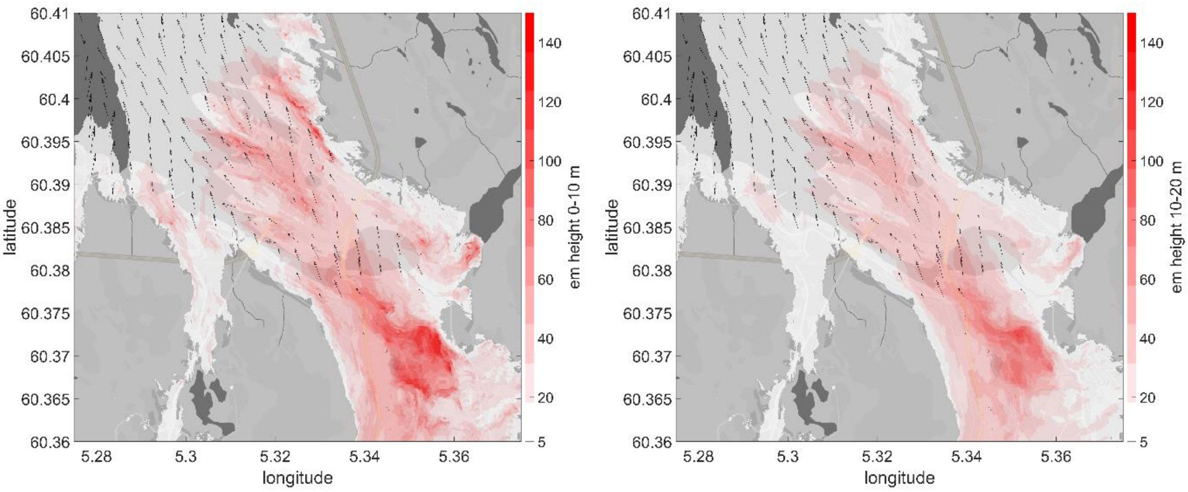
Supplementary material

Sensitivity to emission height

In Wolf et al. (2019) we used tracer emissions directly at the ground, meaning that all $PM_{2.5}$ emissions were assumed to be initially paced into the first grid-cell above the surface. This setup was criticized as one leading to overestimation of the near-surface concentrations due to the excessively weak turbulent mixing in the first grid box above the surface. In this study, we use higher emission heights of 15 m above the surface for the entire model domain. Thus, the pollutant is ingested into the second grid box above the surface. This modified setup reduces concentrations as compared to Wolf et al. (2019). In order to assess the impact of the elevated emission height on this reduction, a full sensitivity study is necessary. We simulated the surface (at 5 m) $PM_{2.5}$ concentration using four different emission heights and a smaller computational domain studied in Wolf et al. (2019). The updated emission factor from the present study is used. The $PM_{2.5}$ maps are shown in Figure S1. The absolute surface layer concentrations of particulate matter are decreasing with increasing emission height. Simultaneously, the pollution pattern remains very similar. The sharp spatial gradients that exist in some places for emissions into the lowest grid-box above topography are reduced gradually with increasing emission heights.



