

## SOUTH AFRICA

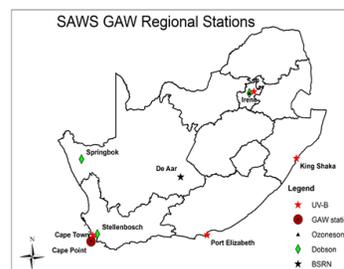
### A report for the 11<sup>th</sup> UNEP/WMO Ozone Research Managers Meeting [11ORM]

The South African Department of Forestry, Fisheries and the Environment (DFFE) serves as the focal point for this country's implementation of the Vienna Convention and the Montreal Protocol on substances that deplete the Ozone Layer. Therefore, it has a responsibility to protect the environment and the well-being of people also according to the Constitution of the Country. The South African Weather Service (SAWS) is an agency of the DFFE and is tasked with the responsibility focusing on research and monitoring of atmospheric ozone and keeping check on the Ozone Layer.

## 1. OBSERVATIONAL ACTIVITIES

### Ozone-Atmospheric Research and Monitoring Activities

A large portion of the in-country sustained systematic atmospheric monitoring is conducted by the South African Weather Service. In particular, this is done by the research and monitoring program under the auspices of the World Meteorological Organization's (WMO) Global Atmosphere Watch Station (GAW) at Cape Point and its Regional GAW Network of stations. Figure below shows WMO global stations, the Cape Point GAW global laboratory and the regional network.



### 1.1 Column measurements of ozone and other gases/variables relevant to ozone loss.

The first South African column ozone measurements were made during 1964 until 1972 with Dobson #089 operating from Pretoria. This has been as a result of the IGY initiatives around the world. Due to skills capacity and instrument challenges Dobson 089 was decommissioned in 1972. After that, reinstating South Africa's commitment to the Vienna Convention, the Weather Service now operates two Dobson ozone spectrophotometers, #089 at Irene near Pretoria (25.9 S, 28.2 E) since 1989, and #132 at Springbok (29.7 S, 17.9 E) since 1995. Both these instruments have been regularly calibrated with reference to the world standard. A modest program of Dobson (#035) observations has started at the Stellenbosch Offices, under the auspices of the Cape Point GAW activities.

The Dobson Ozone Spectrophotometers at Springbok D132 has been operating well during this period conducting daily Total Ozone (TO3) column observations. Dobson 089 from Irene experienced optical wedge belt problems in 2014 and again some rain damage in 2015, but was repaired and placed back in operation. Dobson 035, on "permanent" loan from the UK Met. Office, has most unfortunately not been operating continuously at Cape Point since we still need to do some building construction changes to the GAW laboratory. Therefore, the observation program at Stellenbosch has been undertaken since 2016. The value of the WMO/UNEP Dobson inter-calibrations also proves that the data sets can be made totally compatible and sustain a consistent long-term station record.

The South African Dobson data sets are maturing towards long-term climatic data sets. Over this period some 300 000 daily total ozone observations has been made. Since 2002 to 2014 the Irene Dobson Total Column ozone shows a slight positive trend, but the negative trend indication remains over recent years. Together with the data from the Irene balloon ozonesoundings, we are also investigating the questions whether pollution is also a contributing to enhanced “bad” ozone levels in the troposphere and near surface. Some of the research results is delivered in the articles as listed further below.

## **1.2 Profile measurements of ozone and other gases/variables relevant to ozone loss**

### **1.2.1 Ozone Soundings:**

The Weather Service has been conducting Ozonesondes since 1990. After a three year break the Weather Service has been fortunate to reinstate its Vaisala ECC RS92 Ozonesonde sounding program from Irene, a GAW regional station, in September 2012. Currently the soundings are conducted with the Vaisala MW41 Digicora and RS41 GPS sondes and 1200g totex balloons. Thus we can state that we have been using the same system since 1990 when we started, which implies the data sets is much more compatible. Irene operated weekly ozone sounding since 1990 until early 2007 with a few data gaps. We joined the Southern Hemisphere **A**dditional **O**Zonesondes (SHADOZ) program under leadership of the principle investigator Dr. Anne Thompson in 1997. This is a program from NASA, USA, and all data is submitted to WOUDC and NDACC as well. <http://croc.gsfc.nasa.gov/shadoz/>. The Irene ozone sounding program continues with ascents every two weeks. Some gaps in the data do occur, due to stock not being replenish in time and capacity capabilities.

