# Treatment of the near ground effect in Lagrangian stochastic methods applied to a 2-D point source dispersion after an isolated obstacle in a neutral flow.

## Context

In PDF methods, the probability density function (PDF) on a given state vector is estimated by following in their displacement a large number of particles, each one being associated instantaneous quantities of interest. Such methods are more and more used in atmospheric flows especially in the scope of the dispersion of pollutants. These flows are in general greatly impacted by the presence of the ground but the influence of the latter one are often mistreated. The goal of the present poster is to highlight the effect of the wall on the dynamic of the particles and the necessity to properly treat it. The mean fields necessary to resolve the stochastic differential equation (SDE) driving the dynamic of the particles are estimated in advance by a moment approach (Hybrid methods). The particles are modeled using the simplified Langevin model (SLM), where the blue terms are mean terms issued from finite volume (FV) methods which have to be interpolated at the position of the particles.

$$\mathrm{d}X_i = U_i\mathrm{d}t \qquad \mathrm{d}U_i = \underbrace{\left(-\frac{1}{\rho}\frac{\partial \overline{P}}{\partial x_i} - \frac{U_i - \overline{U_i}}{\mathcal{C}_l\frac{k}{\epsilon}}\right)dt}_{\text{Deterministic Part}} + \underbrace{\sqrt{\mathcal{C}_0\epsilon}\,\mathrm{d}W_j}_{\text{Stochastic Part}}$$

## 1-D surface boundary layer

### Boundary condition for rough and smooth walls [1, 2]

- Keep the particles in the domain
- Be applied directly on the instantaneous quantities
- Represent the physics in the logarithmic zone → Elastic rebound

$$U_i^{in} = U_i^{out} - 2\frac{\overline{u_i w}}{\overline{w^2}}W^{out}$$

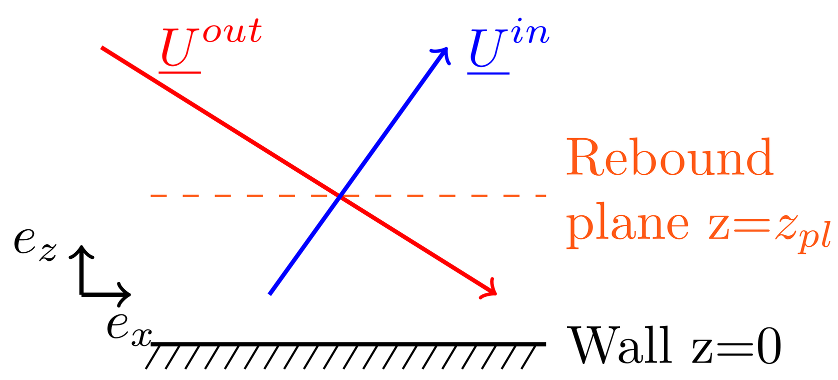
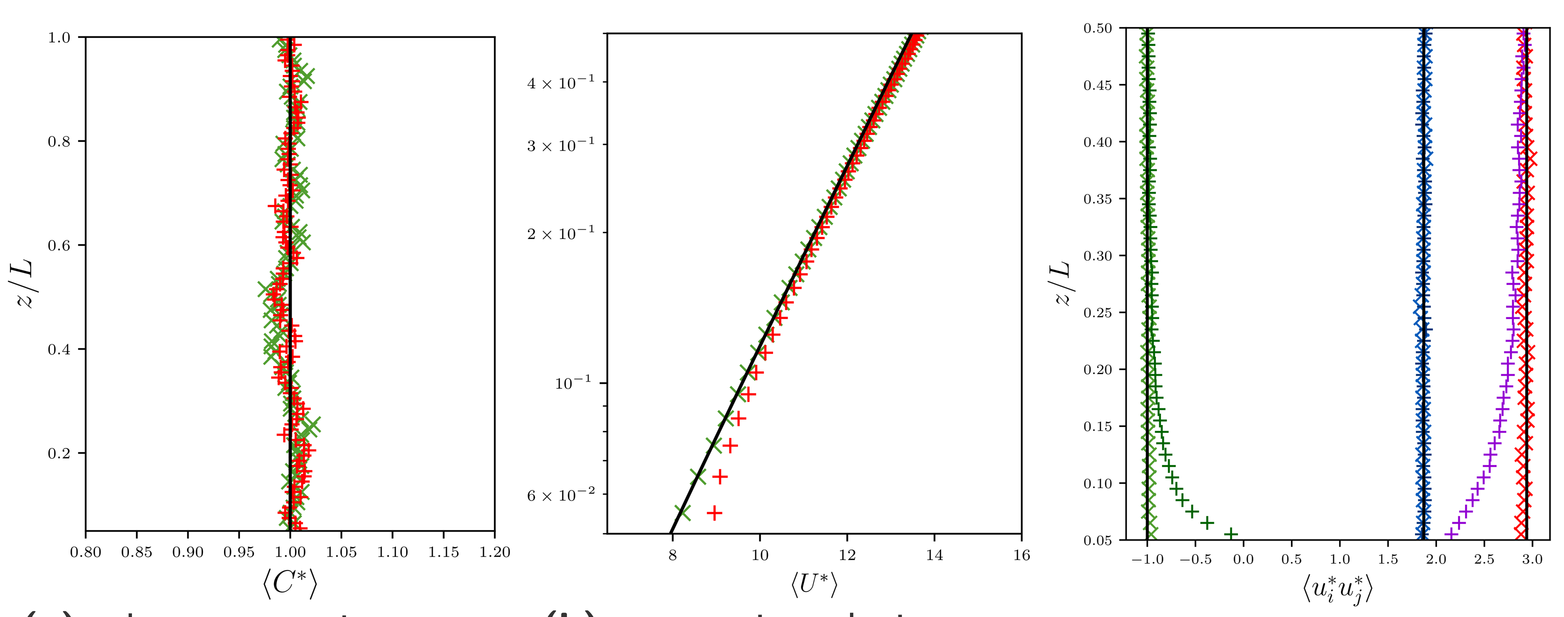



