The “White Hurricane” Storm of November 1913

A Numerical Model Retrospective

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Great Storm of 1913

A Numerical Model Retrospective

- November 7-11, 1913
- Over 250 lives lost at sea
- At least 12 ships sank (including some of the newest and largest in the fleet)
- At least 30 other ships driven ashore, crippled or destroyed
- Likely the worst natural disaster to hit the Great Lakes (and one of the deadliest in North American history)

~ Est. time of loss 5-8 pm EST Sunday Nov. 9

~ Est. time of loss from 6 pm EST Sunday Nov. 9 to 2 am EST Monday Nov. 10

8 ships lost and 187 lives

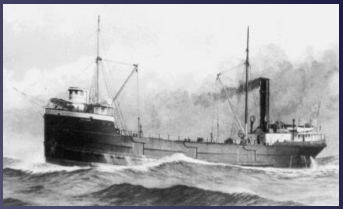
Because of lack of onboard radio communication in 1913, the exact times of most ship sinkings can only be estimated.

SHIPS LOST IN THE 1913 STORM

JOHN A. McGEAN – lost Lake Huron near Sturgeon Point. Still Missing.

ARGUS – lost Lake Huron near Pt. Aux Barques on Nov 9

ISAAC M. SCOTT – lost Lake Huron near Alpena on Nov. 9

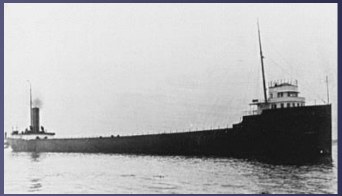


REGINA – lost Lake Huron near Harbor Beach on Nov 9

PLYMOUTH– lost Lake Michigan near Green Bay.

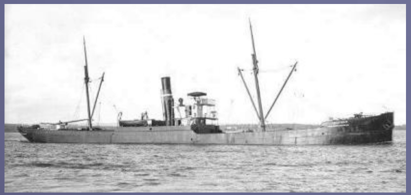
HYDRUS– lost Lake Huron near the center of the lake on Nov 9. Still Missing.

CHARLES S. PRICE – lost Lake Huron near Lexington on Nov 9.



JAMES C. CARRUTHERS- lost Lake Huron near Goderich Ontario on Nov 9. Still Missing.

HENRY B. SMITH – lost Lake Superior near Marquette on Nov. 9



LEAFIELD – lost Lake Superior near Angus Island on Nov 11. Still Missing.

WEXFORD– lost Lake Huron near Grand Bend Ontario on Nov. 9

LIGHTSHIP LV82 – lost Lake Erie near Buffalo Harbor on Nov 10.

Great Storm of 1913

A Numerical Model Retrospective

Why do a numerical model simulation ?

1. In 1913, there were widely spaced weather observations over the Great Lakes region, and a subset of those along Great Lakes coasts. There were virtually no observations over water like the buoy observations of today.

2. The only marine weather records that exist are anecdotal accounts and estimates from survivors. For the Great Storm of 1913 these accounts include sustained wind speeds up to 70 mph, gusts as high as 90 mph, and waves to 35 feet in height.

3. An accurate numerical simulation affords scientists and historians a more detailed look at the conditions mariners may have encountered and insights into the timeline evolution of the storm and why the loss of life was so sudden and staggering.

4. Of particular interest were wave conditions, as several large boats were caught unprepared for such extreme conditions.

Great Storm of 1913

A Numerical Model Retrospective

About the models…

- This study leveraged the capabilities of the Weather Research and Forecast (WRF) modeling system to produce a detailed reconstruction of atmospheric conditions; and the NOAA Great Lakes Environmental Research Laboratory - Donelan Wave Model (GDM) to reconstruct the resultant sea state.

- Surface wind and temperature output from the WRF simulation were used to drive the GDM wave model simulation.

- The GDM provides approximations for significant wave height (average of the highest 33rd percentile), dominant wave period, and wind wave direction.

- As a companion calculation, an estimate of peak wave height (average of the highest 5th percentile) from the wave energy distribution is produced to characterize reasonably observed worst case wave conditions.

- The return frequency of the peak wave is also calculated based upon the dominant wave period and the statistical occurrence of the highest 5th percentile wave. The return frequency gives an estimate of how frequently ships experienced "worst case" waves during the storm.

Caveat: In any sort of numerical model simulation, there can be several sources of error and a perfect simulation is usually unattainable. This is especially true of a one hundred year retrospective. Nonetheless, even a less-than-perfect simulation affords important context into what happened and when.

Great Storm of 1913

A Numerical Model Retrospective

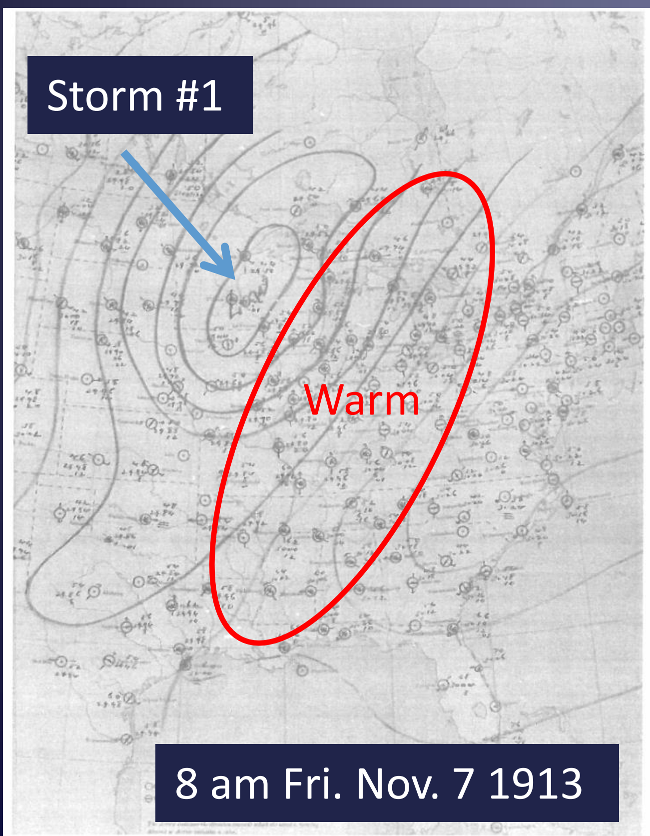
<u>The Great Storm of 1913 is really a tale of two storms</u>.

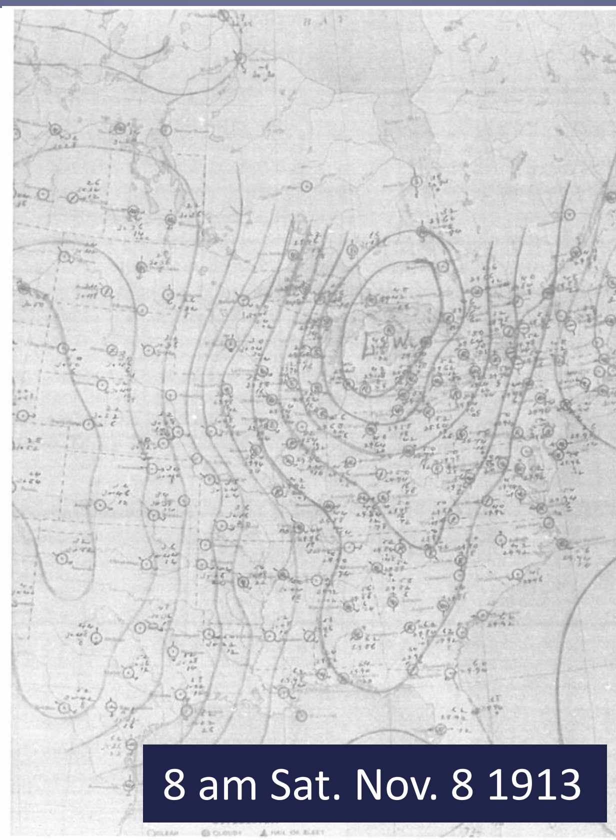
- The first, called the "Pre-Storm" for the purposes of this presentation, impacted primarily Lake Superior and Lake Michigan on November 7th and 8th.
  - The "Pre-Storm" was formidable in its own right – with storm force winds, heavy snow, lake effect snow squalls, freezing spray and high seas. Several large ships were severely damaged and run-aground across the breadth of the lake.
- The second storm, called the "White Hurricane", occurred on November 9th-11th and was the result of an unusual "atmospheric phasing" of the "Pre-Storm" to the north and a developing storm over the southeast United States.
  - The resultant "meteorological bomb" over the eastern Great Lakes would produce prolonged hurricane force winds, blinding snow squalls, freezing spray, and massive wave trains over the Great Lakes.
  - The "White Hurricane" was the deadliest and most intense phase of the Great Storm of 1913 – and is the focus of this Numerical Model Retrospective.

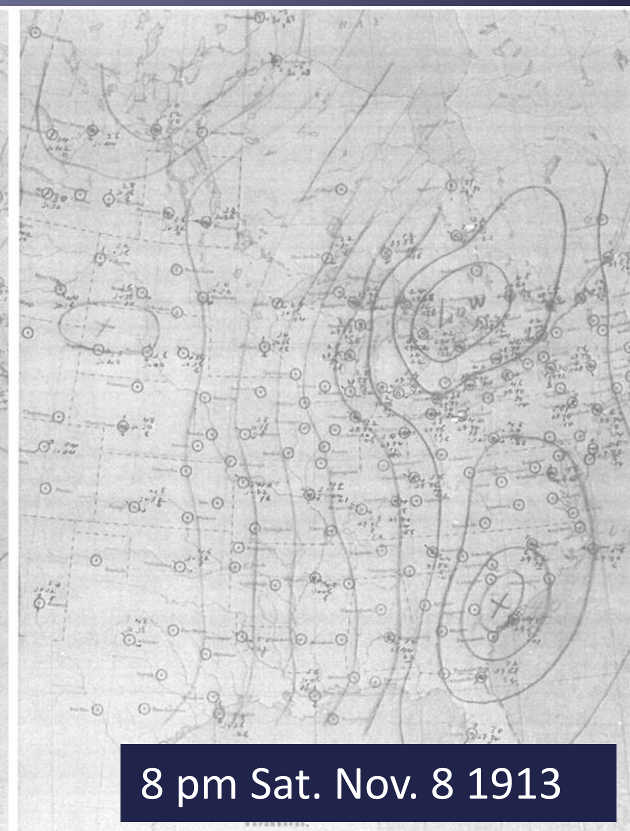
Great Storm of 1913

A Numerical Model Retrospective

The "Pre-Storm": Unseasonably warm conditions existed across the Great Lakes on November 7th ahead of an advancing low pressure system and sharp cold front. Gale and Storm Warning flags were hoisted around 10 am Friday for Lake Superior in anticipation of southwest gales associated with the approaching front. Passage of the cold front would bring storm force winds to Superior by Friday evening.





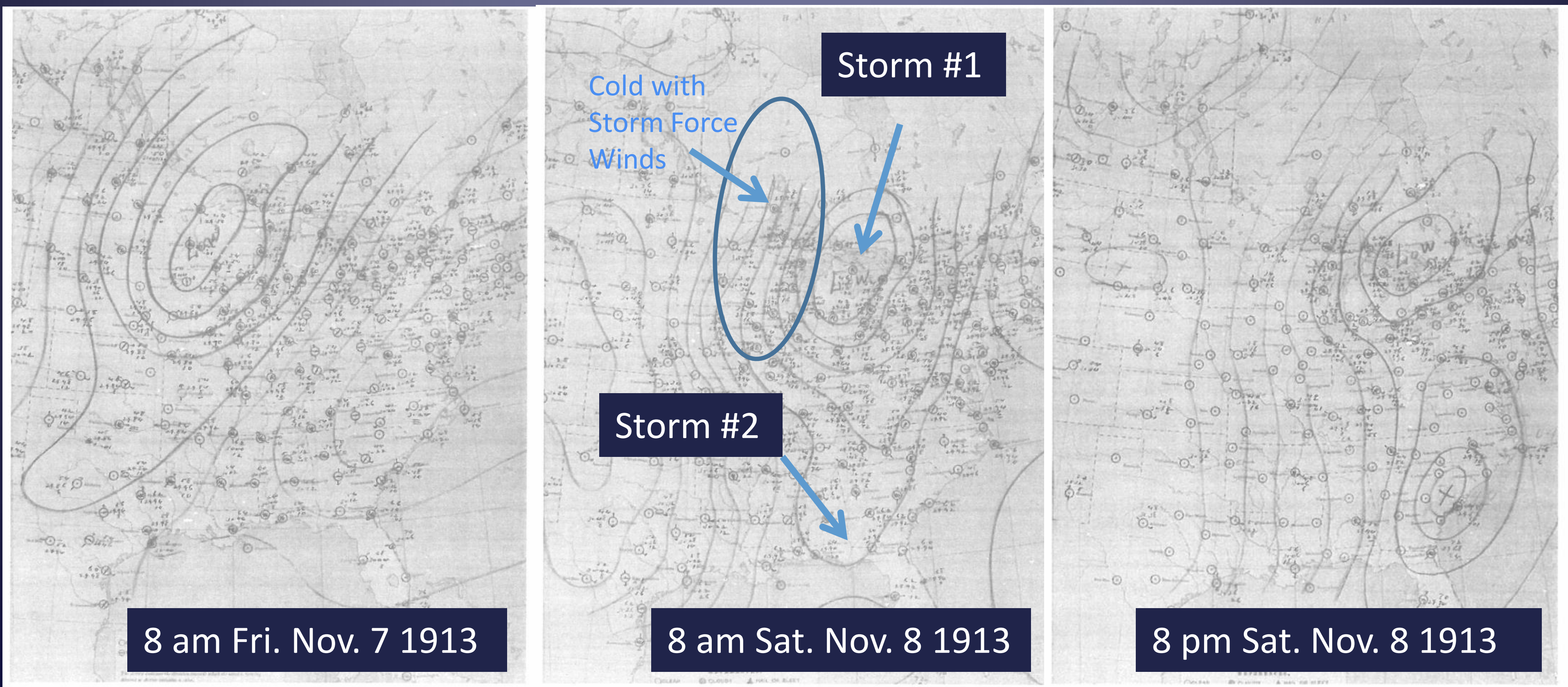


Original hand-drawn maps courtesy of Environment Canada - Toronto

Great Storm of 1913

A Numerical Model Retrospective

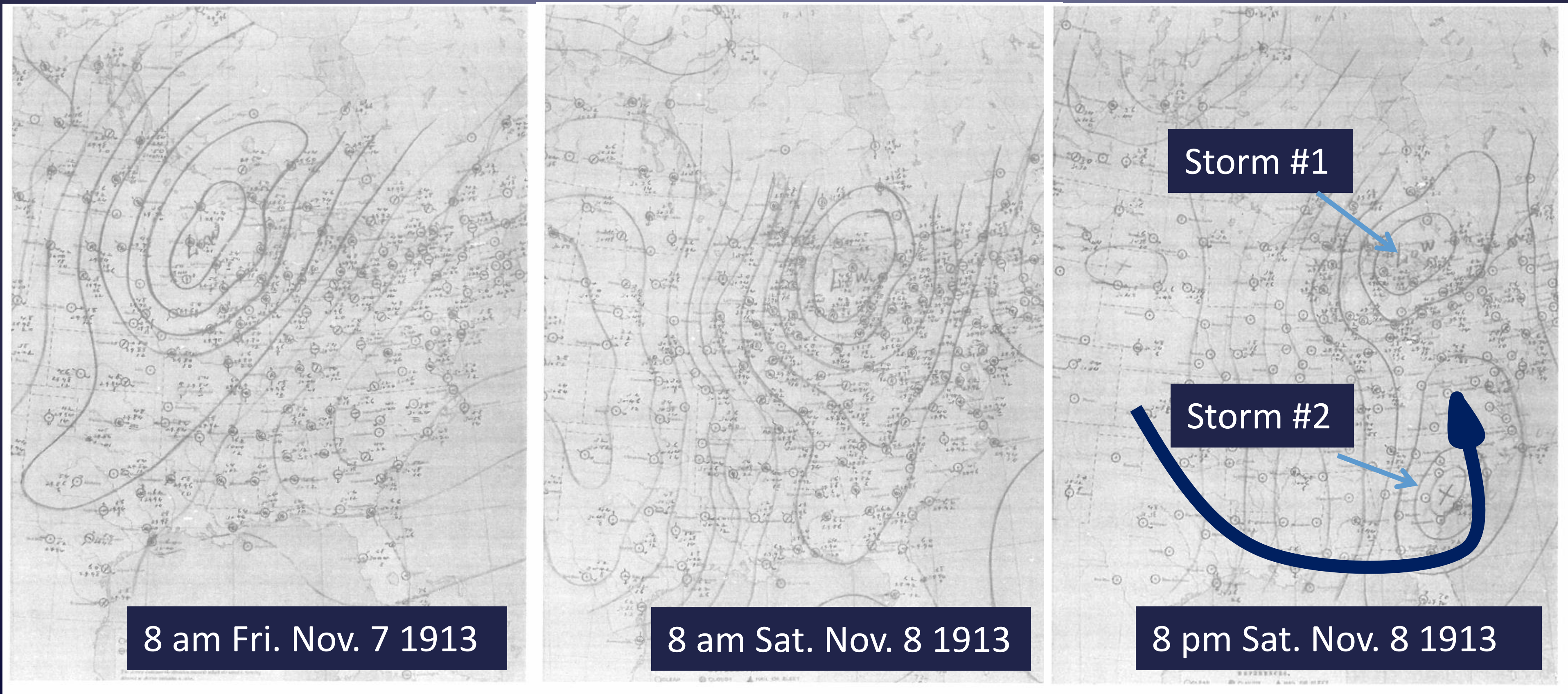
The "Pre-Storm": Twenty-Four hours later the low and front had moved across the U.P. of Michigan. Sudden storm force northerly winds and high waves would come to Lake Superior by Friday evening (7th). After midnight (early Saturday morning) the Turret Chief, LC Waldo, Huronic, and Nottingham would all be driven ashore. By 8 am Saturday, a weak new low pressure would develop along the Gulf Coast.



Great Storm of 1913

A Numerical Model Retrospective

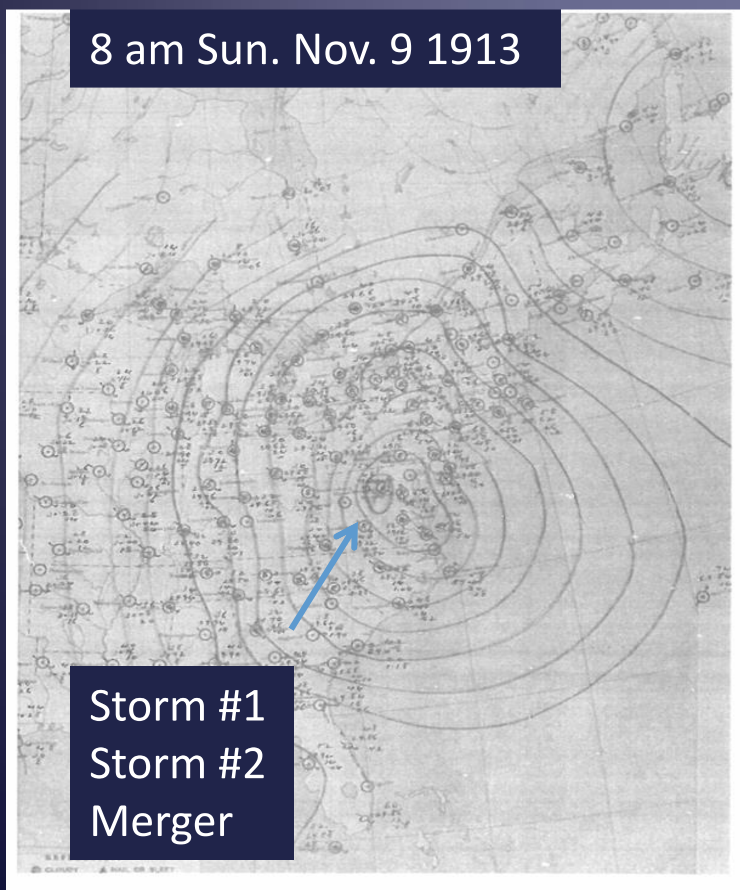
The "Pre-Storm": During the day Saturday, Storm #1 would stall and weaken over Lake Huron allowing a slight lull in winds and waves over the Upper Great Lakes. However, unknown to all at the time, a very strong upper level jet stream was passing over the southern U.S. and would force a new low (Storm #2) northward. Within the next 8 hours the storms would phase and strengthen in what is known as a "meteorological bomb".

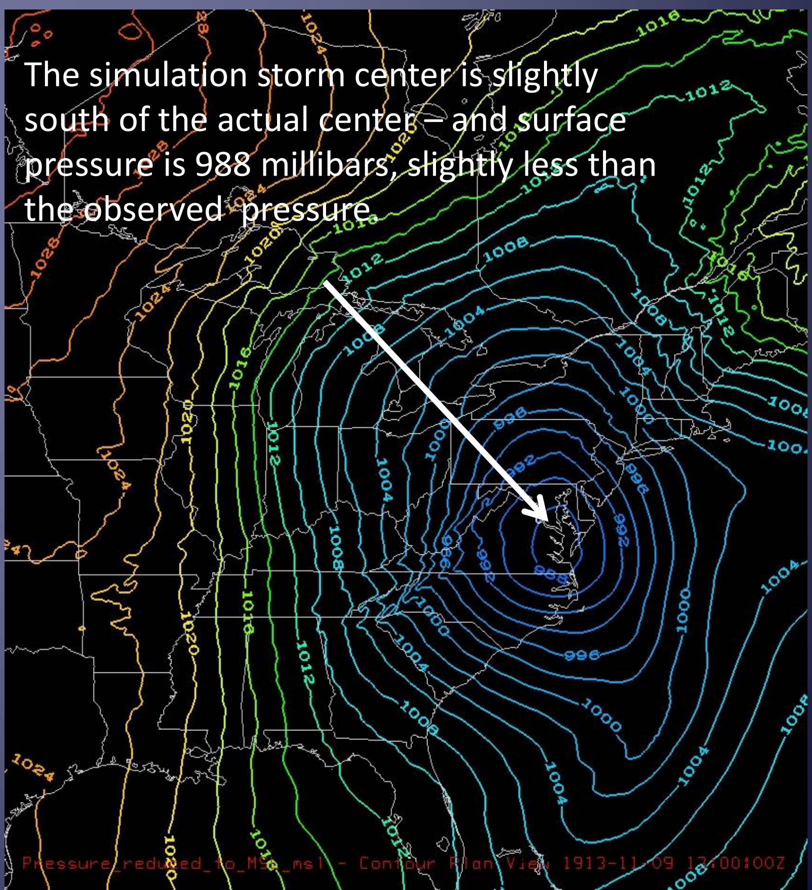


Great Storm of 1913

A Numerical Model Retrospective

The “White Hurricane”: When the storms phase, the southern-most storm becomes dominant. This begins the deadliest portion of the event – called the “White Hurricane”. At this point we can begin an evaluation of the computer simulation to determine its validity for calculating surface winds and waves. At 8 am Sunday, the two storms have phased within the past 12 hours into one large storm near Washington DC.



