From shoaling, through breaking, to wave runup: how lidar scanners can help improve and validate phase-resolving models

Kévin Martins

Chargé de Recherche CNRS à :

LIttoral ENvironnement et Sociétés (LIENSs) - UMR 7266

Co-authors (& mentors :)

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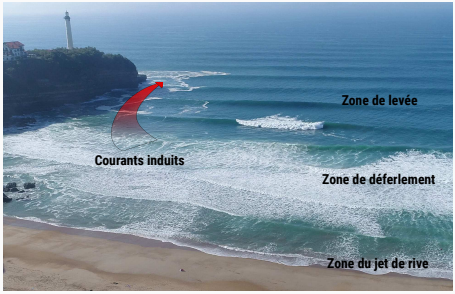
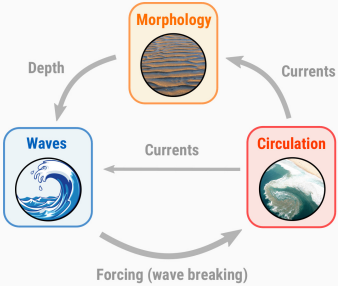
Philippe Bonneton

Journées de Modélisation des Vagues à Phases Résolues

Ile d'Aix; October 6, 2023

Wave **breaking** = Principal forcing of the nearshore circulation





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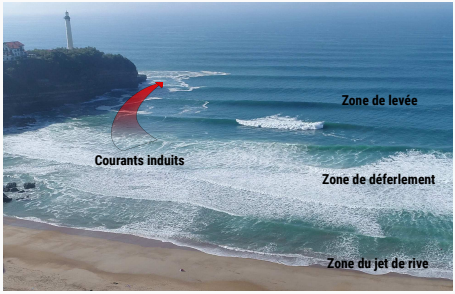
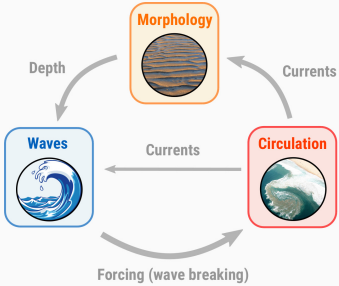


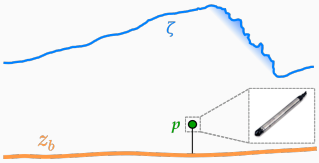


In situ measurements are essential for better understanding breaking processes:

- ▷ breaking criteria, energy dissipation rates and so on...
- ▷ statistics, e.g. extrema (both on ζ and H), runup
- ▷ ...

Measuring nearshore waves with **pressure transducers** deployed at the bottom:

- ▷ Robust & cheap, but providing point measurements



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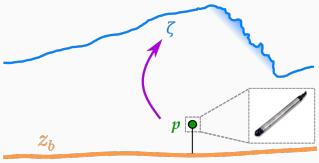

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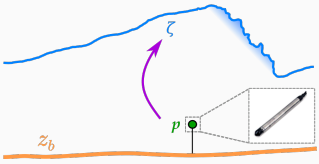
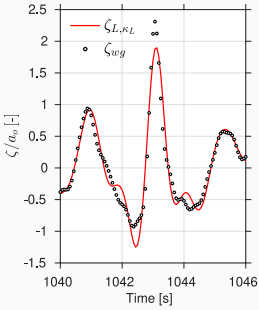
"Classic" linear reconstruction of ζ:
Attenuation of p along the vertical in cosh ($\kappa_L h$)

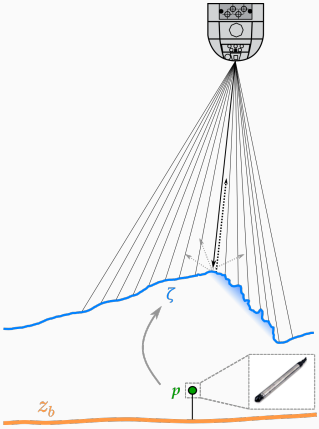




Martins et al. (2021, JPO)

