Reviewer #1

General comments

The authors have adequately addressed all my previous questions and suggestions. I appreciate the effort put into the revisions. I just have a few remaining minor comments for consideration.

The authors would like to thank the reviewer for appreciating the effort put into the revisions. The answers to remaining minor comments can be found below in blue.

Specific Comments

Line 285: Should it be "GFASv2.1" or just "GFAS"? Both terms appear throughout the manuscript, but it would be helpful to use a single, consistent term to improve clarity.

We have replaced the term "GFAS" with "GFASv1.2" to be consistent throughout the manuscript.

Figures S4: Thank you for including Figure S4 as requested. However, this figure is not mentioned in the analysis presented in the Results section. Does it not provide any relevant insights? Even if that's the case, it would be good to briefly reference the figure and clarify its role. For example, when discussing Table 4 and 6, the authors could also refer to Figure S4 and comment on aspects such as: Where are the highest correlations found? Where are the lowest? Do the extremes occur in the same countries? What might explain these patterns?

Following the reviewer's suggestion, we have included multiple references to Figure S4 in the Results section:

"The monthly cycles obtained with the three temporal profile databases present correlations of 0.67 (CAMS-REG-TEMPO versus TNO) and 0.79 (CAMS-REG-TEMPO versus GENEMIS) (Table 4), with the highest correlations occurring in Finland (0.89 for CAMS-REG-TEMPO versus TNO) and Italy (0.87 for CAMS-REG-TEMPO versus GENEMIS) (Fig. S4)." (lines 268 to 270 of the revised manuscript)

"At the country level, maximum correlations occur in UK (0.9) and Czech Republic (0.91) when comparing CAMS-REG-TEMPO versus TNO and CAMS-REG-TEMPO versus GENEMIS, respectively. Negative correlations of -0.2 (CAMS-REG-TEMPO versus TNO) and -0.22 (CAMS-REG-TEMPO versus GENEMIS) are observed for Spain (Fig. S4), mainly due to the differences in the proposed profile for the agricultural waste burning emissions." (lines 291 to 293 of the revised manuscript)

"NH3 exhibits the largest differences in monthly emission distributions (Fig. 2), especially when comparing CAMS-REG-TEMPO and TNO profiles (correlation coefficient of 0.39, Table 4), the country-level monthly correlations showing large variations, with values

ranging from 0.88 (Malta) to -0.15 (Sweden) (Fig. S4)." (lines 304 to 306 of the revised manuscript)

"The GENEMIS profile is more in line with that of CAMS-REG-TEMPO (correlation coefficient of 0.78, Table 4, and 16 countries out of 29 showing correlations above 0.65, Fig. S4)," (lines 317 to 318 of the revised manuscript)

"Correlation values are generally consistent across individual countries, with 24 countries out of 29 presenting correlations above 0.8 (Fig. S4)." (lines 344 to 345 of the revised manuscript)

Lines 355–362: The authors observe substantial differences in the correlations (Figures S4–S6) for countries with country-dependent profiles?

As shown in Fig. S4 to S6, extreme (highest/lowest) correlation values are not always occurring in the same countries. Countries showing the largest/lowest correlation values vary depending on the pollutant considered. Country-level CAMS-REG-TEMPO versus TNO and CAMS-REG-TEMPO versus GENEMIS correlations depend on two factors: i) the contribution of each sector to overall emissions and ii) the differences between temporal profiles proposed by CAMS-REG-TEMPO, TNO and GENEMIS for the sectors that present the largest contributions to total emissions. Therefore, there is not a specific pattern in the resulting correlation coefficients that can be attributed to the use or not of country-dependent profiles. The reasons behind the extreme correlation values shown in Fig. S4 to S6 are related to multiple aspects that depend on the study case. Two examples are provided here to ilustrate this reasoning:

Spain: Monthly correlations for $PM_{2.5}$ are 0.88 (CAMS-REG-TEMPO versus TNO) and 0.94 (CAMS-REG-TEMPO versus GENEMIS), while for NMVOC the correlations are -0.2 (CAMS-REG-TEMPO versus TNO) and -0.22 (CAMS-REG-TEMPO versus GENEMIS). The lower correlations reported for NMVOC when compared to $PM_{2.5}$ are due to: i) the larger contribution of agricultural waste burning emissions (GNFR_L) to total NMVOC emissions when compared to total $PM_{2.5}$ emissions (15.6% versus 2.6%) and ii) the large differences between the CAMS-REG-TEMPO, TNO and GENEMIS monthly profiles proposed for agricultural waste burning emissions. Correlations for $PM_{2.5}$ monthly emissions are large because more than 55% of total $PM_{2.5}$ emissions are related to the use of residential and commercial combustion sector (GNFR_C), for which CAMS-REG-TEMPO, GENEMIS and TNO propose similar monthly profiles, with emissions increasing during cold months.

