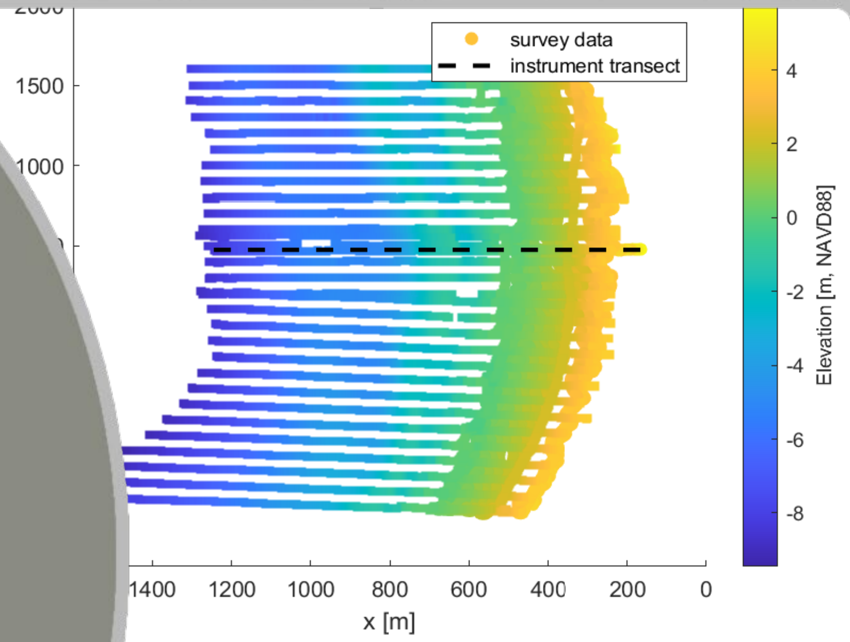


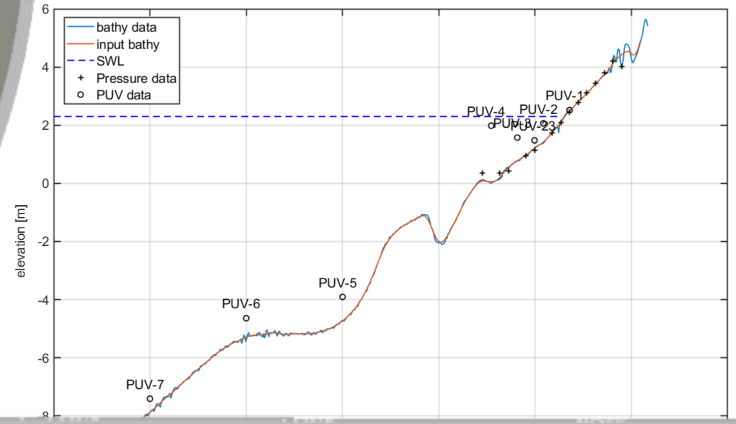
CMS-C2SHORE MODEL DATA VALIDATION TO THE SCRIPPS FIELD MONITORING SITE AT AGATE BEACH

CMS/CSHORE WORK UNIT

Cody Johnson and Brad Johnson

COASTAL INLETS RESEARCH PROGRAM

FY21 TECHNICAL DISCUSSION



Mission Support
Technology Transfer
CIRP
Research & Development

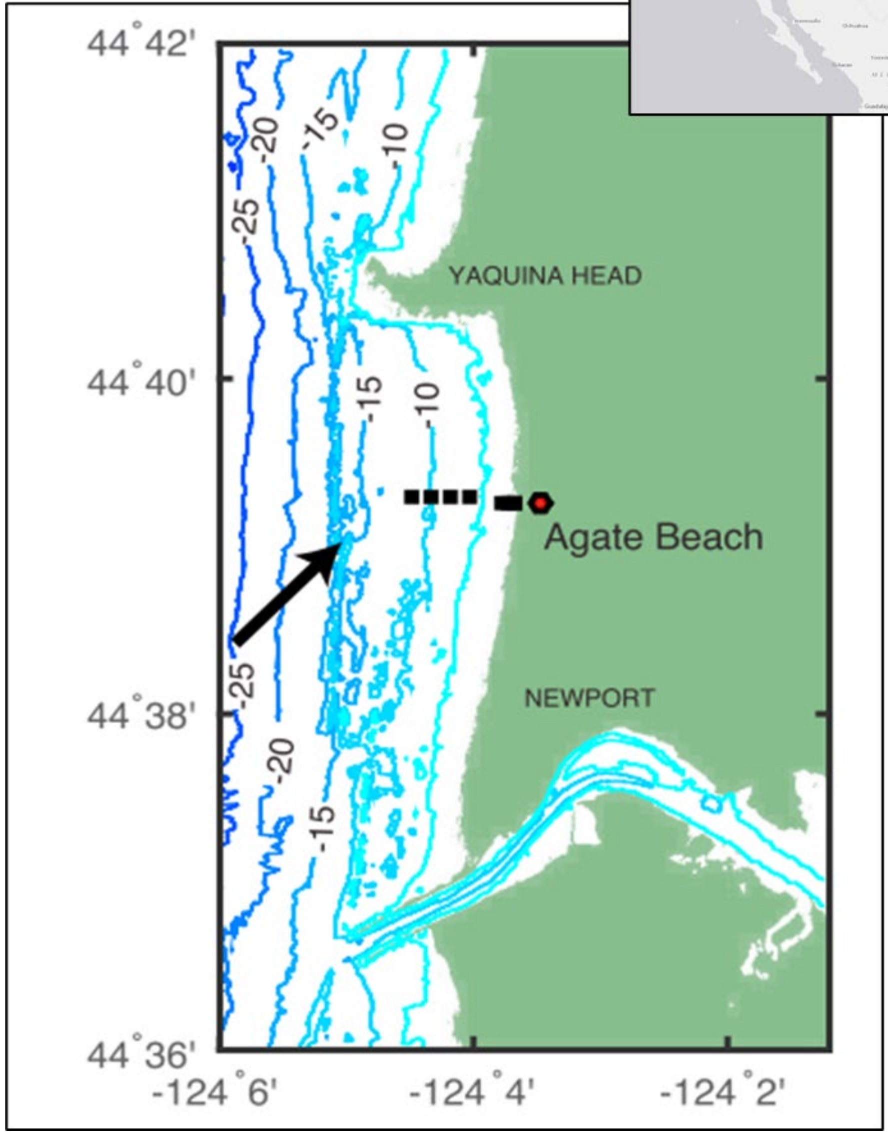
US Army Corps of Engineers

CHL COASTAL & HYDRAULICS LABORATORY

ERDC ENGINEER RESEARCH & DEVELOPMENT CENTER

Agate Beach Data set

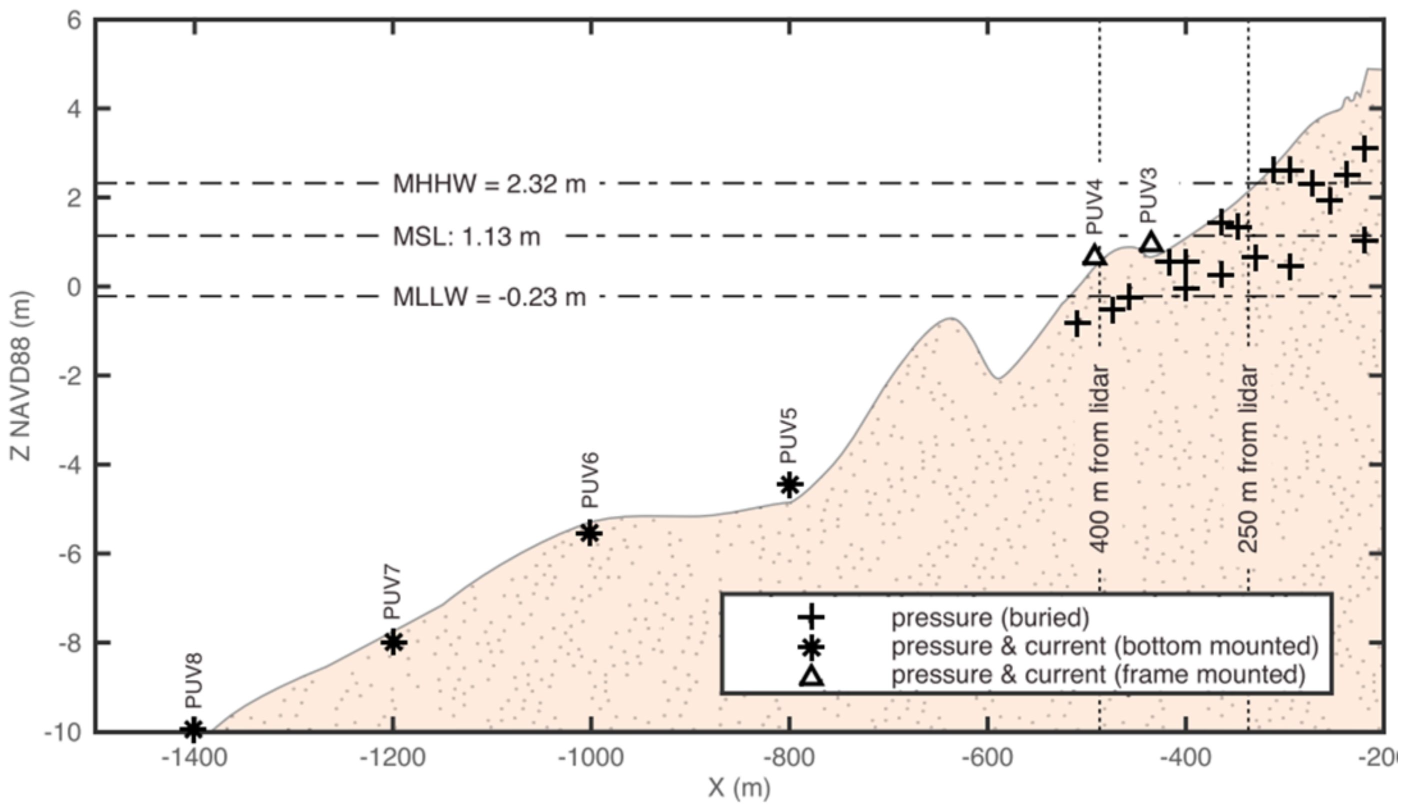
- Observations collected between 9/19 and 11/2, 2013
- Tidal range ~ 2 m
- Offshore wave heights ranged from 1.2 m – 4.7 m and peak period from 10 s -- 16.6 s
- Topobathymetry measured in cross-shore transects w/ GPS-equipped ATV, dolly, and jetski
- Mild slope (1/50 – 1/70)