### **1.2.2 LIDAR:**

Light Detection and Ranging (LiDAR) equipment at the School of Chemistry and Physics (SCP) from the University KwaZulu Natal University (UKZN) – Durban Westville campus was recently calibrated as part of an experiment to operate three LiDARs simultaneously and interpret their performance. The LiDARs were the fixed and portable UKZN ones as well as the Council for Scientific and Industrial Research (CSIR) National Laser Centre (NLC) mobile LiDAR.

The equipment, one of only two LiDAR systems in the country, assists research into remote sensing techniques and atmospheric pollution measurements conducted by the Atmospheric Research Group in the SCP, and is calibrated when necessary. The latest calibration came after refurbishment of the equipment, which was moved to the Westville campus from Howard College eight years ago. One LiDAR system was donated to UKZN from the Université de la Réunion through a Memorandum of Understanding.

UKZN's fixed LiDAR conducts daily observations for understanding the aerosol and cloud structure over Durban and Ulundi at the campus the University of Zululand. Aerosol measurements indicate atmospheric pollution levels. UKZN's portable LiDAR has scanning capability and is used for studying pollution dispersion and bio-mass burning evolutions in the atmosphere (e.g. farmers' burning of agricultural land for re-cultivation). The group is also involved in joint collaborative research with Algeria, which involves the building of a system for forest fire detection, with two masters and three PhD students conducting research on this subject.

### **1.2.3 Air-Quality:**

The South African Air Quality Information System (SAAQIS) is a DFFE/SAWS collaborative project which provides an online platform for managing air quality information in South Africa. It makes data available to stakeholders including the public and provides a mechanism to ensure uniformity in the way air quality

data is managed i.e. captured, stored, validated, analysed and reported on in South Africa. The website is a mechanism for ensuring uniformity in the way air quality data is captured, validated, analysed and reported. Data is gathered via an established National Ambient Air Quality Monitoring Network (NAAQMN). The SAAQIS Ambient Air Quality Monitoring Module is an online platform that houses and provides access to ambient air quality data and reports from a number of registered air quality monitoring stations across the country. The objective is to provide all stakeholders with relevant, up-to-date and accurate information on ambient air quality in South Africa to support informed decision making. One hundred and forty five air quality monitoring stations are currently registered as data providers to SAAQIS (116 are government owned, 29 are industry owned). - <https://saaqis.environment.gov.za/> . The station parameters being monitored include amongst others PM 2.5 and 10.0, SO<sub>2</sub>, NO<sub>x</sub>, CO, O<sub>3</sub>, BTEX, and the normal meteorology including global radiation. Air quality forecasting is undertaken with the Unified Model from the UK Met office NAME III model at the South African Weather Service.



#### 1.2.4 The Cape Point WMO GAW global station:

The pristine location of the Cape Point Global Atmosphere Watch GAW station (34.3S, 18.5E) enables measurements to be made in air that has passed over the vast clean Southern Ocean. Such long-term observations are representative of background conditions, making it possible to detect changes in the atmosphere's composition.

Measurements include a wide range of parameters namely: - surface O<sub>3</sub>, gases which lead to stratospheric ozone depletion such as: CFCl<sub>3</sub>, CCl<sub>2</sub>F<sub>2</sub>, CCl<sub>2</sub>F-CClF<sub>2</sub>, CH<sub>3</sub>CCl<sub>3</sub>, CCl<sub>4</sub>, SO<sub>2</sub> and N<sub>2</sub>O greenhouse gases in the troposphere such as CO<sub>2</sub> (22 years), CH<sub>4</sub> (30 years) and reactive gases such as CO with a 40 year record. The measurement of atmosphere total gaseous mercury (Hg) concentrations also has a long standing record and forms part of the international GEMS project. Wet chemistry and passive sampling is conducted on the parameters, NO<sub>2</sub>, NH<sub>3</sub>, SO<sub>2</sub> and O<sub>3</sub>. This all is complemented with traditional meteorological and climate parameters being monitored.

