Aerosol optical properties over an urban industrial area, Raipur, Chhattisgarh, India

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Abstract Optical properties of aerosols including Aerosol optical depth (AOD), Angstrom exponent (AE) and Single scattering albedo (SSA)) were derived and analyzed for classifying the aerosols and identification of possible sources with percentage contribution over an urban-industrial city Raipur, India, during the year 2019 to 2021. The mean annual values of AOD and AE during 2019–2021 were 0.53 ± 0.2 and 1.20 ± 0.33 respectively, with the highest AOD (AE) values in summer: (0.67 ± 0.21 (0.98 ± 0.13)), spring: (0.52 ± 0.17 (0.93 ± 0.23)), autumn: (0.59 ± 0.21 (1.36 ± 0.26)) and winter: (0.44 ± 0.15 (1.49 ± 0.15)) respectively. The results revealed the dominance of finer aerosols with higher (lower) AE value during the winter (summer) season. Whereas, lower (higher) SSA values during the winter (summer) indicated the presence of absorbing types of aerosols. Based on the aerosol optical characteristics (AOD versus AE), three distinct aerosol types were discovered throughout the study period, namely mixed aerosols (60%), biomass-urban (37%), and dust aerosols (3%). To discriminate between urban and biomass burning aerosols, optical characteristics (AE versus SSA) were examined and found three main sources: mixed aerosols (71%) urban-industrial (21%) and biomass burning aerosols (8%). These findings will be useful for identifying potential sources as well as serve as an input for estimating the radiative forcing caused by regional aerosols.

Keywords Aerosol optical depth (AOD) · Angstrom exponent (AE) · Single scattering albedo (SSA)

1 Introduction

Atmospheric aerosols may alter the earth’s radiation budget directly by the absorbing and scattering the solar radiation [1], and indirectly by altering the microphysical cloud properties such as an increase in cloud droplet concentration and cloud retention time [2, 3]. Aerosols also have a significant adverse health impact [4]. For investigations of aerosol influences on climate, knowledge of aerosol optical characteristics is essential. Most of the aerosols are having scattering nature imparting a cooling potential causing negative radiative forcing (RF), except absorbing aerosols having a warming potential leading to positive RF like black carbon (BC). This mainly depends upon the particle size distribution, shape, optical properties of aerosols and refractive index [5]. Aerosols cloud interaction may affect the warming and cooling potential of aerosols and radiative forcing estimation which mainly depends upon the presence of aerosols and clouds in the atmosphere [6, 7]. Absorbing type aerosols will be more effective, when it lies over the dark surface (clouds) [8] and influence of aerosols loading on cloud fraction is still less clear.

Aerosols directly affect global climate change which mainly depends upon the optical properties of aerosols such as aerosol optical depth (AOD), angstrom exponent (AE), single scattering albedo (SSA) [9]. Aerosol optical depth is one of the key parameters for investigating the dust loading by determining the total aerosols extinction effect, and the angstrom exponent value can be used for getting information about the particle size [10]. The single scattering albedo can be used to classify the aerosol type by providing insight into...
Aerosols optical properties can be monitored by satellite remote sensing (Moderate Resolution Imaging Spectroradiometer (MODIS), Multi-angle Imaging Spectroradiometer (MISR)) and ground-based instrumentation (Multiwave Radiometer, Sun Photometer) on a regional and global scale [14]. Although ground-based observation of aerosols optical properties has higher precision than satellite-based monitoring, it requires further improvement due to the impact of varying surface albedo, topography, algorithm retrieval, and reception. Even though, due to the non-availability of the ground-based instrumentation, long-term, and continuous observations, MODIS and MISR are proved to be a better tool for spatio-temporal observations of AOD and have also been used worldwide [2]. Earlier, several studies have been carried out to compare and correlate the values of aerosol optical depth obtained from the ground-based and satellite-based measurement techniques. They have found better correlation \( r = 0.869 \) to 0.905, AERONET and MODIS [14], \( r = 0.79 \) MODIS and AERONET [15]. The better correlation is found \( r = 0.86 \) among MODIS AOD and ground-based measurement AOD [18]. Several studies on the optical properties of aerosols have been carried out worldwide including Karachi, Pakistan: [19]; Tangshan (industrial), China: [20]; Lumbini, Nepal: [15]; Baghdad, Iraq: [21]; Beijing and Kanpur: [22] and over Indian sub-continents, most of the studies are confined to the Indo-Gangetic Plain (IGP) region [18, 23–34], Himalayan region [15, 24, 25] and South-Western part [26].

