NEARSHORE DEPTH-INVERSION FROM LIDAR SCANNERS: CURRENT PROGRESS, LIMITATIONS AND FUTURE PERSPECTIVES

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INTRODUCTION

Scanning terrestrial lidars can simultaneously measure beach topography and sea-surface elevations across the surf-zone at high resolution. These maps of sea-surface elevations can be used to extract wave properties, which can then be inverted for depth and combined with beach topography observations, offering an exciting avenue for quantifying the morphological changes of sandy beaches at various temporal scales. As water depth decreases in this nearshore region, non-linear amplitude dispersion effects become increasingly relevant to wave shape and propagation and such effects need to be accounted for when estimating depth from remotely-sensed wave dispersive properties. Martins et al. (2023) recently proposed a new non-linear (Boussinesq) depth-inversion method to estimate nearshore depths from dense maps of sea surface elevation measurements. Here, we present our preliminary efforts aimed at implementing this Boussinesq approach to multiple lidar datasets collected recently in the field at the US Army Engineer Research and Development Center's Field Research Facility (FRF) in Duck NC.

METHODS

A 2 week-long campaign was organized during September 2022 at the FRF with the objective to implement the Boussinesq approach of Martins et al. (2023) in natural conditions. Sea-surface elevation datasets were collected in bursts of 25-30 min with three lidar systems: one single-beam lidar fixed on the dune system (O'Dea et al., 2019) and two UAV-mounted multibeam lidars. The cross-shore extent covered by the lidars varied with the conditions but generally extended from the swash zone to a few meters seaward of the breaking point, thus covering the entire surf zone. Bathymetric profiles were acquired daily for validation purposes with the Coastal Research Amphibious Buggy (CRAB). The depth-inversion approach follows Martins et al. (2023): dominant phase speed spectra c_{obs} are estimated from cross-spectral analyses of spatially dense sea-surface maps collected by lidars, while predictions of these phase speeds (c_{rms}) are made with the Boussinesq theory of Herbers et al. (2002). The mean water depth is estimated by minimizing the error between measured and predicted phase speed spectra.

RESULTS

In the shoaling region, the Boussinesq theory of Herbers et al. (2002) accurately predicts the observed 10—50% frequency-dependent deviations of phase speed from the linear dispersion. The skills of the Boussinesq theory to estimate depth are thus much improved compared to the linear prediction (relative error <5% compared to a 40% error, Figure 1), demonstrating the potential of lidar systems to accurately estimate depth around the breaking region. In the surf zone, predictions of phase speeds are also improved compared to linear predictions, but are not as good as in the shoaling region. This will be discussed during the presentation, where we will also address the difficulties to implement the Boussinesq approach to field data and the perspectives for future work.

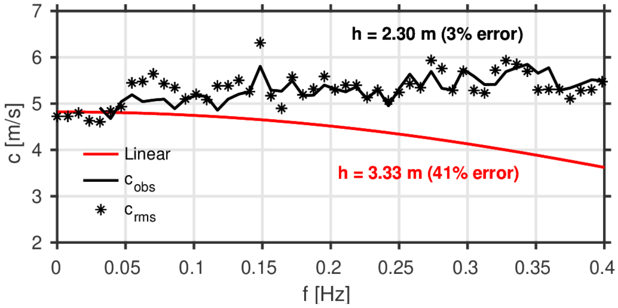

Figure 1 – Observed (c_{obs}) phase speed spectra compared with linear and Boussinesq (c_{rms}) predictions before breaking. The depth estimate h and the relative error are given in the same color (19UTC - 12 Sept. 22; f_p = 0.065 Hz; H_{sig} = 1.5 m).

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