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THE EFFECT OF WOOD BURNING ON PARTICULATE MATTER CONCENTRATIONS IN FLANDERS, BELGIUM

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Abstract:
Since 2010, new estimations of the particulate matter emissions in Flanders have been made by using a tier-II approach. By means of a survey, the quantity of the wood consumption by households, buildings (services sector), industry and agricultural sector in Flanders has been estimated. These surveys also provided data on the installation stock in Flanders, such as the type (fireplaces, pellet stoves, …) and age of the heating installation. Besides the wood consumption and use patterns, emission factors of particulate matter per type of wood and per type and age of heating installation were also updated based on international, recent literature on emission factors. Both new estimations resulted in an actualization of the particulate matter emissions of the residential wood burning in Flanders. Overall, the estimations were a factor 13 higher than the old estimations. This factor 13 is due to a factor 4 increase in the average emission factor and a factor of 3.4 in the wood consumption. As a result, heating in the residential sector is estimated to be the most important emission source for primary particulate matter (37% of all primary emissions) in Flanders.

In order to confirm these results, measurements of levoglucosan, a wood burning tracer were made in open air, in order to estimate the contribution of wood burning in the ambient concentrations (all sectors). It was shown that about 10% of the particulate matter concentrations in winter were due to wood burning, while in summer this amounted only 2 to 3%.
In a final step, a dispersion model has been used in order to check the consistency of both results. It is shown that the increased emissions are consistent with the measured particulate matter concentrations due to wood burning. Indeed, the increase in emissions by a factor 13 is needed to understand the high levoglucosan concentrations in ambient air in Flanders.

Key words: *wood burning, emission estimates, levoglucosan*

INTRODUCTION

Recently, wood burning by Flemish households was discussed quite intensively in Flemish press and also in the Flemish parliament. The attention for this environmental topic originated from interesting, new estimations of PM emissions and concentrations in the ambient air. Three major studies have been done and are discussed in detail in this paper. Firstly, new estimations of wood burning particulate matter emissions in Flanders have been made. Secondly, measurements of levoglucosan in ambient air have been done. Finally, a dispersion model has been used to check the consistency of the results of the two previous studies.

EMISSION ESTIMATES

Since 2010, new estimations of the particulate matter emissions in Flanders have been made by using a tier-II approach (Renders et al., 2011; Aernouts et al., 2013a, 2013b). By means of a survey, the quantity of the wood consumption by households, buildings (services sector), industry and agricultural sector in Flanders has been estimated. A survey is necessary as not all consumed wood is purchased, e.g. some of the wood is sourced locally or waste wood is used. These surveys also provided data on the installation

stock in Flanders, such as the type (fireplaces, pellet stoves, …, e.g. Figure 1) and age of the heating installation.

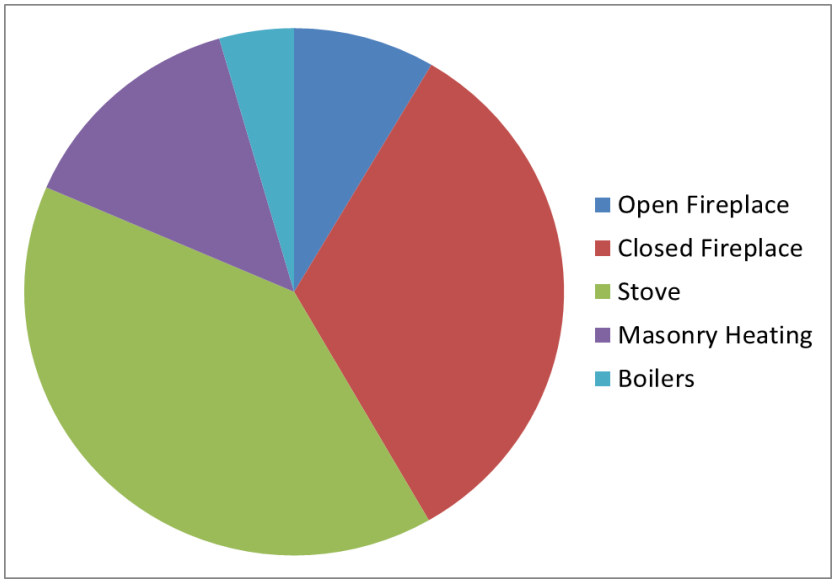

Figure 1: Amount of wood used in different type of wood burning installations.

