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# The 25-26 February 2010 Damaging New England Windstorm

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ABSTRACT

*The cyclone that affected northern New England on 25-26 February 2010 brought considerable snow, flooding rain and most significantly, damaging winds to the region. In New Hampshire alone, over 270,000 customers lost power, making it the state's second worst storm on record in terms of outages.*

*Mid-latitude cyclones frequently produce strong winds in New England during the cool season. However, impacts of the magnitude observed on 25-26 February 2010 are uncommon. The 925 hPa and 850 hPa U wind components were as much as five standard deviations below normal. This resulted in widespread wind damage being observed.*

*What makes this storm so unique as opposed to other strong cyclones that have affected New England are its synoptic and mesoscale aspects. This storm showed characteristics of a Norwegian cyclone as well as a Shapiro-Keyser cyclone. However, the data available does not definitively put it in either category. The storm occurred overnight, when the atmosphere is usually decoupled sufficiently, producing a stable layer and preventing stronger winds aloft from reaching the surface. In addition, the damaging winds came from the east and northeast, indicating that this storm was not a typical Norwegian cyclone. Typically cool season damaging winds are from the west and associated with a cold front*

*The purpose of this paper is to document this event as completely as possible, highlighting the anomalous nature of this storm. Surface observations, radar imagery and other real time tools were used to track the system and associated damaging winds across coastal sections of northern New England. Other factors of this impressive storm are examined such as snow, rainfall, and coastal and marine impacts.*

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## 1. Introduction

A strong extratropical cyclone affected northern New England on 25-26 February 2010, resulting in significant snow, flooding rain and damaging winds to the region. Wind damage was reported along the New England coast from near Boston, MA to Quoddy, ME, and as far inland as Concord, NH (NCDC 2010). In New Hampshire alone, over 270,000 customers lost power as thousands of trees were downed, making it the second worst storm recorded in terms of power outages in New Hampshire (Fig. 1). There were almost five times more outages than the January 1998 ice storm. There were several reports of wind gusts in excess of 78 kt (90 mph) (Fig. 2), and the Portland, Maine (PWM) ASOS observed its highest wind gust ever recorded (records date back to 1940) , 68 kt, or 78 mph prior to losing commercial power. (Table 1). It is conceivable a higher gust may have occurred and was not recorded as commercial power went out briefly at PWM late on the 25.th

It is not unusual for extratropical cyclones to produce strong winds in New England during the cool season (October through May). Typically, the strongest winds associated with cyclones occur following the passage of the cold front, where less stable conditions allow turbulent momentum transfer in the colder air. The timing of the damaging winds with the cyclone in this study (late evening 25 February 2010 and early morning 26 February 2010) and the wind direction (east to northeast) suggest that this cyclone was not a typical extratropical cyclone for New England. The extent of the wind damage, as well as the wind direction associated with the wind damage, was characteristic of cyclones that usually affect the west coast of North America (Mass and Dotson 2010) or Western Europe (Wernli et al 2002).

The Shapiro-Keyser cyclone model (Shapiro and Keyser 1990) offers an alternative process for cyclone development to the Norwegian cyclone model (Fig. 3a and 3b). In this model, the weaker cold front remains nearly perpendicular to the stronger warm front. The warm frontal zone is advected around the cyclone center, forming a bent-back front (Fig 3b). Frequently, the strongest winds are closely aligned on the cold side of the bent-back front. Damaging winds, when they do occur across New England, are generally from the northwest, during the afternoon and evening hours, and accompanied by the passage of a cold front. While there was not enough data to conclude whether this was a Shapiro-Keyser cyclone or perhaps a hybrid, the fact that the damaging winds came from the east and northeast and occurred overnight, both from an atypical direction and at an atypical time for high winds, suggests that the Shapiro-Keyser cyclone model could explain the damaging wind pattern in this event.

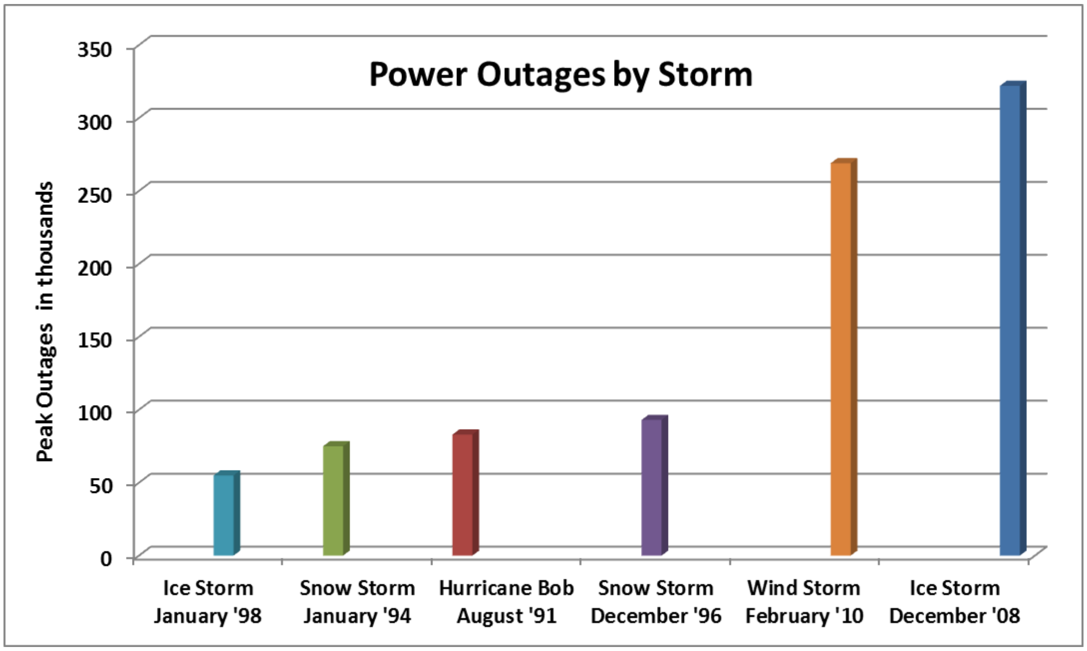


**Figure 1.** Peak number of Public Service of New Hampshire (PSNH) customers in New Hampshire without power per storm (PSNH 2013).

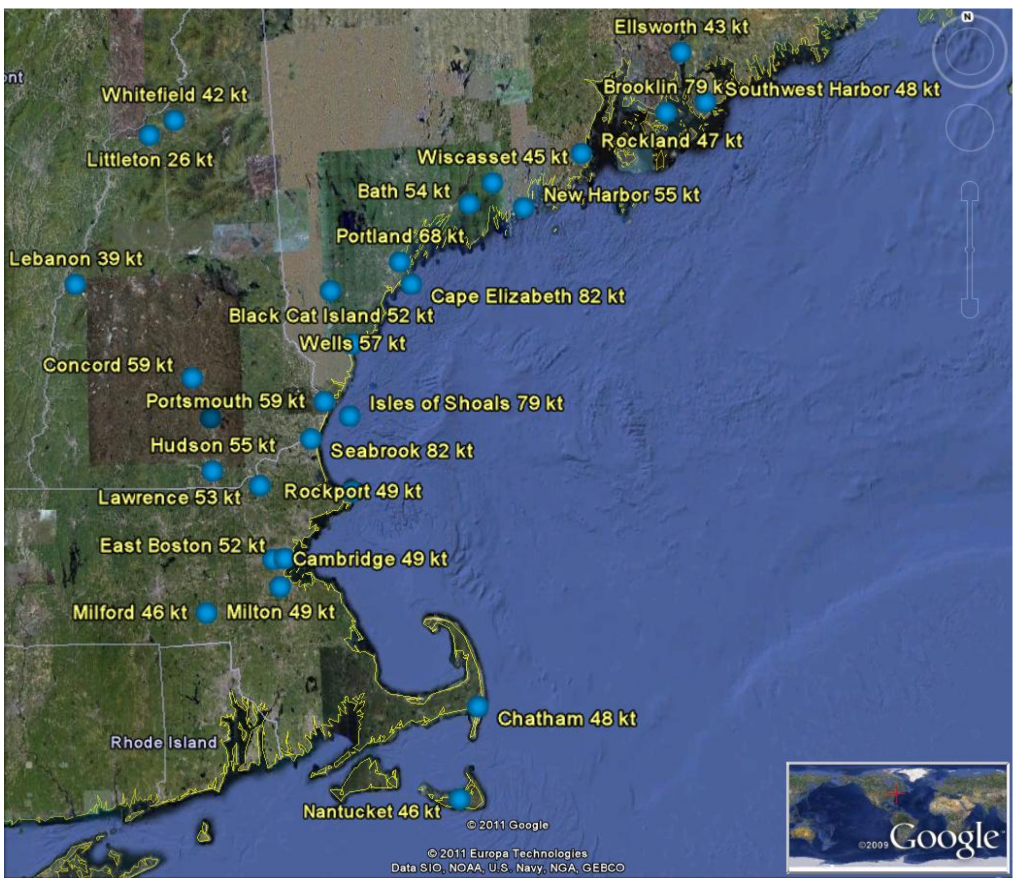


**Figure 2.** Plot of peak wind gusts (knots) on 25-26 February 2010. Sensors are at different heights which are listed in Table 1.

