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Research Article

ROLE OF SATELLITE DERIVED PRODUCTS IN MONITORING THE FOG AT JPNI AIRPORT PATNA

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ABSTRACT

Winter season (December –February) time over North-West India is badly affected by low visibility Phenomena (Fog /Mist /Haze) every year. Mostly radiation fog generated in clear sky, calm wind and humid (~90 %) conditions or after passing the westward moving synoptic scale weather systems prevails over the area. The day to day activities related to traffic (land, sea, air) and related economic growth of the country severely affected. Timely forecasting of fog is very difficult task for meteorologists. With the help of recently developed new visualization tool, Real time Analysis of Products and Information Dissemination (RAPID) it is possible to diagnose the trend of intensity and areal extent of fog in nearly real time basis with the help of satellite derived products. Satellite wind derived products, like shear and shear tendency play an eminent role in the dispersal of fog /stratus over the area. Proper discrimination of fog /stratus in the present Indian scenario is extremely difficult. In near future with the help of technological advancement of INSAT Imager and sounder the discrimination of fog /stratus can be done. In the present work both INSAT-3D and the role of wind shear and shear tendency derived from Meteosat -7 satellites available on Cooperative Institute of Meteorological Satellite studies (CIMSS) global website link is highlighted with reference of Patna airport of Bihar district.

Keywords: *Wind Shear, Shear Tendency, Fog and Stratus, Outgoing Long Wave Radiation*

INTRODUCTION

Patna airport ($25^{\circ}35^{'}37^{''}N$, $85^{\circ}05^{'}31^{''}E$)is known as Jai Prakash Narayan International (JPNI) airport and one of the main airport of east central India. The height of the JPNI airport is 52 meter above mean sea level (msl). It has ENE-WSW run way (1800 meter) orientation along with densely populated botanical garden at the eastern end. Due to short run way the effect of fog during winter time is the most crucial. The favorable conditions for its development are light or calm wind, clear sky, high moisture and lack of turbulence and visibility reduces to less than 1000 meter. The regions of Patna and neighboured comprise of major agricultural fields or local moisture source like Ganga river which also take part in fog formation and its persistency as these localized conditions have important role in radiation fog formation.

Some statistical characteristics of fog during the year 2000-2010 have been studied by Laskar *et al.*, (2013) and found that the fog events are increasing during last 10 years. Similar type of studies in the resent past has been done by various authors at other airports of India (Mishra and Mohapatra, 2004; Roy *et al.*, 2004; Suresh *et al.*, 2007; Suresh and Mohapatra, 2008). Fog has been classified into following categories of different intensities as per visibility conditions of a particular hour: general fog: If visibility <1000 meters; light fog : If visibility <1000 meters but ≥500; moderate fog: If visibility <500 meters but ≥ 200; thick fog : If visibility <200 meters but ≥50; Very thick fog: If visibility <50 meters. A day is called as a foggy day *i.e.*, a general fog day if at least one observation has reported visibility <1000 meters out of all hourly data of 24 observations a day starting from 0000 UTC of a date till 2300 UTC. Similarly, number of hours of a particular fog has been counted for day to day as per number of hours of reporting of visibility at a particular range as defined before (Jenamani, 2012). The importance of the fog study during night time is done by Bendix (2002) over Germany and adjacent areas and over Northwest India using Moderate Resolution Imaging Spectroradiometer (MODIS) and Indian Satellite (INSAT) data by Giri and Sharma (2011), Chaurasia *et al.*, (2011). Apart from the use of satellite data (Lee *et al.*, 2010) modelling studies can also be carried out for the occurrence of prolonged fog over the Indian region (Choi and Speer, 2006; Shi *et al*., 2010).

MATERIALS AND EMTHODS

Data and Methodology

The meteorological data of visibility (November to February, 2011-2015) used for the present work is taken from meteorological centre, Patna. Satellite (INSAT-3D or KALPANA) derived products are extracted from the recently launched visualization tool, Real time Analysis of Products and Information Dissemination (RAPID) by India Meteorological Department (IMD) & Indian Space Research Organisation (ISRO). Satellite derived wind and shear tendency data utilized in this work has been taken from the global website: http://tropic.ssec.wisc.edu/real-time/ at three hourly intervals.

RESULTS AND DISCUSSION

Figure (1) shows the mechanism of the radiation fog formation over the area. Moist air close to surface starts lifting up by turbulent mixing till the inversion layer of the atmosphere. Figure (2) below shows the fog frequency of light, moderate, thick and very thick fog based on visibility condition of Jai Prakash Narayan Airport (JPNI) Patna. The frequency of fog occurrence is slightly reduced during 2011-2015 as compared to the previous study conducted by Laskar *et al.*, (2013). This may be because the fog generation mechanism during winter season is normally affected by WDs weather systems and Fog dispersal rate is induced by the movement of WDs. The number of WDs which affected Bihar region during November to February is comparatively lesser than the study conducted by Laskar *et al.*, (2013). The frequency of light fog is about 52 % followed by moderate fog (~18 %) and thick and very thick fog (~15 %) each (figure 2).

Role of Satellite Derived Products

The areal extent of fog during day time is easily monitored by the visible image of the INSAT-satellite. It has different texture in image over the fog area due to different reflectivity values. During night brightness temperature difference of shortwave infrared and infrared 1 or 2 channel differences will provide the fog signature over the area. In this study fog conditions during January and February are monitored with satellite derived products. The satellite derived products for one fog spell, 13 January, 2015 to 19 January, 2015 is given in this study. Figures other cases are not given here for brevity. It is seen from the limited data set of the study that:

Thermal infrared brightness temperature for both the channels of infrared (10.5-11.5 um & 11.5 to 12.5 um) lies between 290 K to 280 K over the fog area (Figure 7). The water vapour brightness temperature ranges between 250 K to 265 K over the foggy area (figure 6). The upper tropospheric humidity (UTH) changes between 5 to 14 % over the fog area (figure 5). Similarly, the outgoing long wave radiation (OLR) values lies between 250 to 280 watt /m^2 over the foggy area. The rate of increasing or decreasing the fog area (figure 3) is monitored easily by computing the area of fog in consecutive satellite images using the RAPID tool. If the fog area increasing fast and wind shear is low (negative tendency within 10 knots) then we can reschedule our flight. It helps in root forecast also by observing the direction of the filling of fog area over the region.

Wind Shear and Wind Shear Tendency

Figure 9(a, b) below shows the deep layer shear tendency derived from Meteosat -7 satellite wind products. Decreasing shear tendency rate of the order up to 10 knot is favorable for fog formation and increasing shear tendency of the order of 10 -20 knot will support the dissipation of fog. This product is available every three hourly on global web –site. By analyzing the trend of shear tendency one can reschedule the flight operation. If the tendency is decreasing then there will be the possibility of fog persistency around that region. During winter season the region is normally affected by WDs weather systems which can easily be monitored by the wind shear and its tendency products. Fog dispersal rate is induced by the movement of WDs. Movement of WDs is coupled with atmospheric motion at different layers of the atmosphere and decided by the rate of wind shear or its tendency. By seeing the gradient of winds at various layers the movement of clouds over the area is decided. If shear tendency is increasing and of the orders of 20 to 30 knots, clouds will be disorganize faster and weather will be almost clear and free from fog. For deciding the fog intensity visibility values are also shown in figure 8.

Concluding Remarks

During winter time starting from November to February JPNI airport, Patna come across several occasions of reduced visibility (Foggy like) conditions. The overall frequency of fog decreased slightly during last 5 years (2011-2015) as compared to year 2001 to 2010.

The rate and direction of areal extent of fog can easily be computed using recently developed visualization tool RAPID jointly by ISRO and IMD.

INSAT imager derived products like OLR,UTH, brightness temperatures of infrared and water vapour channels play an eminent role during fog conditions. It is observed from the limited period of the study that:

Thermal infrared brightness temperature for both the channels of infrared (10.5-11.5 um & 11.5 to 12.5 um) lies between 290 K to 280 K over the fog area (Figure 7). The water vapour brightness temperature ranges between 250 K to 265 K over the foggy area (figure 6). The upper tropospheric humidity (UTH) changes between 5 to 14 % over the fog area (figure 5).

Similarly, the outgoing long wave radiation (OLR) values lies between 250 to 280 watt /m^2 over the foggy area. If the fog area increasing fast and wind shear is low (negative tendency within 10 knots) then we can reschedule our flight. It helps in root forecast also by observing the direction of the filling of fog area over the region.

Fog /stratus discrimination is still a great challenge. In future, with the advanced of latest sounder and imager specifications a new methodology of forecasting the fog with satellite inputs can be made.

ACKNOWLEDGEMENT
The author is grateful to the Director General of IMD for providing the data of this study.

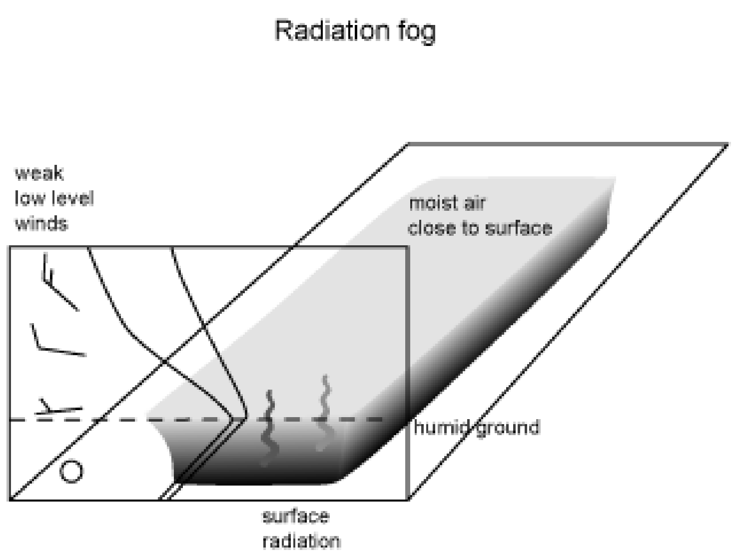

Figure 1: Mechanism of radiation fog

Source:(http://www.zamg.ac.at/docu/Manual/SatManu/main.htm?/docu/Manual/SatManu/CMs/FgStr/backgr.htm)

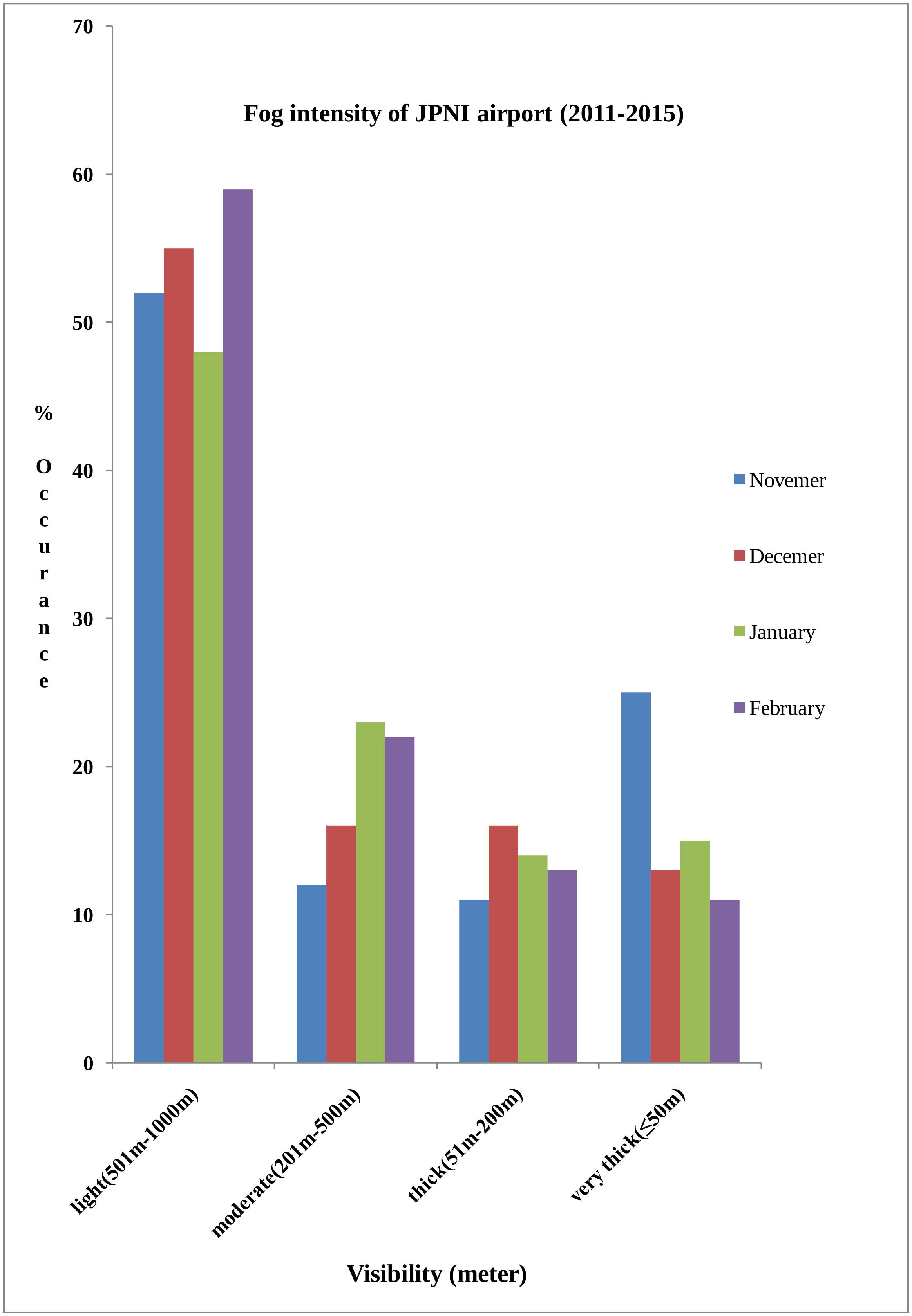

Figure 2: Intensity of fog at JPNI airport (2011-2015)

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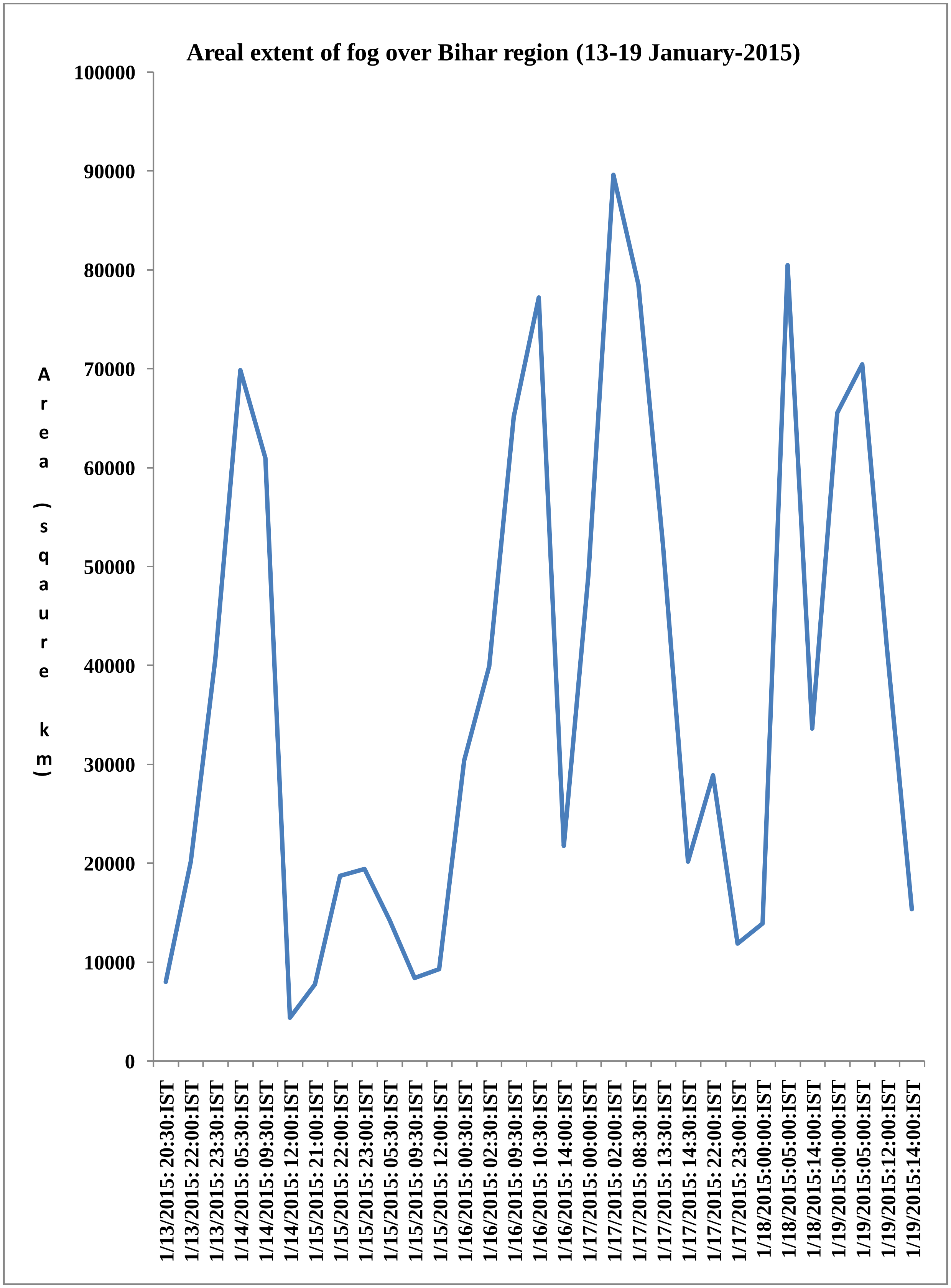

Figure 3: Areal extent of fog over Bihar region (13-19 January-2015)

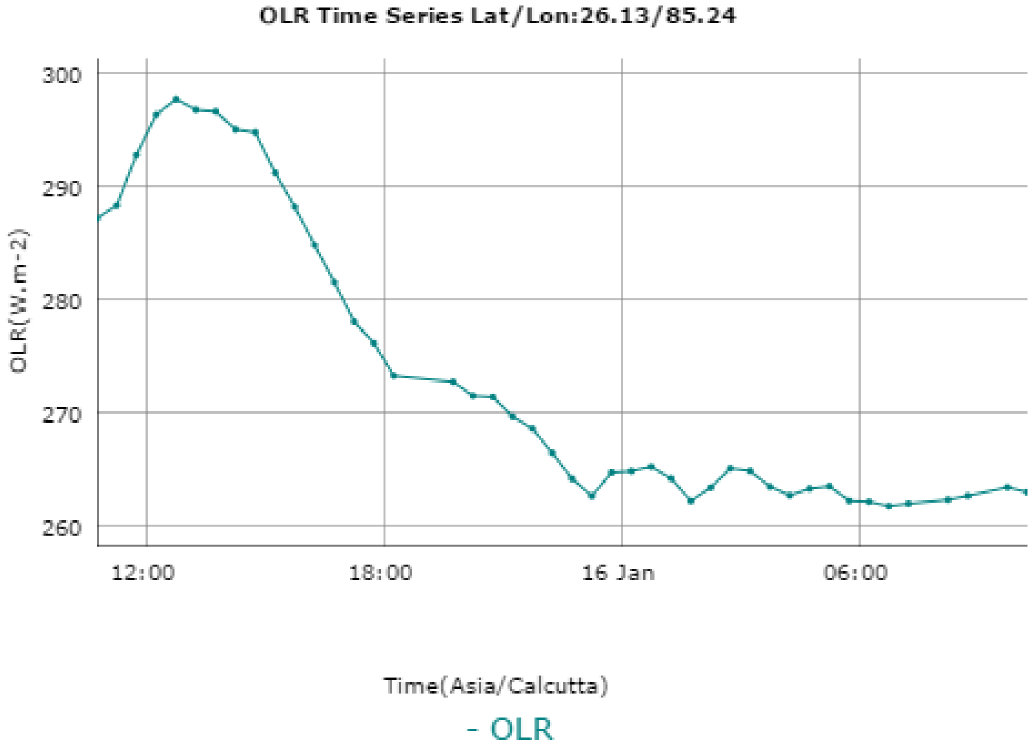

Figure 4: Outgoing long wave radiation (OLR) at lat /lon 26.13/85.24 on 16 January-2015

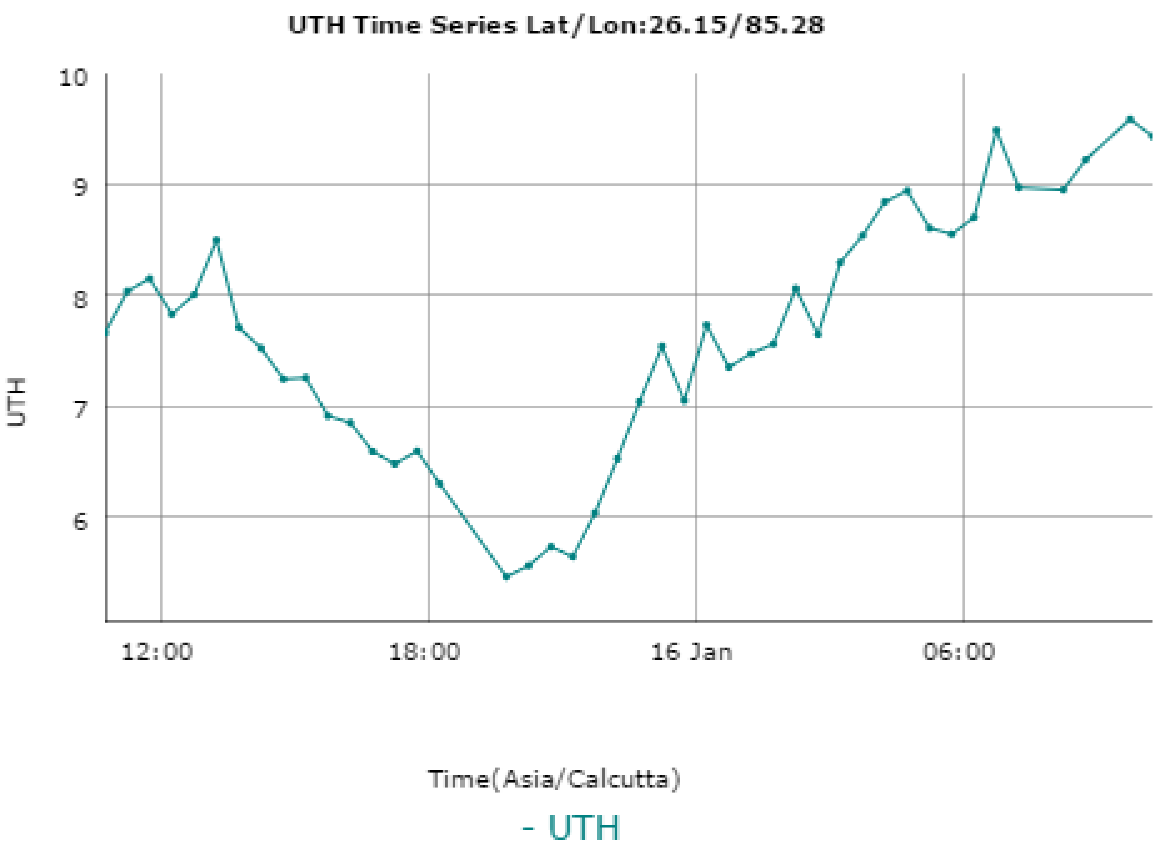

Figure 5: Upper tropospheric humidity (UTH) at lat /lon 26.15/85.28 on 16 January-2015

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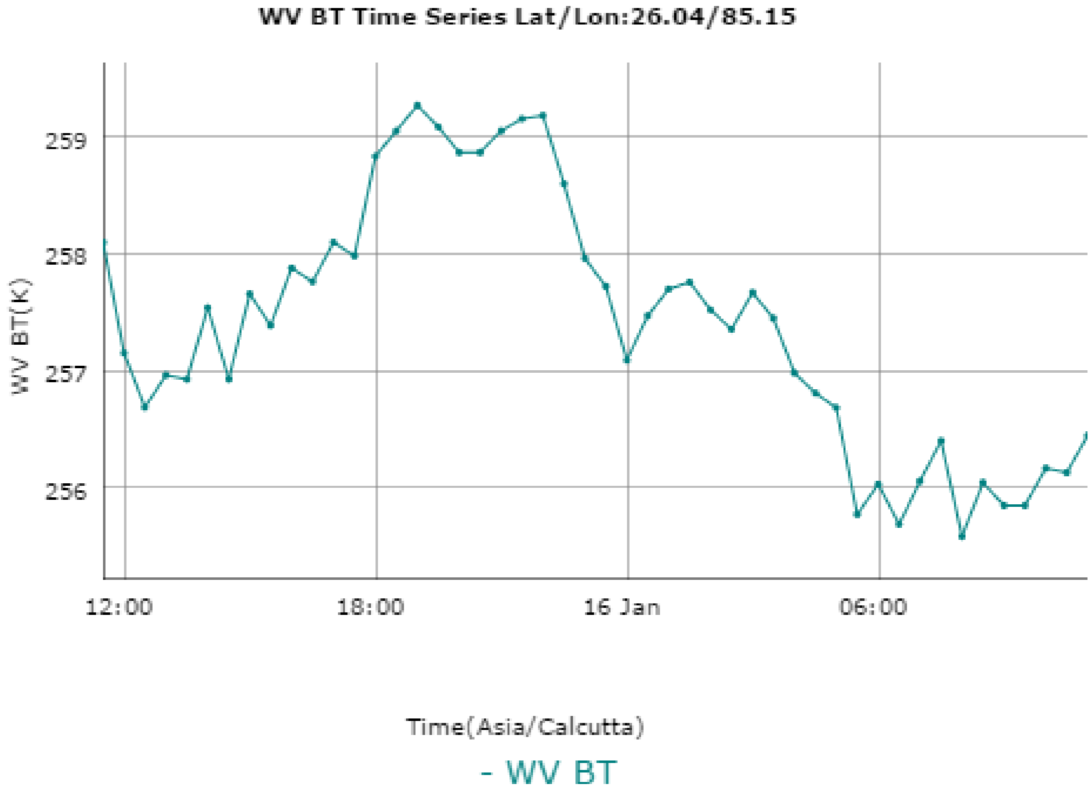

Figure 6: Water vapour brightness temperature (WV-BT) at lat /lon 26.04/85.15 on 16 January-2015

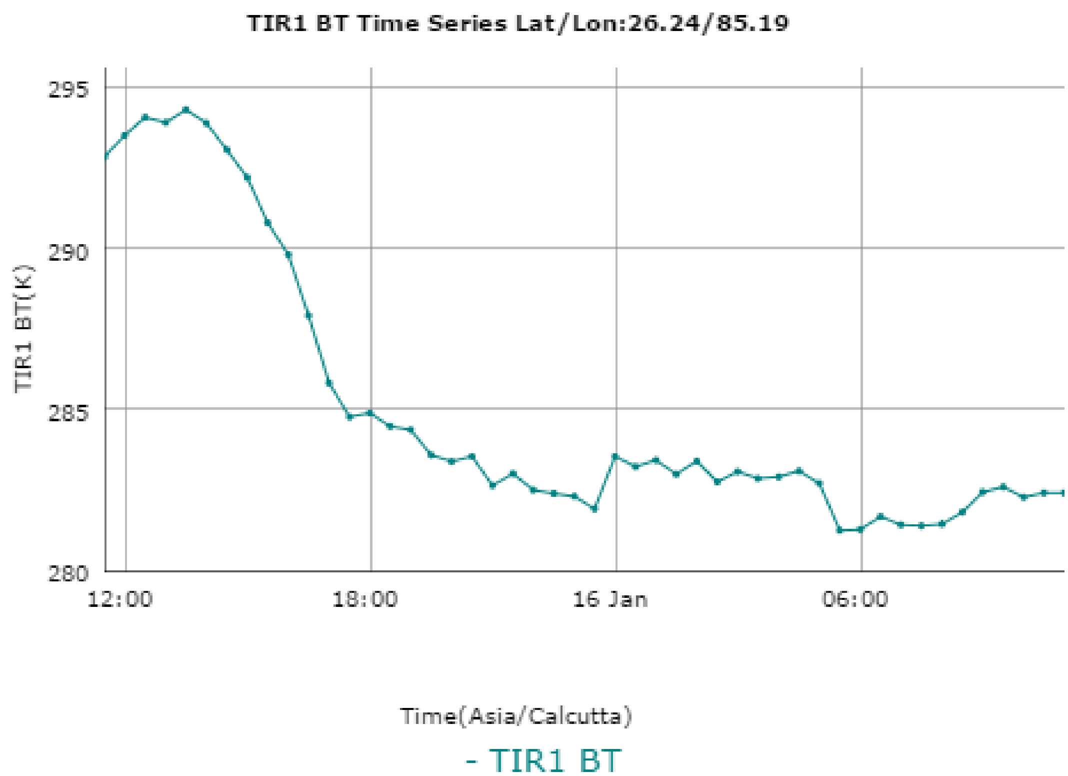

Figure 7: Infra-red brightness temperature (IR1-BT) at lat /lon 26.24/85.19 on 16 January-2015

