Report on Ozone Monitoring in Nigeria for the 12th WMO/UNEP Ozone Research Managers Meeting

Geneva, 24 - 26 April 2024

1. OBSERVATIONAL ACTIVITIES

The main agency responsible for carrying out research and monitoring of ozone, UV radiation and related atmospheric constituents is the Nigeria Meteorological Agency (MIMET). However, other government agencies such as the National Space Research & Development Agency also carry out some researches on ozone. Nowadays, there is increase in number of researchers from many universities and research institutions within and outside Nigeria that are carrying out researches to monitor column Ozone, among other ozone researches over Nigeria.

The National Ozone Office promote the monitoring of zone and ozone research with the primary aim of supporting the government policies on environment and thereby contribute positively to the implementation of the Vienna Convention for the protection of the ozone layer and it's Montreal Protocol. The increasing participation of these institutions has greatly enhanced the development of the national programme on ozone monitoring and research in Nigeria.

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

The monitoring of total column ozone and other atmospheric constituents under the auspices of WMO Global Atmosphere Watch (GAW) programme started in Nigeria in 1993 with the establishment of a GAW station each in Lagos and Oshogbo by the Nigerian Meteorological Agency (NIMET). The GAW stations measured total column ozone and the measurements are archived in the database of the Nigerian Meteorological Agency (NIMET). However, the stations are out of service and efforts are being made to resuscitate the stations for effective operation.

Throughout 2018, NIMET operated a monitoring station in the centre of Abuja. The NIMET station monitored concentrations of PM10, CO, NOx, and SO2. A monitor for O3 (2B Technologies Model 202 Ozone Monitor supplied by Air Monitors, UK). The monitor uses the absorption of UV light at 254 nm to measure the concentration of ambient ozone. The ozone monitor was maintained and calibrated by NIMET according to the manufacturer's instructions. The ozone was recorded every 5 min and was calculated to 1 h and 8-hour running mean and monthly mean reflecting the WHO and Federal Ministry of Environment proscribed limits. The data for the period of measurements is available on request from NIMET.

The National Space Research and Development Agency of Nigeria set up an Ozone monitor 2B Technologies model 201 and did some campaign measurements of ozone concentrations over three locations, Abuja, Anyigba and Kano, within 2019 – 2021.

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

A couple of researchers have engaged assorted satellite data and reported research works showcasing profile measurements of ozone and other gases/variables relevant to ozone loss over Nigeria. These includes the works of Oluleye & Okogbue, (2013), Marais et al (2014), and Emeka (2022) among others. For example, Marais et al (2014) presented the MOZAIC observations of vertical O_3 profiles from commercial flights for Lagos and Abuja in January to February, 2003 - 2004 at 18 - 21 and 18 - 19 local time, respectively. These are shown in Fig. 1 together with the corresponding mean model profiles for January to February 2006 sampled at the same local time.

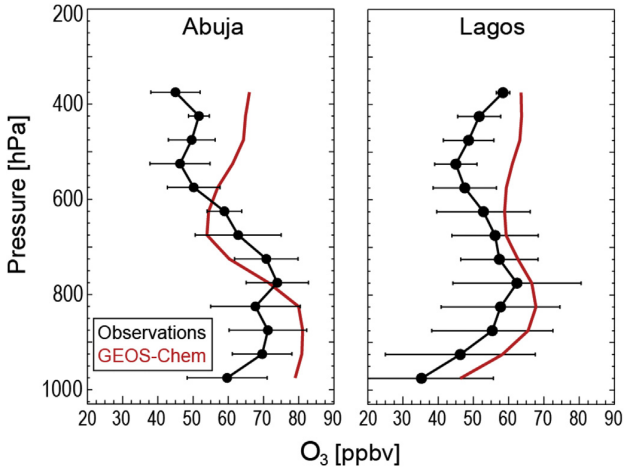

***Fig. 1. Mean vertical profiles of O3 concentrations over Abuja and Lagos in January -February. MOZAIC observations are for 3 descent flights over Abuja and 16 over Lagos at 18-19 and 18-21 local time, respectively, in 2003-2004. Horizontal lines are 1s standard deviations. Corresponding GEOS-Chem profiles are means for January-February 2006 at the same local time [After* Marais et al., 2014].**

1.3 UV measurements

NIMET has since commenced measurements of surface UVB and Solar radiation at several locations in Nigeria in addition to the GAW stations in Lagos and Oshogbo. The automatic weather stations that measure these parameters and some meteorological variables were set up as part of the implementation of the Agency's programme on studies relating to the effects of UV-B on human health and the ecosystems. The UV is measured with silicon photodiode sensor.