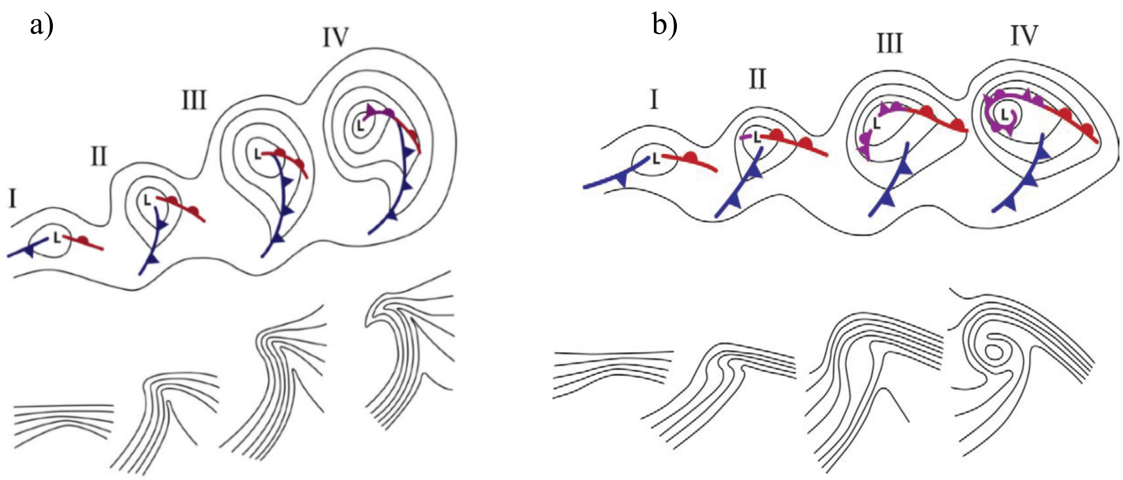


**Figure 3.** (a) The Norwegian cyclone model and the (b) Shapiro-Keyser model. In 3a, (I) is the incipient wave, (II) is the development phase, (III) shows the beginning of the occlusion phase and (IV) shows the cyclone fully occluded. The bottom images on the left show the orientation of the isentropes. Like the Norwegian cyclone model, the process for the Shapiro-Keyser cyclone in 3b. starts with the incipient wave (I). The frontal fracture follows (II) as the cold front remains perpendicular to the warm front. The bent-back phase follows (III) with the warm seclusion (IV) ending the process. The blue lines represent surface winds on the cool side of the cyclone, and red lines depict surface winds in the "warm sector" of the cycle. From Schultz and Vaughn (2011).

## 2. Case Overview and Impacts

*a. Synopsis*

A strong cyclone affected New England on 25-26 February 2010 after deepening quickly off the mid-Atlantic coast (Fig. 4). This storm caused widespread wind damage, damaged coastlines, and spread significant amounts of snow and rain across the region. The following sections outline the outcome and damages that occurred across New England.

*b. Precipitation Totals and Impacts*

This storm produced impressive rainfall and snowfall amounts across New England as onshore-oriented flow brought high moisture values into the region. Rain and snowfall amounts were gathered from automated surface observation stations (ASOS), Community Collaborative Rain, Hail, and Snow (CoCoRaHS) volunteers, and NWS cooperative observer reports.

Rainfall amounts were highest on the coast and ranged from a maximum of six to eight inches centered near South Portland to two to three inches over inland areas (Fig. 5). Flooding was reported on streams and rivers in Sagadahoc, Lincoln, and Knox Counties, all along the coast. In addition, flooding occurred on the Presumpscot River in Westbrook and Portland, Maine (NCDC Storm Data). Several homes and businesses were flooded causing $125,000 in damages, according to

Storm Data (NCDC Storm Data). The river crested 8.5 feet above flood stage.

Snowfall amounts were found on the cold side of the system, generally from the western Maine Mountains to the White Mountains of New Hampshire and the Green Mountains of Vermont (Fig. 6). The highest amounts topped two feet in northern and central Vermont. Snowfall amounts tapered off quickly towards the warmer air located near the coast.

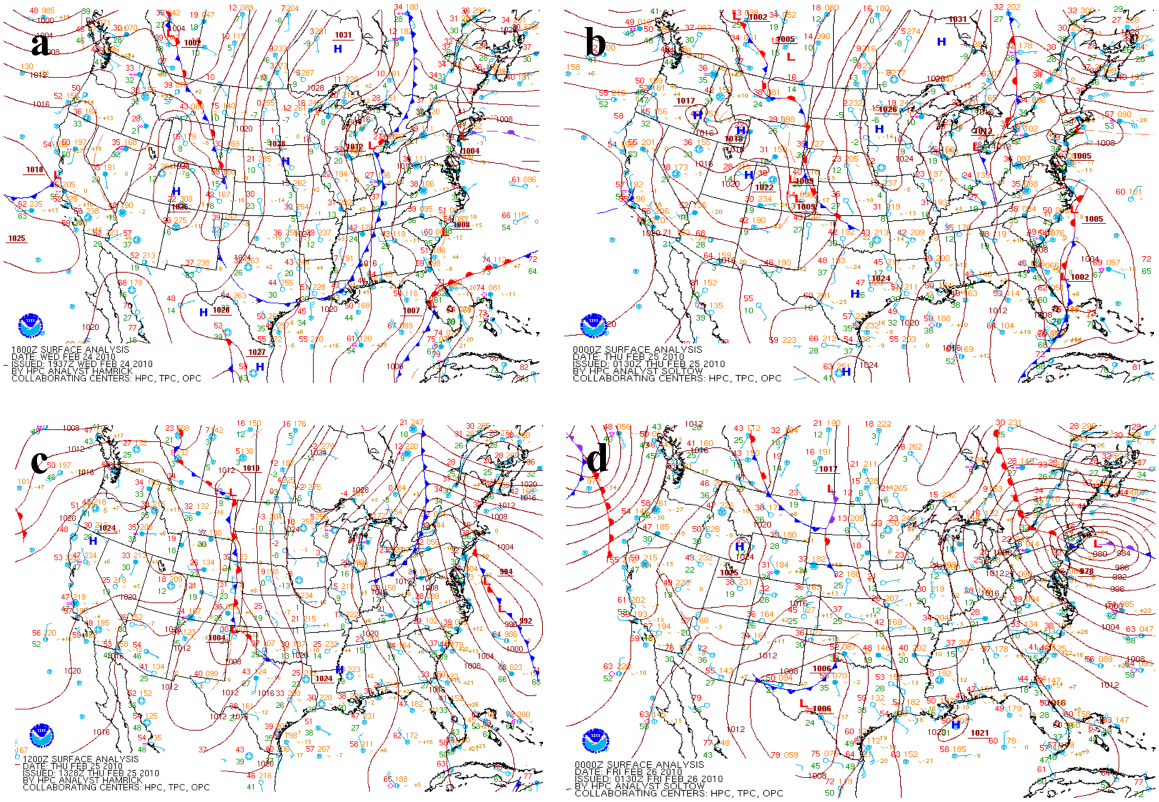


**Figure 4**. Hydrometeorological Prediction Center (HPC) surface pressure analysis from (a) 18 UTC 24 February 2010, (b) 00 UTC 25 February 2010, (c) 12 UTC 25 February 2010, and (d) 00 UTC 26 February 2010.

