ARSAIO Overview: Atmospheric Research in Southern Africa and Indian Ocean: A South Africa – France bilateral collaborative programme

Venkataraman Sivakumar, Hassan Bencherif, Cathy Liousse, J. P. Beukes, Gideon van Zyl, Paola Formenti, S. J. Piketh, Caradee Yael Wright

News

ARSAIO Overview: Atmospheric Research in Southern Africa and Indian Ocean: A South Africa – France bilateral collaborative programme

Venkataraman Sivakumar[1], Hassan Bencherif[2], Cathy Liousse[3], Johan Paul Beukes[4], Pieter Gideon van Zyl[4], Paola Formenti[5], Stuart Piketh[4] and Caradee Yael Wright[6]

[1] School of Chemistry and Physics, University of KwaZulu-Natal, Durban, South Africa
[2] Laboratoire de l'Atmosphère et des Cyclones, CNRS UMR 8105, Reunion University, Reunion Island, France
[3] Laboratoire d'Aérologie, CNRS UMR 5560, Toulouse, France
[4] North West University, Potchefstroom, South Africa
[5] Laboratoire Interuniversitaire des Systèmes Atmosphériques, CNRS UMR 7583
[6] South African Medical Research Council, Environment & Health Research Unit, and University of Pretoria, Department of Geography, Geoinformatics and Meteorology, Pretoria, South Africa

The "Atmospheric Research in Southern Africa and Indian Ocean" (ARSAIO) project is a research consortium of more than 25 researchers and 30 students. It is funded through a bi-lateral research programme between South Africa and France. The first phase was completed in December 2013. Now in its second phase, the project shall be completed by the end of 2017. Here, we provide an overview of the Universities/Institutes involved and French and South African co-ordinators who are investigating the structure and dynamics of the atmosphere by utilising different in-situ, space-borne and model simulation techniques.

Introduction

In the present context of global change, atmospheric and climatic research should be more organized in the framework of international collaborations and research networks. During recent years, the importance of systematic monitoring of atmospheric structure, dynamics and composition has been confirmed by satellite and ground-based observations. Together with land use change, the aerosol burden disrupts the surface/atmosphere radiative balance, as well as cloud properties, and induces regional climatic impacts. Over southern Africa, and the neighbouring oceanic regions of the Indian Ocean, these regional impacts are influenced by dynamical climate variability and play an important role in global climate change. The quantitative characterisation of these anthropogenic aerosols and their relative climatic impact is still uncertain. In this domain, the improvement and the use of integrative climate modelling tools is a necessity for environmental management and climate change mitigation (IPCC 2001, 2007). Compared to developed regions of the northern hemisphere, the tropical and austral regions of the southern hemisphere are poorly documented in terms of climate change, even though they are important components of the global atmosphere.

Scientific collaborations between French and South African laboratories started in the early 1990's with the SAFARI 1992 project dealing with the atmospheric impact of biomass burning in southern Africa. Then a long-term strong collaboration was established between French (Laboratoire d'Aérologie) and South African groups (Potchefstroom University, now called North-West University), through the IDAF (IGAC DEBITS Africa) network. Since 1994, both laboratories have been involved in the development of an African network devoted to the study of tropical atmospheric chemistry and deposition though the framework of the global programme DEBITS. This collaboration led to a cooperation programme (PICs) dealing with air pollution and climate change in South Africa called SACCLAP (Seasonal and annual trends of air quality at the South Africa scale and its impact on regional climate, health and biogeochemical cycles).

In 1997, the Laboratoire de l'Atmosphère et des Cyclones (LACy, Reunion University) and the Service d'Aéronomie (now called LATMOS) initiated a collaboration in atmospheric sciences with the University of KwaZulu-Natal (UKZN). This collaboration resulted in the implementation of a LiDAR (Light Detection and ranging) system in Durban. The Durban LIDAR was installed in 1998 - 1999, and the first operational measurements took place in 1999 (Bencherif et al., 2000). French operators and engineers travelled to Durban under the framework of a bilateral research Memorandum of Understanding to operate the system during specific campaigns (5 campaigns of several weeks each year from 1999 to 2005) and to maintain it (ten times in less than ten years). With the help of South African students and thanks to the Reunion University Student Exchange Programme, more than 20 Masters students have been able to travel to Durban to contribute to LiDAR campaigns, learn about LiDAR and other remote sensing technics, and have helped with data analysis. This cooperation has achieved nearly 400 measurement nights during the 1999-2005 period. It has resulted in one completed PhD degree, co-supervised by French and South African scientists, and several publications in peer-reviewed scientific journals.

Several cooperation projects in atmospheric research between French Centre National de le Recherche Scientifique (CNRS) laboratories and South African universities or institutes have been conducted, but they often rely on individual initiatives between two research groups. These collaborations would certainly benefit from a general collaboration framework that could be provided by an international research consortium, hence the 'Atmospheric Research in Indian Ocean and Southern Africa' (ARSAIO) project was established in 2010 by Venkataraman Sivakumar and Hassan Bencherif. The structure of the project aims to foster exchanges of scientist and students, and contribute to building important

scientific projects that could be supported by the European Union, by the French National Research Agency (ANR) or by other international institutions.

