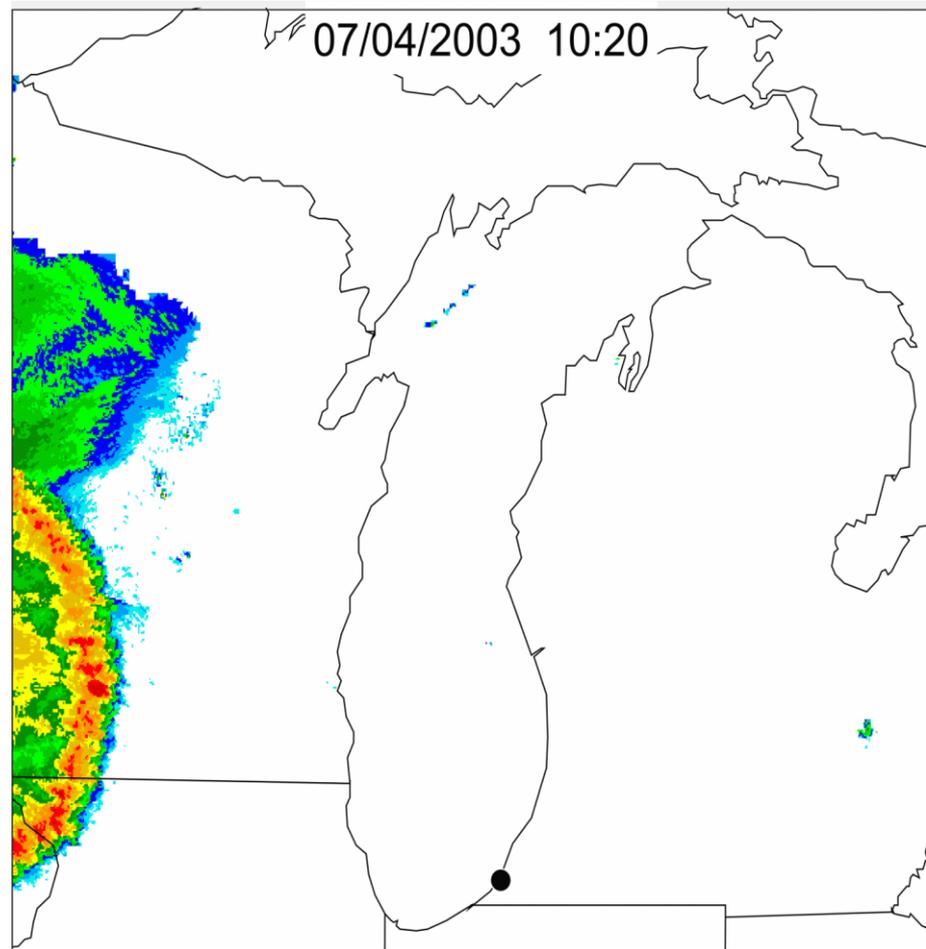


# Unexpected Rip Currents induced by a Meteotsunami

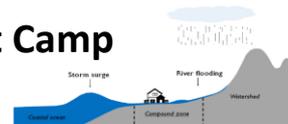


NOAA SCHISM Workshop and Boot Camp

February 17, 2021

**Chin Wu**

Álvaro Linares, Adam Bechle, Eric Anderson, Dave Kristovich



PRAIRIE  
RESEARCH INSTITUTE

# Dangerous *Rip Currents* in the Great Lakes



Great Lakes Current Incident Database  
(2002-2020)

**733 Incidents**

**214 fatalities**

Superior

Lake Michigan

**504 Incidents**

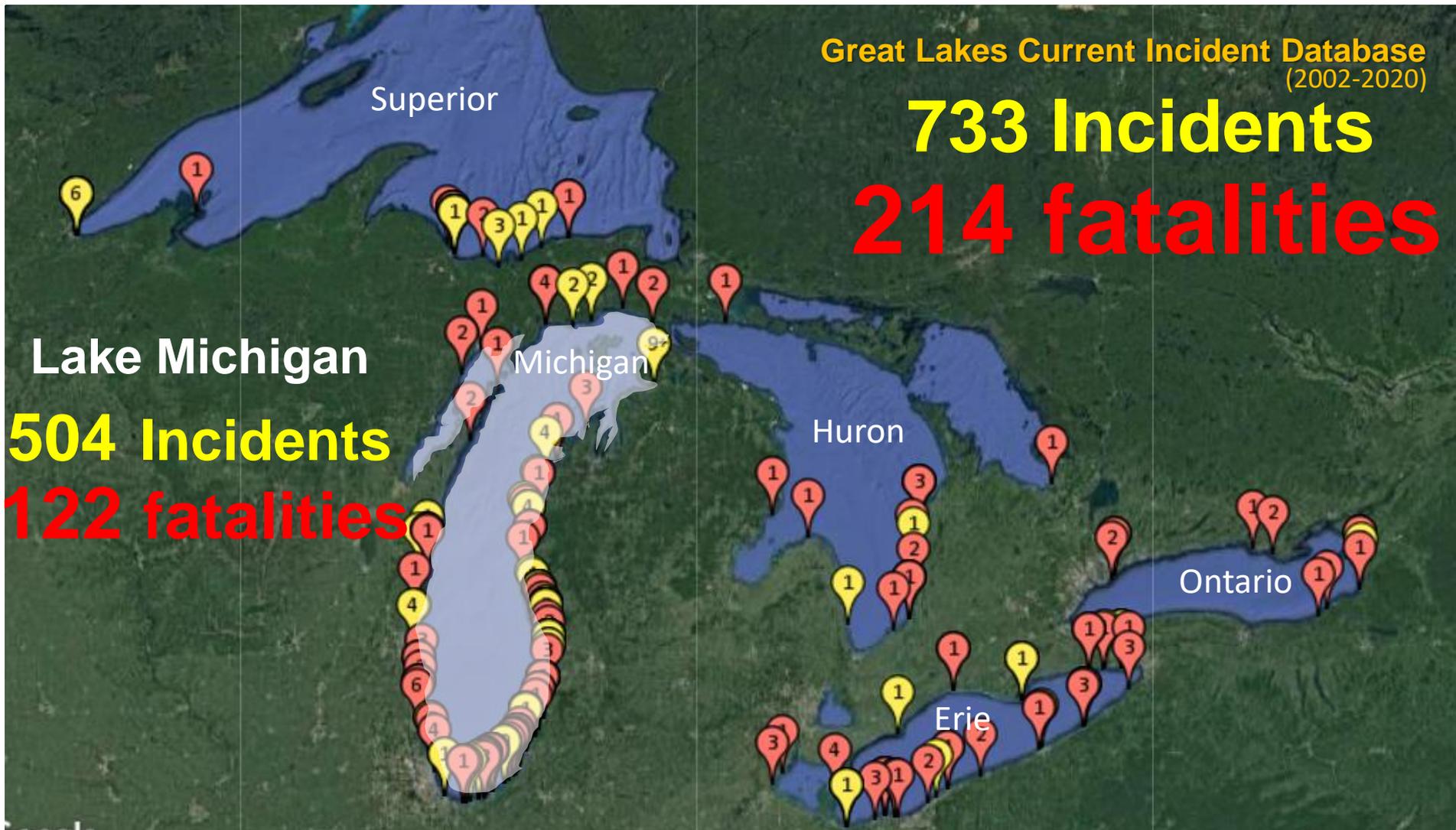
**122 fatalities**

Michigan

Huron

Ontario

Erie



# a Meteotsunami

## On 4 July 2003

### Ambient conditions

- Sunny sky



26°C @ 9 am

32°C @ 5 pm

- Warm temperature

- Low wind speed  $1 \sim 3 \text{ m/s}$

- Populated beach

*Federal holiday on a Friday*

### Sudden change in weathers

- **Convective storm** crossed the Lake in 80 min
- **Precipitation** over Warren < 15 min
- **Sunny again**

## Chicago Tribune

### 4 drown, 3 missing in Lake Michigan

Victims had ties to Chicago area

July 06, 2003 | By Manya A. Brachear and John Biemer, Tribune staff reporters.

The CBS News logo, featuring the CBS eye symbol to the left of the words "CBS NEWS" in a bold, white, sans-serif font on a dark blue background.

