Convention on Long-range Transboundary Air Pollution

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Reporting of Black Carbon emissions

A comparison of data submitted under the Air Convention and alternative datasets

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Technical report CEIP

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Executive Summary

Black carbon (BC) is a key short-lived climate forcer and an air pollutant with significant impacts on human health. Although reporting of BC emissions remains voluntary under the Convention on Long-range Transboundary Air Pollution, 42 Parties submitted BC data in 2024. This report assesses the completeness, methodological consistency and comparability of reported BC emissions and compares national inventories compiled by CEIP with alternative datasets from GAINS and CAMS.

Residential stationary combustion (1A4bi) is the dominant source of BC emissions that contributed on average 43.75% of total BC emissions in the year 2022. Most countries used a Tier 2 methodology for reporting in sector 1A4bi - Residential Stationary. In contrast, emissions from venting and flaring, agricultural residue burning and waste-related activities often rely on basic Tier 1 methodologies or remain unreported altogether.

Comparisons between CEIP, GAINS and CAMS BC emission estimates, three datasets that are compiled by different institutions, that use different approaches but that are not completely independent from each other show that the strongest overall alignment is observed between GAINS and CAMS, while the comparison between CEIP and CAMS shows lower, yet still significant, correlation.

A few countries exhibit very low correlations between the datasets. In these cases, the low or even negative correlations likely reflect fundamental differences in sectoral allocation, activity data selection, or emission factor choice rather than random deviations. Such anomalies highlight the need for targeted review efforts during the annual inventory review process. Future studies could delve deeper into the reasons behind low correlations in certain sectors or countries, potentially identifying areas where data collection methodologies or emission models could be refined.

Introduction

Definition of black carbon

Black Carbon (BC), a component of fine particulate matter (PM ≤ 2.5µm), is produced by the incomplete combustion of biomass from wildfires and the burning of fossil fuels. Black carbon strongly absorbs visible light, is insoluble in water and common organic solvents (Coppola et al. 2022). Pure black carbon particles are rare in the atmosphere as they quickly mix with other aerosols upon emission (Motos et al. 2020). Black carbon-containing aerosols contribute to atmospheric warming by directly absorbing solar radiation and indirectly accelerating snow and ice melt (Bond et al. 2013).

BC is not only an important climate forcer, but it is also a pollutant that adversely impacts human health. Epidemiological studies have shown that exposure to black carbon is associated with increased cardiopulmonary morbidity and mortality (Anenberg et al. 2012). Toxicological studies suggest that black carbon may act as a universal carrier for a wide range of chemicals with varying toxicity to the human body (Janssen et al. 2012).

Measures targeting black carbon are expected to yield significant short-term reductions in global warming. The importance of addressing both global warming and air quality was emphasized by the parties to the Convention on Long-range Transboundary Air Pollution. In response to the findings of the Ad Hoc Expert Group on Black Carbon (UNECE, 2010a), the Executive Body of the Convention decided to include black carbon, as a component of PM, in the revision of the 1999 Gothenburg

Protocol to Abate Acidification, Eutrophication, and Ground-level Ozone (Gothenburg Protocol) (UNECE, 2010b).

Reporting of black carbon under the Air Convention

With the growing recognition of BC significance, developments in international policy regarding emissions reporting have progressed. Since the Executive Body Decision 2013/04, Parties to the Air Convention have been formally encouraged to submit inventory estimates of their national BC emissions (UNECE, 2013). In 2015, reporting templates were updated to include BC emissions data, marking a pivotal step towards more comprehensive tracking of this pollutant (EMEP Status Report, 2024).

Under the 2023 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution, Parties are strongly encouraged to report their BC emissions. Specifically, they are urged to provide emissions inventory data for BC from the earliest year possible, using the latest methodologies outlined in the EMEP/EEA guidebook (UNECE, 2022, para. 8, para. 38 and para. 43). For projected emissions, BC data should be submitted following the template provided in Annex IV of the Guidelines (UNECE, 2022, para. 46).

