Author's response

Dear Editor,
Thank you for reviewing our manuscript number ESS-2021-2018. We have gone through all the referee's commentaries and adjusted the manuscript accordingly. After this paragraph you will find our responses. The style used in the response letter is the following: the original general comments made by the referee are kept in normal text (initiated with R), our responses are *in blue italics initiating with A* (Authors). The corresponding edit in the manuscript will be included in red.

Referee comments 1 (RC1)
Anonymous Referee #1, 09 Sep 2021

High definition spatial distribution maps of on road transport exhaust emissions in Chile 1990-2020; Osses et al.; essd-2021-218.

R1: This manuscript describes the methodological aspects in preparing a high resolution (0.01ºx0.01º) inventory of road transport emission for Chile for years 1990-2020. It includes GHG gases (CO_2 CH4) and air quality pollutants (CO, VOC, NOx, PM, and BC). Special emphasis is given to latter one. It considers the impact of changing emissions standards in emissions trends. The analysis includes a comparison with international EDGAR data set, showing good agreement in CO2 but important differences in SLCP.

R1: General comments

R1: The comparison with EDGAR is a very important and useful analysis that benefit the international inventory community to achieve better and reliable global emissions models. A good/plausible explanation is given for the encountered differences with EDGAR.

A: Given the importance of the comparison highlighted by the Reviewer, the analysis has been expanded (see next answer) and additional explanations have been added to the text in section 3.2.4. See details in next answer.

R1: In this line it is recommendable that the authors also include a comparison with the **Community Emissions Data System (**CEDS). Moreover, to better emphasizes the uncertainties level of the proposed inventory, it should show, if possible, in a summary table, other emissions calculated for Chile, either national/regional or by cities, for GHG and/or SCLP if available.

A: We appreciate the comment since we fully agree it is important to reinforce the comparison analysis. Thus, in addition to EDGAR, CEDS and CAMS datasets for Chile have been included in section 3.2.4, with extended comments explaining similarities and differences. Additionally, the official inventory reported by the Chilean government for GHG (INGEI) and a national estimate of transport emissions using LEAP model have been added to the comparison analysis. In summary, our emission inventory for exhaust on-road transportation emissions (INEMA) is compared with two local national inventories (INGEI, LEAP) and three global models (EDGAR, CAMS, CEDS).

Section 3.2.4 has been reformulated as follows:

A direct comparison of emissions from this study with other emissions estimate~~d~~ was performed to ~~by the EDGAR global model (Janssens-Maenhout et al., 2017),~~ reflect~~s~~ the differences in estimation approaches between local (bottom-up) and global (top-down) models, as well as the sensitivity to different assumptions in the estimates. Figures 8, 9 and 10 show the comparison among local estimates from this work - ~~(~~INEMA~~)~~, the National Emissions Inventory – INGEI (MMA, 2020) and an estimate using the LEAP model – (Kuylenstierna et al., 2020); and global estimates by the EDGAR v. 4.3.2 global model (Janssens-Maenhout et al., 2017) - EDGAR, ~~and EDGAR v.4.3.2 estimates~~ the CAMS-GLOB-ANT v. 4.2 dataset – CAMS (Granier et al., 2019), and the CEDS dataset – CEDS (McDuffie et al., 2020), for CO$_2$, CH$_4$, PM, BC, CO, and NO$_x$ from 1990 to 2020, according to the pollutants available in each estimate.

CO$_2$ and methane emissions are compared in Figure 8. There is a good agreement in CO$_2$ emissions and trends among most of the estimates for most of the period, which indicates that the activity level, i.e. fuel consumption, is consistent between top-down and bottom-up approaches. The largest difference is observed for the LEAP inventory from 2015, caused by a sudden reduction in 2015 and a slower increase between 2015 and 2020~~between this study and EDGAR, with a mean annual difference of -1.0% [-10.5%, 9.4%] and a Pearson r = 0.99~~. Methane emissions show similar trends but different levels between this work (INEMA) and EDGAR from 1990 to 2004, global estimates being higher than the local estimate by 20% to 43%. The trends became divergent since 2005, with decreasing emissions in the local estimate and increasing emissions in EDGAR, CAMS and CEDS. EDGAR and CAMS estimates were very similar between 2000 and 2011. Later, CAMS estimates increased linearly and more slowly than EDGAR emissions. On the other hand, EDGAR and CEDS estimates were the same between 2000 and 2014. Later, CEDS increased slightly more slowly than EDGAR. The decrease in the CEDS estimate between 2019 and 2020 is not reported in EDGAR.

