AERONET STATION IN DIBRUGARH, NORTHEAST INDIA AND AEROSOL VARIATIONS

DR. SHUKLA ACHARJEE
ASSISTANT PROFESSOR
NASA AERONET- PI
DIBRUGARH UNIVERSITY
ASSAM, INDIA

Presentation - Thursday 3rd Feb, 2023
Hanoi, Vietnam

The story of AERONET STATION, Dibrugarh

INTRODUCTION

•From 2018, the NASA AERONET station is operational on the campus of Dibrugarh University (latitude 27.451N, longitude 94.897E; Fig. 1) which is located in the upper Brahmaputra basin of north-east India surrounded by Arunachal hills, dense forest, and oil/gas producing wells.

•In this region, biomass burning, oil refineries, tea industries, brick kilns, forest fires, and other anthropogenic emissions are the major sources of air pollution.

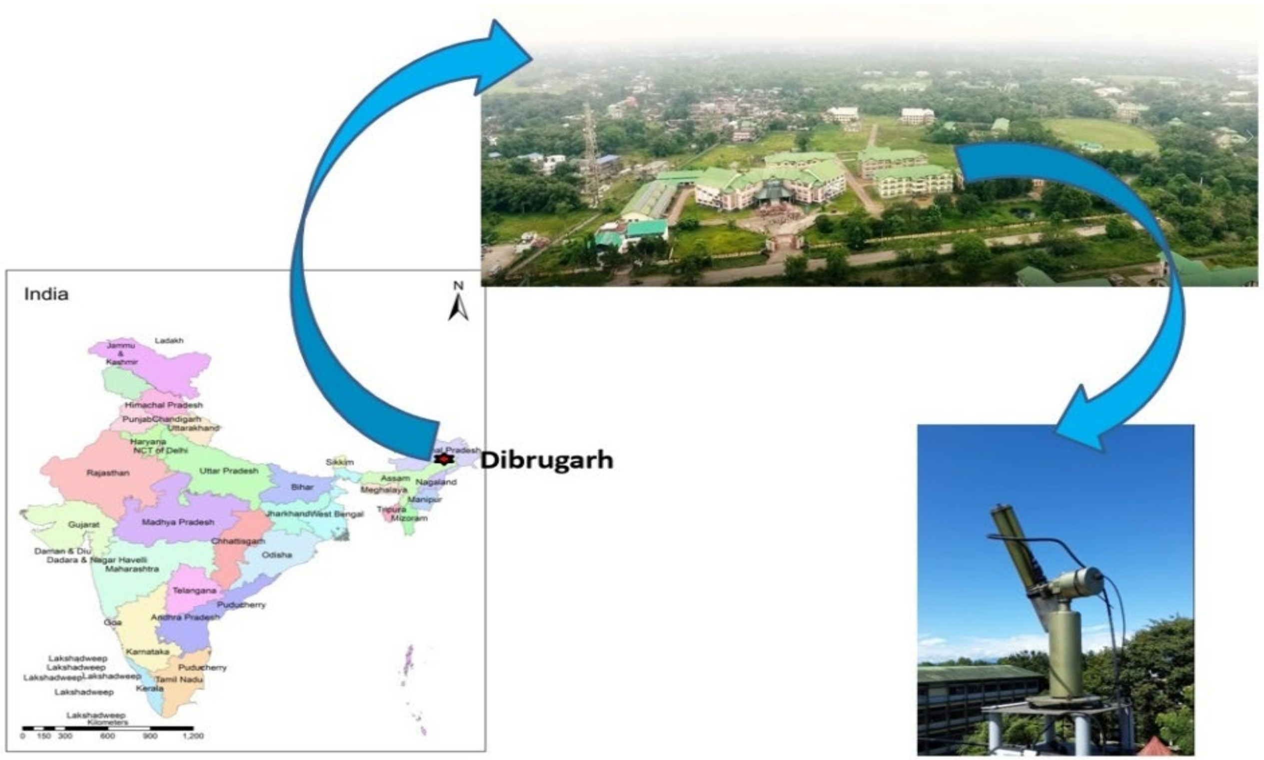


Fig. 1. AERONET is deployed on the campus of Dibrugarh University

DATA

AERONET data

The data is observed in near-real-time and processed by the NASA team and available at the AERONET web portal (https://aeronet.gsfc.nasa.gov/). Currently, we have used the Version 3 dataset with an improved algorithm.

Meteorological Data:

We have considered meteorological data (air temperature, station level pressure, relative humidity, wind velocity, and wind direction) through the Reliable Prognosis (https://rp5.ru/Weather_in_the_world) for the periods 2018 and 2021.

Satellite Data:

For the current analysis, we have also used the Aqua MODIS AOD data at the wavelength of 550 nm. The daily data is averaged over the Dibrugarh with a spatial resolution of 1km×1km.The daily AOD datasets are acquired using Google Earth Engine (https://code.earthengine.google.com/) and the data is provided by Land Processes Distributed Active Archive Center (LPDAAC) geoportal (a component of NASA's Earth Observing System Data and Information System (EOSDIS)) (https://lpdaac.usgs.gov/products/mcd19a2v006/).

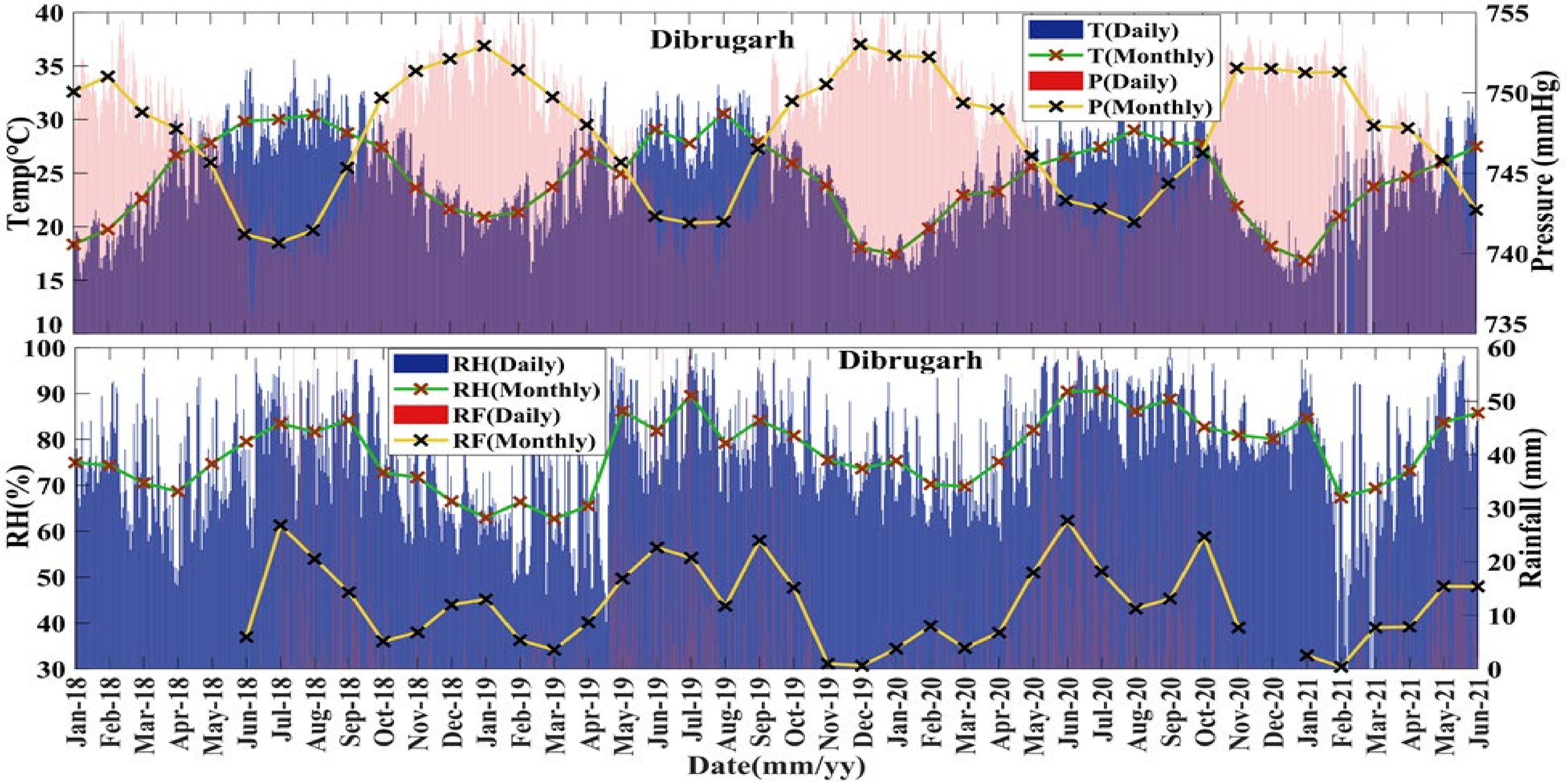


Fig. S1. Temporal variability (daily and monthly) of Air Temperature (°C), Station level pressure (mm Hg), relative humidity (%), and rainfall (mm) at Dibrugarh.

Dibrugarh has a humid subtropical climate with high humidity (99.67%) in July, the highest rainfall (123 mm) is in June during the pre-monsoon season, and low humidity (35%, dry)observed during the winter months(DJF)

•The maximum and minimum temperature increases during the monsoon and temperature decreases during the post-monsoon season, with a daily minimum equal to the pre-monsoon season and a maximum of 26°C.

•The relative humidity level is normally 60%, during monsoon season, and reaches up to 80% and above with winter signifying a subtropical humid environment.

