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LSGI 522 LAB 3 REPORT

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I. In the given assignment, we are asked to monitor sand and dust storms using satellite data. The analysis has been made by using ERDAS ER Mapper while the BTD Dust Index Map has been prepared using ArcMap.

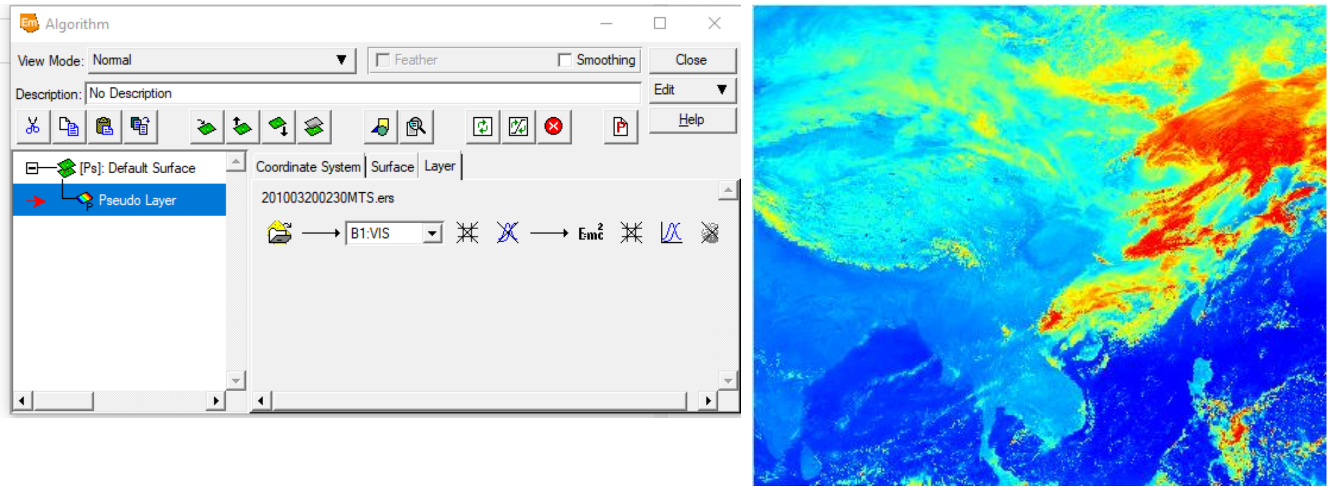

Figure 1. After importing the HDF File, we load the dataset for analysis. This image shows the display of the VIS band.

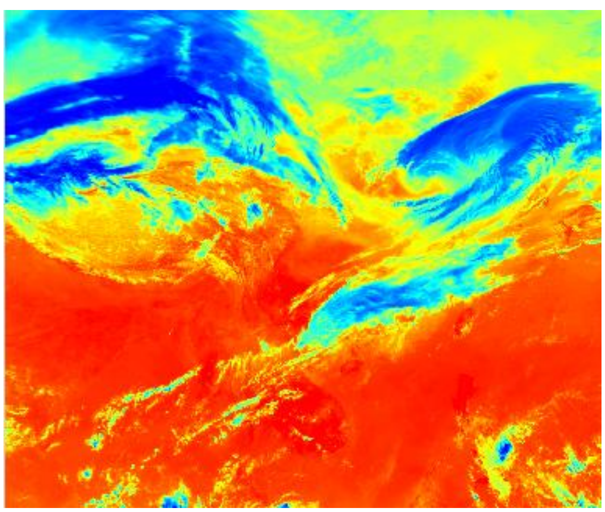

Figure 2. Duplicating the pseudo layer and displaying the IR1 band.

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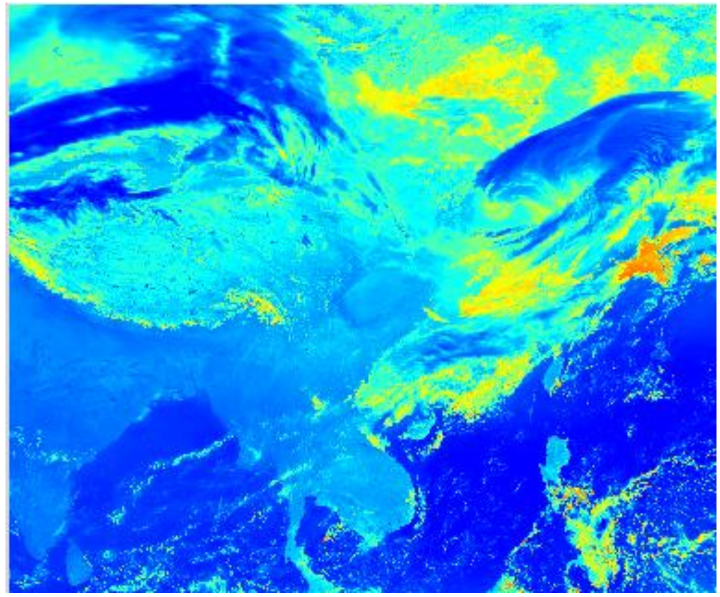
Figure 3. Selecting 1st layer and applying formula: press E=mc² button to open the “Formula Edit” window. On the menu bar, choose “Standard”->”Threshold between two varibles”, you will see the textbox changed below the button of “Apply Changes”. Then input the characters below:

if (INPUT1 < 0.4) and (INPUT2 >257) then INPUT1 else null

and set INPUT1 to VIS and INPUT2 to IR1, press Apply changes to see the effort.



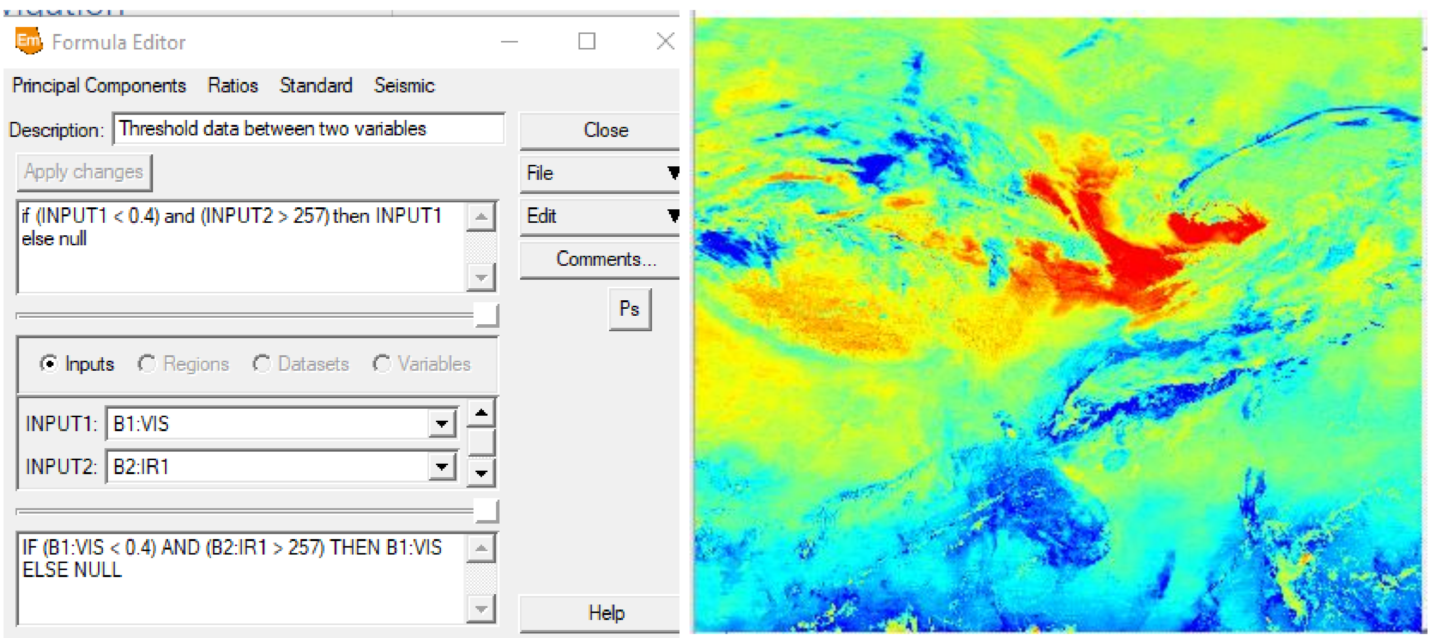


Figure 4. Figure above shows the calculation for BTD [11, 12]. (Left) Open the formula edit window and applying the formula: On the menu bar, select “Standard”->”Differences of two inputs” to calculate the BTD[11,12] which introduces in the first section. Because the BTD[11,12] will be negative for the dust region, here we set INPUT1 as IR2 and INPUT2 as IR1 to make the values positive in order to display the dust region in warm color. (Right) After applying formula. Dust region shown in warm colour.

