Time Dependent Wave Setup During Hurricanes on the Mississippi Coast

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Motivation

- TO UNDERSTAND THE APPARENT DIFFERENCE IN WAVE SET-UP CALCULATED WITH SIMPLE ANALYTIC EXPRESSIONS AND COMPLEX NUMERICAL MODELS

Summary of Conclusions

- **EFFECTS NOT ACCOUNTED FOR IN THE ANALYTIC EXPRESSIONS APPEAR TO ACCOUNT FOR THE DIFFERENCES**
- **THESE INCLUDE:**
  - **Wave-driven circulation**
  - **Unsteady Conditions**
  - **Steepness-limited breaking offshore**
- **WORK STILL PROGRESSING**

Equation for Mean Water Surface Displacement at the Shoreline

$$\bar{\eta}(0) = \bar{\eta}_b + \frac{3\kappa^2/8}{1+3\kappa^2/8} h_b$$

Result based on constant kappa

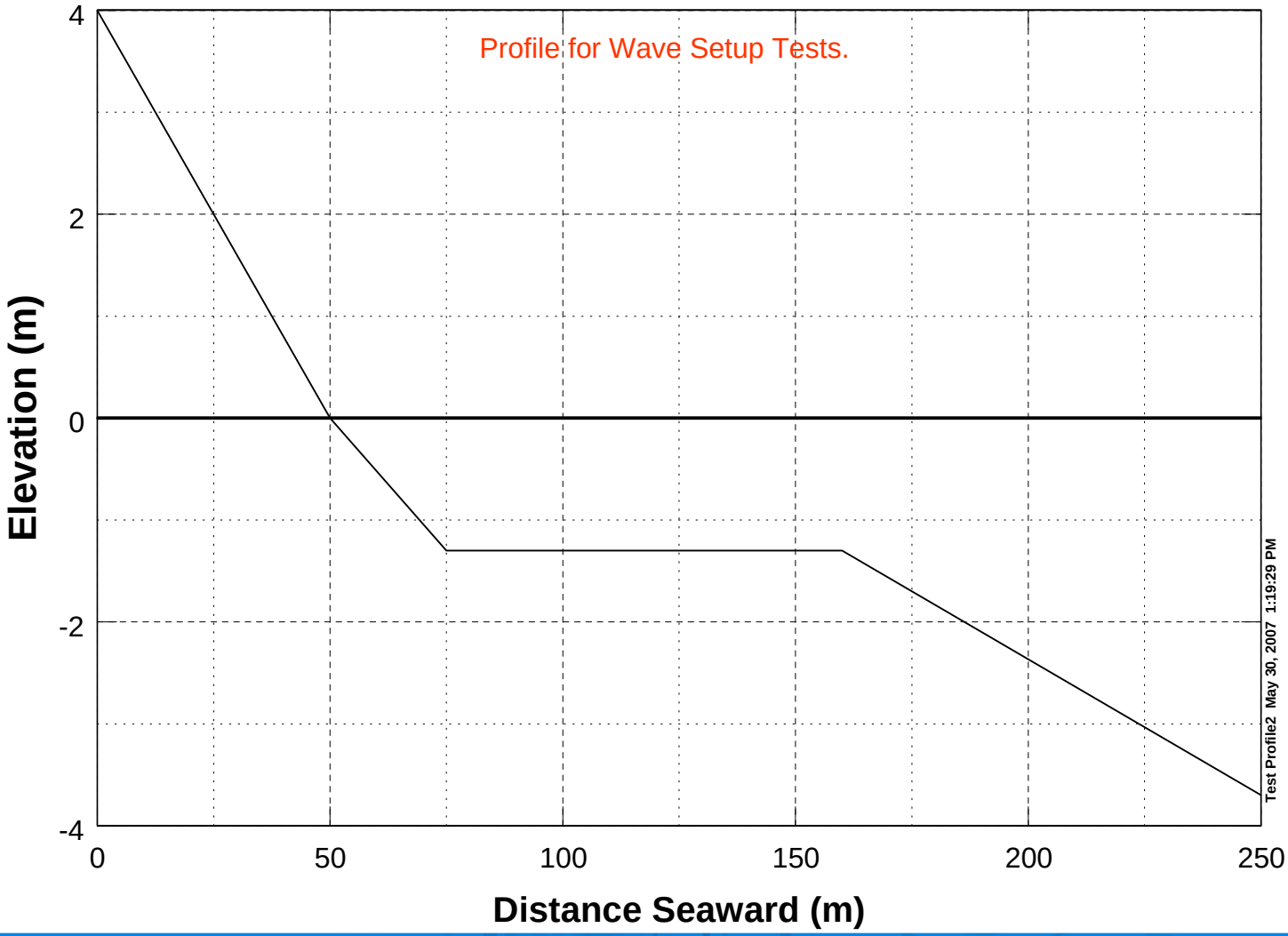
for $\kappa = 0.8,$

$$\bar{\eta}(0) \cong 0.19 H_b$$

Modeled Wave Setup

- **The Maximum Wave Setup Magnitude (at the Shoreline) can vary from as much as 23% of the Breaking Wave Height to as little as 4%**