~~Emissions of other pollutants show large differences and even divergent trends for the same period. CH$_4$ emissions were higher in this study than EDGAR between 1990 and 2007 and lower between 2008 and 2020, with differences between -43.1% and 144.3%. Trends were similar between 1990 and 2004, but divergent after 2008, with the local inventory showing a constant decrease, and the global inventory showing increasing emissions.~~

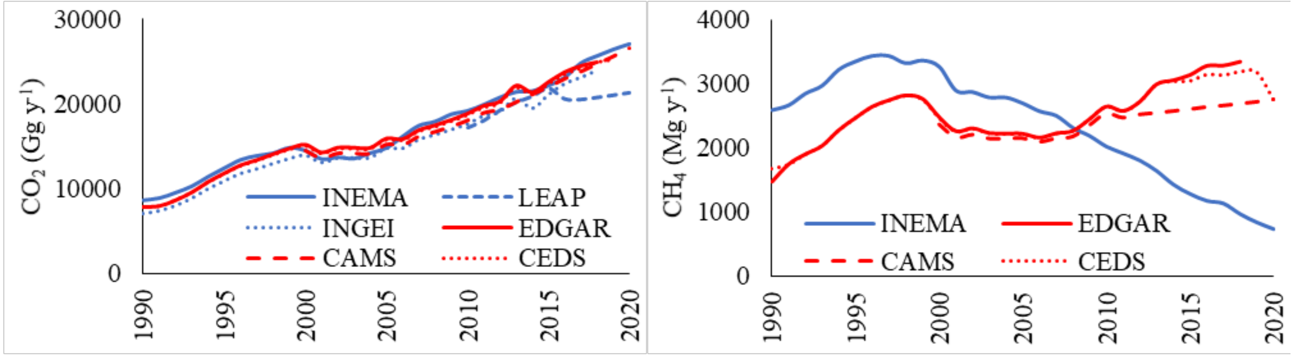


Figure 8. Comparison between CO$_2$ (left) and CH$_4$ (right) between this work (INEMA) and other local and global emission inventories ~~and EDGAR v4.3.2~~

Figure 9 shows emissions estimates for PM and BC. With the exception of CEDS, there was a good agreement between local and global emissions inventories between 1990 and 1998. However, EDGAR and CAMS show~~followed by~~ a sudden increase in 1999 that cannot be explained by a change in activity and is likely due to a change in the emission factors used in those inventories. Furthermore, after 1999, these global inventories show~~and~~ a consistent increasing trend~~in the global inventory~~. Such trend that was not followed by local estimates, which show a stabilization between 1997 and 2005, and a rather consistent decrease since 2007. As a result, EDGAR and CAMS PM (BC) emissions ~~differences between~~from 1999 to~~and~~ 2015 were between 85% (87%) and 315% (208%) higher than those from~~for PM (BC) with respect to~~ the local inventory. ~~Standards for diesel vehicle emissions and sulphur fuel content have been greatly improved since 2000 in Chile, so~~

~~EDGAR estimates and increasing trends in PM and BC seem to be wrong.~~ On the other hand, CEDS estimates for BC were even higher than EDGAR and CAMS estimates for the whole period, although they followed similar trends between 2000 and 2015. CEDS/INEMA BC emission ratios range from 2.76 to 5.69, suggesting that BC emission factors in the CEDS dataset are significantly higher than those used in this work. Since this work's emission factors are based on the COPERT model and the actual vehicle technology distribution, higher PM and BC emission factors used in EDGAR and CEDS imply assumptions of an older fleet in global inventories. Standards for diesel vehicle emissions and sulphur fuel content have been greatly improved in Chile since 2000, so EDGAR, CAMS and CEDS emissions and increasing trends for PM and BC are likely overestimated.

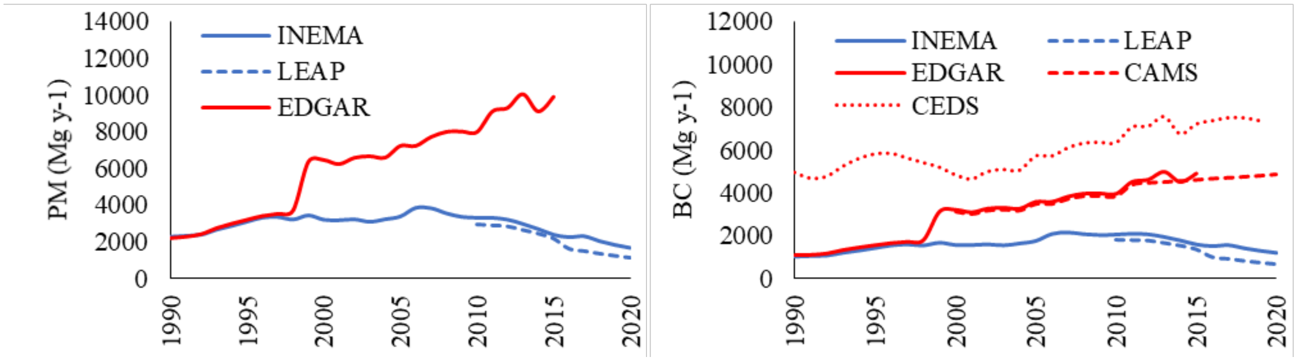


Figure 9. Comparison of~~between~~ PM$_{2.5}$ (left) and BC (right) emissions between this work (INEMA) and other local and global inventories ~~and EDGAR v4.3.2~~

