Earth Observation and Data Analysis

Homework 3

Submitted by:

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1. Data quality check

All data bands were visually inspected for SEVIRI 08/05/2010 data and found to be of good quality without any considerable noise:

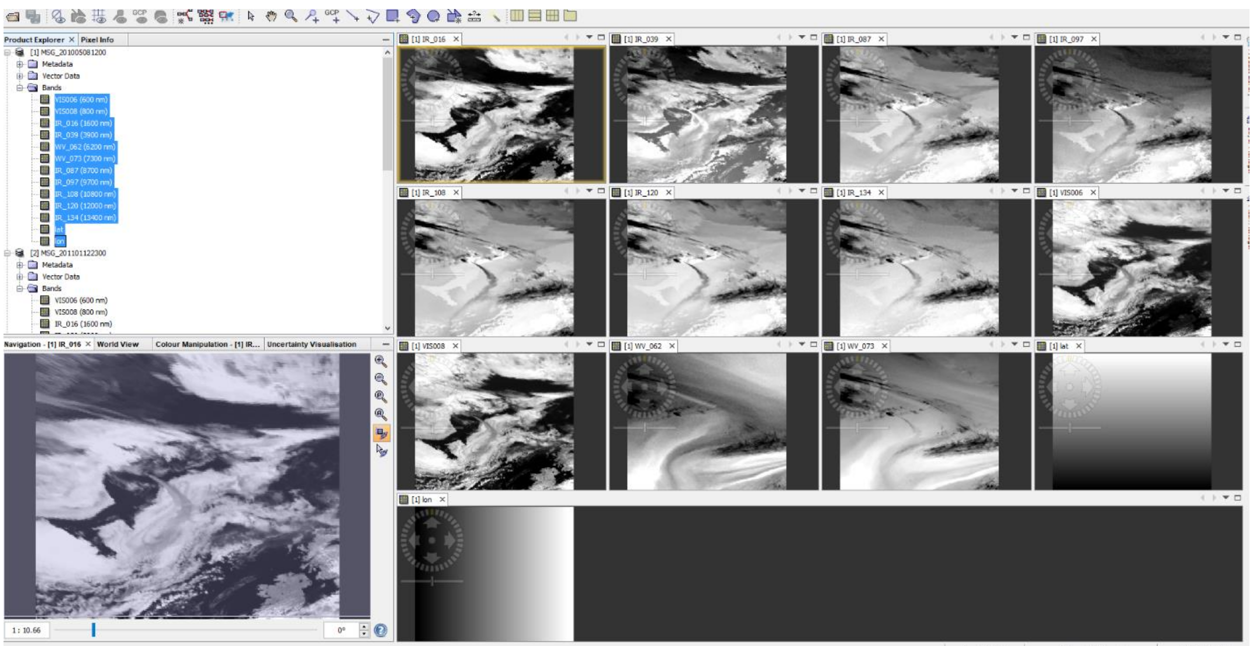


Fig 1.1 Data quality check for SEVIRI data bands (08/05/2010)

All data bands were visually inspected for SEVIRI 12/01/2011 data and the following bands were found to be particularly noisy as visible in the following screenshot: IR_016, VIS006 and VIS008

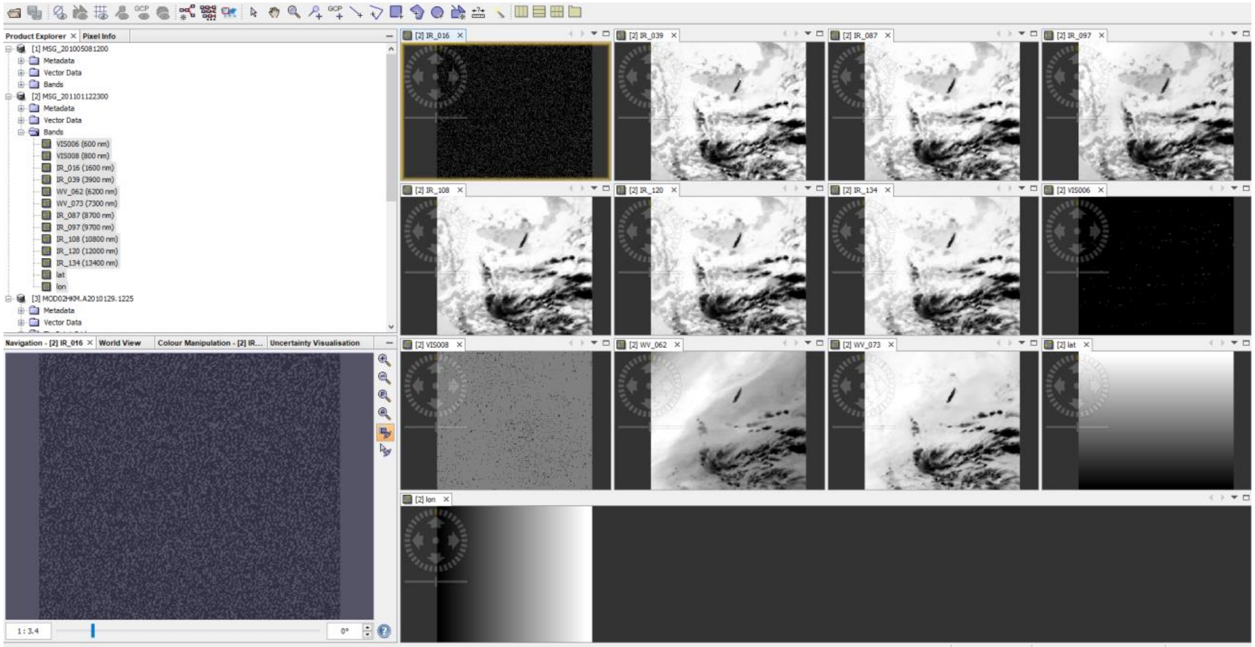


Fig 1.2 Data quality check for SEVIRI data bands (12/01/2011)