Since the formal encouragement to report BC emissions, a total of 45 CLRTAP Parties have submitted BC emissions estimates for at least one year in their time series. In the 2024 submission, 32 Parties to the Air Convention had submitted a complete time series of national total BC emissions covering the period from 1990 to 2022, 40 Parties had submitted a time series from 2000 onwards and 43 Parties had reported BC emission estimates for 2022 (EMEP Status Report, 2024).

In its 62nd session (May 2024), the Working Group on Strategies and Review discussed a draft plan for the revision of the Gothenburg Protocol, including ongoing and required activities and the prioritization of activities and decisions. One of the issues identified as requiring further attention in the revision process was the question of how to deliver further reductions of black carbon emissions (UNECE, 2023a).

Alternative black carbon emission datasets used in the work for the Air Convention

Apart from BC emission datasets reported under the Air Convention there are several other datasets that include BC emission estimates. For the work of the Air Convention among others the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) and the Copernicus Atmosphere Monitoring Service (CAMS) dataset are especially relevant.

The GAINS model estimates historical emissions of 10 air pollutants and 6 greenhouse gases (GHGs) for each country, using data from international energy and industrial statistics, national inventories, and information supplied by individual countries.

CAMS provides daily analyses and forecasts of global long-range transport of atmospheric pollutants, as well as background air quality assessments for Europe. For the present work especially the gridded dataset – the CAMS-REG-v2 emissions inventory, which provides high-resolution data (0.1° x 0.05°) for the main air pollutants in UNECE-Europe from 2000 to 2015 is relevant (Kuenen et al., 2021).

Methods

The CEIP dataset comprises reported emission data from EMEP countries and gap-filled emissions (see below). Parties to the LRTAP Convention submit their emissions inventories as sectoral emissions (NFR19-1) and national total emissions, following the UNECE guidelines for reporting emissions and projections data under the LRTAP Convention (UNECE, 2022). The reported NFR sector emissions are then aggregated into 13 GNFR sectors used in the gridding procedure. A crosswalk between the NFR and GNFR sectors can be found in Annex I, Table A1, and includes the following sectors**:**

1. A_PublicPower
2. B_Industry
3. C_OtherStationaryComb
4. D_Fugitive
5. E_Solvents
6. F_RoadTransport
7. G_Shipping
8. H_Aviation
9. I_Offroad
10. J_Waste
11. K_AgriLivestock
12. L_AgriOther
13. M_Other

The methodology for estimating emissions is described in the EMEP/EEA guidebook, which outlines a tiered approach. The Tier 1 method is applicable to all sources and substances and is based on readily available statistical information, suitable for countries that have ratified Convention protocols. The Tier 2 method is used for key categories and when country-specific data are available. Finally, the Tier 3 methodology applies when facility-level data and/or advanced models are utilized (EMEP/EEA, 2023).

The data were collected from the Informative Inventory Reports and emission inventories in the NFR-19 format submitted under the Air Convention.

The CEIP gap-filling process

When countries do not report BC data, or when the reported data are incomplete or contain errors, the missing or erroneous information must be addressed. The Centre on Emission Inventories and Projections (CEIP) applies a systematic quality control and gap-filling procedure in such cases. CEIP experts review quality control graphs to identify where data are missing and to assess whether the reported emissions are plausible. When data from 1990 onwards are either missing or implausible, CEIP selects the most suitable method to fill these gaps or replace the data, drawing from a set of predefined techniques (CEIP, 2024b).

One common approach is to fill or replace the time series with alternative emission estimates, e.g. from the GAINS[1] dataset, when no data, or no plausible data, are available. This can be applied across all GNFR (Gridded Nomenclature for Reporting) sectors, or selectively to individual sectors, depending on the case (CEIP, 2024b).

