EFFECT OF AMBIENT SHEAR IN HYPOPYCNAL PARTICLE-LADEN FLOWS

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Buoyant hypopycnal particle-laden flows are the major mechanism of particle transport in numerous natural systems such as river plumes, coastal currents, sea floor black smokers, volcanic clouds and magma chambers. Hypopycnal flow is a classification of gravity currents in which the fluid current is lighter than the ambient fluid, resulting in a gravity current flowing on top the ambient fluid. In the present study, we give attention to sediment/salt systems to better understand the *settling-driven* mechanism, proposed by [1], under the influence of ambient shear using the Boussinesq approximation.

This configuration was initially studied with linear stability theory (LST) with hyperbolic tangent profiles as base flow, using a modal temporal approach [2]. Results indicate that the presence of settling particles (modeled here as a constant value settling velocity u_s) propitiates the growth of a three-dimensional unstable mode based on the settling-driven mechanism. This mode has a growth rate strongly dependent with the spanwise wavenumber β, the Richardson number Ri, and the particles settling velocity u_s. Other parameters, with weaker influence, were also considered in the analysis: the Reynolds number Re, and the streamwise wavenumber α. For some combinations of these parameters, the new 3D mode grows faster than the well known Kelvin-Helmholtz mode.

Direct numerical simulations (DNS) were performed, with the **Incompact3D** [3] solver, to verify the growth rate values obtained in the linear study and to further explore the dynamics of this new three-dimensional mode. This objective is accomplished with parameters recovered from the LST study. In this abstract we present a DNS using $u_s = 4 \times 10^{-2}$, $Re = 10^3$, $Ri = 0.14$, $\alpha = 0.44$, and $\beta = 5$, with spatial domain considering one wavelength in the streamwise direction (x_1), two wavelengths in the spanwise direction (x_3), and a sufficiently large normal direction to minimize boundary perturbations. The perturbation growth rate expected from the LST, for the given parameters, is 9.275×10^{-2}.

Figure 1 shows results for this simulation. Figure 1a presents the perturbation kinetic energy gain, $G(t)$, over time where two linear growth regions are identified. The LST growth rate is verified in the first region, with a relative error of 2.27%, while the second section shows a faster growth that can be related to the displacement of the sediment concentration base state with time. Figure 1b and Fig. 1c shows the sediment concentration perturbation field, φ'_1, at the sediment/salt interface for $t = 23$ and $t = 40$ respectively. This two characteristic times are marked in Fig. 1a with: the bullet for $t = 23$, and the square for $t = 40$. It is noted that the perturbation fields in Fig. 1b and Fig. 1c presents the 3D structure expected from the LST, respecting the numbers of streamwise and spanwise wavelengths.

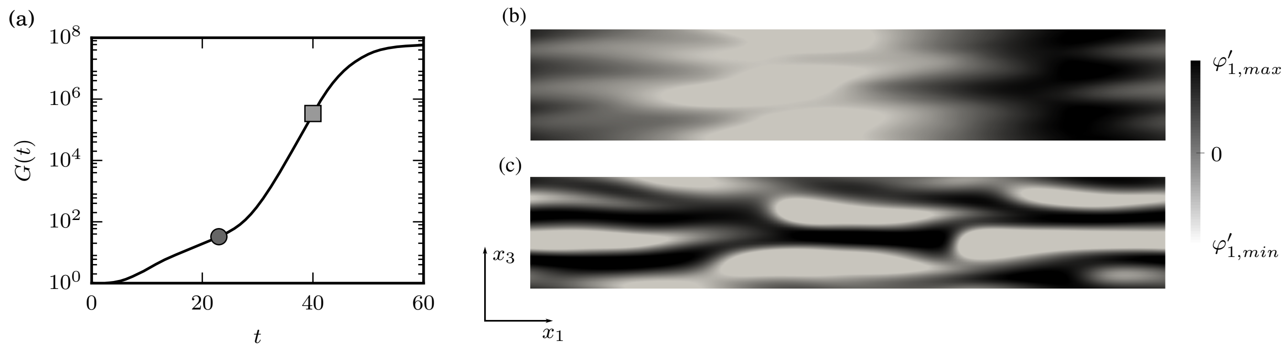

Figure 1. Preliminary DNS results: The perturbation's kinetic energy gain $G(t)$ over the time (a) and the perturbation field of sediment concentration (φ'_1) in the sediment/salt interface for $t = 23$ (b) and $t = 40$ (c).

The linear stability analysis will be extended, with aid of the DNS tool, to consider the sediment concentration base profile displacement with time to comprehend better the second interval, and to answer the question: "Is this the same unstable mode with greater growth rate, or is this another mode?".

References

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