

**WEDA Webinar**

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# **High fidelity Numerical Modeling : Coastal hydrodynamics and morpho dynamics**

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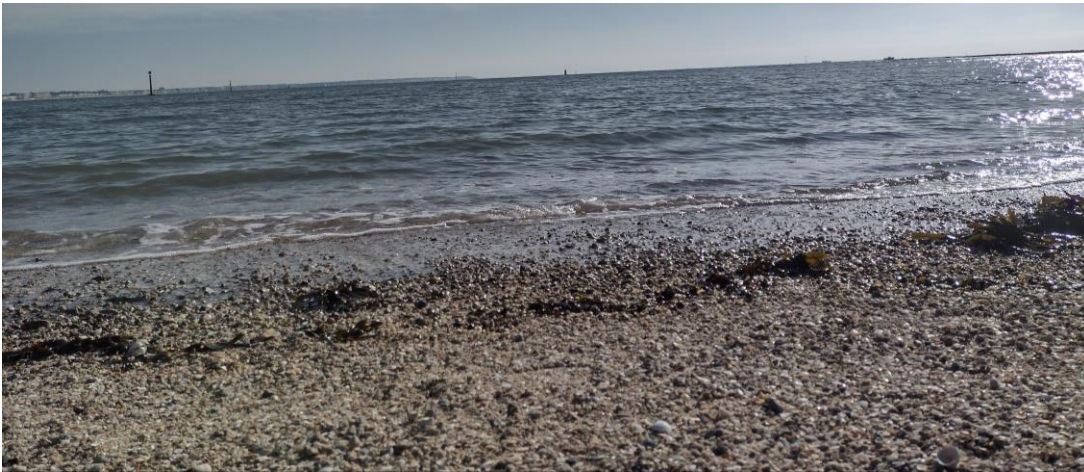
# Outlines

- Introduction –Need to understand mobility of sand grains.
- Numerical Model Set up .
- Hydrodynamics Study : Wave evolution and runup comparison with experimental data.
- Morphological study: Beach profile and comparison with experimental data.
- Sediment transport profiles.
- Summary.
- Conclusion and Take home message :Dredging and coastal communities.

