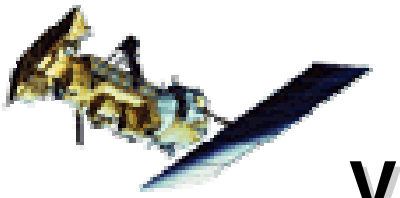

Variability of Aerosol Index, Ultraviolet Radiation and Ozone from Satellite Observations over Nigeria and their Potential Uses

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Department of Meteorology

Federal University of Technology, Akure, Nigeria

Acknowledgments:

NASA/GSFC TOMS Ozone Processing Team

NASRDA

Imoh B. Obioh

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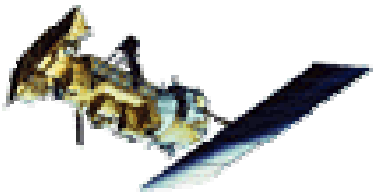

Outline

- Basic Knowledge on Ozone and UV Variability in Low Latitudes.
- **Challenges Facing Nigeria.**
- **Steps Taken by Nigeria Towards the Protection of the Ozone Layer**
- **Mean Ozone, Erythemal UV and Aerosol Index Pattern over Africa and Nigeria**
- **Potential Applications of Satellite-retrieved Data for Environmental Monitoring**

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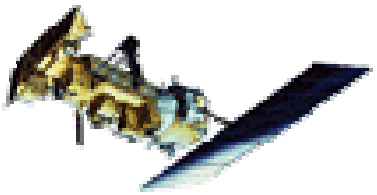
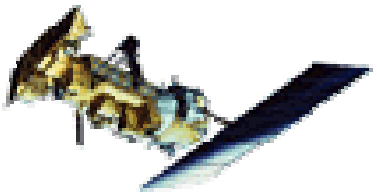


Preamble

- **There has been very little measurements undertaken in the tropics to measure the base levels of stratospheric ozone depletion and the associated UV radiation penetration to the surface.**
- **Most equatorial regions are underdeveloped and have no means of monitoring Ozone, UV or atmospheric aerosols**
- **In the last few years, monitoring stations of surface and vertical ozone are evolving at equatorial regions monitoring surface and vertical ozone, plus other relevant meteorological parameters.**
- The objective of this presentation is to present some of the challenges facing a developing country in Africa (Nigeria) and the possible ways to overcome the difficulties.



Basic Knowledge on Ozone and UV Variability in Low Latitudes

- In general, lower latitudes have small ozone column thickness which does not vary much seasonally
- This implies that solar UV-B penetration is a maximum at the tropics throughout the year
- The overall effect of the low ozone content and the small seasonal variability is that in the equatorial regions, UV-B penetration would be many times that of the mid- to high latitudes
- Homogeneous reduction in the stratospheric ozone concentration would produce higher UV-B in the low latitudes
- High UV flux may produce severe biological and physiological effects – enhancement of severe tropical diseases and medical problems (herpes, hepatitis, cataracts, immune deficiency and reduced life expectancy)

➔Seasonal variations:

- summer: synoptic scale, small variability
- winter: planetary scale, large variability

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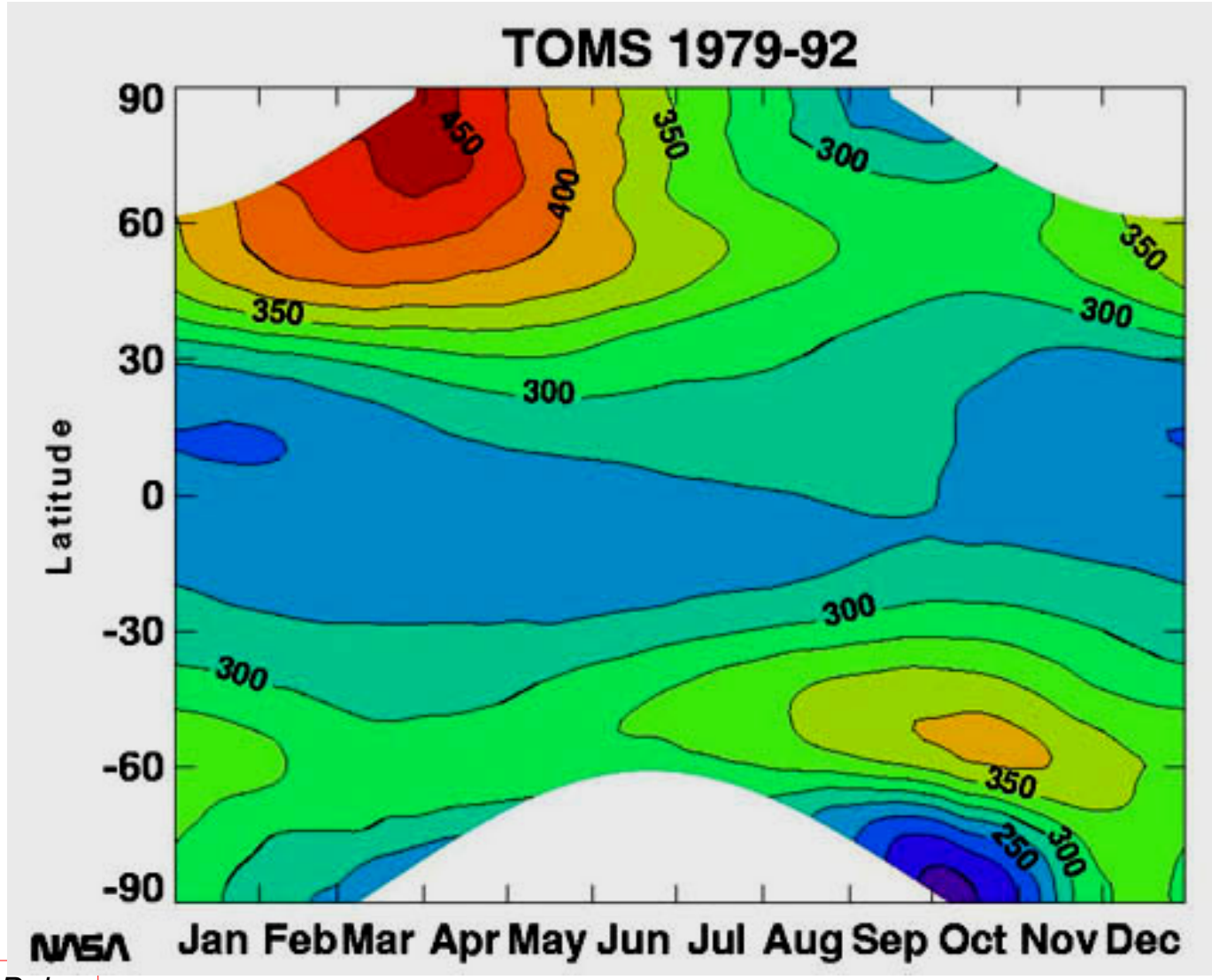
Time-Latitude Cross Section of Ozone



e.g. Andrews, Holton, and Leovy (1987; p.395)

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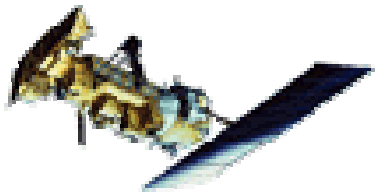

Basic Knowledge on Ozone and UV Variability in Low Latitudes

- UV radiation can be measured as an irradiance – the power incident upon a surface unit area – in units of W/m^2, or as a radiant exposure, or dose – the energy incident upon a surface unit area during a specified period of time – in units of J/m^2
- An action spectrum describes the relative effectiveness of UV radiation at a particular wavelength to produce a particular biological response.
- The biological response may refer to various detrimental effects on biological subjects including humans, animals or plants.
- An action spectrum for a given biological effect is used as a wavelength-dependent weighting factor to the spectral UV irradiance (280 to 400nm) and then integrated over wavelength to find the actual biologically effective irradiance (in W/m^2).
- The effective UV dose (in J/m^2) for a particular exposure period is found by summing (integrating) the effective irradiance over the exposure period.
- The Erythermal Action Spectrum (Mckinlay and Diffey, 1987) is internationally accepted as the standard index for normal skin response to the UV-A to UV-B

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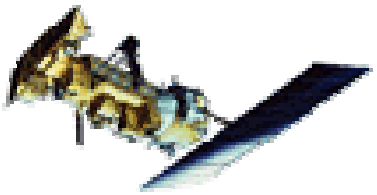
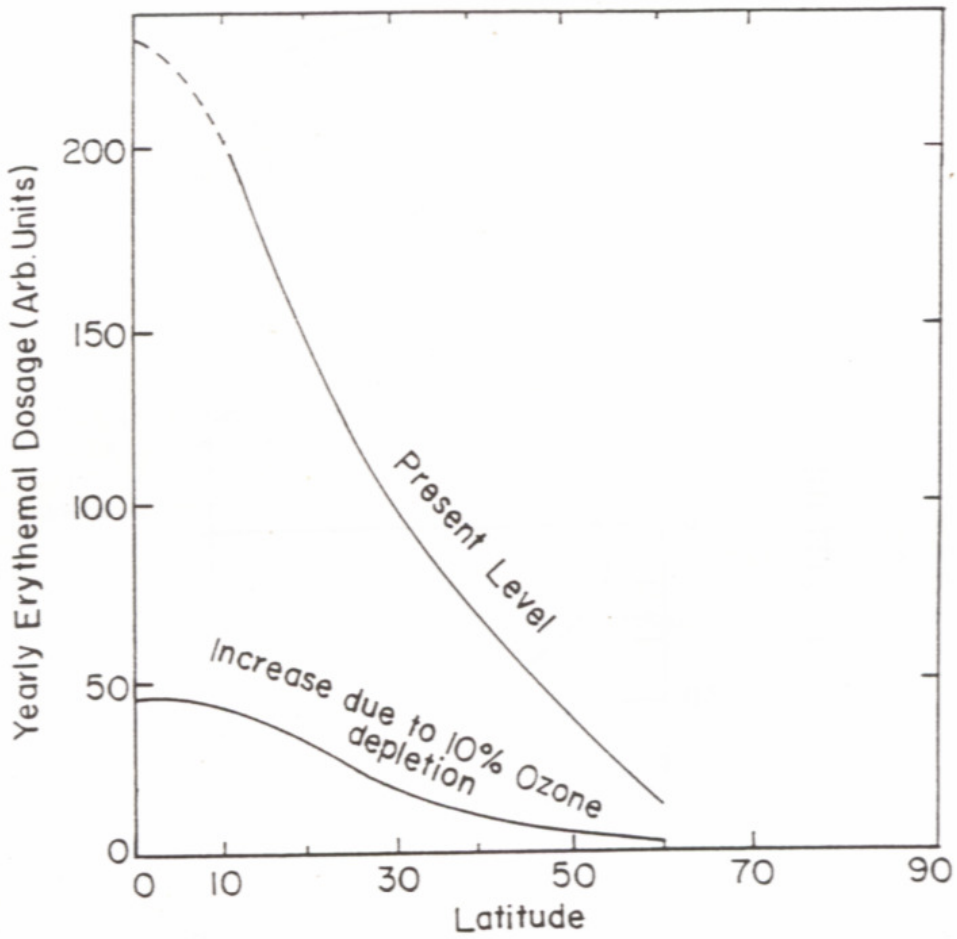


Possible Effect of Increase in UV due to Ozone Depletion



Typical Variations of Erythemal Dosage (joules/cm^2) with Latitude as Measured During Clear Days (Ilyas, 1991)

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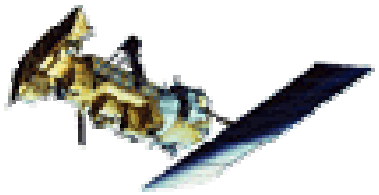

Challenges Facing Nigeria

- Large population
- Nigeria is an oil producing nation and in gas flaring is still a major challenge.
- About 5 million Nigerians are living with HIV, the precursor of AIDS.
- Majority of the population are poor.
- Live expectancy is short (55 years).
- False sense of protection associated with the dark skin colour pigment.
- High outdoor activities
- No proper education on danger of increased UV-B, higher tropospheric ozone, lower stratospheric ozone:
  - viral infections, eye damage (cataract), damage to the immune system, reduced life expectancy. Impacts on terrestrial ecosystem, aquatic ecosystem, biogeochemical cycles, air quality, etc.

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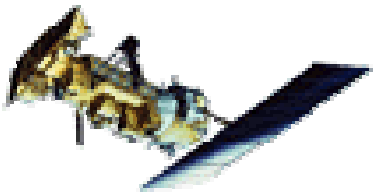

The Nigerian Experience

- About 40 Automatic Weather Station installed since 2004/2005 including UV meters.
- However, the network is not functioning properly
- NIMET spearheaded the setting up of monitoring stations for Total Ozone Monitoring System and the surface UV-B.
- There are very few ozone monitoring stations in Sub-Saharan Africa apart from South Africa.
- Public Information providing warning on Air Quality/UV-Index is currently non-existent in Nigeria.

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The Nigerian Experience

Recycling the use of second-hand "Tokunbo" (imported refrigerators and air conditioners)

Gas Flaring in the Niger Delta regions of Nigeria

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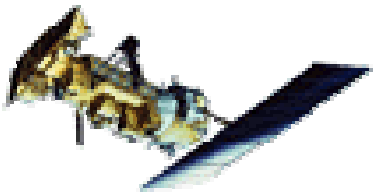

The Nigerian Experience

- Nigeria participated actively in all negotiations leading to the resolution of Article 5 of the Montreal Protocol concerning the special needs of developing countries.

- Nigeria signed and ratified the protocol on October 31, 1988.

- Meteorological services (NIMET) was able to set up of monitoring stations for Total Ozone and the surface UV-B. These stations remain the only stations in Nigeria today. They are also among the few ones in Sub-Saharan Africa apart from South Africa.