## Stormy Lake Michigan

### Claims 7



By MELISSA CHEUNG | AP | July 7, 2003, 2:40 PM

Warren Dunes

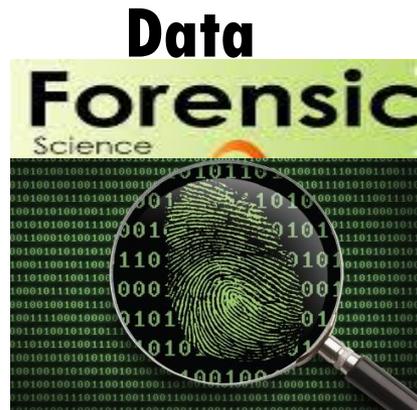
# Conjectures

The *disaster* was caused by

- Water levels
- Wave heights
- Rip currents



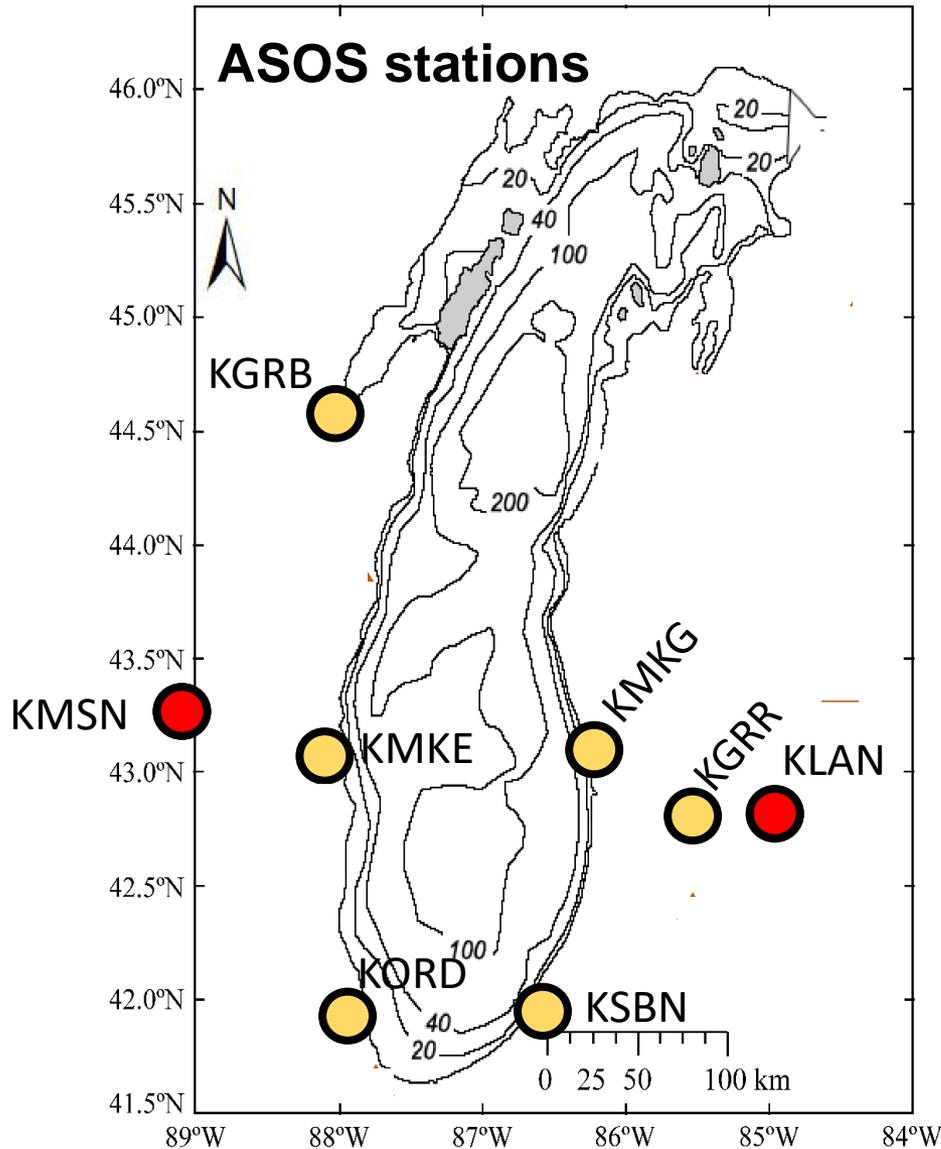
The cause of the *7 deaths* remains a puzzle!



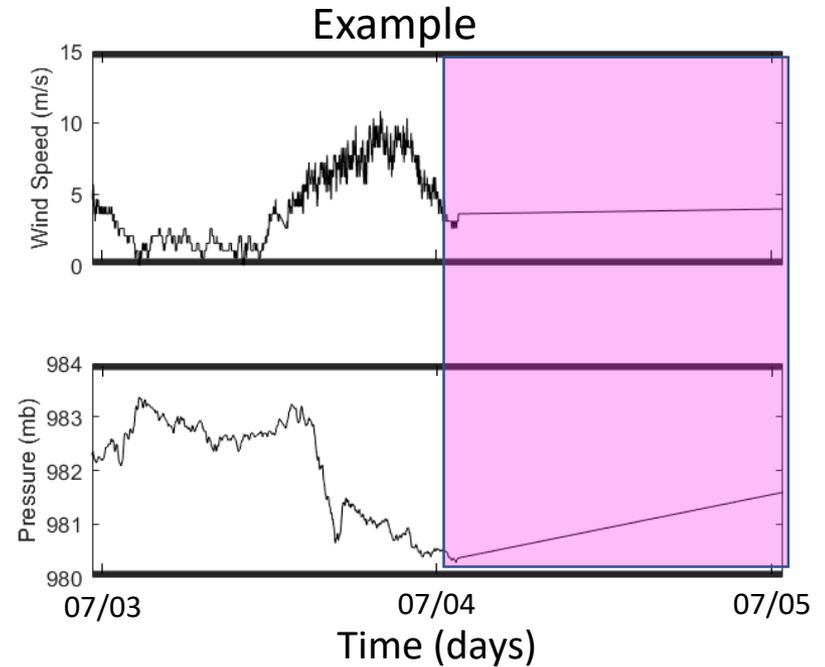
*mystery*



# Atmospheric Data



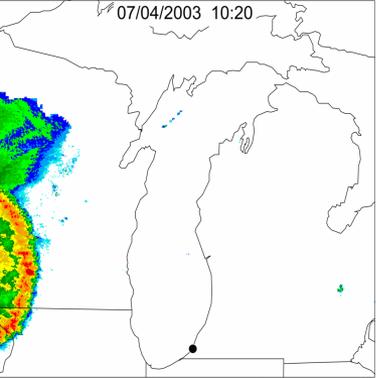
- ▲ 15 min interval
- 1 min interval in 2003



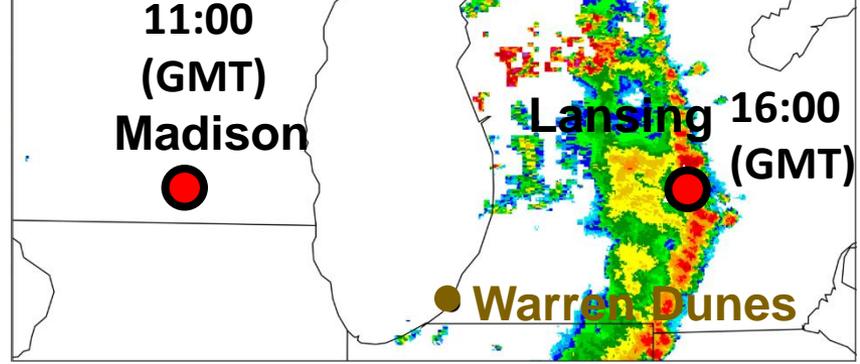
Missing data on July 4 .? ?

● Available data





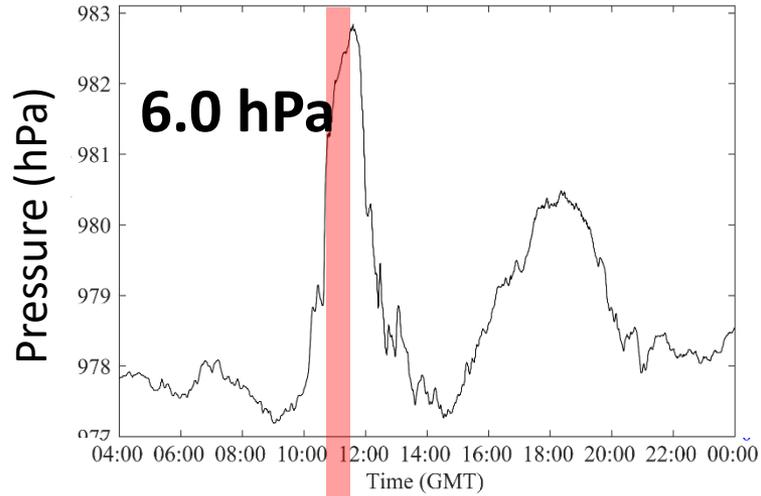
# Atmospheric Disturbances



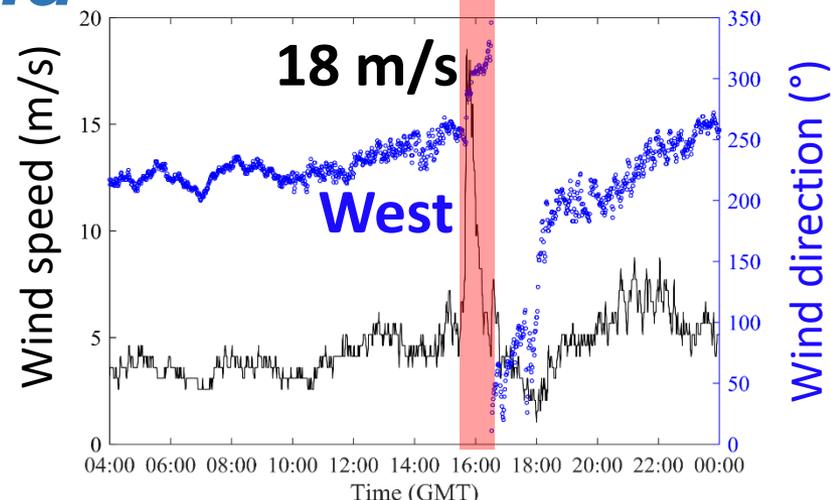
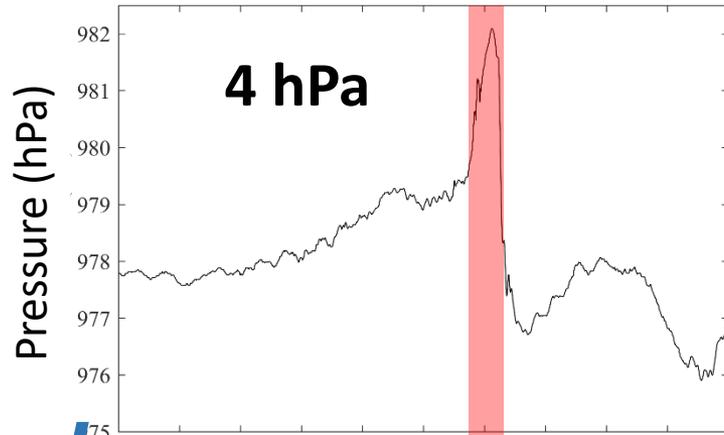
Madison Airport

## Pressure

Lansing Airport



## Wind

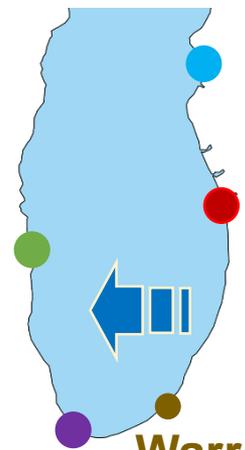
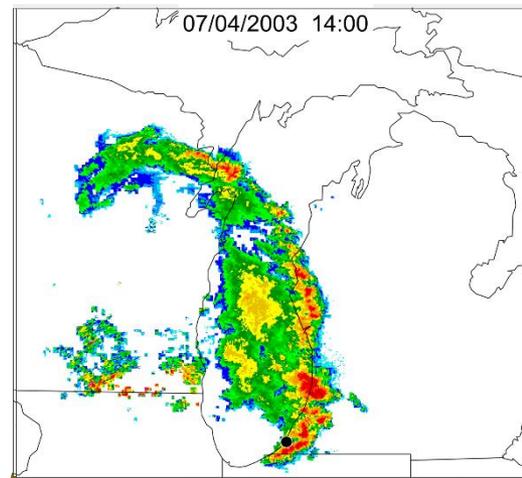