# Introduction



Port sedimentation - @DHI group

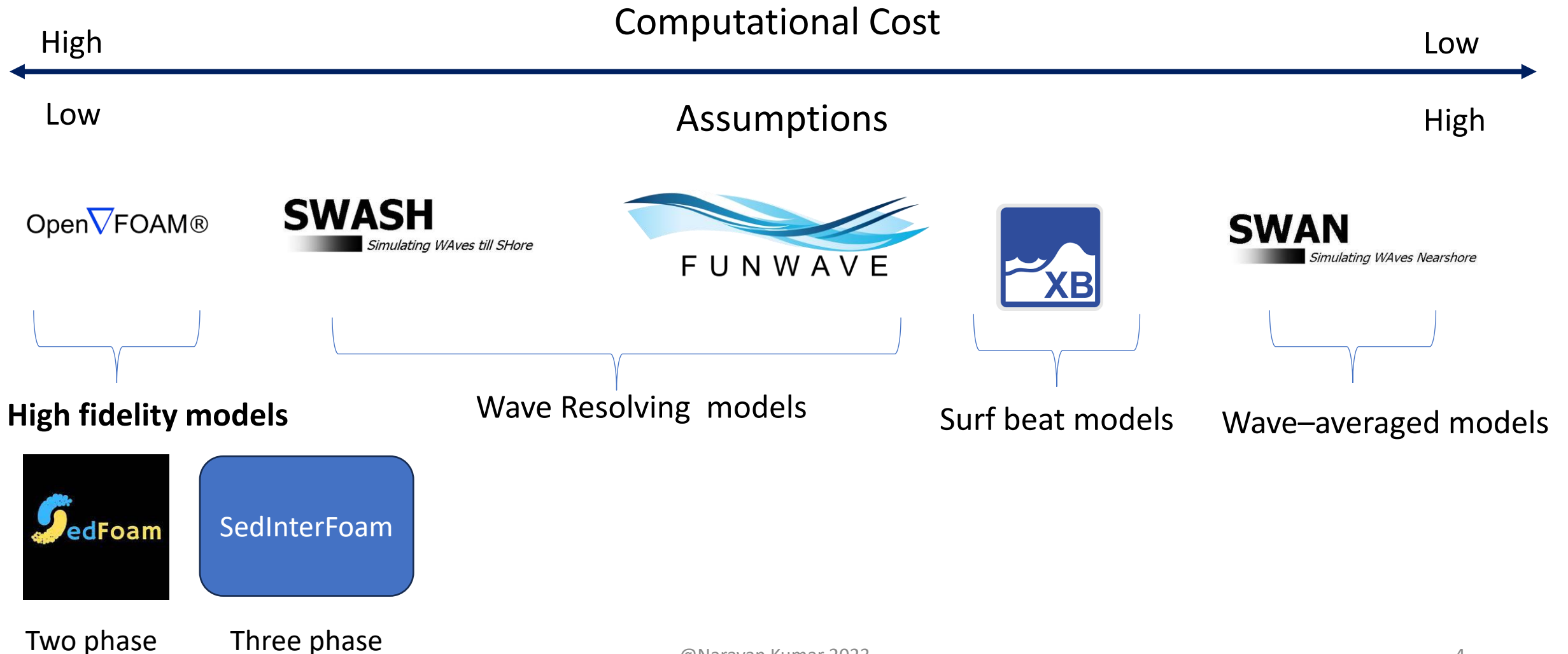


Le Pouliguen Beach , France - @Narayan



Coastal erosion of sea cliffs at Happisburgh, Norfolk UK -@Andrew Dunn

# Introduction



# Modeling Coastal Sediment Transport using “sedInterFoam”

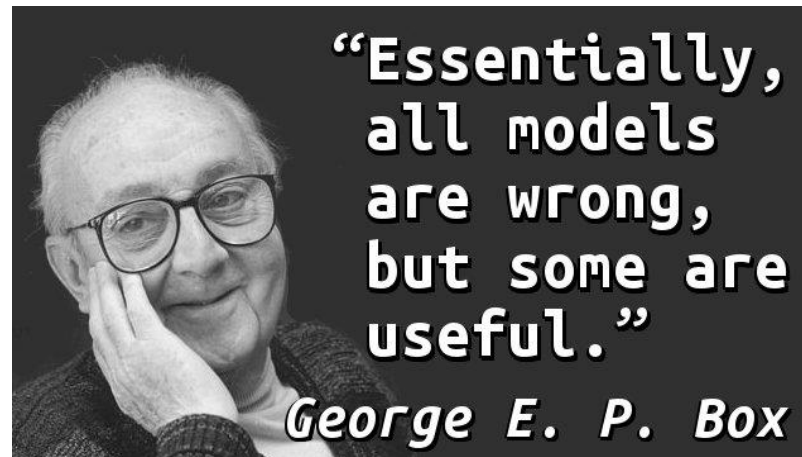
○ sedFoam - resolves sediment transport phenomena

Cheng et.al 2017

○ waves2Foam - wave generation and absorption

N.G.Jacobsen et.al 2012

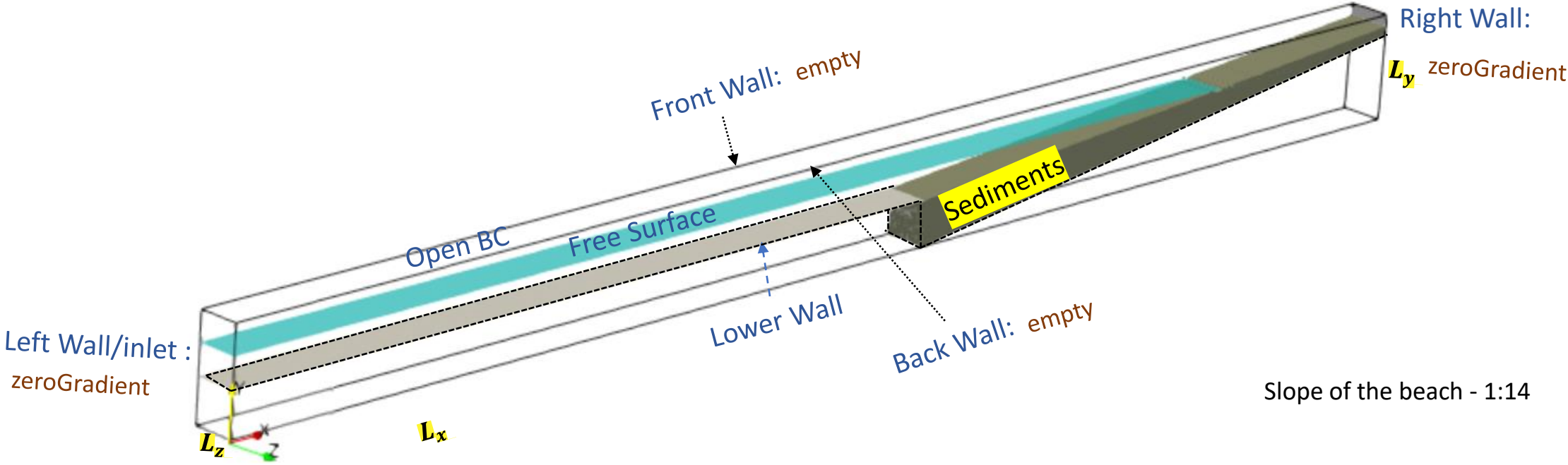
**sedFoam + waves2Foam + 3<sup>rd</sup> phase (air) interface = sedInterFoam**