Research actions

The primary objective of the project ARSAIO (Atmospheric Research in Southern Africa and Indian Ocean) is to co-ordinate and work-together for investigating the structure and dynamics of the atmosphere by using ground-based, in-situ, space-borne and model simulation techniques. The ARSAIO research activities focus on obtaining a better understanding of southern tropics/sub-tropical areas, including:

- Atmospheric pollution and climate change in southern Africa;
- Troposphere ozone and aerosol studies over the Indian Ocean Region;
- Greenhouse gas and solar ultraviolet radiation measurements;
- Middle atmosphere dynamics and thermal structure;
- Water vapour variability in the Upper Troposphere-Lower Stratosphere (UT-LS) region; and
- Stratospheric ozone variability, transport and mixing processes in the southern tropics.

Several measurement sites around the region are involved in the project (Figure 1). The project further strengthens the research collaboration between participating French and South African partners in order to understand the aerosol and dust characteristics in the sub-tropical Southern Hemisphere. Globally, the sub-tropical Southern Hemisphere region is the least understood due to the lack of ground-based and remote sensing instruments.

The main objective of the GDRI project is to coordinate research actions and to provide a framework to build cooperative projects in response to calls for proposals from the European Union (EU), or other funding agencies.

The project involves the participation and training of Doctoral and Masters students as well as collaborations between South Africa and France. In addition to human capital development and student/research exchange between the countries, a research network exists and a number of joint research publications have been produced (see next column).

The present GDRI ARSAIO project (2nd phase) is organized into three research actions jointly managed by a French and a South African coordinator:

- Action 1: *Impact of anthropogenic pollution on southern Africa on climate change and health*
- Action 2: *Transport and deposition of mineral dust in western southern Africa*
- Action 3: *Stratosphere and troposphere interactions: ozone, water vapour, aerosols and UV radiations variability and change*

Annual workshops, conference, seminars, and training programmes are carried out to discuss research results, strengthen the research focus of the collaboration and strength student involvement in the project. To date, this has been a successful collaboration with several publications produced. A list of the most recent research articles is provided below:

- Toihir M, Bencherif H, Sivakumar V, El Amraoui L, Portafaix T, and Mbatha N. Comparison of total column ozone obtained by the IASI-MetOp satellite with ground-based and OMI satellite observations in the southern tropics and subtropics, *Ann Geophys* 2015, 33: 1135–1146.
- Liousse C, Assamoi E, Criqui P, Granier C and Rosset R, African combustion emission explosive growth from 2005 to 2030, *Environ. Res Letters* 2014. DIO:10.1088/1748-9326/9/3/035003.
- Vet R, Richard S, Carou S, Shaw M, Ro C, Aas W, Baker A, Bowersox VC, Dentener F, Galy-Lacaux C, Hou A, Pienaar JP, Gillett R, Forti MC, Gromov S, Hara H, et al. A global assessment of precipitation chemistry and deposition of sulfur, nitrogen, sea salt, base cations, organic acids, acidity and pH, and phosphorus. *Atmospheric Environment* 2014, 93: 3-100.
- Olakunle O, Sivakumar V and Mbatha N. A case study of energy deposition and absorption by magnetic cloud electrons and protons over the high latitude stations effects on mesosphere and lower thermosphere, J. Terr. *Atmos and Oceanic Sciences* 2014, 25(2): 219-232.

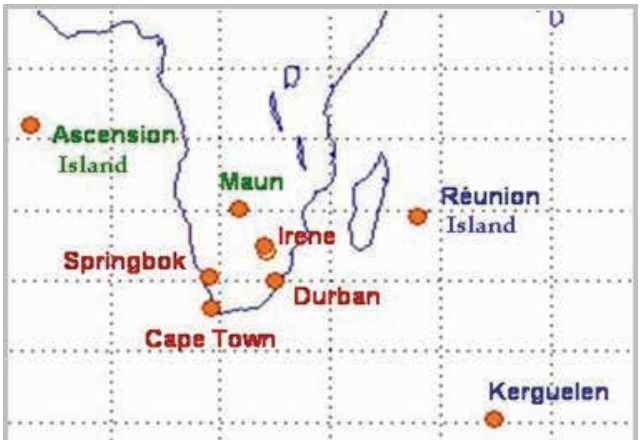

***Figure 1**: Location of French, South African and complimentary observational sites used in the framework of the GDRI ARSAIO project.*

Acknowledgements

The ARSAIO project is supported by the French Centre National de la Recherche Scientifique (CNRS) and the South African National Research Foundation (NRF-UID 78682). Authors acknowledge the CNRS and NRF for their continuous financial support.

References

Bencherif H, Morel B, Moorgawa A, et al., 2000, First validation of stratospheric temperature profiles obtained by a Rayleigh LIDAR over Durban, South Africa. *South African J. of Sci*., 96:487–492., 2000.

IPCC, 2001, *Third Assessment Report of the Intergovernmental Panel on Climate Change: Mitigation*.

IPCC, 2007, *Fourth Assessment Report of the Intergovernmental Panel on Climate Change: Mitigation and Climate Change*.