Particle resuspension by a periodically-forced impinging jet

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When hovering over sandy terrains, the rotor of helicopters generates a downward jet that interacts with the soil and induces resuspension of dust and debris. This phenomenon, called rotary-wing brownout, can be extremely dangerous because it drastically reduces the pilot's visibility during landing or takeoff. To mitigate the impact of brownout, a detailed knowledge of the turbulent flow field generated by the recirculating rotor downwash must be accompanied by a detailed understanding of the particle resuspension mechanisms. In this work, we investigate these mechanisms using an Eulerian-Lagrangian approach based on large-eddy simulation of the turbulent flow and Lagrangian tracking of the particles. The wake generated by the helicopter is modelled as a vertical impinging jet, to which a sequence of periodically-forced azimuthal vortices is superposed. The resulting flow field provides a unique range of flow scales with which the particles, initially placed on a thin layer just above the ground, can interact. Downstream of the impingement region, layers of negative azimuthal vorticity (secondary vortices) form on the upwash side of the primary azimuthal (large-scale) vortices: These layers then detach from the surface together with the near-wall (small-scale) vortices populating the wall-jet region. We show how the dynamics of sediments is governed by their interaction with these structures and we determine whether or not particle resuspension occurs depending on sediment size and inertia. After initial lift-up from the impingement surface, particles are accumulated in regions where near-wall vortices roll around the impinging azimuthal vortex, forming rib-like structures that either propel particles away from the azimuthal vortex or entrap them in the shear layer between the azimuthal and secondary vortices. These trapped particles are more likely to reach the outer flow region and generate a persistent cloud of airborne particles.

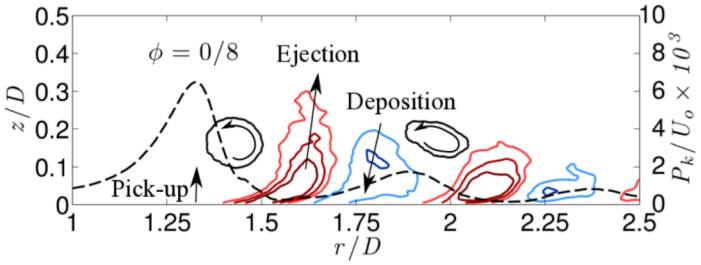

Figure 1: Particle pick-up rate, P_k (dashed line), and vertical flux (colored iso-contours) in the wall-jet region at jet phase $\Phi = 0/8$. Red contours correspond to particle ejections away from the bottom surface, blu contours correspond to particle motions towards the surface. Primary vortices are indicated by the solid black lines with arrows. From Wu et al. (2017).

References

W. Wu, G. Soligo, C. Marchioli, A. Soldati and U. Piomelli. *Particle resuspension by a periodically forced impinging jet.* J. Fluid Mech. (2017), vol. 820, pp. 284-311.