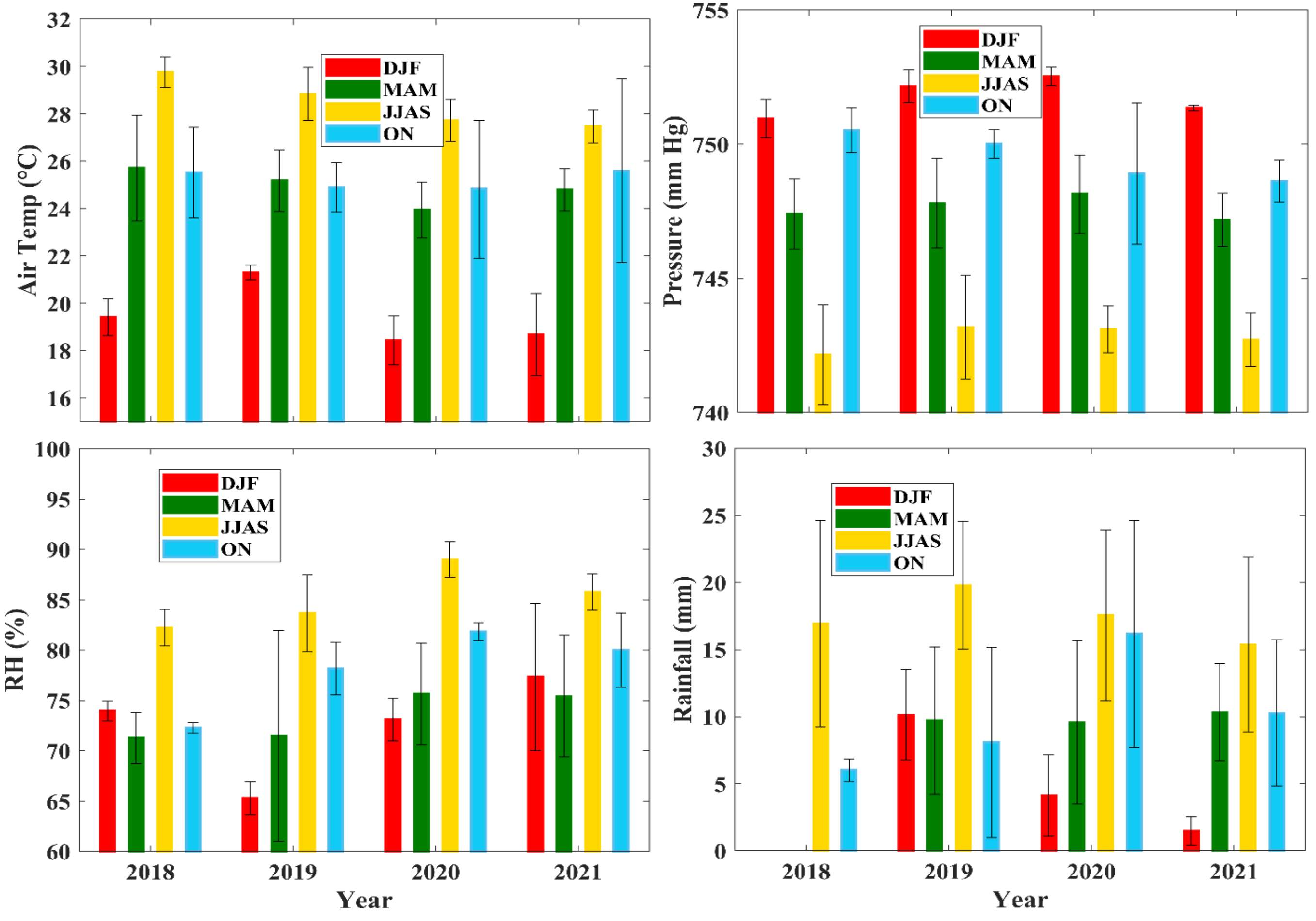
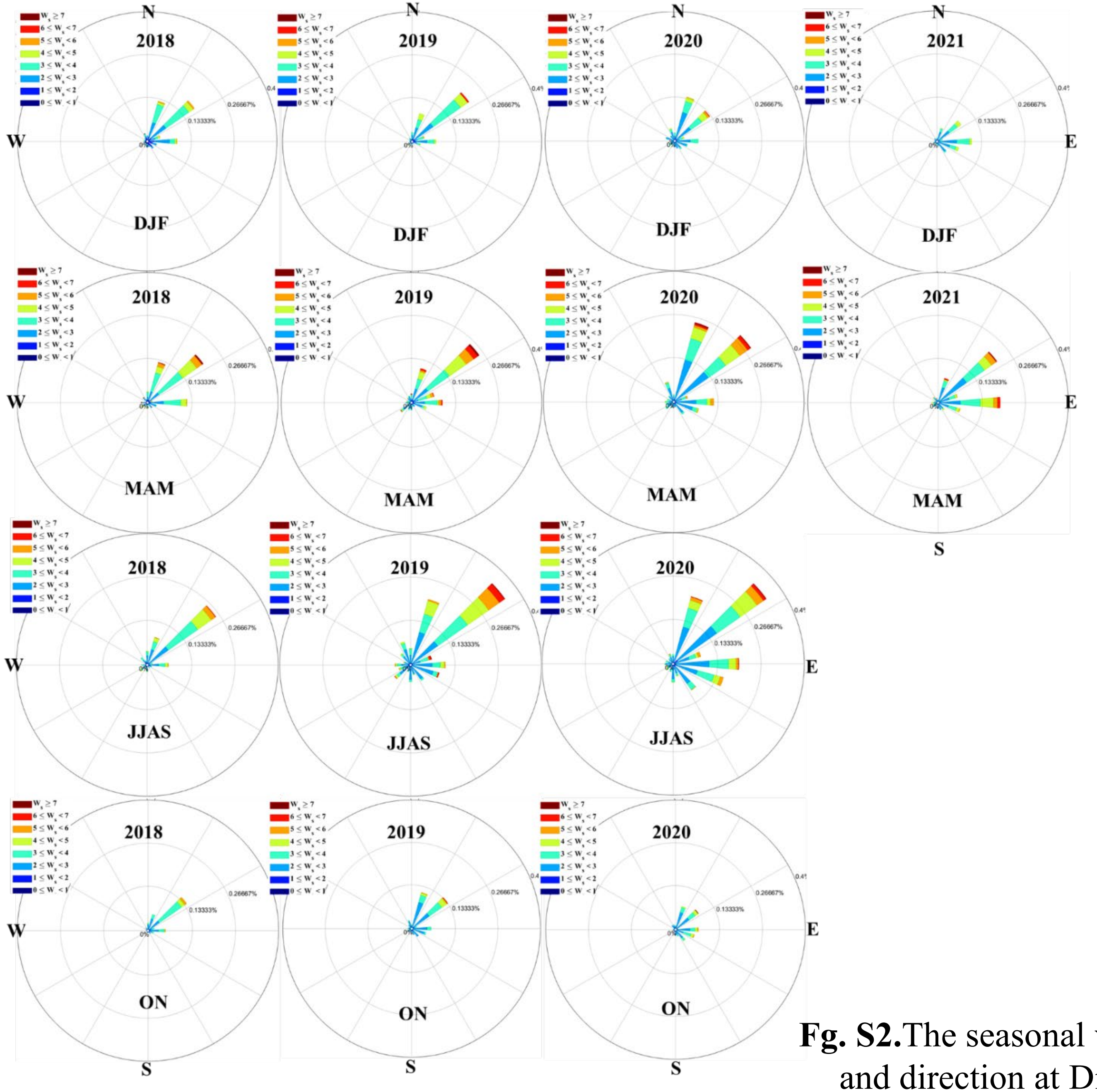


Fig. 2. The seasonal means of Air Temperature, Air Pressure, Relative Humidity, and Rainfall at Dibrugarh Station.

•Wind plays an important role in local climatology and helps in the transportation of air pollutants. During the winter season (DJF), the winds are mostly north to easterly with some fraction of southerly and westerly winds (**Fig. S2**).

•The Indo-Gangetic Plains (IGP) is one of the highly polluted areas, and the outflow from the IGP seriously affects the aerosol properties measured at the Dibrugarh location depending upon the meteorological conditions, wind speed, and wind direction.



Fg. S2. The seasonal wind speed and direction at Dibrugarh

•Fig.3(a) shows the properties of the aerosols in the wavelength range 340-1600 nm with strong seasonal and inter-annual variability from January 2018 to April 2021.

•A maximum AOD peak (>1) is observed from mid-January to mid-March and the second maxima peak is from September to November 2018

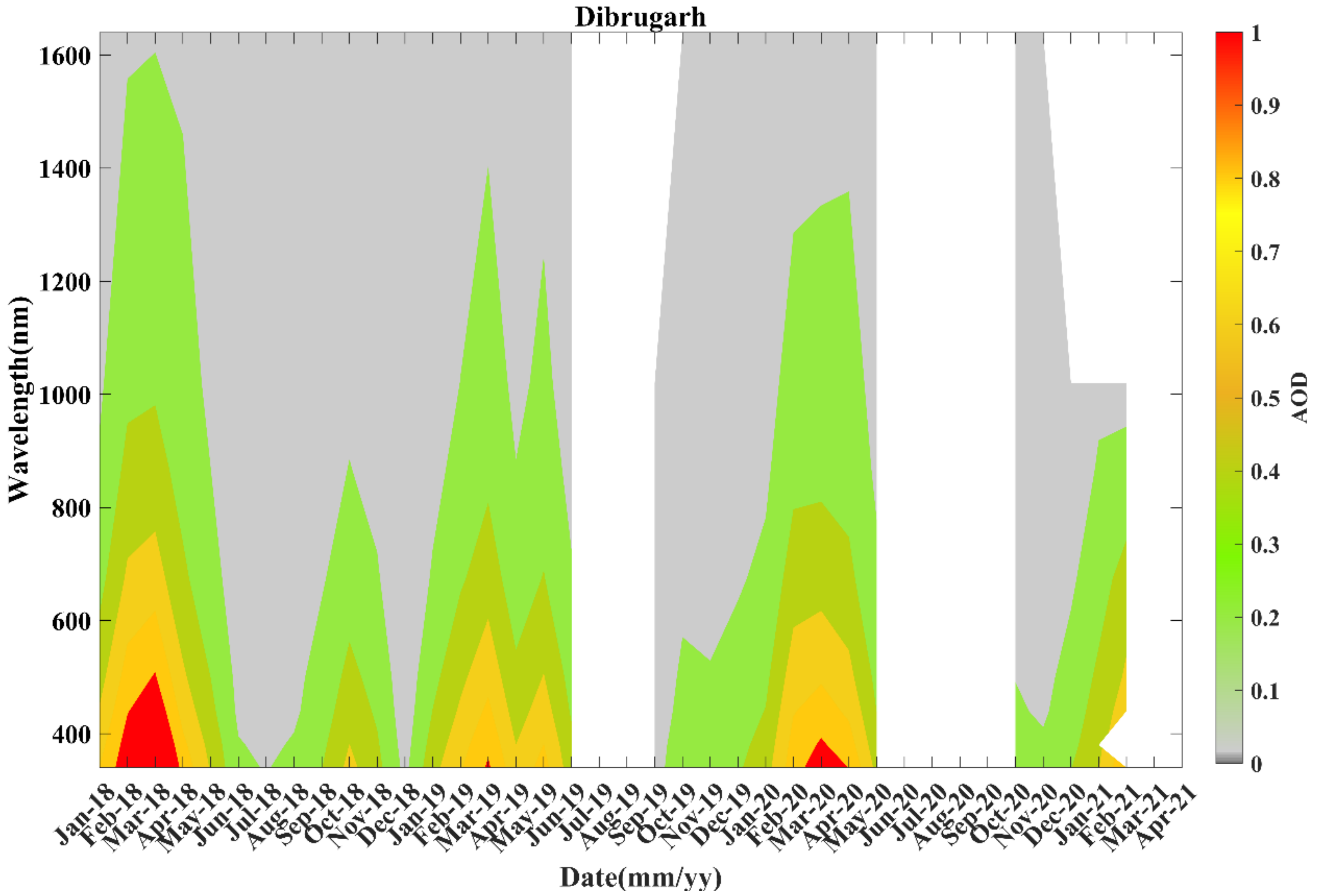


Fig. 3a. Wavelength dependency of the Aerosols optical depth at Dibrugarh station.

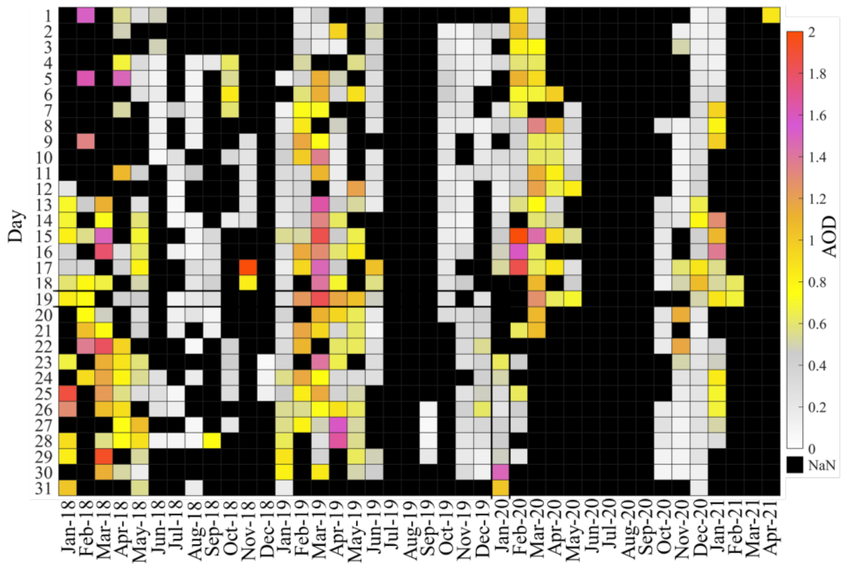


Fig. 3b. The daily mean AOD (00 nm) from January 2018 to April 2021.

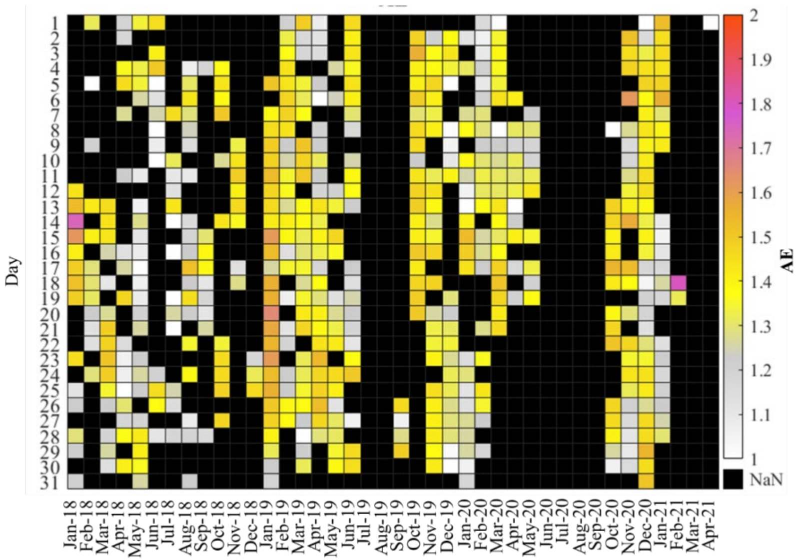


Fig. 3c. The daily mean Angstrom Exponent (AE) from January 2018 to April 2021.

