A Review of Wind and Wave Measurements from a NOAA Buoy during the Provincetown IV Ferry Incident of August 13, 2014

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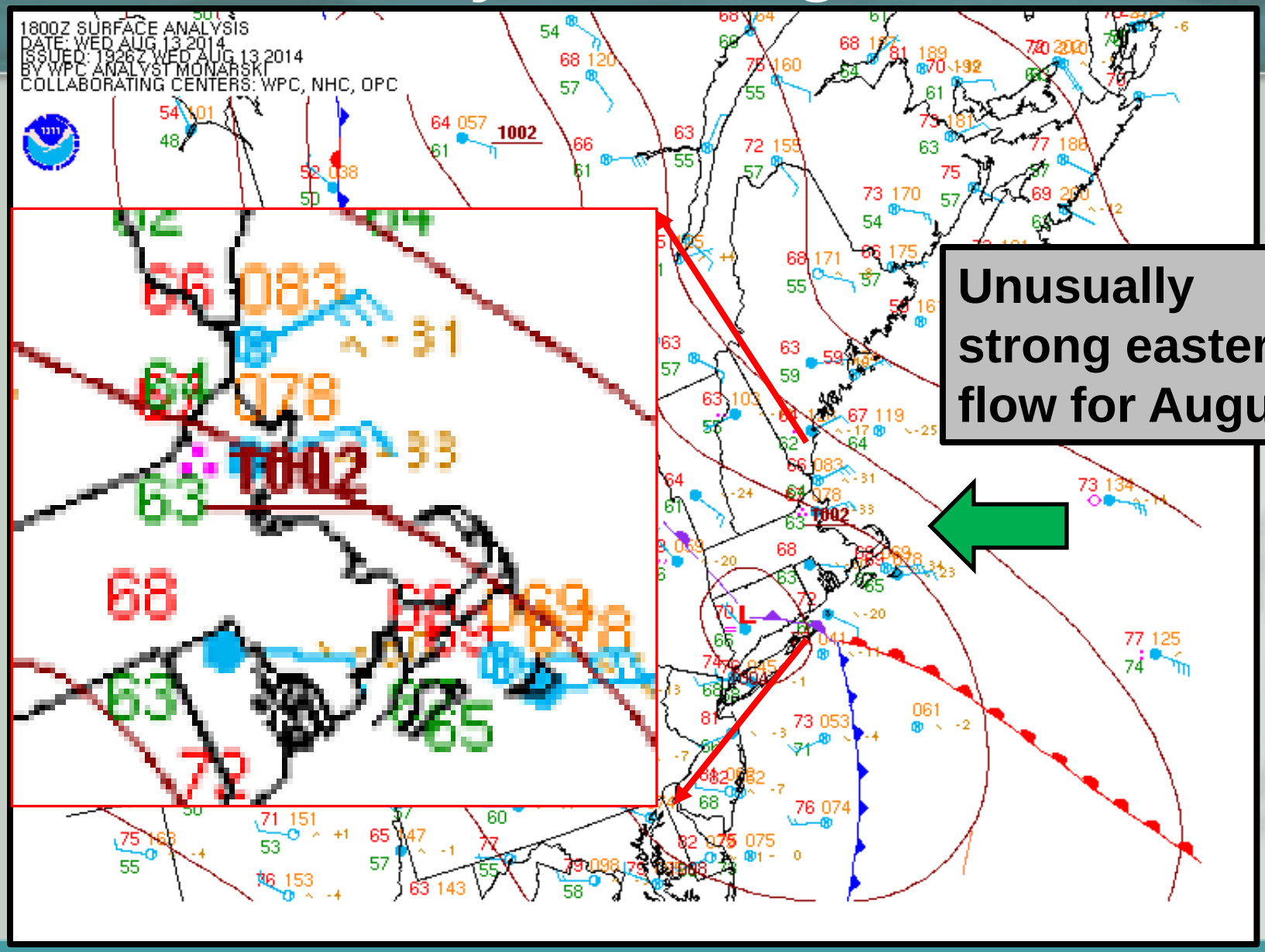
Wednesday, 13 August 2014



NWS Boston Marine Forecast Discussion

THIS AFTERNOON...***BEEN CONCERNED ABOUT MARGINAL GALE GUSTS*** BUT FOR MOST PART COASTAL WATER WINDS GUSTING BETWEEN 25 AND 30 KT. ***THIS IS YIELDING ROUGH SEAS FOR THIS TIME OF YEAR WITH HEAVY RECREATIONAL BOATING USE***. LOW PRES MOVES ACROSS COASTAL CT-RI- MA THIS AFTERNOON. LOW RISK OF A FEW STRONG TSTMS THIS AFTERNOON ESPECIALLY OVER THE SOUTH COASTAL WATERS WITH STRONG WIND GUSTS...AND EVEN ISOLATED WATERSPOUT IN SOUTH COASTAL WATERS NOT OUT OF THE QUESTION. GALE FORCE WIND GUSTS ARE POSSIBLE IN THE STRONG TSTMS.

Forecasters were concerned about unusually rough seas for August and winds possibly reaching Gale force (34 KT)

NWS Boston Forecasts

MASSACHUSETTS BAY AND IPSWICH BAY-

352 AM EDT WED AUG 13 2014

...SMALL CRAFT ADVISORY IN EFFECT THROUGH LATE TONIGHT…

.TODAY...SE WINDS 15 TO 20 KT WITH GUSTS UP TO 30 KT. **SEAS 4 TO 6 FT.** PATCHY FOG. SHOWERS. VSBY 1 TO 3 NM...DECREASING TO 1 NM OR LESS THIS AFTERNOON.

MASSACHUSETTS BAY AND IPSWICH BAY-

117 PM EDT WED AUG 13 2014

...SMALL CRAFT ADVISORY IN EFFECT THROUGH LATE TONIGHT...

.THIS AFTERNOON...SE WINDS 15 TO 20 KT WITH GUSTS UP TO 30 KT. **SEAS 4 TO 7 FT**. AREAS OF FOG. RAIN WITH A CHANCE OF TSTMS. VSBY 1 TO 3 NM.

