Kenya Report for Eighth Meeting of the Ozone Research Managers (8ORM) of the Parties to the Vienna Convention, 2 to 4 May 2011, Geneva, Switzerland

INTRODUCTION

The International Conference on Tropical Ozone and Atmospheric Change held in Penang, Malaysia in February 1991 underscored the lack of atmospheric ozone measurements and research in the equatorial region. Realizing the importance of developing countries in the tropics to play a more important role in the global initiatives to achieve a better understanding of the atmospheric changes and the effects on the environment linked to ozone changes, Kenya has initiated its active involvement in the World Meteorological Organization (WMO) Global Ozone Observing System (GO3OS) with the launching of its ozone monitoring programme in 1984. The ozone monitoring programme involves monitoring of ozone concentrations at the surface, the vertical profile and total column ozone in the atmosphere.

OZONE MONITORING ACTIVITIES (CURRENT STATUS)

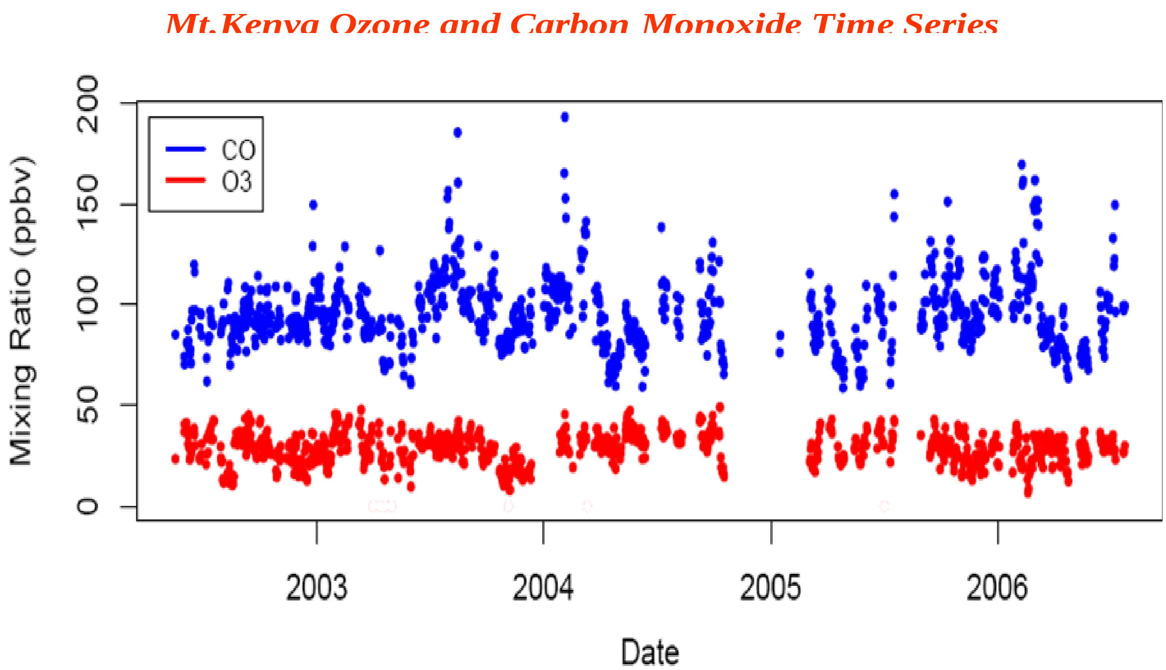
Kenya has three ozone monitoring stations with one dormant station namely:

-Mount Kenya Global GAW station
-Nairobi Regional GAW station
-Chiromo urban air pollution monitoring station.
-San Marco Equatorial Site (SMES) under SHADOZ project.

(A) Mount Kenya GAW station

The Global GAW station Mt. Kenya (MKN), management by Kenya Meteorological Department, is located at high altitude (Altitude: 3678m a.s.l, Longitude: 37.297^{o} East, Latitude: 0.062^{o} South,) in equatorial Africa. This location provides a unique opportunity to monitor background air as well as to conduct research in a data-sparse region of the world.

