Comparison of emission profiles in the CMAQ model

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Annotation

Comparison of 3 temporal emission profiles for residential heating in Slovakia was performed. These profiles were used for the CMAQv4.7.1 model with 4.7 km resolution for Slovakia and surrounding countries. A new temporal emission profile was developed and compared with emission profile used previously. A constant emission profile was also used and compared, to assess the impact of temporal emission profiles on the resulting concentrations. The simulations were validated against the air quality stations in Slovakia. Diurnal, seasonal and annual differences between the emission profiles were analyzed.

Key words: air quality modelling, temporal emission profile, emission factors, residential heating.

Anotácia

V tomto príspevku sme porovnávali 3 časové emisné profily pre lokálne kúreniská na Slovensku. Tieto profily boli použité v modeli CMAQv4.7.1 s rozlíšením 4,7 km pre Slovensko a okolité krajiny. Vytvorili sme nový emisný profil, ktorý sme následne porovnávali s doteraz zaužívaným emisným profilom. Pre ohodnotenie vplyvu časových emisných profilov na výsledné modelové koncentrácie sme spustili simuláciu s konštantným emisným profilom počas celého roka. Simulácie boli validované voči staniciam NMSKO. Emisné profily sme analyzovali z pohľadu denných, sezónnych a celoročných rozdielov.

Kľúčové slová: modelovanie kvality ovzdušia, časový emisný profil, emisné faktory, lokálne kúreniská.

1 Introduction

To run the chemical transport models, well prepared emission inputs are required. Emissions are usually available in an aggregated form for the whole country - a sum of all emissions of a given pollutant for a given year in tons, which needs to be spatially and temporally disaggregated to be used in a model (a top-down approach). Alternatively, the emissions may be computed with a bottom-up approach, which takes into account the emissions of individual sources and makes an aggregate for a given area (e.g. municipality). These data are spatially disaggregated by default but need to be additionally temporally disaggregated. Both approaches require preprocessing into a suitable input format for the model.

The temporal disaggregation is done differently for individual emission sectors. In this paper, we focus on emissions from residential heating. Our emissions are mostly acquired by the bottom-up approach. The temporal disaggregation takes into account the daily, weekly, and seasonal variation of every pollutant.

To determine the importance of temporal variability of the residential heating emission profiles for regional chemical transport model, we compared 3 simulations with different temporal emission profiles, as described in the next section.

2 Description of simulations and emission profiles

Three simulations with different emission profiles for residential heating were run on CMAQv4.7.1 with 4.7 km resolution for year 2017. The model domain is shown in Figure 1. The meteorological inputs were simulated by the WRF model.

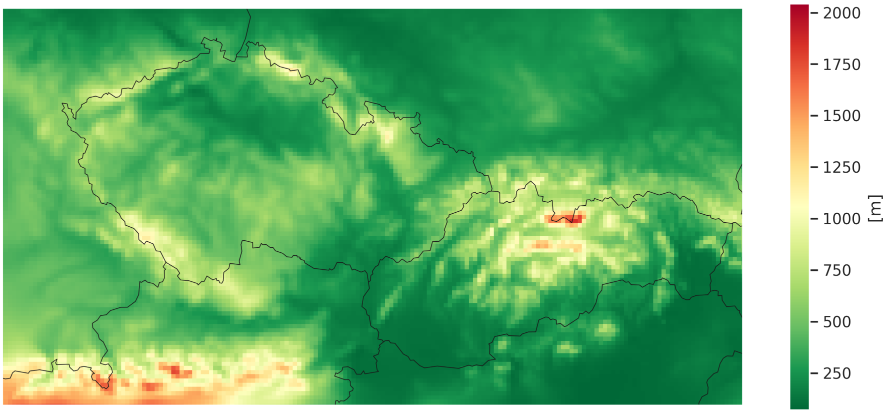

Figure 1: Model domain terrain elevation in m above the sea level.

The emission aggregates from residential heating were computed bottom-up for municipalities in Slovakia [1]. The emissions for the rest of the domain were provided by the TNO emission database [2]. The residential heating includes family houses, residential complexes and commercial buildings with source power less than 5 MW. Central heating (which may be used to heat residential complexes) with power more than 5 MW is considered a middle sized emission source and falls into a different emission stream. The bottom up approach takes into account the fraction of fuels used for each municipality (for Slovakia, see [3]). The simulations differ only in their temporal disaggregation of the residential heating emissions in Slovakia. All other emission streams (traffic, agriculture, industry...) have their specific temporal profiles adapted from [4]. These profiles are the same for all three simulations. Emission factors of these profiles have specific values for each month, day of the week and hour of the day. For a given emission stream, the same emission profile is used for all grid cells. The residential heating profile for the rest of the domain apart from Slovakia is also constructed using these factors.

The first emission profile for residential heating in Slovakia was implemented in FUME [5] emission processor, and it was previously used at SHMÚ for the air quality modelling with model CMAQ. The annual variation of this emission profile is computed according to the mean temperature of the domain, therefore it is the same for all grid cells. In the newer version of FUME an option for calculating the specific emission profile for every grid cell is implemented, however this version was not used in our previous simulations. The daily emission factors are originally from [4], the same as for the rest of the domain. We will use this profile as our reference, hence we further call this profile the `ref` profile.