Marine Reports: 13 August 2014

Time (EDT)	Location	Wind (kt)	Waves (Ft)	Visibility (Mi)
10 am	Nantucket Sound	ESE 25-30	3-5	5, Light Rain
11 am	Boston Harbor	E 15-20	4	4, Light Rain
1245 pm	Buzzards Bay	ESE 25	4	10

- **NWS Boston calls ferries and pilot boats 3 times per day to solicit real-time reports, which augments buoy reports.**
- **All indicated the forecast was verifying well.**
- **No indication of seas higher than 7 feet or winds reaching Gale force (34 kt).**

"Rogue wave hits Provincetown ferry"

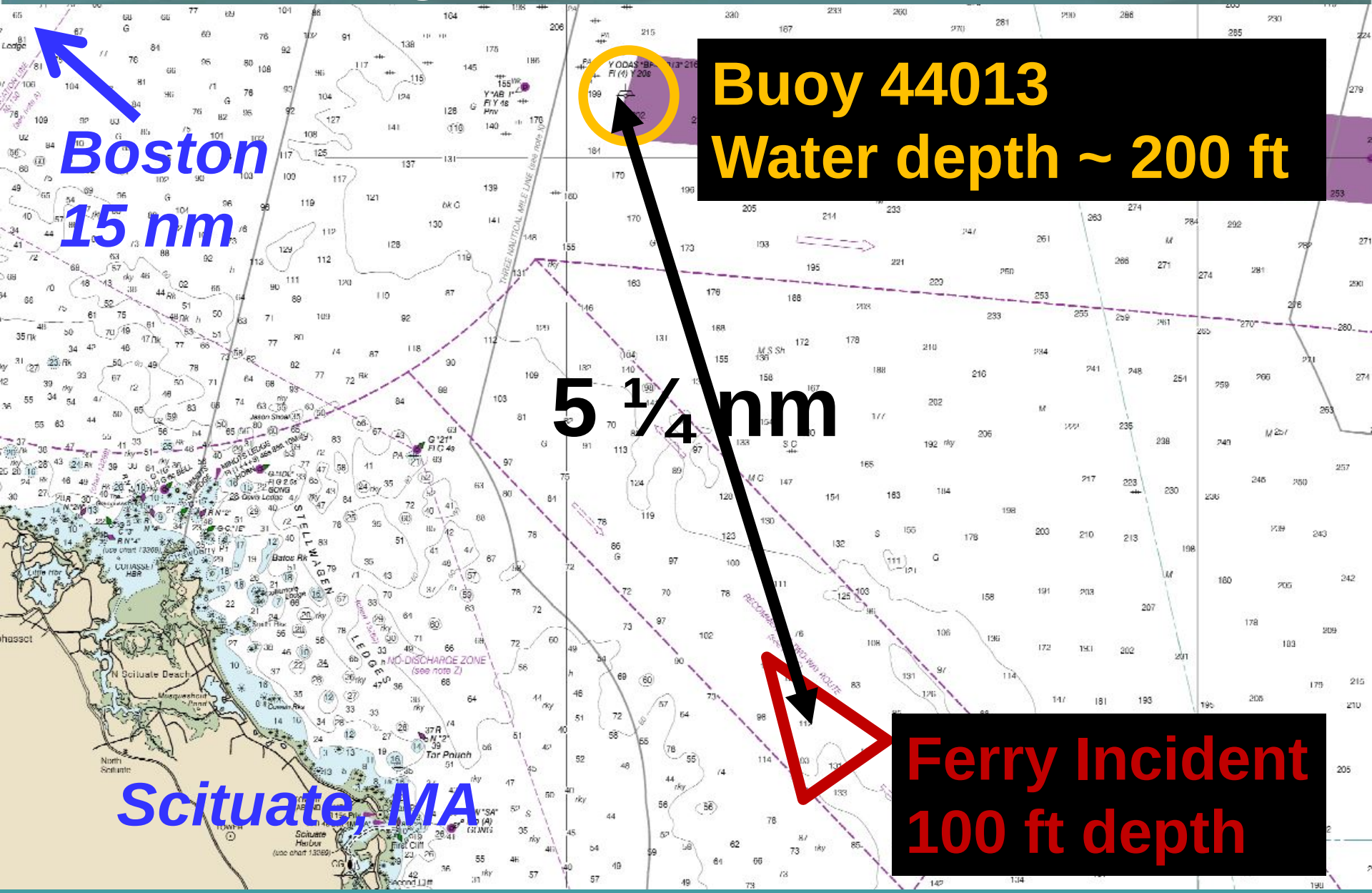
- *A Provincetown ferry was temporarily disabled and suffered damage when it was struck by a 20-foot wave off Scituate ….*

- Boston Herald (2014)

- Automatic Identification System (AIS):
  - At 3:50:41 PM EDT, *Provincetown IV* Ferry, carrying 42 passengers, is en route from Provincetown, MA to Boston towards the northeast at 27 knots
  - At 3:53:32 PM EDT, the ferry is hove to with the bow facing westward
- Waves ~ 5 feet, 5 seconds from the Southeast
- Rogue Waves > 2 - 2.2 x Significant Wave Height

  As 20 ft > 11 ft

13 August 2014, 3:53 PM EDT



Buoy 44013 (Boston Buoy)

