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SEASONAL AND ANNUAL VARIATION OF AEROSOL LOADINGS OVER AFRICAN REGION DURING THE LAST FOURTEEN YEARS

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***Abstract*— AOD in Africa has escalated in the past two decades due to increasing anthropogenic activities in that region. The densely populated regions of South Africa are undergoing rapid industrialization resulting in enhanced emissions in the atmosphere, thereby making Africa one of the major hotspots of aerosols. In this study, African region is divided into four sub-regions i.e. North Africa, East Africa, South Africa, and West Africa. This paper presents the seasonal and annual study of aerosol optical depth (AOD) in African region using level-3 data acquired from MODIS (1°×1°) and MISR (0.5° × 0.5°) satellite sensors for fourteen year period (2001-2014). Temporal (seasonal and annual) variations along with percentage change in AOD i.e. tendencies have been reported. It is observed that the findings are in agreement as seen by both the sensors in most of the cases.**

***Keywords*— MODIS, MISR, Aerosol optical depth, Africa.**

I. INTRODUCTION

Aerosol monitoring from satellite data provides the opportunity to have a synoptic view of polluted areas. Aerosols are minute particles suspended in the Earth's atmosphere. These are primarily created either by natural phenomenon or by anthropogenic activities. Anthropogenic aerosols (organic particles, black carbon etc.) are relatively easier to identify, monitor and control, whereas the natural (soil dust, volcanic dust, oceanic sulphates, sea salt) sources are hard to control. Aerosols interact both directly and indirectly with the Earth's radiation, henceforth affect climate. The direct effects of aerosols include absorption and scattering of sunlight whereas indirectly, the aerosols modify the size of the cloud particles thereby affecting precipitation. Aerosols, not only have impact over the climate change but their adverse effects are apparent over human health. Aerosol optical depth (AOD) is an optical property of aerosols that characterizes their loading within an air column. Satellite remote sensing of aerosols plays a significant role in analyzing and characterizing aerosols locally, regionally and on global scale.

In the last two decades, many airbrone (aircraft, balloons) and spacebrone (satellite, space shuttle) remote sensing systems have been utilized for studying the earth's surface and atmosphere ranging from moderate to high resolutions. This paper presents the seasonal and annual variation of aerosol optical depth over African region calculated over the period of 2001-2014 as seen by the two sensors of NASA, i.e. MODIS and MISR.

Attempts have been made over time to study aerosols distribution globally and regionally. Studies have been carried out on regions of Africa in specific. Humid climate of Africa has strengthened monsoon season due to gradual orbital increase in summer season. Therefore this climate is capable of rapid and large amplitude climate transitions [1, 2]. Anthropogenic source of black carbon mostly concentrated tropically; mixed with aerosols can form transcontinental plums of atmospheric brown clouds which can be harmful for human health [3, 4]. Previous study over South Africa shows that the background biomass burning component of the total aerosol loading, summer and winter constituents of the haze layer are demonstrated by sulphuraerosols [5].Yet other studies shows that the Sahel region has replaced the Central Sahara as the source of atmospheric aerosols in North Africa and dust emission associated with the described mechanism may influence the radiation budget over West Africa [6, 7]. The present study focuses on variation of aerosol optical depth over African region for the period (2001-2014). Annual and seasonal average aerosol variations have been presented using level-3 MODIS and MISR data. The percentage relative changes have also been reported.

II. STUDY AREA AND DATA USED

This study is carried over African landmass using two satellite sensors. Africa is the home to the world's 54 countries