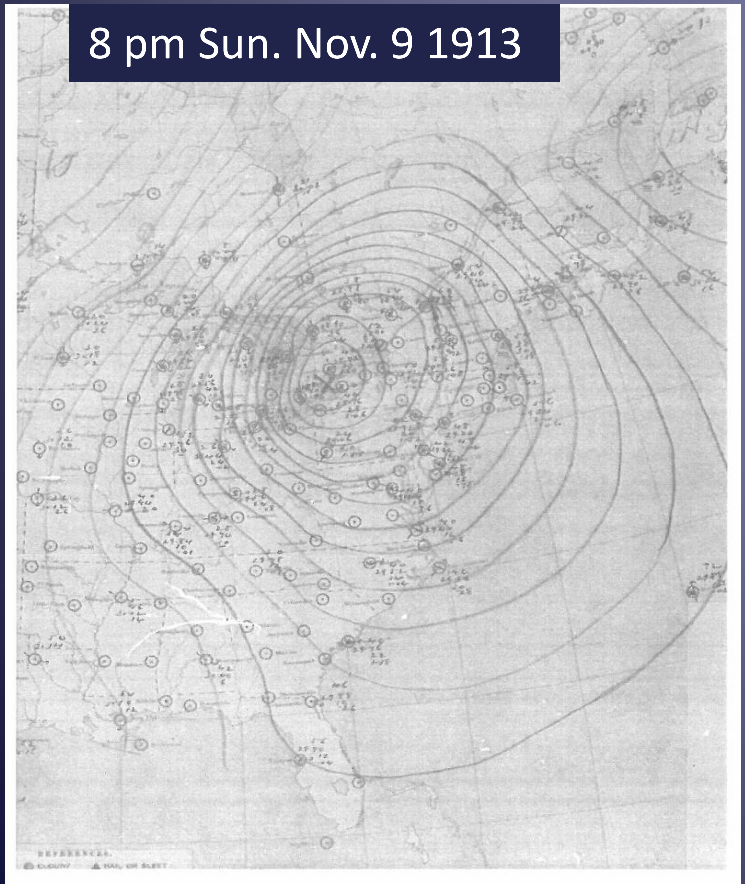


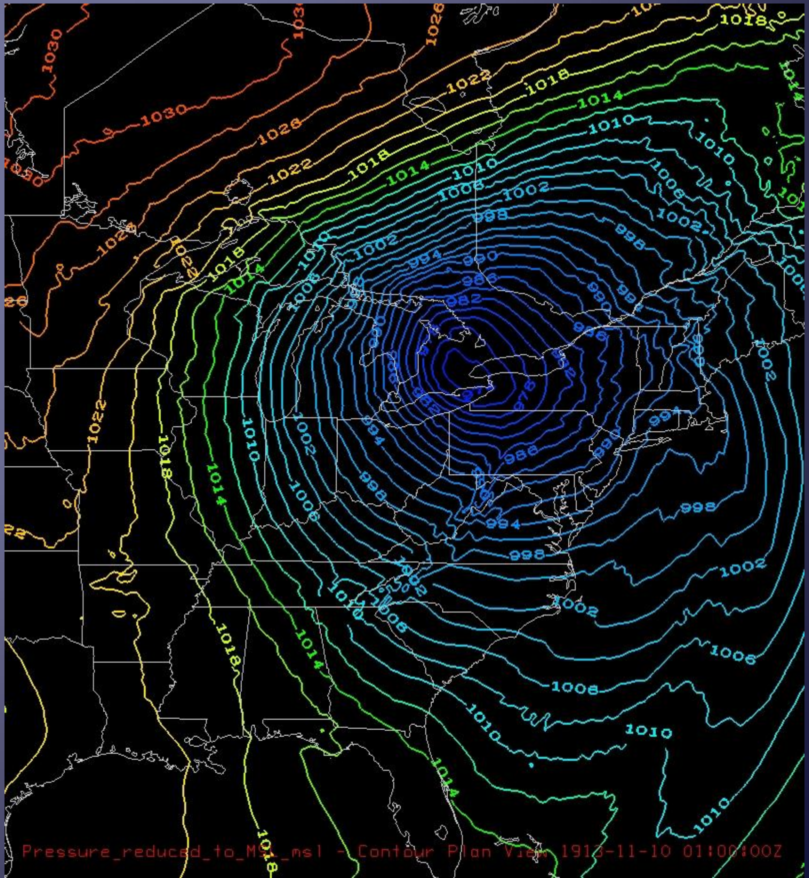
Great Storm of 1913

A Numerical Model Retrospective

The “White Hurricane”: By 8 pm Sunday the storm has strengthened dramatically and moved north into the Great Lakes. The actual low passed directly over Erie PA with a central pressure of 969 millibars – deepening 31 millibars in 24 hrs – a true “meteorological bomb”. The simulation was remarkably accurate for such a rare event with a 974 millibar low centered between Erie and Buffalo.

8 pm Sun. Nov. 9 1913

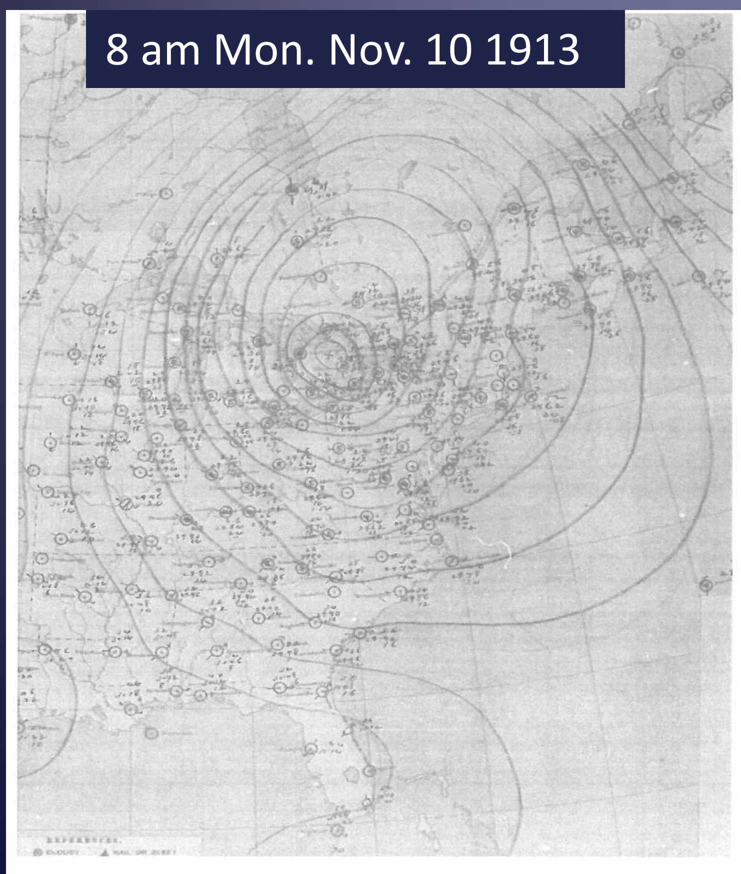


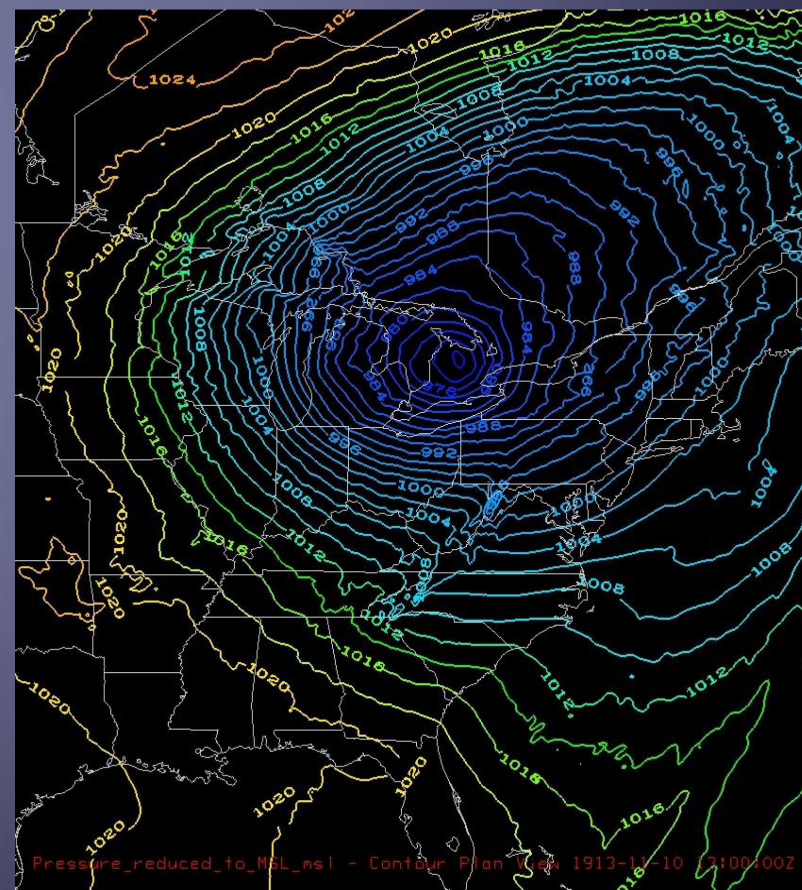


Great Storm of 1913

A Numerical Model Retrospective

The "White Hurricane": In the subsequent 12 hours (Sunday night), the storm barely moved while maintaining its strength. By 8 am Monday, the storm center was north of Toronto and a central pressure of 975 millibars. The computer simulation placed the center just west of that location with a central pressure of 972 millibars. Again, this was remarkably accurate.

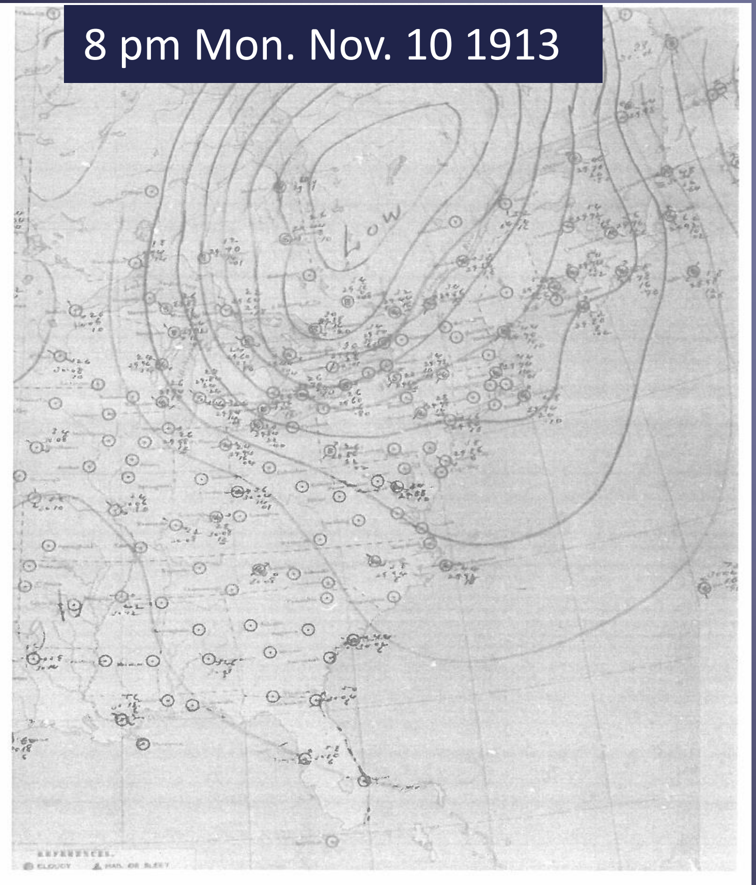




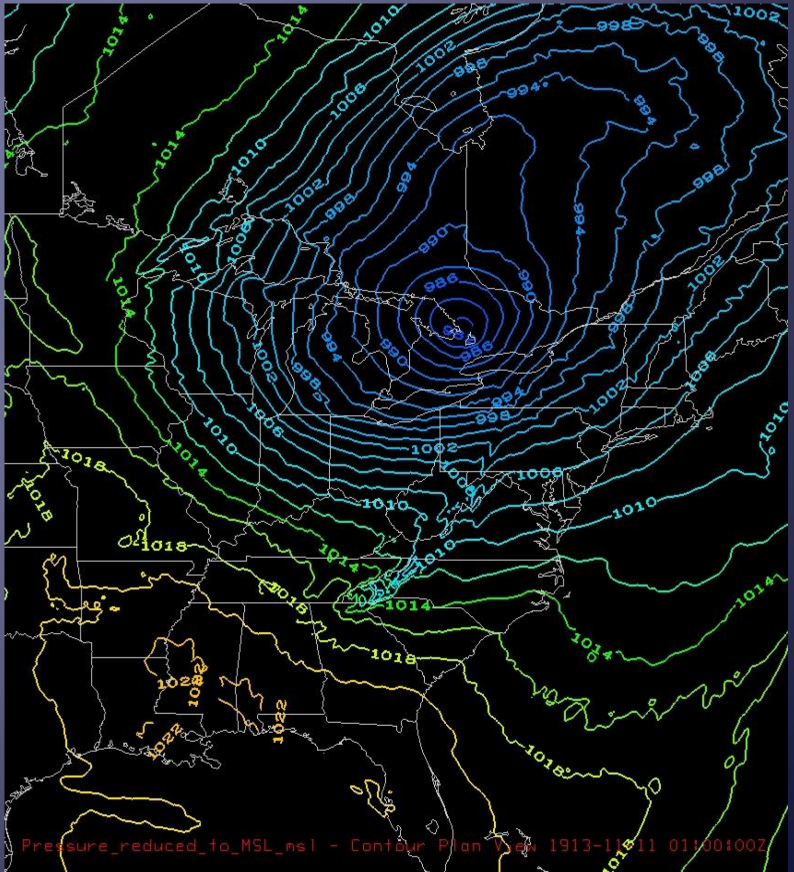
Great Storm of 1913

A Numerical Model Retrospective

The “White Hurricane”: By Monday evening, the storm begins to weaken and finally move off to the northeast. The hand-drawn analysis misplaces the actual low center, and the computer simulation is actually more correct. The simulation produces a storm that is a little stronger than actuality at this point, but is still reasonably close. By Tuesday the storm rapidly moves northeast ending the event.



8 pm Mon. Nov. 10 1913



Great Storm of 1913

A Numerical Model Retrospective

The accuracy of the computer simulation is quite remarkable considering;

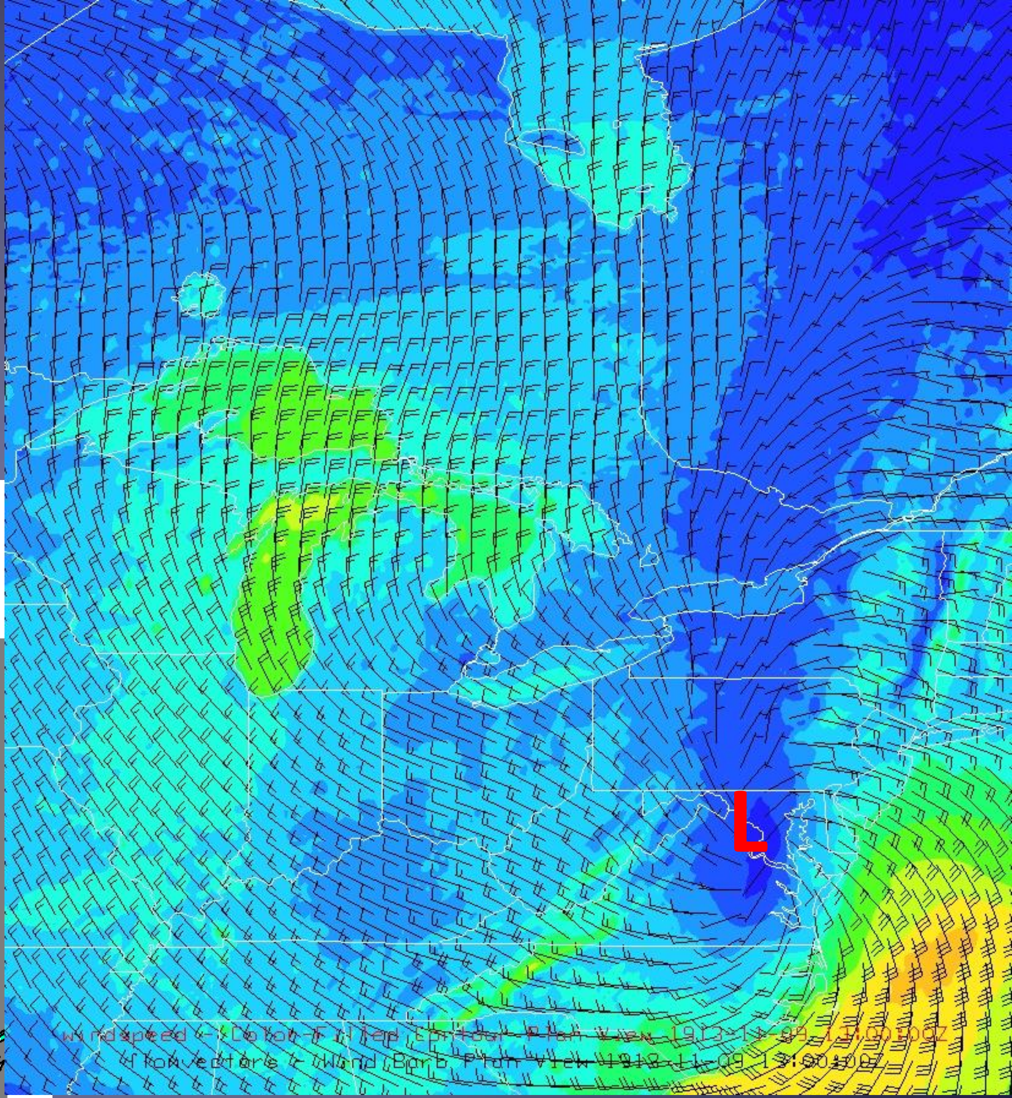
- The surface observation datasets required to initialize the model were relatively sparse by modern standards.
- The absence of upper air (balloon) observations and satellite observations make it difficult to adequately prescribe upper atmospheric conditions necessary for a viable simulation.

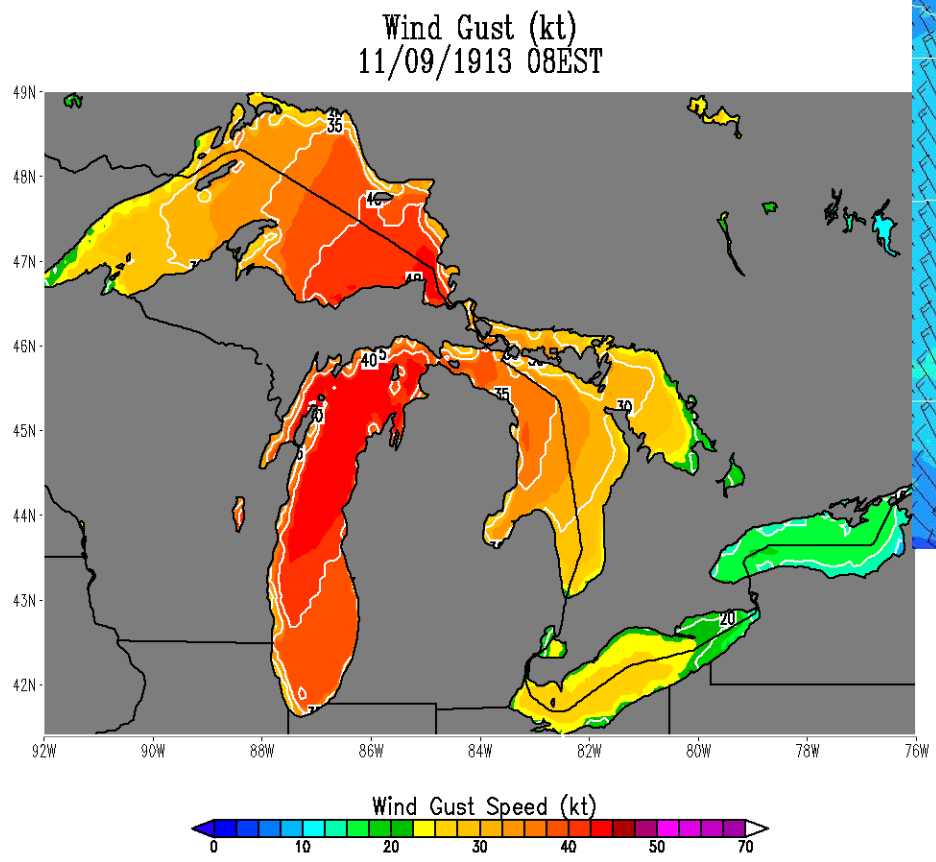
It has been shown that the Great Storm's surface pressure conditions as depicted by the computer simulation are closely correlated with the actual observed conditions.

The storm location and central pressure are very close, giving confidence that the wind and wave conditions derived from the simulation will be representative of what mariners actually encountered 100 years ago.

Simulation Results:

Immediately after the merger occurs and the low is near Washington D.C., winds have gone northerly over the Lakes – and began to increase after a slight lull. By 8 am on the 9th, winds over the upper lakes are 25 kts and gusts to 40 kts.



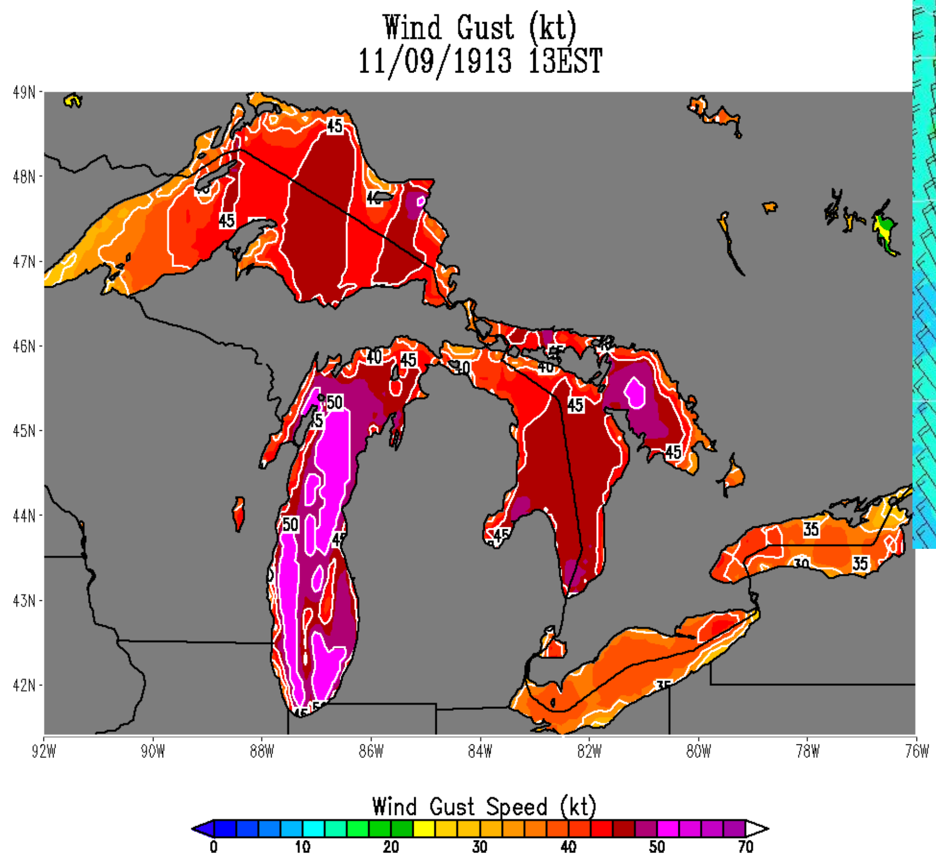


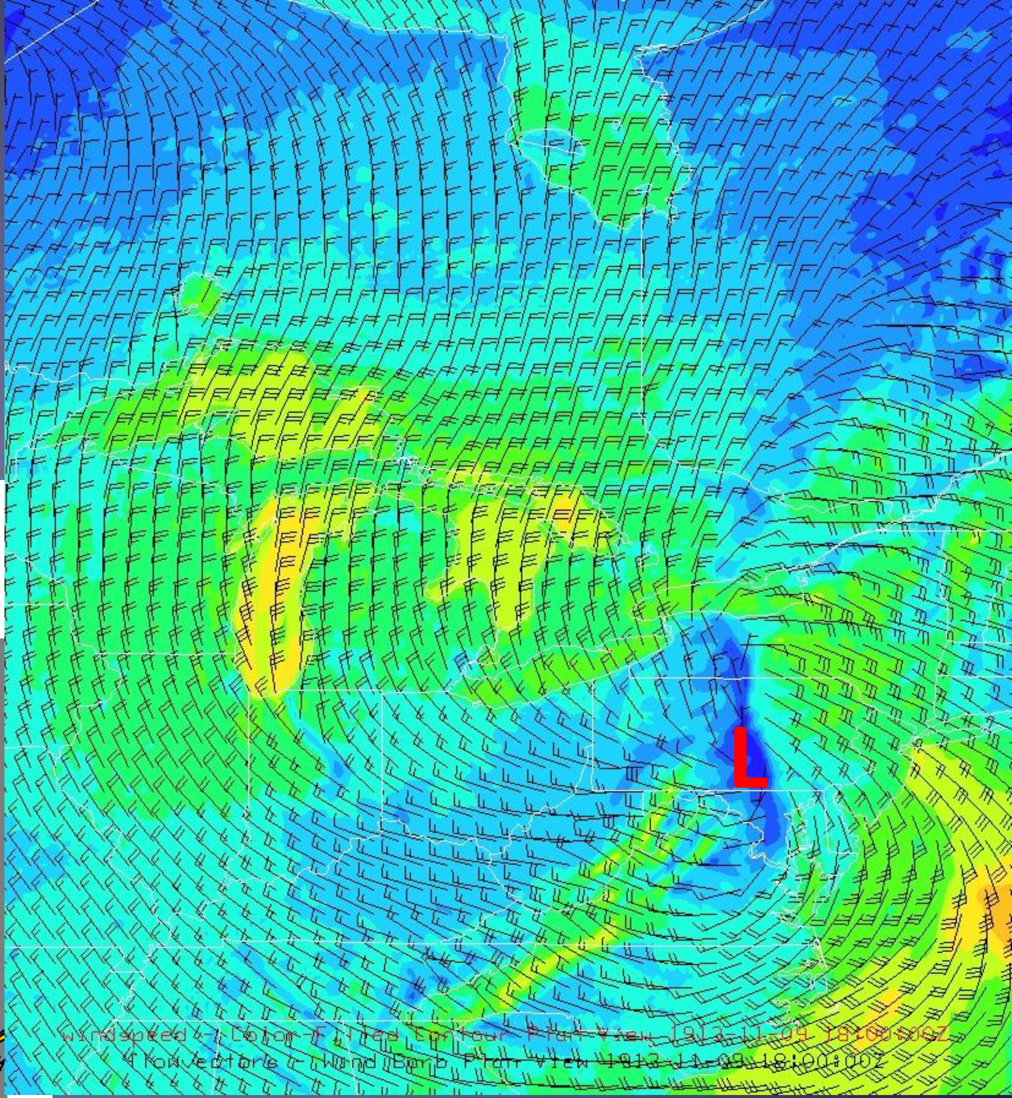
As shown by the simulation, in the next 8 to 12 hours, conditions over Lakes Huron and Erie will dramatically deteriorate as the “White Hurricane “ spins up.

