Deltares
Enabling Delta Life

DSD 2016: XBeach and Earth Observation course: Assessment of Nature-based Flood defenses

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RISC-KIT
RESILIENCE-INCREASING STRATEGIES FOR COASTS - TOOLKIT
WWW.RISCKIT.EU

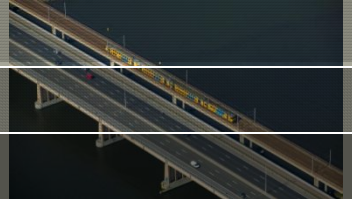
FAST
FORESHORE ASSESSMENT USING SPACE TECHNOLOGY

XB-VEG

Program of today

Time	Type	Description
09:15	**Theory**	The different modes of XBeach (i.e. stationary, surfbeat, nonhydrostatic)
09:30	**Theory**	XBeach-VEG
09:45	**Hands-on**	Lovas (2000) by van Rooijen et al., 2016 – understanding the impact of vegetation on wave height and setup
11:00	**Theory**	Earth Observation – from image to info
11:15	**Hands-on**	Continue with the exercise Lovas (2000)
12:00	**Practical**	RISCKIT and FAST information
12:30	**Lunch**	
13:30	**Practical**	Nesting: XBeach to LISFLOOD
14:00	**Hands-on**	The vegetated foreshore of Tillingham, UK - from hazard to inundation with Xbeach and LISLFOOD
17:00	**Closure & drinks**	

Program of today



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Part 1A. Theoretical background: recap

THE DIFFERENT MODES OF XBEACH (STATIONARY, SURFBEAT, NONHYDROSTATIC)

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Motivation to develop XBeach

Impact Hurricane Matthew. at Vilano Beach FL, 10/9, video credit Tom Kane
Source: https://twitter.com/StuOstro/status/785532989497368576?s=02

