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Drivers of modulation instability of oblique wave-current interaction: Insights from physical model tests

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MOTIVATION

Natural processes drive the nonlinear interactions between waves and currents, but robust reproduction of systems and states in natural environments is still rather limited and therefore physical model tests of wave-current conditions are required. Usually, assessments of processes and loads on coastal structures are derived from experiments either regarding flow only or waves only in independent physical models and allegedly exclude the interaction between waves and currents as a sort of regular feature. Assessments of loads on coastal structures stemming from oblique wave-current interaction remain a challenging and underresearched topic. For this reason, experiments in a 3D wave-current basin as a first step were performed to thoroughly investigate drivers and effects of oblique wave-current interaction. Experiments comprise long-crested regular and irregular wave trains on obliquely opposing and following currents for different wave periods, wave heights and flow rates. The second step will comprise experiments of oblique wave-current and structure interaction.

METHODOLOGY

To observe the physical processes of wave-current interaction, it is essential to proceed as fol-lows:

1. Detailed flow experiments without waves (current alone, CA) in order to characterize the undisturbed currents.

2. Detailed wave experiments without current (waves alone, WA) in order to characterize the undisturbed waves.

3. Wave-current (WC) experiments in order to determine the deviations from only-current and only-wave conditions in order to identify the wave-current interactions.

Following this approach, an accurate evaluation of the processes of wave-current interaction is carried out and includes side effects of the testing facility.

RESULTS

The Fourier Transformation (FT) analysis shows that sideband amplitudes arise in the frequency spectrum and get gradually more pronounced with increasing flow velocities. In order to determine the origin for the presences of these sidebands, special regard was put on the effects of time frame definitions for the FT analysis. The results show that problems with periodicity within FT can be excluded. Therefore, this effect of sidebands with increasing flow velocities evokes the impression of modulation instabilities.

Also, the oblique waves were strongly modified by the current and wave groups emerged. The wave group characteristics are more pronounced with increasing flow velocities and show similarities to results of studies on relationships between abnormal waves and wave group characteristics.

The results of modulation instabilities and wave group characteristics in relation to the wave-current interactions will be presented and discussed at the conference.