Besides the wood consumption and use patterns, emission factors of particulate matter per type of wood and per type and age of heating installation were also updated based on international, recent literature on emission factors (Renders et al., 2011). Both new estimations resulted in an actualization of the particulate matter emissions of the residential wood burning in Flanders. Overall, the estimations were a factor 13 higher than the old estimations (591 to 7991 ton/year). This factor 13 is due to a factor 4 increase in the average emission factor (128 to 510 ton/PJ) and a factor of 3.4 in the wood consumption (4.6 to 15.6 PJ). As a result, heating in residential sector is estimated to be the most important emission source for primary particulate matter (37% of all primary emissions) in Flanders (Figure 2) (Vanpoucke et al., 2013).

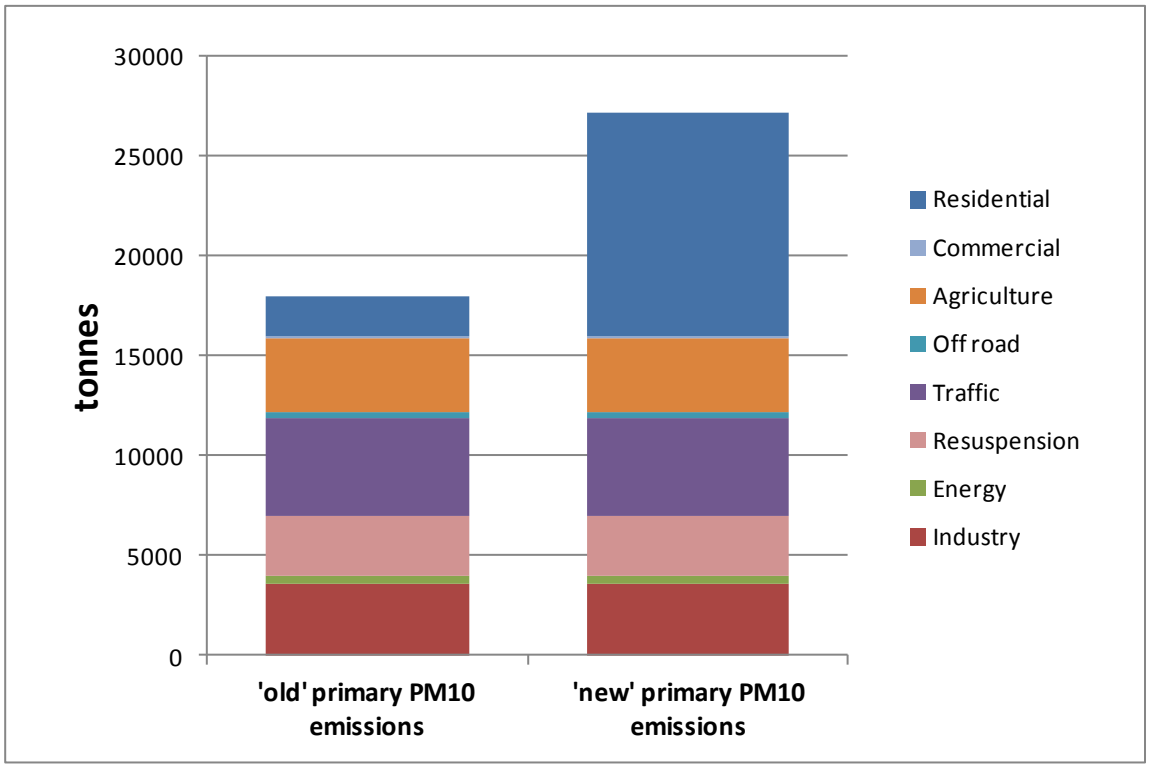

Figure 2: Primary PM_{10} emissions (tonnes/year) for the different sectors before (left) and after (right) the application of the new wood use and emission factor data in the Flemish Emission Inventory.

