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IMPACTS OF AEROSOL CHARCTERISTICS ON SURFACE SOLAR RADIATION AN URBAN STATION LUCKNOW

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ABSTRACT

Various studies analyzing long-term surface solar radiation measurements suggested a widespread decrease in solar radiation reaching at the Earth's surface. This decrease can be caused due to the changes in cloud cover and the mass and optical properties of aerosols present into the atmosphere. In the present work, surface reaching solar radiation data obtained from CPCB Lucknow along with the satellite-derived (MODIS) aerosol products and surface meteorology, particularly visibility were investigated simultaneously at an urban station Lucknow over the middle part of the Indo-Gangetic Basin (IGB) region in north India for a period of three years (January 2016-Decemeber 2018). These parameters showed large variability on daily, monthly and seasonal time scales during the study period. To understand the impact of aerosols on surface solar radiation, a correlation analysis was done between solar radiation and simultaneously measured aerosol parameters. Solar radiation was found to be significantly correlated (negative) with aerosol optical depth (AOD; R±0.18), indicating an increase in AOD will reduce the incoming solar radiation at the Earth's surface. It is also negatively correlated with the Angstrom exponent (AE; R±0.32), a qualitative indicator for aerosol sizes, suggesting a decrease in solar radiation influenced mostly with an increase in fine mode aerosols (i.e. an increase in AE values), which may differ seasonally. Results suggest an increase in AOD may decrease the visibility and thus reduce incoming solar radiation. Study further reveals that the coarse-mode aerosols dominate during summer (Mar-Jun) and monsoon (Jul-Sep) seasons, whereas fine mode particles enhanced during post-monsoon (Oct-Nov) and winter (Dec-Feb) seasons. Potential temperature change artery has been identified and discussed using concentration weighted trajectory analysis of 5-days air mass back trajectories from the Air Resources Laboratory (ARL), National Oceanic and Atmospheric and Administration (NOAA).

1. Introduction

Under clear sky conditions the Aerosol Radiative Flux (ARF) is the distinction among approaching and active sun powered motion in the nearness and nonappearance of pressurized canned products. The radiative motion inside the environment (ATM) with pressurized canned product be acquired from either satellite information or model figuring, utilizing "got input information" while the "motion", without vaporized, from the model perception (Lesins et al, 1999). Radiative transition, estimated in W/m2, can be portrayed as the greatness of intensity as photons or other rudimentary particles produced through a given district. At the point when restrainedto the infrared range, radiative transition goes about as warmth motion, and moves toward becoming irradiance when episode upon a surface(Pollack et al., 1993).

Radiative transition is ordered into two sorts –

(i) Short Wave (SW) radiative transition and

(ii) Long Wave (LW) radiative transition.

Both of transitions are the aftereffect of specular and diffuse impression of infrared waves. Short wave radiation profoundly affects certain biophysical procedures, for example, photosynthesis and land surface vitality spending plan and long wave radiative transition is the result of both down welling as will infrared vitality just as discharge by the surface(Pawar et al., 2012).

Airborne impact on environmental radiative transitions goes before a constraining capacity that can change the atmosphere in critical ways. ARF is a noteworthy watched environmental difference in the previous century and in foreseeing future climate(Russell et al., 1999). The SW and LW radiative motions are basic parts of vitality equalization, and assume an indispensable job for understanding the climate and atmosphere inside the atmosphere(Karatz et al., 2000). Pressurized canned products apply Direct Radiative Effects (DRE) due on dispersing and retention of sunlight(Satheesh and Ramanathan, 2000). Airborne dissipating is the predominant vaporized constraining that prompts the cooling of the environment. Assimilation of sunlight based radiation by pressurized canned products prompts the warming of the encompassing, changing along these lines the temperature and quality of convection(Chou et al., 2005). The extent of DRE relies upon the overall extent of regular and anthropogenic pressurized canned products constituents which have show qualities and size assessment(Griggs et al., 2002). The direct radiative compelling because of the biomass consuming mist concentrates is a touchy capacity of the size conveyance of airborne particles. The DRE because of anthropogenic and regular pressurized canned products is characterize as the impact of these vaporizers on the radiative motions and the change in radiative motion because of just anthropogenic mist concentrate sprayer be named as airborne direct radiative forcing(Chung et al., 2005).(Chakraborty et el, 2010) considered the effect of engrossing airborne on the recreation of atmosphere over the Asian locale in an environmental general flow model and they demonstrate that, the retaining mist concentrates increment short wave warming of the lower troposphere and decrease the warmth at the surface. Up to this point, few examinations have been led on vaporized optical properties in Lahore and Karachi(Alam et al., 2011b), (Alam et al., 2012), (Alam et al., 2014a) and (Alam et al., 2014b). The radiative constraining in New Delhi was contemplated and increment in warming was seen at the highest point of the atmosphere(Pandithurai, 2008). The direct radiative compelling of Indian Ocean locale during spring 1999 was decreased in atmosphere(Collins et al., 2002).(Qin et al., 2009)reported that the warming rate is expanded over Tibetan Plateau (China).(Deepshikha et al., 2005) inferred the residue engrossing effectiveness over the north Indian Ocean on the bases of METEOSAT perception in the U-V noticeable and infra-red range, and saw that the residue from desert zones of Arabian Peninsula was less retaining than the one collaborating with anthropogenic vaporizers which gives solid proof to incidental residue particles with dark carbon. (Menon et al., 2002) contemplated the atmosphere impacts of the dark carbon pressurized canned products in the East Asian storm district and found the marvel of northern dry season/southern flooding happened in summer during the previous 50 years in China. Warming impacts because of carbonaceous mist concentrates in the air went up in the Himalayan district joined by the debilitating of the Hadley and polar courses in the Northern Hemisphere(Zhang et al., 2009).

