

# Real-time Wave and Current Observations at the CBOS York River Buoy

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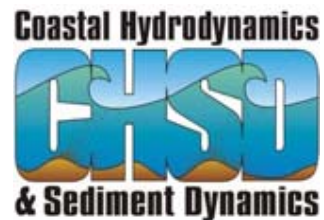
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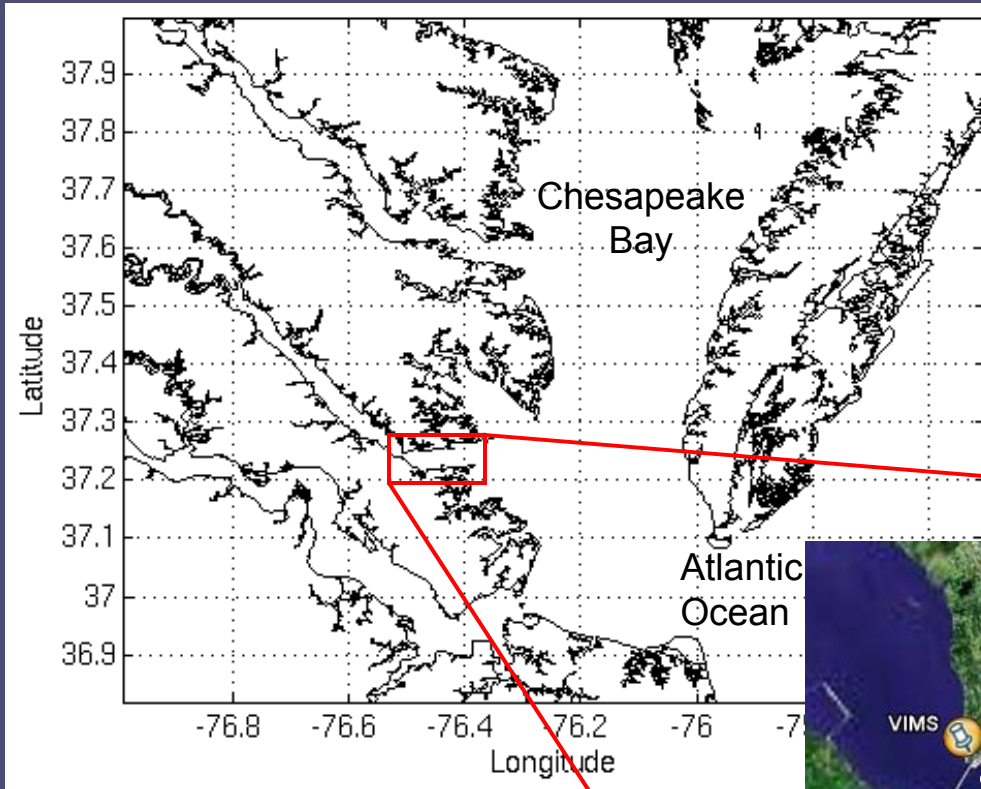
## Outline

1. VIMS Observing System
2. Buoy Infrastructure
3. Real-time Data
4. Instrument Comparisons
5. Preliminary Analysis
6. Conclusions

Virginia Institute of Marine Science



# Study Location - York River, VA



- Tributary of Chesapeake Bay
- Partially-mixed estuary with ~1m tidal range
- Up to ~1m/s currents at spring tide



- 2 buoys: Gloucester Point and Goodwin Islands

# Buoy Infrastructure Instrumentation

- Nortek Current Meters
  - 1 MHz Aquadopp Current Profiler (1.5m)
  - 2 MHz Aquadopp Current Meter (1.2m)
- Nortek Wave Gage
  - 1 MHz AWAC
- Falmouth Scientific CTD Sensor
- Solar panels and batteries
- Fiber optic cable to land base station



# Aquadopp Current Meter

## Blanking Sensitivity

- “Puckhead” transducer - vertically mounted, 3 horizontal beams oriented north, 1m below surface
- *Objective*: assess sensitivity of velocity measurement to flow disturbance from buoy

| Blanking | Cell center | Cell range    |
|----------|-------------|---------------|
| 0.35 m   | 1.10 m      | 0.35 - 1.85 m |
| 1.0 m    | 1.75 m      | 1.0 - 2.5 m   |
| 2.0 m    | 2.75 m      | 2.0 - 3.5 m   |
| 3.0 m    | 3.75 m      | 3.0 - 4.5 m   |
| 4.0 m    | 4.75 m      | 4.0 - 5.5 m   |

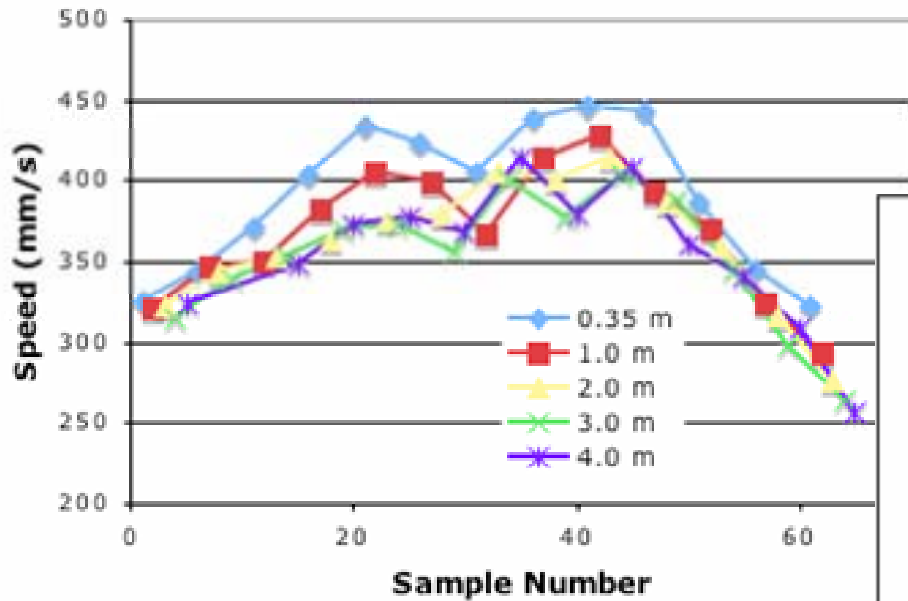


Beam geometry

# Aquadopp Current Meter

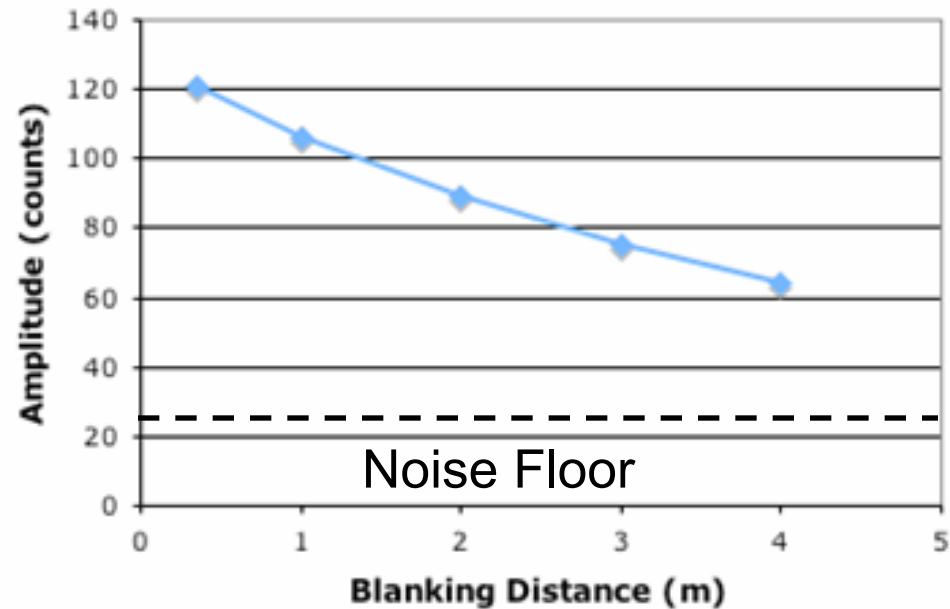
## Blanking Sensitivity: Ebb current

**Current Magnitude**



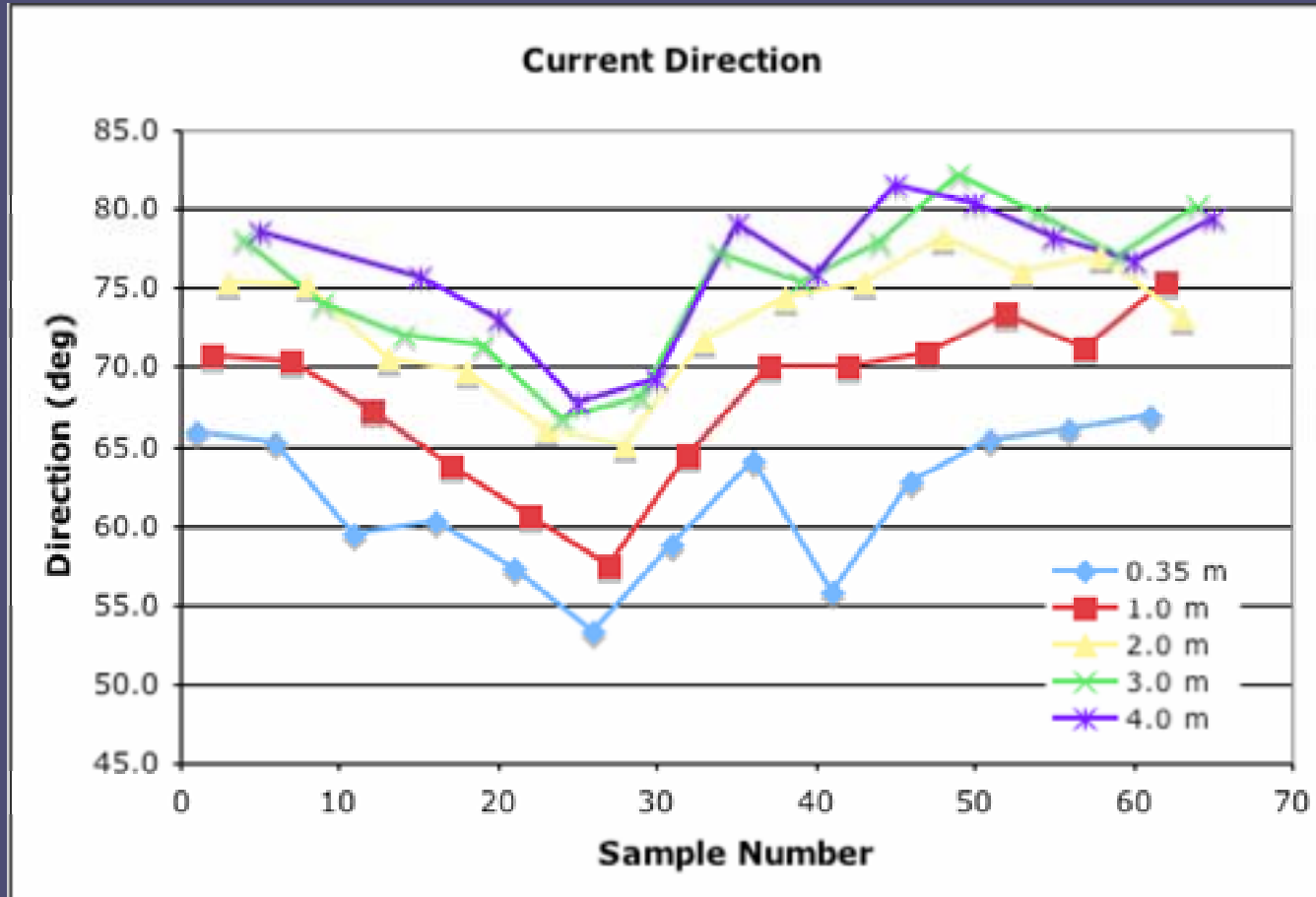
Sufficient SNR out to 4m blanking distance