CO and NOx emissions and trends are shown in Figure 10. CO emissions were considerably higher in the global inventories (EDGAR, CAMS and CEDS) than in the local inventories (INEMA and LEAP), with a mean difference of 254% [95% - 811%], and the trends were divergent since 2006, with increasing emissions in the global inventories and decreasing emissions in the local inventories. This is likely due to assumptions of an older fleet and, therefore, higher CO emission factors in the global inventories. A similar situation was observed for EDGAR and CEDS NOx emissions compared to local estimates, which showed rather similar levels between 1990 and 2005, with larger differences between 1993 and 1998, and ~~but trends~~ diverged after 2005, with increasing emissions in the global inventories and decreasing emissions in the local inventories. Differences increased from 9% in 2009 up to 70% in 2015, with respect to local inventories. Once again, these differences suggest that global estimates did not reflect improvements in Chile's vehicle fleet after 2005. Finally, it is worth noting that CAMS NOx emissions were significantly and lower than EDGAR estimates, although they follow similar trends. This was an unexpected finding, since CAMS emissions of other pollutants were essentially the same as EDGAR's between 1990 and 2011 and differed only in the trends of the following years, becoming linear for CAMS. A revision of CAMS NOx emissions is, therefore, recommended.

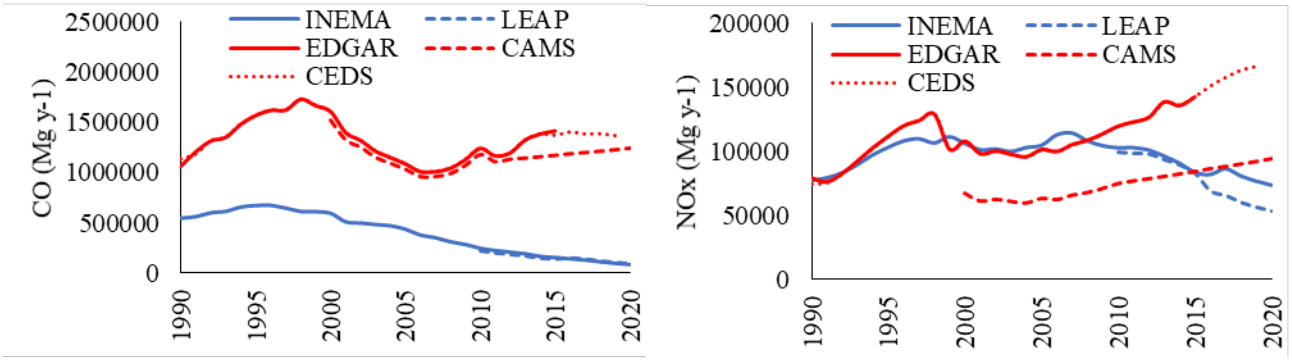


Figure 10. Comparison between CO~~NOx~~ (left) and CO~~NOx~~ (right) between this work (INEMA) and other local and global emission inventories ~~and EDGAR v4.3.2~~

Finally, the CO/NOx ratio and its trends are shown in Figure 11, which not only includes Chile but also a comparison with European and two other countries in the Latin America and the Caribbean (LAC) region between 1970 and 2020. The CO/NOx ratio was much higher in the global inventories than in the local inventories, with a mean difference of 209% [90% - 457%] between EDGAR and INEMA estimates for Chile, and shows a decreasing trend in both, with more fluctuations in the global inventory. The differences in emissions and trends for CO and NOx suggest that global emission inventories use emission factors that correspond to technologies older than those that have been and are currently~~being~~ used in Chile. Considering the differences between EDGAR data and this study's results for Chile, trends in CO/NOx ratio for other European and LAC countries were included. A big difference appears between these two groups of fleets, the CO/NOx ratio being much higher for LAC selected countries~~examples~~. In other words, according to EDGAR figures, LAC CO/NO ratios reach European values 40 years later (1970 versus 2012), which seems inaccurate according to local estimates. Chile's CO/NOx ratios are in the same range as those found in European countries, which is supported by the fleet renewal shown in Figure 11. Most of the Chilean fleet consists of Euro II/2 and Euro III/3 vehicles, which have much lower CO/NOx ratios that pre-Euro ones. This suggests that vehicle fleet assumptions and, therefore, emission factors used in global emission inventories for LAC countries should be revised.