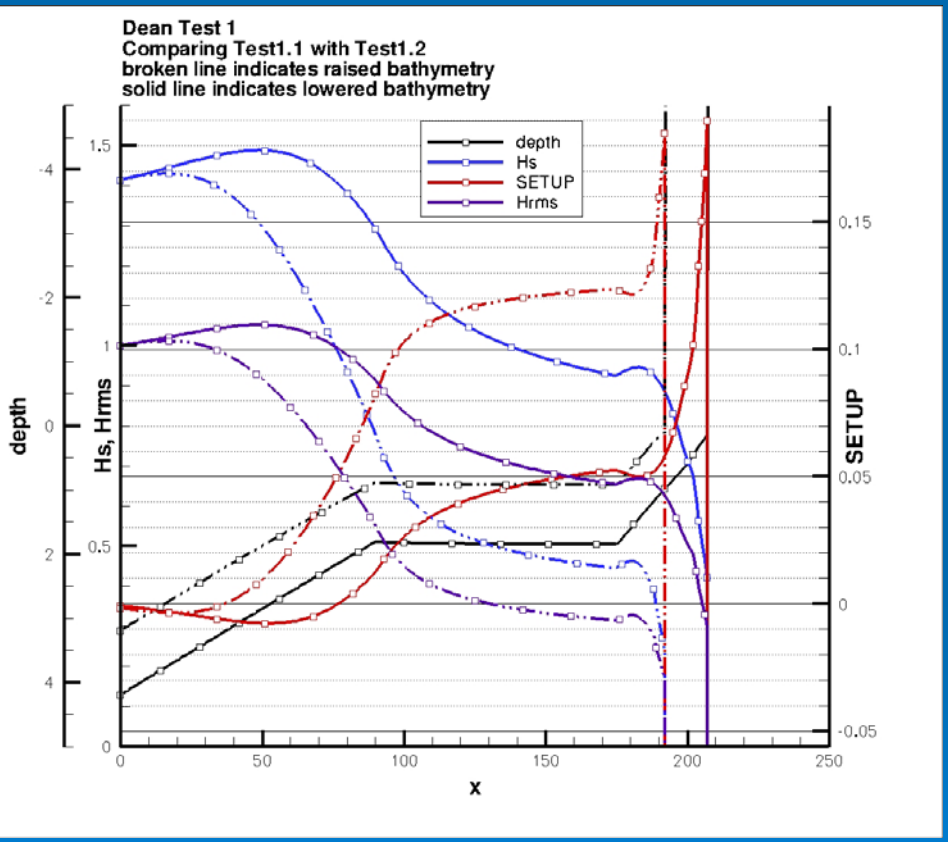
SWAN Test Series 1



Results from tests 1.1 and 1.2

Only depth varies

Hs = 1.414m, T = 8s

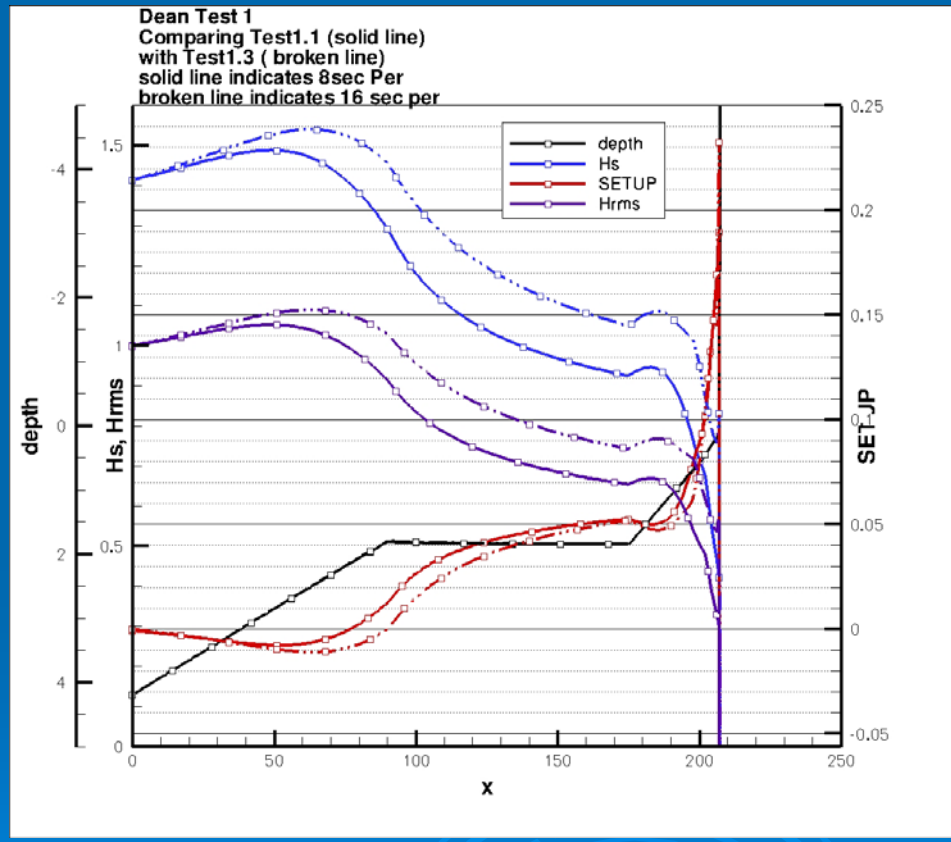


$$\left(\overline{\eta}/H_o\right) = 0.185\text{-}0.19$$

Results from tests 1.1 and 1.3

Only period varies

Hs=1.414m, T=8s, 16s



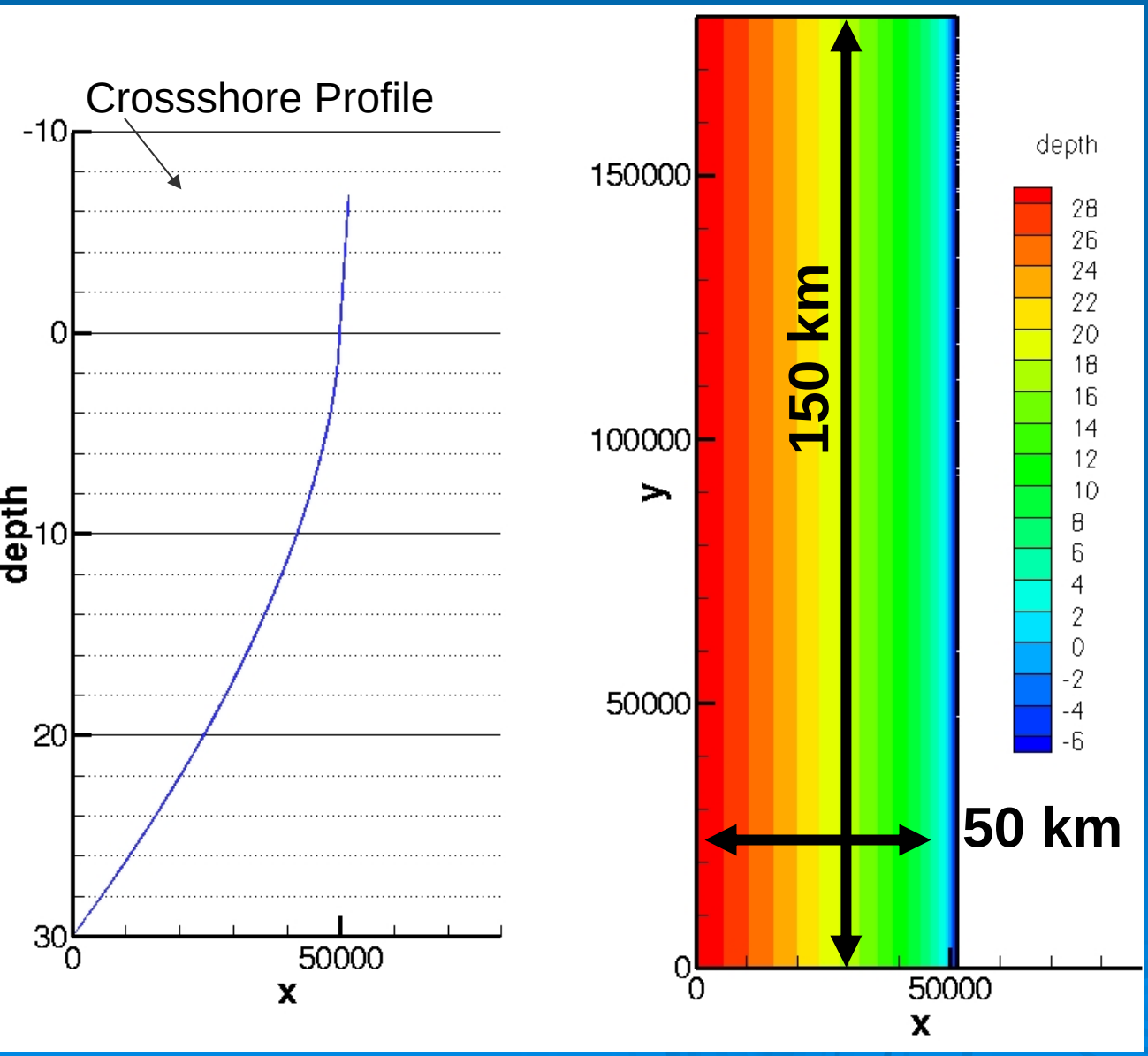
$$\left(\overline{\eta}/H_o\right) = 0.19\text{-}0.23$$

