2022 International Conference on Recent Progresses in Science, Engineering and Technology (ICRPSET), Faculty of Engineering, University of Rajshahi, Rajshahi-6205, Bangladesh, 26-27 December, 2022

Pattern Analysis of Aerosol Optical Depth and Its Relationship with Meteorological Parameters over Bangladesh During the Covid-19 Pandemic Lockdown

Md. Nayem Jaman Tusher
Department of Electrical and Electronic Engineering
Begum Rokeya University, Rangpur
Rangpur-5400, Bangladesh
nayemjamantusher@gmail.com

Md Monirul Islam
Department of Electrical and Electronic Engineering
Begum Rokeya University, Rangpur
Rangpur-5400, Bangladesh
rajib.mmi@gmail.com

Md. Abu Sayed
Department of Electrical and Electronic Engineering
Begum Rokeya University, Rangpur
Rangpur-5400, Bangladesh
sayedbrur26@gmail.com

Tareq Rageb Ahsan Bin
Nanjing University of Information Science and Technology
Nanjing, China
ragebahsan9@gmail.com

***Abstract*—This study looks at the relationship between aerosol optical depth (AOD) and meteorological parameters during the COVID-19 lockdown in Bangladesh. Aerosols in the atmosphere are liquid or solid particles suspended in the air. AOD is an essential parameter of atmospheric aerosol and has become a significant uncertainty in global climate simulation. The patterns of AOD, meteorological parameters and relationships among them were analyzed across Bangladesh during the covid-19 lockdown period using MODerate Resolution Imaging Spectroradiometer (MODIS) and Global Land Data Assimilation System (GLDAS) remote sensing data. Higher AOD values were observed in western part of Bangladesh and lower AOD values were observed over the hilly area of the eastern part of the country. Highest precipitations were found in the Sylhet division on the other hand lowest precipitations were recorded in the southwestern regions of the Khulna division. An intensive peak land surface temperature was observed in Gazipur of Dhaka division. Wind speed was gradually decreasing from the southern to the northern direction. Lowest AOD and highest precipitation rate were observed in July 2020. Peak values of AOD, land surface temperature, and wind speed occurred in January, May, and June of 2021 respectively. Precipitation and wind speed were both minimum in December 2020, whereas land surface temperature was minimum in January 2021.**

***Keywords*—MODIS, TRMM, AOD, Meteorological parameters, covid-19 Pandemic, Bangladesh**

I. INTRODUCTION

Beginning in December 2019, when it was first detected in China, the COVID-19 pandemic has afflicted people all over the world [16]. The pandemic presents a number of difficulties for both industrialized and developing nations and the ecosystems in which people live. On March 7, 2020, Bangladesh experienced first ever COVID-19 case [17]. Aerosols in the atmosphere are very small liquid, solid or both particles suspended in the air and their diameters typically range from a few nanometers to a few micrometers. Aerosols have a variety of effects on the global climate system and have become a significant contributor to global climate change [3]. Aerosols change cloud attributes through altering the size of cloud droplets, cloud albedo, cloud lifetime, and precipitation [1, 4]. Aerosol optical depth (AOD) is the vertical integral of incoming solar radiation dispersed or absorbed by air over the whole height of the atmosphere. Temperature, wind speed, humidity, precipitation, and barometric pressure are all basic meteorological characteristics. The rain precipitation rate, surface temperature, and wind speed are our primary concerns. One of the most crucial factors affecting the development of plants is precipitation [10]. The study of aerosols using masses is a prominent method. Aerosols are produced in two ways: cloud processing and moist deposition. Removal from the environment Dry deposition and coagulation processes also remove aerosols from the atmosphere. Aerosol particles have a shorter life expectancy than most other gases in the atmosphere, and they move over vast distances on a frequent basis. Satellite observations are a great technique to learn about the features of aerosols [2, 8]. Satellite remote sensing, in particular, like as MODerate resolution The Imaging Spectroradiometer (MODIS) is a low-cost approach to track the optical characteristics of aerosols [5]. MODIS uses Terra and Aqua satellites to give global aerosol optical information with spatial and temporal resolutions across land and sea [6, 9]. Aerosol ratios are steadily rising, particularly in Asia, as a result of rising populations, increasing urbanization with resulting changes in land, increased industrialization, and more motorized traffic [7]. MODIS aerosol ablations are utilized to investigate the spatial-temporal variability of aerosol optical depth in this study. Additionally, MODIS sea salt data and MODIS air temperature data are used to understand better how climatic circumstances affect aerosols over Bangladesh.

