IMD Met. Monograph No.: ESSO/IMD/SAT. MET/RAPID/01(2017)/08

Real-time Analysis of Product and Information Dissemination – User Guide

Prepared by:

Virendra Singh, Amit Kumar, Ghansyam Sanger

Reviewed by:

M Mohapatra

National Satellite Meteorological Centre
India Meteorological Department, Ministry of Earth Sciences,
Govt. of India, New Delhi

Contents

Real-time Analysis of Product and Information Dissemination – User Guide

1) Introduction

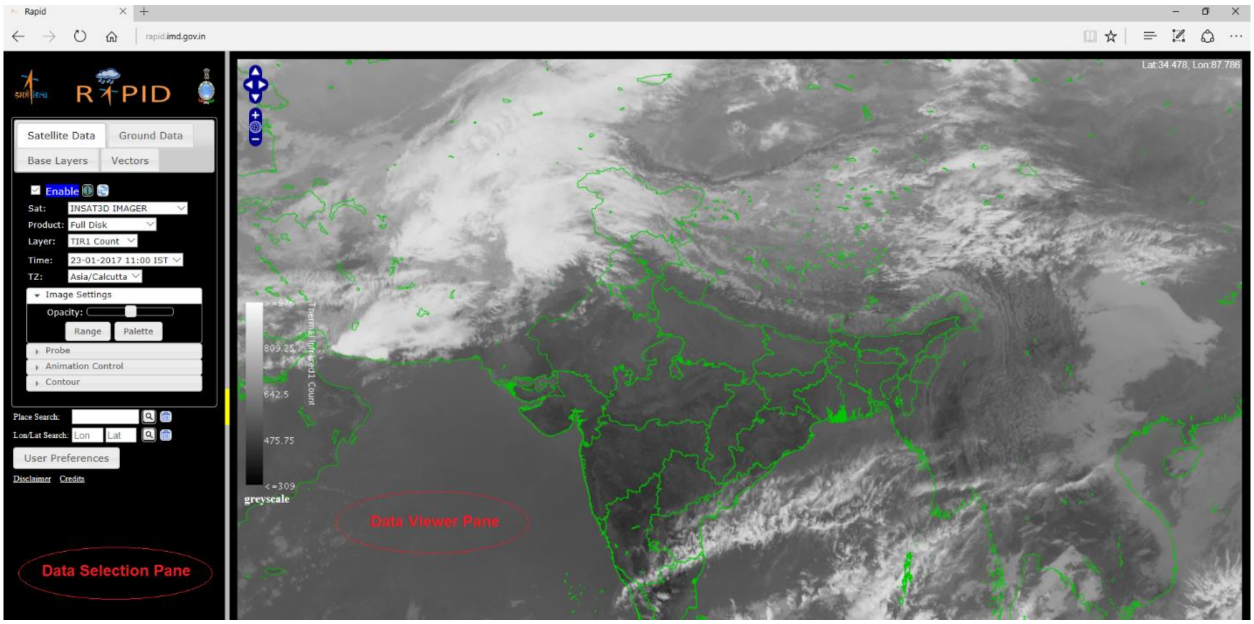
Real time Analysis of Products & Information Dissemination called RAPID is a web based quick visualization and analysis tool for satellite data and products. This introduces Next Generation Weather Data Access & Advanced Visualization Application that touches the life of common man in one or other way ranging from severe weather monitoring to various sectoral applications like agriculture, tourism, sports etc. For example, we can assess the fog over railway tracks and surface transportation highways, aviation, navigation & a pilot can monitor the location, intensity & movement of cumulonimbus clouds enroute.
This tool was conceptualized and developed by Satellite Application Centre (SAC), ISRO in collaboration with India Meteorological Department (IMD), New Delhi to enhance the visualization and analysis of INSAT Meteorological Satellite data on real time basis by the forecasting community. This system is operationally sustained by National Satellite Meteorological Centre (IMD), New Delhi. This tool is hosted at http://www.rapid.imd.gov.in/.

1.1. The salient features of RAPID:

- It connects atmospheric science and geosciences.
- There is no specific Operating System/ software/ library / compiler required on the desktop to access RAPID. It is accessed through web browser.
- It provides features of interest to scientific community
- RAPID follows Open Geospatial Consortium's (OGC) open standards.
- Web Mapping Service (WMS) – For visualization of meteorological data (Satellite and ground observations).
- Extensions written for scientific community
- Zero learning curve
- It can overlay Map Boundaries (World Coastline, State, District Boundaries, Gridlines) with configurable:
  - Color
  - Opacity
  - Thickness
  - Contrast Stretch
  - Lookup Table Application
- It has Probe Data feature (on the fly) i.e. analysis of data
  - Point
  - Time Series
  - Vertical Profile
  - Transect
  - Area Measurement
  - Distance Measurement
- Animation can be generated and visualized in it.
- Day and Night time microphysics RGB Composites imageries are available in it.
- Contouring feature over meteorological data.

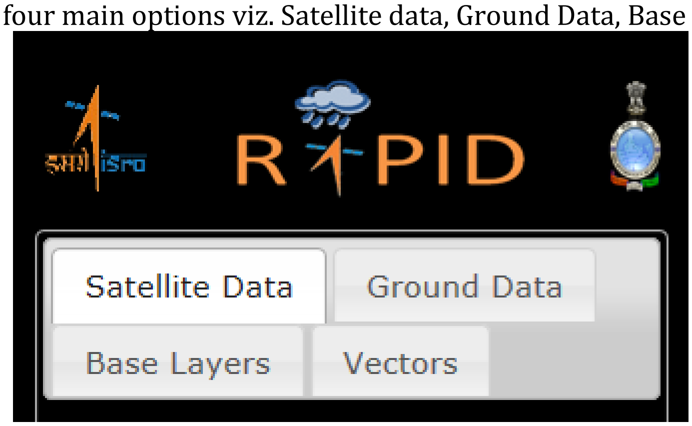
- Map background can be changed based on user preference.
- Base layers can be chosen from:
    - Open Street Map
    - Indian Sub Basins
    - FMO Basins
    - True Marble
    - Blue Marble
    - Bhuvan

The RAPID viewer consists of two panes. On the left of the screen is ***Data Selection Pane*** and on the right, is ***Data viewer pane***.



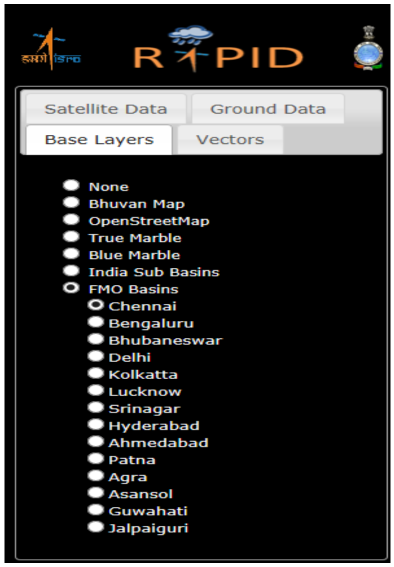
2. Data Selection pane:

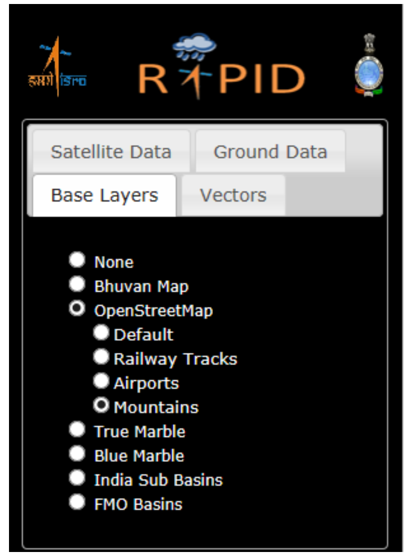
This is the area where user can select the data which is to be visualized. This has four main options viz. Satellite data, Ground Data, Base Layers and Vector.



2.1 Base layers:

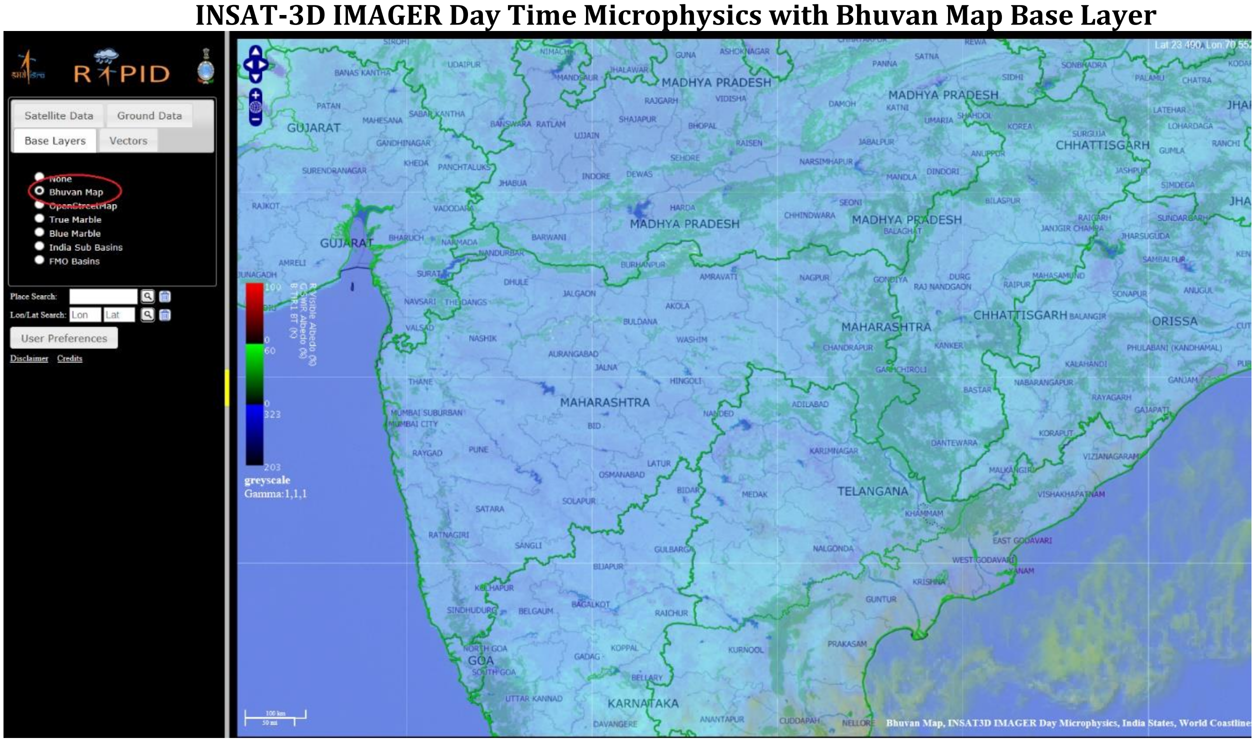
Here user can select the base layers over which the image to be overlaid. The users have various options in base layer to select the following options: - Bhuvan Map, Open Street Map, True Marble, Blue Marble, India Sub Basins and FMO Basins.





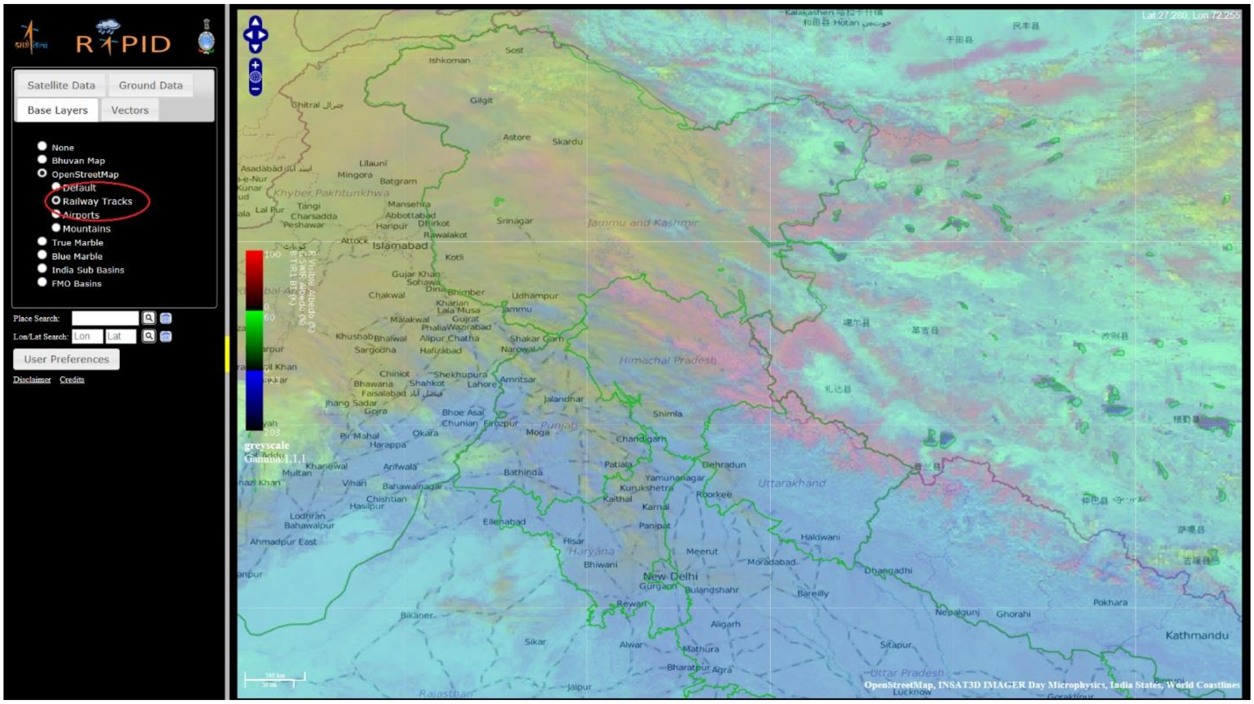
i) **Bhuvan Map:** Bhuvan (lit: Earth) is a software application which allows users to explore a 2D/3D representation of the surface of the Earth especially over Indian region and user can zoom up to town level.

INSAT-3D IMAGER Day Time Microphysics with Bhuvan Map Base Layer

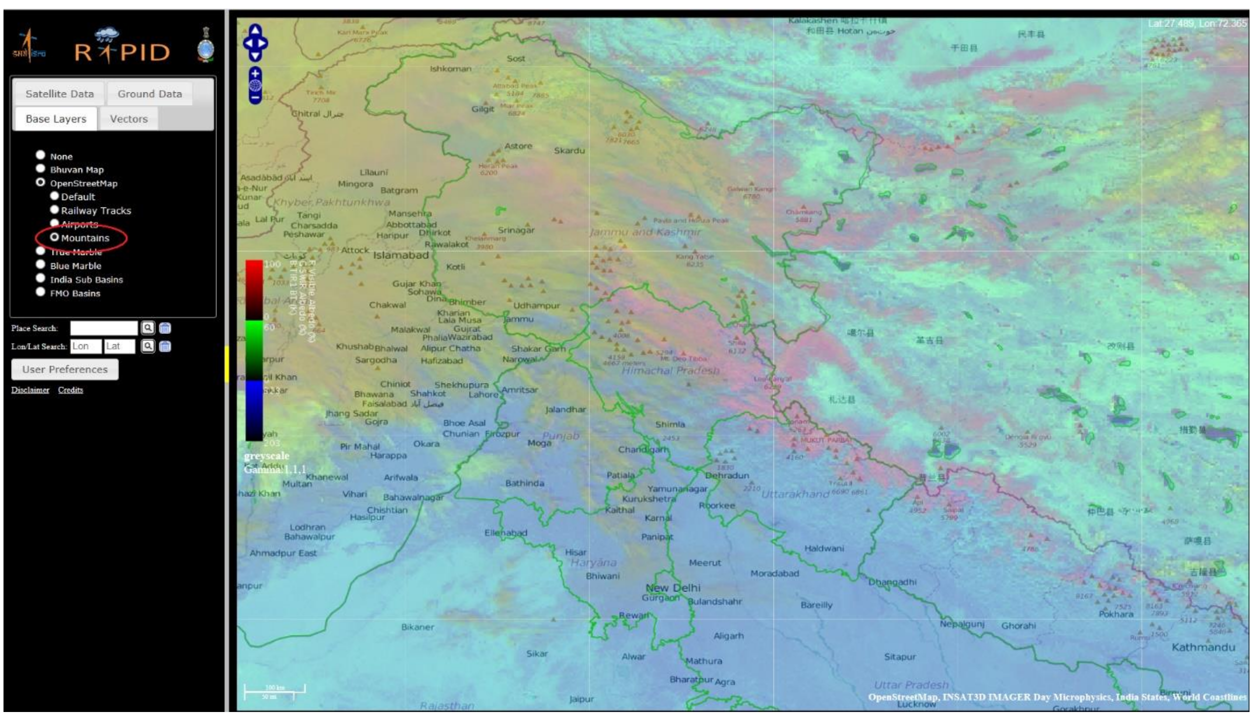


ii) **Open Street Map:** Open Street Map (OSM) is a collaborative project to create a free editable map of the world by open source community and it is used in RAPID to visualize meteorological data over this layer and zoom it to desired location. It further gives freedom to the users for selecting either one option from Railway tracks, Mountains and Airports in this base layer in order to monitor and visualize meteorological data over them. This facilitates the visualization of Fog over Railway Tracks and Aerodromes particularly.

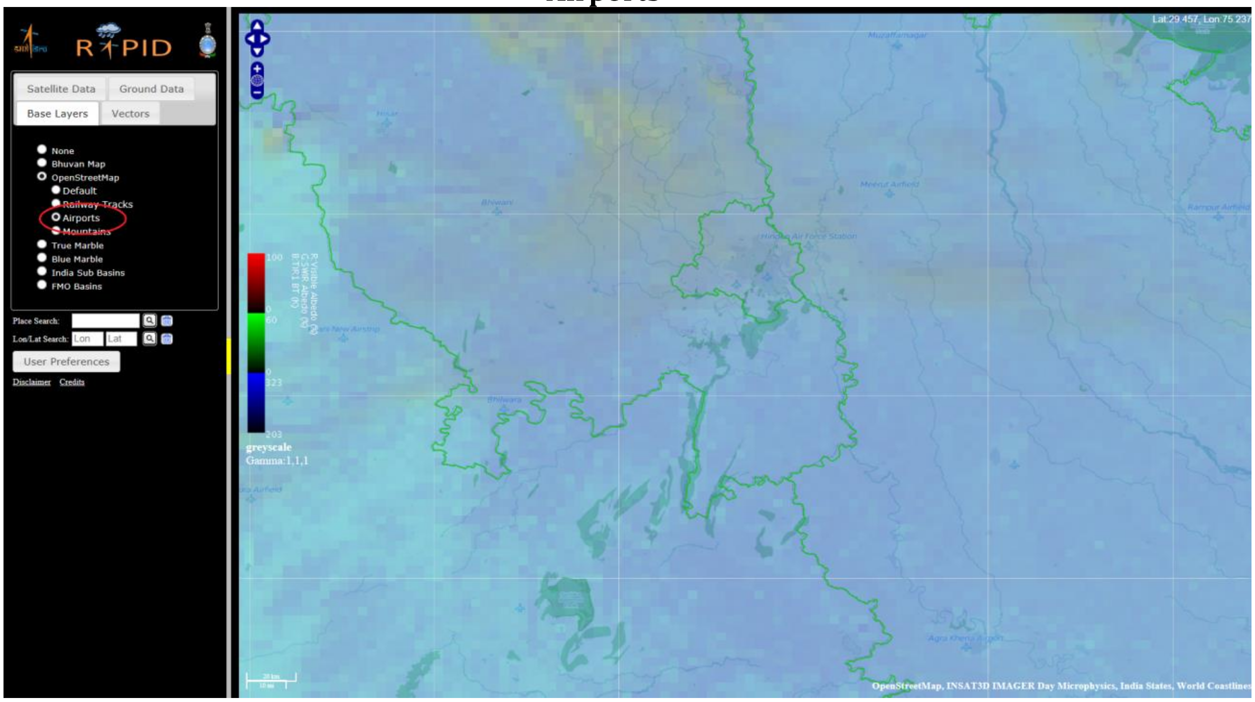
INSAT-3D IMAGER Day Time Microphysics with Open Street Map Base Layer – Railway Track



INSAT-3D IMAGER Day Time Microphysics with Open Street Map Base Layer - Mountains

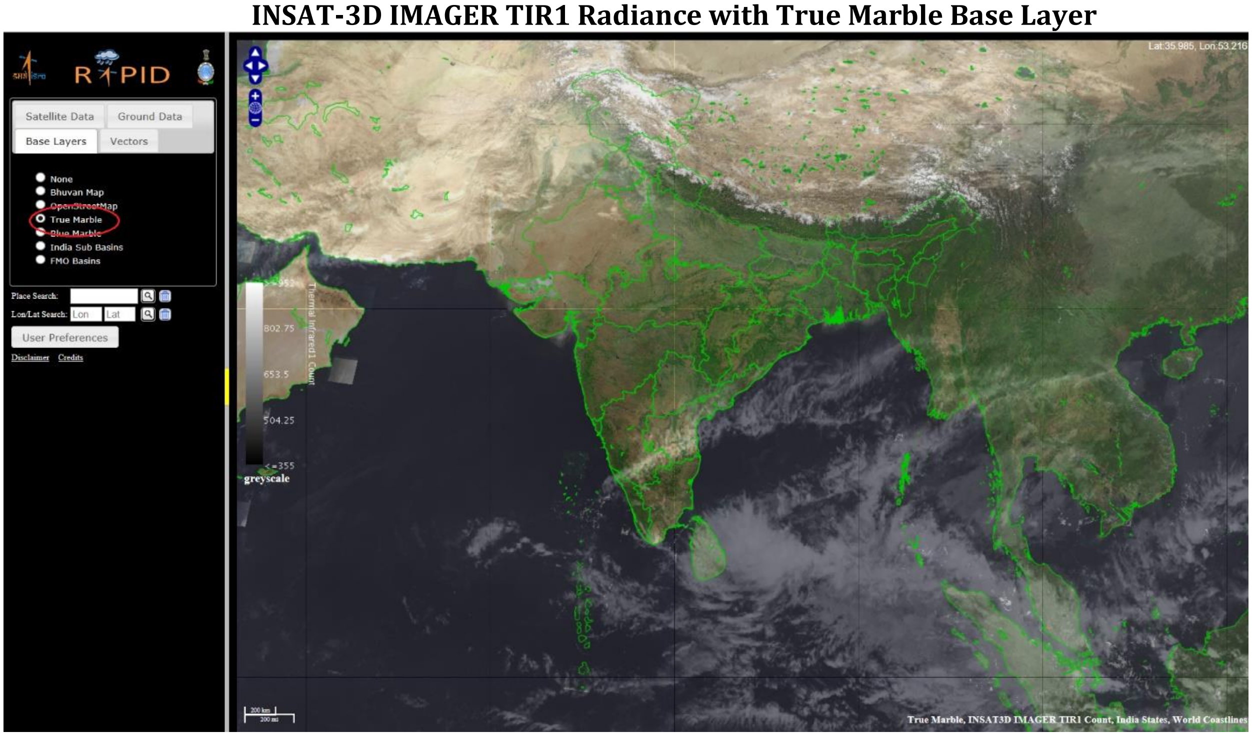


INSAT-3D IMAGER Day Time Microphysics with Open Street Map Base Layer – Airports



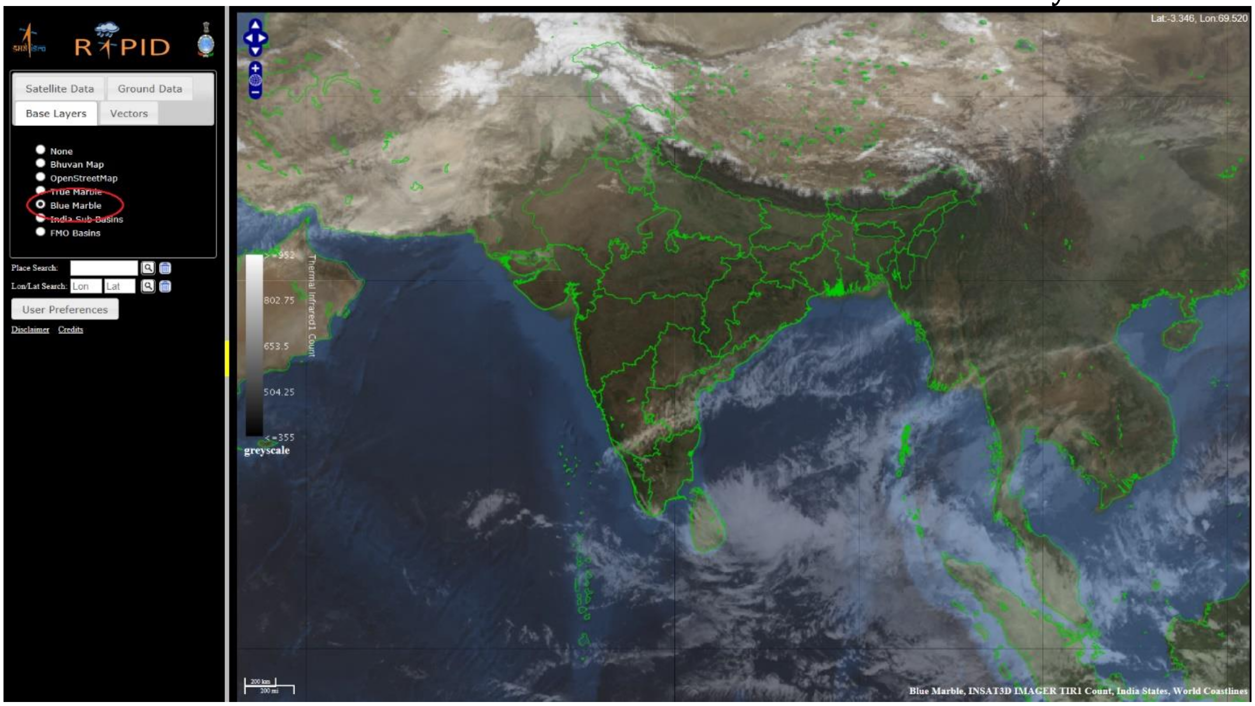
iii) True Marble: It is the standard base layer.

INSAT-3D IMAGER TIR1 Radiance with True Marble Base Layer



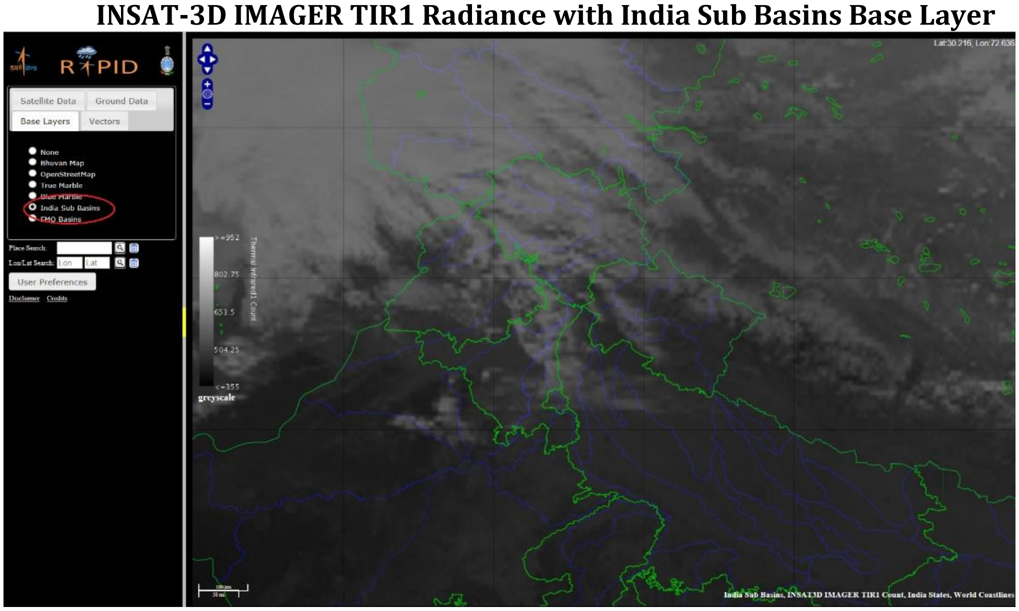
iv) Blue Marble: It is the standard base layer.

INSAT-3D IMAGER TIR1 Radiance with Blue Marble Base Layer



v) India Sub Basins: This layer contains all Indian river basins and sub basins as base layer and facilitate user to visualize particularly Rainfall product over River Basin/Sub-Basin

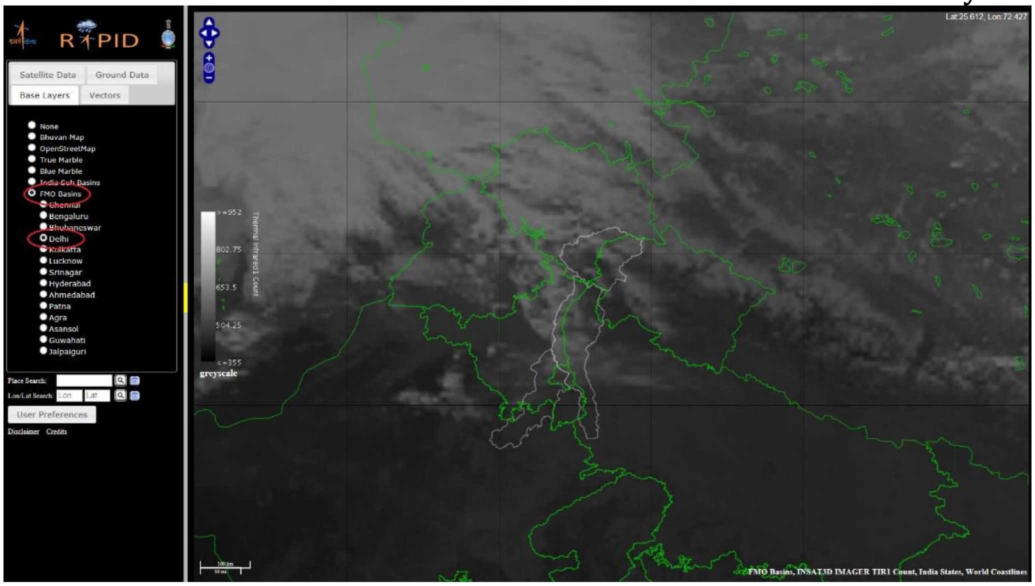
INSAT-3D IMAGER TIR1 Radiance with India Sub Basins Base Layer



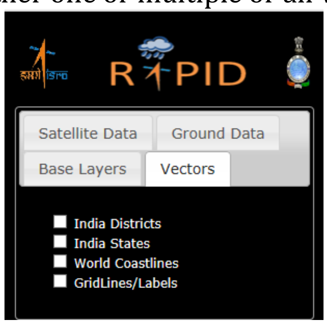
vi) FMO Basins: India Meteorological Department has divided the Indian river basins into fourteen Flood Meteorological Office (FMO) basins i.e. Chennai, Bengaluru, Bhubaneswar, Delhi, Kolkatta, Lucknow, Srinagar, Hyderabad, Ahmedabad, Patna, Agra, Asansol, Guwahati &

Jalpaiguri and user has the flexibility to select one of the FMO basins depending on his/her area of interest to visualize rainfall products available in RAPID.

INSAT-3D IMAGER TIR1 Radiance with FMO Basin- Delhi as Base Layer

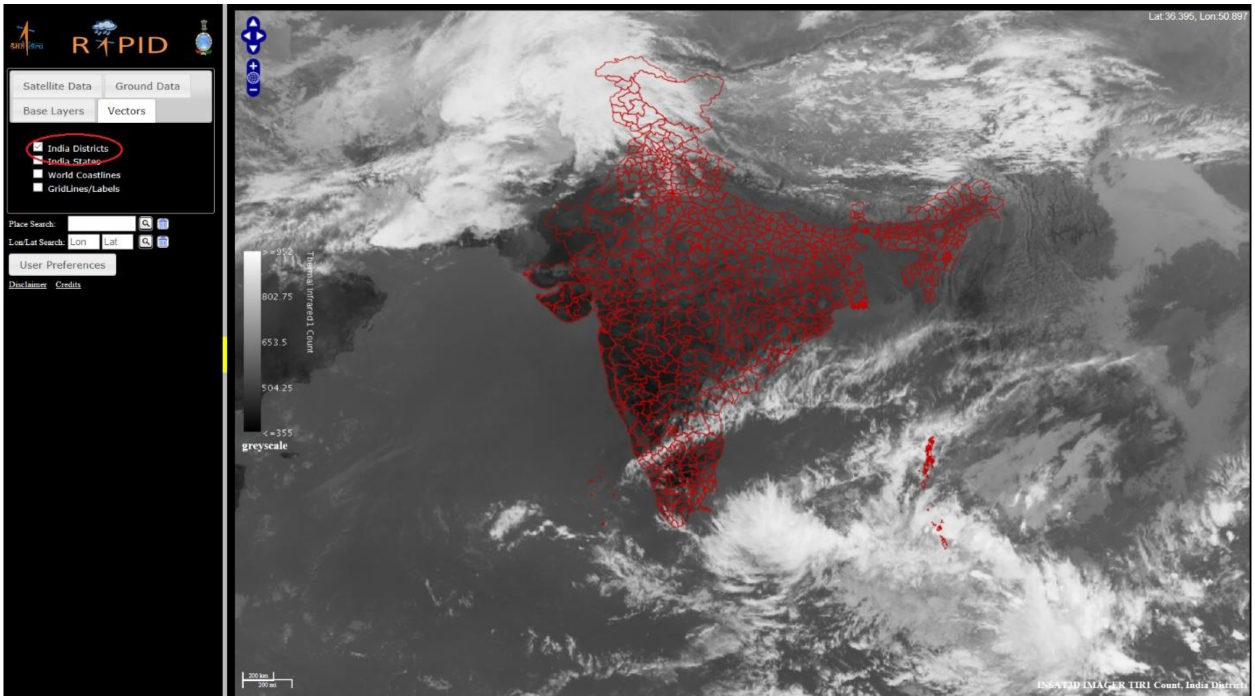


2.2 Vectors: Under this tab user can select the vectors i.e. the map boundaries viz: India Districts, India States, World Coastlines & Gridlines/Labels to be displayed in the data viewer pane. Depending on the user choice either one or multiple or all vectors can be selected.



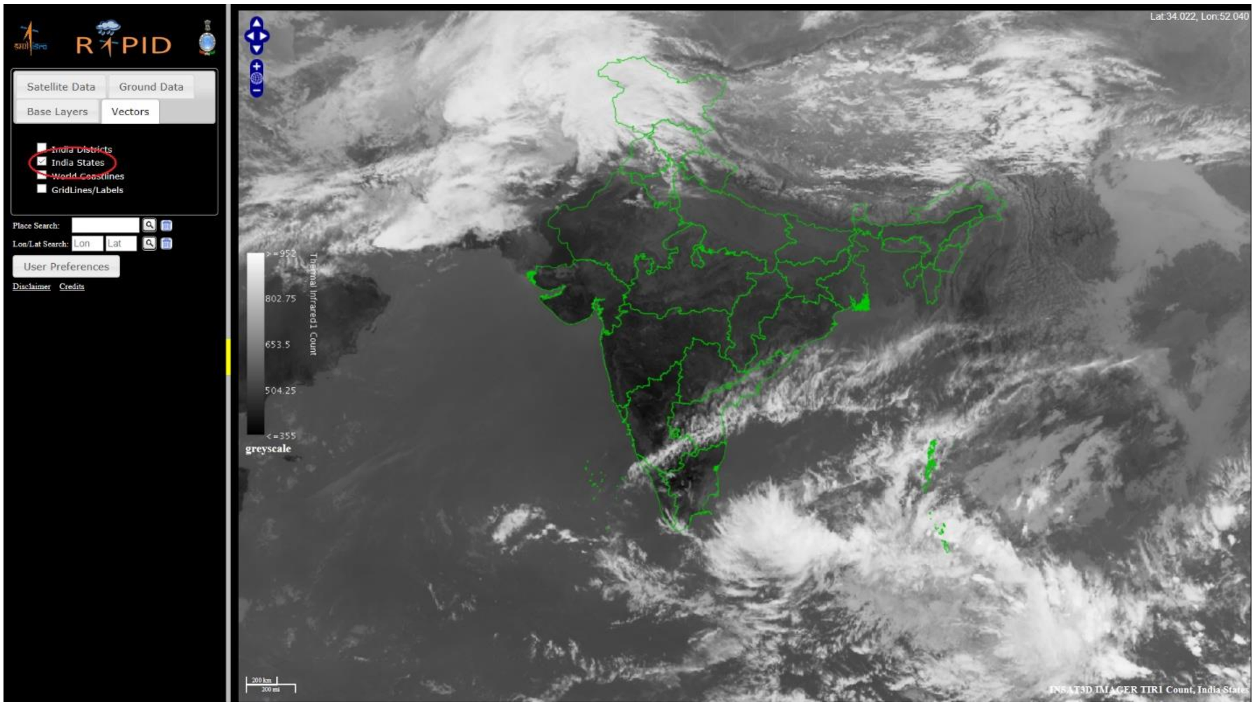
i) India Districts: User can overlay meteorological data (satellite & ground observation data) over India Districts boundary map.

INSAT-3D IMAGER TIR1 Radiance with India Districts as Vectors



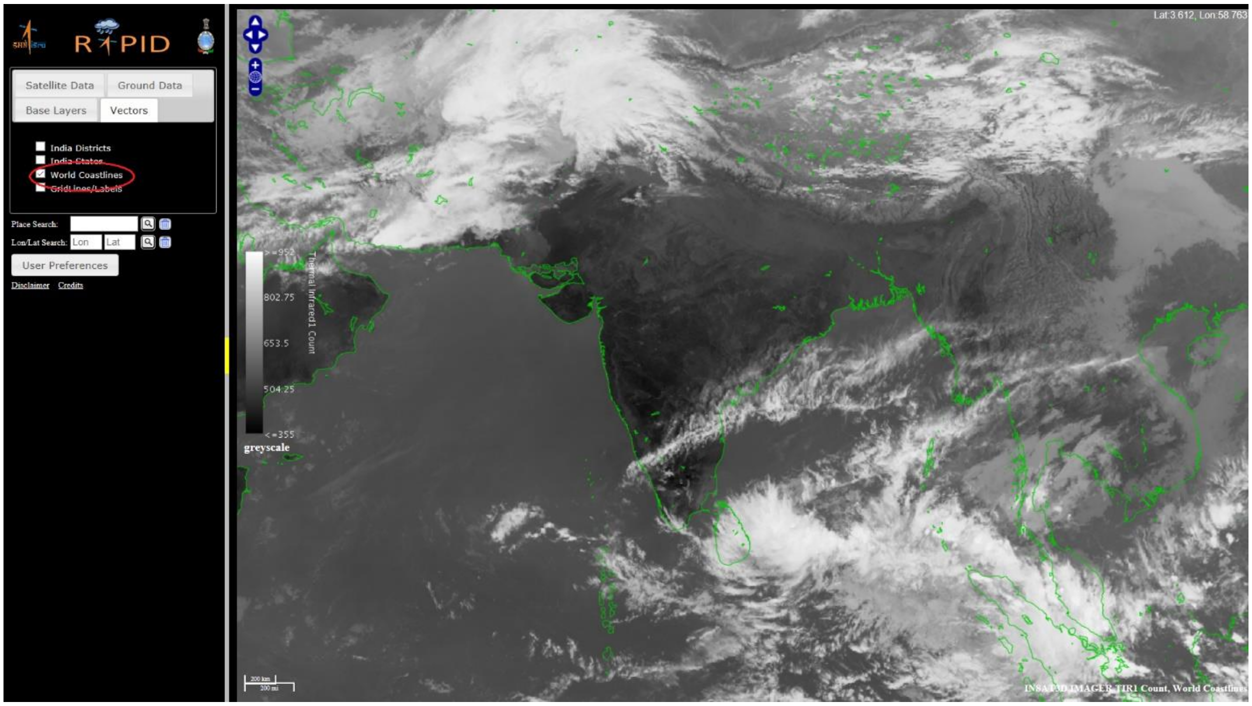
ii) India State: User can overlay meteorological data (satellite & ground observation data) over India State boundary map.

INSAT-3D IMAGER TIR1 Radiance with India States as Vectors



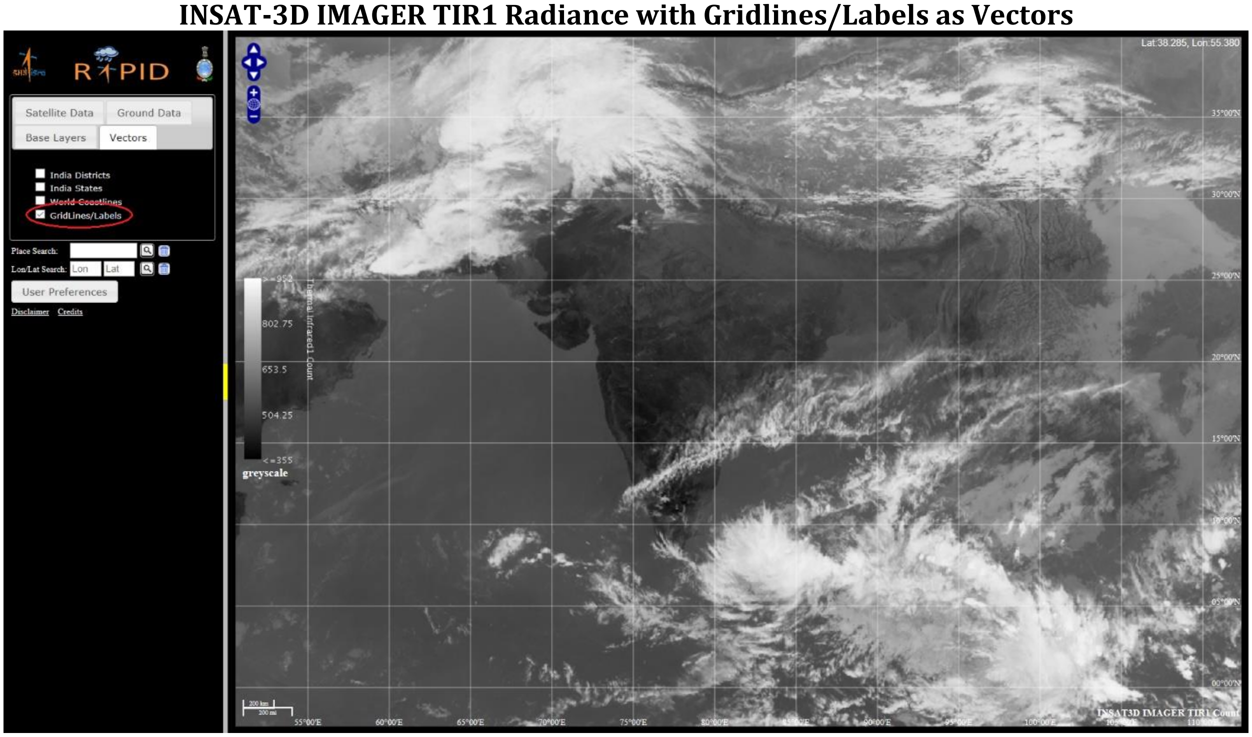
iii) World Coastlines: User can overlay meteorological data (satellite & ground observation data) over world coastlines map.

INSAT-3D IMAGER TIR1 Radiance with World Coastlines as Vectors



iv) Gridlines/Labels: User can overlay meteorological data (satellite & ground observation data) over gridlines.

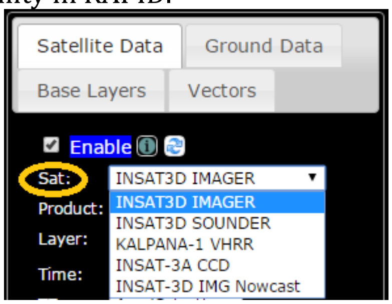
INSAT-3D IMAGER TIR1 Radiance with Gridlines/Labels as Vectors



2.3 Satellite Data: Under this tab the user is free to select payloads of current operational INSAT Meteorological satellites of INSAT-3D and Kalpana-1 satellites. In this selection, user has a freedom to visualize the channel images and products of satellite of his/her choice after clicking enable button. Under this tab user has to select five parameters viz. Sat (satellite/sensor), Product, Layer, Time and TZ (time zone) in order to visualize the selected satellite data.

1.3.1. Sat (Satellite):

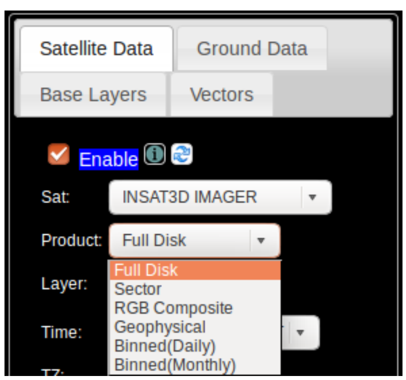
In first step user has to select either one satellite along with desired payload out of the available options i.e. INSAT-3D Imager, INSAT-3D Sounder, Kalpana-1 VHRR and INSAT-3D IMG Nowcast. INSAT-3D IMG Nowcast shows the possible future images using the Nowcasting tool developed by IMD and SAC. In future more options will be made available as per the data availability in RAPID.



1.3.2. Product:

In the second step, user has to select any one out of various products based on Sat selection in first step, as mentioned below:

i) ***INSAT-3D IMAGER Products*****:** If user selects INSAT-3D IMAGER in 'Sat' option, then user can choose following different products:



(a) **Full Disk:** Shows the full disk scan image of TIR1 Count, TIR1 Radiance, TIR1 BT, TIR2 Count, TIR2 Radiance, TIR2 BT, MIR Count, MIR Radiance, MIR BT, WV Count, WV Radiance, WV BT, VIS Count, & SWIR Count with domain size of the image is 55°N - 55°S, 10°E - 153°E.

(b) **Sector:** Shows the India and adjacent portion for TIR1 Count, TIR1 Radiance, TIR1 BT, TIR2 Count, TIR2 Radiance, TIR2 BT, MIR Count, MIR Radiance, MIR BT, WV Count, WV Radiance, WV BT, VIS Count, & SWIR Count with domain size of the image is 50°N - 50°S, 20°E - 130°E.

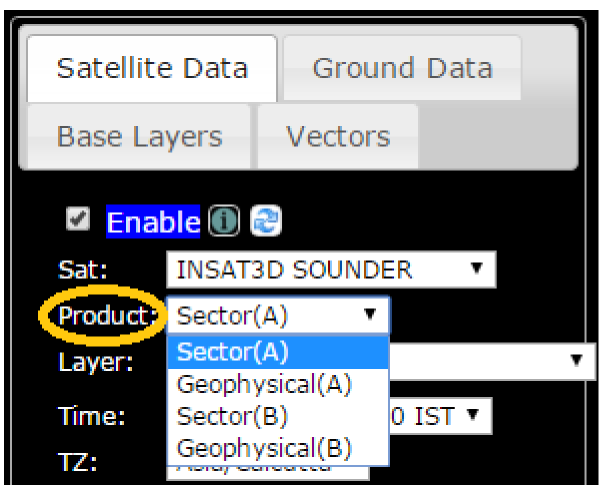
(c) **RGB Composites:** RGB composite images are produced by composing satellite images colored in red, green and blue (RGB). In the multi-spectral imager era RGB composites are an excellent addition to the tools available at the forecasters' bench. In an operational environment, it is important of course, to judiciously select the RGB composites and limit their number to a strict minimum in accordance with the problems at hand. At the same time one should strive for composites being available at night and day for maximizing feature identification. Two specific RGB products viz Day Microphysics RGB, Night Microphysics RGB are generated in IMD by using data from INSAT-3D Imager.

(d) **Geophysical:** Allows user to select different derived products such as Outgoing Longwave Radiation, Sea Surface Temperature, Upper Tropospheric Humidity, Land Surface Temperature, Aerosol Optical Depth, Rainfall (HEM), Rainfall (IMR), Rainfall (GPI), Snow and Fog/Low Cloud.

(e) **Binned (Daily):** These products are generated by binning all the 48 set of derived products data available on that particular day such as Outgoing Longwave Radiation, Sea Surface Temperature, Upper Tropospheric Humidity, Rainfall (HEM), Rainfall (IMR) and Rainfall (GPI). In case of rainfall estimated products (IMSRA/HEM/GPI), it is an accumulated value from 0330 UTC to the 0300 UTC of next day and will be available with the date stamp of previous day. For example, the daily accumulated rain of 07th day of November is the rainfall from 0330 UTC of 07th day of November to 0300 UTC of 08th day of November. The parameter is to be chosen from 'Layer' option.

(f) **Binned (Monthly):** These products are formed by binning all the derived product data of that parameter of that particular month such as such as Outgoing Longwave Radiation, Sea Surface Temperature, Upper Tropospheric Humidity, Rainfall (HEM), Rainfall (IMR) and Rainfall (GPI). In a way, this is a monthly average parameter of that parameter. In case of rainfall products, it is an accumulated value from 0330 UTC of previous 1st day to the 0300 UTC of first day of next month. The parameter is to be chosen from 'Layer' option.

ii) ***INSAT-3D SOUNDER Products*****:** If user select INSAT-3D SOUNDER in 'Sat' option then in Products user can choose are among these options



(a) **Sector-A:** This shows the image of Indian region for 19 channels i.e. SWIR1 Count, SWIR1 Radiance, SWIR1 BT, SWIR2 Count, SWIR2 Radiance, SWIR2 BT, SWIR3 Count, SWIR3 Radiance, SWIR3 BT, SWIR4 Count, SWIR4 Radiance, SWIR4 BT, SWIR5 Count, SWIR5 Radiance, SWIR5 BT, SWIR6 Count, SWIR6 Radiance, SWIR6 BT, MWIR1 Count, MWIR1 Radiance, MWIR1 BT, MWIR2 Count, MWIR2 Radiance, MWIR2 BT, MWIR3 Count, MWIR3 Radiance, MWIR3 BT, MWIR4 Count, MWIR4 Radiance, MWIR4 BT, LWIR1 Count, LWIR1 Radiance, LWIR1 BT, LWIR2

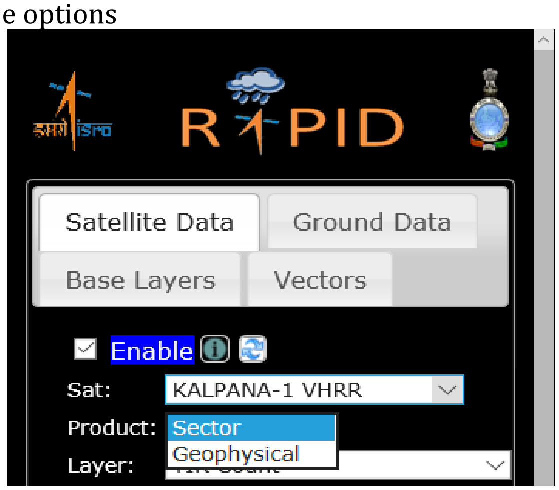
Count, LWIR2 Radiance, LWIR2 BT, LWIR3 Count, LWIR3 Radiance, LWIR3 BT, LWIR4 Count, LWIR4 Radiance, LWIR4 BT, LWIR5 Count, LWIR5 Radiance, LWIR5 BT, LWIR6 Count, LWIR6 Radiance, LWIR6 BT, LWIR7 Count, LWIR7 Radiance, LWIR7 BT, VIS Count & VIS Radiance. Dimensions of Sector A are 7N-40N, 60N-96N.

(b) Sector-B: This shows the image of Indian Ocean region for 19 channels i.e. SWIR1 Count, SWIR1 Radiance, SWIR1 BT, SWIR2 Count, SWIR2 Radiance, SWIR2 BT, SWIR3 Count, SWIR3 Radiance, SWIR3 BT, SWIR4 Count, SWIR4 Radiance, SWIR4 BT, SWIR5 Count, SWIR5 Radiance, SWIR5 BT, SWIR6 Count, SWIR6 Radiance, SWIR6 BT, MWIR1 Count, MWIR1 Radiance, MWIR1 BT, MWIR2 Count, MWIR2 Radiance, MWIR2 BT, MWIR3 Count, MWIR3 Radiance, MWIR3 BT, MWIR4 Count, MWIR4 Radiance, MWIR4 BT, LWIR1 Count, LWIR1 Radiance, LWIR1 BT, LWIR2 Count, LWIR2 Radiance, LWIR2 BT, LWIR3 Count, LWIR3 Radiance, LWIR3 BT, LWIR4 Count, LWIR4 Radiance, LWIR4 BT, LWIR5 Count, LWIR5 Radiance, LWIR5 BT, LWIR6 Count, LWIR6 Radiance, LWIR6 BT, LWIR7 Count, LWIR7 Radiance, LWIR7 BT, VIS Count & VIS Radiance. Dimensions of Sector B are 13S-10N, 55E-96E.

(c) Geophysical (A): This allows user to choose geophysical parameters (Temperature Profile (Phy), Water Vapor Profile (Phy), L1 Precipitable Water, L2 Precipitable Water, L3 Precipitable Water, Total Precipitable Water, Lifted Index, Dry Microburst Index, Surface Skin Temperature (Phy), Wind Index & Maximum Vertical Theta-e) in sector A to be selected in Layer drop box.

(d) Geophysical (B): This allows user to choose geophysical parameter (Temperature Profile (Phy), Water Vapor Profile (Phy), L1 Precipitable Water, L2 Precipitable Water, L3 Precipitable Water, Total Precipitable Water, Lifted Index, Dry Microburst Index, Surface Skin Temperature (Phy), Wind Index & Maximum Vertical Theta-e) in sector B to be selected in Layer drop box.

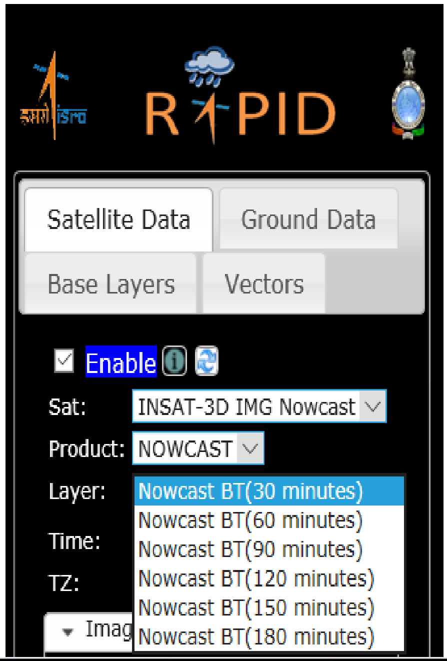
iii) *KALPANA1-VHRR Products:* If user select KALPANA1-VHRR in 'Sat' option then in Products user can choose are among these options

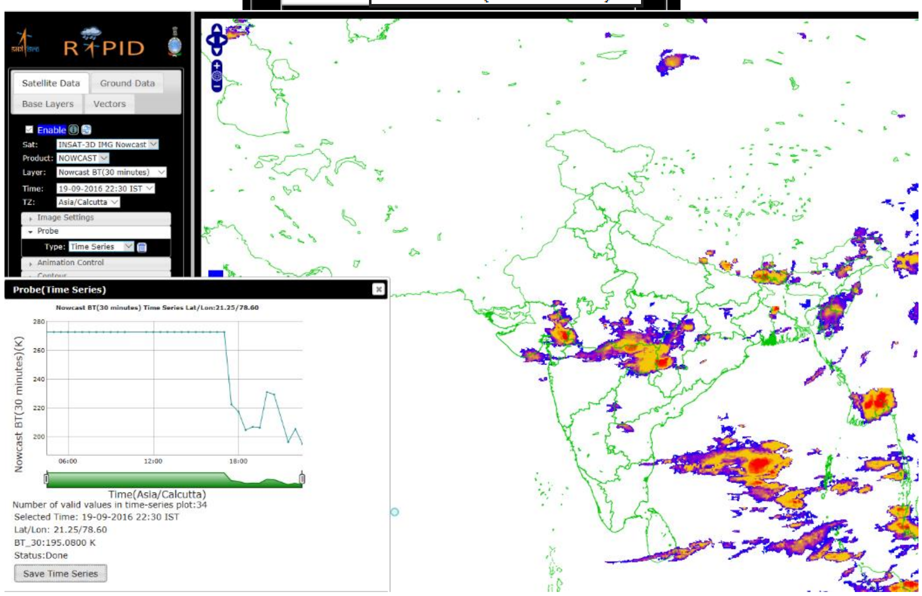


(a) Sector: Sector product refers to the observations of various channels present in Kalpana-1 Satellite.

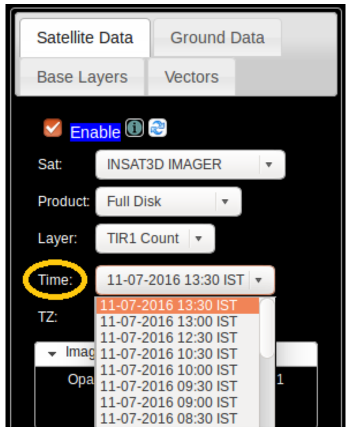
(b) Geophysical: This allows user to choose geophysical parameter derived from Kalpana-1 Satellite payloads.

iv) *INSAT-3D IMG Nowcast:* the forecasted brightness temperature layers can be chosen. It is available at every half hour up to 3 hours as shown below from layer tab.

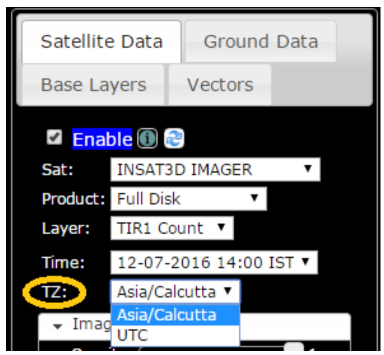




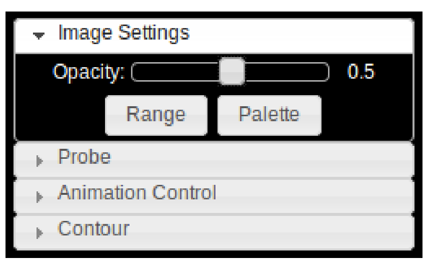
1.3.3. Time: Here user can select the Time for which the image is to be visualized. Latest 94 images of 3D Imager, 3D Sounder and 3A VHRR are kept at the server which can be accessed online.



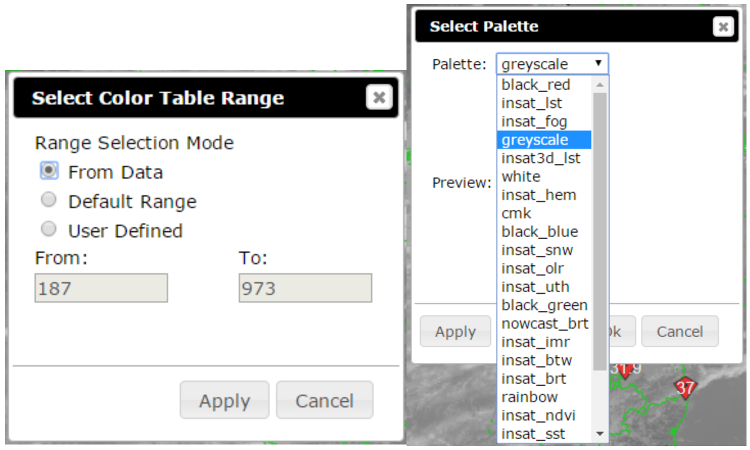
1.3.4. TZ (Time Zone): Here user can select the Time zone according to user need. Currently on Asia/Calcutta and UTC are available for selection.



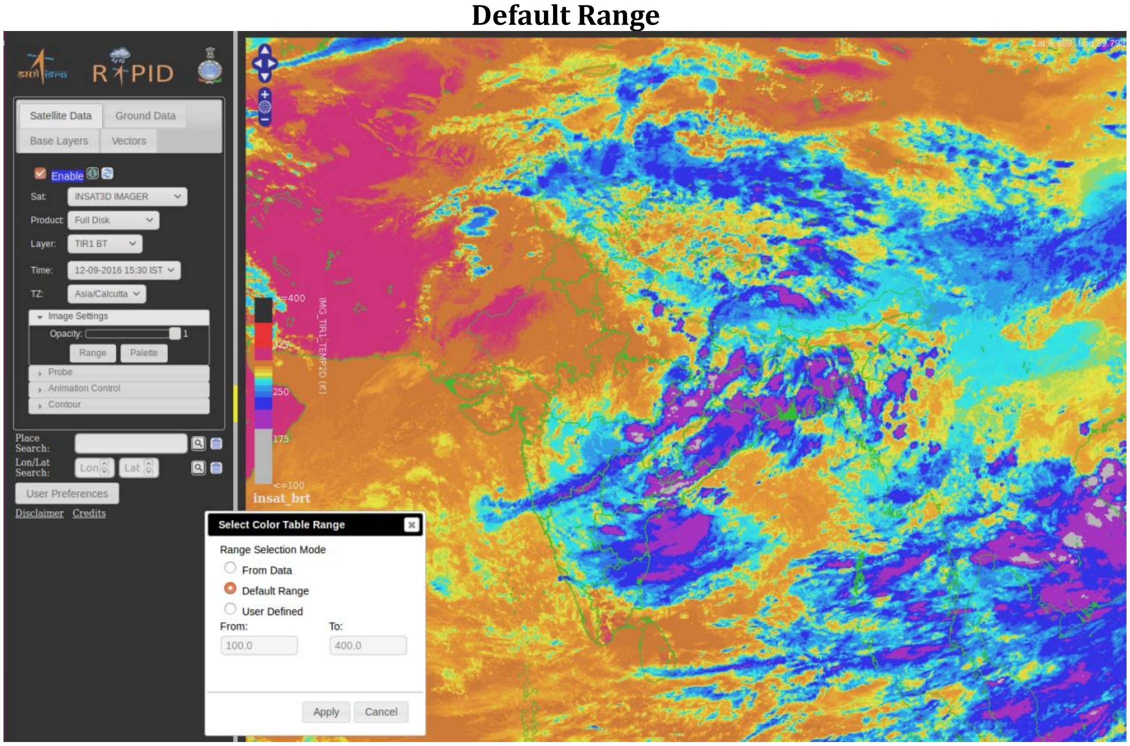
1.3.5. Image Settings: Here user can select the Opacity of the layer for better visualization of overlaid images. 0 corresponds to complete transparent and 1 to opaque.



i) ***Range Selection:*** User can choose Range as well as Palette according to user need. These options help in bringing out the desired and targeted outputs.

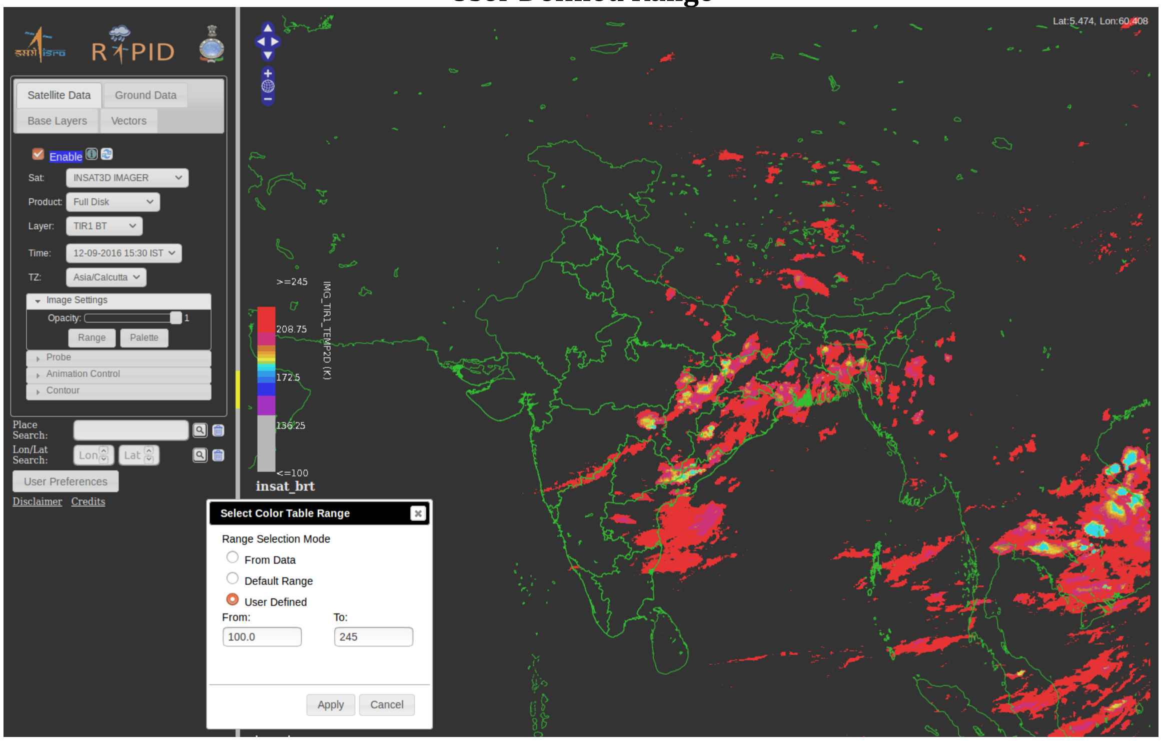


Default Range

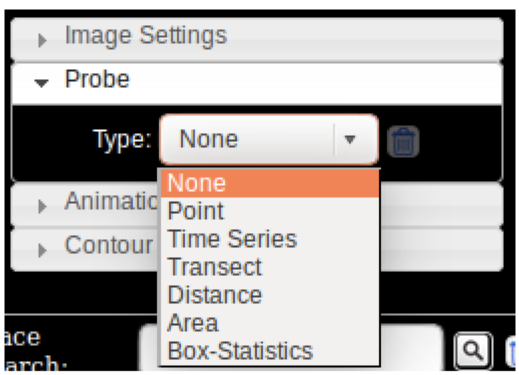


User Defined Range: This option can be useful for TIR1 BT, to identify thunderstorm cells. In this user-specific range can be entered for specific visualization.

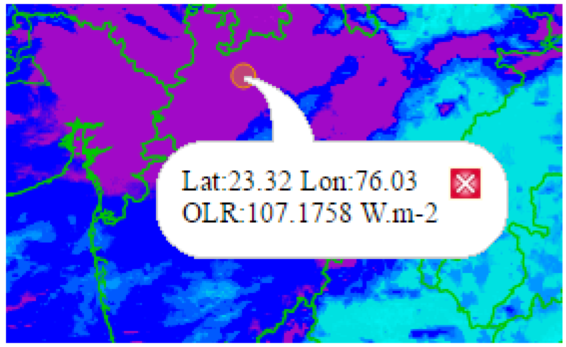
User Defined Range



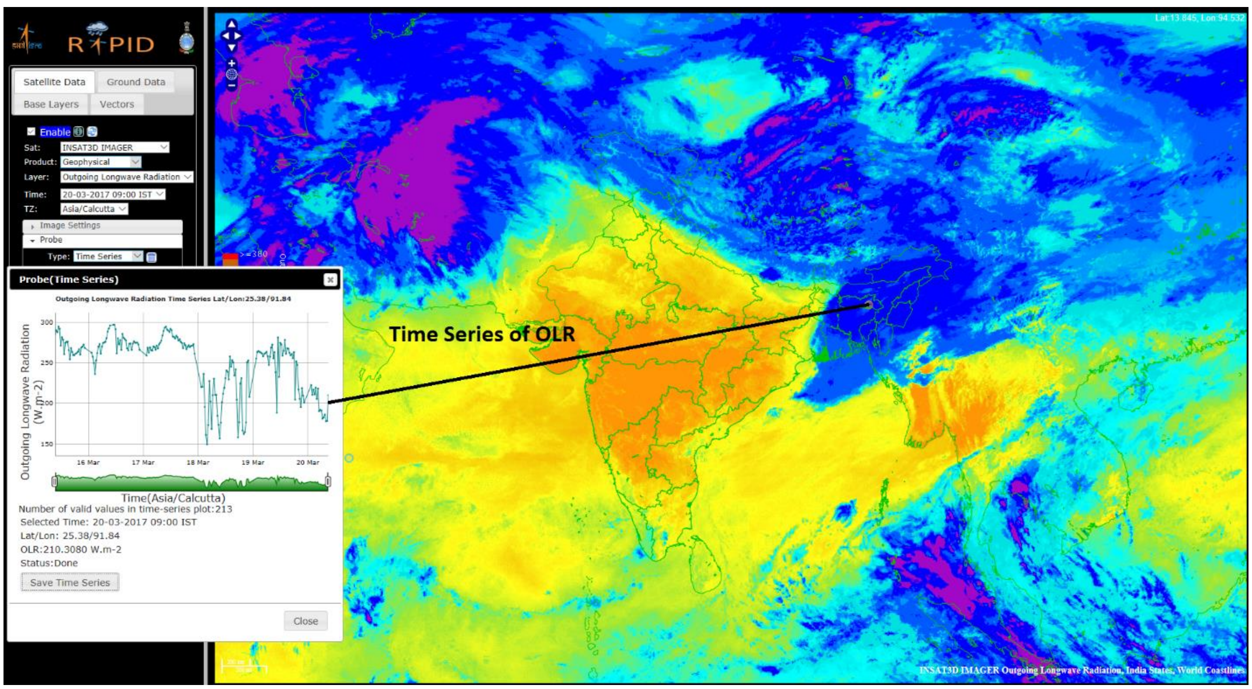
1.3.6. Probe: This tool allows user to extract more information in the form of digital values out of an image/product dataset and is very helpful for the analysis of the image data from forecasting point of view. User can select among 6 different options to probe the image data as shown below:



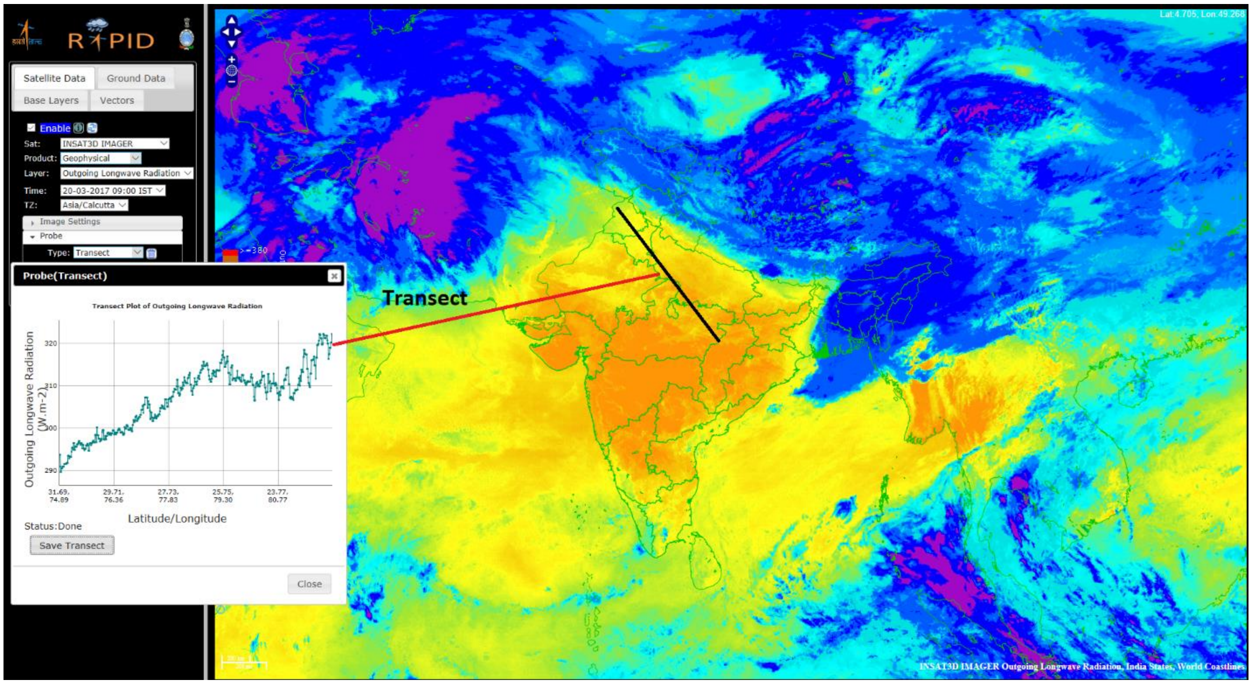
i) *Point:* User can use this option to get the information at a particular point. User need to select this option and click the point location on image to be probed. It shows the Latitude, Longitude and the digital value of data along with the unit of the parameter at that point as shown in the example of OLR parameter.



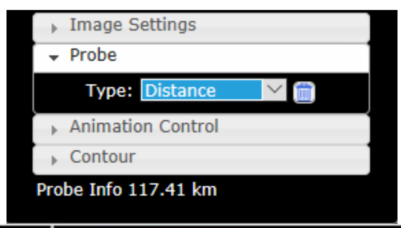
ii) ***Time Series:*** Under this option user can plots a time series graph of the parameter of his choice at a particular point. User need to select this option and click the point location on image to be probed. This allows user to know the variation of that particular parameter in time at that particular point. This can be helpful to study the temporal variation of parameter at that point to probe the events that have occurred or to know the trend of variation helping forecaster to foresee the possible future development. A example here shows the time series plot of OLR at that particular point. On moving cursor over the time series graph digital value of parameter with date and time will be displayed.

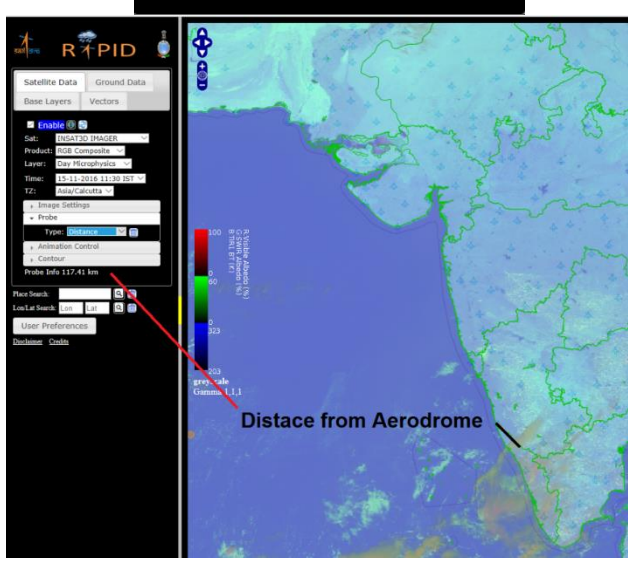


iii) ***Transect:*** Under this option user can visualize the variation of the parameter along a line in the form of plot. This option is very helpful for route forecast in aviation sector. To use this option user has to click at the starting point and then draw the line across which plot is required and at the end of this line, user has to double click in order to generate Transect plot. This will draw a line on image and the graph will be shown alongside as shown below. This is important tool particularly for the aviation forecasters' community which needs to know the variation of a parameter along the flight routes.

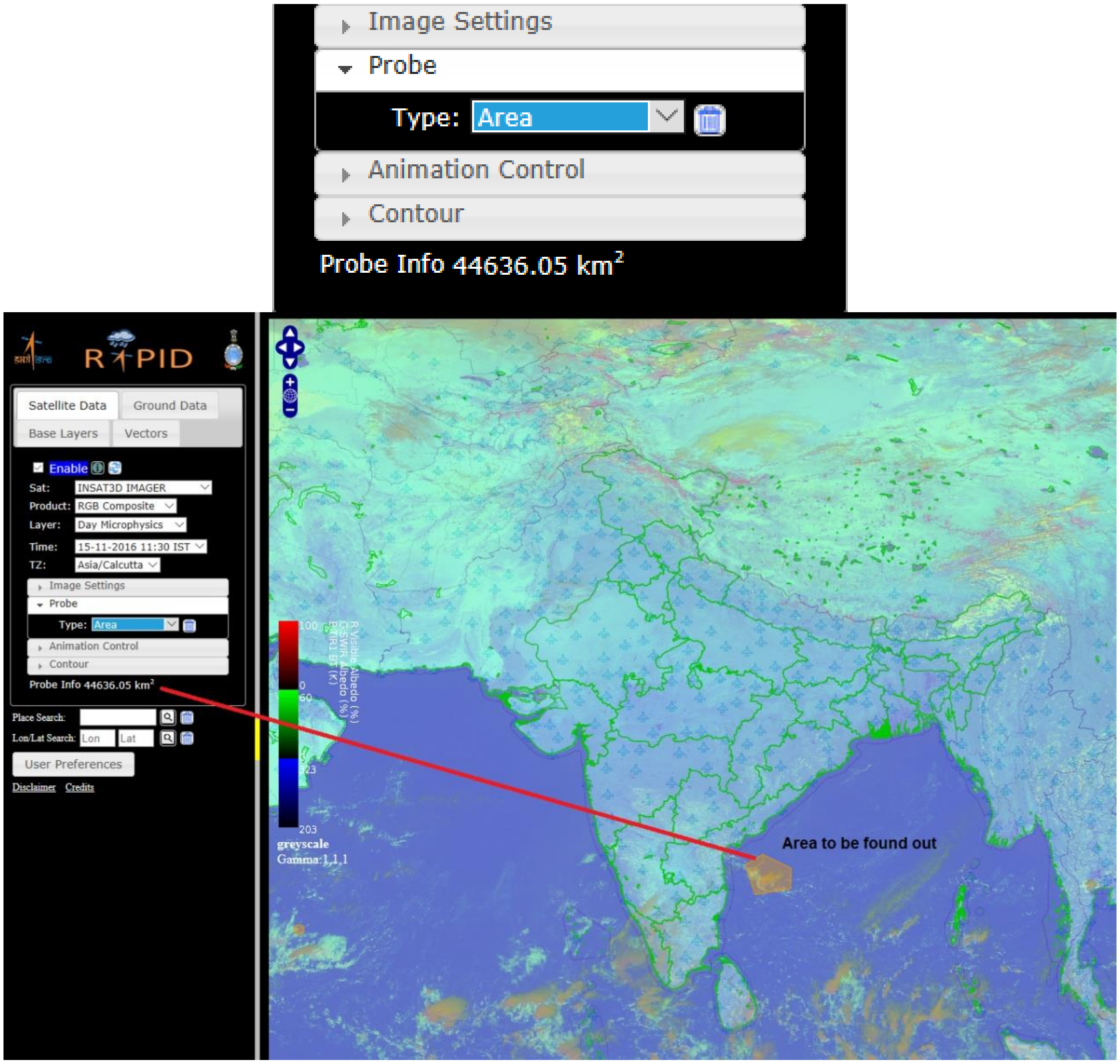


iv) ***Distance:*** Under this option user can measure the distance between two points on image or distance of cloud from particular station. User need to select this option and then click at two different points on the image to get the distance between them. This is useful for forecasters to check the future possible movement of system towards their station. This is very useful to predict the time at which a weather event will cross a particular location by calculating speed using distance observation at two different time. The distance is shown at the bottom as shown in the alongside figure.

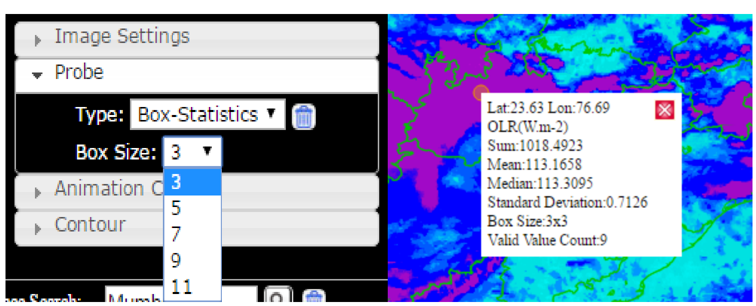




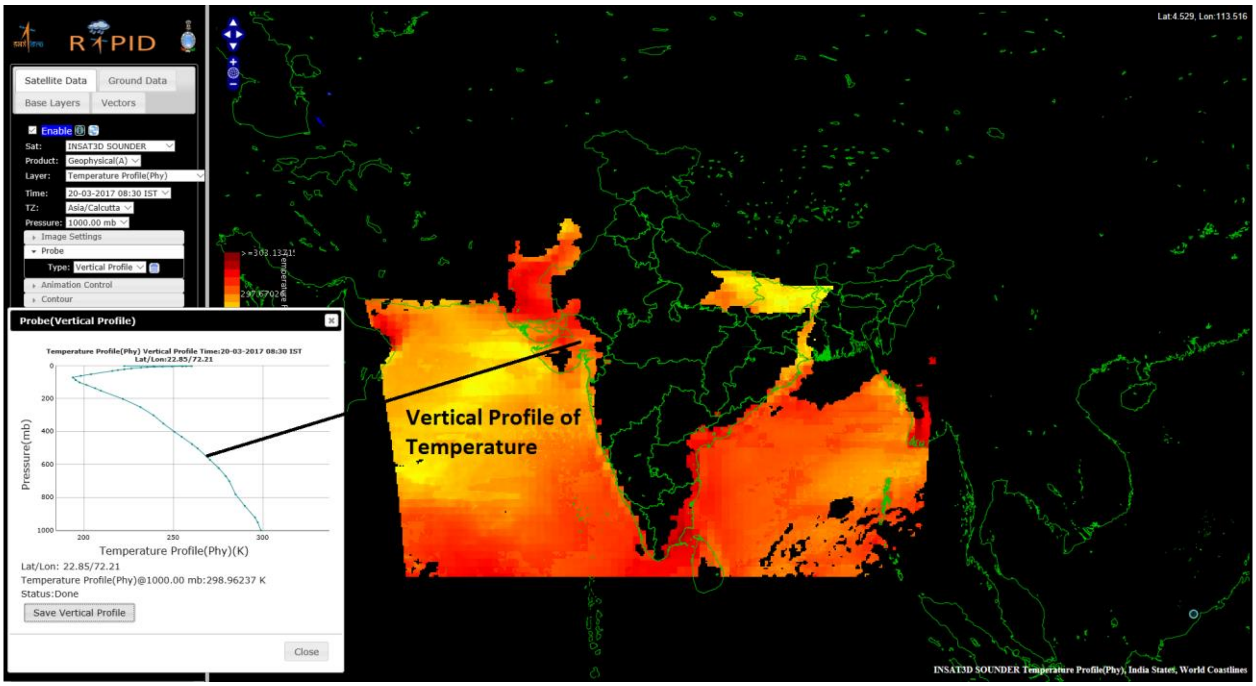
v) ***Area:*** Under this option user can measure the area of weather system/cloud/rainfall affected area on the image data. User need to select this option and then define a closed area on image with number of clicks ending in double click. This area can be of any shapes (regular/irregular).



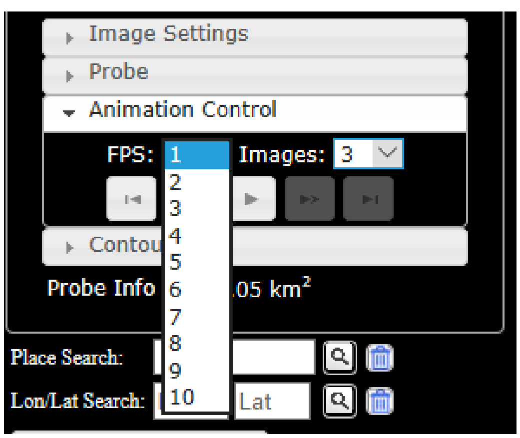
vi) ***Box Statistics:*** This tool allows user to get the statistics information of a box around a point. This box can be of 3x3, 5x5, 7x7, 9x9 & 11x11 pixel size. User has option to choose this from the drop-down menu of box size. Once user select these two options and click on the image user get the statistical information of that box as shown in the alongside figure.

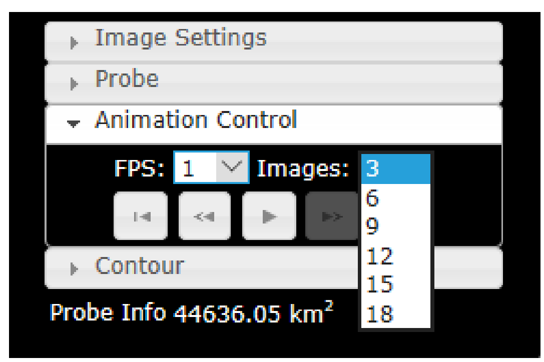


vii) ***Vertical Profile:*** *T*his option is available to user when he/she selects Sounder under Satellite tab and Geophysical under Products tab and Temperature Profile or Humidity Profile under Layer tab. The vertical profile of temperature is available at 40 levels (1000hPa to 0.1hPa) and vertical profile of humidity is available at 21 levels.



1.3.7. Animation Control: This tool allows user to make an animation using available images. User has options to choose FPS (Frames per second) and the number of images to be used in animation. Once user select these options and click the play symbol the animated will be displayed in the data viewer pane. This is useful to see the movement of weather systems.





1.3.8. Contour: This tool allows user to draw the contour lines in the image. User need to check the enable and then select the color bar / palette to be used, minimum and maximum values and the interval. Once user select all this and press Interval the contour lines will be drawn on the image accordingly. This is useful to analyze the image while concentrating on specific area / gradient.

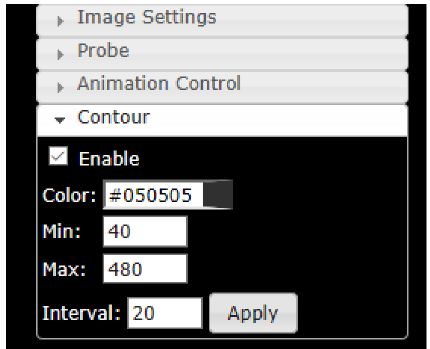
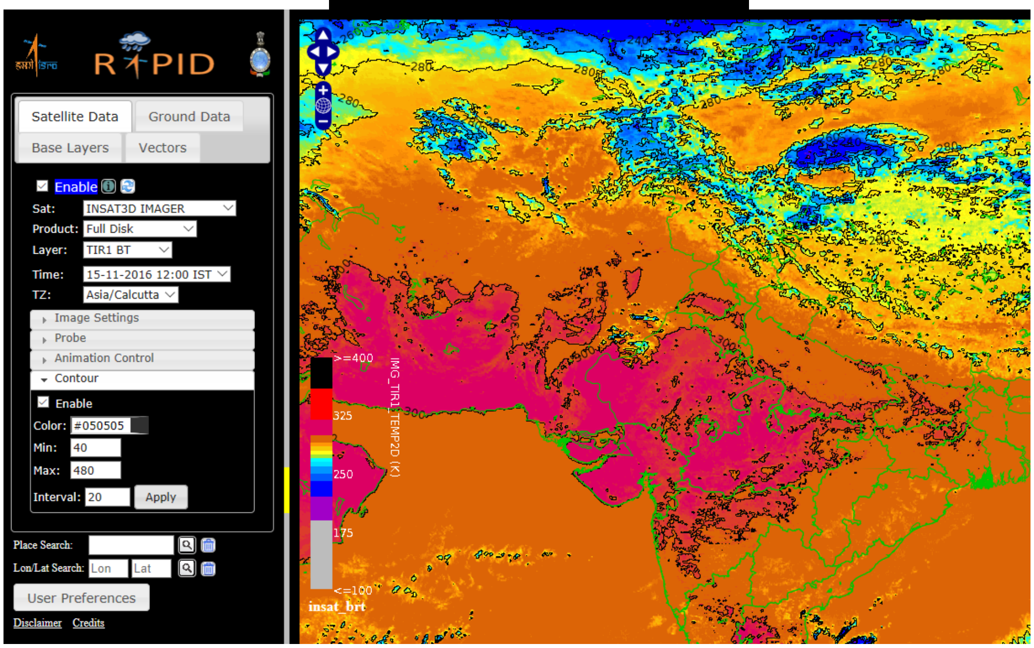
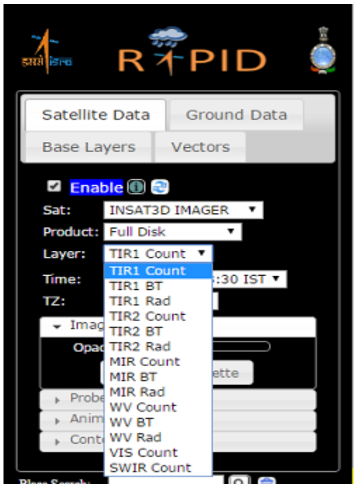


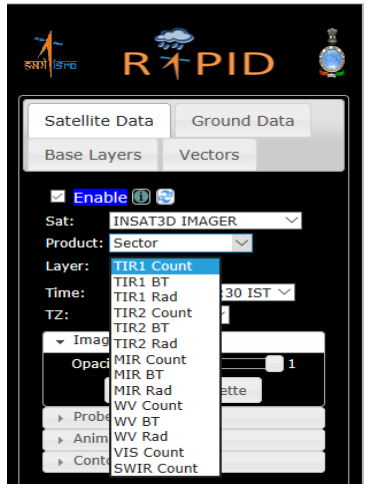
Image Settings
Probe
Animation Control
Contour
Enable
Color: #050505
Min: 40
Max: 480
Interval: 20
Apply


RAPID
Satellite Data
Ground Data
Base Layers
Vectors
Enable
Sat: INSAT3D IMAGER
Product: Full Disk
Layer: TIR1 BT
Time: 15-11-2016 12:00 IST
TZ: Asia/Calcutta
Image Settings
Probe
Animation Control
Contour
Enable
Color: #050505
Min: 40
Max: 480
Interval: 20
Apply
Place Search:
Lon/Lat Search: Lon Lat
User Preferences
Disclaimer
Credits
>=400
325
250
175
<=100
IMG_TIR1_TEMP2D (K)
insat_brt

1.3.9. Layer: Under this tab user have various options of selection subject to the selections carried out under Sat and Product tabs as mentioned in step 1 & 2. Corresponding to each set of selections, Layer tab have different options which are detailed below.

I. ***INSAT-3D IMAGER* - FULL DISC or SECTOR*:*** If user has selected INSAT-3D IMAGER under 'Sat' tab and either **FULL DISC** or **SECTOR** under 'Product' tab**,** then the following options become available under 'Layer' tab for selection:



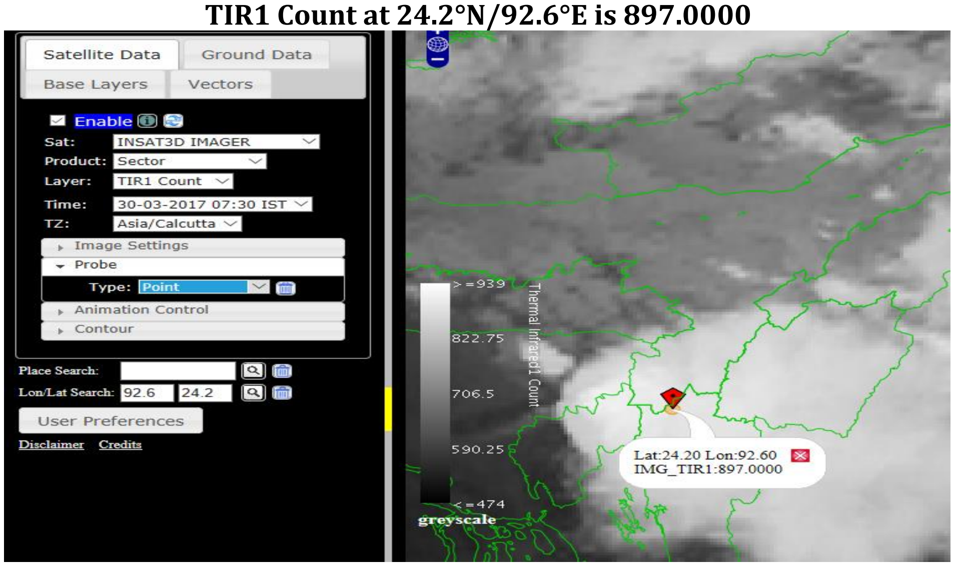


Out of these options either one can be selected: visible (VIS Count), Short Wave Infrared (SWIR Count), Thermal Infrared-1 (TIR1 Count, TIR1 BT and TIR1 Rad), Thermal Infrared-2 (TIR2 Count, TIR2 BT and TIR2 Rad), Mid Infrared (MIR Count, MIR BT and MIR Rad), and Water Vapor (WV Count, WV BT and WV Rad).

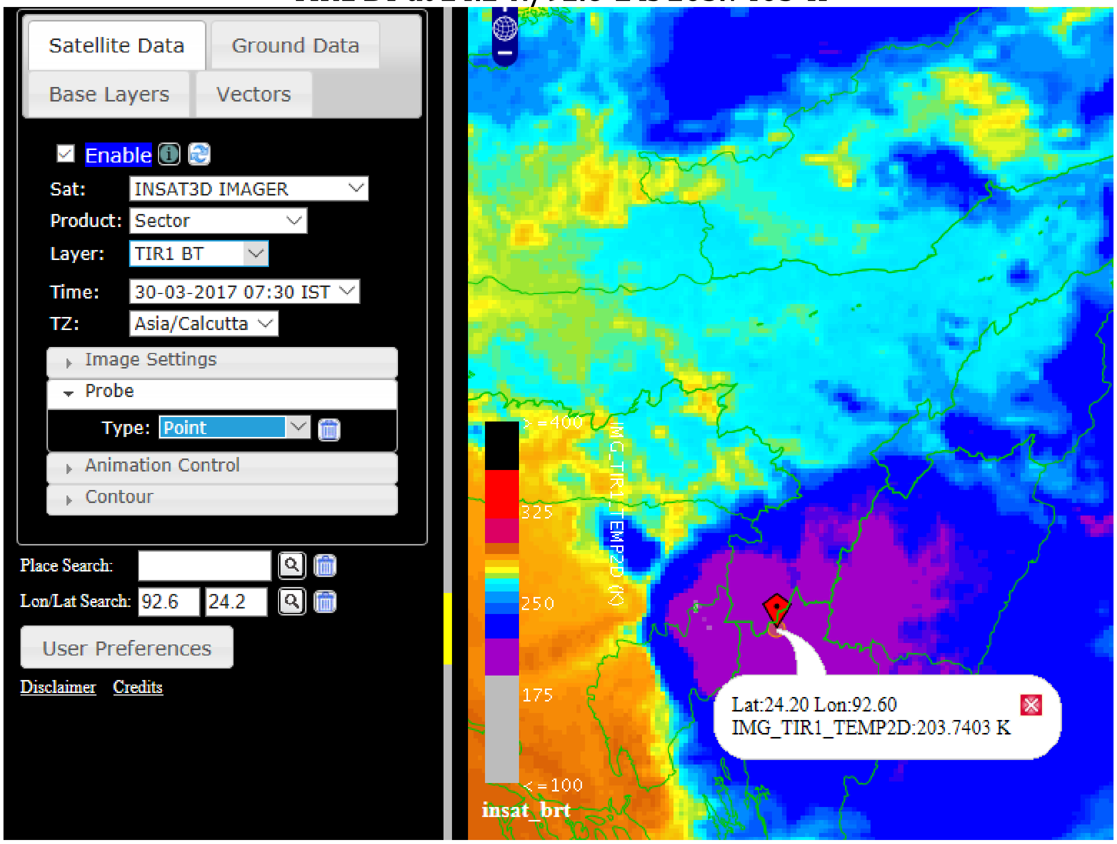
The actual radiance measured by sensor is converted into a digital number (called Count) onboard at payload itself and is then transmitted to earth station. The value of Count lies in the range from 0 to 1023. Count is converted into Radiance (Rad) and Brightness Temperature (BT) during processing of satellite data.