Measuring nearshore waves with **lidars**:

- ▷ Relatively cheap & non intrusive
- ▷ Direct and highly-resolved measurements of ζ



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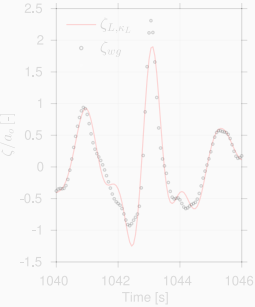
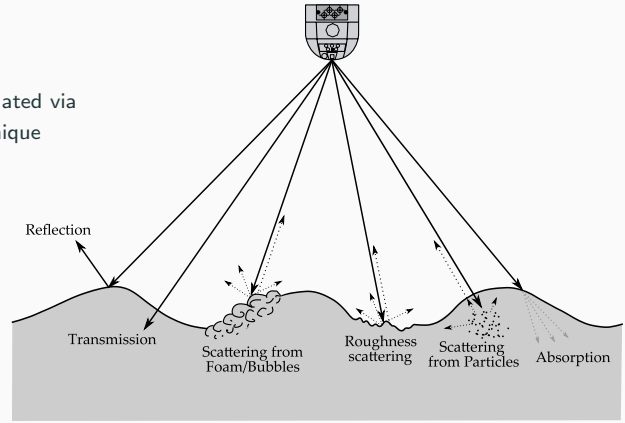


Lidar: Light detection and ranging

Typical applications:

- ▷ surveying
- ▷ detection systems

Principle: distance estimated via the 'time of flight' technique



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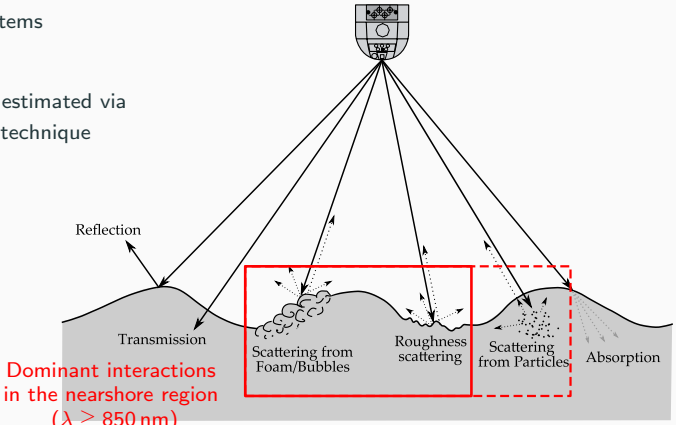
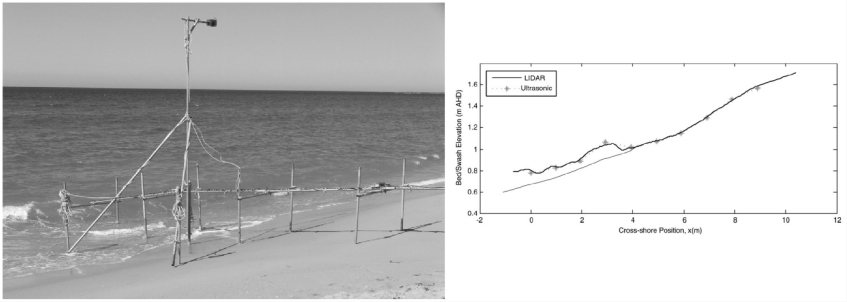


Dominant interactions in the nearshore region ($\lambda \gtrsim 850\,\text{nm}$)

- **1999**: First measurements in the (very) nearshore by Irish et al. (2006)
  - ▷ 4-rangefinder lidar wave gauge (LWG) to estimate directional spectra

