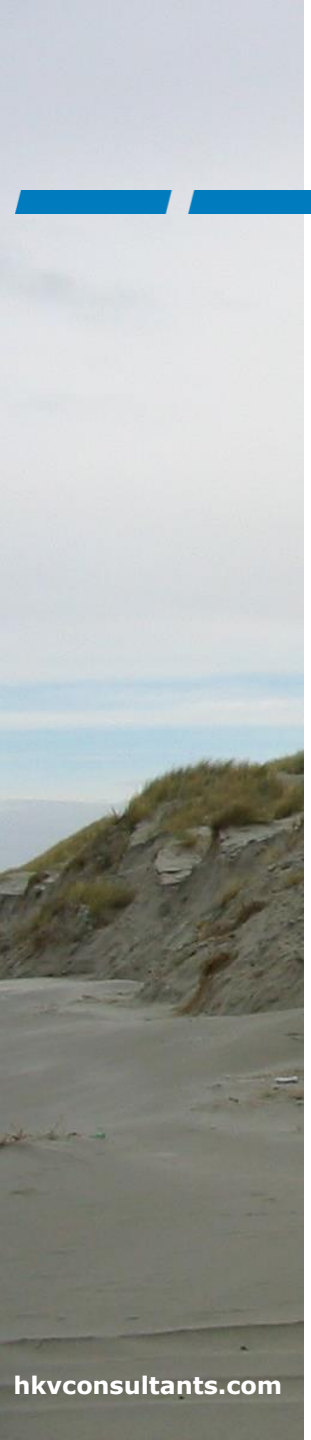


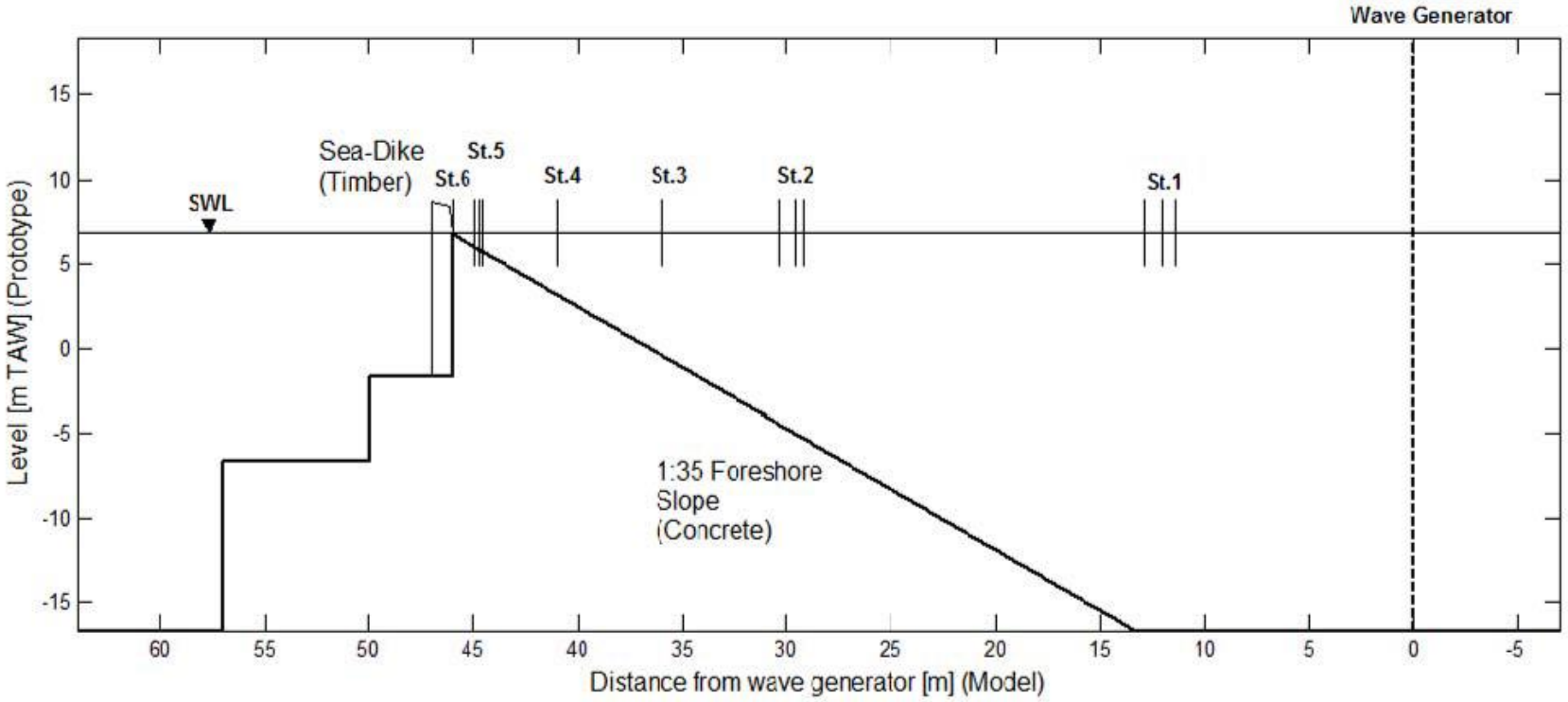
Coastal structures: wave overtopping

Vincent Vuik

Activities

- Validation XBeach for wave overtopping over coastal structures
- XBeach in non-hydrostatic mode
- Data set: Wenduine wave overtopping scale model (provided by Flanders Hydraulics)
- Comparison with SWASH

