COMBINING X-BAND RADAR AND VIDEOCAMERAS DATA TO STUDY WAVE PROPAGATION

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Summary The evolution and characteristics of nonlinear water waves propagating in the nearshore are studied by means of long-term field monitoring. This is achieved by the combined use of two different but complementary remote sensing tools, i.e. video monitoring systems and marine X-band radars. This work describes a preliminary study of the wave propagation, with a particular focus on wave breaking, in the area of the Misa River estuary (Senigallia, Italy), where both X-band radar data and video monitoring products are available.

INTRODUCTION

Wave propagation in the nearshore is a complex process entailing a number of nonlinear mechanisms (e.g. steepening and breaking) that largely force the local hydrodynamics, sediment transport and morphodynamics. As waves shoal towards the shoreline, their increase in size allows for nonlinear mechanisms to set in, these most often leading to wave breaking. This aspect brings an issue that direct measurements with in-situ instruments (e.g. wave gauges) is characterized by limits in the spatial collection of information. Remote sensing tools are convenient for obtaining information on wave physics at the nearshore, as their measurements can cover a relatively wide area, this allowing for a clearer understanding of the relationship between the wave forcing and the flow circulation (e.g. generation of macrovortices [1]). Video monitoring (VM) and X-band radar (XBR) are widely used to observe nearshore morphodynamic processes and wave propagation starting from the 90's [2,3]. The capabilities and precision of these instruments are enhanced by progressive processing methods or combined use of instruments [4,5,6]. Our previous efforts on exploiting the data from VM and XBR yielded to a good agreement with observations [7,8]. Our aim is to combine data of VM and XBR to better resolve nearshore wave mechanisms.

METHODOLOGY

The study area is the Misa River (MR) estuary (Senigallia, Italy), a very dynamic system where the strong interactions between river and sea forcing takes place (Figure 1a). Nearshore processes occurring at/near the river mouth have been observed for some years through two remote sensing systems, i.e. the VM station SGS and an X-band radar (blue and red pins in Figure 1a). The SGS station is composed of five cameras, acquiring a 10-minutes video at 2fps, and a snapshot every hour from 5 AM to 5 PM. The post-processing of the data provides useful products to study the wave propagation, such as time-exposure images (Timex) to identify breaking lines and, indirectly, submerged sandbars [8] or Timestacks to investigate wave runup. The X-band radar collects data for the spatial-temporal characterization of the sea state and estimation of the surface currents and bathymetry. Extensive data processing, using the REMOCEAN system [9], is needed to elaborate the raw data images with the aim to determine the elevation η (x,y,t) of the sea surface.

(a) (b) (c)

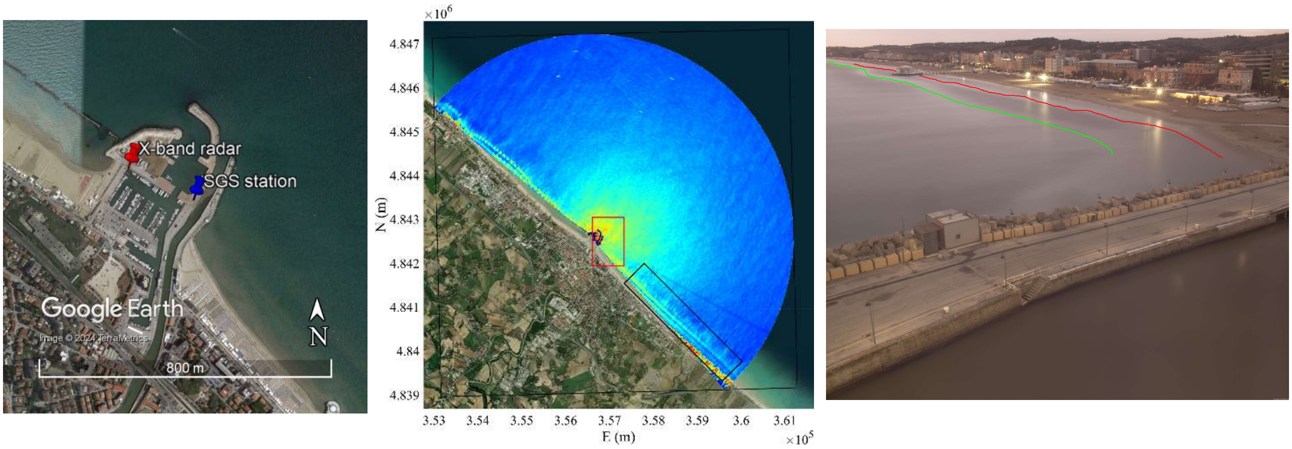

Figure 1. (a) Location of the SGS station and X-band radar in the MR estuarine area. (b) Averaged raw radar image, from which two parallel features are visible to the southeast of the MR estuary (black-framed region). (c) Timex oblique image of the camera framing the nearshore area to the southeast of the MR estuary, from which similar features are identifiable (highlighted in red and green).