Deployment over the Field Research Facility pier at Duck, NC

- **2009**: First 2D scans of bores running up a sandy beach (Blenkinsopp et al., 2010).
  - ▷ High spatial ($\sim O$(mm) at nadir) and temporal (10-35 Hz) resolution
  - ▷ Ideal for capturing interactions at the shoreline

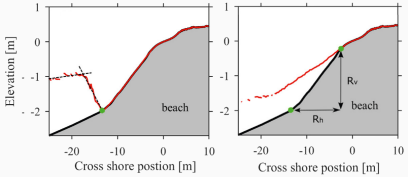


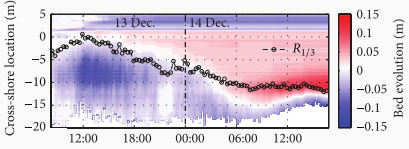
Test deployment at Narrabeen-Collaroy, Australia

PhD (2014-2017)

UNIVERSITY OF BATH

- **2014-2017**: Analysing wave transformation in the surf zone with lidars.





Martins et al. (2016, JS); Sous et al. (2016, AWR); Bergsma et al. (2019, CSR)

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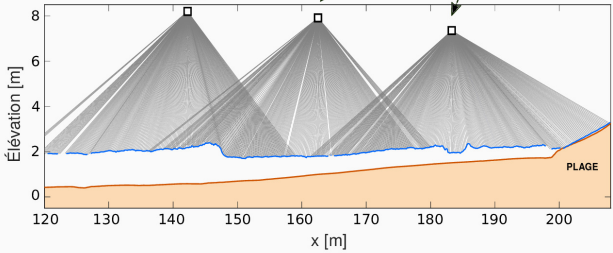

Animation en temps réèl, pour illustrer les données !

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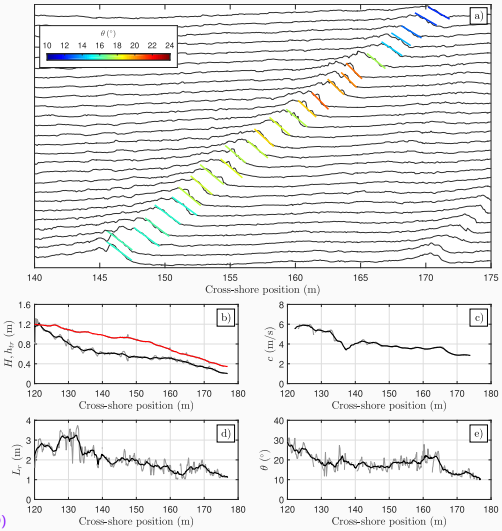
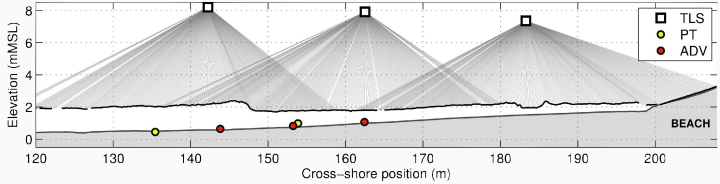


Martins et al. (2018, JGR-O)

Co-localised pressure and lidar measurements collected in a natural surf zone:

- ▷ Analyze non-hydrostatic processes
- ▷ Validation of surface elevation reconstruction methods



Validation of the non-linear weakly dispersive method of Bonneton et al. (2018 CENG):

$$\zeta_{SL} = \zeta_{hyd} - \frac{h}{2g}\partial_t^2 \zeta_{hyd} \quad (1)$$

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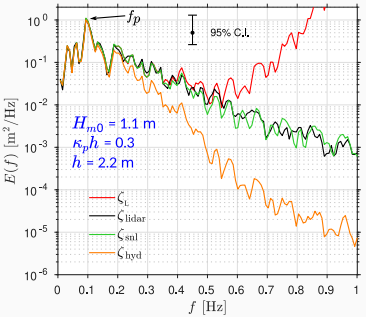
Transition shoaling/outer surf zone