2D Wave Setup Approach

- **BC tests on 1-D with steady winds**

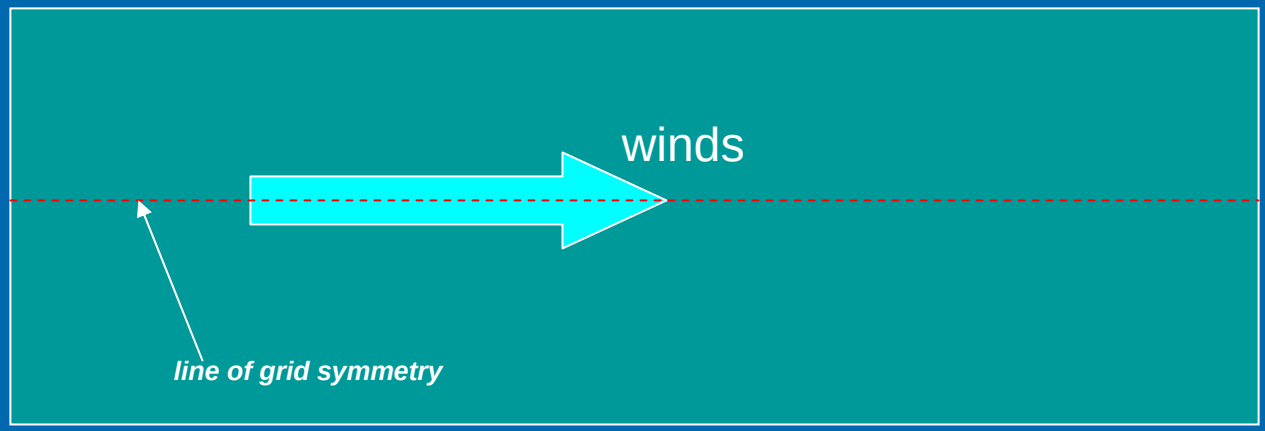
- **1-D with steady winds**
  - Uniform forcing of 50 m/sec (time and space)
  - Zero offshore wave BC
  - 9m, 10s offshore wave BC
- **1-D with unsteady winds**
  - Uniform forcing over domain (space)
  - Gaussian wind profile (time) with peak wind of 50 m/sec
  - Zero offshore wave BC
- **2-D test with steady winds**
  - Forcing of 50 m/sec only 50km alongshore w/ center at 90km
  - Zero offshore wave BC
  - 9m, 10s offshore wave BC
- **2-D test with unsteady winds**
  - Forcing only 50km alongshore w/ center at 90km
  - Gaussian wind profile (time) with peak wind of 50 m/sec
  - Zero offshore wave BC

Test Domain



- One profile
  - Slightly steeper than that found off Miss. Coast
  - 51.5 km crossshore with max depth of 30m
    - 1:1700 average slope
  - 180km alongshore

