SOMaR3 – Meeting

Dynamics of Near Shore Wave Breaking observed by Coherent Marine Radar

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Outline

1. Part - Doppler processing
   \[\rightarrow\] pros and cons of common Doppler calculation methods

2. Part – characteristic patterns of breaking waves in grazing incidence coherent radar backscatter
   \[\rightarrow\] how can we identify wave breaking in range time images
Doppler processing

\[ v_D = \frac{c \Delta \Phi f_S}{4 \pi f_R} \]

Phase difference

FFT

\[ v_D = \frac{\lambda}{2 \cos \alpha f_D} \]
Phase difference method

Benefits
- robust and fast method
- confidence as indicator of reliability

Disadvantages
- no additional information

\[ C_i = \frac{A_{j+1} e^{i\Phi_{j+1}}}{A_j e^{i\Phi_j}} \]

\[ conf = \frac{|\Sigma C_i|}{\Sigma |C_i|} \]
FFT - Method

Benefits

- Doppler peaks are easy to separate
- Spectral moments can be extracted

-> Extracted parameters like number of peaks, std, skewness or kurtosis may provide information about the scatterer behaviour inside one radar footprint

Disadvantages

- Computational time
- Time resolution
Measurement site

Permanently: X-band radar, meteorology, Waverider buoy
Temporary: pressure gauges, ADCP, smaller GPS-Waveriders
Range-time radar data

Uncalibrated intensity [dB]

- Open sea
- Longshore sandbar
- Surf zone

- 2D-FFT
- Structure tensor

- Period
- Wave length
- Phase velocity

Depth [m]
Manually tracked breaker

**Intensity [dB]**

**Doppler velocity [m/s]**

- Distance to radar [m]
- Time [s]
- Values range from 1 to 7
Manually tracked breaker spectrogram
Manually tracked breaker spectrogram

Relative spectral density [-]

Distance travelled [m]

Time travelled [s]

Doppler velocity [m/s]

Depth [m]

\[ \frac{V_D}{c} \quad \text{or} \quad \frac{1 - I_{\min}}{I_{\max} - I_{\min}} \quad [-] \]
Manually tracked breaker spectrogram

Relative spectral density [-]

Distance travelled [m]

Time travelled [s]

Doppler velocity [m/s]

Depth [m]

\( \frac{V_D}{c} \) or \( \frac{I - I_{min}}{I_{max} - I_{min}} \) [-]
Spacial behaviour of Doppler spectra at different stages of the breaking process
Spacial behaviour of Doppler spectra at different stages of the breaking process

Doppler velocity [m/s]

Distance to radar [m]

Time [s]

Abstand zum Radar [m]

5 t=811.52

6 t=812.544

7 t=813.568

8 t=814.592
Spatial behaviour of Doppler spectra at different stages of the breaking process
Bimodal Doppler spectra

Intensity [dB]

Distance to radar [m]

Time [s]

Doppler velocity [m/s]

Time [s]
Max intensity vs. max Doppler velocity

location of local maxima (calculated in space) of intensity (black dots) and doppler velocity (gray dots)
Max. intensity vs. max. Doppler velocity

\[ \Delta r = r(\text{max}(v_D)) - r(\text{max}(l)) \]
Breaking criteria
Summary and open questions

• characteristics of Doppler spectra can provide useful hints about the breaking process

• detection of wave breaking is possible from a kinematical as well as from a geometrical point of view

Questions:
• how do we define the onset of wave breaking?

• are there any chances for a validation of the detection methods?

• automation of detection methods?
Thanks for you attention!