# NOAA NTHMP Mapping & Modeling Subcommittee Benchmarking Workshop: Tsunami Current

# NEOWAVE Validation

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# Outline

- NEOWAVE Model Introduction
- Prior Model Validation - 2011 Tohoku Tsunami
  - Honolulu Coast
- Benchmark Cases
  - BM1
  - BM2
  - BM5
- Conclusions

# NEOWAVE
# Non-hydrostatic Evolution of Ocean Wave

## Governing Equations

- Depth-integrated, Non-hydrostatic Equations
  - Weakly dispersive waves through non-hydrostatic pressure

    (Stelling and Zijlema, 2003; Yamazaki *et al.*, 2009 & 2011)

## Numerical Schemes

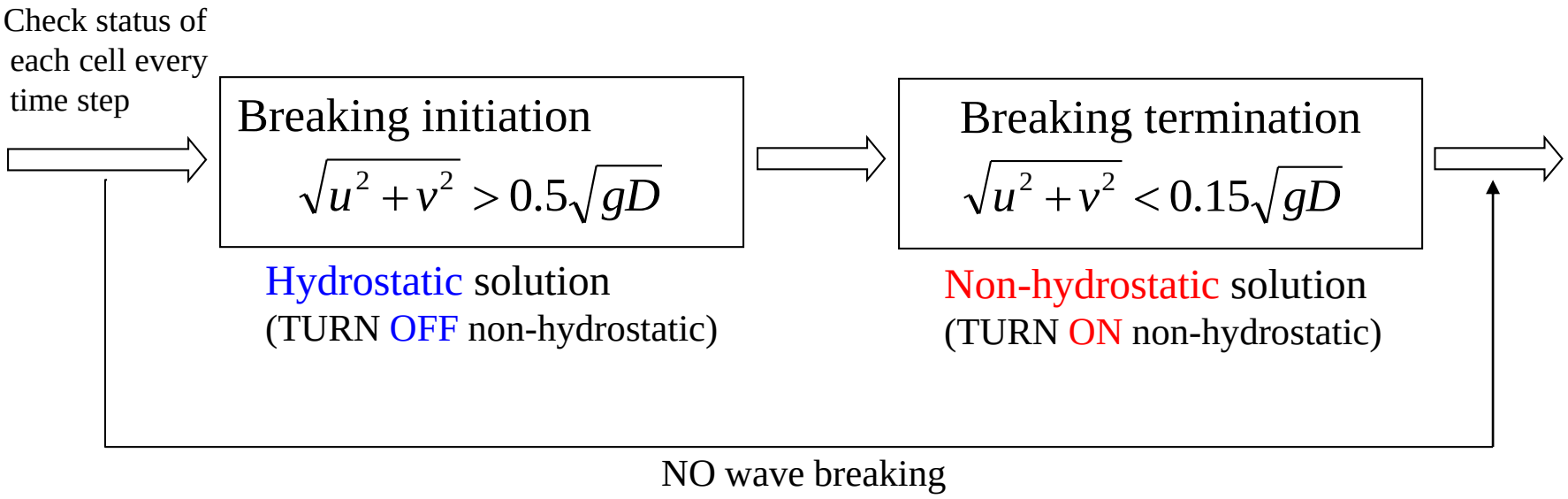
- Semi-implicit, Finite Difference (FD) Model
  - Explicit hydrostatic solution
  - Implicit non-hydrostatic solution
- Two-Way, Grid-Nesting Scheme
  - Standard grid refinement scheme for FD tsunami models
- Momentum Conserved Advection (MCA) Scheme
  - Shock capturing scheme for FD models

    (Stelling and Duinmeijer, 2003; Yamazaki *et al.*, 2009 & 2011)

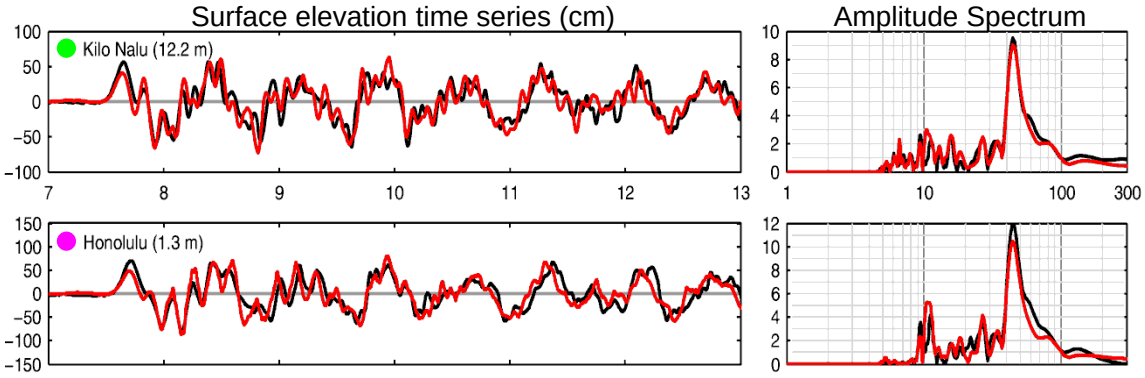
# Non-hydrostatic/Hydrostatic Hybrid Scheme

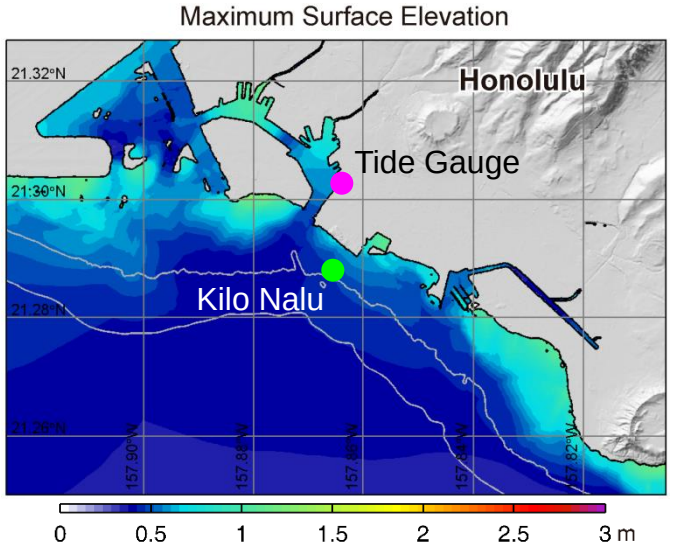
## Approximation of Energetic Breaking Waves as Bores

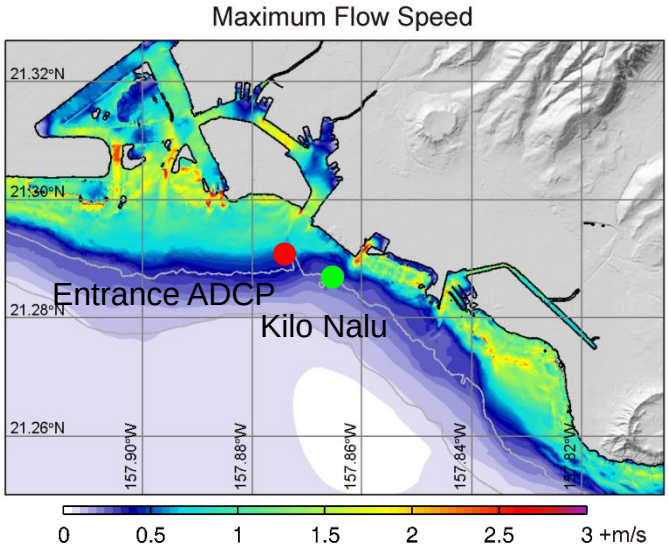
- Dispersive wave model generates artificial spike when wave front becomes steep at wave breaking or bore development
- Breaking region may consider hydrostatic for bore approximation
  - Hydrostatic pressure is main driving force
  - Non-hydrostatic pressure effects are negligible

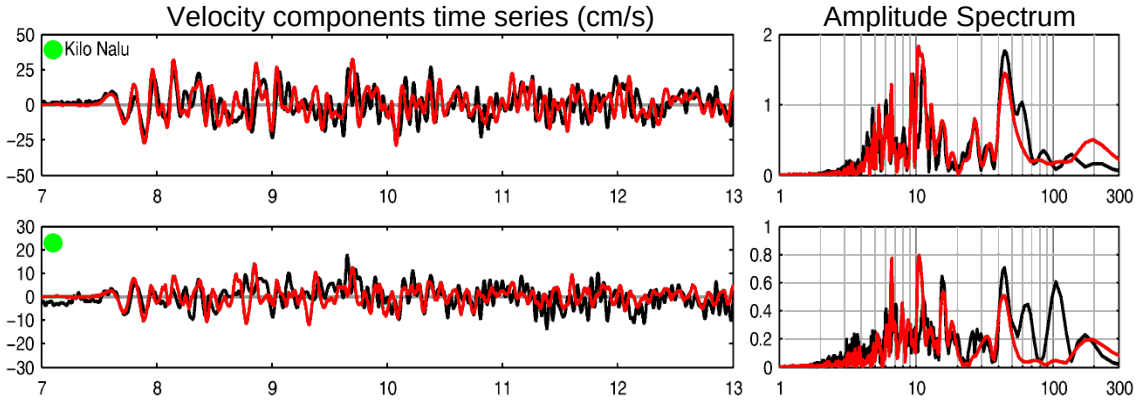


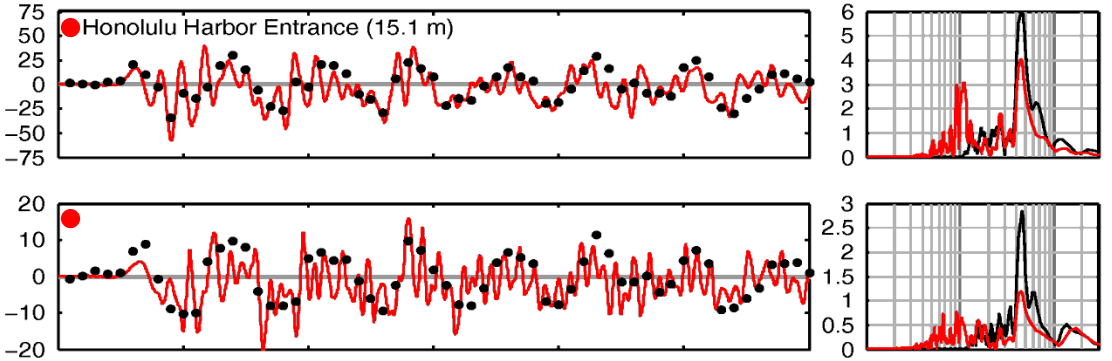
# Prior Validation with 2011 Tohoku Tsunami




High Sampling Rate Mea.

