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Atmospheric Measurement Techniques Discussions

Interactive comment on "High-resolution mapping of urban air quality with heterogeneous observations: a new methodology and its application to Amsterdam" *by* Bas Mijling

Anonymous Referee #2

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GENERAL COMMENTS

The manuscript describes a relatively simple but quite portable urban-scale modelling system for air quality based on AERMOD, which has the capability of assimilating point-based observations using statistical interpolation. The system is demonstrated for the city of Amsterdam using observations of nitrogen dioxide from both the official reference stations as well as a low-cost sensor network. The topic of the manuscript is highly relevant and the described system is an elegant solution for better exploiting data from low-cost air quality sensor networks in an objective and meaningful fashion and to thus address the growing need of ever more detailed high-resolution maps of

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Discussion paper

urban air quality. Overall the manuscript is very well written and clearly structured, and I highly recommend it for publication once some of the issues listed below are adequately addressed.

One of my main concerns relates to the lack of detail in some of the sections, but particularly in the section that is supposed to demonstrate the added value from assimilating low-cost sensor data (Sec 6). Given that multiple previous studies have already successfully assimilated regular stations observations using OI (e.g. Tilloy et al. 2013), one of the more novel aspects of this study is the assimilation of low-cost air quality sensors. The manuscript goes through great lengths of building up a dispersion model system with simplified emissions as well as an OI assimilation scheme, but the added value from low-cost sensor networks is covered in just a few lines towards the end without much detailed analysis. I think the manuscript could be a lot stronger and have more impact if a more comprehensive analysis of this were carried out in Section 6.

Secondly, Section 2.2.1 on traffic emissions (which are crucially controlling NOx/NO2) left me scratching my head at times. I realize that the system is designed to be portable and thus the necessary input data should be kept to a minimum, but I wonder if some of the simplifications taken here are defensible. In particular spatial interpolation of traffic monitoring sites seems to me a quite crude approximation that introduces significant uncertainties in the modelling. Further, what about distinguishing different types of vehicles? Regular cars versus heavy trucks? Euro 4/5/6 emissions categories? These things can have a very significant impact on the modelling results for NO2 and I wonder if some more care in setting up the modelling would not be beneficial in the long run? This is particularly a concern in the sense that OI should technically only be used when model and observations are unbiased against each other and ignoring certain high polluting vehicle classes could introduce potentially damaging biases. At the very least, the author should discuss these potential issues and lay out future steps to resolve these problems. In the best case scenario, it would be good to see some sensitivity studies testing the modelled NO2 sensitivity to inclusion of these different classes.

Thirdly, I feel that the manuscript could benefit from some more detail on how the error characteristics of the observations were derived. Estimating uncertainties from reference instruments and low-cost sensors on its own is a difficult subject and the paper does not provide the reader with information on how these were estimated or how such uncertainties were then transformed into error characteristics suitable for ingestion in the OI scheme. Such a discussion should be included in the paper and I believe this would strengthen the authors conclusions.

Finally, given that 90% of the paper deals with modelling and data assimilation, I do find the choice of AMT for this manuscript slightly puzzling and I feel that the paper would probably be better suited for a journal more focused on modelling or general air quality issues. However since the editor has accepted the paper to AMTD I assume that the material is considered suitable for the journal.

DETAILED COMMENTS

L15: "Retina" - why is it called this? Include the full name if this is an acronym.

L16/17: how are these percentages to be interpreted? Would be good mention here how accuracy is defined. Something as simple as "... a typical accuracy (defined here as [...]) of 39%" or similar

L23: "enhanced understanding of reference measurements". Please

L38: "adding value". I suggest you give an example of what you consider as adding value to the measurements or otherwise better write "exploting the measurements"

L39: In single-author papers it looks quite odd to use plural terms such as "our" and "we". Consider revising.

L43: I would add here that it depends on the mapping resolution and the pollutant. The required sampling density increases with the desired spatial resolution of the map. Furthermore, NO2 with is very sharp spatial gradients will always require a much denser network than for example mapping PM2.5 with its relatively smooth spatial gradients.

L60: The introduction/background section is missing a reference and a discussion of Tilloy et al (2013) (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/jgrd.50233), who have essentially done the same as this paper (OI of point-based observations into an urban-scale AQ model).

L61: Again, the name "Retina" comes a bit out of the blue. You should probably introduce here what the acronym stands for.

L70: I would be a bit careful with the term "calibration" in this context, given that it has a very specific meaning for measurements (both reference as well as sensors). Maybe reword or describe a bit more thoroughly what happens in this step.