II. METHODOLOGY

A. Study Area

Bangladesh is a South Asian country that is growing, extremely inhabited and severely polluted. It has a size of 148,460 square kilometers and has a population of 167,897,465 people. It has the greatest density of population among big countries, with 1,134.54 people per square kilometer. In the west, north, and east, it shares the longest border with India (Fig. 1). In the west, north, and east, it shares the longest border with India. It also shares a border with Myanmar in the southeast, and the Bay of Bengal begins in the south. Bangladesh is divided into six divisions. Sylhet receives the most rain, while Khulna receives the least. Bangladesh is one of the largest and most fertile areas of the Indo-Gangetic plain. Bangladesh's diversified physical environment has an influence on land use practices. Its topography is flat. Bangladesh seems to be the world's biggest delta, formed more by Ganges, Meghna and Brahmaputra River systems. Bangladesh's key climatic features include high temperatures, high humidity, and significant seasonal changes in weather patterns.

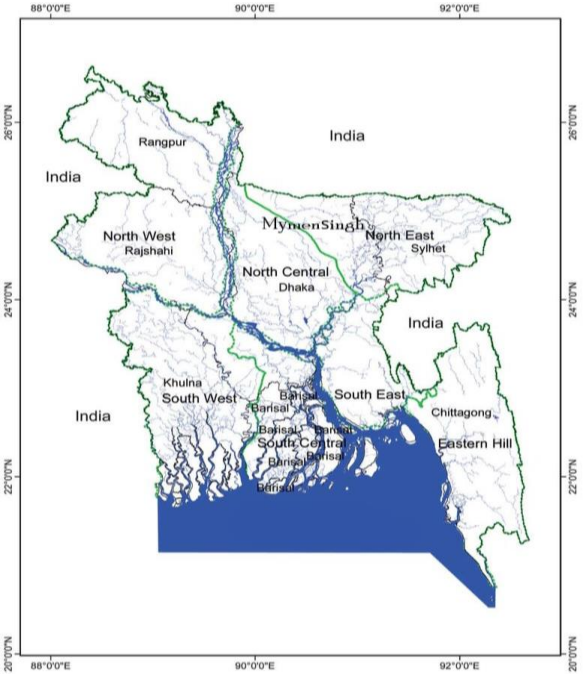


Fig. 1. Geographical map of study area.

B. Data

a) MODerate resolution Imaging Spectroradiometer (MODIS): The MODIS sensor aboard NASA's Terra and Aqua satellites collects data on the atmospheric, land, and ocean environments. 36 spectral channels are present. For in-depth analyses of aerosol distributions on local, regional, global, and temporal scales, MODIS aerosol products are highly helpful [11]. . The datasets used in this paper were derived from the MODIS Terra satellite with Level 3 aerosol products. AOD (Dark target) datasets were used for the period 2020-03-01 to 2021-08-01 over Bangladesh.

b) Global Land Data Assimilation System (GLDAS): Using cutting-edge land surface modeling and data assimilation techniques, the Global Land Data Assimilation System (GLDAS) will assimilate satellite- and ground-based observational data products in order to provide the best fields of land surface states and fluxes [12]. Used GLDAS in determining the climatic characteristics of Rain precipitation rate, Near surface wind speed and Land surface temperature over Bangladesh for the lockdown period 2020-03-01 to 2021-08-01.

