Coastal Wave Energy Dissipation: Observations and STWAVE Performance

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Motivation

1. A significant challenge to numerical wave modeling is capturing the dynamics of wave transformation in coastal waters

2. Dissipation processes are the least well-represented in numerical wave models

3. Careful measurements of coastal wave transformation are required to support the advancement of improved model physics

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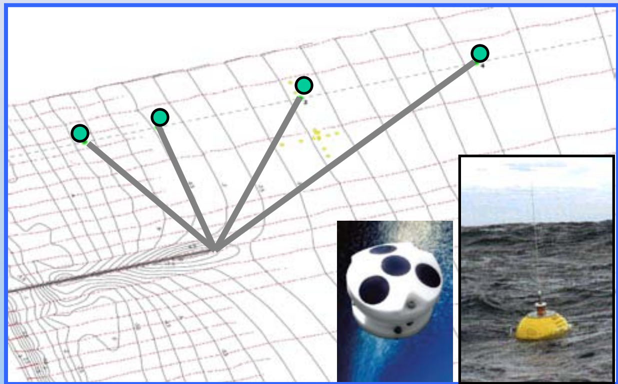
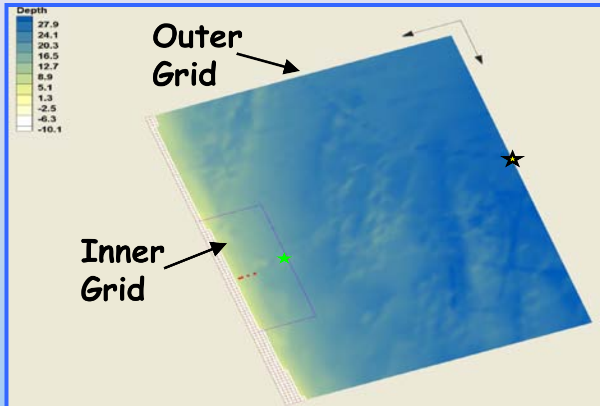
Approach



1. Data obtained from a new cross-shore wave and current array in the energetic environment off Duck, NC

Approach



1. Data obtained from a new cross-shore wave and current array in the energetic environment off Duck, NC

2. **Set up a high-resolution wave modeling test bed for the STeady-state spectral WAVE model – Full Plane version (STWAVE-FP)**

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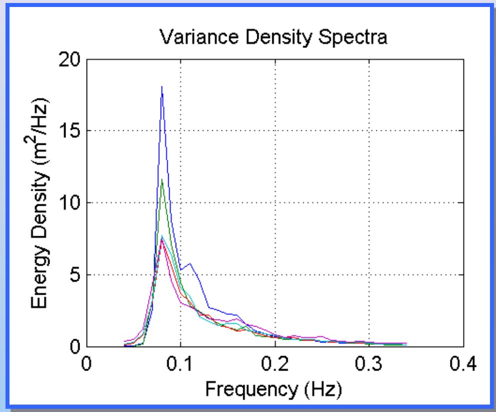
Approach



1. Data obtained from a new cross-shore wave and current array in the energetic environment off Duck, NC

2. Set up a high-resolution wave modeling test bed for the STeady-state spectral WAVE model – Full Plane version (STWAVE-FP)

3. **Quantify performance of the bottom friction source term in an energetic sandy coast environment.**

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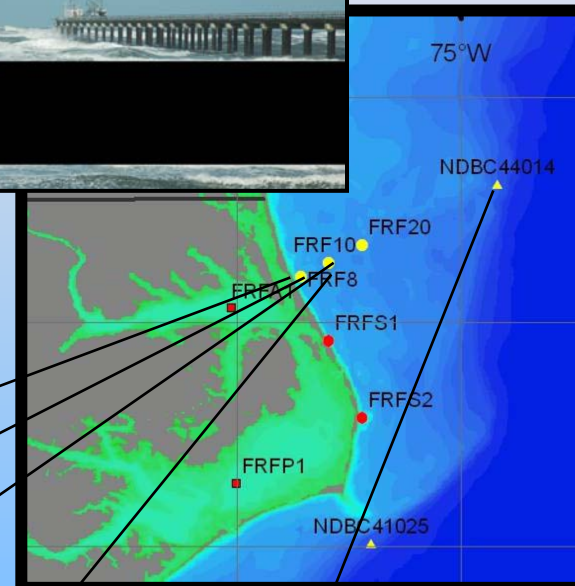
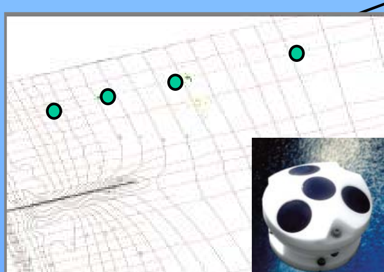
FRF Cross-Shelf Wave and Current Array

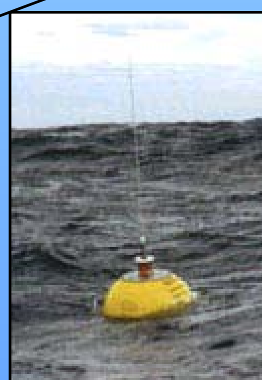
Data Collections

- 4 Nortek AWAC sensors
- 2 Datawell Waverider buoys
- NDBC Station 44014
- Pier-based meteorological station
- ARGUS Video system
- 24/7 Real-time data processing
- Monthly bathymetric surveys

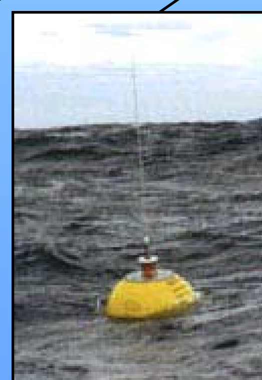




8-m Array; Nearshore AWAC Array (5-11 m depth)

