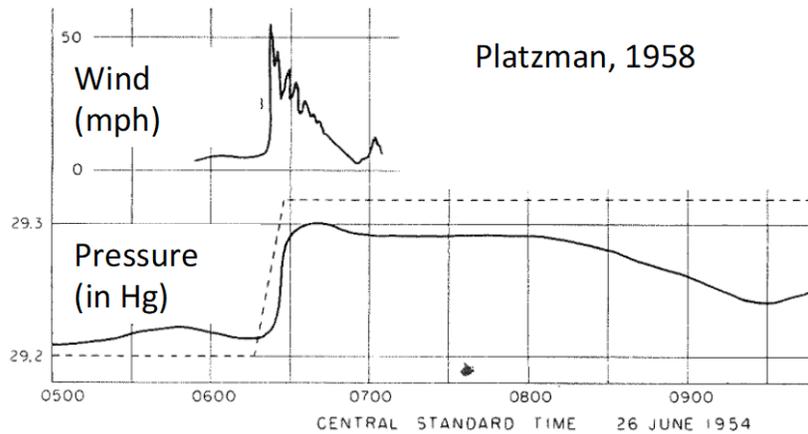
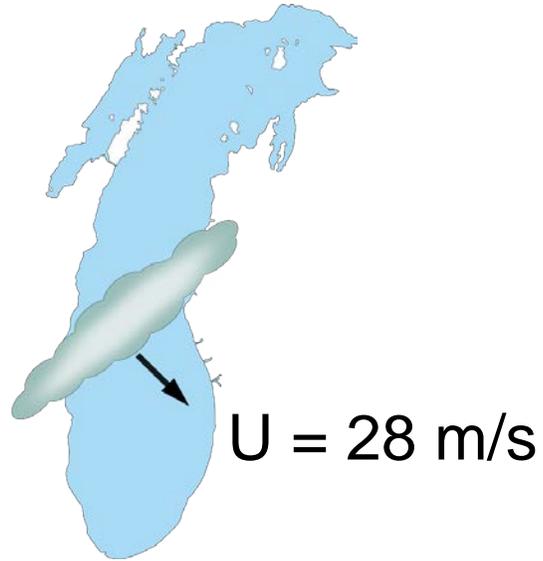
June 26