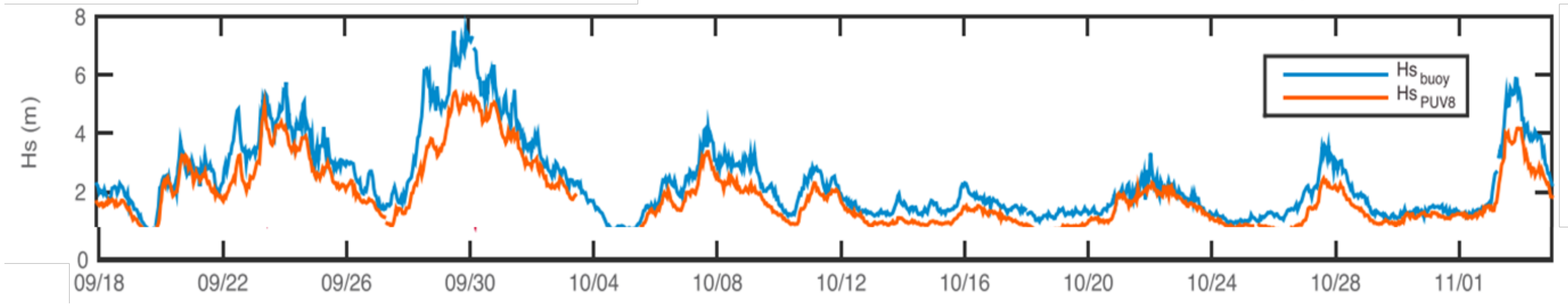


Fiedler, J. W., Brodie, K. L., McNinch, J. E., & Guza, R. T. (2015). **Observations of runup and energy flux on a low-slope beach with high-energy, long-period ocean swell**. Geophysical Research Letters, 42(22), 9933–9941.

Agate Beach data set

- 18 pressure sensors
  - Between -1 m and +3 m NAVD88
  - fs = 2 Hz
- 9 frame mounted PUV sensors
  - Between MSL and h=11 m
  - Controlled for shore normality
  - Deviated less that 30% from linear waves
  - Removed energetic nearshore eddy motions



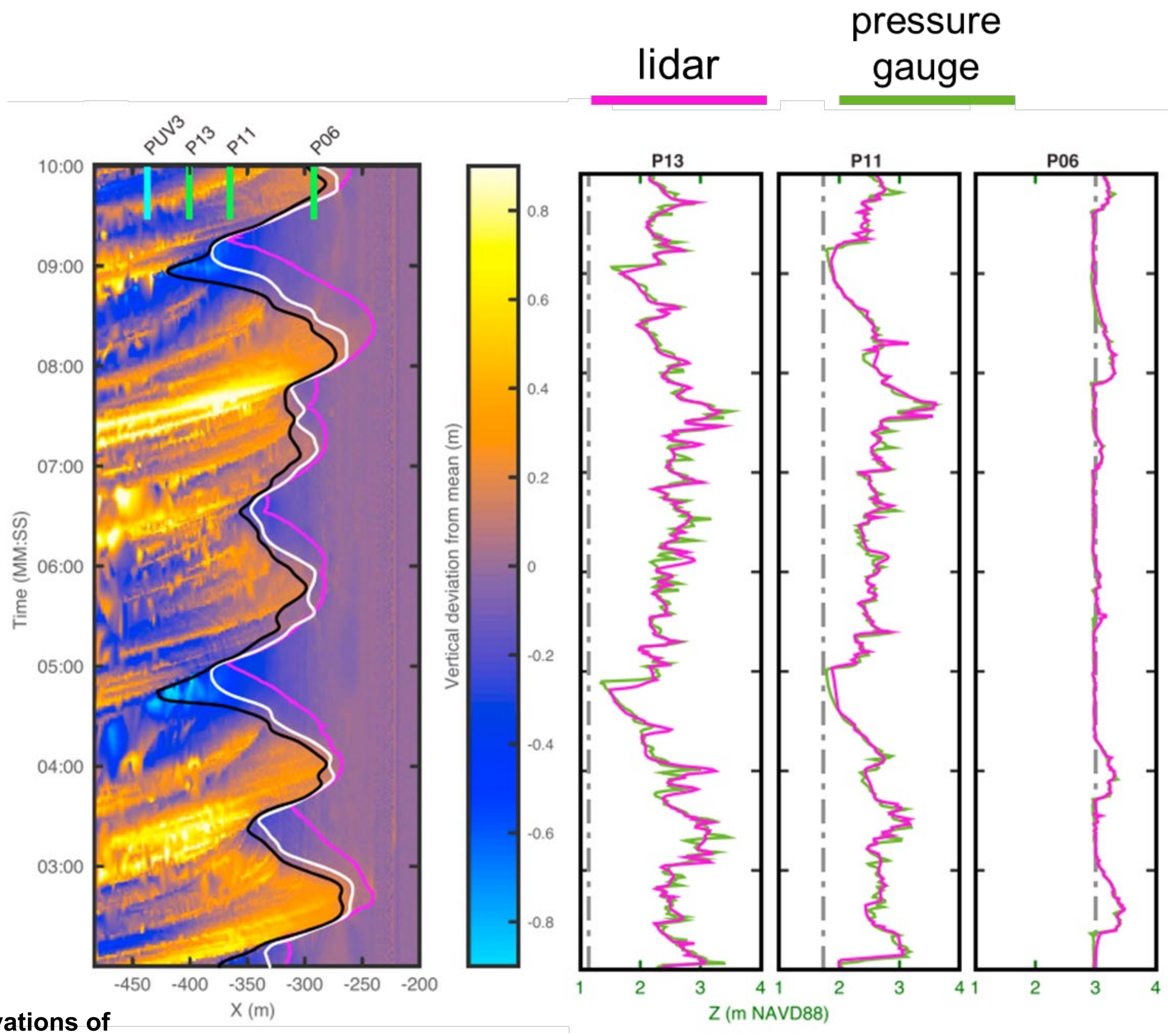


Agate Surface Wave data

- H_0 = [0.5m, 7.5m]
- QA/QC on PUV data to ensure conditions were dominated shore normal surface waves
    1. Ratio of observed pressure/velocity variances differed from LTW by 30%
    2. Data where IG band alongshore squared velocity to cross-shore exceeded 0.55 and velocity magnitudes > 1 cm were rejected
    3. Data with KE/PE > 0.25 in the IG band were rejected
- PUV-8 was within surfzone for highest energy case

Agate Lidar data

- Narrow beam, 1550 nm wavelength lidar
- fs = 7 Hz
- Lidar scans were rectified with independently surveyed targets
- Some noise due to long range (400 m)



