University of Utrecht

Morphodynamics of Wave-dominated Coasts
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Practical 4

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Course coordinator:	Prof. dr. G. Ruessink

A. Kotilis	6631032
M. De Botton Falcon	6748546
E.J.V. Smolders	6008399

1 4.2 Theoretical example

- *Include also in the figure the cross-shore evolution of the set-up, the dissipation due to breaking and the dissipation of the roller. Discuss the evolution of the different variables.*

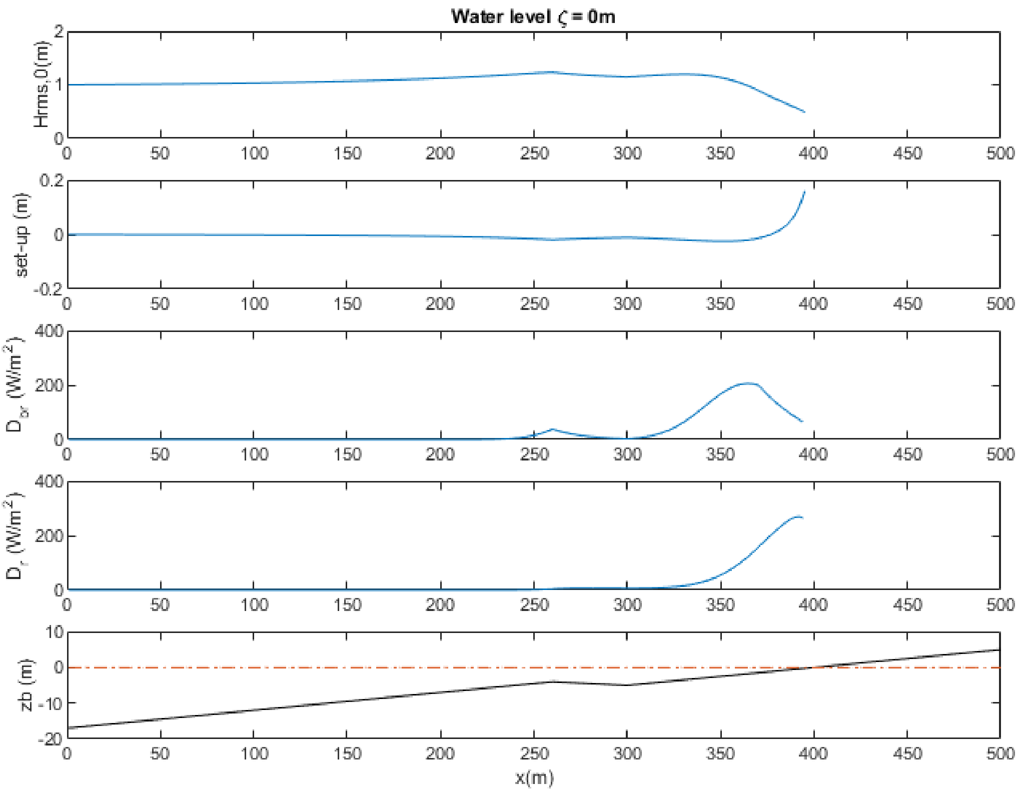

Figure 1.1: Cross-shore evolution of the root mean square wave height(Hrms), the set-up, the dissipation of the breaking(D_{br}), the dissipation of the roller (D_r) and the bed profile(zb), for $\zeta = 0$, predicted by the BJ model.

Figure (1.1), demonstrates the cross-shore evolution of the different parameters predicted by the BJ model. The model estimates the values of the wave properties at each cross-shore location. These properties are: the set up, the dissipation due to breaking(D_{br}) and the dissipation of the roller(D_r). In this simulation, the values of the model are set as: $H_{rms,0} = 1m$, $\theta_0 = 0°, T_0 = 10s, \zeta = 0m$, where $H_{rms,0}$ is the root mean square wave height, θ_0 is the angle of incidence of the wave, T_0 is the period and ζ is the mean water level. Finally, zb is the bed profile.

