An Assessment of Thunderstorm Characteristics Associated with the Marine Accident of 17 July 2011

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1. Introduction

Following is a brief assessment of the thunderstorms which impacted northern Lake Michigan during the late evening of July 17, and resulted in the tragic loss of two lives during the 2011 Chicago to Mackinac Yacht race.

Early anticipation was very good that strong to severe thunderstorms would impact portions of the Great Lakes, including northern Lake Michigan, on Sunday, July 17. A complex of strong thunderstorms moved from Wisconsin and Upper Michigan into Lake Michigan Sunday evening. Initially, these storms were relatively disorganized and marginally severe. However, as the storms approached the Fox Islands region, radar indicated the rapid intensification of one particular cell just prior to midnight EDT. As it intensified, this storm also exhibited small areas of strong radar detected low level winds. The location and timing of this storm evolution appears to be well correlated with the marine accident.

2. Early Anticipation

a. Storm Prediction Center, Norman OK

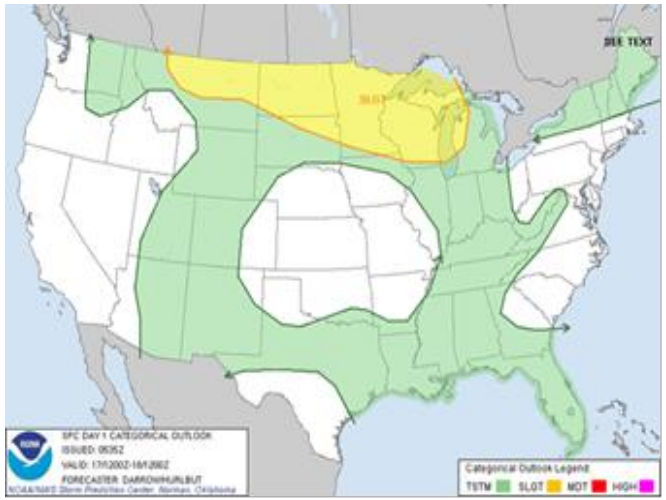
The Storm Prediction Center (SPC) in Norman, OK issues severe weather outlooks, severe thunderstorm and tornado watches, and mesoscale convective discussions to describe the expected development and evolution of severe weather across the United States. The severe weather outlook graphic shown below (left image) was issued at 1:35 am EDT July 17 (approximately 24 hours before the accident). This "Day 1" outlook placed central and northern Lake Michigan in a "Slight Risk" of severe weather between 1200 Z (8:00 am EDT) July 17 and 1200 Z (8:00 am EDT) July 18. A Slight Risk implies that "well-organized severe thunderstorms are expected, but in small numbers and/or low coverage."

SPC later issued a Severe Thunderstorm Watch at 8:25 pm EDT on July 17 (approximately 3 ½ hours before the accident). This watch covered portions of northeast Wisconsin, upper Michigan, and northern Lake Michigan. This watch area is shown below (center image).

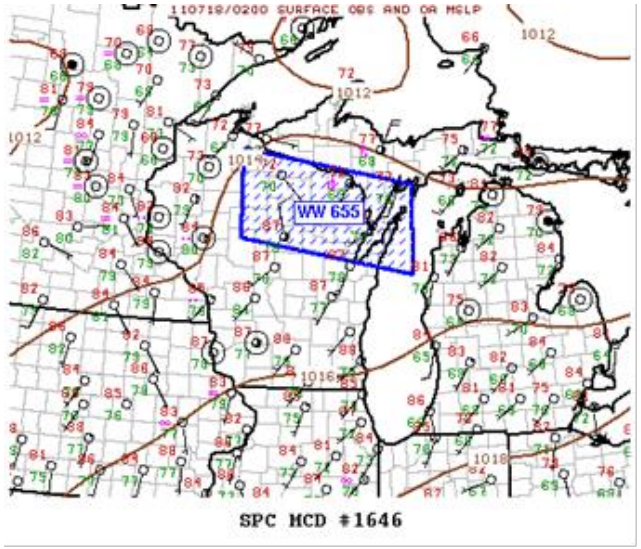
At 12:06 pm EDT July 18 (near the time of the accident) SPC issued a Mesoscale Convective Discussion (MCD) for portions of Wisconsin, Lake Michigan, and Michigan. The MCD area is shown below (right image). The MCD text follows:

AN EXTENSIVE CORRIDOR OF STRONG THUNDERSTORMS HAS EVOLVED FROM THE ERN U.P. OF MI...SWWD INTO ECNTRL WI. THIS ACTIVITY IS PROPAGATING/DEVELOPING EWD AT A FAIRLY QUICK PACE...IN EXCESS OF 40KT...AND WILL SOON SPREAD ACROSS THE REMAINDER OF NRN LAKE MI INTO NRN LOWER MI. LATEST RADAR DATA SUGGESTS HAIL MAY APPROACH ONE INCH IN A FEW OF THE STRONGER CORES...OTHERWISE GUSTY WINDS APPEAR TO BE THE PRIMARY CONCERN AS THIS ACTIVITY MOVES DOWNSTREAM INTO A LESS BUOYANT ENVIRONMENT. CURRENT THINKING IS THE GREATEST RISK FOR DAMAGING WINDS WILL OCCUR ALONG THE SRN HALF OF THE MCS FROM LAKE MI INTO ECNTRL WI. GIVEN THE WEAKER INSTABILITY DOWNSTREAM DO NOT ANTICIPATE ISSUING ANOTHER WATCH.

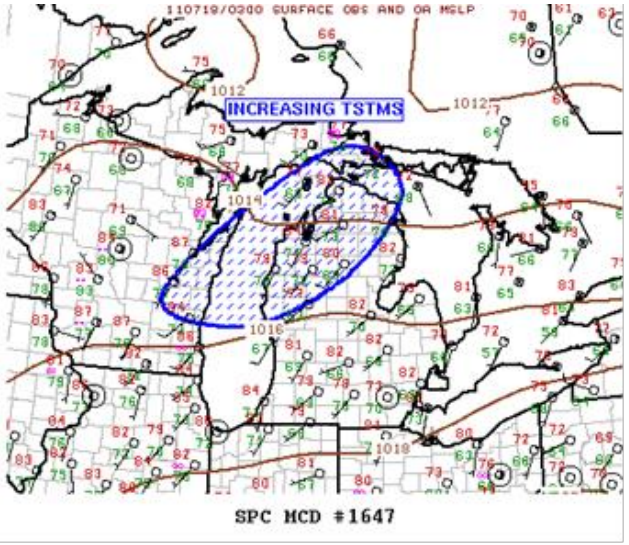
Note that while strong thunderstorms were expected to move across Lake Michigan and into Lower Michigan, another downstream severe weather watch was not anticipated (and was not issued) due to a "less buoyant environment" and "weaker instability".



SPC Day 1 Severe Weather Outlook



Severe Thunderstorm Watch



Mesoscale Convective Discussion

b. National Weather Service, Gaylord MI

Local National Weather Service (NWS) offices issue Hazardous Weather Outlooks (HWO) to highlight the potential for hazardous weather during the upcoming seven day period. NWS Gaylord issued a HWO at 4:38 pm EDT July 15 (over 2 days before the accident) which highlighted strong and potentially damaging thunderstorms Sunday night and Monday. The HWO specifically stated "any storms that do develop Sunday night and Monday may contain damaging winds."