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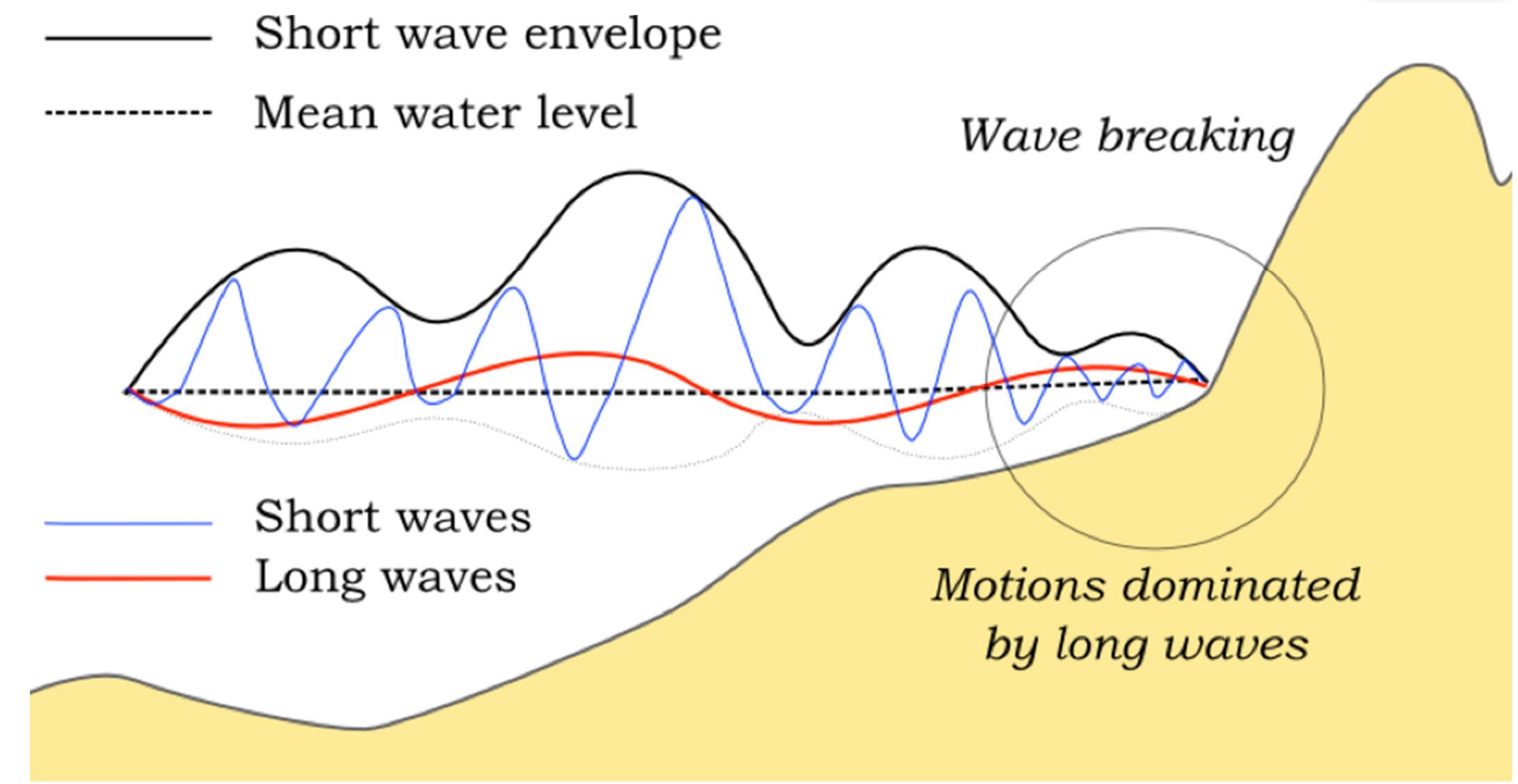
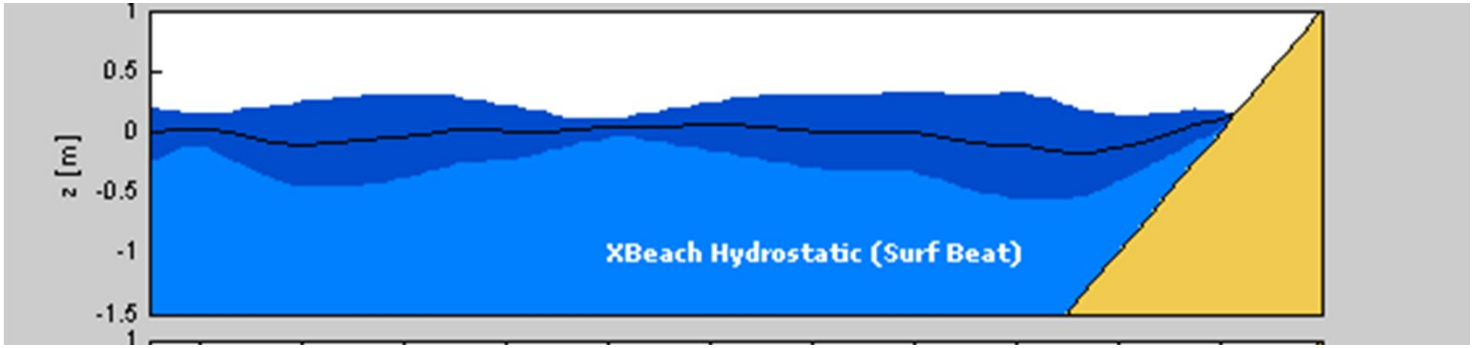
Relevant wave processes



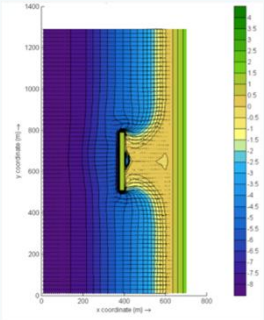
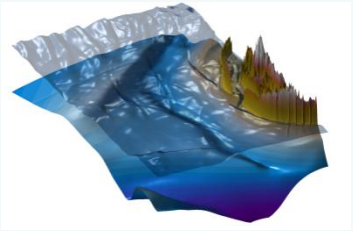
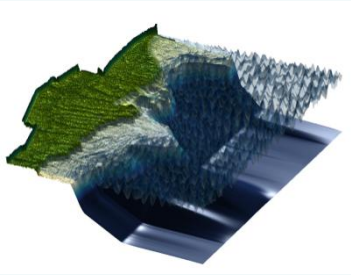
Nederhoff (2014). Modelling the effects of hard structures on dune erosion and overwash. Hindcasting the impact of Hurricane Sandy on New Jersey with XBeach