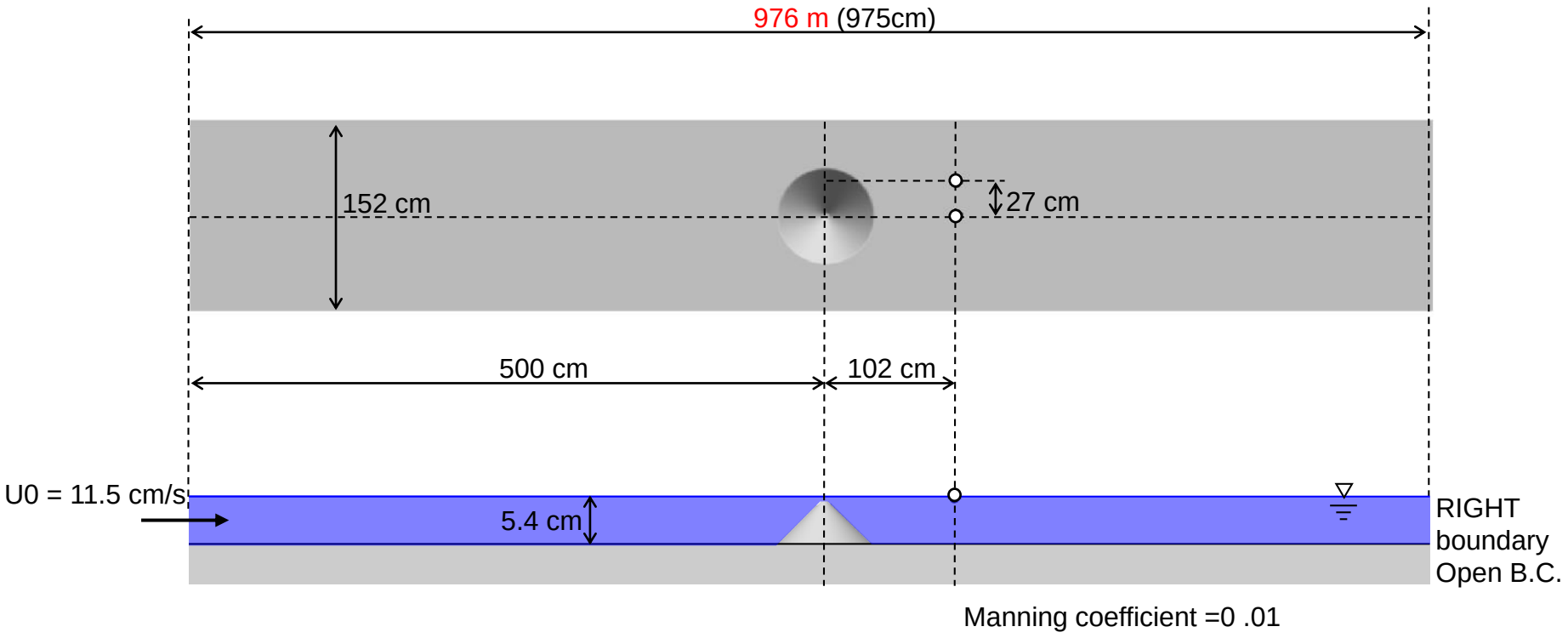
Low Sampling Rate Mea.

NEOWAVE

# BM NO.1

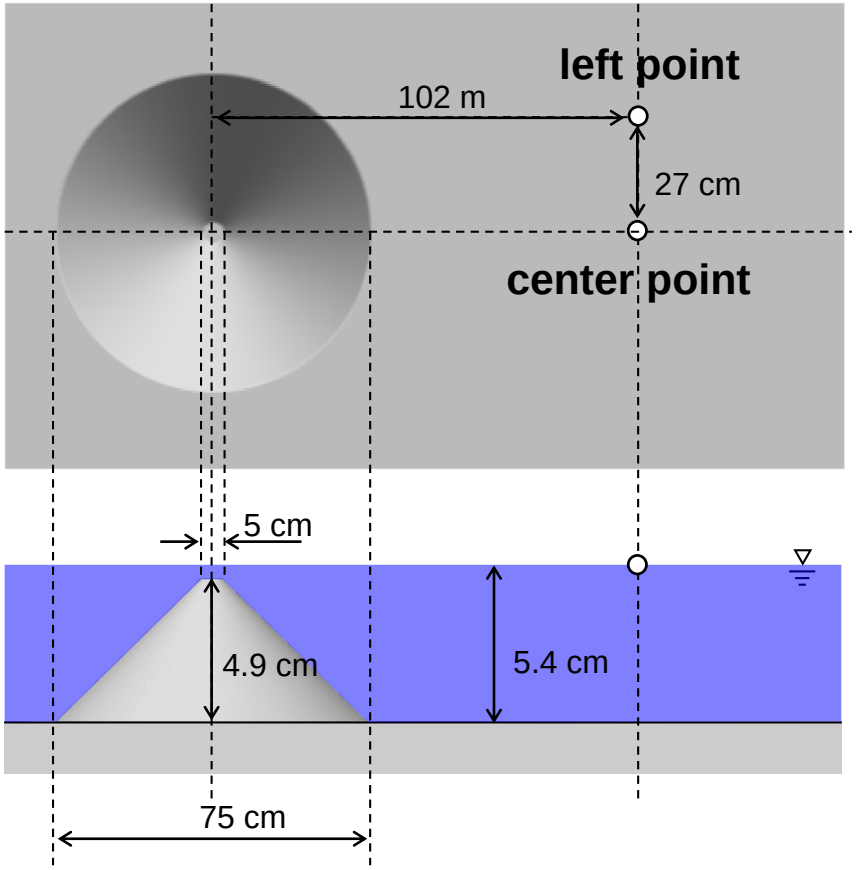
## Shallow-Water Flow around Submerged Conical Island

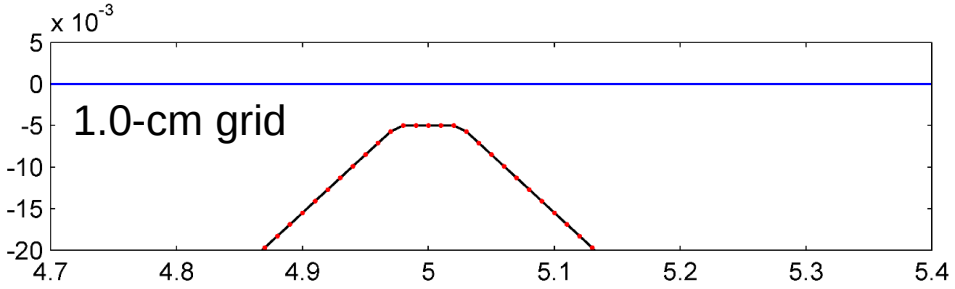
(Lloyd and Stansby, 1997)

