

This manuscript presents the Differential Matched Filter (DiffMF), a novel extension of the conventional matched-filter framework designed to suppress false enhancements in imaging-spectroscopy retrievals of greenhouse gases. Overall, I found the manuscript to be very well written and carefully organized. The mathematical derivations are clear, and the figures are particularly effective in illustrating both the motivation and the behavior of the proposed method. I especially appreciate the interpretation of matched-filter retrievals in terms of the scale and cosine-similarity components, (S_{scale}) and (S_{cos}) . This decomposition provides an intuitive and useful perspective for understanding why false-positive enhancements occur and why conventional matched-filter retrievals may assign large concentrations to spectra that do not genuinely contain the target-gas absorption signature.

More broadly, the manuscript provides a fresh perspective on the long-standing false-positive problem in imaging-spectroscopy plume detection. The use of wavelength derivatives of the whitened spectra is interesting, computationally straightforward, and potentially useful for automated plume-screening applications. The analysis using a large number of EMIT scenes further strengthens the manuscript.

I therefore recommend publication after minor revision. I have only a few comments that I believe would further improve the manuscript.

1. Discussion of Xiang et al.

In the Introduction (L53), the manuscript states, when discussing Xiang et al., that:

“However, the approach requires candidate plumes to have been labeled in advance, often by a human operator.”

I am not sure that this characterization is entirely accurate. As I understand it, the method proposed by Xiang et al. can also be used as an automated means of distinguishing true gas enhancements from false-positive enhancements, rather than necessarily requiring candidate plumes to be manually labeled beforehand.

Conceptually, I see an interesting connection between the two approaches. DiffMF evaluates the similarity between the target and observed spectra through their wavelength-dependent derivatives, whereas the approach of Xiang et al. evaluates how closely the spectral shape of an observed enhancement agrees with the expected gas-absorption spectrum. In this sense, both approaches attempt to introduce additional spectral-shape information beyond the retrieved matched-filter concentration itself.

I therefore suggest that the authors reconsider or clarify this statement and provide a more precise comparison between DiffMF and the method of Xiang et al. Such a comparison would also help readers better understand the specific novelty and advantages of DiffMF.

2. Possible interpretation in the logarithmic domain

One suggestion that may improve the physical interpretation of the method is to consider whether the derivation could be formulated, or at least discussed, in the context of a logarithmic matched filter.

For gas absorption, the logarithmic transformation provides a particularly intuitive representation because, under the Beer–Lambert approximation,

$$\ln(L) - \ln(L_{\mathrm{background}})$$

is more directly related to the gas absorption coefficient and gas enhancement. In such a representation, the spectral shape associated with the gas absorption may be easier to interpret than in radiance space.

I do not think the authors necessarily need to reformulate the entire DiffMF algorithm in the logarithmic domain. However, it would be useful to discuss whether DiffMF could be similarly derived from a log-domain matched-filter framework and whether doing so would change its behavior or interpretation.

Relatedly, an informative additional diagnostic figure could compare, for several representative false-positive surface types,

$$\ln(L_{\mathrm{false}}) - \ln(L_{\mathrm{background}})$$

with the target-gas absorption coefficient k , or the corresponding unit absorption spectrum used in the retrieval. Such a comparison could provide a very intuitive illustration of why these surface spectra produce large conventional MF responses despite differing from the true gas absorption structure. It could also visually demonstrate which spectral discrepancies are emphasized by the first- and second-derivative DiffMF formulations.

I consider this primarily a suggestion rather than a requirement, but I believe such an analysis would substantially strengthen the physical interpretation of the proposed method.

3. Clarification of color scales in figure captions

For Figures 1 and 2, and possibly other retrieval maps in the manuscript, please explicitly describe the meaning and units of the color bars in the figure captions. For example, it would be helpful to state clearly that the color scale represents retrieved concentration length in ppm-m and to indicate whether the different DiffMF orders use the same or different color ranges.

This information can currently be inferred from the text and figures, but including it directly in the captions would make the figures more self-contained.

Overall, this is a strong and interesting manuscript. The proposed DiffMF framework provides both a practical tool for suppressing false enhancements and a useful way of interpreting the spectral origin of false-positive matched-filter retrievals. The manuscript is clearly written, the mathematical presentation is convincing, and the figures effectively support the main conclusions. I recommend publication after minor revision.