

Resolving High Frequency Surface Gravity Waves: Implications for Coastal Engineering & Observing Systems



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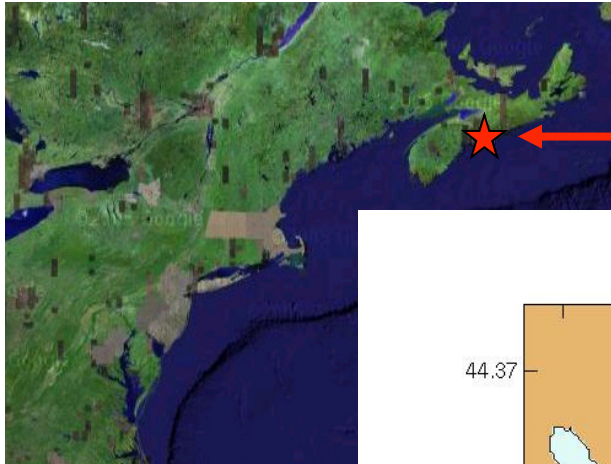
Motivation



Study of High Frequency Wave Events in Lunenburg Bay

- **Event 1: locally generated storm (wind only)**
- **Event 2: Tropical Storm Nicole (wind + swell)**
- **Winds over both events have similar magnitude, duration and direction (fetch)**

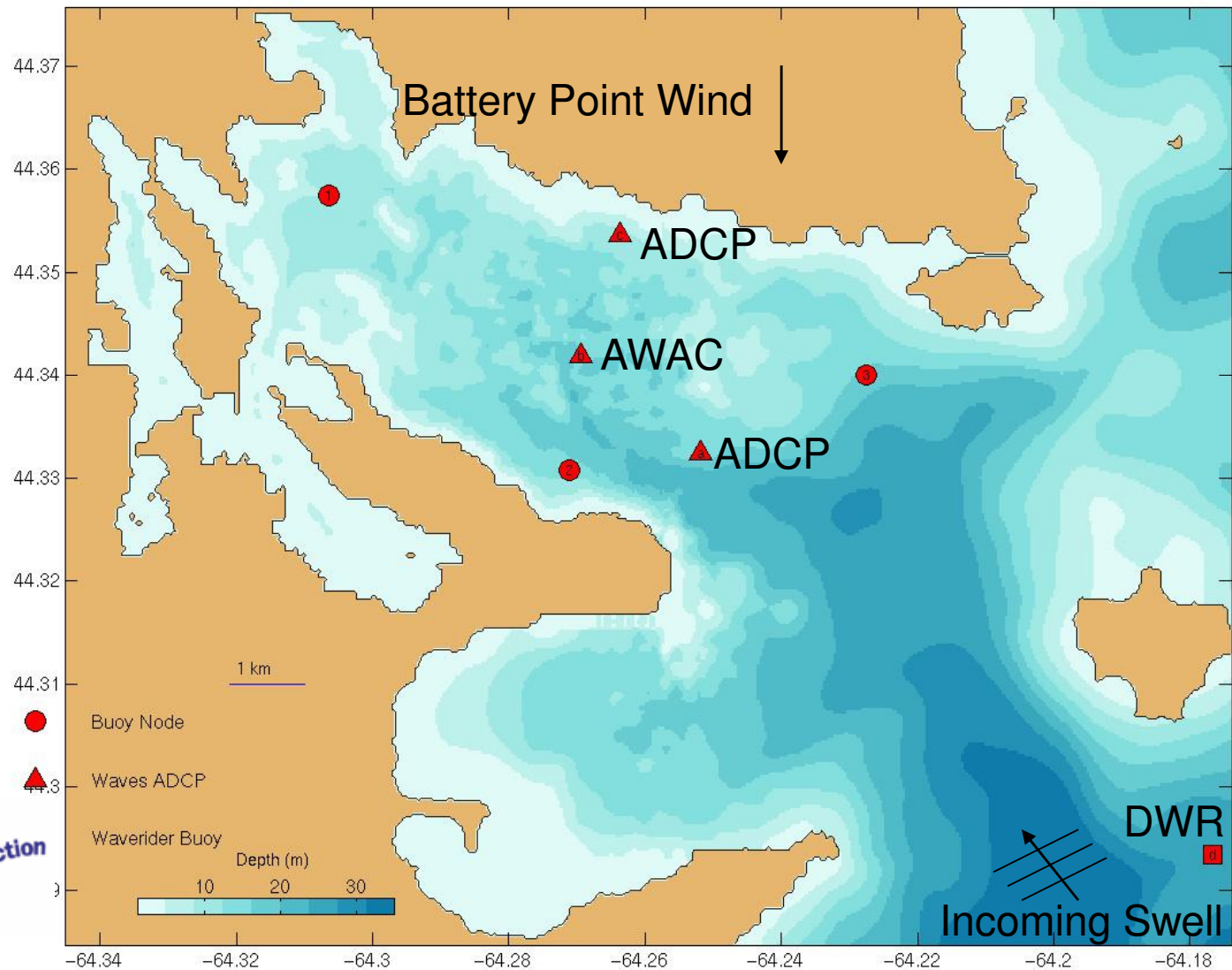
- **Discuss measurement methods**
- **Frequency limitations**
- **SWAN model comparisons**
- **H_S and H_{max} comparisons**
- **Implications to real-time observing systems**

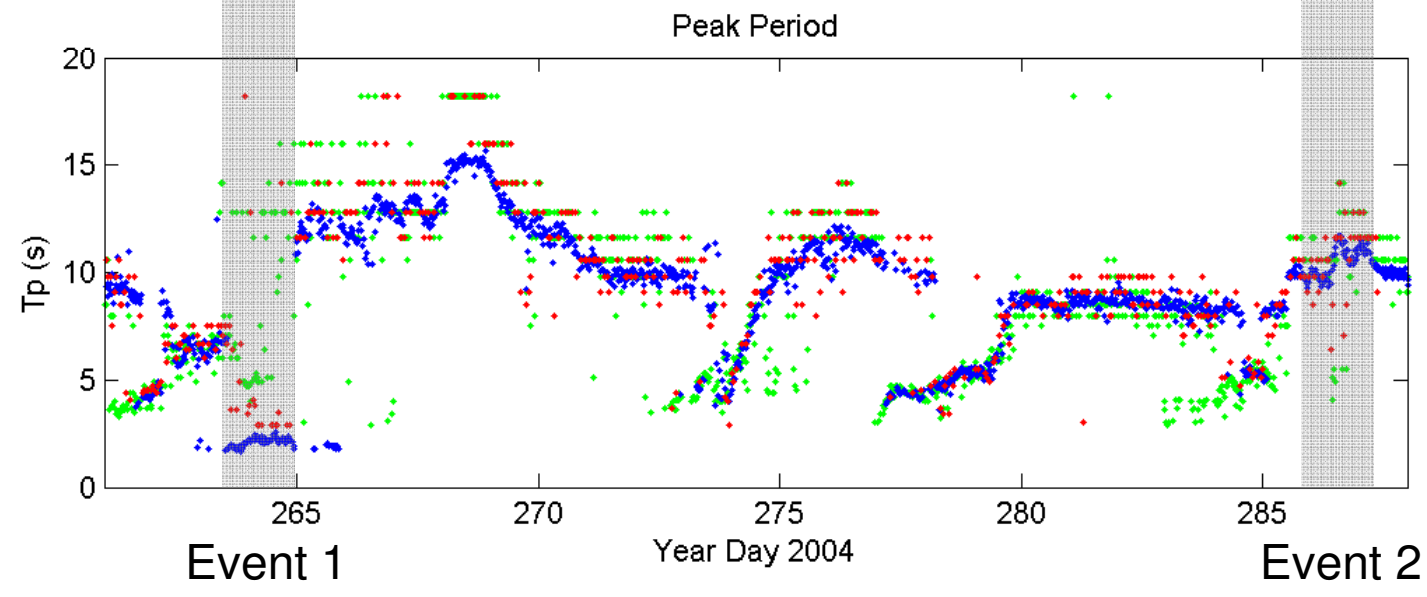
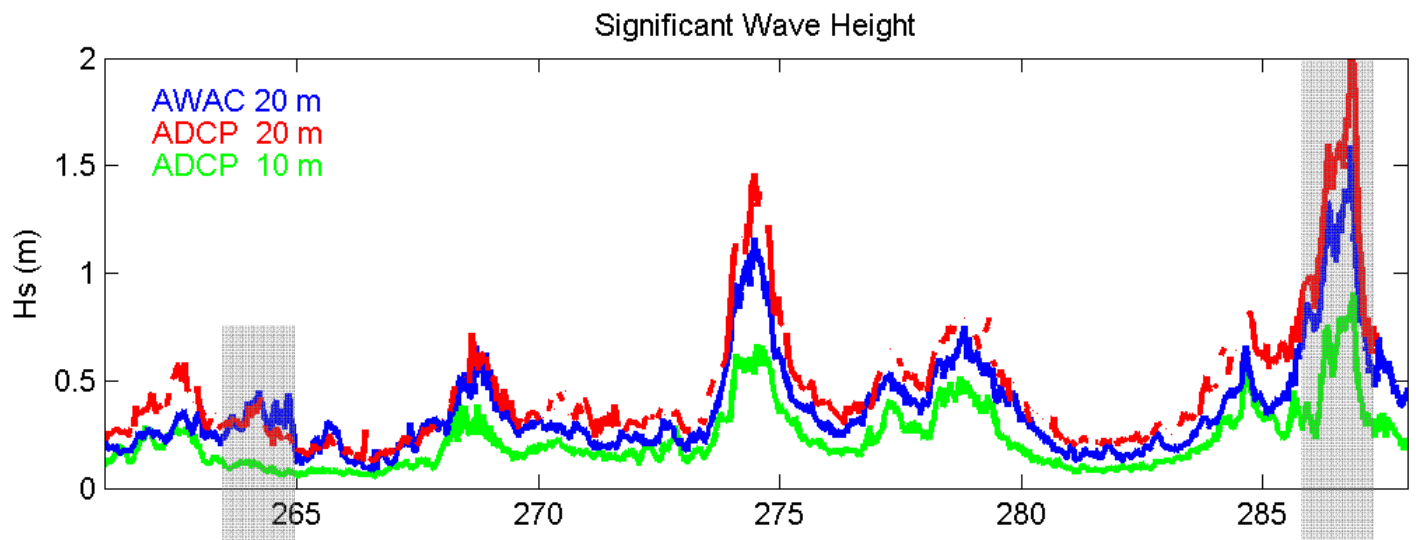