LEVOGLUCOSAN MEASUREMENTS IN AMBIENT AIR

In order to confirm these results, measurements of levoglucosan, a wood burning tracer, were made in open air (VMM, 2011; 2013), in order to estimate the contribution of wood burning in the ambient concentrations (all sectors). Sampling was done for 24 hours with a Leckel SEQ47/50 instrument that samples 55 m³ of air on a filter. After sampling the filters were reweighed in the lab to determine the total PM10 concentration in the air. Then different parts of the filters were sent to specialized laboratories for the determination of levoglucosan. This product is an oxidation product of cellulose or starch and is a good tracer of wood burning emissions. Based on Austrian research (Schmidl et al., 2008; Caseiro et al., 2009) the PM contribution of wood burning was estimated to be equal to 10.7 times the levoglucosan concentrations. This factor is well within the range of values in European studies albeit somewhat low to the average value (Maenhaut, 2013). Two measurement campaigns were performed (February 2010-February 2011 and June 2011-July 2012) at in total 10 Flemish locations. In the first campaign, filters were analysed every sixth day, while in the second campaign, this was done every fourth day.

Using these measurements, it was shown that about 10% of the particulate matter concentrations in winter were due to wood burning, while in summer this amounted only 2 to 3% (Figure 3). Furthermore, it is important to note that on days that the PM10 daily limit of 50 µg/m³ was exceeded, the average contribution was even higher (almost 6 µg/m³). It was estimated that a significant part of the exceedences of the European daily limit value would be avoided if no wood burning would be present.

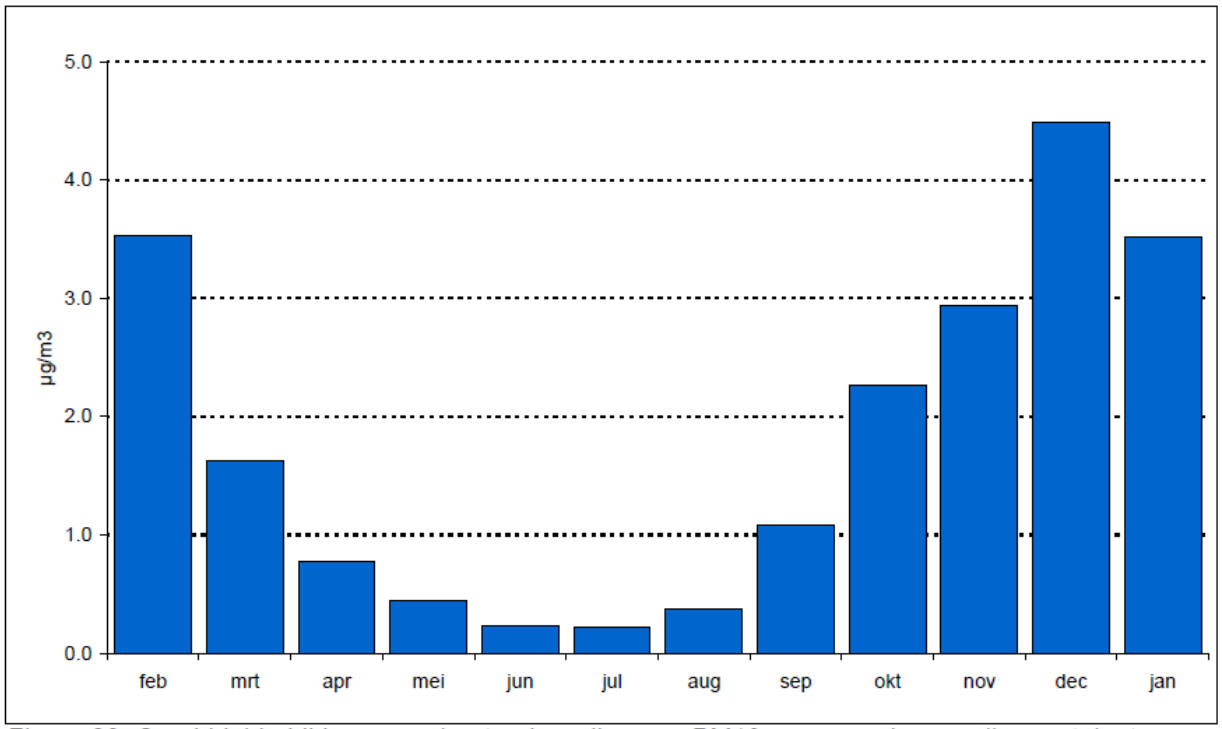

Figure 3: Mean (over all measurement locations) contribution of wood burning to the total PM10-concentrations, per month from February 2010 to January 2011.