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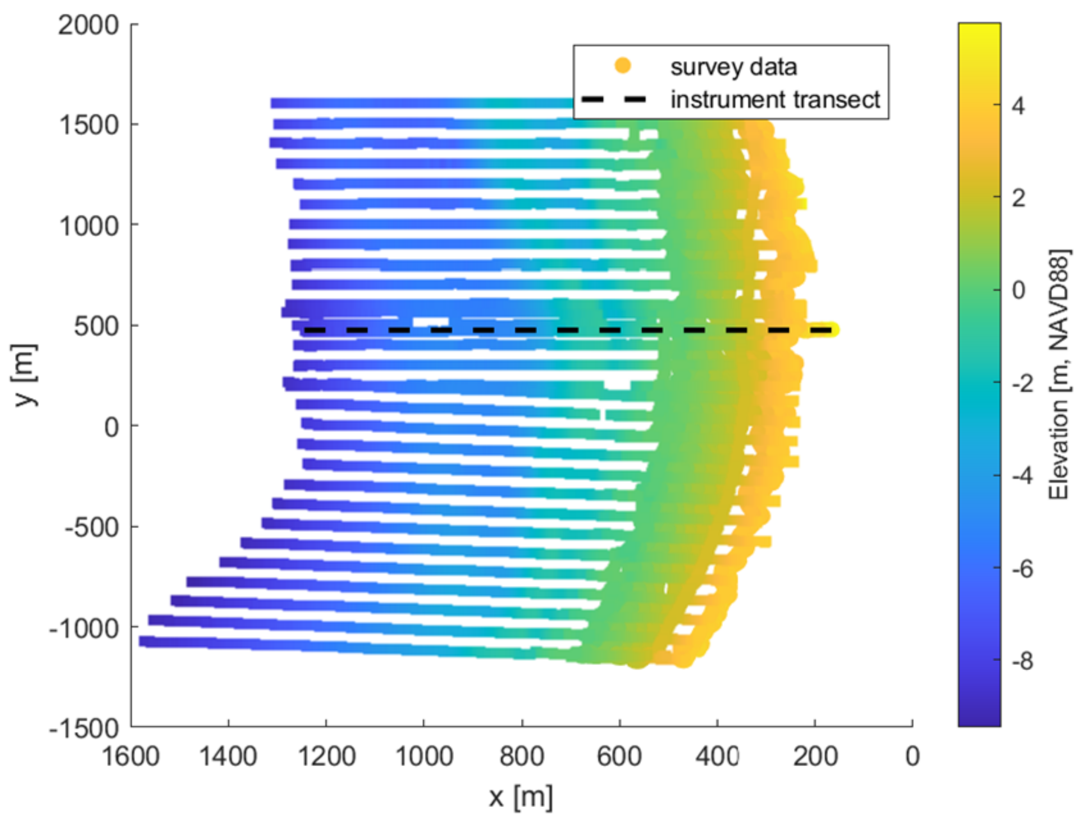
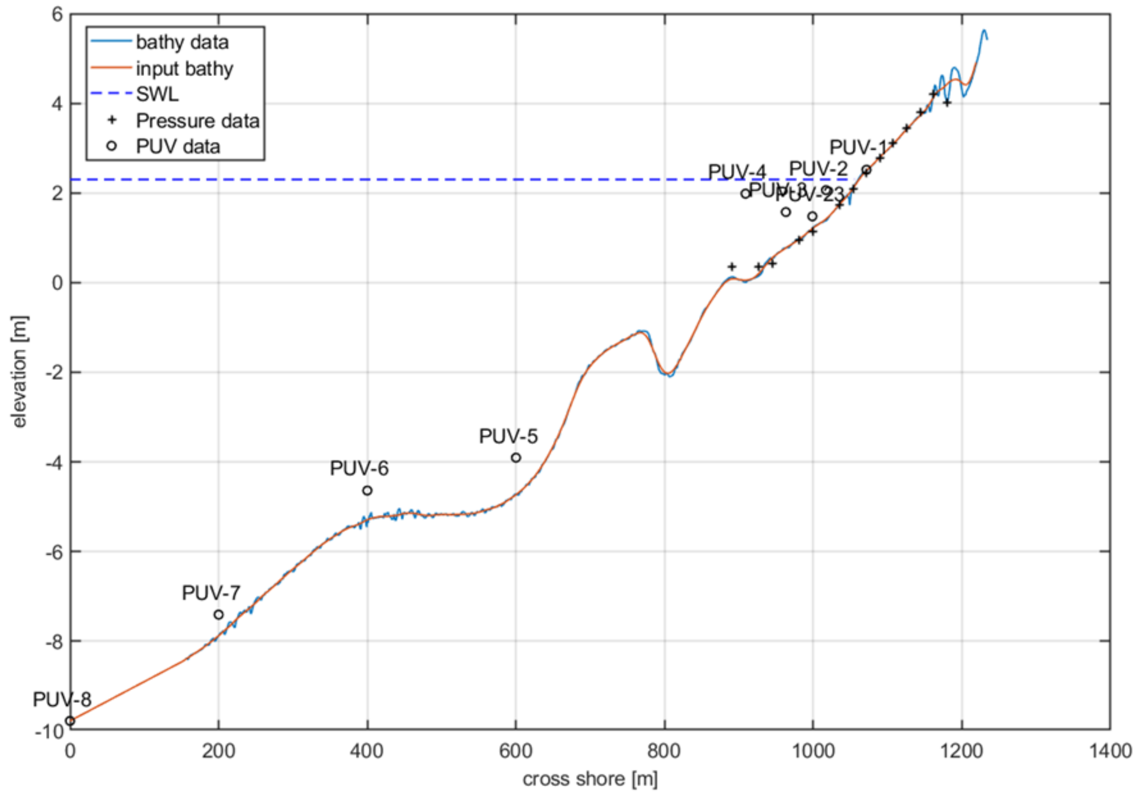
Case A - Bathymetry





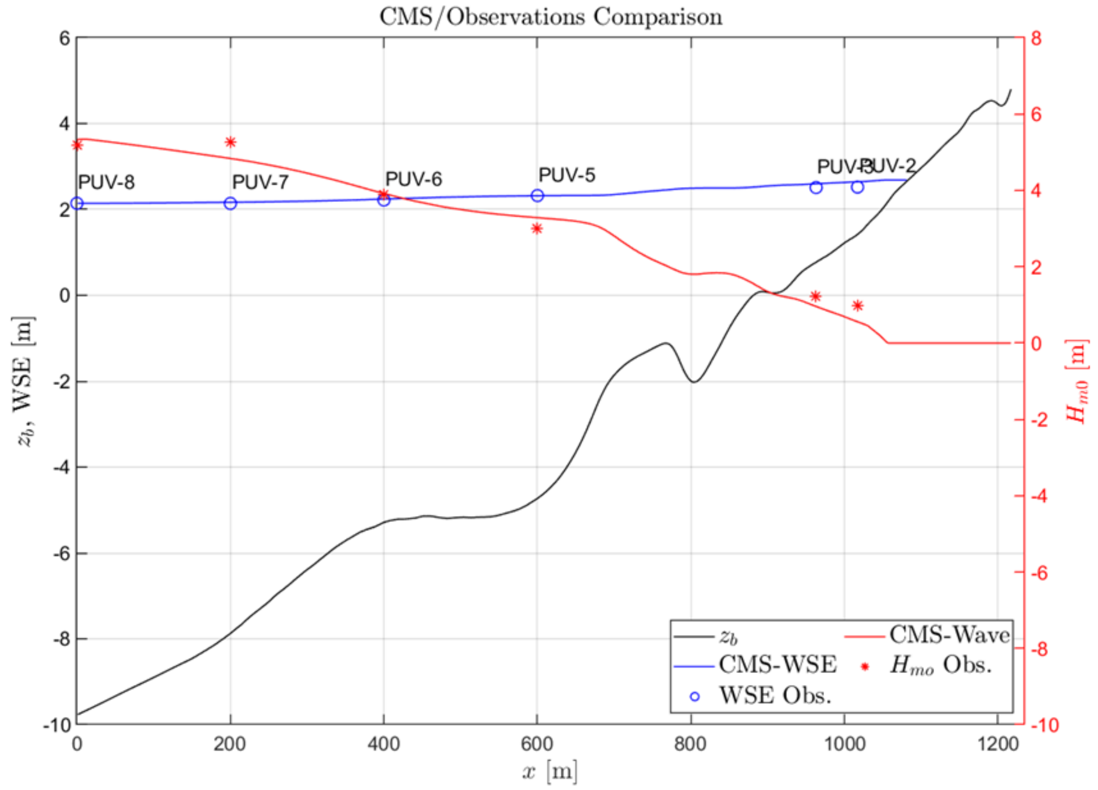
CMS – Set up

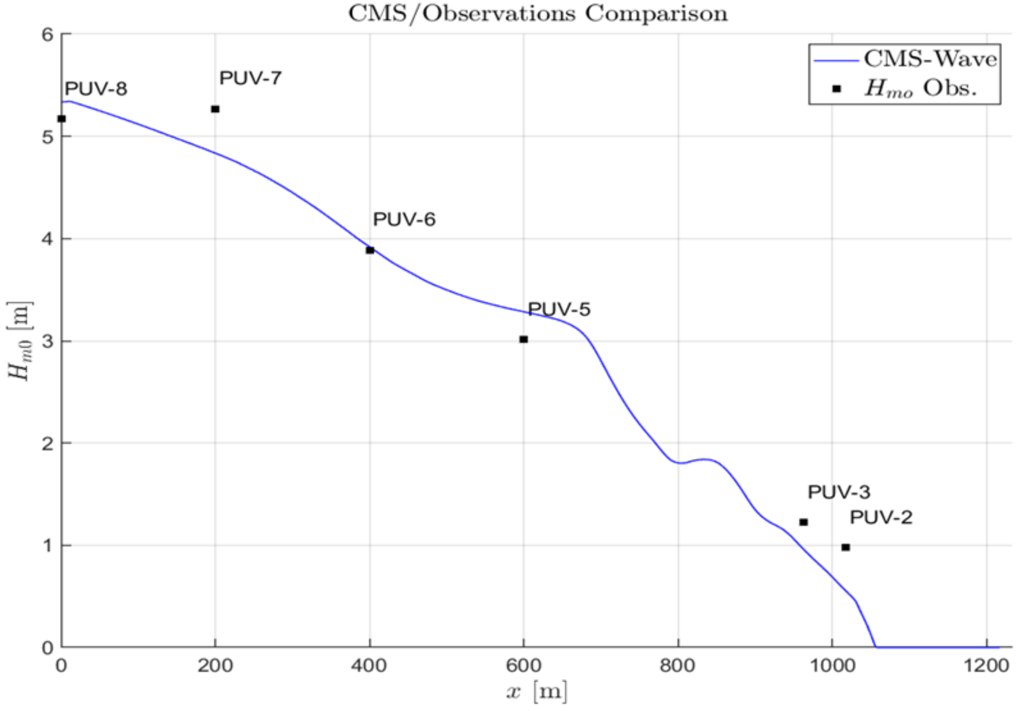
- ny, nx = 10, 609 cells
  - Essentially 1DH
  - Alongshore uniform
- dx = 2m
- dt = 180 s (implicit solver)
- Constant water level boundary condition
- TMA spectrum for wave boundary condition

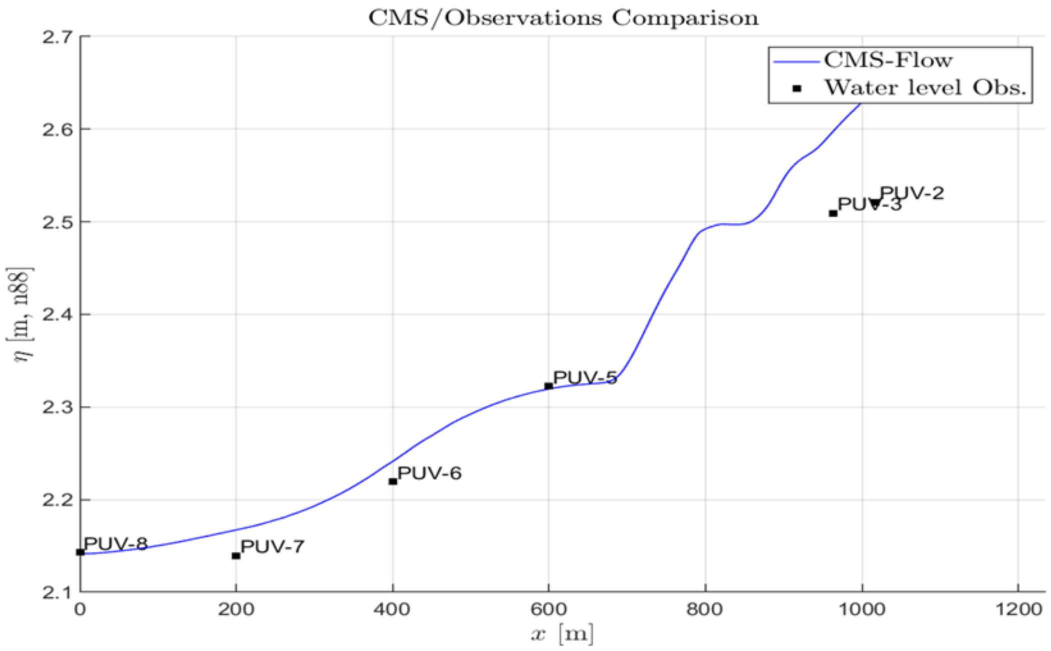
Cases

case	Experiment	SWL [m, n88]	Hm0 [m]	Tp [m]	Breaking Formula	Steering interval [min]
A1	2013-09-28	2.1	5.3	15.6	Battjes and Janssen	60
A2	“	“	“	“	“	30
A3	“	“	“	“	Goda	60
A4	“	“	“	“	“	30
B1	2013-10-16	2.5	1.6	13.0	Battjes and Janssen	60
B2	“	“	“	“	“	30
B3	“	“	“	“	Goda	60
B4	“	“	“	“	“	30