Lunenburg Bay, Nova Scotia

Bathymetry and Equipment Location

4 km wide
8 km long
5 - 20 m deep



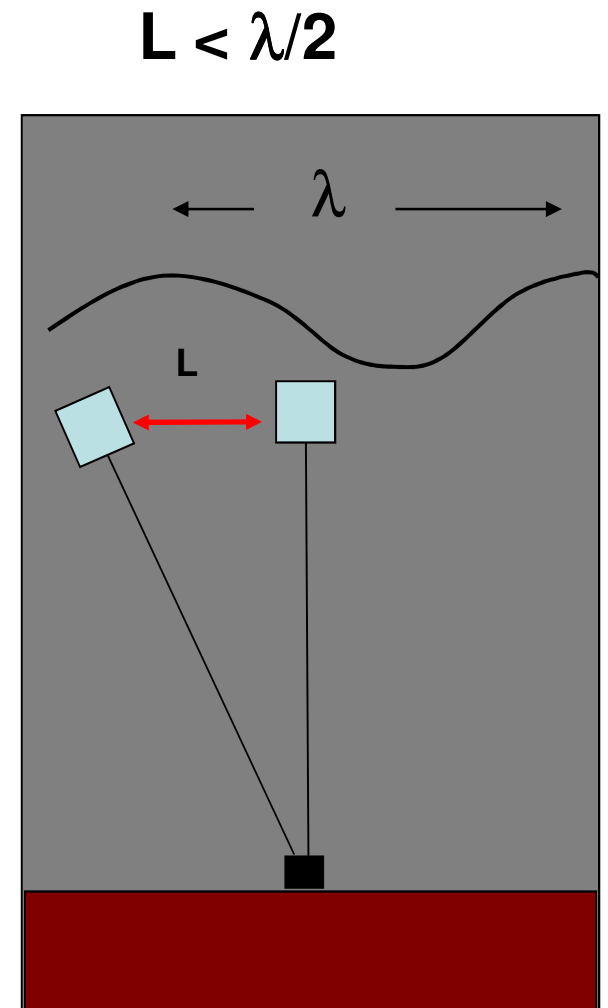


ADCP Frequency Limitation with Depth

Velocity is primary method

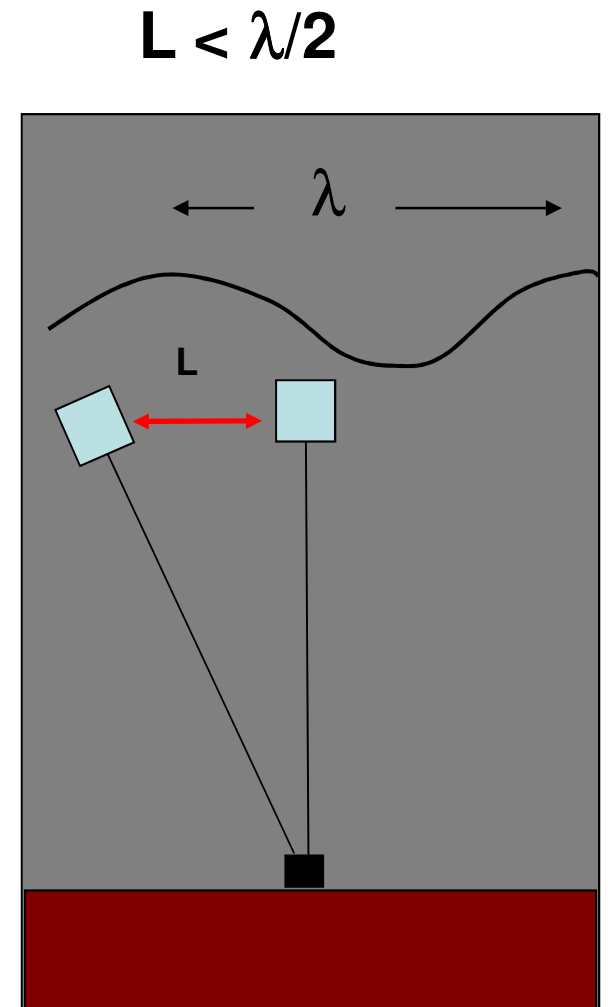
**Measurement cell separation
Must be less than half wavelength**

**Separation increases for greater
Depths**



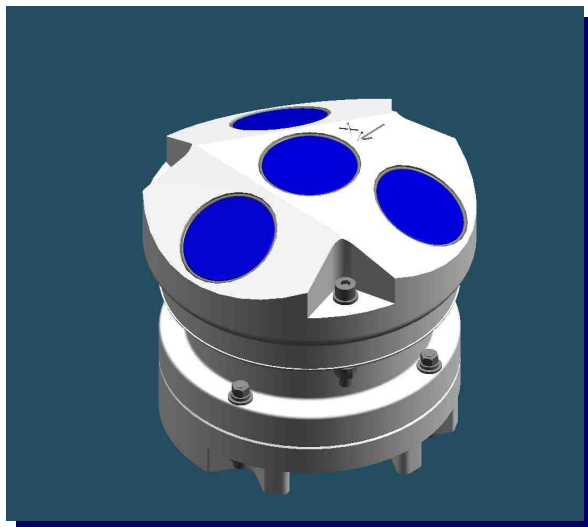
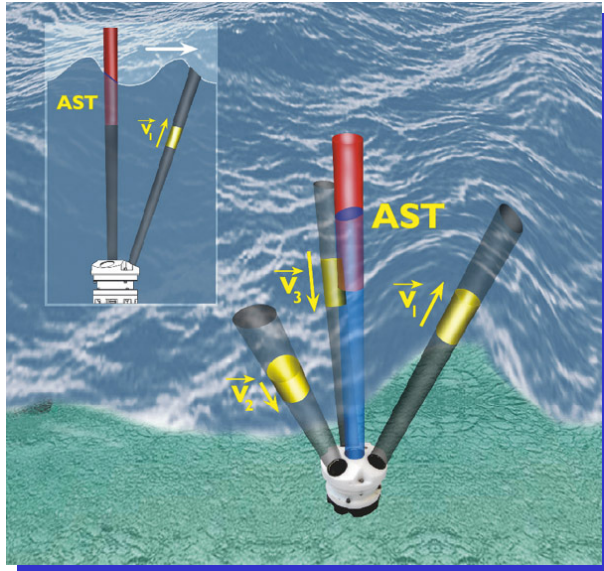
ADCP Frequency Limitation with Depth

Depth (m)	Freq (Hz)	Period (s)
5	0.7	1.45
10	0.45	2.20
15	0.37	2.70
20	0.30	3.30
25	0.28	3.57
30	0.26	3.85
35	0.24	4.15
40	0.23	4.35
45	0.21	4.75
50	0.20	5.0
55	0.19	5.25
60	0.18	5.55

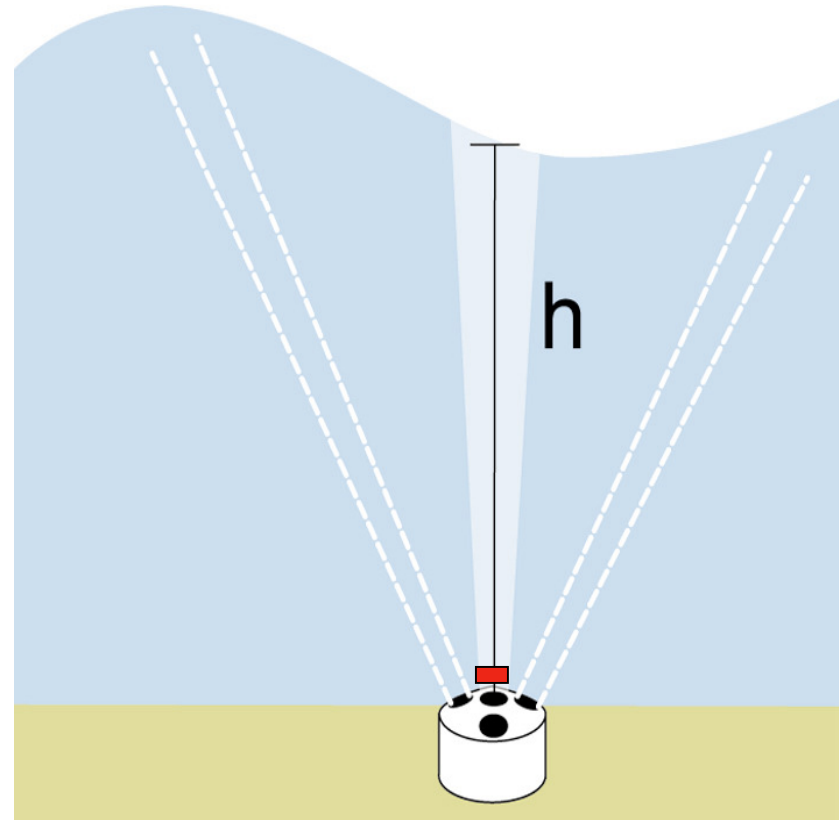


Nortek AWAC:

Acoustic Surface Tracking (AST) is Primary Method



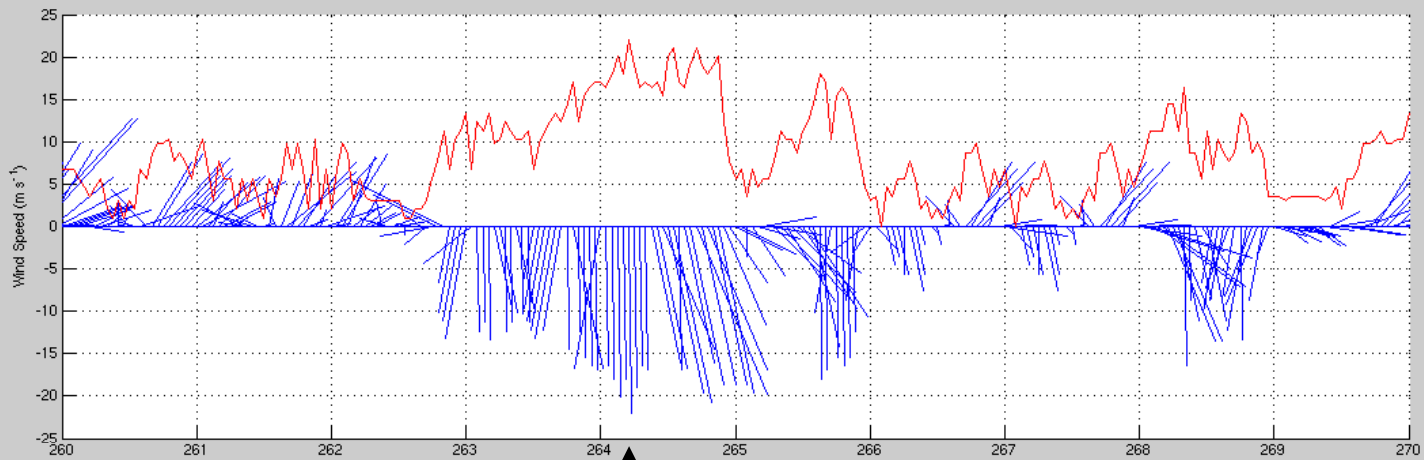
Center beam acoustically tracks the surface position (wave height & period) at 4 Hz with no attenuation due to depth