See NDBC (1996) for complete details on wave measurements

-3-meter Aluminum Discus Hull

-Reports once per hour

-2 R.M. Young propeller anemometers mounted ~ 5 m above the water line

- 8 and 10-minute averages

-Directional Wave System

-Samples minutes 20 to 40

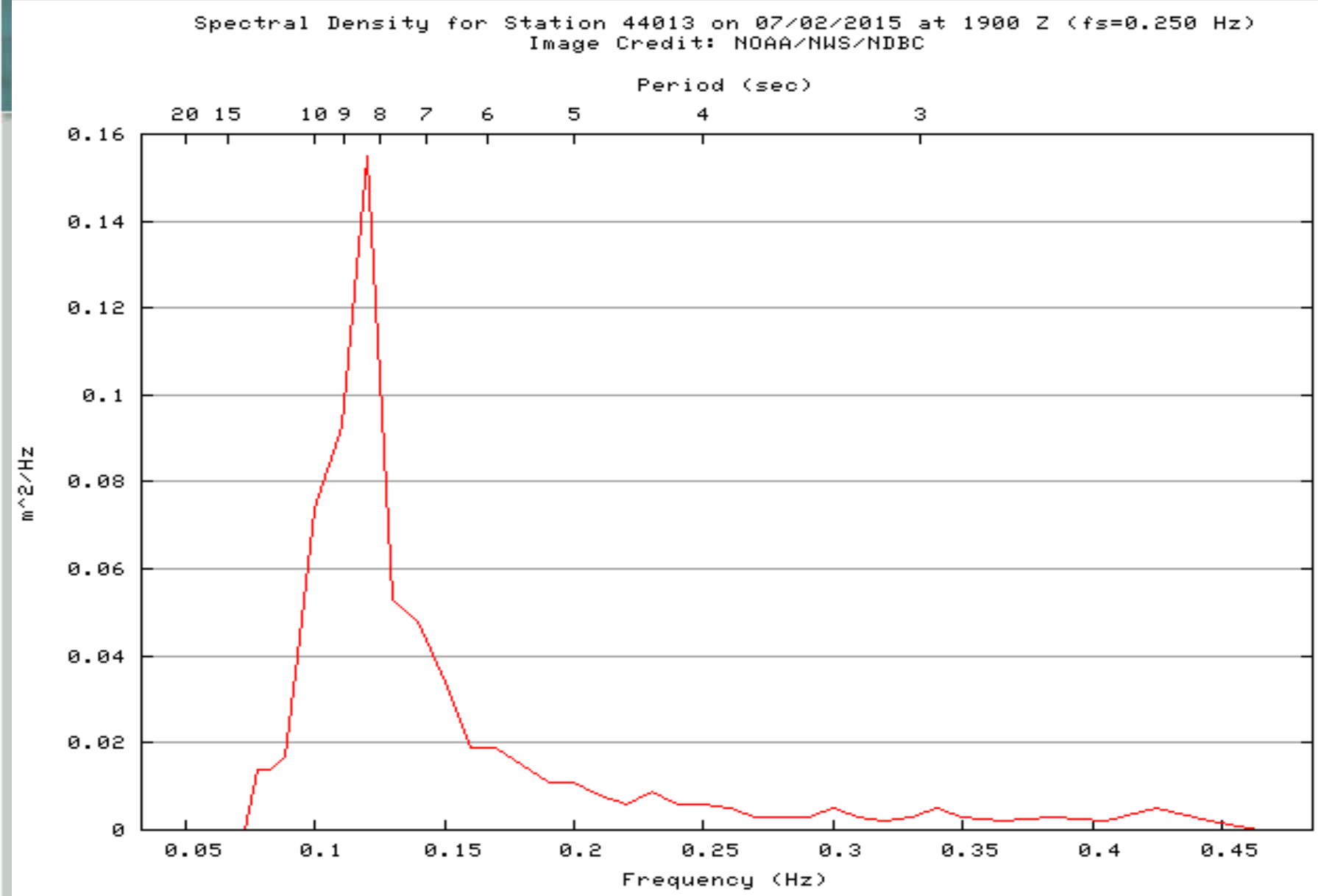
-Strapped-down accelerometer

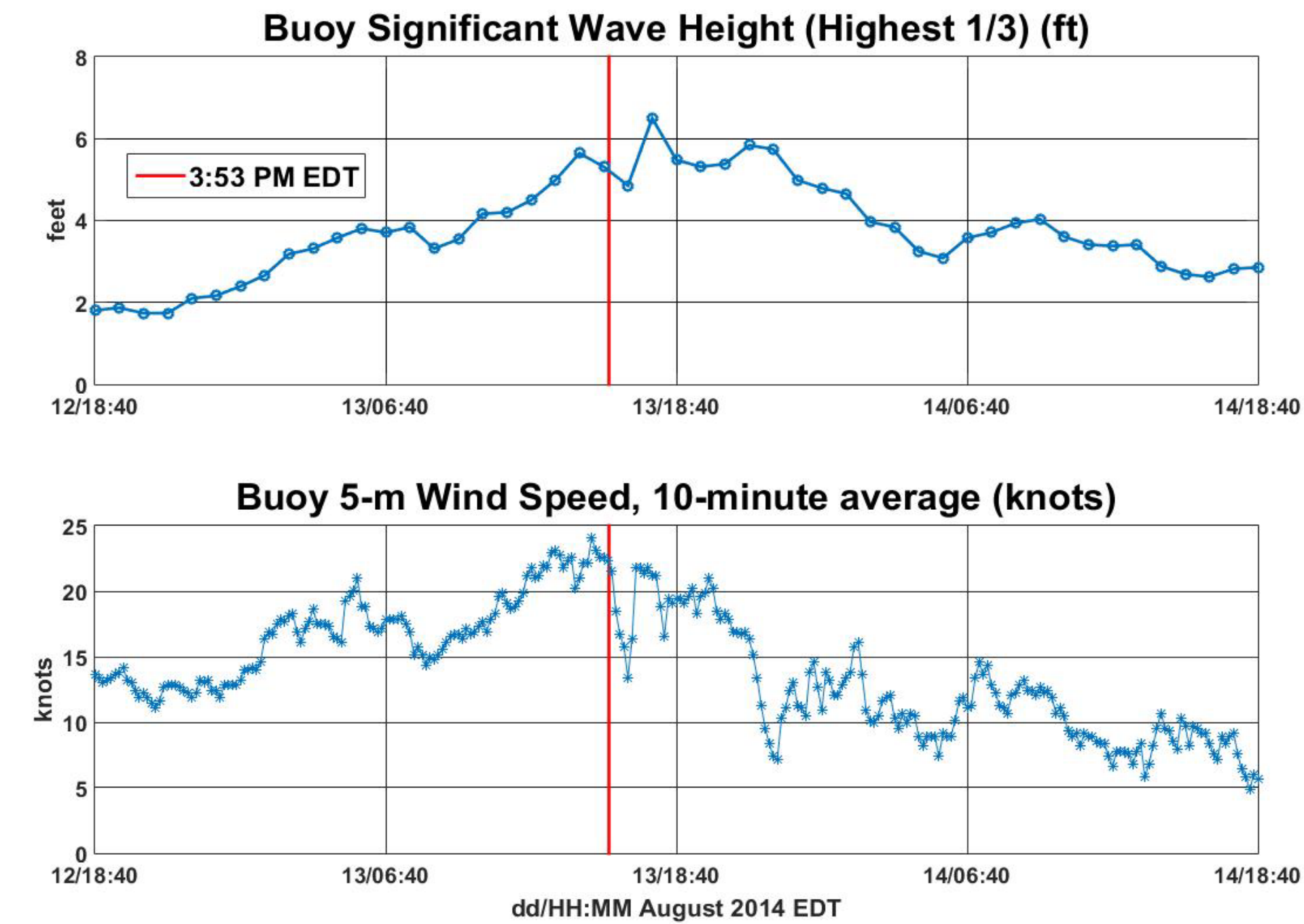
-Buoy Tilt/Slope for Directions

-Acceleration & Slopes -> FFT ->

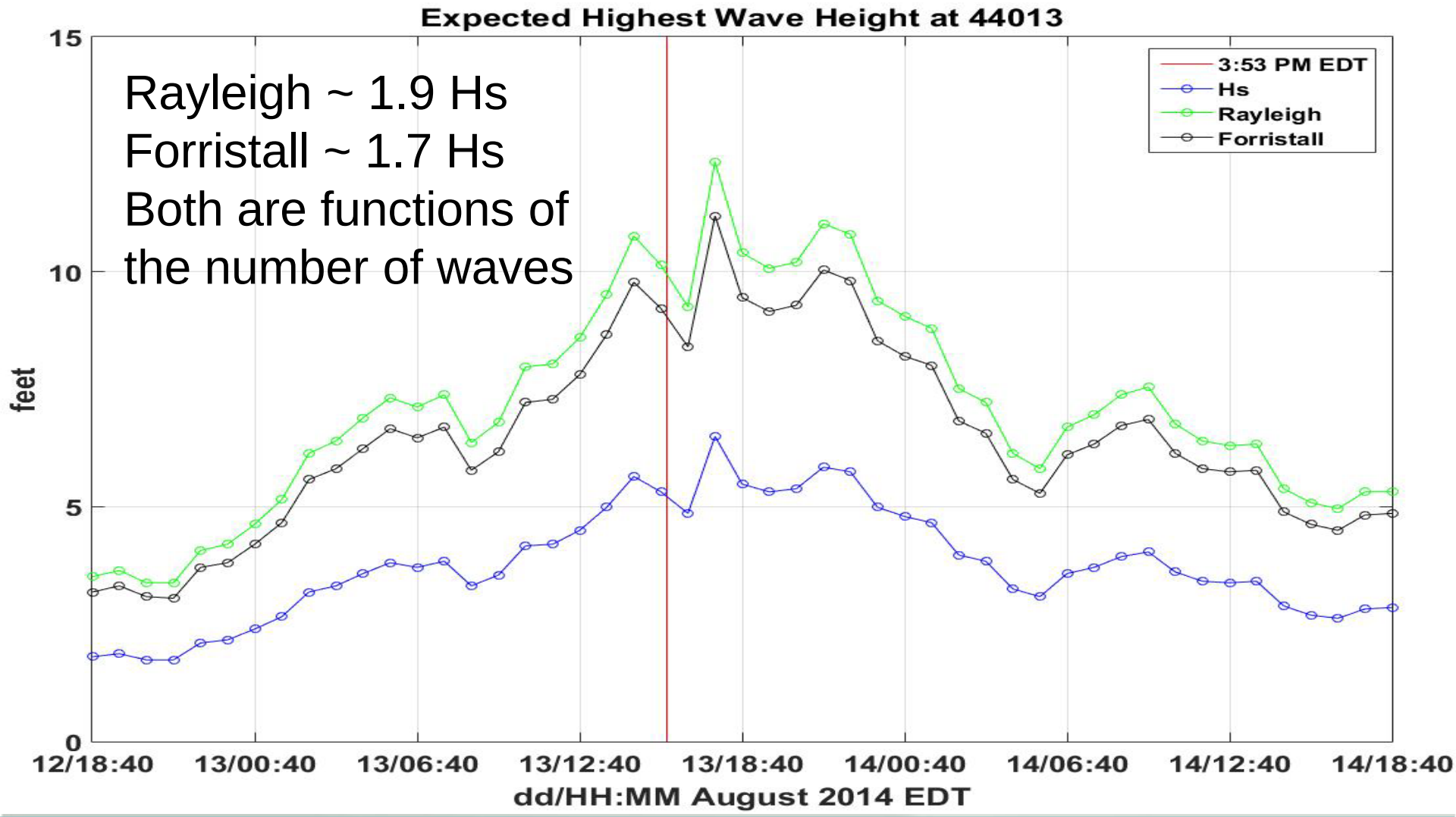
- Spectra, Heights, Periods, Directions

www.ndbc.noaa.gov/show_plot.php?station=44013&meas=spec&uom=E




Buoy Significant Wave Height (Highest 1/3) (ft)
feet
3:53 PM EDT
0
2
4
6
8
