Earth Observation and Data Analysis

Homework 3

Submitted by:
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1. Perform data quality check

All data bands were visually inspected and found to be of good quality without any considerable noise.

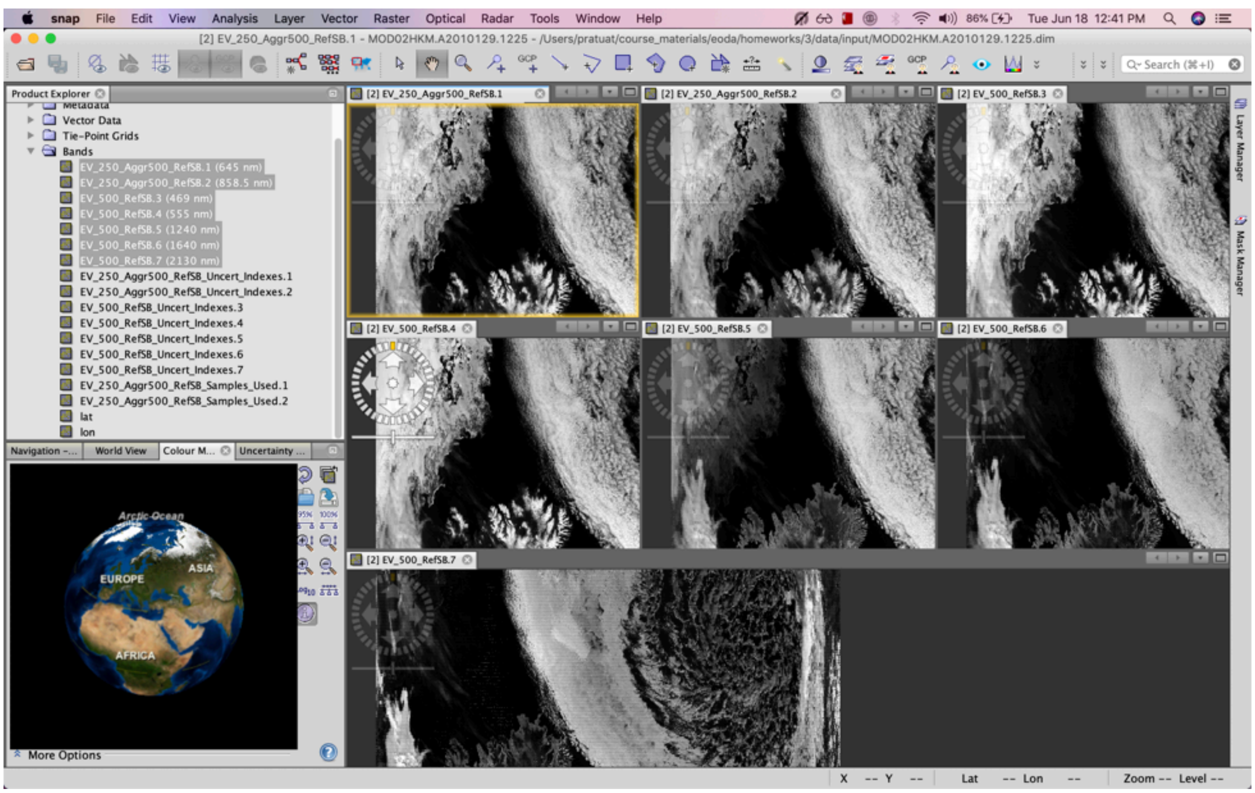


Fig 1.1 Data quality check for SEVIRI data bands

2. Perform and display "visible" RGB composite with MODIS data

MODIS data channel 1 (EV 250 Aggr500 RefSB 1) was selected as red, channel 4 (EV 500 RefSB 4) as green and channel 3 (EV 500 RefSB 3) as blue to build the RGB visible composite of the data.

