2D OVERTOPPING AND IMPACT EXPERIMENTS IN SHALLOW FORESHORE CONDITIONS

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CREST
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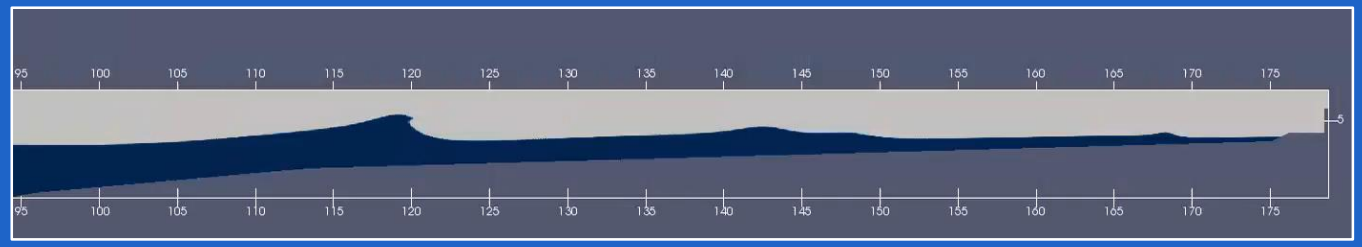
Hofland *et al.* (2017)

Deep [14,24,3]	$\frac{h_t}{H_{m0,o}} > 4$
Shallow [14,24]	$1 < \frac{h_t}{H_{m0,o}} < 4$
Very Shallow [28]	$0.3 < \frac{h_t}{H_{m0,o}} < 1$
Extremely Shallow [1,5][a]	$\frac{h_t}{H_{m0,o}} < 0.3$

Foreshore slope range Belgian coast: 1/20 – 1/90



Numerical modelling

Experimental modelling

Field measurements

Main objectives of the 2D experiments

1. Effect foreshore and its slope on:

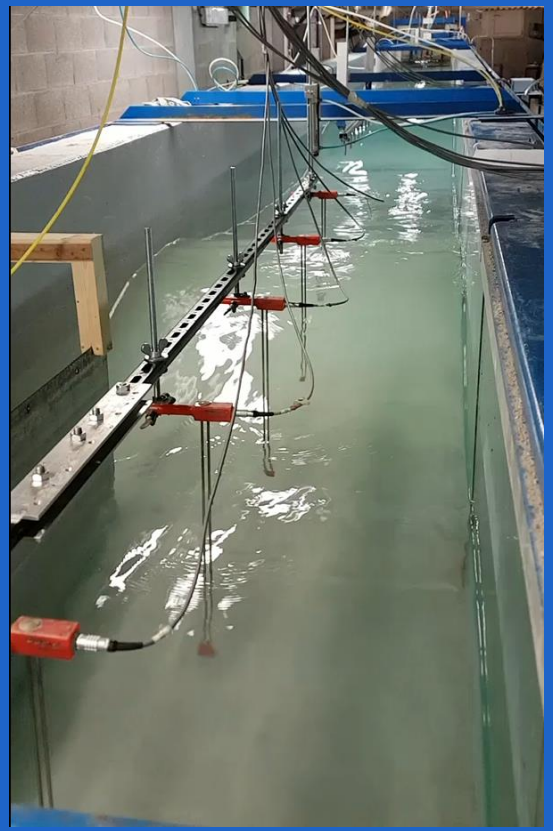
   a. Wave transformation up to the dike toe

   b. Wave overtopping over the sea dike and wave impact forces on buildings on top of the dike