# Water Levels



NOAA/NOS Gauges

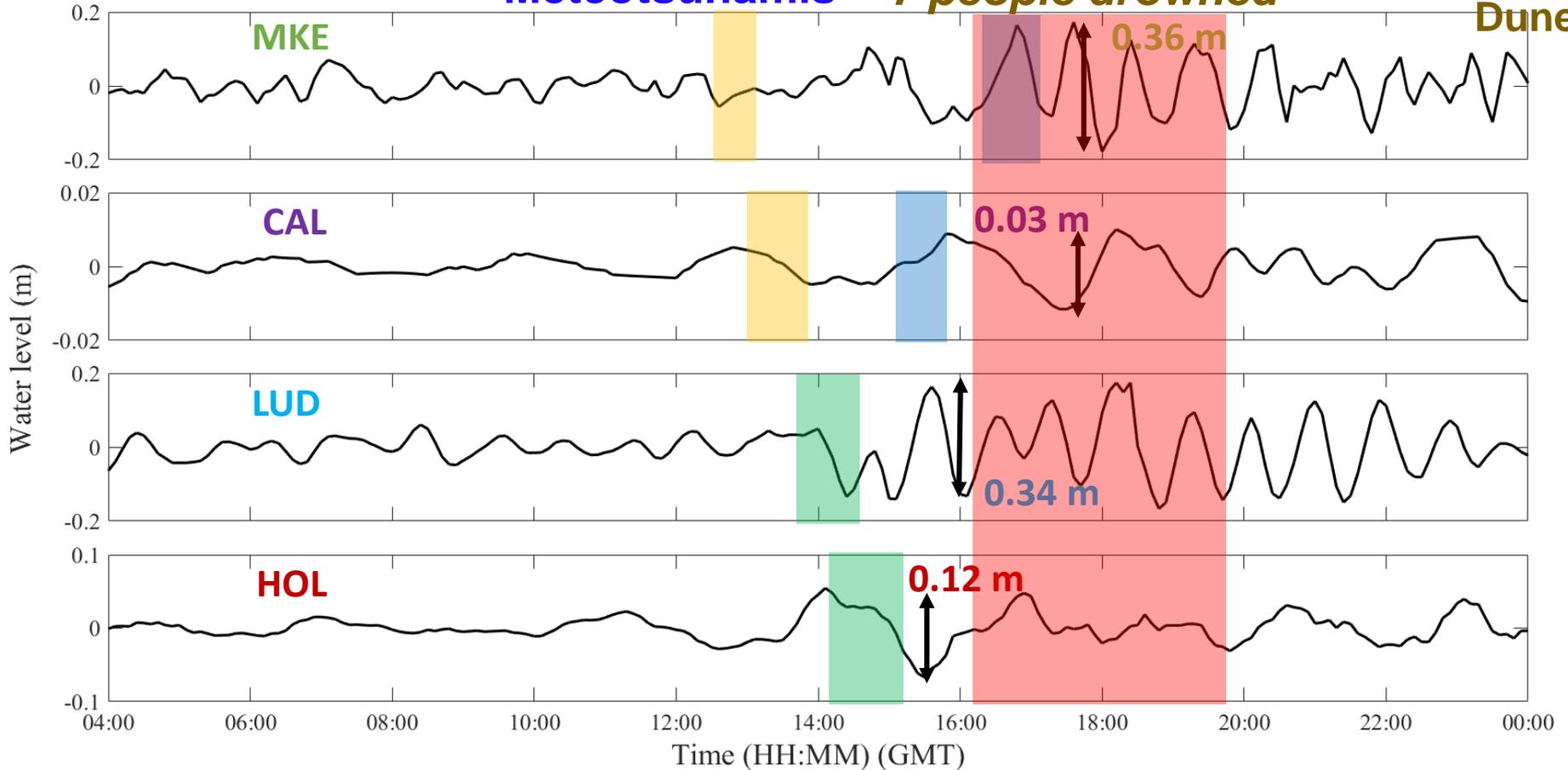
12:00  
(GMT)



Meteotsunamis

7 people drowned

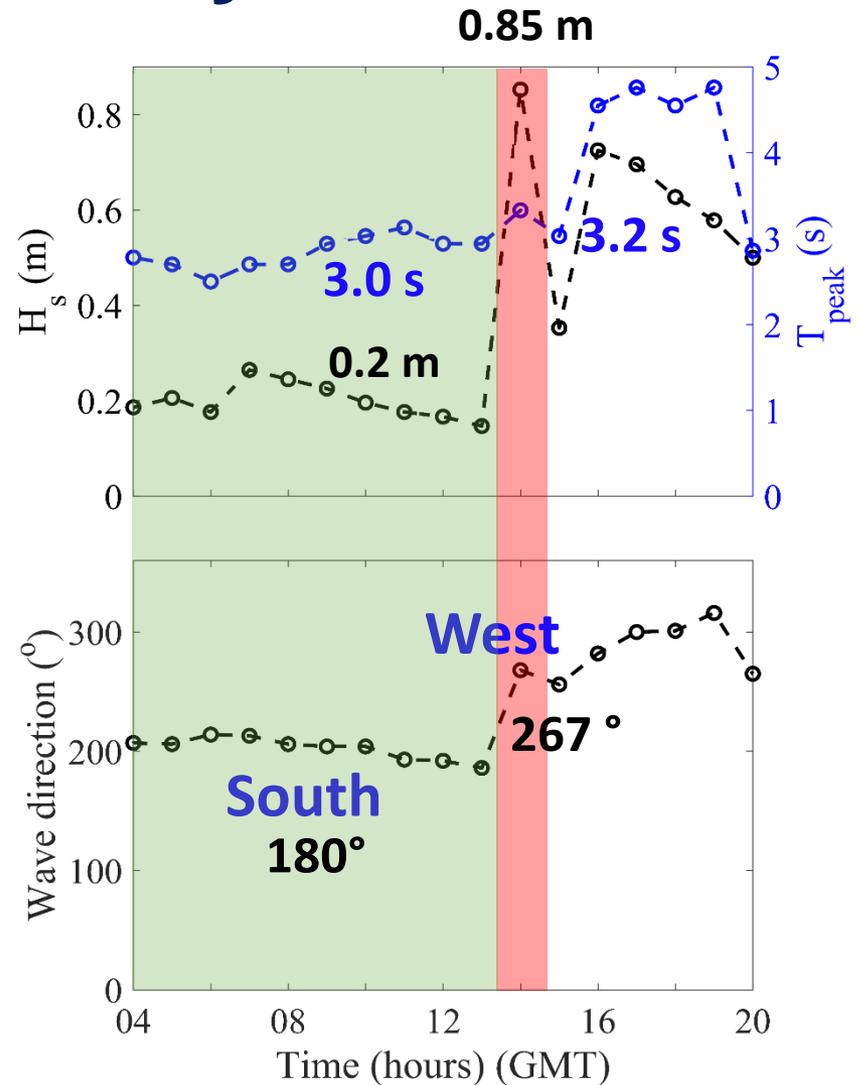
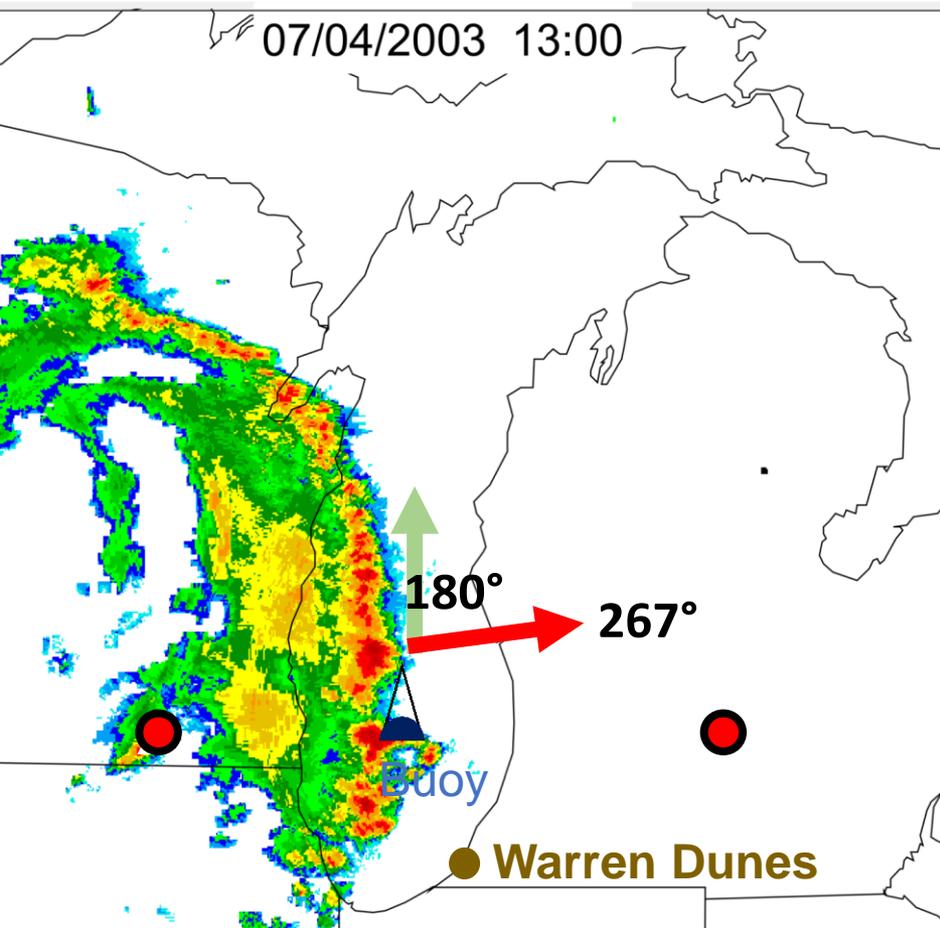
Warren  
Dunes