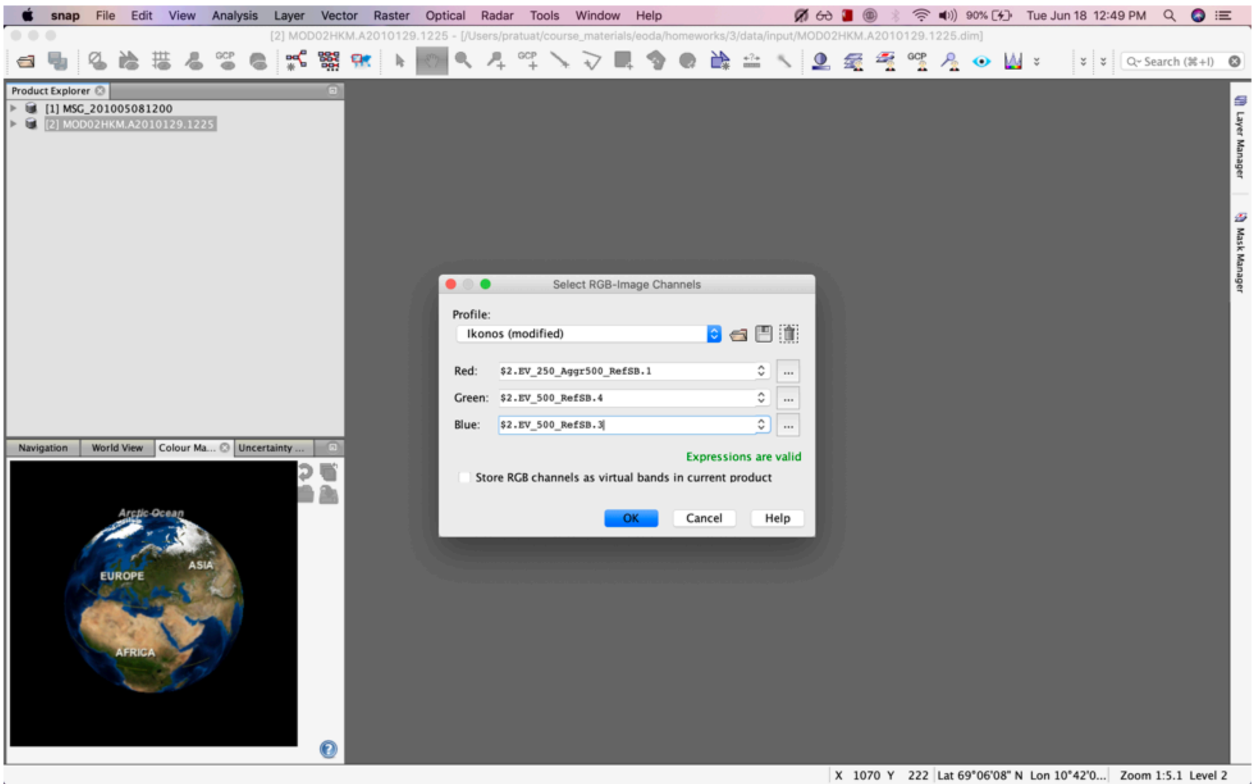


Fig 2.1 MODIS RGB composite bands

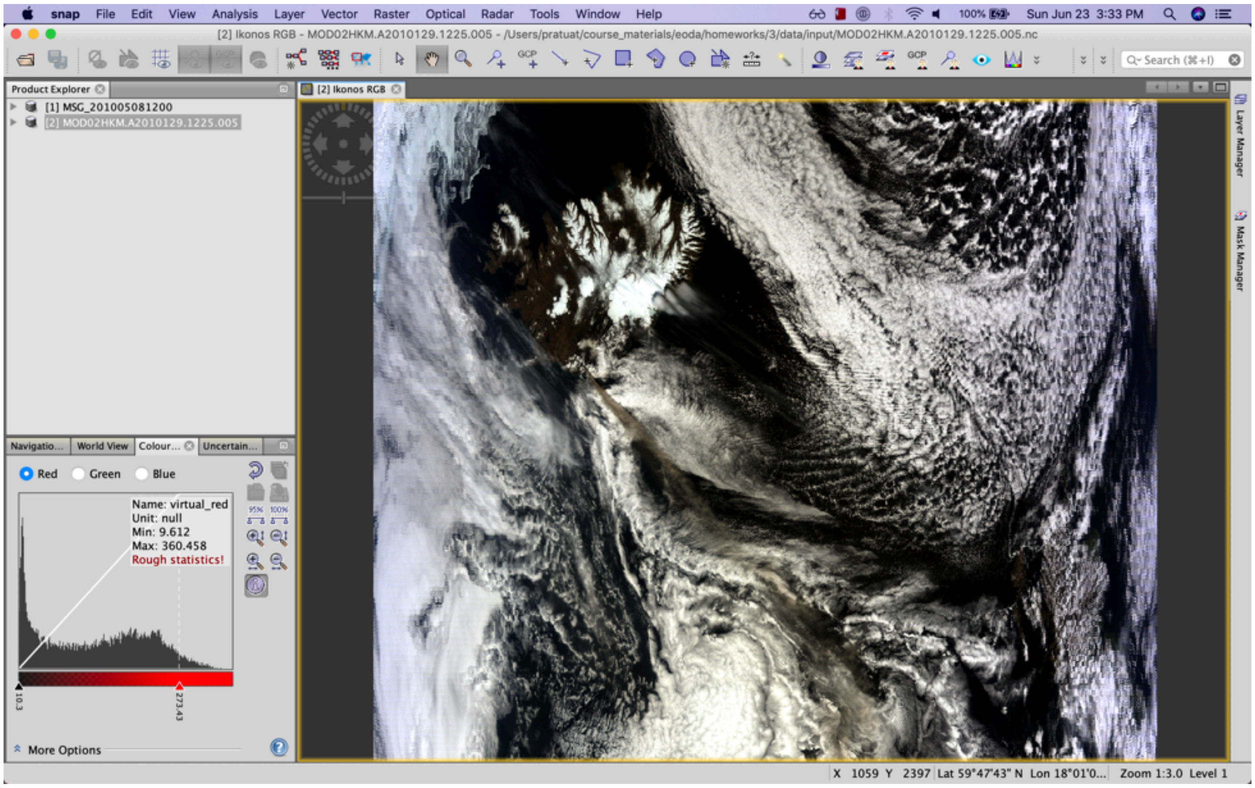


Fig 2.2 MODIS RGB composite visualization

Volcanic ash cloud were visually detectable surrounding the region of interest.

3. Perform and display "virtual" RGB composite using SEVIRI data channels

As for SEVIRI data, we used IR_087, IR_108 and IR_120 bands as red, green and blue channels respectively to build the visible composite of the data.

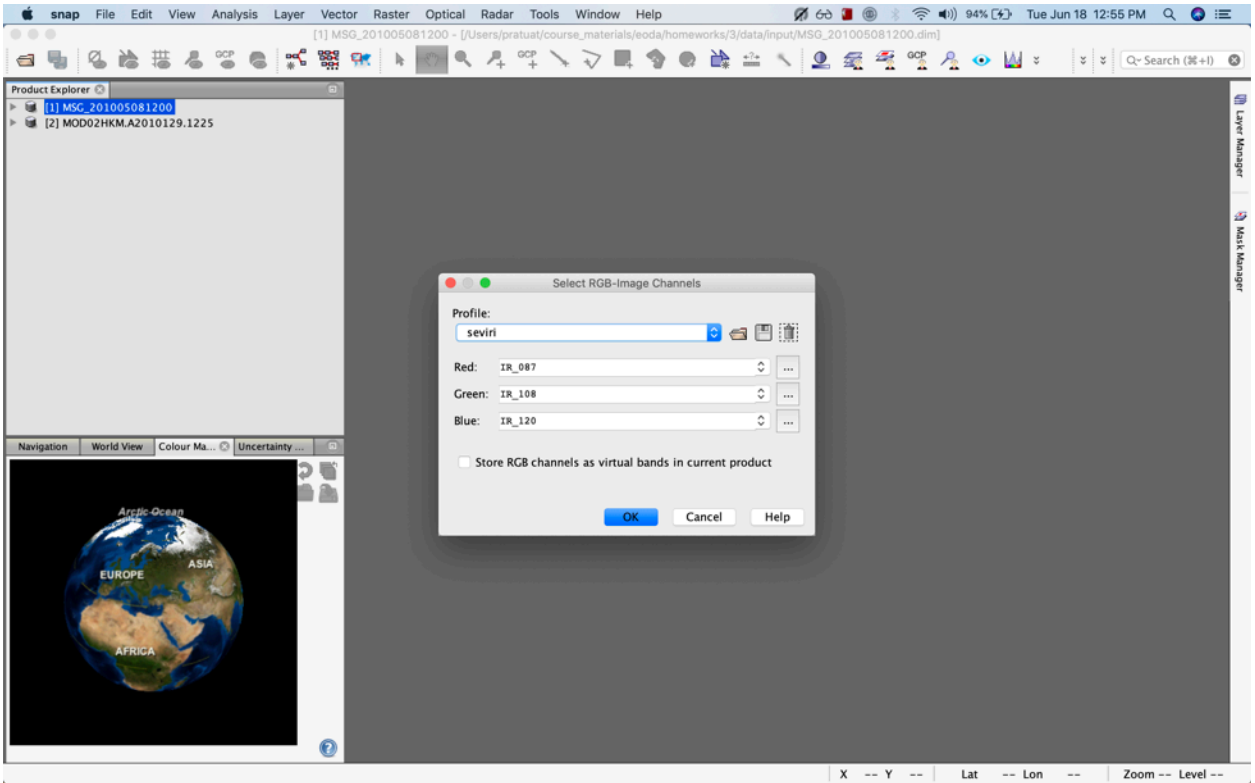


Fig 3.1 SEVIRI RGB composite bands

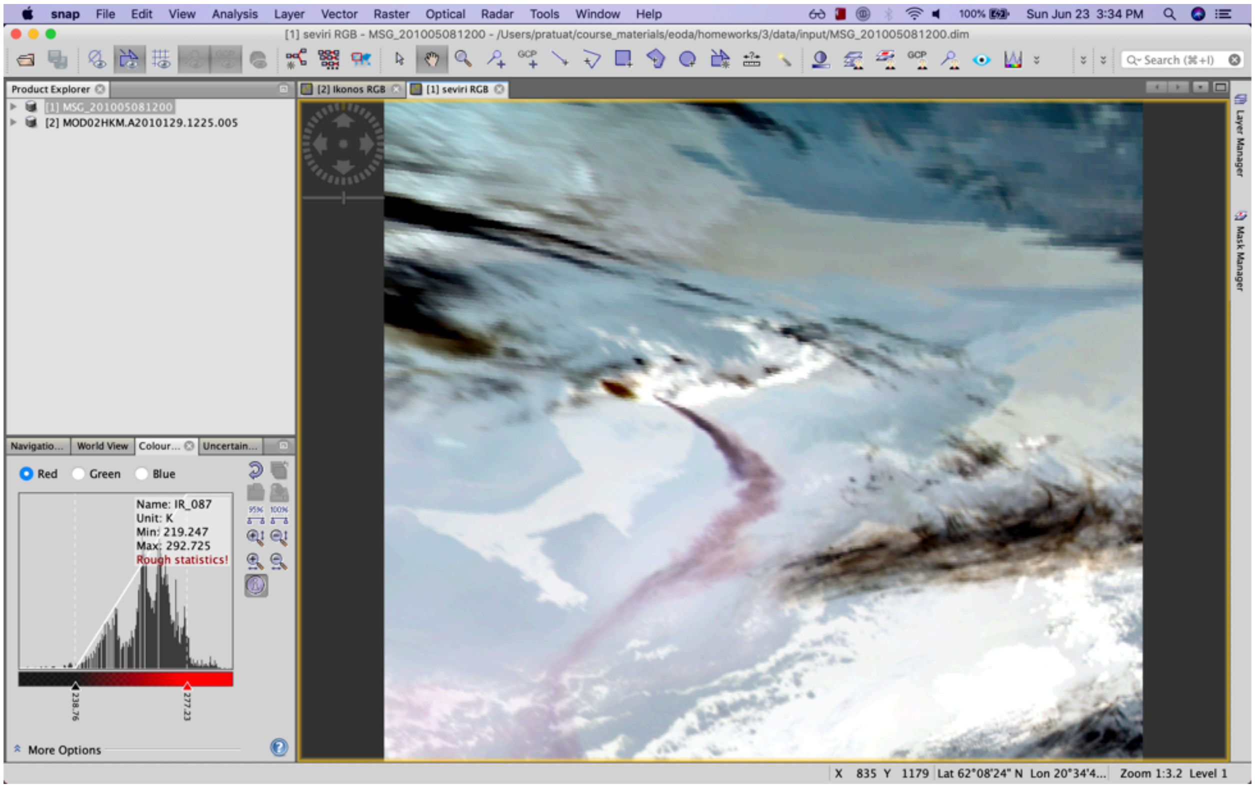


Fig 3.2 SEVIRI RGB composite visualization

Presence of volcanic ash clouds is clearly visible in the resulting RGB composite.