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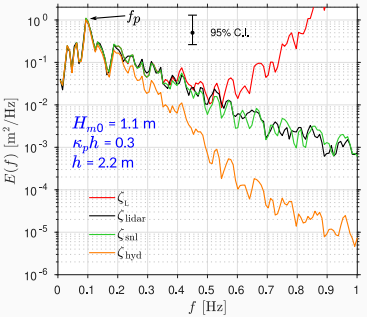

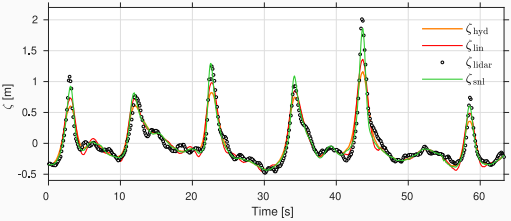

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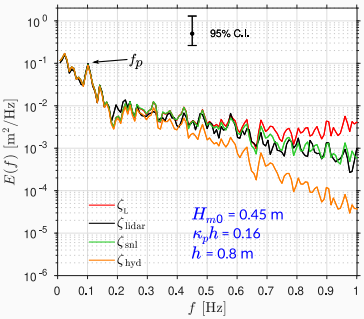
Inner surf zone



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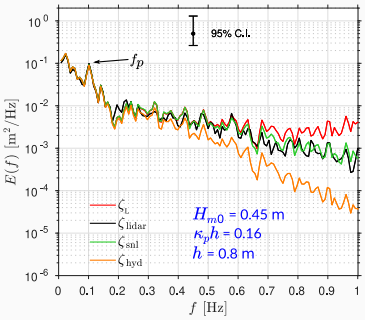

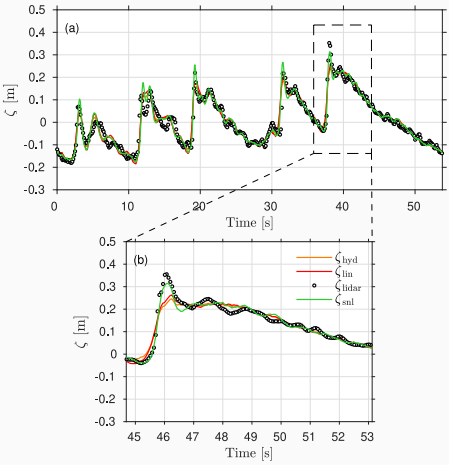

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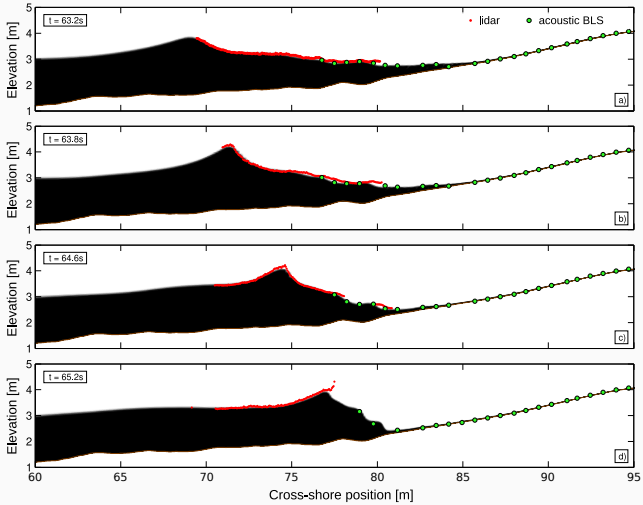
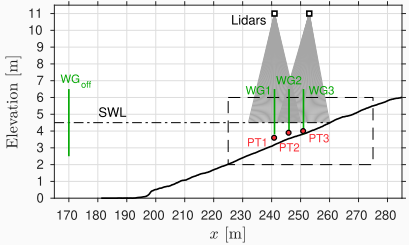
Consistency between measurement techniques, and with models (here OpenFOAM)



