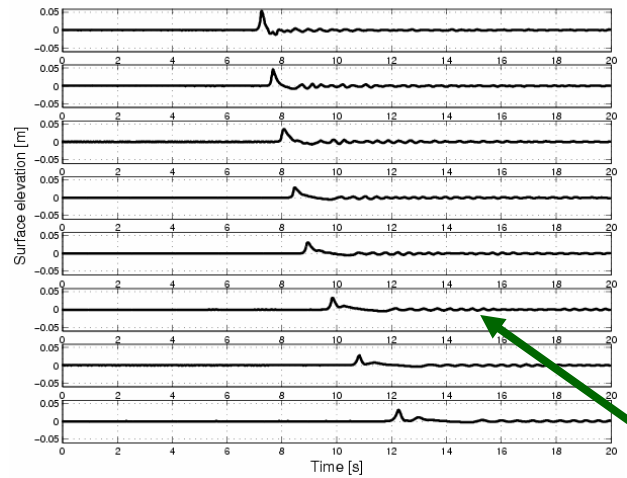
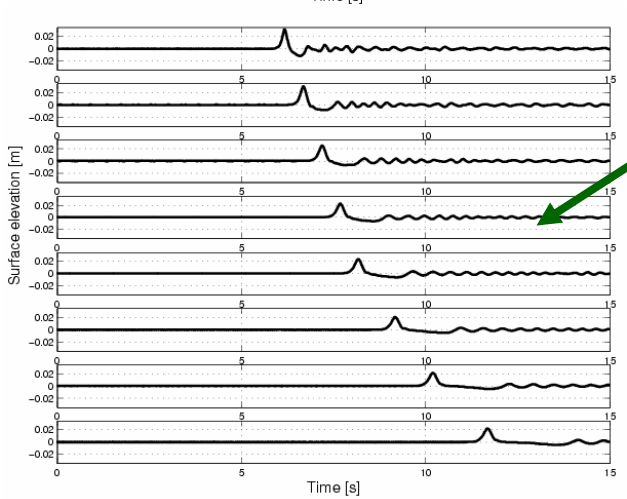
Generation and propagation of vertical slump generated waves: 2D experiments





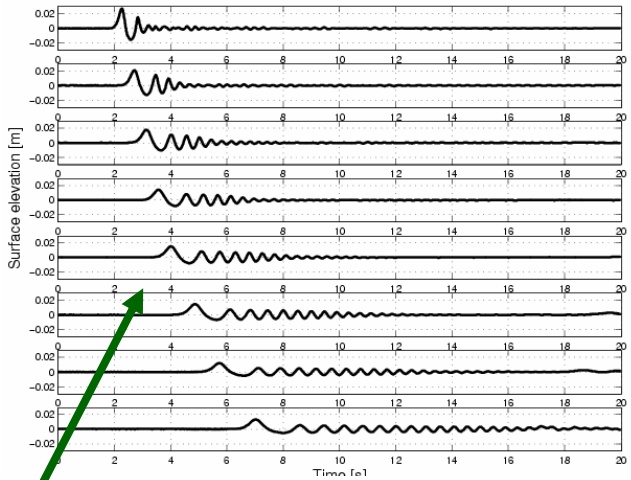
A wide range of wave type was generated during experiments

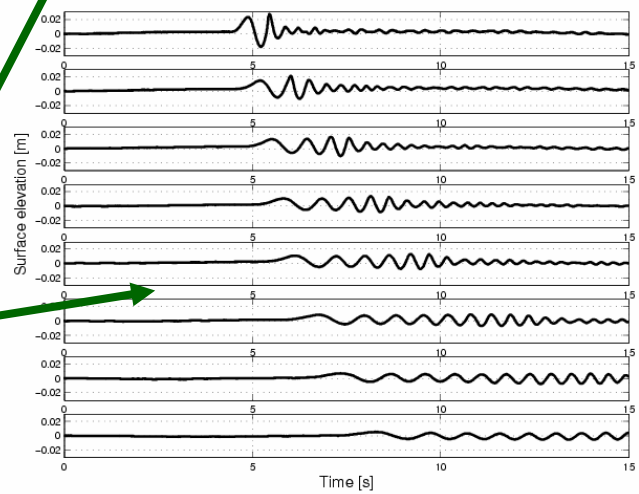
likebore waves

solitary waves

cnoidal waves

linear waves

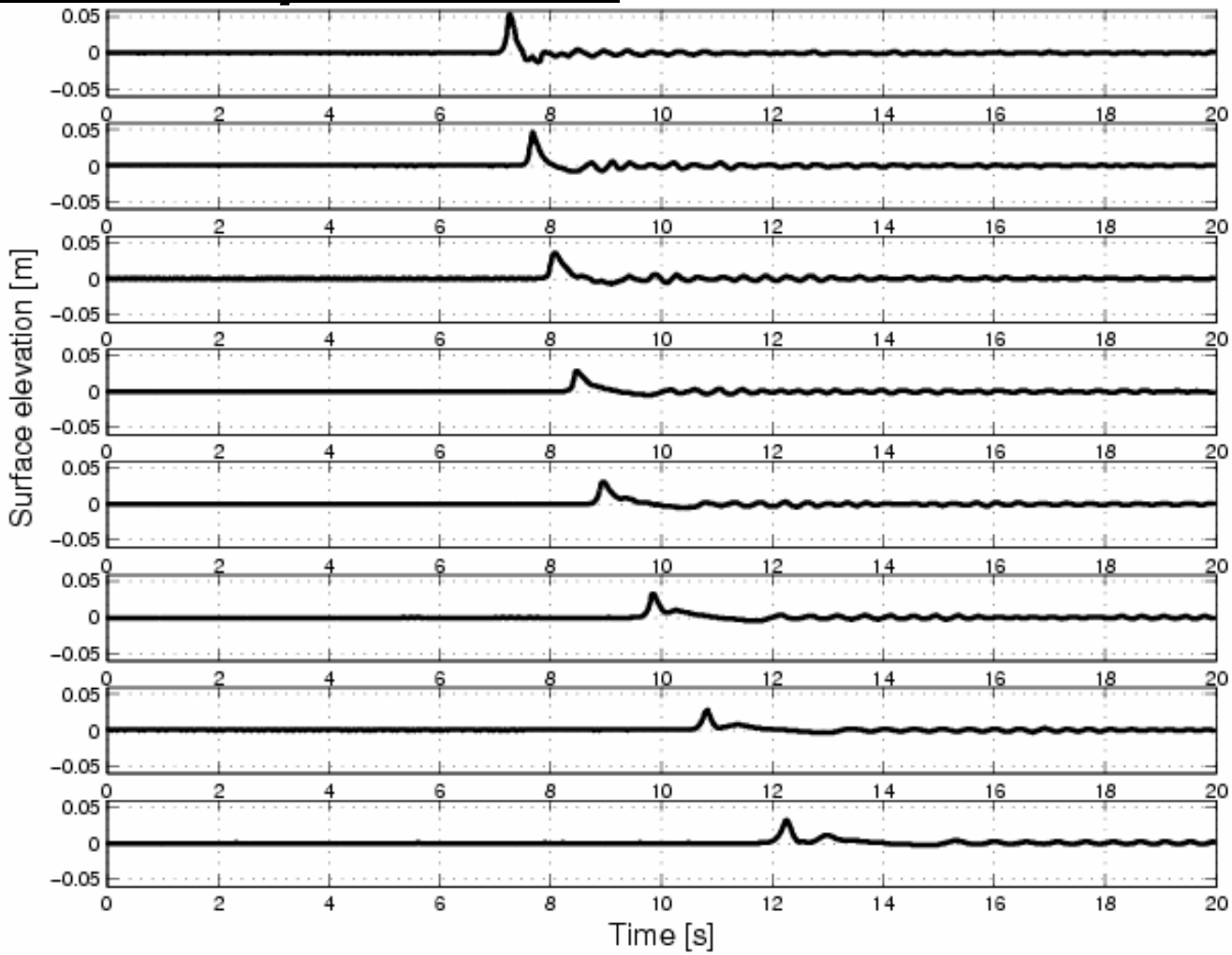




Generation and propagation of vertical slump generated waves: 2D experiments

2D experiments:

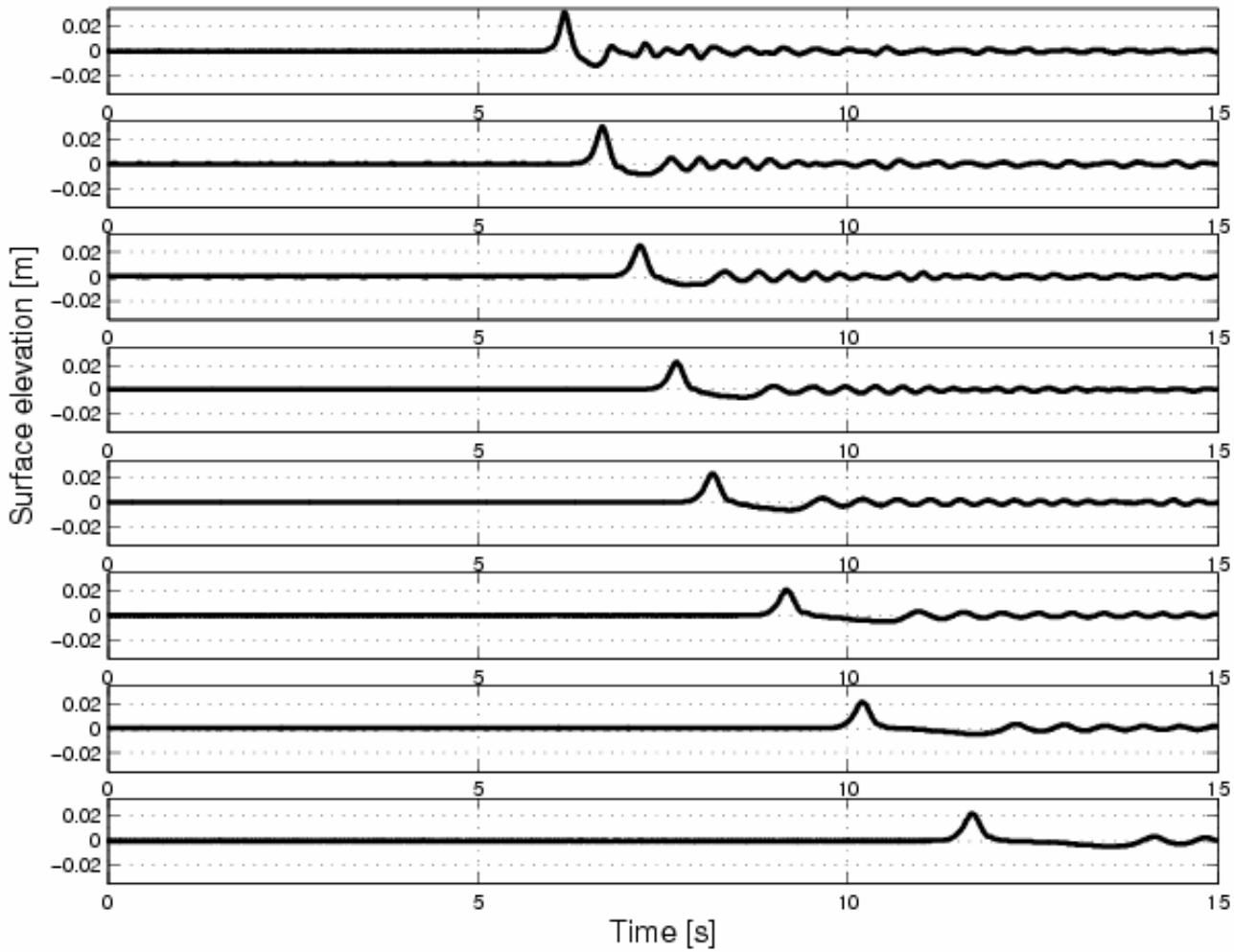
Likebore waves



Generation and propagation of vertical slump generated waves: 2D experiments

2D experiments:

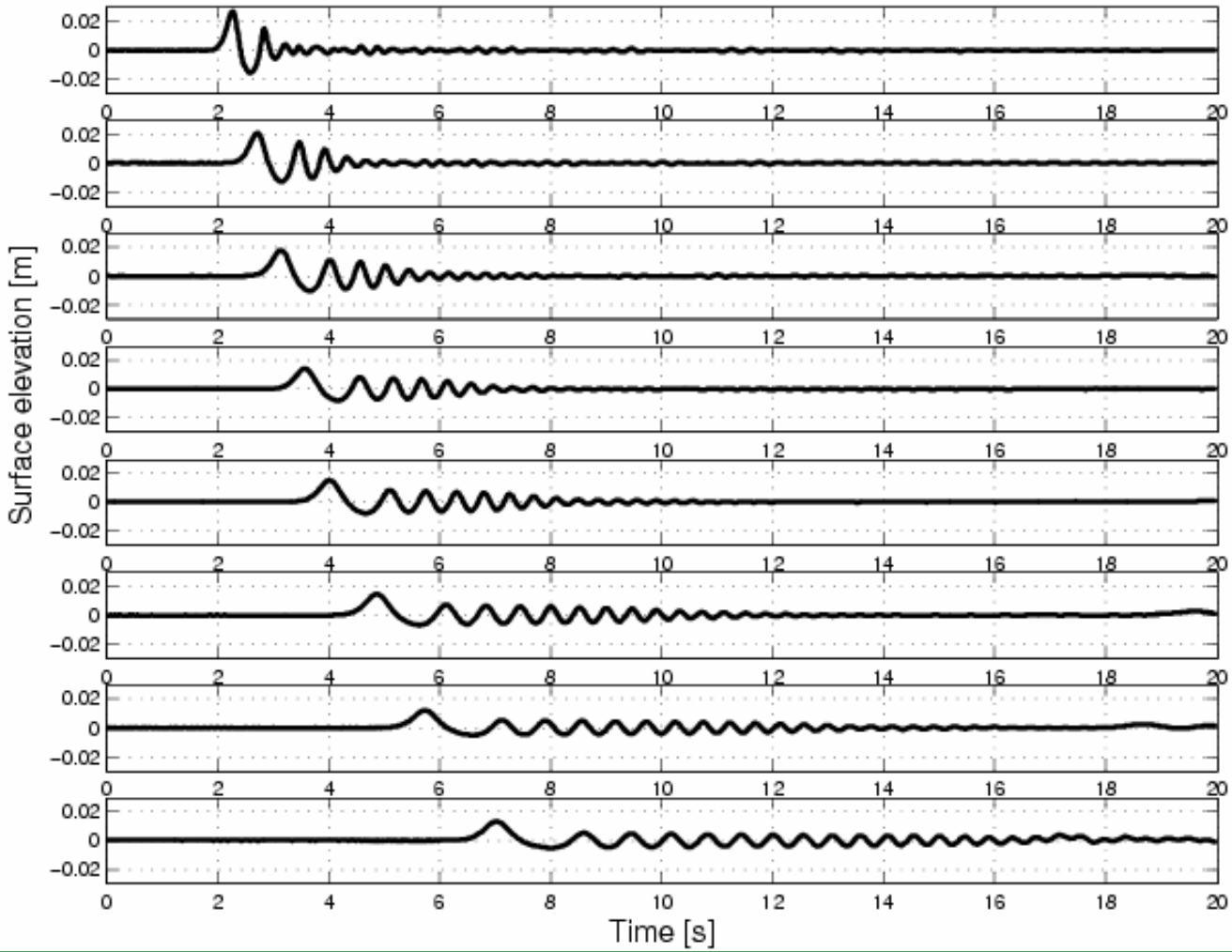
Solitary waves



Generation and propagation of vertical slump generated waves: 2D experiments

2D experiments:

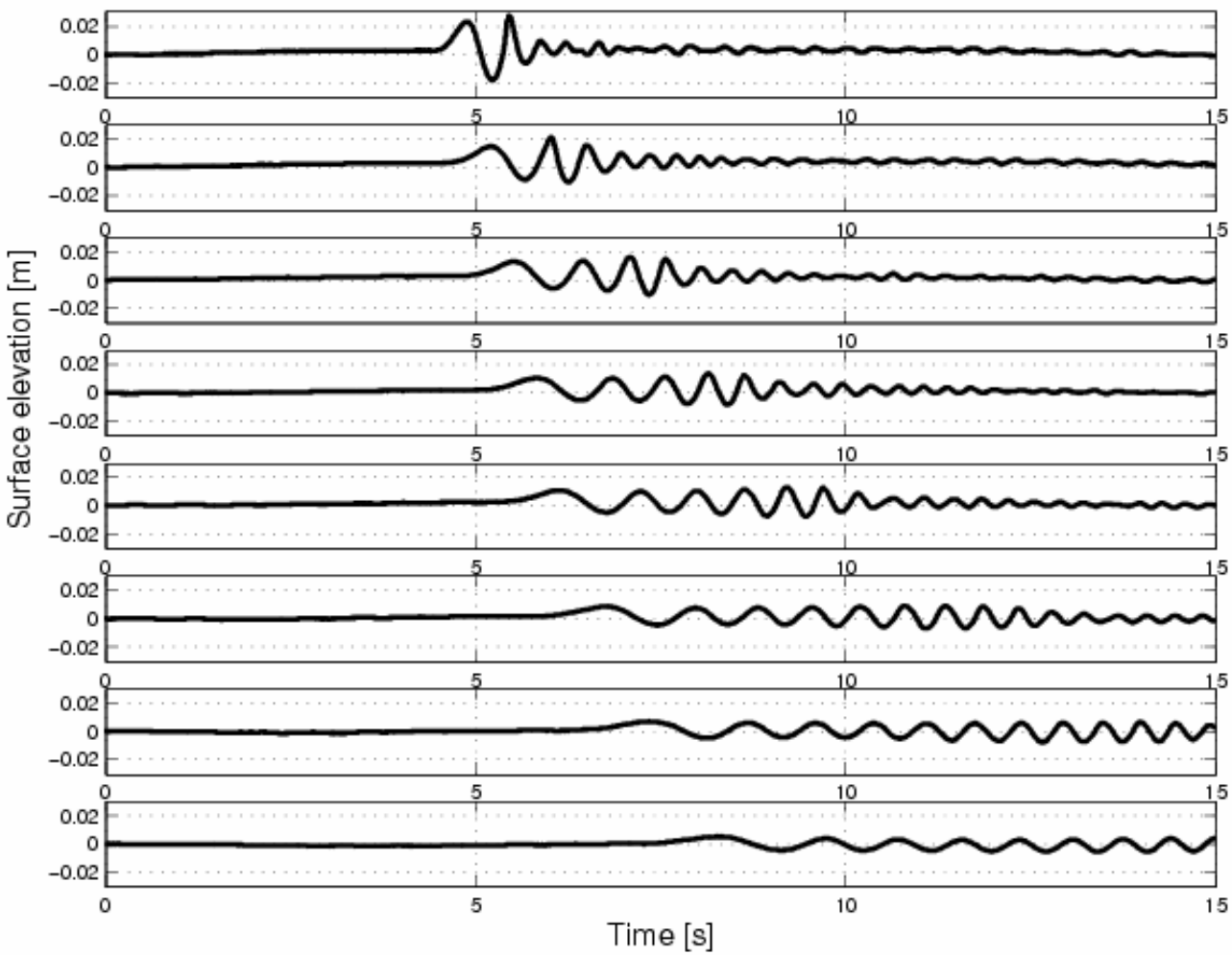
Cnoidal waves



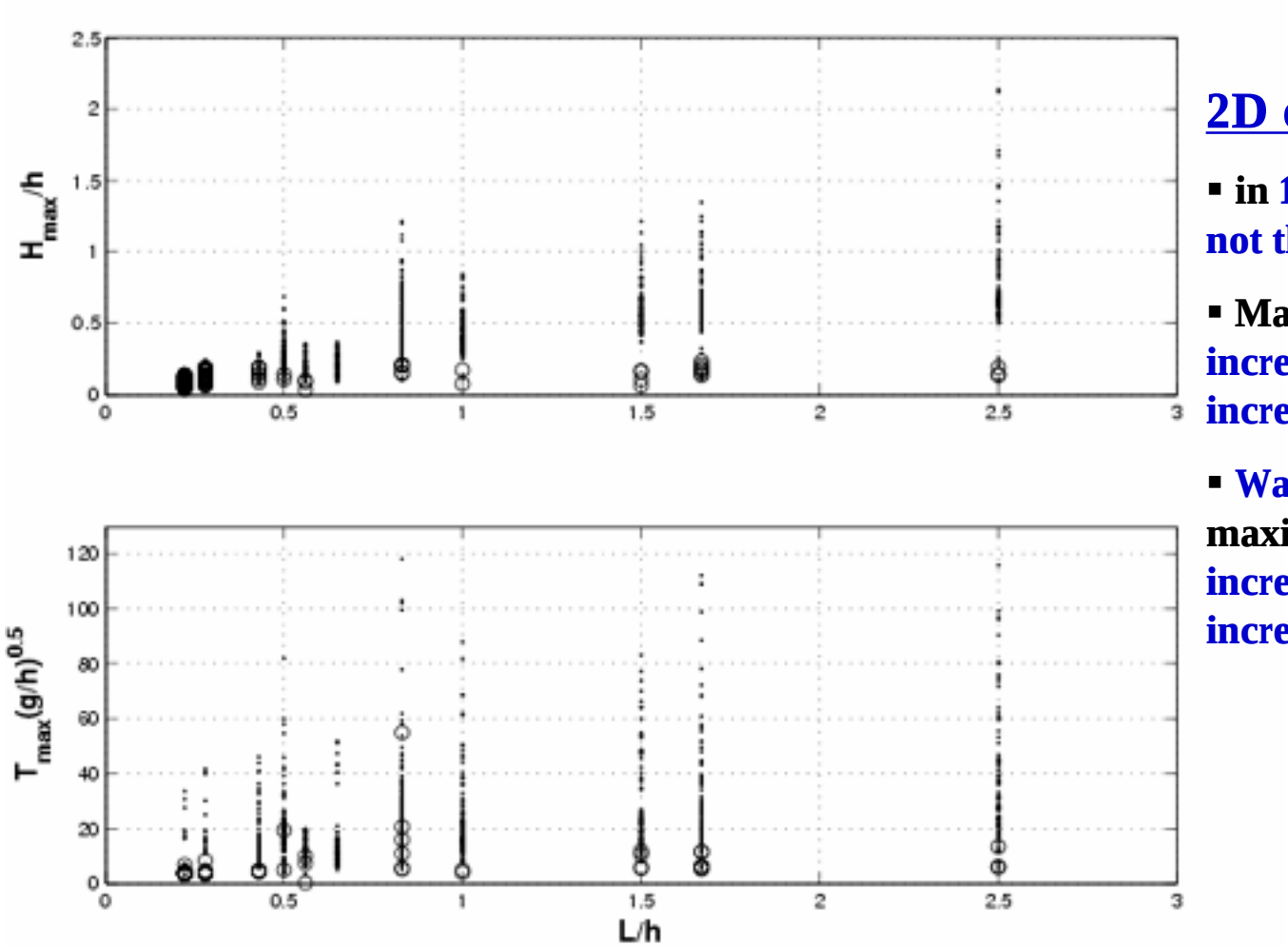
Generation and propagation of vertical slump generated waves: 2D experiments

2D experiments:

Linear waves



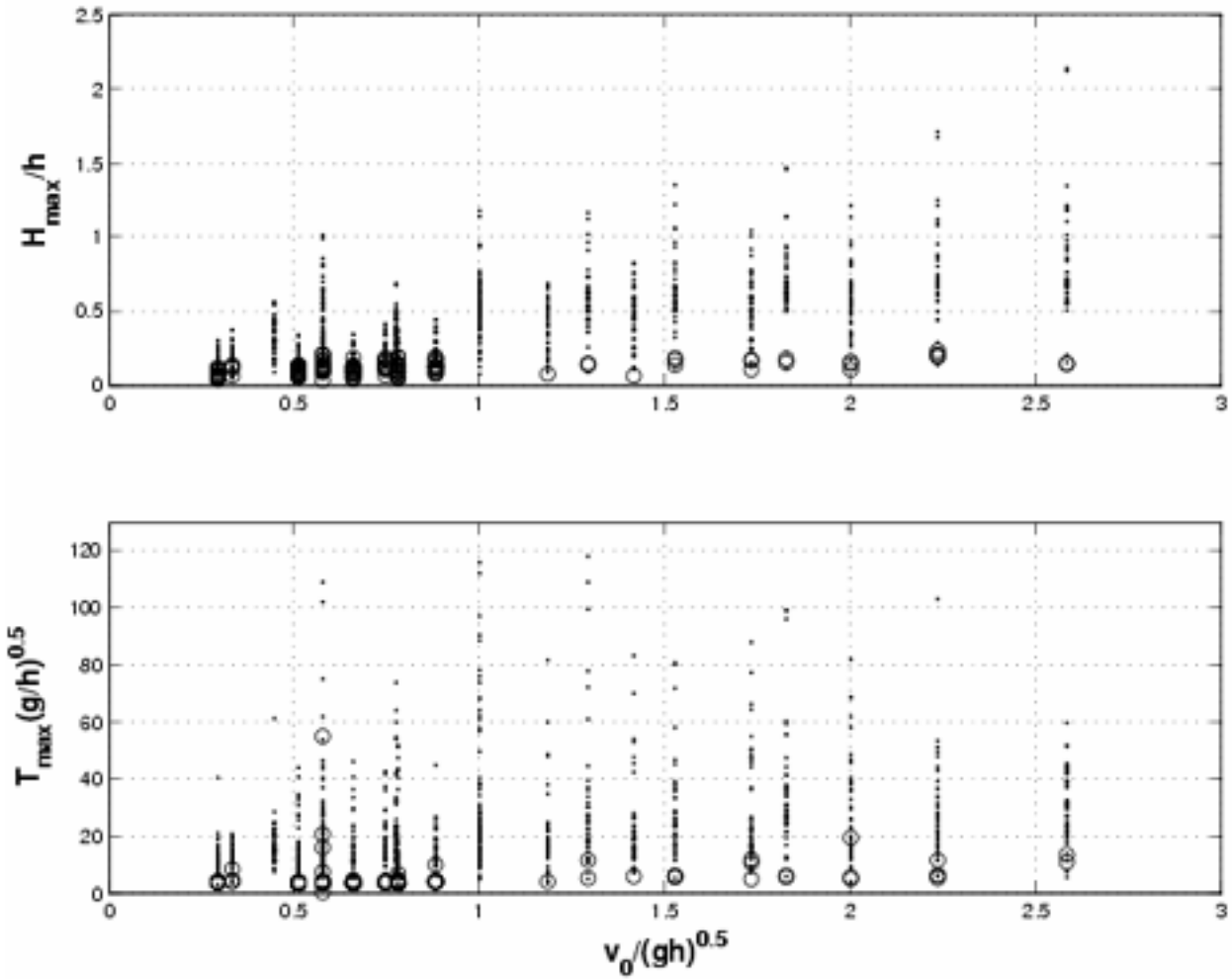
Generation and propagation of vertical slump generated waves: 2D experiments



2D experiments:

- in 12% of tests the first wave is not the highest
- Maximum wave height increases as landslide length increases
- Wave period related to maximum wave height increases as landslide length increases