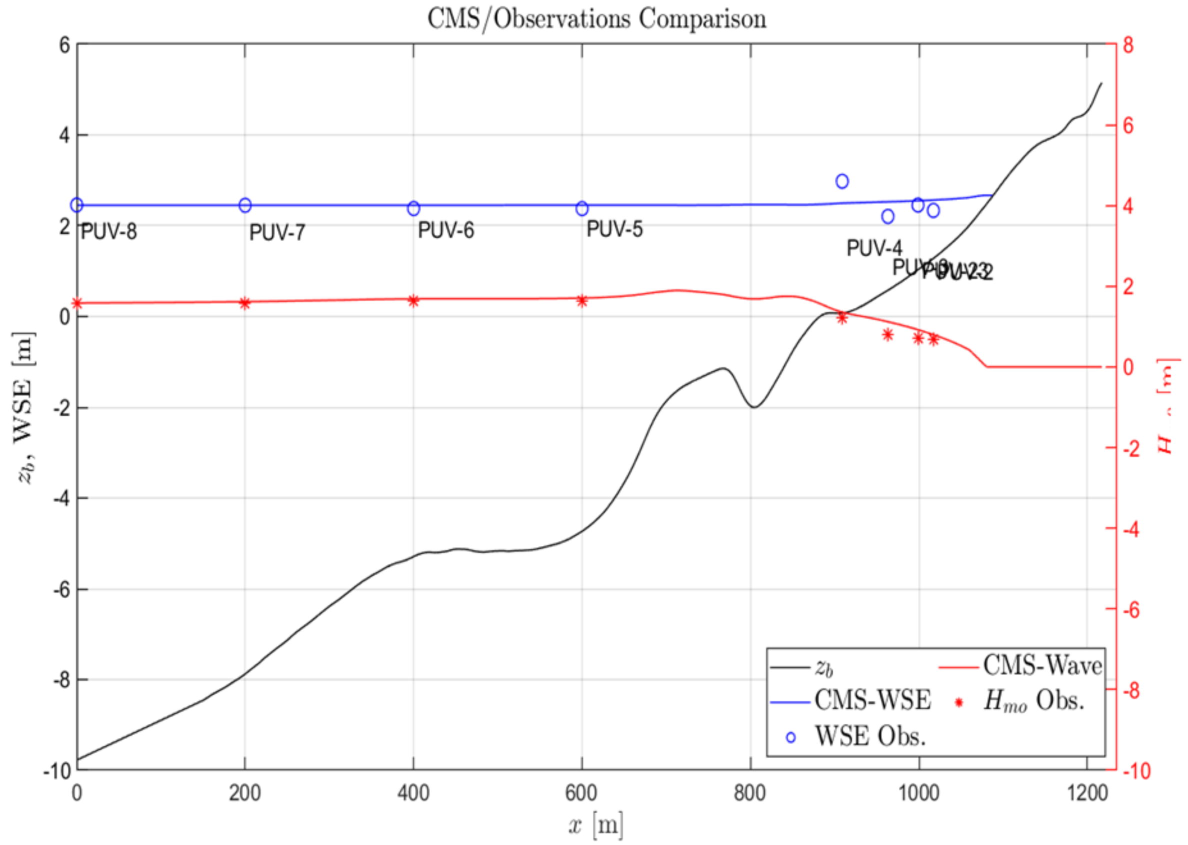
Results: Case A1

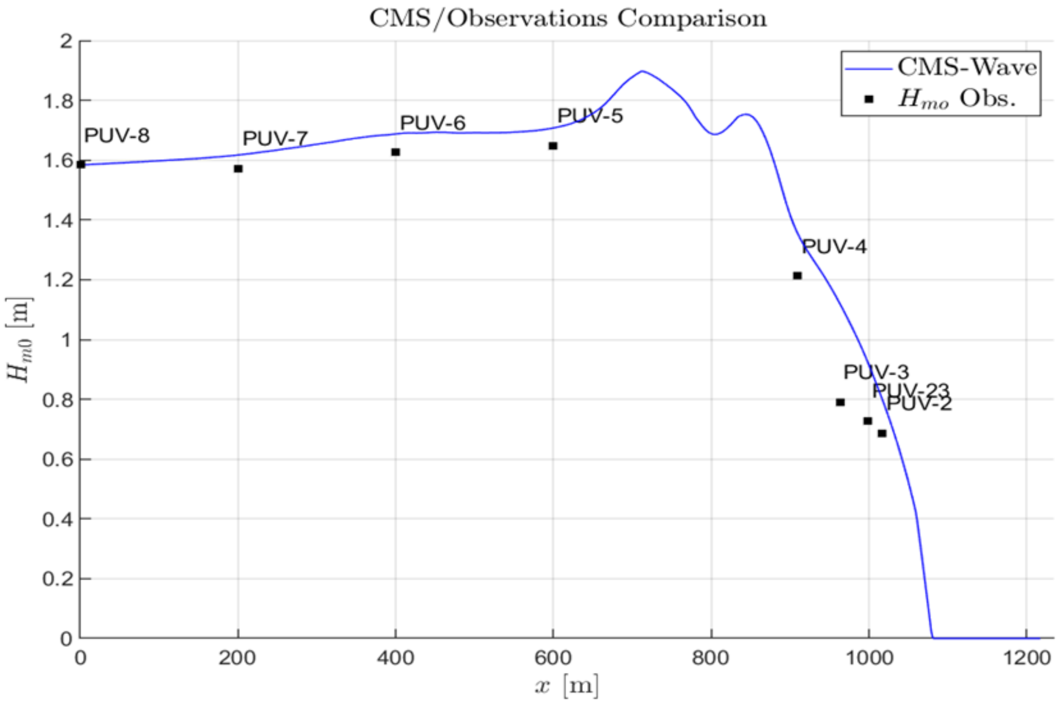


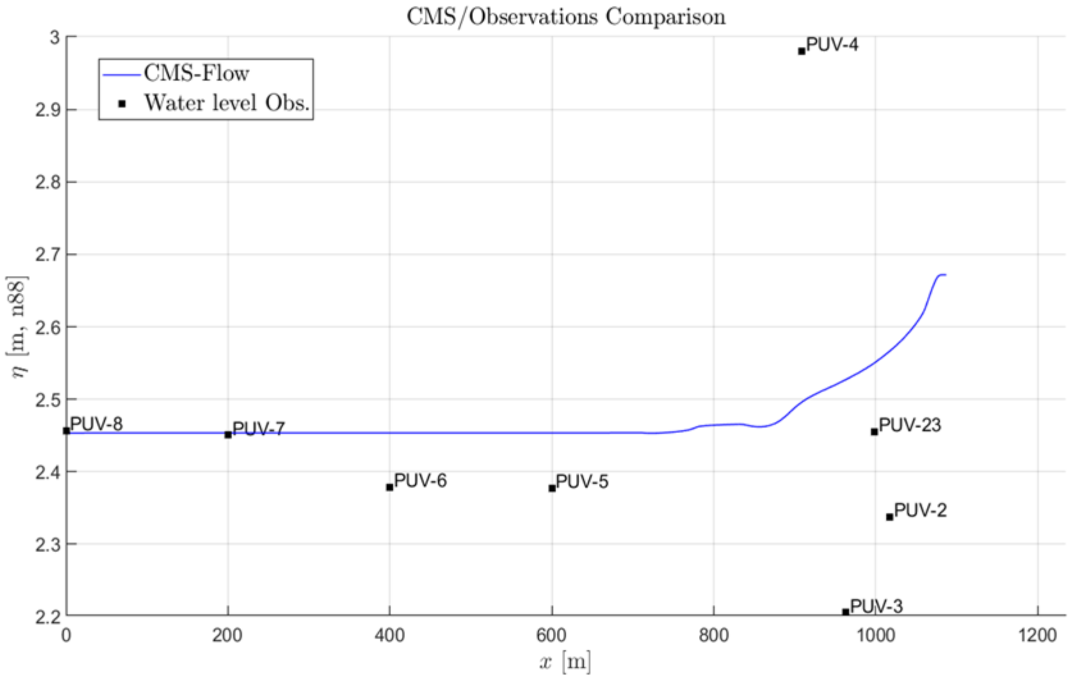




Results: Case B1





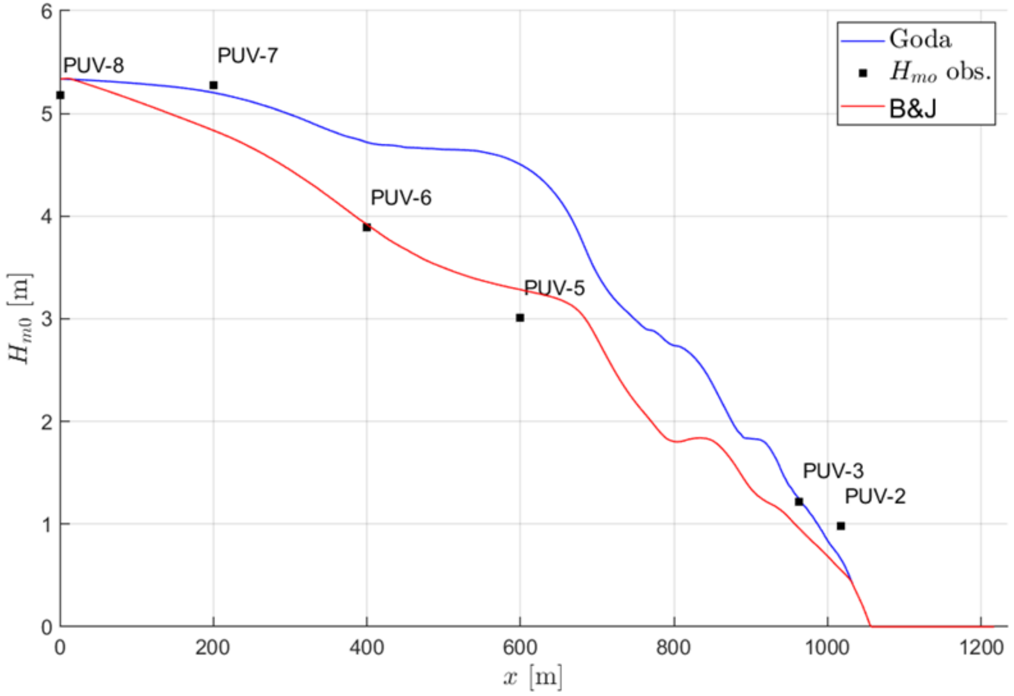


CMS results statistics

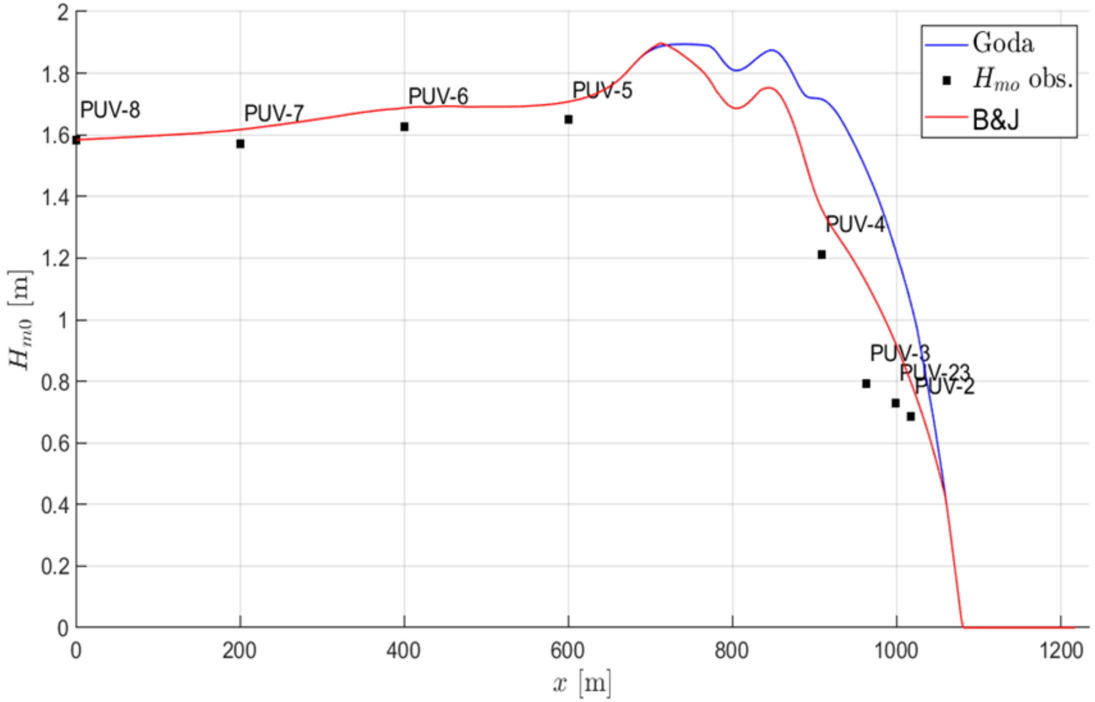
case	NRMSE, Hm0 [%]	Nbias, Hm0 [%]	NRMSE, WSE [%]	Nbias, WSE [%]
A1	**7.0**	**-2.5**	**16.6**	**11.2**
A2	8.6	-7.0	15.8	-9.7
A3	16.7	8.3	39.5	19.5
A4	12.2	5.0	21.6	17.4
B1	15.9	11.7	67.4	3.8
B2	**11.0**	**7.9**	**67.4**	**3.8**
B3	39.0	27.8	67.4	3.8
B4	41.26	28.9	67.4	3.8

Wave Breaking Formulas

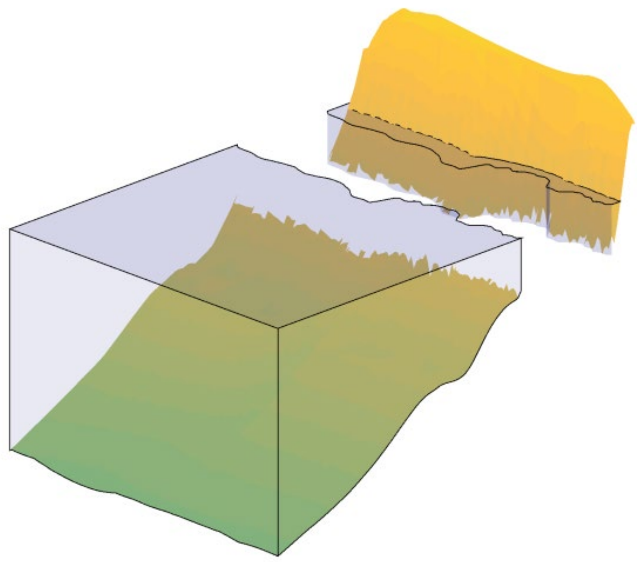
Case 1



Case 2



Swash Modeling



Scope of CMS SWASH:

- Instantaneous
- Wave and currents are combined
- Demarcation is a minimum depth
- Hydrodynamics are one-way coupled (appropriate for simulations with low current at interface)
- Transport is two-way coupled
- Bed conservation is rigid

Swash Modeling

- Based on momentum eqn (As the energy eqn has lost meaning)