Martins et al. (2017, CENG)

Comparing surf zone wave measurement techniques in the Hannover wave flume

- Resistance-type of wave gauges (WG 1–3)
- Pressure transducers (PT 1–3)
- Lidars



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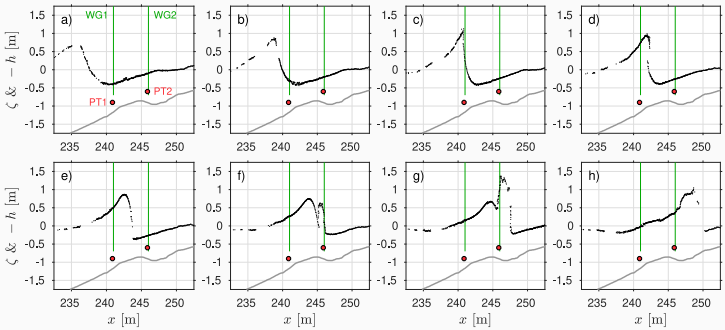

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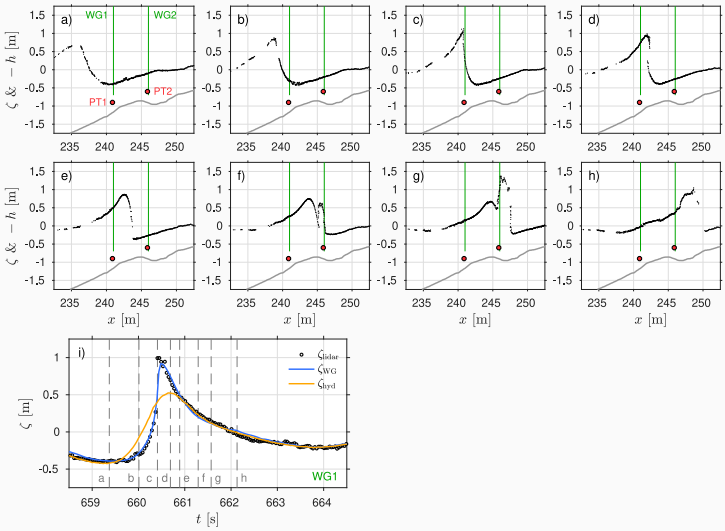

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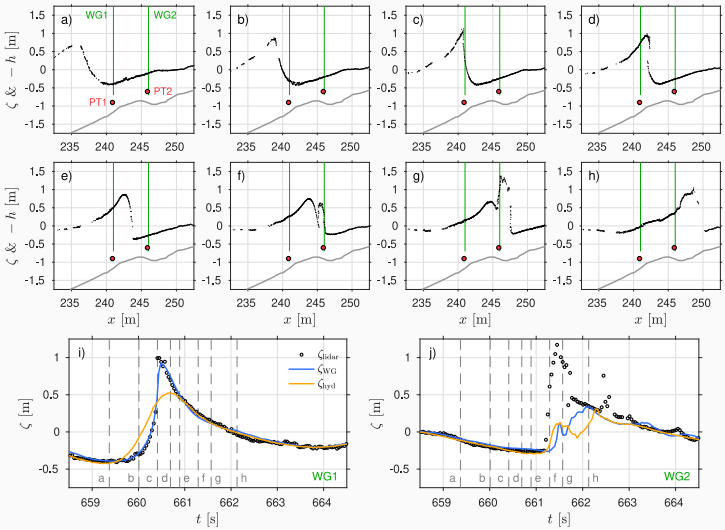

