Acoustic and optical turbidity response to altering particle size distribution during extreme events

Matthias Baeye, Louise Delhaye, Michael Fettweis

Royal Belgian Institute of Natural Sciences, Operational Directorate Natural Environment (OD Nature), Rue Vautier 29, 1000 Brussels, Belgium (email: mbaeye@naturalsciences.be)

INTRODUCTION

Acoustic and optical devices are commonly used to measure suspended sediments in the water column. However, these two types of instruments have different responses (Fig. 1), this difference is generally recognised as depending on the composition of the sediment. **Acoustic devices are better at "hearing" sand** while **optical ones are better at "seeing" mud**.

In this poster, we present preliminary results to attempt to differentiate sand from mud composition based on the correlation between optical and acoustic responses (Fig. 2).

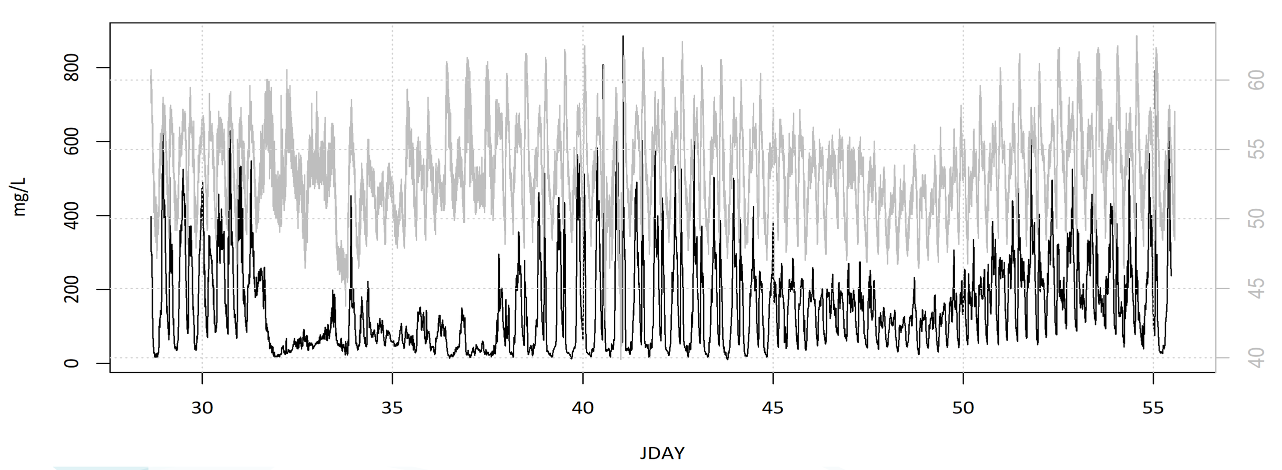

Fig. 1. Time-series of the acoustic and optical responses against the Julian day.

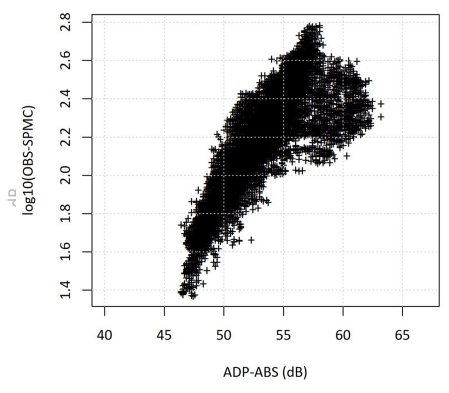

Fig. 2. Correlation between acoustic and optical responses.

MATERIALS & METHODS

150 days of data were collected with a benthic tripod at one sampling location in the Belgian part of the North Sea (Fig. 3) in 2008 and 2009. Measurements with optical backscatterance sensor (OBS Campbell Sc.), acoustic Doppler profiler (ADP Sontek 3MHz) and laser in-situ scattering and transmissometry (LISST-100X Sequoia) took place at 2.3 meter above the seabed.

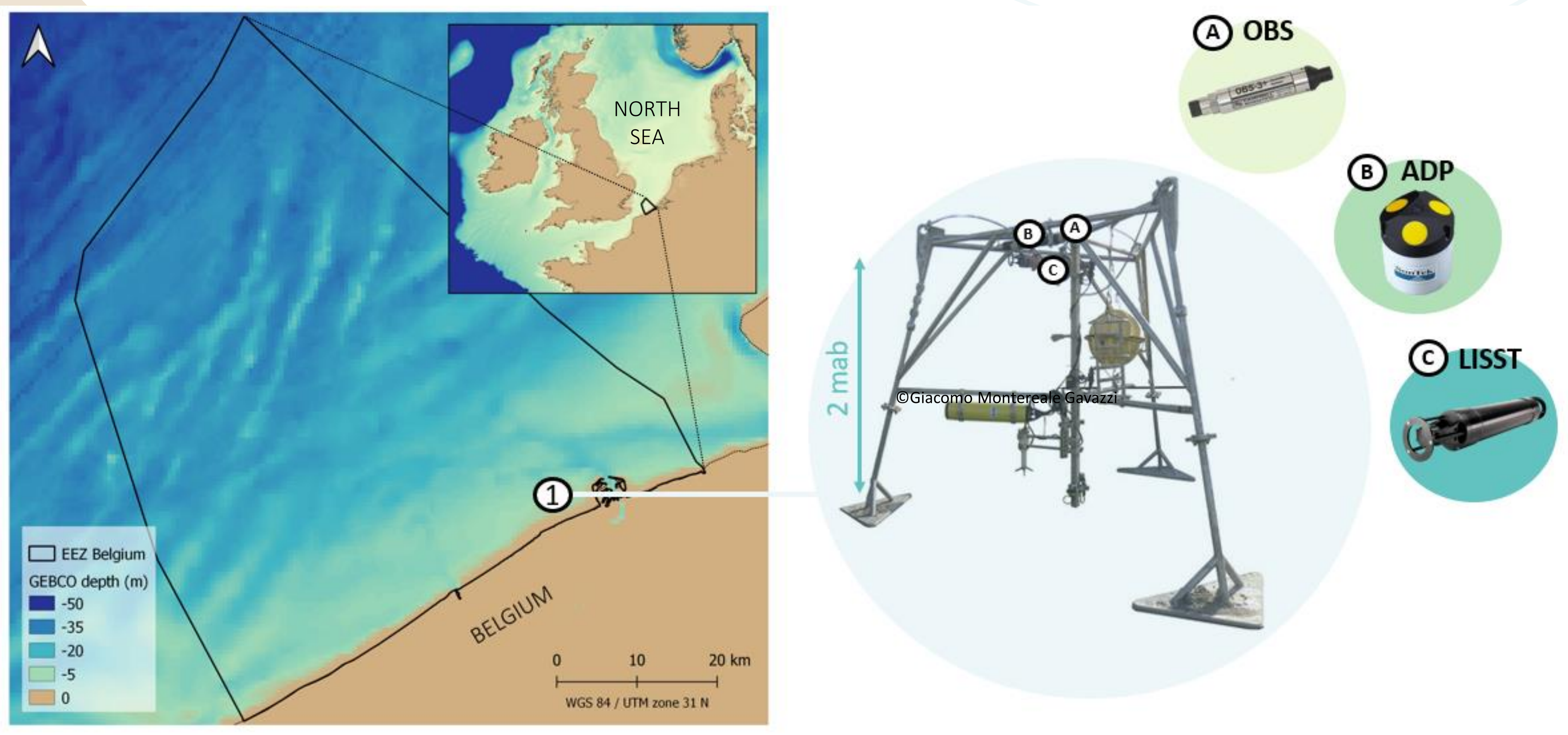

Fig. 3. Sampling location and instruments used for the collection of the data.

A regression line was then fitted between the acoustic (ADP) and optical (OBS) sensor responses over a moving 12.4-hour window (i.e. 1 tidal cycle). **It is then assumed that the slope varies under altering hydrodynamic conditions**.
A **positive** slope (and strong R^2) corresponds to calmer periods (no wave activity and low TKE), while a **negative** slope (and weak correlation) corresponds to more extreme events of high TKE and waves (Fig. 5). Based on regression slope distribution, three cases were defined (higher turbulence: <mean-1 SD, medium state: mean-1SD to mean+1SD; calm conditions: >mean+1SD)

The turbulent kinetic energy (TKE) was calculated as follow:

$$k = \frac{1}{2}\left(\overline{(u')^2} + \overline{(v')^2} + \overline{(w')^2}\right)$$

When looking now into the percentage size fraction >62.5 µm, measured by the LISST, higher percentages occur for the positive slope values cases. This is associated to the well-known process of flocculation in the area (Fettweis et al. 2012). However, there is also a significant amount of sand-sized particles in suspension during the higher turbulence, implying solid (quartz) particles and not anymore mud flocs in suspension. The latter explains the poor correlation as the acoustic and optical sensor do behave differently.