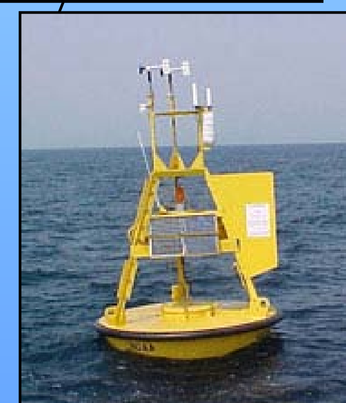


17-m Datawell Waverider



26-m Datawell Waverider

26-m Weather Station



48-m NDBC 44014

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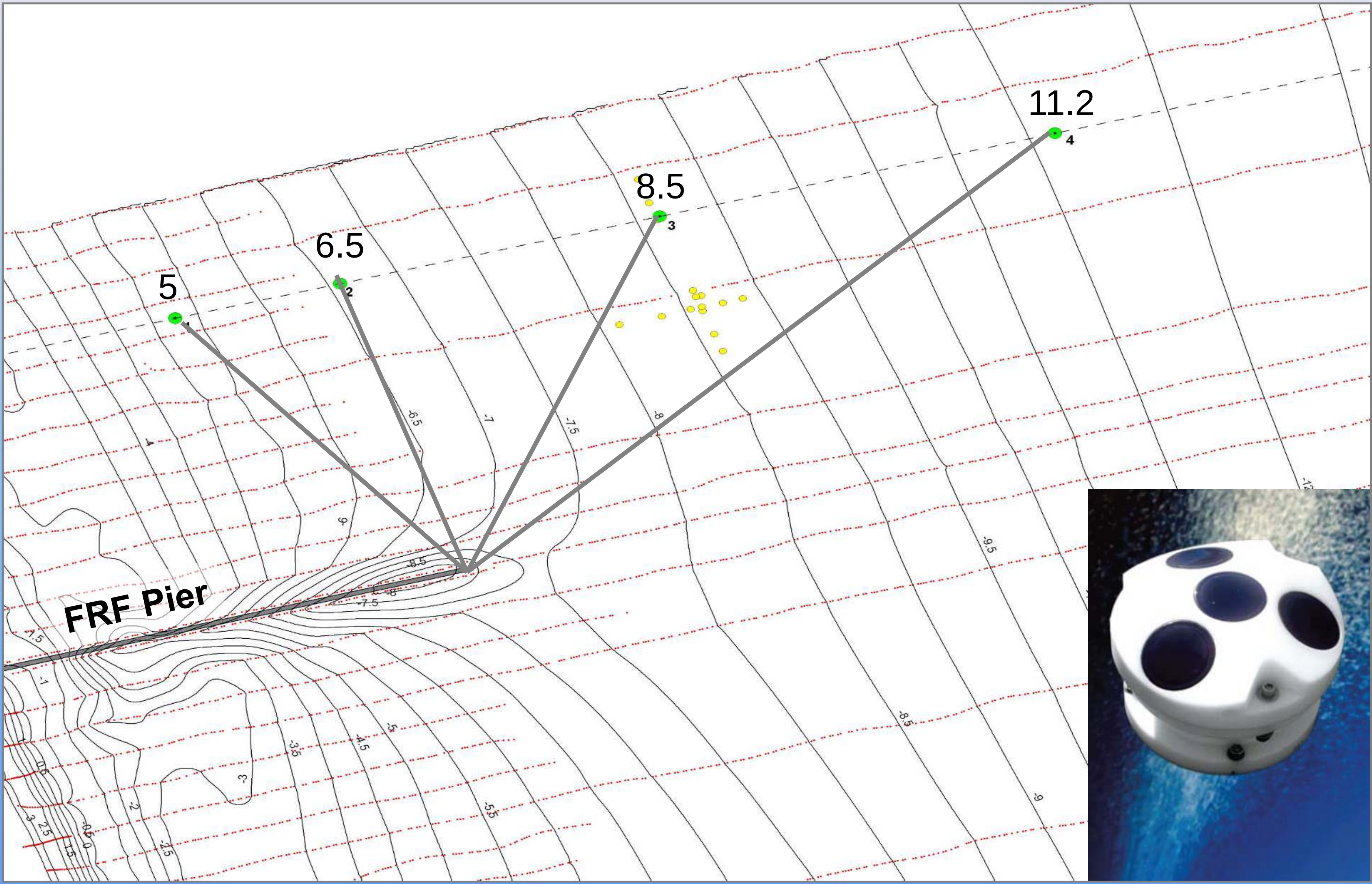
Acoustic Wave and Currents (AWAC) Station Depths (m)