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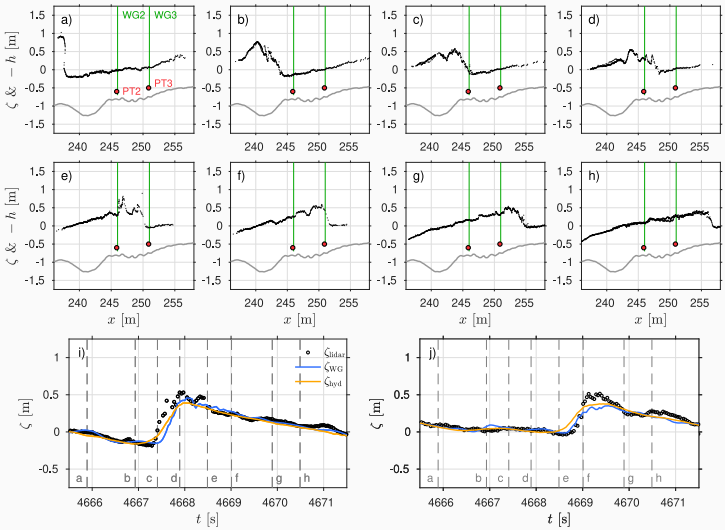
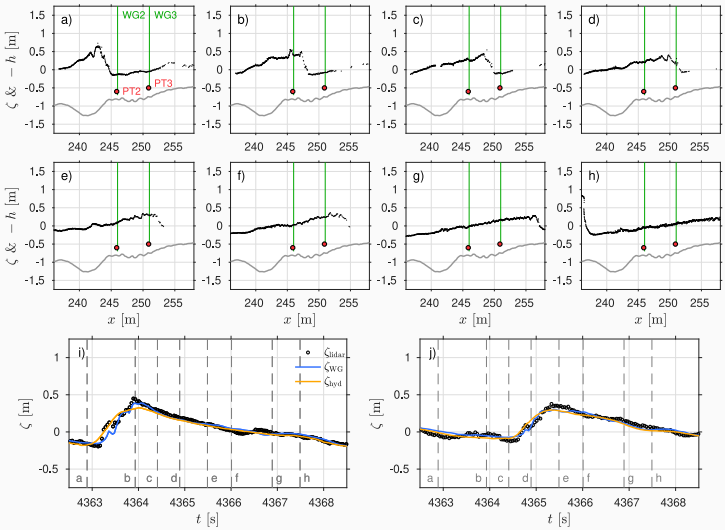


Comparing (inner) surf zone wave measurement techniques in the Hannover wave flume



Issue with 'concept' of ζ in the outer surf identified by Kimmoun & Branger (2007, JFM)

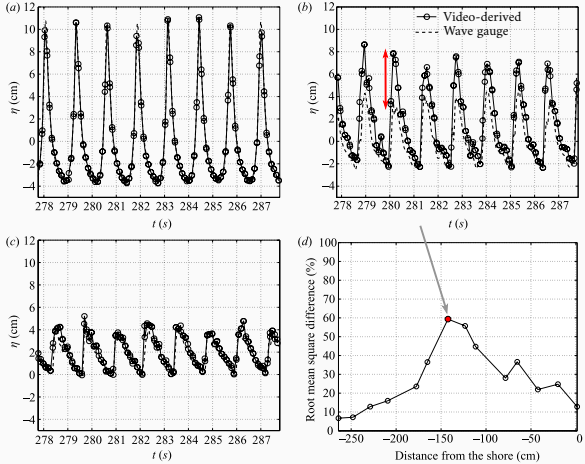


FIGURE 6. Time series comparison between wave gauge elevation (dashed lines) and automatic surface detection from PIV images (circles). Distance from shoreline: (*a*) 248 cm (incipient breaking), (*b*) 142 cm (splash-up event), (*c*) 42 cm (roller). (*d*) r.m.s. difference (%) between the PIV surface detection and the wave gauge measurements.

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  - importance of non-hydrostatic and non-linear effects in surf zone waves
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Merci!