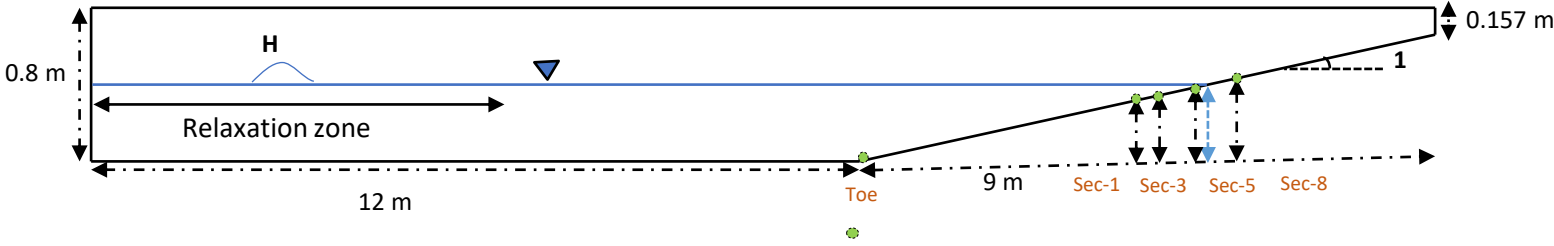
# Numerical Model Set Up

- Two-dimensional three phase flow solver.
- Using open Source CFD toolbox OpenFOAM®
- Modeled using  $\kappa - \epsilon$  Reynolds Averaged Navier Stokes ( RANS)
- Time step is adaptive
- Maximum CFL (Courant–Friedrichs–Lewy) condition: 0.1 - For convergence
- Interface tracking – Volume of fluid (VOF) method

# Boundary condition



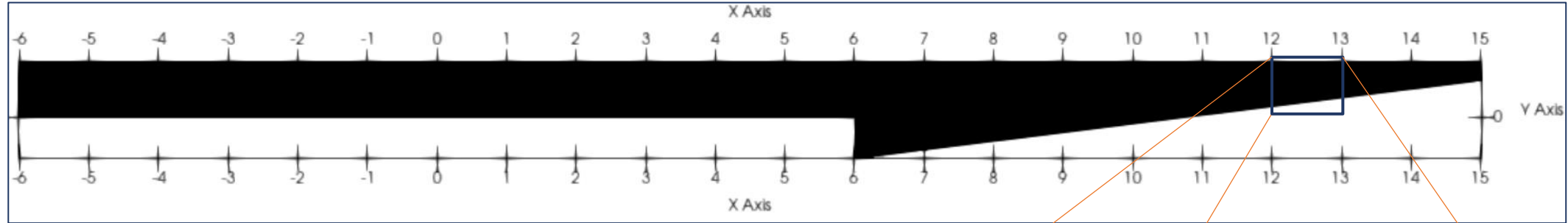
Slope of the beach - 1:14



# Mesh design( Unstructured)

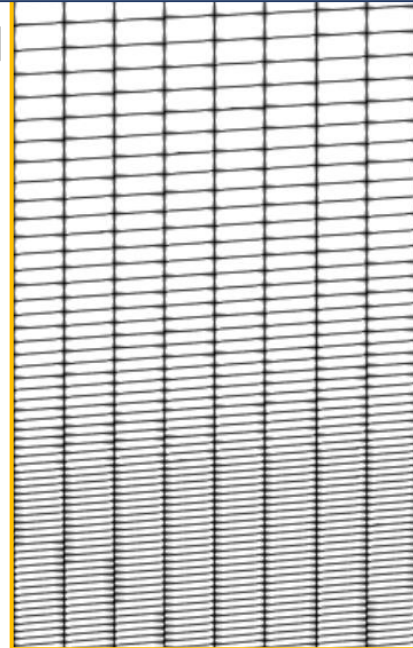
“Mesh design is the heart and soul of the Numerical modelling”

[A]

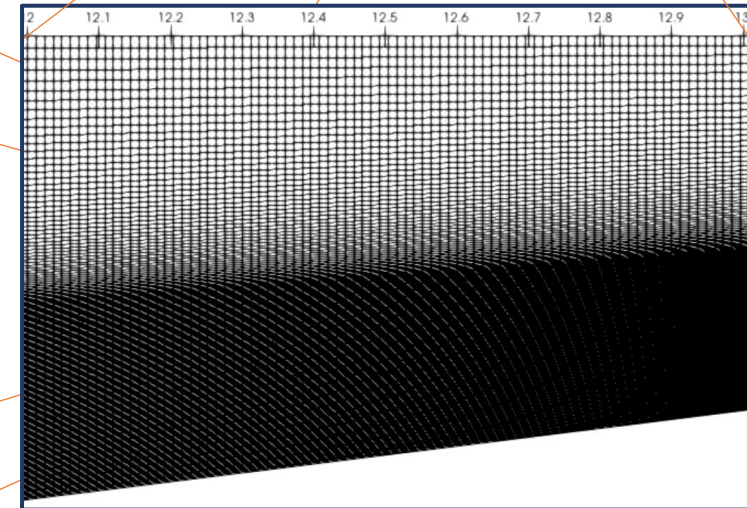


$N_x \times N_y \times N_z = 1750 \times 55 \times 1$

[C]