- All time-dependent term are lost (OK for thin film)

$$\frac{\partial}{\partial s}\left(\overline{U_s^2 h} + \frac{g}{2}\overline{h^2}\right) = -g\overline{h}\frac{\partial z_b}{\partial s} - c_f\overline{|U_s|U_s}$$

$$M = \overline{U_s^2 h} + \frac{g}{2}\overline{h^2}$$

$$\frac{\partial}{\partial x}\left(M\cos\alpha\right) = -g\overline{h}\frac{\partial z_b}{\partial x} - c_f\overline{|U|U}\cos\alpha$$

$$\frac{\partial S_{xx}}{\partial x} = -\rho g h\frac{\partial \overline{\eta}}{\partial x} - \overline{\tau_b}$$

Swash Modeling

$$\frac{\partial}{\partial x}(M\cos\alpha) = -g\overline{h}\frac{\partial z_b}{\partial x} - c_f\overline{|U|U}\cos\alpha$$

where $M = \overline{U_s^2 h} + \frac{g}{2}\overline{h^2}$

A far-reach here:

$$U \sim \sqrt{g\overline{h}} \qquad M \sim g\overline{h}^2 \sim gH_{rms}^2$$

$$M \simeq A_0 g\overline{h}^2 \qquad c_f' g\overline{h} \simeq c_f\overline{|U_s|U_s}$$

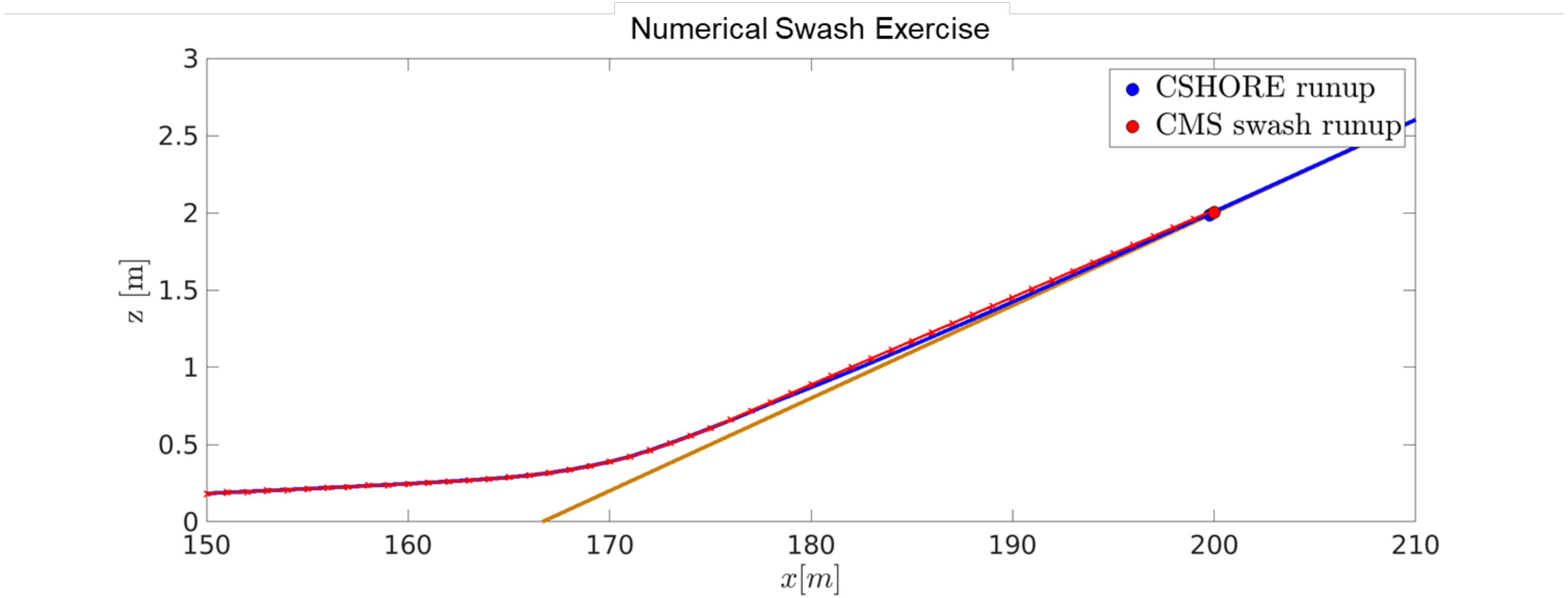
How far is the reach?