**Mean Amplitudes**



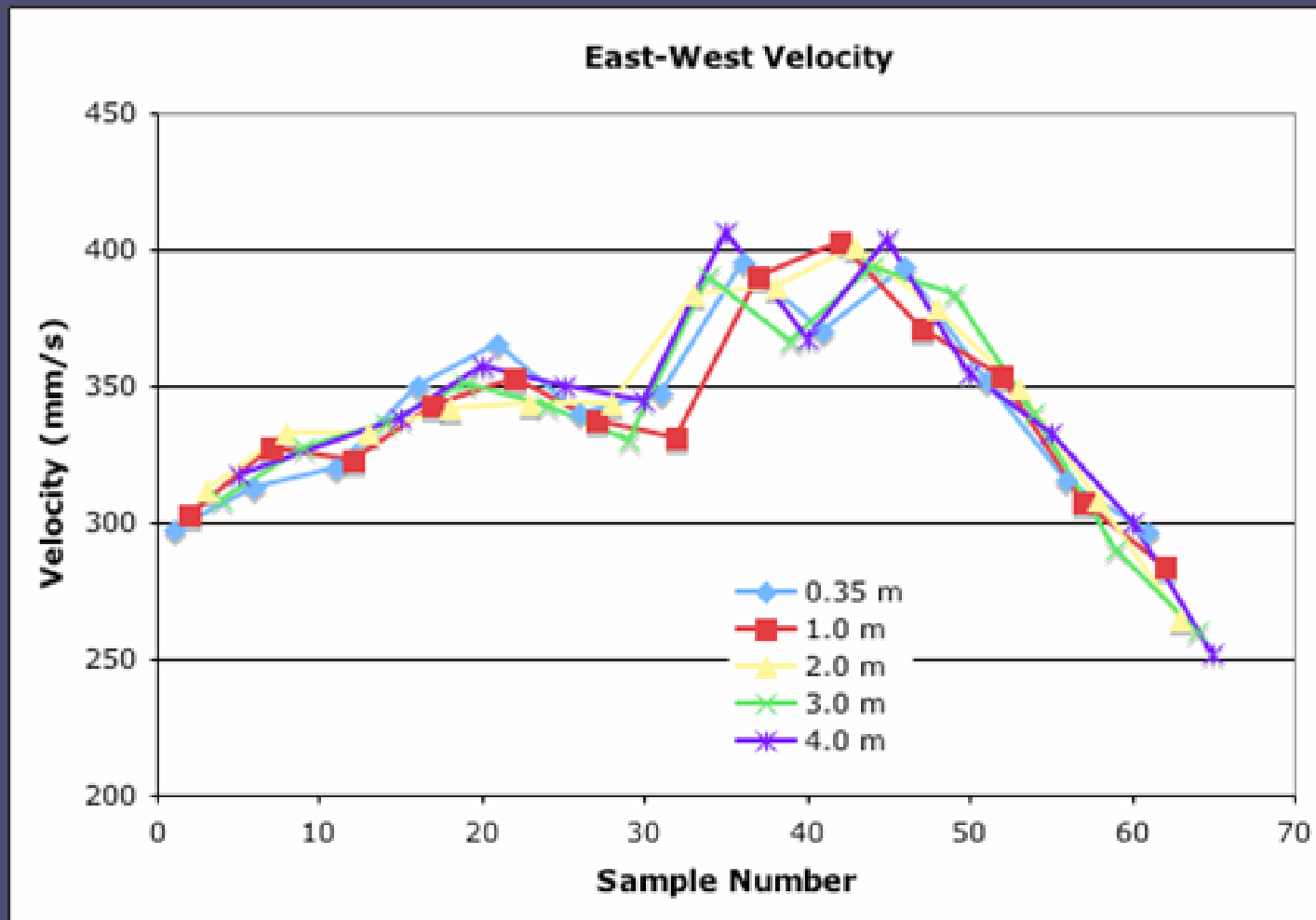
In general, current magnitude enhanced near buoy by ~5 cm/s

# Aquadopp Current Meter Blanking Sensitivity: Direction



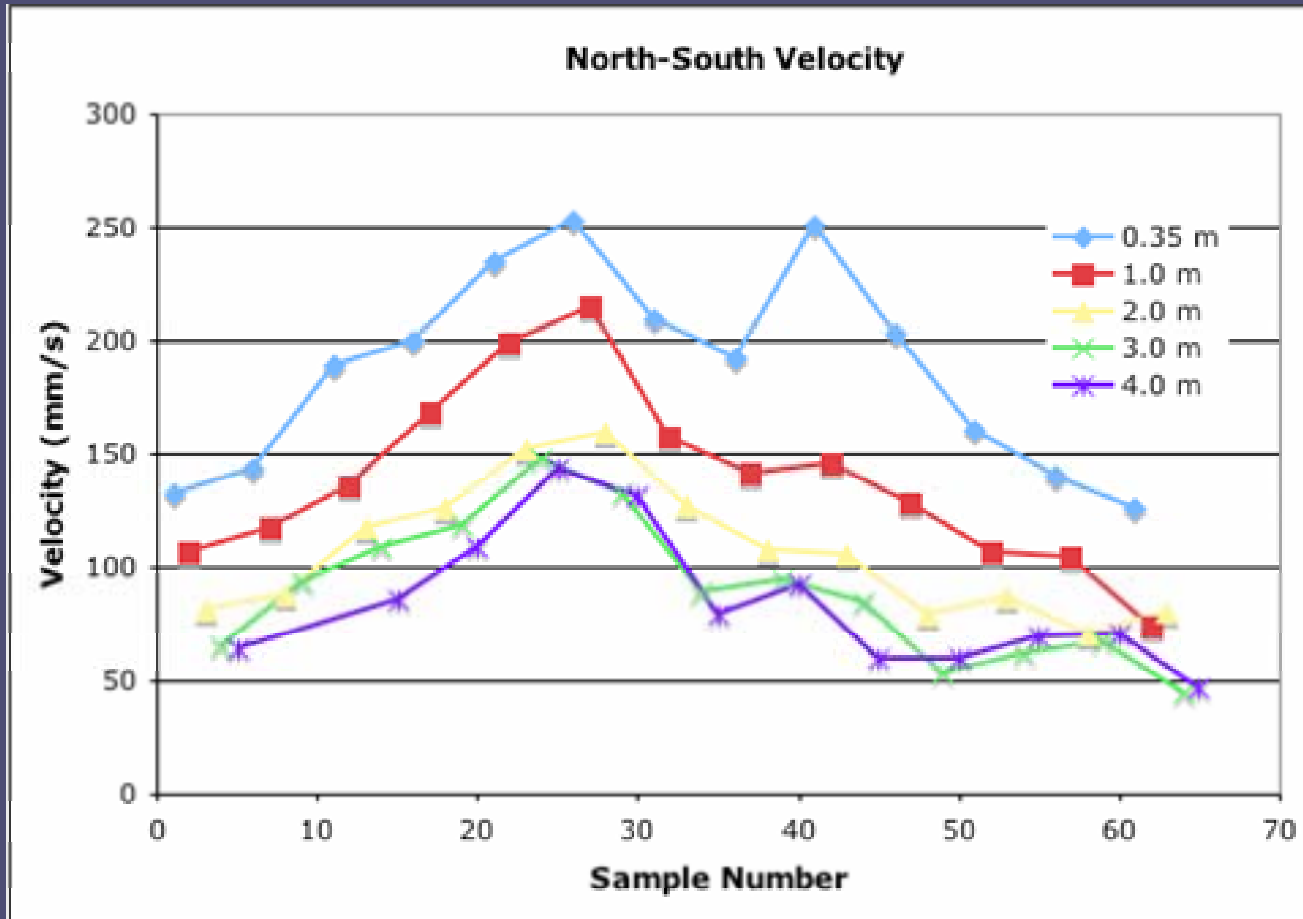
Direction shifted by 10-15° to north near buoy

# Aquadopp Current Meter Blanking Sensitivity: East Component



# Aquadopp Current Meter

## Blanking Sensitivity: North Component



North component enhanced by ~10 cm/s near buoy

# Aquadopp Current Meter

## Blanking Sensitivity: Ebb Current

### *Conclusions*

1. East component of velocity independent of blanking distance
2. North component enhanced by  $\sim 10$  cm/s near buoy
3. Magnitude and direction shifted by 5 cm/s and  $10-15^\circ$  near buoy
4. 3-4m blanking distance sufficient



*Working hypothesis:* on ebb, eastward current encounters flat stern of buoy and is jetted outwards, enhancing the north component of velocity near the buoy

# Real-time Wave and Current Observations at the CBOS York River Buoy

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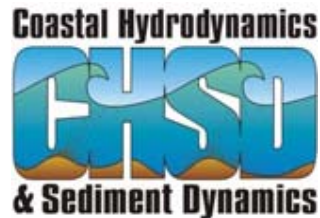
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# Aquadopp Output $\Rightarrow$ Real-time display

VIMS Campus

Field Site

Acquisition  
Computer

Wireless telemetry  
2.4 GHz 802.11b

Goodwin  
Base Station

File copy  
↓  
Scheduled Task

UNIX  
Server

Real-time  
Web Display

Fiber  
Cable

Binary  
Data  
File

VIMS Network

HTML  
Plots

Windows PC  
MATLAB



NOMAD

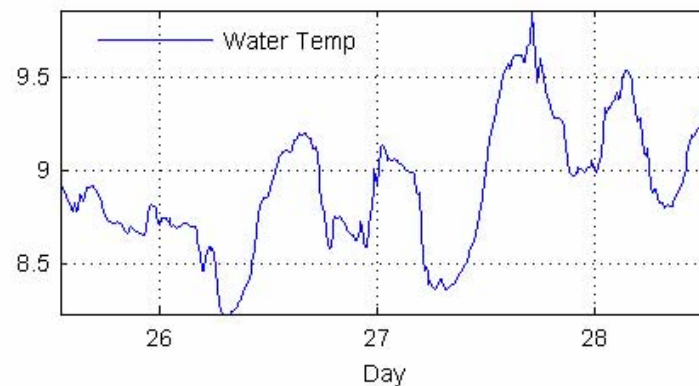
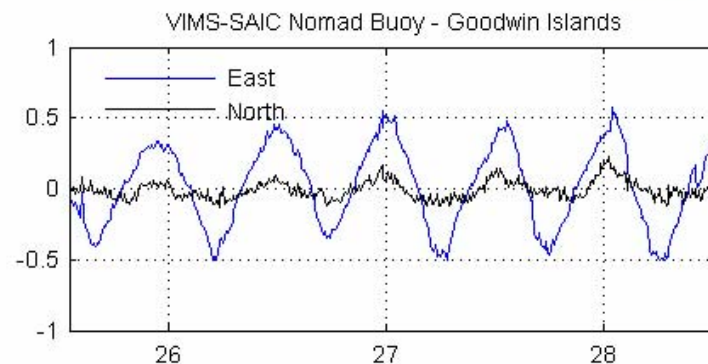
VIMS Observing System - Conditions at Goodwin Islands

These data are collected from a buoy-mounted Nortek Aquadopp Puckhead acoustic Doppler current meter located north of Goodwin Islands, near the York River mouth, VA.