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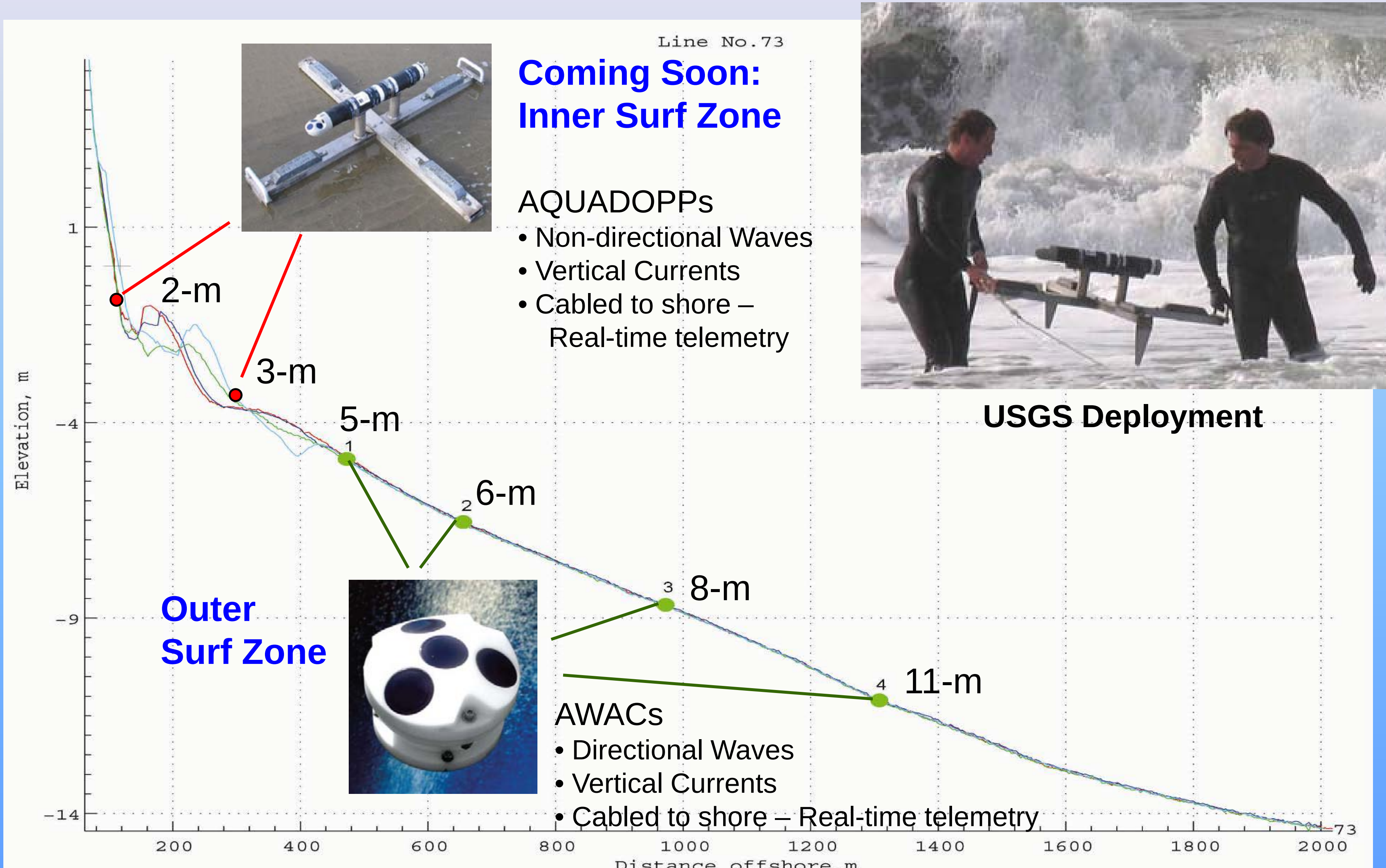
Cross-Shore Transect



USGS Deployment

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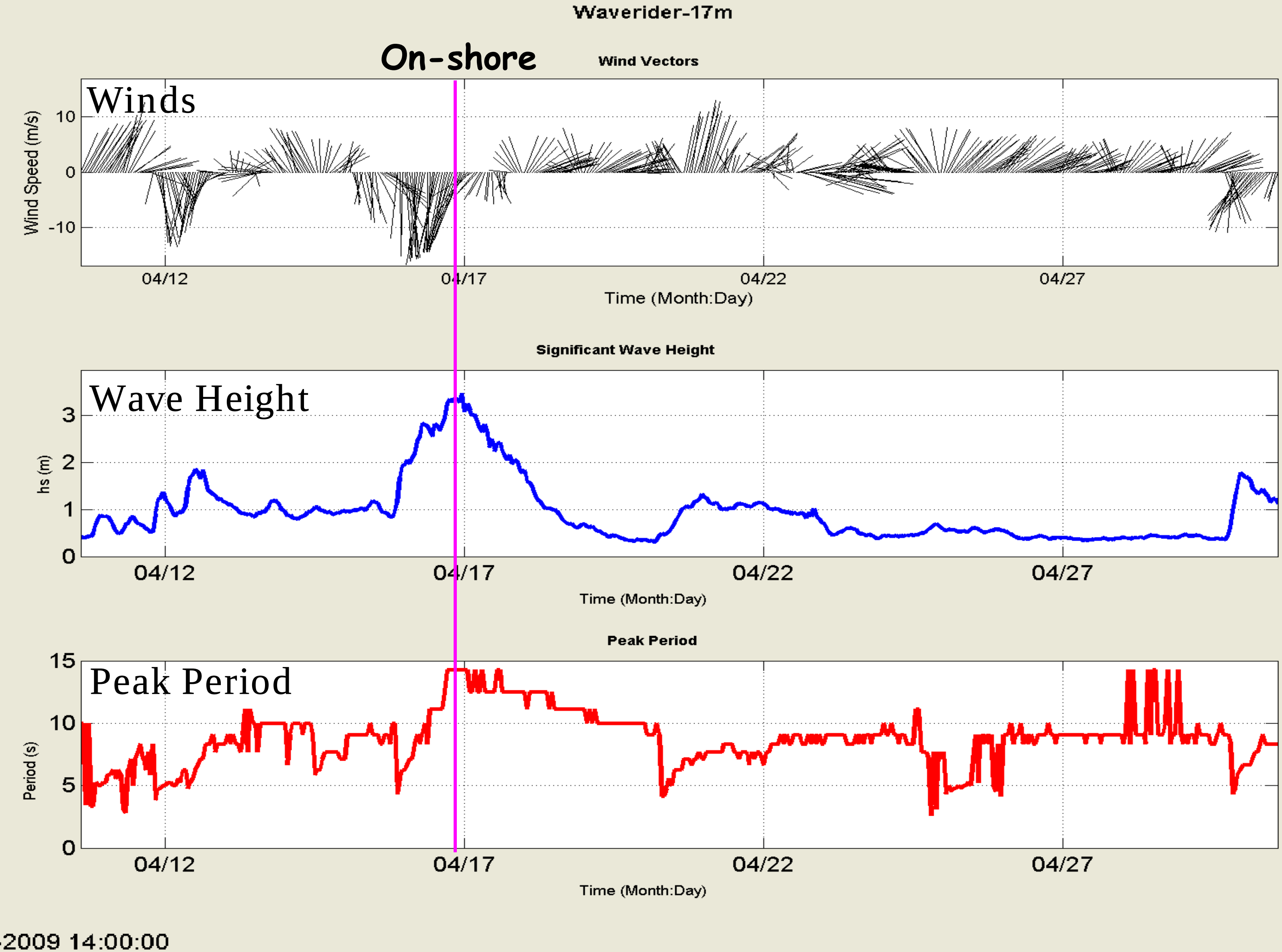
April 2009 Nor'easter