DISPERSION MODELLING

In a final step, a dispersion model has been used in order to check the consistency of both results (Veldeman et al., 2013). Therefore, the bi-gaussian IFDM-model was applied, using emissions estimated with the new wood consumption and before and after applying the new emission factors. Only emissions within Flanders were taken into account. To account for emissions outside of Flanders, an average background concentration of 0.2 µg/m³ was imposed. The spatial distribution of the emissions was based on the population distribution and the rural/urban characteristics. The temporal distribution of the emissions was based on the system of degree days with a limit value for the daily average temperature of 15°C. It is shown that the increased emissions are consistent with the measured particulate matter concentrations due to wood burning. Indeed, the increase in emissions by a factor 13 is needed to understand the high levoglucosan concentrations in ambient air in Flanders (Figure 4).

The large amount of scatter, both on the spatial validation and temporal validation was to be expected. First of all, the emissions were spread as surface sources at a 1x1 km² scale. However, wood burning has a strong local component which is not known. Secondly, wood burning is in principal not used as primary heating source in Flanders, but is used in many cases for enhancement of the coziness of a room. As a result, the use of degree days will not represent the inherent variability in wood burning. Furthermore, some of the outliers on Figure 4 (upper part) can be explained. The locations closest to the frontiers (N029, RT01 and somewhat less LR02) are in general underestimated, which was to be expected as the contribution due to regions outside of Flanders is expected to be larger, but was kept constant.