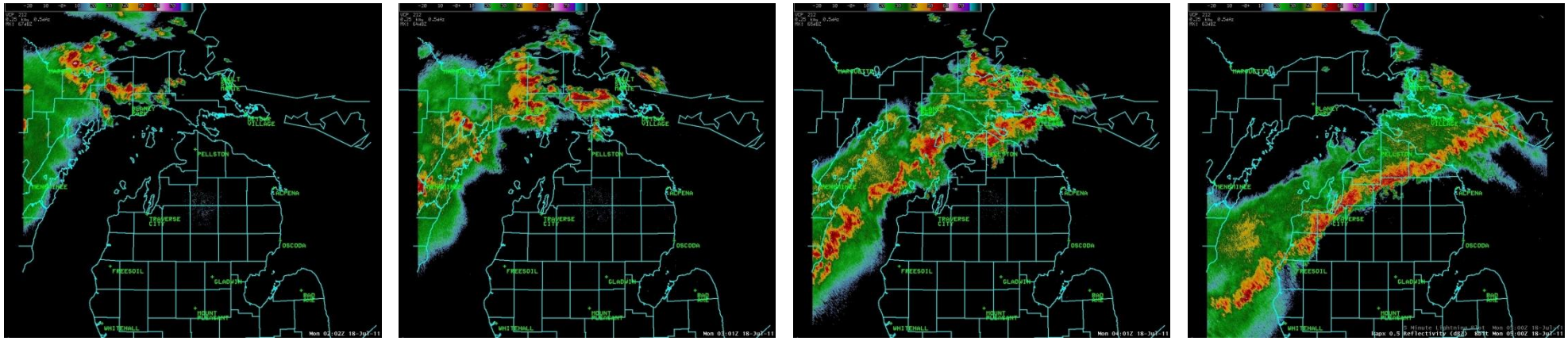
Sunday evening (July 17) NWS Gaylord issued Marine Weather Statements at 9:53 pm EDT (about 2 hours before the accident) and 10:47 pm EDT (about 1 hour before the accident) highlighting storms approaching the waters of northern Lake Michigan. These statements referenced winds of "30 knots or higher". These statements also indicated that these storms could "pose a serious hazard for boaters", and that "boaters should consider heading for shore before the storm arrives."

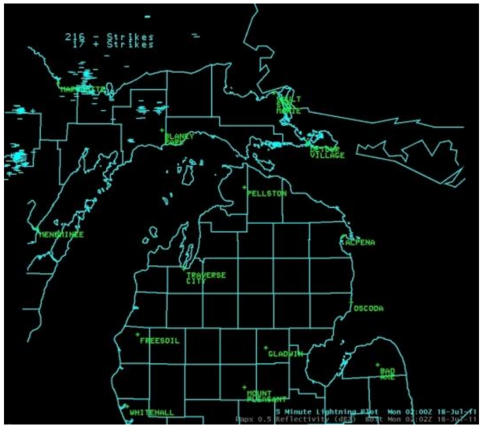
Finally, a Special Marine Warning was issued at 11:55 pm EDT (just before the accident) and referenced strong winds of "34 knots or greater". The warning also stated, "Mariners can expect gusty winds...high waves...dangerous lightning...and heavy rains. Boaters should seek safe harbor immediately...until these storms pass." Both marine weather statements and the special marine warning were broadcast on NOAA Weather Radio.

3. Overall Thunderstorm Evolution

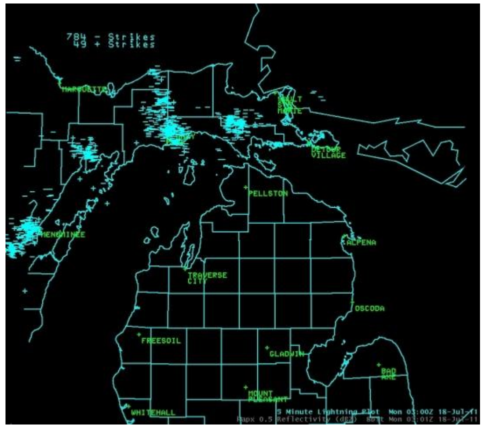
During the late evening of July 17, a disorganized cluster of thunderstorms over Wisconsin and Upper Michigan moved into Lake Michigan and eventually evolved into a line of thunderstorms that crossed northern Lower Michigan. From a radar perspective, the storms were initially somewhat disorganized and marginally severe. As the cluster of storms progressed into Lake Michigan, however, one particular cell rapidly developed and intensified just prior to midnight EDT. This storm (the evolution of which is described below) impacted the Fox Islands region very close to the location of the marine accident. The images below show this thunderstorm progression. Note the strong storm and concentration of lightning strikes near the Fox Islands around midnight EDT.

