Response to Review
Anonymous Reviewer #2

The authors use a U-Net image segmentation model to detect SO2 plumes and measure their emissions from TROPOMI data. The detection part is well-done and creates a valuable database of detected SO2 plumes. The emission calculations, while promising, could benefit from some refinement. I suggest reducing the focus on emissions unless the wind-related concerns are thoroughly addressed. The manuscript is on the right track for publication after the revisions below.

We thank the reviewer for their comments. We have addressed the suggestions below.

- *Model Performance: In line 104, the authors say the model's precision and recall are 65.7% and 74%. Does this mean 35% of predictions are incorrect and 26% of cases are missed? I assume this is decent for a U-Net model, but more explanation would help readers who are not familiar with U-Net understand the model's performance. Also, how does this accuracy compare to other plume detection techniques, including the authors' previous work? Providing precision and recall for volcano sources alone would be useful, as performance is likely better for larger sources. This would show that some errors come from the signal-to-noise level of SO2 observations.*

These precision and recall percentages are not directly interpretable as plumes missed or not, as segmentation models work on a pixel per pixel basis. For example, the model may correctly detect a plume in the test dataset but draw a smaller or larger mask than the test data and would therefore be penalised. We have added this to the manuscript.

Comparisons against other models (including our previous work) would be misleading as the scores are not directly comparable. This is particularly the case for our previous work using a classification method (where we could say if the model found a plume or not) but also true if there were other plume detection models as factors such as image size impact the results.

To provide precision and recall for just volcano sources we would have to rely on previous knowledge of volcanic plumes to test the model. This would then introduce another uncertainty on the accuracy of the volcanic plume labelling.

- *Training Data: The training truth is based on manually selected grid cells. While this makes sense due to lack of better options, manual labeling introduces uncertainties. Discussing these uncertainties would be helpful.*

We added the following statement in the manuscript: “Because the training dataset was created manually and relied on the authors’ judgement of what constitutes a plume, the model cannot outperform the quality of this dataset. Any biases or recurring misclassifications present in the training examples may be learned by the model and subsequently propagated into the final results. An alternative approach would be to augment the training dataset with model-simulated SO_2 plumes, but for this study we chose to rely exclusively on real data to maximise the diversity of scenes and plume morphologies that may not be captured in model simulations.”

- *Emission Calculation: Volcanic SO2 emissions have been estimated by Carn et al. and Vitali et al. More details can be found here: https://so2.gsfc.nasa.gov/. How is your method different? My main concern is the use of 10-meter U and V wind fields. As pointed out by the authors themselves, near-surface winds are not suitable for volcano plumes. While concerns about computation cost are valid, using winds at the correct height is essential for emission estimates. I recommend a sensitivity study to show the impact is limited, at least for one case. Otherwise, the emission estimates are less reliable. Comparing volcanic emissions with estimates by Carn et al. would also be strongly recommended.*

As suggest by other reviewers, we have decided to reduce the emission estimate section down to one example of what could be done and improved on in future iterations. If these improvements are made in future work, then we will compare estimates with Carn et al.

- *Data Availability: I suggest the authors make the plume database publicly available to support further research.*

We have uploaded the data to the following repository**:** https://zenodo.org/records/18302024 . This has been added to the manuscript. These data are open access.