COMOROS

1. OBSERVATIONAL ACTIVITIES

Ozone monitoring and research activities are actually achieved by the National Agency of Civil Aviation and Meteorology (ANACM) in collaboration with Comoros Ozone office since the implementation of SAOZ instrument at Moroni station (43,246E; -11,711S ; 20m) in October 2023. Now total column ozone and NOx database is under construction. We take this opportunity to acknowledge the "General Trust Fund for Financing Activities on Research and Systematic Observations Relevant to the Vienna Convention" for having supported the Comoros project aimed to establish the ozone observatory in Comoros Union. Total column of zone measurements recorded from this observatory will be presented in this report

However, before the SAOZ operationalisation, ozone research activities have been performed by ANACM scientists in collaboration with the Laboratory of Atmosphere and Cyclone (LACy) of Reunion University (the French university of south west Indian Ocean). The aim of this activity is to observe daily and seasonal variations of total ozone over Comoros. Research activities are focused on the use of satellite measurement (mainly OMI satellite data) to determinate daily variation of total column ozone (TCO) concentration for a complete annual cycle of satellite observation over Comoros. The obtained results will be presented in this report.

Regarding solar UV radiation monitoring and research activities, the ANACM has a Kipp & Zonen radiometer since September 2019 and solar UV radiation over Moroni is measured by using a broadband UV radiometer since December 2019. UV index database is available at ANACM and a research work is done and published (the title of the paper is: Monitoring solar radiation UV Exposure in the Comoros: https://doi.org/10.3390/ijerph181910475). Other research works regarding the study of cloud influence on UV index have been achieved and defended (by a Master student from LACy supervised by the Comoros Ozone research Manager). In this report, we present some results about daily and seasonal behaviour of solar UV index as observed at Moroni station

1.1. Ozone observation

Total ozone observation and monitoring is done by using a SAOZ instrument. The SAOZ operates in the visible and ultraviolet spectral bands in which measures the sunlight scattered from the zenith sky in the wavelength range between 300 nm and 600 nm. The spectral resolution value is evaluated to 0.8 nm. SAOZ instrument is dedicated to measure total ozone and nitrogen columns under a solar zenith angle up to 91°. Observation is performed during sunrise and sunset with a precision of 3 and 5% respectively. The daily average is taken as the mean of sunrise and sunset measurements.

Other research activities are achieved in collaboration with the Laboratory of Atmosphere and Cyclone (LACy) of Université de la Reunion. Global data of total ozone from OMI aura satellite have been used. It is about the V8 L3 OMI-TOMS product. OMI-TOMS products are retrieved using two wavelengths: the 317.5 and 331.2 nm are employed under most conditions, while 331.2 and 360 nm are specially employed for conditions of high ozone concentration and high solar zenith angle. This product is accessible via https://disc.gsfc.nasa.gov.dataset/OMITO3G_003/summary?keywords=OMI%2F/Aura.
Daily total ozone measurement recorded over Reunion islands and Comoros are retrieved and analysed in order to quantify daily and seasonal variation of ozone over Comoros

1.2. UV observation

UV index measurements are achieved at Moroni station using a SUV (Smart Ultraviolet) Radiometer. The UV radiometers SUV series is designed to measure global UV irradiance in the different UV bands:

- SUV-A covers the range between 315 and 400 nm
- SUV-B covers the range between 280 and 315 nm
- SUV-E is designed to match the sensitivity of the human skin with regard to the ISO 1766:1999 / CIE S 007 / E-1998.

The UV-Index can be calculated from the SUV-E output. The radiometers are designed for continuous outdoor use in routine monitoring applications with the sun as a source. It can also be used in indoor applications, bearing the specifications of the source (generally a lamp) and of the radiometer in mind.

Cloud nebulosity measurement are achieved via imagery camera as known as the SkyCam vision. The SkyCam Vision is a camera system used by the InstaCast firmware, which provides forecasts every 30 seconds from whole-sky images acquired in the visible waveband using a fisheye lens. The camera sensor is set in a high definition range (HDR) mode to construct a fused image from intermediate images at different exposure times. The resulting image shows enhanced contrasts and illuminations of cloud scenes as compared to cameras with no HDR mode. The camera includes a global horizontal irradiance (GHI) sensor used as a “truth” measurement basis to perform the forecasts. The camera also includes an onboard mini-PC together with a data storage device to perform a local processing of the images. The forecasts are communicated directly over the local network of the power plant to the energy management system (EMS) through Modbus TCP/IP protocol. The cloud fraction and nebulosity are retrieved using a cloud classification method

UV index and cloud fraction measurements recorded at Moroni station are used to study daily and seasonal variation of UV index and with respect to associated parameters such as ozone, cloud fraction and solar zenith angle.