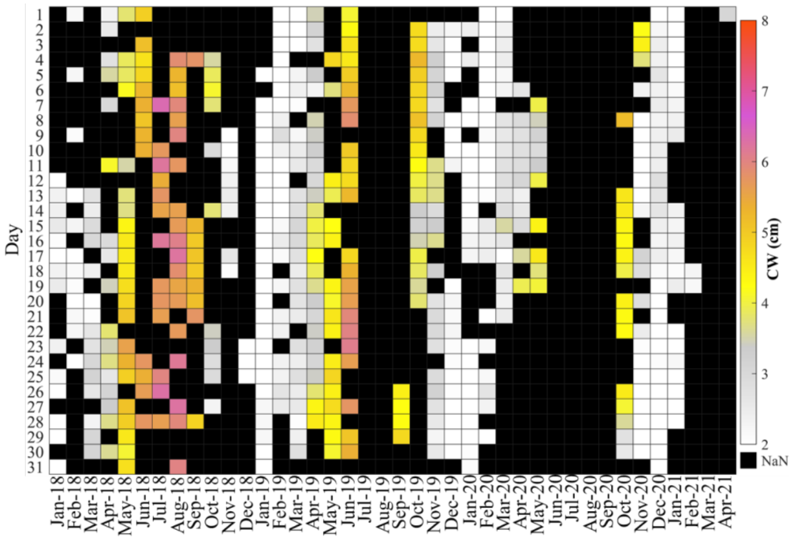


Fig. 3d. The daily mean column water (cm) from January 2018 to April 2021.

- The daily mean AOD (500nm), column water (CW), and Ångström Exponent (AE; 440-870nm) are shown in Figs. 3(b),3(c), and 3(d).The daily mean AOD values during winter and pre-monsoon seasons are mostly higher.

- During February and March, the daily mean AOD values are sometimes 2 times the monthly mean AOD values.

For the source characterization, we plotted the AE against AOD (Fig. 3(e)) and categorized the sources into six categories.

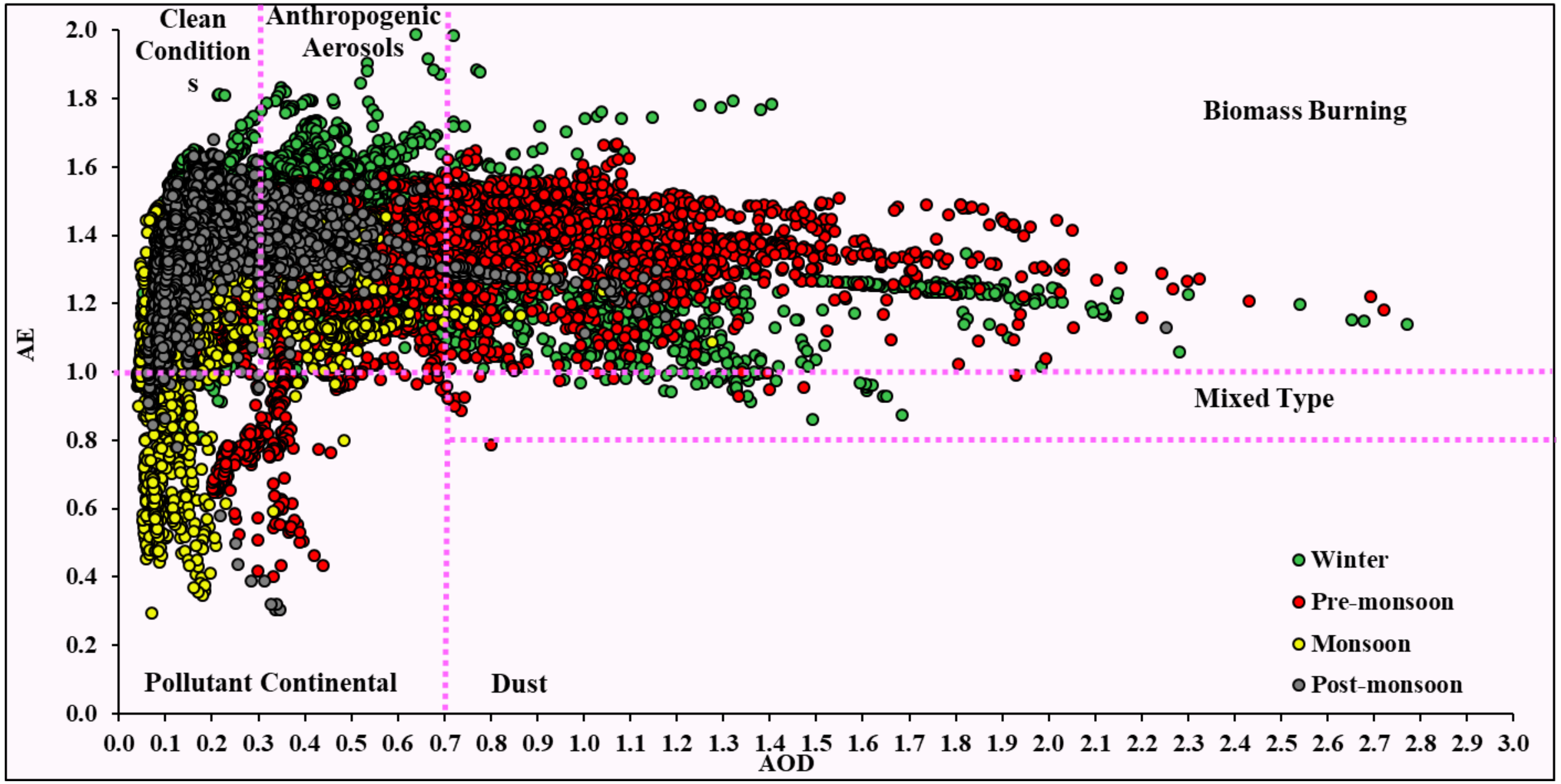


Fig. 3e. Angstrom Exponent variation with AOD during different seasons. Characterization of Aerosols shows the effect of anthropogenic activities at Dibrugarh.

•During the winter season (December to February), the influence of anthropogenic aerosols is observed to be highest (62.38%), followed by clean conditions (28.82%) and biomass-burning aerosols (4.17%).

•The share of pollutant continental (3.64%) and mixed aerosols (3.81%) is quite low.

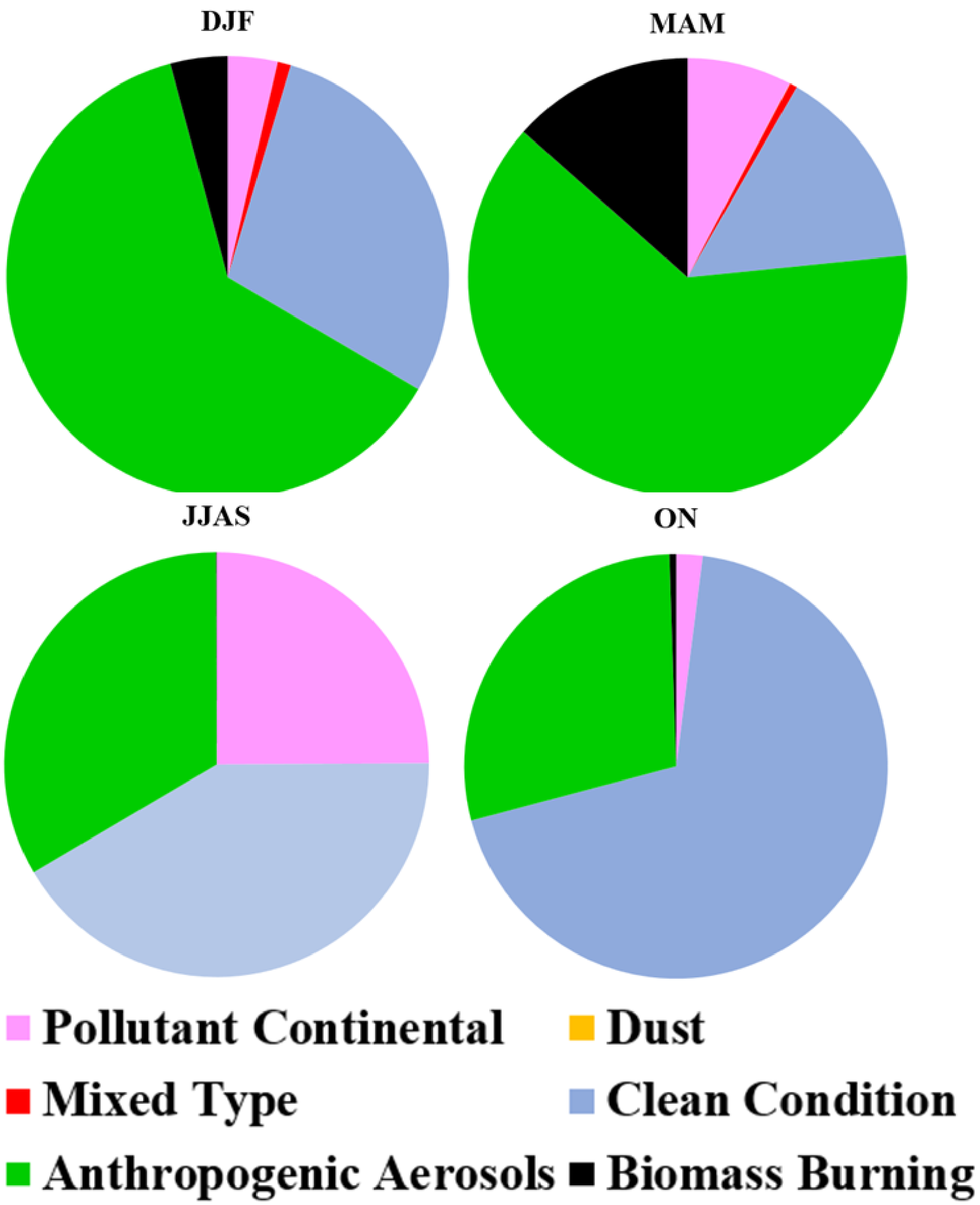


Fig. 4. Percentage variation of different types of aerosols in different seasons.

•We have analyzed airmass trajectory both in the forward and backward direction.

•The long-range transport of airmass from the western parts of India has also been observed during this season.

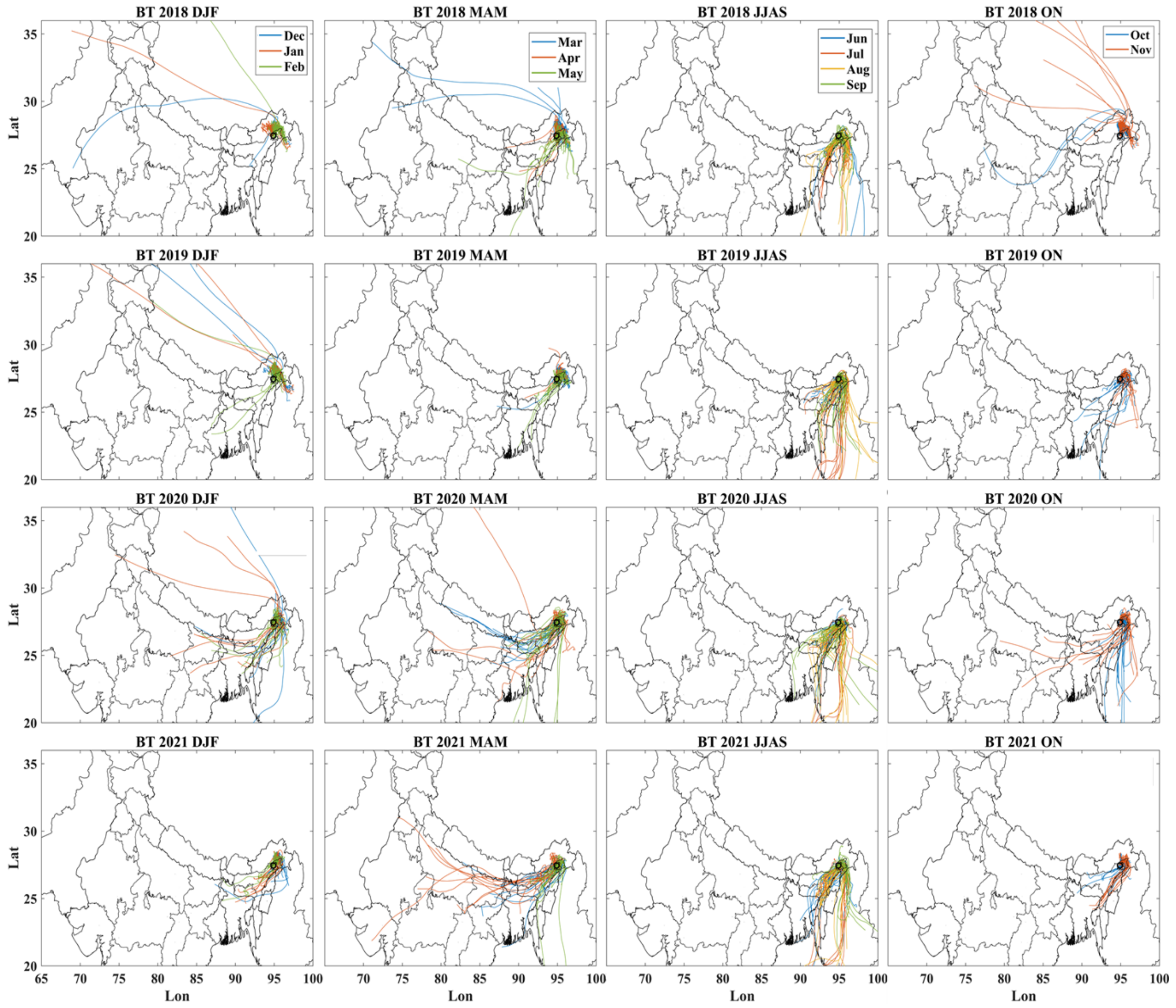


Fig. 5. The 100 hours backward trajectory for (i) DJF, (ii) MAM, (iii) JJAS and (iv) ON during 2018 to 2021. The long-range transport of airmass to Dibrugarh can be seen clearly. The trajectory clearly show the different sources of airmass in different seasons.