It is observed that while the wave approaches the sandbar($x \sim 260m$), $H_{rms,0}$ slightly increases due to shoaling, as the velocity of the wave decreases due to bed friction. Further on, the wave breaks resulting in a decrease of the wave height and finally, before it reaches the coast, it shoals again until it breaks causing $H_{rms,0}$ to decrease to 0. This affects the dissipation of the breaking, D_{br}, where two peaks can be observed at the points where the waves break and lose energy. Moreover, dissipation due to breaking causes the roller, D_r, to start growing and after $x \sim 330m$, it keeps developing until its maximum when the wave breaks. Looking closely at $x \sim 260m$, it can be noticed that the dissipation due to breaking is bigger than the one of the roller. Also, the roller comes a little later than the breaking which states that the energy that is lost in wave breaking is transferred into the roller. After the second breaking, the energy of the roller peaks higher than the breaking energy meaning that the roller can be developed by additional parameters, like wind speed. Regarding the set-up which is the change in mean water height, it can be observed that before the shoaling there is a negative change(set-down) while at the breaking point a positive change occurs meaning a rise in the mean water level.

- *Run simulations for $\zeta = +1$ m and -1 m. Compare the results to the initial simulation and explain the differences (changes in intensity/location of breaking, wave heights, etc.)*

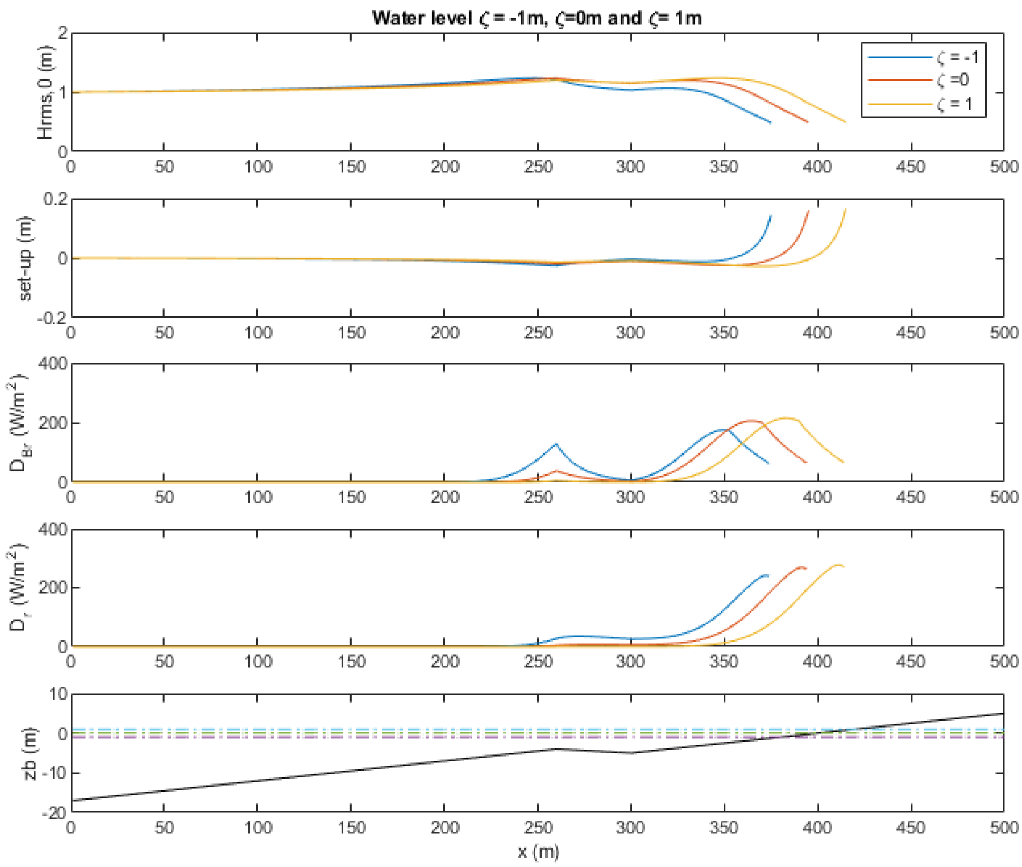

Figure 1.2: Cross-shore evolution of the different parameters for $\zeta = -1m$ and $\zeta = 1m$.

