Imperial College London

Natural Environment Research Council

2024_14_Civil_AC: Using advances in image processing to understand and model the occurrence of oceanic breaking waves

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When the wind blows over the ocean surface the transfer of momentum and energy from the atmosphere to the ocean drives the generation of ocean waves. In steady state, breaking waves dissipate the same amount of energy as the wind inputs to the wave field. When these waves break, they generate thousands of bubbles beneath the water surface that play fundamental roles in weather and climate regulation in ways that are not fully understood.

Observing and measuring breaking waves in the ocean is extremely challenging: breaking waves occur randomly in large sea states and generate the most extreme surface flows in the ocean. This makes the placement of instruments to measure their kinematics and dynamics on a routine basis almost impossible. Consequently, optical remote sensing techniques that can image the sea surface and quantify wave breaking using digital image processing techniques are vital to further our understanding of breaking waves in the ocean and climate systems.

In this project you will use, refine and improve an existing, state-of-the-art, image processing code to improve our understanding on the frequency of occurrence, scale and severity of individual breaking waves. The Automated Whitecap Detection and Tracking (AWDAT) code has been developed in a prior PhD project with collaborators Dr. Alvise Benetazzo and Dr. Filippo Bergamsaco and is able to identify and track individual whitecaps in a series of sea surface images. You will apply AWDAT to sea surface images from a stereovision system installed on the Acqua Alta Oceanographic Tower in the Adriatic Sea. You will use machine learning algorithms to improve the accuracy, precision and recall of AWDAT and extend its functionality by explicitly incorporating stereovision measurements of sea surface elevation from the state-of-the-art Waves Acquisition Stereo System (WASS) software.

The data you generate will (i) be combined with extensive laboratory measurements to understand the fluid dynamics and onset of wave breaking (ii) be used to characterise the strength of oceanic wave breaking (iii) help evaluate parameterisations of energy dissipation in 3rd generation spectral wave models. Your research will enable you to develop a complete picture of the geometric, kinematic and dynamic properties of oceanic breaking waves in unprecedented detail.

If you have a strong curiosity about ocean waves and fluid mechanics, which is supported by a first class honours degree in Physics, Mathematics, Oceanography, Computer Vision or another numerate background then send an email to Dr. Callaghan (mailto:acallaghan@imperial.ac.uk) for further information on the project.

The successful candidate can expect to gain extensive experience in digital image acquisition and processing, wave physics and data analysis.