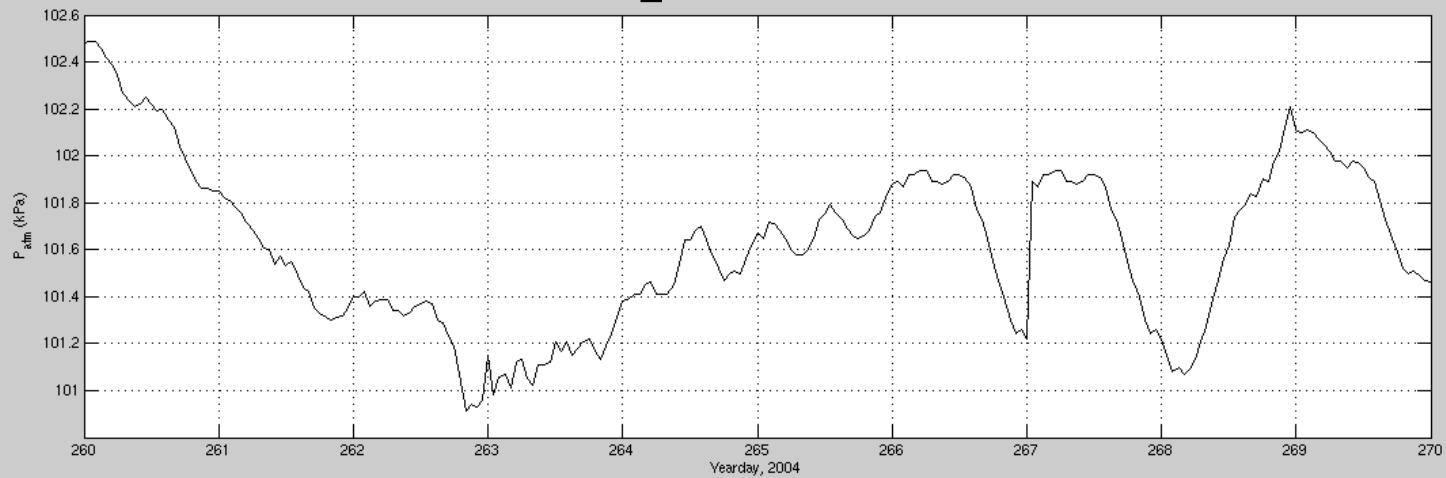
EVENT 1: Local Storm

Wind 20 m/s from North

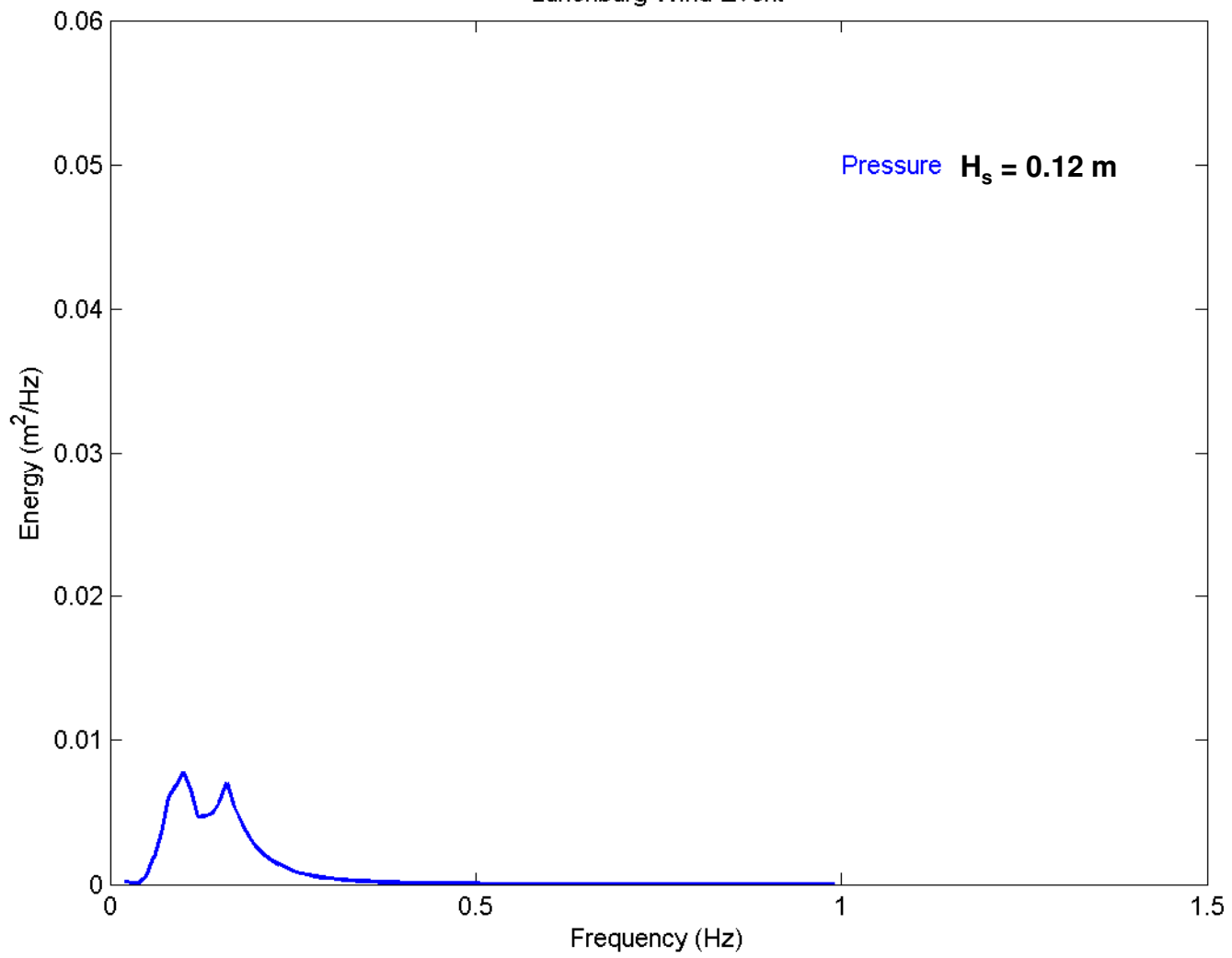
Wind



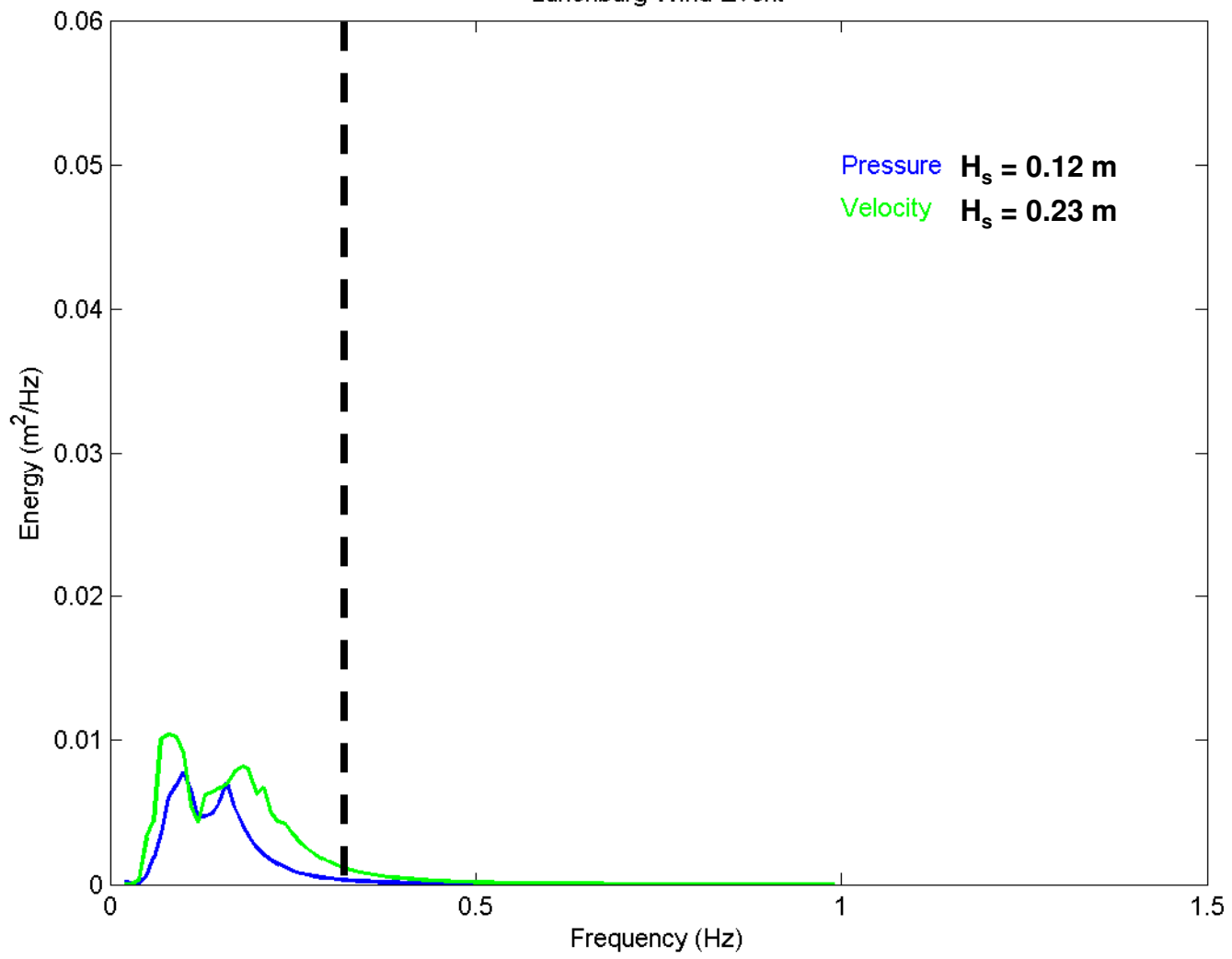
Baro. Pressure



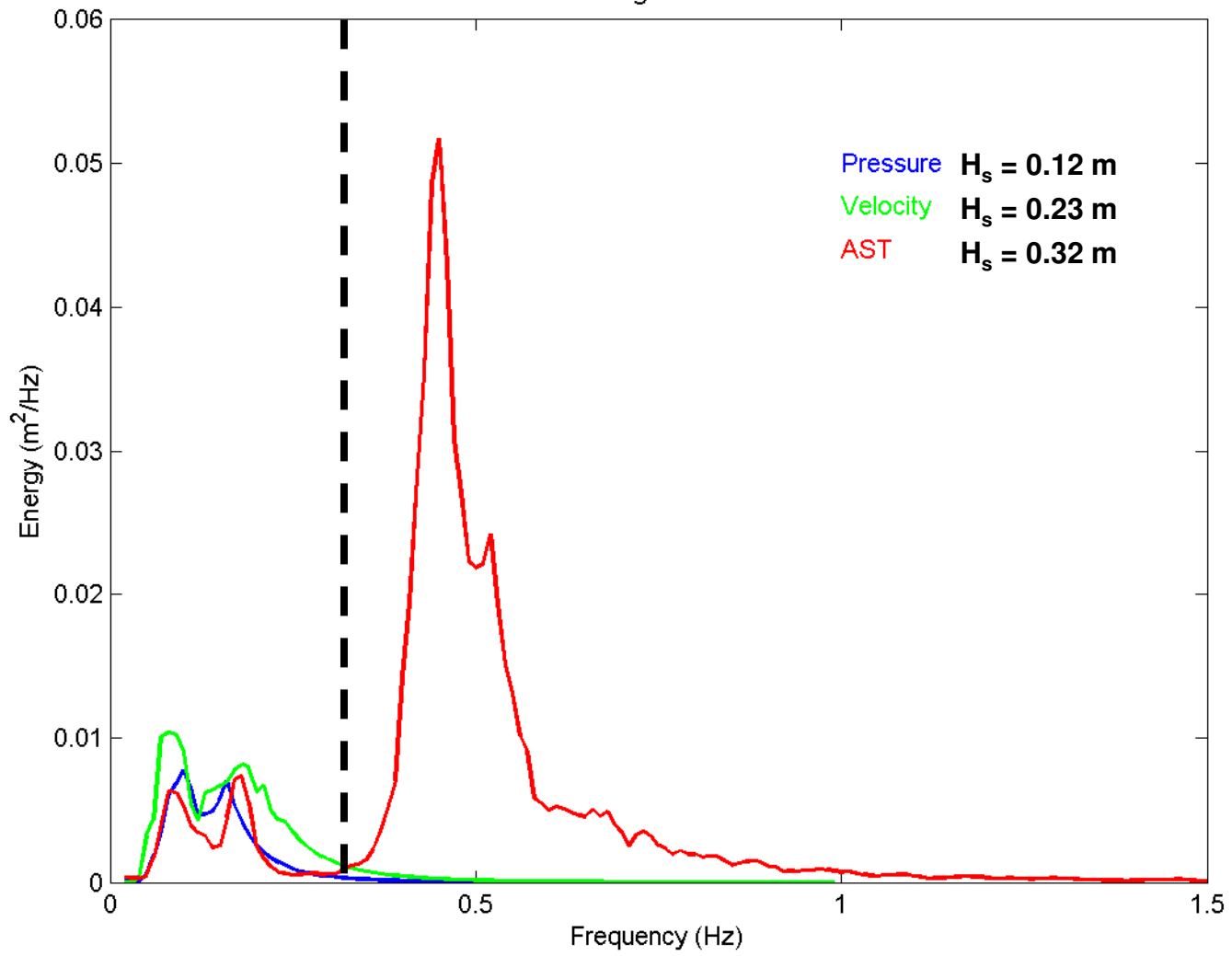
Lunenburg Wind Event