[B]



*Sediment pit* :  $N_x \times N_y \times N_z = 748 \times 37 \times 1$



# Sediment ,Wave Parameters and Numerical Probes

## Solitary Wave

Water surface elevation

$$\eta = H \operatorname{sech}^2 \left( \sqrt{\frac{3gH}{4}} \frac{1}{h} t \right)$$

Length of the sediment bed: 8.976 m (From Toe to end of the beach)

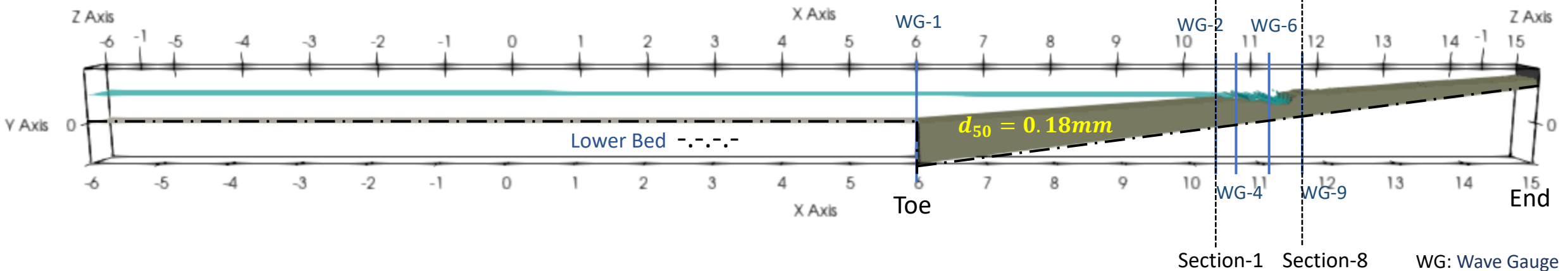
Thickness/Height of sediment bed : Varying along the beach slope

: At section-1 - 34.4 cm / 0.344m

## Wave Parameters

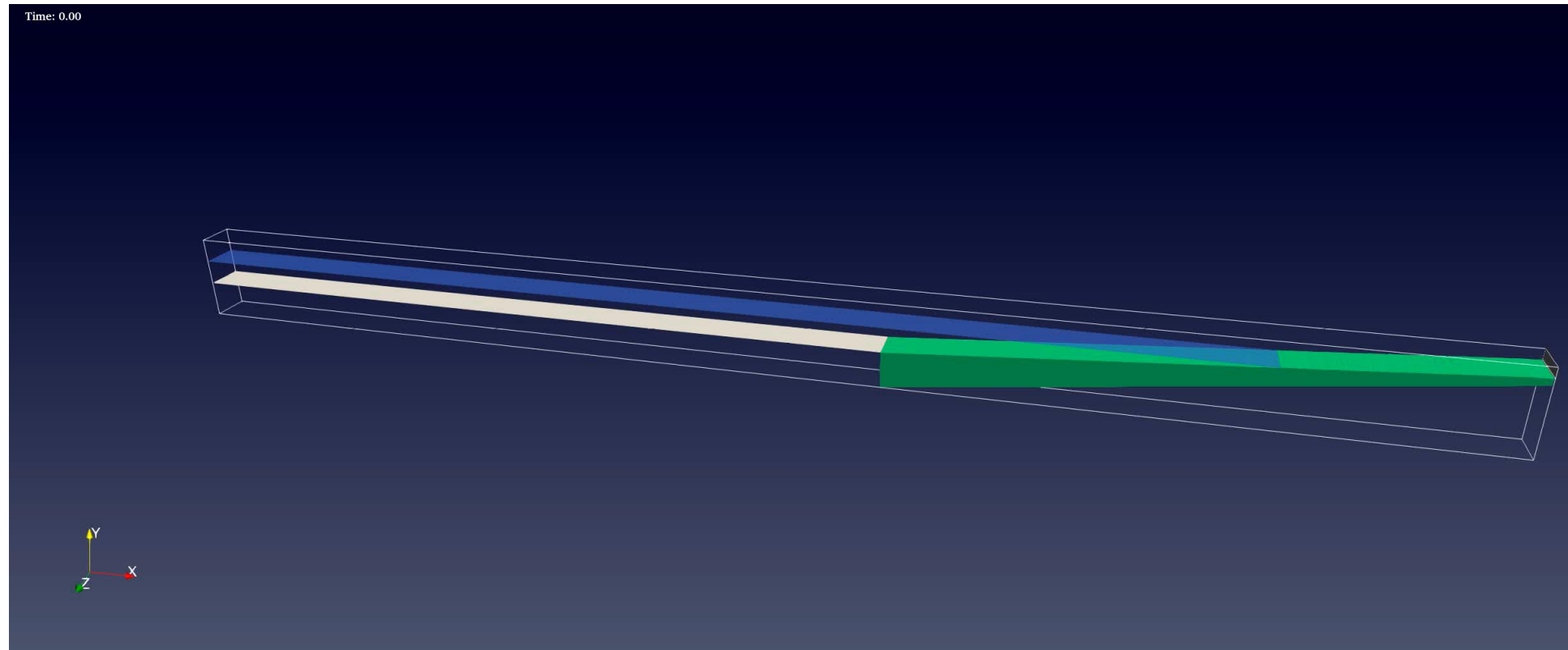
| Water Depth [h] | Wave Height [H] | Wave period [T] |
|-----------------|-----------------|-----------------|
| 0.4 m           | 0.071m          | 3.48 s          |

