Estimation of PM 2.5 and Pm 10 During an Intense Dust Episode over Indian Region Using Satellite Data Set

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ESTIMATION OF PM 2.5 AND PM 10 DURING AN INTENSE DUST EPISODE OVER INDIAN REGION USING SATELLITE DATA SET

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ABSTRACT

Mineral dust is a major constituent of airborne particles in the atmosphere. It plays an important role in many environmental processes. Mainly impact of aerosols on climate related processes that involve radiation and clouds. Dust contributes about 80% to the total global aerosol loading. The Sahara Desert and desert over the Arabian region, Pakistan and Afghanistan border and Thar desert are main dust area across the globe. Wind-speed, rainfall, vegetation covered, surface type is the major factor responsible for mineral dust emission. The modelling of dust sources is perhaps the most difficult task facing climate modelers. PM 2.5 and PM 10 has been examined in association with aerosol optical depth using remotely sensed MODIS AOD data sets. PM 2.5 and PM 10 has been studied over Thar desert and Delhi form 05 June 2018 to 21 June 2018. The present analysis shows significant positive correlation between ground data and satellite PM 2.5 or PM 10 in Delhi or Rajasthan region expect PM 10 of Almar and Srinath Puram (Kota) station.

Keyword: Dust, Aerosol, AOD, PM $_{2.5}$ and PM $_{10}$

1.INTRODUCTION

Dust is the more of the most contributed to the total aerosol emission across the globe about 80% of the total aerosol emission dust particle. Dust aerosols have a wide range of effects on the natural environment and human beings including: changing precipitation and temperature, modifying ocean and land biogeochemistry, and causing respiratory diseases as well as other human health problem. These effects emphasize the importance in examining wind changes in dust source areas and how the changes influence dust storms (frequency and intensity). Sand and dust storms (SDS) are atmospheric events created when small particles are blown from land surfaces. SDS occur when strong, turbulent winds flow over dry, unconsolidated, fine-grained surface materials where vegetation cover is sparse and sometimes altogether absent. These conditions are most commonly found in the world's drylands—deserts and semi-deserts—and hence this is where SDS are most frequent. Sand storms occur within the first few meters above the ground surface, but finer dust particles can be lifted much higher into the troposphere, where strong winds frequently transport them over great distances Airborne dust presents serious risks for human health. Dust particle size is a key determinant of potential hazard to human health. Particles smaller than 10 μm, often get trapped in the nose, mouth and upper respiratory tract, thus can be associated with respiratory disorders such as asthma, tracheitis, pneumonia, allergic rhinitis and silicosis.

2.DETAILS OF EVENT

The National Capital Territory (NCT)of Delhi is recognized as one of the most polluted regions in the world [1] . Several studies have estimated that annual PM2.5 concentrations in Delhi NCT exceed India's annual National Ambient Air Quality Standard (annual NAAQS) of 40 µg/m3 by more than 200%. The Thar Desert is one of the most fragile ecosystems of India. Its low and uncertain rainfall, high temperatures, high wind speeds, and a rolling sandy topography dominated by 10 to 40 m high sand dunes, provide an awe-inspiring glimpse of desolation and emptiness in the western part of Rajasthan in India and adjoining part of Pakistan, between the Aravalli Hill Ranges and the fertile Indus Valley. As weather grows hot and the winds pick up in late spring, dust storms start to blow across India. The most intense dust storms usually occur just before monsoon season. But 2018 year has been worse than usual. "Every year in April, May, and June, we seen heavy dust loading" In May 2018, India experienced a period of extreme weather, including intense dust and lightning storms. A new burst of storms from June 12-15 over New Delhi led to severe pollution, causing citizens to suffer through poor breathing conditions. A dust storm originated in the western state of Rajasthan on June 12, 2018, as high winds kicked up dust from the Thar desert [2]. Over the next few days, the dust travelled across north central India. "High pollution levels during this time of the year in Delhi were unusual and primarily due to dust storms from Rajasthan. Rajasthan is facing extremely dry weather conditions that time, with high temperatures and wind speeds," [3] The high wind speed and surface temperature condition were conductive in establishing a cyclonic circulation and subsequent dust storm generation. This particular event has been used here for demonstrating the skills of satellite derived AOD value in the form of particulate matter of different size. We estimated PM2.5 and PM10 period between 5 June 2018 to 25 June 2018. In this period high dust emission took place over the Thar region, that travelled to Northern part of India like Delhi region and subsequent degraded the air quality [4] . Here we estimated the PM 2.5 and PM 10 value from satellite data for Delhi and Rajasthan region during this time period. Delhi is located Latitude and longitude coordinates are: 28.610001, 77.230003. Rajasthan is the largest state by area in India. It is located on the western side of the country, located between 23 30’ and 30 11’ North latitude and 69 29’ and 78 17’ East longitude.

