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Aerosol Optical Depth Comparison study from Satellite Observations over the West-ern Indian Region-Surat

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Abstract: Aerosol Optical Depth (AOD) was measured along the Tapi River in the Gulf of Khambhat in Surat, Gujarat (INDIA). Satellite data from MODIS for Aerosol Optical Depth (AOD) have been collected from the Gio-vanni site developed by NASA. In this study the data for the period of 5 years (January to December 2015 to 2019) has been discussed. Variations in regional meteorological conditions are related to aerosol optical depth characteristics. Annual average AOD variation was seen in the data obtained from January to Decem-ber 2015-2019. The average annual changes of Aerosol Optical Depth (AOD) revealed peak value during the monsoon season, while the seasonal mean Aerosol Optical Depth (AOD) was least during the pre-monsoon season, and it was somewhat moderate in winter season. The post-monsoon season's variations of aerosol op-tical depth (AOD) are comparable to the winter and pre-monsoon seasons in 2016. Following that, values increased and exceeded maximum in both Aqua and Terra measurements, owing to changes in the local boundary layer.

Keywords: Aerosols Optical Depth, MODIS, AQUA, TERRA

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1. Introduction

Aerosol in the atmosphere is a suspension of liquid and solid particles with radii ranging from a few nanometers to 100 metres. These are very dynamic in space and time, and they have significant local and regional consequences, including reduced visibility, pollution from urban air, and potential health consequences (Jacobson 2002, Pope et al. 2002). Aerosols have a both direct as well as indirect effect on solar energy transmission (Ramanathan et al. 2001). The scattering (and absorption) of incoming radiation from solar diminishes surface insolation as a direct impact. The indirect effect is due to changes in cloud droplet size, as a results cloud albedo rises and potential cloud lifetimes. It leads to a decrease in surface solar exposure. Optical radiation scattering and absorption are affected by their size distribution, refractive index, and total atmospheric loading. As a result, solar radiation reaching the Earth's surface gets attenuated or obliterated (Ranjan et al., 2007).

Aerosols in the atmosphere are determined as one of the major contributors to extensive unpredictability in climate sensitivity, and they also increase the concentration of greenhouse gases in the atmosphere. Atmospheric aerosols can effectively impact the radiation budget and climate directly and indirectly by modifying the density and size of cloud droplets, resulting in altering the formation of the cloud, cloud albedo, cloud's period of existence, and chances of condensation. Dust aerosols also have a substantial impact on atmospheric radiative and climate forcing via their interactions with clouds, which influence cloud optical characteristics and precipitation efficiency.

2. Data and Methodology

2.1. . Satellite-based measurement of aerosols

Scientist have been using different techniques to measure the AOD over the land and oceans but, it's quite difficult to measure. Remote Sensing method is useful and powerful techniques for studying and monitoring the AOD over land and ocean on a global as well as regional scale. However, it is difficult to observed the spatial-temporal distribution of the above characteristics on a regular basis from the ground.

Satellite observations contain detailed information over a long timescale and a vast geographic area. Aerosol monitoring uses space-based equipment to extract the atmospheric involvement from the total signal collected by the satellite sensor. Moderate-resolution Imaging Spectroradiometer (MODIS) instrument has been used in this study for the measurement of aerosols from the atmosphere. The MODIS two sensors on NASA's Terra (operational since February 2000) and Aqua (operational since June 2002) satellites monitor the Earth from polar orbit. This satellite passes over the equator at different crossing times, with Terra and Aqua cross at 10:30 local time and at 13:30 local time respectively (Ma et al., 2013).

Many investigators have studied the effectiveness of atmospheric data from MODIS on Terra and Aqua. According to Kaufman et al., (1997) the capability of space-borne sensors to study the optical behavior of aerosols and their limitations has been discussed in detail. Presently, many Earth-orbiting satellites provide aerosol optical depth on daily basis, the entire global coverage. Remote sensing sensors such as Sea-WiFS, AVHRR and MODIS, have produced a large amount of data that has attracted the attention of scientists for analysis and application in climate modelling.