On top of the Python programming language, pandas is an open-source data analysis and manipulation tool that is quick, strong, adaptable and simple to use. Additionally, Seaborn is a Python data visualization package built on the matplotlib framework. It offers a sophisticated user interface for creating eye-catching and useful statistics visuals.

C. Equations

The connections among two or more dataset elements (or features) are a common focus of statistical analysis and data science. The features are the characteristics or traits of each observation in the dataset, which consists of data points. The ratio of the correlation of the x axis and the y axis to the product of their standard deviations serves as a measurement of the linear correlation between two characteristics. The letter r is frequently used to indicate it. And you may use the following equation to quantitatively express this value:

$$r = \Sigma_i((x_i - \text{mean}(x))\ (y_i - \text{mean}(y)))\ (\sqrt{\Sigma_i}\ (x_i - \text{mean}(x))^2\ \sqrt{\Sigma_i}(y_i - \text{mean}(y))^2)^{-1}$$

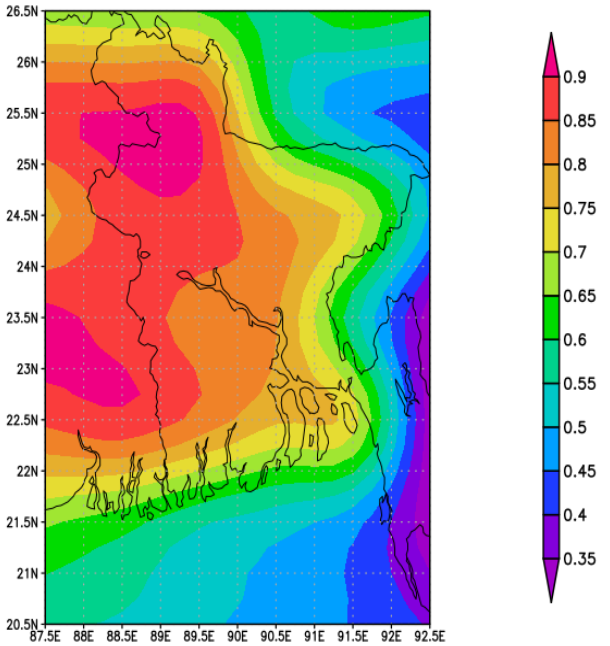


Fig. 2. Spatial distribution of AOD (Dark target) over Bangladesh for the period 2020-03-01 to 2021-08-01.

III. RESULT AND DISCUSSION

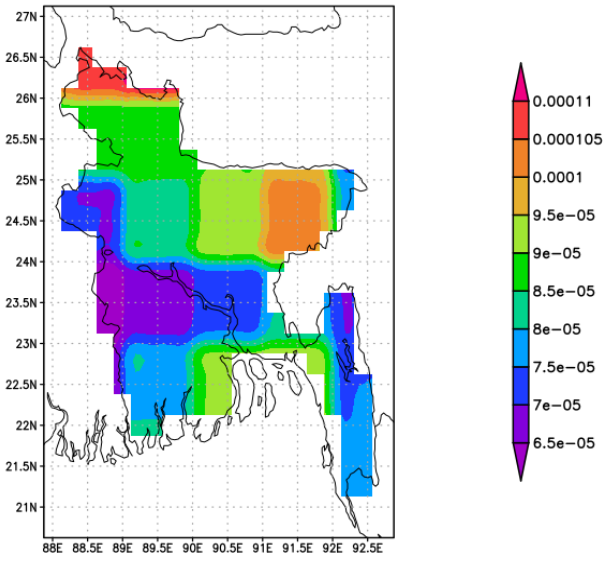
A. Spatial distribution of AOD (Dark target)

The spatial distribution of Aerosol optical depth (dark target) in Bangladesh during the period of 2020-03-01 to 2021-08-01 is presented in Fig. 2. It has been shown that AOD distributions vary greatly across Bangladesh. The western sections of the study region, particularly the Rangpur, Rajshahi, and Khulna divisions, have high AOD

