EGU23-465

Sharing is encouraged

New observations of climate-relevant properties of atmospheric aerosols in Namibia, southern Africa

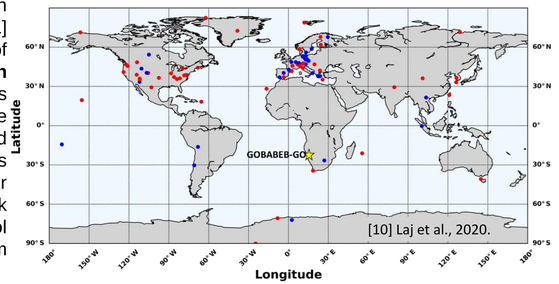
francois.hemeret@lisa.ipsl.fr

F. Hemeret[1], P. Formenti[1], C. Di Biagio[1], B. Language[2], S. Chevaillier[1], A. Feron[1], M. Cazaunau[1], R. Torres-Sánchez[3], S.J. Piketh[4], F. Engelbrecht[5], R. Moola[6], U. Bezuidenhoudt[7], B. Luyanda[7], E. Marais[7] and G. Maggs-Kölling[7]

(1) Université Paris Cité and Univ Paris Est Creteil, CNRS, LISA, F-75013 Paris, France; (2) Univ Paris Est Créteil and Université Paris Cité, CNRS, LISA, F-94010 Créteil, France; (3) Univ Paris Est Créteil and Université Paris Cité, CNRS, LISA, F-94010 Créteil, France & CIQSO, Robert H. Grubbs Building, University of Huelva, Campus El Carmen, E21071 Huelva, Spain; (4) North-West University, School for Geo- and Spatial Sciences, Potchefstroom, South Africa; (5) University of the Witwatersrand, Global Change Institute, Johannesburg, South Africa; (6) University of the Witwatersrand, School of Geography, Archeology and Environmental Studies, Johannesburg, South Africa; (7) Gobabeb-Namib Research Institute, Walvis Bay, Namibia

Introduction

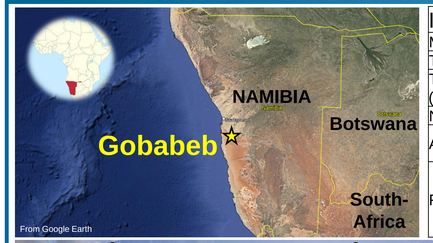
Context and motivations : Southern Africa, and in particular its western part, Namibia, is considered a **climate change hotspot** by the IPCC [1] and is at risk of severe temperature-related changes. The role of **aerosols** in this context is still not completely quantified, due to **their high spatial and temporal variability**, as well as the many sources responsible for **the complex mixture.** Most of the past regional climate modelling (RCM) [2] and intensive field campaigns [3]-[8] focussed primarily on constraining the radiative effects of the seasonal biomass burning aerosols generally occurring in the end of the austral winter (August to October), above the boundary layer. However, due to the lack of continuous observations as shown in the figure on the right, the aerosol spectral optical properties are not studied enough to provide a firm understanding of regional aerosol load and interaction with radiation [9].



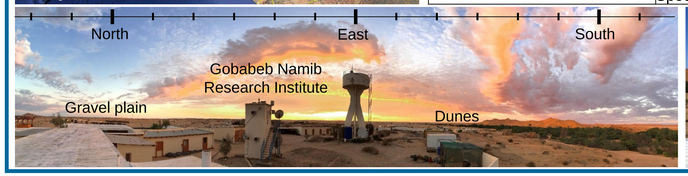
Here we present the first long time series of aerosol observations at ground level in Namibia. We address the following scientific questions :

1. What are aerosol mass concentration and optical properties in the boundary layer over continental Namibia?
2. What is the aerosol vertical stratification through the atmospheric column?
3. What is their temporal variability?