When a significant portion of the data is considered plausible, experts may choose to extrapolate the missing or implausible values for the years at the beginning or end of the time series. The decision on how to extrapolate is made by evaluating various trends, such as assuming constant emissions, using trends from GAINS estimates, or relying on reported national totals if they seem reliable, or even a combination of these methods.

[1] ECLIPSE v6b for the gap-filling performed in 2024

In cases where $PM_{2.5}$ emissions are reported as plausible, but BC emissions are either missing or appear questionable, a ratio-based approach may be used. This involves multiplying the reported $PM_{2.5}$ emissions by BC fractions specific to the GNFR sectors, which are derived from GAINS estimates. Typically, the ratios from the country in question are used, but for smaller countries that are not resolved in GAINS, BC fractions from neighbouring countries might be applied. This method can also be focused on specific sectors.

For years in between periods of plausible data, linear interpolation can be used to estimate missing or implausible emissions. This interpolation method can be applied independently or in combination with the extrapolation techniques described earlier, depending on the data patterns and the experts' judgment.

The GAINS dataset

The GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) model, developed by the International Institute for Applied Systems Analysis (IIASA), is an advanced integrated assessment model that evaluates both the costs and effectiveness of strategies for controlling air pollution and mitigating greenhouse gas (GHG) emissions. It supports policymakers by assessing the interactions between air quality management and climate policies, allowing for optimized solutions that achieve multiple environmental objectives simultaneously (IIASA, 2024a).

The GAINS dataset (ECLIPSE v6b) provides comprehensive estimates of historical emissions across 10 air pollutants and 6 greenhouse gases for each country (IIASA, 2024b). The model adopts a bottom-up approach to emissions estimation, where data are gathered and analysed in fine detail. Emissions calculations rely on specific activity data, such as fuel consumption, production rates, and vehicle mileage, in combination with standardized emission factors. The GAINS model covers a wide array of economic sectors and activity classes, gathering activity data from both international and national statistics, with further inputs provided by expert teams from collaborating countries.

The model's emission factors are standardized and based on established sources like the IPCC Guidelines as well as other peer-reviewed scientific literature. This standardized approach helps ensure that the model's outputs are scientifically robust and internationally comparable. For more information on the GAINS model's structure, methodology, and applications, refer to the detailed documentation available online (IIASA, 2024c, Klimont et al., 2017).

The CAMS dataset

The Copernicus Atmosphere Modelling System (CAMS) is a comprehensive framework designed to monitor and forecast atmospheric composition across Europe and beyond. CAMS integrates data from satellites, ground-based monitoring stations, and advanced numerical models to deliver real-time information on various atmospheric components, including greenhouse gases, aerosols, and air pollutants.

Important products generated by CAMS are a gridded distribution of both anthropogenic and natural emissions at the European and global levels. One such gridded dataset is the CAMS-REG-v2 emissions inventory, which provides high-resolution data (0.1° x 0.05°) for the main air pollutants in UNECE-Europe from 2000 to 2015 (Kuenen et al., 2021).

The CAMS-REG-v2.2.1 inventory employs 2017 national air emission inventory data, supplemented by information from sources such as GAINS and EDGAR. These data sources provide comprehensive information on emissions from various sectors, such as transportation, industry, agriculture, and natural sources like wildfires and vegetation.

Data analysis

Analysis of the information on the sectors 1A4bi - Residential Stationary, 1B2C - Venting and Flaring, and 3F - Field burning of agricultural residues provided in the 2024 Informative Inventory Reports (IIR) were compiled and sorted into tables.

Country data of BC emissions data for sector 1A4bi - Residential Stationary was downloaded from CEIP.

Country total data were utilized for comparative analysis. Emission data from all datasets were aggregated into the 13 GNFR sectors. All datasets were cleaned by removing missing data (NA values), and no unit transformation was necessary since the data were already standardized in the same units. The analysis focused on data reported for the year 2020 and countries that submitted data for BC were used for the assessment.

