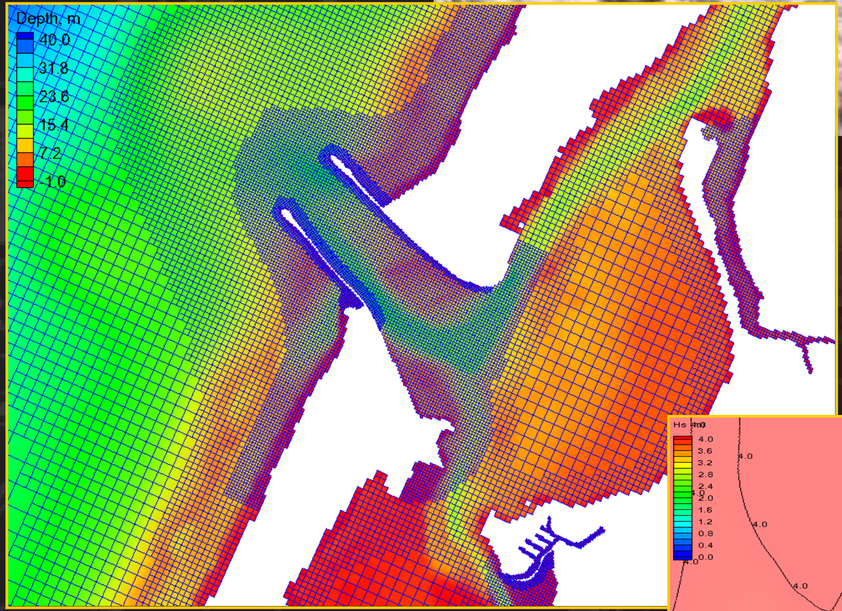
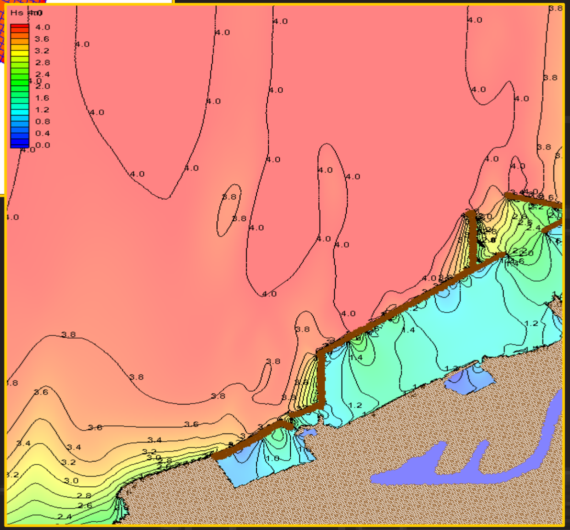
# CMS-WAVE BACKGROUND AND CAPABILITIES

**Mitchell Brown**
**Liz Holzenthal**
**Honghai Li**
**Lihwa Lin**

Coastal & Hydraulics Laboratory
US Army Engineer Research and Development Center (ERDC)

**CMS Basics Webinar Series**
**29 July – 02 August 2024**



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# OVERVIEW OF CMS-WAVE

- Steady-state (time-independent), half-plane, two-dimensional spectral transformation solved by finite-difference, forward-marching implicit scheme
- PC-based efficient model, stand-alone or coupled to CMS-Flow, a circulation and sediment transport model, through the SMS interface
- Emphasis on wave-structure-land interactions for practical coastal engineering projects

# CAPABILITIES

- Wave diffraction, reflection (forward & backward), breaking, bottom friction dissipation
- Wind input, wave-current interaction
- Wave transmission at structures
- Wave run-up, overtopping, overland flow
- Variable grids with nesting
- Nonlinear wave-wave interaction & infra-gravity waves
- “Fast mode” for quick calculations & prelim runs

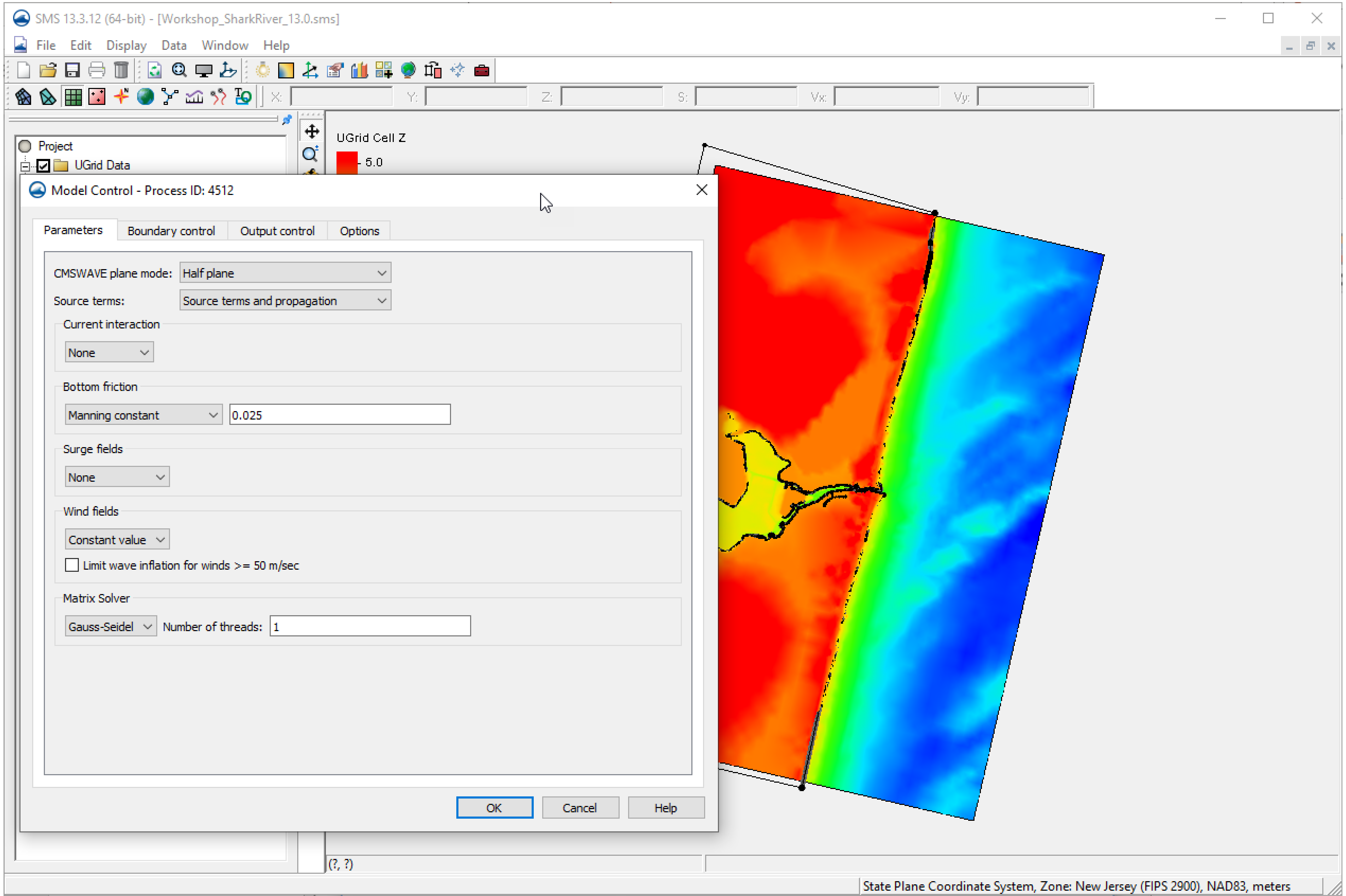
# CMS-WAVE CAPABILITIES

Structures: Diffraction, Reflection, Transmission, Run-up and setup

| Capability | CMS-Wave |
|---|---|
| Spectrum transformation | Directional |
| Refraction & shoaling | Represented |
| Depth-limited wave breaking | Choice among four formulas |
| Roller | Represented |
| **Diffraction** | **Theory** |
| **Reflection** | **Represented** |
| **Transmission** | **Formulas** |
| **Run-up and setup** | **Theory** |
| Wave-current interaction | Theory |
| Wave-wave interaction | Theory |
| Wind input | Theory |
| White capping | Theory |
| Bottom friction | Theory |