A complex blend of aerosol constituents exists in the atmosphere as a consequence of the diversity of aerosol species. It is difficult to distinguish the biomass burning events from the urban industrial aerosols, hence it is better to perform correlation analysis between AE and SSA to distinguish the both [13]. Till now, fewer investigations have been conducted to classify the aerosols types based on aerosol optical properties over Indian cities; Kanpur- [30]; Delhi- [31]; Bengaluru- [32]; Jaipur- [33] and only study by Rani and Kumar [34] have been found over the present region (Chhattisgarh). They have analyzed the spatial distribution of MODIS derived AOD over India during Covid \(-\) 19 pandemic phase (State-wise). These aerosol characteristics may be determined using consistently accurate retrieval data from ground-based sun photometer networks. Ground-based measurements, however, could only offer information on the aerosol characteristics over certain locations, despite the sun-photometer observations’ capacity to deliver valid aerosol properties data by avoiding surface reflectance interference. In order to offer systematic retrieval of aerosol optical characteristics at regional and global scales, satellite remote sensing techniques are crucial due to the geographical constraints imposed by fixed sites and the lack of ground-based data. Furthermore, satellite data have demonstrated the capacity to estimate air pollution concentrations close to the surface. To the best of our knowledge, till now no specific studies have been found on aerosol optical properties as well as on the classification of aerosol types and possible sources over the present study region which will help to accurately estimate the contribution of regional aerosols on global estimation of radiative forcing.

Large uncertainties exist in the global climate model despite a better understanding and availability of ground-based and satellite-based data on a global scale, due to the composite chemical and physical characteristics of aerosols. Aerosols in the atmosphere are distributed very unevenly throughout time and space. The spatial-temporal distribution and aerosol optical properties must thus be sufficiently understood. To improve the precision of the numerous current models, detailed knowledge of aerosol optical properties is required. Therefore, it is required to conduct a comprehensive study on the optical properties of aerosols over the present region.

The knowledge of spatiotemporal aspects of aerosol optical properties and their sources remains confusing due to insufficient study in this area, despite a number of pertinent studies being undertaken elsewhere. This work sought to fill these information gaps by characterising and comparing the aerosol optical properties from 2019 to 2021, identifying contributing sources to air pollution based on aerosol optical characteristics, and investigating the temporal fluctuations of optical properties in the study region. With a better understanding of aerosol characteristics in the area as a result of this work, governmental organisations may be better equipped to prepare for minimising the serious problems with air pollution.

### 2 Data and methodology

#### 2.1 Study area and data retrieval

As shown in Fig. 1, Raipur, an urban-industrial city (21°15′00″ latitude and 81°37′47″ longitude) is situated in the eastern central part of India in Chhattisgarh state which shares its border with 7 states. As a state with an energy surplus, Chhattisgarh is a suitable location for industrial enterprises. The city is surrounded by the industrial clusters, largely steel and sponge iron, cement plant, agricultural-based industries within the periphery of about 20 km radius. As per the Chhattisgarh State Industrial Development Corporation’s (CSIDC), the total production of Chhattisgarh state for steel, cement and aluminium is about 25%.
and 15% of India’s production respectively [35]. In a report published by the World Health Organization (WHO), Raipur was ranked seventh (2016) in the list of most polluted cities [36]. Raipur city has a tropical wet and dry climate; temperatures are moderate except from April to June when they can reach a maximum of 48 °C. The winter season typically lasts from November through January, with a minimum temperature of 5 °C. According to the Indian Meteorological Department’s (1971–1996) atlas of wind roses, the winds flow from the southwest (SW) 32% of the time and from the northeast (NE) (23% of the time).