$$T = 2\pi \sqrt{\frac{4}{3gH}} h$$

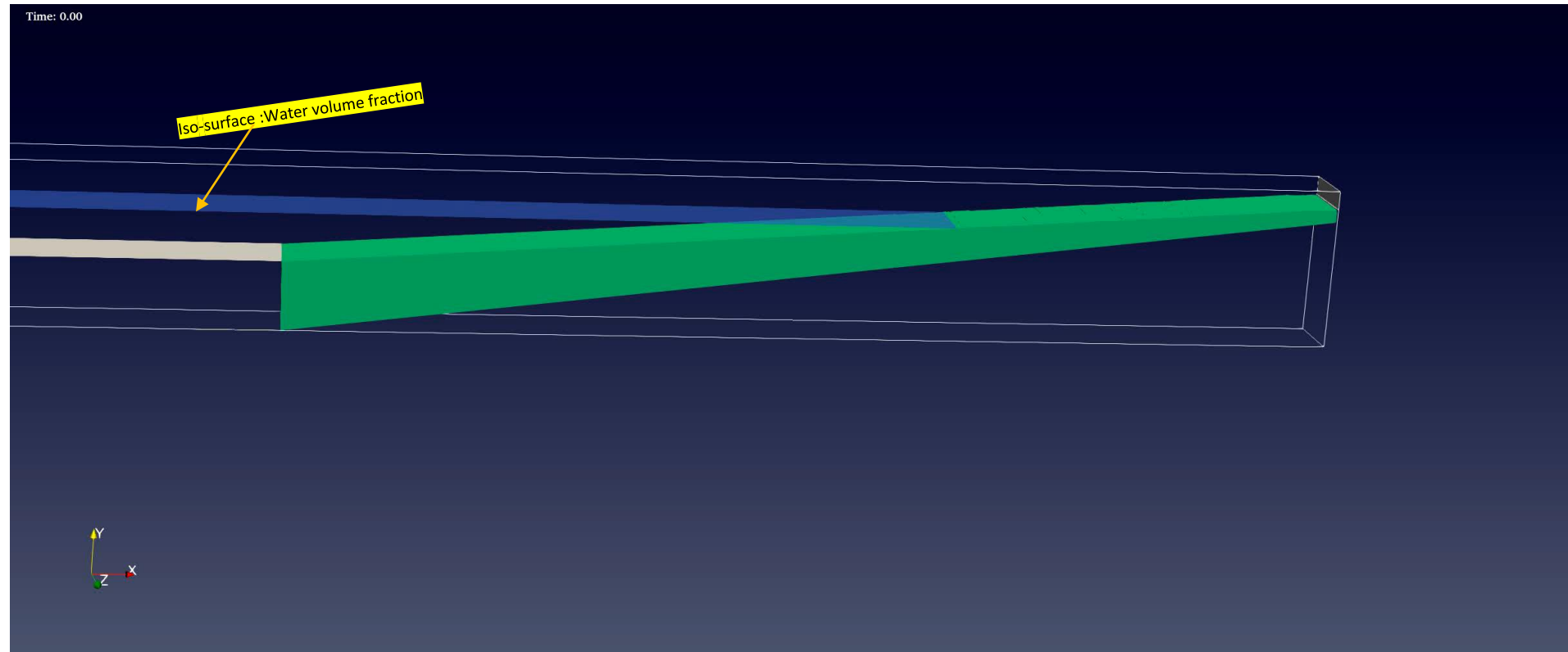


|      | Sec-1 | Sec-3 | Sec-5 | Sec-8 |
|------|-------|-------|-------|-------|
| y(m) | 0.331 | 0.348 | 0.382 | 0.418 |
| x(m) | 10.63 | 10.87 | 11.35 | 11.85 |

