Le carbone-suie dans l'atmosphère Européenne : identification, transfert, dépôts et impacts

Marco ZANATTA

Laboratoire : IGE

Directeur de thèse : Paolo Laj / Martin Gysel (PSI)

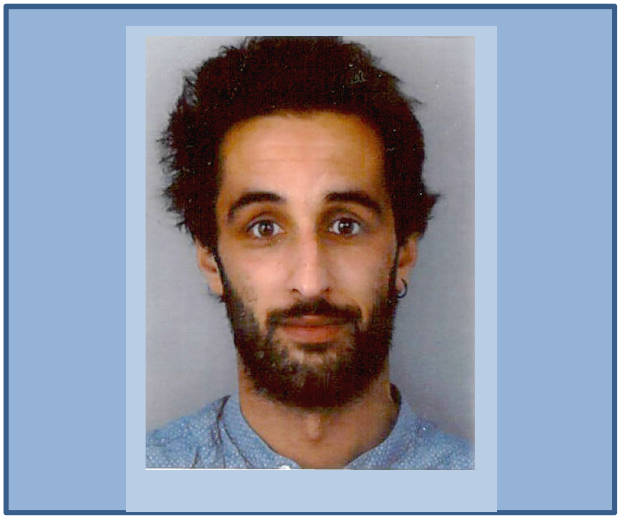
Co-financeurs : Paul Scherrer Institute (PSI), Suisse (50%)

École doctorale : TUE

Début / Soutenance : 01/10/2012 - 04/04/2016

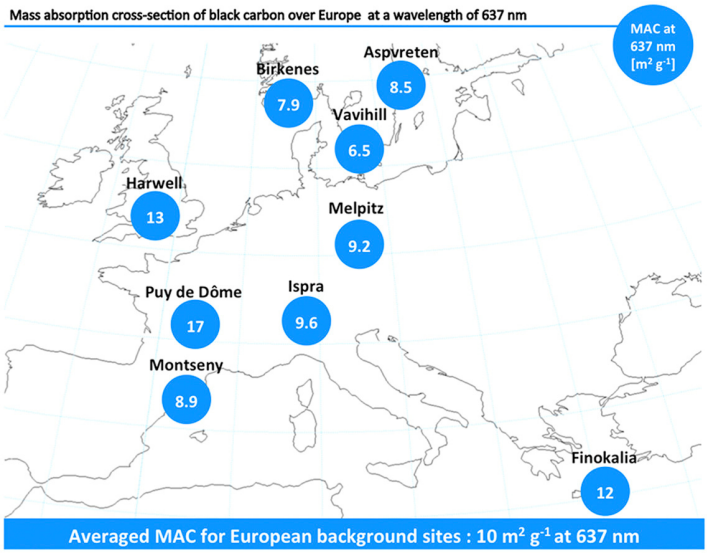
Formation : Master in Analytical Chemistry, University of Pavia, Italie

Poste actuel : Postdoc Alfred Wegener Institute Bremerhaven, Allemagne



Résultats majeurs et illustrations

- Harmonization of absorption coefficient and elemental carbon measurements for European locations.
- The mass absorption cross-section of black carbon is homogeneous over Europe.
- Presence of non-absorbing matter induces an enhancement of black carbon absorption.
- Application of single particle photometry for the quantification and characterization of black carbon particles in mixed phase clouds.



Zanatta et al., 2016

Résumé de la thèse

Black carbon (BC) induces a warming effect (RF_{BC} = +1.1 W m^{-2} ± 90%) through two main pathways: aerosol-radiation interaction (RF_{ari}) and aerosol-cloud interaction (RF_{aci}). Both BC-radiation and BC-cloud interaction are affected by the mixing of black carbon with other non-refractory and non-absorbing matter present in the atmosphere. Within this thesis we investigated the variability of the light absorbing properties of black carbon, the mixing of black carbon, and the impact on light absorption and ice activation.

In the first part of this thesis we investigated the spatial and seasonal variability of the mass absorption cross section (MAC) over Europe. MAC values were determined from ambient observations of elemental carbon mass concentrations (m_{EC}) and absorption coefficients (σ_{ap}). Site specific MAC values were found to be spatially homogeneous, suggesting that the overall MAC average 9.5 ± 1.9 m^2 g^{-1} at a wavelength of 637 nm might be representative of BC at European background locations.