The present work broke down the spatio-fleeting varieties in Aerosol Optical Depth (AOD), and Long Wave (LW) Aerosol RadiativeFluxes (ARF) at TOA, SRF and in ATM utilizing Clouds and the Earth's Radiant Energy System (CERES) and Moderate Resolution Imaging Spectroradiometer (MODIS) instruments information over Lucknow, Agra, delhi over ther period 2016-2018. The connection among ARFs and AODs has been inspected for various examination areas.

2 Methodologies

2.1 Site description

The Indo-Gangetic Plain (IGP) envelops a tremendous territory, representing ∼21 % of the land zone of India. It is a thickly populated area obliging ∼40 % of the Indian populace. Quickly developing economy and expanding populace have troubled this area, bringing about a wide scope of anthropogenic exercises. Countless warm power plants, a large portion of them coal nourished, are grouped along this area (Nair et al., 2007). The IGP constantly creates anthropogenic contamination from urban, modern, and provincial burning sources. What's more, it is influenced by convection-instigated winds driving desert and alluvial residue into the air during the pre-storm season (Dey et al., 2004; Remer et al., 2008). The blending of regular and anthropogenic mist concentrates results in complex microphysical and synthetic properties, which demonstrate an extremely solid occasional variety.

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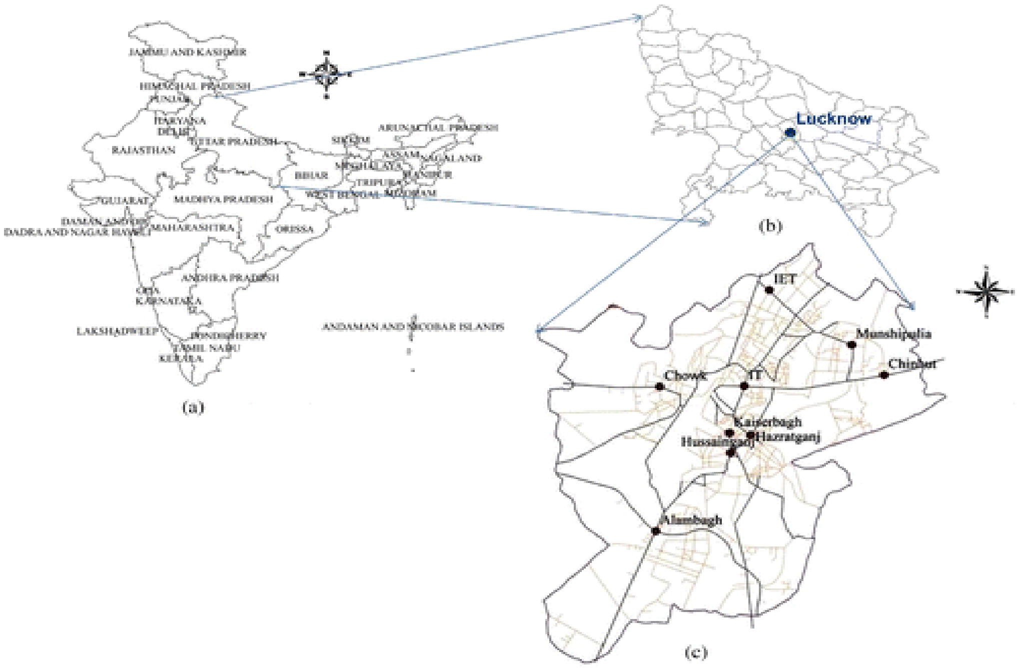

Lucknow (Urban territory/Metropolitan area) is quickest developing city with populace of 2,902,920 (Census of India, 2011) and lies between 26° 52′ Latitude and 80° 56′ Longitude at 128 m above ocean level. Being a piece of center Indo Gangetic Plane, the city distinctively encounters damp sub-tropical atmosphere with three particular season viz. summer (March to June, 38–46 °C), storm (July to October) winters (November to February, 3–15 °C). Run of the mill meteorological conditions in winter with low wind speed and low blending stature limit dispersion, weakening and transport of air toxin bringing about elevated amounts of particulate issue.