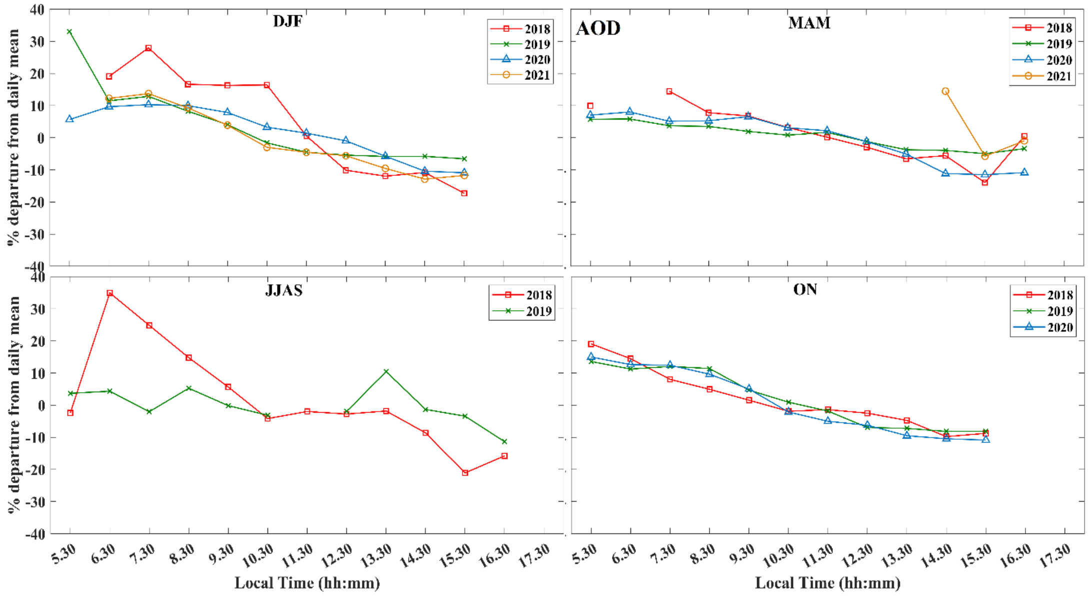


Fig. 6a. Diurnal Variations AOD for different seasons - DJF, MAM, JJAS, and ON during 2018-2021.

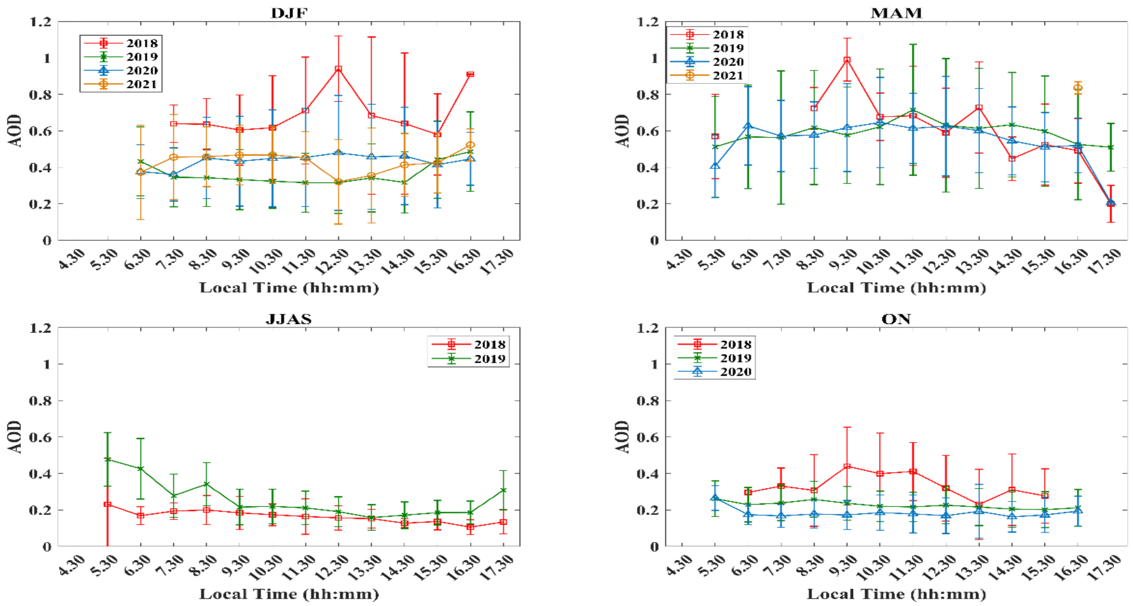


Fig. S3a. Diurnal Variations AOD (hourly average) for different seasons - DJF, MAM, JJAS, and ON during 2018-2021.

- The maximum variations in AOD values are seen during the morning and evening hours whereas variations in the afternoon are comparably lower.

- The hourly average values are higher in the noontime during winter, pre-monsoon, and post-monsoon seasons .

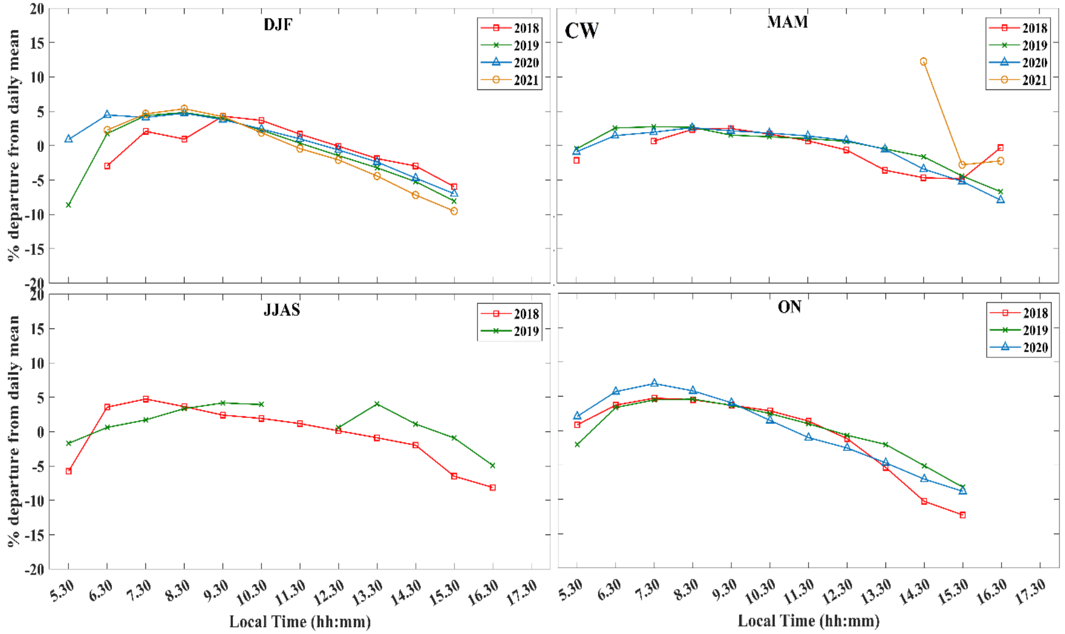


Fig. 6b. Diurnal Variations column water (CW) for different seasons - DJF, MAM, JJAS, and ON during 2018 - 2021.

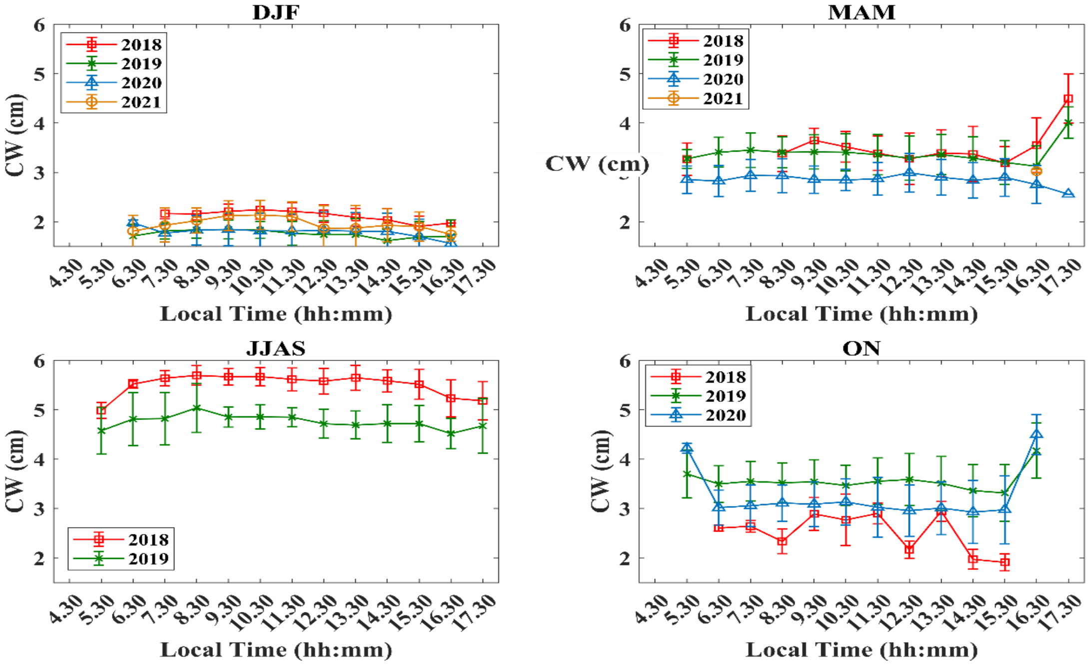


Fig. S3b. Diurnal Variations CW(hourly average) for different seasons - DJF, MAM, JJAS, and ON during 2018-2021.

- Fig.6(b) shows diurnal variations of CW. A negative departure is observed in the early morning hours. Between 07:30 to 08:30 hours, a positive peak is observed in all seasons.

- Based on the hourly average values, the CW values are observed to be highest during monsoon season (JJAS) followed by post-monsoon months (ON) and pre-monsoon months (MAM) (Fig. S3(b)).

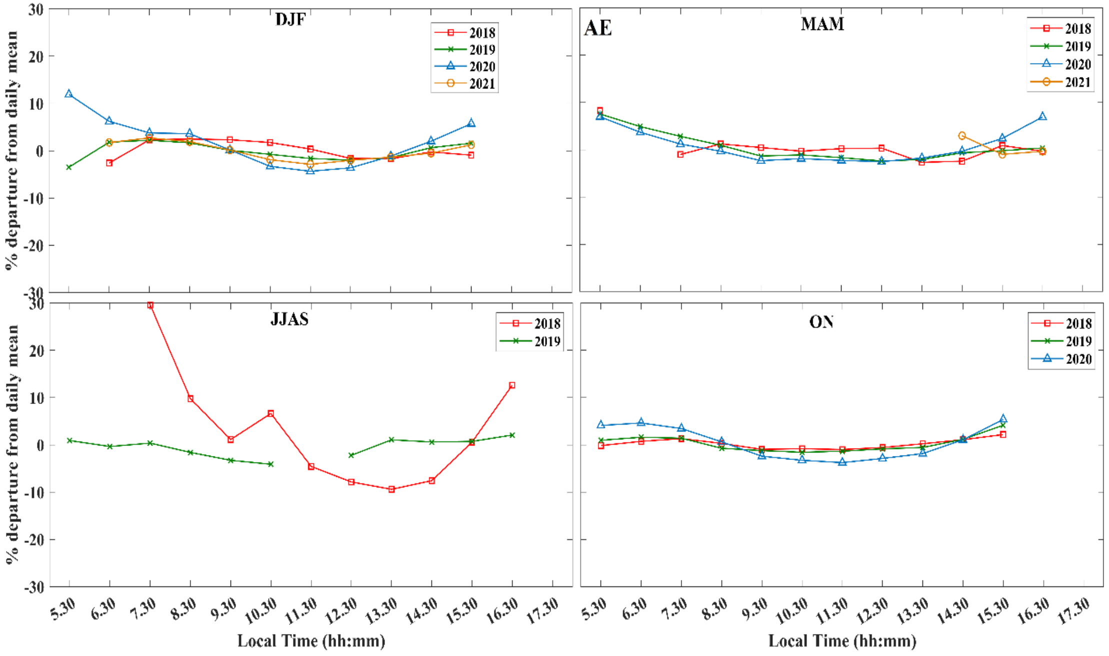


Fig. 6c. Diurnal Variations AE for different seasons - DJF, MAM, JJAS, and ON during 2018-2021.

