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Heat wave episode 24-27 May-2020 monitored through INSAT-3D satellite data over the Indian region

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Abstract

Satellite derived products play an important role to monitor the weather events in each season throughout the year over India. In the year 2020, during lock down period 24 to 27th may-2020 almost all parts of the india witnessed blistering heat wave conditions. This may be attributed to the northward shift of jet stream with ridge aloft can cause many parts of India (especially central India) including Pakistan will face heat wave conditions. This situation is well captured by insat-3d derived products (outgoing longwave radiation, land surface temperature, land surface albedo and upper tropospheric humidity etc) was found to be very useful in diagnosing the heat wave spread over the Indian region. It has been observed that outgoing long wave radiation (OLR) lies>300 watt/m^2, upper tropospheric humidity (UTH 5-20 %) Land surface albedo (LSA 15-35 %), Land surface temperature (LST > 315°K) and net radiation (600 -800 watt.m^2) have been noticed during the prevailing heat wave condition over India during 24-27 May-2020.

Keywords: Heat wave, INSAT-3D, satellite derived products

1. Introduction

INSAT-3D, an Advanced Weather Satellite has completed two successful years in orbit on July 26, 2015. It was launched by Ariane VA214 flight from French Guyana on July 26, 2013 at 01:24 hrs (IST) [1]. INSAT-3D is an exclusive mission designed for enhanced meteorological observations and monitoring over land and ocean surfaces for weather forecasting and disaster warnings. INSAT-3D is the first Indian geostationary satellite, equipped with sounder instrument that provides frequent good quality atmospheric profiles (temperature, humidity) over Indian landmass and adjoining areas [1].

The main objective of the INSAT-3D mission is to provide high quality observations for monitoring and prediction of weather events as well as for the study of climate. The state-of-the-art instruments like "Imager" and "Sounder" onboard INSAT-3D satellite provide a wide range of atmospheric products such as cloud coverage images, atmospheric winds, sea and land surface temperatures, humidity, quantitative rainfall, earth's radiation, atmospheric profiles, ozone, atmospheric stability parameters, fog, snow, aerosols. These products are immensely helpful in monitoring day-to-day weather and prediction of extreme events like tropical cyclone, thunderstorm, cloud burst and heat waves. Detail of the payloads are given below:

Imager: It is a multi-spectral Imager (optical radiometer) capable of generating the images of the earth in six wavelength bands significant for meteorological observations, namely, visible (0.55-0.75 µm), short-wave infrared (1.55-1.70 & 11.5-12.5 µm)& Visible (0.5 -0.75 µm), near infrared (middle infrared (3.8-4.0 µm), water vapour (6.5-7.1µm) and two bands in thermal infrared (10.2-11.3µm regions. The Imager generates images of the earth disk in every 26 minutes and provide information on various parameters, namely, outgoing long-wave radiation, quantitative precipitation estimation, sea surface temperature, snow cover, cloud motion winds, etc [2].

Sounder: INSAT-3D carries a 19 channel Sounder, with 18 narrow spectral channels in short-wave infrared, middle infrared and long wave infrared regions and one channel in the visible region. It provides information on the vertical profiles of temperature, humidity and integrated ozone. These profiles are available for a selected region over Indian landmass every one hour and for the entire Indian Ocean Region every six hours. Sometimes the other internationally satellite derived information also provides a useful resource for value addition like European satellite through Copernicus Climate Change Service provides the data globally. Their models show that hotter and drier weather is highly likely to stretch across key agricultural regions in the European Union, potentially compounding drought conditions that have been made worse by climate change.

Abnormally high temperatures have led to billions of dollars in lost revenue over the past year. During the northern hemisphere's winter months, energy producers had to curtail fuel supplies because everyone from homeowners to heavy industry didn't need as much heat as usual. Record temperatures in July 2019 forced power plants to shut, delayed trains and scorched crops [2].

2. Data and Methodology

The INSAT-3D data maps generated by analyzed through Real-time analysis of products and information dissemination (RAPID), a web-based interface developed by ISRO. This gateway is globally available in public domain for users and forecasters to view and analyze INSAT-3D/3DR images. The INSAT-3D data utilized in this study has been taken from India Meteorological Department satellite division, Lodi Road, New Delhi. The products derived from INSAT-3D Imager data have been analyzed during the time of heat wave conditions prevailing over the country and neighbored areas during lockdown period (24-27th May-2020). The observational facts like increase of outgoing long wave radiation (OLR in watt/m^2), upper tropospheric humidity (UTH in %) Land surface albedo (LSA in %), Land surface temperature (LST in degree °C or °K) and net radiation (in watt .m$^{2)}$ have been utilized [2].

3. Results and discussions

Outgoing Long wave Radiation (OLR)

It is seen from the figures 1 (a-d) the INSAT-3D derived outgoing long wave radiation is very useful in assessing the dry and wet conditions over the Indian region. Outgoing Long Wave Radiation (OLR) is the total longwave radiative flux (in units of W/m^2), emitted to space by the earth-atmosphere system integrated from radiances emitted at all angles and all frequencies. OLR

is not directly measured but is calculated from the retrieved state. OLR has been widely used as a proxy for convective activity in the tropics. Susskind et al. [3-5] used the first nine years of AIRS retrievals to attribute changes in OLR to the effects of El Niño/ La Niña oscillations on the distributions of tropical water vapor and cloud cover. Higher values of OLR (> 300 watt /m^2 indicated almost dry weather and it covers entire India except some southern parts on all 4 days 24-27 May-2020, Figures 1 (a-d).

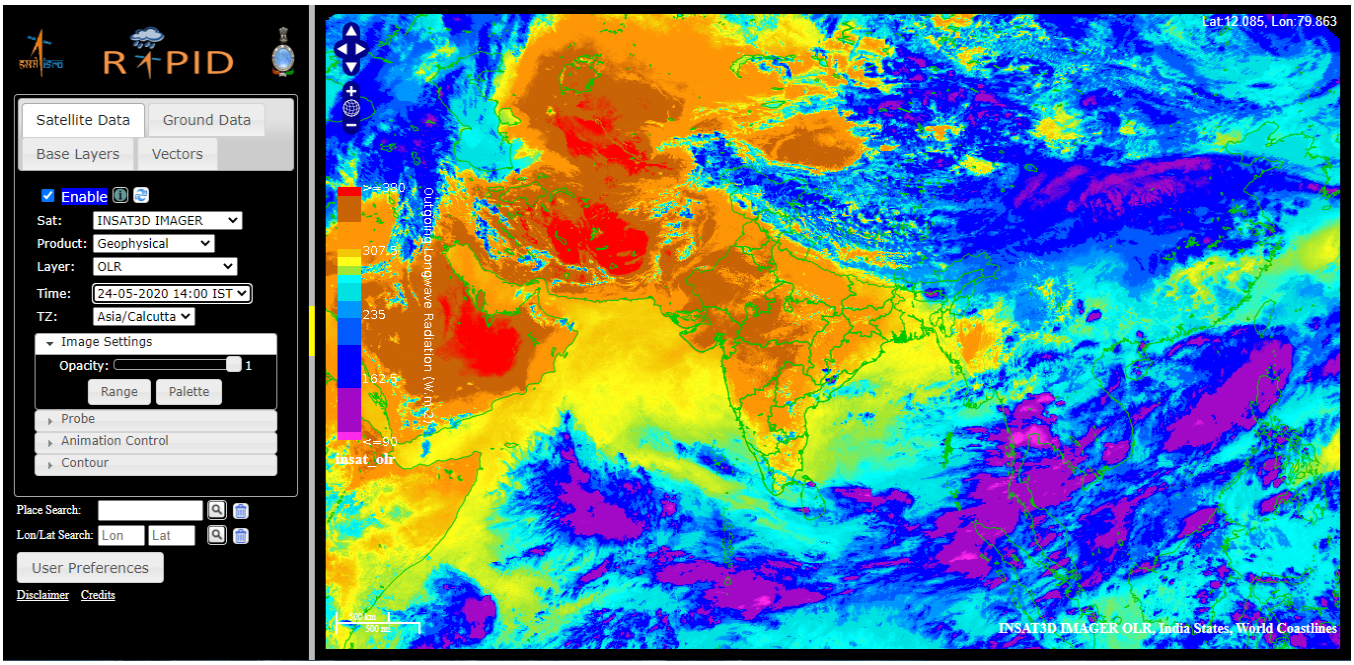

Figure 1 (a) With rapid urbanization, population growth and anthropogenic activities, an increasing number of major cities24 May-2020 outgoing long-wave radiation (OLR): 14:00 IST.