Corresponding to Thermal Infrared1 selection all the three Layers i.e. TIR1 Count, TIR1 BT, TIR1 Radiance has been shown below as an example. Similarly, other channel data can be visualized.

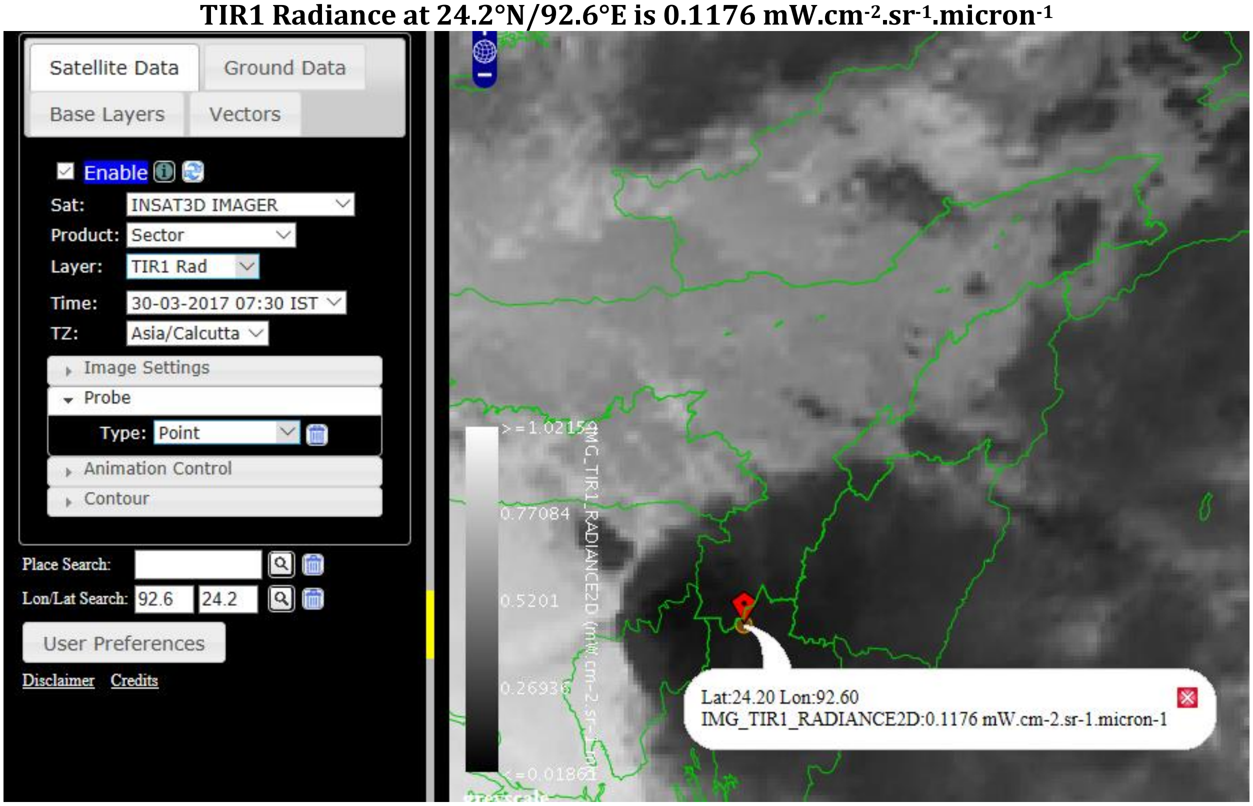
TIR1 Count at 24.2°N/92.6°E is 897.0000



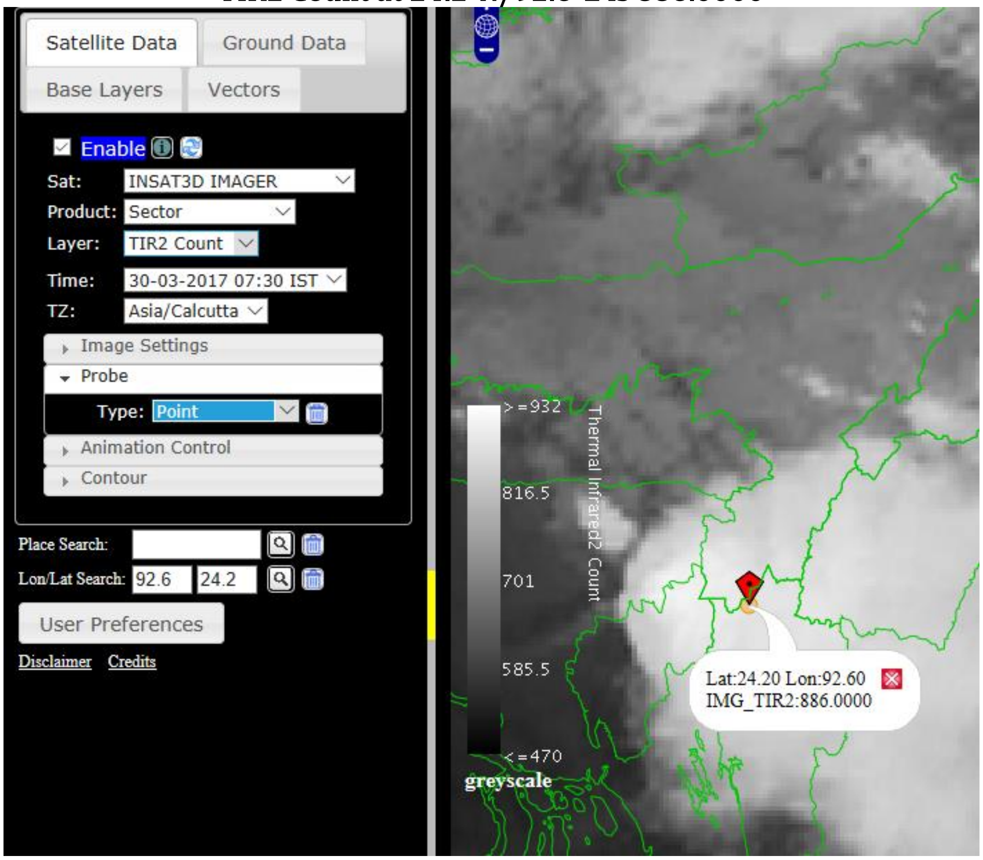
TIR1 BT at 24.2°N/92.6°E is 203.7403°K



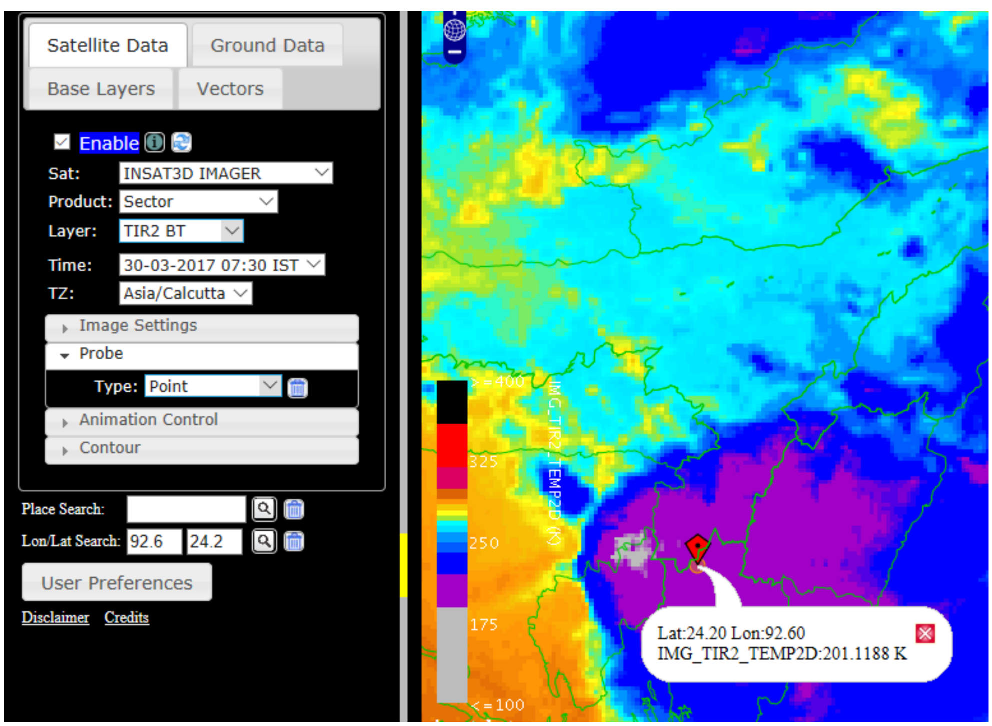
TIR1 Radiance at 24.2°N/92.6°E is 0.1176 $mW.cm^{-2}.sr^{-1}.micron^{-1}$



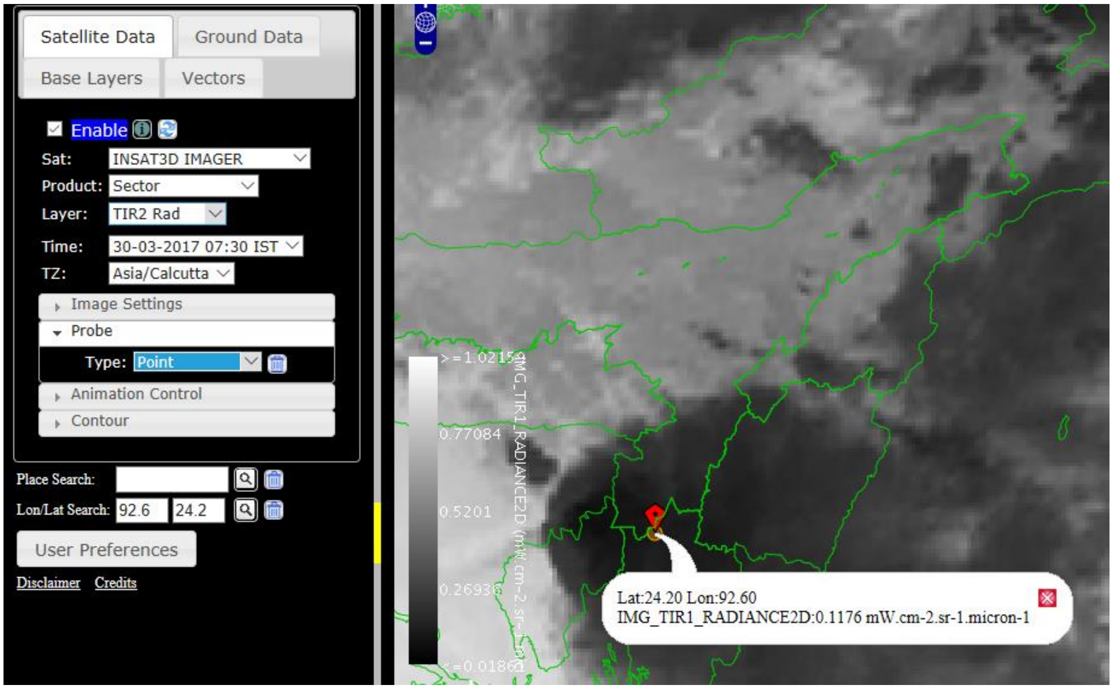
TIR2 Count at 24.2°N/92.6°E is 886.0000



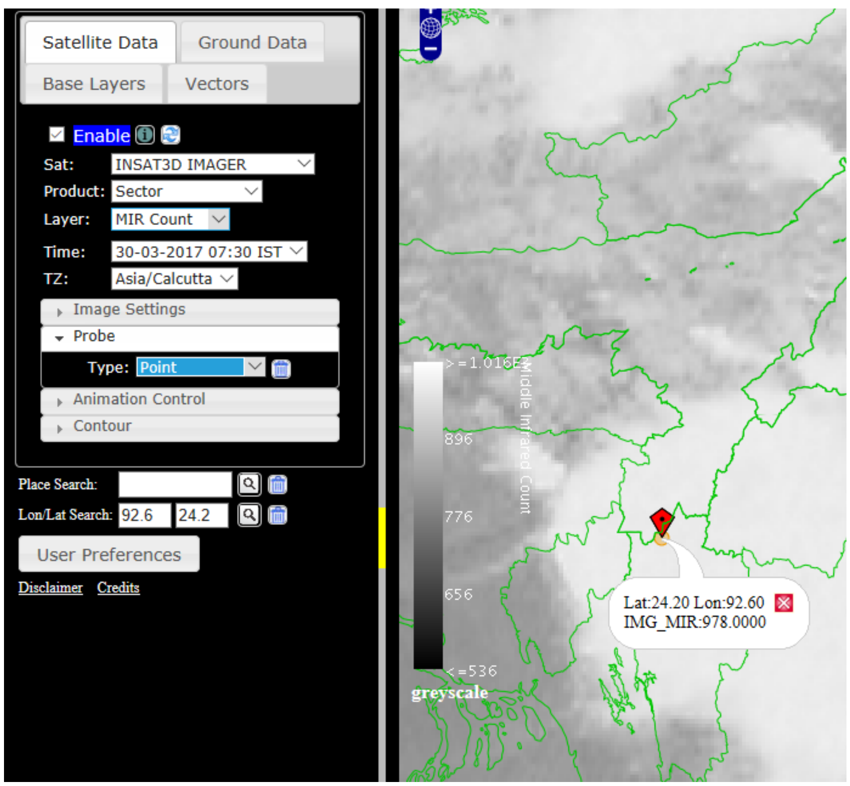
TIR2 BT at 24.2°N/92.6°E is 203.7403°K



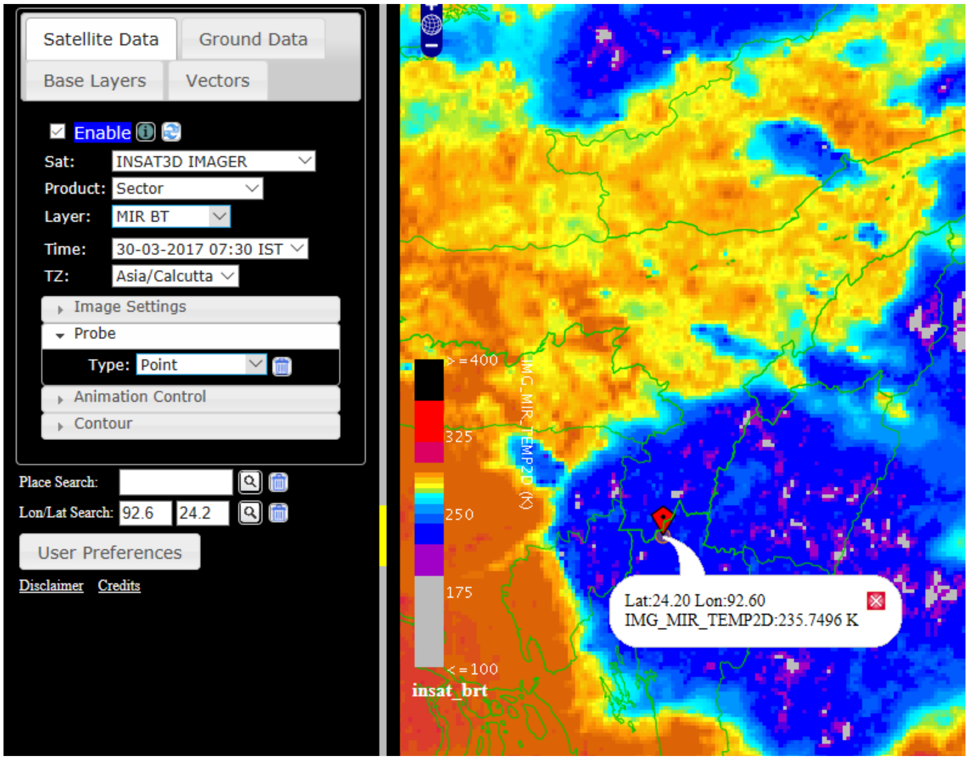
TIR2 Radiance at 24.2°N/92.6°E is 0.1176 mW.cm-2.sr-1.micron-1



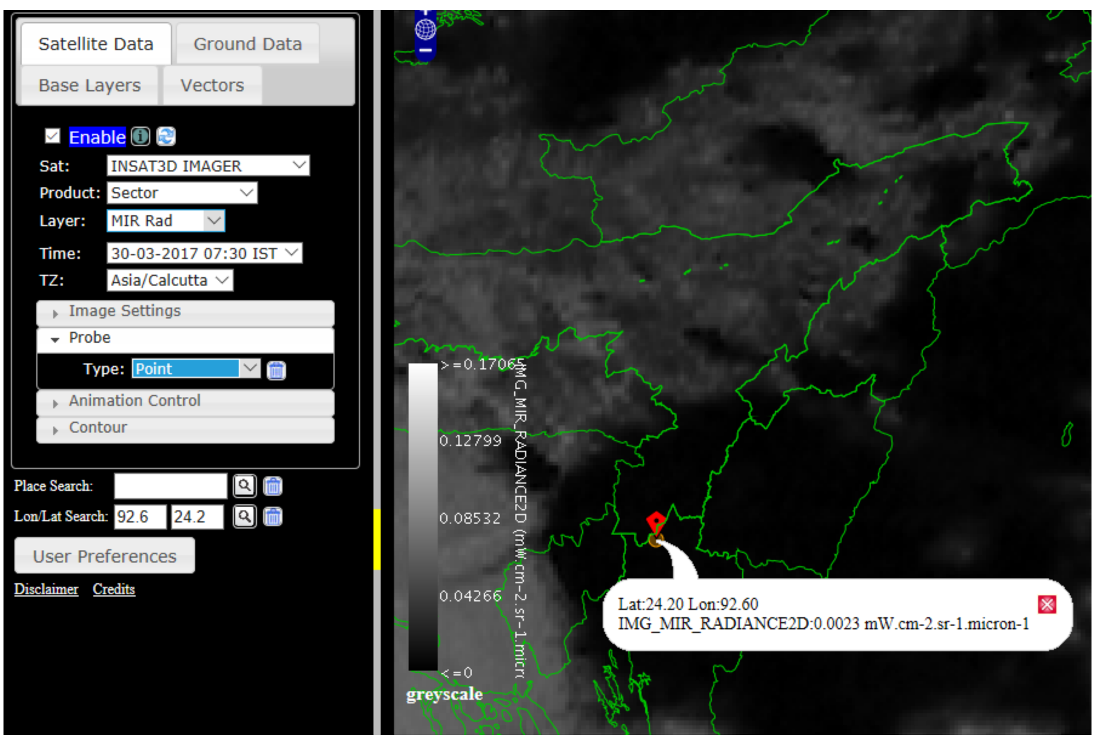
MIR Count at 24.2°N/92.6°E is 978.0000



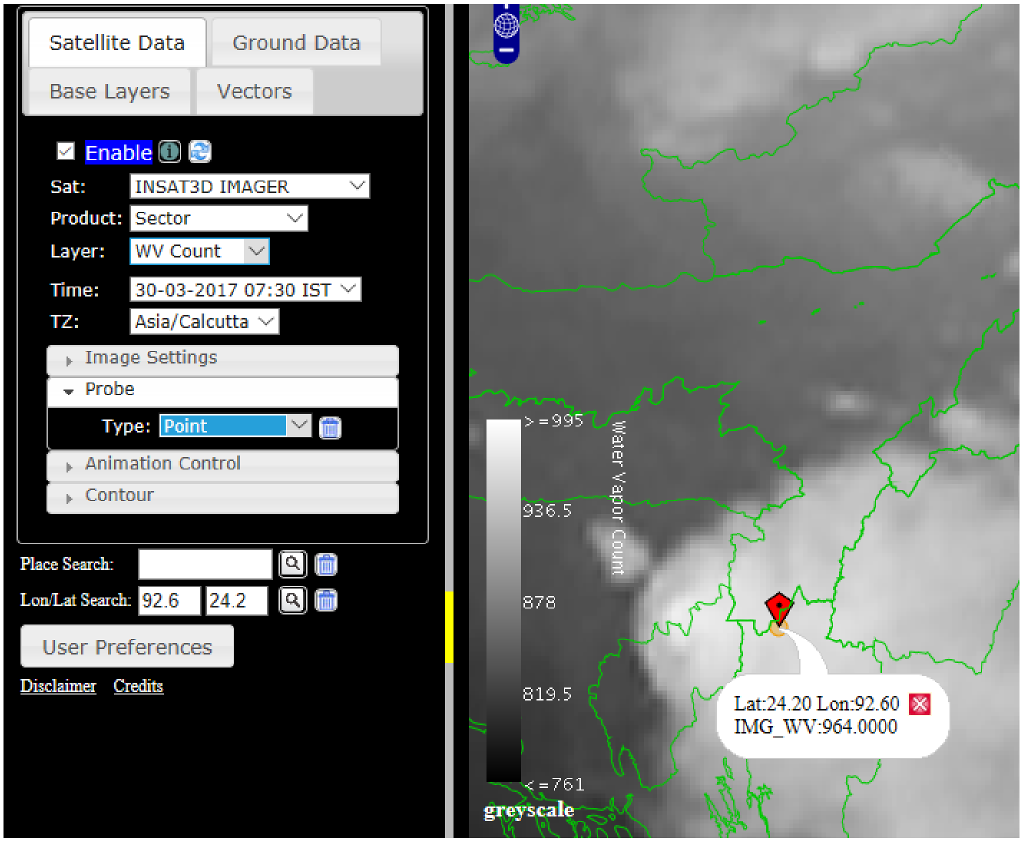
MIR BT at 24.2°N/92.6°E is 235.7496°K



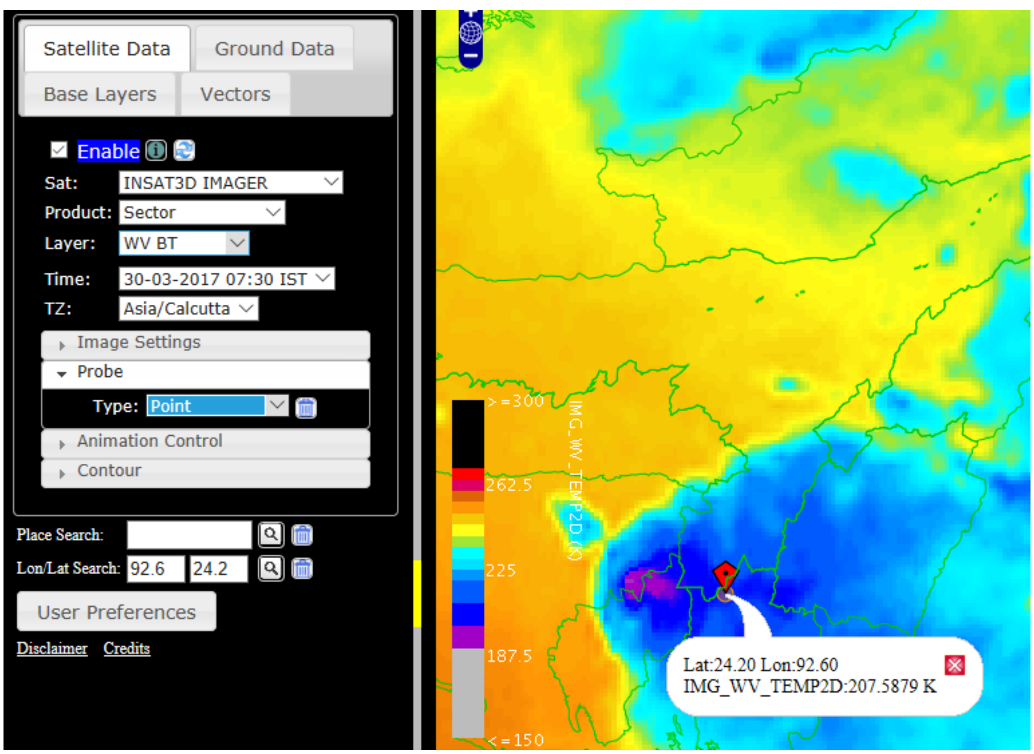
MIR Radiance at 24.2°N/92.6°E is 0.0023 mW.cm^{-2}.sr^{-1}.micron^{-1}



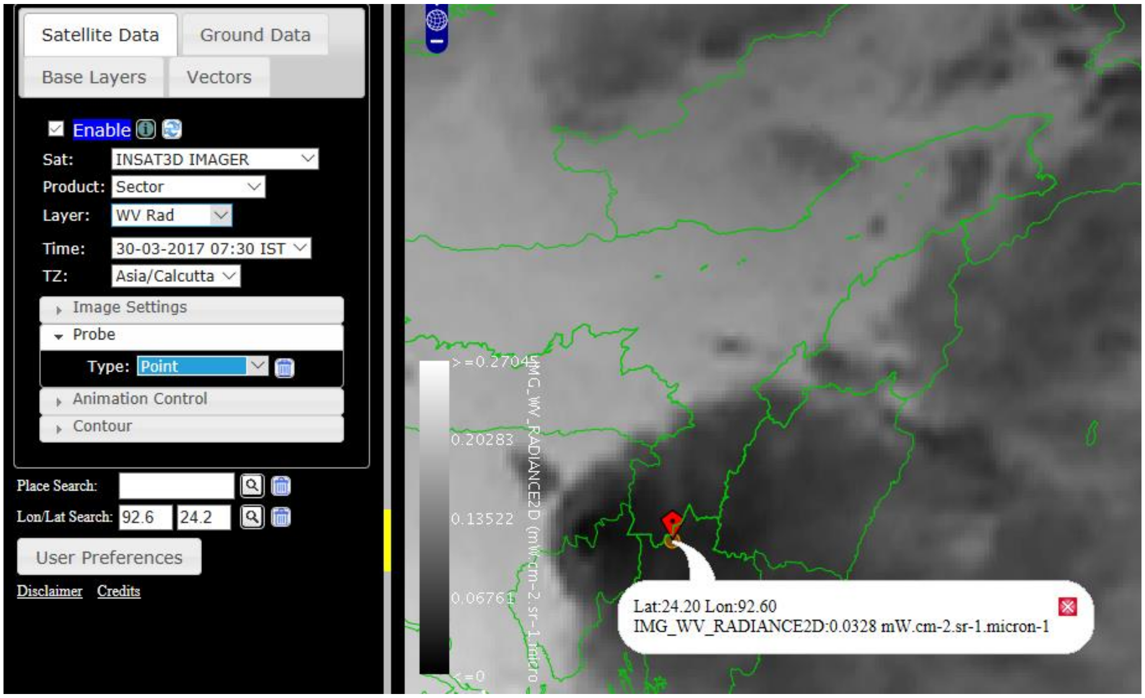
WV Count at 24.2°N/92.6°E is 964.0000



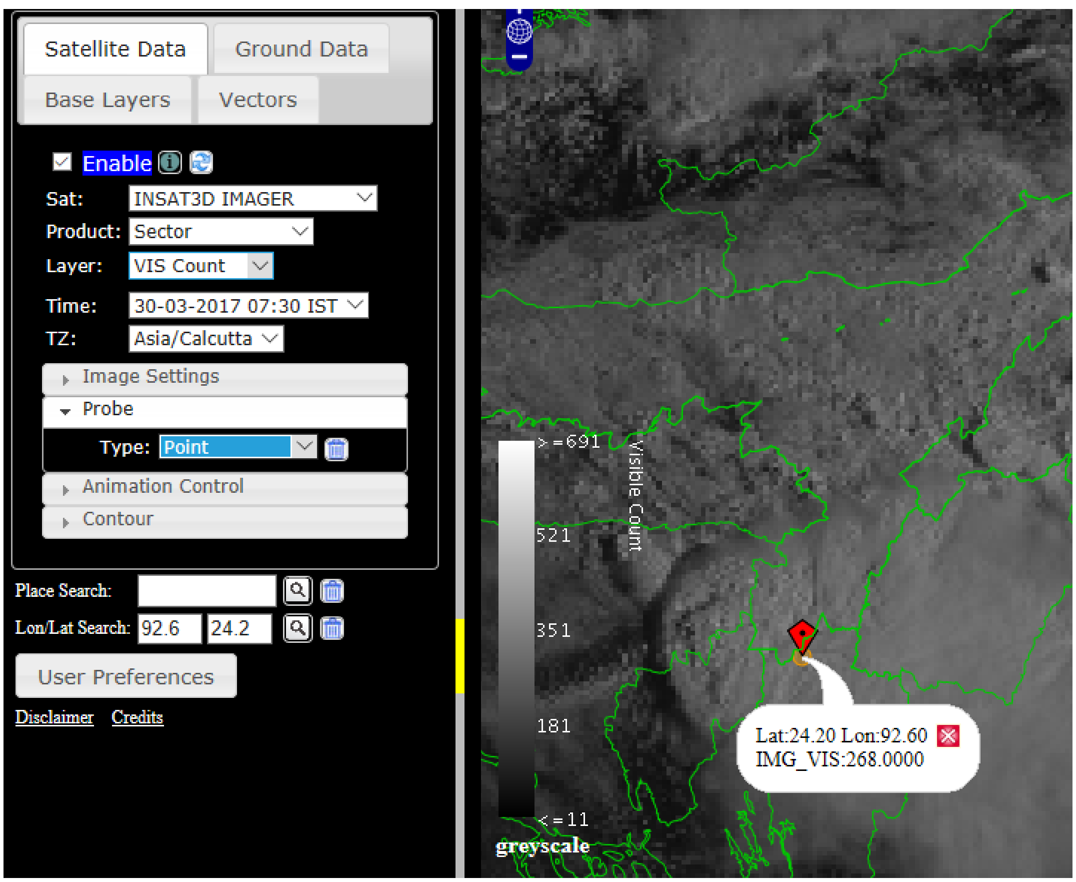
WV BT at 24.2°N/92.6°E is 207.5879°K



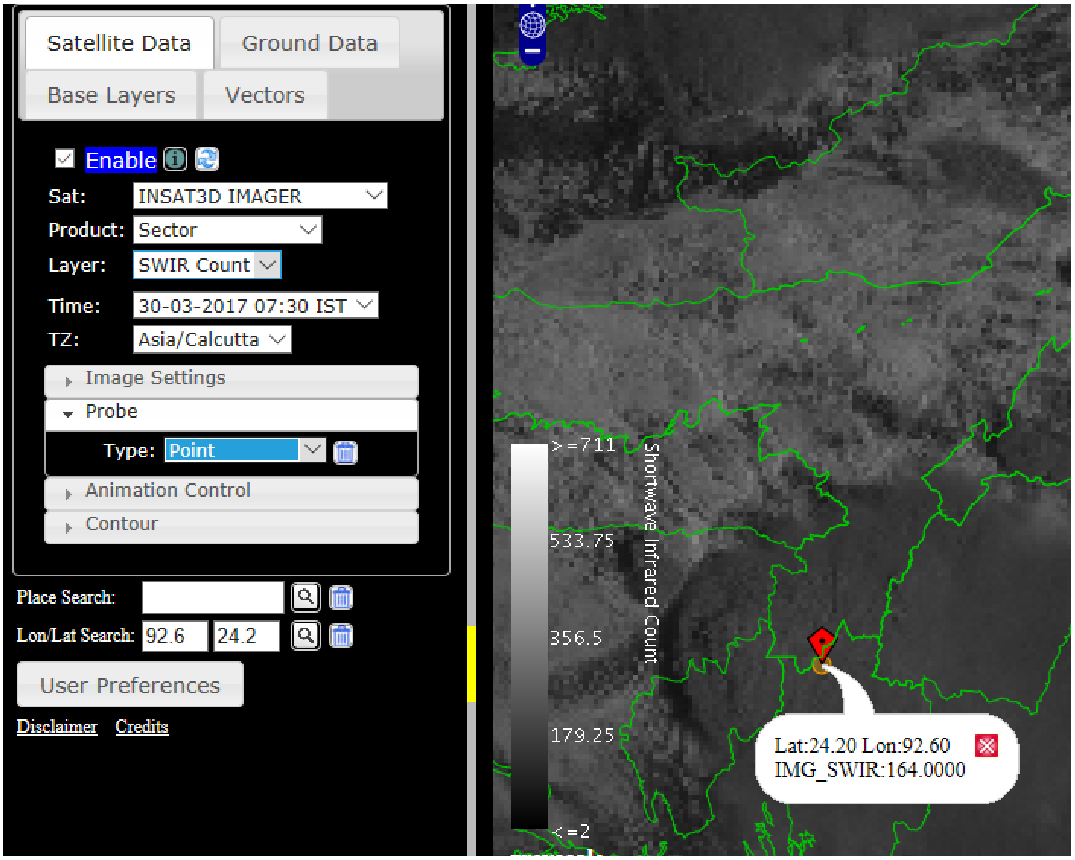
WV Radiance at 24.2°N/92.6°E is 0.0328 $mW.cm^{-2}.sr^{-1}.micron^{-1}$



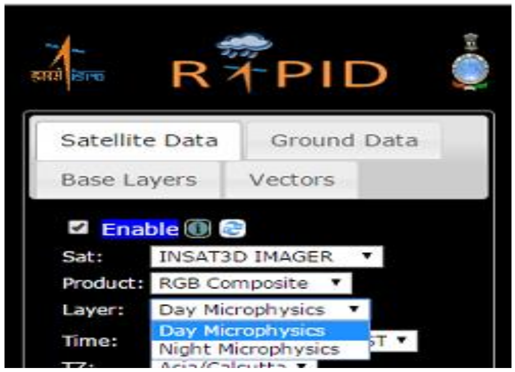
VIS Count at 24.2°N/92.6°E is 268.0000



SWIR Count at 24.2°N/92.6°E is 164.0000



II. ***INSAT-3D IMAGER - RGB Composite:*** If user has selected INSAT-3D IMAGER under 'Sat' tab and RGB Composite under 'Product' tab**,** then the following options become available under 'Layer' tab for selection: Day Microphysics (DMP) and Night Microphysics (NMP).



Day Microphysics RGB Imagery
Channel combination "recipes" of the Day Microphysics RGB

- **In the RED beam** - The visible reflectance at 0.64 µm approximates the cloud optical depth (thickness) and amount of cloud water and ice. Typically, water cloud is more reflective than ice cloud and thus will have a stronger red beam component. This channel also gives information about the surface of the earth.

- **In the GREEN beam** – The 1.67 µm SWIR (shortwave infrared) solar reflectance gives a qualitative measure for cloud particle size and phase. Typically, smaller water droplets or small ice particles have a higher reflectivity, resulting in a stronger green beam component. A sandy earth surface also has a strong reflectance in this channel.

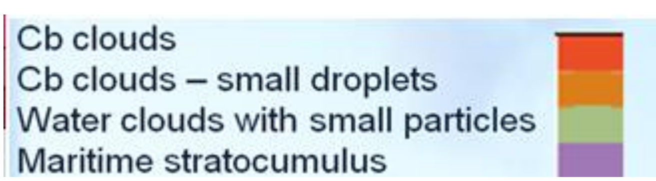
- **In the BLUE beam** - The 10.8 µm TIR1 brightness temperature is a function of surface and cloud top B. temperatures. The scaling for this beam results in a strong blue beam component for warm surfaces, whereas cold cloud tops will not have any contribution in this beam.

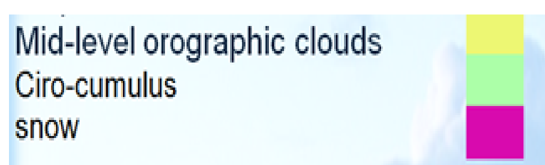
This color scheme is useful for cloud analysis, convection, fog, snow, and fires.

Day microphysics RGB scheme

Beam	**Channel**	**Range**	**Gamma**
Red	VIS(0.55-0.75 µm)	0 …+100 %	1.0
Green	SWIR(1.67µm)	0 ... +60 %	1.0
Blue	IR(10.8 µm)	+203 ... +323 ºK	1.0

This product is used during the daytime because a solar reflectance component is adopted. Colors and their interpretation are based on I. M. Lensky and D. Rosenfeld:Clouds-Aerosols-Precipitation Satellite Analysis Tool (CAPSAT), Atmos. Chem. Phys.,8, 6739-6753, 2008i.





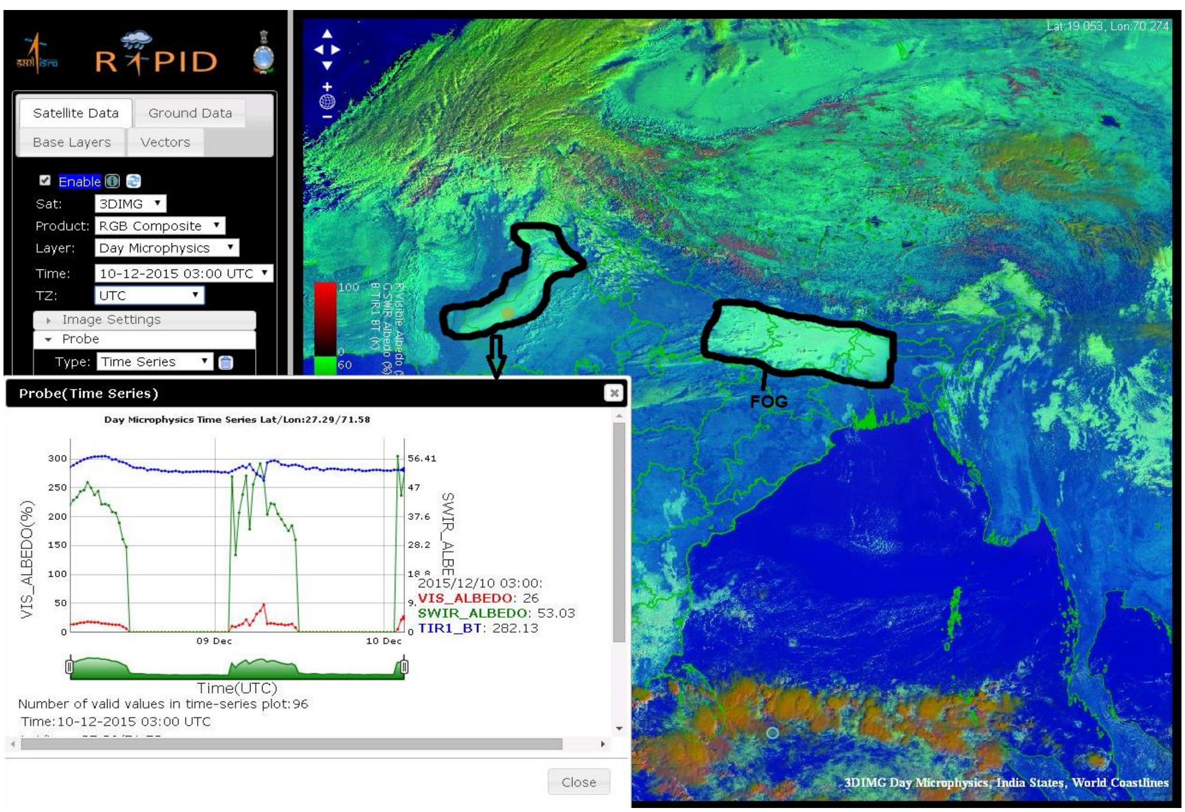
Day time fog can be viewed and analyzed by visible imagery, SWIR imagery, Day-time Microphysics RGB Imagery. To distinguish between Fog and Low Clouds the user may use the following criteria,

- Fog will have sharp boundary, while low clouds will not have sharp boundary.
- In animation Fog will remain stationary while low clouds will show some movement.

In Day-time Microphysics RGB imagery **Fog** look like this

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Fog pixel** value lies in the following range,

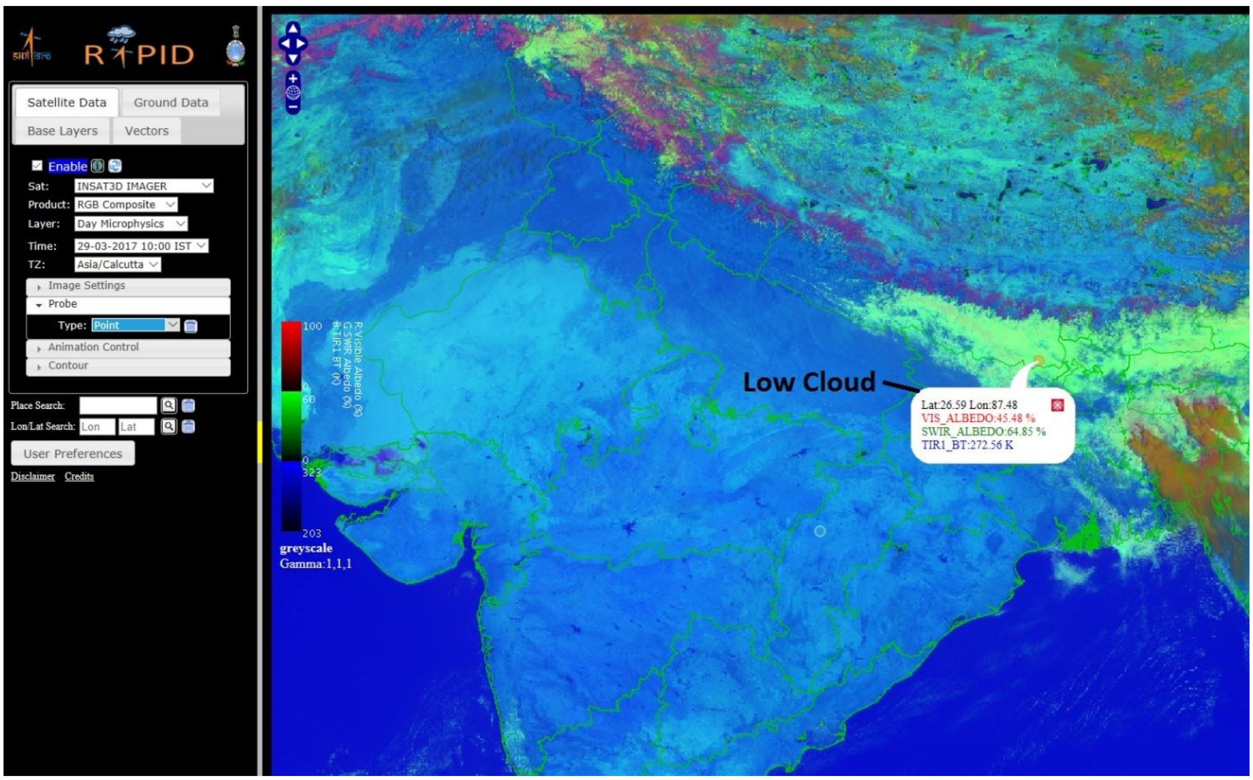
VIS Albedo	25 to 50 %
SWIR Albedo	35 to 60 %
TIR1	270ºK to 290ºK



In day time microphysics RGB imagery, **Low cloud**s look like this.

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Low cloud**s **pixel** value lies in the following range,

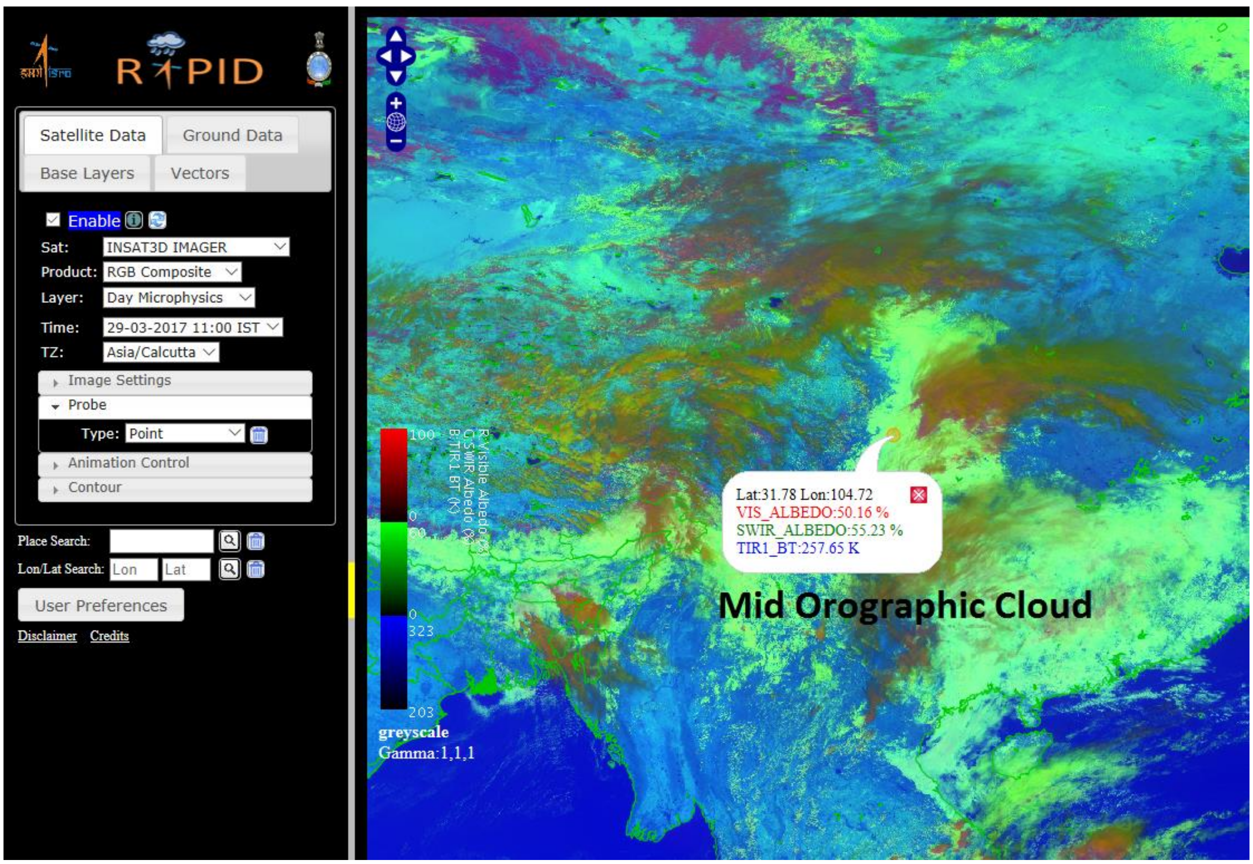
VIS Albedo	30% to 45%
SWIR Albedo	40% to 60%
TIR1	255ºK to 270 ºK



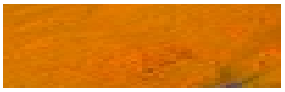
In Day-time Microphysics RGB imagery **Mid-Level Orographic Cloud** look like this

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Mid-Level Orographic Cloud pixel** value lies in the following range,

VIS Albedo	30% to 50%
SWIR Albedo	40% to 60%
TIR1	245ºK to 260 ºK

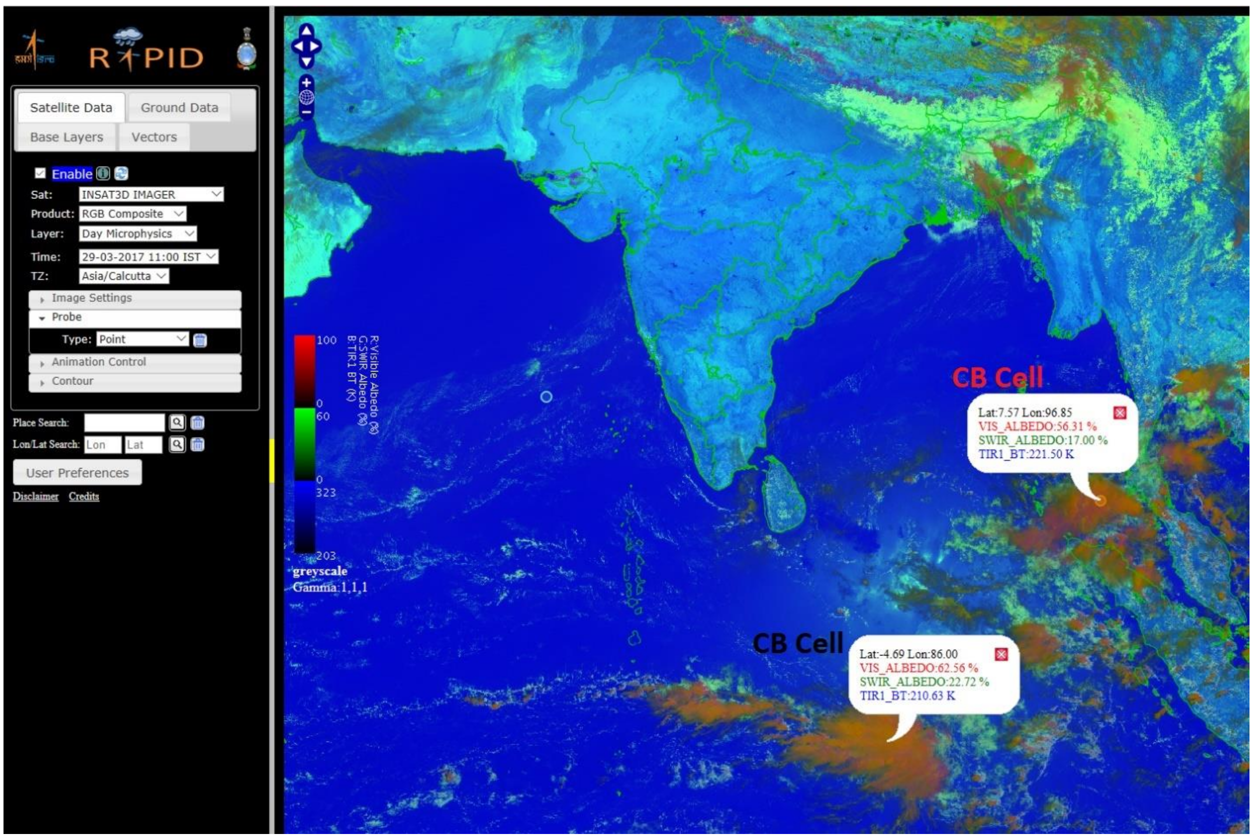


In Day-time Microphysics RGB imagery **CB cell** look like this



If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **CB cell pixel** values lies in the following range,

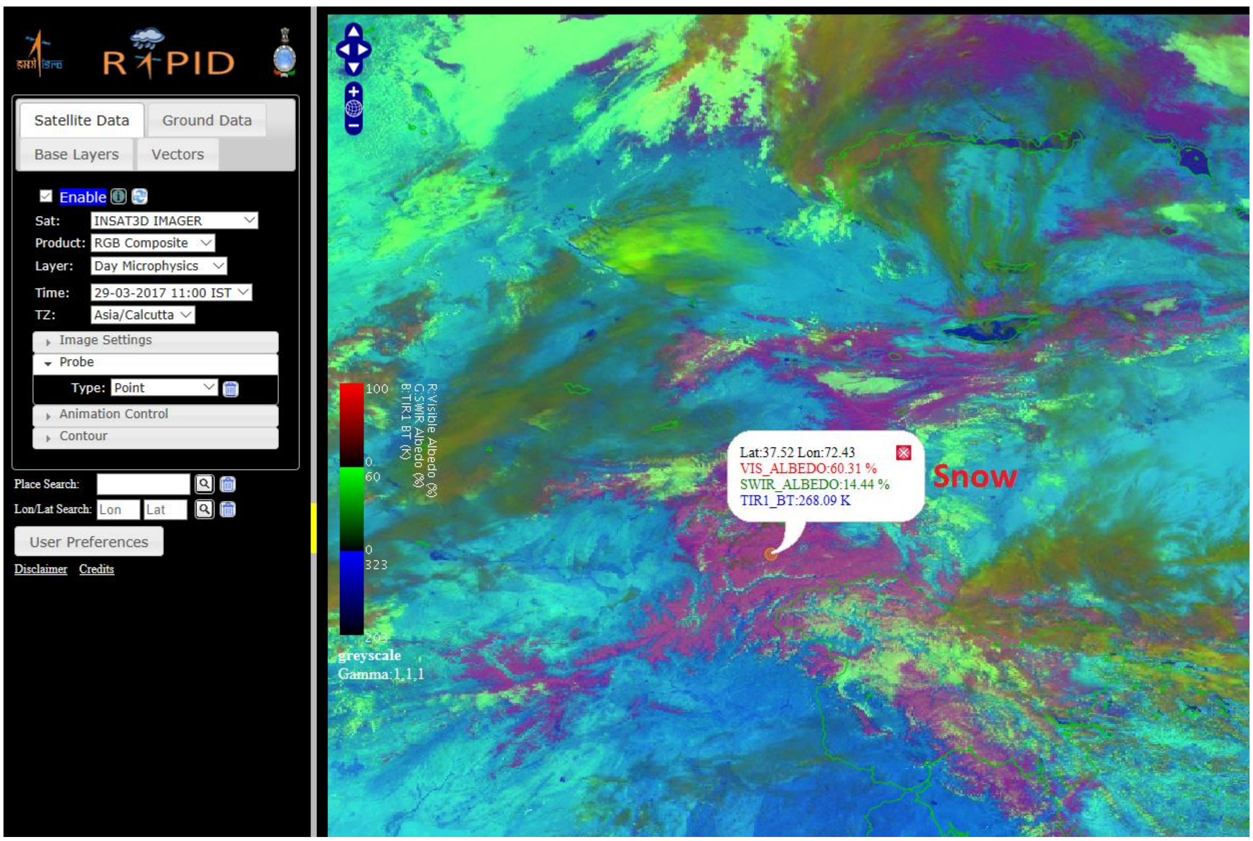
VIS Albedo	>50 %
SWIR Albedo	<25 %
TIR1	<245ºK



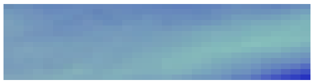
In Day-time Microphysics RGB imagery **Snow** look like this

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Snow pixel** value lies in the following range,

VIS Albedo	>35 %
SWIR Albedo	<20 %
TIR1	260ºK to 280 ºK

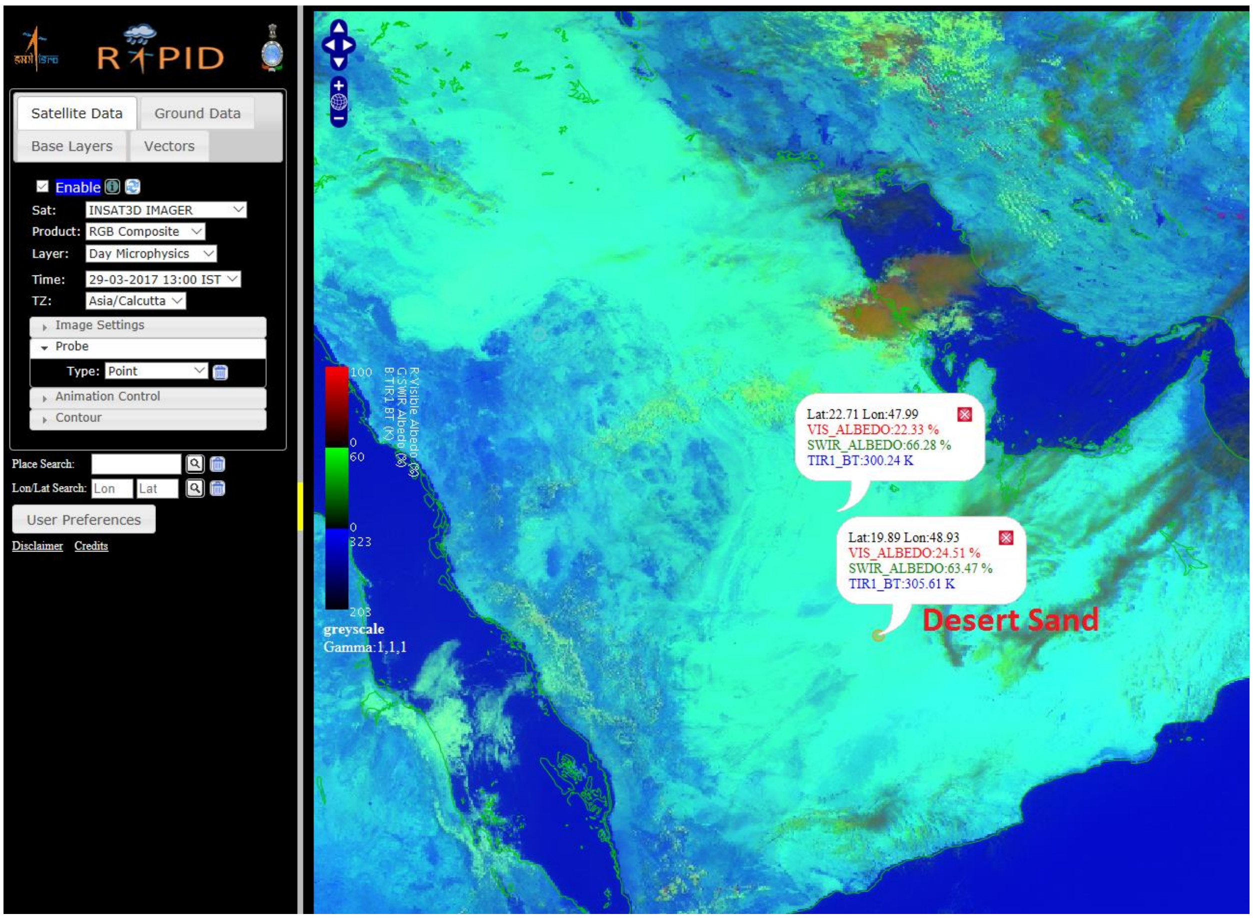


In Day-time Microphysics RGB imagery **Sand / Dust** look like this

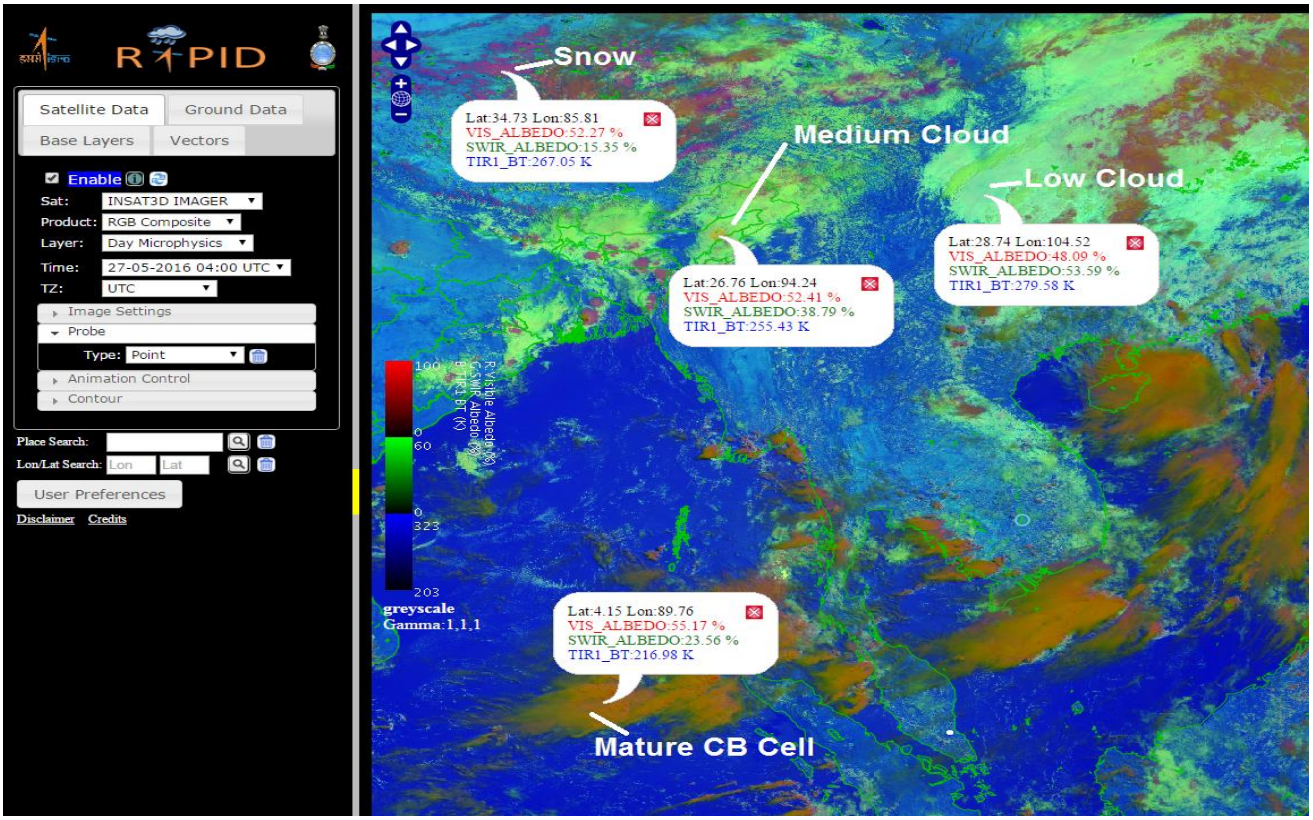


If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Sand / Dust pixel** value lies in the following range,

	Sand	**Dust**
VIS Albedo	20% to 30%	20% to 30%
SWIR Albedo	40% to 70%	30% to 40%
TIR1	290ºK to 320 ºK	275ºK to 295 ºK



Snow, Low, Medium, CB Cloud



Advantages:

- Can clearly distinguish between ice phase clouds at high elevations and water phase clouds at lower elevations, providing a pseudo three-dimensional view of the atmosphere
- Can identify subtle microphysical variations within clouds that are not apparent on other images or RGBs
- Helps discriminate between precipitating and non-precipitating water clouds
- Can help identify severe convective clouds with strong updrafts

Limitations:

- The RGB is complicated in terms of the number and variety of colors and requires expertise to interpret it but it is a very powerful product
- Only available during daytime

However, these ranges may change from place to place and over time, user may work out the values of their areas.

Night-time Microphysics RGB Imagery

The Night Microphysics RGB product is designed and tuned for monitoring the evolution of nighttime fog and stratus clouds. Other secondary applications include detecting fires, classification of clouds in general, snow and low-level moisture boundaries.

The distinction between low clouds and fog is often a challenge. While the difference in the TIR1 10.8µm and MIR 3.9µm channels is applied to meet this challenge, the Night-time Microphysics RGB adds TIR2 12.0µm channel difference to indicate cloud thickness and enhance areas of warm clouds where fog is more likely.

Other applications of Night-time Microphysics RGB include analysis of cirrus and contrail clouds, fire hot spots, and snow.

Channel combination recipe of the Night Microphysics RGB

- **In the RED beam:** The channel differencing gives an indication of optical depth. It uses TIR2 – TIR1. There is a strong signal in this beam for thick clouds. For thin meteorological cloud there is greater absorption by the "dirty window" 12 µm channel. In addition, the 12 µm radiation is absorbed more strongly in ice phase cloud compared to water phase clouds.

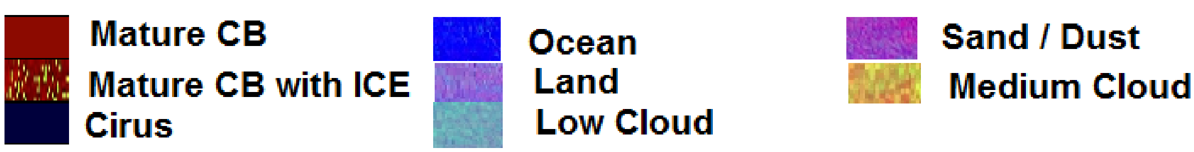
- **In the GREEN beam:** This channel differencing is used in fog/low cloud detection method. . It uses TIR1 – MIR. The 3.9 µm radiation has lower emissivity compared to the 10.8 µm radiation for small water droplet clouds. Therefore, there is a large contribution to the green beam in this RGB product for water clouds with small droplets. There is also a significant contribution from desert surfaces.

- **In the BLUE beam:** The 10.8 µm infrared brightness temperature is a function of surface and cloud top temperatures. The scaling for this beam results in a strong blue beam component for warm surfaces.

Night-time microphysics RGB scheme

Beam	Channel	Range	Gamma
Red	IR12.0 µm - IR10.8 µm(TIR2-TIR1)	-4 … +2 K	1.0
Green	IR10.8 µm - IR3.9 µm (TIR1-MIR)	-4 … +6 K	1.0
Blue	IR10.8 µm (TIR1)	+243 … +293 K	1.0

Some of the identified clouds and features are listed below for reference,



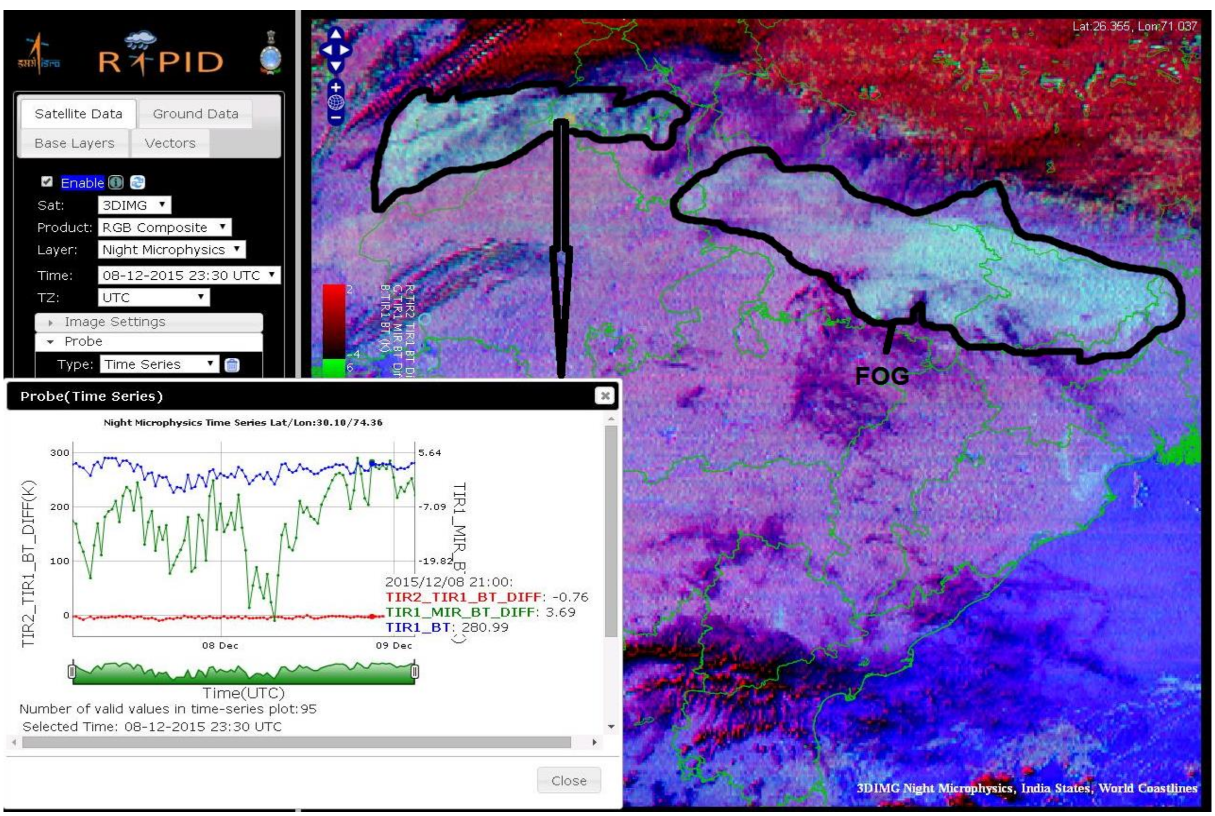
Fog can also be detected through **Night-time Microphysics RGB Imagery.** Fog and low clouds in warm climates tend to have aqua or light blue areas in the RGB. This appears very light green in colder climates because the 10.8 µm thermal channel used for the blue band contributes less.

In Night-time Microphysics RGB imagery, **Fog** look like this

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Fog pixel** value lies in the following range,

TIR2BT – TIR1BT	Negative value
TIR1BT - MIRBT	>2.5ºK
TIR1BT	270ºK to 290ºK

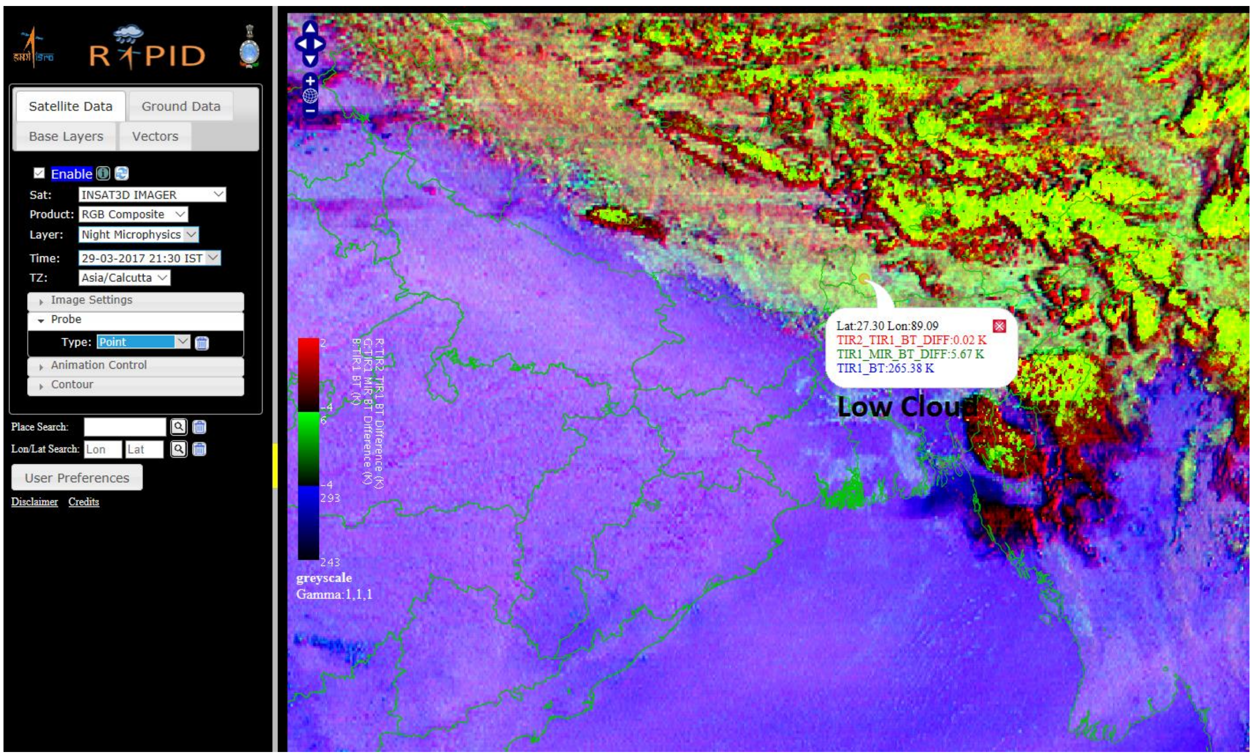
The 3.9 µm channel is subject to noise at very cold temperatures. Fog at high latitudes in winter may have noise in the pixels representing fog. Similarly, the depiction of very high, cold clouds (i.e. cumulonimbus tops) will have yellow pixels mixed in areas of dark red for this RGB due to the 3.9 µm channel noise at such temperatures.



In Night-time Microphysics RGB imagery, **Low clouds** look like this.

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Low clouds pixel** value lies in the following range,

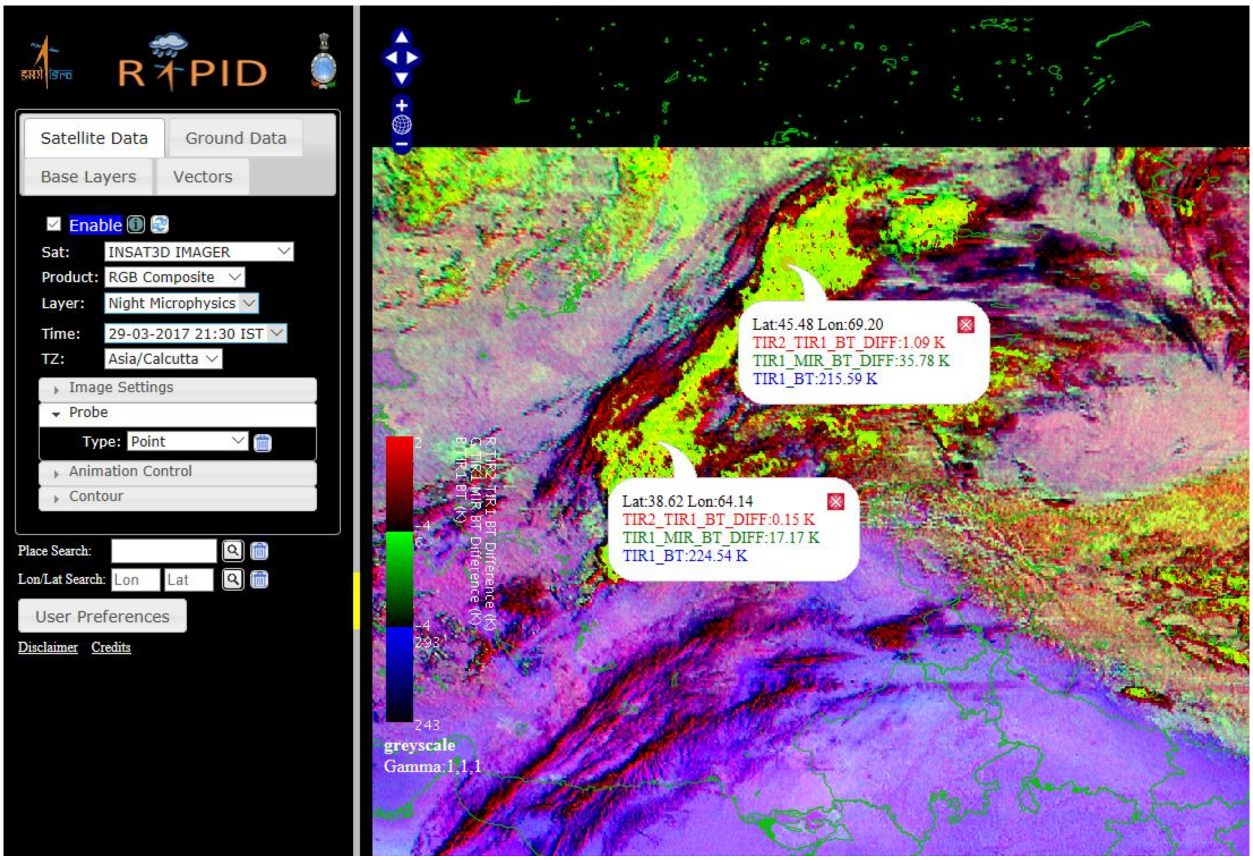
TIR2BT – TIR1BT	Positive
TIR1BT - MIRBT	Positive
TIR1BT	250ºK to 268ºK



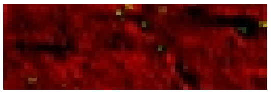
In Night-time Microphysics RGB imagery, **Medium cloud**s look like this.

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Medium cloud**s **pixel** value lies in the following range,

TIR2BT – TIR1BT	Positive
TIR1BT - MIRBT	Positive
TIR1BT	245ºK to 260ºK

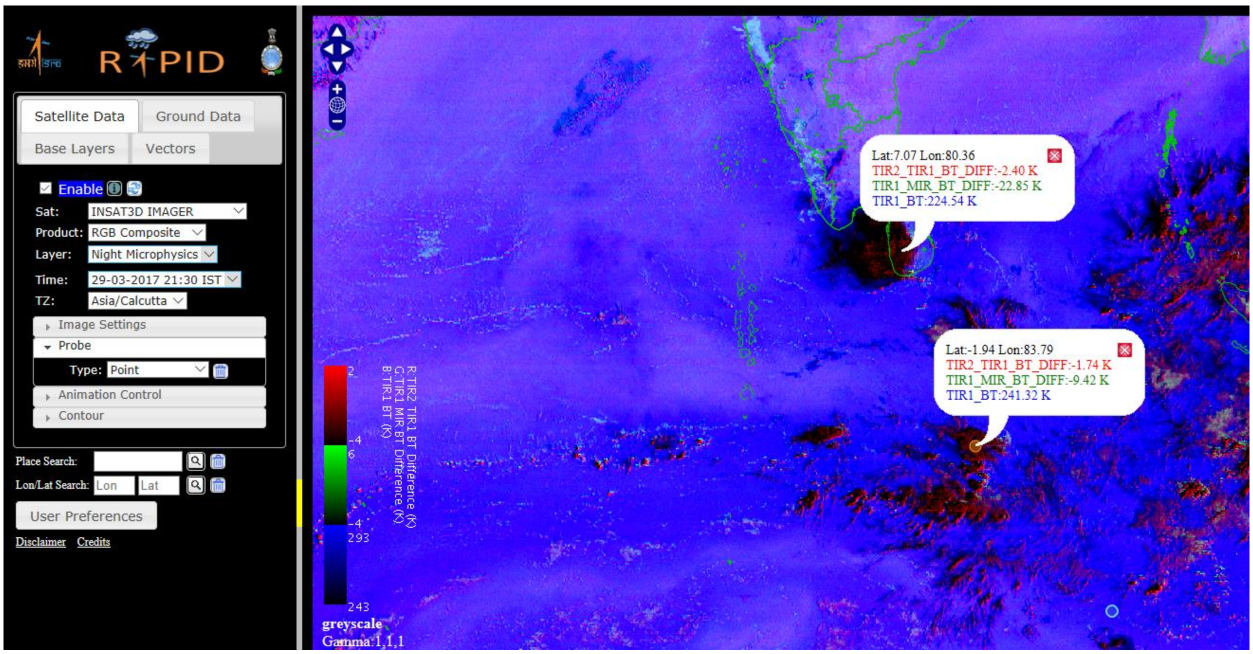


In Night-time Microphysics RGB imagery, **CB Cell** look like this



If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **CB Cell pixel** value lies in the following range,

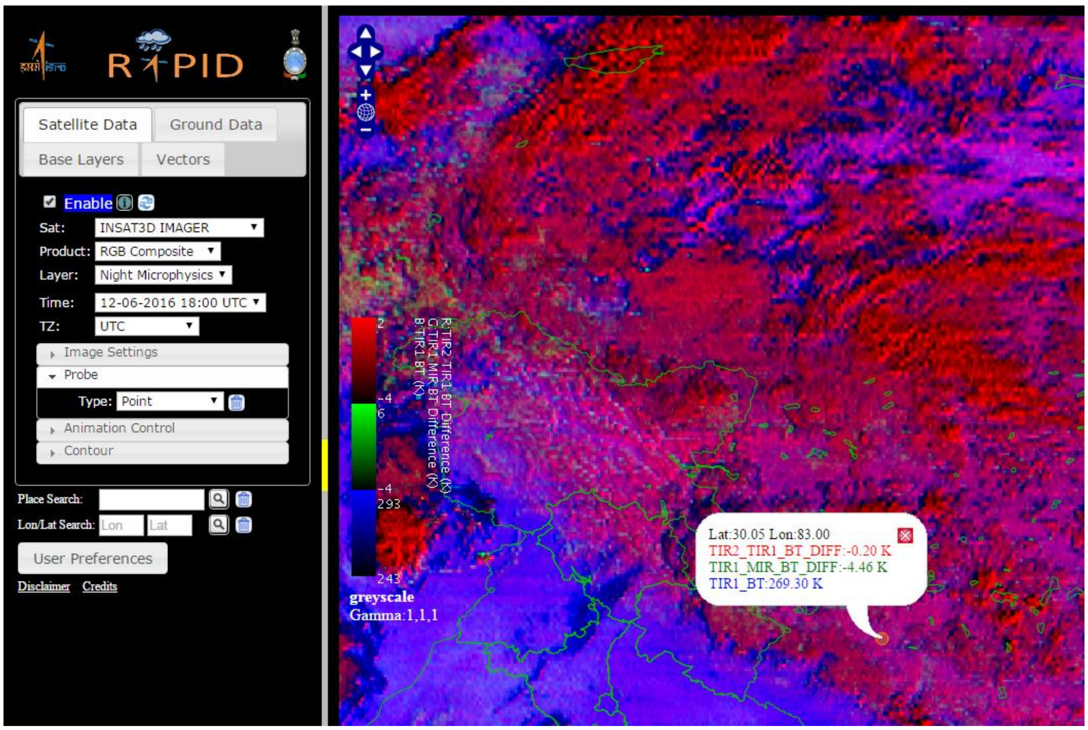
TIR2BT – TIR1BT	Positive
TIR1BT - MIRBT	Negative
TIR1BT	<245ºK



In Night-time Microphysics RGB imagery, **Snow** look like this.

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Snow pixel** value lies in the following range,

TIR2BT – TIR1BT	Negative
TIR1BT - MIRBT	Negative
TIR1BT	260ºK to 290ºK



In Night-time Microphysics RGB imagery, **Sand / Dust** look like this.

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Sand / Dust pixel** value lies in the following range,

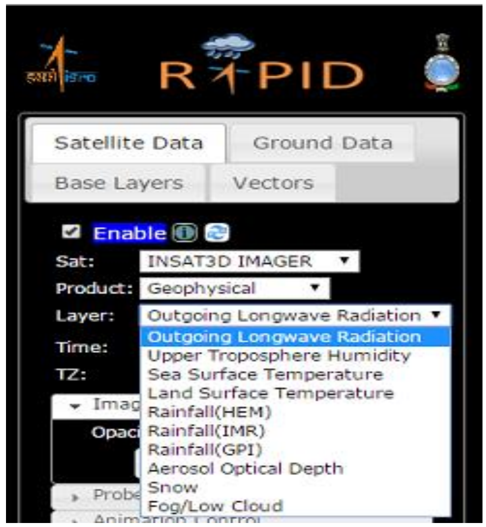
	Sand	**Dust**
TIR2BT – TIR1BT	Negative	Negative
TIR1BT - MIRBT	Negative	Negative
TIR1BT	280ºK to 290ºK	275ºK to 285ºK

However, these ranges may vary from place to place and over time, user may work out the values of their areas.

Advantages:

This RGB enhances the fog/stratus signal is very important for aviation, public weather forecasting, especially with higher resolution of INSAT 3D Imager.

III. ***INSAT-3D IMAGER - Geophysical:*** If user has selected INSAT-3D IMAGER under 'Sat' tab and Geophysical under 'Product' tab**,** then the following options become available under 'Layer' tab for selection: Outgoing Longwave Radiation, Sea Surface Temperature, Upper Tropospheric Humidity, Land Surface Temperature, Aerosol Optical Depth, Rainfall (HEM), Rainfall (IMR), Rainfall (GPI), Snow and Fog/Low Cloud.



a) Outgoing Longwave Radiation (OLR): The OLR is very important parameter for numerical modeling of weather/climate as well as for radiation budget studies. OLR is identified as one of the "Essential Climate Variables" in WMO Global Climate Observing System (GCOS).

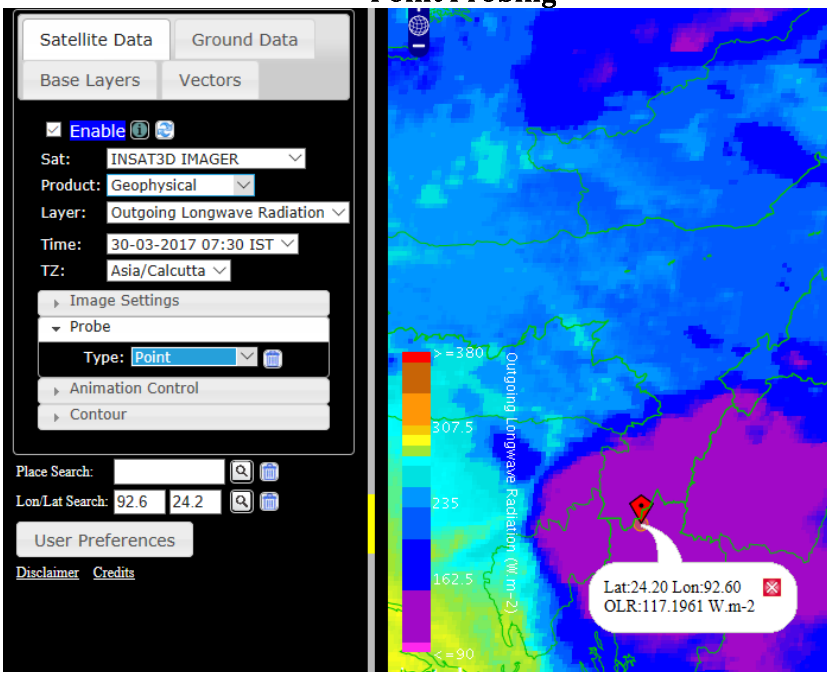
The response of earth system to the solar diurnal heating is reflected in OLR. Everybody that has temperature above absolute 0°K (-237.15 C) emits radiation. The wavelength of the radiation is inversely proportional to the temperature of the body (Wien's displacement law). Earth gets heated by the insolation in short wave. It reradiates energy back in long wave radiation. The total amount of the thermal radiation (4–100 µm wavelength bands) that is emitted from the earth-atmosphere system to the outer space is called outgoing longwave radiation (OLR).

Applications

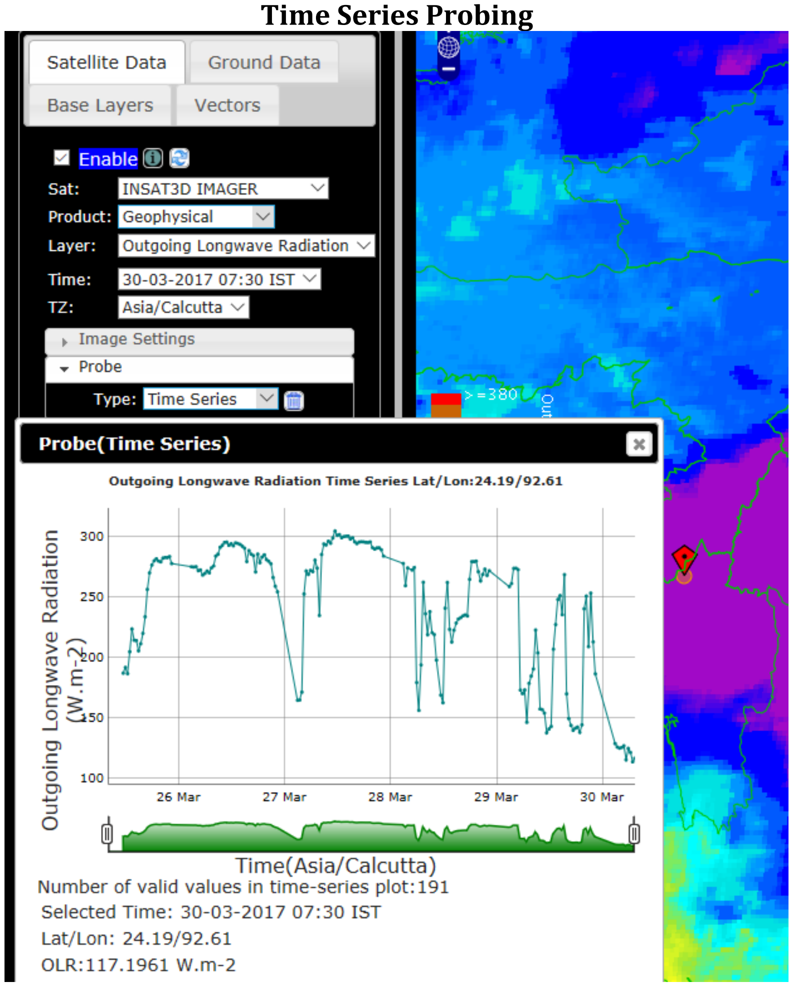
The estimates of outgoing longwave radiation prove useful in climate sensitivity and diagnostics (e.g., Schmetz and Liu, 1988), numerical weather forecasting and climate models. Traditionally radiation budget studies of the earth-atmosphere system have been carried out using OLR data. The top of the atmosphere radiative energy balance between net incoming solar radiation and OLR is crucial in determining the large-scale atmospheric circulation and, therefore, the synoptic evolution that is important for weather and climate prediction. OLR is an important factor in the Earth's Radiation Budget which affects the atmospheric circulation especially over tropics. Position and movement of ITCZ and Madden-Julian oscillation is very well tracked using OLR. Generally, values less than 250 Wm^{-2} would give a good indication of the cloudiness over the tropics. Low OLR values indicate strong convective systems over the particular area.

The sample example of OLR as visualized in RAPID is shown below.

