Tunnel aerosol characterization during the PhotoPAQ campaign in Brussels, Belgium

LEIBNIZ-INSTITUT FÜR TROPOSPHÄRENFORSCHUNG

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Introduction

Air pollution is known to directly affect human health by interactions with the respiratory and cardiovascular systems. Consequently, air quality of urban areas appears to be an extremely challenging task. The main approach considered at the moment, is based on the reduction of primary anthropogenic emission like industries, car exhaust and house heating. However, by driving through city tunnels which are commonly used to facilitate car traffic inside large cities, drivers and their passengers can be exposed to extremely high aerosols concentrations. In the frame of the PhotoPAQ project (PHOTOcatalytic remediation Processes on Air Quality), aerosol measurements were performed in the city tunnel Leopold II (Brussels, Belgium). This poster summarized the first results.

Tunnel Leopold II

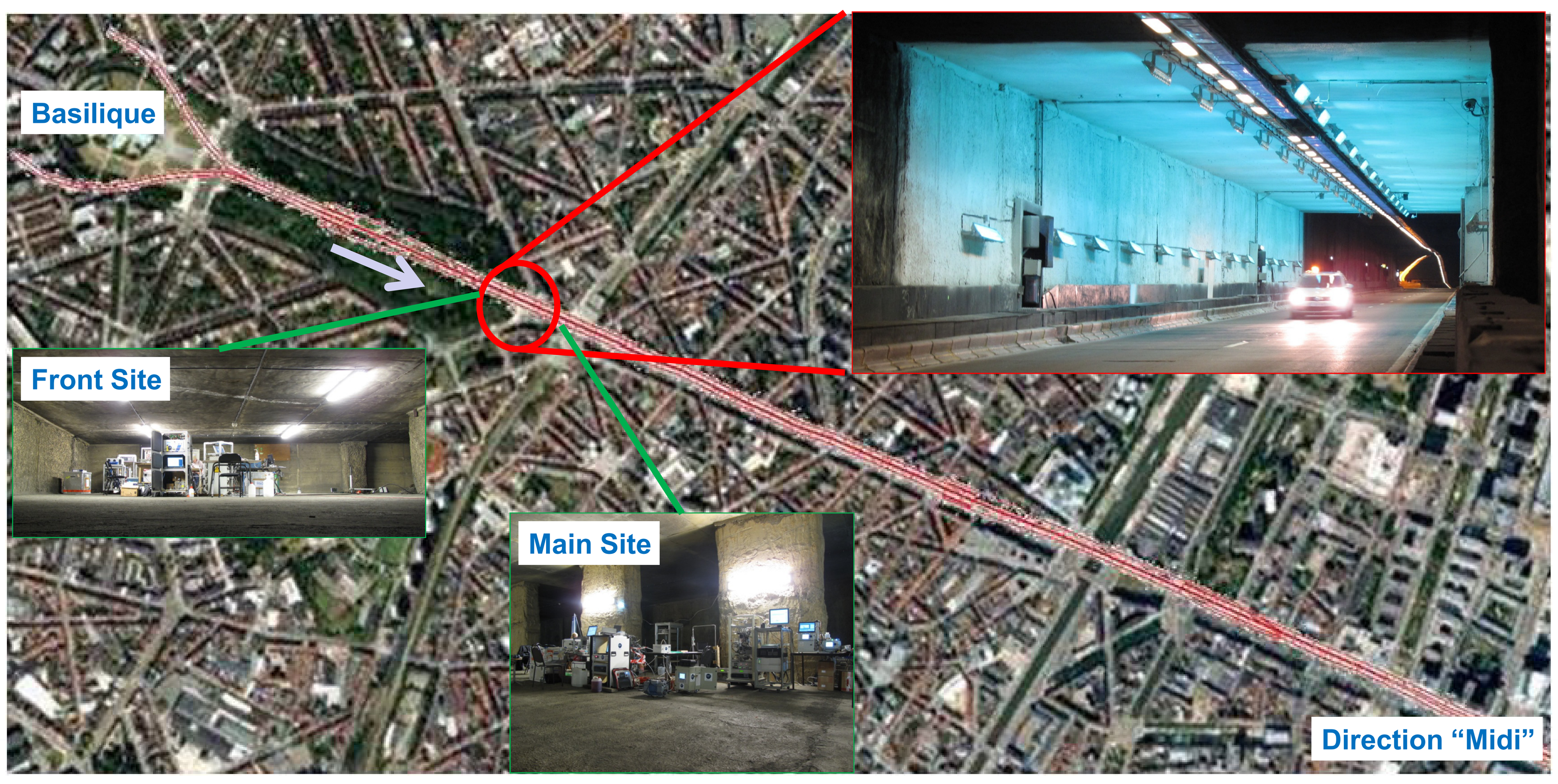

Figure 1: The Leopold II tunnel and the experimental section.

Location: City tunnel Leopold II (Brussels, Belgium) (Fig.1).

Tunnel: - 2 tubes of 2.5 km length each
- about 2300 vehicles per hour (mainly private car)

Sampling stations: one before (Front Site) and one at the end of the experimental section (Main Site)

Measured parameters:
- Gas phase: NO_x, CO_2, VOCs
- Particle phase: aerosol chemical composition by AMS (both stations), MAAP (Main Site), 10-stage Berner impactor (Main Site)

Special event on Sunday 19.09: Brussels car free day. No traffic from 07:00 to 19:00