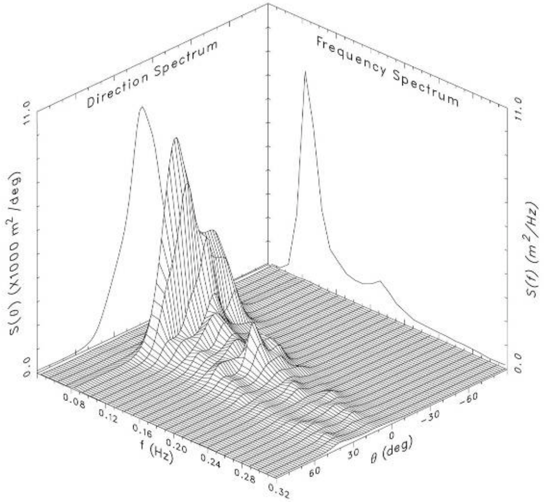
UNCLASSIFIED

# CMS-WAVE SMS 13.3 MODEL CONTROL

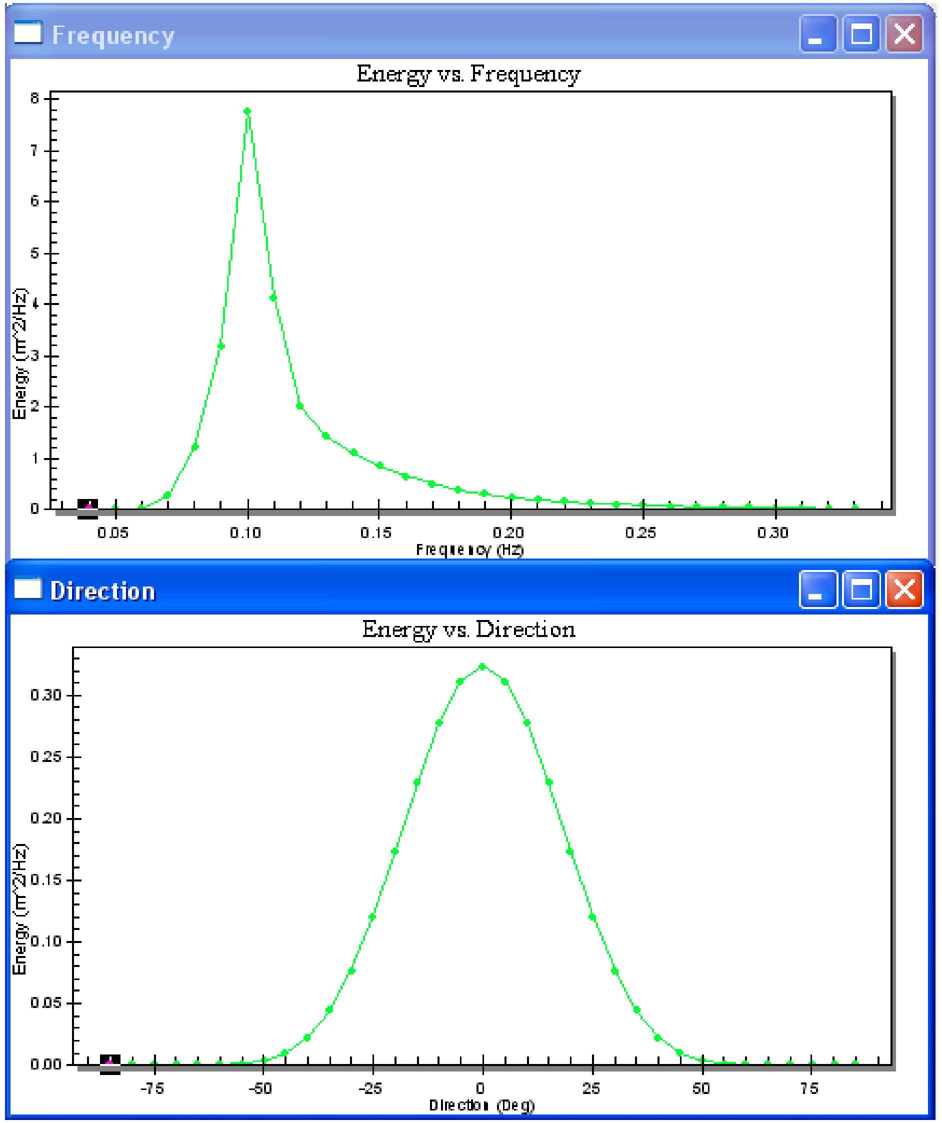


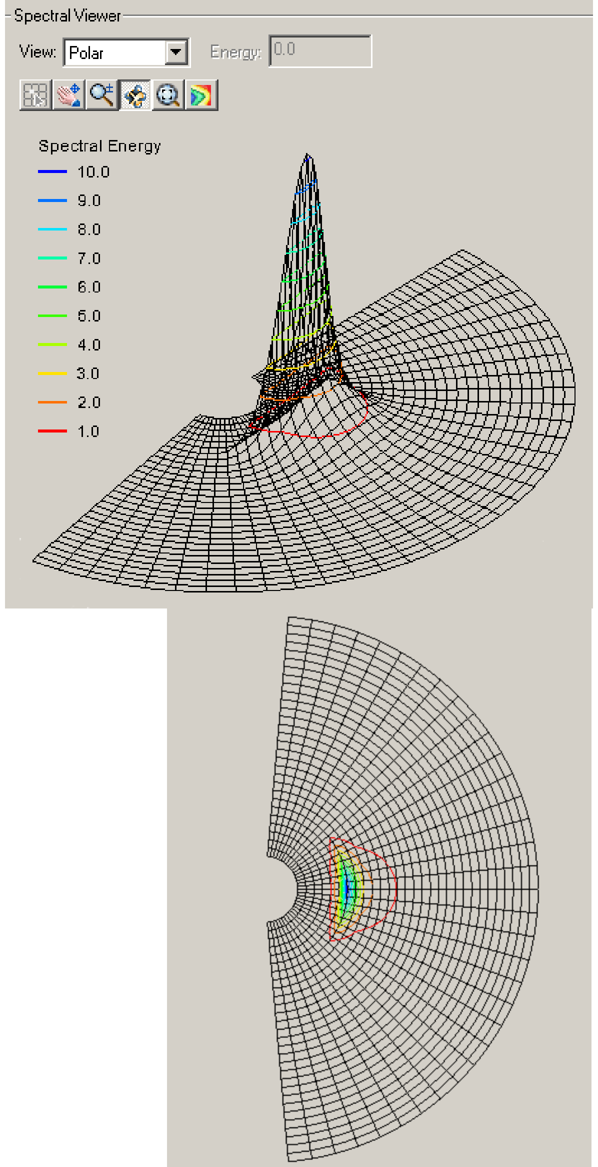
# INCIDENT WAVE SPECTRUM

- NDBC/NOAA Ocean Buoys
- CDIP Coastal Buoys
- Project specific measurements (ADCP)
- Theoretical spectra (SMS)