2. RESULTS

2.1. Daily and seasonal ozone variation

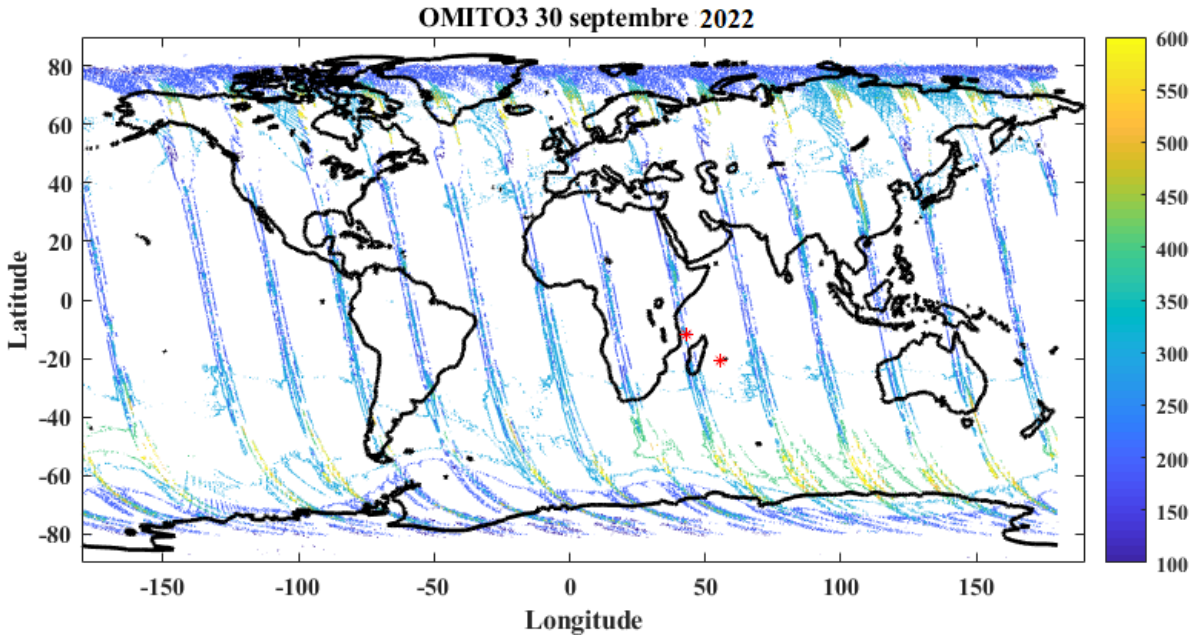

Figure 1: global map of total column of ozone recorded by OMI Aura satellite for the date of 30 September 2022

Work presented here is the first result obtained from analysis of total column ozone recorded over Comoros by OMI satellite and ground based instruments. With its good spatial coverage Satellite observations offer the best way to provide TCO measurement over the globe and allow having ozone data in a specific region where there is not ground-based instrument. However their height and temporal resolution is poor in comparison to some instruments such as SAOZ, Dobson or Brewer. It is therefore necessary to compare the satellite measurements with ground based for validation. Figure 1 present global map of measurements form OMI instrument for a day where the Comoros islands were scanned. Comoros islands and Reunion are presented by reds stars. Daily ozone values recorded over Comoros Islands and Reunion are retrieved. The following criterions are used to define the retrieving region:

Coordinate	Latitude (°S)		Longitude (°E)	
	Minimal	Maximal	Minimal	Maximal
Comoros islands	13°	-11°S	42.30°	45°
Reunion island	21.5°	20.8°S	55°	60°

Daily ozone value for each region is obtained by averaging measurements recorded over the selected region. In order to validate the obtained dailies data, ozone measurements recorded by SOAZ at Reunion is compared with the satellite co-located measurements. Here the relative difference, correlation coefficient and bias error between the two instruments are calculated. Figure 2a shows temporal variation of TCO measured at Reunion by SOAZ instrument (red line) and from OMI satellite (black line) for the time period of 01 January to 31 December 2023. Figure 2b is the relative difference between the two observations with respect to the ground based measurement. It is apparent that the daily and seasonal variation between SAOZ and satellite observation are found to be consistent and the obtained relative difference is within ±10%. The correlation coefficient R^2 obtained between OMI and ground-based measurements was evaluated and found to be around 0.84. The daily bias error is assessed at 0.5%± 2.2(1σ).