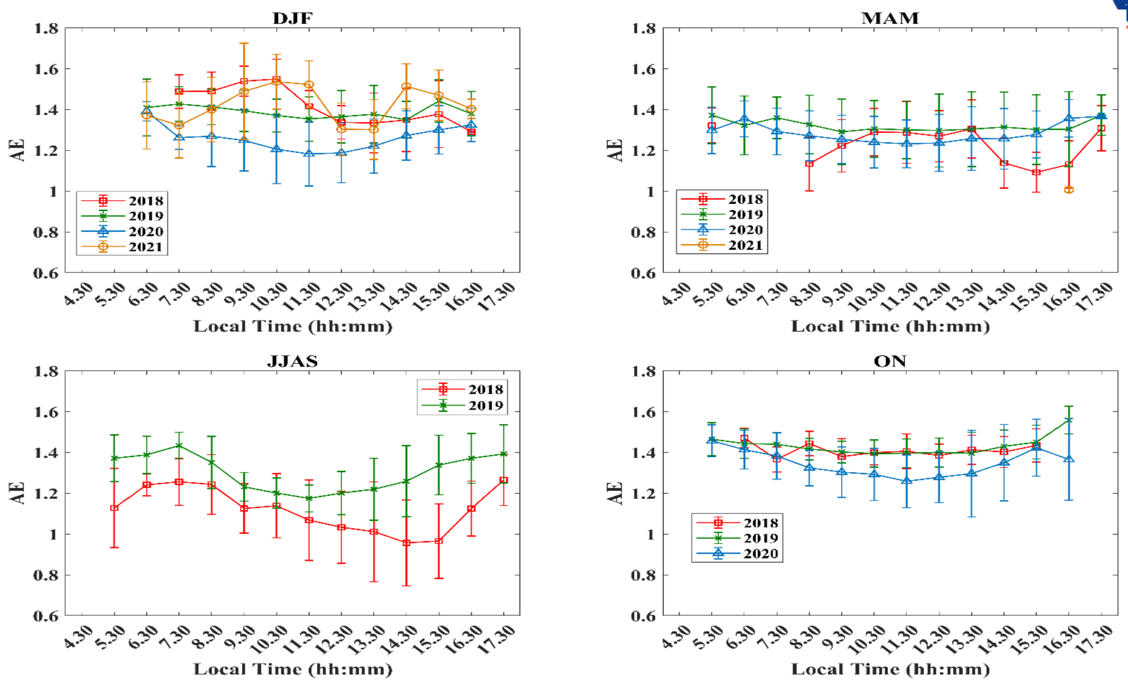


Fig. S3c. Diurnal Variations AE(hourly average) for different seasons - DJF, MAM, JJAS, and ON during 2018-2021.

- The maximum variations in AE values are also seen during morning and evening hours and lower variations are observed between 09:30 to 13:30 hours.
- During pre-monsoon, monsoon, and post-monsoon seasons, AE values show a positive shift in early morning hours whereas, during the winter season, the variation is mostly low or negative (Fig. 6(c), Fig. S3(c)).

•During JJAS, scattered patterns show the rise in the coarse particle as the number of scattered points show FMF < 0.5, whereas the AOD values are mostly less than 0.5which shows the impact of the polluted continental and clean conditions.

•The fine aerosol concentration is higher during the ON as Fine Mode Fraction (FMF) and AOD values are mostly higher than 0.5. These changes in the FMF and AOD values also strengthen the analysis of aerosols based on AOD and AE values and provide a better estimate of the sources and types of aerosols.

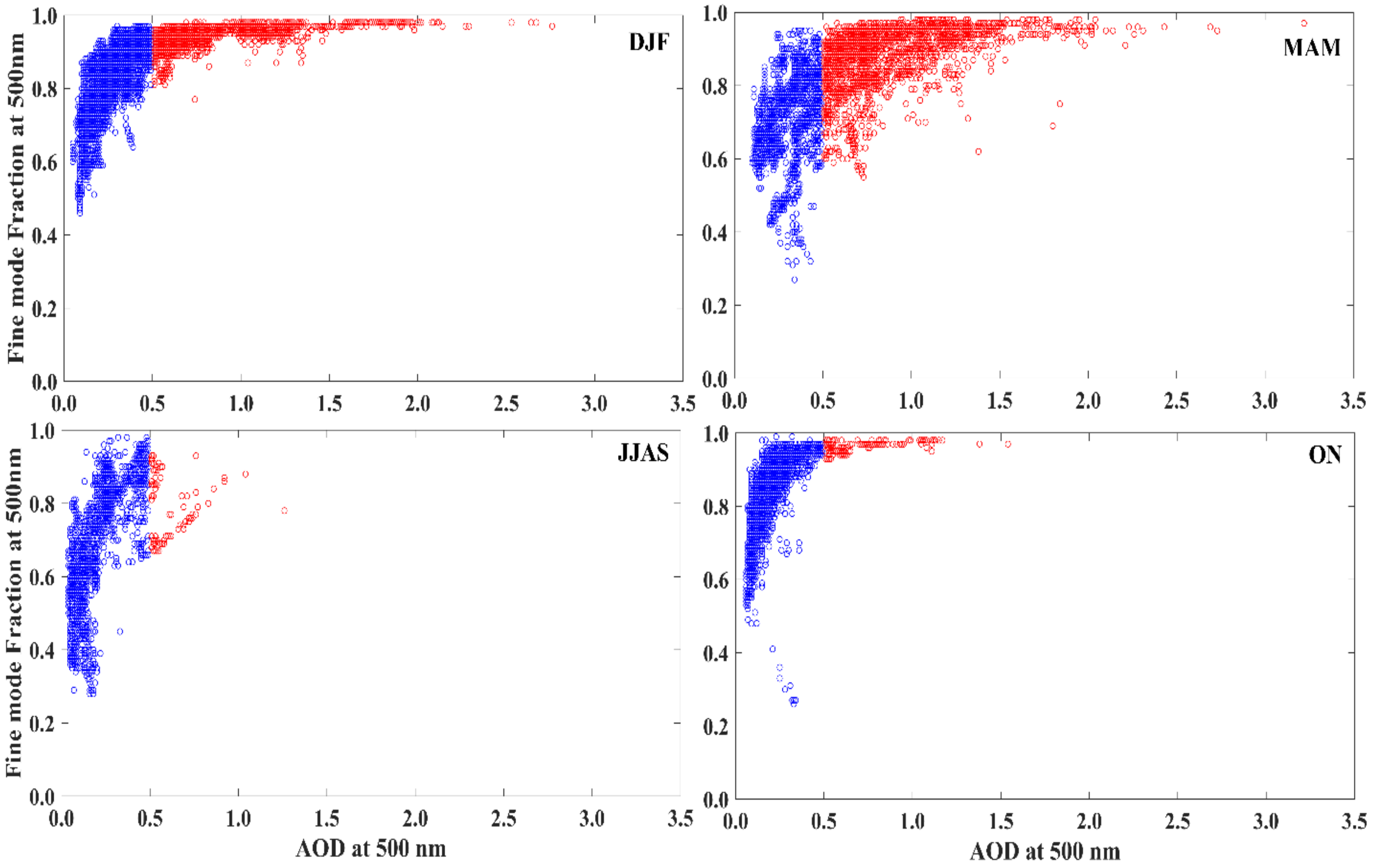


Fig. 7. Variation of Fine mode fraction (500nm) with AOD (500nm) during various seasons.

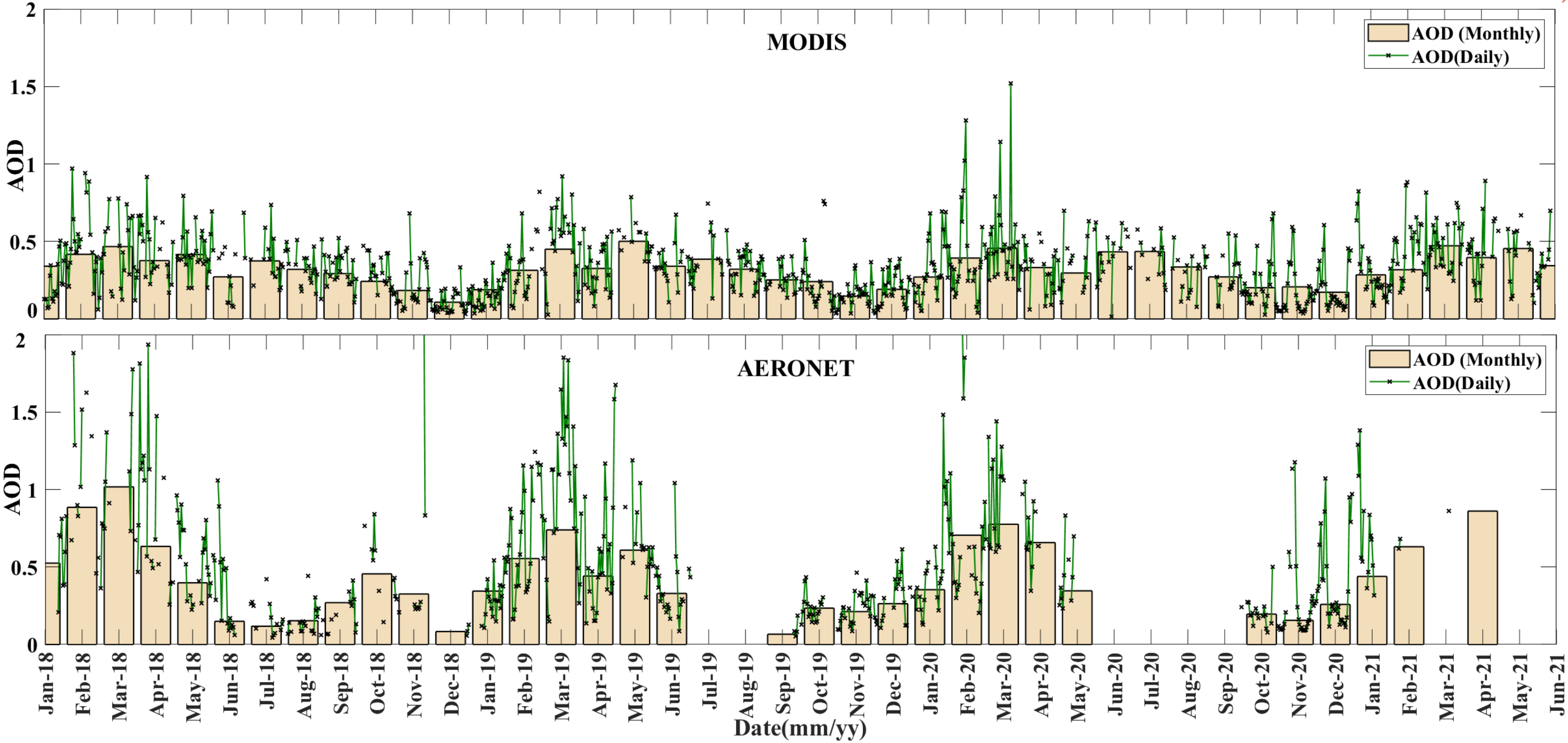


Fig. S4. The daily mean and monthly mean variation of AOD. The upper figure shows the temporal variation of AOD by MODIS satellite (MODIS/006/MCD19A2 product with 1km×1km resolution and averaged over Dibrugarh District) and the lower figure shows the temporal variation of Dibrugarh AERONET station data.

•The correlation in MODIS-derived daily mean AOD and AERONET AOD is shown in Fig.8.

•MODIS and AERONET data show an R^2 of 0.684 whereas AOD values are higher using AERONET with respect to MODIS (Fig.8).