[ [Location Map](#) | [Deployment](#) ]



| Conditions at Goodwin Island             |                |
|--|----------------|
| <b>Sensor: 28-Mar-2006 13:04:08 EST</b>  |                |
| Water Temp:                              | 9°C, 49°F      |
| Water Depth:                             | 1.3 (m)        |
| Pitch:                                   | -2.1°          |
| Roll:                                    | -2.6°          |
| Heading:                                 | 353.1°         |
| Battery:                                 | 13.3 (V)       |
| <b>Current: 28-Mar-2006 13:04:08 EST</b> |                |
| Surface:                                 | 0.45 m/s @ 73° |
| East:                                    | 0.44 (m/s)     |
| North:                                   | 0.13 (m/s)     |

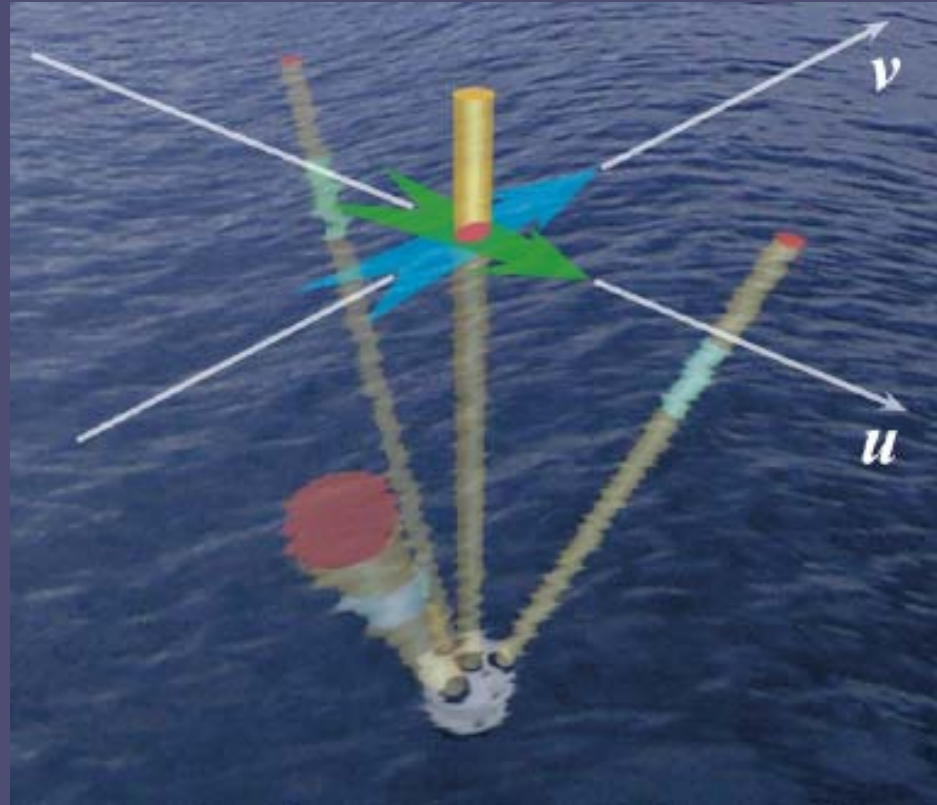


\*\*\*NOTE: This webpage is for test purposes only. VIMS does not guarantee the accuracy of these data.

# Real-time waves

## AWAC/NIP and acoustic modems

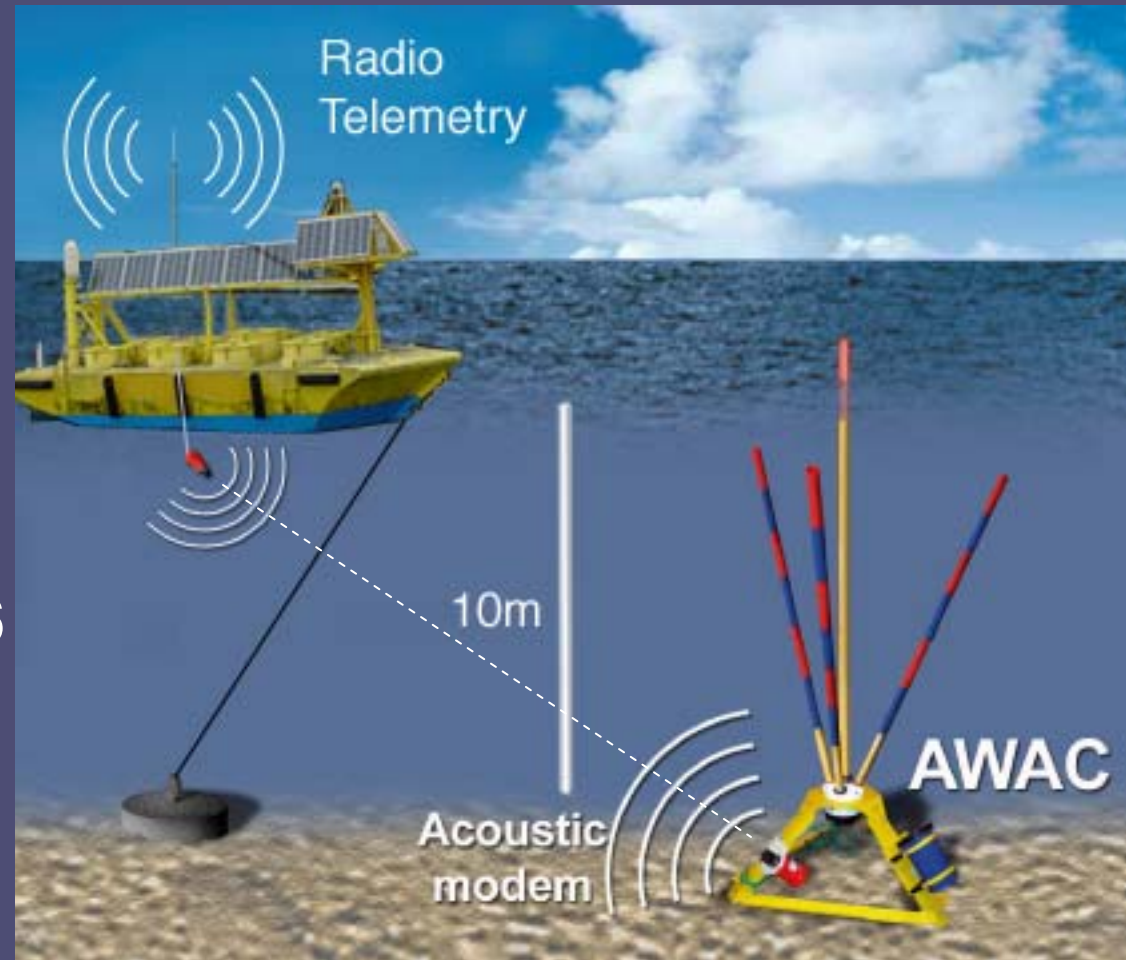
- Bottom mounted, upward looking profiler
- 17 minute wave burst
- Velocity and pressure: 2048 samples at 2 Hz
- AST: 4096 samples at 4 Hz
- Wave interval: 1 hr
- Current interval: 15 minutes



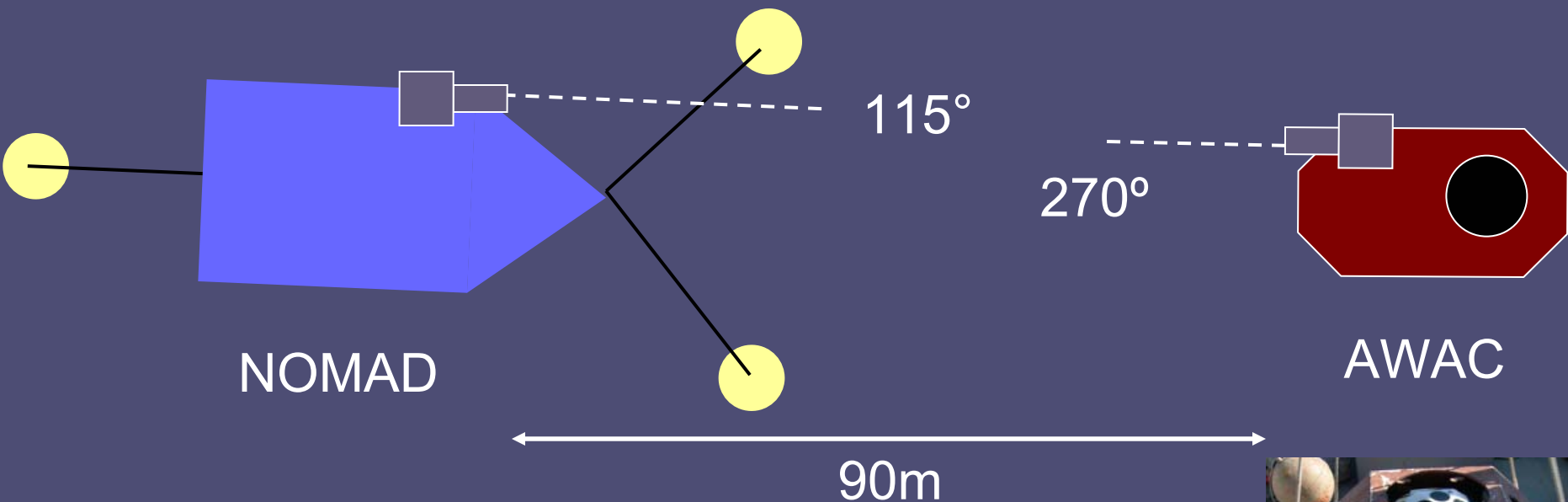
# Real-time waves

## AWAC/NIP and acoustic modems

- AWAC/NIP deployed in 10m
- Linkquest UWM-1000 at 10° off horizontal
- Radio telemetry back to VIMS
- Deployment: Feb 16 - April 11, 2006
- Re-deploy: April 13, 2006

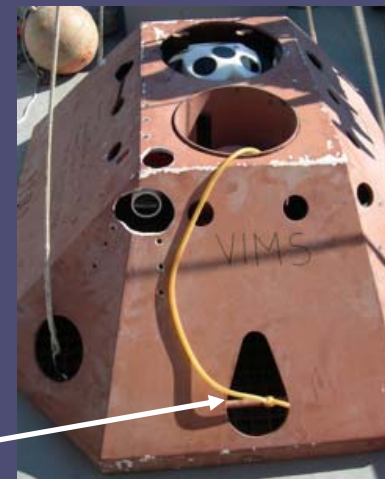


# Idealized NOMAD/AWAC Geometry



Deployment - use fast update preset to check heading using acoustic modem/radio link and onboard computer, then switch to data collection preset.