Aerosol chemical composition

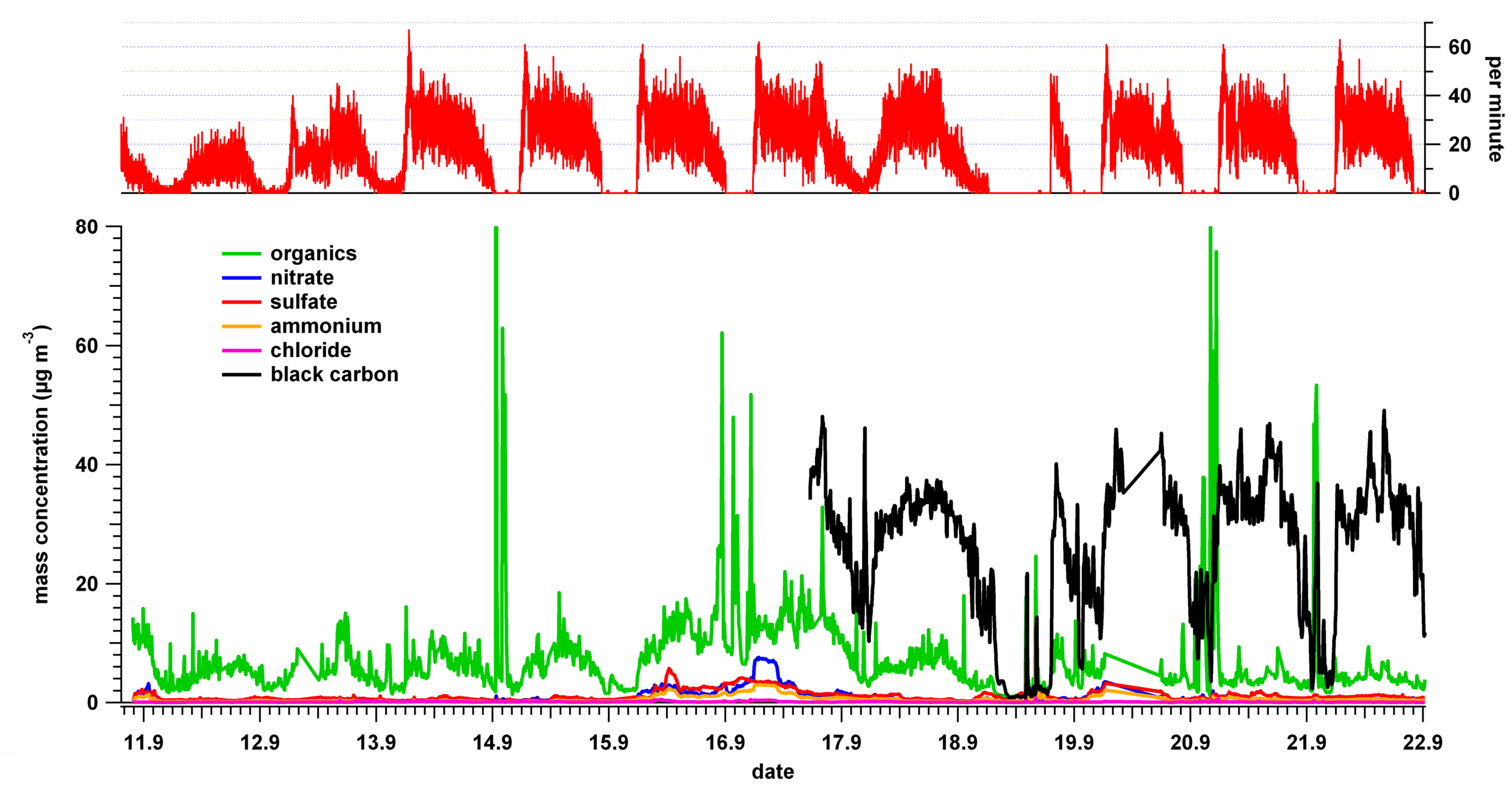

Figure 2: Time series of the aerosol chemical composition as measured by AMS and MAAP. The number of cars crossing the experimental section is indicated in top panel.

Figure 2 shows the aerosol chemical composition measured by AMS (organics, nitrate, sulfate, ammonium and chloride) completed by the black carbon concentration measured by MAAP (only after 16.9). Aerosols mainly consist of black carbon and organic (Fig. 3). Their concentrations clearly follow the number of cars present inside the tunnel. Interestingly, nitrate and sulfate mass concentrations increase on 15.9 to 17.9 which is not related to traffic emissions but to the influence of out-side air flow that can be introduced into the tunnel by car induced air flow and/or by ventilation. This will be confirmed by the size distribution analysis (Fig. 5).

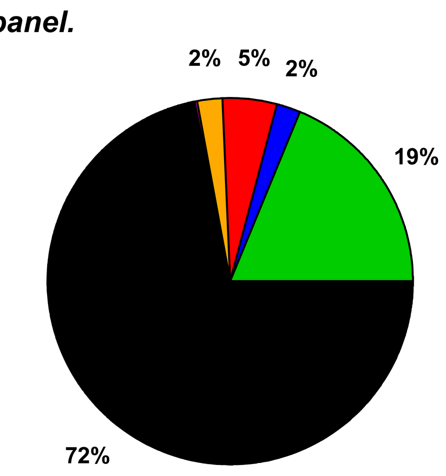

Figure 3: Average aerosol chemical composition during the second half of the campaign.