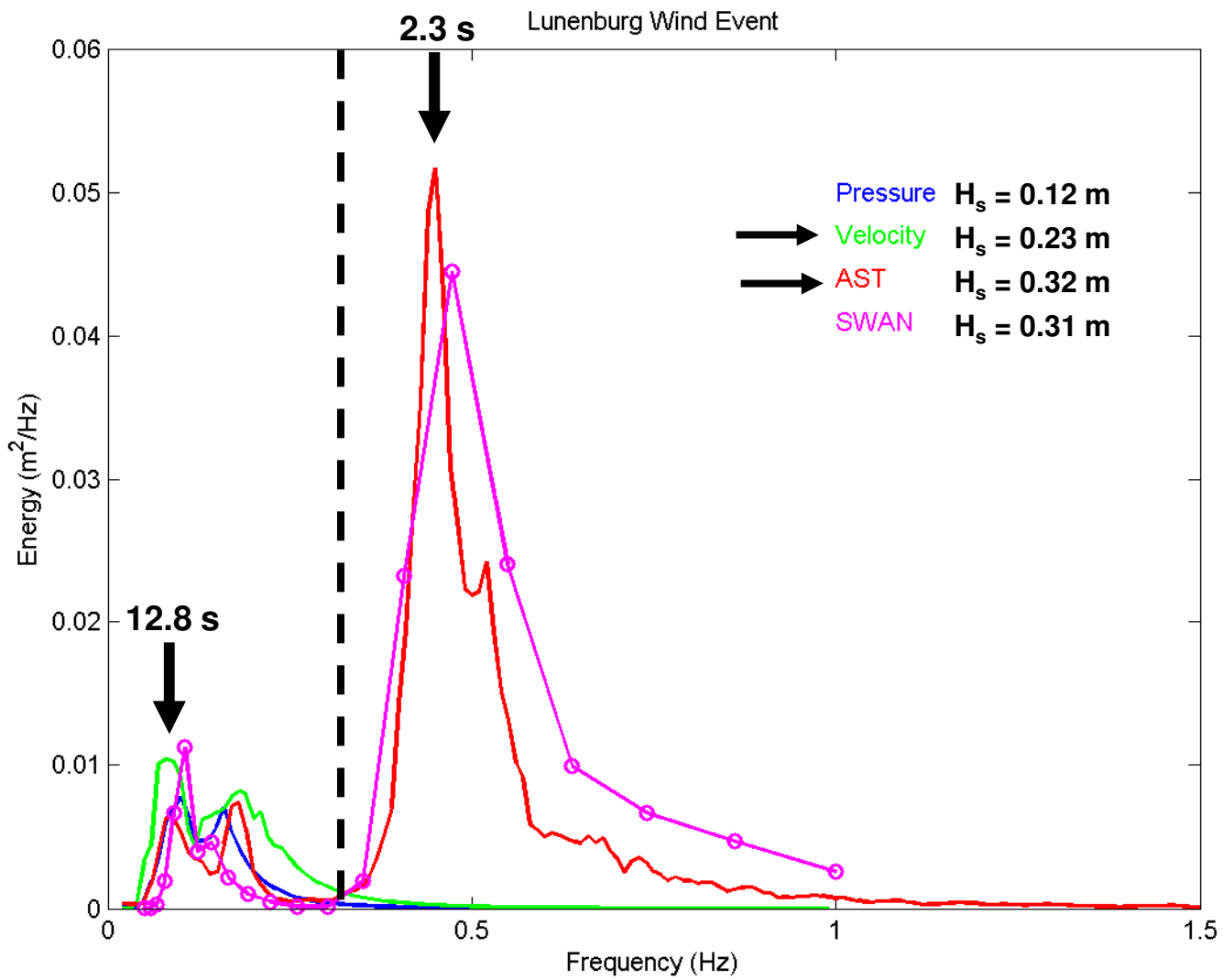


Lunenburg Wind Event

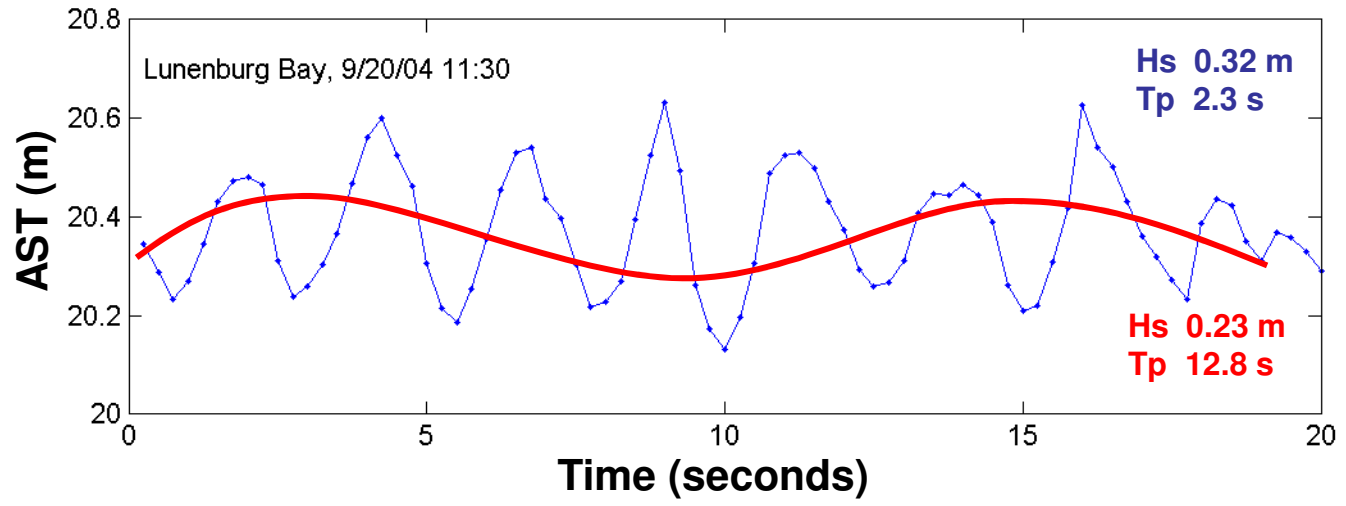


Lunenburg Wind Event





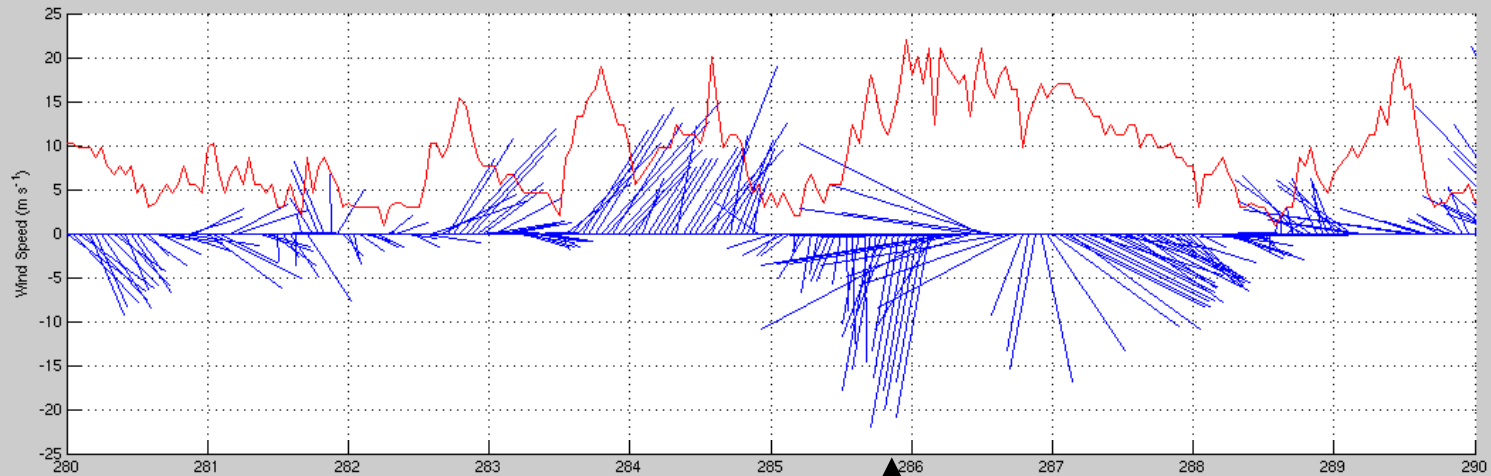
Wave Height Time Series



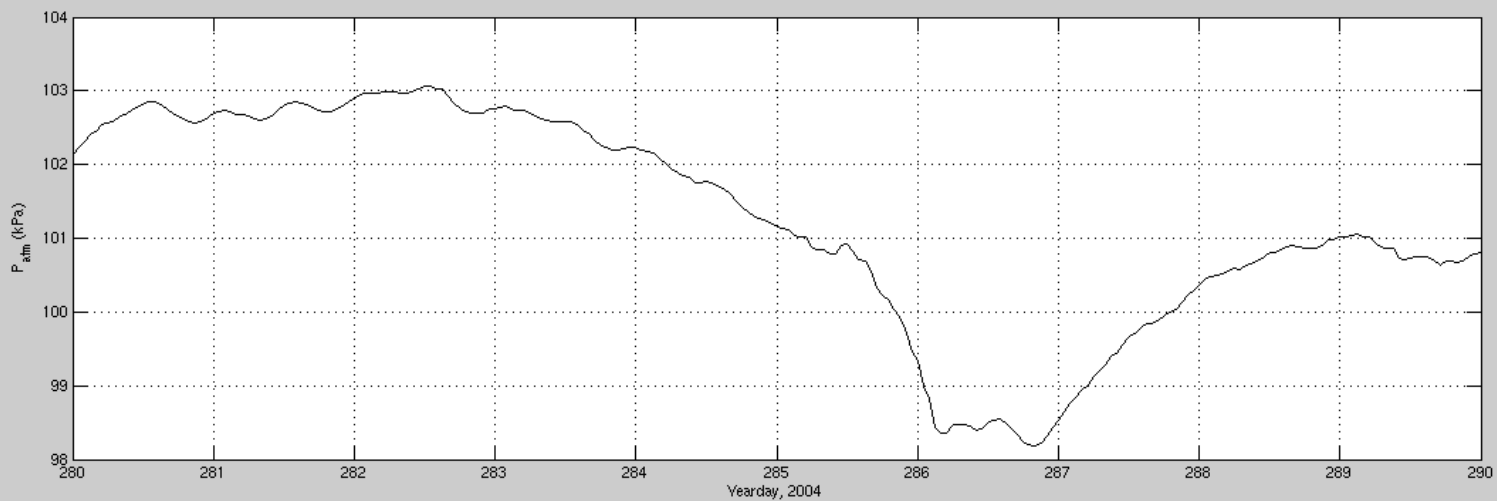
