Probabilistic Environmental Modeling System for Munitions Mobility

MR-2733

Meg Palmsten
U.S. Naval Research Laboratory

In-Progress Review Meeting
15 May 2018

MR-2733: Probabilistic Environmental Modeling System for Munitions Mobility

Performers: Meg Palmsten, Allison Penko

Technology Focus

- *Nowcast/hindcast munitions burial and migration with coupled hydrodynamic, morphologic, and mobility models*

Research Objectives

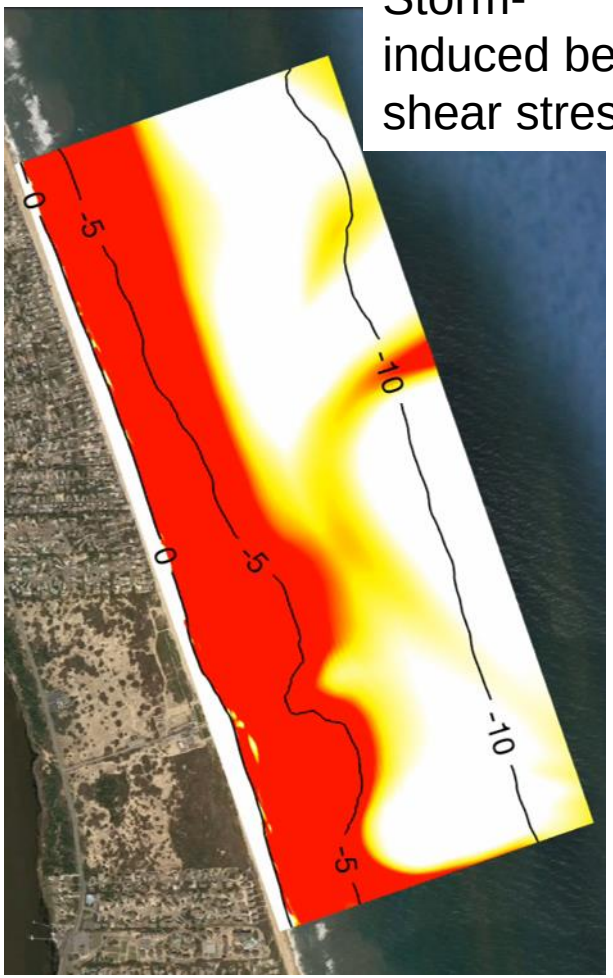
- *How do improved estimates of hydro- and morphodynamics improve estimates of munitions mobility and burial?*
- *What is the role of time-dependence in estimating the probability of munitions mobility and burial?*
- *How do we accurately represent hydro- and morphodynamic uncertainty in probabilistic models of munitions mobility and burial?*

Project Progress and Results

- *Set up Delft3D at Duck, NC*
- *Generated ensemble simulations*
- *Simulated waves and currents for Sept-Oct 2015*
- *Tested model in data starved scenarios*

Technology Transition

- *Develop cartographic visualizations of munitions mobility and burial*
- *Informal discussions with end users at SERDP Symposium*



Storm-induced bed shear stress

Social Media Content

- **Ocean Sciences 2018**
  - *Researchers from the U.S. Naval Research Laboratory presented key findings about the role of bathymetry on munitions mobility at the 2018 Ocean Science Meeting in Portland, OR*

- **Coastal Imagining Research Network (CIRN) Workshop**
  - *Researchers from the U.S. Naval Research Laboratory will present results demonstrating the application of the remotely sensed bathymetry to hindcast mobility and burial of unexploded ordinance in shallow water at the Coastal Imaging Research Network Workshop 4-8 June, 2018*

- **Simulations of waves and currents during Hurricane Joaquin**
  - In an effort to validate models of munitions mobility and burial, researchers at the U.S. Naval Research laboratory hindcast waves and currents on the Outer Banks of North Carolina during Hurricane Joaquin

Performers

U.S. NAVAL RESEARCH LABORATORY

Margaret Palmsten, PhD

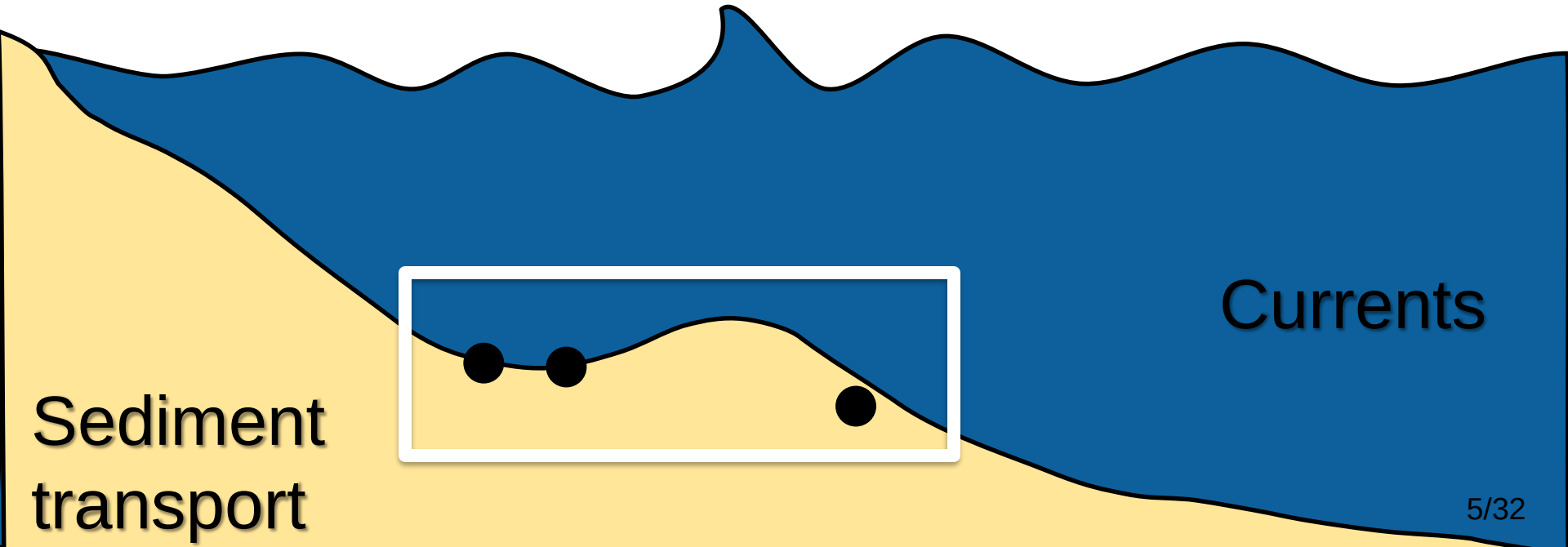
Probabilistic modeling
Nearshore remote sensing

Allison Penko, PhD

Hydrodynamic modeling
Morphodynamic modeling

Problem Statement

Waves



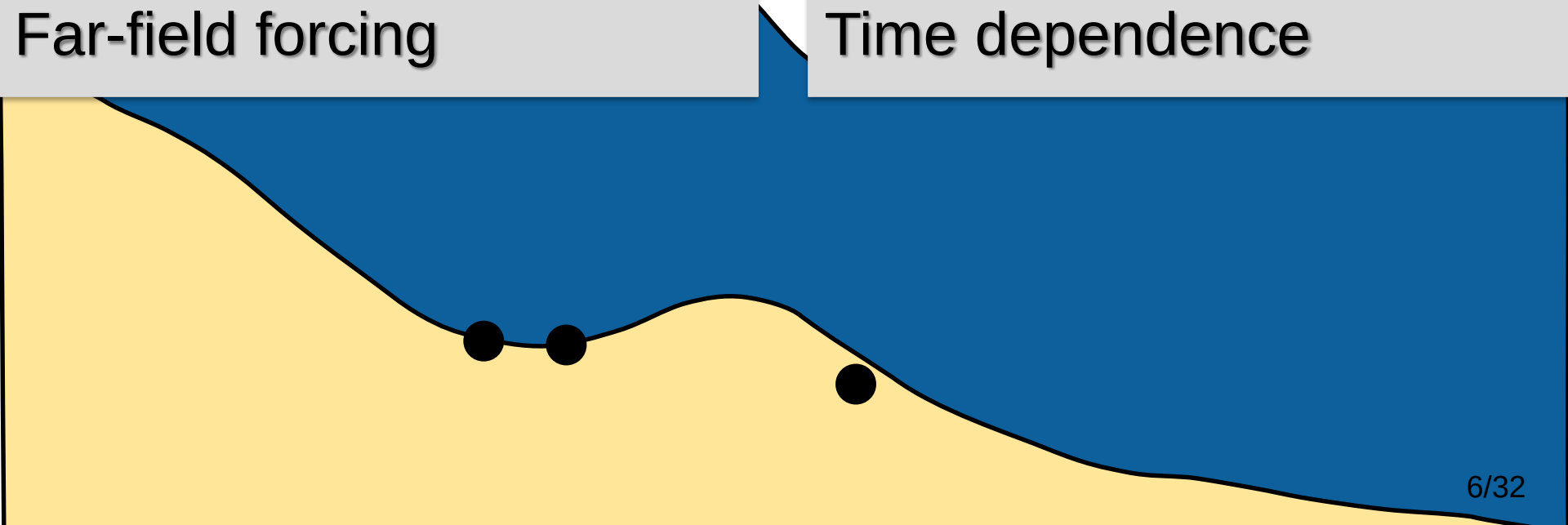
Problem Statement

What is probability that munitions will be exposed?

Where have munitions congregated?