- 3 meter wave struck Chicago
- 7 people drowned

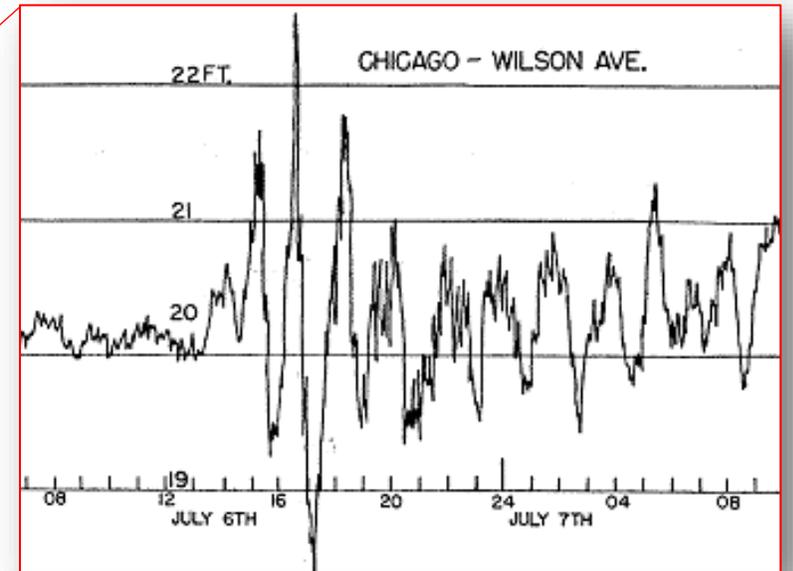
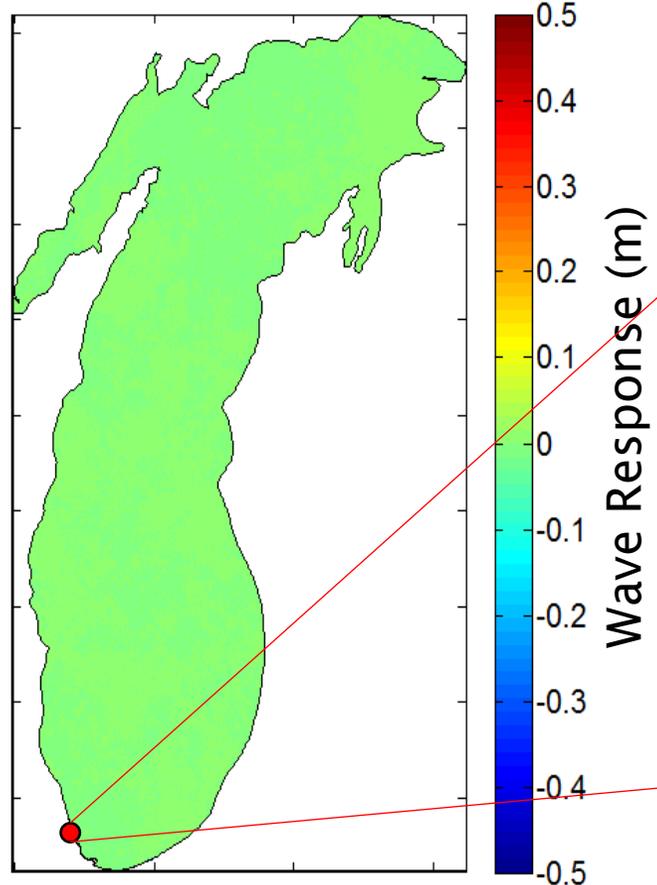
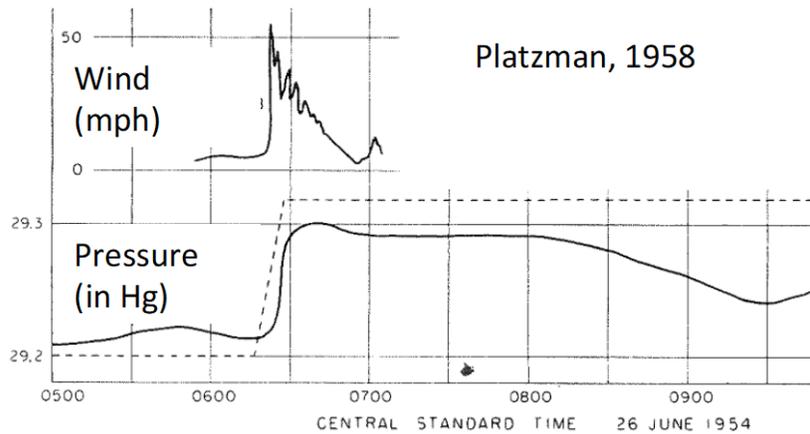
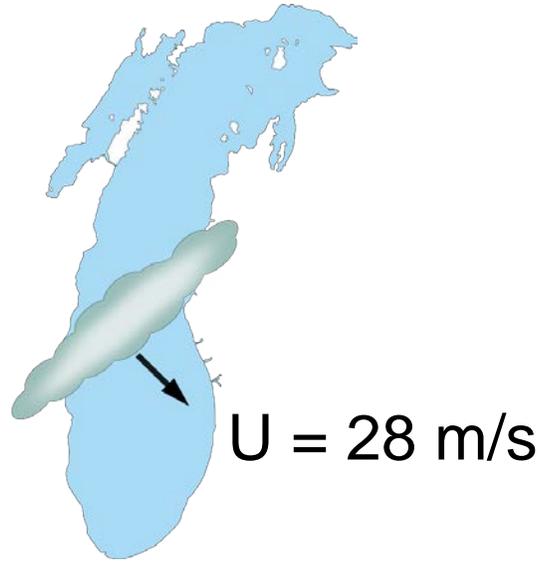
July 6