2.2 Datasets and analyses (instrumentation)

In this examination distinctive datasets and their determined properties have been used.MODIS satellite is a key instrument that introduced on the Terra (EOS AM) and Aqua (EOS PM) satellites which were propelled in December 1999 and May 2002, separately. Land's circle around the earth toward the beginning of the day it goes from north to south over the equator, while Aqua disregards south to north the equator toward the evening. MODIS utilizes 36 ghostly groups with wavelengths ran (0.41 µm-14.4 µm). MODIS instrument give a great deal of data about meteorological, earthbound, and waterfront environment. It has (250-1km) spatial and (1-2) days fleeting goals, yet for certain parameters it likewise gives a spatial goals of 10 km[18]. MODIS utilizes various techniques for recovery information over seas [19] and over land [20] and for land it demonstrates less exactness [21]. The MOD08 AOD month to month information items from Terra level-3 AOD at wavelength 550nm with a spatial goals of 1o × 1o km from December 2002 to February 2005 were used in this examination. More data on recovery of AOD information is accessible at site http://modis-atmos.gsfc.nasa.gov.

The Clouds and the Earth's Radiant Energy System (CERES) instruments fly on a few National Aeronautics and Space Administration Earth Observing System (EOS) satellites beginning in 1998 and now it is a key constituent of the Earth Observing System (EOS) program. The CERES broadband examining radiometers are changed adaptation of the Earth Radiation Budget Experiment (ERBE) radiometers [22]. CERES screens tiny changes in the Earth's vitality balance, the contrast among approaching and active vitality and decide the Earth's vitality parity giving a long haul record of this indispensable ecological parameters that will be solid with those of its antecedents. The CERES instruments likewise give radiometric estimation of the Earth's climate from three broadband channels. The CERES instrument is checking Earth, guaranteeing accessibility of estimation of the vitality at TOA, at the SRF and at a few chose levels inside ATM [5]. CERES information give TOA radiative transitions a factor of 2 to 3 less blunder than the ERBE information. In this examination we have utilized CERES item having simultaneous data of Clear-sky_TOA_LW_Flux and Clear-sky_Sfc_Net_LW_Flux-Mod_B for the investigation time frame. The detail on recovery of ARF information is accessible at site http://disc.sci.gsfc.nasa.gov/giovanni.

3. Results and discussion

3.1 Annual and seasonal variations in AOD

In this examination, we determined time arrangement of month to month mean AOD values from MODIS at 550nm for the time of January 2016-december 2018 and found that the month to month mean MODIS AOD qualities went from 0.36-1.09, 0.51-1.02 and 0.47-1.31over lucknow in 2016, 2017, 2018 separately. Figure 2(a) demonstrated that the most astounding normal AOD was seen in 2018 (1.31), and the least in 2016 (0.36). Consistently

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AOD accomplished yearly top in the long stretch of June in lucknow. Yearly and occasional normal AOD qualities and standard deviations recovered by MODIS lucknow during the investigation time frame was given in Table 1.