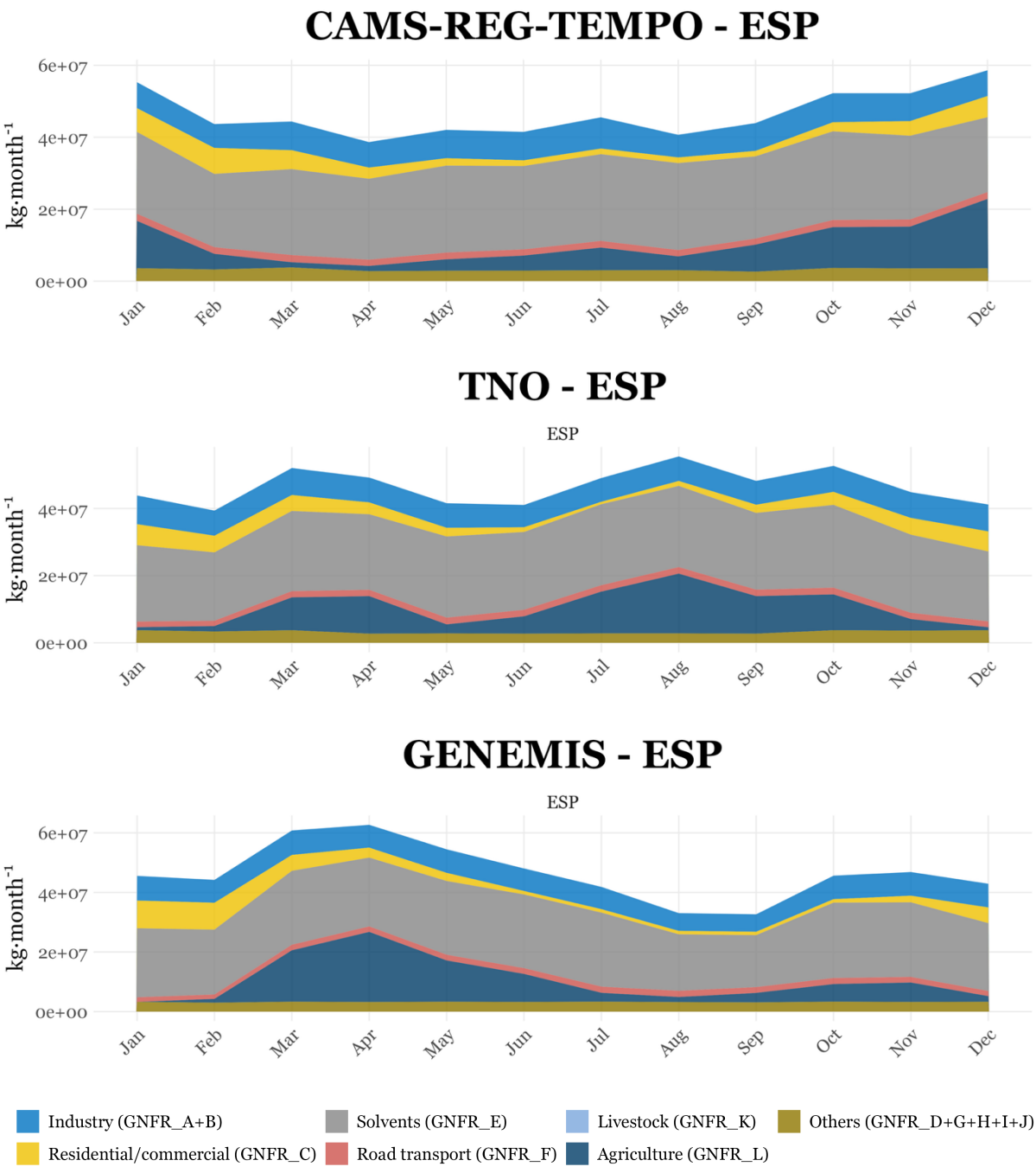

Figure - NMVOC emission temporal distributions obtained per sector for Spain when using the CAMS-REG-TEMPO, TNO and GENEMIS profiles, respectively