- 2 meter wave struck Chicago
- “Much more severe” than June 26
- Swept cars from parking lot

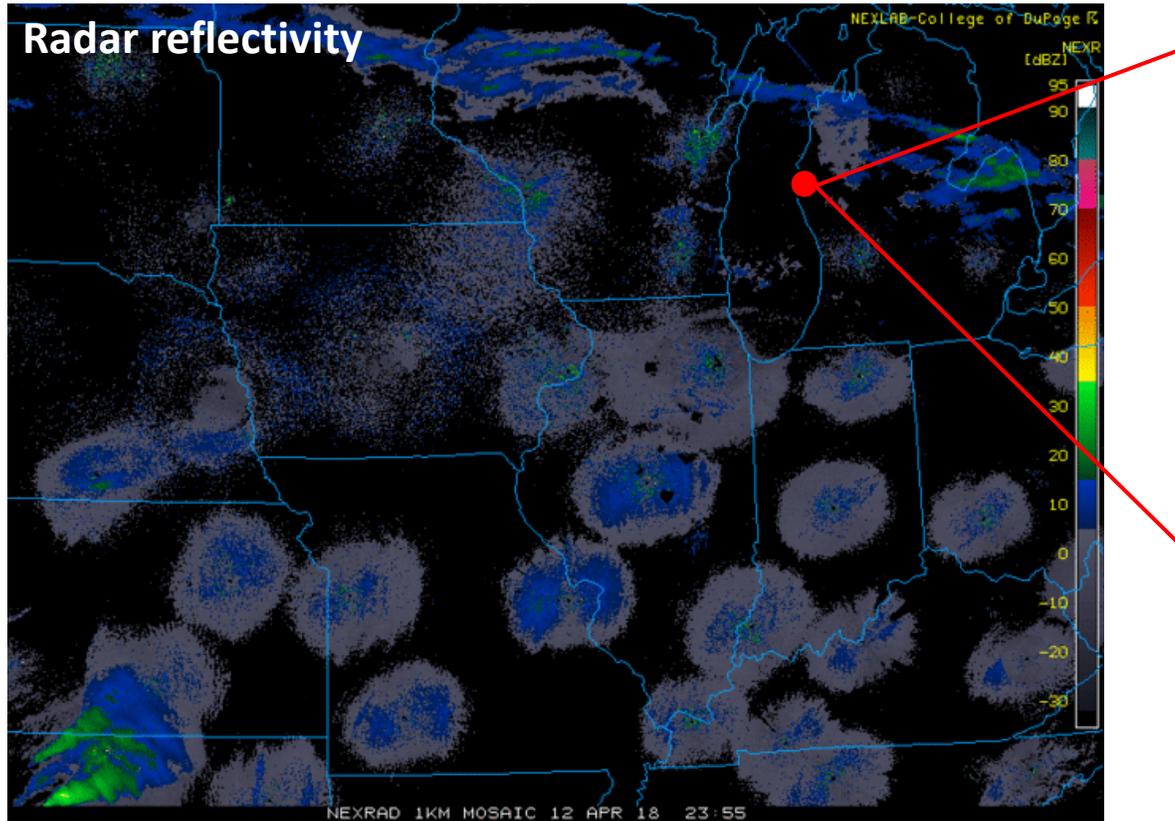
Meteotsunami | Chicago 1954



