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Nonlinear waves on depth-varying currents: the role of vorticity

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When waves interact with a depth-varying current, it is well-known that the current velocity at the water surface, the surface vorticity and the depth-variation in the vorticity have a significant effect on the wavelength, the water particle kinematics and the wave shape. In such cases the current profile determines the vorticity distribution. If this varies with depth, the wave motion will also become rotational and, as a result, the classical wave theories become invalid. The present study has considered such cases, investigating the effect of both favourable and adverse depth-varying currents on regular waves. The results are based upon an analytic stream function solution and a numerical multilayer model; the latter approximating the current profile by a sequence of linearly-sheared layers, each layer having a constant vorticity. Both linear and nonlinear waves were considered and the current profiles taken from offshore engineering design. The preliminary results emphasise the importance of both the surface velocity and the surface vorticity. They also indicate that an accurate incorporation of the surface vorticity may be sufficient in offshore engineering applications, provided the waves are not too steep. Future work involves the investigation of combined irregular waves and currents.