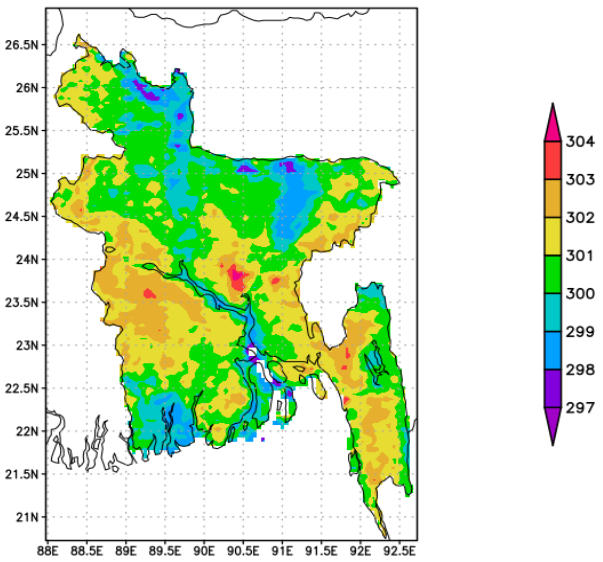
values, but the eastern regions especially Sylhet and Chittagong divisions have lower AOD values, showing a cleaner atmosphere with reduced aerosol loading. In [11, 18], similar findings are also presented. Due to diverse aerosol sources, such as dust, biomass burning, industry emissions, and transportation, AOD is greater and the angstrom exponent is less over the plains area than it is over the mountainous area [13].

B. Spatial distribution of meteorological parameters

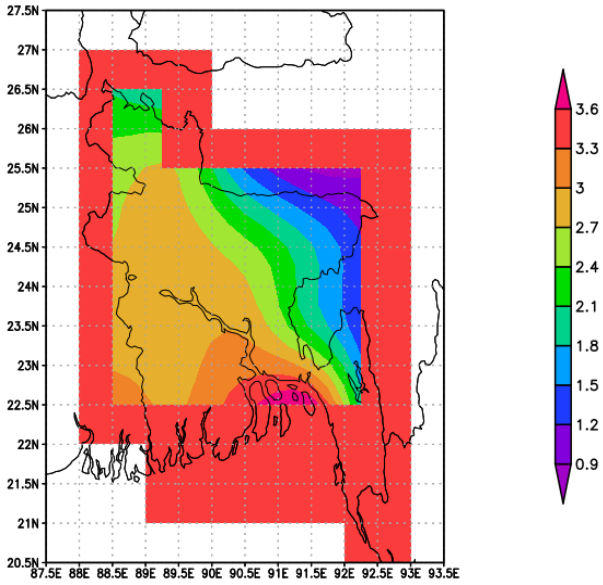
The spatial distribution of meteorological parameters (rain precipitation rate, land surface temperature and wind speed) in Bangladesh during the period of 2020-03-01 to 2021-08-01 is presented in Figure 3. In figure 3(a), the southwestern part of Bangladesh has the lowest rain precipitation rate, which is highest in the northern part. Again, in Chittagong also less is seen due to the hilly region. And the southern part of Bangladesh has a medium rain precipitation rate. In figure 3(b), the highest land surface temperature is seen in Gazipur of the Dhaka division. Rajshahi, Chittagong, and Khulna all have substantially higher rates. Again, Rangpur, Mymensingh, and coastal regions exhibit low land surface temperatures and Barisal division has a medium land surface temperature. In figure 3(c), the wind speed is highest in the ocean area and the lowest northeast corner of Bangladesh. The wind speed from the ocean area towards the northeast gradually decreases but the speed towards the northwest decreases rapidly.



(a) Rain precipitation rate



(b) Land surface temperature



(c) Wind speed

Fig. 3. Spatial distribution of meteorological parameters. (a) rain precipitation rate, (b) Land surface temperature and (c) wind speed over Bangladesh for the period 2020-03-01 to 2021-08-01.

