Undular bore development over a laboratory fringing reef

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Introduction

- Fringing reefs occur around low-lying islands, which are particularly vulnerable to flooding
- Infragravity waves (T>25 s) often dominate the hydrodynamics on the reef flat and drive shoreline motion at reef-fronted beaches
- Understanding their transformation over the reef flat is key to mitigate flooding risks in the future

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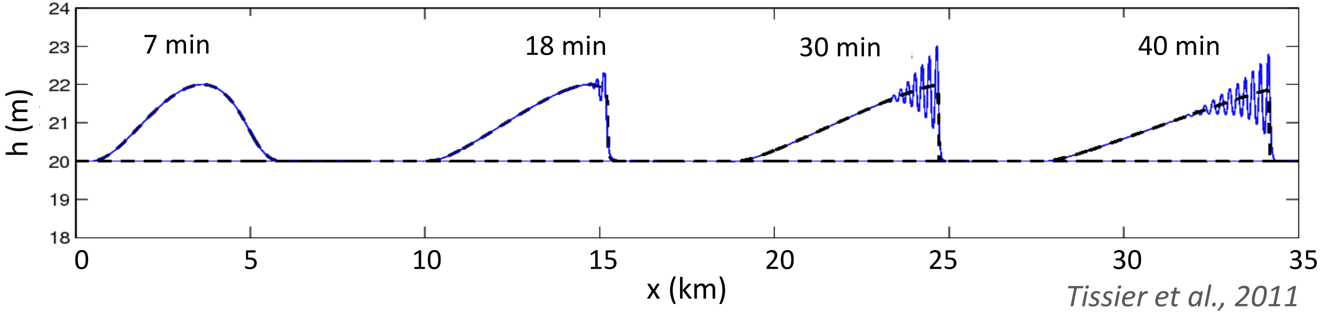
Introduction – Undular bore formation

- Non-hydrostatic effects can become important when long waves steepen in shallow water