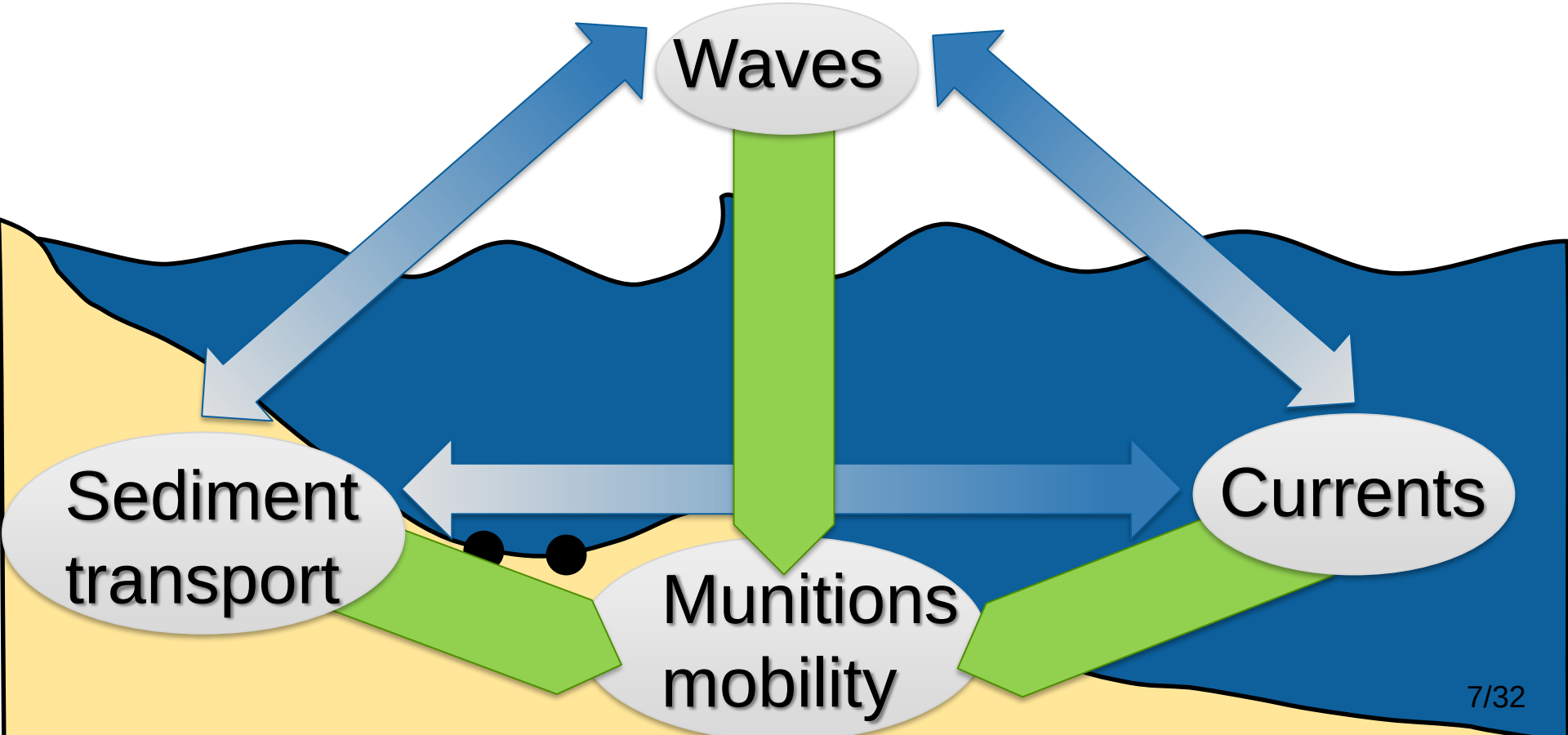
Far-field forcing

Time dependence



Technical objective

Informed decisions



Science questions

Improvement from far-field model?

Time-dependence?

Uncertainty?

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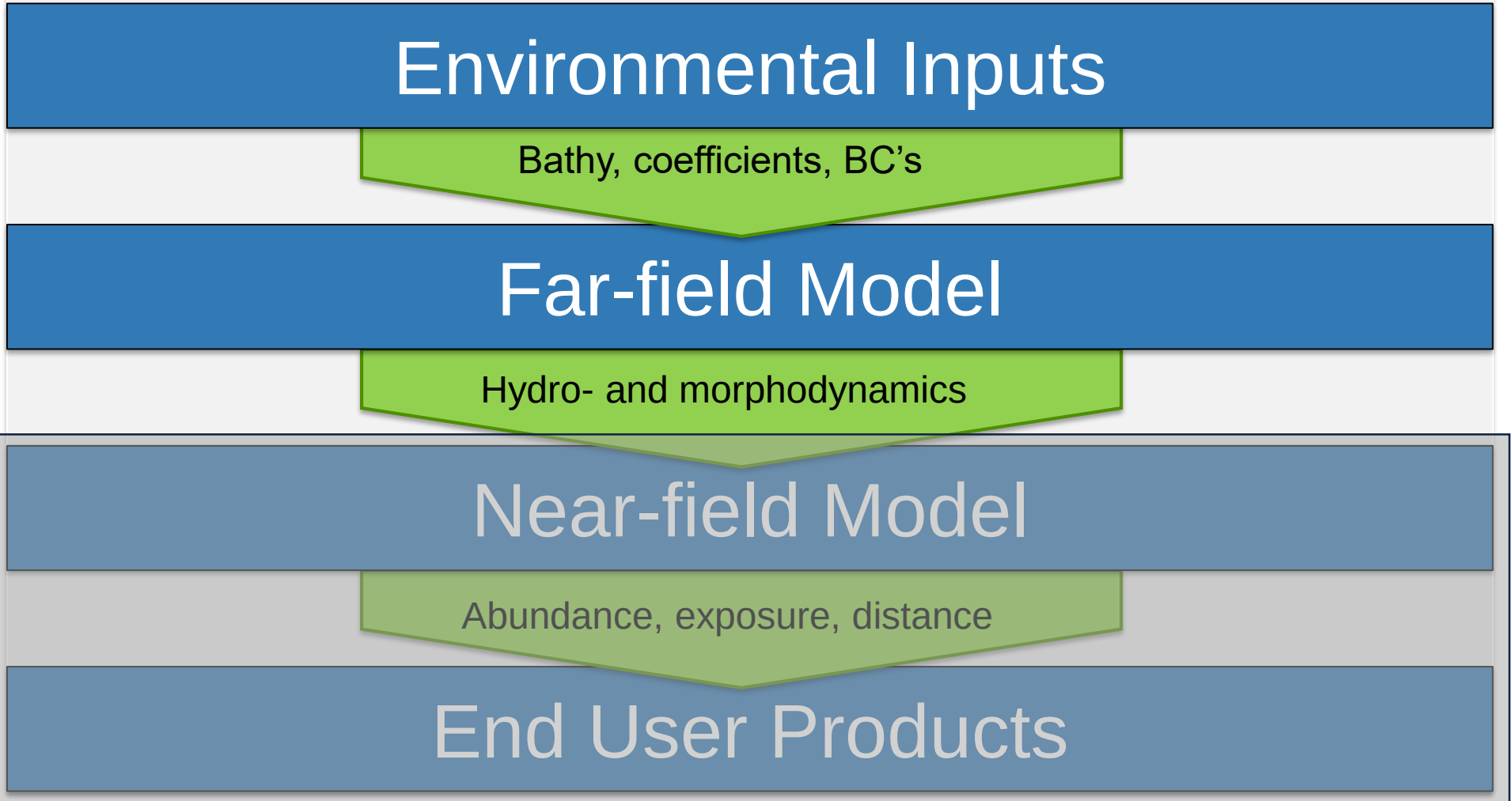
TECHNICAL APPROACH

Probabilistic Environmental Modeling System for Munitions Mobility



Environmental Inputs

TASK 1
Set up Delft3D at FRF

Coastal Imaging Tower

Inner Grid 1.2 km x 3.2 km
5 m x 20 m grid cells
241x161

Outer Grid 3.7 km x 12 km
50 m x 100 m grid cells
75x121

17m WaveRider buoy

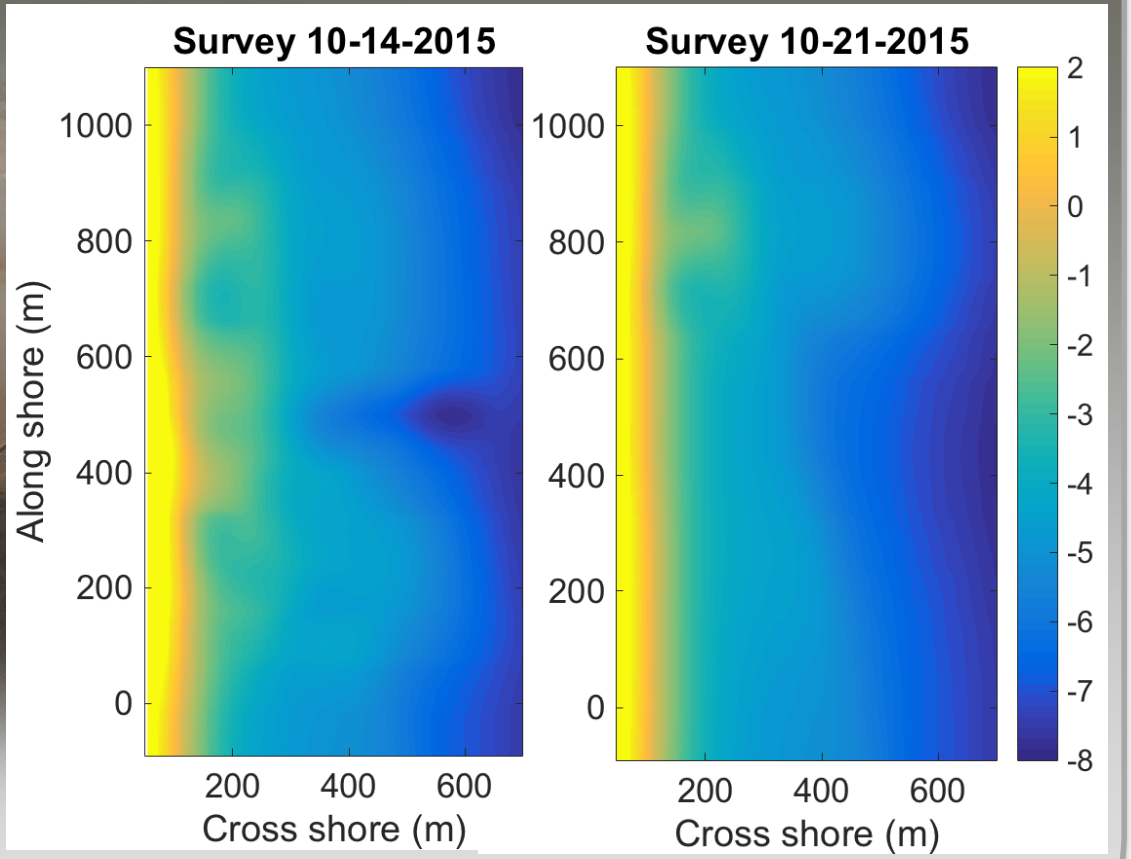
le Earth
TerraMetrics
AA, U.S. Navy, NGA, GEBCO