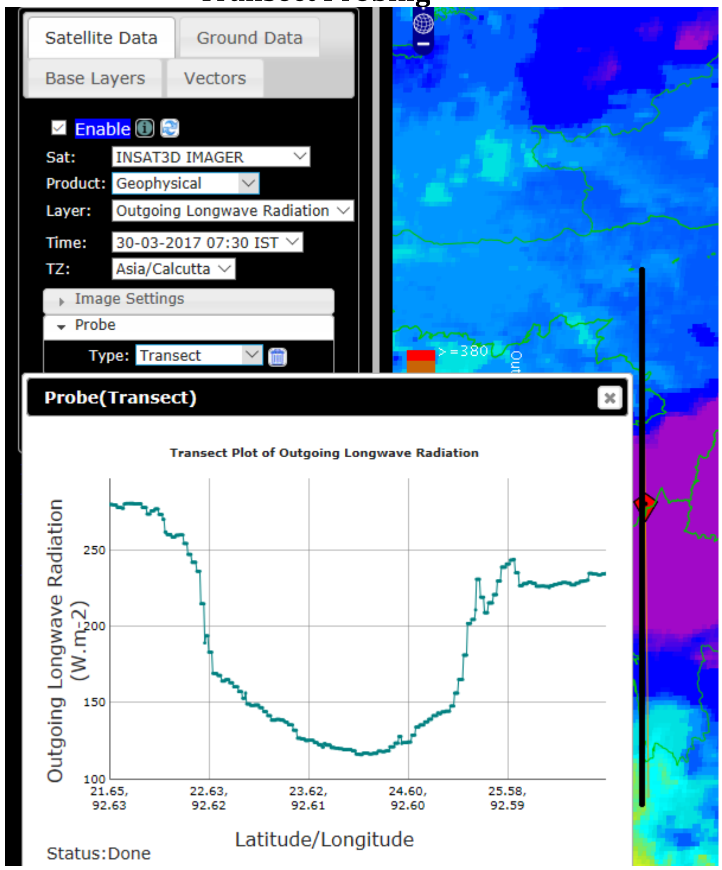
Point Probing



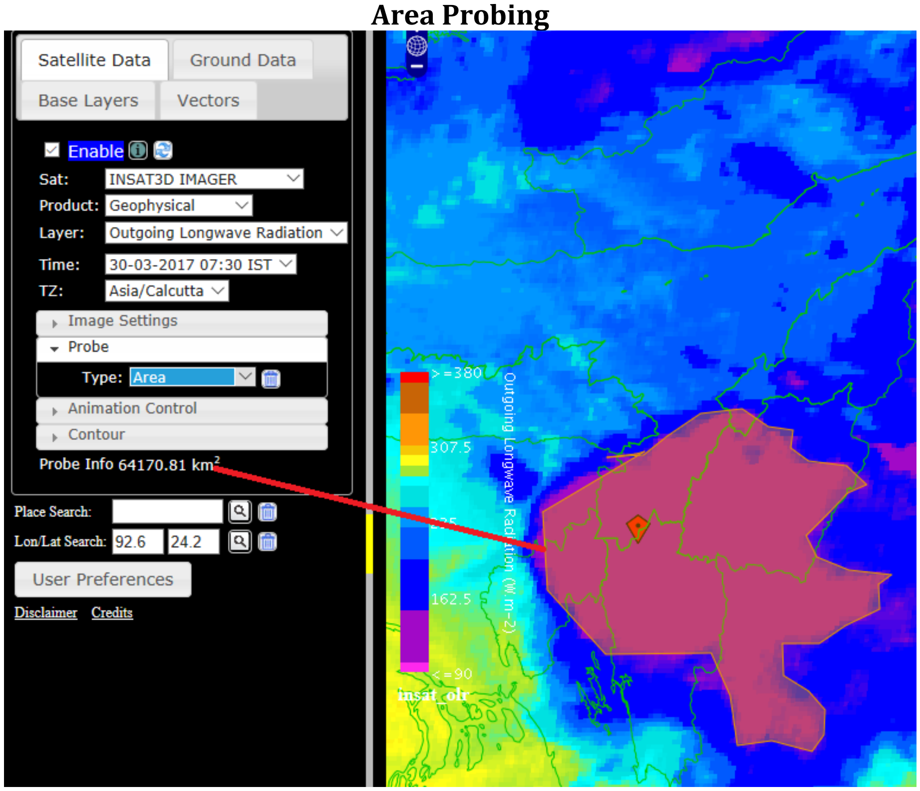
Time Series Probing



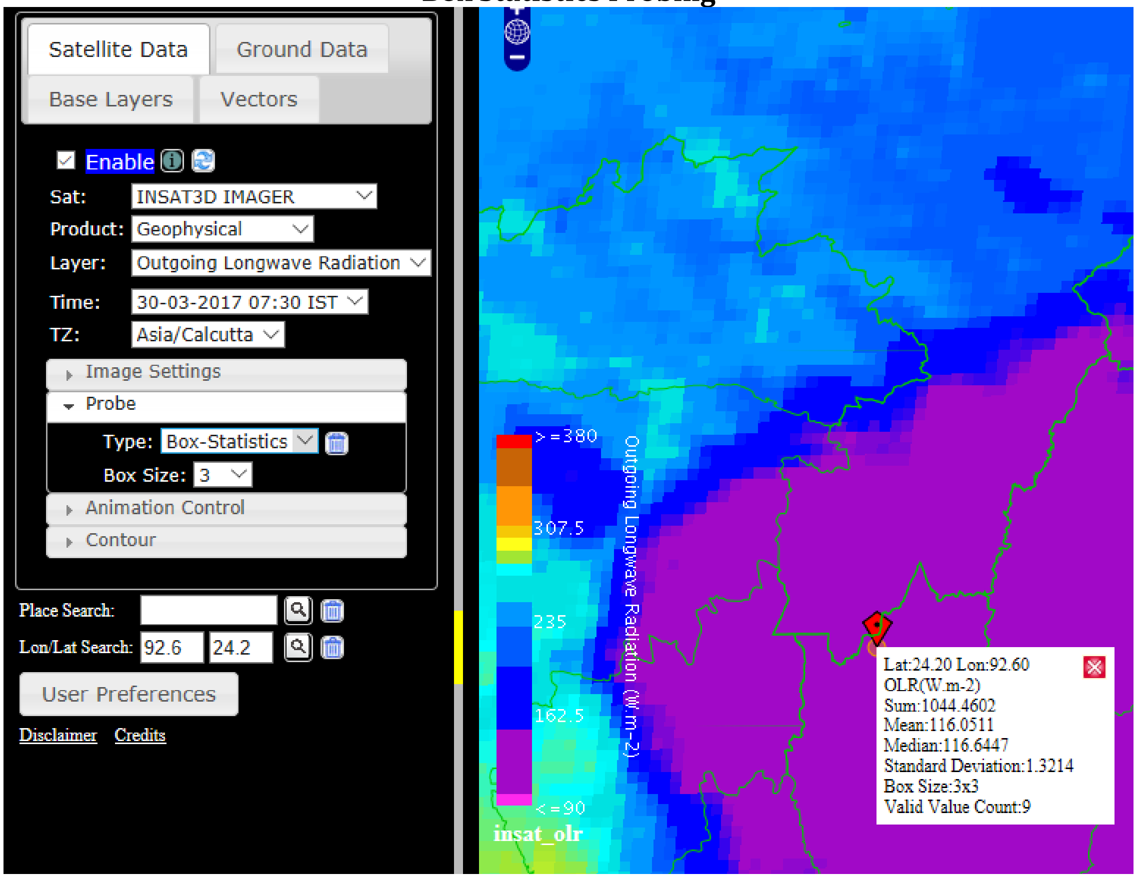
Transect Probing



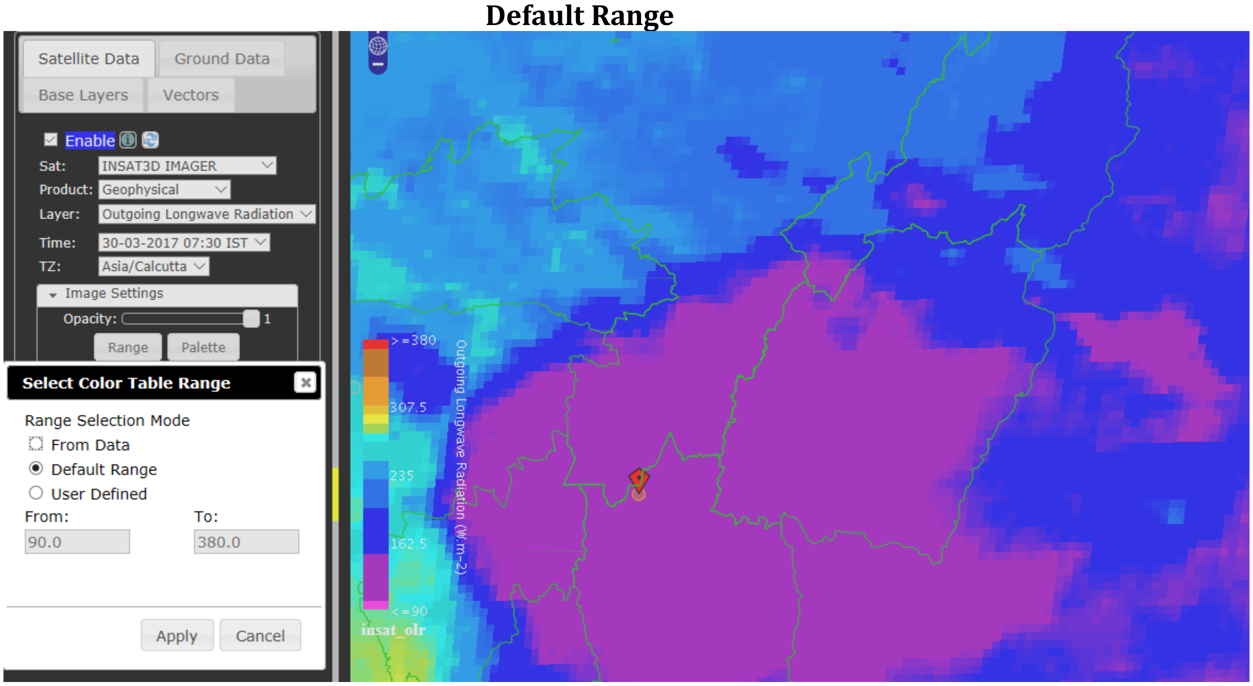
Area Probing



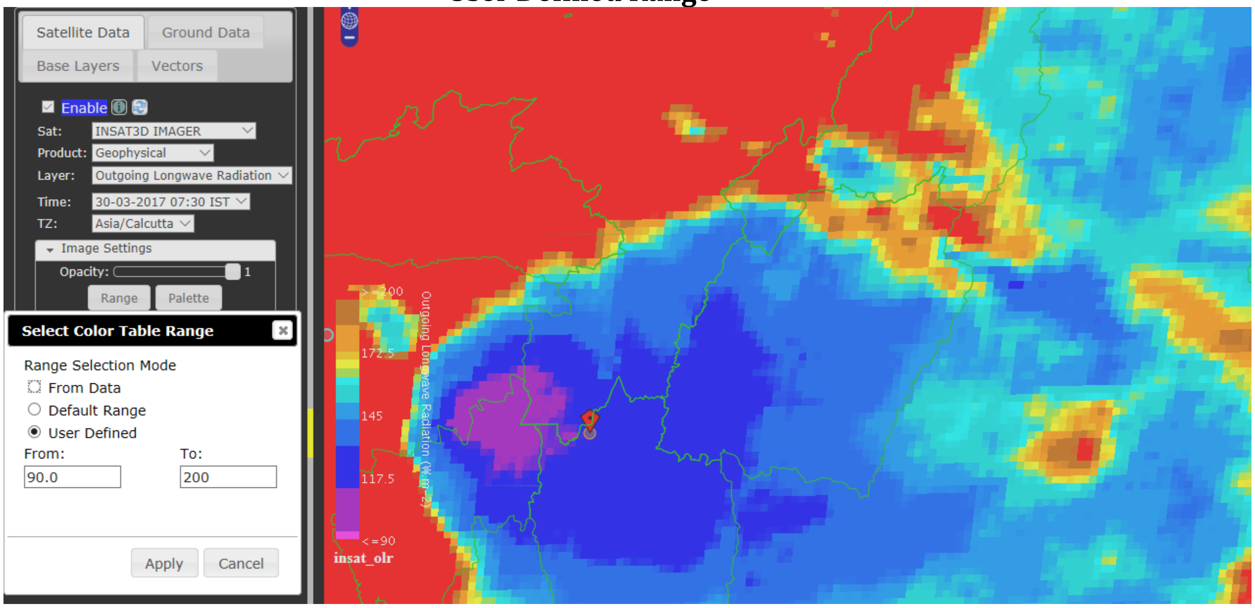
Box Statistics Probing



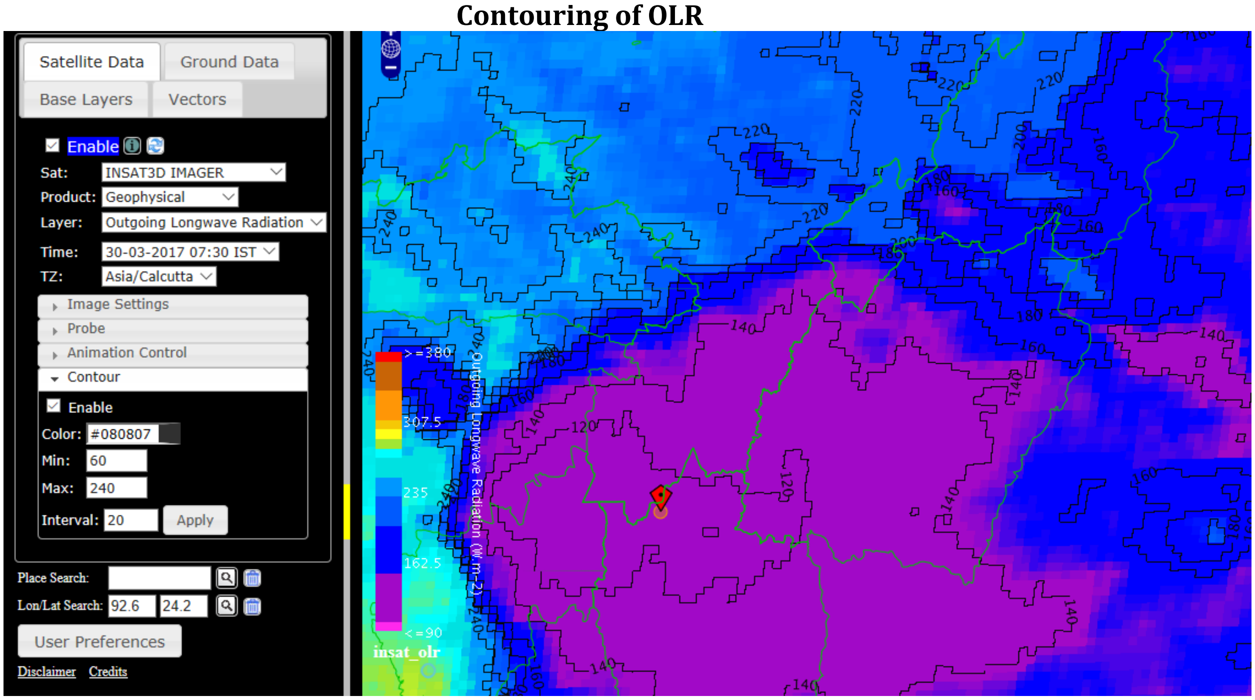
Default Range



User Defined Range



Contouring of OLR



b) Upper Troposphere Humidity (UTH): Moisture present in the atmosphere plays an important role of carrying heat from oceans to the upper atmosphere. It is measured in terms of relative humidity which is amount of moisture air parcel can hold with respect to saturated air parcel at that temperature. Upper Tropospheric Humidity (UTH) refers to the mean relative humidity of the atmosphere between approximately 500 hPa and 200 hPa. UTH is basically an estimate using the weighting function of the water vapour channel. Therefore, UTH is more likely a representative of the relative humidity around the atmospheric layer where weighting function of water vapour channel peaks.

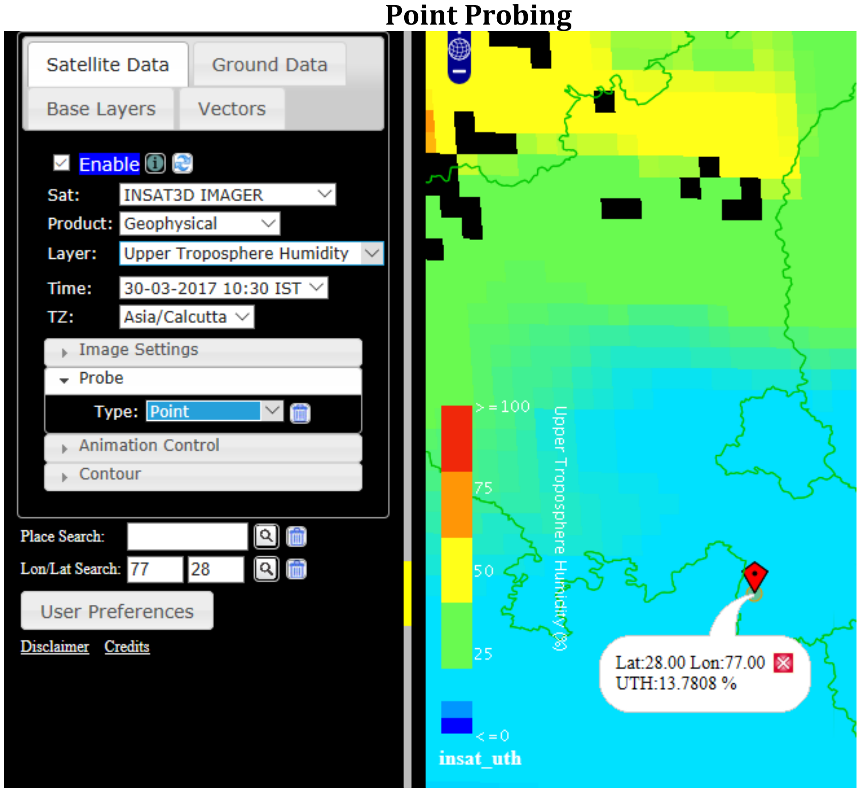
UTH from satellite measurements gives a synoptic view which is useful to monitor variations in water vapour in the upper troposphere on a global and regional scale.

Applications

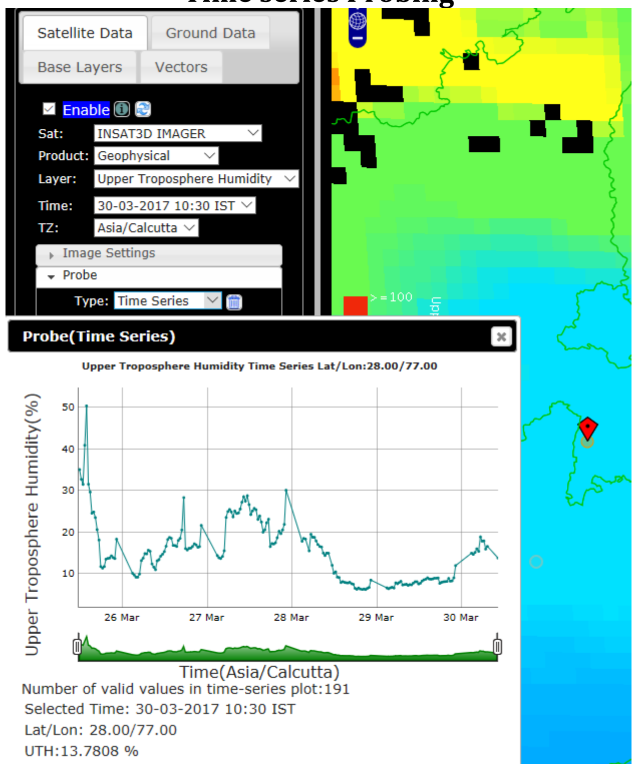
Upper tropospheric humidity is a crucial thermodynamic factor in the atmospheric science. It defines the way heat is exchanged in atmospheric layers. UTH product using satellite remote sensing is used in monitoring distribution of water vapour on regional to global scale. It is a useful product for a forecaster for synoptic analysis. The regions of enhanced UTH coincide with deep convection and colder cloud top temperatures. UTH is an important parameter that helps in diagnosis of convective processes in the atmospheric model simulations. It is also used in studying the patterns of water vapour movement in atmosphere and atmospheric rivers.

The sample example of UTH as visualized in RAPID is shown below.

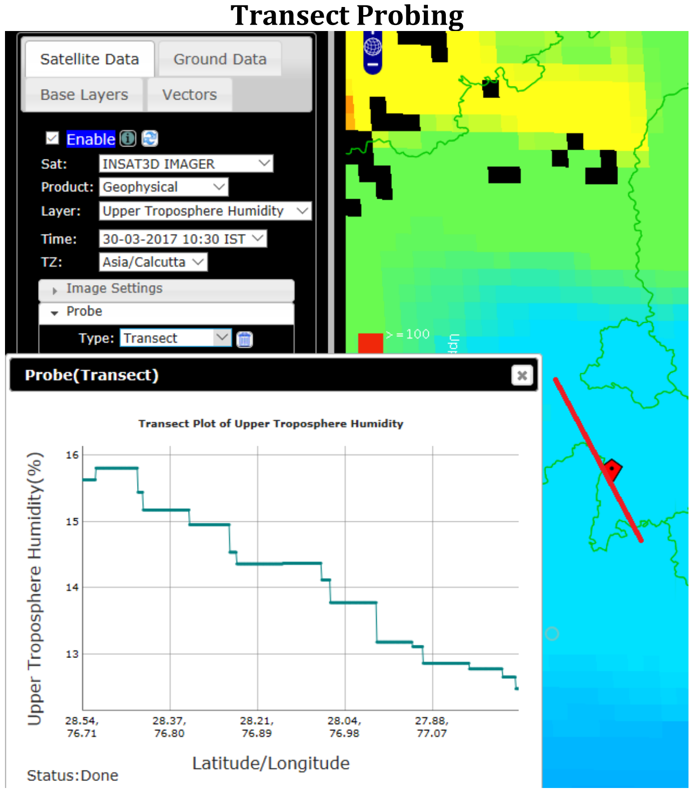
Point Probing



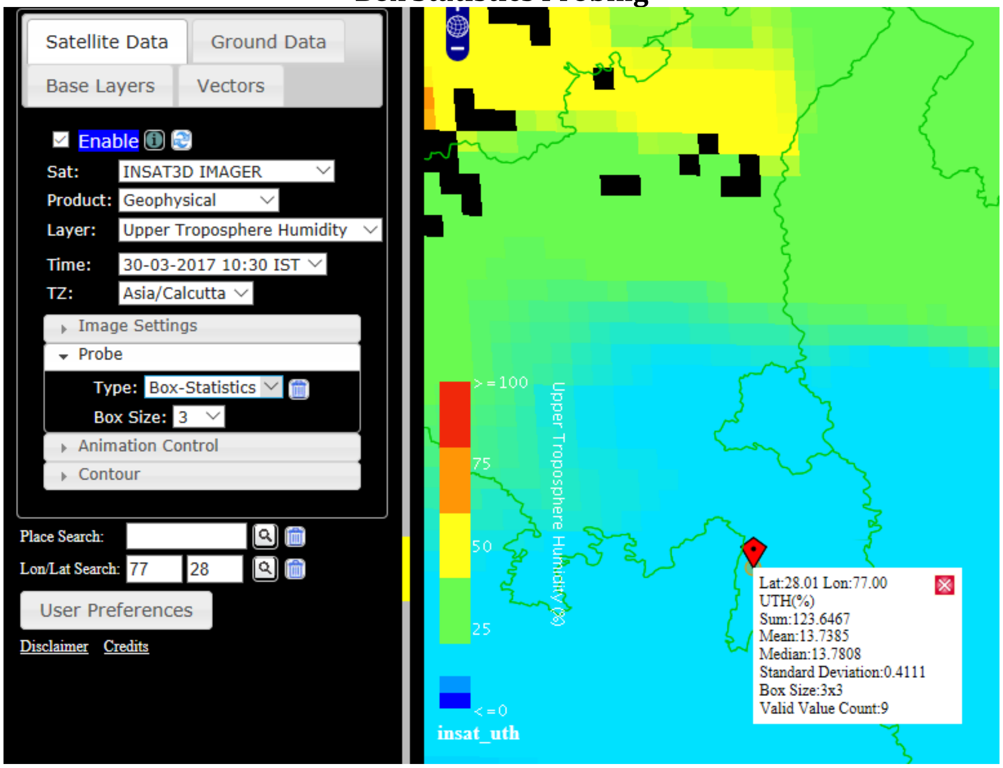
Time series Probing



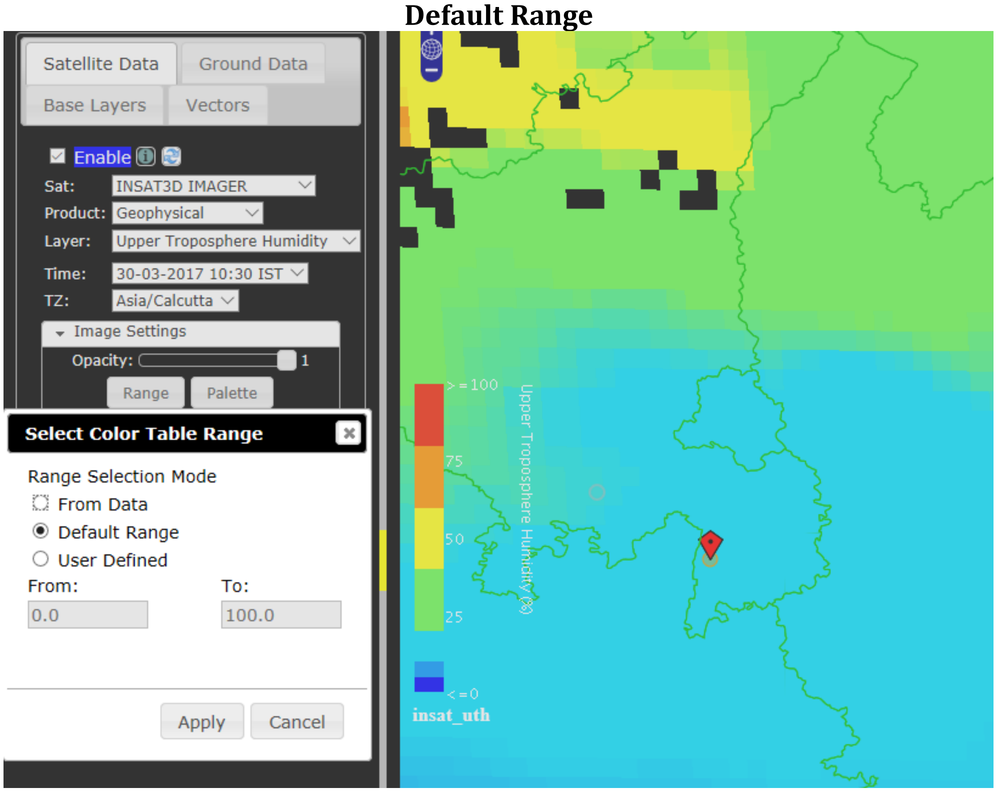
Transect Probing



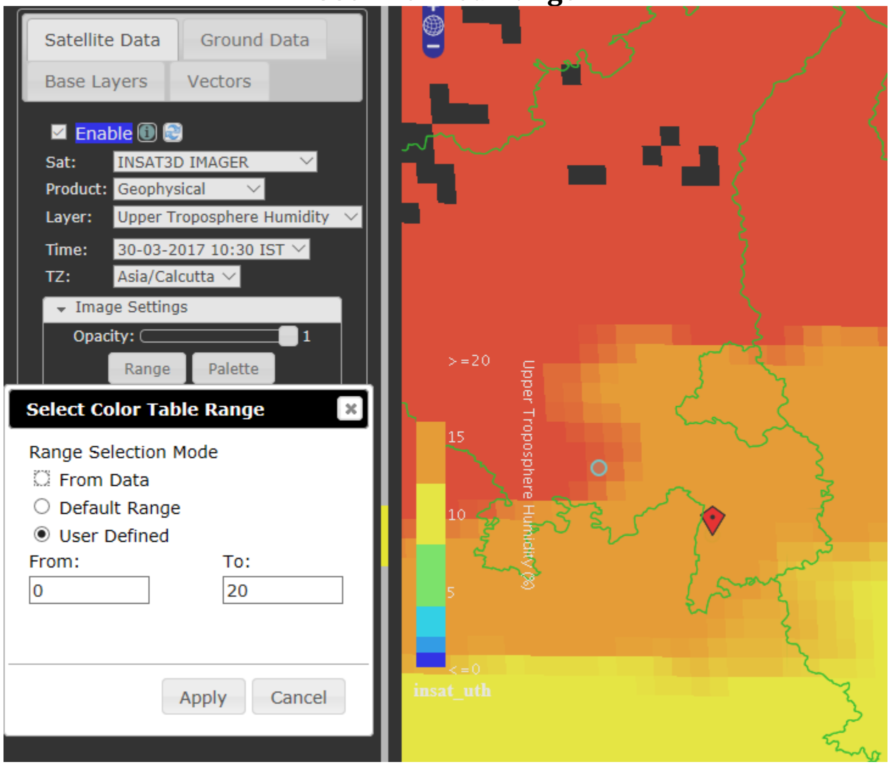
Box Statistics Probing



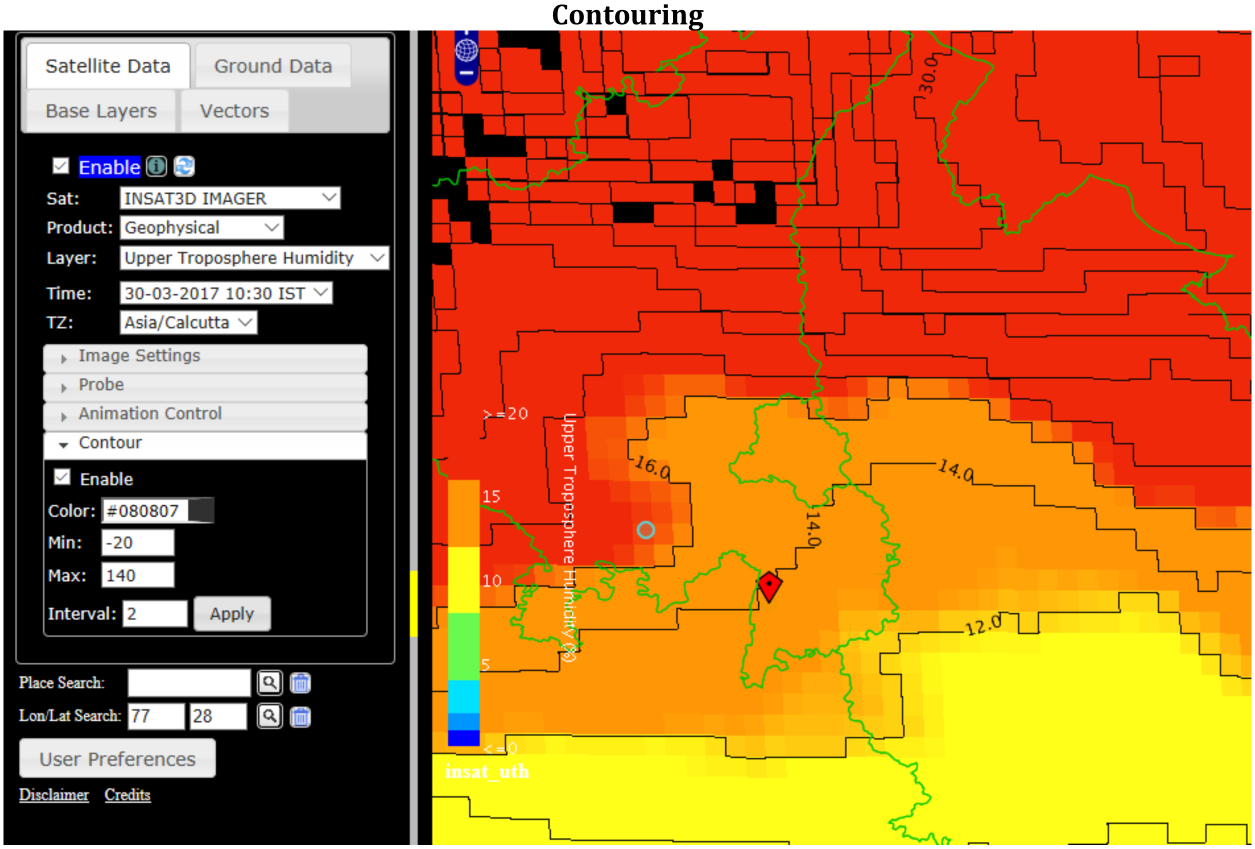
Default Range



User Defined Range



Contouring



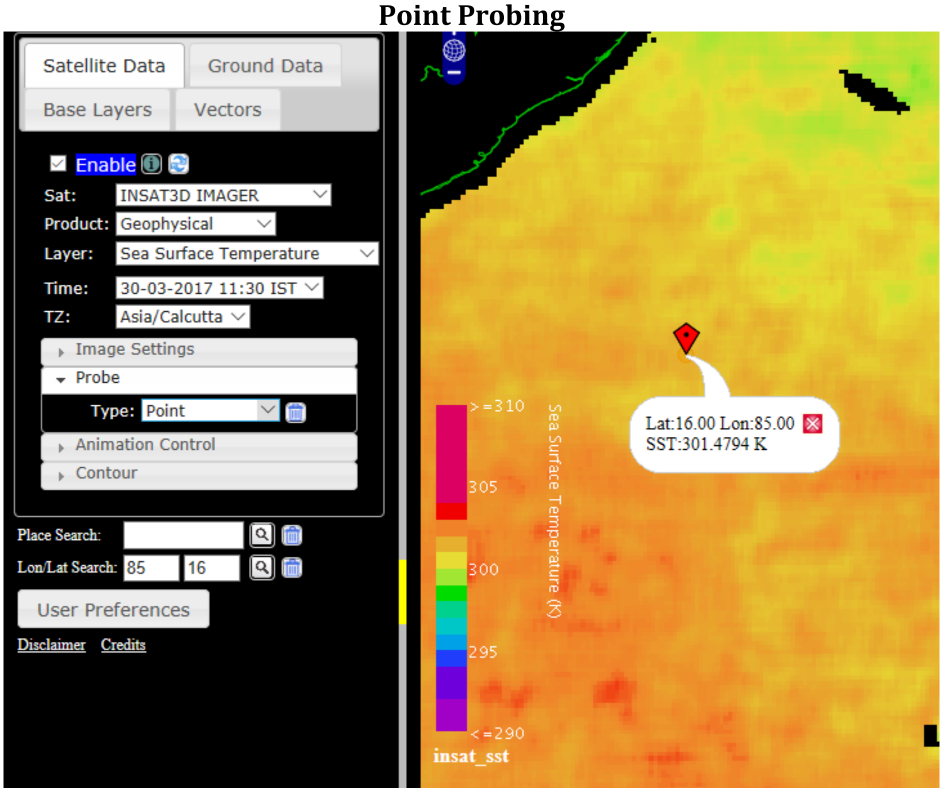
c) Sea Surface Temperature (SST): Sea surface temperature is a key climate and weather measurement in the field of meteorology. Sea Surface Temperature (SST) is the temperature of the water present at the surface of sea/ocean. Oceans store high amount of energy in the form of heat given the high heat capacity of water. Atmospheric flow patterns, weather causes variation in the SST. SST also has a large influence over the atmospheric circulation, weather and climatic conditions. Thus, SST plays an important role in ocean-atmosphere coupled system. Anomalous changes in SST in a particular region have potential to affect the global weather conditions.

Applications

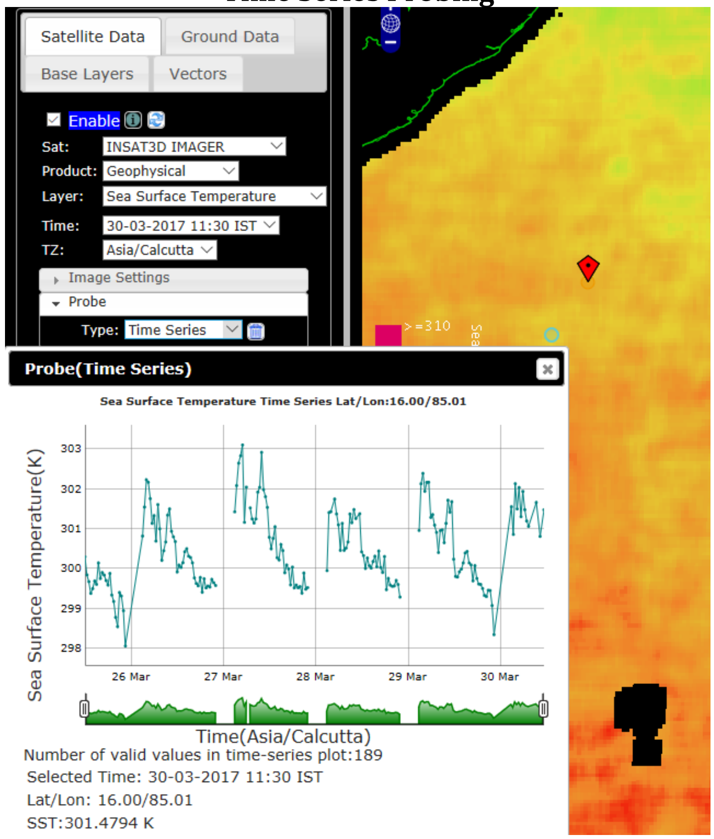
SST is one of the most important forcing factors in atmospheric as well as coupled models driving the atmospheric circulation. Numerical weather simulations are considered as initial value problems. Thus, SST is the most important input going in all kind of atmospheric or oceanic numerical models. Accuracy of SSTs in turn decides the outcomes of the simulations. SST study is particularly important in tropics as it has the highest SSTs observed over the world oceans. Higher SSTs is one of the factors for cyclogenesis. SSTs are known to affect the precipitation over different regions in the world. SST affects ocean dynamics thereby altering the ocean currents and dependent biology. Oceans distribute heat that is received in tropics to the sub and extra tropics.

The sample example of SST as visualized in RAPID is shown below.

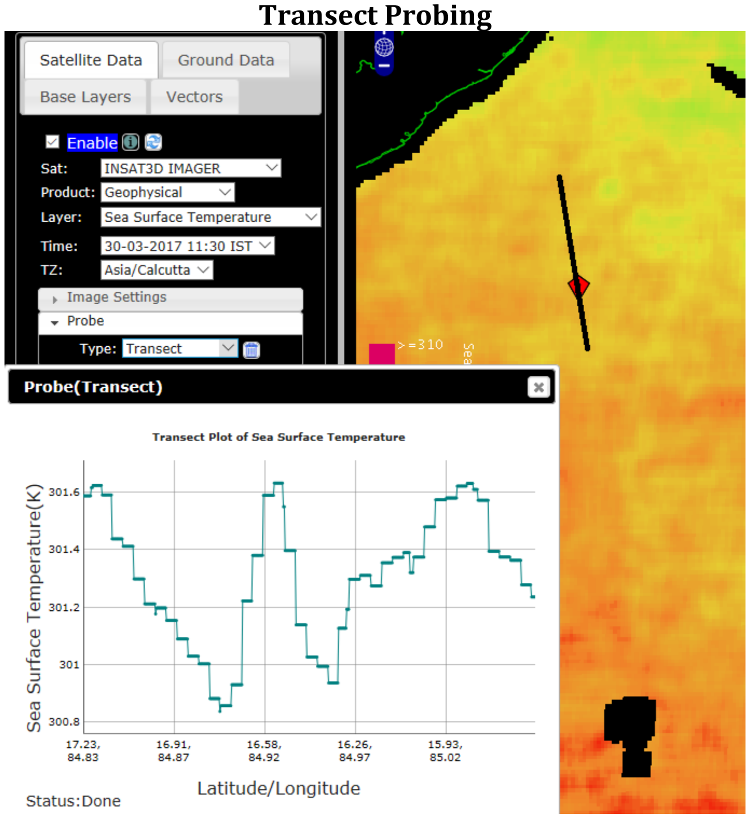
Point Probing



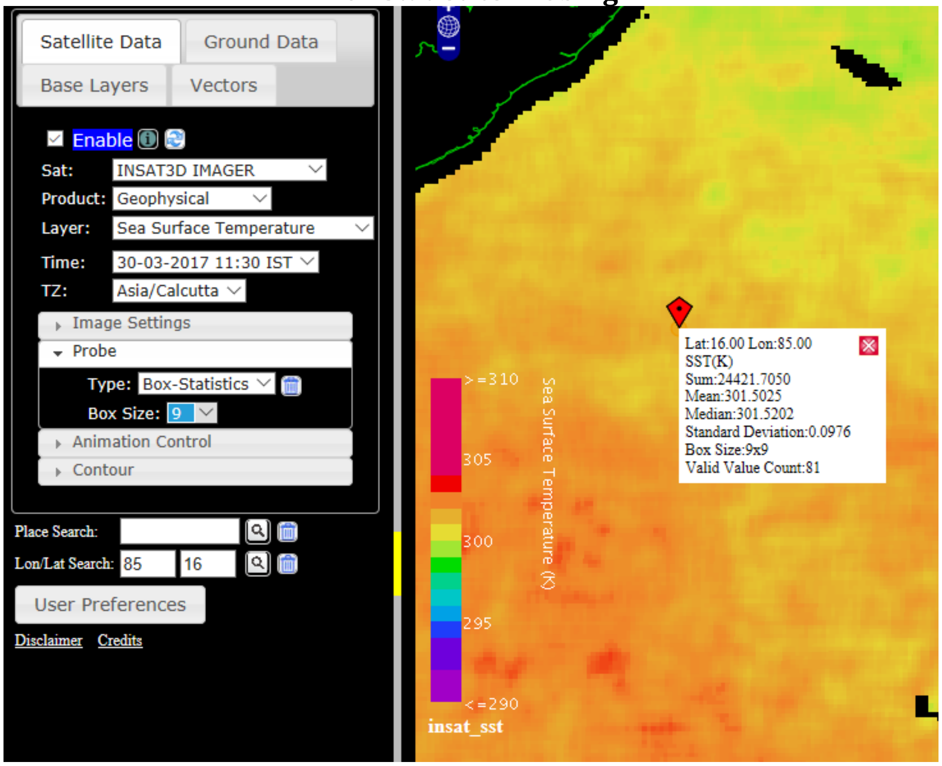
Time Series Probing



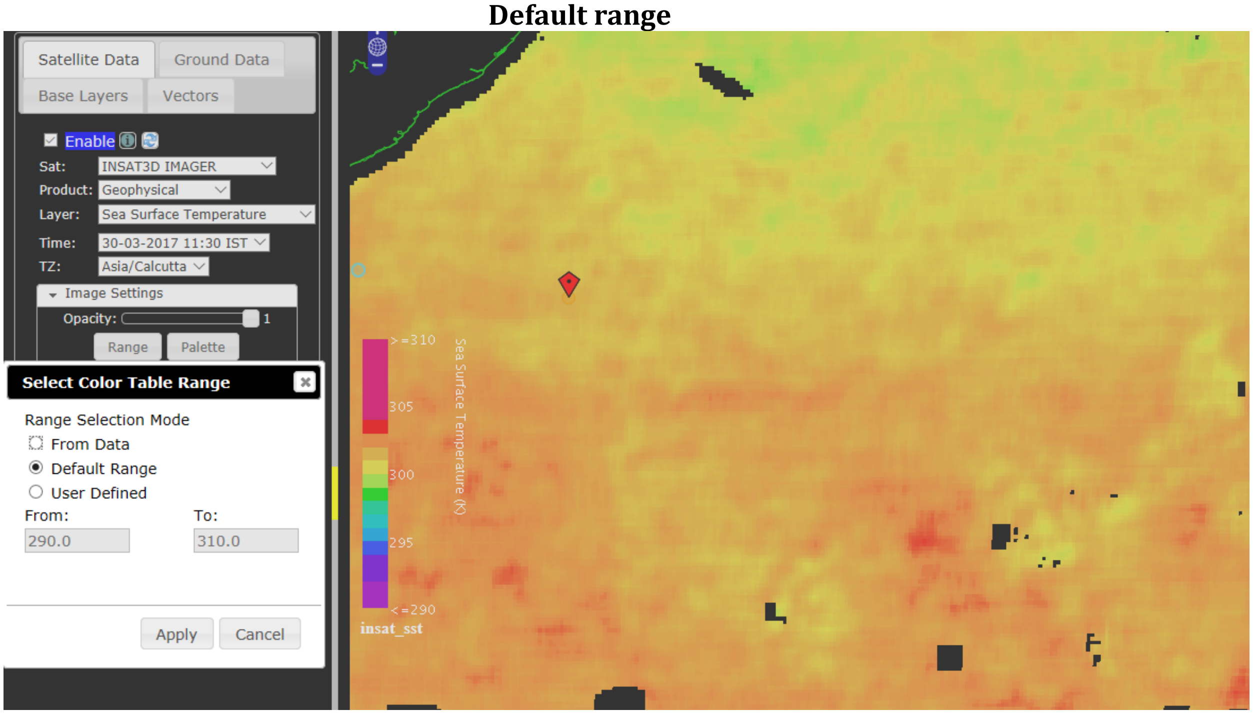
Transect Probing



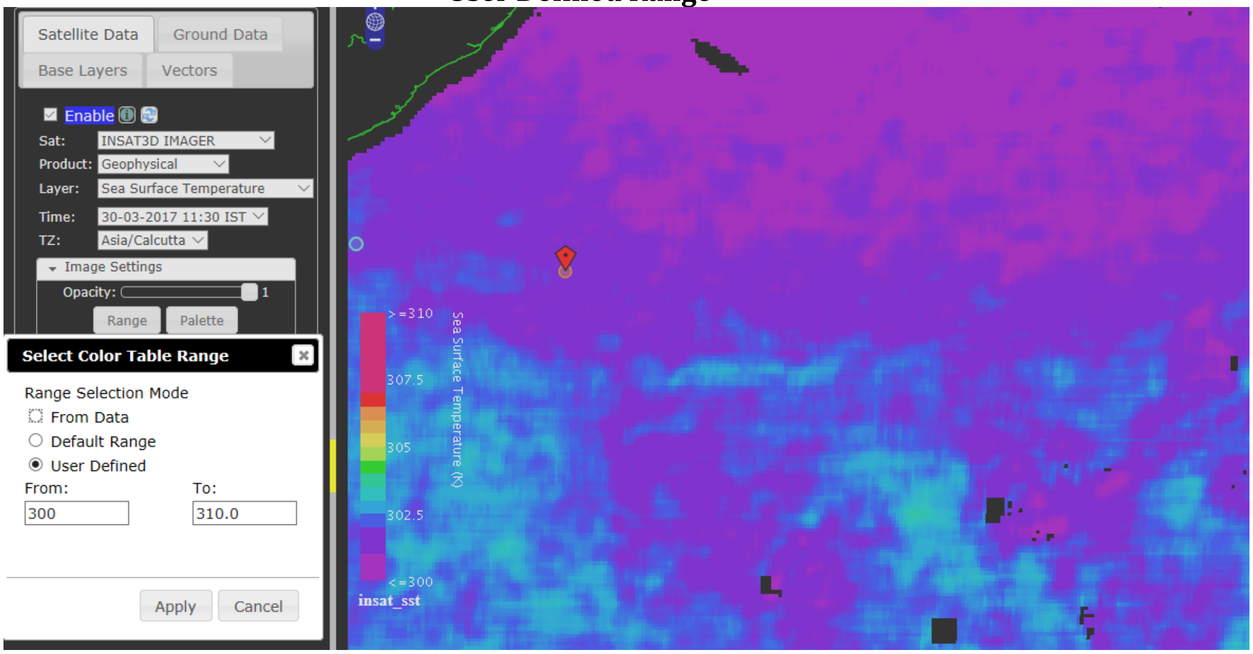
Box Statistics Probing



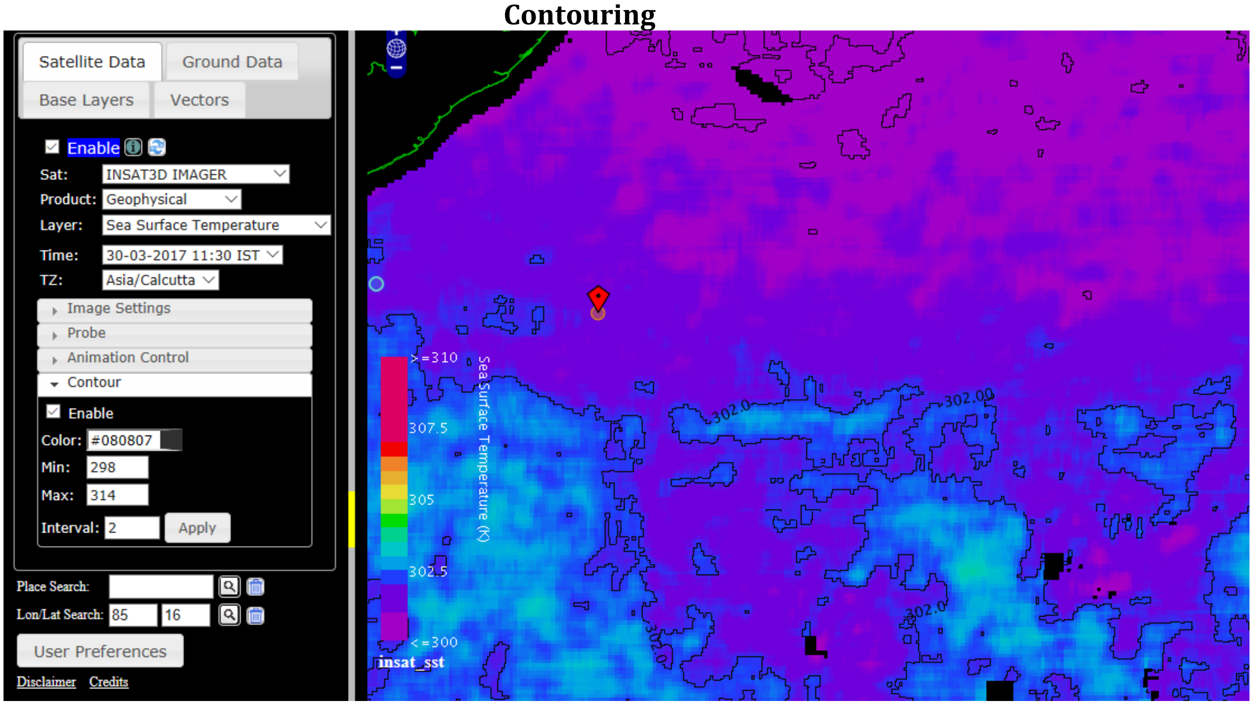
Default range



User Defined Range



Contouring



d) Land Surface Temperature (LST): Land surface temperature is the temperature of the of the earth's surface at particular location. For a satellite, surface is whatever it sees on ground like snow, grassland, forest or a building. It is thus different from the temperature mentioned in the daily weather report.

Being the direct driving force behind exchange of OLR and turbulent heat fluxes at the planetary boundary layer land surface temperature (LST) is one of the most important parameters in the physical processes of surface energy and water balance at local through global scales. Hence it is needed as an input parameter to various atmospheric, hydrological and bio-geo-chemical studies.

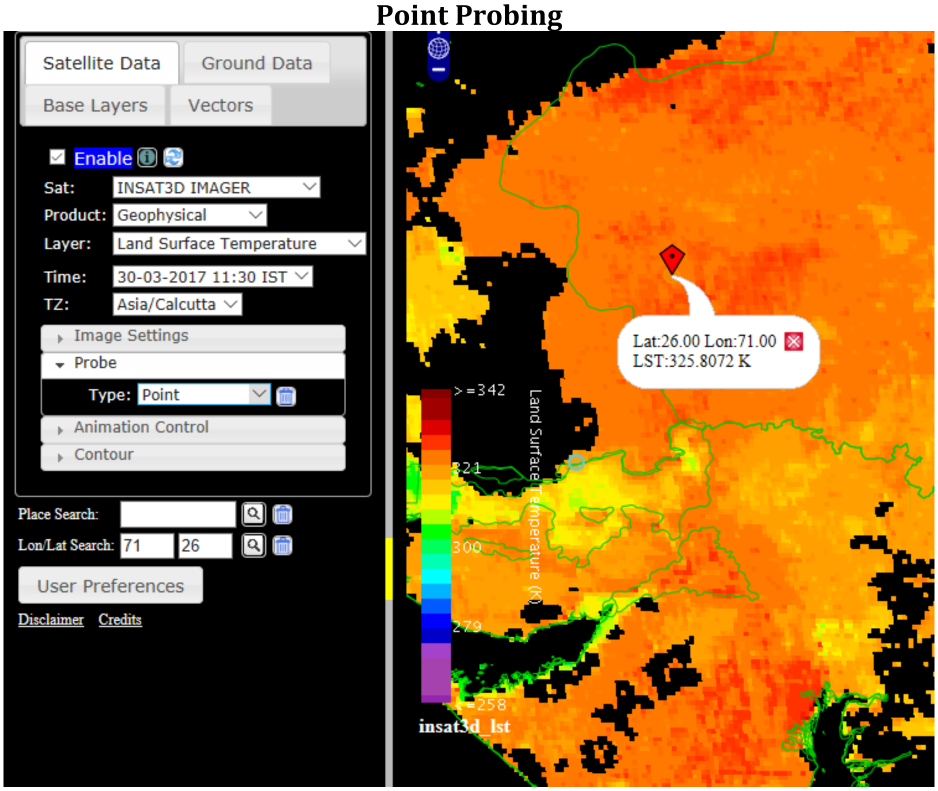
Applications

Land surface temperatures are used to study the temperature trends over the land. It is monitored to study effect of atmospheric greenhouse gases on earth's surface and in turn glaciers, ice sheets and also the vegetation. Farmers can use land surface temperature maps to evaluate water requirement for their crops during summer.

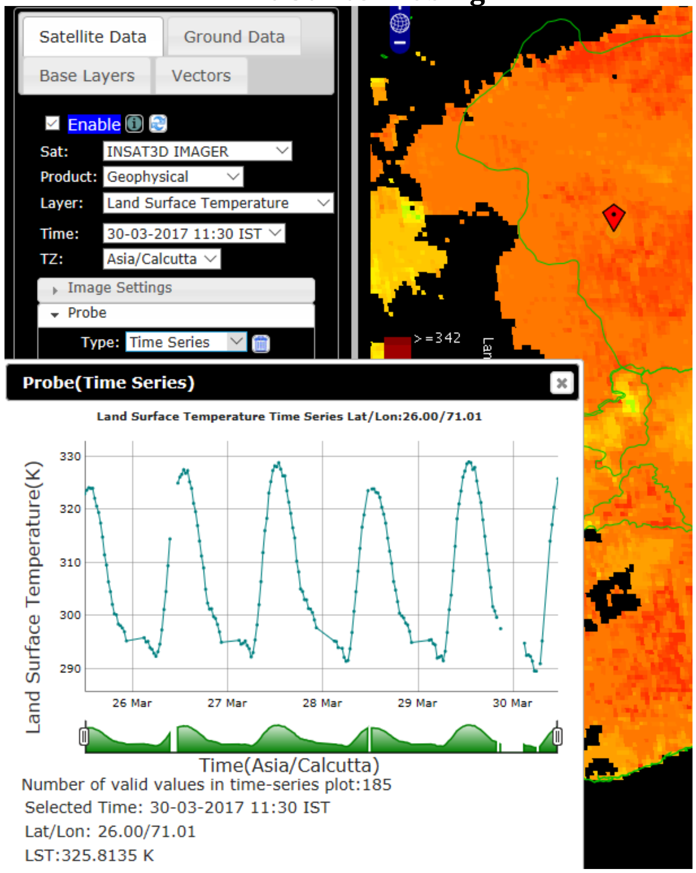
LST is an important parameter in numerical weather prediction. It is used along with sea surface temperature to simulate the atmospheric processes. It is also used in agricultural and hydrological modeling.

The sample example of LST as visualized in RAPID is shown below.

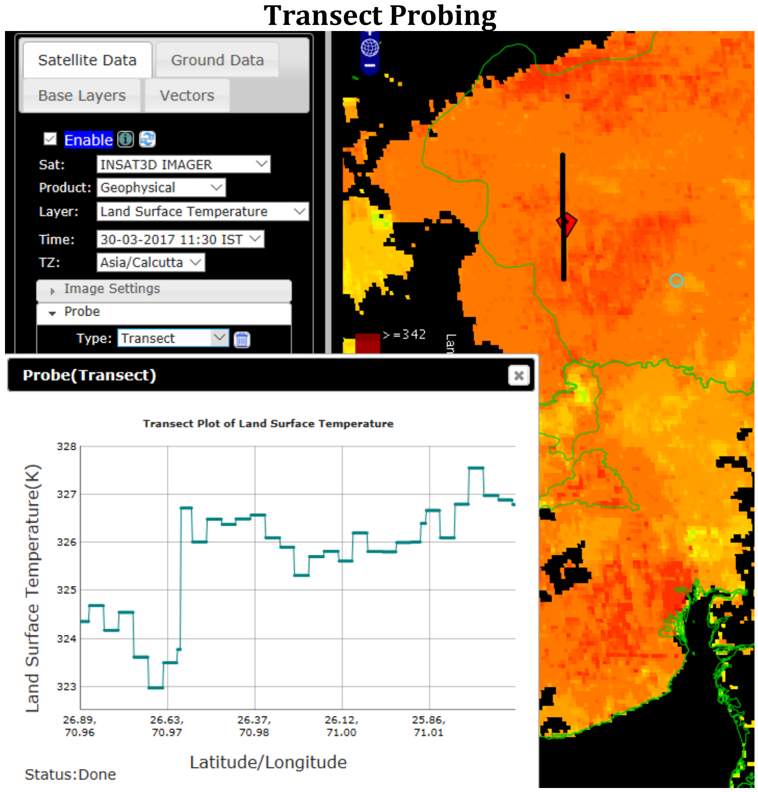
Point Probing



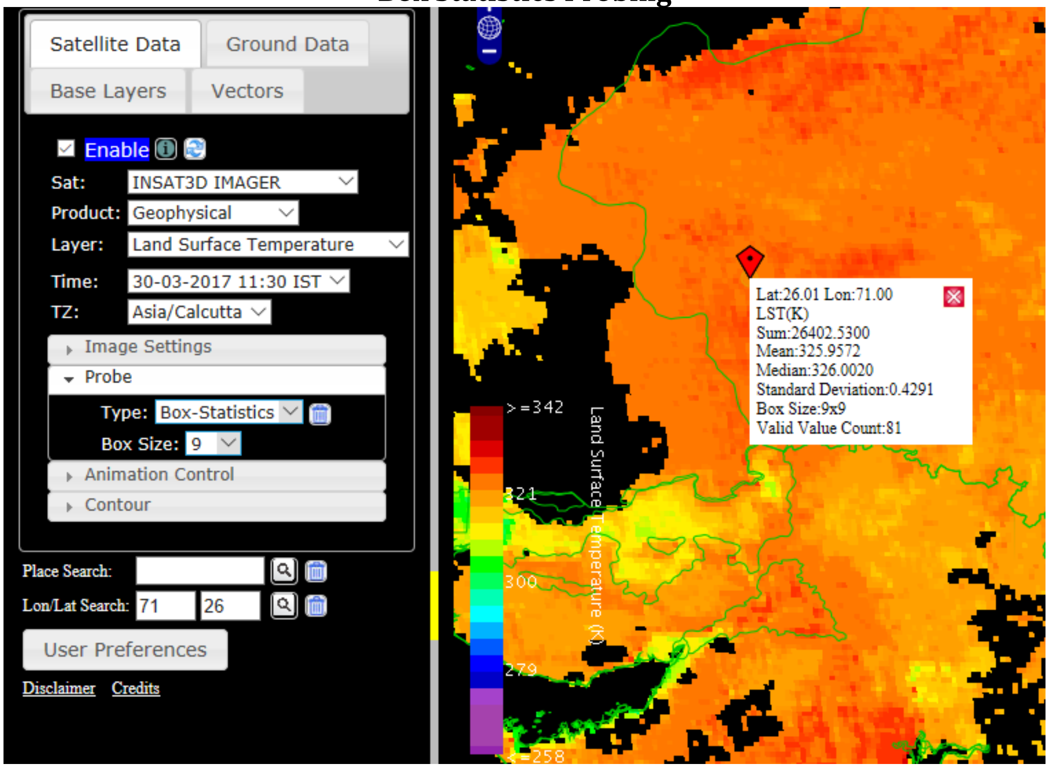
Time Series Probing



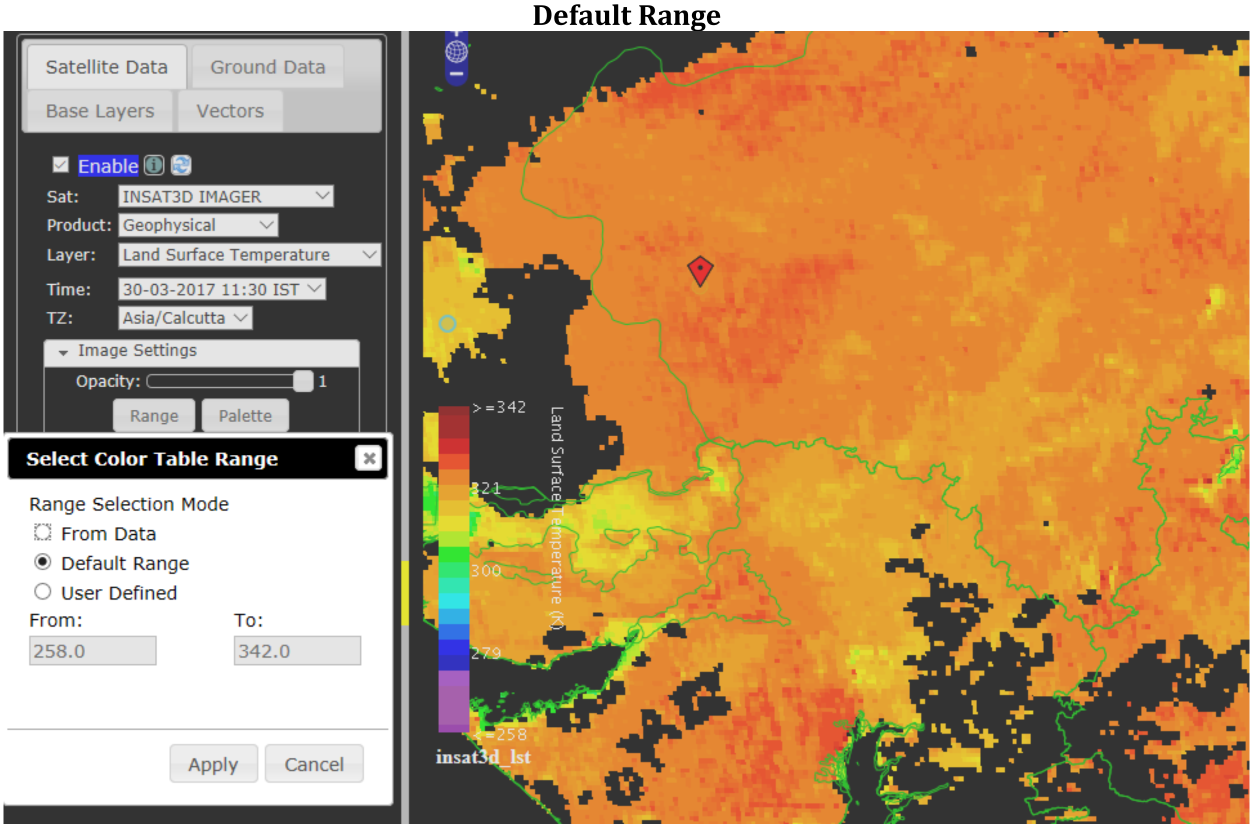
Transect Probing



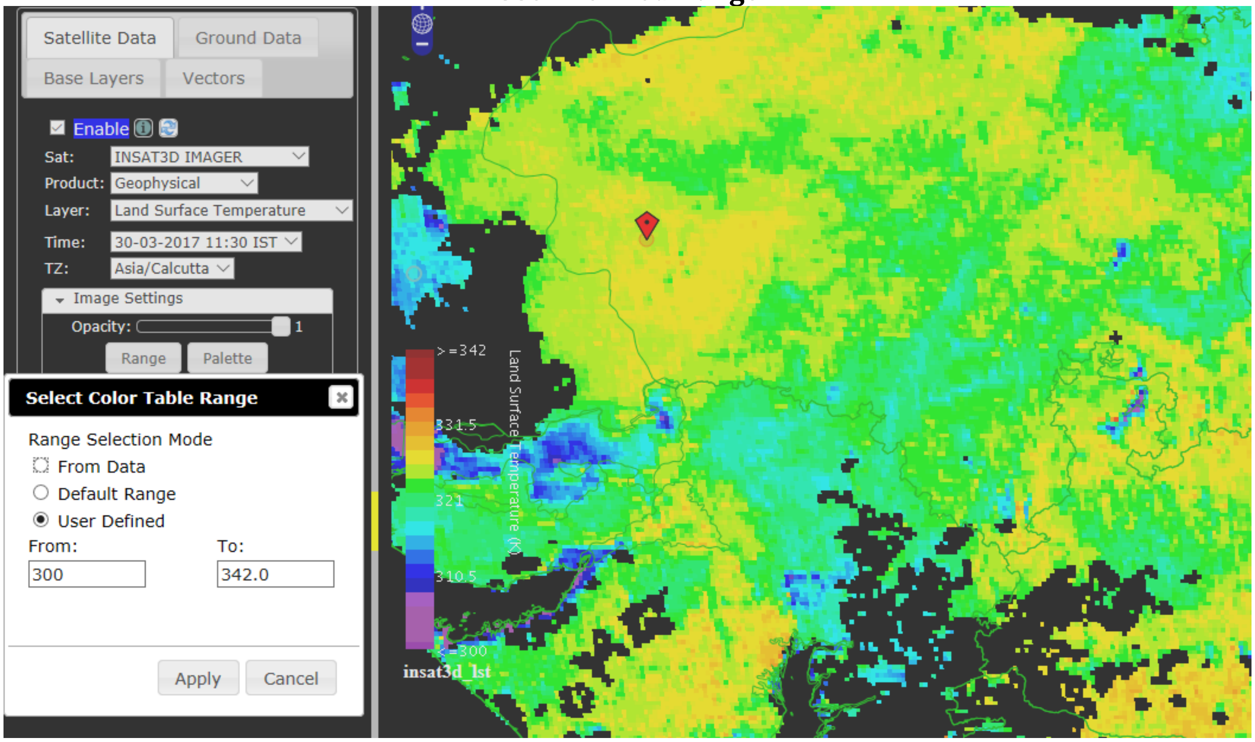
Box Statistics Probing



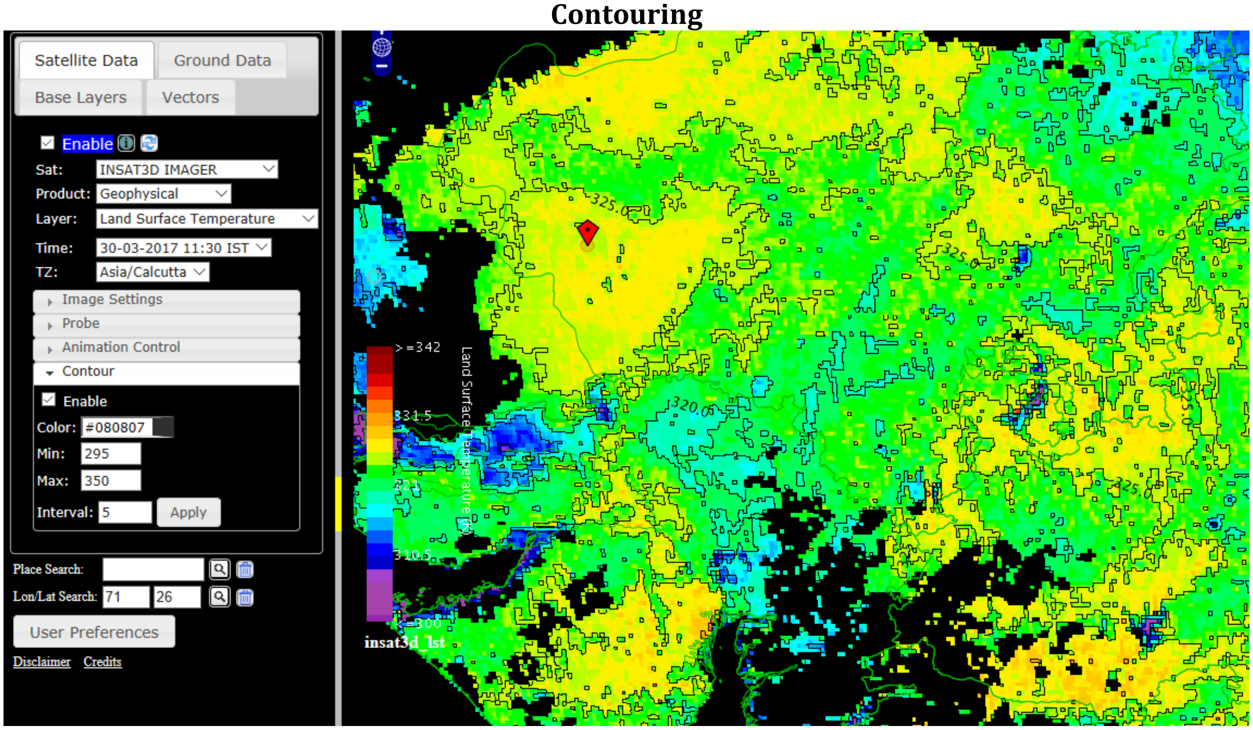
Default Range



User Defined Range



Contouring

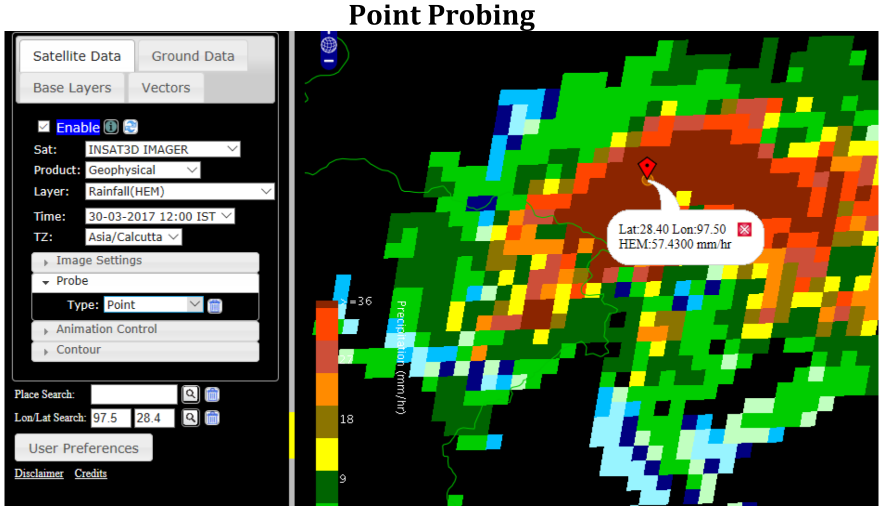


e) **Rainfall Estimates:** At present three rain estimate products are being generated from INSAT-3D namely; Quantitative Precipitation Estimate (GPI), INSAT Multispectral Rainfall Algorithm (IMR) and Hydro Estimator (HEM).

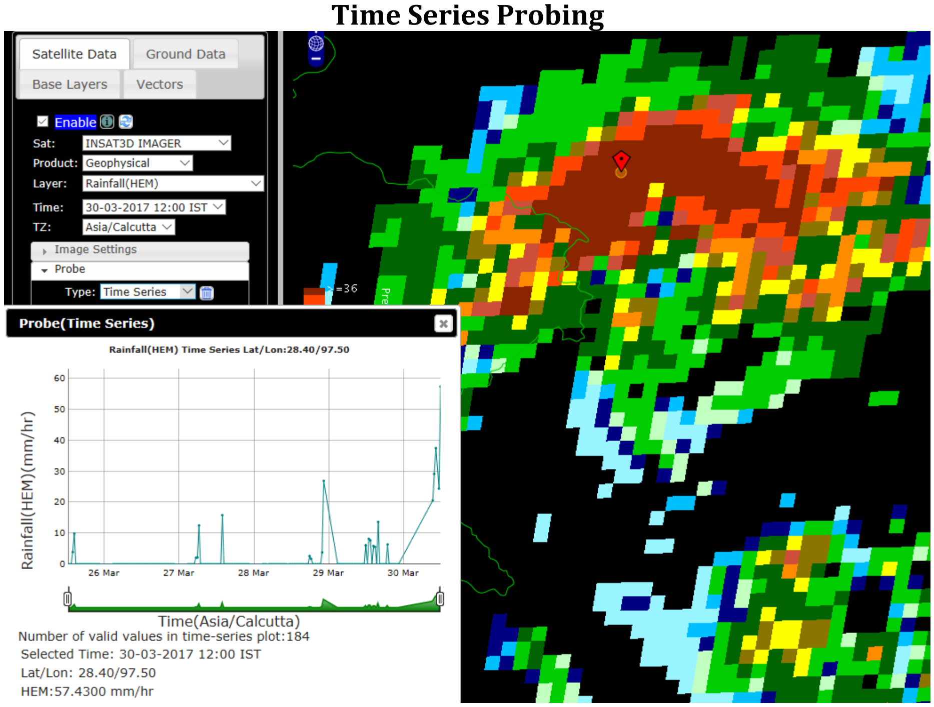
   i) **Hydro Estimator (HEM):** Product derived using TIR-1 along with NCEP/GFS parameters, and earth elevation model. Thermodynamic model is used for calculating EL / LNB correction for warm rain. Orographic correction is carried out using wind and elevation model. Dry atmospheric correction is carried out using RH. Rain is determined at each pixel using different relationships for convective/strati form type, and relationship dynamically calculated for each pixel. This product can be used to identify the location of rain/heavy rain quantitatively.

   The sample example of HEM as visualized in RAPID is shown below.

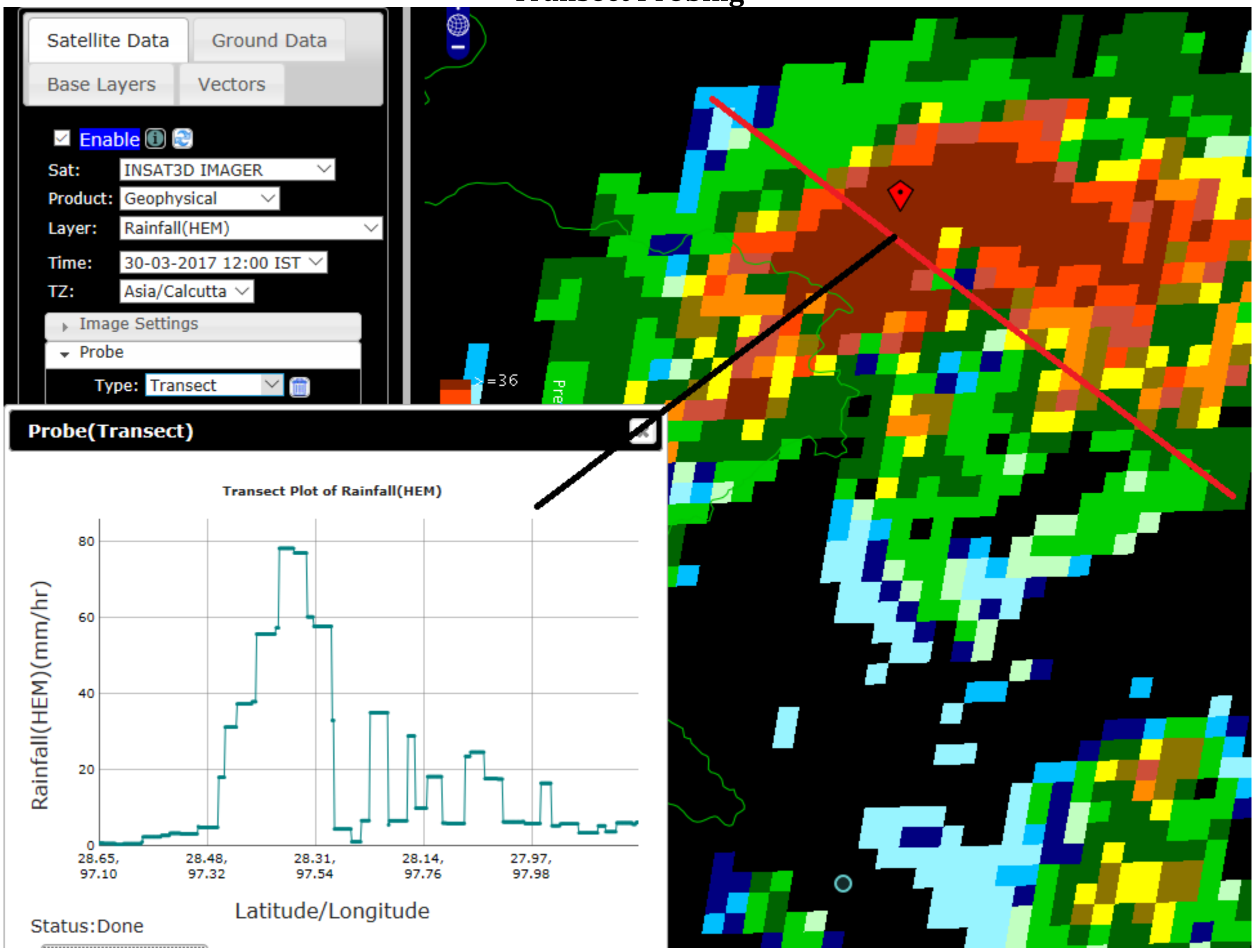
Point Probing



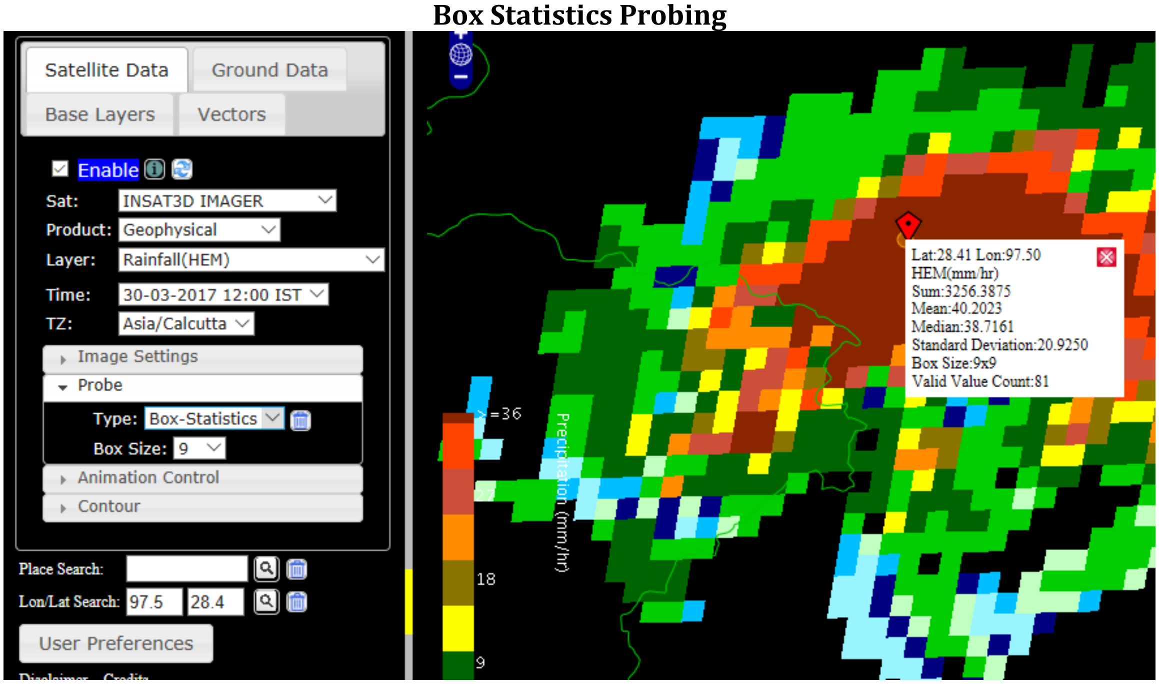
Time Series Probing



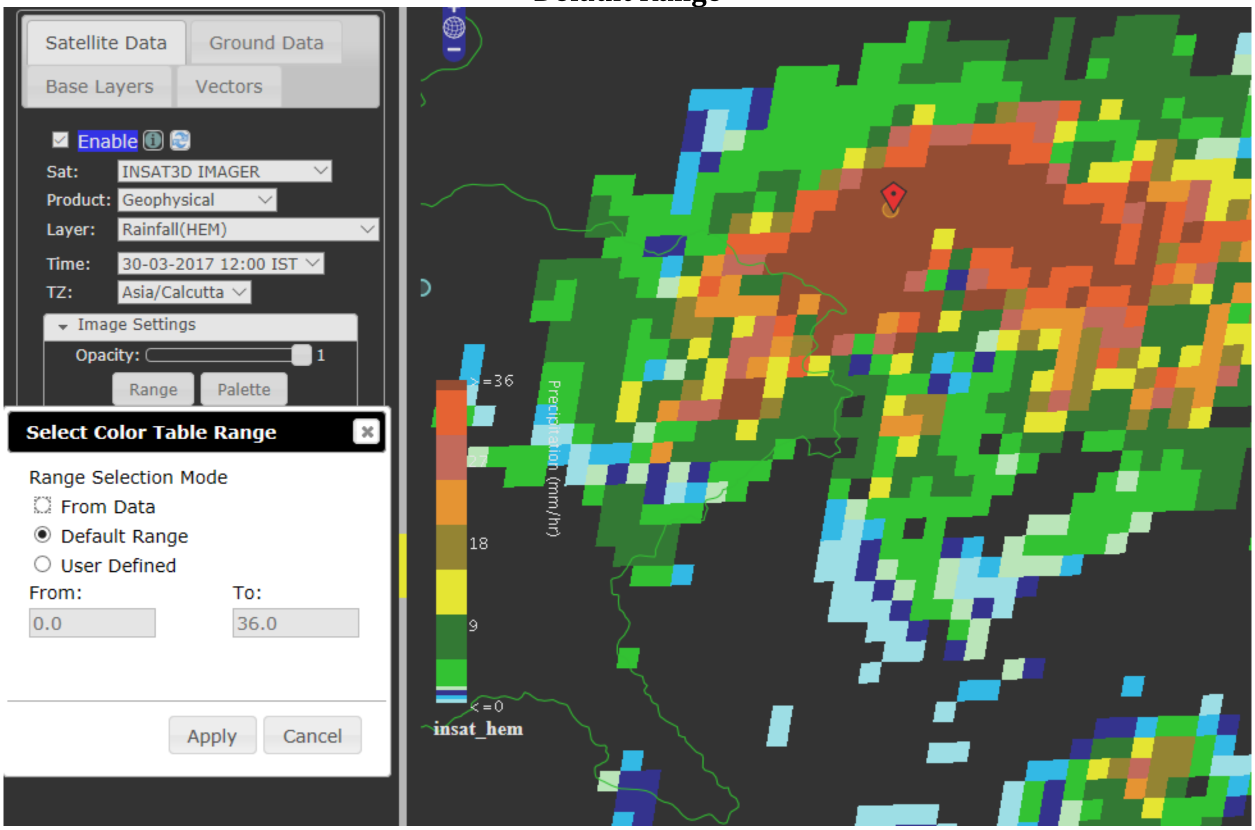
Transect Probing



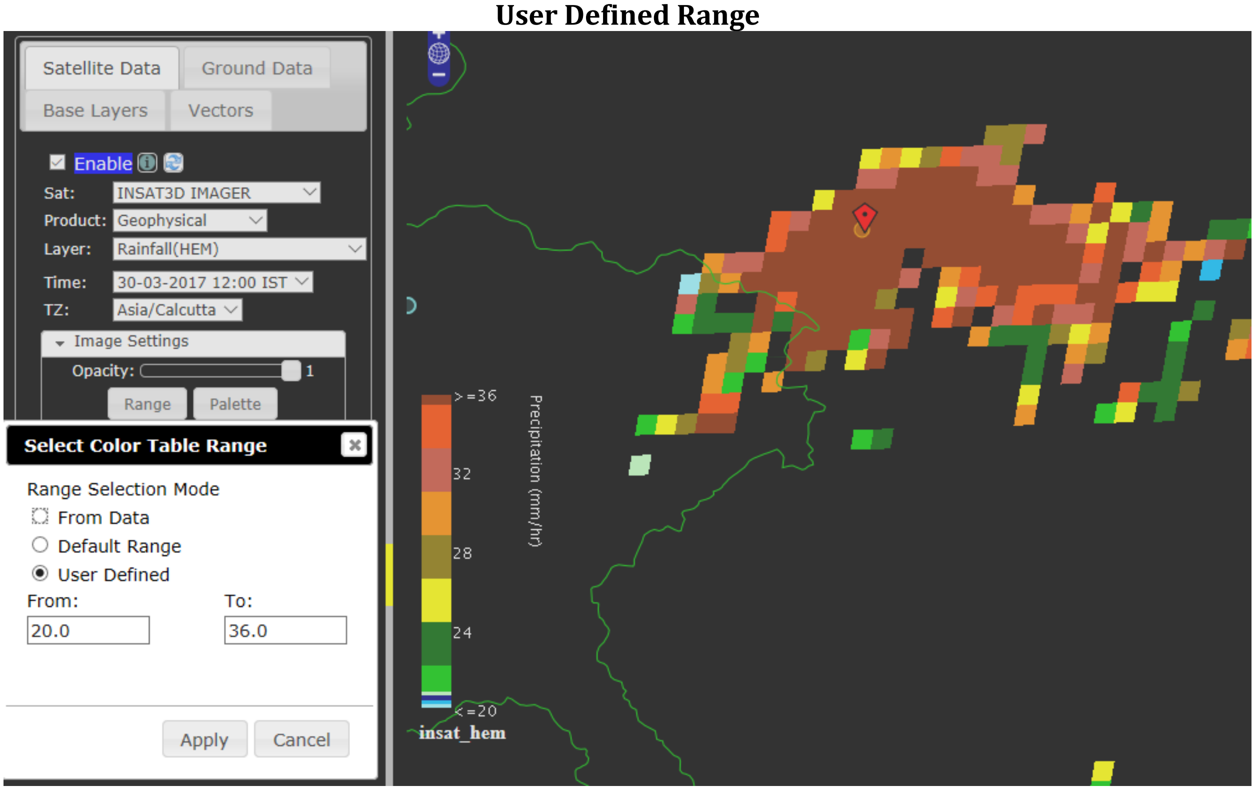
Box Statistics Probing



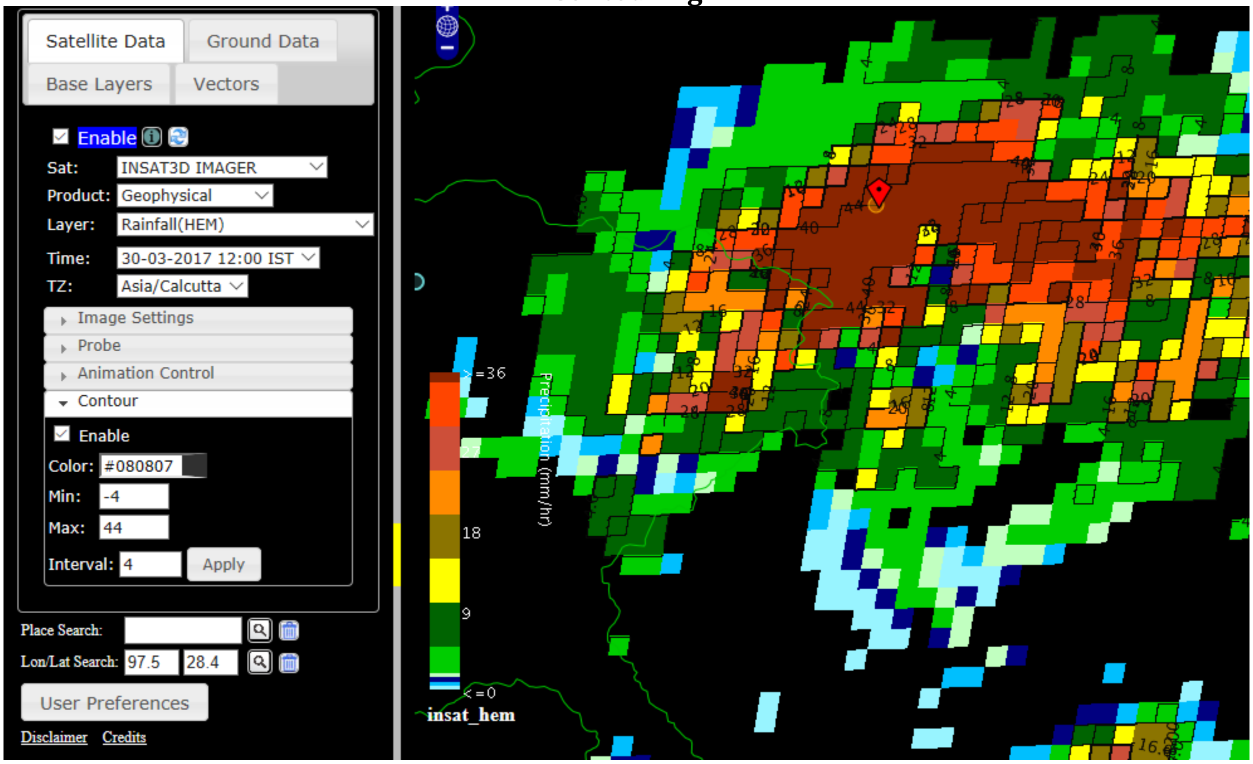
Default Range



User Defined Range



Contouring

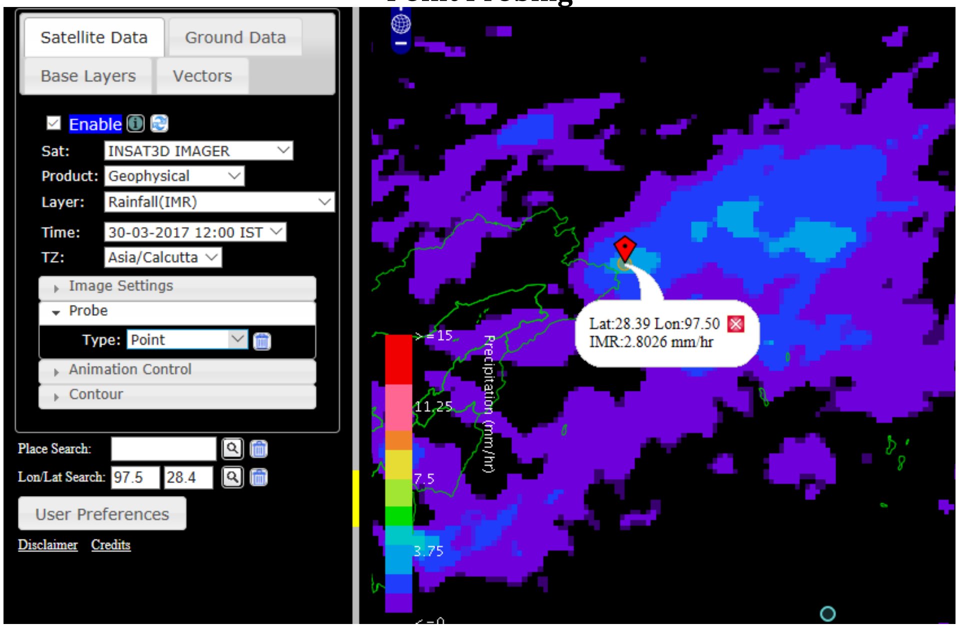


ii) **INSAT Multi Spectral Rainfall Algorithm (IMR):** A multiple regression based algorithm empirical relationship is used to estimate IMR from infrared channels after calibrating with MW based rain estimates (from TRMM-PR, TMI, SSM/I).

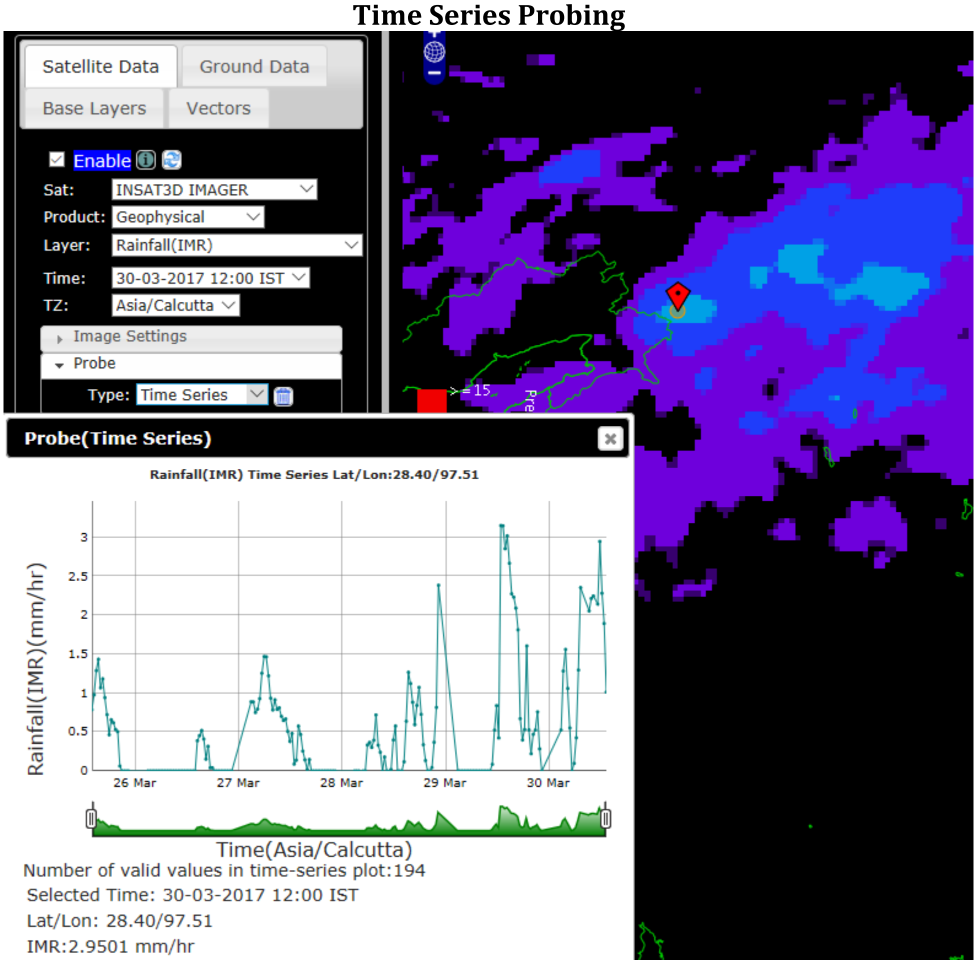
The IMR approach is used to optimize the identification of raining clouds located at a given altitude estimated from the cloud-top temperature. This product can be used to identify the location of rain/rain-rate quantitatively. It can also distinguish thick cirrus clouds from deep convective cores.

The sample example of IMR as visualized in RAPID is shown below.

