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

Month	Year									Grand Total
	1999	2000	2001	2002	2003	2004	2005	2006	2007	
1		569		742	575			705	744	3335
2		634		663	546			672	625	3140
3		676		699	579			738	611	3303
4		1		1	1			718	450	1171
5	118	715		349	716	608		744	725	3975
6	623	718	269	684	715	714		720	652	5095
7	553	735	736	596	742	91		744	675	4872
8	604	738	556	433	429		120	741	599	4220
9	645	705	717	544			720	703		4034
10	651	735	738	723			738	670		4255
11	658	716	715	605			720	719		4133
12	653	260	741	212			742	719		3327
Grand Total	4505	7202	4472	6251	4303	1413	3040	8593	5081	**44860**

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

HF RADAR DESCRIPTION

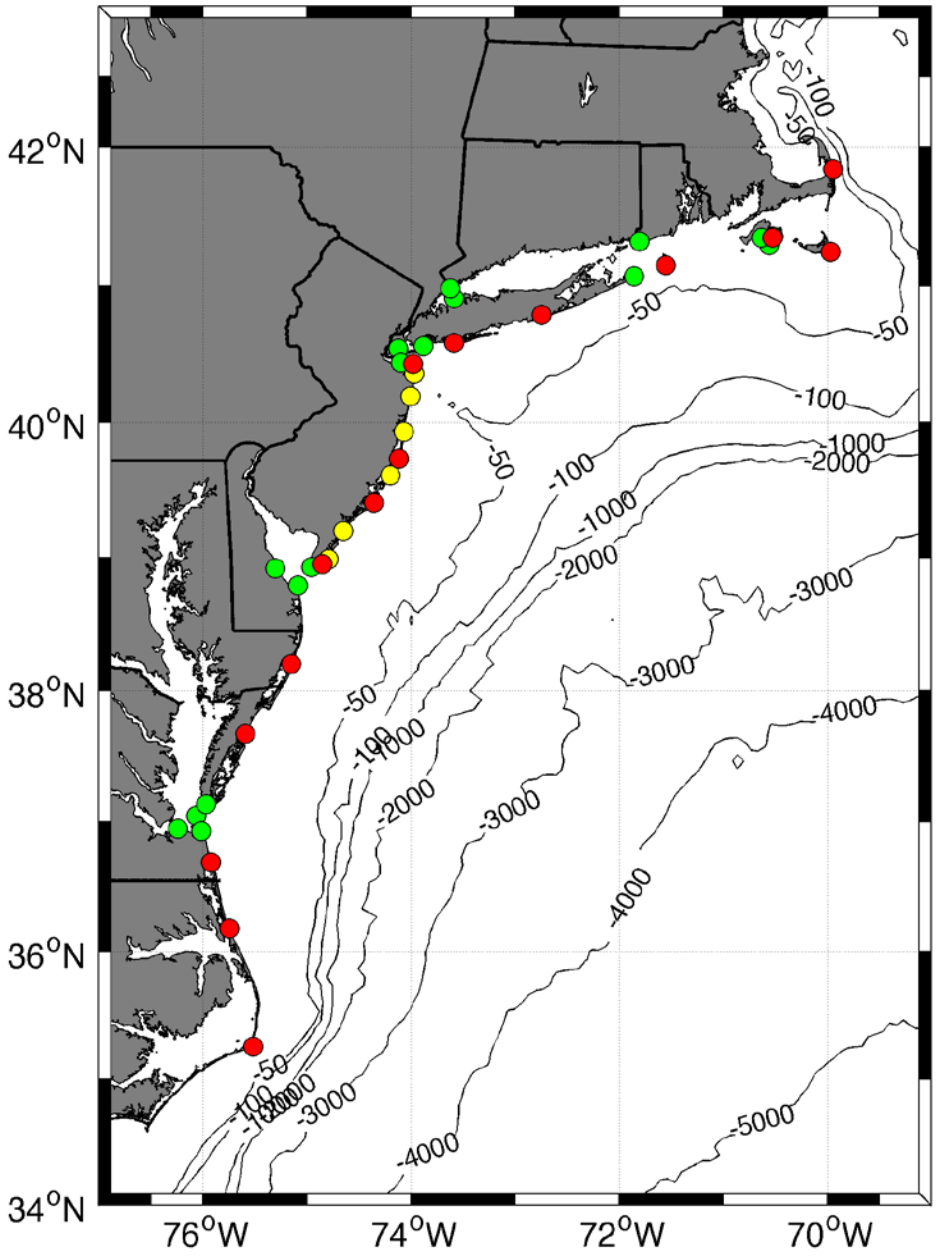
A Shore-Based Direction-Finding HF Radar:

The SeaSonde, developed by CODAR

MIDATLANTIC NETWORK

	5 MHz	13 MHz	25 MHz
U Mass	1		
WHOI			1
U Conn			1
URI			1
Stevens			1
Rutgers	1	1	1
Delaware			1
ODU/CIT	1		1
UNC	1		
9	17	8	17

41 Stations in Total

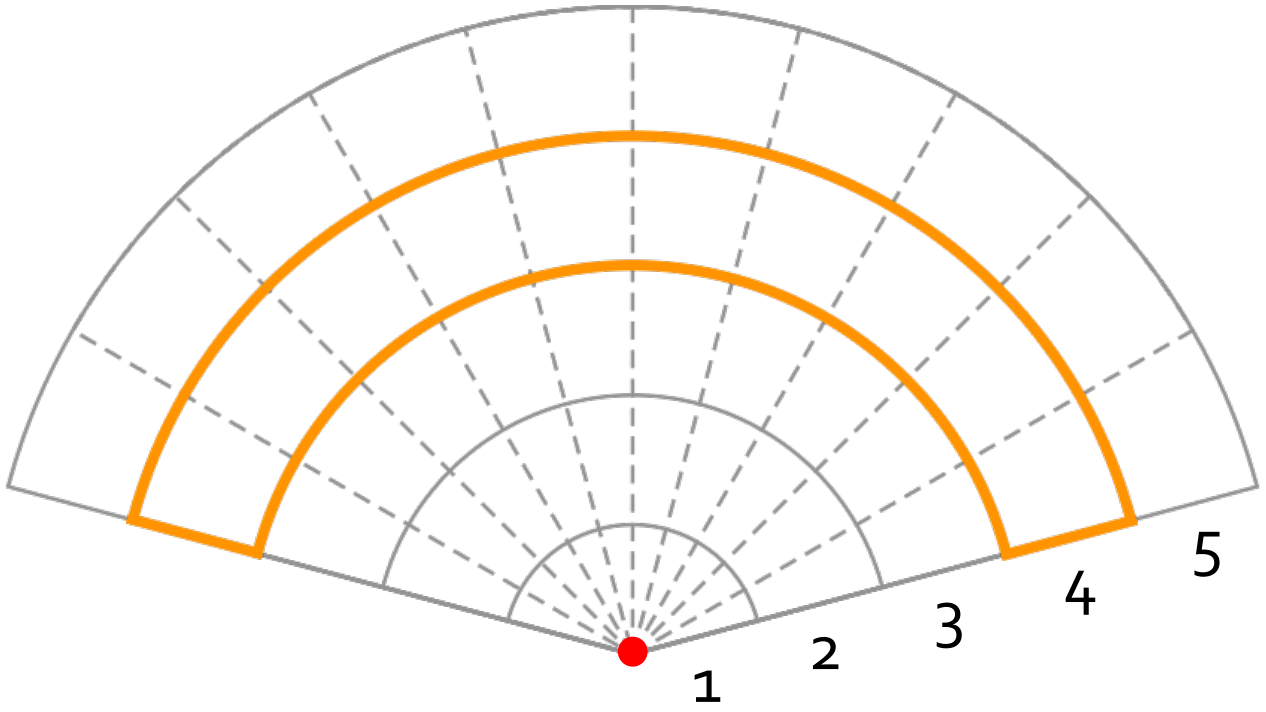


What Is HF RADAR?