2. Providing a validation dataset for the numerical modelling

2D Experimental modelling – Overview

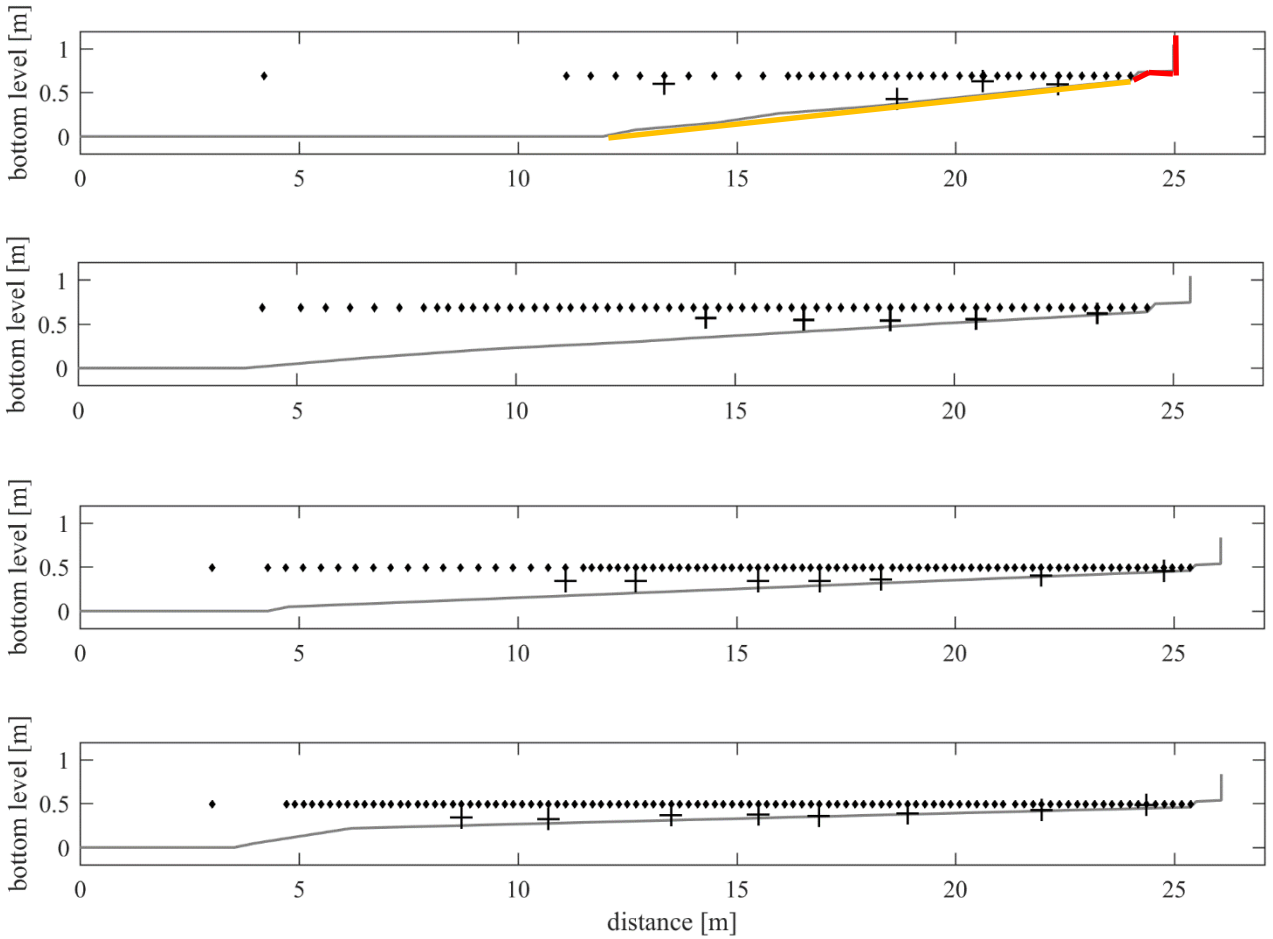
High spatial resolution of surface elevations



