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Marked enhancement absorption of black carbon traced by aircraft measurements within the Paris urban plume

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Black carbon (BC) is a significant short-lived climate forcer due to its strong absorption of solar radiation. During transport BC can get coated with other species, altering its mixing state and optical properties. Understanding BC aging rates and timescales, as well as its optical properties at different aging stages, is crucial for assessing its climate impact. Yet, studies on BC aging with time and their effects on optical properties are limited.

This study presents the evolution of BC properties within an urban plume using airborne measurements conducted by the Safire ATR-42 research aircraft during the ACROSS (Atmospheric ChemestRy Of the Suburban foreSt) campaign from June 15 to July 7, 2022. ACROSS aimed to sample the Paris urban plume at different distances from the emission sources in the Île-de-France region by integrating coordinated observations from aircraft and ground-based.

We analysed 11 flights with simultaneous measurements of BC mass concentration by a Single Particle Soot-Photometer (SP2), aerosol optical properties, monitored by a modified airborne dual-wavelength CAPS-PM_{SSA} monitor and CO₂ concentration, measured using a PICARRO gas analyser. Chemical-transport-model simulations were also performed using the WRF-CHIMERE model to support the interpretation of the results.

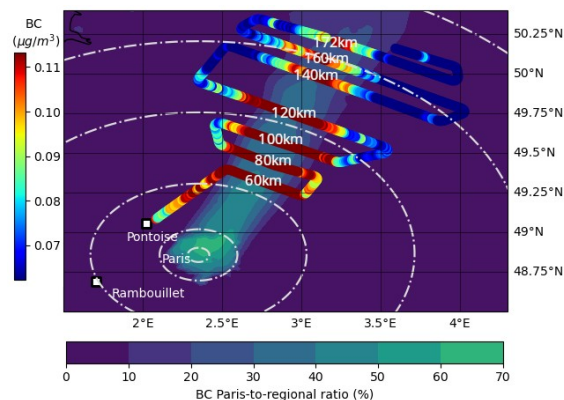


Figure 1: Comparison of BC mass concentration measured by the SP2 during Flight 28 and WRF-CHIMERE simulation data at 200m of altitude, highlighting enhanced BC tracing along the plume from Paris.

Figure 1 depicts the spatial distribution of BC mass concentration measured by the SP2 during the Flight 28 (F28). Higher concentrations are observed downwind of Paris, consistent with the plume traced by the WRF-CHIMERE model. These concentrations gradually decrease over time due to dilution of the plume. To provide an overview of BC properties evolution, we developed a systematic identification of in-plume vs background air masses method based on the 75th and 25th percentile of BC mass concentration. Results of the temporal evolution of BC mass concentration, aerosol absorption coefficient at 630nm, and their relationship, known as the BC mass absorption coefficient (MAC_{BC}) are shown in Figure 2. We note a gradual increase in the MAC_{BC} value over the course of the 9h of transport, suggesting a secondary process increasing BC coating thickness and absorption enhancement. Analyses are underway to examine the mixing state and BC properties evolution for all flights.

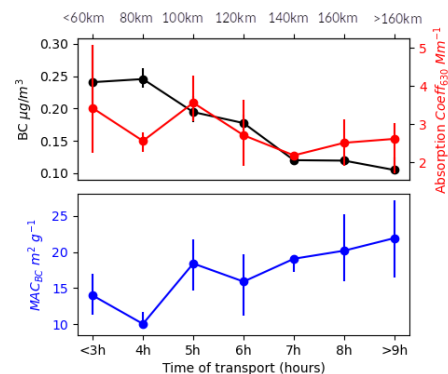


Figure 2: Evolution of BC mass concentration (black), absorption coefficient at 630nm (red) and BC mass absorption coefficient at 630nm (blue) as a function of transport time during Flight 28. Markers represent the median value and the error bars correspond to the interquartile range.

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