In the present study, AOD, AE and SSA were retrieved from the Ozone Monitoring Instrument (OMI) sensor and Modern Era-Retrospective Analysis for Research and Applications (MERRA-2) [37]. The values for the AOD and SSA utilized in this investigation were obtained from an ozone monitoring system for the Raipur region in Chhattisgarh using OMI/Aura Near UV Aerosol Optical Depth and Single Scattering Albedo L3 1 day 1.0 degree x 1.0 degree V3 (OMAERUVd) provided by Goddard Earth Sciences Data and Information Services Center (GES–DISC) through Earthdata, NASA. OMAERUVd (1 deg Lat/Lon grids) is a Level-3 daily global gridded product produced by the OMI science team. It is advised to utilize the 0.388 m SSA dataset due to the inherent errors in the predicted spectral dependency, which may not reflect all aerosol types/conditions globally. Because retrievals at 0.50 m in the OMAERUV dataset are not directly produced from observations but are transformed from 0.388 m retrievals assuming a spectral dependence model dependent on the chosen aerosol model, the OMI SSA at 0.388 m is used [25]. Angstrom exponent retrievals is done through MERRA-2 tavg1_2d_aer Nx: 2d,1-Hourly, Time-averaged, Single-Level, Assimilation, Aerosol Diagnostics V5.12.4 (M2T1NXAER). M2T1NXAER (or tavg1 2d aer Nx) is a Modern-Era Retrospective Analysis for Research and Applications version 2 hourly time-averaged 2-dimensional data collection (MERRA-2). Integrated aerosol properties such as column mass density of aerosol constituents (black carbon, dust, sea salt, sulfate, and organic carbon), surface mass concentration of aerosol components, and total extinction (and scattering) aerosol optical thickness (AOT) at 550 nm are all included in this collection. The MERRA-2 reanalysis is recommended as in AE retrievals. In general, globally MERRA-2 outperforms Copernicus Atmosphere Monitoring Service (CAMS), with an RMSE of 0.126 compared to 0.144 for CAMS [38-39].
2.2 Methodology for classifying the aerosols

Aerosol optical properties are commonly used to assess the interaction of particles with radiation. Aerosol optical depth (AOD) is the quantification of atmospheric aerosols from the top of aerosol to the earth’s surface and is defined as the extinction of solar radiation over a vertical column with a unit cross-section, it is one of the important optical properties to derive the concentration of aerosols. It can be monitored by ground-based along with satellite-based instrumentation. Angstrom exponent (AE) is commonly used to characterize the dependence of aerosol optical thickness or aerosol extinction coefficient on wavelength; it can be calculated using the angstrom power law. A higher (lower) value of AE indicates the dominance of finer (coarser) aerosols. Single Scattering Albedo (SSA) is the ratio of scattering and extinction coefficient and it is a very important parameter required for the assessment of radiative forcing. A higher (lower) value of SSA indicates the presence of scattering (absorbing) type of aerosol in the atmosphere. SSA is a crucial statistic for the influence on the climate as well as a significant variable to define the aerosol absorption of solar radiation, at a given value of the SSA, the aerosol impacts on the radiation budget at the top of the atmosphere (TOA) fluctuate.

In the present study, aerosol optical properties (AOD, AE, and SSA) were derived and analyzed for the first time to assess the inter-annual variability over the urban-industrial city of Raipur, India from 2019 to 2021, followed by the classification of aerosol types and identification of potential sources. Due to the strong dependency between AOD and AE on wavelength, characterization of aerosol can be performed to identify the aerosol types, in this study, the primary technique is based on the technique for linking aerosol load (i.e., AOD) with particle size (i.e., AE). As seen in Table 1, the AOD, AE and SSA, which are generated from MODIS, are used in conjunction with two approaches from Kaskaoutis et al. [12] and Giles et al. [13] to differentiate aerosol types. This approach has been used previously [10, 12, 21, 29], and all of these earlier works were grounded on Eck et al. [9]. It is challenging to distinguish the biomass burning events from the urban industrial aerosols; better correlation can be performed between AE and SSA [13]. As listed in Table 1, aerosols are classified into four distinct types: dust, urban, mixed and biomass burning. This study will be useful for examining the climatic impacts of particles, determining their likely source, and estimating the radiative forcing caused by aerosols in the current location.