12/18:40
13/06:40
13/18:40
14/06:40
14/18:40
Buoy 5-m Wind Speed, 10-minute average (knots)
knots
0
5
10
15
20
25
12/18:40
13/06:40
13/18:40
14/06:40
14/18:40
dd/HH:MM August 2014 EDT

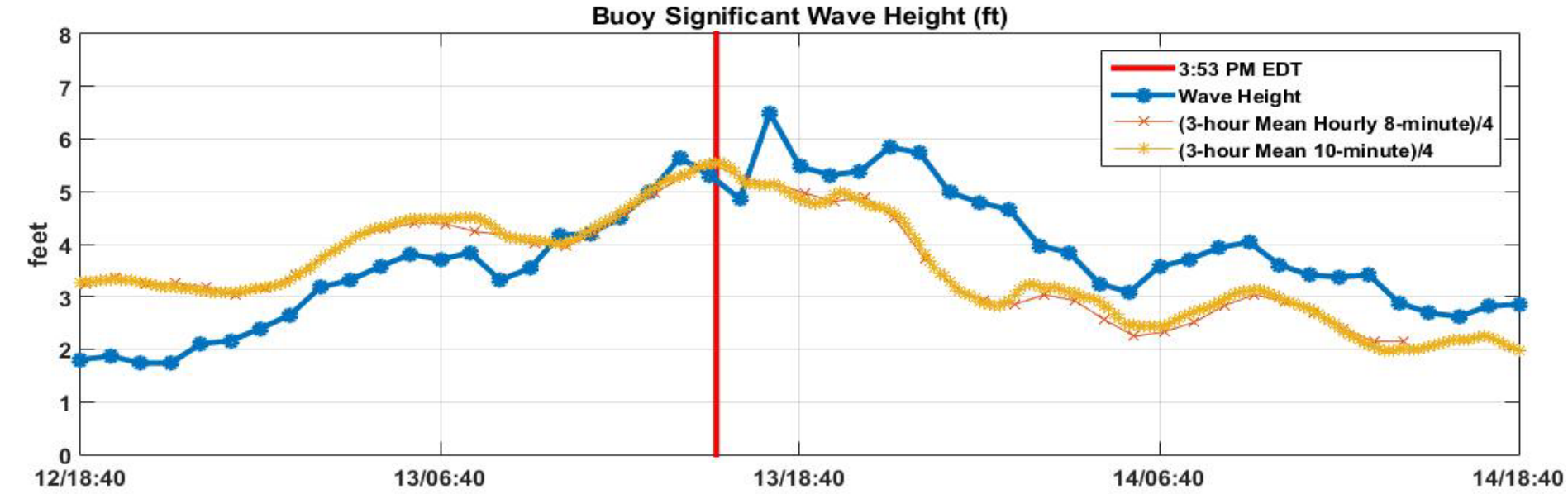
NDBC does not attempt to report highest wave because hull response and noise correction are applied in frequency domain ashore. Power constraints prevent on-board computations. Communications constraints prevent sending back time series
Can estimate Expected (Mean) from the bulk parameters using Raleigh (WMO, 1988) or Forristall (1978)

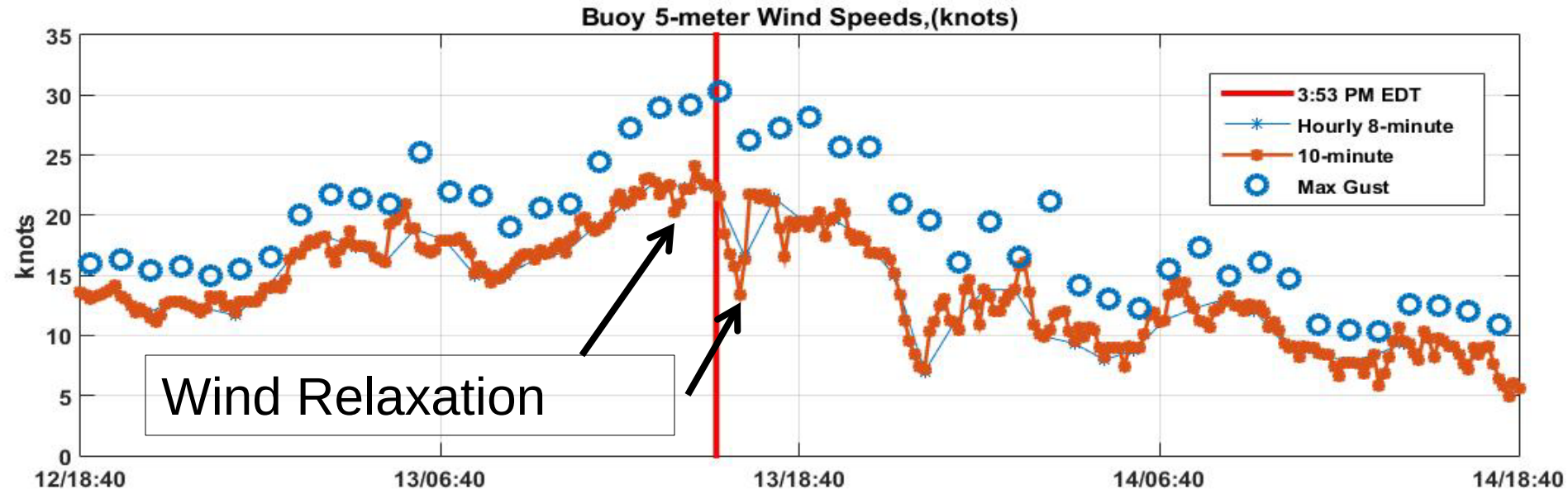


Rogue (Freaque or Freak) Waves

Following Babinin and Rogers (2014)