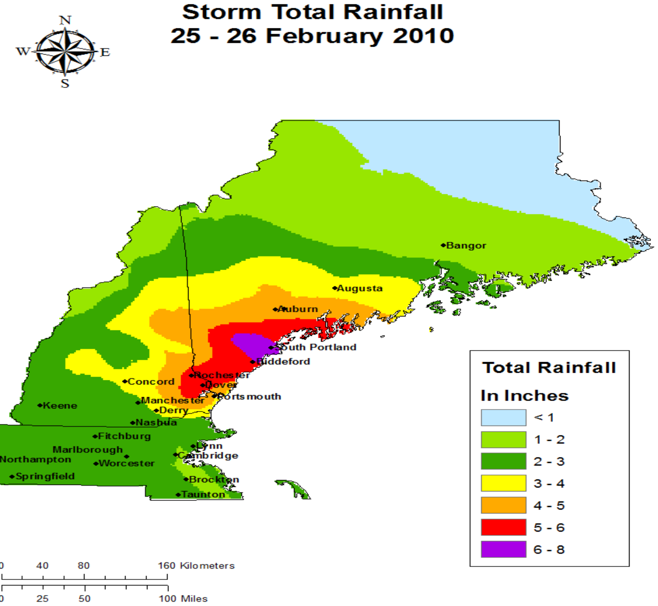


**Figure 5.** 24-hour rainfall (in) ending 0000 UTC 26 February 2010.

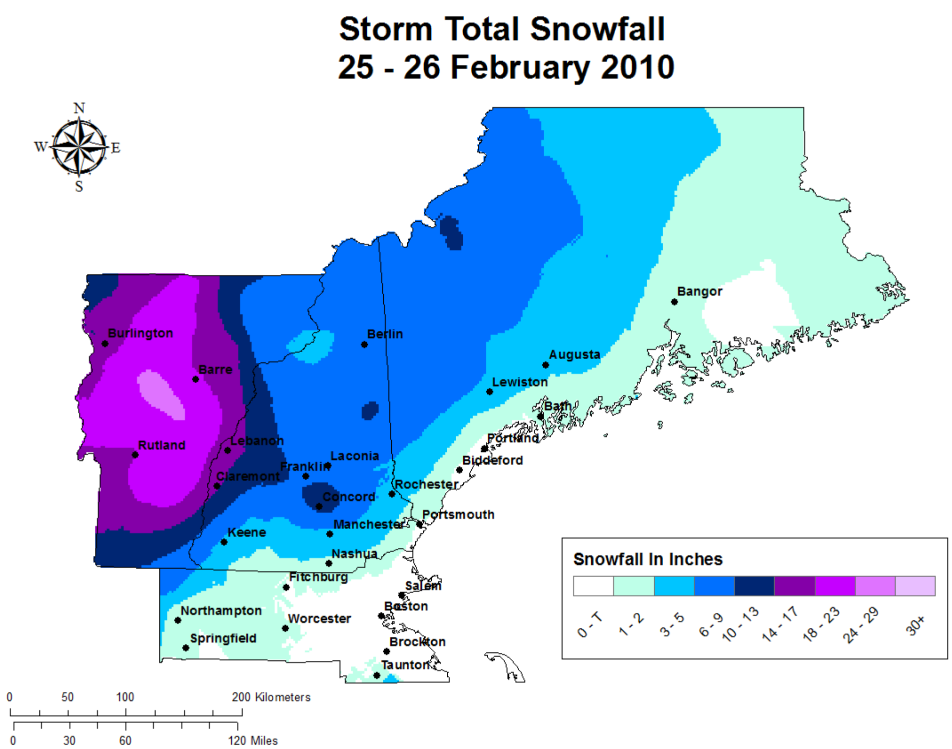


**Figure 6.** Storm Total Snowfall from 25-26 February 2010.

*c. Coastal Flooding and Impacts*

Prolonged south and southeast winds during the time leading up to the event contributed to widespread coastal flooding, splash-over, and erosion. Long period swells were slow to subside, causing minor flooding in Portland and Saco, Maine (NCDC Storm Data).

Storm surge with this event peaked at 2.7 feet around high tide during the evening of 25 February (Fig. 7). This was the 17$^{th}$ highest tide recorded at PWM (Table 2). Even though the astronomical high tide was only 8.8 ft, the addition of the storm surge resulted in a storm tide of nearly 12 ft with seas of 23 ft, caused significant flooding in low-lying communities such as Saco, Kennebunk, and Kennebunkport, Maine (NCDC Storm Data). A peak wind gust of 79 kt at Isles of Shoals generated waves as high as 32 ft.

Coastal damages were reported at beaches and seacoasts across New England (NCDC Storm Data). Homes and seawalls sustained significant damage. Rocks and other debris were washed onto coastal roads.

*d. Wind Gusts*

While the 1800 UTC 25 February 2010 HPC surface analysis lacked enough observations to definitively determine that the occlusion process had commenced, the 1945 UTC 25 February 2010 IR image showed cloud structures suggestive of an occlusion (Fig. 8). This assessment is based largely on the weakening cold front structure on the satellite image (indicated by the low level stratocumulus south of the cyclone) and the cooling clouds tops north of the low level warm front.

The 0000 UTC 26 February 2010 surface analysis showed the warm front extending from the surface low back into southwest Connecticut and southeast New York (Fig. 9a). The 0000 UTC 26 February 2010 925 hPa and 850 hPa analyses implied the strongest warm air advection over southeastern New England (Fig. 10a and 10b). At both the surface and 850 hPa, the strongest pressure gradient was north of the surface cyclone. Surface-based winds on the west and southwest side of the surface cyclone were gusting between 25 and 30 kt.

The 0000 UTC 26 February 2010 observed sounding for Gray ME (GYX) showed the top of the mixed boundary layer at 860 m (2250 ft; Fig. 11a). The wind at the top of the mixed layer was 69 kt (79 mph). An Aircraft Meteorological Data Relay (AMDAR) sounding from Logan International Airport (BOS) at 0255 UTC 26 February 2010 (Fig. 11b) showed an east northeast wind of 60 kt at 330 m (1000 ft). It is likely that because the high winds resided at the top of the mixed layer, all that was needed was forcing to bring the momentum to the surface (Fig. 11a).

The 0300 UTC 26 February 2010 surface analysis showed that the bent-back front extended across southeast New England (Fig. 9b).

As the storm approached eastern Massachusetts, Gulf of Maine Ocean Observing System (GoMOOS) Buoy A, located in the eastern Massachusetts Bay, recorded a three-hourly pressure fall of near 10 hPa. The peak wind gust measured at GoMOOS Buoy A (57 kt, 66 mph) occurred just before the minimum central pressure was observed (Figs. 12a and 12b).

At 0400 UTC February 26 2010, the warm front stretched from central Massachusetts through southeast New Hampshire (Fig. 9c). The frontal position placed the best pressure gradient across southern New Hampshire and southwest Maine. As the front approached the NOAA Coastal-Marine Automated Network (C-MAN) platform on the Isles of Shoals NH (IOSN3), the pressure dropped 10 hPa in three hours. As was the case with the GoMOOS buoy in Massachusetts Bay, winds backed just ahead of the strong pressure falls. The peak wind observed at IOSN3 (79 kt, 91 mph) occurred at about the same time as the minimum pressure (Figs. 12c and 12d).

A peak wind of 82 kt (94 mph) was recorded at the Seabrook Nuclear Power Plant in Seabrook NH at 0300 UTC 26 February 2010. Other peak wind speeds observed in New Hampshire include 59 kt (68 mph) at the ASOS at Concord NH and by an observer at the Pease International Tradeport in Portsmouth NH (PSM). The high winds brought down thousands of trees, which caused extensive damage to power lines and equipment (PSNH 2013). It was the second-worst storm in terms of outages in the history of Public Service of New Hampshire (second only to the ice storm of December 2008).

High winds also affected southwest Maine between 0300 UTC and 0400 UTC 26 February 2010. A peak wind of 82 kt (94 mph) was recorded at Cape Elizabeth ME (Fig. 2). The ASOS at the Portland International Jetport (PWM) reported a peak wind gust of 68 kt (78 mph). To account for the fact that these wind sensors are at different heights, they were standardized to 10 m using the method described by Thomas et al (2004) and recorded in Table 1.

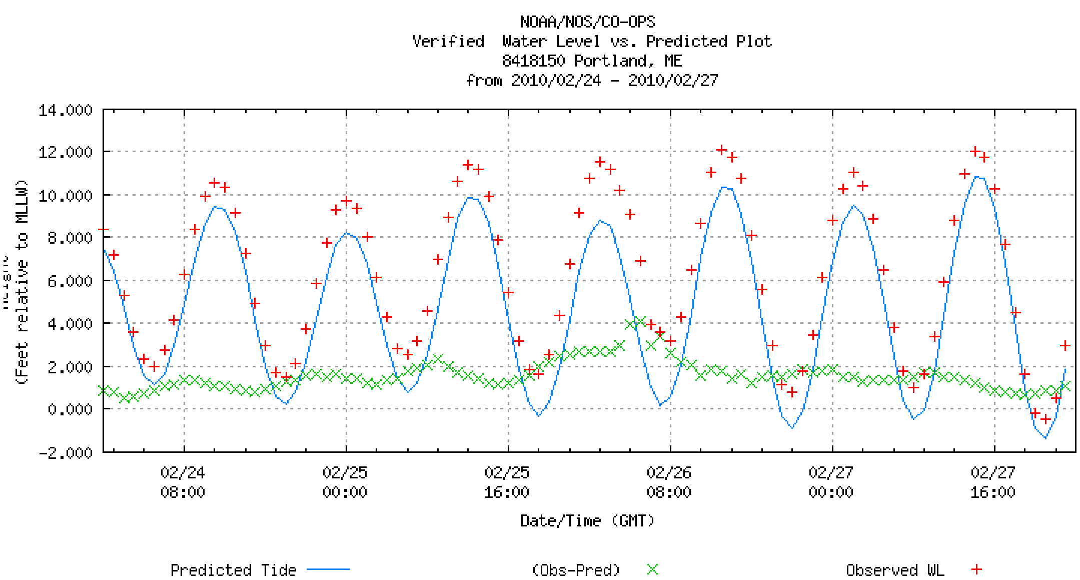


**Figure 7.** The observed high tide versus the predicted high tide along with the difference between the two at Portland, ME, relative to the Mean Low Level Water (MLLW). The highest storm surge was 2.7 feet.

