The Structure of Airflow over Waves

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New sustainable solutions must be found to capture natural renewable energy resources. In order to make full use of these resources, we require a deep understanding of the physical dynamics of ocean waves, wind and the interaction between the two. The present study gives an important contribution to the wind-wave interaction problem by focusing on the intermediate flow regime.

A detailed laboratory investigation into the airflow over water waves was carried out and the results show how important the recirculation cell and the location of the critical height line are in determining the dynamics of the airflow. Serious questions concerning the relevance of the mean horizontal velocity profile have also been raised. Three distinct regions in the airflow have been identified: the recirculation cell centred around the critical height line, the streamwise flow above and a reverse flow below the recirculation cell. The results also show that the airflow at height above the water surface maybe very different from that which would be predicted if one simply considered the wave profile.

A comprehensive set of data from a new LES code and standard $k-\varepsilon$ RANS turbulence model were also obtained. The three distinct regions of flow observed in the laboratory are successfully reproduced in the numerical solutions. The surface pressure and shear stress profiles for the LES suggest that in the intermediate flow regime, wave growth is promoted and that in order to achieve any unifying theory of wave growth, the recirculation cell must be accounted for. Indeed, the present results suggest that the recirculation cell is a critical feature of the flow field in the intermediate regime.