3 Result and discussions

3.1 Overview of AOD, AE and SSA

The mean annual values of AOD and AE during 2019–2021 were 0.53 ± 0.2 and 1.20 ± 0.33 respectively, with highest AOD values during spring (0.98 ± 0.21) and lowest AOD values in winter (0.44 ± 0.15). Highest AE values were noted during winter (1.49 ± 0.15) with lowest AE values in spring (0.93 ± 0.23). This clearly indicates the presence of scattering aerosols in summer and absorbing aerosols in winter based on the AOD and AE values, fall and winter shows a drop in the frequency and severity of dust storms and wildfires, resulting in low AOD levels [29]. Additionally, SSA values were also investigated and found average value as 0.93 ± 0.07 with lower in winter and spring (0.92 ± 0.03) and higher during summer (0.95 ± 0.01). This occurs due to the presence of absorbing aerosols emitted at urban areas in winter and scattering aerosols in summer [41].

For the present study region, the average AOD (AE): 0.53 ± 0.2 (1.20 ± 0.33) was found to be comparable with Kaskaoutis et al. [12] 0.67 ± 0.13 (1.17 ± 0.12) over an urban industrial city of Raipur, India from 2019 to 2021, followed by the classification of aerosol types and identification of potential sources. Due to the strong dependency between AOD and AE on wavelength, characterization of aerosol can be performed to identify the aerosol types, in this study, the primary technique is based on the technique for linking aerosol load (i.e., AOD) with particle size (i.e., AE). As seen in Table 1, the AOD, AE and SSA, which are generated from MODIS, are used in conjunction with two approaches from Kaskaoutis et al. [12] and Giles et al. [13] to differentiate aerosol types. This approach has been used previously [10, 12, 21, 29], and all of these earlier works were grounded on Eck et al. [9]. It is challenging to distinguish the biomass burning events from the urban industrial aerosols; better correlation can be performed between AE and SSA [13]. As listed in Table 1, aerosols are classified into four distinct types: dust, urban, mixed and biomass burning. This study will be useful for examining the climatic impacts of particles, determining their likely source, and estimating the radiative forcing caused by aerosols in the current location.

| Table 1 Aerosol classification [29] |
|-----------------------------------|
| Type of aerosols                  | AOD value | AE value |
| Biomass burning & Urban-Industrial| 0.2 to 1.0 | 1.5 to 2.5 |
| Mixed                             | 0.2 to 1.0 | 0.5 to 1.5 |
| Dust                              | 0.2 to 1.0 | <0.5   |
| Clean Marine                      | <0.1      | <1.4   |
| Types of aerosols [13]            | SSA value | AE value |
| Biomass Burning                   | 1.5 to 2.5 | 0 to 0.92 |
| Urban                             | 0.92 to 1.0 | 1.5 to 2.5 |
| Mixed                             | 0 to 1.0  | 0.5 to 1.5 |
| Dust                              | 0 to 0.95 | <0.5   |

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Kanpur [41] indicating the dominance of coarser aerosol dust. Shaik et al. [18] have investigated the SSA, AOD and AE values in northern India and found comparable (SSA: 0.88, AE: 1.15 and AOD: 0.75 (Delhi)) with the present study region. Mukherjee and Vinoj [44] also found comparable results with the study area (AE: higher than unity and AOD: 0.39 to 0.96; higher (lower) in the month of February (July)) and lower AE value (dominance coarser aerosols) at Bhubaneswar. In India, a consistent increase (inconsistent trend) in the AOD was found from March to December (Pre-monsoon and summer monsoon) during the ARFI project of ISRO over Indian sub-continent [46]. Whereas, David et al. [46] did not find any strong seasonal variation over India and found about five times higher AOD over India as compared to United States. Yang et al. [29] have investigated the spatio-temporal distribution of aerosol optical properties over Australia and found the annual mean range of AOD (0.05 to 0.15), much lower than the present study region (0.52) which indicates better air quality. The annual average single scattering albedo (SSA), an indicator of aerosol absorption capacity and aerosol content, is somewhat higher in March and September, showing the presence of scattering aerosol in the spring and autumn seasons. In contrast, lower SSA values were found in December, indicating the existence of absorbing aerosols. The observed seasonal variation of SSA over the present region was found to be comparable with the studies conducted in Beijing, China [47]; Ahmedabad [28]; Kadappa [27]; YRD region, China [48]. Higher AOD was observed over the present region as compared to the Himalayan region and Australian locations. Whereas, observed values of SSA and AE were comparable with the South Asian industrial cities, indicating the dominance of the finer and absorbing aerosols during the winter season. The observed values of AOD, AE and SSA over the present study region have also been compared with other cities also and displayed in Table 2.