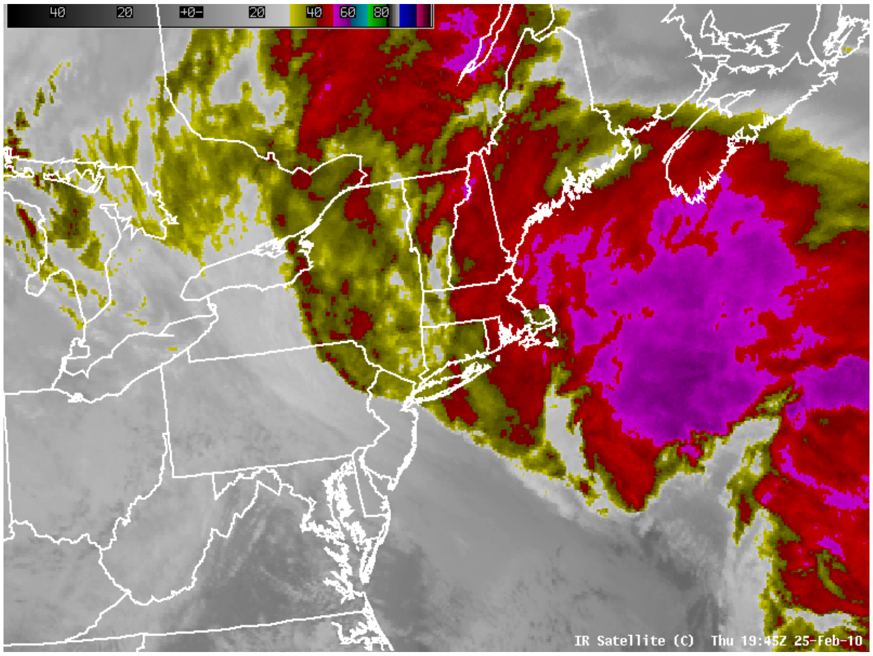


**Figure 8.** IR satellite image for 25 February 2010 at 1945 UTC.

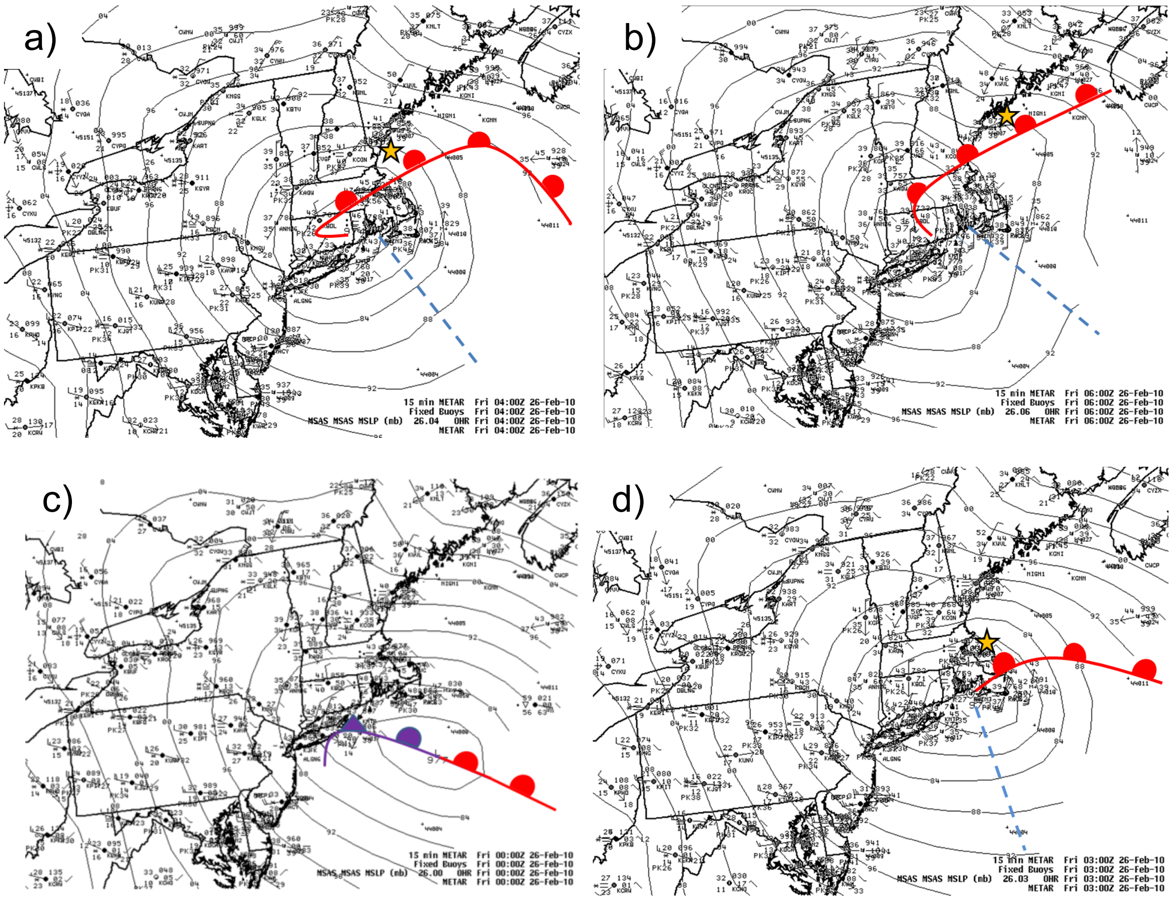


**Figure 9.** (a) 0000 UTC 26 February 2010 Multi-Functioning Satellite Augmentation System (MSAS) surface analysis; (b) 0300 UTC 26 February 2010 surface analysis. The gold star denotes the location of the GoMOOS Buoy A, located in eastern Massachusetts Bay; (c) 0400 UTC 26 February 2010 surface analysis. The gold star denotes the location of the C-MAN station at the Isles of Shoals, NH (IOSN3); and (d) 0600 UTC surface analysis. The gold star denotes the location of GoMOOS Buoy E.

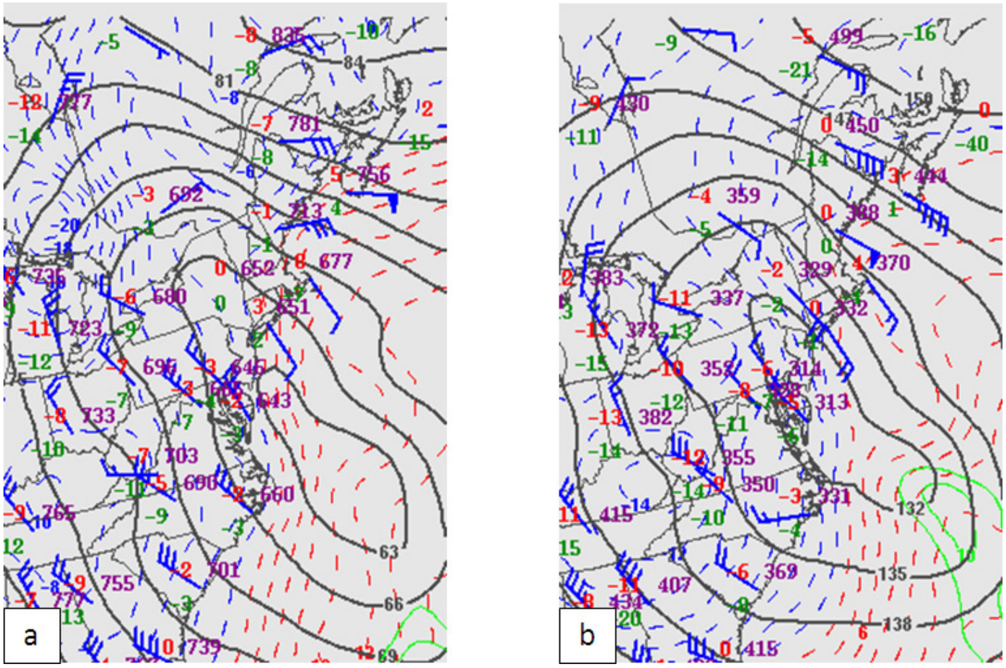

**Figure 10.** (a) 1200 UTC 25 February 2010 SPC 925 hPa analysis (b) and 850 hPa analysis.

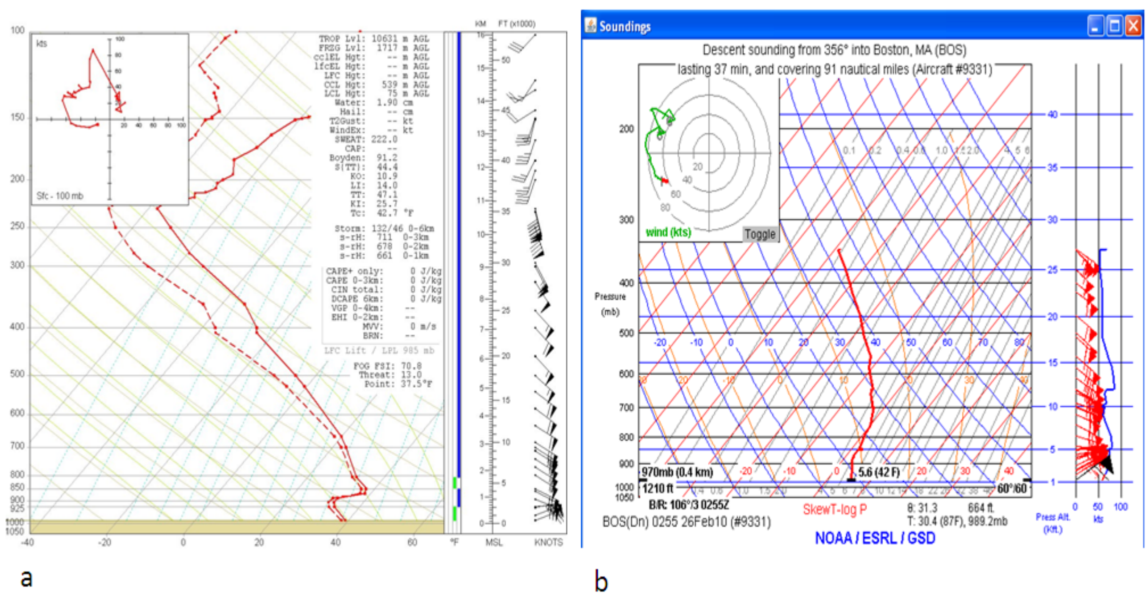


**Figure 11.** (a) 0000 26 February 2010 UTC Gray ME (GYX) observed sounding and (b) the 0255 UTC 26 February 2010 AMDAR sounding from Logan International Airport (BOS).