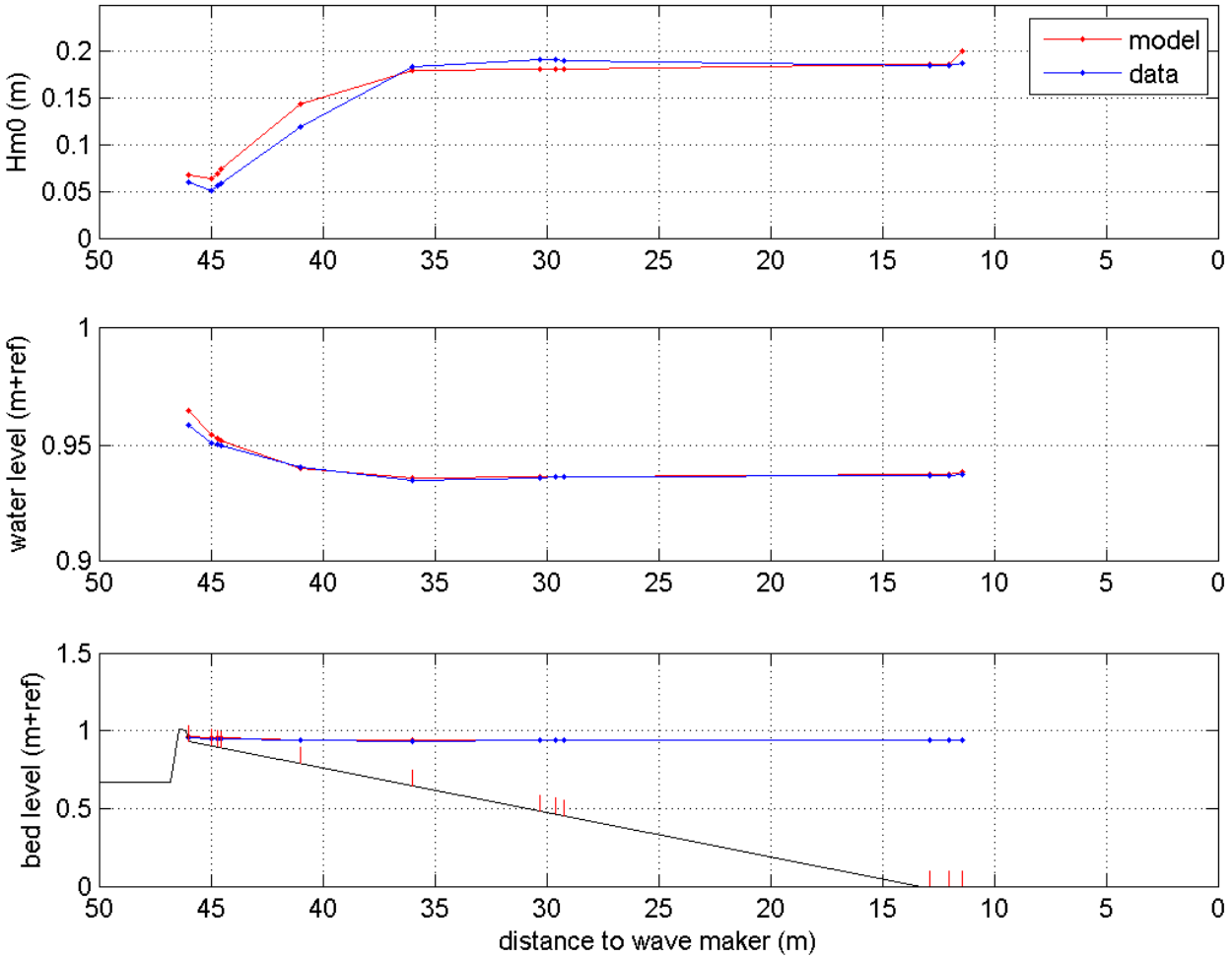
Wenduine scale model



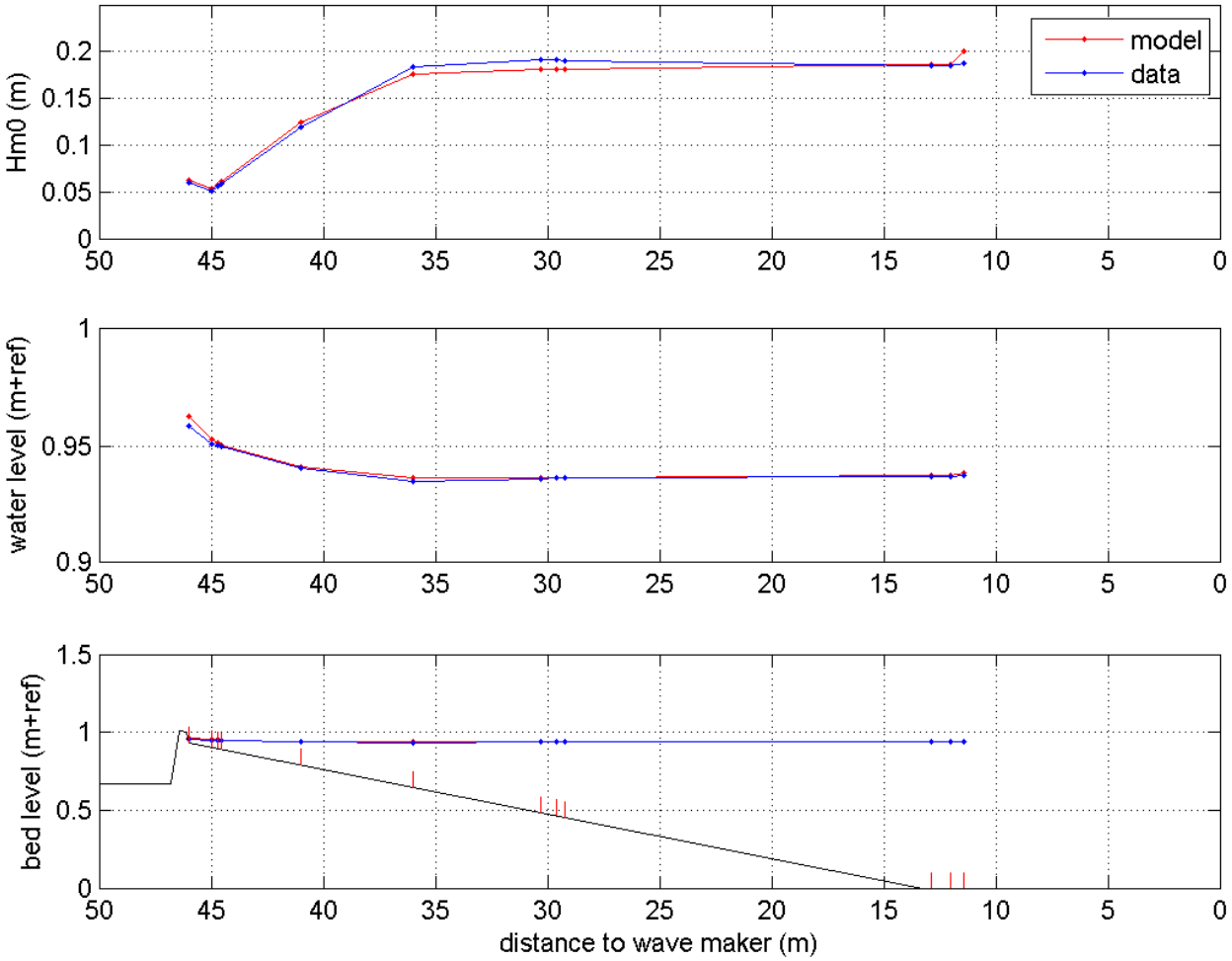
XBeach model

- Time series of incoming wave determined (Mansard & Funke)
- Boundary condition: water level incoming wave & corresponding orbital velocity (FFT)
- Increase amplitude of signal (multiplier) to obtain the right incident wave height
