OBSERVING LITTORAL WAVES BY DOPPLER RADAR

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1. INTRODUCTION

The dissipation of the wave energy and the transformation of the wave propagating over uneven bottom towards the shore has been subject of study for decades. Many experiments has been implemented since the 60's, indicative publications for wave tanks experiments: [1], [2], [3] and for field surveys such as:[4], [5] and [6] the DUCK94 project. At the best of the cases, DUCK 94, there were less than twenty sensors measuring wave height. By this it turned out that the monitoring of a shoaling wave field is still undersampled by using in situ measurements. Recently this problem started being countered by using ground based remote sensing techniques, e.g. from cameras: [7] or from coherent radar systems [8] and [9]. This paper presents for first time, the monitoring of the wave field propagating the last nautical mile towards the coast by using a ground based Dopplerized X-band radar.

2. METHODOLOGY

The instrumental setup of the experiment includes a dopplerized radar system with horizontal polarization, a meteorological station, 2 wave riders and 2 tide gauges. The area of investigation is an exposed littoral dune coast (South List, Sylt Isle) in the German Bight. The radar was operated from the shore to measure velocities at the sea surface; the antenna is directed against the direction of wave propagation. The radar was developed on the base of nautical X-band radar [10] in cooperation of IfK/GKSS with the Electrotechnical University of St. Petersburg, Russia. The main change of the nautical system was the coherentisation of the transmitter/ receiver module to detect the Doppler frequency shifts in 254 range cells, with spatial resolution of 7.5 m. The resulting range is 1920 m, along a radial beam and the temporal length of the observation is 10min, the sampling frequency is 1024 pulses per second.

Three cross sections of the averaged backscattered radar power in the arc of the directional spread of the wave field and the occurred radial Doppler velocities are obtained. Chunks of 256 successive radar pulses were used for the calculation of the Doppler spectra by fast Fourier transformation, each of them is validated according to the spectral width and the radial velocity is calculated as $v = 0.5\lambda_{radar}\frac{m_1}{m_0}$, where λ_{radar} is the radar wavelength and m_0 and m_1 the null and first moment of each spectrum. The spectra of the resulted velocities are calculated and compared with the spectra of the horizontal velocity measured by the wave riders.

3. RESULTS AND DISCUSSION

The visualized structures of the velocity in space and in time demonstrate the motion towards the shore as the time increase, wave propagation, and the impact of the bathymetry on the horizontal velocity, Fig 1. For each individual measurement the standard deviation of the speed is calculated, which is related with the local heave (Fig. 2), the waves break above the long-shore bar. The distance of the wave breaking zone depends on the momentary water level that is steed by the tide. For the validation of the radar observation simultaneous buoy measurements of the horizontal velocity taken 2km northern from the area of radar observation, are used. The two time series of horizontal velocities of the buoy and of the one radar cell have been acquired over the same depth. The comparison of the two spectra illustrates that the peak frequencies are the same, but the maximum spectral density of the buoy is higher than from the radar (Fig. 3a and 3b). Nevertheless this obvious discrepancy lies within the geophysical range of variability and has a value that has to be expected from independent observations.

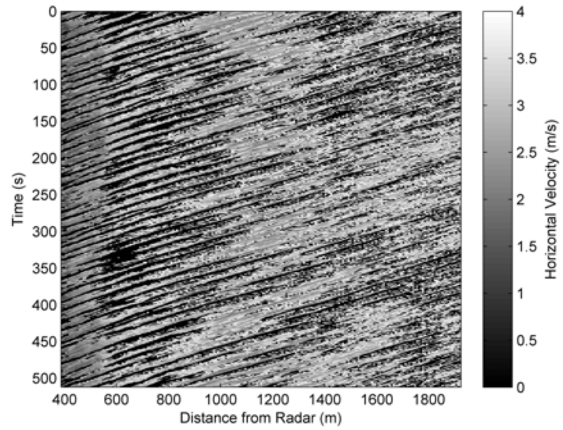

Figure 1. Time – range map of horizontal Doppler speed of a 10min wave observation.

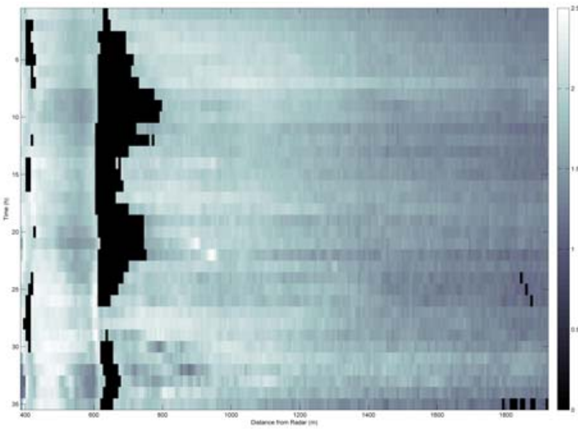

Figure 2. Time - range map of the standard deviation of the horizontal speed covering 40 hours with a 10 minutes average each hour for 40 hourly samples as function of the distance from the radar.

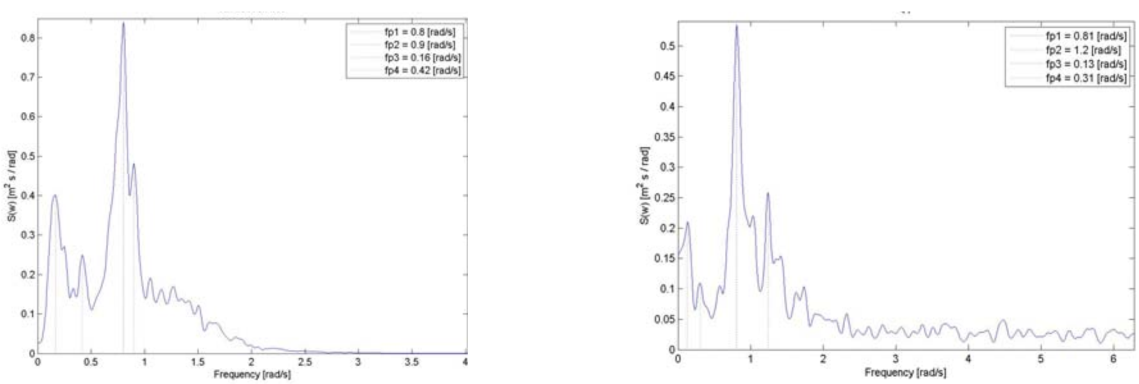

Figure 3a-b. Left: The spectrum of the horizontal velocity measured by buoy. Right: The spectrum of the horizontal velocity measured by radar; the distance from radar is approximately 1200m.

4. REFERENCES

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