

A Long Term Study on Atmospheric Aerosols over Indian Subcontinent

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Abstract: *Atmospheric aerosols are small particles present in the atmosphere and their size ranges from few nanometres to micrometers. Though atmospheric aerosols have short life time it is found from different studies that they impact the climate change in a considerable manner. They may scatter, reflect or absorb solar radiation and hence alter the heat budget on the earth. They are produced due to different natural and anthropogenic process. The study of their impact on climate change is very complex as the chemical composition varies and depends on their origin. They impact human health as well as our climate. Thus study of atmospheric aerosols is very important and necessary. Satellite measurements of aerosols give us an opportunity to study atmospheric aerosols over a large region. There are different satellites measuring aerosol loading at different spatial and temporal resolutions. We have used MODIS (Moderate Resolution Imaging Spectroradiometer) onboard Terra, AOD data for a long period of twenty years (2001-2020). The validation details and quality of MODIS AOD is described in detail in the paper. Decadal, Inter annual, seasonal and monthly variation of Atmospheric aerosol loading is studied and the results are discussed in detail in the paper. The study indicates that the atmospheric aerosol loading is more during monsoon and less during winter. It is also noticed that northern part of India is highly loaded with aerosols when compared to southern India. Anthropogenic activities have decreased to a large extent everywhere owing to forced lockdown in the year 2020. This caused a major decrease in aerosol loading in the atmosphere indicating that the major pollutants are due to industrial emissions. The results show that the decrease in loading for a single year did not have any influence on the climate. It gives an indication that the aerosol loading has to be decreased and this process should continue for a long time to restore a clean environment.*

Keywords: MODIS (Moderate Resolution Imaging Spectroradiometer), AOD(Aerosol Optical Depth), Anthropogenic activities,

1. Introduction

India is a country with diverse climate regions. It is a peninsula and hence affected strongly by ocean winds. The diversity IV climatic regions caused a variety of living styles and thus it is often

referred to as a Subcontinent. And India stands second in the world in terms of population and it is nearly 17.7% of world's population. India is mainly agriculture based country and the economy depends upon the monsoon rainfall. The study of atmospheric aerosols over Indian

subcontinent is very important and necessary as the aerosol loading influences both in terms of human health and climate. The influence of atmospheric aerosols is termed to be most uncertain as the result depends upon the chemical constituents and their life time Myhre, et al. 2013. The study of atmospheric aerosols is complex as their life time is very small and it is difficult to identify their source, Cao, J. 2017. Aerosols are produced from different sources both natural and anthropogenic. Their size distribution also varies over a large range enhancing the complexity of their study. Aerosols with large size reside for a very short time and fine particles reside in the atmosphere for a long time. They influence the local weather, human mortality and even visibility, Emeteri et al, 2017; Zhao et al 2020 ; Jeong G,2020. Different studies have reported the influence of aerosols on visibility over New Delhi, Singh et al , 2008. Safai et al 2019, Singh et al 2012. People in different cities are exposed to health risks due to accumulated aerosols in the region Colbeck, et al 2010. Manisalidis et al 2020. Griffin, R. J. (2013). Owing to the importance of study of atmospheric aerosols, an attempt is made in this article to study the aerosol loading over Indian subcontinent using a long term data(2001-2020) acquired from MODIS (MODerate Imaging Spectroradiometer).

2. Data and Methodology

Level 2 of Collection 5 MODIS aboard Terra AOD data for a period of Nineteen years (2001-2020) has been used for this study (MODIS Website). The resolution of level 2 data is $0.1^\circ \times 0.1^\circ$ (approximately 10Km) at nadir (Satvencho et al 2004). The quality of MODIS AOD has been well documented by Levy et al. (2007; 2010) and Remer et al. (2005). MODIS AOD is validated by different group and the details are available in Kiran et al 2013. The region, within 40°

N and 5° N and 65° E and 99° E is selected for the study and it is subdivided into 7225 grids each of size $0.4^\circ \times 0.4^\circ$. AOD is plotted for each month to analyse monthly and seasonal variations in annual as well as decadal scale. AOD is plotted for all months during the study period but a few instances are used in the paper to study their variation. AOD plots for the year 2020 are plotted to check the impact of lockdown on the emissions and hence aerosol loading.