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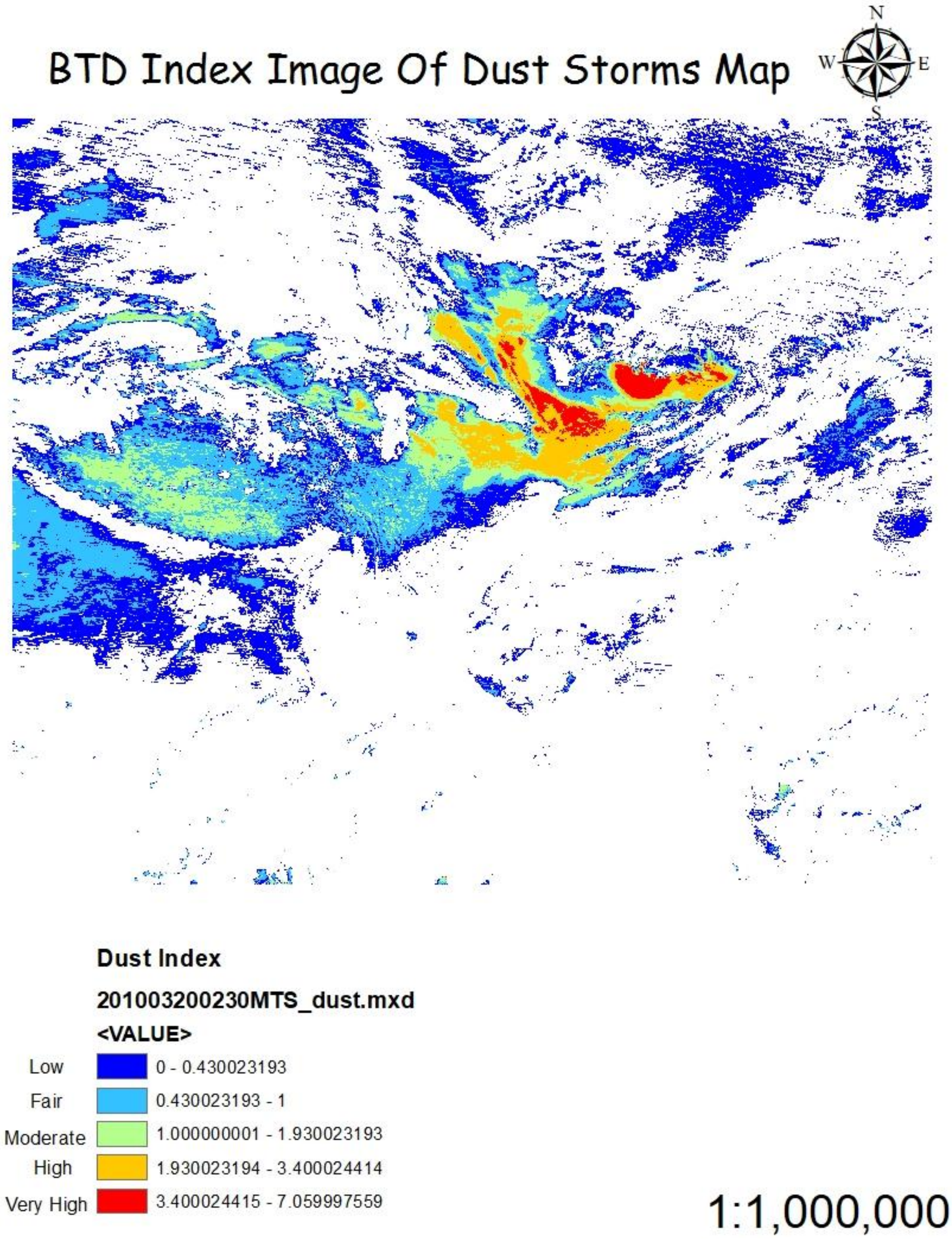
II. Dust Index Classification