2.2. M***ODIS (Moderate Resolution Imaging Spectroradiometer)***

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a novel sensor or devices that can characterize global aerosol features both spatially and temporally. MODIS was launched on NASA's Terra satellites in December 1999 and Aqua in May 2002, includes 36 channels ranging from 0.41 to 15 m in spectral range and three spatial resolutions: 250 m (two channels), 500 m (five channels), and 1 km (twenty-nine channels). Retrieval from Aerosol uses seven of these channels (0.47–2.13 m) to recover characteristics of aerosol, as well as additional wavelengths in other areas of the spectrum to identify the clouds and river sediments (Ackerman et al. 1998; Gao et al. 2002; Martins et al. 2002; Li et al. 2003). MODIS, in contrast to prior satellite sensors that lacked adequate spectrum diversification, has the great potentiality to determine the optical thickness of aerosols, with better accuracy as well as aerosol size determination metrics (Tanré et al. 1996; Tanré et al. 1997).

3. Results and Discussions

3.1. Daily AOD Variation over Surat region

Many aerosols work in India are focused on the black carbon aerosol effect and the effect on climate in the globe. MODIS Aqua and Terra satellite data for 2015 are shown in Figure-1 and Figure-2, respectively, to illustrate the day-to-day variations of AOD over the Surat region. The data gap in the middle part of the figure shows the unavailability of data during the monsoon months as the MODIS retrieval algorithm detects and screens out the cloud contamination (Frey et al., 2008). The figure represents the variations of AOD at 550 nm on the vertical axis during the corresponding day of the year (DOY) on the horizontal axis.

The higher values of AOD around the monsoon period may be due to the contamination of the cloud. Comparatively high AOD (> 0.5) is observed around February, which is the winter period in this region. The overall trend observed in both MODIS Aqua and Terra observation follows a similar pattern with variation in the number of records and values. This difference in Aqua and Terra observations is due to the difference in time of period and continually varying atmospheric conditions at the time of observations.

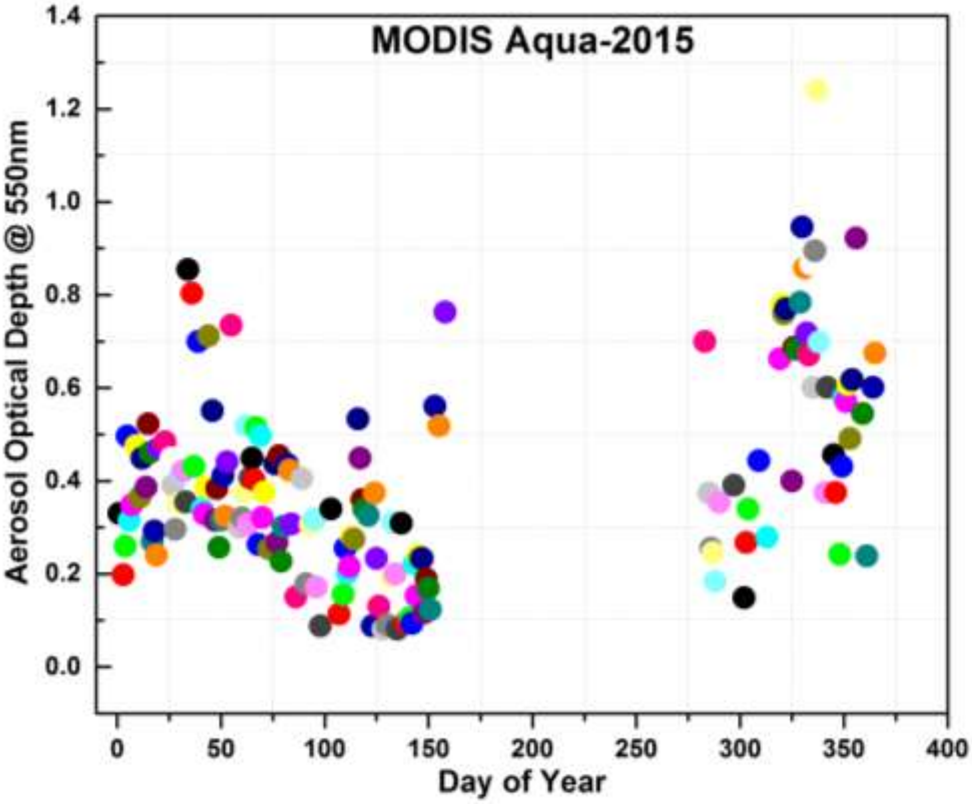

Figure 1. Daily variation of AOD during 2015 using MODIS Aqua observations.