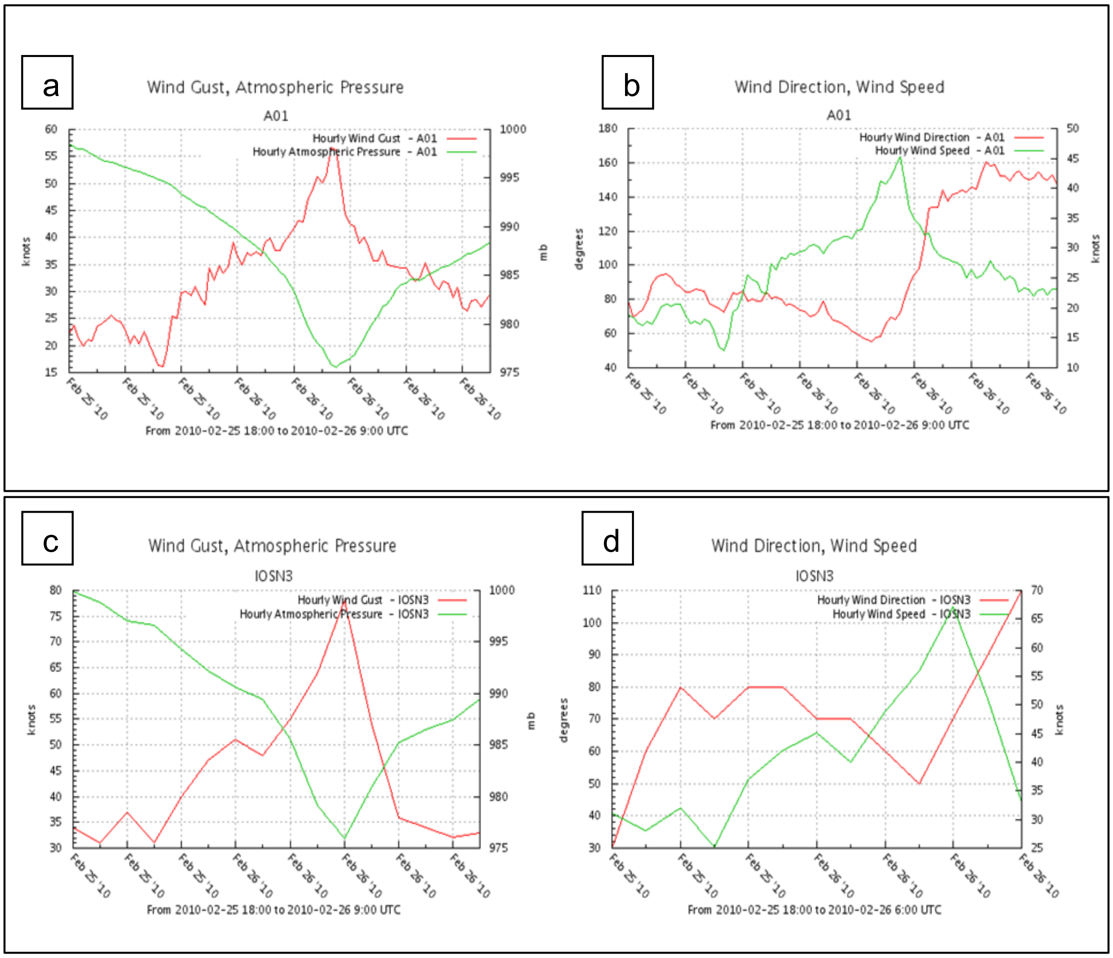


**Figure 12.** (a) Hourly wind gust and atmospheric pressure and (b) wind direction and wind speed at GoMOOS Buoy A, located in eastern Massachusetts Bay; (c) hourly wind gust, atmospheric pressure, (d) wind direction, and speed at the C-MAN located at the Isles of Shoals, NH.

By 0600 UTC 26 February 2010, the bent-back front extended across the coastal waters of central Maine (Fig. 9d). GoMOOS Buoy E is denoted as a star in Fig. 9d. At this location, unlike the other ocean observing platforms, the peak wind occurred prior to the minimum central pressure reading (Fig. 13). A secondary peak wind gust occurred coincident with the lowest pressure reading.

At 0631 UTC 26 February 2010, The IR satellite image (the first photograph available after the nocturnal satellite imager eclipse period) showed the coldest cloud tops well north and west of the cyclone center (Fig. 14).

By 0700 UTC 26 February 2010, the surface analysis showed two areas of strong pressure gradients (Fig. 15). The first was located across central and eastern Maine. A peak wind of 47 kt was reported by the GoMOOS Buoy I (denoted by a star in Fig. 15), and a peak wind of 65 kt was reported by a mesonet site in West Quoddy ME. However, there were not as many peak wind gust reports across this area as there were further south and west, possibly due to power outages.

The other area of a strong pressure gradient was located over southeast New England. The cold conveyor belt wrapped completely around the surface cyclone, producing strong wind gusts of 45 kt at Block Island, RI (KBID) and 41 kt at Martha's Vineyard MA (KMVY). Further southwest, across southeast New York, New Jersey and eastern Pennsylvania, peak wind gusts from the west ranged between 25 and 35 kt.

At 0900 UTC 26 February 2010, the surface cyclone backed into southeast New York (not shown). Again, there were two areas of strong pressure gradients. The first was located across the easternmost Maine and New Brunswick province in Canada. NOAA buoy 44027 recorded a peak wind gust of 45 kt, but again due to power outages, few other surface based observations were available. The other region was located across southeast New England. However, peak wind speeds were generally less than 40 kt. The surface cyclone was in the process of weakening, as the minimum central pressure increased 3 hPa in three hours.

By 1200 UTC 26 February 2010, the surface cyclone continued to weaken (not shown). The pressure gradient had also weakened with peak wind gusts generally less than 35 kt.

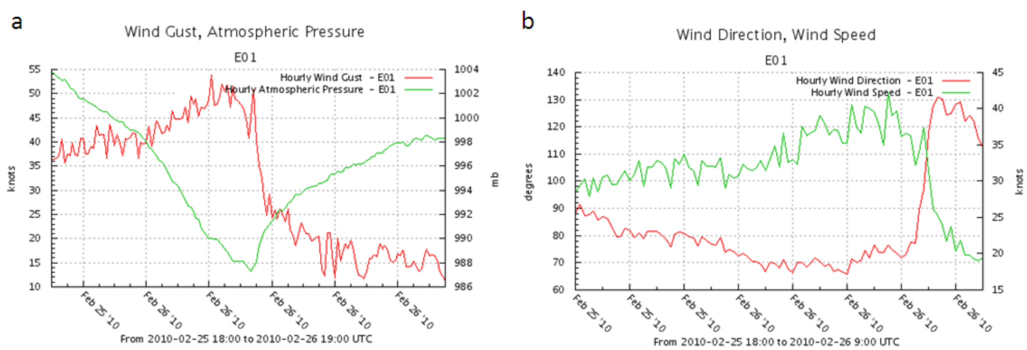


**Figure 13.** (a) Hourly wind gust and atmospheric pressure (b) and wind direction and wind speed for GoMOOS Buoy E, located on the central Maine shelf.

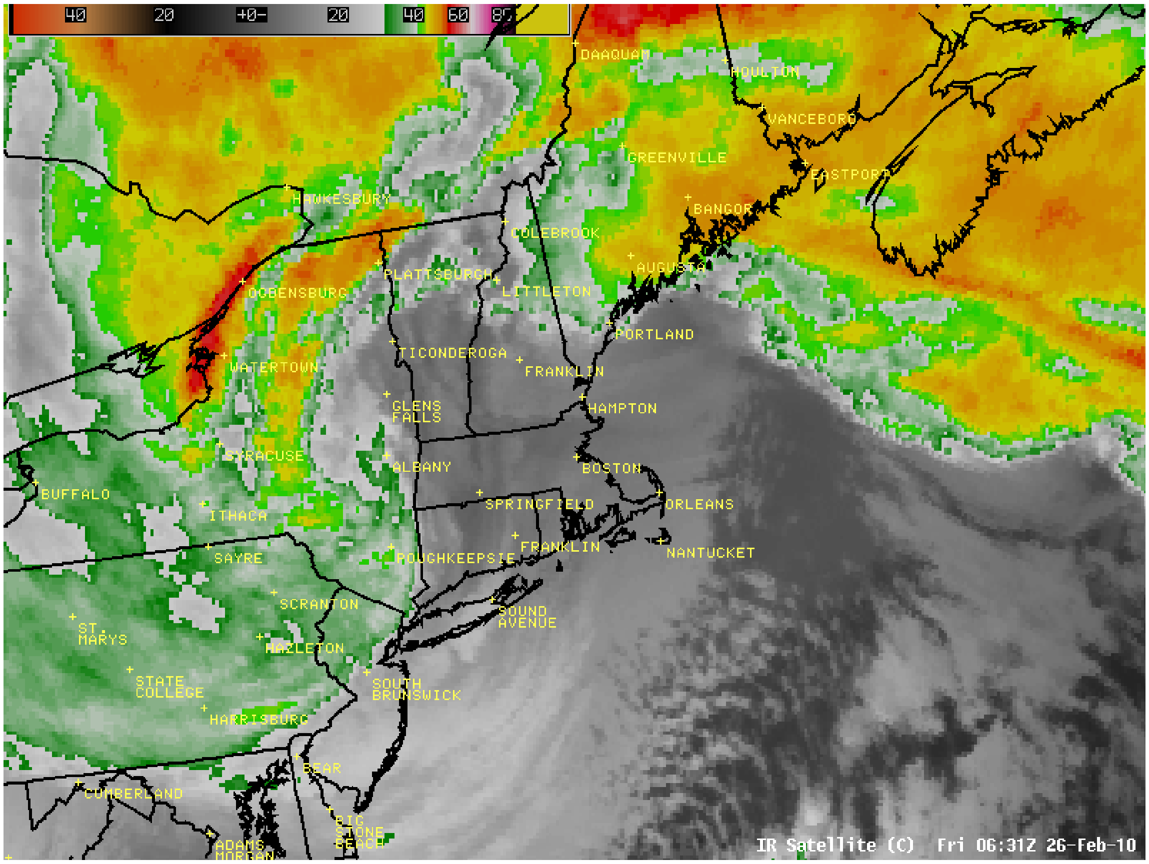


**Figure 14.** 0631 UTC February 2010 IR satellite image. Notice the low level stratocumulus south of the cyclone indicating that the cold frontal structure is weakening.