8am EST Sunday Nov. 9, 1913

Simulation Results:

By 1 pm the low has moved northward into Pennsylvania and is strengthening rapidly. This causes winds to increase over Lakes Huron and Michigan – gusting to 45-50 knots.



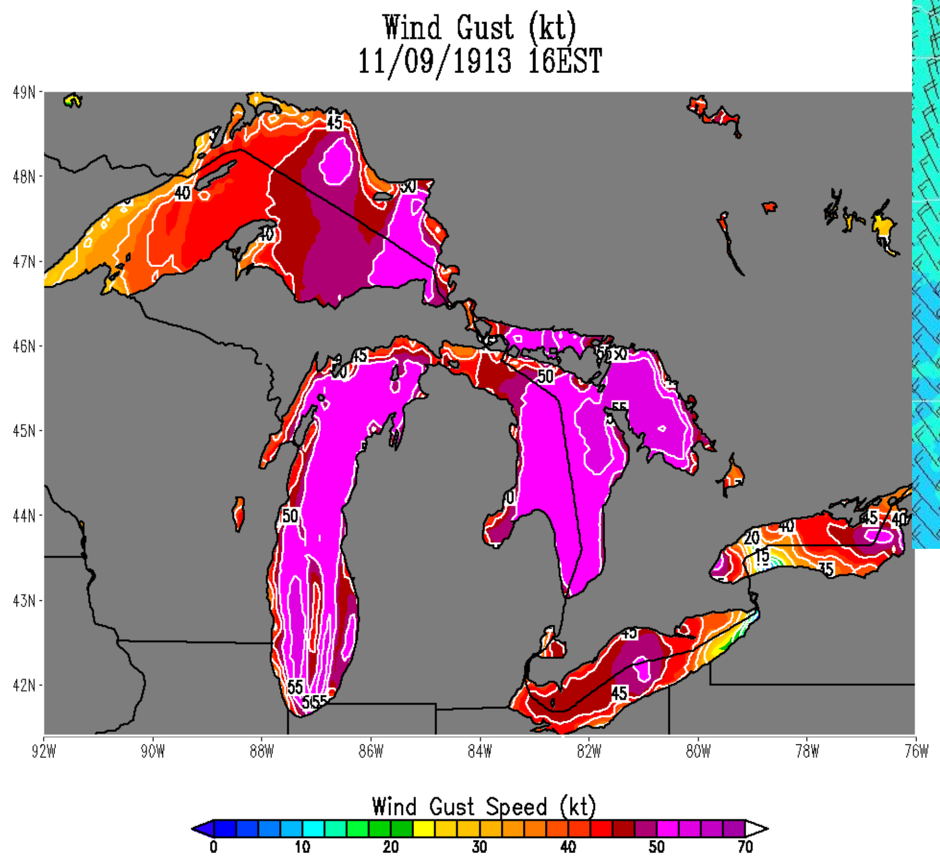


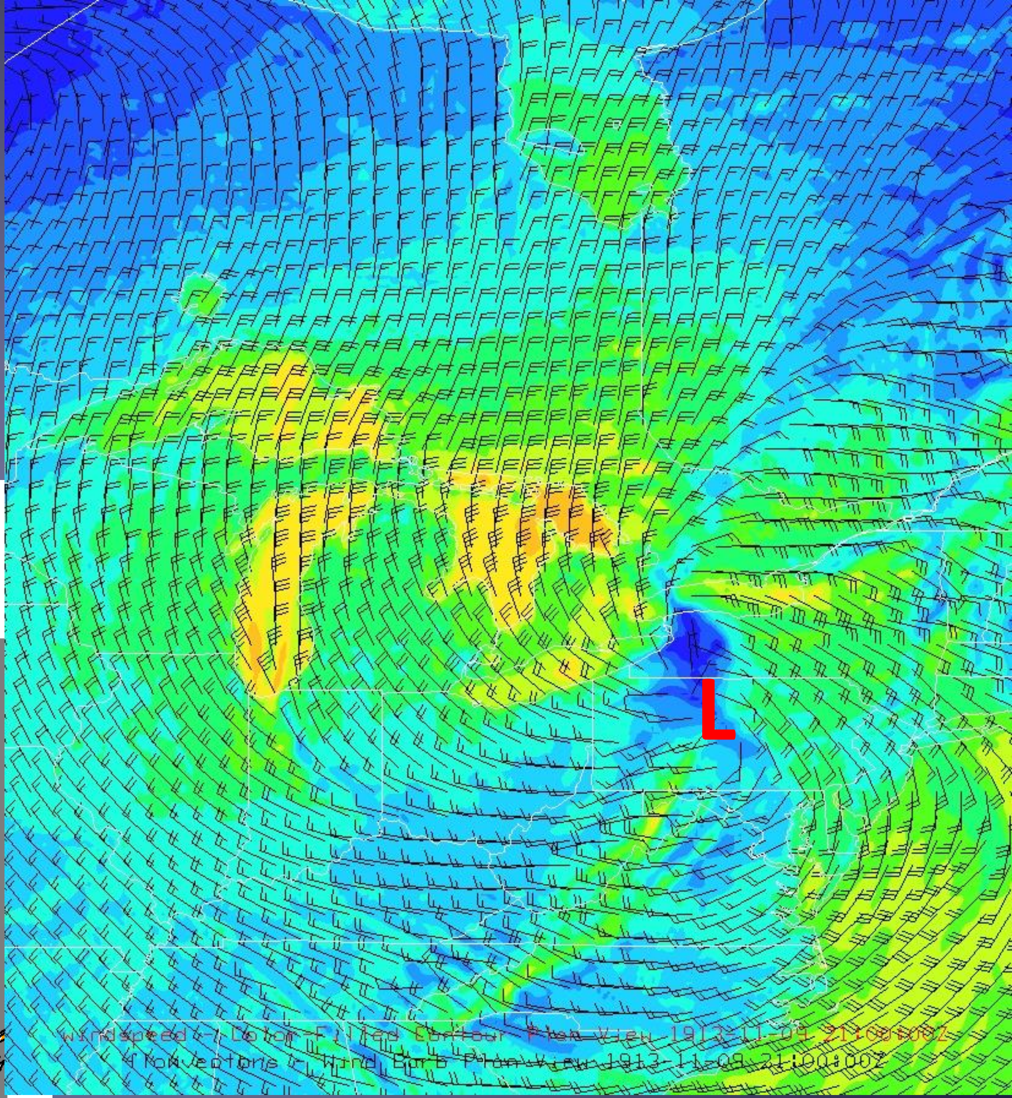
In fall, the waters of the Great Lakes try to hold their summer warmth. When cold air passes over, the air becomes unstable and mixes stronger winds aloft down to the water surface. This frequent combination gives rise to the "Gales of November".

1pm EST Sunday Nov. 9, 1913

Simulation Results:

By 4 pm Sunday, the simulated low has backed northwestward toward the Lakes. Winds and cold are increasing as the deepening low approaches. At this time, many boats were in the water over Lake Huron.



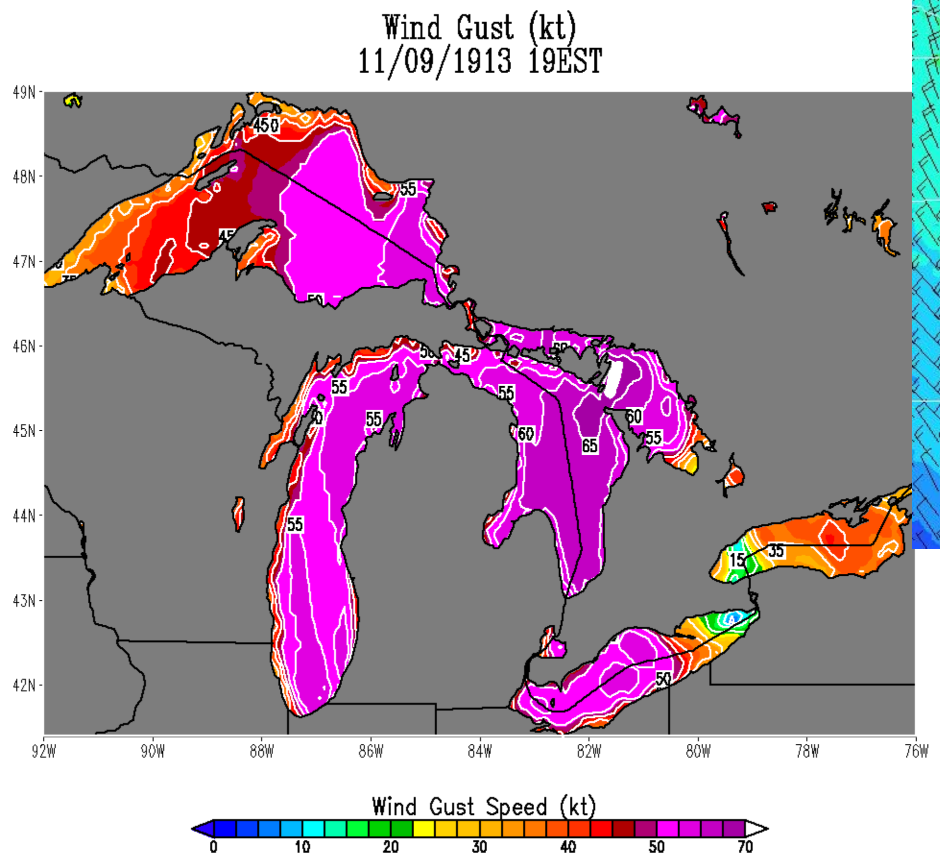


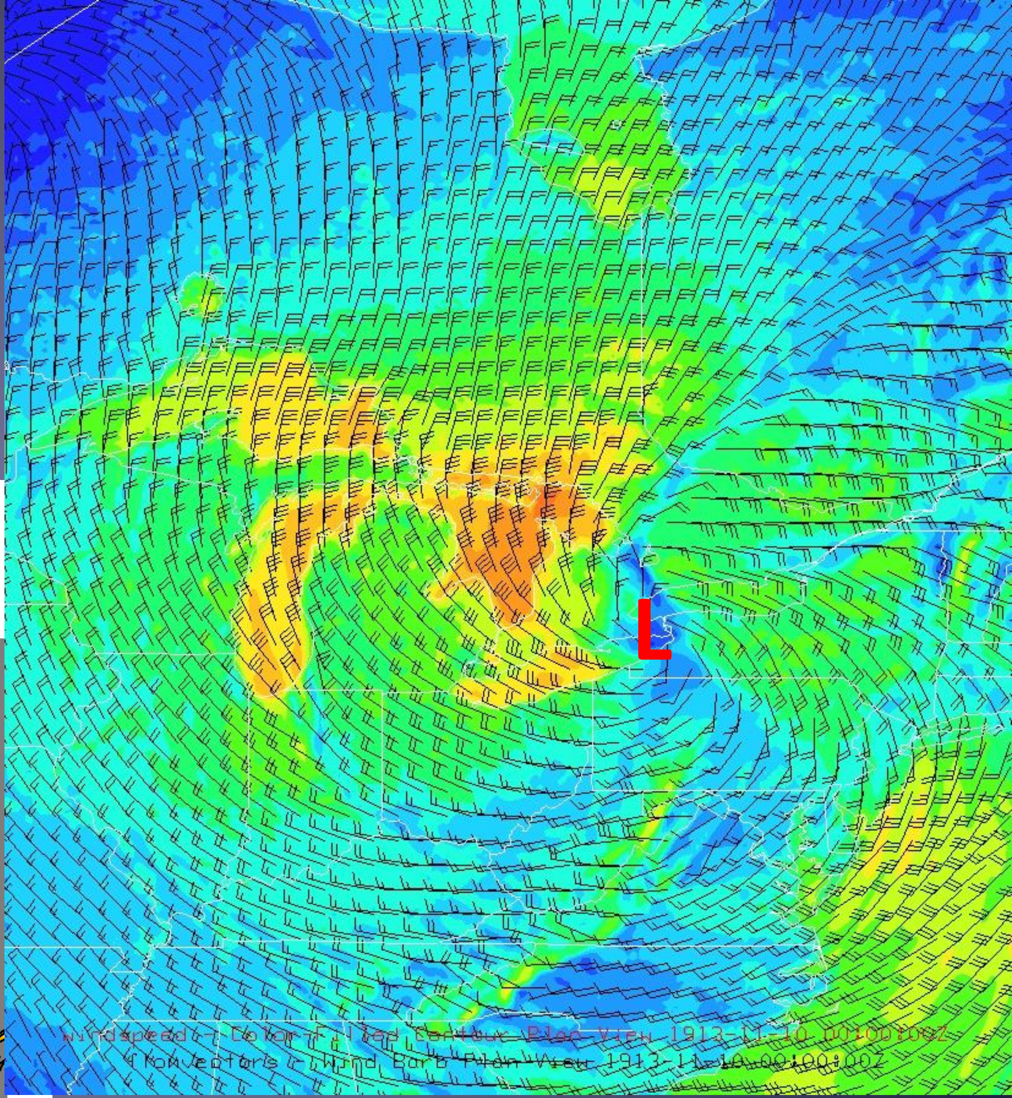
Measured gusts at Cleveland peaked at 62 knots (over 70 mph) at 440 pm. Many “Weather Bureau” offices were located on top of large buildings in cities. Measurements at those heights often overestimated conditions experienced near the ground.

4pm EST Sunday Nov. 9, 1913

Simulation Results:

By 7 pm Sunday, the simulation shows the low moving between Buffalo and Erie and slowly toward the northwest. In just the past 3 hours note the rapid increase in winds over Lake Erie and Lake Huron (gusts to 65-70 knots/80 mph in Georgian Bay).



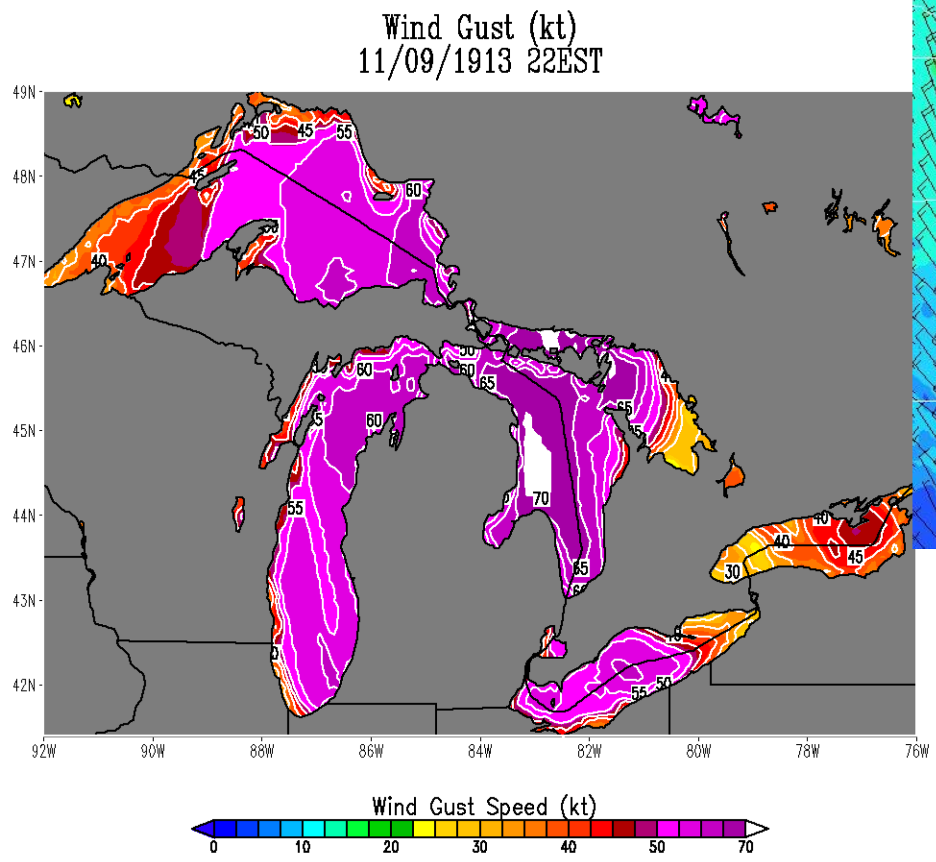


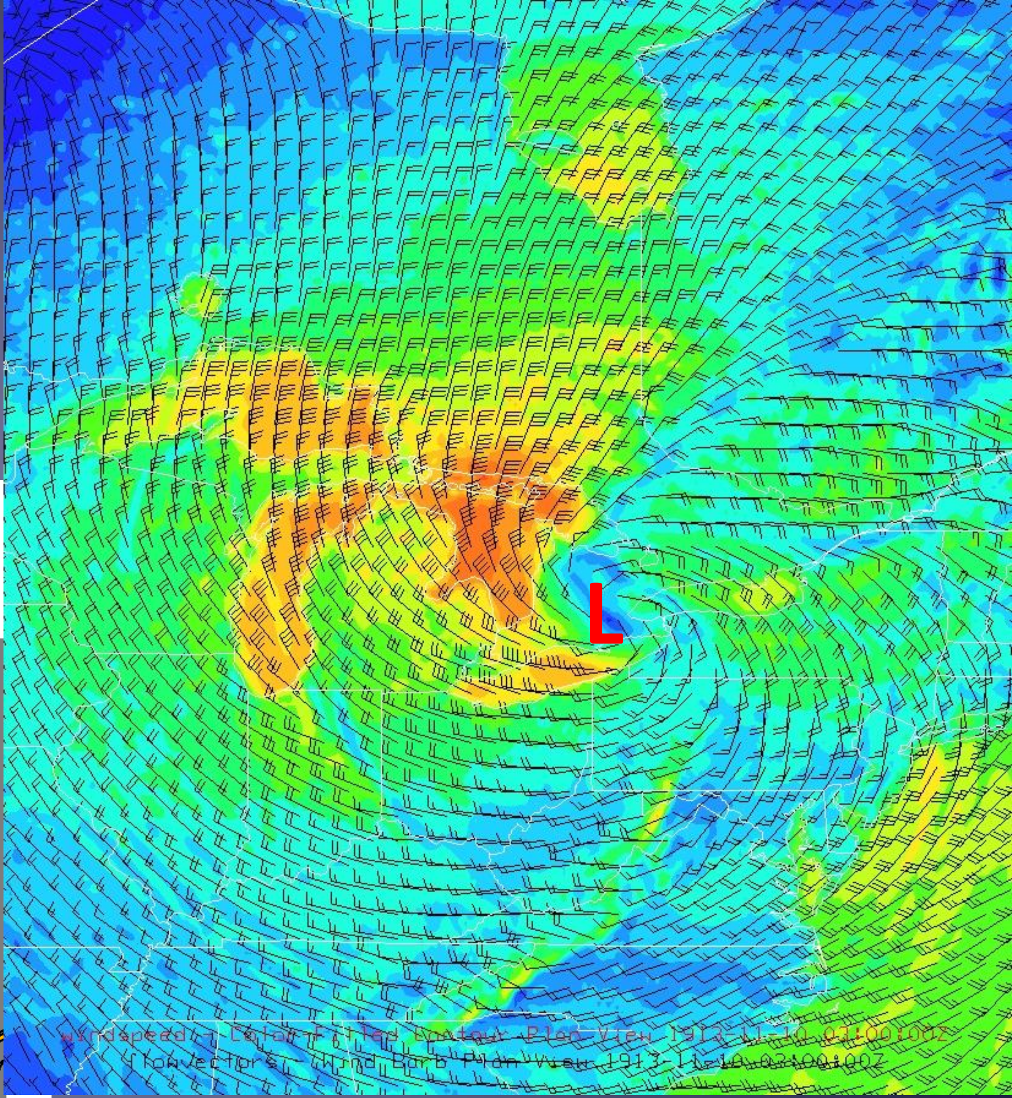
The air over all but Lake Ontario was cold enough for heavy, wind-driven snow. Over the upper lakes there was even colder air adding a component of lake effect snow squalls.

7pm EST Sunday Nov. 9, 1913

Simulation Results:

By 10 pm Sunday, hurricane force gusts are projected over most of Lake Huron with maximum winds likely 80-90 mph. Sustained winds are likely approaching 60 mph throughout the evening hours.