Furthermore, UV-A, UV-B and global radiation (DNI, total and diffuse with a Solys2 tracking station), are also measured as well as the normal surface meteorological parameters. <sup>222</sup>Radon measurements to assist with the classification of air masses arriving at Cape Point have been successfully established. This Radon monitoring is continuing with collaboration with ANSTO, Australia.

Since 2005 a project was undertaken, with collaboration of NOAA, USA scientists for the continuous measurements of aerosols. This is now a well-established program at the Cape Point GAW station and includes physical, chemistry and optical properties being measured. The latest addition was the establishment of Aerosol Optical Depth (AOD) precision filter instrument, which is regularly calibrated or exchanged at PMOD, Switzerland.

[GAW Precision Filter Radiometer Network \(GAWNET\) http://www.pmodwrc.ch/worcc](http://www.pmodwrc.ch/worcc).

### **1.3 UV-B measurements:**

Since January 1994 the South African Weather Service has maintained a routine program for monitoring erythemally weighted UV-B radiation at Cape Town (34.0S, 18.6E), Durban (30.0S, 31.0E) and Pretoria (25.7S, 28.2E), De Aar (30.7S, 24.0E) and Port Elizabeth (33.9S, 25.5E). The equipment used in this network is the Solar Light Model 501 Robertson-Berger UV-Biometer. The program was motivated by and in collaboration with the School of Pharmacy at the Medical University of Southern Africa (MEDUNSA), near Pretoria. The main purpose of the UV-Biometer network is to make the public aware of the hazards of excessive exposure to biologically active UV-B radiation, and it contributes to the schools' awareness programs for education. Regular enquiries from scholars are dealt with to satisfy their need to acquire more ozone and ultraviolet radiation knowledge. Celebrations around 16 September, each year, usually focus on public awareness. At these events the ministerial appearance encourages and informs scholars on the issues and actions of government.

The main UV research is undertaken by the Council for Scientific and Industry Research (CSIR) under the leadership of Dr. C Wright now residing at the Medical Research Council of South Africa. Their research unit is conducting research and monitoring of UVB exposure amongst scholars and many other outdoor activities by means of tagged badge dosimeters. The SunSmart Schools Research Project, which was co-funded by the Cancer Association of South Africa (CANSA), the South African Medical Research Council and the CSIR. In one outcome of the research, CSIR environmental health researchers have drafted a sun protection policy for schools and a roadmap for future actions. <http://www.ehrn.co.za/sunsmart/>. The SAWS UV-B network thus supports the research efforts into health risk areas posed by UV intensity over the country. Research in this regard is also undertaken by the North West University - School of Health and the University of Pretoria.

Since 2014 the SAWS has revamped its Solar Radiation network with 12 SOLYS2 tracking stations. High quality DNI, GHI and DIFF are measured at twelve stations representing the different climate zones of the country. In addition UVB and UVA (for the first time) is included in these measured parameters. Instruments used for this is the CMP11 and UVS-AB-T UVB and UVA radiometers from Kipp&Zonen. This new network is a tremendous advantage for addressing our Ozone and UV issues in the country as well and displays cross uses of technology for covering energy project aims and atmospheric research. This includes the De Aar Base-Line Surface Radiation Network (BSRN) station which was in-active between 2008 until 2014, but now back in full operations.

The Southern African Universities Radiometric Network (SAURAN) is an initiative of the Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University and the Group for Solar Energy Thermodynamics (GSET) at the University of KwaZulu-Natal and others. SAURAN aims to make high-resolution, ground-based solar radiometric data available from stations located across the Southern African region, including South Africa, Namibia, Botswana and Reunion Island. Most of our stations provide direct normal irradiance (DNI), global horizontal irradiance (GHI) and diffuse horizontal irradiance (DHI) at 1-minute, hourly and daily time averaged intervals, using state of the art Kipp & Zonen radiometers. Their focus remains on the alternative energy sector and more detail can be found at. <http://www.sauran.net/>

#### 1.4 Calibration activities:

SAWS is recognised by the WMO as a Regional Dobson Calibration Centre. SAWS has hosted Dobson Spectrophotometer Inter-calibrations for the African Dobson in 2000, 2009 and in 2019. During October 2019, Dobson instruments, experts and operators gathered from different countries to participate in a two-week long Intercomparison campaign. The following countries was invited and participated in the Irene event: South Africa, United States of America, Germany, Kenya, Nigeria, Botswana, and India (from a special request). From the onset, Seychelles decided not to participate because they are not planning to revive their Dobson observation program for the future.