Different XBeach hydrodynamic modes



surfbeat mode
Wave conditions vary on wave group scale, IG waves resolved

Overview different hydrodynamic modes

Type	Stationairy	Surfbeat	nonhydrostatic
Goal	Schematic short waves	Fully resolve long waves	Propagation of individual waves
Hydrodynamics	no	yes, but only for long waves	yes, for all waves
Morphodynamics	moderate wave conditions	extreme conditions (e.g. hurricanes)	*under development*
Computational time	Short	Medium	Long
Time-scale	Long-term	Short to medium	Short
Example			

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Part 1B. Theoretical background

VEGETATION MODULE IN XBEACH

Sheets used from Arnold van Rooijen

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Implementation XBeach-VEG

Vegetation characteristics:

- Stem height (av ≈ 0.3 m)
- Stem diameter (bv ≈ 0.003 m)
- Vegetation density (N; varies with the seasons)
- Drag coefficient (Cd ≈ 0.15)

→ **Vegetation factor (Av)**

Physics:

- Effect of vegetation on incident (short) waves
- Effect of vegetation on infragravity waves and mean flow
- Effect of vegetation on wave setup

Schematization:

- Vertically non-uniform vegetation (e.g. mangroves)
- Horizontally non-uniform vegetation (different types per location)

Implementation: instationary and surfbeat

- **Incident (short) waves (Mendez & Losada, 2004; Suzuki et al., 2011):**

$$\frac{\partial A}{\partial t}+\frac{\partial c_x A}{\partial x}=-\frac{D_w+D_v}{\sigma}\ , \text{with}$$

$$D_v=\frac{\sinh^3 ks+3\sinh ks}{3k\cosh^3 kh}\cdot\frac{\rho\widetilde{C_D}b_v N_v}{2\sqrt{\pi}}\cdot\left(\frac{gk}{2\omega}\right)^3 H_{rms}^3$$

- **Infragravity waves (surfbeat mode) and flow (Dalrymple et al. 1984):**

$$\frac{\partial \eta}{\partial t}+\frac{\partial u^L h}{\partial x}=0$$

$$\frac{\partial u^L}{\partial t}+u^L\frac{\partial u^L}{\partial x}=-g\frac{\partial \eta}{\partial x}-\frac{\tau_{b,x}+F_w+F_v}{\rho h}$$

$$F_v=F_{vm}+F_{vw}$$

Short wave effects (non-linear)