Wave overtopping

Wave forces

2D Experimental modelling – Model setup



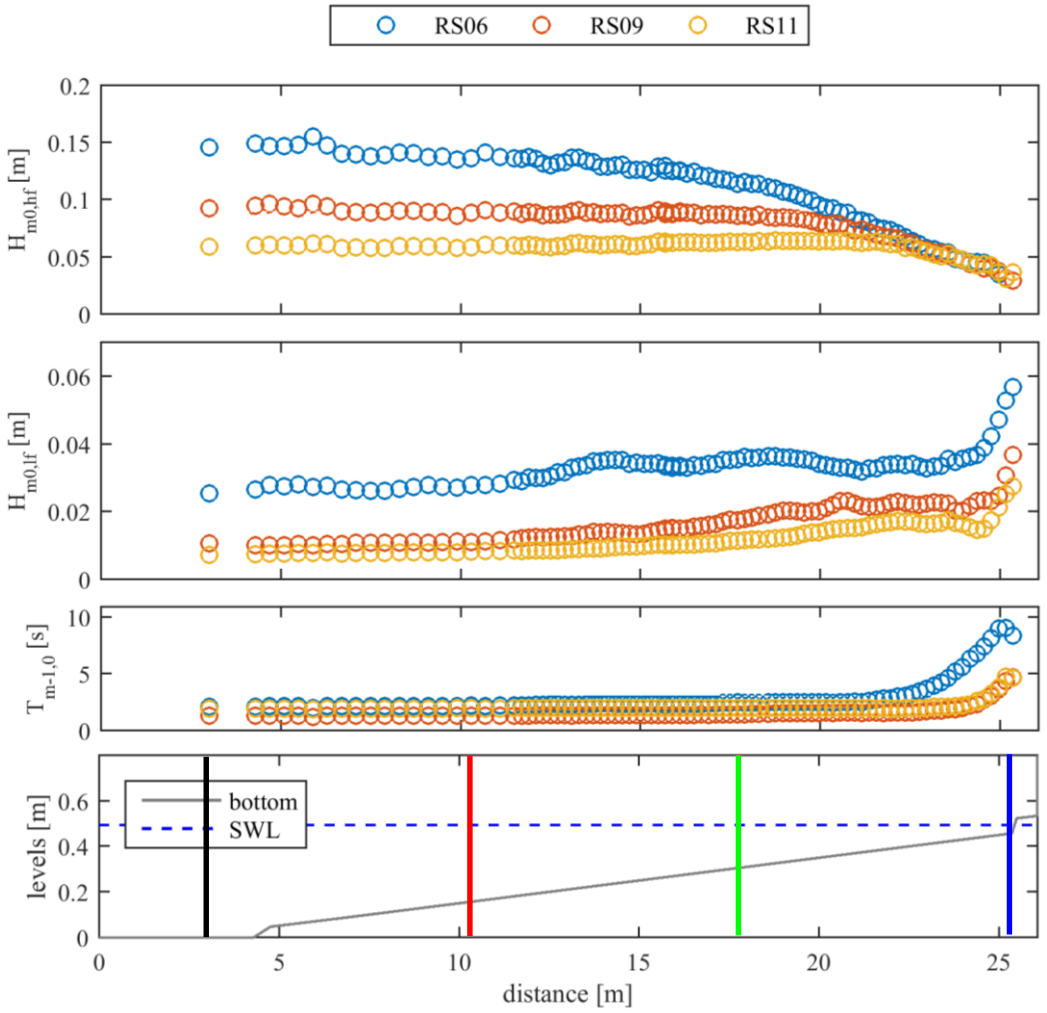
cf. Boers (1996) , van Dongeren *et al.* (2007), Ruessink *et al.* (2013)