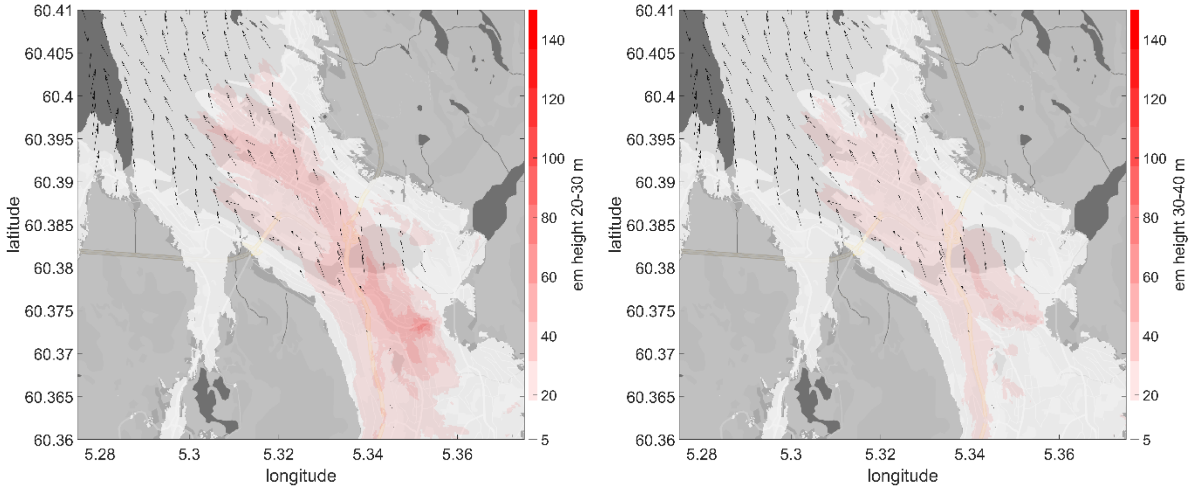


Figure S1: $PM_{2.5}$ concentrations resulting from emissions at different heights (the centre box heights at 5, 15, 25 and 35 m) above the ground in the model. Data overlay the grayscale map from Map data ©2019 Google.

In terms of absolute numbers, the distribution of surface concentrations of $PM_{2.5}$ for the different emission heights is summarized in Figure S2. A clear decrease in the median pollutant concentration (of all grid boxes in the computational domain) is visible for increasing emission heights. For emissions into the lowest grid-box above topography, the median $PM_{2.5}$ concentration is 16.18 µg/m^3 with maximum values as high as 157.65 µg/m^3. For emissions into the second grid-box above topography, these values are reduced to 16.18 µg/m^3 and 122.67 µg/m^3, respectively. For emissions into the fourth grid-box above topography, the values have decreased to 6.68 µg/m^3 and 43.27 µg/m^3. The most extreme concentrations decrease faster than the median concentrations possibly due to the reduced emission of pollutants in the areas with near surface local cold-pools and high local accumulation.

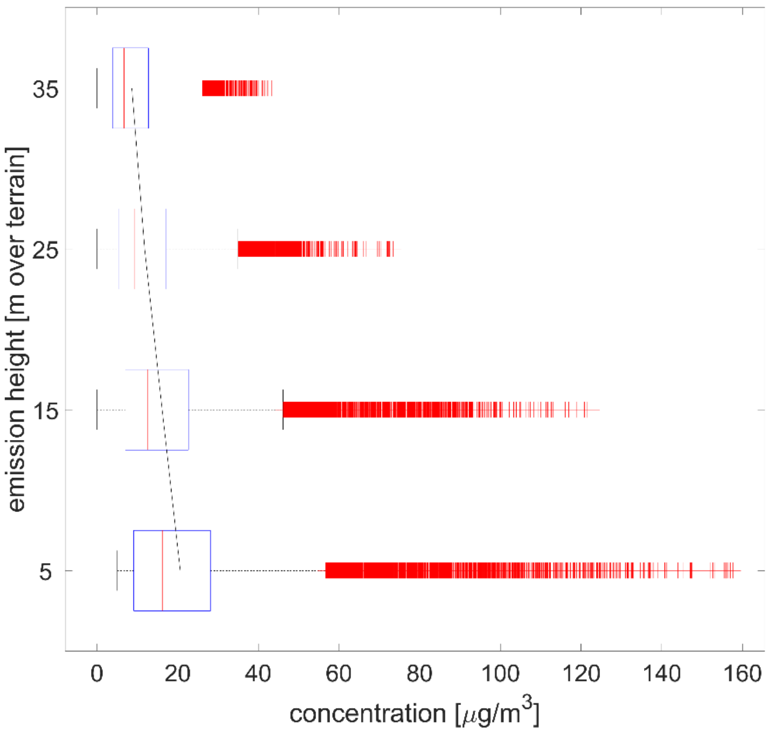


Figure S2: Box- and whiskers plot of the PM2.5 concentrations for emissions at different emission heights in the model. The y-axis indicates the centre height of the grid-boxes, where initial emissions were ingested. Boxes show the 25'th and 75'th percentile of the simulated data. The red lines indicated median, while the dotted(?) black line indicates the mean values. Whiskers are maximum 1.5 times as long as the distance of the 25'th and 75'th percentiles. Larger values are indicated by red markers.

This, however, also indicates that the factor 10 reduction in the emission values in both studies most likely is not connected to an underestimated emission height. Initial emissions at between 30 and 40 m above topography are unrealistic for small houses and the prevailing inversion conditions. Simultaneously, $PM_{2.5}$ concentrations would still be strongly overestimated even for such a high emission height. Other explanations for this overestimation of the emission factors could be an overestimation of the expected usage of wood-ovens in general, or an overestimation of the amount of burned fuel per oven over a given period. However, we have not further investigated this but used input information provided. An improved emission mapping would be helpful for future studies involving studies of local $PM_{2.5}$ distribution from burning wood for heating.