The stations is equipped with one ozone analyzer (TEI 49C). The instrument was initially calibrated at WCC-Empa. Consistent measurements of surface ozone started in May 2002 at MKN, and time series are available since then. All comparisons were done according to Standard Operating Procedures. Data is regularly checked for consistency with time series plots, and submitted to QA/SAC Switzerland. QA/SAC continues to work with the station operators to transfer the responsibility of data evaluation to Kenya meteorological department staff. Ozone data have been submitted to the World Data Centre for Surface Ozone at JMA (WDCGG). The submitted data sets currently span the period from June 2002 to May 2006.



The station also monitors N_2O (Flask sampling) and CH_4 (Picarro G1301) which are both GHGs and ODSs.

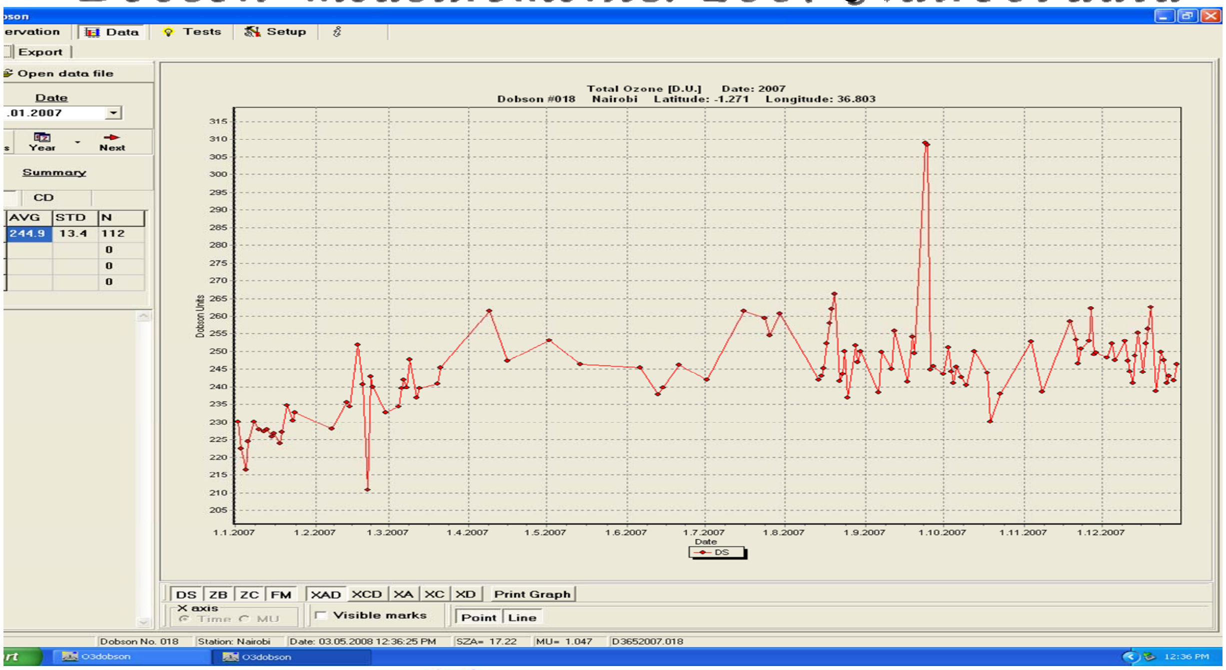
(B) Nairobi Regional GAW station

The Nairobi Regional GAW station is managed by Kenya Meteorological Department. It is located close to the equator (Altitude: 1795m asl, Latitude: 1.30 S, Longitude: 36.75 E) in Eastern Africa, and corresponds to a unique site location for the detection of ozone in tropical region.

Nairobi ozonesonde observatory, that measures the vertical profile of ozone, has been in operation since 1996. It uses a Lightweight, balloon-borne instrument mated to a conventional meteorological radiosonde. It has an electrochemical concentration cell (ECC) that senses ozone as it reacts with a dilute solution of potassium iodide to produce a weak electrical current proportional to the ozone concentration of the sampled air. During its ascent through the atmosphere, the ozonesonde transmits ozone and standard meteorological quantities to the ground receiving station. These measurements are performed ones per week and submitted to Switzerland.

Nairobi regional GAW station also measures the total column of ozone using Dobson spectrophotometer number 18 since 2005. However, these measurements started at the University of Nairobi in 1984 until 2005 when the instrument was transferred to Kenya Meteorological Department.

