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Aerosol complex refractive index retrieval in the Paris urban area and its forested surroundings during the ACROSS field campaign: variability and constraint for direct radiative effect estimation in regional models

Ludovico Di Antonio¹, Claudia Di Biagio², Matthias Beekmann², Aline Gratien², Paola Formenti², Astrid Bauville¹, Antonin Bérge¹, Joel Ferreira de Brito³, Mathieu Cazaunau², Servanne Chevaillier², Barbara D'Anna⁴, David Owen De Haan⁵, Olivier Favez^{6,11}, Cecile Gaimoz¹, Olivier Garret¹², Leila N. Hawkins⁷, Julien Kammer⁴, Brigitte Language^{1,14}, Franck Maisonneuve¹, Griša Močnik⁸, Anne Monod⁴, Gael Noyalet², Diana Pereira², Sebastien Perrier¹⁰, Jean-Eudes Petit⁹, Drew Pronovost⁷, Véronique Riffault³, Sydney Riley⁷, Matthieu Riva¹⁰, Marwa Shahin⁴, Guillaume Siour², Brice Temime-Roussel⁴, Chenjie Yu², Pascal Zapf², Gilles Foret¹, Jean-François Doussin¹, Christopher Cantrell^{1,13}, and Vincent Michoud²

¹Univ Paris Est Creteil and Université Paris Cité, CNRS, LISA, F-94010 Créteil, France

²Université Paris Cité and Univ Paris Est Creteil, CNRS, LISA, F-75013 Paris, France

³Centre for Energy and Environment, IMT Nord Europe, Institut Mine-Télécom, Université de Lille, Lille, 59000, France

⁴Aix Marseille Univ, CNRS, LCE, Marseille, France

⁵Department of Chemistry and Biochemistry, University of San Diego, 5998 Alcalá Park, San Diego, California 92110, United States

⁶Institut National De L'environnement Industriel et Des Risques (INERIS), Parc Technologique Alata BP2, 60550 Verneuil-en-Halatte, France

⁷Department of Chemistry, Harvey Mudd College, 301 Platt Blvd, Claremont, California 91711, United States

⁸Center for Atmospheric Research, University of Nova Gorica, Nova Gorica SI-5000, Slovenia

⁹Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS-UVSQ, IPSL, Université Paris-Saclay, 91191 Gif-sur-Yvette, France

¹⁰Univ. Lyon, Université Claude Bernard Lyon1, CNRS, IRCELYON, 69626 Villeurbanne, France

¹¹Laboratoire Central de Surveillance de la Qualité de l'Air (LCSQA), 60550, Verneuil-en-Halatte, France

¹²Ville de Paris, Service parisien de santé environnementale, 75013, Paris, France

¹³University of Colorado, Atmospheric and Oceanic Sciences (ATOC), Boulder, CO 80309

¹⁴now at Unit for Environmental Sciences and Management, North-West University, Potchefstroom, South Africa

The complex refractive index (CRI) is one of the key parameter driving aerosol spectral optical properties and direct radiative effects (DRE). Its value and spectral variation under different conditions, such as anthropogenic- and biogenic-dominated environments and anthropogenic-biogenic mixing situations, remains not fully understood. As a consequence, oversimplified representations of aerosol optical properties are generally used in climate models. Therefore, measurements of aerosol CRI in different environments and their inclusion in models are needed. The field observations from the ACROSS campaign, performed in June-July 2022 in the

Ile de France region, are used in this study to deepen the knowledge of aerosol optical properties, aiming to improve the aerosol representation in the CHIMERE model and provide the best constraint for DRE simulations. Measurements obtained both at the Paris city center and the Rambouillet rural forest sites during ACROSS are considered, in order to explore the CRI variability from anthropogenic-dominated to biogenic-dominated environments, including anthropogenic-biogenic mixing situations. The CRI retrievals at seven different wavelengths, performed by combining the Mie theory with optical and size distribution measurements, are representative of different atmospheric conditions, aerosol loadings as well as type and chemical compositions. In fact, the June-July 2022 period was characterized by highly diversified weather conditions: 1) two strong heatwaves, promoting SOA build-up and favoring the export of the Paris pollution plume towards the forest site; 2) Saharan dust events transported from the upper atmosphere to the ground; 3) biomass burning episode; 4) periods with reduced anthropogenic influence. The CRI retrievals under these different conditions and their link to particulate chemical composition is investigated. Hence, the CRI dataset presented here constitutes a unique dataset from which models can benefit to validate and constrain simulations and DRE estimations, under both urban and biogenic emissions influence. These data, in conjunction with those from the aircraft observations during ACROSS, are used to initialize and perform sensitivity studies on the aerosol DRE, using the CHIMERE-WRF coupled model, the OPTSIM model for the aerosol optical properties and the Rapid Radiative Transfer Model for GCMs (RRTMG).

Keywords: Complex refractive index, direct radiative effect, aerosol mixing, urban, forest