- 50 ppwl → dxmax = 0.14 m, dxmin = 0.02 m
- Calibration: manning roughness coefficient & maximum breaking steepness
- Wave overtopping: $\mathrm{q} = \frac{1}{T}\int_0^T uh \,\mathrm{dt}$

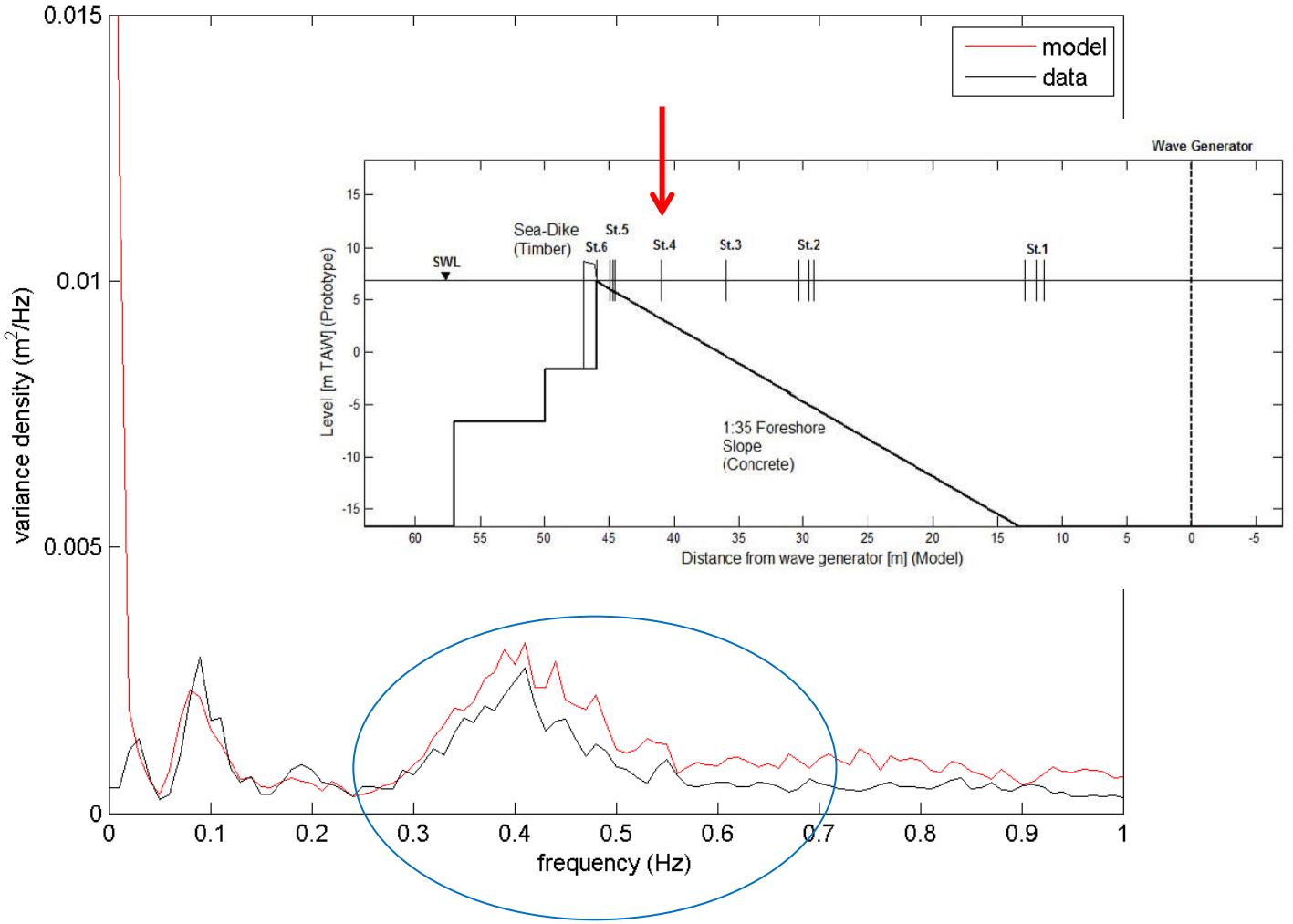
Results maxbrsteep = 0.60 (default)