  → **Formation of undulations behind the front**

<u>*Example: tsunami-like wave in the nearshore (d=20 m)*</u>



Tissier et al., 2011

Introduction – Field observations of undular bores over coral reefs

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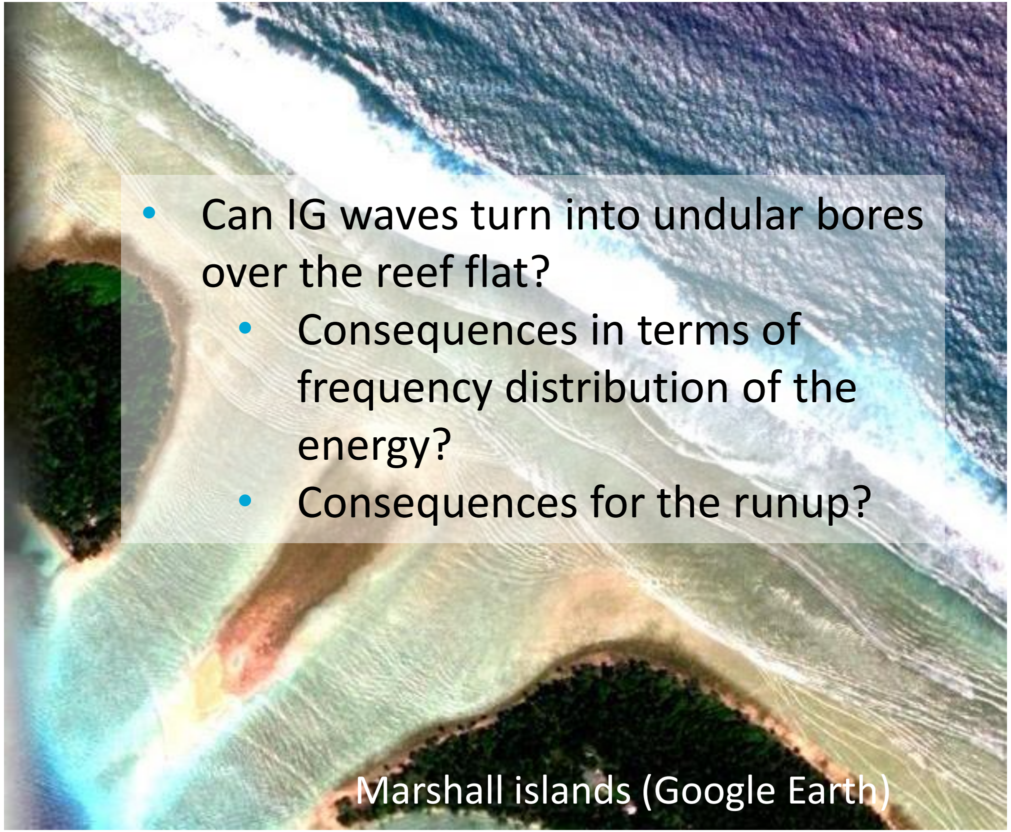
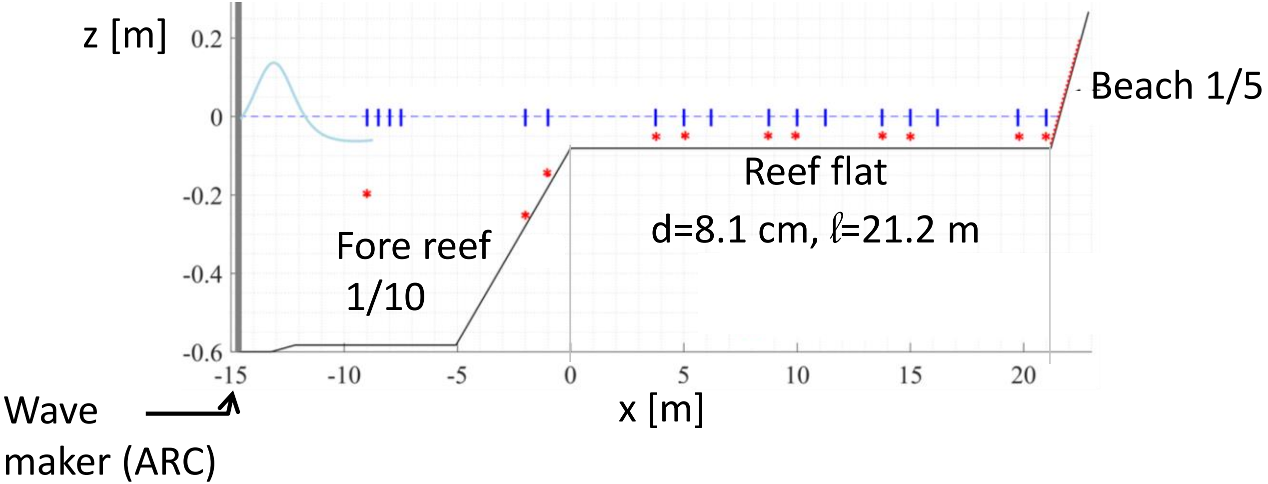


- Can IG waves turn into undular bores over the reef flat?
  - Consequences in terms of frequency distribution of the energy?
  - Consequences for the runup?

Marshall islands (Google Earth)