4. Perform and display ash-cloud transects on SEVIRI RGB composite data

In this section, SNAP polyline drawing tool was used to trace the direction of the ash cloud in the visible composite layer.

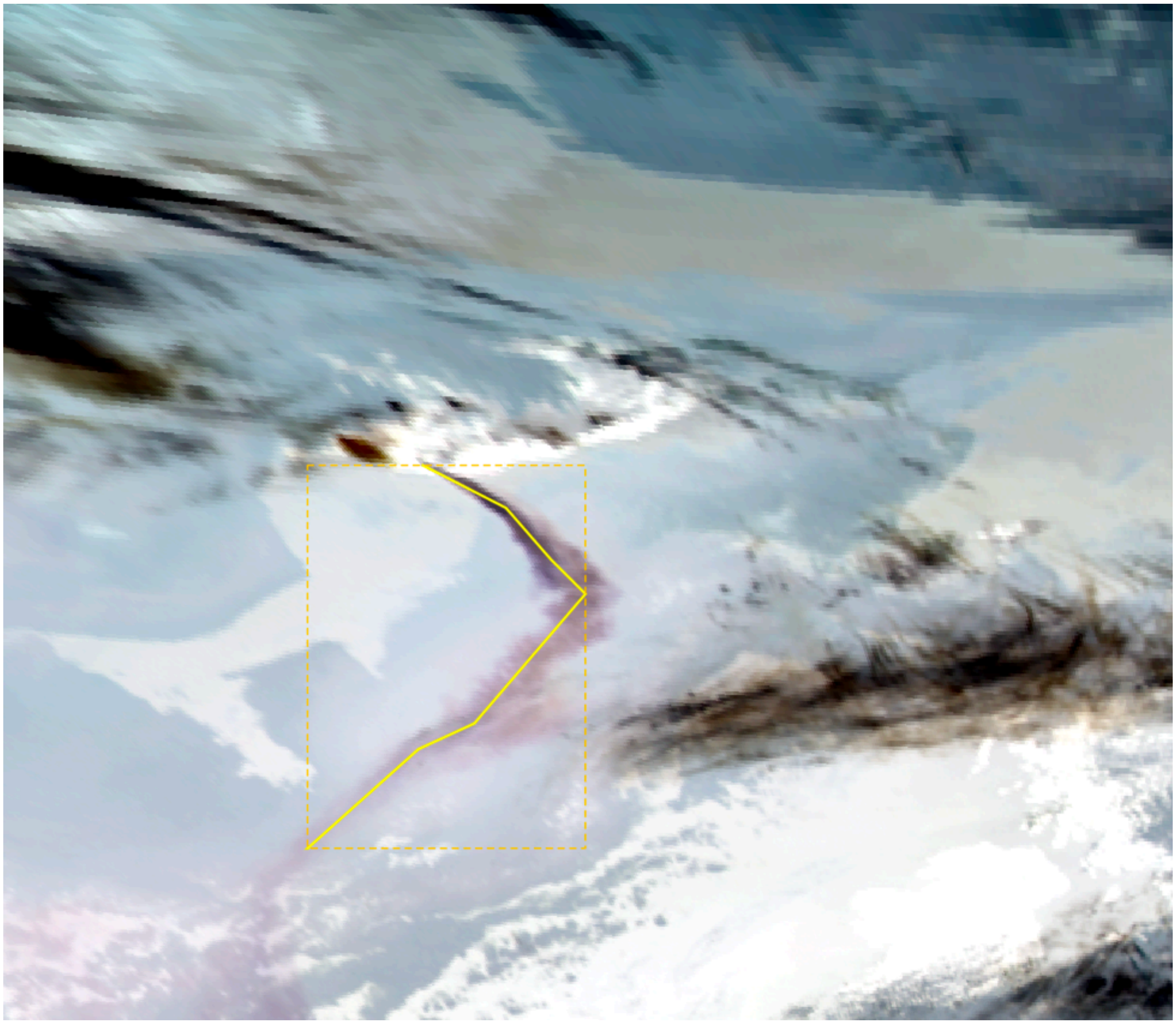
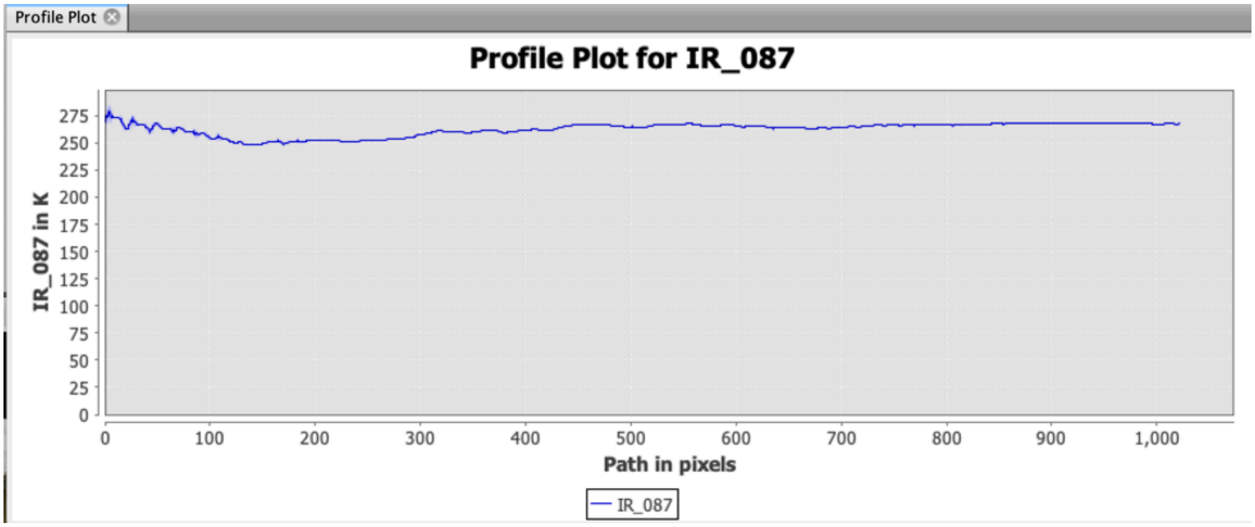
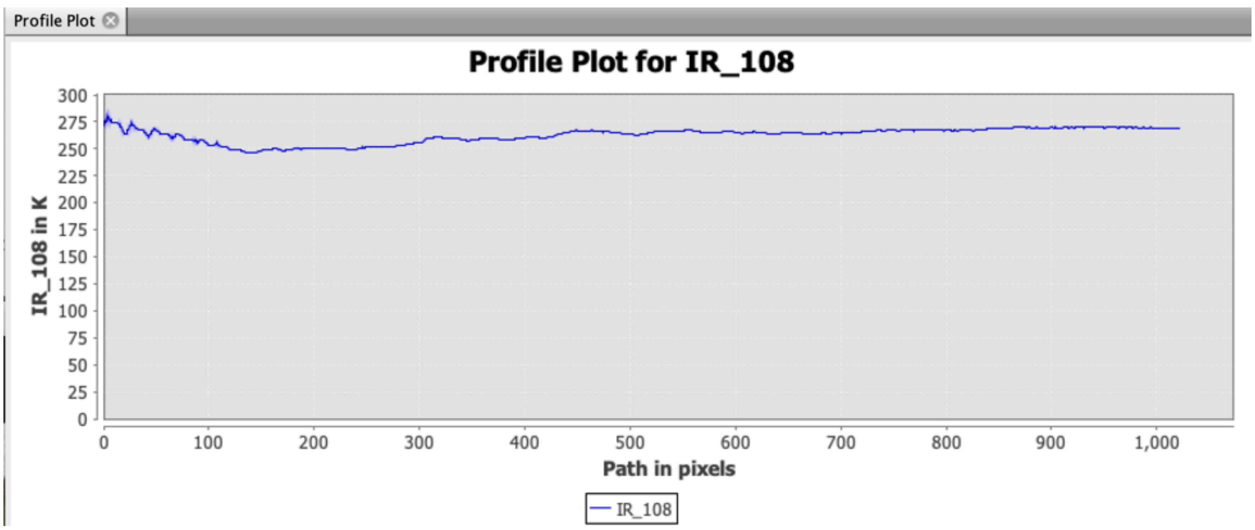
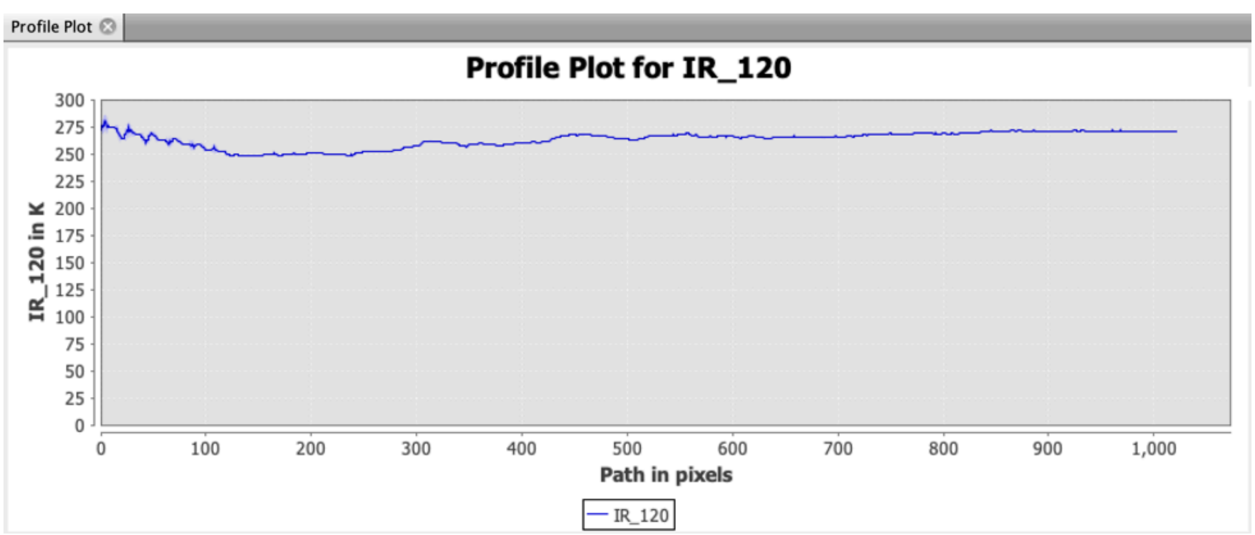