- **Generally > 2 or 2.2 x Significant Wave Height (H_s)**
- **Short-lived, location-limited**
- Rogue waves arise due to non-linear instabilities
- Wave Height is limited by Wave Breaking:
  - Steepness
  - Wind
- Get Higher Waves by Delaying Breaking
  - Wind Relaxation
  - Suppression of short period (steep) waves

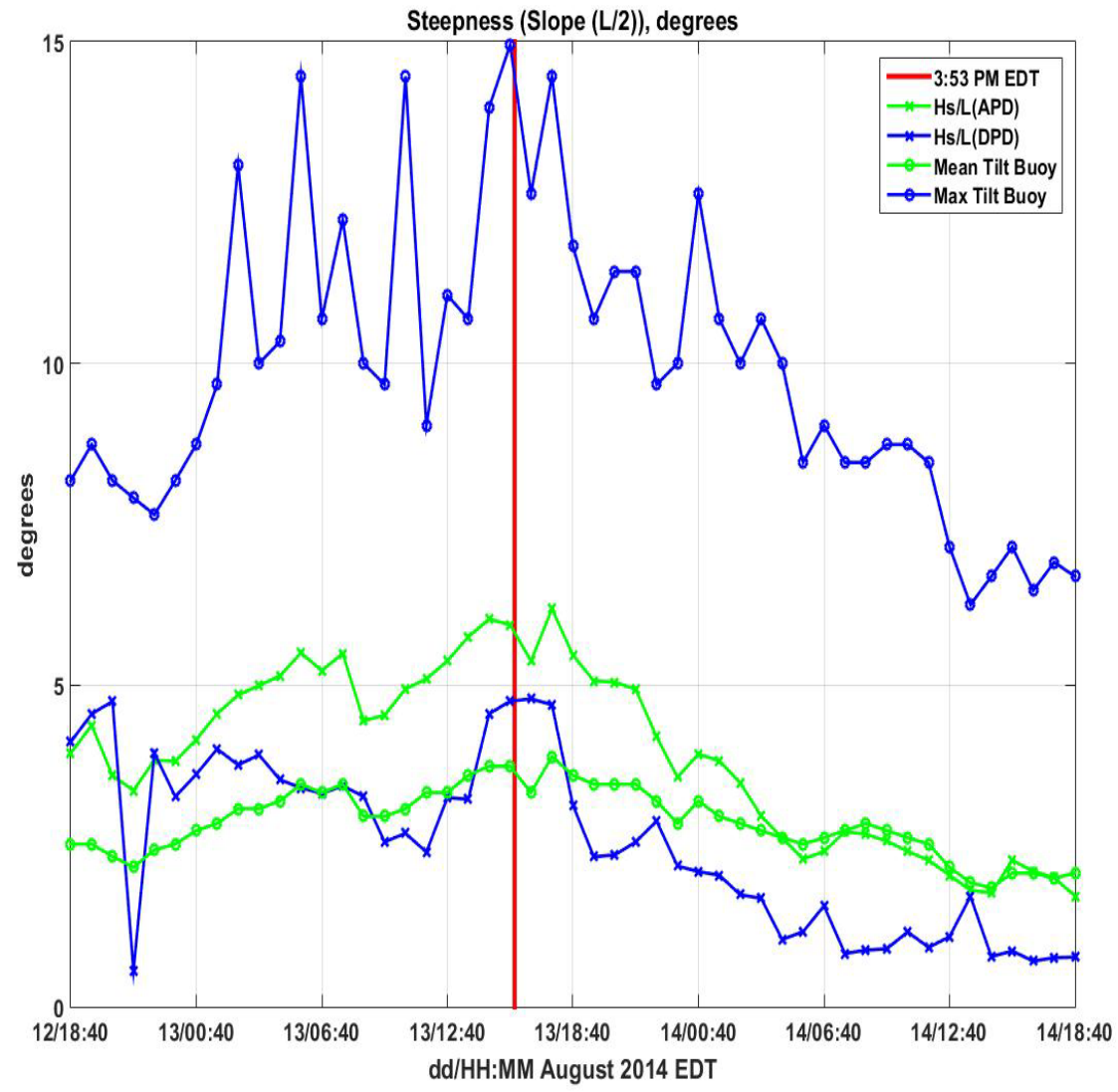

Buoy Significant Wave Height (ft)
feet
0
1
2
3
4
5
6
7
8
12/18:40
13/06:40
13/18:40
14/06:40
14/18:40
3:53 PM EDT
Wave Height
(3-hour Mean Hourly 8-minute)/4
(3-hour Mean 10-minute)/4


Buoy 5-meter Wind Speeds,(knots)
knots
0
5
10
15
20
25
30
35
12/18:40
13/06:40
13/18:40
14/06:40
14/18:40
3:53 PM EDT
Hourly 8-minute
10-minute
Max Gust
Wind Relaxation