C. Area averaged time series of AOD (Dark Target)

Fig. 4 displays the monthly time series and trend of the AOD across Bangladesh from 2020-03-01 to 2021-08-01. It is reported that AOD, which began to rise in October, reaches its peak in January 2021 across Bangladesh. It can be observed that it begins to fall in June and continues there until July. But From January to June there are some ups and downs in AOD all over Bangladesh.

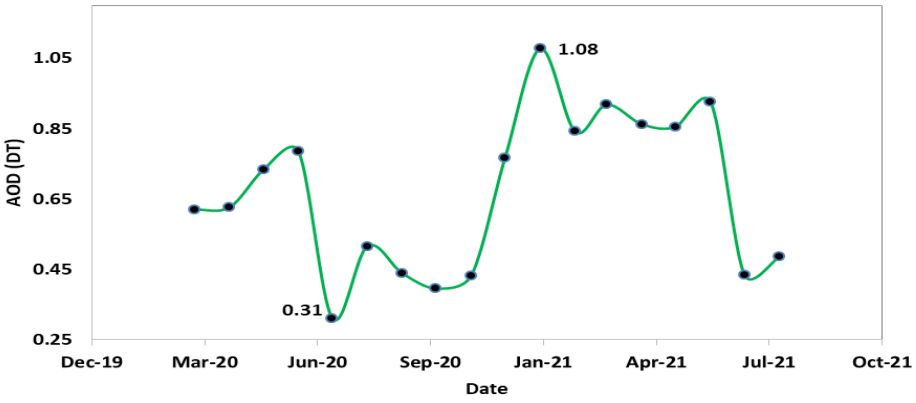
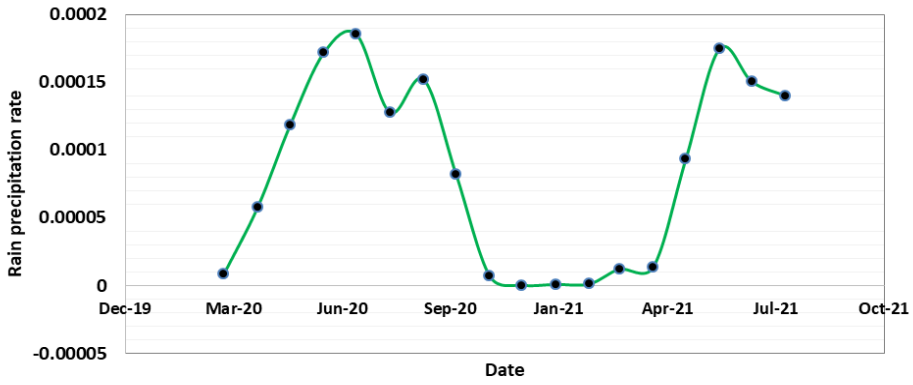


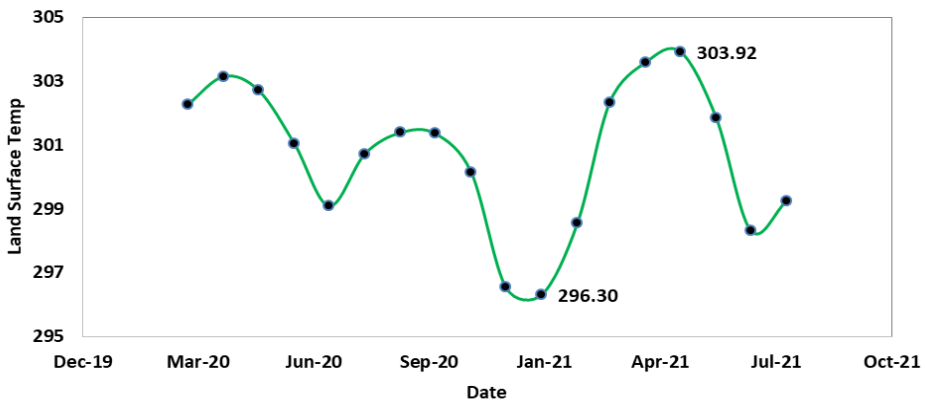
Fig. 4. Area averaged time series of AOD (Dark Target).