# Wind Waves

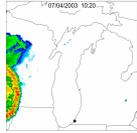


## NDBC Buoy

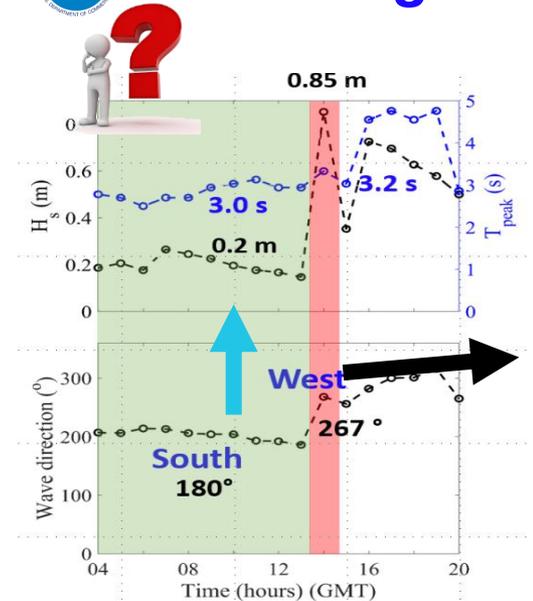
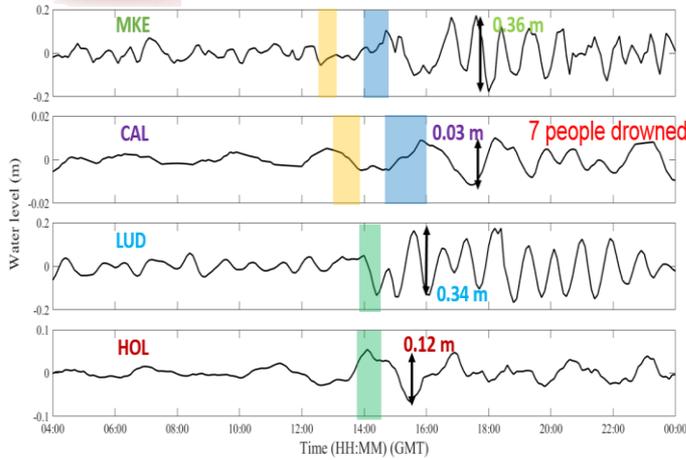




# Data Forensics



? ~ 0.3 m (1 ft)