IG waves and mean flow

$$F_{vm}=0.5\rho C_D\cdot(Av)\cdot u^E|u^E|$$

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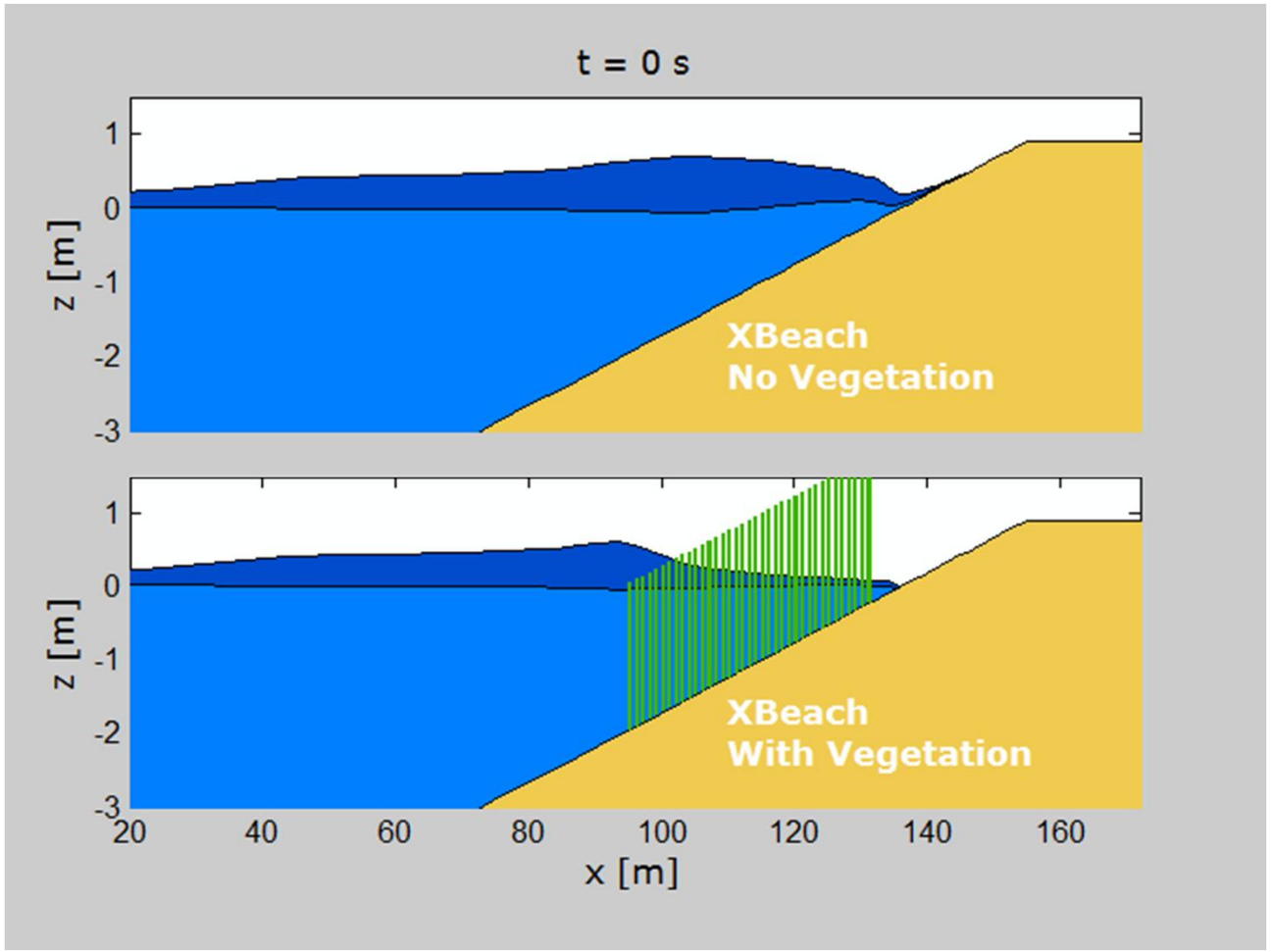
Visual: impact vegetation in surfbeat mode



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Implementation: non-hydrostatic mode

- **Non-hydrostatic mode resolves the incident wave shape**
  - no need for wave shape parameterization

- Vegetation effects can be included by **adding drag force** (Dalrymple et al., 1984) to **momentum equations**:

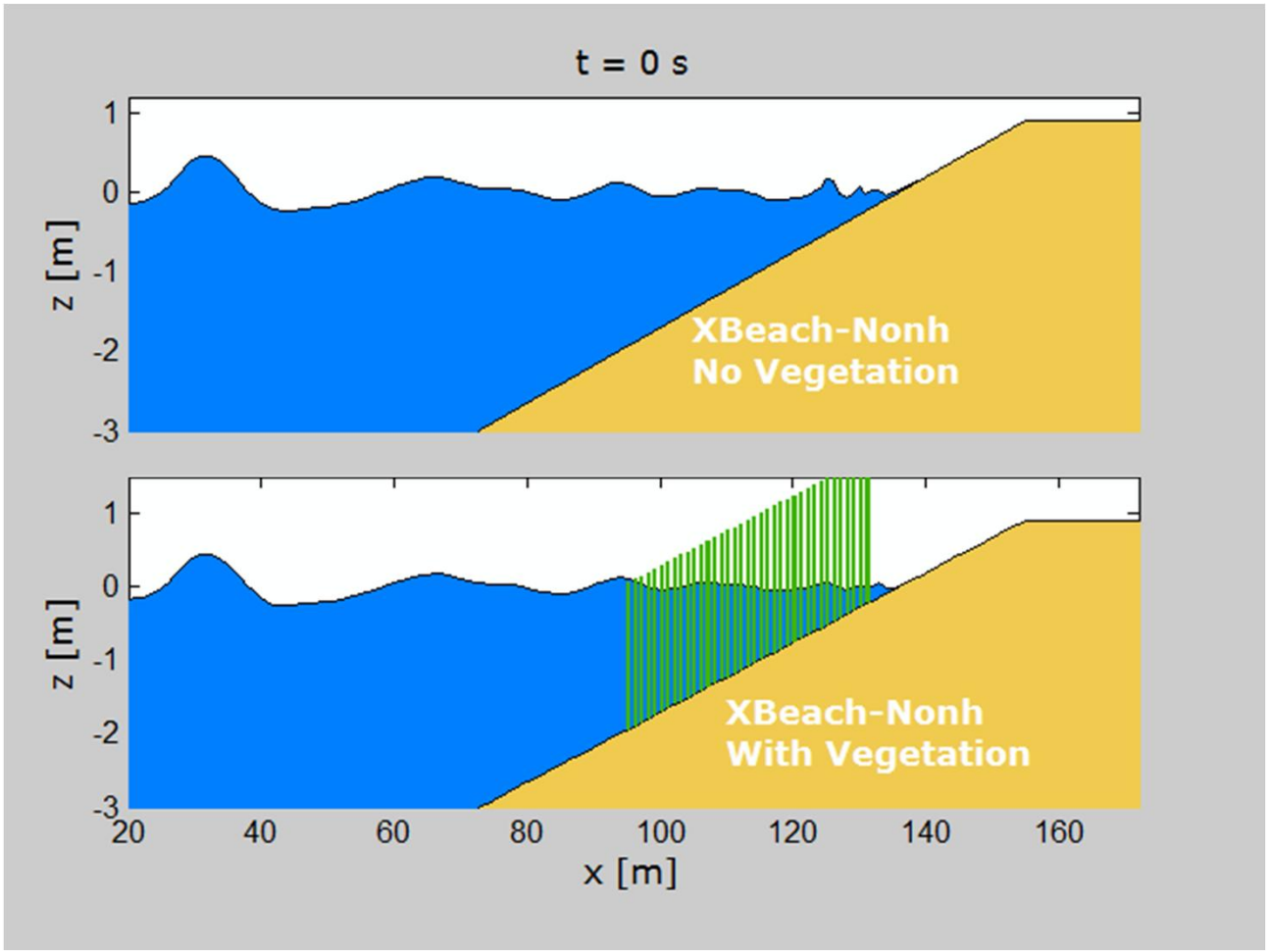
$$\frac{\partial \eta}{\partial t} + \frac{\partial uh}{\partial x} = 0$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} - \upsilon_h \frac{\partial^2 u}{\partial x^2} = -g\frac{\partial \eta}{\partial x} - \frac{\partial \bar{q}}{\partial x} - \frac{\tau_{b,x}}{\rho h} + \frac{F_{v,\mathrm{nh}}}{\rho h}$$