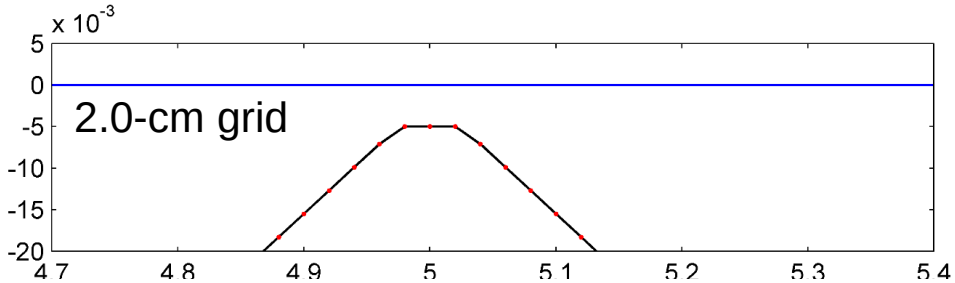


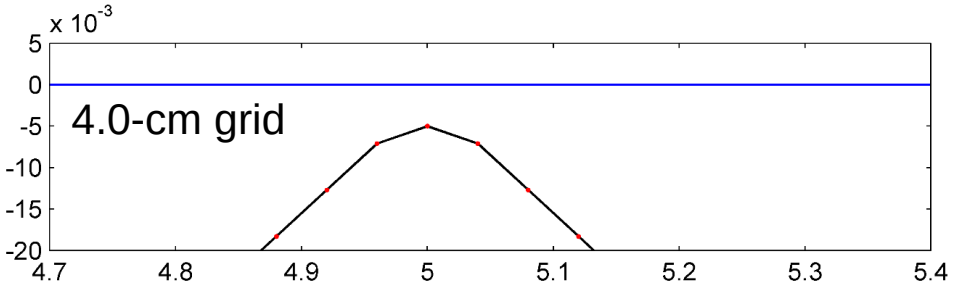
# BM NO.1

## Close View of Conical Island with Three Resolutions



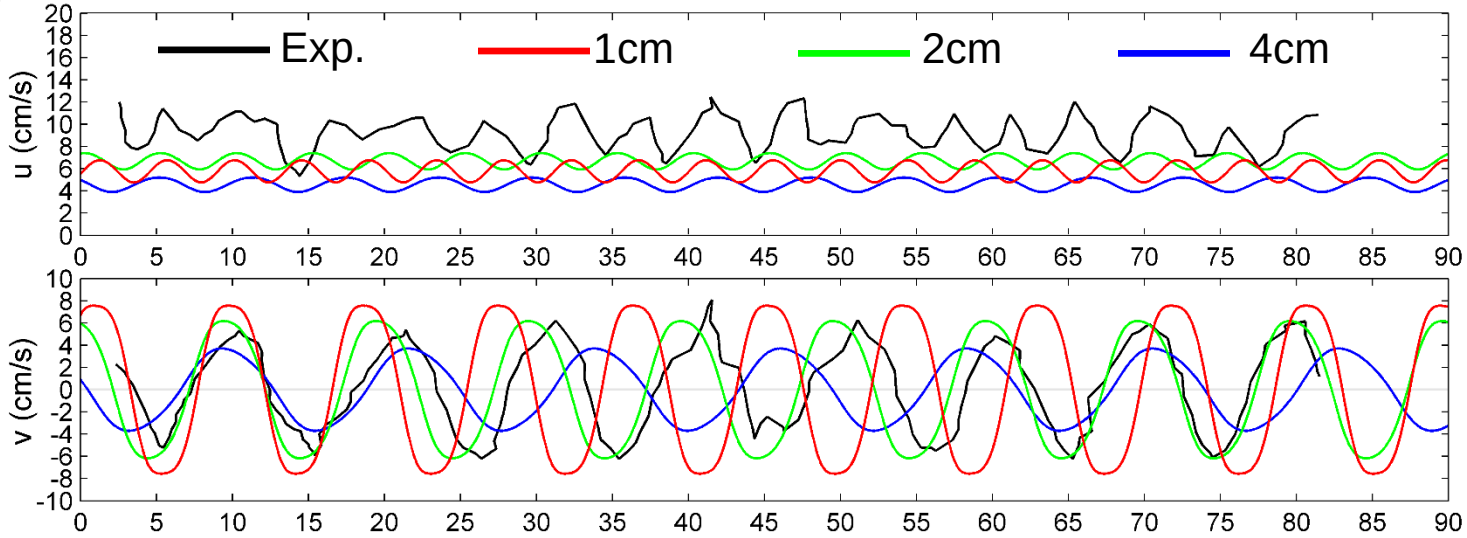



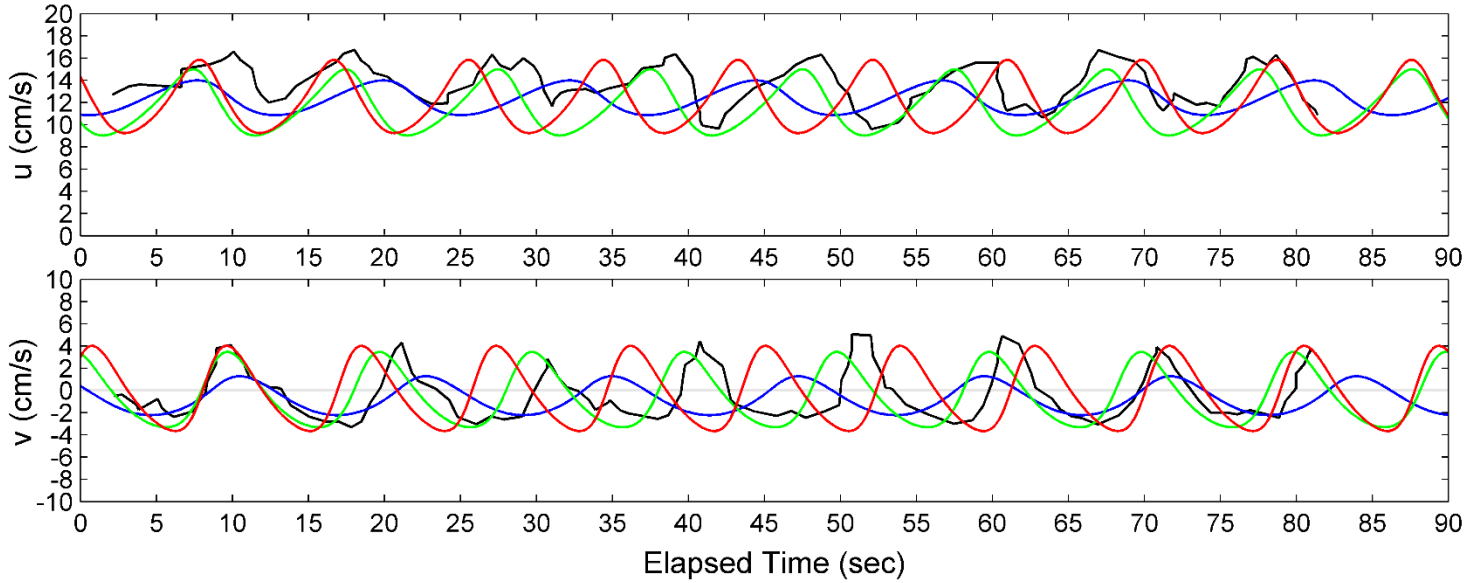



# BM NO.1 – Velocity Comparison

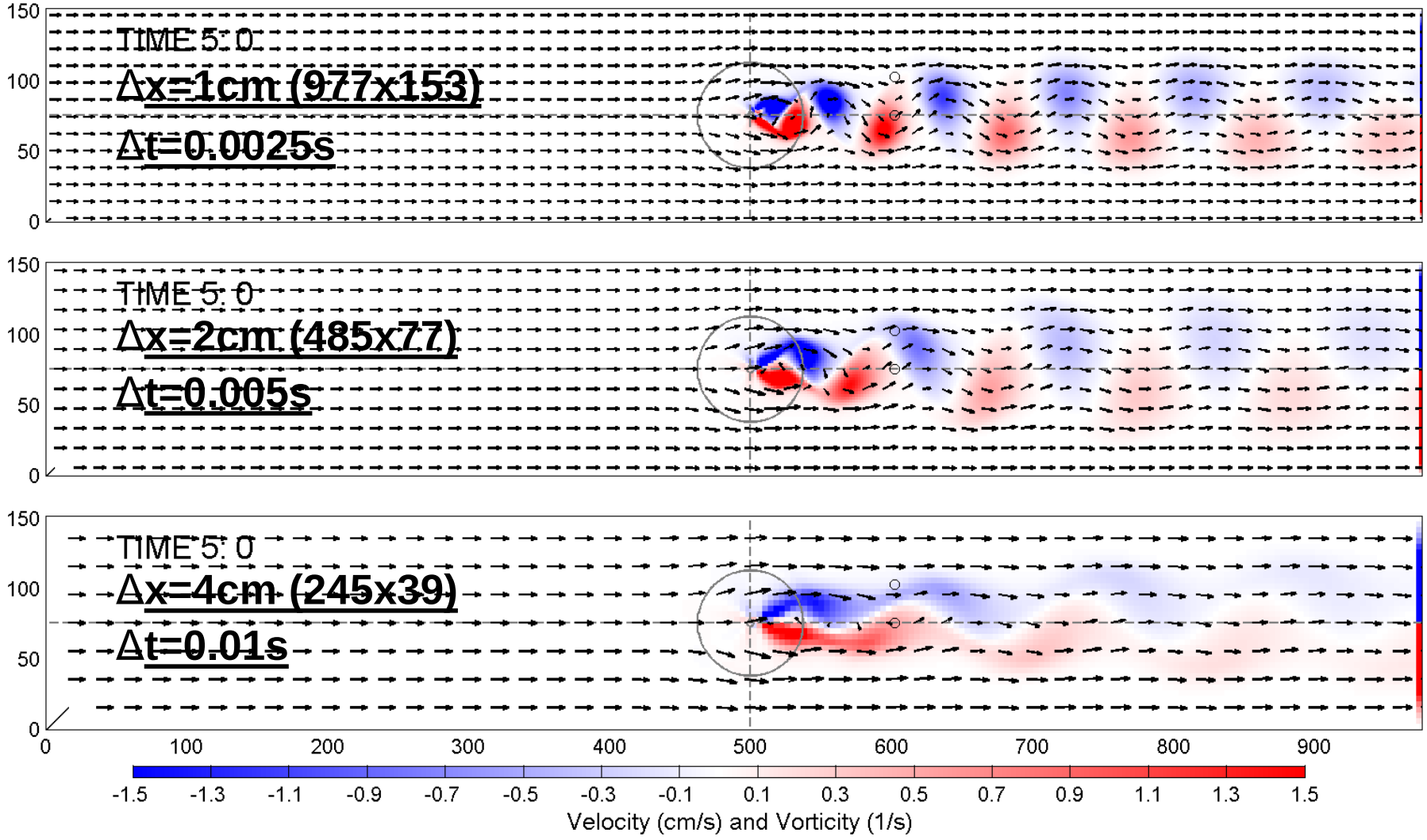
**center point** ( x, y ) = ( 1.02m, 0.00m )