All data bands were visually inspected for MODIS 09/05/2010 data and found to be of good quality without any considerable noise:

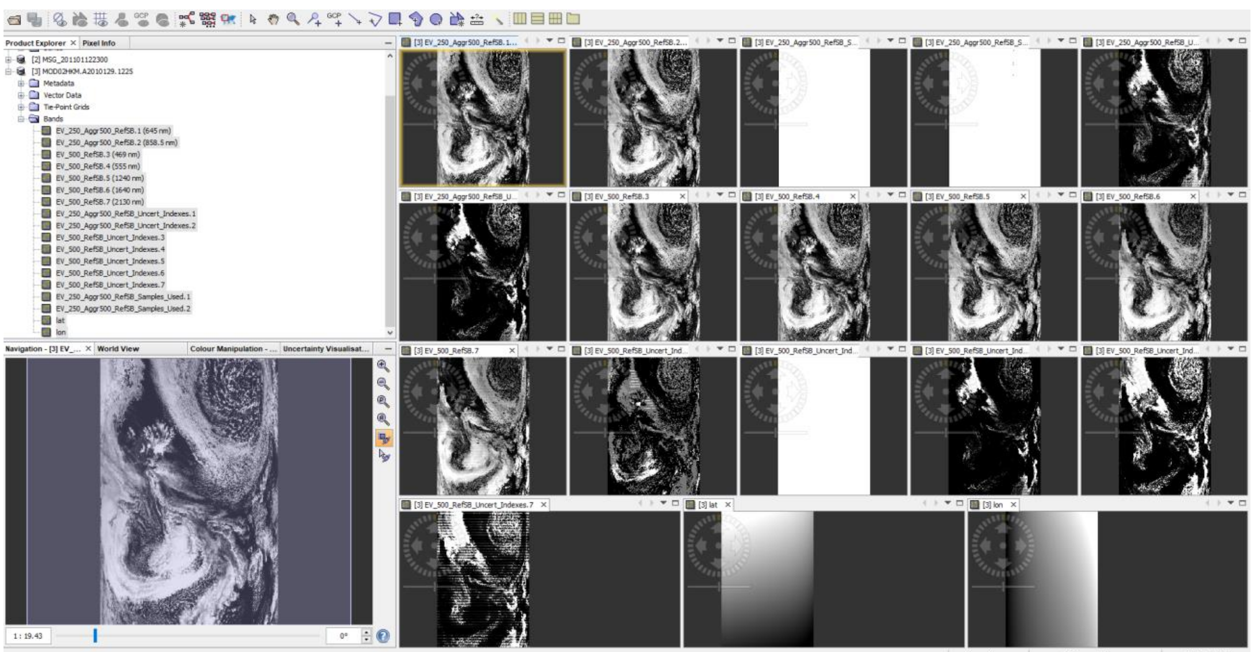


Fig 1.3 Data quality check for MODIS data bands (09/05/2010)

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

MODIS data Band 1 (EV_250_Aggr500_RefSB.1) was selected as Red, Band 4 (EV_500_RefSB.4) as Green and Band 3 (EV_500_RefSB.3) as Blue to build the RGB visible composite of the data.