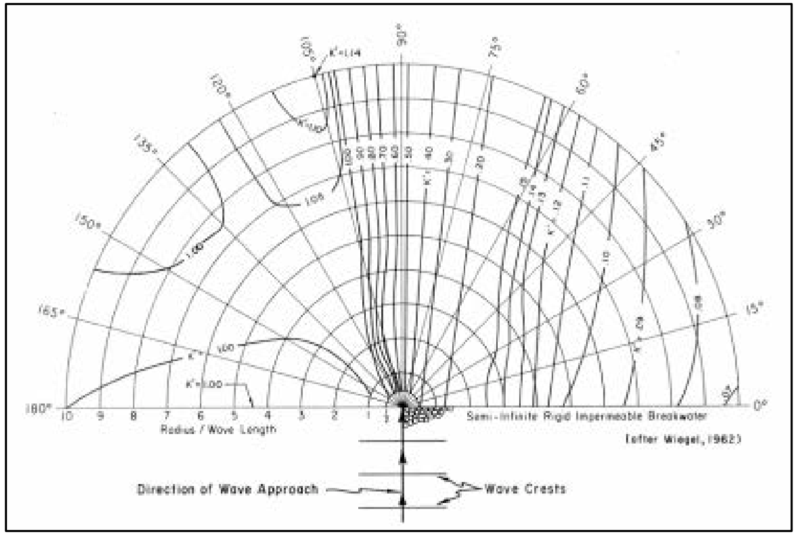


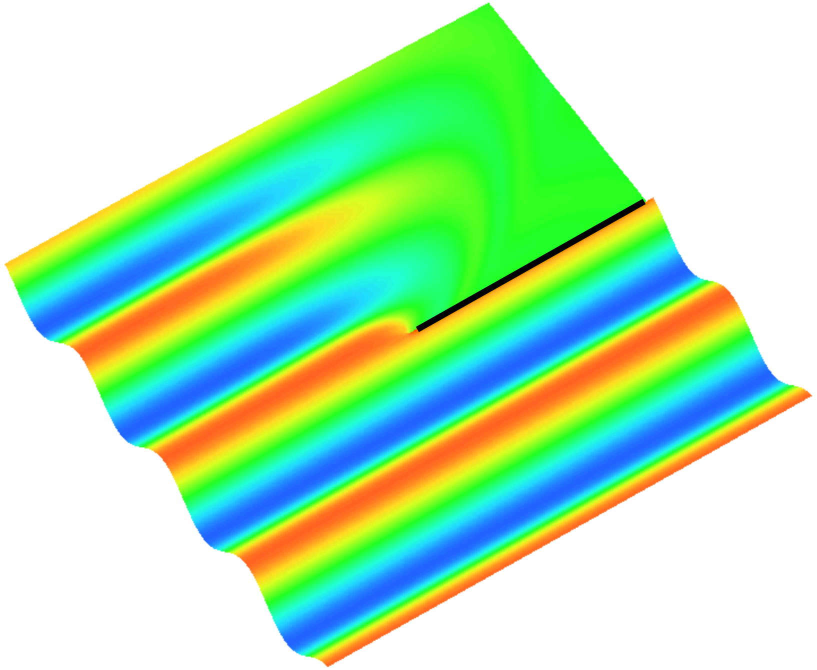

# SMS WAVE SPECTRUM DISPLAY

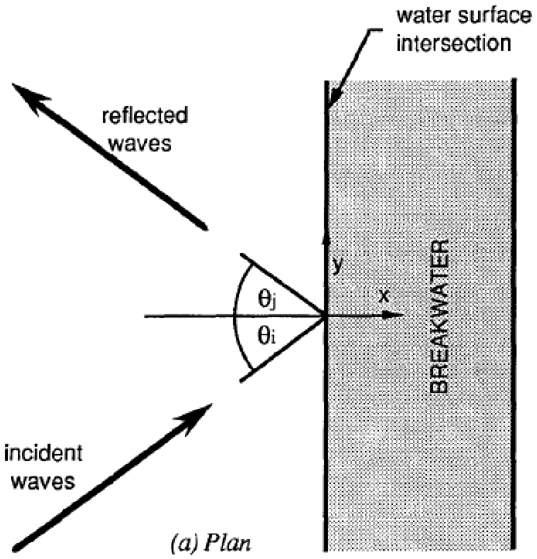


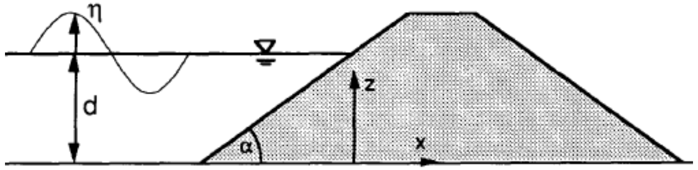
# JETTIES & BREAKWATERS
# WAVE DIFFRACTION AND REFLECTION



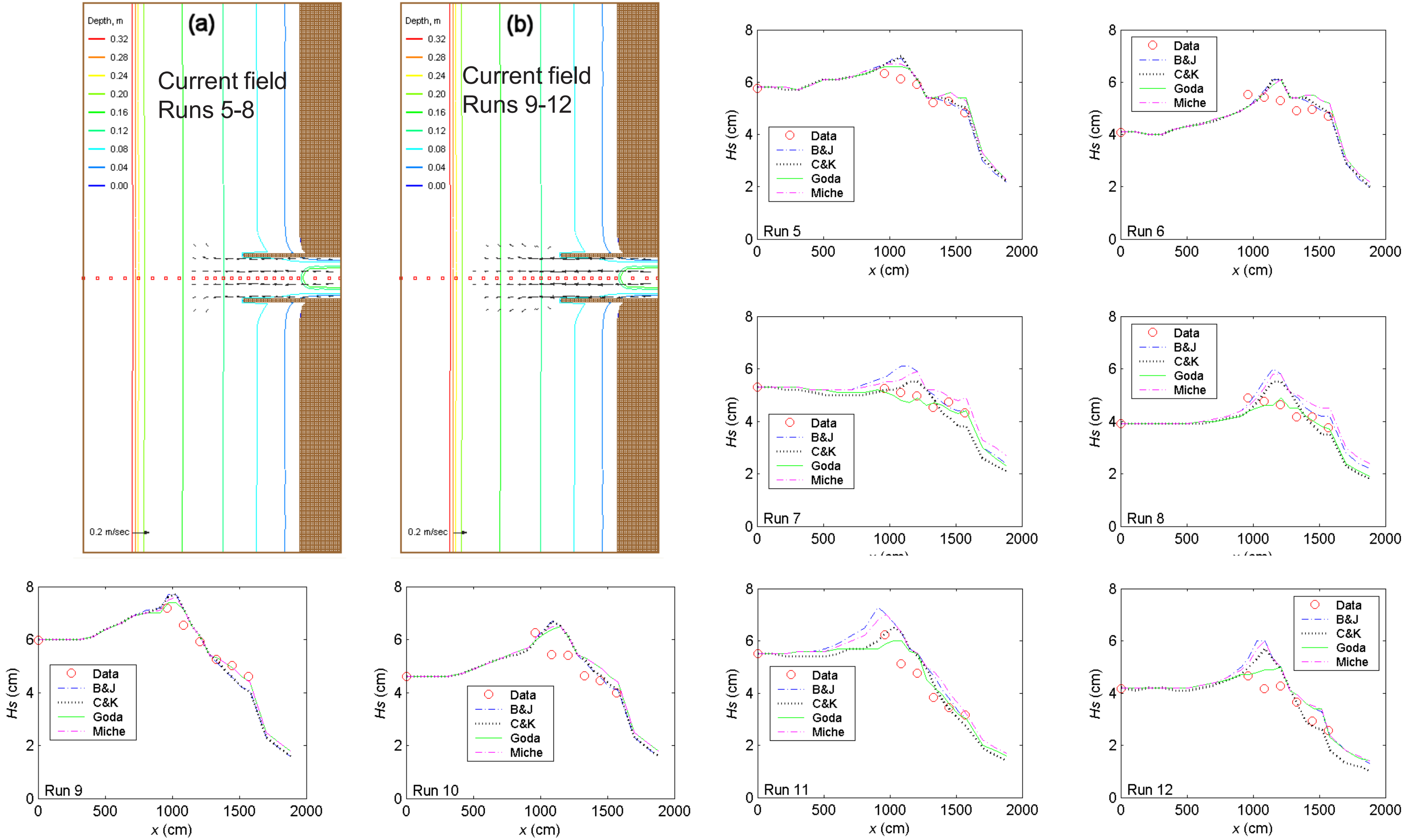



*(a) Plan*

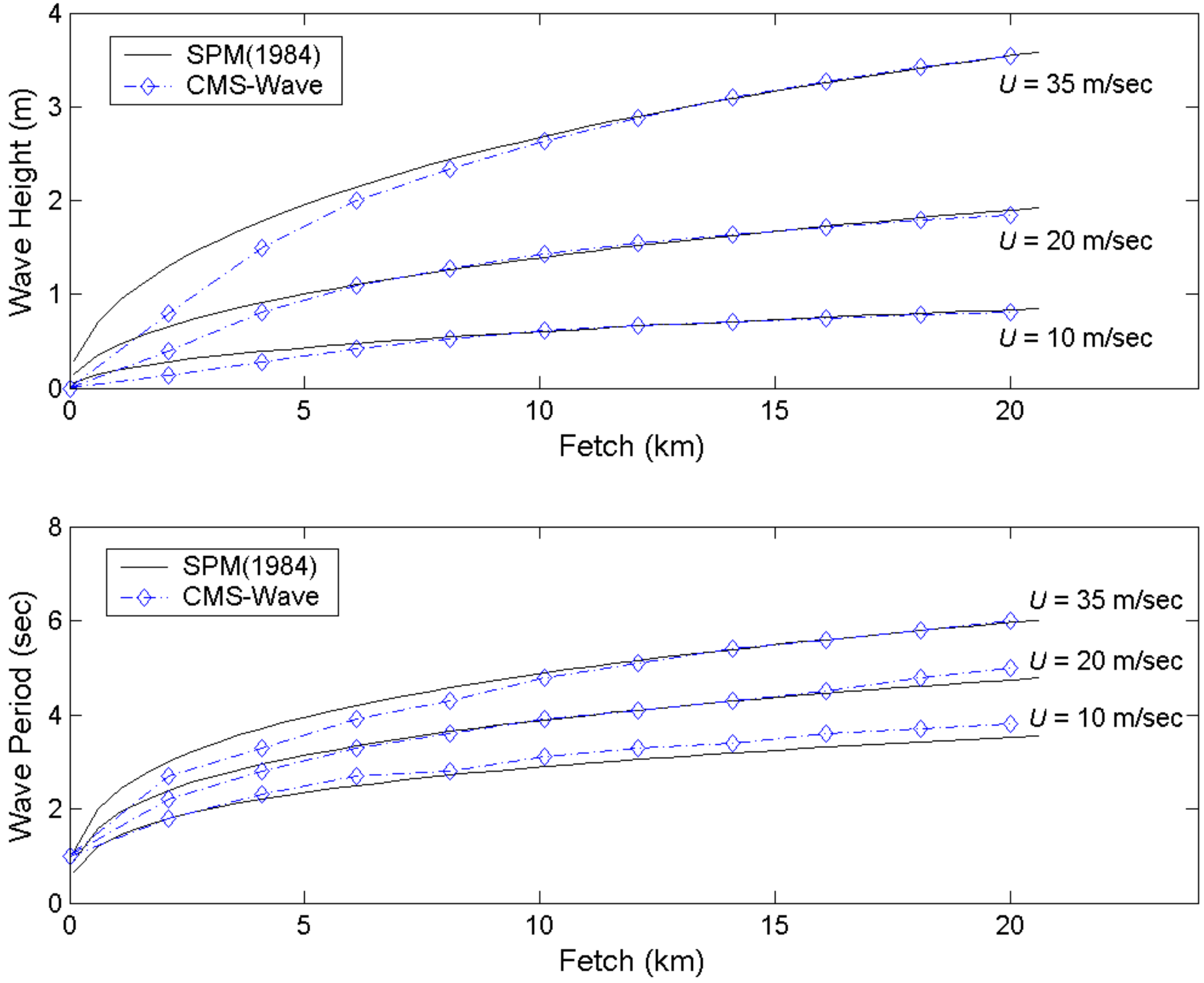



*(b) Elevation*

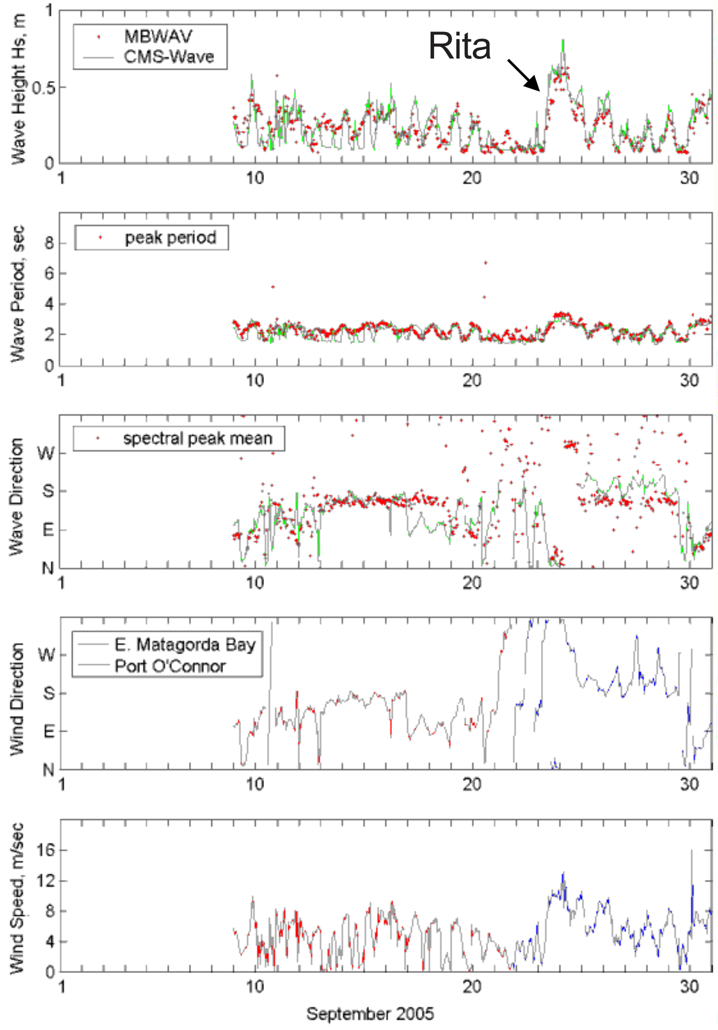
# WAVE BREAKING FORMULAS

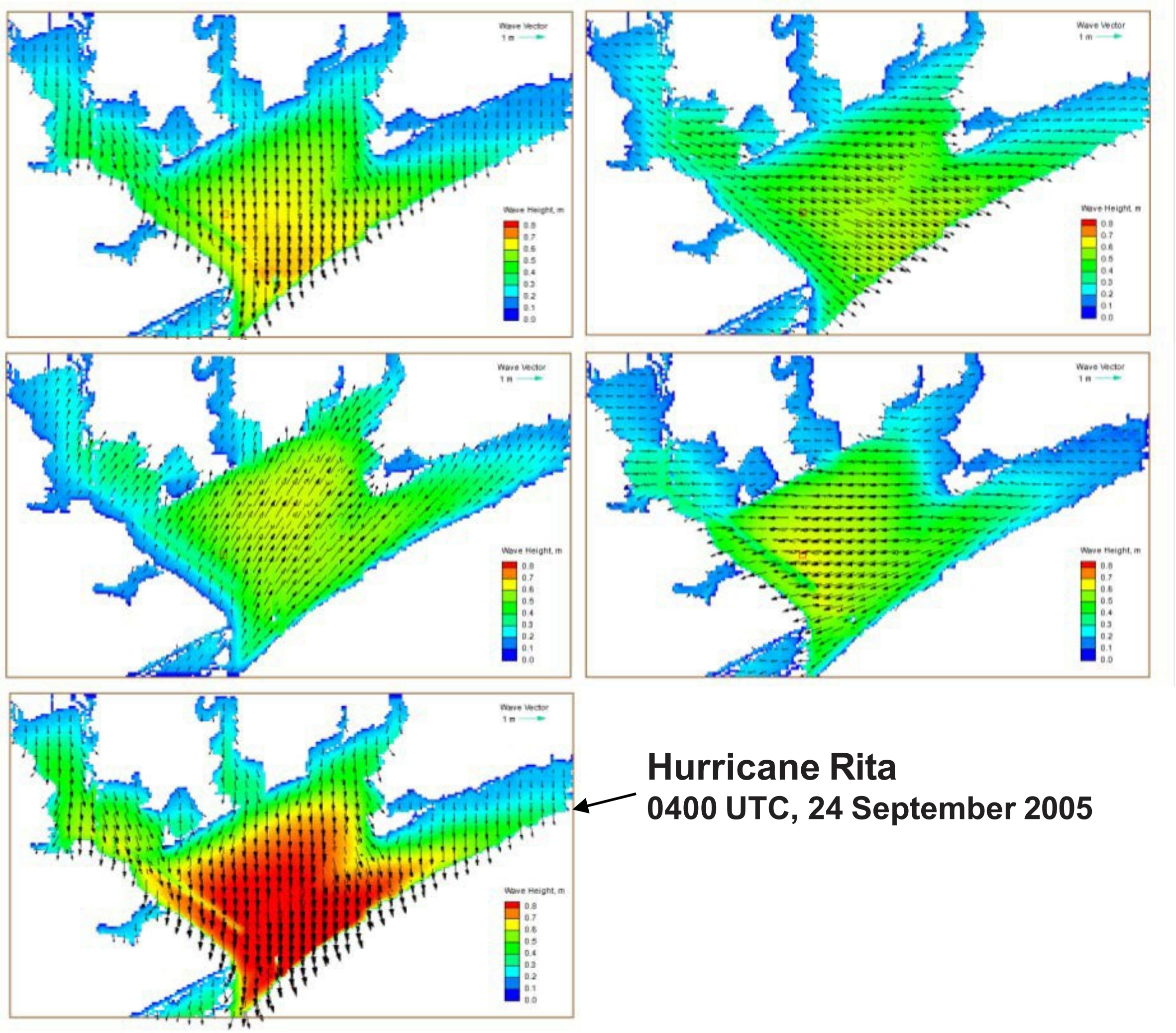


# WIND-WAVE GENERATION



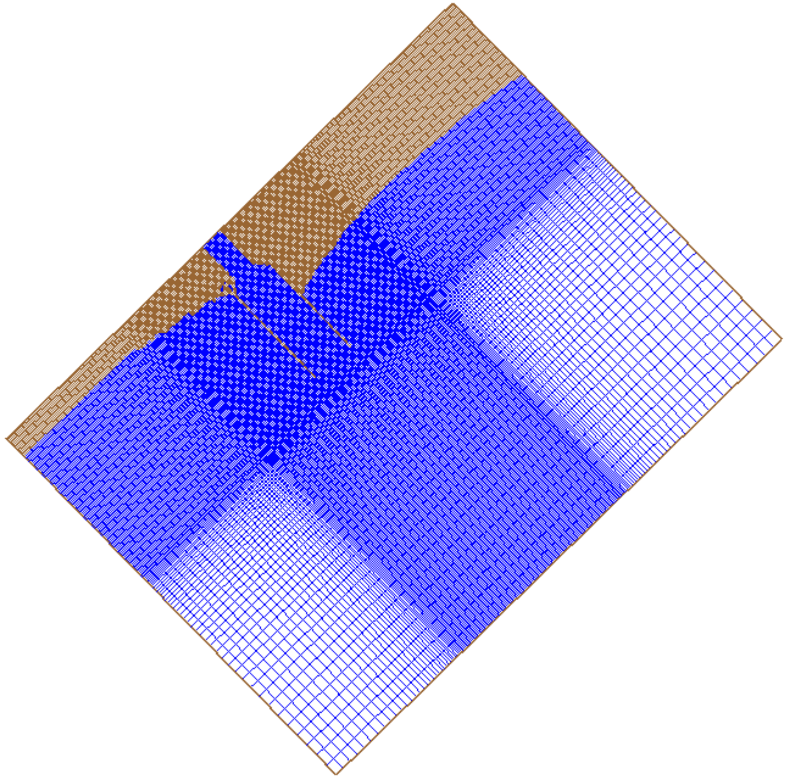
# WAVE GENERATION
# *MATAGORDA BAY, TX*



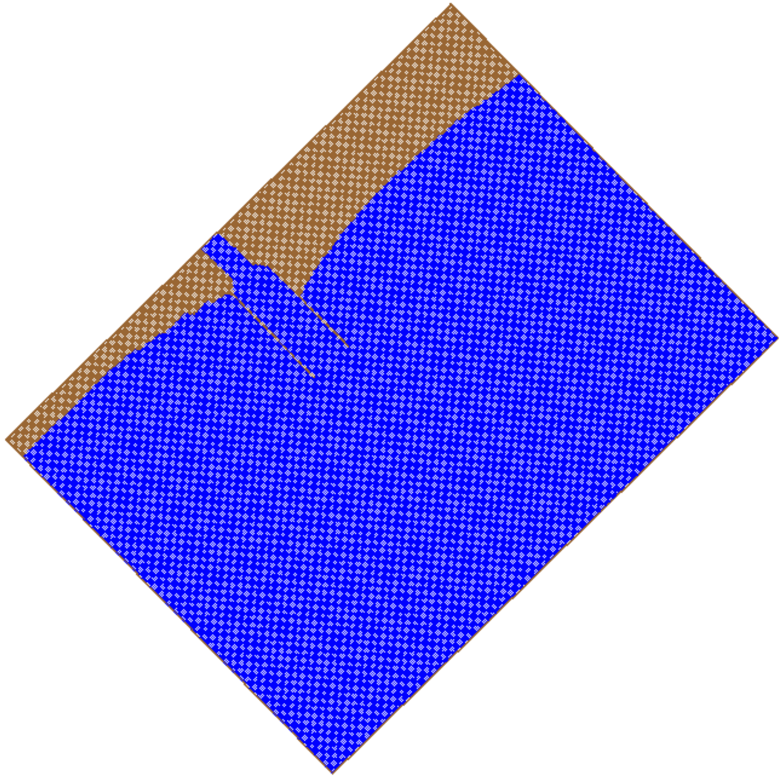



Hurricane Rita
0400 UTC, 24 September 2005