Thunderstorm Evolution (Radar Reflectivity is shown on top, Cloud-to-Ground Lightning Strikes is shown on bottom)

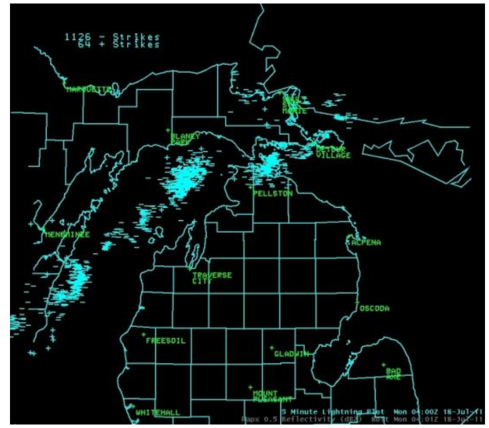




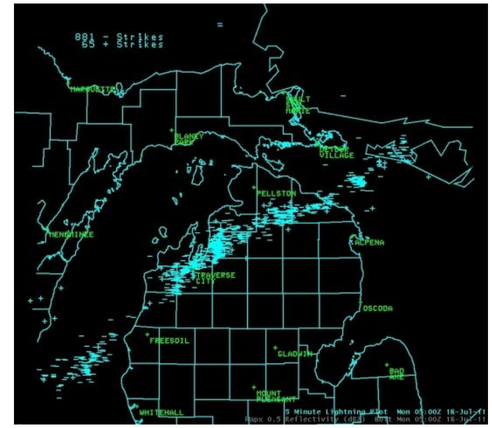
2200 EDT (10:00 pm)



2300 EDT (11:00 pm)



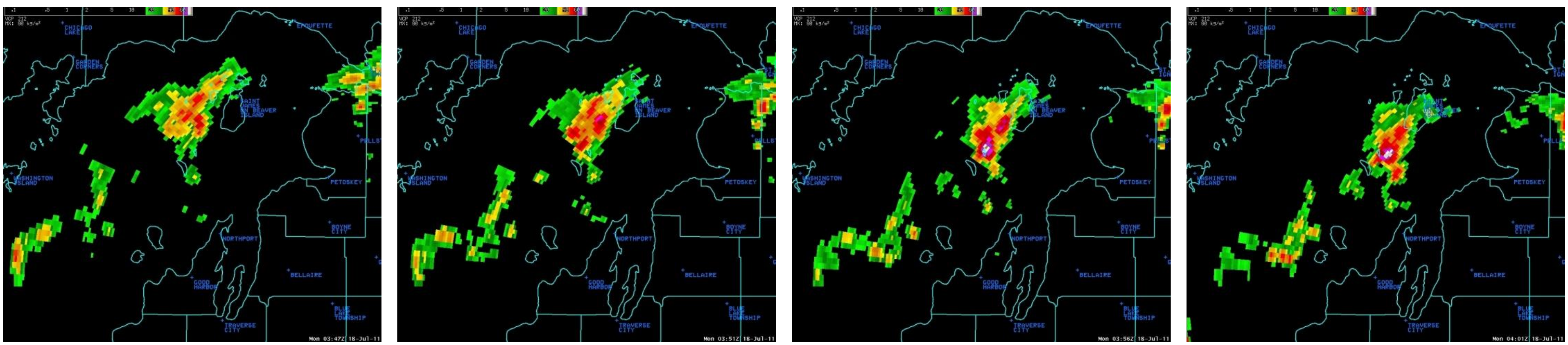
0000 EDT (12:00 am)