**Figure 1 :** Equation and scheme of the Lagrangian wall boundary condition

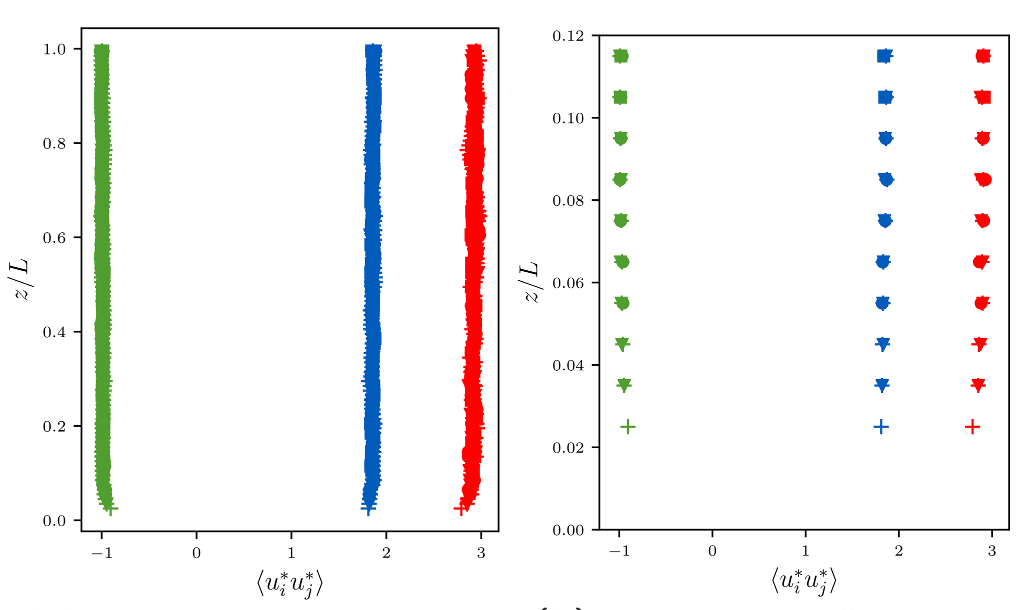
### Necessity to use the proper non elastic rebound plane:




**(a)** rel. concentration **(b)** streamwise velocity **(c)** resp. $\langle uw\rangle, \langle ww\rangle, \langle uu\rangle$

**Figure 2 :** Effect of the standard wall boundary condition (×) compared to the elastic boundary condition(+) and the analytical solution ( black line) with a rough wall