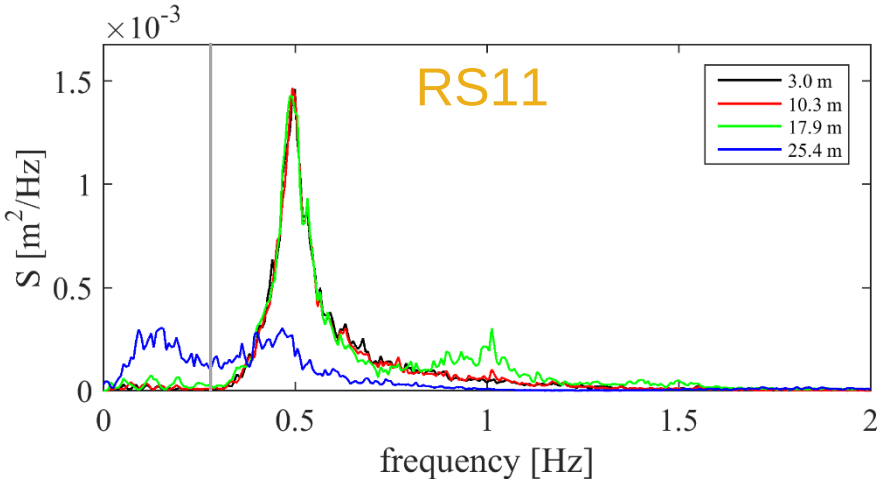
2D Experimental modelling – Test matrix

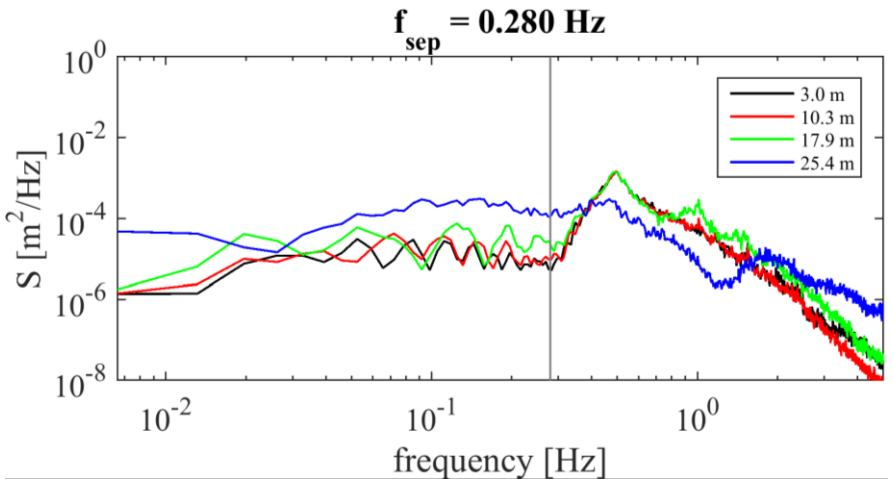
test ID	Order	h_o	$H_{m0,o}$	$T_{p,o}$	cot(θ)	$h_t/H_{m0,o}$	HSR	OVT	WIF
[-]	[-]	[m]	[m]	[s]	[-]	[-]	[-]	[-]	[-]
RS01	2nd	0.65	0.20	2.4	20, 35, 50 (1:25), 50 (1:35), 80	0.06	No	Yes	Yes
RF01	1st	0.65	0.20	2.4	35, 50 (1:25)	0.06	No	Yes	Yes
RS02	2nd	0.65	0.20	2.0	20, 35, 50 (1:25), 50 (1:35), 80	0.06	Yes*	Yes	No
RS03	2nd	0.65	0.20	1.6	20, 35, 50 (1:25), 50 (1:35), 80	0.07	No	Yes	No
RS04	2nd	0.65	0.12	1.6	20, 35, 50 (1:25), 50 (1:35), 80	0.10	Yes*	No	No
RS05	2nd	0.65	0.08	2.4	20, 35, 50 (1:25), 50 (1:35), 80	0.15	Yes	Yes	Yes
