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Numerical Simulation of Dispersion from Urban Greenhouse Gas Sources

Anders Nottrott, Sze Tan, Yonggang He, and Renato Winkler
Picarro Inc, Santa Clara, United States (anottrott@picarro.com)

Cities are characterized by complex topography, inhomogeneous turbulence, and variable pollutant source distributions. These features create a scale separation between local sources and urban scale emissions estimates known as the Grey-Zone. Modern computational fluid dynamics (CFD) techniques provide a quasi-deterministic, physically based toolset to bridge the scale separation gap between source level dynamics, local measurements, and urban scale emissions inventories. CFD has the capability to represent complex building topography and capture detailed 3D turbulence fields in the urban boundary layer.

This presentation discusses the application of OpenFOAM to urban CFD simulations of natural gas leaks in cities. OpenFOAM is an open source software for advanced numerical simulation of engineering and environmental fluid flows. When combined with free or low cost computer aided drawing and GIS, OpenFOAM generates a detailed, 3D representation of urban wind fields. OpenFOAM was applied to model scalar emissions from various components of the natural gas distribution system, to study the impact of urban meteorology on mobile greenhouse gas measurements. The numerical experiments demonstrate that CH4 concentration profiles are highly sensitive to the relative location of emission sources and buildings. Sources separated by distances of 5-10 meters showed significant differences in vertical dispersion of plumes, due to building wake effects. The OpenFOAM flow fields were combined with an inverse, stochastic dispersion model to quantify and visualize the sensitivity of point sensors to upwind sources in various built environments. The Boussinesq approximation was applied to investigate the effects of canopy layer temperature gradients and convection on sensor footprints.