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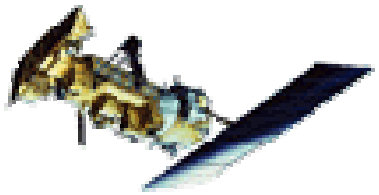

Steps Taken by Nigeria Towards the Protection of the Ozone Layer

- Nigeria has set the effective date to attain the status of 0% gas flaring to be July 31st 2008.
- Federal Ministry of Environment was empowered (through Degree No. 88 of 1988) establishing the Federal Environmental Protection Agency (FEPA), to control environmentally harmful substances especially CFCs and Halons that are known to affect the ozone layer.
- No recorded production of Ozone Depleting Substances (ODSs) in Nigeria but it was estimated that 2,650 and 3,459 (in thousand tonnes) of HCFC/CFC/Halons were released to the atmosphere in 1999 and 2000 respectively by one of the multilateral oil producing companies.
- Nigeria's total ODS consumption is met through importations by a limited number of companies.
- The total ODS import into Nigeria in 1994 for instance, is estimated at about 1157.0 ODP tones of which CFC-11 and CFC-12 account for about 85% (UNIDO, 1995).
- Nigeria has banned the importation of used refrigerators and freezers as a commitment of its support to discourage illegal production of CFCs.

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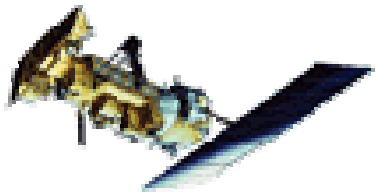

Steps Taken by Nigeria Towards the Protection of the Ozone Layer (Cont'd)

- UNIDO (a major implementer of the Montreal Protocol) is involved in CFC phase out in the air conditioning and refrigeration industries and services in Nigeria.

- According to UNIDO (2000), the on-going UNIDO programmes in Nigeria, valued at approximately $8.2 million, include two CFC phase-out programmes in two indigenous companies.

- A number of institutions have taken initiatives to provide the monitoring and research needed to improve the understanding of surface and stratospheric ozone issues in Nigeria.

- For instance, Obafemi Awolowo University, Ile-Ife, set up an automatic air quality monitoring station in Lagos in 1991, measuring trace gases mixing values including surface ozone.

- The Nigerian Meteorological Agency (NIMET) started the monitoring of ozone layer in April 1993 with the installation of the Dobson Spectrophotometer for the measurement of Total Column ozone.

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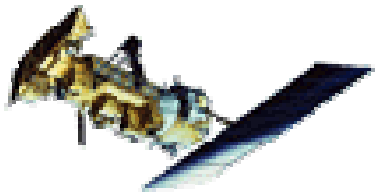

Steps Taken by Nigeria Towards the Protection of the Ozone Layer (Cont'd)

- The station at Oshogbo was established within the framework of the Global Ozone Observing System (GO_3OS) and it is located at Lagos (Lat. 06° 36′N; Long. 03° 26′E;) and at Osogbo (Lat. 07° 47′N; Long. 04° 29′E).

- Total ozone has been measured three times daily and the data transmitted to World Ozone Data Centre in Canada.

- Parameters measured at the WMO GAW Station at Osogbo include surface ozone with UV Photometric ozone Analyzer, UV-B radiation, aerosols, etc.

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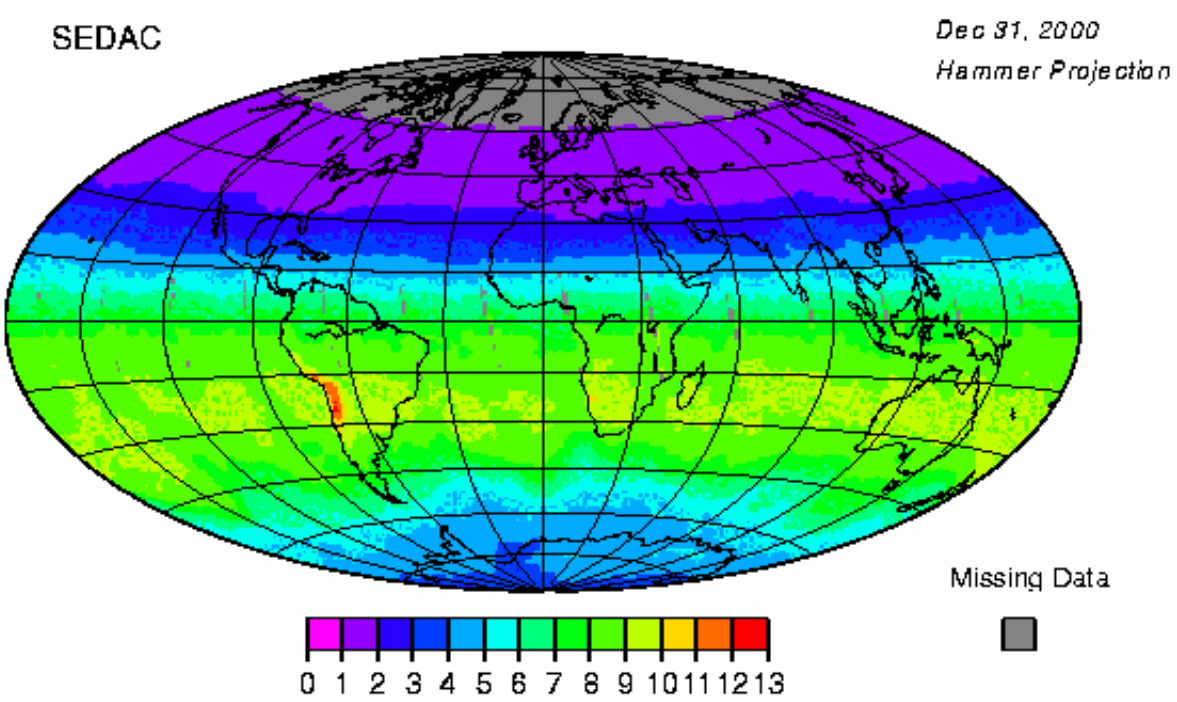
Daily Erythemal Dose Estimates Using Earth Probe/TOMS data



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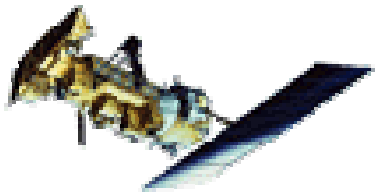
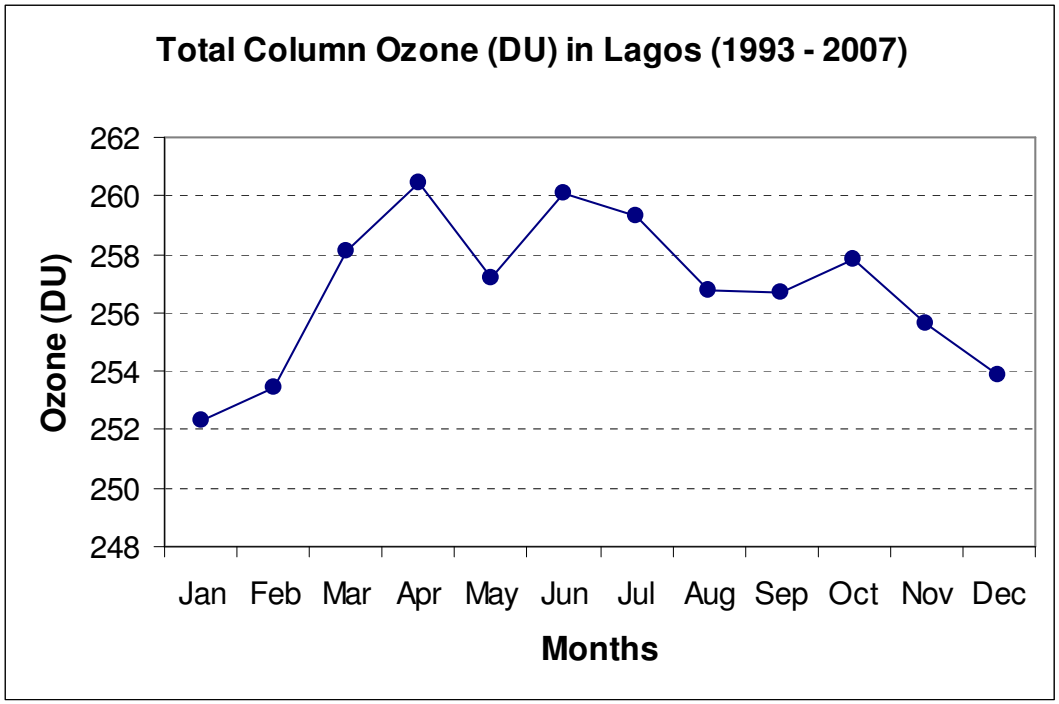
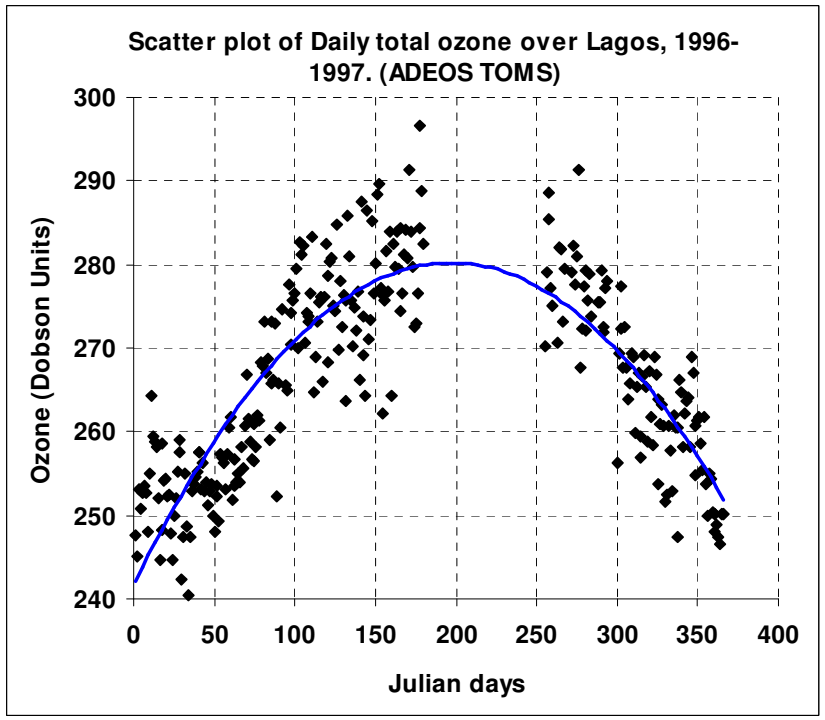


Monthly and Daily Characteristics of Ozone over Lagos



Surface Measurements



TOMS Measurements

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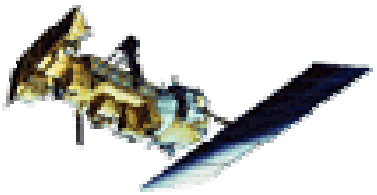
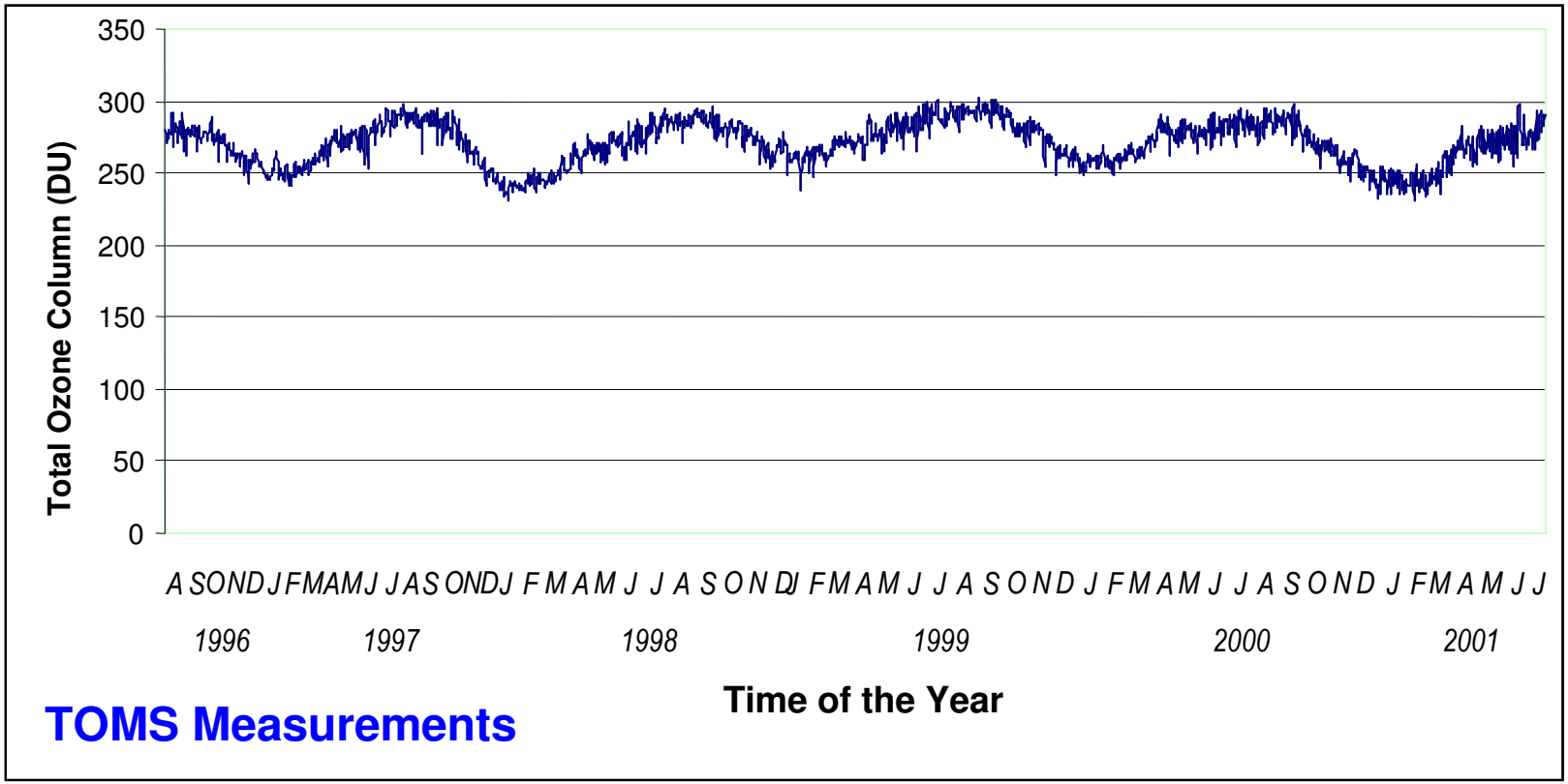