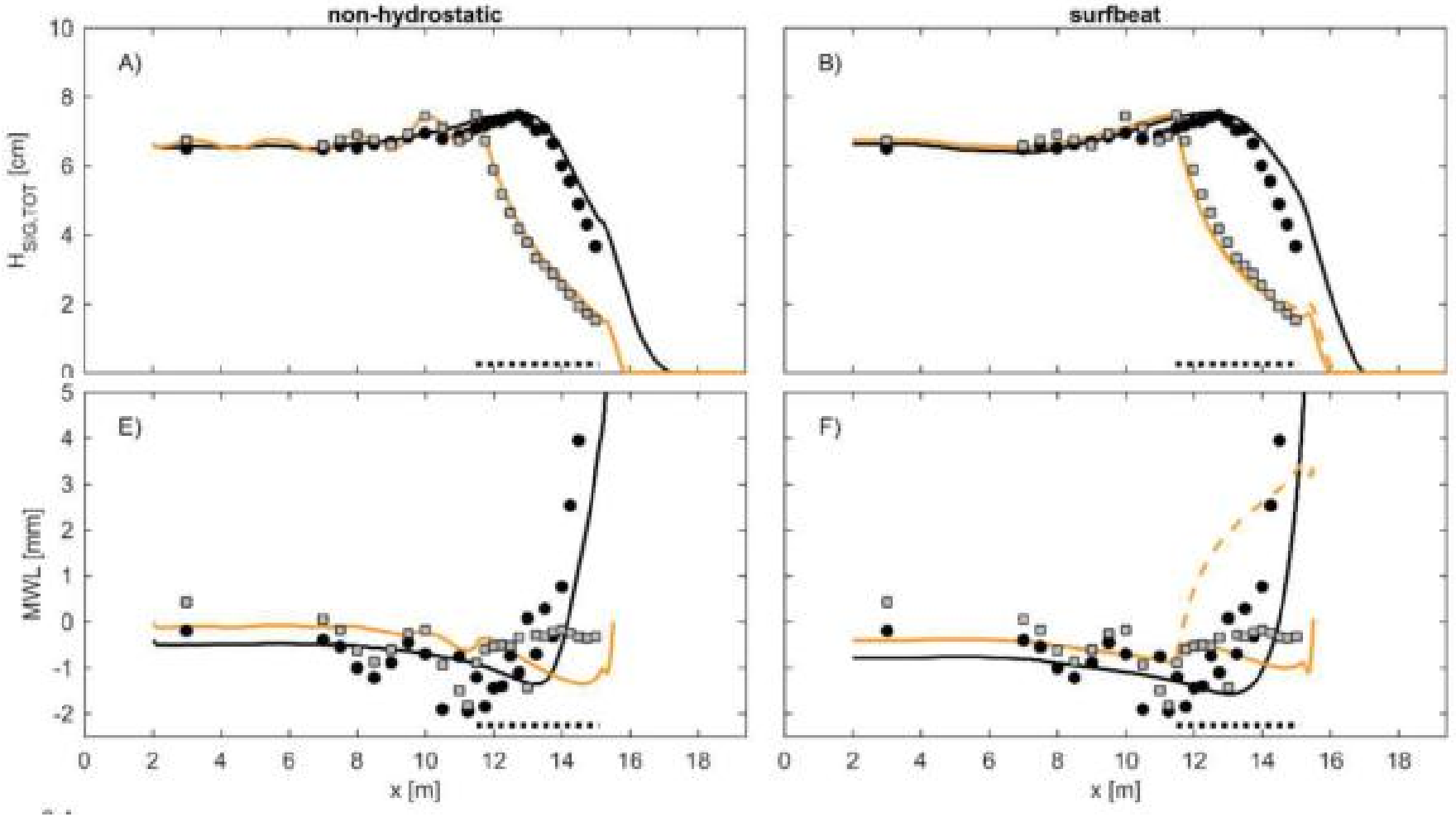
$$A_v = \int_0^{h_{v,i}} N_i * b_i$$

$$F_{vnh} = 0.5\rho C_D \cdot (Av) \cdot u|u|$$

Visual: impact vegetation in nonh mode



Validation XBeach-VEG



Van Rooijen et al. (2016). Modeling wave setup on vegetated coasts.
Experiment r40091240 reported by Wu et al. [2011].

