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Non-hydrostatic unstructured grid modeling of trapped internal waves and lee waves

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Internal lee waves and trapped internal waves have all been observed in a wide range of estuaries, inlets and coastal seas. In general these coastal systems have complex bathymetry and coastlines that need to be resolved. Therefore we adopt an unstructured grid approach and use the Finite Element model, Finlab. It is a conservative, fully non-hydrostatic FE model. It uses a new element developed by R.J. Labeur and has minimal numerical dissipation. We consider internal lee waves and trapped internal waves generated by stratified flow over small scale bed features. First we present internal wave simulations that validate the model, highlighting the advantages of the new element. Then we present a unique comparison of internal lee wave data from a flume, in which a fully developed turbulent flow was established, and numerical simulations. We also present simulations of resonant trapped internal waves and hydraulic jumps. We demonstrate that flow separation has an important influence on both the development of the internal lee wave train downstream of a topographic feature and on the conditions under which resonant and critical internal flow is achieved. Internal lee waves and trapped internal waves generated by stratified flow over small scale bed features make a significant contribution to turbulence production in a stratified body of fluid during a tidal cycle. We show that the conditions for a resonant response are frequently met on the slack tide and can lead to the generation of large amplitude internal waves in coastal environments.