EVENT 2: TS Nicole

Wind 20 m/s from North

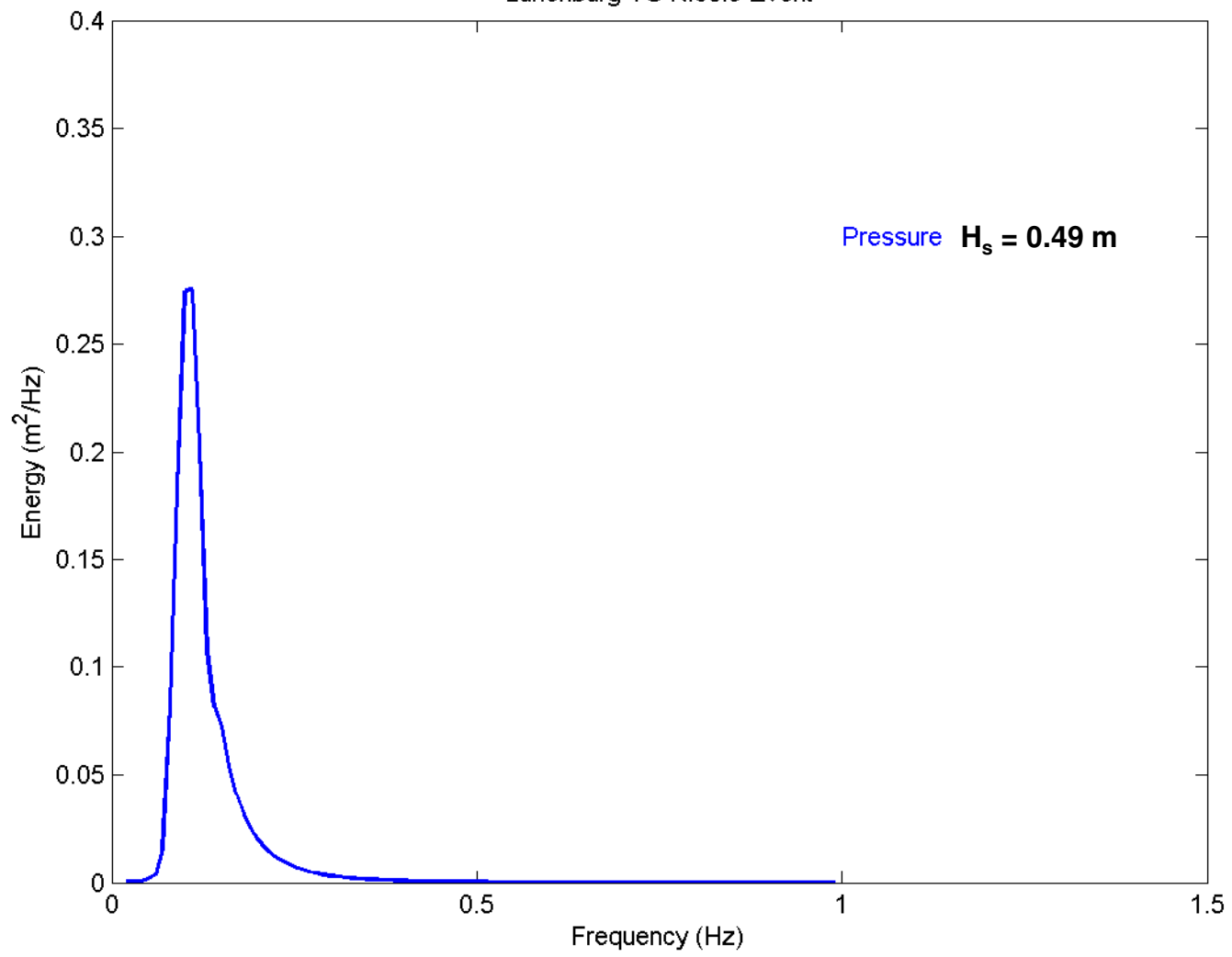
Wind



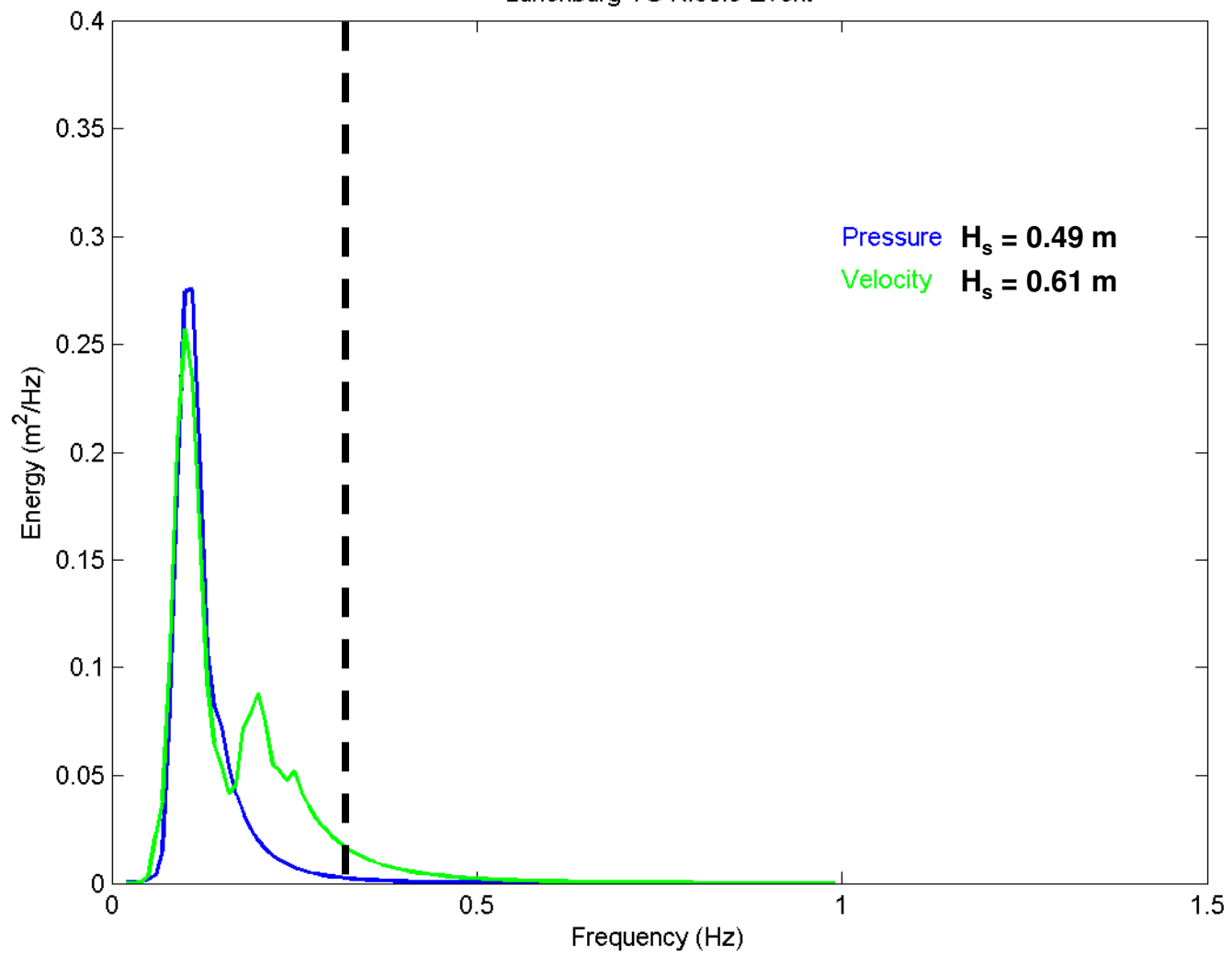
Baro. Pressure



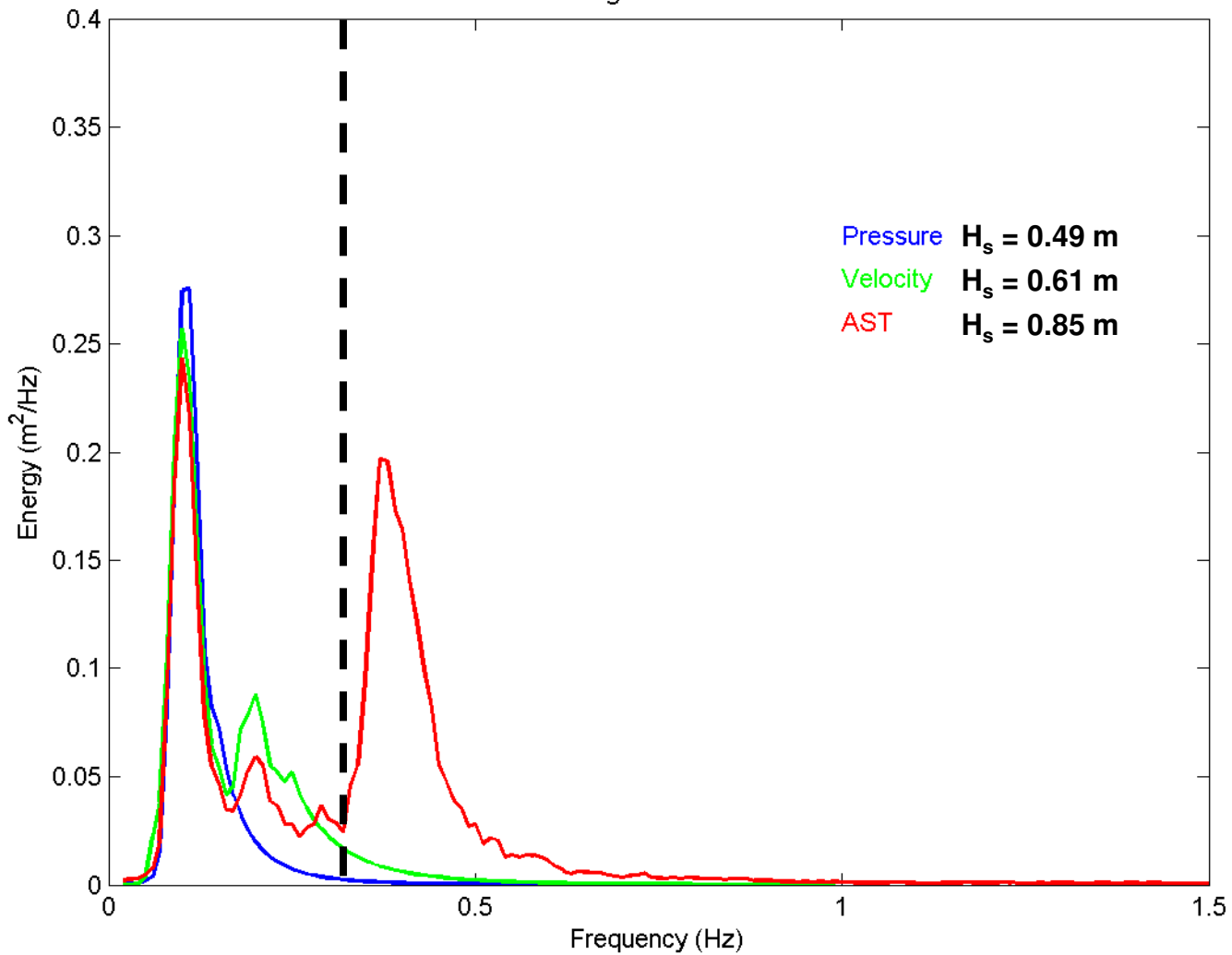
Lunenburg TS Nicole Event



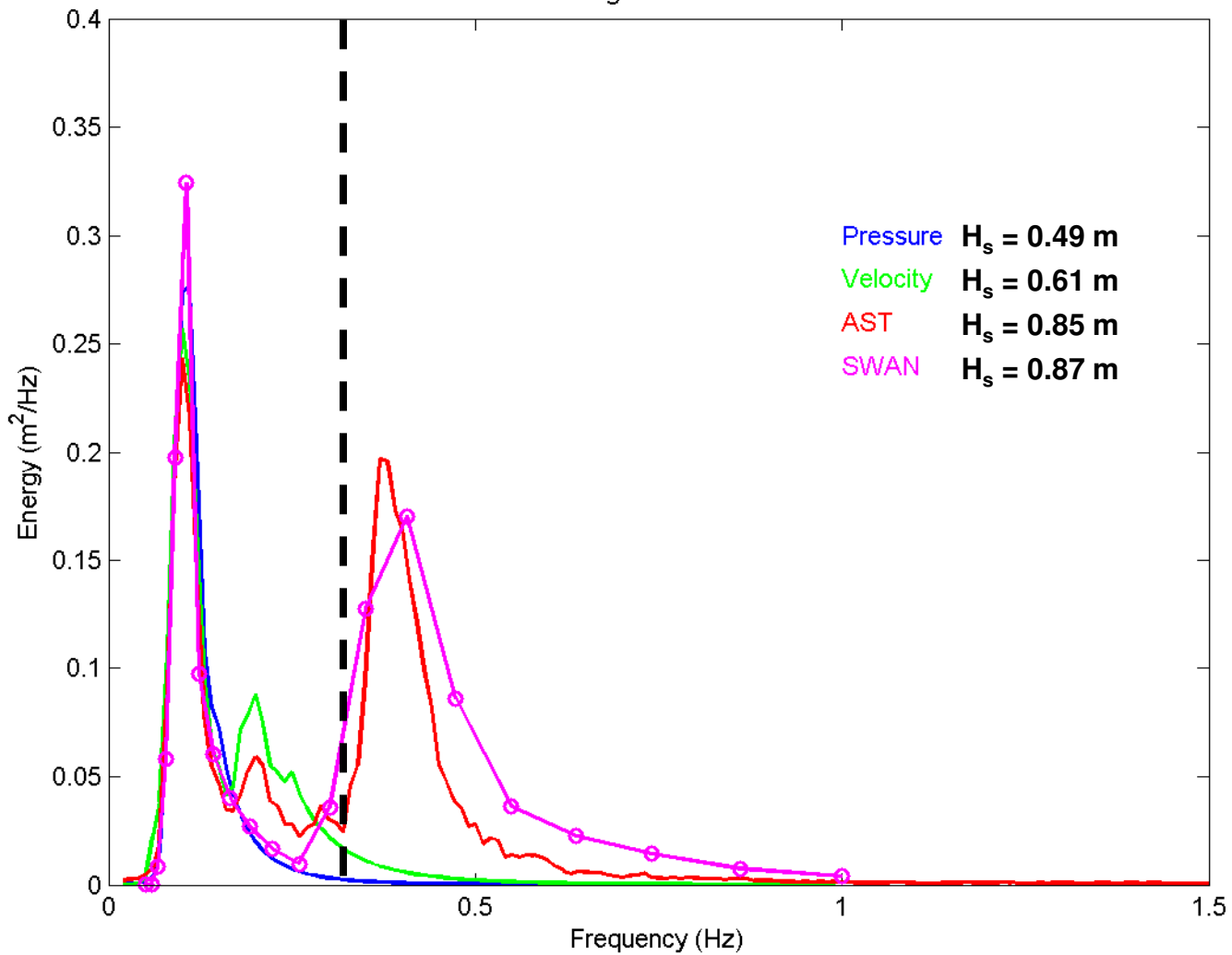