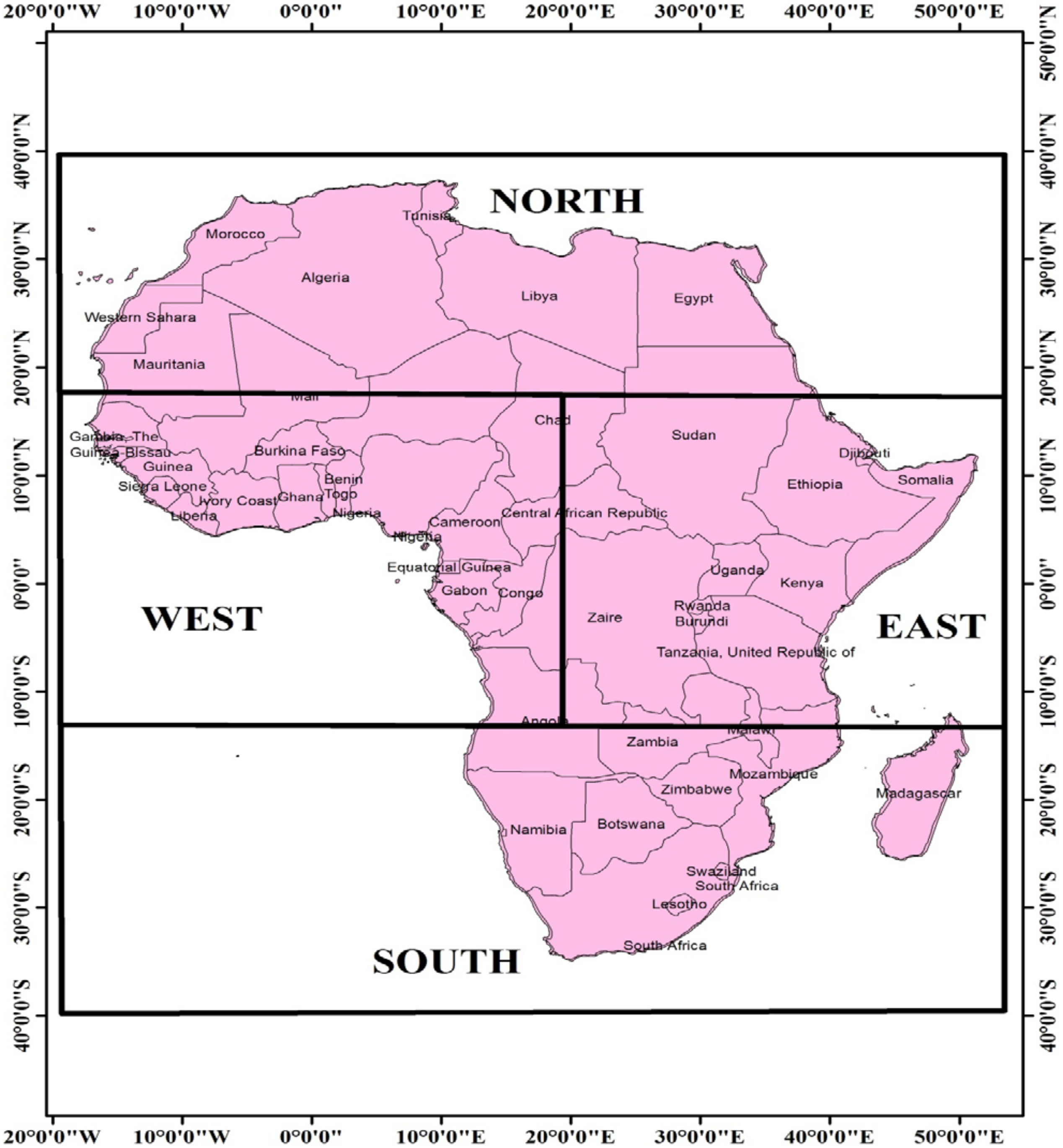

Figure1 Study area (divided into four sub regions)

It is the second largest and second most populous continent on earth with the population above 1.166 billion, located primarily in the Eastern and Northern hemispheres. Though it covers only 6% of the Earth's total surface area, it comprises 20.4% of its land area i.e. 30.2 million km sq. In this study African region is divided into four sub-regions i.e. North Africa, South Africa, East Africa, and West Africa. The continent is surrounded by the Mediterranean Sea to the north, the Atlantic Ocean to the west and the Indian Ocean to the southeast (shown in Figure 1).

Satellite data is one of the most suitable tools for monitoring temporal variations of aerosols at a global scale. Presently our knowledge about the aerosol variation in Earth's atmosphere has increased by the availability of the several satellite sensors like MODIS, MISR, OMI, POLDER, CALIPSO, AVHRR, TOMS etc. Satellite data from MODIS (MODerate Imaging Spectroradiometer) and MISR (Multi-Imaging Spectro Radiometer) both onboard Terra platforms have been utilized in the study. Terra orbits in the range of 705 km and scans at the rate of 20.3 rpm. MODIS has thirty-six channels spanning the spectral range from 0.41 to 15 m respectively in 3 spatial resolutions: 250m (2 channels), 500m (5 channels), and 1000 m (29 channels). For the purpose of aerosol retrieval it uses seven channels from its thirty six channels ranging from 0.47 µm to 2.13 µm [8]. MODIS aerosol retrieval algorithm uses look-up table (LUT) approach with a predefined set of aerosol loadings and geometry [9]. MISR consists of nine cameras; each camera is fixed at a particular viewing zenith angle in the down track direction and possesses four spectral bands of 446 nm, 558 nm, 672 nm and 866 nm with a cross –track ground spatial resolution of 275m to 1.1km [10]. In this study, MODIS and MISR level-3 AOD data products (MOD_08_M3 L3) and (MISR_AM1_CGAS) at 1°x1° and at 0.5°x0.5° spatial resolutions have been analyzed.

