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Numerical study and modelling of turbulence modulation in a particle laden slab flow

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Abstract. This paper describes a numerical and theoretical study of the mean and turbulent interphase kinetic energy transfer in gas–particle flows using direct numerical simulation for the continuous phase, that directly resolves all the turbulent scales of the fluid flow, coupled with a Lagrangian prediction of trajectories of discrete particles.

The configuration corresponds to a slab of particles injected at high velocity into an isotropic decaying turbulence. The particles are small compared to the turbulent length scale and the volume fraction of the dispersed phase is low. The limitations of the computational technique are first considered and its accuracy is evaluated by analysis of the kinetic energy and dissipation rate budgets. The momentum transfer between particles and gas causes a strong acceleration of the fluid by the particles in the slab region and enhances the turbulence at the periphery due to the production by the mean gas velocity gradients. The analysis of the interphase transfer terms in the gas turbulent kinetic energy equation shows that the direct effect of the particles is to damp the turbulence in the core of the slab but to enhance it in the periphery. This last effect is due to a strong correlation between particle distribution and instantaneous gas velocity. Simulations reveal that the transfer of kinetic energy from gas turbulence towards the particle agitation is not an efficient process: most of the energy is transformed in wakes and dissipated. Another issue concerns the model and the validity of its closure assumptions in two-phase flows. It is shown that the gradient hypothesis for turbulent diffusion terms is not affected by turbulence modulation while the Boussinesq approximation overestimates the Reynolds stress tensor depending on loading and Stokes number. The modelling of the gas turbulent dissipation rate is also questioned.