0100 EDT (1:00 am)

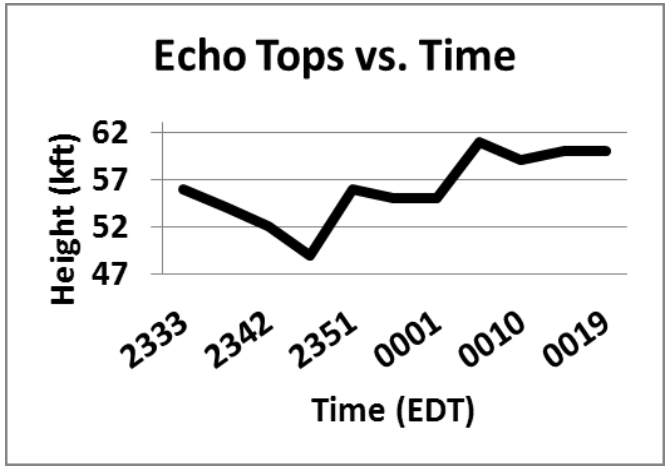
4. Individual Thunderstorm Cell Evolution

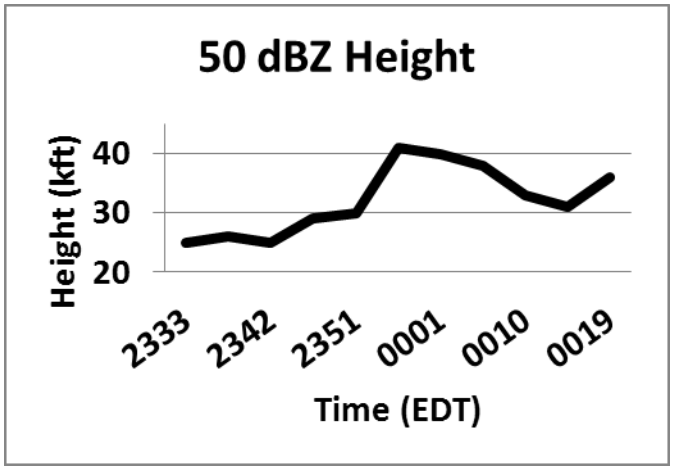
Within the eastward advancing cluster of thunderstorms, one cell underwent rapid development and intensification just prior to midnight. This evolution is captured in the series of "Vertically Integrated Liquid" (VIL) images shown below. VIL is a measure of the total amount of precipitation within the vertical storm column and can indicate changes in storm strength, as well as the likelihood of hail. Note in this time sequence the developing cell near the Fox Islands during the time leading up to midnight.

