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Ultrafine particles and black carbon measurements at an urban background site in Milan

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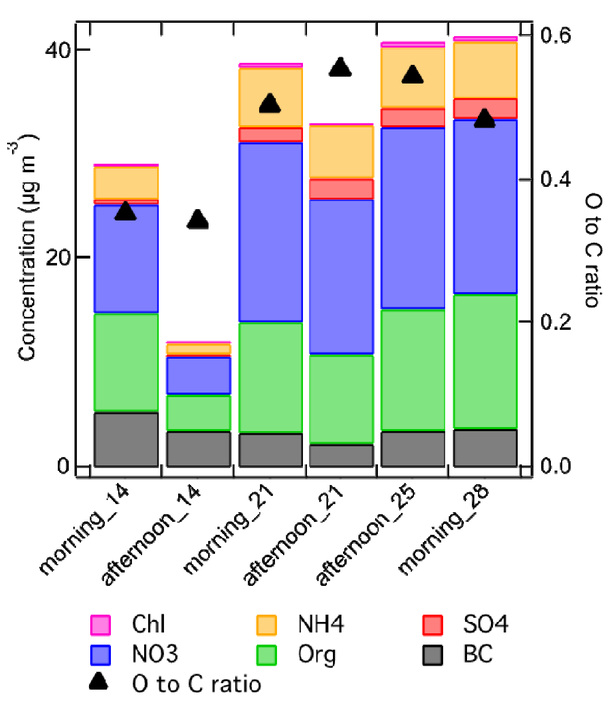
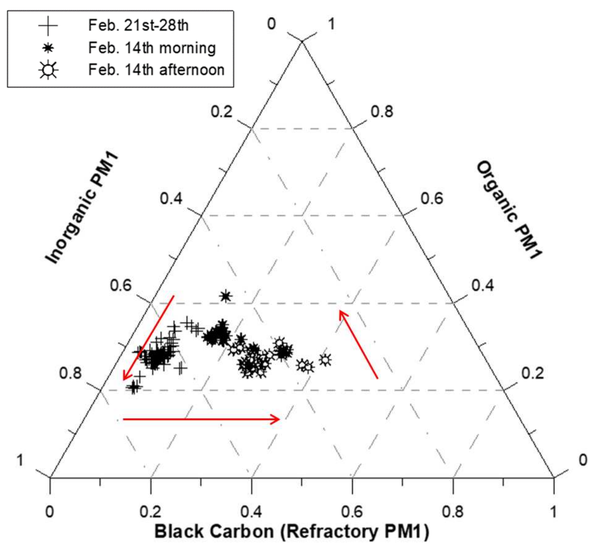
Background

During the PoAir intensive air quality monitoring campaign over Northern Italy, collocated measurements of fine and ultrafine particles were performed at an urban background site in Milan for a few days in February 2014. Concurrent measurements at high time resolution of the different features of airborne particles (optical properties, number size distribution, chemical composition) have been performed in order to investigate the potential for a better understanding of the nature and origin of submicron particles in urban environments.
Black carbon (BC) was measured through Laser-Induced Incandescence (LII) technique (Italian Patent ITRM20090617), microaethalometer AE51 (AethLabs), multi-angle absorption photometer (MAAP); size-resolved particle number concentration (PNC) in six size bins (20-30 nm, 30-50 nm, 50-70 nm, 70-100 nm, 100-200 nm, and > 200 nm) through a TSI 3031 UFP monitor; non-refractory PM1 chemical composition through a High Resolution - Time of Flight - Aerosol Mass Spectrometer (HR-TOF-AMS).
All measurements were taken at 10-min time resolution, thus enabling to capture the short-period fluctuations, due to fresh emissions from combustion sources (namely from the traffic source), typical of kerbside locations but that can also affect urban background sites.

PM1 chemical composition





BC: 5-40% (avg. **13.8%**)
Organics: 20-40% (avg. **28.5%**)
Inorganics: 60-80% (avg. **57.7%**)

