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Intra-Seasonal and Annual Variation of Aerosol Chemical Species Retrieved From MERRA-2 Model over a Semi-Arid Region

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Abstract

The present paper investigates the intra-seasonal and annual variations of different aerosol species retrieved from Modern-Era Retrospective analysis for Research and Applications, (MERRA-2) model over a semi-arid region,Anantapur, in southern peninsular India during 2013 to 2018. The intra-seasonal mean total aerosol optical depth was found to be highest in monsoon (0.35 ± 0.06), and summer (0.30± 0.04) during the study period.The SO_4 aerosol optical depth was found to be 0.17± 0.02, 0.16 ± 0.02, 0.11 ± 0.01, 0.13 ± 0.02 during winter, summer, monsoon and post-monsoon, respectively. According to the findings, SO4 aerosol optical contributed the most to the total aerosol optical depths in both the summer and winter, indicating that anthropogenic aerosols predominated at that time.

Keywords: Total aerosol optical depths, anthropogenic aerosols, MERRA-2, semi-arid region.

1. Introduction

Atmospheric aerosols are a mixture of liquid and solid particles suspended in air. These aerosols originate from diverse sources, including both natural and human activities (Alam et al., 2014; Beegum et al., 2009). They comprise various constituents such as dust particles formed through wind erosions of surface soils, sea salt particles, volcanic ash, aerosols emitted during forest fires, and particles generated by waves breaking over oceans. Aerosol particles also originate from various anthropogenic activities, such as transport, power plants, industry, domestic heating, agriculture, and cement production. Aerosols notably impact the Earth-atmosphere energy balance through various atmospheric mechanisms(Hansen et al., 2000; Ramanathan et al., 2001). One of these phenomena is the direct aerosol effect, where aerosols disperse and absorb solar and terrestrial radiation (Sinha et al., 2012).Seasonal variations in the long-range movement of dust particles from west Asia and northwest India, as well as geographically diverse human emission sources, make it difficult to analyze aerosols across South Asia (Bibi et al., 2015; Babu et al., 2013). The semi-arid climate zone of Anantapur in southern peninsular India is a hotspot for several aerosol sources because to its downwind conditions, dry continental environment, and lack of rainfall. Therefore, in this present study we analyzed intra-seasonal and annual variations of different aerosol species from 2013-2018 over Anantapur.

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2 Instrumentation and site description

2.1 MERRA-2

Since 1980, Modern-Era Retrospective analysis for Research and Applications (MERRA-2 has been a NASA reanalysis product. Multi-decade meteorological and aerosol observations were integrated into the global climate data system to generate the data for MERRA-2. Spurious trends and numerical jumps linked to modifications in the meteorological observation system have been reduced by the concurrent assimilation and integration of multiple sets of satellite data and data from the ground-based Aerosol Robotic Network. With a resolution of 50 × 50 km and 0.625 × 0.5, the MERRA-2 data set comprises 361 latitude grid points and 576 longitudinal grid points.There are many uses for its analytical aerosol field (Bocquet et al., 2015). Regional models, air-quality forecasts, and instruments for studying aerosol-weather-climate interactions can all be built from these fields. The total AOD and monthly AOD values for dust, sea salt aerosol, sulfate, black carbon, and organic carbon were retrieved from 2013–2018 with a geographical grid of 77–78 °N and 14–15 °E.

2.2 Site description

The location falls within the Indian state of Andhra Pradesh's continental semi-arid Rayalaseema area (Fig. 1).