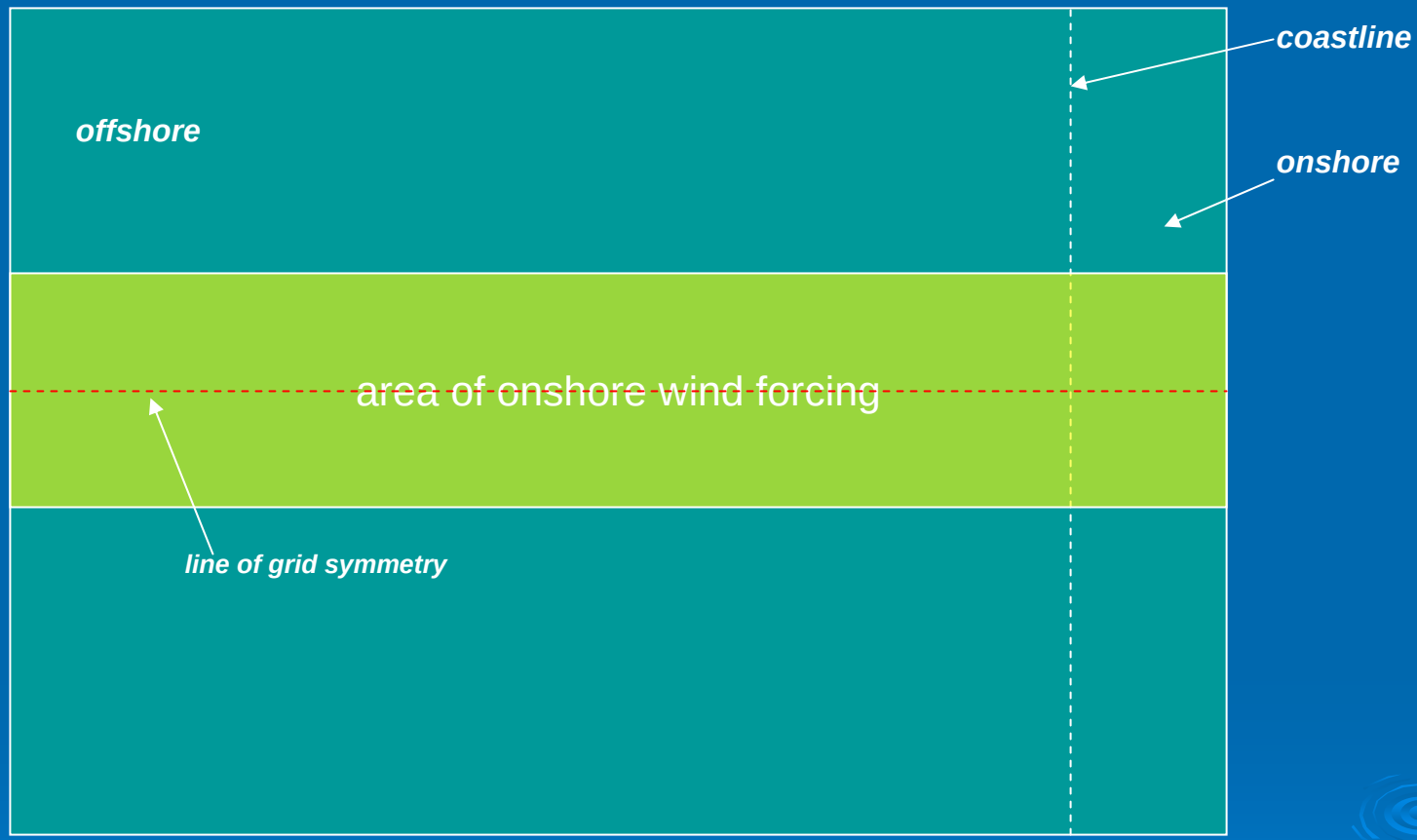
1-D spatially uniform forcing



top view

side view

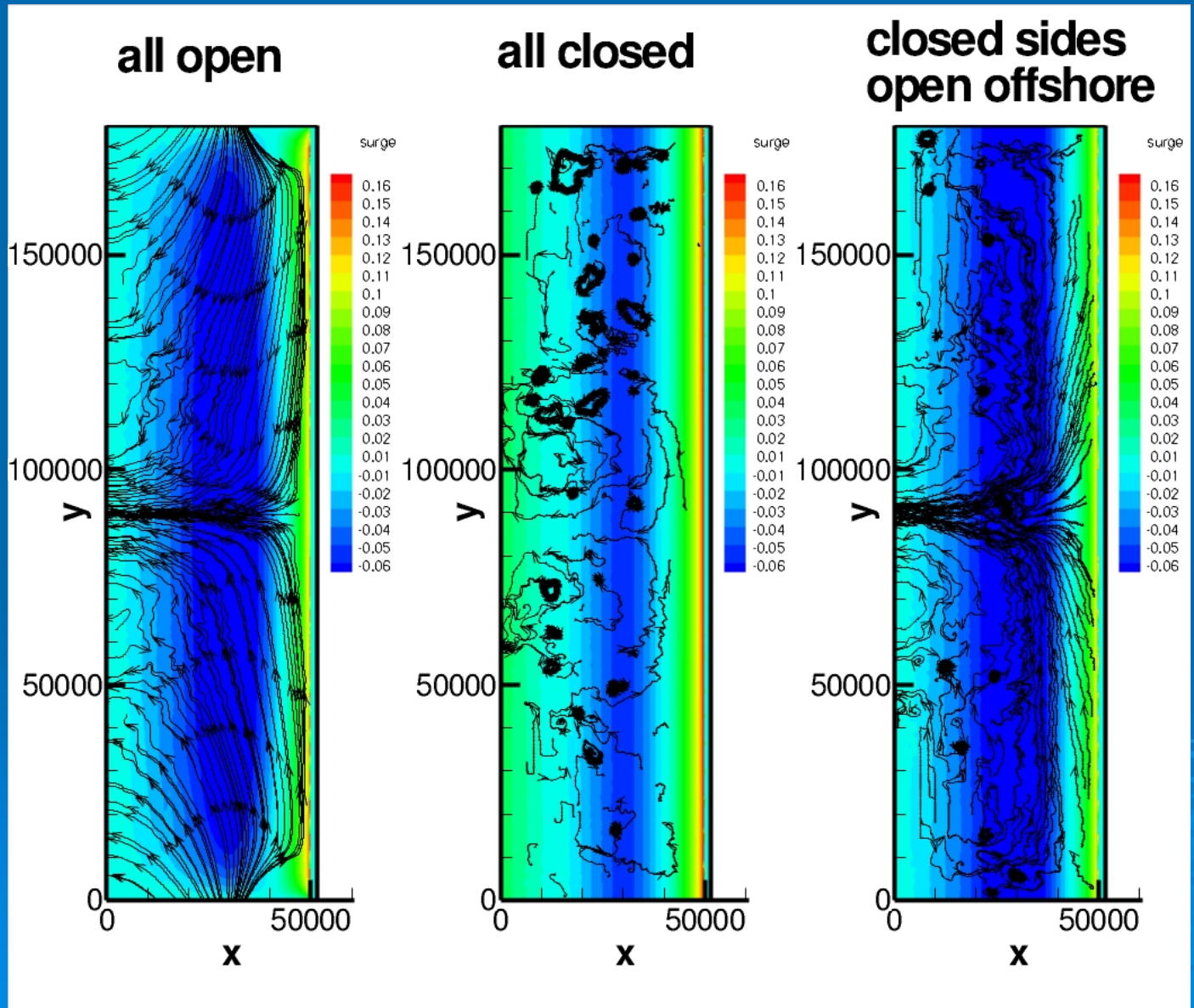
2-D forcing 50km wide swath of domain



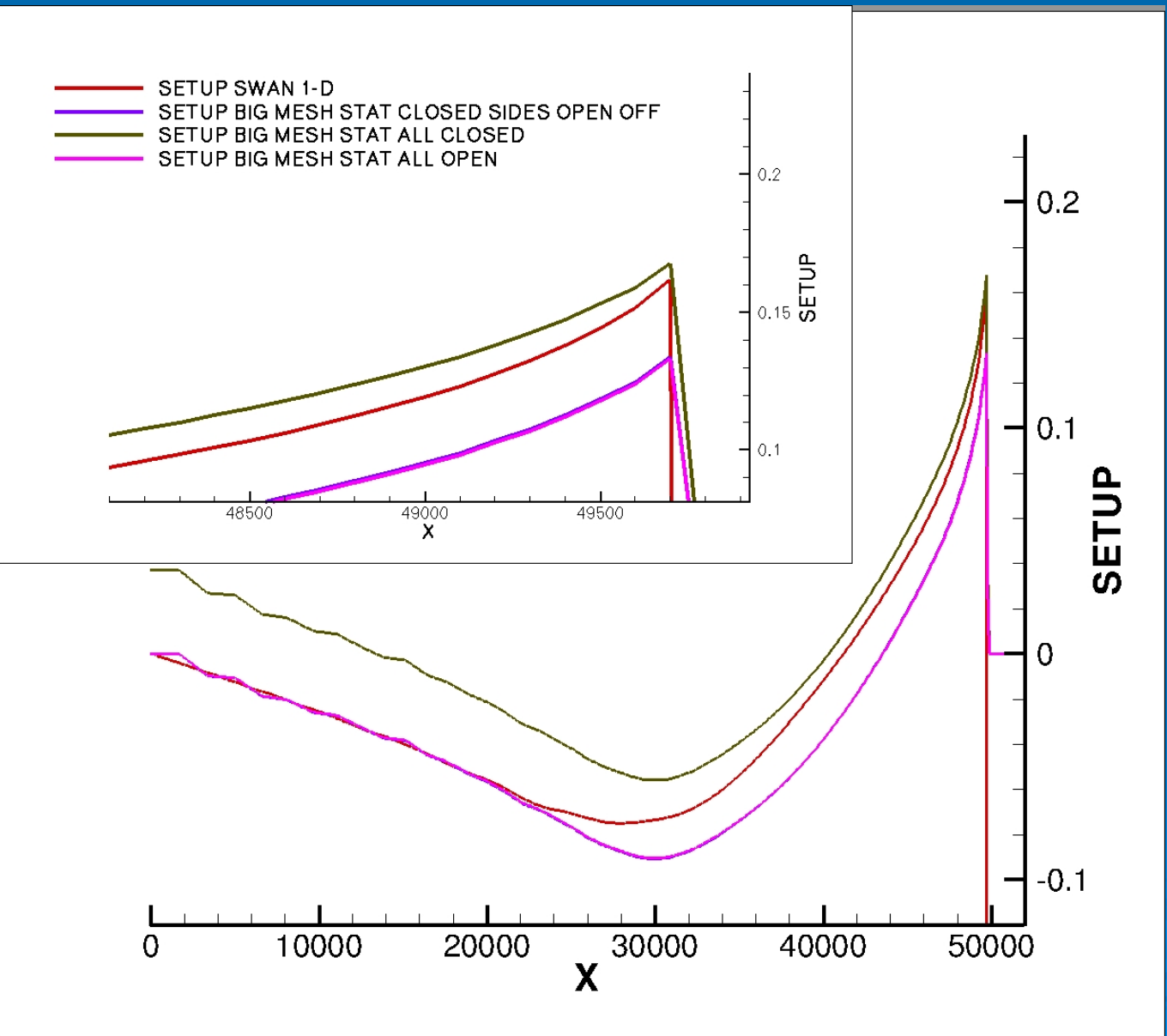
Test Boundary Condition Effects

- 1-D steady uniform wind, with wave growth by SWAN
  - 50 m/sec
