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Numerical Simulation of a Compressible Turbulent Boundary Layer with Suspended Particles applied to Pyroclastic Density Currents

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Pyroclastic density currents and other geophysical problems like cloud dynamics and avalanches involve the dispersion of small particles in turbulent flows. Such flows are characterized by complex interactions between the turbulent structures and the solid phase, leading to a non-uniform particle distribution. In the presence of a rigid boundary, like the ground on a mountain slope, the turbulent structures are substantially altered by the presence of a new length scale - the distance to the ground - and are very different from structures appearing for example in an isotropic turbulence. In this paper, we present a numerical study of dispersed solid particles in a hot, compressible, turbulent boundary layer as a model for pyroclastic density currents (PDCs) on a mountain slope in oder to investigate the mechanisms of particle-turbulence interactions, the preferential particle concentration and agglomeration. For this purpose, the flow is described by the compressible Navier Stokes equations and the particle motion is governed by Newton's law. In this approach, the particles are treated in a lagrangian way by tracking the position and motion of each individual particle. A two-way coupling mechanism describes the interaction between the two phases. In this type of coupling, the particle distribution and trajectories are affected by the action of forces imposed by the fluid and also the particles effects on the fluid motion are taking into account at each time step. The coherent structures that are present in turbulent boundary layers play an important role on the particle motion: they drag particles in streaks toward and away from the wall in a so called ejection, as well enable the appearance of concentrated and diluted regions. The reason for such behavior is still not completely understood. In order to contribute to the understanding of this phenomenon, we propose to study this problem based on Direct Numerical Simulation and statistical investigation of the results of particle densities.