Code_Saturne®

Stochastic Lagrangian Modeling of Particle Deposition and Resuspension with *Code_Saturne*

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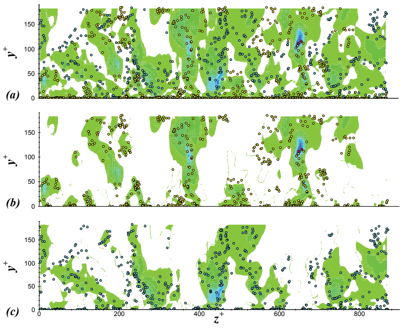
We present new stochastic models to simulate particle deposition and particle resuspension in turbulent flows, using the Lagrangian module of Code_Saturne. The deposition model takes into account the interaction between particles and coherent structures within boundary layers, while the resuspension model is mainly based on the interaction between particles and surface roughness. These models have been tested in simple cases, and the results show good agreement with available experimental data.

Deposition [1]

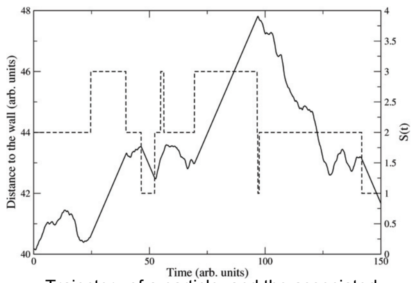
A 1D, boundary-layer model of the velocity of the flow seen by a particle is proposed. It explicitly simulates the interactions of particles with the near-wall coherent phenomena governing the wall-normal transport of particles (the so-called sweep and ejection events). For this purpose, a Markovian jump process named S(t), driving other stochastic processes, is introduced to model the coherent events.

Modeled mechanism



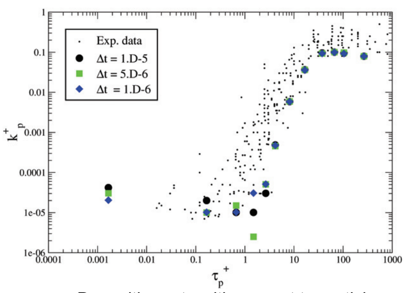
Particle interaction with boundary-layer coherent structures

One aspect of the proposed modeling



Trajectory of a particle, and the associated realization of S(t)

Result obtained



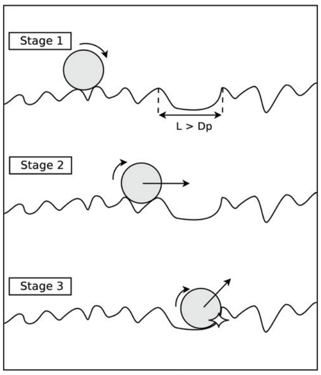
Deposition rate with respect to particle inertia for different time steps

The model is first validated by comparing results obtained in the fluid-particle limit to available statistics of the boundary layer. Then, the deposition velocity is computed, and good agreement with experimental data is obtained. Furthermore, the two deposition regimes ("free-flight" and "diffusional") recently identified by DNS simulations are qualitatively retrieved.

Resuspension [2]

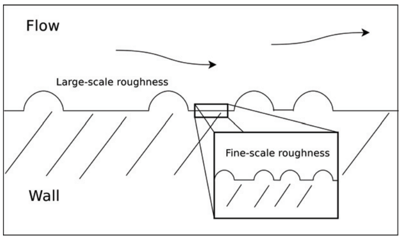
Since the probability of direct pull-off is very small due to the low-level of fluid wall-normal velocity fluctuations in the immediate vicinity of the wall, this model is based on a different description: a particle, initially motionless on the wall, can start to roll or to slide if the hydrodynamic forces (or their moment) are high enough.

Modeled mechanism



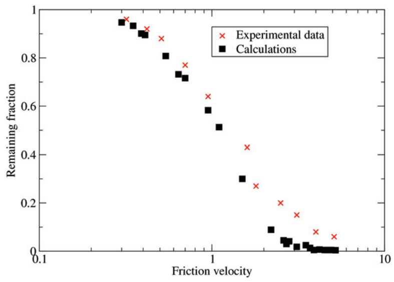
Particle interaction with surface roughness

One aspect of the proposed modeling



A double-scale, Poisson distributed wall roughness

Result obtained



Calculated resuspended fraction with respect to the friction velocity

The model focuses on the role played by surface roughness in the reentrainment process: during its motion along the wall, a particle may hit surface asperities, given that the surface is never perfectly smooth. In this case, it can be reentrained into the flow (and thus leave the wall) if its kinetic energy is greater than the van der Waals potential energy responsible for particle adhesion. In order to estimate this adhesion force and the probability of particle-asperity interaction, the surface is modeled by a random succession of hemispherical asperities. The model has been numerically implemented, and computational results show good agreement with available experimental data.

References

[1] M. Guingo, J.-P. Minier: *A stochastic model of coherent structures for particule deposition in turbulent flows*, Phys. Fluids 20, 2008 (053303)

[2] M. Guingo, J.-P. Minier: *A new model for the simulation of particle resuspension by turbulent flows based on a stochastic description of wall roughness and adhesion forces,* J. Aerosol Sci. 39, 2008, pp.957-973