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Nor’easter Wind Sea

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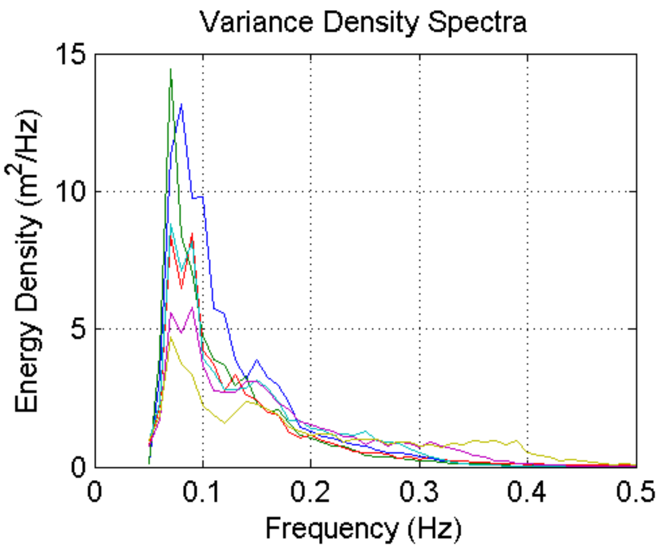
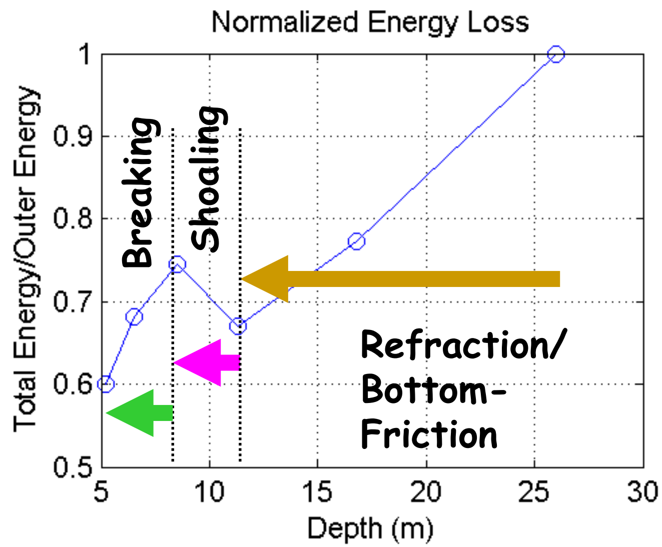
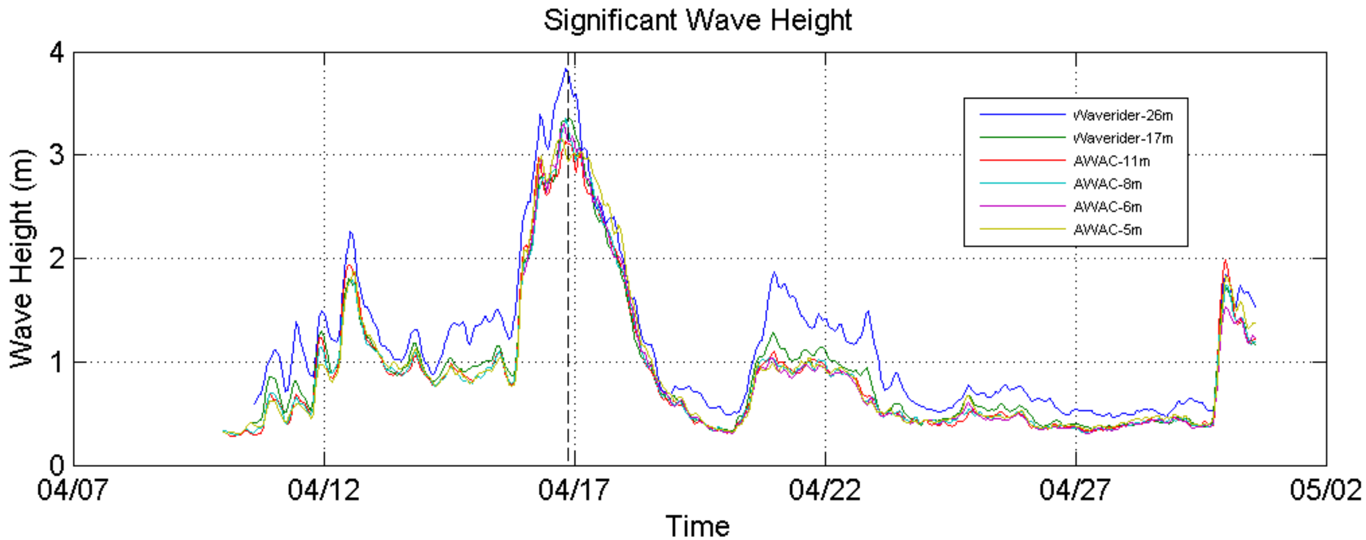
Nor'easter Wind Sea Wave Transformation