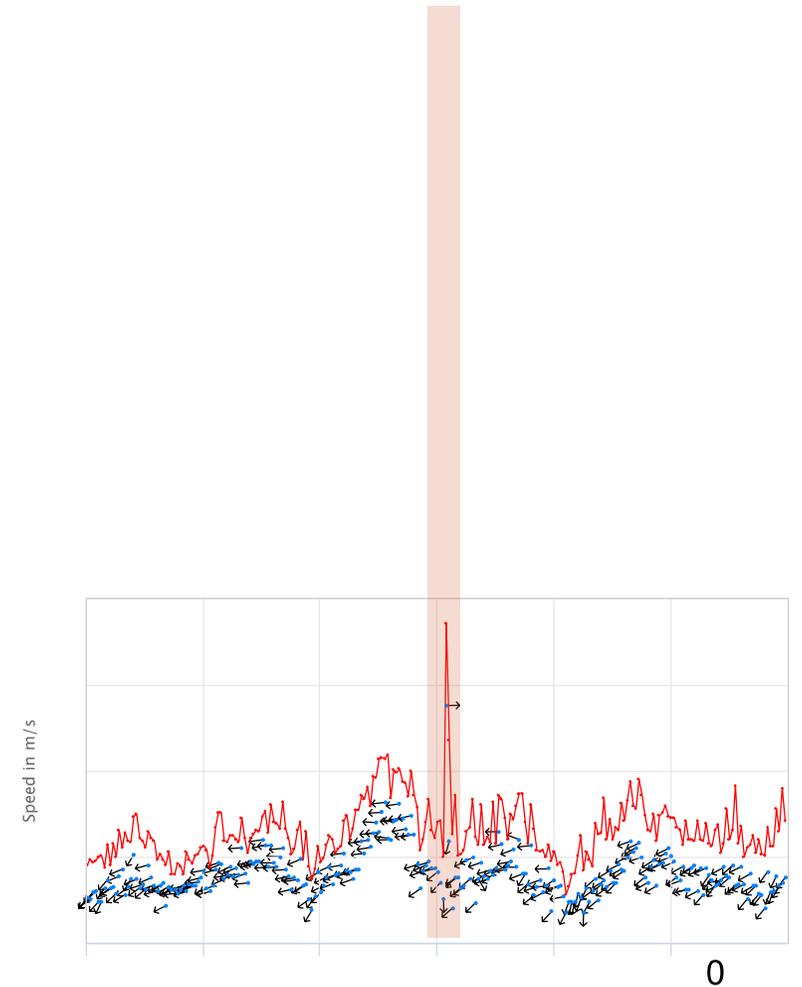
Meteotsunami | Chicago 1954



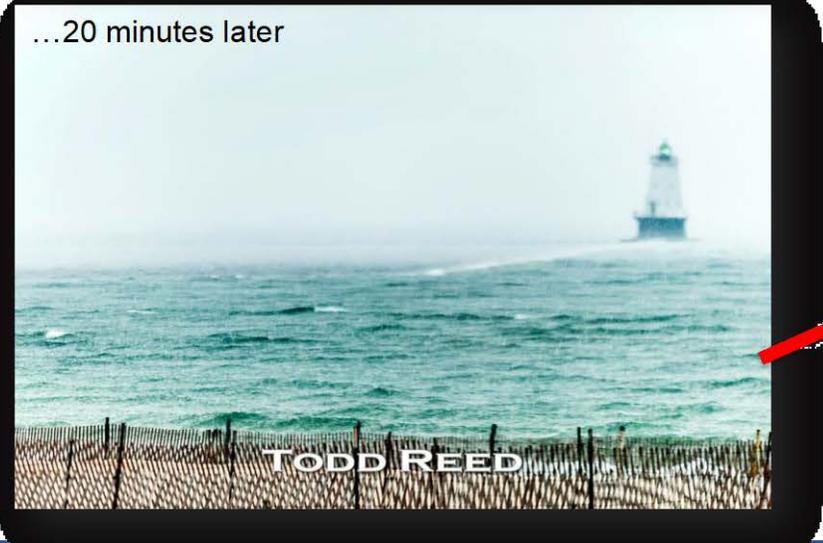
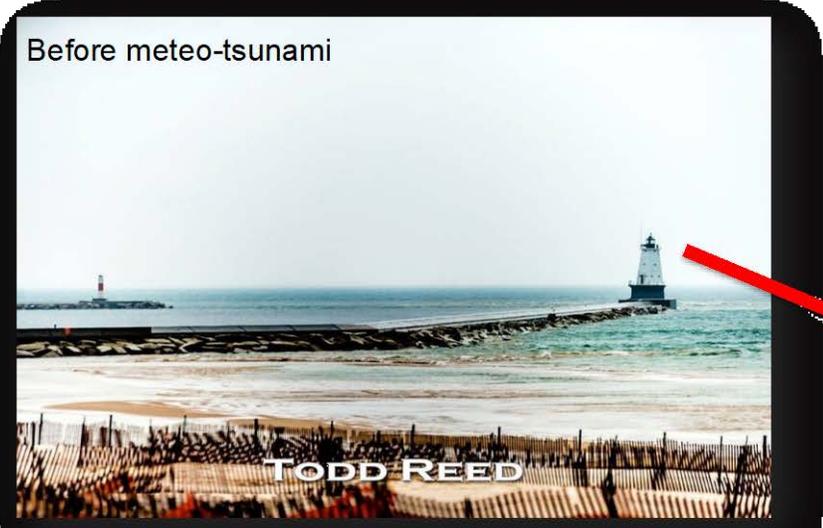
Meteotsunami | Ludington 2018



