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A Urban Air Quality Service with the Large-eddy Simulation Model PALM

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Many global cities experience air quality problems. They are partially related to excessive emission of polluting substances, but also to insufficient dilution of pollutions in the urban atmosphere. Accurate account for pollution diffusion and advection pathways in a complex urban physical environment requires high resolution numerical modeling. Such modeling is provided by a turbulence-resolving large-eddy simulation model. In a series of our studies, we utilized the large-eddy simulation modeling system PALM for study and pre-operational analysis of air quality hazards caused by residential wood combustion in Bergen, Norway. This problem – high concentrations of smoke aerosol particles in the lowermost urban atmosphere – is rather typical for Northern towns. The problem could be seen as an advection–diffusion problem applied to geographically distributed small-scale pollution sources. It has not been considered before from the point of view of minimization of the extreme impact of distributed emission on the urban population. Our study builds up real data and specific urban configurations. The model PALM runs at spatial resolution of 10m in an urban-sized modeling domain of 29km by 35km with a real spatial distribution of the pollution source and with realistic surface boundary conditions that characterize a medium-sized urban area fragmented by water bodies and hills. We investigated the turbulent diffusion of a passive scalar associated with small-sized particles (PM2.5) emitted by household stoves. The study considers air pollution effects that could be observed under different policy scenarios of stove replacement; modern woodstoves emit significantly less PM2.5 than the older ones, but replacement of stoves is costly and challenging. We found significant accumulation of near-surface pollution in the local stagnation zones. The simulated concentrations were larger those obtained only due to the local PM2.5 emission, indicating dominant trans-boundary contribution of pollutants for other districts. We demonstrate how the source of critical pollution can be attributed through model disaggregation of emission from specific districts. Ours has been expanded to service for the local affected groups. Important policy-related implication of the study is that there are certain priority urban districts where reduction of emission will have disproportional effect on air quality improvement for the whole city. This study identifies urban districts where limited incentives would result in the strongest reduction of the population's exposure to PM2.5. Event website