Laboratory data

J. Dekkers, 2017 Hydraulic Engineering lab



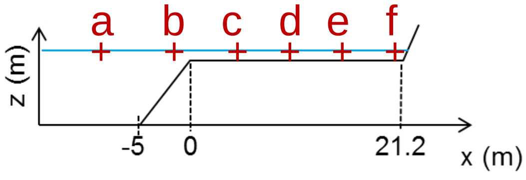
Scale factor n_L=20

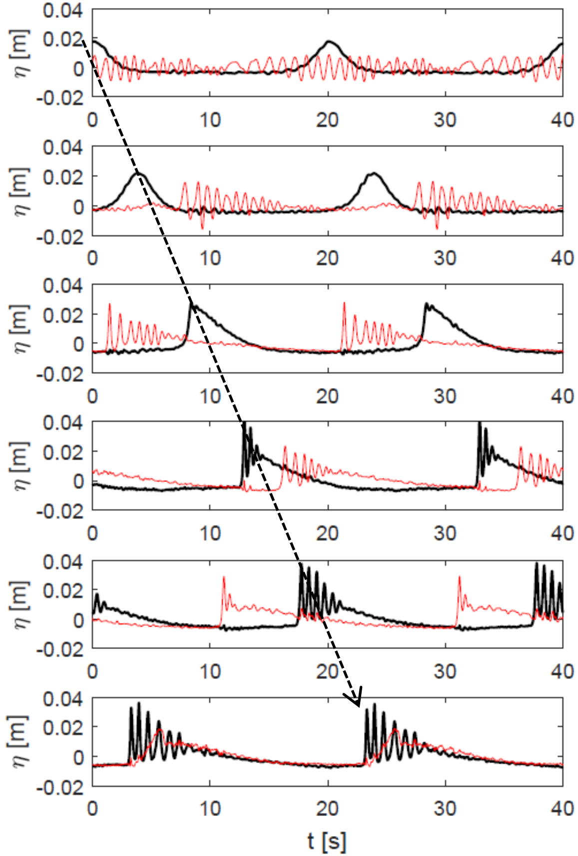
- Colocated measurements of free surface elevation (|) and velocity (*)
- Runup meter (.....)

In this presentation: focus on **regular long wave** cases (cnoidal waves), scaled to represent **infragravity waves** (T=10-20 s → $T_{prototype}$ =45-90 s).