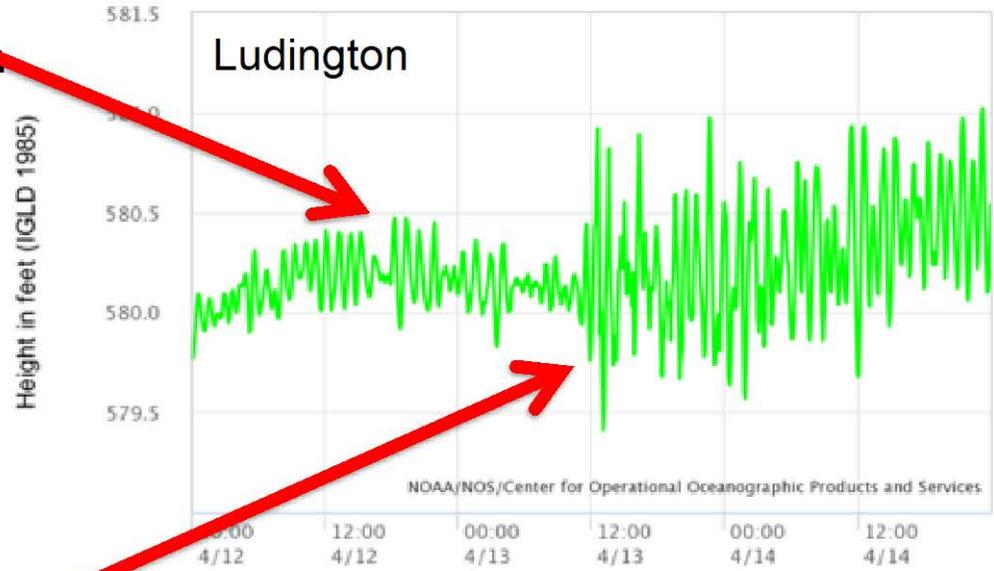
Friday, April 13th, 2018



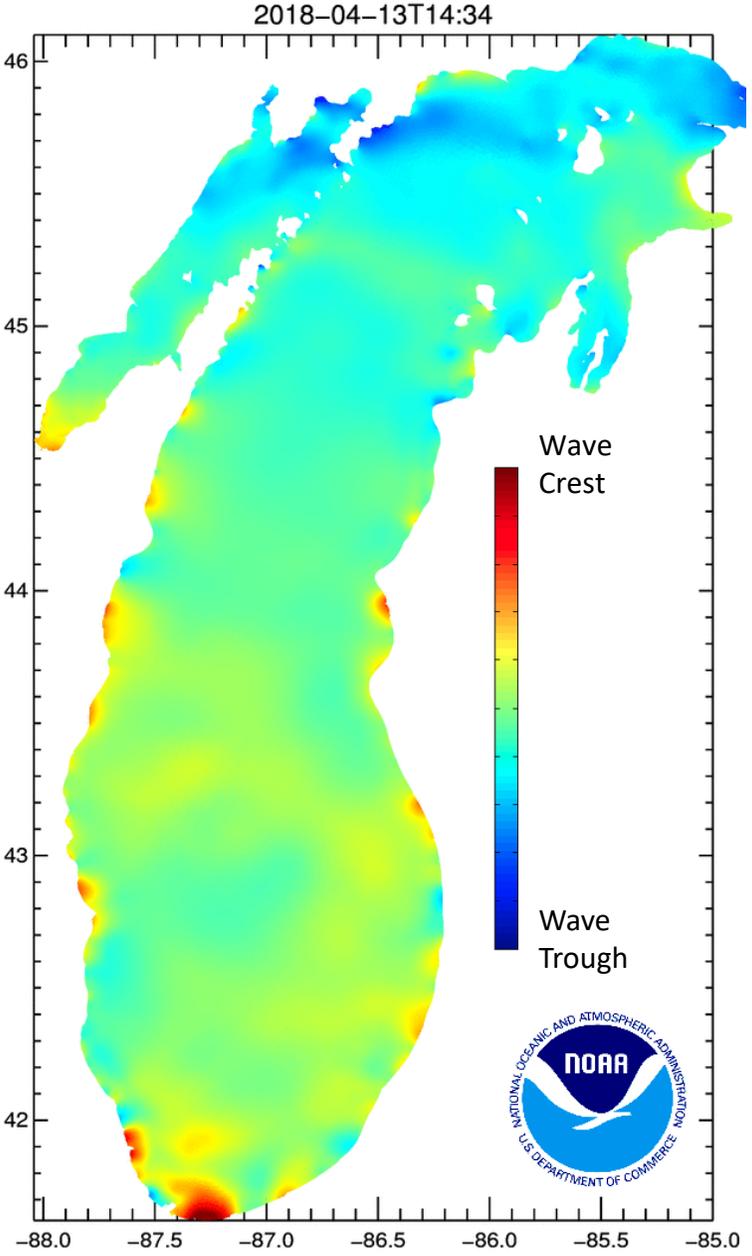