**left point** ( x, y ) = ( 1.02m, 1.27m )

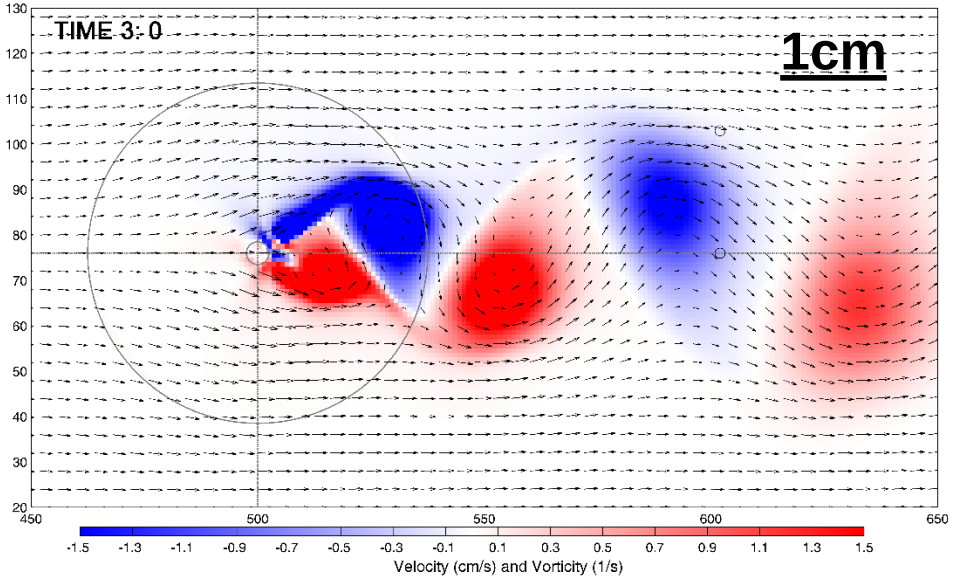


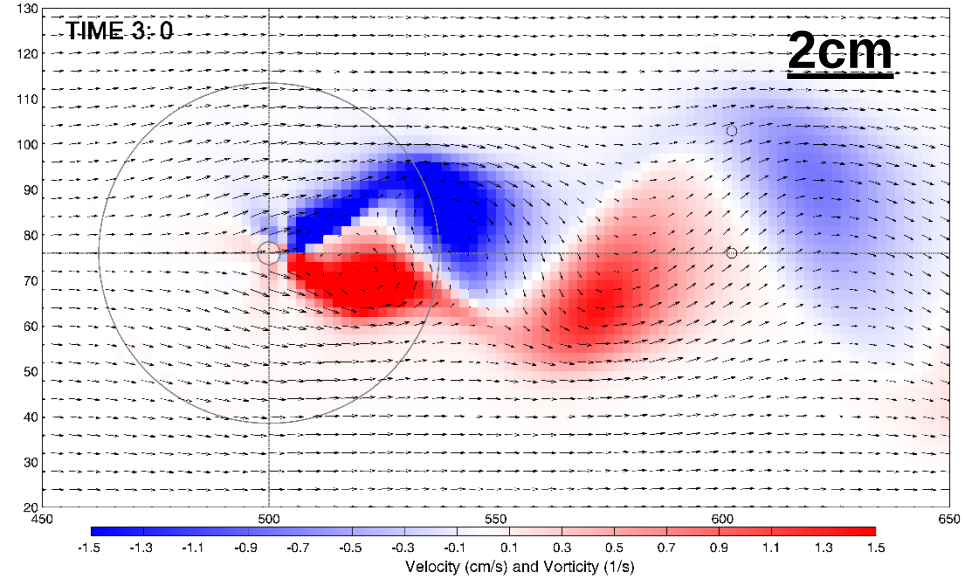
# BM NO.1 – Vortex Field Comparison

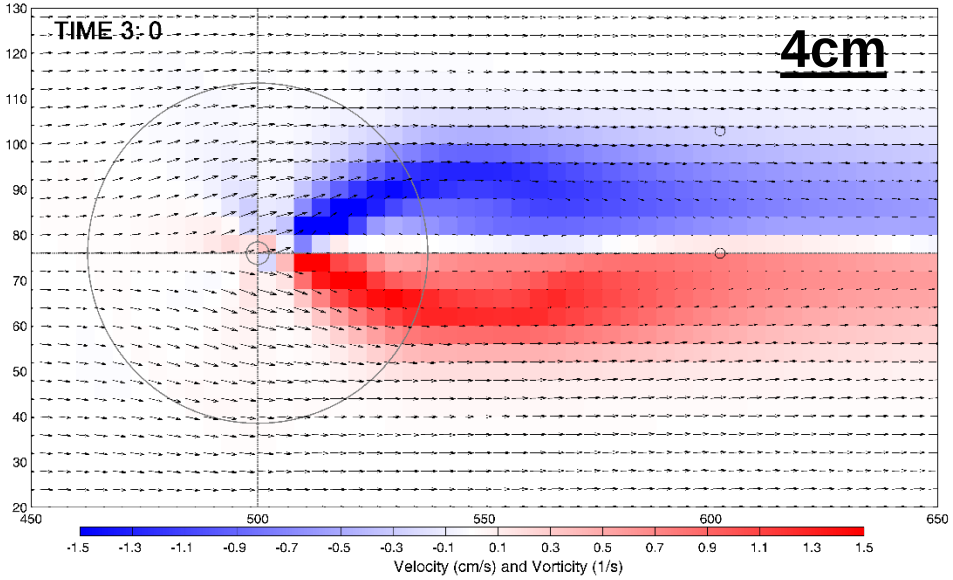


# BM NO. 1 – Vortex Field Closeview

- Vortices are formed faster in finer grid
- Clear boundary between clockwise and counterclockwise vortex field