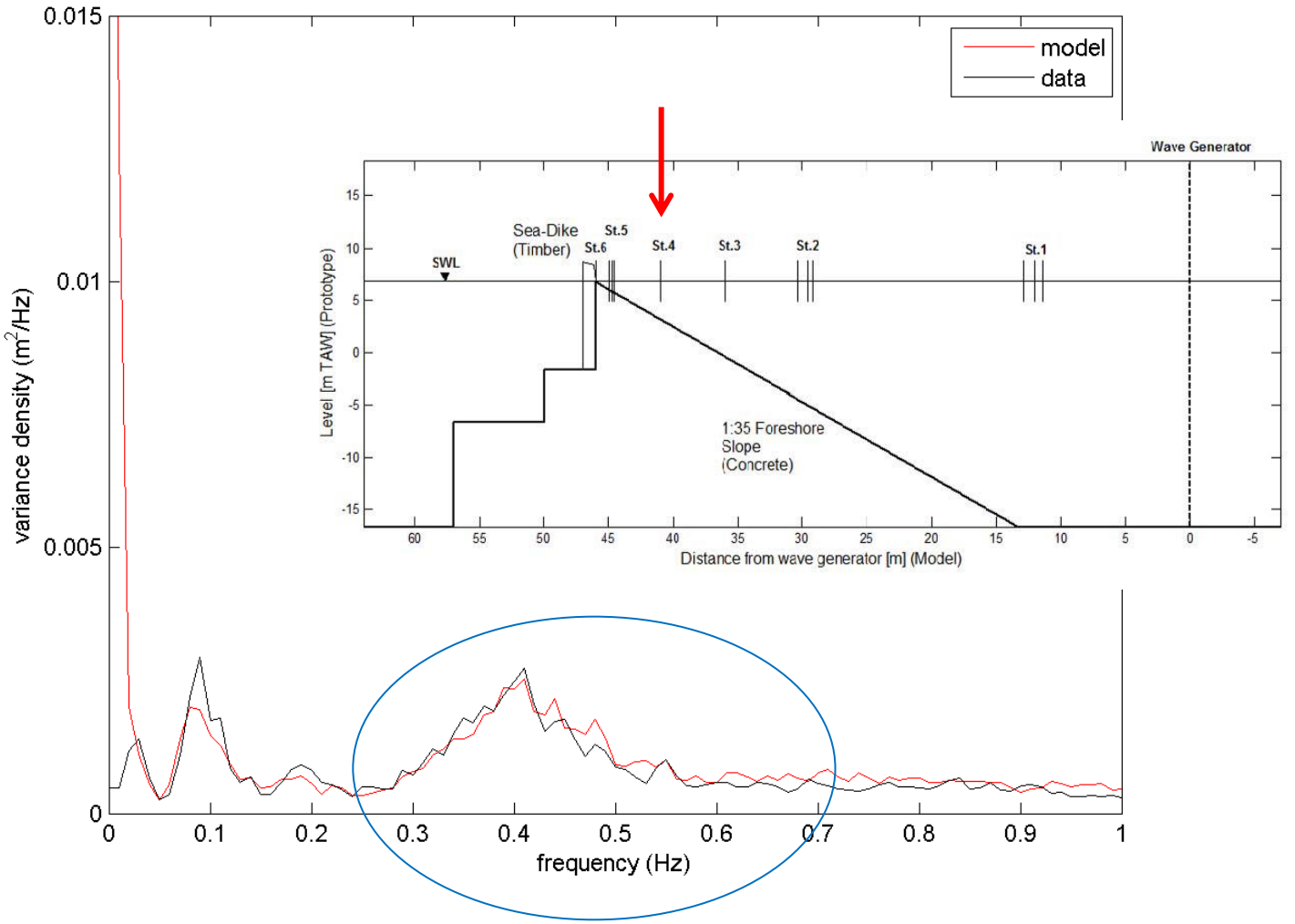
Reduce maxbrsteep to 0.35



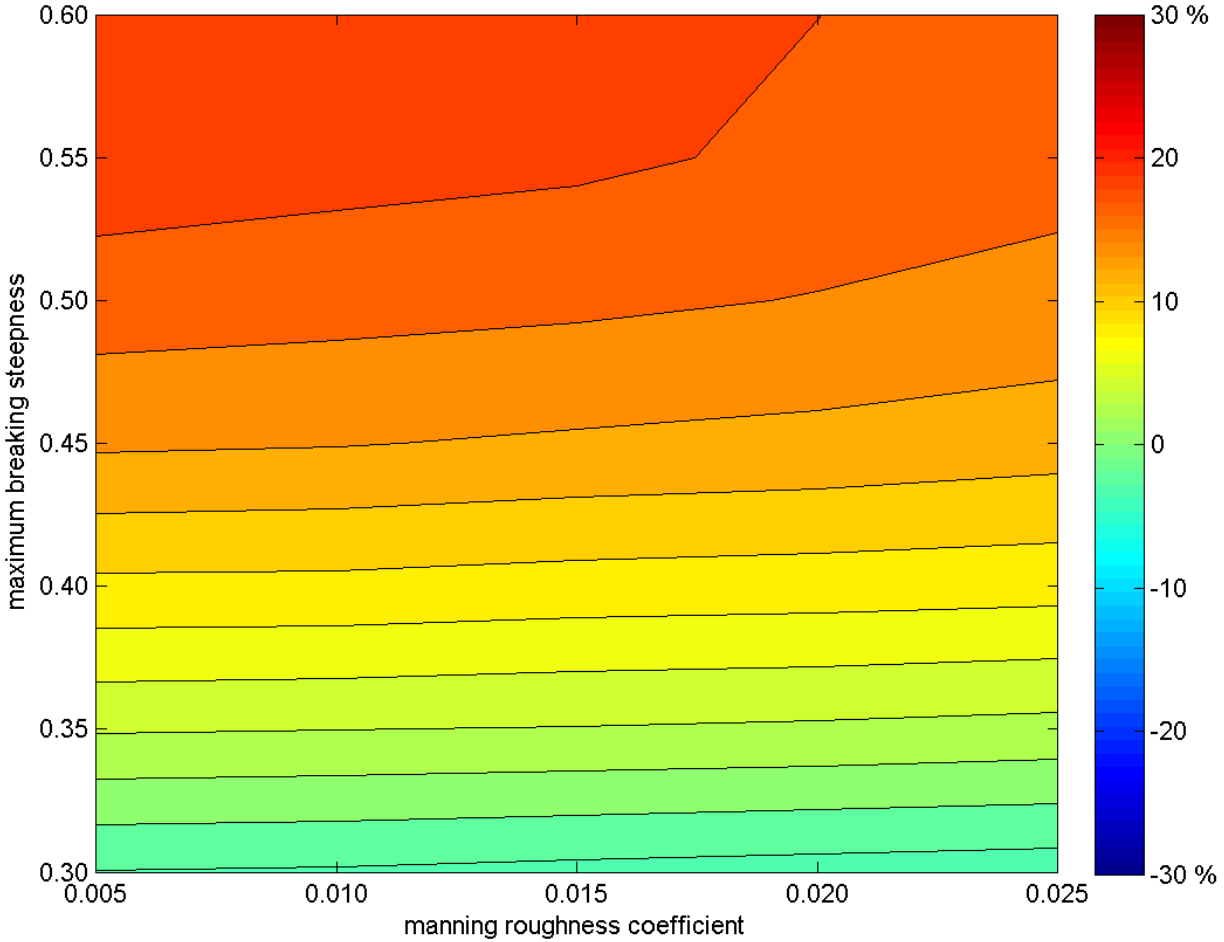
Spectrum maxbrsteep = 0.60 (default)