The second emission profile was developed in this work to improve the CMAQ model predictions. For the annual emission profile, the Copernicus methodology [6] based on heating degree days (HDD) concept [7] was used. We will denote this profile as the `cop` profile. Here, the HDD factor is defined as a difference between the average outdoor temperature measured at 2m T_o and a threshold temperature T_t, for each day d and grid cell $[x, y]$ of the domain.

$$HDD(d,x,y) = max(T_t - T_o, 1) \tag{1}$$

To avoid numerical problems, 1 is taken as HDD when $T_t - T_o < 1$. The threshold temperature T_t is considered as the outdoor temperature above which the buildings do not need heating. The choice of T_t depends on local climate and characteristics of buildings and it is tricky to choose it for larger regions. Recommended T_t to be used for Europe is 15.5 °C, but this is mostly because it is a historical norm for the UK [7]. In Slovakia, the heating season officially starts on a third consecutive day with the average daily temperature beyond 13 °C [8]. Since the intention of the emission profile in the model is to credibly capture the emissions from heating, we decided it would be the most suitable to use the threshold value equal to 13 °C for our profile.

The described method has a lot of limitations. Large amount of residential sources, such as family houses, are not regulated as central heating and the house owners heat their houses based on their feeling. Therefore, it is impossible to determine the start of the heating season for all residential sources. Nevertheless, we decided to use the value of 13°C as the threshold temperature, as this is the historical standard in Slovakia. However, we didn't account for the necessity of three consecutive days with the mean outdoor temperature below 13°C. Using a higher threshold temperature would result in more heating days in early autumn and slightly smaller emission factors for winter. However, the differences are quite small and mostly apparent for the transitional periods in autumn and spring, as can be seen in Figure 2.

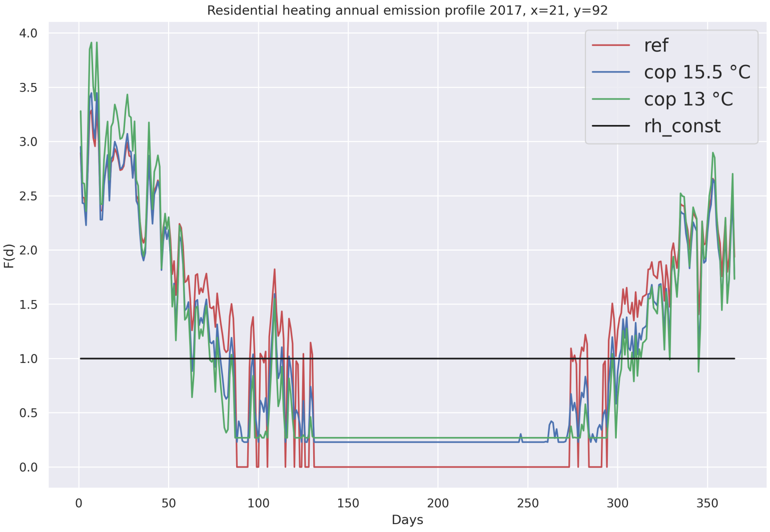

Figure 2: Comparison of annual emission profiles for residential combustion at the Bratislava, Jeséniova station grid cell.

The resulting emission factors $F(d,x,y)$ are computed from HDD for each day and grid cell of the domain as

$$F(d,x,y) = \frac{HDD(d,x,y) + f\overline{HDD(x,y)}}{(1+f)\overline{HDD(x,y)}}, \tag{2}$$

where $\overline{HDD(x,y)}$ is the annual mean $HDD(d,x,y)$ for the specific grid cell $[x,y]$ and f is a constant offset value, which accounts for combustion from cooking and heating of water, which is constant during the year. We used $f = 0.093$ as suggested for solid fuels in [9] for Europe. However, even for $f = 0$, $F(d,x,y)$ always has a positive minimum value in summer.

Diurnal profile is superimposed onto the annual profile. For diurnal profile we chose the same emission factors as used in the `ref` profile. Copernicus diurnal profiles for both developed and developing countries, presented in [6], were also considered. We decided that these suggested profiles are not representative for our region for the lack of morning local maximum in the developed countries profile for residential heating and midday local

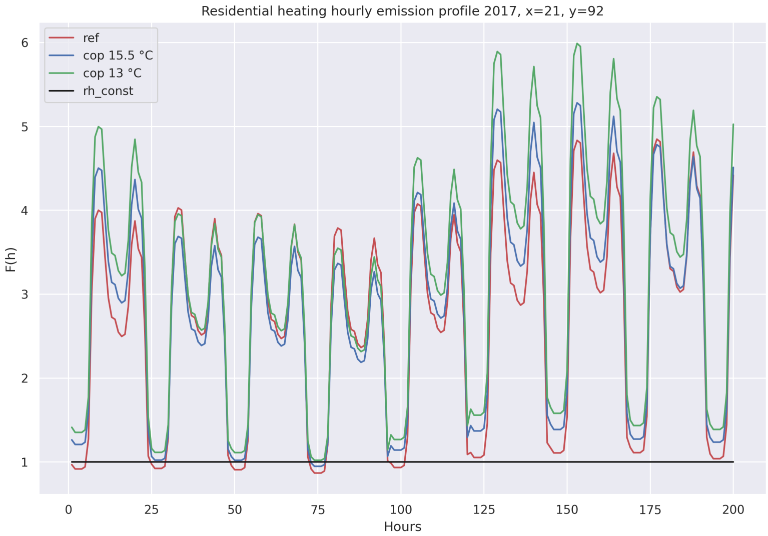

Figure 3: Comparison of hourly emission profiles for residential combustion for the first 200 hours of 2017 at the Bratislava, Jeséniova station grid cell.

maximum in the developing countries profile due to cooking. We were not able to find a better and more recent daily emission factors than the ones published in [4]. Comparison of hourly profiles is presented in Figure 3.