2.1 Monthly variation of AOD

Aerosol optical depth is plotted as a monthly average to study the monthly variation of aerosols over the study region. It is observed from the plot that AOD is less over the study region during the months of December, January , February and March when compared to other months. It is found that AOD is more during September and October. The reason may be due to accumulation of aerosols due to small wind velocity in winter. The trend is more or less similar throughout the study period. High AOD is observed in the western coast and Indogangetic plain. The reason for high AOD in the Indo Gangetic plain is attributed to its Geography and existence of more Industries giving out lot of emissions Jethva, et al 2005. Reason for high AOD in the west coast may be due to transport of dust from Arabian Desert. The true colour images (fig 2. And fig.3) strengthens the conclusion(MODIS website) the figures show the transport of dust from Arabian Desert to western part of India. The Arabian Sea and Bay of Bengal are loaded with considerable amount of Aerosols in the monsoon season(June, July, August & September). This may be due to aerosols carried by the monsoon winds coming from west to east and generally we have winds from west to east in this season. The climatological plot of wind direction and humidity over different months is available from Kiran Kumar & S.V.B.R., 2012. The same

trend is observed in the year 2012. The plot for 2012 has been selected instead of 2010 as the year 2012 has more data points

and the data is available for every month. The comparison shows that there is a clear increase in AOD.

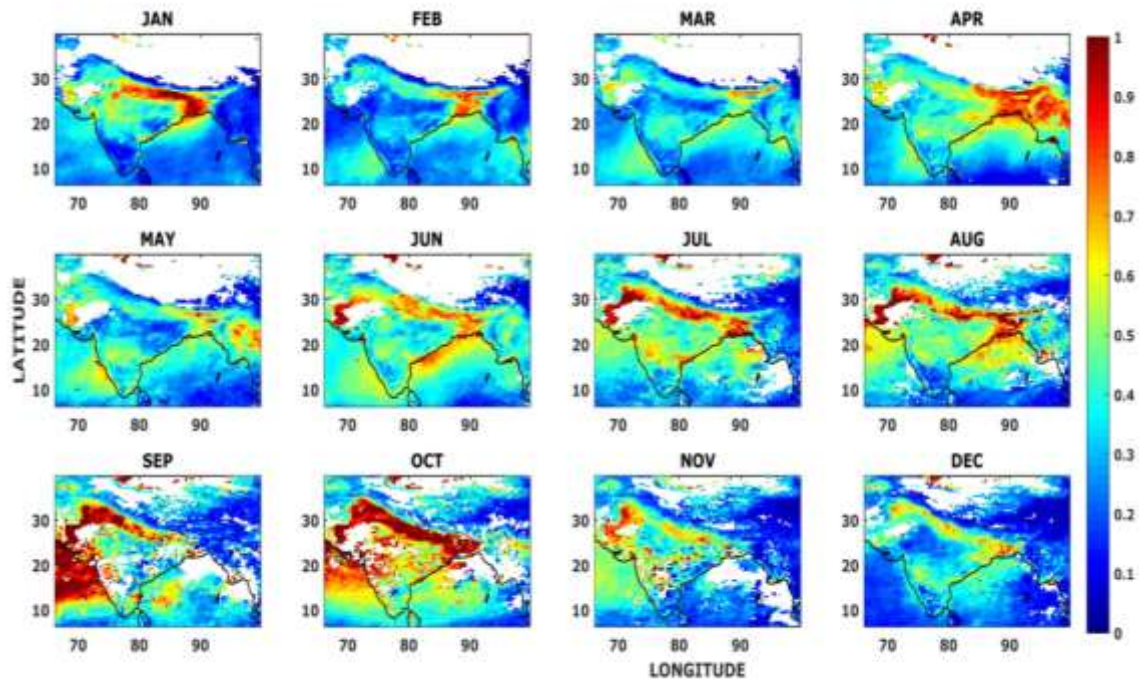


Figure 1. Monthly AOD for the period 2001

AOD for the year 2018 is also plotted to compare the magnitude of AOD with that of 2020. AOD values for the year 2020 are small when compared to that of other years which gives an indication that the emissions have decreased due to lock down owing to corona break out. There is no significant change in the other climate parameters as

decrease in emissions for one year may not be sufficient to cure the loss happened to climate in the past years. The comparison of data for the year 2001, 2012 and 2018 shows that there is a considerable increase of AOD every year. This shows that Emissions due to manmade activities are increasing year by year which is not good for the climate and human health.