guide line to bow



String ID

# NIP ASCII Output

```
GoodwinAWAC_04_03_06.TXT
S,03.04.06 13:03:37,11.3, 10.318, -0.20, 2.80,332.5,11.4,1473,000000
C,03.04.06 13:03:37, 1, 0.168,245.7,000000
C,03.04.06 13:03:37, 2, 0.154,235.6,000000
C,03.04.06 13:03:37, 3, 0.218,251.6,000000
C,03.04.06 13:03:37, 4, 0.272,252.9,000000
C,03.04.06 13:03:37, 5, 0.321,241.9,000000
C,03.04.06 13:03:37, 6, 0.386,265.8,000000
C,03.04.06 13:03:37, 7, 0.363,261.6,000000
C,03.04.06 13:03:37, 8, 0.275,268.1,000000
C,03.04.06 13:03:37, 9, 0.196,284.0,000000
C,03.04.06 13:03:37, 10, 0.465,348.5,000000
C,03.04.06 13:03:37, 11, 0.192,315.2,000000
C,03.04.06 13:03:37, 12, 0.234,251.3,000000
C,03.04.06 13:03:37, 13, 0.292,244.4,000000
C,03.04.06 13:03:37, 14, 0.340,257.6,000000
C,03.04.06 13:03:37, 15, 0.357,271.9,000000
W,03.04.06 13:04:38, 1.61, 2.12, 10.0, NAN,107.0,0.88, 0.22, 0.26, 0.35, 1.69, 1.69, 10.31, 1,000000
S,03.04.06 13:33:37,11.3, 10.294, -0.20, 2.80,332.5,11.4,1473,000000
C,03.04.06 13:33:37, 1, 0.124,239.3,000000
C,03.04.06 13:33:37, 2, 0.096,255.5,000000
C,03.04.06 13:33:37, 3, 0.181,261.4,000000
C,03.04.06 13:33:37, 4, 0.208,250.3,000000
C,03.04.06 13:33:37, 5, 0.234,258.9,000000
C,03.04.06 13:33:37, 6, 0.301,272.1,000000
C,03.04.06 13:33:37, 7, 0.225,264.4,000000
C,03.04.06 13:33:37, 8, 0.257,252.1,000000
C,03.04.06 13:33:37, 9, 0.179,275.8,000000
C,03.04.06 13:33:37, 10, 0.412,326.4,000000
C,03.04.06 13:33:37, 11, 0.188,296.3,000000
C,03.04.06 13:33:37, 12, 0.194,266.8,000000
C,03.04.06 13:33:37, 13, 0.234,272.2,000000
C,03.04.06 13:33:37, 14, 0.289,264.6,000000
C,03.04.06 13:33:37, 15, 0.245,261.8,000000
S,03.04.06 13:48:37,11.2, 10.270, -0.30, 2.80,332.5,11.4,1472,000000
C,03.04.06 13:48:37, 1, 0.080,301.1,000000
C,03.04.06 13:48:37, 2, 0.077,289.9,000000
```

Log serial output using  
Windows HyperTerminal

$H_{m0}$ ,  $H_{1/10}$ ,  $H_{max}$ ,  $T_z$

Need to know data format  
ahead of time

# NIP Output $\Rightarrow$ Real-time display

VIMS

Field

Acquisition  
Computer

Radio telemetry



File Copy  
Scheduled Task

UNIX  
Server

Real-time  
Web Display

Acoustic  
Modem

ASCII  
Data  
File

VIMS Network

HTML  
Plots

Windows PC  
MATLAB



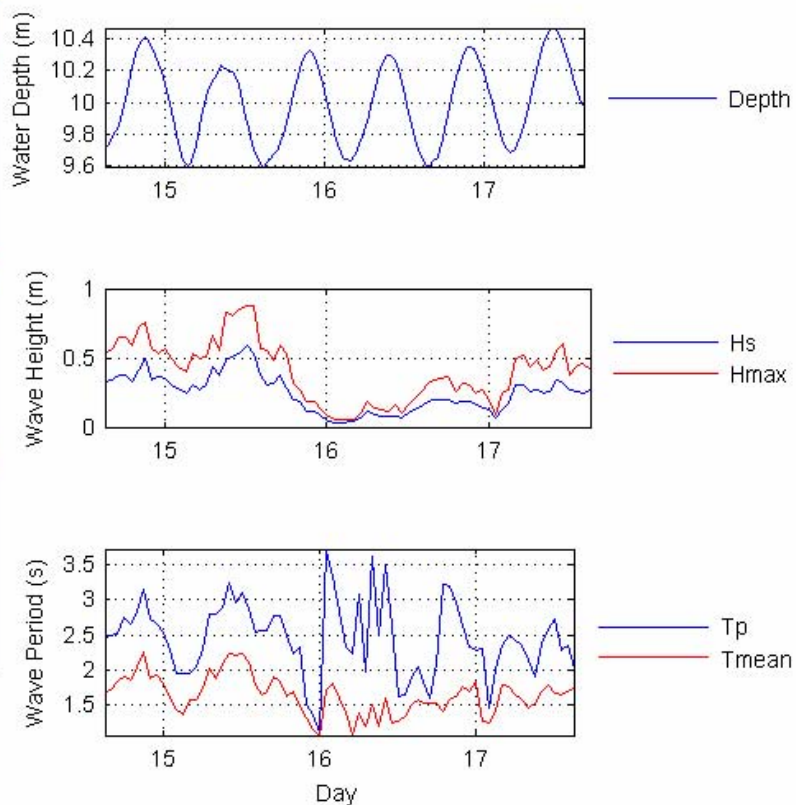
AWAC

**VIMS Observing System - Conditions at Goodwin Islands**

These data are collected from a bottom mounted, upward looking Nortek Acoustic Wave and Current Meter (AWAC) in approximately 10m water depth north of Goodwin Islands, near the York River mouth, VA. Data are transmitted via underwater acoustic modem to a surface buoy and a radio link back to VIMS completes the telemetry. [ [Location Map](#) | [Deployment](#) ]



| Conditions at Goodwin Island            |                             |
|---|-----------------------------|
| <b>Sensor: 17-Mar-2006 17:03:37 EST</b> |                             |
| Water Temp:                             | 10°C, 50°F                  |
| Water Depth:                            | 9.9 (m)                     |
| Pitch:                                  | -0.3°                       |
| Roll:                                   | 2.8°                        |
| Heading:                                | 332.3°                      |
| Battery:                                | 11.8 (V)                    |
| <b>Wave: 17-Mar-2006 16:04:38 EST</b>   |                             |
| Sig. Wave Height:                       | 0.31 (m)                    |
| Max Wave Height:                        | 0.52 (m)                    |
| Peak Period:                            | 2.7 (sec)                   |
| Mean Period:                            | 1.9 (sec)                   |
| Mean Direction:                         | 73.3°                       |
| Current Profile                         |                             |
| Bottom:                                 | 0.19 m/s @ 62°<br>17:03 EST |
| Mid:                                    | 0.25 m/s @ 87°<br>17:03 EST |
| Surface:                                | 0.05 m/s @ 79°<br>17:03 EST |



\*\*\*NOTE: This webpage is for test purposes only. VIMS does not guarantee the accuracy of these data.

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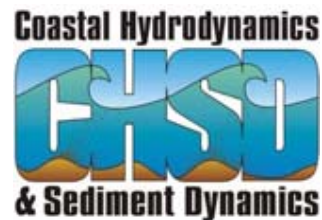
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5. Preliminary Analysis
6. Conclusions

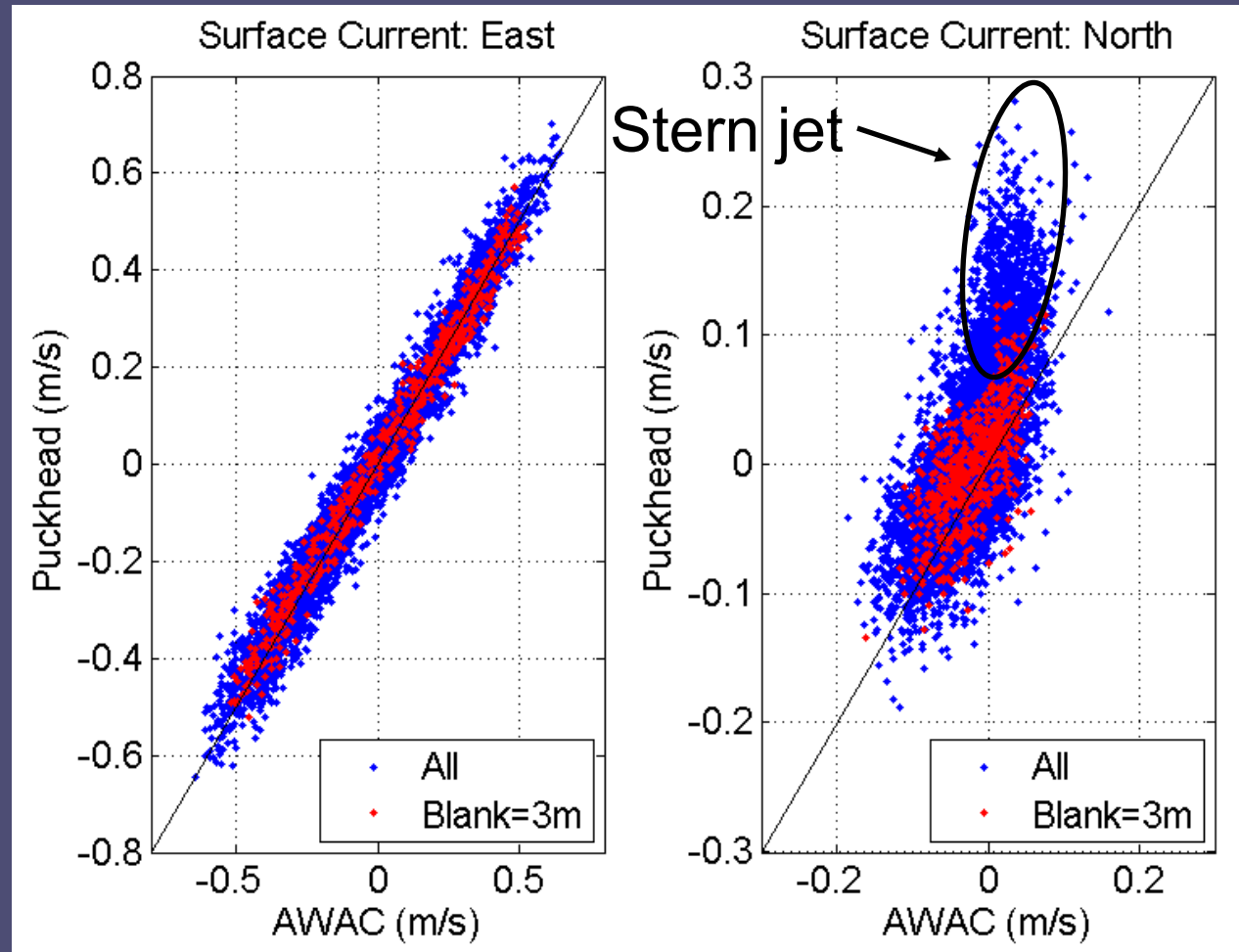
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# Instrument Comparisons

