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Methane emissions from a landfill: Numerical analysis of flight experiment data

Yujie Cai (1), Xuhui Cai (1), Raymond Desjardins (2), Devon Worth (2), and Ramesh Srinivasan (3)

(1) Peking University, College of Environmental Sciences and Engineering, Environmental Sciences, China (caiyjshine@pku.edu.cn), (2) Science and Technology Branch, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada, (3) National Research Council of Canada, Aerospace, Flight Research Laboratory, Ottawa, Ontario, Canada

Methane (CH4) is an important greenhouse gas. CH4 emission from landfills is regarded as the third largest anthropogenic emission source in the world. Precious estimate of CH4 emissions depends on well designed experiment and detailed analysis. This study is trying to estimate a landfill's CH4 emission strength by analyzing the observation data from a flight experiment, which was carried out in Eastern Ontario, Canada, on May 6, 2011. Dispersion plume of CH4 downwind the landfill at about 140 m a.g.l. is synthesized with observation data at 14 flight tracks. The observation result is characterized by unstable boundary layer condition, stronger wind, and shifting wind direction in about 72 min of the experiment. To replicate the boundary layer turbulence and the CH4 dispersion during the experiment, a combined large-eddy simulation (LES) and Lagangian stochastic (LS) particle dispersion modeling method is used. A preliminary simulation run with mean meteorological parameters in the experiment duration is carried out. The results well reproduced the shifts of wind direction as well as the dispersion plume, but in a smaller magnitude in comparison to the reality. Therefore, two sets of LES runs are carried out to represent the boundary layer turbulence before and after the wind shift. Another fact in the LES runs is found that, the simulated turbulent velocity variances are systematically smaller than the observed counterparts. In response to this discrepancy, additional terms are incorporated into the LS dispersion model so that to represent the turbulence dispersion process properly. With these treatment, the LES-LS modeling result replicated the dispersion plume both in lateral width and in concentration distribution shape. Then, by using the simulated relationship between source and concentrations/vertical fluxes in space, the CH4 emission rate of the landfill is estimated as 2366 (kg hr-1) or 2055 (kg hr-1), in contrast to the observed CH4 concentrations and vertical fluxes respectively.