III. RESULTS AND DISCUSSION

Figures 2 and 3 show the annual and seasonal variations and relative change in AOD over the African region. Southern Africa receives low aerosol loading whereas high loading is spotted at western part of Africa. Moderate aerosol optical depths are observed in eastern part of Africa. In the last seven years (2008-2014), concentrations of aerosols have increased in some parts of Angola as well in western Africa. In the desert land of North Africa where MODIS is not able to retrieve aerosol optical depth, MISR does so and reports an overall increasing aerosol loading in the past decade. In the parts of United Republic of Tanzania and South Africa, the tendency of aerosols was again found to be decreasing.

In winter monsoon and post-monsoon seasons, aerosol loadings are lower as compared to the other two seasons i.e. pre-monsoon and monsoon respectively. In West Africa and Central African Republic, however, aerosol loadings remain high as compared to the other two regions. Both MODIS and MISR record increasing aerosol tendencies in winter and post-monsoon seasons in parts of United Republic of Tanzania, which is an indicative of increasing anthropogenic activities in these regions. In pre-monsoon and monsoon seasons, MISR records high aerosol optical depth values in West African main land. The tendencies of aerosol optical depth are found to be decreasing in most of the parts of United State and Zaire during this period which could be linked to decreasing dust events recorded during the last seven years.