REFERENCES

Fettweis et al. 2011. "Hydro-meteorological influences and multimodal suspended particle size distributions in the Belgian nearshore area (southern North Sea)", Geo-Marine Letters.

Pearson et al. 2021. "Characterizing the Composition of Sand and Mud Suspensions in Coastal and Estuarine Environments Using Combined Optical and Acoustic Measurements". Journal of Geophysical Research: Oceans, 126(7).

RESULTS

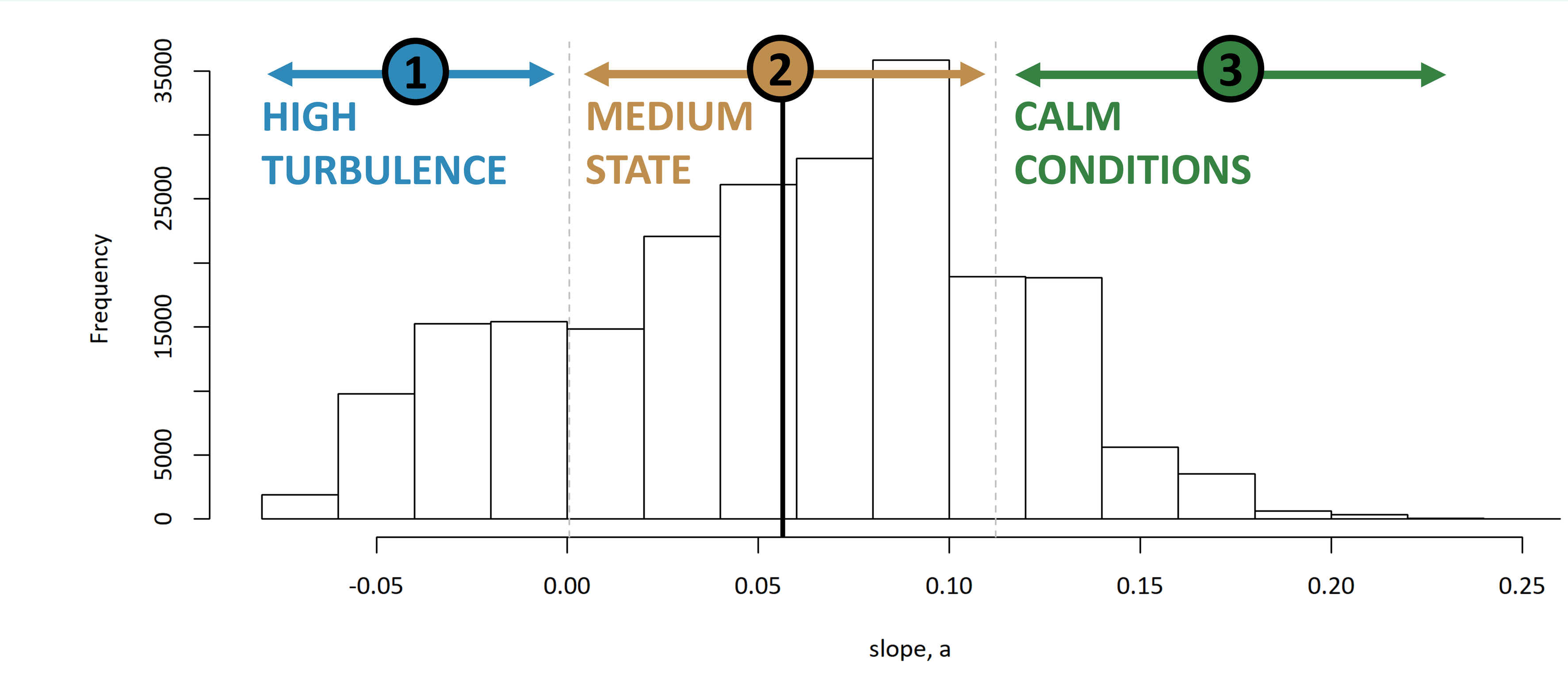

Fig. 4. Histogram of the slope values distribution. Dashed vertical lines refer to 1 standard deviation (SD), and solid black line to the mean slope.