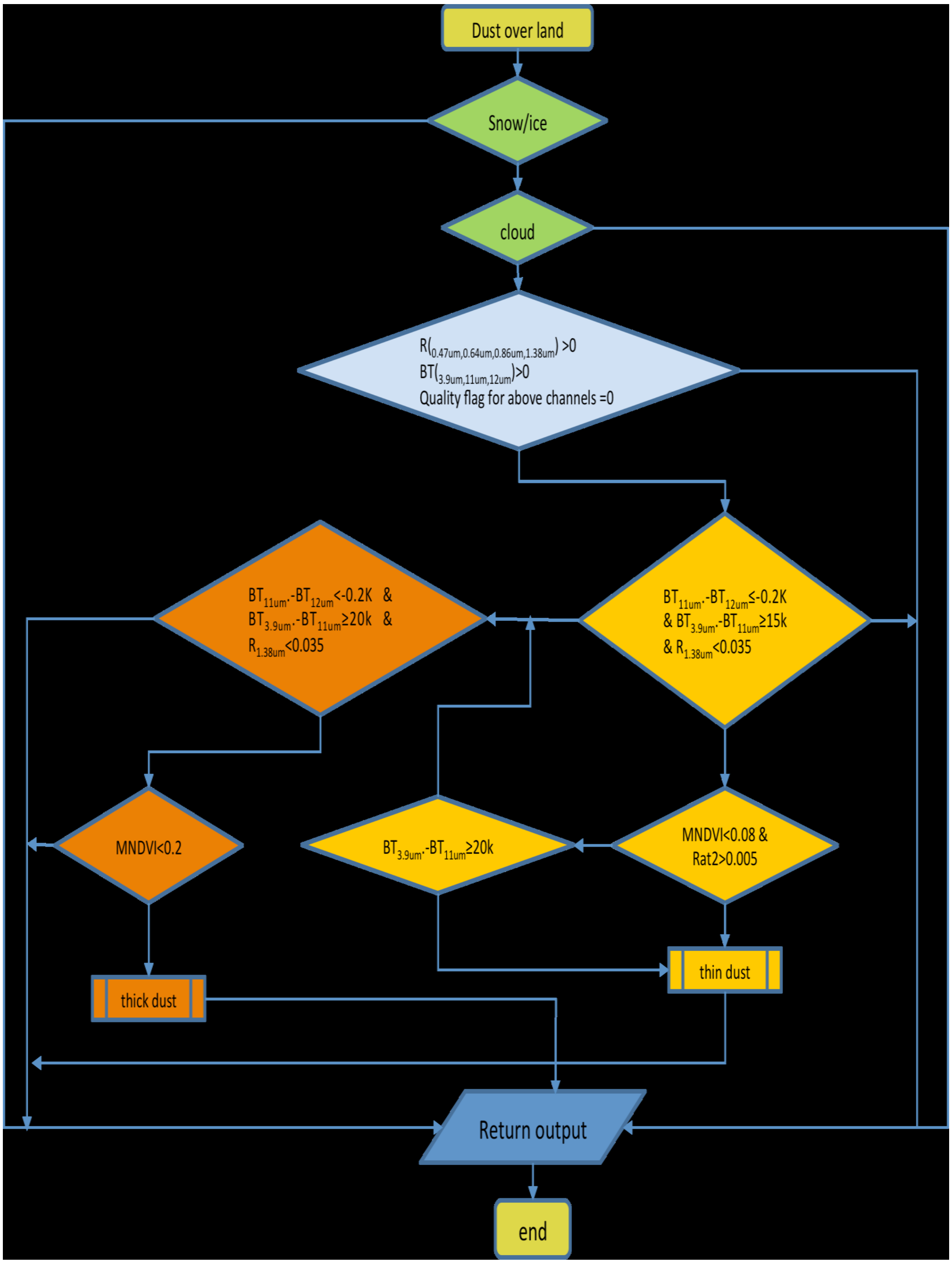


The above map shows the classification of the dusty areas into five categories:
Low (indicates less dusty areas)
Fair
Moderate
High
Very High (indicates very high amount of dust in the area represented by red colour)

Aerosols have certain wavelength dependent properties which is why there is a need for differentiation between dust, cloudy areas, smoke, etc. The bulk transmittance of many aerosols displays a strong spectral variation in the 8-10 m and 10-12 m regions. This is also a spectral region over which the atmosphere is fairly transparent. For these reasons, techniques have been developed which successfully employ satellite radiance measurements at 11 and 12 m to detect aerosols.

The 11-12 μm brightness temperature difference is displayed with a color enhancement with colours used for brightness temperature differences. The dust cloud is detected in red colour as shown on the map.

III. The figure below shows the calculations and processes to analyze dust over land:



For

Dust detection over land, the brightness temperature test implemented is as follows:

$BT11\mu m - BT12\mu m \leq -0.5K$ & $BT3.9\mu m - BT11\mu m \geq 20K$

The above formula is used to remove cloudy pixels. Dust absorbs more radiation at 12 µm than 11 µm, which causes the brightness temperature difference between the two to become negative. Moreover, there is absorption and emission of water vapor in the 11 and 12 µm channels. Because the weighting function for the 11 µm channel peaks lower in the atmosphere (higher in temperature) than the 12 µm channel does, the presence of a dry air mass, often associated with dust events, will tend to reduce the positive BT11□m − BT12□m values associated with clear-sky atmospheres. In addition, dust has a larger absorption at 12 µm than at 11 µm, so that dust plumes generally have a higher emissivity and lower transmissivity in the 12 µm channel [4,14].