Fig 4.1 Polyline drawn for ash-cloud transects

SNAP Profile plot tool was used to generate ash-cloud transects with the following outcomes for three bands.







5. Perform and display Brightness Temperature Difference (BTD) using SEVIRI data

Here we used SNAP band-math tool to compute and display Brightness Temperature Difference (BTD) using two spectral bands IR_108 and IR_120 as following.

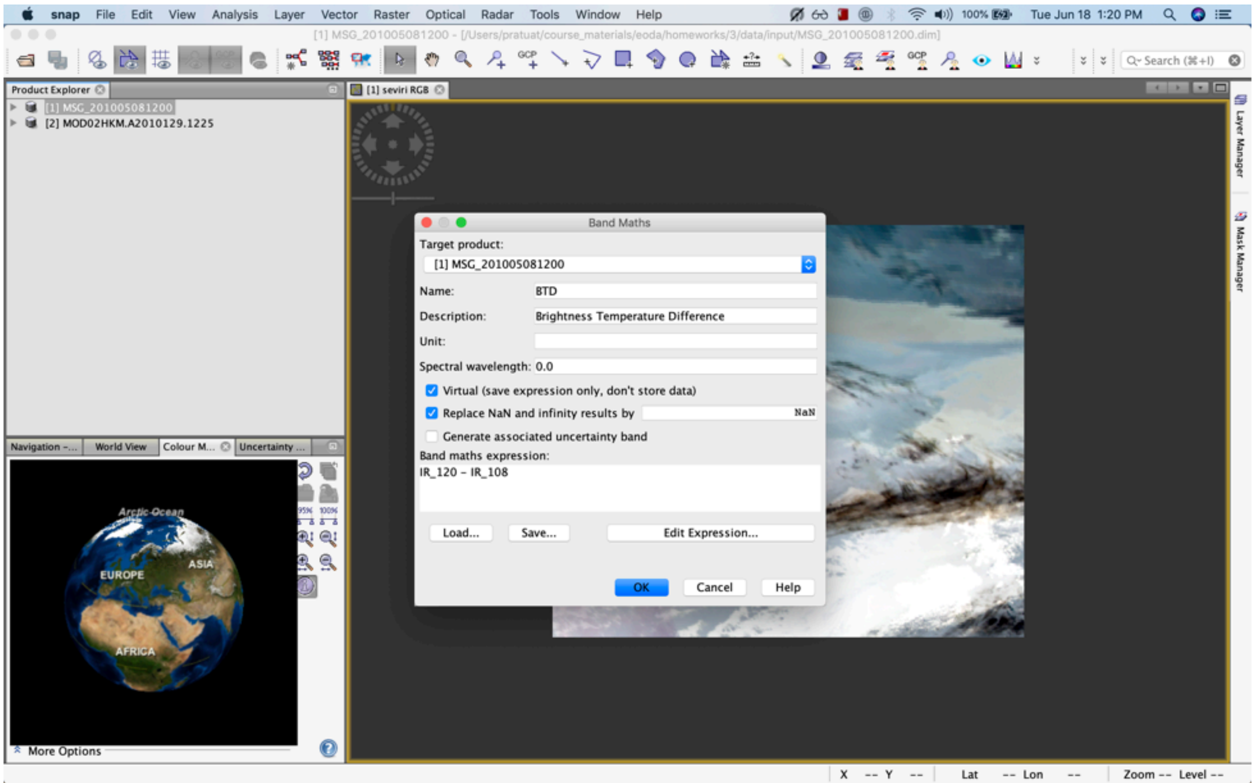


Fig 5.1 Brightness Temperature Difference (BTD) band math

BTD detection technique when applied to the SEVIRI data, yielded following image with maximum differential intensity for volcanic ash cloud represented in dark blue color.

