Mapping the three-dimensional heterogeneity of the urban atmosphere through measurement network synergy

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Abstract

The dynamics of the atmospheric boundary layer (ABL) present the link between synoptic-scale weather conditions and the heterogeneous processes of the urban environment. They severely impact the horizontal transport and vertical dilution of heat, moisture, and pollutants. To better understand these dynamics, it is critical to quantify spatial variations in temperature, wind and turbulence at different scales both horizontally and in the vertical dimension. While this three-dimensional heterogeneity of the urban atmosphere is

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represented by numerical simulations with increasing detail, multi-variable observations are urgently required – not only to support model evaluation but also to enable vital process studies. Coordinated by the PANAME multi-project initiative, significant advances in measurement network design have recently been made in the Paris region. This study highlights how novel observations and increased measurement site density are used to better quantify the three-dimensional variations of the urban atmosphere. A network of microwave radiometers, Doppler wind lidars, and automatic aerosol lidars, is operated along a rural-suburban-urban transect to monitor variations in key variables such as temperature, wind, turbulence, aerosols. Differential absorption lidars were operated in summer 2022 to retrieve profiles of other constituents (H2O, O3). Advanced products, such as the height of the boundary layer, aerosol mass profiles, or characteristics of the nocturnal low-level jet are diagnosed using automatic detection algorithms. In addition to those novel vertical measurements, the density of the meteorological surface station network (Meteo-France) has been increased to capture the micro-climates of characteristic local climate zones. The synergy of dense surface-station networks and the multi-variable profile measurements provides insights on the urban atmosphere at an unprecedented level of detail. These allow us to effectively study the implications of different weather conditions on urban micro-climates and air quality. Access to visualisation and data is organized in the PANAME web portal under development by AERIS.

Keywords: atmosphere dynamics, ground, based remote sensing, dense sensor networks