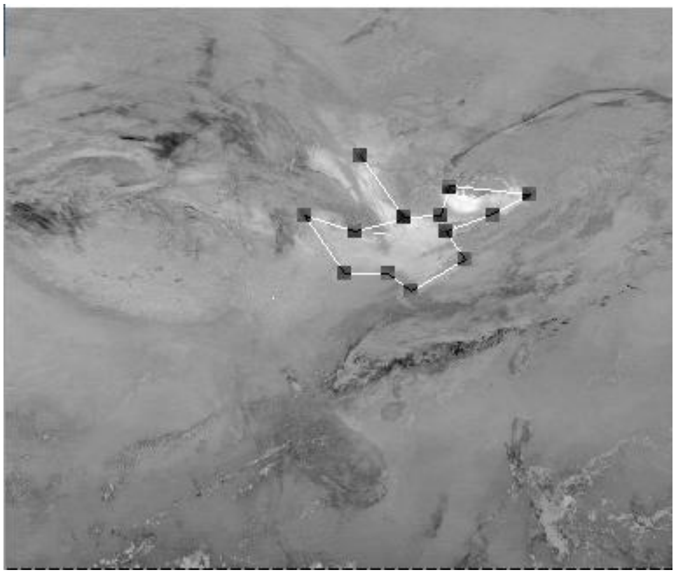
For high altitude or elevated dust layers, the increased temperature separation between the dust layer and the surface, and the coincident reduction of dry air closer to the peak of the 11 µm weighting function, makes the split window brightness temperature difference less positive. This difference has also been observed to be affected by the optical thickness of a given dust plume, so that with thick optical thickness the BT11 µm − BT12 µm difference has a negative value.

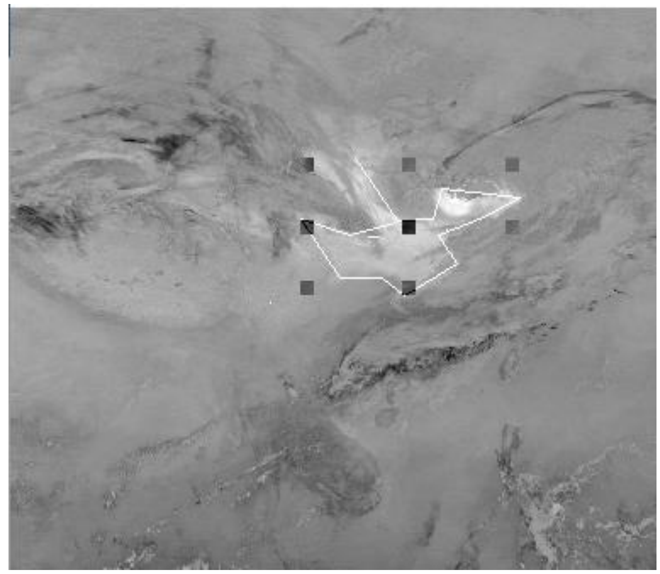
IV. Dust detection over the Ocean

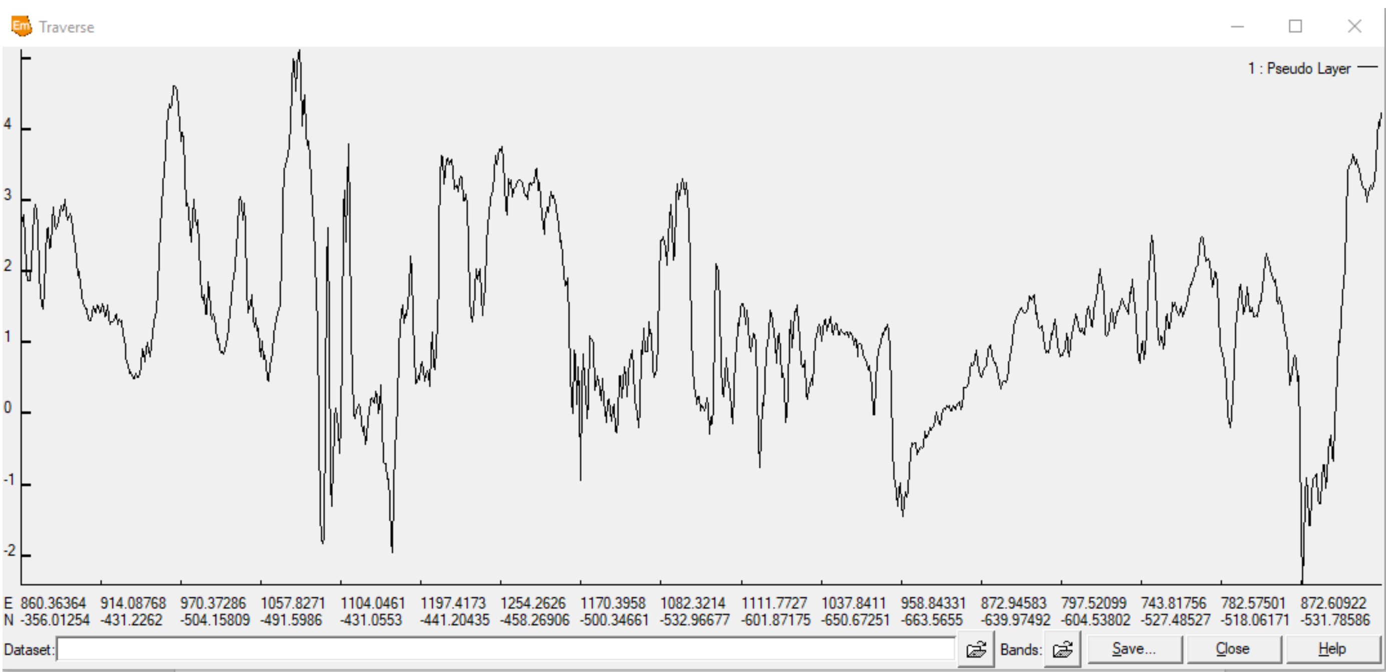
If $BT11\ \mu m - BT12\ \mu m < 0.1K$ and $-0.3 \leq NDVI \leq 0$ then the pixel is set as dust contaminated.