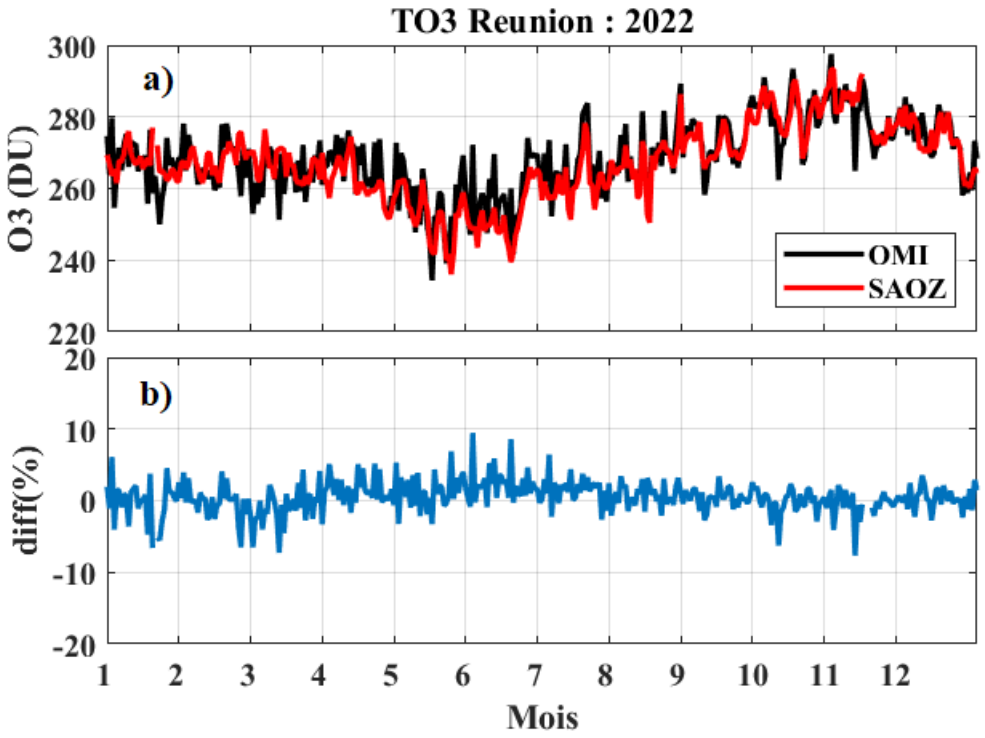

Figure 2: (a): the time evolution of TCO over Reunion as observed by OMI satellite (black line) and SOAZ (red line) in 2022 (from 1 January to 31 December). (b) :The relative difference between the two observations.

This result indicates that OMI slightly overestimate total ozone with respect to SAOZ. However this overestimation is not very significant as the root mean square recorded between the two observations is less than 4DU. This difference is in part due to the different instrumental characteristics, thus OMI satellite data can be used to product ozone temporal evolution for the case of Comoros. Time-evolution of TCO as observed by the OMI instrument is presented in figure 3. In 2022 the daily mean value vary between 285.68DU and 236.18DU with a maximum in spring and a minimum in winter. However, high values are also observed in autumn season, especially from march to middle April due to equinox process. During this period, solar radiation increase in tropical region, leading to an increase in ozone production over the region. These observations show that Total Ozone over Comoros is modulating by annual and semi-annual cycle. Similar results are reported by Toihir et al. (2018) where the annual and semi-annual cycle of ozone have observed in time-evolution of TCO over equatorial and tropical sites.

