PAPER • **OPEN ACCESS**

Satellite observation analysis of aerosols loading effect over Monrovia-Liberia

To cite this article: M E Emetere *et al* 2017 *J. Phys.: Conf. Ser.* **852** 012009

Satellite observation analysis of aerosols loading effect over Monrovia-Liberia

M E Emetere,[1] F Esisio, [1] and F Oladapo [1]

[1]Department of Physics, Covenant University Canaan land, P.M.B 1023, Ota, Nigeria

E-mail : moses.emetere@covenantuniversity.edu.ng

Abstract. The effect of aerosols loading most often results in aerosols retention in the atmosphere. Aside the health hazards of aerosol retention, its effect on climate change are visible. In this research, it was proposed that the effect of aerosol retention also affects rain pattern. The Tropical Rainfall Measuring Mission (TRMM) layer 3 observations and the multi-imaging spectro-reflectometer (MISR) was used for the study. The aerosols loading over were investigated using sixteen years satellite observation in Monrovia-Liberia. Its effect on the rain rate over the region was documented. The results show that aerosol loading over the region is high and may have effect on farming in the nearest future. It was affirmed that the scanty AOD data was as a result of the rain rate that is higher within May and October.

1. Introduction

Several studies have been dedicated to modeling of aerosols and a good number of these models have established a proven degree of accuracy. For example, a multilayer analysis of a ground-based sun photometer of aerosol optical properties was carried out by some researcher [1] and compared with satellite observations over West Africa. Daily observations of satellite imaging of aerosol precipitations were made from 2005 – 2009 at three sites in West Africa and in an area within the Atlantic Ocean. Specific locations observed include Agoufou area of Mali, Banzoumbou area of Niger, Cape Verde in Tropical Atlantic Ocean and Ilorin Area of Nigeria. The results of the findings showed that the four stations had different annual precipitation, temperature and relative humidity. Spatial, seasonal and interannual variation of the aerosol loading over sahelian West Africa were detected by satellite (MODIS and TOMS) and ground-based AERONET Sunphotometer sensor between 2005-2009 as determined daily, monthly and annually showed that the Moderate resolution imaging spectro radiometer (MODIS) and TOMS retrieved as a ratio of aerosol optical depth to the aerosol interval AOD/AI were in good agreement with ground-based AERONET data.

Yang et al [2] carried out a study on the simulation of aerosol dynamics which includes a comparative review of algorithms used in Air Quality Models. The paper is focused on four areas including coagulation, condensational growth, nucleation, and gas particle mass transfer. The sectional and modal approaches were the analytical techniques adopted for analysis where they confirmed that the sectional approach has the capacity to make good predictions for coagulation and condensational growth phenomena. Based on the work, they recommended apt simulation of the rate of condensation with nucleation rates because of the inherent influence of environmental conditions. For mass transfer situations, they suggested an explicit treatment of the problem especially in situations where the volatile species undergo equilibrium reactions for components of different particle sizes where coarse particles are Present. Simulations were carried out for urban conditions in an area and over a period of 12 hours. The formulated algorithms for the four cases mentioned gave good results. The numerical solution adopted to describe the condensational growth rate of particles in the range of 0.001-10 μm has its limitation in the area of 3D simulation. However, the review confirms the reliability of the CIT, GATOL, Models-3, SAQM-AERO, UAM-AERO and UAM-AIM the following tools for handling coagulation and condensational growth of aerosol particulates. Based on the models mentioned, the nucleation rates predicted showed variations. They noted that all simulations were conducted in a standalone mode i.e. outside their 3-D host air quality models however, they suggested the need for further evaluation of some promising algorithms for aerosol dynamics and thermodynamics for a 3-D gridded setting where emissions, transport, dispersion, and deposition of aerosols are inherent.