V. BTD Discrepancies of the three different areas.

Dusty region

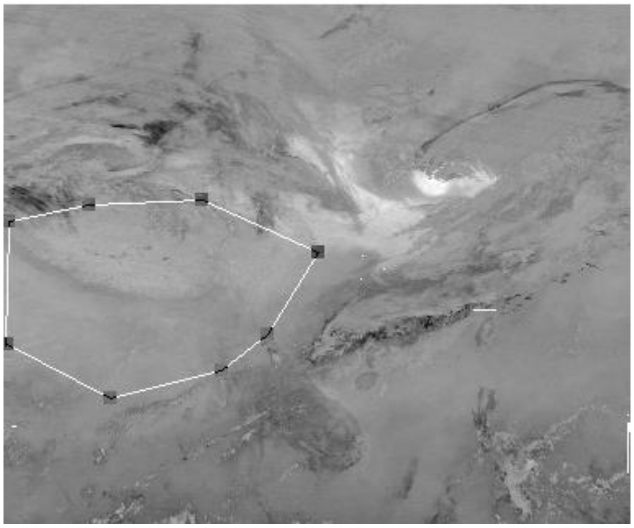


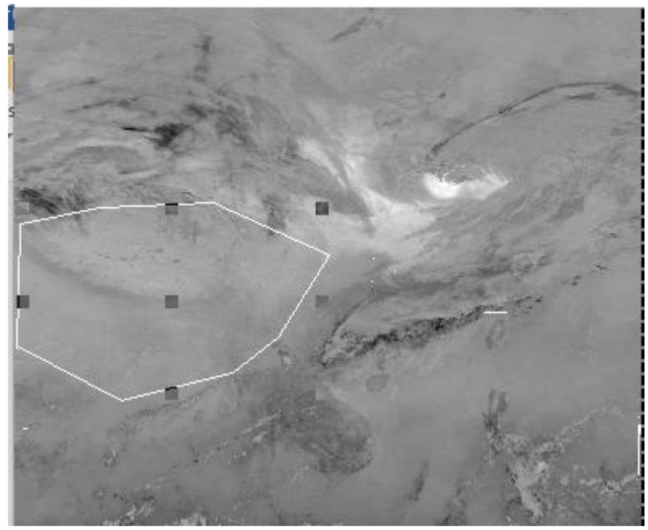


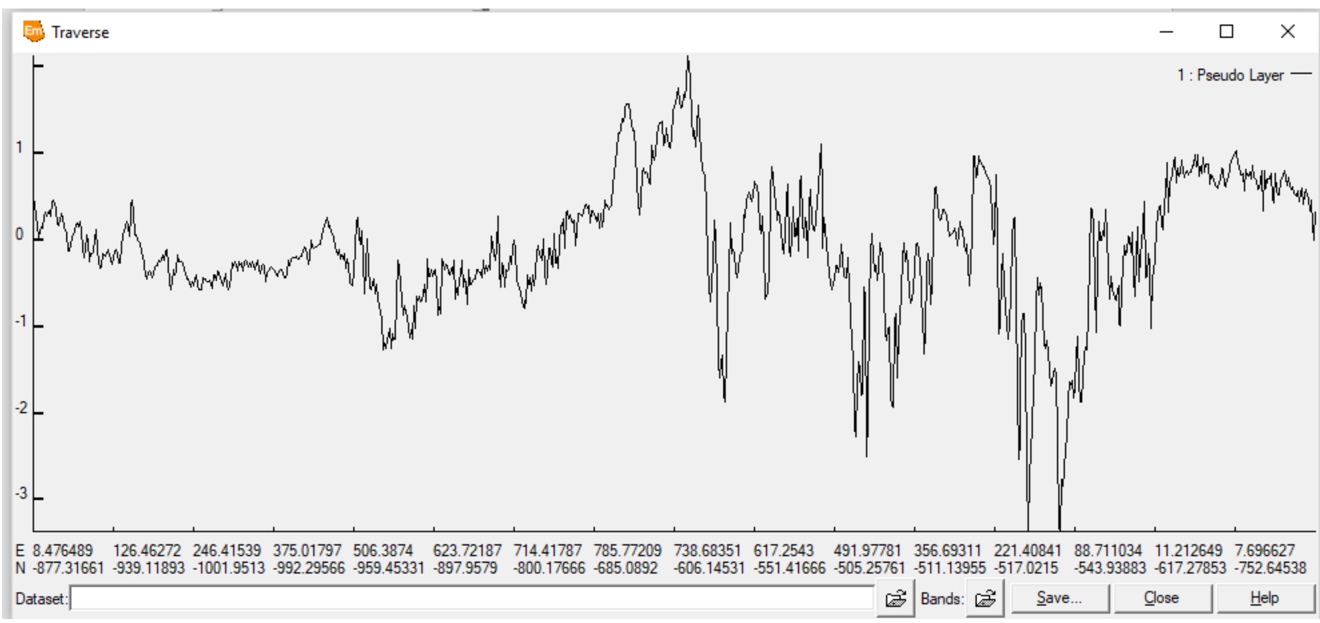


In the above images we see a graph of positive values which indicate the dusty region. By applying the formula, we indicate dusty areas with positive values and are shown in warm colour range from -2.43156506597 to 4.62090419704. From the graph, we can assume the negative values to be less or negligible.