IG wave transformation

Here: H_0=2cm; T_0=20 s



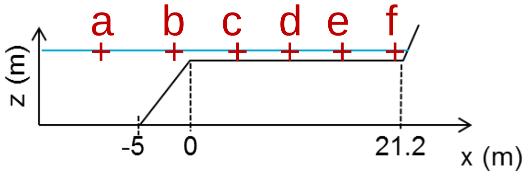


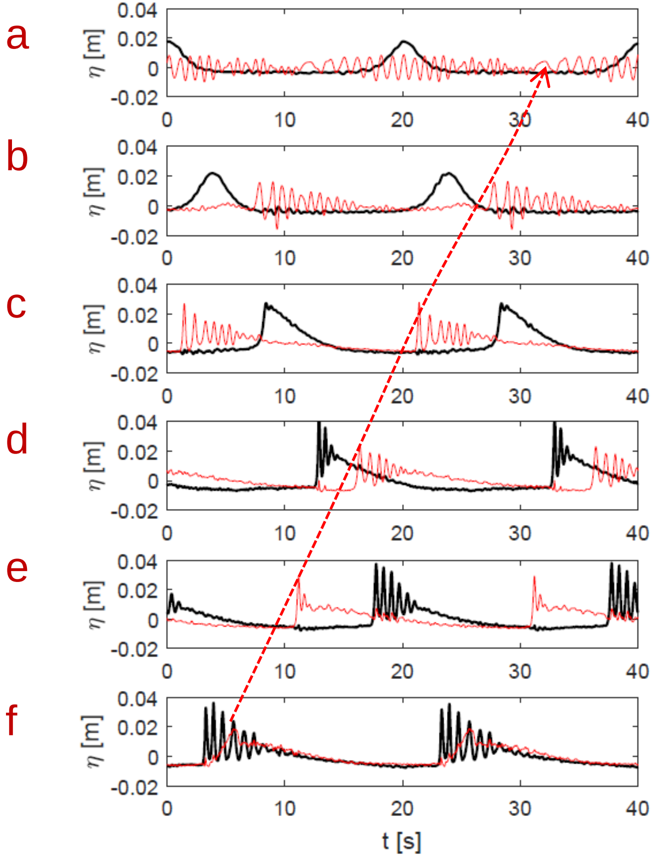
incident

reflected

IG wave transformation

Here: H_0=2cm; T_0=20 s





incident

reflected

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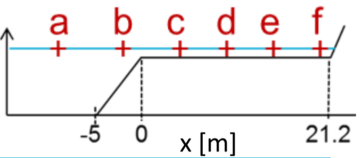
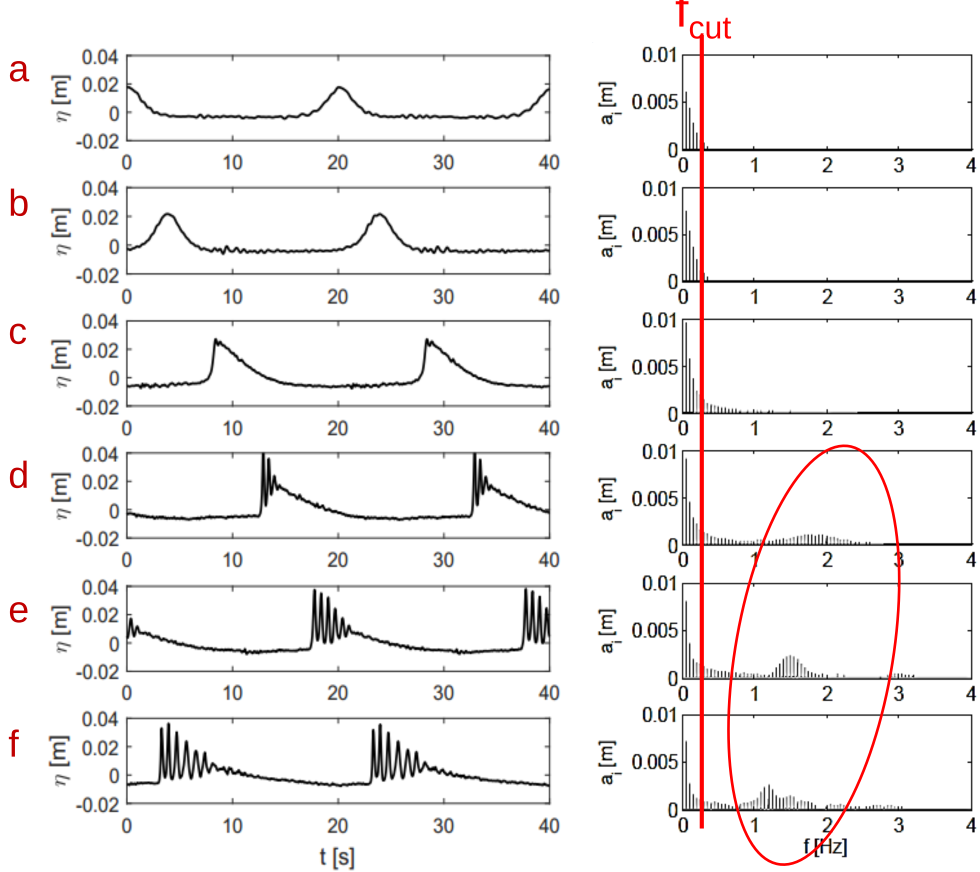
IG wave transformation (incoming signal)



H_0=2cm; T_0=20 s

Elevation timeseries

Amplitude spectra



Secondary peak, downshifting in time

Energy transfer out of the 'IG frequency' band ($f<f_{cut}$, with $f_{cut} \approx$ 0,04 Hz in prototype)