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Overview XBeach-VEG

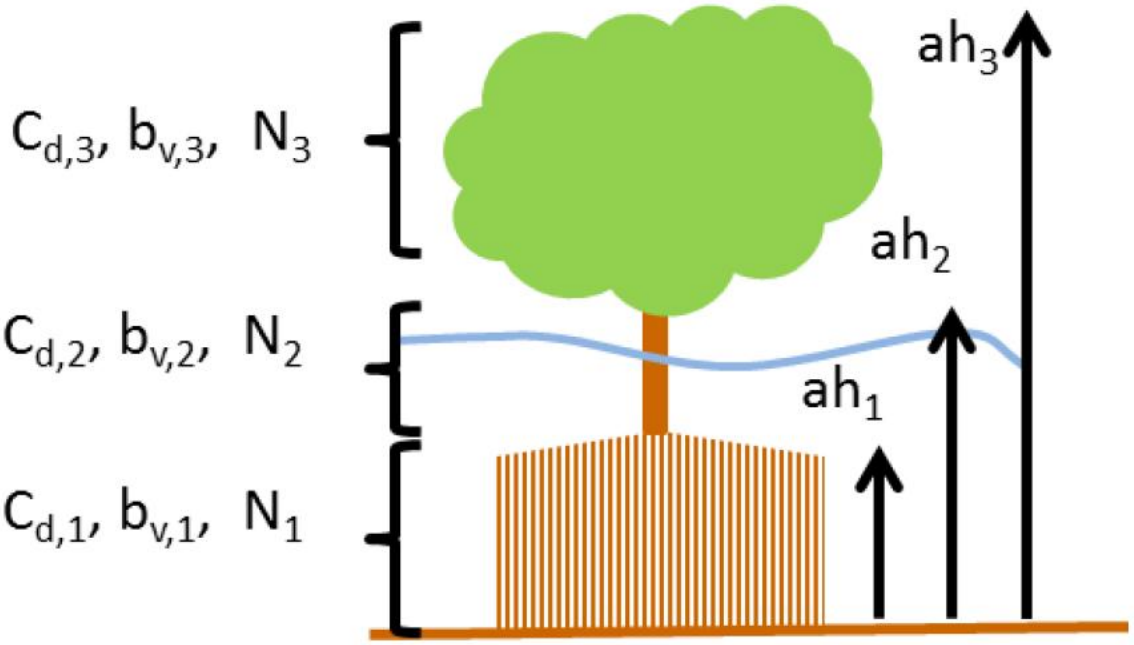
- XBeach Vegetation Module (XBeach-Veg)
  - Incident (short) wave dissipation
  - Infragravity wave and (mean) flow dissipation
  - Wave setup effect
  - Vertical schematization of plants + horizontal distribution
  - Implementation for stationary, surfbeat and nonh mode

- **Summarized in IAHR conference paper (van Rooijen et al., 2015) and JGR-Oceans publication (van Rooijen et al., 2016)**

- Work was funded through the Office of Naval Research (ONR) Coastal Geosciences Program ‘Modeling the Mekong Delta’

Practical: how to apply in XBeach (1/2)?

- Define
  - The different vegetation species *veggiefile*
  - The location of the vegetation *veggiemap*



Deltares (2015). XBeach technical reference

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Practical: how to apply in XBeach (2/2)?

- **In params.txt**
  - Vegetation = 1
  - Veggiefile = veggiefile.txt;
  - Veggiemapfile = veggiemapfile.txt;
- **Veggiefile.txt**
  - seagrass.txt
  - mangrove.txt
- **Veggiemap.txt**
  - 0 is no vegetation
  - 1 refers to first listed, 2 to second etc.
  - e.g. [0 0 1 1 2 2 1 1 0];

seagrass.txt

```
ah = 0.2
Cd = 1.0
bv = 0.02
N = 1200
```

mangrove.txt

```
nsec = 3
ah = 0.5 0.8 1.3
Cd = 2.0 1.0 2.0
bv = 0.05 0.15 0.1
N = 1000 50 500
```


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Part 1C. Hands on

LOVAS (2000) EXPERIMENTS (MODELS CREATED BY VAN ROOIJEN ET AL., 2016)