Measurements validation

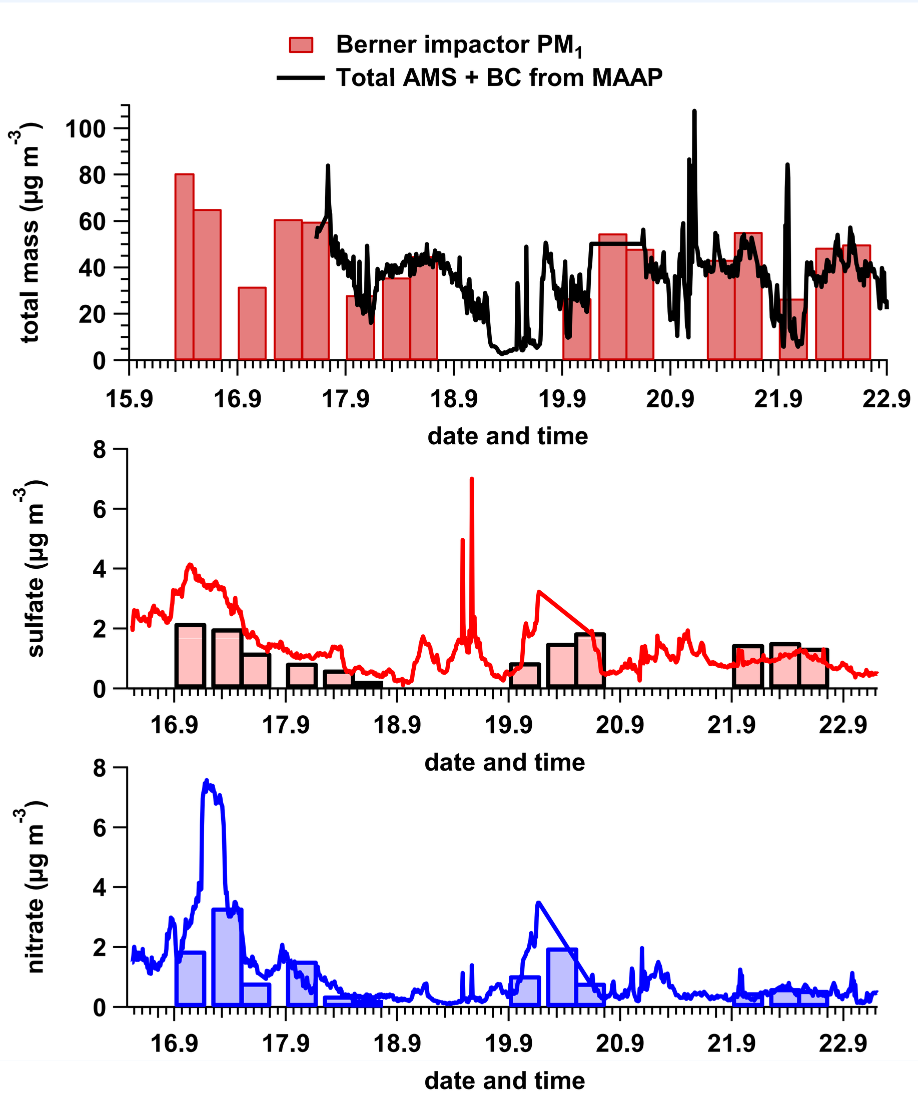

Figure 4: Comparison between on-line (AMS and MAAP) and off-line (Berner impactor samples) aerosol chemical composition

The first 6 stages of the Berner impactor samples were summed in order to estimate the PM_1 mass concentration of nitrate and sulfate as well as the total aerosol mass (Fig. 4). A good agreement between on-line and off-line instruments can be observed. Therefore, the AMS measurements are suitable.