Annual Cycle of Ozone over Lagos



Annual Cycle of Total Ozone Column Variability over Lagos based on EarthProbe Observations (Obioh, et al, 2003)

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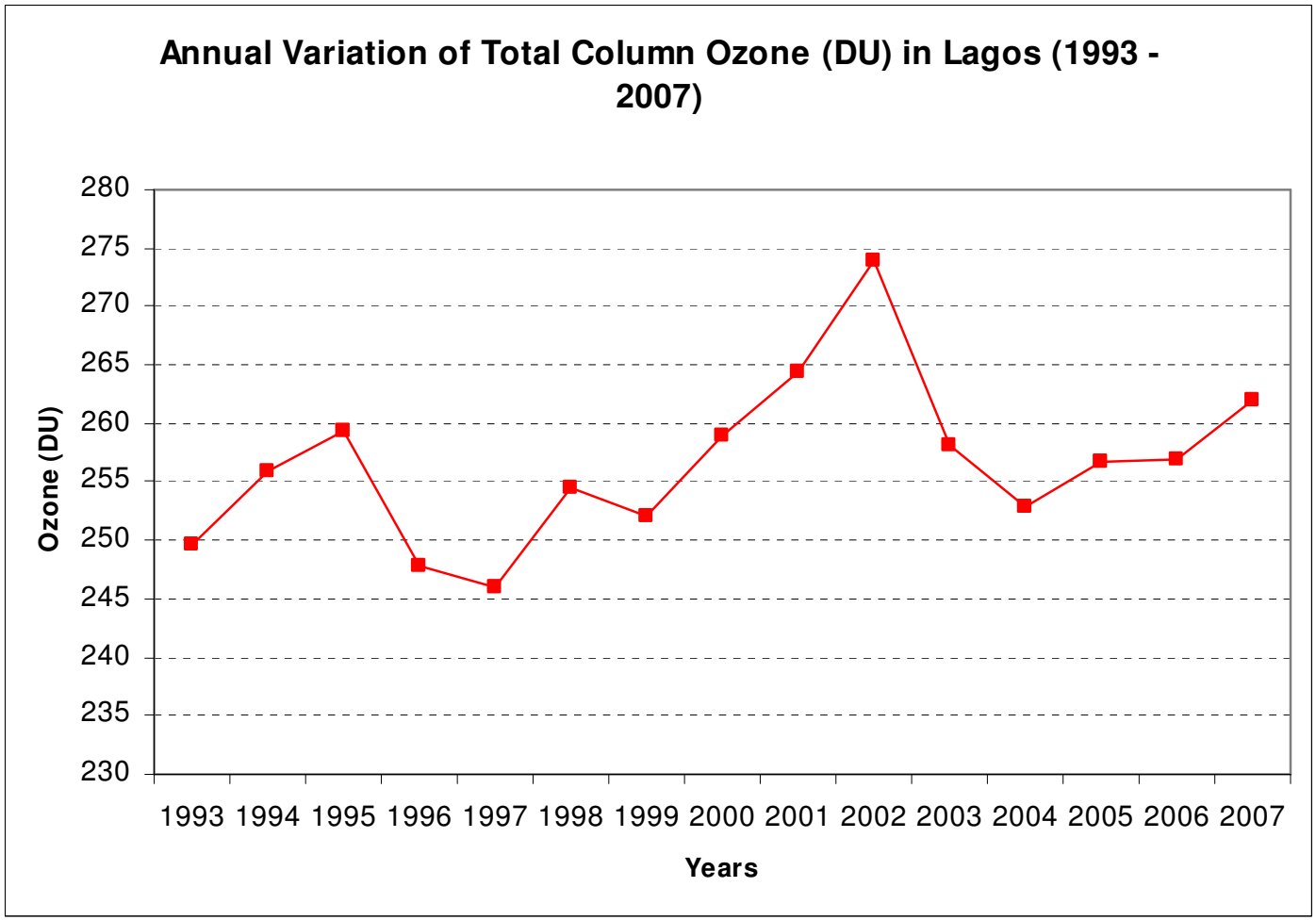
Annual Variations of Total Ozone over Lagos



Surface total ozone measurements

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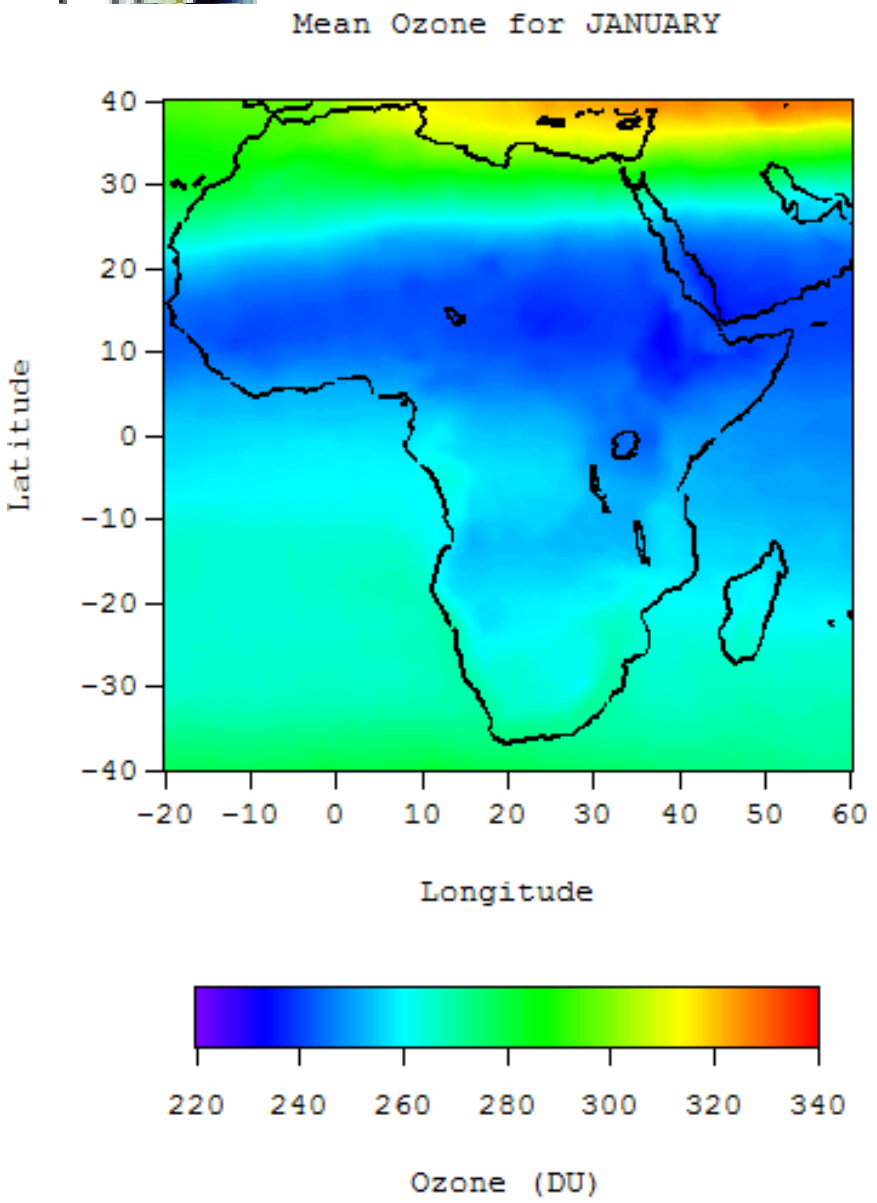

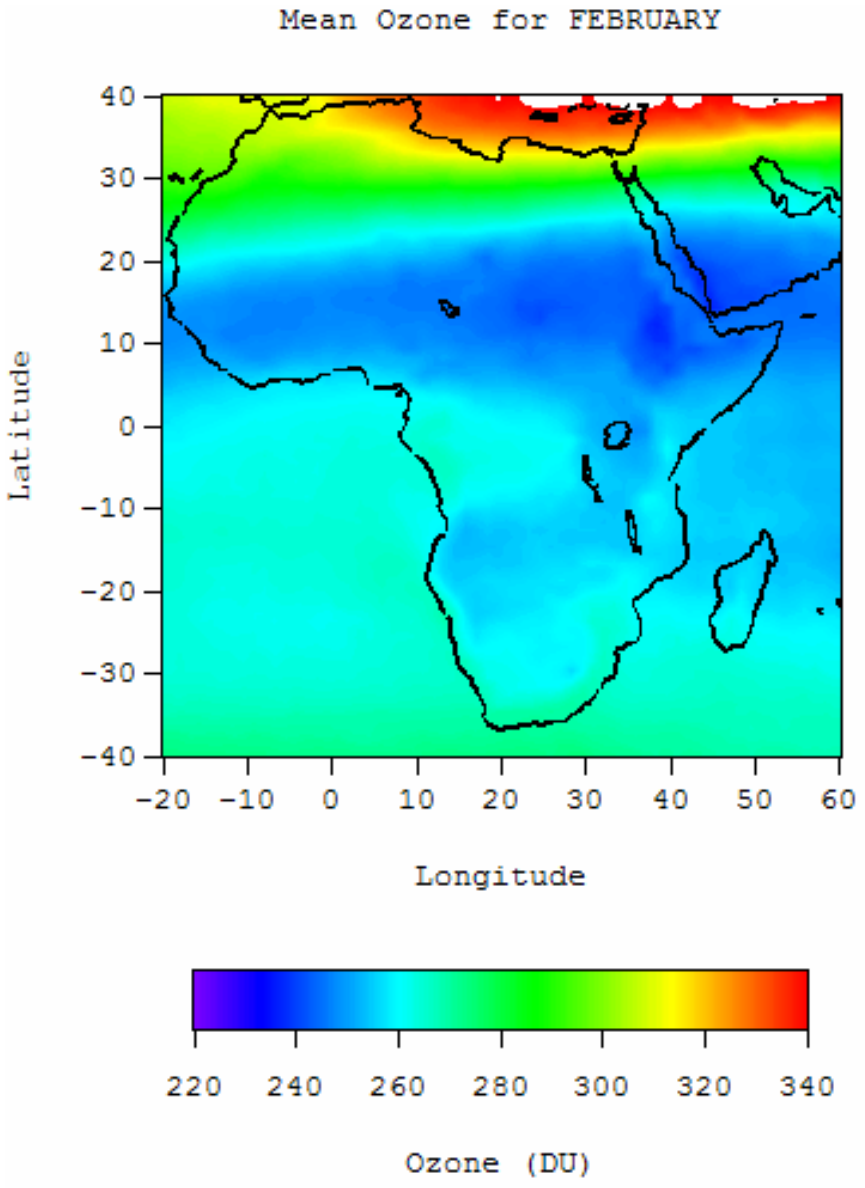

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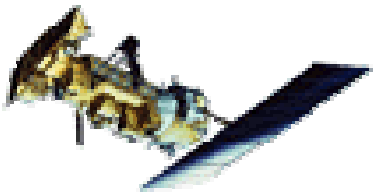