All data was compiled, and visualisations were performed in R version 4.2.1. The raw data were imported into R using the *read.csv* function. Data were filtered and aggregated using functions from the *dplyr* package, and necessary transformations were applied. For visualization, various plots were created using the *ggplot2* package, including bar charts, scatter plots, and line graphs, to explore relationships and trends within the data using a Logarithmic scale to view the data.

Further a Pearson correlation analysis was performed in R to evaluate the correlation between the CEIP, GAINS (ECLIPSE v6b), and CAMS (CAMS-REG-v2.2.1) datasets.

Results

Tier methods

Three NFR sectors were analysed for BC emission estimates in all countries that submitted an IIR in 2024. The NFR sectors chosen were 1A4bi - Residential Stationary, 1B2C - Venting and Flaring (oil, gas, combined oil, and gas) and 3F - Field burning of agricultural residues. In total 42 countries reported BC emission data. In the sector 1A4bi - Residential Stationary, 16 countries used a Tier 1 method to report BC emissions, 21 countries used a Tier 2 method. Whilst only countries 5 did not provide information (4 NAs) or reported the emissions as not estimated (1 NE) (Table 1). In the 1B2C - Venting and Flaring, 17 countries used a Tier 1 method, 6 used a Tier 2 method and 1 country used a Tier 3 method. While 18 countries did not provide information (14 NAs) or reported the emissions as not estimated (4 NEs) (Table 1). In the sector 3F - Field burning of agricultural residues, 12countries used a Tier 1 method, 6 used a Tier 2 method and no country used a Tier 3 method. While 24 countries did not provide information (19 NAs) or reported the emissions as not estimated (5 NEs) (Table 1).

Annex II (Table A.2) provides an overview of which country used which tier method.

Table 1: Summary of Tier methodology for sectors 1A4bi - Residential Stationary, 1B2C - Venting and Flaring, and 3F - Field burning of agricultural residues from the IIR of countries.

Tier Method / ***Sectors***	**Tier 1**	**Tier 2**	**Tier 3**	**No Information**
1A4bi	16	21	0	1 NE 4 NA
1B2c	17	6	1	4 NE 14 NA
3F	12	6	0	5 NE 19 NA

Most countries reported BC emissions for all sectors by referencing either the EMEP/EEA guidebook, while some used country specific statistical data and methods or other references like the IPCC handbook (Table 2).

Table 2: References for the BC emission factors used to calculate emissions for 1A4bi - Residential Stationary, 1B2C - Venting and Flaring, and 3F - Field burning of agricultural residues according to the IIRs.