  - Zero wave BC's
- 3 BC's Tested in ADCIRC forced with SWAN wave forces
  - All Open Boundaries with water level set to zero
    - Currents inflowing from sides and out-flowing to offshore
  - All Closed
    - Weak currents and little circulation
  - Open Offshore and Closed Sides
    - Currents inflowing and out-flowing to offshore
    - Strong offshore currents in center of domain

Contour Plot of Set-up and Streamtrace of Depth Averaged Current



Crossshore Set-Up for ADCIRC BC Tests compared to 1-D SWAN



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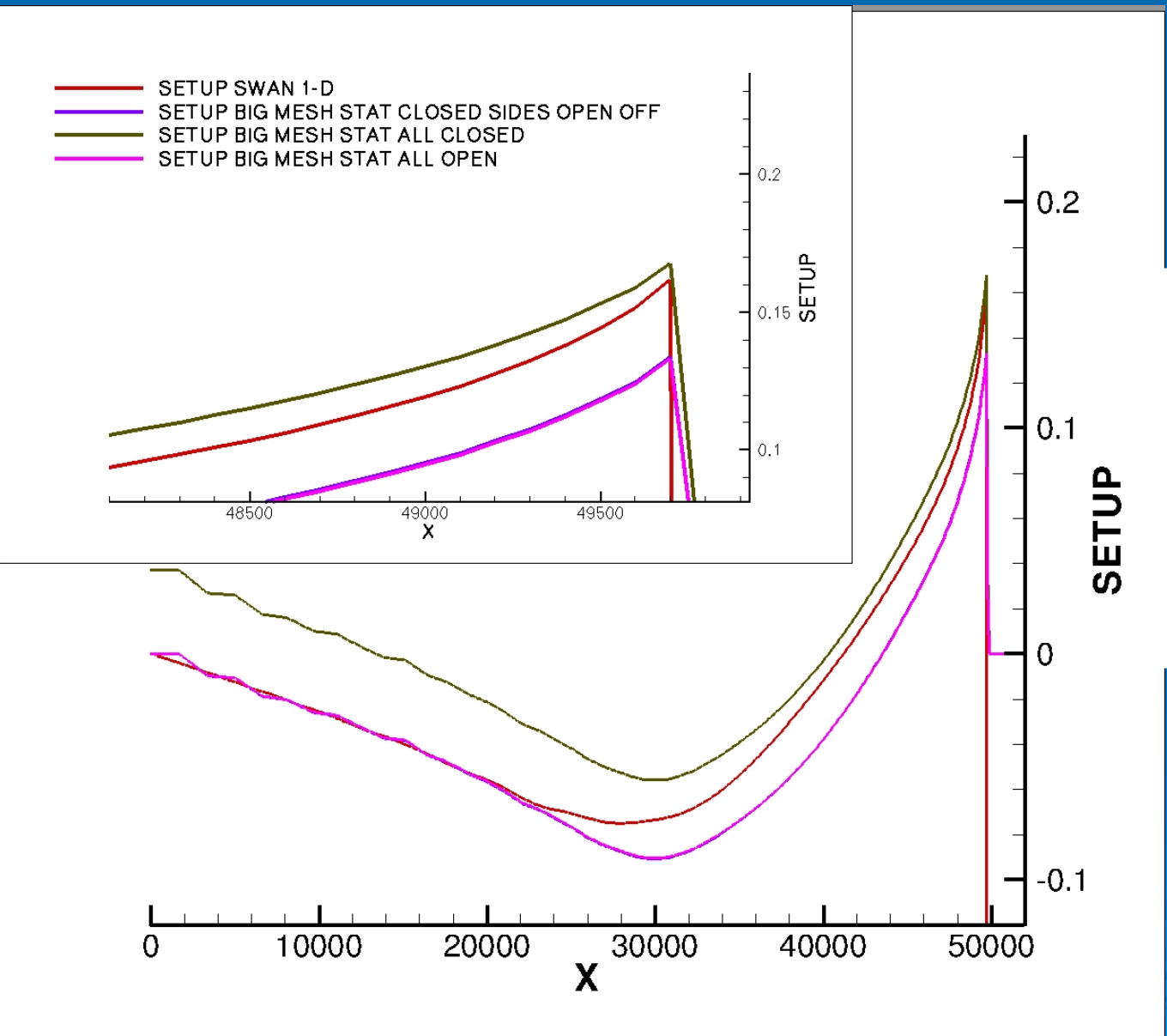
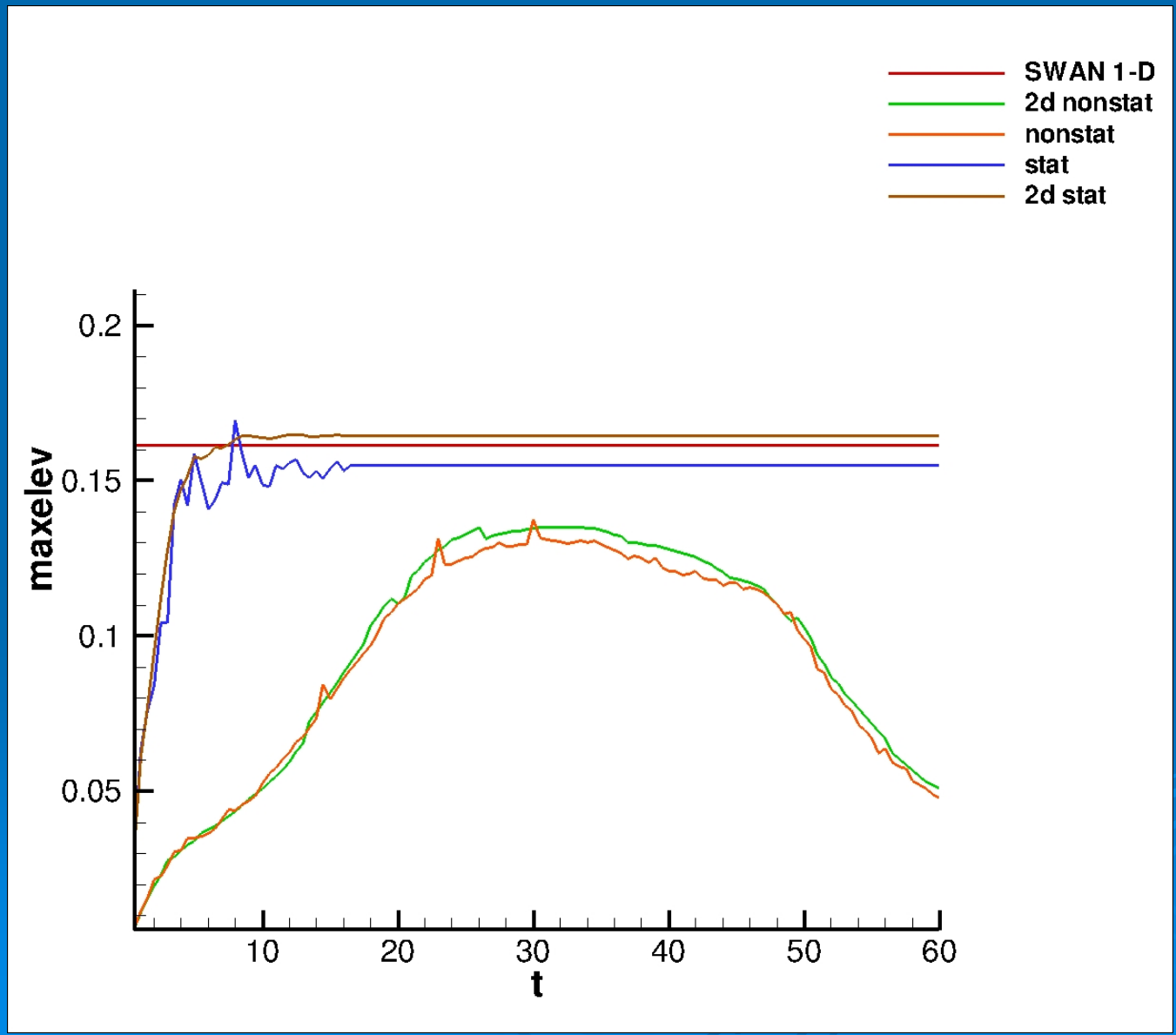


