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Variation characteristic of regional Atmospheric Aerosol Properties from MODIS and its possible influence in rainfall

Jyotirmayee Satapathy*, Hari Sanker and Bharath Chandran
Department of Physics
Amrita Vishwa Vidyapeetham
Amritapuri, India
*jsatapathy84@gmail.com

***Abstract*— Satellite derived atmospheric aerosol properties have proved to be an efficient way in monitoring aerosol distribution over a period as well as over a region continuously. Moderate resolution Imaging Spectroradiometer (MODIS) derived, various aerosol properties over three geographically and socio-economically different regions in Kerala, India are considered over 2 years to study the aerosol distribution. Two consecutive years of rainfall data are considered over those places from Global precipitation Measurement (GPM) mission to understand the possible impact of these aerosol properties in influencing rainfall subsequently. Results promise for extensive research in understanding the characteristics of different aerosol properties and its influence in rainfall.**

***Index Terms*— Aerosol, MODIS, GPM, rainfall**

I. INTRODUCTION

Aerosols are now playing very important role in affecting the earth-atmosphere radiation budget, directly by scattering and absorbing the incoming solar radiation and indirectly by affecting the cloud formation in terms of cloud condensation nuclei [1]. The tropospheric atmospheric composition can affect the Earth's climate in several important ways on different scales [2]. The structure and its complex optical properties of aerosols and their extreme heterogeneous spatial and temporal distributions play important role in the dynamics of aerosol and the associated influence on climatic conditions [3]. The aerosol size distributions over urban, industrialized and densely populated regions are also widely different due to the difference in its composition and origin. This causes the difference in aerosol emissions in different socio-economic regions as well as different geographic regions which lead to the different local climatic conditions such as rainfall. Aerosols over Indian subcontinent region have shown impact on radiative forcing that causes cooling or negative forcing at the surface and hence warming or positive forcing at the top of atmosphere [4]. Therefore, the aerosols and their various complex attributes have got significant role in affecting the climate of region which needs an extensive study.

Satellite remote sensing has been assisting as an essential tool for monitoring the aerosol budget and studying their radiative effects on climate so far. Moderate resolution Imaging Spectroradiometer (MODIS) on board the Earth Observing System (EOS) Terra and Aqua satellites [5] provides an excellent opportunity in deriving spectral information of various aerosol parameters attributed to different spectral forcing over a wide band UV-Visible region with a substantially good spatial resolution. With the help of MODIS data, the spatial variability as well as temporal variation of aerosol and its properties can be assessed over a specific region [6]. In this work, three regions of different socioeconomic as well as geographic conditions of Indian southern subcontinent have been chosen to understand the variability characteristics of aerosol data over a period. Effort has been made to understand the various properties of aerosols influenced by urbanization and region specific reasons depicted in the variation from MODIS derived aerosol products [7]. Preliminary studies have been done to understand the influence of variation in aerosol properties in the subsequent rainfall conditions of those different regions. The rainfall data has been taken from Global precipitation Measurement (GPM) mission.

II. STUDY AREA

Kerala, the southern-west region of Indian subcontinent has one side Arabian coast line and in the other side Western *g*hat mountain range. Three places in the region viz., *Kochi*, *Alleppey* and *Munnar* with different geographical conditions are considered to understand the different perspectives of aerosols pertaining to a specific region. Kochi and *Alleppey* are in the coast whereas *Munnar* is at high altitude. Similarly, there exists difference in the socio economic conditions among these three places. To understand the effect of urbanization on aerosol content and aerosol properties, the relatively urban area, i.e. *Kochi* is considered with respect to *Allepey* and then follows *Munnar*. *Munnar* and *Alleppey* have higher vegetation

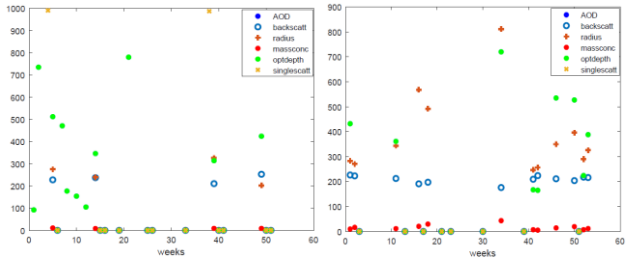
content as compared to Kochi. *Munnar* is a hill station with highest green mass whereas *Alleppey* has large back water area near coast.