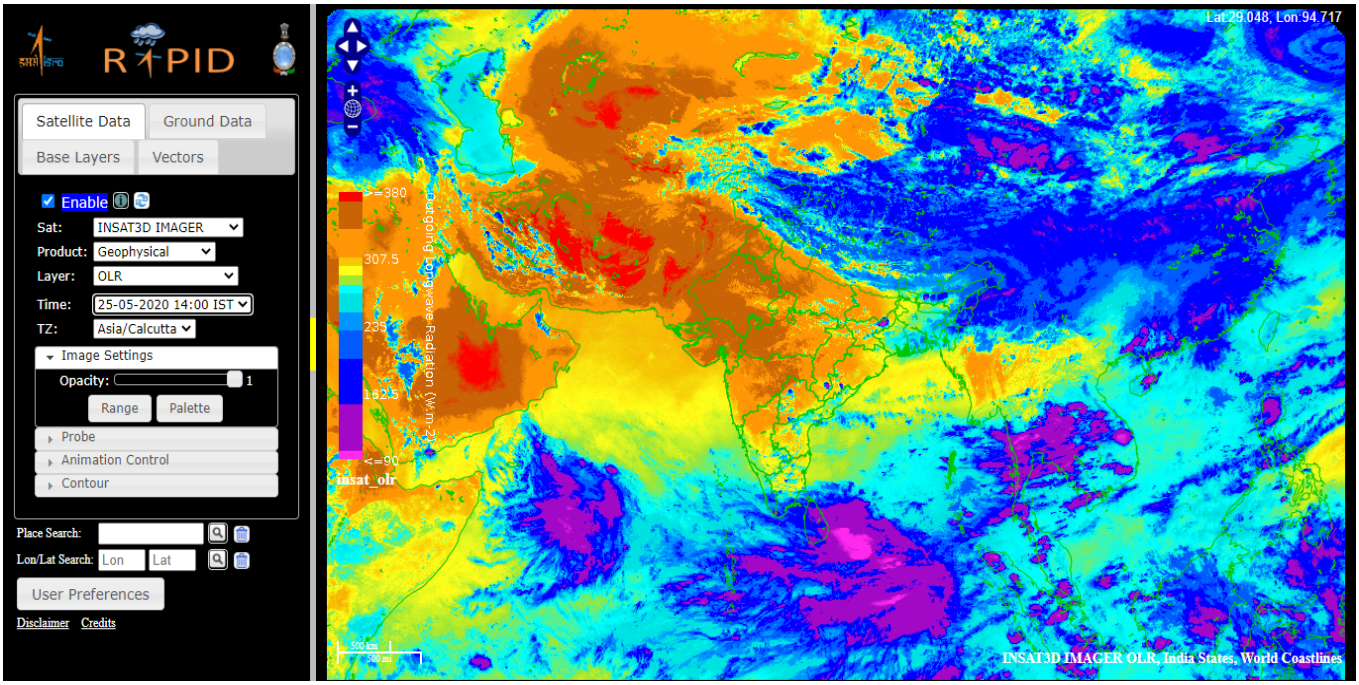

Figure 1 (b) 25 May-2020 outgoing long-wave radiation (OLR): 14:00 IST.

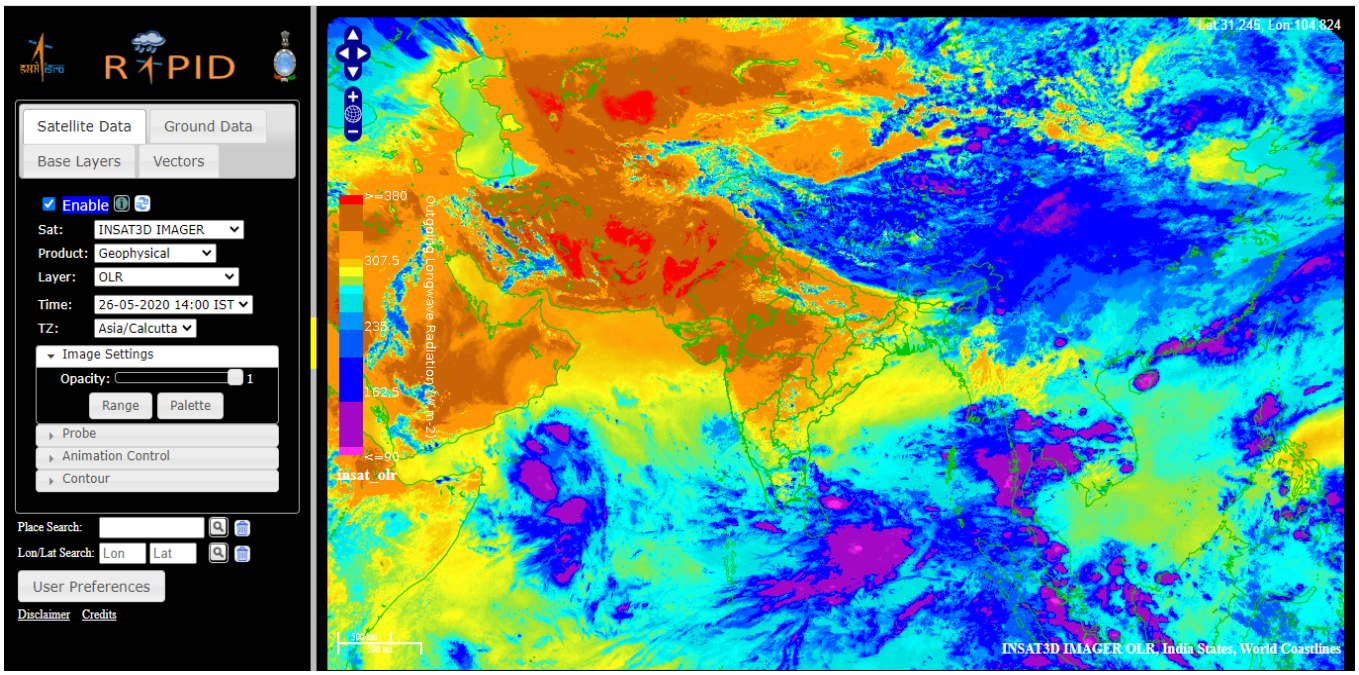

Figure 1 (c) 26 May-2020 outgoing long-wave radiation (OLR): 14:00 IST.

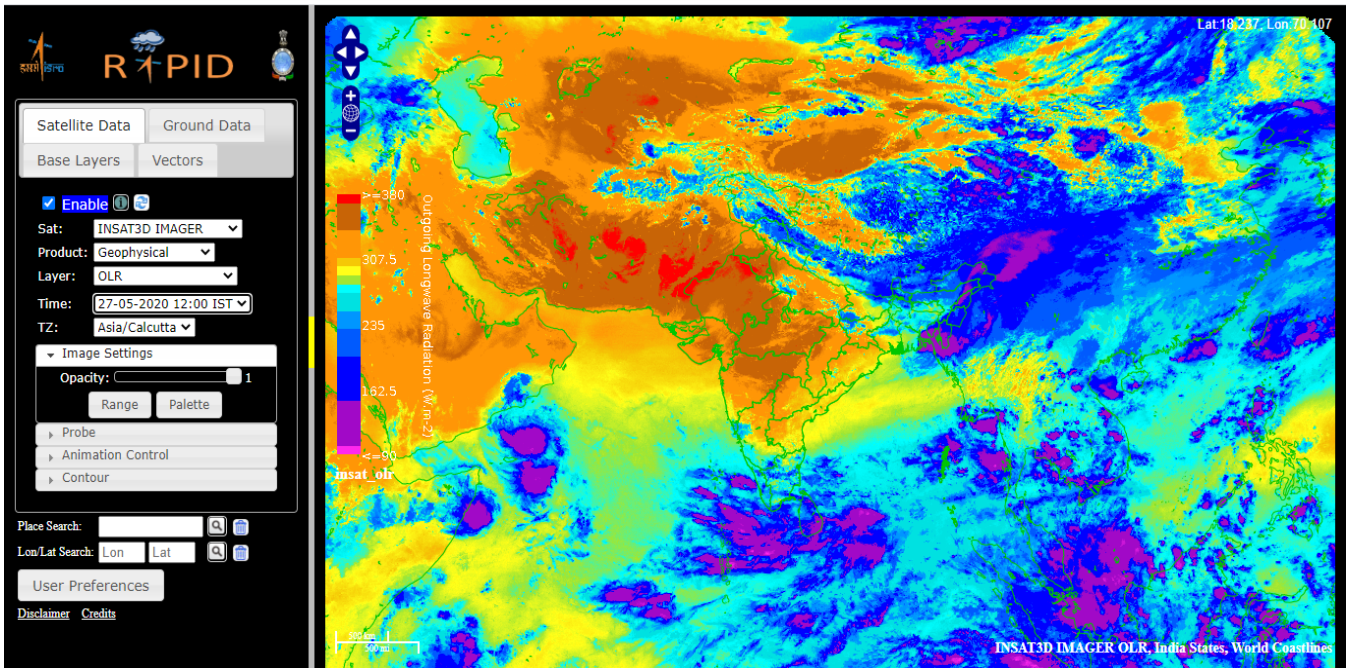

Figure 1 (d) 27 May-2020 outgoing long-wave radiation (OLR): 14:00 IST.

Land Surface Temperature (LST)

The Land Surface Temperature (LST) is the radiative skin temperature of the land surface, as measured in the direction of the remote sensor. It is estimated from Top-of-Atmosphere brightness temperatures from the infrared spectral channels of a constellation of geostationary satellites (Meteosat Second Generation, GOES, MTSAT/Himawari). Its estimation further depends on the albedo, the vegetation cover and the soil moisture.

LST is a mixture of vegetation and bare soil temperatures. Because both respond rapidly to changes in incoming solar radiation due to cloud cover and aerosol load modifications and diurnal variation of illumination, the LST displays quick variations too. In turn, the LST influences the partition of energy between ground and vegetation, and determines the surface air temperature. LST values derived from INSAT-3D data sets shows > 315 °K for all four days 24-27th May-2020, figures 2 (a-d).