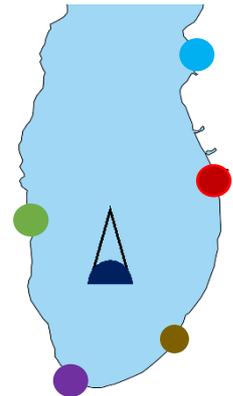


**Meteotsunami**

**Low potential to cause a *disaster***

**Too low to cause an *incident***

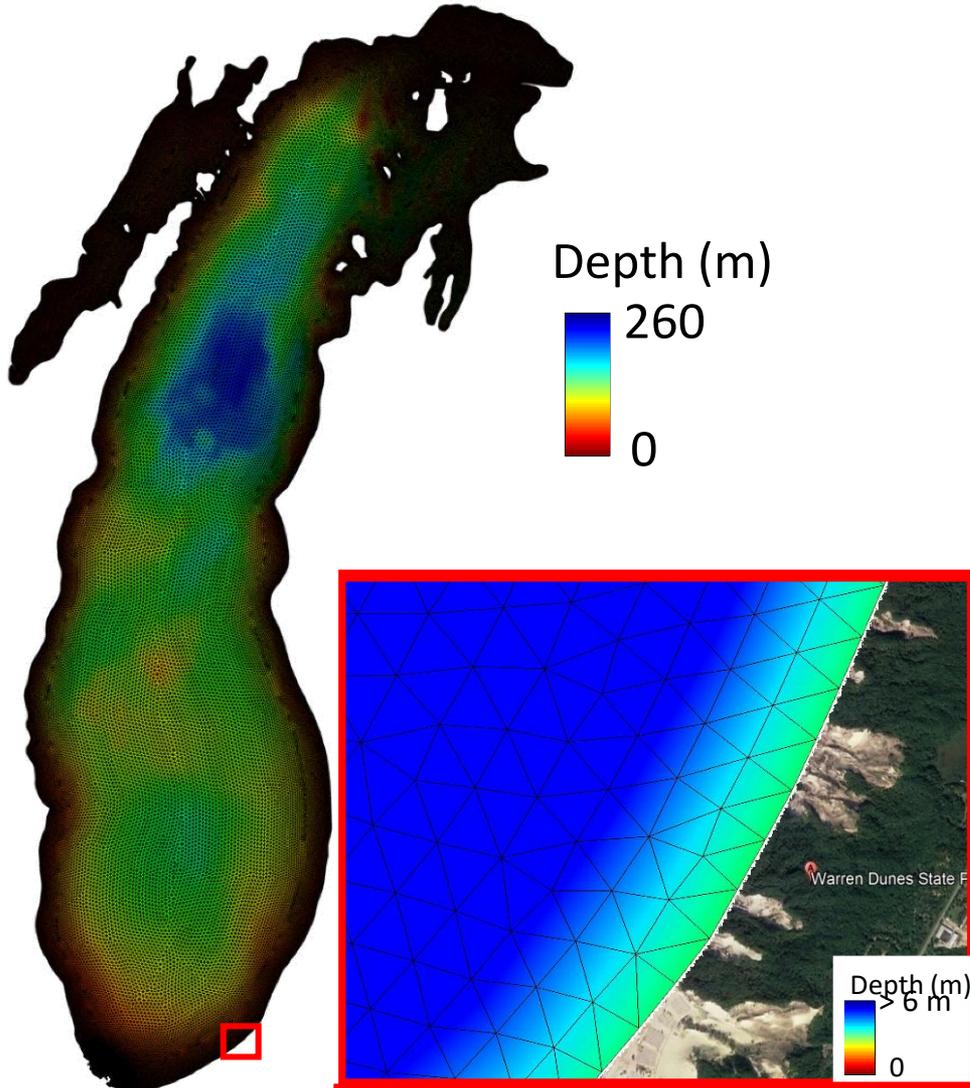
**No Site Information at Warnen Dunes**



# Modeling Forensics

# Current - Wave interactions Modeling

SCHISM ↔ WWMIII



## Setup

- Grid resolution: **300 – 600 m**
- Vertical coordinate: 20 layers

## Used in **meteotsunamis**

- Bechle & Wu (2014), *Nat. Hazards*
- Linares et al. (2016), *J. Geophys. Res.*

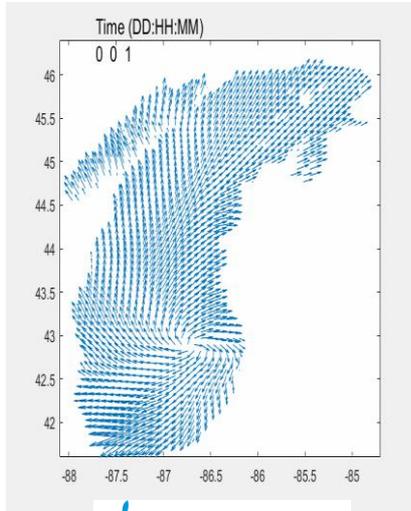
## Used in **wave climates**

- Anderson et al. (2016), *J. Geophys. Res.*
- Anderson and Wu (2018), *JGLR.*

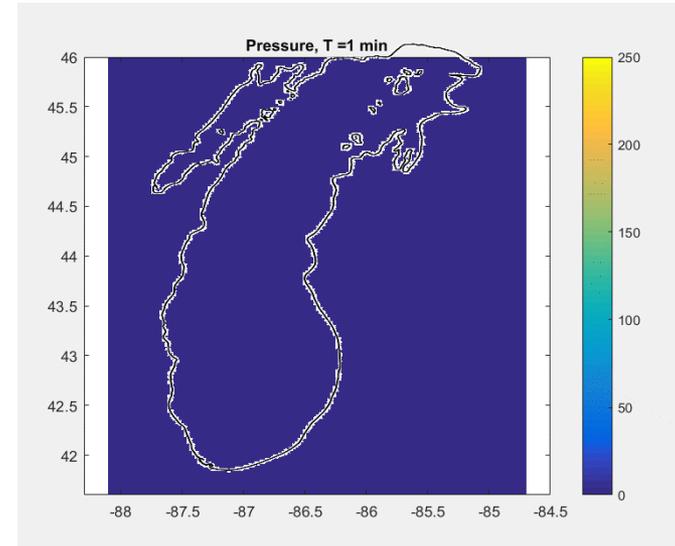
## Atmospheric Forcing

# Reconstruction

## Ambient Winds

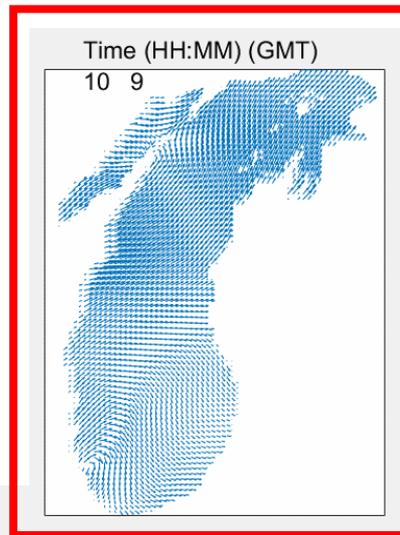


## Storm Disturbances



are overwritten by

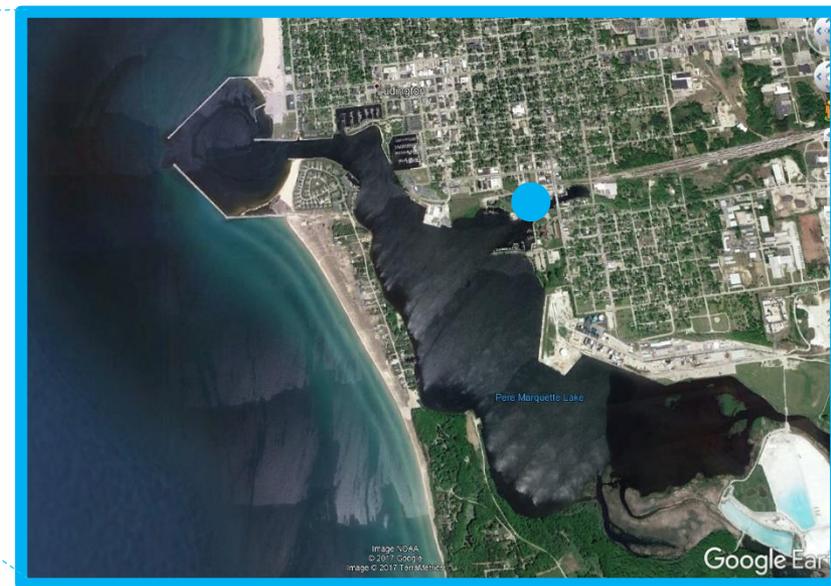
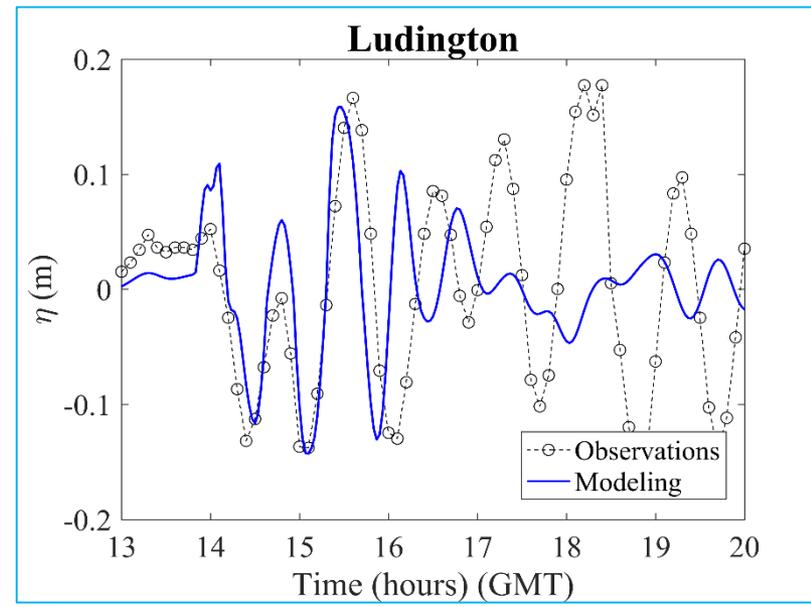
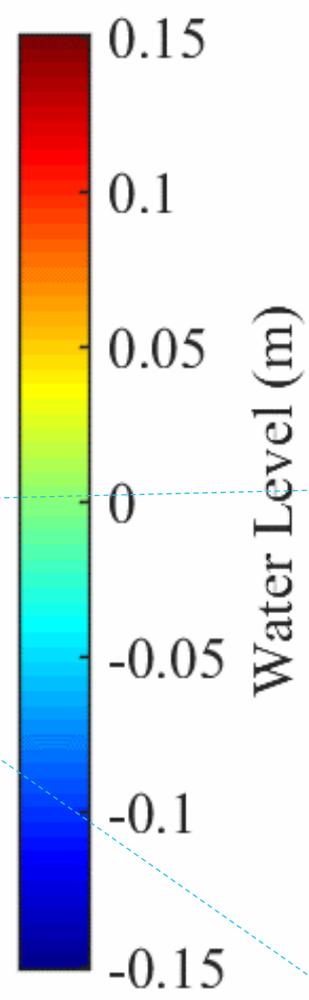
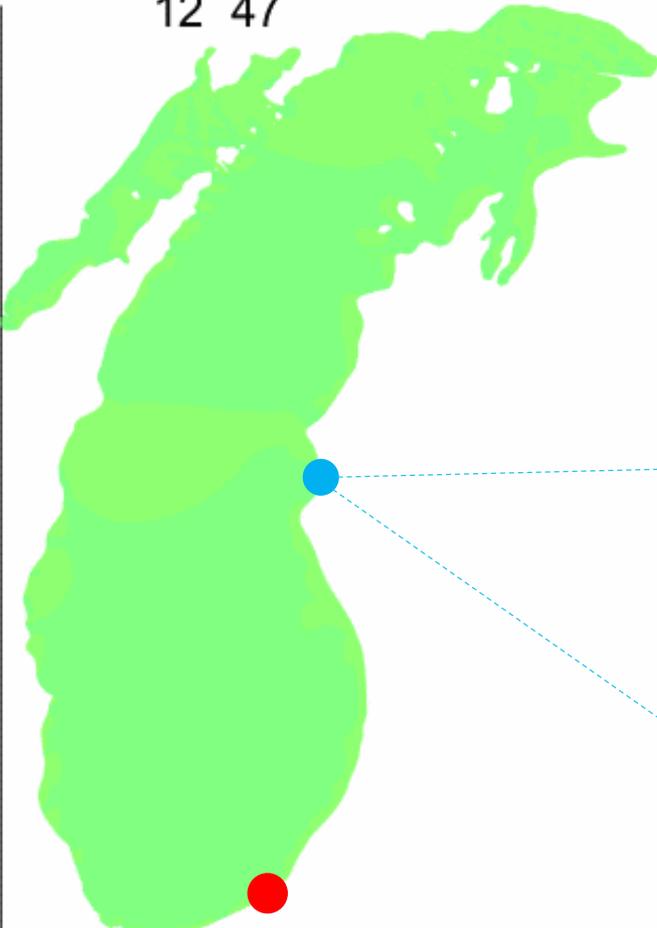
## Ambient Winds



## Disturbances

# Water Level Fluctuations

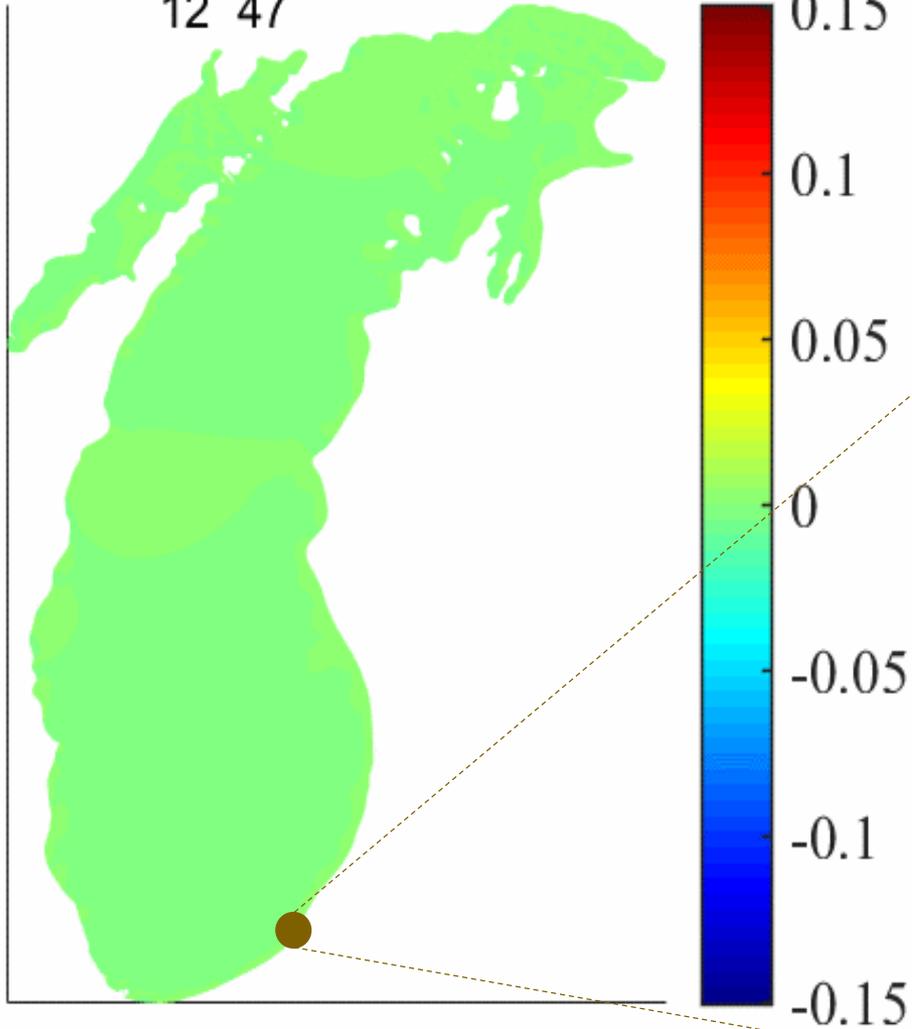
Time (HH:MM) (GMT)  
12 47



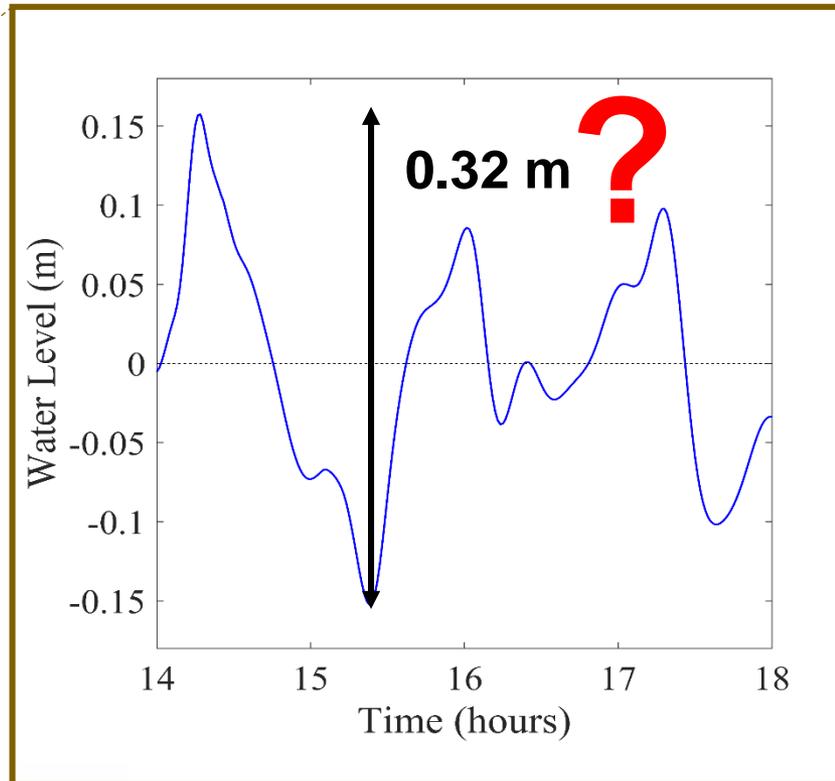
# Water Level Fluctuations

Time (HH:MM) (GMT)