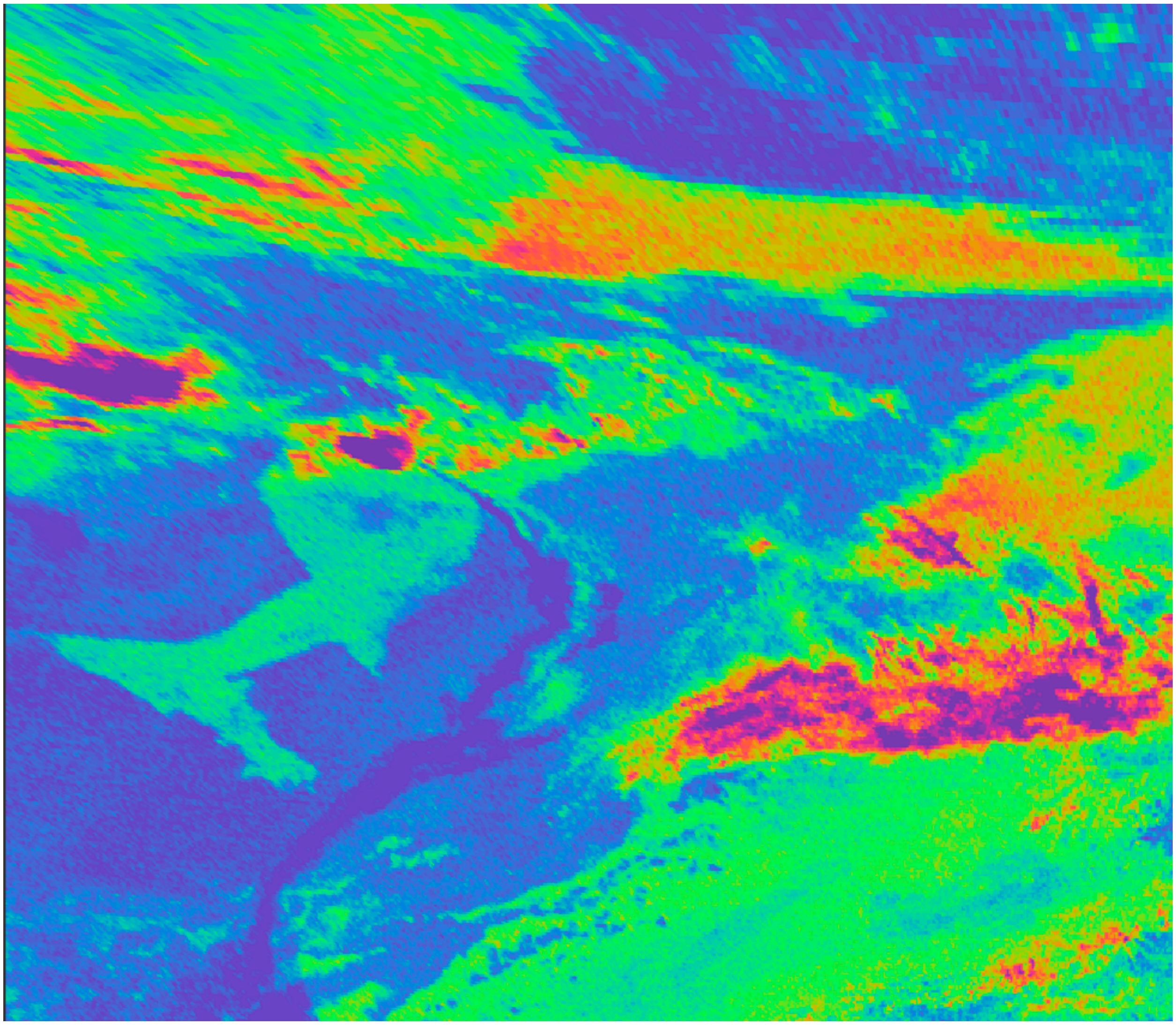


Fig 5.2 Results of BTD measure on SEVIRI data

6. Implement Volcanic Ash Detection Algorithm (VASD) using SNAP processing tools

We implemented basic version of VASD by factoring in strong absorption of infrared radiation between 8 and 14 um by silicate particles. In this algorithm we classify pixel as ash cloud or non-ash cloud depending upon the comparative intensity of IR_108 band alongside IR_120, IR_039 and IR_087. The band math for the algorithm is,

$$
\begin{aligned}
IR\_120 - IR\_108 &> 0 \\
IR\_039 - IR\_108 &> 0 \\
IR\_087 - IR\_108 &> 0
\end{aligned}
$$

The implementation of VASD algorithm in SNAP band-math toolbox is

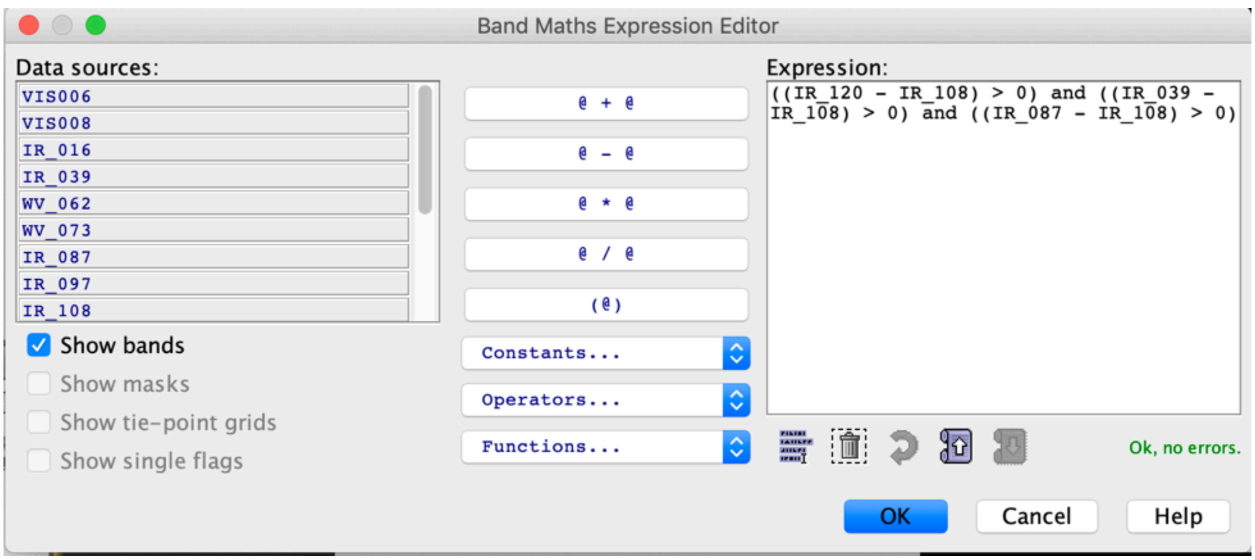


Fig 6.1 Band-math for Volcanic Ash Detection

If a pixel satisfies all of above condition, it is classified as ash-cloud else none and hence we get is a binary image as following.

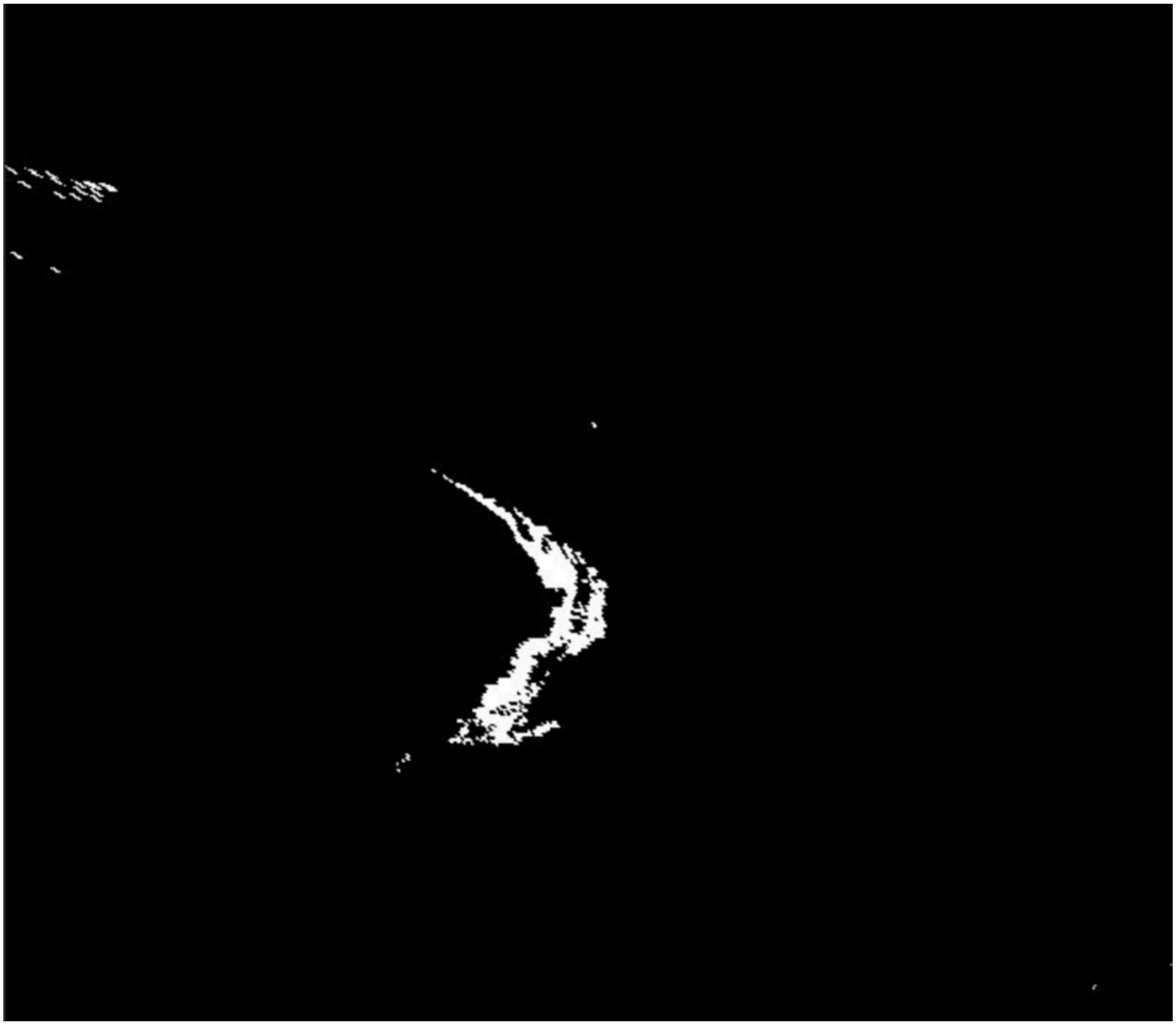


Fig 6.2 Binary image for Volcanic Ash Detection

7. Apply VASD (algorithm 1 and 2) and interpret their output results and differences

We used second method to estimate the presence of ash-cloud using SNAP band math tool.