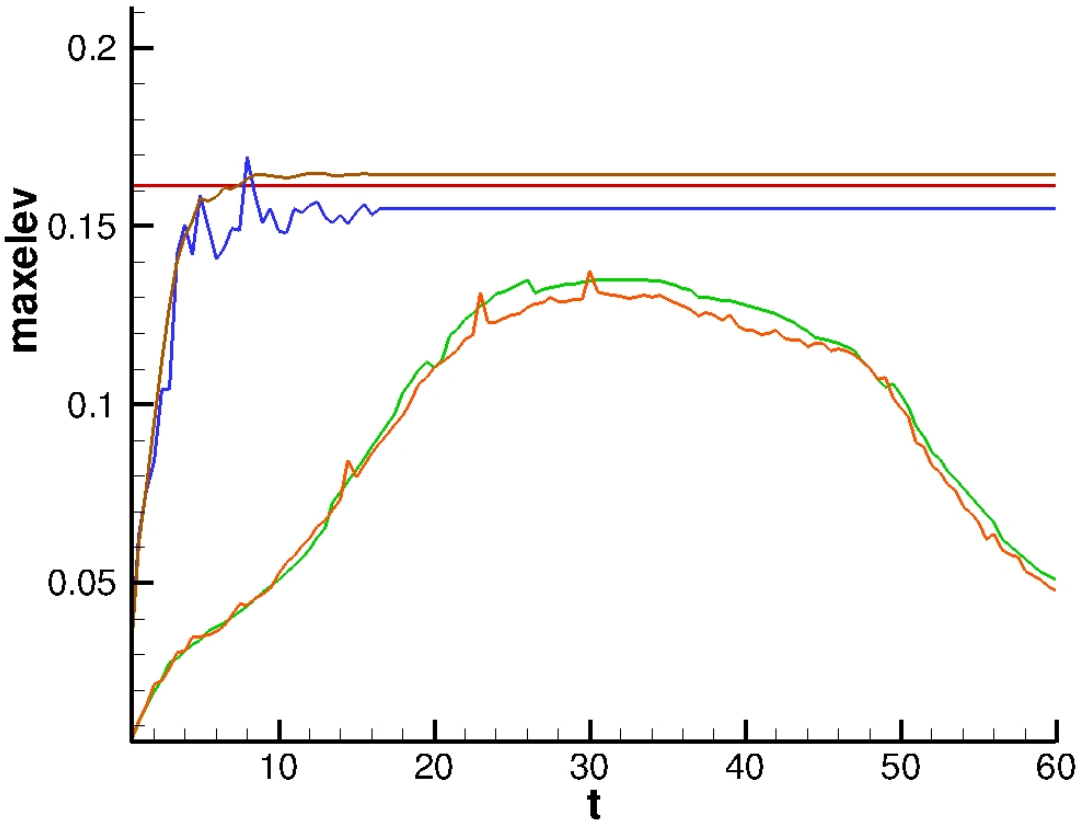
IN THIS TEST WAVE-DRIVEN CIRCULATION REDUCES SET UP BY~25 %

UNSTEADY CONDITIONS

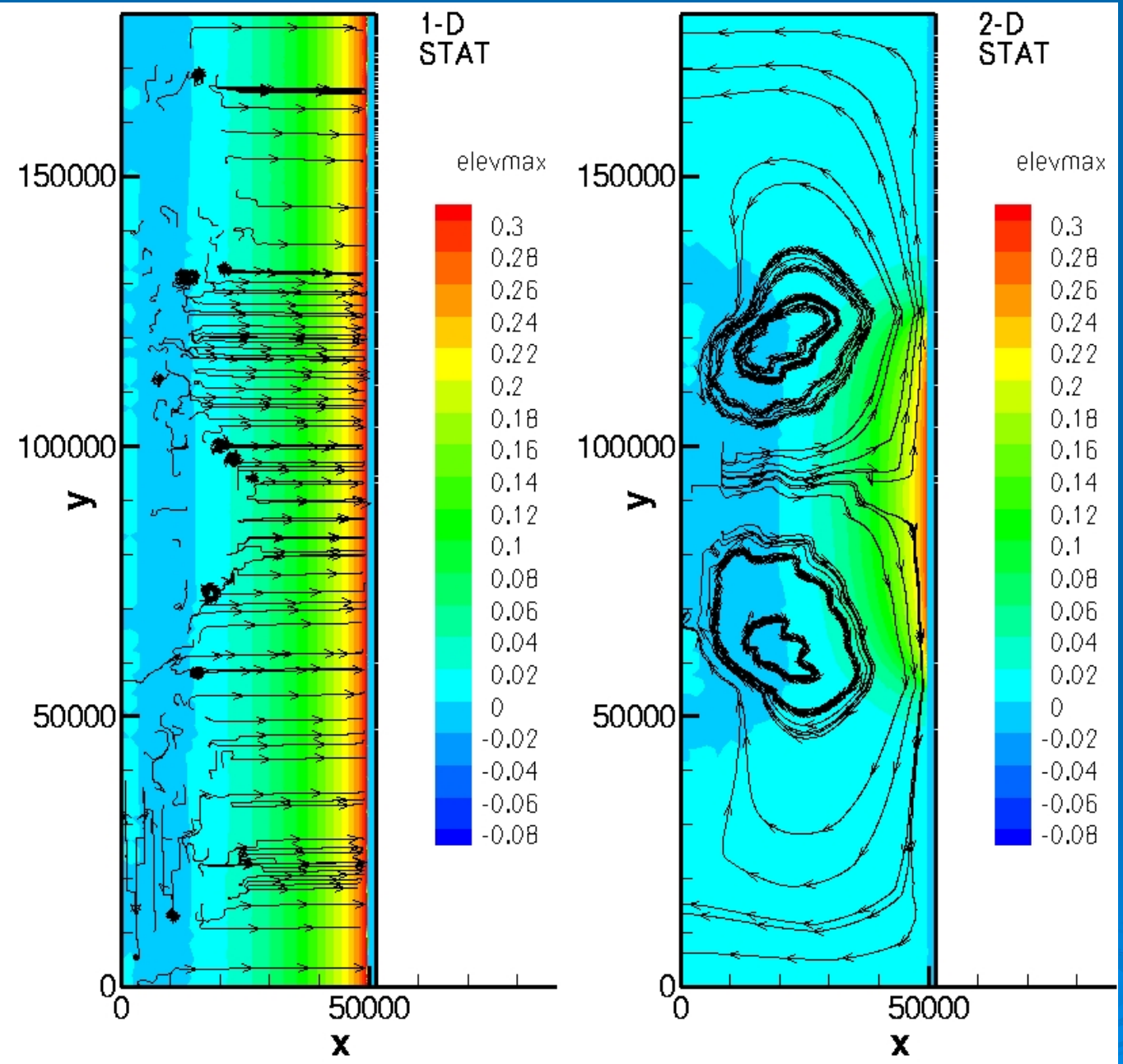


Maximum elevation in domain for steady stationary and unsteady nonstationary 1-D and 2-D tests compared to SWAN and DEAN 1-D

IN THIS TEST UNSTEADY CONDITIONS REDUCE SET-UP BY ~ 20%



Results from 9m, 10 sec wave BC simulation



Steady Stationary Test Results with Streamtrace

Initial Conditions

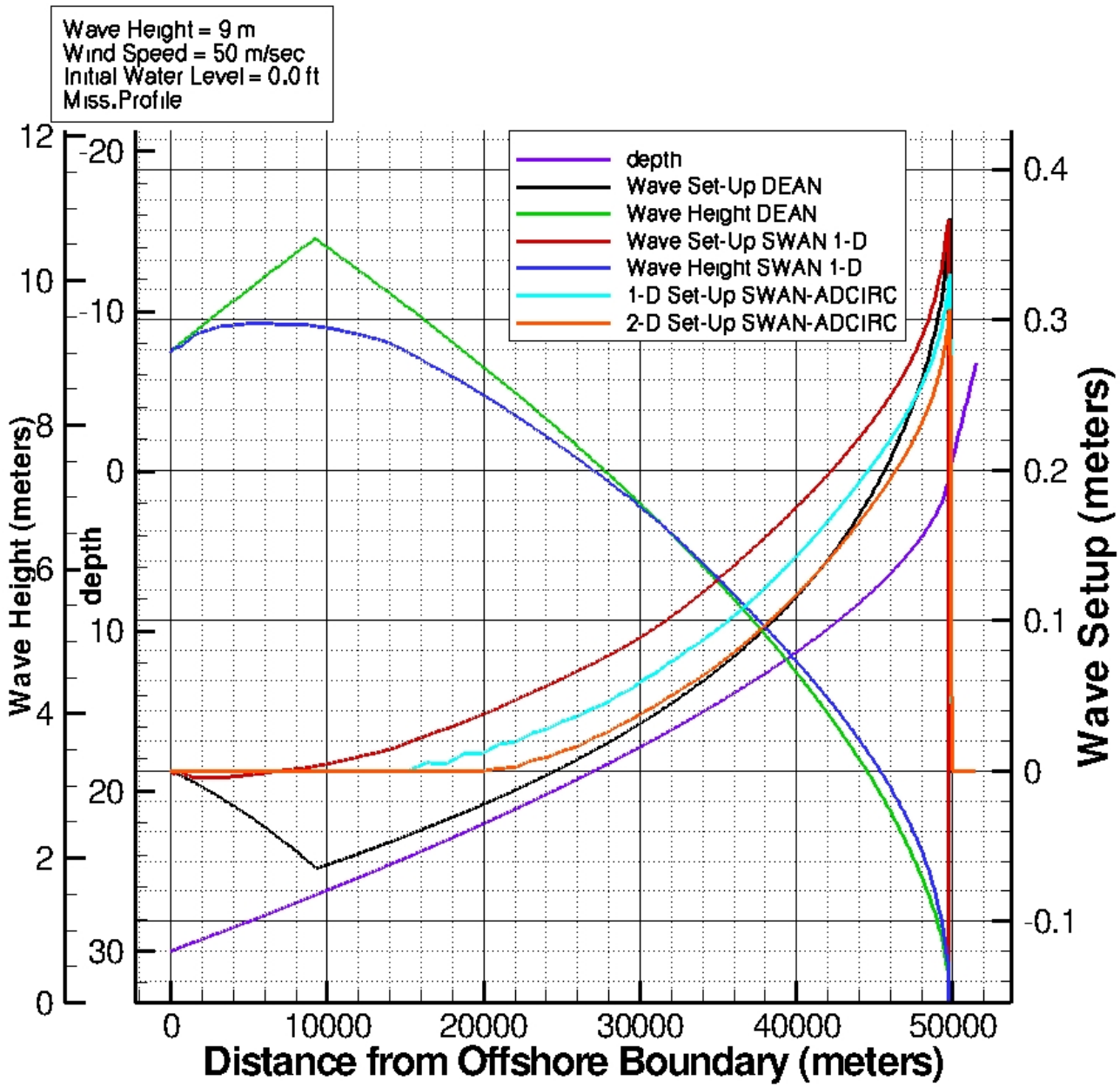
WIND:

50 m/sec

WAVE:

9m, 10sec

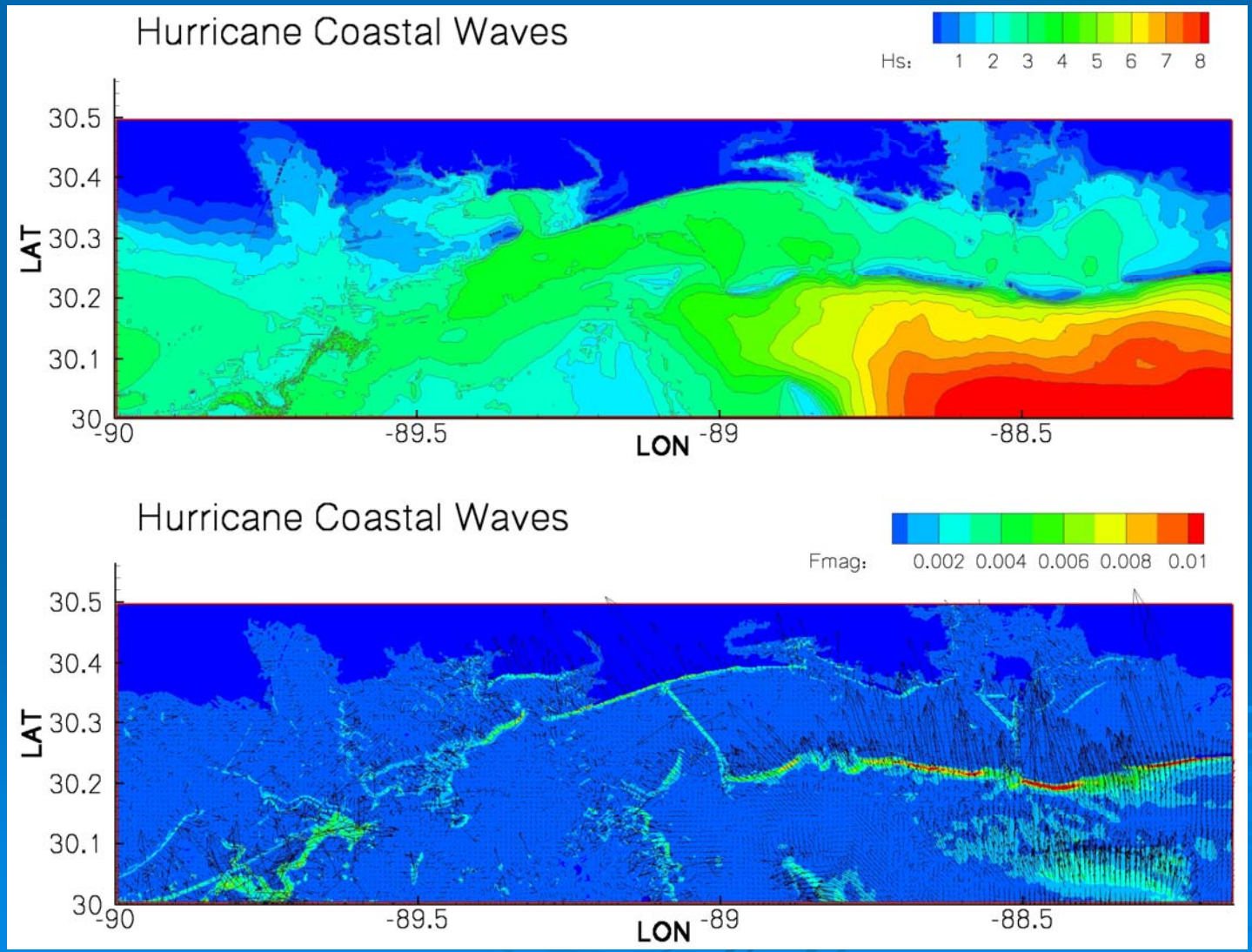
Offshore Wave BC: Hs=9m, 10 sec



$\left(\overline{\eta} / H_o\right)$

05	Dean 1D k = 0.4
.06	SWAN 1D
.052	ADCIRC 1D
.048	ADCIRC 2D

Hurricane Katrina Max Wave Results (height and forces)



Wave Summary

- 15-20km offshore of barrier islands
  - Hs = 8-9m, Hrms=5.66-6.36m
  - Localized region of shoreward directed wave forces (breaking)
- 2-3km offshore of barrier islands
  - max shoreward directed wave forces (breaking)
  - Hs = 5-6m, Hrms=3.53-4.2m

Set-Up Summary

- **Set-up at Barrier Islands**
  - **0.4 - 0.5m**
  - **Hs = 8m, Hrms=5.66m**
    - **Max wave height located 20 km offshore of barrier islands**
    - $\left(\overline{\eta}/H_o\right)$ **~ 7-9%**
  - **Hs = 5-6m, Hrms=3.53-4.2m**
    - **Max wave height located 2-3 km offshore of barrier islands**
    - $\left(\overline{\eta}/H_o\right)$ **~ 9-14%**

Set-Up Summary

- **Set-up at Coast**
  - **0.3 - 0.4m**
  - **Hs = 8m, Hrms=5.66m**
    - **Max wave height located 40 km offshore**
    - $\left(\overline{\eta}/H_o\right)$ **~ 6-6.5%**
  - **Hs = 5-6m, Hrms=3.53-4.2m**
    - **Max wave height located 20 km offshore**
    - $\left(\overline{\eta}/H_o\right)$ **~ 9-12%**

Summary of Conclusions

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