# VARIABLE RECTANGULAR-CELL GRIDS

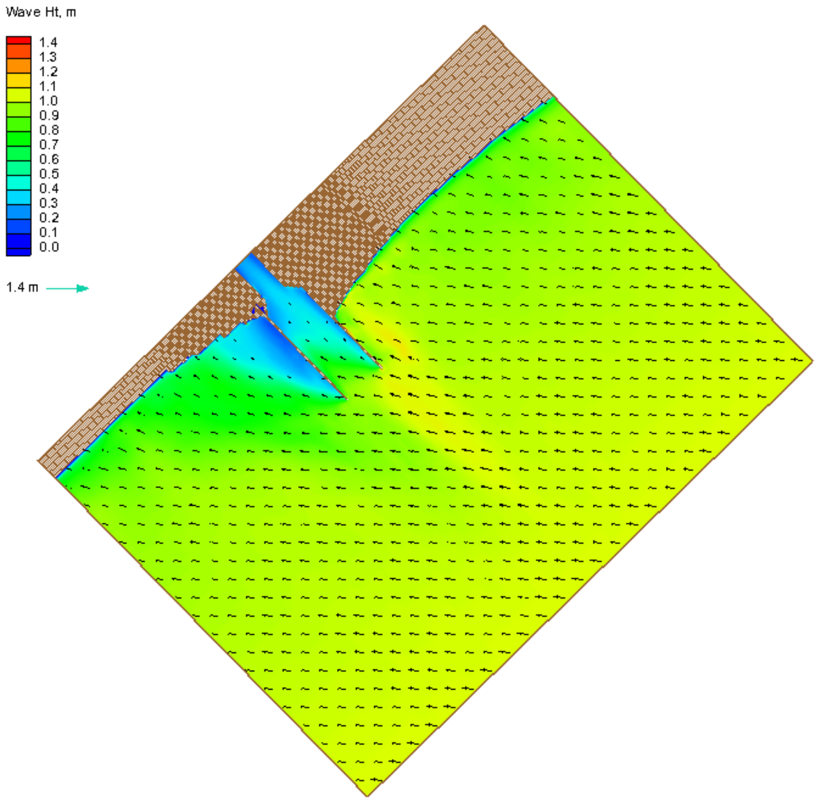


Variable-rectangular cells
Total 223 x 172 cells

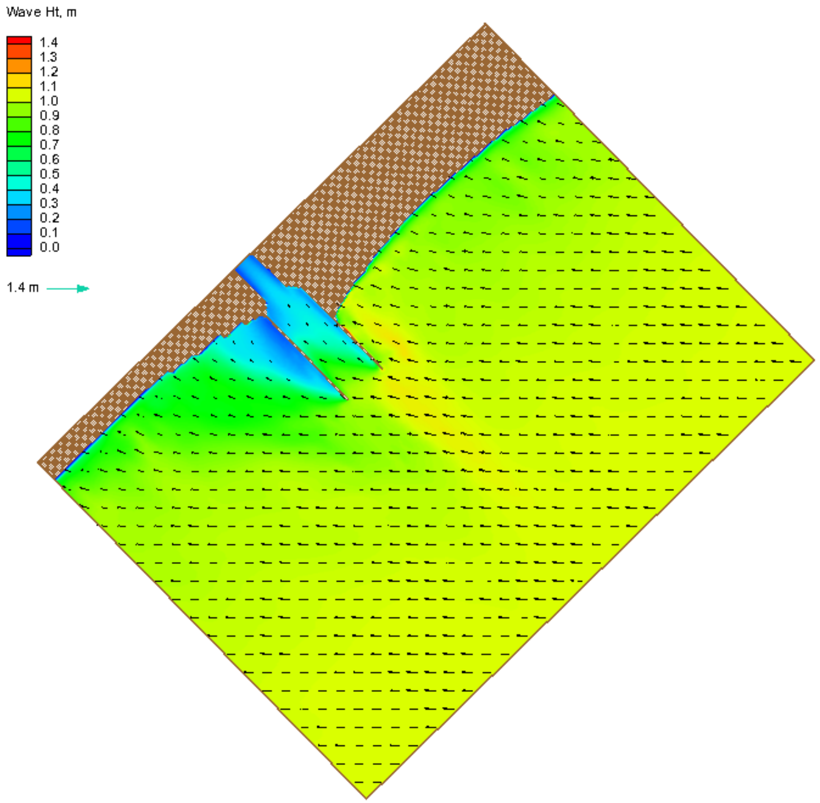


Square (20 m x 20 m) cells
Total 316 x 426 cells

# CMS-WAVE ON VARIABLE GRIDS

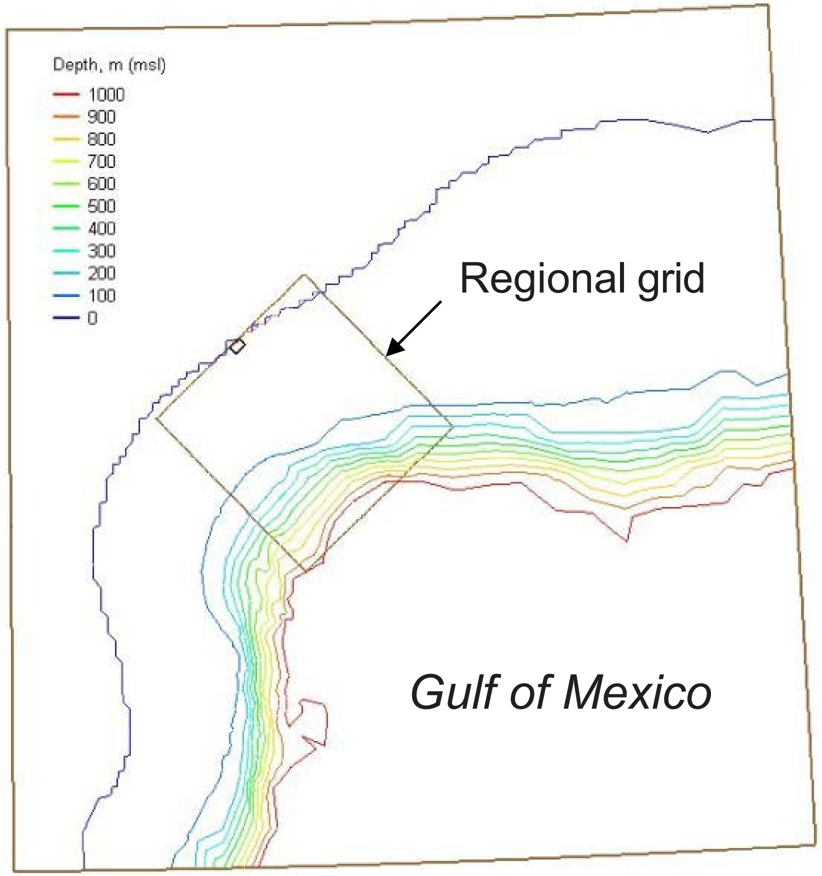


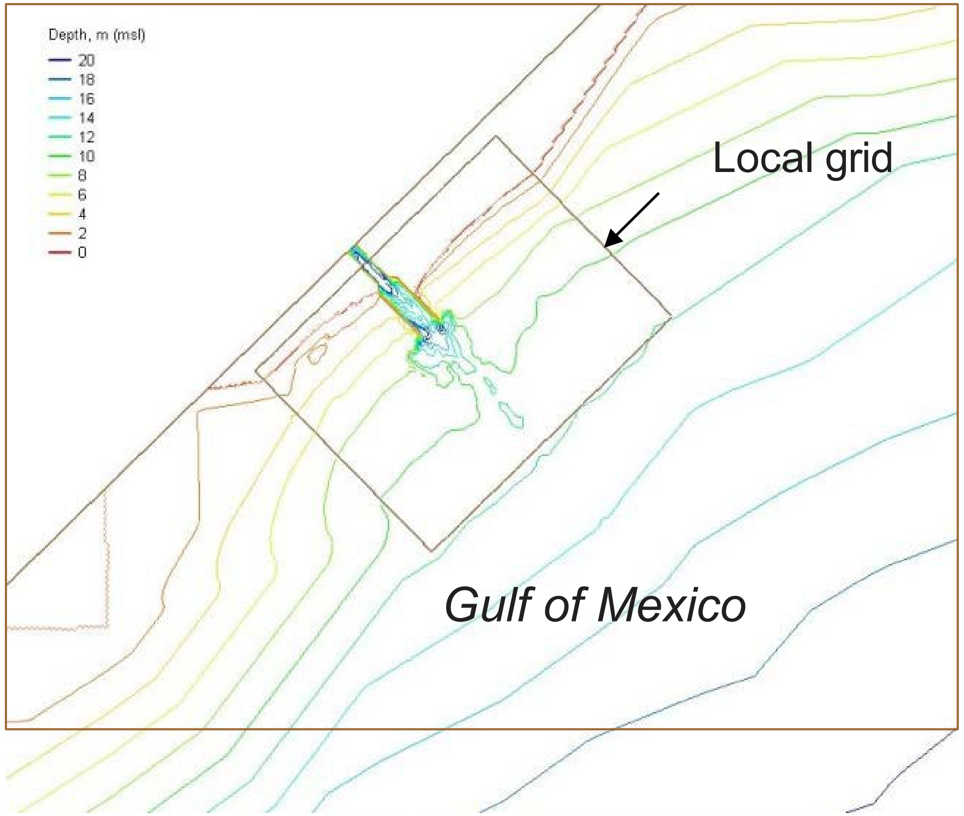

Variable-rectangular cells
Total 223 x 172 cells



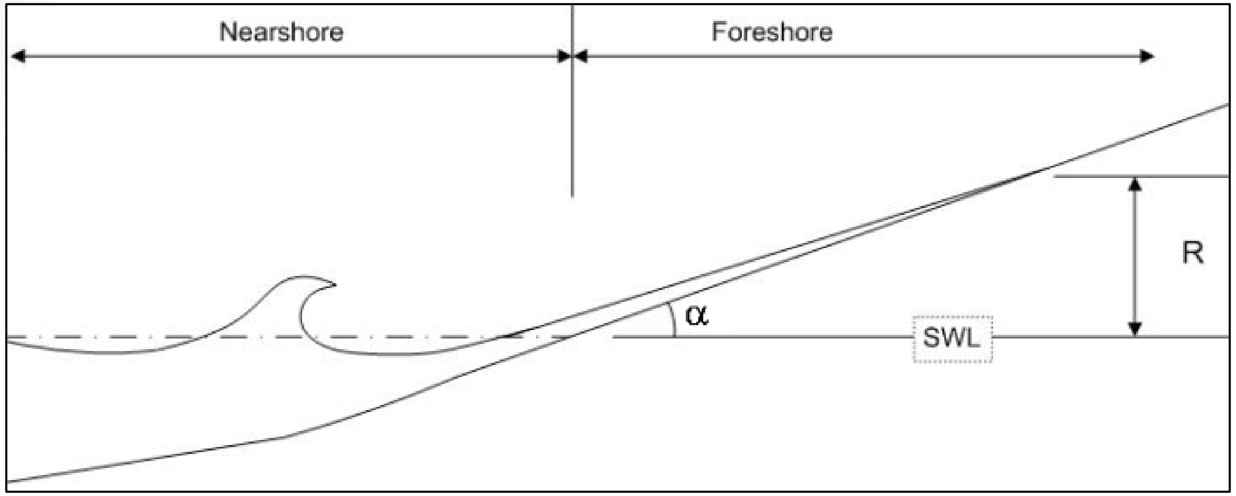

Square (20 m x 20 m) cells
Total 316 x 426 cells

# GRID NESTING



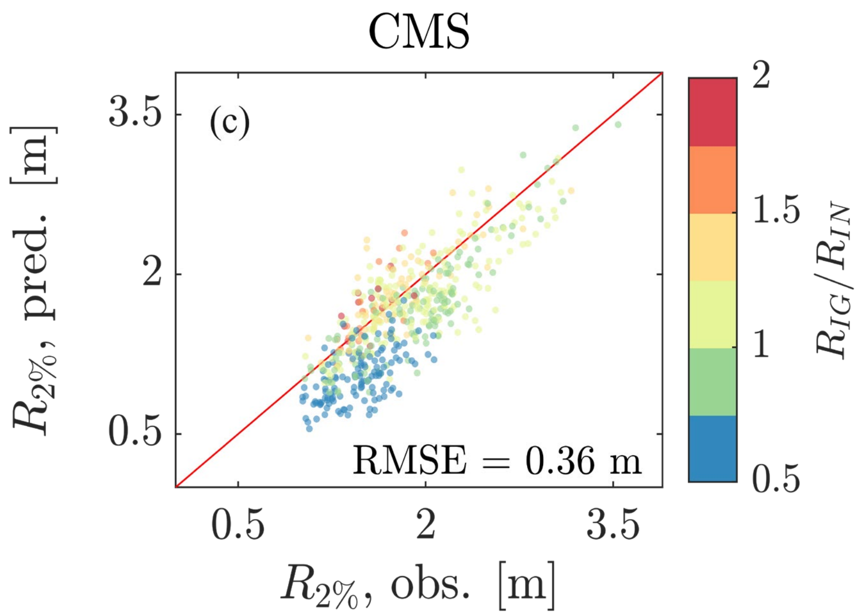



# WAVE RUNUP




**Wave runup (*R*) –** maximum vertical extent reached by any single broken wave as it rushes up a sloping beach or structure

**Two-percent runup (*$R_{2\%}$ or $R_{2p}$*) –** the runup level exceeded by only the largest 2-percent of runup values




Improved $R_{2\%}$ formulation under development. Preliminary methodology described in TR by Holzenthal and Johnson (2024*)

# Floating Breakwater

An analytical formula of the transmission coefficient for a rectangle floating breakwater of width *B* and Draft *D* (Macagno 1953):

$$K_t = \left[ 1 + \left( \frac{kB \sinh \left( \frac{kh}{2\pi} \right)}{2 \cosh k(h - D)} \right)^2 \right]^{-1/2}$$

# BOTTOM-MOUND BREAKWATER

Vertical wall breakwater (Kondo and Sato, 1985):

$$K_t = 0.3\ (1.5 - \frac{h_c}{H_s}), \quad \text{for} \quad 0 \le \frac{h_c}{H_s} \le 1.25$$

Composite or rubble-mound breakwater:

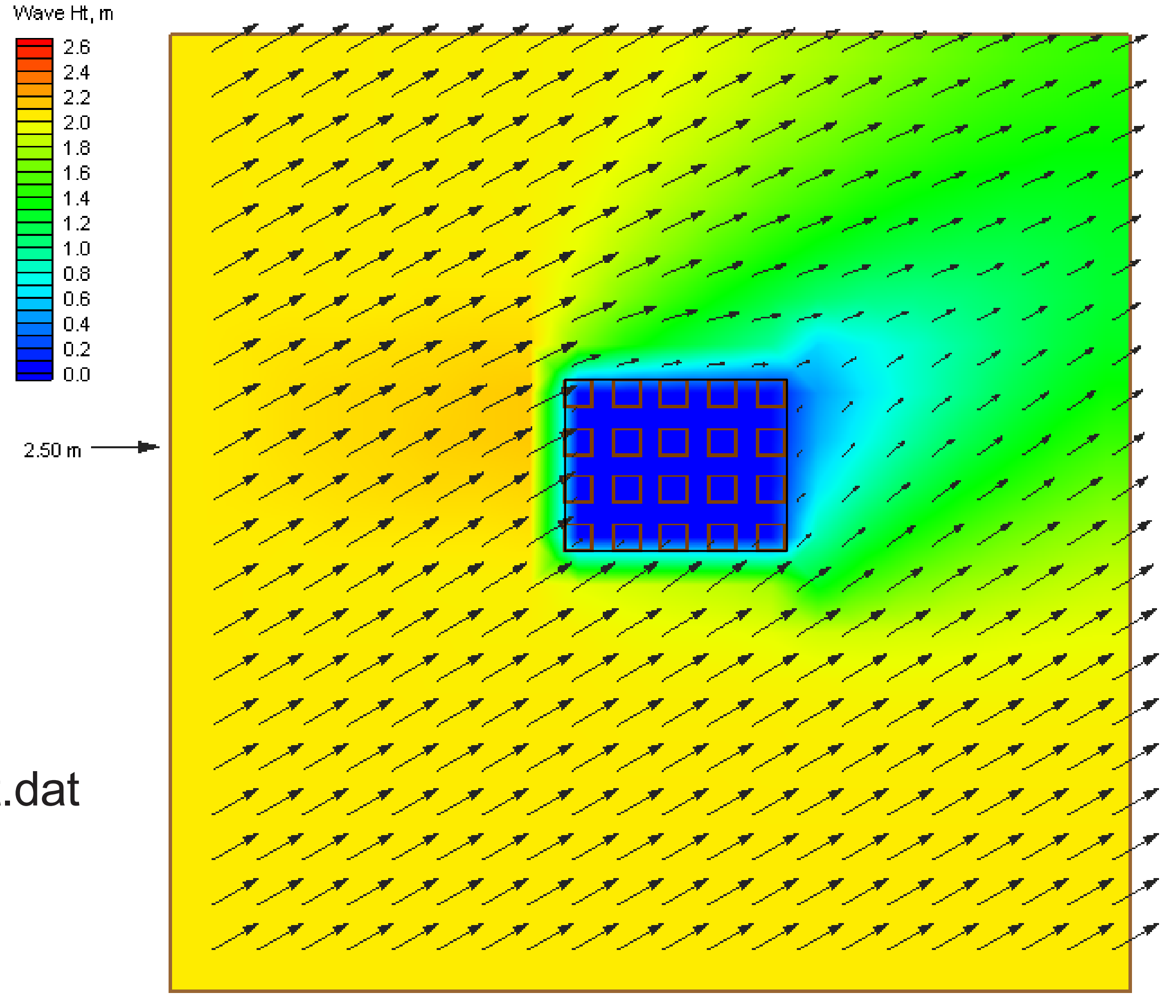
$$K_t = 0.3\ (1.1 - \frac{h_c}{H_s}), \quad \text{for} \quad 0 \le \frac{h_c}{H_s} \le 0.75$$

where $h_c$ is the crest height (above mean water level) and $H_s$ is the incident wave height.

# IDEALIZED ISLAND EXAMPLE

```
20
 9 10
10 10
11 10
12 10
13 10
 9 11
10 11
11 11
12 11
13 11
 9 15
10 15
11 15
12 15
13 15
 9 16
10 16
11 16
12 16
13 16
```

struct.dat




20 feature cells

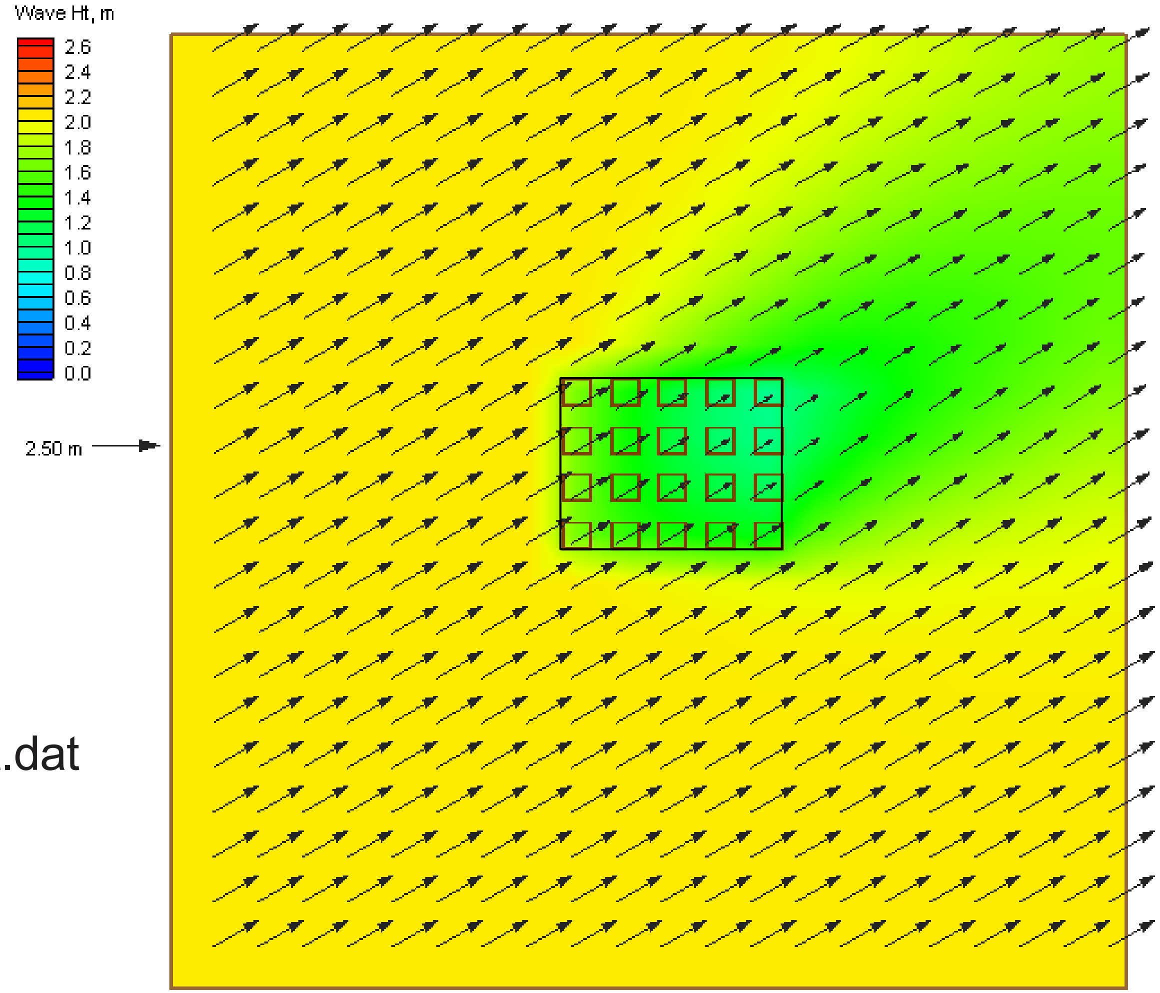
input depth = 10 m

incident wave:
2 m, 6 sec,
30 deg oblique
(gamma = 4)

# IDEALIZED FLOATING BREAKWATER

```
20
 9 10 3 2
10 10 3 2
11 10 3 2
12 10 3 2
13 10 3 2
 9 11 3 2
10 11 3 2
11 11 3 2
12 11 3 2
13 11 3 2
 9 15 3 2
10 15 3 2
11 15 3 2
12 15 3 2
13 15 3 2
 9 16 3 2
10 16 3 2
11 16 3 2
12 16 3 2
13 16 3 2
```

struct.dat




20 feature cells

Input depth = 10 m

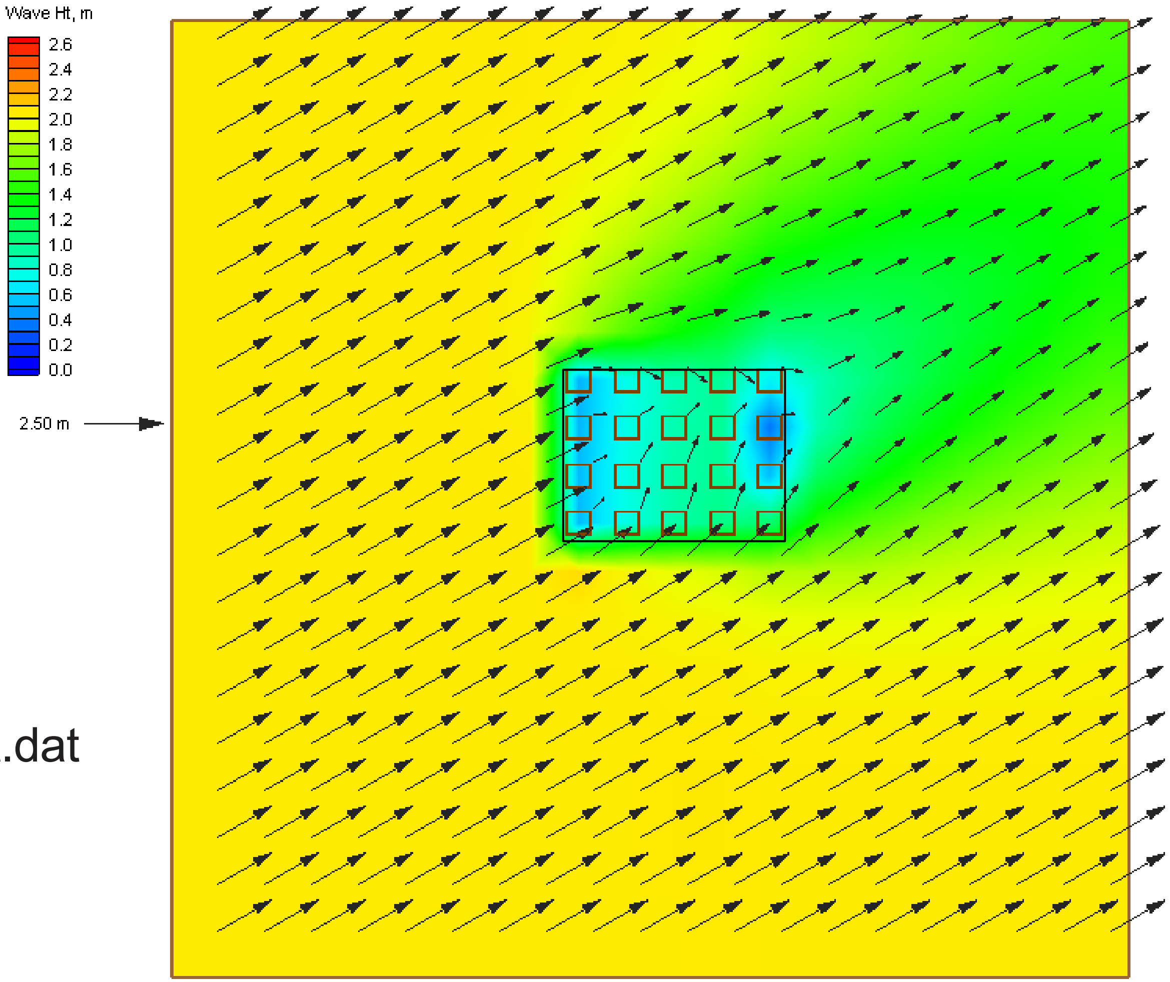
incident wave:
2 m, 6 sec,
30 deg oblique
(gamma = 4)