The spatial domain framed by the VM (red rectangle in Figure 1b) partially overlaps with the area observed by the XBR (coloured semi-circle in Figure 1b), so that the two data can either be 1) exploited to study the same process, occurring in the common area, or 2) combined to investigate a wider area through the XBR and improve the results in the nearshore area by means of the VM. As an example, Figure 1 shows the presence of two shoreline-parallel features to the southeast of the MR estuary, highlighting the presence of a pair of submerged longshore-uniform sandbars, in both the raw XBR image (Figure 1b, black-framed) and the Timex VM image (Figure 1c). The Timex image is created by averaging the intensity values of each pixel over the 10-minute sampling period. In this way, moving features, such as individual waves, are not visible but more stable characteristics are highlighted, like wave breaking regions, which are visible on this image as bands of high intensity values.

PRELIMINARY RESULTS

Sea clutter images are not visible when the sea is calm, thereby, a relatively energetic storm event is chosen to analyse XBR data and obtain the wave characteristics. Then FFT analyses have been applied to get the one-dimensional wave energy spectrum, and wave characteristics are retrieved from the spectrum results. The dominant wave direction is evaluated nearly 25°N and it is in good agreement with buoy measurements (Figure 2-a). The peak period varies between 7 to 9 seconds during this event and the significant wave height varies between 0.75 to 0.9 meters (Figure 2-b, c).

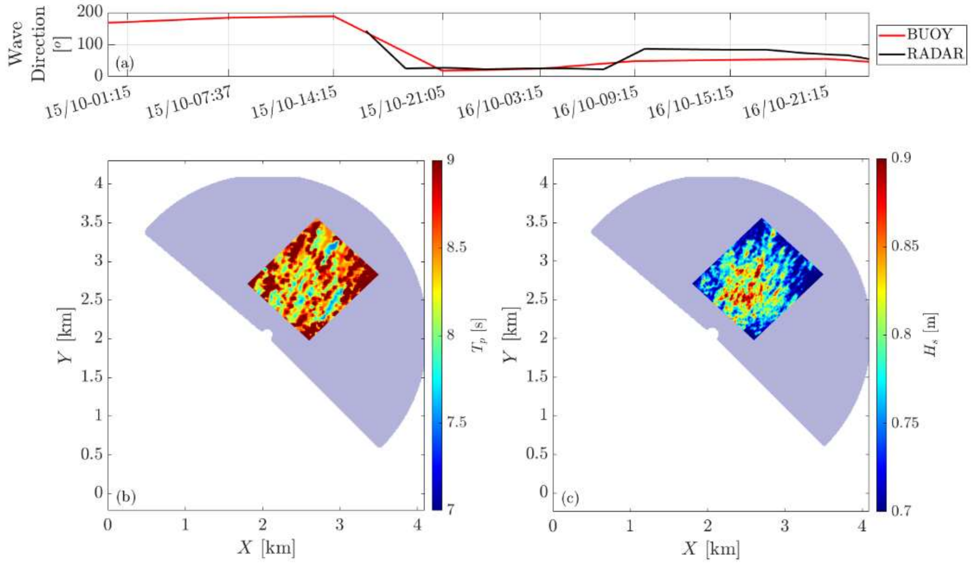

Figure 2. 2-day time series comparison of wave direction from XBR and RON buoy (a), spatial variation of peak period (b) and significant wave height (c) on 16th October 2023, 01:39 AM, evaluated from XBR data.

Since the 1D spectrum provides limited information, we are adapting 2D spectra for the ongoing analyses. Additionally, we are also putting an effort to extract information on wave breaking patterns from both VM and XBR data and combine them to precisely capture the breaking. The outcomes of these improvements will be illustrated at the Conference.

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