Figure above: - Six of the eight Dobson outside the Irene office undergoing an Intercomparison event from 06:00am until 11:00 am. Two other instruments are inside the workshop room (Figure 2), undergoing repairs before joining the next exercise on following days.

SAWS also participated in the JOSIE 2017-SHADOZ Campaign (October/November 2017). A major goal of JOSIE-2017 was operator training with data-handling capability to sustain SHADOZ stations and to produce even better quality data from each sounding that is launched. In parallel with the simulation experiments, organised lectures and tutorials was attended. The execution of our standard operational procedures (SOP's) are carefully maintained.

The Cape Point Global GAW station regularly takes part in scheduled instrument and data audits under the auspices of the WMO GAW community. This is mainly in collaboration and scheduled with WMO and the EMPA, Switzerland group.

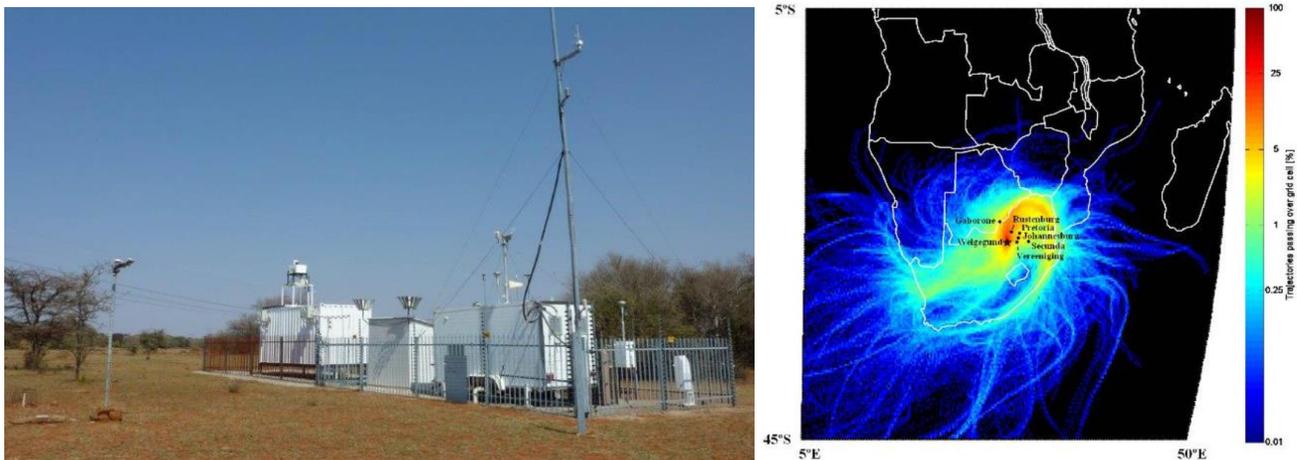
#### 1.4 The Welgegund measurement station:

The Welgegund atmospheric measurement station is located on a grazed grassland-savannah approximately 100 km west of Johannesburg (Gauteng) metropolitan area in South Africa. The site is frequently hit by pollution plumes from Johannesburg metropolitan area and the western Mpumalanga industrial Highveld, with frequent clean air injections from the west. The site is operated jointly by the North-West University (NWU), the University of Helsinki (UH) and the Finnish Meteorological Institute (FMI).

The aim of the project was to help to train students of the North-West University in atmospheric measurements and increase scientific knowledge in atmospheric physics and chemistry in southern Africa. From the beginning, the focus was on long-term measurements instead of short campaigns.

Before the infrastructure as seen below, a measurement trailer was constructed in Finland during the winter 2005-06 with funding from Finnish Foreign Ministry and exported to the site. The main research aim at the site is to observe different atmospheric parameters relevant for climate change, regional

pollution, atmosphere-ecosystem interactions, aerosol chemistry and physics based on long-term measurements. A comprehensive set of parameters are measured continuously measure at this site. <https://www.welgegund.org/observations>. Various field campaigns over the years has also been undertaken by the Scientific Group of the North West University.