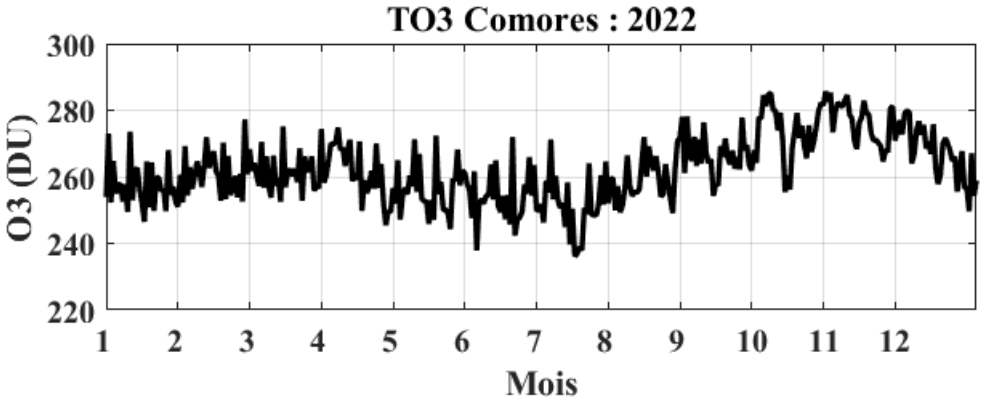

Figure 3: Time-evolution of TCO over Comoros as observed by OMI satellite for the period from 1 January to 31 December 2022

As mentioned above, the TCO observation and monitoring are achieved at ANACM since the operationalisation of SAOZ instrument at Moroni station in October 2023. Measurements recorded from 10 October to 31 December 2023 are presented in figure 4. One can see the decline curve of TCO from November to December indicating the end of annual cycle. However, these data should be compared with others co-located ground-based and satellite measurements before to be used for scientists studies. So an inter-comparison campaign should be organised in order to validate data from Comoros SAOZ instrument.

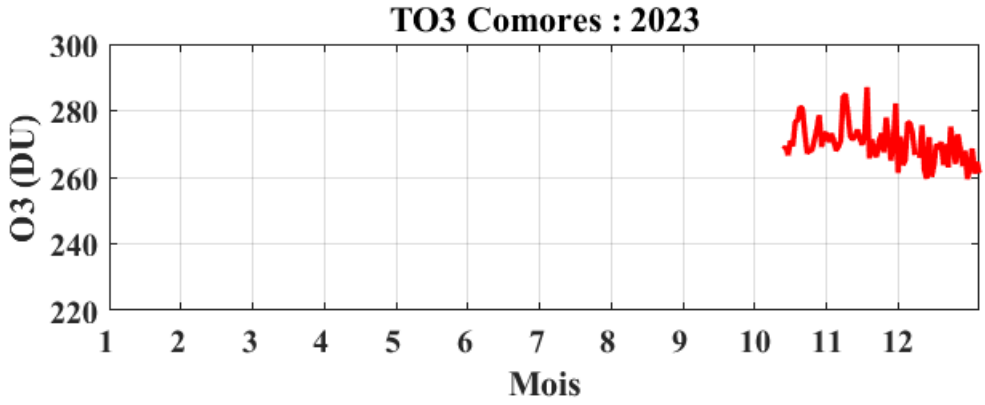

Figure 4: daily mean data recorded by SOAZ ground based instrument at Moroni station from 10 October to 31 December 2022

2.2. UV result

Ultraviolet measurements are achieved at Moroni station (-11.71, 43.24) since 7 December 2019 in the framework of UV-indien project. The project has taken end since December 2021; however UV index and cloud observation are continuously performed on the site. Here we present some result regarding daily and seasonally variation of UV index at Moroni. Figure 5 present time-evolution of UV index and solar zenith angle.