Mean Monthly Ozone Animation over Africa

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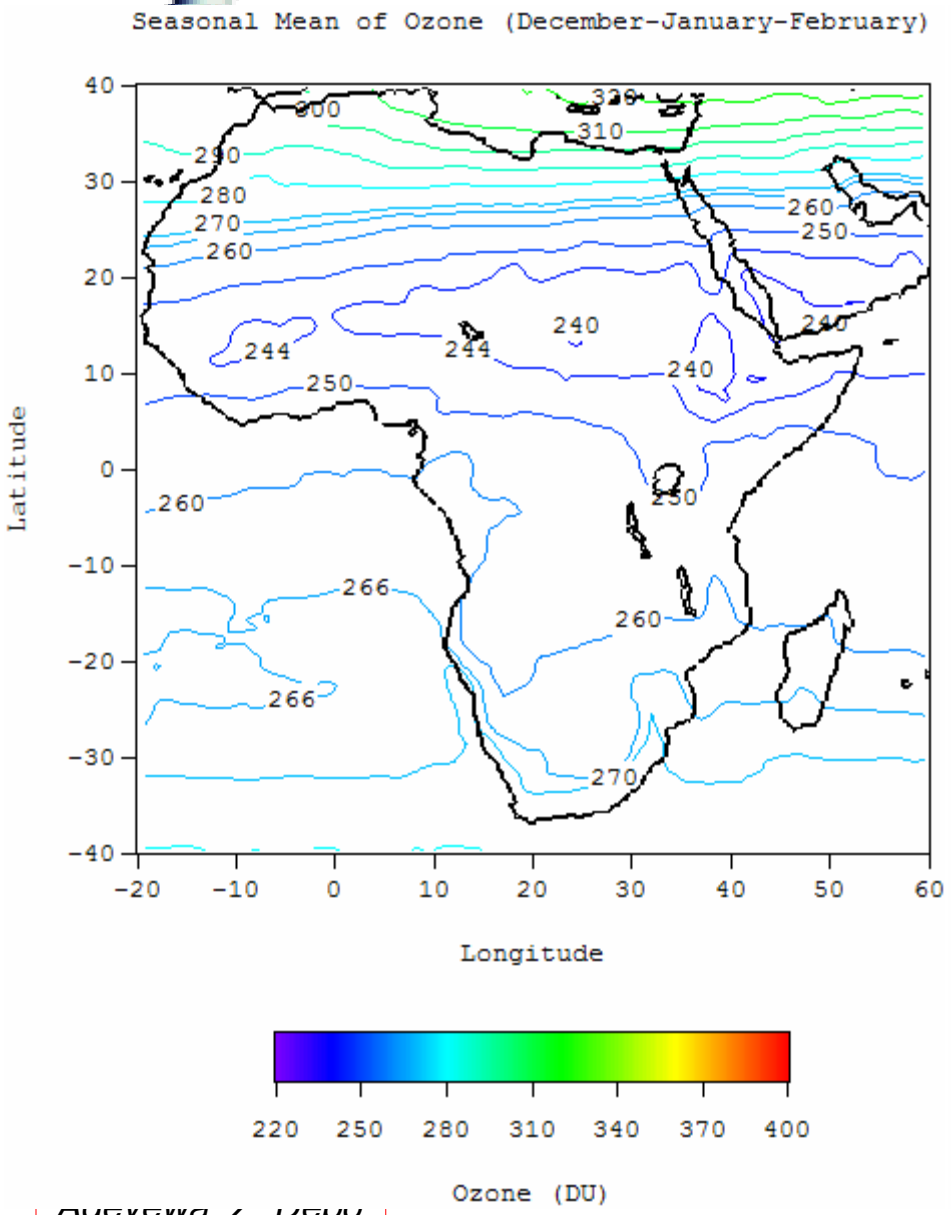
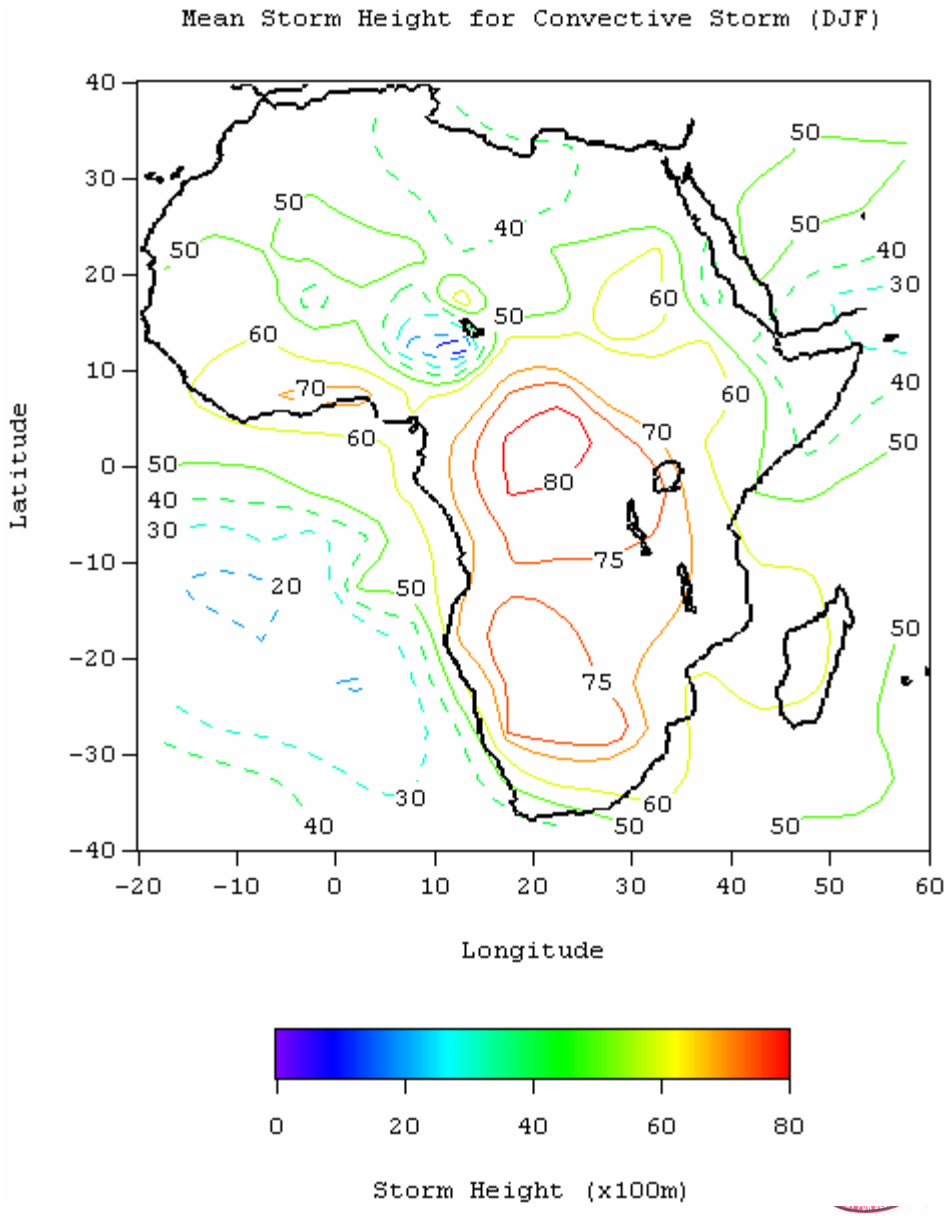
Comparison of Seasonal Total Ozone over Africa and Storms Heights by TRMM Satellite





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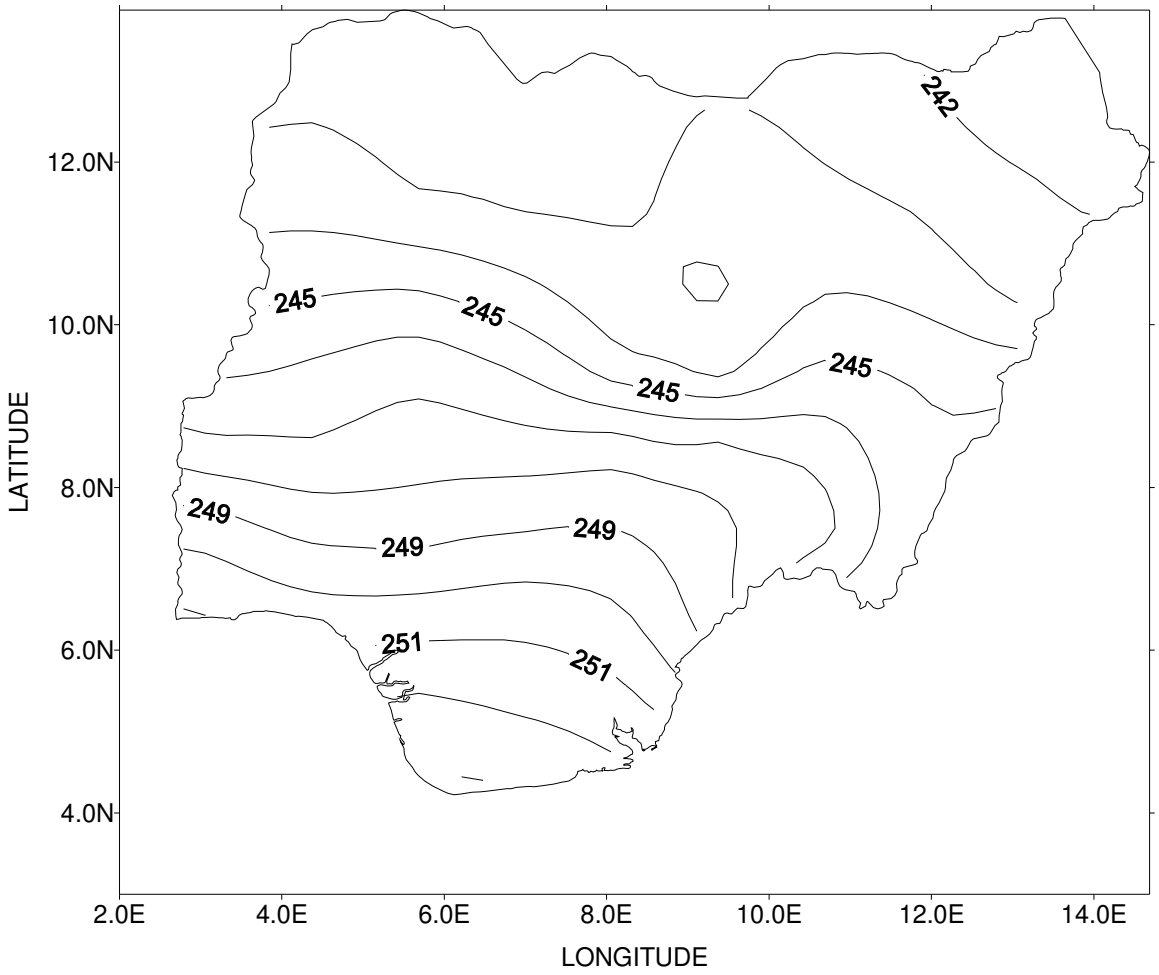
Mean Ozone Pattern in Nigeria during January



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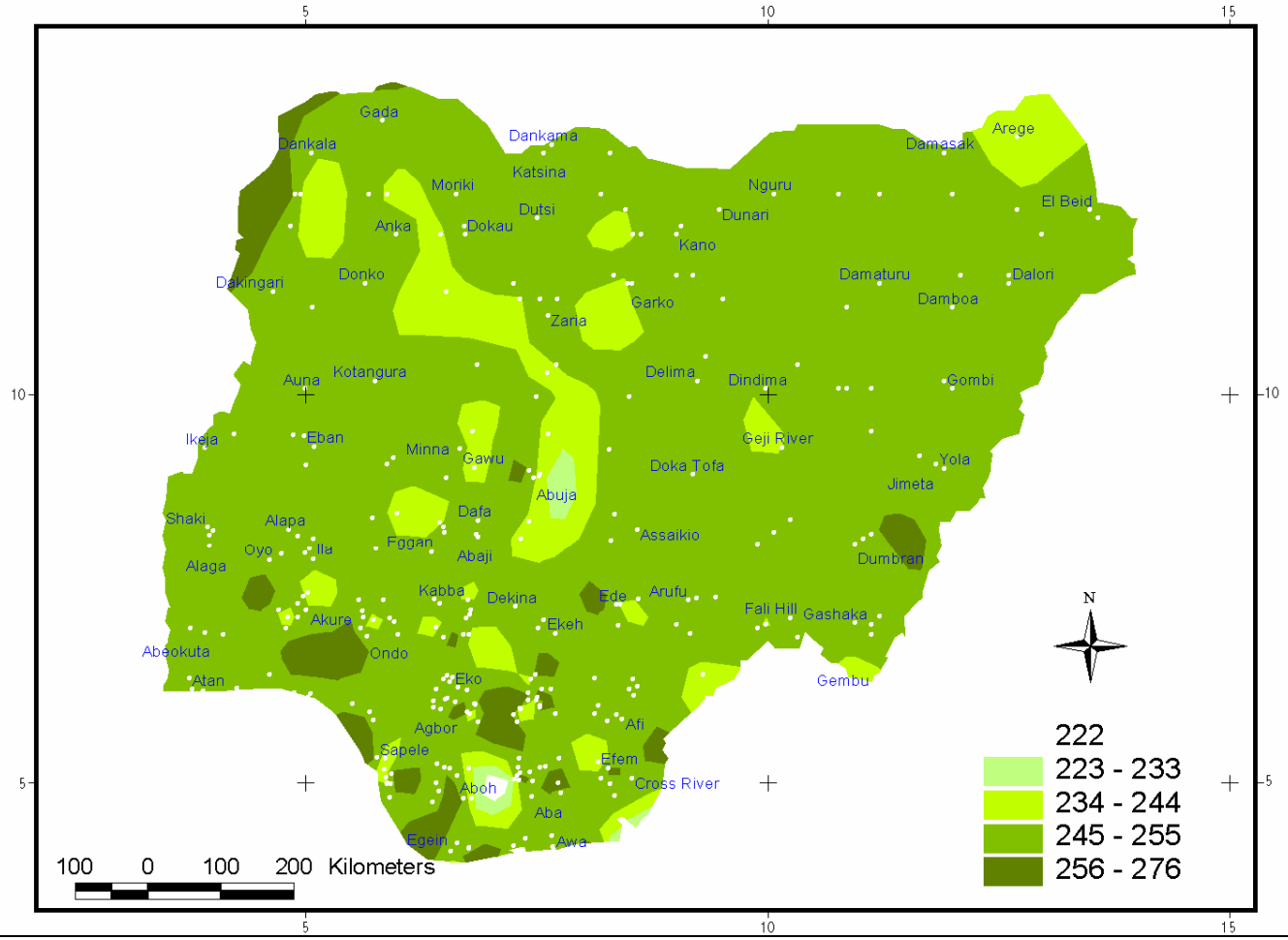
Min Ozone Pattern in Nigeria (January) [Obioh, et al, 2003]



Spatial Variation of TOMS Satellite Data over Nigeria During the Months of January, Representing Minimum Total Column Ozone over Nigeria.