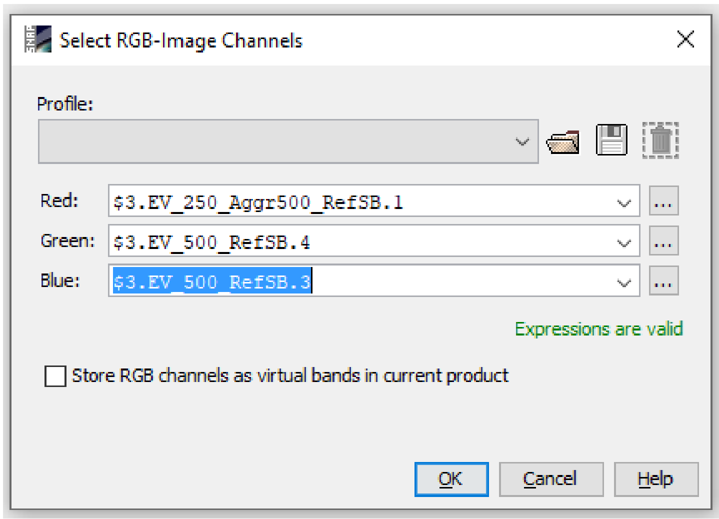


Fig 2.1 MODIS RGB composite chosen bands

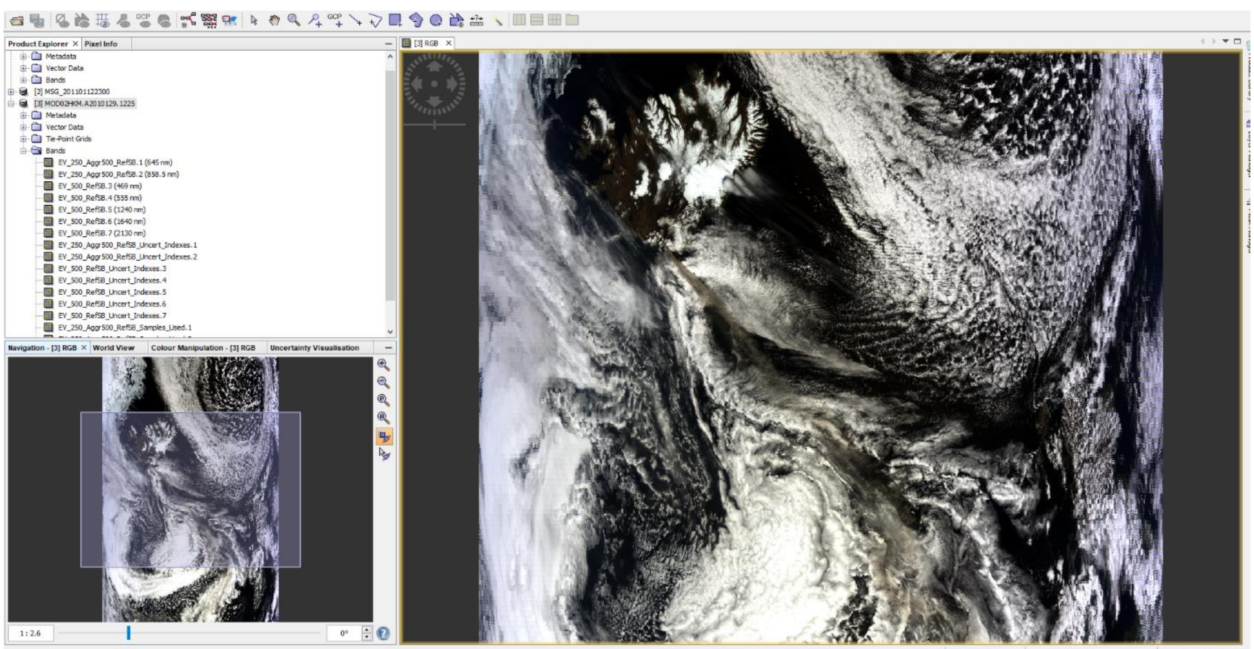


Fig 2.2 MODIS RGB composite visualization

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

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

In this case, we respectively used IR_087, IR_108 and IR_120 bands as Red, Green and Blue channels to build the visible composite of the SEVIRI data.