## Surface Current: AWAC vs. Puckhead

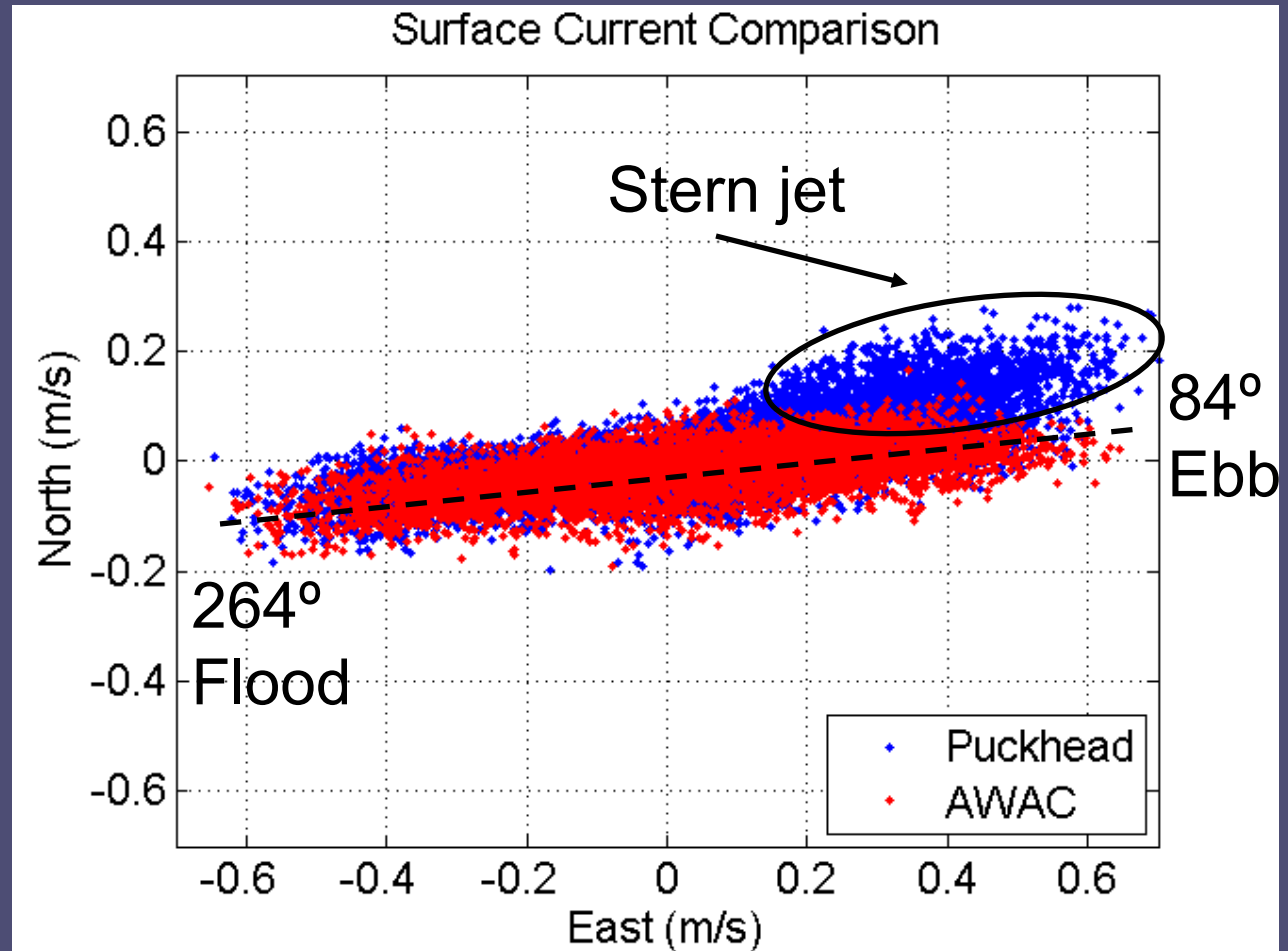
- Use AWAC bin closest to surface
- RMS diff:  
East: 4.4 cm/s  
North: 3.9 cm/s
- Stern jet enhancement on ebb flow



# Instrument Comparisons

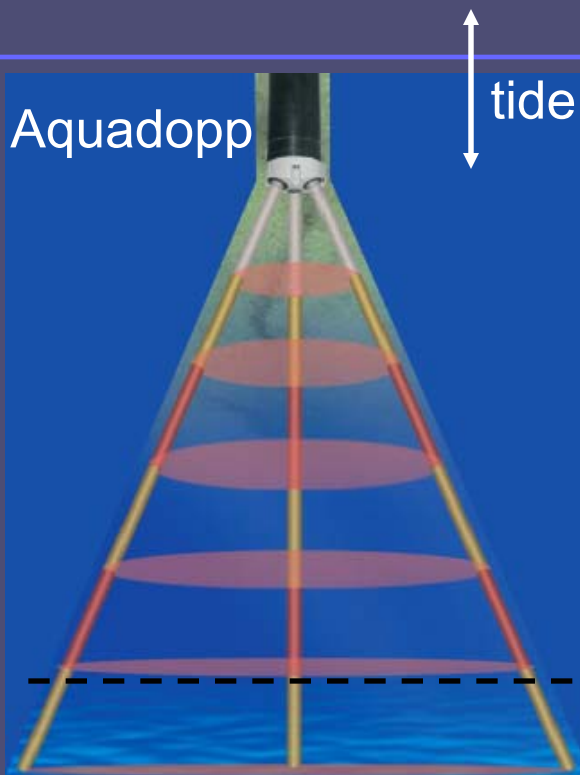
## AWAC vs. Puckhead

- Apparent shift in ebb direction artifact of stern jet
- AWAC surface current measurement shows true orientation of tidal ellipse
- Currents aligned with channel morphology

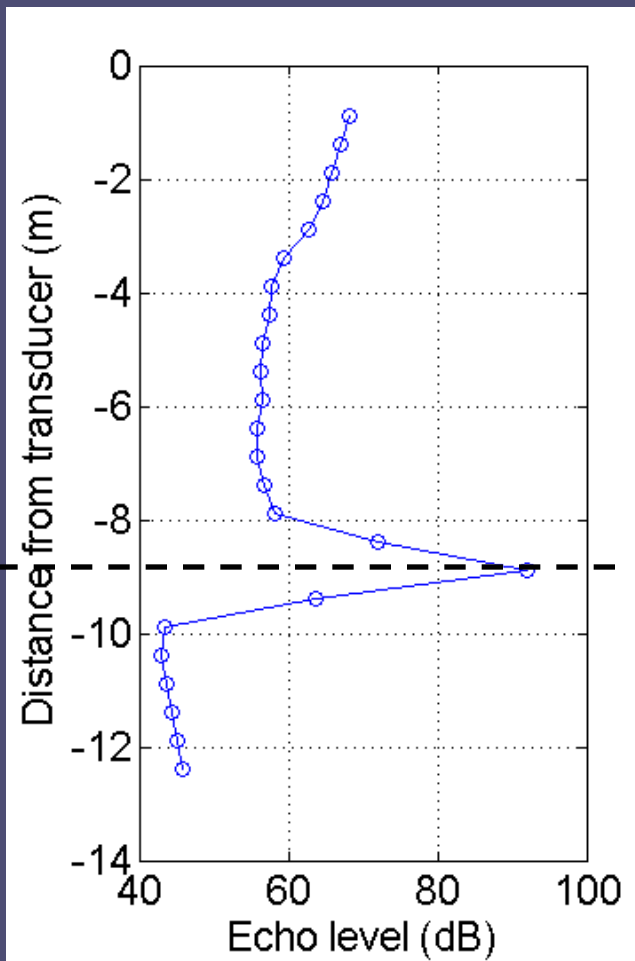


# Instrument Comparisons

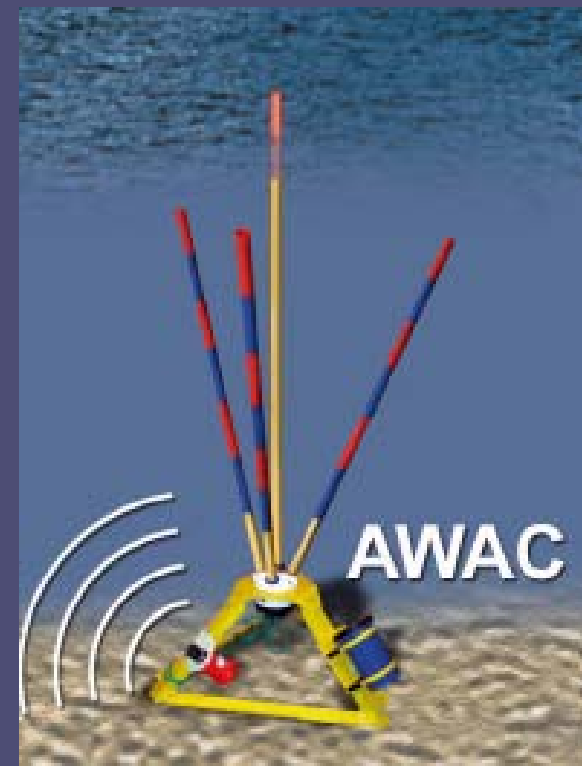
## Profiles: Referencing cell elevations