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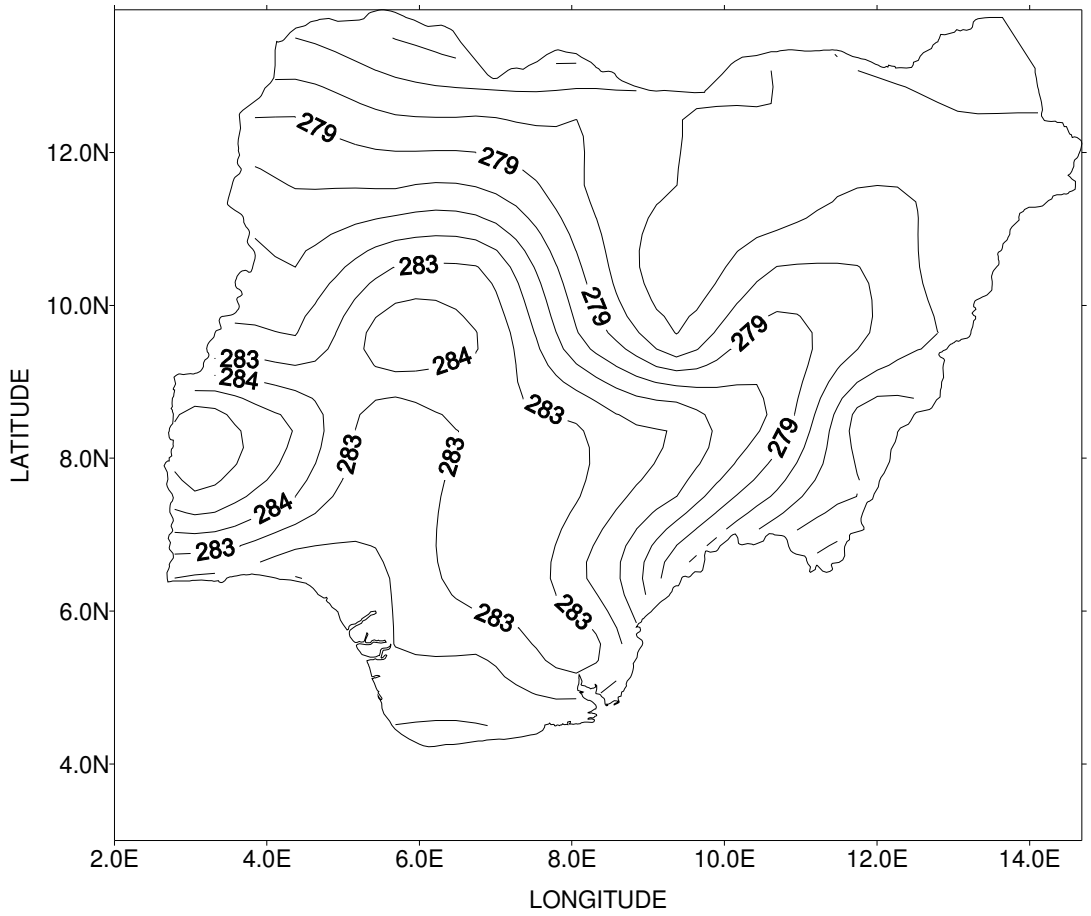
Mean Ozone Pattern in Nigeria during August



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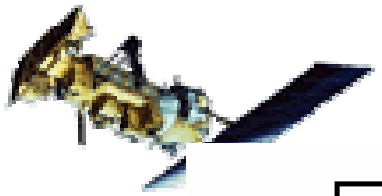
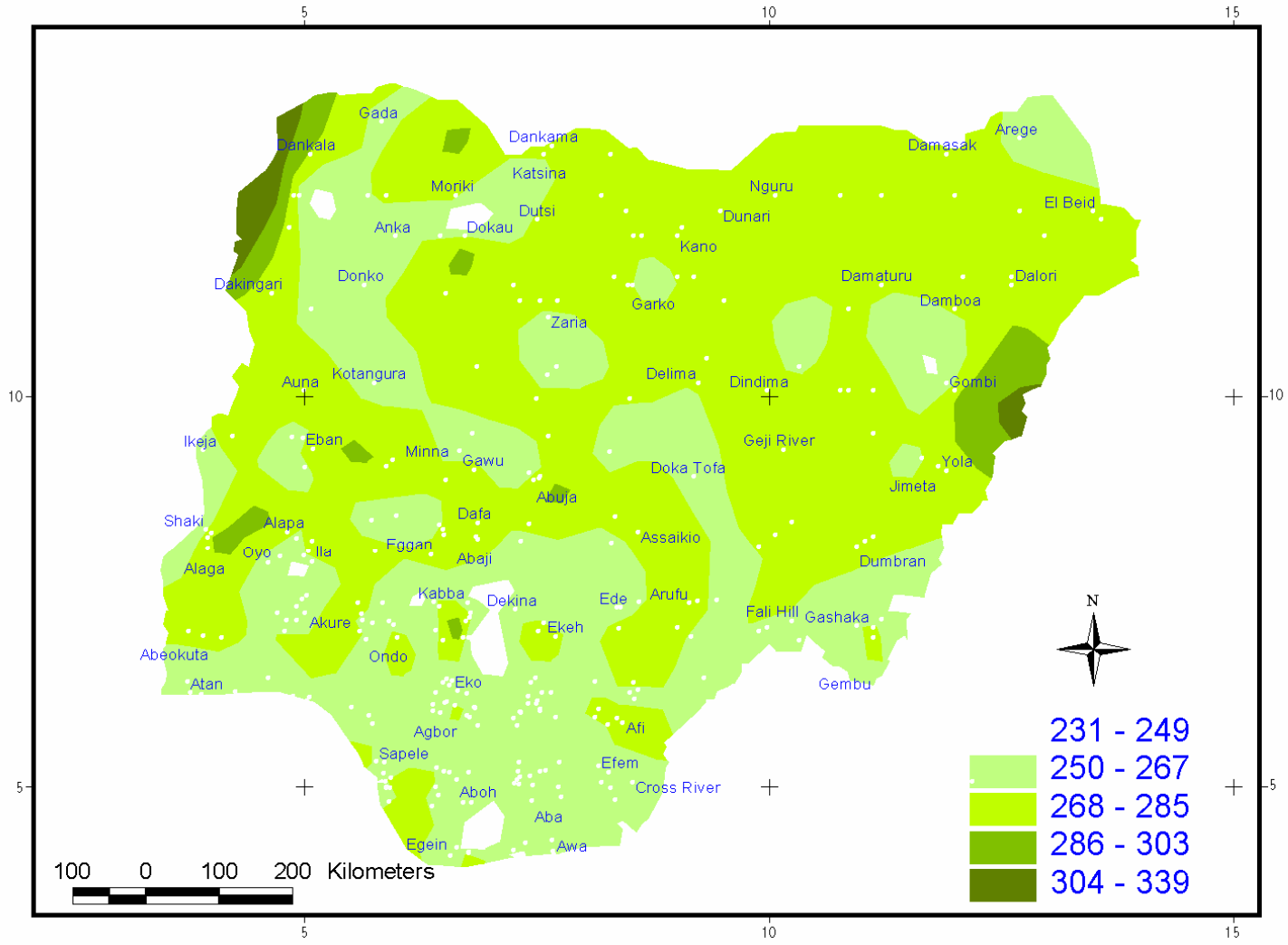
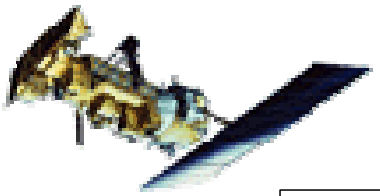
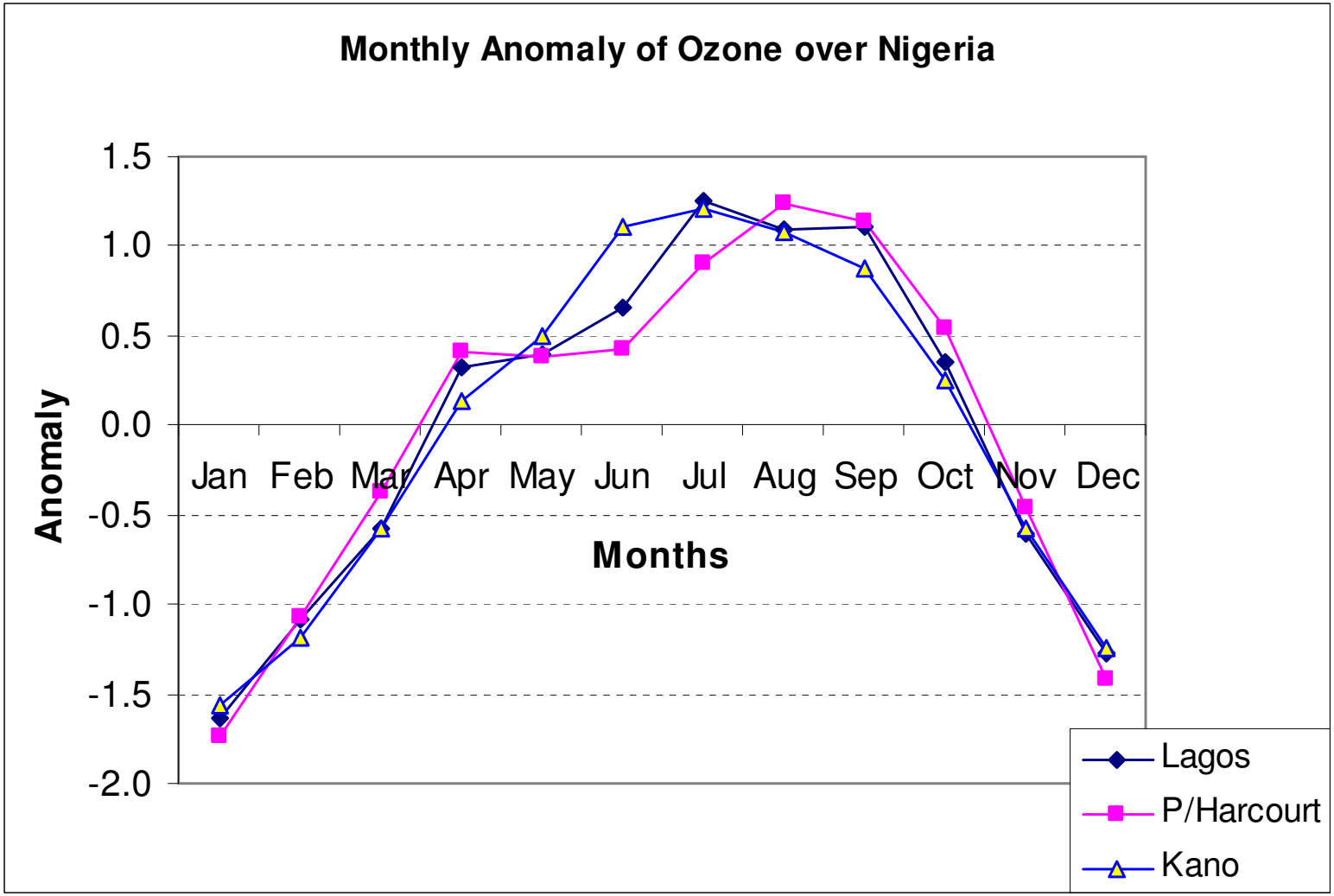


Max Ozone Pattern in Nigeria (August) [Obioh, et al, 2003]



Spatial Variation of TOMS Satellite Data over Nigeria during the Months of August, Representing Maximum Total Column Ozone (Obioh et al, 2003)