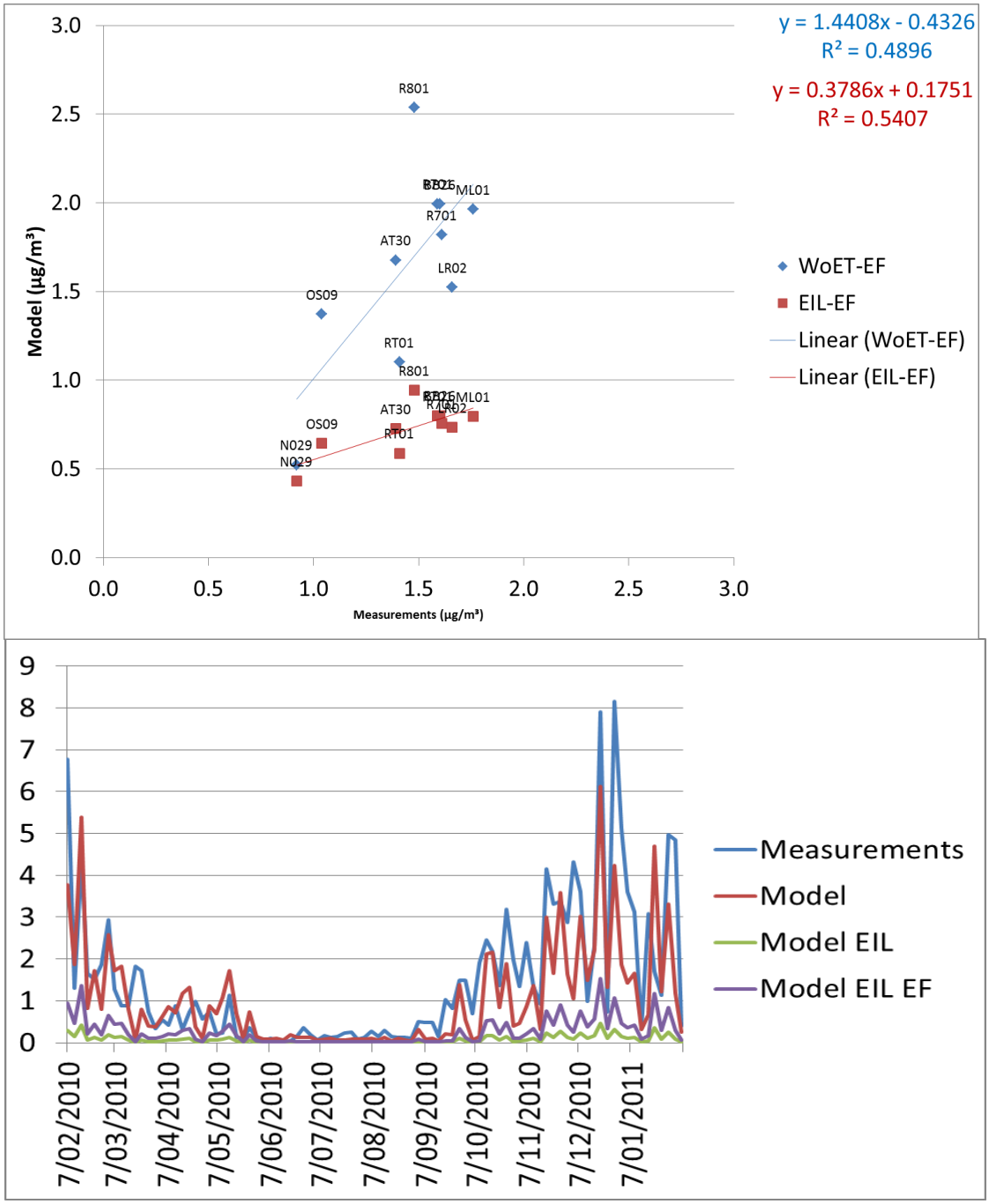

Figure 4: Comparison of the modelled and measured PM10-concentrations attributed to wood burning. Upper part: spatial validation, on the X-axis: measurements (in µg/m³), on the Y-axis: model data (in µg/m³). Every dot represents the average over time of one measurement location; blue dots using the new emission estimates, red dots using the new wood consumption data but the old emission factors. Below: temporal validation: average concentrations due to wood burning (in µg/m³) over all locations. Blue: measurements; red: model data with new wood consumption and new emission factors; green: model data with old wood consumption and old emission factors; purple: model data with new wood consumption and old emission factors.

CONCLUSIONS

Based on new estimations of emissions, ambient air measurements of levoglucosan and a modelling study confirming these, new estimations of particulate matter wood burning emissions were presented to the Flemish Government. The differences between the current estimations and the previous ones were quite large, amounting to a factor 13.

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REFERENCES

Aernouts K., Jespers K., Dams Y., 2013a. Energiebalans Vlaanderen 2011, 2013/TEM/R/XXX, maand 2013

Aernouts K., Jespers K., Dams Y., 2013b. Energiebalans Vlaanderen 2012 (voorlopig), 2013/TEM/R/XXX, maand 2013.

Caseiro A. et al., 2009. Wood burning impact on PM10 in three Austrian regeions, Atm. Env., 43, 2186-2195.

Maenhaut W., Methods to determine the contribution of wood burning in PM and their uncertainty, Wood Burning Workshop Ghent, 2-3 Dec. 2013, http://www.joaquin.eu/03/MyDocuments/Maenhaut_VMM_2013_talk2.pdf

Renders, N., De Weedt, Y., Gijsbers, M., Jespers, K., Van Esch, L., Wevers, M., 2011. Emissies door houtverbranding - Sectoren gebouwenverwarming en landbouw, 2011/TEM/R/158.

Schmidl, C. et al., 2008. Chemical characterisation of fine particle emissions from wood stove combustion of common woods grown in mid-European Alpine regions, Atm. Env., 42, 126-141.

Vanpoucke C., Fierens F. and Lefebvre W., 2013. Domestic wood burning emissions in Flanders: underestimated? Wood Burning Workshop Ghent, 2-3 Dec. 2013, http://www.joaquin.eu/03/MyDocuments/Woodburning_emissions.pdf

Veldeman N., Janssen L., Viaene P., Deutsch F., Maiheu B., Lefebvre W., Vankerkom J., Vranckx S. and Janssen S., 2013. Rapport activiteit in 2013 uitgevoerd in kader van de referentietaak 12 “Kenniscentrum Luchtkwaliteitsmodellering”, 2013/RMA/R/XXX.

VMM (2011), Chemkar PM10, Chemische karakterisering van fijn stof in Vlaanderen - 2010

VMM (2013), Chemkar PM10, Chemische karakterisering van fijn stof in Vlaanderen, 2011-2012