Cloudy region

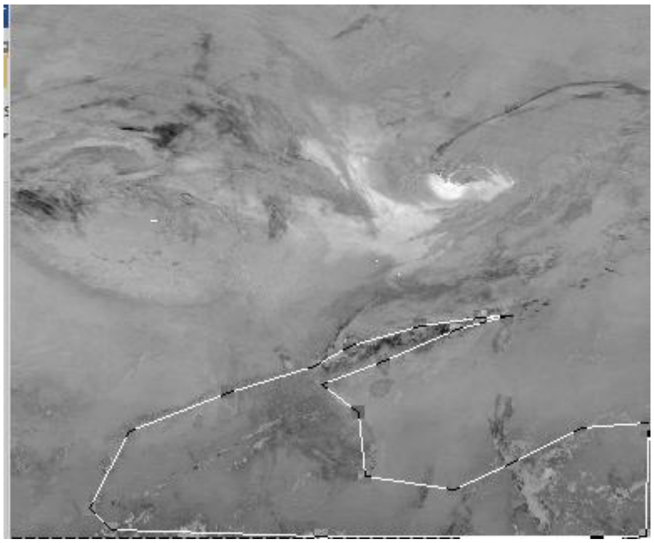


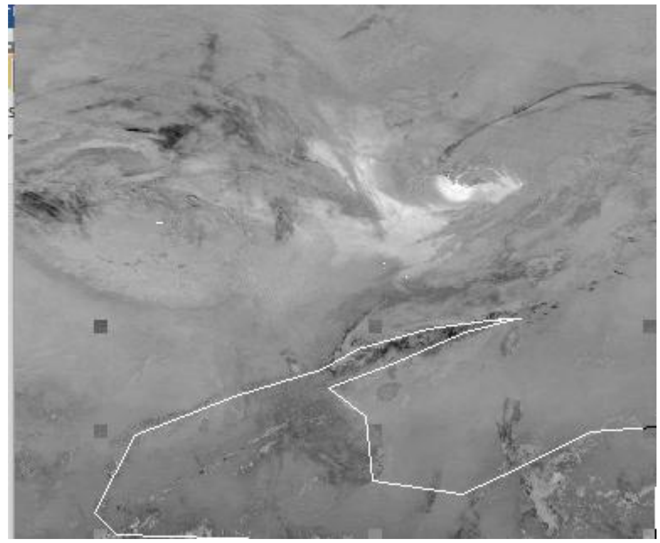


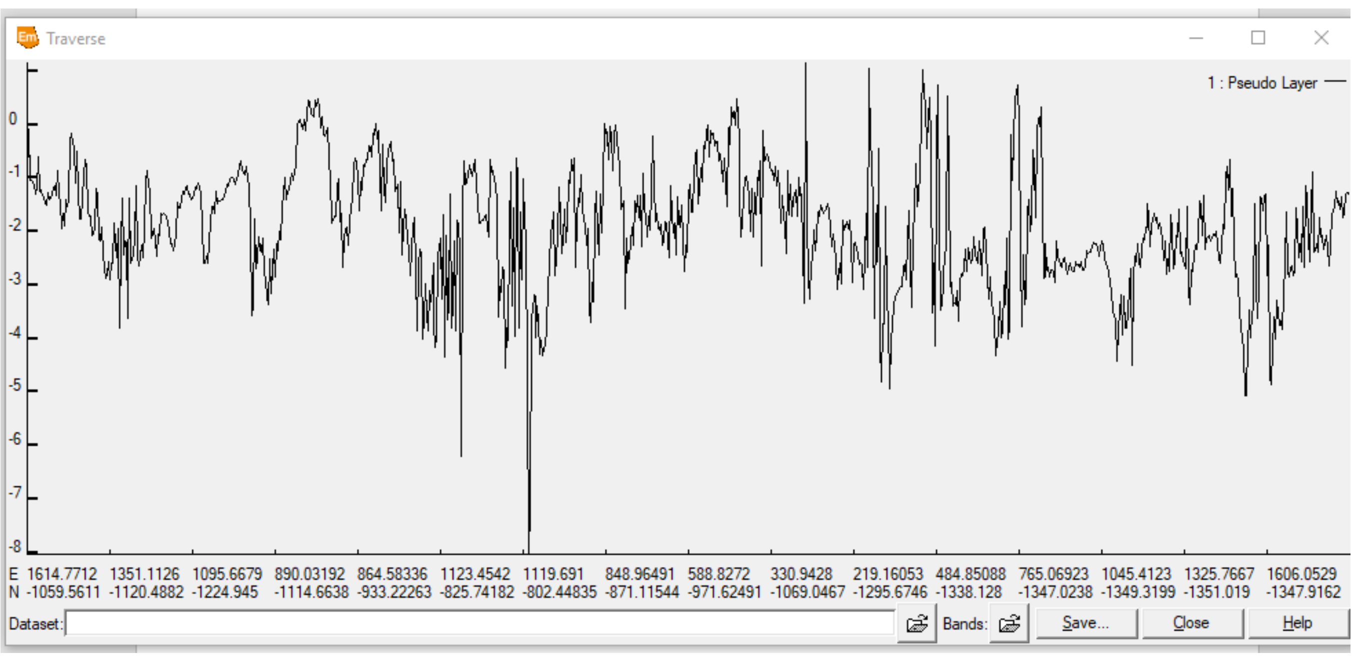


Based on geographical knowledge, a cloud is generally formed by water vapour and dust particles. On this note, we see that the cloudy region has values ranging from -3.345896431 to 2.141962457.

Clean region







A “clean” region indicates an area which has very less or negligible dust particles. The graph shows negative values which are opposite to that obtained for the “dusty region”. The values range from -7.003801059 to 0.885226613.

Reports published in the past have indicated a widespread dispersion of dust particles from dust storms over many parts of Asia. The frequency of dust storms in Asia, have created the need for satellite data to monitor and predict such occurrences. The growing concern about environmental protection and development of techniques has resulted in interested developments in satellite remote sensing. Satellite remote sensing can play a vital role in monitoring environmental changes, including deterioration of air quality from dust storms, the power and frequency of which has increased over the past few decades.

Satellite remote sensing provides a broad spectral range from the visible to infrared regions. Records can be obtained from various satellites out of which the famous MODIS, provides 36 spectral bands from visible to infrared with both morning (Terra) and afternoon (Aqua) tracks, and may be well suited for dust detection. Dust indices which are used to monitor dust storms are divided into