Find location of bottom from echo return



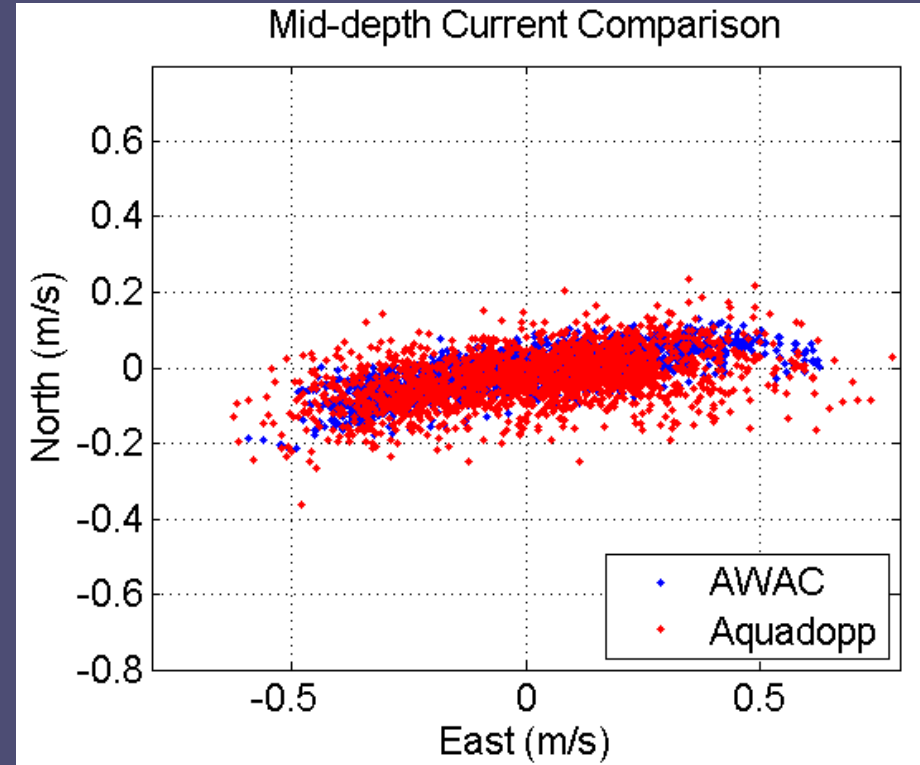
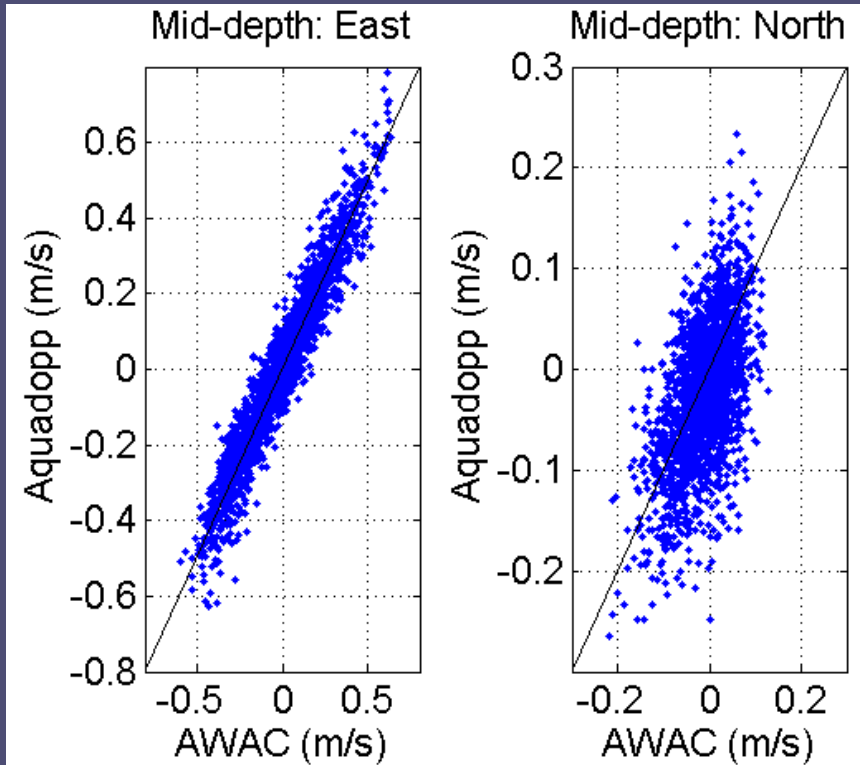
Surface ▼



Match up AWAC and Aquadopp cell elevations

# Instrument Comparisons

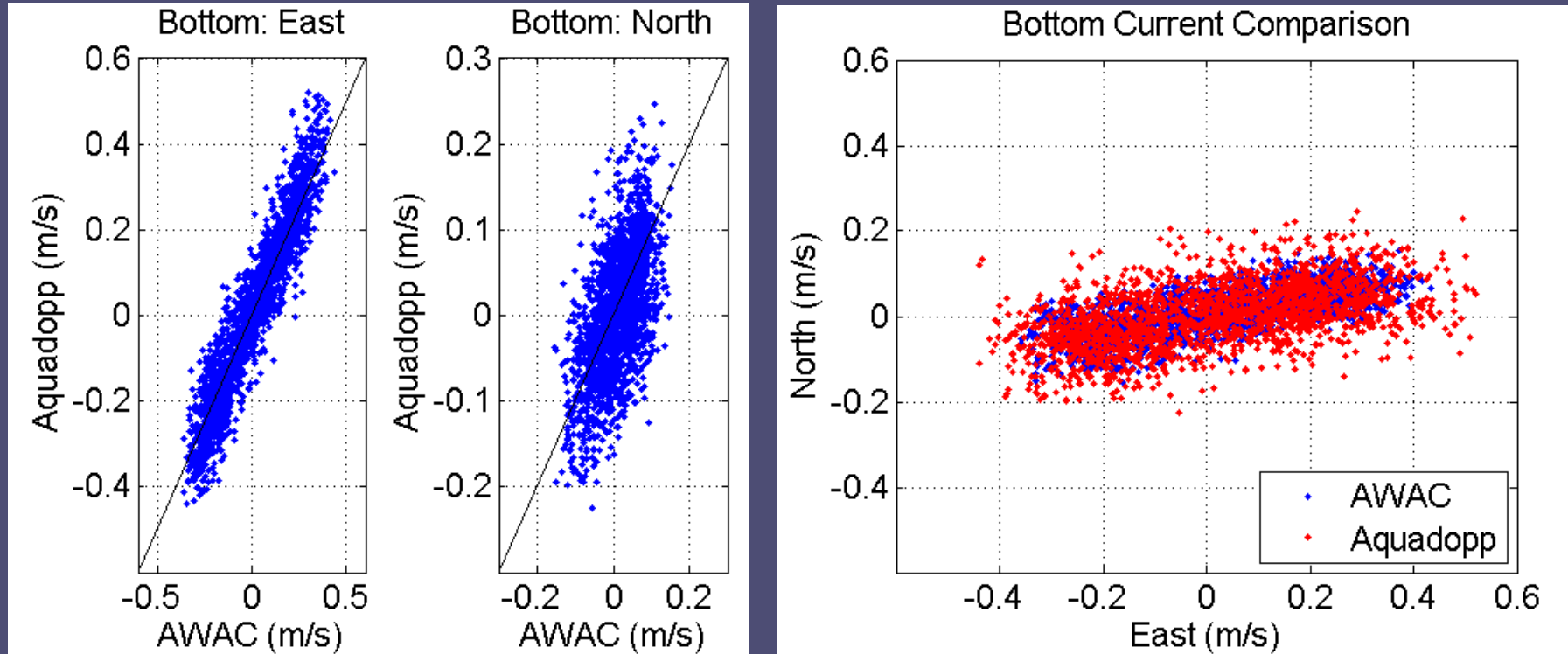
## AWAC vs. Aquadopp Profiler



Mid-depth = 5 m above bed

# Instrument Comparisons

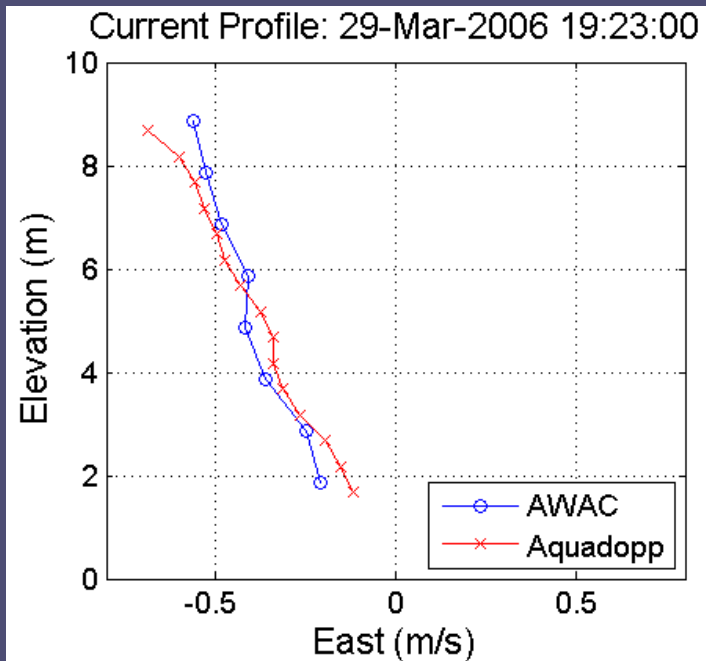
## AWAC vs. Aquadopp Profiler



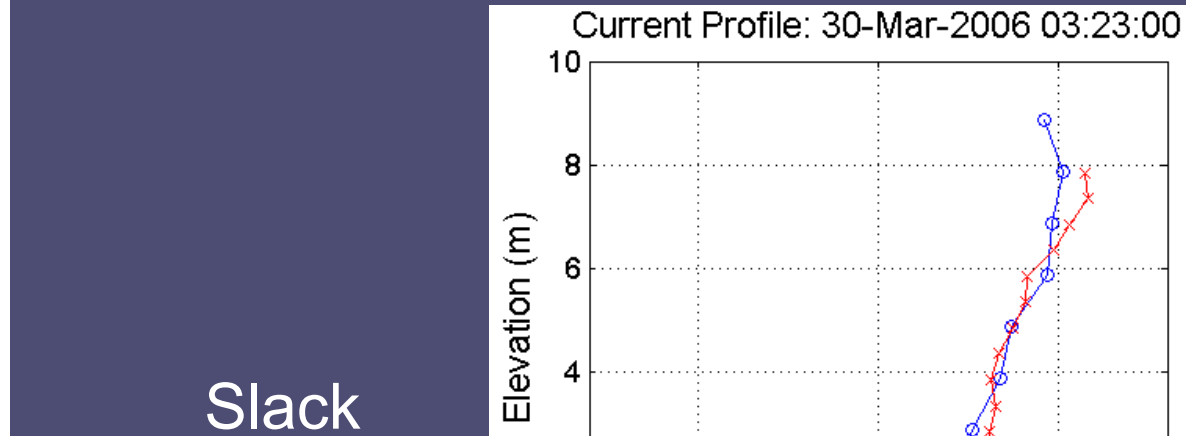
Bottom = 2 m above bed

# Instrument Comparisons

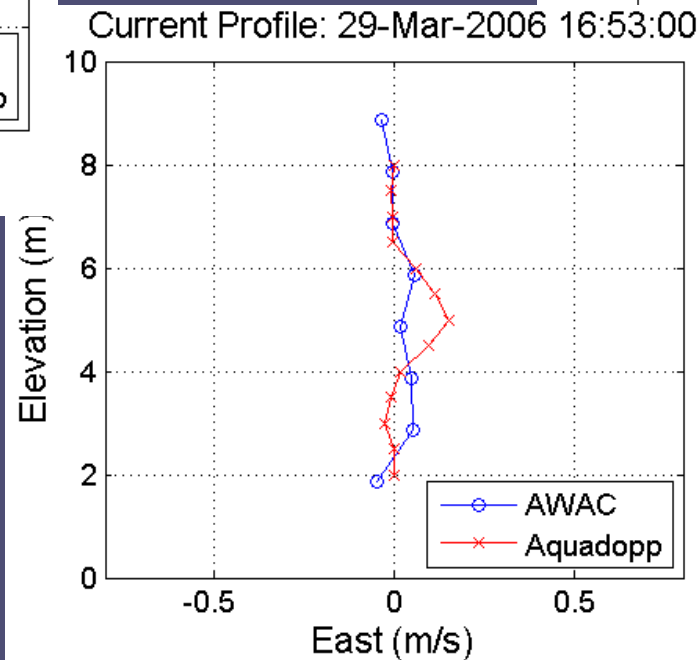
## AWAC vs. Aquadopp Profiler



Flood



Slack



Ebb

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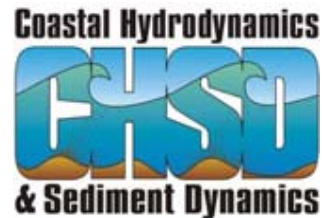
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## Outline