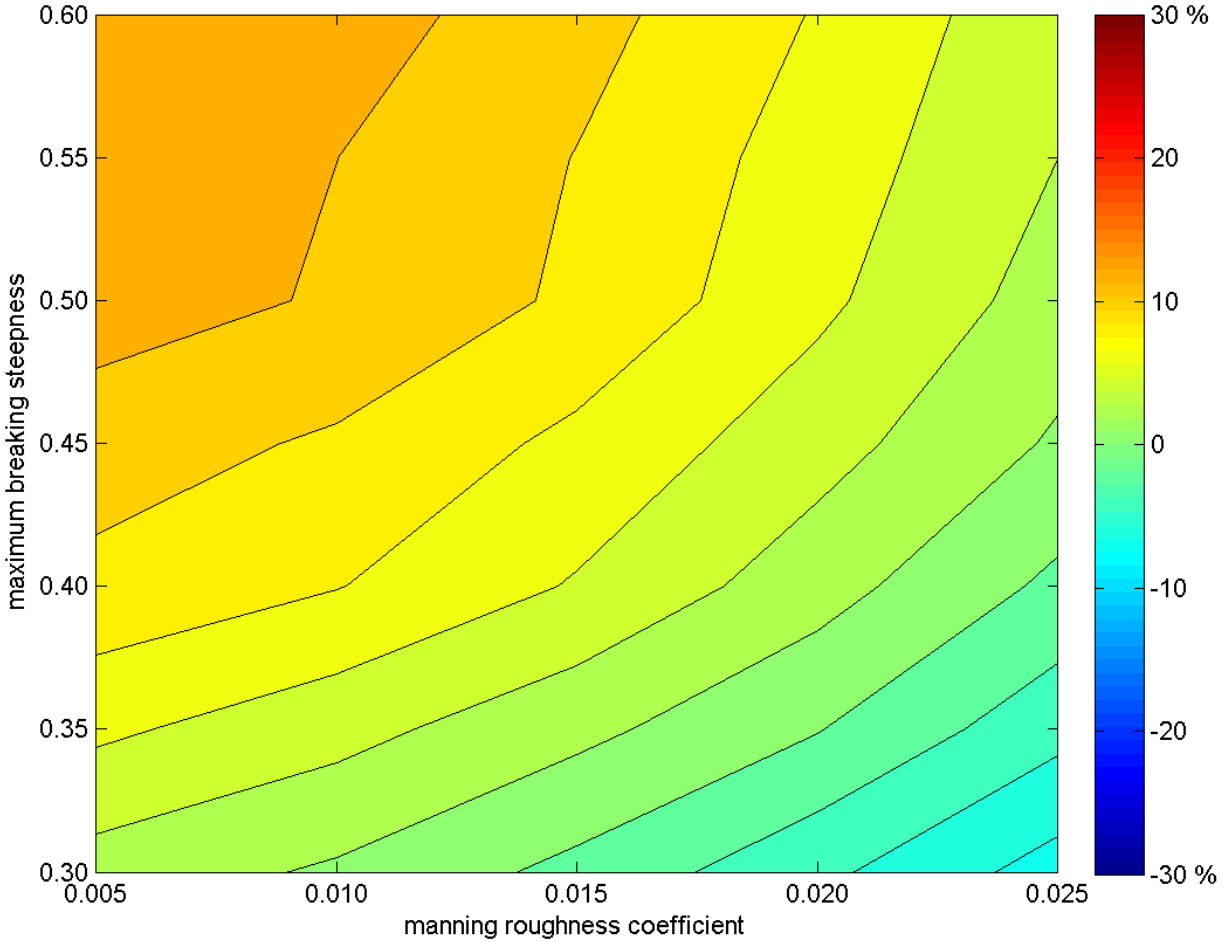
Reduce maxbrsteep to 0.35



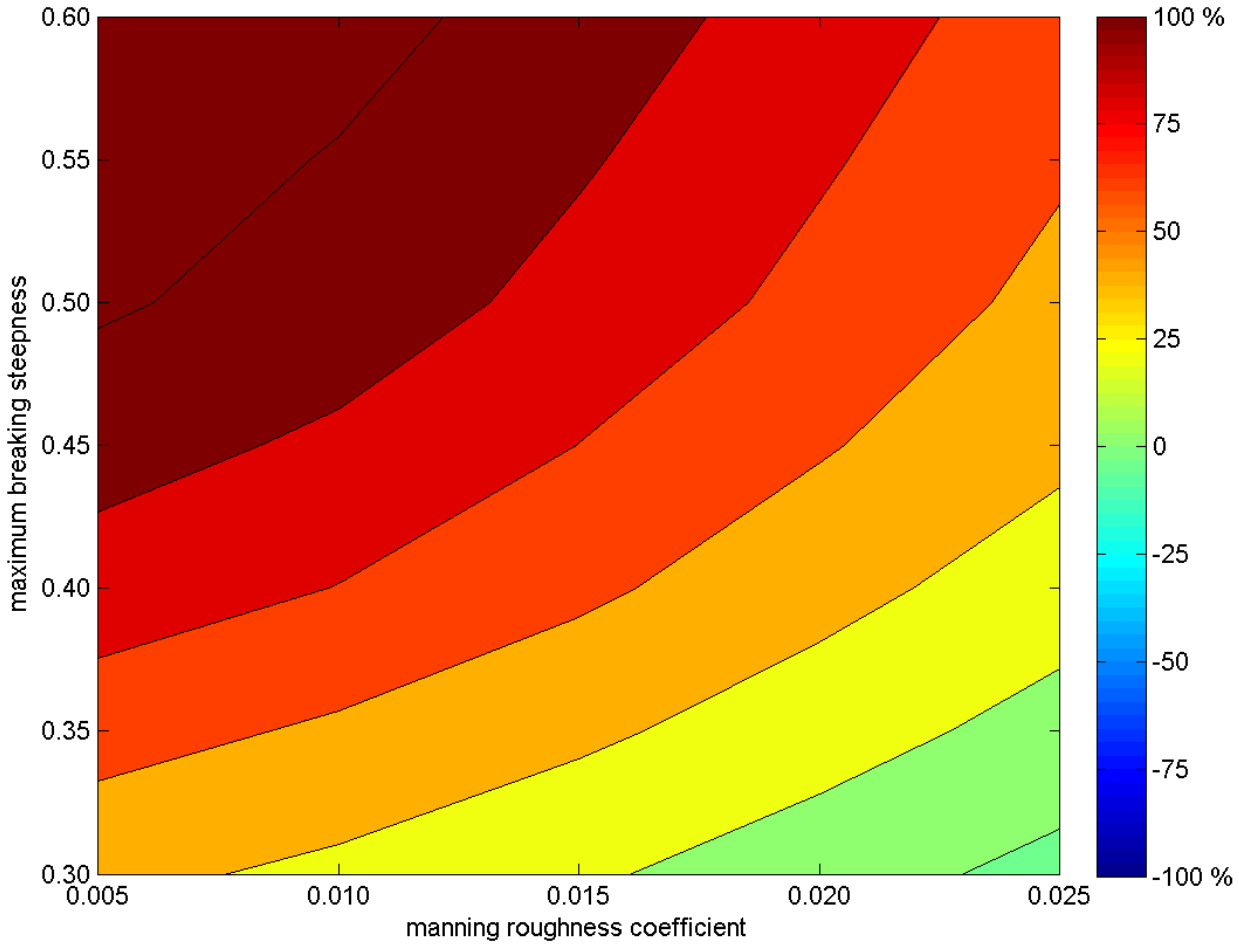
Difference in H_{m0} at station 4



Difference in H_{m0} at station 6 (dike toe)



Difference in overtopping discharge



All tests with simple dike geometries

default: maxbrsteep = 0.60, n=0.010 s/m$^{1/3}$

test	maxbrsteep	friccoef	Q data	Q model	Q dif	h data	h model	h dif	Hm0 data	Hm0 model	Hm0 dif	Tmm10 data	Tmm10 mode	Tmm10 dif
1	0.60	0.010	0.51	1.15	127%	0.959	0.965	0.006	0.059	0.067	13%	4.43	3.72	-16%
2	0.60	0.010	0.54	1.44	165%	0.959	0.965	0.006	0.060	0.065	8%	4.44	3.52	-21%
4	0.60	0.010	0.58	31.52	5350%	0.959	1.001	0.041	0.061	0.088	45%	4.56	2.45	-46%
11	0.60	0.010	1.82	2.91	60%	0.979	0.982	0.003	0.071	0.081	14%	4.26	3.36	-21%
37	0.60	0.010	0.61	1.08	77%	0.962	0.966	0.004	0.061	0.068	11%	4.53	3.66	-19%
38	0.60	0.010	0.55	1.69	207%	0.962	0.968	0.006	0.063	0.071	12%	4.64	3.45	-26%
39	0.60	0.010	0.52	1.26	144%	0.961	0.966	0.005	0.062	0.066	7%	4.57	3.58	-22%
40	0.60	0.010	0.55	1.87	240%	0.962	0.969	0.007	0.059	0.068	15%	4.33	3.44	-20%
57	0.60	0.010	0.56	1.01	79%	0.959	0.965	0.006	0.060	0.068	14%	4.38	3.68	-16%