PM1 average composition and ageing

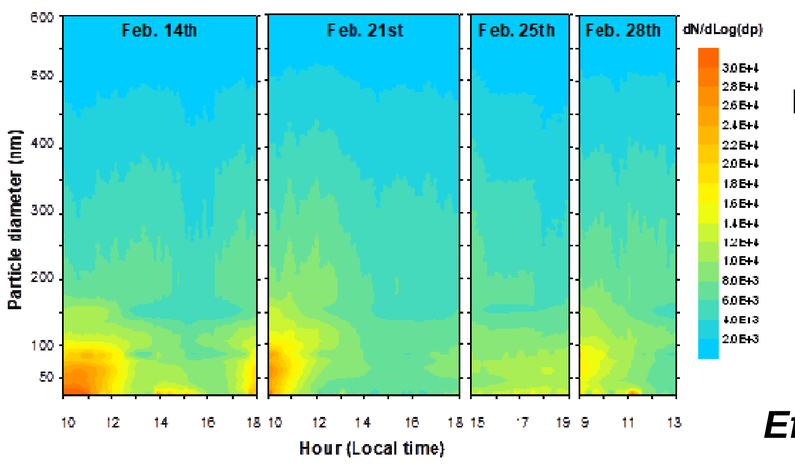
BC = 3.1 µg m^{-3}, Organics = 13.0 µg m^{-3},
NO_3^- = 13.0 µg m^{-3}, SO_4^{2-} = 1.4 µg m^{-3} NH_4^+ = 4.2 µg m^{-3}

- **Ammonium nitrate dominating over ammonium sulfate coherently with the relatively low temperature and with the NO_x (high) and SO_2 (low) concentrations in Milan urban area.**

Oxygen-to-carbon ratio of Organic Aerosol: 0.34-0.55 range

- **Dominant contribution of processed OA (typically O:C > 0.4) over primary combustion OA (typically O:C < 0.2)**

Particle number and size



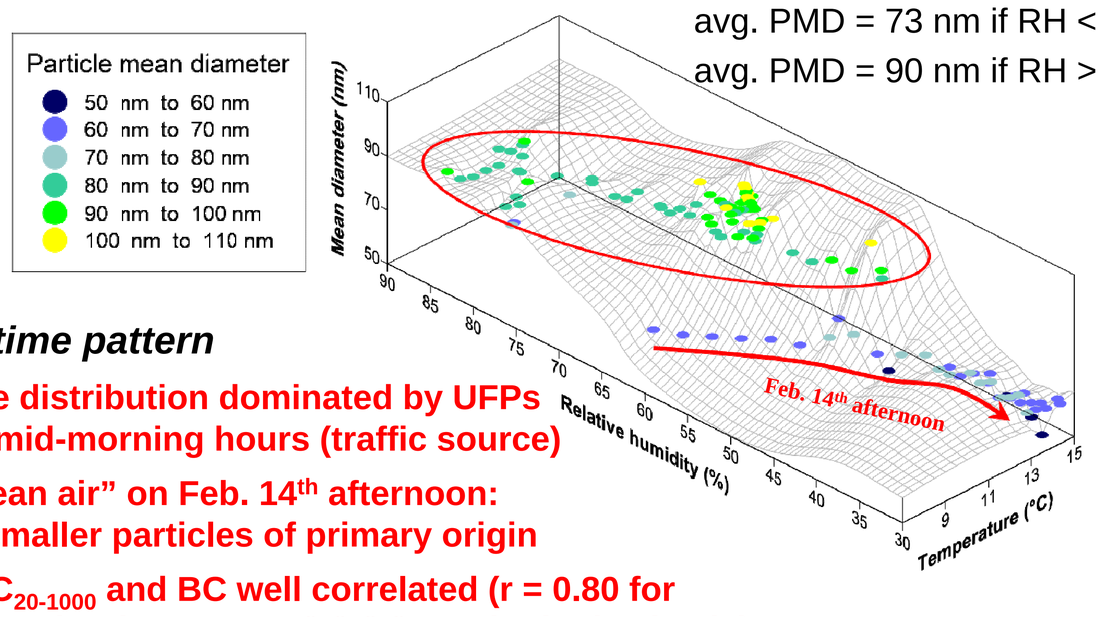
Concentration levels

$PNC_{20\text{-}1000}$: 5.7·10^3 - 24·10^3 cm^{-3}
(avg. **10.3·10^3 cm^{-3}**)
$PNC_{20\text{-}100}$: 3.8·10^3 - 20·10^3 cm^{-3}
(avg. **7.8·10^3 cm^{-3}**)