### Independence on the rebound height within the log. zone:

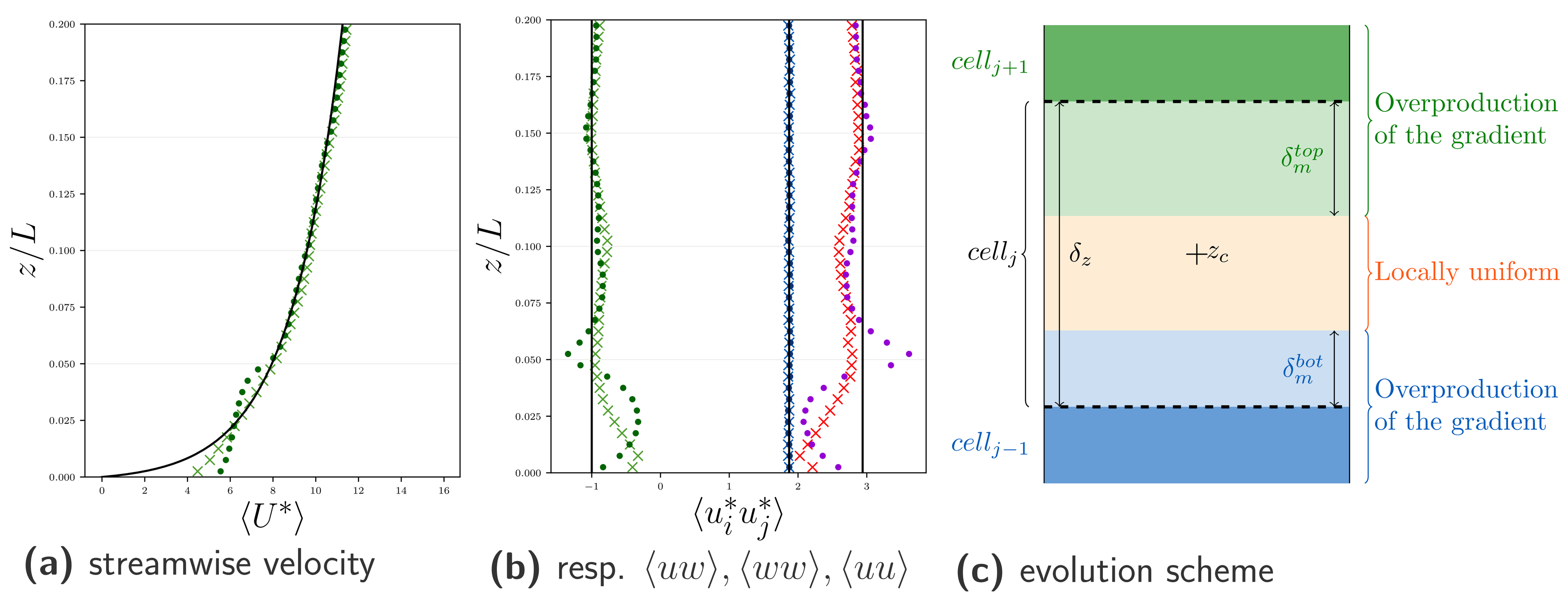



**(a)** whole domain **(b)** zoom near wall

**Figure 3 :** Independence on the rebound plane height within the logarithmic zone shown on the second order moments. Different physical heights are used yielding resp. to: $z_{pl}^+ = 335$ (■) , $z_{pl}^+ = 167$ (×), $z_{pl}^+ = 100$ (▼) and $z_{pl}^+ = 67$ (+), with $z_{pl}^+ = \frac{z_{pl}u_\tau}{\nu}$

### Interpolation issue

- Better treatment of the non-uniformity within a cell: $P_1$ interpolation
- Quantities of main interest:
  - $\underline{U}$: $\nabla \underline{U}$ necessary for the production term of the Reynolds tensor
  - $T_L = \mathcal{C}_l\frac{k}{\epsilon}$: $\propto z$ more accurate interpolation than $\epsilon \propto 1/z$




**(a)** streamwise velocity **(b)** resp. $\langle uw\rangle, \langle ww\rangle, \langle uu\rangle$ **(c)** evolution scheme

**Figure 4 :** Zoom on the near wall results obtained on a 20 cells mesh using a $P_0$ interpolation on all fields(•) and using $P_1$ interpolation for the velocity and Lagrangian time scale (×). The gray lines represent the face of the coarser mesh

## 2-D point source dispersion after an isolated obstacle [3]

- Hybrid method on the dynamic
- Stand alone methods on the concentration
- Only particle issued from the source are simulated with $\mathrm{d}C = 0$
  - no micro-mixing considered
  - concentration constant along each particle trajectory
- Estimation of the scalar flux $\langle u_i c\rangle$ possible

$$\langle u_i c\rangle = \langle C\rangle(\langle U_i\rangle^s - \overline{U_i}) \tag{1}$$

- with $\langle U_i\rangle^s$ the mean velocity of the particle issued from the source
- with $\overline{U_i}$ the mean velocity of the fluid extracted from FV solver