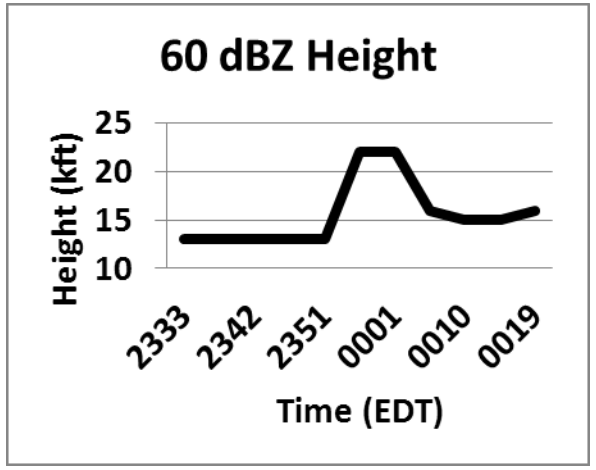


2347 EDT (11:47 pm) **2351 EDT (11:51 pm)** **2356 EDT (11:56 pm)** **0001 EDT (12:01 am)**

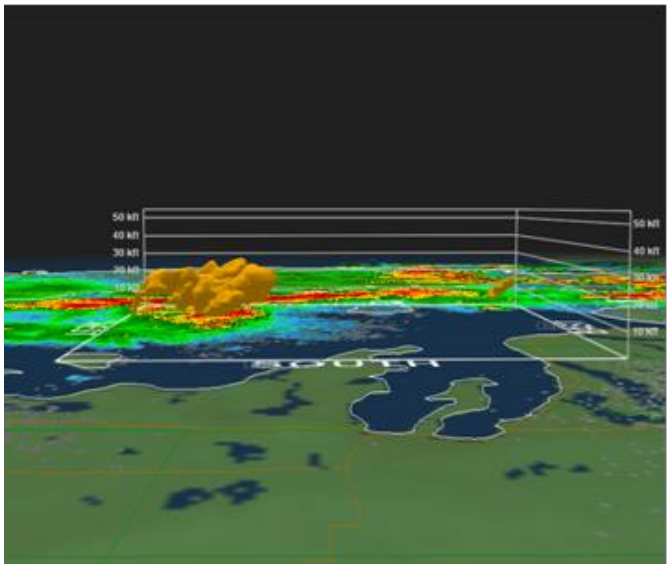
This storm strengthening was also shown in other radar characteristics that forecasters examine to infer storm structure and severity. For example, **Echo Top** (left image below) is the top of the storm as viewed by radar. Higher Echo Tops tend to produce stronger thunderstorms. **50 dBZ Height** (center image below) and **60 dBZ Height** (right image below) show the height of intense radar returns. The higher the 50/60 dBZ height is, the more likely a storm is to produce heavy rain and hail. This is also related to the ability of a storm to produce strong winds associated with downbursts.



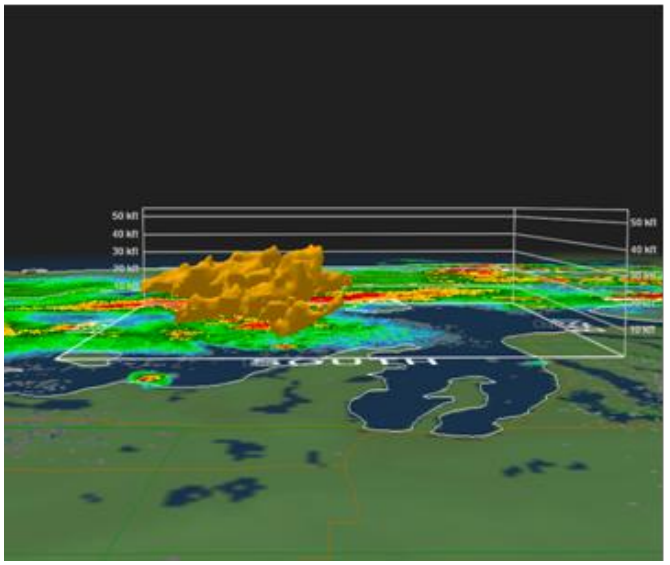




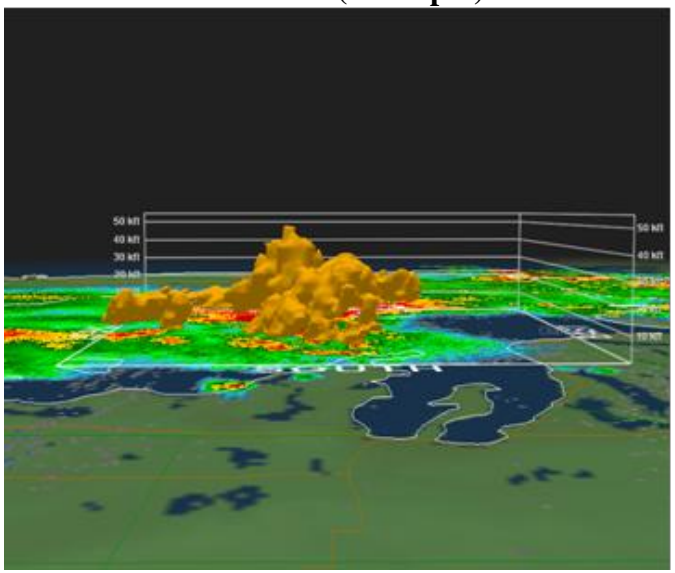
Below is a series of three dimensional perspectives of the 45 dBZ radar "isosurface". These images are looking north from just south of Traverse City MI. You can imagine this as an outline of the region of heavy precipitation within the thunderstorms. Note how one cell builds rapidly upward between 11:38 pm and 11:56 pm EDT, indicating a strengthening storm.