$$\frac{\partial S_{xx}}{\partial x} = -\rho g h\frac{\partial \overline{\eta}}{\partial x} - \overline{\tau_b}$$

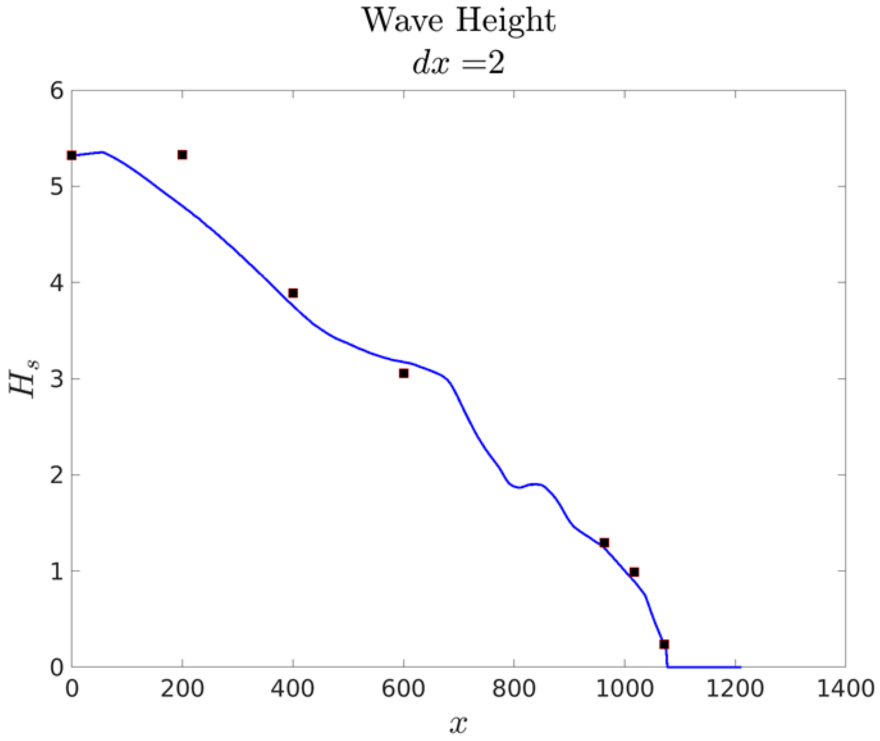
$$S_{xx} \sim g\overline{h}^2$$

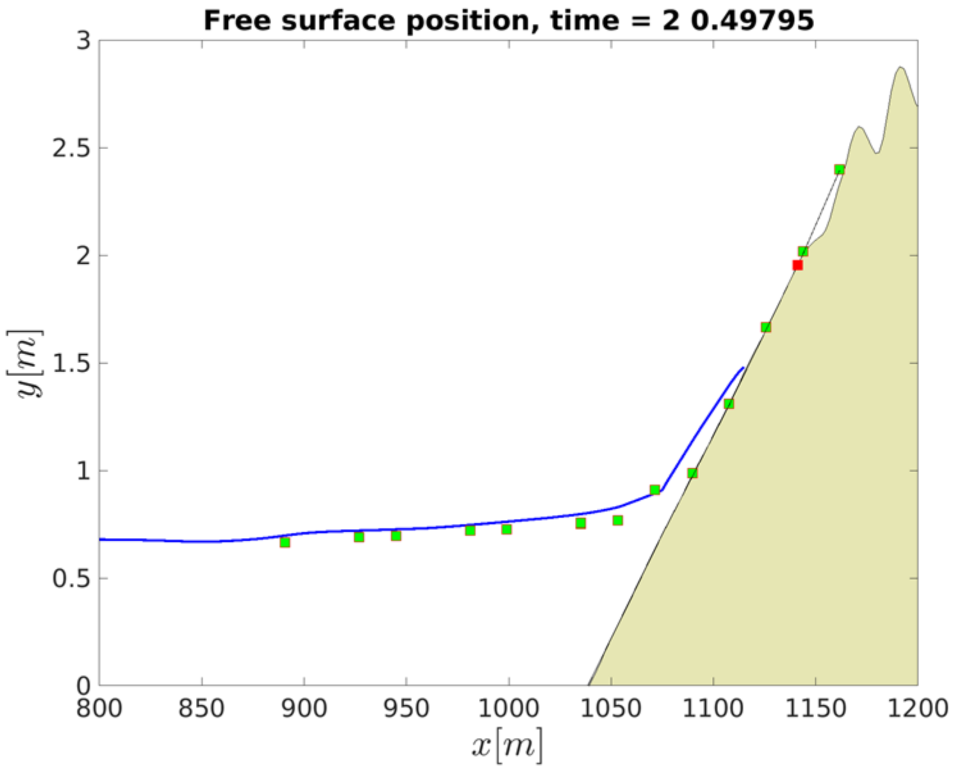
Swash Modeling

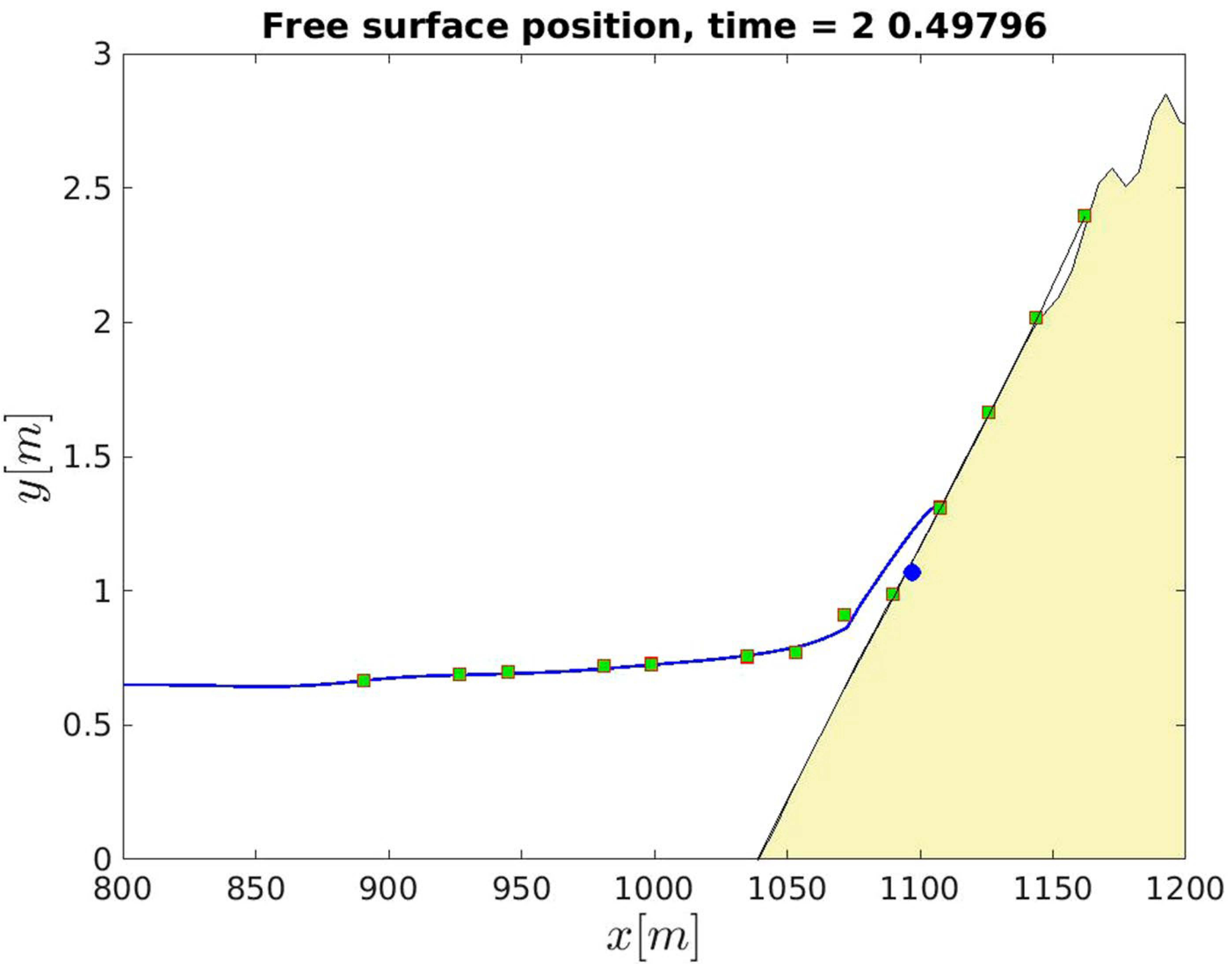
$$\frac{M_{i+i} - M_i}{\Delta x} = -g\overline{h_i}\frac{\partial z_b}{\partial x} - c_f' g\overline{h}$$

