

## Aerosol and Black Carbon Over Indo-Gangetic Basin During Lighting Festival (Diwali) Period Using Aethalometer and Back Trajectory Datasets.

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**Abstract:-** —Every year, in the Post-monsoon season Diwali (lighting Festival) a Indian festival basically it is Northern India festival produce numerous health hazardous Problem due to formation of various greenhouse gases, black carbon and fog formation over the Indo-Gangetic Plains (IGP) of Indian region during the winter season. It is believed to create numerous health hazards, economic loss, and cross-country transportation of aerosols. It has attracted the global scientific community's attention to address the uncertainties pertaining to its formation and physico-chemical properties. In this paper, we made an attempt to study the aerosol black carbon conditions that occurred over the north Indian region and long-range transport of aerosols from the fog region over the Indo-Gangetic region during November 2010, using Modis/Terra data, backward trajectory and ground-based observations from Aethalometer on aerosol variation in urban region Ranchi, India. Aethalometer measurements showed a considerable increase in aerosol black carbon Concentration in non-polluted area BIT-Mesra, Ranchi. Which show that what will increment in densely polluted areas in Indo-Gangetic Plains regions. During the festival period compared to a normal day before and after Diwali November 2010.

**Keywords**—Aerosol, Black carbon, Anthropogenic emission, Lighting festival

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### 1. INTRODUCTION

The Indo-Gangetic Plain (IGP) encompasses a vast area, (accounting for ~21% of the land area of India), which is densely populated (accommodating ~40% of the Indian population) Nair et al;(2007). Highly growing economy and population over this region results in a wide

range of anthropogenic activities Prasad et al;(2005). The Indo-Gangetic Plains (IGPs) are one of the world's largest and highly agriculturally productive areas encompassing a vast area from Indus (areas in Pakistan and parts of Punjab and Haryana in India) and the Gangetic Plains (Uttar Pradesh (UP), Bihar, Ranchi and West Bengal in India, Nepal and Bangladesh).Each year, during the months of October and November, Diwali (lighting festival) festival in the Indo Gangetic Plains (IGPs) has significant impact on greenhouse gas emissions, fog and aerosol loadings over the region .Shailesh et al; (2009).

In Indian context, studies have also been reported on the air quality degradation for the firework activities during Diwali festival but they are few. Ravindra et al.(2003) reported that fireworks lead to short term variation in air quality and observed 2 to 3 times increase in PM10 and TSPM concentrations in Hisar city (India) during Diwali festival. Kulshrestha et al.(2004) reported high level of different trace elements in ambient air of Hyderabad, which was due to fireworks during Diwali festival. Barman et al.(2008, 2009) reported the remarkable increase in PM2.5 concentration in Lucknow city due to firework activities during Diwali festival. Effect of firework activities during Diwali on surface Ozone has also been reported in Delhi (Ganguly et al., 2009; Attri et al., 2001). There is one more important pollutant in Diwali festival is black carbon, which is rarely noticed during study of pollutant. The aerosol and black carbon is also expected to have an impact on agriculture, the general economy and the global and regional climate. Gautam et. al ;(2007). In post-monsoon season start the ground temperatures are lowering comparisons to the upper atmosphere layers, inhibiting the dispersion of air and pollutants, and, thus, the cool outside air will cause moisture to condense in to fog. The physico-chemical interactions among gases, particles, and fog droplets can influence the composition of aerosol, as fog droplets provide ideal sites for chemical reactions involving gaseous pollutants. In winter season fog forms in the lower layer of the troposphere where aerosols and gases are most abundant. The concentrated fog may occasionally result in potential hazards for human health, vegetation, and buildings. Highly soluble gases are generally abundant in polluted air and may contribute to higher occurrences of fog in polluted air. The properties of aerosols (size and chemical composition) have a strong impact on the occurrence of fog. Aerosol loading over the Indo-Gangetic Plains (IGP) is increasing, with the growing population, industrialization, and urbanization, which has significant impact as long range transport of aerosol over oceanic region and weather and climatic conditions of India,. Among the many possible disastrous climatic consequences due to increasing aerosols in the IG Plains, an increase in frequency of fog occurrence over the region, especially in its western parts, i.e., the northern plains during winter. There is

availability of abundant moisture sources in the river Ganges, its tributaries, and their various canal networks for irrigation. Moisture from vast cultivated wheat fields in the region and under favourable atmospheric conditions leads to increasing trends of dense fog during winter season. Aerosol, black carbon mixed fog affects the day-to-day lives of millions of people living in this region, resulting in poor visibility down to less than 100 m, causing frequent flight and train delays and even a significant number of deaths from vehicular accidents in many severe events.

In this paper, Aerosol black carbon variation during Diwali festival which comes in post-monsoon season conditions over the Indian region were analyzed using ground-based measurements and satellite data in order to understand the long-range transport of aerosol over IGP in Ranchi station.

## **2. OBJECTIVES**

- To analyze the aerosol and black carbon variations across the IGPs during the Diwali (lighting festival).

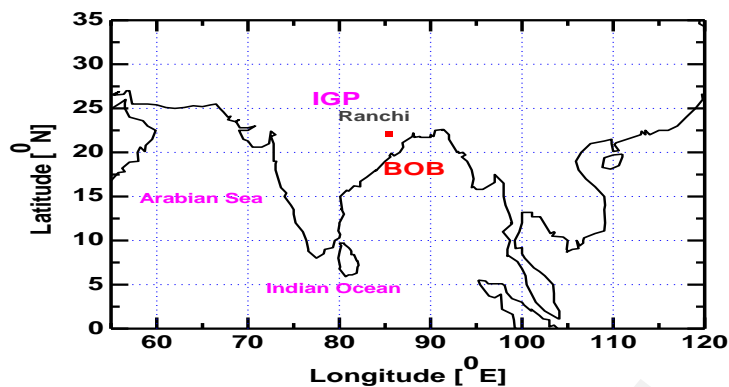
## **3. Data and Methodology:-**

We have used Aethalometer, from BIT Mesra Ranchi, as well as a back-trajectory model and satellite data to retrieve aerosol loadings and black carbon over Ranchi, Indo-Gangetic plains caused due to anthropogenic activities.

### **3.1 Experiment site and Measurement:-**

The instruments used were an Aethalometer, a simple rugged instrument for field experiments, estimated Black carbon by measuring the change in the transmittance of its quartz filter tape onto which the particles impinge. Aethalometer, seven wavelength black carbon measuring, has been operated, for the first time, at Birla Institute of Technology (BIT Mesra,) Mesra, Ranchi, Jharkhand, Climate of the Jharkhand in general is tropical with hot summers and cold winters. Located between the Latitude  $23^{\circ}25'N$ , Longitude  $85^{\circ}24'E$  and attitude on an elevation of 300 to 610 meter above sea level, the climate ranges from dry semi humid to humid semi-arid types. There are regional variations and some parts of the state like Ranchi, Netarhat, and Parasnath have pleasant climate even during the summers. Maximum rainfall takes place during the months from July to September that accounts for

more than 90% of total rainfall in the state with annual rainfall of 1400mm. Precipitation is rather variable. Winter season precipitation is meager and highly variable. There are on an average 130 rainy days in a year and 75 days, rainfall is below 2.5 mm. On 55 rainy days evaporation level is more than 2.5 mm per day. As per estimate out of the average annual precipitation of 10 million hectare meter in the state about 20 % is lost in the atmosphere, 50 % flow as surface runoff and balance 30% soaks into the ground as soil moisture and ground water.



**Fig. (0.1).** Map of Indian subcontinent showing the observational site – Ranchi (23.42N, 85.33E and 650m MSL)

To study the characteristic of Aerosol, Black carbon during lighting festival (Diwali) in Northern India. The experiment site Ranchi compared with the Indo-Gangetic basin, which is one of the most polluted regions in the world (Dey and Tripathi, 2007). Therefore, the possible aerosol types present over the station could be a mixture of water soluble, dust like and soot-type aerosols. Diwali is mega festival for Northern India region, mostly times it comes under Oct-November Month, which is winter season, fog and inversion are dominated on that period. Various types of chemical based fireworks used for enjoyment and lighting. Recently, Prasad et al. (2004, 2005) has carried out seasonal study of AOD over Indian subcontinent and has found that the Indo-Gangetic basin suffers with very high AOD. Di Girolamo et al. (2004) have recently observed high pool of aerosol over the Bihar province (north-eastern region in the Indo-Gangetic basin) using MISR data in India during winter season. Massie et al. (2004) analyzed TOMS data from 1979 to 2000 for the winter season (November–February) and have found large AOD over the IG basin. In the present paper, we show the characteristics of aerosol over Indo-Gangetic Plains of India during specific time period of winter season.

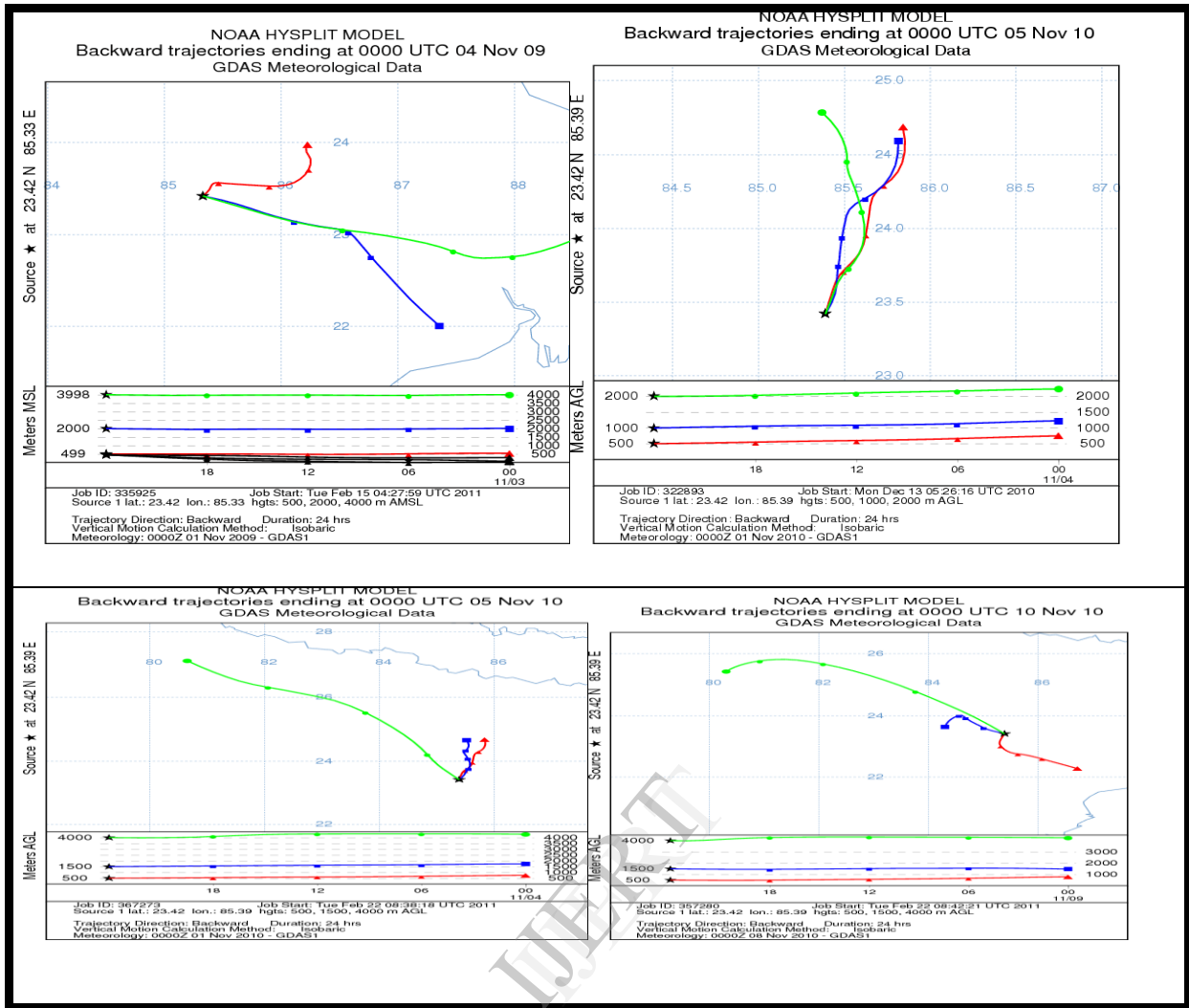
### 3.2 Satellite-Based Measurements

Aerosol particles, such as black carbon soot, are visible from space, enabling a global estimate of the presence of a variety of pollutants using satellite data.

TERRA/AQUA satellite-based MODIS instruments have been acquiring daily global data in 36 spectral bands from visible to thermal infrared. The MODIS sensor is onboard the polar orbiting NASA-EOS Terra and Aqua spacecrafts with equator crossing times of 10:30 and 13:30 local solar time, respectively. The data used in this study include Terra/Aqua satellite-based MODIS aerosol products.

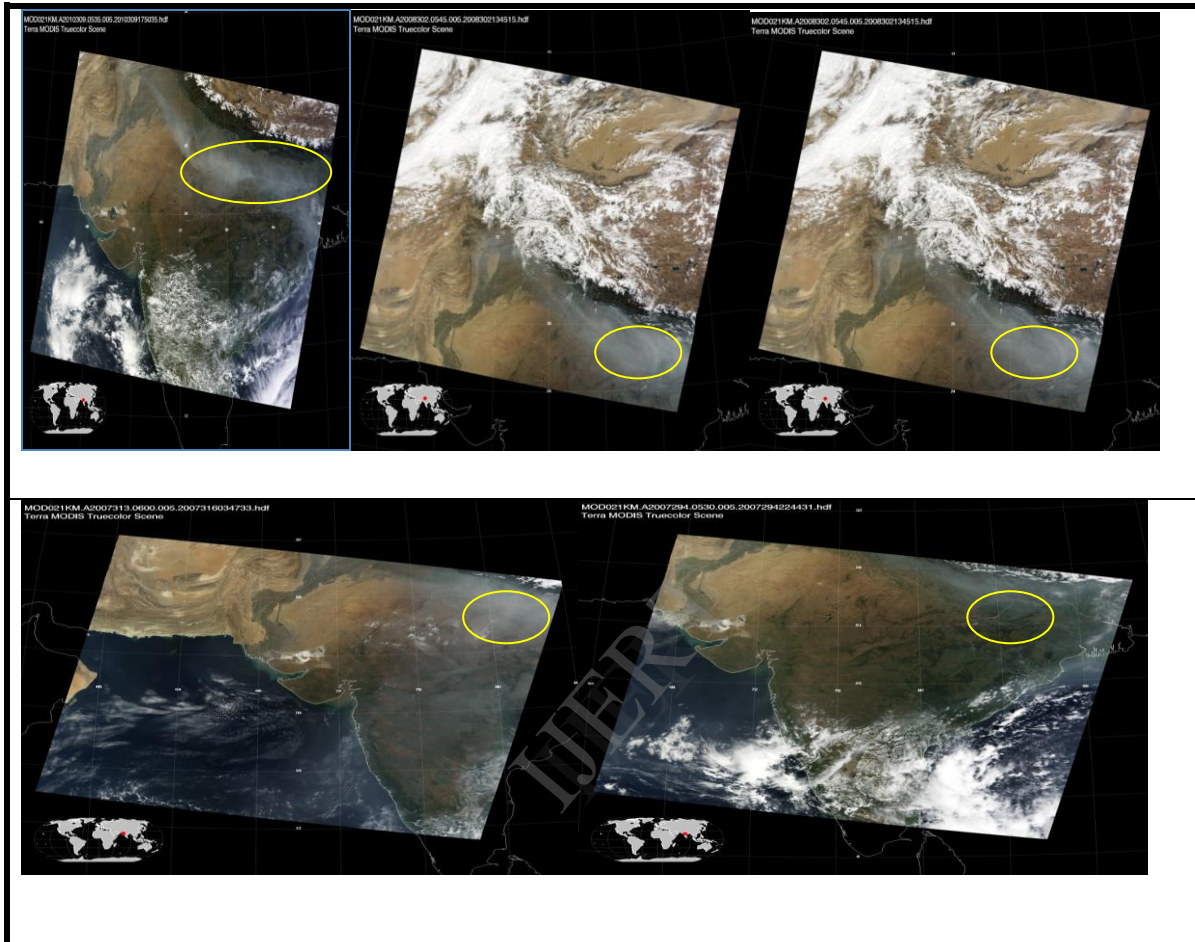
- **Prevailing Meteorology and Air Mass Back Trajectories**

The prevailing meteorology during the study period over Ranchi was composed predominantly of calm synoptic conditions with weak winds, clear skies and absence of precipitation. No major weather systems or cyclonic depressions were encountered in the study area during the Diwali time 2010 at Ranchi station. Aerosol properties over semi-humid arid regions would be significantly modified by the advection of aerosols from adjoining Indo-Gangetic basin under favourable wind conditions. With a view to examine the effect of air mass trajectories, which act as potential conduits for aerosol transport, using HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory) model of NOAA (<http://www.arl.noaa.gov/ready/hysplit4.html>), seven-day back trajectories for all days during the period of study were computed. Clusters of 7-day back trajectories arriving off Ranchi for 500 m, 1000 m, and 2000 m height levels are shown in Figure (1) November 5<sup>th</sup>, 2010.



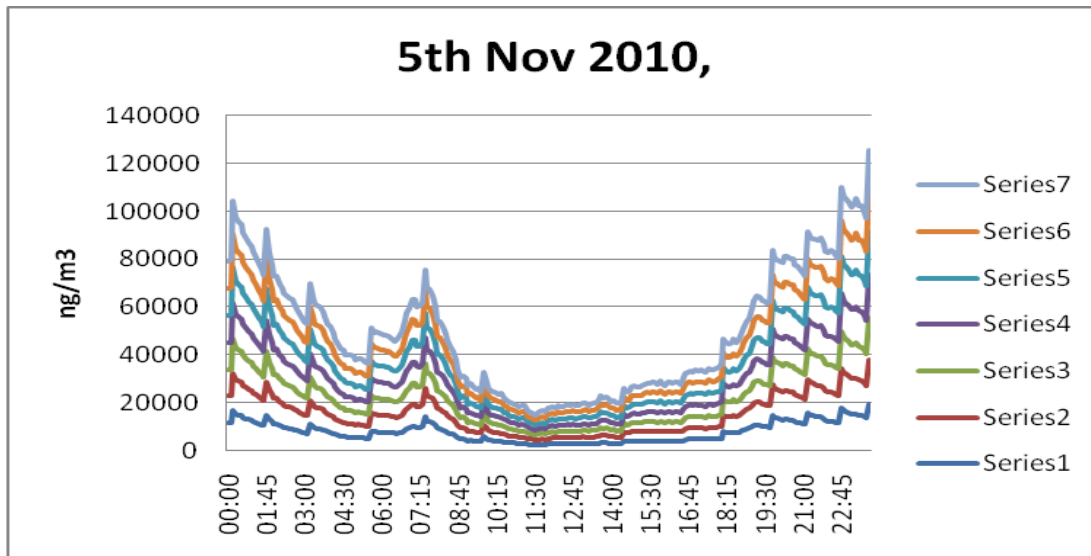
**Figure(1).**-Backward trajectory of 1<sup>st</sup>, 5<sup>th</sup> and 10<sup>th</sup> Nov 2010

It shows that the study region over Ranchi is influenced mainly by the advection from the Indo-Gangetic plains India at 2000 m (free troposphere), whereas at lower levels, (500 m and 1000 m) advection is mainly from continental region with very few trajectories extending up to Indo-Gangetic plain.

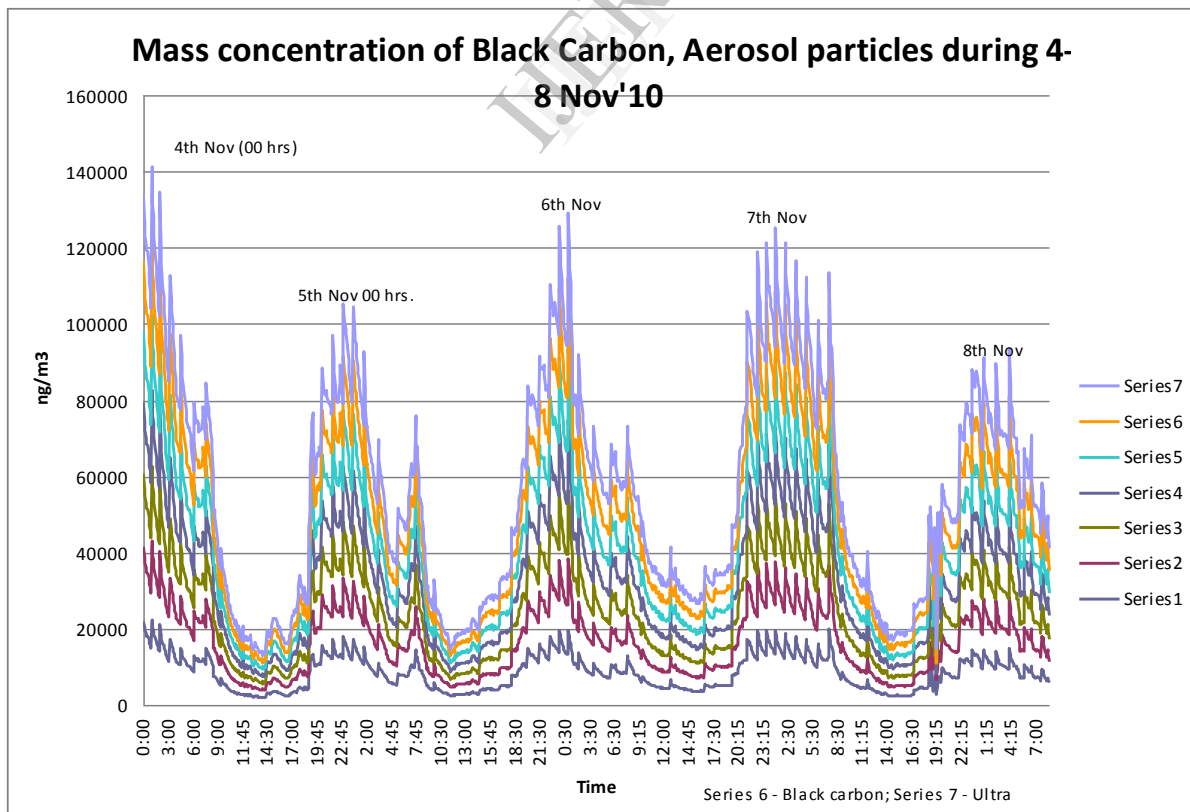


**Figure (2)**-Modis/Terra Image 5<sup>th</sup> Nov.2010,17<sup>th</sup> Oct.2009,28<sup>th</sup> Oct.2008,9<sup>th</sup> Nov2007,and 21<sup>st</sup> Oct.2006

#### 4. RESULTS AND DISCUSSION



**Figure-(3)-** Showing aerosol concentration on Diwali (lighting festival) on all seven wavelength as conc(1)-370nm, conc(2)-470nm, conc(3)-520, conc.(4)-590, conc(5)-660nm, conc (6, black carbon)-880nm and conc.-950nm.





**Fig-(4)-** Showing aerosol concentration on before and after Diwali (lighting festival) on all seven wavelength as conc(1)-370nm, conc(2)-470nm, conc(3)-520, conc.(4)-590, conc(5)-660nm, conc (6, black carbon)-880nm and conc.-950nm

We have characterized the impact of extensive anthropogenic activities associated with major Indian festival known as “Diwali” celebrated on 05th November, 2010 on aerosol properties over Ranchi, Indo-Gangetic Plains using from Aethlometer. **Figure – 3** Showing aerosol concentration on Diwali (lighting festival) on all seven wavelength as conc(1)-370nm, conc(2)-470nm, conc(3)-520, conc.(4)-590, conc(5)-660nm, conc (6 (black carbon)-880nm and conc.-950nm and **Figure-4** Showing aerosol concentration on before and after Diwali (lighting festival) on all seven wavelength as conc(1)-370nm, conc(2)-470nm, conc(3)-520, conc.(4)-590, conc(5)-660nm, conc (6, black carbon)-880nm and conc.-950nm on the festive day of 05th November, 2010 in the IGP area and hazy atmospheric conditions due to fireworks over India are clearly visible in **Fig.2**

This high aerosol loading above the Indo-Gangetic Plains in post-monsoon is mainly attributed to the long-range transport of continental anthropogenic aerosols due to fireworks associated with the festive activities of Diwali. It is clear from the **Fig.2** image taken from Modis/Terra on Diwali festival of 2006-2010 that Indo-Gangetic plains was influenced by anthropogenic aerosol loading during the Diwali period. High levels of pollution are found over region due to extensive fireworks during the festival.

**Fig. 1** Shows the seven-days air mass back trajectories ending above the Ranchi (where high Aerosol value observed) during 5<sup>th</sup> November 2010. It is clear from Fig. 1 that, the air masses originated from the continental region enriched with aerosols and trace gases of anthropogenic origin.

Each year, the northern part of India, especially the Indo-Gangetic Plains (IGP) region, suffers from intense aerosol, black carbon during Diwali Festival in post –monsoons season due to typical meteorological, environmental, and prevailing terrain conditions. The IGP region is highly influenced by western disturbances during Post-monsoon season, which provide ideal conditions for the accumulation of pollutants within the boundary layer and often results in fog formation.

### Satellite Observations

Figs. 2 shows the Terra/Aqua MODIS visible in all Diwali festival figures is prevalent over Indo Gangetic Plains which is shown as a thick mass of white haze . It is common to see dense fog in northern India during Diwali festival in Post-monsoon season.

## 5. CONCLUSIONS

Fireworks ignition during the Diwali festivities significantly affects atmospheric composition around the Indian subcontinent and oceanic region. In this study, we have shown that the changes in atmospheric composition are even detectable by Aethalometer and back trajectory.

Results of data analyses showed that –

The increase in the aerosol optical depth may have occurred due to coagulation of liquid water with aerosol basically in Post-monsoon season, thereby forming larger size aerosol which increase the residence time of fog over indo-Gangetic plains.

Local meteorological condition can not eliminated as the night on Diwali festival in which huge amount of firework of set off. Thus large amount of smog, sulphur dioxide and other gases released in the atmosphere might have converted into aerosols and black carbon. There was cooling of about 5°C to 6°C at surface due to which there was a suppressed level of atmospheric turbulence which may have also resulted in the increase residence time of fog in winter and aerosol optical depth.

### Acknowledgement:

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