The third emission profile has no temporal variation for residential heating throughout the whole year - the aggregated emissions from residential combustion are equally divided into every hour of the year. This profile will be further recalled as `rh_const` (residential heating - constant).

3 Validation of the simulations with different emission profiles

We performed validation of the results of the three runs against the observations from the NMSKO (National air quality monitoring network) stations in Slovakia. The validation results are presented for all stations together as well as for specific station types:
1) RB - rural background stations
2) OB - other background stations (including suburban and urban background stations)
3) UT - urban traffic stations
4) B - all background stations (RB+OB)
When evaluating the model for its accuracy, the background stations are the most suitable for validation. Since they are placed further away from large emission sources, they are the most comparable to the mean concentrations of the model. We excluded industrial stations from the validation, since these stations are heavily influenced by a large emission source. Large emission sources have a specific temporal emission profile, therefore, they are not suitable for the purpose of comparing emission profiles for residential heating.

Here, we validate only the model results for PM_{10} and $PM_{2.5}$, since these are the pollutants of main concern from local residential heating [10]. As stated in [10], residential heating comprises almost 80% of the $PM_{2.5}$ emissions and around 65% of the PM_{10} emissions in Slovakia.

In the following tables, these evaluation statistics are used - correlation coefficient (R), mean bias (BIAS), root mean square error (RMSE) and factor of 2 (FAC2). The BIAS and RMSE values are in $\mu g{\cdot}m^{-3}$. For the results presented in tables, the statistics are computed from the hourly data. The results for runs `cop` and `rh_const` are displayed as the differences from the `ref` run values. When evaluating those results, the + or - sign may signify an improvement or worsening, depending on the given statistical measure and its value.

Annual mean concentrations of PM$_{10}$ at B stations are presented in Figure 4. The plot is made using the average daily concentrations. We can see, that the 3 model runs are very similar for daily means. We can also see, that the model greatly underestimates the observed concentrations for the whole year, but mostly for the heating season. The observed annual average values for B stations for observations, `ref`, `cop` and `rh_const` runs are 24.36, 6.60, 6.77 and 6.65 μg·m^{-3}, respectively.

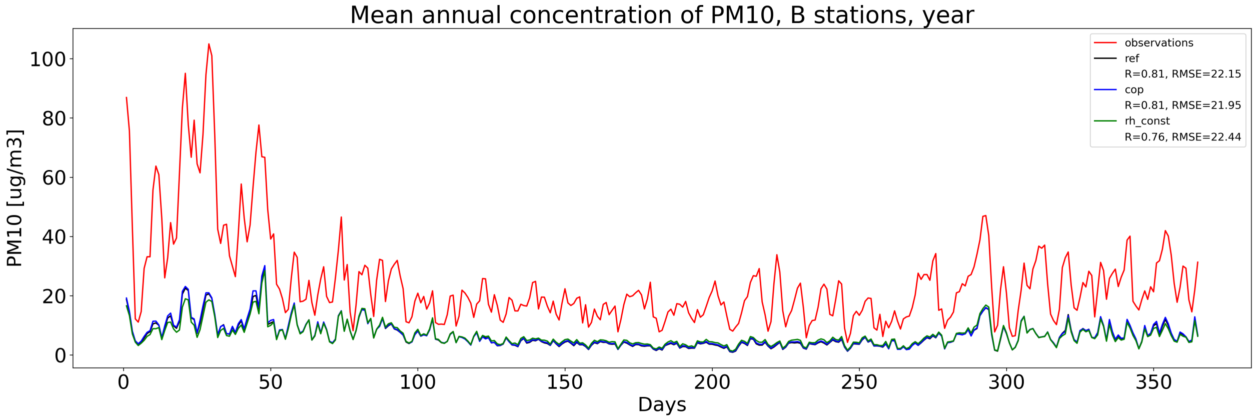

Figure 4: Mean annual PM$_{10}$ concentration profiles for background stations, for observations and 3 model runs, 2017.

The results of hourly validation for station types for PM$_{10}$ are presented in Table 1. We can see a moderate correlation of the `ref` run for all stations. Not surprisingly, the best results were obtained for the RB stations, however, there are only 3 of these stations available for our analysis. We can see, that the `cop` run results are slightly better than the `ref` run in all statistics, however, this improvement is very small.