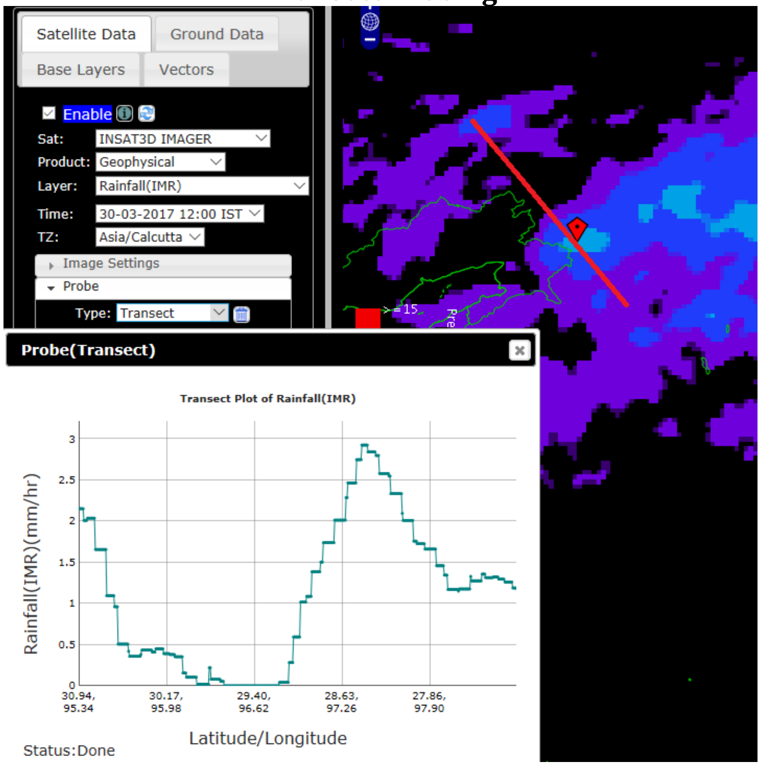
Point Probing



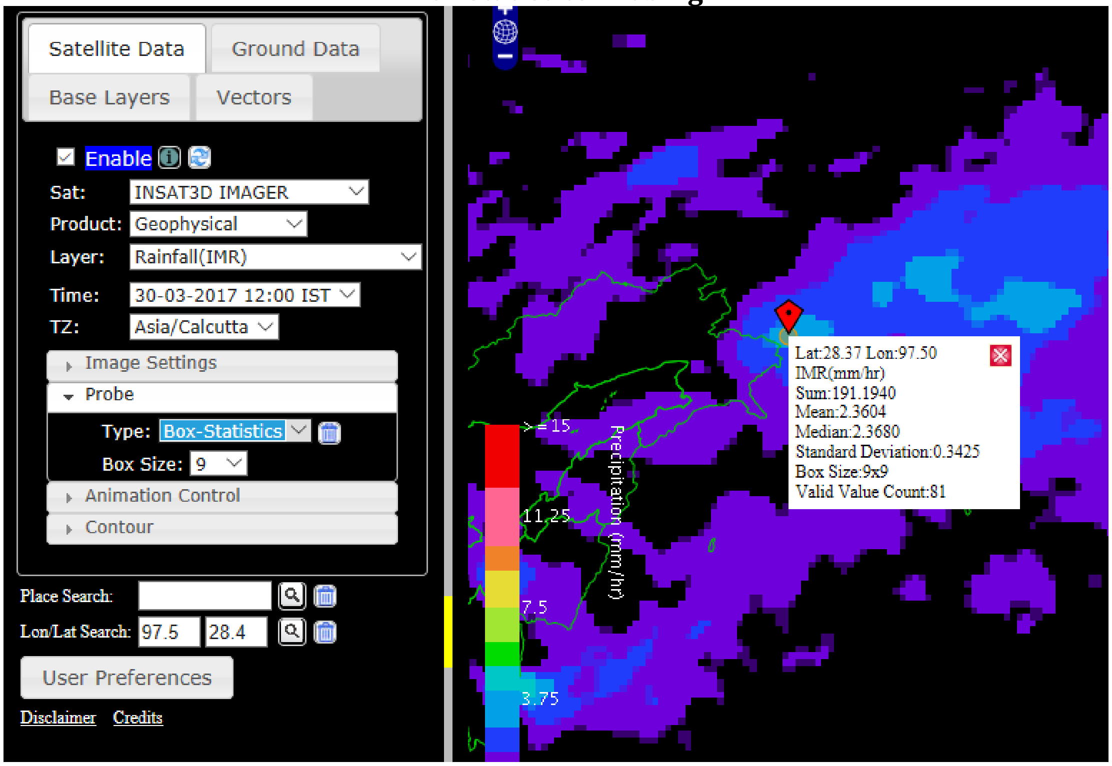
Time Series Probing



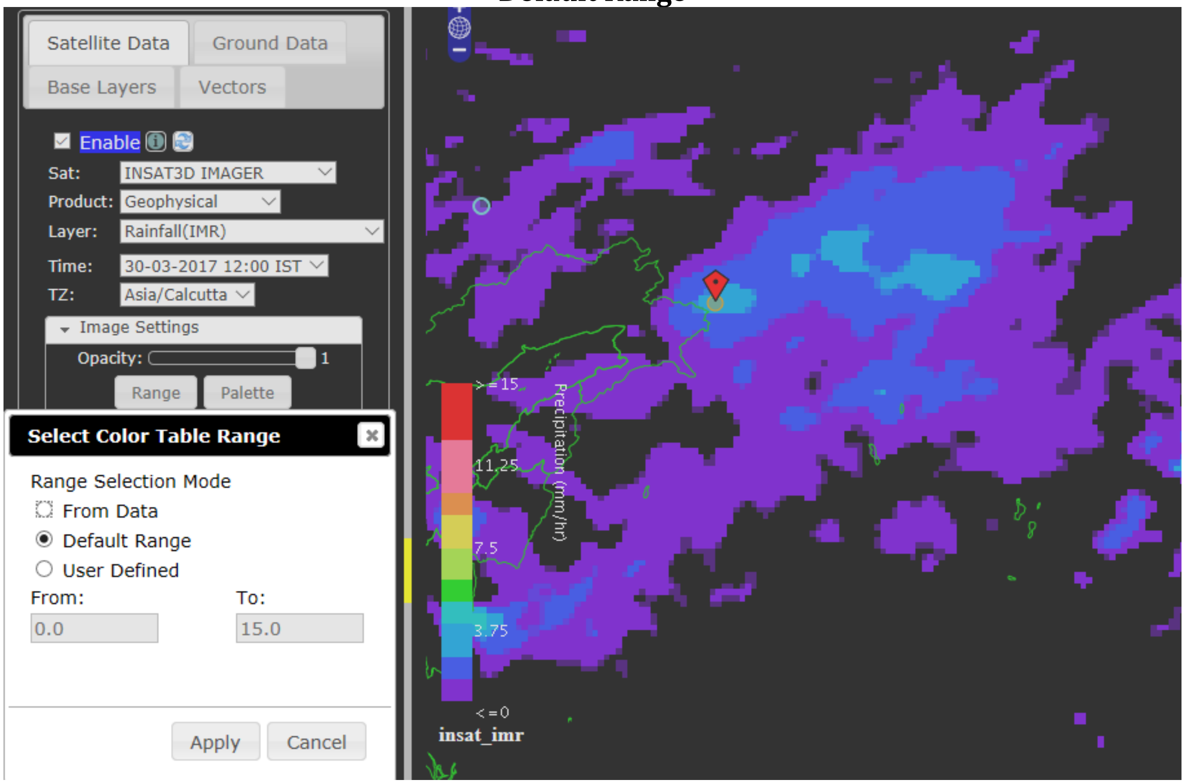
Transect Probing



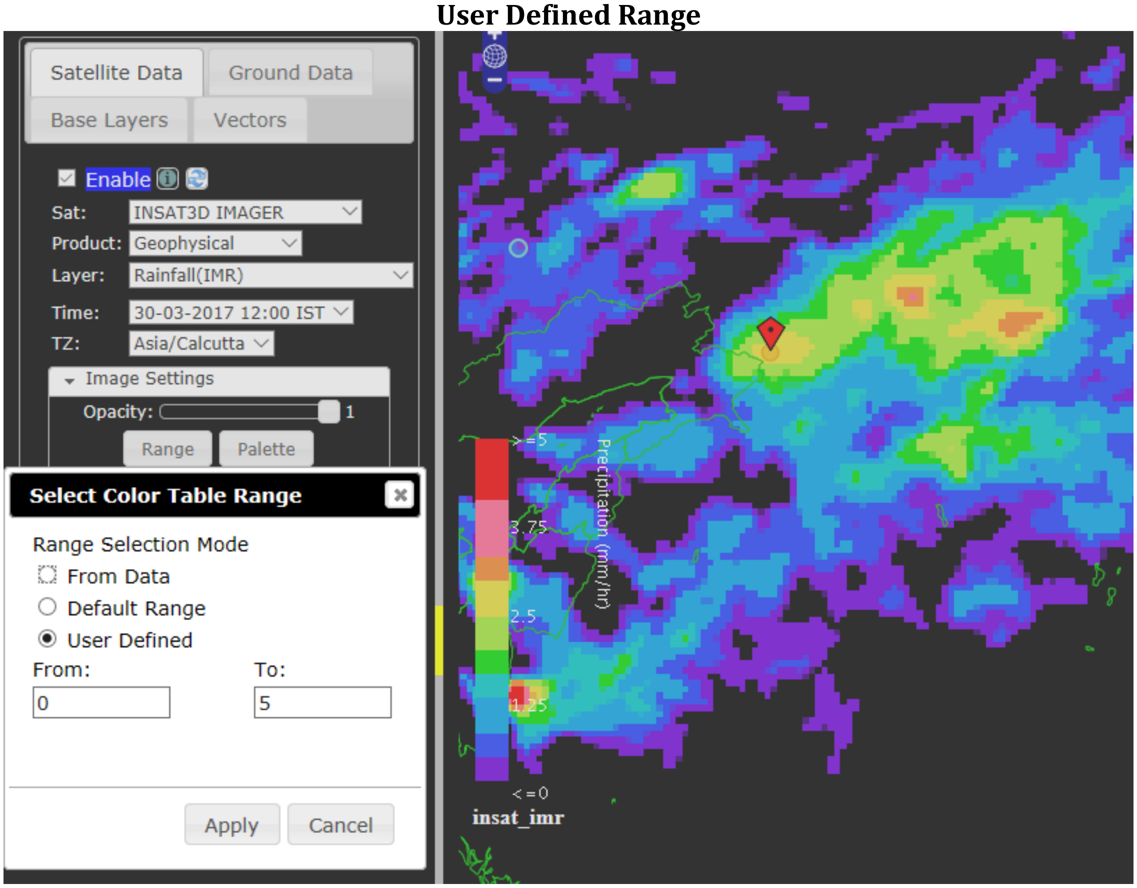
Box Statistics Probing



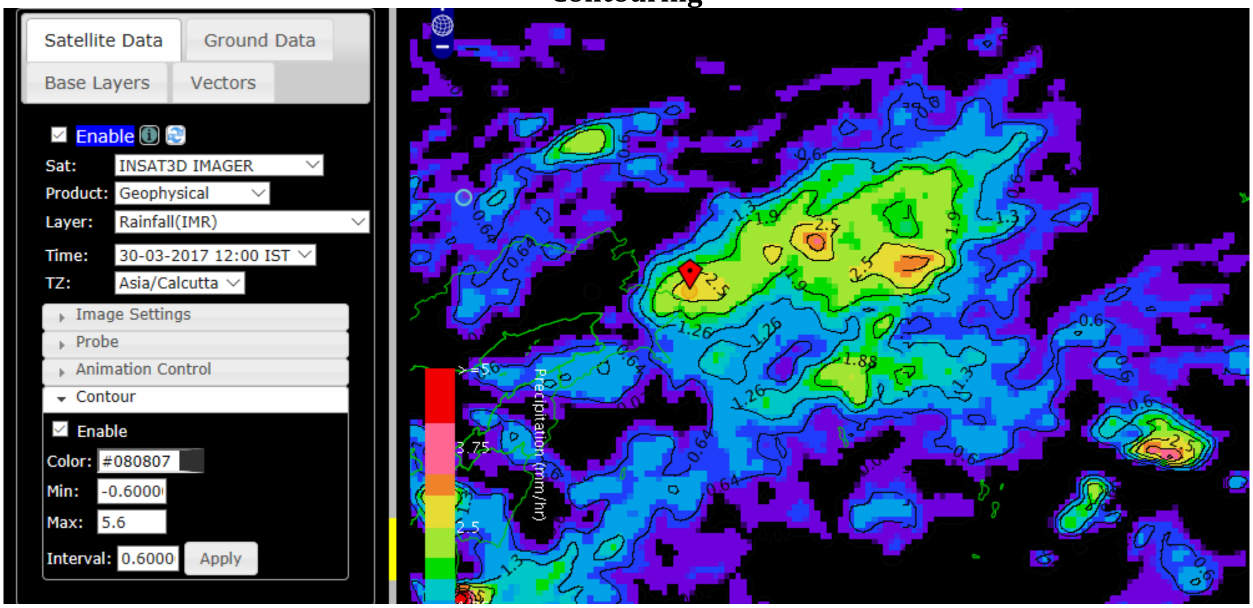
Default Range



User Defined Range



Contouring



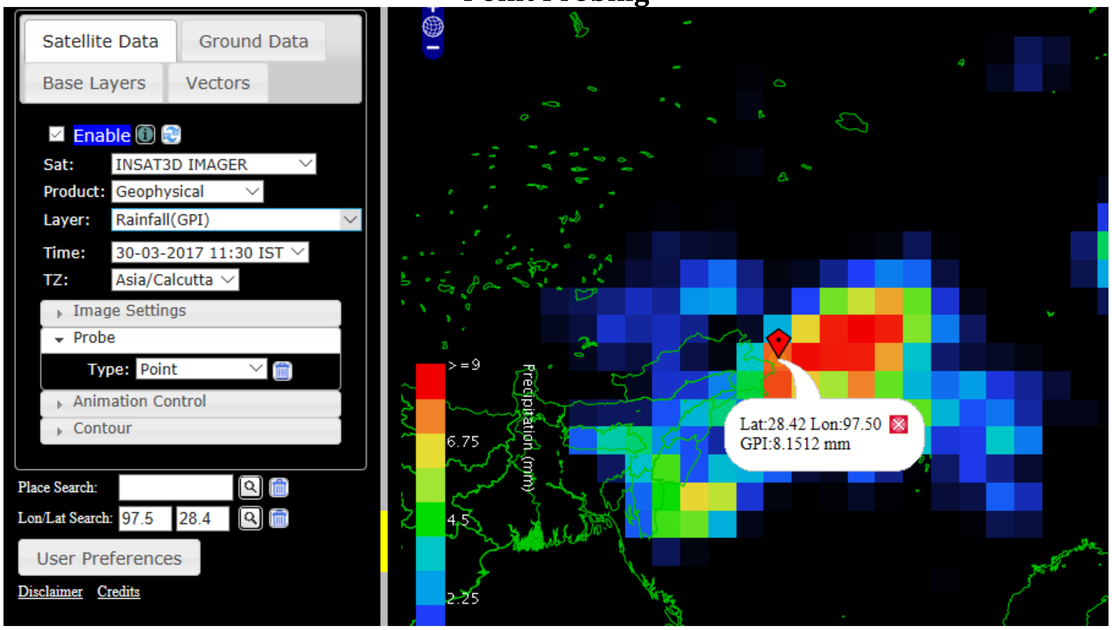
iii) **Quantitative Precipitation Estimate (GPI):** GPI is based on the relationship between cloud-top brightness temperatures and observed rainfall using data from GATE (GARP Atlantic Tropical Experiment) area (Arkin et al. 1989). Studies by Arkin (1979) and Richards and Arkin (1981) using data from the GATE showed that estimates of rainfall could be made using a simple thresholding technique on IR data from geostationary satellites. It is derived by using linear regression relationship between fraction coverage of cold cloud at 1° grid latitude/longitude and provides three hourly accumulated rainfall estimation.

Product Limitations

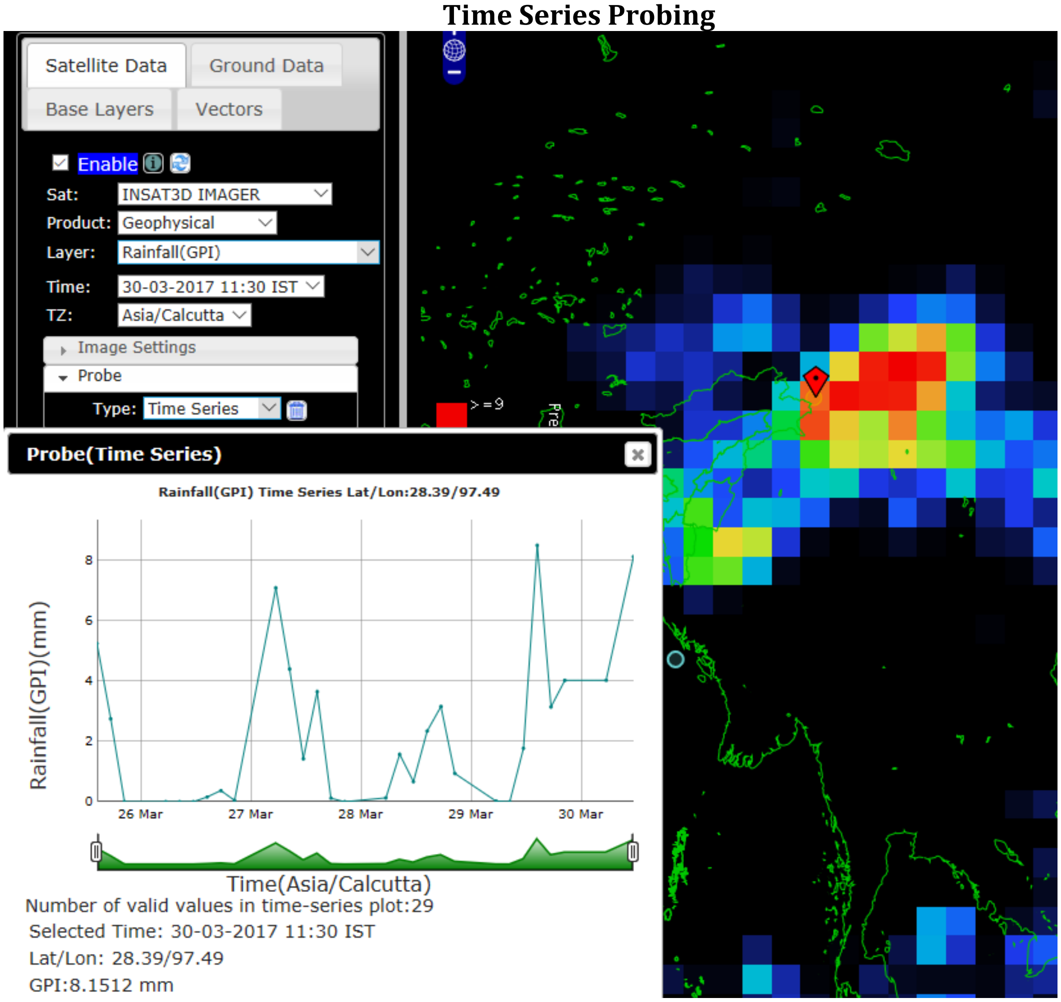
- The product does not estimate rainfall in terrain.
- The product does not give heavy rainfall events because of its range.

The sample example of GPI as visualized in RAPID is shown below.

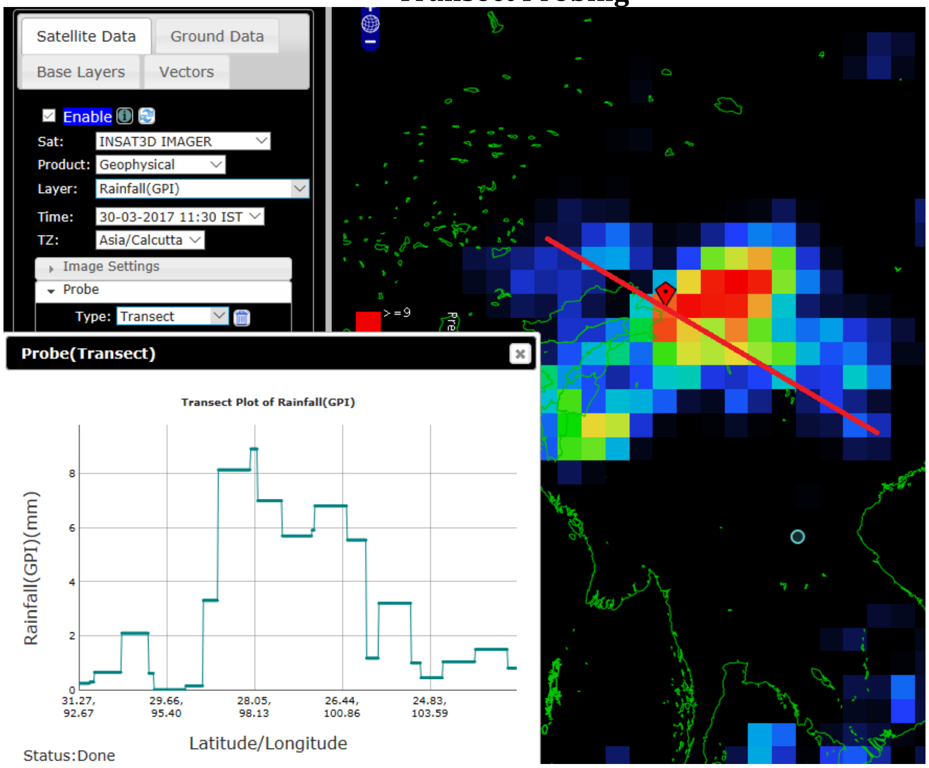
Point Probing



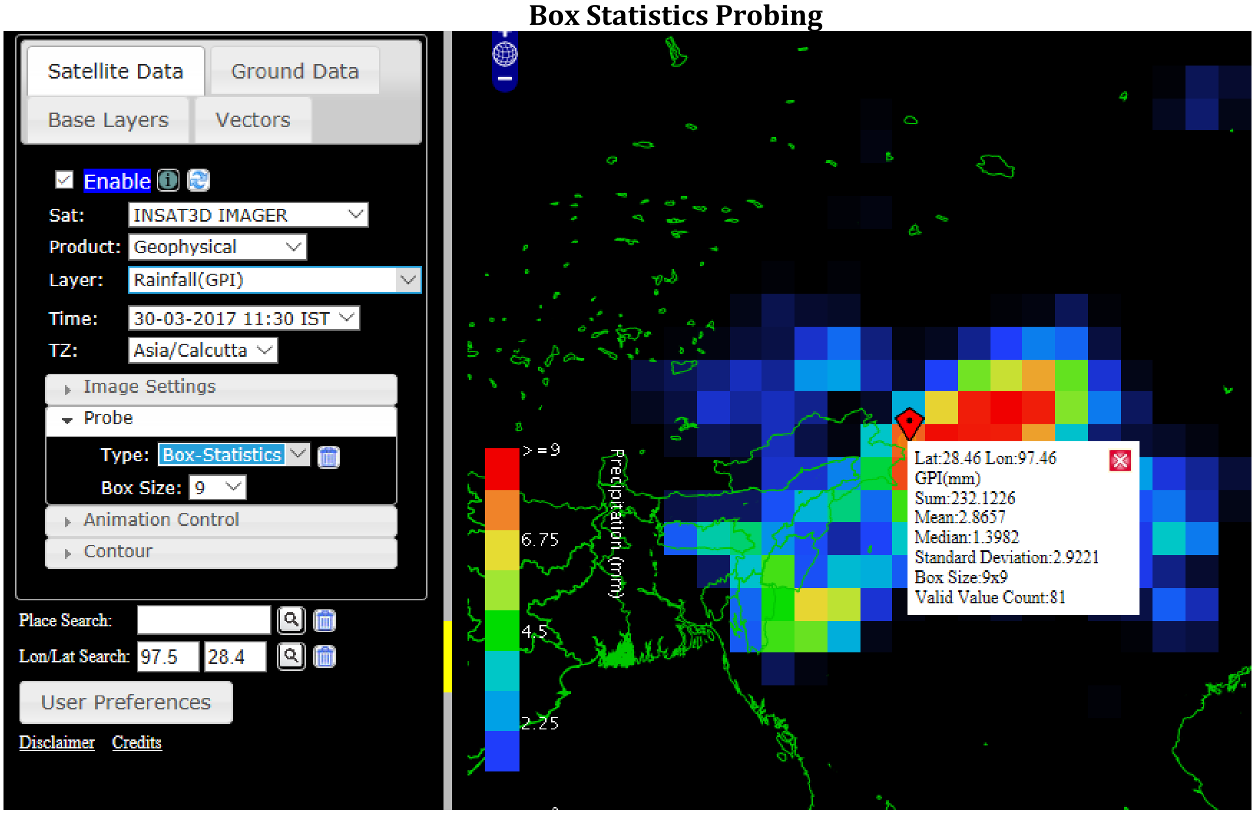
Time Series Probing



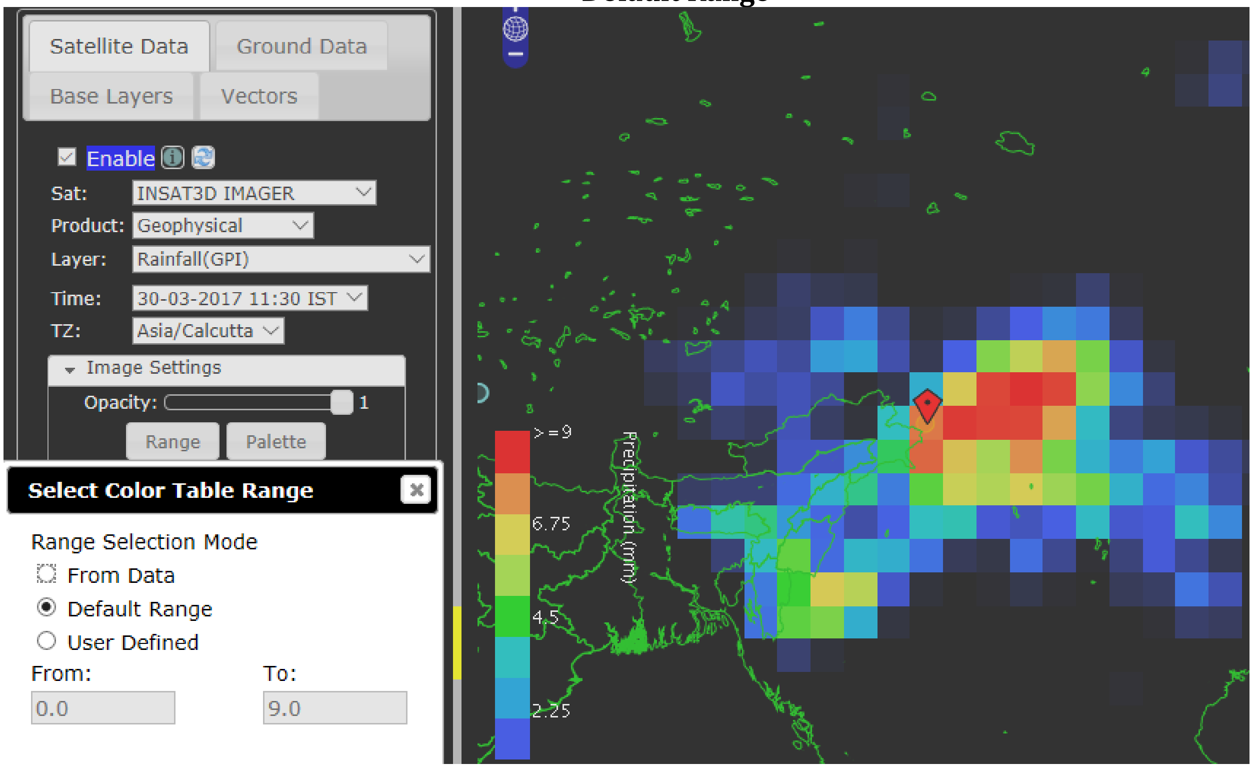
Transect Probing



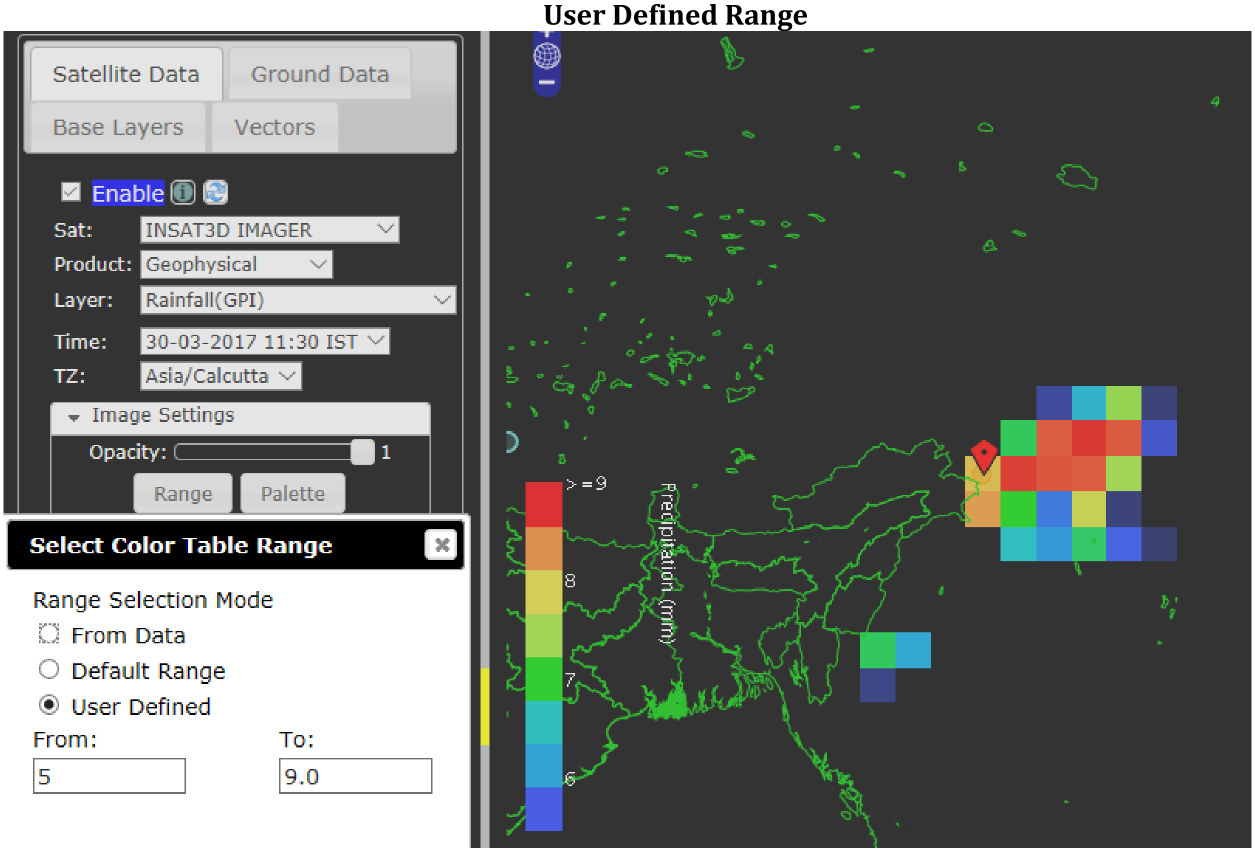
Box Statistics Probing



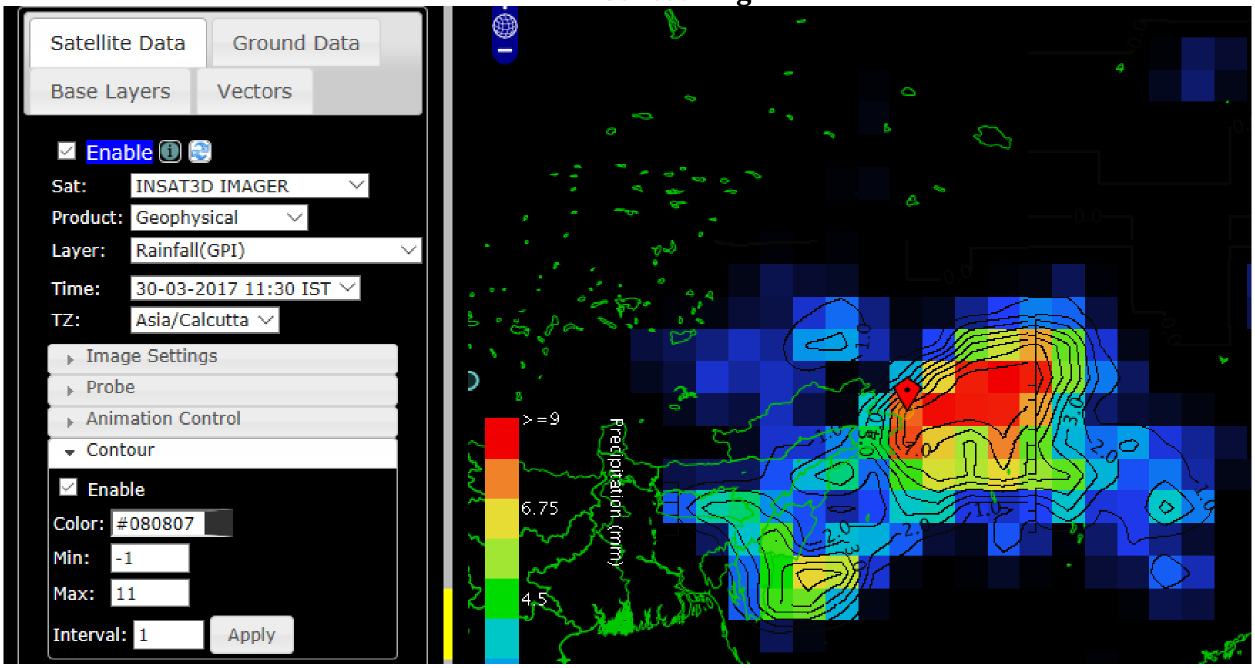
Default Range



User Defined Range



Contouring



f) **Aerosol Optical depth (AOD):** Aerosols are fine suspended particles like dust or haze in the atmosphere. These particles affect sunlight by scattering or absorbing. The measure of extinction of solar radiation caused by these aerosols is termed as aerosol optical depth (AOD). AOD tells us about how much of direct sunlight is prevented from reaching the earth. It depends on the number of aerosols in the vertical column of atmosphere over the location. It is a dimensionless number with value of 0.01 indicating an extremely clean atmosphere and a value of 0.4 indicating a very hazy condition. AODs typically decrease with increasing wavelength and are much smaller for long wave radiation.

Aerosols play an important role in atmosphere. It has direct as well as indirect effect on the atmospheric parameters like insolation, outgoing longwave radiation and clouds. As it alters the radiation passing through the atmosphere it affects the way satellite sensors receives the radiance. Hence all the satellite images undergo atmospheric corrections. Spatio-temporal distribution of aerosols affects the air quality, health hazards, reduced visibility and the heat exchange mechanisms within the earth system. Hence their study is very important. Satellite remote sensing plays an important role in deriving aerosol distribution at regional and global scale.

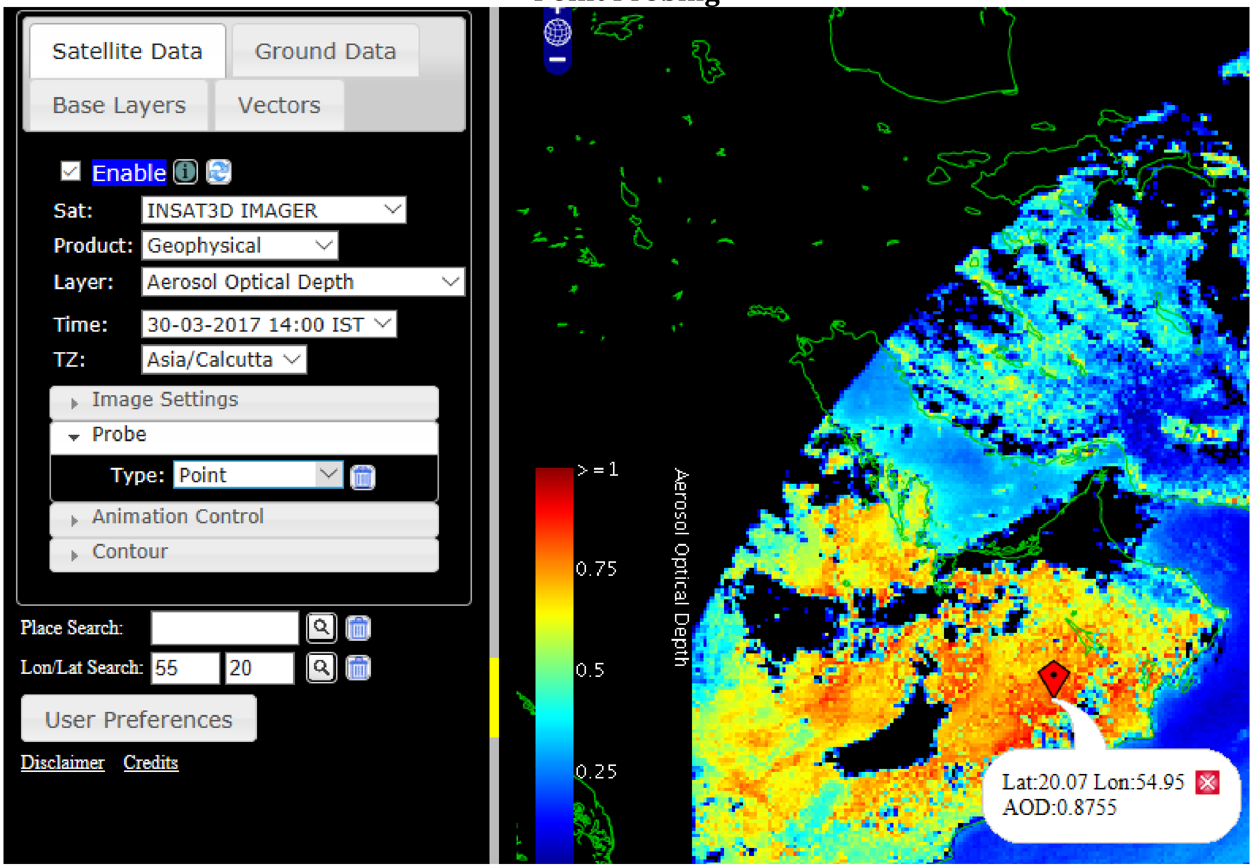
INSAT-3D imager visible band (0.55-0.75 µm) radiances are simulated as a function of geometric angles determining the satellite viewing geometry and time of the day, surface reflectance R, and aerosol optical depth (varying from 0 to 1) at 650 nm.

Application

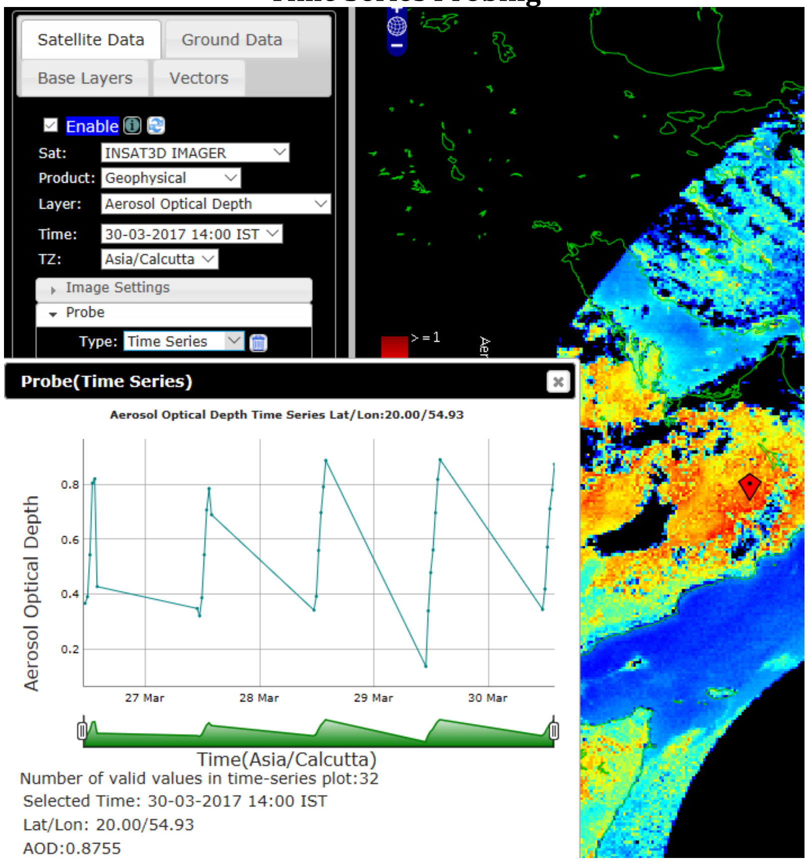
Aerosols have a significant impact on human life beyond the climate element. When in the lower troposphere, aerosols cause poor air quality, reduction of visibility, and public health hazards. Satellite remote sensing provides a means to derive aerosol distribution at global and regional scales. It can be used as validation tool for transport models and tracking of aerosol plumes above clouds and snow/ice.

The sample example of Aerosol Optical Depth as visualized in RAPID is shown below.

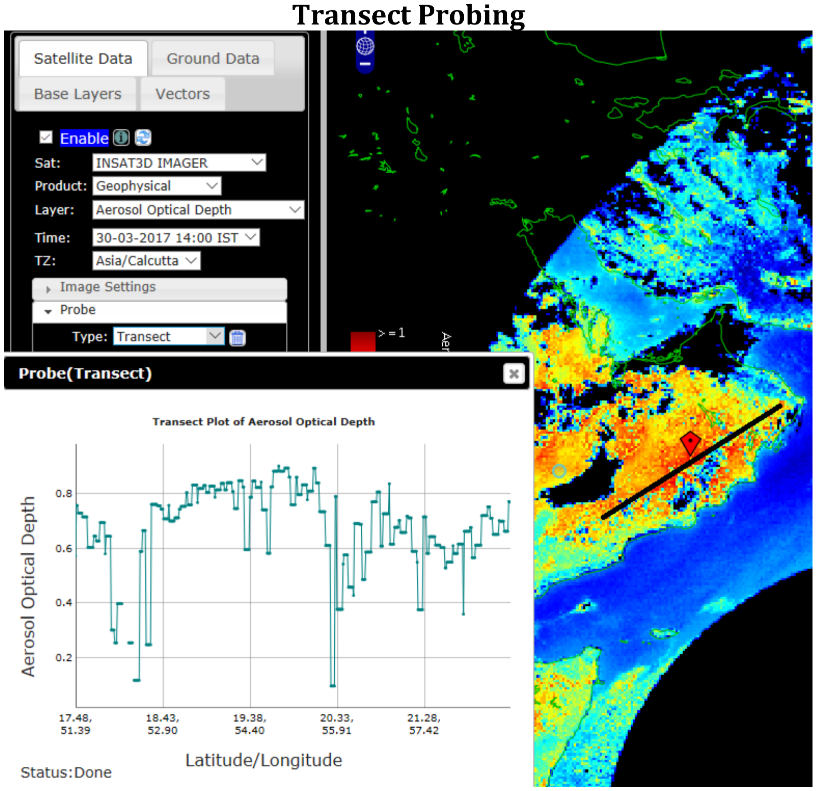
Point Probing



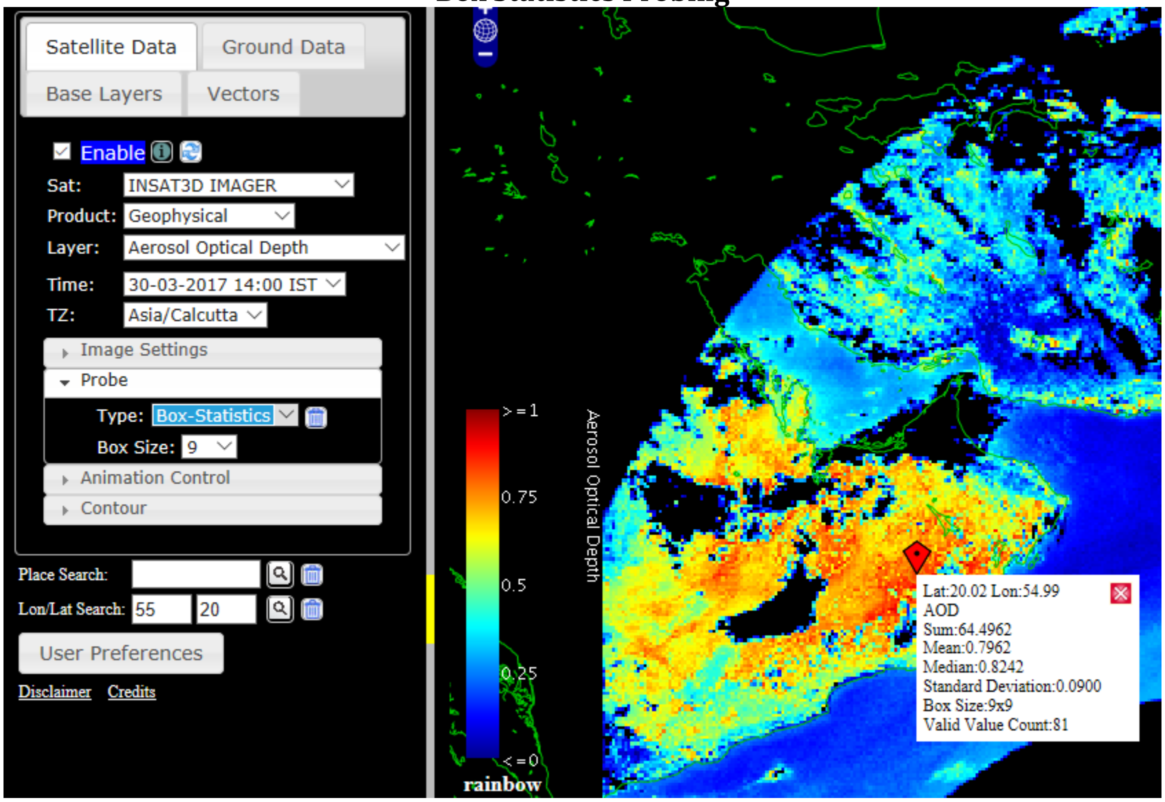
Time Series Probing



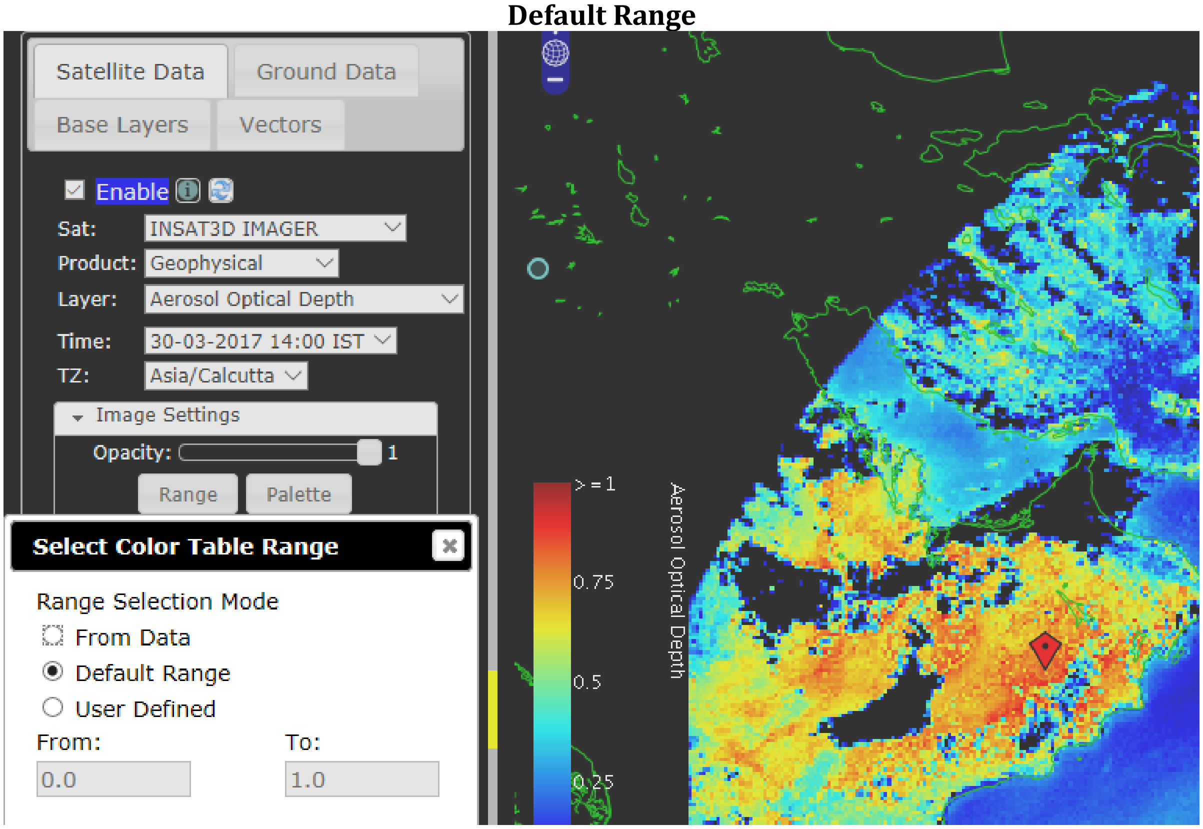
Transect Probing



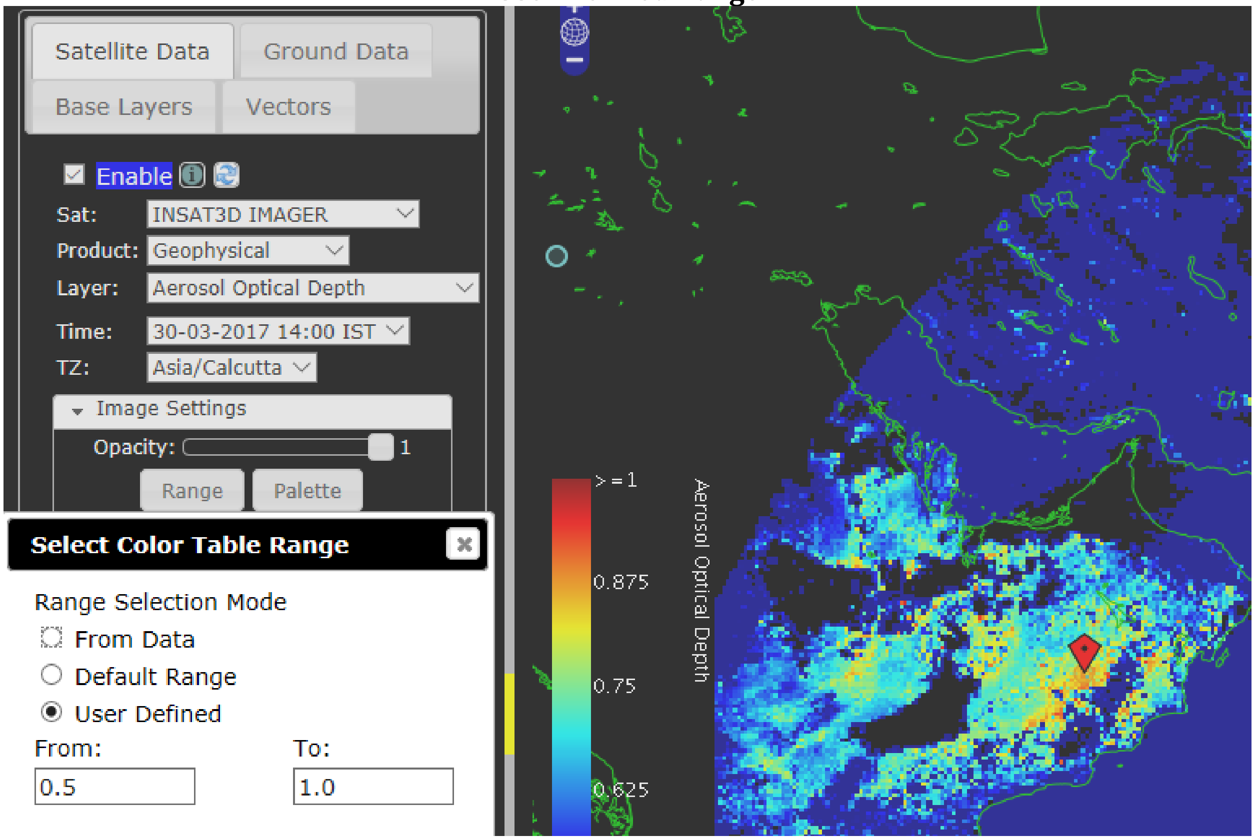
Box Statistics Probing



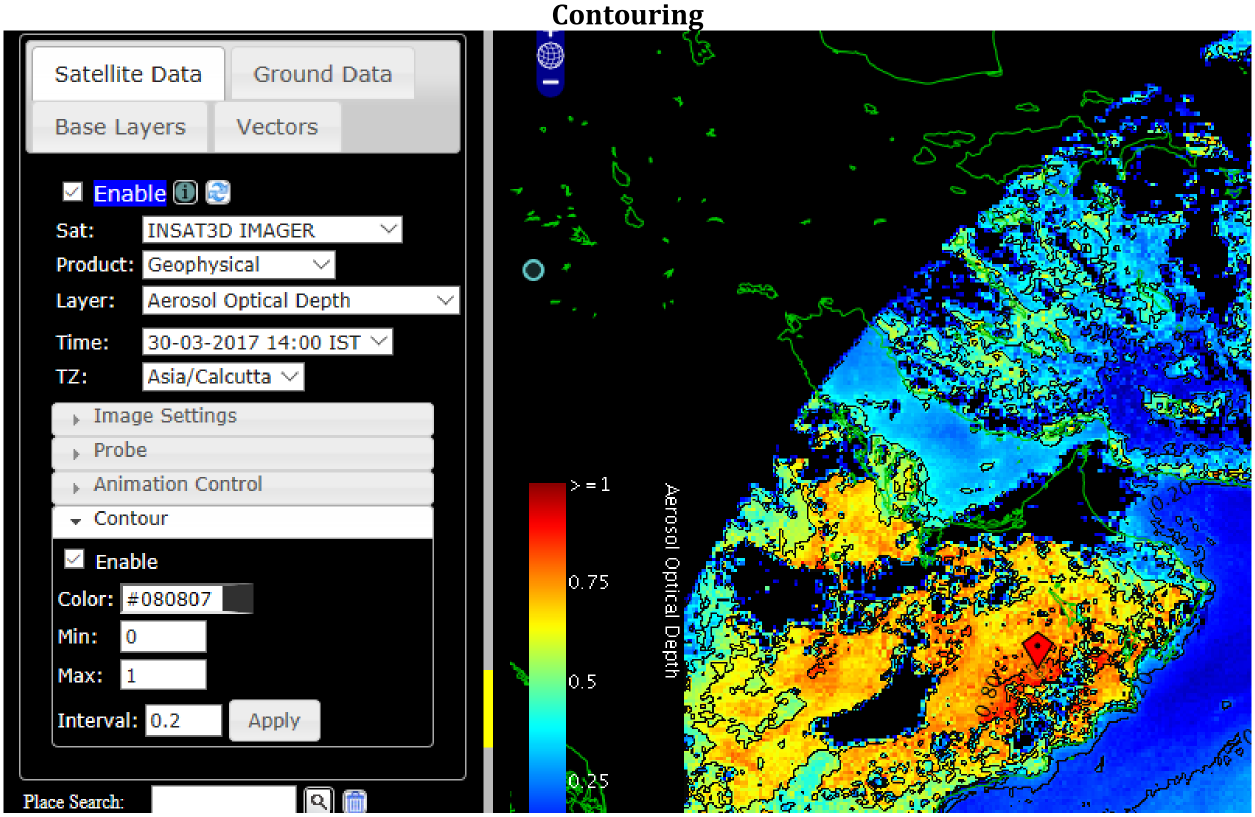
Default Range



User Defined Range



Contouring



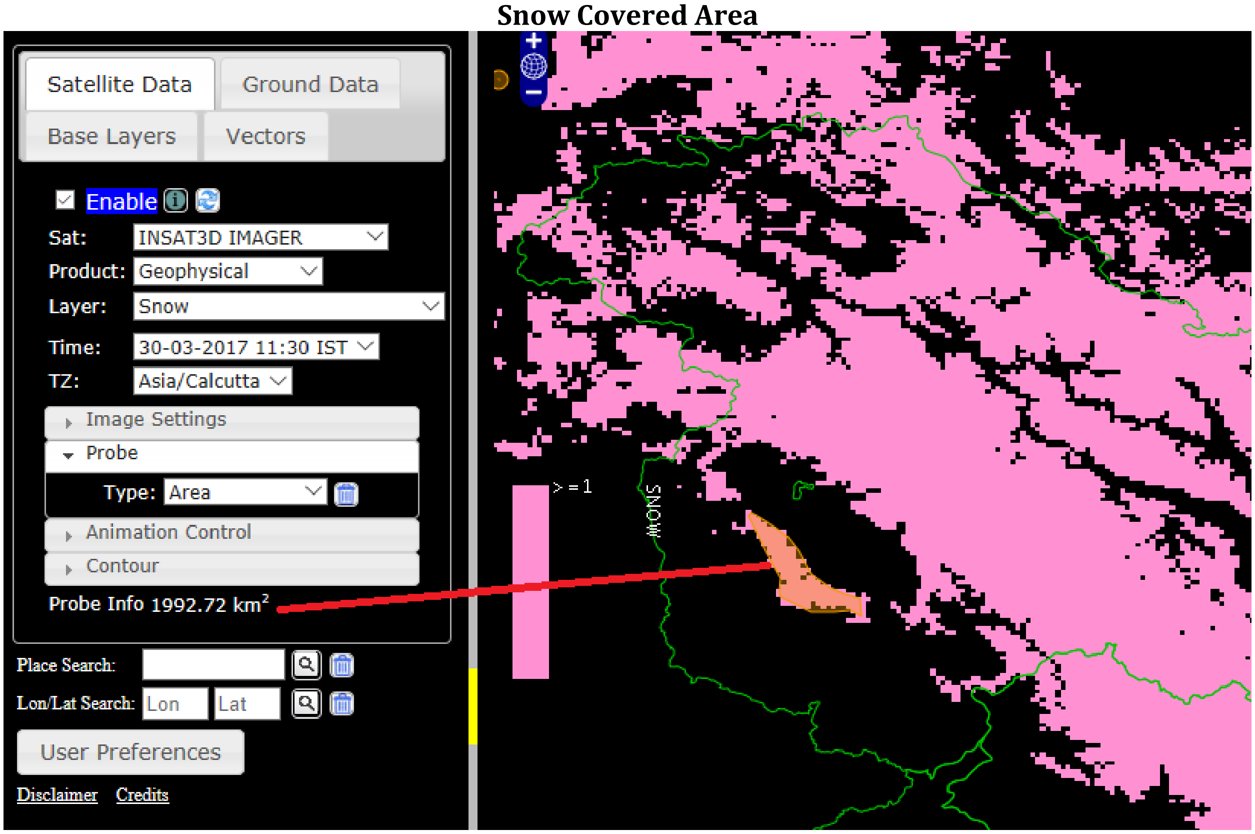
g) Snow: Snow covers almost 40 per cent of the Earth's land surface during Northern Hemisphere winter. This makes snow albedo and area an important component of the Earth's radiation balance. Large areas in the Himalayas are also covered by snow during wintertime. Area of snow can change significantly during winter and spring. This can affect stream flow during spring and summer of the rivers originating in the Higher Himalayas. In addition, snow pack ablation is highly sensitive to climatic variation. Increase in atmospheric temperature can influence snowmelt and stream runoff pattern. Therefore, mapping of areal extent and reflectance of snow is an important parameter for various climatological and hydrological applications. In addition, extent of snow cover can also be used as an input for avalanche investigation.

VIS, SWIR and TIR1 channels of Imager data has been used to extract the snow pixels by calculating Normalized Difference Snow Index (NDSI) as Snow has strong visible reflectance and strong short-wave IR absorbing characteristics. The NDSI is a measure of the relative magnitude of the characteristic reflectance difference between the visible and short-wave IR reflectance of snow at three times a day i.e. 0500, 0530, 0600 UTC and 4kmX4km spatial resolution.

Pure snow has a high NDSI but NDSI decreases as other features are mixed in a pixel. Snow in mixed pixels has an NDSI that is less than that for pure snow.

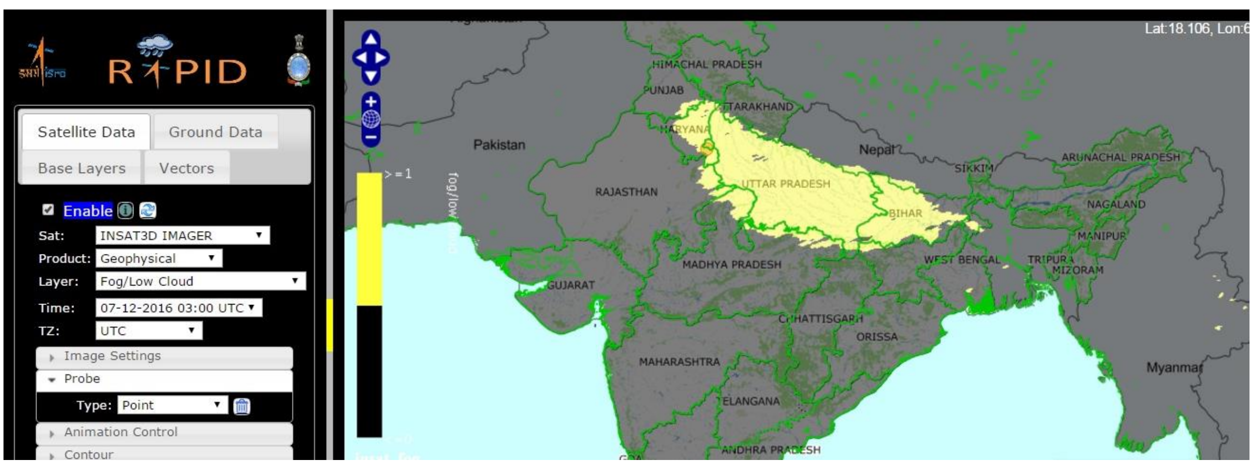
The sample example of Snow as visualized in RAPID is shown below.

Snow Covered Area



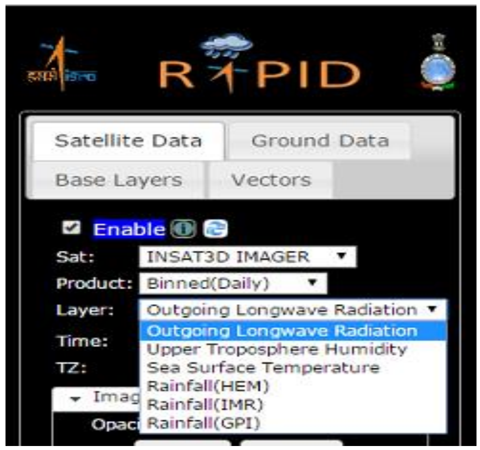
h) Fog/Low Cloud: Fog affects visibility near the surface and hence is an important parameter for aviation, transport on land and sea. Its detection and monitoring by means of satellites is an upcoming area of research. General methodology involves identifying some threshold radiances or brightness temperatures at different wavelengths which can distinguish fog from other cloud and surface features. Night time fog detection is done by looking at the 10.8 and 3.9µm channel brightness temperatures. This technique relies on fog pixels displaying higher brightness temperature differences as compared to clear pixels and those covered by other clouds. This technique is very efficient in detecting fog during night time. Identifying fog during day time is a bit complex. A variety of methods are being tried. But with the radiance measurements very limited in the visible region, many of these methods are not applicable for INSAT. In view of these one can try the use of same infrared channels that are used for night time for day time too. However, difference between the two channel brightness temperatures alone is not sufficient. The threshold identification is dynamic and depends on the solar zenith angle, local surface albedo and a host of radiative transfer model simulations with various fog and cloud properties. In short, the crux of the method is elimination of possibility of different cloud types before coming to the conclusion that the pixel contains fog. Neither day time nor night time algorithm works during dusk and dawn.

The sample example of Fog as visualized in RAPID is shown below.

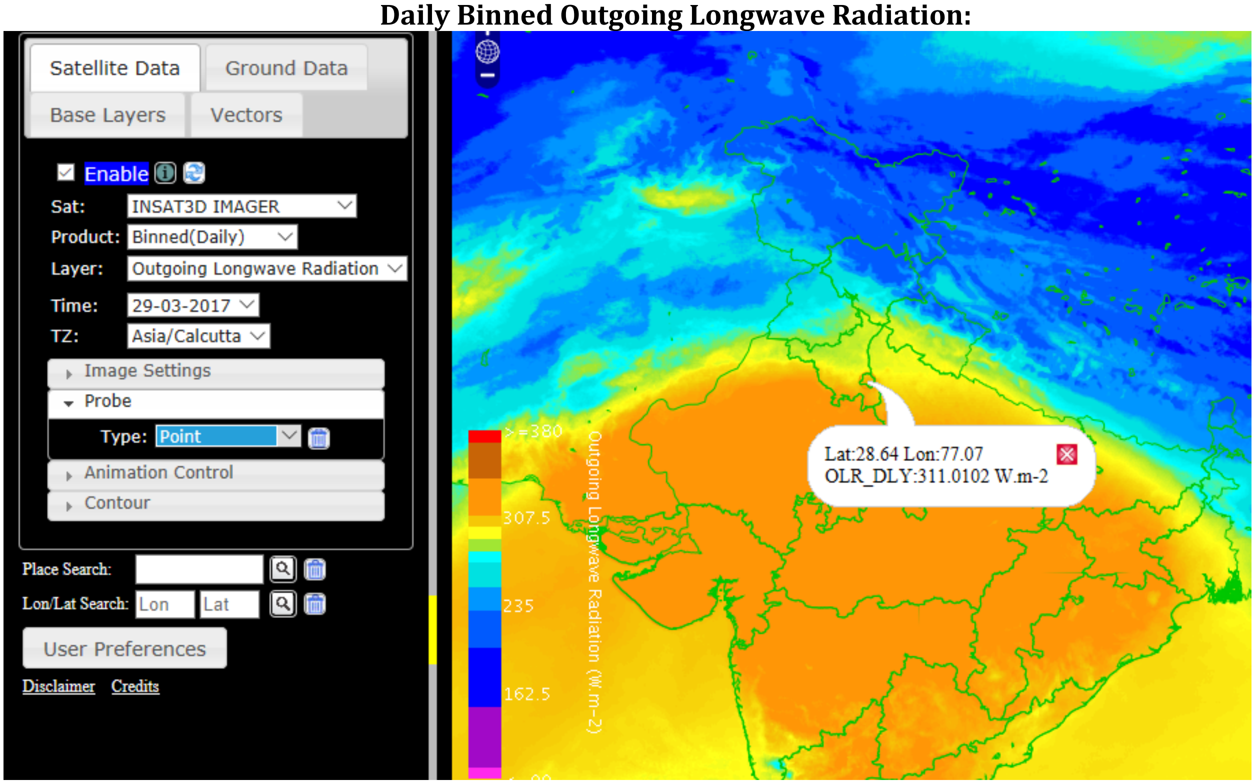


IV. ***INSAT-3D IMAGER - Binned (Daily):*** If user has selected INSAT-3D IMAGER under 'Sat' tab and Binned (Daily) under 'Product' tab, then the following options become available under 'Layer' tab for selection: Outgoing Longwave Radiation, Sea Surface Temperature, Upper Tropospheric Humidity, Rainfall (HEM), Rainfall (IMR), Rainfall (GPI). OLR, SST, UTH are average value of a day i.e. from 0000UTC to 2330UTC. In case of rainfall estimated products (IMSRA/HEM/GPI), it is an accumulated value from 0330 UTC to the 0300 UTC of next day and will be available with the date stamp of previous day. For example, the daily accumulated rain of 07th day of November is the rainfall from 0330 UTC of 07th day of November to 0300 UTC of 08th day of November. The parameter is to be chosen from 'Layer' option.

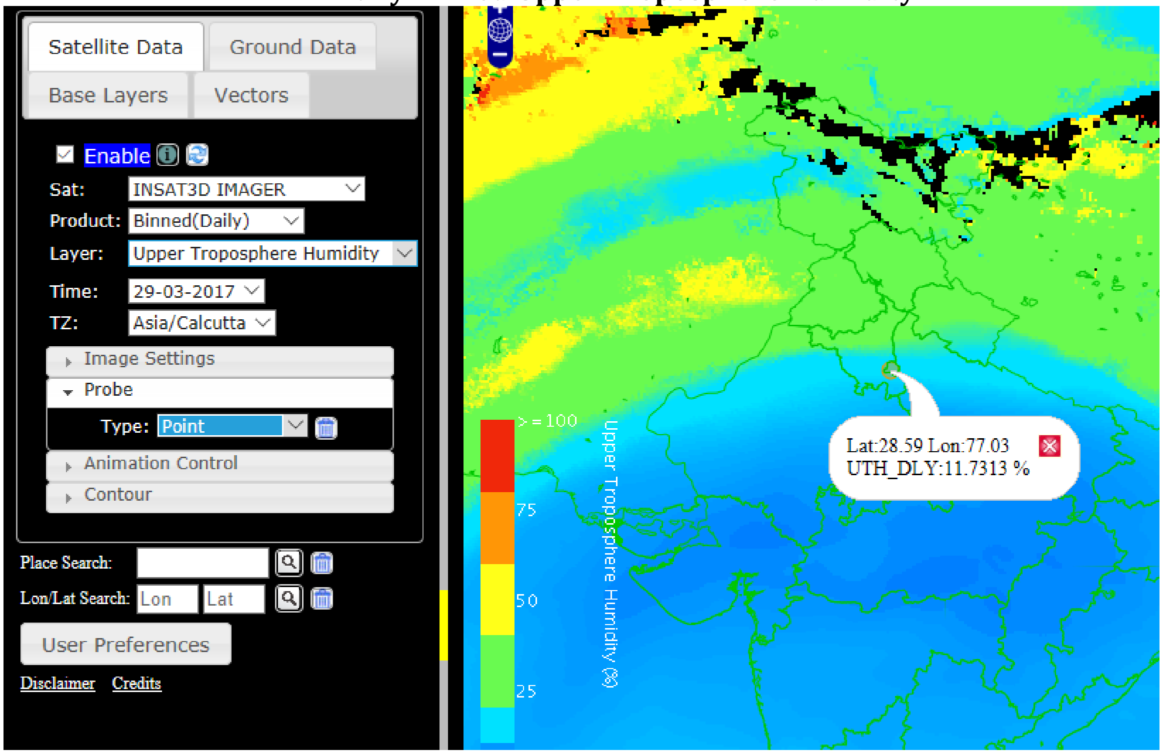
User can monitor the trend at a particular location by plotting time-series on daily scale.



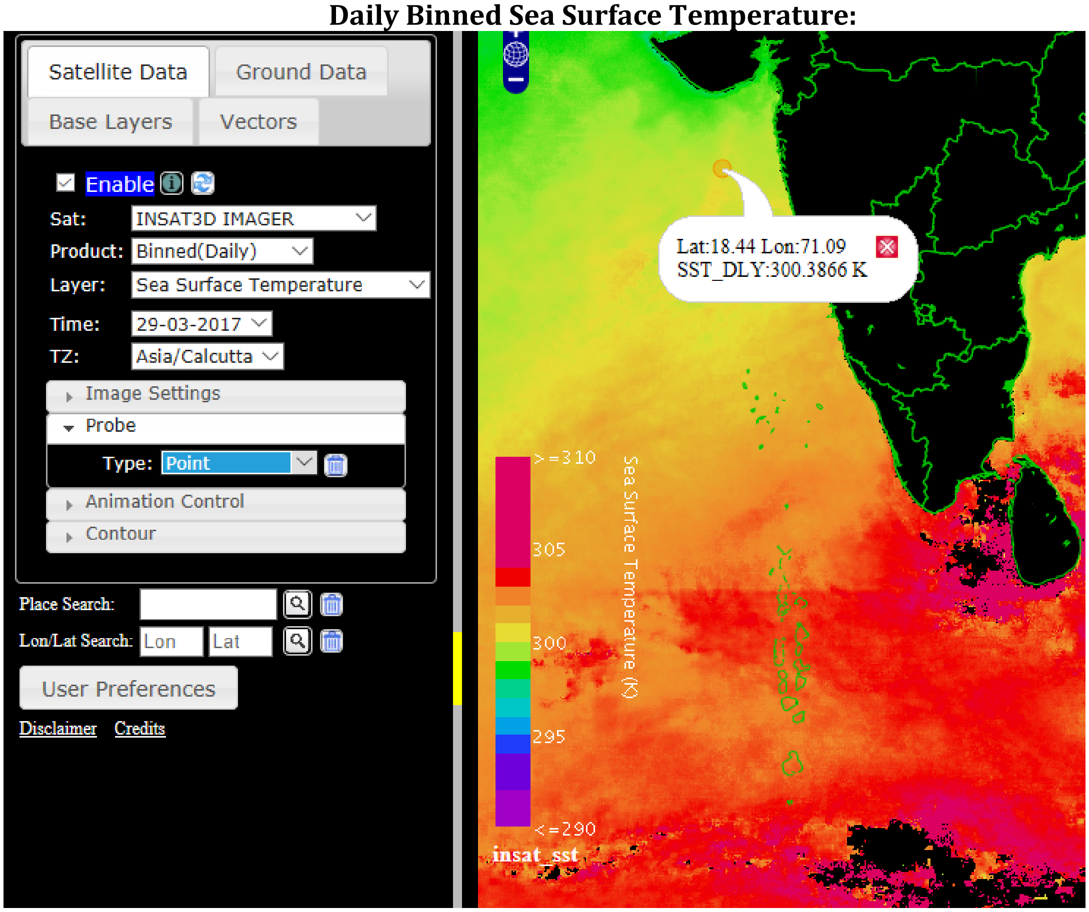
Daily Binned Outgoing Longwave Radiation:



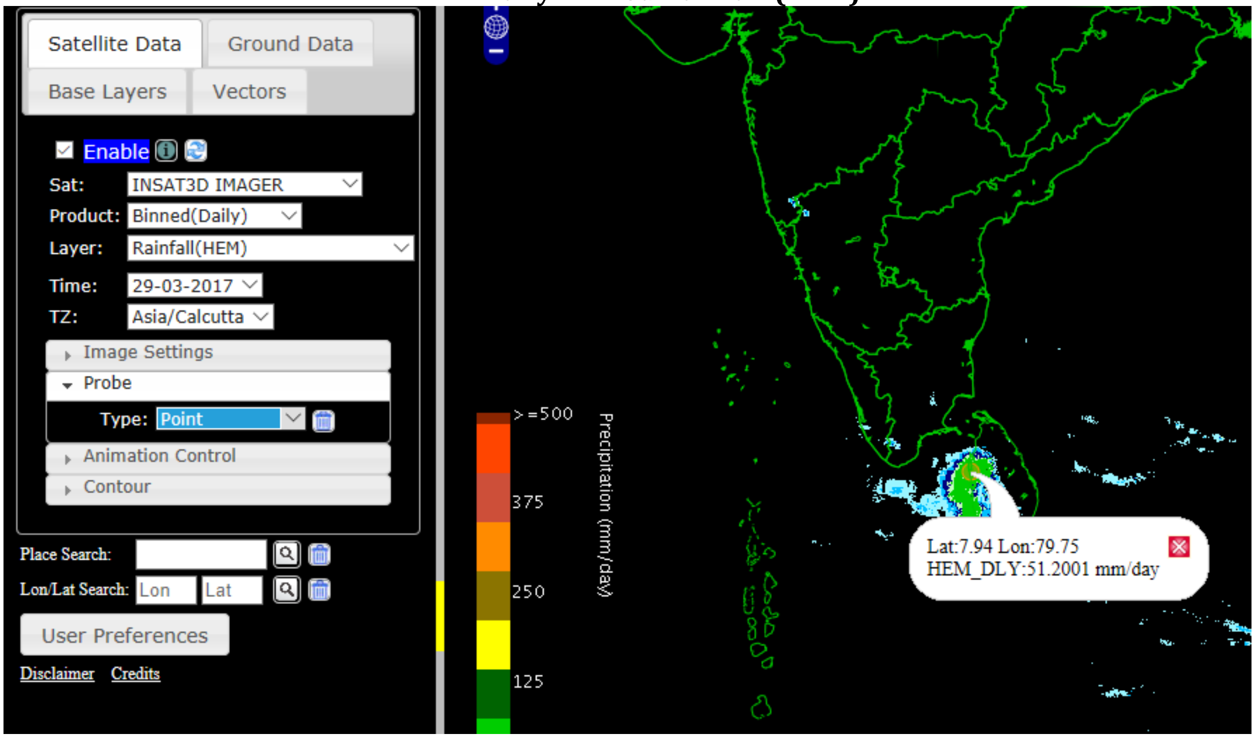
Daily Binned Upper Troposphere Humidity:



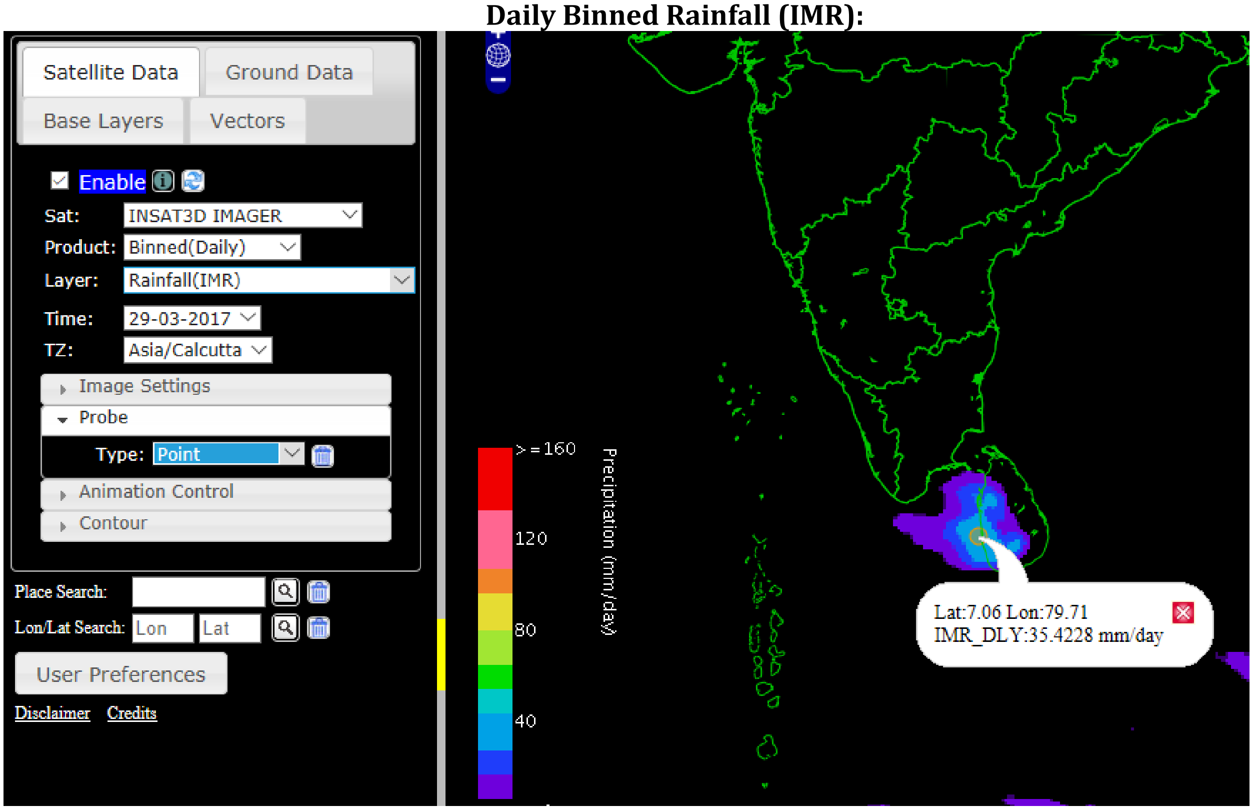
Daily Binned Sea Surface Temperature:



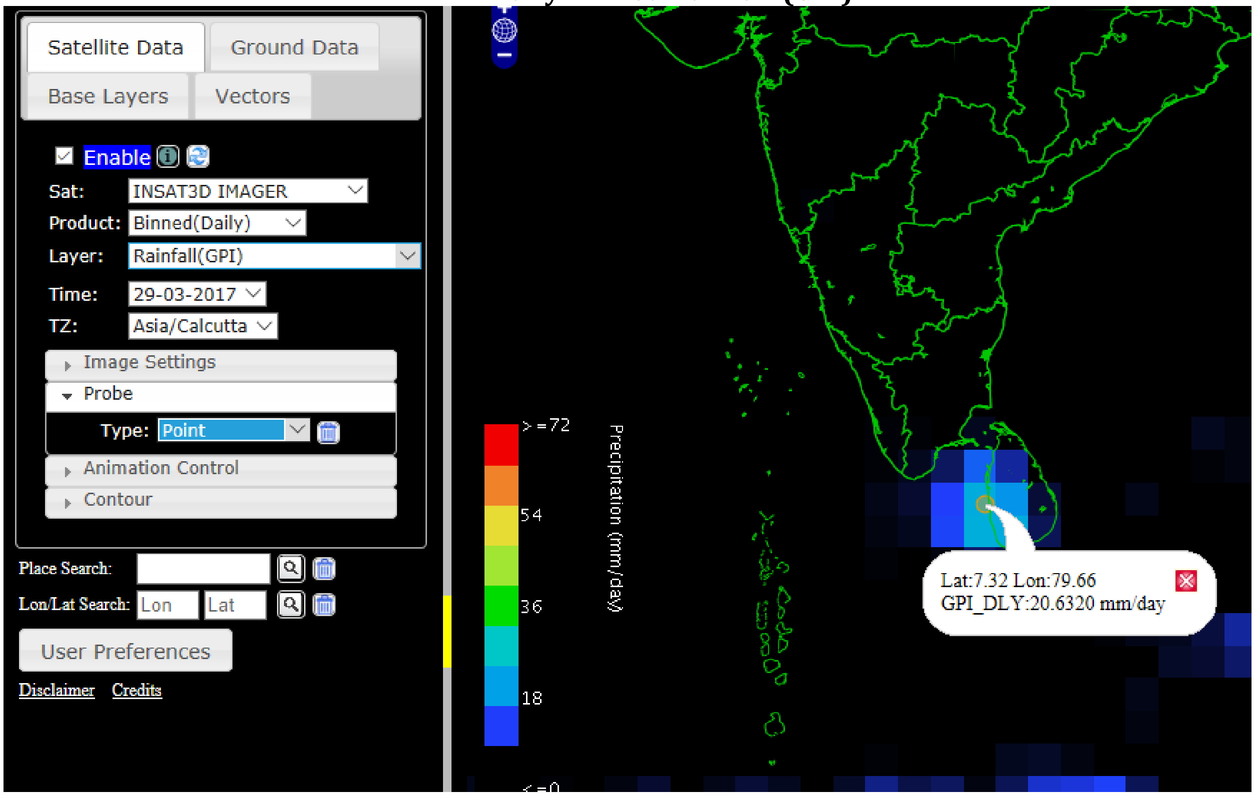
Daily Binned Rainfall (HEM):



Daily Binned Rainfall (IMR):

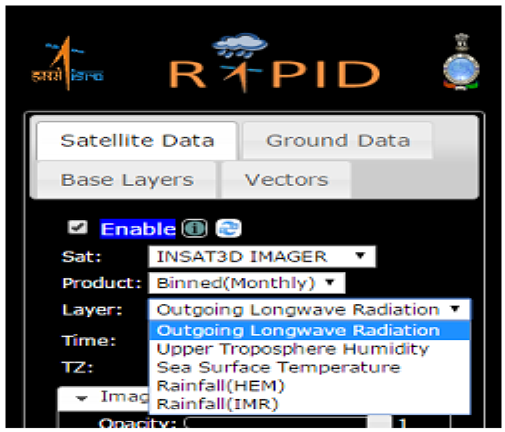


Daily Binned Rainfall (GPI):

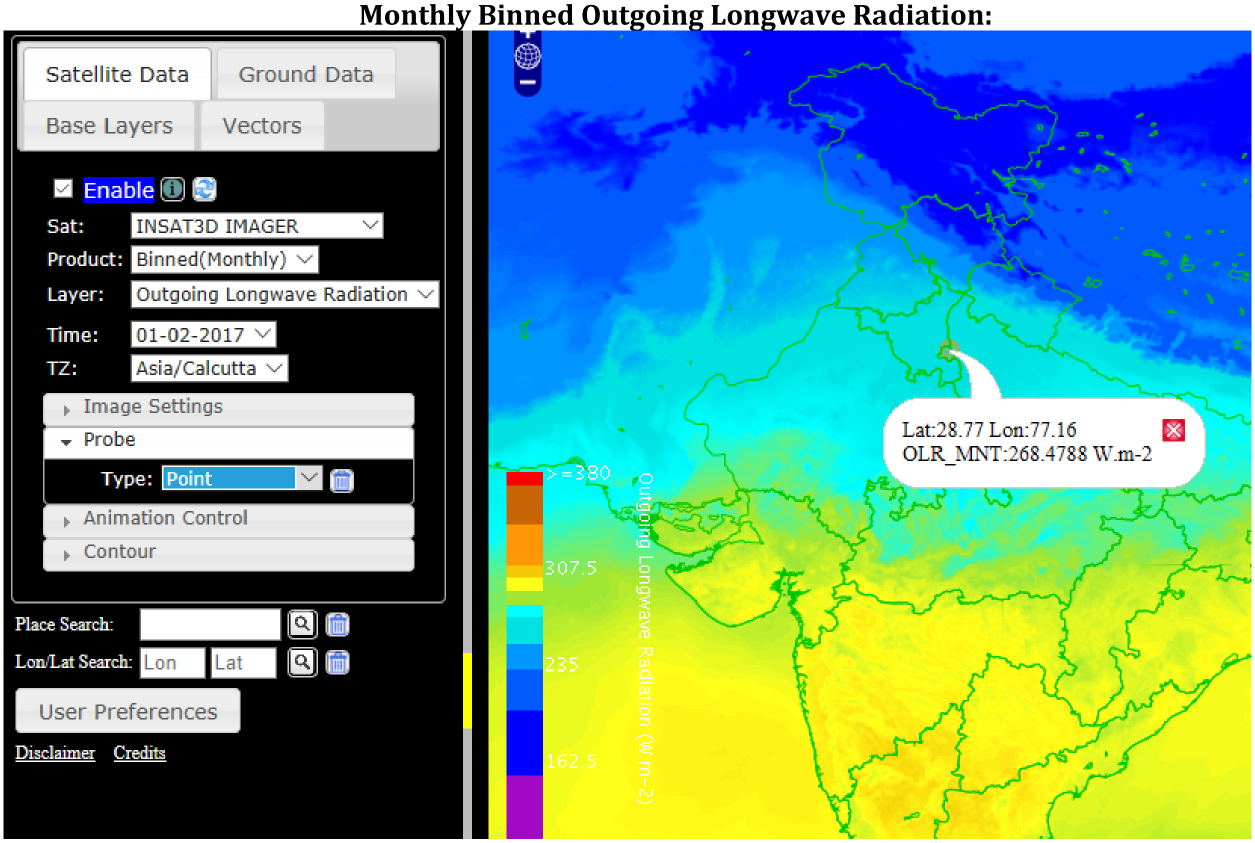


V. ***INSAT-3D IMAGER - Binned (Monthly):*** If user has selected INSAT-3D IMAGER under 'Sat' tab and Binned (Monthly) under 'Product' tab, then the following options become available under 'Layer' tab for selection: Outgoing Longwave Radiation, Sea Surface Temperature, Upper Tropospheric Humidity, Rainfall (HEM), Rainfall (IMR), Rainfall (GPI). OLR, SST, UTH are monthly average value of all days in a month i.e. from 0000UTC to 2330UTC for all days. In case of rainfall products, it is an accumulated value from 0330 UTC of previous 1st day to the 0300 UTC of first day of next month. The parameter is to be chosen from 'Layer' option.

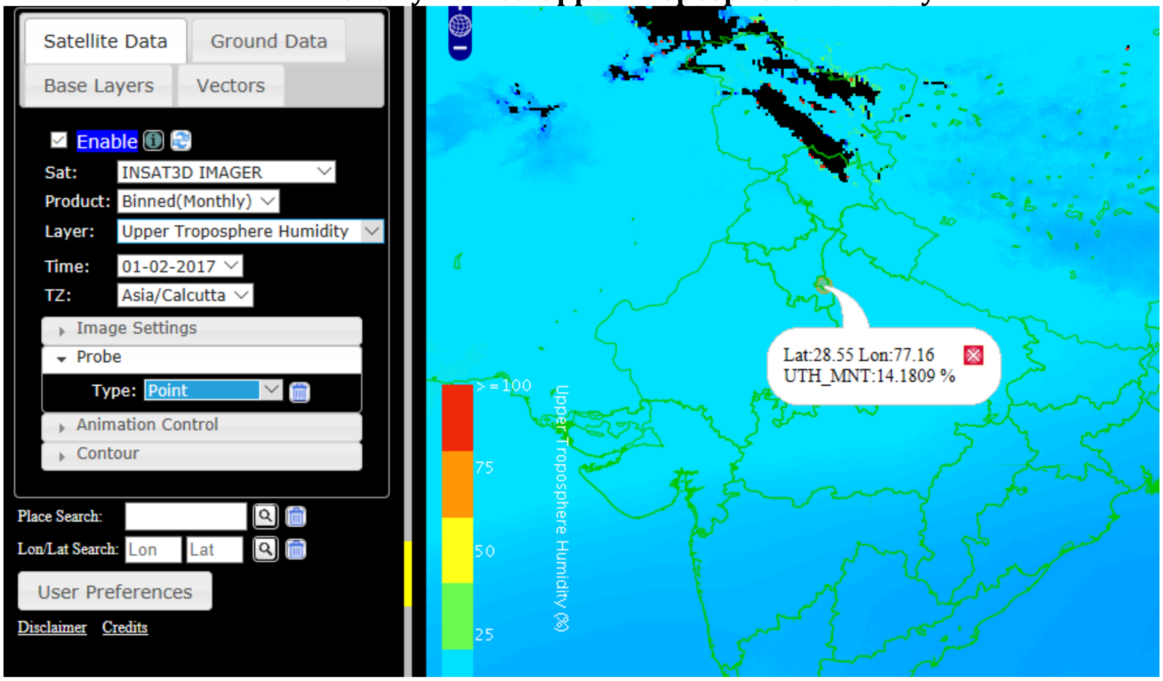
User can monitor the trend at a particular location by plotting time-series on monthly scale.