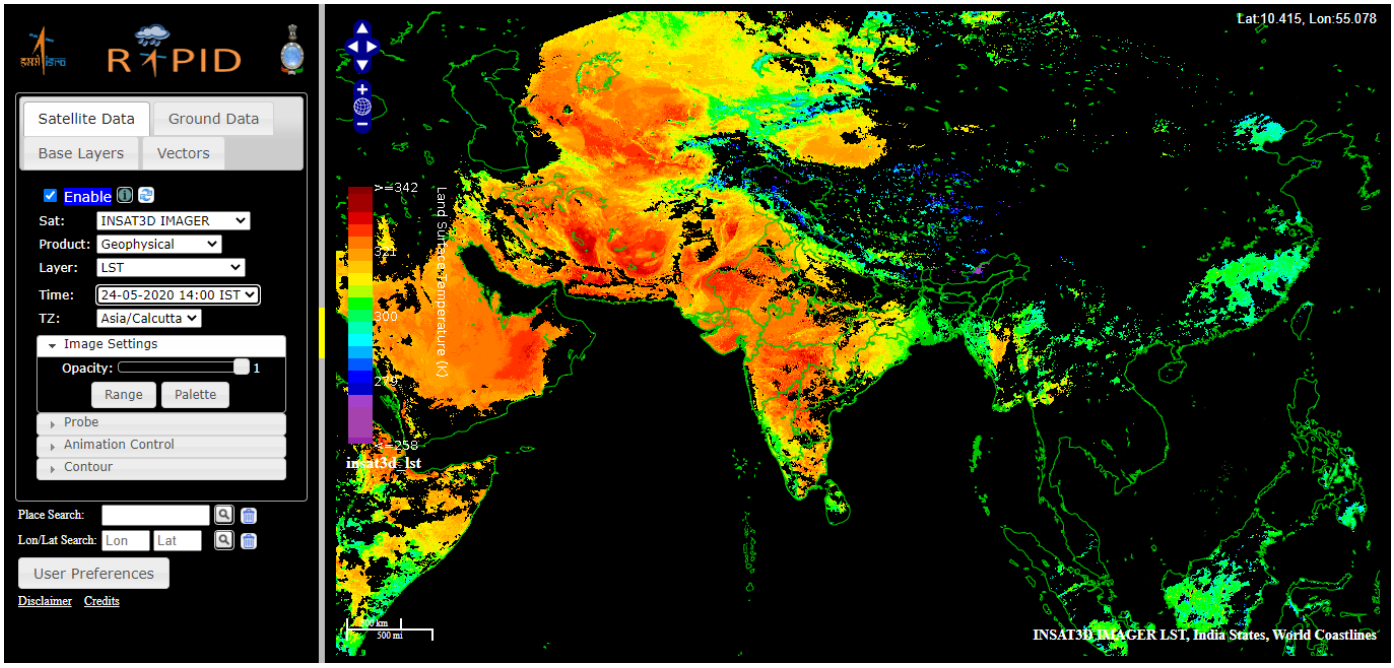

Figure 2 (a) 24 May-2020 Land Surface Temperature (LST): 14:00 IST.

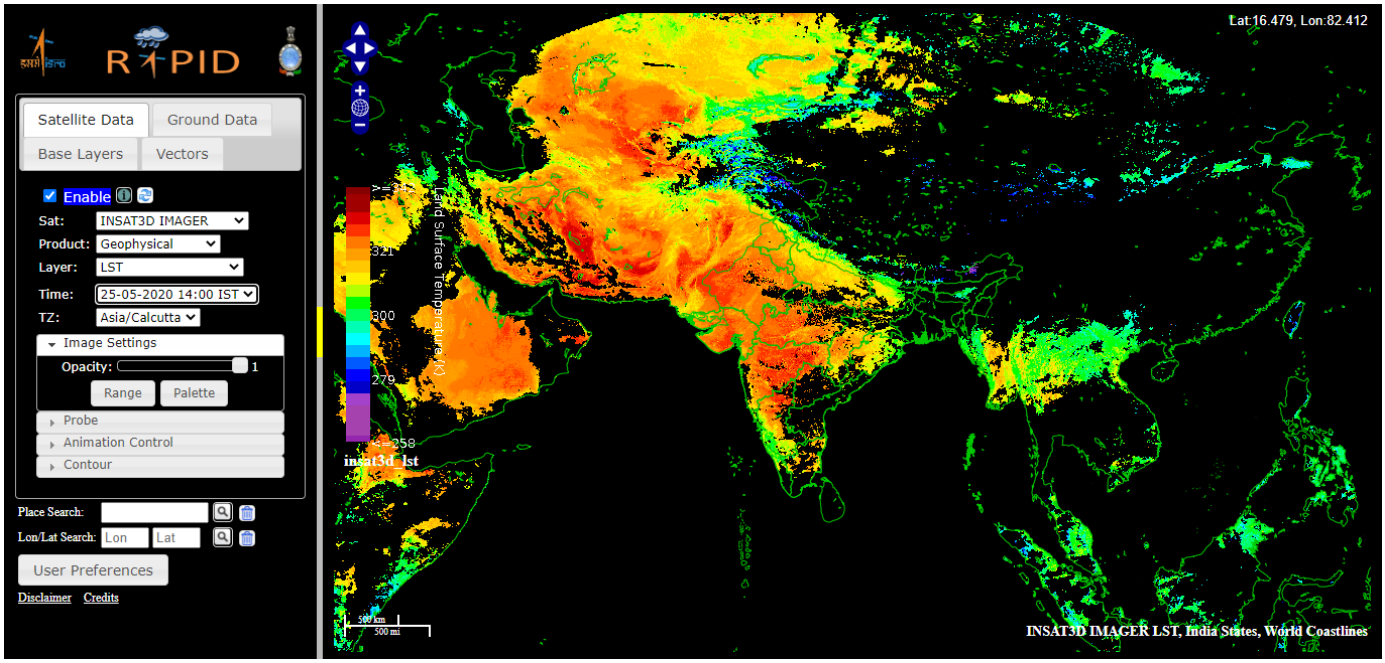

Figure 2 (b) 25 May-2020 Land Surface Temperature (LST): 14:00 IST.

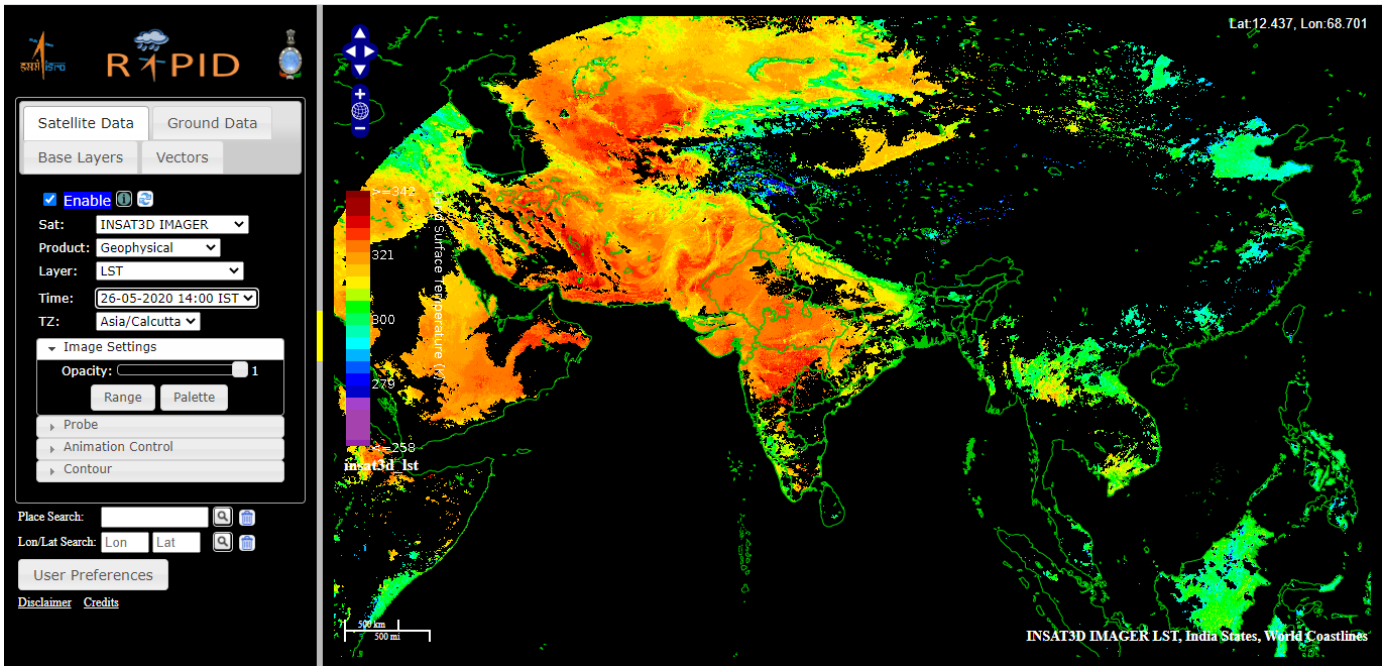

Figure 2 (c) 26 May-2020 Land Surface Temperature (LST): 14:00 IST.