$$60 + 10(IR120 - IR108) + (IR039 - IR108) > 100$$

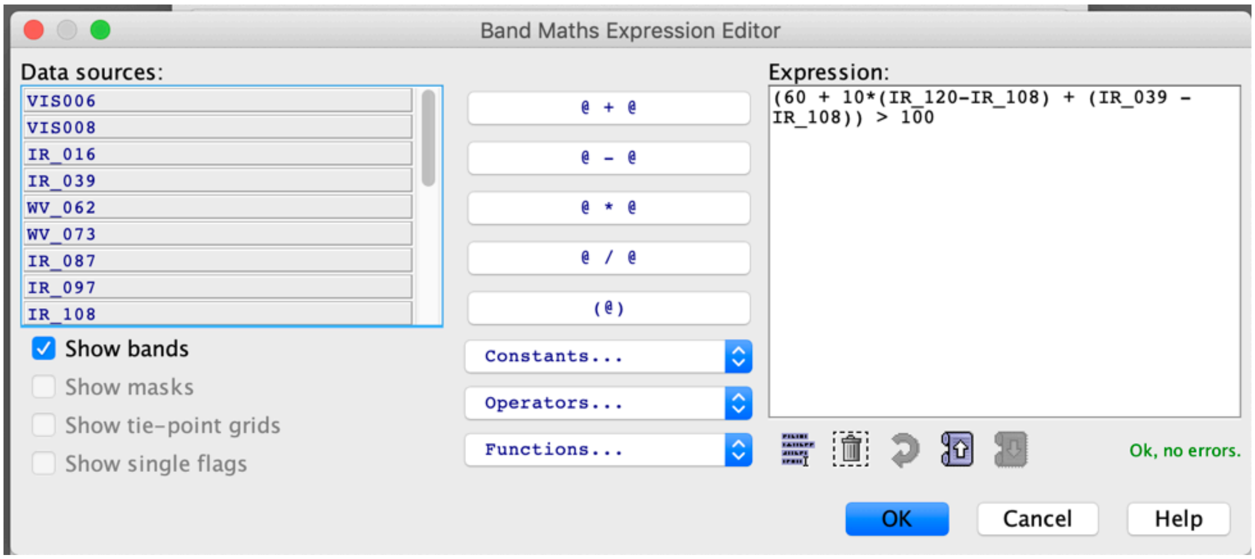


Fig 7.1 Band-math for Volcanic Ash Detection

The resulting output is

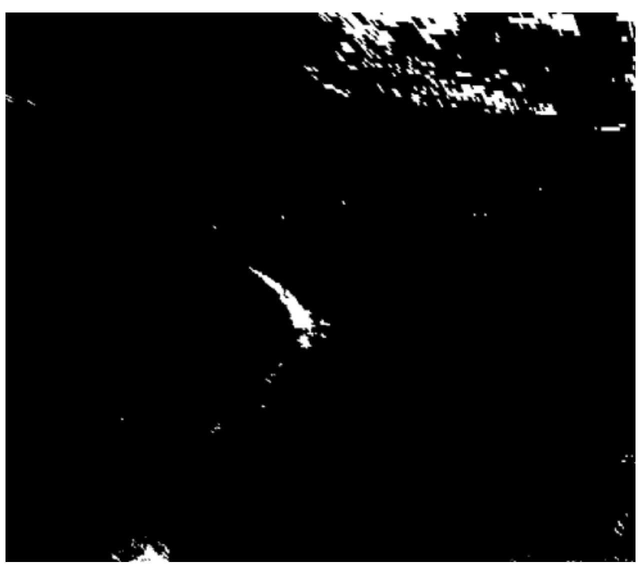


Fig 7.2 Binary image for Volcanic Ash Detection

The new algorithm tend to have higher sensitivity compared to first algorithm such that we observe higher number of false positivies in the northern region and false negatives in the central region. Hence either way this algorithm performs worse than the first one.

8. Develop and implement a TIR optical thickness retrieval algorithm by applying the no-scattering radiative transfer theory for a thermal homogeneous ash cloud layer noting that TB≤T0 (you can use SNAP, Python/Matlab or R-language environment to implement the algorithm depending on its complexity)

We will use following formula to determine the TIR optical thickness over any given bands.

$$T(\lambda) = T_{BB}(1 - e^{-\tau})$$

T_{BB} is the black body temperature, equivalent to max value in the image
$T(\lambda)$ is the pixel temperature
τ is optical thickness

Hence simplifying the expression, we get

$$\tau = -log(1 - \frac{T(\lambda)}{T_{BB}})$$

9. Apply the TIR retrieval algorithm at 10.8 µm and at 12.0 µm to ash-cloud mask using SEVIRI data and interpret the output results (you can use SNAP, Python/Matlab or R-language environment to implement the algorithm depending on its complexity). Note that thermodynamical data (useful to compute the Planck law) can be retrieved from http://weather.uwyo.edu/upperair/sounding.html

In this section we mask the two input bands, IR_108 and IR_120 using VASD binary image and respectively apply the TIR optical thickness retrieval algorithm.