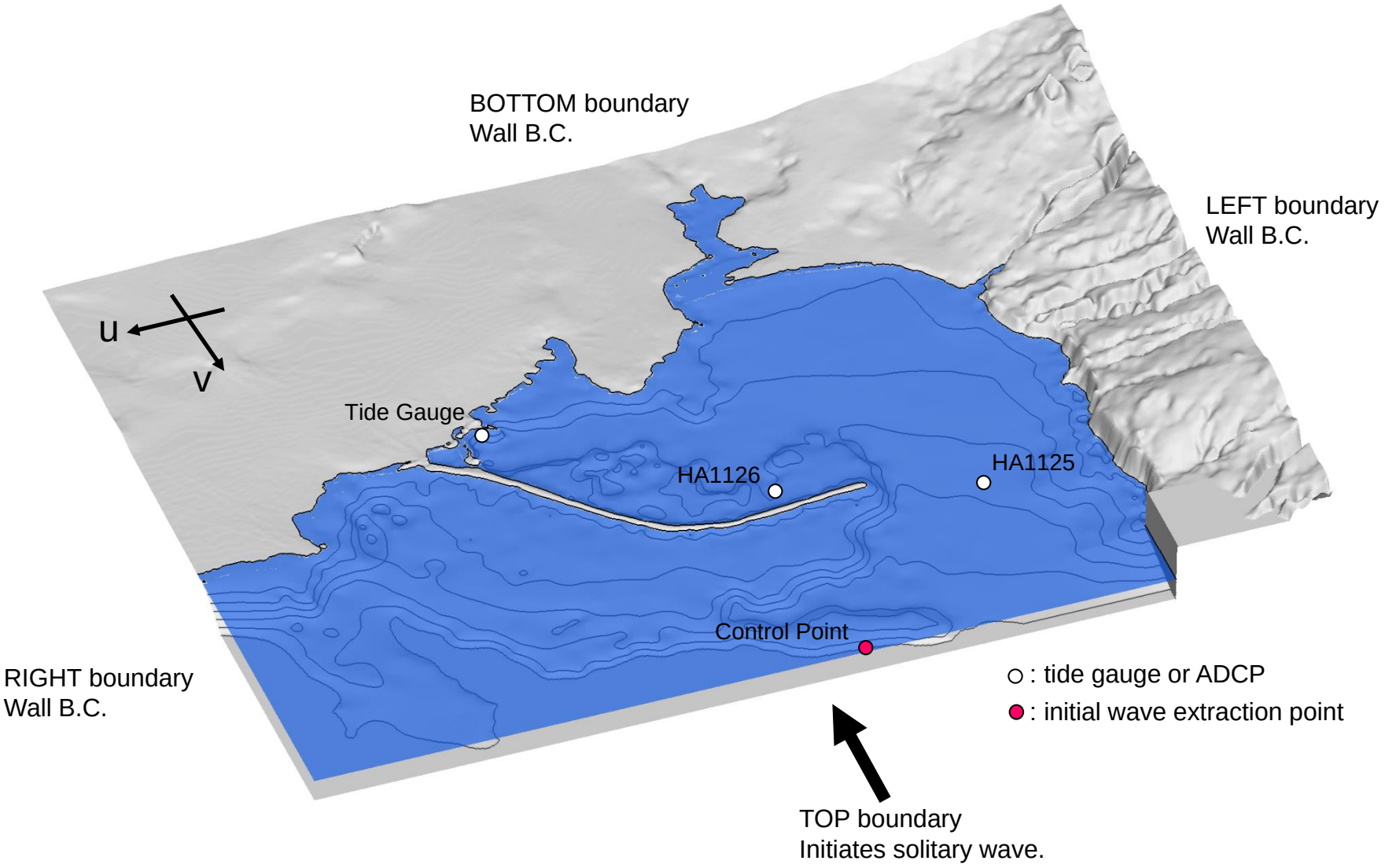


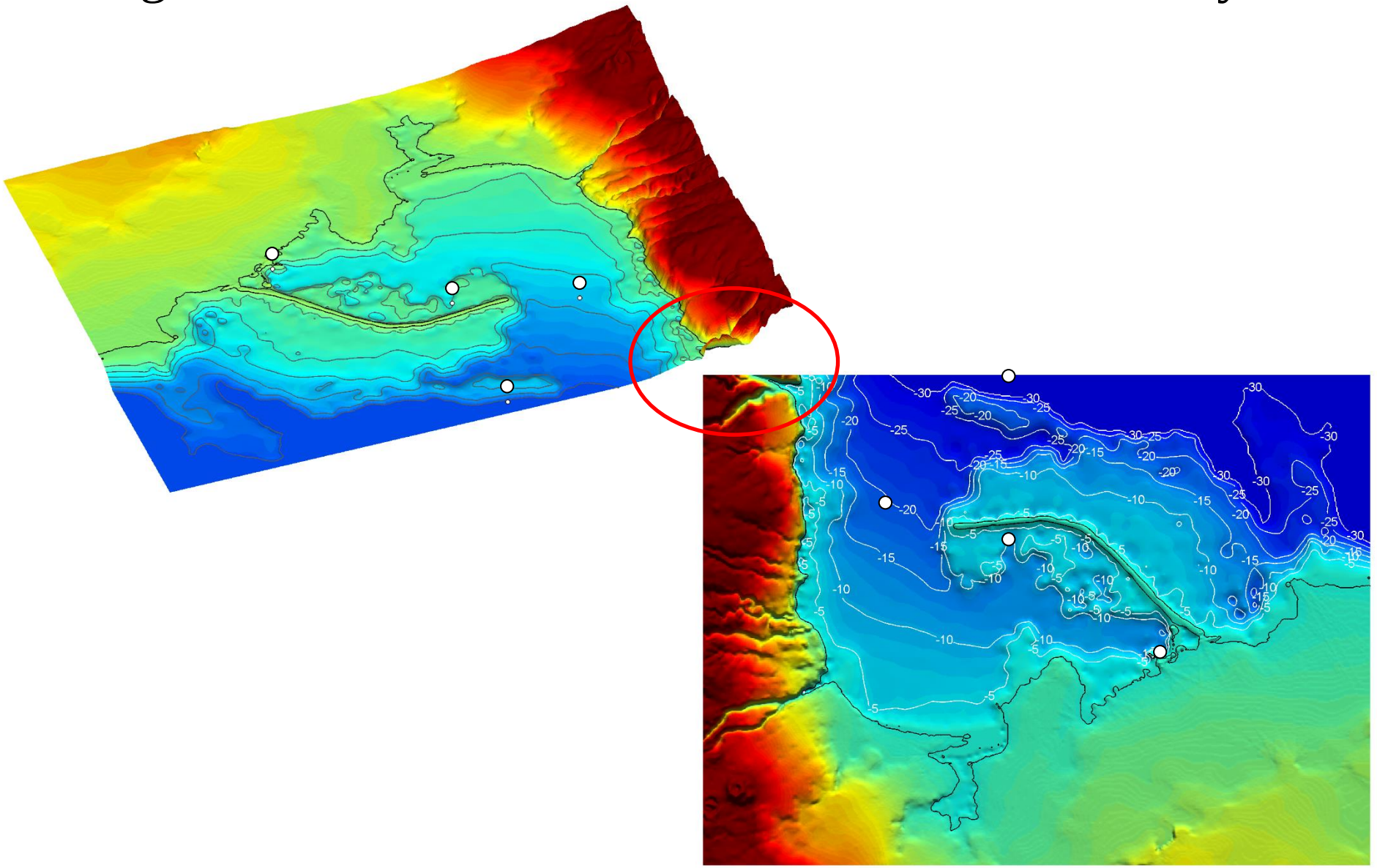
# BM NO.2

## Shallow-Water Flow around Hilo Bay



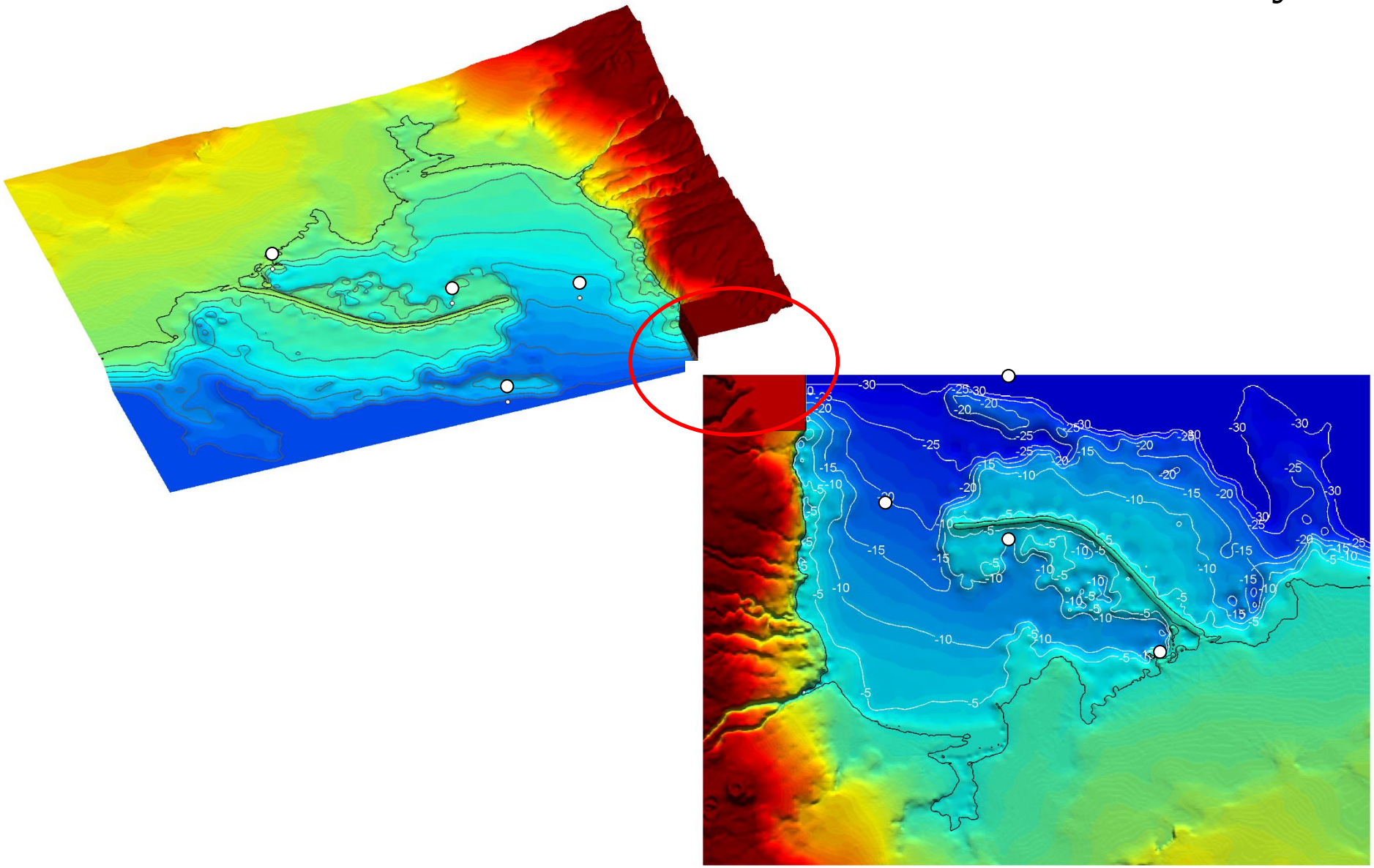
# BM NO.2: DEM Data Modification

Original NTHMP Hilo DEM Data - Induce Instability

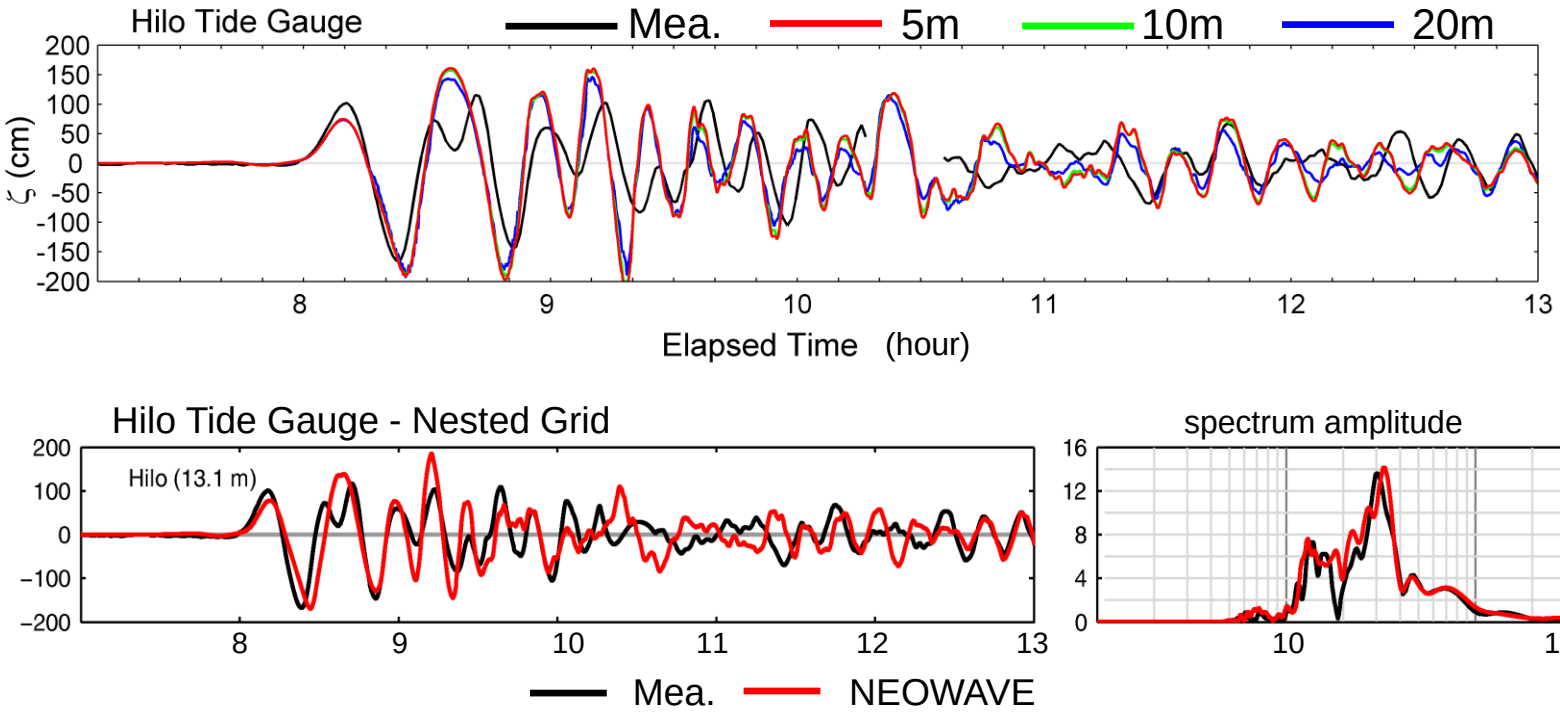


# BM NO.2: DEM Data Modification

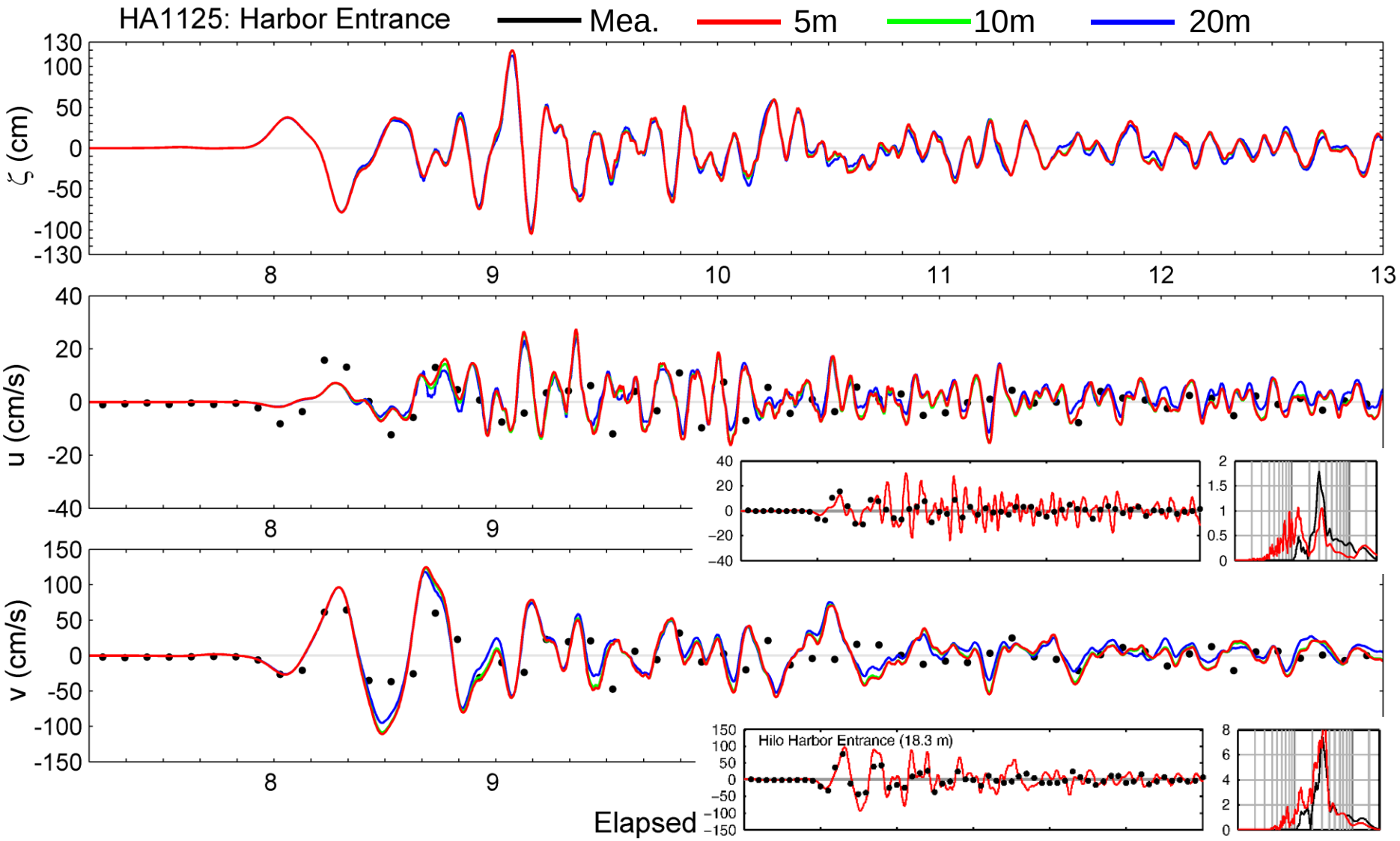
Modified NTHMP Hilo DEM Data - Remove Instability