Simulation period: September – October 2015, BathyDuck Experiment

Environmental Inputs

TASK 1

Set up Delft3D at FRF

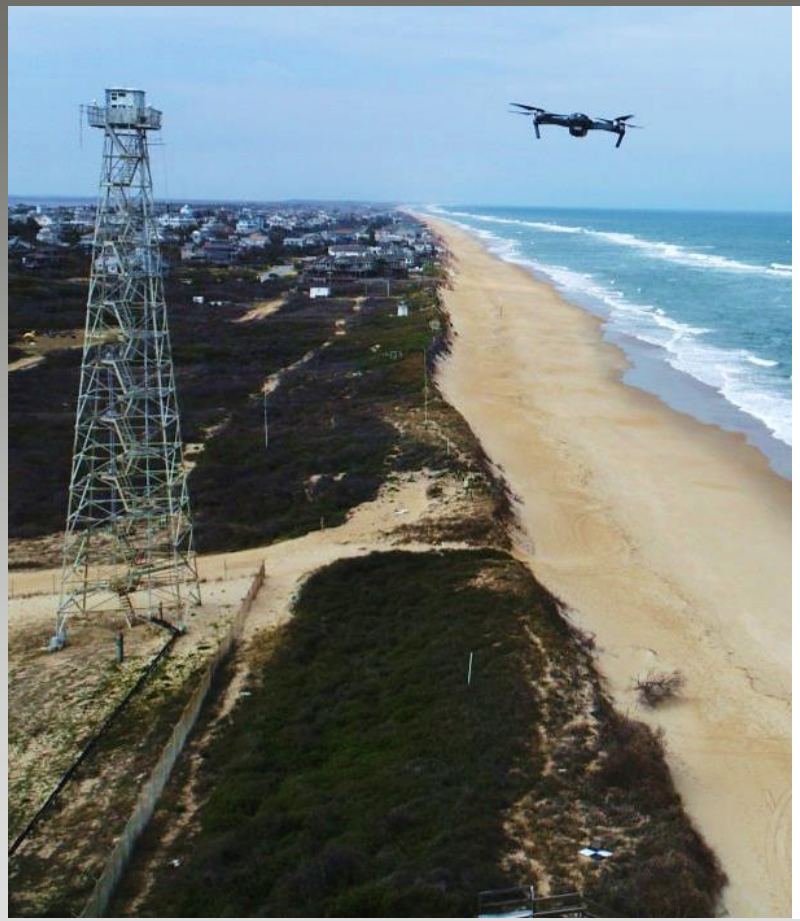


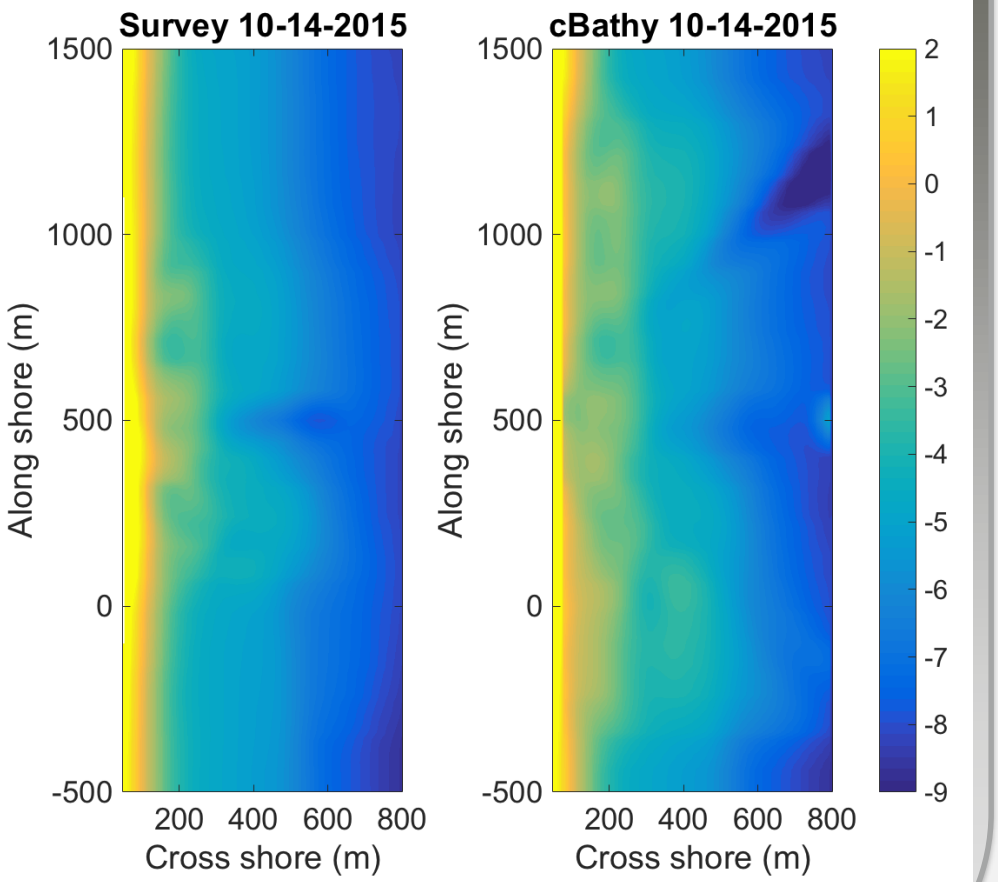
Surveyed bathymetry: USACE Integrated bathymetry product

Environmental Inputs

TASK 1

Set up Delft3D at FRF





Low cost (1 order of magnitude) alternative to bathymetry survey

Environmental Inputs

TASK 1

Outer domain:

- Coupled FLOW-WAVE model setup
- Directional wave spectra from 17 and 26 m buoy on all three boundaries
- Neumann boundary conditions at North and South boundaries
- Wind from Duck Pier
- NOAA DEM bathymetry

Inner domain:

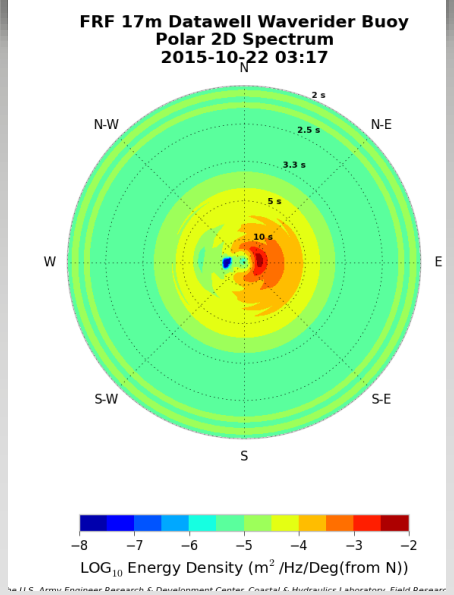
- Coupled WAVE-FLOW-MOR model setup
- WAVE forced with directional spectra from outer grid
- FLOW forced with output from outer grid: North boundary BC: Currents, Offshore BC: Riemann, South BC: Water Level
- Bottom friction: Manning's n = 0.02

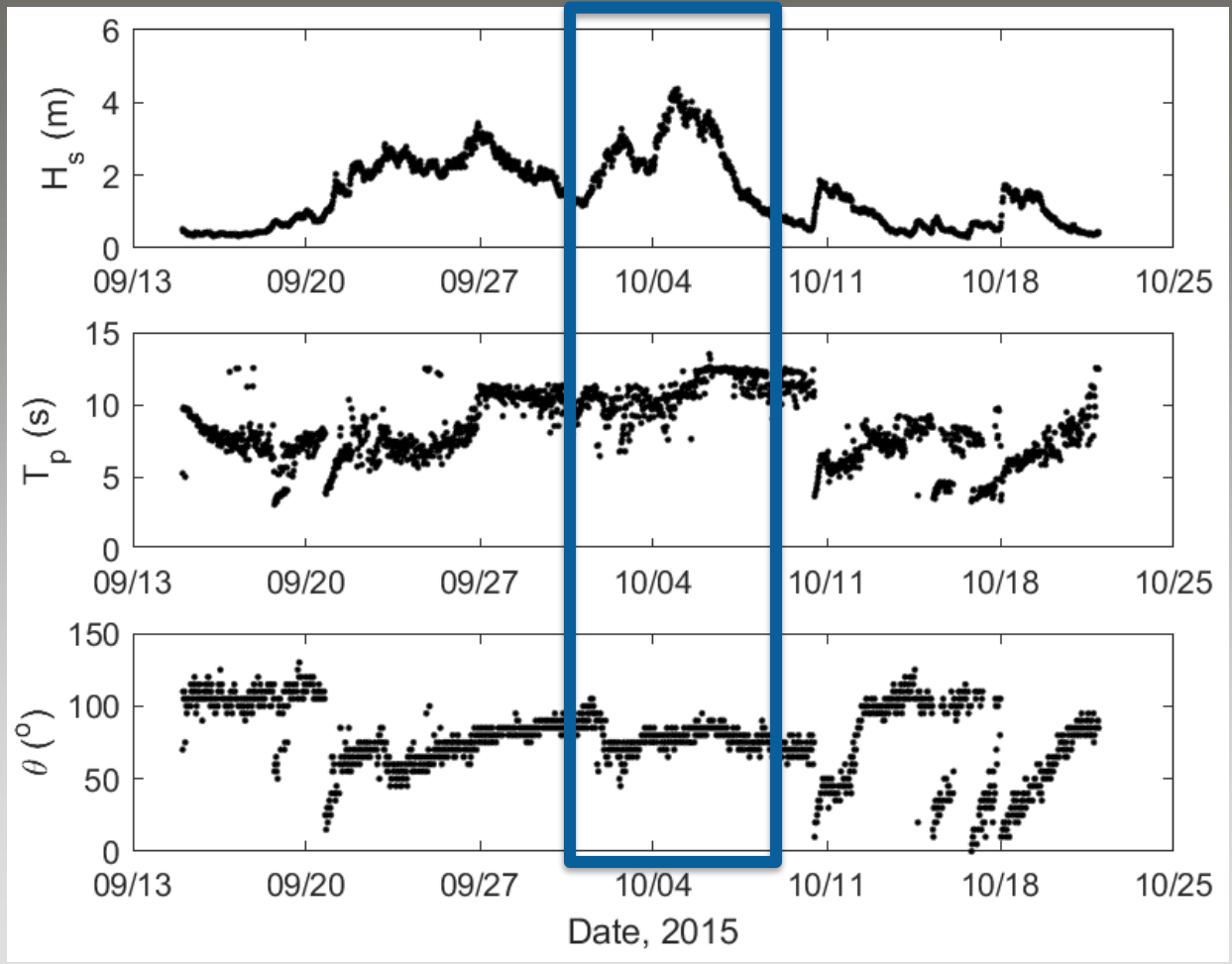
Morphology:

- van Rijn (2004) sediment transport formulation
- d_{50} = 0.25 mm

Environmental Inputs

TASK 1
Boundary Conditions



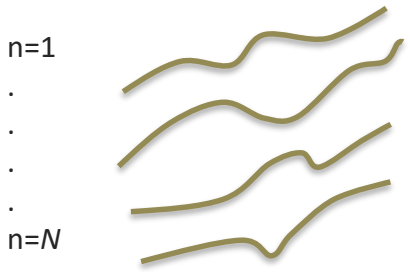


Environmental Inputs

TASK 2

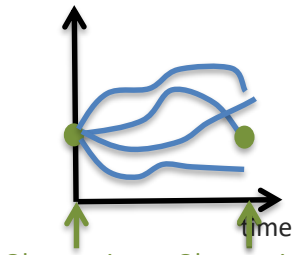
Adapt ensemble method

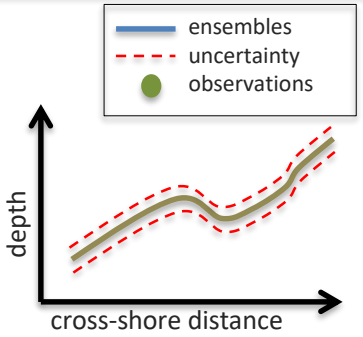
1) **CHOOSE** parameters and ranges



2) **RUN** ensembles in Delft3D

3) **DETERMINE** model sensitivity and uncertainty



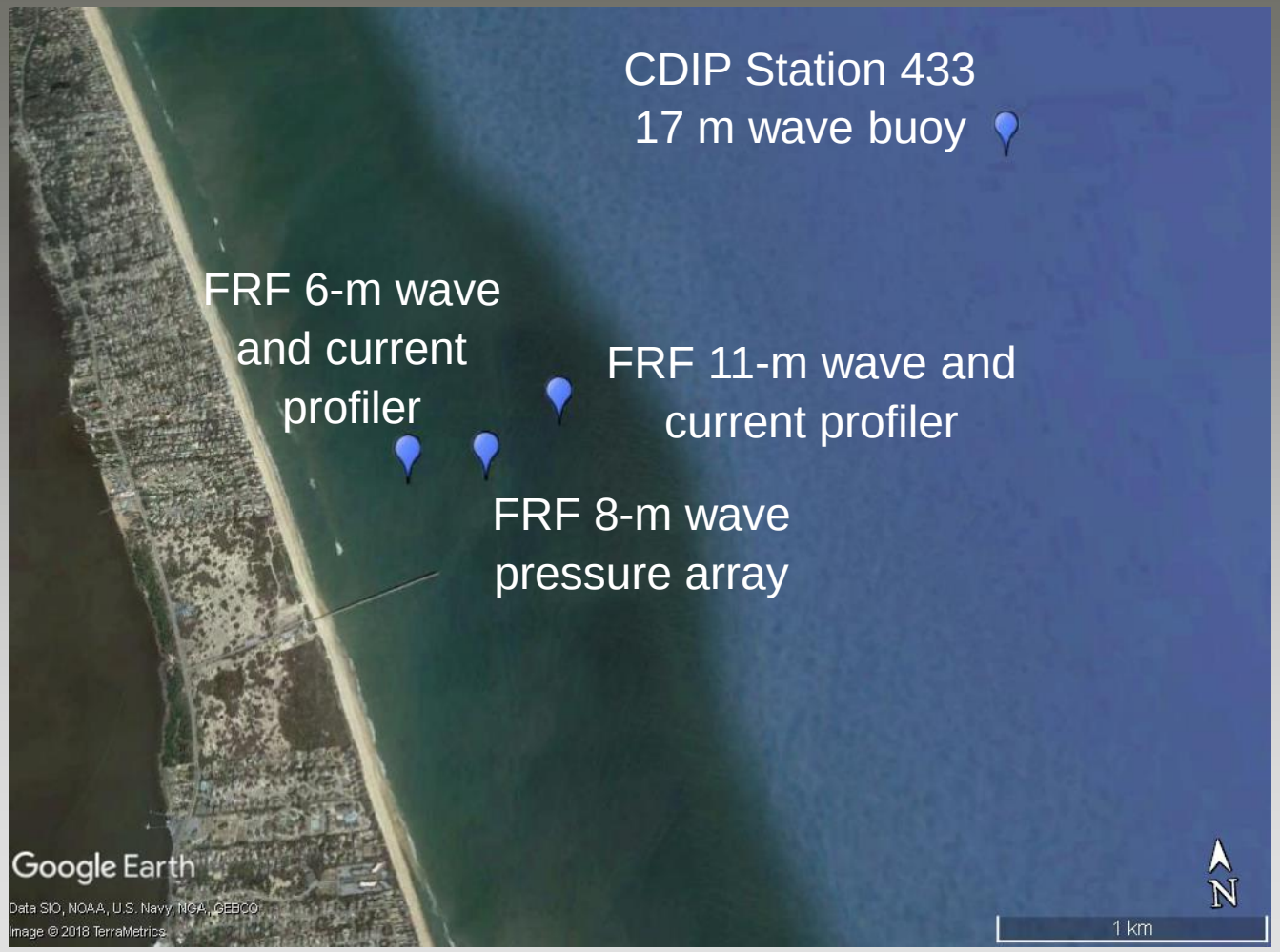


4) **REVISE** parameters and ranges

Far-field model

TASK 3

Comparison data



Far-field Model

TASK 3

Model-data comparison

$$RMAE = \langle|\chi_m - \chi_o|\rangle / \langle\chi_m\rangle \qquad BSS = 1 - \frac{\sum_{j=1}^{N}(|z_m - z_o|)^2}{\sum_{j=1}^{N}(z_i - z_o)^2}$$

van Rijn et al. (2003) Model error classification

Qualification	Wave height, RMAE	Velocity, RMAE	Morphology; BSS
Excellent	<0.05	<0.1	1-0.8
Good	0.05-0.1	0.1-0.3	0.8-0.6
Reasonable	0.1-0.2	0.3-0.5	0.6-0.3
Poor	0.2-0.3	0.5-0.7	0.3-0
Bad	>0.3	>0.7	<0

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RESULTS

Results

Modeled **waves** with **excellent** accuracy (Task 1 & 3)

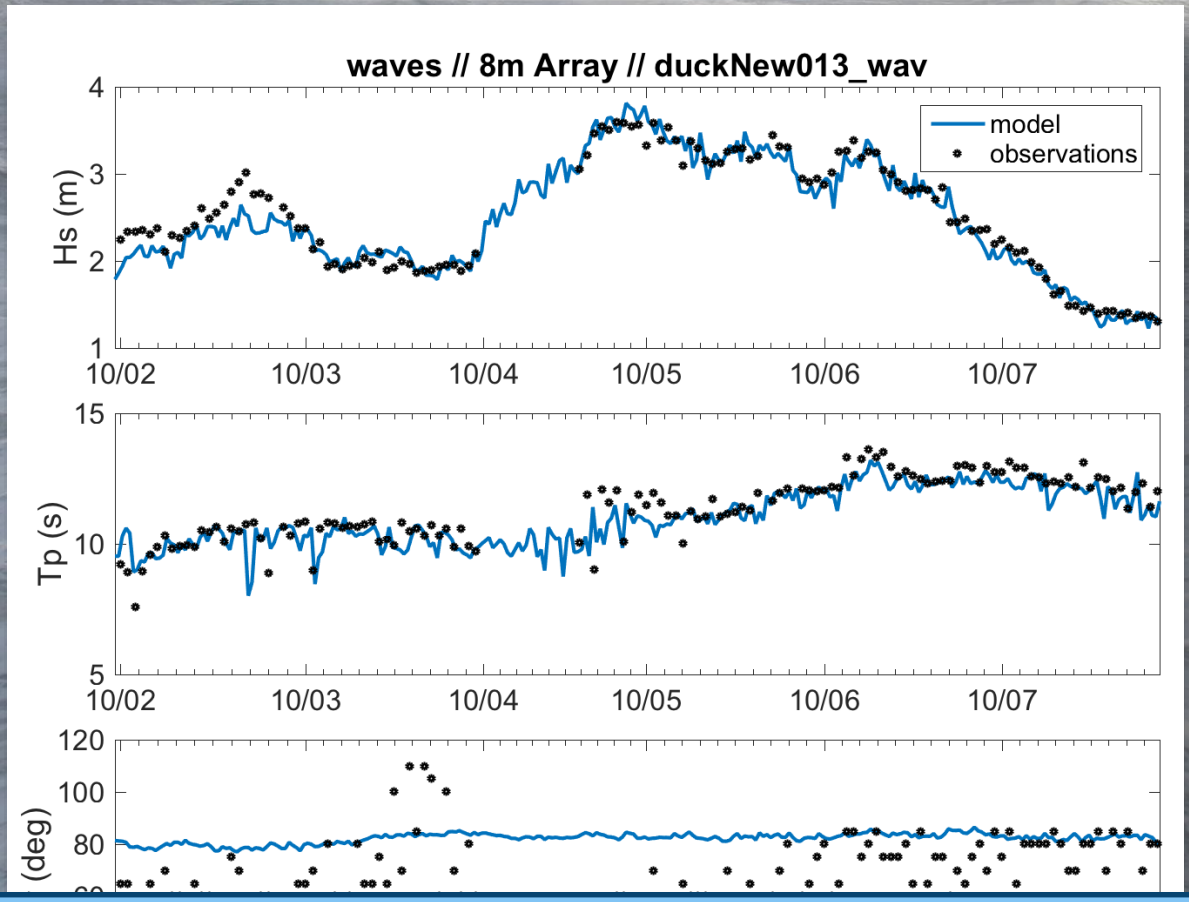
Modeled **currents** with **good** accuracy (Task 1 & 3)

Modeled **morphologic** change **qualitatively** (Task 1 & 3)

Quantified differences in **data-starved** scenario (Task 2 & 3)

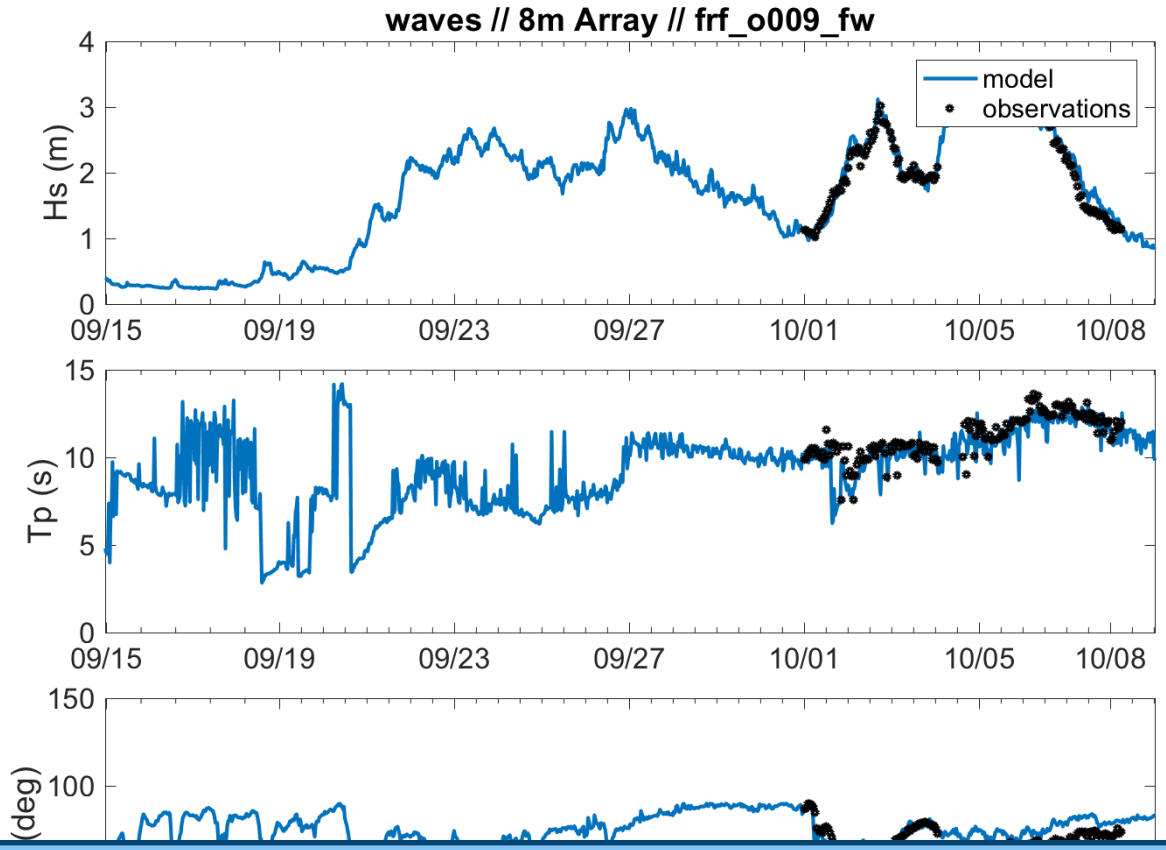
Quantified sensitivity and **uncertainty** with ensembles (Task 2 & 3)