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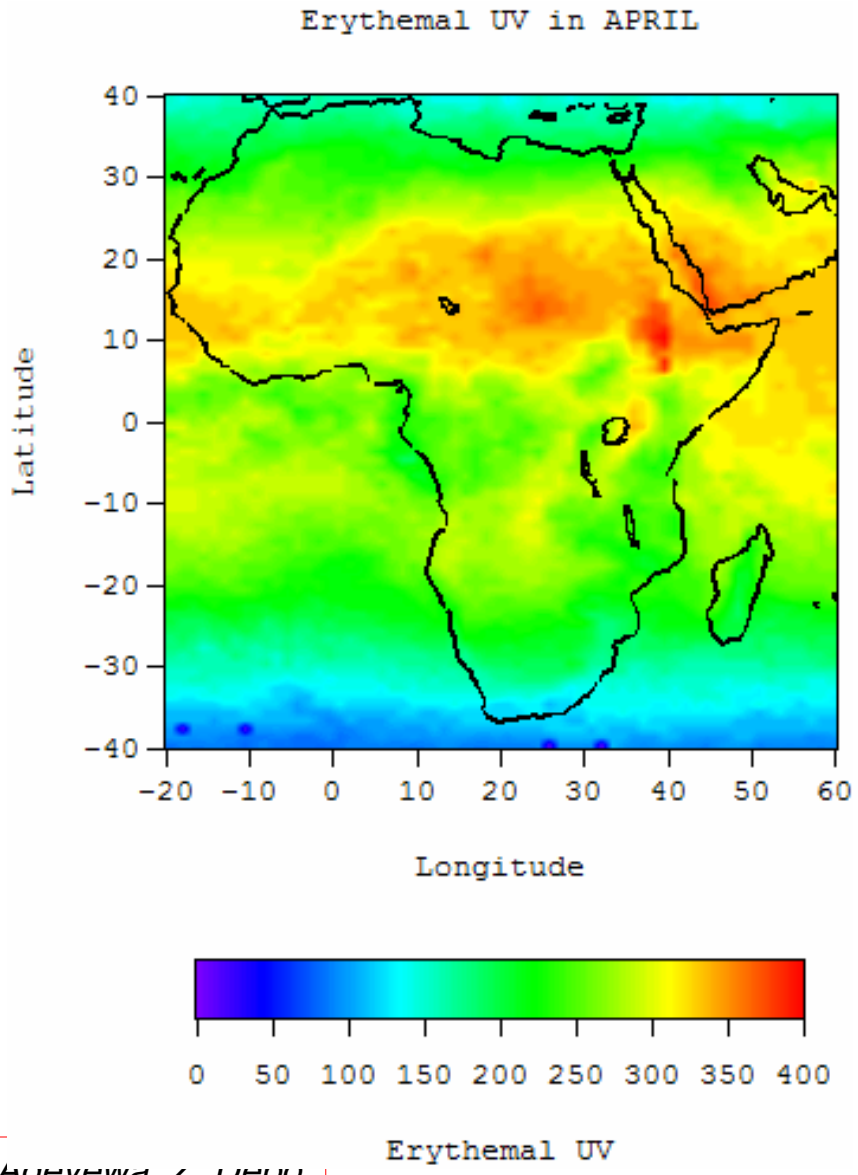
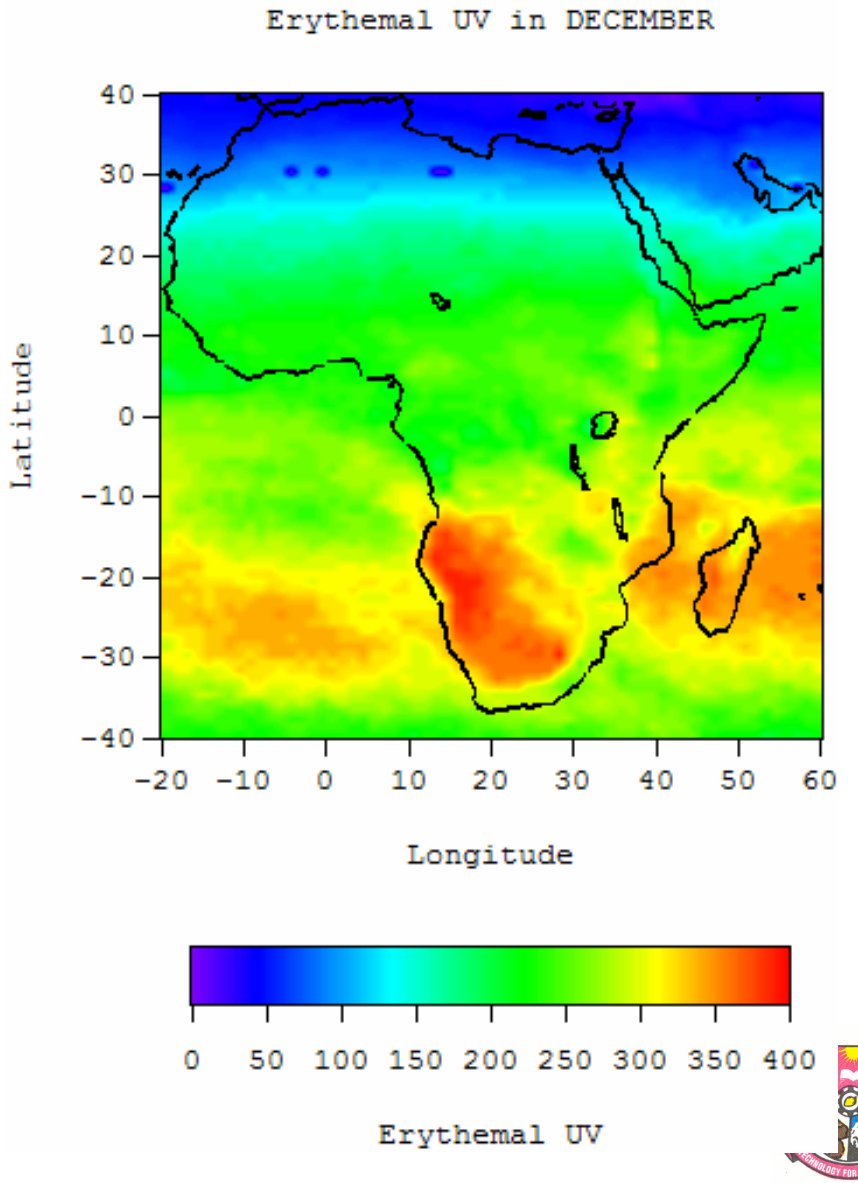
Typical Erythemal UV Pattern over Africa during Wet/Dry Seasons





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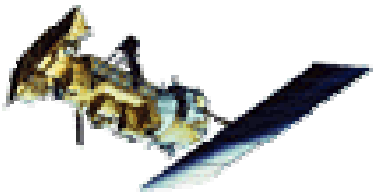

Mean Monthly Erythemal UV Variation over Africa

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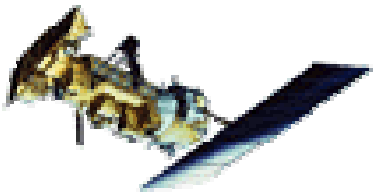
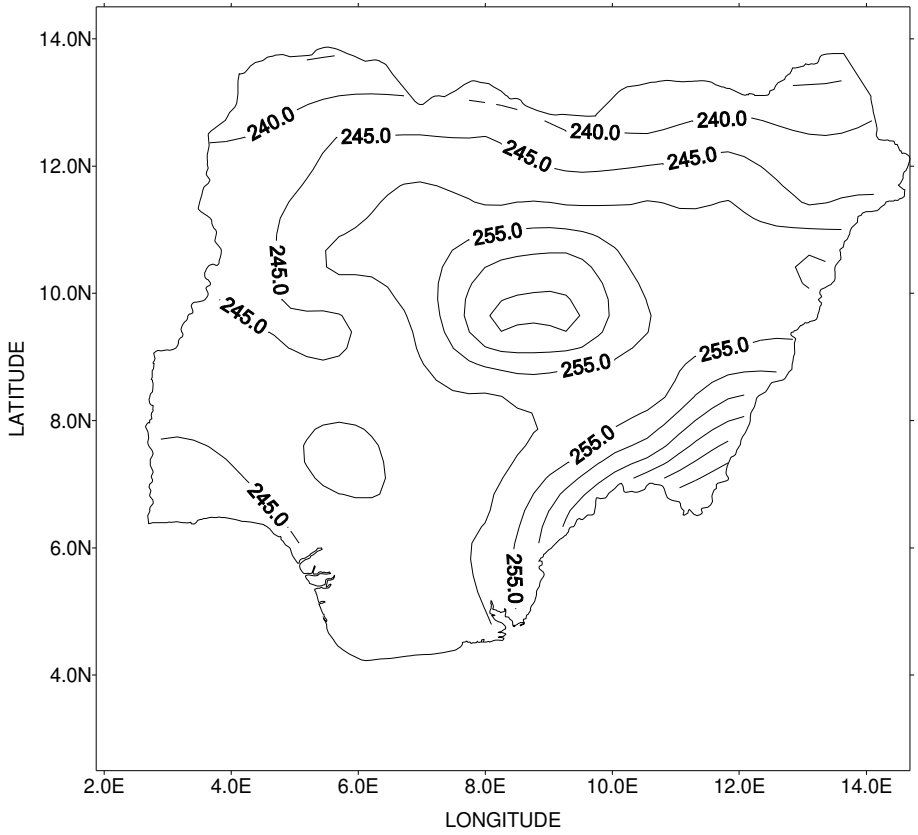
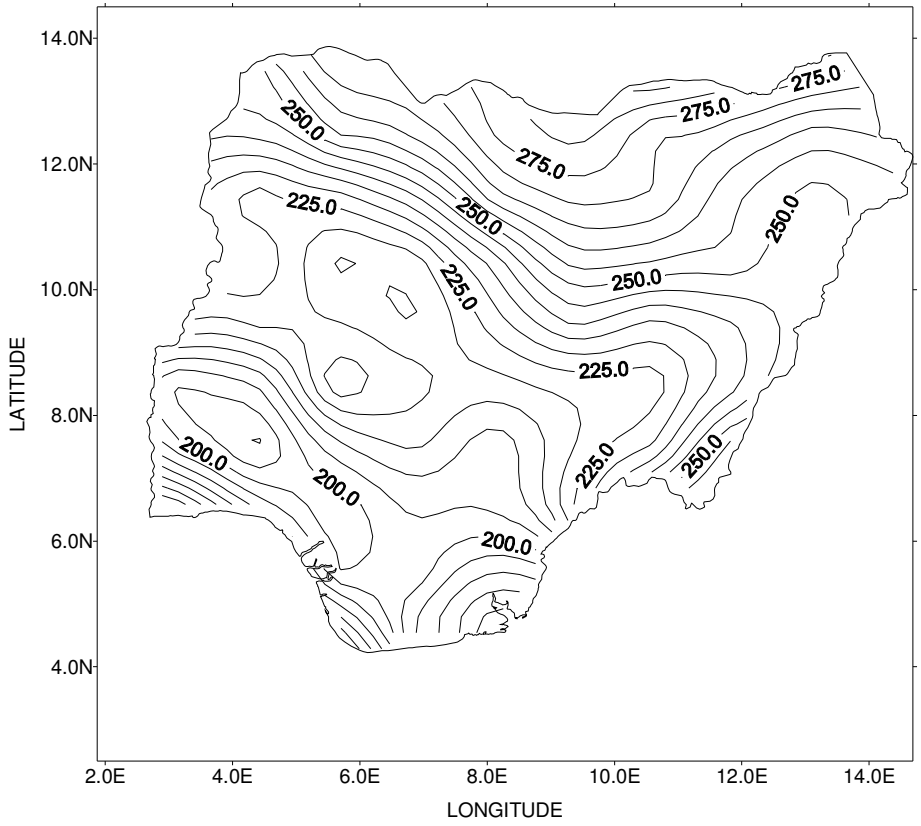


Mean Erythemal UV Pattern in Nigeria during Dry/Wet Seasons





Dry Month

Wet Month

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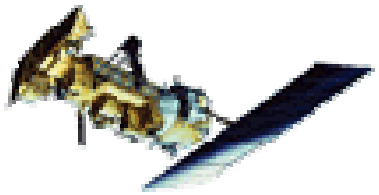