Concentration profiles were generated based on calculations for an empty hollow tube and for another filled with rash rings. It was confirmed that a tube filled with packing has higher separation efficiency relative to an empty tube filled with a gaseous mixture (i.e. air and water) comprising aerosols. Separation efficiencies varied along the channel length as well as their flow regimes that were estimated from Reynolds Number. The determination of particle concentration profiles and the estimation of separation efficiencies using mathematical correlations/models can compare accurately with those obtained using contact devices can compare with model calculations. The obtained equations can be used for calculating the concentration distribution of aerosols and the efficiencies of industrial gas separators present at petrochemical and gas producing stations.

In this study, we intend to investigate the aerosol loading over Monrovia using established model [1] and estimate its effect on the rain rate over the location.

2. Methodology

In the past, no aerosols ground observation was available; hence, the satellite observation was adopted. Fourteen years satellite observation was obtained from the Multi-angle Imaging SpectroRadiometer (MISR). The MISR operates at various directions i.e. nine different angles (70.5°, 60°, 45.6°, 26.1°, 0°, 26.1°, 45.6°, 60°, 20.5°) and gathers data in four different spectral bands (blue, green, red, and near-infrared) of the solar spectrum. The blue band is at wavelength 443nm, the green band is at wavelength 555nm, the red band wavelength 670nm and the infrared band is at wavelength 865nm. MISR acquire images at two different levels of spatial resolution i.e. local and global mode. It gathers data at the local mode at 275 meter pixel size and 1.1 km at the global mode. Typically, the blue band is to analyze coastal and aerosol studies. The green band is to analyze Bathymetric mapping and estimating peak vegetation. The red band analysis the variable vegetation slopes and the infrared band analysis the biomass content and shorelines.

The raw MISR dataset was processed using the Excel package. The mean for each month were calculated for each year. We tested the accuracy of the data by applying the aerosol dispersion model that was propounded by Emetere et al. [1]. An extension of the dispersion model used is given as

$$\psi(\lambda) = {a_1}^2 \cos\left(\frac{n_1 \pi \tau(\lambda)}{k_y} + \alpha\right) \cos\left(\frac{n_1 \pi \tau(\lambda)}{k_z} + \alpha\right) + {a_2}^2 \cos\left(\frac{n_2 \pi \tau(\lambda)}{k_y} + \beta\right) \cos\left(\frac{n_2 \pi \tau(\lambda)}{k_z} + \beta\right) \tag{1}$$

Here α and β are the phase differences, k is the diffusivity, τ is the AOD, ψ is the concentration of contaminant, λ is the wavelength, a and n are atmospheric and tuning constants respectively.

3. Results and Discussion

The Monrovia has the highest cases of scanty data in the locations considered (Figure 1). There were little or no data from March to November. Since Monrovia falls within the tropical monsoonal climate, the scanty AOD data may be as a result of the moisture content [3], cloud scavenging [4], precipitable water content[5] and high rain drop rate [6]. The Tropical Rainfall Measuring Mission (TRMM) layer 3 observations in Figure 3 show the daily rain rate in Monrovia for the year 2012.

Figure 4 shows a monthly rain rate analysis. Hence, it can be affirmed that the scanty AOD data was as a result of the rain rate that is higher within May and October as shown in Figure 4. The AOD pattern over Monrovia agreed with proposed model (Figure 2). Monrovia is constantly under the oceanic wind influence from the Atlantic oceanic. The retrieved AOD may not capture salient events in the lower atmosphere; hence, a radiosonde station is essential in Monrovia to adequately capture the inadequacies in its lower atmosphere.