L98: A reference to AERMOD would be useful here.

L99: "local equidistant coordinate system" - at this point you might as well give the actual projection you used. Presumably something UTM-like?

L100: "road-following grid". This is used as if this a commonly known term, which in my opinion it is not. So first of all you might want to introduce this term a bit more carefully by saying something like "we use a road-following grid, which is essentially....". Secondly, to me it sounds a bit weird to use the term "grid" in this context, when you are basically talking about a spatially irregular and scattered set of receptor points with higher density along road links. I think the term grid should be reserved for a somewhat regular arrangement of cells.

L148-152: I realize that the goal of this paper is not to build the world's best model so a certain amount of simplification is expected, but interpolating traffic flow using IDW seems to be an incredibly crude method. How can this method possibly work? Between two loop counters there will likely be many road segments that either have much more or much less traffic than at the observation sites, so I fail to understand how simply interpolating here can lead to useful results. I think this section needs more detail on how this is carried out and a robust demonstration that the chosen methods

are meaningful.

L164: Don't they assimilate UTD data? In that case it wouldn't be a day old but just a few hours (maybe better write "up to a day old" or so).

L230: This should be Figure 3b? Also, I think this Figure should be discussed a bit more (maybe in the discussion section?) for example with respect to potential reasons for the difference between model and observations, particularly for the highway location.

L235: I recommend to remove the term "geostatistical" here. While OI is mathematically very similar to kriging-based techniques (and it can in fact be shown that it provides identical results to kriging if the same inputs are used) it is not traditionally considered a part of the field of geostatistics. Geostatistics was developed in the mining and earth resources community (Matheron et al.), whereas OI was developed within the meteorological community (Gandin 1965).

L241: Again, I would not use the term "grid" for what is essentially a set of irregular, scattered receptor points.

L265: I think it would be good to mention here that Statistical Interpolation/OI is essentially the same assimilation scheme (just a different mathematical framework) as previous kriging-based approaches. The main advantage of OI over geostatistics (but also an added complexity) is that one has detailed manual control over the Pb covariance matrix, which allows for a more comprehensive specification of the the area of influence for each contributing observation.

L287: extend -> extent (or maybe magnitude?); also reflect -> reflects

L335-340: I think this section should be either left out entirely or expanded upon significantly. As it is currently it does not represent a robust demonstration that low-cost sensors add value to the system, since the effect has only been shown at a single site and not been analysed in detail. Demonstrating that the information from low-cost sensors can improve urban-scale air quality modelling is clearly a very worthwhile goal but

this short section reads unfortunately more like an afterthought than a proper analysis.

L354: I think it would also be worthwhile noting here that, while CAMS is definitely useful for providing background conditions and initial conditions, for NO2 the CAMS forecasts can be very misleading when interpreted at the local scale. The predicted diurnal cycle can often deviate substantially from that observed at urban AQ stations.

L356: Agreed. And in addition the higher resolution from a dispersion model is also much more appropriate than CAMS for applications such as exposure estimates etc.

L374: "Traffic data tend to be harder to obtain". That is very true (and maybe even an understatement) and is one of the most limiting factors in running local-scale dispersion models at random locations. Given that traffic is typically the most important source for NOx I have the suspicion that even the comparatively portable Retina methodology is likely to fail when no such traffic data is available at all. I think it would be worthwhile discussing here that at some point, if nearly all the crucial input data to Aermod is either of low quality or entirely missing, the resulting forecasted concentration fields will be so bad that any type of sophisticated data assimilation of observations is no longer very meaningful.

L396: It might be more detailed, but is it really much better? This section is too qualitative to draw much of a conclusion. As I said above, I think the manuscript would benefit from a more robust analysis along these lines.

Figure 2: The caption should indicate more clearly that the thin lines represent the traffic at individual stations.

Figure 3a: These maps would benefit from some basic cartographic elements, e.g. a background map from OpenStreetmap similarly to Figure 7/8, scale bar, coordinates etc.

Figure 5: "Units are in meters" - not all of them. I recommend to either label all axes properly or to have a more thorough caption describing the various elements of this

busy Figure in more detail. It would also be helpful to have labels for each subplot (a, b, c..) so that they can be better referred to in the caption.

Figure 6: I think it is a bit confusing that the time series is only for 8 days, whereas the scatter plots show an entire month of data. Why not show the time series also for the entire period? If it is a visualization issue, it could be plotted over multiple rows. Similar to my earlier comments I also think that the analysis here would benefit from looking at more than just a single station.

Figure 8: "IJ-tunnel" Should be marked on the map since non-locals will not be familiar with this.

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