draft = 2 m

# IDEALIZED PLATFORM

```
20
 9 10 4 1
10 10 4 1
11 10 4 1
12 10 4 1
13 10 4 1
 9 11 4 1
10 11 4 1
11 11 4 1
12 11 4 1
13 11 4 1
 9 15 4 1
10 15 4 1
11 15 4 1
12 15 4 1
13 15 4 1
 9 16 4 1
10 16 4 1
11 16 4 1
12 16 4 1
13 16 4 1
```

struct.dat




20 feature cells

input depth
= 10 m

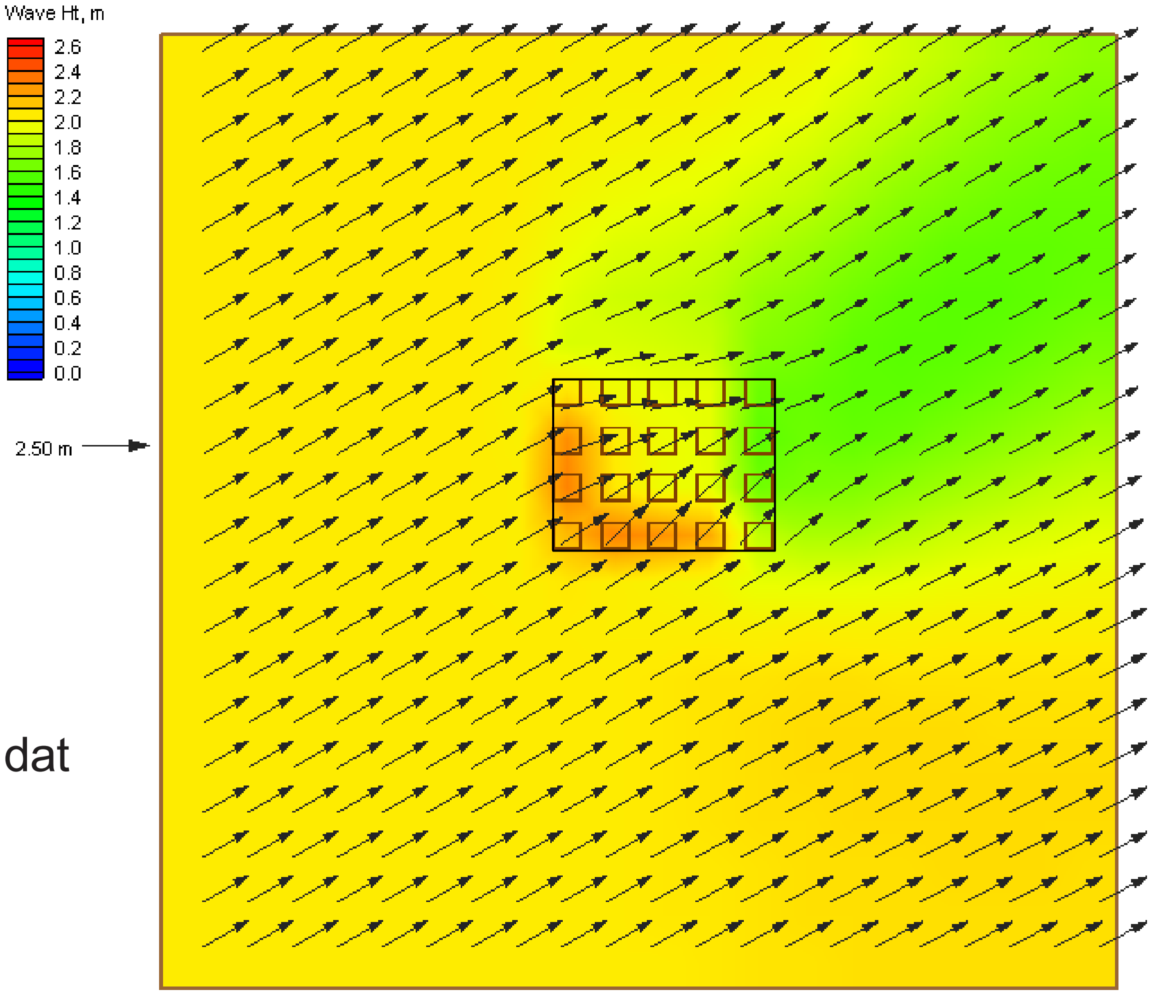
incident wave:
2 m, 6 sec,
30 deg oblique
(gamma = 4)

platform elev.
= 1 m (mwl)

# SUBMERGED PLATFORM

```
20
 9 10 4 -2
10 10 4 -2
11 10 4 -2
12 10 4 -2
13 10 4 -2
 9 11 4 -2
10 11 4 -2
11 11 4 -2
12 11 4 -2
13 11 4 -2
 9 15 4 -2
10 15 4 -2
11 15 4 -2
12 15 4 -2
13 15 4 -2
 9 16 4 -2
10 16 4 -2
11 16 4 -2
12 16 4 -2
13 16 4 -2
```

struct.dat




20 feature cells

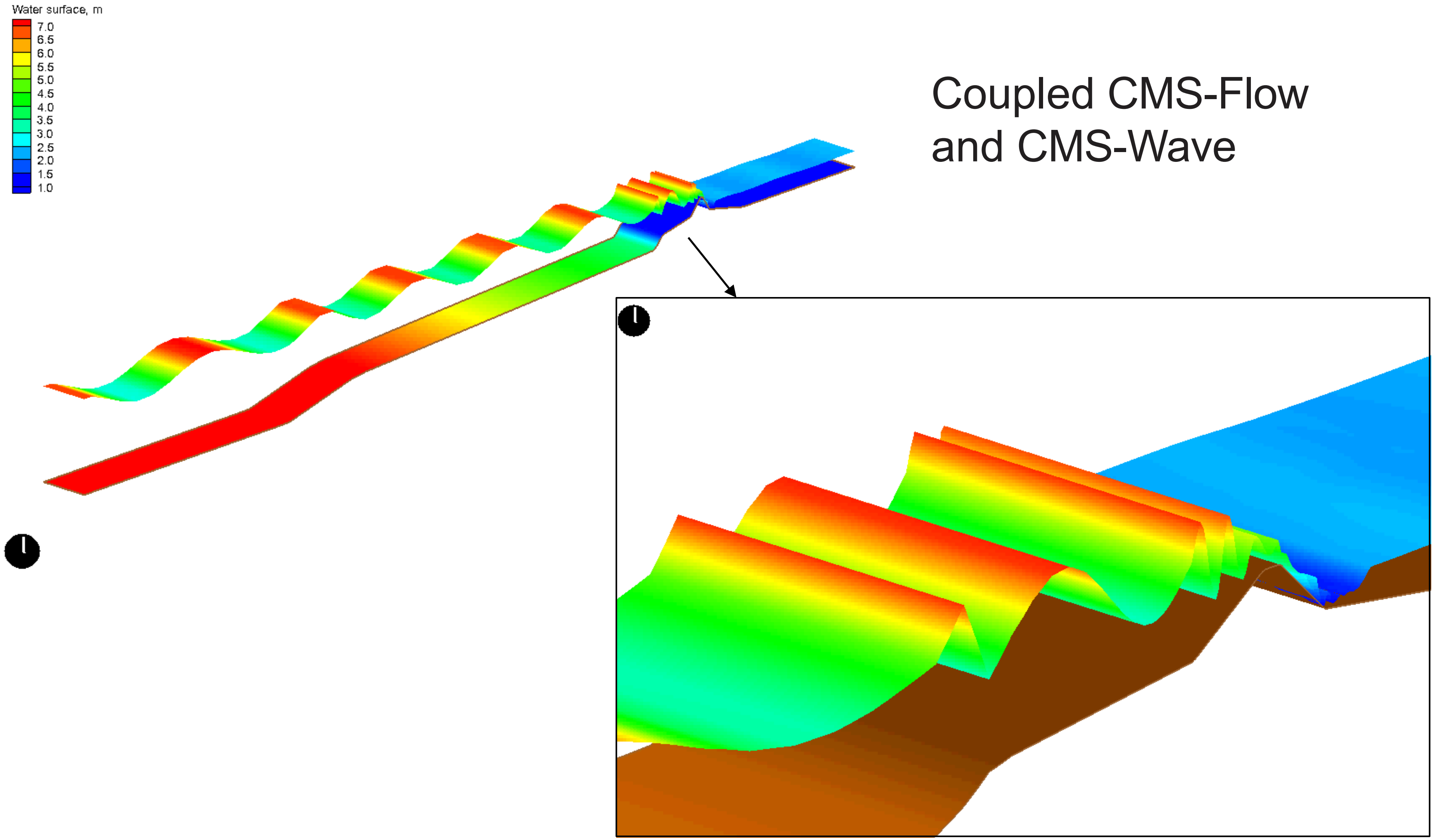
input depth
= 10 m

incident wave:
2 m, 6 sec,
30 deg oblique
(gamma = 4)

platform elev.
= -2 m (mwl)