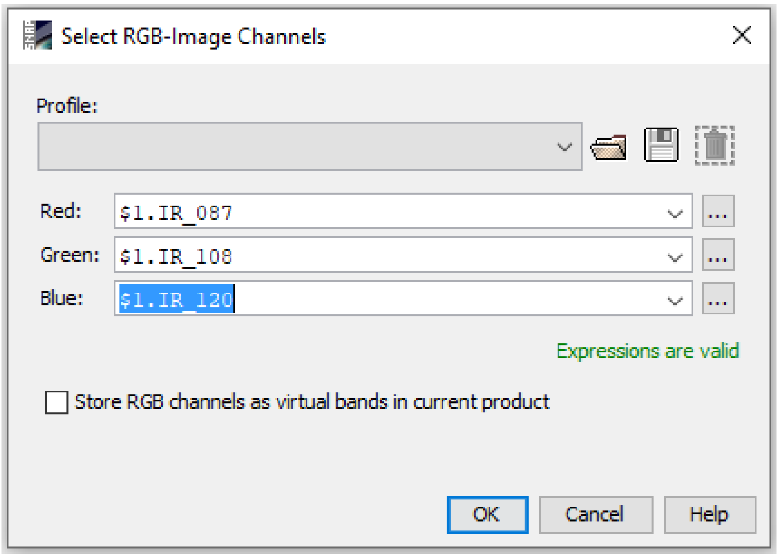


Fig 3.1 SEVIRI RGB composite chosen bands

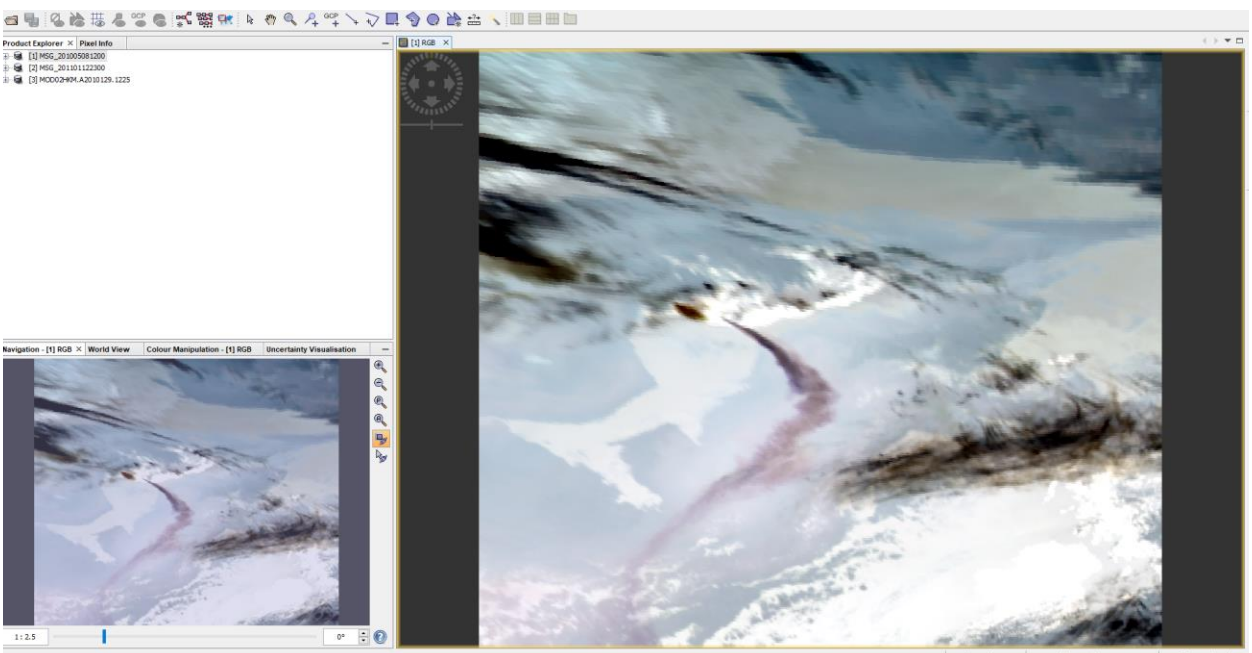


Fig 3.2 SEVIRI RGB composite visualization

Presence of volcanic ash clouds was clearly visible on 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 draw the direction of the ash cloud on the RGB composite layer.