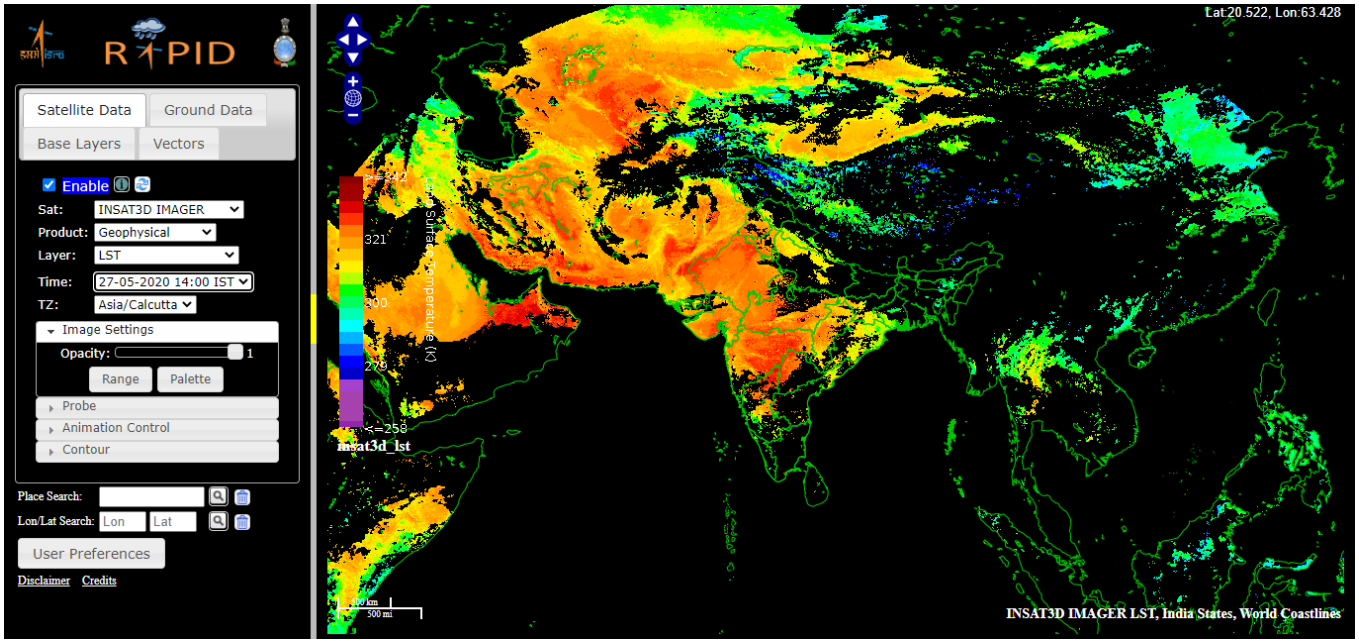

Figure 2 (d) 27 May-2020 Land Surface Temperature (LST): 14:00 IST.

Land surface Albedo (LSA)

It is an important parameter for surface energy balance. It is the reflectance of the solar energy and amount of the short wave radiation to be absorbed by the surface. Land cover changes affect local surface energy balances by changing the amount of solar energy reflected, the magnitude and duration over which absorbed energy is released as heat, and the amount of energy that is diverted to non-heating fluxes through evaporation. [6-8]. The reflectance or absorption of radiation at the

surface depends on the type of land (barren, forest, desert or grassy land) and it then it contribute to the air temperature. Barren and dry land have different LSA as compared to vegetative or forest cover area. INSAT-3D derived LSA ranges 15 to 35 % during the time 24-27 May-2020 over central as well as northwest parts of India, figures 3 (a-d).