groups based on the type of remotely sensed data they use. The BTD, which is based on the thermal absorption of dust in one certain wavelength being larger than that in another, is one of the most popular parameters used in dust monitoring. The brightness temperature difference (BTD) between two thermal infrared bands is a common index for dust detection. The BTD is used to find the epicenter of the dust storm. In the images on the previous pages we see that the BTD has done well in dividing clean areas from cloudy and dusty areas.

Brightness Temperature Difference Algorithm

BTD= Tb (11μm) - Tb (12μm)

What exactly happens behind the formula? An Example ↓

Brightness Temperature Difference:
The subtraction of channel 5 data from channel 4 is referred to as Brightness Temperature Difference. Channel 5 is referred to as the Split-Window IR channel and is centered at approximately 12 microns in wavelength. Channel 4 is the more standard IR channel and is centered at approximately 11 microns. Optically thin clouds emit different amounts of energy at these two wavelengths. Optically opaque (optical depth = 1.0) clouds emit the same amount of energy at these wavelengths. By subtracting these two channels, regions of thin clouds (usually high, thin cirrus) can be displayed very prominently. Also, because of the chemical composition of effluents from volcanic eruptions as well as the emitting characteristics of ash clouds, these data can be quite useful at locating plumes of ash from volcanic eruptions.

VII. BIBLIOGRAPHY

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