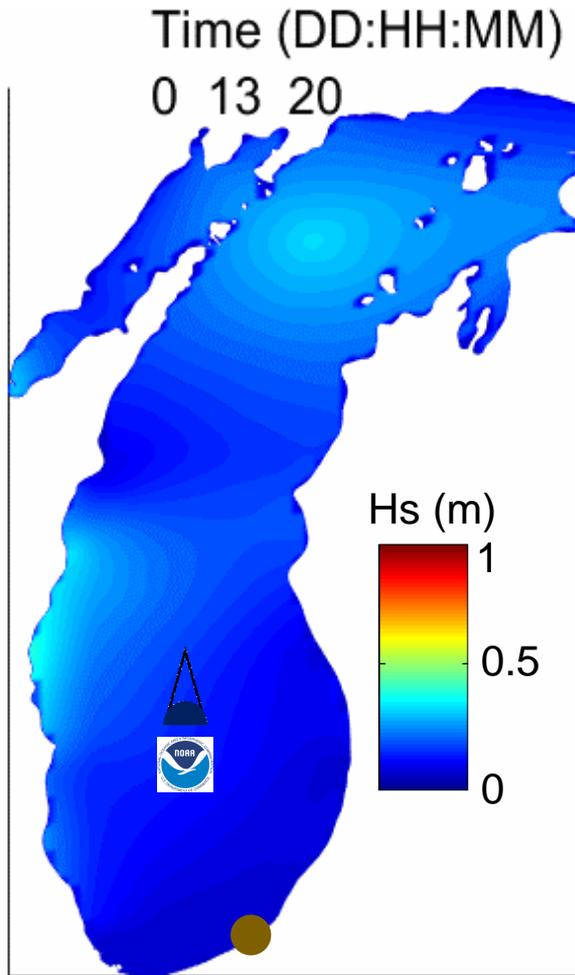
12 47



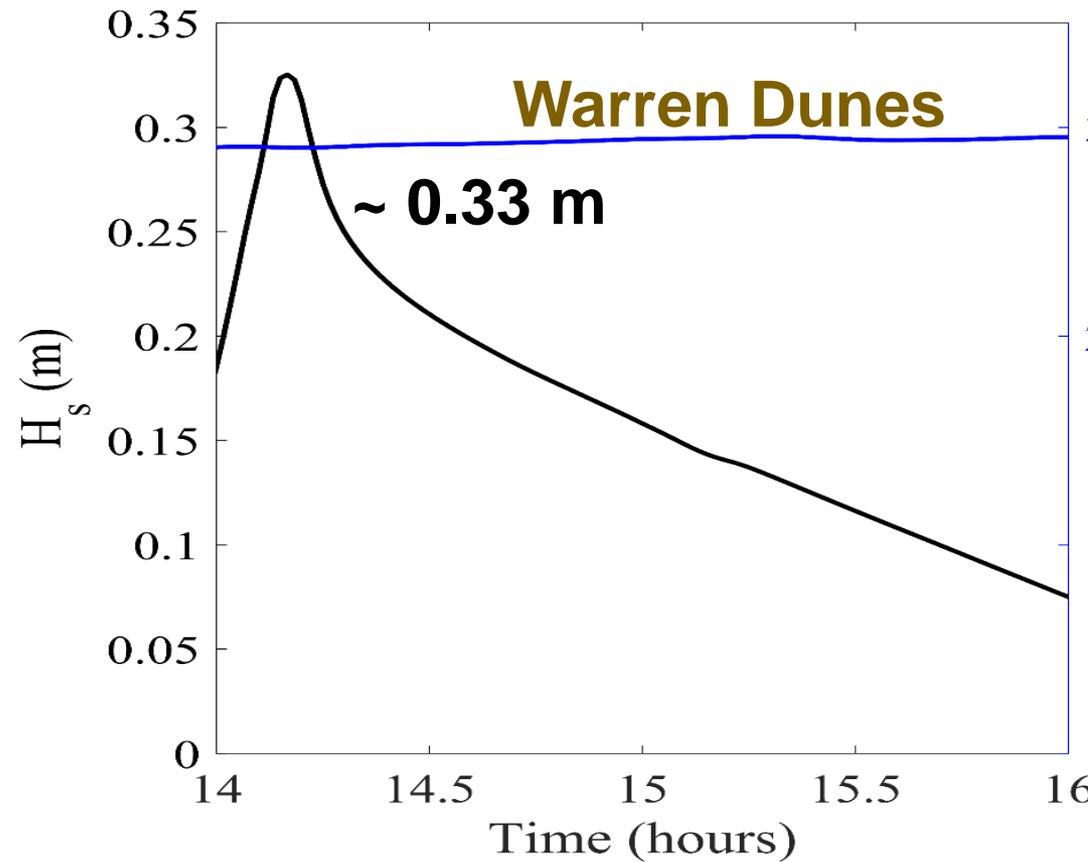
Warren Dunes



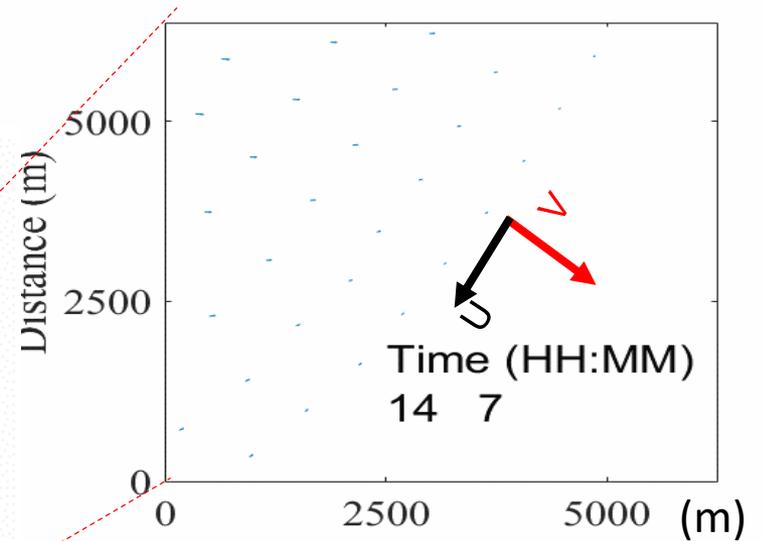
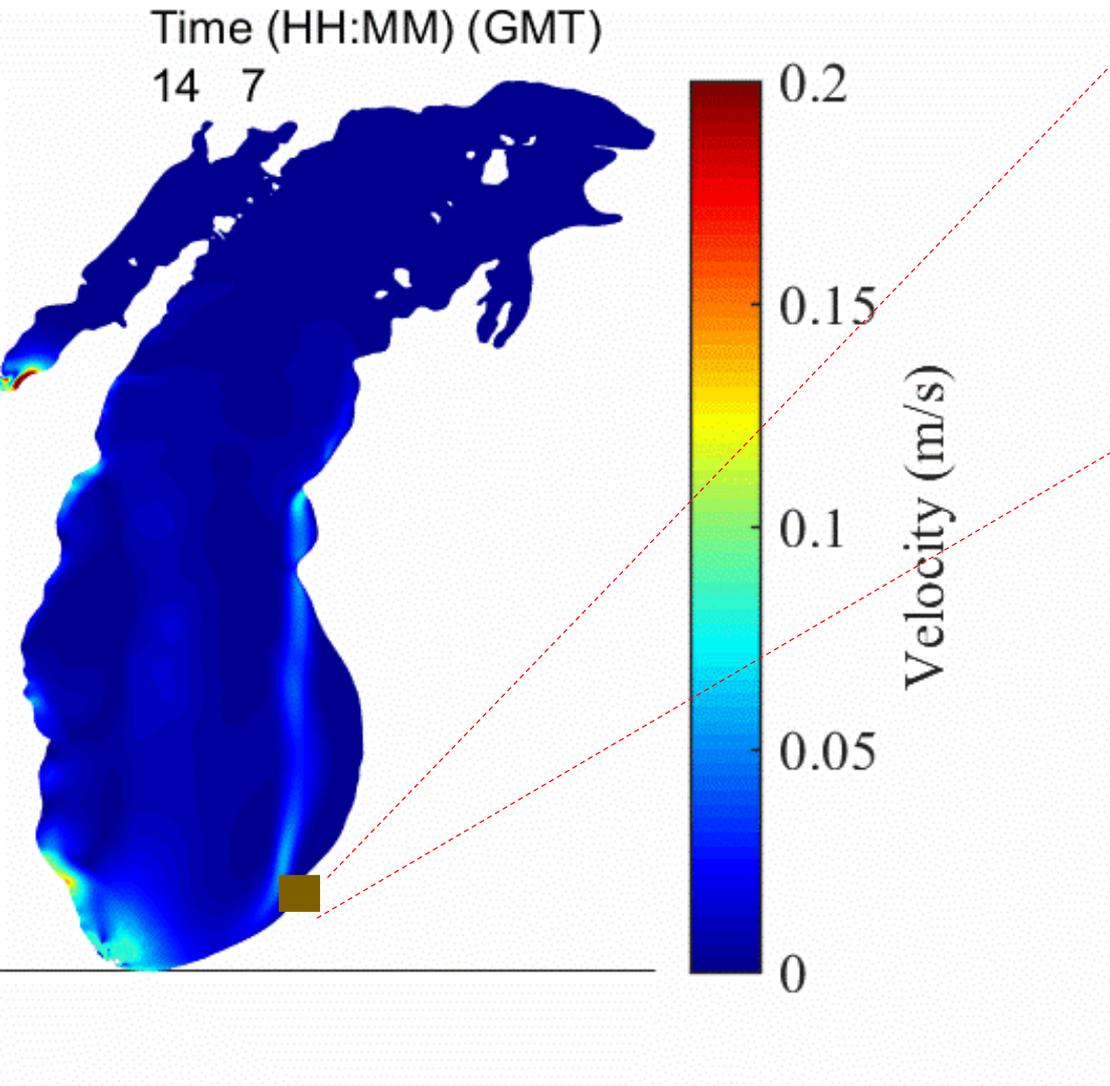
# Wind Waves



Warren Dunes



# Currents at Warren Dunes



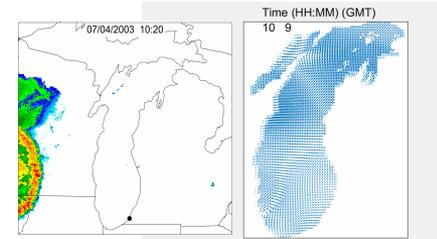
Velocities < 0.15 m/s



# Modeling Forensics



## Warnen Dunes

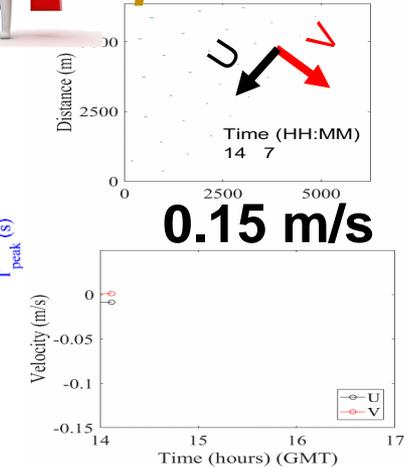
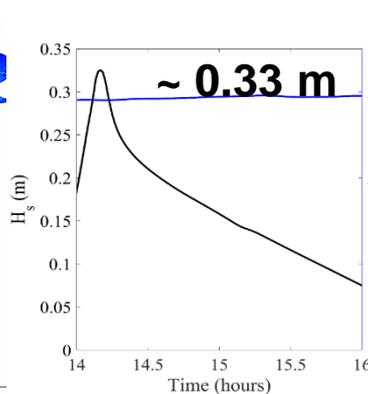
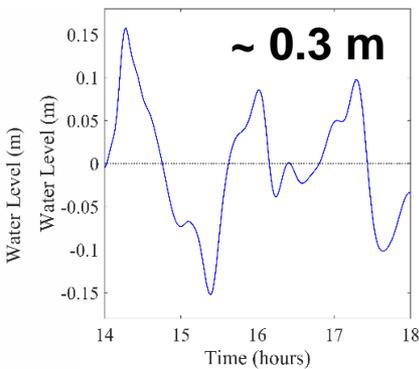
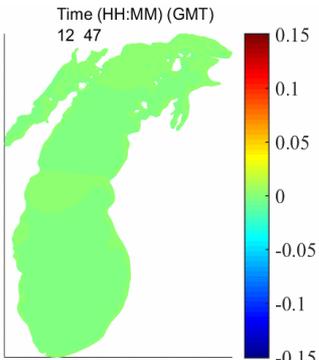