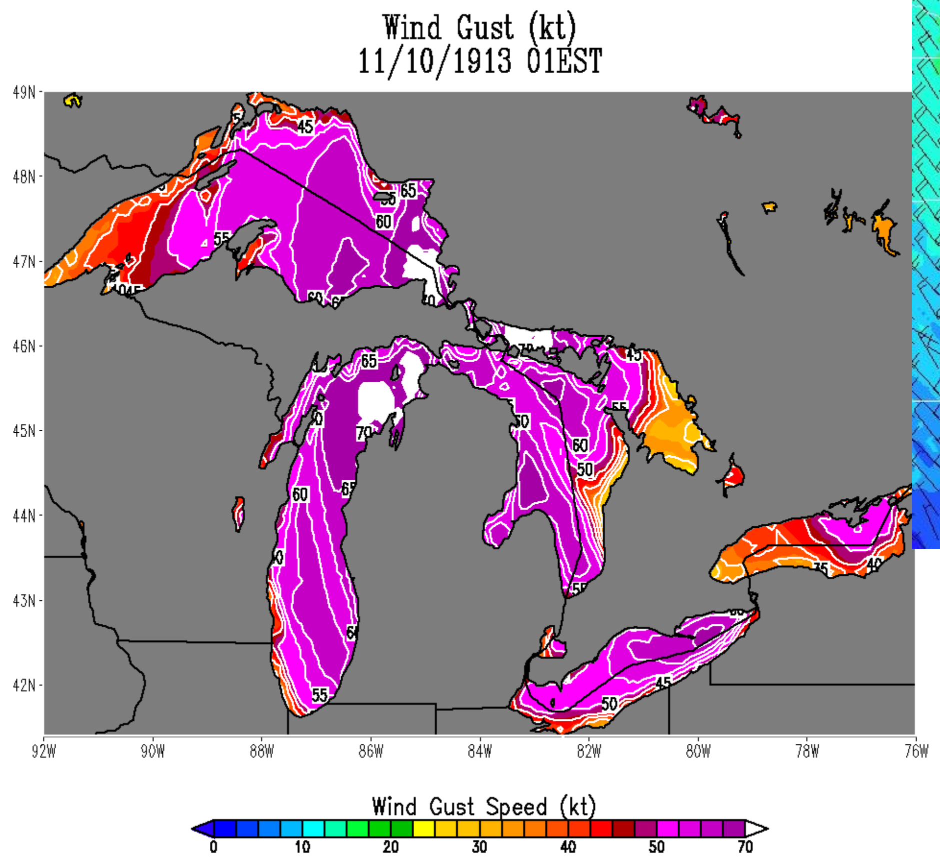


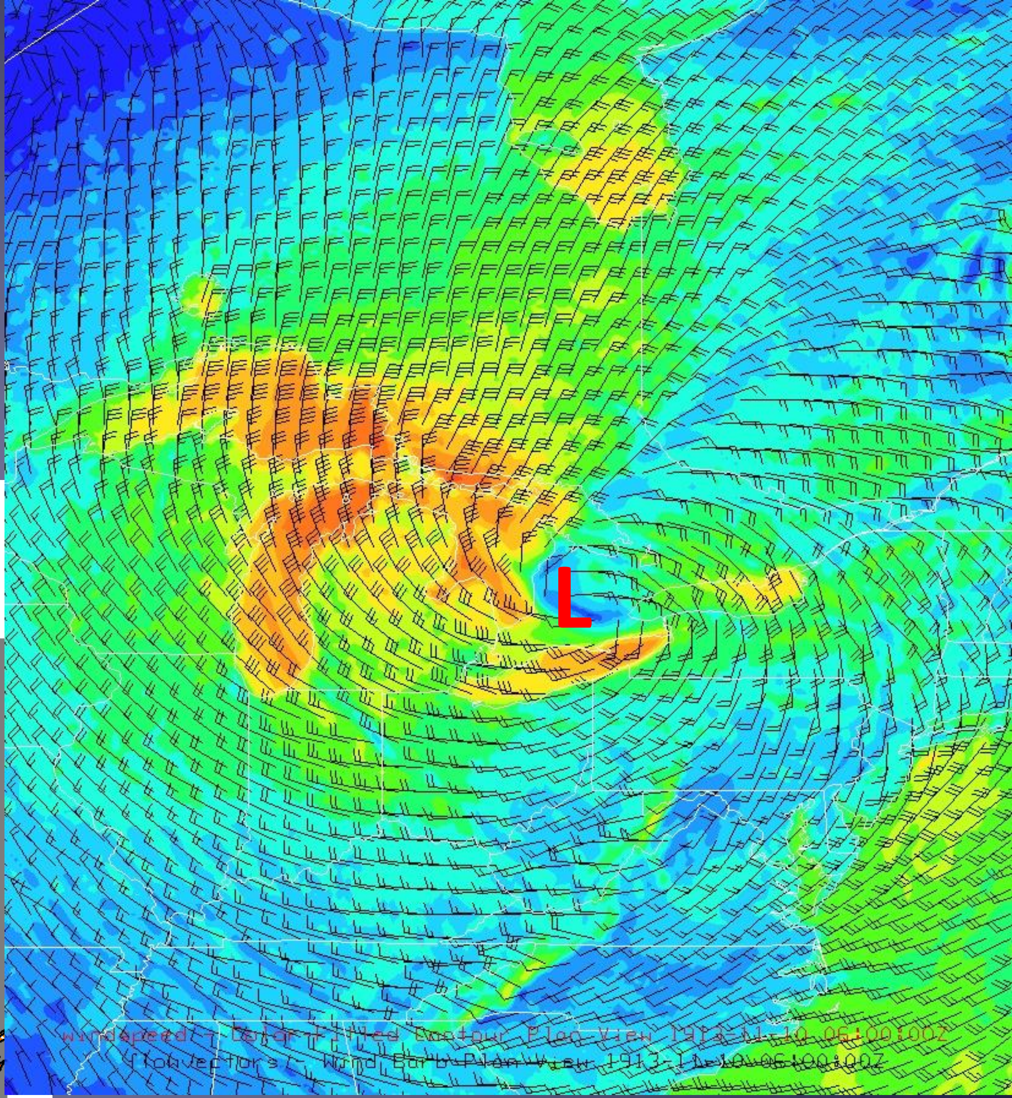
Peak wind gusts measured at Detroit (60 mph) and Port Huron (67 mph) occurred around 8 pm Nov. 9th. Many boats on Lake Huron sank within a few hours of this time.

10pm EST Sunday Nov. 9, 1913

Simulation Results:

By 1 am Monday, the low has migrated northwestward to near London ON. Because of the proximity of the low, winds over Lake Erie start to turn more westerly and increase toward Buffalo. Also 80+ mph gusts have spread into Lakes Superior and Michigan.

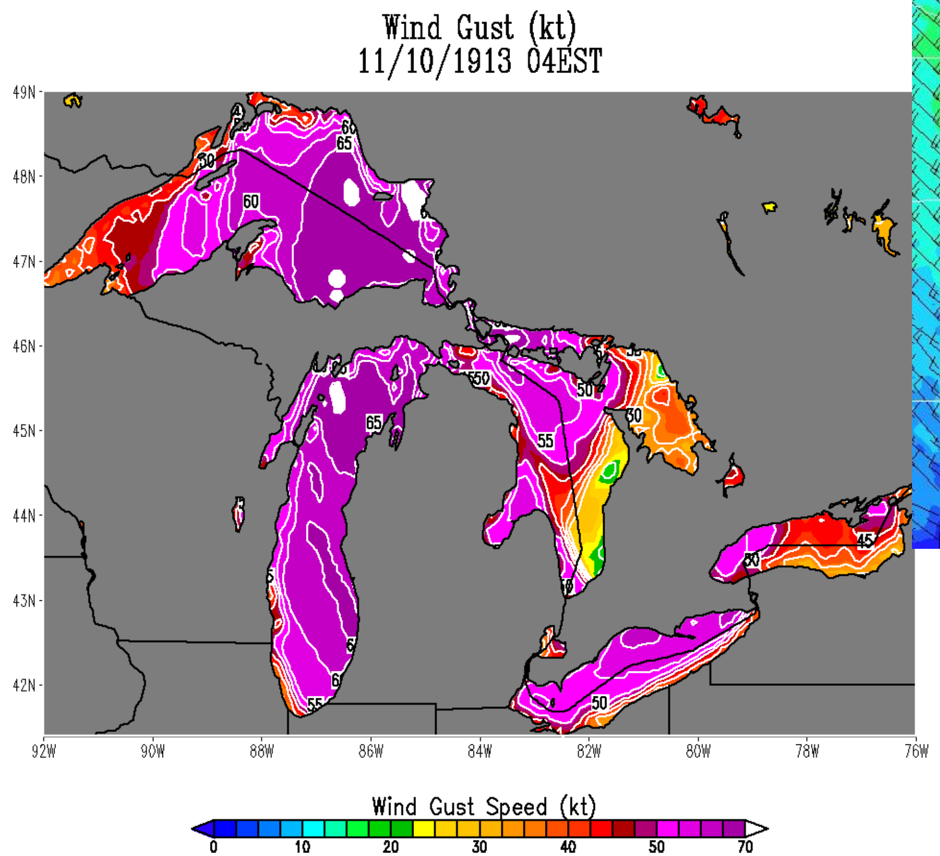


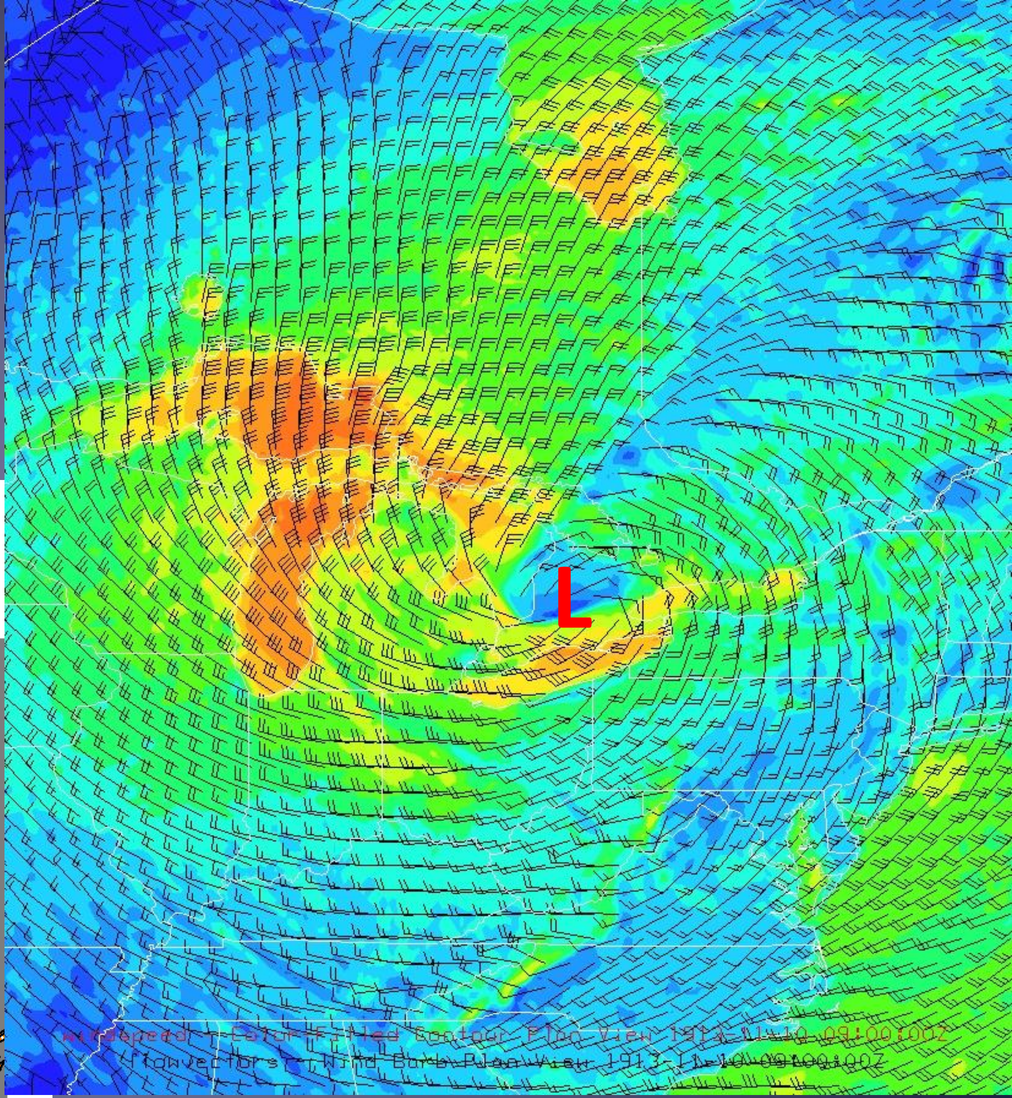


1am EST Monday Nov. 10, 1913

Simulation Results:

By 4 am Monday, the low has stalled over SW Ontario. Winds have started to decrease over Lake Huron, although 80 mph+ gusts are still over eastern Lake Superior and northern Lake Michigan.



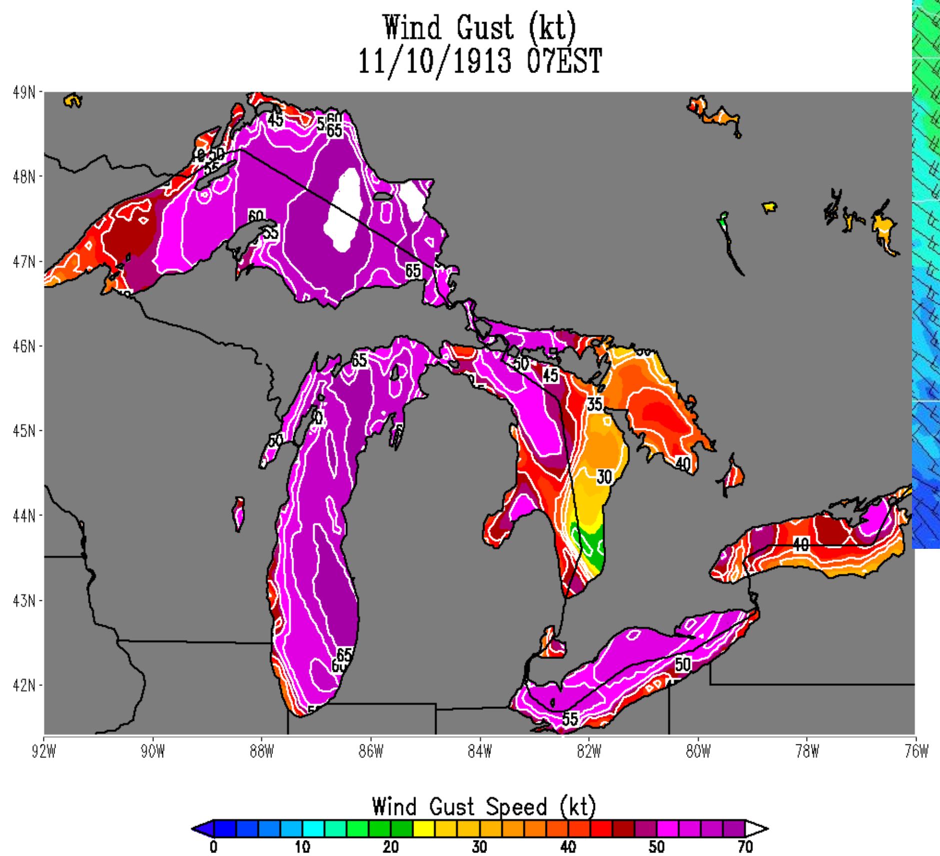


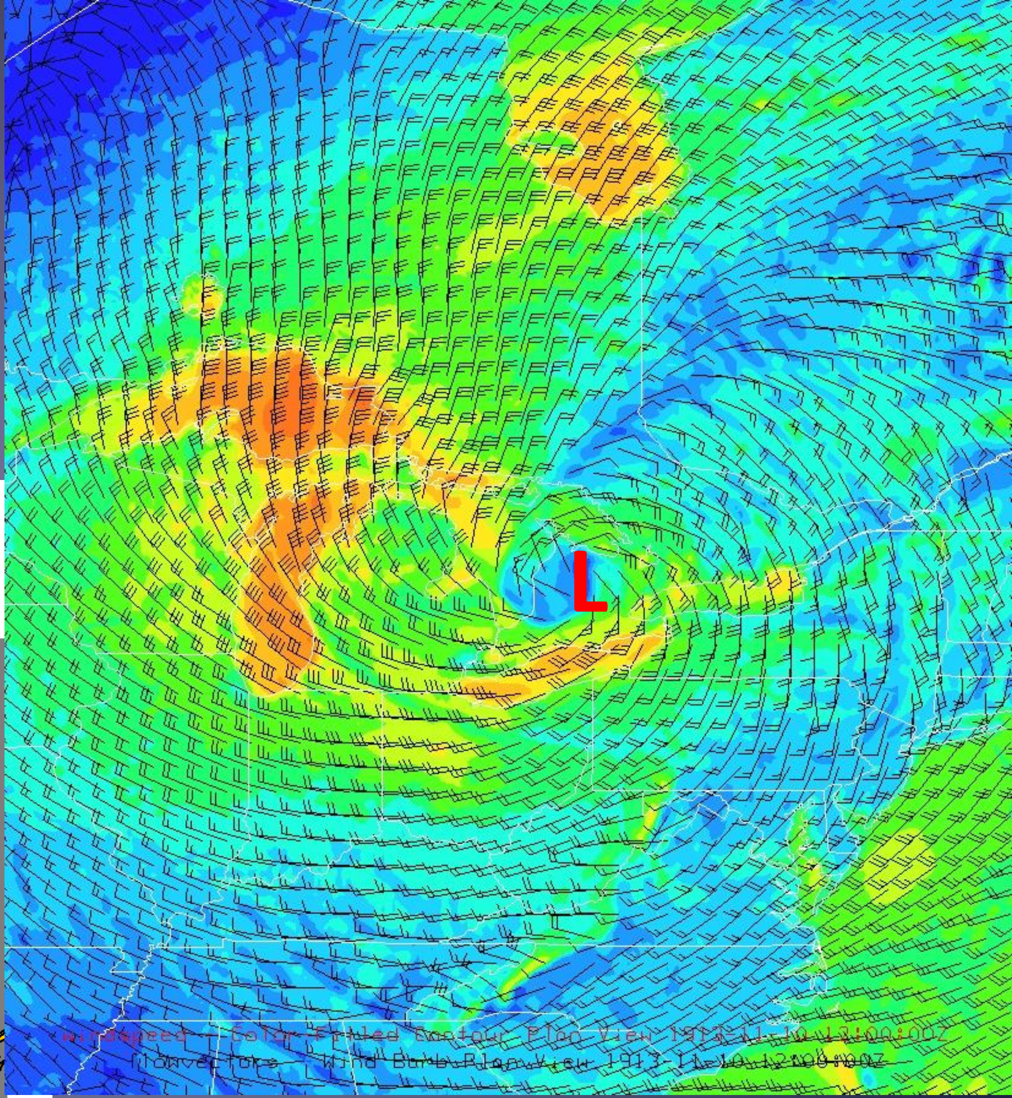
According to the simulation results, Lake Huron experienced 10 consecutive hours of hurricane force gusts from 6 pm 11/9 to 4 am 11/10.

4am EST Monday Nov. 10, 1913

Simulation Results:

By 7 am Monday, the low is still over SW Ontario. Widespread hurricane force wind gusts are projected over eastern Lake Superior and northern Lake Michigan. The simulation predicted gusts 80 mph+ in central Lake Superior.



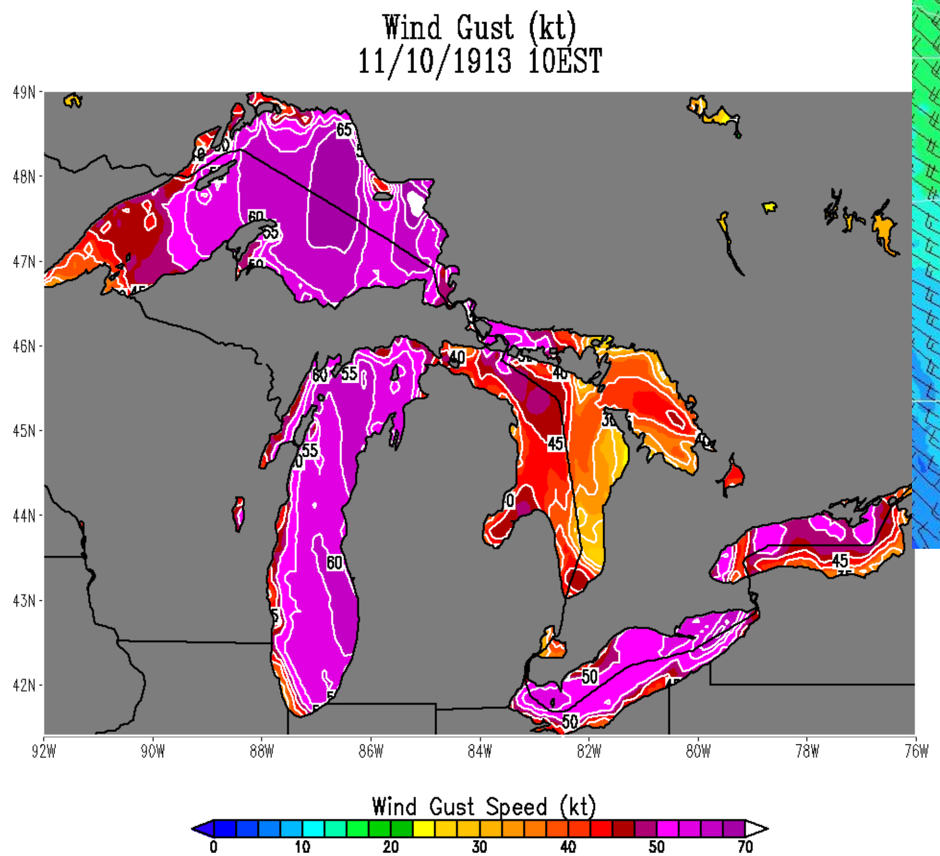


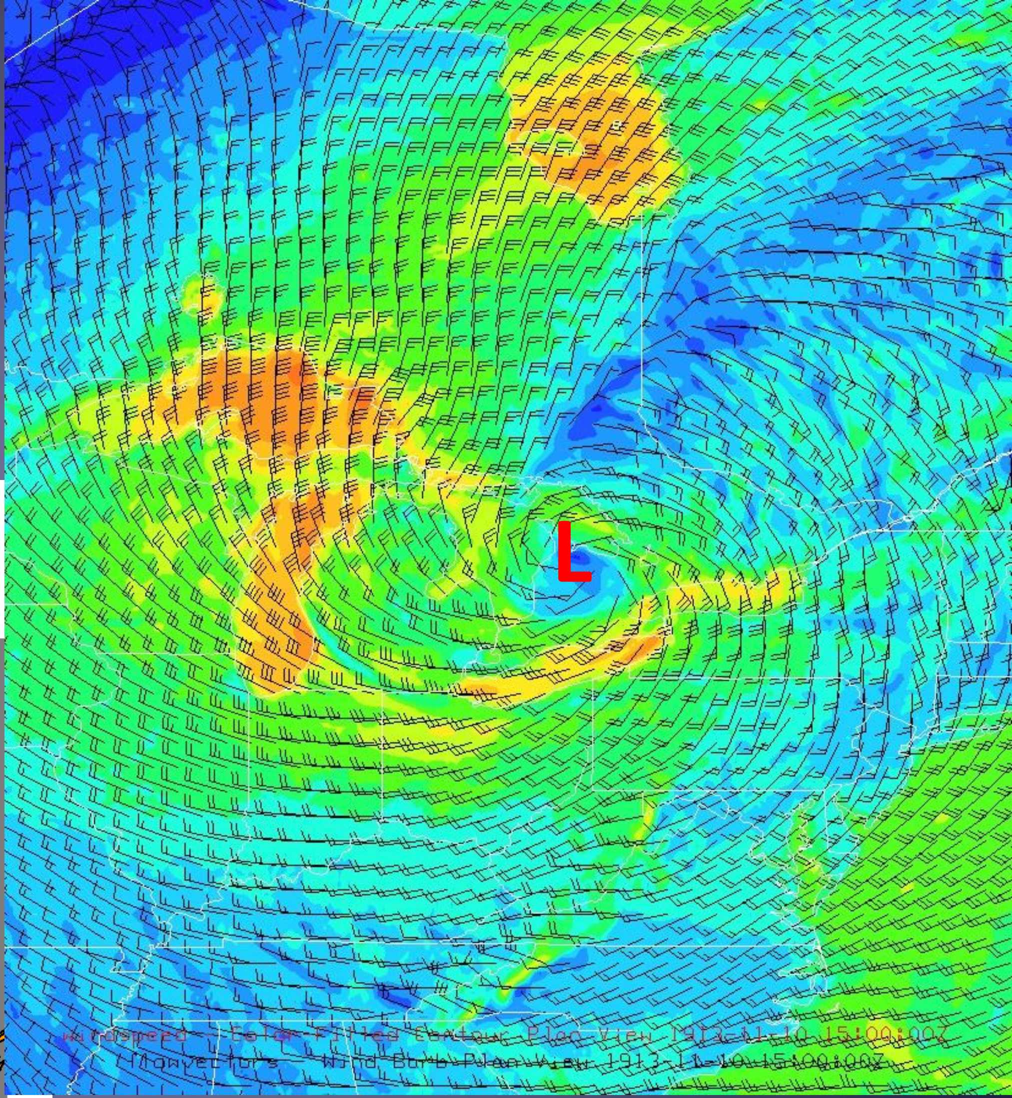
The Captain of the Harvester (which survived the storm) reported gusts estimated as high as 100 mph around 430 am on the 10th, west of Michipicaten Island in Lake Superior.

7am EST Monday Nov. 10, 1913

Simulation Results:

By 10 am Monday, winds on Lake Erie are southwesterly and at hurricane force on the far eastern end of the lake. High winds at this point are likely increasing storm surge water levels near Buffalo Harbor. Water levels at Toledo were 6 feet below normal.