Lunenburg TS Nicole Event



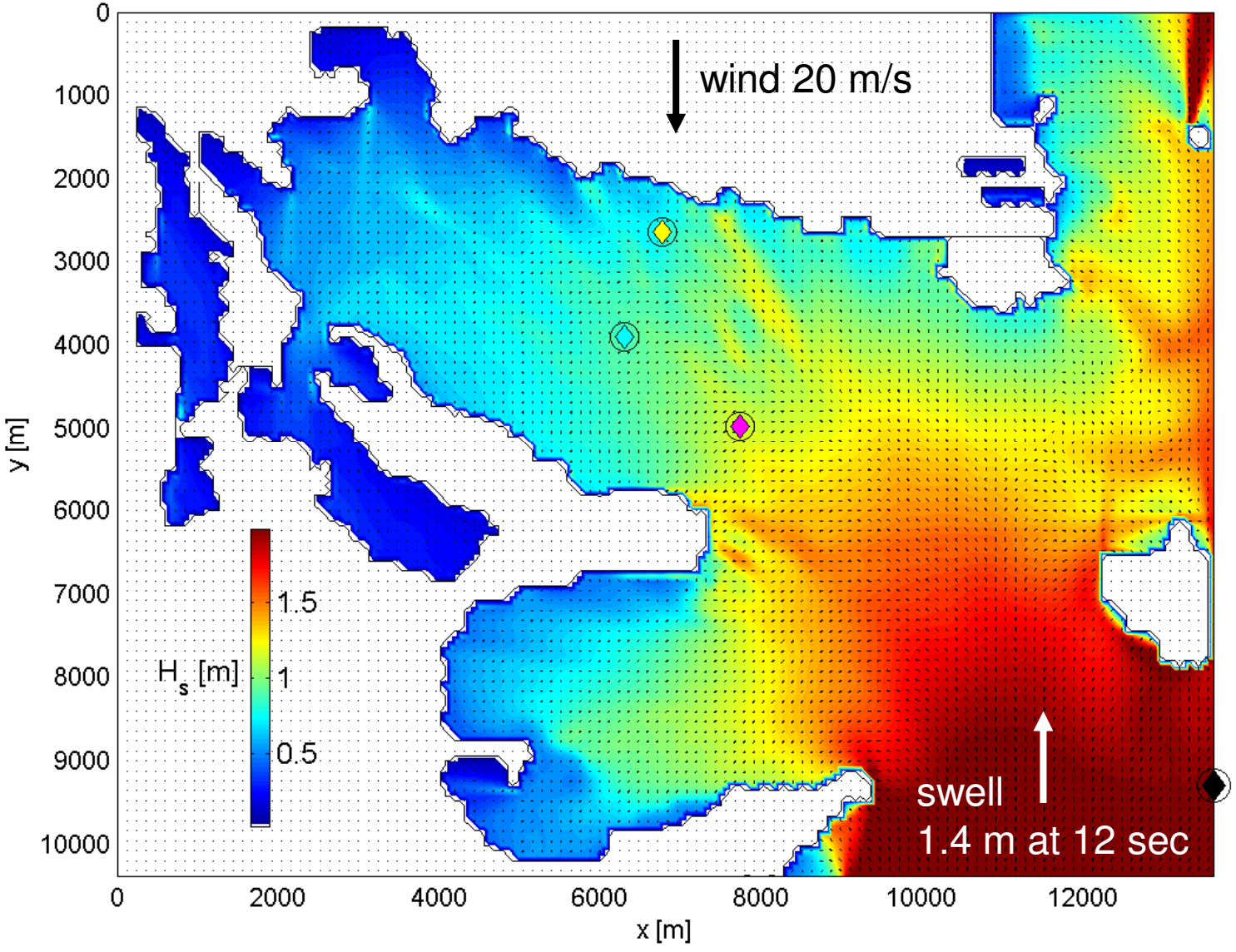
Lunenburg TS Nicole Event



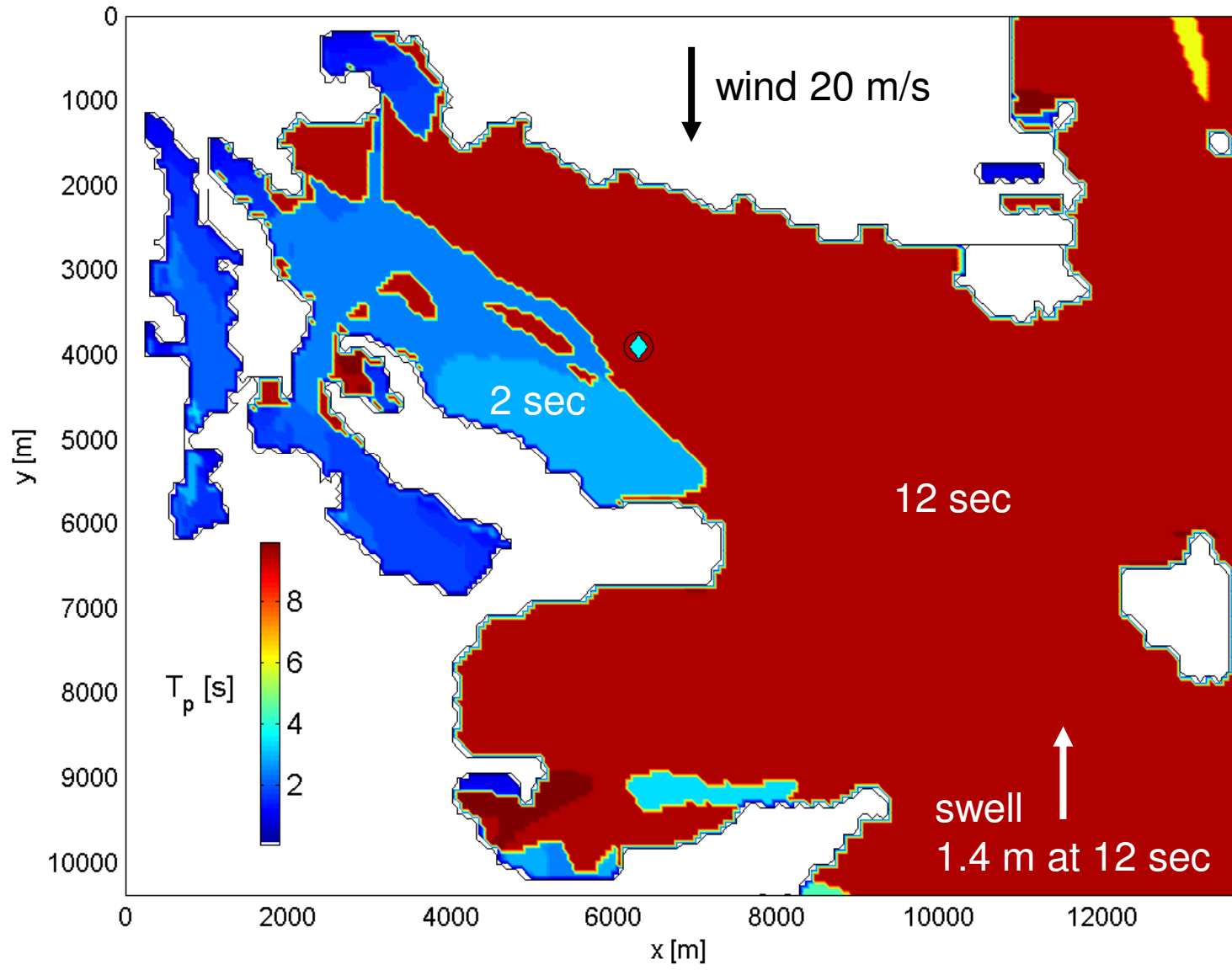
Lunenburg TS Nicole Event



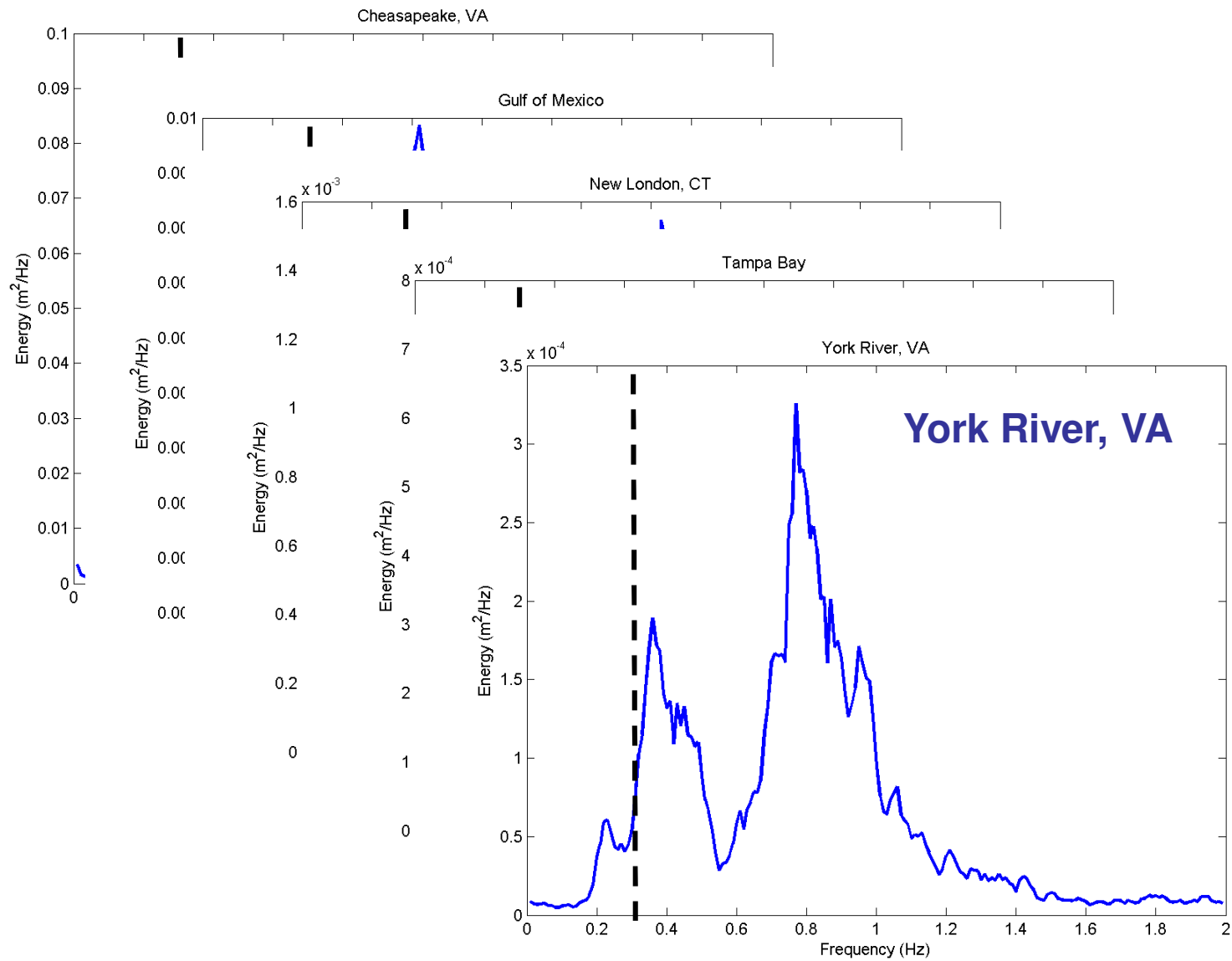
Significant Wave Height



