Comment on amt-2022-173
Anonymous Referee #2


The study "Volcanic cloud detection using Sentinel-3 satellite data by means of neural networks: the Raikoke 2019 eruption test case" by Petracca et al. introduces a scene classification algorithm for the Sentinel-3 Sea and Land Surface Radiometer data based on neural networks. The classification is applied in a case study of the eruption of the Raikoke volcano in 2019. While the focus is on detecting volcanic ash plumes the classification mask also provides information on the surface, underlying surface under volcanic ash, and clouds. Although the paper is well structured and written I miss substantial information on the neural network. No information on how it was coded nor the source were provided. Moreover the results presented in this study lack a comparison with already published findings on the Raikoke eruption and measurements by other instruments. Hence I’d recommend a major revision before publication.

General comments:
In the introduction solely volcanic ash measurements in the mid-infrared are discussed. However the SLSTR mainly has channels in the VIS to near infrared spectral range. I suggest to also introduce VIS/near-IR volcanic ash measurements.

Throughout the manuscript "weather clouds" are mentioned. Please specify what you mean. Ice clouds, liquid clouds, mixed phase clouds, or all?

The description of the case study on the Raikoke eruption lacks references. Please have a look at the publications in this special issue to verify your reconstruction of the plume (in Fig. 1) and to substantiate your estimates of SO2 and ash.

The methodology section I found somewhat confusing. Maybe separate the instrument description from the method description. The description of both instruments, MODIS and
SLSTR, lack some information. What is their spectral range? What is their equatorial crossing time? Since when are they operating? What is the oblique view of SLSTR, which is mentioned later? Which data products were used? First I had the impression that the classification categories (Ash over sea, ash over clouds, sea surface, ...) are MODIS products. Only later I realized that you made up these categories manually from MODIS Eyjafjallajökull observations. Please improve the description.

Concerning the neural network, how did you build the network? Did you use Python and some packages? Did you use anything else? Please provide more information. Also you mention the time benefit of using NNs. How much time did it take to train the NN? How long does it take to analyse a scene with the NN compared to the BTD method? When mentioning the speed advantage, please provide numbers/measurements.

When comparing the results from the BTD-method with the results of the NN-approach, please comment on the sensitivity of both methods (BTD and NN), as well as the manual detection in the VIS, on the ash AOD. Why should the BTD-approach lead to false positives in the case of the Raikoke?

I clearly disagree that Section 4.1 is a validation of the method. The reference is tuned towards an ash plume discernible in RGB satellite images. The detection sensitivity towards ash/aerosol AOD in nadir geometry and VIS spectral range is different to other wavelengths and satellite measurement geometries. Since the NN method relies on multiple wavelengths ranging from VIS to mid-IR, the results should be compared to VIS to mid-IR standard ash/aerosol detection products. Why don't you compare with measurements of other instruments, e.g. TROPOMI, AIRS, IASI, OMI, GOME-2, CALIPSO?

Moreover, the application of this method to only 2 scenes of a single volcanic eruption, measured on the same day is rather inconclusive. Please consider applying the NN method to other volcanic eruptions (as e.g. Gray and Bennartz, 2015, tested their NN approach to 7 volcanic eruptions). Also, how would you method deal with desert dust, which is a challenge to the BTD approach?

**Specific comments:**

*i33-34:* Please specify coarse and fine in µm.

*i34-35:* Volcanic plumes also have a liquid part, as formation of sulfate aerosol starts immediately e.g. see Glasow et al. (2009).

*i60:* When mentioning other volcanic ash detection algorithms, please also consider Gangale et al. (2010) and Clarisse et al. (2013).
I68: I wonder why you are referring to two studies using NNs for ozone retrievals, although sufficient examples for aerosol and clouds are already mentioned.

I87: What does near the vent mean? Please specify the radius around the volcano from which the BT of the plume was derived. Also what does `some distance upwind` mean? Was it always the same distance? Which criteria did you apply?

I92-94: Please remove speculations about the water vapour.

I100: Please explain what is a `multilayer perceptron neural network`?

I108: What is the difference between Sentinel-3A and 3B?

I109: Which procedure is meant here? I don't understand why this is mentioned after the instrument description.

Table 1: Please provide consistently the bandwidth for both instruments. Did you use all channels in the NN?

Fig. 2: Do the text `Neural Network` and the picture mean the same, or are this two different neural networks? Also there are two arrows from SLSTR to both? networks leading to one classification. Are two different networks used for the classification?

I116: What does `nine MODIS data` mean? Is it 9 days of data? Is it 9 swathes? Is it 9 images? Please indicate the lat/long region around Eyjafjallajökull that was selected.

I117: What does pattern mean? Is pattern=pixel?

I133-141: Where and how large are the uncertainties of your ground truth? Are you considering the visual classification of RGB-images as the reference?

I153-154: Is the a posteriori filter only applied to the categories `land` and `sea` or also to `ash over land` and `ash over sea`?
Fig. 5: What are the red and cyan color in the RGB image? Was the "Not classified" class only applied to "Sea" and "Land", or also to "Ash_sea" and "Ash_land"?

I181: Does "... difference between ... channels S8 and S9..." mean mean radiance (S8) - mean radiance (S9)?

Fig. 6: Fig. 6a shows many contrails, but in Fig. 6c only few of them are classified as "Cloud_ice". Can you comment on this? Why are so many classified as "cloud" that was introduced as liquid cloud and which rather represents low altitude clouds?

I189: What do you mean by "pixels identified as volcanic cloud but that are not below the volcanic cloud..."? Please clarify.

I198-199: Here you state, that some pixels were misclassified as "ash_land" instead of "ash_sea". But shouldn't it rather be "ash_cloud"? Most of the area around Raikoke is marked as "cloud" or "ice cloud". It would be surprising if only the region below the volcanic ash plume is not covered by clouds.

I206: What do you mean by "water vapour cloud"? In the RGB images only ice, liquid water, or mixed clouds are visible.

I208: Having VIS RGB images at midnight sounds strange. I assume you mean 0 UTC.

201-214: Why do you think the BTD approach produces wrong positive results in the case of the Raikoke eruption (Fig. 6)? Please explain. I'd rather consider the BTD ash plume realistic, because it pretty much resembles the SO$_2$ plume shape measured by TROPOMI on 23 June (e.g. Leeuw et al., 2021, Cai et al., 2022). How do you know that there wasn't any ash above the contrails and these underlying clouds enhanced the ash signal of the otherwise "thin" ash layer, which remained invisible in regions without underlying cold clouds (=high altitude clouds)?

I220: Do you mean higher opacity here?

Fig. 7c,d: Why are mostly clear regions (43-33N, 170-175E) classified as "Cloud"? Please comment.
What do you mean by ``different scenario''? In terms of season, latitude, and injection height, the training eruption is similar to the showcase of the Raikoke eruption.

Fig. 9: What does the white color indicate? Why does the CSCM detect clouds in apparently clear regions?

Again, what are ``meteo clouds'' and ``meteo ice clouds''? Liquid and ice clouds?

Technical comments:

- I26-27: remove ``it' -> ...which is...
- I27: manually -> manual
- I30: NN, please introduce abbreviations
- I33: by -> of
- I49: region -> regions (2x)
- I66: in -> at
- I84: AHI, please introduce abbreviations

Fig1 caption: was -> were; does -> do

References:


