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DESCRIPTION:

Gravity currents are present in many industrial processes (sewage disposal, mineral filtration, food and pharmaceutical processes) and natural flows (sediment transport in rivers, avalanches). These stratified flows frequently carry a suspended solid phase that controls the average properties of the flow, such as apparent viscosity, leading to a rich dynamic whose optimization/prediction remains crucial environmental and industrial issues, especially in turbulent regimes [1].

Figure 1: LES simulations of density current over a rough bottom, from Bhaganagar et Pillalamarri [6].
The objective of this thesis is to improve the understanding of the particle-flow coupling in gravity currents by using innovative deep learning techniques [2]. This new paradigm offered to fluid mechanics [3] will be at the center of the two axes developed in this thesis:

(i) The improvement of the metrology of stratified flows based on deep learning in order to infer the hydrodynamic field from the observation of the salinity field alone (by light attenuation technique). The main idea is the use of a physics-informed deep neural network model [4] whose training phase can be carried out on a reduced amount of data. Here, the data will be derived from an experimental thesis work that will start in parallel to the LEMTA and will be complemented by numerical simulations from existing codes. The metrological tool will be tested on the well-documented test case of "lock-exchange" in 2D single-phase laminar regime and extended to configurations of increasing complexity (presence of solid phase, complex geometries, 3D, ...).

(ii) The development of a neural model of turbulence RANS (Reynolds-Averaged Navier-Stokes) for gravity currents. In the case of homogeneous turbulence, deep learning has allowed to outperform traditional RANS models [5] but are not applied in the case of particle-laden gravity currents, which is the objective of this axis. This work is part of a collaboration with Kiran Baghanagar of the University of Texas at San Antonio who provides an initial database from high-fidelity simulations [6] and we will consider, to enrich this database and thus improve the expressivity of the neuronal model, the use of generative adversial networks (GANs). This axis will notably contribute to refine the modeling of turbulent mixing processes and consequently the prediction of the latter.

**Candidate profile:**

- Master degree or engineering diploma in mechanics or applied mathematics.
- Proficiency in continuum mechanics.
- Proficiency in computer science (Python/Tensorflow).

**References:**