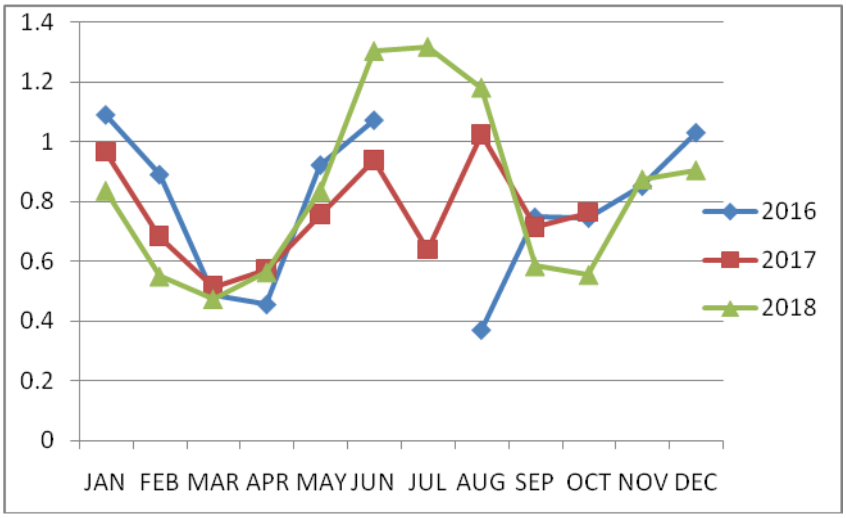

Figure 1

Figure 1 demonstrated that, for lucknow, the most extreme AOD esteem (1.091) was recorded during the long stretch of January 2016; for 2017, the greatest AOD esteem (1.02) in August ; for 2018 , the most extreme AOD estimation of 1.31 was in June

A stamped AOD greatest was seen in month June is because of the expansion in temperature, nonappearance of downpour and gathering of harvests. The AOD esteem 2017 was most noteworthy in eminent. This expanded AOD esteem in august is because of neighborhood air poisons and solid breeze disintegration. Also the diminishing in AOD qualities was seen from September to December for all locales which is expected the cloud rummaging and downpour wash out processes.(Jin et al., 2006) watched most extreme AOD from May to June and the base from November to December over the Tibetan Plateau.

YEAR	ANNUAL	WINTER	SUMMER	PRE-MONSOON	POST-MONSOON
2016	0.79±0.25	1.01±0.51	0.73±0.38	0.65±0.26	0.8±0.37
2017	0.76±0.17	1.03±0.46	0.67±0.48	0.83±0.31	0.78±0.29
2018	0.83±0.30	0.72±0.28	0.77±0.42	0.80±0.42	0.70±0.27

(Sarkar et al., 2006) announced that AOD from March began to increment and achieves a most extreme incentive in June over India.(Alam et al., 2011b) found a similar outcome that AOD expanded from the period of March, achieving its greatest in July over Karachi. Despite what might be expected AOD began to diminish in September and found the low an incentive in December. Our outcomes were additionally predictable to the ones found by (Metwally et al., 2010) utilizing MODIS airborne recoveries over Cairo (Egypt). We likewise done an occasional normal MODIS AOD over Lucknow, for the mid year (June, July, August), winter seasons (December, January, February), pre-rainstorm (March, April, may) and post-storm (September, October, November) for the period January 2016-december 2018.

MODIS recovered AOD shifts essentially over seasons. Figure 2 exhibited the normal AOD values as a component of month, demonstrating regular varieties for the three years with a high AOD esteem in JUNE throughout the SUMMER season aside from in 2016 as information of july and august was not accessible Similarly, high AOD qualities were acquired in the December throughout the winter season for winter months very little information were accessible to mention any exact objective facts. It was additionally obvious from the Figure that late spring AOD's were higher than winters... (Ranjan et al., 2007) revealed that in summer, higher dampness shows higher AOD values.(Balakrishnaiah et al., 2012) watched high AODs values over Pune, Visakhapatnam and Hyderabadduring the mid year season utilizing MODIS satellite information. (Tripathi et al., 2005) recorded greatest AODs values throughout the late spring months recovered from MODIS over Kanpur. (Li et al, 2003) utilized the MODIS information to dissect the regular varieties of AOD in eastern China, and found the higher estimation of AOD in summer because of human exercises and Asian residue. In earthly locales of China, the local month to month normal AOD qualities were broke down from MODIS which demonstrated higher estimations of AOD in summer and lower in winter (wang et al, 2008). (Papadimas et al., 2008) recorded high precipitation rate in winter which causes evacuation of air pressurized canned products and a lower estimation of AOD during this season was watched. (Chen et al. 2010) watched the occasional fluctuation with a higher AOD level in summer and a lower AOD level in winter over Southern Ontari (Canada). So also, (Singh et al., 2010) found that the AOD was higher in summer season than in winter season for various zones of India. (Alam et al., 2014a) broke down the recovery of MODIS AOD over Lahore and noted high AOD values during post-rainstorm than pre-storm. (Choudary et al., 2012) inspected the airborne focuses over Kanpur (India) and that affectionate that AOD information increments during the pre-rainstorm months since residue storms werecommon in the Indo Gangetic Plain. Utilizing MODIS information prior scientists (Kalita et al., 2011) and (Pathak et al., 2013) have announced that most noteworthy flame exercises in the locale happen during pre-storm. (Kharol et al., 2008) have likewise ascribed improved flame exercises topping in pre-rainstorm over North-East India to watched high AOD.