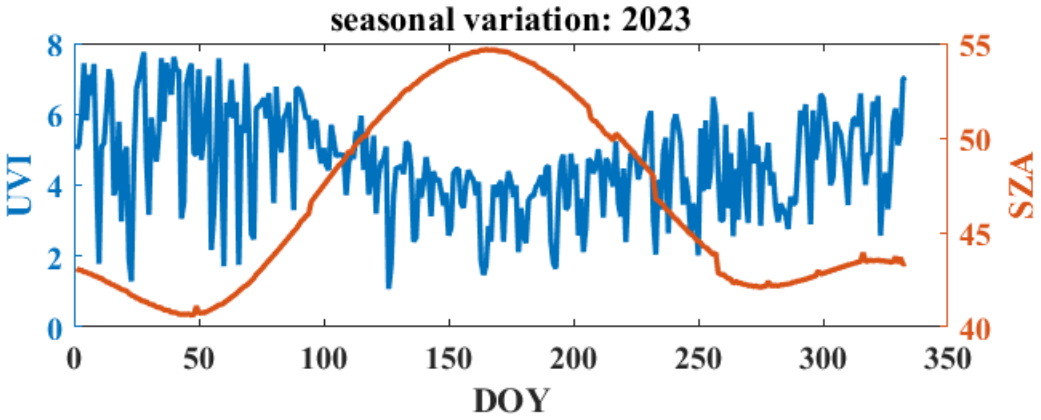

Figure 5: daily value of UVI (blue) recorded from 01 January to 22 November 2023. The superimposed red line is the time-evolution of SZA daily average.

The daily mean of UVI vary from 1.02 to 7.75. Lower and higher UV index values are observed during cloud and clear sky respectively. Minimum UV index is recorded during the winter period while the maximum is observed in summer season. High UV index are also observed in spring period. Seasonally, the high/low UV indexes are associated with low/high seasonal solar zenith angle. Thus skin and eyes protection are important especially during summer and spring season. Regarding the daily variation, maximum UV index is observed between 11am and 1pm local time while the minimum is basically recorded from 5pm when the average SZA is below 45°. Figure 6 present the UVI time evolution from 6am to 5pm with its associated standard deviation.

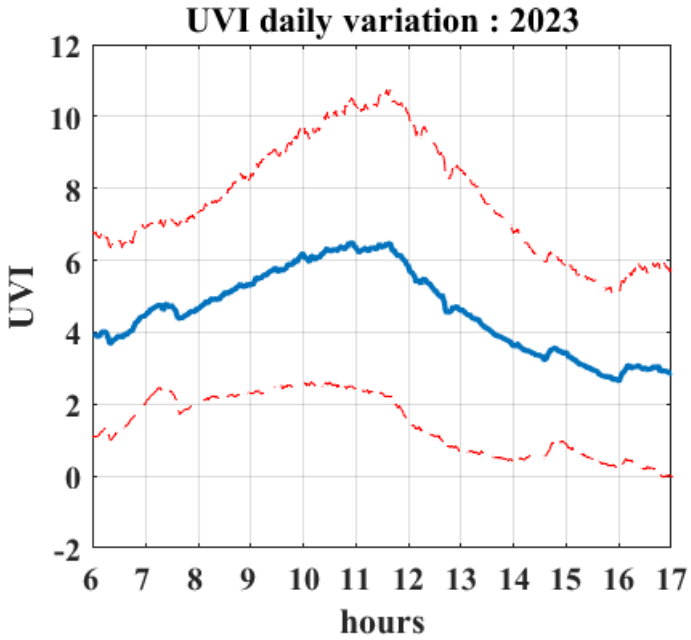

Figure 8: UVI time-evolution (blue curve) and its associated standard deviation (red dotted line).

High variability is highlighted from 11am to 12am where maximum solar UV radiation is recorded. Here the positive standard deviation display values higher than 10. This value are very high than the recommended by WHO. We can conclude from these results that Comoros is among the tropical countries where solar ultraviolet radiation has a very high intensity.

3. FUTURE PLANS, NEEDS AND RECOMMENDATIONS

The agency of civil aviation and meteorology of Comoros (ANACM) wish to participate on inter-comparison campaign of instrument in order to validate or improve TCO product measured by the SAOZ instrument. We need help to maintain ozone observation, to develop research activities and to publish results on a specialised research journal. We are planning to submit a project for getting found under the "General Trust Fund for Financing Activities on Research and Systematic Observations Relevant to the Vienna Convention" in order to support our research observatory. The ANACM make a plan to develop observation and research on aerosol and ozone precursor particles such as CO, VOC and ODS

We need

- a Sun-Photometer for aerosols measurement
- a CO and COV analysers

Capacity building is required to increase capabilities of the preparation and submission of the ORM Comoros national report and support high quality data collection and research on modelling ozone variability and trend.

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