The second part of the work focuses on the coating acquisition of BC and the induced absorption enhancement at the Zeppelin research site in Svalbard, Norway, during the Arctic spring. BC containing particles having a core diameter between 170 and 280 nm were found to have a median coating thickness of 47 nm. The observed coating thickness enhanced the mass absorption cross section by 46%.

In the final part of this work, the role of black carbon as ice nuclei in mixed phase clouds was investigated at the high elevation measuring site Jungfraujoch (Switzerland. BC containing particles were depleted in the ice residuals, with larger and thickly coated BC containing particles being activated more efficiently.

The results obtained in this thesis shed new light on the effect of the mixing state on the optical properties and cloud activation of black carbon particles. Absorbing properties of BC showed a distinct seasonal pattern, while aging was found to consistently increase its absorption behavior. However, black carbon was found not to act as ice nuclei in low tropospheric mixed-phase clouds, where the coating thickness might play a role in the activation efficiency. This work provides freshly determined physical properties derived from ambient observations that will improve the accuracy of future aerosol and cloud radiative forcing estimations.

Collaborations

Continuous collaboration with the Paul Scherrer Institute (Switzerland). Strong interaction with other European institutes: Barcelona (SPA), Leipzig (GER), Ispra (ITA), Clermont Ferrand (FRA), Stockholm (SWE), Oslo (NOR)

Publications à comité de lecture

Zanatta, M.; Gysel, M.; Bukowiecki, N.; Müller, T.; Weingartner, E.; Areskoug, H.; Fiebig, M.; Yttri, K. E.; Mihalopoulos, N.; Kouvarakis, G.; Beddows, D.; Harrison, R. M.; Cavalli, F.; Putaud, J. P.; Spindler, G.; Wiedensohler, A.; Alastuey, A.; Pandolfi, M.; Sellegri, K.; Swietlicki, E.; Jaffrezo, J. L.; Baltensperger, U.; Laj, P. A European aerosol phenomenology-5: Climatology of black carbon optical properties at 9 regional background sites across Europe. *Atmos. Environ.* **2016**, *145*, 346–364, doi:10.1016/j.atmosenv.2016.09.035.

Kupiszewski, P.; Zanatta, M.; Mertes, S.; Vochezer, P.; Lloyd, G.; Schneider, J.; Schenk, L.; Schnaiter, M.; Baltensperger, U.; Weingartner, E.; Gysel, M. Ice residual properties in mixed-phase clouds at the high-alpine Jungfraujoch site. *J. Geophys. Res. Atmospheres* **2016**, 2016JD024894, doi:10.1002/2016JD024894.

Autres publications et presentations

Laborde, M.; Schnaiter, M.; Linke, C.; Saathoff, H.; Naumann, K.-H.; Möhler, O.; Berlenz, S.; Wagner, U.; Taylor, J. W.; Liu, D.; Flynn, M.; Allan, J. D.; Coe, H.; Heimerl, K.; Dahlkötter, F.; Weinzierl, B.; Wollny, A. G.; Zanatta, M.; Cozic, J.; Laj, P.; Hitzenberger, R.; Schwarz, J. P.; Gysel, M. Single Particle Soot Photometer intercomparison at the AIDA chamber. *Atmos Meas Tech* **2012**, *5*, 3077–3097, doi:10.5194/amt-5-3077-2012.

Lim, S.; Faïn, X.; Zanatta, M.; Cozic, J.; Jaffrezo, J.-L.; Ginot, P.; Laj, P. Refractory black carbon mass concentrations in snow and ice: method evaluation and inter-comparison with elemental carbon measurement. *Atmos Meas Tech* **2014**, *7*, 3307–3324, doi:10.5194/amt-7-3307-2014.

2014 Actris General Assembly – Oral - (Athens, Greece)

2015 European Aerosol Conference – Oral - (Milan, Italy)

2016 European Geoscience Union – General Assembly – Oral and Poster - (Vienna, Austria)

2016 Actris General Assembly – Poster – (Frascati, Italy)

Expérimentations sur le terrain

2012: Ny-Alesund (Svalbard, NOR)

2013: Puy du Dome (France), Junfraujoch (Switzerland)

2014: Junfraujoch (Switzerland), Rostock (Germany)