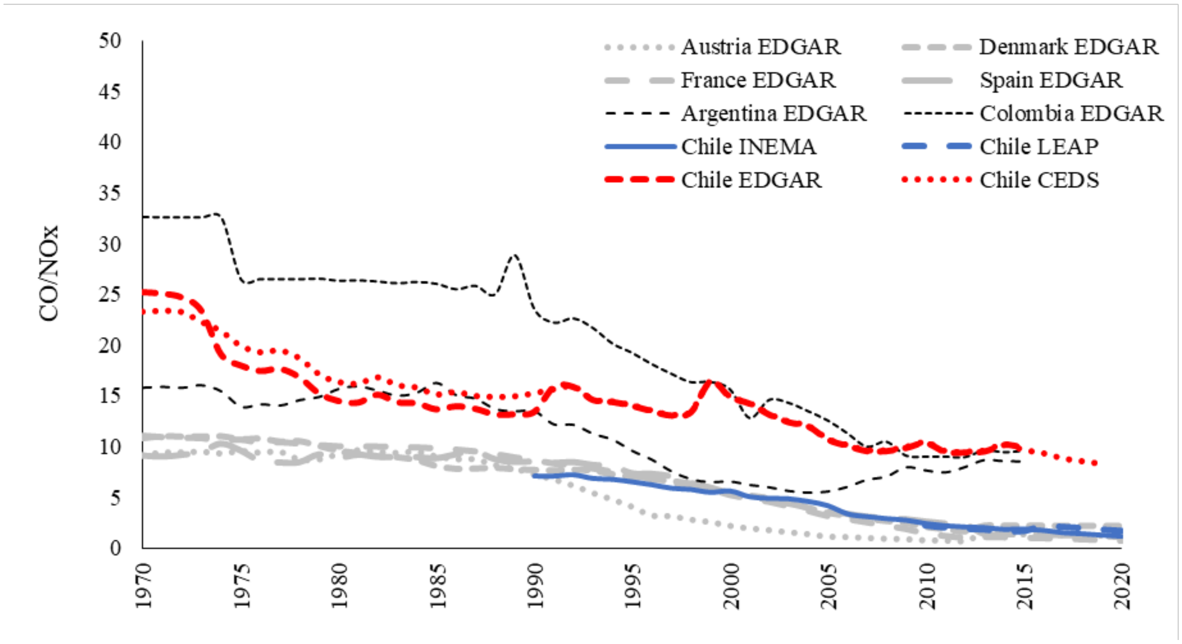


Figure 11. CO/NOx ratios for Chile and different countries from EDGAR and this work. External data obtained from models EDGAR/CEDS/LEAP

R1: The manuscript is well written, is suitable for the inventory special issue and is acceptable for publication after some minor revisions and additional comments.

A: We appreciate the recommendation and performed a complete general revision to the whole final text, adding minor revisions and to integrate the new comparisons and comments.

R1: Other comments:

R1: Line 60 page 8

R1: Determining the active fleet is always a complicated matter, especially when a long time series is calculated. The calculation of active fleet should include deregistration and scrapped rate for each vehicle cohort. This produces that a new registered vehicle in year n will be out of the roads in year n + m (number of active years). Since you are using (new?) registered vehicles, have you estimated how many years each (type of) vehicles with technology j are active? Also fuel consumption an emission factors degrade with aging vehicles. Have you considered any emission factor and fuel consumption function correction for each cohort? Also, VKT may be affected by aging vehicles. Although you calibrate the number of vehicles by fuel sales, some comments should be said with respect to the above point. How are the numbers of vehicles estimated in Figures 2?

A: We did not use new registered vehicles. Data provided by INE corresponds to annual registration of vehicles, i.e., the vehicles that each year pay their circulation permit after having approved the periodic technical inspection (explained in line 326, page 17). We added this explanation to the methodological section, in sub-section 2.1, as follows:

Vehicle fleet composition was based on official government data on annual registration of in-use vehicles, i.e., the vehicles that each year pay their circulation permit after having approved the periodic technical inspection. The National Institute of Statistics (INE, https://www.ine.cl/) provides annual reports of the total number of vehicles ~~in circulation~~ with circulation permit per political region.

Using annual registration of in-use vehicles partially solves the problem of deregistration and scrapped rate for each vehicle cohort. However, some of the vehicles with annual circulation permit may be not used, may have very low circulation rates, or may be used in a different region of that of their registration. To consider these issues, we contrasted calculated fuel consumption (TFC) with real fuel sales by region (line 158) and used a correction factor to adjust the number of registered vehicles in each region, as explained in sub-section 2.2 of the methodology, as follows:

In general, estimates of fuel consumption are lower than fuel sales, which means the number of registered vehicles generates lower activity than reality or specific consumption factors for each vehicle technology are lower than the real driving conditions in Chile. These differences are addressed increasing the number of vehicles according to their technology, matching official fuel sales figures.