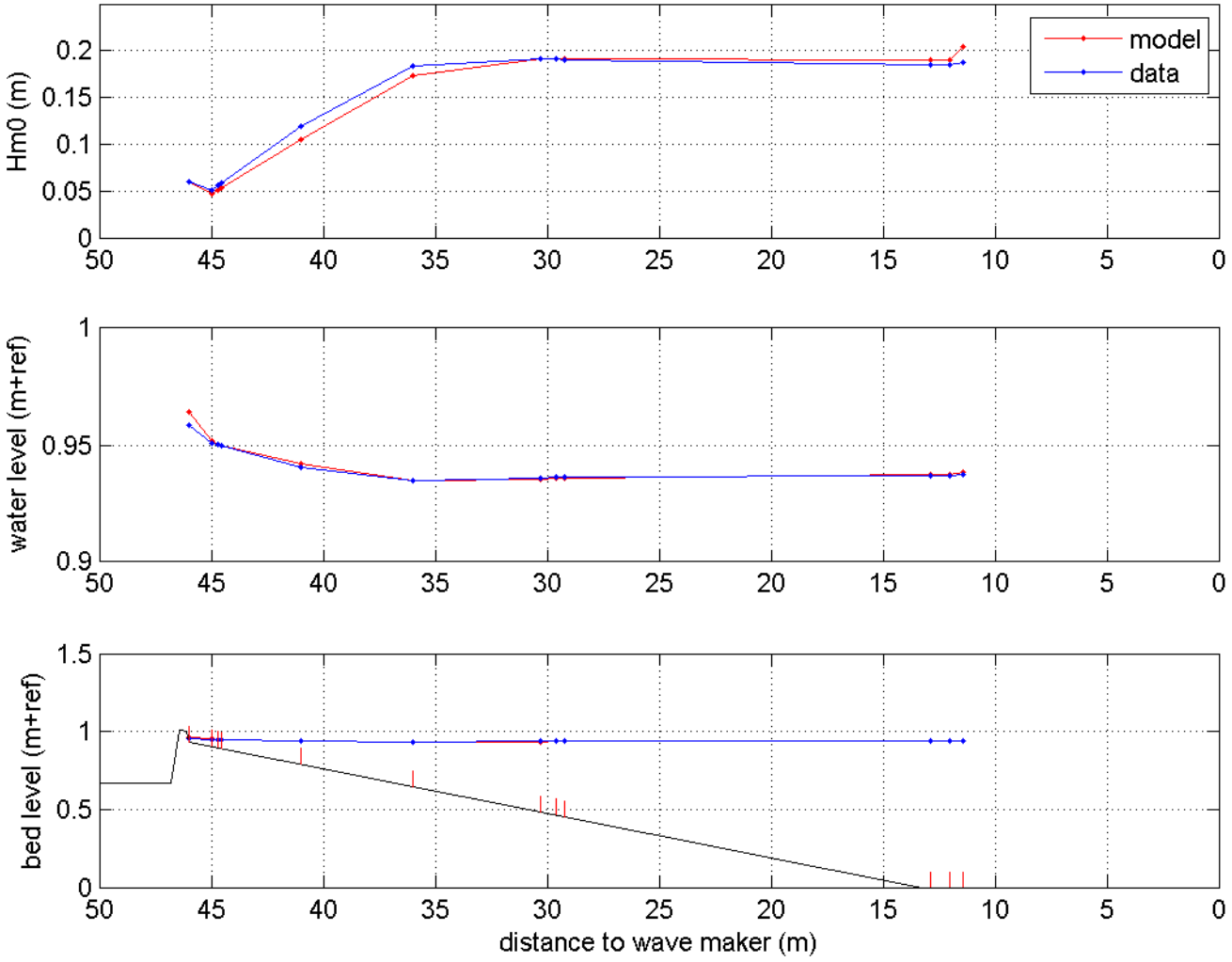
best fit: maxbrsteep = 0.35, n=0.010 s/m$^{1/3}$

test	maxbrsteep	friccoef	Q data	Q model	Q dif	h data	h model	h dif	Hm0 data	Hm0 model	Hm0 dif	Tmm10 data	Tmm10 mode	Tmm10 dif
1	0.35	0.010	0.51	0.79	57%	0.959	0.963	0.004	0.059	0.062	5%	4.43	4.09	-8%
2	0.35	0.010	0.54	1.02	87%	0.959	0.964	0.005	0.060	0.060	0%	4.44	3.94	-11%
4	0.35	0.010	0.58	31.31	5313%	0.959	1.000	0.041	0.061	0.083	36%	4.56	2.60	-43%
11	0.35	0.010	1.82	2.12	16%	0.979	0.980	0.001	0.071	0.073	3%	4.26	3.77	-12%
37	0.35	0.010	0.61	0.72	19%	0.962	0.964	0.002	0.061	0.063	4%	4.53	4.06	-10%
38	0.35	0.010	0.55	1.21	119%	0.962	0.965	0.003	0.063	0.064	2%	4.64	3.93	-15%
39	0.35	0.010	0.52	0.90	74%	0.961	0.964	0.002	0.062	0.060	-2%	4.57	3.91	-14%
40	0.35	0.010	0.55	1.37	149%	0.962	0.967	0.005	0.059	0.062	5%	4.33	3.83	-11%
57	0.35	0.010	0.56	0.67	18%	0.959	0.963	0.004	0.060	0.064	6%	4.38	4.01	-8%