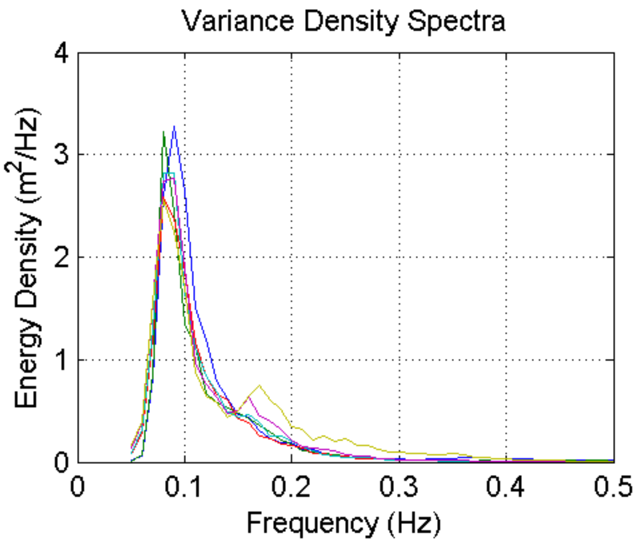


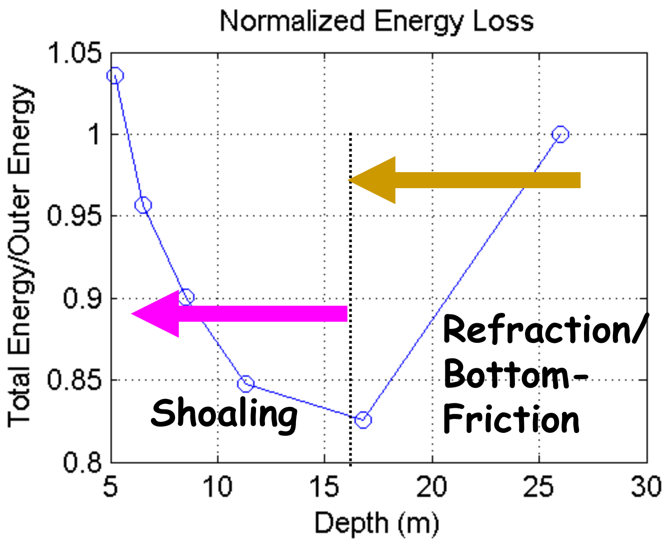


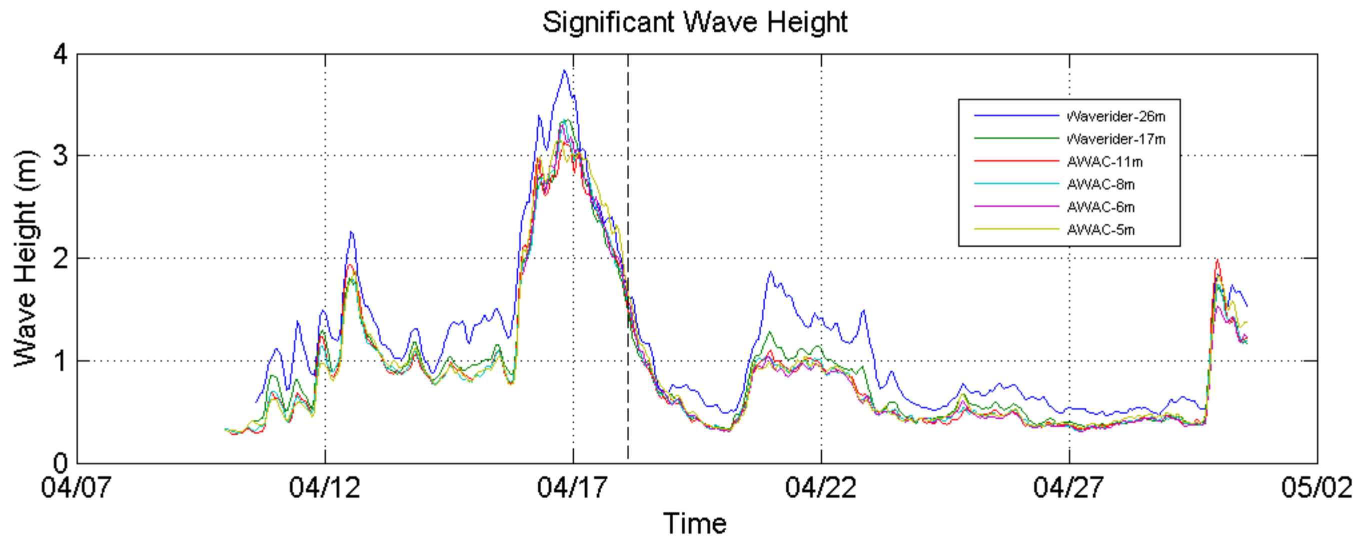


Nor’easter Swell

Nor’easter Swell Transformation







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STWAVE-FP Test Bed

Steady State Waves - Full Plane

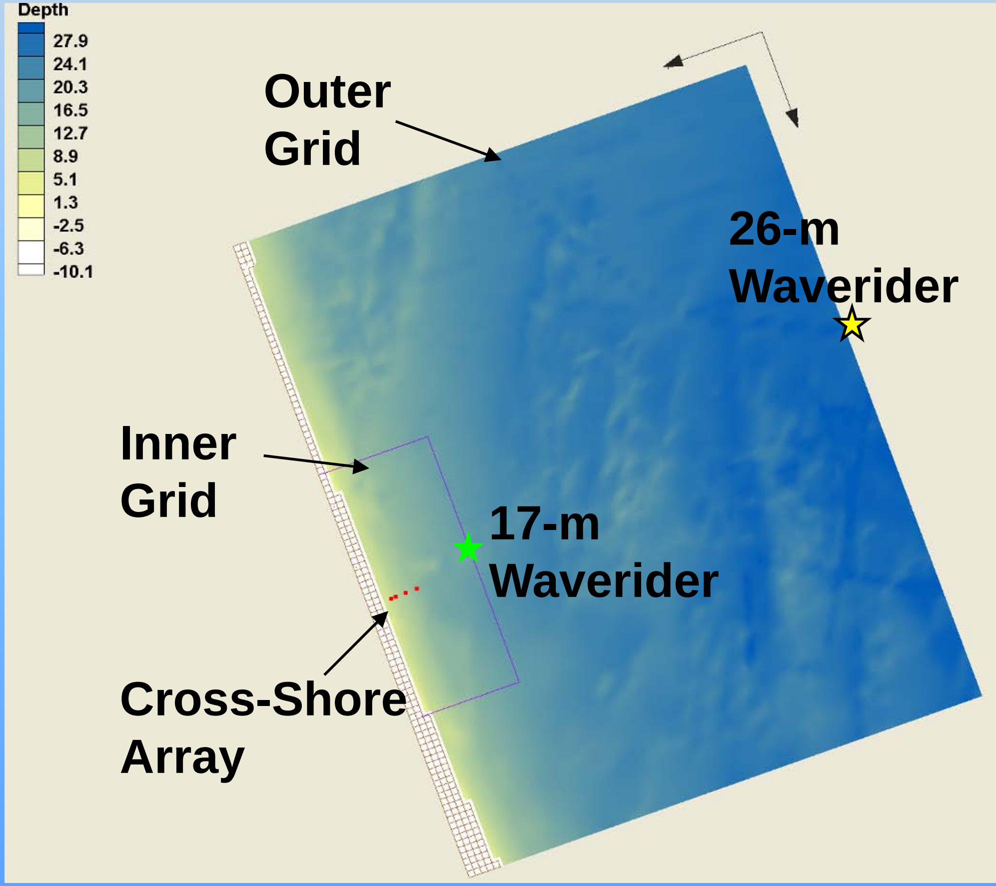
- Capture refraction, shoaling, wave-wave interactions and bottom friction
- Forced by observations at boundaries