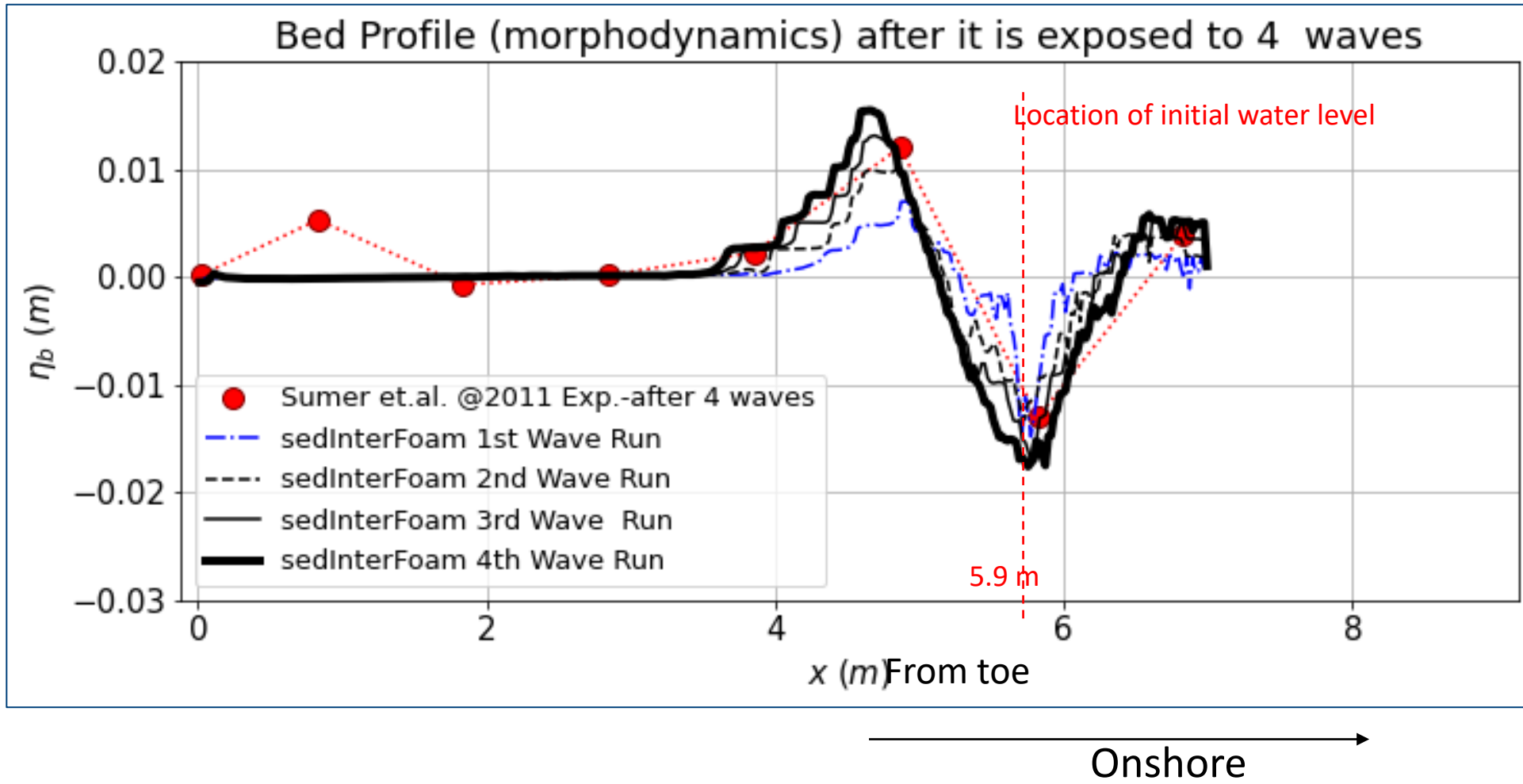
# Hydrodynamics and morpho dynamics



# Hydrodynamics and morpho dynamics



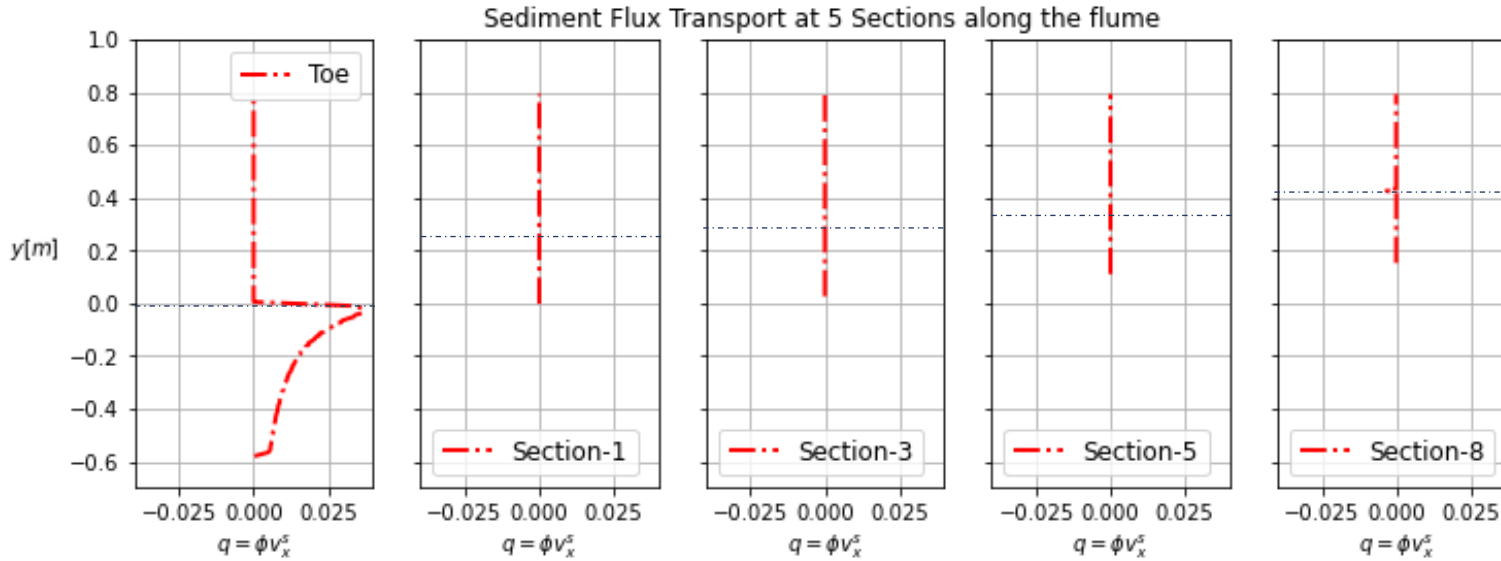
# Wave induced morpho dynamics



Conclusion : Evolution of bed