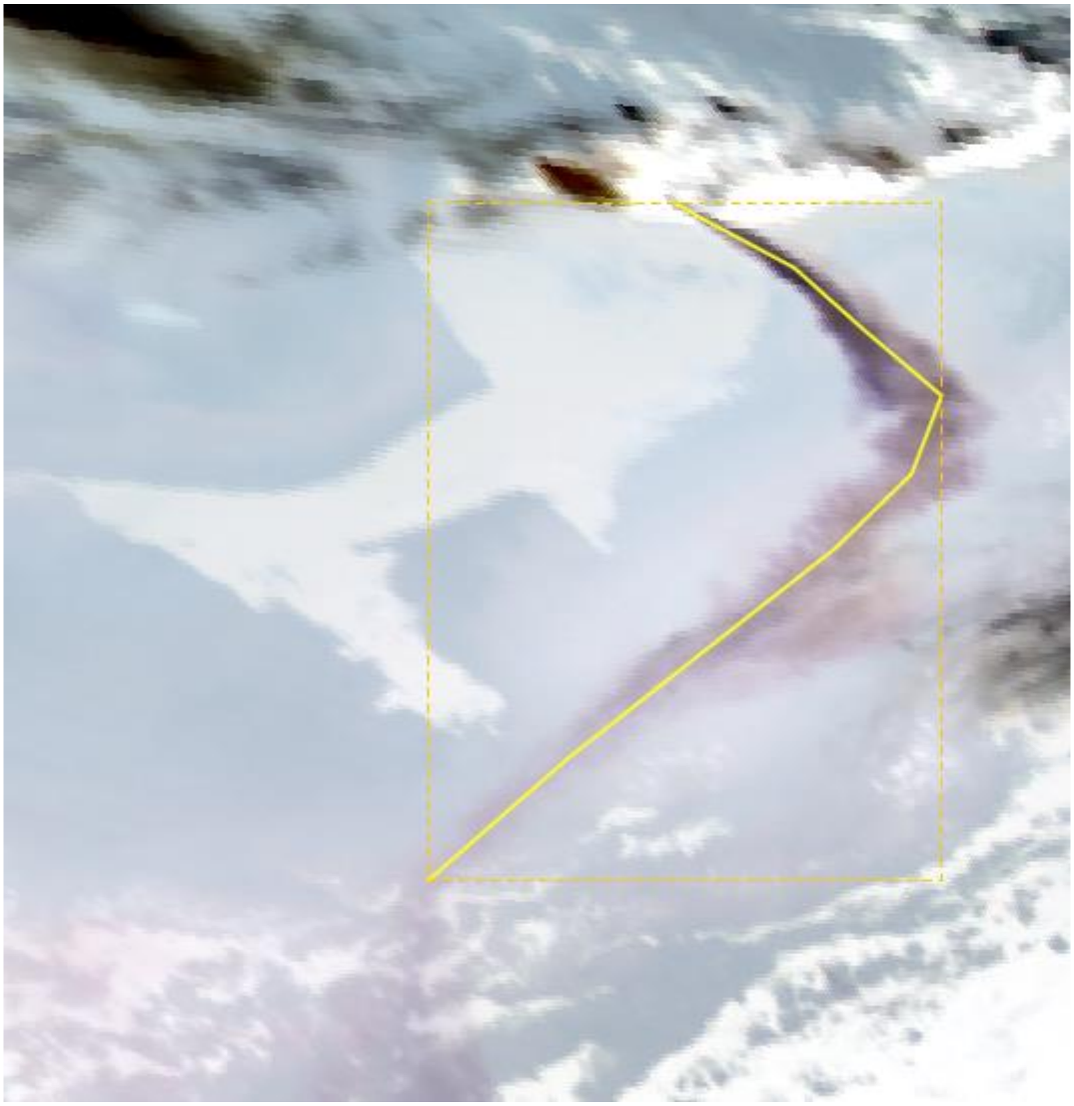
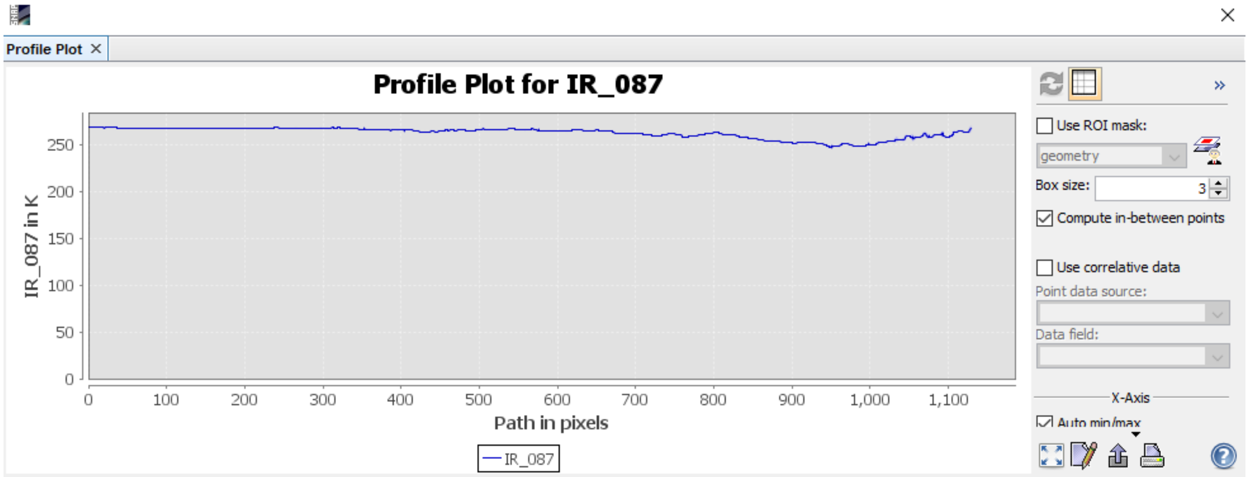
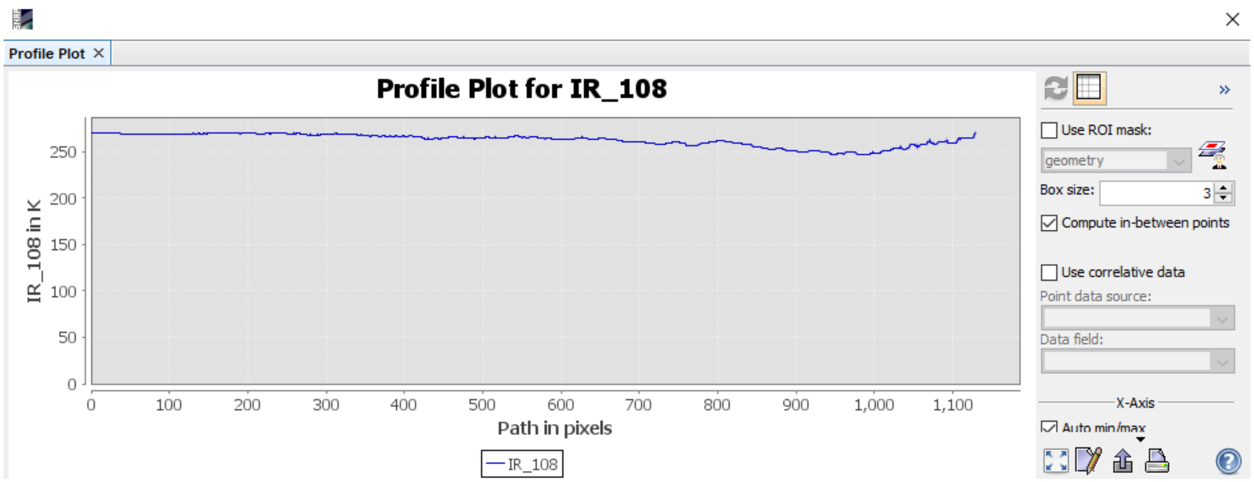
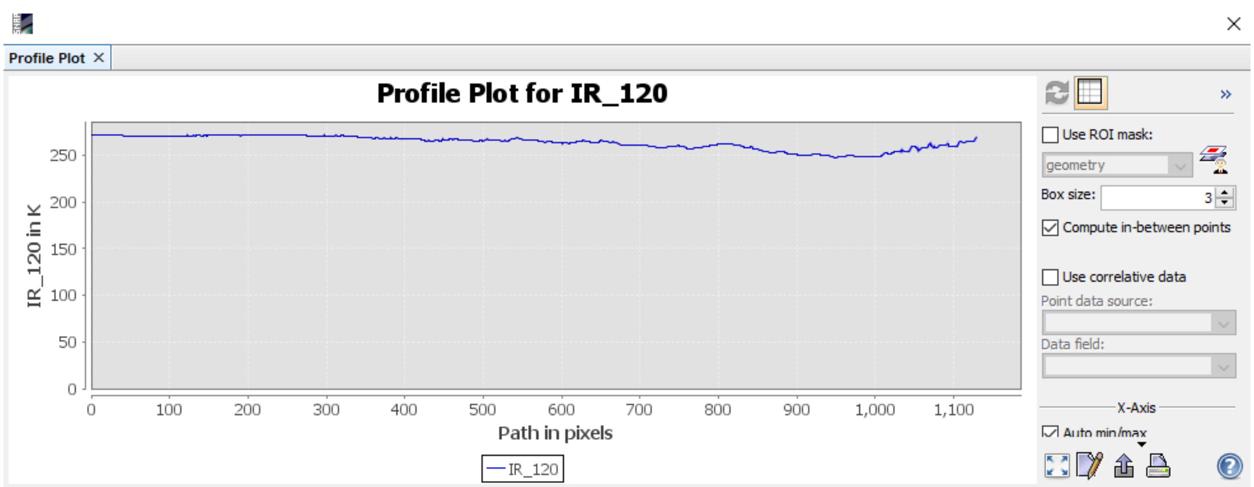