Regarding the emission factors degrading with age, we used COPERT emission factors which consider aging factors for some of the categories and emission components. We added a line explaining this in the subsection 2.3 of the methodology, as follows:

COPERT V considers correction of emission factors by vehicle age for light vehicle categories EURO 3 & 4 and for VOC, CO, NOx. These corrections were also applied.

We did not calibrate fuel consumption by vehicle age. We acknowledge these limitations of the dataset in the conclusions in a new paragraph:

Every dataset has limitations and this is not an exception, INEMA does not include cold start emissions, neither consider a calibration of fuel consumption according to vehicle age. The use of international emission factors is a second best compared to using locally measured emission factors and COPERT does not cover aging for all vehicle categories in the dataset. The impact of COVID-19 is not considered in 2020, but other studies have addressed these effects on urban emissions in Santiago (2020). However, these limitations should not significantly change the results of the paper since the database provided is more accurate and extended than the existing ones, and the comparative analysis with external datasets show differences that need attention.

R1: Some additional considerations should be added with respect to changes in mobility indicators since these are mentioned in the results. Number of vehicles per household, number of vehicles per inhabitants, number of vehicles/GDP per capita and so on. This extra information, although not strictly necessary will enrich your paper and analysis.

A: Thanks for the comment. We considered mentioning some of these general mobility indicators in the description but decided not to do it. The paper covers 30 years and most of these parameters change each year and by region, making difficult to provide a clear summary of information. We *agree this information is not strictly necessary, it would enrich the analysis, but it might confuse the readers since those mobility indicators are not part of the inputs for our emission model.*

R1: Line 110 page 9:

R1: The English should be rephrased, probably the word “between” is not correct and may be replaced by “among”. You are distributing the region’s emissions proportionally to the population density of that region. What is the finest population density scale available in your calculation? Are the roads weighting factors constant to all regions in Chile?

A: Yes, now on page 10 line 218 it should read “among”. The finest population density corresponds to a city according to definition of the National Statistics Institute (INE), i.e., an urban area with more than 5000 inhabitants. The weighting factors vary by region, urban and interurban areas, and by city, and they were provided by the Transport Secretariat, SECTRA (Osses et al, 2010). This explanation and its reference have been added at sub-section 2.4 of the methodology, lines 214-215, page 10, as follows:

The road weight factors vary by region, urban and interurban areas, and cities in a region, and are provided by the Transport Secretariat, SECTRA (Osses et al., 2010).

R1: Although the spatial disaggregation’s methodology is in general understandable, some extra details should be added. It needs some extra clarifications, with regards to the spatial scales. Emissions are calculated in “Regions”, then is downscaled to what? … Districts? -> Municipalities? … How do you derive urban from non-urban areas? Are the roads weights similar in urban / rural areas? Readers may profit from the methodology used in your calculations.

A: Regions are downscaled to urban and interurban roads using the data provided by SECTRA, and then urban areas are downscaled to cities in the region, with are urban areas with at least 5000 inhabitants. This explanation has been added to sub-section 2.4 of the methodology, lines 220-223, page 10:

The Transport Secretariat, SECTRA, provides the proportion of urban and interurban roads per region (Osses et al., 2010) and the urban areas of each region can be associated to cities with population over 5000 inhabitants.

R1: Line 145 page 12

R1: Check typo error “if” : The vehicles in category if heavy diesel…”

A: Yes, it should say “of”, it was mended.

R1: Figure 6: Caption should declare the emissions color scale (e.g. “same as Figure 5”) o added to the figure.

A: Thanks for the observation, “same as Figure 5” was added to the caption.

R1: Figure 10, page 22. The Figure shows CO/NOX ratios for other countries. Please define the references for these data.

A: The references correspond to the three global databases used for comparisons (EDGAR/CAMS/CEDS). This has been added to the figure caption.

Referee comments 2 (RC2)
Anonymous Referee #2, 13 Sept 2021

R2: This manuscript presents a description of a Chilean high resolution gridded emission inventory of road transport exhaust emissions for the period 1990–2020, as well as a comparison against the emissions reported by the EDGAR inventory. As stated by the authors in the introduction section, the availability of high-resolution emission inventories in Chile that are consistent, updated and cover a long period of time is currently limited. Therefore, the dataset presented in the manuscript if of interest and a good contribution to ESSD. I recommend the manuscript to be published once the following comments have been addressed:

R2: Title of the manuscript: I would suggest to rephrase the title from "High-definition spatial distribution maps of (···)" to "High-resolution spatial distribution of (···)" as it is more frequently used in the scientific literature.

A: The title has been modified according to the suggestion:

~~High-definition spatial distribution maps of~~ High-resolution spatial distribution of on-road transport exhaust emissions in Chile, 1990 – 2020.