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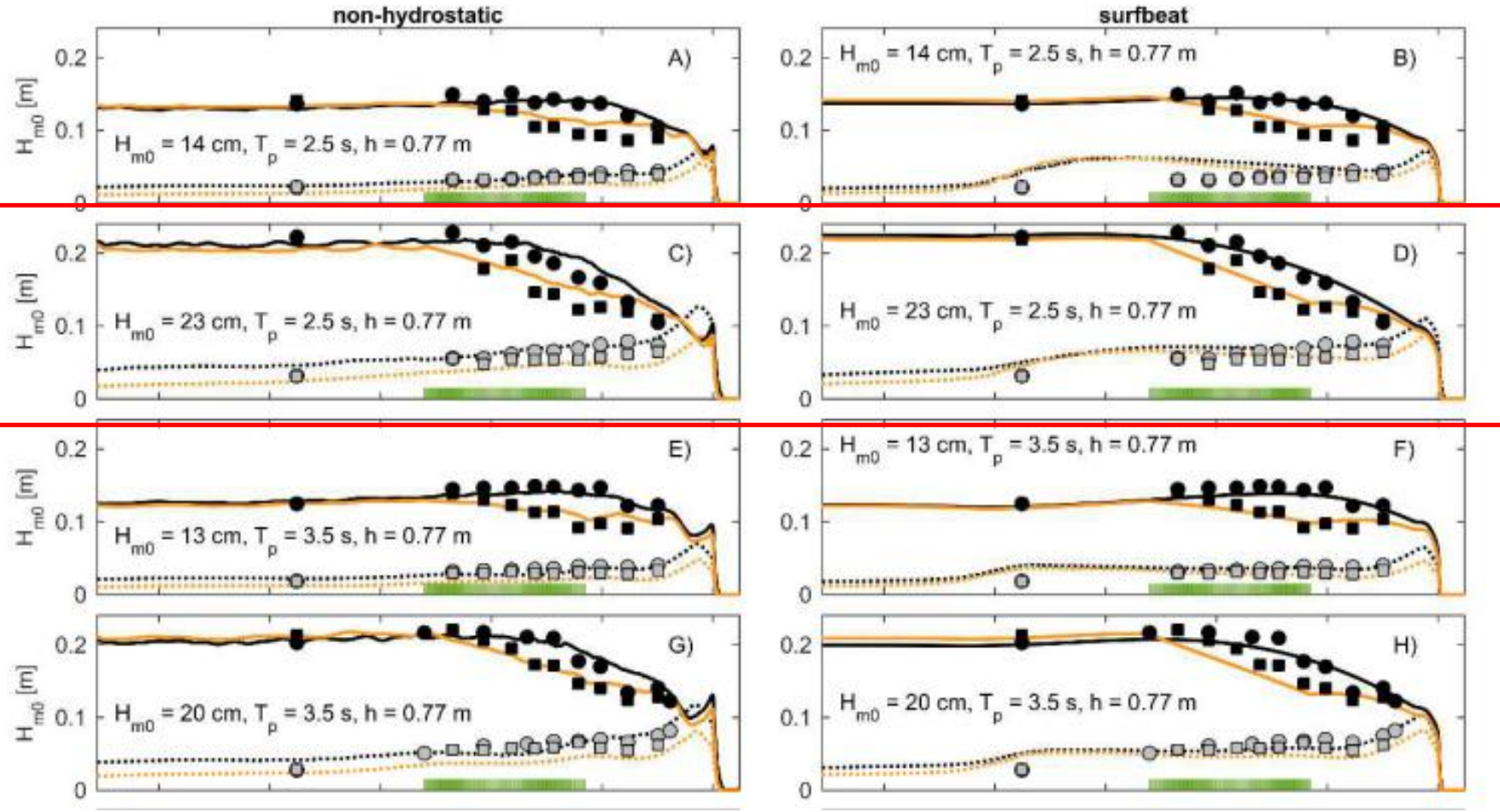
Experiments of Lovas (2000)



Van Rooijen et al. (2016) Modeling the effect of wave-vegetation interaction on wave setup

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