Model Set Up:

Outer Grid = 50x50 m
Inner Grid = 25x25 m
Time Step = 0.5-1 hour

Saved Spectra Locations:
- ☆ CDIP Waverider 26 m
- ★ Waverider 17 m
- ■ AWAC 11 m
- ■ AWAC 08 m
- ■ AWAC 06 m
- ■ AWAC 05 m

Model Domains



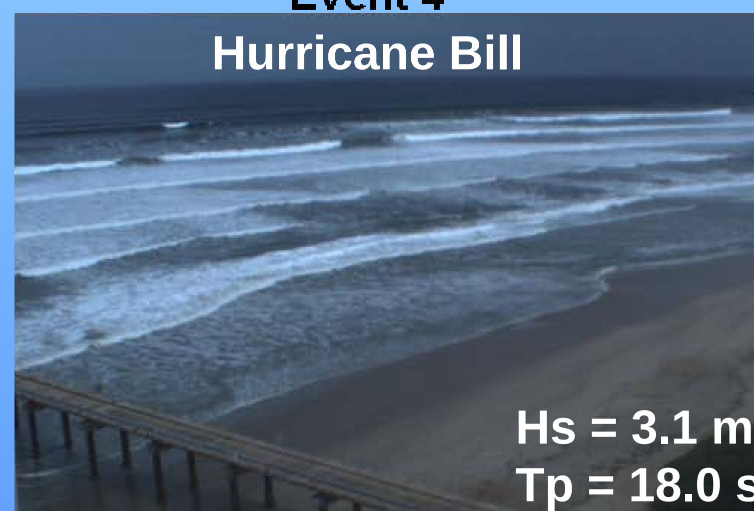
Selected Swell Events

Event 1

Event 2

Event 3

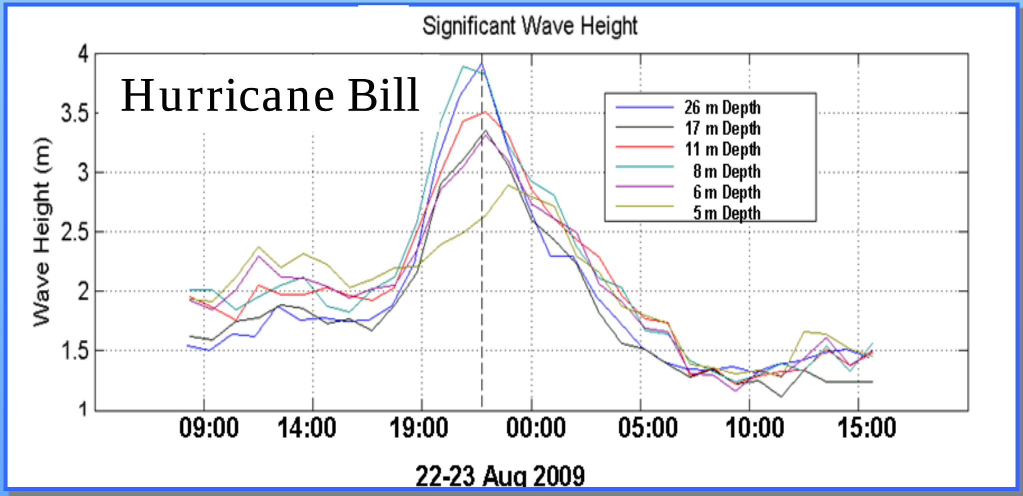
Event 4

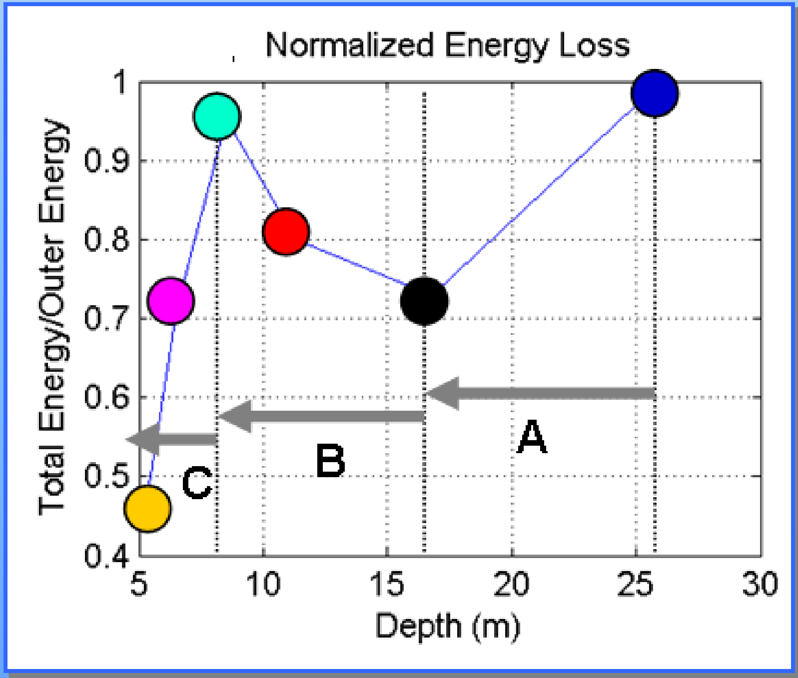


Findings

1. The FRF Cross-Shore wave array captures all phases of wave transformation across the shelf. Three transformation regimes were observed:

   A. Bottom friction dominated
   B. Shoaling dominated
   C. Depth breaking dominated





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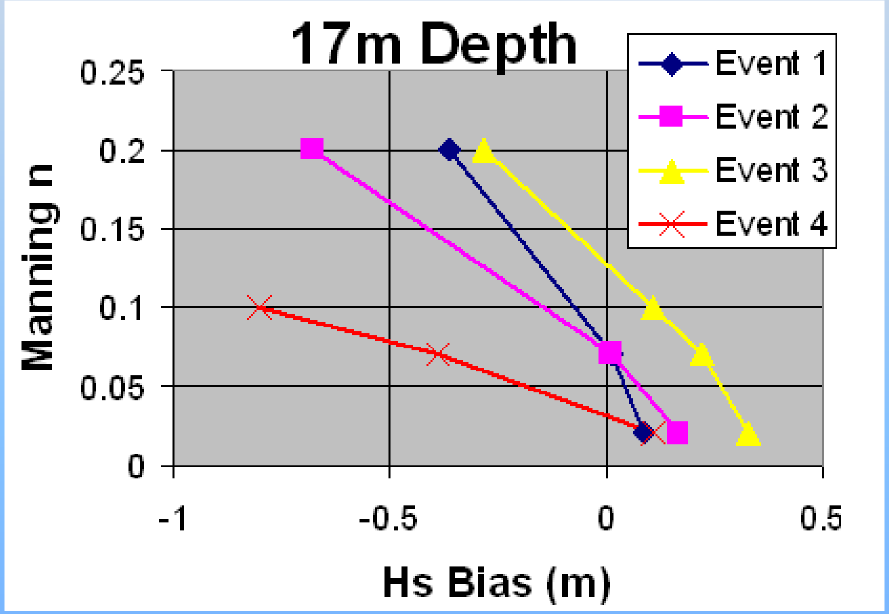
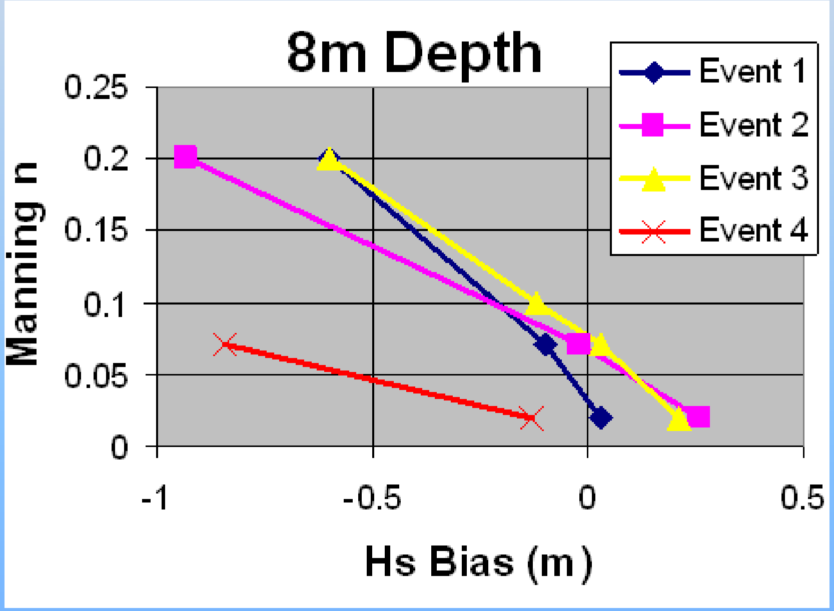
Findings

Dependence of STWAVE-FP Wave-Height Bias on Friction Coefficient (n)





2. Highly nonlinear Event 4 (Hurricane Bill) wave heights significantly under-predicted by STWAVE-FP at these shallow depths (using bottom friction source term)

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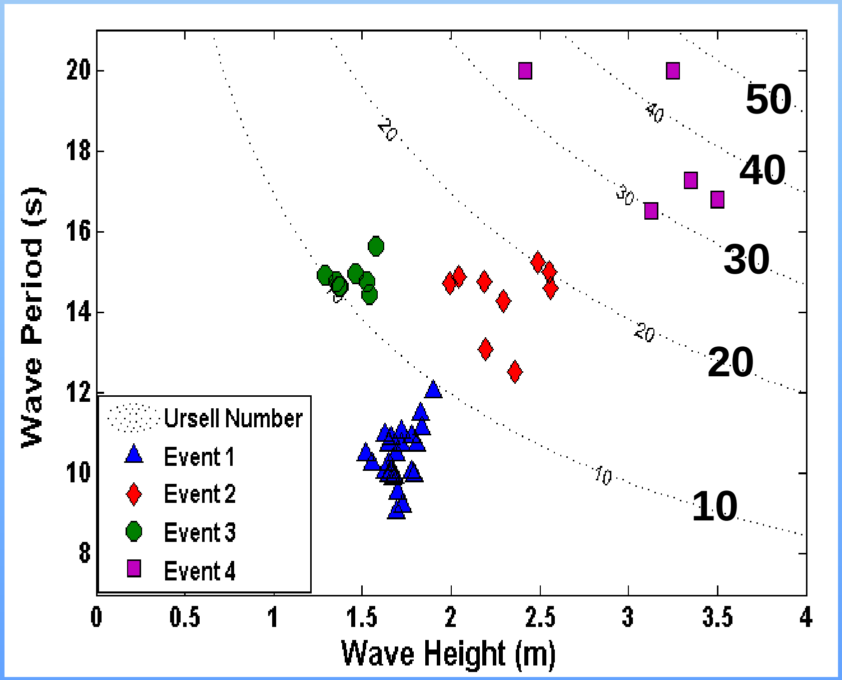
Findings

1. The FRF Cross-Shore wave array captures all phases of wave transformation across the shelf. Three transformation regimes were noted: Bottom friction, Shoaling and breaking.