D. Area averaged time series of meteorological parameters

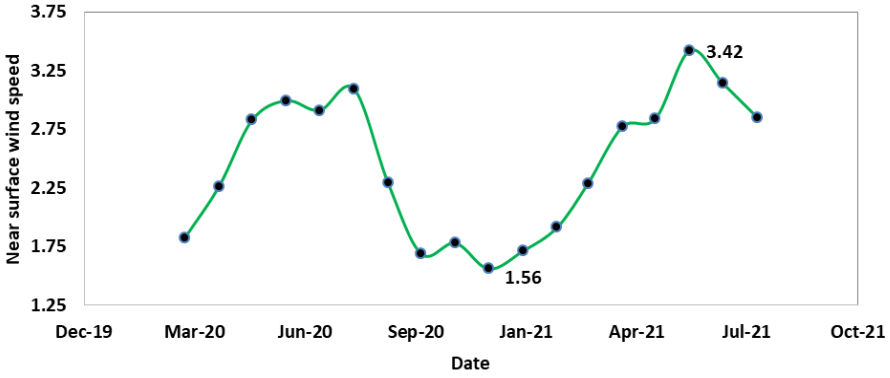
Fig. 5 displays the monthly time series and trend of the meteorological parameters (rain precipitation rate, land surface temperature and wind speed) across Bangladesh for the time period 2020-03-01 to 2021-08-01. Fig. 5(a) exhibits the rain precipitation rate throughout Bangladesh. Rain precipitation rate is highest in June 2020 and lowest from December 2020 to February 2021. Which has been steadily rising since April. It started descending from July 2020 and reached its lowest point in January 2021. Fig. 5(b) depicts the temporal sequence of land surface temperature in Bangladesh. Land surface temperatures are maximum in May 2021 and lowest January 2021. The time sequence of near-surface wind speeds in Bangladesh is depicted in Fig. 5(c). Based on graph, it is observed that the near-surface wind speed rises in December 2020 and maximum in June 2021, then falls from August to December 2020. Highest land surface temperature and wind speed are occurred in 2021's January, May and June respectively. Precipitation and wind speed both are minimum in December 2020 where land surface temperature is minimum in January 2021.



(a) Rain precipitation rate



(b) Land surface temperature



(c) Wind speed

Fig. 5. Area averaged time series (a) Rain precipitation rate, (b) Land surface temperature and (c) Wind speed over Bangladesh for the period 2020-03-01 to 2021-08-01.