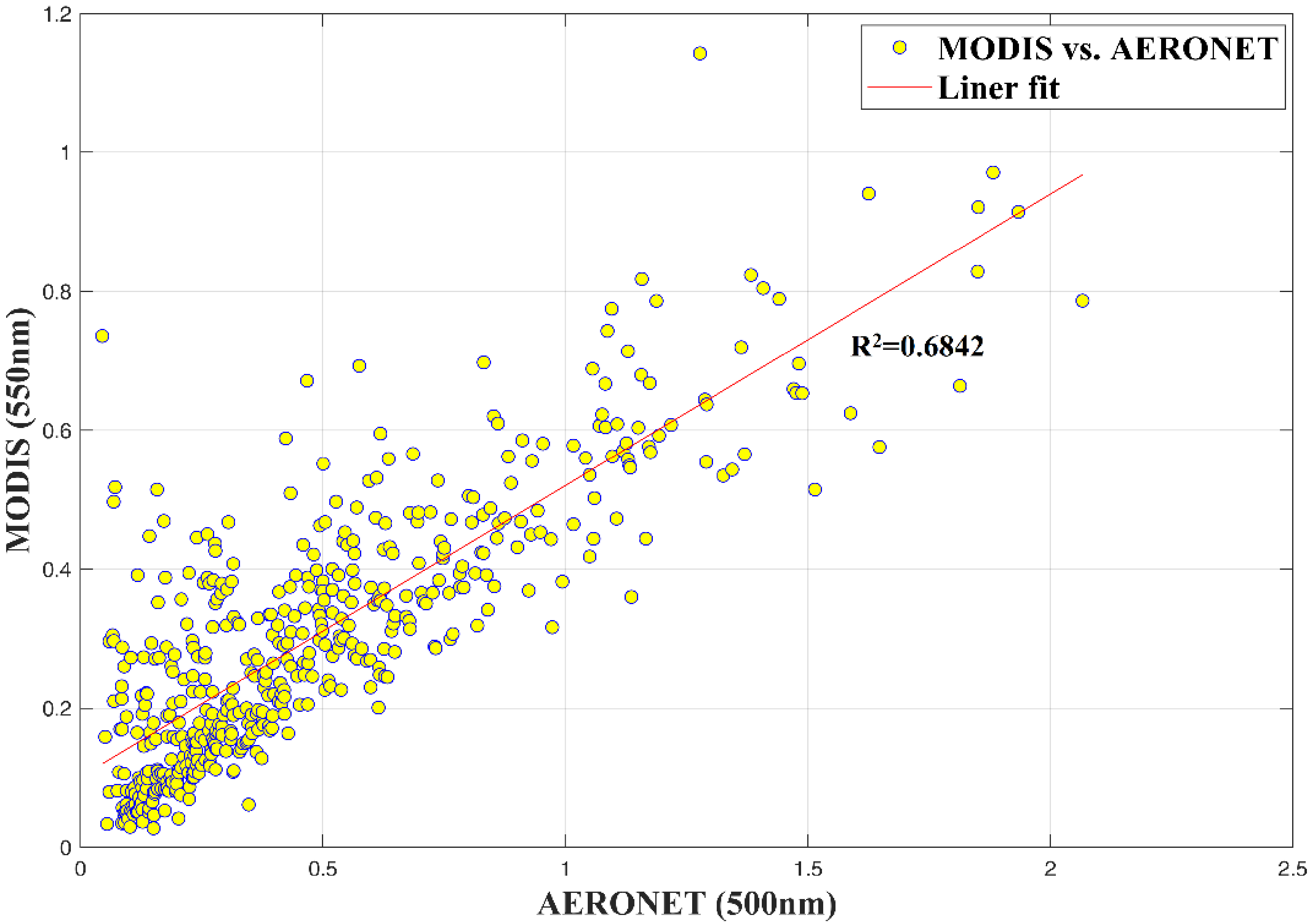


Fig. 8. The polynomial fit of AERONET AOD (500nm) and MODIS AOD (550nm) from Jan 2018 to June 2021.

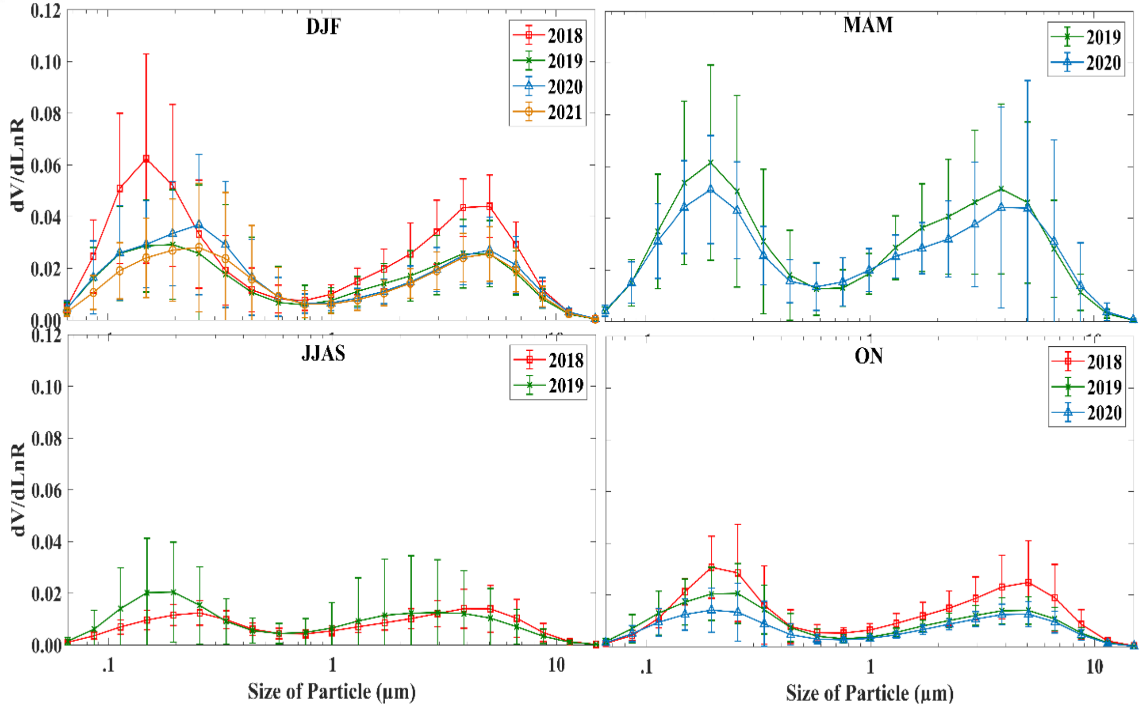


Fig. 9a. Seasonal mean variation of volume size distribution of aerosols from 2018 to 2021.

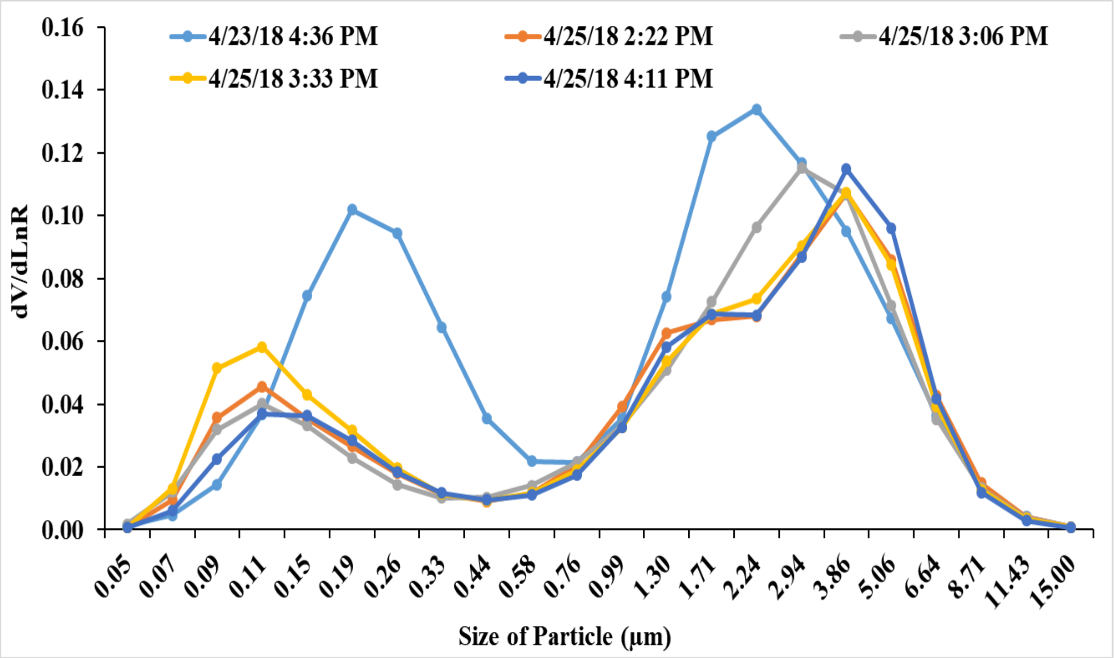


Fig. S5a. The volume size distribution of aerosols on 23 and 25 April 2018.

•The volume size distribution of aerosols at the Dibrugarh station shows bi-model distribution with strong seasonal variations **(Fig. 9(a)).** The maximum volume of aerosols in fine and coarse modes is observed in the radius range of0.11–0.33µm and 2.90–6.64µm respectively.

•During MAM 2019 and 2020, the volume of fine particles is higher compared to coarse particles just like the winter season. During the MAM 2018, we observe a high volume of coarse mode particles **(Fig. S5(a)).**

