Size-segregated particle turbulent fluxes measurements in an urban area in Italy

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Measurements of vertical turbulent fluxes of particles in urban areas are a powerful tool to characterise road traffic pollution and the dynamics of particles in the urban surface layer (Deventer et al., 2015). This information allow characterising the exchange of particles between a city and the atmosphere. In this work, size-segregated fluxes of particles (size range 0.009-3 µm) and CO_2 were investigated in the urban area of Lecce (South Italy) together with fluxes of sensible and latent heat. Measurements were taken at 14 m above the ground on the roof of a building in using the eddy covariance (EC) approach (Contini *et al*, 2012).

Measurements were carried out from 10^{th} March to 24^{th} April 2015 during the experimental campaign AFIRE (Aerosol Fluxes in uRban Environment) using an optimized setup that comprised a Condensation Particle Counter (CPC, Grimm 5.403) and an Optical Particle Counter (OPC, Grimm 1.109), coupled with an ultrasonic anemometer and an IR gas analyzer (Licor LI-7500) for CO_2 and H_2O vapour concentration measurements. The synchronized application of CPC and OPC allowed the direct calculation of particle number concentration and fluxes, for diameters from 0.009 to 0.25 µm by the CPC and from 0.25 to 3 µm in the 16 individual size bins provided by the OPC.

The data sets needed an accurate verification and a consistent post processing (de-spiking of time series, detrending, removal of non-stationary periods) to reduce the effects of meteorological parameters on the calculations of fluxes. Furthermore, because the measurement site was located near various buildings, the subset of data corresponding to wind direction from SW to NNE were selected (leaving 59% of the data) to minimize flow distortions. Fluxes were corrected for high frequency losses due to the limited time response of the CPC (1.3s) and of the OPC (0.5s) and for the effect of density fluctuations.

The aim of this work was to characterize the dynamics of atmospheric aerosol and CO_2 through an analysis of number concentrations and fluxes patterns and their correlation with energy fluxes, meteorological parameters, and vehicular traffic rate. Concentrations and fluxes footprints were also evaluated and analyzed to interpret concentration and fluxes daily patters and their correlation with the local micrometeorology.

The average particle daily concentration patterns show that the major contribution (~10^4 #/cm^3) comes from particles corresponding to smaller diameters and during weekdays. During daytime, the data show two large concentration peaks in morning and evening and a midday peaks indicating a correlation with intense vehicular traffic but also a possible influence of nucleation events. A similar analysis was done for CO_2/H_2O concentration showing that the average CO_2 concentration had a different behavior, with a decrease in diurnal hours, due to the influence of background transport and of the biogenic cycle.

The correlation analysis of the concentration time series associated with particle of different diameter D_p suggested a division into three groups. The first are particles with D_p<0.25 µm, not correlated with OPC concentrations. A second group (i.e. the first 8 classes, up to D_p=0.6 µm) and a third group 0.6 µm<D_p<3 µm that showed a good temporal correlation (r_{xy}> 0.4). The fluxes for the three size classes are shown in Figure 1. Fluxes were dominated by particles in the ultrafine range (D_p<0.25 µm). They were almost zero before 07:00 and became on average positive afterwards, indicating average upward fluxes in all size ranges (i.e. the urban area is a source of particles). This result is compatible with a significant contribution of ground level sources such as road traffic. The lower concentration and fluxes observed during weekend with respect to working days is correlated with the decrease in measured traffic rate. Negative fluxes are sporadically present and their frequency increases for large particles.

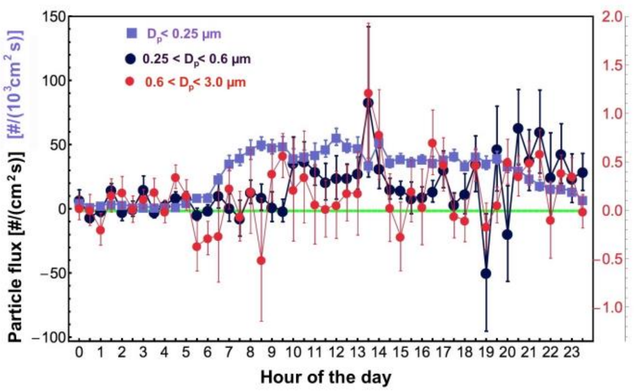

Figure 1. Averaged daily patterns of number particle fluxes for CPC (violet) and OPC (red and black). Error bars represent the standard error.

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