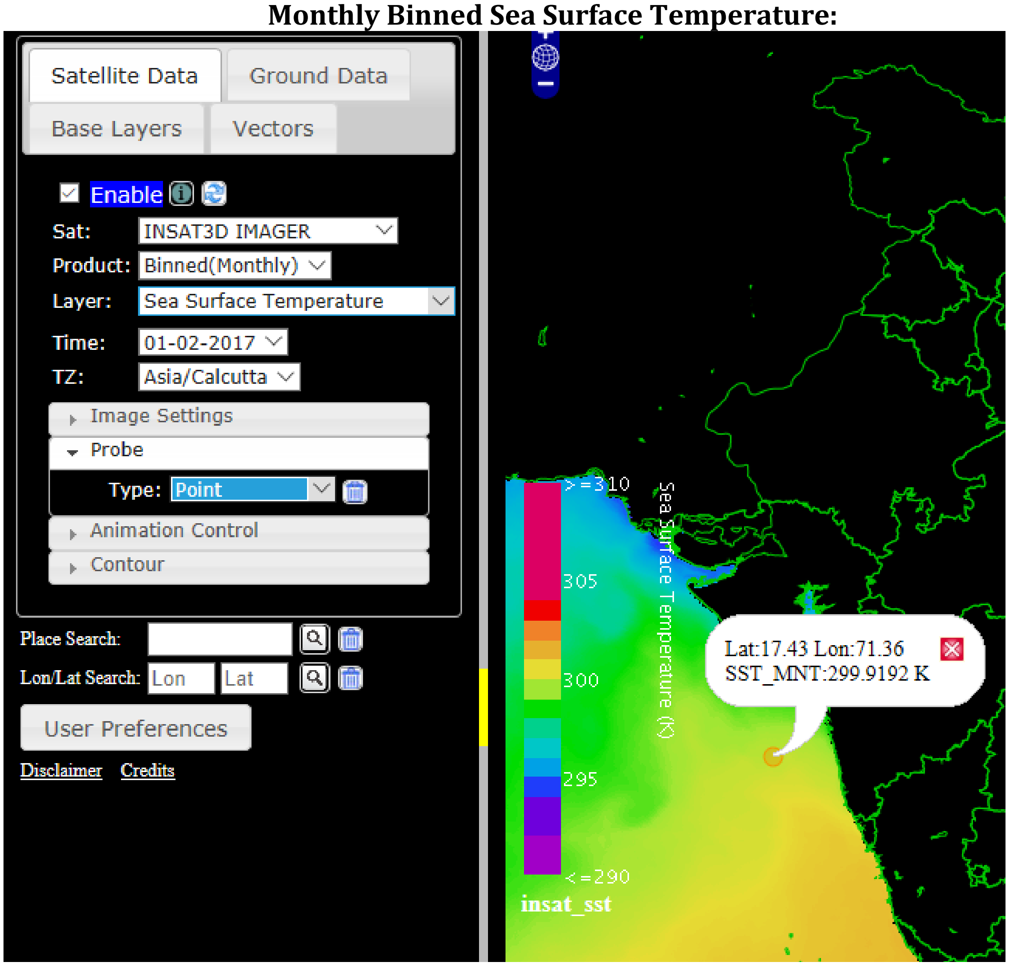
Monthly Binned Outgoing Longwave Radiation:



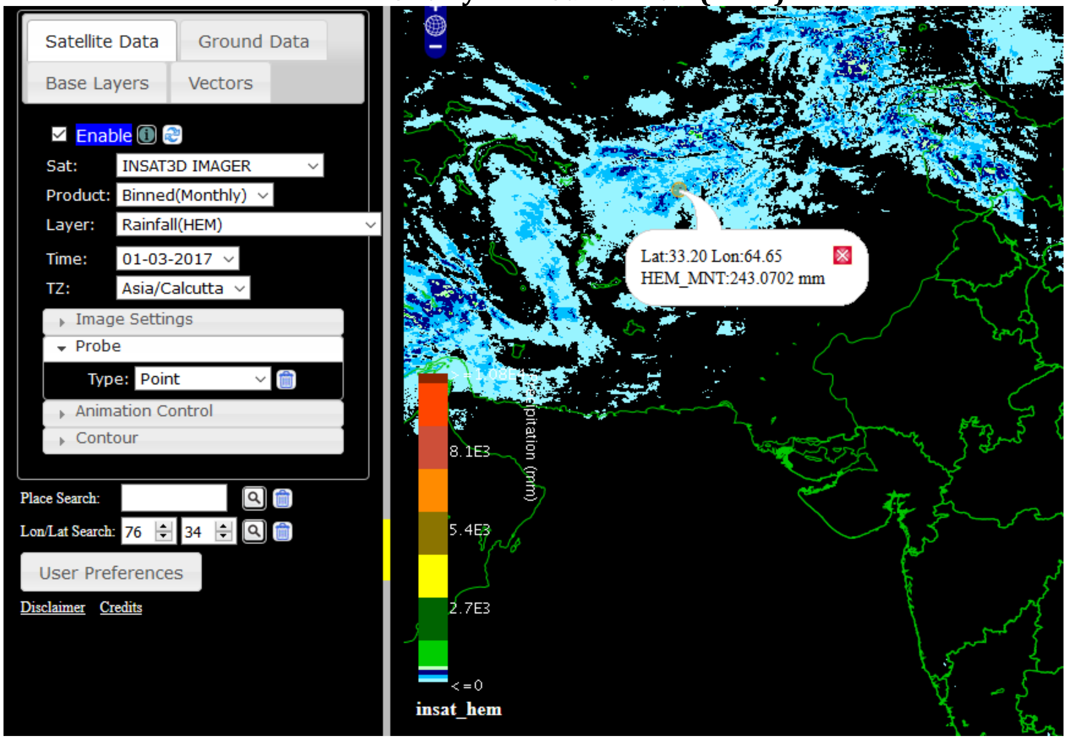
Monthly Binned Upper Troposphere Humidity:



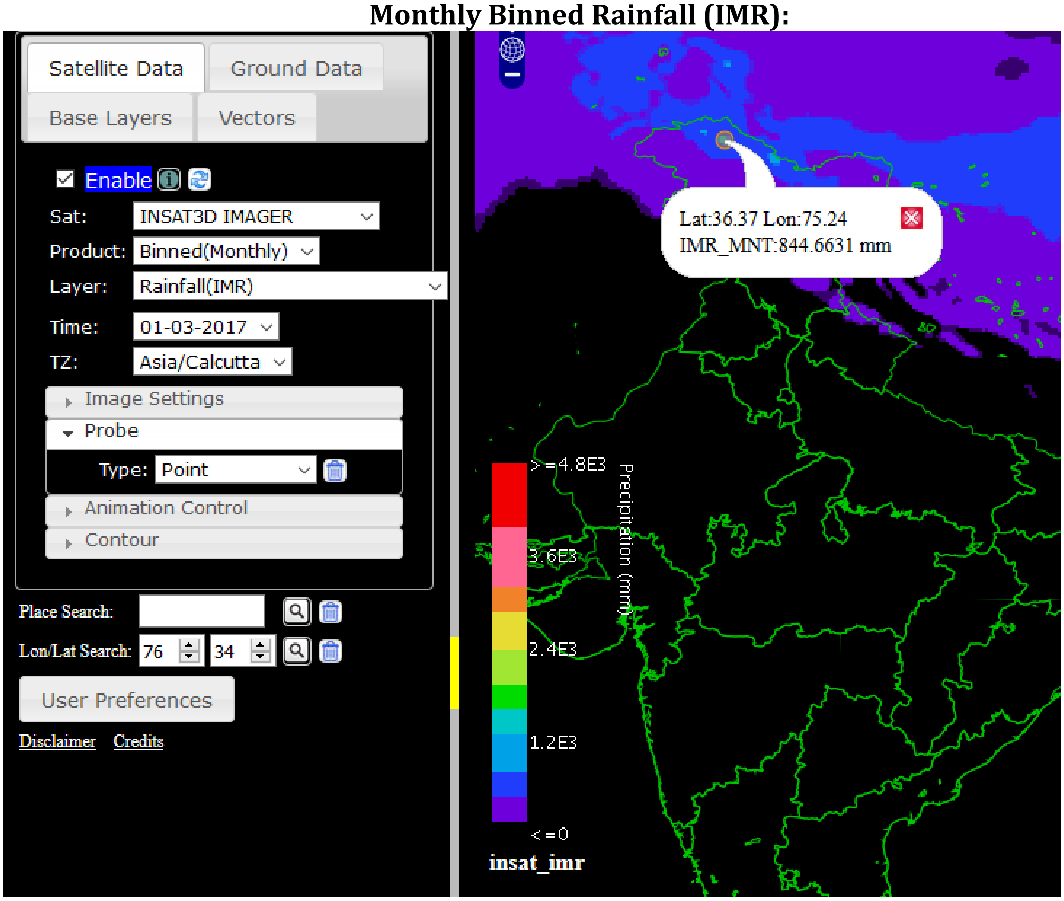
Monthly Binned Sea Surface Temperature:



Monthly Binned Rainfall (HEM):

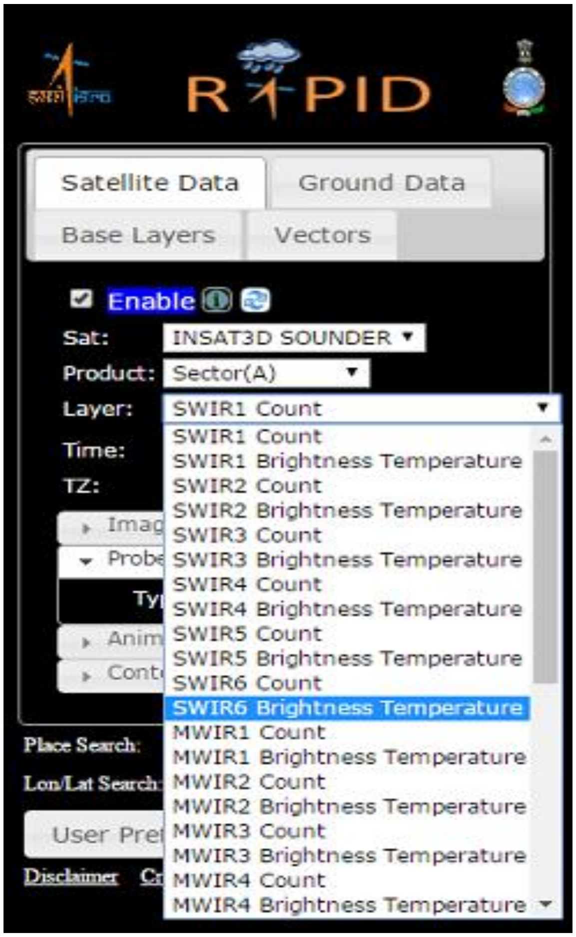


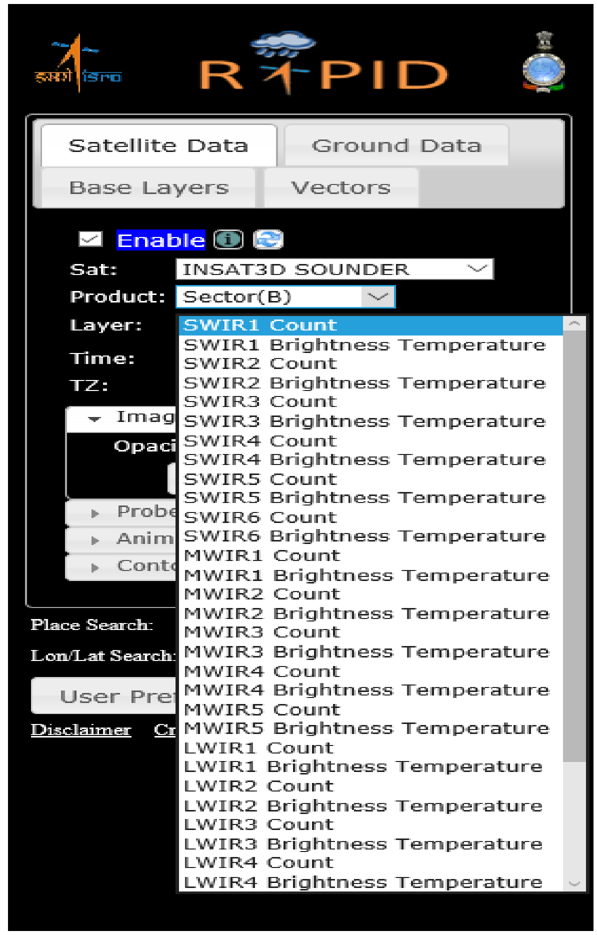
Monthly Binned Rainfall (IMR):



1.3.9.1. INSAT-3D SOUNDER Layers:

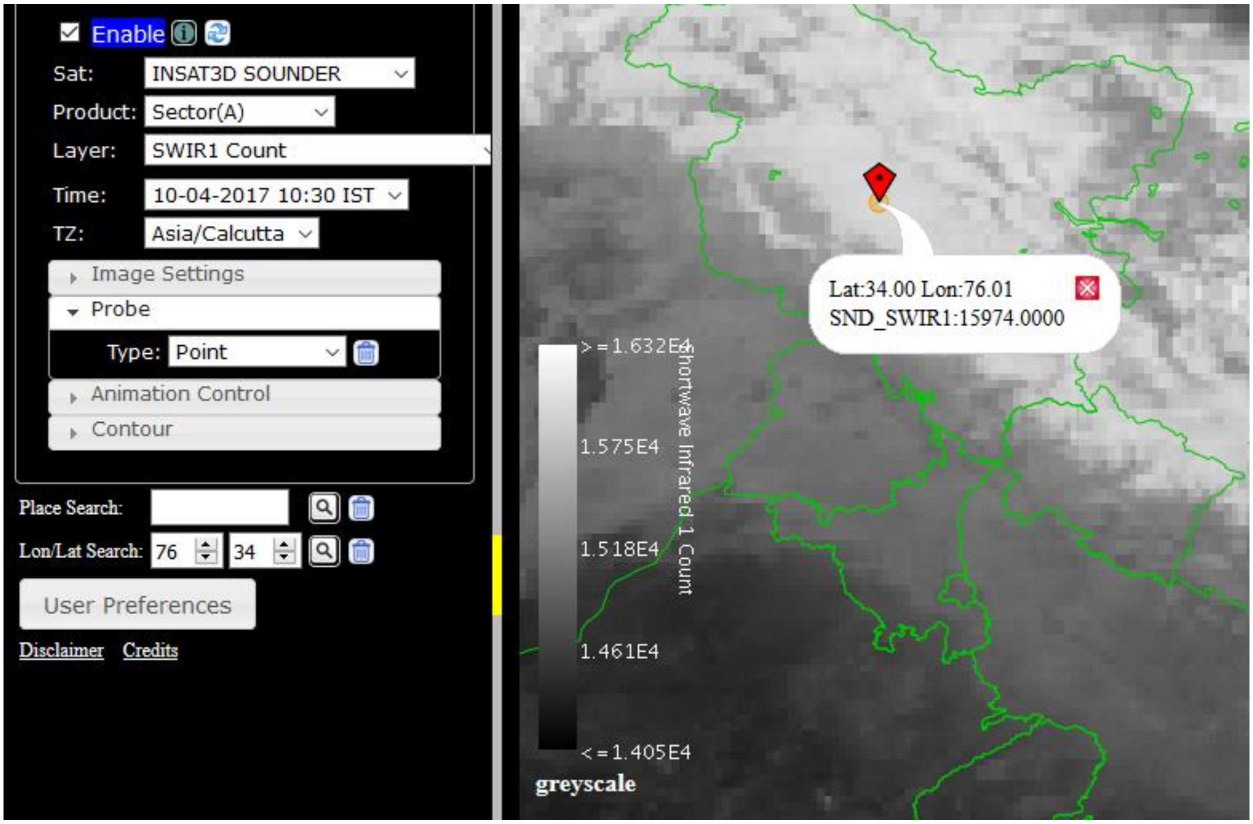
(i) ***Sector-A or Sector-B:*** If user select INSAT-3D SOUNDER in 'Sat' option and in Products user selected either **Sector-A or Sector-B** then in layer drop box user can choose among these:



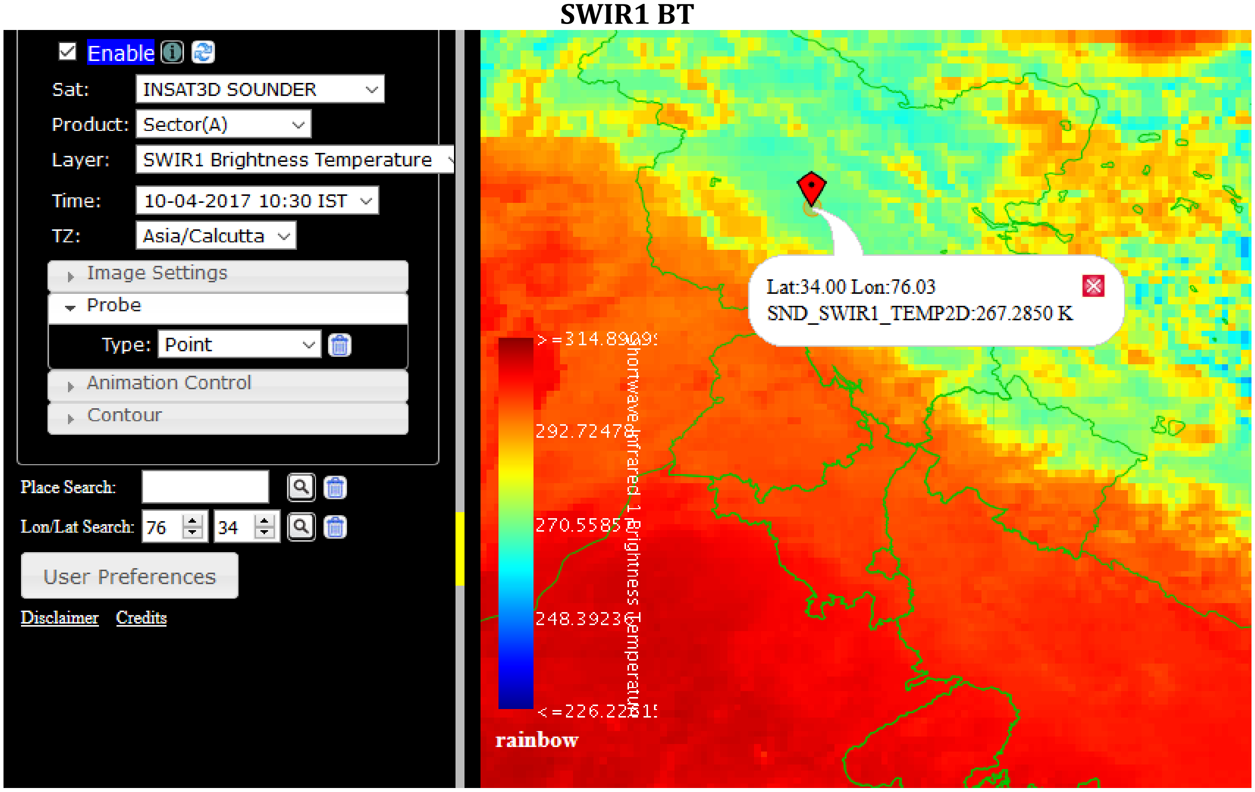


For 3D SOUNDER under the category of sector A and sector B, out of the following options either one can be selected: such as Short Wave Infrared (SWIR (1-6) Count, SWIR (1-6) Brightness Temperature, Mid-Wave Infrared (MWIR (1-5) Count, MWIR (1-5) Brightness Temperature), Long Wave Infrared (LWIR (1-7) Count, LWIR (1-7) Brightness Temperature) and Visible (Visible Count and Visible Radiance).