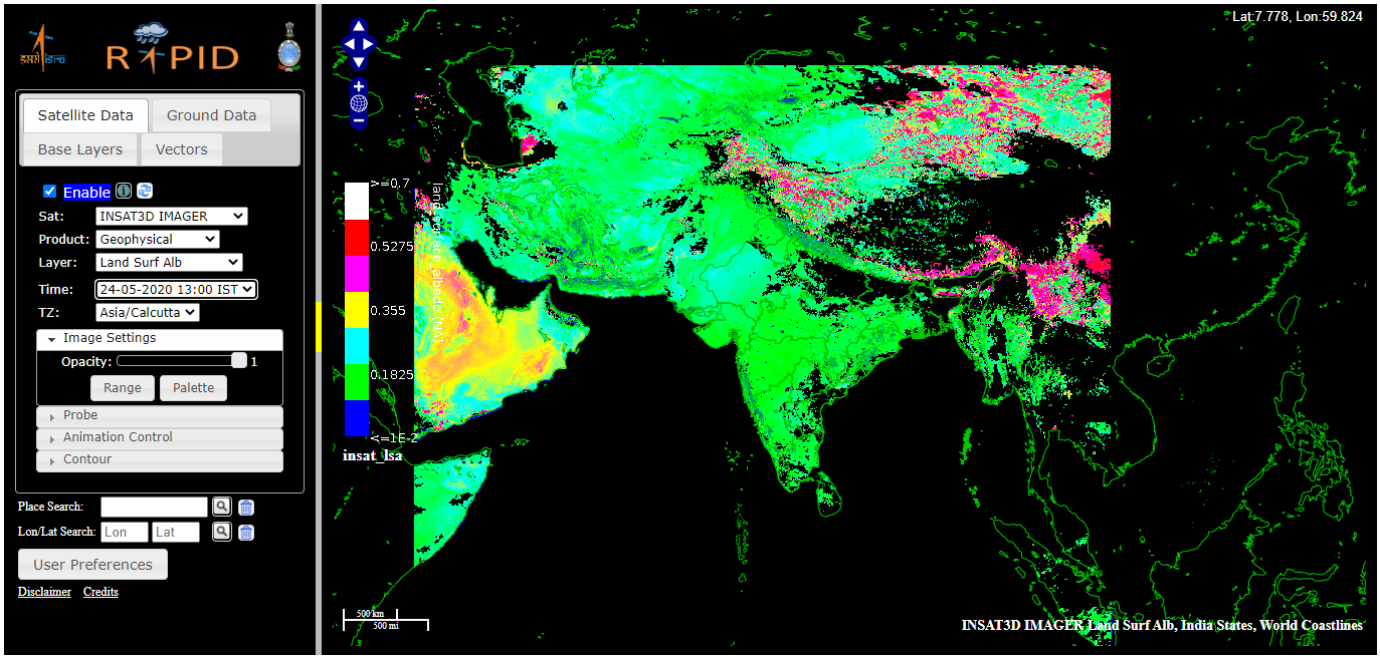

Figure 3 (a) LAND SURFACE ALBEDO -24th May-2020 1300 IST

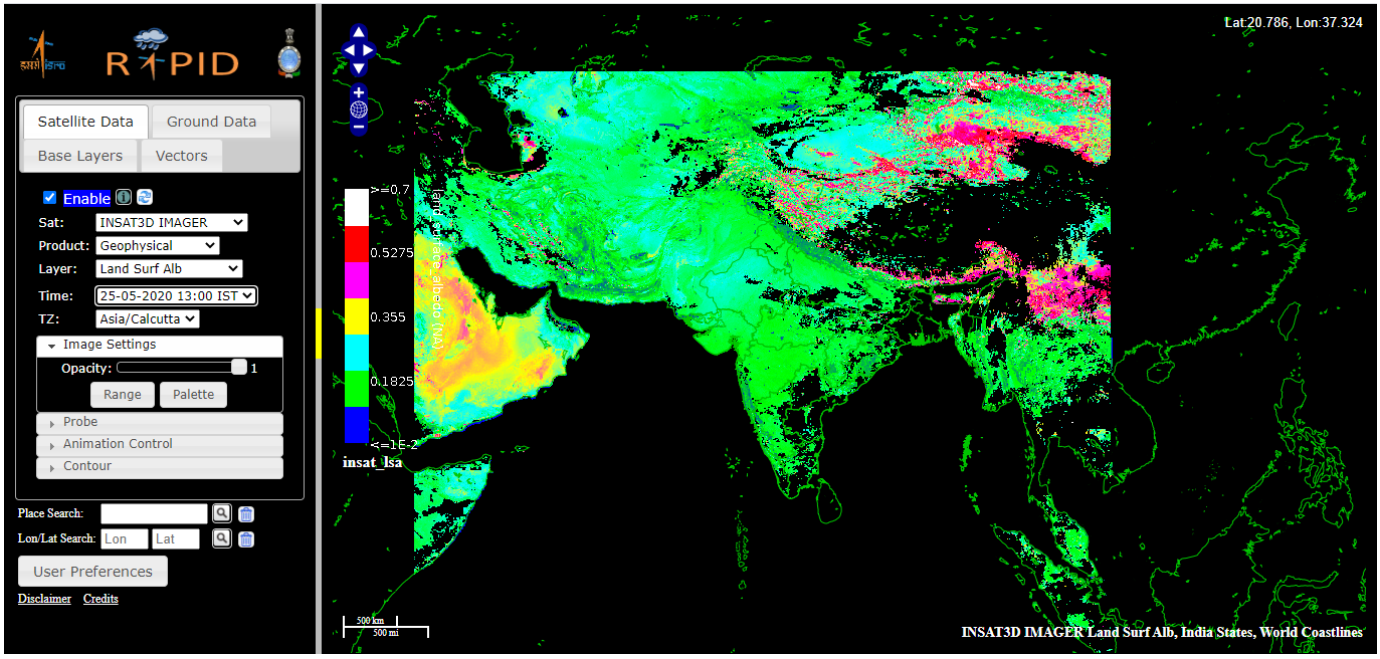

Figure 3 (b) LAND SURFACE ALBEDO 25th May-2020 -1300 IST

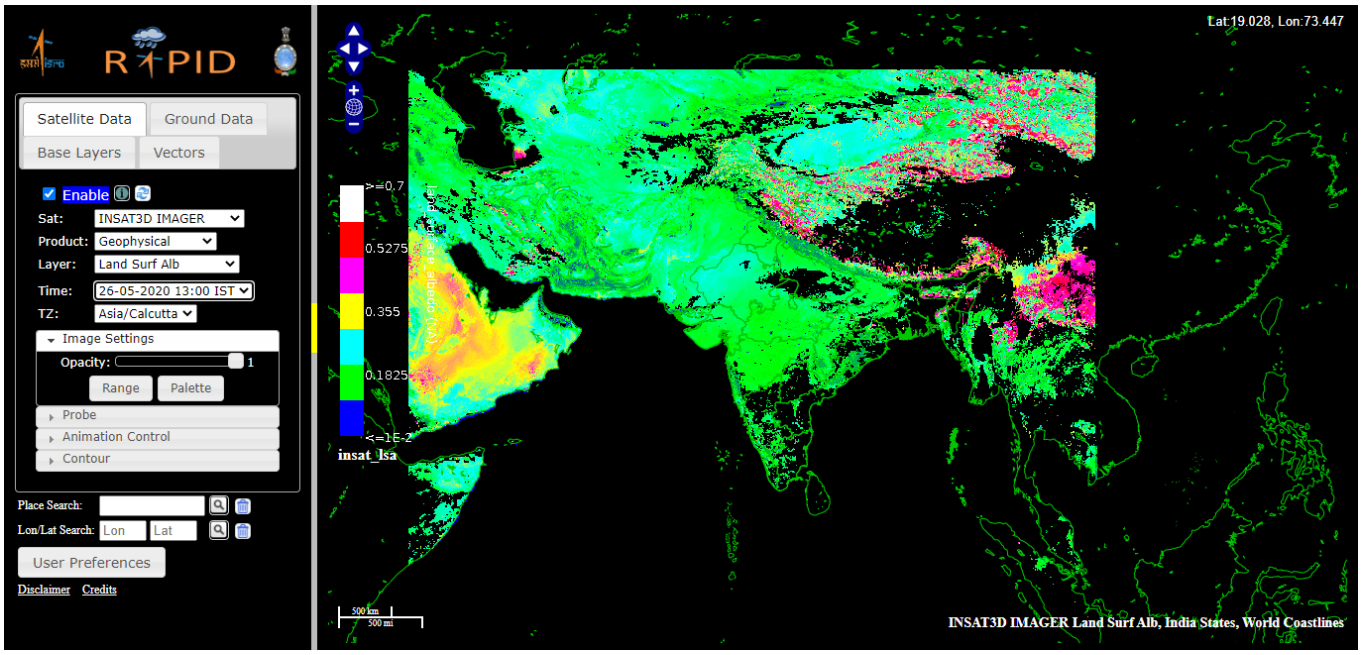

Figure 3 (c) LAND SURFACE ALBEDO 26th May-2020 -1300 IST.

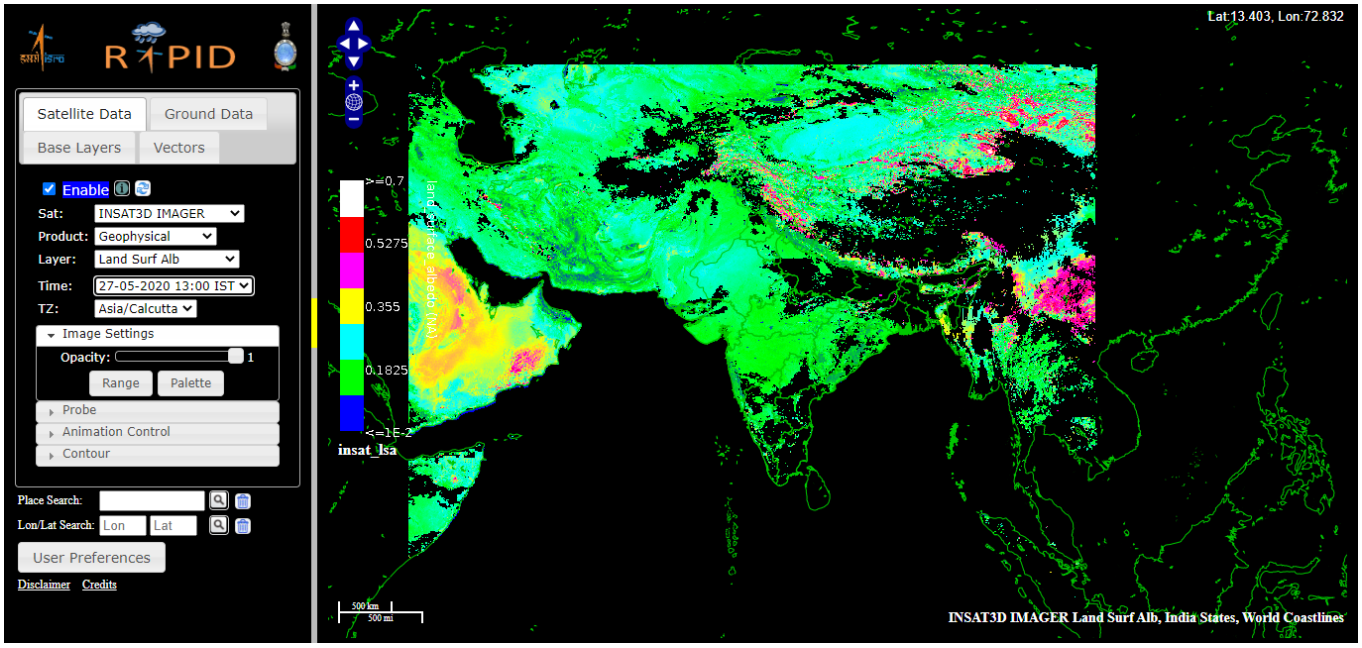

Figure 3 (d) LAND SURFACE ALBEDO 27th May-2020 -1300 IST

Upper tropospheric Humidity (UTH)

Upper tropospheric humidity information derived from INSAT-3D Imager data play an important role in assessing or monitoring the heat wave conditions over Indian region. Water vapour absorption contribution depends on is feedback and contribute significantly in radiative forcing to the atmosphere [9,10]. Water vapour is higher in troposphere as compared to other layers in the atmosphere. Understanding the distribution and variability of UTH is important to understand the air temperature and its distribution in the Indian domain. The range of UTH lies 5 -20 % during 24-27 May-2020, figures 4 (a-d). The co-occurrence of consecutive hot and humid days during a

heat wave can strongly affect human health or humid heat wave hazard in the recent past and at different levels of global warming throughout the globe [11]. Heat wave affected the human lives in many ways depending on the age and regions of the country. Sheridan et al., [12], studied long-term trends in heat-related mortality across 29 US metropolitan areas from 1975 to 2004 to discern the spatial patterns and temporal trends in heat vulnerability. Mortality data have been standardized to account for population trends, and seasonal and interannual variability.

