# New in situ and satellite observations of complex aerosols over Namibia

1. **Scientific context**

The poor characterization and representation of aerosols in the earth's global radiative budget is the largest source of uncertainty in climate models. Contributions from different aerosol sources are difficult to measure, predict and model. Their composition, size and morphology evolve with time and vary in height within the atmosphere. Their effects on the earth's radiative budget are non-linear, not only through their influence on cloud formation, but on their ability to scatter and absorb short-wave and long-wave radiation. The resultant magnitude of the radiative forcing can vary from slightly negative to strongly positive, depending on the presence of clouds, absorbing aerosols and scattering aerosols, as well as their vertical distribution.

The southeast Atlantic is an ideal region to investigate the extent and the importance of the aerosols-radiation-clouds interactions and their effect on the radiative budget, the weather and climate. Low sea-surface temperatures off the coast maintain a semi-permanent stratocumulus cloud deck, extremely effective in reflecting short-wave radiation. Frequent upwelling of dust, lofting biomass burning plumes from extensive fires across southern Africa, marine aerosols and both urban and shipping pollution contribute to the aerosol burden in this region.

Recent international field campaigns, including the French AEROCLO-sA project funded by the CNES, have provided with significant advances on the properties and the impacts of the seasonal biomass burning aerosols transported over southern Africa, amongst all thanks to the synergetic use of in situ and remote sensing measurements. Indeed, in situ measurements are extremely valuable in their capability of using a multitude of sophisticated instrumentation to measure the physical, chemical and optical properties of aerosols. Remote-sensing instrumentation on board satellites, and their demonstrators, while providing less comprehensive direct measurements of aerosol properties, have the benefit of providing long term observations across much of Earth's surface.

Still, high uncertainties persist on light-absorbing properties of the regional aerosols and their interactions with radiation exist. Important and uncertain properties are the spectral extinction, representing the optically active concentration fields; and the wavelength-dependent single scattering albedo, representing the properties of aerosols to absorb and scatter light. These optical properties depend on the physico-chemical (composition, size, morphology and mixing state) properties of the aerosols and must be known as a function of height.

1. **A unique aerosol observational dataset in Namibia**

To fill these science gaps, a new long-term station for in situ aerosol observations has been started by LISA in April 2022 at the Gobabeb Namib Research Institute (23°33’40”S, 15°02’24”E), in the hyperarid Namib desert in Namibia. The new station, targets as much as possible core variables defined by the Global Atmospheric Watch (GAW) program of the World Meteorological Organisation (WMO) and recognized as essential climate variable (ECVs) for Global Climate Monitoring application areas (GCOS), that is the spectral extinction, the single scattering albedo and the particle number size distribution. The station provides with a detailed and long-term quantification of the mass concentrations, the chemical composition and the scattering and absorption optical properties of the surface aerosols. The surface in situ measurements are completed by the columnar measurements by an AERONET sunphotometer. Gobabeb is also long-term site for the «Baseline Surface Radiation Network» (BSRN), providing with spectral radiation measurements at the surface and a ceilometer measuring the aerosol vertical profile, and one of the CAL/VAL stations of the CEOS program, contributed by CNES and ESA.

The first year of observations have allowed validating the measurements, and have shown that Gobabeb is receiving different air masses laden with different aerosol types, both at the surface that along the column. Henceforth the surface station, unique in southern Africa, provides with the possibility of investigating the properties of the complex aerosol mixtures, evaluating their vertical stratification, and estimate their direct radiative effect, at the surface and at the top of the atmosphere.

1. **New remote sensing capabilities**

Recently, an original approach exploiting the new multispectral and hyperspectral capabilities of MetOp and Sentinel 5 Precursor, have provided with new capabilities of observing from space the three-dimensional (3D) distribution of natural and anthropogenic aerosols. Currently, the AEROS5P method applied to the TROPOMI sensor on Sentinel 5 Precursor, which has a particularly fine spatial resolution (5.5 x 3.5 km2), adapted to urban scale, and point sources. Thanks to successive PhDs, the **AEROS5P approach is now adapted to multiple species, including biomass burning, aerosols, mineral dust, and pollution, which make it particularly suitable for advancing our knowledge in southern Africa.**

**Additionally, a new methodology designed to derive aerosol vertical profiles of optical and microphysical properties simultaneously from multi-wavelength lidar measurements of the future CNES/NASA AOS mission is currently being developed at the LISA in collaboration of the LOA laboratory and the GRASP-SAS method.**

1. **The PhD subject**

The proposed PhD subject **aims at providing an original and integrative characterization of the ageing and mixing of aerosols emitted and transported over Namibia, and the implications for radiative effects.** The PhD **will investigate the atmospheric stratification that confines mineral dust, ship plumes and pollution from domestic fires in the surface layer below 1 km. These light-absorbing aerosols are extremely important for the regional climate as they can, by semi-direct effect, dissipate the low-clouds and fog which provide with water to the desert ecosystem. It will also target the description of the evolution of the light-absorbing properties of biomass burning aerosols during the long-range transport within the so-called “rivers of smoke”, intense and defined plumes which dilute and age with time.**

**The strategy of the PhD will be based on a synergistic approach combining in situ surface observations at Gobabeb, the AEROS5P retrievals, as well as complementary spaceborne and ground-based remote sensing products (CALIOP, CATS, MODIS, AERONET, ….) to analyze in priority the two types of situations mentioned above, which have been proven very relevant to the regional and continental climate**. In situ measurements will describe the evolution of optical and microphysical properties of aerosol plumes at different stages of aging and mixing. Satellite observations will be used to assess the 3D pathways of aerosols arriving to Namibia. The in situ/satellite synergism will enable the construction of well documented aerosol models in terms of size distributions and intensive optical properties that will be used as a priori inputs for remote sensing validation. Finally, the aerosol properties and spatial distribution derived from the synergism of in situ and satellite data will be used as input for a radiative transfer model for estimating their direct radiative impact.

**This PhD will provide with new knowledge of the southern African aerosols and its direct radiative effect taking advantage of two areas of expertise, in situ measurement and multi-spectral satellite retrieval. In this respect, it will provide a valuable contribution and a proof-of concept for the preparation of the AOS mission, which will particularly aim the synergism of satellite and suborbital observations for providing a new characterization of aerosols.**

**Your skills**

Master in atmospheric physics or chemistry. Proficiency in data analysis and computer programming **(R, IDL, Python, FORTRAN ...)**. Knowledge of observations and remote sensing. **A good knowledge of English (oral and written) is required. Strong motivation, enthusiasm and willingness to communicate within an international group are requested.**

**Your working environment**

The Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA) is an international leading French institution in atmospheric chemistry and physics for climate, air pollution and human health. 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 supervision of experts in sin situ observations (Dr. P Formenti) and aerosol remote sensing (Dr J. Cuesta), within the international working environment of LISA (post-doc and graduate students of more than 5 nationalities), where she/is will profit from an interdisciplinary, innovative and dynamic extensive training, in addition to personal development possibilities.

The PhD will be conducted in collaboration with GRASP-SAS and the Laboratoire d’Optique Atmospherique (LOA, Dr O. Dubovik), which will provide the candidate with further international exposure on front-edge research and transferable working skills.

To apply

Please send enquiries and applications to

Paola Formenti: paola.formenti@lisa.ipsl.fr