## 3. Synoptic Overview

*a. Storm Development*

Mean sea level pressure patterns in the days immediately prior to 25 February 2010 showed high pressure over the central United States with low pressure over the east coast (Fig. 4). A strong baroclinic zone stretched from southern Quebec towards the southeastern United States and Texas before turning north along the Rocky Mountains. A string of low pressure circulations were staggered along the east coast (Fig 4a).

The cyclone that would ultimately produce the damaging winds over New England had deepened another 10 hPa east of the Mid-Atlantic coast between 0000 UTC and 1200 UTC 25 February 2010 (Fig. 4b and 4c). Twelve hours later the low had developed into a 974 hPa storm and was located about 125 miles south of Cape Cod (Fig. 4d). The 0000 UTC 26 February 2010 HPC surface analysis showed the cyclone was in the occlusion process as the cold front overtook the warm front, forcing warm air aloft (Fig. 4d).

The temperature analyses at 925 hPa and 850 hPa (Fig. 10a and 10b) both implied strong warm air advection over New England. This helped to produce anomalously strong onshore flow which likely contributed to the extent of the damaging winds.

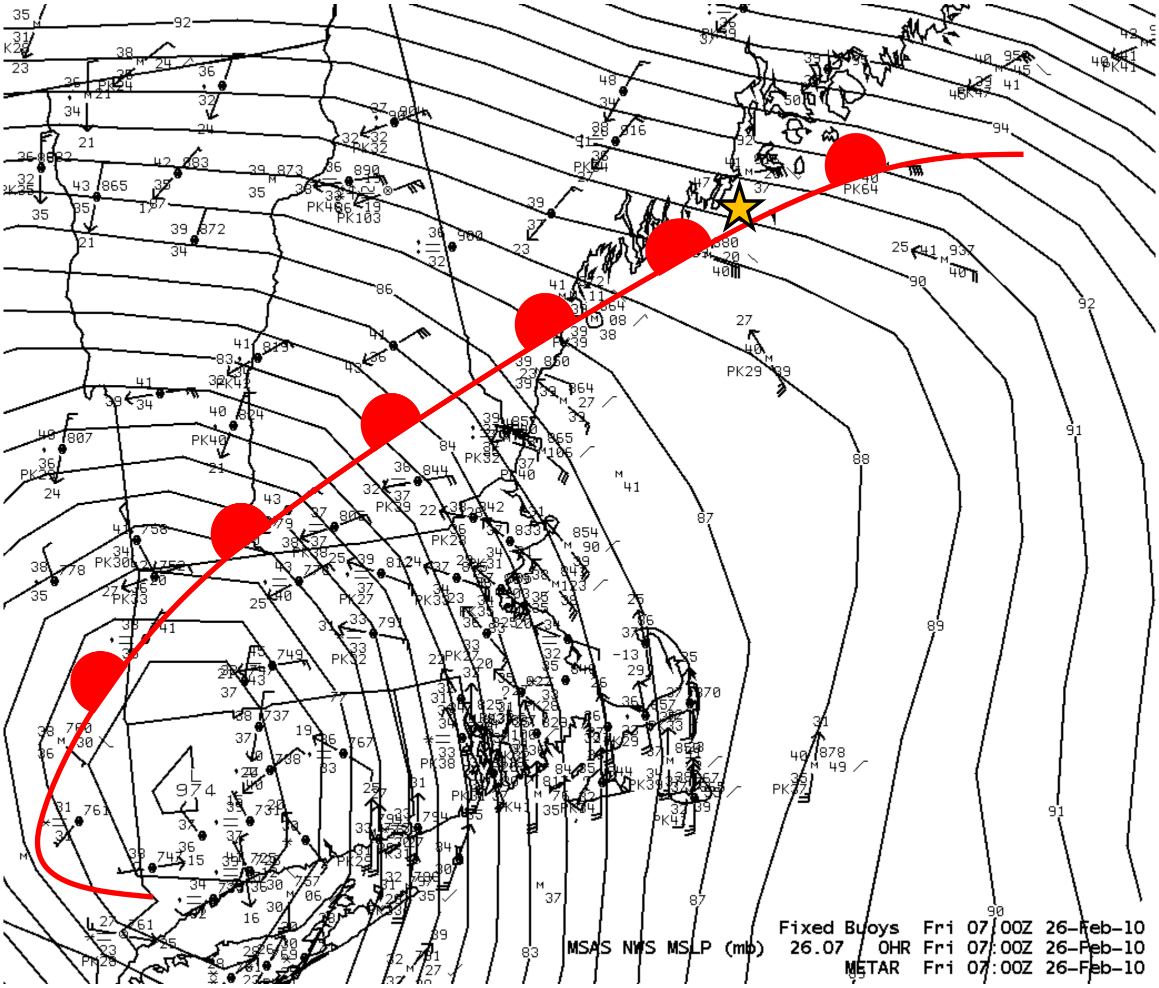

**Figure 15.** 0700 UTC surface analysis. The strongest winds were occurring across the central and eastern Maine coasts, as well as over the coastal waters. However, there were few observations available, due to power outages. The gold star denotes the location of GoMOOS buoy I.

In the days leading up to 25 February 2010, upper level large-scale troughing was in place over most of the United States. As a ridge came ashore on the California coast, the flow became more meridionally amplified. The 500 hPa analysis at 1200 UTC on 23 February 2010 showed a southern stream short wave digging into New Mexico (Fig. 16). This short wave would play an important part in the evolving system, eventually phasing with a sharpening trough over the Midwest. NAM 00-hr forecasts output on a 40 km grid (NAM40) were used to estimate the position of 500 hPa features including vorticity maximums. The NAM40 was used for its sufficient depictions of large scale features and the completeness of the dataset.

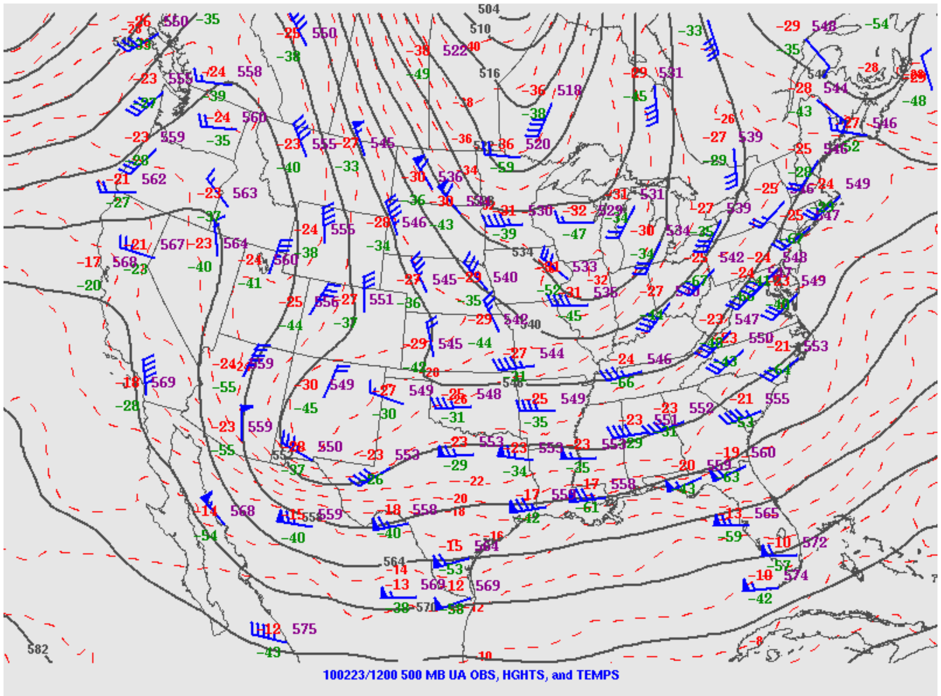


**Figure 16.** HPC 500 hPa analysis at 1200 UTC 23 February 2010.

By 0000 UTC 25 February 2010, the NAM40 forecast showed a closed low had formed at 500 hPa over Northern Indiana (Fig. 17a). Several strong short waves were traveling around the closed low. For the 1200 UTC forecast on 25 February 2010, the upper low had become negatively tilted and was centered over Ohio (Fig. 17b). By that evening the deepening surface storm was over the Virginia coast, with the strongest short wave energy located just east of and south of the upper low. The 0000 UTC 26 February 2010 forecast indicated that the cyclone had moved over Maryland with the strongest vorticity maximum just north of the state (Fig. 17c). The upper low had moved northeast and deepened to a 512 dm storm by 1200 UTC on 26 February 2010 (Fig. 17d). Later in the day the cyclone became vertically stacked, moving inland as it weakened.

At 300 hPa on 1200 UTC on 25 February 2010, the northern jet stream meandered from southern Ontario into the Midwestern and southeastern United States (not shown). The jet then turned north along the Atlantic coastline and headed north towards New England. A robust jet streak of 160 knots associated with the developing storm was forecast to be situated near Florida. The strong jet and the proximity of the left exit region of the jet streak helped create strong divergence aloft, allowing the storm to deepen rapidly. As the storm moved north and stalled near the coast, the jet was directed inland, with a sharp easterly component to the wind (Fig. 18).