A new aerosol observation station



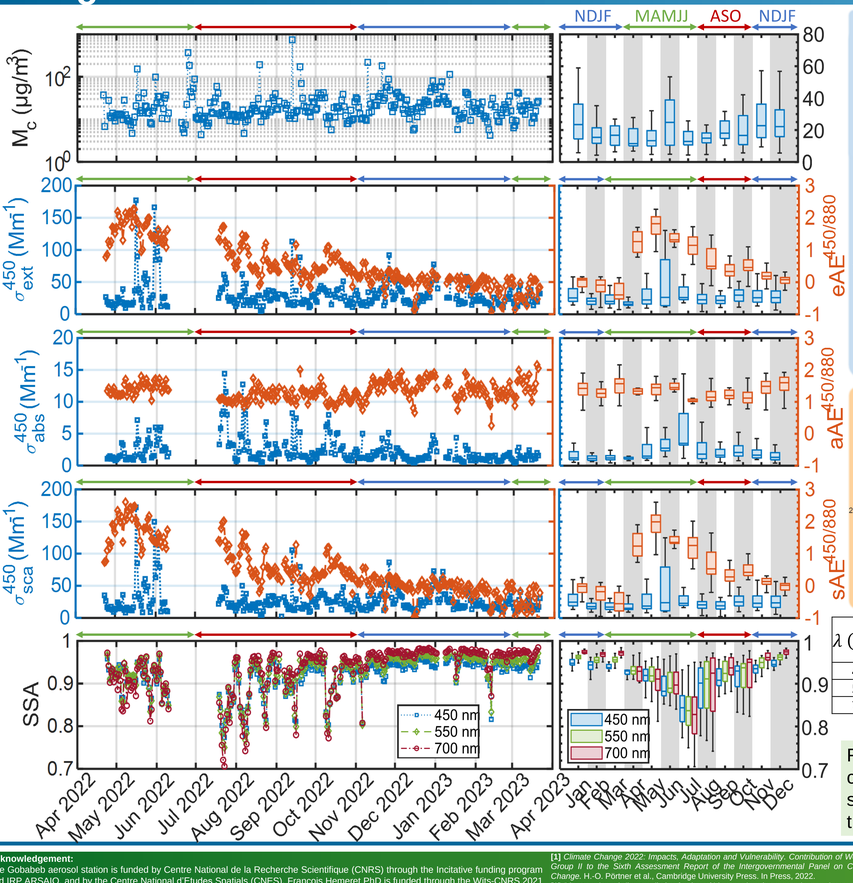
Instrument	Observable
Microbalance Thermo Inc. TEOM	Mass concentration M_c
TSI CPC (model 3010)	Number concentration N_c
TSI Aerodynamic Particle Sizer (APS)	Size distribution (0.5-20 µm diameter) $dN/d\log D_p$
Nephelometer TSI (model 3596)	Scattering coefficient @ 450, 550, 700 nm σ_{sca}
Aethalometer Magee Sci. (AE31)	Absorption coefficient @ 370, 420, 470, 590, 660, 880, 950 nm σ_{abs}
Filter sampling	Aerosol chemical composition (sulfate, black carbon, organic carbon, brown carbon, dust, sea salt …) $C_{sulfate}$, C_{BC}, C_{OC}, C_{BrC}, C_{dust}, C_{salt} Spectral absorption UV/Vis/IR

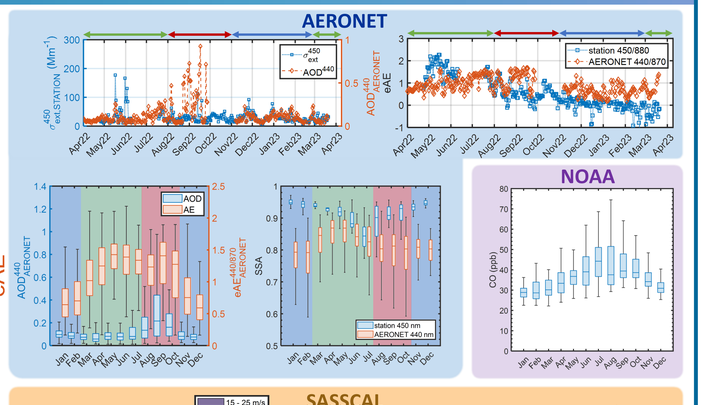


Derived properties studied:

1. Single scattering albedo: $SSA = \frac{\sigma_{sca}}{\sigma_{abs} + \sigma_{sca}}$
2. Extinction coefficient: $\sigma_{ext} = \sigma_{abs} + \sigma_{sca}$
3. Angstrom exponent: $AE = \frac{\log\left(\sigma_{ext}^{\lambda_1} / \sigma_{ext}^{\lambda_2}\right)}{\log\left(\lambda_1/\lambda_2\right)}$
4. Mass ext (abs, sca) efficiencies: $MEE(MSE, MAE) = \frac{\sigma_{ext,abs,sca}}{M_c}$