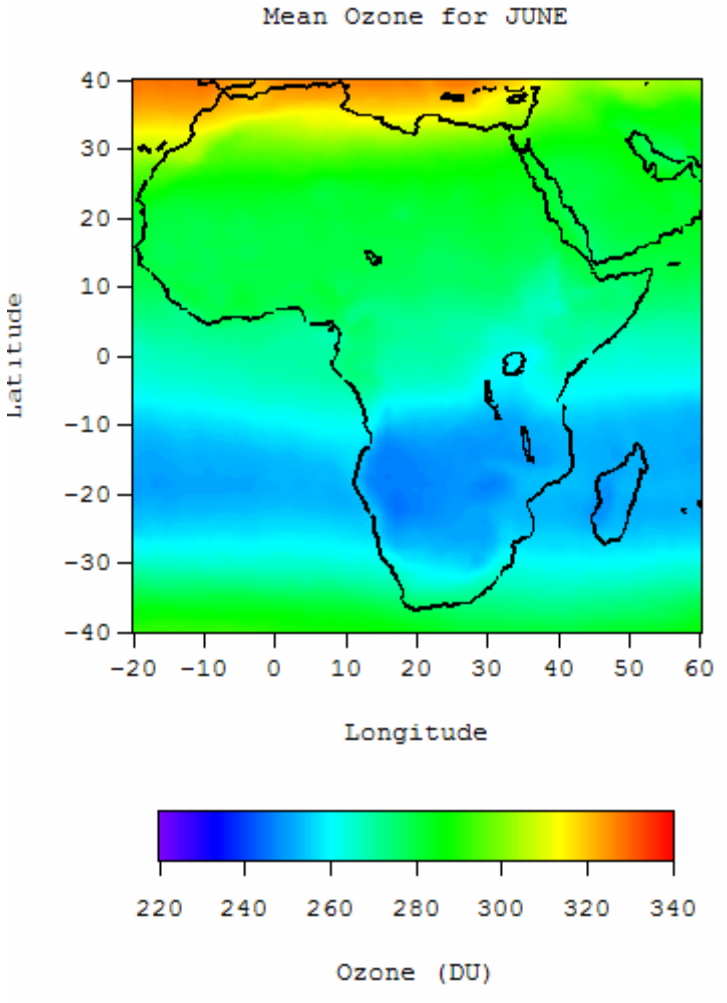

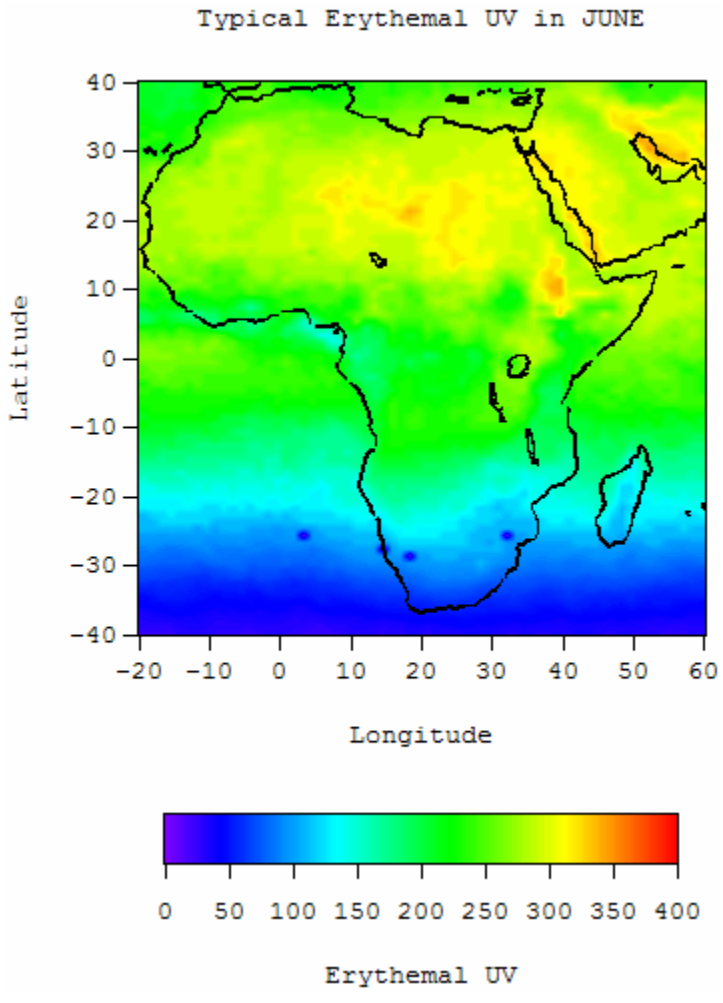

Mean Monthly Aerosol Index Animation

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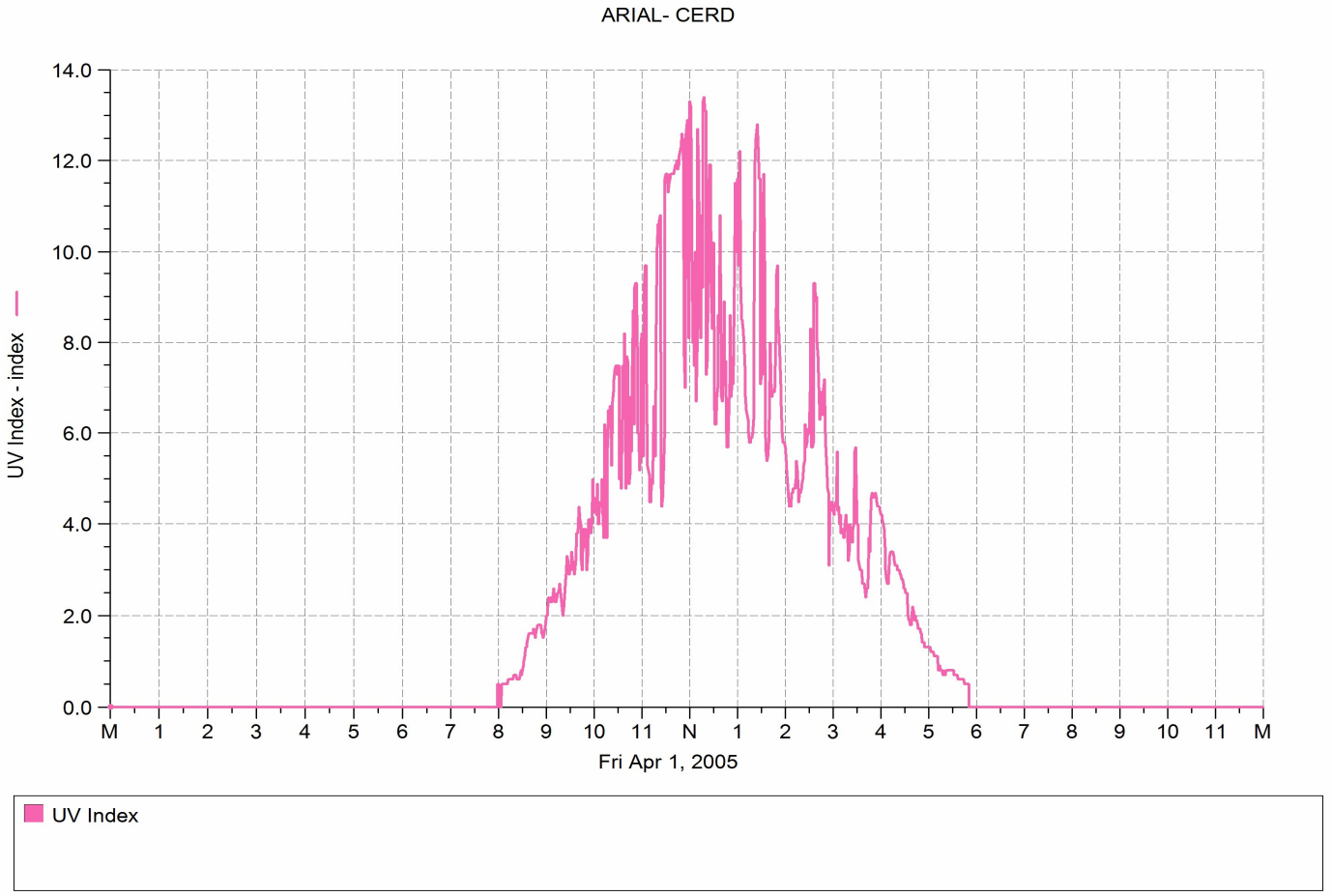
Typical Diurnal Variability of UV Index in April



[Obioh, et al, 2003]

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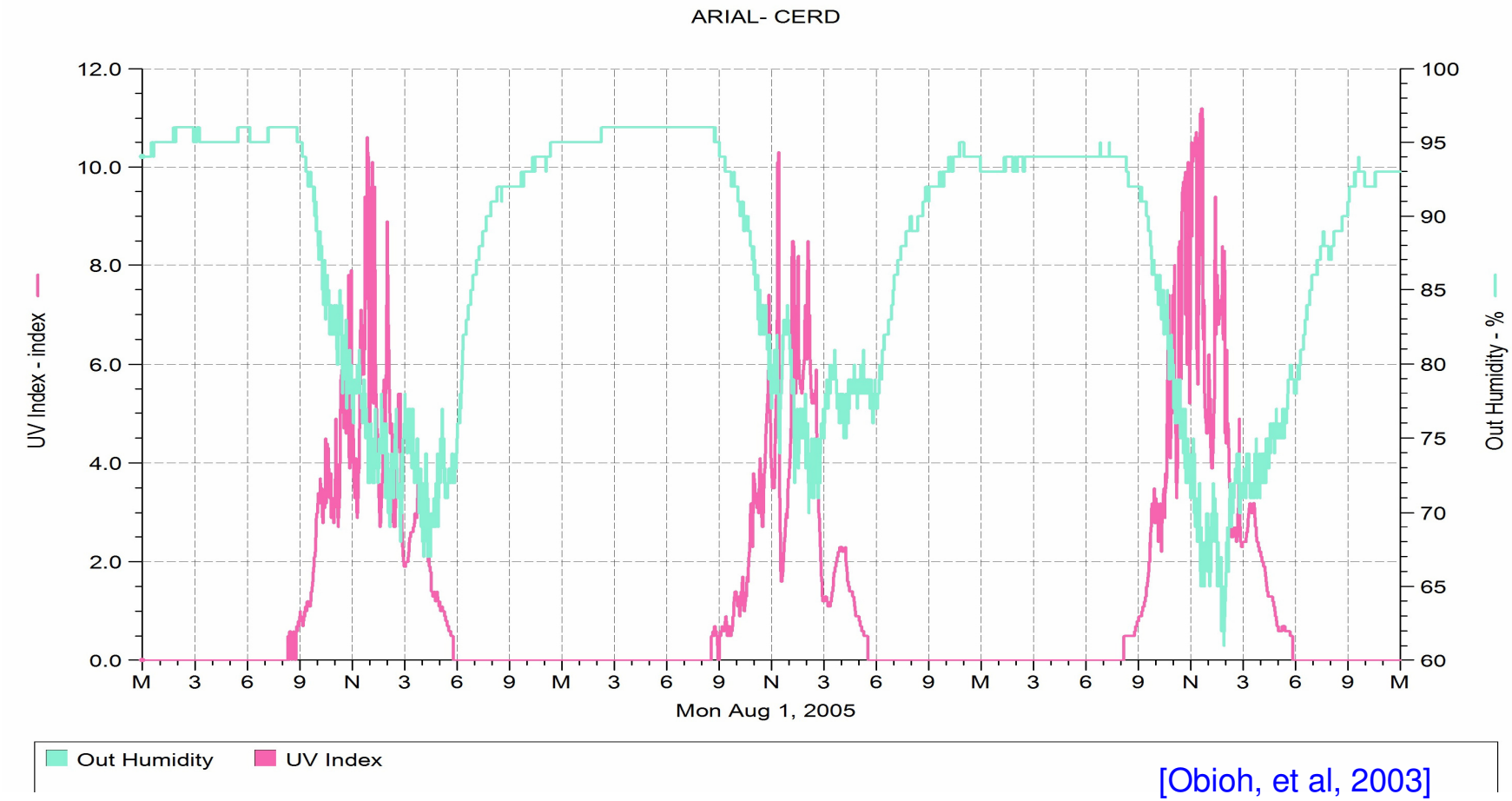
Relationship between UV Index and Atmospheric Moisture Content at Ile-Ife, Nigeria



[Obioh, et al, 2003]

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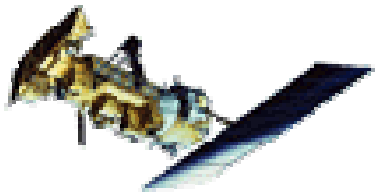
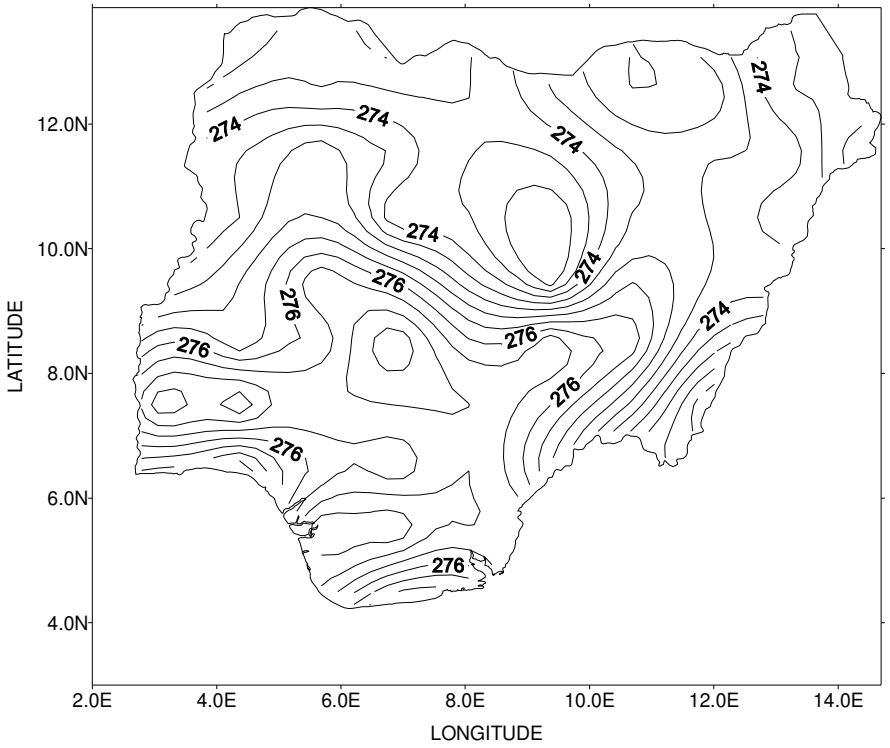
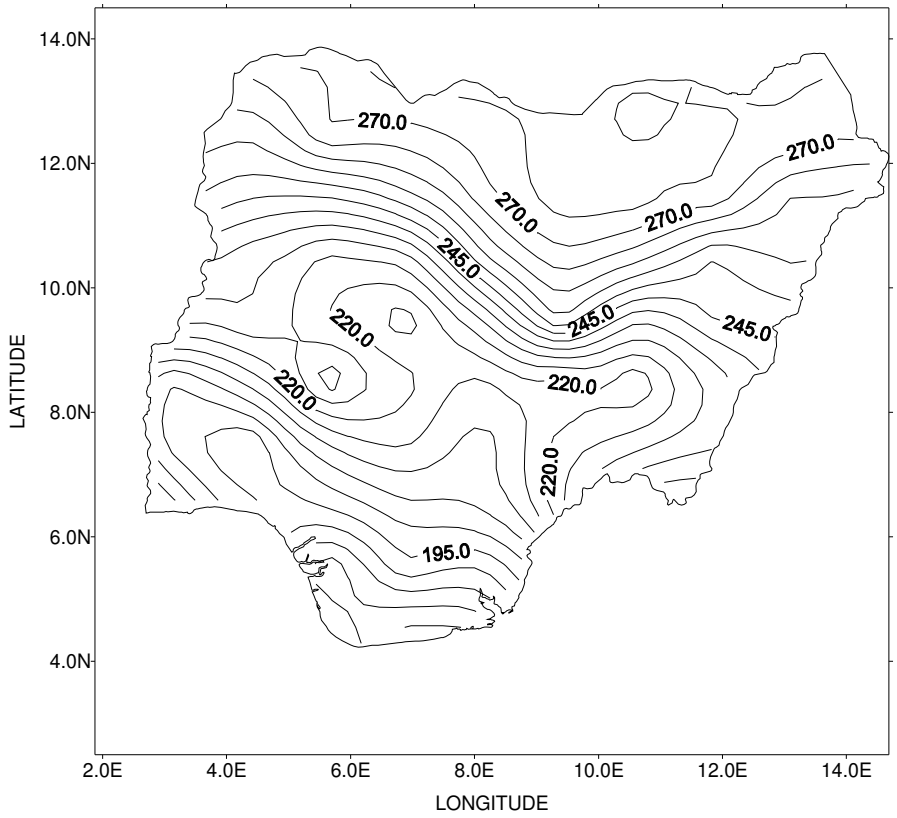


