Study of the influence of Absorbing Aerosol Index over the monsoon on a tropical station using OMI data for two specific years (2005 and 2011)

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Abstract : The present study helps in understanding relationship between aerosol and precipitation. It was found that there is inverse relationship between AAI value and precipitation that is when the concentration of aerosol was more then amount of rainfall decreases. It was observed that during monsoon period of year 2005 and 2011, absorbing aerosol loading was less over study area in 2011 as compared to year 2005, hence there was more rainfall observed in 2011.Thus there is negative correlation between absorbing aerosol and rate of precipitation**.**

Index Terms **- AAI, water precipitation.**

I. Introduction

Aerosols are tiny particles in the form of liquid or solid suspended in the atmosphere. They affect the earth's radiative balance and climate by absorbing and scattering the solar radiation reaching earth's surface. They affect the climate by disturbing the hydrological cycle (Allan et al., 2014). Atmospheric aerosols have direct, indirect and semi-direct effects on precipitation. As a direct effect; they scatter and absorb the incoming solar radiation and outgoing terrestrial radiation. This effect reduces the amount of radiation reaching the earth's surface, hence there is cooling at the earth's surface, thereby aerosol affect evaporation processes and circulation patterns and hence influences precipitation (Kvalevag et al., 2013; Boucher, 2015).

The semi-direct effect refers to absorption of solar radiation by aerosols and heat the cloud in which they are present. It causes evaporation of the cloud droplets and this decreases size of water droplets in clouds. Hence this leads to increase in the temperature in the lower atmosphere and suppresses precipitation. There is still high uncertainty on the overall effects of aerosols on precipitation because most instruments cannot measure aerosols within clouds. Different types of aerosols have different effect on clouds (Cook and Highwood, 2004; Huang, 2006).

Aerosols indirectly affect precipitation by modifying the size and lifetime of clouds. There are two indirect effect, first is the reduction in the size of the cloud condensation nuclei (CCN) due to the increase in the concentration of aerosols, when a constant liquid water content is present in atmosphere, this effect is also known as cloud albedo effect. In this way aerosol suppresses precipitation by decreasing the size of water droplets in clouds. The second indirect effect (cloud lifetime effect) is an increase in cloud lifetime and reflectivity because of the suppression of precipitation, clouds stay for longer time (Andreae, 2004; Twomey, 1977).

Panicker et al. (2010) studied on the different stations of Indian subcontinent using MODIS data during the monsoon season for the period 2001 to 2004. They estimated the indirect effect of aerosols on Indian subcontinent regions for four contrasting monsoon years that is 2001 (normal monsoon rainfall year), 2002 (drought year), 2003 (excess monsoon rainfall year) and 2004 (below normal rainfall year). In 2002 and 2004, Aerosol Indirect Effect (AIE) was positive that is there was reduction in cloud effective radius due to high aerosol loading and hence less rainfall, but in 2001 and 2003 AIE was found to be negative indirect effect. It was stated that the positive and negative AIE may be due to changes in circulation patterns of winds during contrasting monsoon seasons. It was concluded that AIE could be the one of the factor modulating Indian summer monsoon.

Bhawar and Devara (2010), showed the effects of aerosols on hydrological cycle over a tropical station, Pune, India for two successive contrasting monsoon years. They observed that cycle of variations in the absorbing dust aerosols and non-absorbing aerosols repeated after 50 days and more than after 100 days during the normal and weak Monsoon period respectively. There were more variations in the AI values during weak monsoon year as compared to active monsoon year. They observed more concentration of absorbing dust aerosols in weak monsoon period as compared to active monsoon period. Smaller values of CER (Cloud Effective Radius) were observed which indicating less cloud formation or size of clouds decreased too early and hence less precipitation was observed in weak monsoon year. It was observed that the surface temperature was more in weak monsoon year and comparatively less in active monsoon period. Thus values of AOD were observed higher in weak monsoon period, and also the values of surface wind speed were found to be higher in active monsoon this resulted in removal of aerosols by winds from the observational site to the other in this period.

Pandithurai et al., (2007) evaluated the seasonal asymmetry in diurnal variation of aerosol optical characteristics over Pune in western India for 3 years in different seasons. They measured AOD and α to analyze the diurnal variation and its seasonal dependence. Mean AOD at 500 nm in the premonsoon period and winter were about 0.42 and 0.38 respectively. The deviation of AOD values from the daily mean was found to be about ±20% (which is equivalent to AOD of 0.08) in both seasons. Thus a systematic seasonal asymmetry in diurnal variation was found. They observed that AOD were higher in the morning and lower in the afternoon during winter. However, in pre-monsoon, AODs are found to be lower in the morning hours and higher in the afternoon hours. The main reason behind is that in the afternoon temperature is higher, and hence convection process is dominating and also due to higher temperature wind raises and this high speed blowing wind transporting dust locally from one region to another.

It is clear from the earlier studies that there is either positive or negative correlations between aerosol optical depth (AOD) and precipitation intensity based on observation data collected under different environmental conditions. The previous studies show that the effect of aerosols on the hydrological cycle is little known as compared to their effects on the radiation budget. Therefore, it is important to know more about the effects of aerosols on rainfall thus this research paper helps in understanding the relationship between aerosols and precipitation (rainfall).