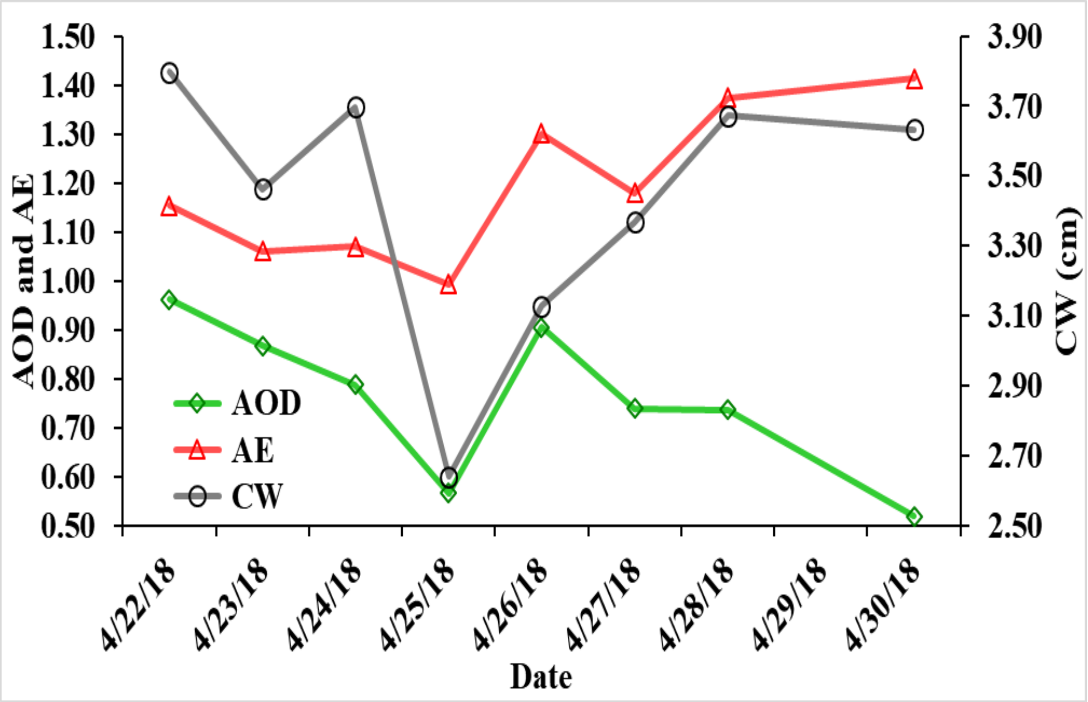


Fig. S5b. The temporal variation of AOD, AE, and CW during 22 – 30 April 2018

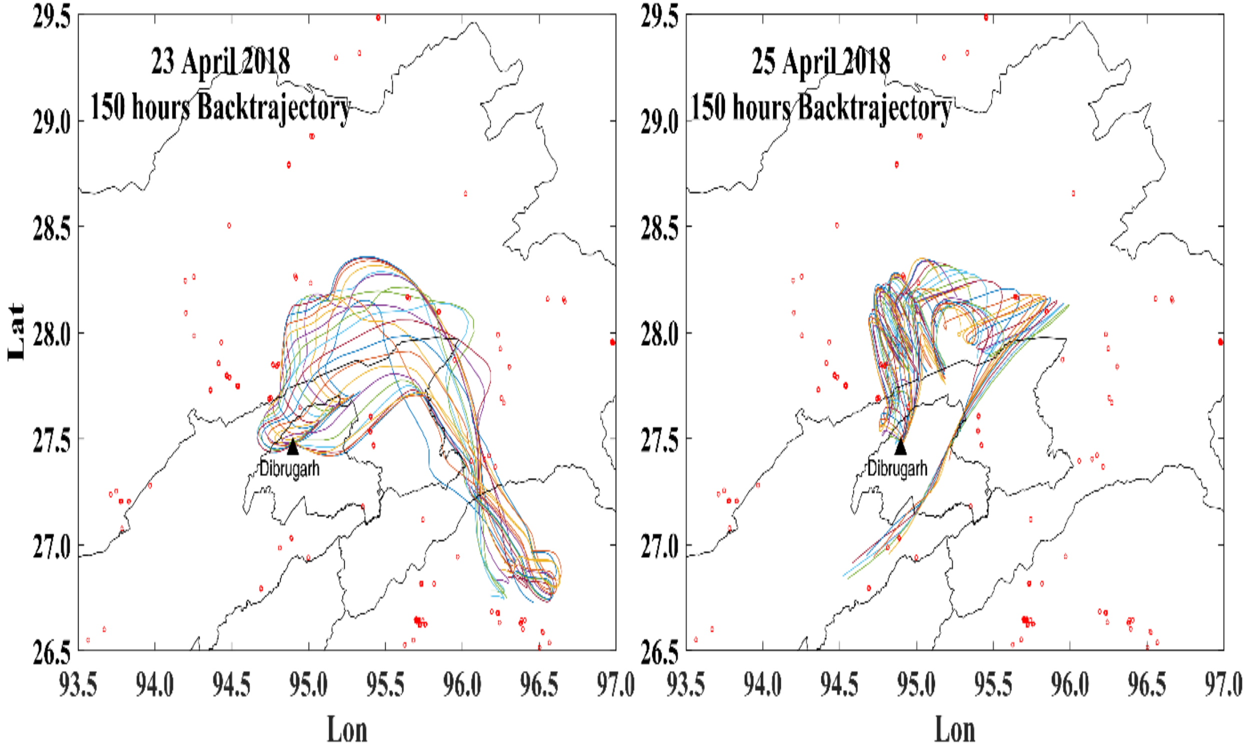


Fig. S5c. The 150 hours backward trajectory on Dibrugarh, Assam on 23 and 25 April 2018. A new trajectory is run after every 1 hour. The color change represents the different times of the day and the red dots represent the fire points on that day.

- AOD and AE values here indicate the presence of mixed aerosols (dust + biomass burning aerosols) (**Fig. S5(b)).**

•The volume of coarse particles is relatively lower during the whole study period with respect to finer particles. Fine dust particles reach over the AERONET location depending upon the meteorological conditions.

•The diurnal variations of the size distribution of the aerosols (**Fig. 9(b)**)are found to be dependent on meteorological conditions.

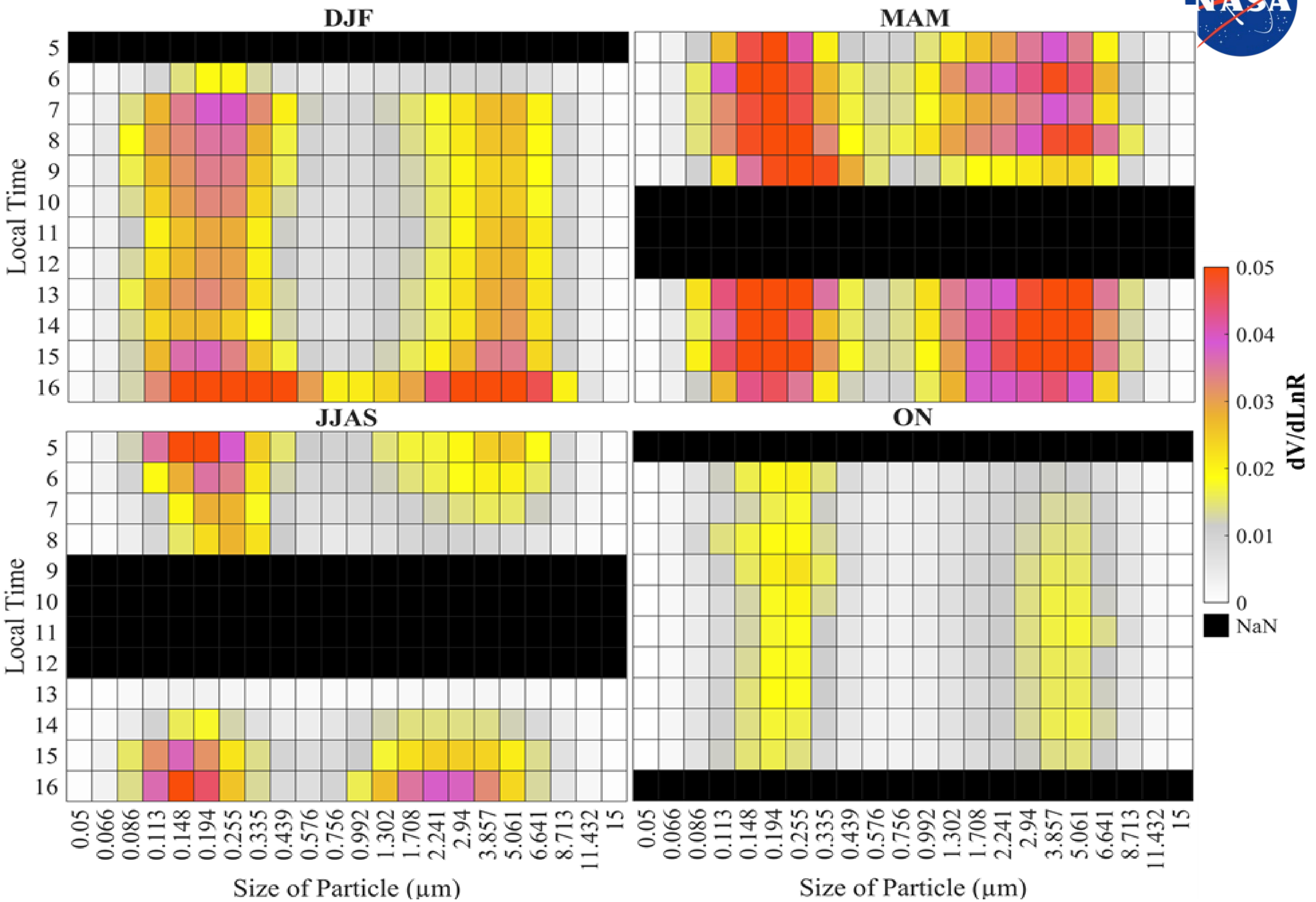


Fig. 9b. Diurnal variation of the size distribution of aerosols during various seasons.

• **Fig. 10(a)** shows variations in the seasonal mean of single scattering albedo from 2018 to 2021.

•During DJF, the SSA values are higher at a lower wavelength and lower at longer wavelengths showing a strong influence of local anthropogenic sources and biomass-burning aerosols.

•During 2020 and 2021, we found a pronounced decline in SSA values (<0.90) showing an increase in the absorbing nature of aerosols.

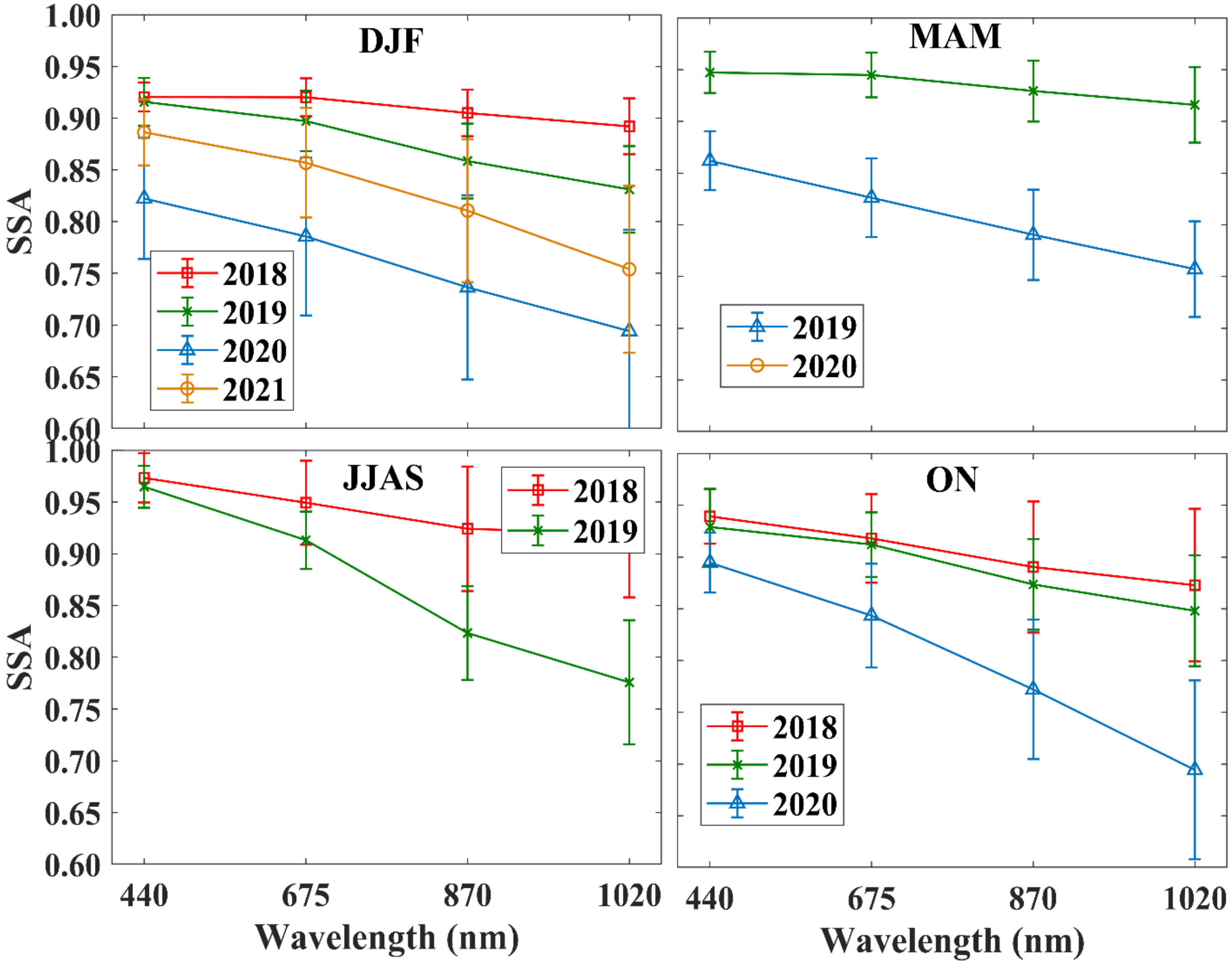


Fig. 10a. Wavelength dependency of seasonal mean SSA from 2018 to 2021.