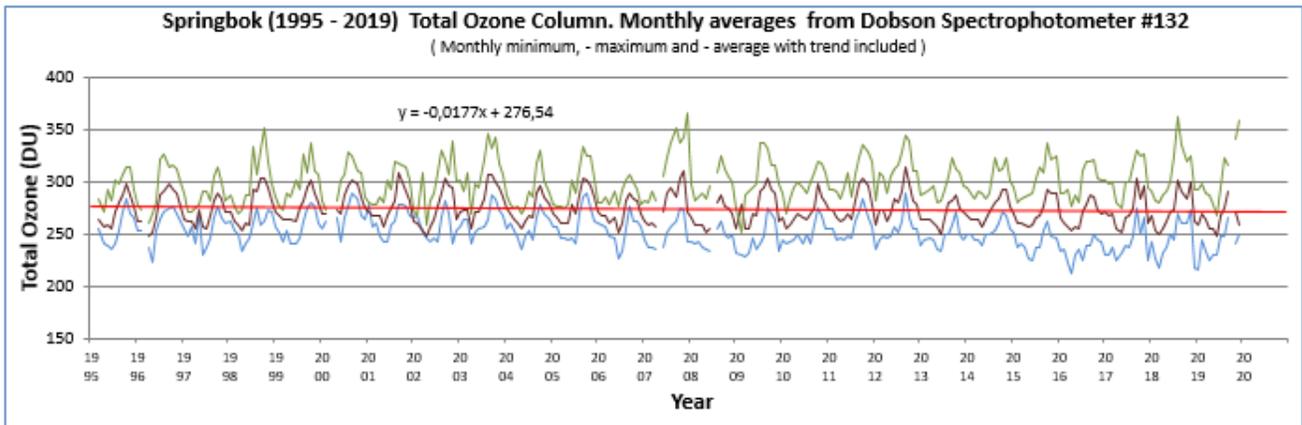
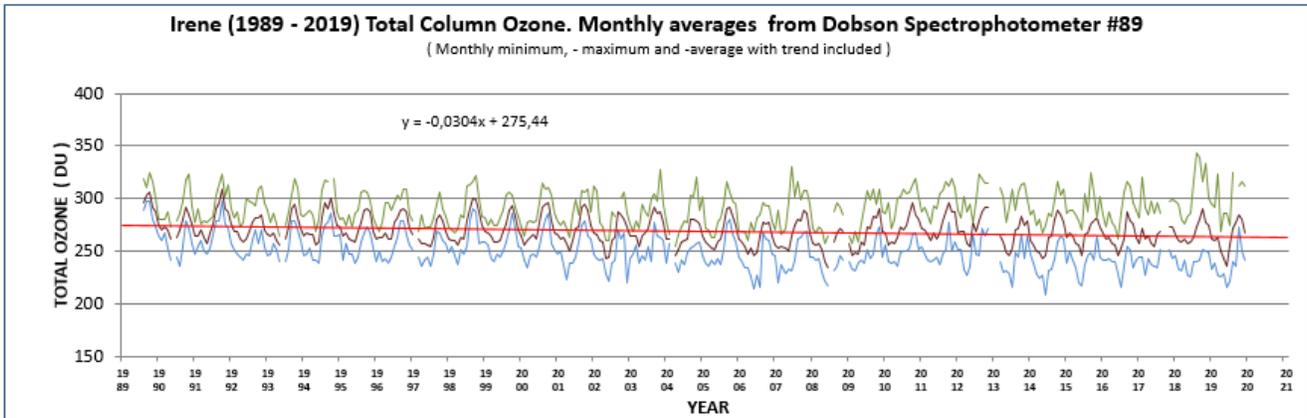
SO<sub>2</sub> emissions and the re-circulation in southern Africa can be seen on the left pane, above. The measurement site is indicated with magenta star. The areas with highest anthropogenic emissions in the whole are located approximately 100-300 km east of Welgegund. Origin of air masses at Welgegund (based on hourly trajectories 2007-2008). The main pollution source areas and capitals are indicated with black dots.