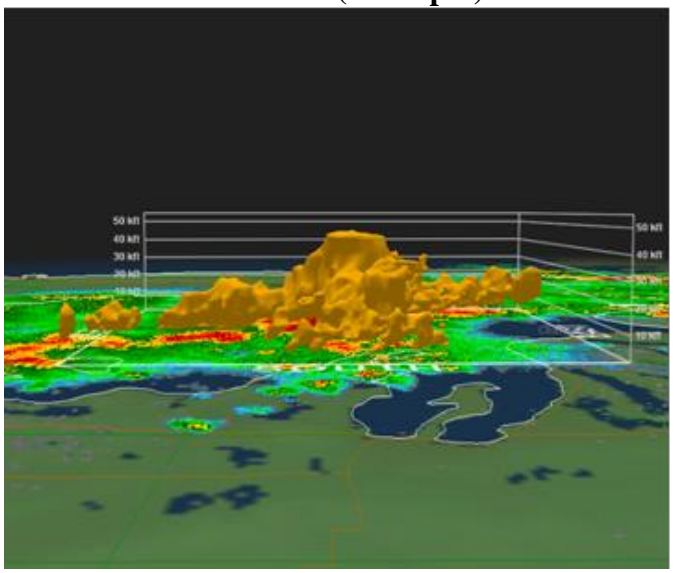
2338 EDT (11:38 pm)



2347 EDT (11:47 pm)



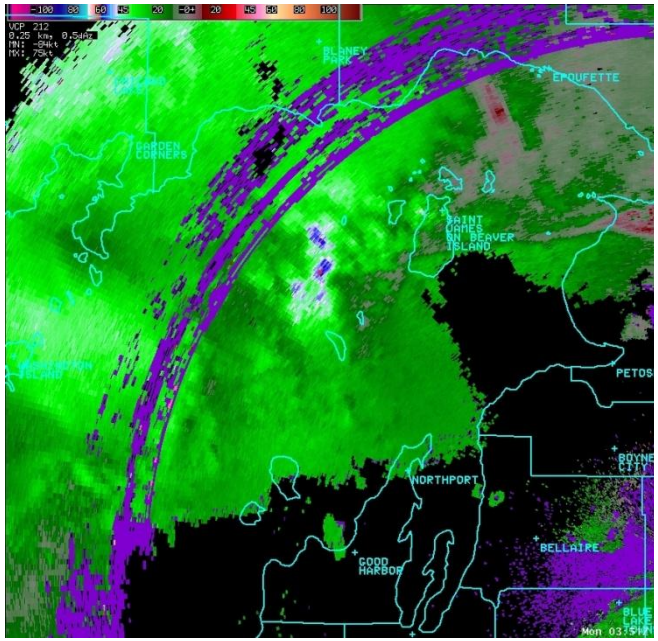
2356 EDT (11:56 pm)