RF05	1st	0.65	0.08	2.4	35, 50 (1:25)	0.15	Yes	Yes	Yes
RS06	2nd	0.69	0.20	2.4	20, 35, 50 (1:25), 50 (1:35), 80	0.26	Yes*	Yes	Yes
RS07	2nd	0.69	0.20	2.0	20, 35, 50 (1:25), 50 (1:35), 80	0.26	No	Yes	Yes
RS08	2nd	0.69	0.20	1.6	20, 35, 50 (1:25), 50 (1:35), 80	0.26	No	Yes	Yes
RS09	2nd	0.69	0.12	1.6	20, 35, 50 (1:25), 50 (1:35), 80	0.43	Yes*	Yes	Yes
RS10	2nd	0.69	0.12	2.4	20, 35, 50 (1:25), 50 (1:35), 80	0.43	No	Yes	Yes
RS11	2nd	0.69	0.08	2.4	20, 35, 50 (1:25), 50 (1:35), 80	0.65	Yes	Yes	Yes
RF11	1st	0.69	0.08	2.4	35, 50 (1:25)	0.65	No	Yes	Yes
RS12	2nd	0.69	0.06	2.4	20, 35, 50 (1:25), 50 (1:35), 80	0.87	No	Yes	Yes
RS13	2nd	0.69	0.04	2.4	20, 35, 50 (1:25), 50 (1:35), 80	1.30	No	Yes	Yes