R2: Vehicle fleet composition: According to the authors, information on the vehicle fleet composition per political region is obtained from official government data. Is this source of information reporting data on registered vehicles or the actual "in-use fleet" (i.e., on-the-road or circulating fleet)? Several studies have highlighted strong discrepancies between registered and in-use vehicle fleet compositions. Official vehicle registries can suffer from certain limitations, including: i) they may include vehicles that have been scrapped (or that are registered but hardly being used) and ii) they include information regarding where the vehicles are registered but not where are actually driven. How did the authors overcome these limitations? Please provide an explanation.

A: Data provided by INE corresponds to annual registration of vehicles, i.e., the vehicles that each year pay their circulation permit after having approved the annual technical revision. We added this explanation to the methodological section, in sub-section 2.1, as follows:

Vehicle fleet composition was based on official government data on annual registration of in-use vehicles, i.e., the vehicles that each year pay their circulation permit after having approved the periodic technical inspection. The National Institute of Statistics (INE, https://www.ine.cl/) provides annual reports of the total number of vehicles ~~in circulation~~ with circulation permit per political region.

Using annual registration of in-use vehicles partially solves the problem of deregistration and scrapped rate for each vehicle cohort. However, some of the vehicles with annual circulation permit may be not used, may have very low circulation rates or may be used in a different region of that of their register. To consider these issues, we contrasted calculated fuel consumption (TFC) with real fuel sales by region (line 155) and used a correction factor to adjust the number of registered vehicles in each region, as explained in sub-section 2.2 of the methodology, with the following text:

In general, estimates of fuel consumption are lower than fuel sales, which means the number of registered vehicles generates lower activity than reality or specific consumption factors for each vehicle technology are lower than the real driving conditions in Chile. These differences are addressed increasing the number of vehicles according to their technology, matching official fuel sales figures.

R2: Total Fuel Consumption (TFC): Could you provide a figure (or summary table) that shows the results of the comparison between calculated TFC and reported fuel sales for each region? This would allow understanding better the discrepancies between the two datasets.

A: Figure 2 has been added to the main text, showing the difference between official fuel sales and estimated total fuel consumption, for gasoline and diesel.

R2: Spatial distribution: Could you provide a reference for the toll barrier vehicle counts used for computing the average road weight factors? Could you provide a summary table with the shares regarding the distribution of vehicles into urban and interurban activity per region? Perhaps this information could be included as part of Table 3 (Annual activity level not only per region and vehicle type but also discriminated between urban and interurban).

A: The reference (MOP, 2020) was added (line 212, page 10) and the official link has been included at the References section.

R2: Emission factors: Authors use the emission factors reported by COPERT 5, which is a vehicle emission calculator originally developed for Europe. Can the authors say something on how precise is COPERT in reflecting the Chilean fleet and driving conditions? Is there any database of measured local emission factors that could be used for comparison purposes?

A: Unfortunately, Chile does not have a robust database of local emission factors covering all existing vehicle technologies and driving conditions. There are some local measurements using dynamometer facilities as well as portable emission measurement systems, but not enough for supporting a national emission model, particularly for newer technologies such as EURO 5/6. The Chilean homologation process allows both US and Europe-based emission standards, but most of the vehicles are certified with EURO standards. For this reason, COPERT has been accepted as an appropriate international model by Chilean researchers and authorities (Osses, 2010; MMA, 2014; Osses, 2014; Tolvett, 2016; Gallardo, 2018; Mazzeo, 2018; Huneeus, 2020).

R2: Cold-start emissions: Are cold-start emissions included in the inventory? These type of exhaust emissions could be significant in certain regions of the country during winter time. Please specify.

A: Cold-start emissions effect was not considered and this was added to the conclusions regarding limitations of the dataset, as proposed by the Reviewer. This is the paragraph with limitations:

Every dataset has limitations and this is not an exception, INEMA does not include cold start emissions, neither consider a calibration of fuel consumption according to vehicle age. The use of international emission factors is a second best compared to using locally measured emission factors and COPERT does not cover aging for all vehicle categories in the dataset. The impact of COVID-19 is not considered in 2020, but other studies have addressed these effects on urban emissions in Santiago (2020). However, these limitations should not significantly change the results of the paper since the database provided is more accurate and extended than the existing ones, and the comparative analysis with external datasets show differences that need attention.

R2: Comparisons with EDGAR (1): At the beginning of section 3.2.4, authors mention that they performed a comparison between INEMA and EDGARv4.3.2. However, it looks to me that the comparison is done against EDGARv5.0, as v4.3.2 reports emissions only until 2012, and v5.0 up to 2015. Please specify and correct if needed.