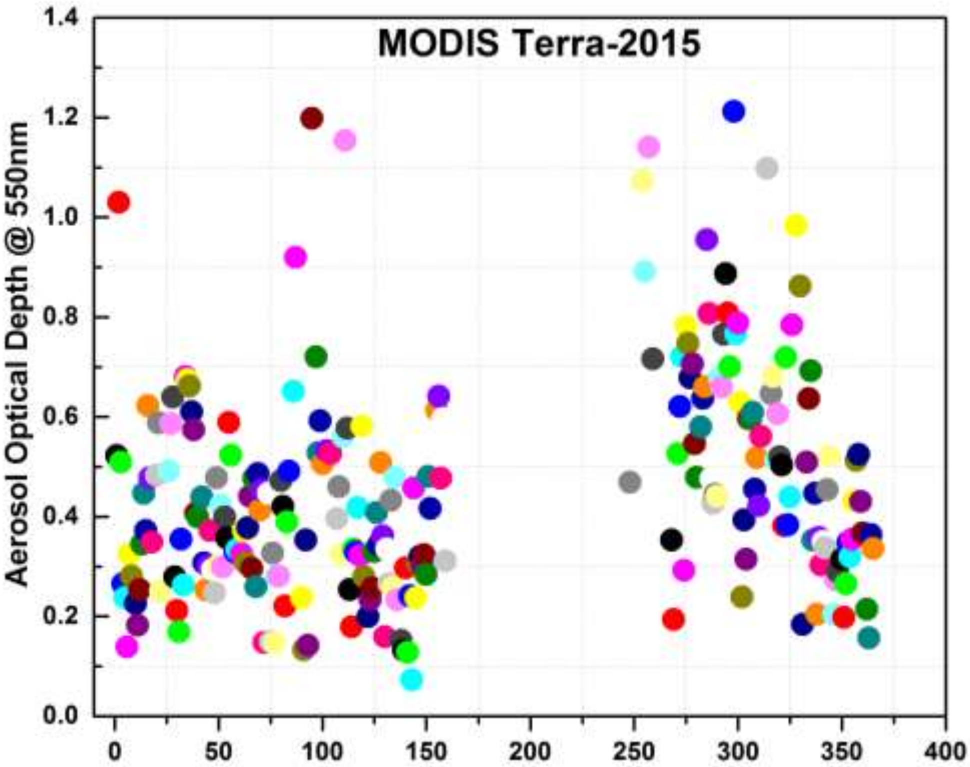

Figure 2. Daily variation of AOD during 2015 using MODIS Terra observations.

3.2 . *Monthly Variations of AOD over Surat*

Figures (3) and (4) depict monthly average aerosol optical depth (AOD) from 2015 to 2019 at 550 nm derived from the MODIS Aqua and Terra satellites sensors. The MODIS AOD retrieval procedure's improved cloud screening algorithm (Mhawish et al., 2017; Sogacheva et al., 2017) reveals a data gap around the monsoon season (June to September). MODIS AOD values higher, throughout these months cloud contamination was observed. The figures (3) and (4) also indicate the yearly inter-comparison of MODIS Aqua and Terra mean observations. In both the satellites, the lower AOD values are usually recorded in May for all years.