## Meteotsunami

? **Water Levels**

? **Wave Heights**

? **Rip currents**



**Low potential**  
to cause a **disaster**

**Too low to**  
cause an **incident**

**Too small to**  
cause **drownings**

Conjectures

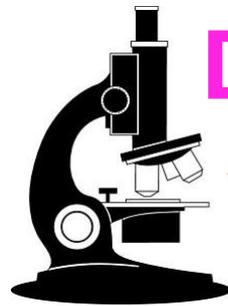
The **disaster** was caused by

- Water Levels
- Wave heights
- Rip currents



Stormy Lake Michigan

Claims 7 CBS NEWS



## Detailed Nearshore Area



## DNA Forensics

# Detailed Nearshore Area DNA

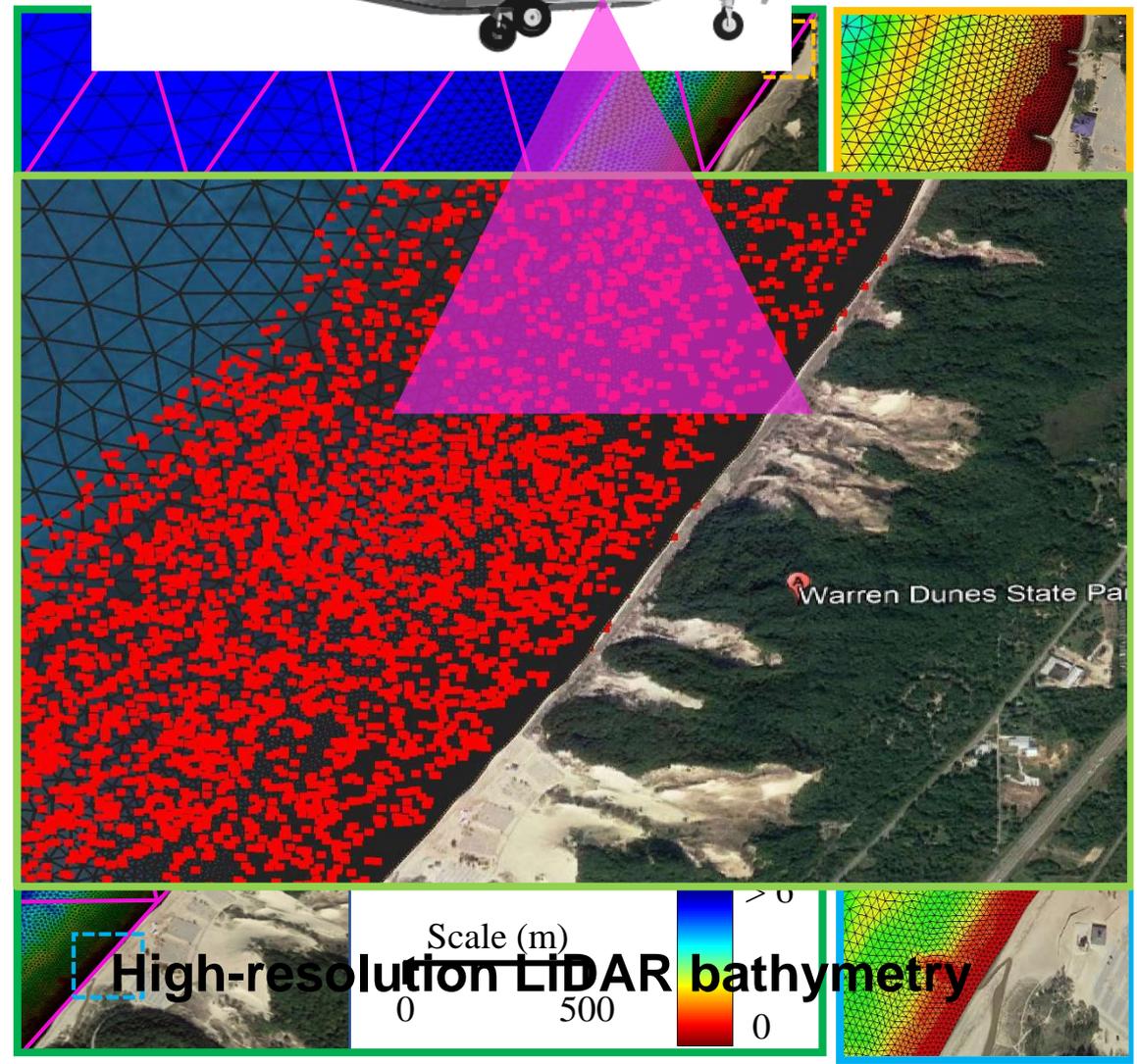
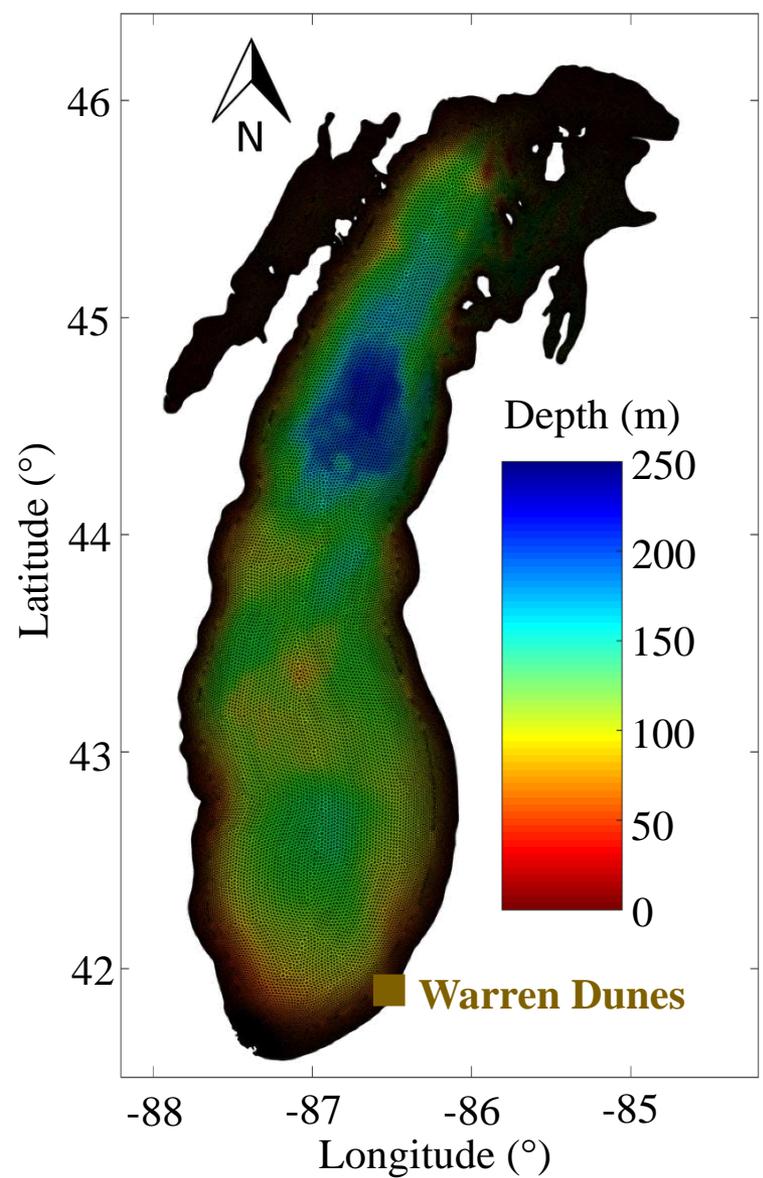


Current-Wave interactions Modeling

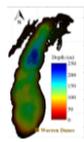
SCHISM

WWMIII

size: 2m

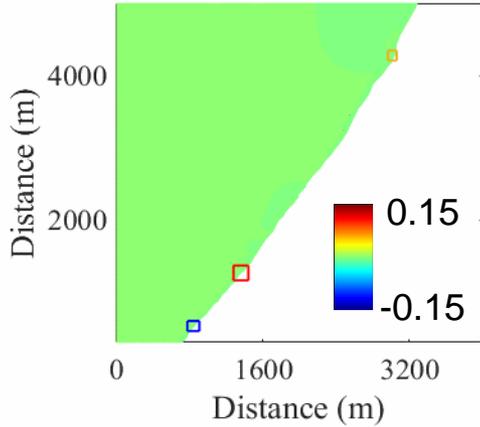


**Grid:** Accurate coastline & Detailed bathymetry



# Warnen Dunes

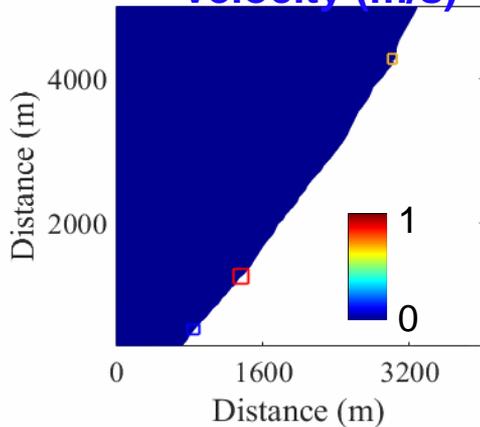
## Water Level (m)