*short test: ~100 waves instead of ~1000 waves

First results – Wave transformation over the foreshore







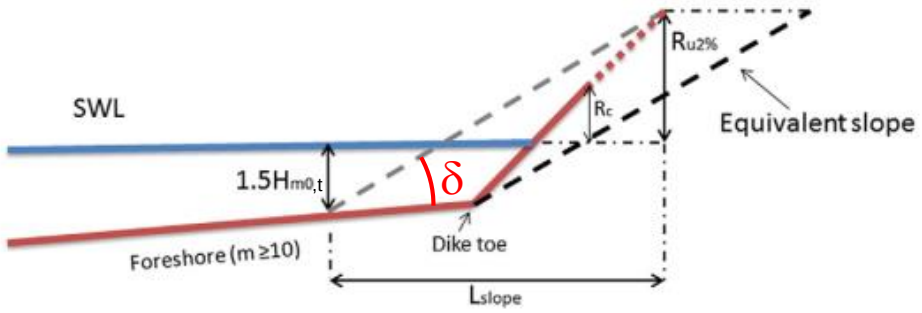
cf. Ruessink *et al.* (2013), de Bakker *et al.* (2015)

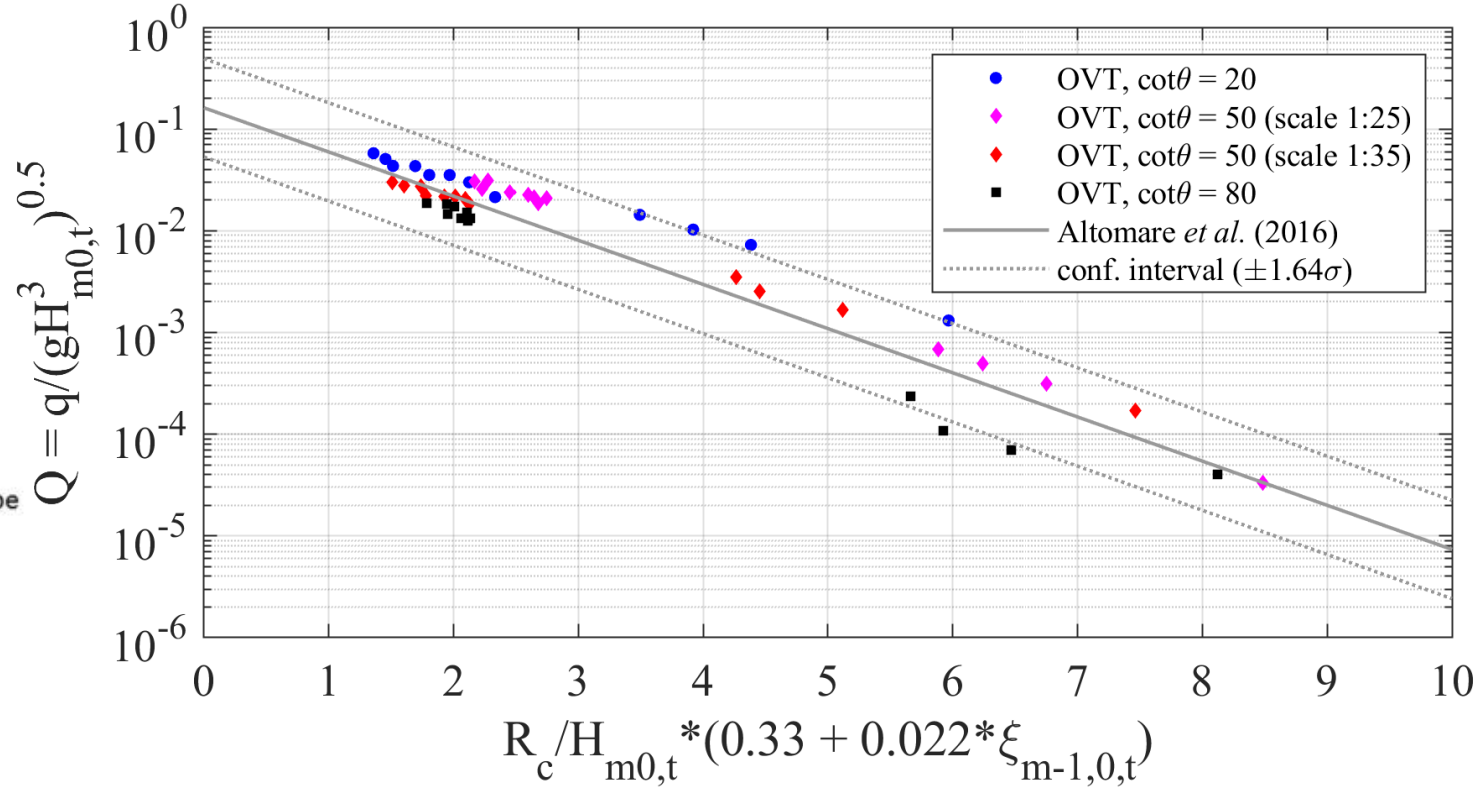
First results – Wave overtopping

Van Gent (1999), recalibrated and extended with equivalent slope concept by Altomare *et al.* (2016):

$$\frac{q}{\sqrt{gH_{m0,t}^3}} = 10^{-0.791} exp\left(-\frac{R_c}{H_{m0,t}(0.33 + 0.022\xi_{m-1,0,t})}\right)$$