1.4 Measurements of substances controlled under the Montreal Protocol

(e.g., flask measurements, high-frequency measurements)

1.5 Calibration activities

The Dobson spectrophotometer at NIMET is calibrated (mercury lamp and standard lamp tests) every month and the calibration data are documented. The instrument has also successfully participated in two international intercomparions organized by WMO for all the Dobson instruments operated in Africa. These took place in Pretoria, South Africa in 2000 and Dahab in Egypt in 2004. Effort is being made to calibrate the Ozone Monitor operated by the National Space Research and Development Agency 'NASRDA'.

2. RESULTS FROM OBSERVATIONS AND ANALYSIS

Using data from the Earth Probe Total Ozone Mapping Spectrometer (EP–TOMS) 1 January 2001 to 31 December 2005 and rainfall data obtained from the Nigerian Meteorological Agency, Oluleye and Okogbue (2013) showed that ozone distribution is mostly controlled by rainfall producing mechanism such that ozone accumulation follows synchronously the migration of wind systems. They further concluded that: "The moist south westerly originating from Atlantic Ocean flows to enhance ozone accumulation as ozone maximum concentration occurs when it takes over the region. On the other hand, north easterly counterpart depletes ozone concentration thereby producing minimum ozone during the dry season. Ozone has a seasonal distribution with minimum occurring during the dry season and maximum occurring during the wet season."

Marais et al, (2014) presented Fig 2 as the surface daily maximum 8-h average (MDA8) O_3 concentrations simulated by GEOS-Chem in surface air for DJF 2006. It is seen that the O_3 concentrations values in central Nigeria exceed 80 ppbv. Their work revealed a major O3 air quality problem as the US health-based standard of 75 ppbv (MDA8) was routinely exceeded

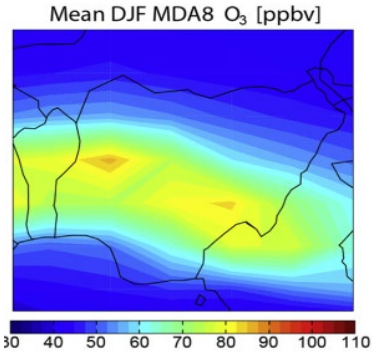

Fig. 2. Mean daily maximum 8-h average (MDA8) O3 concentrations simulated by GEOS-Chem in surface air over Nigeria for December-February 2006. [After Marais et al.,2014]

Using data obtained from NASA's Ozone Monitoring Instrument (OMI) on board an Aura Spacecraft and some meteorological data over fifteen (15) years (2005-2020), Emeka (2022) showed that Maiduguri Metropolis in Nigeria is polluted by tropospheric Ozone. They routinely reported values of higher than 50 ppb (100 µg/m^3) daily 8-hours average exposure, the recommended WHO guideline for the level of tropospheric Ozone

Recently, Ihedike et al, (2023) carried out measurements of real-time time concentrations of ground-level ozone in Abuja and found higher concentrations during the dry (harmattan) season. An implication for health is the fact that concentrations higher than the WHO standard of (eight-hour averaged) 100 µg/m^3, occurred on 53 days over the 5-month dry season. Furthermore, 18 out of the 53 days had ozone concentrations greater than 200 µg/m^3. Daily patterns showed a rise throughout the day, reaching a peak in the evening. Weekday/weekend differences were less pronounced than those found in other studies. Ihedike et al (2003) asserted that high temperatures and local climatic conditions in Abuja encourage the formation of ozone.

Using data from NASA's AURA project, Obafaye et al., (2023) studied the variability of monthly total column ozone over Nigeria from 2005 to 2017. While engaging standard deviation and variance as measures of variability; they took the definition of the variance as the average squared deviations from the mean, and standard deviation as the square root of the variance. The results showed that variance (Fig. 3a) and standard deviation (Fig. 3b) of total column ozone within the country varied between 85–160 and 9–12.5 Dobson units, respectively. They attributed the longitudinal variation in the total column ozone within the country to anthropogenic activities such as biomass burning. The variability increased from west to east within the region.