III. DATA USED

Level-3 MODIS gridded atmosphere daily global aerosol products 'MOD08_D3' and 'MYD08-D3' have been used for this study which comprises Aerosol Optical Depth (AOD), Aerosol Backscattering, Mass Concentration, Size such as radius, single scattering depth etc. Rainfall data (units: mm) is obtained from Global Precipitation Measurement (GPM) Mission for the consecutive two years (2015 and 2017) over these regions. To understand the influence of aerosol products in the next year rainfall, weekly averages over these places are also studied.

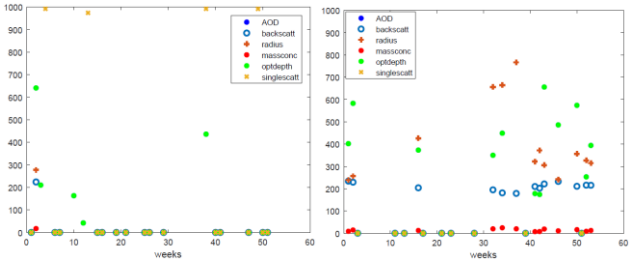
IV. RESULT AND DISCUSSION

Weekly average of various aerosol products for 2014 and 2016 over Alleppey, Kochi and Munnar are plotted in figure 1, 2 and 3 respectively.



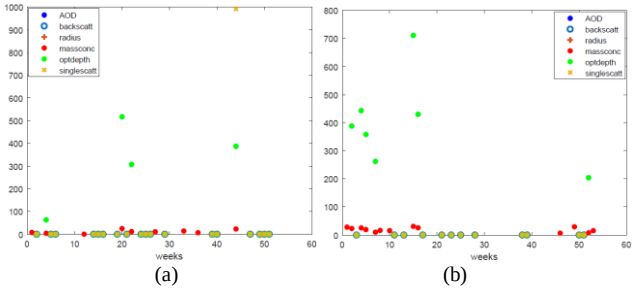
(a) (b)

Fig 1: Aerosol properties over Alleppey (a) 2014, (b) 2016



(a) (b)

Fig 2: Aerosol properties over Kochi (a) 2014, (b) 2016



(a) (b)

Fig 3: Aerosol properties over Munnar (a) 2014, (b) 2016

Aerosol characteristics over Alleppey, a coastal area with reasonable population and relatively less urbanization, are shown in figure 1 for 2014 in (a) and 2016 in (b). It can be seen that Aerosol Optical Depth (AOD) for 550 nm numbers have not shown any significant result but the backscattering coefficient numbers shows significant higher in 2016 than 2014. In both years, it can be seen that the numbers are visible mostly in winter than compared to monsoon. So the aerosol direct effect by absorption or scattering of incoming solar direction is high always in winter and least in monsoon [8]. And, this number has shown a higher trend over 2 years which explains the increase in aerosol due to higher pollution pertinent to the urbanization effect. Optical depth, average over all wavelengths, also show that aerosol effect is high in winter but the yearly average effect is approximately same. Same explanation can also be attributed to the increase in mass concentration, aerosol effective radius but the single scattering coefficient has been consistent. This can be attributed to the type of aerosol content which perhaps has not gone over much variation [9]. But only the content and the size distribution has shown increase over the 2 years over Alleppey.

In case of Kochi, from figure 2, it can be clearly seen that over 2 years from 2014 to 2016 all the aerosol properties irrespectively have shown significant increase. This can be attributed to purely the urban effects as Kochi lies in an urban area and the increase in the pollution level or manmade contributions to the aerosol. Whereas, in case of Munnar, which is with huge greenery, as can be seen from figure 3 that there is not much variation perceived in case of aerosol properties.

So from these results, it can be inferred that urbanization has huge effect on aerosol content. And, this directly by altering the radiative transfer of atmosphere through the scattering and absorbing solar radiation as well as indirectly affecting regional climate consequently over a period. Similarly, coastal regions, viz. Kochi and Alleppey, populated area with have consistent type of aerosol and size distribution which is different from the case of high altitude region such as Munnar. This can be inferred from the back scattering and single scattering coefficient as well as effective radius of aerosols.

In the second part of the work, weekly mean rainfall taken from GPM for the years of 2015 and 2017, the consecutive years of the aerosol properties under study have been plotted in figure 4 and 5 respectively.