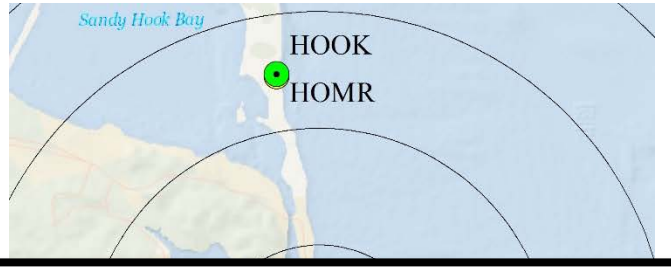
- RADAR = RAdio Detection And Ranging
- HF = High Frequency: 3 - 30 MHz or 100 - 10 m wavelength
- What Can Be Observed/Detected?
  - Currents
    - Most robust environmental data product from HF RADAR systems
    - First-order effect - sea echo from Bragg scattering
  - Waves
    - Second-order effect
    - 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)

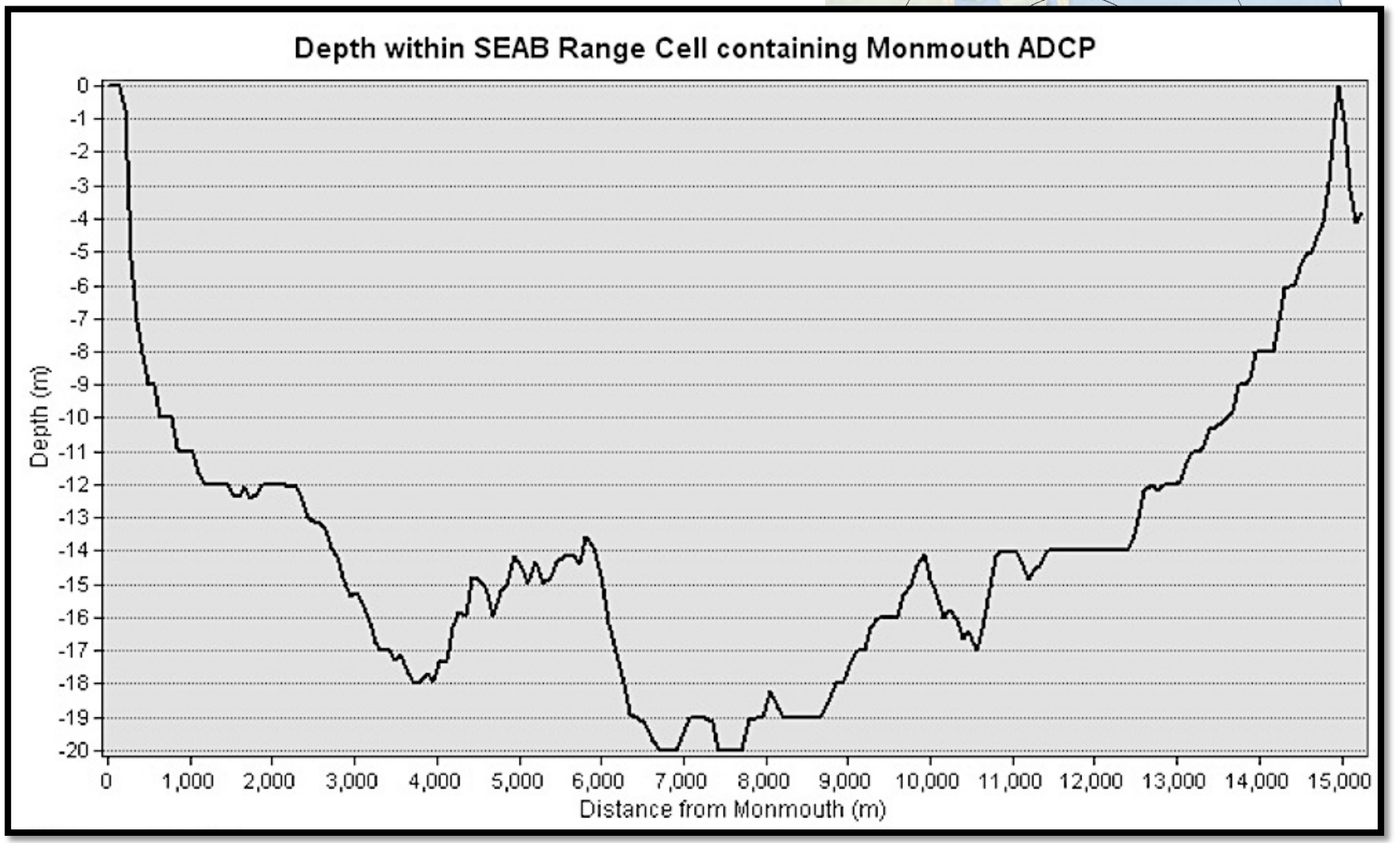
Broad-Beam (SeaSondes) HF Radars

- 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

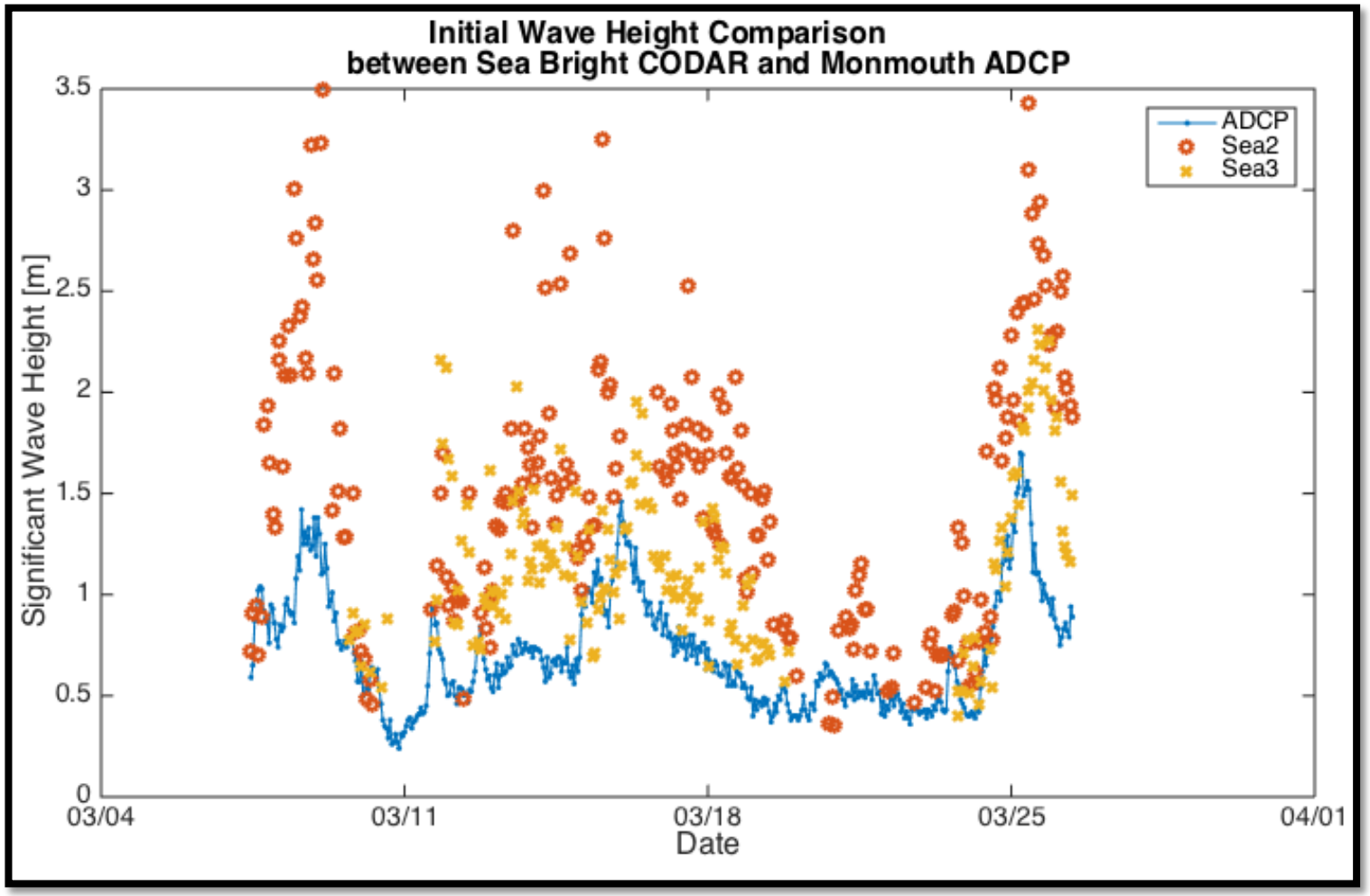


Proof of Concept Site





Are improvements necessary?