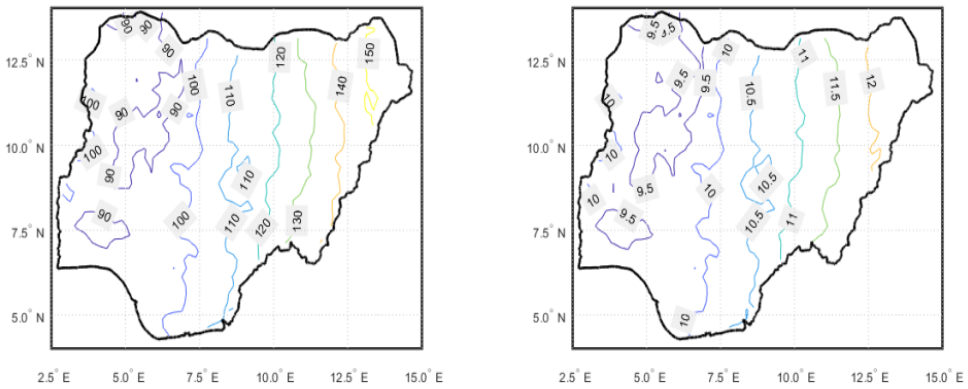

Fig 3. Variance (a) and standard deviation (b) in total column ozone in Dobson Units over Nigeria.

3. THEORY, MODELLING, AND OTHER OZONE RELATED RESEARCH

Fig. 4 by Marais et al., (2014) presented the TES O3 retrieval at 825 hPa, representing a tropospheric column concentration with maximum sensitivity at 800-700 hPa (left panel). The left panel is the vertical sensitivity of the TES 825 hPa retrieval (mean averaging kernel matrix row for Abuja). The right panels show the TES retrievals and the GEOS-Chem O3 values sampled along the TES orbit tracks at the overpass time (0130 and 1330 local) and smoothed by the TES

sensitivity. The TES data were reprocessed to use a fixed a priori (Zhang et al., 2010). Retrievals nearer the surface have a similar vertical pattern of sensitivity but weaker signal. O3 at 800e700 hPa is strongly affected by the Harmattan winds transporting O3-rich air from central to coastal Nigeria, as is apparent from the vertical profiles over Abuja and Lagos (Fig. 1). The TES observations show a maximum over Lagos, consistent with that transport pattern.

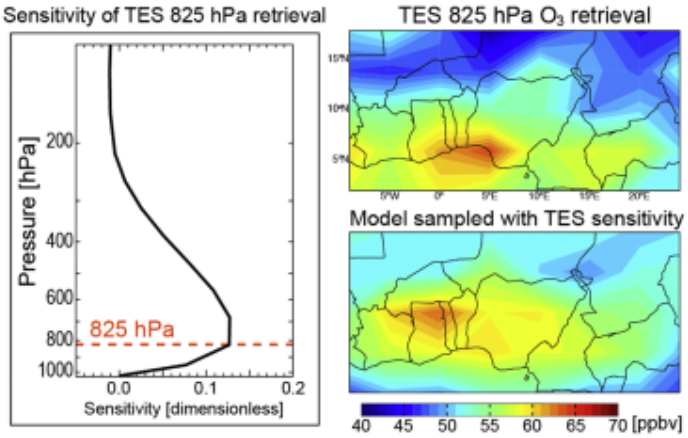

Fig. 4. O3 concentrations measured by TES in the lower free troposphere in DJF 2006 [After Marais et al., 2014]

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Marais et al., (2014) further presented Fig. 5 which showed the simulation by GEOS-Chem of the satellite observations. Values are means for December-February 2006 and include total column CO weighted by the AIRS averaging kernels, tropospheric NO2 column, HCHO column, column average CH4 mixing ratios weighted by the SCIAMACHY averaging kernels, and CHOCHO column. The model is sampled during the satellite overpass times. The horizontal resolution is 2 x 2.5º.

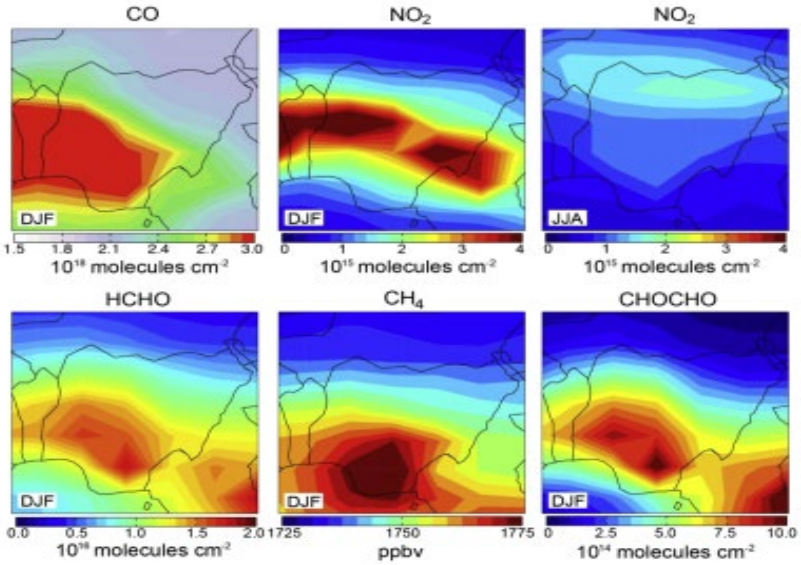

Fig. 5. GEOS-Chem simulation of the satellite observations after applying appropriate corrections to the emission inventories [After Marais et al., 2014]

4. DISSEMINATION OF RESULTS

4.1 Data reporting

Total ozone data measured in Lagos are transmitted monthly to the World Ozone and Ultra-Violet Data Centre (WOUDC) in Toronto, Canada.