9.1 Band math for VASD masking

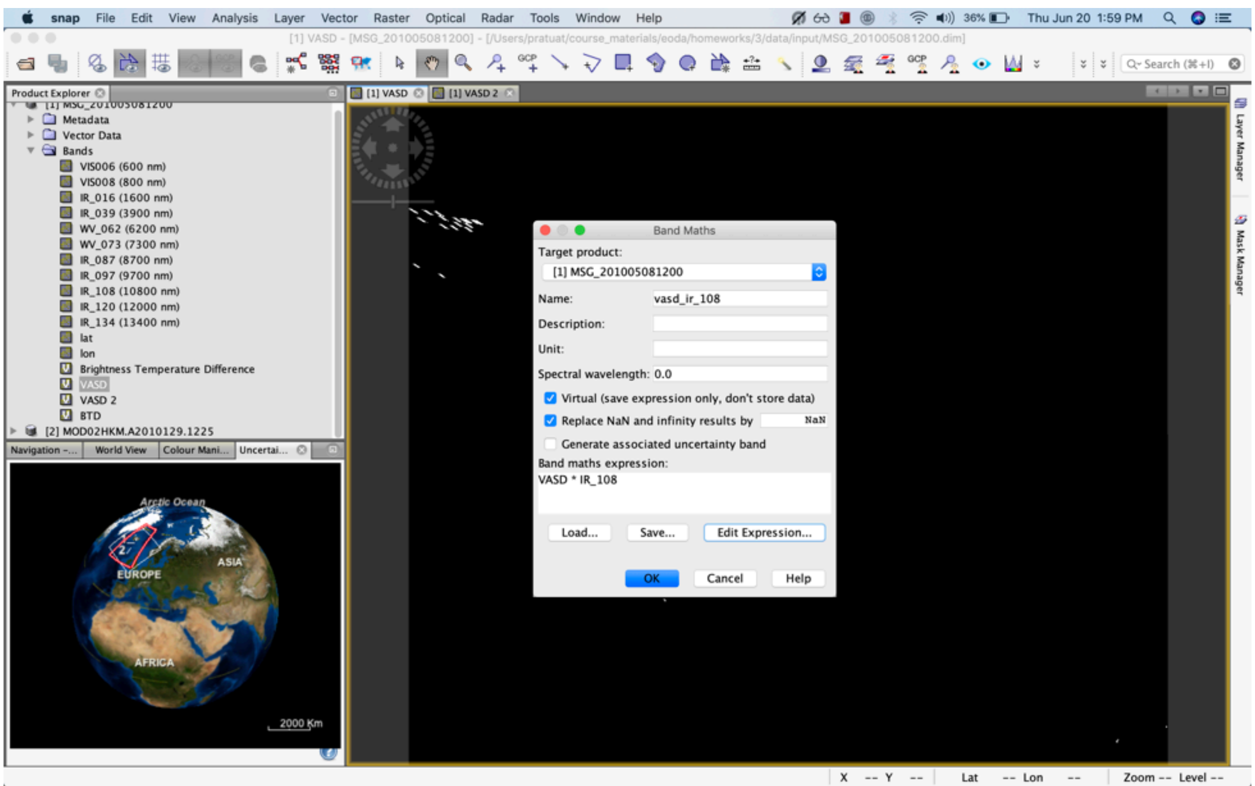


Fig 9.1 Band math for masking IR_108 band

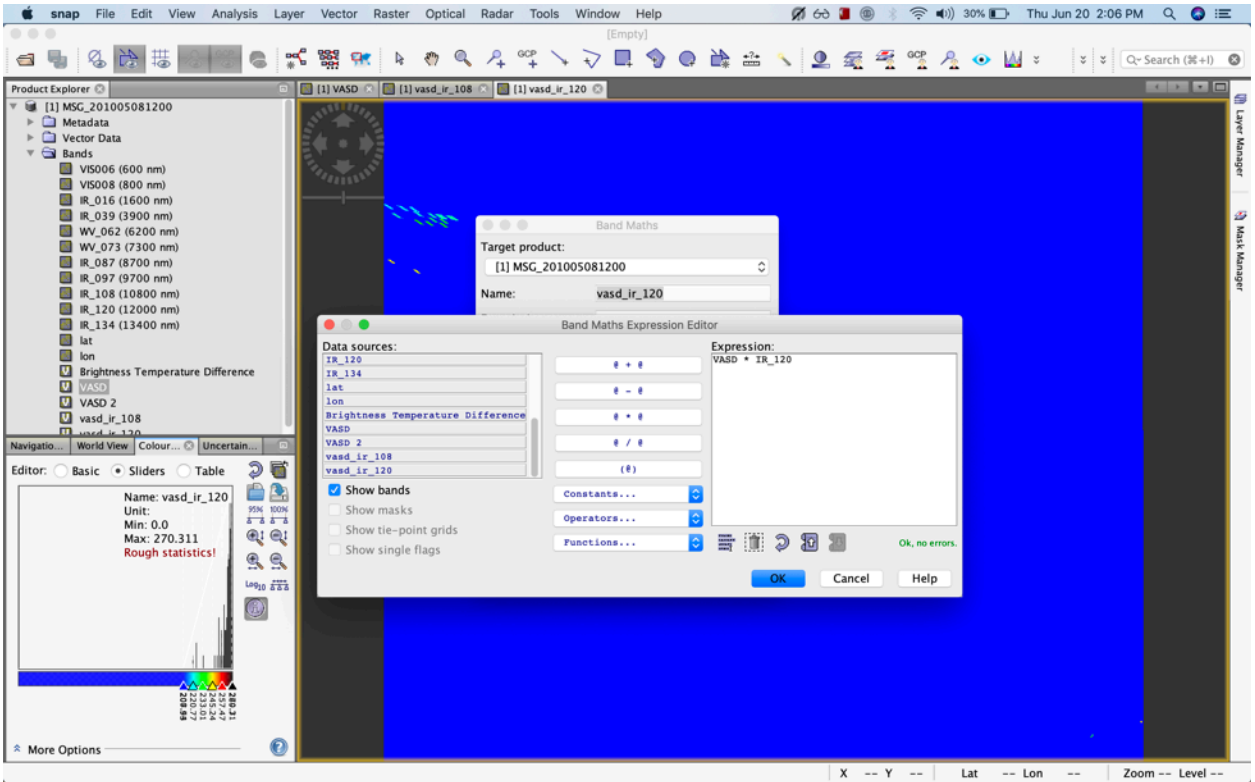
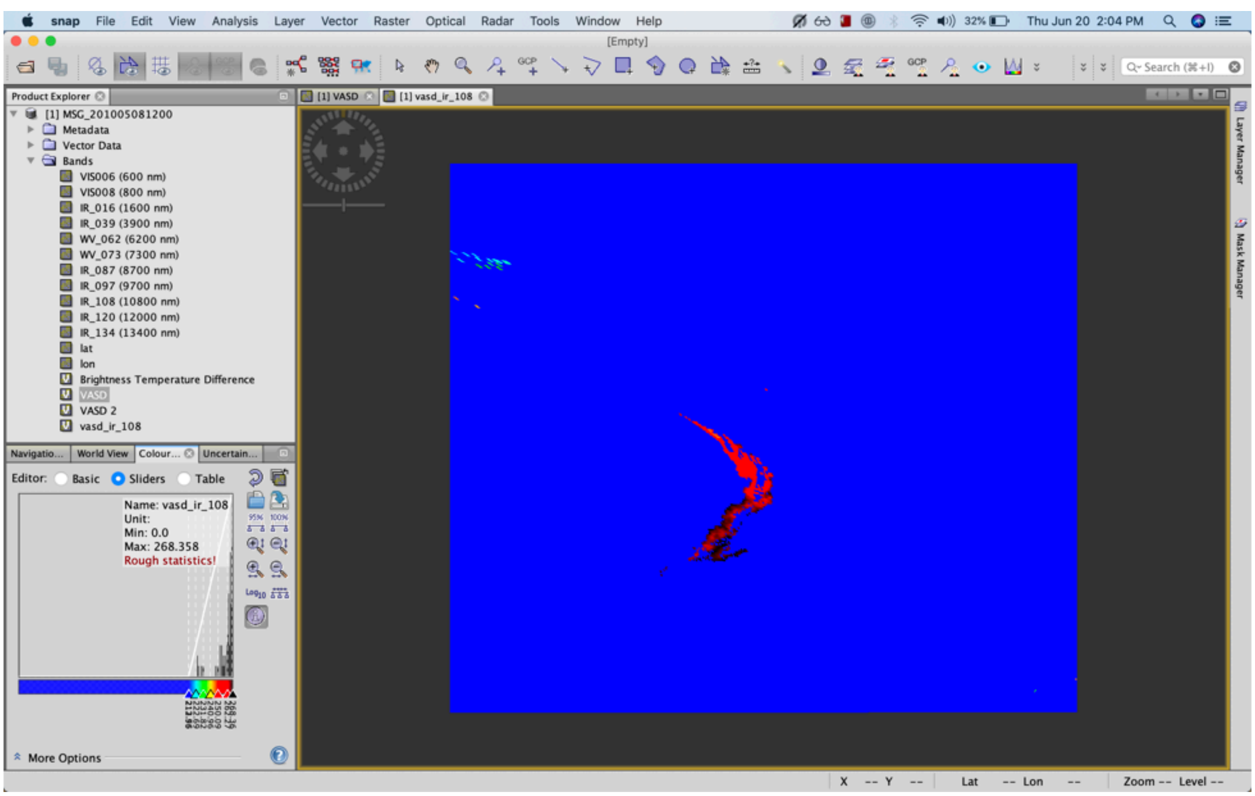