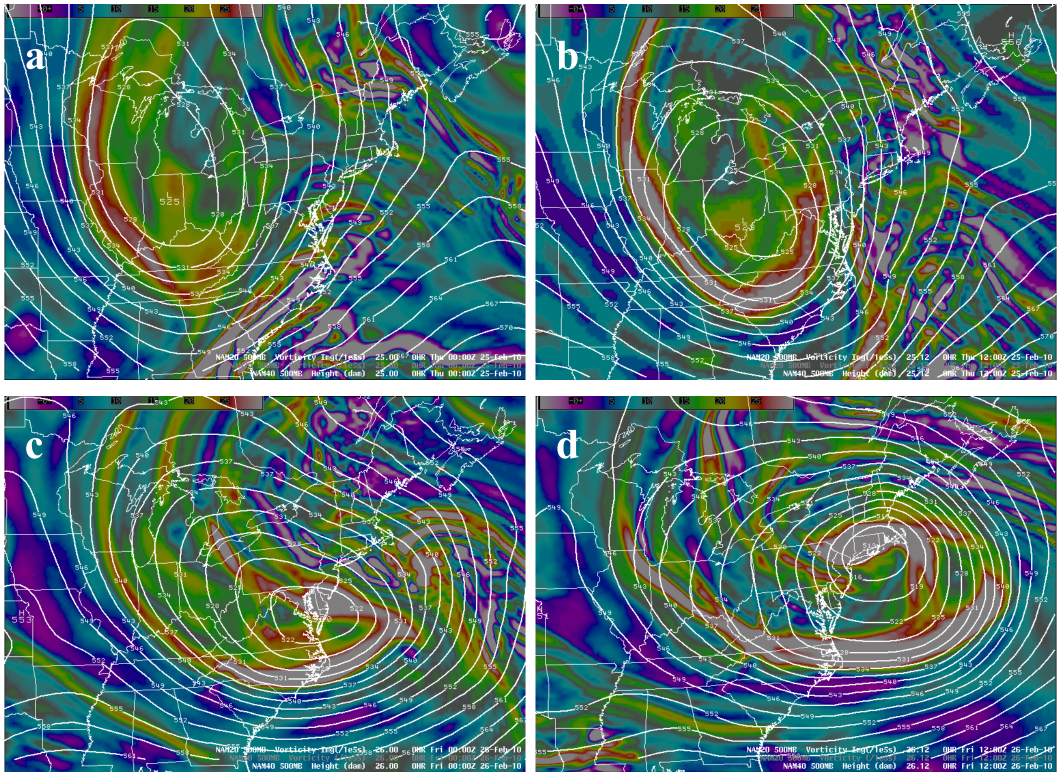


**Figure 17.** NAM40 zero hour analysis from (a) 00 UTC and (b) 12 UTC of 500 hPa heights on 25 February 2010, and (c) NAM40 zero hour analysis from (c) 00 UTC and (d) 12 UTC of 500 hPa heights on 26 February 2010. Vorticity is shaded and given as $10^{-5}$ units per second.

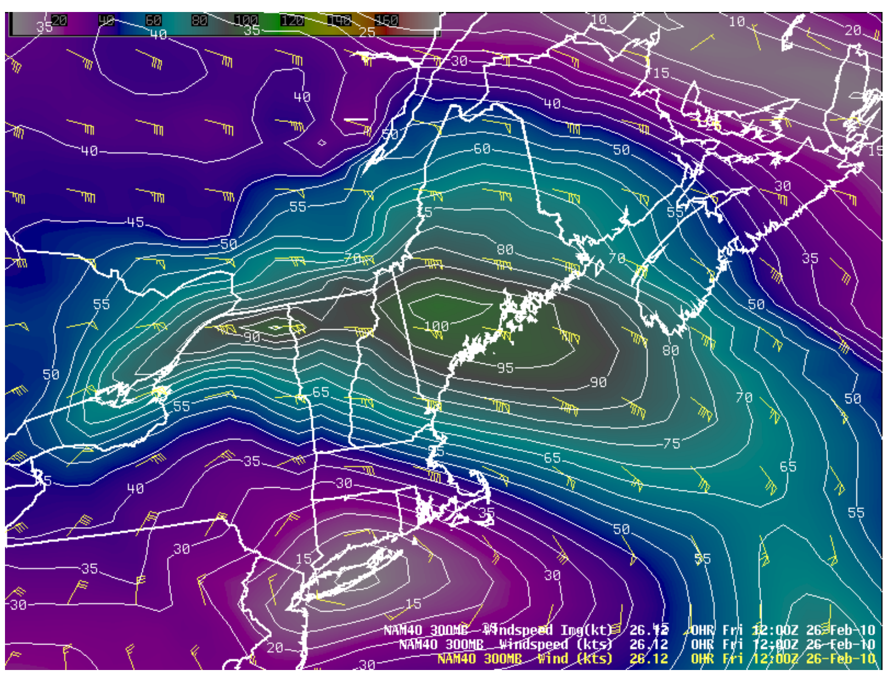


**Figure 18**. NAM40 zero hour forecast from 12 UTC 26 February 2010 of 300 hPa winds and wind speeds, depicting the path of the jet stream.

*b. Cyclone Phase Diagram*

The cyclone phase diagram created by Hart (2003) can be used to determine whether a storm is warm or cold core and whether it is symmetric or asymmetric. An explanation of cyclone phase diagrams can be found here: http://moe.met.fsu.edu/cyclonephase/.

The cyclone phase diagram is divided into quadrants: in the top right are frontal/asymmetric warm-core cyclones, in the bottom right are the non-frontal/symmetric warm-core systems, in the bottom left are non-frontal/symmetric cold core cyclones, and frontal/asymmetric cold-core cyclones are found in the top left quadrant.

A curve is drawn to trace the evolution of a cyclone through time. The beginning of the cyclone's life cycle is labeled with an *A*, the end is labeled with a Z. Many cyclones curve through multiple quadrants.

At the beginning of the 25-26 February 2010 storm's lifetime the cyclone was a strongly asymmetrical cold-core system, or extratropical cyclone, near Florida (Fig. 19). As the storm deepened, it increased its thermal symmetry and became closer to a warm core system. The storm began to weaken and take on additional cold core characteristics once it neared Cape Cod by 1200 UTC 26 February 2010. Using a cyclone phase diagram for forecasting these storms may point towards a hybrid storm system and strengthen confidence in watches and warnings, especially in locations that might not be expected.

*c. Model anomalies*

Hart and Grumm (2001) objectively ranked the significance of synoptic-scale events based on their departures from climatology. The departures were adjusted for the time of year and the location and ranked according to several variables, including height, temperature, wind, and moisture fields. Pennsylvania State University hosts a real-time anomaly website related to this research: http://eyewall.met.psu.edu/.

Their research shows that the above relationship is defined by the equation:

$$\boldsymbol{N = \frac{F-M}{\sigma}} \qquad \textbf{(1)}$$

where *F* is the observed field, *M* is the daily mean value for the variable at that location, and $\boldsymbol{\sigma}$ is the daily mean field variability, or standard deviation at that point. The variable *N* in (1) would then equal the number of standard deviations from normal.

The difference is calculated for four variables: temperature, height, wind, and moisture. The maximum N-value for each of the variables is represented by: $M_{temp}$, $M_{height}$, $M_{wind}$, and $M_{moist}$, respectively. Therefore the total departure is given by:

$$M_{total} = \frac{M_{temp} + M_{height} + M_{wind} + M_{moist}}{4}$$

A rare storm event would have a high $M_{total}$ and in general a longer expected return period.

Among the forecast models, the NAM forecasted 925 hPa and 850 hPa *U*-wind component anomalies between 3 and 5 standard deviations below normal (i.e., strong easterlies) as early as the 1200 UTC run on 24 February 2010 (Fig. 20). This translates to about 39 hours of lead time before the first damaging wind event the evening of the 25th. One could infer that it would not take much downward momentum transfer to mix these anomalously strong winds to the ground, causing widespread power outages and wind damage.

The model anomalies for this case indicate it was a significant event based on research by Hart and Grumm (2001). It is suggested that forecasters utilize available real-time anomaly web sites to help forecast similar and potentially damaging events in the future. This could increase confidence in a widespread and damaging event, and perhaps lead to earlier watches that might better prepare the public for significant precipitation, damaging winds, and coastal impacts.