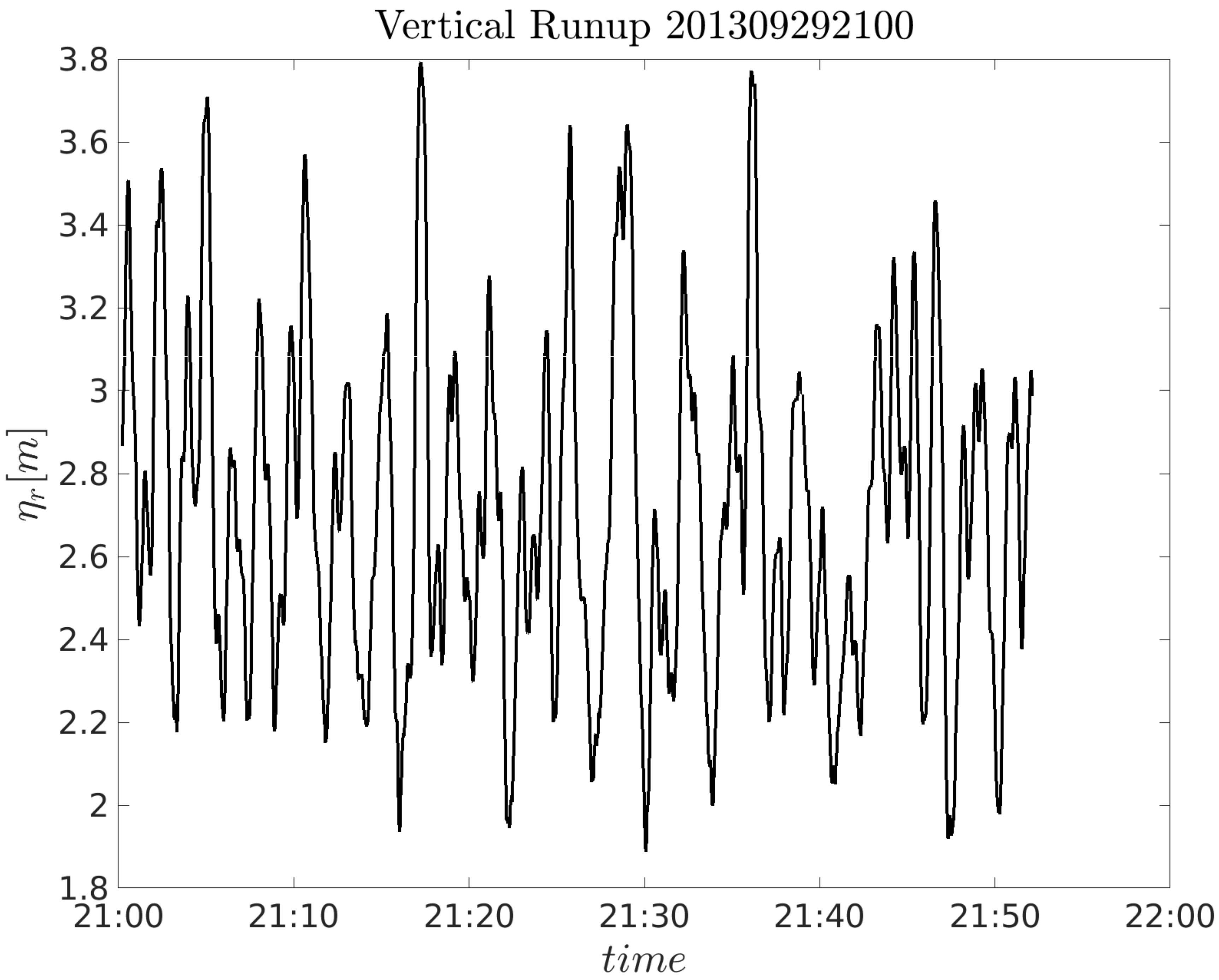


Agate Modeling

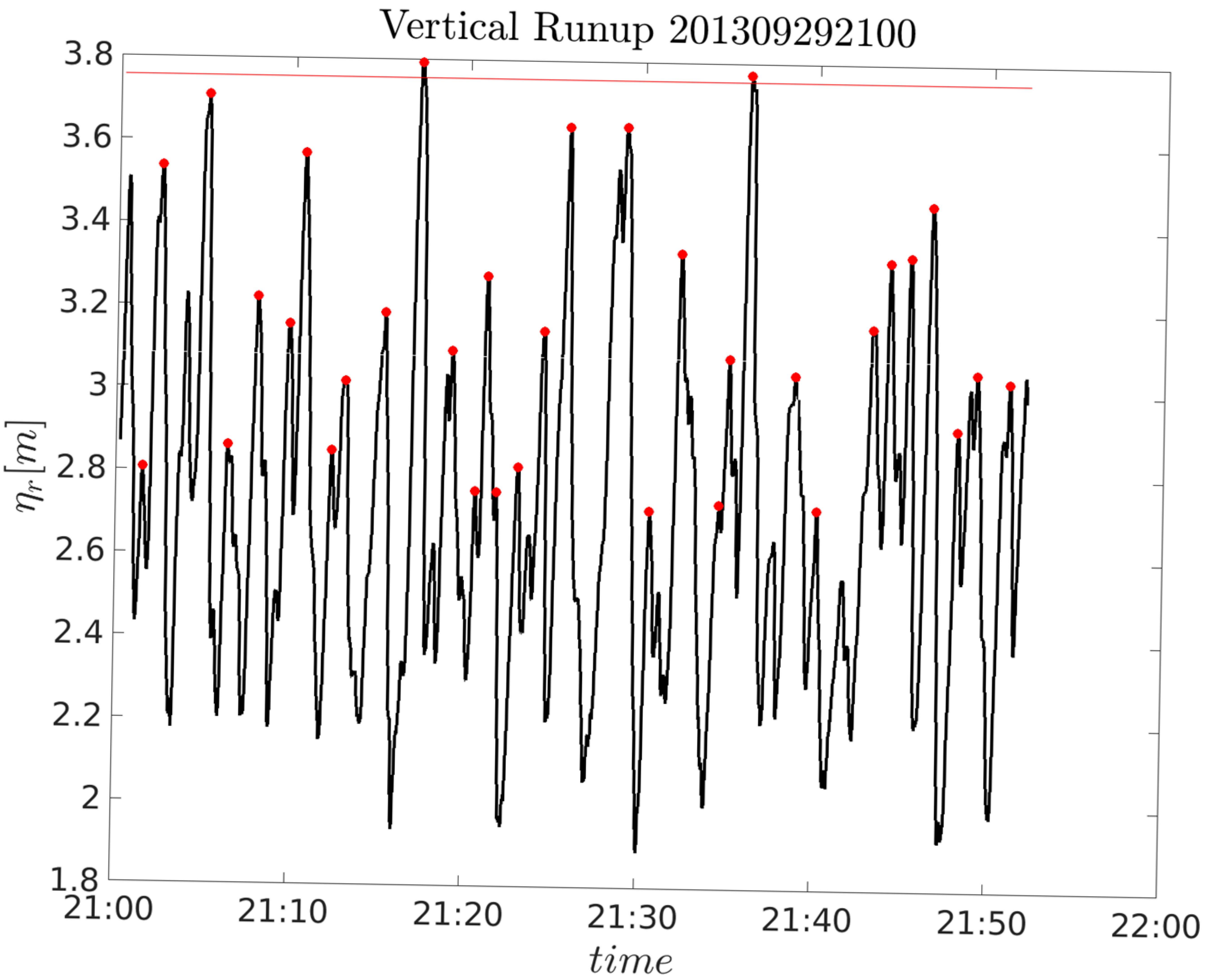




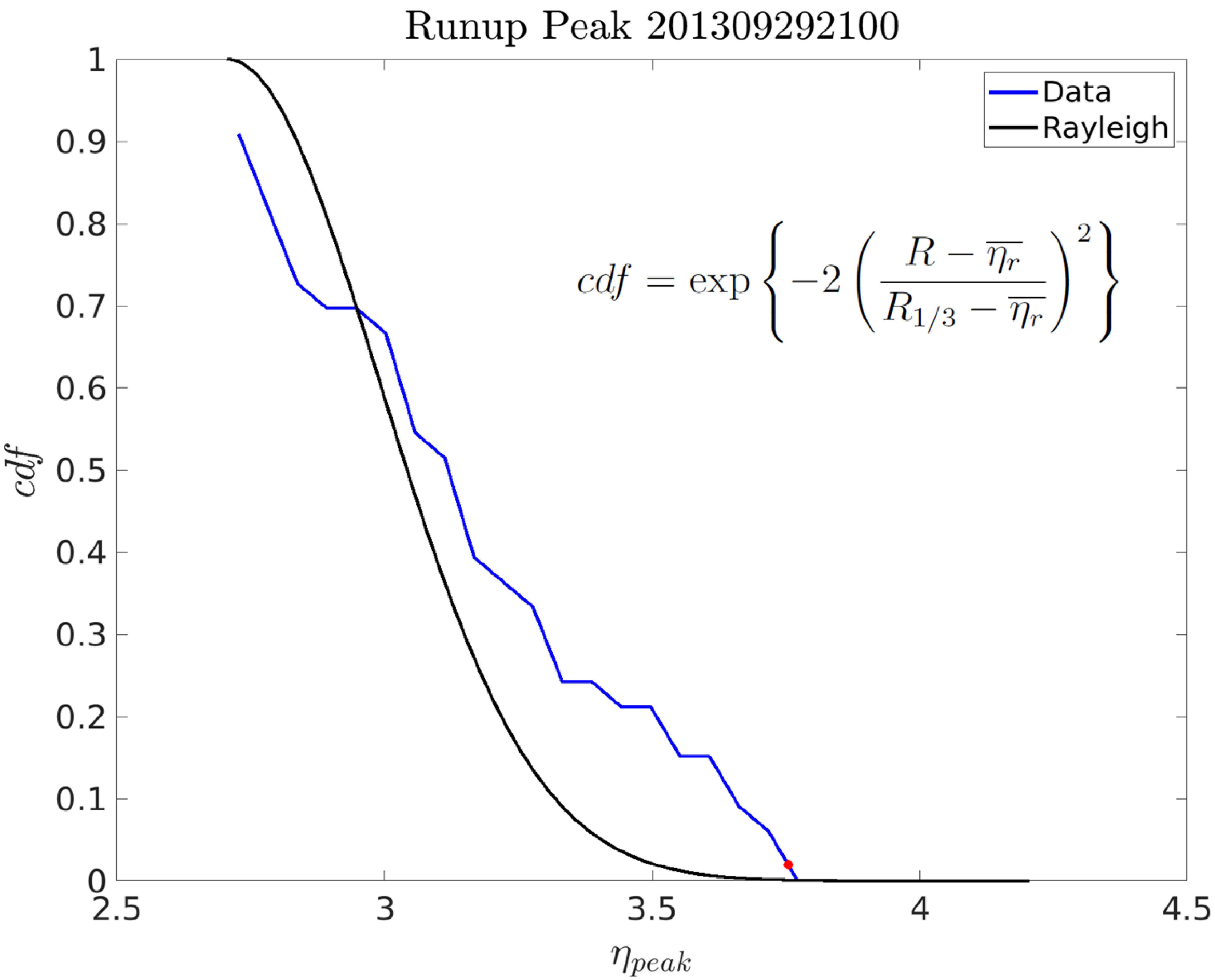

Free surface position, time = 2 0.49796
y[m]
x[m]
3
2.5
2
1.5
1
0.5
0
800
850
900
950
1000
1050
1100
1150
1200