All the data being observed at moment are for campaigns and are stored with various national institutions. They can only be obtained by direct communications. There is a plan to effect transfer of data to WOUDC

4.2 Information to the public

At the National Ozone Office (NOO) of the Federal Ministry of Environment, the Designated National Authority for the implementation of the Montreal Protocol in Nigeria, priority attention is given to public awareness campaign on the consequences of ozone layer depletion. The NOO annually commemorates the International Day for the preservation of the Ozone Layer. This usually include press release by the Honorable Minister of Environment on the importance of the ozone layer, the need to preserve it, national and international efforts in the preservation of the ozone layer and implementation of the Montreal Protocol in Nigeria. The NOO also carries out secondary schools outreach programme and give lectures with the aim of raising awareness among secondary school children on the importance of the ozone layer and its preservation. Awareness and promotional materials are distributed to the children on the importance of the ozone layer. The public awareness efforts of the NOO is yielding results as more Nigerians are getting aware of the importance of the ozone layer and need to preserve it as it can be shown in the country's achievements of meeting the Montreal Protocol's phase targets for HCFCs.

UV forecasts has not started, however, NIMET has started daily forecast of air quality.

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4.3 Relevant scientific papers

Listed in the references.

5. PROJECTS, COLLABORATION, TWINNING AND CAPACITY BUILDING

The National Ozone Office (NOO) of the Federal Ministry of Environment is playing its statutory role as the Designated National Authority for the implementation of the Montreal Protocol in Nigeria. The NOO also collaborates with relevant government agencies and stakeholders in the implementation of the Protocol. Presently, the NOO is implementing the Hydrochlorofluorocarbons (an ODS) Phase out Management Plan (HPMP) project in Nigeria. The NOO annually commemorates the International Day for the preservation of the Ozone Layer. This brings together stakeholders with interest in the preservation of the ozone layer and implementation of the Montreal Protocol in Nigeria.

The National Ozone Office is also implementing the Kigali Cooling Efficiency Project (KCEP) on improving energy efficiency in the cooling sector. The project is aimed at helping the country transition to energy efficient, climate-friendly, affordable refrigeration and air-conditioning technologies. The project will complement the ongoing HCFC phase-out programme by extending its reach and influence on energy efficiency.

The National Space Research and Development Agency do organise annual National Air quality workshops that provide for effective deliberations among stakeholders and capacity building

6. IMPLEMENTATION OF THE RECOMMENDATIONS OF THE 11th OZONE RESEARCH MANAGERS MEETING

- A proposal for acquisition of reference stations has been submitted in response to the call for project proposals for possible support under the Trust Fund
- Promotion of local development of instrumentation
- Continuation of training, capacity building and research on Ozone
- Development of a network of stations for ground measurements of Total Ozone and UV-B radiation.

7. FUTURE PLANS

- A proposal for acquisition of reference stations has been submitted in response to the call for project proposals for possible support under the Trust Fund
- Development of a network of stations for ground measurements of Total Ozone and UV-B radiation.
- Promotion of local development of instrumentation
- Continuation of training, capacity building and research on Ozone for Nigeria and some African countries.
- Seeking increase in network of GAW stations for the monitoring of total ozone, surface ozone, greenhouse gases, UV-B radiation, solar radiation, acid rain, etc.
- Daily UV-B radiation forecast for Nigeria.
- Continuation of awareness campaign on ozone and related issues.
- Enhancing the collaboration with local and international organizations on ozone and related issues.

8. NEEDS AND RECOMMENDATIONS

In order to facilitate the ongoing and planned ozone, UV radiation monitoring and research programmes in Nigeria, assistance will be needed in the following areas:

• Expansion of total column ozone measurements. This will involve among other things, acquisition of Brewer spectrophotometer and other latest instruments.

• Acquisition of instruments for ozone profile measurement.

• Expansion of our UV-B and solar radiation monitoring network.

• Regular calibration of instruments especially in the developing countries to ensure high quality data for research and other purposes.

• Training of personnel to enhance professional competence in monitoring, data processing and research especially in the developing countries.

• Provision of spare parts and essential consumables.

References

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