Fig 4.1 Polyline drawn for ash-cloud transects

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:

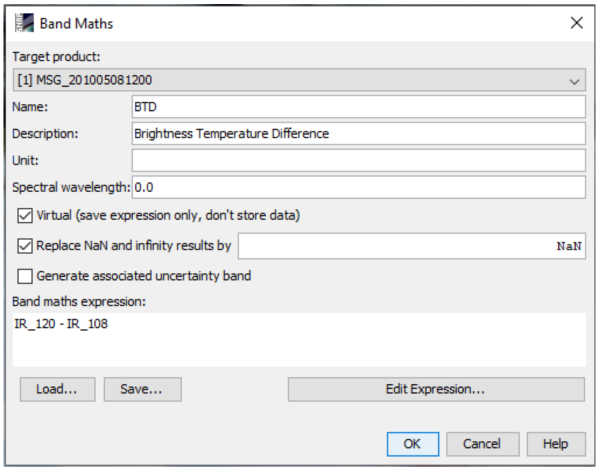


Fig 5.1 Brightness Temperature Difference (BTD) band math

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.

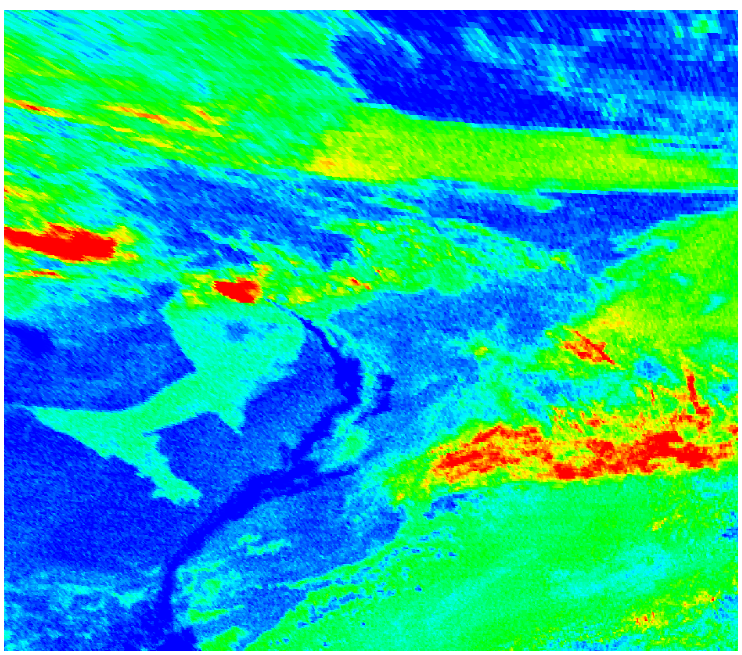


Fig 5.2 Results of BTD computation on SEVIRI data

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

In this section, we implemented basic version of VASD by factoring in strong absorption of infrared radiation between 8 and 14 μm 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,

(IR_120 − IR_108 > 0) AND (IR_039 − IR_108) > 0 AND (IR_087 − IR_108 > 0)

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

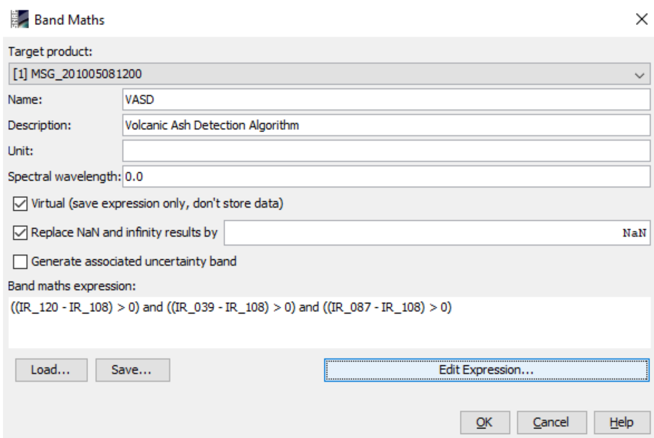


Fig 6.1 Band-math for Volcanic Ash Detection algorithm 1

If a pixel satisfies all the above conditions, it is classified as ash-cloud else none. What we get is therefore a binary image as following:

Fig 6.2 Binary image for Volcanic Ash Detection Algorithm 1

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

In this section, we implemented a second version of the VASD algorithm in order to compare it with the previous.