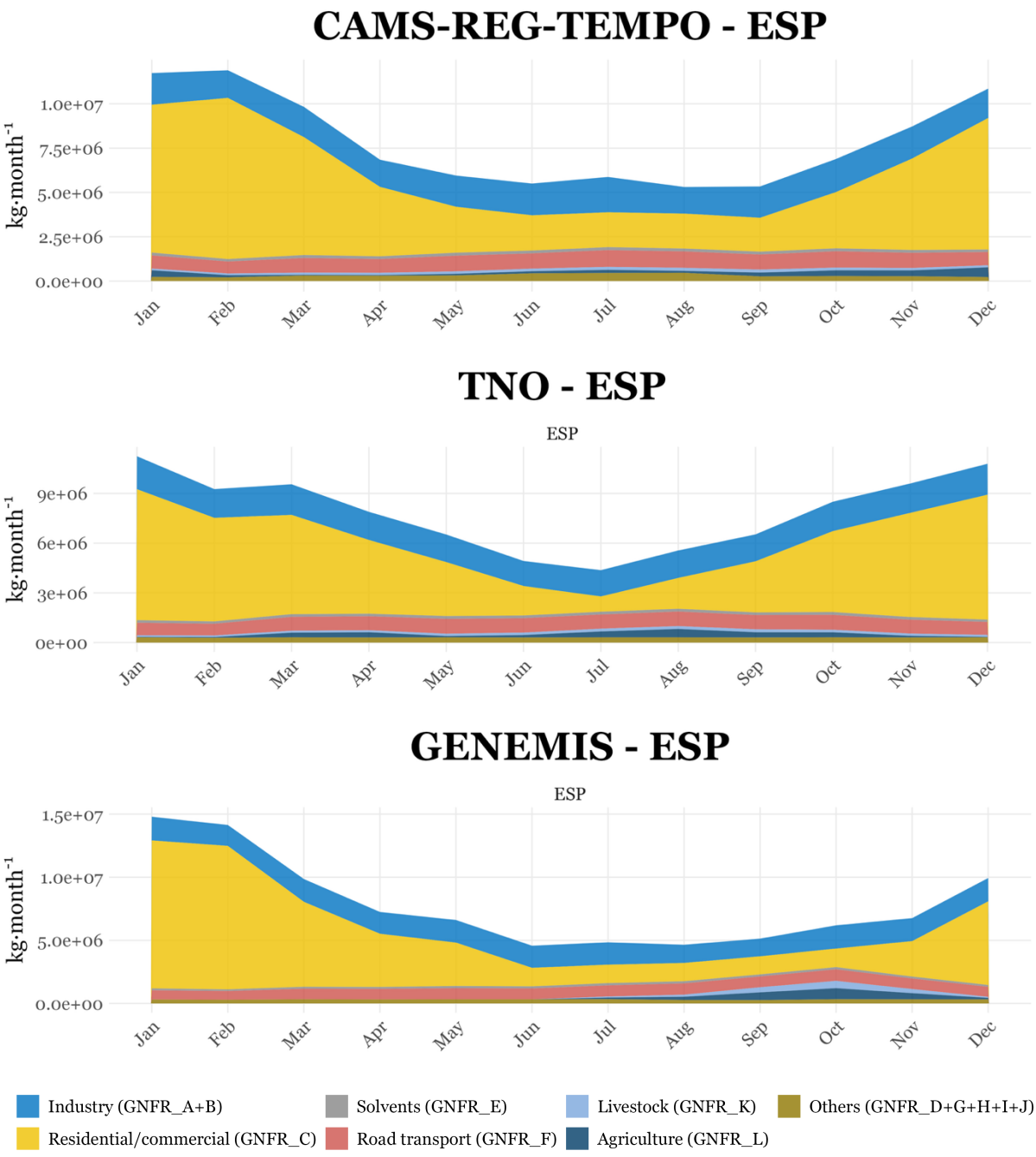

Figure – $PM_{2.5}$ emission temporal distributions obtained per sector for Spain when using the CAMS-REG-TEMPO, TNO and GENEMIS profiles, respectively

