Classification of Breakers and Estimation of Energy Dissipation from Acoustic Signature

Dan Liberzon and Margarita Shtremel
The Technion – Israel Institute of Technology, Haifa, Israel.

Wave-breaking events are challenging to study due to their complexity and intermittency. Over the years, various measurement techniques have been developed to enhance our understanding of wave-breaking under diverse conditions. These methodologies include photographic and video imaging, as well as advanced techniques such as LiDAR and buoy measurements. However, most of these methods are effective only in detecting the most powerful whitecap-generating breakers and lack the ability to identify different types of breakers or provide a quantitative assessment of the energy dissipated during these events. Recent advancements have explored the use of hydrophone arrays to evaluate wave-breaking severity by correlating the size of entrained air bubbles with dissipated wave energy. While promising, these methods are still limited to specific breaker types, such as plungers. We aim to address this limitation by augmenting the existing detection methods for breakers (PTM based method) with the acoustic signature recorded by a single hydrophone.

This report details the latest advancements from our experiments on shoaling breakers conducted in the wind-wave flume at T-SAIL, Technion. We constructed a laboratory setup with a sloping bottom to simulate various types of wave-breaking, including spilling and plunging breakers. Simultaneous measurements of free surface elevation and acoustic signals were performed. identifying the exact moment of wave-breaking inception using the PTM-based detection method, allowed estimation of the energy dissipated during the event and correlation with the corresponding acoustic signal properties, effectively classifying the breakers.

The analysis identified distinct signatures of different breaker types in the acoustic records, detected through the wavelet transform technique. We will demonstrate how the acoustic signature spectrograms differ between breaker types, not only in terms of acoustic energy magnitude but also in spectral composition. These differences already allow for accurate classification of breakers as spillers or plungers. Furthermore, we are in the process of implementing pattern recognition techniques, both traditional and machine learning (ML), to scale up classification capabilities for open sea measurements and to estimate energy dissipation rates.