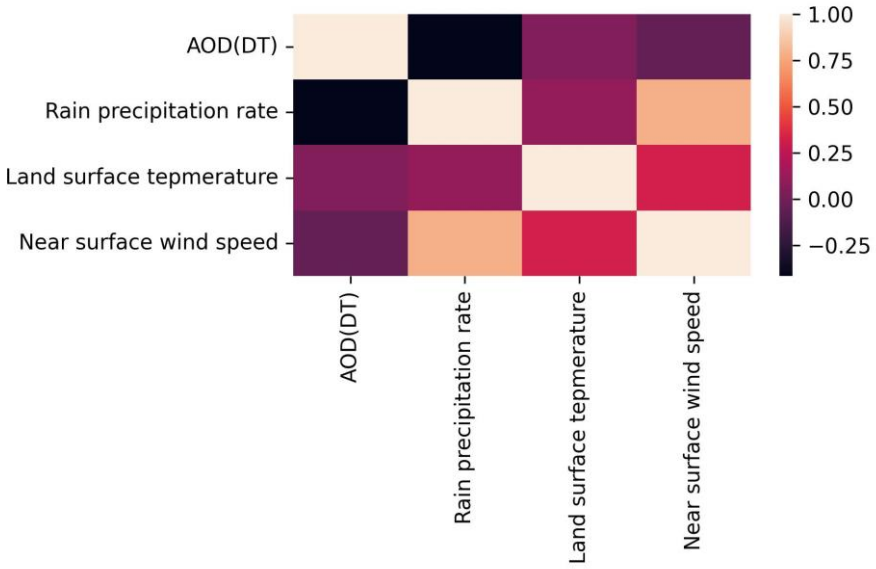


Fig. 6. Co-relation between AOD (Dark target) and Meteorological parameters over Bangladesh for the period 2020-03-01 to 2021-08-01.

E. Co-relation between AOD (Dark Target) and meteorological parameters

Fig. 6 shows the co-relation of meteorological parameters with AOD. A negative correlation (~ -0.40) between AOD and rain precipitation rate was found which indicates that aerosol loading decrease with increase in rainfall. A little bit positive correlation was visualized (~ 0.05) between AOD and Land surface temperature which describes that increasing Land surface temperature increases aerosol loading. Also a negative correlation (~ -0.05) was found between AOD and Near-surface wind speed which means that increasing the Near-surface wind speed decreases aerosol loading.

IV. Conclusion

The purpose of this study was to analyze the pattern of aerosol optical depth and meteorological parameters and co-relation among them over Bangladesh during the covid-19 pandemic lockdown using data from Terra MODIS and GLDAS remote sensing systems and to better understand how aerosols affect the atmosphere. AOD dark target data sets were used for investigating aerosol characteristics. The Rangpur, Rajshahi and Khulna divisions of the country have higher AOD values on the other hand the hilly areas of Sylhet and Chittagong divisions have lower AOD values. The southwest region of Bangladesh has lowest rain precipitation rate, which is highest in Sylhet. The peak land surface temperature is seen in central Dhaka also Rajshahi, Chittagong, and Khulna all have substantially higher rates. Again, Rangpur, Mymensingh, and coastal regions exhibit low land surface temperatures. The wind speed is highest in the sea area. The wind speed from the sea area towards the northeast gradually decreases but the speed towards the northwest decreases rapidly. AOD starts to increase in October and reaches its peak in January. It is evident that it

starts to fall in June and stays there until July. In terms of meteorological factors, the rain precipitation rate is highest in June 2020 and lowest from December 2020 to February 2021, which has been steadily rising since April. It starts descending in July 2020 and reaches its lowest point in January 2021. Land surface temperatures are maximum in May 2021 and lowest in January 2021. Based on the graph, we can observe that the near-surface wind speed rises in December 2020 and maximum in June 2021, then falls from August to December 2020. Peak land surface temperature and wind speed occurred in 2021's January, May, and June respectively. Precipitation and wind speed both are minimum in December 2020 whereas land surface temperature is minimum in January 2021. AOD and rain precipitation rate are negatively correlated. That means decreasing AOD increases the rain precipitation rates or vice versa. AOD and Land surface temperature is slightly positively correlated. Which describes increasing land surface temperature increases AOD values. Also the negative correlation between AOD and Near-surface wind speed indicates that high wind speeds increases AOD values.

ACKNOWLEDGMENT

The authors are grateful to GES-MODIS and GES-TRMM for supplying the satellite datasets.

REFERENCES

[1] S. A. Twomey, M. Piepgrass, and T. L. Wolfe, "An assessment of the impact of pollution on the global albedo," Tellus B, Vol. 36, pp. 356–366, 1984.

[2] S. C. Alfaro, M. M. Abdel Wahab, A. S. Zakey, and B. Chatenet, "Seasonal and inter-annual variability of the aerosol content in Cairo (Egypt) as deduced from the comparison of MODIS aerosol retrievals with direct AERONET measurements," Atmos. Res, Vol. 97, pp. 14–25, 2010

[3] Intergovernmental Panel on Climate Change (IPCC), 2007, Climate Change: The Physical Science Basis, Cambridge University Press, New York, pp. 131–216.