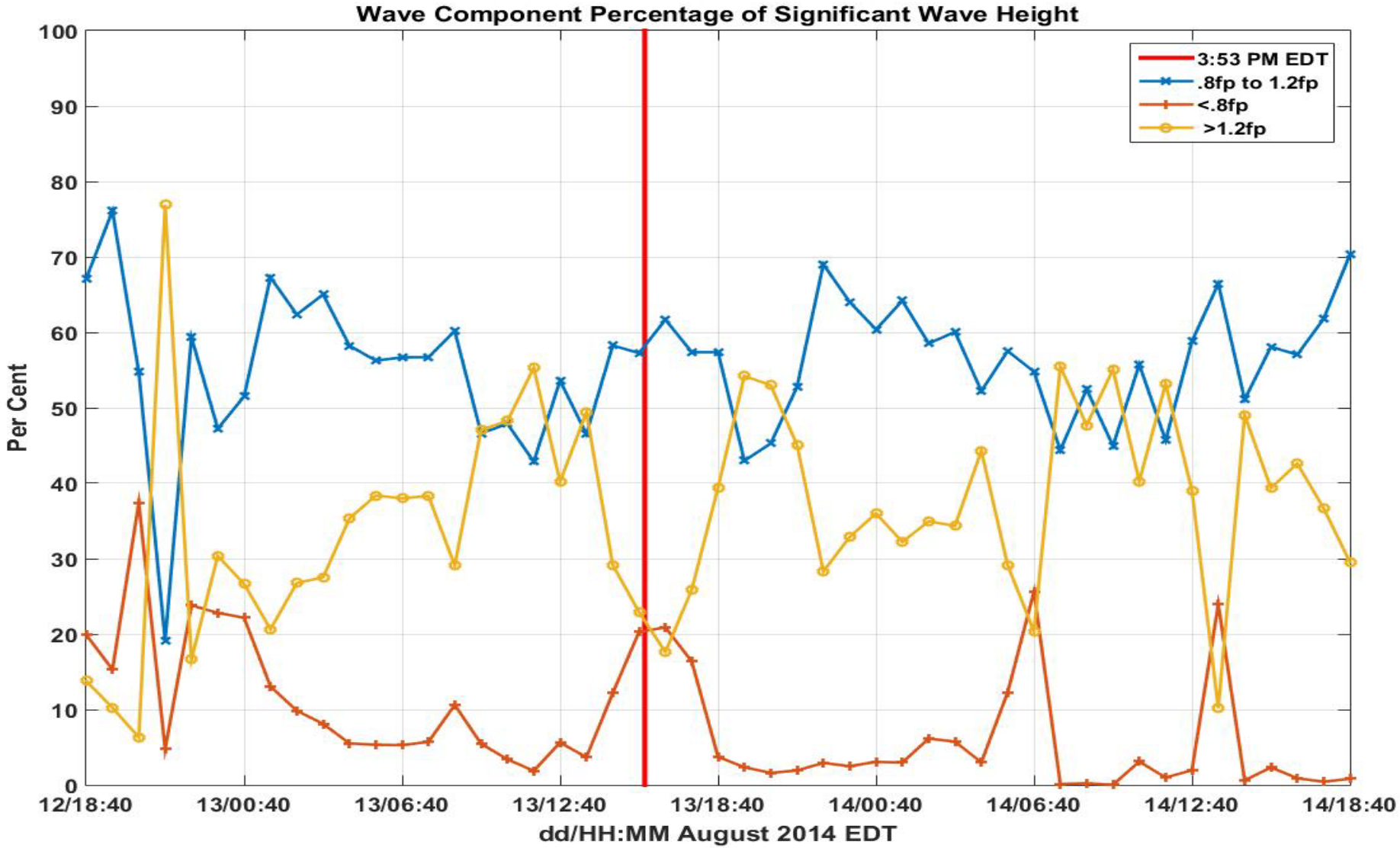
Steepness is one of the factors of Modular Instability

At these wave periods, difference in Wave Length (L) between 200 ft and 100 ft depth < 0.01 m

- L ~ 2π/(g*Period^2)
- Slopes from Buoy Mean Tilt & L (Average Period) peak near event and mainly reflect wave height
- Maximum Buoy Tilt occurs near Event; Several pre-cursor peaks
- Decreasing slopes based on L(Dominant Period) interrupted during event



Limit High-Frequency/Steep Waves



Vessel Speed ~ 27 knots
Wave Phase Speed: 15 knots

… the wave struck the vessel, deflected off the ship's bulkhead and broke through the windshield into the pilot house, the company said. - -
K.Blessing, Boston Globe, 14 Aug 2014

