

Response to Anonymous Referee #1:

Dear Anonymous Referee #1,

Thank you for your comprehensive and thoughtful review of our manuscript. We appreciate the time you invested in providing feedback, which has been very helpful in improving the overall clarity and quality of this research.

We have carefully considered all the points raised and have incorporated your suggestions into the revised manuscript. Our point-by-point responses are provided in the following, with referee comments in blue, our responses in black and manuscript changes in grey.

This paper introduces a new computer-vision method (COCOS) to automatically recognize contrails in satellite images captured by the MSG SEVIRI instrument. In contrast to many recently introduced methods for the detection of contrails in images, it does not explicitly consist of neural networks. This approach is motivated by the idea that it leads to an interpretable, adaptable detection algorithm that can be adjusted to new satellite instruments in the near-future. The improvement in performance, as evaluated using a dataset consisting of manually annotated satellite images, is considerable when compared to previous methods for contrail detection in MSG SEVIRI images

The paper is certainly within the scope of AMT, it is very well-written and it was an enjoyable read: I have only few line-by-line comments, which are given in a separate section below. I do have some more general comments. Once these are considered by the authors, I think the paper is ready to be published.

We thank the reviewer for their positive feedback. We are pleased that the reviewer found the manuscript well-written and an enjoyable read.

My first comment concerns section 2.4 “Contrail Ground Truth” which describes the dataset of annotated MSG images used for developing and evaluating the detection algorithm. After reading this section, I still have many remaining questions:

Since the submission of our manuscript to AMT, a paper on this annotated dataset has been published in ESSD (Santos Gabriel et al., 2026). In this publication the labeling process and properties of the dataset are described in detail. We have added a citation to the revised manuscript in section 2.4. We hope to highlight this other paper by marking them as companion papers.

- Broadly speaking, how were labelers instructed to identify contrails? Was this in any way similar to the instructions used by (Meijer et al., 2022) and (Ng et al., 2024)?

Labelers were all atmospheric scientists, so no special training process was done. They did, however, receive a labeling guide describing the basic properties of contrails in satellite imagery. Labelers were then asked to mark each individual pixel belonging to a contrail if it was at least 10 pixels in size. The following has been added to the manuscript in line 175:

Labelers received a labeling guide on how to identify contrails in satellite imagery and were asked to mark each individual pixel of a contrail.

- How were scenes selected for labeling, and what is the resulting spatio-temporal distribution of annotated scenes?

The scenes were created by randomly selecting times available from MSG3 ranging from 2013 through 2024. They were visually inspected with higher attention to regions more likely to contain contrails. The 140 selected scenes are randomly distributed over the whole SEVIRI disk. See Santos Gabriel et al. (2026) for a plot showing the exact spatial distribution of scenes. The following change has been made to the manuscript in line 172:

Scenes are randomly distributed geographically across the SEVIRI disk, with clusters of higher density over Europe and the North Atlantic.

- What information (other than the image itself) was presented to the labelers? For example, both previously mentioned annotated datasets provided labelers with a sequence of images leading up to the relevant image.

Images spanning one hour prior to and one hour following the timestamp of the target image were provided to account for the temporal evolution of the objects. The additional time series imagery included multiple different RGB composites and brightness temperature images. The following sentence has been added to line 176:

As additional information the labelers received a time series of different RGB composites and brightness temperature images spanning one hour prior to the target image and one hour following the target image.

For my second comment, I refer to a passage from the introduction:

By avoiding machine learning methods, the authors aim to facilitate the future adaptation of COCOS to the Meteosat Third Generation satellite. Furthermore, we gain a deeper understanding of the factors affecting contrail detection—such as why a contrail is detected or missed, which spectral channels contribute most, and which contrail characteristics are most informative, thereby strengthening the use of COCOS for assessing temporal and spatial contrail distributions, evaluating the effectiveness of mitigation strategies (such as flight rerouting), and improving the representation of aviation-induced clouds in climate models and contrail models.

I find the above motivation to avoid a machine-learning based approach sensible. However, I think that the terminology “avoiding machine learning methods” should be modified slightly, as the COCOS algorithm introduced in the paper still relies on the output of another machine learning approach: CiPS.