| S.N | City | Period | SSA | AE | AOD | Concluding Remark | Reference |
|-----|------|--------|-----|----|-----|------------------|----------|
| 1   | Goa  | 2008   | 0.87–0.97 | 0.52–1.53 | 0.26–0.70 | AOD -0.70 (April) | [26]     |
| 2   | Gadanki | 2008–2018 | 0.91–0.95 | 1.75 (March) 0.65 (May) | 0.38 | SSA lower in winter; higher AOD (0.46) in summer | [42]     |
| 3   | Kadapa | 2013–2015 | 0.83–0.92 | 1.30 | 0.75 | Lower SSA and AE (burning hotspot) and better correlation at Delhi (MODIS AOD & ground based) | [27]     |
| 4   | IGP (Patiala, Delhi, Dehradun and Kanpur) | 2003–2017 | 0.91 | 1.30 | 0.75 | AOD during monsoon (higher AOD and AE) | [18]     |
| 5   | Delhi | 2000–2014 | 0.69 | 0.71 | 0.65 | Lower MODIS AOD | [24]     |
| 6   | Gorakhpur | 2014–2018 | 0.92 | 1.05 (Dehradun) 1.49 (Chamoli) | 0.18 (Dehradun) 0.21 (Chamoli) | Higher AOD during post monsoon | [41]     |
| 7   | Chamoli and Dehradun | 2006–2015 | 0.92 | 0.19–1.44 | 0.75 | Higher (lower) AOD during February (July) | [43]     |
| 8   | Varanasi | 2011–2014 | 0.23–1.89 | 0.66 | 0.39 to 0.96 | Higher AOD during winter (July) | [44]     |
| 9   | Jodhpur | 2004–2012 | More than 1 | 0.71 | 0.12 (rural) 0.79 (urban) | Higher AOD & AE in urban region. | [18]     |
| 10  | Bhuvaneshwar | 2014–2015 | 1.12 | 0.71 (semi urban) 1.15 (urban) | 0.12 (rural) 0.79 (urban) | Industrial area | [20]     |
| 11  | China | 2001–2020 | 0.88–0.97 | 0.05 to 0.15 | 0.31–0.92 | Increasing trends was observed at most of the sites. | [29]     |
| 12  | Tangshan, China | 2014–2015 | 0.88–0.97 | 0.17–1.05 | 0.31–0.92 | Mean AOD – 0.48 | [19]     |
| 13  | Australia | 2001–2020 | 0.93 | 1.20 | 0.53 | Highest AOD (AE) values in summer (winter) | Present study | [19]     |
3.2 Monthly, seasonal and inter-annual variation of AOD, AE and SSA

The monthly and seasonal average variation of AOD, AE and SSA throughout the study period (2019–2021) has been investigated and presented in Fig. 2(a) and Fig. 2(b) respectively. In the present study, AOD variation was observed from 0.44 to 0.67. Seasonally, a higher (lower) AOD (AE) value was observed during the summer as compared to the winter, indicating the dominance of the coarser dust aerosols. This is also revealed through the seasonal trend of AE value, lower (higher) in summer (winter) indicates the presence of coarser aerosols [45]. David et al. [46] have found a higher AOD value in summer and the major contributor was inorganic aerosols and dust over the Indian region. Mukherjee and Vinoj [44] have found higher AOD during summer (0.82) and lower (0.44) in monsoon months in Bhubaneswar, India, during the year 2016. Another study at Gorakhpur found a higher AOD (0.73) during summer as compared to monsoon [24]; at Goa (AOD- 0.70), during the month of April [26]; also at Pune, a lower AOD (0.31) was found during winter. However, at Delhi higher AOD was observed during winter and lower in pre-monsoon [23], this may be due to the monitoring techniques and variation in the columnar aerosol loading. Some studies have also been carried out to investigate the variation of AOD with altitude [40, 49] and found a sharp decrease (less variation) in the SSA value with altitude over Varanasi (Jodhpur and Bhubaneswar).

Fig. 2 Variation of optical properties (a) monthly and (b) seasonal from 2019–2021
The SSA values were also investigated and found lesser variation, with lower in winter (0.92 ± 0.03) and higher in summer (0.95 ± 0.01), indicating the presence of absorbing types of aerosols in winter and scattering aerosols mainly in summer. He et al. [47] have found higher SSA (0.80) in summer in Beijing, China during the year 2005–2006; at Ahmedabad, lower SSA (0.83) was observed in winter [28]; at Kadappa, lower OPAC derived SSA (0.83) during winter [27]. Xia et al. [48] have also found a higher (lower) SSA during summer (winter) in YRD region, China from the year 2005–2006.