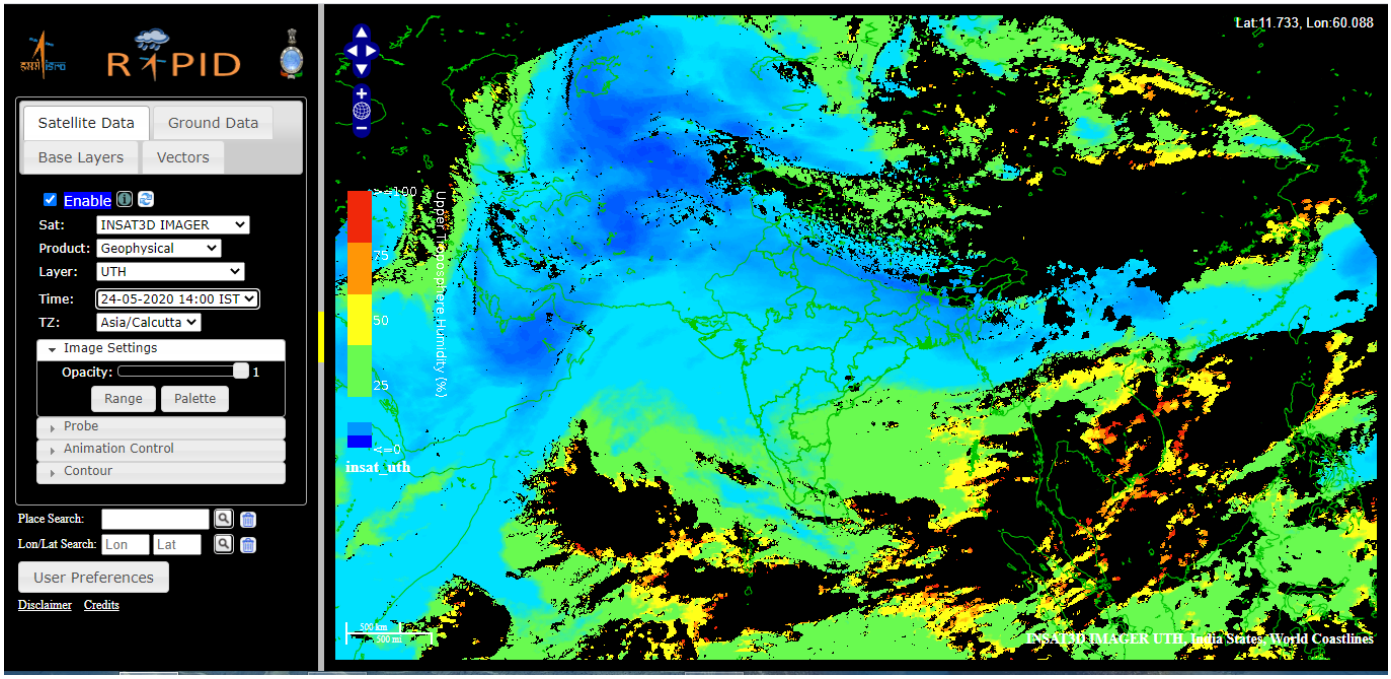

Figure 4 (a) Upper Tropospheric Humidity (UTH) 24th May-2020 at14:00 IST

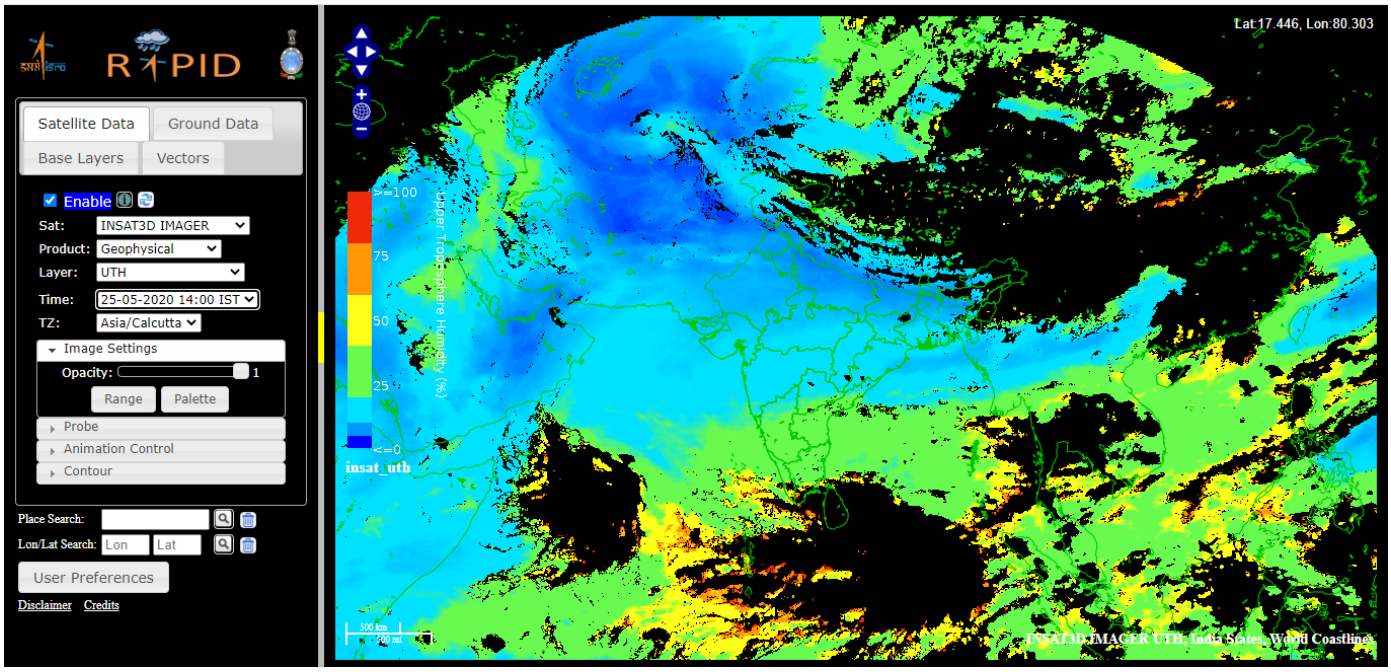

Figure 4 (b) Upper Tropospheric Humidity (UTH) 25th May-2020 at14:00 IST

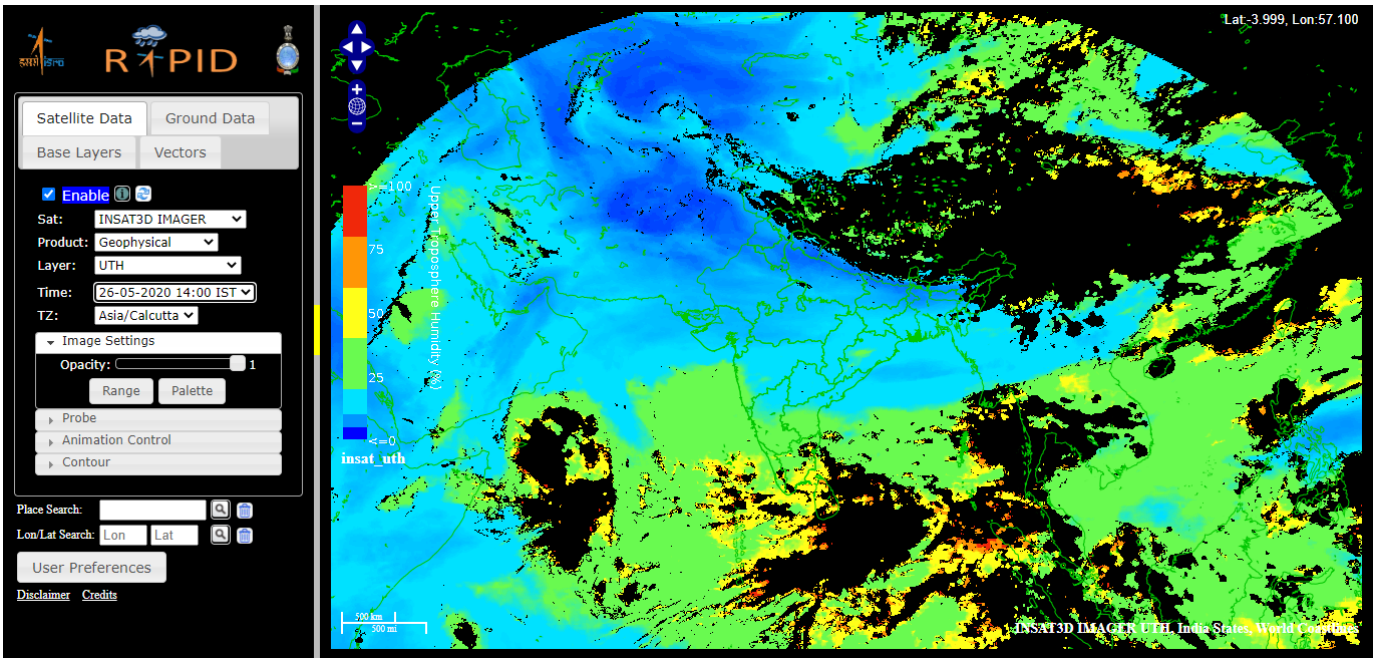

Figure 4 (c) Upper Tropospheric Humidity (UTH) 26th May-2020 at14:00 IST

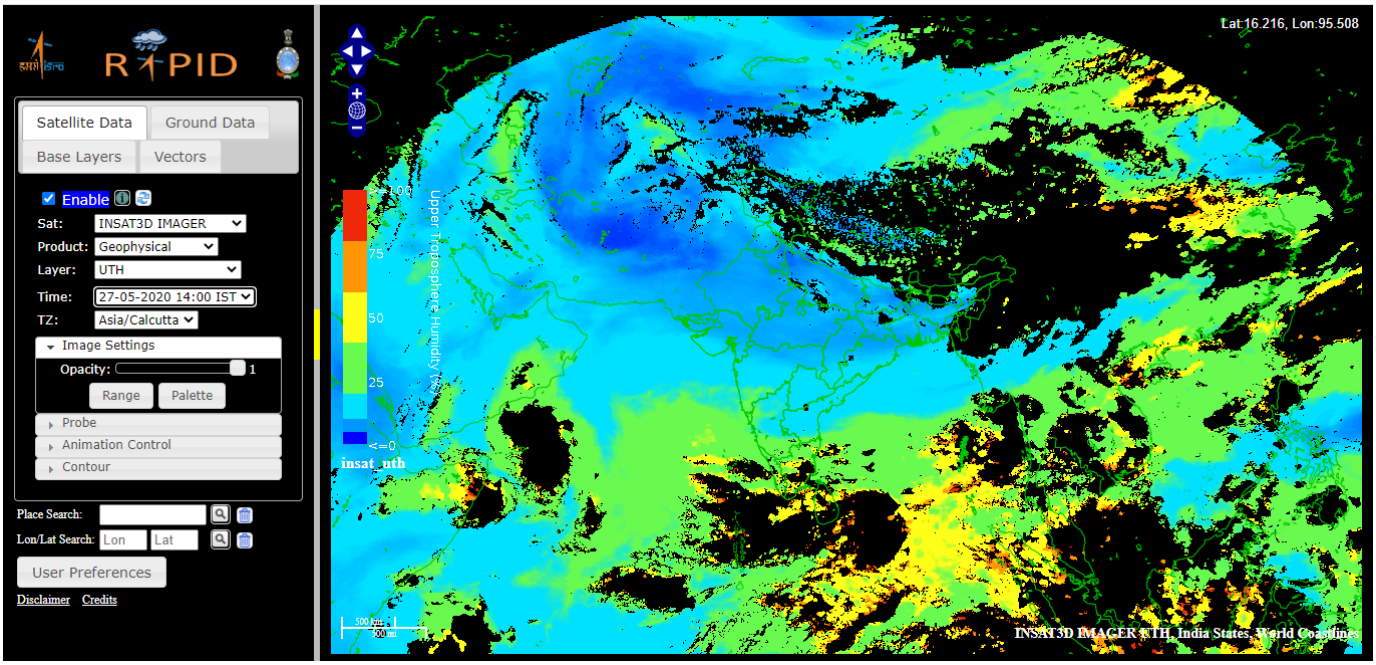

Figure 4 (d) Upper Tropospheric Humidity (UTH) 27th May-2020 at14:00 IST

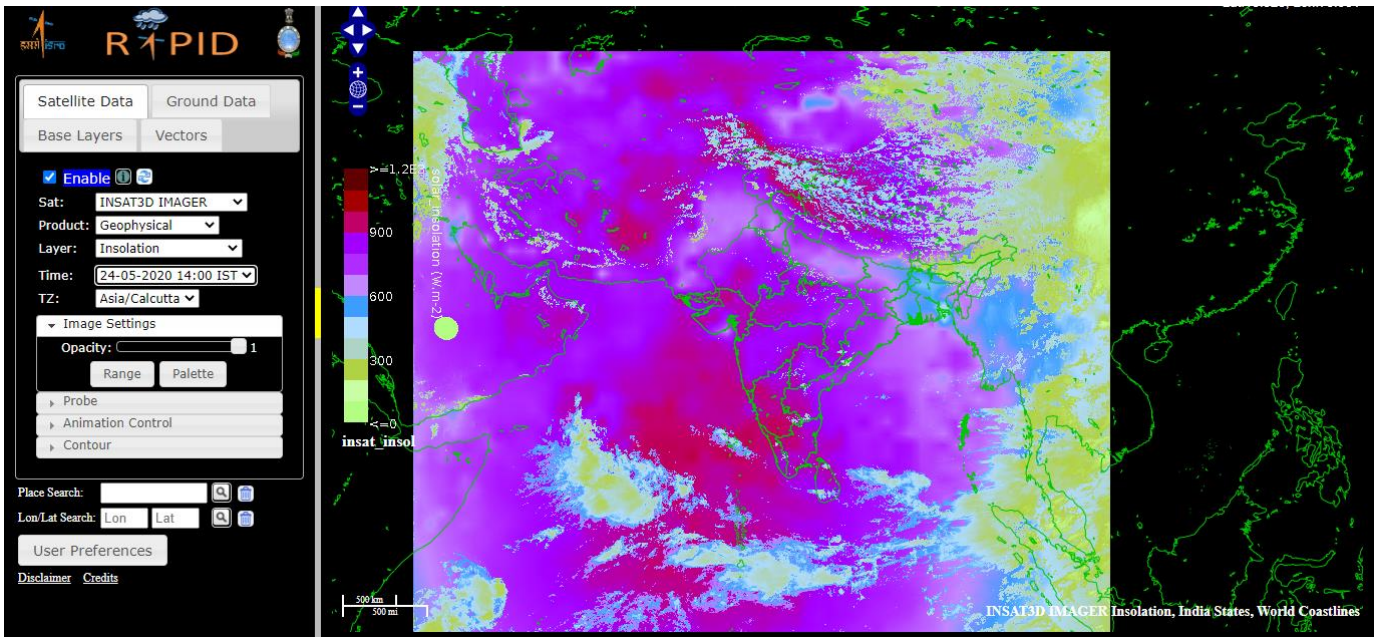

