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VALIDATION OF THE RIO-IFDM-OSPM MODEL CHAIN USING THE ANTWERP "CURIEUZENEUZEN" CITIZEN SCIENCE MEASUREMENT CAMPAIGN

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Abstract: During the month of May 2016, NO_2 concentrations were measured in the city of Antwerp, Belgium, at about 2000 locations using passive samplers (Palmes tubes) by a citizen science initiative called "Curieuzeneuzen". This initiative was initiated by an Antwerp civilian platform called 'Ringland' which strives to improve the quality of living in the city and was supported by a number of Flemish universities and the city council itself.

In this contribution we present a validation exercise using the RIO-IFDM-OSPM air quality model chain used on a regular basis for policy support in Flanders. Apart from indicating an underestimation of the highest concentrations, the study revealed a number of interesting difficulties in dealing with such citizen – science dataset. It was seen that the method of suspension of the sampler can be responsible for an important systematic uncertainty. Furthermore it is shown that the influence of congestion and stop & start at red-light crossings is an important factor to take into account into the model.

Key words: *Model validation, citizen science*

INTRODUCTION

During the measurement campaign, passive samplers were used to measure the average NO_2-concentration at 2000 locations, spread throughout the city. Most of the measurements were done by attaching the passive samplers to a V-shaped cardboard system that could be attached to a front window of a volunteer. Each of these V-shaped cardboard systems contained two passive samplers. They were exposed to the ambient air from the 30th of April 2016 to the 28th of May 2016.

MEASUREMENT CAMPAIGN AND CALIBRATION

In order to compare the passive sampler measurements with the official measurements by the Flemish Environmental Agency, samplers were attached next to the 8 official measurement stations. Based on the results of this intercomparison, it was observed that a strong negative bias was present in the passive sampler measurements. Therefore, a calibration curve was establisehd and this curve was used to correct all other passive sampler measurements. However, the spread of measurements at the official measurement locations was limited to the range of 21-43 $\mu g/m^3$. As a result, the uncertainty on the calibration curve for very low and very high concentrations is high.

In addition, another calibration was required. The passive samplers at the measurement locations were attached without cardboard system. However, most measurements in the citizen science experiment were done attached to the V-shaped cardboard system. To further assess this effect a separate campaign was performed during the summer of 2016, showing that the cardboard system introduces another bias, leading to an extra calibration set and its corresponding uncertainty.

MODEL CHAIN

In this abstract, the model results were obtained using the RIO-IFDM-OSPM model chain, combining the land use regression model RIO for the background concentrations, the Gaussian plume model IFDM for the rooftop concentrations and the street canyon model OSPM for the street canyon increment. This setup is similar to the one in Lefebvre et al. (2013).

VALIDATION

For this validation we use the measurements after applying the different calibration steps discussed above. We ignored the measurements for which the location was unknown or which were attached too high or too low above the ground. As a result, the validation was performed on 1891 measurement locations, or 97% of the total number.

Depending on the location, IFDM or OSPM-results were used as model results. The OSPM results were used at locations within a street canyon for which road traffic emissions were present (and thus traffic) in the street canyon. At other locations, IFDM results were used. Figure 1 shows the different measurement locations and the traffic data that is available for the city of Antwerp. As can be seen from the plot, not all streets in the city are present in the traffic model. As a consequence not all streets are taken into account as a canyon in the IFDM-OSPM model chain. When no traffic data is available from the traffic model, the location is considered as urban background and the corresponding IFDM results is used..

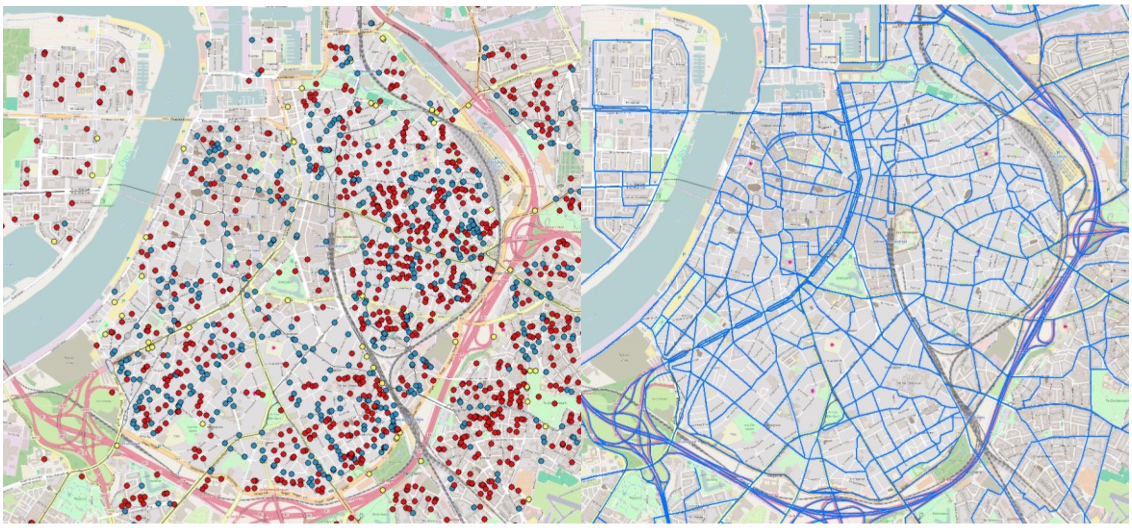

Figure 1: Left side: Measurement locations in the city centre of Antwerp. In blue: street canyons where traffic data was available. In red : IFDM results were used as no street canyon data were available because no traffic data was available. In yellow: IFDM results were used as no street canyon is present. Right side: availability of traffic data in the model chain. Only on blue segments traffic data is available.

