Interplay between turbulence and particles in environmental flows with primary focus on turbidity currents

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The intensity and sustained propagation of a turbidity current depends on an interesting interplay between suspended particles and turbulence. The suspended particles drive the flow and are the source of turbulence in a turbidity current, while the flow turbulence enables resuspension of particles from the bed. If resuspension dominates over deposition the intensity of the current can increase, thereby further increasing resuspension and resulting in a runaway current. On the other hand, stable stratification due to suspended sediment concentration can damp and even kill turbulence. Then deposition dominates over resuspension and the current could laminarize resulting in massive deposits.

The three control parameters are the flow Reynolds number, the Richardson number and the non-dimensional suspension settling velocity. In this talk we present results from direct numerical simulations of various configurations of continuous turbidity currents. The model is applied to study turbulence modulation due to changes in Richardson number and settling velocity, and its effects on the transport capacity of suspended sediment. The results indicate the existence of conditions for the damping of the near-bed turbulence. Under these conditions, sediment in suspension rains out passively on the bed, even though the upper layer may remain turbulent. The above scenario provides a reasonable (but not unique) explanation for the formation of massive turbidities in scenarios of slope change of the bed or loss of lateral flow confinement.

The key mechanism that dictates the rate of resuspension of particles is the effective hydrodynamic force that rolls/lifts the particle from the bed into the bulk. Much of the existing resuspension models are empirically driven. An essential building block to our understanding and physics-based modeling of resuspension is to consider the problem of forces on a particle in a turbulent boundary layer on a rough bed. Time permitting, our recent work in this direction will also be presented.