A: The observation is correct; the dataset corresponds to EDGARv5.0 and it has been corrected through the text and references. The following references where updated:

Crippa, M., Guizzardi, D., Schaaf, E., Solazzo, E., Muntean, M., Monforti-Ferrario, F., Olivier, J.G.J., Vignati, E.: Fossil CO2 and GHG emissions of all world countries - 2021 Report, in prep.

Crippa, M., Solazzo, E., Huang, G., Guizzardi, D., Koffi, E., Muntean, M., Schieberle, C., Friedrich, R. and Janssens-Maenhout, G.: High resolution temporal profiles in the Emissions Database for Global Atmospheric Research. Sci Data 7, 121 (2020). doi:10.1038/s41597-020-0462-2.

R2: Comparisons with EDGAR (2): The discrepancies between the emission trends reported by INEMA and EDGAR are quite significant, especially for NOx. In my opinion, it would be good to include in the comparison other state-of-the-art global emission inventories such as CEDS (http://www.globalchange.umd.edu/ceds/) or ECLIPSEv6b (https://iiasa.ac.at/web/home/research/researchPrograms/air/ECLIPSEv6b.html), in order to see if their trends match better with the one reported by INEMA. Moreover, both CEDS and ECLIPSE report emissions up to more recent years (e.g., 2019).

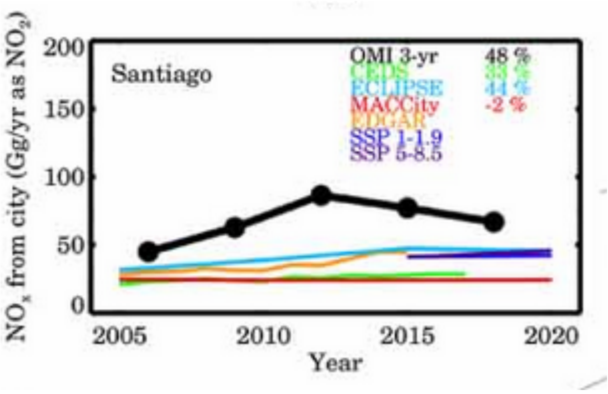
A: We appreciate the comment since we fully agree it is important to reinforce the comparison analysis. Thus, in addition to EDGAR, CEDS and CAMS datasets for Chile have been included in section 3.2.4, with extended comments explaining similarities and differences. Additionally, the official inventory reported by the Chilean government for GHG (INGEI) and a national estimate of transport emissions using LEAP model have been added to the comparison analysis. In summary, our emission inventory for exhaust on-road transportation emissions (INEMA) is compared with two local national inventories (INGEI, LEAP) and three global models (EDGAR, CAMS, CEDS). This answer has already been addressed for Reviewer 1.

R2: Comparisons with EDGAR (3): Regarding the discrepancy between the NOx emission trends reported by INEMA and EDGAR, and considering that road transport is the main contributor to total NOx emissions, perhaps it would be interesting to contrast these results against the evolution of NO2 concentrations in traffic stations for the same period of time (i.e., 1990 to 2015). These would allow seeing if NO2 concentrations show a positive or negative trend (or if concentrations remain unchanged) and subsequently if they correlate better with the trend reported by INEMA or EDGAR.

A: Thank you for the suggestion. Unfortunately, the air quality monitoring network along continental Chile (https://sinca.mma.gob.cl/) does not provide a national coverage of nitrogen dioxide data. Stations outside Santiago do not provide NO2 except for a few sites, and the period covered in those sites is too short to establish long-term trends. Except for mass concentrations of particles, and to some extent sulfur dioxide, the coverage is poor for other pollutants. Another issue is identifying traffic dominated stations. Stations are placed to monitor the compliance of air quality standards set for protecting human health, and not for process understanding. One could try to minimize the effect of residential sources by considering summer values, and rush hours to *capture traffic emissions (See Gallardo et al, 2012). This would be feasible but for a few places, and that would not be particularly helpful identifying national emission trends. In previous work, Menares et al (2020) analyzed NO2 trends from in situ data in Santiago and found increasing trends for the period 2001-2018 over Eastern Santiago, which the authors attribute to changing photochemical regimes.*

In a recent work, Goldberg et al (2021) estimated urban NOx emissions trends for the period 2005-2019 using satellite borne measurements of the NO2 column. Over Santiago they infer increasing emission trends between 2005 and ca. 2012 and declining trends thereafter (See image extracted from the paper). Previously, Duncan et al (2016) estimated a very high trend (30±17%) in the NO2 column as observed from the Ozone Monitoring Instrument (OMI), in some agreement with in-situ data (Menares et al, 2020). The same data but considering the period between 2005 and 2020 results in a small and insignificant trend (-3.13±12.4%), possibly due to considering the pandemic and the political unrest after October 2019.*

Thus, all in all, at this point it appears difficult to resolve the inconsistencies in trends inferred from different data and methodologies. Regional scale modeling studies will provide further insights in the matter, but that of course, is beyond the scope of this paper.