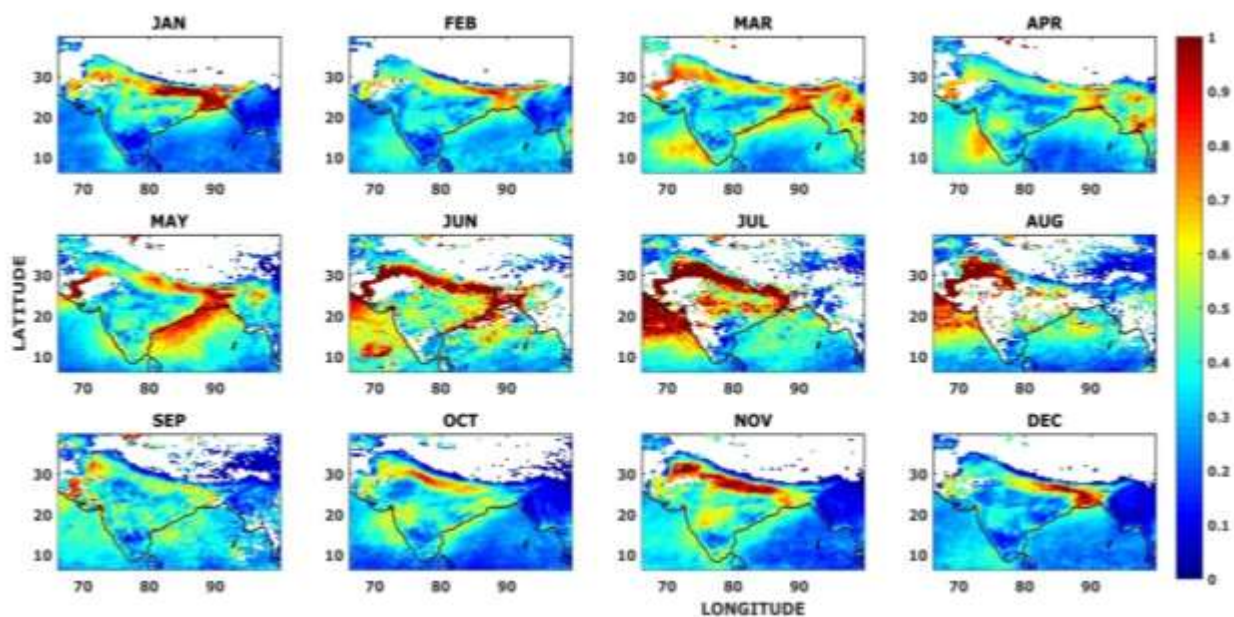


Figure 2 Monthly AOD for the year 2012

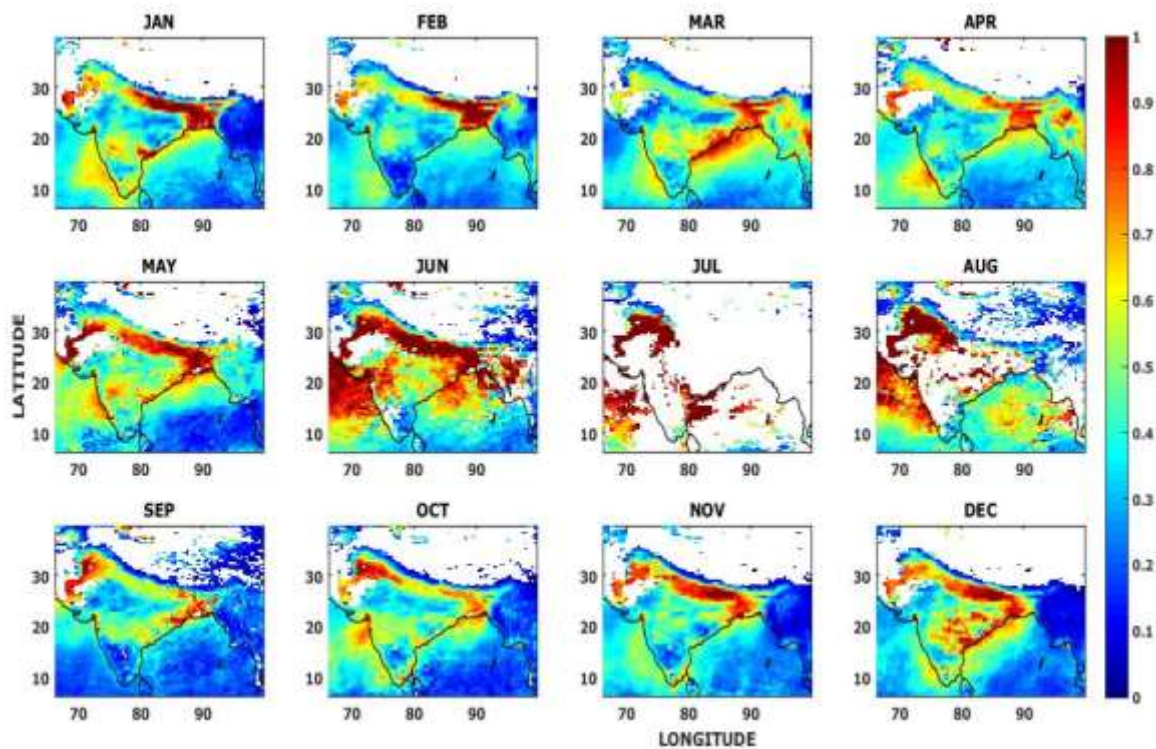


Figure 3 Monthly AOD for the year 2018



Figure 4 Modis True Colour Image over Arabian Sea

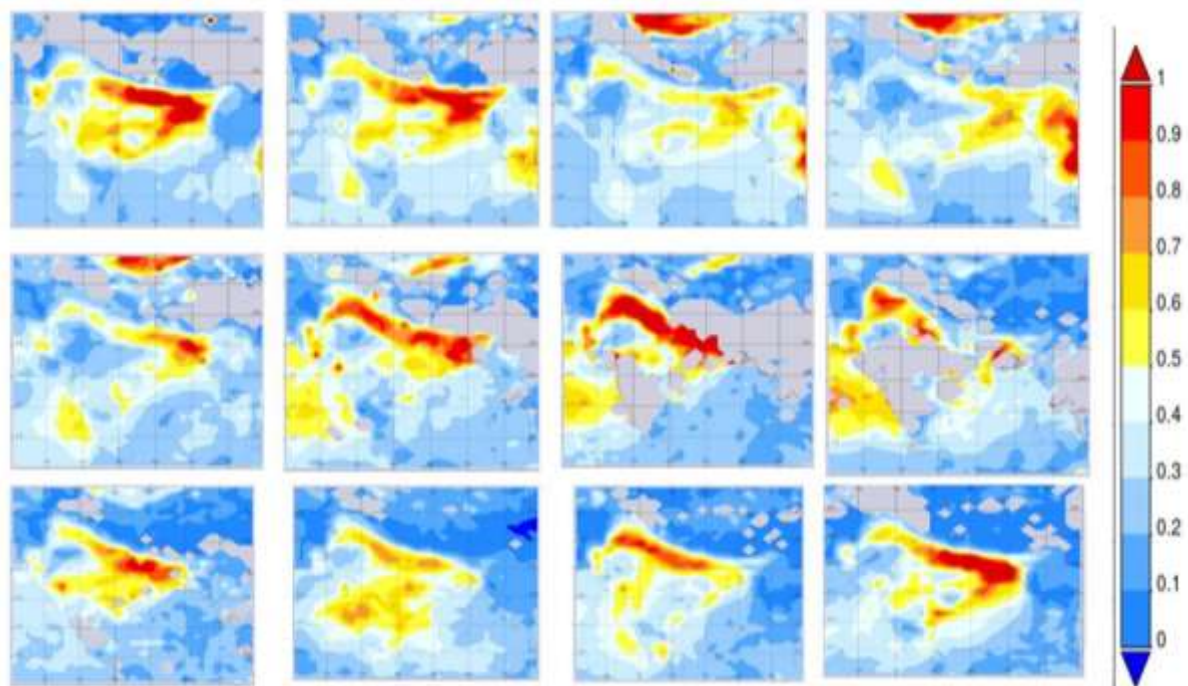


Figure 5 Monthly AOD for the year 2020

3. Results and Conclusion:

The study gives an indication that Aerosol loading is changing over seasons which gives an indication that most of the contribution is due to wind transfer. High AOD in monsoons strengthens this conclusion as winds are westerlies during Monsoon. True colour Images from

MODIS also show that there is a dust transfer from Arabian Sea to western India. The comparisons of plots for different year show that there is a considerable increase of AOD each year. The plots for the year 2020 shows low AOD. All the human activities are almost shut down for a period of Six months and emissions have decreased. This fact gives an indication that most of the pollutants are due to enhanced human activities.

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