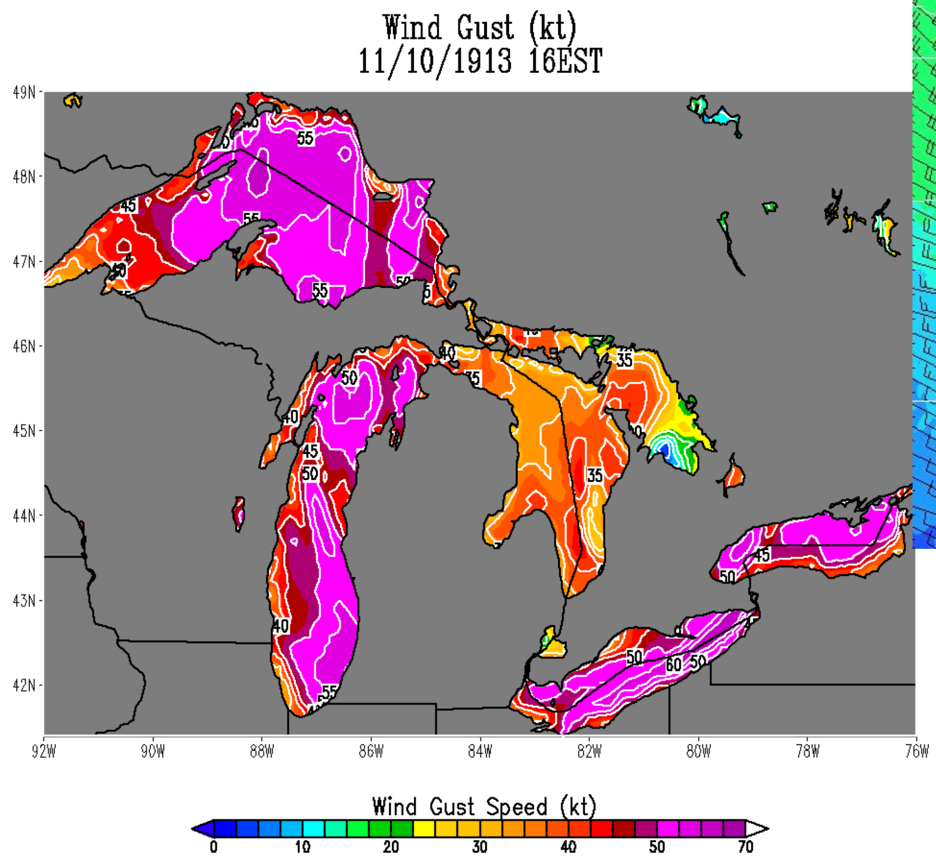


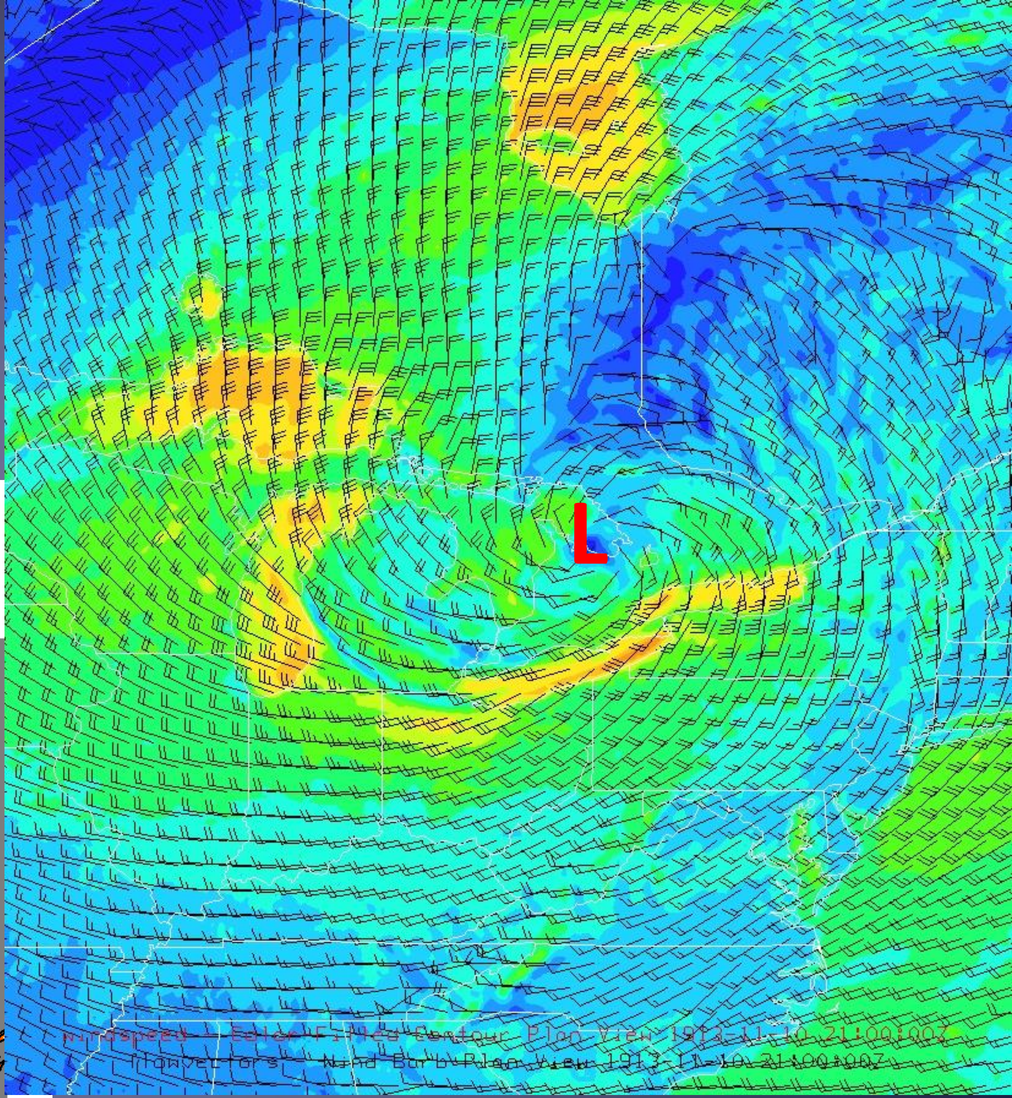
The winds over Lake Michigan have decreased slightly by this time, but not before the simulation produced 13 consecutive hours of hurricane force wind gusts over the lake.

10am EST Monday Nov. 10, 1913

Simulation Results:

By 4 pm Monday, the simulation shows gusts on Lake Superior decreasing but still Storm Force. This is likely an overestimate on Superior and northern lake Michigan. The surface low has weakened, but has barely moved for 16 hours over southwest Ontario.



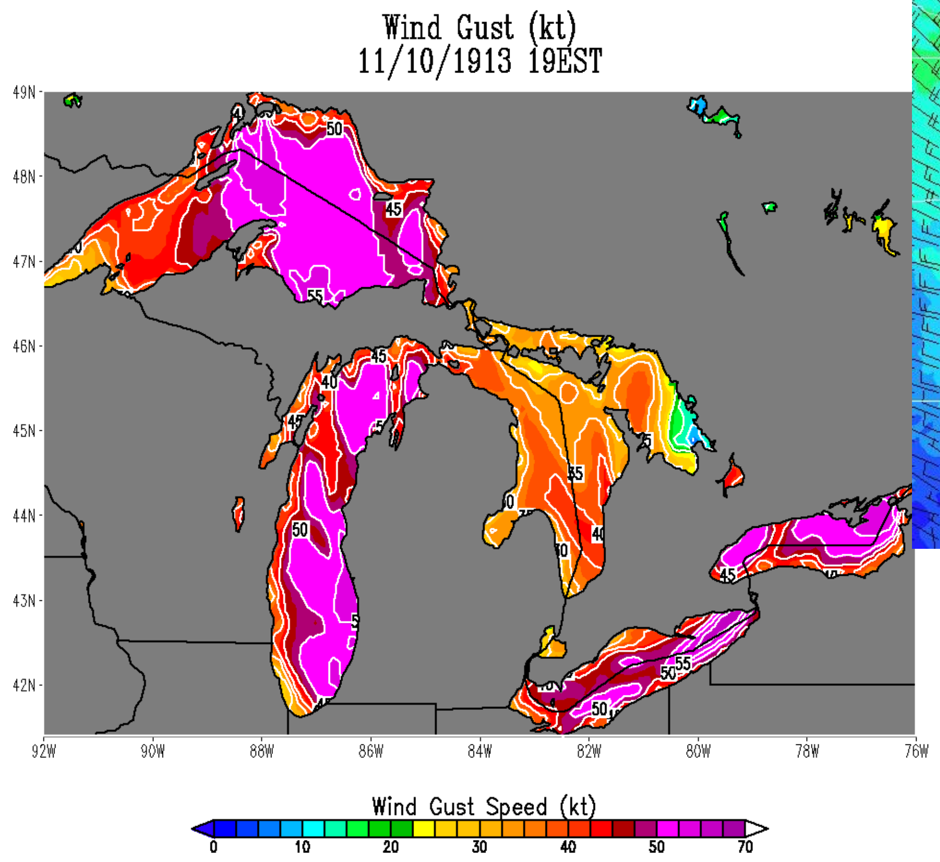


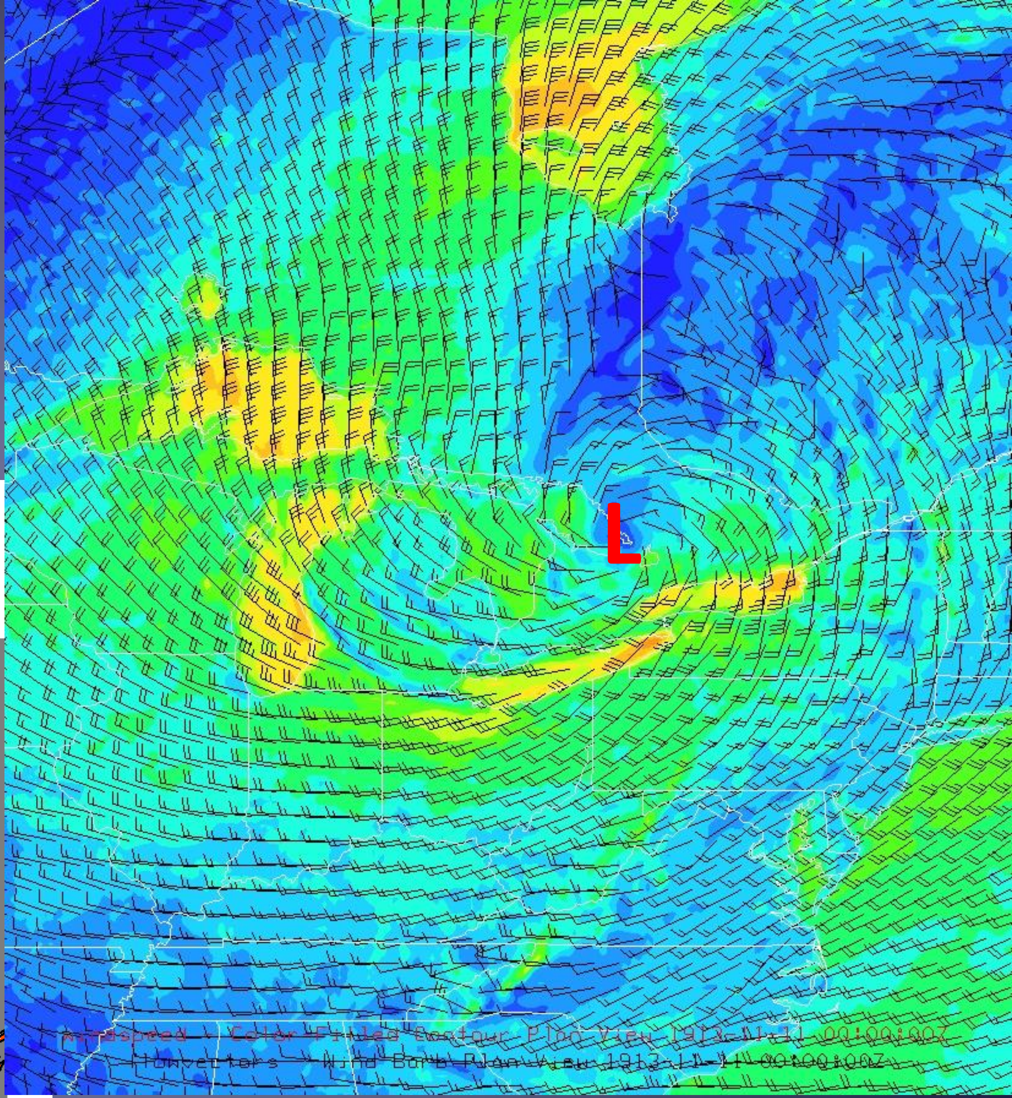
Southwesterly surface wind gusts at hurricane force are still indicated over eastern Lake Erie. Peak wind at Buffalo reached 80 mph around 2 pm.

4pm EST Monday, Nov. 10, 2013

Simulation Results:

By 7 pm Monday, the simulation shows the surface low further weakening and beginning to move off to the northeast across Ontario. Storm Force gusts are still indicated across Lakes Superior, Michigan, Erie and Ontario.

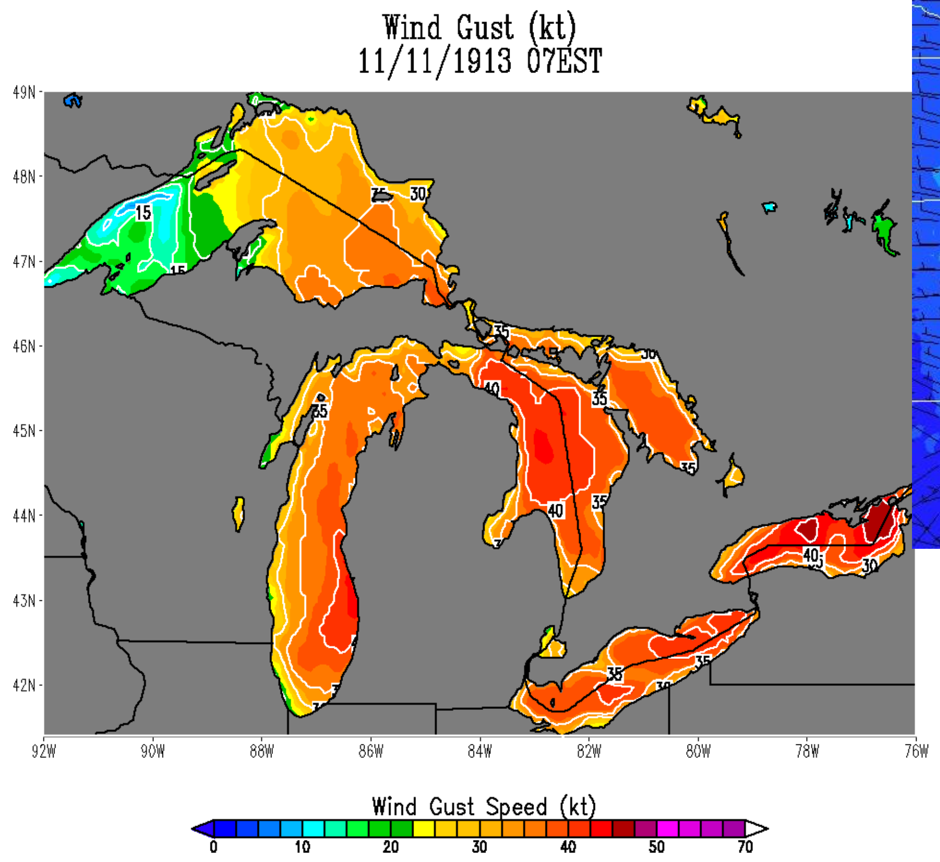


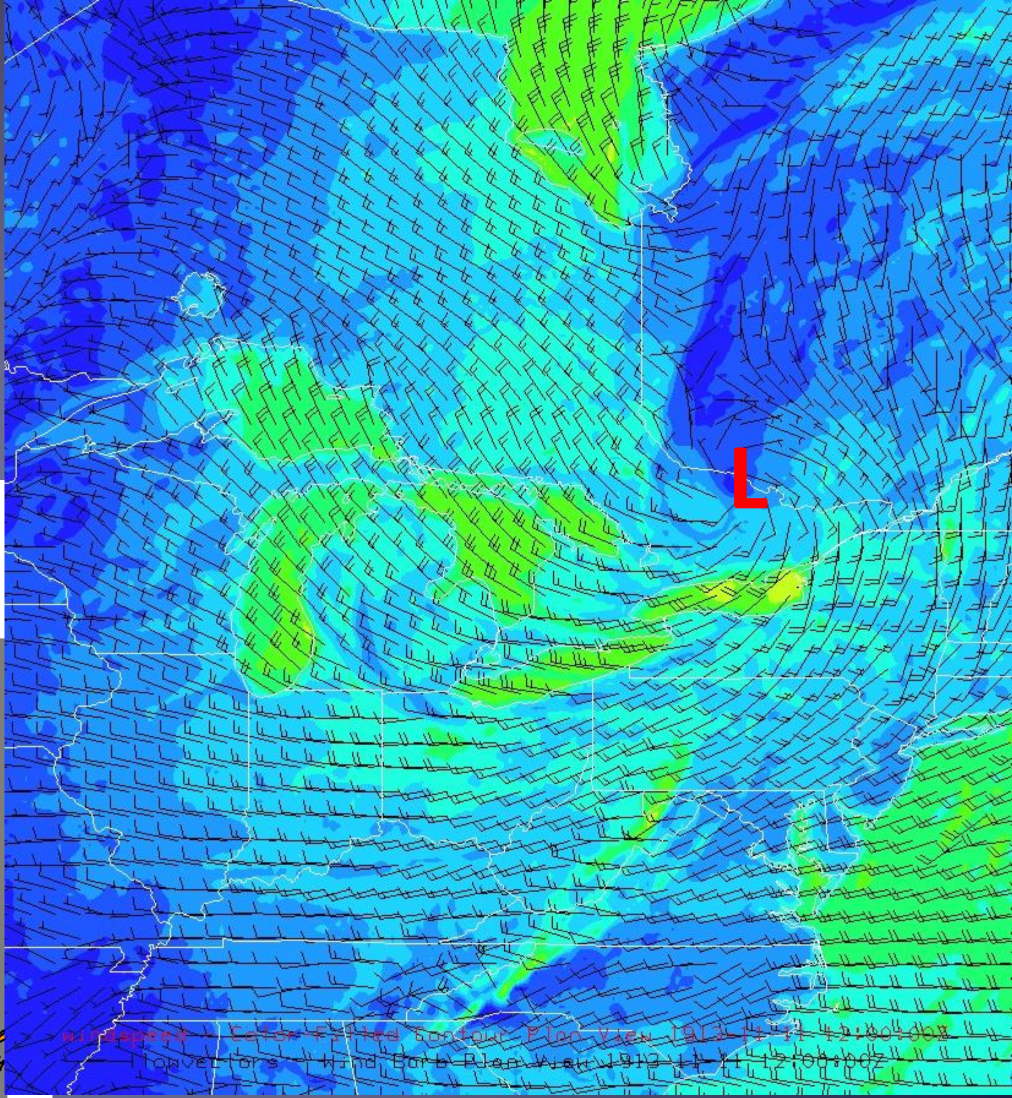


7pm EST Monday Nov. 10,1913

Simulation Results:

After 4 days of high winds, heavy seas, blinding snow squalls, and freezing spray - the storm finally weakens below Storm Force and moves off to the northeast.





7am EST Tuesday Nov. 11, 1913

Summary of Winds

- As the "meteorological bomb" approached the Great Lakes from the southeast – winds dramatically increased over all of the Great Lakes, with frequent gusts exceeding 80 mph predicted by the simulation.

- The projected wind gusts exceeded "hurricane force" (greater than 74 mph) for extended periods over Lakes Huron, Erie, eastern Superior, and Lake Michigan.

  Huron…10 hours
  Superior…20 hours
  Michigan… 13 hours
  Erie…16 hours

- Over southern Lake Huron during the afternoon and evening of Sunday, November 9th, a dramatic increase in wind speeds was indicated. From 1pm EST to 9 pm EST, wind gusts increased from 45 knots (52 mph) to over 70 knots (80+ mph).

- Survivor estimates of wind gusts to 90 mph on Lake Huron the evening of November 9th are not unreasonable given the computer simulation.

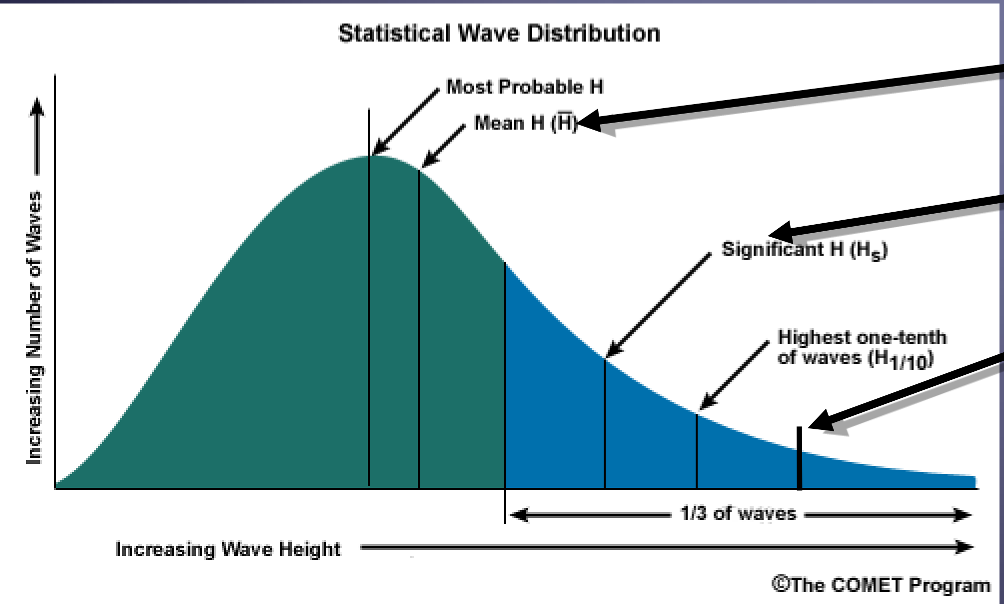
Waves and Wave Spectra

An Explanation

All waves are not created equal. The size of the waves sampled across a period of time (1 hour for example) will vary across a known spectrum/distribution of heights.

Meteorologists and Mariners describe “Significant Waves” as the average of the largest 33% (one third) and “Maximum Waves” as the average of the highest 5% (one twentieth).