Looking at the `rh_const` run results compared to the `ref` run, we can see that subtraction of all temporal variability in the model results mostly in worsening of the correlation of the model with the observations. The differences are rather small for RB stations, but apparent for other station types. The RMSE values increased slightly for the `rh_const` run. The BIAS values for the `rh_const` run are slightly better than the `ref` run, but this improvement is negligible. The improvement of the `rh_const` run is the most apparent for FAC2, which is even better than for the `cop` run. The improvement in BIAS and FAC2 occurs because the `rh_const` run has systematically higher concentration results for the night time. Since the model heavily underestimates the concentrations, any increase in model concentrations will lead to values closer to the observations.

Table 1: Validation results for hourly model predictions of PM$_{10}$, for station types, 2017

	n	coverage	obs. mean	R			BIAS			RMSE			FAC2		
				ref	cop	rh_const	ref	cop	rh_const	ref	cop	rh_const	ref	cop	rh_const
all	33	97.28	26.06	0.53	+0.003	-0.051	-19.31	+0.18	+0.07	27.97	-0.18	+0.25	17.51	+0.78	+1.47
RB	3	98.30	18.24	0.62	+0.003	-0.018	-12.52	+0.08	+0.02	17.28	-0.09	+0.10	20.84	+0.51	+0.60
OB	18	97.37	25.39	0.52	+0.003	-0.061	-18.7	+0.18	+0.06	27.94	-0.16	+0.31	18.62	+0.82	+1.76
UT	11	96.71	28.38	0.54	+0.003	-0.050	-21.3	+0.22	+0.11	29.22	-0.22	+0.21	15.45	+0.83	+1.28

Hourly validation of B stations for PM$_{10}$ for seasons of the year is presented in Table 2. Looking at the `ref` run results, we can see that correlations for the individual seasons are worse than for the whole year. This suggests, that the model better predicts the annual profile of the emissions, than the intraseasonal variability. The `cop` run performed similarly to the `ref` run.

The emission factors for the `rh_const` run are smaller in the winter and larger for the summer compared to the other two runs (see Figure 2). However, the model predictions are heavily underestimated for all simulations throughout the whole year. Therefore, the larger emission factors for the summer make the model concentrations closer to the real values, which is why the `rh_const` BIAS, RMSE, and mostly FAC2 are better for the summer. The correlation for the `rh_const` run deviates from the `ref` run the most in winter.

Table 2: Validation results for hourly model predictions of PM_{10} for background stations, for seasons, 2017.

	coverage	obs. mean	R			BIAS			RMSE			FAC2		
			ref	cop	rh_const	ref	cop	rh_const	ref	cop	rh_const	ref	cop	rh_const
spring	98.77	19.66	0.40	-0.004	-0.007	-12.93	+0.05	+0.28	17.04	-0.02	-0.19	25.46	+0.32	+2.18
summer	97.37	16.50	0.22	-0.000	-0.014	-13.16	+0.19	+0.69	16.01	-0.16	-0.55	8.07	+1.15	+5.16
autumn	98.57	20.65	0.45	-0.002	-0.007	-14.65	+0.04	+0.21	19.98	-0.03	-0.13	21.20	+0.35	+1.68
winter	97.42	35.89	0.47	+0.002	-0.053	-26.94	+0.23	-0.83	40.57	-0.21	+0.94	22.54	+0.82	-2.59
year	97.50	24.36	0.52	+0.003	-0.056	-17.81	+0.16	+0.06	26.67	-0.16	+0.29	18.94	+0.78	+1.59

Annual mean concentrations of $PM_{2.5}$ at B stations are presented in Figure 5. Since $PM_{2.5}$ is a fraction of PM_{10}, its concentrations are always lower than PM_{10}. The observed annual average values for B stations for observations, `ref`, `cop` and `rh_const` runs are 18.27, 6.37, 6.53 and 6.41 $\mu g \cdot m^{-3}$, respectively - the model averages make up around 1/3 of the observed value. For PM_{10}, it was 1/4. Comparing further, for the observed means the $PM_{2.5}$ comprises 75% of PM_{10} For the model values it is 97% for the `ref` run and 96% for the `cop` and `rh_const` run. Therefore, the modeled $PM_{2.5}$ concentrations are on average almost the same as the modeled PM_{10} concentrations.

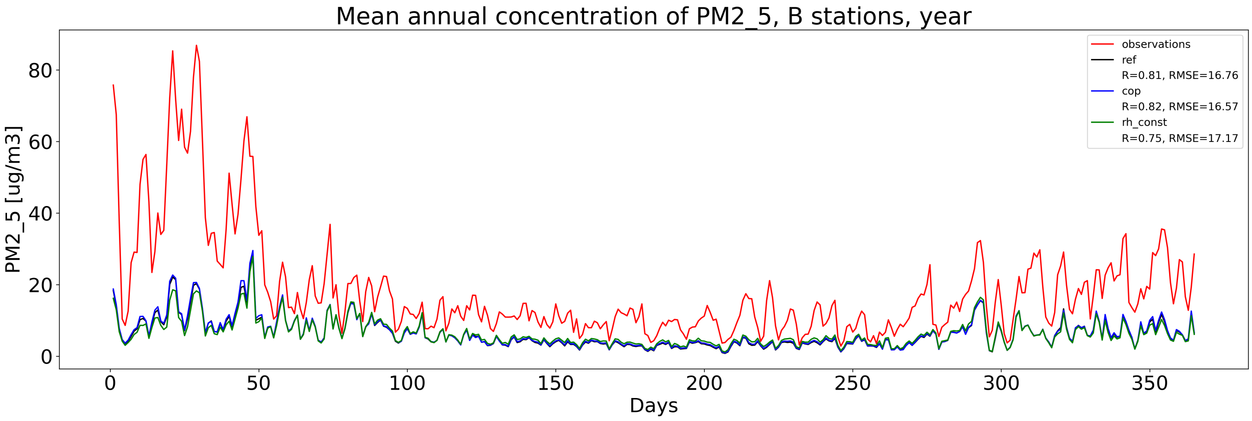

Figure 5: Mean annual $PM_{2.5}$ concentration profiles for background stations, for observations and 3 model runs, 2017.