Dobson measurements: 2007 Nairobi data



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(C) Chiromo urban air pollution monitoring station

The urban air pollution monitoring station was established at the University of Nairobi in 2009. It measures surface one using TEI 49C instrument. The station was started by Kenya Meteorological Department in realization of one of its core function of monitoring environmental pollution and Greenhouse Gases for air quality assessment & climate change detection and attribution over Kenya.

(D) San Marco Equatorial Site (SMES) in Malindi

San Marco equatorial site in Malindi, Kenya (3S, 40E) was incorporated in the SHADOZ Project in 1999 through the sponsorship/partnership with the CRPSM (Centro Ricerche Progetto San Marco) department at the University of Rome 'La Sapienza', along with local Kenyan support staff who generally coordinates weekly sonde launches. Archive data is available from March 2001.

The station has an elevation just below sea-level (-6m) which is ideal for studying the retrieval of lower tropospheric ozone. Nairobi, Kenya which is situated approximately 300 km from Malindi (3S, 40E) has an elevation approximately 1.8 km above sea level and excludes the lowermost part of the troposphere. The Malindi site therefore offers a good ozone comparison with Nairobi profiles.

FUTURE OZONE MONITORING PLAN

Kenya Meteorological Department plans to implement the National Flagship Programmes under Kenya's Vision 2030 which include establishment of climate monitoring stations for air pollution monitoring and climate change detection. Indeed, one station has been established at the University of Nairobi, Chiromo Campus that measures ozone and carbon monoxide. The Meteorological Department plans to establish expand the station by purchasing new instruments and establishing several more stations in the country that will monitor, among other pollutants, ozone.

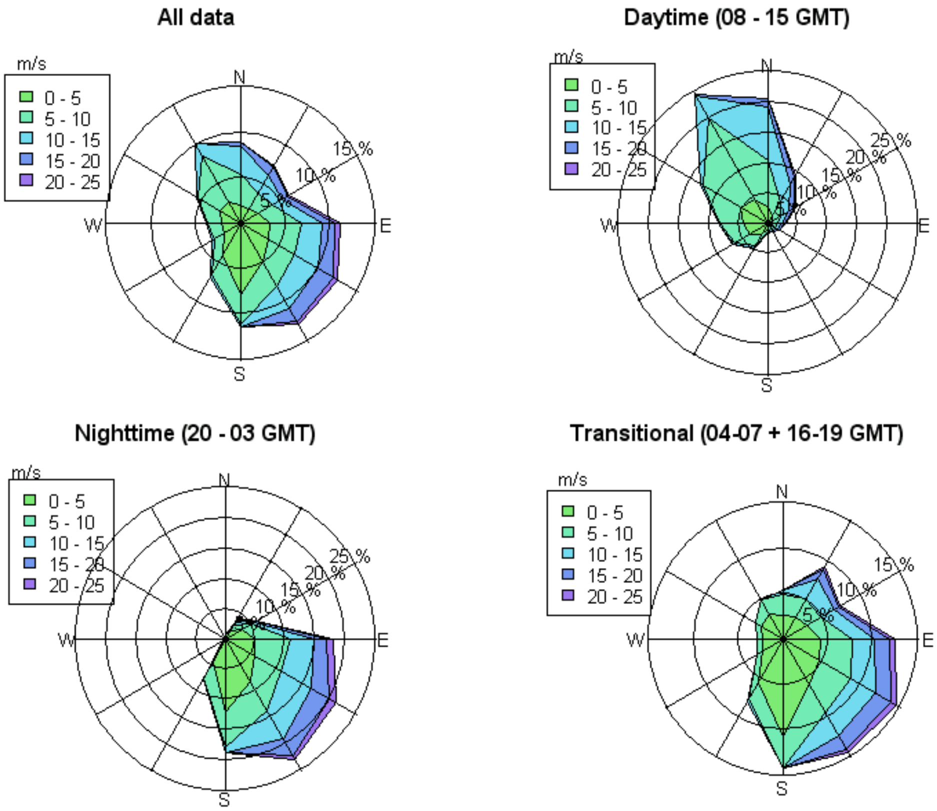
There is needs to secure the financial support to continue long-term monitoring activities (including calibration of instruments, necessary equipment for ozone soundings, UV instruments and associated software upgrades) and data archiving and dissemination services.