[4] V. Ramanathan, P. J. Crutzen, J. T. Kiehl, and D. Rosenfeld, "Aerosols, climate, and the hydrological cycle," Sci, Vol. 294, pp. 2119–2124, 2001.

[5] L. L. Wang, Y. S. Wang, J. Y. Xin, Z. Q. Li, and X. Y. Wang, "Assessment and comparison of three years of Terra and Aqua MODIS aerosol optical depth retrieval (C005) in Chinese terrestrial regions," Atmos. Res., Vol. 97, pp. 229–240, 2010.

[6] Y. J. Kaufman, D. Tanre, L. A. Remer, E. F. Vermote, A. Chu, and B. N. Holben, "Operational remote sensing of tropospheric aerosol over land from EOS moderate resolution imaging spectroradiometer," J. Geophys. Res, Vol. 102, pp. 17-51. 1997.

[7] K. Alam, T. Trautmann, and T. Blaschke, "Aerosol Optical Properties and radiative forcing over mega city Karachi," J. of Atmos. Res, 2011.

[8] [8] M. D. King, Y. J. Kaufman, D. Tanre, and T. Nakajima, "Remote sensing of tropospheric aerosols from space: past, present, and future," Bull. Am. Meteorol. Soc, Vol. 80, pp. 2229–2259, 1999.

[9] D. Tanre, Y.J. Kaufman, M. Herman, and S. Mattoo, "Remote sensing of aerosol properties over oceans using the MODIS/EOS spectral radiances," J. Geophys, Res, Vol. 102, 16-971, 1997.

[10] M, Joanne, Nightingale, and R. P, Stuart, "Assessment of Relationships Between Precipitation and Satellite Derived Vegetation Condition Within South Australia," Australian Geographical Studies, vol. 2, pp. 180–195, 1993,

[11] M.N. Islam, M.A. Ali, and M.M. Islam, "Spatiotemporal Investigations of Aerosol Optical Properties over Bangladesh for the Period 2002–2016." Earth Syst. Environment, Vol. 3, pp. 563–573, 2019.

[12] M. Rodell, "The Global Land Data Assimilation System. Bull. Am. Meteorol," Soc, Vol. 85, pp. 381–394, 2004.

[13] D. Xueliang, S. Chune, W. Biwen, C. Zhenghua, SupingNie, H. Dongyan, and Z. Hao, "Analysis of aerosol characteristics and their relationships with meteorological parameters over Anhui province in China," Atmospheric Research, Vol. 109, pp. 52-56, 2012.

[14] M. I. Mamun, M. M. Islam, and P. K. Mondl, "The seasonal variability of aerosol optical depth over Bangladesh based on satellite data and HYSPLIT model," AME. J. Remote Sens, Vol. 4, pp. 20-29, 2014.

[15] M. I. Mamun, M. M. Islam, A. H. Rasel, and M. Keramat, "An observational study of aerosol optical properties and their relationships with meteorological parameters over Bangladesh," IOSR J. of Appl. Geol. and Geophys, Vol. 2, pp. 75-84, 2014.

[16] S. Gautam, "COVID-19: air pollution remains low as people stay at home," Air. Qual, Vol. 13, pp. 853-857, 2020.

[17] I. Hossain, A. R. Mullick, M. H. Khan, S. A. Ahmad, M. S. Rahman, M. M. Aktaruzzaman "Comorbidity and its Impact on COVID-19 Affected Patients in COVID-19 Dedicated Hospital of Bangladesh," Epidemiol, Vol. 25, pp. 2517, 2020.

[18] S. Tariq, F. Qayyum, Z. Ul-Haq and U. Mehmood , "Long Term Spatio-Temporal Trends in Aerosol Optical Depth and Its relationship with Enhanced Vegetation Index and Meteorological Parameters Over South Asia." Environ. Sci. and Res. Pollut., https://doi.org/10.21203/rs.3.rs-774811/v1,2021.