Figure 5 (a) INSOLATION (watt /m^2) 24th May-2020 at14:00 IST

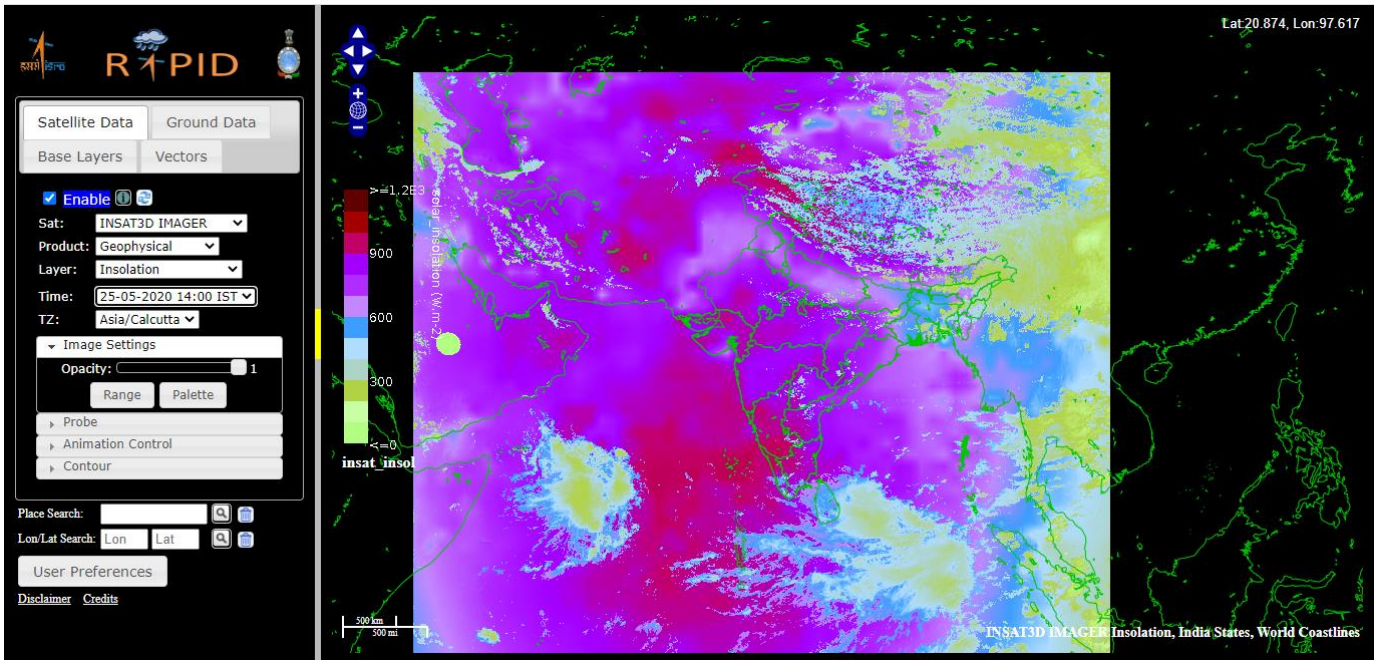

Figure 5 (b) INSOLATION (watt /m^2) 25th May-2020 at14:00 IST

Insolation

The amount and the intensity of insolation vary during a day, in a season and in a year. This variation is contributing significantly the distribution of the air temperature. INSAT-3D derived insolation values during the hot days May 24-27 -2020 ranges from 700 to 900 watt/m^2 at most places of India, figures 5 (a-d).