CODAR ANALYSIS

Taking into consideration water depth

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Addressing the issue of homogeneity over the range cell

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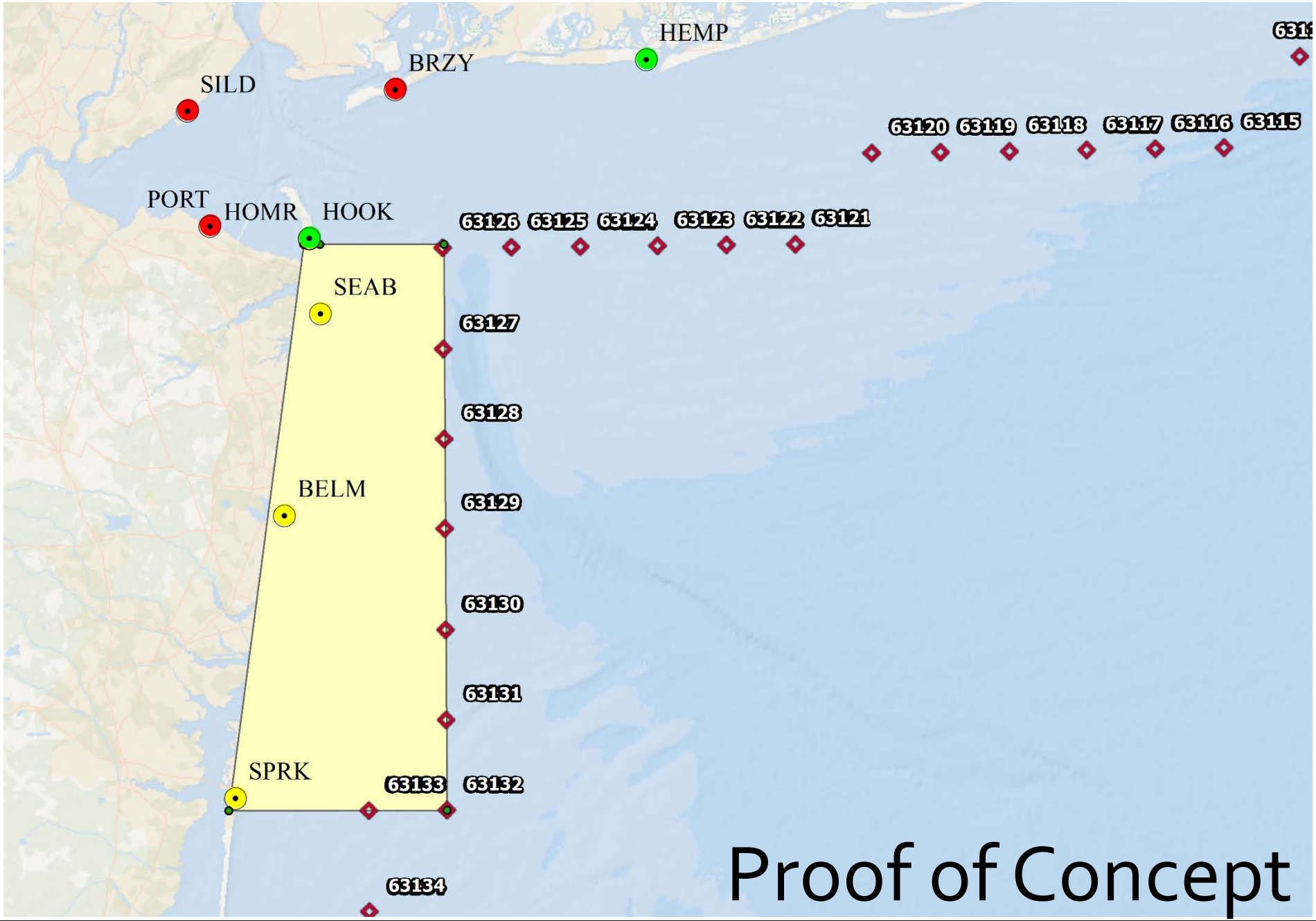
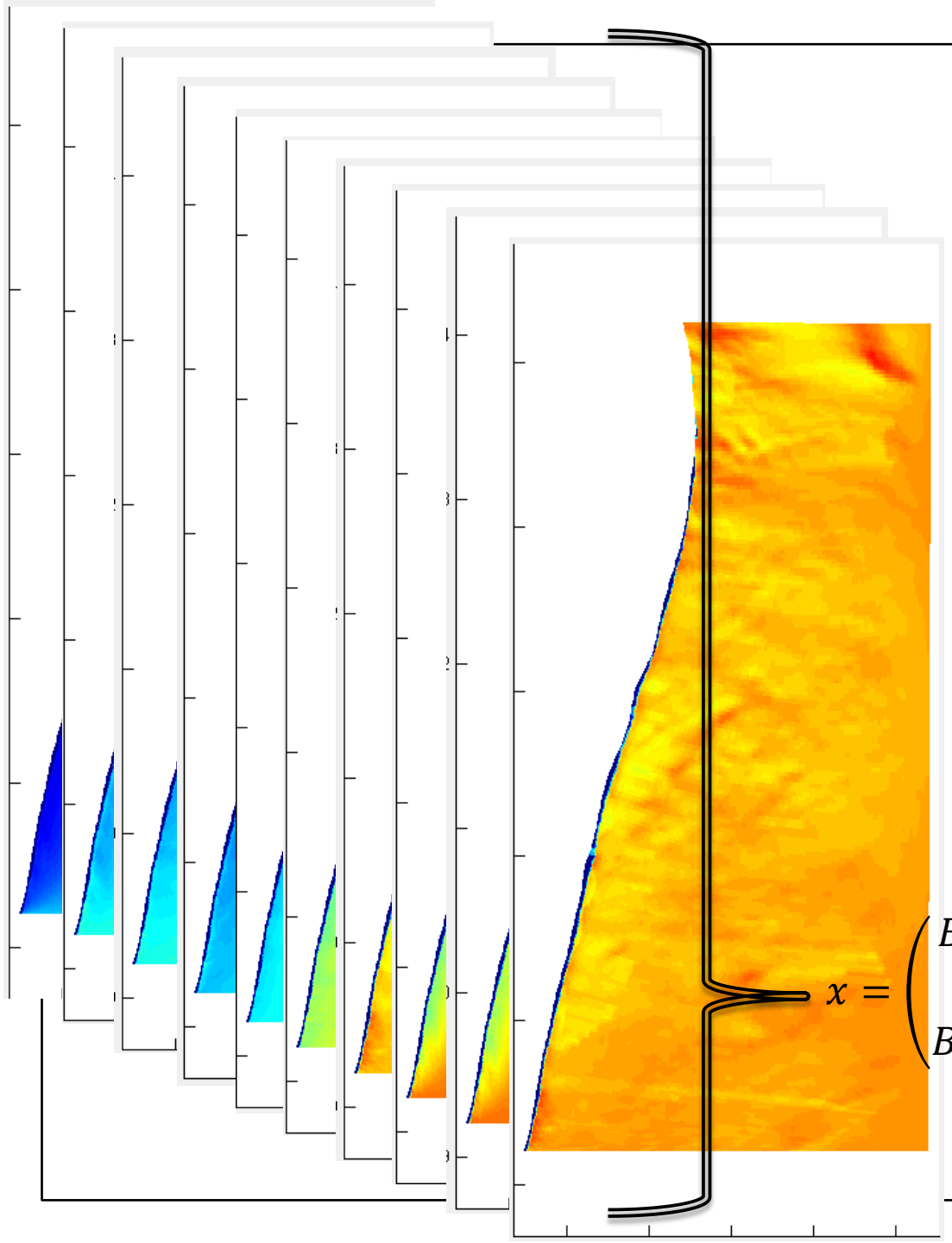
METHODS