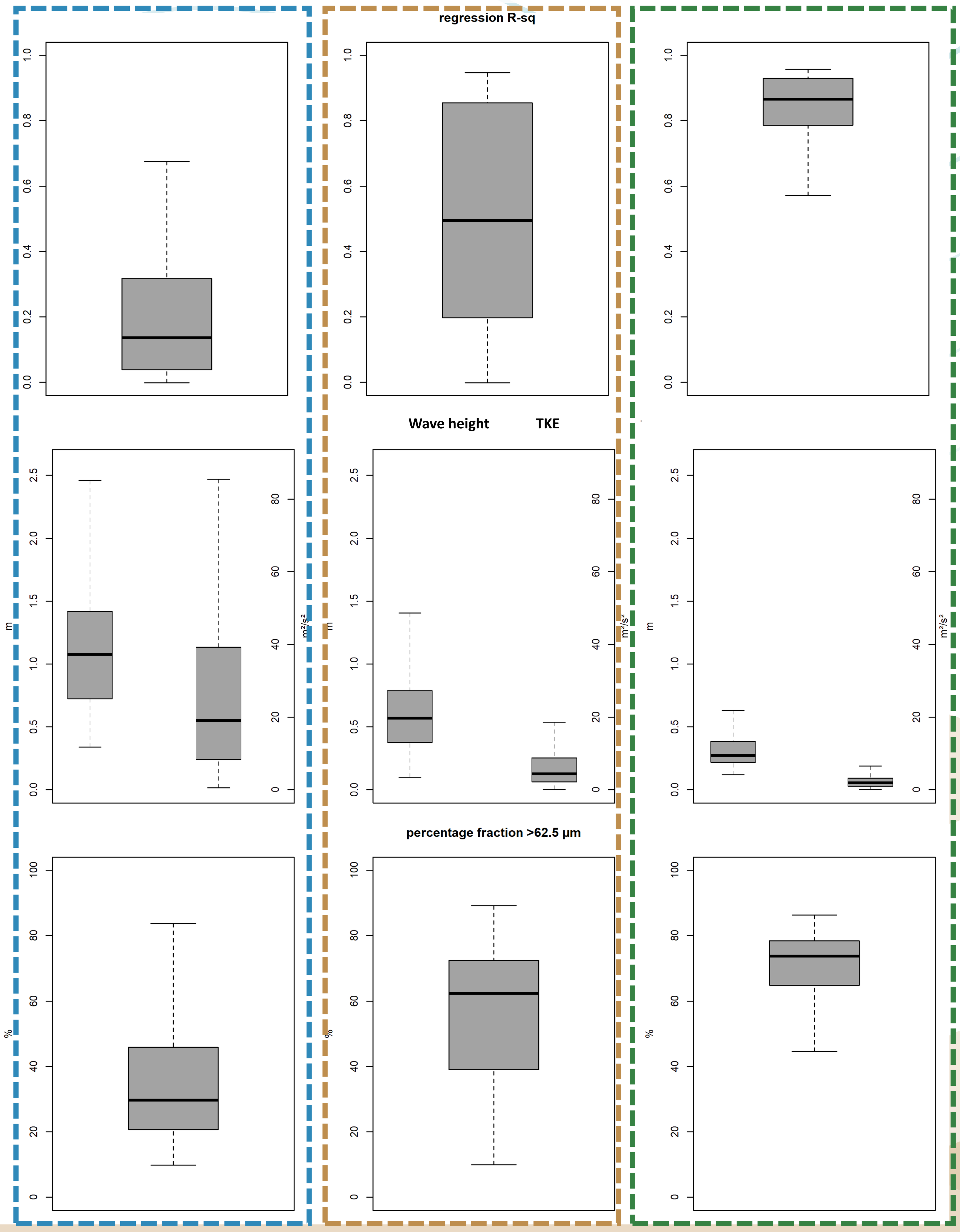

Fig. 5. Boxplots of the R², wave height, TKE and percentage fraction >62.5 µm for the high turbulence, medium state and calm conditions.

Higher turbulence	Medium state	Calm conditions
Poorer correlation	More variability	Better correlation
Silt-clay and sand in suspension	Mix of silt-clay and sand	Only silt-clay (flocculation)
No mud flocs		

CONCLUSIONS & PERSPECTIVES

This work presents only preliminary results showing the importance and complexity of the correlation between acoustics and optics in a turbulent and turbid environment in order to obtain reliable suspended sediment values as well as to be able to distinguish sand from mud.
We show that turbulent conditions display a generally poorer correlation between both instruments and presents a higher concentration of sand and the absence of mud flocs.
Future works include the study of the total dataset (2005-2021) as well as the integration of the SCI as described by Pearson et al. 2021.

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