profile is in good agreement with the experimental result of Sumer et.al.@2011

Accretion (erosion) seaward (landward) of break point

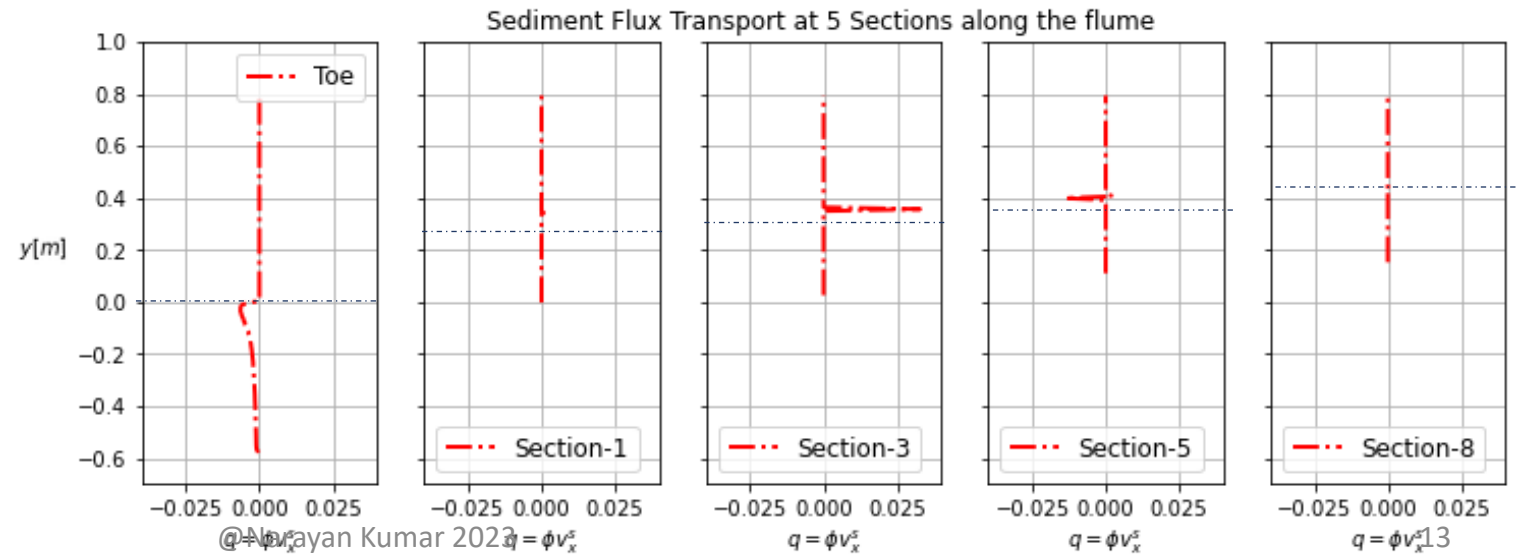
# Sediment transport profile- 1st Wave Run