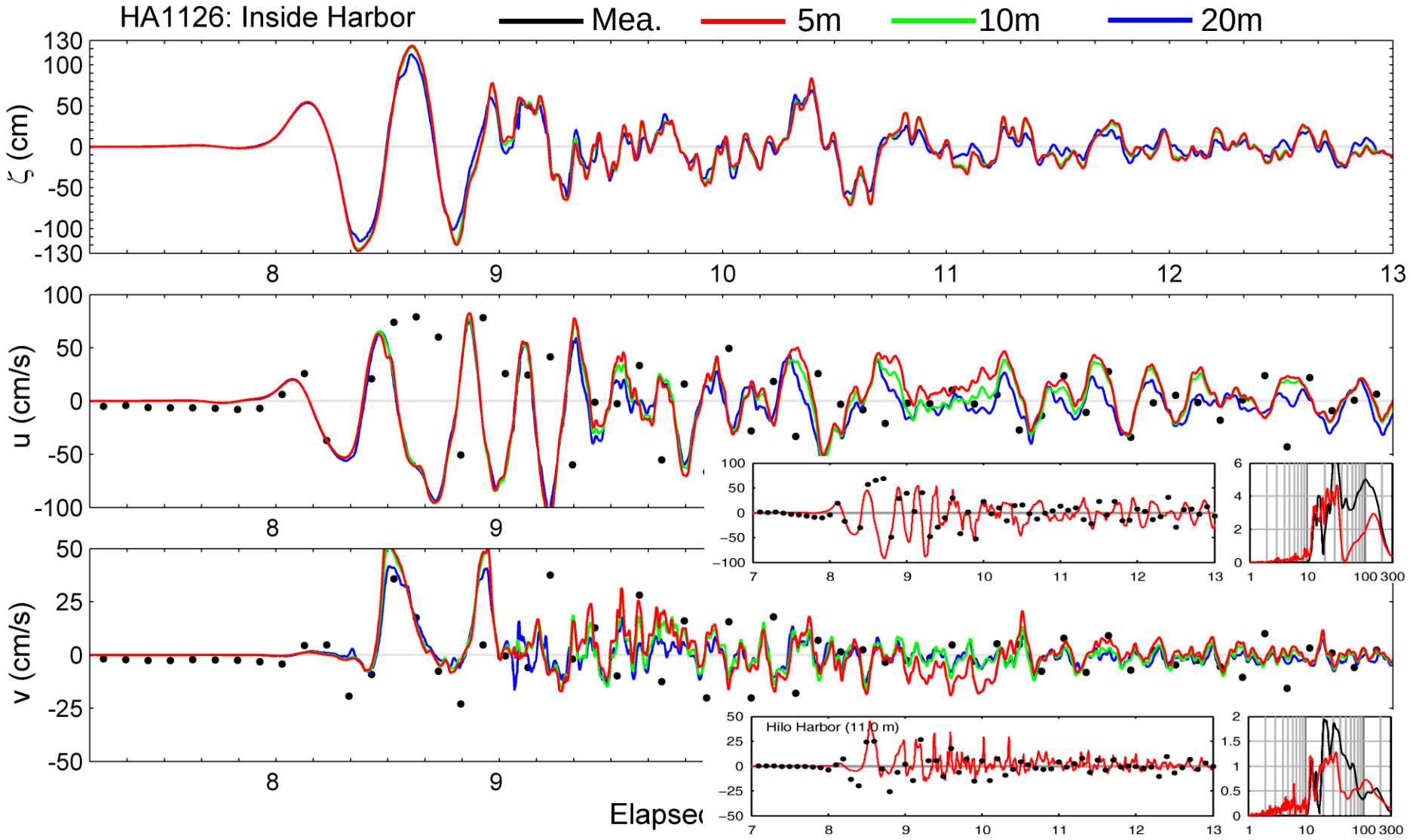
# BM NO.2 – Tide Gauge Comparison



# BM NO.2 – Velocity Comparison

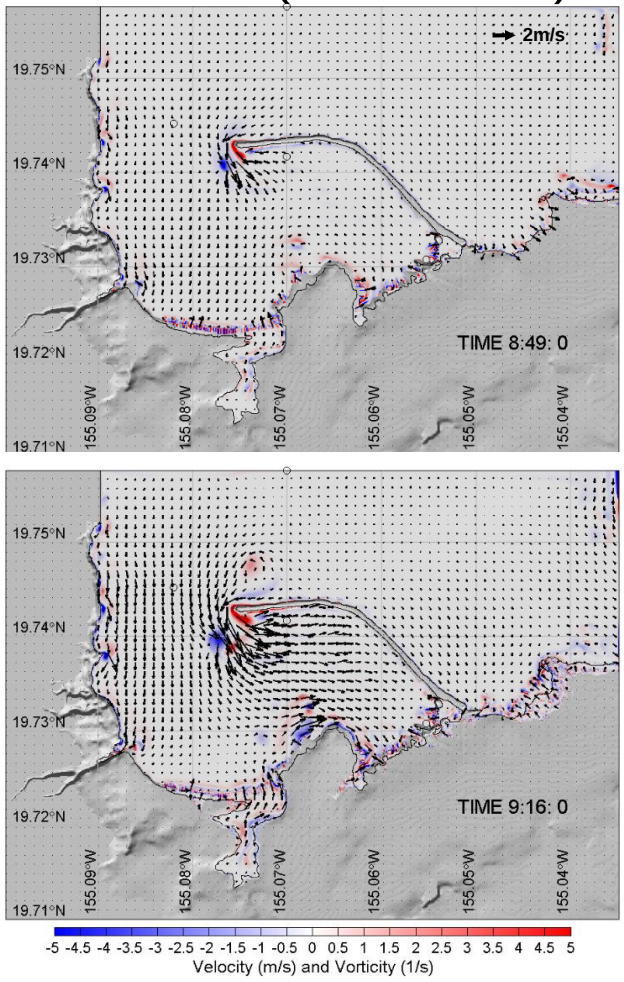


# BM NO.2 – Velocity Comparison

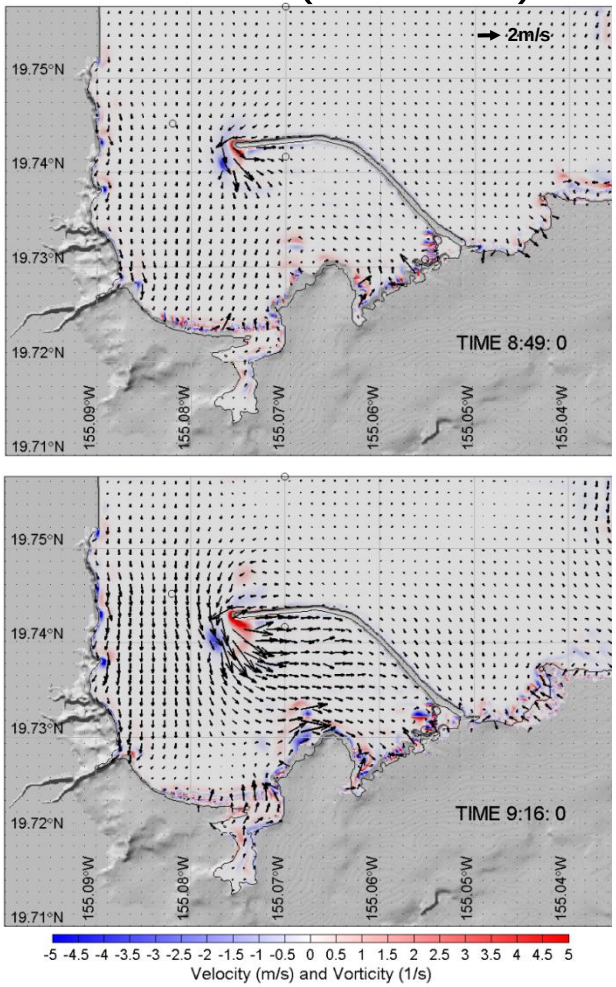


# BM NO.2 – Vortex Field Comparison

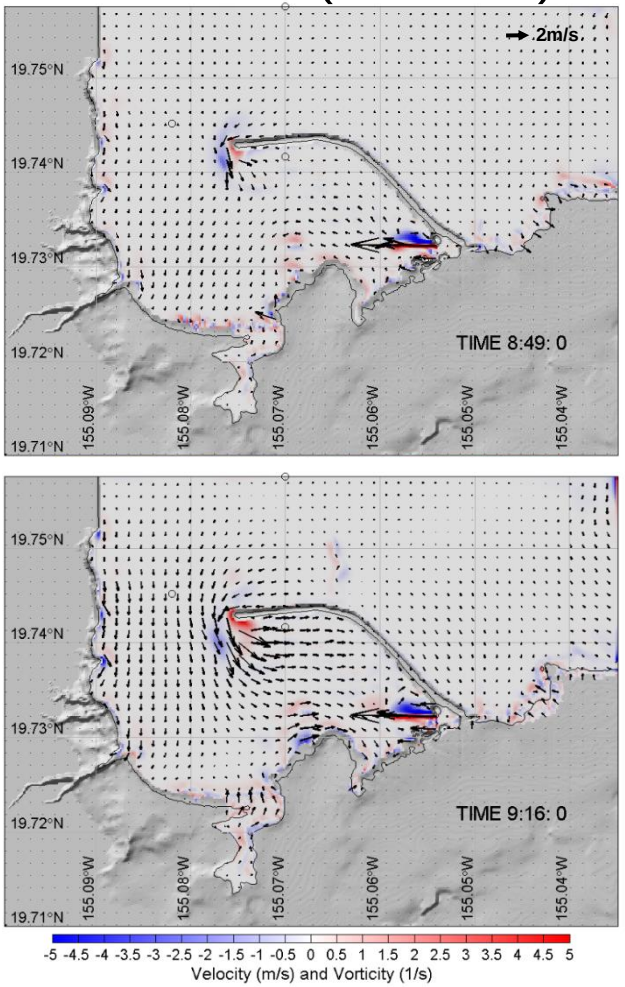
Δt=0.025s
Δx=5m (1401x1029)