Model/Data Comparison: Waves



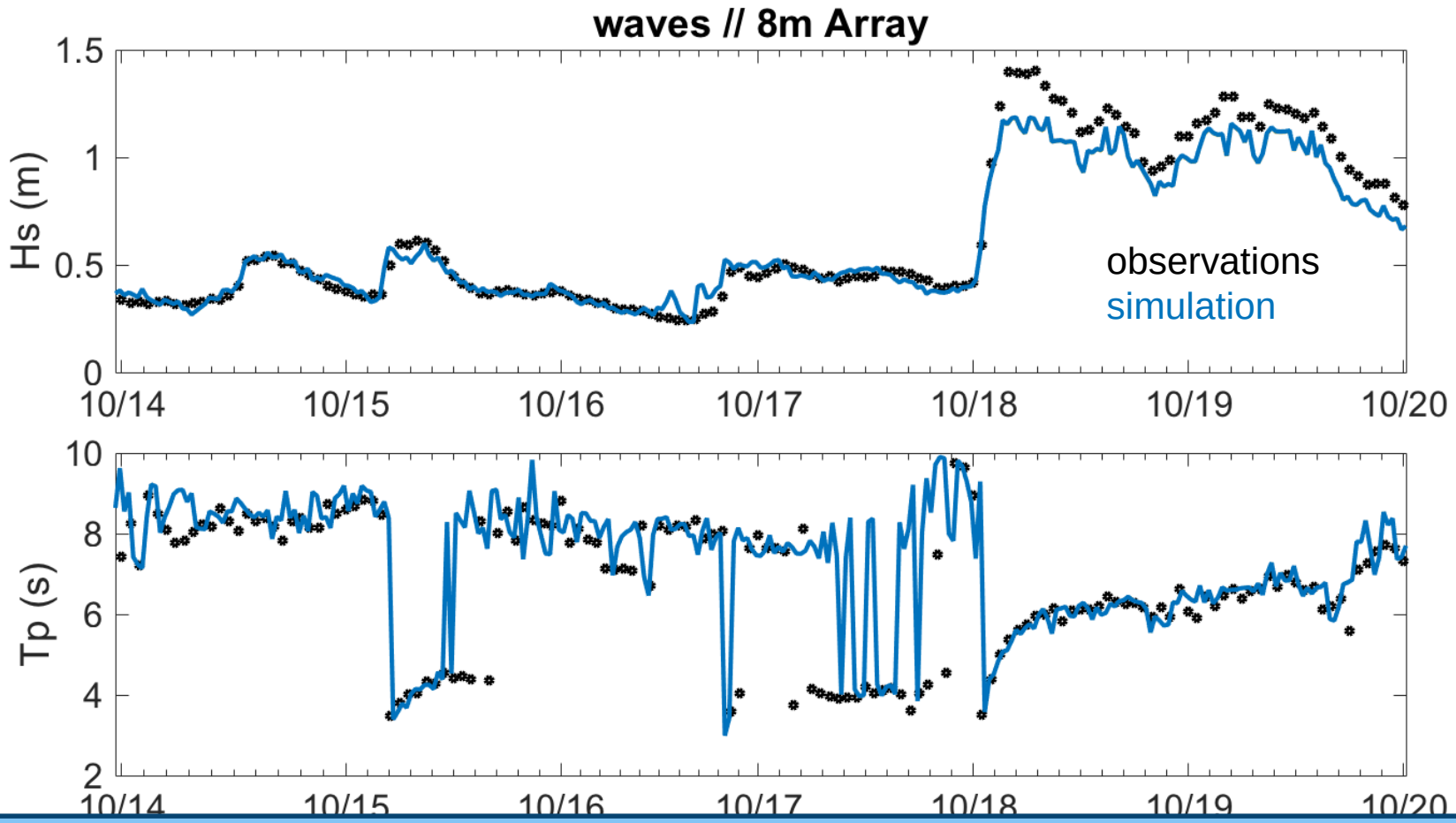
RMAE(H_s) = 0.04, RMAE(T_p) = 0.04,
RMAE(Dir) = 0.23

Model/Data Comparison: Waves



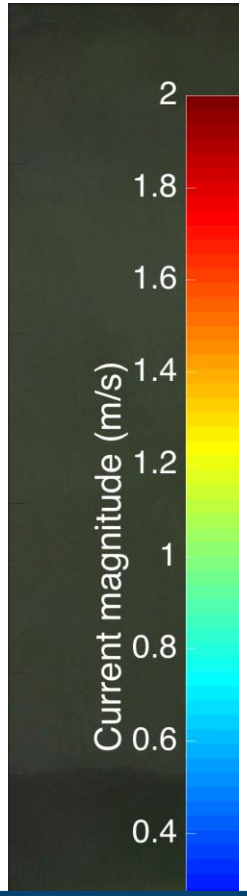
$RMAE(H_s) = 0.05$, $RMAE(T_p) = 0.06$,
$RMAE(Dir) = 0.17$

