

PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DAAA-2026-39**
 (à rappeler dans toute correspondance)

Lieu : ONERA Lille

Département/Dir./Serv. : DAAA/Unité ELV

Tél. : +33 3.20.49.69.10

Responsable(s) du stage : Thomas Huret,
 Geoffrey Tanguy

Email. : thomas.huret@onera.fr

DESCRIPTION DU STAGE

Thématique(s) : 04 - Turbulence

Type de stage : Fin d'études bac+5 Master 2 Bac+2 à bac+4 Autres

Title: Numerical simulation of wind flow fields and extreme turbulent events around complex building geometries

Subject:

The escalating deployment of civil UAVs in urban environments justifies the need for enhanced understanding of the aerodynamic interactions within the Urban Boundary Layer (UBL). Notably, UAVs operating in this regime are susceptible to significant perturbations from both the inherent turbulence of the atmospheric flow and the complex, site-specific, wake dynamics induced by nearby structures. Specifically, our focus lies at the interface between the inertial sublayer and the roughness sublayer, where large-scale turbulent eddies interact with the heterogeneous urban canopy (as depicted in Figure 1), yielding highly variable and site-dependent flow conditions (Stull *et al.*, 1988).

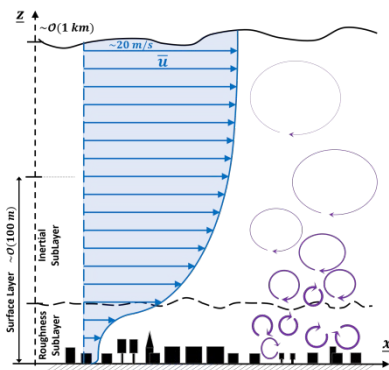


Figure 1 – Atmospheric boundary layer structure (with no thermal forcing)



Figure 2 – Hospital complex in Abbeville (Somme), a typical configuration for UAV-based medical delivery service

The need for a better understanding of the turbulent atmospheric conditions leads to the development of significant experimental and numerical research efforts (e.g. Nithya *et al.* 2024). Numerical simulations on this topic are usually carried out with Large-Eddy Simulations (LES) method (e.g. Giersh *et al.*, 2022), due to its capacity to resolve unsteady phenomenon on part of the turbulence spectrum. At ONERA Lille, a PhD thesis was undertaken on the use of the LES meteorological code Meso-NH (developed by the French meteorological agency Météo-France, Auguste *et al.*, 2020) with the objective of reproducing turbulent wind conditions, and particularly extreme unsteady events, at a resolution close to UAVs typical scales with relevant turbulence inlet conditions. The introduction of obstacles representing built environment is achieved by Immersed Boundary Method (IBM), which is used to perform numerical simulation by a set of wall interaction laws from the solid domain to the fluid domain (without body-fitted meshing of the fluid domain). Currently, the type of obstacles considered consists of simple geometries such as parallelepipeds, immersed in a structured fluid domain mesh.

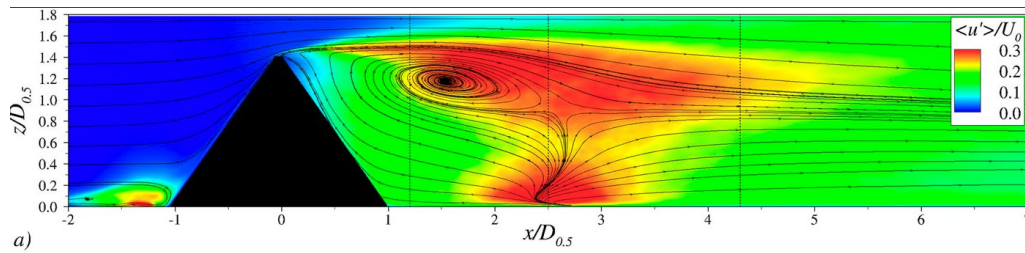


Figure 3 – Turbulence intensity field computed by Large-Eddy Simulation around a wall-mounted pyramid (Ouro et al. 2017). An example of obstacle geometry that may be tested in this internship as a urban obstacle.

Based on the current use of the code Meso-NH, the goal of this internship is to investigate the possibilities and limitations of the code in term of complexity of immersed obstacles geometry. The first part of the project will consist in mastering the use of the simulation code and the current post-processing tools, in particular those used to study extreme events dangerous for drone flight. During a second phase, the intern will investigate the characteristics of the turbulent flows around obstacles with relatively complex features, such as roof slopes, curved shapes and concave structures, intended to improve obstacles realism compared to urban geometries. From this database, the intern will validate the results based on expected turbulent wakes characteristics and suggest guidelines for future modelling of real urban obstacles with complex geometries within Meso-NH.

References :

F. Auguste, C. Lac, V. Masson, and D. Cariolle, "Large-Eddy Simulations with an Immersed Boundary Method: Pollutant Dispersion over Urban Terrain," Atmosphere, 2020. Accessed: Oct. 03, 2025. [Online]. Available: <https://www.mdpi.com/2073-4433/11/1/113>

S. Giersch, O. El Guernaoui, S. Raasch, M. Sauer, and M. Palomar, "Atmospheric flow simulation strategies to assess turbulent wind conditions for safe drone operations in urban environments," Journal of Wind Engineering and Industrial Aerodynamics, vol. 229, p. 105136, Oct. 2022, doi: 10.1016/j.jweia.2022.105136.

P. Ouro, C. A. M. E. Wilson, P. Evans, and A. Angeloudis, "Large-eddy simulation of shallow turbulent wakes behind a conical island," Physics of Fluids, vol. 29, no. 12, p. 126601, Dec. 2017, doi: 10.1063/1.5004028.

D. S. Nithya, G. Quaranta, V. Muscarello, and M. Liang, "Review of Wind Flow Modelling in Urban Environments to Support the Development of Urban Air Mobility," Drones, vol. 8, no. 4, Art. no. 4, Apr. 2024, doi: 10.3390/drones8040147.

R. B. Stull, An Introduction to Boundary Layer Meteorology. in Atmospheric and Oceanographic Sciences Library. Springer Netherlands, 1988. doi: 10.1007/978-94-009-3027-8.

Est-il possible d'envisager un travail en binôme ? Non

Méthodes à mettre en œuvre :

- | | |
|---|--|
| <input type="checkbox"/> Recherche théorique | <input type="checkbox"/> Travail de synthèse |
| <input checked="" type="checkbox"/> Recherche appliquée | <input type="checkbox"/> Travail de documentation |
| <input type="checkbox"/> Recherche expérimentale | <input type="checkbox"/> Participation à une réalisation |

Possibilité de prolongation en thèse : Oui

Durée du stage : Minimum : 5 months Maximum : 6 months (on derogation)

Période souhaitée : Starting in March 2026

PROFIL DU STAGIAIRE

Connaissances et niveau requis :

Fluid mechanics
Interest in atmospheric flow and
Computational Fluid Dynamics (CFD)

Ecoles ou établissements souhaités :

« Ecole d'ingénieur » or Master 2 (Fluid Mechanics)