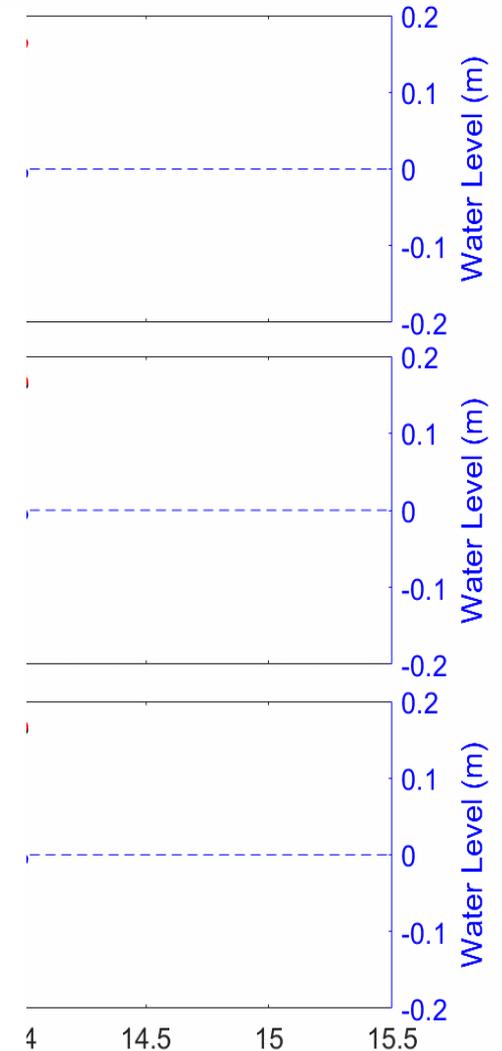
Time (HH:MM)

14 0

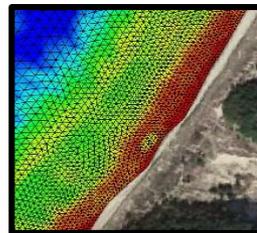
## Velocity (m/s)



# DNA



**Meteotsunami induced**  
**water level changes** ↔  
**current motions**



**Strong rip currents**

Magnitude  $O(1\text{m/s})$

Transient ~ **5 ~ 30 min**

Lasting ~ **3 ~ 5 hours**



Conjectures  
The **disaster** was caused by

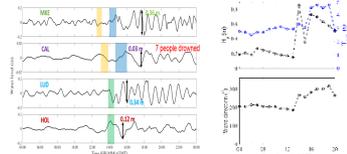
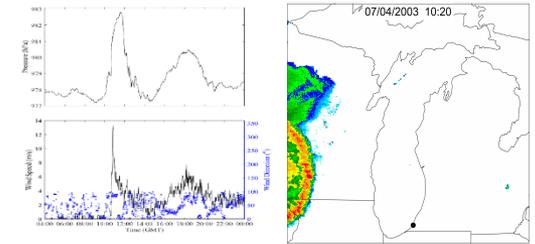
- Water Levels
- Wave heights
- Rip currents

# Summary



## Data Forensics

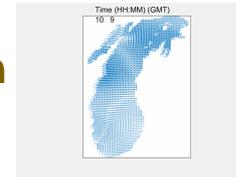
- A **meteotsunami** was generated by a **fast-moving convective storm**
- **Water Levels** were too **low potential** to cause a **disaster**
- **Wind waves** were too **low** to cause an **incident**



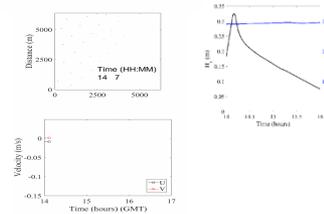
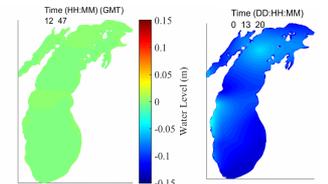
## Modeling Forensics



Warnen  
Dunes



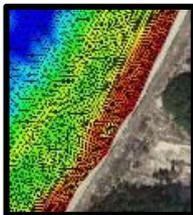
- **Water Levels** were too **low potential** to cause a **disaster**
- **Wind waves** were too **low** to cause an **incident**
- **Rip currents** were too **small** to cause **drownings**



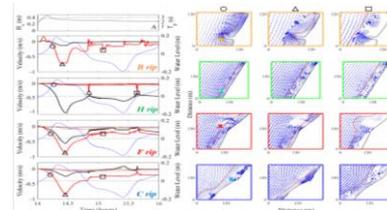
## DNA Forensics



- A **meteotsunami** induced **water levels** and **wind waves** that **interact** Detailed **N**earshore **A**rea to generate a variety of **rip currents**



- Strong **O** (1 m/s)
- Sudden (5 ~ 30 min)
- Lasted (3~ 5 hours)



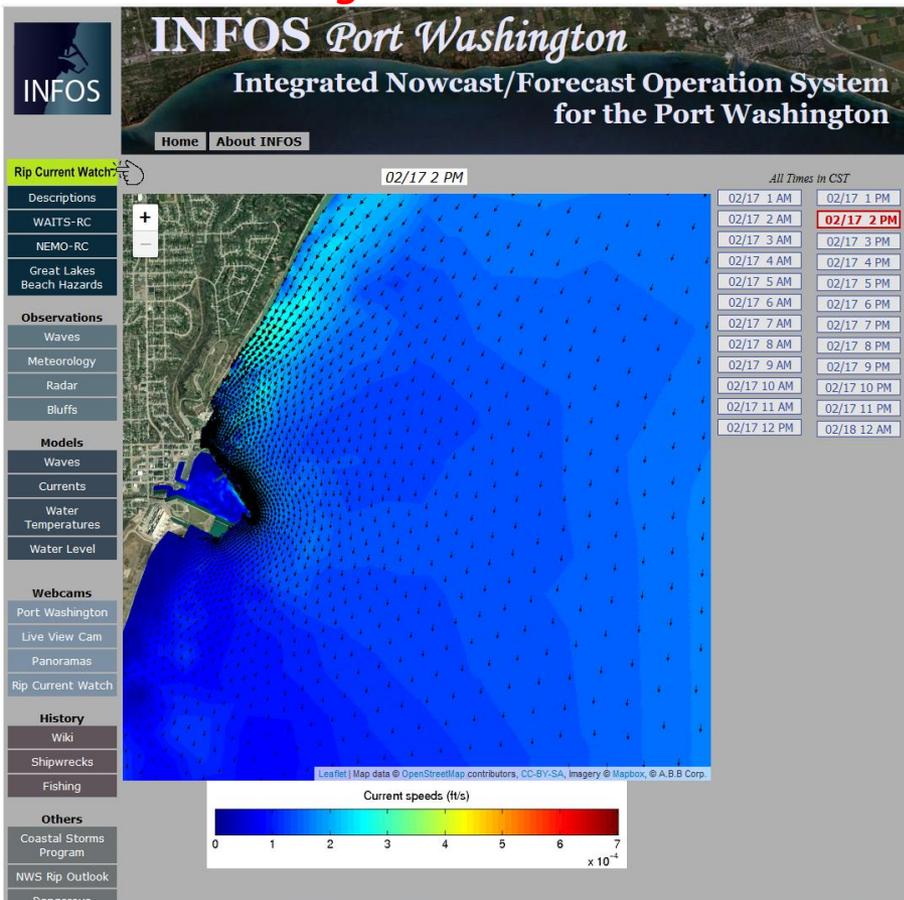
Article | [OPEN](#) | Published: 14 February 2019

## Unexpected rip currents induced by a meteotsunami

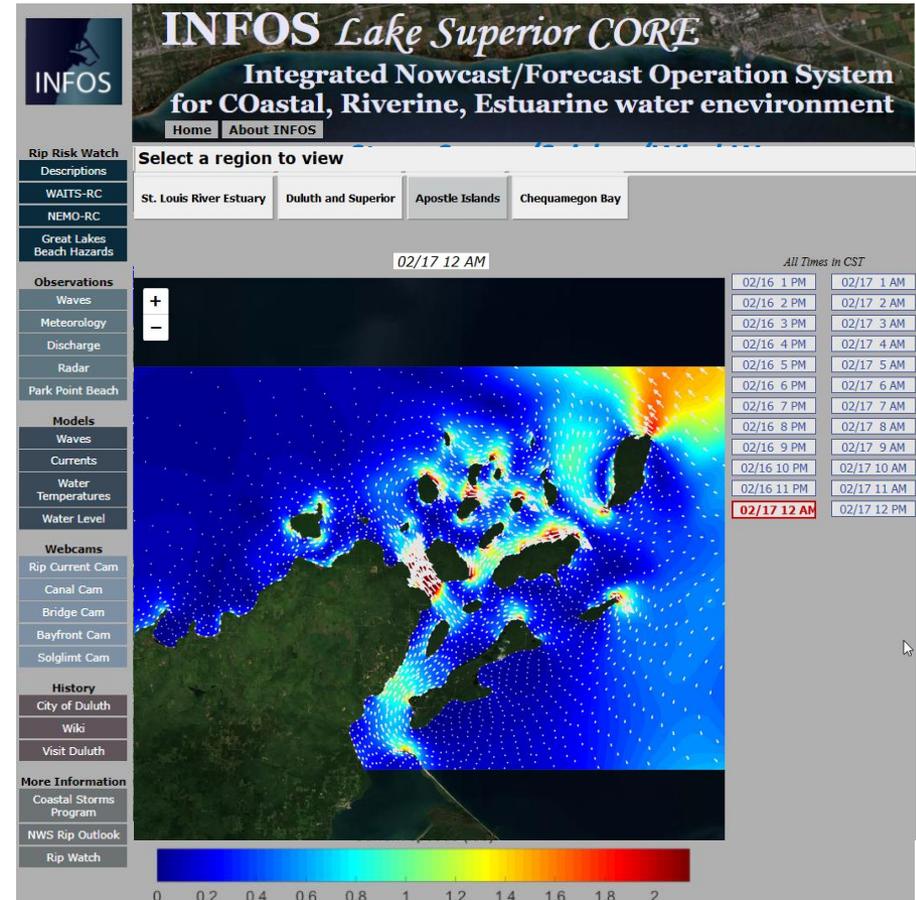
Álvaro Linares, Chin H. Wu , Adam J. Bechle, Eric J. Anderson & David A. R. Kristovich

*Scientific Reports* **9**, Article number: 2105 (2019) | [Download Citation](#) ↓

### Dangerous Currents



### Floods & Currents



[https://infosportwashington.cee.wisc.edu/new\\_model\\_surfcurr.html](https://infosportwashington.cee.wisc.edu/new_model_surfcurr.html)

[https://infosportwashington.cee.wisc.edu/new\\_model\\_surfcurr\\_core.html](https://infosportwashington.cee.wisc.edu/new_model_surfcurr_core.html)