Example…

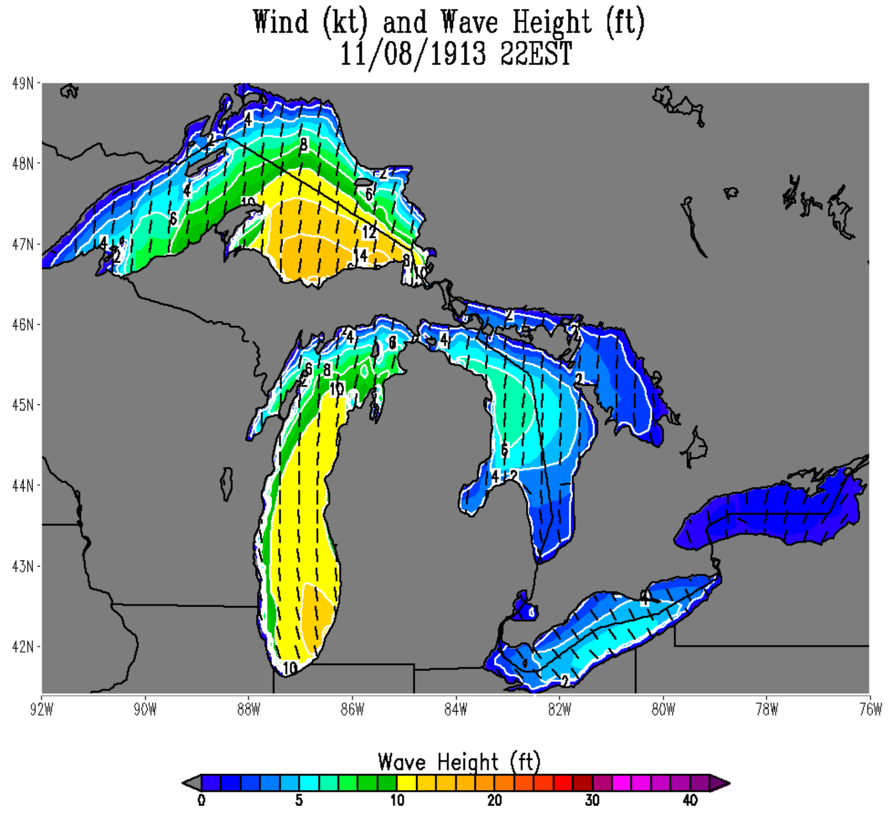


If the average wave over an hour sample is 5 feet with a wave period of 8 seconds…

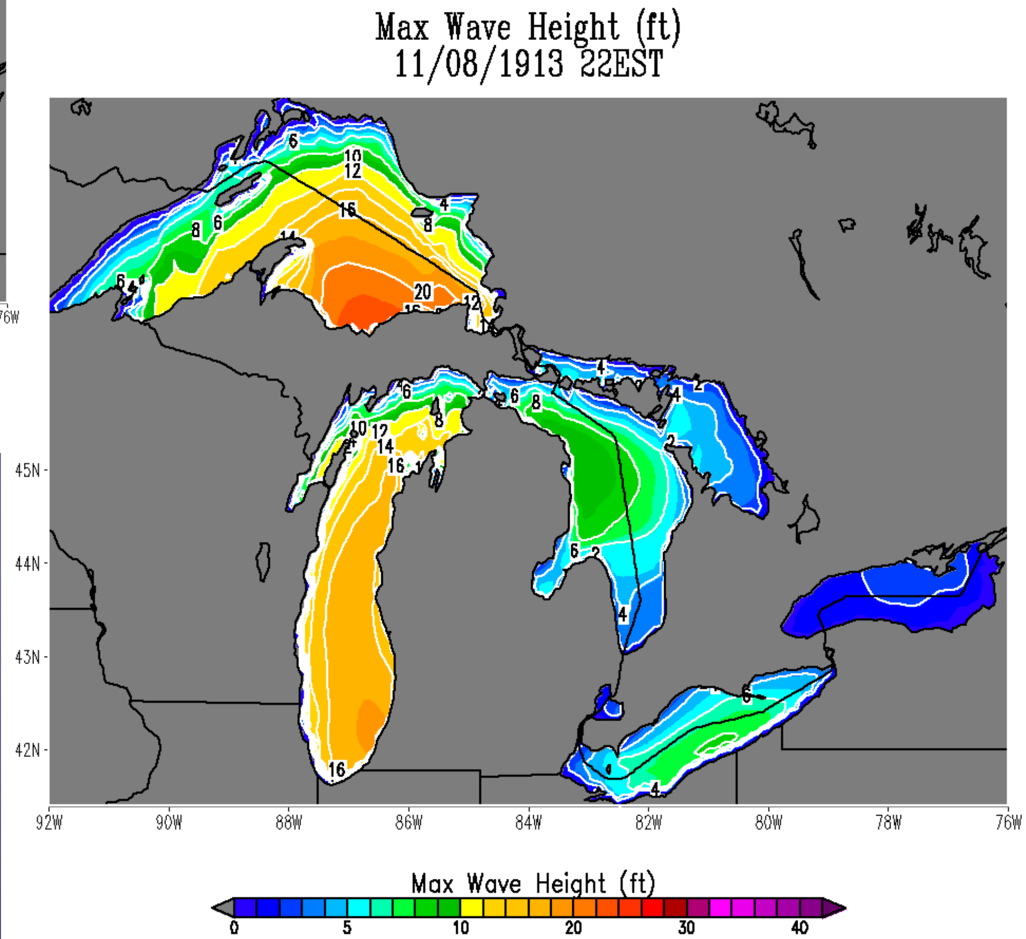
A **“significant wave”** will be 7.8 feet and will occur once every 40 seconds

A **“maximum wave”** will be 8.9 feet and will occur once every 2-3 minutes.

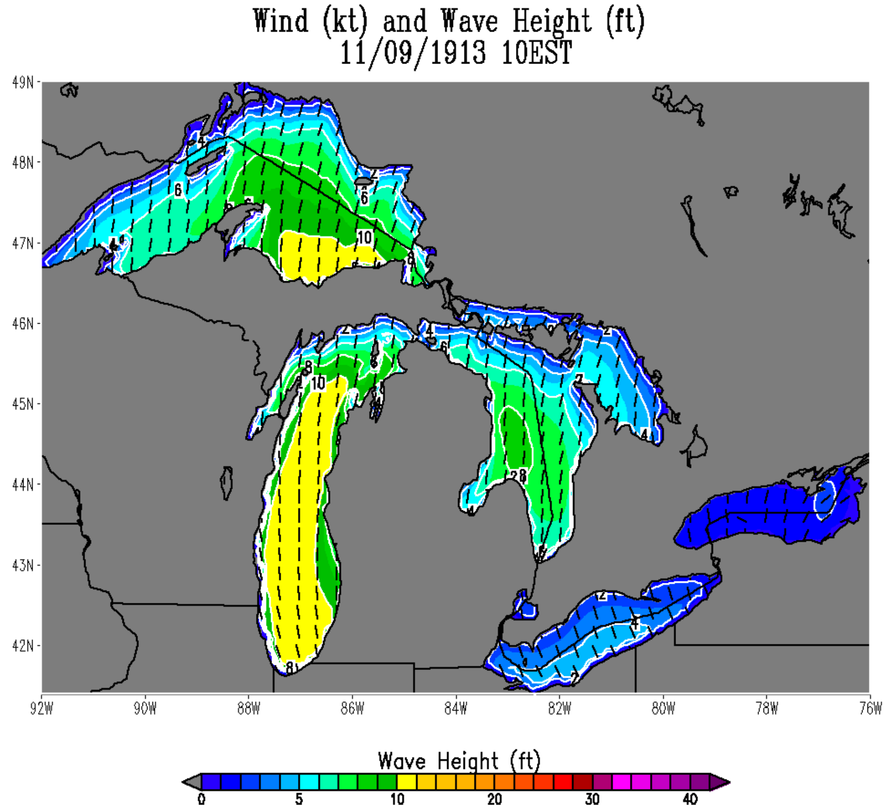
“Maximum Waves” are generally the worst conditions boats will encounter regularly.



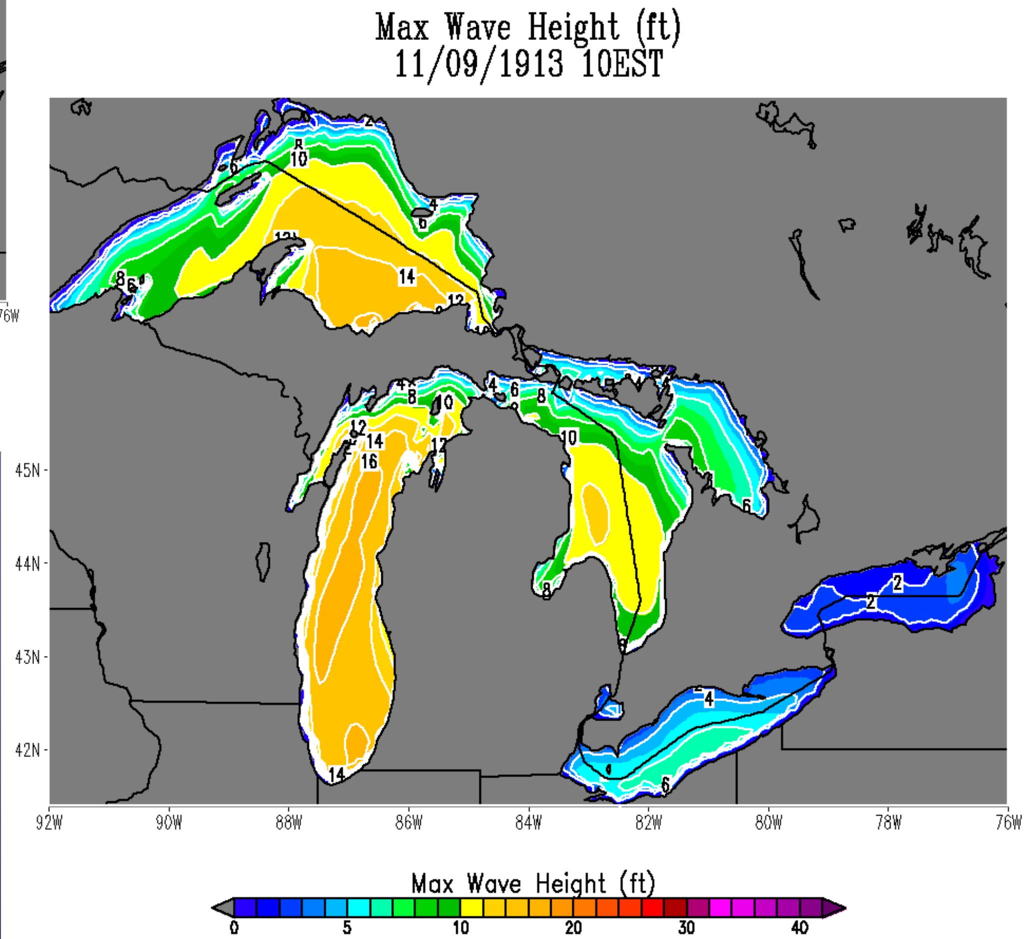
The wave model simulation starts at 10 pm Saturday November 8th. There was a slight lull in the Storm #1 waves at this time with Lake Huron indicating significant waves of 6 feet and max waves of 8 feet. Within 24 hours, things would dramatically change.



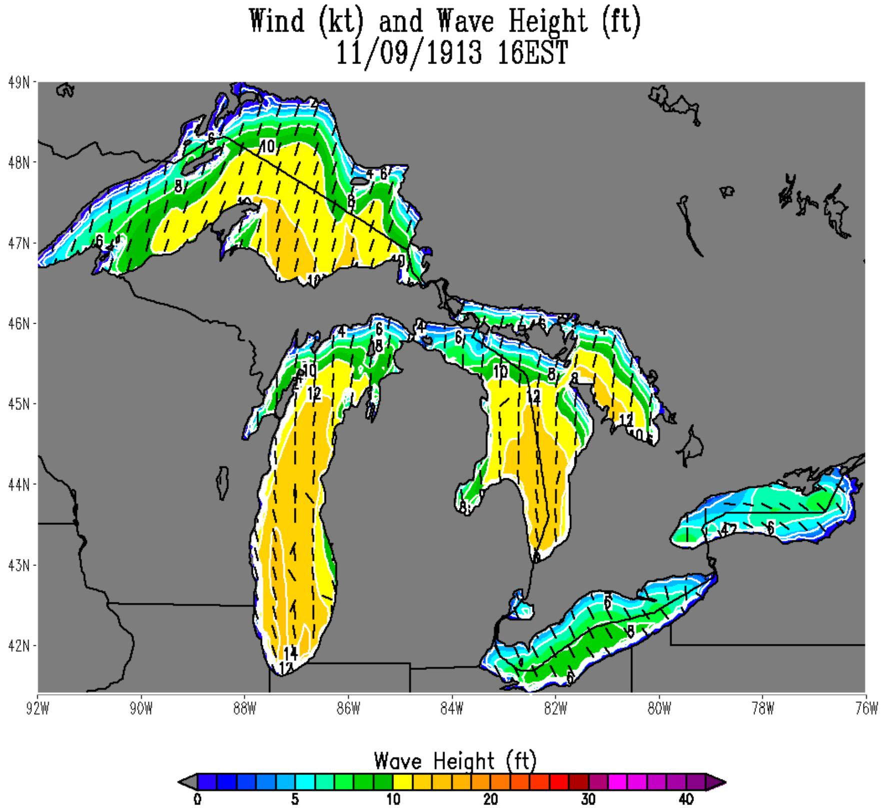
Wave simulations are of particular interest because there were few observations of mid-lake waves during the storm. The only estimates from survivors were that waves reached as high as 35 feet on Lake Huron and Lake Superior at the height of the storm.



At this time, many boats are downbound across Huron heading toward the St. Clair River… as well as many upbound boats passing Port Huron.

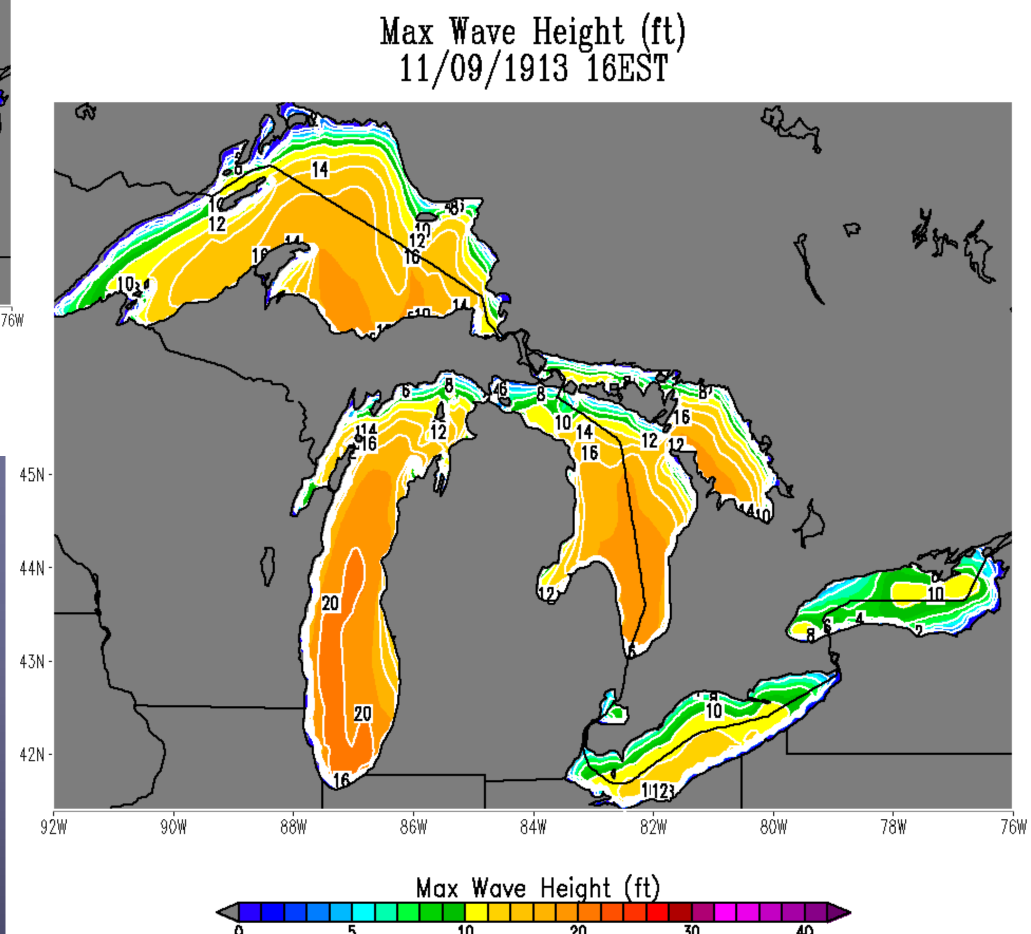


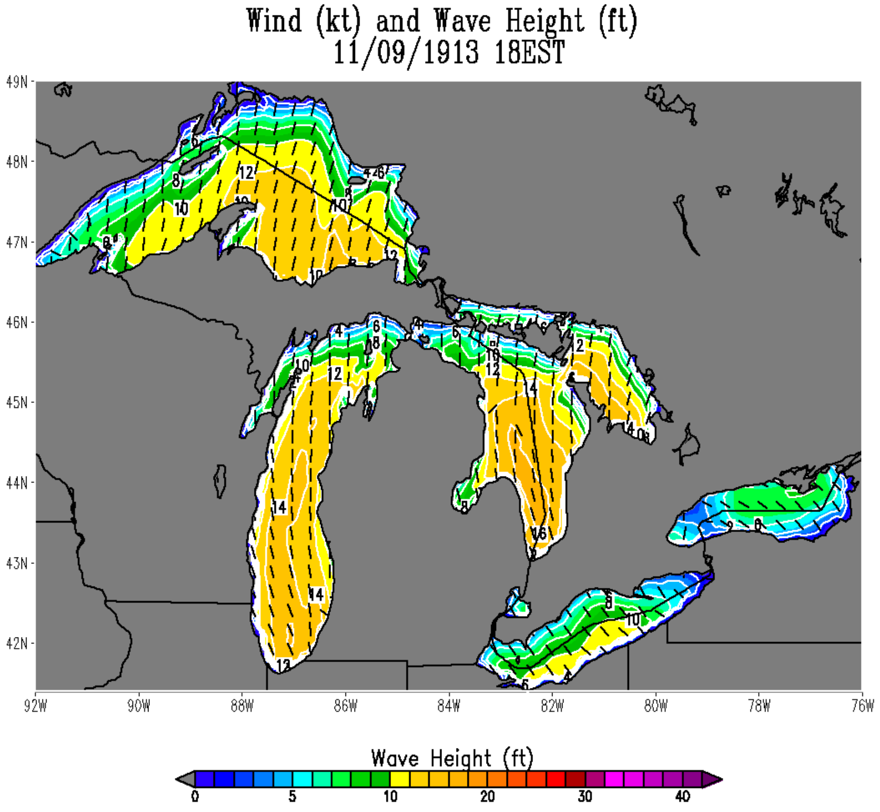
12 hours later at 10 am Sunday, November 9th, the simulation shows waves over Lake Superior seeming to diminish somewhat, but are starting to increase over Lake Huron to 8 to 12 feet.



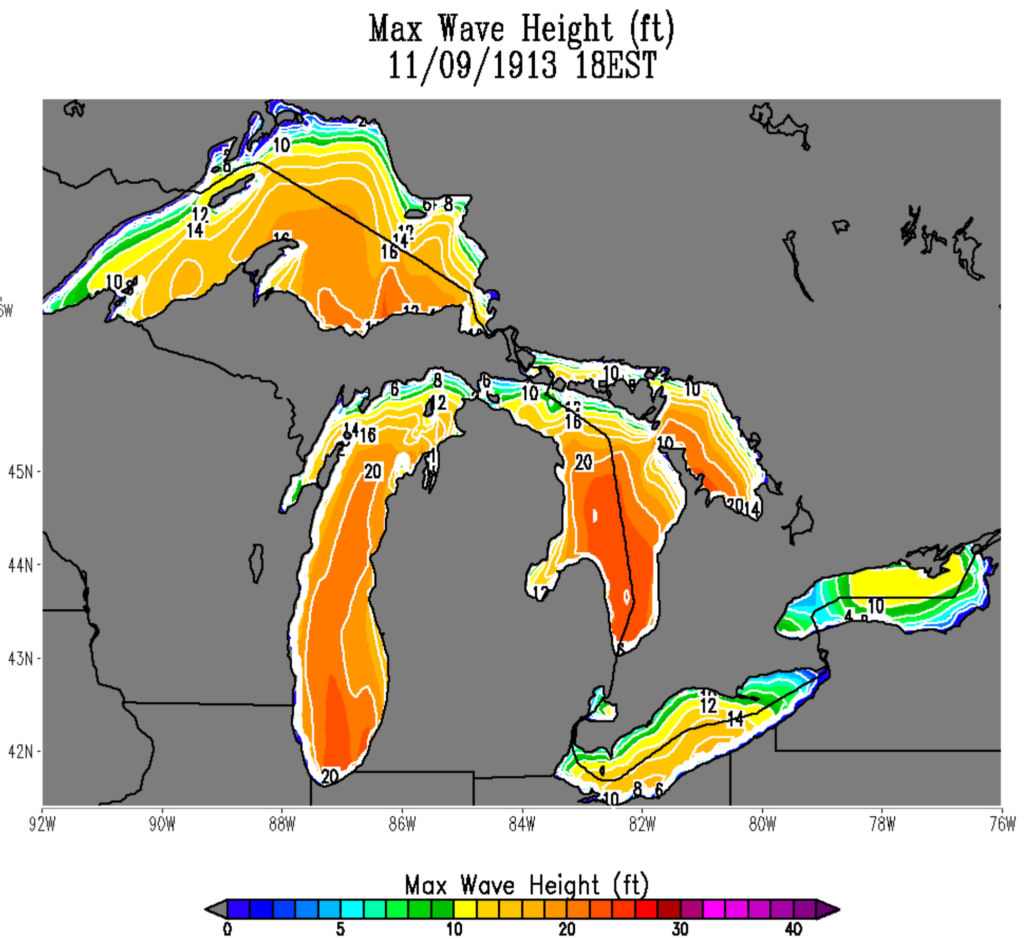
The Henry B. Smith left Marquette Harbor at this time heading for the Soo. In 2013, the Smith was found 30 miles north of Marquette where it sank 100 years ago around 6 pm on the evening of Nov. 9th.

At 4 pm November 9th, the simulation shows waves over all the Great Lakes to be increasing as the center of the "meteorological bomb" crosses Pennsylvania and starts to approach eastern Lake Erie.



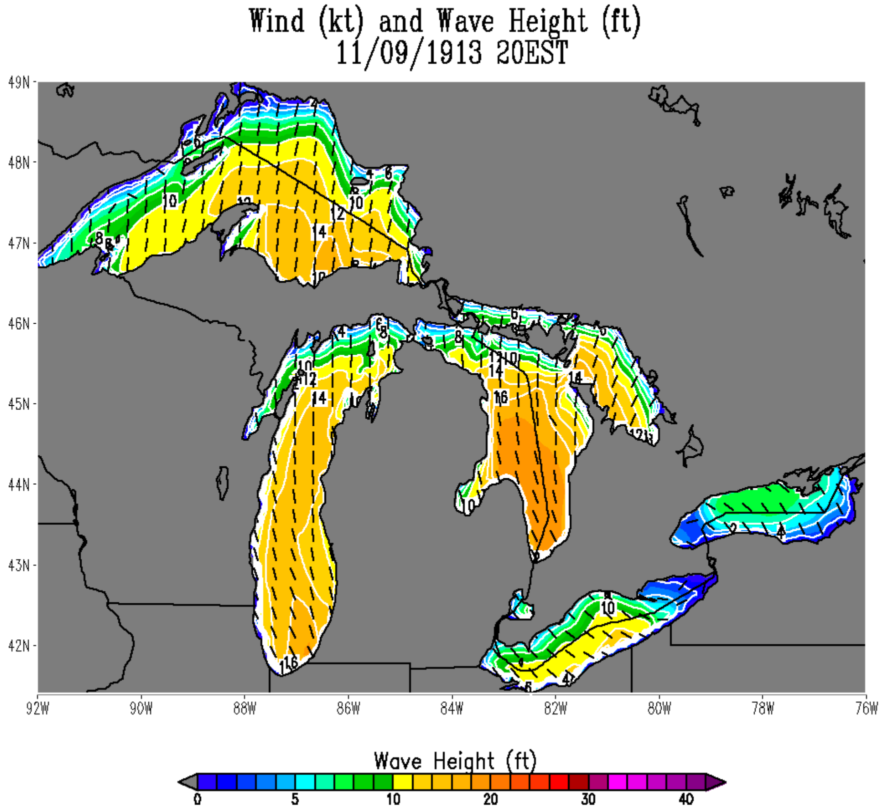


Dominant wave periods in the storm were calculated to be around 10 seconds at this time over Lake Huron. Meaning the return frequency on "significant waves" was 50 seconds, and every 200 seconds for the "maximum waves" .