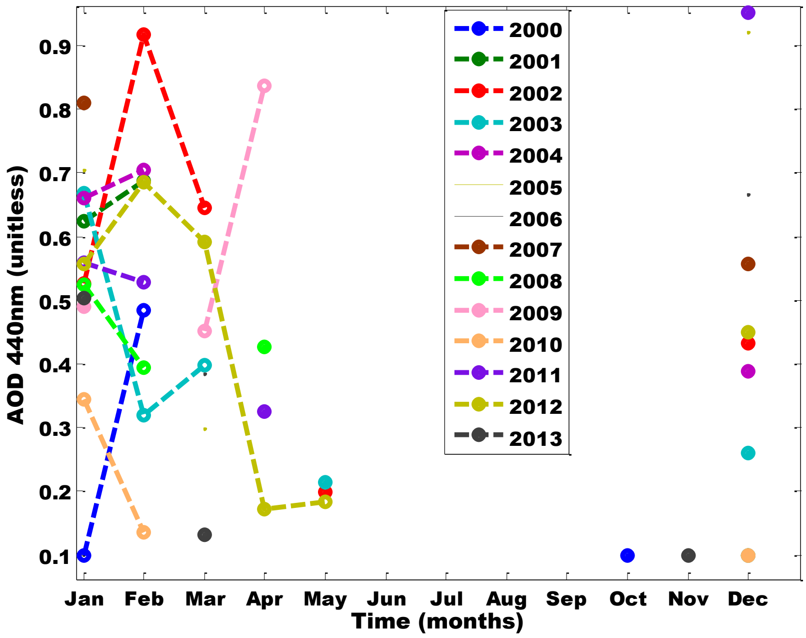

Figure 1. AOD pattern for Monrovia (2000 – 2013)