# CALCULATED WAVE OVERTOPPING R127 SURGE LEVEL = 1.3 M, $H_S$ = 2.3 M, $T_P$ = 14 SEC

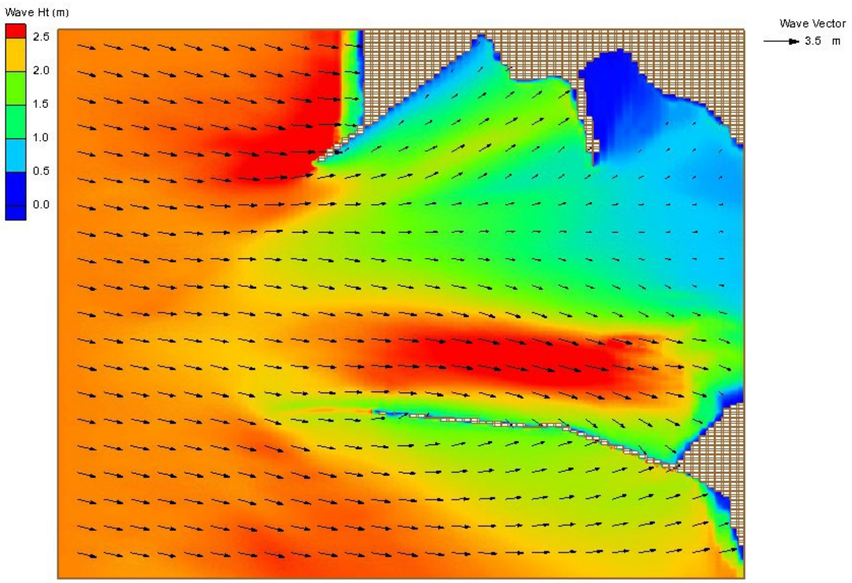
Coupled CMS-Flow and CMS-Wave



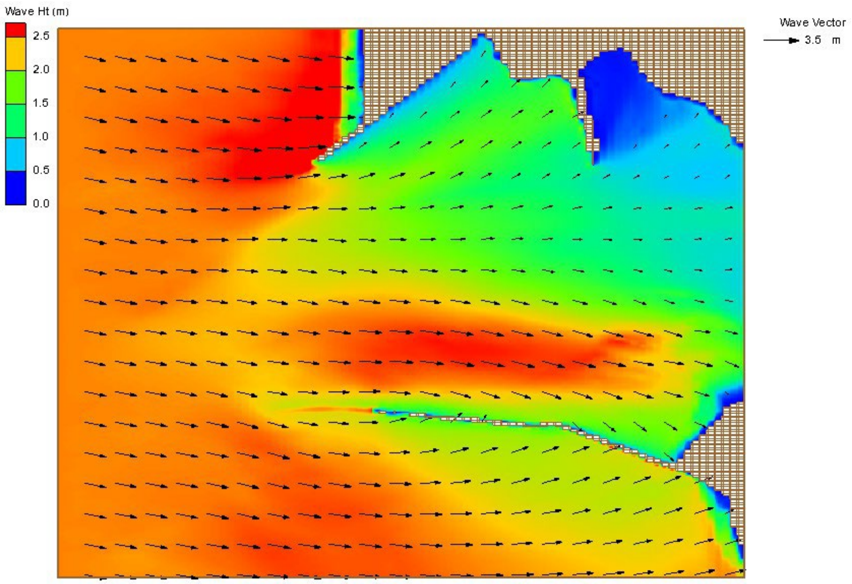
# CMS-WAVE FAST MODE *PRE-TEST USE ONLY*

- Fast mode uses 5 to 7 directional bins with spectral calculations (Standard runs with 35 directional bins)

- Ideal for quick applications, prelim runs, time-pressing project



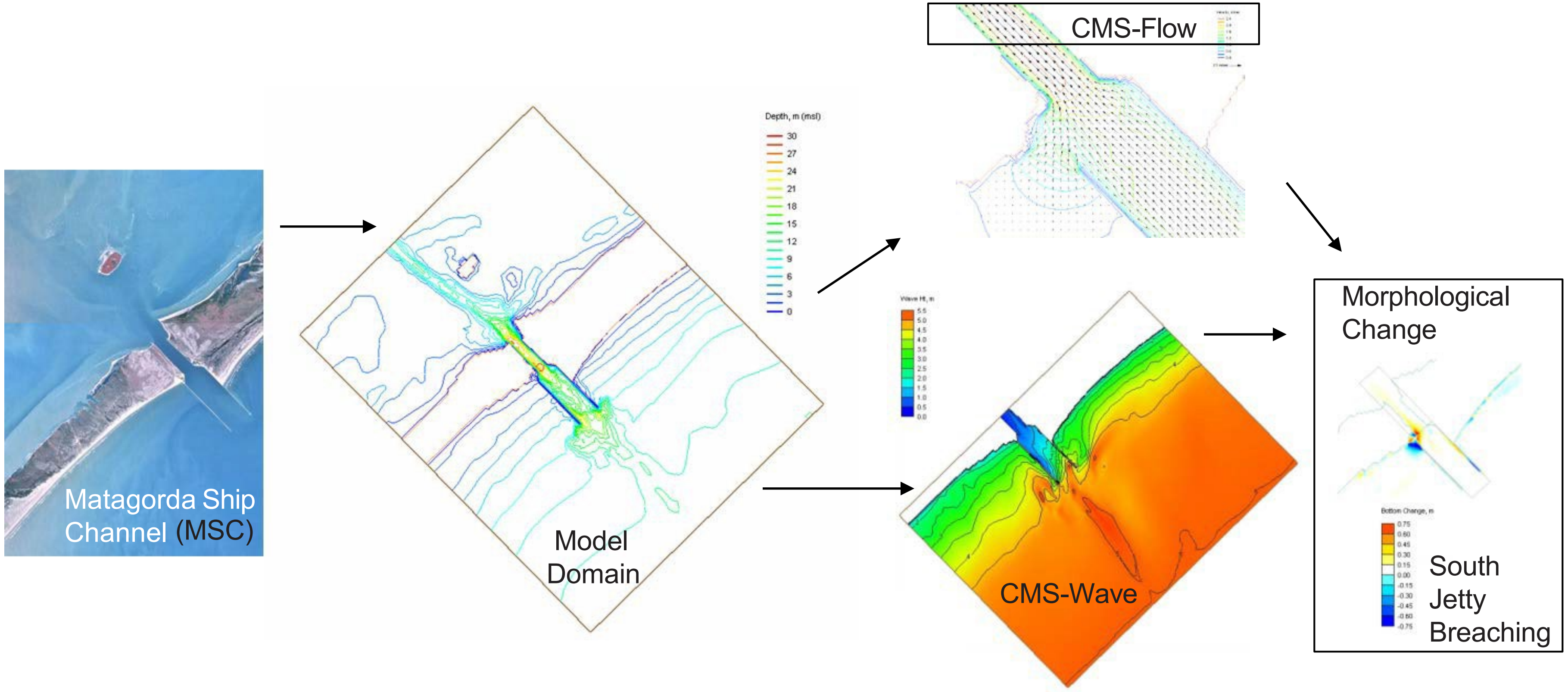

Standard run



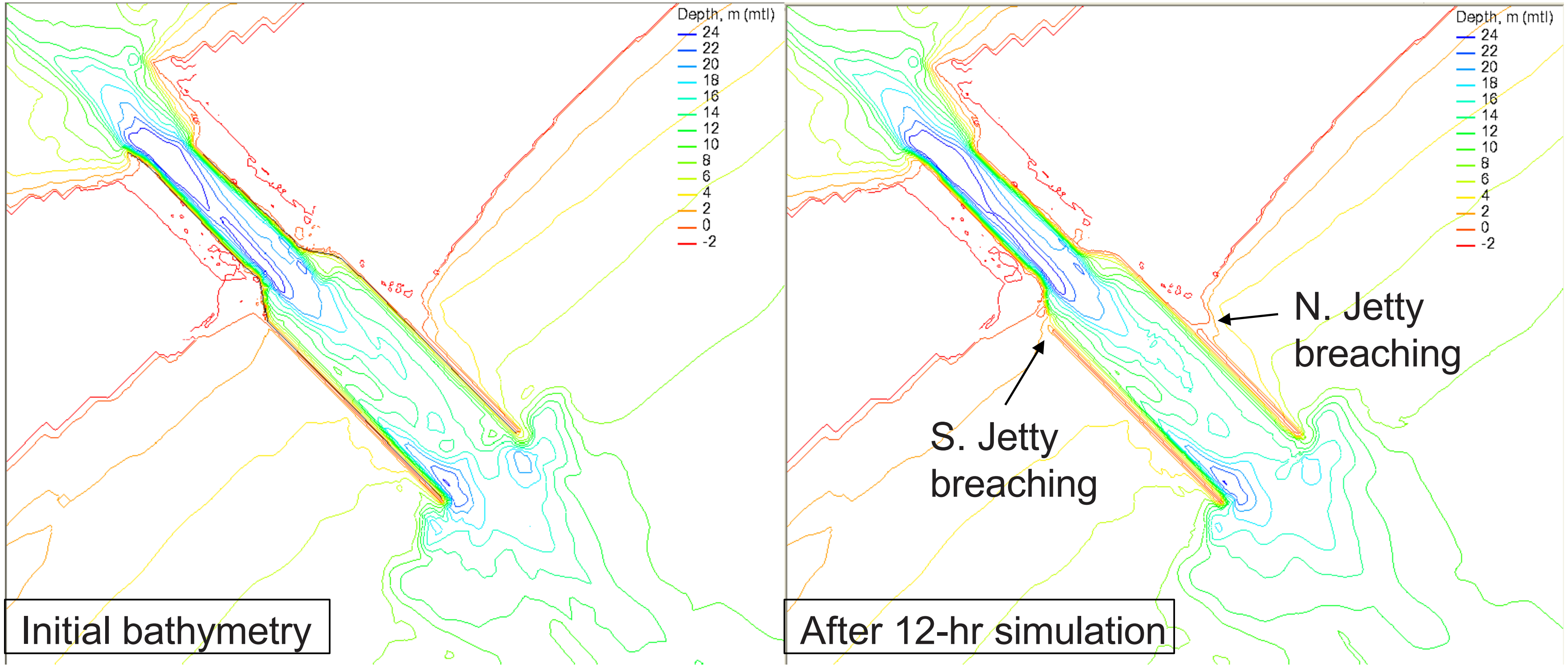

Fast mode

# COUPLING WITH CMS-FLOW

Breaching at Jetty, Simulation at Matagorda Ship Channel, TX



# MSC JETTY WAVE RUN-UP & BREACHING
## *CAT 3 HURRICANE (50-YR LIFE-CYCLE)*




- Peak storm surge level reaches 3.5 m between Hrs 4 and 8
- Incident offshore wave is 7.6 m, 14.3 sec, from south

# QUESTIONS?

## CMS Team

Honghai Li – Honghai.Li@usace.army.mil
Lihwa Lin – Lihwa.Lin@usace.army.mil
Mitchell Brown – Mitchell.E.Brown@usace.army.mil
Liz Holzenthal – Elizabeth.R.Holzenthal@usace.army.mil
Dylan Robinson – Dylan.M.Robinson@usace.army.mil

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