Extreme surface elevation and water velocity in irregular waves propagating over a shoal

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with experimental data from Stian Jorde

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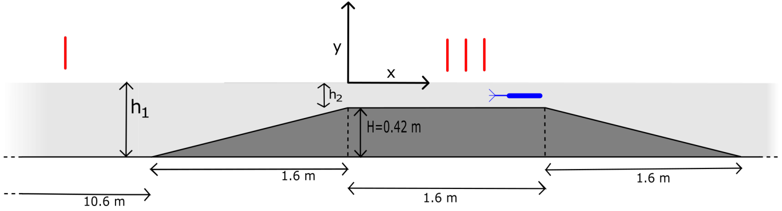
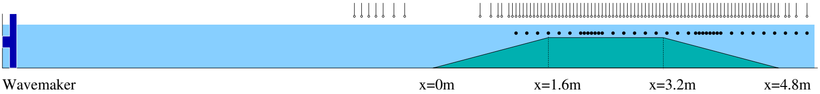
4 May 2020

Experiment of Stian Jorde (2018): measure surface elevation and velocity field in irregular waves over a shoal

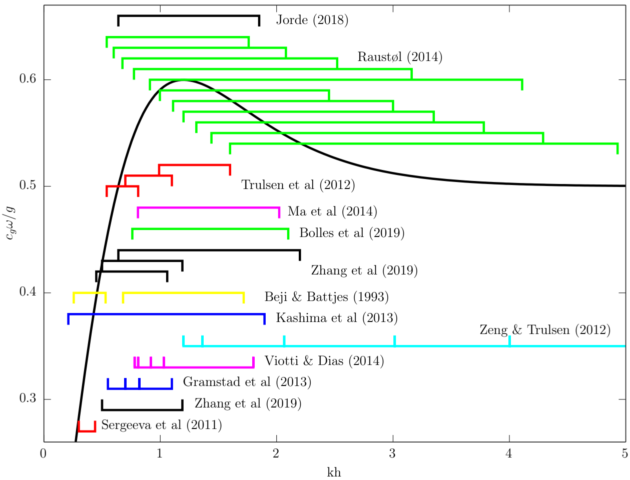
A single run: Surface elevation measured with ultrasound probes at four locations (red), velocity field measured with ADV at one location (blue):



Repeat several times to measure at several locations:



Similar experiments and simulations have been done by many limiting to surface elevation. Simultaneous elevation and velocity measurements only reported by Jorde (2018).



Conclusions from previous work:

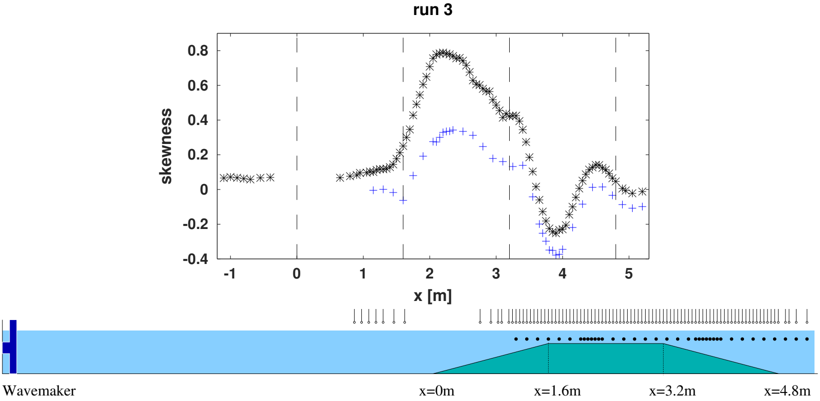
When waves come from deeper water onto a sufficiently shallow shoal there can be large excursions of kurtosis and skewness near the edge of the shoal some distance into the shoal.

Summarized in:

Trulsen, K., Raustøl, A., Jorde, S. & Rye, L. B. (2020) Extreme wave statistics of longcrested irregular waves over a shoal. *J. Fluid Mech.* **882**, R2.

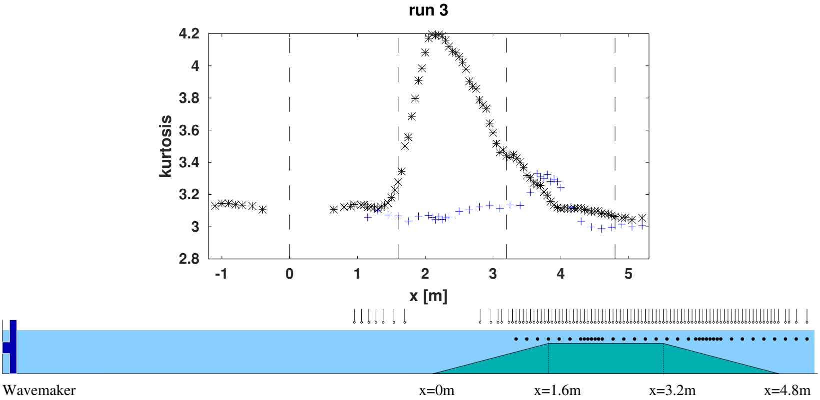
Experimental result of Stian Jorde:

Skewness of surface elevation (black $*$) and of velocity field (blue $+$) behave similarly:



Experimental result of Stian Jorde:

Kurtosis of surface elevation (black $*$) and of velocity field (blue $+$) behave differently:



Are rogue elevation waves and rogue kinematics waves of a different kind?

Higher order comoment analysis:

If rogue elevation waves and rogue kinematics waves are of a different kind, try to visualize how their comoments behave.

Coskewness ($n + m = 3$):

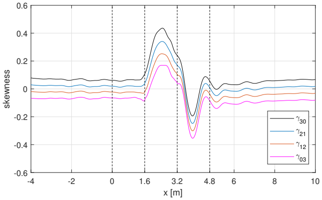
$$\gamma_{n,m} = \frac{E[(\eta - \bar{\eta})^n (v - \bar{v})^m]}{\sigma_\eta^n \sigma_v^m}$$

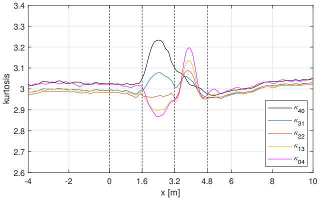
Cokurtosis ($n + m = 4$):

$$\kappa_{n,m} = \frac{E[(\eta - \bar{\eta})^n (v - \bar{v})^m]}{\sigma_\eta^n \sigma_v^m}$$

Sorry, some synchronization problems in our lab prevented us from computing comoments from measurements so far, we hope to present them soon, but in the mean time . . .

Numerical simulations of Christopher Lawrence allowed computing comoments





Conclusions

Laboratory experiments and numerical simulations show that extreme surface elevation and extreme velocity field can be dramatically different as a wave field propagates through an inhomogeneous environment.

We anticipate that a wave train can possess rogue surface elevation waves and rogue velocity waves that are of a different kind.

This can have serious implications for a correct assessment of the threat posed by rogue waves.

Do we need different rogue wave criteria for surface elevation and kinematics?