Response to interactive comment on "Systematic detection of local CH_4 emissions anomalies combining satellite measurements and high-resolution forecasts" by Anonymous Referee #2

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The authors have developed a method of combining modeled forecasts and satellite observations of CH4 to isolate local CH4 anomalies that might be associated with discrepancies in anthropogenic emissions. Identifying emissions from point sources such as power plants against background CH4 can be challenging. The manuscript presents a clever approach for doing so that takes advantage of the newly available high-resolution CH4 retrievals from TROPOMI and the equally high-resolution CAMS forecasts. The confirmation of the previously identified CH4 source in western Turkmenistan is a nice demonstration of the potential utility of the approach. I recommend the manuscript for publication in ACP after the authors have addressed my comments below.

Main comments

1) My main concern is that the specification of the filter parameters seems to be subjective. On lines 209-211 the authors explain that specifying a length scale (sigma) of 5 degrees retains large-scale structures in the signal, whereas a length scale of 0.5 degrees results in the loss of too much signal. As a result, they selected a length scale of 2 degrees. How did they decide when too much signal is lost? It would be helpful if the authors could be more quantitative. In addition, what is meant by "large-scale" in this context? For example, the panels in Fig. 8 for sigma of 0.5, 1.0, and 2.0 for both the 10-day and 30-day windows all look similar to me. I can see the three regions of CH4 enhancements in the southwestern US and Mexico in all six panels, so it is unclear why the case for sigma = 2.0 with a 30-day window is best. If there is a tacit assumption being made about what specific scales are of interest and the type of emissions that are associated with those scales, that assumption should be explicitly stated as it places a constraint in the utility of the approach.

We thank the reviewer for this helpful comment. We agree that the summitted version of the article do not discuss quantitatively the selection of the filter parameters. We do not have however found a quantitative metric or criteria to find the optimal parameters values for the size of the convolution kernel and the length of the window. Given the answer to the comment 2) and the change to an outlier threshold now based on the measurement precision, we justify the size of the kernel as follows. If the kernel is too small, the filtered signal is getting weaker than the measurement precision and very few to no detections of anomalies is made. Conversely if the kernel is large the signal is strong but to the risk of picking up larger patterns than the targeted features, i.e. which are directly related to local emissions in the CH_4 atmospheric distribution. Regarding the window length, we attempted to explain in the text that a short window could fail to give enough coverage to correctly run the convolution filter. In the opposite a long window will maximise the chances to have to good coverage, but the method would lose its ability to provide temporal variability. For those reasons we chose to run the filtering with a 2 degrees kernel size over a window of 30 days. We have now detailed and clarified the text accordingly.

2) In a similar vein, on lines 217-221 the authors stated that they selected a three sigma threshold for the outlier classification because it "provides suitable results." It is unclear how "suitable" is defined here? They stated that a narrower range "starts to fail isolating important anomalies and conversely a wider range might fail to capture useful information." What are the important anomalies that are not detected with the narrower range? The discussion here should be expanded to give the reader a better sense of what are the implications of this threshold for the type of anomalies that can be detected.

We thank the reviewer for this very helpful comment. Concerning the three-sigma standard deviation threshold, we have chosen this value because it is what is commonly used to account for outliers. We however agree that this is not an objective criterion. We have then updated and improved the outlier classification and is now based on the measurement precision that is provided with the TROPOMI CH_4 product. When the absolute value of the filtered departure is above the precision value, we consider this as an anomaly to be displayed. We clarified and modified the text and figures of the paper accordingly.

3) I am also concerned about the lack of discussion about the potential impact of biases. The filtering does remove "large-scale" biases, but it would be helpful if the authors could comment on the impact of spatially and temporally varying biases on smaller scales (i.e., scales between sigma and the "large-scale"). These could arise from the influence of transport errors, for example.

We are not sure to fully understand the reviewer's concern. Features of scales above sigma (the kernel length scale) are removed by the filter. Thus the 'scales between sigma and the "large-scale"' are not impacting the results and analysis here. We clarified the text accordingly (at the end of section 2.1) by defining large-scale in the paper's

context of being the combination of synoptic-scales (2000 km or more) and meso-alpha-scale (between 200 km and 2000 km).

4) Line 269-270: Is the over-prediction in the Los Angeles area seen only in the Aug-Sept period (i.e., in the right panel)? It doesn't seem to be present in the Jun-Jul plot (left panel). If that is the case, it should be noted in the manuscript. What could be the cause of this temporal variation?

We have now detailed the section 4.2 to take into account the reviewer's comment. We have added an additional figure (now figure 10) that covers four 30 days window over the southwestern US and northern Mexico area.

Technical comments

1) Lines 14, 81, 108, 109, 114, 162, 170, 275: A space is needed between the numbers and units, e.g., "9 km" instead of "9km".

Fixed

2) Line 52: I believe the "Pandley et al." reference should be "Pandey et al."

Fixed

3) Line 75: Please change "earth" to "Earth".

Fixed

4) 4) Lines 336, 341, 343, 354, 360: The line spacing between the references is irregular.

Fixed

5) Figure 5: It is difficult to see the features in the plot for Europe. Since the objective here is to show that ability of the model to capture fine scale features, why not plot the European sector with a different scale to better emphasize these features?

Fixed. We adjusted the color scale.

6) Figure 7: It is unclear what is the time period for the data shown here.

Fixed. We added the end of window date in the figure caption.

7) Figure 9: It is difficult to see the yellow/gold colors for the low forecast category.

Fixed, we have changed it to darker color scale.