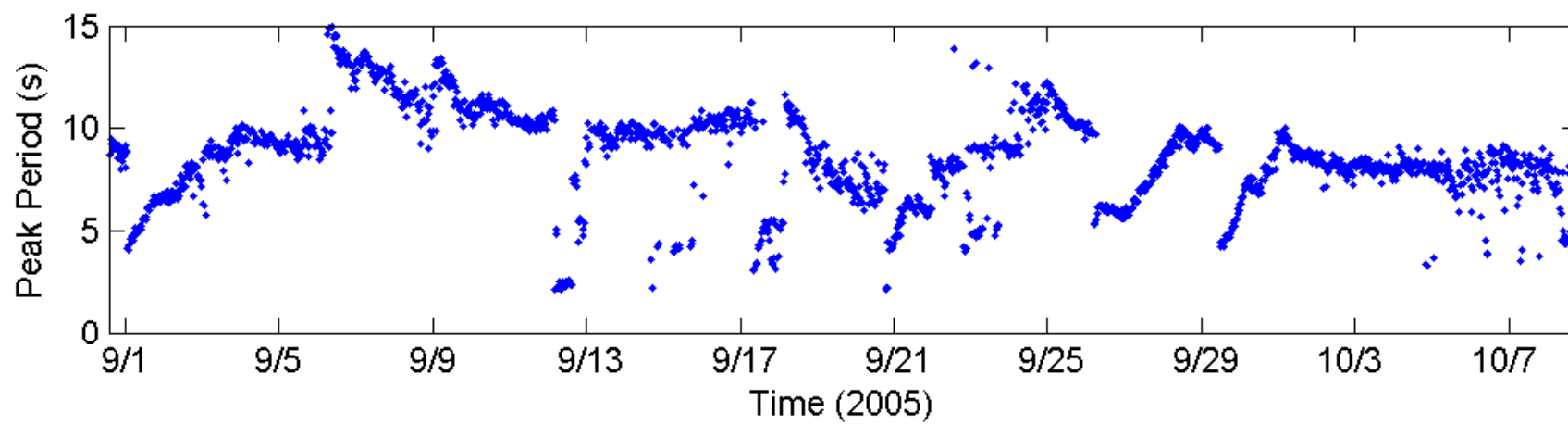
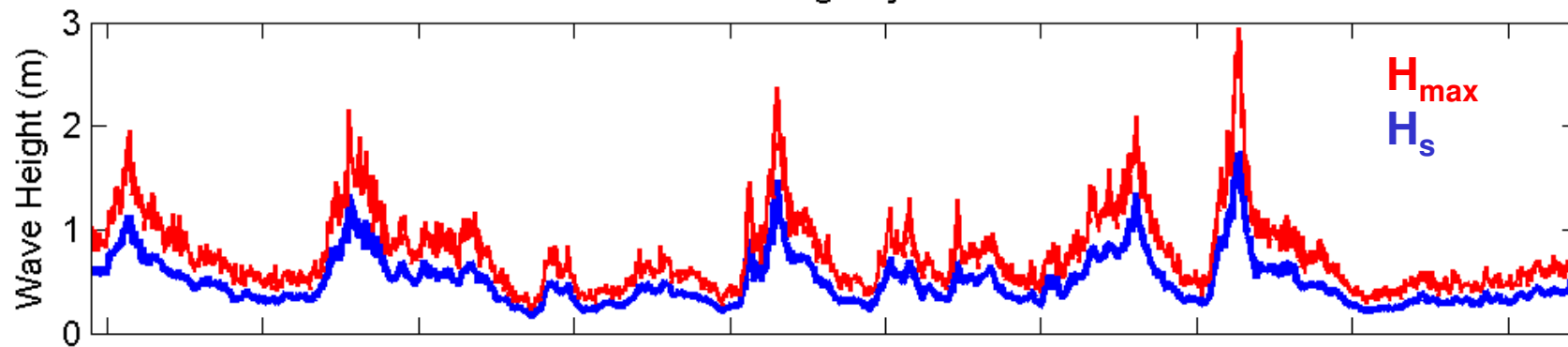
Peak Period



High frequency waves from other AWAC locations:

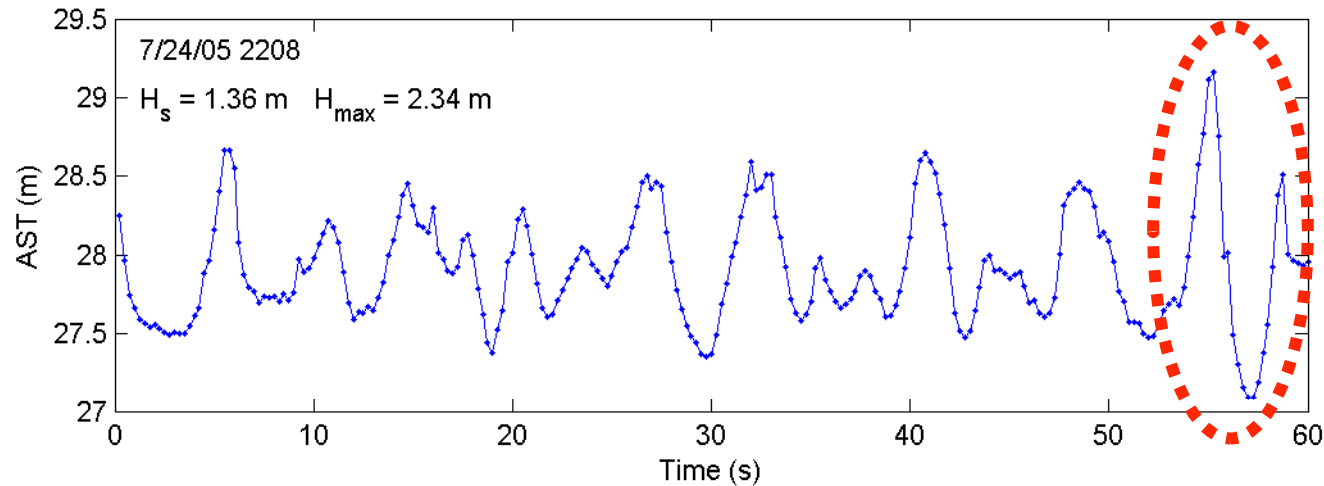


Lunenburg Bay 2005



Significant Wave Height (H_s)

Maximum Wave Height (H_{max})