The terminology was modified in line 66 of the manuscript:

By prioritizing a physically based, rule-driven logic over an end-to-end machine learning architecture, the authors aim to facilitate the future adaptation of COCOS to the Meteosat Third Generation satellite.

Secondly, I think that the paper’s contribution to a “Deeper understanding of the factors affecting contrail detection” could be expanded. Although the analysis of the algorithm’s performance (and its dependency on background/contrail properties) is clear, I would be very interested in learning what parts of /tests within the algorithm contribute mostly to the improvement in performance compared to previous MSG SEVIRI algorithms. For example, suppose the CiPS output is a very important input to COCOS: this knowledge could be used in the design of new contrail detection approaches.

We have expanded the analysis of our algorithm’s performance and have performed an ablation study excluding individual parts of the algorithm to see the contribution of each evaluation step as suggested by the reviewer. This analysis is described in a new section ‘4.4 Contribution of individual evaluation steps’ in the revised manuscript.

Line-by-line comments

- Line 26, it may of interest to the authors to also cite (Sonabend-W et al., 2025)

We thank the reviewer for making us aware of this recently published paper. We have added a citation in the manuscript in line 27.

- Line 87, “This also ensures that contrail detection remains independent of the time of the day” Would it perhaps be better to state this as “remains possible throughout the day”, since variations in scene properties may still occur throughout the day which could possibly affect contrail detection performance?

Yes. This proposed phrasing is better to avoid confusion of the reader, as scene properties might still vary throughout the day. The phrase has been changed accordingly in the manuscript.

- Line 89: there seems to be a “8” missing here

Thank you for noticing this missing number. We have added it to the revised manuscript.

- Line 116: Missing a space between “contrails” and “(“

The missing space has been added.

- Line 222: Note that “gaussian weighted” is spelled differently here than for example line 220

We have checked every occurrence of “gaussian weighted” in the manuscript and have corrected all to be consistent (“Gaussian weighted”)

- Line 415: Seems like there is an additional space at the start of this sentence.

The additional space at the start of this sentence has been removed.

- Figure 8: I would strongly consider replacing the pie charts with other means of visualization. For example, the distribution of “linearity” and “ice optical thickness” could be visualized with CDFs/PDFs.

We have changed figure 8. Linearity and ice optical thickness are now visualized with PDFs where each interval used for performance evaluation in figure 9 is shown by the colored area under the curve. The two categorical properties, surface types and underlying clouds are visualized as bar charts.

References:

Meijer, V. R., Kulik, L., Eastham, S. D., Allroggen, F., Speth, R. L., Karaman, S., and Barret, S. R. H.: Contrail coverage over the United States before and during the COVID-19 pandemic, *Environ. Res. Lett.*, 17, 034039, <https://doi.org/10.1088/1748-9326/ac26f0>, 2022.

Ng, J. Y. H., McCloskey, K., Cui, J., Meijer, V. R., Brand, E., Sarna, A., Goyal, N., Van Arsdale, C., Geraedts, S.: Contrail detection on GOES-16 ABI with the OpenContrails dataset. *IEEE Transactions on Geoscience and Remote Sensing*, 62, 1-14, 2024.

Santos Gabriel, V., Bugliaro, L., Montag, M., Ries, S., Wang, Z., Widmaier, K., Arico, M., Unterstrasser, S., Mayer, J., Menekay, D., Marsing, A., de la Torre Castro, E., Megill, L., Scheibe, M., and Voigt, C.: A manually labeled contrail dataset from MSG/SEVIRI, *Earth Syst. Sci. Data*, 18, 2397–2412, <https://doi.org/10.5194/essd-18-2397-2026>, 2026.

Sonabend-W, A., Geraedts, S., Goyal, N., Ng, J. Y.-H., Van Arsdale, C., and McCloskey, K.: Observing long-lived longwave contrail forcing, *Atmos. Meas. Tech.*, 19, 1951–1972, <https://doi.org/10.5194/amt-19-1951-2026>, 2026.