Particle size distribution analysis

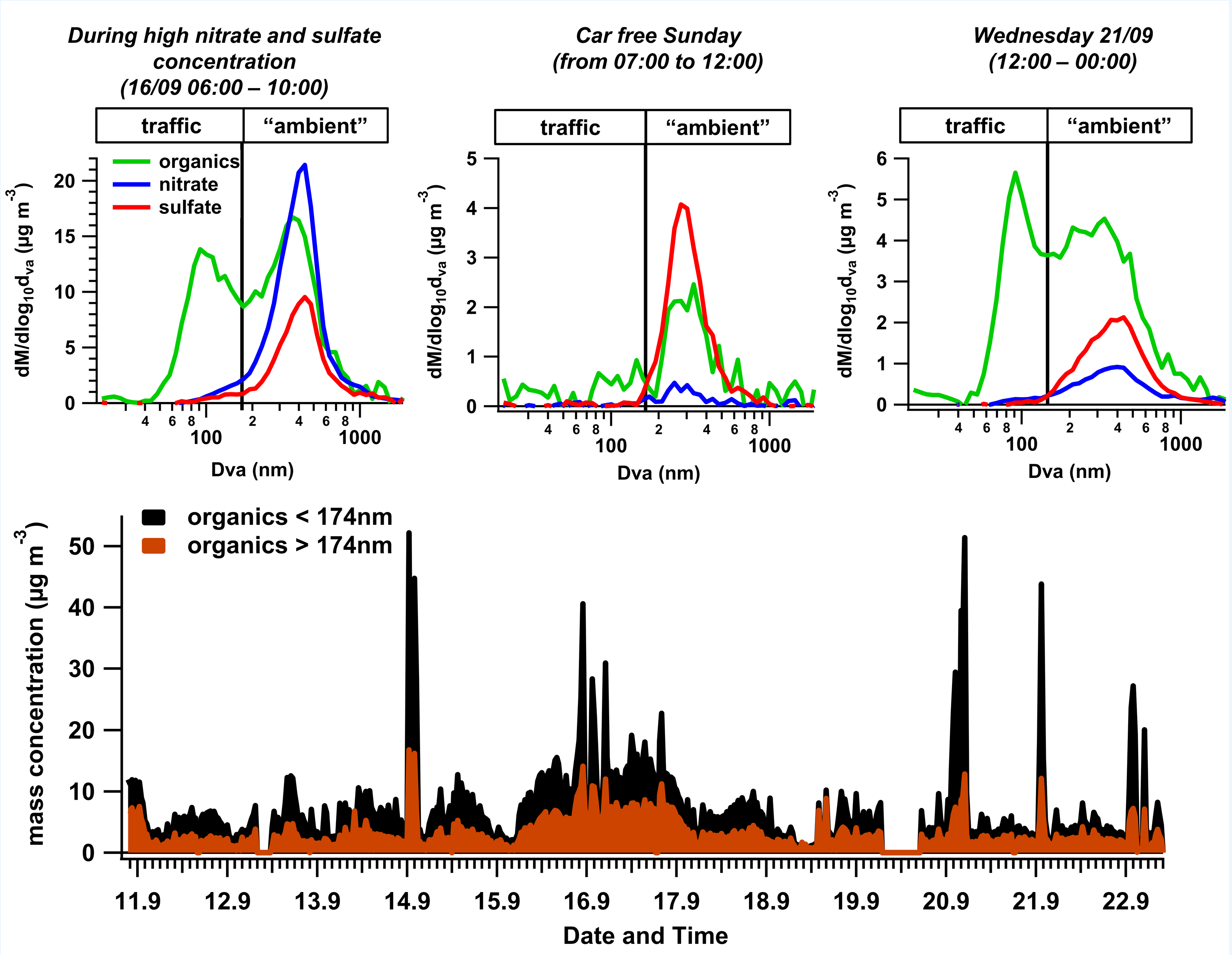

Figure 5: Comparison of the size resolved aerosol chemical composition in organics, nitrate and sulfate during 3 different periods (top) and time series of the estimated organic mass concentration below 174 nm (in vacuum aerodynamic diameter) and above 174 nm (bottom).

Organics size distribution clear shows 2 modes. One peaking at 90 nm (vacuum aerodynamic diameter) and a second one around 350 nm.

However, nitrate and sulfate which are not emitted by cars are only present in the larger mode.

During the car-free Sunday, the larger mode strongly dominates the particle size distribution and may correspond to "ambient" air from outside.

Therefore, it is possible to distinguish particles:

- Below 174 nm, as corresponding to direct car emissions (≈ 48% of total organics)
- Above 174 nm more related to aged particles (≈ 52% of total organics).

Conclusion

Particles present inside the Brussels city tunnel Leopold II were mainly made of black carbon and organics. Presence of nitrate and sulfate which are not produced by cars, highlight contribution of outside "ambient" air. This influence was clearly observed during the car-free day. Based on the double mode of the organics size distribution, the organics signal shows two parts: 48% coming from direct car emissions and 52% resulting from "ambient" organics. These results will be helpful to better understand and control particle mass concentration inside city tunnel.

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PHOTOPAQ
Demonstration of Photocatalytic remediation Processes on Air Quality

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