Long-term time series



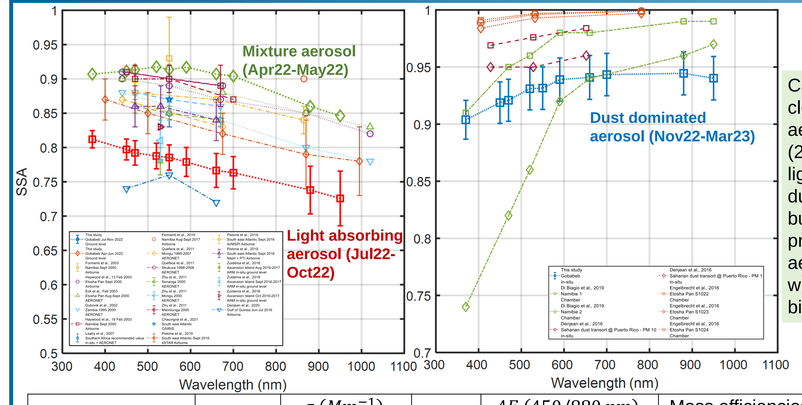


λ (nm)	σ (Mm^{-1}) ext	abs	sca	SSA	AE (450/880 nm) ext	abs	sca	Mass efficiencies(m^2/g) Ext	abs	sca	M_c $(\mu g/m^3)$
450	29.2 ± 3.0	2.27 ± 0.28	26.4 ± 2.7	0.9189 ± 0.0056				2.03 ± 0.16	0.21 ± 0.056	1.87 ± 0.12	
550	26.5 ± 2.6	1.71 ± 0.23	24.3 ± 2.5	0.9278 ± 0.0064	0.476 ± 0.099	1.333 ± 0.040	0.43 ± 0.11	1.78 ± 0.12	0.16 ± 0.047	1.660 ± 0.091	27.8 ± 7.3
700	23.9 ± 2.2	1.26 ± 0.18	22.3 ± 2.1	0.9339 ± 0.0076				1.605 ± 0.099	0.13 ± 0.037	1.538 ± 0.080	

$mean \pm k\frac{std}{\sqrt{n}}$ with k a coverage factor taken equal to 3

First long-term time series of aerosol observations in the boundary layer of continental Namibia show low level of aerosol mass concentration with no seasonality, but with clear seasonality of optical properties and size, in relation to the column and the regional seasonality of aerosol loading.

Case studies



Case studies show (1) a clear influence of dust aerosol during summer (2) strong influence of light absorbing aerosol during the biomass burning season (3) the presence of a mixt aerosol during autumn with potential impact of biomass burning aerosols

Aerosol type	λ (nm)	σ (Mm^{-1}) ext	abs	sca	SSA	AE (450/880 nm) ext	abs	sca	Mass efficiencies(m^2/g) ext	abs	sca	M_c $(\mu g/m^3)$
Light absorbing aerosol	450	39 ± 12	8.1 ± 2.8	31.2 ± 9.8	0.797 ± 0.015				4.35 ± 0.99	0.89 ± 0.20	3.41 ± 0.86	
	550	30.5 ± 9.3	6.7 ± 2.3	23.7 ± 7.1	0.785 ± 0.018	1.28 ± 0.29	0.97 ± 0.16	1.42 ± 0.31	3.44 ± 0.80	0.74 ± 0.18	2.64 ± 0.69	12.4 ± 3.3
	700	22.0 ± 6.2	5.4 ± 1.8	16.6 ± 4.6	0.763 ± 0.023				2.58 ± 0.62	0.60 ± 0.15	1.90 ± 0.50	
Dust-dominated aerosol	450	24.7 ± 7.1	1.9 ± 0.74	22.8 ± 6.5	0.919 ± 0.017				1.71 ± 0.25	0.157 ± 0.075	1.57 ± 0.20	
	550	23.3 ± 6.5	1.5 ± 0.62	21.8 ± 6.1	0.932 ± 0.018	0.31 ± 0.26	1.24 ± 0.14	0.26 ± 0.28	1.58 ± 0.21	0.122 ± 0.056	1.48 ± 0.18	29 ± 18
	700	21.6 ± 5.8	1.1 ± 0.50	20.5 ± 5.5	0.943 ± 0.018				1.52 ± 0.27	0.094 ± 0.040	1.45 ± 0.28	
Mixture aerosol	450	36.8 ± 4.2	2.3 ± 0.17	34.4 ± 4.0	0.9116 ± 0.0033				1.71 ± 0.41	0.157 ± 0.026	1.57 ± 0.38	
	550	29.7 ± 3.6	1.6 ± 0.12	28.0 ± 3.4	0.9136 ± 0.0036	1.628 ± 0.036	1.373 ± 0.028	1.754 ± 0.043	1.58 ± 0.32	0.122 ± 0.021	1.48 ± 0.31	32.0 ± 7.8
	700	21.7 ± 2.7	1.2 ± 0.11	20.5 ± 2.6	0.9041 ± 0.0045				1.52 ± 0.22	0.094 ± 0.018	1.45 ± 0.21	