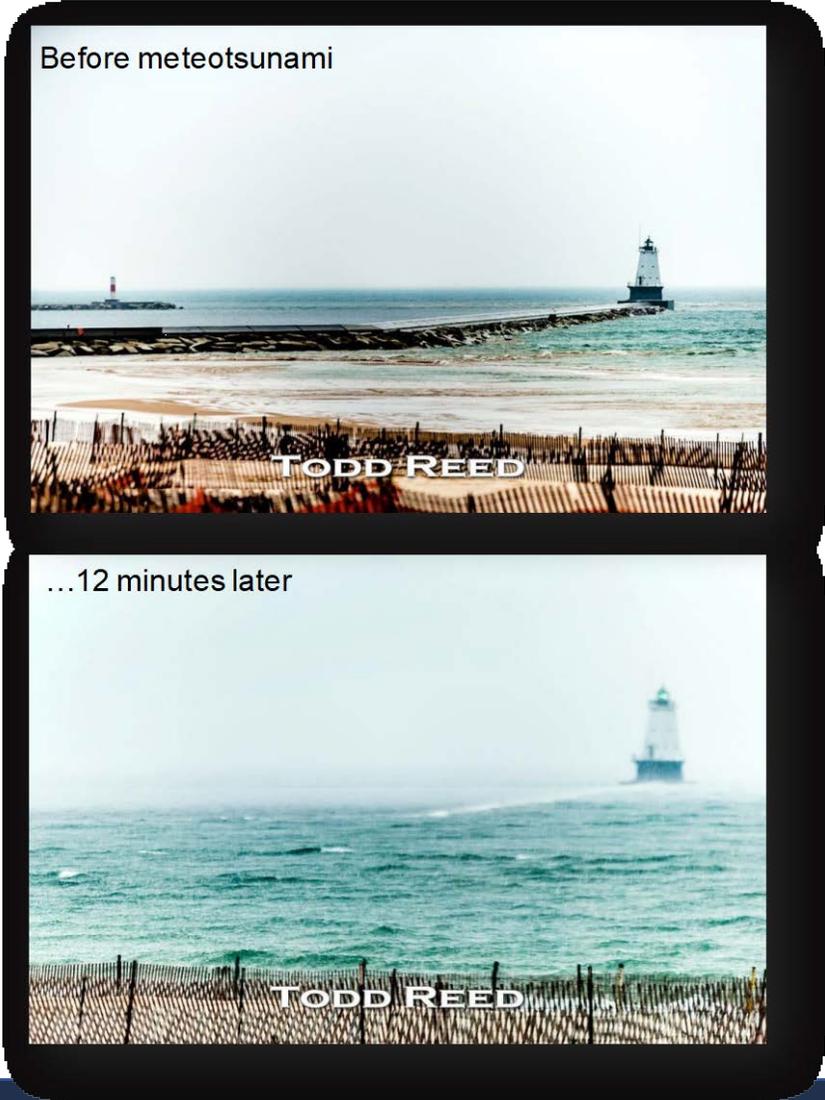
Meteotsunami | Ludington 2018