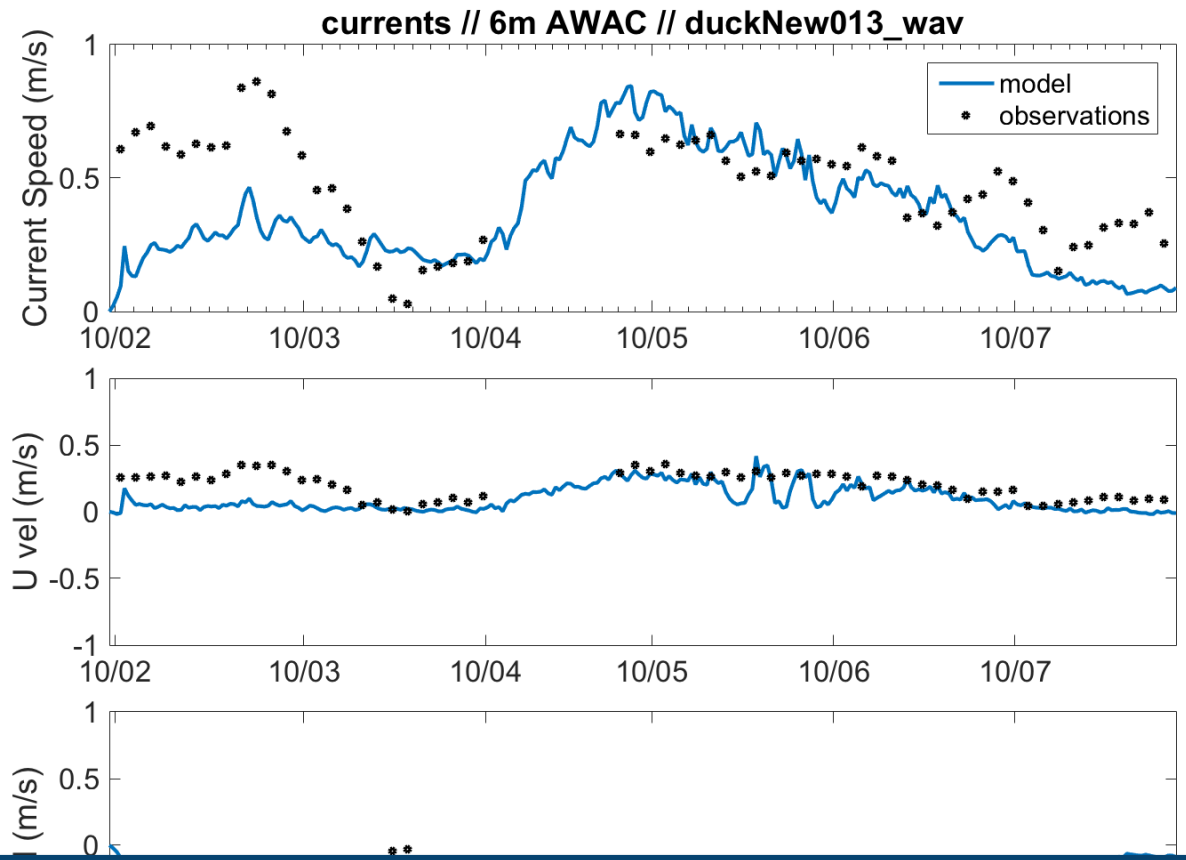
Model/Data Comparison: Waves



$RMAE(H_s) = 0.04$, $RMAE(T_p) = 0.06$

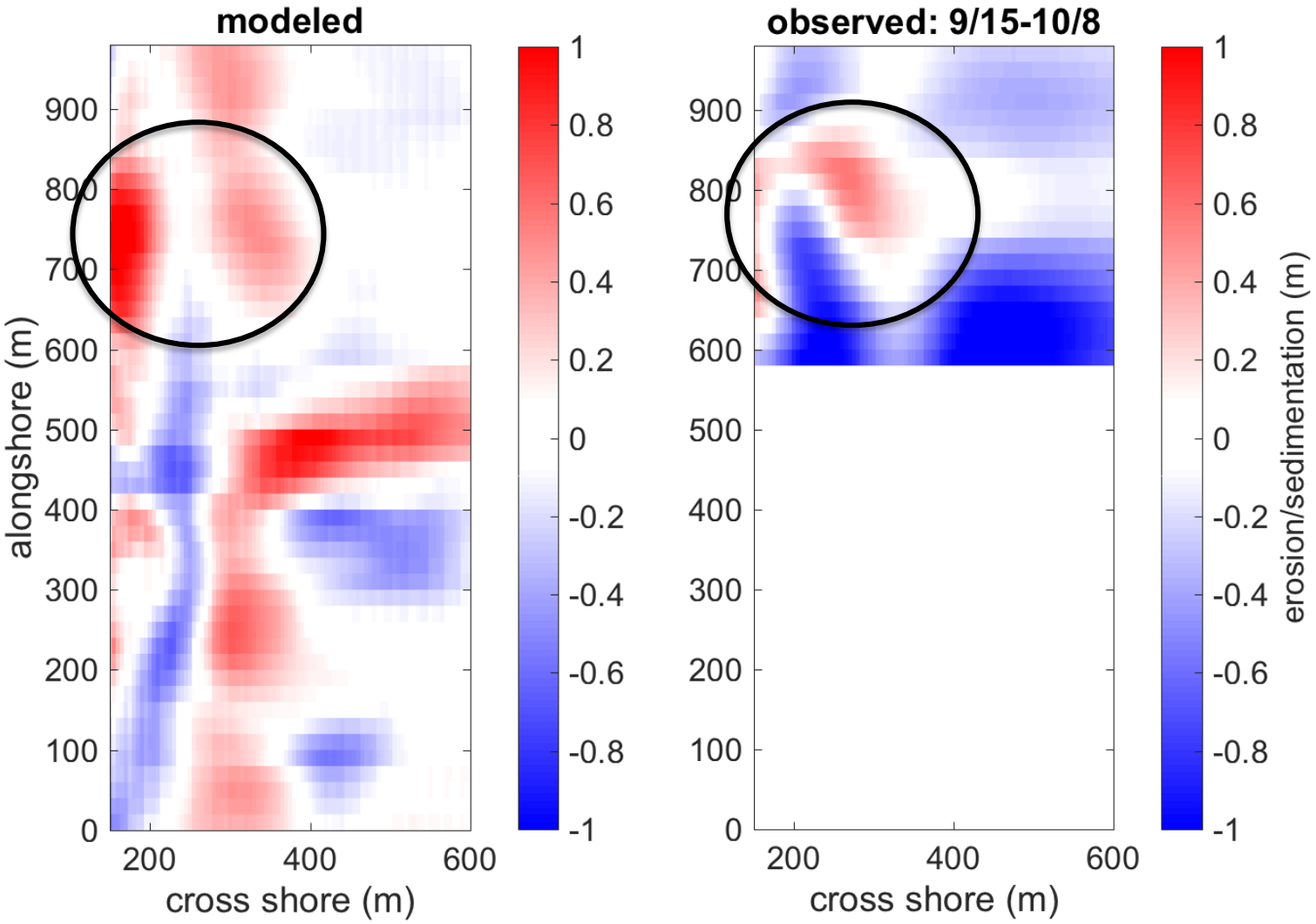
Model/Data Comparison: Currents





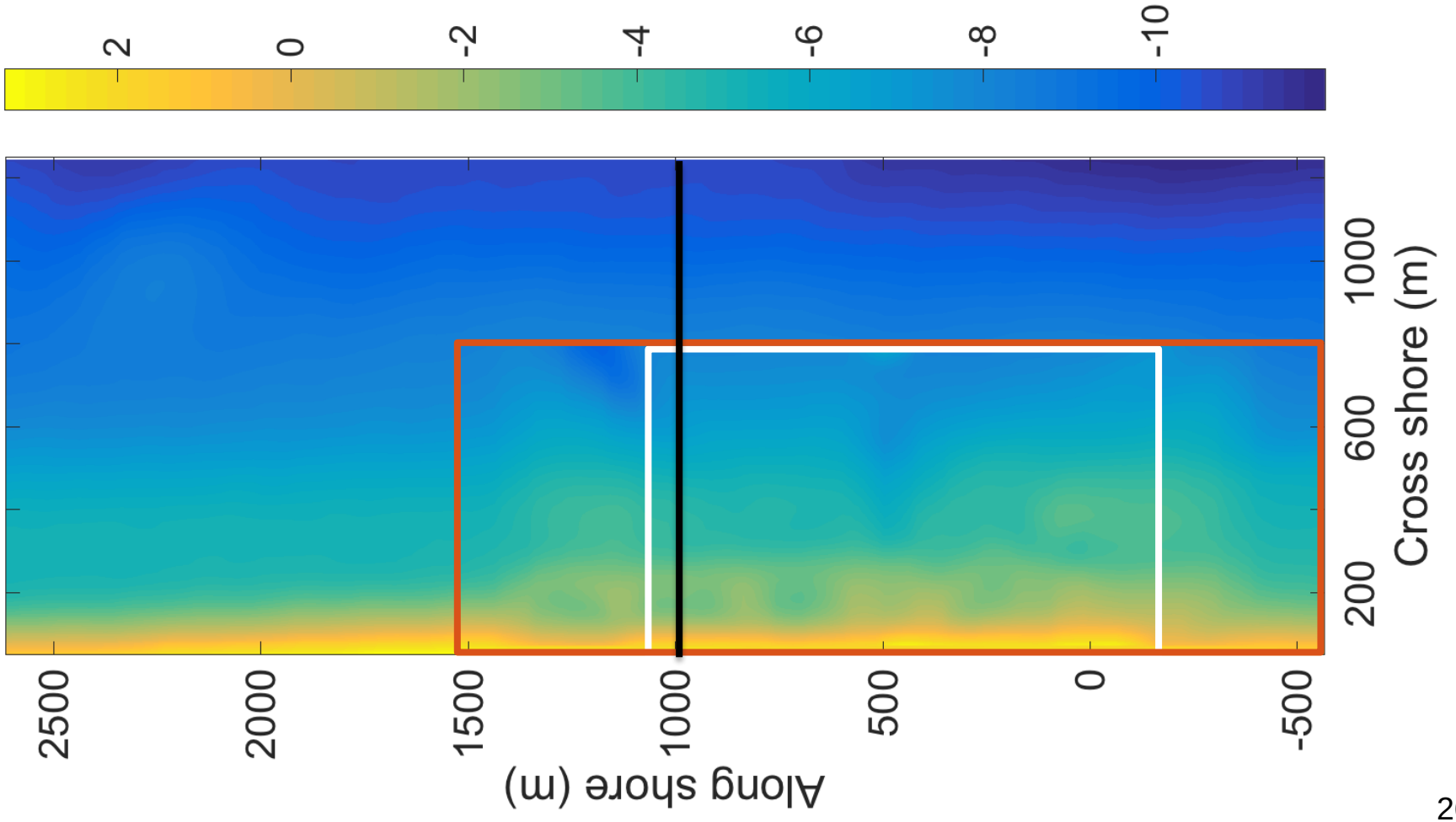
Nest in regional grid

Model/Data Comparison: Morphology

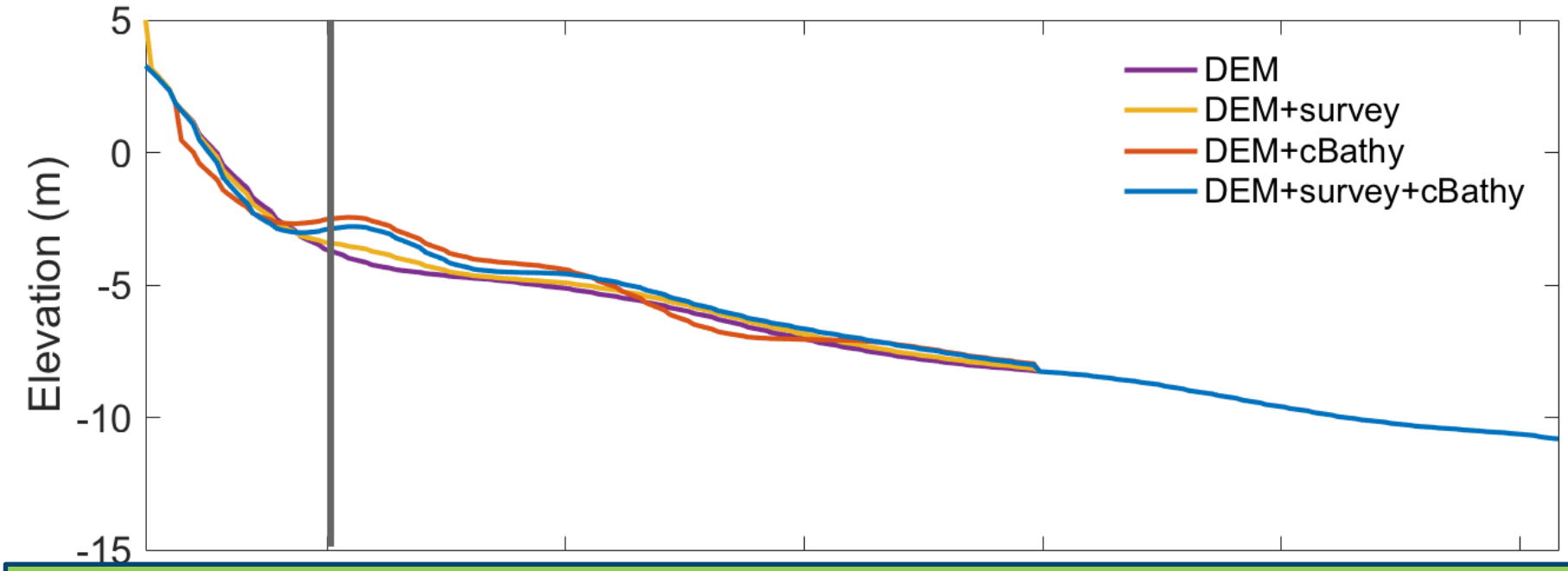


Data starved bathymetry

DEM + survey + cBathy

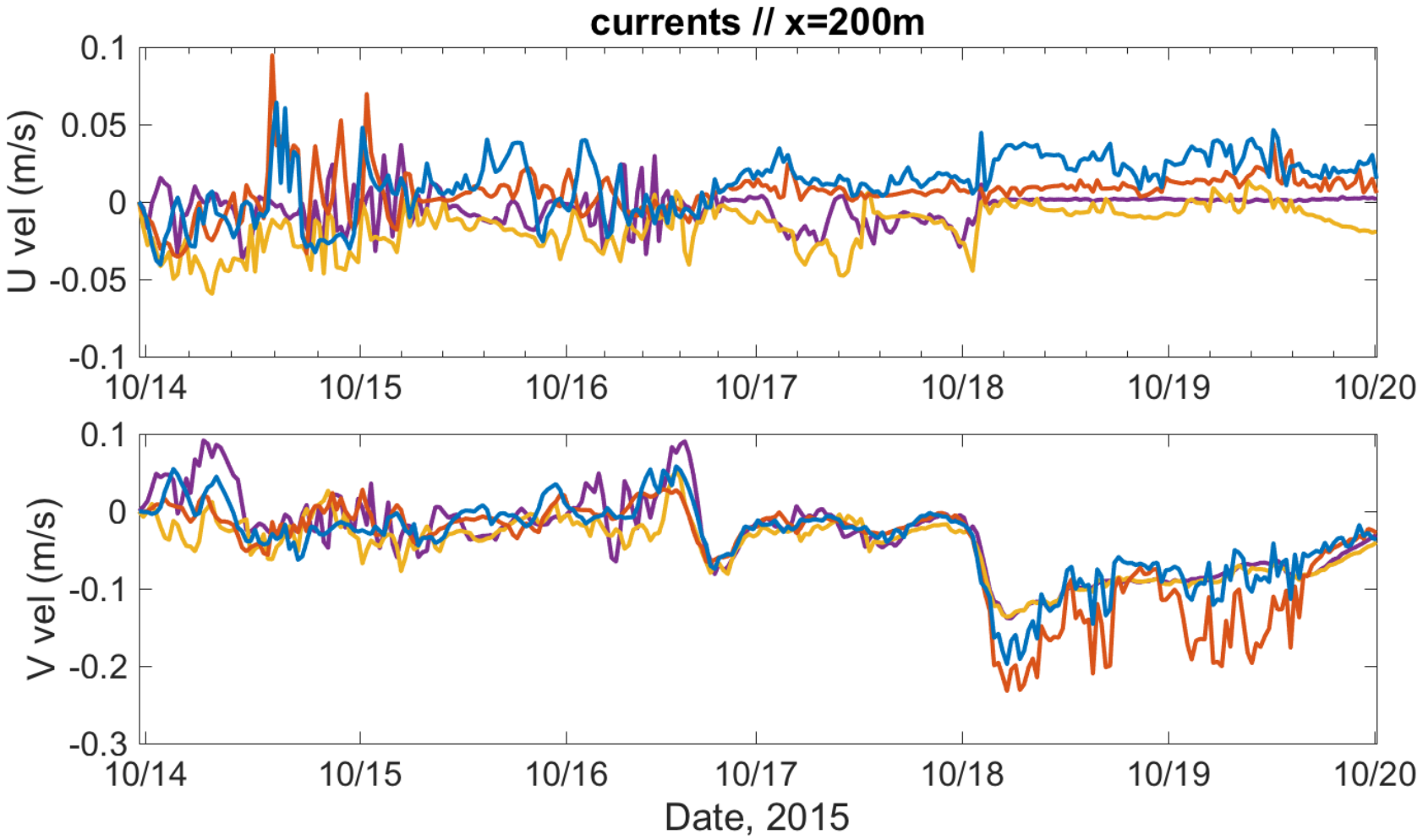