## 2. RESULTS FROM OBSERVATIONS AND ANALYSIS

Ozonesonde, Dobson and Cape Point GAW data sets are available through the WMO World Data Centers (and per direct request) and are frequently used in national and international research and publications projects. During the last two years two PhD thesis utilising the data sets has been obtained.

Trend results from the UV Biometer network is inconclusive, due to the instruments inherent variability. However, South Africa remains one of the world's very high UV prone countries, especially in the summer months, spring and early autumn months. However, a good UVB climatology with the use of the SAWS Biometer network over the last 20-30 years of monitoring.

Trend analysis of the Total Ozone Column from the Irene Dobson spectrophotometer (since 1989) continues to show a slight negative trend. From the graph below it also seems that the variability (the gap between maximum versus minimum averages) is more variable towards the end of the period – this needs further investigation as it is seen at both stations. The Springbok Dobson Ozone trend since 1995 also remains slightly negative overall. The updated – end 2019, Total Ozone Column is shown below:-



### 3. THEORY, MODELLING, AND OTHER OZONE RELATED RESEARCH

The country has limited capacity and actions in this regard. However, various satellite data sets are used to keep check on the ground based Dobson observations. UV effects studies are also being conducted – reference to this is within the selected reference materials further below.

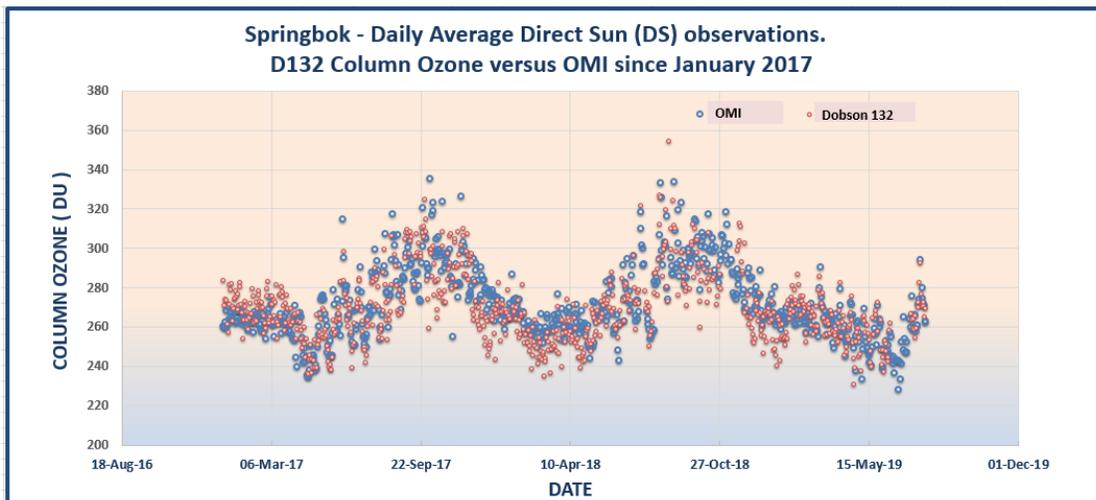


Figure above: - A selective comparison of Springbok Dobson132 and OMI daily TOC values.

## 4. DISSEMINATION OF DATA AND INFORMATION

### 4.1 Data reporting

Measurements from the Dobson Spectrophotometer stations Irene and Springbok are submitted to the WOUDC on an annual basis. This includes the zero-level data files since 2014. The data is usually submitted on an annual basis, as the Dobson software that is in use for formatting purposes, need special handling of data sets which is rather time consuming with many had calculating options to be undertaken. Dobson data for both stations has been submitted to WOUDC until end 2019.

The Cape Point Global GAW station data sets are also being deposited regularly at the World Data Centers, such as WDC-GHG-Japan and for the surface ozone. Ozonesonde data from Irene is taken up in the SHADOZ database, and thus also submitted to WMO WDC WOUDC, Toronto Canada. Solar Radiation Data is submitted to the Base-Line Surface Radiation Network (BSRN) data centre.