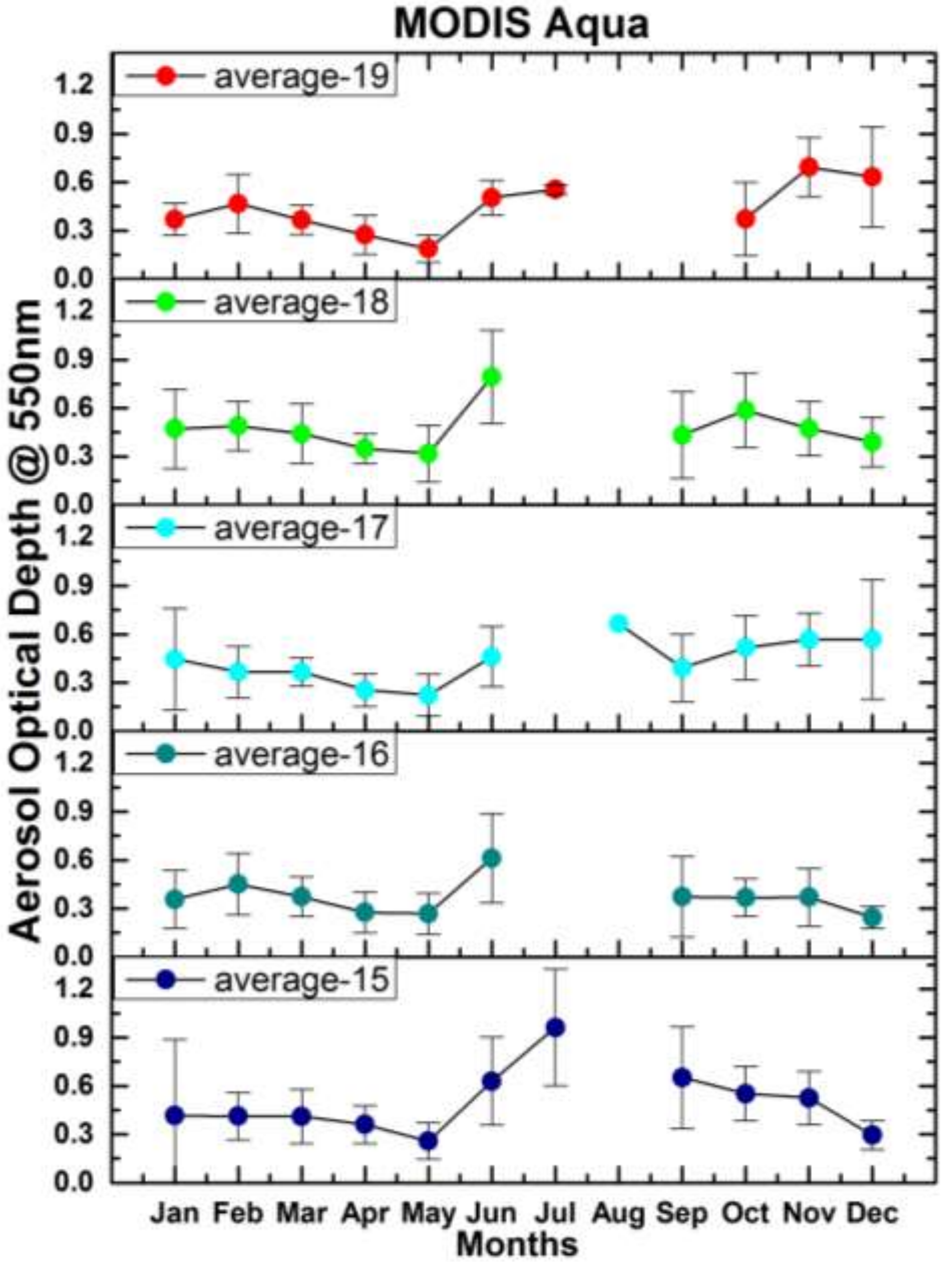

Figure 3. MODIS Aqua AOD (550nm) monthly Variation during year (2015-2019).