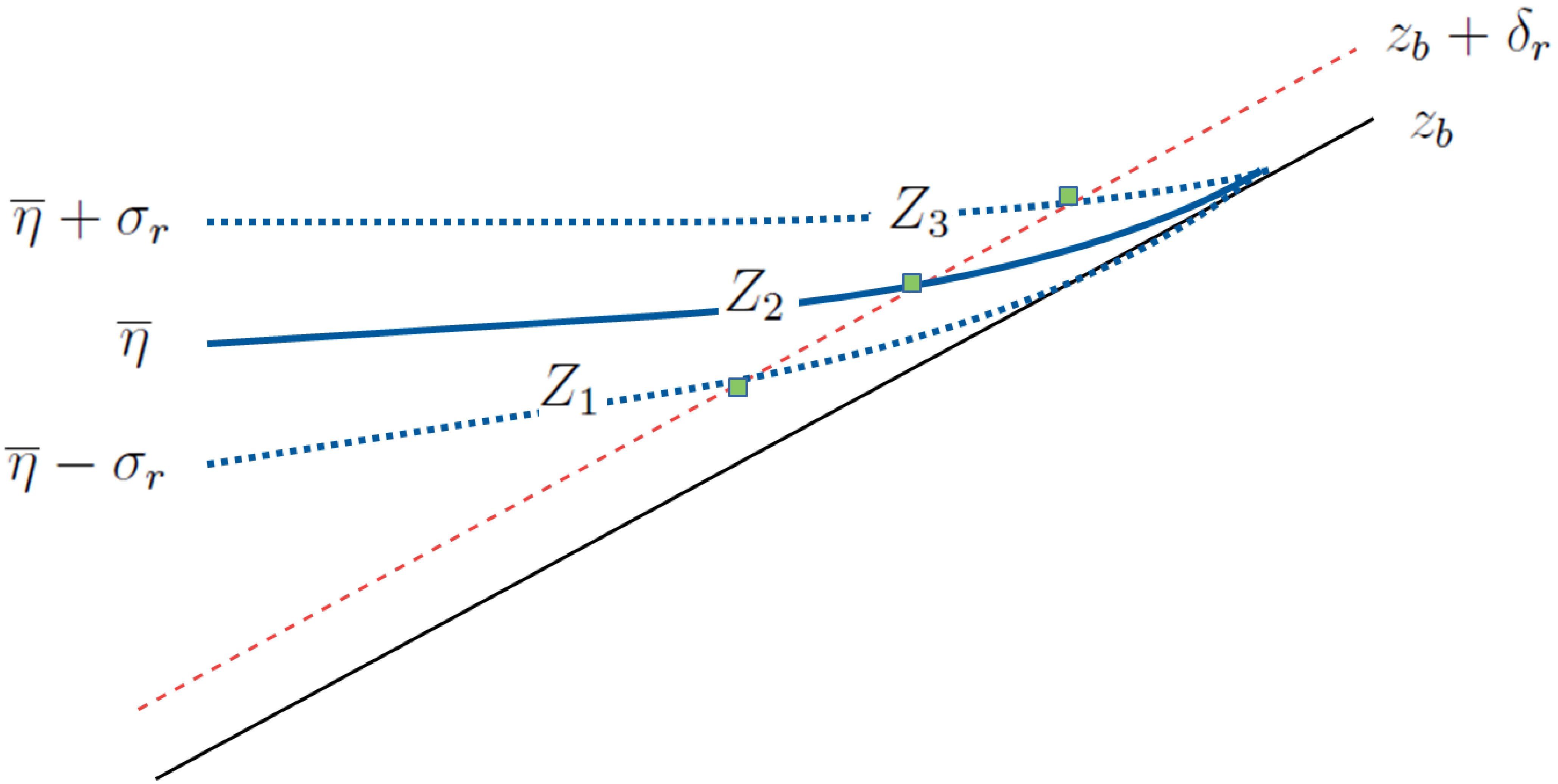
Vertical Runup 201309292100
$\eta_r[m]$
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
21:00
21:10
21:20
21:30
21:40
21:50
22:00
$time$



Vertical Runup 201309292100
$\eta_r[m]$
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
21:00
21:10
21:20
21:30
21:40
21:50
22:00
time


Runup Peak 201309292100
Data
Rayleigh
$cdf = \exp\left\{-2\left(\frac{R-\overline{\eta_r}}{R_{1/3}-\overline{\eta_r}}\right)^2\right\}$
cdf
η_{peak}
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2.5
3
3.5
4
4.5

Swash Hydro to Runup Stats



Swash Hydro to Runup Stats

$$\overline{\eta_r} = (Z_1 + Z_2 + Z_3)/3$$

where

$$R_{1/3} = \overline{\eta_r} + (2 + \frac{\partial\, z_b}{\partial x})\sigma_r$$

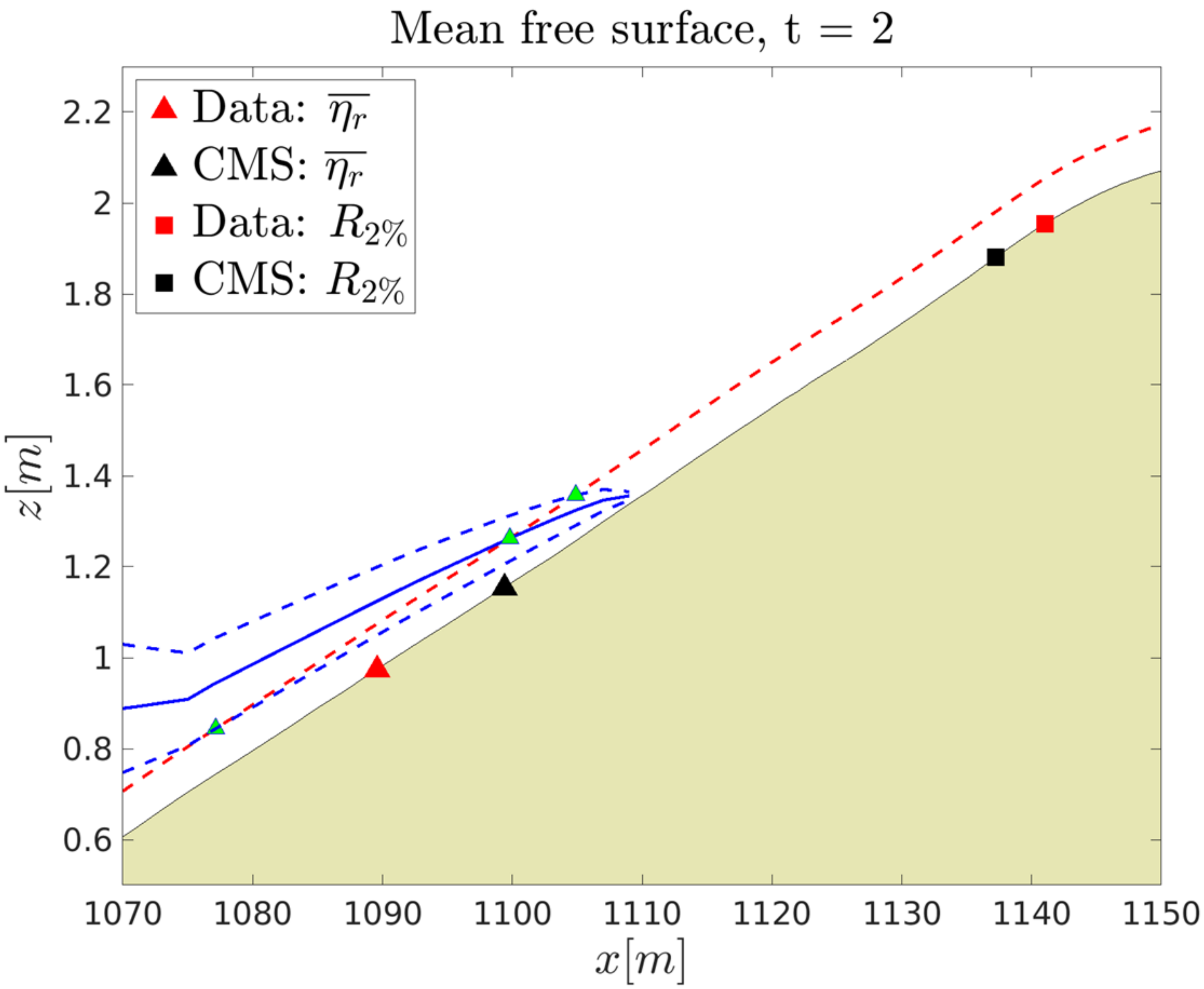
and

$$\sigma_r = (Z_1 - Z_3)/2$$

Making use of the Rayleigh-distributed runup peaks:

$$R_{2\%} = \overline{\eta_r} + 1.4(R_{1/3} - \overline{\eta_r})$$

Swash Hydro to Runup Stats



Swash Hydro to Runup Stats