### 4.2 Information to the public

The SAWS disseminates UV- index values with its daily weather bulletins for the greater Metropolitan areas. Data and information is also shared with the Department Forestry, Fisheries and Environment and to other government entities routinely and as requested. The Ozone Unit of the Department of Environmental Affairs also embarks each year on 16 September to celebrate “world ozone day “. Celebrations are alternatively arrange with events in the rural area of our provinces, to raise awareness and to disseminate information. Ministry Press Release are also prepared and local radio stations are supplied with information to their audiences.

### 4.3 Selective scientific papers

- MKOLOLO, T., MBATHA, N., VENTAKARAM, S., BÈGUE, N., COETZEE, G., AND LABUSCHAGNE, C. 2020. Stratosphere–Troposphere Exchange and O<sub>3</sub> Decline in the Lower Stratosphere over Irene SHADOZ Site, South Africa. *Atmosphere*, 11(6), 586. <https://dx.doi.org/10.3390/atmos11060586>

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- RAMBUWANI, T.G. 2020. *The Impact of Aerosols on Forecasting Short Range Temperature over South Africa*. North-West University, Potchefstroom, 183 pp. <http://hdl.handle.net/10394/35126> (xii, 170 pp.)

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- MBATHA, N., BENCHERIF, H., SIVAKUMAR, V. AND MKOLOLO, T. 2019. Stratospheric Ozone Time Series Prediction and Forecasting Using LSTM and Hybrid ARIMA-ANN approach, in the 35th Annual Conference of the South African Society for Atmospheric Science, 8-9 October 2019, Riverside Sun, Vanderbijlpark [Gauteng], pp. 120-124.- Adesina J., K.R. Kumar, V. Sivakumar and S.J. Piketh, Intercomparison and assessment of long-term (2004-2013) multiple satellite aerosol products over two contrasting sites in South Africa, *J. Atmos. Solar. Terr.Phys*, 148, 82-95, 2016.

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- Du PREEZ, D.J., AJTIĆ, J.V., BENCHERIF, H., BÈGUE, N., CADET, J-M. AND WRIGHT, C.Y. 2019. Spring and summer time ozone and solar ultraviolet radiation variations over Cape Point, South Africa. *Annales Geophysicae*, 37(2), Mar, pp. 129–141. <https://doi.org/10.5194/angeo-37-129-2019>

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## 5. PROJECTS, COLLABORATION, TWINNING AND CAPACITY BUILDING

The French/South African GDRI ARSAIO LIA project continues. This collaboration has now been formalised for over two decades. The following institutions forms part of this initiative. South Africa – North West University - Potchefstroom, University of Kwa-Zulu Natal - Durban, University of Pretoria, The Council for Industrial Research - CSIR, the Medical Research Council and a few other institutions and State Enterprises. France- Laboratoire de l'Atmosphère et des Cyclones, Université de la Réunion, Réunion, and LISA, UMR 7583, Créteil, France.

The French and South African researcher's focuses and coordinate their particular actions/theme, as follow;

- Action 1 Impact of anthropogenic pollution in 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

SAWS is also a collaborator with NASA, USA - Southern Hemisphere Additional OZonesondes (SHADOZ) program under leadership of the principle investigator Dr. Anne Thompson since 1997. <http://croc.gsfc.nasa.gov/shadoz/>).

Collaboration with NOAA, Boulder, USA and DWD, Hohenpeissenberg, Germany continues in light of maintaining the Southern African Dobson responsibilities and operational work.

BSRN (Baseline Surface Radiation Network): With the De Aar site various solar measurements are shared and workshop are attended.

The De Aar weather office also form part of the Global Atmospheric Passive Sampling (GAPS) study with aims to demonstrate the feasibility of using passive samplers to assess the spatial distribution of persistent organic pollutants on a worldwide basis.

Global Mercury Observations System (GMOS) – Cape Point GAW station contributes to this international Program. South Africa has also acceded to the Minamata Convention. Currently the Cape Point GAW station is also managing a country wide program for setting in place and operational country wide monitoring network for measuring gas-phase mercury air-concentration at various hot spots. The international Minamata agreement is currently a focal initiative to expand the South African Mercury atmospheric monitoring program.