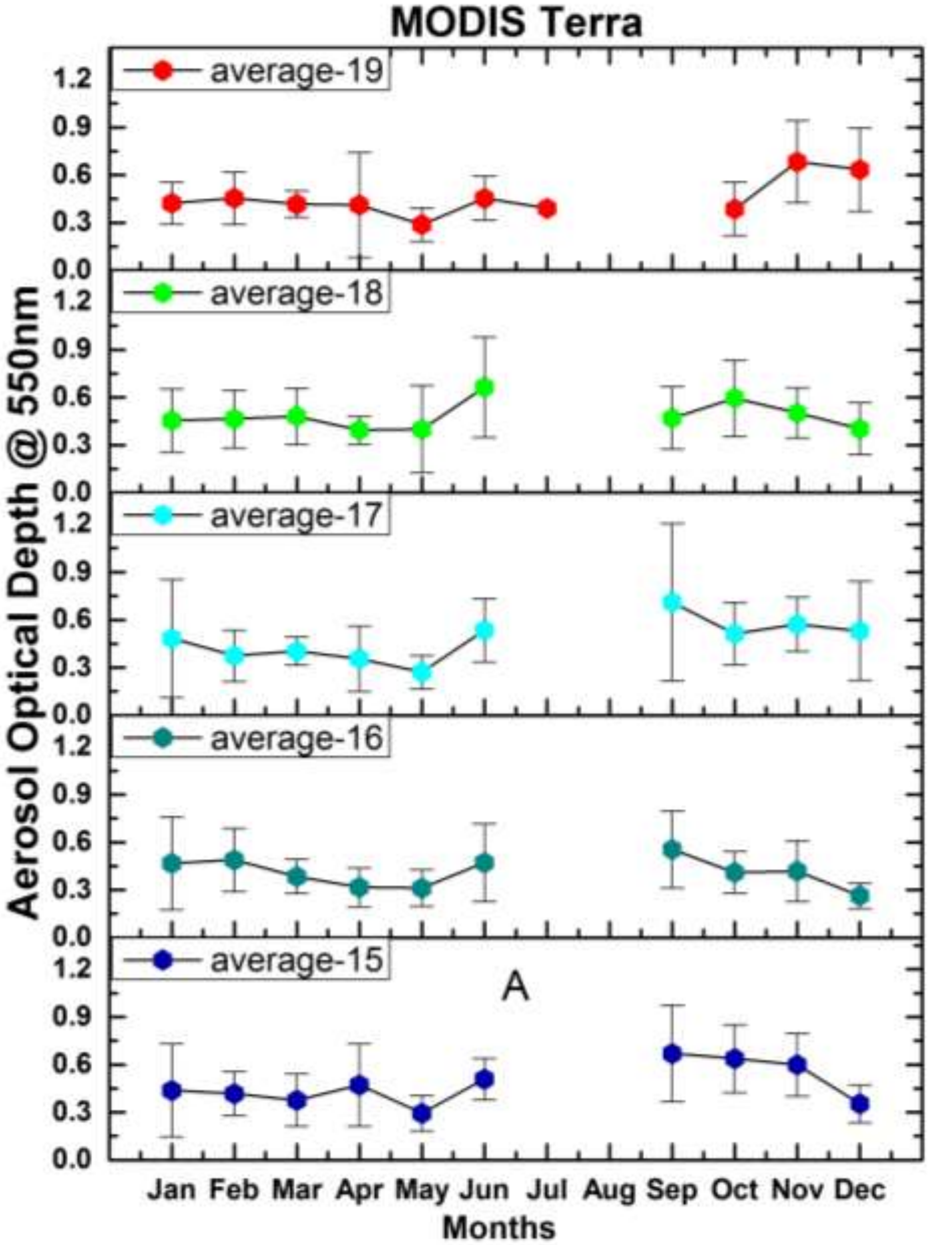

Figure 4. MODIS Terra AOD (550nm) monthly Variation during year (2015-2019).

3.3. . Seasonal Variation over Surat region

The study regions experiences four seasons annually which can be categorised as winter or dry (December to February), Pre-monsoon (March to May), monsoon (June to September) and post-monsoon (October to November). Seasonal mean of MODIS Aqua and Terra AOD at 550 nm for winter, pre-monsoon and post monsoon months shown in the figure (5) respectively.