The results of hourly validation for station types for $PM_{2.5}$ are presented in Table 3. The $PM_{2.5}$ results are mostly similar to the PM_{10} results, however, the FAC2 almost doubled for $PM_{2.5}$. For the `ref` run, the BIAS for $PM_{2.5}$ is 65% of the mean observed value for all stations, for PM_{10} it is 74%. The RMSE however, is larger for $PM_{2.5}$ at 112% of the observed mean for all stations, compared to 107% for PM_{10}. The correlation is almost the same for both fractions, except for UT stations, where PM_{10} correlation is higher. From these results we can say that $PM_{2.5}$ is less underestimated by the model on average, which happens due to overall smaller observed $PM_{2.5}$ concentrations while the modelled $PM_{2.5}$ concentrations are almost as high as PM_{10} concentrations. The RMSE is worse for $PM_{2.5}$.

Table 3: Validation results for hourly model predictions of $PM_{2.5}$, for station types, 2017

	n	coverage	obs. mean	R			BIAS			RMSE			FAC2		
				ref	cop	rh_const	ref	cop	rh_const	ref	cop	rh_const	ref	cop	rh_const
all	32	95.44	18.79	0.52	+0.004	-0.065	-12.31	+0.18	+0.06	21.06	-0.16	+0.35	31.4	+1.16	+2.29
RB	3	97.58	12.89	0.62	+0.004	-0.029	-7.31	+0.08	+0.02	12.58	-0.08	+0.17	39.36	+0.77	+1.50
OB	18	95.34	19.19	0.53	+0.003	-0.075	-12.73	+0.17	+0.05	22.16	-0.15	+0.43	31.75	+1.19	+2.51
UT	10	94.70	19.23	0.49	+0.006	-0.060	-12.49	+0.21	+0.09	20.57	-0.18	+0.29	29.49	+1.23	+2.23

Hourly validation of B stations for $PM_{2.5}$ for seasons of the year is presented in Table 4. The results are similar to PM_{10} seasonal results, with the differences as described for Table 3.

Table 4: Validation results for hourly model predictions of $PM_{2.5}$ for background stations, for seasons, 2017.

	coverage	obs. mean	R			BIAS			RMSE			FAC2		
			ref	cop	rh_const	ref	cop	rh_const	ref	cop	rh_const	ref	cop	rh_const
spring	94.17	13.85	0.42	-0.004	-0.013	-7.42	+0.05	+0.27	11.07	-0.02	-0.13	41.97	+0.47	+3.01
summer	95.69	9.54	0.19	-0.002	-0.015	-6.37	+0.18	+0.68	8.99	-0.13	-0.43	28.40	+2.27	+7.91
autumn	97.30	14.31	0.44	-0.003	-0.021	-8.52	+0.04	+0.20	13.49	-0.01	-0.05	35.27	+0.33	+1.57
winter	97.11	30.62	0.47	+0.003	-0.059	-21.92	+0.22	-0.83	34.16	-0.20	+0.94	28.22	+0.85	-2.97
year	95.66	18.27	0.54	+0.004	-0.070	-11.94	+0.16	+0.04	21.04	-0.15	+0.40	32.86	+1.13	+2.36

4 Seasonal analysis of the average daily concentration profiles

We are going to analyze average diurnal concentration profiles made by averaging the concentrations for each hour of the day from the selected period. These averaged profiles filter out random effects caused by fluctuations in meteorology, atmospheric chemistry or emissions. Therefore, they capture the concentration profile for the average meteorology, chemistry and emissions. Correlations of these profiles are different than the correlations computed using the hourly values, which are presented in tables in Section 3. We normalized the profiles, to better see the daily variability within the profiles without having to account for the large model underestimation. Normalized profiles are multiplied by 24 to have convenient values around 1.

Slovakia lies within the Central European Time (CET) zone. The change to Summer CET (SCET) occurs on the last Saturday of March and back to CET on the last Saturday of October. To maintain consistency, the results are presented in UTC, which is delayed by 1 hour compared to CET and by 2 hours compared to SCET. The emission profiles are also shifted accordingly. Hence, both spring and autumn have one month of CET and 2 months of SCET.

Since the validation showed that model concentrations for PM_{10} and $PM_{2.5}$ are almost the same, we do not include results for $PM_{2.5}$ further.