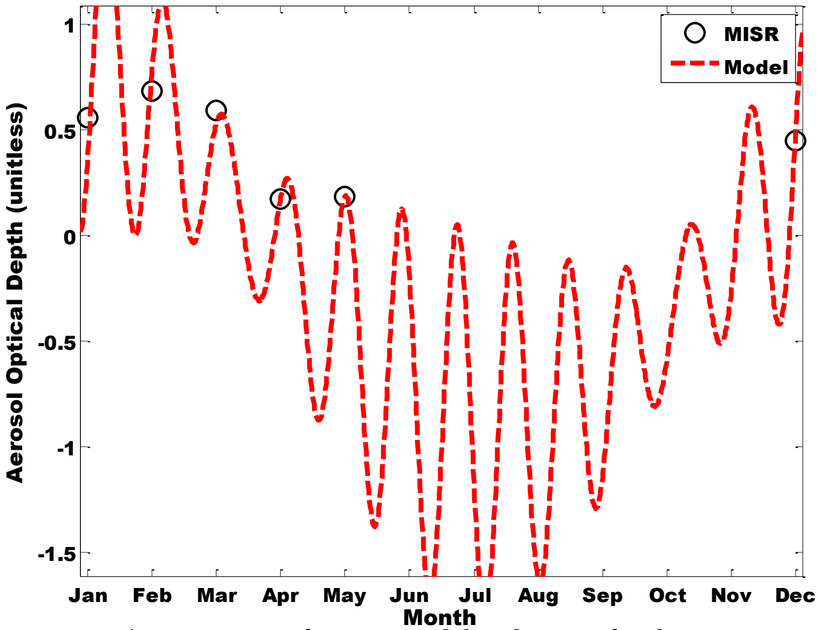

Figure 2. AOD for new model and MISR for the year 2001

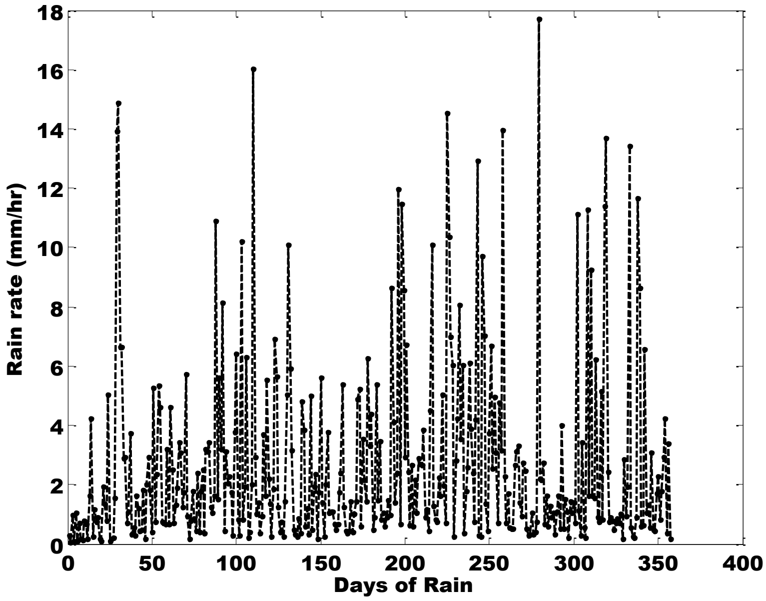

Figure 3. Daily Precipitation rate over Monrovia 2012

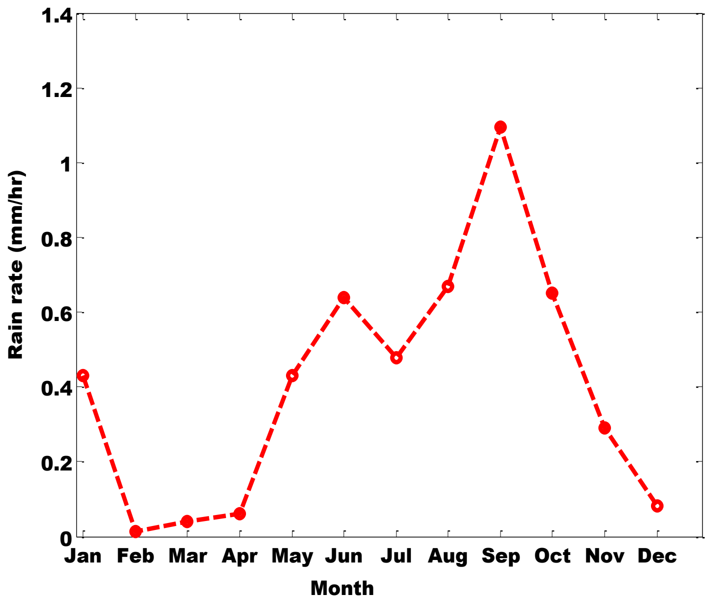

Figure 4. Monthly Precipitation rate over Monrovia 2012

.

The statistical results of the AOD are shown in Table 1 below. The highest frequency of data was found in 2012. The AOD for 2002, 2005 and 2011 was high with 0.92, 0.92 and 0.95 respectively. The highest mean was recorded in 2007. However, the result is not reliable becomes of the number of data for the year i.e. 2. Hence, the highest mean for 2011 was chosen because it had an average number of data i.e. 4. From the statistical analysis, the aerosols loading in 2011 is very significant. It shows that though the scanty measurement, the aerosol loading over Monrovia is far beyond the WHO limit [7].

Table 1. Statistical dataset for aerosol loading over Monrovia

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Number of values	3	3	5	5	3	3	3
Maximum	0.48	0.69	0.92	0.67	0.7	0.92	0.67
Mean	0.23	0.47	0.54	0.37	0.58	0.64	0.52
Standard error	0.13	0.19	0.12	0.08	0.1	0.18	0.08
Standard deviation	0.22	0.32	0.27	0.18	0.17	0.32	0.14
Coefficient of variation	0.97	0.69	0.49	0.48	0.29	0.49	0.27

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Number of values	2	4	4	3	4	6	3
Maximum	0.81	0.52	0.84	0.35	0.95	0.69	0.5
Mean	0.68	0.36	0.47	0.19	0.59	0.44	0.25
Standard error	0.13	0.09	0.15	0.08	0.13	0.09	0.13
Standard deviation	0.18	0.18	0.3	0.13	0.26	0.22	0.22
Coefficient of variation	0.26	0.51	0.64	0.69	0.44	0.49	0.92

In recent time, the focus of the West Africa atmospheric exploration by our team changed with specific emphasis on how to maximally control pollution by a unique awareness programme. Pilot studies on mobile apps were embarked upon. The initial successes were without its challenge. However, at this stage of the research we have designed an algorithm shown in Figure 5.