60 + 10 (IR_120 – IR_108) + (IR_039 – IR_108) > 100

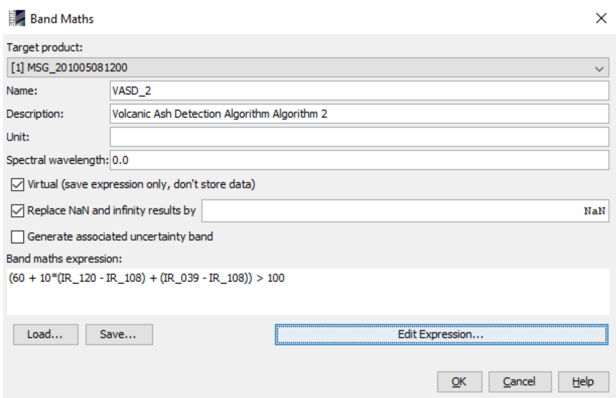


Fig 7.1 Band-math for Volcanic Ash Detection algorithm 2

The resulting binary image is:

Fig 7.2 Binary image for Volcanic Ash Detection Algorithm 2

The new algorithm tended to have higher sensitivity compared to first one in such a way that we could observe a higher number of false positivies in the northern region and false negatives in the central region. We then state that this variant of the 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 $\boldsymbol{T_B \leq T_0}$

In this section, we used the following formula to determine the TIR optical thickness over any given band.

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

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

Simplifying the expression, we get:

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

9. Apply the TIR retrieval algorithm at 10.8 μm and at 12.0 μm to ash-cloud mask using SEVIRI data

In this section we masked the two input bands, IR_108 and IR_120 using the VASD binary image and applying the TIR optical thickness retrieval algorithm implemented in the previous section.

