Sand Waves and Bedform-rectified Turbulence

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The linear instability of tidal sand waves has been studied using multiple models, analytical and numerical. Numerical and analytical models have highlighted that the correct representation of the response of turbulence (or eddy viscosity, ν_T) to the perturbed bed plays a crucial role in determining the linear growth rate curve of the perturbations. In the present work, we will show that the definition of the near-bed velocity used in some analytical eddy viscosity formulations (e.g. Komarova and Hulscher, 2000) underpins the accurateness of the resulted model. Furthermore, we have investigated the influence of different turbulence closure schemes on the eddy viscosity distribution over a small sinusoidal bedform using the ROMS model. The resulted eddy viscosity shows limited sensitivity to the choice of the closure scheme or the stability function. Comparing previous analytical results with ROMS model outputs reveals that the former fails to accurately represent the phase lag between the first-order response of eddy viscosity to depth variation and the sinusoidal bedform. The numerical experiments further suggest that a candidate analytical fit to the eddy viscosity could involve nonlinear response to water depth, which will also have impacts on the linearized version of eddy viscosity, consequently playing a role in the linear stability analysis of tidal sand waves. The proposed parameterisation takes the form $\nu_T = c * |u_b| * H_0 * (1 + h/H_0)^{\Gamma}$, where Γ is a parameter larger than 1, c is a constant, h is the depth undulation, H_0 is the mean depth and u_b is the near-bed velocity. Based on the eddy viscosity distribution predicted by some relevant physical model experiments, the observed nonlinear depth-dependence might be attributed to the relative enhancement of turbulence on the leeside of the bedform, which could be more pronounced than the relative damping on crests.

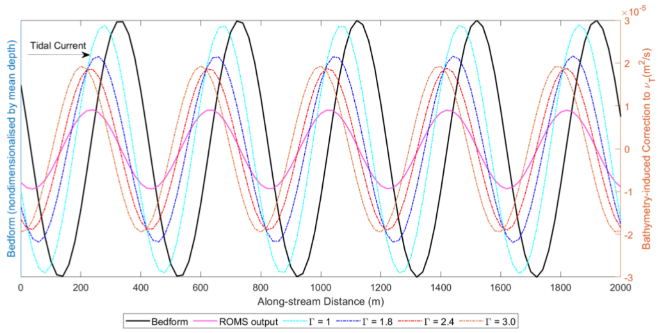

Figure 1: The figure shows the along-stream variation in the bathymetry-induced variation in ν_T according to different models (see legend for details). The undulation has a wavelength of 400 m. The analytical form whose phase agrees best with the ROMS model has $\Gamma = 2.4$.

References

N.L. Komarova and S.J.H. Hulscher *Linear instability mechanisms for sand wave formation.* Journal of Fluid Mechanics (2000), vol. 413.