Geoscientific Model Development Discussions

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Comment on gmd-2021-386

Sharon Gourdji (Referee)

Referee comment on "Effects of point source emission heights in WRF–STILT: a step towards exploiting nocturnal observations in models" by Fabian Maier et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-386-RC1, 2022

This is an excellent study, which is very well-written and clear and with very useful implications for atmospheric inverse modeling, particularly in urban areas. A few small questions and concerns for clarification should be addressed before final publication:

- To use the VSI approach, does one also need an inventory containing the vertical height profiles of all point source emissions? This would be great to have, but in practice, this may currently exist in Europe only. (For example, I don't believe that the Vulcan product for the USA contains height of emissions sources now, nor other products like FFDAS or ODIAC.)
- What are the additional computational requirements of the VSI relative to the SSI approach? Also, how would one go about creating a footprint from a single tower with a mix of the VSI approach for nearby point sources and the SSI for farther-away emissions sources? How would one do that practically with the WRF-STILT framework?
- I was left wondering what are the relative impacts of mixing assumptions versus PBL height errors when using night-time measurements. Could you include a small theoretical example to demonstrate the impact of realistic mixing height errors with the VSI approach and nighttime observations?

Other small comments:

- Abstract, line 28: "to fall below 0.1 ppm" à during day or nighttime or both?
- Page 3, line 61: "nighttime situations showed a relative bias of more than 50%" -> in which direction is this bias?
- Is 100 particles enough for this study? I assume you would get the same results using

500 particles or more, but it might be worth a small check for sensitivity here.

- Figure 1: This is a nice map, although it's a bit hard to see the country outlines and the actual distance from point sources to measurement locations. Consider additionally including a histogram or barplot of distance to nearest point source(s) for each measurement location? To what extent do existing measurement locations follow the ICOS recommendations to stay at least 40 km away from strong anthropogenic sources? (And how did ICOS derive this recommendation in the first place?)
- Page 3, line 61: "a relative standard deviation of about 40%" in mixing height, or errors in mixing height? Also, please clarify for following sentence.
- Page 4, lines 62-64: if the uncertainty in daytime mixing height translates into uncertainties of ~3 ppm and 30% of the simulated biogenic signal during summer, what does this tell you about nighttime uncertainties? Just complete the thought here. Also, in reference to the previous comment, this article develops a better approach to dealing with mixing assumptions in STILT but doesn't address or improve mixing height errors. So, what is the relative impact of these two types of errors on both daytime and nighttime measurements?
- Page 5, lines 88-95: this is a great explanation for why the ability to use nighttime observations in inversions would be very useful and is a prime rationale for your study. I suggest adding a statement to this effect in the abstract about why this work would be very helpful for other researchers for the reasons laid out here.
- Page 7, line 141: please spell out what TNO stands for, for those not familiar. In general, it might be nice to describe this inventory in a bit more detail for non-European audiences, especially because you are relying on the height profiles in this inventory to implement your VSI approach. Also, for the differing spatial resolutions between Germany and the rest of Europe, is this how it's produced in Super et al, 2020, or do you aggregate emissions yourself for the purposes of this study?
- Page 9, lines 189-191: How would time-varying emissions affect these TNO height profiles (e.g. with some emission sources starting and stopping again)? Also, do the TNO height profiles shown in Figure 3b represent sector-specific averages? Or are heights included for individual point source locations as well?
- Figure 7f: it is nice to have a consistent y-scale with the subplot above (7c), but it's a bit confusing with the arrows and negative values. Consider changing the y-scale to include negative values for both.
- Page 11, lines 247-250: is there a physical reason why these errors would be lower in summer than in winter? I think this could be interesting for the reader.
- Page 16, lines 349-357: it's a bit hard to follow the argument here. For example, the statement "However, the power plant within a 5 km radius yields lower ffCO2 contributions during stable PBLH < 500 m conditions than during PBLH > 500 m situations" à is this referring to the VSI approach? And the opposite is true for the SSI approach? It sounds like it from the statement in the next paragraph that "the SSI approach simulates on average almost 5 ppm larger ffCO2 contributions than the VSI approach for the closest power plant during stable conditions." This is just for the 30-m tower, correct, and not the 200-m tower? Also, the possible explanation mentioned for the VSI behavior, is this in the model, in reality or both?
- Page 16, line 362: what are the typical inlet heights for ICOS tower stations?
- Page 20, line 461: "inaccurate representation"
- References: please use better indentation to distinguish each reference.