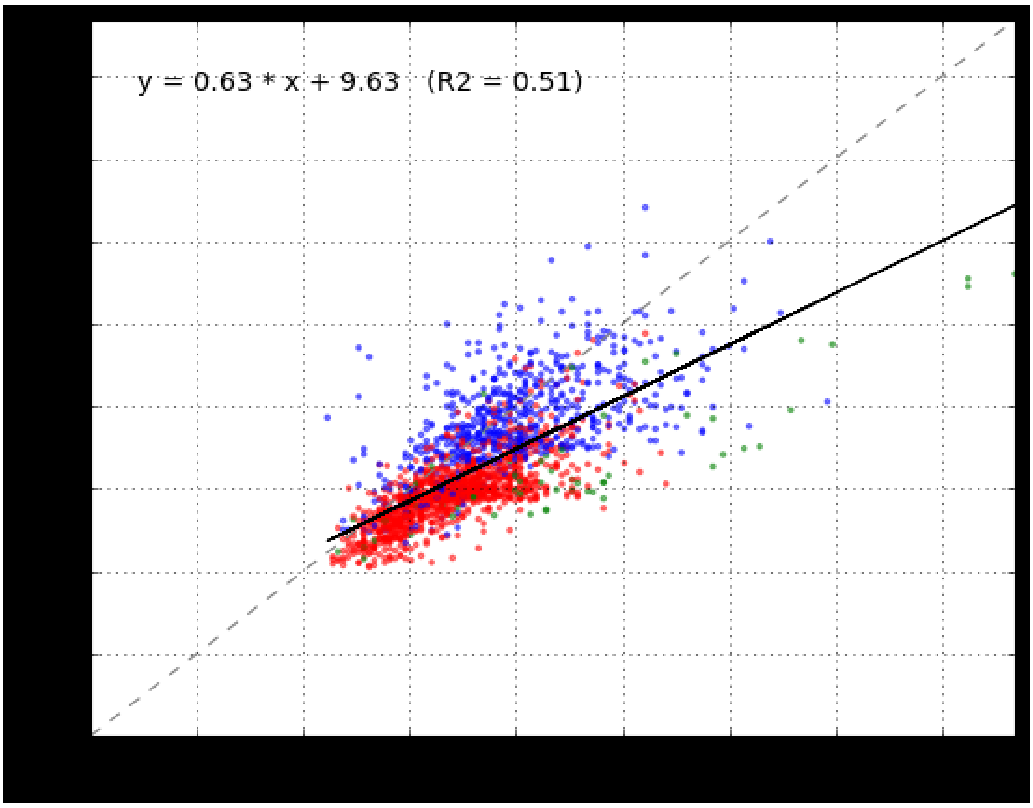

Figure 2: Scatterplot of the NO_2-concentrations (in µg/m^3) at all locations in the Curieuzeneuzen campaign. In blue: street canyons where traffic data was available. In red : IFDM results were used as no street canyon data were available because no traffic data was available. In green: IFDM results were used as no street canyon is present

Figure 2 shows the scatterpolot of measurements and modelling.

We see that the measurements are underestimated by the model results. The mean bias is 11%. This bias is especially present at the locations with the highest concentrations. The root mean square error (RMSE) is equal to 18% and is mainly influenced by the highest locations.

Furthermore, we see that the bias for locations for which OSPM was applied is much lower (4%, blue points in Figure 2). On the contrary, the bias is large for the red points (no traffic data available). Almost all of these points are measured in street canyon locations (or at least half-open street canyons) as the cardboard systems were attached to the windows of a home at the street side. However, for these points, no traffic data is present in our model, leading to a local street effect of 0 µg/m^3. It is certain that in reality this local street effect is higher (These are streets with traffic, albeit probably not so much traffic, and are at least half-open street canyons), explaining the strong bias in these results.

Finally, the bias for the points where traffic data was available, but no street canyons were recognized is quite high. Most of these points are at least half-open street canyons (see above), but as the model was not capable of determining the street width of those, no street canyon calculations were done. A specific subset are points where half of the street canyons if formed by objects which are not buildings, such as the railway embankment. However, this embankment is not present in the buildings dataset and thus the OSPM model will not determine this street to be a street canyon.

Furthermore, we expect the following reasons to be important in explaining the differences between the model and measurements.

- The traffic data used in the modelling has some strong artefacts. First of all, only a subset of the streets (about 50%) is available in the traffic data. Furthermore, it was shown previously that the number of busses in the dataset is too low (Hooyberghs and Lefebvre, 2014).
- The model is probably too conservative in estimating the emissions in congested streets with a lot of start-stop traffic. This is mainly due to the absence of data about these congestions.
- Uncertainties on the measurements can play a large role. As discussed above, the uncertainty on the calibration is much higher at higher concentrations. Furthermore, the height of the measurements in this campaign was not constant. This also leads to extra scatter.
- The model chain uses some assumptions, including the location of the street canyon (and the necessity of buildings at both sides of the road before a street canyon is modelled). Furthermore, the OSPM calculations were not made at exactly the measurement locations. Although these differences will be small, it is possible that this leads to a different building-road configuration.

CONCLUSIONS

We have shown that our model has skill in reproducing the measurements made during a citizen science campaign in the city of Antwerp. However, the validation has shown that quite some aspects in both modelling and measurements can be improved.

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