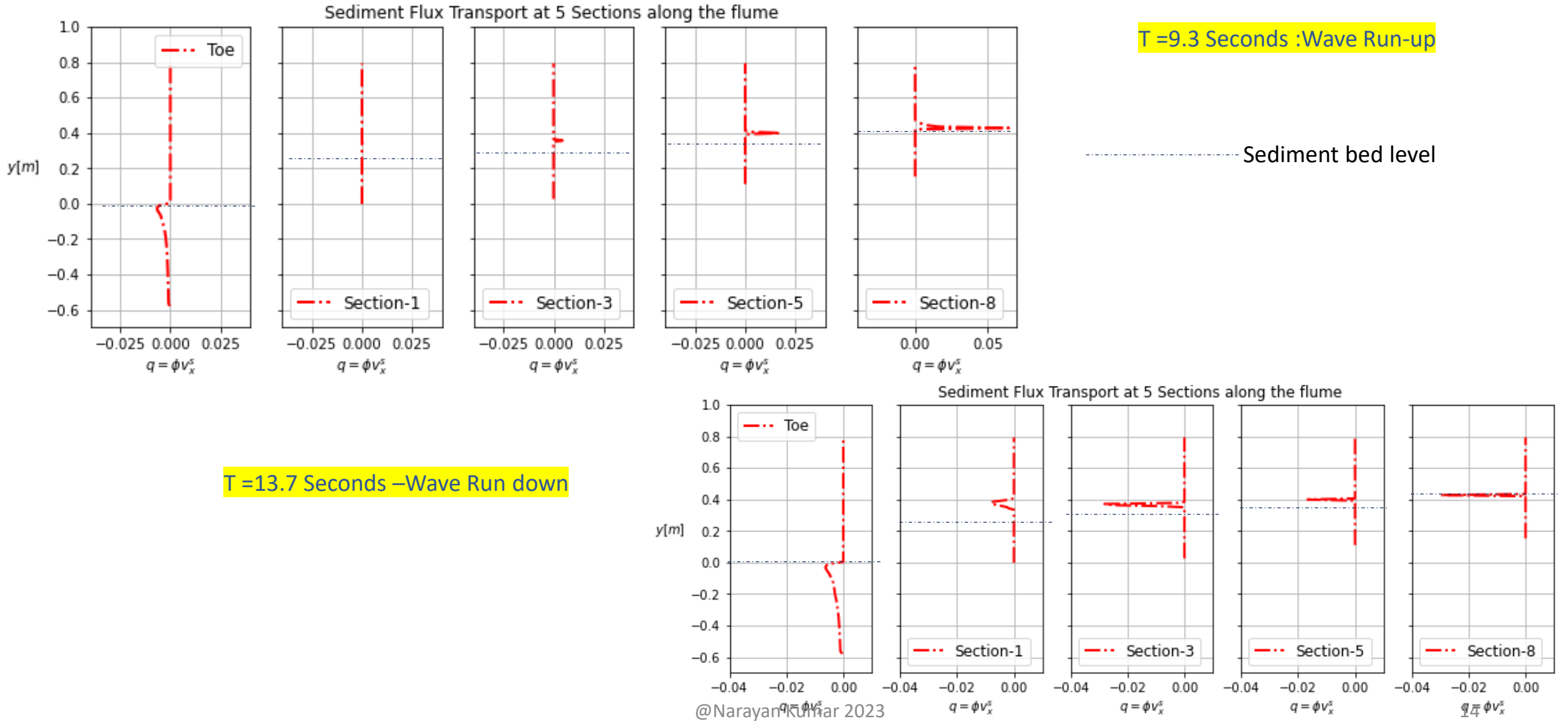
T = 5.5 Seconds : Wave propagation and Shoaling

..... Sediment bed level

T = 8.4 Seconds – Wave Breaking



# Sediment transport profile-1st Wave Run



# Summary

## Sediment(Erodible) Bed

- Water surface elevation shows discrepancy with measured data during rundown due to weaker hydraulic jump, which may be due to higher permeability of sediment bed in the model.
- Predicted beach profile evolution is in good agreement with the measured data.
- Sediment flux profiles are examined.

# Conclusion and Take home Message

- sedInterFoam (3 phase solver ) is an extension of sedFoam (2 phase solver ).
- sedinterFoam inherited the features of sedFoam 's turbulence resolving models (RANS or LES).
- Implementation of the open source three-phase flow model sedInterFoam opens the way to investigate coastal processes in the swash zone or configurations for which free surface effects are not negligible.
- The model has been successfully applied to a two-dimensional solitary wave breaking configuration to compare the numerical results with the existing experimental results ( Sumer et.al.2011) and validated the implementation of the free surface resolution algorithm.



## **For dredging and coastal communities**

- Model has greater skill in predicting erosion and accretion of sediment.
- Sediment bed consolidation/liquification can also be predicted based on excess pore pressure.
- Quantifying the sediment transport will help in understanding the frequency of dredging .



**sedInterFoam**

Thank you everyone for your attention !



Questions are most welcome !

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**sedFoam**

Time: 0.00