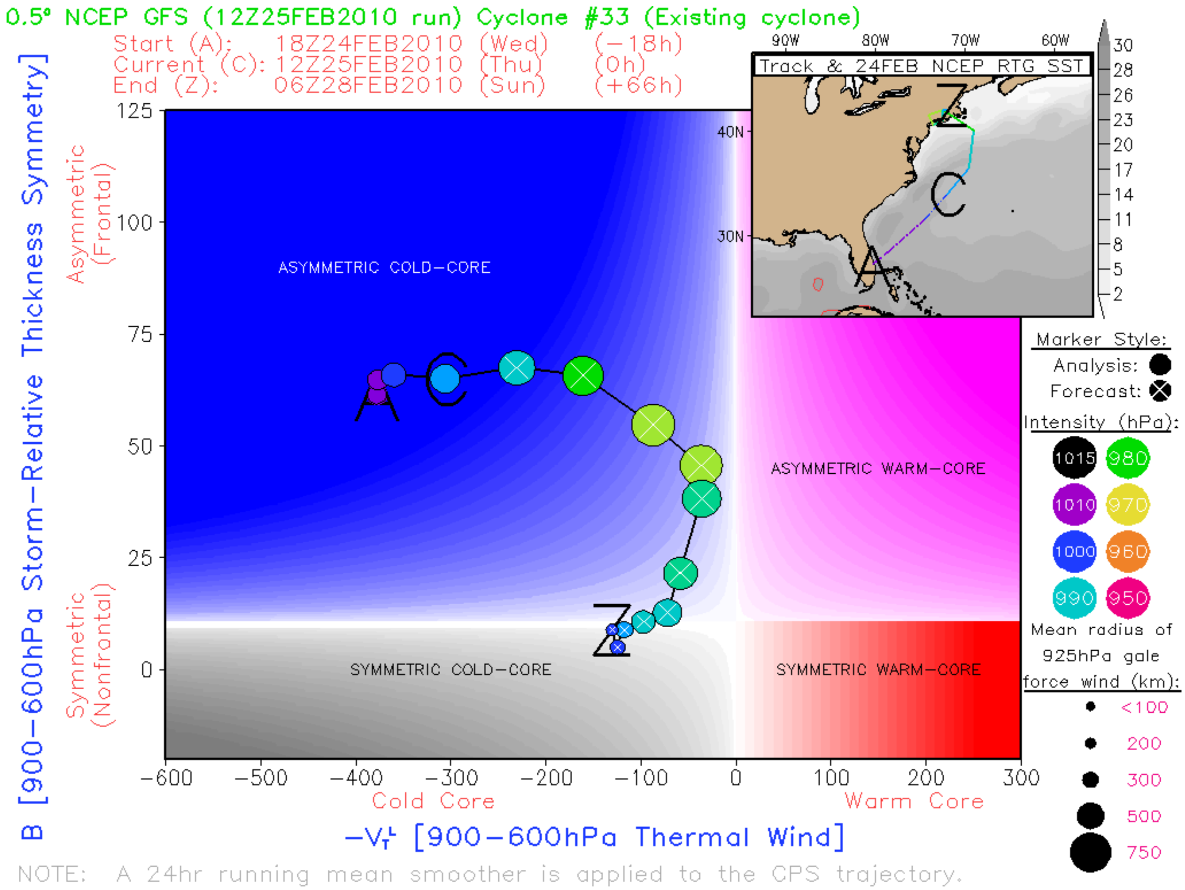


**Figure 19.** Cyclone Phase Change diagram showing the cyclone from its incipient stage near point A to its dissipation near point Z. (Real-time diagrams available at http://moe.met.fsu.edu/cyclonephase/).

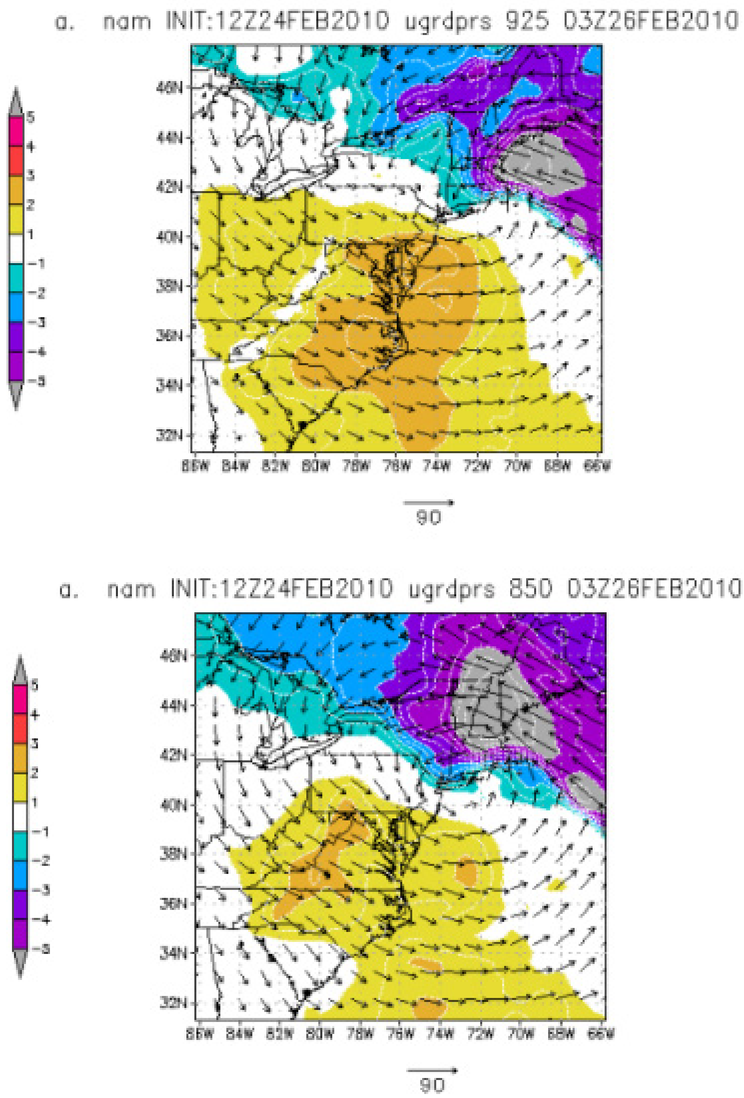


**Figure 20.** The 925 hPa and 850 hPa *U*-wind anomaly plots using the North American Mesocale Model (NAM) from 1200 UTC 24 February 2010 valid at 0300 UTC 26 February 2010, showing standardized anomalies between 3 and 5 standard deviations below normal.

## 4. Summary

The 25-26 February 2010 extratropical cyclone brought significant snowfall and flooding rain to northern New England, but was more remarkable for the extent of the damaging winds it produced. In New Hampshire alone, more than one-quarter of a million customers lost power during the storm, making it the state's second worst storm in terms of outages.

Coastal flooding and splash over due to the storm surge resulted in road washouts and flooded homes and businesses (NCDC Storm Data). A 79 knot wind gust at the Isles of Shoals resulted in near-shore waves as high as

32 feet. While it is not unusual for extratropical cyclones to produce strong winds in New England during the cool season, the meteorological features and resulting impacts of this storm were uncommon. Typically, damaging winds do not occur at night in the cool season due to the process of atmospheric decoupling. This typically produces a stable layer at the surface and prevents stronger winds aloft reaching the ground. The wind direction (east northeast) of the winds was also uncommon for damage. Usually damage occurs along the cold front as it moves east, which would produce west winds.

There is some evidence that this storm was not a typical Norwegian cyclone but had some characteristics of a Shapiro-Keyser cyclone. Shapiro-Keyser cyclones occur more often over the ocean and across the western portions of Europe and western North America. While there is limited information concerning the occurrence of Shapiro-Keyser cyclones on the East Coast, this event suggests that may indeed occur here.

It is thought that this case study will be studied and used for improving pattern recognition of these types of storm systems when and if they impact New England in the future. In addition to using this case study for increasing situational awareness, forecasters are encouraged to use real-time anomaly information which may help to highlight the potential of these rare cyclones in advance of their development.


## Acknowledgements

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**Table 1.** A list of wind gusts recorded 25-26 February 2010. Wind gusts are standardized to 10 m.

| Site Name | Observation Type | Height of Wind Sensor (m) | Original Maximum Wind Gust (knots) | Standardized Wind Gusts (knots) |
|---|---|---|---|---|
| Bath, ME | Mesonet | 2 | 54 | 66.2 |
| Beverly, MA | ASOS | 10 | 58 | 58.0 |
| Black Cat Island, NH | Mesonet | 2 | 52 | 63.7 |
| Camp Ellis, ME | Mesonet | 2 | 54 | 66.2 |
| Cape Elizabeth, ME | Mesonet | 2 | 82 | 100.5 |
| Central Maine Shelf (E01) | GoMOOS Buoy | 5 | 54 | 58.7 |
| Concord, NH | ASOS | 10 | 59 | 59.0 |
| East Boston, MA | ASOS | 10 | 52 | 52.0 |
| Isles of Shoals | C-MAN | 30 | 79 | 70.2 |
| Manchester, NH | ASOS | 10 | 55 | 55.0 |
| Massachusetts Bay (A01) | GoMOOS Buoy | 5 | 57 | 61.9 |
| New Harbor, ME | Mesonet | 2 | 55 | 67.4 |
| Penobscot Bay (F01) | GoMOOS Buoy | 5 | 48 | 52.1 |
| Portland, ME | ASOS | 10 | 68 | 68.0 |
| Portsmouth, NH | ASOS | 10 | 59 | 59.0 |
| Seabrook Nuclear Power Plant | Mesonet | 2 | 82 | 100.5 |
| Wells, ME | Mesonet | 2 | 57 | 69.9 |
| West Quoddy Head Light | RAINWISE | 2 | 61 | 61.0 |
| Western Maine Shelf (B01) | GoMOOS Buoy | 5 | 52 | 56.5 |

**Table 2.** The top seventeen storm surges at Portland, Maine. Storm surge is measured in feet and references the MLLW.

| Date | Storm Surge (feet) |
|---|---|
| March 3, 1947 | 4.3 |
| March 1, 1914 | 4.1 |
| December 14, 1917 | 3.9 |
| February 19, 1972 | 3.6 |
| November 26, 1950 | 3.5 |
| February 7, 1978 | 3.5 |
| October 30, 1991 | 3.5 |
| November 30, 1945 | 3.3 |
| August 31, 1954 | 3.3 |
| December 2, 1942 | 3.2 |
| March 16, 1956 | 3.1 |
| January 15, 1940 | 3.0 |
| February 7, 1951 | 3.0 |
| November 13, 1925 | 2.9 |
| December 9, 2009 | 2.8 |
| April 16, 2007 | 2.7 |
| February 25, 2010 | 2.7 |