9.1 Using VASD for masking IR_108 and IR_120

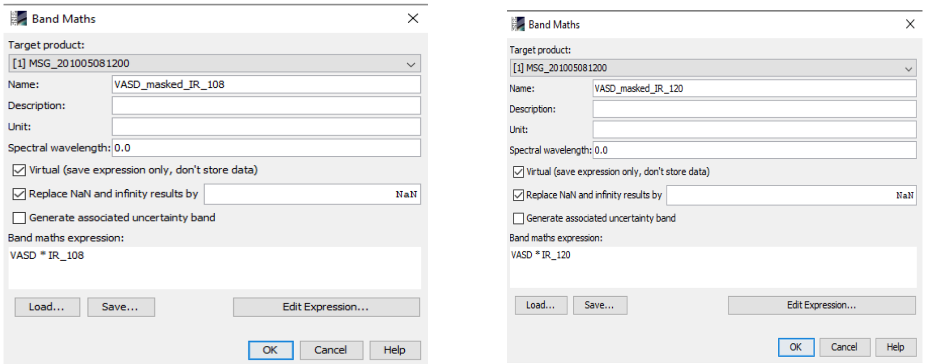


Fig 9.1 Band math for masking IR_108 band

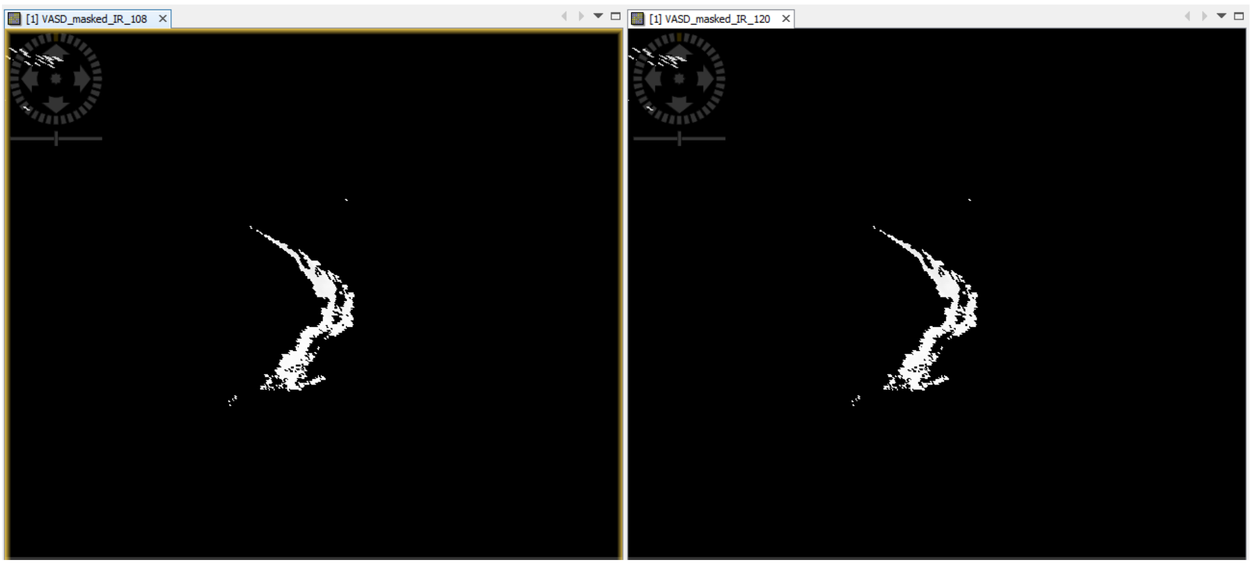


Fig 9.4 Result band IR_108 and IR_120 after VASD masking

9.2 Using TIR optical thickness retrieval algorithm for masking IR_108 and IR_120

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

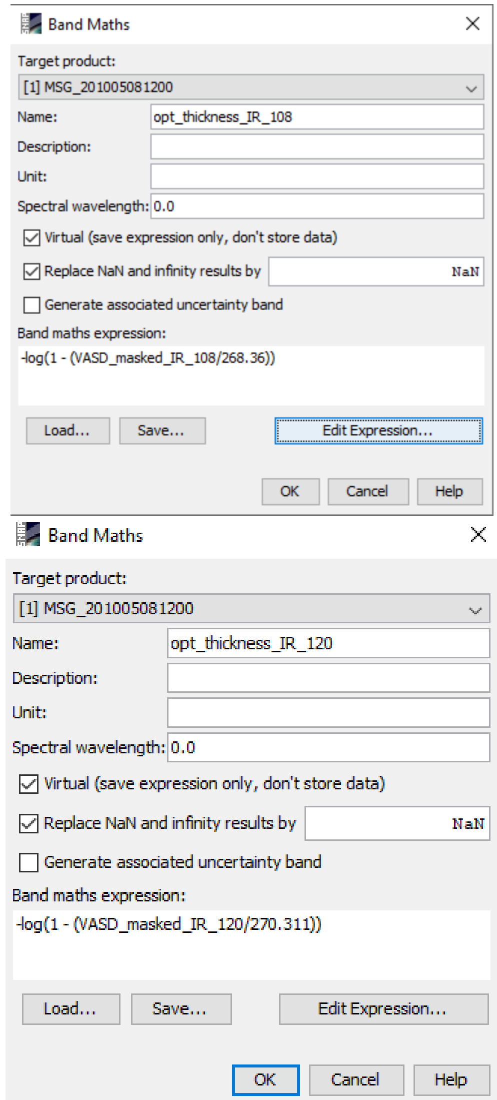


Fig 9.5 Band math for TIR optical thickness of IR_108 and IR_120

Results:

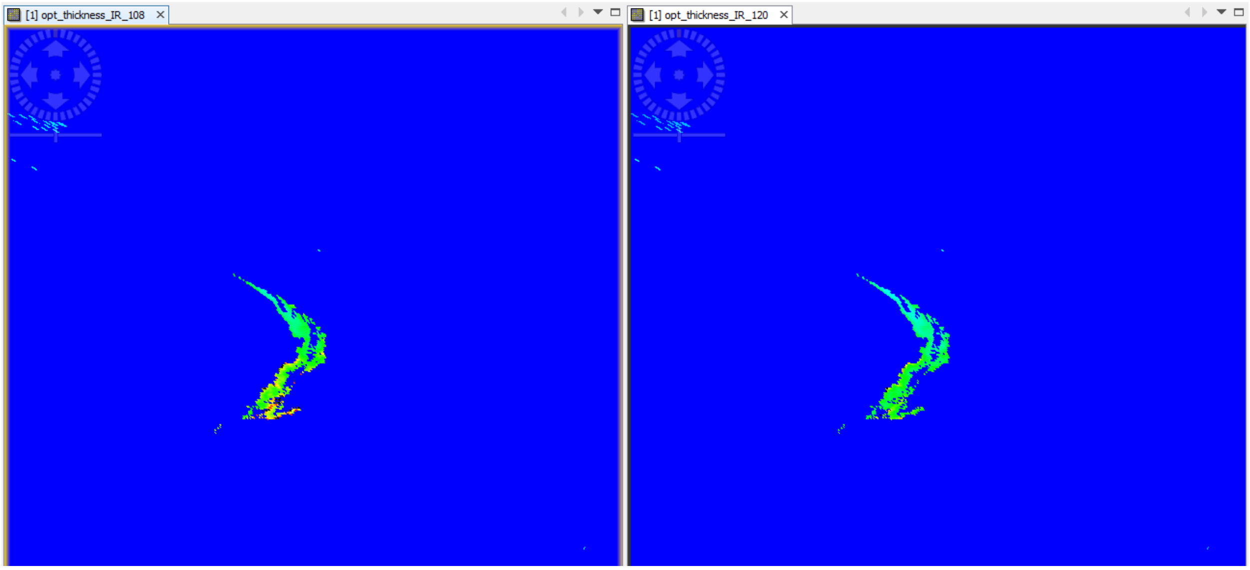


Fig 9.7 TIR Optical thickness for IR_108 and IR_120 band