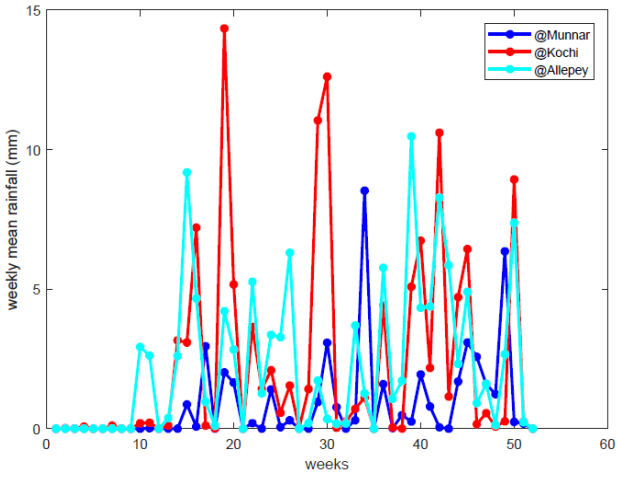


Fig 4: Rainfall in 2015

From figure 4, it can be seen that Kochi has reported higher rainfall than Alleppey followed by Munnar. This could be attributed to the geographical conditions as well as monsoon and wind pattern. Besides, some aerosols can play the role of hygroscopic particle or cloud condensation nuclei to enhance cloud formation and subsequent rainfall [10]. But from figures 1(a), 2(a),and 3 (a), it can be seen that at Kochi in the year 2014, the traces of aerosol has been less compared to the other places. When observed from figure 5, where rainfall taken over 2017 are plotted, it can be seen the drastic decline of rainfall over all the places, Kochi has shown significant decline relatively. The absolute decline of rainfall over all the places could be attributed to monsoon related factors but the higher decline as observed at Kochi compared to other places could be correlated to the significant rise in aerosol content and its properties over Kochi than other places as seen from figure 1(b), 2(b) and 3(b).

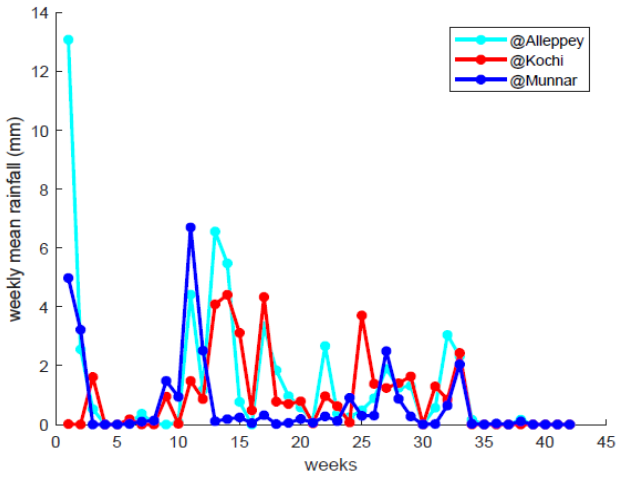


Fig 5: Rainfall in 2017 till October

This work is a preliminary study. To understand the implications of aerosol in real time weather activities as well as long term climatic condition, a detailed analysis of individual properties and its influence as well as radiative transfer is needed to be carried out. Nevertheless, a brief sense can be obtained from the study that explains which type of aerosols or size distribution can influence the rainfall which can further be attributed to backscattering, single scattering coefficient, optical depth and thus, effective radius.

V. CONCLUSION

In this piece of work, weekly averages of several aerosol properties as retrieved by MODIS over 2014 and 2016 are plotted over three different socio-economic as well as geographic regions are plotted which showed the variation characteristics of different aerosol properties pertaining to the social and urban evolution of these places over the year. For urban places such as Kochi, result showed huge increase in the aerosol content and its contribution to the atmosphere through its various influences in scattering and absorption which can be attributed to the urbanization as witnessed by the city unlike other two places.

To understand the possibility of the influence of aerosol in the subsequent year local rainfall scenario, rainfall data taken from GPM are also plotted over the mentioned regions for the year 2015 and 2017. The significant decrease in rainfall in place like Kochi can be reasoned with increase in the aerosol. Furthermore, an extensive study would be required to understand the exact influence of aerosols in the rainfall.

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