3.2 Aerosol radiative forcing (ARF)

3.2.1 Annual and seasonal variation in ARF

The Long Wave (LW) and Short Wave (SW) radiative motions at the surface are significant segments of the Earth's radiation balance (net progression of vitality). Consequently, the vitality transitions are critical to comprehend environmental change, characterized by changes in the Earth's vitality balance. In this area normal ARF was determined for the LW clear sky inside the environment (ATM) utilizing CPCB information. The distinction of the two (TOA - SRF) gives ARF inside the environment (ATM). The month to month normal yearly and regular ARF inside the air (ATM) during clear-sky days for the investigation time frame January 2016-december 2018 were appeared Table 2. The ARF over Lucknow for ATM 2016, 2017, 2018 was in the range from 82-288w/m2, 20-137 W/m², 26-95 W/m2.The transient varieties of airborne constraining in clear sky driving exhibited in the figure 4(a-d) that the normal compelling in the long wave district inside the environment was greatest in the period of walk/april for the years 2016, 2017 and 2018.. It was noticed that the month to month varieties of airborne driving over contemplated timeframe wre not uniform. After June the vaporized focus diminished all around

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gradually due to monsoonal downpour bringing about most reduced airborne surface compelling. In like manner, in 2016 AOD was high in September/October because of anthropogenic compelling at surface and climate. In the long wave district, cooperation of mists with the long wave radiation prompting increment in the climatic compelling (Dey, S. also, Tripathi, 2008). In a worldwide study,(Miller et al., 1999) have discovered that the residue radiative compelling during June–August at the TOA and surface were in the scope of - 2 to +2 and - 5 to - 10 W/m2.(Alam et al., 2014b) revealed longwave ARF values in the scope of +6 W/m2 and +20W/m2 at the world's surface and +7W/m2 and +30W/m2 at the TOA delivering warming impact in the atmosphere.(Chinnam et al., 2014) additionally noted warming impact inside the environment constraining utilizing LW locales over Kanpur. (Adesina et al., 2014) revealed over Gorongosa recorded the month to month mean ARF at TOA, SRF and ATM in the scope of - 6 to - 22 W/m2, - 16 to - 89 W/m2 and 10 to 68 W/m2, separately.

YEAR	ANNUAL(W/m^2)	WINTER(W/m^2)	SUMMER(W/m^2)
2016	169.04	189	244
2017	86.32	93.70	124
2018	58.83	35.10	82.6

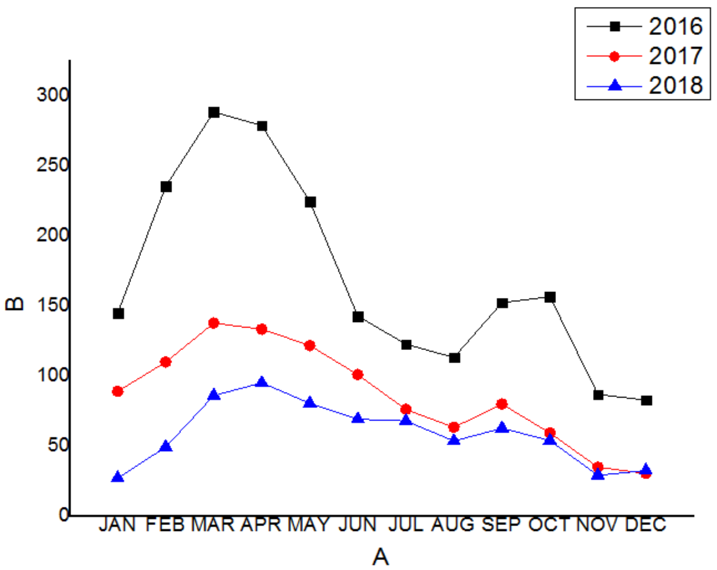

Figure 2

Conclusion

This paper accentuation on as the yearly and occasional varieties of month to month mean AOD values from MODIS and vaporized optical and radiative driving from CERES information for the time of January 2016-December 2018 over lucknow area.

The significant finishes of the examination are:

1. The most extreme AOD esteem (1.091) was recorded during the long stretch of January 2016; for 2017, the greatest AOD esteem (1.02) in August ; for 2018 , the most extreme AOD estimation of 1.31 was in June

2. The ARF over Lucknow for ATM 2016, 2017, 2018 was in the range from 82-288w/m2, 20-137 W/m², 26-95 W/m2.

3. Over the examination areas change in AODs is seen because of regular variety in light of wind speeds, relative dampness, and temperature changes.

4. Utilizing CERES information, we broke down the unmistakable sky long-wave airborne radiative driving at top of the air and at surface to register barometrical constraining which prompts warming of the air information.

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