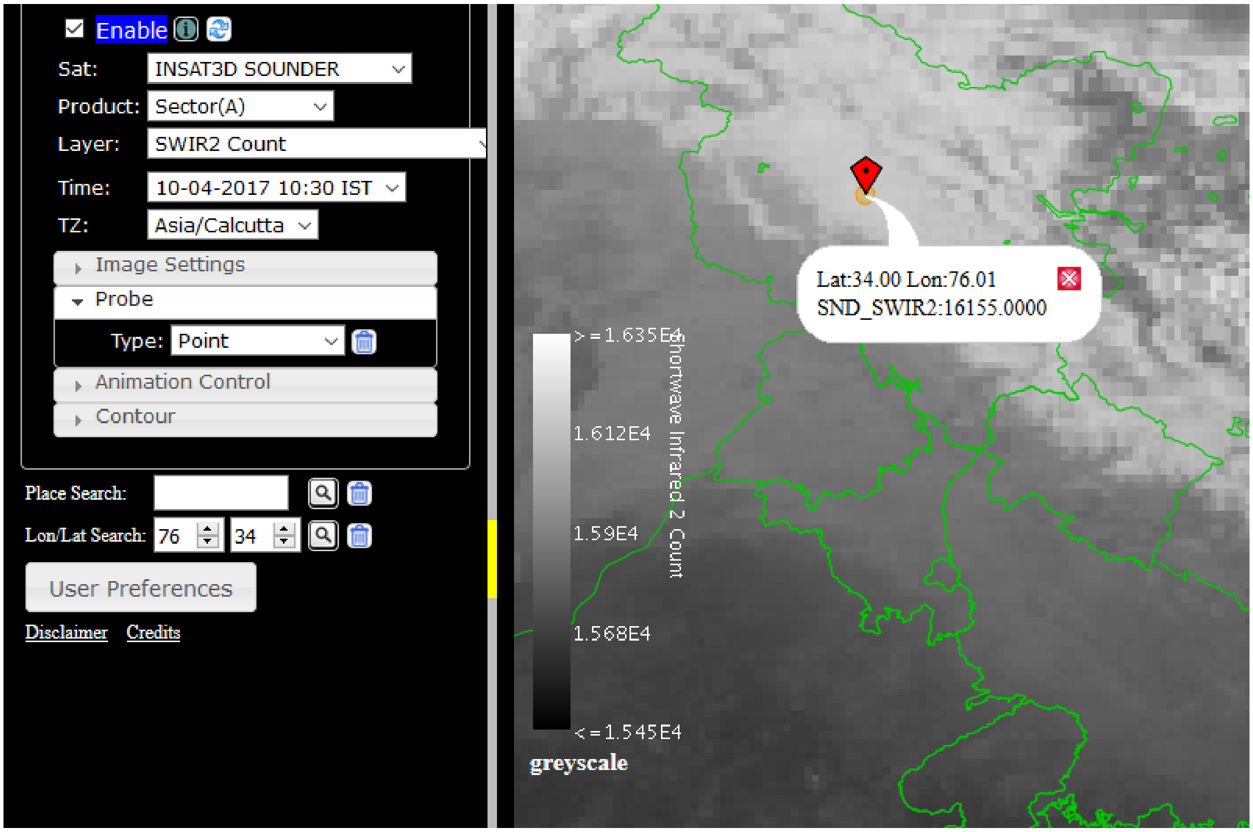
SWIR1 Count



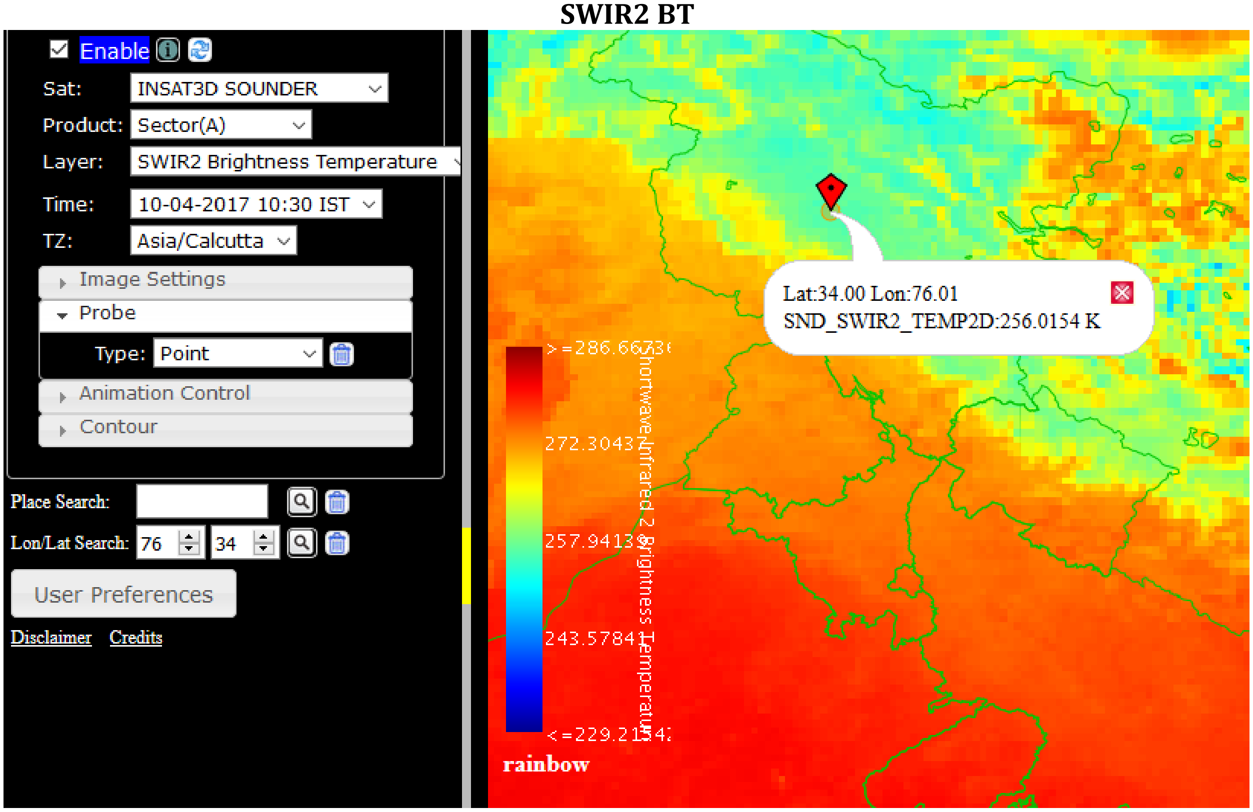
SWIR1 BT



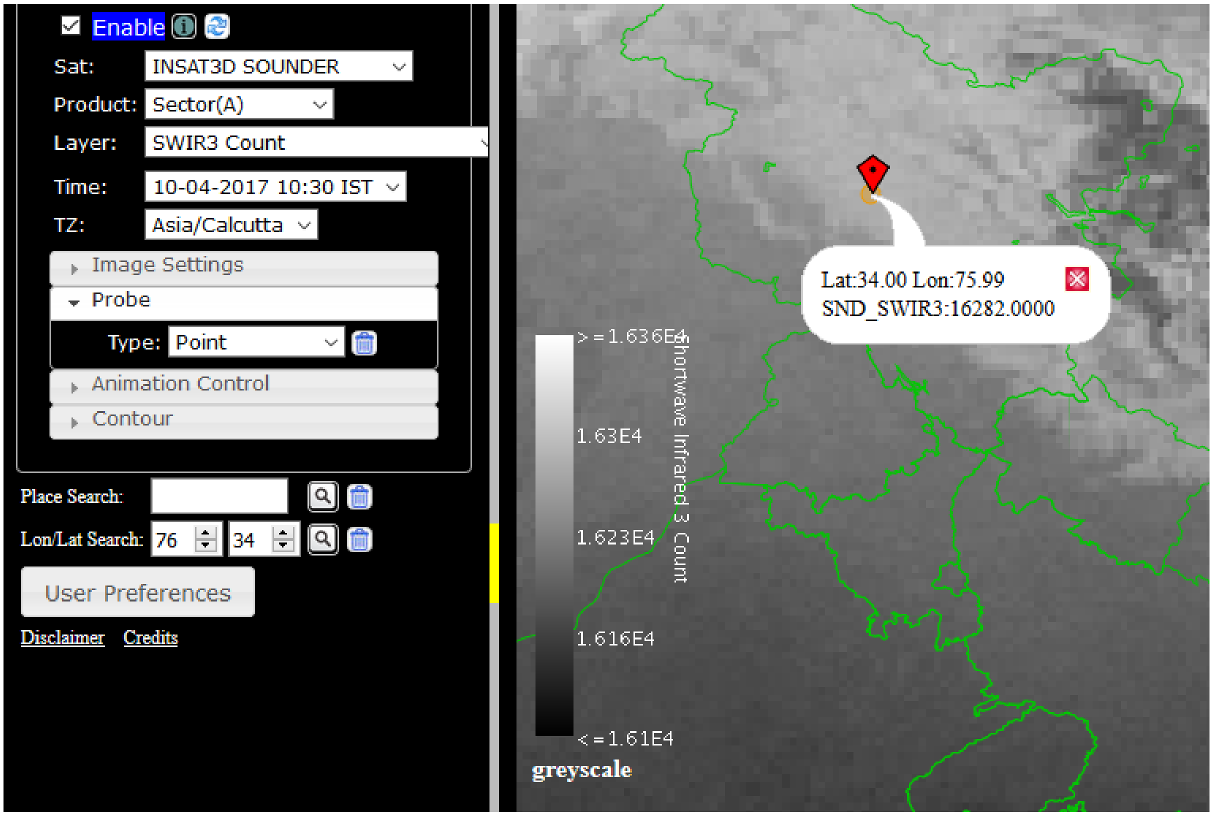
SWIR2 Count



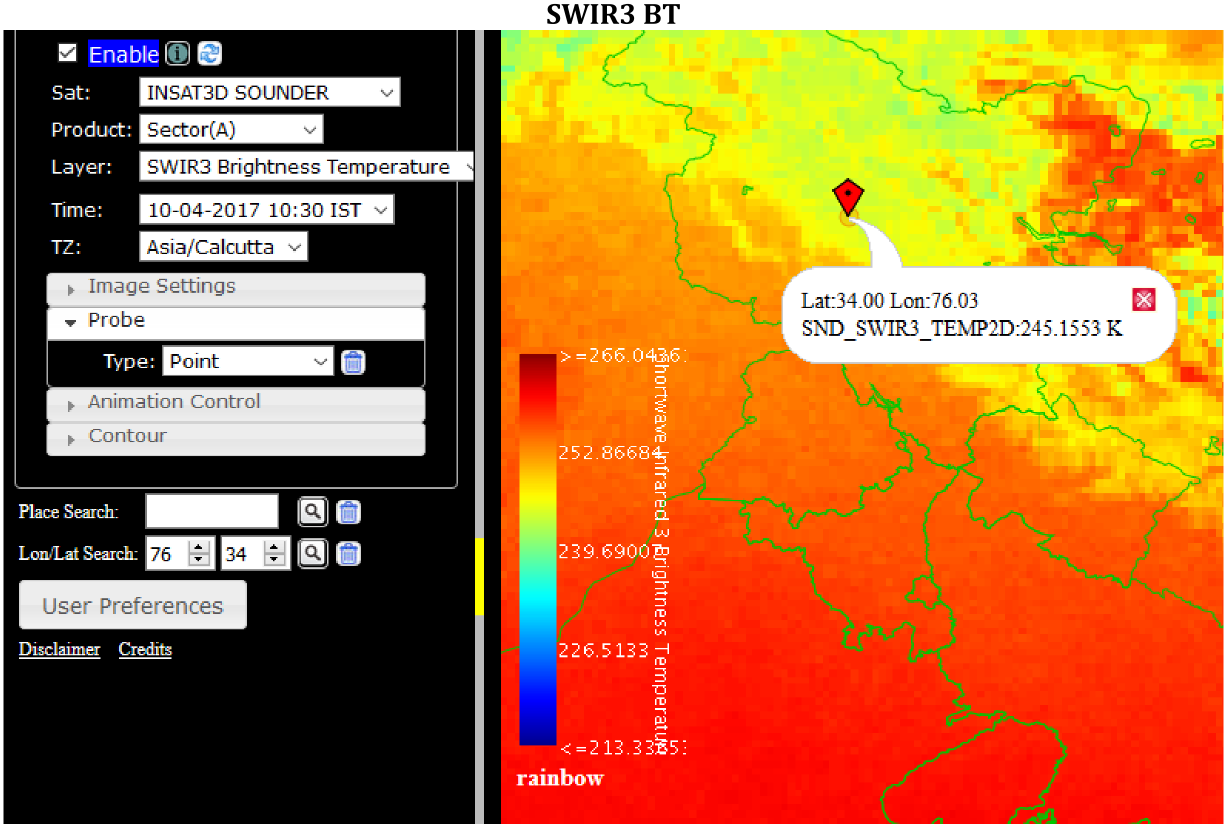
SWIR2 BT



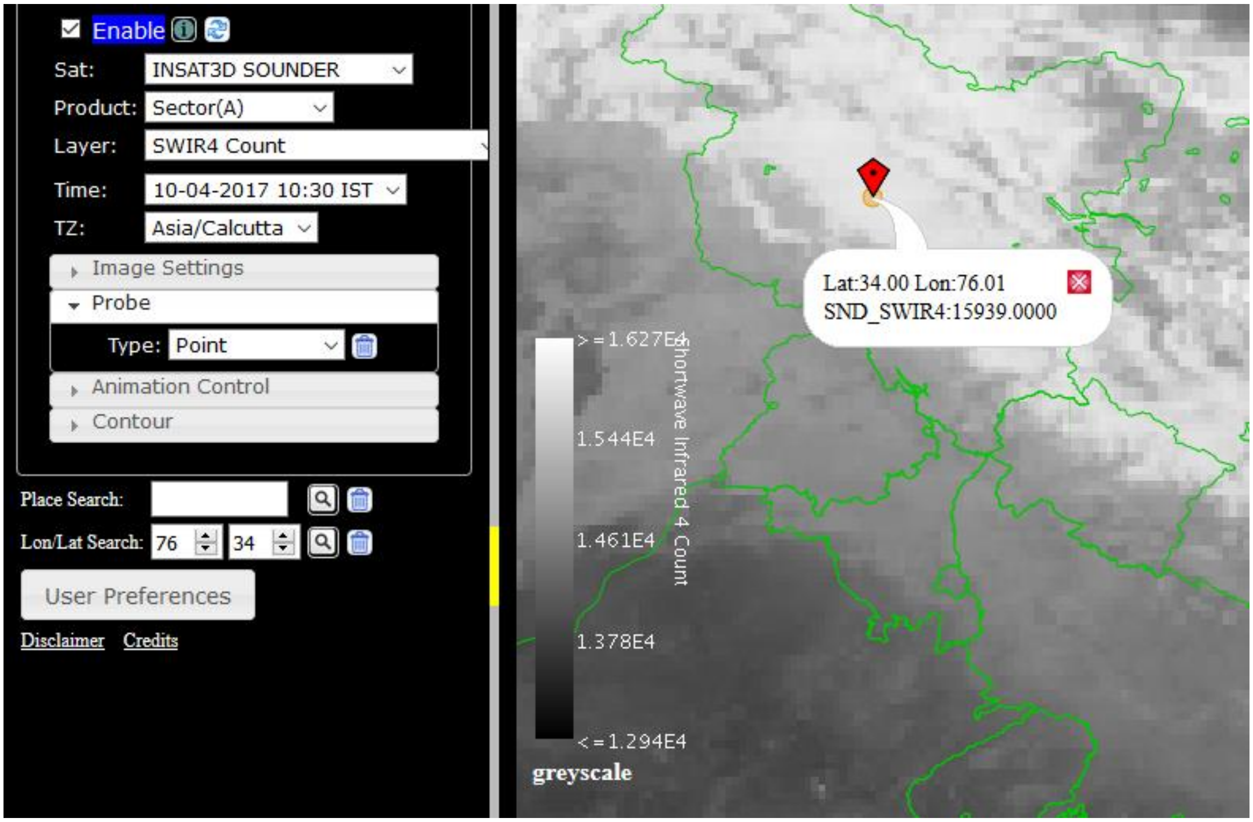
SWIR3 Count



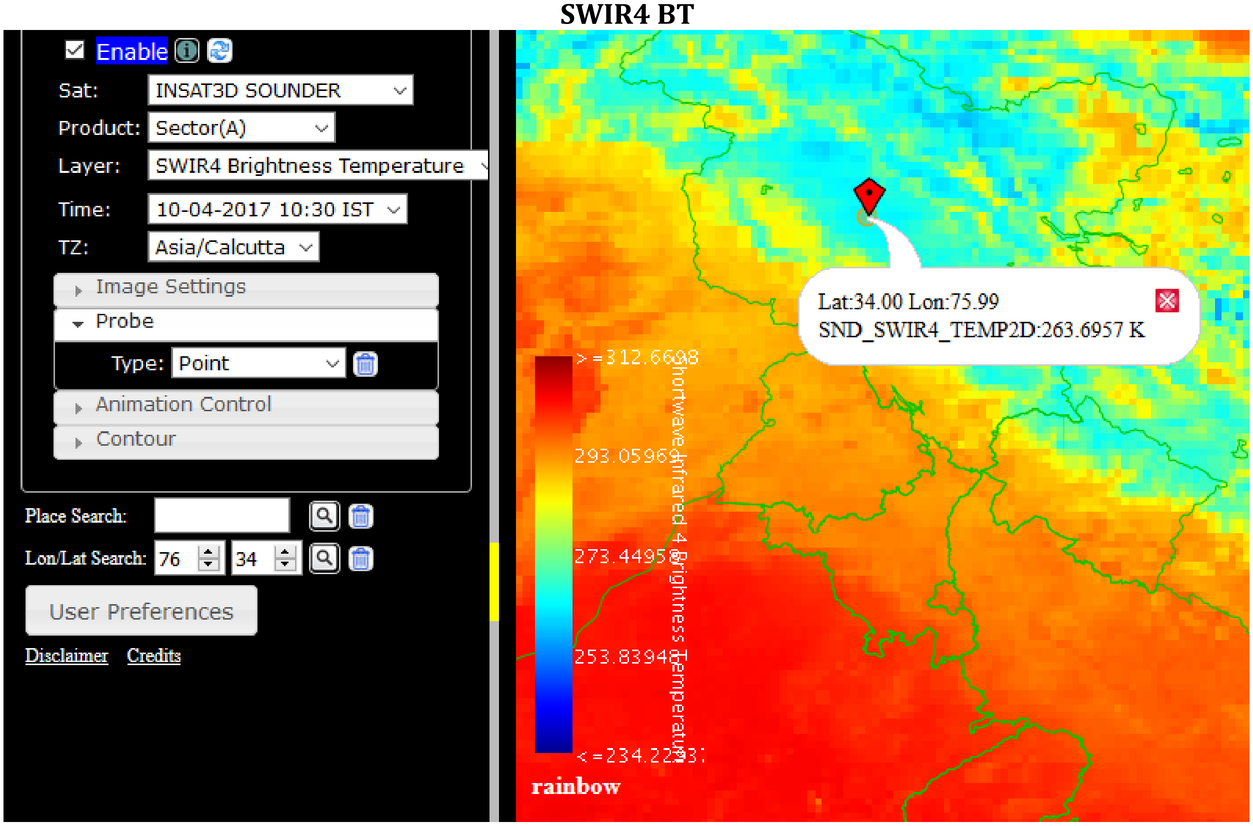
SWIR3 BT



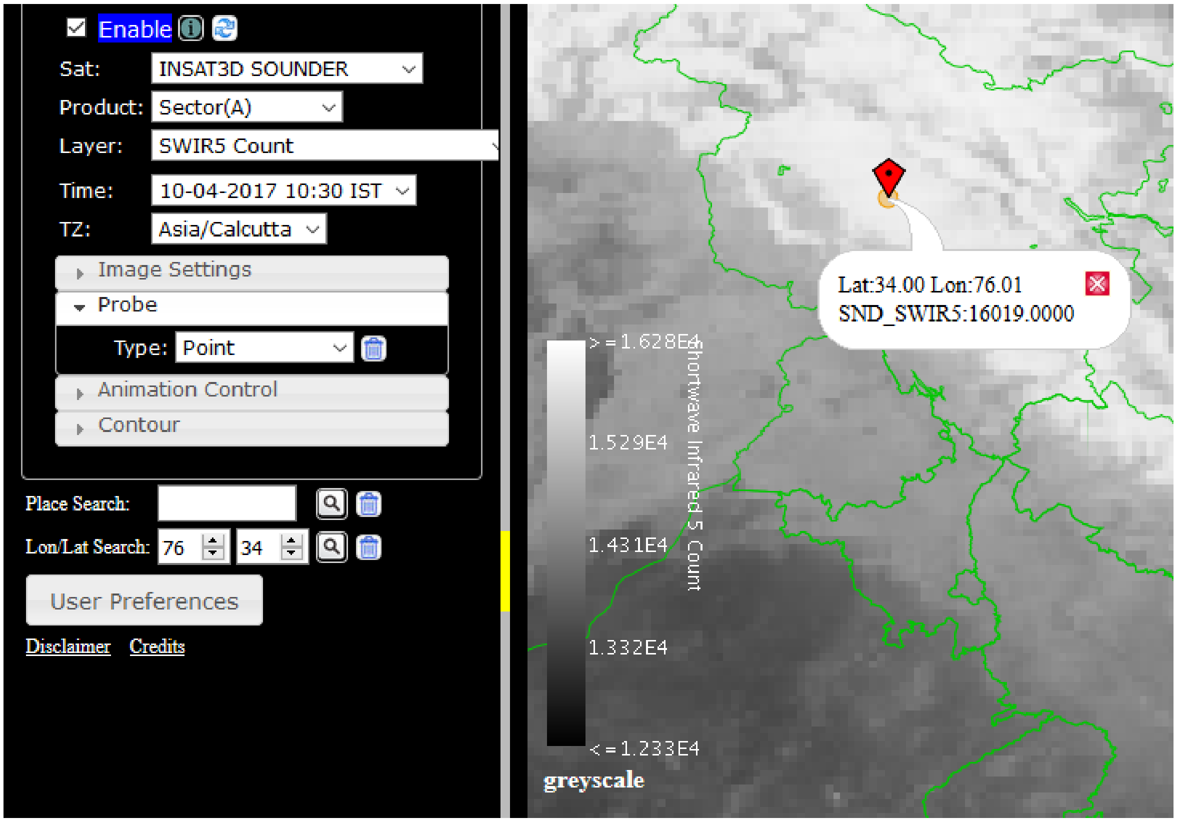
SWIR4 Count



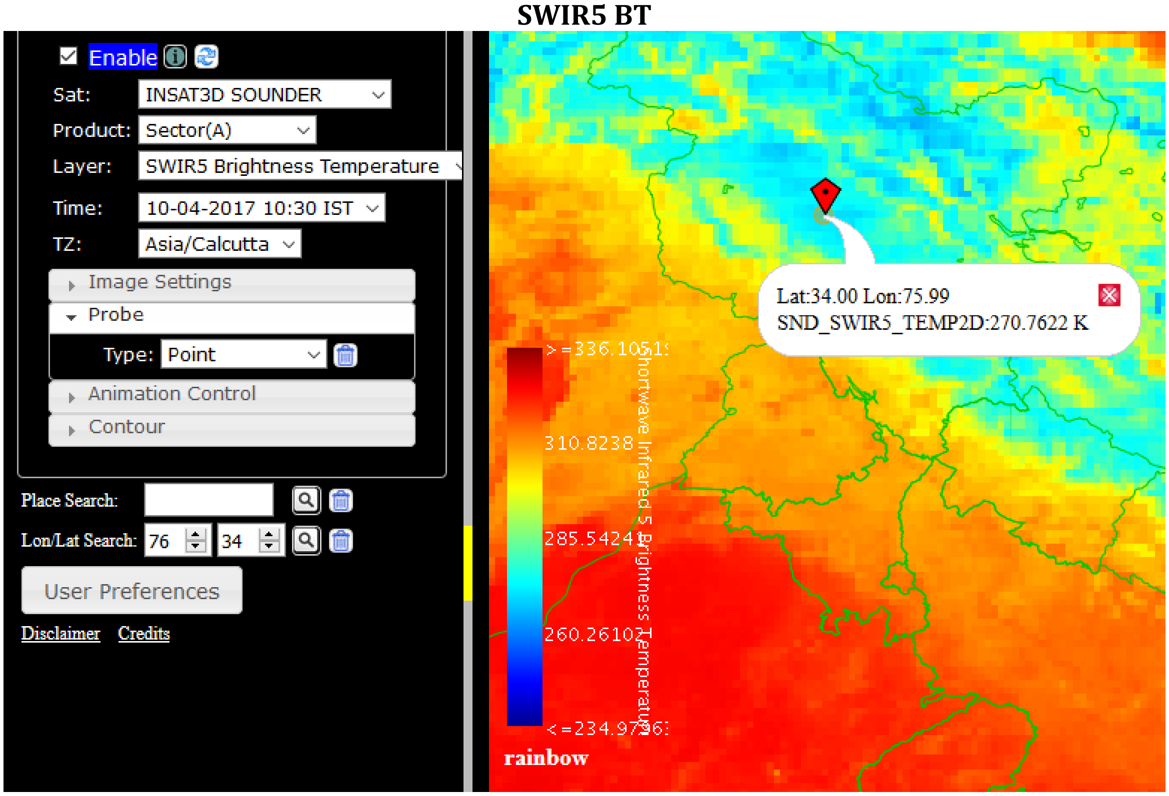
SWIR4 BT



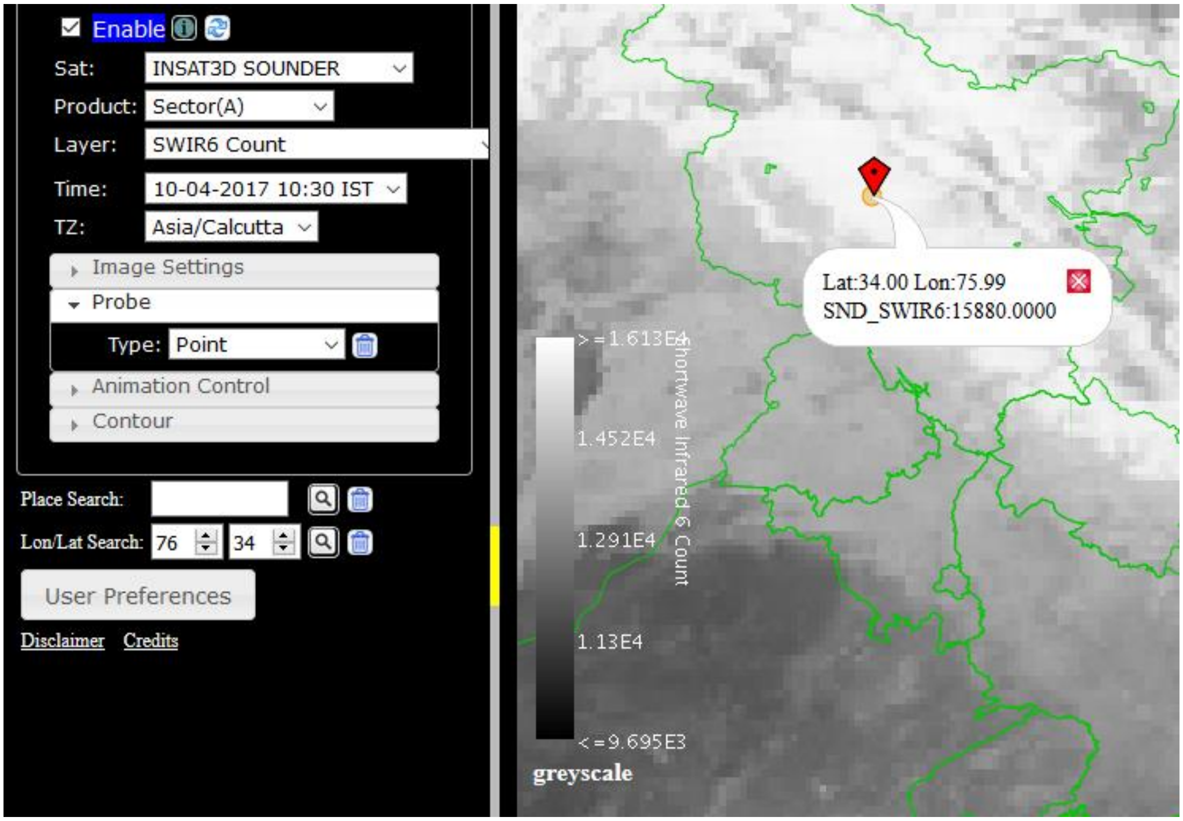
SWIR5 Count



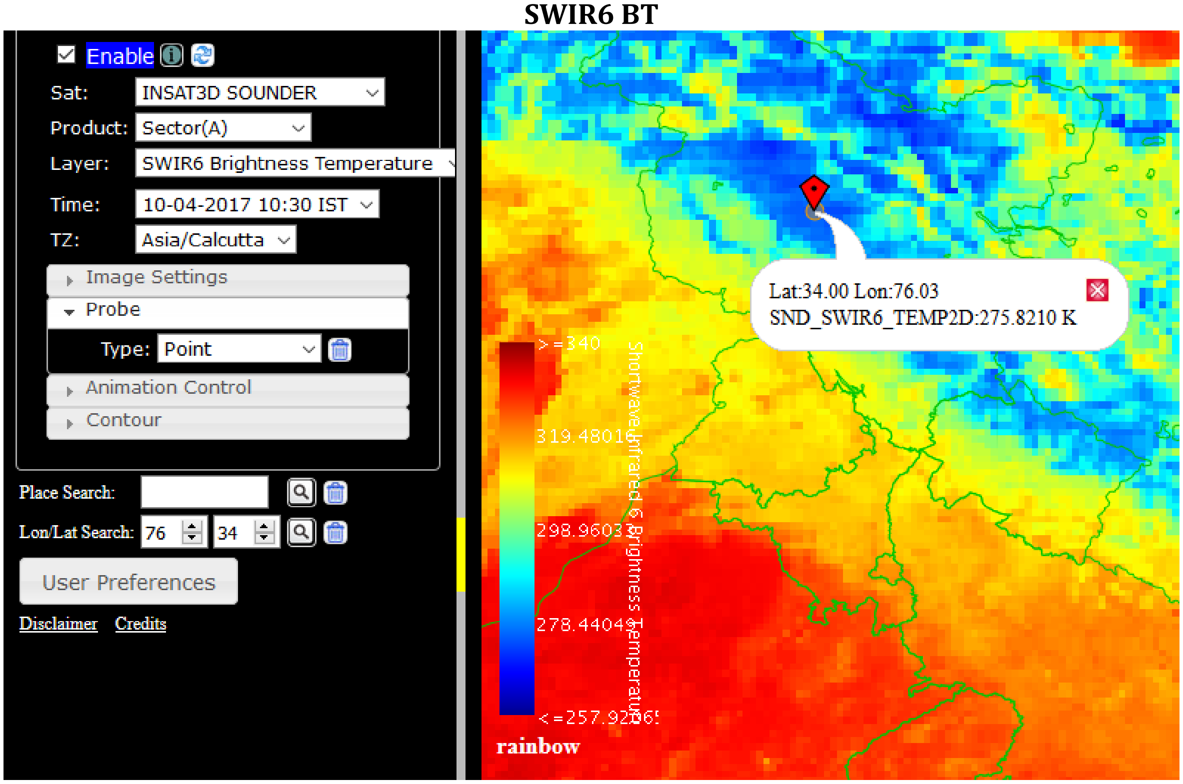
SWIR5 BT



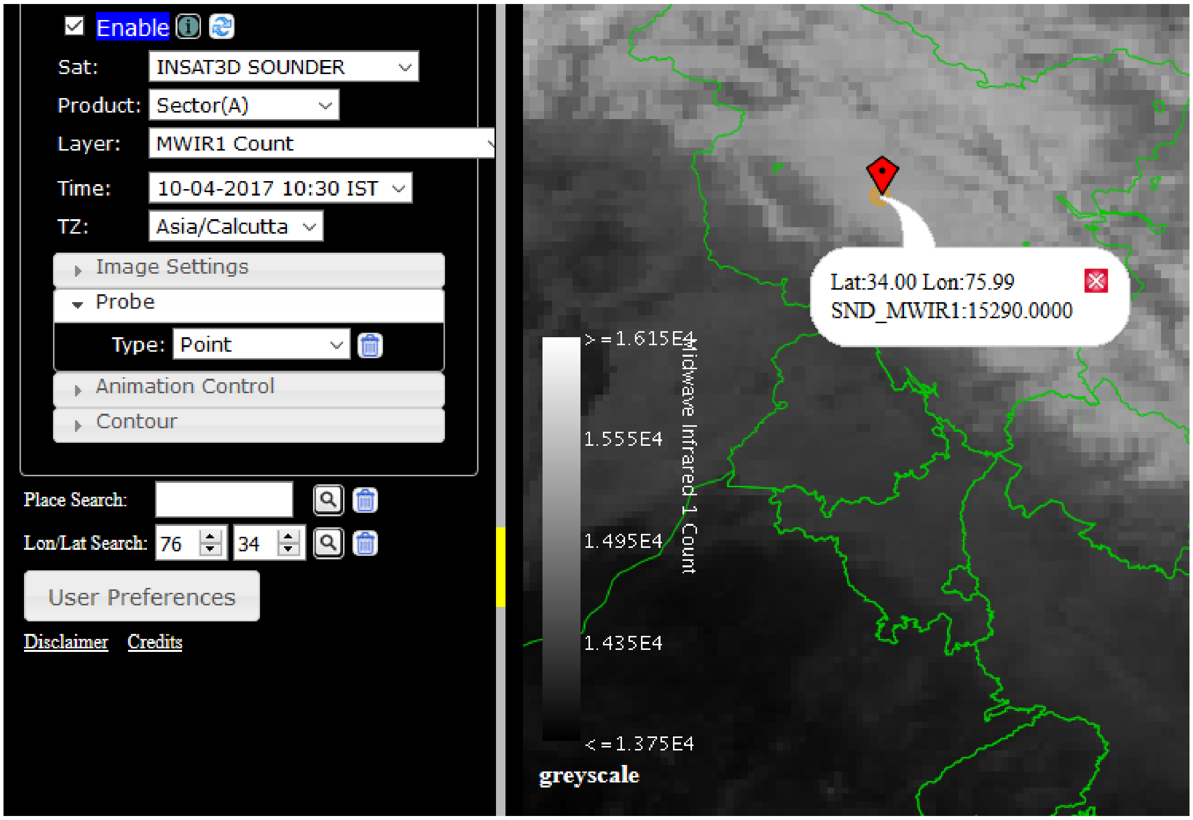
SWIR6 Count



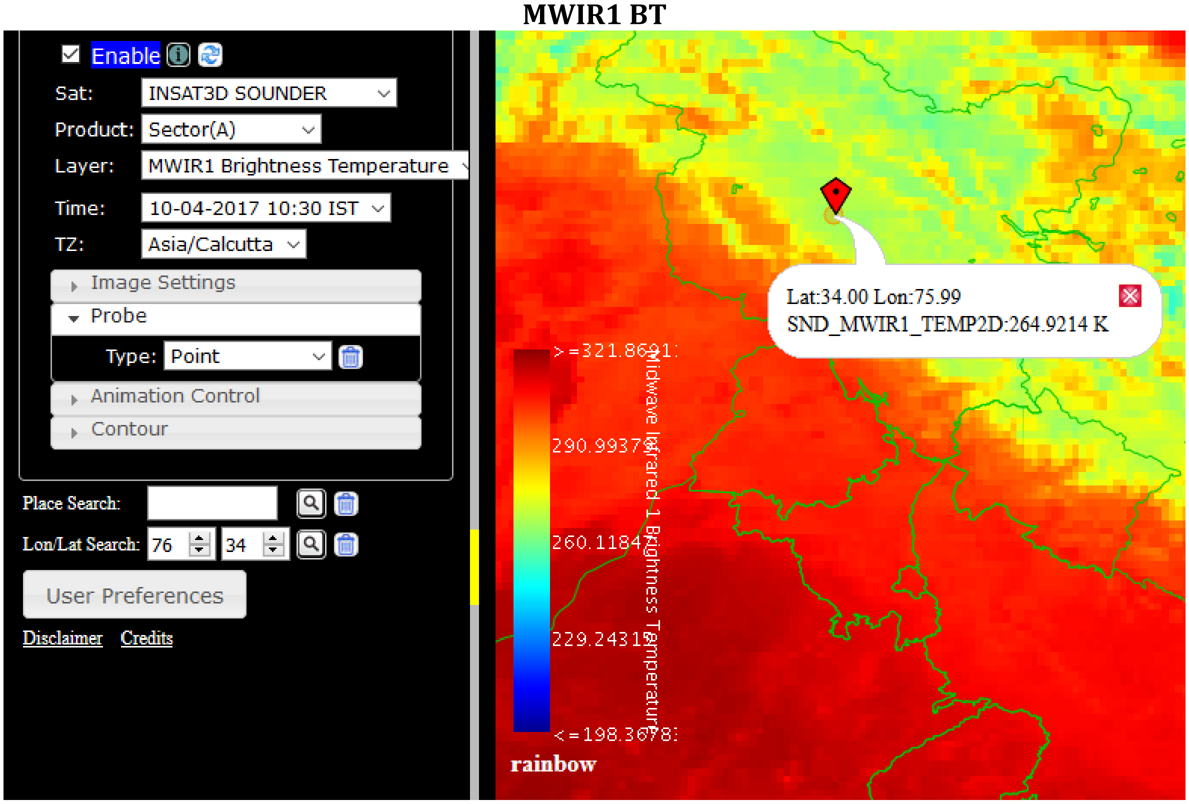
SWIR6 BT



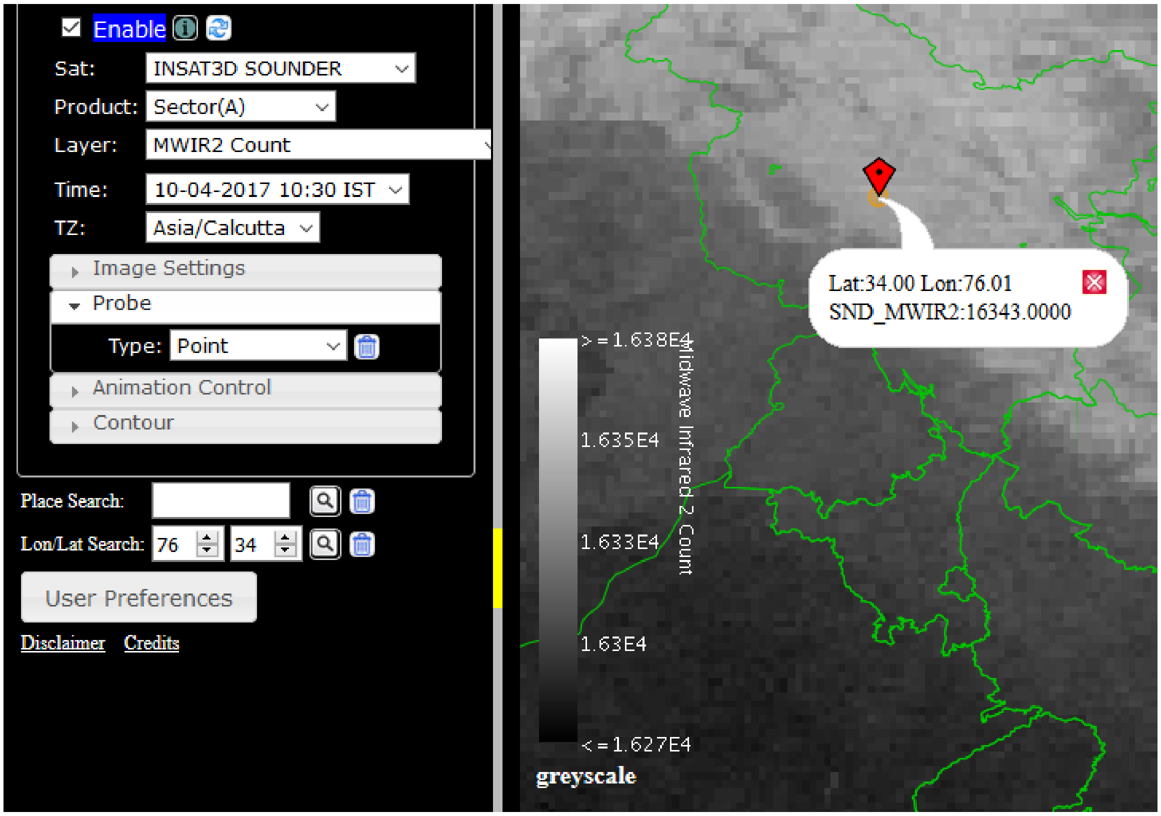
MWIR1 Count



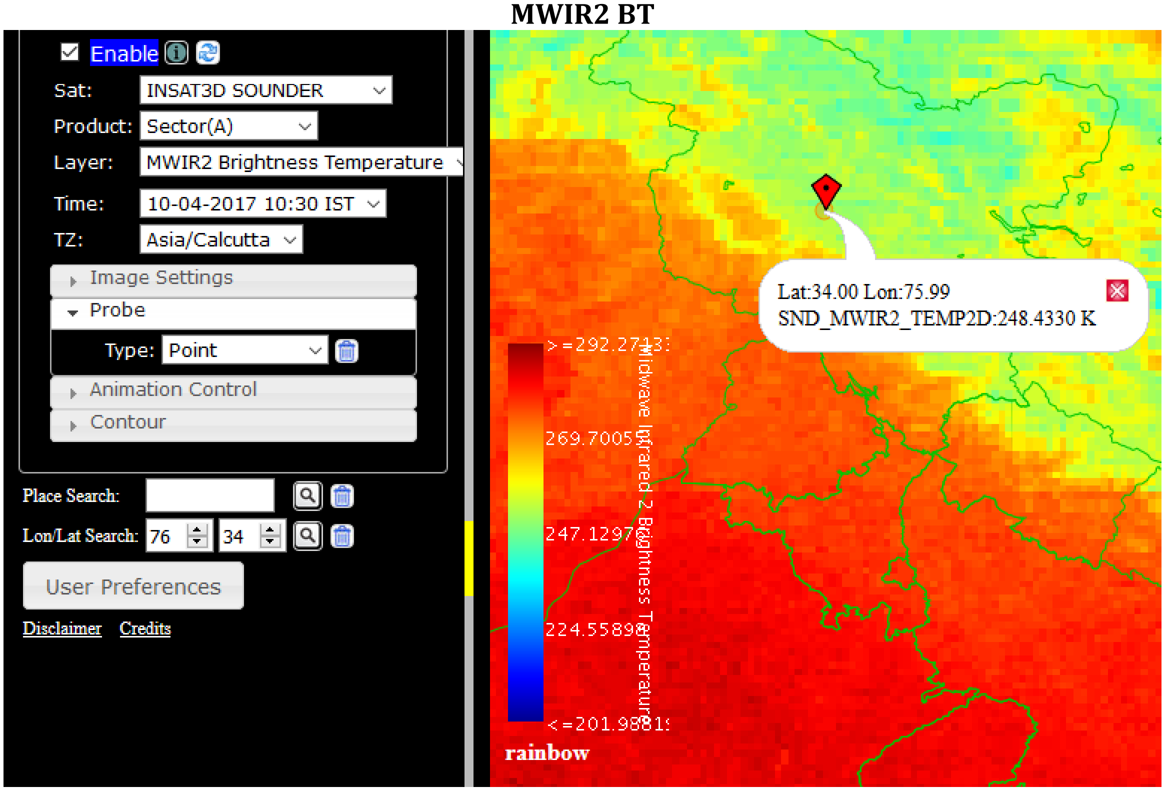
MWIR1 BT



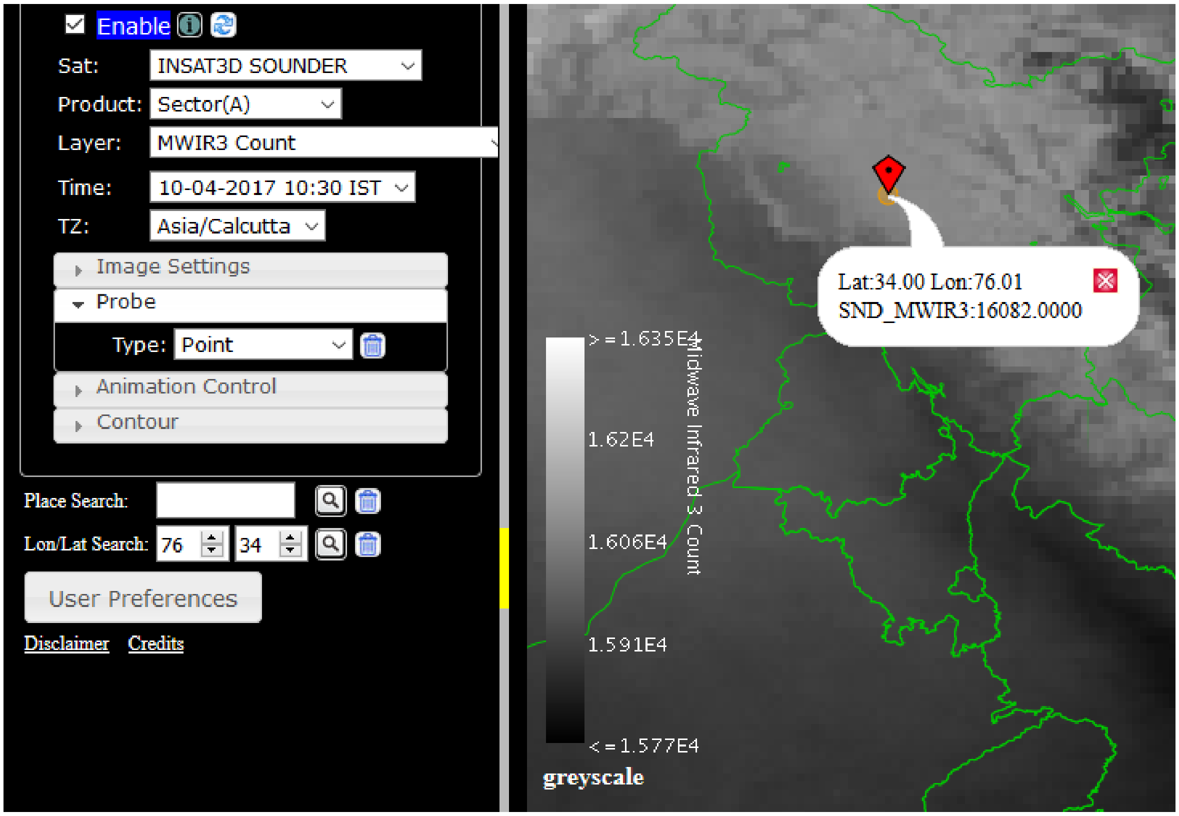
MWIR2 Count



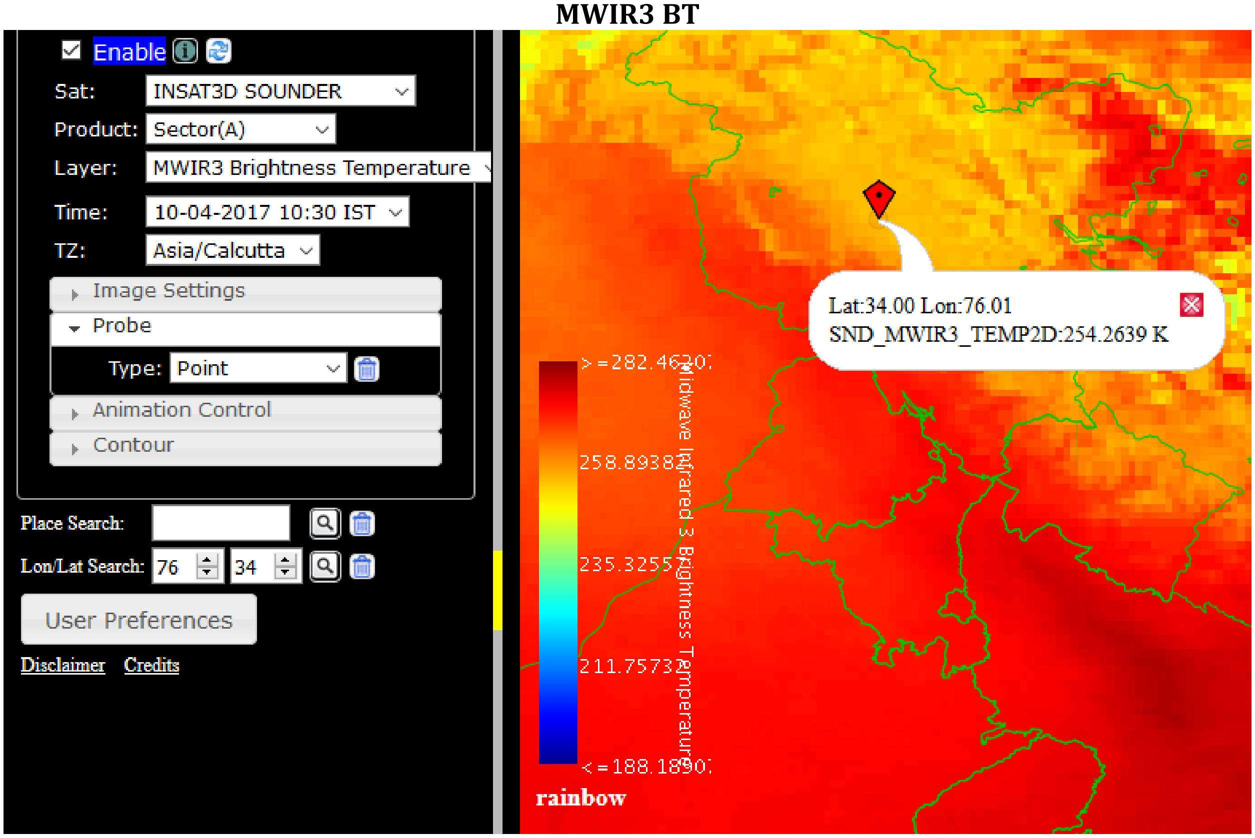
MWIR2 BT



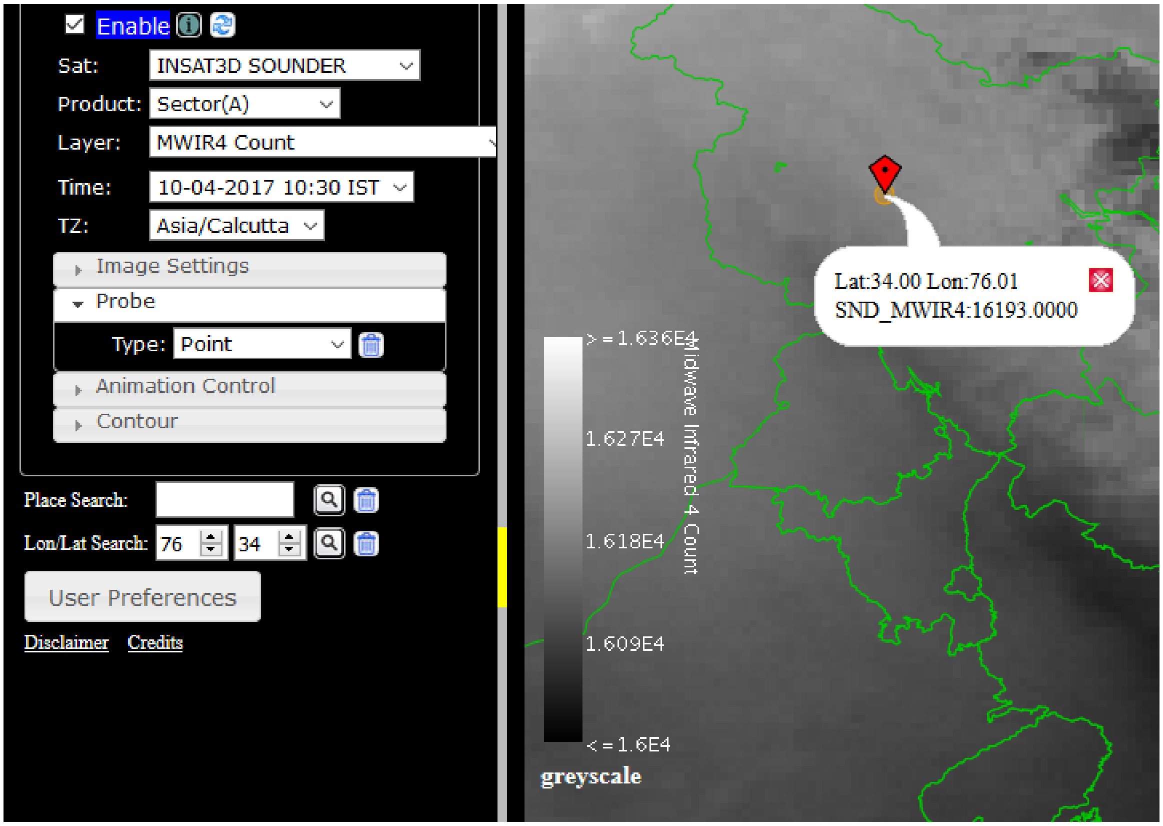
MWIR3 Count



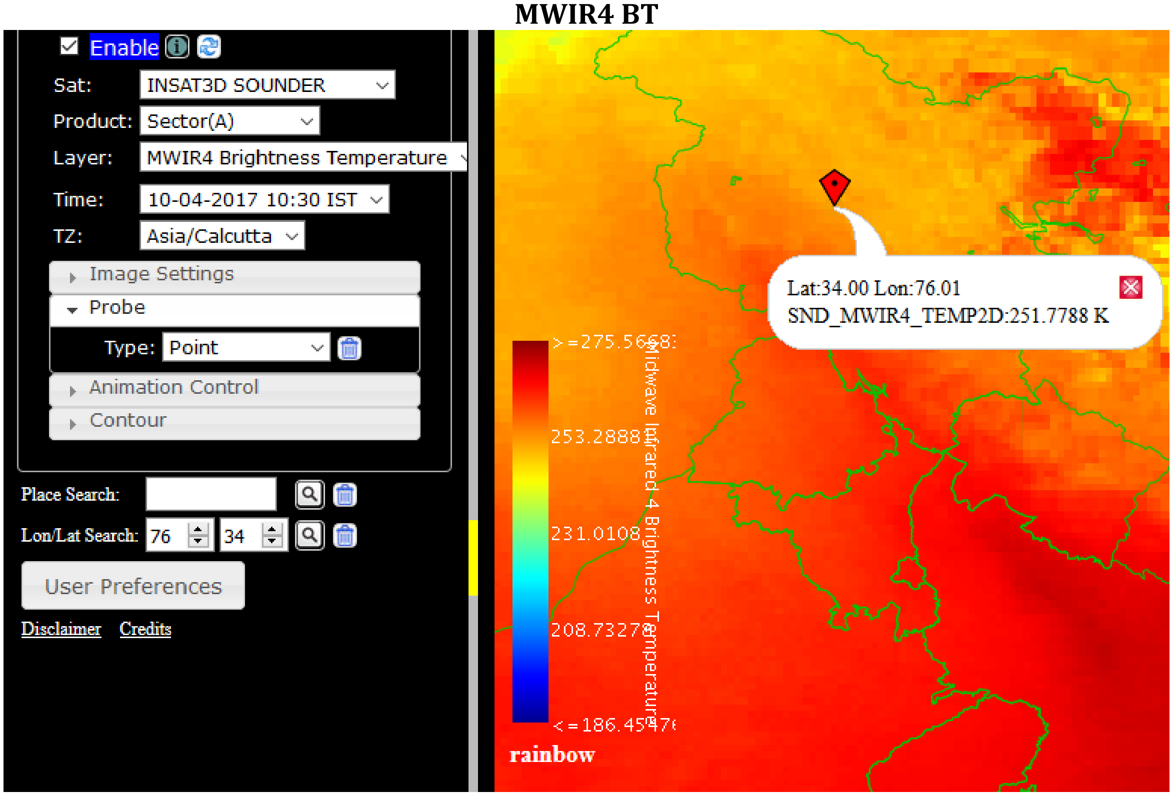
MWIR3 BT



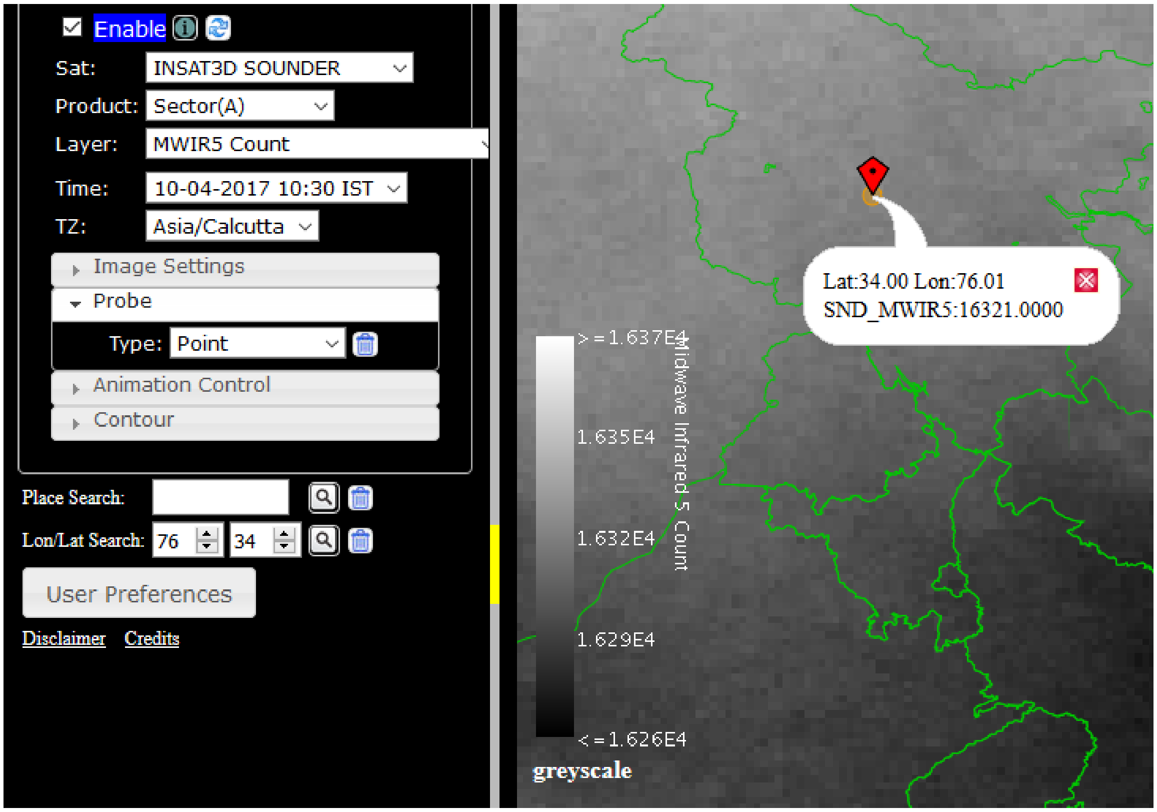
MWIR4 Count



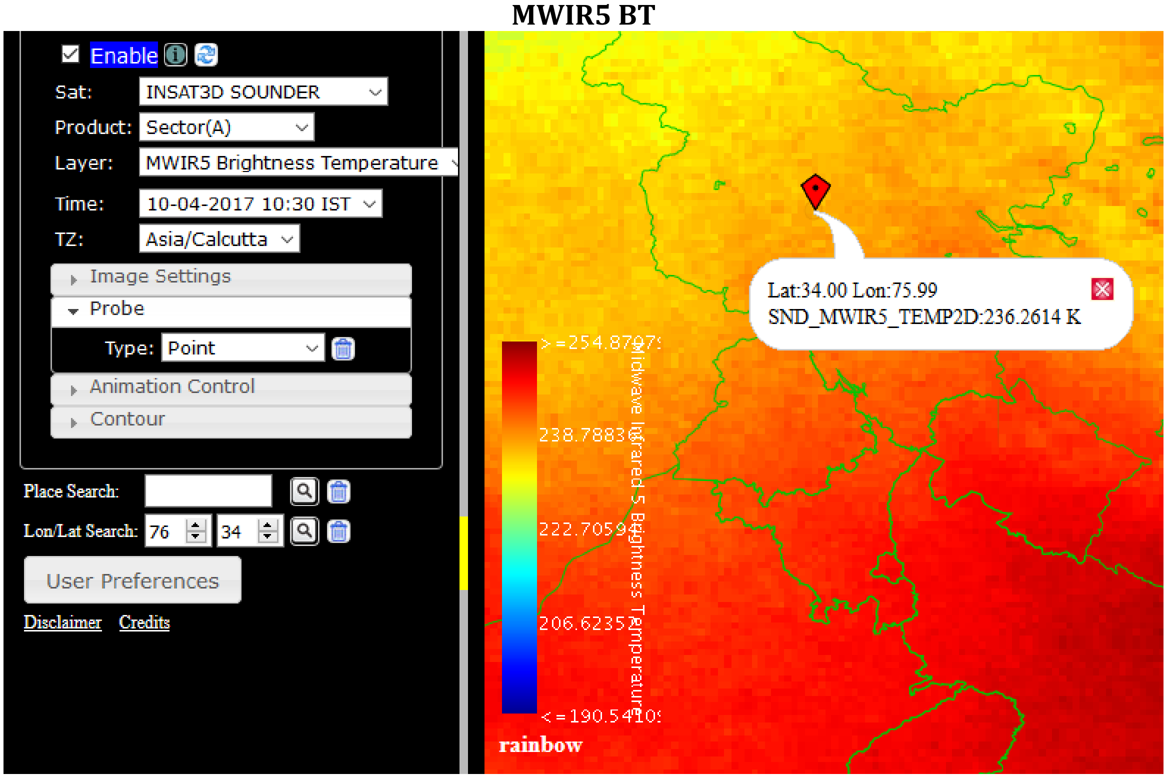
MWIR4 BT



MWIR5 Count

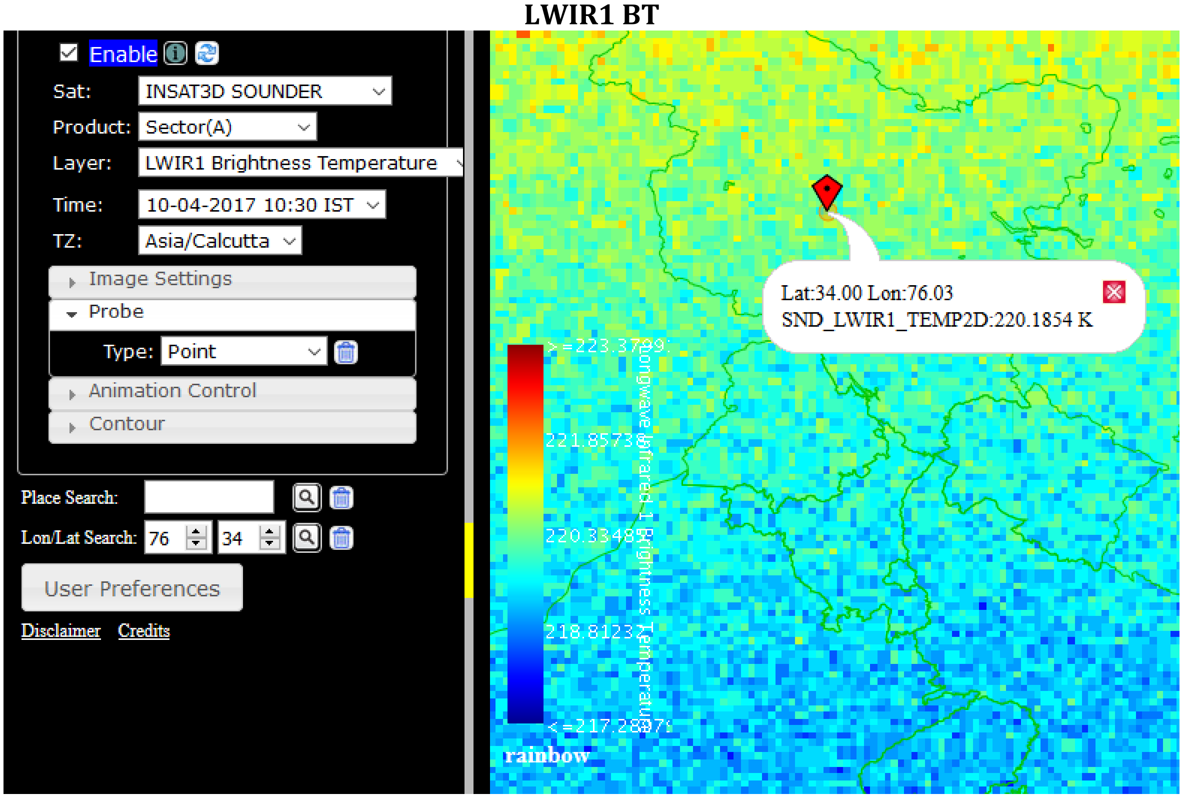


MWIR5 BT

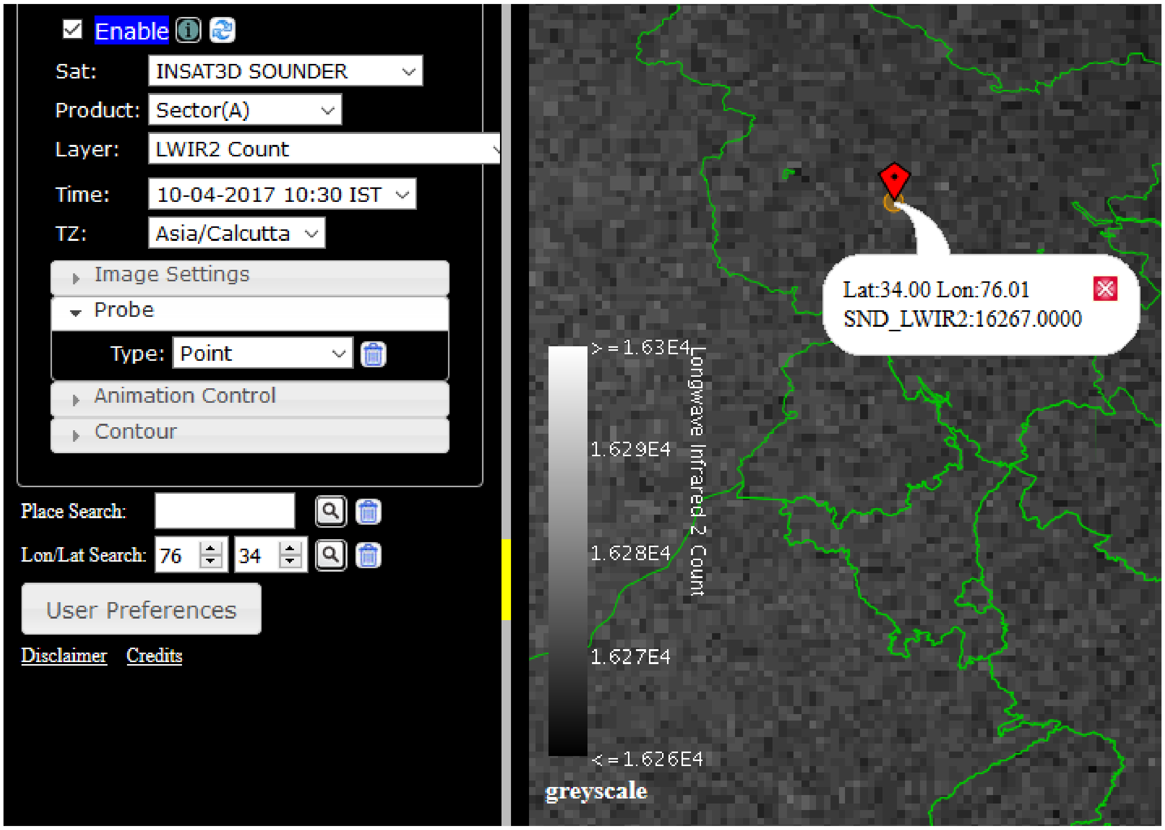


LWIR1 Count

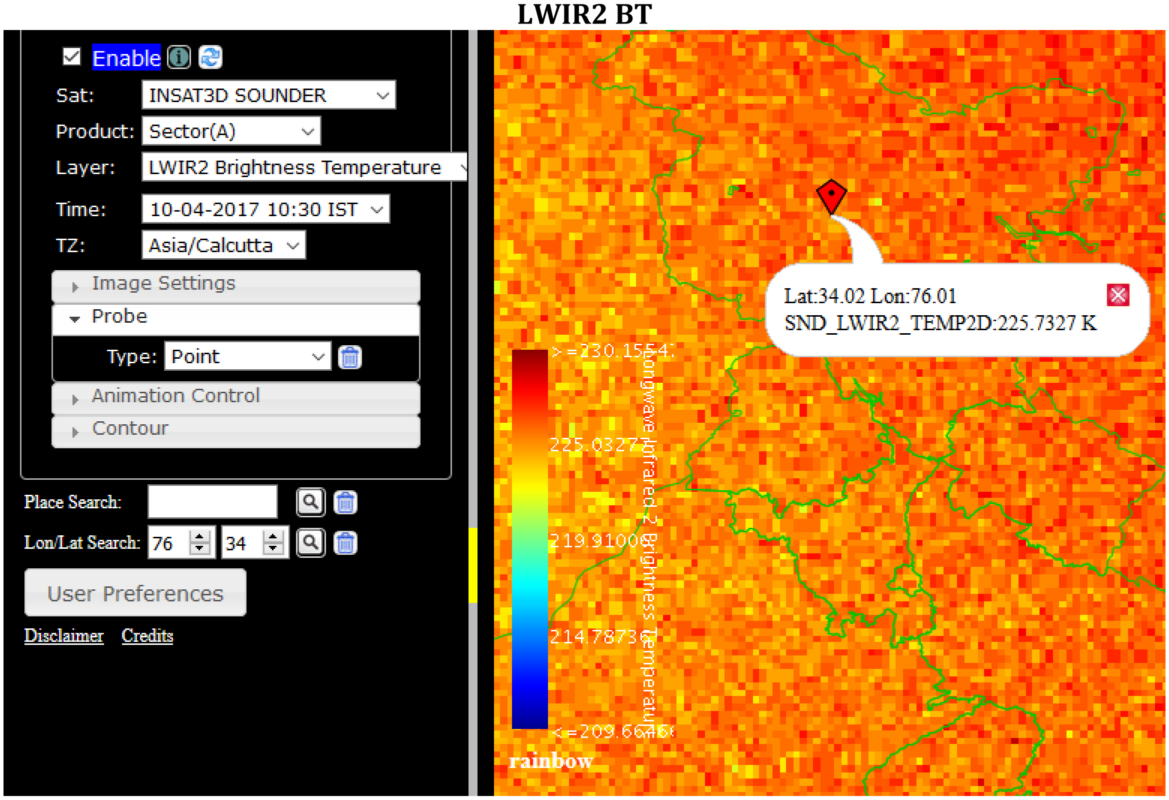
LWIR1 BT



LWIR2 Count

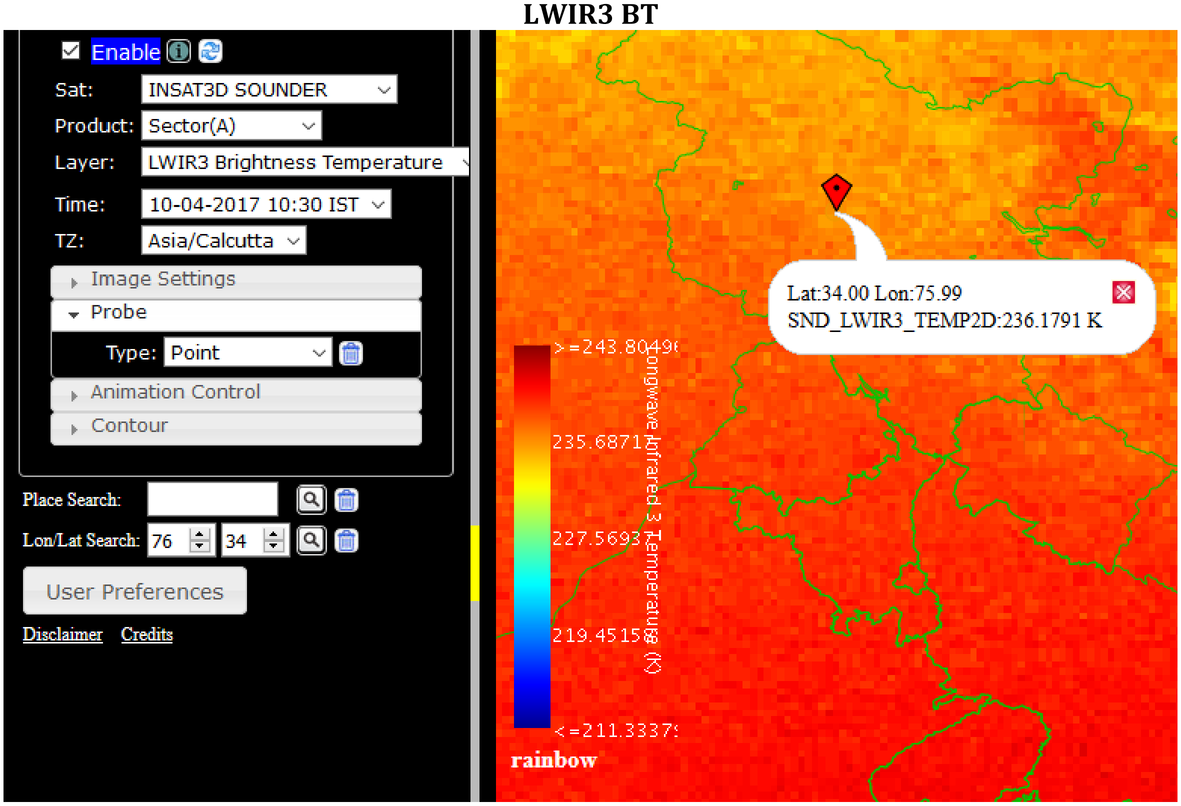


LWIR2 BT

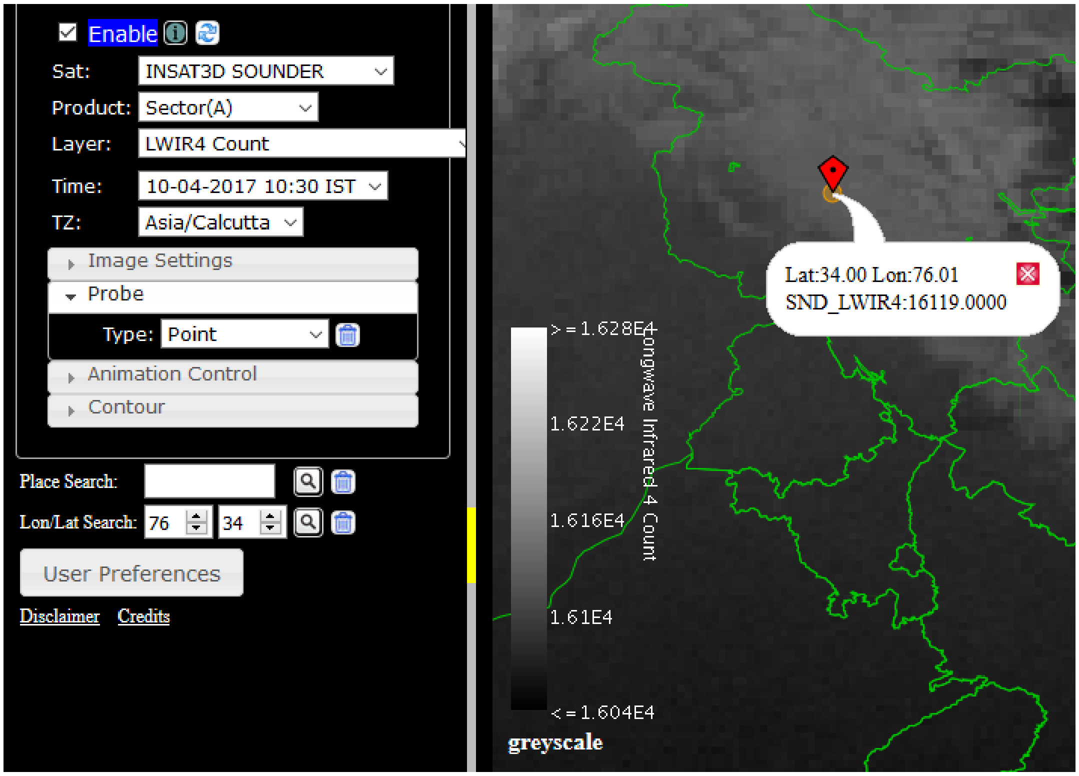


LWIR3 Count

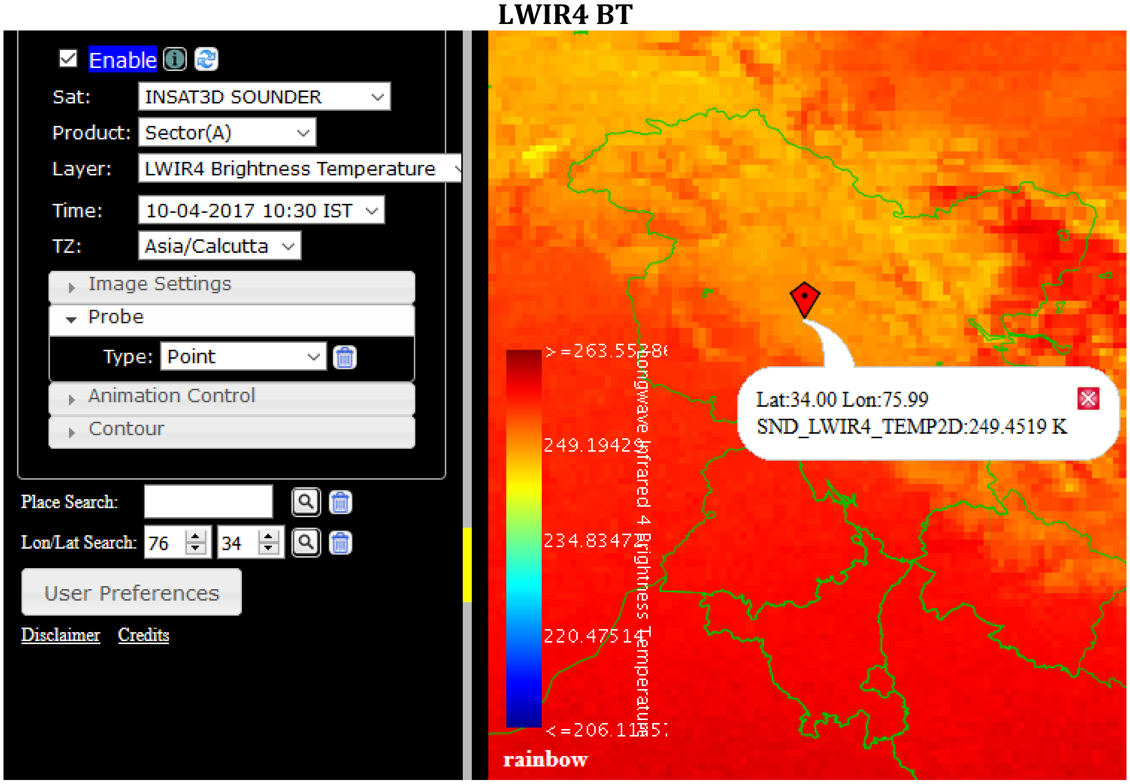
LWIR3 BT



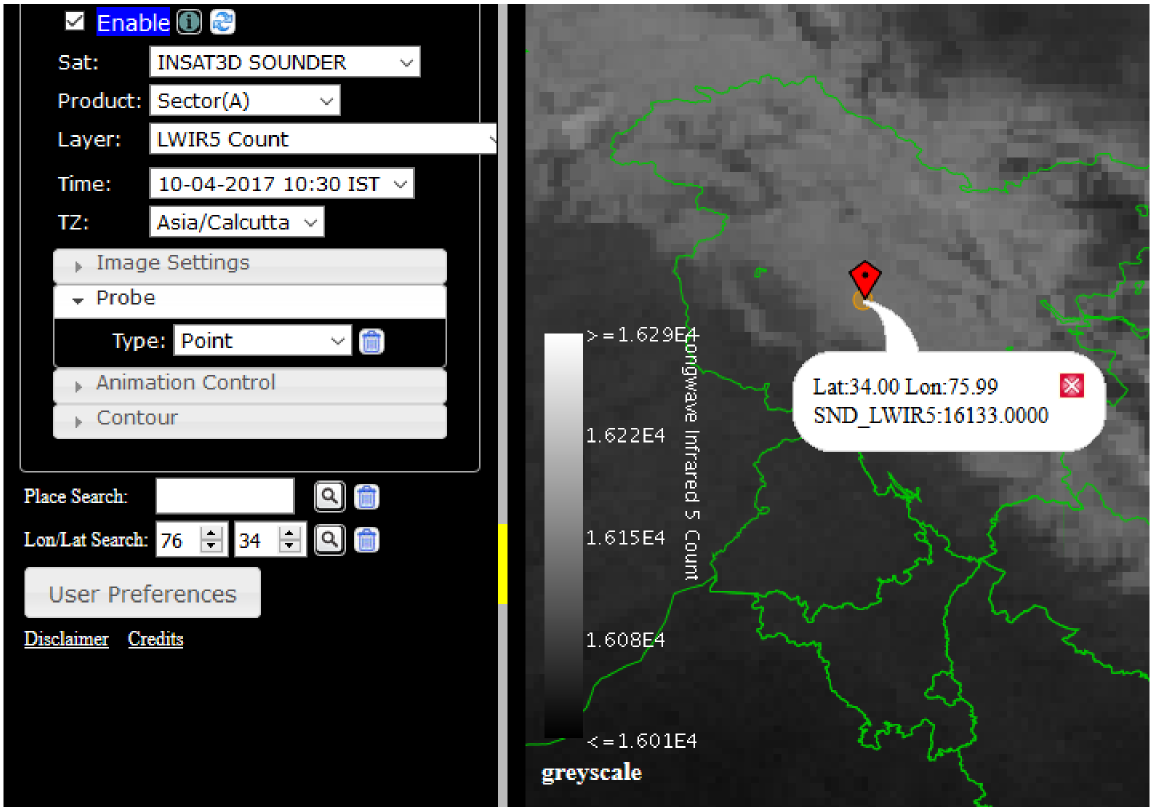
LWIR4 Count



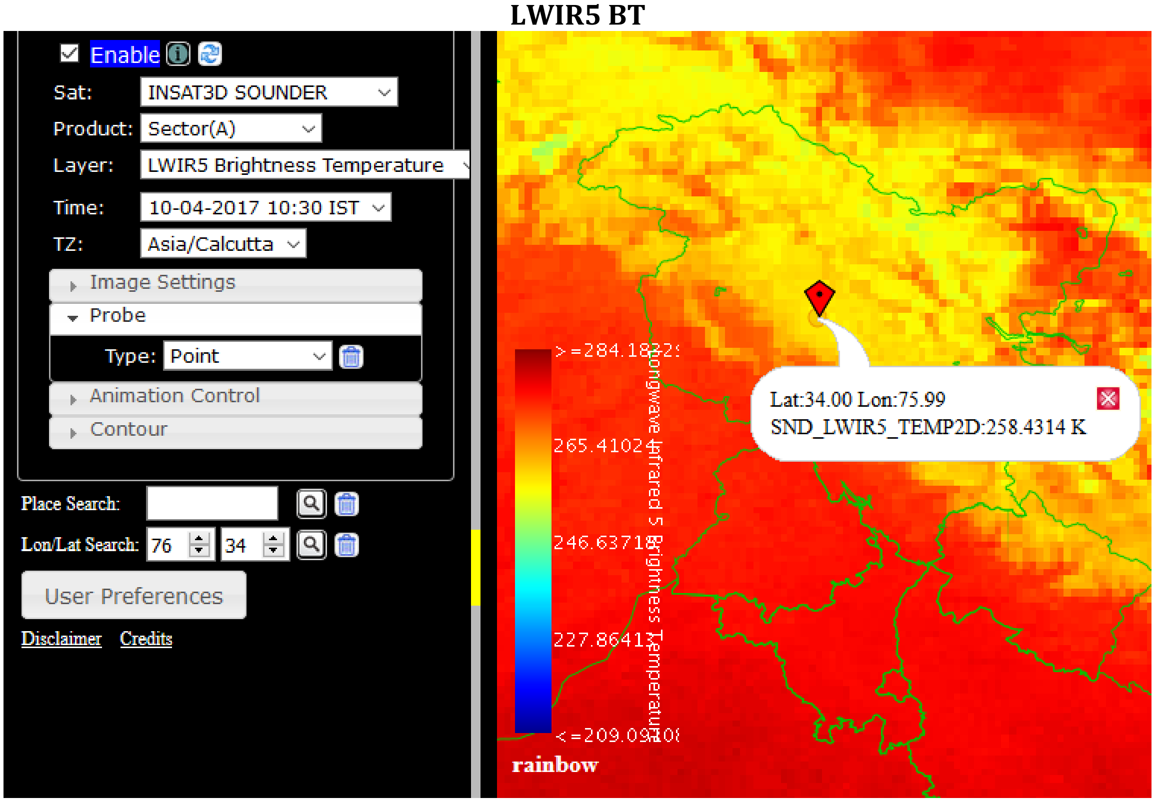
LWIR4 BT



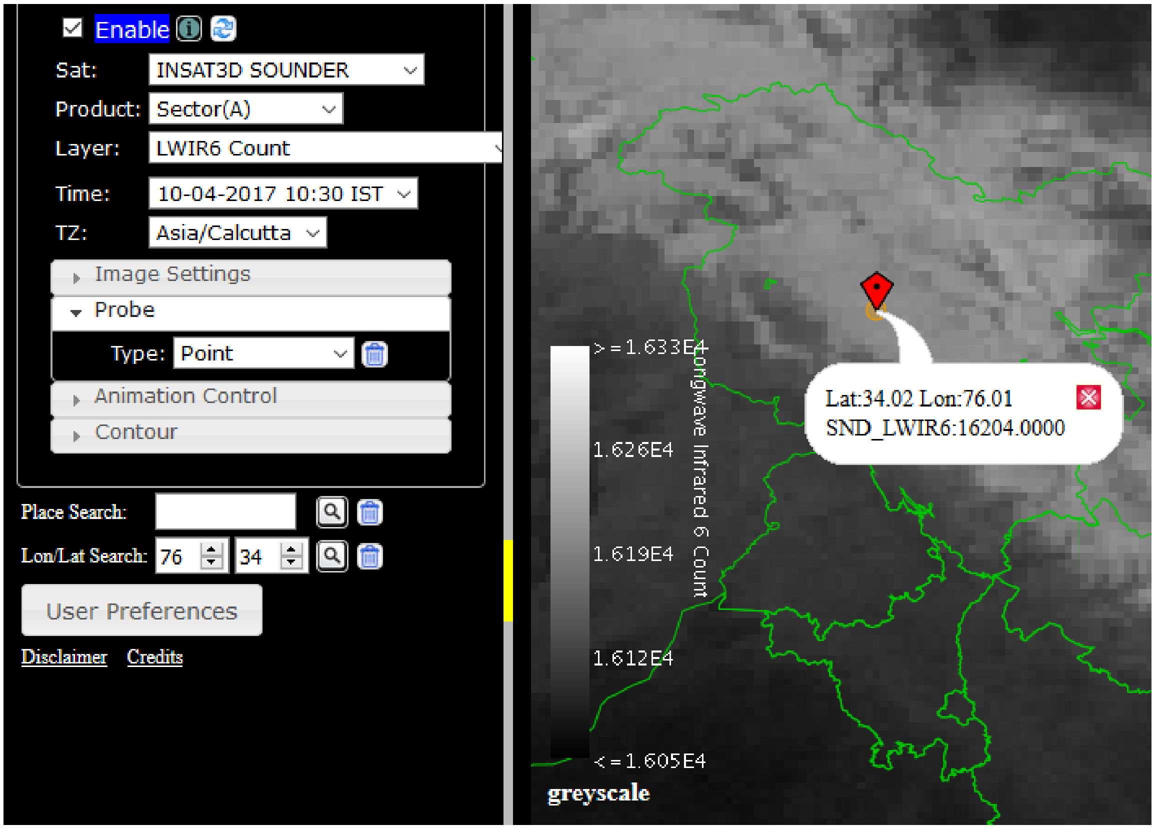
LWIR5 Count



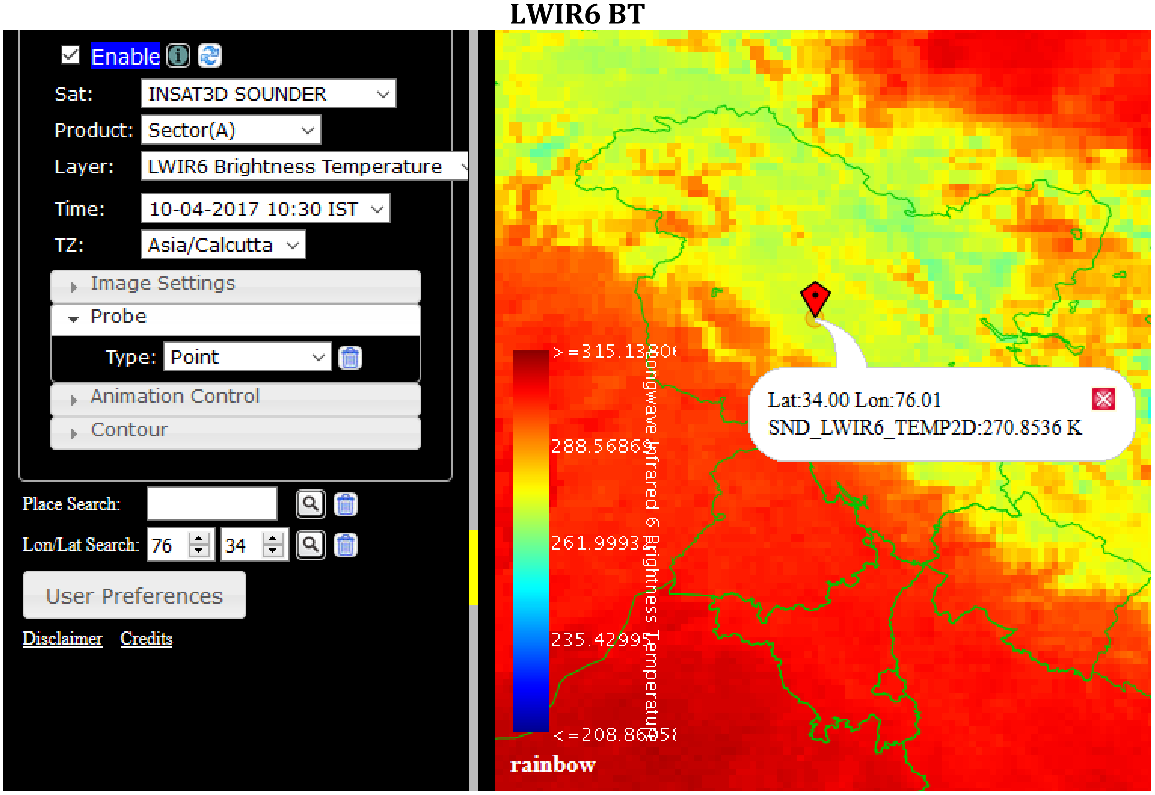
LWIR5 BT



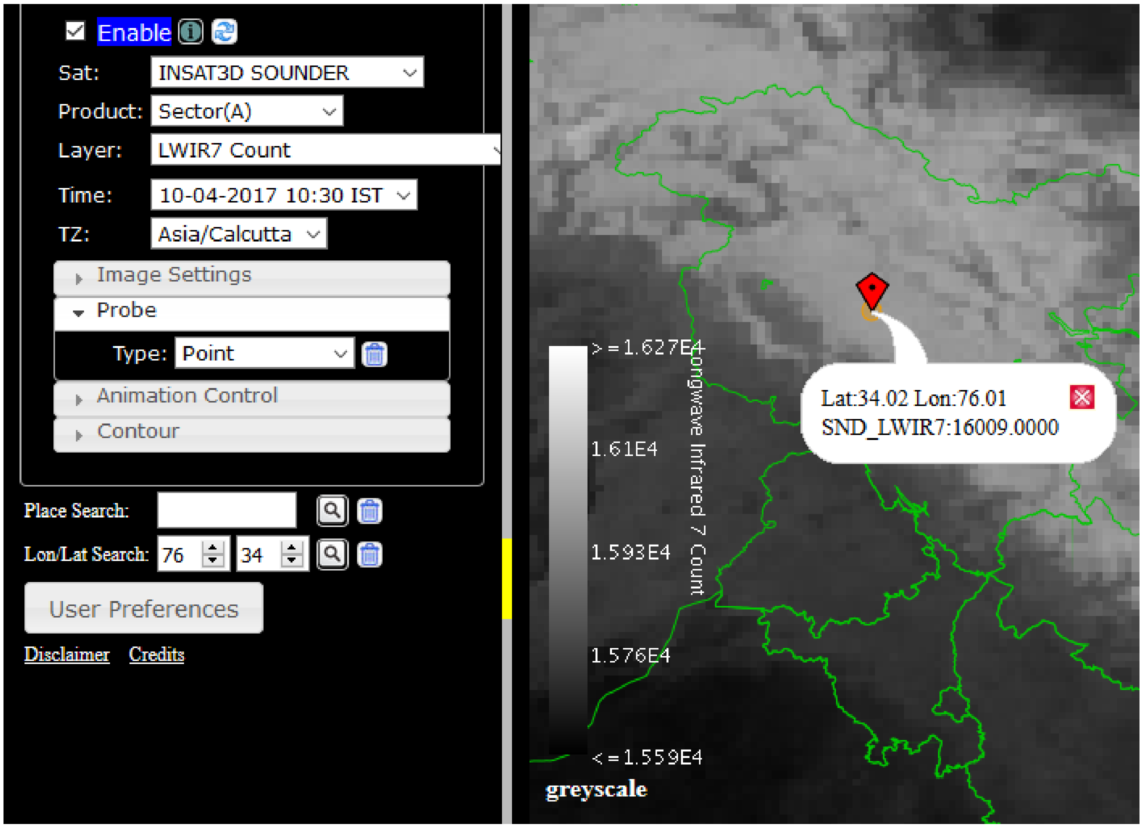
LWIR6 Count



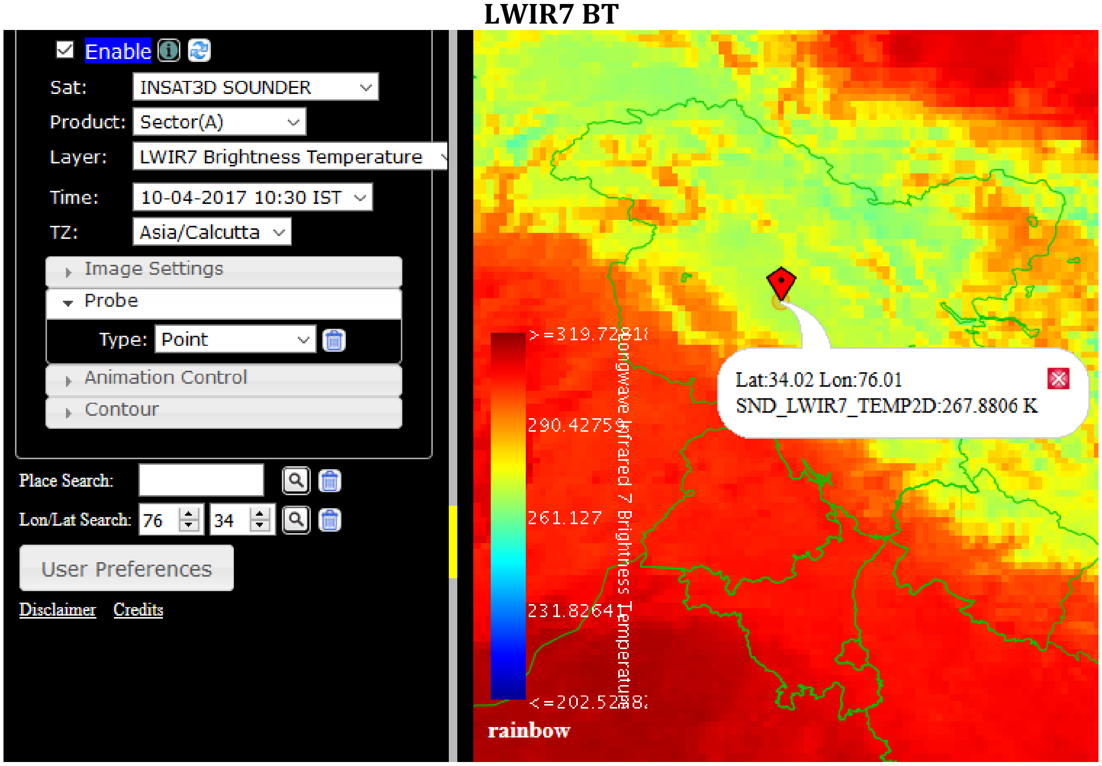
LWIR6 BT



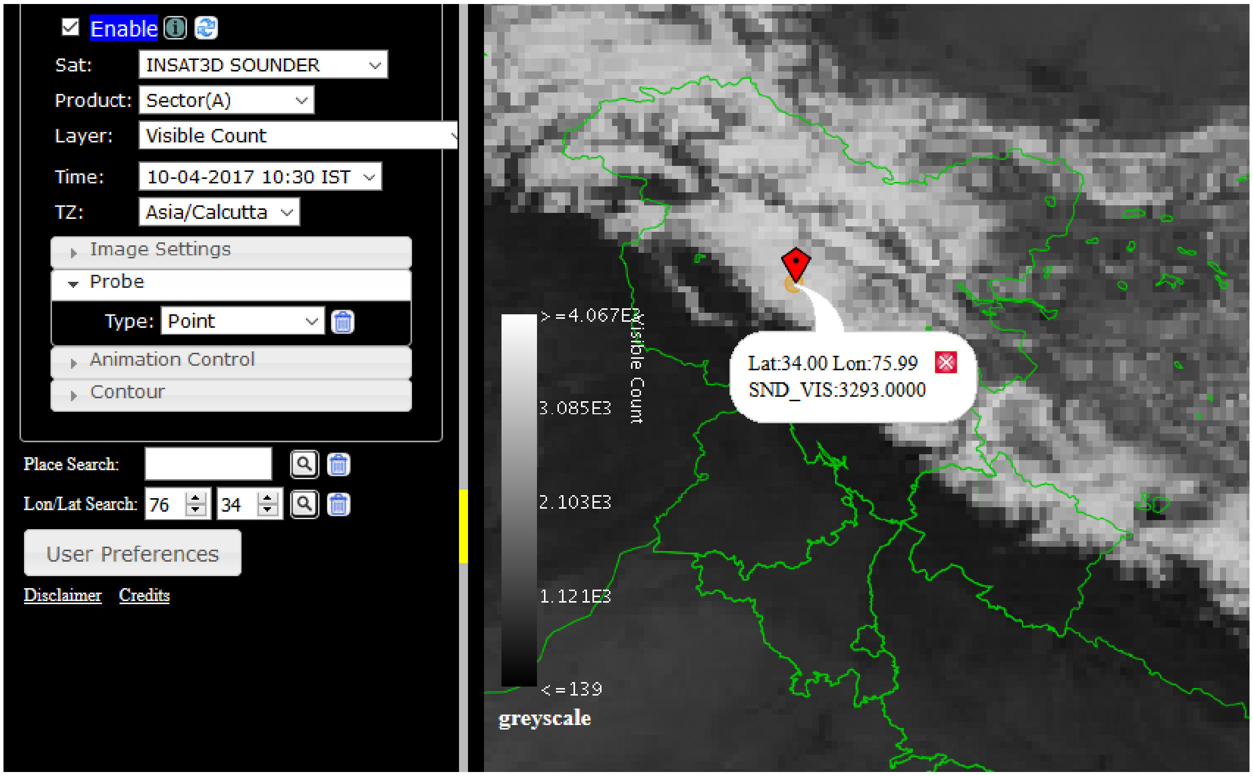
LWIR7 Count



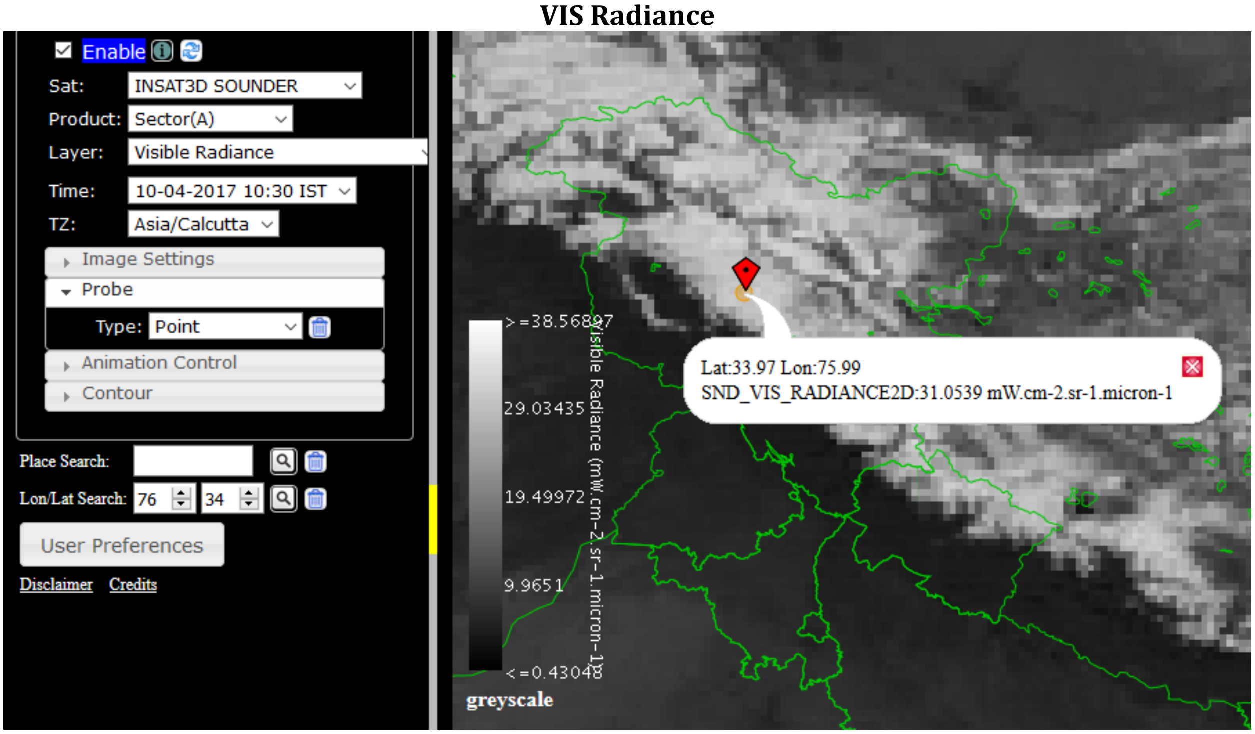
LWIR7 BT



VIS Count



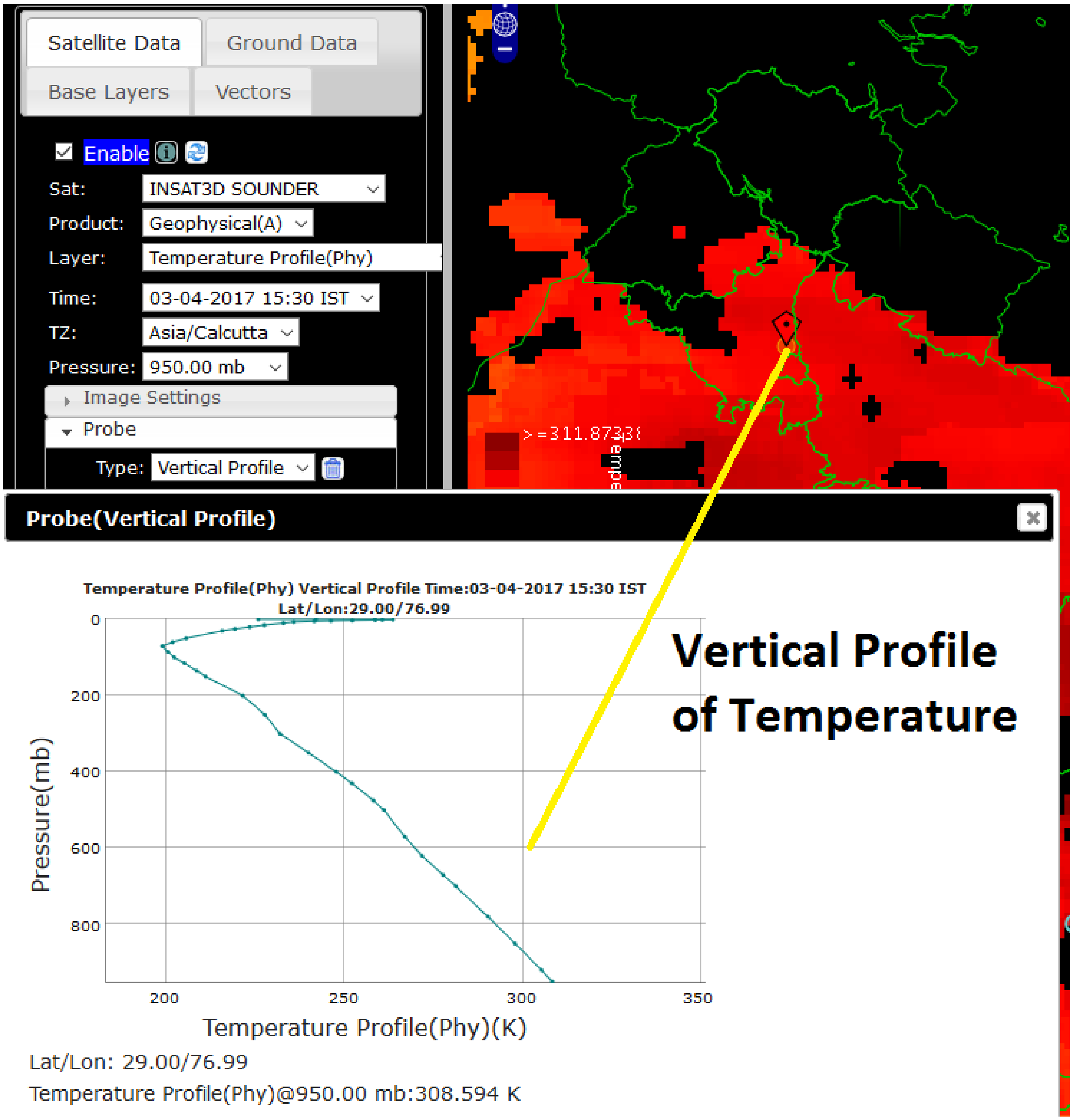
VIS Radiance



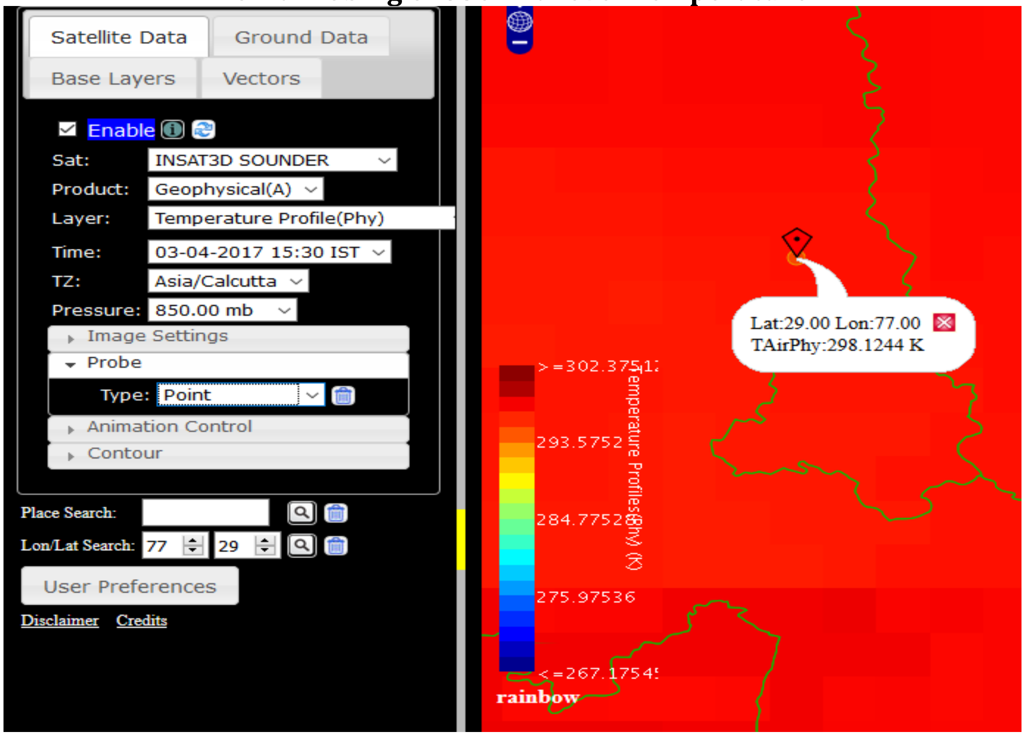
(ii) ***Geophysical (A) or Geophysical (B):*** If user select INSAT-3D SOUNDER in 'Sat' option and in Products user selected either **Geophysical (A) or Geophysical (B)** then in layer drop box user can choose among these:

The following options are available to the user to choose parameters from Temperature Profile, Water Vapour Profile, Total Precipitable Water, Layer Precipitable Water, Lifted Index, Dry microburst Index, Surface Skin Temperature, Wind Index, Maximum vertical Theta. Vertical profiles of Temperature and Water Vapor can be viewed by checking vertical profile option available in probe.

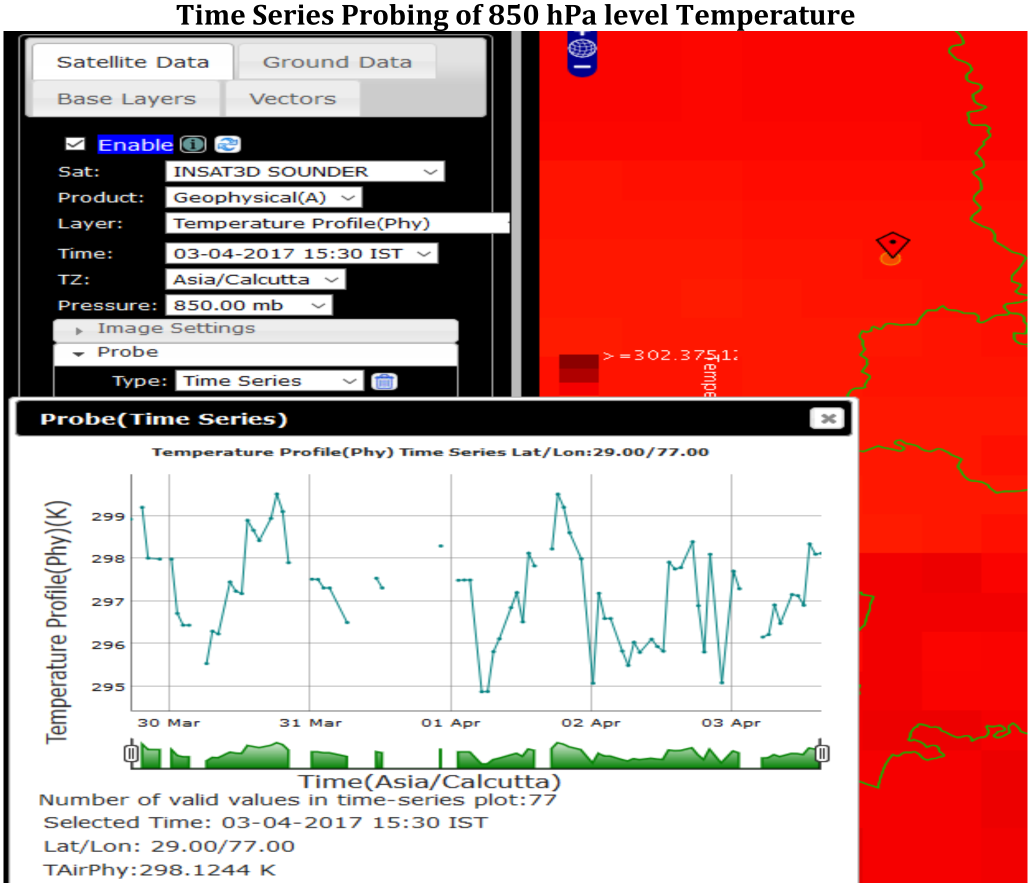
1. Temperature Profile (Phy): The algorithm is designed for retrieving vertical profiles of atmospheric temperature from clear sky infrared radiances in different absorption bands observed through INSAT-3D. Sounder derived profiles include temperature at 40 vertical pressure levels from surface to about 70 km i.e. from 1000hPa to 0.1hPa. An example of vertical profile of temperature along with the probing of one layer i.e. 850hPa level is shown below, similarly probing can be performed for all remaining 39 pressure levels too.



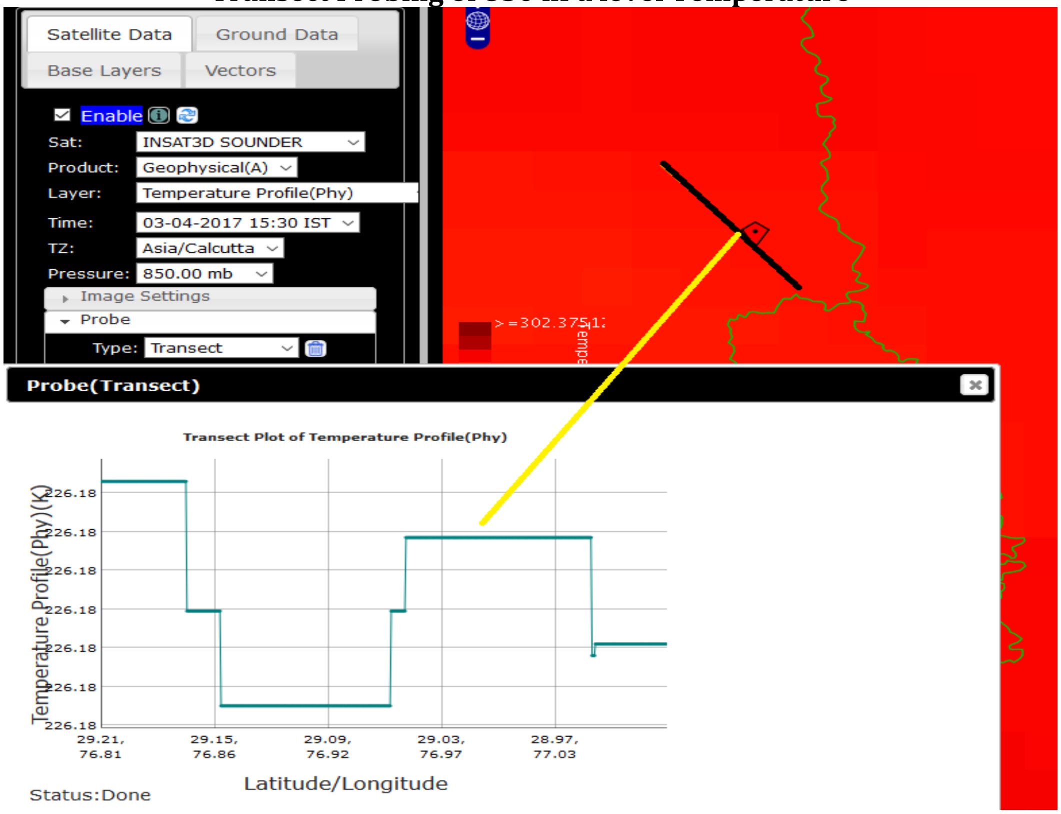
Point Probing of 850 hPa level Temperature



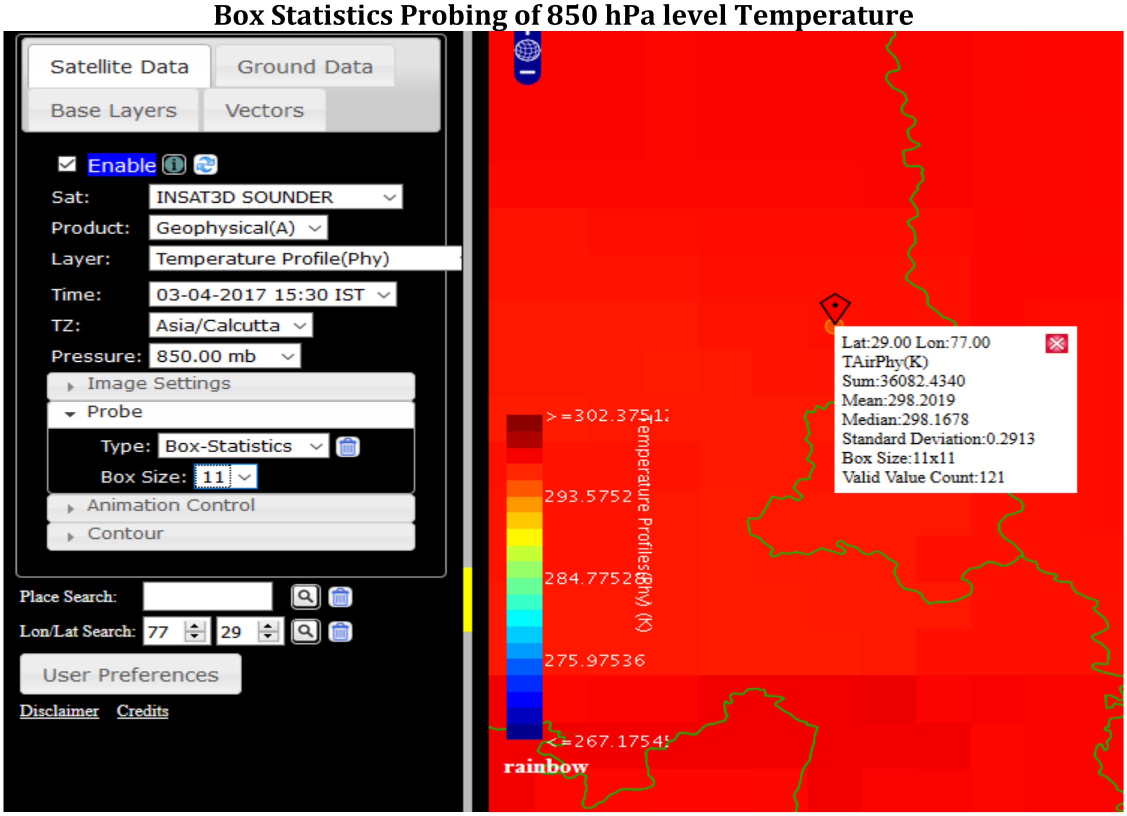
Time Series Probing of 850 hPa level Temperature



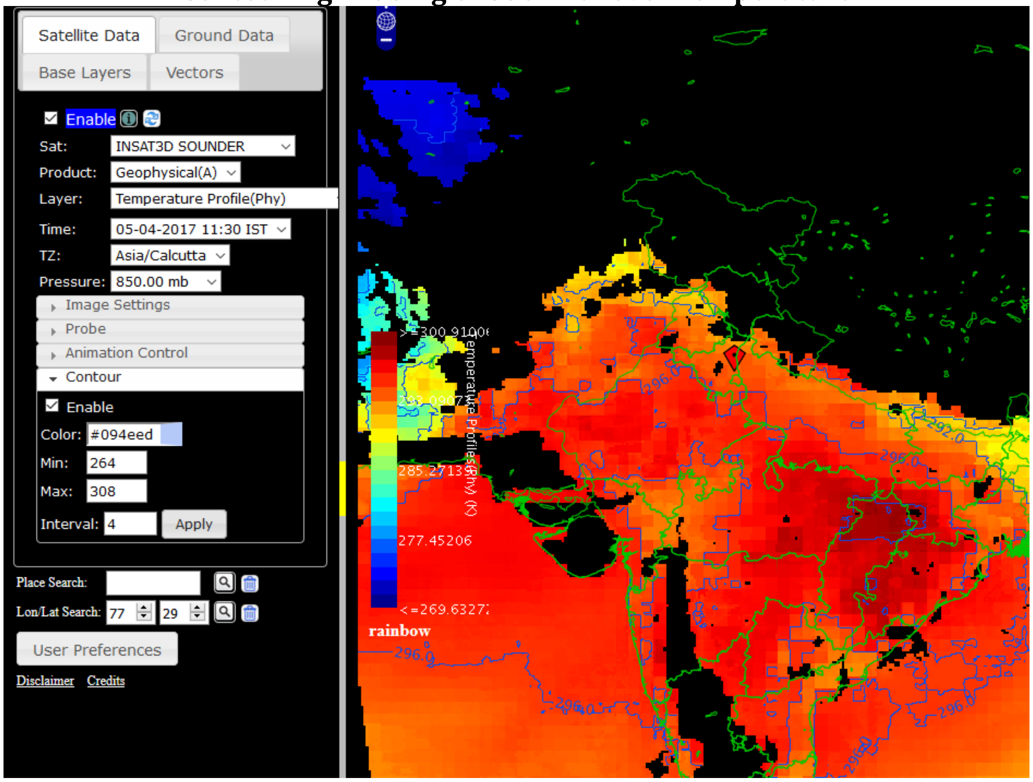
Transect Probing of 850 hPa level Temperature



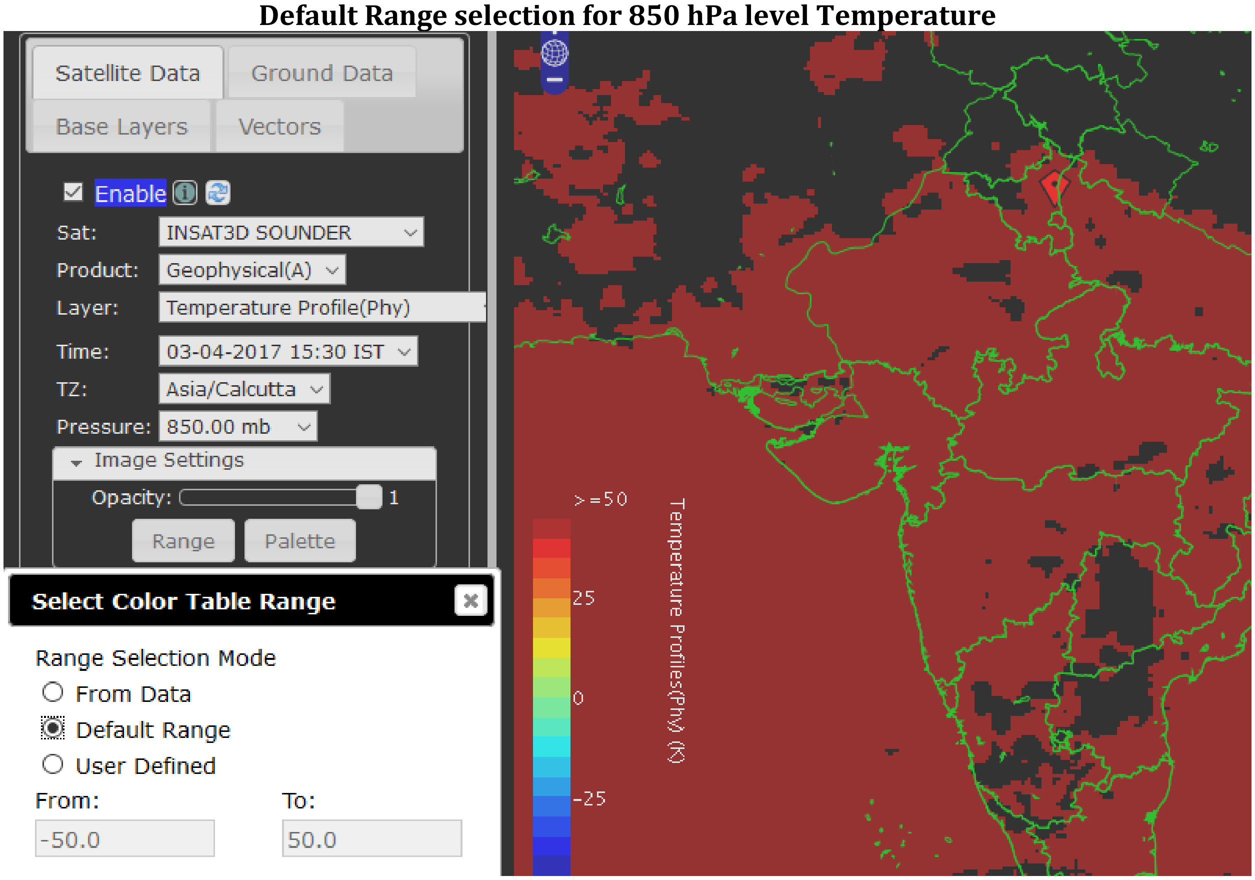
Box Statistics Probing of 850 hPa level Temperature



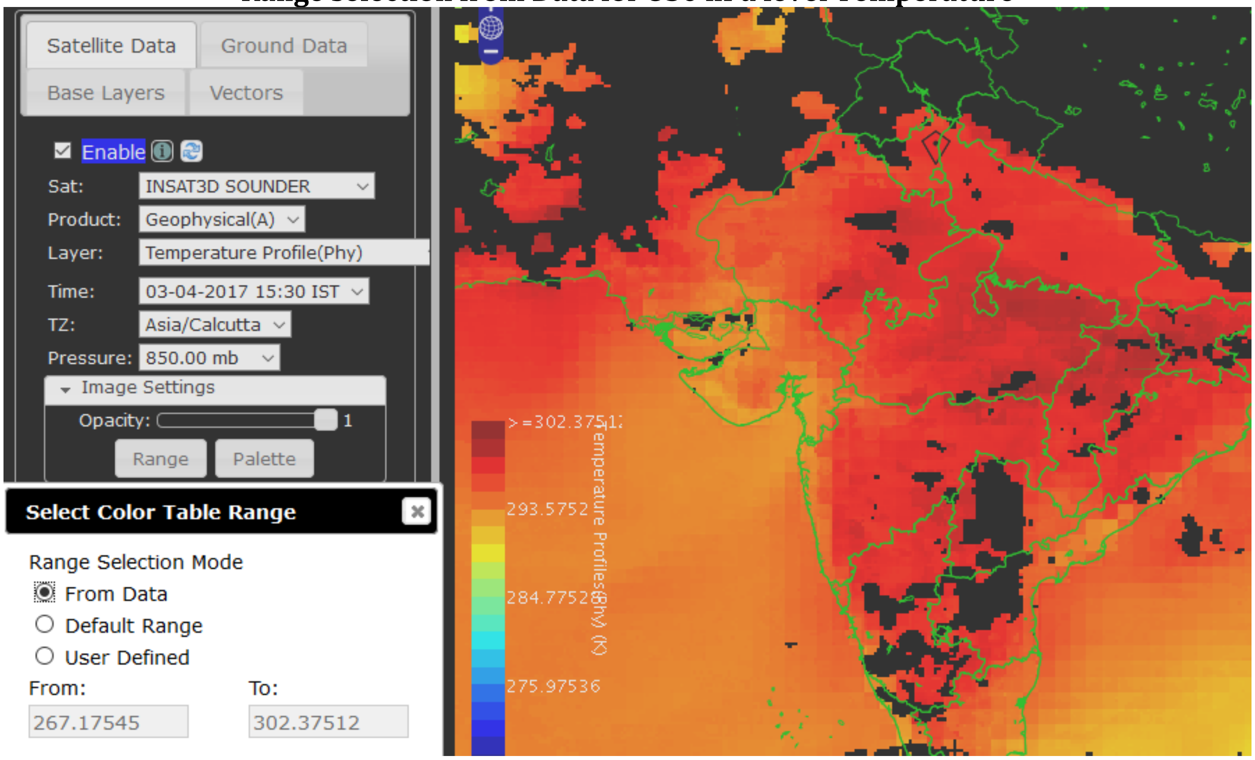
Contouring Probing of 850 hPa level Temperature



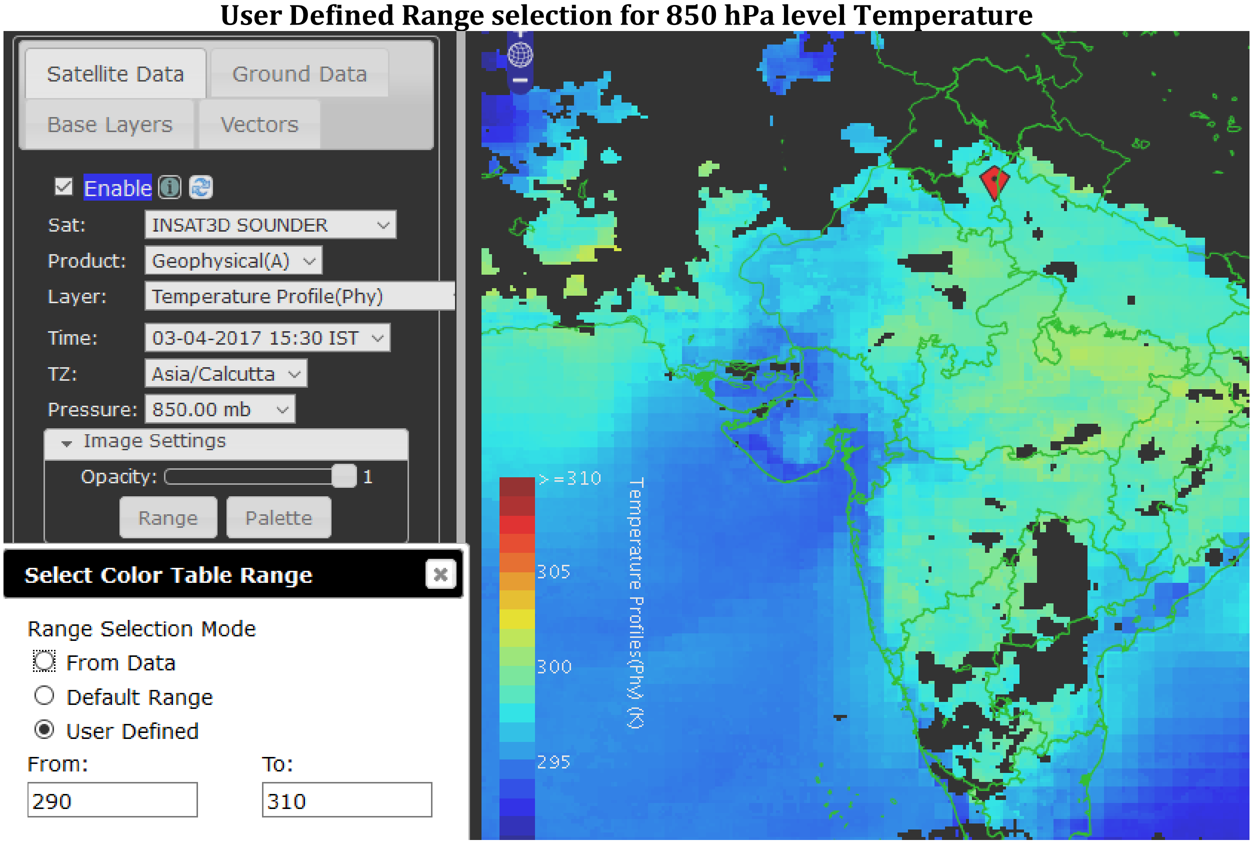
Default Range selection for 850 hPa level Temperature



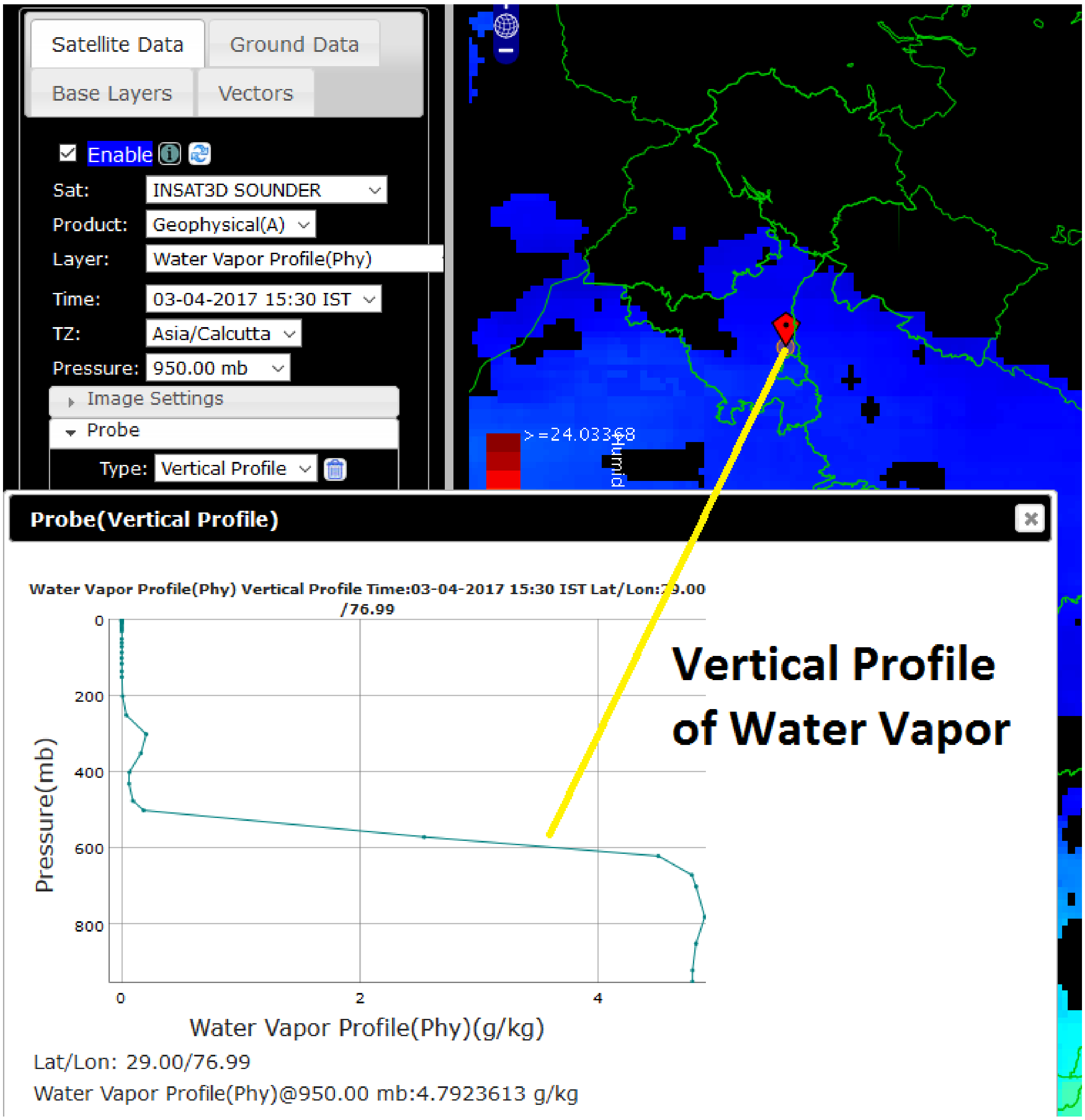
Range selection from Data for 850 hPa level Temperature



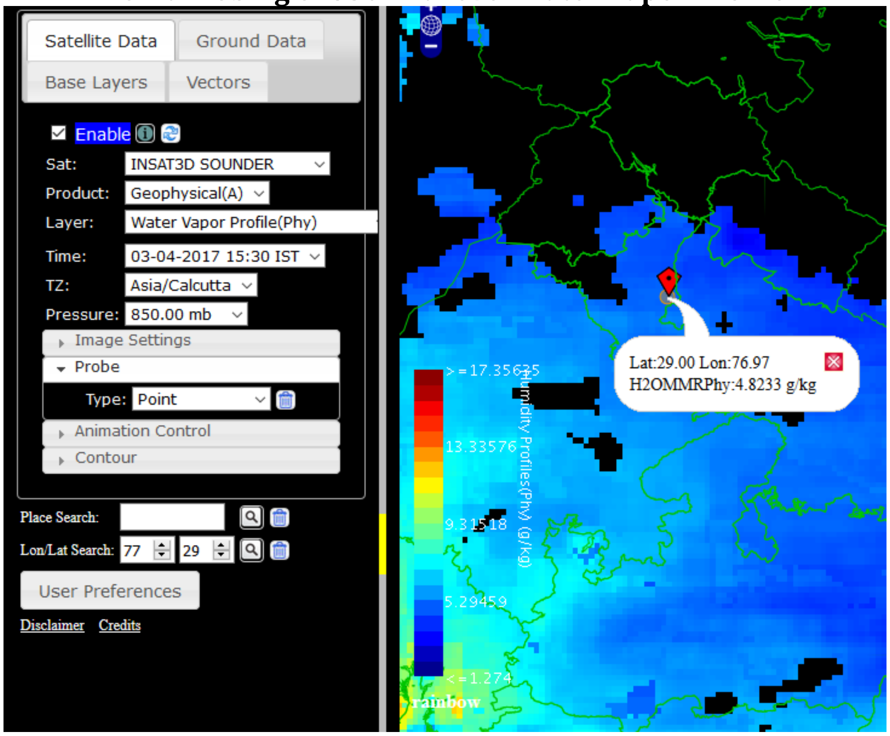
User Defined Range selection for 850 hPa level Temperature



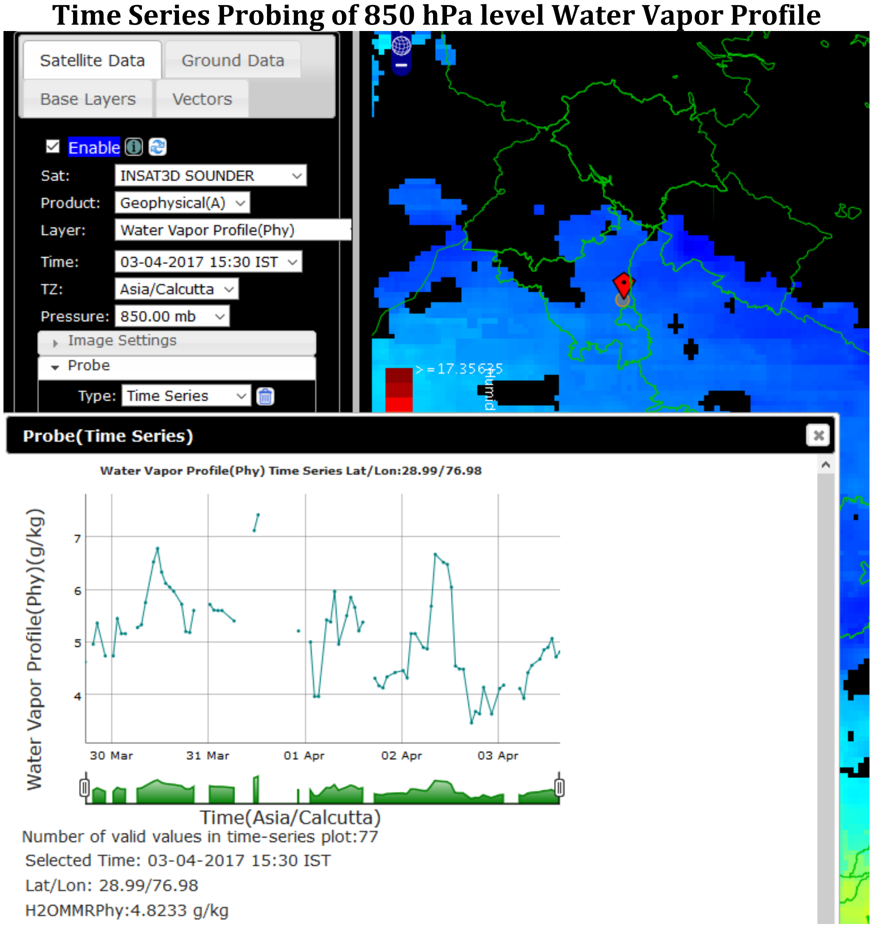
2. Water Vapor Profile (Phy): The algorithm is designed for retrieving vertical profiles of atmospheric moisture from clear sky infrared radiances in different absorption bands observed through INSAT-3D. Sounder derived profiles include water vapor at 21 levels from surface to around 15 km. An example of vertical profile of water vapor along with the probing of one layer i.e. 850hPa level is shown below, similarly probing can be performed for all remaining 20 pressure levels too.



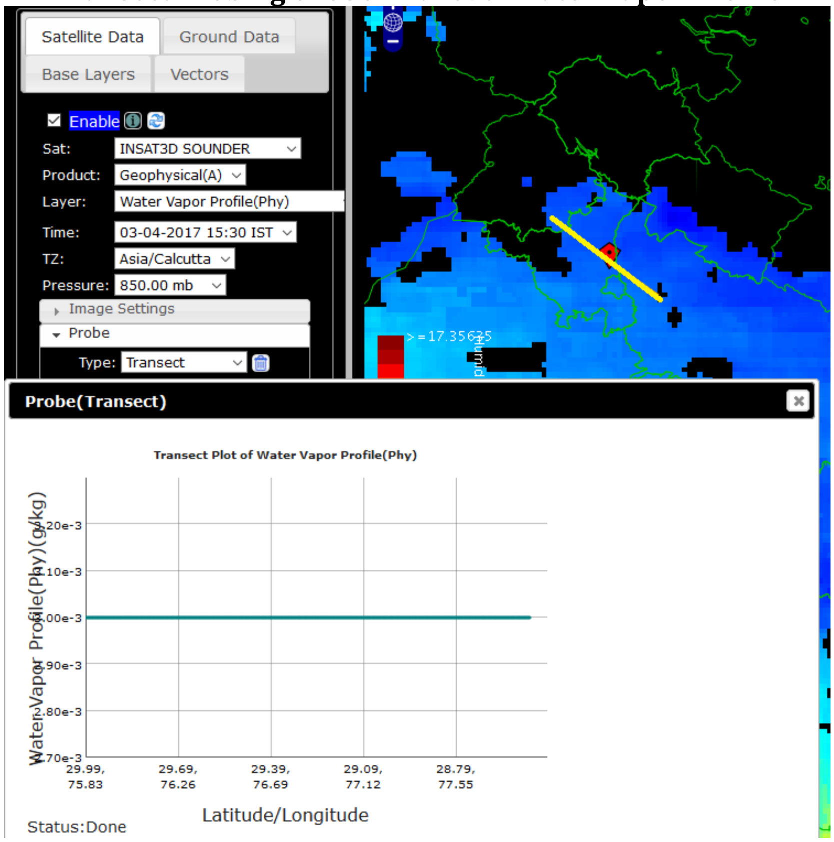
Point Probing of 850 hPa level Water Vapor Profile



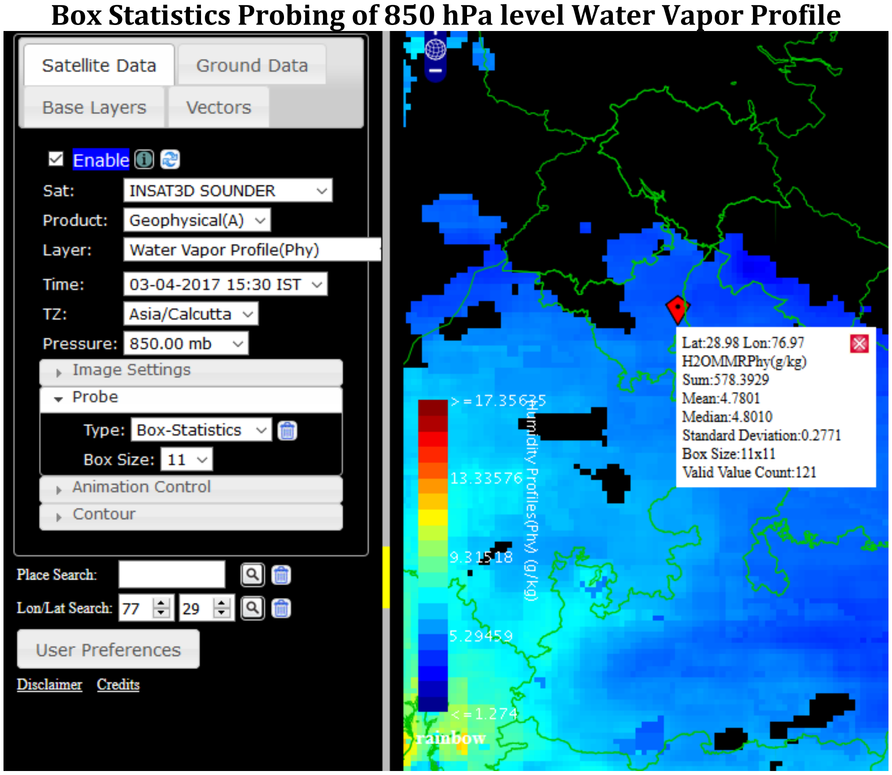
Time Series Probing of 850 hPa level Water Vapor Profile



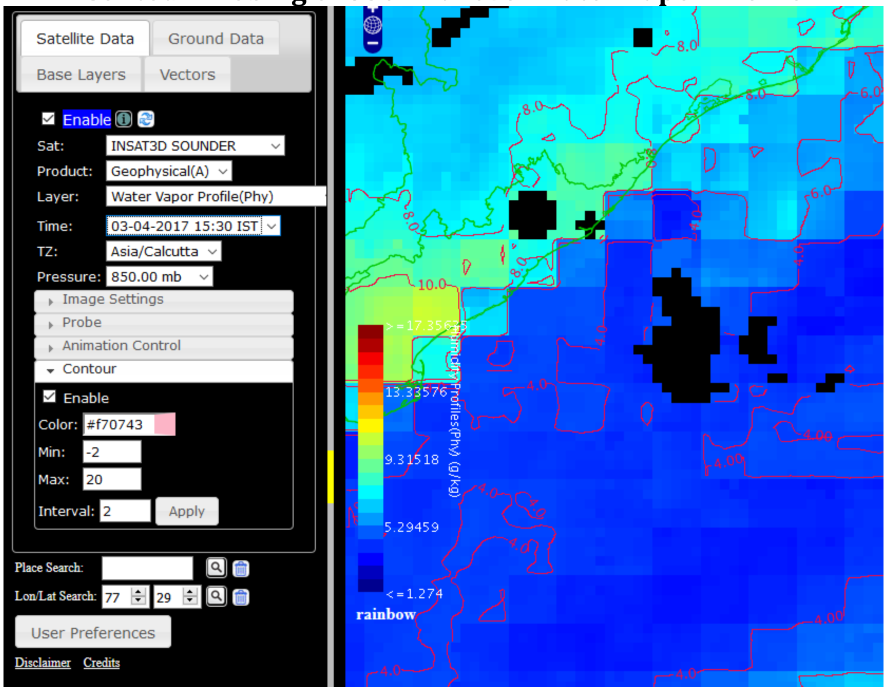
Transect Probing of 850 hPa level Water Vapor Profile



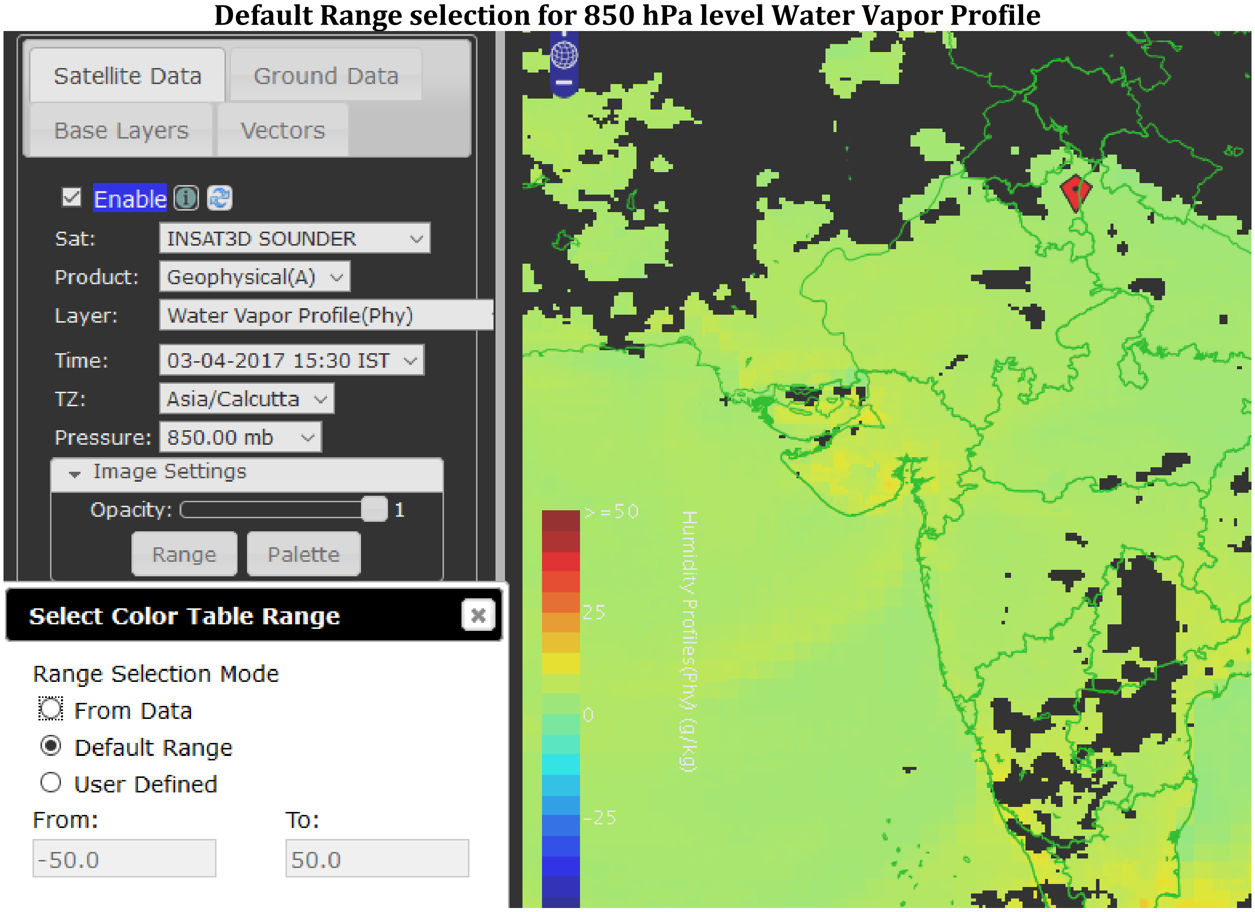
Box Statistics Probing of 850 hPa level Water Vapor Profile



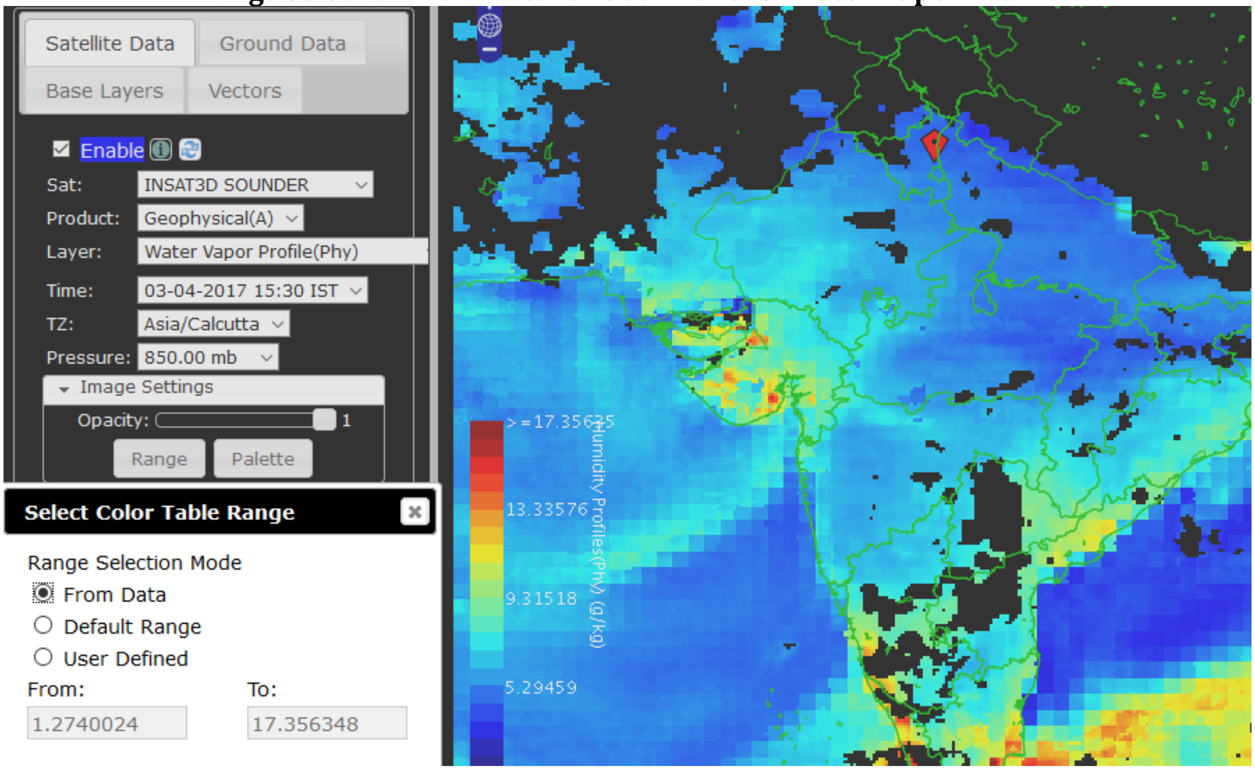
Contour Probing of 850 hPa level Water Vapor Profile



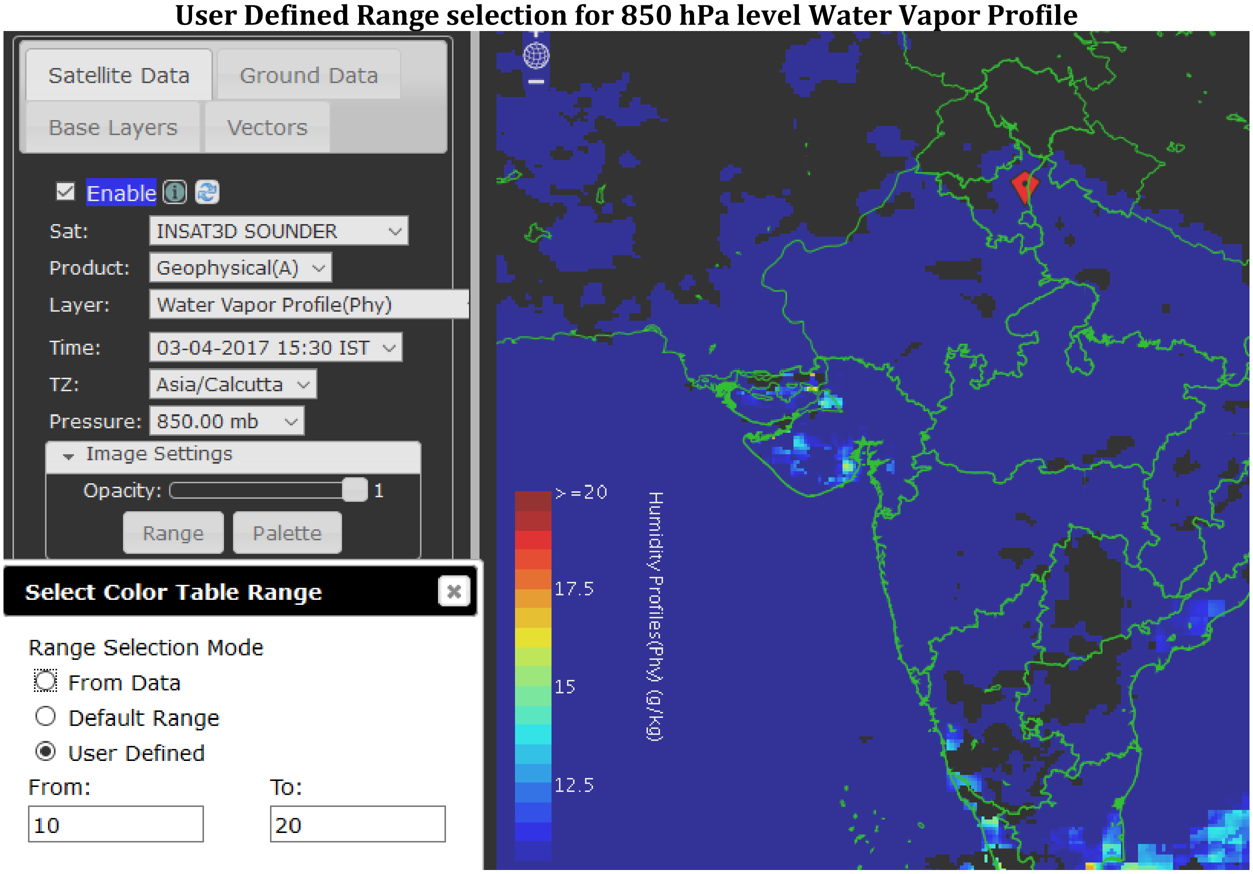
Default Range selection for 850 hPa level Water Vapor Profile



Range selection from Data for 850 hPa level Water Vapor Profile



User Defined Range selection for 850 hPa level Water Vapor Profile



3. L1 Precipitable Water: Precipitable water is the depth of water in a column of the atmosphere, if all the water in that column were precipitated as rain. As a depth, the Precipitable water is measured in millimeters or inches. Layer Precipitable water may be computed using the formula

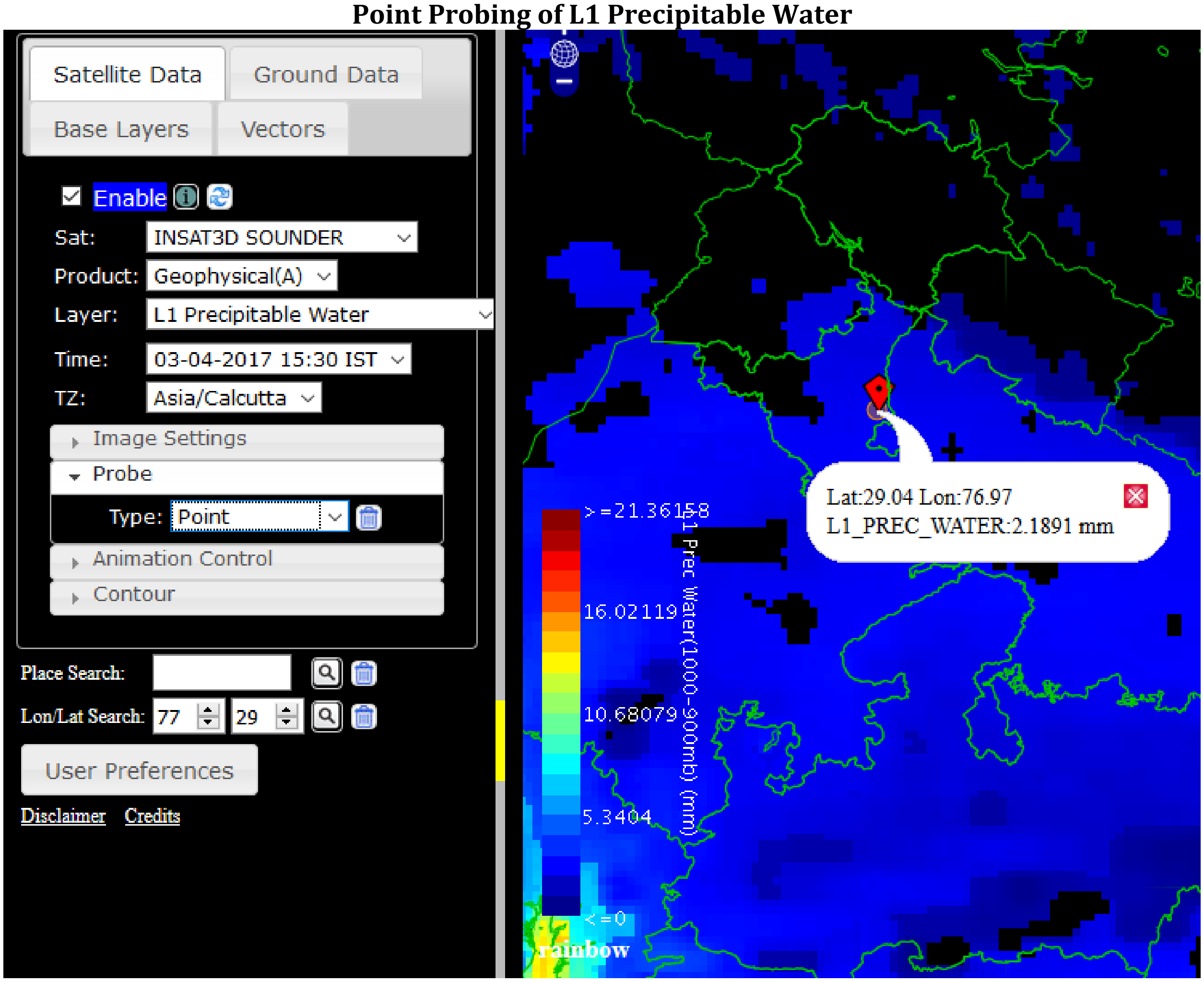
$$^{P1}PW_{P2} \quad q\, dp/g$$

Where p1 and p2 are bounding pressures of each layer in Pa, q – specific humidity in Kg/Kg. Total Precipitable water is also computed from the same formula with p1 as surface pressure and p2 as top of the atmosphere pressure (i.e. about 100 hPa beyond which water vapor amount is assumed to be in negligible). Unit of Precipitable water is mm depth of equal amount of liquid water above a surface of one square meter (if pressure is in Pa and specific humidity is in Kg/Kg).

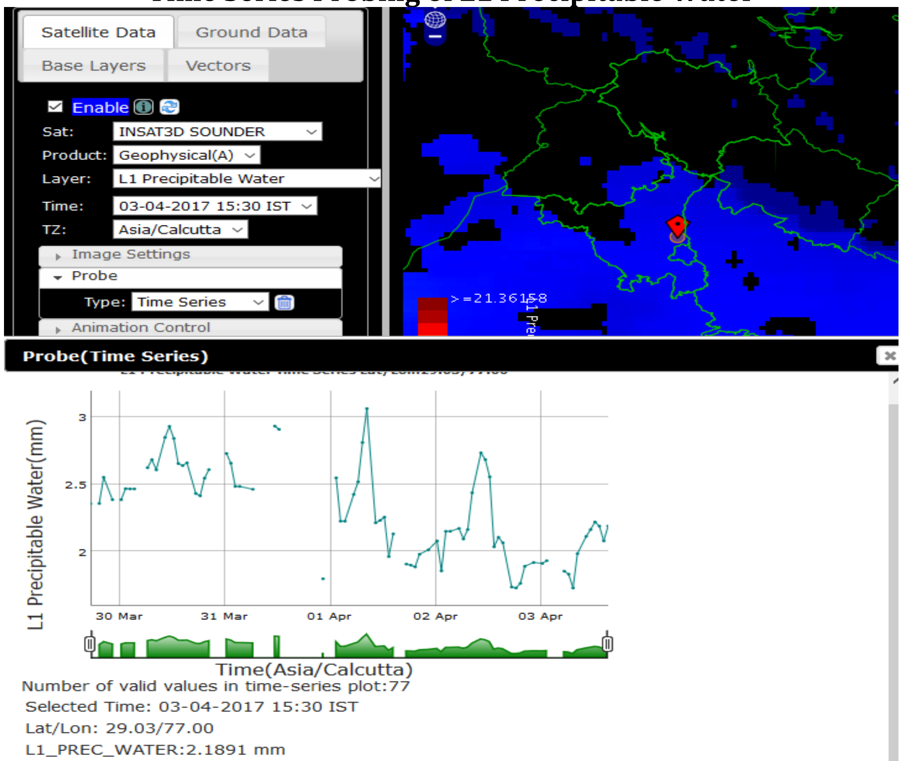
Use: Layer & Total Precipitable water products can provide details about tropical cyclone structure, e.g. Asymmetries and moisture gradients that aid in interpreting tropical cyclones interaction with dry/moist air.

