Imperial College London

Natural Environment Research Council

2024_16_Civil_AC: Underwater stereovision imaging of bubble plumes beneath short-crested breaking waves

Supervisors: Dr Adrian Callaghan (mailto:a.callaghan@imperial.ac.uk); Dr. Filippo Bergamasco (Ca' Foscari University of Venice, Italy); Dr. Alvise Benetazzo (Italian Institute of Marine Sciences, Venice, Italy)

Department: Department of Civil and Environmental Engineering

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 ocean 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. The number, sizes, rate of production and time-evolving spatial distribution of bubbles beneath breaking waves is very poorly known and not well constrained. This is primarily due to the difficulty in making appropriate at-sea measurements in conditions with vigorous wave breaking. This lack of knowledge places limits on the evaluation of models of bubble-mediated gas exchange and aerosol production fluxes which directly influence weather and climate and how they are mathematically modelled. One way to fill these knowledge gaps is to perform controlled experiments of wave breaking in state-of-the-art wave basins.

To address these knowledge gaps, in this project you will collaborate with experts in wave mechanics and stereo imaging to map out the space and time-evolving bubble population beneath carefully-controlled laboratory breaking waves. You will build a set of underwater cameras, construct an underwater stereovision imaging solution and generate short-crested breaking waves with the state-of-the-art 20 m by 10 m directional wave basin in the Hydrodynamics Laboratory in the Civil and Environmental Engineering Department in Imperial College London. You will use the image-derived data to (i) understand the evolution of bubbles in a turbulent fluid flow, (ii) to identify bubble fragmentation events due to bubble-turbulence interaction and (iii) to determine the relationship between sub-surface bubbles and evolving surface foam. Furthermore, you will perform small-scale experiments with a high-speed camera to constrain the fluid dynamics behind foam evolution through rupture and coalescence. To translate your laboratory results to ocean conditions, you will have access to a database of measurements of more than 180,000 breaking waves from a prior project. The project will be co-supervised by Dr. Filippo Bergamasco at the Ca' Foscari University of Venice, Italy, and Dr. Alvise Benetazzo at the Italian Institute of Marine Sciences, Venice, Italy.

If you have a strong curiosity about ocean waves, fluid mechanics and state-of-the-art image processing which is supported by a first class honours degree in Physics, Mathematics, Oceanography, Computer Vision or another numerate background, then please send an email to Dr. Callaghan (a.callaghan@imperial.ac.uk) for further information on the project. The successful candidate can expect to gain extensive experience in digital image acquisition and processing, laboratory methods, wave and bubble physics and data analysis.