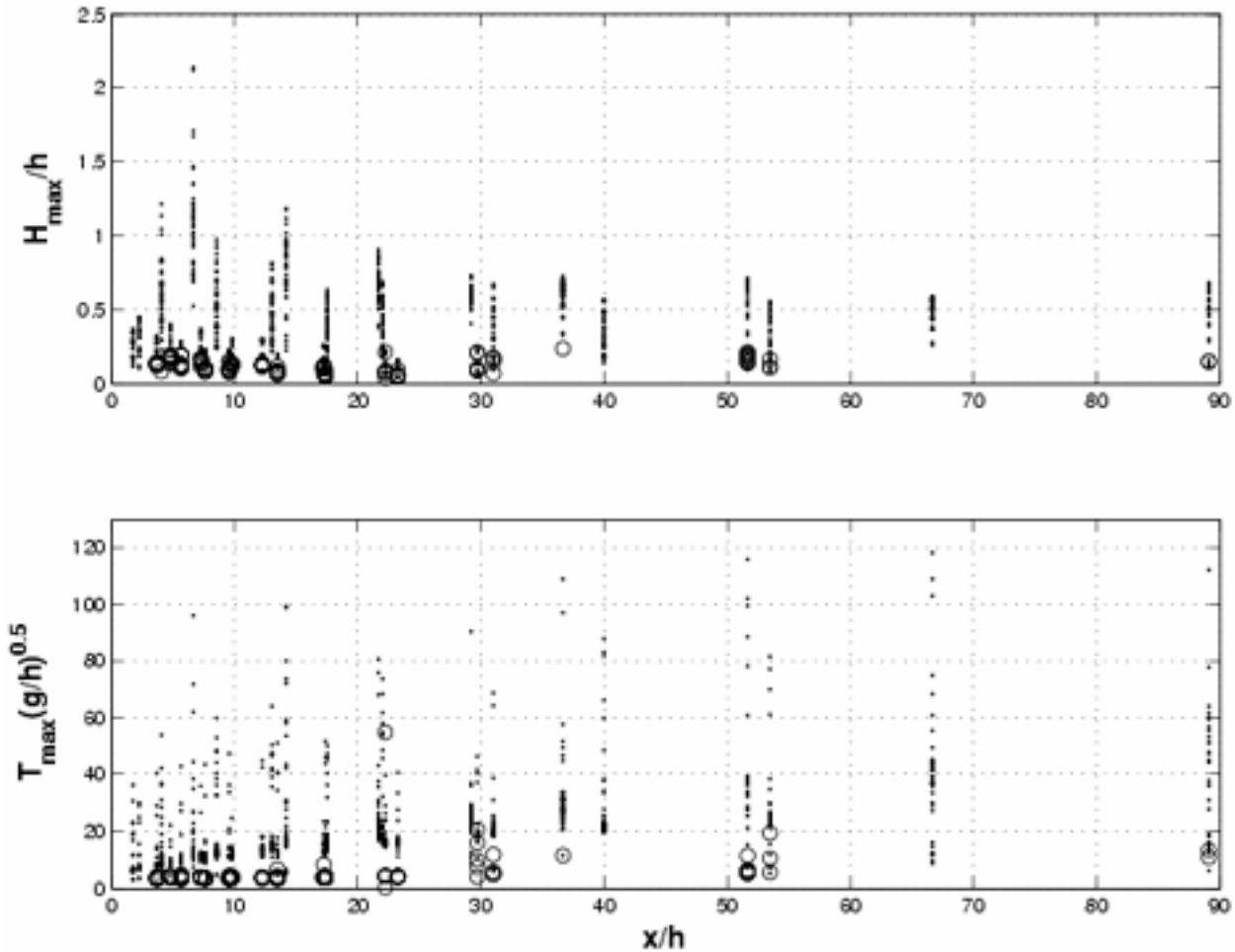
Generation and propagation of vertical slump generated waves: 2D experiments



2D experiments:

- **Maximum wave height increases as landslide energy increases**
- **Wave period related to maximum wave height slightly increases as landslide energy increases**

Generation and propagation of vertical slump generated waves: 2D experiments



2D experiments:

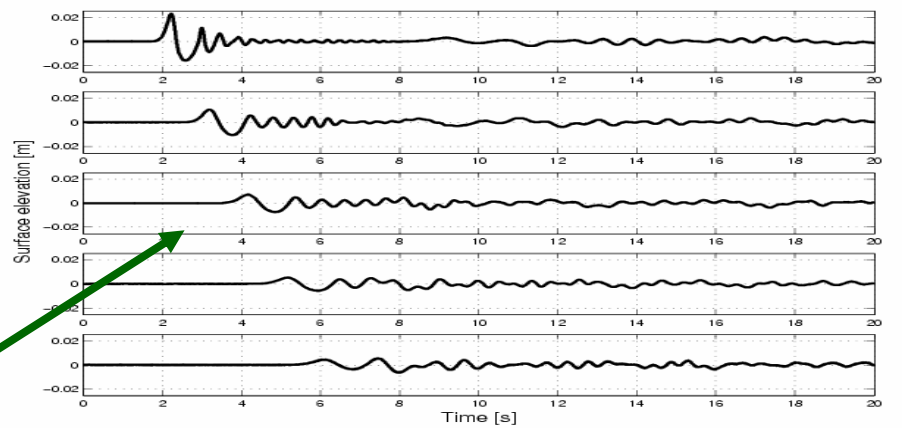
- **Maximum wave height decreases as distance from generation area increases**
- **Wave period related to maximum wave height increases as distance from generation area increases (frequency dispersion)**

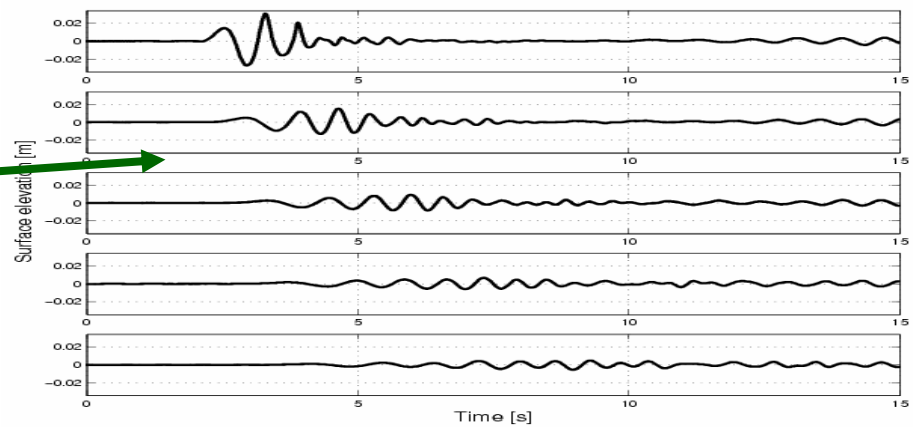
Generation and propagation of vertical slump generated waves: 3D experiments

Also in this tests a wide range of wave type was generated during experiments

cnoidal waves

linear waves

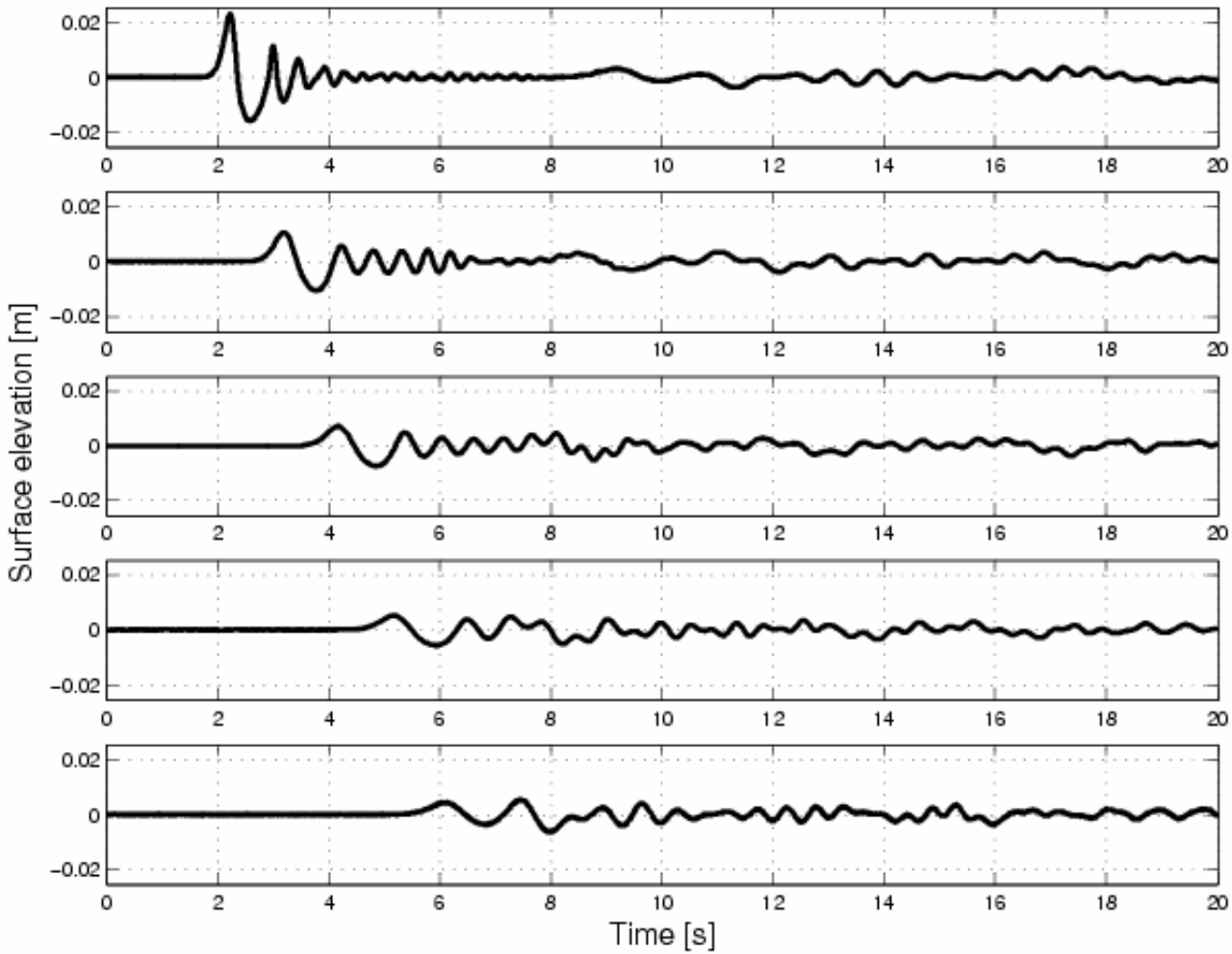




Generation and propagation of vertical slump generated waves: 3D experiments

3D experiments:

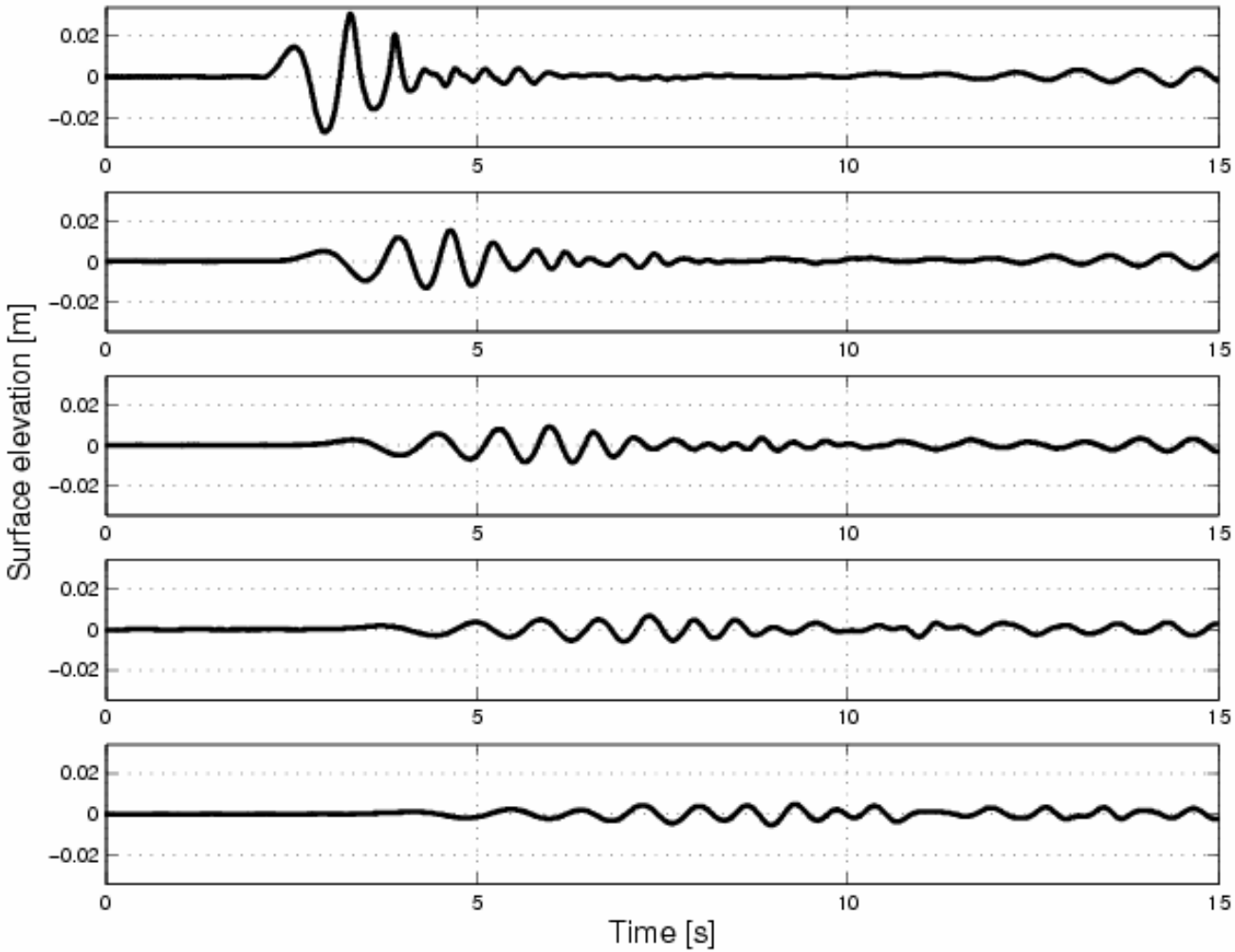
Cnoidal waves



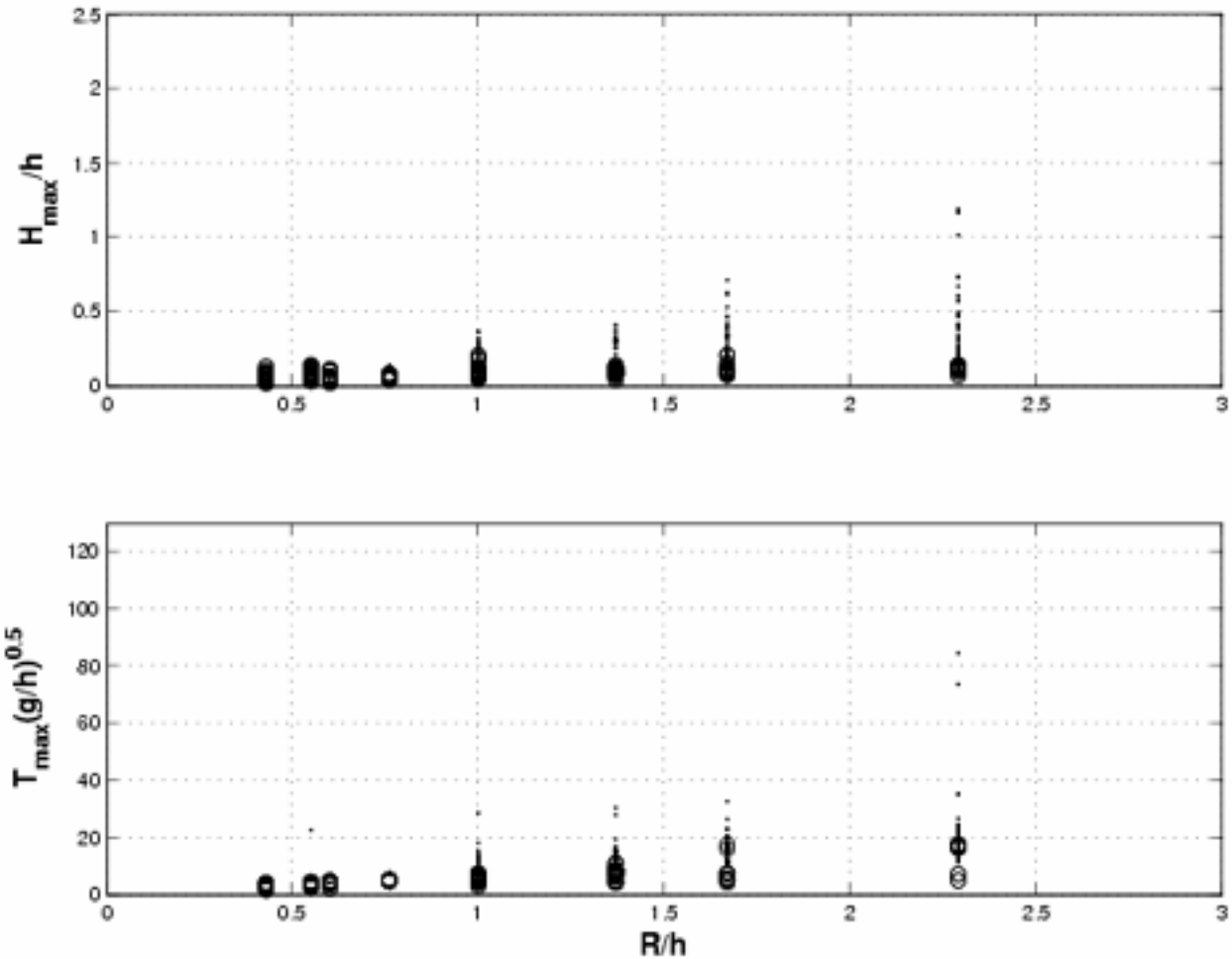
Generation and propagation of vertical slump generated waves: 3D experiments

3D experiments:

Linear waves



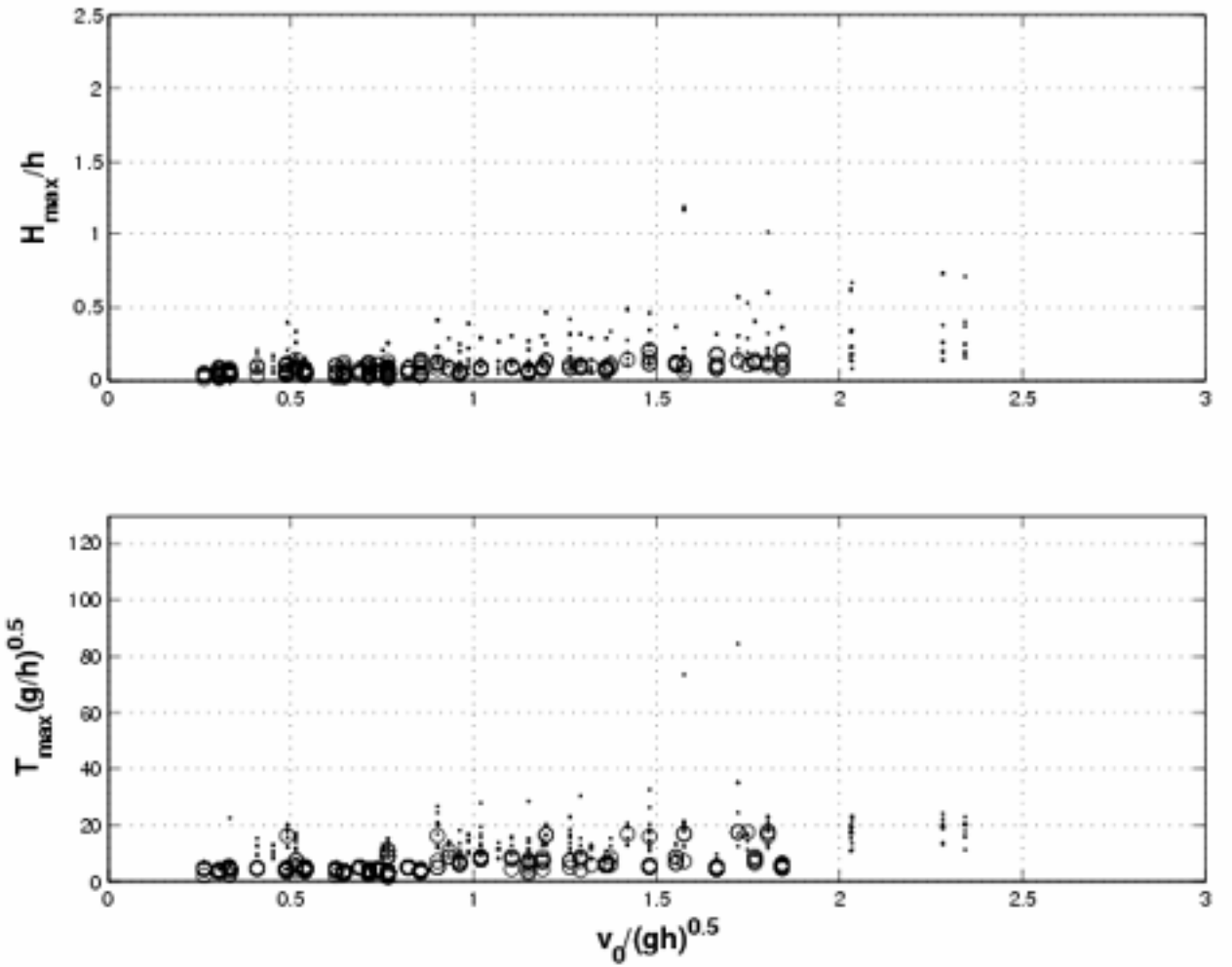
Generation and propagation of vertical slump generated waves: 3D experiments



3D experiments:

- in the 50% of tests the first wave is not the highest
- Maximum wave height increases as landslide length increases
- Wave period related to maximum wave height increases as landslide length increases

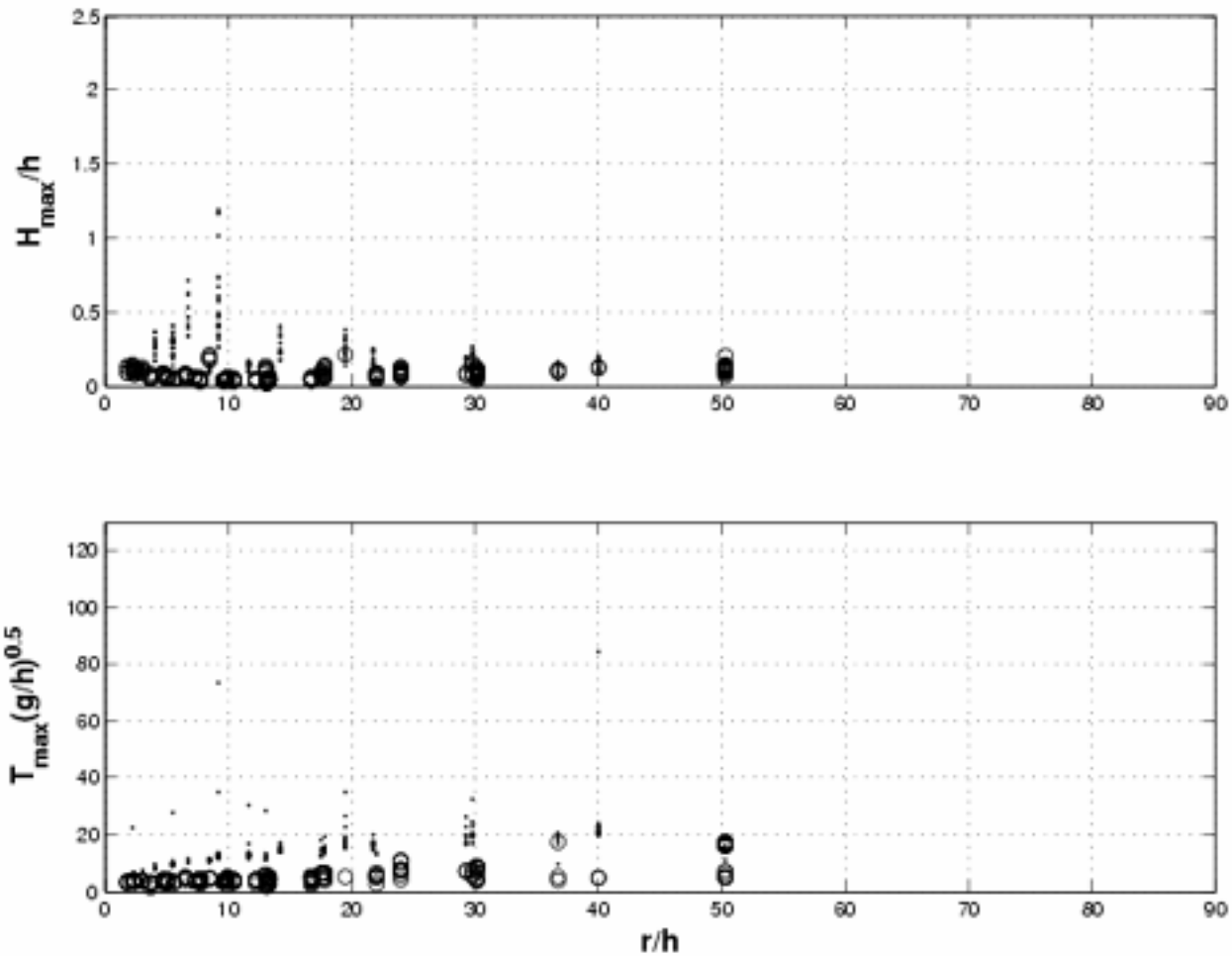
Generation and propagation of vertical slump generated waves: 3D experiments



3D experiments:

- **Maximum wave height increases as landslide energy increases**
- **Wave period related to maximum wave height slightly increases as landslide energy increases**

Generation and propagation of vertical slump generated waves: 3D experiments



3D experiments:

- **Maximum wave height decreases as distance from generation area increases**
- **Wave period related to maximum wave height increases as distance from generation area increases (frequency dispersion)**

Generation and propagation of vertical slump generated waves: the experimental findings

2D experiments:

- likebore waves, solitary waves, cnoidal waves and linear waves were observed
- in 12% of tests the first wave is not the highest
- Maximum wave height increases as landslide length increases
- Wave period related to maximum wave height increases as landslide length increases
- Maximum wave height increases as landslide energy increases
- Wave period related to maximum wave height slightly increases as landslide energy increases
- Maximum wave height decreases as distance from generation area increases
- Wave period related to maximum wave height increases as distance from generation area increases (frequency dispersion)

Generation and propagation of vertical slump generated waves: the experimental findings

3D experiments:

- cnoidal waves and linear waves were observed
- in 50% of tests the first wave is not the highest
- Maximum wave height increases as landslide length increases
- Wave period related to maximum wave height increases as landslide length increases
- Maximum wave height increases as landslide energy increases
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- Maximum wave height decreases as distance from generation area increases
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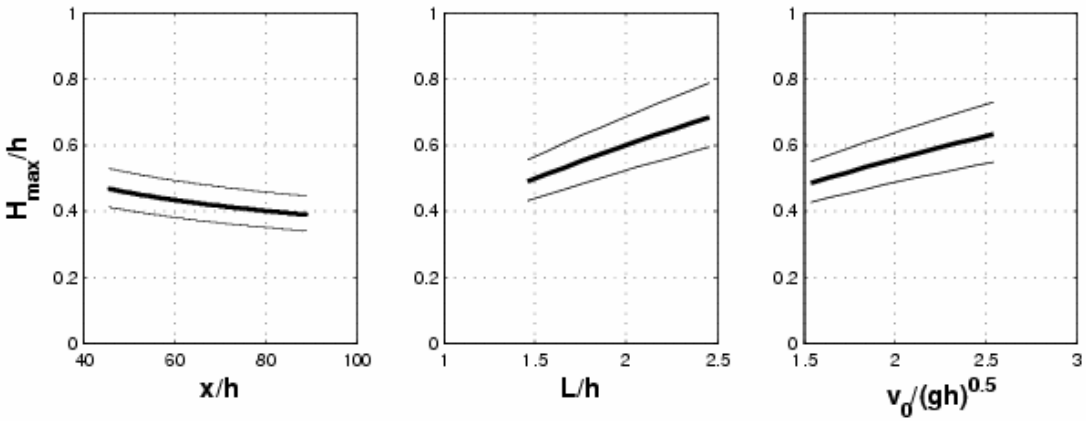
Generation and propagation of vertical slump generated waves: the new empirical formulations