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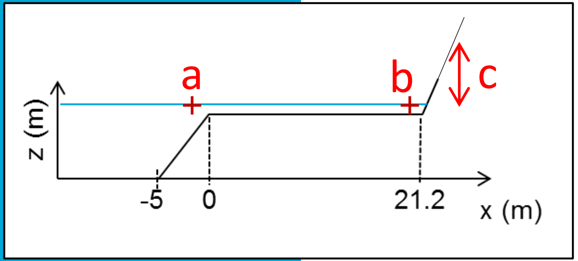
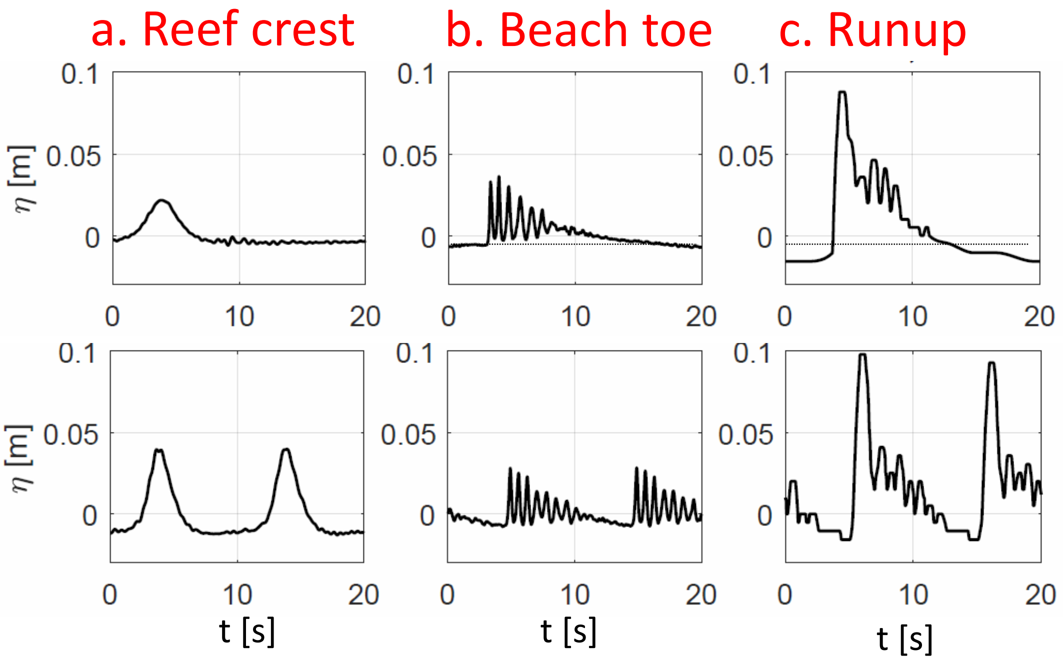
Runup on the back-reef beach