$$\xi_{m-1,0,t} = \frac{\tan\delta}{\sqrt{2\pi H_{m0,t} / gT_{m-1,0,t}^2}}$$

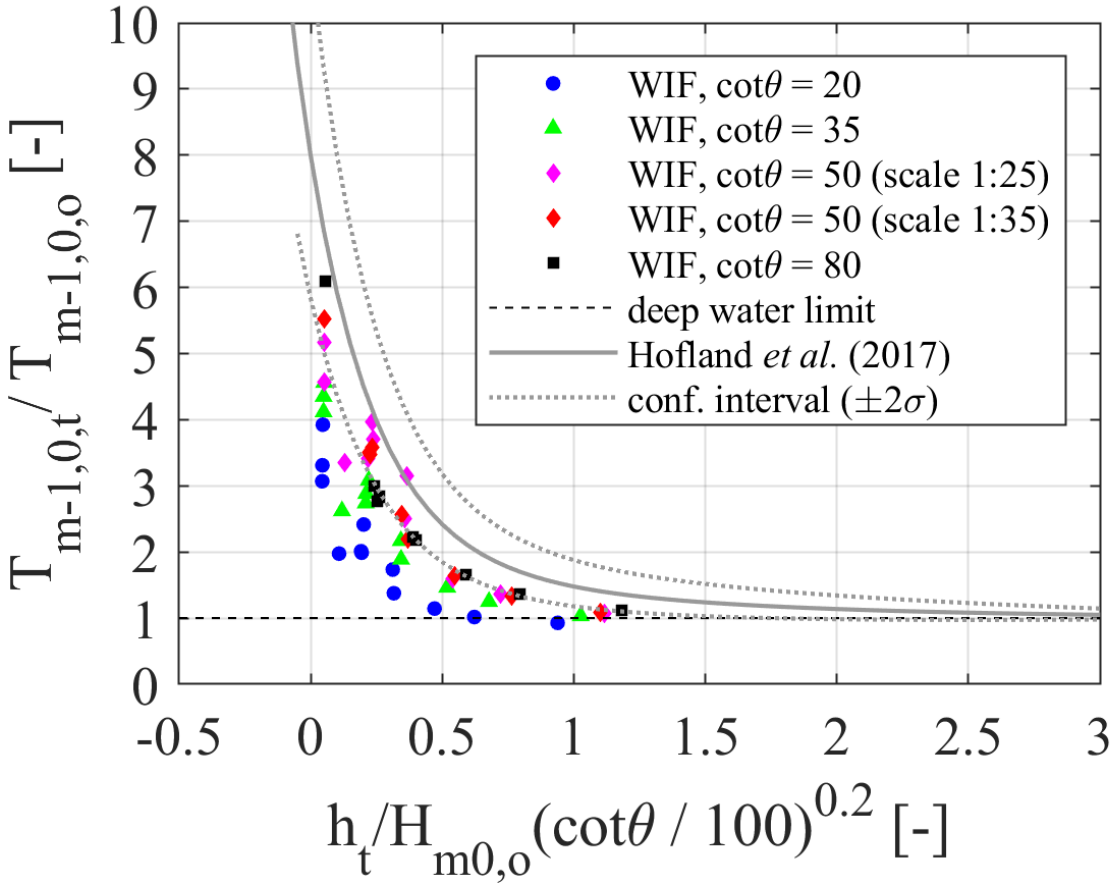




First results – Spectral wave period $T_{m-1,0}$ at the dike toe

Hofland *et al.* (2017): $\frac{T_{m-1,0,t}}{T_{m-1,0,o}} - 1 = 6\,exp(-4\tilde{h}) + exp(-\tilde{h})$