Cyprus: Monthly correlations for NMVOC are 0.87 (CAMS-REG-TEMPO versus TNO) and 0.79 (CAMS-REG-TEMPO versus GENEMIS), while for NO_x the correlations are -0.42 (CAMS-REG-TEMPO versus TNO) and -0.71 (CAMS-REG-TEMPO versus GENEMIS). The lower correlations reported for NO_x when compared to NMVOC are due to: i) the larger contribution of energy industry emissions (GNFR_A+B) to total NO_x emissions when compared to total NMVOC emissions (45.7 % versus 2.8%) and ii) the large differences between the CAMS-REG-TEMPO, TNO and GENEMIS monthly profiles proposed for the

energy industry sector. Correlations for NMVOC monthly emissions are large because more than 60% of total NMVOC emissions are related to the use of solvent sector (GNFR_E), for which CAMS-REG-TEMPO, GENEMIS and TNO propose the same monthly profile.

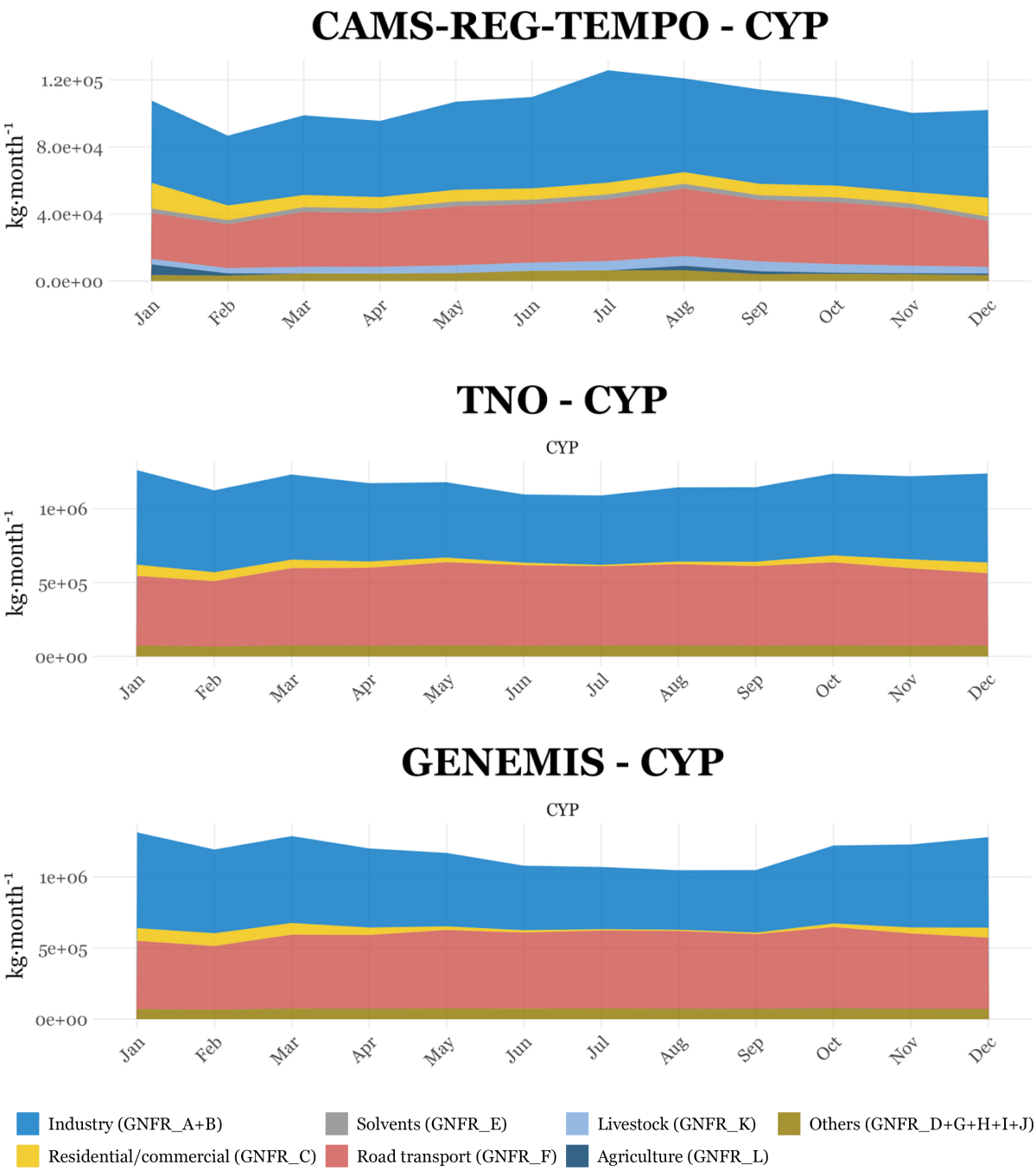

Figure – NO_x emission temporal distributions obtained per sector for Cyprus when using the CAMS-REG-TEMPO, TNO and GENEMIS profiles, respectively