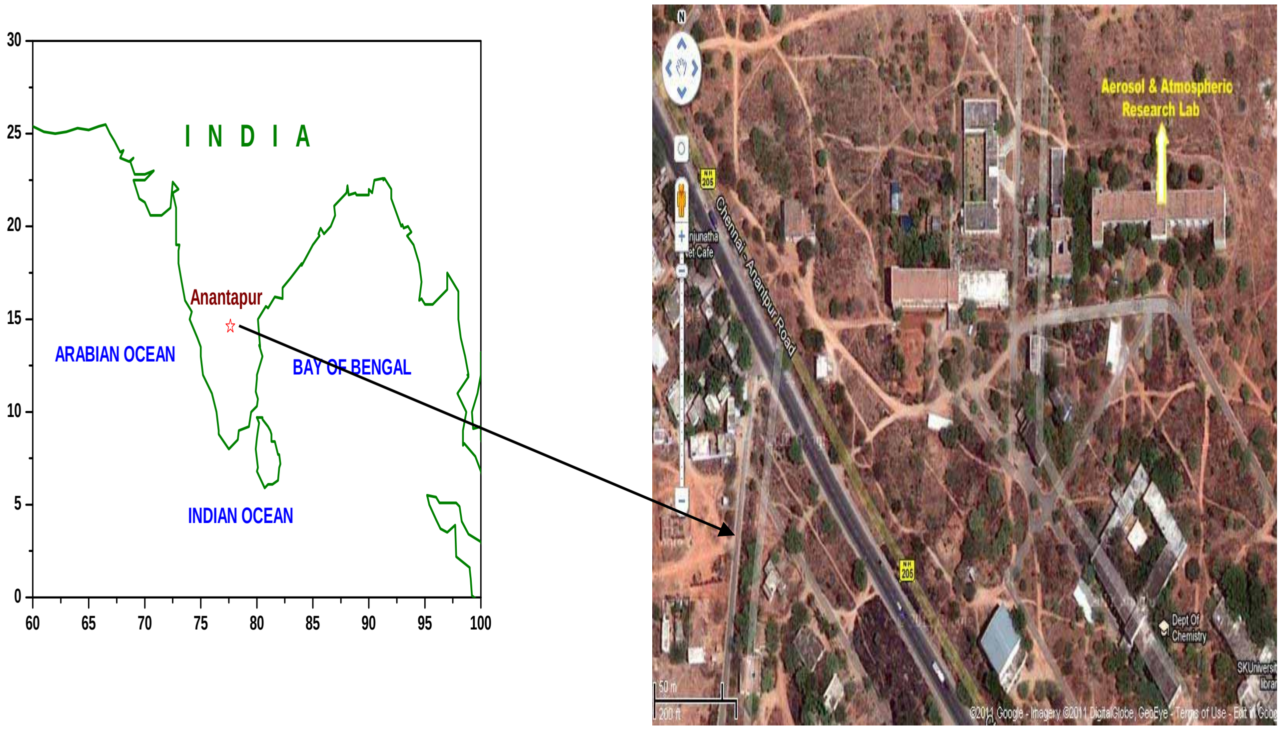

Fig.1. Location map

Within a 50-kilometer radius of this measurement site, there are numerous cement plants, limekilns, brick slab polishing businesses, and stone crusher machinery. Every day, large volumes of particulate matter are released into the atmosphere by these sectors. Due to its remote location from both the east and west coastlines, the study area does not fully benefit from the monsoon season. The yearly average rainfall is roughly 500 mm, while the state average in Andhra Pradesh is roughly 900 mm.

3. Results and discussion

3.1 Temporal variations of MERRA-2 estimated various aerosol species

Figure 2 shows intra-seasonal averaged temporal variation of different aerosol species retrieved from MERRA-2 model over the study region from 2013 to 2018. The intra-seasonalmean totalAOD varied from 0.22-0.42 during winter; 0.27-0.32 during summer; 0.27-0.44 during monsoon; 0.22-0.31during post-monsoon for the entire study period (Fig. 2a).