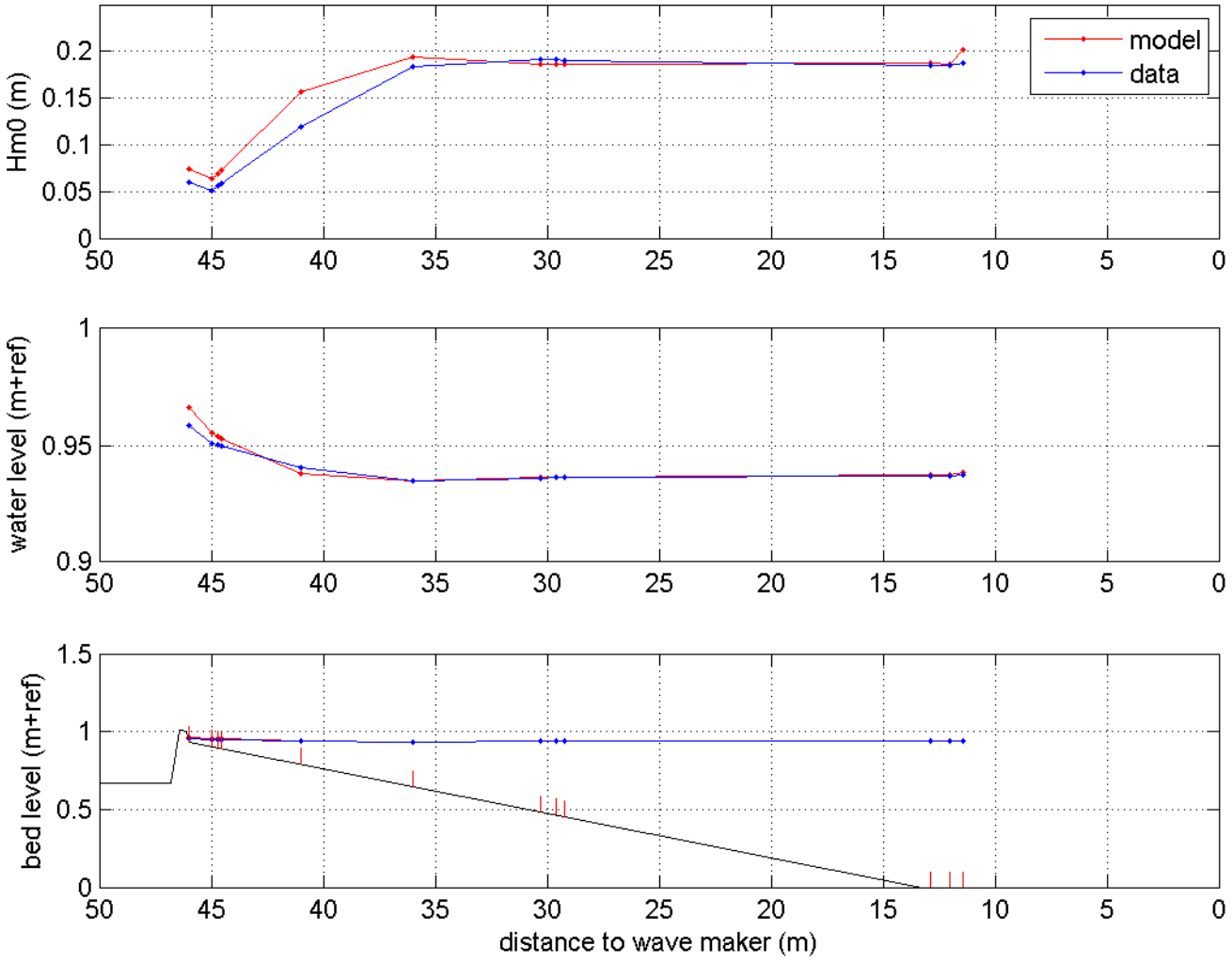
SWASH model

- 1 layer used as kd<<1
- Upwind scheme with strict momentum conservation selected
- No variable grid resolution possible (yet)
- dx = 0.04 m
- Water level specification at boundary suffices, SWASH computes orbital velocities itself

SWASH, maxbrsteep = 0.60, dx = 0.04 m



XBeach, maxbrsteep = 0.60, dx = 0.04 m



All tests with simple dike geometries

XBeach: maxbrsteep = 0.60, n=0.010 s/m$^{1/3}$

test	maxbrsteep	friccoef	Q data	Q model	Q dif	h data	h model	h dif	Hm0 data	Hm0 model	Hm0 dif	Tmm10 data	Tmm10 mode	Tmm10 dif
1	0.60	0.010	0.51	1.15	127%	0.959	0.965	0.006	0.059	0.067	13%	4.43	3.72	-16%
2	0.60	0.010	0.54	1.44	165%	0.959	0.965	0.006	0.060	0.065	8%	4.44	3.52	-21%
4	0.60	0.010	0.58	31.52	5350%	0.959	1.001	0.041	0.061	0.088	45%	4.56	2.45	-46%
11	0.60	0.010	1.82	2.91	60%	0.979	0.982	0.003	0.071	0.081	14%	4.26	3.36	-21%
37	0.60	0.010	0.61	1.08	77%	0.962	0.966	0.004	0.061	0.068	11%	4.53	3.66	-19%
38	0.60	0.010	0.55	1.69	207%	0.962	0.968	0.006	0.063	0.071	12%	4.64	3.45	-26%
39	0.60	0.010	0.52	1.26	144%	0.961	0.966	0.005	0.062	0.066	7%	4.57	3.58	-22%
40	0.60	0.010	0.55	1.87	240%	0.962	0.969	0.007	0.059	0.068	15%	4.33	3.44	-20%
57	0.60	0.010	0.56	1.01	79%	0.959	0.965	0.006	0.060	0.068	14%	4.38	3.68	-16%

SWASH: maxbrsteep = 0.60, n=0.010 s/m$^{1/3}$

test	maxbrsteep	friccoef	Q data	Q model	Q dif	h data	h model	h dif	Hm0 data	Hm0 model	Hm0 dif	Tmm10 data	Tmm10 mode	Tmm10 dif
1	0.60	0.010	0.51	1.13	124%	0.959	0.965	0.006	0.059	0.059	-1%	4.43	4.39	-1%
2	0.60	0.010	0.54	1.56	186%	0.959	0.966	0.007	0.060	0.060	0%	4.44	4.26	-4%
4	0.60	0.010	0.58	13.35	2207%	0.959	1.010	0.051	0.061	0.099	62%	4.56	2.67	-42%
11	0.60	0.010	1.82	3.37	85%	0.979	0.980	0.001	0.071	0.076	6%	4.26	4.11	-3%
37	0.60	0.010	0.61	1.36	125%	0.962	0.966	0.004	0.061	0.063	4%	4.53	4.46	-1%
38	0.60	0.010	0.55	1.68	204%	0.962	0.968	0.006	0.063	0.065	3%	4.64	4.33	-7%
39	0.60	0.010	0.52	1.32	155%	0.961	0.966	0.005	0.062	0.060	-3%	4.57	4.42	-3%
40	0.60	0.010	0.55	2.13	288%	0.962	0.969	0.007	0.059	0.063	6%	4.33	4.20	-3%
57	0.60	0.010	0.56	1.18	108%	0.959	0.965	0.006	0.060	0.063	4%	4.38	4.45	2%

Conclusions

- For default settings in XBeach for maxbrsteep, short wave breaking is underpredicted, and wave overtopping is overpredicted
- Wave overtopping highly sensitive to computed water level (wave set-up) as freeboard is small
- Boundary effect: sudden decrease in wave height
- Tendency to underpredict $T_{m-1,0}$ at dike toe
- Remarkable difference between SWASH and XBeach for maxbrsteep
- Performance for larger freeboards?