OZONE EXISTING RESEARCH

Currently, we do not have any major ozone research activities in progress. However, several researches on ozone are being conducted by University students at both under graduate and post graduate level. Several researches based on ozone have been conducted in Kenya.

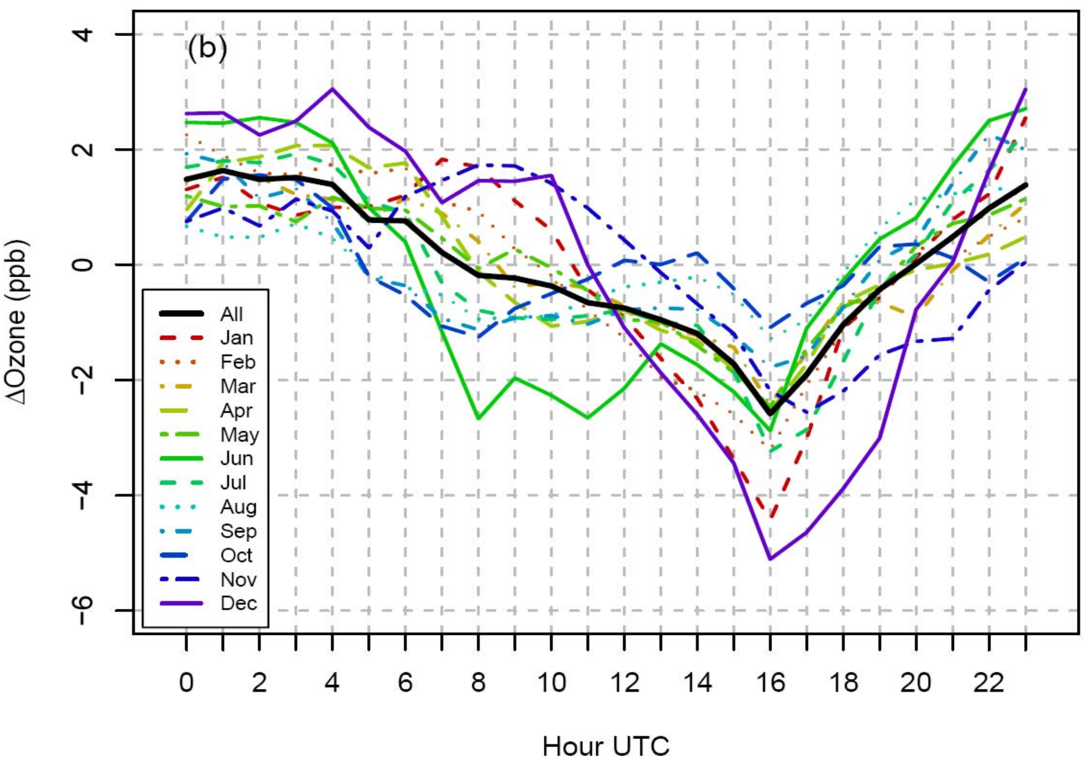
Since Mount Kenya GAW station is at high attitude, the site experiences thermally induced wind systems that disturb free tropospheric conditions. A study to investigate the suitability of the station showed that throughout the whole year the station is influenced by thermally induced wind systems and the atmospheric boundary layer (Henne et al. 2008).

The filters distinguished between thermally and synoptically influenced days. Thermally influenced days (86%) dominated. However, maxima in specific humidity were also reached in the afternoon on synoptically influenced days and were attributed to mixing in the convective boundary layer. During nighttime, downslope wind dominated that carries undisturbed free tropospheric air masses. Nevertheless, during 24% of all nights the specific humidity was also elevated, possibly indicating the presence of residual layers. It is recommended that nighttime data only (2100–0400 UTC) be used for analysis of long-term trends of the free tropospheric background while the remaining data can be used to characterize composition and trends of the regional atmospheric boundary layer.



Wind distribution at Mount Kenya GAW station: Showing, all data, daytime (0800-1500 UTC), nighttime (2000–0300 UTC), and transitional, or remaining, hours (1600–1900 and 0400–0700 UTC).