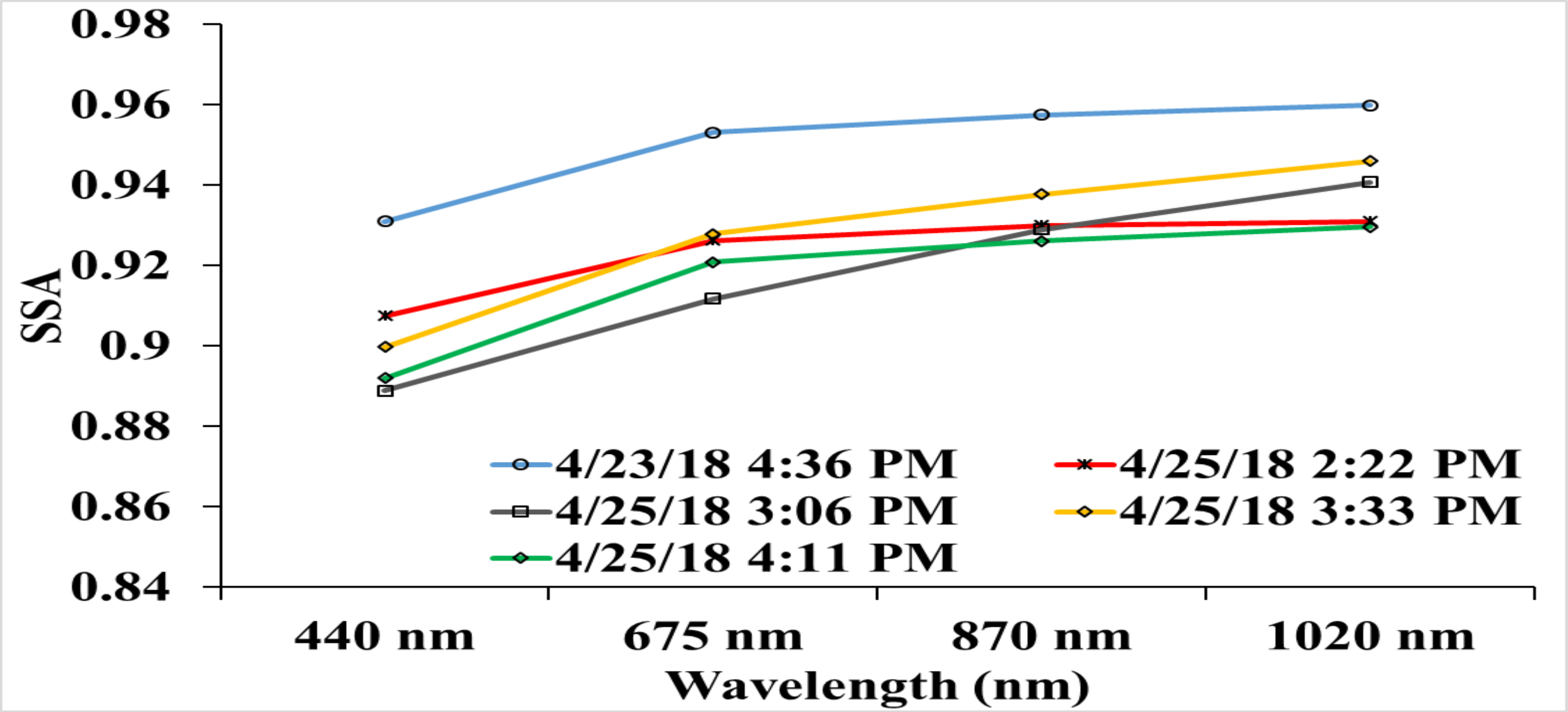


Fig. S5d. Wavelength dependency of SSA on 23 and 25 April 2018.

•During MAM, the SSA values are higher at a higher wavelength (> 0.90) and lower at lower wavelengths(< 0.90) due to the presence of mixed aerosols in 2018 **(Fig. S5(d)).**

•We investigated the diurnal variations of the SSA in different seasons.

•The impact of the rise in the local emission is strongly observed (**Fig. 10(b)**).

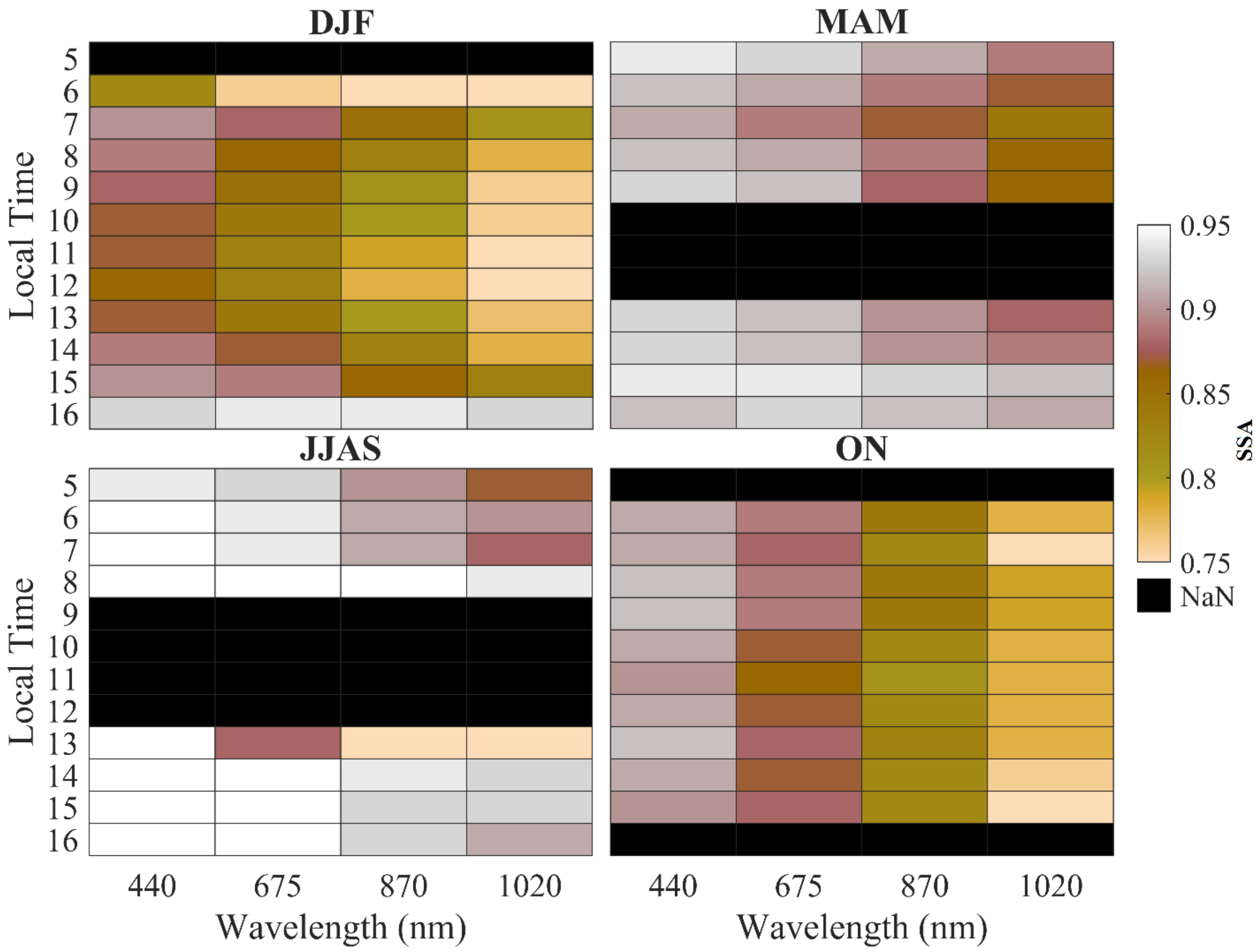


Fig. 10b. Diurnal variation of Single Scatter albedo during various seasons.

•The monthly mean radiative forcing RF_{BOA} and RF_{TOA} values are observed to be negative during 2018 and 2019 and are shown in **Fig. 11**.

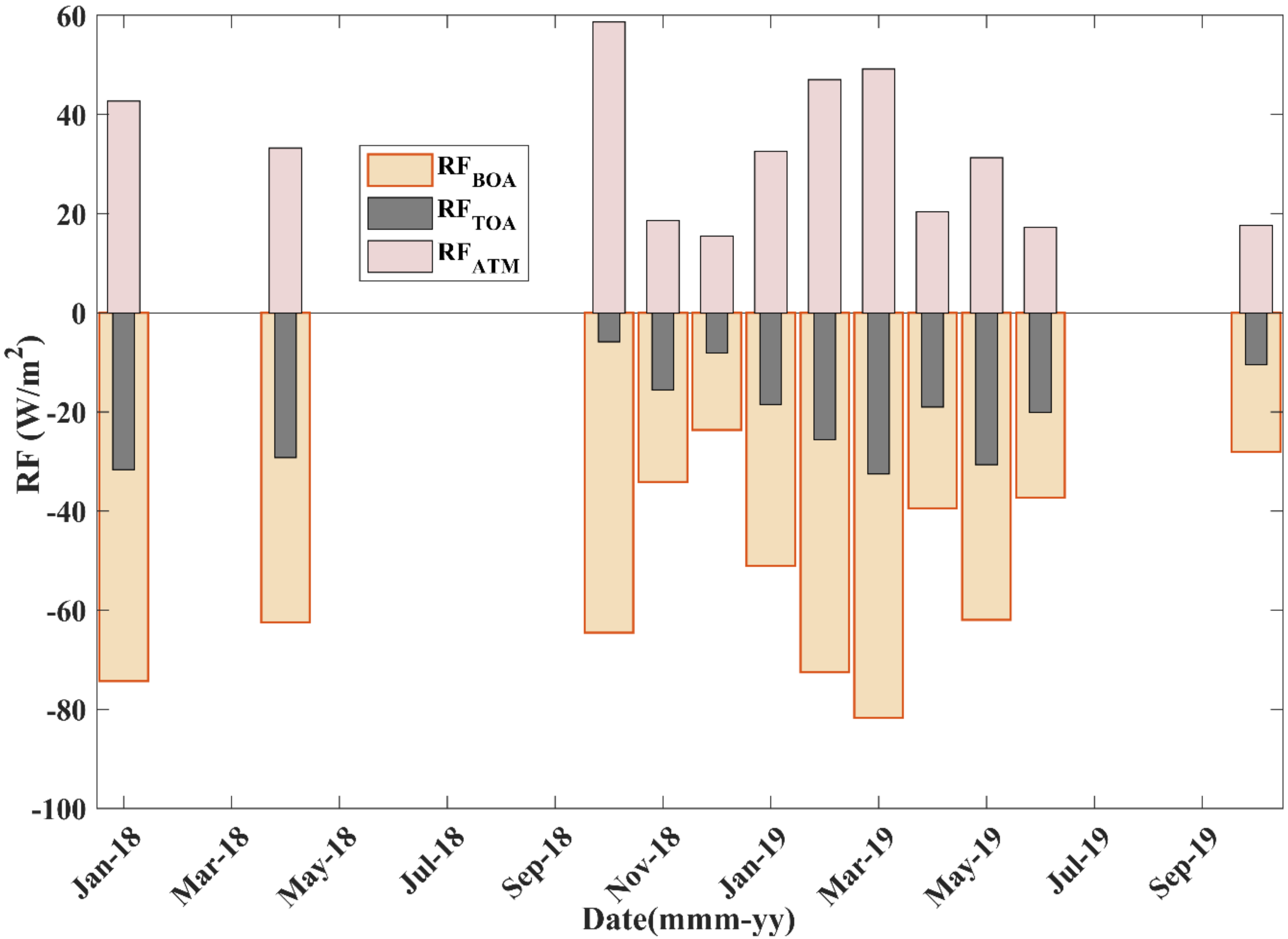


Fig. 11. Monthly mean radiative forcing of total aerosols for atmosphere (RF_{ATM}), Bottom of the atmosphere (RF_{BOA}),and Top of Atmosphere (RF_{TOA}) from 2018 to 2019. No data is available for 2020 and 2021

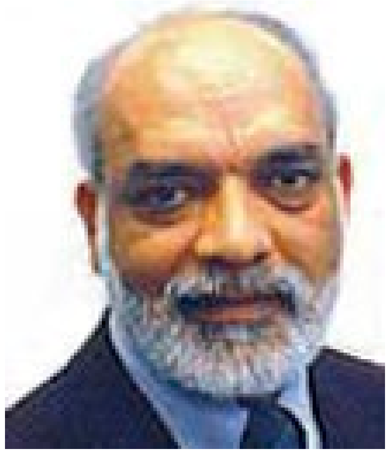
CONCLUSIONS

- The rise in anthropogenic activity has increased aerosol concentration in Dibrugarh.
- Long-range transport of airmass and mixing of aerosols are observed that show strong variability.
- The airmass outflow from IGP has a significant effect on the aerosol characteristics of Dibrugarh.
- MODIS-derived AOD and AERONET AOD values show a good correlation, with R^2 = 0.68.
- SSA values indicate the presence of scattering aerosols but in 2020, a sudden decline in the SSA values shows a strong rise in the absorbing aerosols.
- Throughout the study period (2018–2021), the positive radiative forcing indicates the rise in atmospheric heating.

FUTURE WORK

- The presence of dust from western parts of India to Dibrugarh is quite interesting and we are planning to discuss in our future study.

- The sources of the dust aerosols can also be from big regions like the Thar desert and the Gulf peninsula, and also oceans can be the major source of marine aerosols.

Brent Holben
Greenbelt, Maryland, United States · AERONET Project Scientist, Physical Scientist · NASA

Dr. Ramesh Singh
Professor, Schmid College of Science and Technology; Environmental Science, Chapman University

Akshansha Chauhan, PDF, Center for Space and Remote Sensing Research, National Central University, Taoyuan, *Taiwan*

The Team

QUESTIONS

Please mail me: sacharjee@dibru.ac.in

THANK YOU