DEBITS Program - LSCE, CNRS, France. North West University has been actively taking part in this initiative over a very long period. IDAF (IGAC DEBITS Africa) network joined 1994

Training assistance from GAWTEC <http://www.schneefernerhaus.de/e-gawtec.htm> , Germany. Over the years many South African scientist have benefited from this successful initiative. We can only congratulate the GAWTEC organisations on their major achievements over the years.

National Collaborating Institutions :- Ozone and related monitoring and research are conducted mostly at a few academic institutions such as the University of KwaZulu Natal in Durban, the University of Cape Town, The University of North West, Potchefstroom, University of Pretoria, CSIR-Council for Scientific and Industrial Research and the Medical Research Council.

## **6. IMPLEMENTATION OF THE RECOMMENDATIONS OF THE 10th<sup>th</sup> OZONE RESEARCH MANAGERS MEETING**

The main focus has been to maintain the existing ozone observations, monitoring and research activities, to enable for the quality long-term data sets to mature even further. Capacity building has also received good attention with students enrolling for post graduate studies, over a wide ozone related field. Additional staff members has also been recruited to assist with Dobson and Ozone soundings at the Irene Weather office. This to ensure sound continuity and skills transfer for the future uphold of current networks. During the last two years two PhD thesis utilising the data sets has been obtained.

One difficult area that has been experienced in the adherence of especially the regular Dobson Spectrophotometer international calibrations. The latest Intercomparison for African Dobson's where conducted at Irene in November 2019, and before that the event was held in 2009 and 2000.

Dobson 035, ( since 2016 ) has started with a modest observation total ozone program at the Stellenbosch weather office (about 40km west of Cape Town) to compliment Cape Point GAW program. Capacity for a substantial observation program is still hampered due to the small staffing compliment currently residing at the Cape Point Global station.

The establishment of mechanism to improve data turn-around, into near real time data dissemination still remains a large challenges as the quality assurances and final data checks remain to be a very hands-on process to deal with. It is hope that SAWS will be able to purchase and establish a Brewer Spectrometer instrument at Cape Point, as part of a future replacement program for the Operating Dobson instruments.

## **7. FUTURE PLANS**

The main aim is to maintain the operability and quality of the current available monitoring infrastructure through the appropriate institutions. For SAWS the UV, Dobson and Ozonesonde programs will remain a priority, within means, as to ensure the growth of the long-term data records. With this focus on frequent calibration of instruments and to avoid and rectify data gaps of the past, and to safeguard the primary long-term data sets of atmospheric parameters.

The focus will remain on capacity building enabling students to obtain post- graduate studies in this important atmospheric field.

It still remains a goal to expand the SAWS GAW – ozone related monitoring activities in South Africa, towards the Southern Oceans and Antarctica. However plans seem to fail, due to the prevailing current unsatisfactory economic climate and the many other priorities we are being faced with. South Africa has access to Gough (UK) and Prince Edward Island Group (RSA) in the Southern oceans and

the SANAE-IV Antarctic base. South Africa also has a new research vessel the Agulhas-II which could play a major role in the relevant atmospheric monitoring as it traverses the Southern Oceans on routine research and relief voyages. It can be mentioned that during the recent past a few successful ozonesonde ascents has been undertaken in the Southern Atlantic Ocean and at Antarctica from the SA Agulhas II. However the program still needs to be established in a sustainable manner.

## **8. NEEDS AND RECOMMENDATIONS**

There is a continued need for maintaining systematic monitoring of the ozone layer, this in spite of what is perceived to be the success story of the Montreal Protocol. Full recovery is still a few decades away, and we need to account for all the atmosphere/climate feedback mechanisms and their uncertainties as the ozone layer enters the recovering phase. Internationally, strong support for maintaining ground-based observation stations with long-term data records must continue, especially in the world's data sparse regions.

There is an existing need to monitor the ozone depleting substances (CFC's and HCF's) with more intensity and at more locations globally and in South Africa.

It is essential to continue with the provision and development of international data archive facilities and instrument calibration standards and inter-comparisons. Collaboration and assistance of the international community remains the cornerstone of these efforts.

For some instruments the software for data processing could be upgraded and be made more user friendly. Software such as Dobson tools could keep track with the IT technology advances, but this would mean specialised efforts and investment for some experts to develop, test and adopt as a global standard.

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