Funded CNRS PhD Student Opportunity, France

Start between 01/10/2021 and 01/12/2021

Constraining the radiative effects of complex aerosol mixtures in southern Africa: an experimental study of their chemical composition, spectral optical properties and hygroscopicity

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Climate projections point to southern Africa as a climate change hotspot, where drastic warming and drier conditions will occur[1]. In recent decades, temperatures in the interior regions have risen at about twice the global temperature increase[2]. Under low-mitigation emission scenarios (RCP8.5), southern Africa, including Namibia, could face temperature rises of 3-4°C by mid-century and 4-7°C by the end of the century[2,3]. Temperature increases translate into increased extreme events such as heatwaves and a more prolonged and intense burning season[2]. These projected changes imply potential risks to agricultural, economic productivity, human and ecological systems, health, and water resources[4,3], including the Namibian fog, a medium and vector to deliver, supply, and regulate the flow of critical limiting resources (water, elements, light) to one of the most extreme climate regimes and ecosystems of southern Africa, the hyper-arid coastal Namib desert.

Climate projections are still characterised by an inadequate process-based understanding of thermodynamic and circulation changes in the atmosphere. Crucial to this process-level understanding are aerosol particles, short-lived, reactive species influencing global climate through direct interactions with radiation and indirectly as cloud condensation nuclei. The Intergovernmental Panel for Climate Change Assessment Reports emphasised that aerosols contribute the largest uncertainty to evaluating the global radiative forcing[5], as information on the global aerosol distributions, composition, microphysical properties, and ageing in the atmosphere are lacking[5].

The objective of this thesis work is to contrain the light-absorption and hygroscopicity properties of the complex organic/inorganic aerosol mixtures that characterise the Namibian ecosystems as a result of the interplay of the seasonal forest fires, the oceanic biogenic emissions and the aeolian erosion mineral dust. This work will be based on intensive field observation periods that be conducted at the Gobabeb Research and Training Center, in the heart of the hyperarid Namib Desert, and on the analysis of collected samples using the new PRAMMICS (Plateforme Régionale d'Analyse Multi-Milieux des Micro-contaminants) analytical platform at LISA in Créteil. The thesis will combine a detailed characterisation of the inorganic and organic composition of aerosols, including elemental tracers, water-soluble fraction, organic acids, and sugars by meansof state-of-the-art analytical techniques (XRF, ICP-MS, IC, thermo-optical analysis, ….), to the observation of the light optical properties using in situ (nephelometer, aethalometer) and remote sensing techniques (sunphotometer, radiometer).

Context. This thesis work is part of the project "A novel French-South Africa synergy to advance the characterisation and radiative impacts of aerosols in southern Africa" which is funded as part of the Wits-CNRS 2021 PhD joint programme framework by the Centre National de la Recherche Scientifique (CNRS) and the University of the Witswatersrand (Wits) for the period 2021-2024. The project aims at reducing uncertainties in the estimation of the radiative effect of carbonaceous aerosols on the southern African climate. The primary objective of the project is to advance the characterisation of direct and indirect radiative effects of aerosols in southern Africa using advanced modelling with the first African-based Earth System Model (WITS) and extensive characterisation of the speciation, light-absorption properties, hygroscopicity and solubility of complex aerosol mixtures, particularly secondary organic aerosols and mineral dust (CNRS).

Expected results. The study will allow characterizing the spectral light-absorption and hygroscopic properties of complex aerosol mixtures to relate these properties to the chemical composition. In particular, this research project will achieve the chemical speciation of secondary organic aerosols (SOA) that are expected to be a significant fraction of the sampled aerosol in this region, as well as a dominant global aerosol specie. This PhD research project will provide with the most relevant aerosol microphysical models which will serve to evaluate the microphysical schemes of the African-based Earth System Model and to allow a major advances in estimating the aerosol radiative forcing in the regional climate of southern Africa.

Hosting laboratory. Joint research unit of the CNRS, the University Paris-Est Créteil and University of Paris, the LISA is based in Créteil, in the outskirts of Paris, less than 30 minutes by public transport (metro and suburban train) from the Paris city centre. The successful candidate will beneficiate of the international working environment of MEREIA group at LISA (>15 staff members, post-doc and graduate students of more than 5 nationalities), and will profit from an interdisciplinary, innovative and dynamic extensive training, in addition to personal development possibilities. Net salary is around 1715 euros per month, inclusive of full social benefits (insurance, medical care, pension fund).

Possible collaborations. The PhD student will be led to interact and collaborate with different actors in France and internationally, which will contribute crucially to his/her scientific enrichment. This thesis works articulates around field observations at the Gobabeb Research and Training Center conducted in collaboration with the NorthWest University in South Africa. Field observations will provide a complete characterisation of the aerosol mixtures occurring in the region, and their potential to shape low clouds and fog, which will be used to constrain the aerosol models within the first African-based Earth System Model by the Global Change Institute at the University of the Witwatersrand in South Africa. The PhD student will be able to take advantage of this scientific dynamism within the MEREIA group and interact in a privileged way with several actors of the international community working on the same research topic.

Profile and skills. The candidate must have a master's degree in chemistry or physics and have a good knowledge of atmospheric sciences. Knowledge of radiation transfer and/or organic chemistry will also be appreciated. The candidate must have programming skills (R, IDL, Python,...), capacities in statistical analysis of data sets, a good level of English (oral and written), as well as a taste for teamwork and strong motivation. Ability and willingness to travel and conduct extensive field work are mandatory.

Please send applications including CV, motivation letter and name of one or two reference persons to Paola Formenti (paola.formenti@lisa.ipsl.fr)

References

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