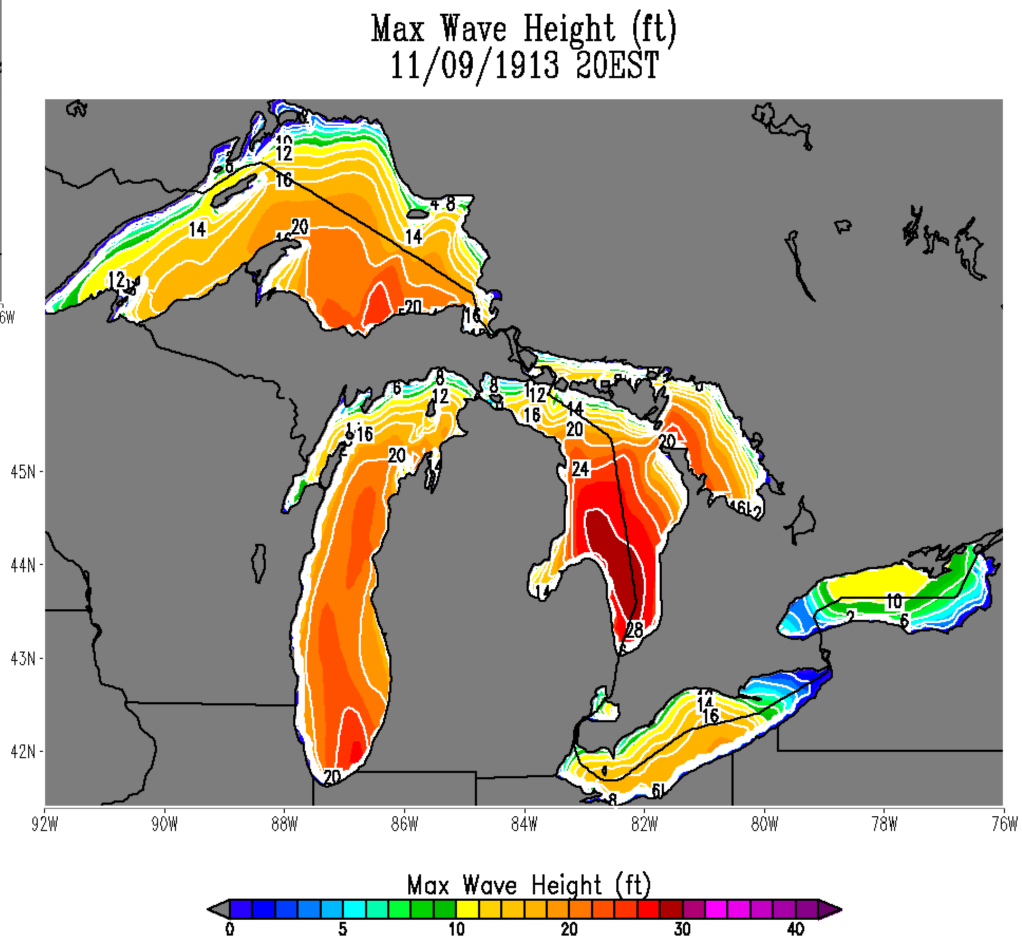


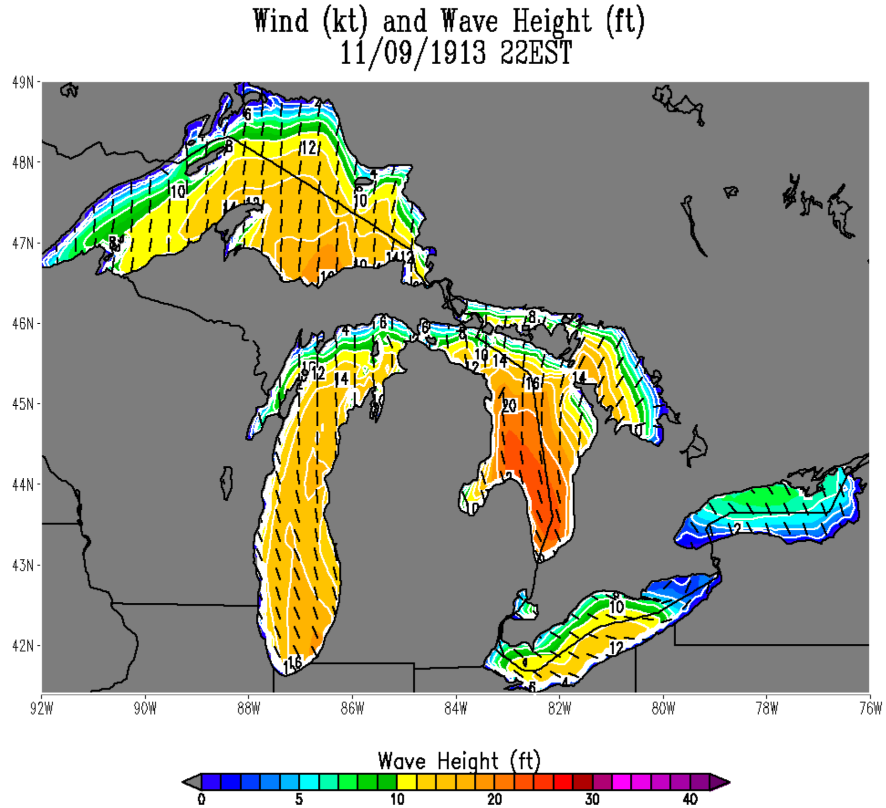
In just 2 hours time (4 pm to 6 pm), predicted waves over Lake Huron jump to "maximum" values of 24 feet – an increase of 6 feet. Boats from Alpena to Port Huron were seeing a significant deterioration in wind and wave conditions. The Argus was lost ~6 pm near Pt. Aux Barques.

The Howard Hanna, John McGean, Isaac Scott, H.P. Hawgood, and Hydrus all likely sank or were driven aground during the next two hours – caught in rapidly building seas over the south half of Lake Huron.



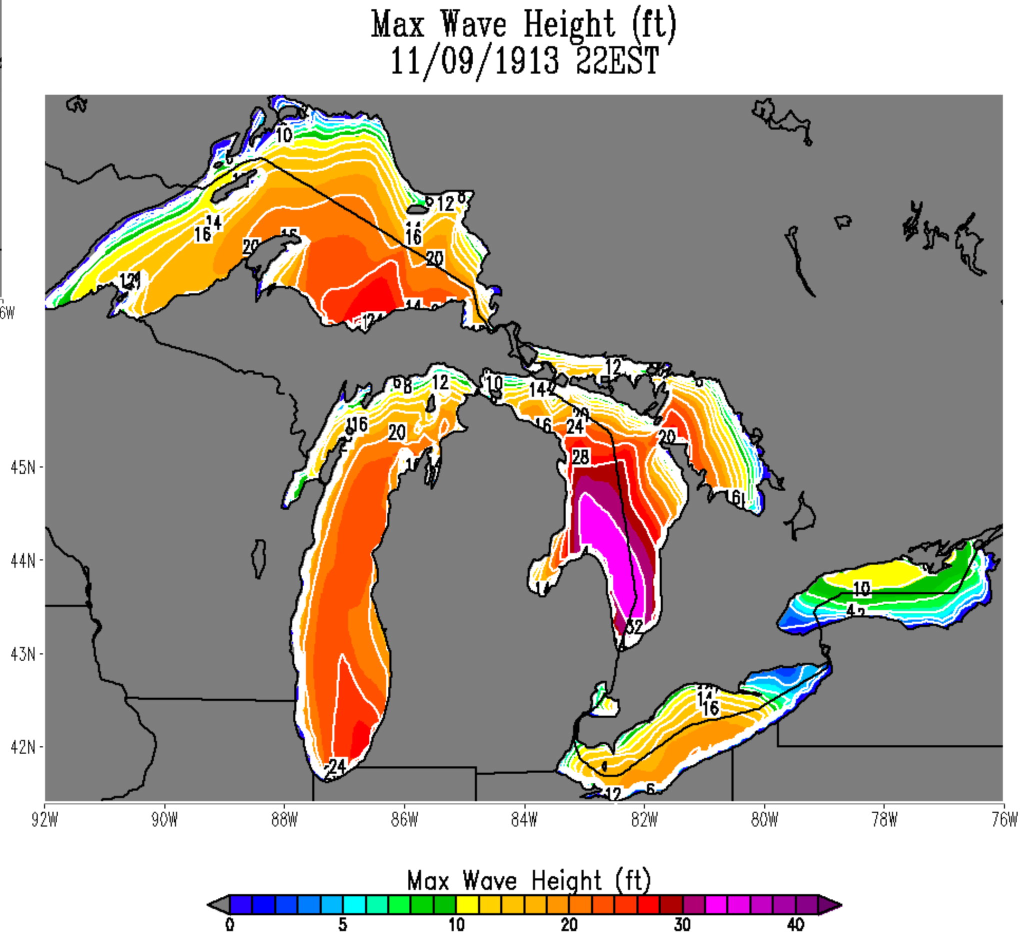
By 8 pm, November 9, simulated wind gusts over Lake Huron are exceeding 80 mph and “maximum waves”, occurring every 3 minutes 20 seconds, are estimated at 28 feet. The next 4 hours over Lake Huron have been described as the deadliest in Great Lakes history.

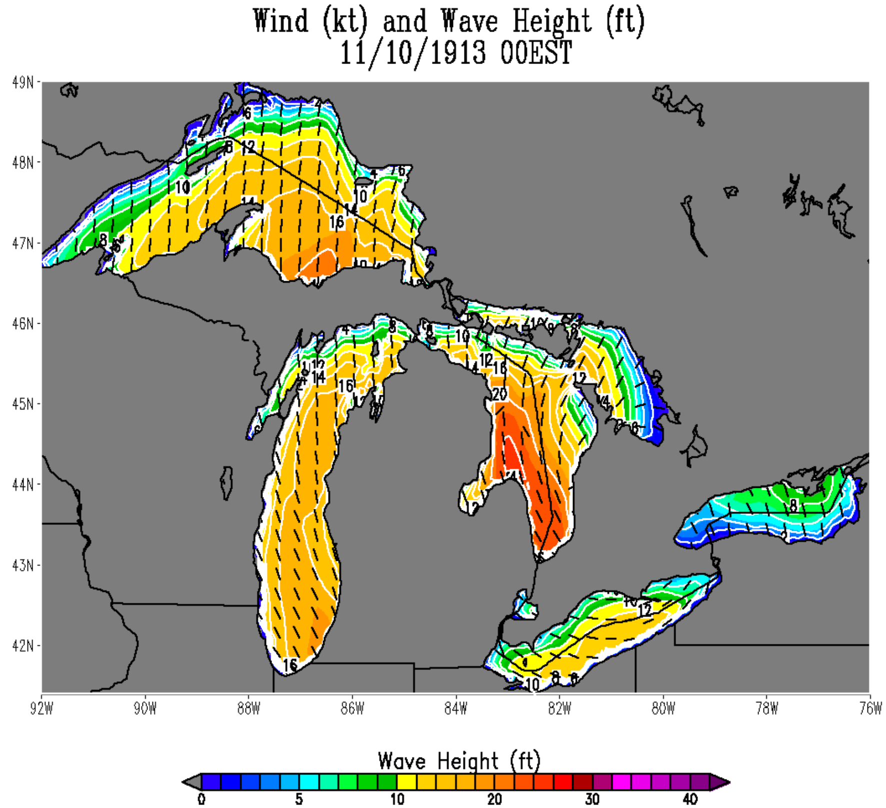




Around 11 pm it was estimated that the Charles Price and Regina went down near Harbor Beach and Port Sanilac MI respectively. The P.O. Mills was driven aground near Harbor Beach.

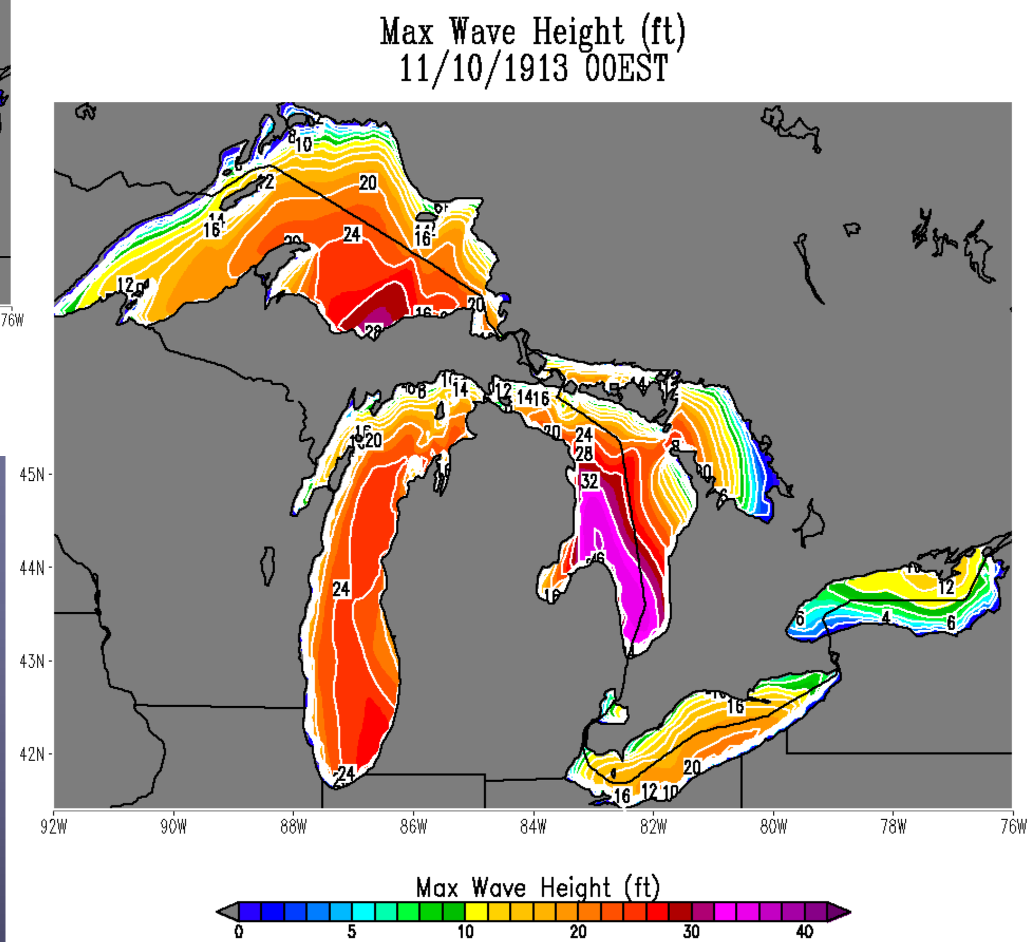
By 10 pm, November 9th, waves are continuing to build substantially in the simulation to as high as 32 feet – which would have made safe navigation nearly impossible. In 6 hours time, simulated waves have almost doubled in size over southern Huron.



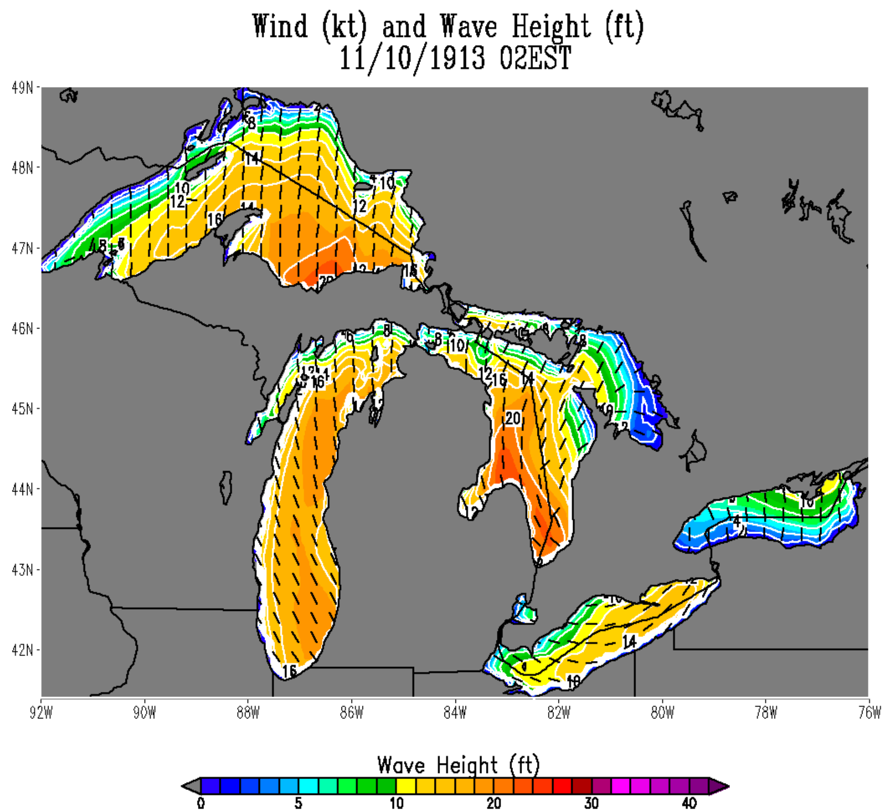


Around midnight, it was speculated that the Wexford and James Carruthers went down in southeast Lake Huron near Goderich and Grand Bend ON. At 1230 am the Motoa was forced aground just offshore of Pt. Aux Barques MI.

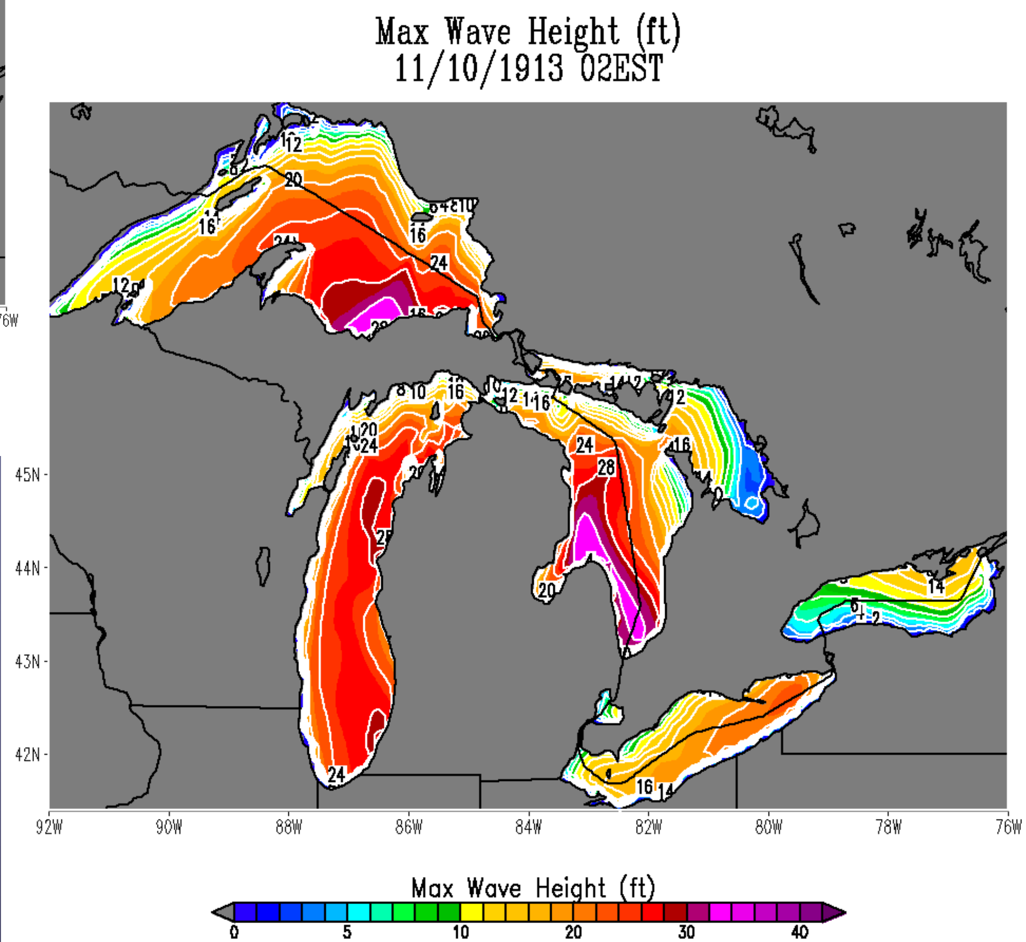
By midnight on November 10th, the simulation reaches the peak of the storm over Lake Huron. At this time wind gusts were 75-80 mph and peak “maximum waves” were as high as 36 feet near Port Austin MI.

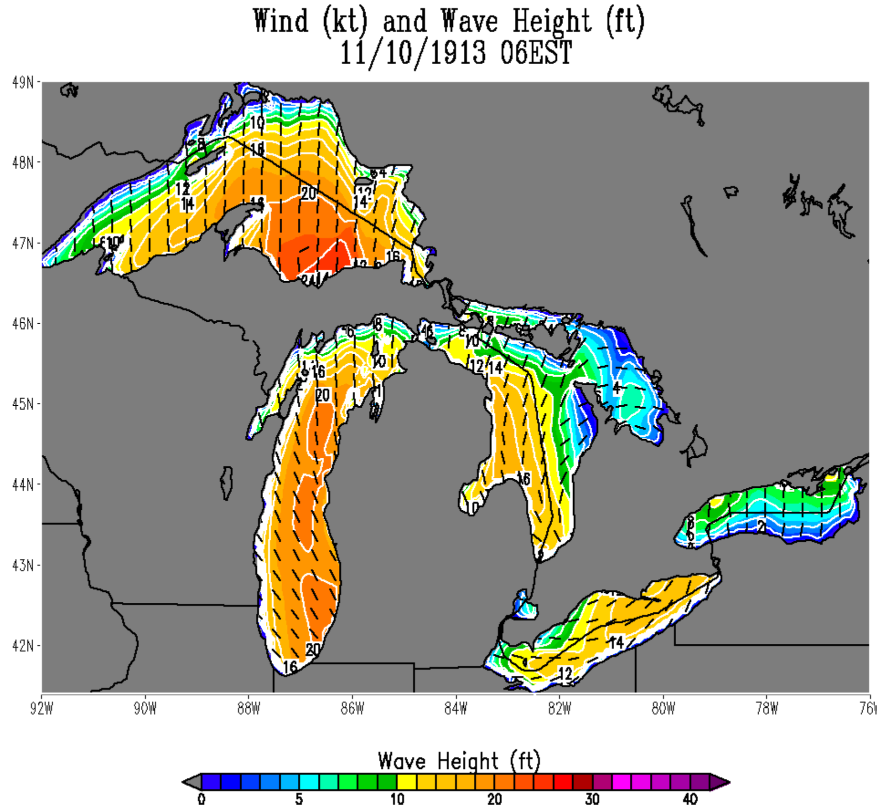


The prior 6 hour period from 6 pm to Midnight on November 9, 1913, was one of the deadliest weather events in North American history. A total of 9 large Great Lakes vessels and over 200 souls were lost in those 6 hours.

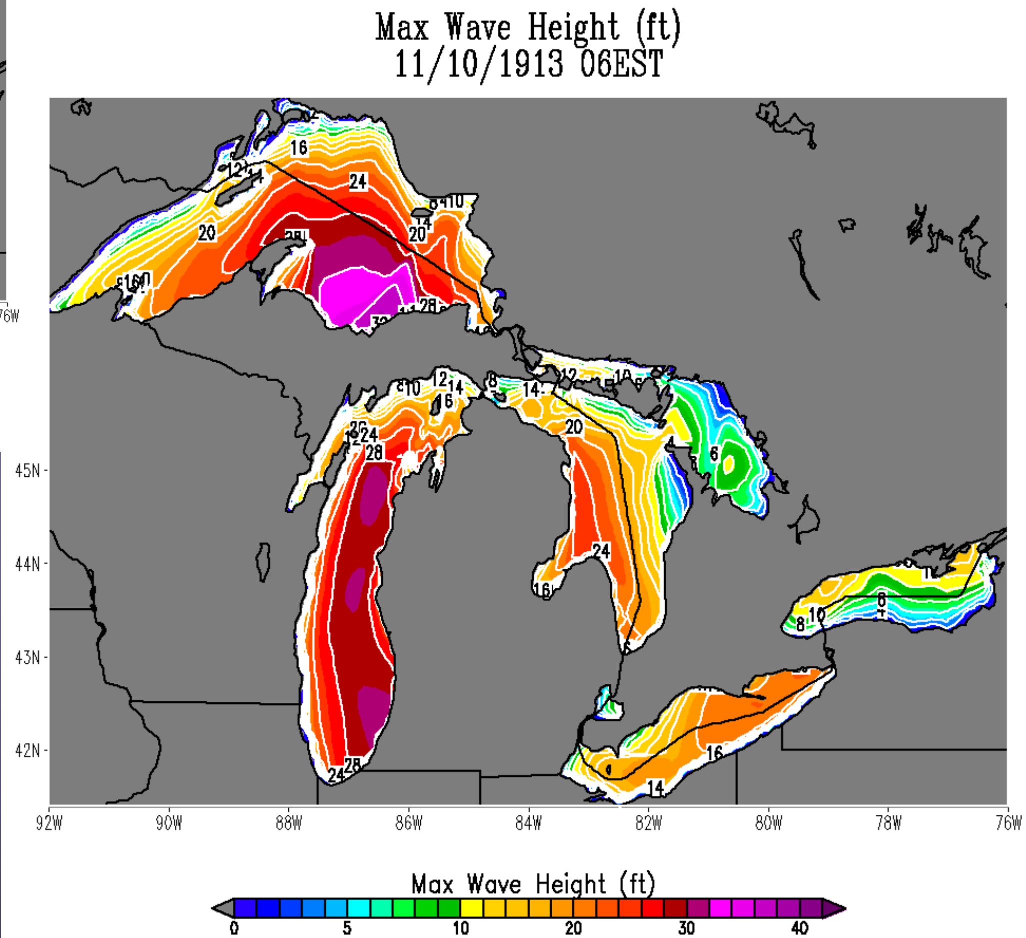


By 2 am, November 10th, while a raging storm continues over Lake Huron, the storm center was moving to between Toronto and London ON. This movement starts to force the highest winds west over eastern Superior and northern Lake Michigan.