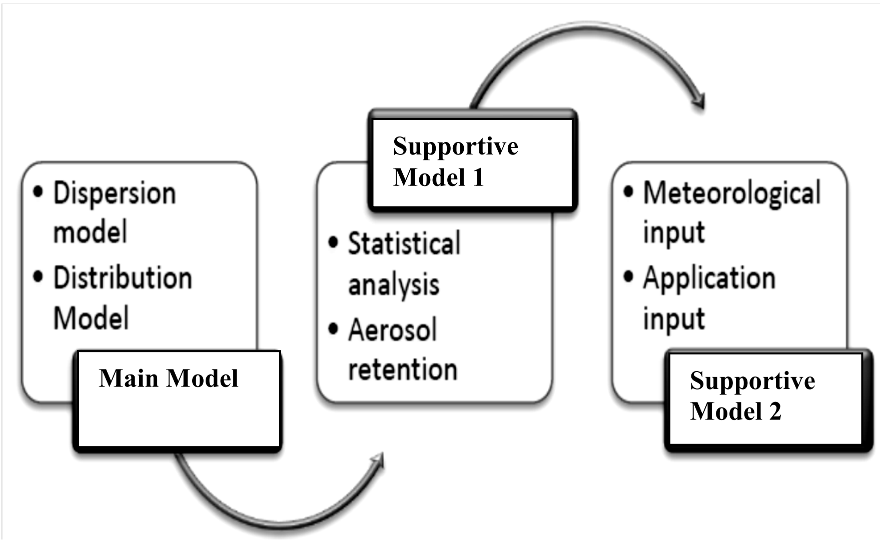

Figure 5. Proposed software description of environmental software

4. Conclusion

The aerosols loading over Monrovia is very high. The effect was observed on the overall rain rate over the region. Hence, if nothing is done to ameliorate the continuous aerosols loading, it may lead to partial famine in the nearest future.

Appreciation
The authors gratefully acknowledge Covenant University.

References
[1] Emetere Moses E., Akinyemi M.L. & Oladimeji T.E. 2016. Statistical Examination Of The Aerosols Loading Over Kano-Nigeria: The Satellite Observation Analysis, *Scientific Review Engineering and Environmental Sciences,* **72** 167-176
[2] Yang, Y., Liao, H. and Lou, S.-J., 2014. Simulated impacts of sulphate and nitrate aerosol formation on surface-layer ozone concentrations in China. *Atmospheric and Oceanic Science Letters*, **7(5)** 441-446.
[3] Adebiyi, A.A., Paquita, Z. and Steven, J.A., 2015, The convolution of dynamics and moisture with the presence of shortwave absorbing aerosols over the southeast atlantic. *Journal of Climate*, **28** 1997–2024.
[4] Dani, K.K., Maheskumar, R.S., and Devara, P.C.S., 2003. Study of total column atmospheric aerosol optical depth, ozone and precipitable water content over Bay of Bengal during BOBMEX-99. *Journal of Earth System Science*, **112 (2)** 205-221.
[5] Vijayakumar, K. and Devara, P.C.S., 2013. Study of aerosol optical depth, ozone, and precipitable water vapour content over Sinhagad, a high-altitude station in the Western Ghats. *International Journal of Remote Sensing*, **34 (2)** 613-630.
[6] Boucher, O. and Quaas, J., 2013. Water vapour affects both rain and aerosol optical depth, *Nature Geosciences*, **6** 4–5
[7] UN Report (2016). http://www.un.org/sustainabledevelopment/blog/2016/09/vast-majority-of-world-6-76-billion-people-living-with-excessive-air-pollution-un-report/