$$\theta T_{m-1,0,o}\sqrt{g/H_{m0,o}} < 0.62$$

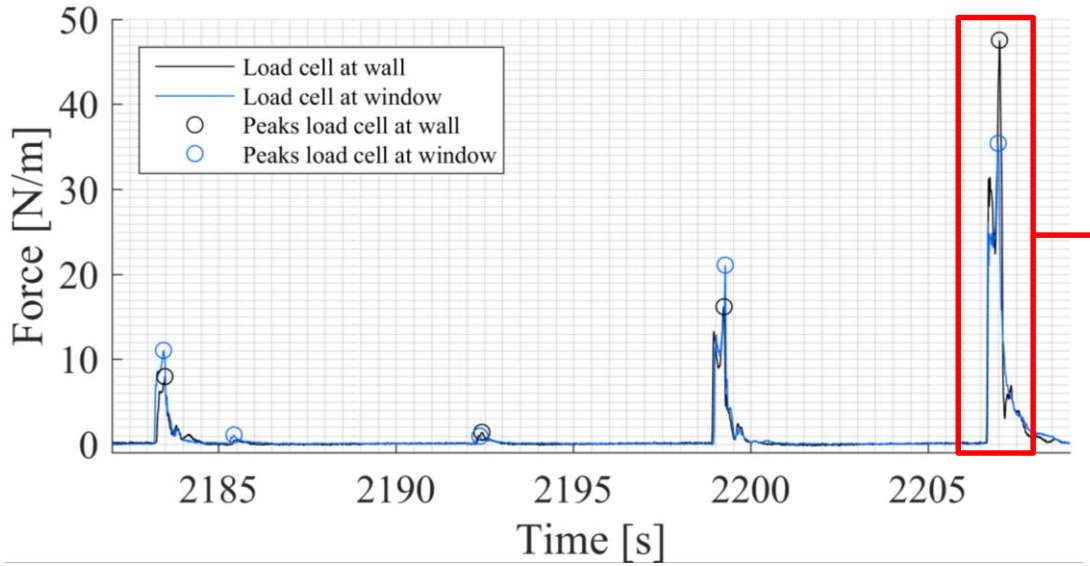


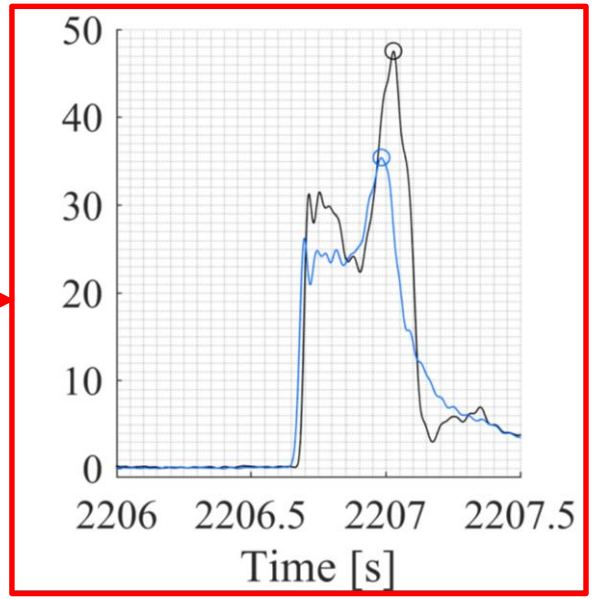
test ID	h_o	$H_{m0,o}$	$T_{m-1,0,o}$	1/20	1/35	1/50	1/80
[-]	[m]	[m]	[s]	[-]	[-]	[-]	[-]
RS01	0.65	0.20	2.2	**0.76**	0.44	0.31	0.19
RS02	0.65	0.20	1.8	**0.64**	0.36	0.25	0.16
RS03	0.65	0.20	1.5	0.51	0.29	0.20	0.13
RS04	0.65	0.12	1.5	**0.66**	0.38	0.26	0.16
RS05	0.65	0.08	2.2	**1.21**	**0.69**	0.48	0.30
RS06	0.69	0.20	2.2	**0.76**	0.44	0.31	0.19
RS07	0.69	0.20	1.8	**0.64**	0.36	0.25	0.16
RS08	0.69	0.20	1.5	0.51	0.29	0.20	0.13
RS09	0.69	0.12	1.5	**0.66**	0.38	0.26	0.16
RS10	0.69	0.12	2.2	**0.99**	0.56	0.39	0.25
RS11	0.69	0.08	2.2	**1.21**	**0.69**	0.48	0.30
RS12	0.69	0.06	2.2	**1.39**	**0.80**	0.56	0.35
RS13	0.69	0.04	2.2	**1.71**	**0.98**	**0.68**	0.43

First results – Wave impact forces

Load cell at window

Load cell at wall





→ M. Streicher, Wednesday 8:10 a.m.

Conclusions & Future work

1. HSR tests show a significant increase of long wave energy close to the dike

2. The foreshore slope value has a clear influence:
   a. On the accuracy of the prediction formula for wave overtopping: it is sensitive to the foreshore slope value for high freeboard values
   b. On the accuracy of the prediction formula for $T_{m-1,0,t}$: it makes an overestimation for steep slopes

3. Important observation of variability of load cell force measurements over the width of the flume

Thank you for your attention!

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