20 ft

5 ft

94' 10" / 28.9 m

Wave Length ~128' / 39 m

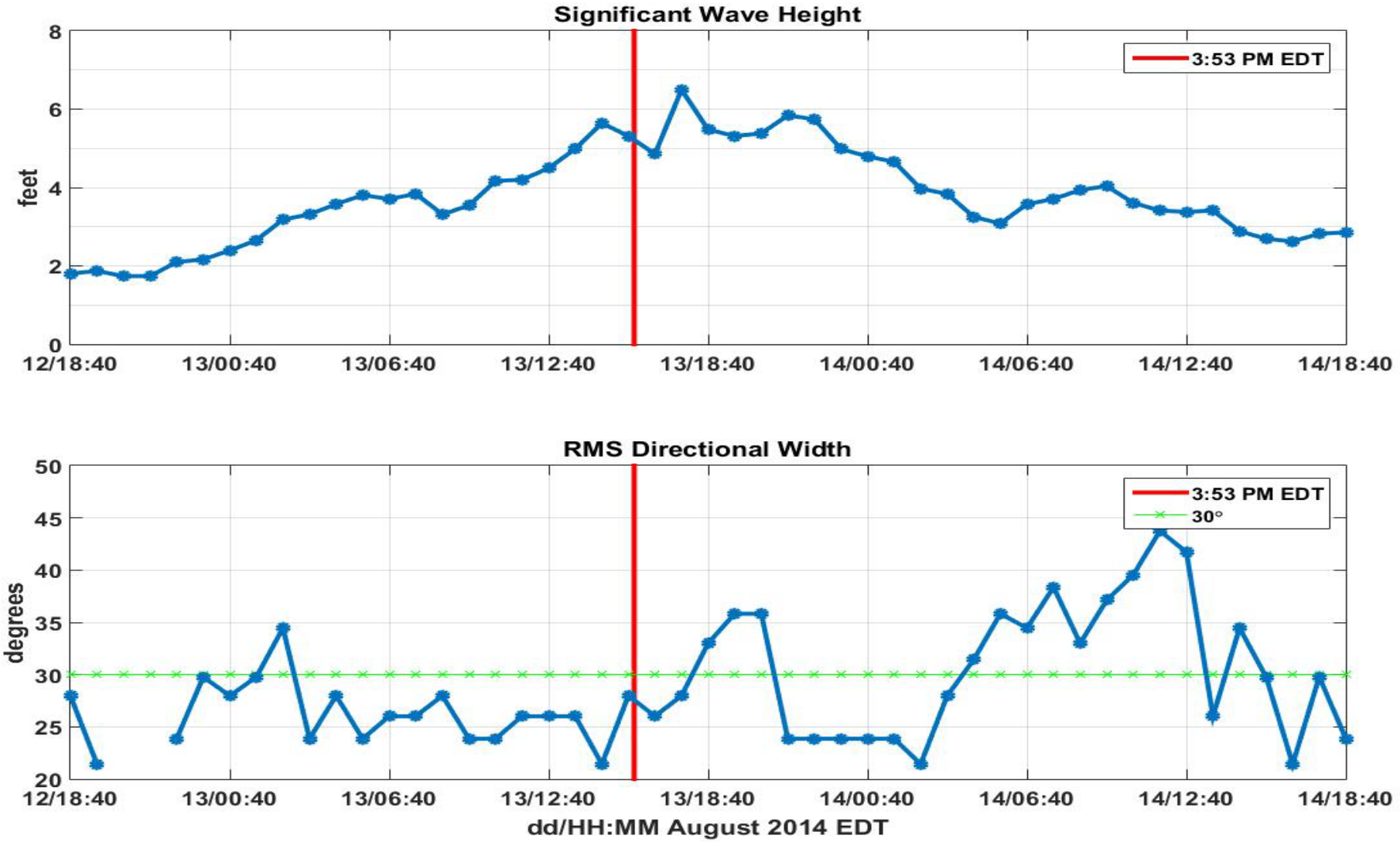
Concluding Remarks

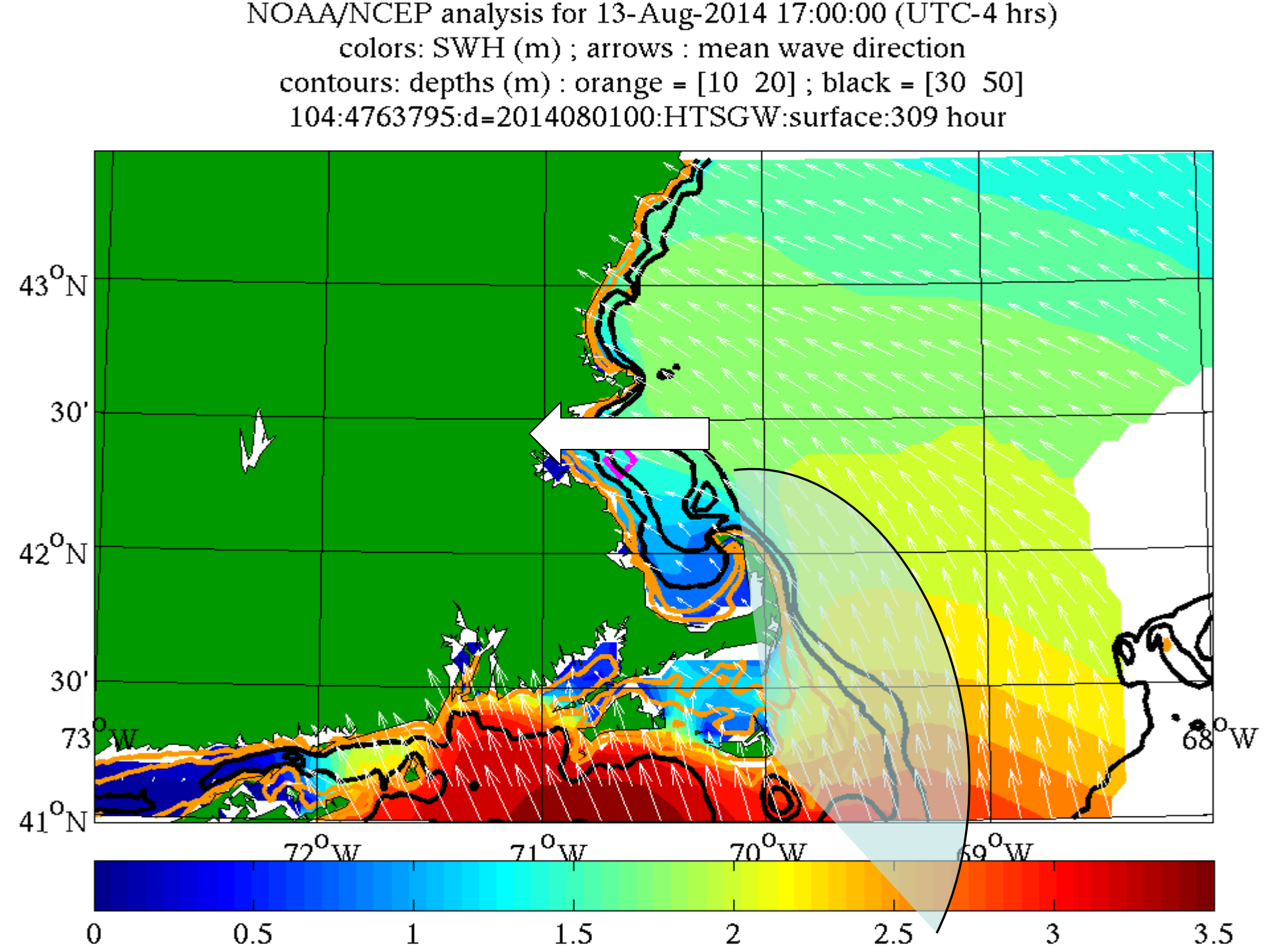
- Sample of One
- Buoy high-resolution winds and spectral data can indicate the presence/absence of possible rogue/dangerous wave conditions (e.g., steepening, wind relaxation, suppression steep/short period, or crossing waves)
- At this time, must rely on statistical estimates of maximum wave heights
- Examining 3 years of 44013 data to see how often conditions occur
- In May, 2 more instances – NH & FL. Other buoys
- Recording sensor outputs. May lead to post-deployment analysis for maximum and rogue waves or development of efficient on-board processing and real-time detection