When the parameters are plotted for $\zeta = 1m$ and $\zeta = -1m$, it is noticed that in low tide, $\zeta < 0$, the wave height decreases seawards and as a result the breaking of the wave occurs at an earlier stage in the bed profile. The dissipation due the breaking intensifies during low tide which results in a build up of the roller earlier than the other two cases. The set-up is less than the case where $\zeta = 0$ and occurs at an earlier point. During high tide, $\zeta > 0$, the breaking appears later than the case of $\zeta = 0$, since the wave "feels" the elevation of the bed less and does not break in the sandbar. This causes a delay to the shoaling effect. Dissipation due to the breaking is low at the sandbar but higher at the coast since the wave height is higher and results in bigger energy loss when it breaks. That also causes a bigger and more aggressive roller. The set-up is increased and moved landwards.

- *Analyse now wave transformation for $H_{rms,0} = 0.5$ m and 2 m, with $\zeta = 0$ m.*

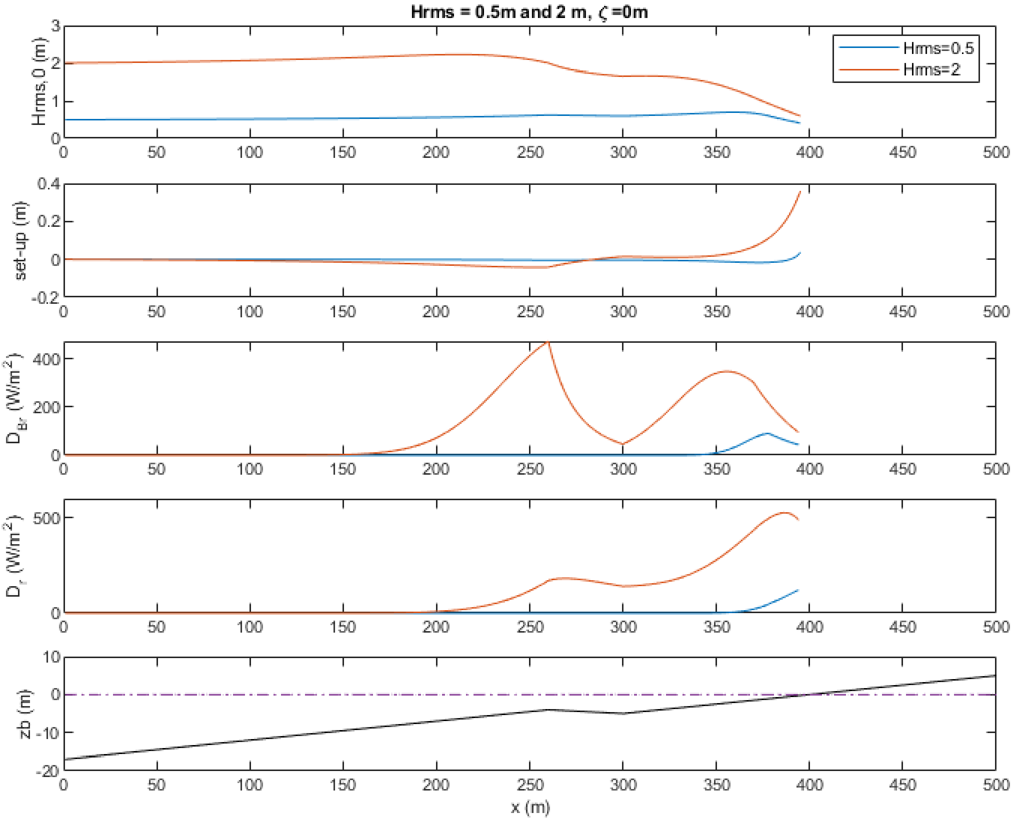

Figure 1.3: Cross-shore evolution of the different parameters for $H_{rms,0} = 0.5m$ and $H_{rms,0} = 2m$.

The simulation is ran for different values of $H_{rms,0}$. In Figure (1.3), it is observed that as the wave height increases, the dissipation due to breaking and the roller are greater resulting in more energy loss. This is also expected from equation(1.1) that describes the dissipation due to breaking:

$$D_{br} = \alpha \rho g \frac{H_{max}^2}{4T} Q_b \tag{1.1}$$

Similarly, the increase of the set-up can be explained through equation(1.2).

$$E = \frac{1}{8} \rho g H_{rms}^2 \tag{1.2}$$

The mean wave energy, based on the linear theory, increases with the mean square wave height. Higher waves lose more energy when they break in the shore and the energy of the roller is unleashed resulting in increases mean water level.

