Reviewer 2

Reviewer 2: The paper presents a comprehensive and meticulous investigation into the degassing and alteration structures of the fumarole field at La Fossa cone on Vulcano, offering valuable insights into the complex dynamics of volcanic activity. Using innovative methodologies, including close-range remote sensing, mineralogical and geochemical analyses, and surface degassing measurements, the authors provide a detailed and multi-faceted examination of the degassing system.
One of the study's most commendable aspects is its integration of high-resolution drone-derived imagery with traditional analytical techniques. This approach enables a nuanced spatial analysis, allowing the authors to accurately identify and characterize major active units. Furthermore, the quantification of thermal energy release provides valuable quantitative data on the relative importance of different degassing features within the system, enhancing our understanding of volcanic processes.
The authors demonstrate a commendable level of transparency and rigour by acknowledging potential limitations, such as gas plume distortion affecting image quality. This ensures the reliability and validity of their findings, reflecting a commitment to scientific integrity and strengthening the credibility of the study's conclusions.
Overall, this paper represents a significant contribution to the field of volcanic degassing research. By elucidating the complex interplay between surface manifestations, alteration gradients, and gas emissions, the study advances our understanding of volcanic systems and provides a solid foundation for future research in this area. Its comprehensive approach and meticulous attention to detail make it a valuable resource for scientists and researchers working in volcano monitoring and hazard assessment.

Reply: We appreciate this positive feedback and thank you for reviewing our manuscript. We addressed all your suggestions and modified our manuscript accordingly. Please find the detailed replies to each of your suggestions below.

Reviewer 2: Here I list minor comments that I hope may improve the final version of the manuscript:
- The authors mention some fumaroles (e.g., F0) but do not show them in the figures in the main text (only supplementary). They are not also mentioned in the discussion. The fumaroles F0, FA, F5AT and F11 have distinct features that could correlate with the paper's findings. I recommend reading Aiuppa et al. 2006 GRL and Tamburello et al. 2011 JVGR. These historical fumaroles should be plotted at least in Fig. 1 and 6.

Reply: We agree that showing the locations of fumaroles could help to better orient in the Figures and added the locations of fumaroles F0, F5AT, F11, and FA to Figure 1 and Figure 6, and the respective description in the Figure captions. Further, we added the labels for relative flux values to Figure 6A/B.

Reviewer 2: Authors describe the colour of the 4 different surfaces. I suggest that it could be more straightforward to show these colours (or a palette of colours for each type) in one of the figures;

Reply: We appreciate this comment. We intended to show color samples for surface types 1-4 in Figure 4 below Figures A and B as small subfigures. We understand that they were too small for easy viewing. We have now increased the size of these color samples and added descriptions to the figure caption.

Reviewer 2: Please describe in Figure 4 caption what the letters a-g are;

Reply: We agree and now better highlight in the Figure caption what the labels a-g mean. The respective sentence now reads "The labels a-g demark notable large-scale anomaly units that can be observed in both, the optical and the thermal data."

Reviewer 2: The bars in Figure 6a-b are hard to read. I suggest to use coloured circles with a colour bar. I suggest to calculate also the ratio between fluxes (CO_2/S_{tot}, where $S_{tot} = SO_2 + H_2S$) and to plot their distribution to highlight the role of sulfuric gases

Reply: We appreciate this comment. However, we tried different versions of this figure before but concluded that the bar plot was the best representation for showing the relative fluxes. Calculating the ratios from these measurements would certainly be interesting. However, we feel that calculating ratios from our results is not optimal due to the differential uncertainties of the instrument applied. We would feel a need to compare measured ratios to real in-situ data first. We have more gas data from other years and will look into that in more detail, but note that this is beyond the scope of the present study.

Reviewer 2: 150 Fumarolic temperature rose up to 690 °C in May 1993 (Chiodini et al., 1995) Chiodini G., Cioni R., Marini L. and Panichi C. (1995) Origin of fumarolic fluids of Vulcano Island, Italy and implications for volcanic surveillance. Bull. Volcanol. 57, 99–110. http://dx.doi.org/10.1007/BF00301400

Reply: We appreciate this comment and modified the text. It now reads: "Gases of the high-temperature fumaroles (HTF) emerge with temperatures >300 °C, but temperatures have been exceeded during previous volcanic crises (Harris et al., 2012, Diliberto, 2017). Temperatures of up to 690 °C were reported from May 1993 by Chiodini et al. (1995)."

Reviewer 2: 240 Please explain how the 40°C threshold has been chosen;

Reply: We appreciate this comment and have now defined thermal units and temperature thresholds in more detail.
Specifically, the temperature thresholds were defined after analyzing our infrared and optical data as well as based on previous knowledge of fumarole locations from previous field campaigns. When classifying pixels based on their temperatures, they form spatial clusters. We

found that the 40°C temperature threshold outlines well the physical locations (depressions or fracture-like shapes in the surrounding fumarole crust) of major high-temperature fumaroles.
The 22-40°C threshold defines larger contiguous clusters, which we interpret as rather diffuse features. However, these assumptions are partly arbitrary but a necessary approximation in order to define spatial boundaries and be able to quantify thermal emissions, size and extent of different active units.
In the text, we changed lines 240 and the following to: “The temperature map was used to define the thermal structure. We observed several distinct thermal spatial units with temperatures significantly above the background temperature, that can be distinguished in high-temperature fumaroles (HTF in the following) and areas of rather diffuse thermal surface heating (Figure 4 B/D). To constrain these units spatially for further comparison, we had to approximate spatial boundaries what was done after comparison to our optical data and based on knowledge of previous observations by defining the temperature thresholds of T = 22-40°C for the diffuse heated areas and T> 40°C for HTF. The 40°C threshold resembles well the known locations and extent of HTF in the upper fumarole field.”

Reviewer 2: 530 Also, halogen may play a role in chemical leaching (Aiuppa et al., 2009 Chem Geo);

Reply: Yes we agree with this statement. We cannot constrain this process with our data set but have now added a reference to this possibility.

Reviewer 2: 543 "higher gas flux" should be "higher acid gas fluxes"?

Reply: We agree and modified the phrase to “… a higher acid gas flux…” as suggested.

Reviewer 2: 544 "we observe similar" looks incomplete

Reply: We appreciate this comment and changed the respective sentence to the following wording: “Analyzing the broader area of the central crater region we can infer multiple other areas where we observe similar changes of colorization indicating similar argillic or strong silicic alteration effects at the surface, in particular, located on the southern inner crater, the outer crater rims, the 1988 landslide area (Madonia et al. 2019) and the northern flank towards Vulcano Porto. These zones of strong alteration are indicated in red in Figure 1B.