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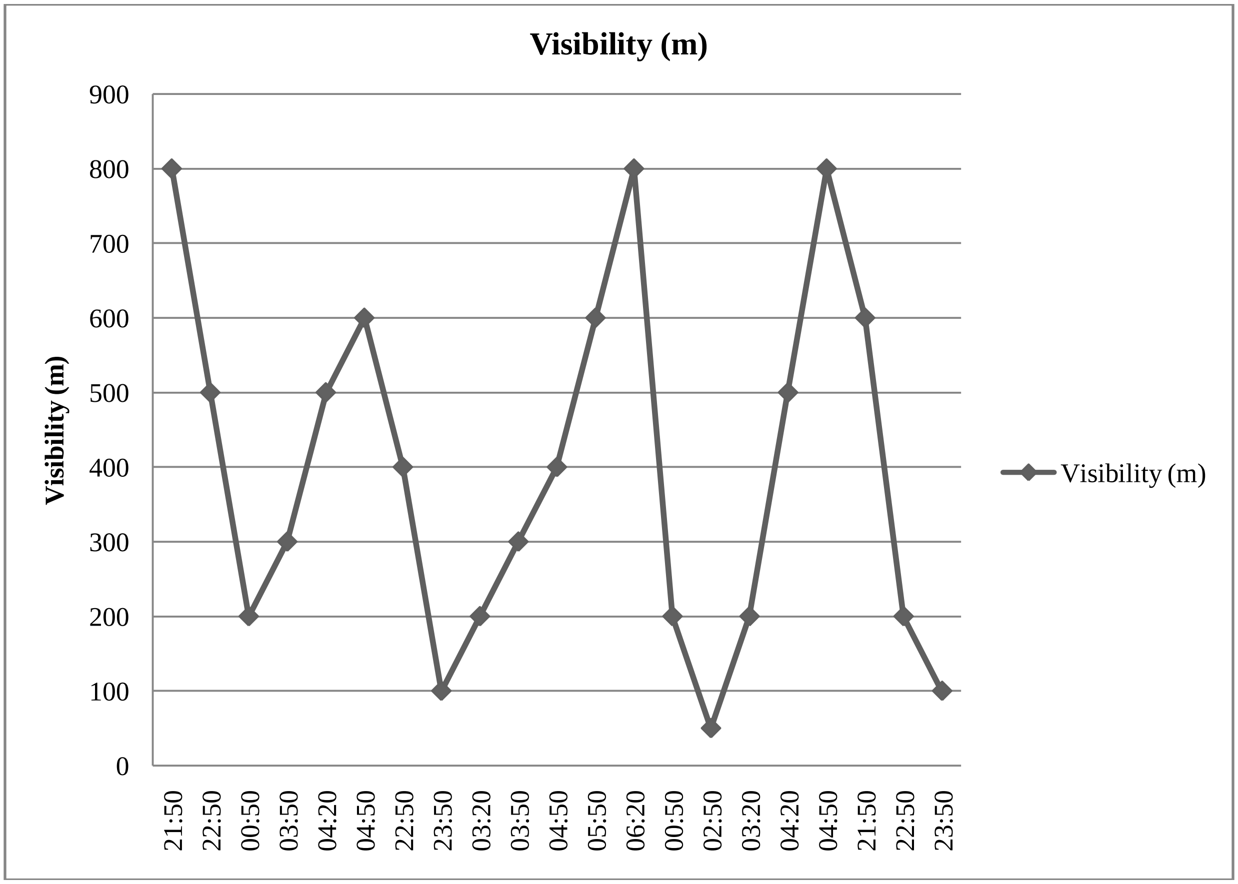