For $H_{rms,0} = 0.5m$, the wave is not shoaling and does not break at the sandbar. As a result, there in no dissipation due to breaking thus no roller follows along. Finally, the wave breaks at the coast producing a small roller which results in a minor increase of the set-up.

- *Finally, run the model with $\theta_0 = 22.5°$ and 45°, using ζ = 0 m and $H_{rms,0}$ = 1 m. Analyse the results*

Figure 1.4 shows the model outcome with $\theta_0 = 22.5°$ and $45°$ using $\zeta = 0$ m and $H_{rms,0} = 1$ m. It is observed that the H_{rms} for $\theta_0 = 45°$ is lower than for $\theta_0 = 22.5°$. This is due to the fact that the energy, and hence the wave height, decreases due to wave refraction. The larger the incoming wave angle, the more refraction you have. The waves break somewhere after 250 m and start to shoal again at 300 m where after they break again at around 350 m. This is also nicely illustrated in the plots of the dissipation due to breaking and rolling. A small peak in the D_{br} plot can be observed just after 250 m coinciding with the wave breaking observed in the $H_{rms,0}$ plot and one larger peak just after 350 m coinciding with the second wave breaking event. The roller dissipation doesn't show a clear peak at around 250 m, but if one looks closely, a small rise of D_r is observed. Furthermore, the roller dissipation starts to increase at around 340 m until it reaches it maximum at around 390 m which arises mainly due to dissipation of breaking. Because the energy of the waves is higher in the case of $\theta_0 = 22.5°$, the breaking and roller dissipation is therefore also larger. Lastly, the difference in set-up is observed to be rather small.

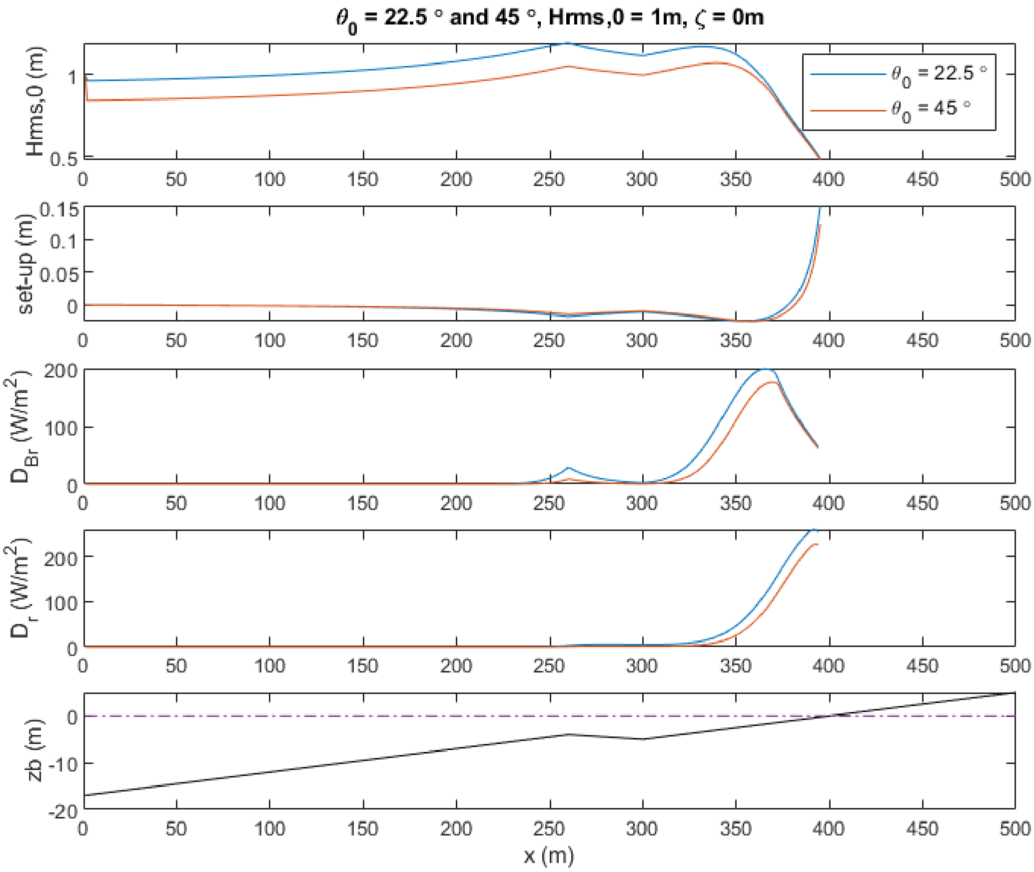

Figure 1.4: Cross-shore evolution of the different parameters for $\theta_0 = 22.5°$ and $45°$, using $\zeta = 0$ m and $H_{rms,0} = 1$ m.