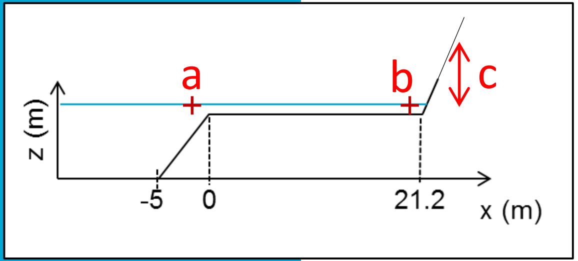


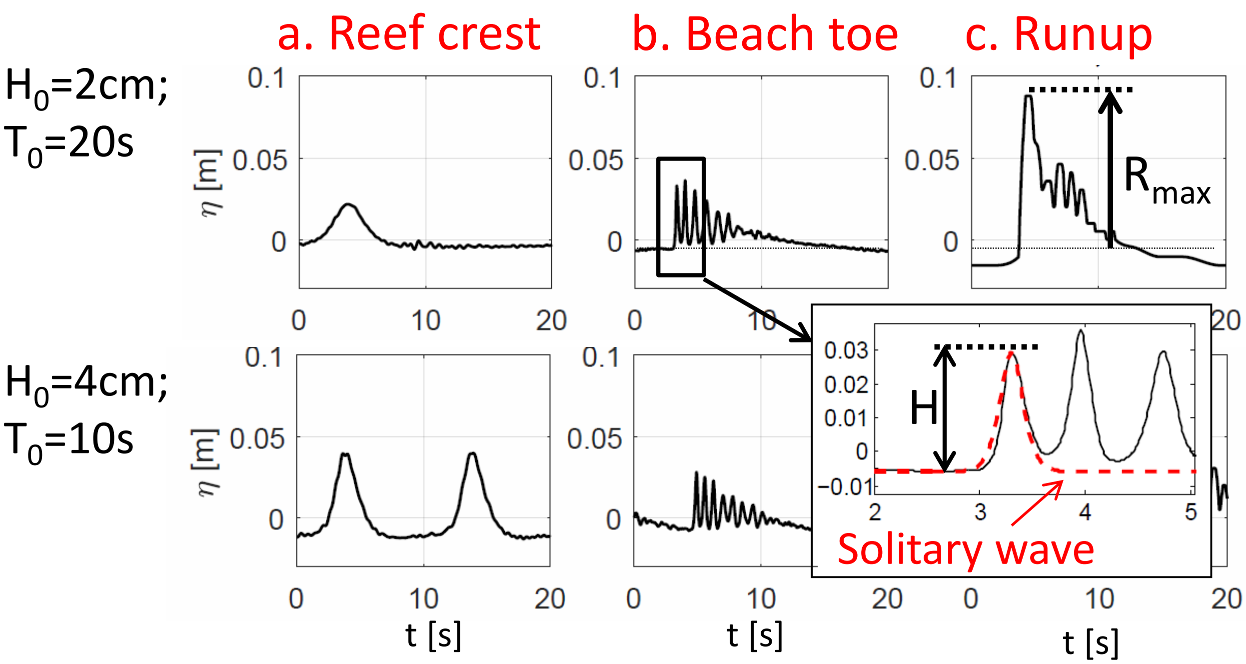
H_0=2cm;
T_0=20s

H_0=4cm;
T_0=10s



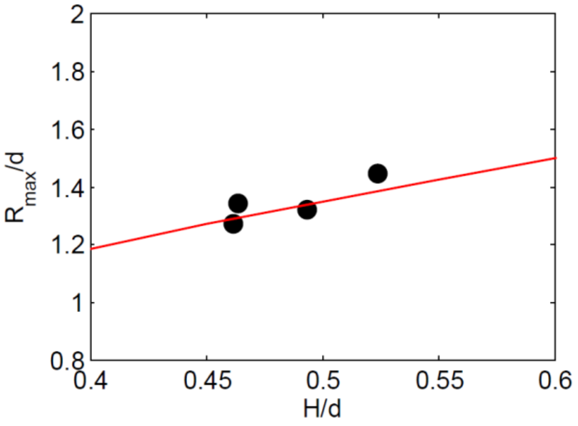
Runup on the back-reef beach





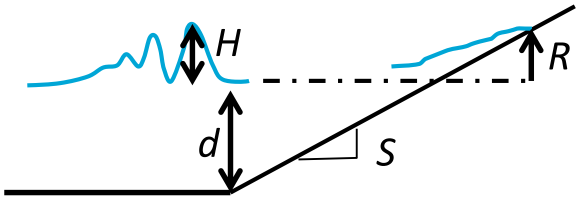
Runup on the back-reef beach

- Max runup fairly well-described by empirical formula derived for breaking **solitary waves**



- Measured runup
- Fuhrman and Madsen, 2008

$$R_{max} = 3{,}9H\ \xi^{0{,}42}\ and\ \xi = S/(H/d)$$



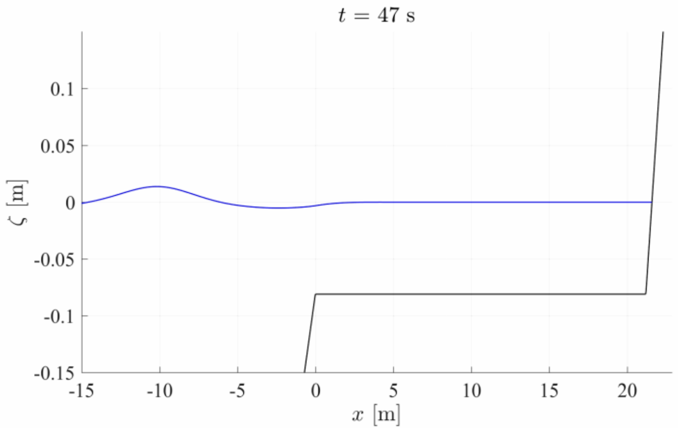
Conclusions

- Infragravity-scaled regular waves formed undular bores over our lab fringing reef for all 4 cases considered
- Development of undulation associated with a significant energy transfer towards short-wave frequency band
- Reef width sufficient to allow for the first undulation to develop into a solitary wave that controls maximum runup

Next steps

- *Analysis bichromatic wave cases*
- *Numerical modelling*

Numerical modelling using SWASH (Zijlema et al. 2011)



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