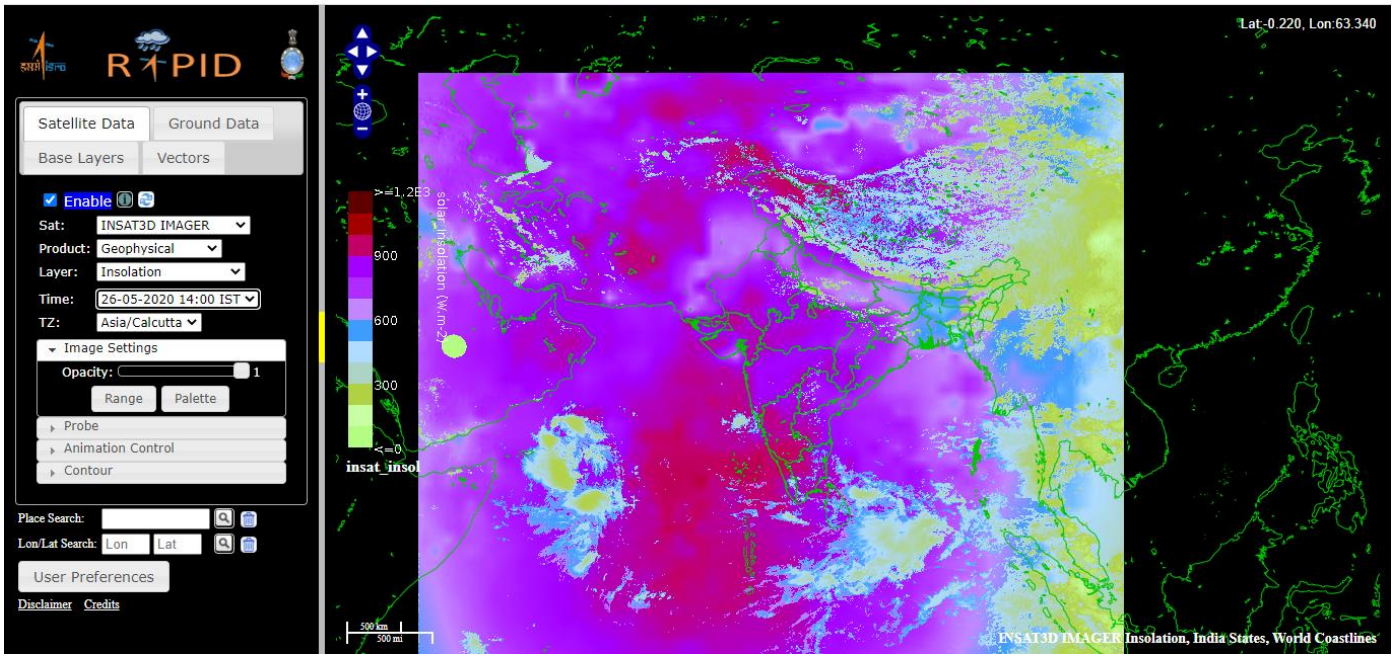

Figure 5 (c) INSOLATION (watt /m^2) 26th May-2020 at14:00 IST

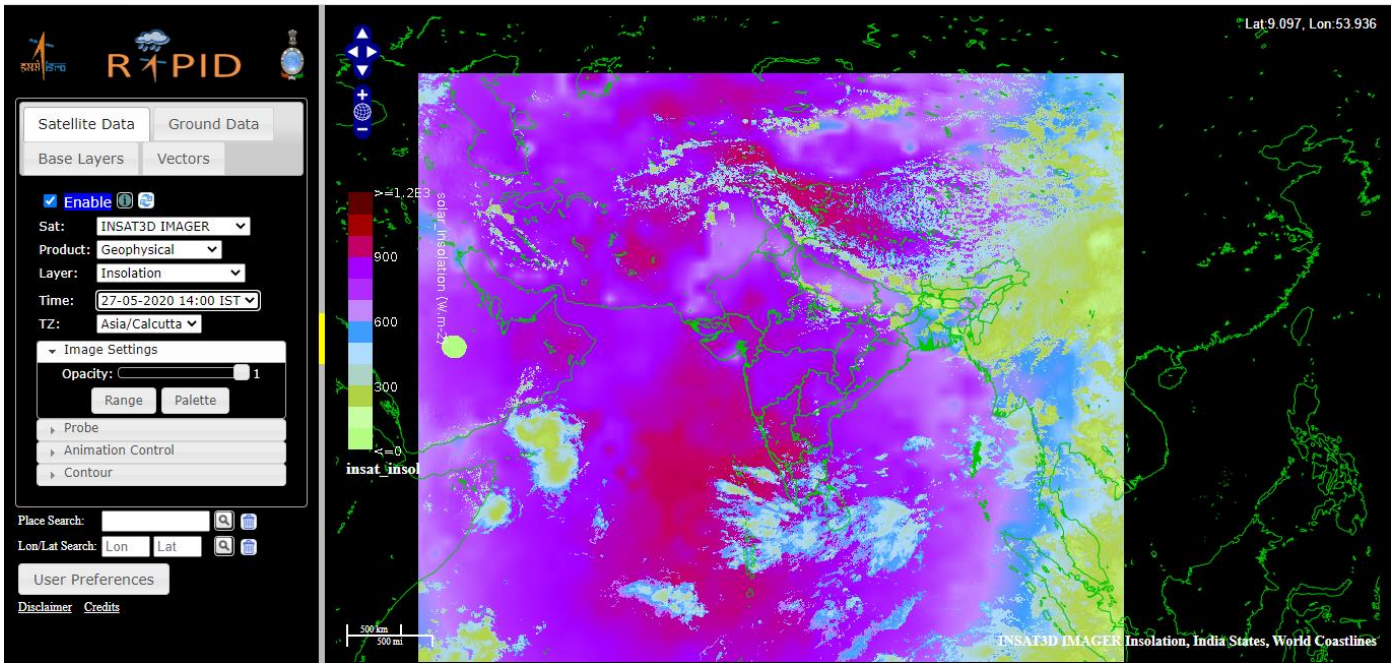

Figure 5 (d) INSOLATION (watt /m^2) 27th May-2020 at14:00 IST

Net Radiation

It is seen that with rapid urbanization, population growth and anthropogenic activities, an increasing number of major cities throughout the country the net radiation distribution also affected and urban areas are more sensitive for heat as compared to rural areas. INSAT-3D derived net radiation values varies 600 to 800 watt /m^2 during 26-27th May-2020 at the time blistering heat wave conditions, figures 6 (a-b).

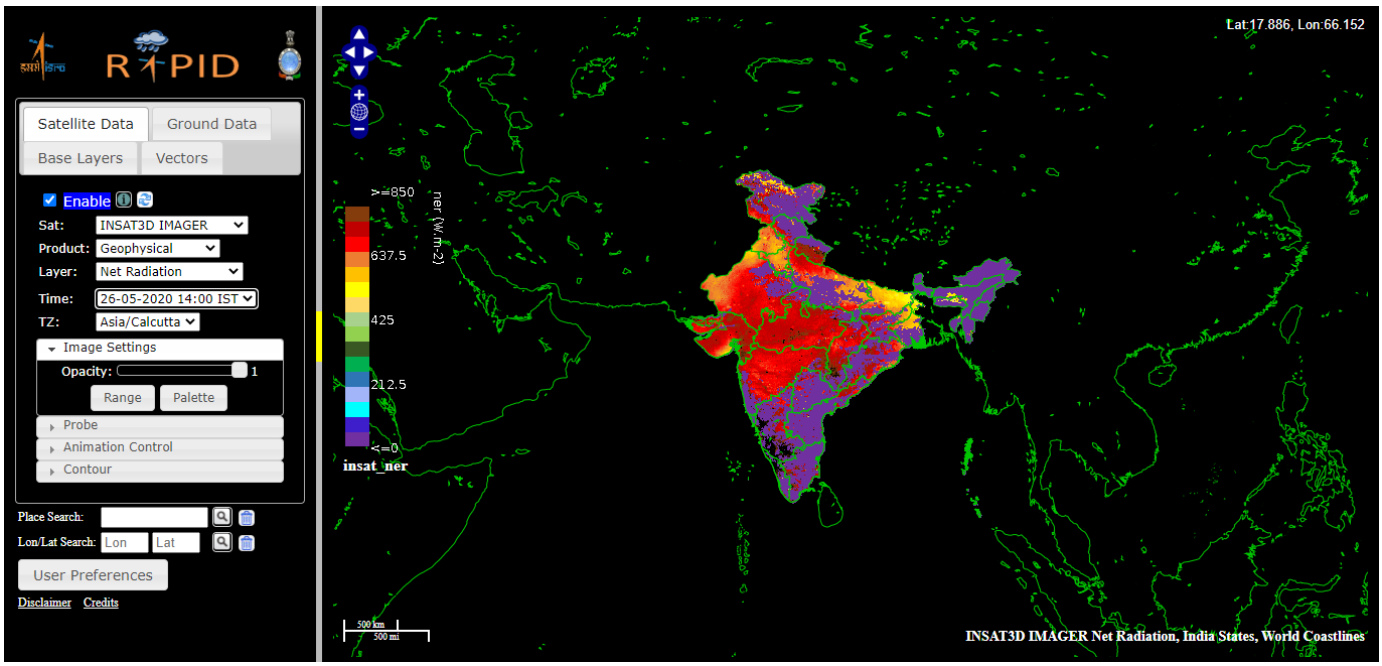

Figure 6 (a) NET RADIATION 26th May-2020 watt/m2 (14:00 UTC)

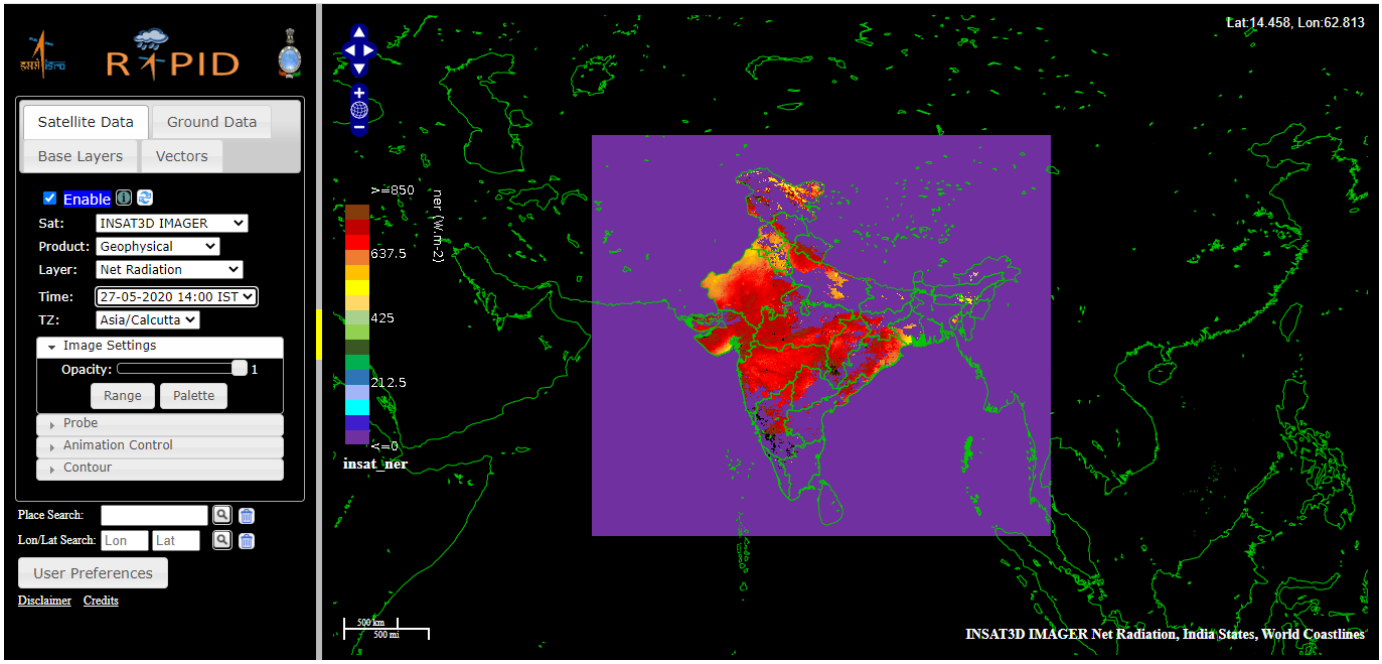

Figure 6 (b): NET RADIATION 27th May-2020 watt/m2 (14:00 UTC)

4. Concluding Remarks

It is seen that rapid urbanization, population growth and urbanization changes the overall scenario of weather patterns. The extreme weather events affects the lives of the people with many number of new diseases spread, like COVID-19. From the above study it is clear that the INSAT-3D satellite derived products helps to understand the extreme weather patterns or

behavior like heat wave discussed in this paper. It is seen that, OLR lies> 300 watt/m^2, upper tropospheric humidity (UTH 5-20 %) Land surface albedo (LSA 15-35 %), Land surface temperature (LST > 315 °K) and net radiation (600 -800 watt .m$^{2)}$ have been noticed during the prevailing heat wave condition over India during 24-27 May-2020.

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Conflicts of interest: The author stated that no conflicts of interest.

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