

Studying light-absorbing aerosols properties in Northern France through combined in-situ observations, emission inventory, and individual back-trajectory analyses

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Aerosols influence the Earth’s climate directly through scattering and absorption of solar radiation and indirectly by affecting cloud properties.

Near real-time in situ measurements (Table 1) are performed routinely within the fine (PM₁) fraction of aerosols on the ATOLL (ATmospheric Observations in liLLe) platform, a suburban site located on the rooftop of a University of Lille building (50.61 °N; 3.14 °E). The French Hauts-de-France region (HdF) is impacted by many anthropogenic sources (e.g. road traffic, residential sector, agriculture and industries) and maritime transport.

Table 1. List of in situ instrumentation and measured parameters in the PM₁ fraction at the ATOLL site.

Instrument	Measured Parameter	Time resolution
ACSM	Org, NH ₄ , SO ₄ , NO ₃ , Cl (NR-PM ₁)	~30 min
Aethalometer (7λ)	σ _{abs} & eBC	1 min
Nephelometer (3λ)	σ _{scat}	1 min
SMPS	Number size distribution	5 min

In this study, observations were enriched by integration with hourly 72h Hysplit back-trajectories and the latest version of the EDGAR (Emissions database for Global Atmospheric Research) emission inventory, described by Crippa *et al.* (2020). This so-called GARplit approach aims to assess the emission sources associated with the local vs. transboundary origins, allowing to characterize the corresponding optical properties of light-absorbing aerosols measured in ATOLL. The proposed method complements the more classical wind direction analysis combined with source apportionment, while going more into details than typical back-trajectory clustering methods.

At the ATOLL site, the averaged single scattering albedo (SSA) at 525nm is 0.77 ± 0.12 (1σ), evidencing the presence of high absorbing aerosols. Seasonal variations of the Absorption Ångstrom Exponent (AAE) in 470 – 880 nm show a marked increase during the cold seasons (1.60 ± 0.15) compared to summer (1.30 ± 0.08) due to emissions from biomass burning (BB).

By applying the GARplit method over a 3-year dataset at ATOLL, Black Carbon (BC) source emissions are expected to be 9% local (greater Lille area), 27%

domestic (rest of the country) and 64% transboundary (with Belgium 15%, eastern Europe 10%, UK 7%, Netherlands 4%; the rest of Europe and emissions above oceans – from the shipping sector – making up the remainder). Considering the emission sector (Figure 1), roughly half of BC originate from the traffic (33%) and residential sectors (21%), followed by industry (21%) and shipping (19%).

Since Velazquez-Garcia *et al.* (*submitted*) observed a significant contribution of Brown Carbon (BrC) in the region, we explore more specifically BrC lifetime and origins. During the cold season, results show that BrC light absorption is mainly related to fresh BB (82%) from the residential sector, while aged BB and the traffic sector has minimal BrC absorption (3%), highlighting a photobleaching effect after transport.

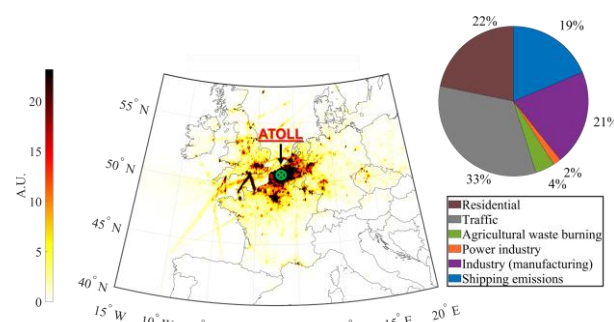


Figure 1. Spatial (in Arbitrary Units) and sectoral (in percentage) allocation of Black Carbon (BC) amounts observed at ATOLL over the period 07/2017 - 12/2019.

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Crippa, M., Solazzo, E., Huang, G., Guizzardi, D., Koffi, E., Mutean, M., Schieberle, C., Friedrich, R., Janssens-Maenhout, G (2020) *Sci Data* 7, 121.

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