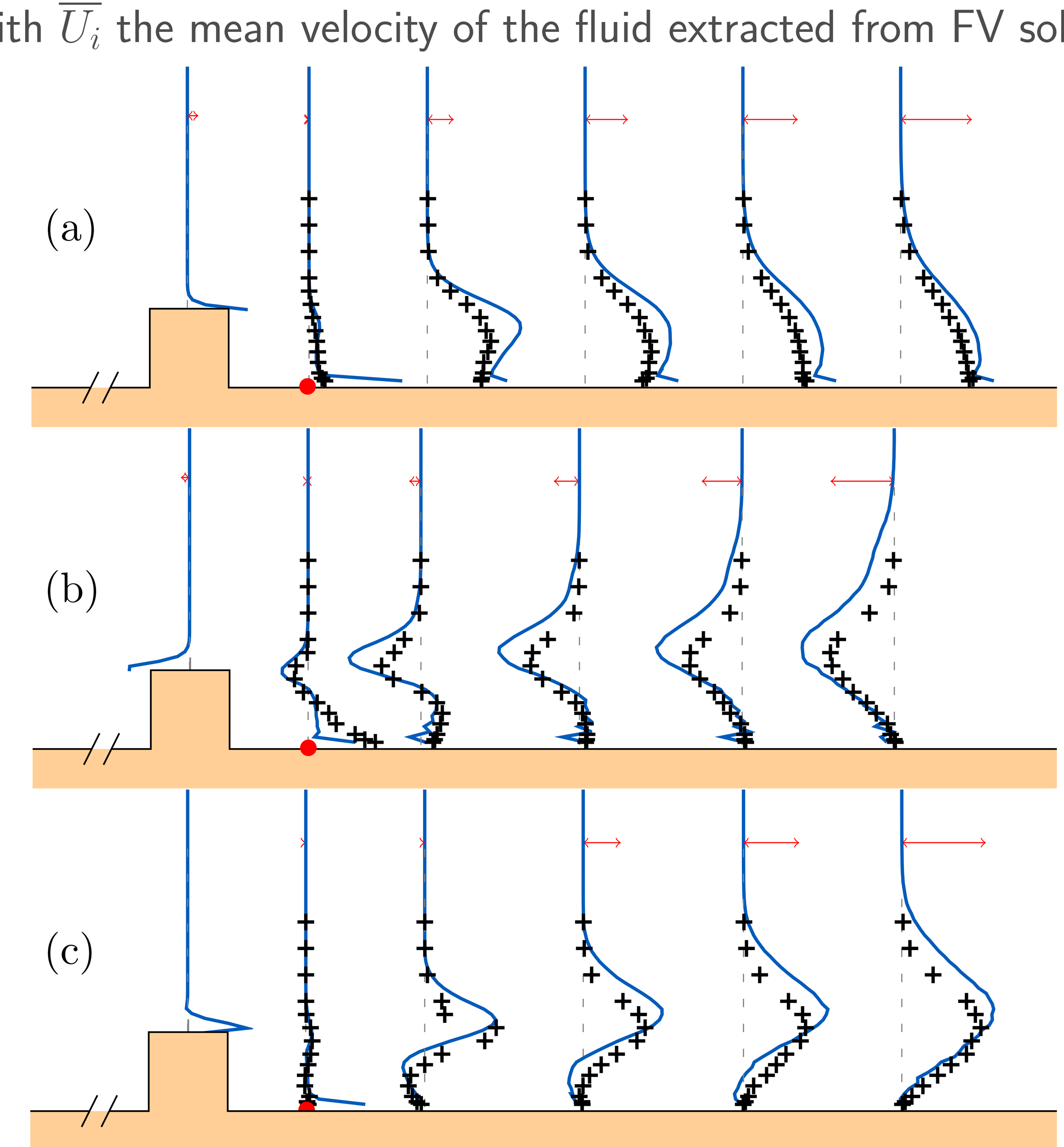



**Figure 5 :** Results obtained for a point-source dispersion after an obstacle of height H; the the source (red dot) is set 1H after the obstacle. The results obtained are compared with experimental data (+) [3] for respectively (a) the mean concentration $\langle C\rangle$ ,(b) the streamwise and (c) the normal scalar flux $\langle uc\rangle$, $\langle wc\rangle$. Note that the scale depends of the position; the red span is a reference value constant for all position.

## REFERENCES


[1] T. Dreeben and S.B. Pope, Wall-function treatment in pdf methods for turbulent flows, Physics of Fluids, 9, p 2692-2703, 1997.

[2] J-P. Minier and J. Pozorski, Wall-function treatment in pdf methods for turbulent flows, Physics of Fluids, 11, p 2632-2644, 1999.

[3] H. Gamel thesis:Caractérisation expérimentale de l'écoulement et de la dispersion autour d'un obstacle bidimensionnel.



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