

Atmos. Meas. Tech. Discuss., referee comment RC2
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Comment on amt-2021-177

Anonymous Referee #1

Referee comment on "Automated detection of atmospheric NO₂ plumes from satellite data: a tool to help infer anthropogenic combustion emissions" by Douglas P. Finch et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-177-RC2>, 2021

General comments

The paper of Finch et al. entitled 'Automated detection of atmospheric NO₂ plumes from satellite data: a tool to help infer anthropogenic combustion emissions' examines the potential of using a deep learning method to detect plumes in satellite NO₂ retrievals. This paper is a nice piece of work with a novel approach. Although their work on the plume detection is very solid I do have some critical remarks on the relationship with CO₂ emissions. Nevertheless, the developed method seems promising and with more satellite instrument coming into place this manuscript is very relevant for the scientific community.

Specific comments

In the introduction the authors describe the importance of establishing a national CO₂ emission baseline as starting point for climate mitigation efforts. Although I agree this baseline is very important, I would like to point out that the reported annual country-level emissions of fossil fuel CO₂ are very accurate. However, when looking at specific (urban) areas or facilities and/or at shorter time scales the uncertainties increase. As in the remainder of the manuscript the focus is on plumes from urban centres and industrial facilities I would stress this difference to clearly describe the importance of this work. Also on pg. 2, lines 32-33 'Compiled inventories, which rely on self-reporting, provide estimates on these emissions but rely on assumptions that can sometimes lead to inaccurate values.'

At several places in the manuscript the authors say that NO₂ is a tracer of incomplete combustion, but strictly speaking this is not true and I would rather say a tracer of fossil fuel combustion. The authors explain this well on pg. 2, lines 51-53. Also in the discussion on why plumes from natural gas flaring are lacking this is mentioned and I doubt whether this conclusion is valid.

Pg. 5, lines 153-154: The authors describe that the plume coordinate is determined by looking for the maximum value. What does this mean for images which contain multiple plumes? Also, I'm wondering whether a difference in performance exist for images with one vs. multiple plumes. Could the authors also indicate how many of these images contain multiple plumes?

Pg. 7, lines 180-181: I think it's also likely that the reverse is true, namely that anthropogenic emissions are incorrectly discarded as biomass burning emissions, while they can easily be co-located. This leads me to the question what the goal of this exercise exactly is. Do the authors aim to detect plumes that are almost certainly anthropogenic and use that for verification of those specific locations? Or is the goal to detect as many anthropogenic plumes as possible for a full verification of global or national emissions? This is also related to their decision to remove images with a <75% confidence that a plume is present in that image. Could the authors reflect on this?

Pg. 9, lines 200-201: 'Discrepancies between known sources and the NO₂ plumes, especially over China and India suggest that inventories being used to identify power plants are out of date.' This could be one explanation, but given the authors' conclusion that 92% of the CO₂ emissions are covered with their methodology it also seems likely that the missing sources are rather small and therefore more difficult to detect.

Pg. 9, lines 219-220: 'Persistence of plume detection locations (Figure 4) provide confidence that we observing point sources.' Could the authors indicate how often the same location is sampled on average and is there a seasonality in the detection of certain sources? Later in the manuscript the authors compare the detected sources and total emissions with monthly CO₂ emissions and therefore the timing may play a role. I also wonder whether the 92% of CO₂ emissions covered by the plumes are based on annual emissions?

Pg. 14, line 276: 'The impetus for our study is using NO₂ as a tracer for anthropogenic emissions of CO₂ and methane.' Methane has not been mentioned before in the manuscript (except for the introduction) and I would like to point out that the conclusions drawn here for CO₂ may not apply to methane. The emission sources of methane are very different and therefore also the relationship between NO₂ plumes and CH₄ emissions. More nuance is needed in this statement.

Pg. 16, lines 299-300: I agree with this statement, but I would rather move this to the introduction. Now the introduction seems to suggest that the authors want to establish a CO₂ baseline emission, which is in fact not true.

Technical corrections

Pg. 2, line 39: Please update the reference in this line (International Marine Organization).

Pg. 5, lines 124-125: '... were individually normalised to remove the influence the magnitude of image NO₂ features, ...' Please correct this sentence.

Pg. 7, line 167: '... from burning fossil fuels and biomass burning...' Please replace with 'burning of fossil fuels' or 'fossil fuel and biomass burning'.

Pg. 7, line 168: '... across the global...' Replace 'global' with 'globe'.

Pg. 9, line 220: '... that we observing...' Please correct this sentence.

Pg. 11, line 232: 'We anticipate this improve...' Please correct this sentence.

Pg. 16, lines 290-291: '... an inefficient form or combustion...' Please correct this sentence.