1.1 4.3 Model/data comparison

- *Create a figure with 4 vertical subplots in which the predicted cross-shore evolution of the wave height for each tide is plotted together with the observed H_{rms} as calculated in Chapter 1. Furthermore, on the bottom figure, plot the bed level evolution as a function of the position.*

Figure 1.5 displays the predicted cross-shore evolution of the wave height for each tide together with the observed H_{rms} as calculated in Chapter 1. The bottom subplot depicts the bed elevation with horizontal lines corresponding to the different tidal levels. It can be seen that the observed values of H_{rms} as calculated in Chapter 1 correspond closely with the modeled H_{rms} for all three tides and follow the same trend, although in the low tide case the observed values are somewhat lower than the modeled values.

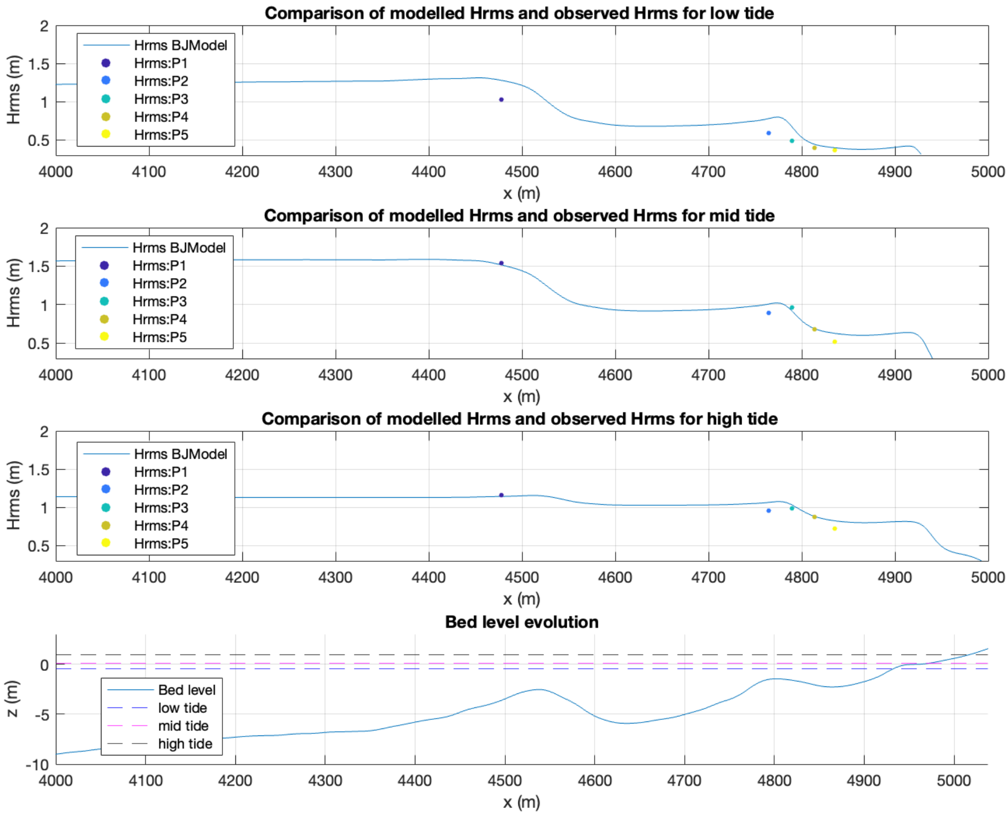

Figure 1.5: Top three figures: Cross-shore evolution for each tide with observed H_{rms}. Bottom figure: bed level evolution as a function of position with regions delimiting low, mid and high tide.