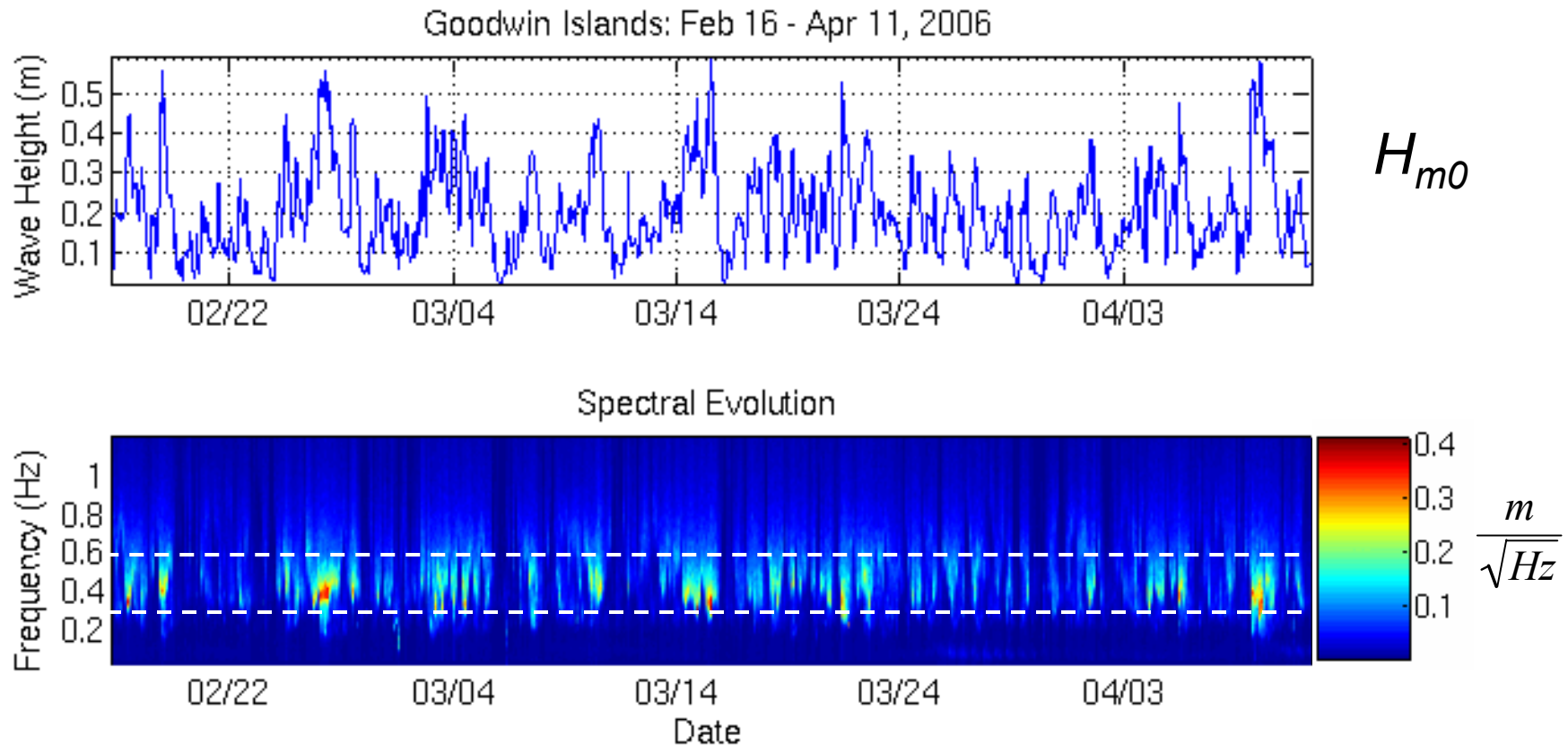
1. VIMS Observing System
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# Preliminary Analysis

## Spectral Evolution

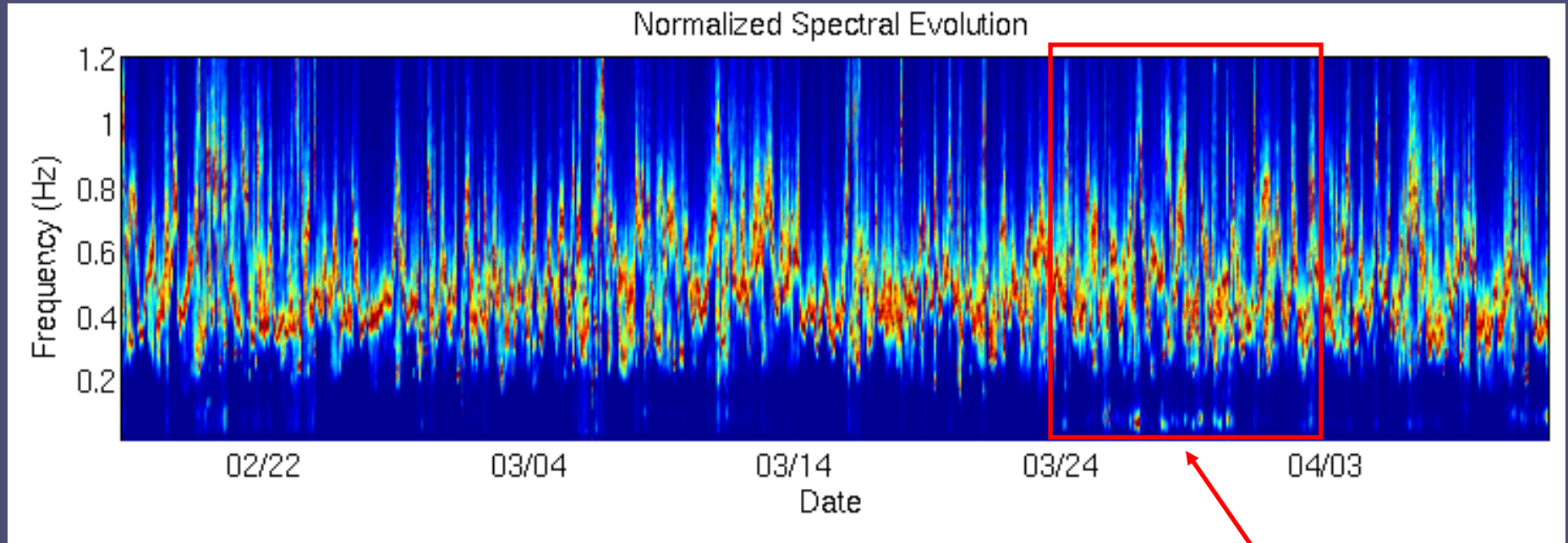


Wave energy concentrated in 1.5-3s range

Typical storm events:  $H_{m0}=0.5\text{m}$ ,  $T_p=3\text{s}$ ,  $H_{max}=1.0\text{m}$

# Preliminary Analysis

## Spectral Evolution



Focus area

Normalize each spectrum by spectral peak to bring out low energy components at lower frequencies.

# Preliminary Analysis Spectral Evolution

AWAC

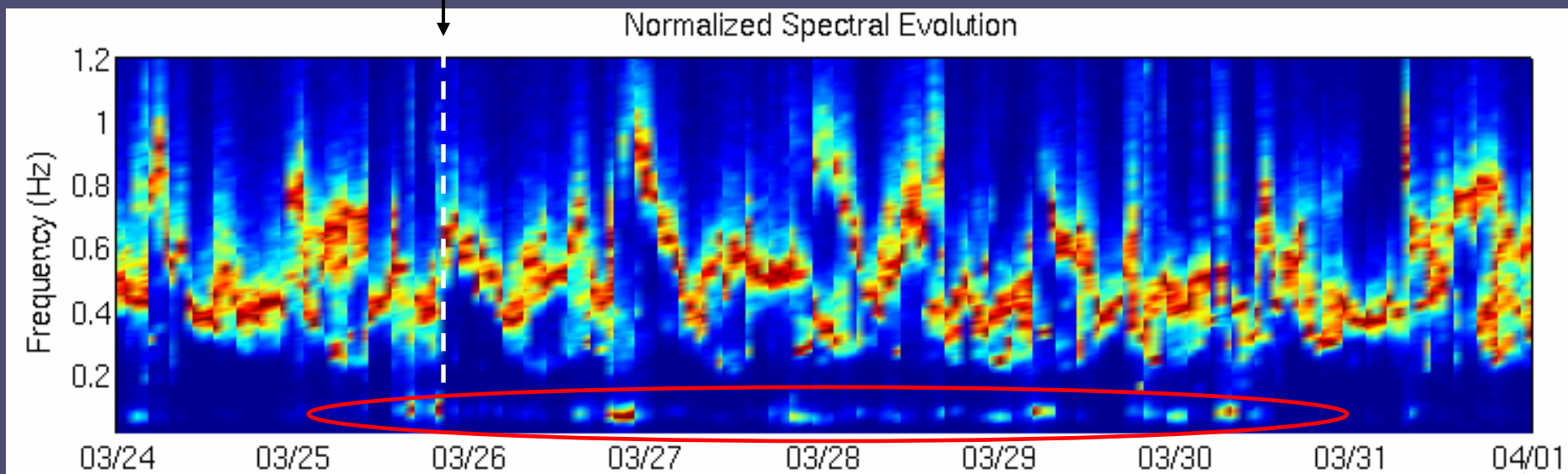
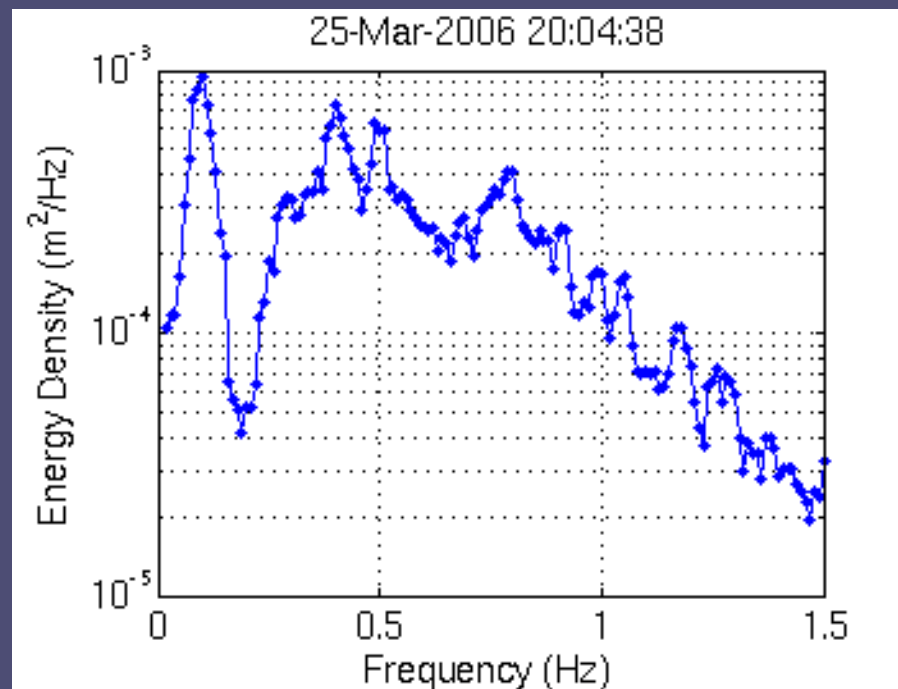
$H_s = 0.07\text{m}$