Δt=0.05s
Δx=10m (701x515)




Δt=0.1s
Δx=20m (351x258)



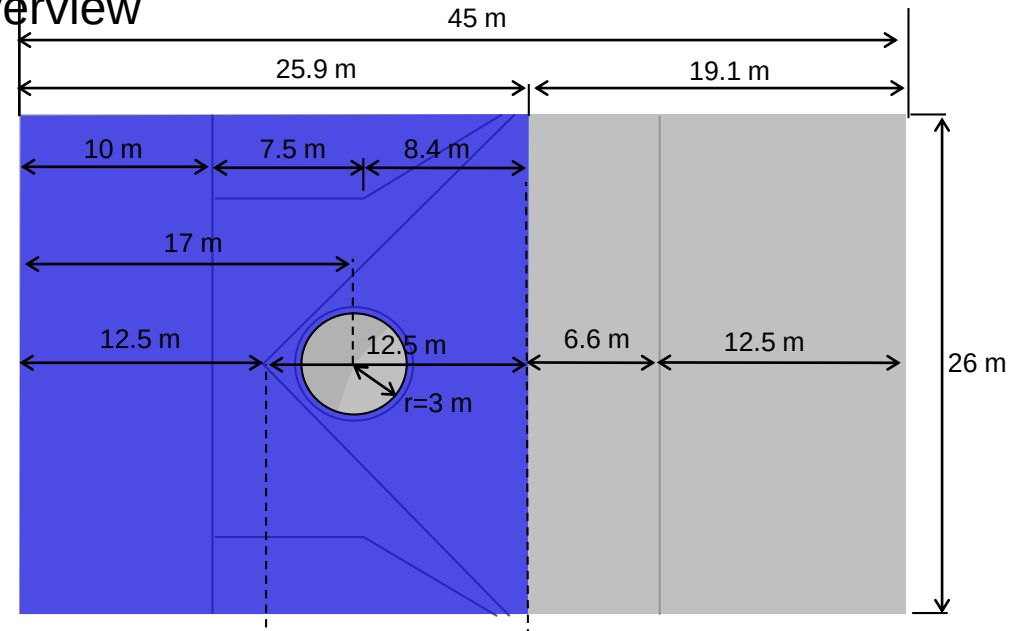
# BM NO. 5

## Shallow Shelf with a Conical Island

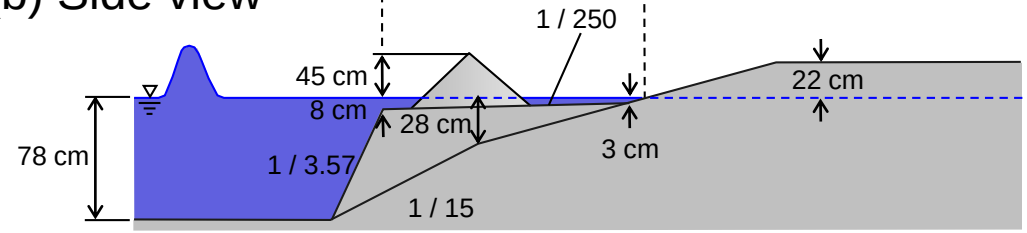
- Inundation Science & Engineering Cooperative (ISEC) Community Workshop
- Oregon State University, Corvallis, Oregon, July 8 - 10, 2009 (http://isec.nacse.org/workshop/isec_workshop_2009/)



(a) Overview




(b) Side view



# BM NO. 5

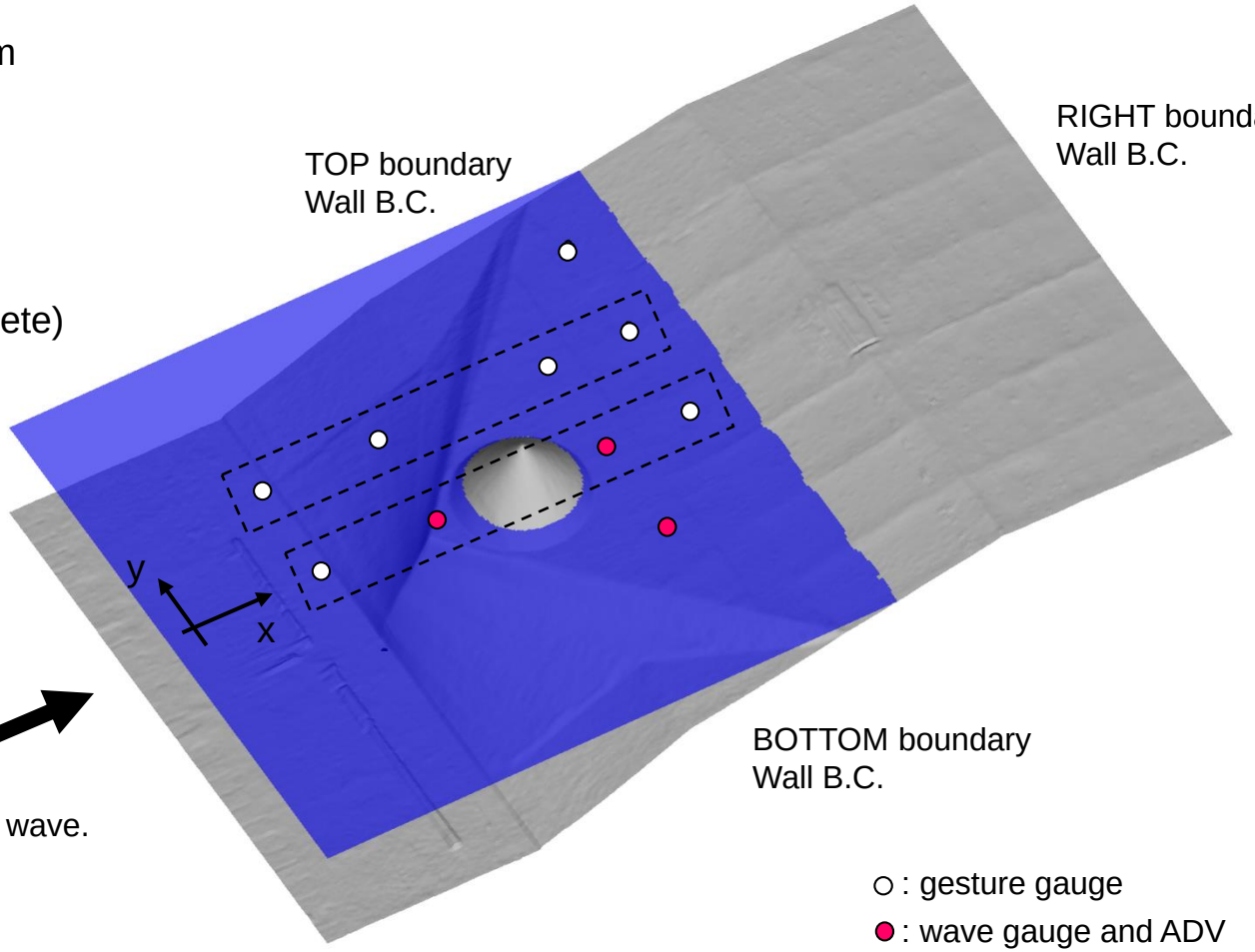
## Model Setup

Gird spaces:
$\Delta x = \Delta y$ = 5cm, 10cm, 25cm

Time step:
$\Delta t$ = 0.002s, 0.003s, 0.01s

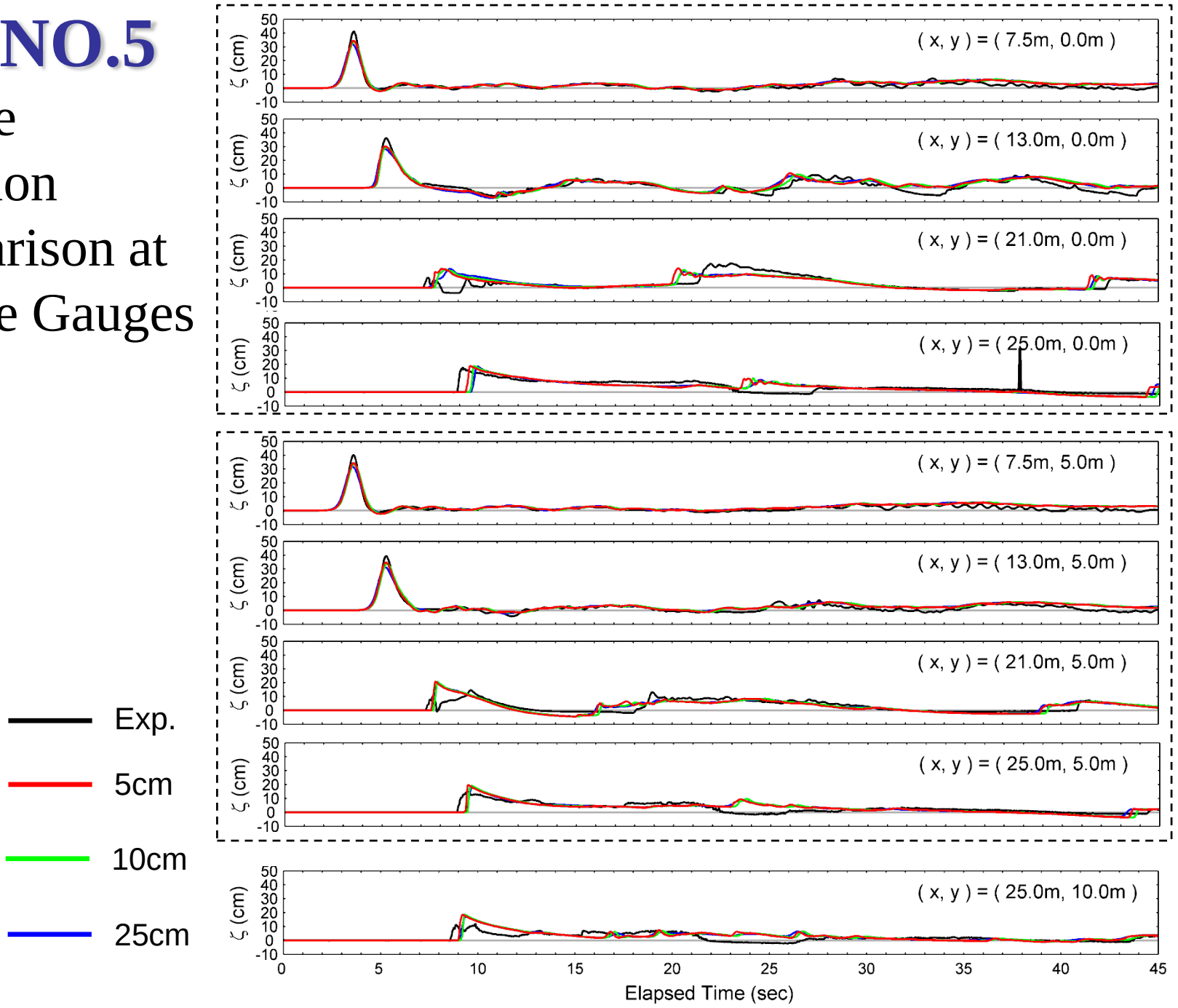
Manning coefficients:
$n$ = 0.012 (for finished concrete)