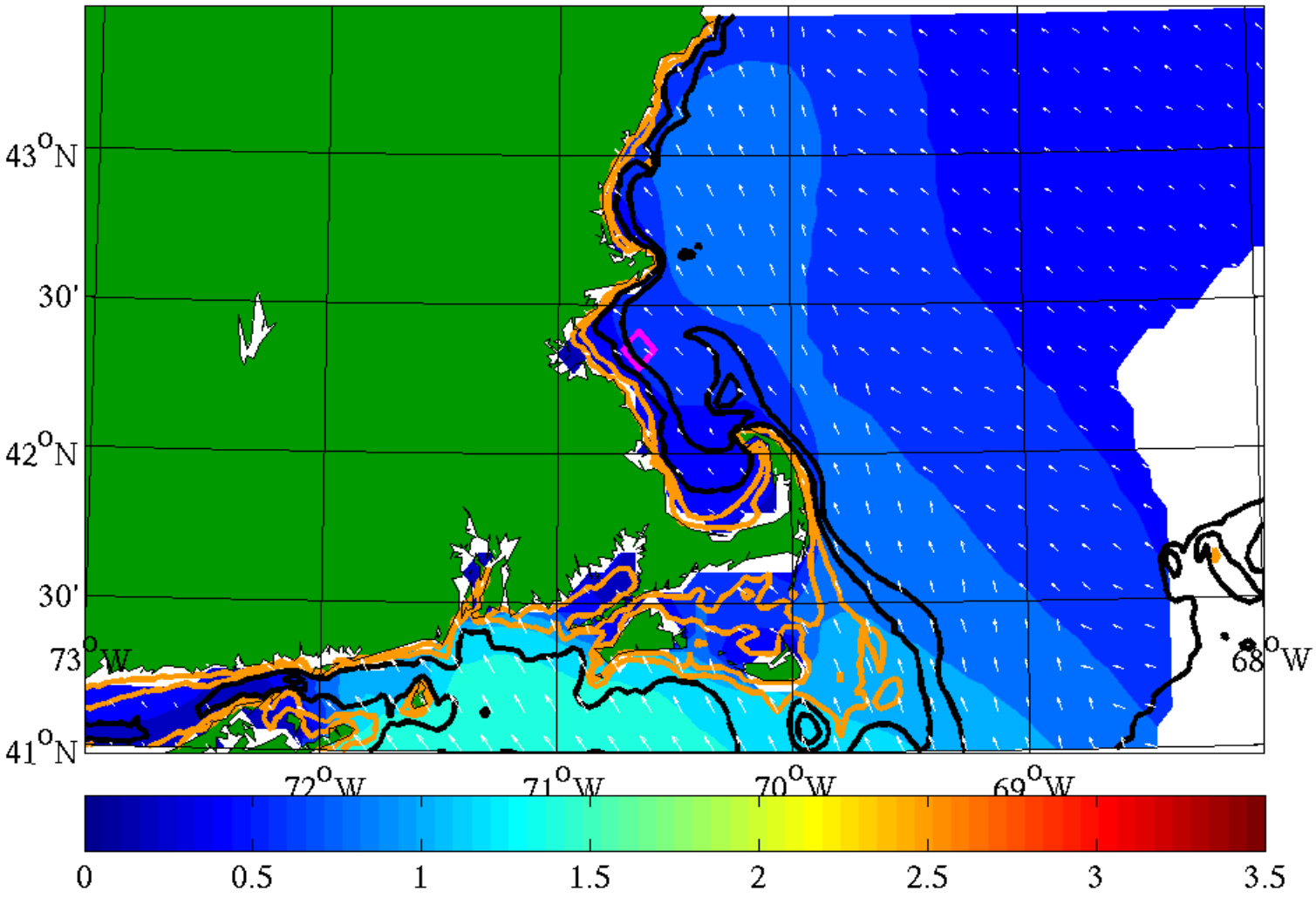
References

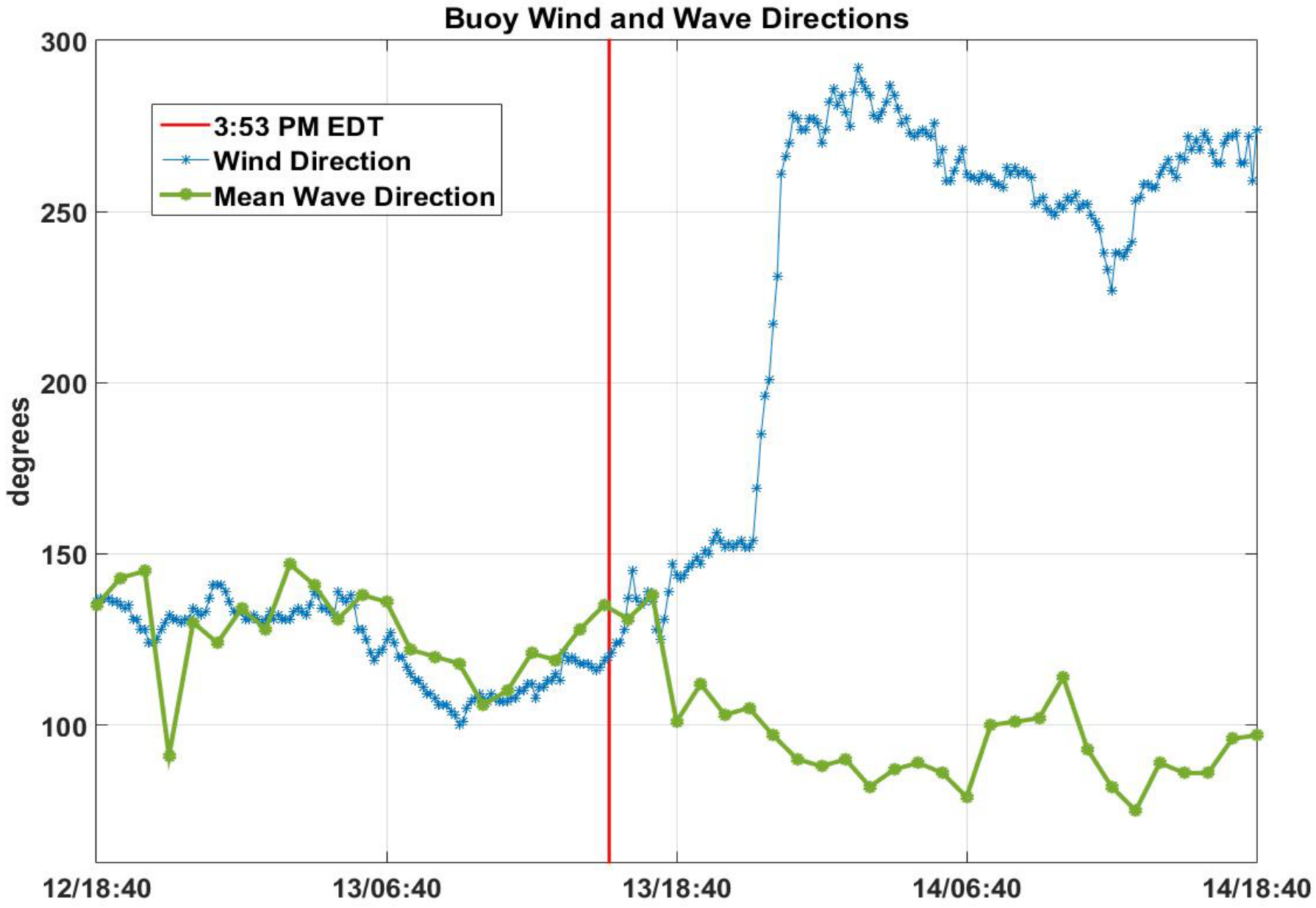
- Babanin, A. V. and Rogers, W. E., 2014: Generation and limiters of rogue waves, *Int. J. Ocean Clim. Syst*., **5**, pp. 39–49.
- Boston Herald, 2014: available at: http://www.bostonherald.com/news_opinion/local_coverage/2014/ 5 08/rogue_wave_hits_provincetown_ferry, last access: 10 October 2014.
- Forristall, G. Z. ,1978: On the statistical distribution of wave heights in a storm*, J. Geophys. Res*., **83**(C5), pp. 2353–2358, doi:10.1029/JC083iC05p02353.
- NDBC, 1996: *NDBC Technical Document 96-01, Nondirectional and Directional Wave Data Analysis Procedures*, [available at http://www.ndbc.noaa.gov/wavemeas.pdf]
- WMO, 1988: *Guide to Wave Analysis and Forecasting, WMO No. 702*, pp. 1-16 to 1-17.

Generally unidirectional waves indicated by directional width < 30° during the event




NOAA/NCEP analysis for 13-Aug-2014 17:00:00 (UTC-4 hrs)
colors: SWH (m) ; arrows : mean wave direction
contours: depths (m) : orange = [10 20] ; black = [30 50]
104:4763795:d=2014080100:HTSGW:surface:309 hour
43°N
30'
42°N
30'
41°N
73°W
72°W
71°W
70°W
69°W
68°W
0
0.5
1
1.5
2
2.5
3
3.5


NOAA/NCEP analysis for 12-Aug-2014 23:00:00 (UTC-4 hrs)
colors: SWH (m) ; arrows : mean wave direction
contours: depths (m) : orange = [10 20] ; black = [30 50]
98:4484730:d=2014080100:HTSGW:surface:291 hour
43°N
30'
42°N
30'
41°N
73°W
72°W
71°W
70°W
69°W
68°W
0
0.5
1
1.5
2
2.5
3
3.5


Buoy Wind and Wave Directions
3:53 PM EDT
Wind Direction
Mean Wave Direction
degrees
300
250
200
150
100
12/18:40
13/06:40
13/18:40
14/06:40
14/18:40