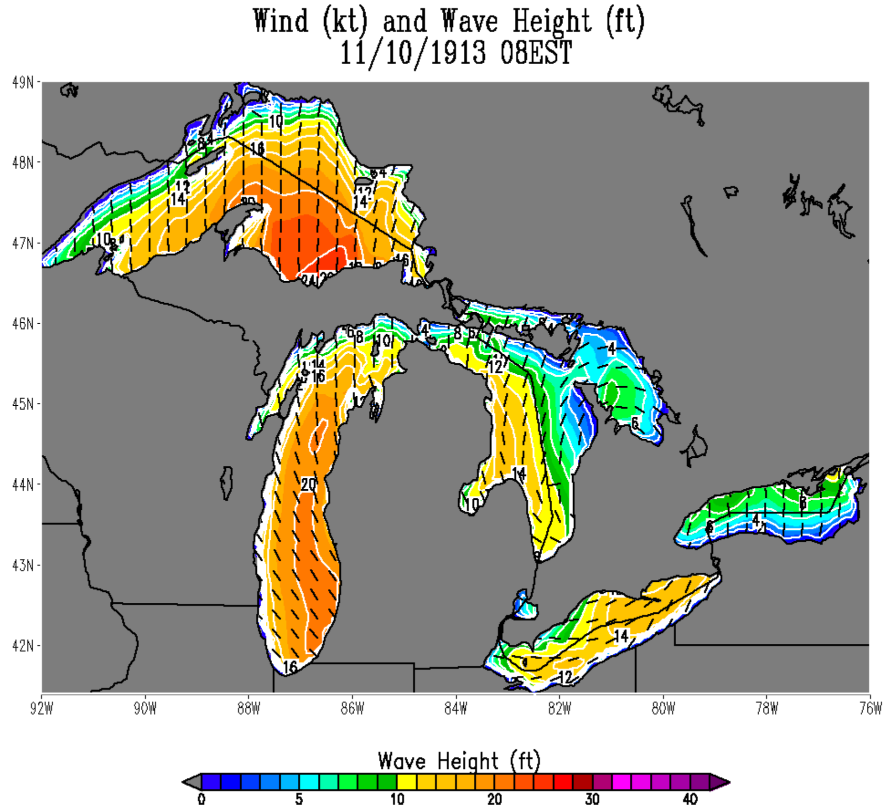




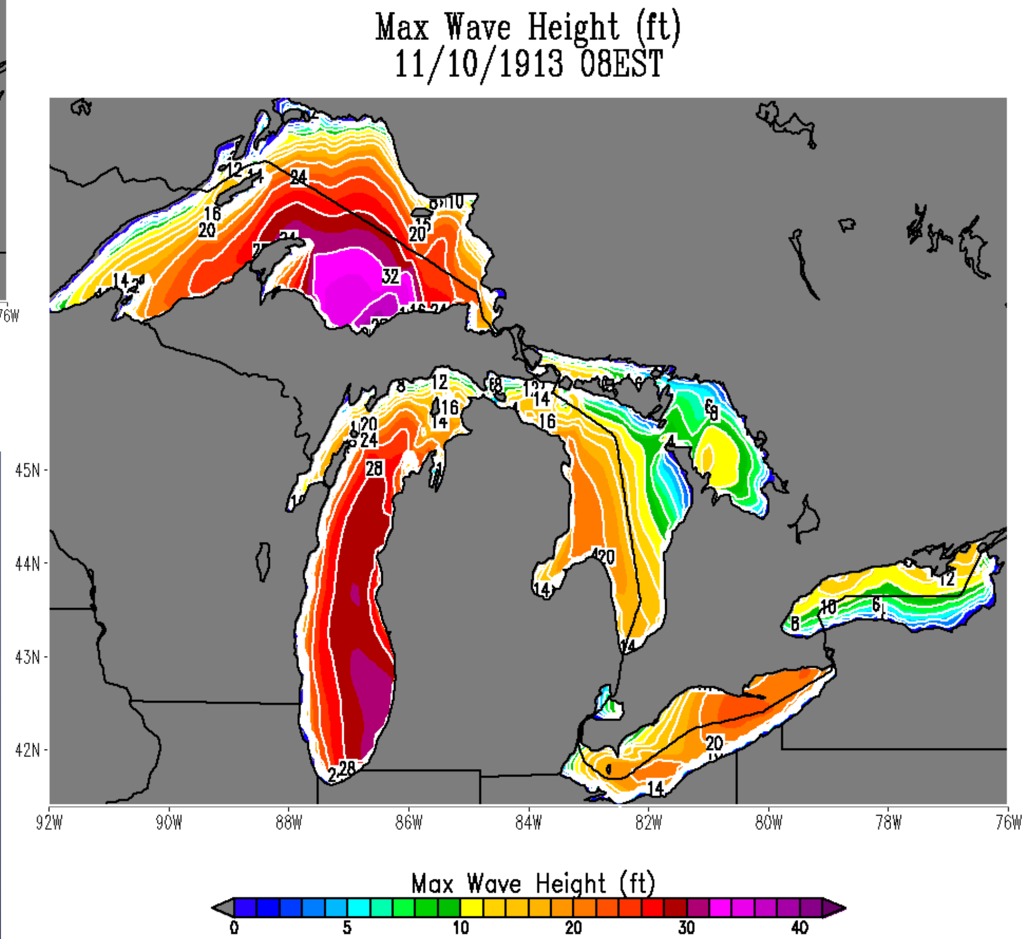
At 645 am on the 10th, the Sheadle reported that winds and waves over southern Lake Huron had decreased enough such that the captain could turn the ship northward and then downbound again to avoid running aground in the storm.



By 6 am, November 10th, the highest simulated winds and waves have moved westward over Lake Superior and Lake Michigan. Winds of 80+ mph over Lake Superior have produced “maximum waves” to 36 feet along Pictured Rocks National Lakeshore.

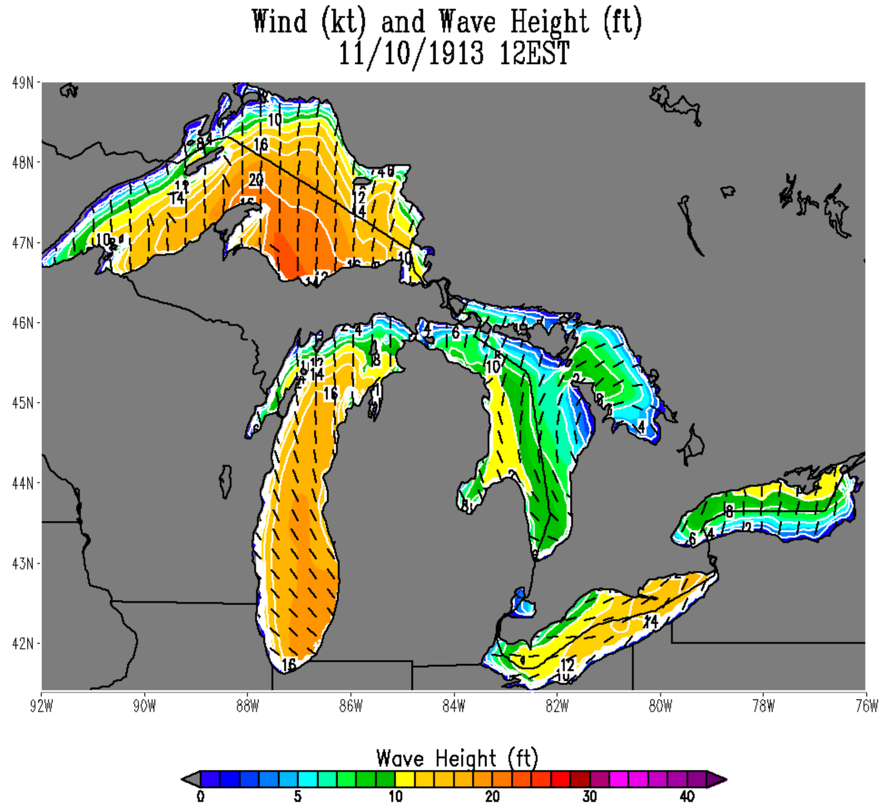


Additionally, increasing west to southwest winds over Lake Erie were building waves of over 22 feet in the eastern basin toward Buffalo.



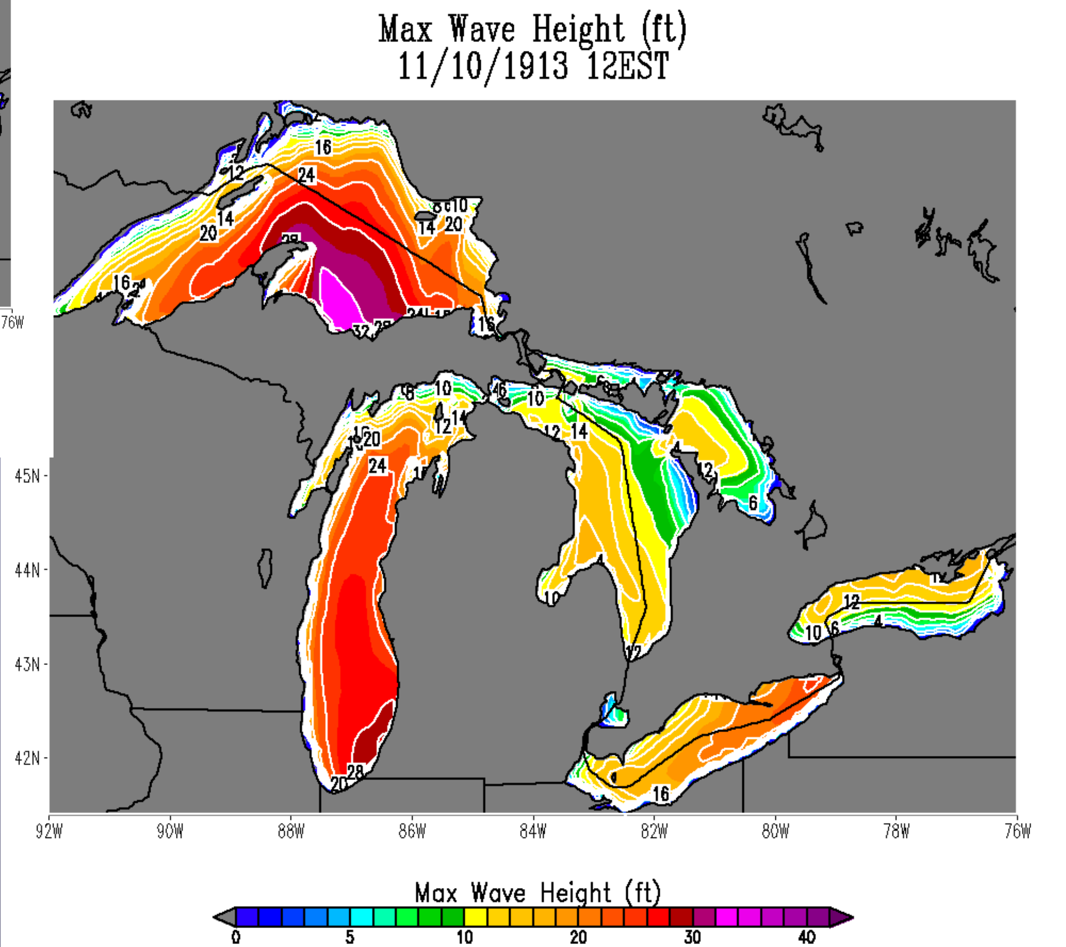
By 8 am, November 10th, the simulation projected the highest waves of the storm just east of Munising Harbor near 38 feet.

At 10 am, the Sylvania still reported massive waves near Whitefish Point over Lake Superior.

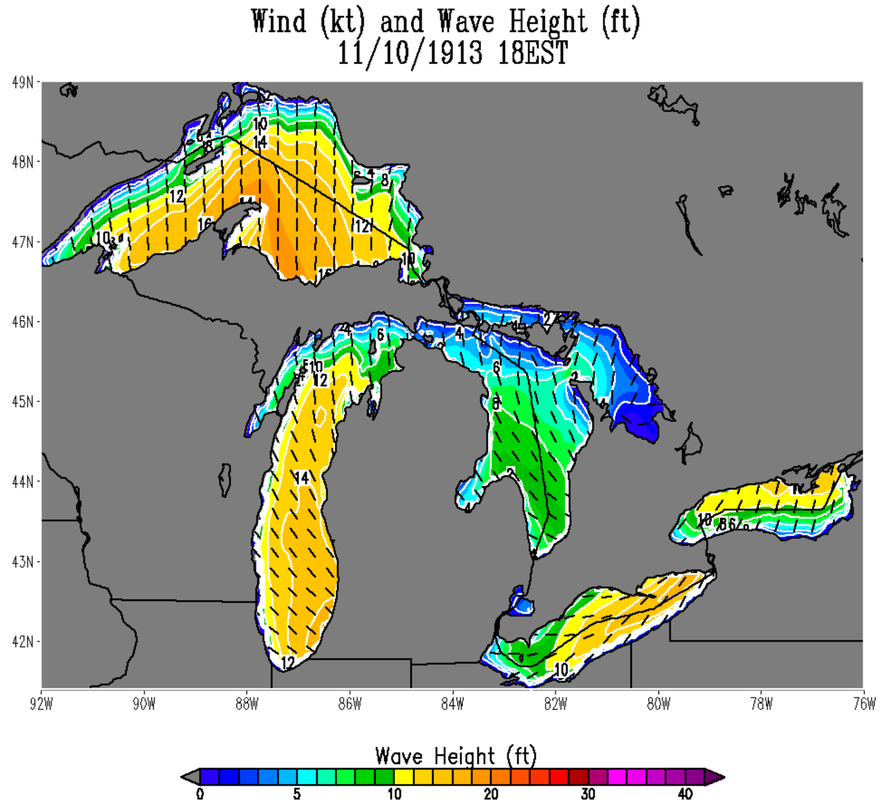


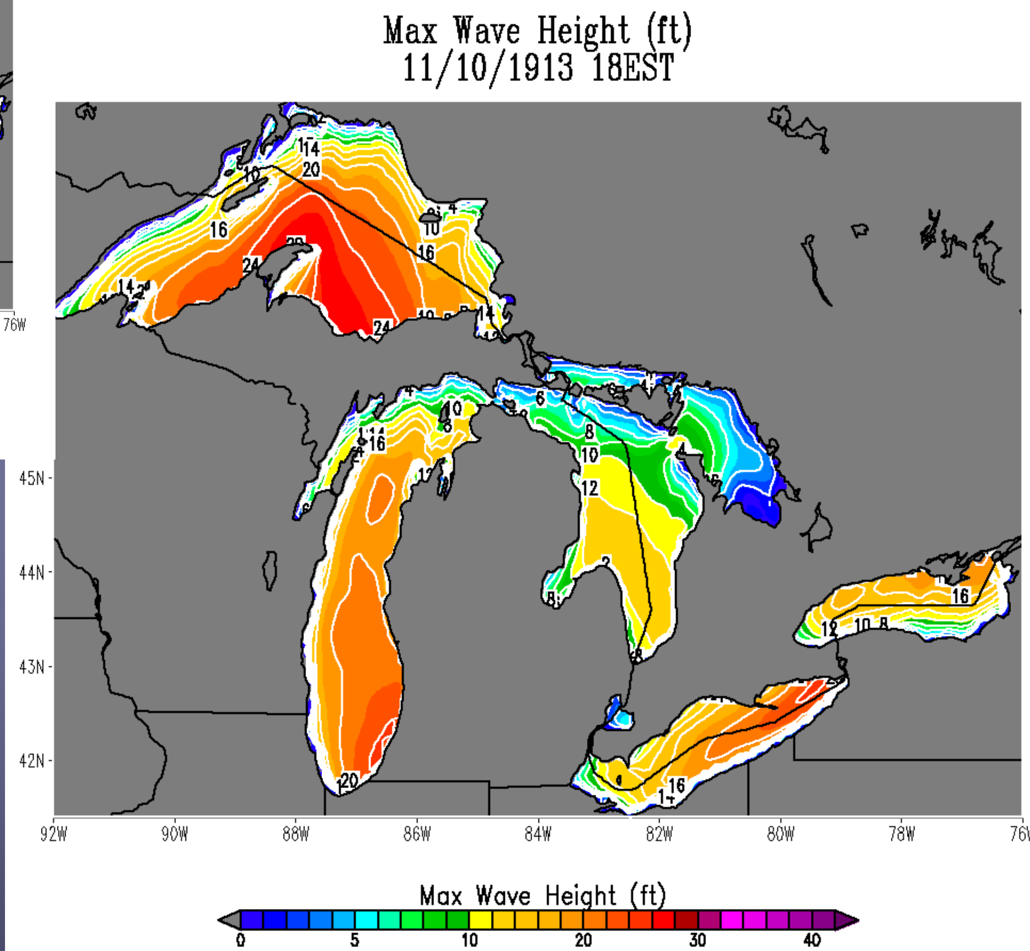
Strong southwesterlies (hurricane force gusts) over Lake Erie were projecting 24 foot "maximum waves" near Buffalo Harbor. Lightship 82 was lost near Buffalo, although the time is unknown. Midday on Monday the 10th would be a strong possibility.

By Noon, November 10th, the simulation projected decreasing winds and waves over most areas, although "maximum waves" to 32 feet are still indicated near Marquette and Munising. This is likely an overestimate by the computer simulation.

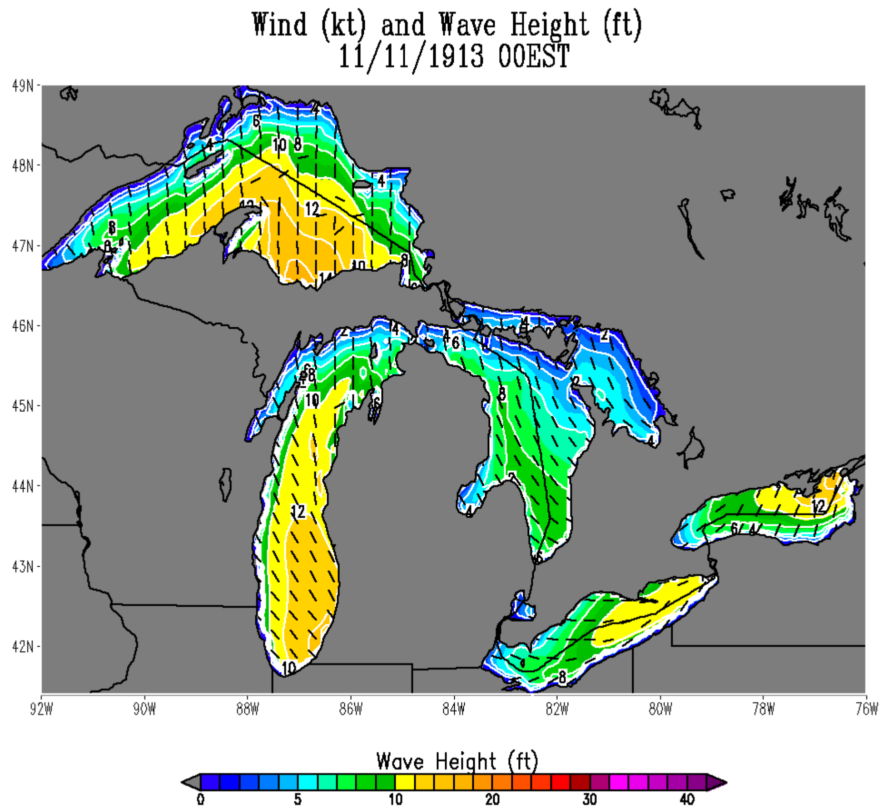


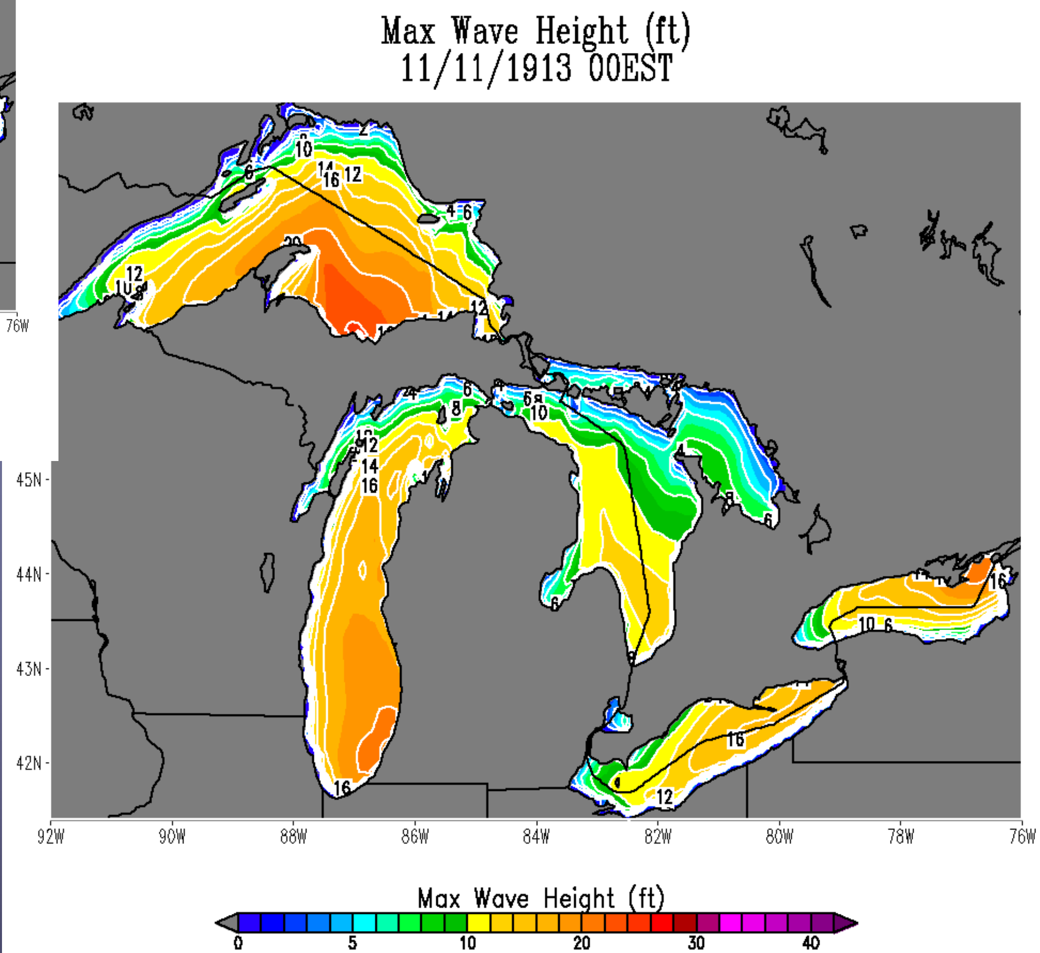
Strong southwesterlies and high waves are still projected over eastern Lake Erie. Such a prolonged period of strong winds likely produced extremely high storm surge – possibly in excess of 6 feet above normal at Buffalo.





By 6 pm, November 10th, the simulated waves are still high, but the low is gradually weakening as it passes northeast between Toronto and Georgian Bay.





By midnight, November 11th, winds and waves finally begin to dramatically weaken as the low heads northeast toward Quebec.

Summary of Waves

- Survivor estimates of waves as high as 35 feet over Lake Huron were confirmed by both wave theory and the computer simulation.

- Waves likely doubled in height from the afternoon to the evening of the 9th, catching many boats off guard. Waves were especially deadly around the mouth of Saginaw Bay, where several large boats encountered incredible winds and waves.

- With seas running north to south, waves to 36 feet were occurring with a return frequency of less than 3 ½ minutes. The dominant wave period was 10 seconds, indicating large waves were very steep.

The Great Storm of 1913

- The period from 6 pm to Midnight on the evening of November 9th was likely the deadliest in Great Lakes history when 9 large ships and over 200 souls were lost. Of those, 8 boats and 187 lives were lost over southern Lake Huron. This period also represents one of the deadliest weather events in North American history.

- With predicted “maximum waves” to 36 feet or more, return frequency just over 3 minutes, prolonged periods of hurricane force wind gusts, and very steep waves - large vessels caught in the “trough” were at risk of capsizing.   At least 3 of the large boats, were found upside down indicating that they had capsized in the large waves.

- The computer simulation appears to have adequately captured the wind and wave conditions at the peak of the storm; quite remarkable considering the challenges of doing a 100 year retrospective simulation with limited data. This gives confidence that the results can be further studied by meteorologists and historians for further insights into the deadly events of 100 years ago.

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