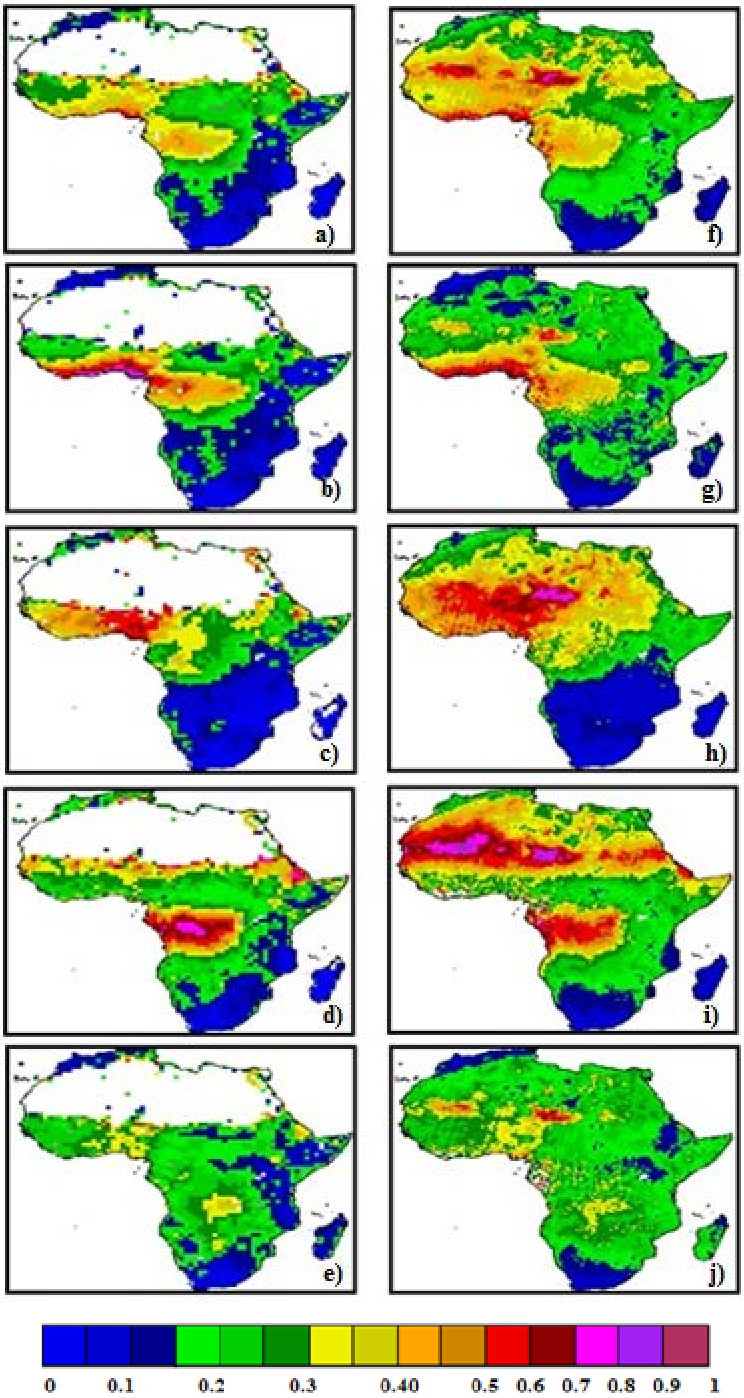

Figure 2 AOD annual and seasonal variations;
MODIS : (a) Annual (b) Winter (c) Pre-Monsoon (d) Monsoon (e) Post-Monsoon
MISR: (f) Annual (g) Winter (h) Pre-Monsoon (i) Monsoon (j) Post-Monsoon