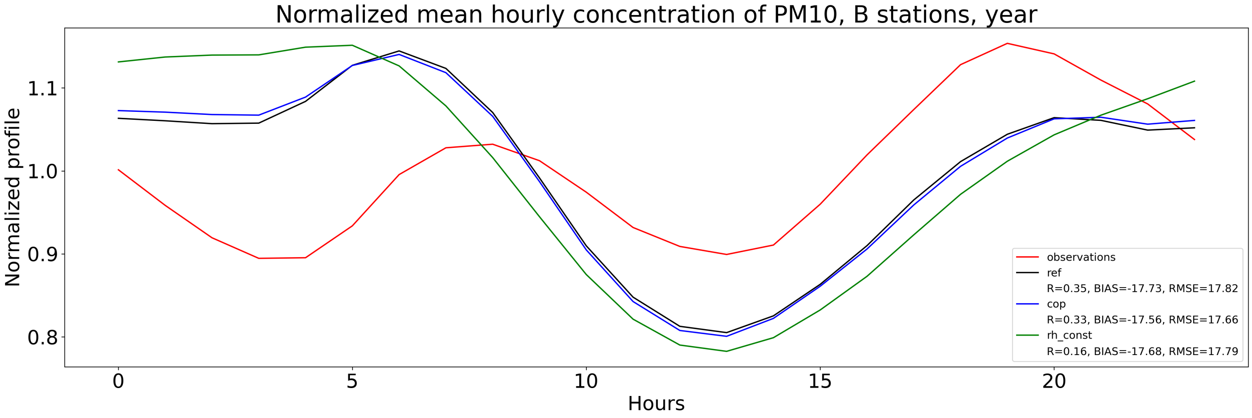

Figure 6: Normalized average diurnal concentration profiles for background stations, for observations and 3 model runs, UTC, 2017.

The average normalized hourly PM_{10} concentration profiles for B stations are presented in Figure 6. We can see, that the `ref` and `cop` runs are almost identical, with the `ref` run having a slightly better correlation and slightly worse BIAS and RMSE. For spring, summer and autumn, the results for these two runs differ slightly more, with the `ref` run having better correlations (not presented in a figure). There are two distinct local maxima in the observed profile, for morning and evening hours. The `ref` and `cop` modeled profiles also have 2 local maxima, however the morning one is much larger than the observed and the evening one is smaller and less distinct. The modelled maxima are also shifted compared to the observations - the modelled morning maximum peaks at 6 AM UTC while the observed peaks at 8 AM UTC. The modelled evening maximum peaks at 8 PM UTC, the observed peaks at 7 PM UTC.

The `rh_const` profile only has one daily maximum for early morning hours and a distinct minimum at midday. Since the emissions of this profile are constant throughout the day, this daily profile is caused solely by the average daily meteorology and atmospheric chemistry. The midday minimum is caused predominantly by turbulent mixing, which starts upon sunrise, peaks at noon and then gradually decreases. There is little mixing in the night, so the concentrations can build up and cause the before-sunrise maximum.

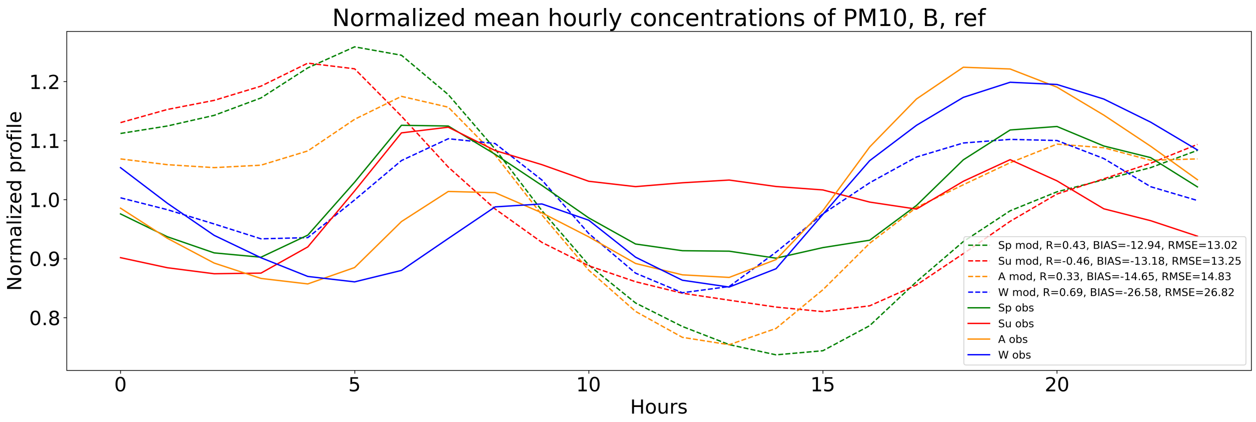

Figure 7: Normalized average diurnal concentration profiles for background stations for seasons, for observations and `ref` model run, UTC, 2017.

The average normalized hourly PM$_{10}$ concentration profiles for B stations for the `ref` run and seasons of the year are presented in Figure 7. We chose this run because it had the best correlations out of the runs in this case, although the `cop` run is very similar.