Figure 8: Visibility on 11, 12, 13 and 16 January-2014 at JPNI airport Patna

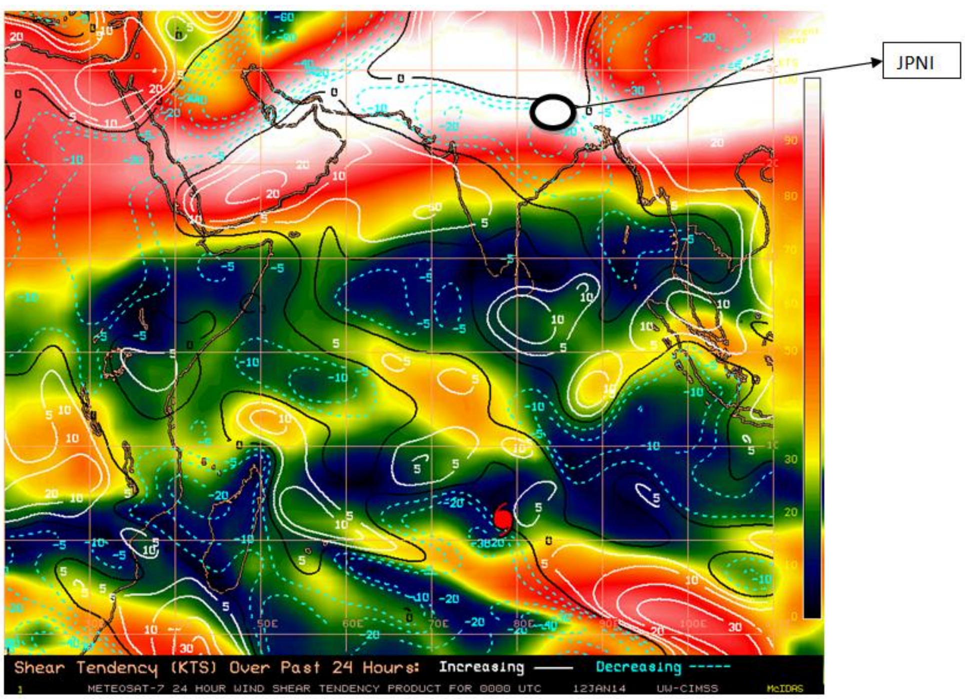

Figure 9 (a): Shear tendency 12 January-2014 at 0000 UTC
{Decreasing shear tendency (10 to 20 knots) over Patna Area (25.6 N & 85.14 E)}

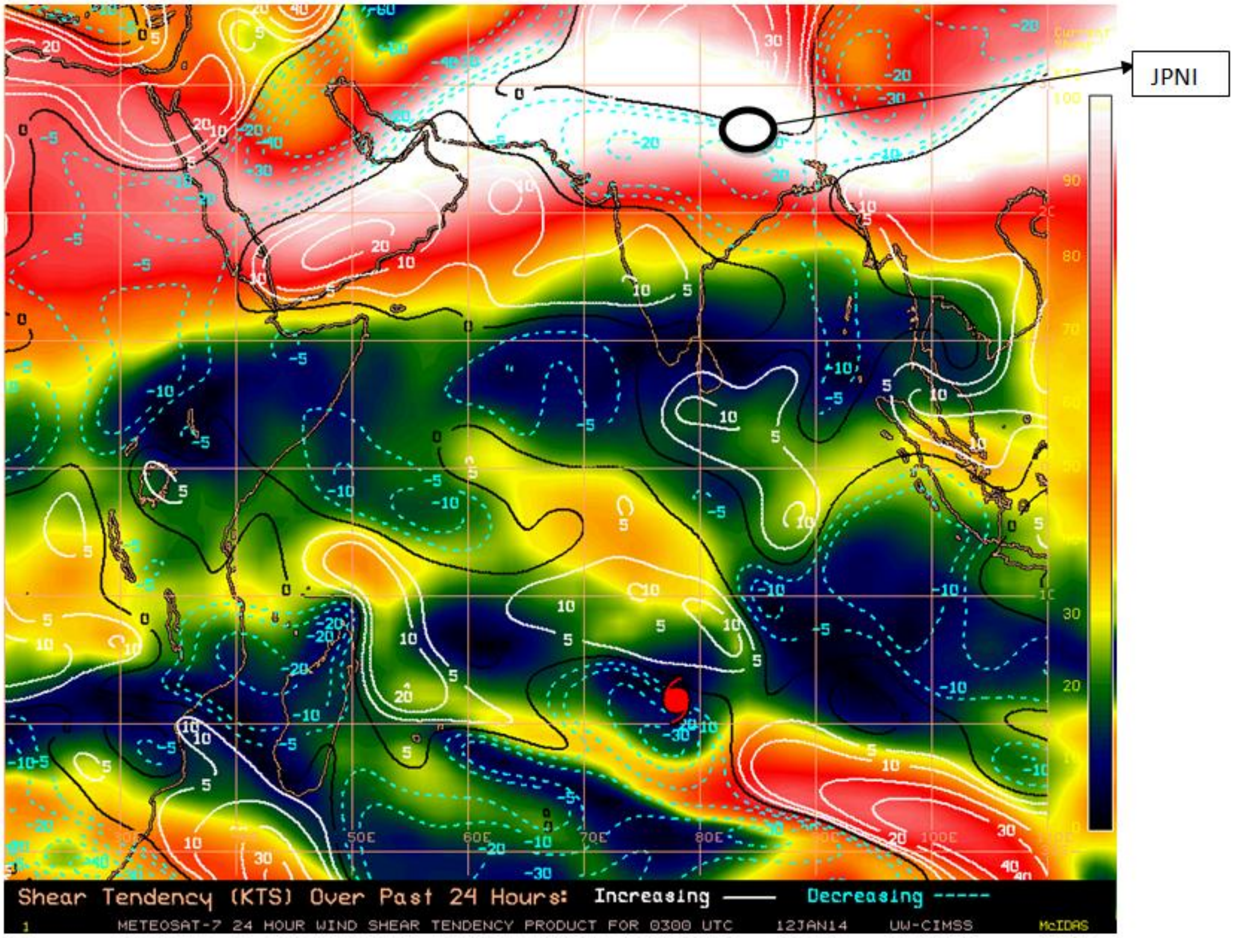

Figure 9 (b): Shear tendency 12 January-2014 at 0300 UTC
{Decreasing shear tendency (10 to 20 knots) over Patna Area (25.6 N & 85.14 E)}

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