Fig 9.2 Band math for masking IR_120 band



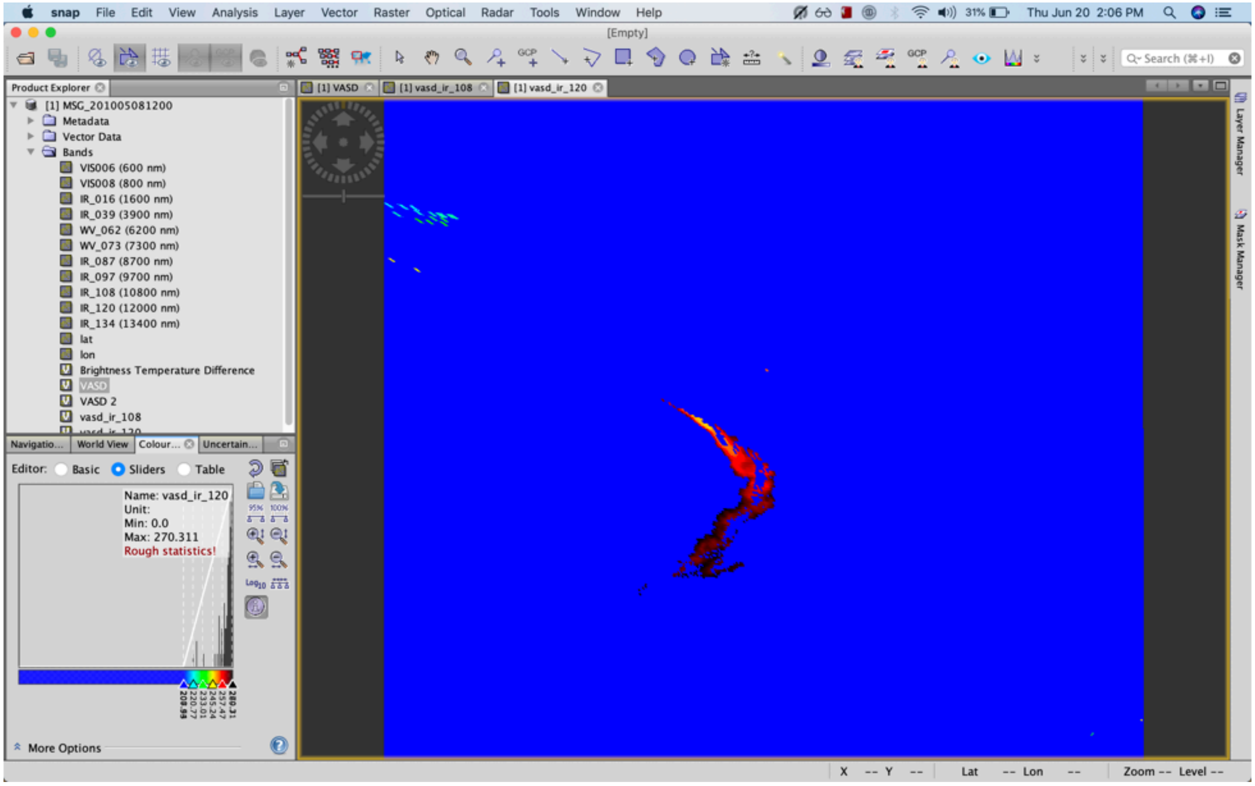


Fig 9.4 Result band IR_120 after masking

9.2 Band math for TIR optical thickness retrieval

Previously described TIR optical thickness retrieval algorithm was applied to masked bands using band math tool, (max value T_{BB}, for IR_108 band is 268.36 and for IR_120 is 270.311) as following.

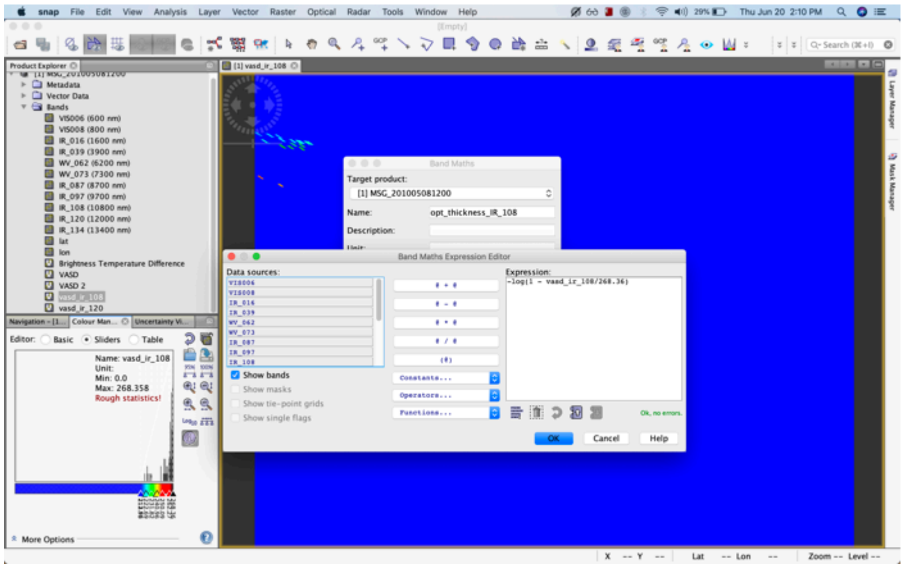


Fig 9.5 Band math for TIR optical thickness of IR_108

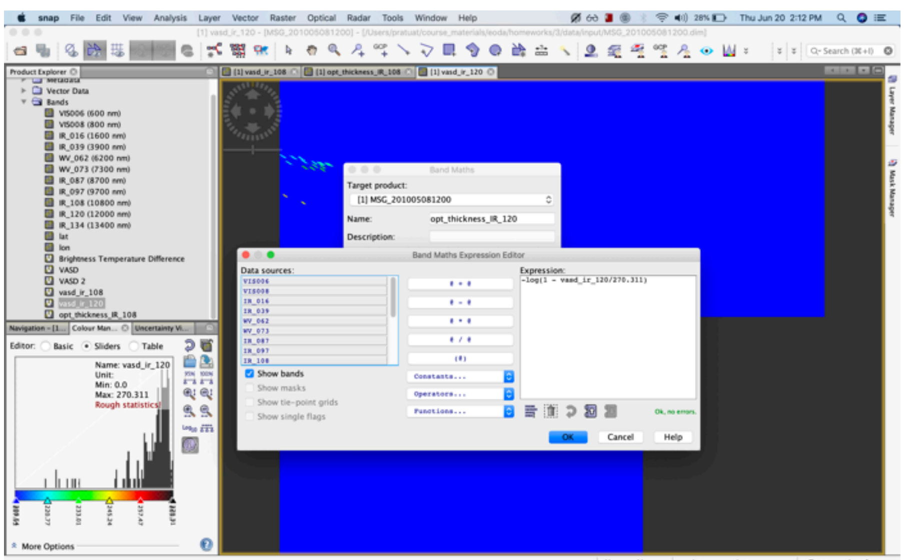


Fig 9.6 Band math for TIR optical thickness of IR_108

Results

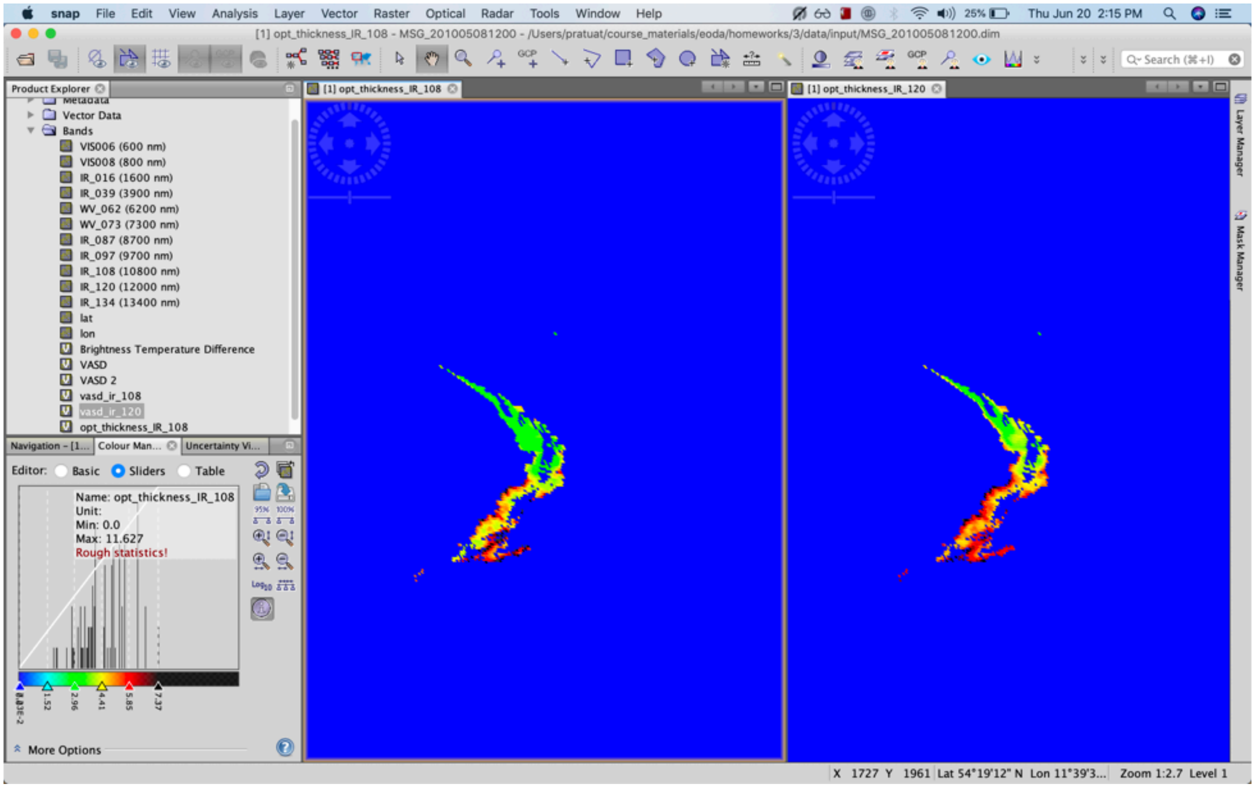


Fig 9.7 TIR Optical thickness for IR_108 and IR_120 band