2. Highly nonlinear Event 4 (Hurricane Bill) wave heights significantly under-predicted by STWAVE-FP at these shallow depths (using bottom friction source term)

3. **Wave nonlinearity is a critical factor influencing STWAVE-FP results in shallow water. The Ursell Number was used as a guide in selecting valid runs.**

$$N_{Ursell} = \frac{g H_s T_p^2}{d^2}$$



Findings

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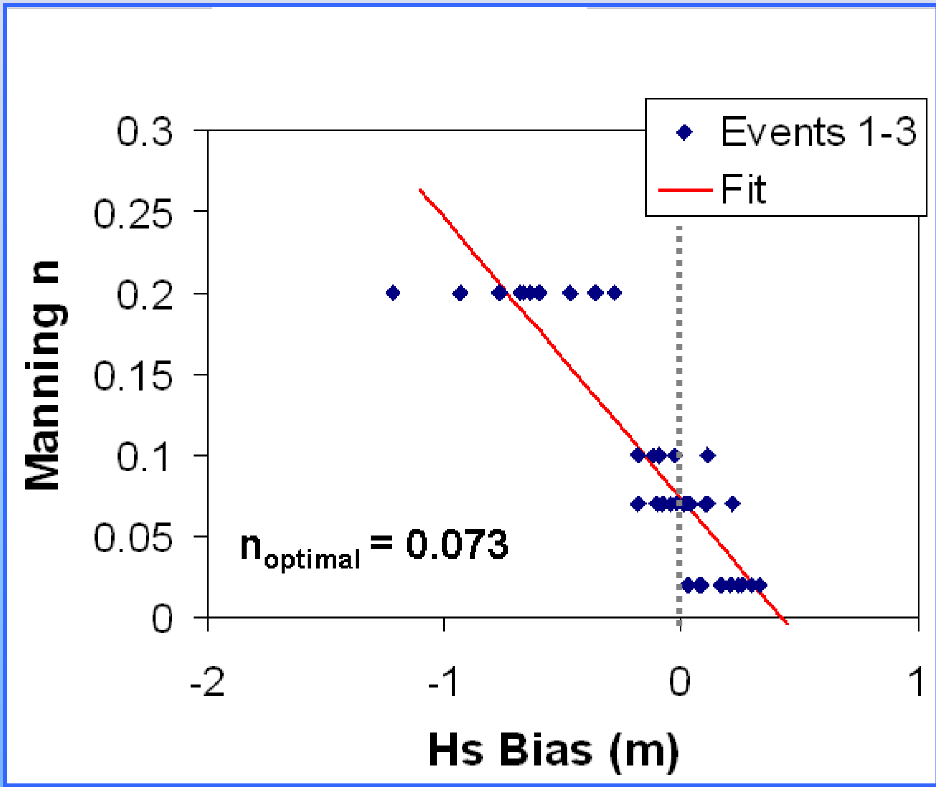
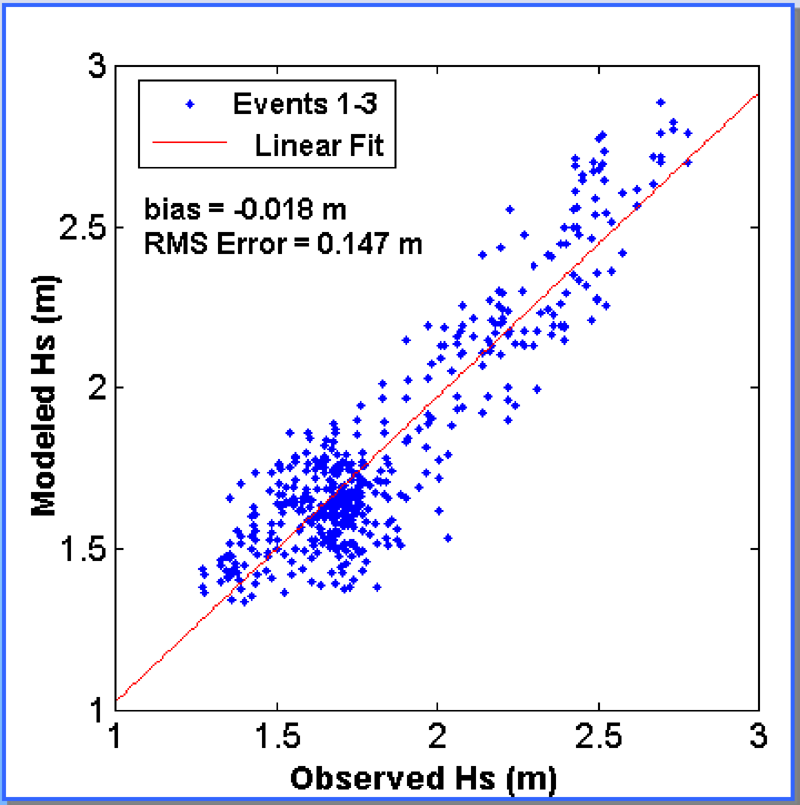
Model Hs Bias and Friction Coefficient



Model Performance with n = 0.07



4. Combined data from 3 wave events at all stations yields an optimum Mannings bottom friction coefficient of $n \approx 0.07$, resulting in a wave height bias of -0.02 m and RMS error of 0.15 m.

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Findings

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Thank You…