,

Laboratoire Inter-universitaire des Systèmes Atmosphériques

lisa

PROPOSITION DE STAGE DE RECHERCHE DE M2

LABORATOIRE : LISA, Laboratoire Interuniversitaire des systèmes atmosphériques

TITRE DU SUJET DE STAGE : Experimental and numerical study of the spectral optical properties of black carbon aerosols

COORDONNEES DU RESPONSABLE :

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SUJET :

It is now recognized that climate change is occurring and that atmospheric aerosols take part in it through a direct & indirect effect on the planetary energy balance. The direct radiative effect of aerosols, due to the scattering and absorption of shortwave (SW) and longwave (LW) radiation, is negative for most species (sulfates, dust,..) that mostly scatter SW radiation and so induce a net cooling of the Earth–atmosphere system. However, light-absorbing black carbon (BC) aerosols generated by fossil fuel combustion and biomass burning strongly absorb SW radiation and induce a positive effect at the Top-Of-Atmosphere that adds to global warming. By contributing to a large part of the total atmospheric absorption by aerosols BC is the main sources of global and regional warming after carbon dioxide.

As of today, the direct radiative effect of BC remains unknown and this because of the poor knowledge of its spectral optical properties driving the interaction with atmospheric radiation. These properties are: the complex refractive index (CRI=n-ik; the parameter describing the scattering/absorption particle capacity), the mass absorption (MAC, m^2g^{-1}), scattering (MSC), and extinction cross–sections (MEC) and the single scattering albedo (SSA; the scattering to extinction ratio). In particular little is known about the magnitude and spectral variation of these properties in ambient conditions (i.e. as a function of the relative humidity RH) and their possible modifications as a function of different atmospheric aging processes (i.e., heterogeneous reaction with gases), as well as the link to the particle chemical composition.

Two weeks experiments in the CESAM large simulation chamber (Experimental Multiphasic Atmospheric Simulation Chamber, *http://www.cesam.cnrs.fr*) available at LISA were performed in July 2019 in order to investigate BC spectral optical properties and their changes due to atmospheric aging. CESAM is a 4.2 m^3 evacuable, pressure– temperature– and humidity–controlled chamber where aerosols can be generated, maintained in suspension, processed, and deposited under controlled conditions. The chamber is equipped with state–of–the–art payload for the gas and aerosol phases. During experiments, the extinction spectrum of BC was measured in situ at high spectral resolution in the continuum SW to LW spectral range and at different RH levels thanks to an in situ UV-Vis spectrometer

(0.3–1 µm range, 1 nm resolution) based on a multi-reflection white cell that is a recent major innovation of CESAM and that will combine to an FTIR spectrometer already available in the chamber (2–16 µm range, <0.05 µm resolution). In combination, a set of "classical" optical instruments working at discrete wavelengths in the SW were employed (Cavity Ring Down and filter–based techniques).

For experiments, the BC aerosols were generated by a commercial burner and different experiments were performed with the aim of investigating the impact of different aging processes on the optical properties of the aerosols. In particular BC were 1/ left to coagulate in the chamber to investigate possible morphological restructuration; 2/ BC were made to interact with water, ozone and SO_2 or alfa-pînene to form a sulfate or organic coating around the particles.

The size, density, mass and morphology of the suspended aerosols and their changes during aging were monitored by a complete set of advanced techniques (optical/mobility sizers, a centrifugal particle mass analyser, and electronic transmission microscopy). A comprehensive study of the chemical composition was also performed by combining different state–of–the–art techniques.

The objective of the stage is to take in charge the analysis of optical and size distribution measurements in order to derive the optical signals and size spectrum of the BC and analyze their changes between and during experiments in link with particle aging. Optical and size data will be then combined and used to derive the complex refractive index of the aerosols by numerical modelling using an appropriate optical theory. Results will be combined with the literature and interpreted to investigate the relationship to composition.

Skills required: data analysis, programming capabilities (IDL, R, or others)

Prerequisites: knowledge in aerosols physics or atmospheric radiative transfer

Length: 4–6 months

Starting date: flexible (February to March 2020)