Summary of the LES-DPS simulations

This document summarizes the modeling and the simulation setup of the gas/particle channel flow configurations handled in the frame of this workshop. The structures of the data files are described at the section 3.

1 Large Eddy Simulation of the carrier fluid flow

The simple eddy viscosity model employed to account for the effects of the small scales on the resolved ones reads (Piomelli et al., 1988, Phys. Fluids):

$$\nu_t = l^2|\overline{S}|, \quad l = C\left[1-\exp\left(-\frac{y^{+3}}{A^{+3}}\right)\right]^{1/2}(\Delta x\Delta y\Delta z)^{1/3}, \quad A^+ = 25 \tag{1}$$

The Smagorinsky-type constant C is set to 0.1 and $|\overline{S}|$ is the magnitude of the large-scale strain-rate tensor.
A staggered mesh comprised of 65^3 grid points is used. Grid points in the wall-normal direction are distributed with non-uniform spacings according to a tangent hyperbolic function such that $\Delta y^+_{\min} \simeq 0.18$ and $\Delta y^+_{\max} \simeq 4.9$. The grids are uniform in the streamwise and spanwise and the spacings are $\Delta x^+ \simeq 29.45$ and $\Delta z^+ = \Delta x^+/2$, respectively.

2 Lagrangian tracking of discrete particles

The interpolated fluid velocity $u_{f@p,i}$ at the position of the particle in the particle motion equation (in which only drag acts on the particles) should be given by:

$$u_{f@p,i} = \overline{u}_{f@p,i} + \delta u_{f@p,i} \tag{2}$$

$\overline{u}_{f@p,i}$ stands for the *ith* component of the interpolated resolved velocity at the particle position. $\delta u_{f@p,i}$ is the subgrid turbulent velocity contribution. However, in the present work only the resolved velocity is interpolated at the particle position without any additional contribution to account for the subgrid turbulence contribution, i.e:

$$u_{f@p,i} = \overline{u}_{f@p,i} \quad , \quad \delta u_{f@p,i} = 0 \tag{3}$$

Fourth-order Lagrangian polynomial interpolation scheme is used to calculate the locally undisturbed fluid velocity at the particle position $u_{f@p,i}$.

3 Format of the data

The numerical results are provided according to the format specified in the tables **1**, **2** and **3** for the fluid, the particle phases and the fluid-particle correlations, respectively. Two kind of LES of the gas flow are performed:

Fluid phase					
1	2	3	4	5	6
y_f^+	$\frac{U_f}{u_\tau}$	$\frac{\left\langle u_f'^2 \right\rangle_f^{1/2}}{u_\tau}$	$\frac{\left\langle v_f'^2 \right\rangle_f^{1/2}}{u_\tau}$	$\frac{\left\langle w_f'^2 \right\rangle_f^{1/2}}{u_\tau}$	$\frac{\left\langle u_f' v_f' \right\rangle_f}{u_\tau^2}$

Table 1: Structure of the result files for the LES of the carrier phase.

1. With the model (1): results are contained within the file "*Fluid_LESWM.dat*",
2. Without model: results are saved in the file "*Fluid_LESNoM.dat*".

For particles, three Stokes $St = 1$, $St = 5$ and $St = 25$ are simulated and the results are contained in the files:

- for carrier flow simulated using eddy viscosity model (1): "*Particle_Stokes_LESWM_St1.dat*", "*Particle_Stokes_LESWM_St5.dat*" and "*Particle_Stokes_LESWM_St25.dat*";
- for carrier flow simulated without eddy viscosity model: "*Particle_Stokes_LESNoM_St1.dat*", "*Particle_Stokes_LESNoM_St5.dat*" and "*Particle_Stokes_LESNoM_St25.dat*".

For fluid-particle correlations, the results are provided within the following files:

- "*Fluid-Particle_Stokes_LESWM_St1.dat*", "*Fluid-Particle_Stokes_LESWM_St5.dat*" and "*Fluid-Particle_Stokes_LESWM_25.dat*" (for cases with LES+model);
- "*Fluid-Particle_Stokes_LESNoM_St1.dat*", "*Fluid-Particle_Stokes_LESNoM_St5.dat*" and "*Fluid-Particle_Stokes_LESNoM_St25.dat*" (for cases with LES+No Model).

Another group of files: "*cp_projection_LESWM_St1.dat*", "*cp_projection_LESWM_St5.dat*", "*cp_projection_LESWM_St25.dat*", "*cp_projection_LESNoM_St1.dat*", "*cp_projection_LESNoM_St5.dat*" and "*cp_projection_LESNoM_St25.dat*" contain the particle concentration according to the tangent hyperbolic bin distribution recommended within the benchmark proposal. Within these result files, the first column stands for the wall-normal coordinate (in wall unit) and the second column is the particle concentration obtained from the projection of the primary results onto the benchmark grid.

Particle phase								
1	2	3	4	5	6	7	8	9
y_p^+	$\frac{U_p}{u_\tau}$	$\frac{\left\langle u_p'^2 \right\rangle_p^{1/2}}{u_\tau}$	$\frac{\left\langle v_p'^2 \right\rangle_p^{1/2}}{u_\tau}$	$\frac{\left\langle w_p'^2 \right\rangle_p^{1/2}}{u_\tau}$	$\frac{\left\langle u_p' v_p' \right\rangle_p}{u_\tau^2}$	α_p	$\frac{c_p}{c_{p_0}}$	n_p

Table 2: Structure of the result files for the particle phases.

Fluid-particle correlations						
1	2	3	4	5	6	7
y_p^+	$V_{d,y} = \frac{\left\langle v_{f@p} - v_p \right\rangle_p}{u_\tau}$	$\frac{U_p}{u_\tau}$	$\frac{\left\langle u_{f@p}'^2 \right\rangle_p^{1/2}}{u_\tau}$	$\frac{\left\langle v_{f@p}'^2 \right\rangle_p^{1/2}}{u_\tau}$	$\frac{\left\langle w_{f@p}'^2 \right\rangle_p^{1/2}}{u_\tau}$	$\frac{\left\langle u_{f@p}' v_{f@p}' \right\rangle_p}{u_\tau^2}$

Table 3: Structure of the result files for the fluid-particle correlations.