- **UFP = 70-80% of total PNC**

Effect of Relative Humidity

avg. PMD = 73 nm if RH < 60%
avg. PMD = 90 nm if RH > 60%

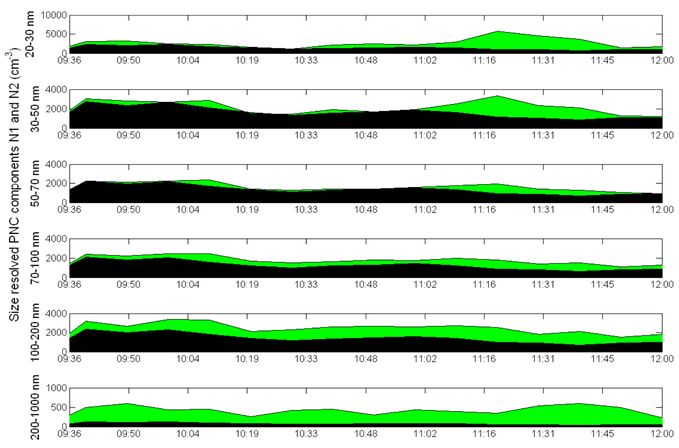


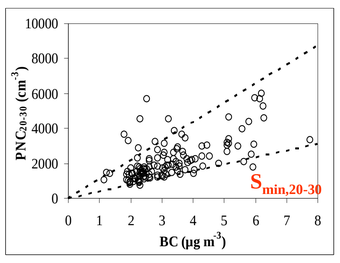
UFP time pattern

- **Size distribution dominated by UFPs on mid-morning hours (traffic source)**
- **"Clean air" on Feb. 14th afternoon: smaller particles of primary origin**
- **$PNC_{20\text{-}1000}$ and BC well correlated (r = 0.80 for the entire dataset; r = 0.6-0.9 on single-day basis)**

PNC split

Primary combustion particles: N1 = $S_{min,PNC}$·BC
Secondary aerosol: N2 = N – N1

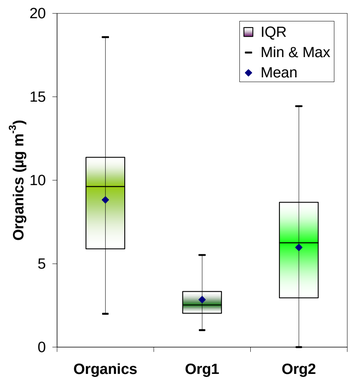


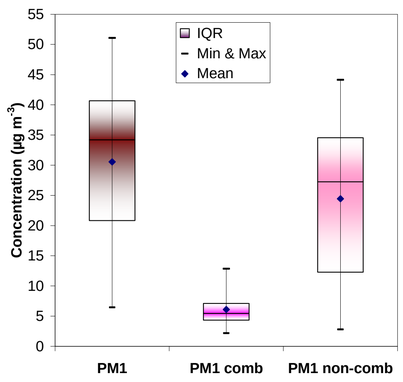


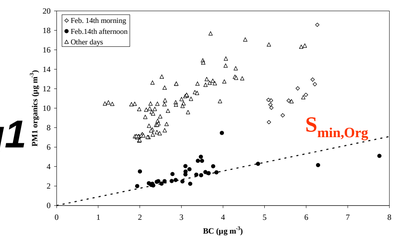
- **N1: the most part (65%) of $PNC_{20\text{-}1000}$, with higher contributions (71-77%) for the size bins between 30-100 nm**
- **N2: only 35% of the total of $PNC_{20\text{-}1000}$, with the highest contribution (70%) in the $PNC_{200\text{-}1000}$ size bin**

PM1 organic matter split

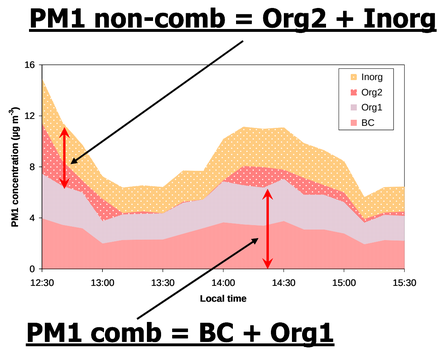
Primary organic particles: Org1 = $S_{min,Org}$·BC
Secondary organic aerosol: Org2 = Org - Org1







PM1 non-comb = Org2 + Inorg



PM1 comb = BC + Org1

- **$S_{min,Org}$ from "clean air" event: 0.88 $\mu g_{Org}/\mu g_{BC}$**
- **PM1 organic mass mostly secondary (67.8%) giving 19.6% of PM1**
- **Secondary ("non-combustion generated") organic and inorganic components accounting for about 80% of PM1 mass, but down to 40% on "clean air" event**

Conclusions

- Despite the small dataset, highly resolved data show a potential for a better understanding of the nature and origin of ultrafine and submicron particles in urban environments
- BC as a tracer of primary emission from combustion processes allows splitting particle number and organic mass concentration data between primary and secondary components
- Primary, "combustion-generated", aerosol is responsible for the most part of particle number (especially in the UFP range), conversely with limited contribution to PM1 mass, except for the "clean air" event