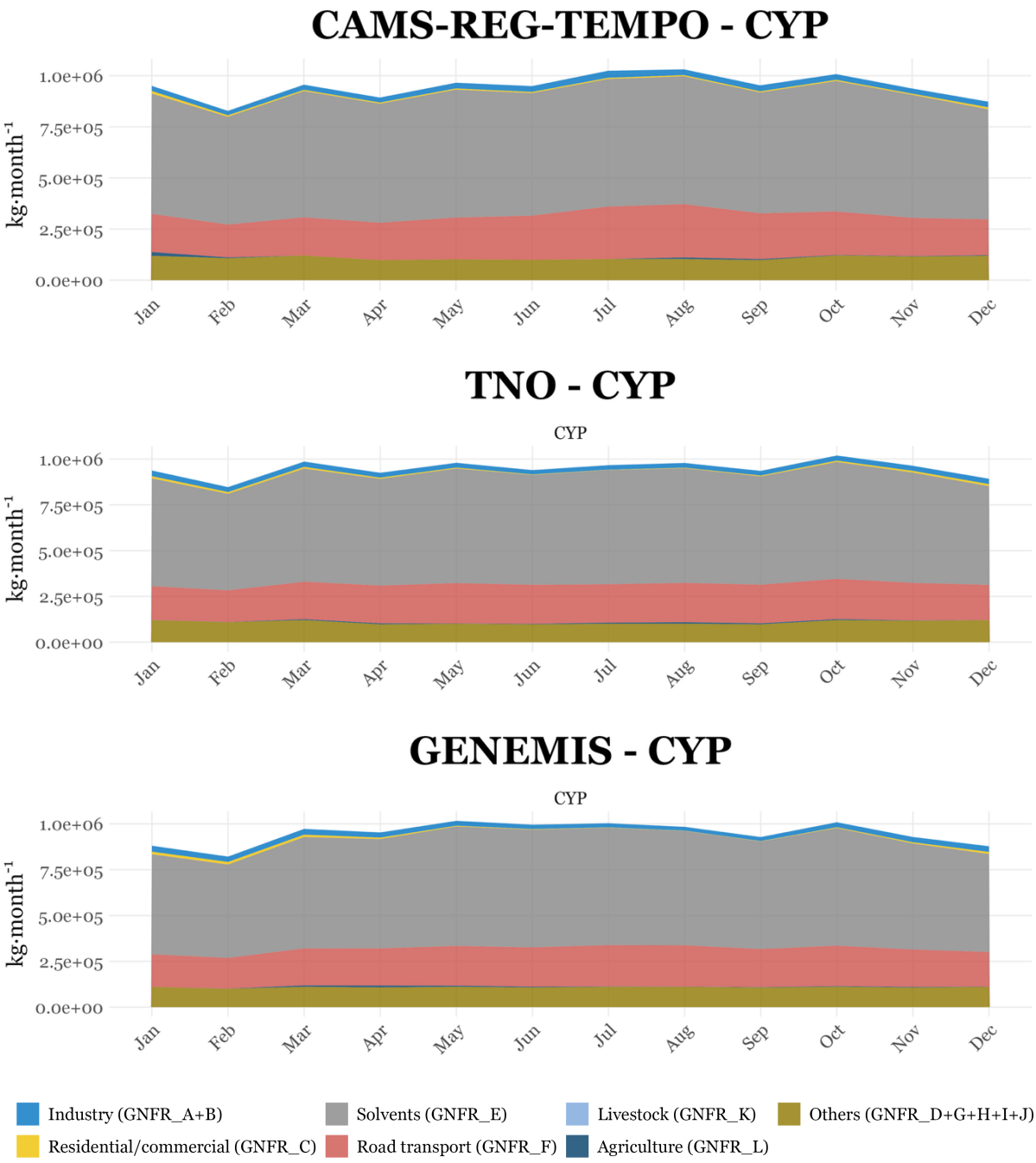

Figure – NMVOC emission temporal distributions obtained per sector for Cyprus when using the CAMS-REG-TEMPO, TNO and GENEMIS profiles, respectively

Lines 393–395: Please verify the reported correlations. They seem to be reversed. Shouldn't it be 0.94 for CAMS-REG-TEMPO and GENEMIS, and 0.89 for CAMS-REG-TEMPO and TNO?

