Wave celerity from video imaging: validation with in-situ Pre-ECORS data

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A large amount of research has gone into the problem of predicting nearshore bathymetry from remote sensing techniques. Video systems are the emerging tool as they are relatively cheap and allow to cover a wide range of time scales for hydro- and morpho-dynamical processes. Existing video methods to estimate bathymetry from sea surface are based on wave characteristics: essentially energy dissipation (Aarninkhof et al. 2003, Roelvink et al. 2003) and wave phase speed (Stockdon and Holman, 2000). Indeed, bottom bathymetry is a key parameter of wave transformation in the nearshore.

Wave energy dissipation method is limited to breaking areas. However in presence of complex bedforms, wave breaking is not continuous in both longshore and cross-shore directions and this can generate important errors in bathymetric estimations (Aarninkhof et al. 2003). On the other hand, wave speed method is potentially accurate in the whole nearshore area.

In this presentation, two methods to determine wave speed in the nearshore area from video images will be tested using in situ data. The main objective is to focus on the quality of the wave speed extracted from video images since it will be a key parameter in the precision of the determination of the bathymetry.

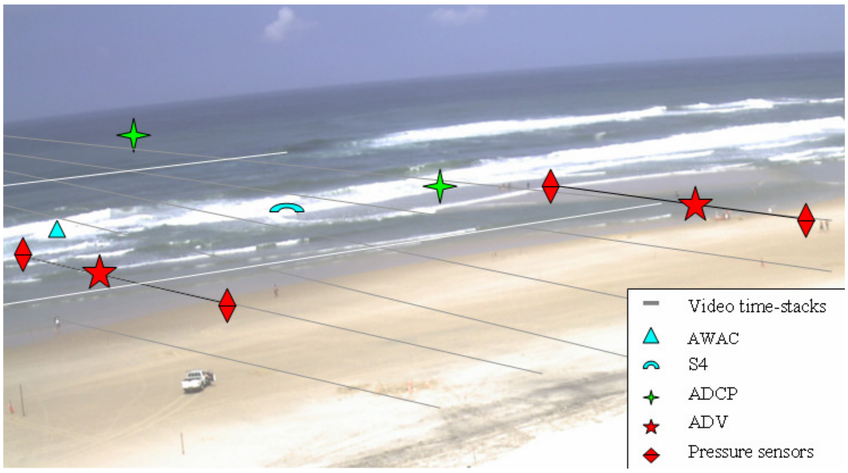

Figure 1: Pre-ECORS07 (Biscarrosse beach) Deployment of instruments versus video time-stacks arrays.

A new video system CamEra has been installed in April 2007 at Biscarrosse beach on the Aquitain coast in France in collaboration with the NIWA (New Zealand). The system is constituted of 5 high resolution cameras allowing a view field of 2 km in the alongshore direction in the inter-tidal area. Images are grabbed four times per hour. A field experiment, Pre-ECORS07 has been done in June

2007 in front of the video system. During the field experiment waves conditions have varied from low (H<1m) to highly energetic (H>2.5m) and again calm conditions within one week.
From video images, 10 minutes of pixel intensity time-series are created in some locations. Time-stacks arrays have been set-up to correspond with cross-shore pressure sensors lines and with cross-shore topographic survey lines (Figure 1). Instruments are synchronized in time.

Pixel intensity time-series at 2Hz are extracted at pressures sensor locations (8Hz) (Figure 2). Water elevation and pixel intensity time-series are compared to check if there is good correlation as previously established by Lippmann and Holman (1991).
Results show a good correlation with a remaining bias due to the shift between wave crests and pixel intensity maxima. Nevertheless, lighting, wave height, type of wave (shoaling, breaking) can significantly change wave's signature on video images. The results of the sensitivity of these parameters will allow us to better estimate the influence of each of them on correlation. Uncertainties and robustness of video technique within a wide range of conditions will be discussed.

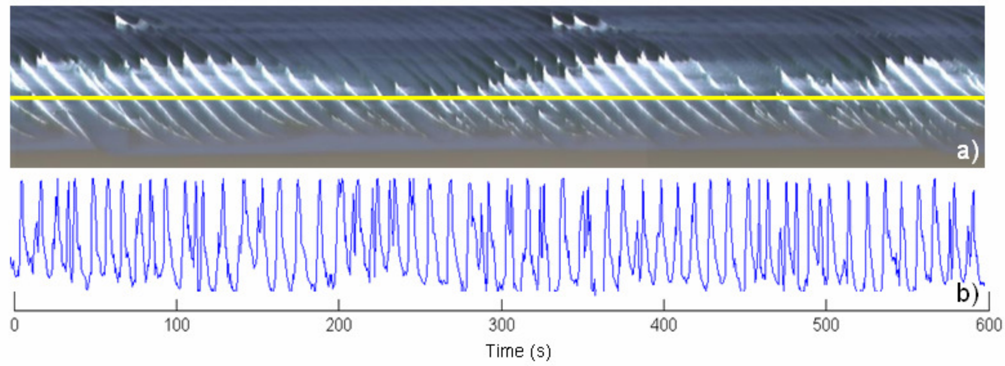

Figure 2:
a) Cross-shore time-stacks

b) Pixel intensity time-series at a specific cross-shore location (yellow line)

Wave celerity can be obtained from pixel intensity cross-shore time-stacks. Two methods are described and compared using Pre-ECORS data. The first method is based on Stockdon and Holman (2000) and uses a Complex Empirical Orthogonal function (CEOF) technique to estimate wave phase speed. The second method uses cross-correlation to directly estimate wave phase speed (in cross-shore direction) defined as the ratio between cross-shore distance and signal time lag within this distance.
Validity domains and accuracy of these methods are studied as a function of parameters affecting wave field's signature.

The overall applicability of pixel intensity time-stacks to estimate wave phase speed will be discussed in the perspective of using it for a depth estimation tool.

References

Aarninkhof, S., 2003: Nearshore Bathymetry derived from Video Imagery. Delft University Thesis.

Kennedy, A.B., Dalrymple, R.A., Kirby, J.T., and Chen, Q., 2000: Determination of inverse depths using direct Boussinesq modeling, J. Waterway, Port, Coastal and Ocean Eng., 126(4), 206-214.

Lippmann, T.C., and Holman,R.A., 1991: Phase speed and angle of breaking waves measured with video techniques; Proc. Coastal Sediments '91, New York: ASCE, pp. 542-556.

Roelvink D, Aarninkhof S, Wijnberg K and Reniers A, 2003: Quantification of 2D subtidal bathymetry from video. Delft report.

Stockdon H.F., Holman R.A., 2000: Estimation of Wave Phase Speed and Nearshore Bathymetry from Video Imagery, Journal of Geophysical Research. Vol. 105, No. C9, pp 22,015--22,033.