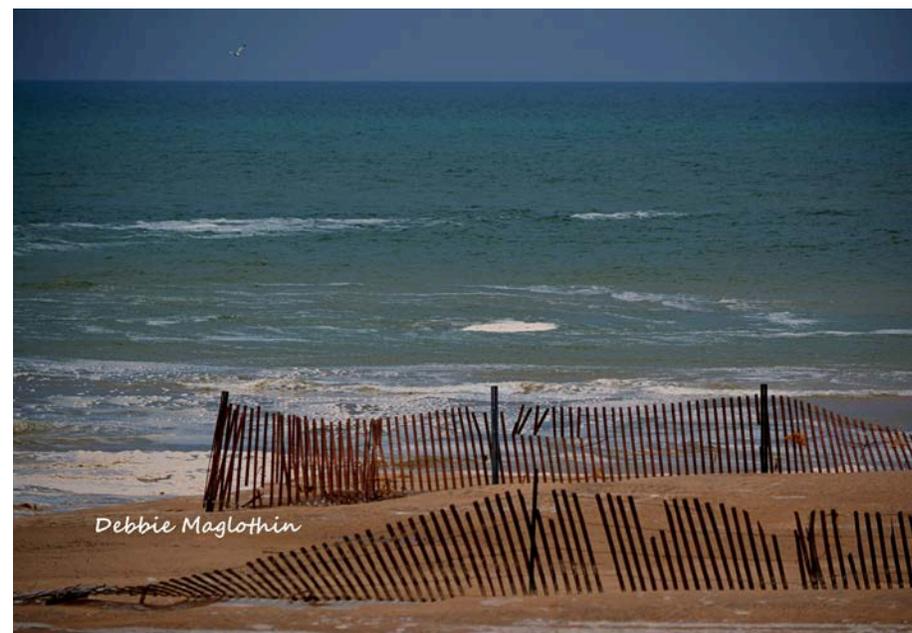


Observed Water Level



Meteotsunami | Ludington 2018





Summary | Freak waves and meteotsunamis

- Wind waves and seiches occur frequently
- **Meteotsunamis** are rare, **Freak waves** are even rarer
- They are not the same thing!
- **Freak waves**
 - Tall, steep, and suddenly appear (and then gone)
- **Meteotsunamis**
 - Long waves (~10 km) that happen over several minutes (~20 min)
 - Flood shorelines, rapid currents, swamped marinas

Summary | Freak waves and meteotsunamis

- **Freak waves**

- May be difficult to predict (where and when)
- Hard to measure

- **Meteotsunamis**

- We understand the weather "ingredients" needed to create them
- Our computer models can simulate them
- Water level observations around the lakes can detect them
- *Forecasting them may be in the near future!*

Thanks!



Eric J. Anderson, Ph.D.
Civil and Environmental Engineering
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