Data starved bathymetry

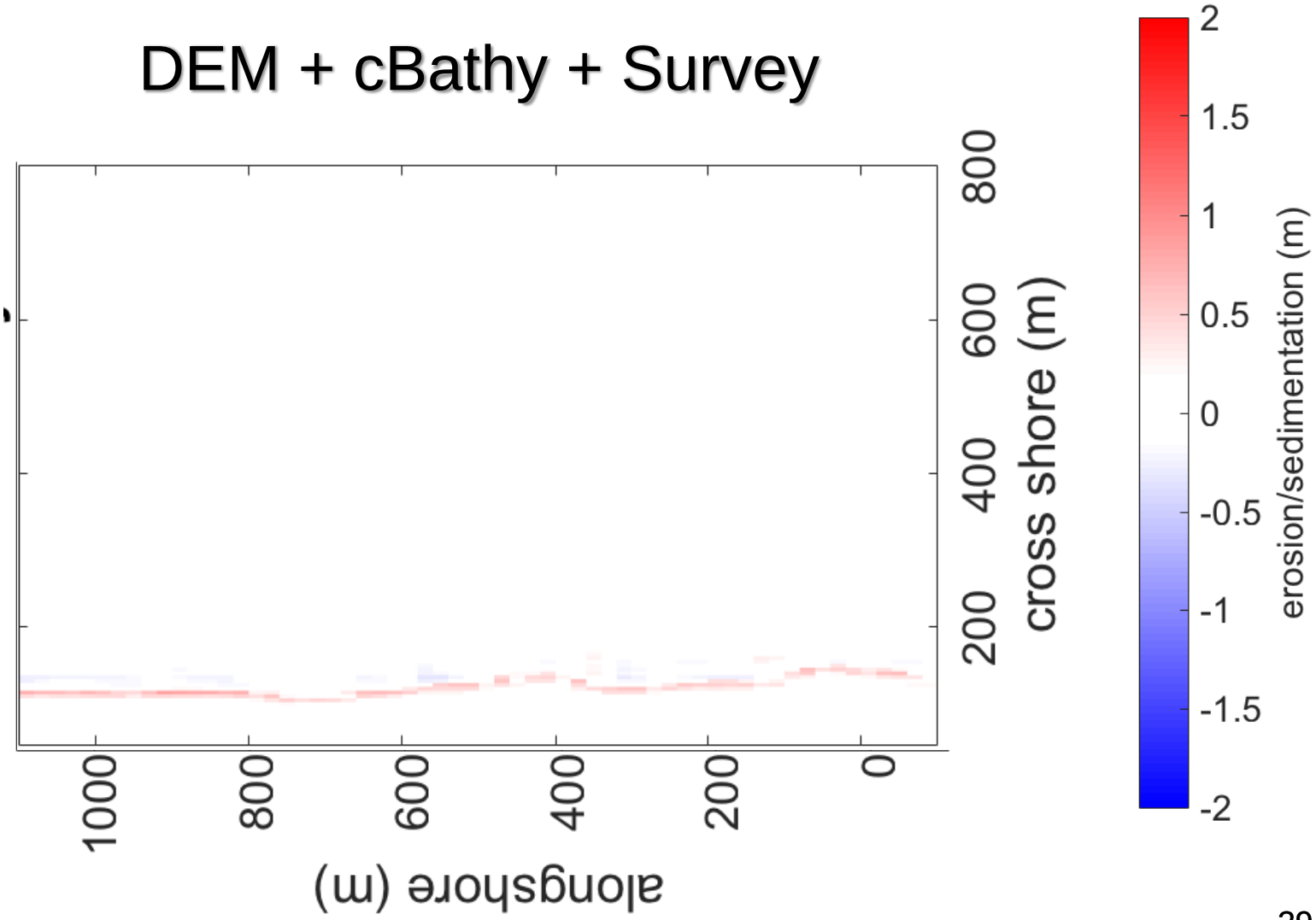


Currents speed vary by ~30% (Holman et al, 2014)

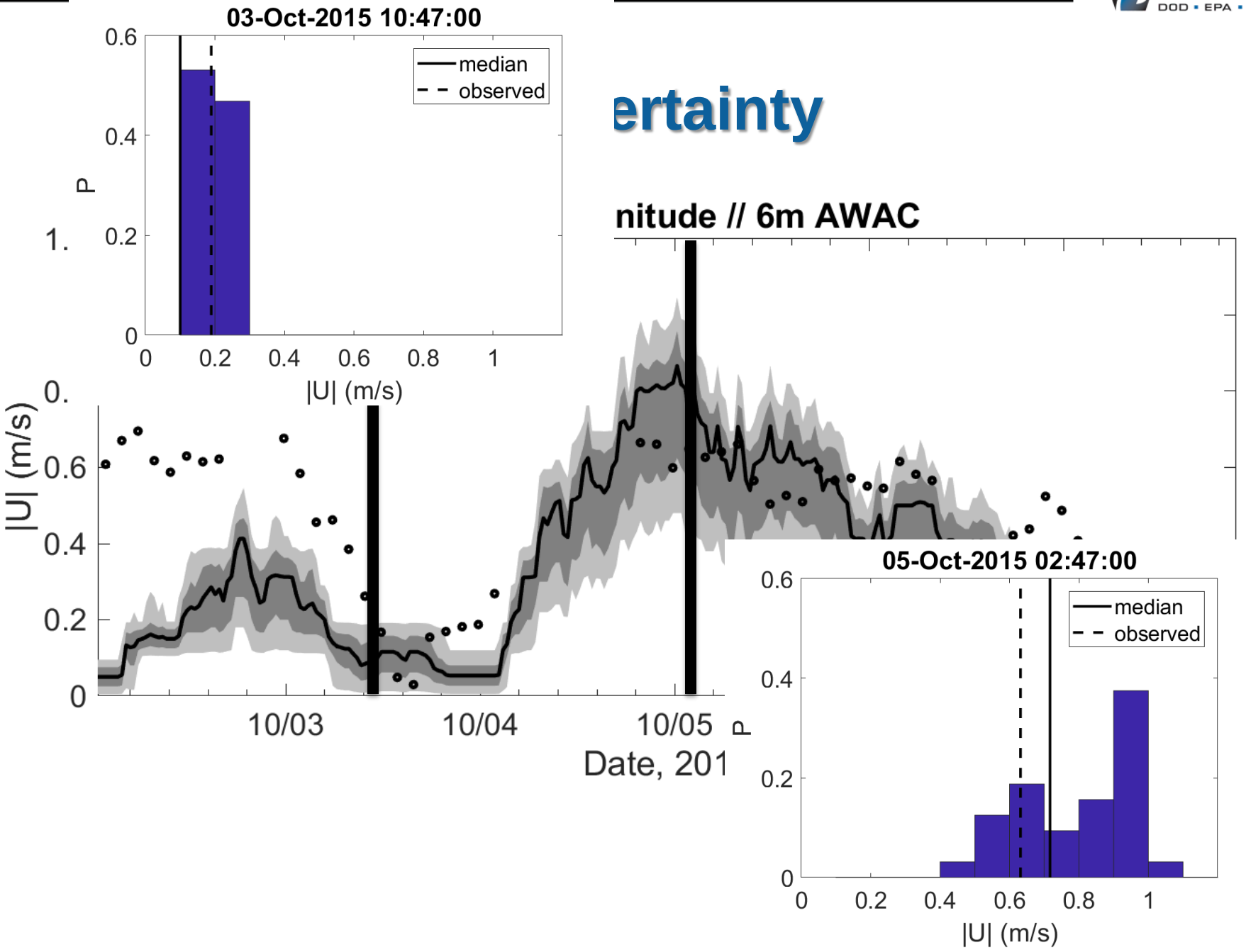
Data Starved bathymetry: Currents



Data Starved bathymetry: Morphology



ertainty


03-Oct-2015 10:47:00
median
observed
P
|U| (m/s)
nitude // 6m AWAC
|U| (m/s)
10/03
10/04
10/05
Date, 201
05-Oct-2015 02:47:00
median
observed
P
|U| (m/s)