We can see that the correlation is quite high for winter and moderate for spring and autumn. There is moderate anti-correlation for the summer. The summer emissions of PMs are mostly from the agricultural dust, therefore using the residential heating daily emission profile is not accurate. Looking at the observed profiles of other seasons: the winter profile has a large evening maximum and a much smaller morning maximum, the autumn profile is similar but shifted in UTC due to time change; the spring profile has similarly sized morning and evening maxima, however the evening maximum is broader and the maxima are further apart than for autumn and winter. The effect of distancing of the two daily maxima further from each other may be caused by prolongation of days in the summer.

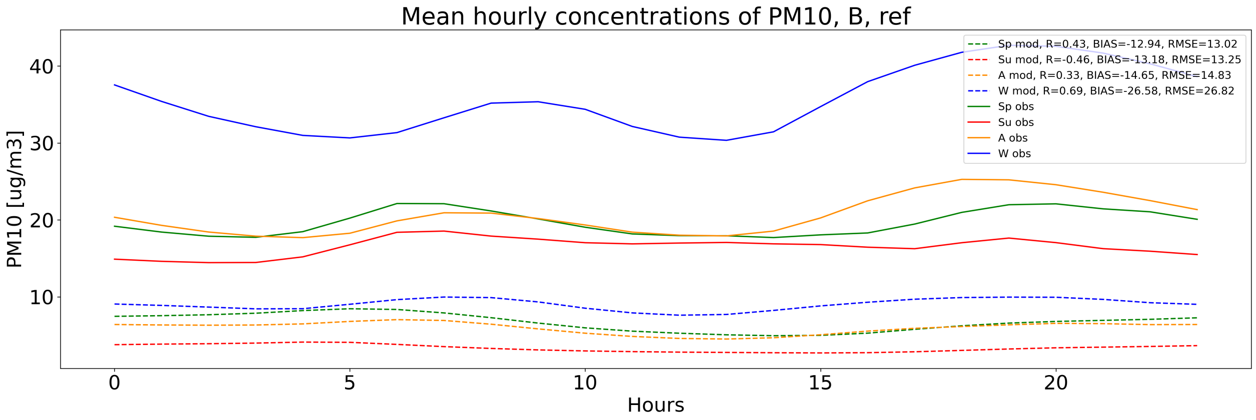

Figure 8: Average diurnal concentration profiles for background stations for specific seasons, for observations and `ref` model run, UTC, 2017.

The average hourly PM_{10} concentration profiles for B stations for the `ref` run and seasons of the year without normalization are presented in Figure 8. Here, we can clearly see the differences in concentration values throughout the year, but the diurnal variation of the profiles is less apparent due to different y-axis scales.

5 Conclusion

Three model simulations with different temporal emission profiles for residential heating in Slovakia were run. The profiles `ref`, `cop` and `rh_const` as well as the simulation details are described in Section 2.

The results of the simulations for PM_{10} and $PM_{2.5}$ were validated against the NMSKO air quality stations. The results of validation of hourly model concentrations are presented in Section 3. Although the correlations of model results for both pollutants were moderate, the model heavily underestimates the observations throughout the whole year (average BIAS -19.3 $\mu g \cdot m^{-3}$ and -12.3 $\mu g \cdot m^{-3}$ for PM_{10} and $PM_{2.5}$, respectively). The `cop` run improved the model predictions compared to the `ref` run, but only by a negligible amount.

The `rh_const` run correlation for all stations was 0.48 compared to 0.53 for the other two runs. The concentration profile of the `rh_const` still had a distinct daily minimum as the other runs, caused by the daily turbulent mixing; however it was lacking the nighttime minimum. Its nighttime concentrations were therefore higher, which resulted in smaller average BIAS and higher average FAC2 values for this run. However, considering that the profile lacks any temporal variation, the results are surprisingly close to the other two runs; this is also apparent from the daily mean concentrations (Figures 4 and 5).

While the observed $PM_{2.5}$ on average makes up around 75% of the observed PM_{10}, modelled $PM_{2.5}$ makes up around 97% of the modelled PM_{10} concentrations. For this reason, although the validation results for both PM fractions were similar, the $PM_{2.5}$ concentration results are less underestimated by the model.

We analyzed the average diurnal concentration profiles of observations and three model simulations in Section 4. The average diurnal profiles for the `ref` and `rh_const` runs were almost identical for the whole year and differed slightly for other seasons except winter. Both modeled profiles maintained the two daily maxima for morning and evening hours, although the morning maximum is much larger than the observed and the evening maximum is smaller and less distinct. As mentioned before, the `rh_const` run lacks the nighttime concentration minimum; it peaks at early morning hours and then decreases as the turbulence starts to develop in the mixed layer.

The average seasonal concentration profiles for the `ref` run were also analyzed. For summer, the used daily emission profile for residential heating is not suitable, since most of the PMs in the summer come from agriculture and dust. Therefore, the model anticorrelates for summer. The highest correlation of 0.69 is achieved for winter; 0.43 and 0.33 for spring and autumn, respectively.

Our intention in this work was to improve model predictions by developing a new temporal emission profile for residential heating. We used CAMS methodology (Section 2) to compute annual emission profiles in every grid cell of the domain and superimposed a diurnal emission profile onto the annual. We expected this profile to improve the modelled predictions compared to the previously used emission profile, but both profiles produced very similar results. However, the results of the run without the temporal variation were very similar as well. For example, for the summer months, the `rh_const` run emission factors were much higher than for the other two runs, but the resulting concentrations were close to the other runs. Therefore, it seems that the importance of the temporal emission profile is not as high as we thought and that the meteorology and chemistry of the model are the decisive factors for the resulting concentration values. However, the resolution of our model might be too coarse to properly detect the temporal profile. The finer the resolution, the more important the temporal disaggregation.

