MeshGraphNets for 3D atmospheric flow in Urban Environment for Atmospheric Dispersion

Armand de Villeroché* [1], Vincent Le Guen [1], Rem-Sophia Mouradi [1], Patrick Massin [1], Marc Bocquet [1], Alban Farchi [1], Sibo Cheng [1], Patrick Armand [2]

[1] CEREA, École des Ponts, EDF R&D, Institut Polytechnique de Paris, Île-de-France, France
[2] CEA, DAM, DIF, F-91297 Arpajon, France

Abstract

Urban and industrial areas are vulnerable to accidental releases of pollutants. To accurately determine the pollutant's plume position and affected areas, it is essential to understand the atmospheric flow around the affected site. This flow can be precisely computed using Computational Fluid Dynamics (CFD). However, CFD computation is expensive and slow, making it unsuitable for emergency response. Machine learning offers a promising alternative as it is usually much faster, but must first be trained on CFD-generated data. In this study, we propose a database of atmospheric simulations with varying meshes and atmospheric stability conditions. Meshes are built by randomly sampling buildings and placing them in space. For each mesh, values of the Monin-Obukhov length and of the ground roughness are sampled, leading to different turbulent regimes and overall trajectory behaviors. We then train a MeshGraphNet (MGN) on this database. The performance of the trained neural network on unseen scenarios with different initial conditions has been evaluated in this study.

Keywords: Computational fluid dynamics, deep learning, graph neural networks, atmospheric dispersion, atmospheric stability