Conclusion and perspectives

Boundary layer of continental Namibia is overall dominated by dust aerosol with low mass concentration. Clear seasonality of optical properties was observed, due to **(1)** presence of dust dominated aerosol in summer Nov-Feb **(2)** pre-burning season impact in Mar-Jul with aerosol mixt of dust/light absorbing aerosol that could be BBA **(3)** High absorbing aerosol events during the biomass burning season in Aug-Oct. Comparison with AERONET observations also show some similarity with ground measurement during the pre-burning season.

What comes next ?
- Confront result with RCM
- Radiative effects calculation

More data to analyse :
- Chemical analyses of filter sampling
- Ceilometer
- Size distribution

Acknowledgement:
The Gobabeb aerosol station is funded by Centre National de la Recherche Scientifique (CNRS) through the Incitative funding program and IRP ARSAIO, and by the Centre National d'Etudes Spatiales (CNES). François Hemeret PhD is funded through the Wits-CNRS 2021 PhD joint programme. The authors thank the AERONET team for establishing and maintaining the sunphotometer at Gobabeb. We are also grateful to the NOAA Global Monitoring Team and especially to Dr. G. Petron for giving access to the latest CO observation.

[1] *Climate Change 2022: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* H.-O. Pörtner et al., Cambridge University Press, In Press, 2022.
[2] *Direct and semi-direct radiative forcing of biomass-burning aerosols over the southeast Atlantic (SEA) and its sensitivity to absorbing properties: a regional climate modelling study.* M. Mallet et al., Atmospheric Chemistry and Physics, 20, 13191-13216, 2020.
[3] *The Aerosols, Radiation and Clouds in Southern Africa field campaign in Namibia.* P. Formenti et al., American Meteorological Society, 2019.
[4] *The southern African Regional Science Initiative (SAFARI 2000): overview of the dry season field campaign.* R.J. Swap et al., South African Journal of Science, 98, March/April 2002.
[5] *Overview of the Dust and Biomass-burning Experiment and African Monsoon Multidisciplinary Analysis Special Observing Period-0.* J.M. Haywood et al., Journal of Geophysical Research: Atmospheres, American Geophysical Union, Vol. 113, D00C17, 2008.
[6] *An overview of the ORACLES (ObsoRvations of Aerosols above Clouds and their intEractionS) project: aerosol-cloud-radiation interactions in the southeast Atlantic basin.* J. Redemann et al., Atmospheric Chemistry and Physics, 21, 1507-1563, 2021.
[7] *Layered Atlantic Smoke Interactions with Clouds (LASIC) Science Plan.* P. Zuidema et al., U.S. Department of Energy, DOE/SC-ARM-14-037, December 2015.
[8] *The CLoud-Aerosol-Radiation Interaction and Forcing: Year 2017 (CLARIFY-2017) measurement campaign.* J.M. Haywood et al., Atmospheric Chemistry and Physics, 21, 1049-1084, 2021.
[9] *Short-Lived Climate Forcers.* In: *Climate change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* S. Szopa et al., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 817–922, 2021.
[10] *A global analysis of climate-relevant aerosol properties retrieved from the network of Global Atmosphere Watch (GAW) near-surface observatories.* P. Laj et al., Atmos. Meas. Tech., 13, 4353-4392, 2020.

Data management

Data base of those observation is in preparation by the French national center for Atmospheric data and services AERIS. Meanwhile they can be requested to **francois.hemeret@lisa.ipsl.fr & paola.formenti@lisa.ipsl.fr**.