Utilize a SWAN model to generate a lookup table of 2D wave fields



Proof of Concept

- Curvalinear
  - M = 244
  - N = 190
- Includes:
  - Depth-induced breaking
  - Quad & Triad interactions
  - Bottom friction
  - Wind growth
  - Whitecapping
- One Month (March 2012)



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
- Rance Cell 3 @ Belmar = 0.25 m, etc.

$$x = \begin{pmatrix} Bel\ HS_{R_1}(t_1) & Bel\ HS_{R_2}(t_1) & \cdots & Bel\ DP_{R_{n-1}}(t_1) & Bel\ DP_{R_n}(t_1) \\ \vdots & & \ddots & & \vdots \\ Bel\ HS_{R_1}(t_m) & Bel\ HS_{R_2}(t_m) & \cdots & Bel\ DP_{R_{n-1}}(t_m) & Bel\ DP_{R_n}(t_m) \end{pmatrix}$$

Extracting a 2D wave field

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

$$x = \begin{pmatrix} Bel\ HS_{R_1}(t_1) & Bel\ HS_{R_2}(t_1) & \cdots & Bel\ DP_{R_{n-1}}(t_1) & Bel\ DP_{R_n}(t_1) \\ \vdots & & \ddots & & \vdots \\ Bel\ HS_{R_1}(t_m) & Bel\ HS_{R_2}(t_m) & \cdots & Bel\ DP_{R_{n-1}}(t_m) & Bel\ DP_{R_n}(t_m) \end{pmatrix}$$

- 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

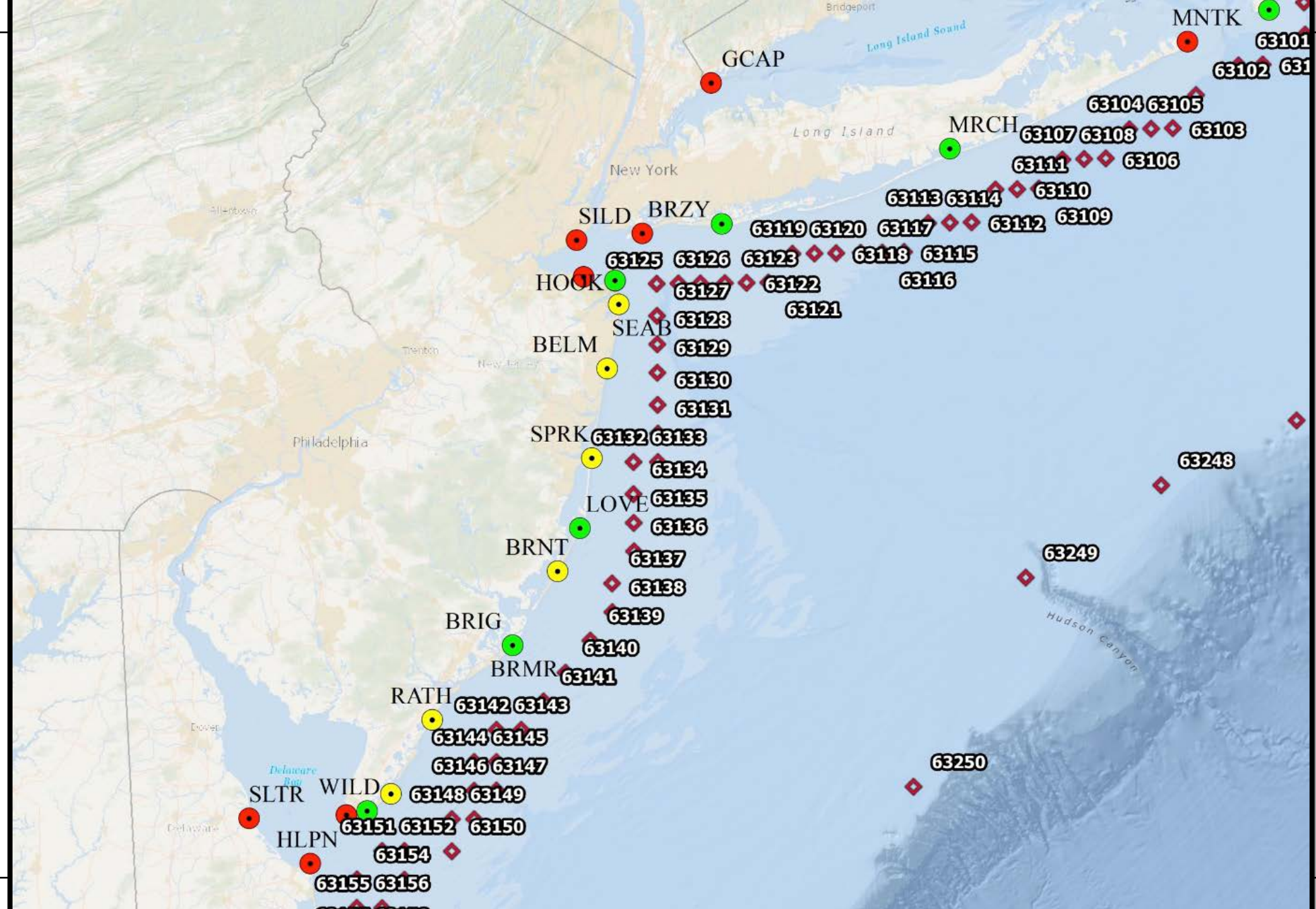
- Looks promising
- But, a little knowledge is a dangerous thing

- 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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Questions?

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