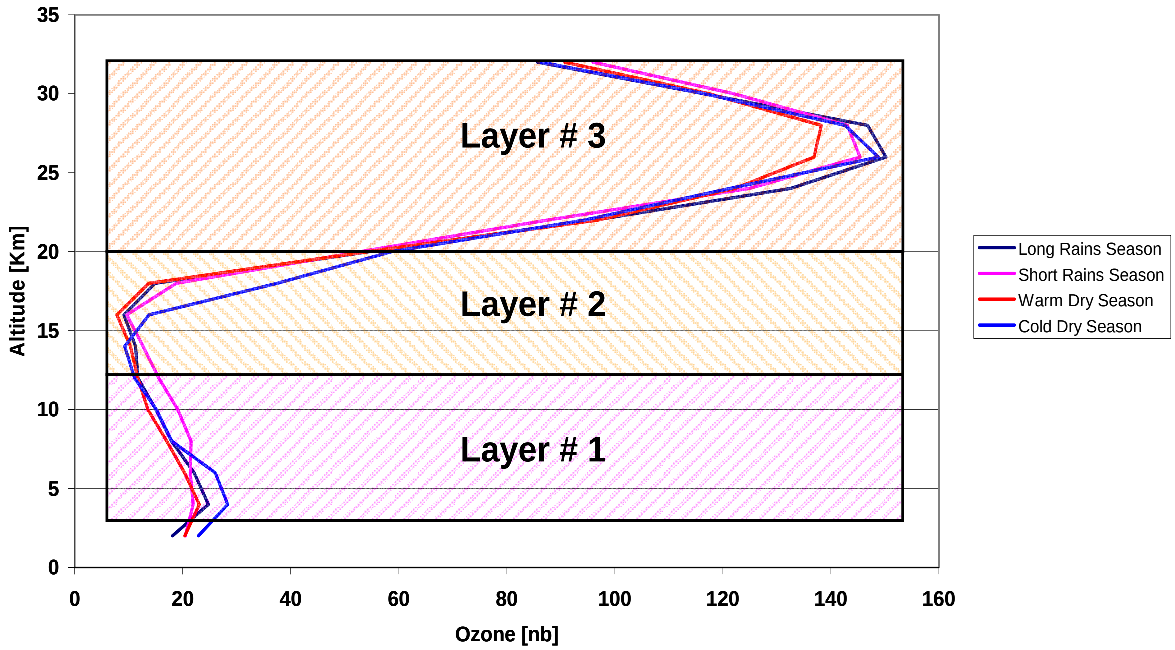
Representativeness and climatology of carbon monoxide and ozone at the global GAW station Mt. Kenya in equatorial Africa showed diurnal and seasonal variation of ozone. Henne et al. (2008) observed a frequent development of slope wind circulations at MKN and turbulent vertical transport of boundary layer air towards MKN during daytime. These transport processes manifest themselves in a pronounced diurnal cycle of CO mixing ratios. Shortly after sunrise (04:00 UTC) CO starts to rise as a result of advection of more polluted ABL air and reaches a maximum between 11:00 and 13:00 UTC. The average diurnal amplitude was 15 ppb. This pattern recurs during all months of the year, with increased amplitude (25–30 ppb) during July and September



Diurnal cycle of ozone

O3 showed a weaker annual cycle with a minimum in November and a broad summer maximum. Inter-annual variations were explained with differences in southern African biomass burning and transport towards MKN. Although biomass burning had little direct influence on the measurements at MKN it introduces inter-annual variability in the background concentrations of the southern hemisphere that subsequently reaches Kenya.

A statistical analysis of ozone profiles over Nairobi split into 3 layers reveals strong yearly variation in the free troposphere and the tropopause region, while ozone in the stratosphere appears to be relatively constant throughout the year. Total ozone measurements by Dobson instrument confirm maximum total ozone content during the short-rains season and a minimum in the warm-dry season (Ayoma et al, 2002).



Mean "Seasonally averaged" ozone profile over Nairobi based on 8 years of ozone sounding, *for respectively long-rains, short-rains, warm-dry and cold-dry season.*

As a first output of this analysis indicate that the relative ozone variability in the "stratosphere" is weak, thus indicative of small changes in the ozone concentration in the stratosphere over Nairobi during the last 8 years. On the contrary in the "free troposphere" and "tropopause" regions we observation showed significant changes: up to 40% of peak to peak variation with a well defined yearly cycle. This tropospheric ozone variability is higher than expected and may partially be attributed to turbulent air motions (Ilyas, 1991).