2D empirical formulation:

H_{max}

a_{max}

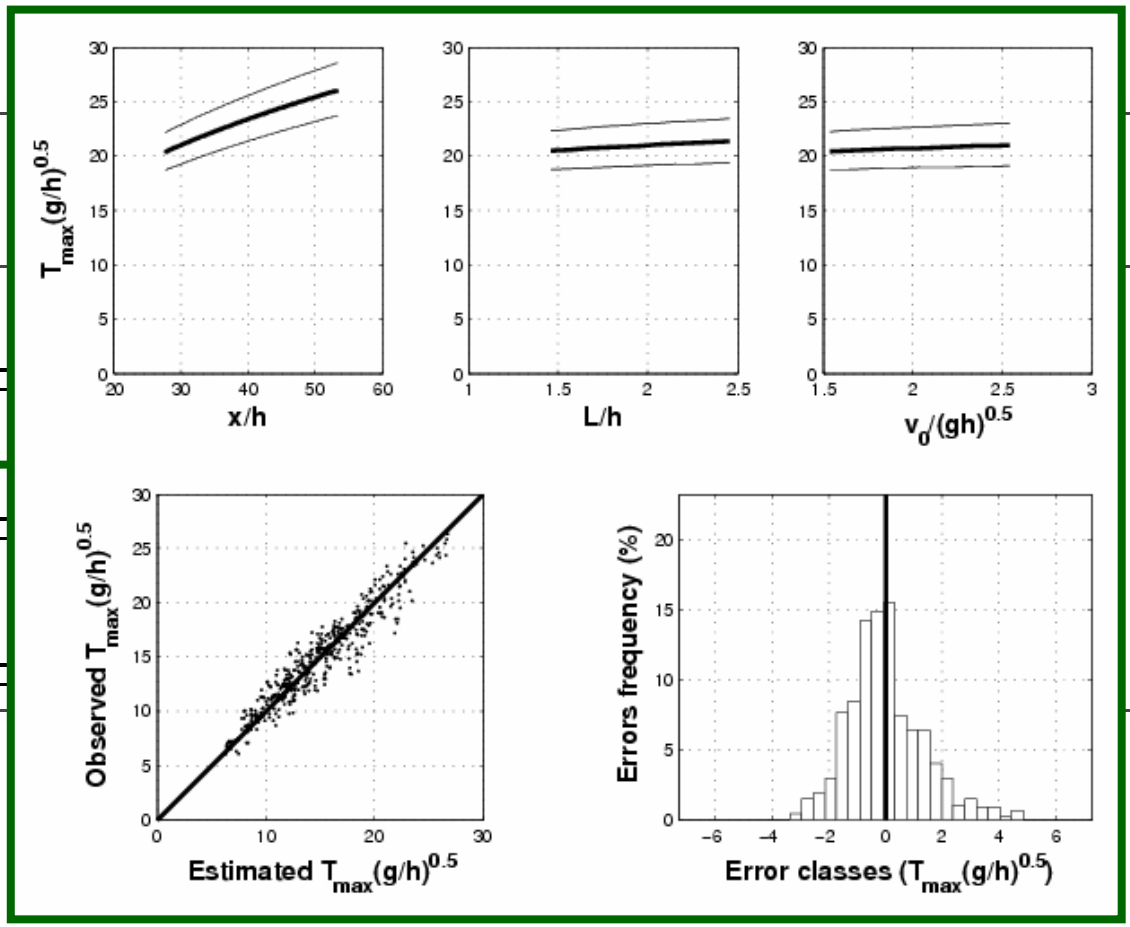
T_{max}



R^2	$\bar{\varepsilon}$
0.84953	0.07802
0.87447	0.062935
0.91291	1.0238

Generation and propagation of vertical slump generated waves: the new empirical formulations

2D empirical formulation:



	R^2	$\bar{\varepsilon}$
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Generation and propagation of vertical slump generated waves: the new empirical formulations

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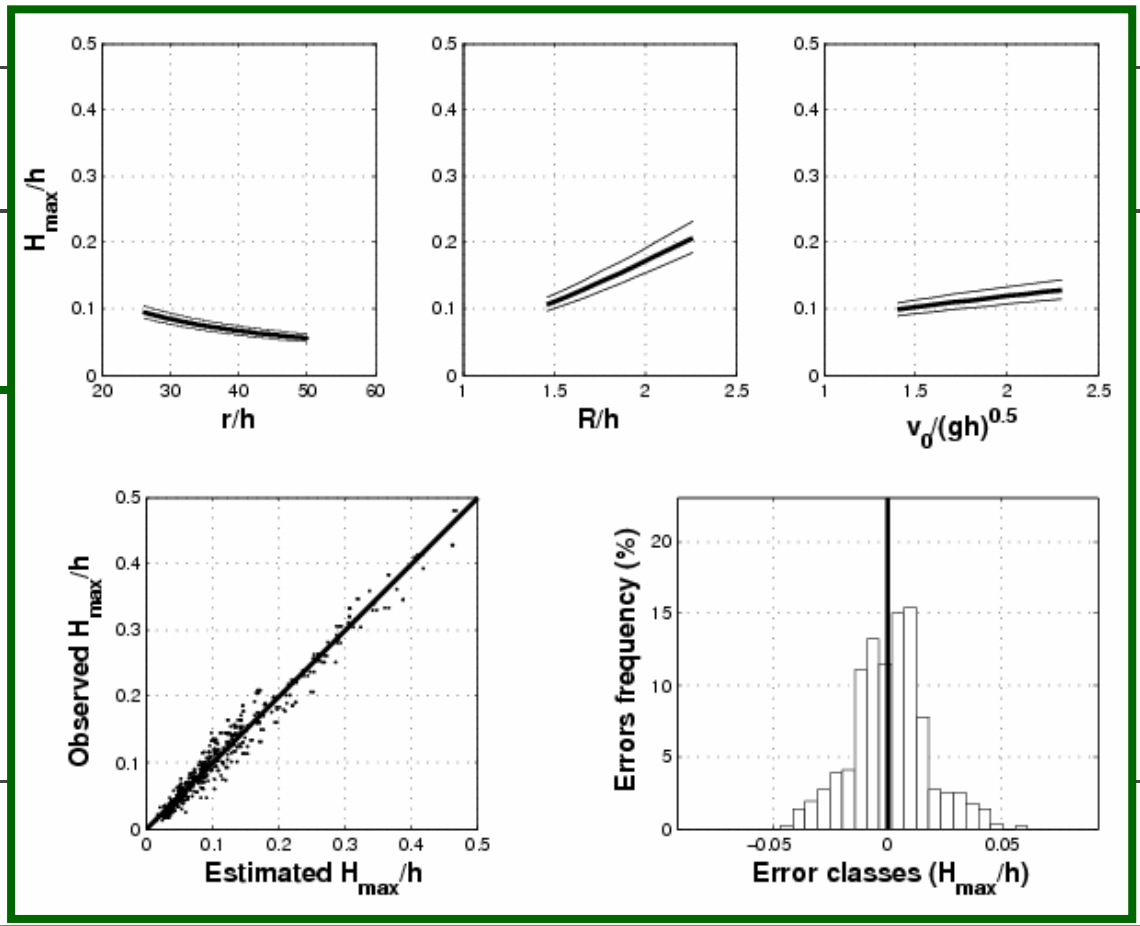
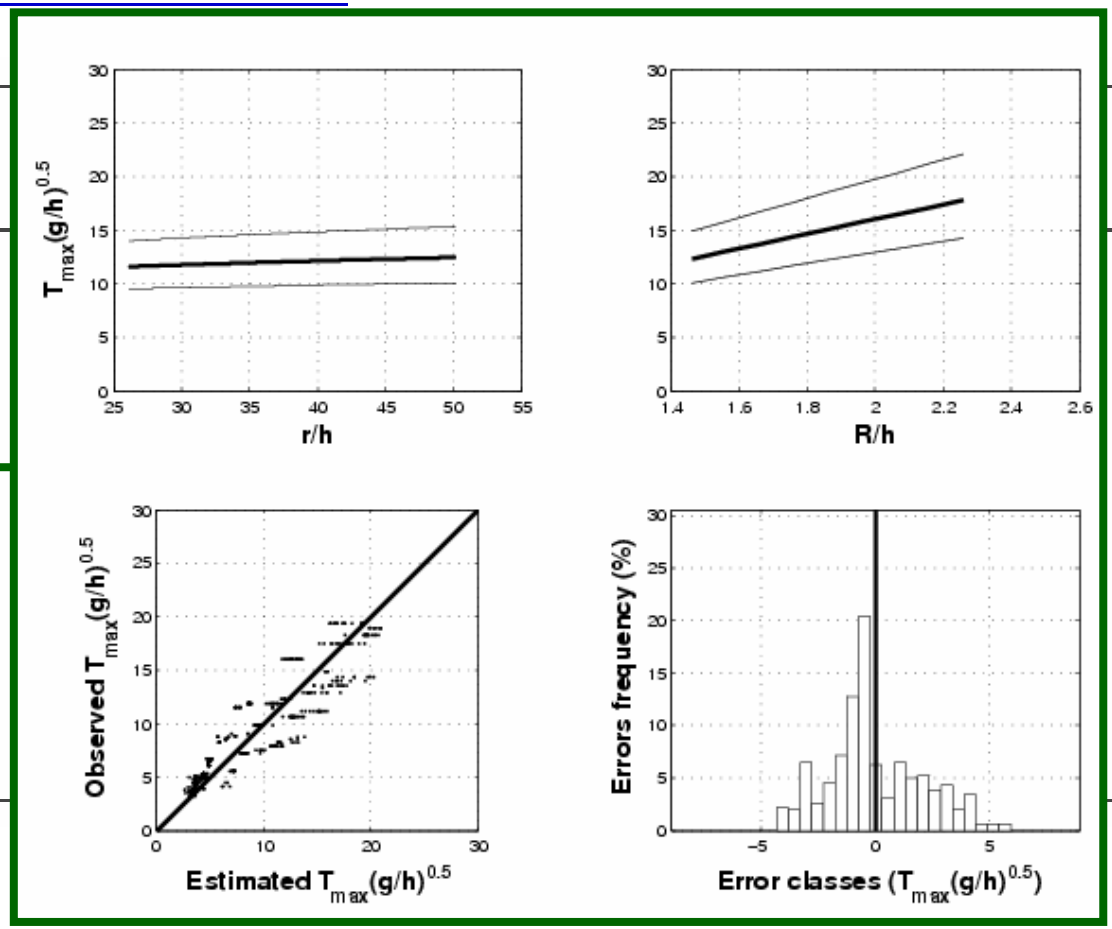