L1 corresponds to the Layer1 i.e. from 1000hPa to 900hPa. The various probing options are shown below:

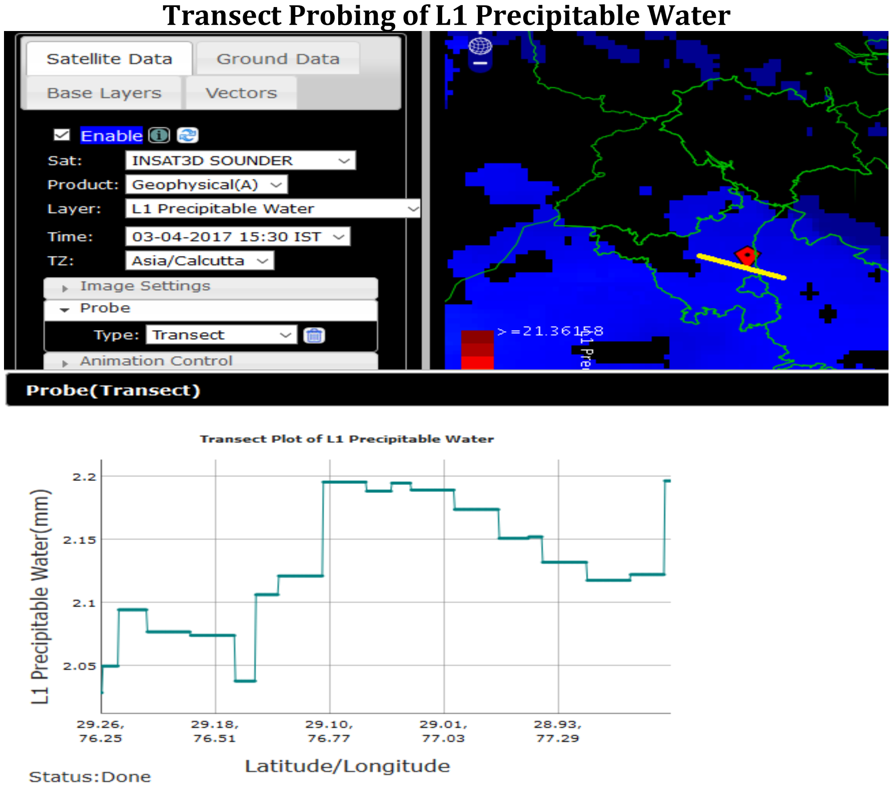
Point Probing of L1 Precipitable Water



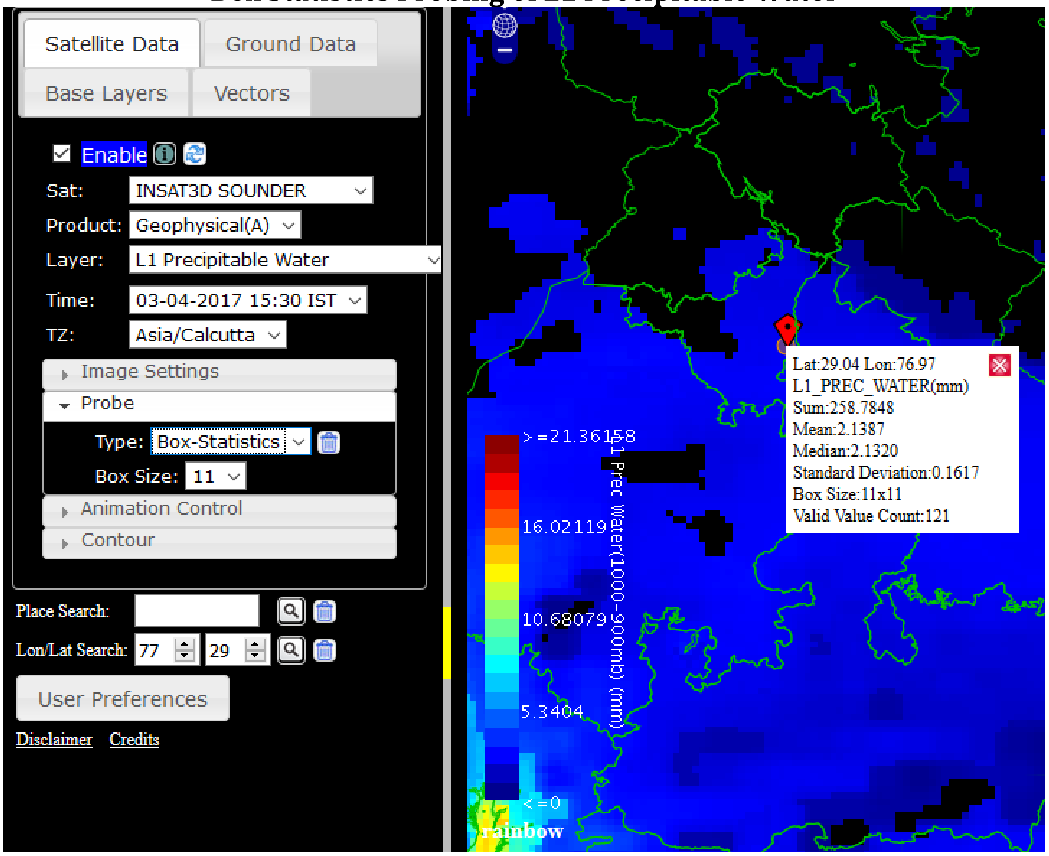
Time Series Probing of L1 Precipitable Water



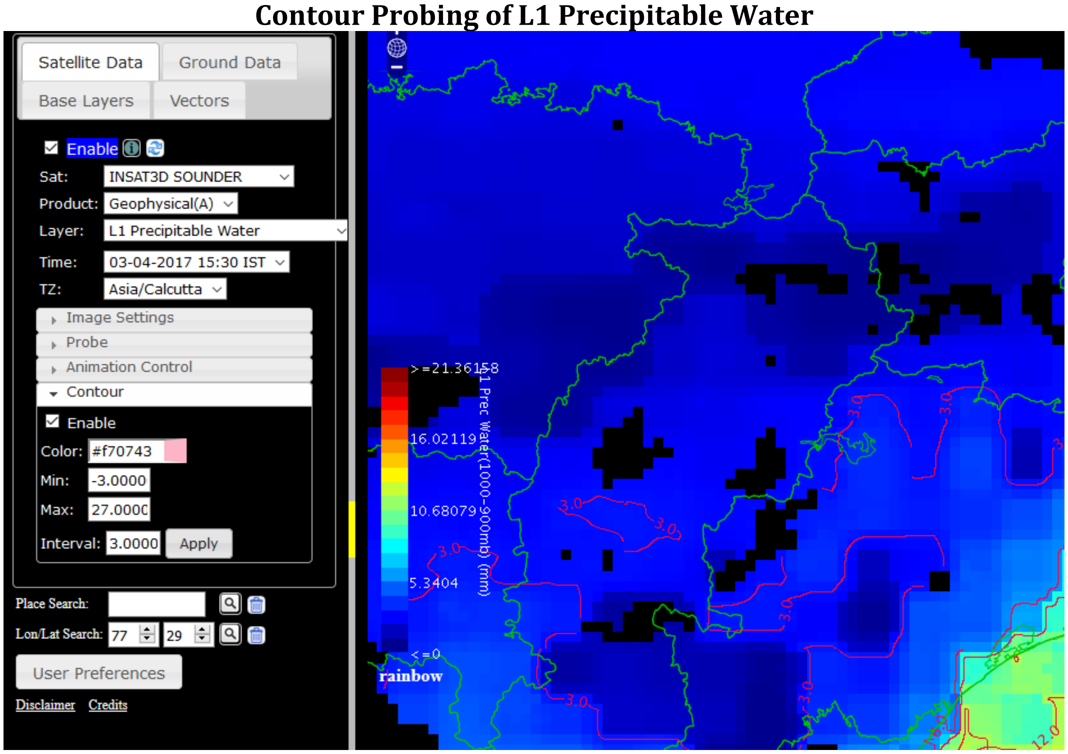
Transect Probing of L1 Precipitable Water



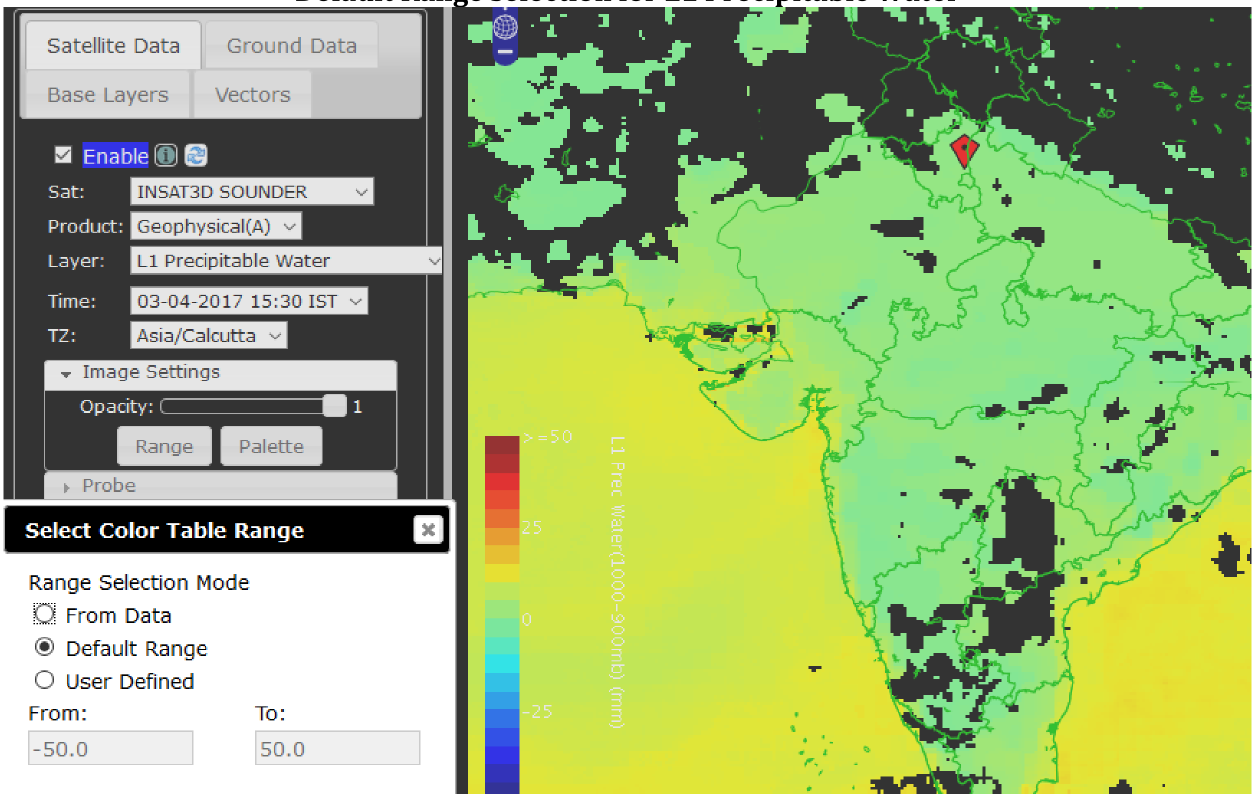
Box Statistics Probing of L1 Precipitable Water



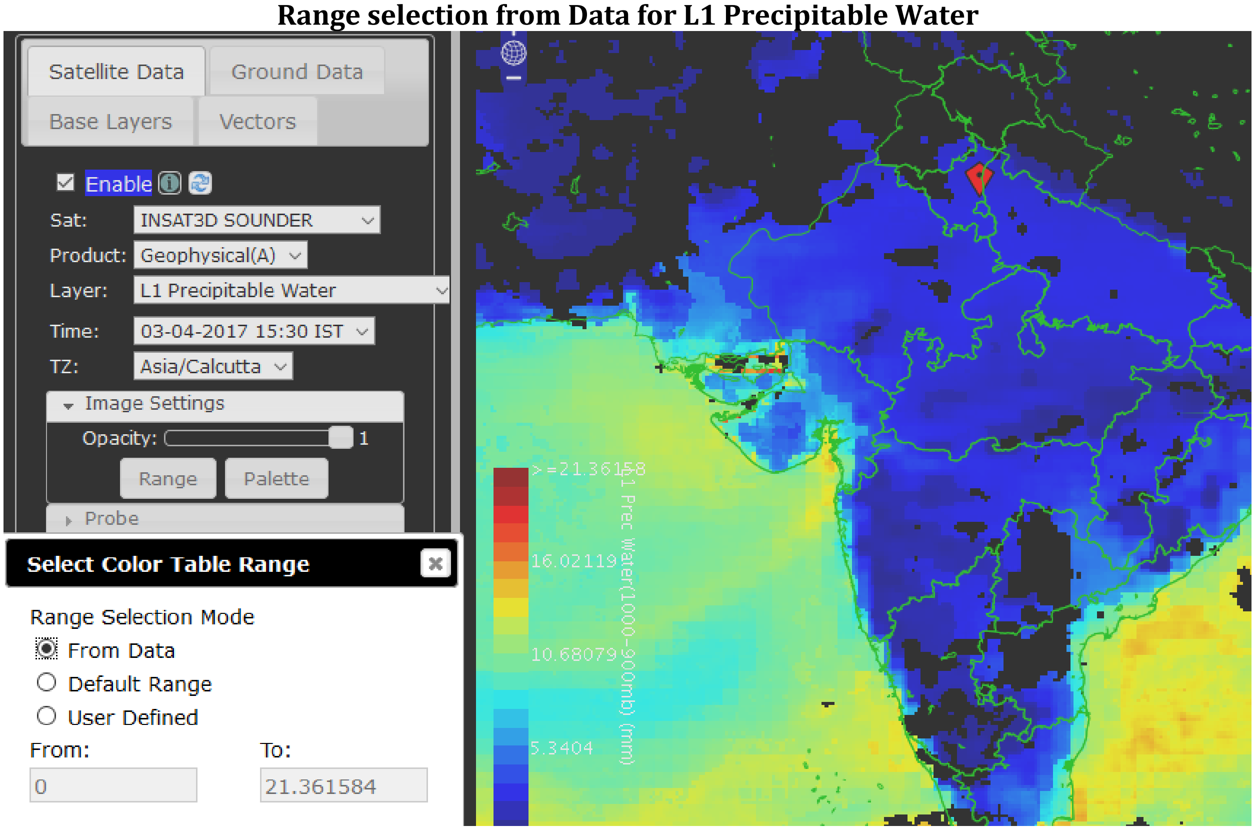
Contour Probing of L1 Precipitable Water



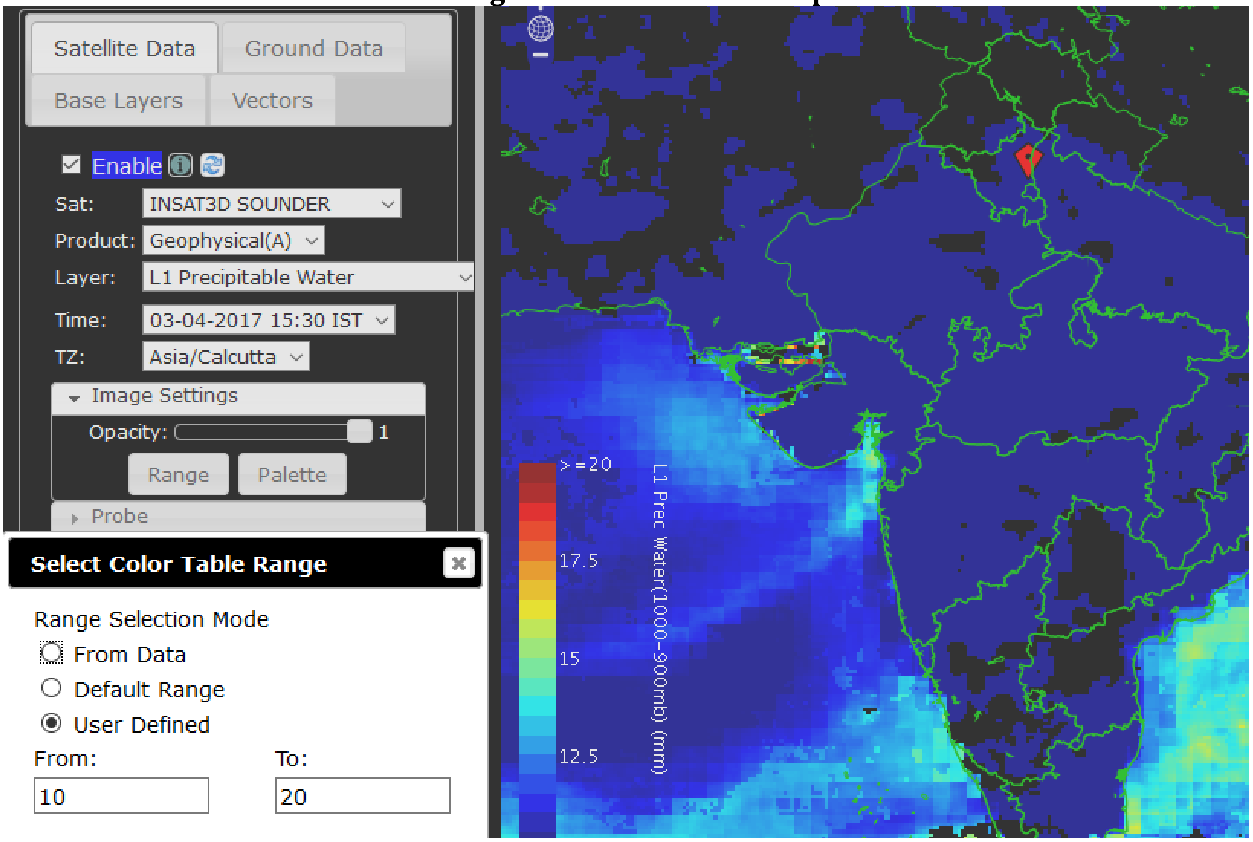
Default Range selection for L1 Precipitable Water



Range selection from Data for L1 Precipitable Water

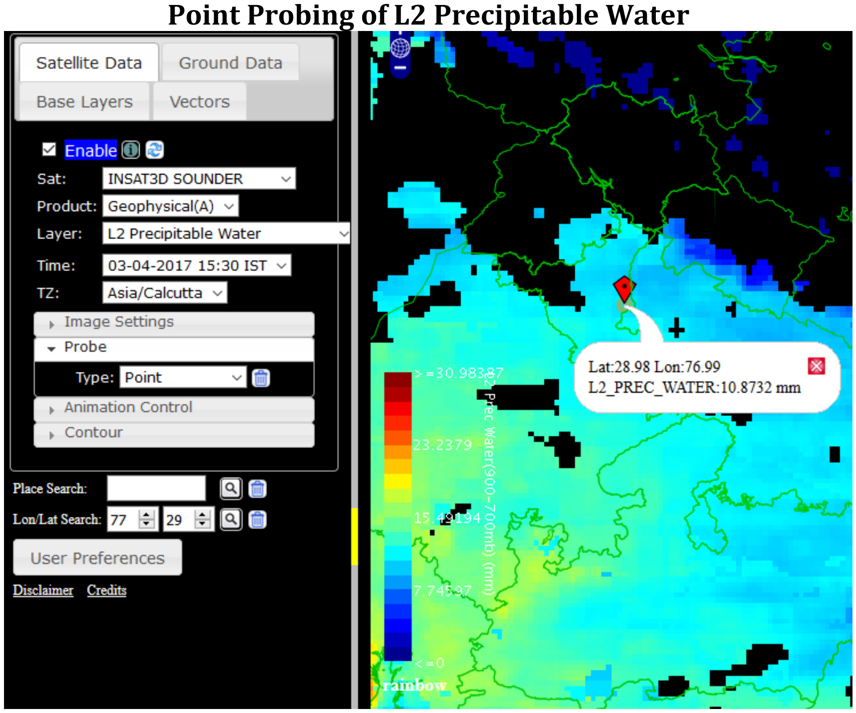


User Defined Range selection for L1 Precipitable Water

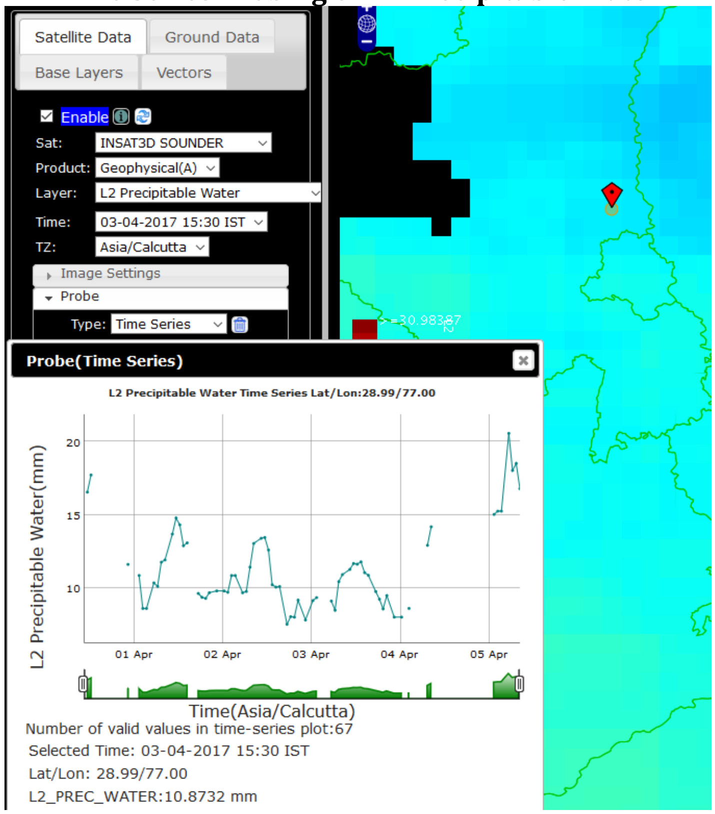


4. L2 Precipitable Water: L2 corresponds to the Layer1 i.e. from 900hPa to 700hPa.

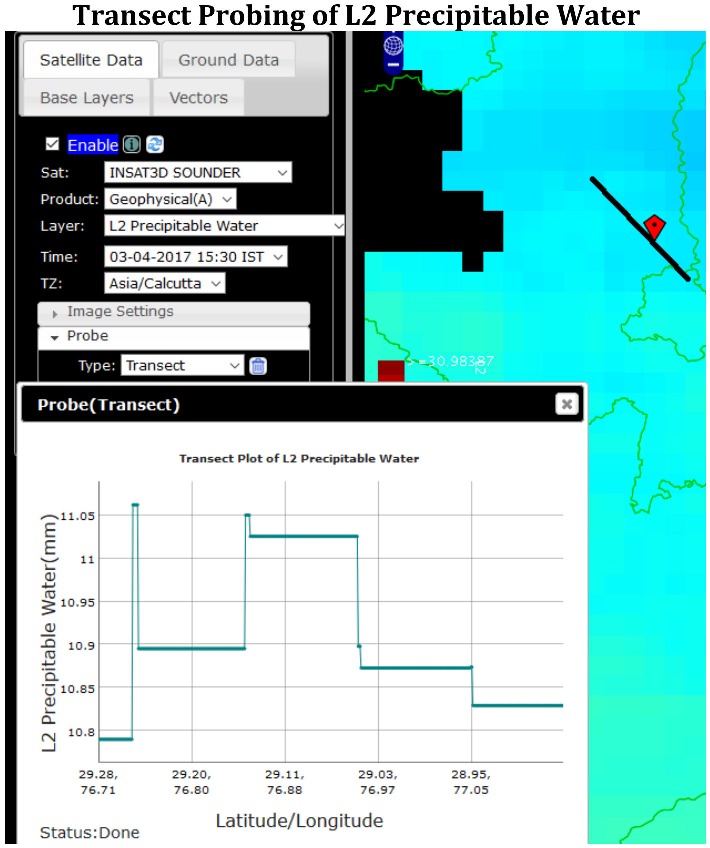
Point Probing of L2 Precipitable Water



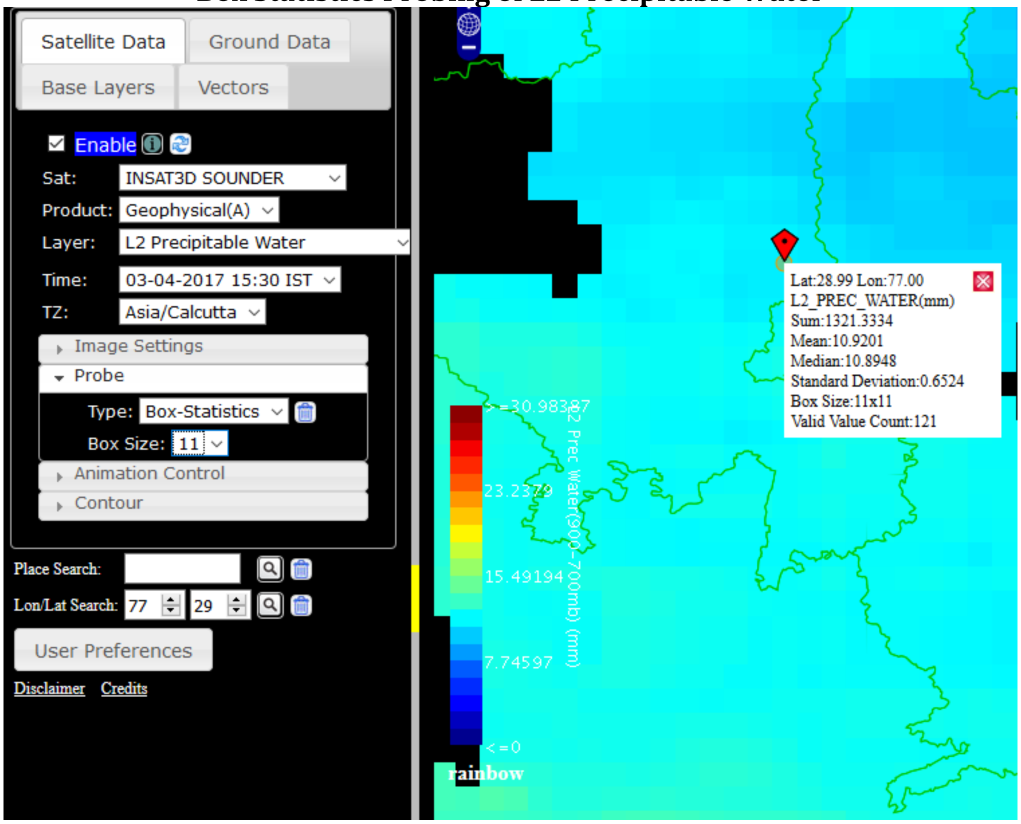
Time Series Probing of L2 Precipitable Water



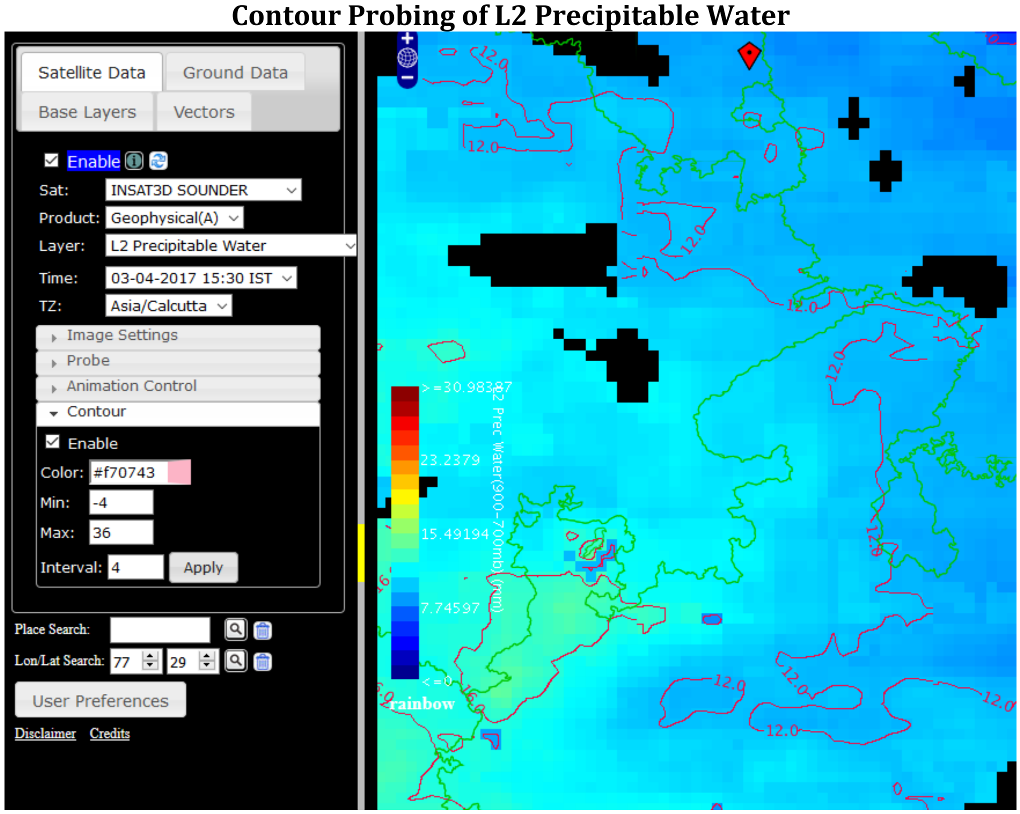
Transect Probing of L2 Precipitable Water



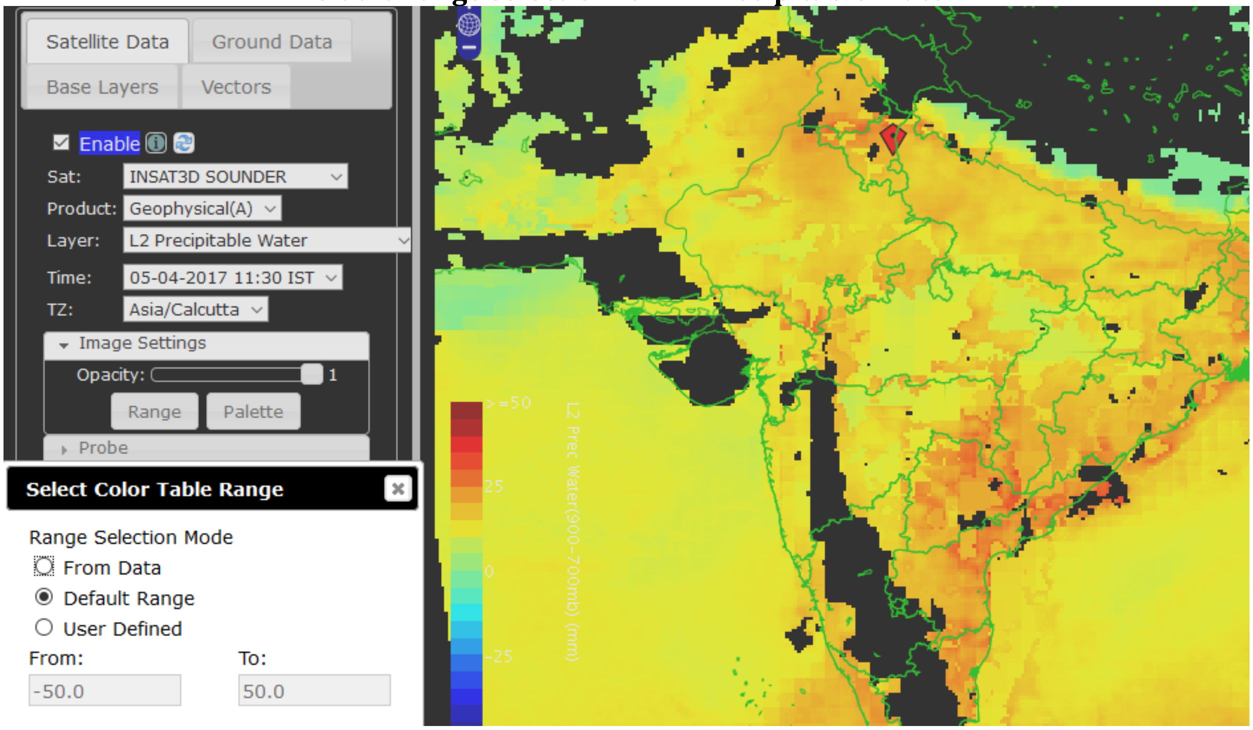
Box Statistics Probing of L2 Precipitable Water



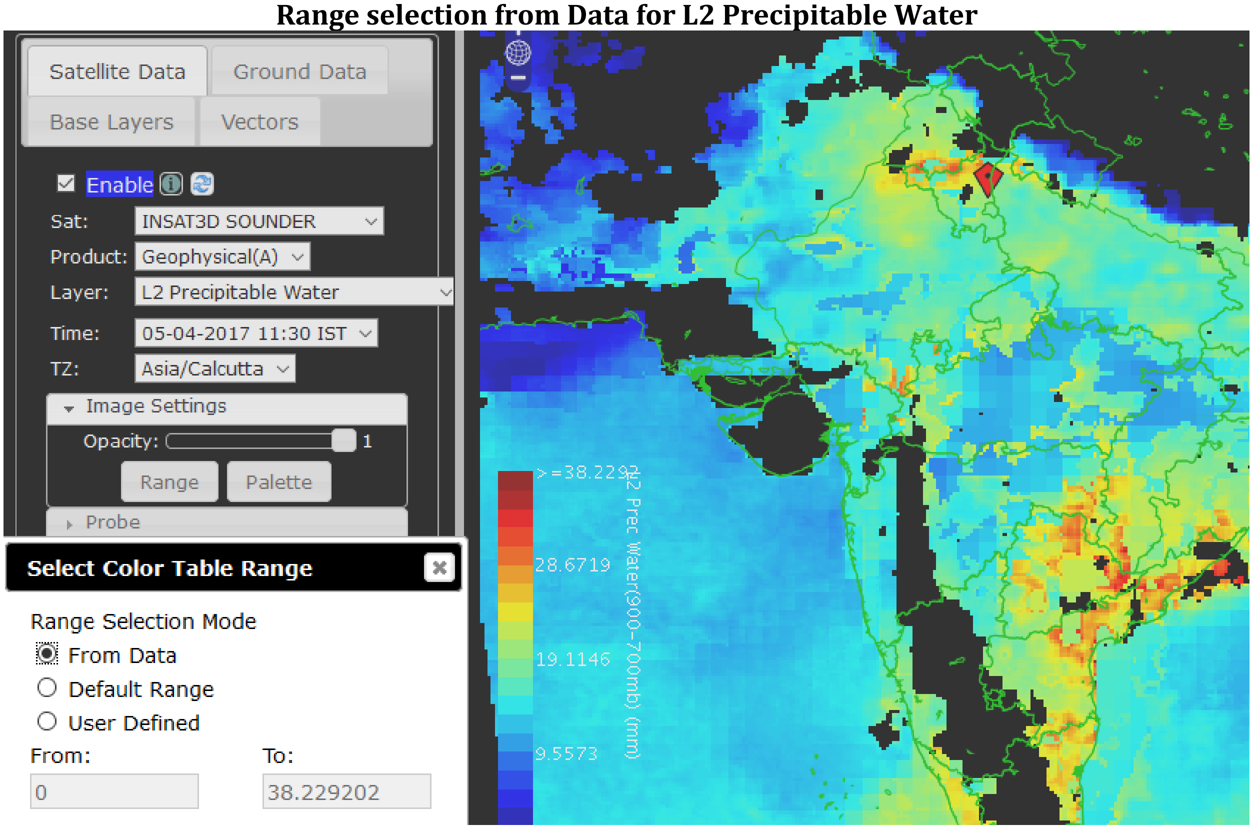
Contour Probing of L2 Precipitable Water



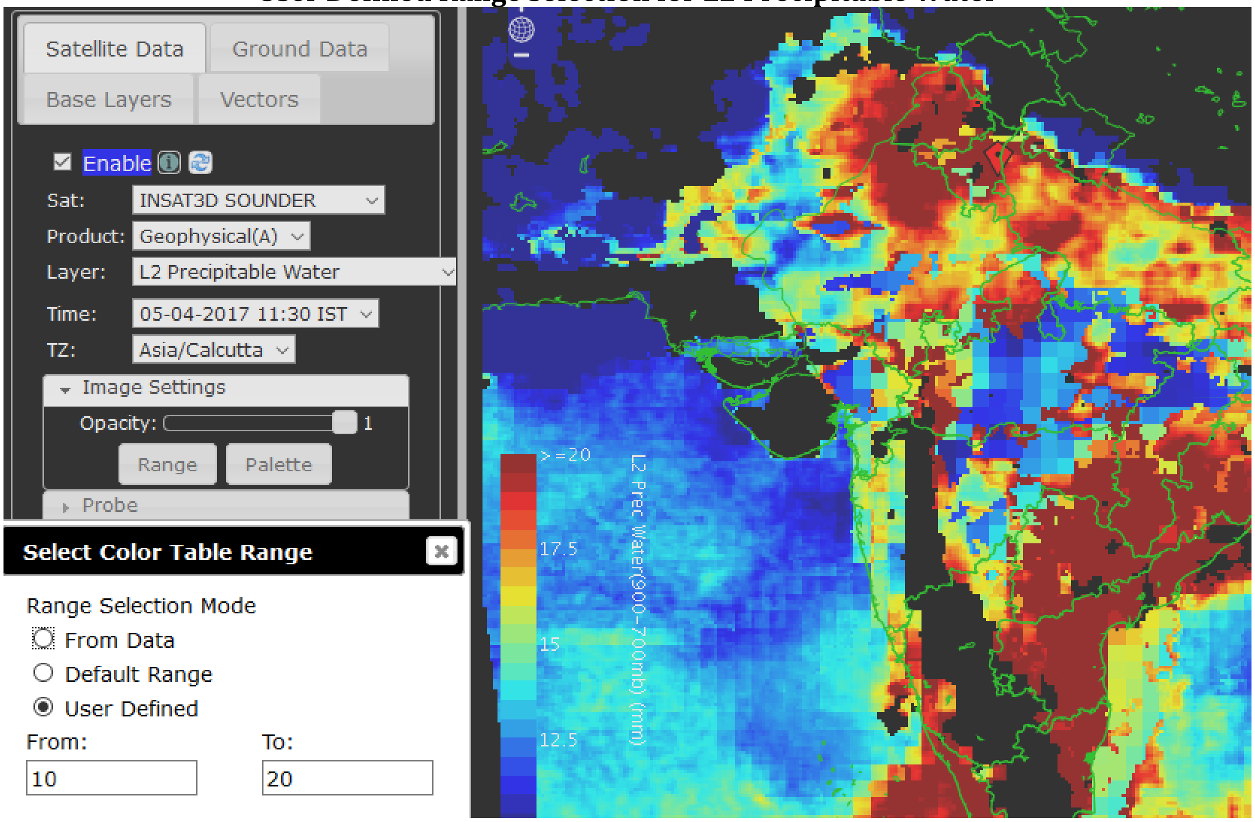
Default Range selection for L2 Precipitable Water



Range selection from Data for L2 Precipitable Water

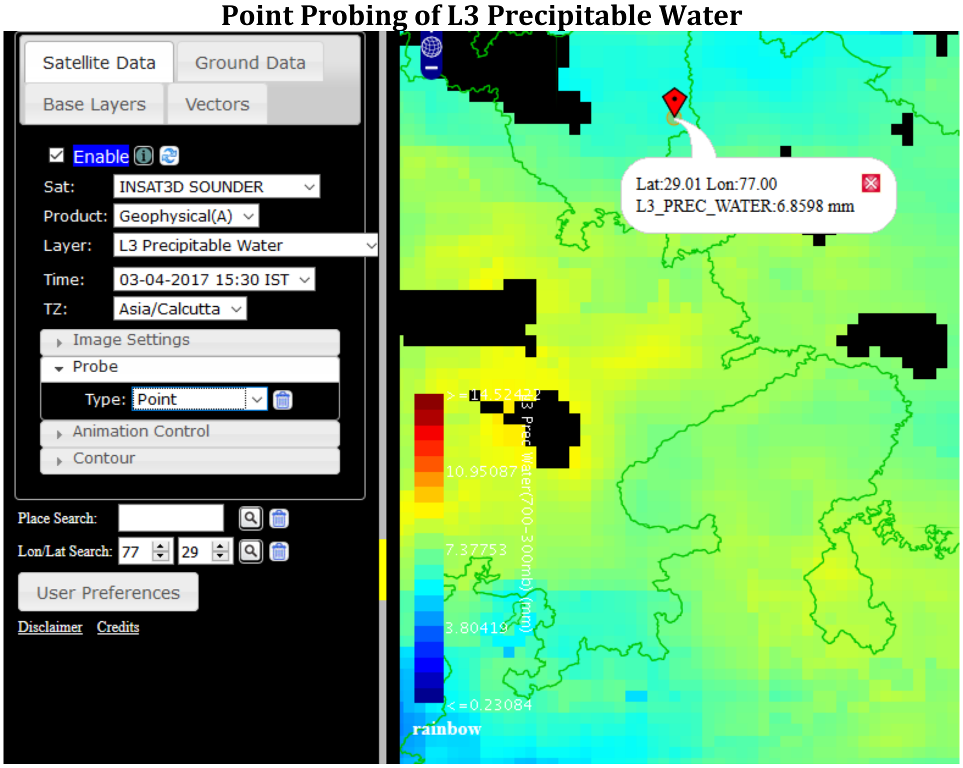


User Defined Range selection for L2 Precipitable Water

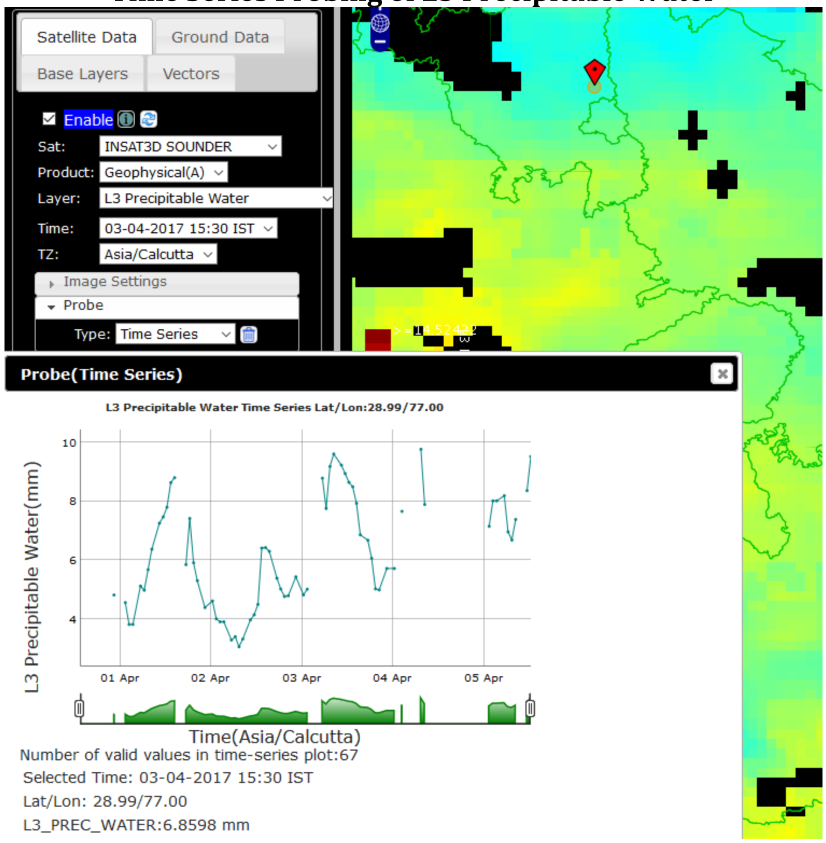


5. L3 Precipitable Water: **L3 corresponds to the Layer1 i.e. from 700hPa to 300hPa**. The various probing options are shown below:

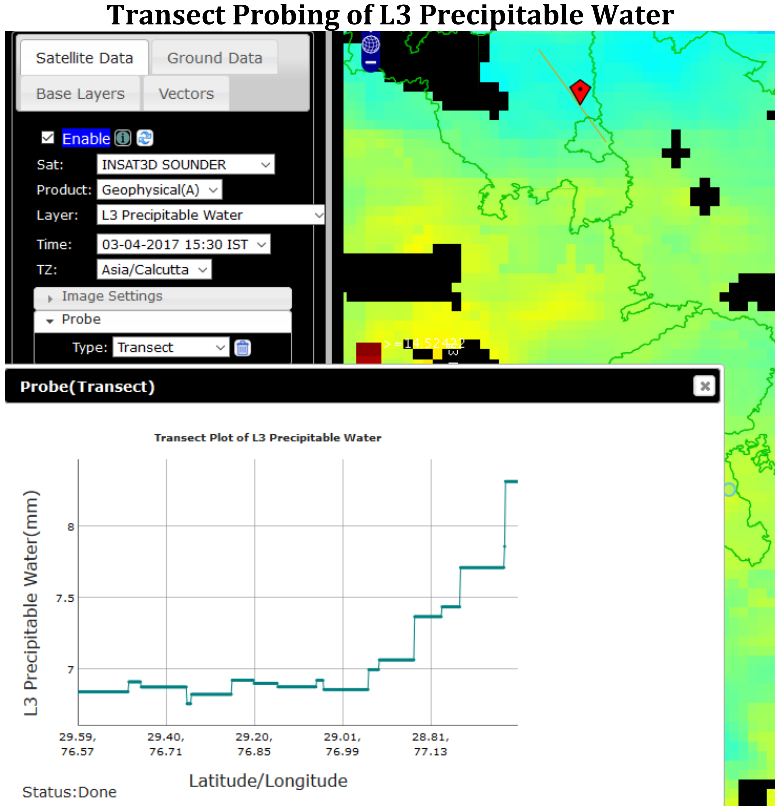
Point Probing of L3 Precipitable Water



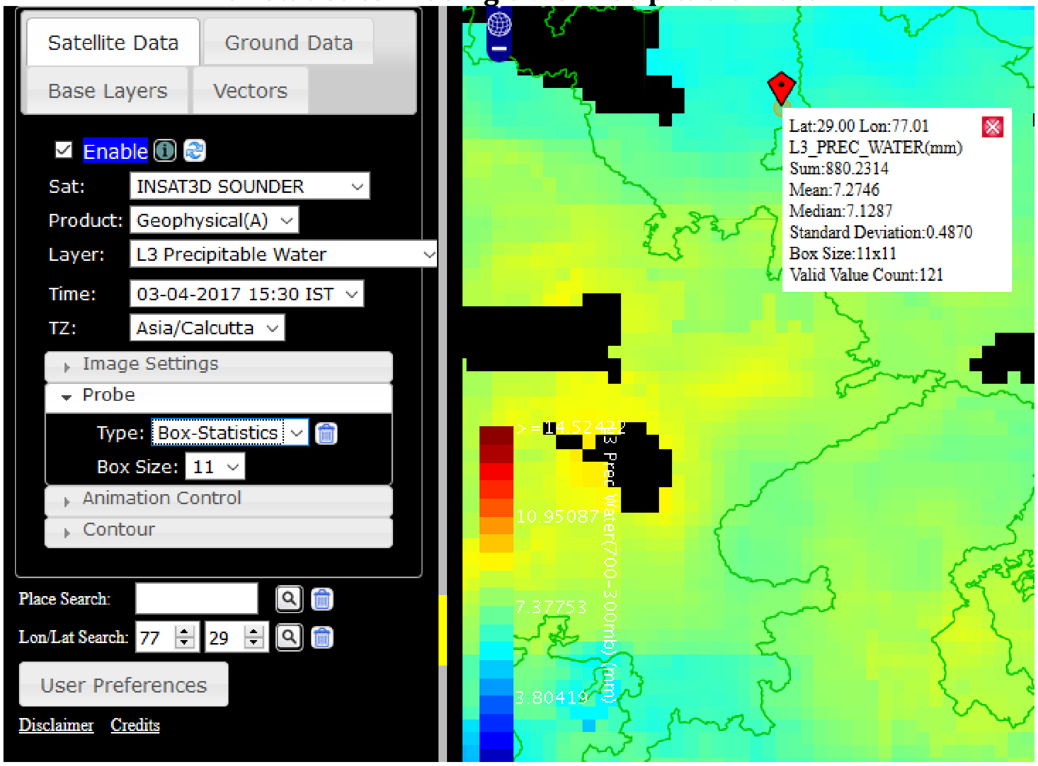
Time Series Probing of L3 Precipitable Water



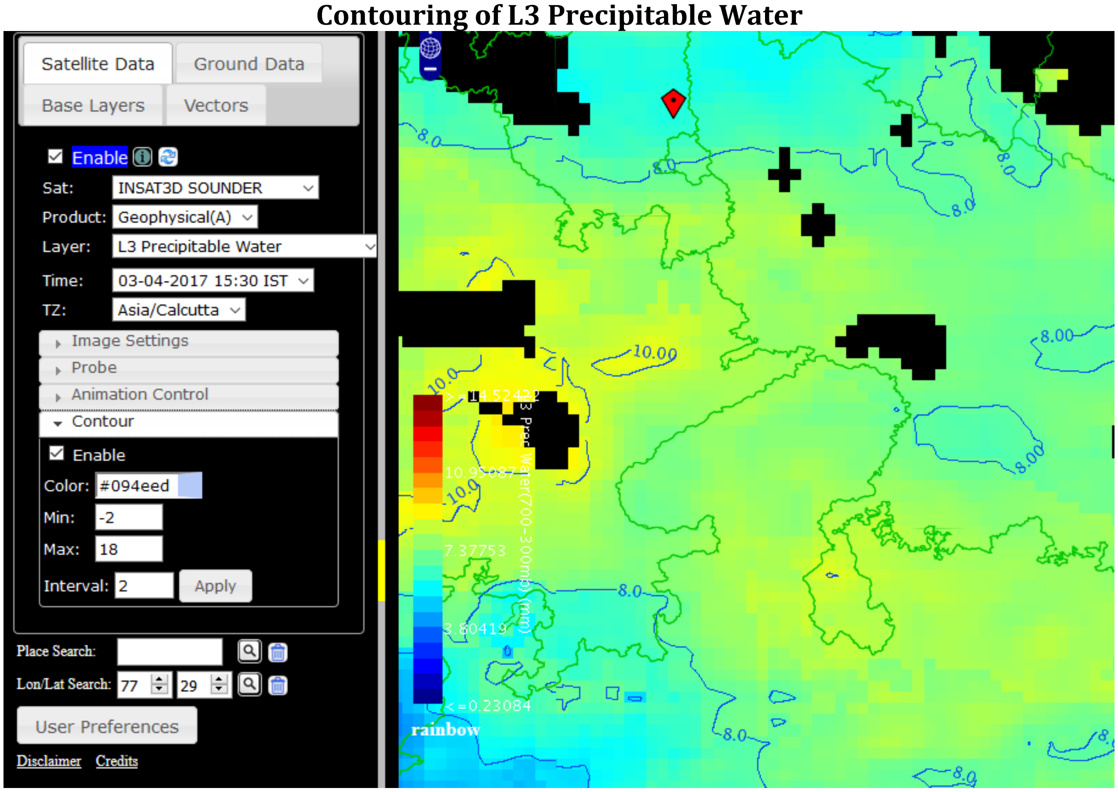
Transect Probing of L3 Precipitable Water



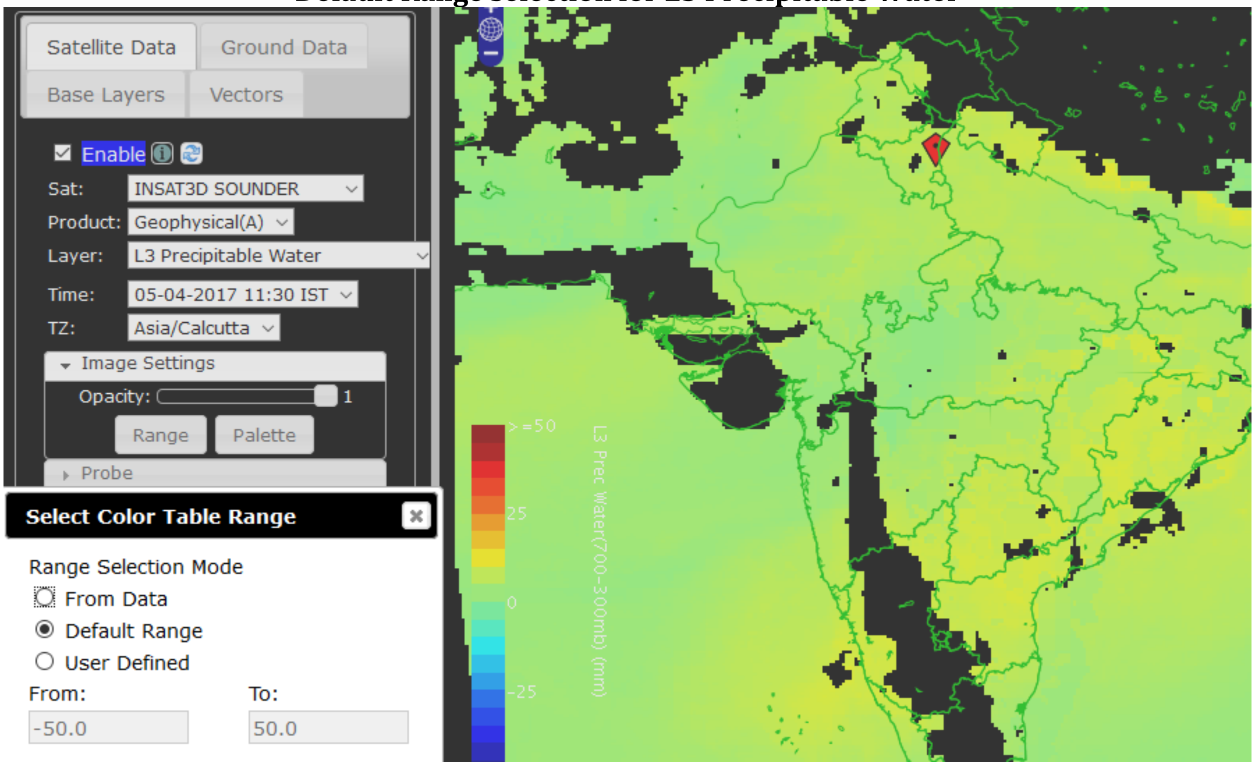
Box Statistics Probing of L3 Precipitable Water



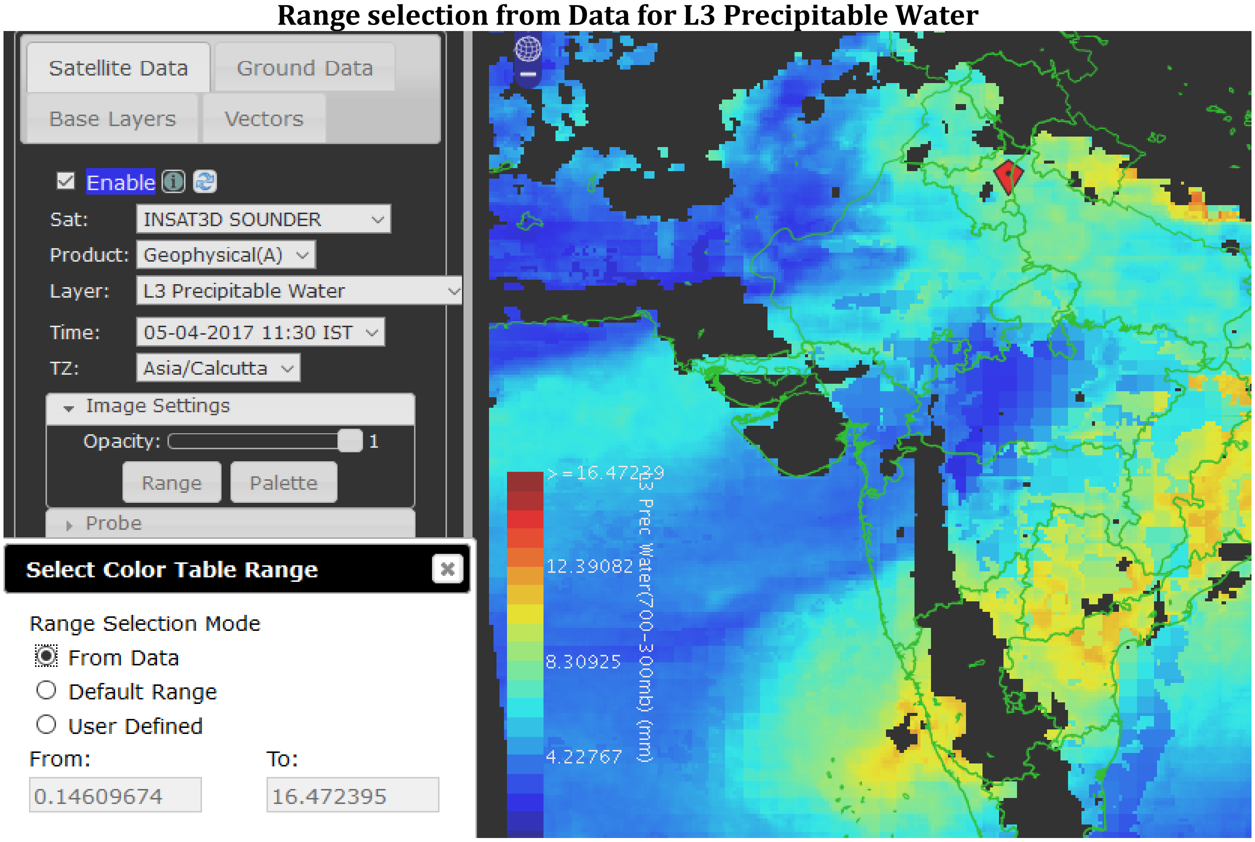
Contouring of L3 Precipitable Water



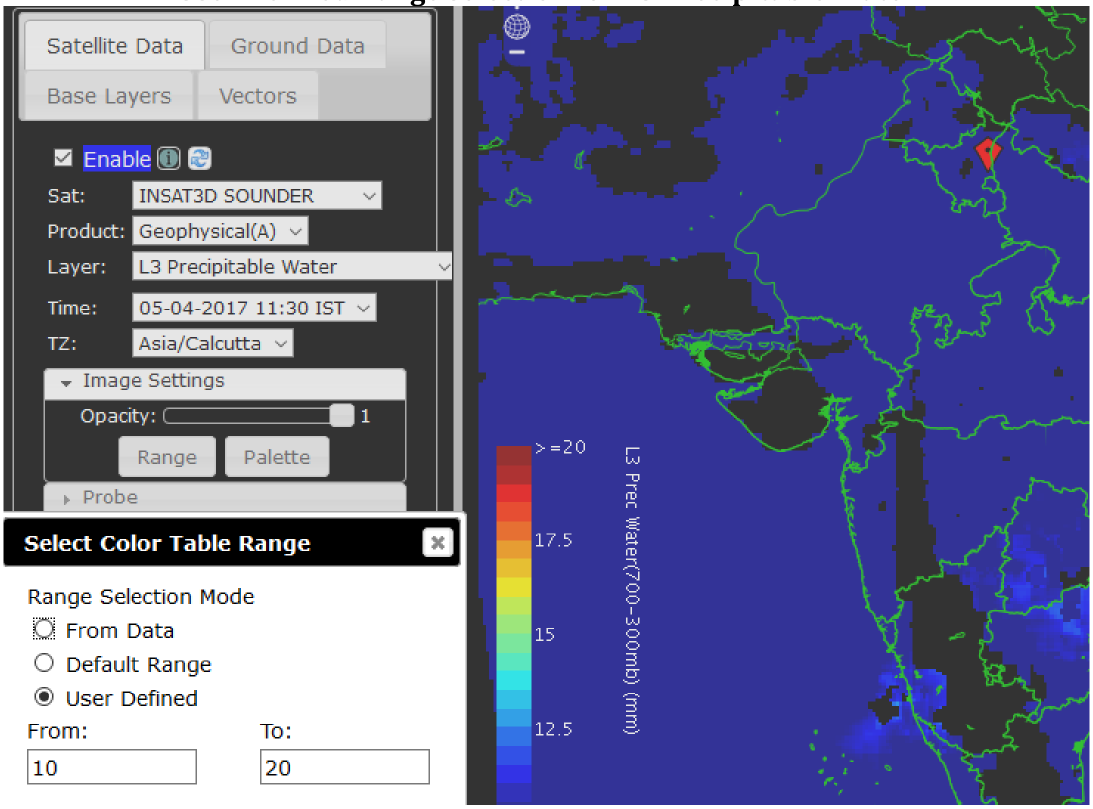
Default Range selection for L3 Precipitable Water



Range selection from Data for L3 Precipitable Water



User Defined Range selection for L3 Precipitable Water



6. Lifted Index: LI (Lifted Index) is an indice used to assess low level parcel instability of the troposphere. LI can be computed using computer algorithms but can also be determined graphically. To do this, generally, the parcel is lifted from the portion of the planetary boundary layer (PBL) that lies below the morning inversion. The air here should be about 60 to 65%RH, which is then lifted along the dry adiabat to the lifting condensation level (LCL), which is the intersection of that curve with the average mixing ratio in the boundary layer. Once the LCL is found, the parcel is lifted along the moist adiabat to 500 mb. It is then that one finds

$$\mathbf{LI = Te(p) - Tp(p).}$$

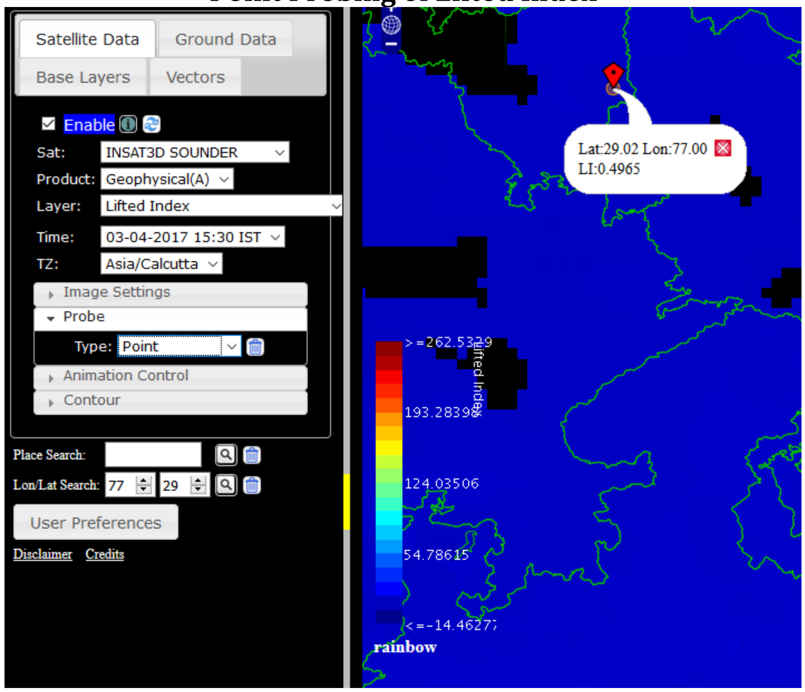
LI is generally scaled as follows:

- LI 6 or Greater, Very Stable Conditions
- LI Between 1 and 6: Stable Conditions, Thunderstorms Not Likely
- LI Between 0 and -2: Slightly Unstable, Thunderstorms Possible, With Lifting Mechanism (i.e., cold front, daytime heating, ...)
- LI Between -2 and -6: Unstable, Thunderstorms Likely, Some Severe With Lifting Mechanism
- LI Less Than -6: Very Unstable, Severe Thunderstorms Likely with Lifting Mechanism

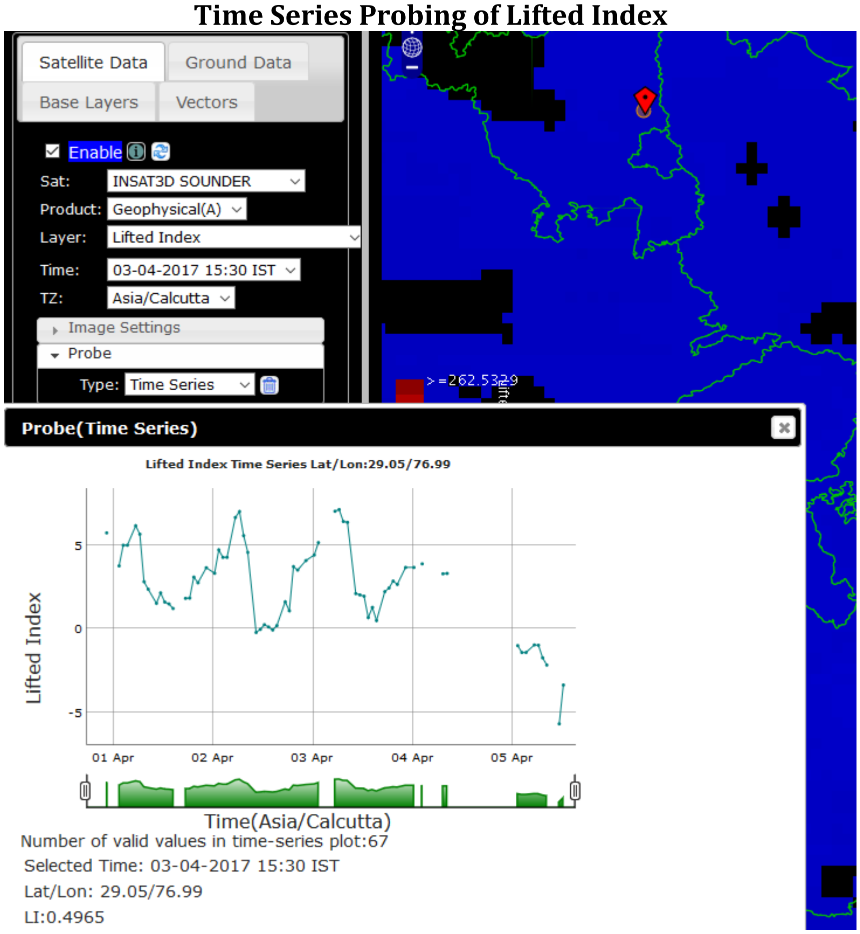
Use: Time series of geographical pattern of LI may be monitored to large scale convective activity and its relation to synoptic circulation systems.

The various probing options are shown below:

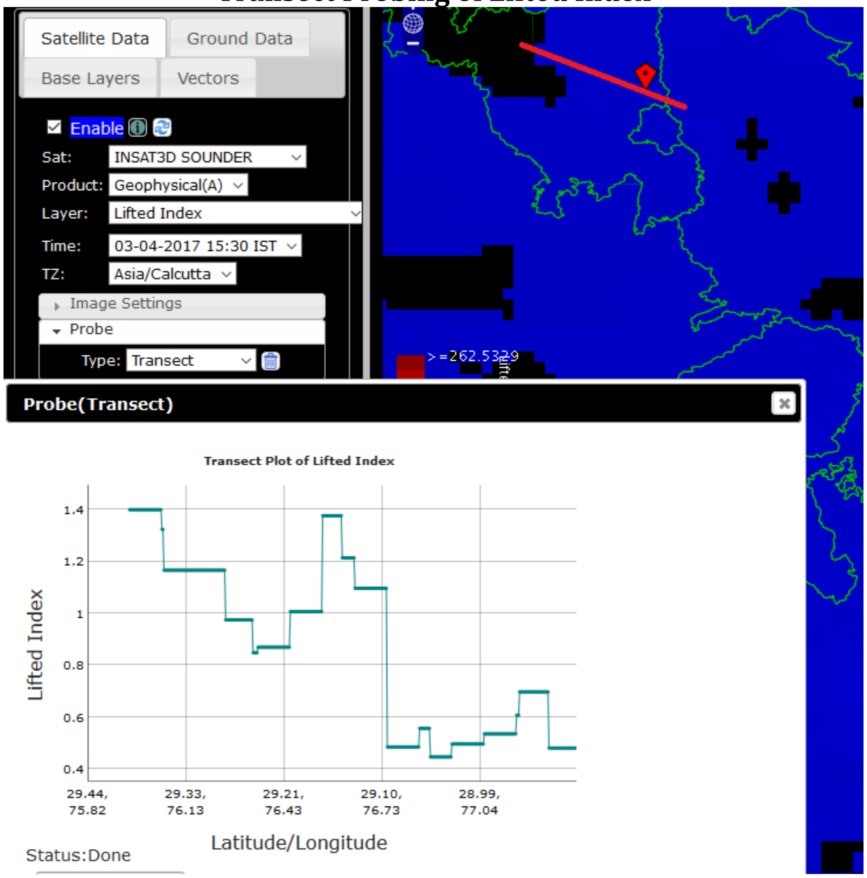
Point Probing of Lifted Index



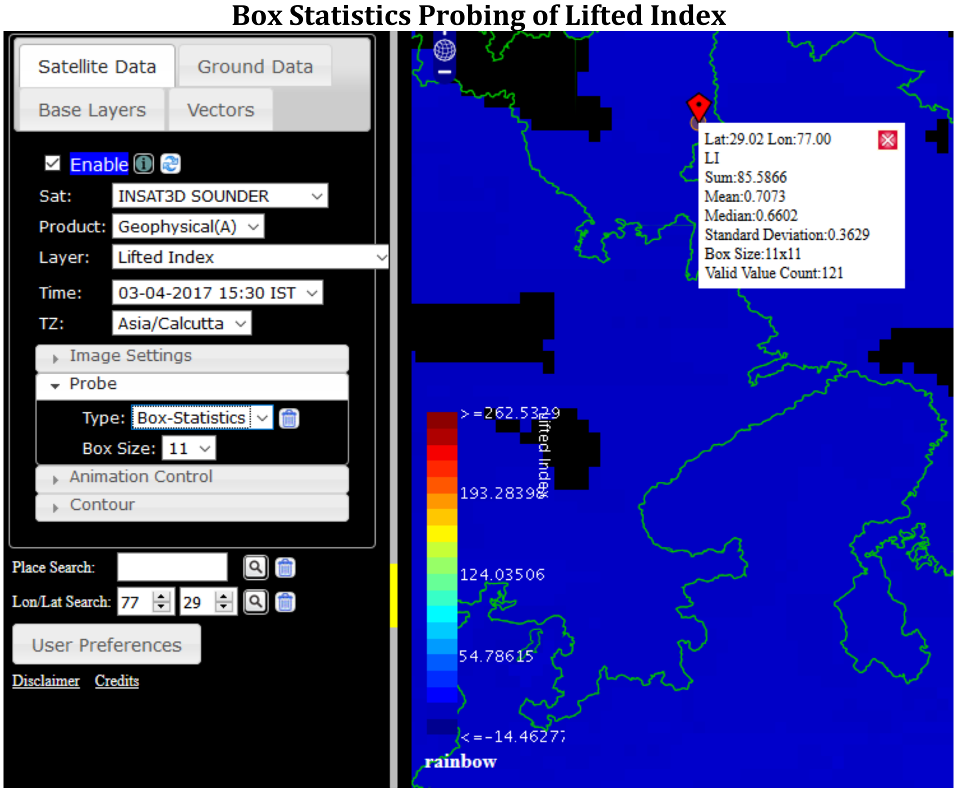
Time Series Probing of Lifted Index



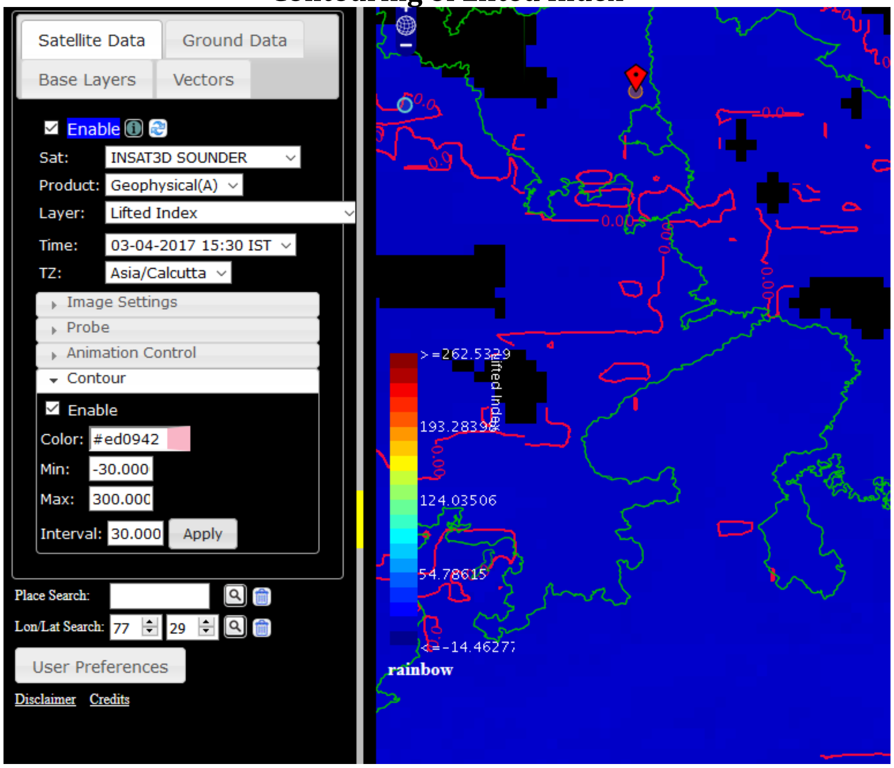
Transect Probing of Lifted Index



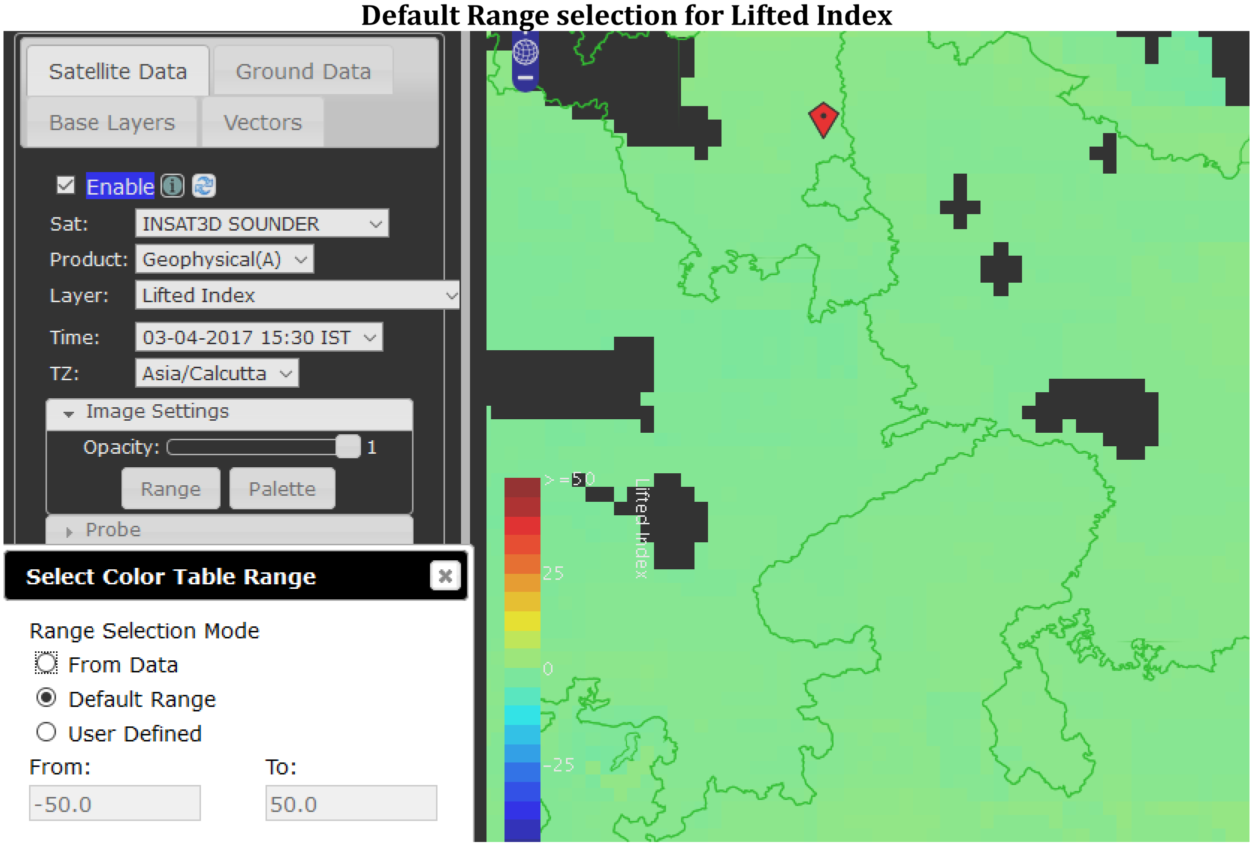
Box Statistics Probing of Lifted Index



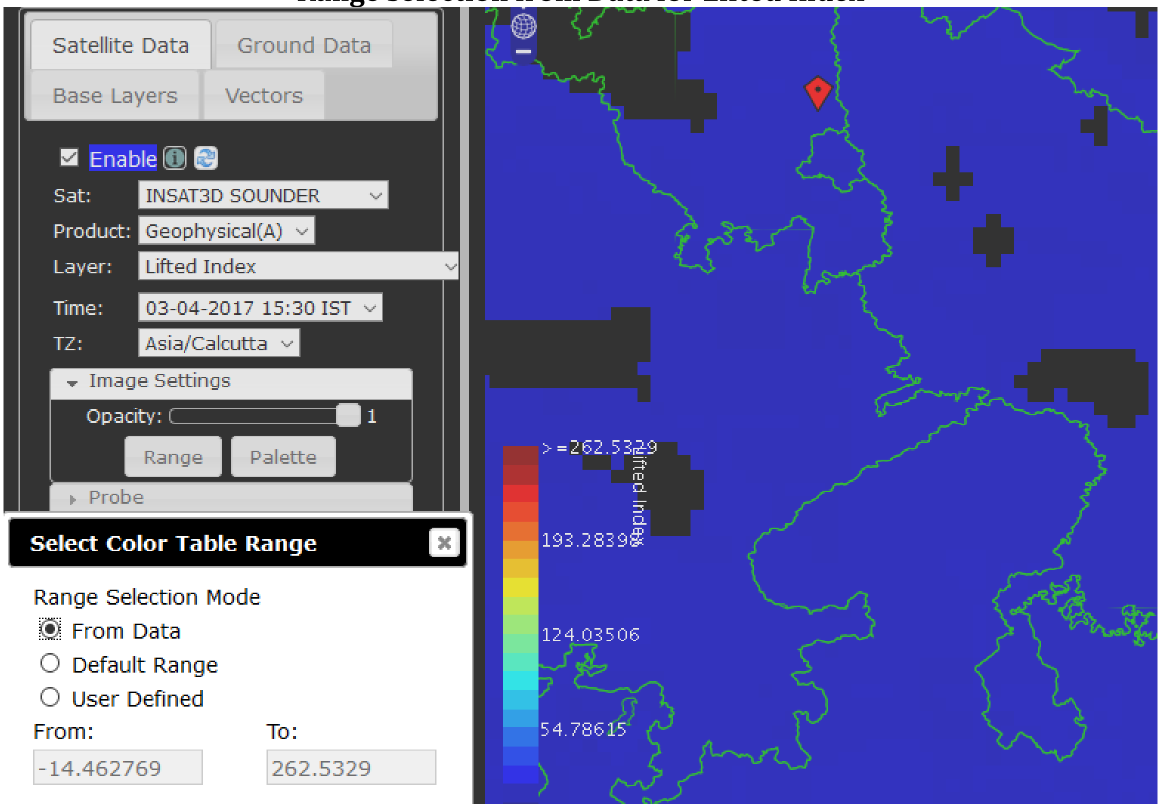
Contouring of Lifted Index



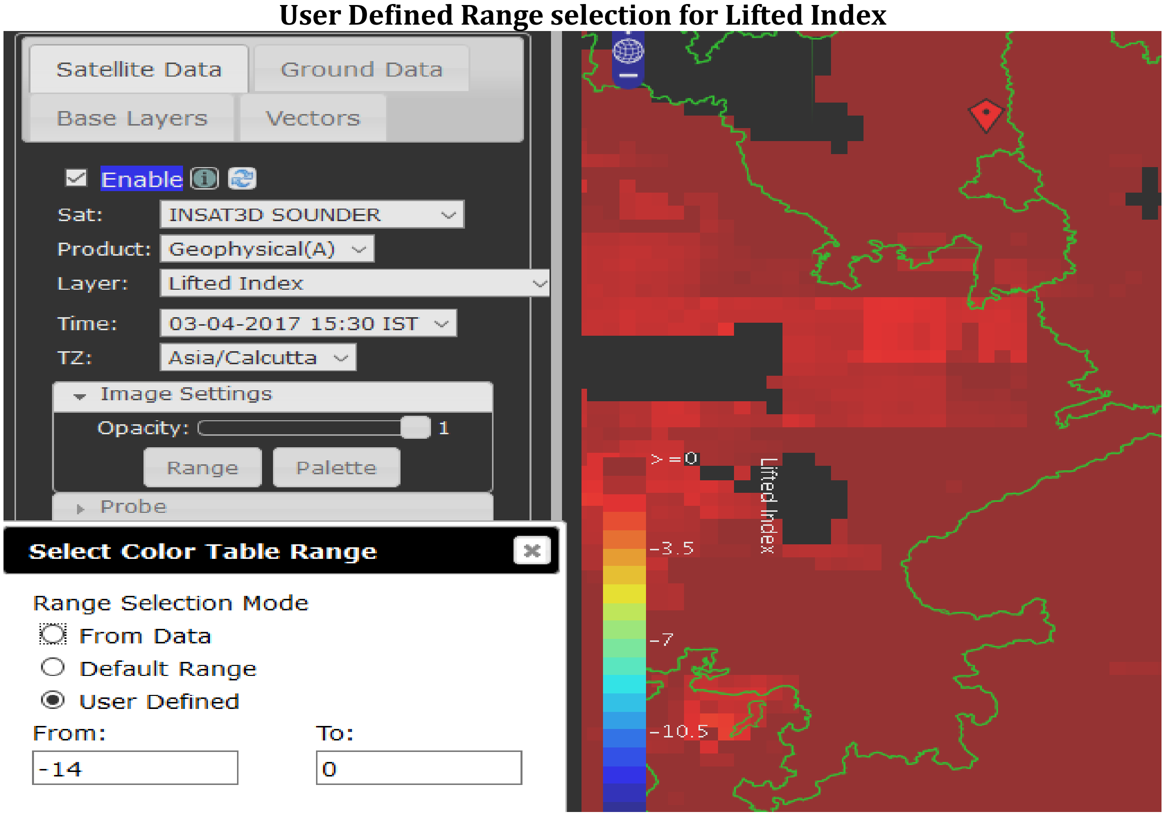
Default Range selection for Lifted Index



Range selection from Data for Lifted Index



User Defined Range selection for Lifted Index



7. Dry Microburst Index: When rain falls below the cloud base or is mixed with dry air, it begins to evaporate and this evaporation process cools the air. The cool air descends and accelerates as it approaches the ground. When the cool air approaches the ground, it spreads out in all directions and this divergence of the wind is the signature of the microburst. Dry microbursts, produced by high based thunderstorms that generate little to no surface rainfall, occur in environments characterized by a thermodynamic profile exhibiting an inverted-V at thermal and moisture profile.

Dry microburst index is generally calculated using the formula,

$$DMI = \Gamma + (T - Td)700 - (T - Td)500$$

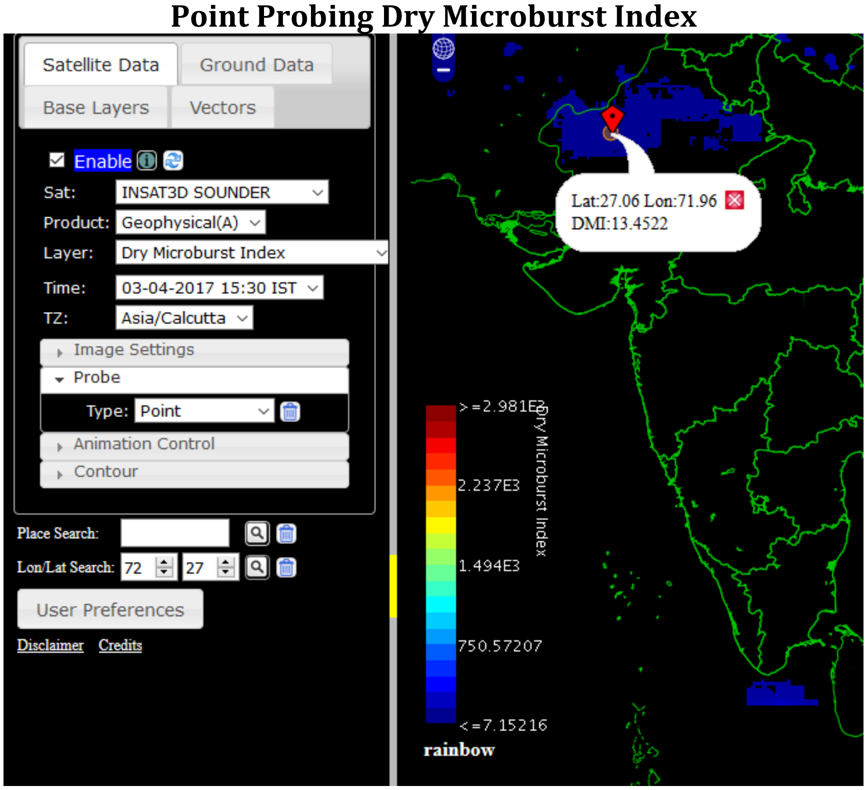
Γ - lapse rate (0C km-1) of the layer from 700 hPa to melting level (i.e. layer at 0o C), T – Temperature (0C), Td – Dew point (0C). Usually DMI is not calculated for any retrieval unless the following three conditions are satisfied:

- Γ > 6 K km-1 (somewhat stable for convective activity)
- (T - Td)700>= 8 K (implies a very dry atmosphere close to surface)
- (T-Td)500<= 8 K (implies some level of saturation at this level) Suitability of these conditions needs to be studied for the Indian region.

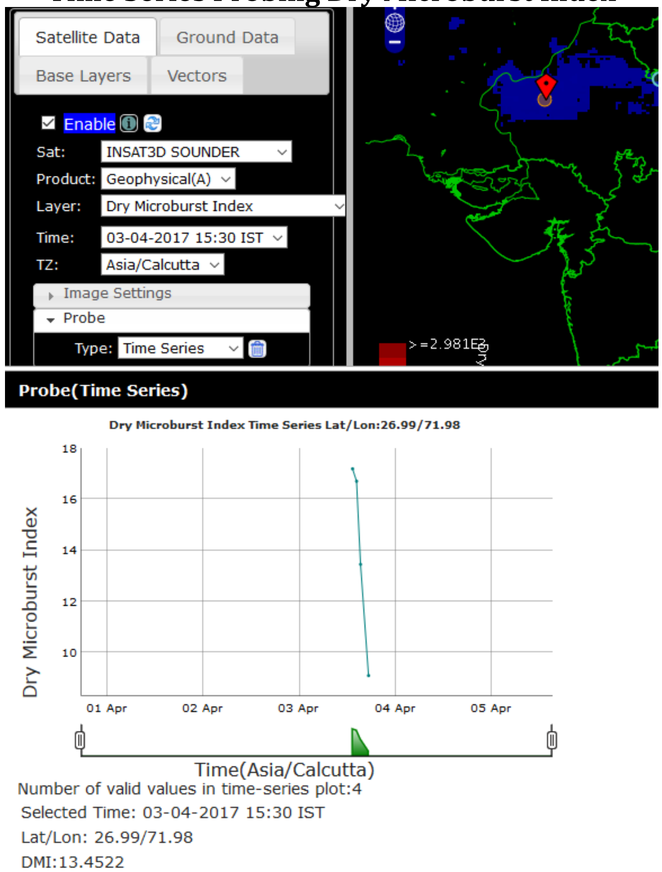
Use: Strong evaporational cooling in the sub-cloud layer, resulting in little or no precipitation at the surface and generally dry microburst occurs in situations characterized by high convective cloud bases.

The various probing options are shown below:

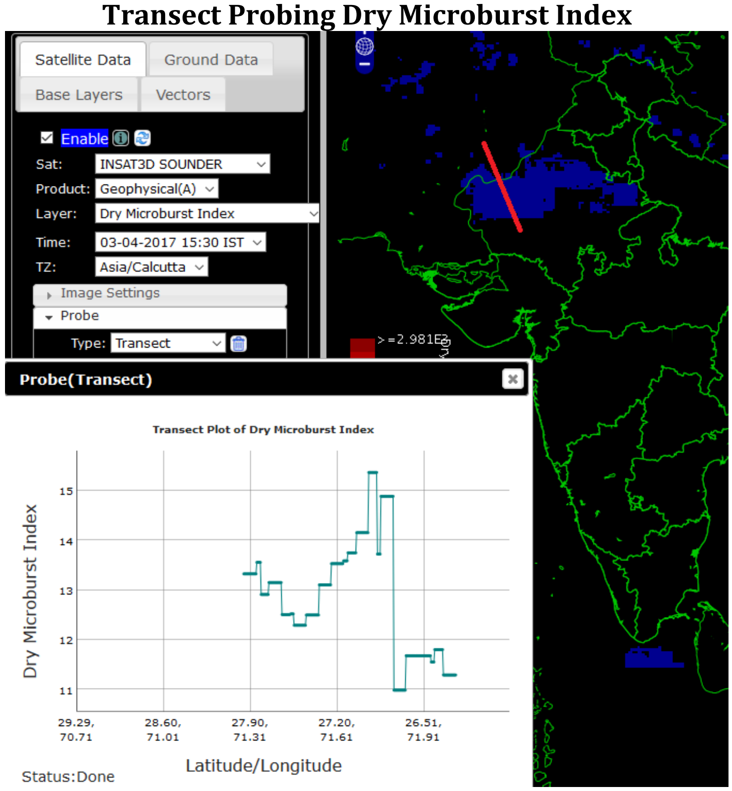
Point Probing Dry Microburst Index



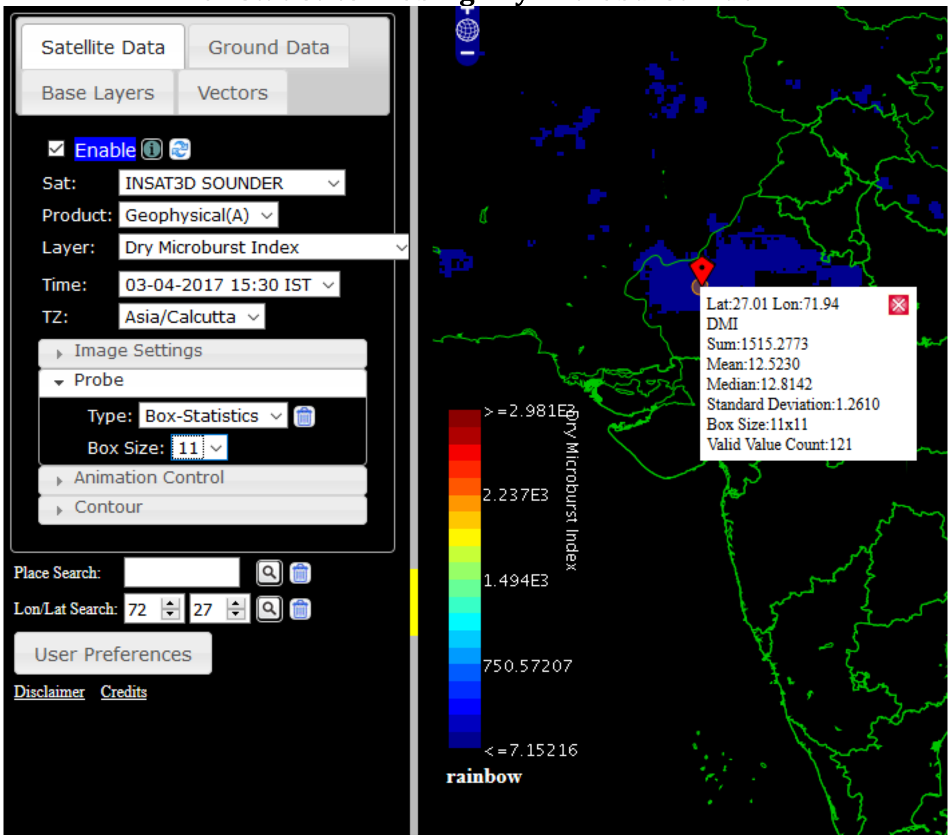
Time Series Probing Dry Microburst Index



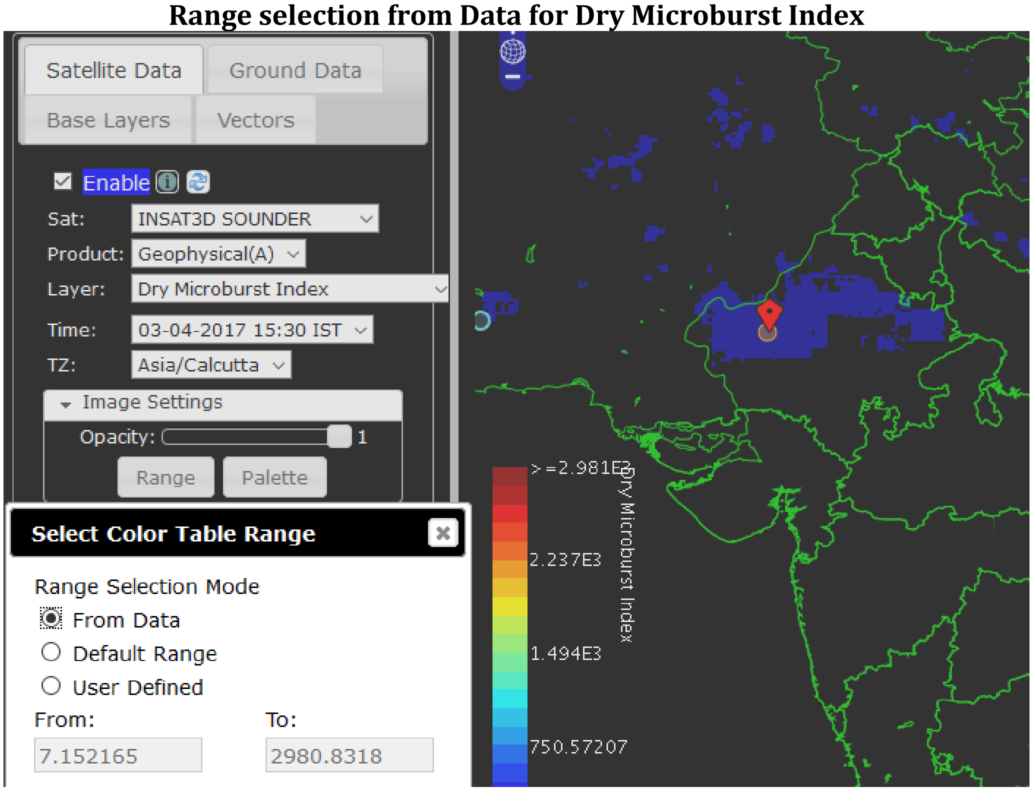
Transect Probing Dry Microburst Index



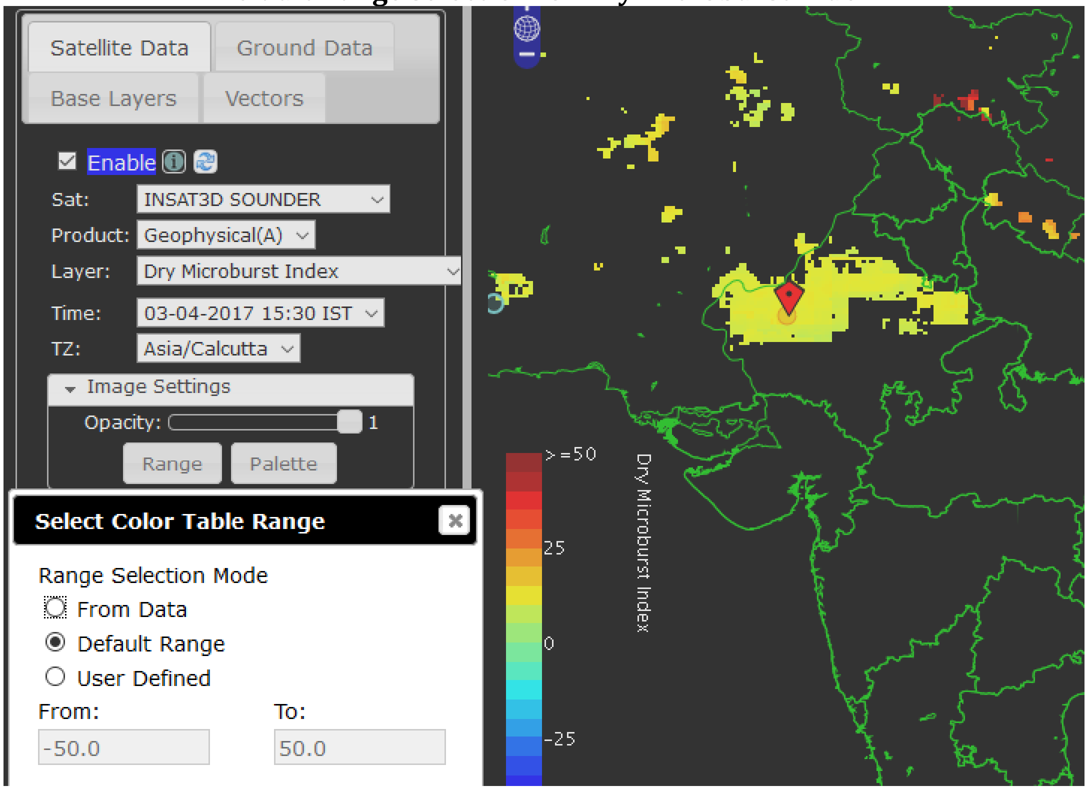
Box Statistics Probing Dry Microburst Index



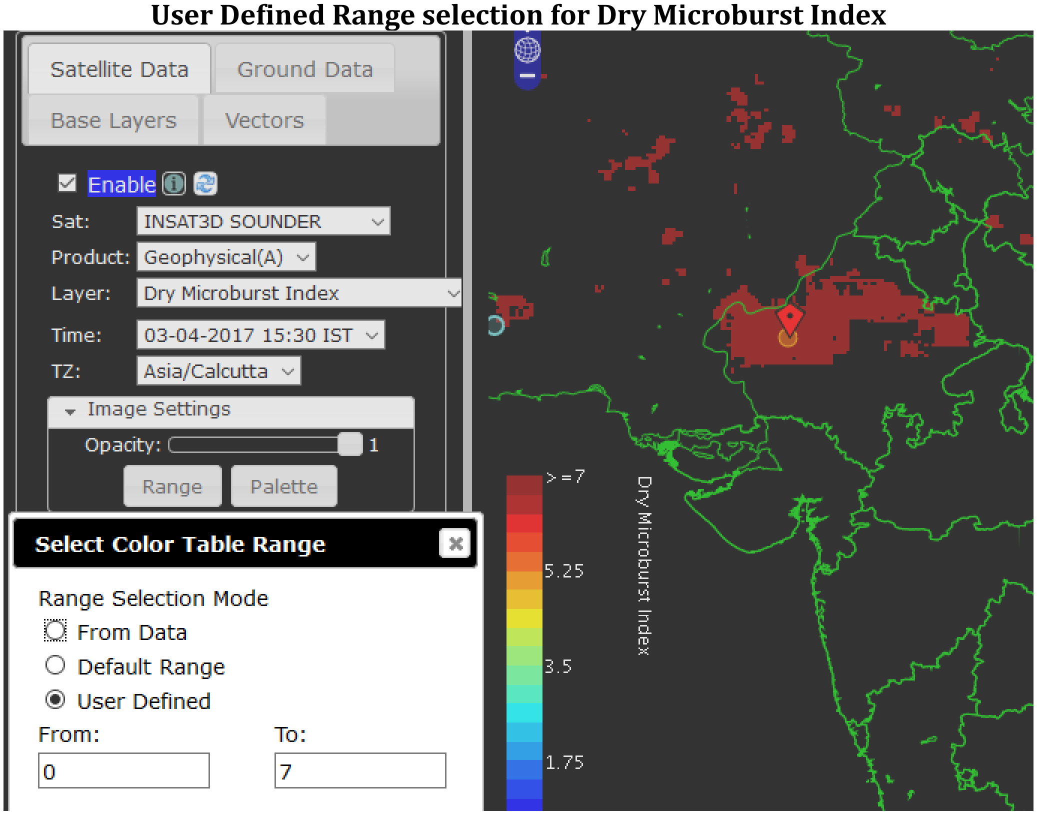
Range selection from Data for Dry Microburst Index



Default Range selection for Dry Microburst Index

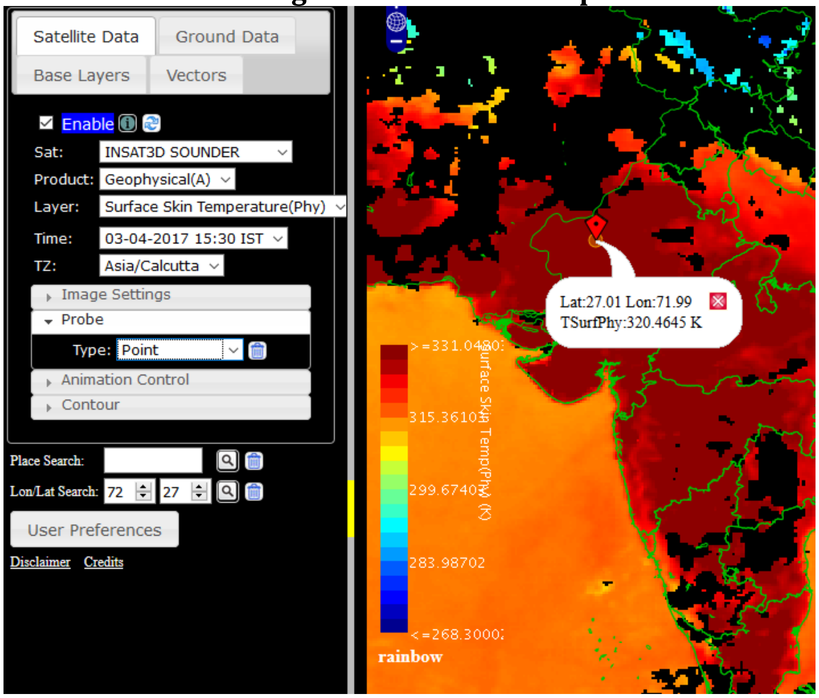


User Defined Range selection for Dry Microburst Index

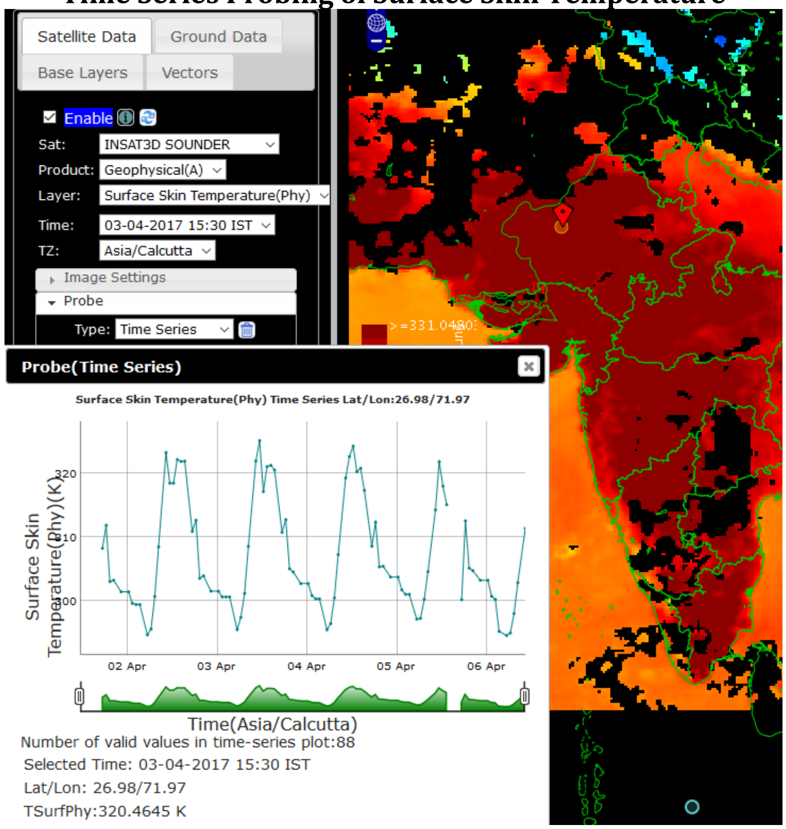


8. Surface Skin Temperature (Phy): This product shows the skin temperature of surface. The various probing options are shown below:

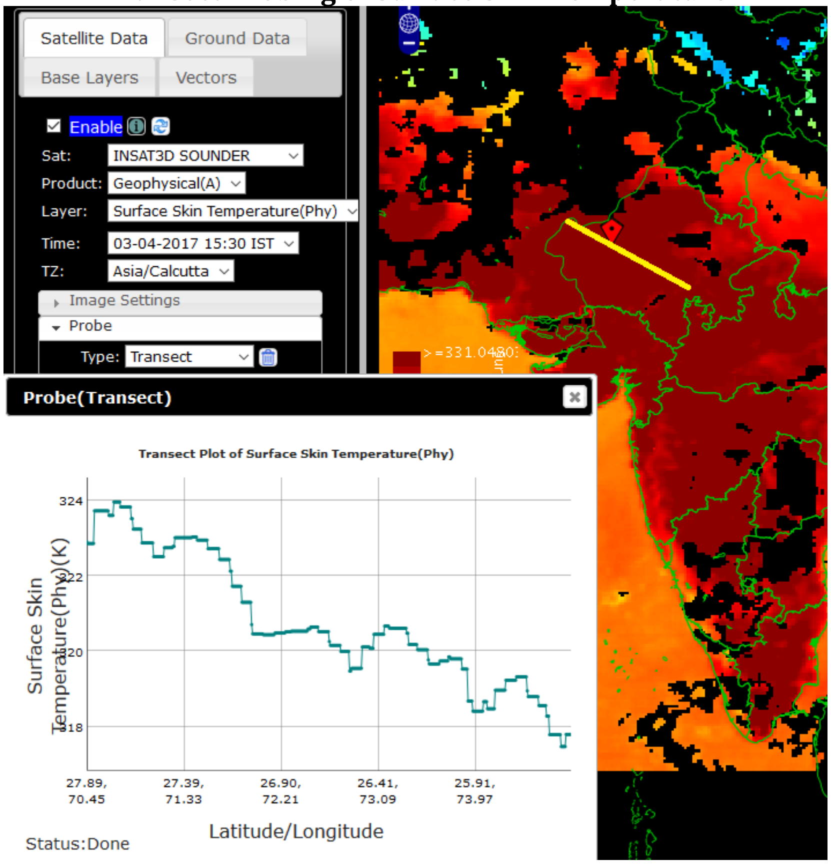
Point Probing of Surface Skin Temperature



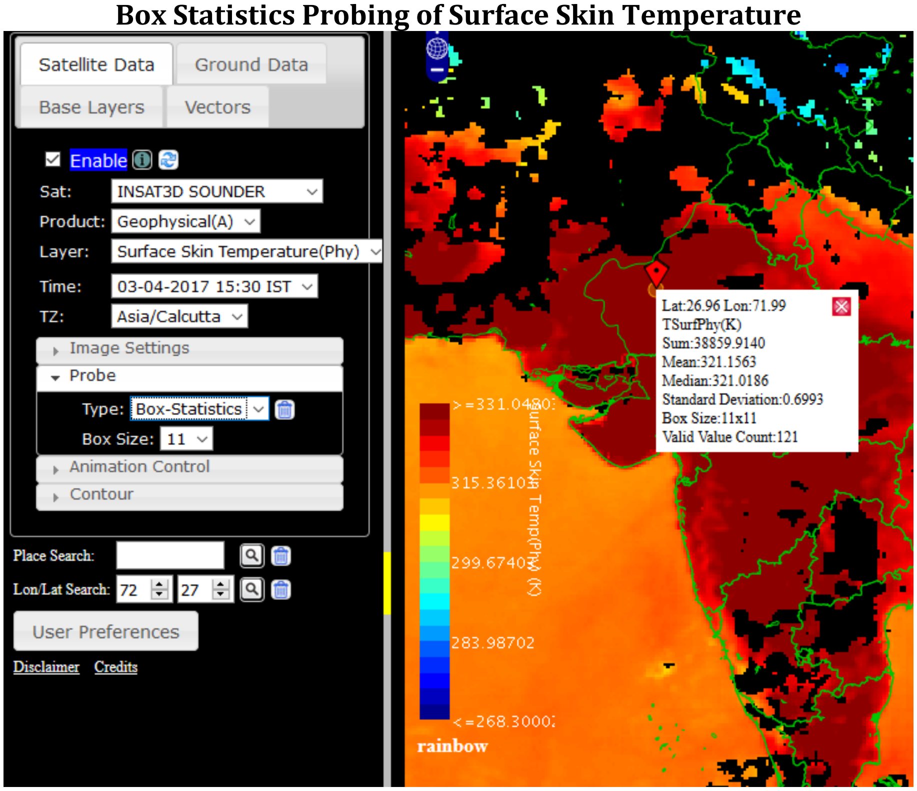
Time Series Probing of Surface Skin Temperature



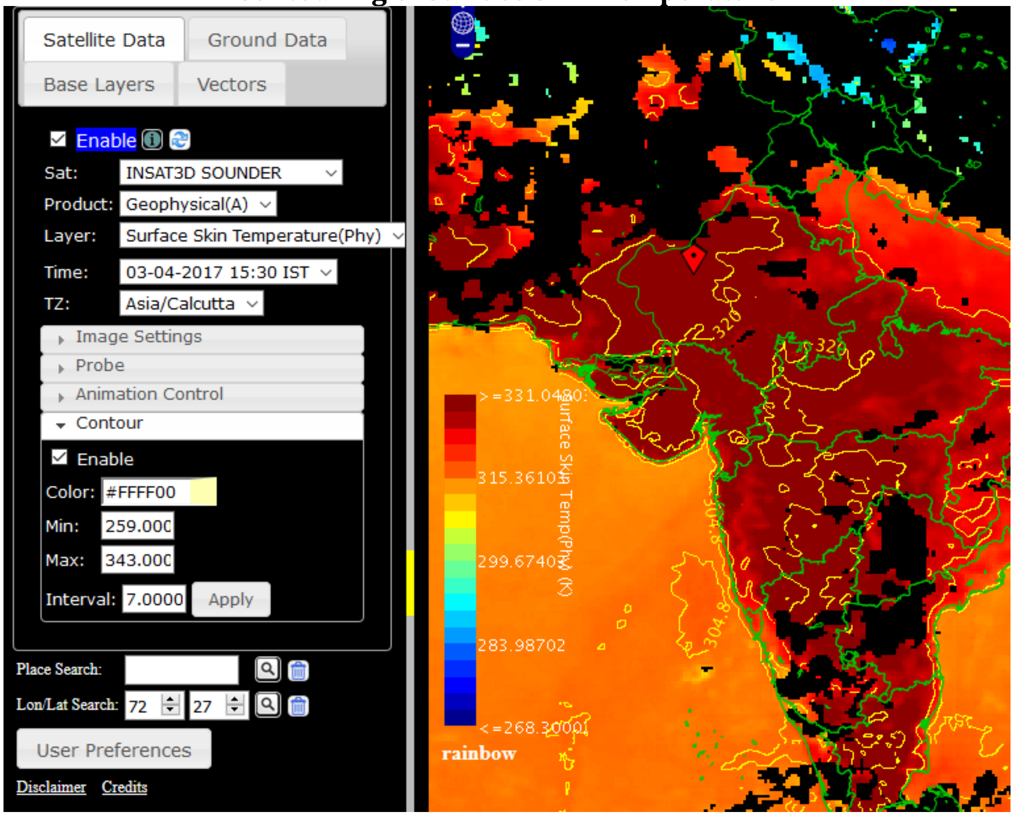
Transect Probing of Surface Skin Temperature



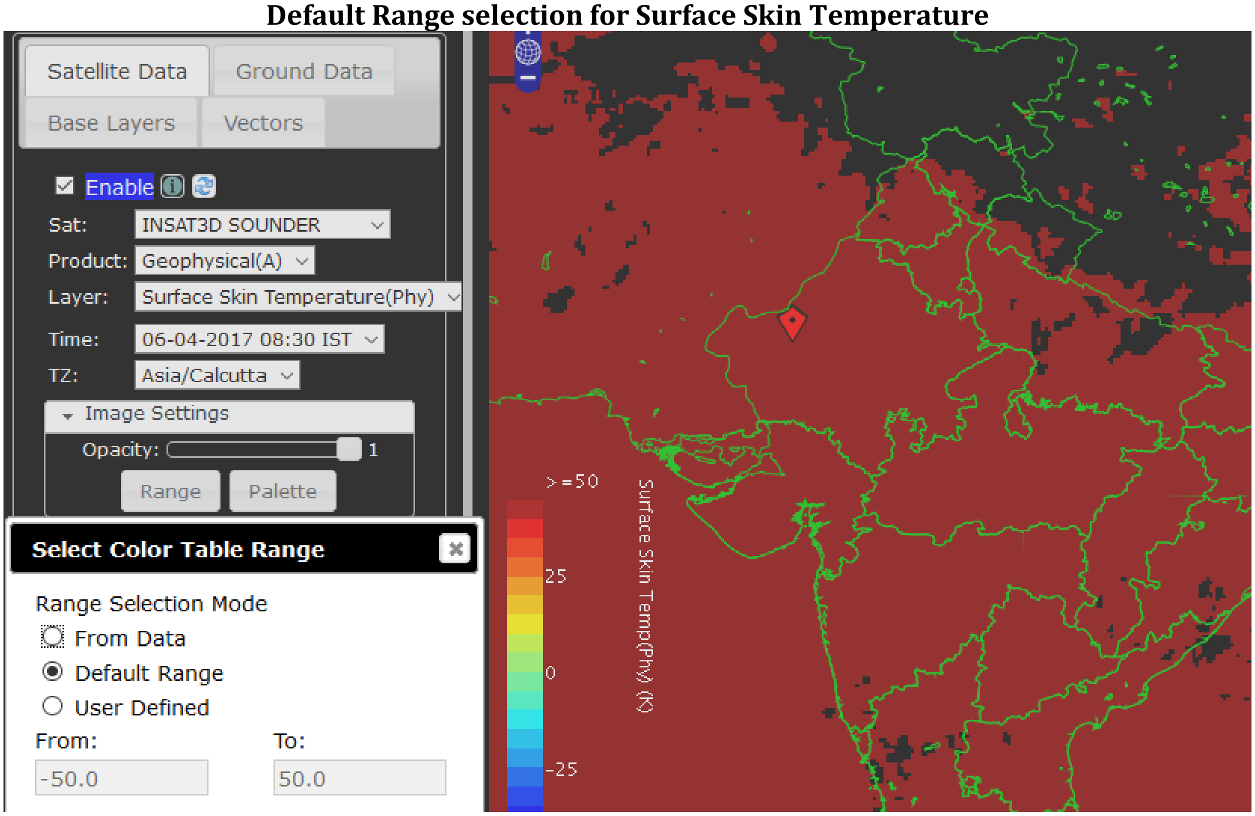
Box Statistics Probing of Surface Skin Temperature



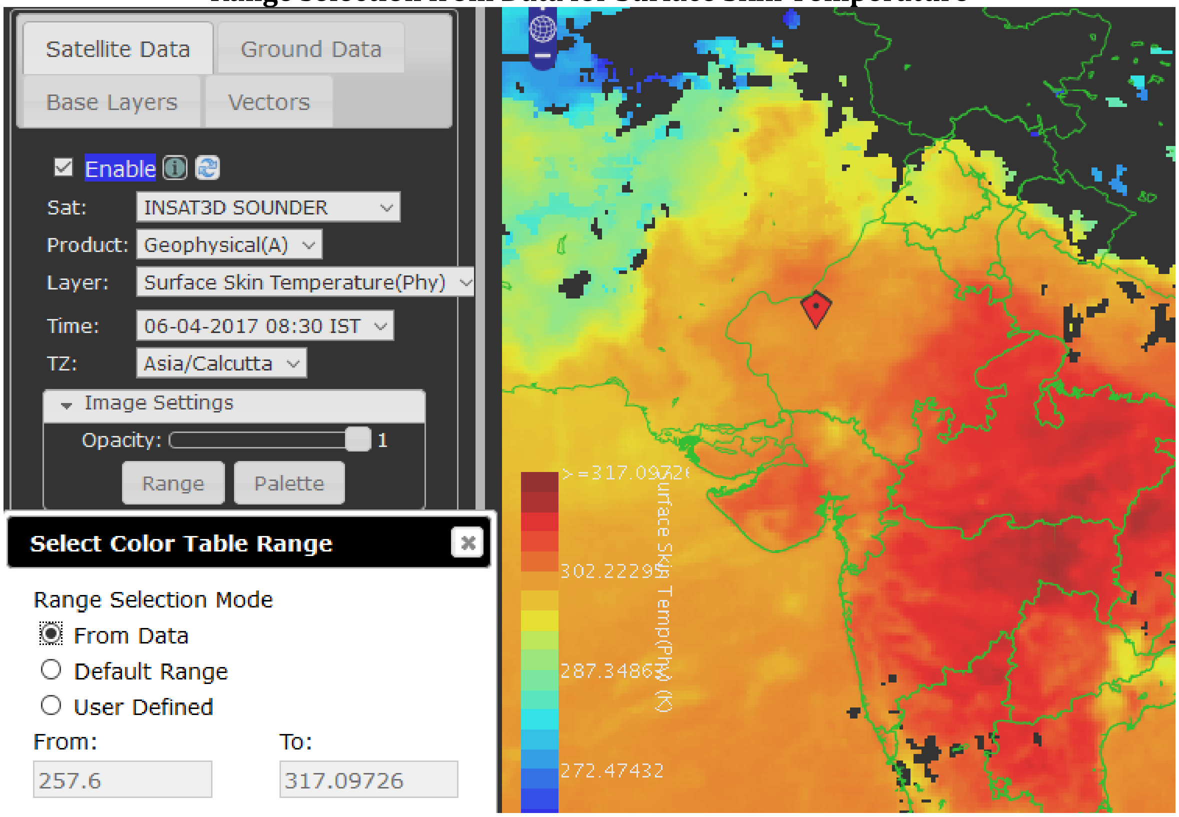
Contouring of Surface Skin Temperature



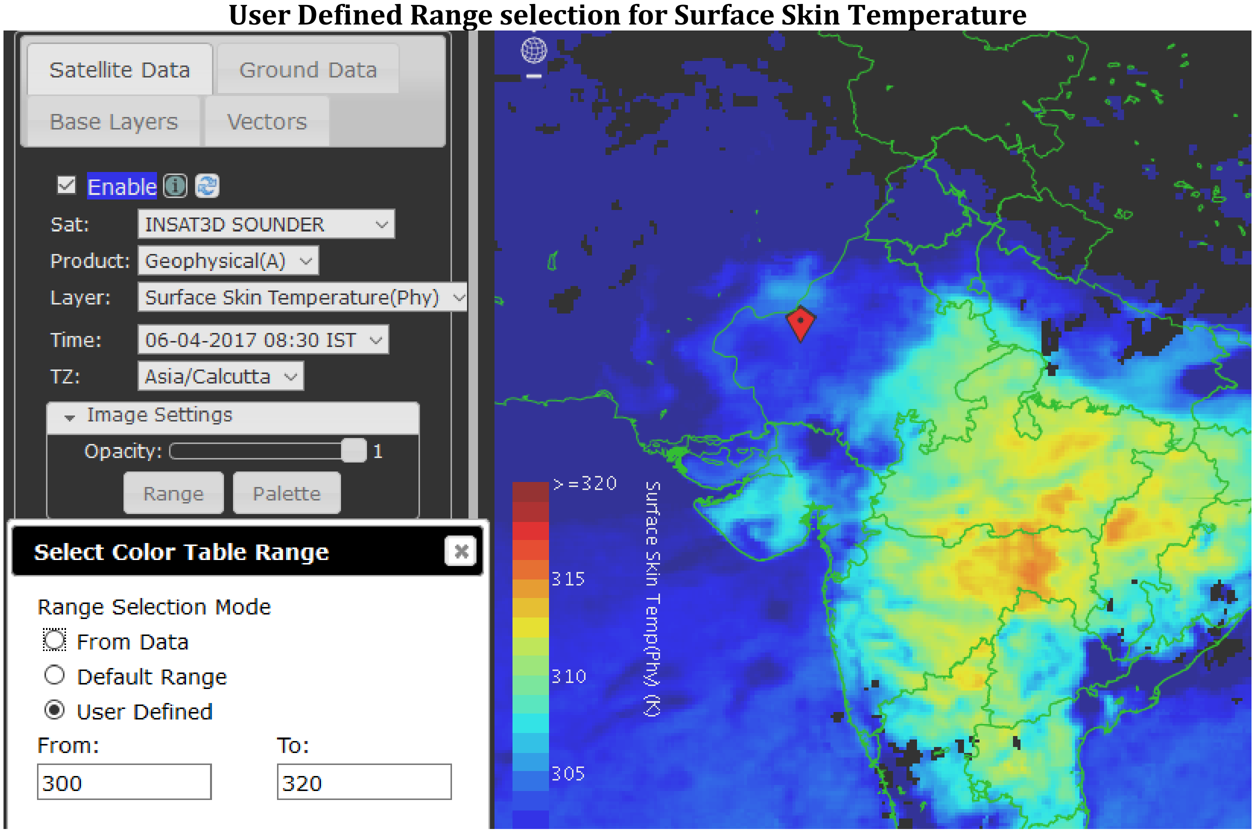
Default Range selection for Surface Skin Temperature



Range selection from Data for Surface Skin Temperature



User Defined Range selection for Surface Skin Temperature



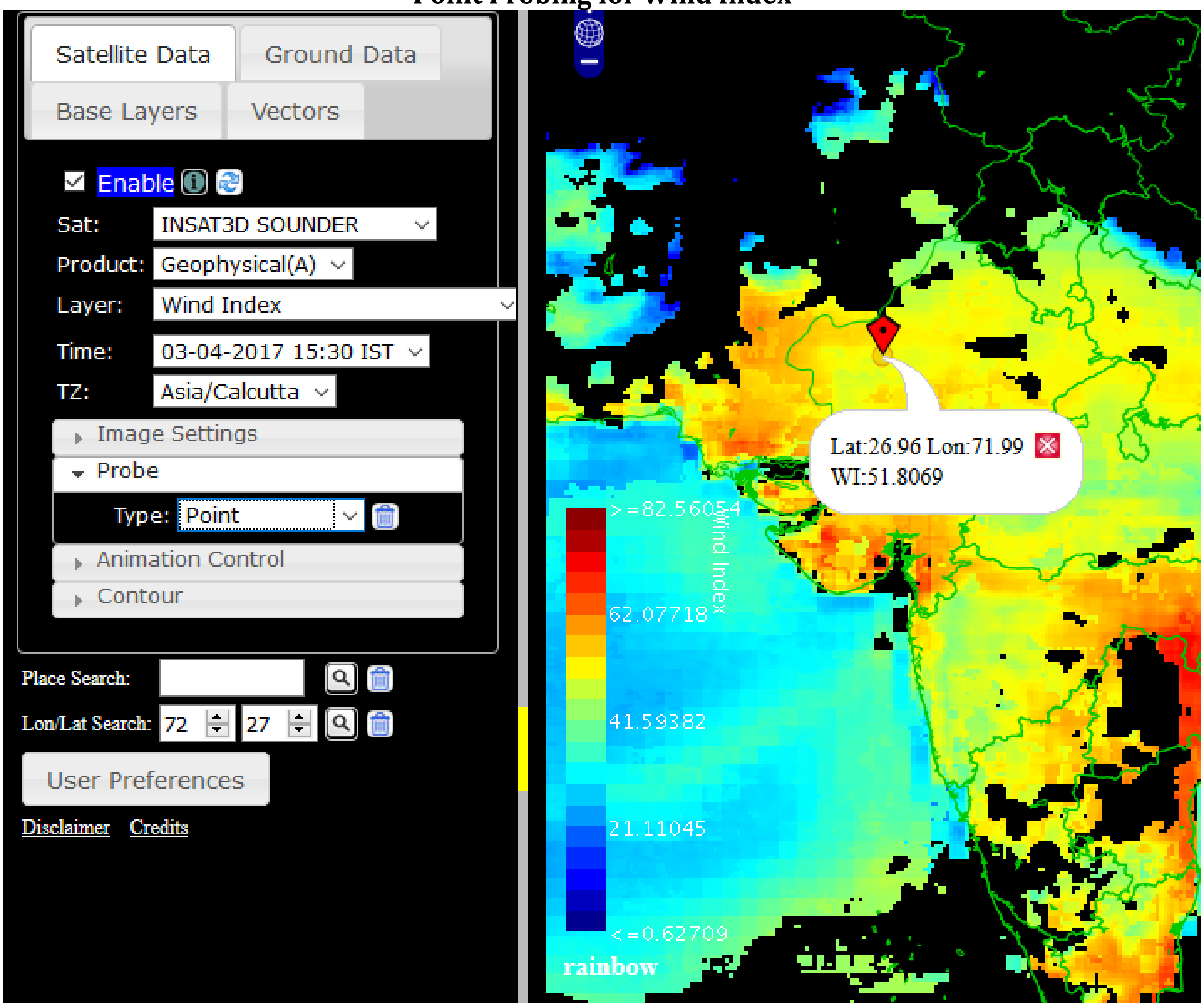
9. Wind Index: Wind Index (WI) is a parameter based on vertical equations of momentum and continuity with certain simplifying assumptions. It is given by the formula

$$WI = 5[H_M R_Q (T^2 \; 30 \; Q_L \qquad 2Q_M]^{1/2}$$

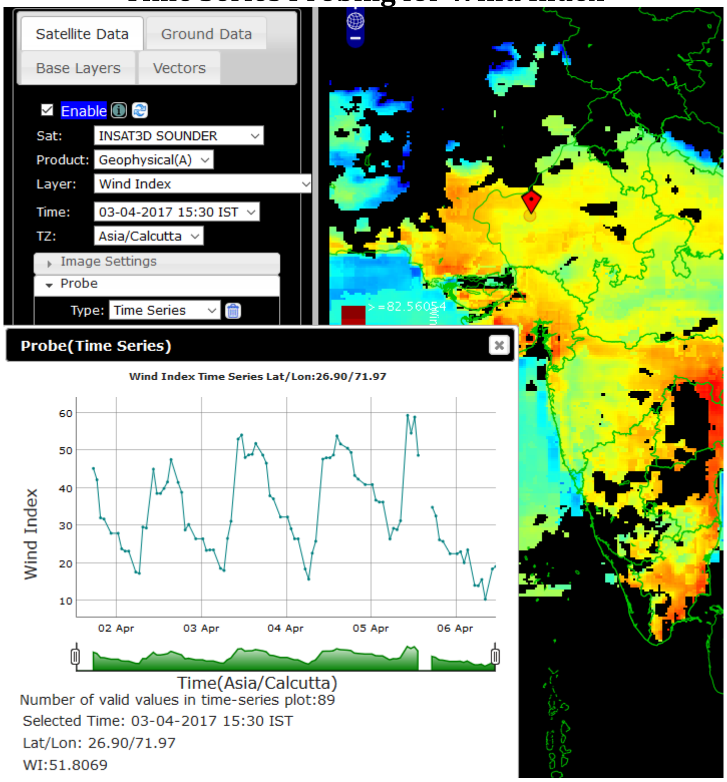
Where WI – Maximum wind gust (knots, at the surface)
HM – Height above ground of melting level (in km)
RQ – QL/12 but not >1, QL – Mean mixing ratio (g/Kg) in lowest 1 km
T – Lapse rate (ºC km-1) from surface to melting level, QM – Mixing ratio at melting level.

Use: Wind index provides guidance on the maximum possible wind gusts and this is useful for generating short-range warnings and forecasts.

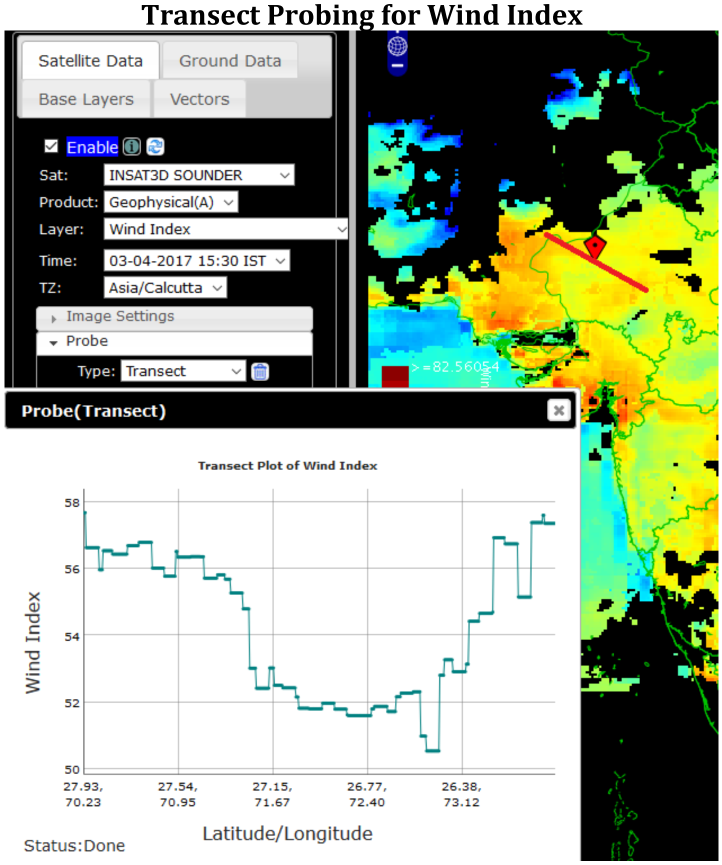
Point Probing for Wind Index



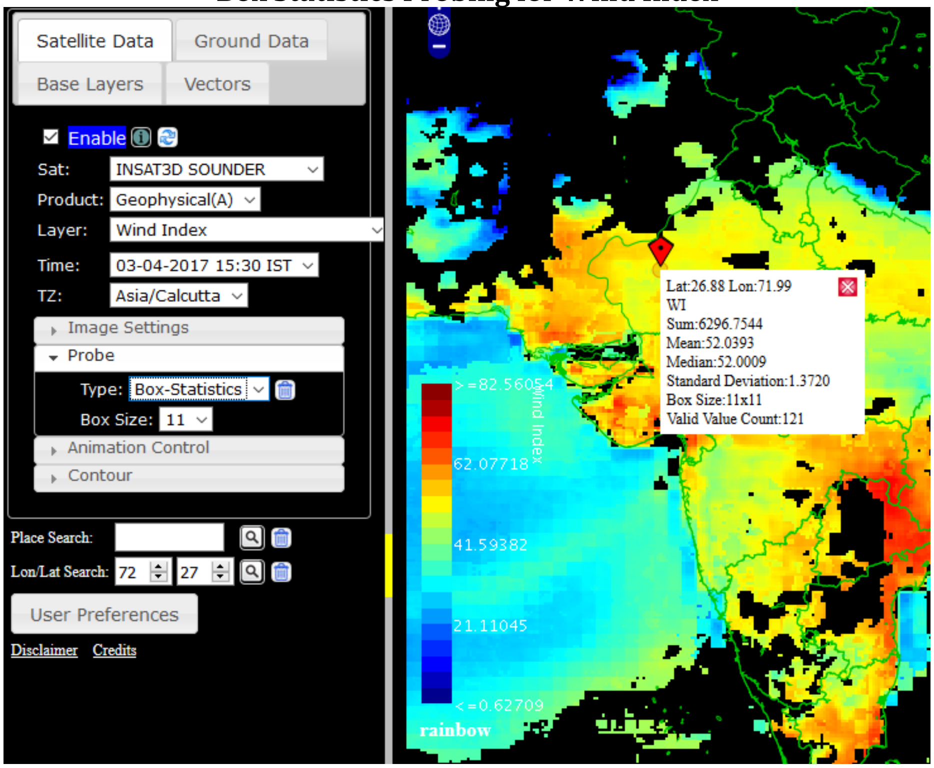
Time Series Probing for Wind Index



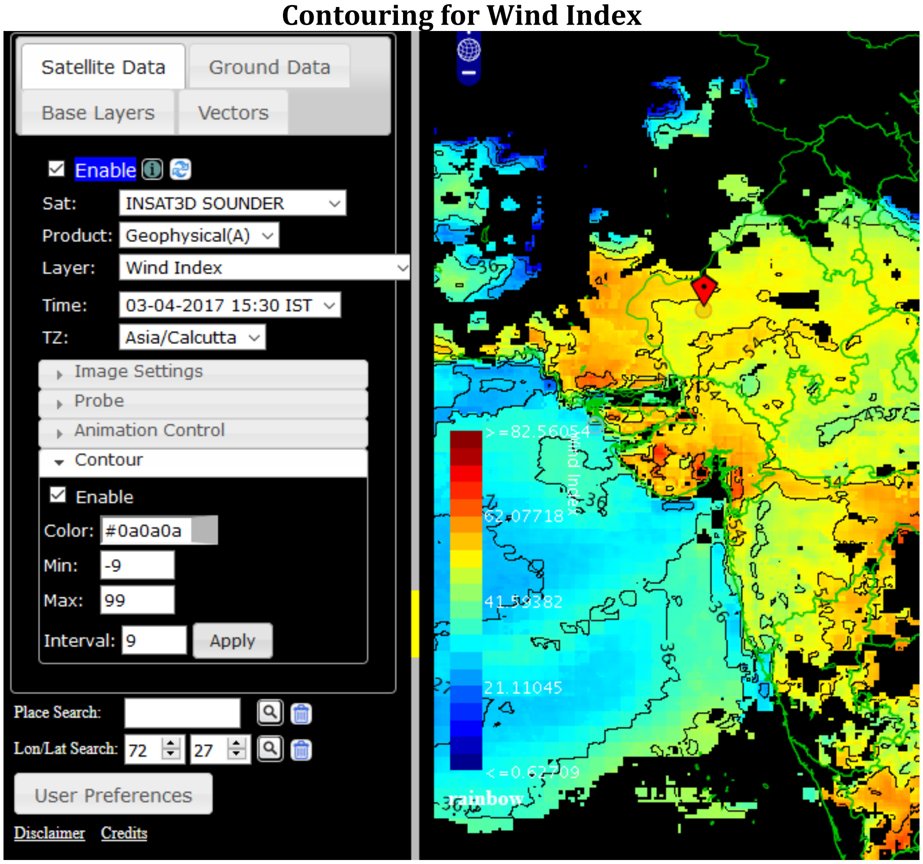
Transect Probing for Wind Index



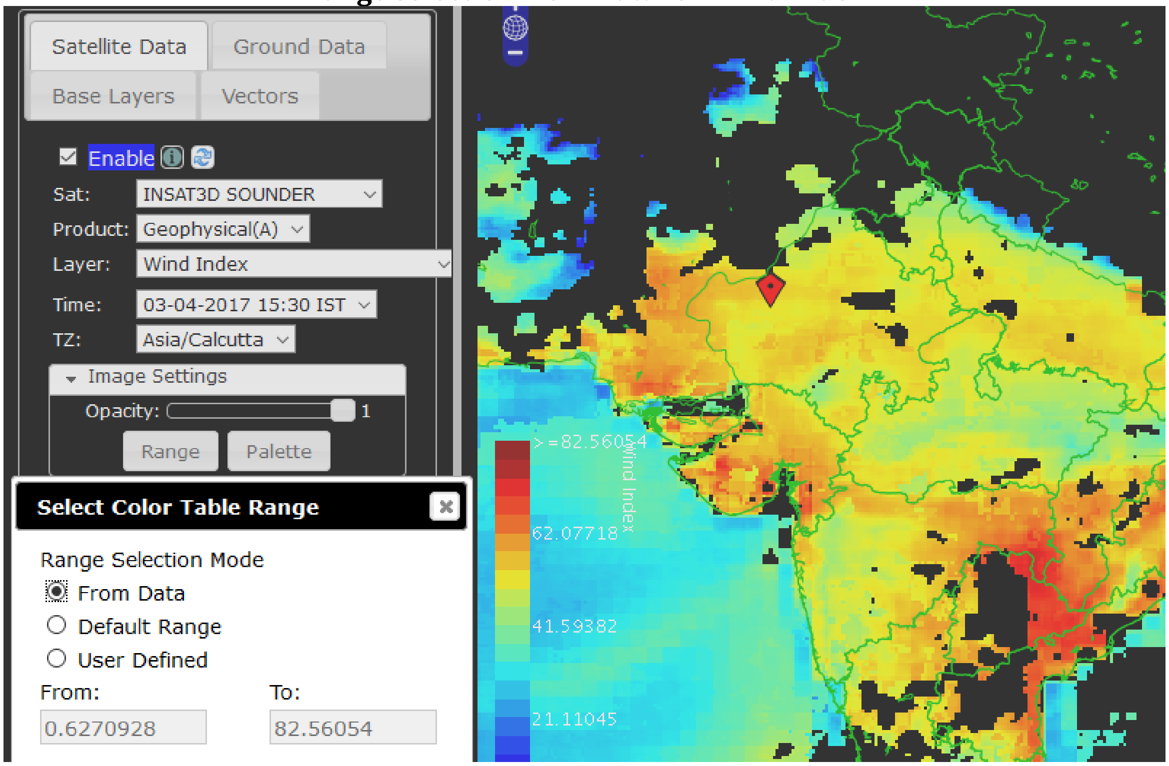
Box Statistics Probing for Wind Index



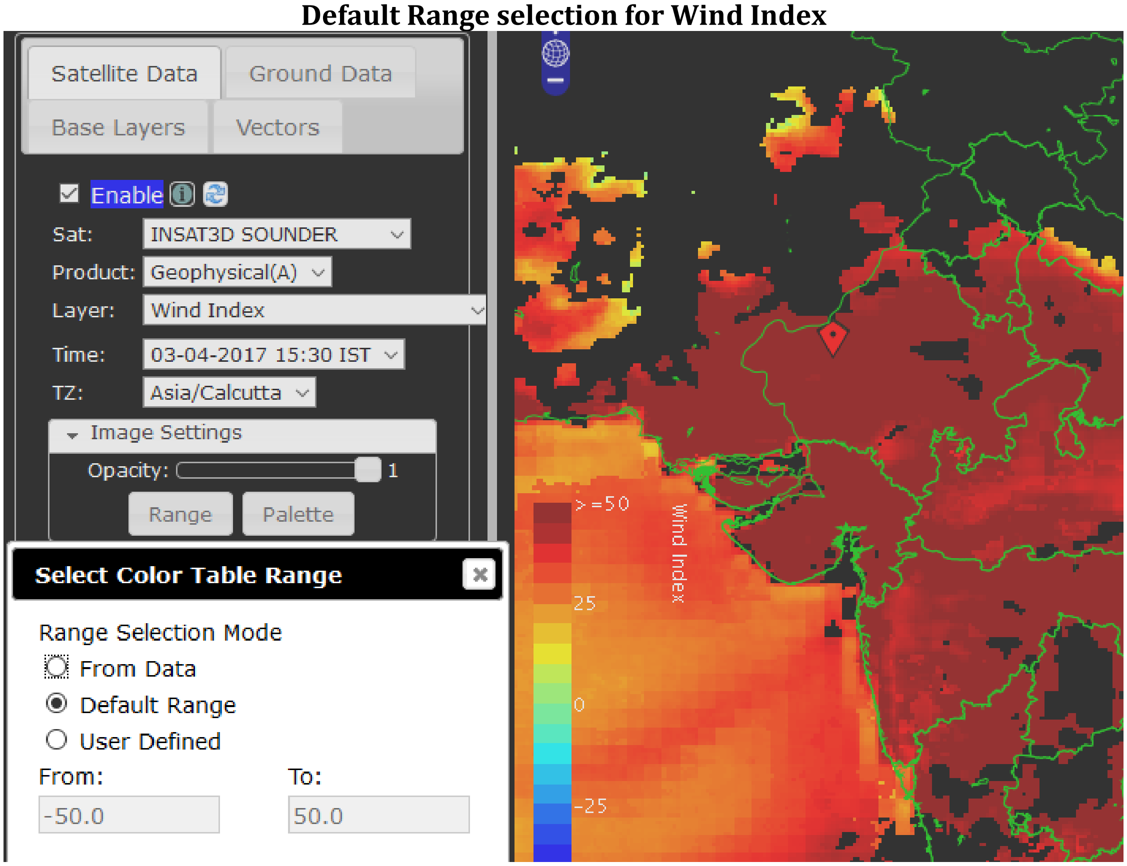
Contouring for Wind Index



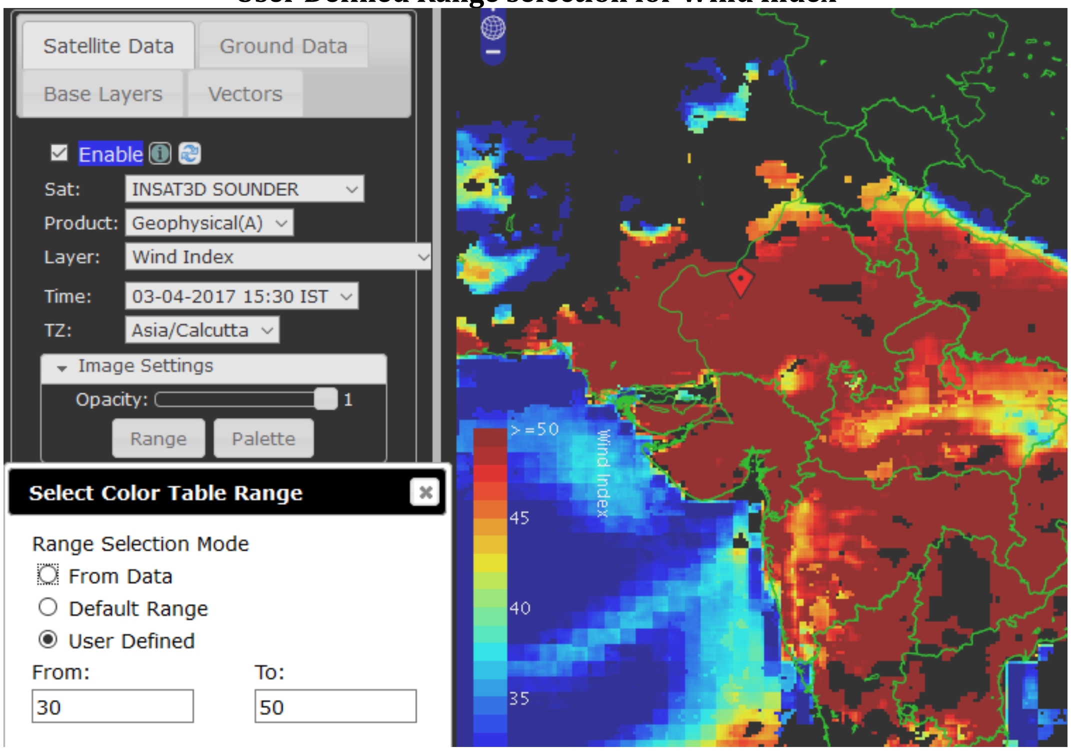
Range selection from Data for Wind Index



Default Range selection for Wind Index



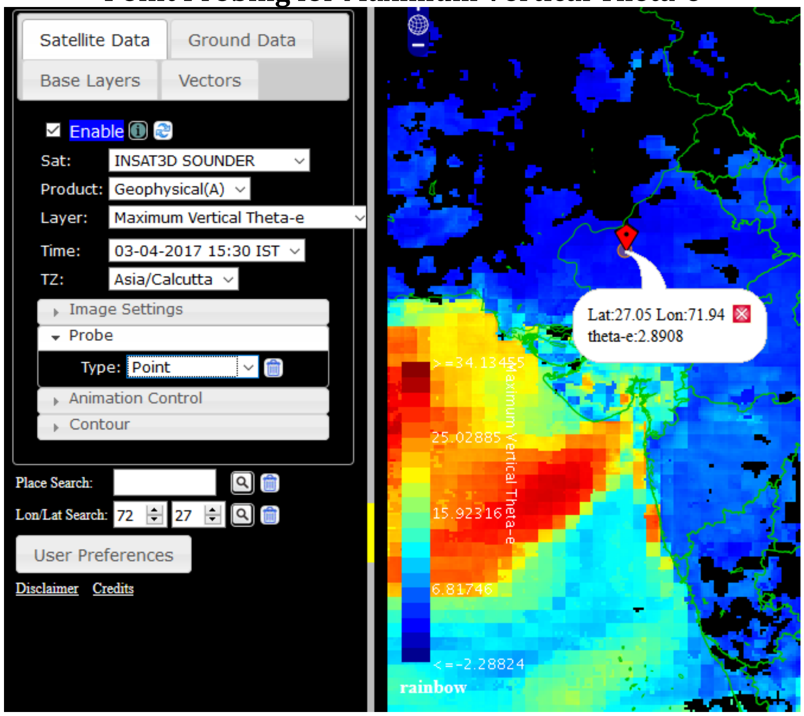
User Defined Range selection for Wind Index



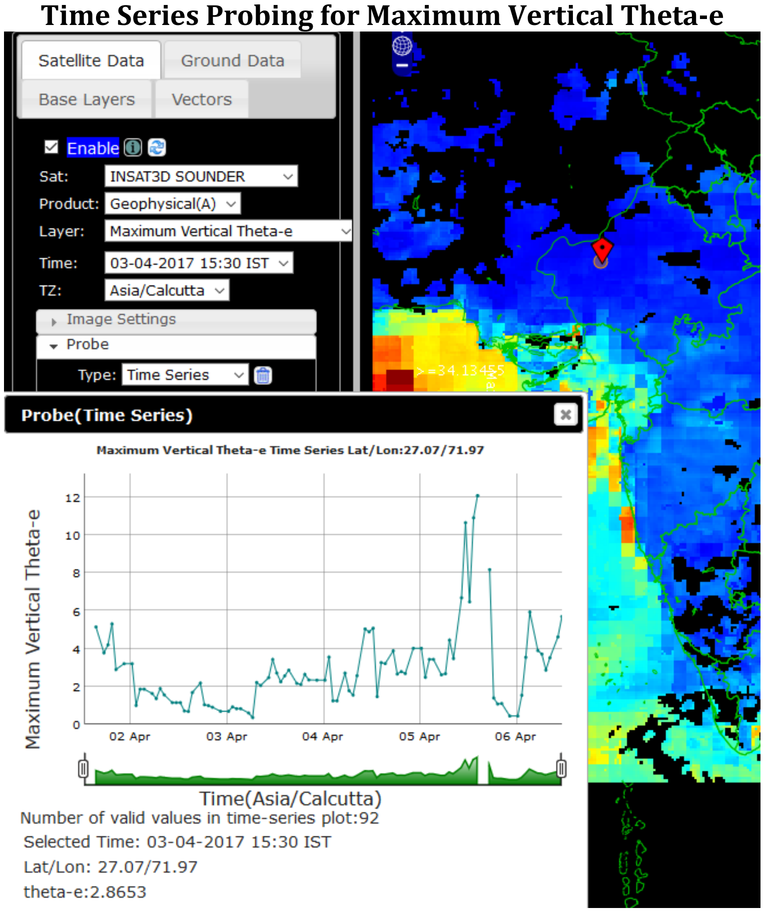
10. Maximum Vertical Theta-e: Equivalent potential temperature (θe) is the potential temperature that a saturated air Parcel would have if raised moist adiabatically to the top of the atmosphere. As the moisture decreases with height, θe also decreases with height and reaches a minimum in the middle troposphere, then increases again into the upper troposphere.

    Use: The maximum vertical θe differential between middle troposphere and the boundary layer is a measure of atmospheric instability in the vertical direction. If larger the theta-e differential, then more unstable is the atmosphere in the vertical direction.

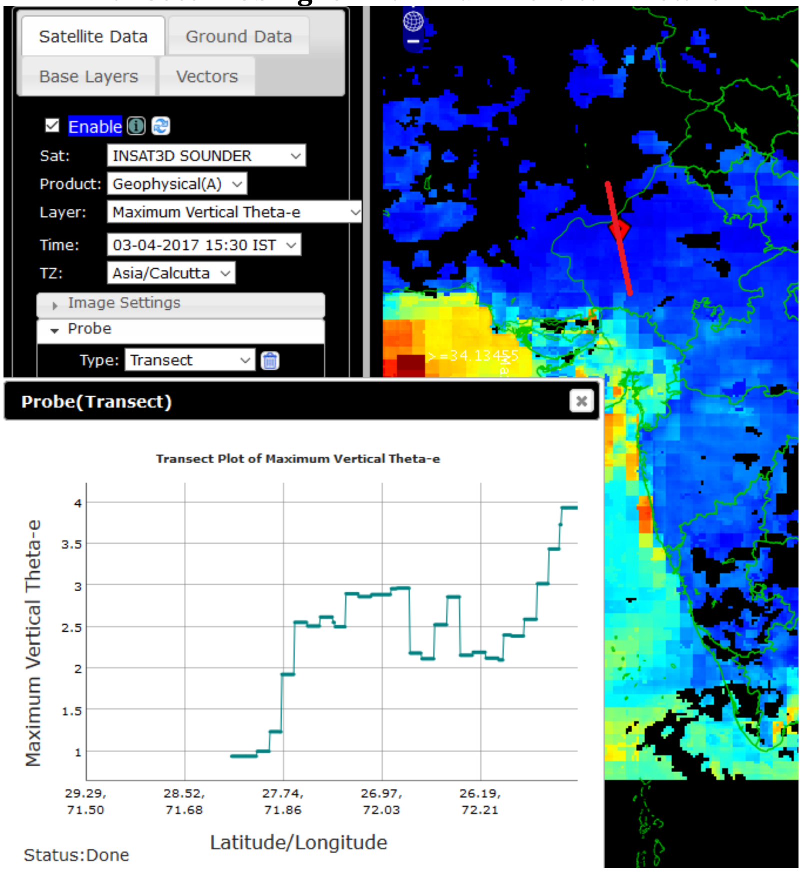
Point Probing for Maximum Vertical Theta-e



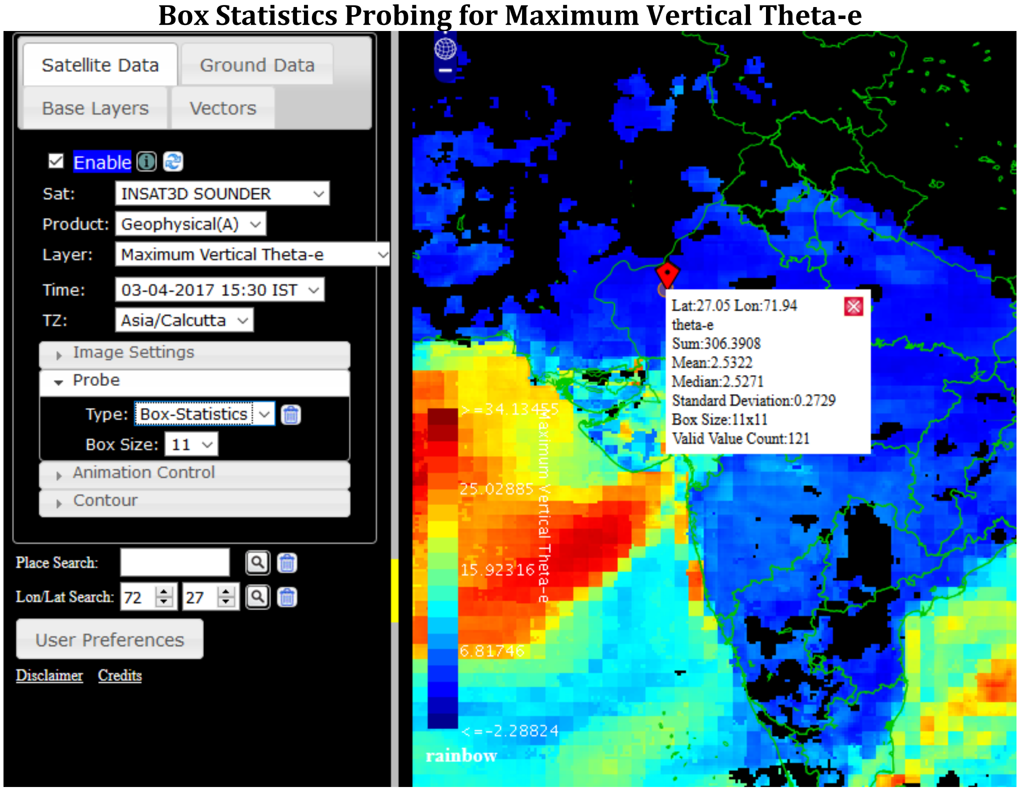
Time Series Probing for Maximum Vertical Theta-e



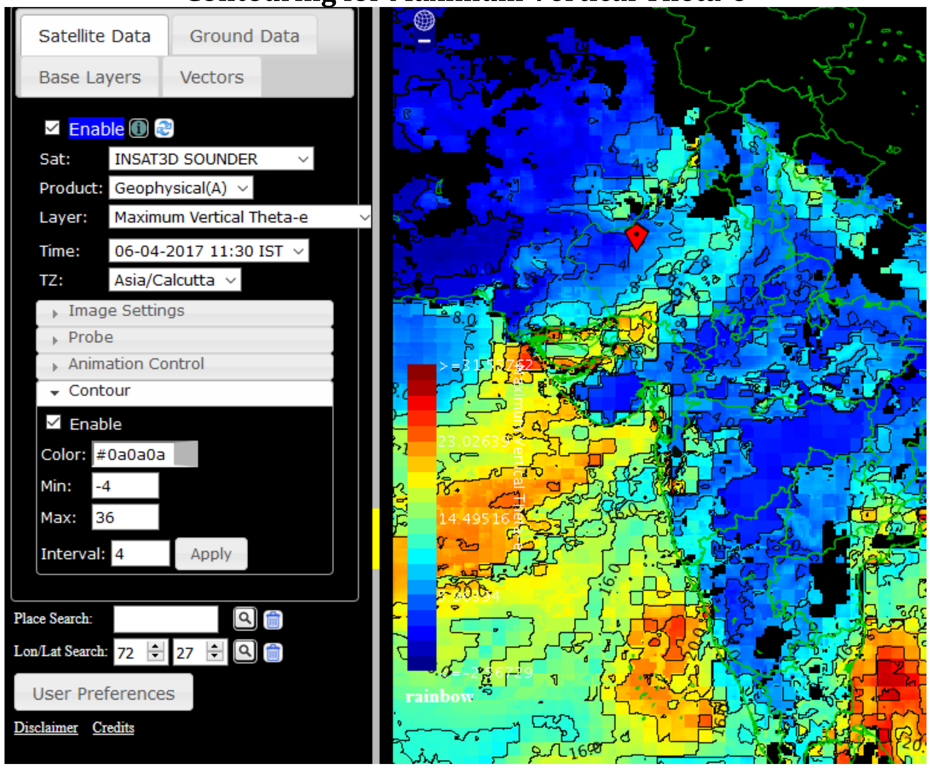
Transect Probing for Maximum Vertical Theta-e



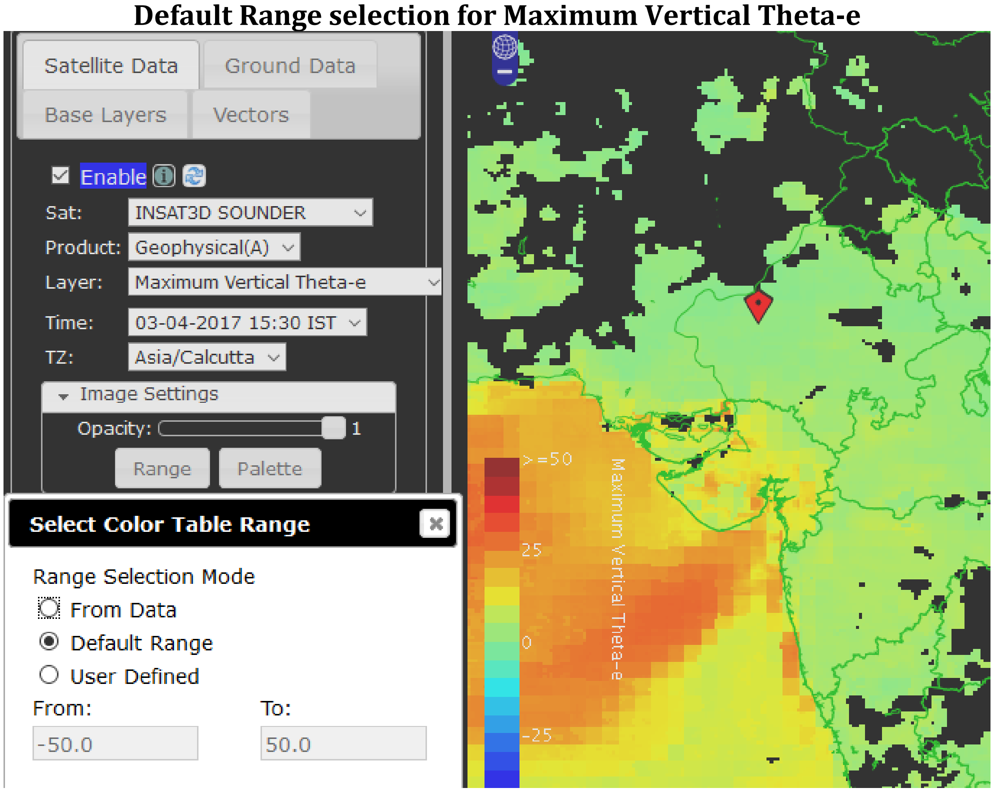
Box Statistics Probing for Maximum Vertical Theta-e



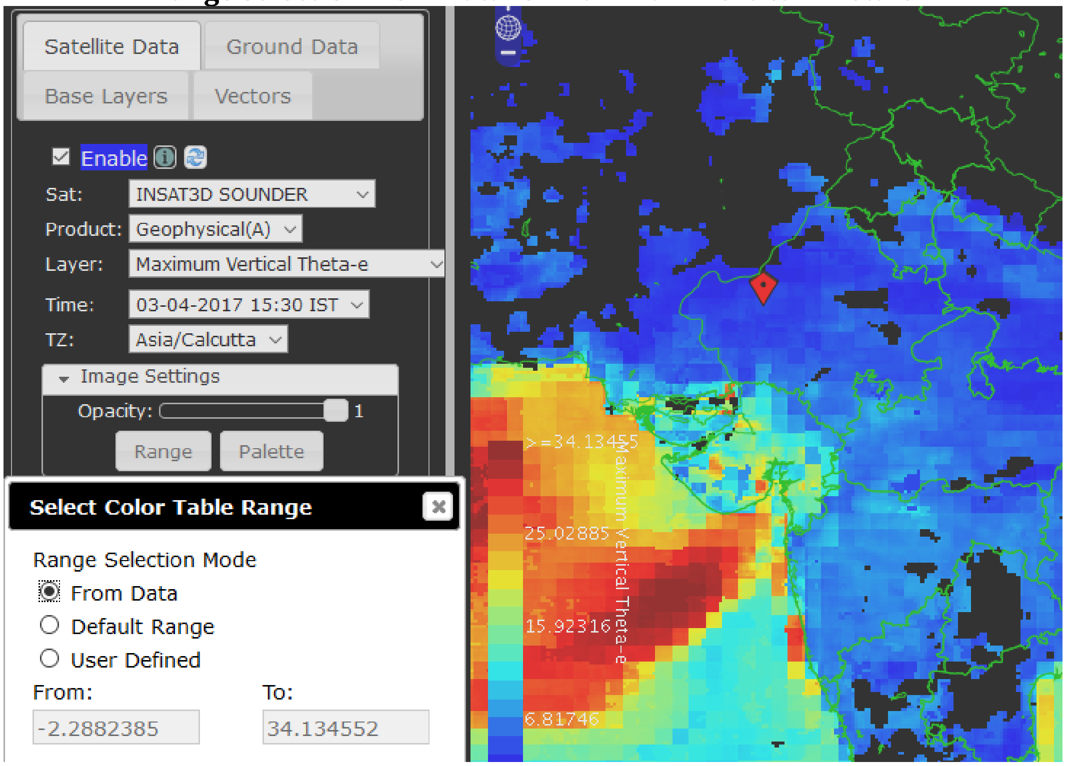
Contouring for Maximum Vertical Theta-e



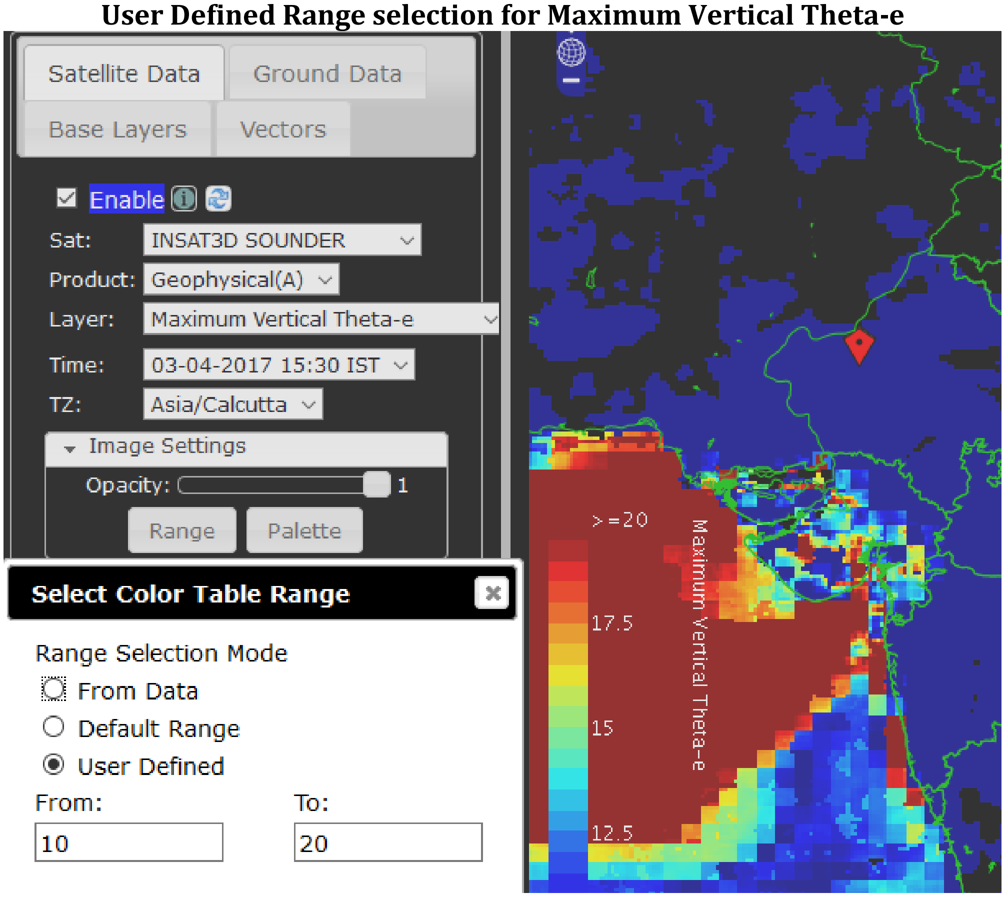
Default Range selection for Maximum Vertical Theta-e



Range selection from Data for Maximum Vertical Theta-e

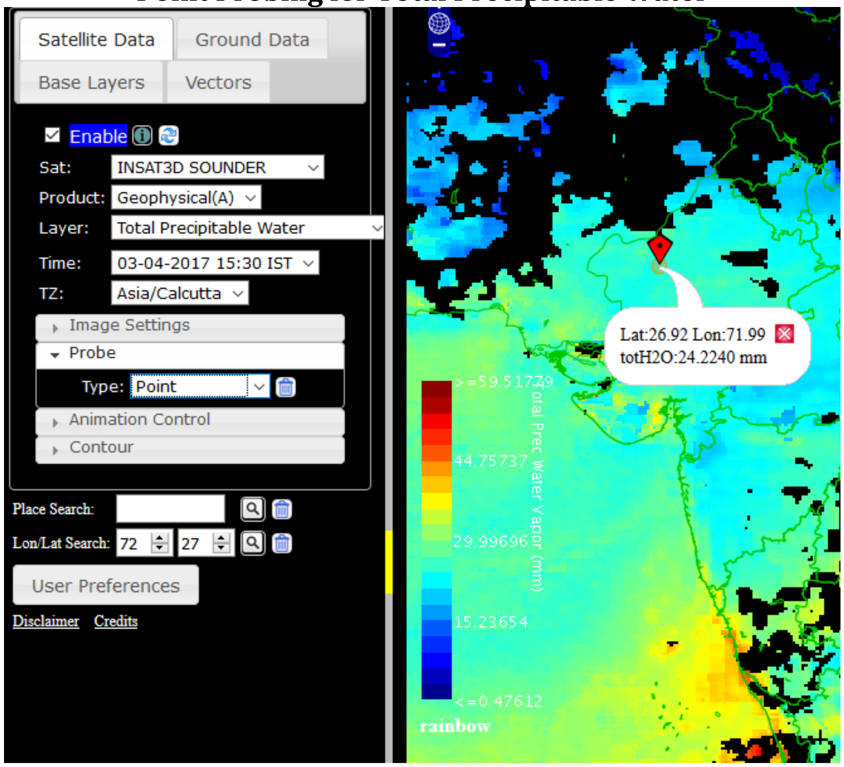


User Defined Range selection for Maximum Vertical Theta-e

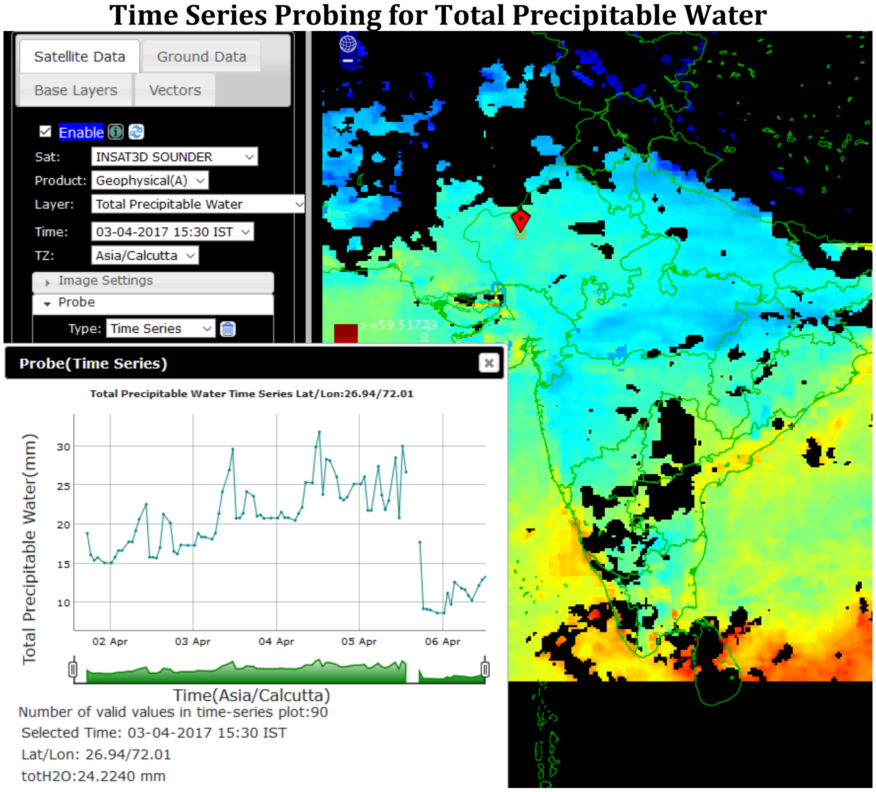


11. Total Precipitable Water: Total Precipitable water of the column, is the sum total of the three layer precipitable water i.e. L1 precipitable water, L2 precipitable water & L3 precipitable water.

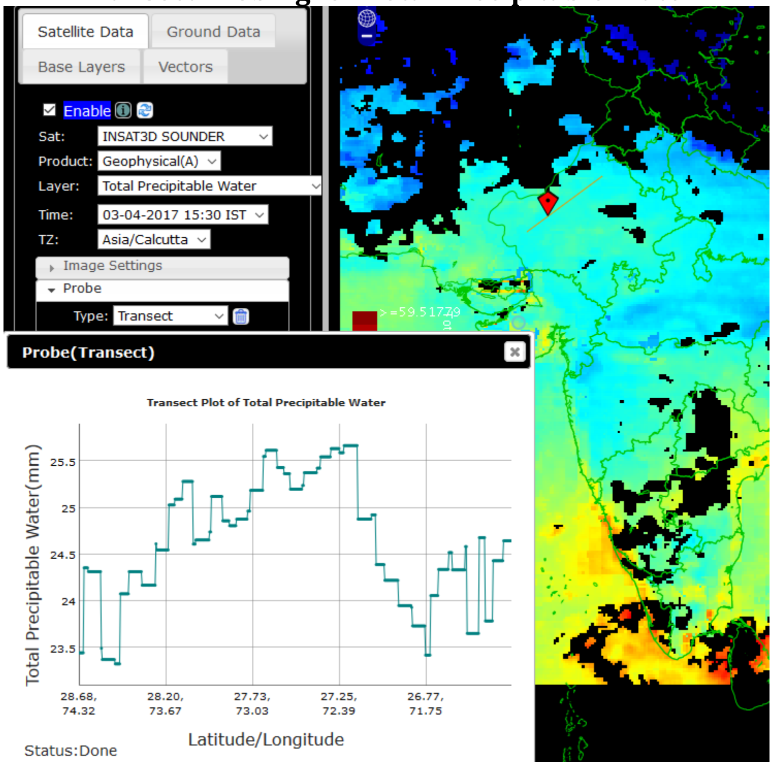
Point Probing for Total Precipitable Water



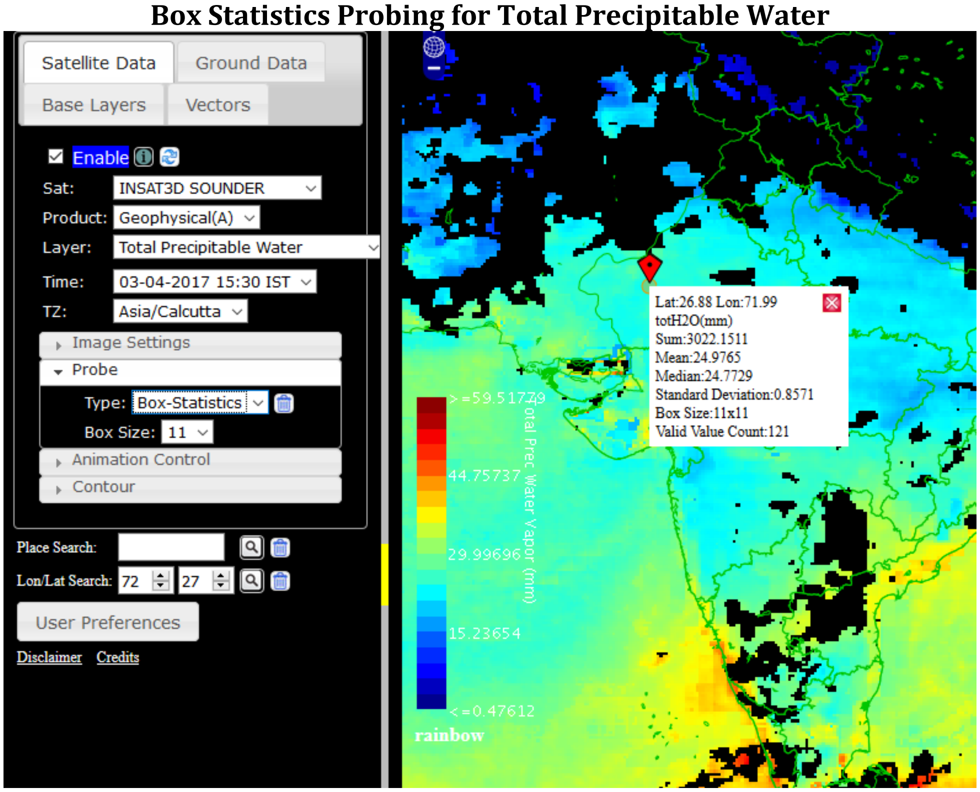
Time Series Probing for Total Precipitable Water



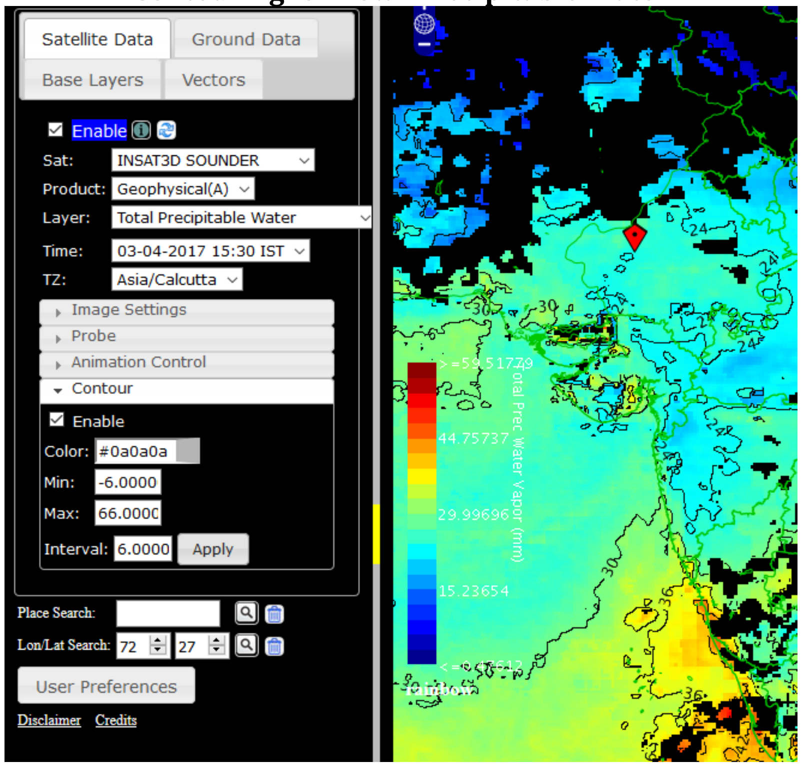
Transect Probing for Total Precipitable Water



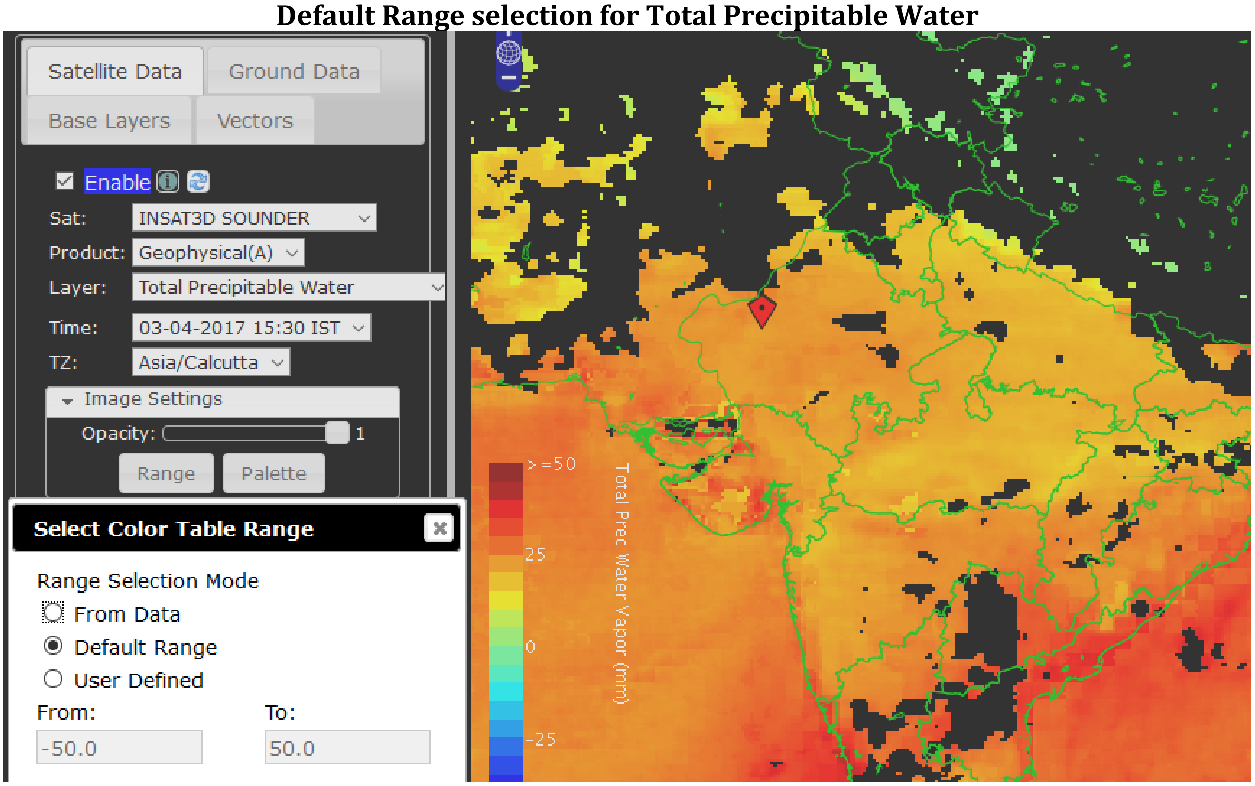
Box Statistics Probing for Total Precipitable Water



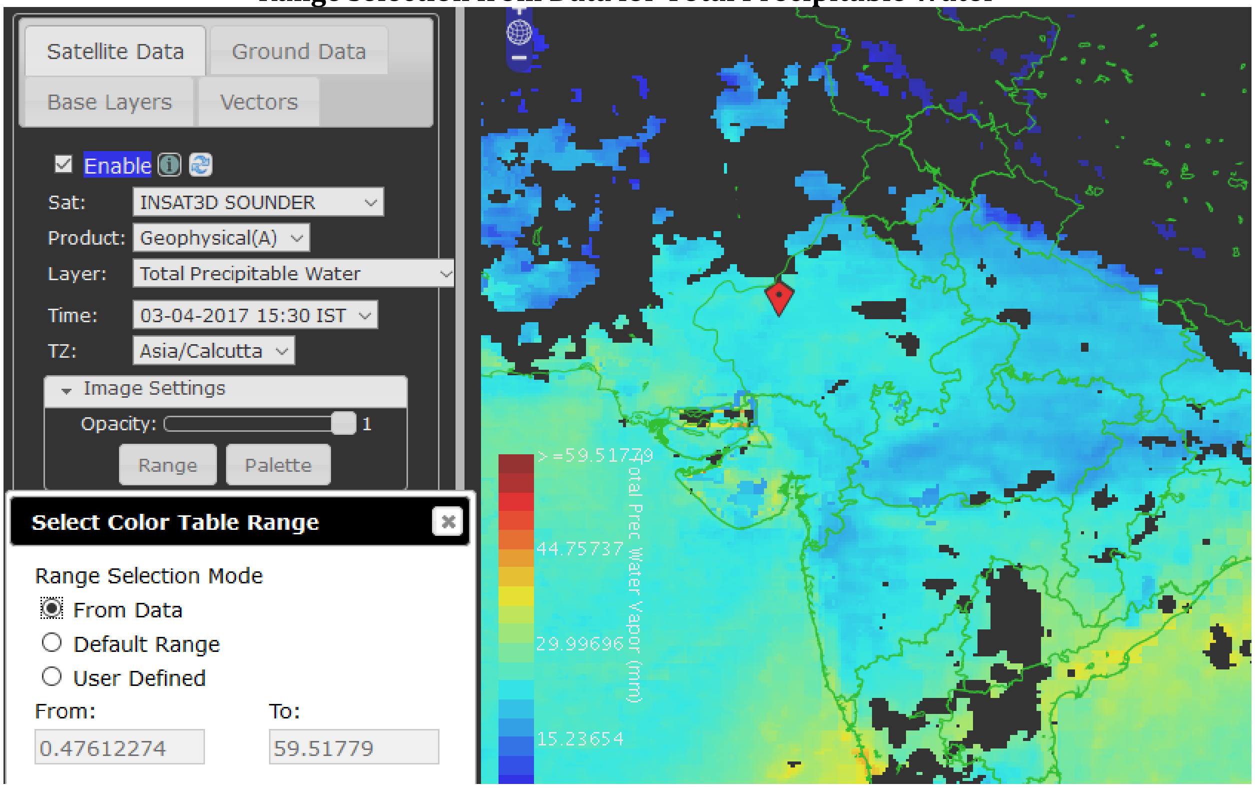
Contouring for Total Precipitable Water



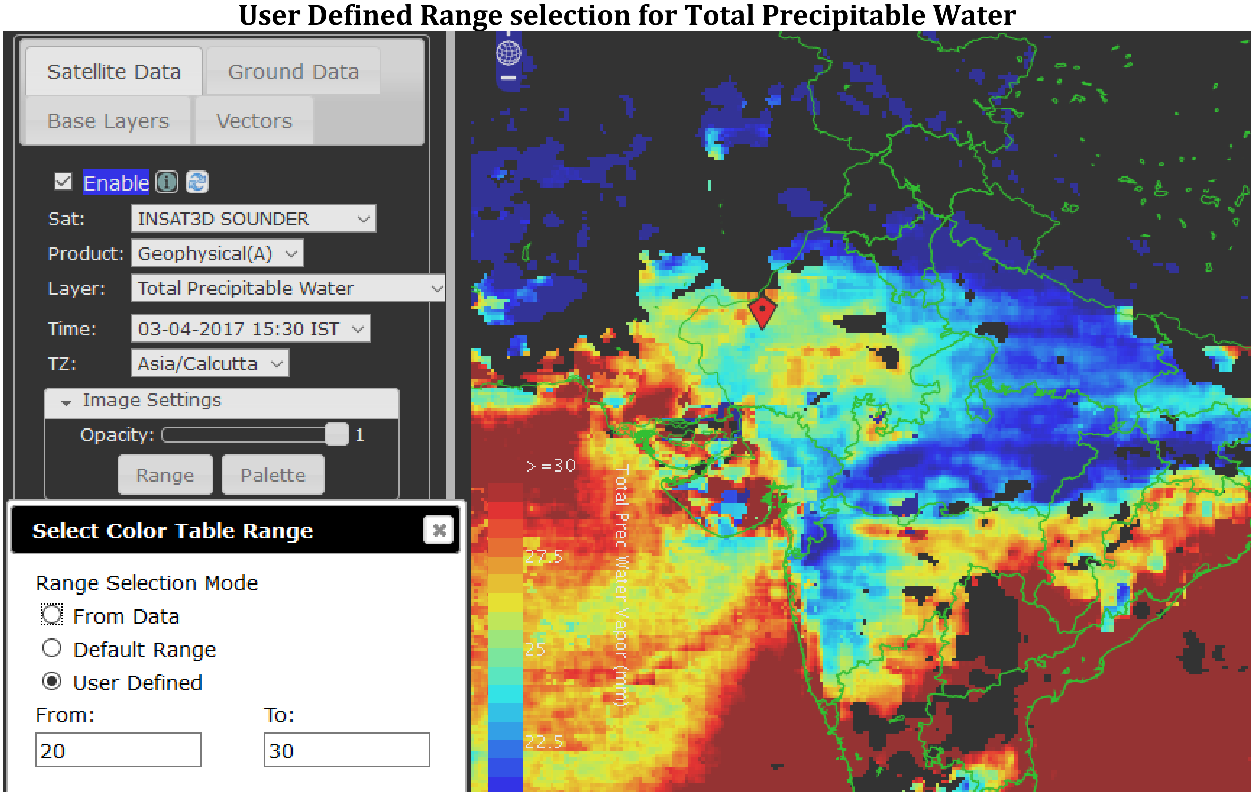
Default Range selection for Total Precipitable Water



Range selection from Data for Total Precipitable Water



User Defined Range selection for Total Precipitable Water

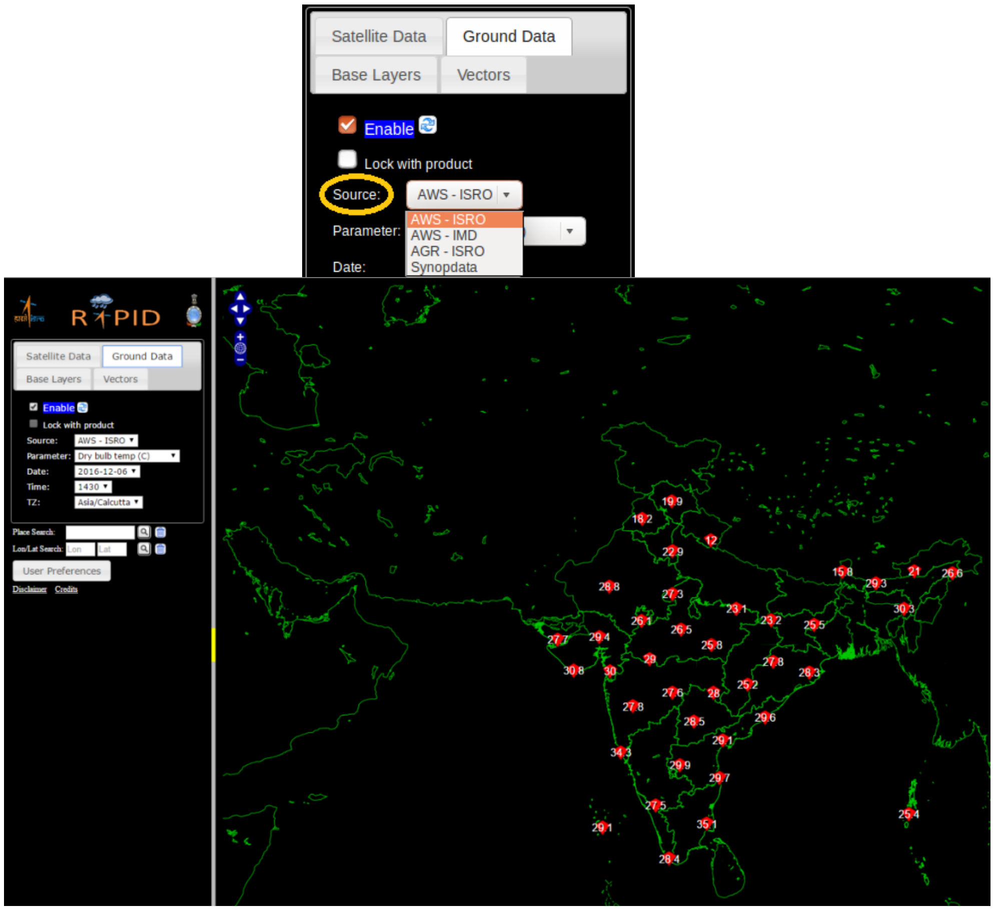


1.3.9.2. KALPANA1-VHRR Layers: Kalpana1 VHRR offers similar products to INSAT-3D Imager.

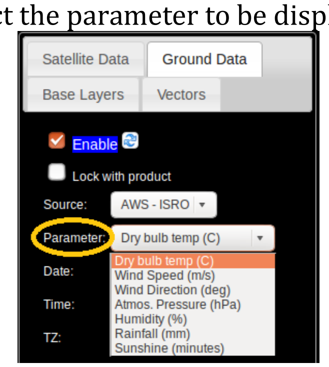
2.4 Ground Data:

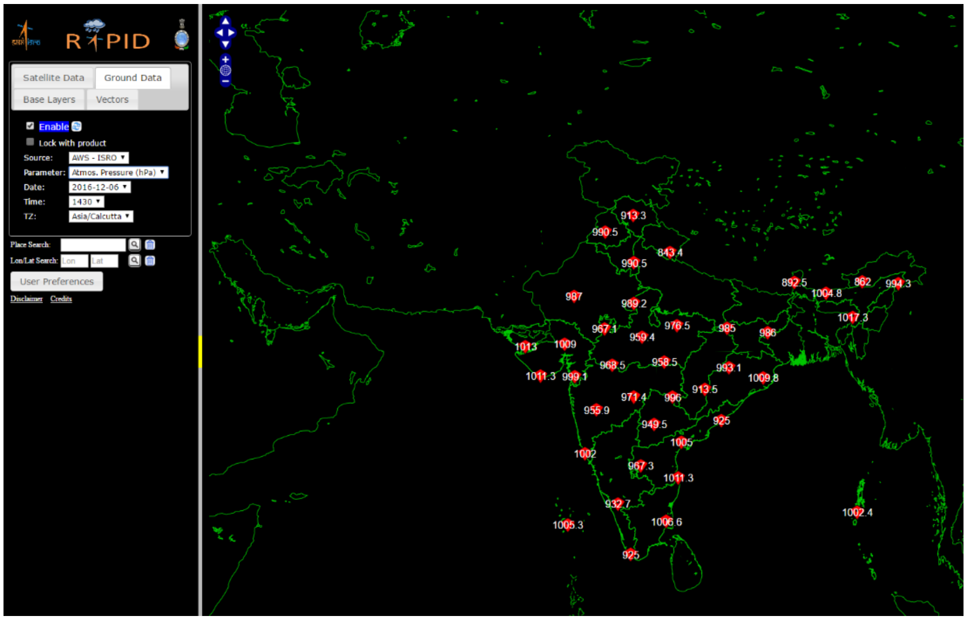
Here user can select the ground data that is to be visualized. This can be chosen using 5 options viz. Source, Parameter, Date, Time and TZ (time zone).

2.4.1.Source: Here user needs to select the source of the data from the available option. AWS - ISRO: Automatic weather stations (ISRO), AWS – IMD: Automatic weather stations (IMD), ARG – ISRO: Automatic rain gauges (ISRO), Synop data: Synoptic data (IMD observatory data). All these data can be visualized by superimposing them on satellite imagery.

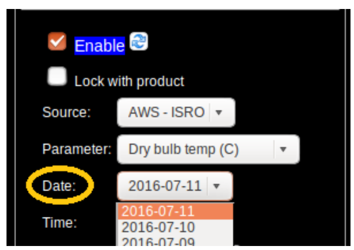


2.4.2.Parameter: Here user can select the parameter to be displayed from the available options.

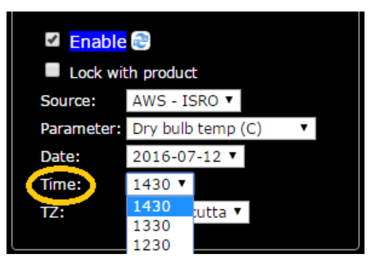




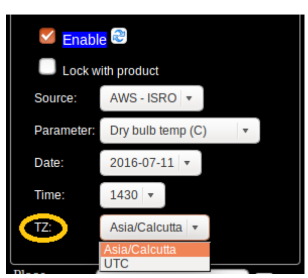
2.4.3.**Date:** User need to select the date from the drop-down menu



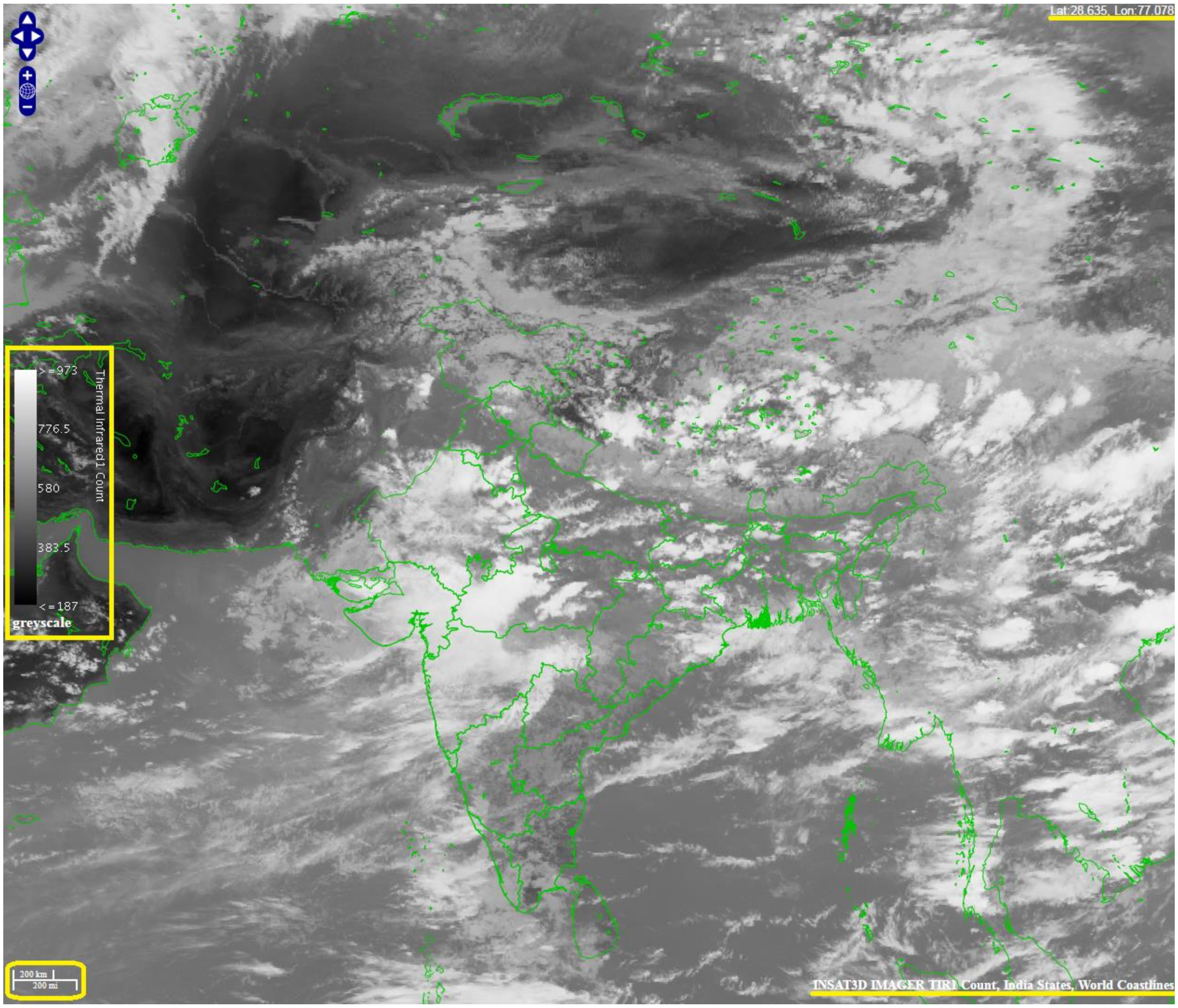
2.4.4.**Time:** User is required to choose the time for which data to be displayed.



2.4.5.**TZ (Time Zone):** User needs to select the time zone out of the two available options.



3. **Data Viewer Pane:** This is on the right of the screen where the image is displayed along with other data / base layers/ vectors selected. In the top right corner, it shows the latitude longitude of the current point. At the top left corner panning and zooming options are given with blue background. At the center left it shows the color bar with the scale. At the bottom left is the geographical scale which changes according to the magnification applied. The Image that is being displayed along with the vectors selected is shown at the right bottom of this data viewer pane.



Acknowledgements

The authors expressed their sincere gratitude to Dr. K.J. Ramesh, DGM, IMD, Dr. S.K. Peshin, Scientist-G and Head Satellite Meteorology Division, IMD and Director SAC for their guidance and encouragement in carrying out this report. The authors duly acknowledge the contribution of Dr. A.K. Mitra, Shri. Chinmay Khadke and officials and other staff members of Satellite Meteorology Division, IMD for providing their valuable information and feedback used in this report.

Feedback

Feedbacks and suggestions about this user guide are welcomed on virendra61.singh@imd.gov.in & amitkumar.777@imd.gov.in.

Acronyms

AOD: Aerosol Optical Depth

ARG: Automatic Rain Gauge

AWS: Automatic Weather Station

BT: Brightness Temperature

DMI: Dry Microburst Index

FPS: Frames per second

GPI: GOES Precipitation Index

HE: Hydro Estimator

IMD: India Meteorological Department

IMSRA: INSAT Multi Spectral Rainfall Algorithm

ISRO: Indian Space Research Organization

L1: Level1

L2: Level2

L3: Level3

LI: Lifted Index

LPW: Layer Precipitable Water

LST: Land Surface Temperature

LWIR: Long Wave Infrared

MIR: Mid Infrared

MWIR: Mid Wave Infrared

OLR: Outgoing Longwave Radiation

QPE: Quantitative Precipitation Estimate

Rad: Radiance

Sat: Satellite

SST: Sea Surface Temperature

SWIR: Short Wave Infrared

Synop: Synoptic hour observatory data

TIR1: Thermal Infrared 1

TIR2: Thermal Infrared 2

TPW: Total Precipitable Water

TZ: Time Zone

UTH: Upper Troposphere Humidity

VHRR: Very High Resolution Radiometer

VIS: Visible

WI: Wind Index