The reviewer is right. The correlation values were reversed. We corrected it.

Figure 2: I suggest not numbering this as Figure 2. Instead, it could be labeled as Figure 1 with the caption "(continued)". Additionally, the figure is not referenced in the analysis. The same comment applies to Figures 4 and 5.

We decided to keep the original labelling for Figures 2, 4 and 6, following with what is proposed in other Copernicus publications (e.g., Guevara et al., 2023; https://essd.copernicus.org/articles/14/2521/2022/).

Figures 2, 4 and 5 are referenced at the beginning of Section 3.1, as well as in different parts of the text, for instance:

"Figure 1 to Figure 6 compare the monthly, weekly and hourly emission temporal distributions for key pollutants" (line 252 of the revised manuscript)

"NH3 exhibits the largest differences in monthly emission distributions (Fig. 2), especially" (line 304 of the revised manuscript)

"For SOx (Fig. 5), differences in hourly emission cycles are rather small" (line 461 of the revised manuscript)

We have added a reference to Fig. 2 that was missing:

"For PM10 (Fig. 2), all three temporal profile datasets allocate" (line 324 of the revised manuscript)

We also found two cases where we were wrongly referencing to Fig.3 instead of Fig.4. We have corrected these two cases as follows:

"(…) with all three datasets assuming a near-flat weekly distribution of emissions (Fig. 4)." (lines 397 to 398 of the revised manuscript)

"For PM10 and PM2.5, similar discrepancies are observed across datasets (Fig. 4)." (line 400 of the revised manuscript)

Section 3: The manuscript states that the analysis was conducted by season, which is not entirely accurate. As mentioned in the first round of review, in Europe, the winter months are December, January, and February. The authors have actually conducted a quarterly (three-month) analysis, not a seasonal one.

We agree with the reviewer. We have replaced the term "season" by "quarter" both in the revised versions of the manuscript and the Supplementary Material.

Line 678: Please consider replacing "7 models" with "7 out of 11 models" for greater precision.

Replaced

Figure 10: It's not quite accurate to say that JFM corresponds to winter or that JAS corresponds to summer, as these periods span across different meteorological

seasons. In Europe, winter runs from December to February and summer from June to August. What are the highest values referring to emissions? Clarifying this in the figure captions would be helpful for the reader. In general, it might be clearer if each figure were introduced and explained at the beginning of the corresponding subsection (as the authors did in Section 3.3), rather than relying heavily on long figure captions. For example, in Figure 10, the caption says: "The JFM and JAS periods were selected because they represent winter-like and summer-like conditions as well as the highest and lowest values of the year."

We have replaced the concepts "winter-like" and "summer-like" conditions by "cold weather" and "hot weather" conditions. The highest values refer to observed concentrations, not emissions. This aspect has also been clarified.

Following the reviewer's comment, we have removed these explanations from Figure 10 caption and added them in a new paragraph that introduces all figures related to NO_2 results (beginning of Section 3.2.1):

"Figures 9 to 11 show the comparison between the observed and modelled NO_2 monthly, weekly and diurnal cycles for the ENS and the spatial median of the monthly, weekly and diurnal temporal correlations obtained for the ENS and each individual CAMS model in expA and expB. For the weekly (Fig. 10) and diurnal (Fig. 11) results, selected quarters are shown because they represent cold and hot weather conditions, periods with the highest and lowest observed NO_2 concentrations of the year or periods were the ENS show an improvement and deterioration of the correlation when using CAMS-REG-TEMPO, respectively. Results for the remaining quarters are reported in the Supplementary material (Figure S8 and S9)." (lines 574 to 579 of the revised manuscript)

We have followed the same approach in Sections 3.2.2 (O_3 results), 3.2.3 (PM_{10} results) and 3.2.4 ($PM_{2.5}$ results).