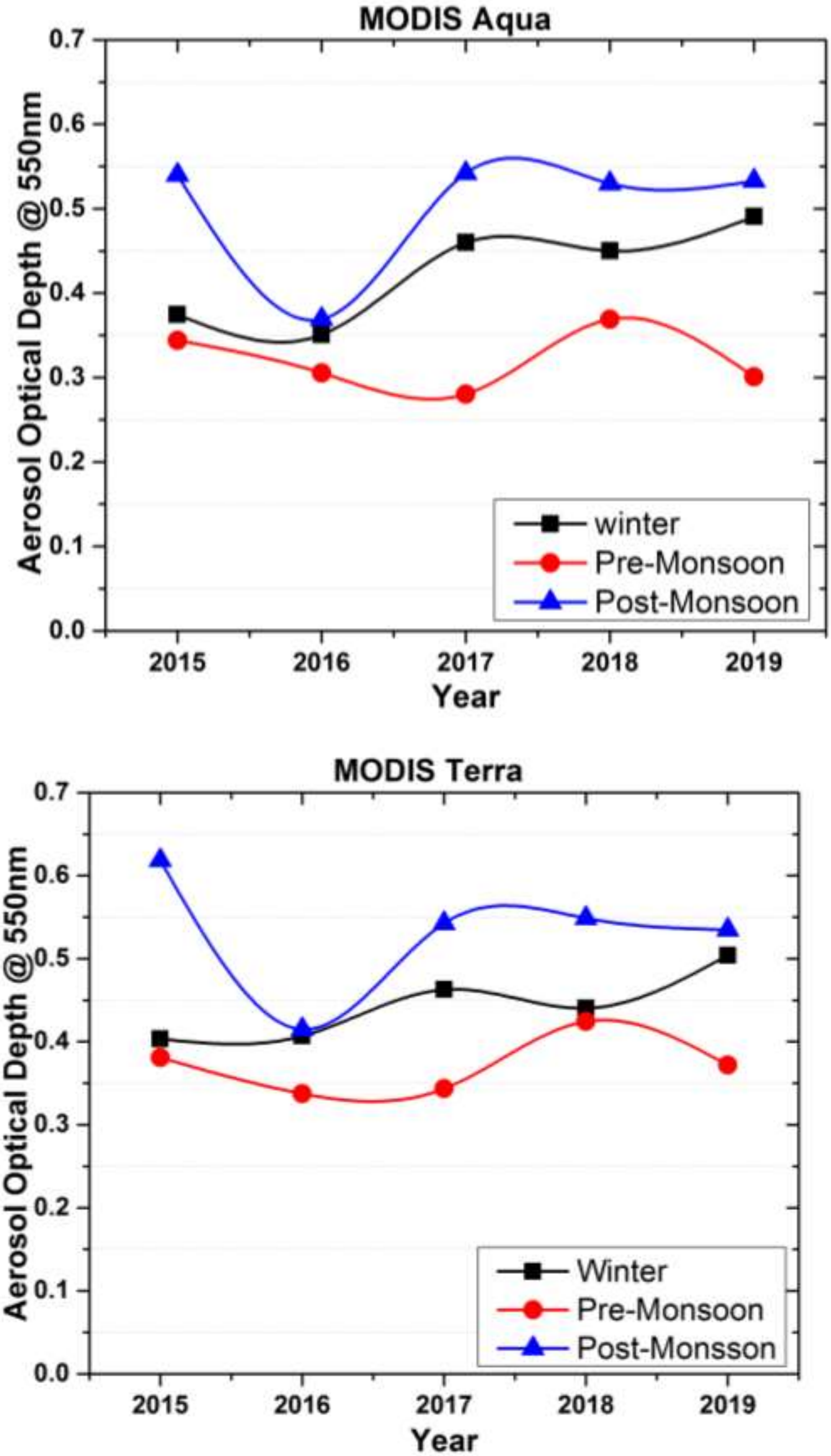

Figure 5. MODIS Aqua and Terra AOD (550nm) seasonal Variation during year (2015-2019).

4. Summary and conclusions

The lowest AOD values are found during the pre-monsoon season, whereas the winter season has a moderate AOD. In 2016, the post-monsoon season shows similar variation to the winter and pre-monsoon seasons, although values rise after that and peak in both Aqua and Terra observations. The seasonal variations of MODIS Terra AOD shows higher value compared to the Aqua AOD values.

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