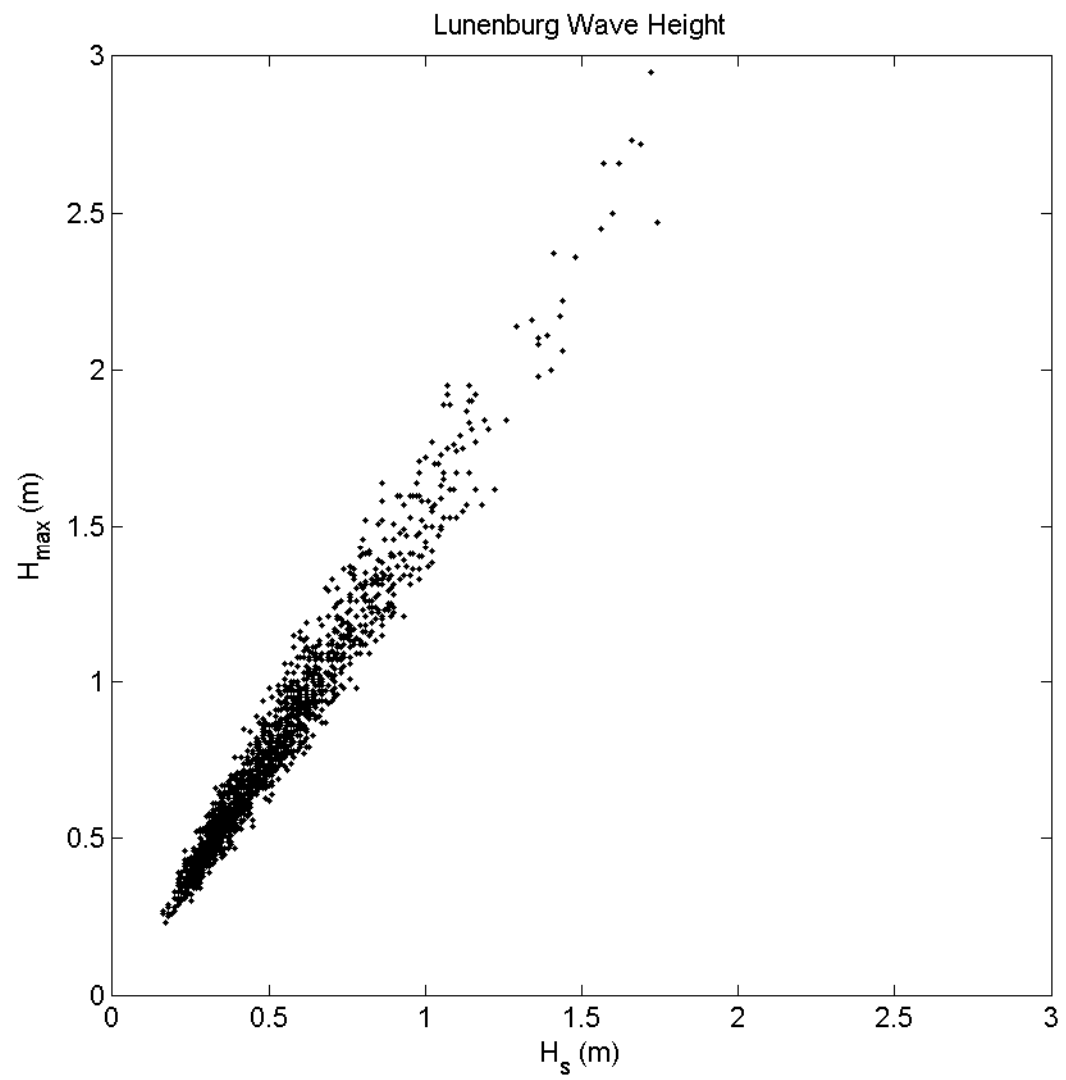


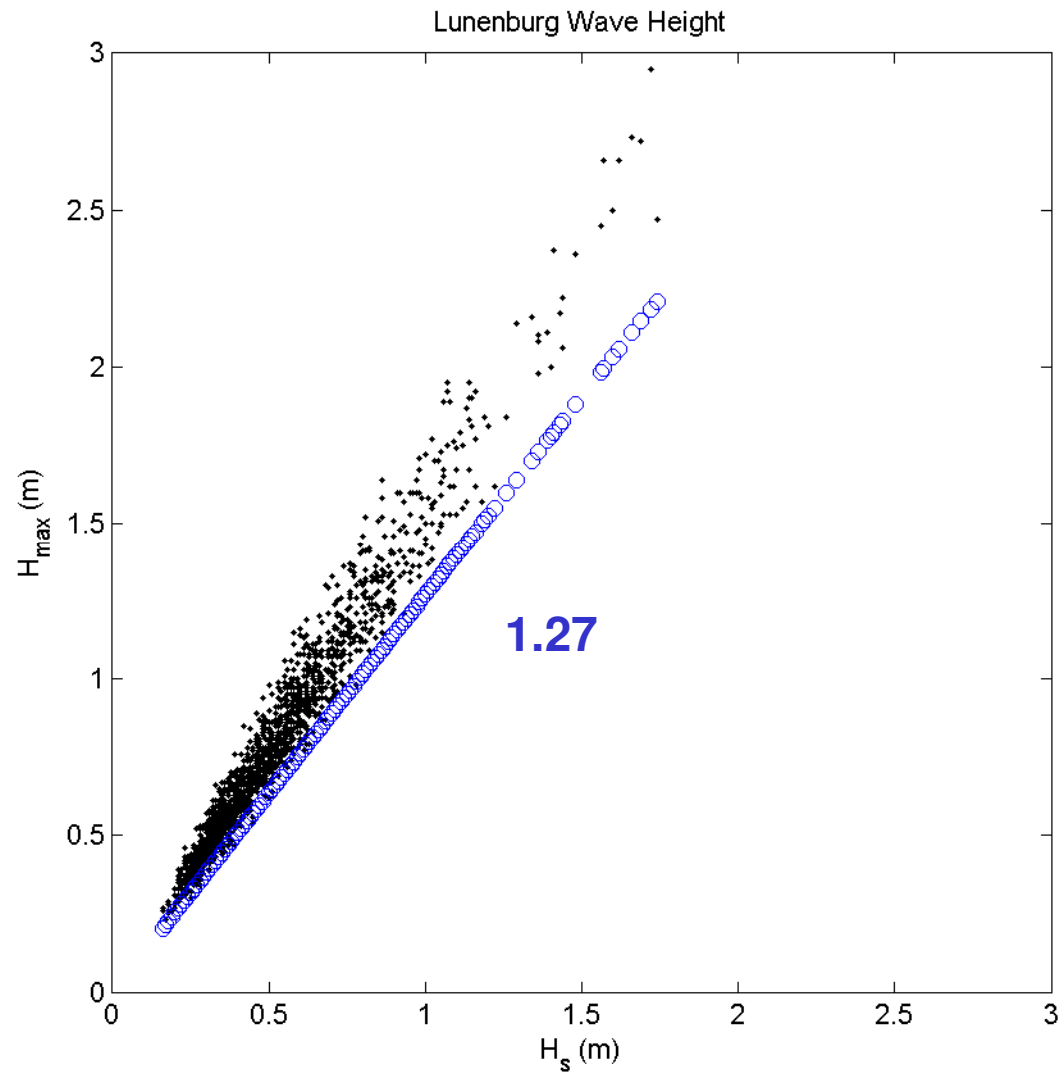
H_s

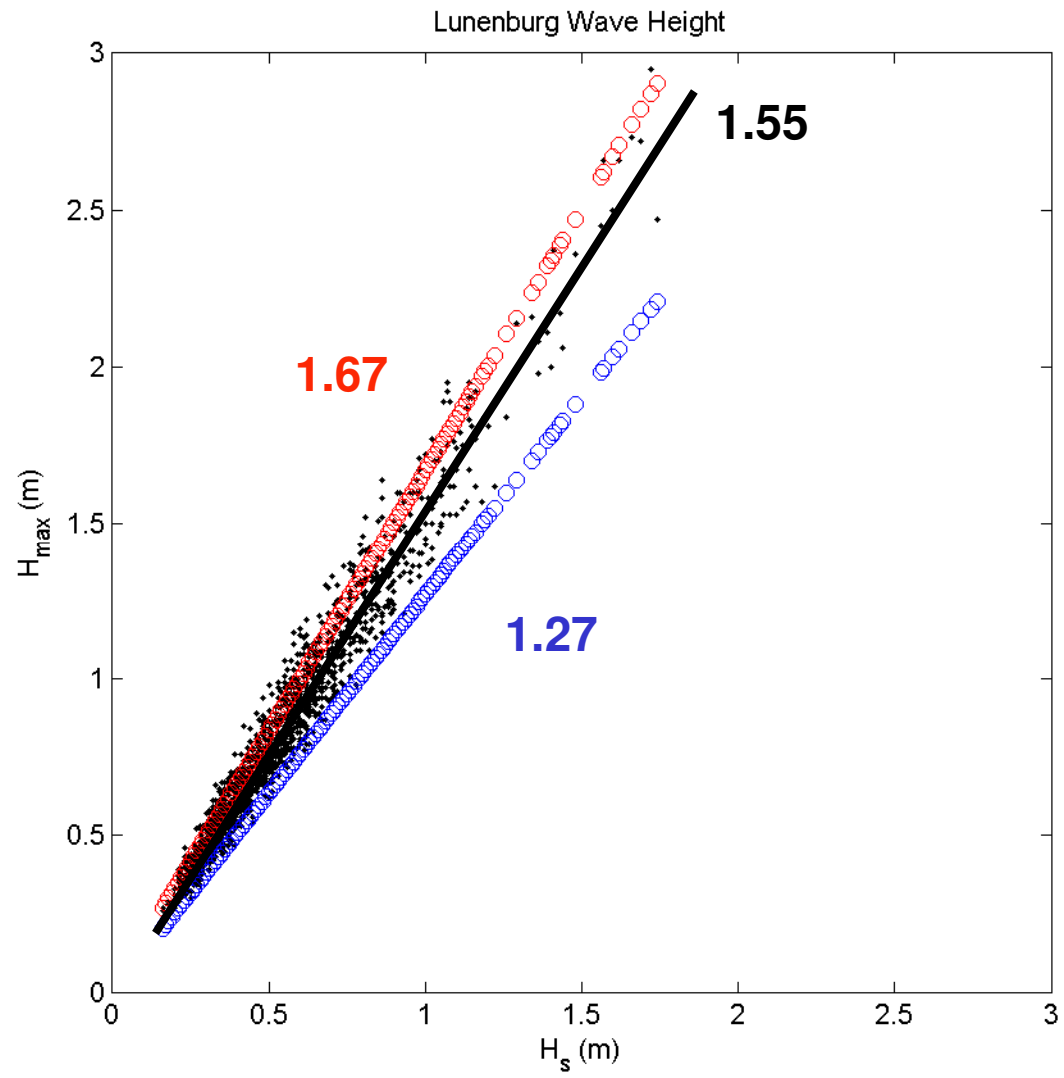
- wave train –
“mean of the 1/3 largest waves”
- spectral –
 $4\sqrt{m_0}$

H_{max}

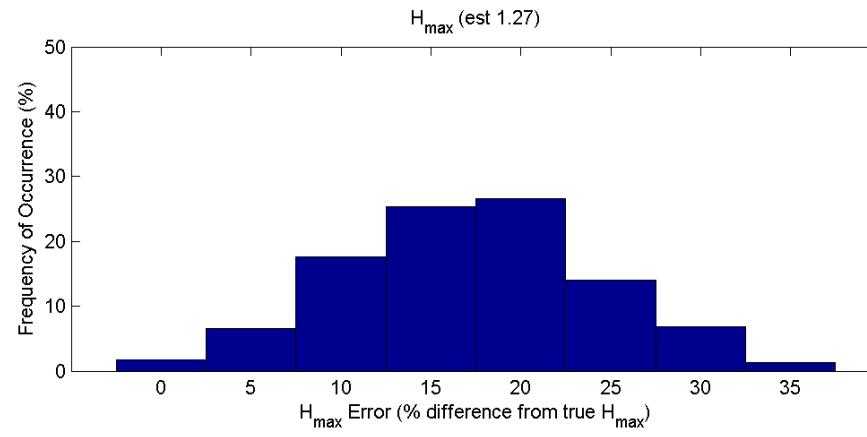
- wave train –
find the largest wave
- linear transfer function –
 $1.67 * H_s$







H_{\max} Skill



Influence of Spectral Width on Wave Height Parameter Estimates in Coastal Environments

Justin P. Vandever¹; Eric M. Siegel²; John M. Brubaker³; and Carl T. Friedrichs, M.ASCE⁴

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- AWAC data from 10 offshore, coastal and estuarine environments
- H_{\max}/H_s ratio dependence on spectral bandwidth
- Provides empirically derived equations relating ratio to spectral bandwidth
- Provides two methods to predict H_{\max} from spectrum when AST time series is unavailable
- Average skill better than 10% error

http://www.nortekusa.com/PDF/AWAC_ASCE_2008.pdf

Scientific Summary

- High frequency waves, generated by local winds, are common in Lunenburg Bay and other coastal environments
- With a required frequency limitation of 0.3 Hz (3.3 sec), important higher frequencies in the spectrum are neglected
- High frequency wind waves add substantially to the total wave energy and contribute to the significant wave height
- High frequency waves are important to:
 - recreational boaters (white caps, dangerous/steep)
 - engineering studies (design / wear, floating structures)
 - air-sea interaction (white caps, bubbles, water quality)
 - energy transfer / dissipation
 - model forcing / initial conditions
- Need acoustic surface tracking to resolve high frequency waves from remote (bottom mounted) sensors

Engineering & Observing Implications

- Should strive to observe as much of the wave spectrum as possible because locally generated wind-waves can dominate wave conditions
- When high frequency waves are not well resolved:
 - significant wave height can be misreported by a factor of up to 50%
 - the peak period that is reported may not represent the dominate sea state
- H_{\max} estimated via transfer function (1.67) provides errors greater than 20% more than 20% of the time
- New empirically derived equations based on spectral width can improve H_{\max} estimates (without AST) to within about 10% error or better