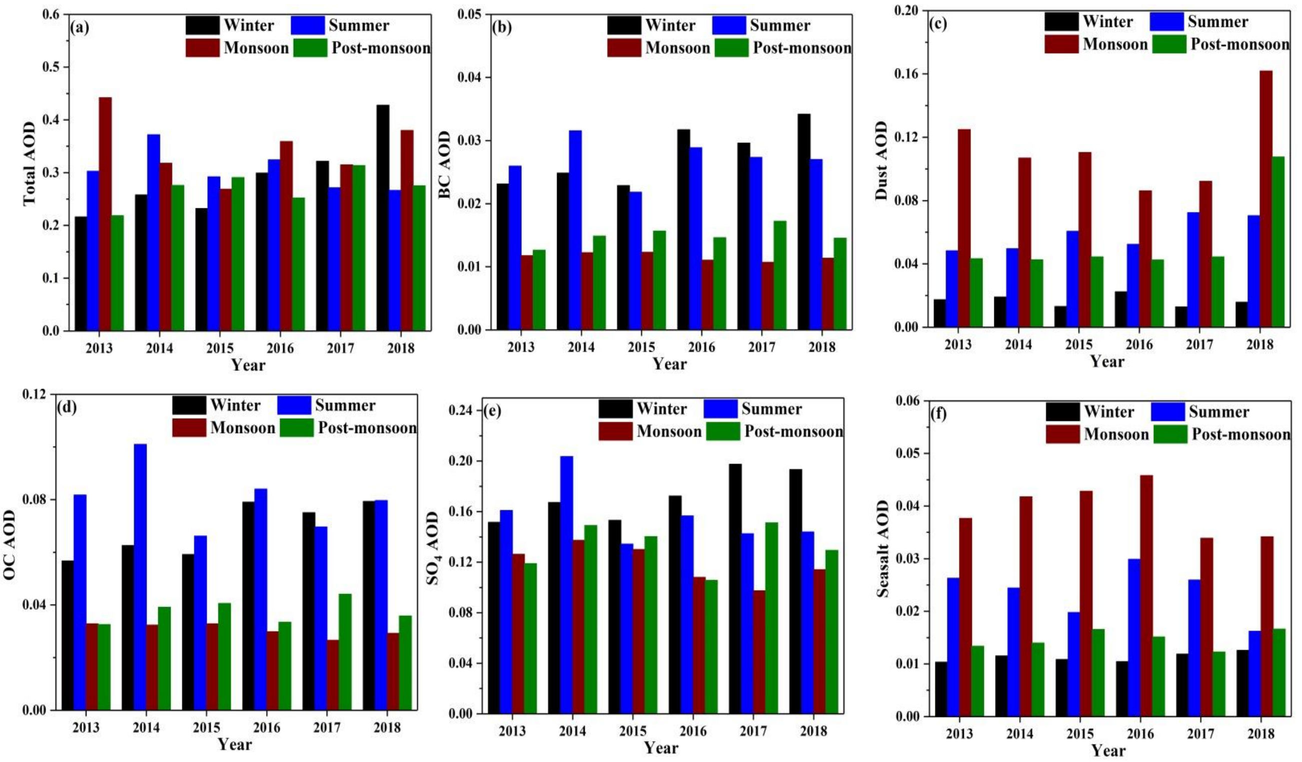

Fig.2. Intra-seasonal variation of different species aerosol optical depth retrieved

The highest total AOD value (0.44) was noticed in 2013 monsoon, while the lowest (0.21) was observed in 2013 winter. The highest SO4AOD was noticed in 2017winter and lowest was noticed in 2017 monsoon (Fig. 2d). The results revealed that the AOD showed an increasing trend from winter to attain its highest seasonal during summer and monsoon season and then finally decrease in post-monsoon. In contrast, the post-monsoon season has the lowest AOD values which can be attributed to less dust particles due to low wind speed and interns reduced the AOD. Dust is a major contributor to the total AODs as compared to other types of aerosols during the monsoon.The highest column dust concentration during monsoon is attributed to the transport of dust aerosols from the Middle-East through the Arabian Sea in favor of southwesterly winds. Furthermore, due to favorable conditions, different agriculture activities, construction, and demolition roads & building, etc., are carried out in

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summer season which also contribute to dust elevation in this season, also drier conditions in summer increase dust surface mass concentration by making the soil and other surfaces more prone to erosion and making it easier for dust particles to become suspended in the air. Additionally, dry conditions can cause vegetation to die off or become less robust, which can leave the soil more exposed and susceptible to erosion. When soil is exposed, it can be more easily carried away by the wind, resulting in more dust in the air.

3.2 Intra-seasonal and annual variations of MERRA-2 aerosol optical depths

The intra-seasonal mean AOD showed in highest during monsoon (0.35 ± 0.06), followed by summer (0.30± 0.04), winter (0.29 ± 0.08), and lowest in the post-monsoon (0.27 ± 0.03).