Ozone and Erythemal UV Pattern in Nigeria during June



Ozone



Erythemal UV

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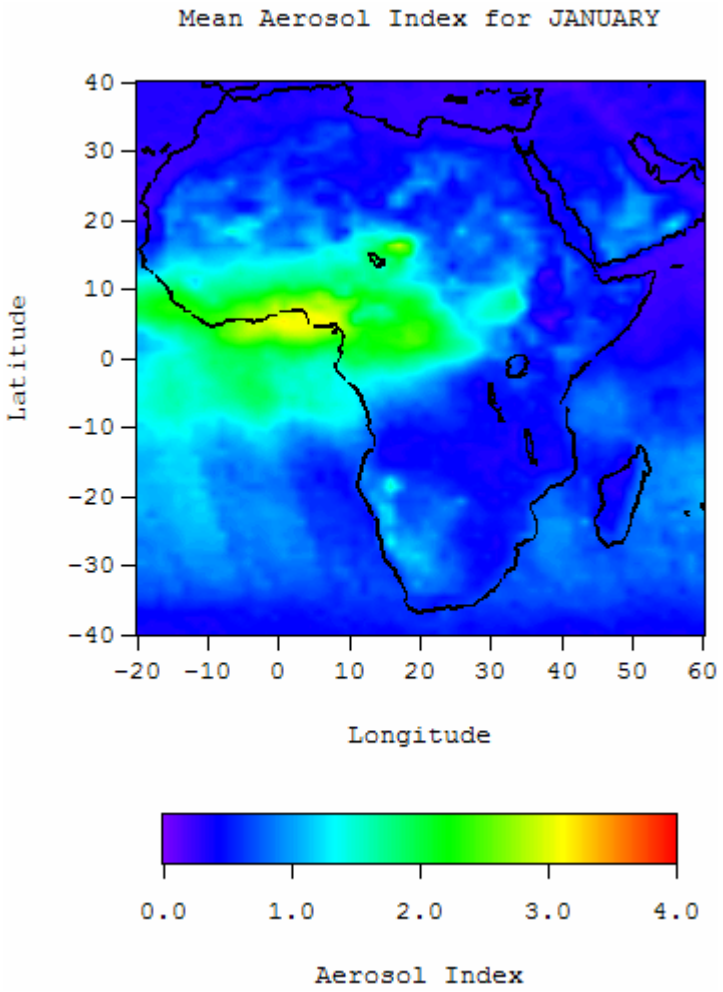
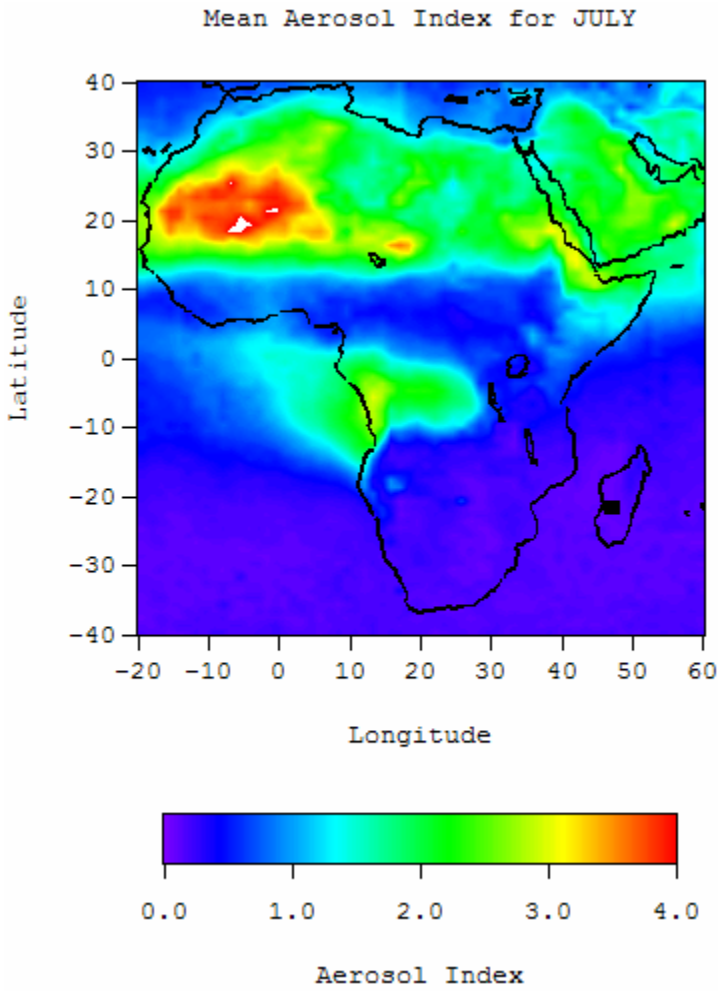
Mean Pattern of Aerosol Index over Africa during Dry/Wet Seasons





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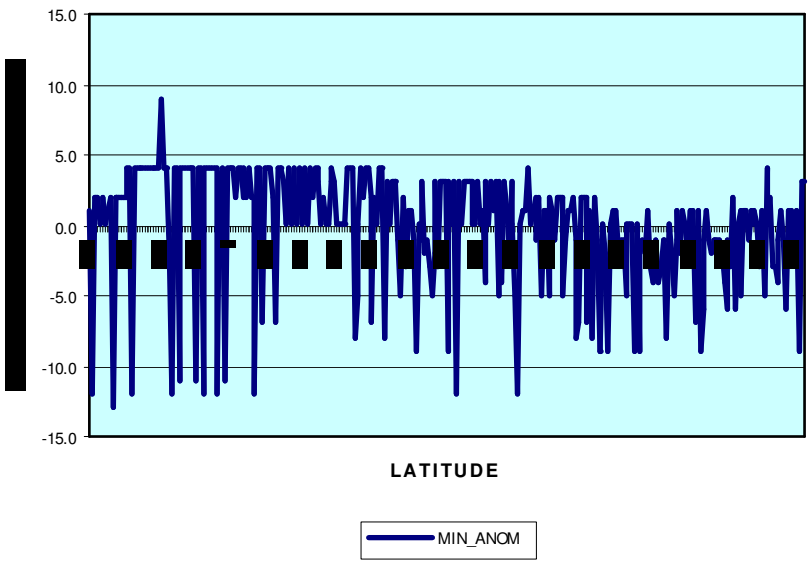
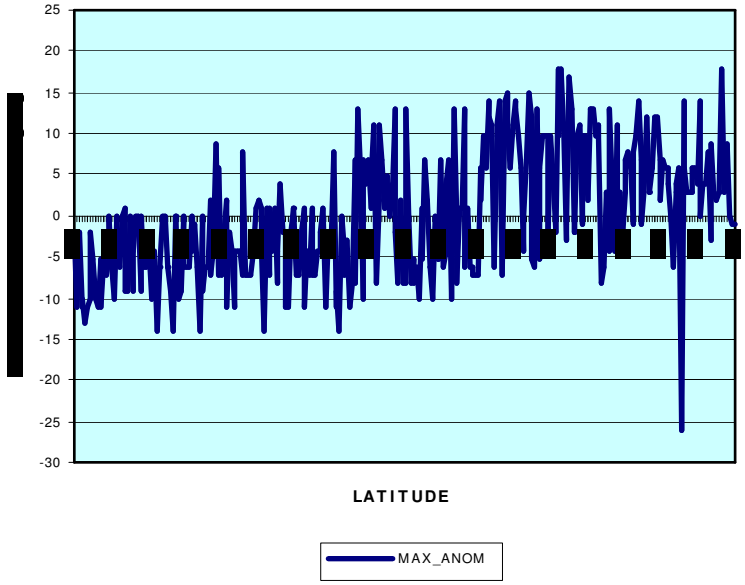
Trends in TOMS Ozone over Nigeria as a Function of Latitude

(a) TOMS Trends Based on Minimum Ozone Data



(b) TOMS Trends Based on Maximum Ozone Data



[Obioh, et al, 2003]

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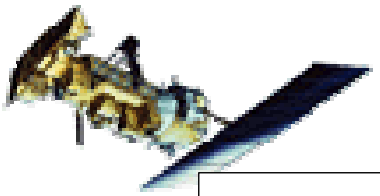

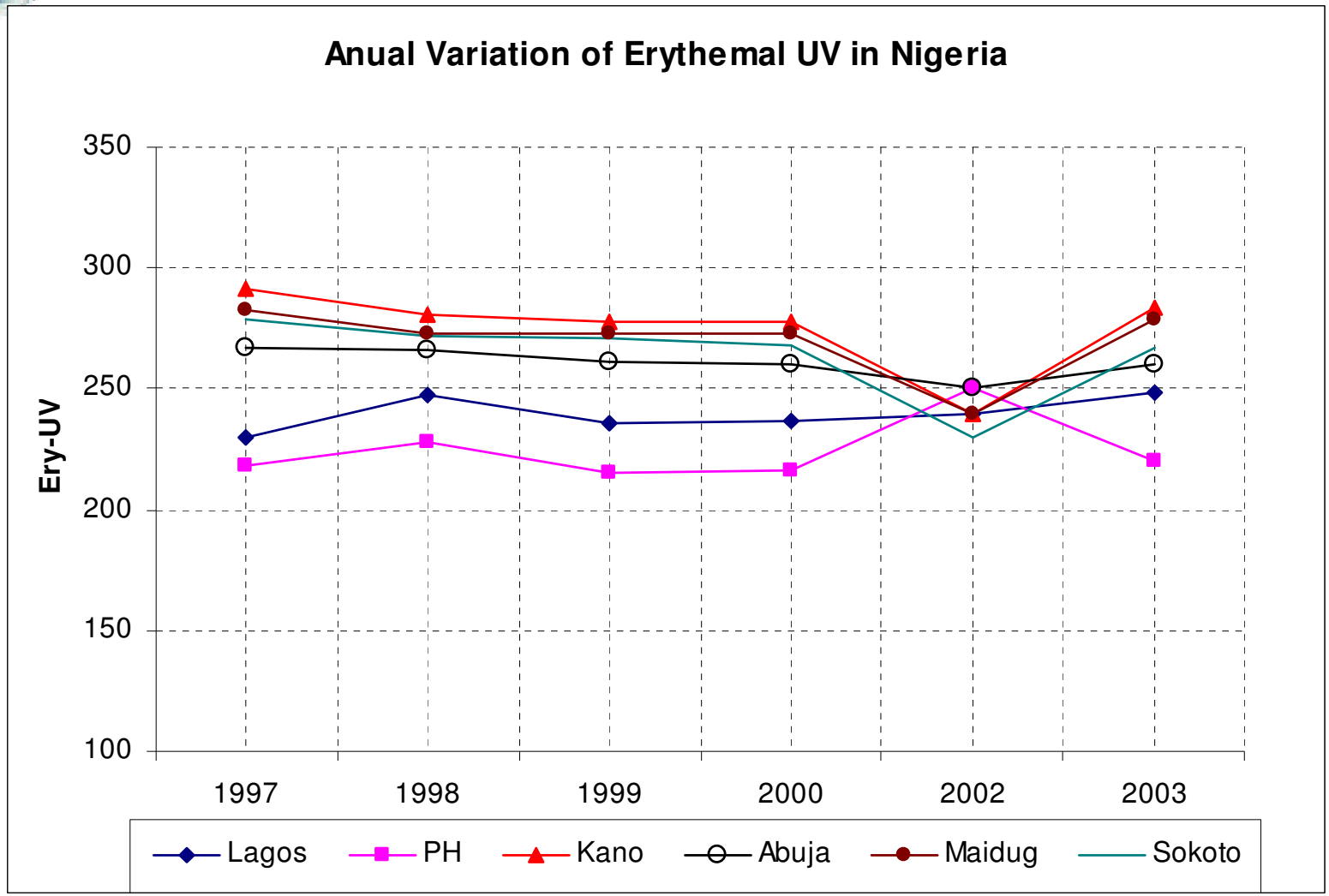

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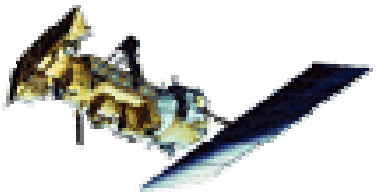

Potential Applications of Satellite-retrieved Data for Environmental Monitoring

- Retrieval of satellite data could be used for the purpose of reporting and forecasting ozone, UV and Air Quality

- Satellite data serves as indispensable tools in understanding the environment particularly for data-sparse regions in developing countries

- In conjunction with observations of total ozone at the surface, UV-B and tropospheric air quality, early warning systems can be set up in major cities.

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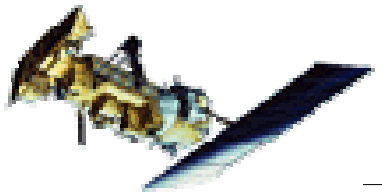
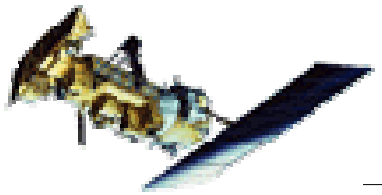


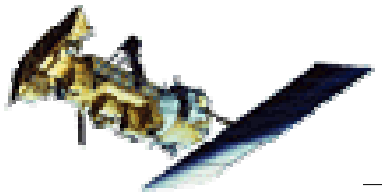
What We Need to Do

- Need to identify the framework to integrate ozone layer issues into national economic planning.
- Need for a funded network of the Nigerian Meteorological Agency, the Federal Ministries of Environment, Industry, and Science and Technology and the universities
- Need to establish centres of excellence in different aspects of environmental science and technology.
- Need for public awareness programmes and information dissemination systems on ozone, UV and air quality issues to the general public.
- Education and outreach projects to help protect the public from the health effects of overexposure to UV radiation.
- The failed project on UV Index, a tool for providing daily forecast of the next day's likely UV levels in at least 36 cities should be revisited



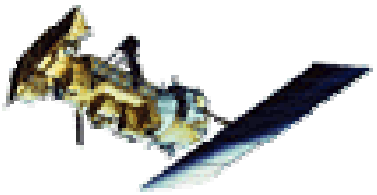
What We Need to Do

- A deliberate effort to increase the network of monitoring stations in the country.
- Total ozone monitoring at the surface, UV-B and Tropospheric Air Quality.
- Establish Ozone/UV-B database for the protection of the public.
- Encourage and support research in CFC substitutes and retrofitting of used refrigerators and other equipment using CFCs.



Conclusions

- The use of space data has contributed to the general understanding of variations and consequences of environmental variables.
- Nigeria has committed itself to the use of space technology for sustainable development. The launching of two satellites in the recent past is a testimony to this commitment.
- Nigeria is willing to initiate and implement daily forecast of Ozone, UV and Air Quality in at least 36 cities, representing each state of the country.
- In the nearest future, efforts will be made to integrate surface observations with near-real-time space-based data for effective and efficient forecast services to the public.



Thanks!

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