MODIFYING AND IMPLEMENTING AN INVERSION ALGORITHM FOR WAVES FROM A BROAD-BEAM HF RADAR NETWORK

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Overview

• Motivation/ Introduction
• HF Radar Description
• Methods
  • CODAR Analysis
  • Delft3D WAVE Model
• Results
• Conclusions
• Future Work

• Things to Keep in Mind
  • In Progress
  • (Focused on the method)
  • Limited Results

• Feedback is extremely appreciated
Introduction/ Motivation

• Nearshore gauges are...
  • Expensive
  • Prone to failure
  • Relatively rare

• Coastal engineers need accurate high-resolution wave information:
  • Wave height;
  • Wave period;
  • Wave direction; etc.

• Rutgers University & partners operate HF radars in the Mid-Atlantic Bight
  • ~12 years of data
  • All levels of data are archived

• When successful will provide a 2D wave field across the Mid-Atlantic Bight
## Volume of Observations

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Data from nearshore wave gauge in Avalon, NJ (operated by Stevens)
HF RADAR DESCRIPTION

A Shore-Based Direction-Finding HF Radar:

The SeaSonde, developed by CODAR
### MID ATLANTIC NETWORK

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**41 Stations in Total**
What Is HF RADAR?

• RADAR = RAdio Detection And Ranging
• HF = High Frequency: 3 - 30 MHz or 100 - 10 m wavelength
• What Can Be Observed/Detected?
  • Currents
    • Most robust environmental data product from HF RADAR systems
    • First-order effect - sea echo from Bragg scattering
  • Waves
    • Second-order effect
    • Subject to perturbation theory limits - upper wave height limitation
  • Discrete “Targets”
    • Ships: dual use w/ current mapping (under development)
    • Ice Packs/Bergs (work done in 70’s - more being done currently)
Broad-Beam (SeaSondes) HF Radars

- Ocean wave spectrum is *homogeneous* over the range cell
- Waves are *fetch limited*; wave periods greater than 6 seconds from offshore are assumed non-existent.
- Wave refraction is ignored, and
- Subsequently waves are assumed to be deep water waves
Proof of Concept Site

Depth within SEAB Range Cell containing Monmouth ADCP

[Graph showing depth vs. distance from Monmouth]
Are improvements necessary?
CODAR ANALYSIS
Taking into consideration water depth

Addressing the issue of homogeneity over the range cell
METHODS

Utilize a SWAN model to generate a lookup table of 2D wave fields
• Curvalinear
  • M = 244
  • N = 190

• Includes:
  • Depth-induced breaking
  • Quad & Triad interactions
  • Bottom friction
  • Wind growth
  • Whitecapping

• One Month (March 2012)

Proof of Concept
Creating the lookup table

Take the average value of wave height or period, for each Range Cell, Time Step, Radar Site.

For example,
- Range Cell 2 @ Belmar = 0.21 m
- Range Cell 3 @ Belmar = 0.25 m, etc.

\[
x = \begin{pmatrix}
    Bel \, HS_{R_1}(t_1) & Bel \, HS_{R_2}(t_1) & \cdots & Bel \, DP_{R_{n-1}}(t_1) & Bel \, DP_{R_n}(t_1) \\
    \vdots & \vdots & \ddots & \vdots & \vdots \\
    Bel \, HS_{R_1}(t_m) & Bel \, HS_{R_2}(t_m) & \cdots & Bel \, DP_{R_{n-1}}(t_m) & Bel \, DP_{R_n}(t_m)
\end{pmatrix}
\]
Extracting a 2D wave field

- Collect the wave characteristics generated by the relevant SeaSonde:
  - Construct a search table (format matches the lookup table)

\[
x = \begin{pmatrix}
\text{Bel } HS_{R1}(t_1) & \text{Bel } HS_{R2}(t_1) & \cdots & \text{Bel } DP_{R_{n-1}}(t_1) & \text{Bel } DP_{R_{n}}(t_1) \\
\vdots & \ddots & \vdots \\
\text{Bel } HS_{R1}(t_m) & \text{Bel } HS_{R2}(t_m) & \cdots & \text{Bel } DP_{R_{n-1}}(t_m) & \text{Bel } DP_{R_{n}}(t_m)
\end{pmatrix}
\]

- Utilizing an Euclidean distance between each observation
  - Find the best fit in the lookup table by minimizing the total distance

- Extract the corresponding 2D wave field from the lookup reference
Initial Results

- Looks promising
- But, a little knowledge is a dangerous thing

Initial Conclusions
- Approximately 25% improvement*
- Utilizing only wave characteristics does not result in a unique best fit
- SWAN model is not validated for this application
FUTURE WORK
Future Work

• Extend SWAN model
  • Entire WIS time frame (1980-2012)
  • One model for entire Mid-Atlantic Bight

• Better summary of lookup instances
  • Wave averages for 5-, 13-, and 25-MHz range cells
  • Incorporate existing current maps

• Combine depth effects & spatial inhomogeneity corrections

• Validation & Verification
  • SWAN Model
  • CODAR Corrected Measurements
Questions?

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