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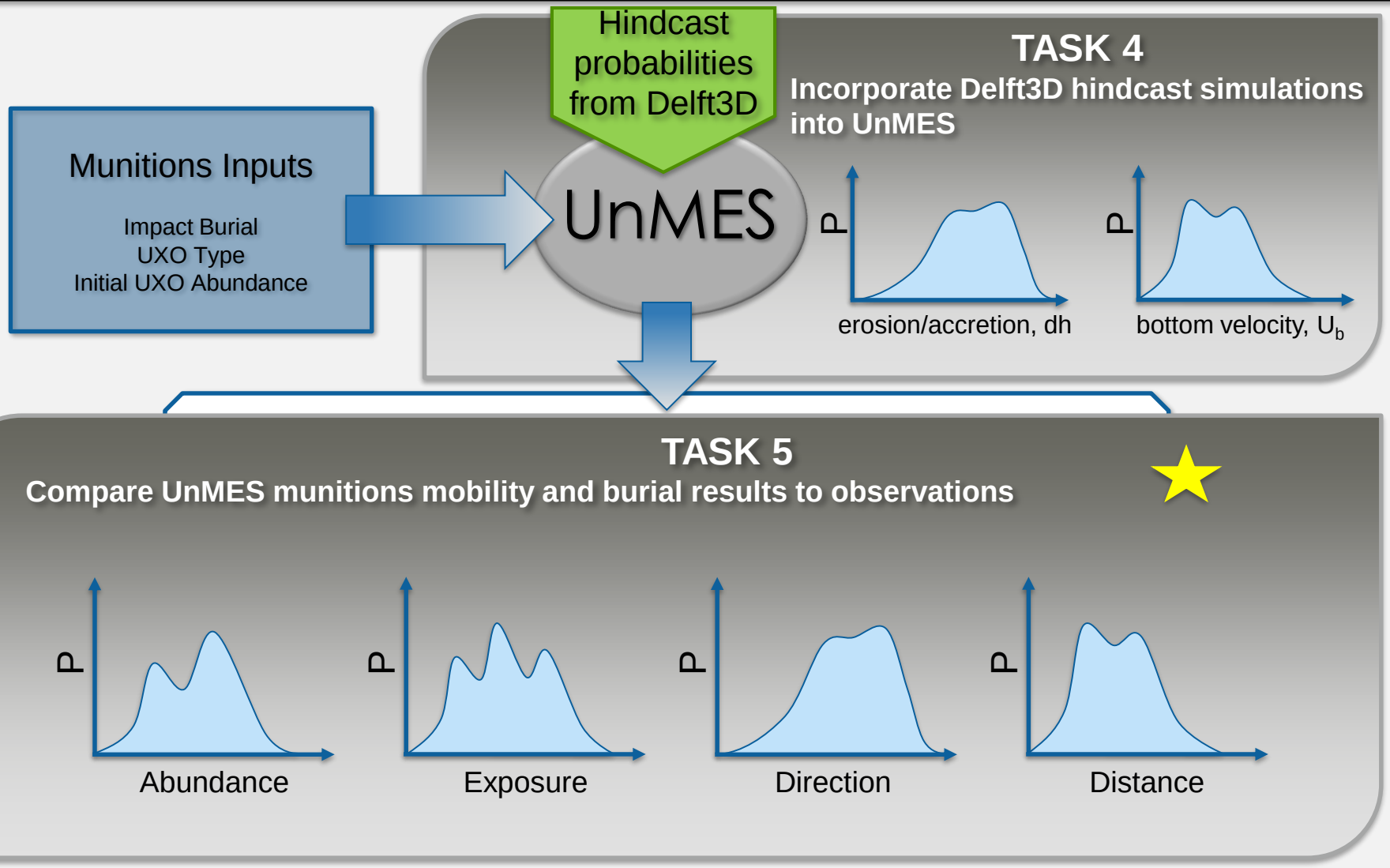
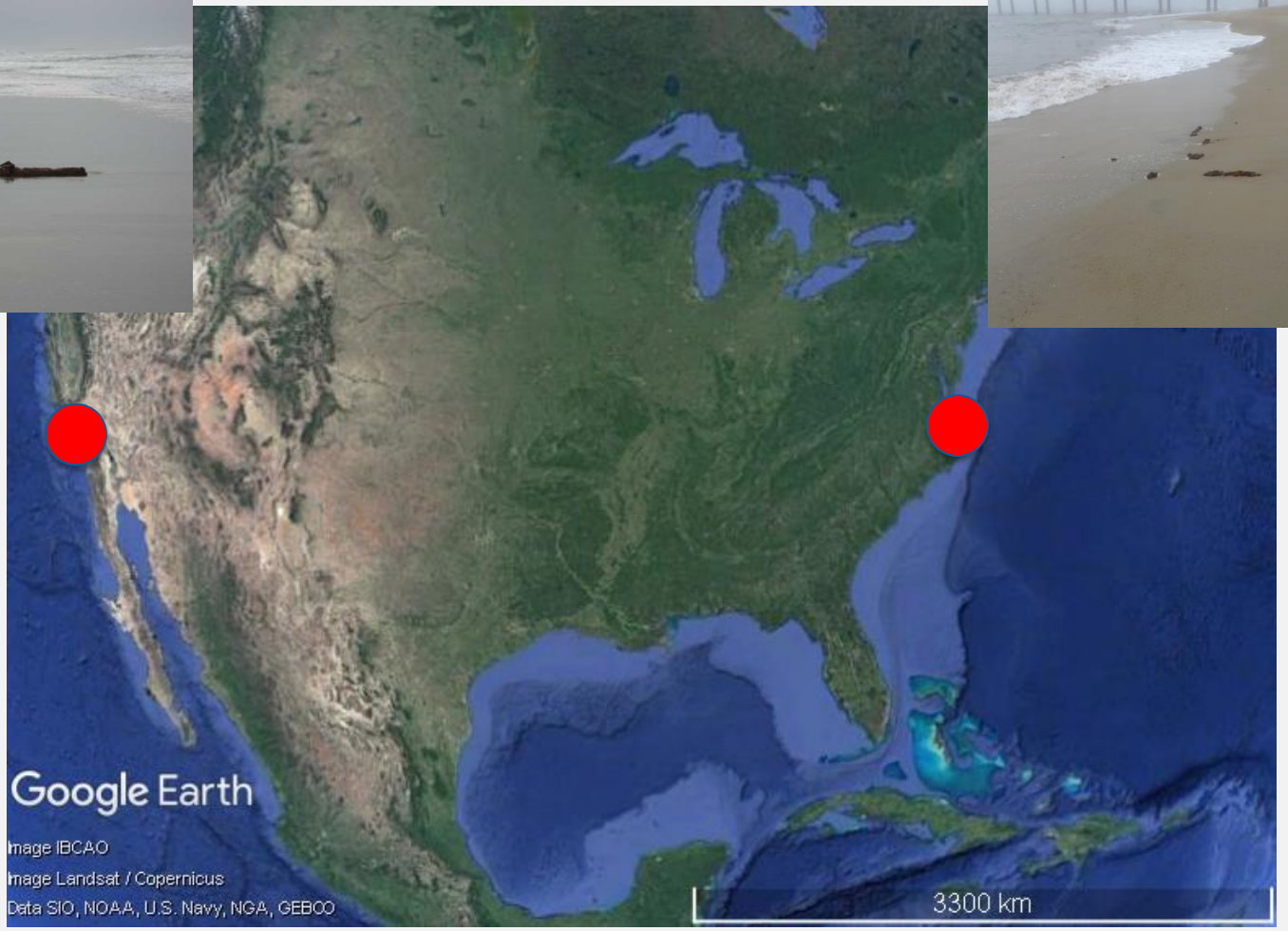
FY18 Tasks

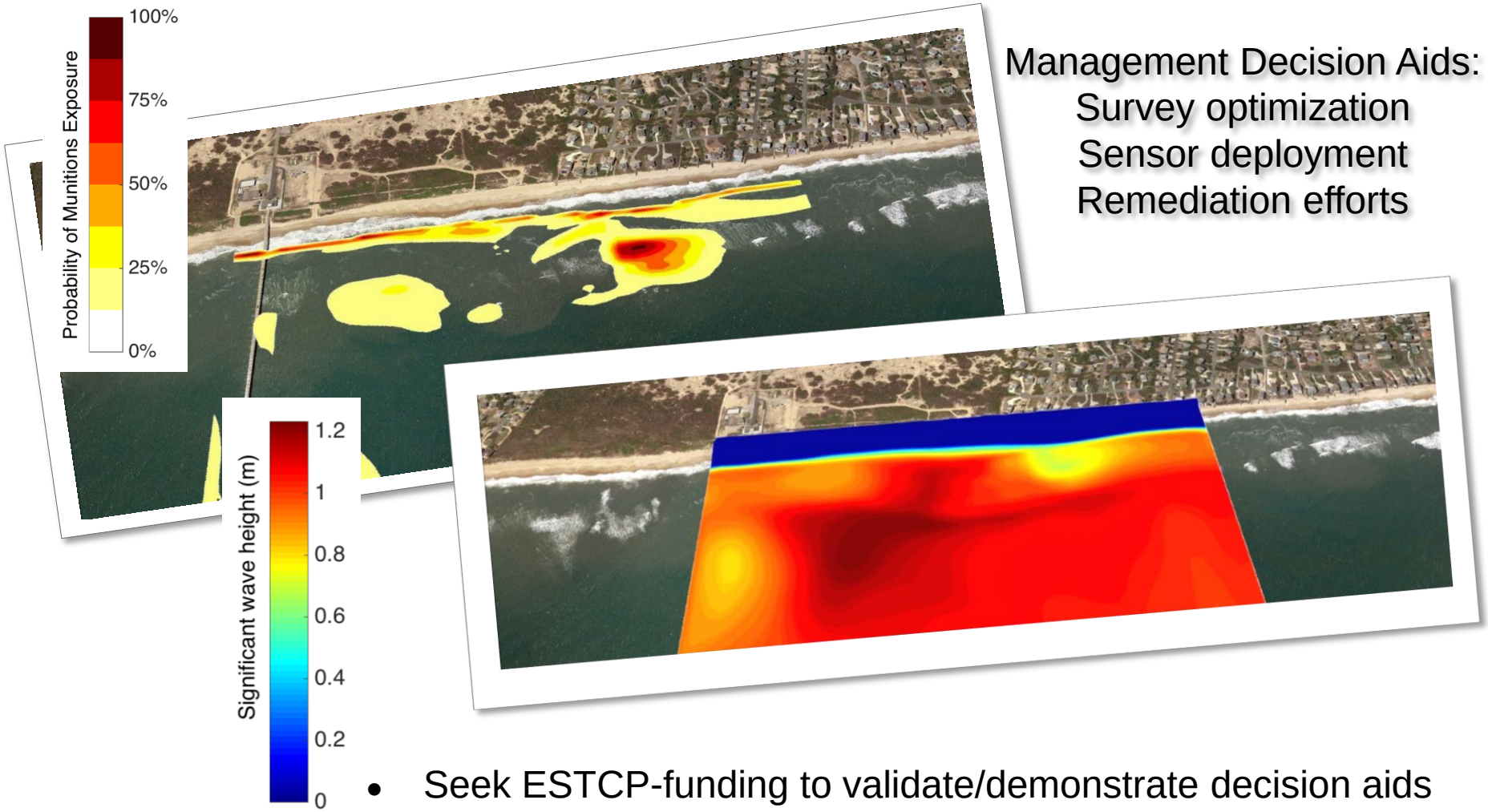

Hindcast probabilities from Delft3D
TASK 4
Incorporate Delft3D hindcast simulations into UnMES
Munitions Inputs
Impact Burial
UXO Type
Initial UXO Abundance
UnMES
P
erosion/accretion, dh
P
bottom velocity, U_b
TASK 5
Compare UnMES munitions mobility and burial results to observations
P
Abundance
P
Exposure
P
Direction
P
Distance

FY19 Tasks



Set up and test coupled model at additional study site

Transition Plan



Management Decision Aids:
Survey optimization
Sensor deployment
Remediation efforts

- Seek ESTCP-funding to validate/demonstrate decision aids
- Discussion with end users at SERDP Symposium

BACKUP MATERIAL

These charts are required, but will only be briefed if questions arise.

Model/Data Comparison: Currents