- *Estimate the modelled wave heights at the exact location of the sensors for each tide using the interpolation function.*

The modelled wave heights are determined using the interpolation function in Matlab and given in Table 1. A comparison between the observed and modeled wave height is shown in Figure 1.6 where it is shown that the the modelled and observed H_{rms} are almost identical, although for the first 3 positions in the low tide case the observed values are somewhat lower than the modelled values.

modelled H_{rms} [m]			
Sensor position	Low tide	Mid tide	High tide
P1	1.197	1.42	1.029
P3	0.7742	0.9987	1.009
P4	0.6587	0.9021	0.9854
P5	0.4357	0.6752	0.8735
P6	0.3926	0.6190	0.8157

Table 1: Estimation of the modelled waveheight [m] at the different sensor locations for the low, mid and high tide measurements.

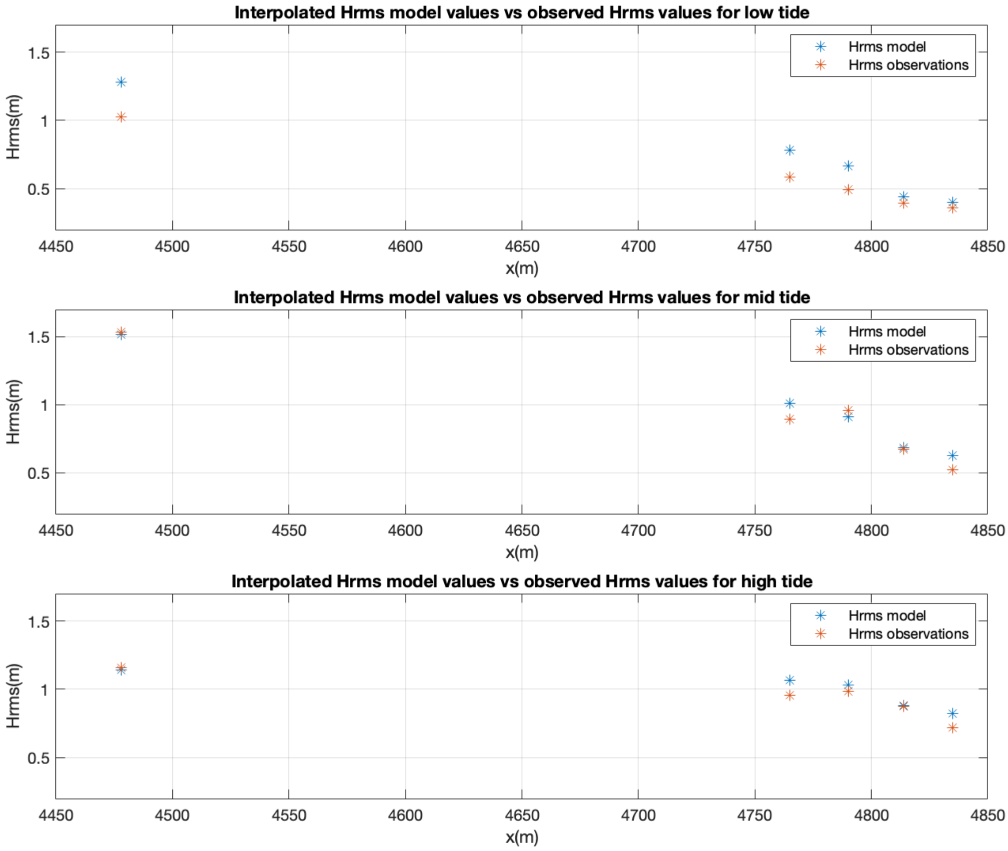

Figure 1.6: Comparison between interpolated modelled wave heights and observed wave heights for each sensor position.

- *Compute the root mean square error (in terms of wave height) for each tide separately and then for the full dataset.*

Table 2 depicts the root mean square error (RMSE) for each tide and for the full dataset. The RMSE is largest for the low tide, which is as expected because in Figure 1.6 it was already shown that the observed and modeled wave height values differed the most for low tide. The RMSE for the mid and high tide are relatively low. Because the RMSE for the low tide case is relatively high, the RMSE for the full data set becomes higher than for the mid or high tide.

Type of tide	e_{rms}
Low tide	0.1641
Mid tide	0.0736
High tide	0.0716
Full data set	0.1118

Table 2: Root mean square erros for the different tides and the full dataset.