3.METHODOLOGY

MODIS AOD satellite data was downloaded from htpp://lpdaac.usga.gov/ for the period between 5 June to 25 June 2018. Version 6 data product is a Moderate Resolution Imaging Spectroradiometer (MODIS) Terra and Aqua combined Land Aerosol Optical Depth (AOD) gridded Level 2 product produced daily at 1 (km) pixel resolution. The data product contains blue band AOD at 0.47 µm, green band AOD at 0.55 µm, AOD uncertainty, fine mode fraction over water, column water vapor over land and clouds, smoke injection height, AOD QA, AOD model at 1km, cosine of solar zenith angle, cosine of view zenith angle, relative azimuth angle, scattering angle, and glint angle at 5km. A low-resolution browse image is also included showing AOD of the blue band at 0.47 µm created using a composite of all available orbits. Ground data has been taken from Central Pollution Control Board (CPCB) and Delhi Pollution Control Committee (DPCC). Consistent data, available from 12 sites, are used to generate PM2.5 and PM10 by MODIS AOD data [4].

4.RESULT

4.1 Analysis PM $_{2.5}$ of Rajasthan

This event happens over the Afghanistan and Pakistan border but suffused dust particle transported toward the Indian region contribute to PM2.5 and PM10 particle (Rajasthan to Delhi). The PM $_{2.5}$ level started spiking from 6 June in Thar desert. The value of PM $_{2.5}$ in 5 June is 142µg/m3.and 6 June is 297 µg/m3 and 7 June is 116 µg/m3. In this period the sand is highly mobile due to strong south-westerly winds occurring before the onset of the monsoon. The PM 2.5 level started spiking from 12 June in Thar desert at Rajasthan state. An average PM 2.5 is 300 µg/m3 between 12 June to 18 June but highest PM 2.5 concentration in 14 June 2018 is 616 µg/m3 in Thar region so at that time dust emission is more in this region. After 18 June 2018 PM 2.5 decreasing suddenly PM2.5 concertation due to wind changes It is observed from all the PM 2.5 map of Rajasthan. High dust emission take place in period between 12 June to 18 June 2018. 14 June show the highest value of PM 2.5 is 616 in Thar desert(fig.1).

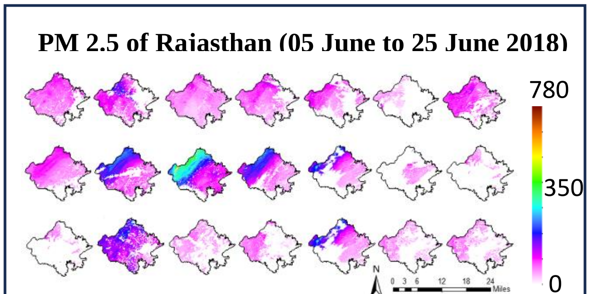

Figure 1

Table-1 PM 2.5 of Rajasthan (correlation coefficient)		
Sn	Station name (area)	Correlation
1	VK Industrial Jaipur	0.27
2	Almar	-0.05
3	Collectorate jodhpur	0.15
4	IndiraColony Vistar, Pali	0.69
5	Shrinath Puram, Kota	-0.17

4.2 Analysis of PM_{10} of Rajasthan

PM 10 concentration of 5 June is 216 µg/m3. 6 June is 667 µg/m3, 7 June is 234 µg/m3, 8 June is 476 µg/m3,9 June is 337 after concentration increasing gradually. The PM 10 level started spiking from 12 June in Thar desert. The value of PM10 in 12 June is 371 µg/m3,13 June is 1121 µg/m3 and 14 June is 1308. The PM 10 level started decline from 19 to 25 June in Thar desert. while on 22 June the value is 441 µg/m3 and 21June value is 224 µg/m3.High dust emission take place in period between 12 June to 18 June 2018. 14 June show the highest value of PM 2.5 is 1308 µg/m3 in Thar desert (fig 2). It has noticed that at the pre phase of the monsoon season the PM 10 values are higher than during the monsoon season. The correlation analysis between CPCB PM10 and satellite PM 10 indicates a significant positive correlation in all station. However, the analysis between these parameters shows (Table2) significant positive correlation in all station.

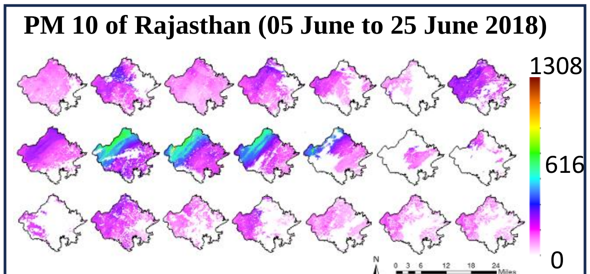

Figure 2

Table-2 PM 10 of Rajasthan (correlation coefficient)		
S.No	Station name	Correlation
1	VK Industrial Area Jaipur	0.27
2	Collectorate jodhpur	0.31
3	Indira Colony Vistar, Pali	0.77
4	Shrinath Puram, Kota	0.37

4.3 Analysis of PM $_{2.5}$ of Delhi

Long range transport of aerosols might be the second reason behind the high PM 2.5 values observed over the Indian land region (Delhi). The value of PM2.5 in 5 June is 294µg/m3.and 6 June is 56 µg/m3 and 7 June is 95 µg/m3. The PM 2.5 level started spiking from 12 June in Delhi. The value of PM25 in 12 June is 175 µg/m3,13 June is 956 µg/m3 and 14 June is 656 after decline take place(fig.3). Major dust come from Thar region. At that period 12 to 18 June 2018 large amount of dust emission take place in Thar desert, it transfers to nearby region like Delhi so at this time Delhi region also show the high amount of dust storm. and Delhi has generally large pollutant because of the vehicle emission and residue burring in Panjab and Haryana state. so highly pollutant area is east and west side of Delhi. The average PM 2.5 concentration between 19 June to 25 June is 100 µg/m3. The PM 2.5 concentration is decline day by day because dust event stops and monsoon reached Delhi at 25 June. The PM 2.5 concentration is higher in 12 June to 18 June period mainly in the east and west side of Delhi because Rajasthan border connected to west side of Delhi. It is observed from the time series plots that, during the 13 June PM 2.5 values are high because dust event (12 June 2018) occurs in Thar region of Rajasthan at that event large amount of dust emission take place and transferred to nearby region so Delhi shows higher PM 2.5 concentration in 13 June 2018 than other days.

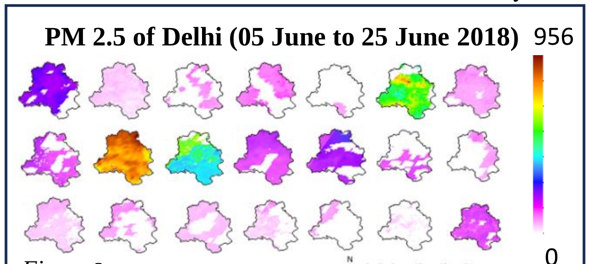

Figure 3

The correlation analysis between CPCB PM 2.5and satellite PM 2.5 indicates a significant positive correlation over day (Table-3). However, the analysis between these parameters shows significant positive correlation in all station.