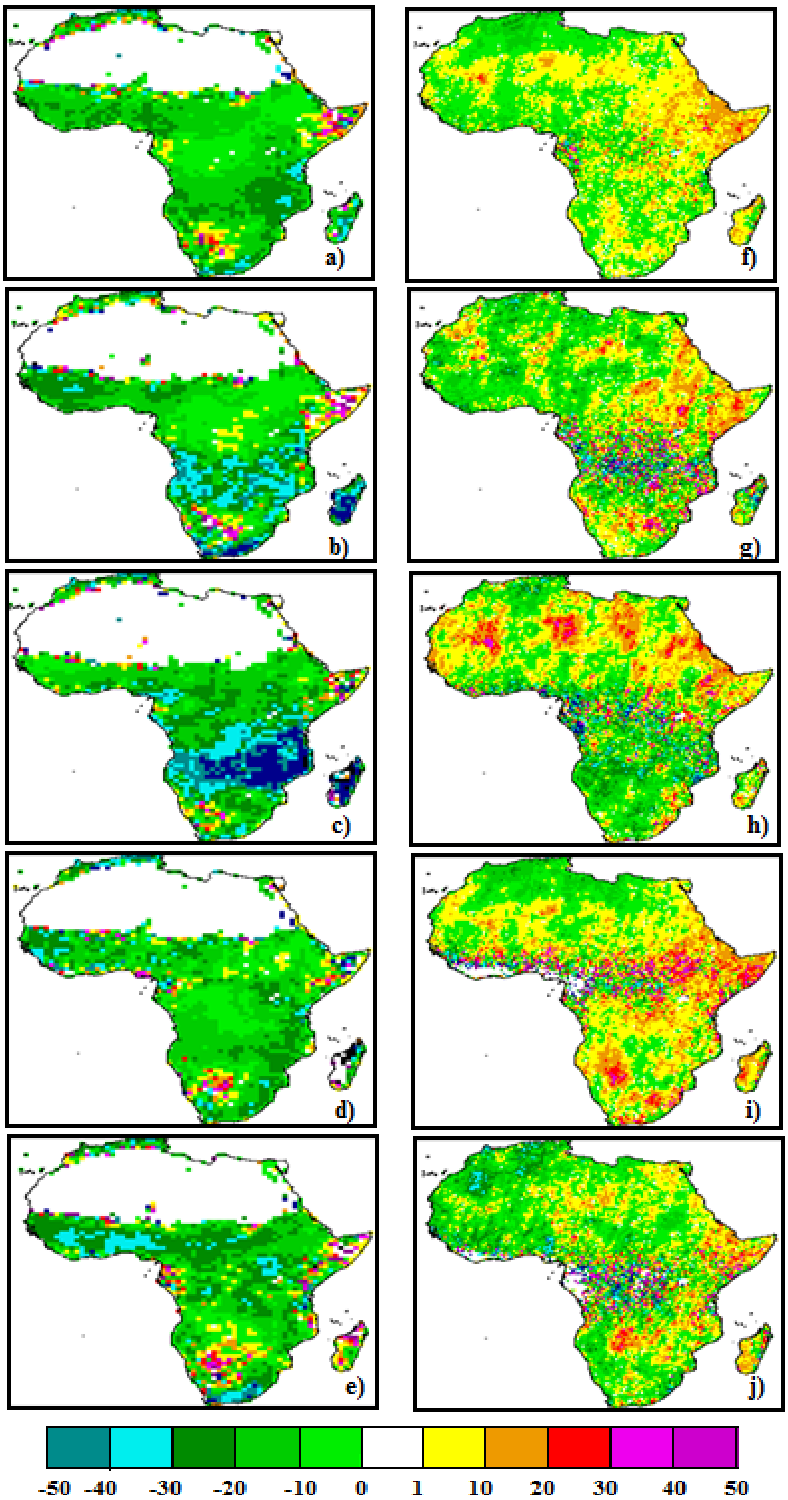

Figure 3 AOD percentage relative variations;
MODIS : (a) Annual (b) Winter (c) Pre-Monsoon (d) Monsoon (e) Post-Monsoon
MISR: (f) Annual (g) Winter (h) Pre-Monsoon (i) Monsoon (j) Post-Monsoon

IV. CONCLUSION

The study presents annual and seasonal variation of aerosol optical depth over African region during the last fourteen years using data from two different satellite sensors. The aerosol retrieval methods used by MODIS and MISR are based on look-up table approach, but are based on different algorithms. It can be noted that when MODIS fails to retrieve the data in North African region, MISR provides the same at higher spatial resolution. Though there are places of disagreements in case of relative changes, the overall annual and seasonal variation reported by both the sensors match quite well. This work can be extended by considering other aerosol properties e.g. single scattering albedo, angstrom exponent, absorbing index etc. Such studies are crucial to estimate quantitatively the spatial distribution of aerosols over a longer period of time in addition to in situ observations specific over particular locations.

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REFERENCES

[1] Ortiz, Joseph, Tom Guilderson, Jess Adkins, Michael Sarnthein, Linda Baker, and Martha Yarusinsky. "Abrupt onset and termination of the African Humid Period:: rapid climate responses to gradual insolation forcing." *Quaternary science reviews* 19, no. 1 (2000): 347-361.

[2] Giannini, Alessandra, Michela Biasutti, Isaac M. Held, and Adam H. Sobel. "A global perspective on African climate." Climatic Change 90, no. 4 (2008): 359-383.

[3] Ramanathan, Veerabhadran, and Gregory Carmichael."Global and regional climate changes due to black carbon." *Nature geoscience* 1, no. 4 (2008): 221-227.

[4] Nway, Declan. "Adapting climate research for development in Africa." Wiley Interdisciplinary Reviews: Climate Change 2, no. 3 (2011): 428-450.

[5] Piketh, S. J., H. J. Annegarn, and P. D. Tyson. "Lower tropospheric aerosol loadings over South Africa: The relative contribution of aeolian dust, industrial emissions, and biomass burning." *Journal of Geophysical Research: Atmospheres (1984–2012)* 104, no. D1 (1999): 1597-1607.

[6] Mbourou, G. N'Tchayi, J. J. Bertrand, and S. E. Nicholson."The diurnal and seasonal cycles of wind-borne dust over Africa north of the equator." *Journal of Applied Meteorology* 36, no. 7 (1997): 868-882.

[7] BouKaram, D., CyrilleFlamant, P. Knippertz, O. Reitebuch, Jacques Pelon, Michel Chong, and Alain Dabas. "Dust emissions over the Sahel associated with the West African monsoon intertropical discontinuity region: A representative case‐study." *Quarterly Journal of the Royal Meteorological Society* 134, no. 632 (2008): 621-634.

[8] Kaufman, Yoram J., A. E. Wald, L. Remer, Bo-Cai Gao, Rong-Rong Li, and L. Flynn. "The MODIS 2.1-μm channel-correlation with visible reflectance for use in remote sensing of aerosol." *IEEE Transactions on Geoscience and Remote Sensing* 35, no. 5 (1997): 1286-1298.

[9] Remer, Lorraine A., Y. J. Kaufman, D. Tanré, S. Mattoo, D. A. Chu, J. Vanderlei Martins, R-R. Li et al. "The MODIS aerosol algorithm, products, and validation." *Journal of the Atmospheric Sciences* 62, no. 4 (2005): 947-973.

[10] Diner, David J., J. C. Beckert, T. H. Reilly, C. J. Bruegge, J. E. Conel, R. Kahn, J. V. Martonchik et al. "Multi-angle Imaging SpectroRadiometer (MISR) instrument description and experiment overview." *IEEE Transactions on Geoscience and Remote Sensing* 36, no. 4 (1998): 1072-1087.