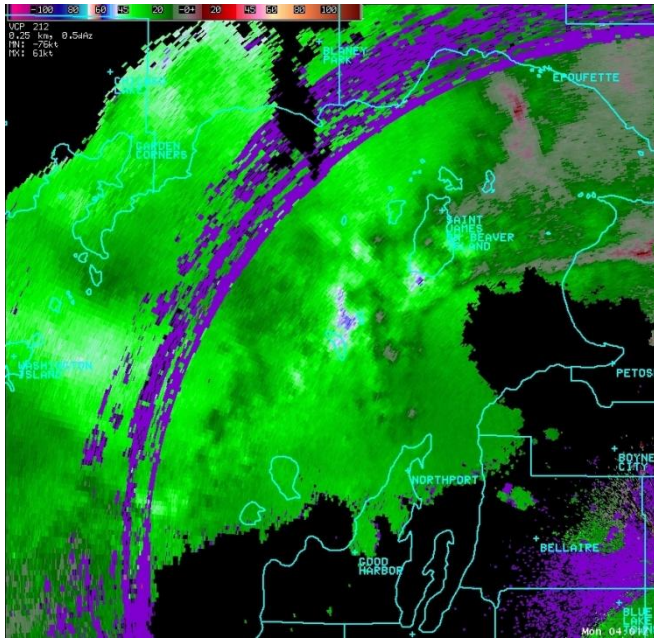
0005 EDT (12:05 am)

5. Evolution of Strong Winds

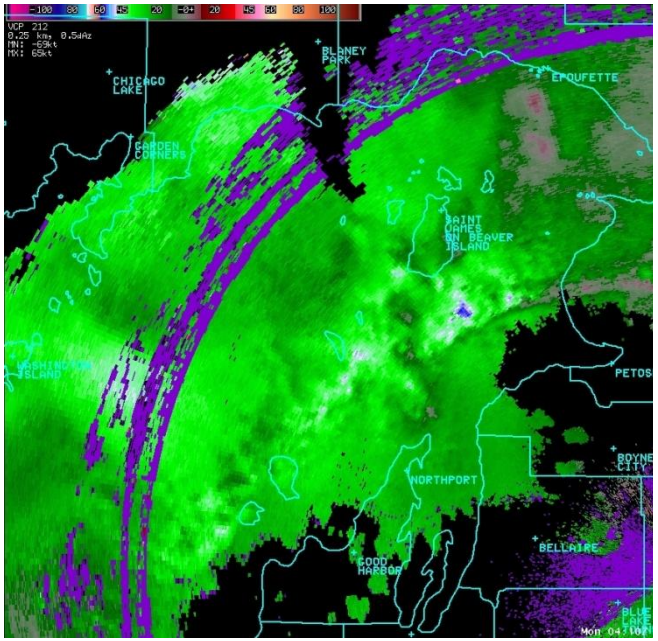
Several small areas of strong low-level winds were associated with the complex of thunderstorms crossing Lake Michigan. The images below show ground-relative radial wind velocity from the Gaylord WSR-88D. Note the small areas of stronger winds passing between Beaver Island and the Fox Islands with radial velocities of 55 to 60 knots (these are the small pockets of blue within the otherwise green color pattern). It is important to note that while these wind velocities are at the lowest level detectable from the Gaylord radar, they are not ground level winds. Due to how the radar operates, the wind velocities near the Fox Islands represent winds at roughly 5,000-6,000 feet above ground (lake) level. There is no way to directly measure the winds at the surface outside of the observations. However, given the 11:38 pm EDT measurement of 45 knots at the northern Lake Michigan buoy about 30 miles southwest of the Fox Islands (not to mention the subsequent eyewitness accounts) it is certainly reasonable to assume that winds of around 55 to 60 knots reached the lake surface.



2351 EDT (11:51 pm)



0001 EDT (12:01 am)



0010 EDT (12:10 am)

6. Conclusion

Strong thunderstorms impacted much of central and northern Lake Michigan during the late evening and overnight hours of July 17-18. Radar data suggests the strongest storms occurred within a corridor from near the northern Lake Michigan buoy, east-northeast to the vicinity of the Fox Islands and Beaver Island, then east to near Charlevoix. The rapid intensification of one cell in the vicinity of the Fox Islands – as noted by VIL, Echo Top, and the growth and subsequent decay of the 50-60 dBZ reflectivity cores – suggests a downburst likely occurred very close to the time and location of the marine accident. This downburst would have significantly enhanced the winds within the thunderstorm complex.