$T_p = 10.2\text{s}$

NDBC

$H_s = 2\text{m}$

$T_p = 9\text{s}$



# Preliminary Analysis Spectral Evolution

AWAC

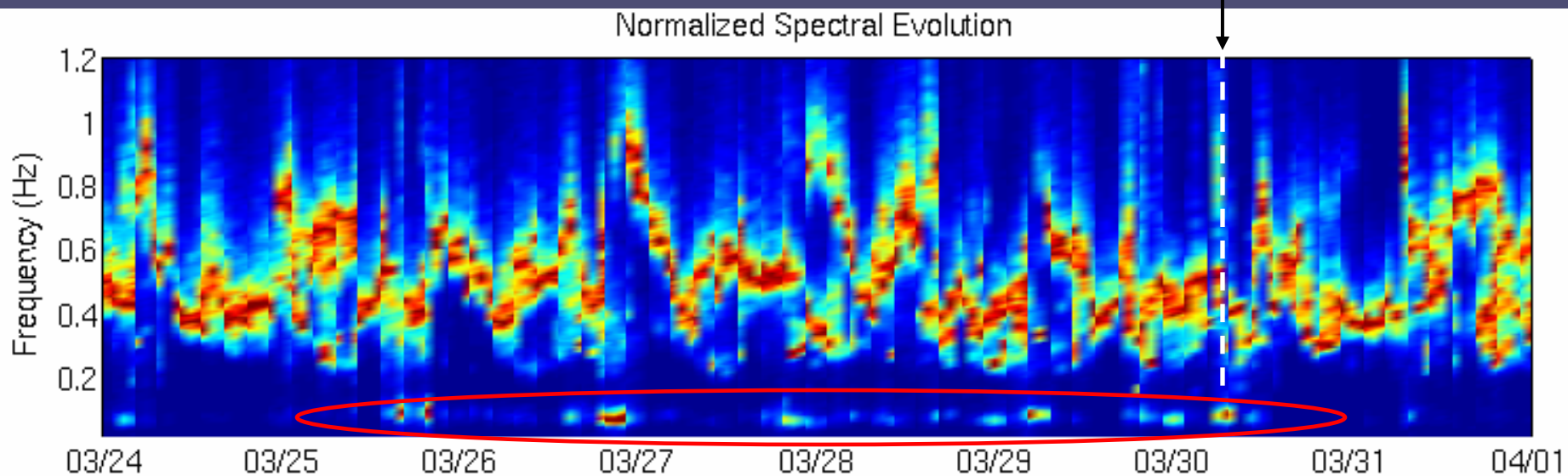
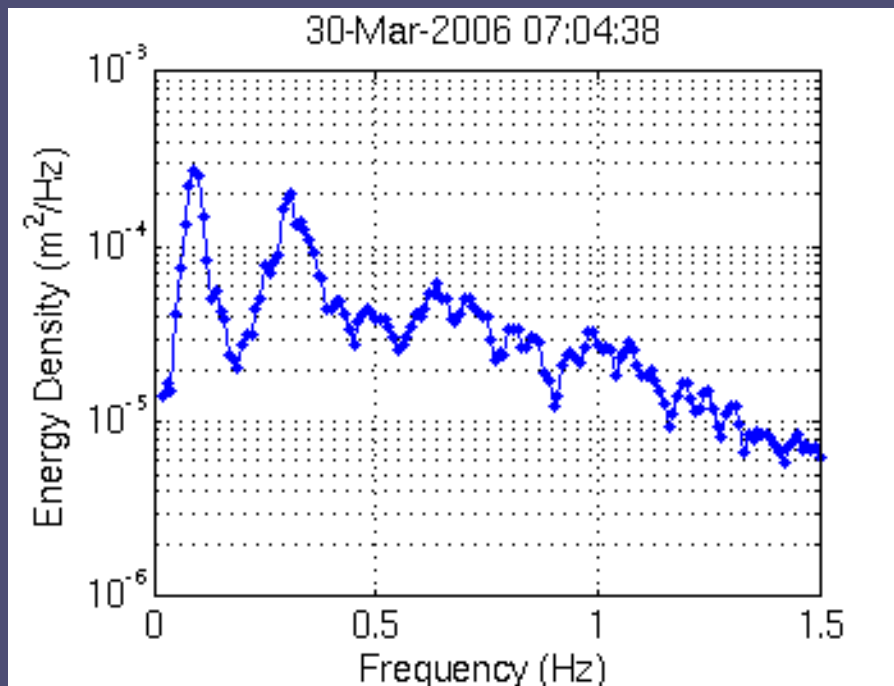
$H_s = 0.03\text{m}$

$T_p = 10.9\text{s}$

NDBC

$H_s = 1.0\text{m}$

$T_p = 11.1\text{s}$



# Conclusions

## *Aquadopp Current Meter*

- Improper choice of blanking led to errors in surface current magnitude and direction of 5 cm/s and 10-15°
- Blanking sensitivity trials indicate that 3m is sufficient to avoid flow disturbance on ebb

## *AWAC/NIP System*

- Acoustic modem link in 10m depth and 90m distance fairly robust and reliable when modems are angled
- While challenging, it is possible to process real-time time NIP ASCII output for data delivery to web
- 83% of NIP data strings captured successfully

# Conclusions

## *Instrument Comparisons*

- Good overall agreement in magnitude and direction for surface, mid, and bottom currents
- Good qualitative agreement in profiles for ebb, flood, and slack currents

## *Waves: AWAC/NIP*

- $H_{m0} = 0.1-0.6\text{m}$ ,  $T_p = 1-3\text{ s}$ ,  $H_{max} > 1.0\text{m}$
- Preliminary evidence suggests presence of ocean swell at Goodwin Islands site

# Future Work

## *Short-term*

- Bring new sensors online: Buoy MET package, surface CT
- Make real-time data available at VIMS website: AWAC, Puckhead, Aquadopp
- Refine NIP ASCII file I/O

## *Long-term*

- Flow-through biosensors for detection of contaminant concentrations
- Archived database: VIMS partnership with INCOGEN
- Develop service schedule and protocols for NOMAD instrumentation and infrastructure

# Acknowledgements

- Tood Nelson - keeper of the VIMS buoys
- Eric and Malcolm for technical support
- NDBC for NOMAD buoy
- SAIC hardware and deployment

Questions?  
[justin@vims.edu](mailto:justin@vims.edu)  
804-684-7902



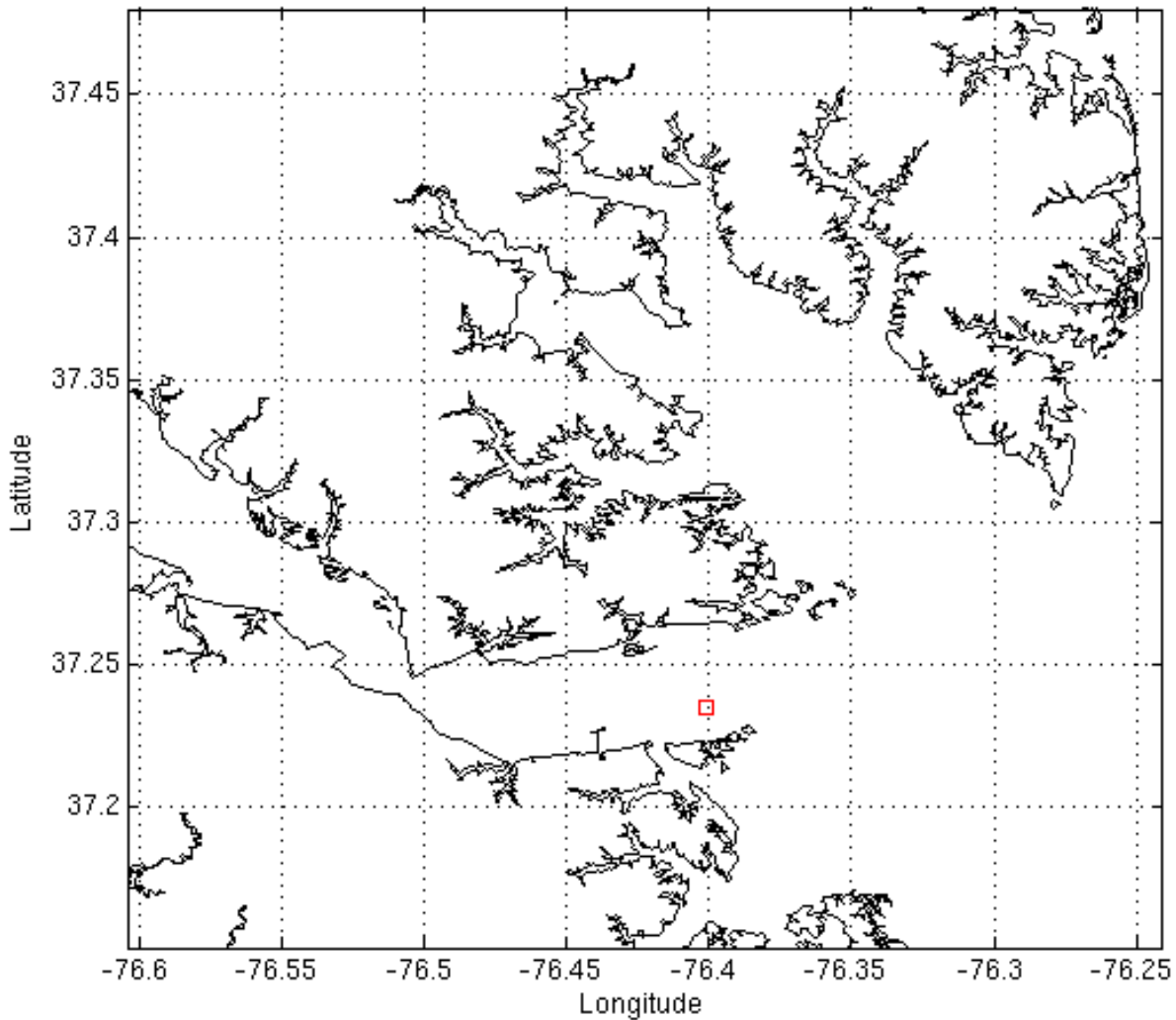
# Challenges: Instrument Fouling



April 18, 2006

Nortek Seminar - Vandever, Brubaker, and Friedrichs

SAIC NOMAD Buoy Location



# Preliminary Analysis Spectral Evolution

AWAC

$H_s = 0.11\text{m}$

$T_p = 1.8\text{s}$

NDBC

$H_s = 2\text{m}$

$T_p = 12.5\text{s}$