II. DATA SET AND SITE DESCRIPTION

In the present study the AOD data are retrieved from the Ozone Mapping Instrument (OMI) at 354nm/388nm of UV region, also known as AAI (Absorbing Aerosol Index). AAI data obtained from OMI are in the gridded form of resolution 1°×1.25° latitude-longitude. The rain fall or precipitation data is retrieved from the website of Government of Rajasthan (India). In the present paper we have taken Banswara (23.11°N, 74.375°E), India as our study area, which belongs to the southern part of Rajasthan. The tropic of cancer also passes through this region. The climate of Banswara region is extremely hot and exhausting during summer, temperature ranges from 30°C to 46°C in the months of March to June. The Mahi river flows here. The average annual rainfall in district is 950.3mm and humidity percentage is 57. Here mining is done in large amount. Here in Fig. 1, the study area is indicated by red arrow.

Fig. 1 Location of study area

III. DATA ANALYSIS AND METHODOLOGY

For analyzing the AAI daily gridded data of OMI at 354nm/388nm, first the related data is downloaded from its site for each day of years 2005 and 2011. Since the raw data was in the gridded form and our focus was on a particular station Banswara (23.11°N, 74.375°E), so we have extracted the data of this particular coordinate from this raw data. In this data some data was not related to site, so that data was also eliminated from that. After it we calculate the monthly mean value of AAI data. At last we plot a graph between monthly mean values of AAI data with their month for a particular year. To establish a relation between AAI data and total rain fall, the total rain fall for a particular month of the year is calculated from its raw data. And then a curve is plotted between total rainfall (mm) and months on the same graph in which AAI was plotted. Since there is very few rainy days on the site, so in establishing the relation between AAI and total rain fall, we use only particular months which have rainy days.

The results and conclusion obtained on the basis of this study is given in the next section.

IV. RESULTS AND DISCUSSION

The graph is plotted between months, mean AAI and total rainfall over the study region for the year 2005 and 2011 is shown in the Fig. 2 and 3 respectively. These particular years are chosen because in these years maximum rainfall was observed in the monsoon period. The AAI values were observed highest in months of March, April and May (pre monsoon) as compared to Monsoon period i.e., June to September months and post monsoon period. The main reason of it is because of cutting of the crop, burning of crop residue. Also this observing site is on the tropic of the cancer and hence the temperature at this site was very high during the summer and this much of high temperature ignite the forest fire naturally, and increase the aerosol concentration.

In the year 2005 and 2011 total rainfall were observed maximum in September (373 mm) and August (1000mm) months respectively. The total rainfall in year 2011 was more as compared to 2005 during monsoon period, whereas the AAI values were observed higher over study area in 2005. So in year 2005 rainfall is less as compared to year 2011 due to high aerosol loading in 2005 at the time of monsoon. In this way rain fall depends on the AAI values, as AAI value decrease the rain fall increase or both values are negatively correlated to each other (Fig. 2 and 3) and its value is found to be 0.78 and 0.58 in 2005 and 2011 respectively. Thus there is a negative correlation between average AAI value and total rainfall.

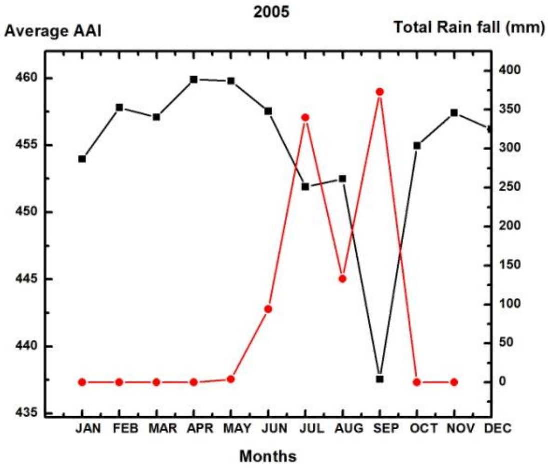

Fig. 2

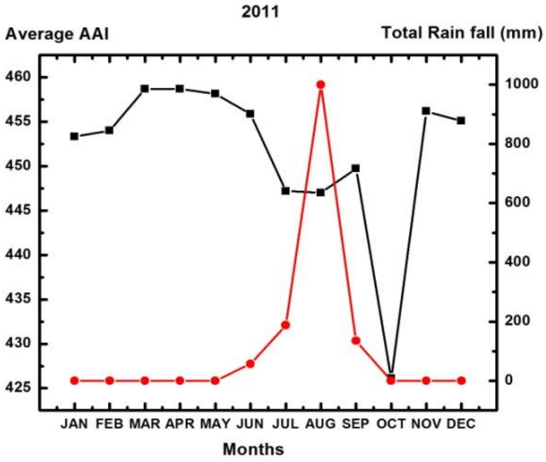

Fig. 3

So we divide the above retrieved data of foF2 into these three time period. After dividing or separating the data into three regions we calculate the medium value of each hour for a particular month (January) for separately for each year. After it we plotted the medium value against the hour for January month for each year and each time region, separately. After it we fitted the above plotted graphs linearly and obtain the slope, adjusted correlation coefficient (R) and P value for each year and for time period for the study period. Also we obtain the percentage of confidence level (%CL) by using the P value. The slope and R value is shown in each graph (Fig. 1, 2 and 3), whereas R and %CL is shown in Table 1. To establish a relation between rate of change (ROC) of foF2 and sunspot number, the graphs for it are also shown for each time period (Fig. 4). The result and conclusions are discussed in next section of this paper.

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