Duncan, B. N., Lamsal, L. N., Thompson, A. M., Yoshida, Y., Lu, Z. and co-authors. 2016. A space-based, high-resolution view of notable changes in urban NOx pollution around the world (2005–2014. J. Geophys. Res. Atmos. 121, 976–996. doi: 10.1002/2015JD024121

Gallardo, L., Escribano, J., Dawidowski, L., Rojas, N., de Fátima Andrade, M., Osses, M., 2012. Evaluation of vehicle emission inventories for carbon monoxide and nitrogen oxides for Bogotá, Buenos Aires, Santiago, and São Paulo. Atmos. Environ. 47, 12–19. https://doi.org/10.1016/j.atmosenv.2011.11.051

Goldberg, D.L., Anenberg, S.C., Lu, Z., Streets, D.G., Lamsal, L.N., E McDuffie, E., Smith, S.J., 2021. Urban NO x emissions around the world declined faster than anticipated between 2005 and 2019. Environ. Res. Lett. 16, 115004. https://doi.org/10.1088/1748-9326/ac2c34

Menares, C., Gallardo, L., Kanakidou, M., Seguel, R., Huneeus, N., 2020. Increasing trends (2001–2018) in photochemical activity and secondary aerosols in Santiago, Chile. Tellus, Ser. B Chem. Phys. Meteorol. 72, 1–18. https://doi.org/10.1080/16000889.2020.1821512

* https://airquality.gsfc.nasa.gov/no2/world/south-and-central-america/santiago

R2: Comparisons with EDGAR (4): The EDGARv5.0 emission inventory includes estimates of PM emissions from road surface wear and road vehicle tyre and break wear based on the EMEP/EEA guidebook 2019 Tier 1 approach. If I understood correctly, these sources of non-exhaust emissions are not considered in INEMA and could explain some of the discrepancies shown between the two datasets for PM. Please comment on that.

A: INEMA does not consider non-exhaust PM emissions. The results from external datasets (EDGARv5.0, CAMS, CEDS, LEAP) have been selected only for exhaust emissions from on-road transportation in Chile, assuring the comparison is based on the same source. Attending this comment, we have double-checked this analysis and there is no mixing of exhaust and non-exhaust PM emissions in the comparison.

R2: Comparisons with EDGAR (5): Figures 7, 8, 9 and 10: Please include the whole time series of the INEMA emissions (up to 2020)

A: The updated figures, with additional datasets for comparison, include the whole time series for INEMA (1990-2020).

R2: Effect of COVID-19 restrictions: the time series presented by the authors include the year 2020, which was heavily affected by COVID-19 restrictions. I think it would be very relevant to include a section discussing the results for 2020 and quantifying how they compare to the previous year (2019) (i.e., how total emissions decreased as a consequence of COVID-19). This comment is also linked to the previous one about representing the whole 1990-2020 trend in figures 7 to 10.

A: We absolutely agree. This emission model was designed and run before COVID-19 effects on mobility and does not consider 2020 reductions in emissions. However, the methodology should incorporate this disruption if the updated official figures of fuel sales are used in the calculation, but the validated 2020 National Energy Balance is not available yet. Nevertheless, there are other recent publications addressing COVID-19 effects on urban vehicle emissions and air quality in Santiago. We have included this issue as a limitation of the dataset (see next answer), offering the reader another reference were COVID-19 impacts have been studied.

R2: Conclusions: I would recommend to the authors to re-structure the conclusions section and add a new subsection entitled "Limitations of the dataset", in which they clearly state what are the limitations of the current inventory (e.g., non-inclusion of cold-start emissions, use of EU emission factors instead of local EF, ...).

A: A paragraph on limitations of the dataset has been added to the conclusions.

R2: Others (1): Replace MP2.5 for PM2.5 in the text

A: The acronym was replaced by the English version.

R2: Others (2): The reference (Gomez, 2020) is missing

A: The reference was added and the spelling corrected because it should be "Gómez"

R2: Figure 5: For clarification, I would suggest to change the units to e.g., kg/year. Also, it would be interesting to see the spatial distribution not only of the emissions in specific urban regions but across the whole country.

A: Since we are building this emission inventory for other users such as ECCAD (https://eccad.aeris-data.fr/) and the information has been uploaded as a doi dataset (http://dx.doi.org/10.17632/z69m8xm843.2), we are using Gg as a common unit for all compounds. For this reason, we consider it is better to present the data in the same format.

Regarding regional distribution, it is rather interesting, however the Metropolitan Region dominates with approximately 50% of the national emissions. We considered some approaches for including this analysis, but finally decided not to do it and we would like to maintain this decision.

R2: Figure 6: Please add a legend

A: Thanks for the observation, "same as Figure 5" was added to the caption.