The increasing trend in the AOD with a higher value in the year 2021 (0.60) is observed as in comparison to the previous years 2019 and 2020 (0.48). Figure 2 shows the monthly variation of AOD, AE and SSA during the study period. The spatial distribution of monthly and multi-year averaged AODs for the years 2019–2021 reveals that the patterns of AOD spatial distributions in 2019 and 2020 were comparable. In 2021, the magnitude of the geographical distribution of AOD fluctuated somewhat which may be related to the higher contribution from dust aerosols during this period. Whereas, a higher AE value was found in the year 2020, mainly in the month of June, indicating the finer aerosols, may be due to the pronounced anthropogenic activities during the Covid-19 unlock down phase. Lesser variations were observed in the SSA, mainly depending on the type and nature (scattering or absorbing) of aerosol [34].

### 3.3 Aerosol types classifications based on AE, AOD and SSA

The optical properties of aerosols such as; AOD, AE and SSA value can be used for gathering information about the particle size and to classify the aerosol type along-with possible sources by providing their nature (scattering and absorbing) [9, 12, 13].

Figure 3 depicts the three-season AOD vs. AE vs. SSA scatter plots, based on the values defined in the previous studies [29]. For the present study region, based on the aerosol optical properties (AOD vs. AE), three different aerosols types were identified during the study period mainly, mixed aerosols (60%), biomass-urban (37%), and dust aerosols (3%). Whereas, based on (AE vs. SSA), mixed aerosols (71%) urban-industrial (UI) (21%) and biomass burning (BB) aerosols (8%) were identified.

These findings revealed that throughout the winter season, study region was dominated by mixed aerosols (49%), which originated from a variety of sources, including vehicular and dust, followed by urban- industrial aerosols (30%) may be due to anthropogenic activities and shallower planetary boundary layer (about 545.0 m) and biomass burning (18%). Bibi et al. [30] have identified the dominant aerosol type as biomass and urban during autumn-winter at Kanpur. In another study conducted in Bengaluru, it was determined that mixed forms of aerosol predominate across all four seasons. Comparable to research conducted in New Delhi, mixed and dust aerosols predominated in the present investigation during pre-monsoon [31].

### 4 Conclusion

Optical parameters of aerosols (Aerosol optical depth (AOD), Angstrom exponent (AE), and Single scattering albedo (SSA)) were derived and examined in order to categorize the aerosols and identify likely sources over the urban-industrial metropolis of Raipur, India, over the years 2019 to 2021. The annual mean values of AOD, SSA and AE during the study period were 0.53 ± 0.20, 0.93 ± 0.07 and 1.20 ± 0.33 respectively. The spring season had the highest AOD readings (0.98 ± 0.21) while winter season had the lowest (0.44 ± 0.15). Higher AE value is found during winter (1.49 ± 0.15) and lower during spring (0.93 ± 0.23). Based on the AOD and AE values, this clearly shows the existence of scattering aerosols in the summer and absorbing aerosols in the winter. This indicates the dominance of finer aerosols with absorbing nature during winter. The SSA values were also examined, and it was discovered that there was less variance, with winter values being lower (0.92 ± 0.03) and summer values being higher (0.95 ± 0.01). This suggests the presence of absorbing types of aerosols in winter and scattering aerosols mostly in summer. Based on the aerosol optical characteristics (AOD and AE), during the study period, three distinct aerosol types were identified; mixed aerosols (60%), biomass-urban (37%), and dust aerosols (3%) and for (AE and SSA), mixed aerosols (71%), urban-industrial aerosols (21%), and biomass burning aerosols (8%) were identified. In all seasons, dominance of the mixed type of aerosols (biomass burning, urban-industrial and dust aerosols) is found. The above results will be helpful for the estimation of regional aerosols induced radiative forcing, future research on climate change, cloud precipitation pattern, microphysical features of clouds, and regional changes over agricultural activities.
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Data availability

The data is available at https://doi.org/10.6084/m9.figshare.21443229.

Declarations

Conflict of interest

The authors have no conflict of interest to declare.

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