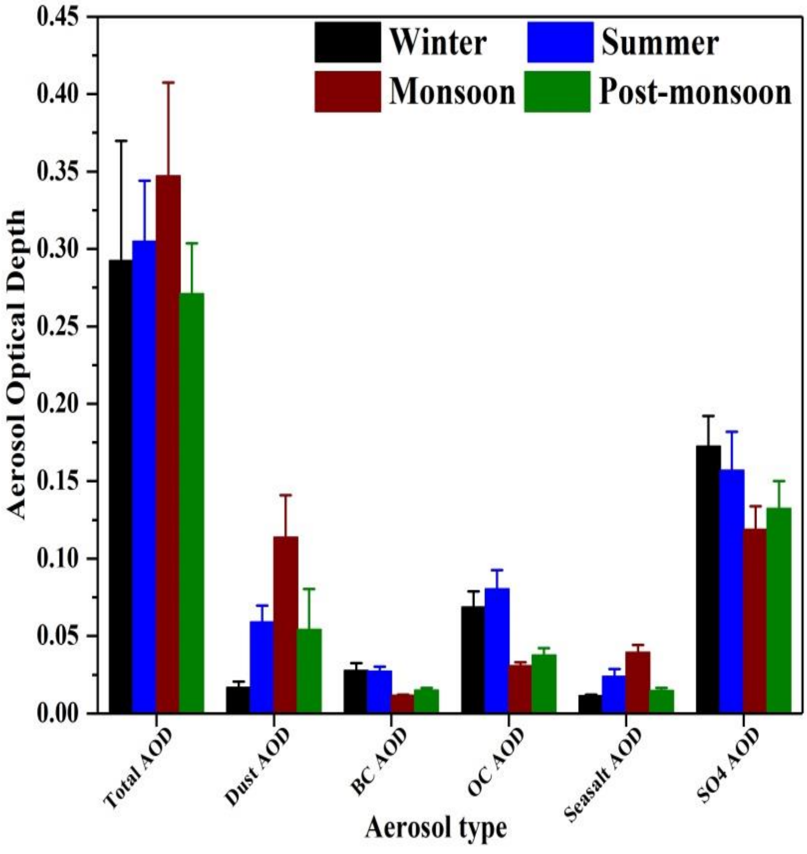

Fig.3.Seasonal variation of different species aerosol optical depth retrieved from MERRA-2 model during 2013-2018

In addition, due to favorable condition in summer season, the regional dust activities also contribute in increasing the AOD.The seasonal pattern as AOD was detected for SO_4AOD having maximum seasonal higher during winter (0.17 ± 0.02), followed by summer (0.16 ± 0.02), post-monsoon (0.13 ± 0.01), and lowest in the monsoon (0.12± 0.01) season (Fig.3).

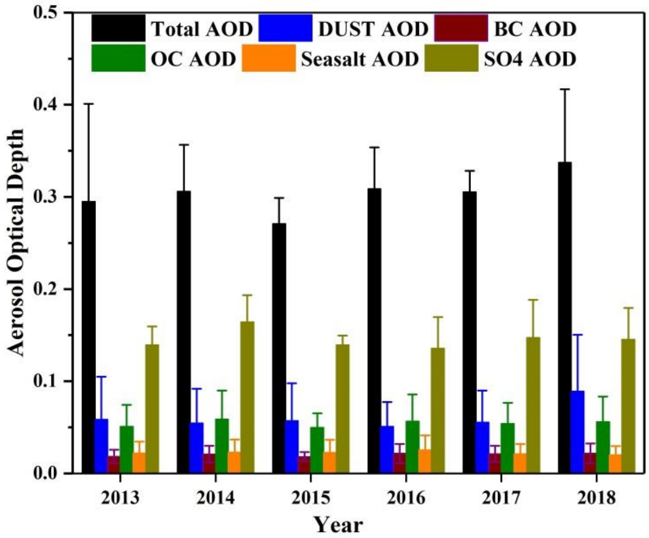

Fig.4. Annual variation of different species aerosol optical depth retrieved from MERRA-2

The intra-annually averaged different AOD species retrieved from MERRA-2 model is shown in Fig.4.The intra-annually averaged total AOD, DUST AOD, BC AOD, OC AOD, SO4 AOD and seasalt AOD was about 0.30± 0.05, 0.06± 0.04, 0.02± 0.008, 0.05± 0.02, 0.14± 0.02, 0.02± 0.01 during the study period. The SO4 AOD was the dominant species and contributes major portion of the total AODs over the study period. Higher AOD values in summer are due to less precipitation and higher temperatures, which can lead to drier conditions causing more dust to be suspended in the air. Additionally, there are more human activities such as construction and agriculture, in contrast, during the winter; there is generally more precipitation and lower temperatures, which harder for dust and other aerosols to become airborne.Furthermore, many outdoor activities such as agriculture and construction are decreased during the winter. The higher BC mass concentration in winter months is attributed to the lower temperature which results in shallowing of the surface boundary layer hence pollutants are trapped in a lesser volume. Moreover, the greater usage of wood and coal for indoor cooking and heating purposes in winter season results in elevation of BC concentration. In addition, crop residues are burned in the open field after harvesting, from which the pollutants get trapped due to hazy and foggy conditions in winter and hence results in increasing the BC AOD. In contrast, the lower concentration of BC AOD in monsoon was owing to the uplifting of planetary boundary layer height, which aided in the dispersing of BC particles. Furthermore, anthropogenic BC emissions from fossil fuels are quite lower in monsoon season due to lesser combustion processes. Moreover, the lowest concentration of BC in monsoon is also attributed to scavenging caused by wet removal processes triggered by the intense precipitation during this season.

4.0 Conclusions

The paper analyzes the intra-seasonal and annual variations of different aerosol species aerosol optical depths retrieved from MERRA-2 model over a semi-arid region in southern peninsular India. The total aerosol optical depth showed distinct seasonal variation with highest in summer and monsoon months and lowest in the winter and Post-monsoon months. The SO4 aerosol optical depths showed highest during winter months in all the years indicates that aerosols released from anthropogenic activities.

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