Table-3 PM 2.5 of Delhi region (correlation coefficient)		
S. No	Station name (area)	Correlation
1	NPL, New Delhi	0.55
2	Delhi University	0.42
3	income tax	0.77
4	new Delhi	0.58
5	Airport (T3)	0.50
6	IMD, Lodhi Road	0.61
7	IMD, Aya Nagar	0.57

4.4Analysis of PM $_{10}$ of Delhi

The value of PM10 in 5 June is 404to 259µg/m^3,6 June is 268 to 40µg/m3 and 7 June is 169.6 to 91µg/m3. A highest value of this period is 10 June 791.15 to 311.12. North -west part of Delhi is highly affected by dust storm emission because it nearby thar region and wind direction. The PM 10 level started spiking from 12 June in Delhi region. the value of PM10 in 12 June is 723 µg/m3,13 June is 1173 µg/m3 and 14 June is 991 µg/m3.Decline after 16 June. A highest value of this period is 16 June 1523 then decline the PM 10 concentration because of the wind direction. North -West Delhi has higher pollutant, high value of PM 10 concentration. The PM 10 concentration is higher in

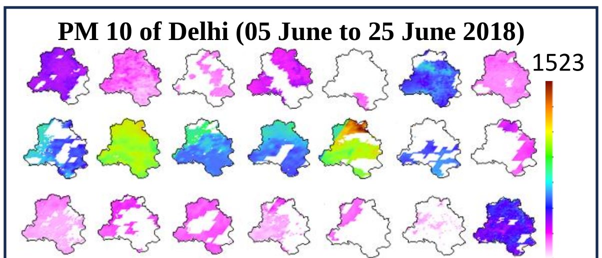

Figure 4

12 June to 18 June period mainly because carry wind North-west direction from thar region toward Indo-Gangetic plain. It is observed that, during the 13 June to 18 June 2108(Fig. 4), PM 10 values are high because dust event (12 June 2018) occur in Thar region of Rajasthan at that event large amount of dust emission take place and transferred to nearby region so Delhi show higher PM 10 concentration in 13 June to 18 June 2018 at different station has high value in different day due to the wind movant than other days. The correlation analysis between CPCB PM10 and satellite PM 10 indicates a significant positive correlation over day. However, the analysis between these parameters shows significant positive correlation in all station (Table-4).

Table-4 PM 10 of Delhi (correlation coefficient)

S. No	Station name (area)	Correlation
1	NPL, New Delhi	0.58
2	Delhi university	0.65
3	IGI Airport	0.54
4	CRRI, Mathura Road	0.72
5	IMD, Aya Nagar	0.74
6	IMD, Lodhi Road	0.80
7	Income tax	0.77
8	New Delhi	0.57

5.CONCLUSIONS AND RECOMMENDATION

Dust generation is a highly nonlinear process that is very sensitive to climate change. satellite-based estimates of PM 2.5 and PM 10 are conservative estimates because of two factors. In the presence of extremely high pollution cases, the atmosphere becomes too bright to retrieve aerosols and instead are misclassified as clouds. The modelling of dust sources is perhaps the most difficult task facing climate modelers. PM 2.5 and PM 10 has been examined in association with aerosol optical depth using remotely sensed MODIS AOD data sets. PM 2.5 and PM 10 has been studied over Thar desert and Delhi form 05 June 2018 to 21 June 2018[5]. The present analysis shows significant positive correlation between ground data and satellite PM 2.5 or PM 10 in Delhi or Rajasthan region expect PM 10 of Almar and Srinath puram (Kota) station. The advantage of pollution monitoring using high-resolution satellite data for the development of air quality management plan at large scale, especially in India where adequate ground-based pollution monitoring network is currently lacking. Though the network is being expanded, it may take decades to reach adequate spatial and population-based coverage. In that way, satellite data can provide guidance in placing monitors by identifying local hot spots. Considering wide ranging impacts of dust aerosols on various socio-economic factors, it is suggested to improve the forecasting skills of the models after combing the satellite data sets, and also installation of more ground-based instruments for monitoring dust activities and validations of models and satellite data sets.

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