OZONE PLANNED RESEARCH

Currently, we do not have any major ozone research project to determine the status of ozone level in Kenya. This is occasioned by lack of adequate ozone observation stations. Consequently, more stations that will monitor total column of ozone, ozone profile and UV need to be established. This will lead to establishment of ozone mapping that will validate the satellite measured global coverage.

RECOMMENDATIONS OF 7ORM

(A) Research Needs

Implementation of 7ORM

There has been little implementation of the recommendations on research from 7ORM. However, awareness to conduct research on ozone has been enhanced through seminars and workshops. This has led to publication of a few international journals in conjunction with twinning partners (EMPA).

Future Recommendations

Several factors inhibit research activities in Kenya. These include:

-Budgetary constraints. The funds allocated for research is inadequate leading to few being conducted. External sourcing of research fund would be welcomed.

-There is little ozone data in the tropics especially in Equatorial Africa. Governments in this region should be sensitized on the need to establish more ozone monitoring stations.

-There are inadequate computing facilities especially for research that involve Global models. Twinning with more advanced research centers should be encouraged.

(B) Systematic observation

Implementation of 7ORM

In filling data gaps in geographic coverage, the government has established an urban air pollution monitoring station at the University of Nairobi that measures surface ozone. Last year, Kenya commenced measurements of methane (CH_4) at Mount Kenya GAW station which is both GHGs and ODSs. CH4 is measured by a Picarro G1301 instrument.

Archived data reports of ozone sondes include the simultaneous water vapour profiles measured by meteorological radiosondes and the data is available for ozone research and monitoring from the relevant world data center.

Future Recommendations

There is poor spatial distribution of ozone monitoring station in Kenya, one at Mount Kenya and two in Nairobi. Consideration of the redistribution of observation sites from areas highly populated with stations to those areas that are poorly populated should be undertaken. This would require both infrastructure and equipment support in order to establish new stations.

(C) Data Archiving

Implementation of 7ORM

The government provides funding for archiving raw data from ozone observational networks, and also facilitates submission of the data to the WOUDC. It is understood that archiving raw data does not replace the archiving of final data products.

The ozone data is archived in such a manner that they can be made easily accessible to scientists and the general public within a reasonable period of time.

Future Recommendations

Since, before being archived, ozone data must be quality assessed to ensure that it is of the highest possible quality, the staff must be fully trained in data management and quality assurance. This will ensure that data submitters continue to adhere to existing data submission protocols, particularly information on standard operating procedures and calibration histories, in order to maintain the overall quality and therefore the reputation of the entire archive. It is acknowledged that obtaining data of this quality is costly and time-consuming but is nonetheless an essential task and so data providers should be adequately funded and recognized for their efforts in providing this data to global archives for the furtherance of ozone and UV science.

(D) Capacity Building

Implementation of 7ORM

The instruments used in ozone measurement require sophisticated calibration and maintenance, much of which is unavailable in Kenya without international intervention. At present, there are insufficient number of regional centres for research, calibration, and training in developed and, especially, in developing countries. To fill this gap, Kenya has established a regional and bilateral cooperation and collaboration (twinning) with Swiss Federal Laboratories for Material Testing and Research (EMPA).

EMPA provide resources and opportunities for scientific and technical training, at and beyond the instrument-operation level, thereby allowing instrument operators and other scientific personnel in Kenya to use their data, other available data, and models in both regional and international research areas. EMPA conducts a biennial system and performance audit of surface ozone and carbon monoxide at the global GAW station Mount Kenya.

The WMO-GAW Training and Education Centre (GAWTEC) established in Germany has been successful in providing training in measurements and instrument calibration to all our staff involved in ozone measurements.

Future Recommendations

Resources should be provided to support more scientists from Kenya to attend conferences and workshops. This will enhance their skills and gain the necessary experience in ozone related research. Resources for the exchange and visits of personnel from monitoring stations in developed and developing countries should be increased in order to ensure technology and knowledge transfer and sustained measurement programmes. Extra establishment of regional centres for research, calibration, and validation in developing countries should be encouraged.

Conclusion

Procurement of instruments, establishment of necessary infrastructure and securing operational costs along with necessary human resource development are utmost necessary for enhancing the existing ozone stations and establishment of the new ones. When this is realized, it will contribute to the ongoing research to the various institutes on impact of both ozone and UV radiation on human health and environment.

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