	R^2	$\overline{\varepsilon}$
H_1	0.95632	0.018128
T_1	0.83259	1.7056
H_{max}	0.97483	0.012894
T_{max}	0.83704	1.7085

Generation and propagation of vertical slump generated waves: the new empirical formulations

3D empirical formulation:



	R^2	$\overline{\varepsilon}$
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T_1	0.83259	1.7056
H_{max}	0.97483	0.012894
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Generation and propagation of vertical slump generated waves: comparison with existing formulae

	Factor	x/h	L/h	$v_0/(\sqrt{gh})$	R^2	$\bar{\varepsilon}$
	a_1	a_2	a_3	a_4		
H_{max}	0.8967	-0.2725	0.6417	0.5308		
	± 0.0383	± 0.0169	± 0.0289	± 0.0313	0.84953	0.07802
a_{max}	0.5718	-0.2145	0.8322	0.3975		
	± 0.0257	± 0.0162	± 0.0308	± 0.0318	0.87447	0.062935
T_{max}	5.6384	0.3744	0.0782	0.0527		
	± 0.2007	± 0.0116	± 0.0168	± 0.0159	0.91291	1.0238

	Factor	r/h	R/h	$v_0/(\sqrt{gh})$	R^2	$\bar{\varepsilon}$
	a_1	a_2	a_3	a_4		
H_1	0.8790	-0.9341	1.7114	0.5531		
	± 0.0424	± 0.0251	± 0.0485	± 0.0353	0.95632	0.018128
T_1	6.6322	0.1774	0.5083	0.1115		
	± 0.4605	± 0.0263	± 0.0487	± 0.0353	0.83259	1.7056
H_{max}	0.7650	-0.8281	1.5350	0.5270		
	± 0.0234	± 0.0153	± 0.0311	± 0.0272	0.97483	0.012894
T_{max}	6.229	0.1104	0.8472			
	± 0.4865	± 0.0297	± 0.0537		0.83704	1.7085

$$\frac{H_{max}}{h} = 0.12 \left(\frac{r}{h}\right)^{-0.4} \left(\frac{w}{h}\right)^{0.79} \left(\frac{s}{h}\right)^{0.5} \left(\frac{v_0}{\sqrt{gh}}\right)^{0.17} e^{0.6\cos\theta - 0.8\sin\gamma}$$

$$T_{max}\sqrt{\frac{g}{h}} = 2.5 \left(\frac{l}{h}\right)^{0.1} \left(\frac{v_0}{\sqrt{gh}}\right)^{0.29} \left(\frac{r}{h}\right)^{0.18} e^{0.22\sin\gamma}$$

Panizzo, 2004

Generation and propagation of vertical slump generated waves: comparison with existing formulae

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Panizzo, 2004

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Panizzo, 2004

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Panizzo, 2004

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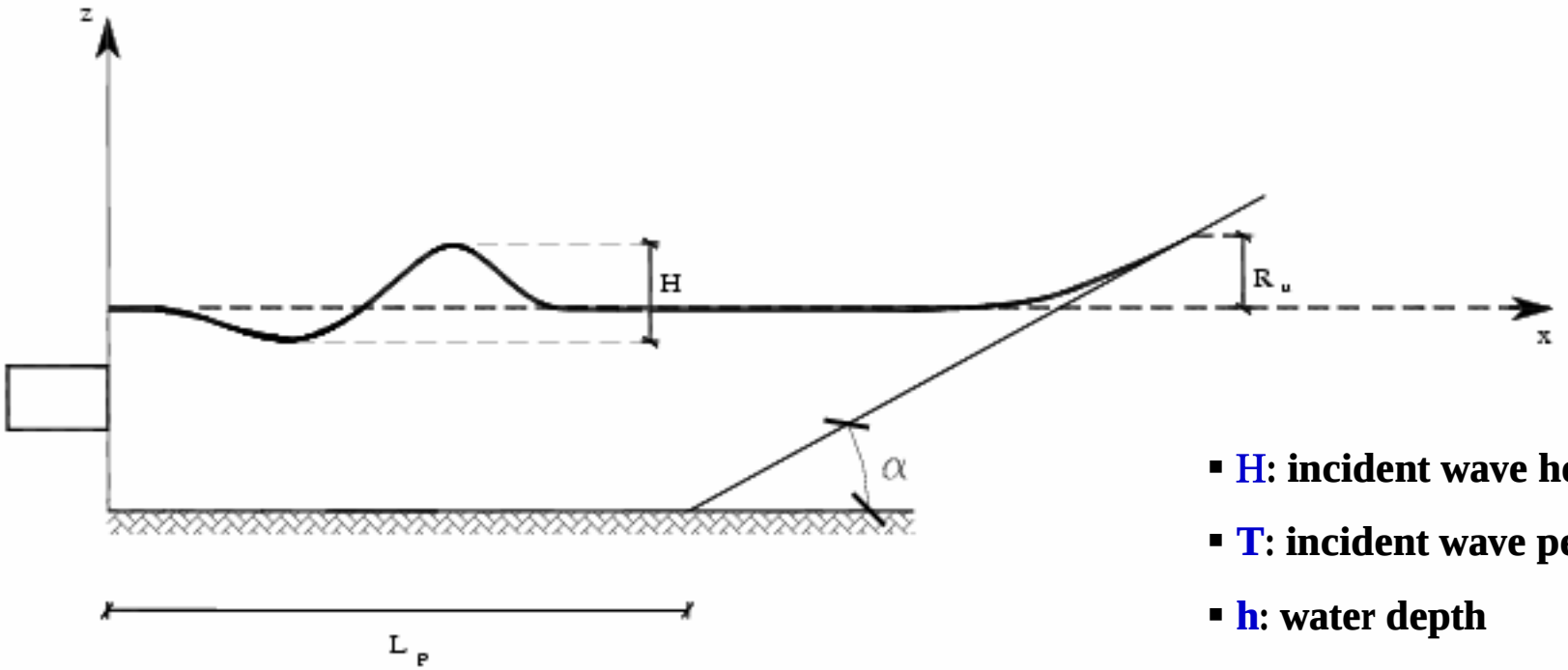
$$\frac{H_{max}}{h} = 0.12 \left(\frac{r}{h}\right)^{-0.4} \left(\frac{w}{h}\right)^{0.79} \left(\frac{s}{h}\right)^{0.5} \left(\frac{v_0}{\sqrt{gh}}\right)^{0.17} e^{0.6\cos\theta - 0.8\sin\gamma}$$

$$T_{max}\sqrt{\frac{g}{h}} = 2.5 \left(\frac{l}{h}\right)^{0.1} \left(\frac{v_0}{\sqrt{gh}}\right)^{0.29} \left(\frac{r}{h}\right)^{0.18} e^{0.22\sin\gamma}$$

Panizzo, 2004

Impulsive wave runup: the problem

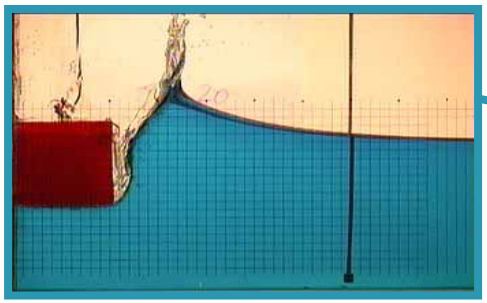


$$R_u = f\left(H, T, h, \alpha, \rho, \mu, g, \delta\right).$$

$$\frac{R_u}{h} = \phi\left(\frac{H}{h}, T\sqrt{\frac{g}{h}}, \alpha, \frac{\mu}{\rho h\sqrt{gh}}, \delta\sqrt{\frac{\rho\sqrt{gh}}{\mu h}}\right)$$

- H: incident wave height
- T: incident wave period
- h: water depth
- α: beach slope
- ρ: water density
- μ: water viscosity
- g: gravitational acceleration
- δ: beach roughness

Impulsive wave runup: the experiments



Scott Russel Wave Generator