Initial condition
Solitary wave
$h$ = 78cm
$A$ = 0.5 $h$



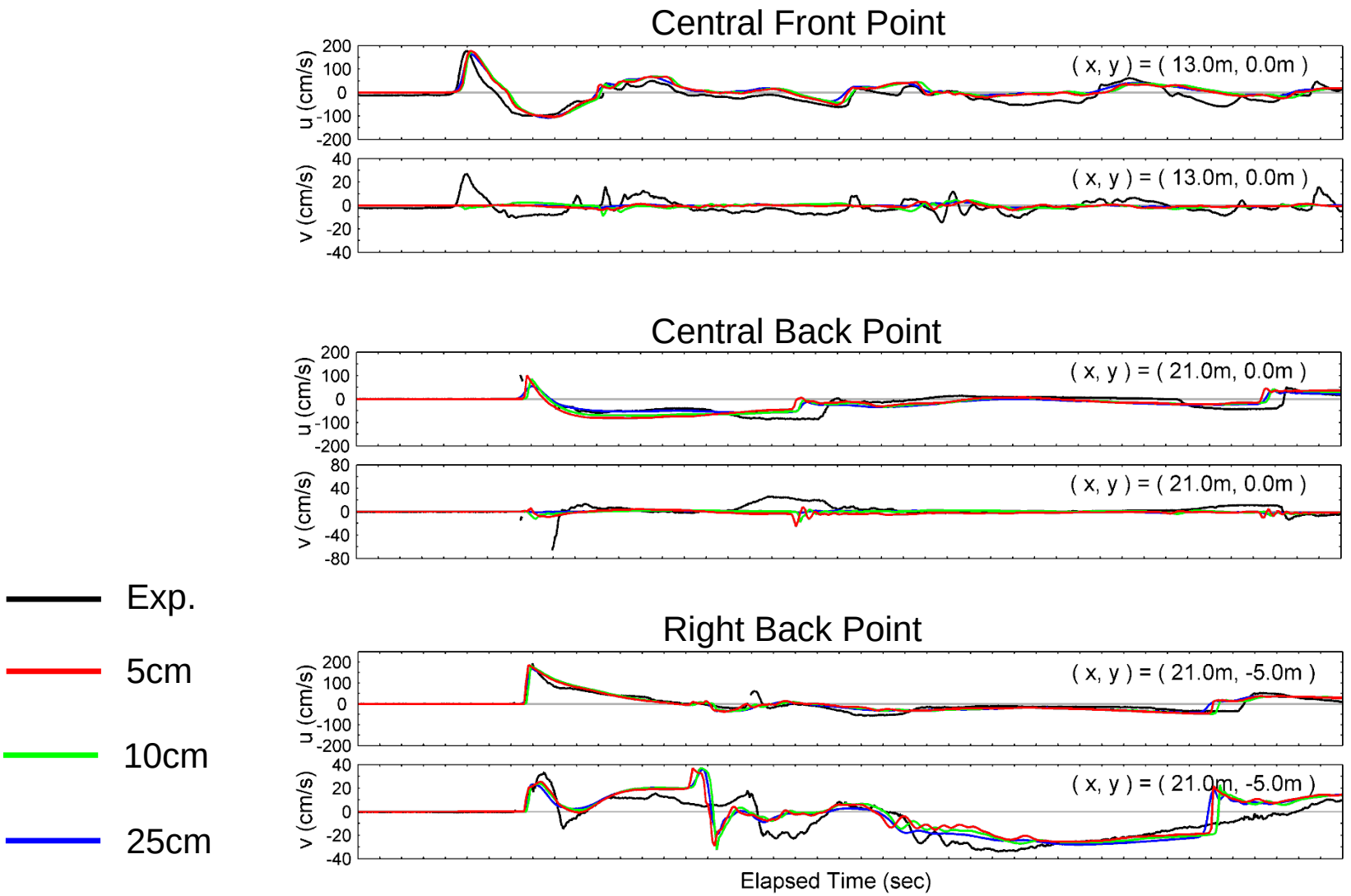
# BM NO.5

Surface Elevation Comparison at Gesture Gauges



# BM NO.5

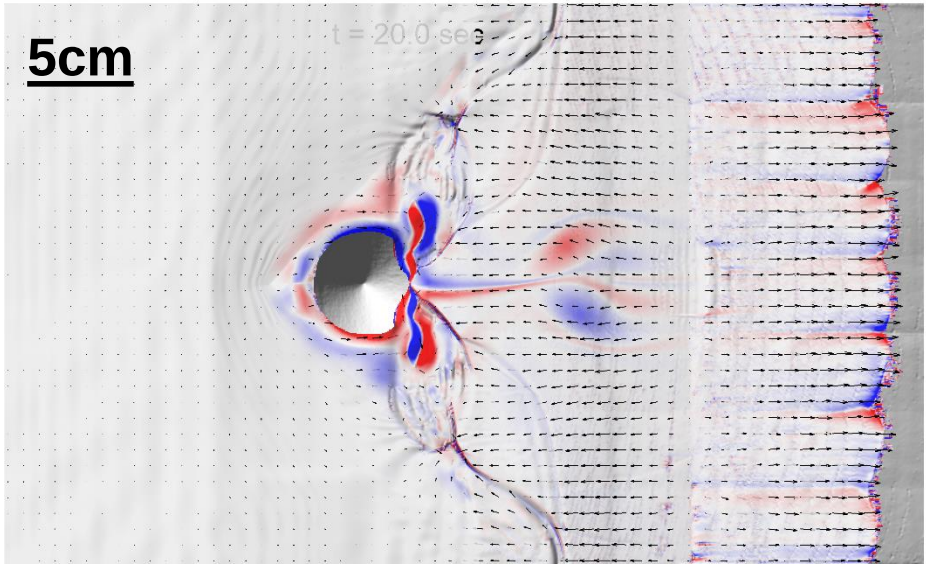
## Velocity Components Comparison at ADVs

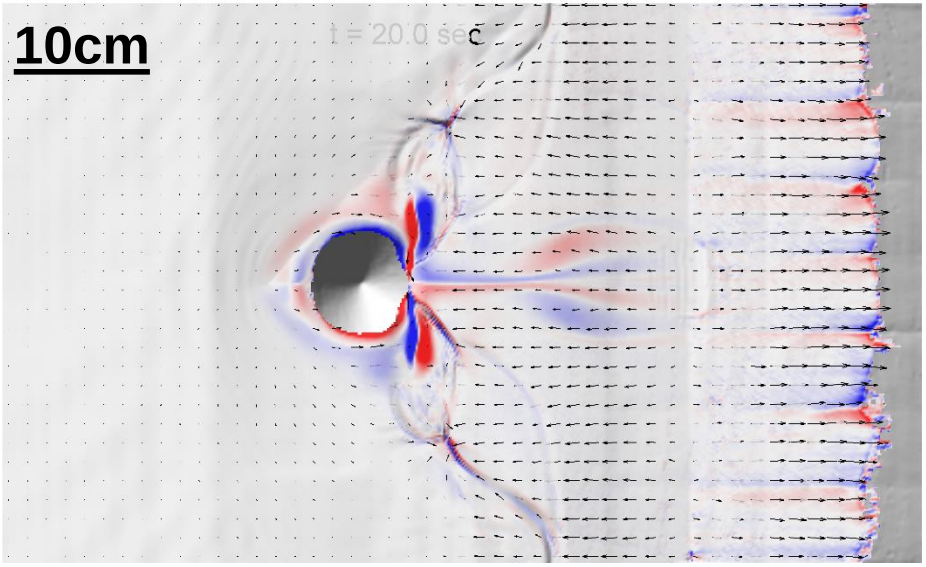


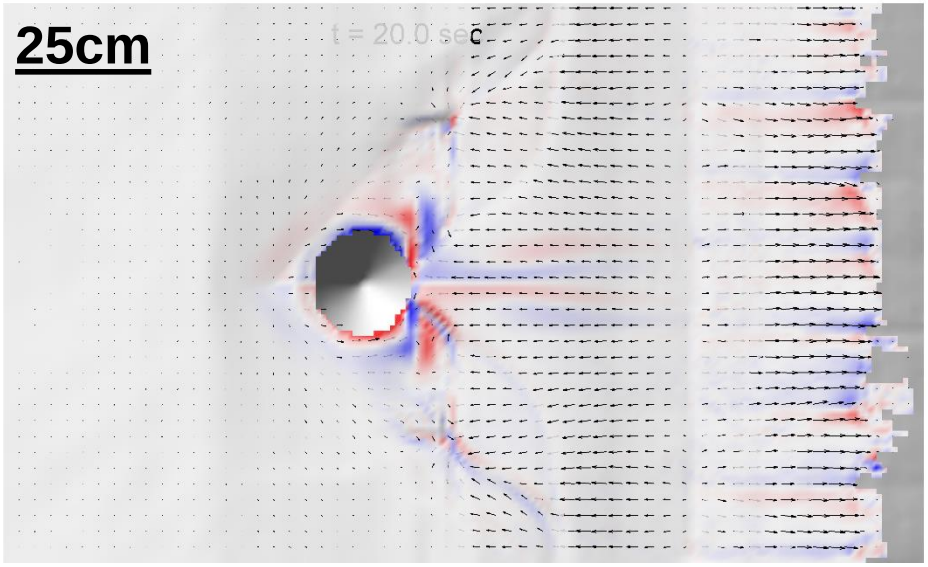
# BM NO. 5

## Vortex Field Comparison

- Vortices are generated in the wake and around the island
- Vortex strength is weaker in coarser grid but general pattern remains in all three grid sizes
- Runup process also involve vortex field



# Conclusions

- NEOWAVE can reproduce the mean flow which is less sensitive to resolution
- Numerically generated vortex field depends on
  - Spatial and temporal resolution
  - Bottom friction
  - Numerical scheme
  - Generation mechanism
- Relation with physical vortex field