From the results it is evident that the largest deficiency of the model is a large underestimation of the modelled concentrations. The underestimation is probably caused by insufficient size of the input emissions, but also the model meteorology might cause the emissions to disperse too much. That would also explain, why the results of the `rh_const` run were very close to the other two runs, even though its emissions were much lower or higher. The resulting underestimation is most likely a combination of both meteorology and insufficient emission inputs. Unless the underestimation of the model is solved, further improvement of the temporal disaggregation of the model will not produce better results.

Although the developed emission profile did not improve the model results as expected, this work enabled us to better understand the relevance of temporal emission profiles in the model and variability of the observed profiles. It also served as an inspiration for further analysis of the observed emission profiles in Slovakia. If temporal disaggregation needs to be improved in the future, the observed concentration profiles could serve as a guide for the emission profiles, which could even change throughout the year. Future research might also include several simulations with varying emissions or boundary conditions, to assess their impact on the resulting concentrations in comparison with meteorology.

References

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Abstrakt

Modely kvality ovzdušia vyžadujú ako vstup časovo a priestorovo rozčlenené emisie. Emisie sú však zvyčajne prístupné v emisných databázach vo forme agregovaných dát pre celú krajinu a danú znečisťujúcu látku (okrem bodových zdrojov, pre ktoré sú dostupné presné súradnice a parametre). Pre potreby modelovania je potrebné plošné a líniové emisie rozčleniť do modelovej domény a priradiť im príslušný ročný, týždenný a denný chod. V tejto práci sa zaoberáme časovým emisným chodom pre lokálne kúreniská na Slovensku. Emisie z lokálnych kúrenísk použité v našich simuláciách boli vypočítané pre územie Slovenska metódou zdola-nahor v práci [1]. Touto metódou získame agregované emisie pre každú bunku domény, ktoré je ďalej treba časovo rozčleniť.

Hlavným zámerom tejto práce bolo vylepšiť modelové výstupy pre koncentrácie znečisťujúcich látok na základe upraveného časového rozčlenenia emisií pre lokálne kúreniská na Slovensku. Na základe metodiky CAMS bol vytvorený nový emisný profil, ktorý bol následne porovnávaný s emisným profilom používaným v našich simuláciách doteraz. Tieto emisné profily boli použité v simuláciách modelu CMAQv4.7.1 s rozlíšením 4,7 km. Taktiež bola spustená simulácia s konštantným emisným profilom počas celého roka. Výsledky troch simulácií, ktoré sa líšili len v časovom rozčlenení ich emisných profilov pre lokálne kúreniská na Slovensku, boli validované voči staniciam NMSKO. Zamerali sme sa na validáciu pevných častíc PM_{10} a $PM_{2,5}$, keďže lokálne kúreniská sú ich najväčším zdrojom.

Implementácia nového emisného profilu do modelu CMAQ priniesla len zanedbateľné vylepšenie výsledkov simulácie. Nový aj doteraz používaný emisný profil mali skoro identický priebeh. Obe simulácie vykazujú koreláciu s pozorovaniami pre PM_{10} rovnú 0,53 a pre $PM_{2,5}$ rovnú 0,52, v priemere pre všetky stanice. Pre konštantný emisný profil sa korelácia modelu znížila na 0,48 pre PM_{10} a na 0.46 pre $PM_{2,5}$. Všetky 3 simulácie výrazne podhodnocujú pozorované koncentrácie - priemerný BIAS pre PM_{10} je rovný -19,3 μg$\cdot$m^{-3} a -12,3 μg$\cdot$m^{-3} pre $PM_{2.5}$. Modelové výstupy pre $PM_{2.5}$ sú menej podhodnotené ako PM_{10} v porovnaní s priemernou hodnotou koncentrácie $PM_{2.5}$ v ovzduší, a to z dôvodu nižších pozorovaných koncentrácií $PM_{2.5}$ zatiaľ čo modelové koncentrácie $PM_{2.5}$ dosahujú až 97% modelových koncentrácií PM_{10}.

Výsledky validácie hodinových dát simulácie s konštantným emisným profilom sa len málo líšia od výsledkov simulácií s časovým priebehom emisií. Výraznejšie rozdiely vidíme v priemernom dennom chode koncentrácií. Denné priemery koncentrácií sú však pre všetky simulácie skoro identické a to aj pre obdobia, kedy konštantný profil spôsobuje výrazne nižšie či vyššie modelové emisie. Z toho môžeme usúdiť, že meteorológia a chemizmus modelu majú rozhodujúci vplyv na výsledné koncentrácie. Meteorológia môže byť taktiež zodpovedná za systematické podhodnotenie modelových výstupov, a to prílišnou disperziou znečisťujúcich látok. Výsledné podhodnotenie modelu je pravdepodobne spôsobené kombináciou meteorológie a nedostatočných emisných vstupov do modelu.