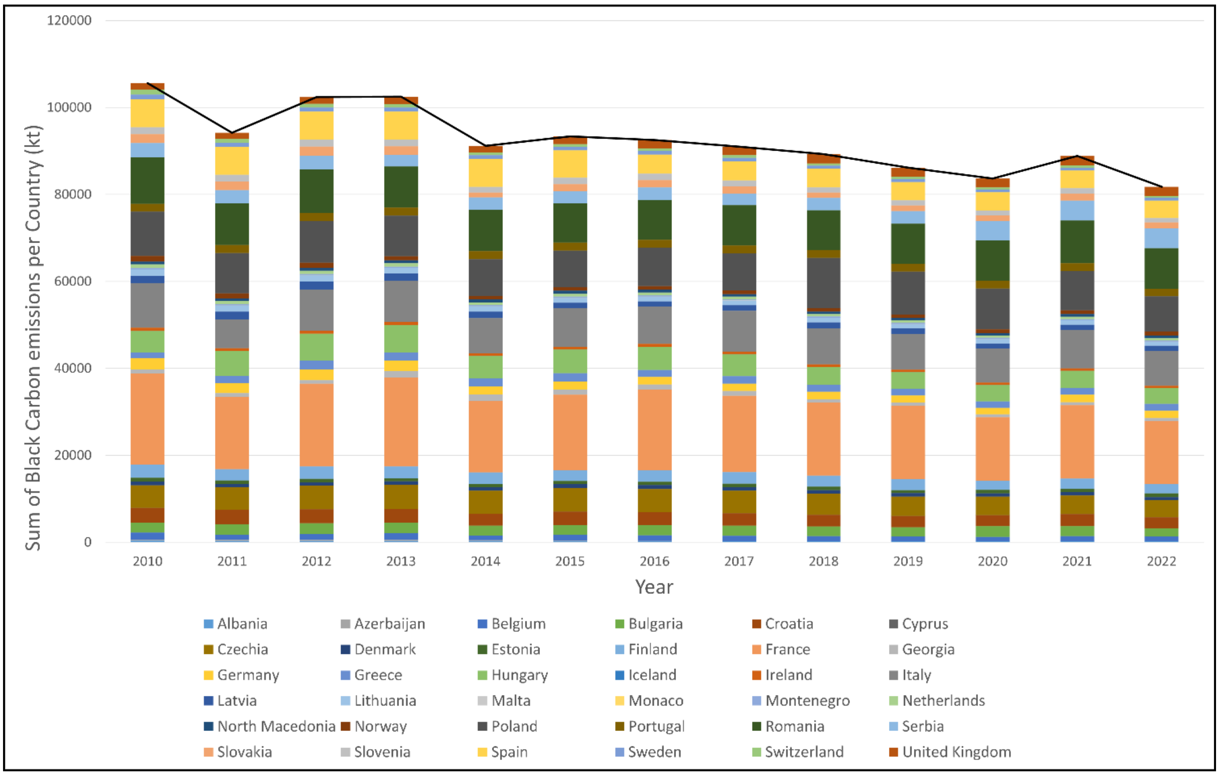
Country	Informative Inventory Report		1A4bi - Residential Stationary - Source of the BC in report	1B2C - Venting and Flaring - Source of the BC in report	3F - Field burning of agricultural residues - Source of the BC in report
	Submission year	Language			
Albania (AL)	2024	English	IPCC default + statistical office Albania	IPCC default + statistical office Albania	EMEP/EEA 2019
Armenia (AM)	2024	English	UNECE/ EMEP handbook	No information	No information
Belgium (BE)	2024	English	Data from EPB certificates, EMEP 2023, ADEME	No information	No information
Bulgaria (BG)	2024	English	EMEP/CORINAIR 2019	EMEP/CORINAIR 2019	EMEP/CORINAIR 2019
Canada (CA)	2024	English/French	EPA 2022 & ECCC	EPA 2022 & ECCC	EPA 2022 & ECCC
Switzerland (CH)	2024	English	EMEP/EEA guidebook 2019	EMEP/EEA guidebook 2019	No information
Cyprus (CY)	2024	English	EMEP/EEA guidebook 2019	EMEP/EEA guidebook 2019	EMEP/EEA guidebook 2019
Czechia (CZ)	2024	English	EMEP/EEA 2016	EMEP/EEA 2016	No information
Germany (DE)	2024	English	EMEP/EEA 2019	No information	No information
Denmark (DK)	2024	English	EMEP/EEA 2019	EMEP/EEA 2019	No information
Estonia (EE)	2024	English	EMEP/EEA 2023	No information	No information
Spain (ES)	2024	English	MITECO + EMEP/EEA 2019	MITECO + EMEP/EEA 2019	EMEP/EEA 2019
Finland (FI)	2024	English	EMEP/EEA 2019	EMEP/EEA 2019	EMEP/EEA 2019
France (FR)	2024	French	EMEP/EEA 2019	EMEP/EEA 2019	EMEP/EEA 2019
UK (GB)	2024	English	EMEP/EEA 2019	EMEP/EEA 2019	EMEP/EEA 2019
Greece (GR)	2024	English	EMEP/EEA 2023	EMEP/EEA 2023	No information
Croatia (HR)	2024	English	EMEP/EEA 2023+ GB2023	EMEP/EEA 2023+ GB2023	EMEP/EEA 2023+ GB2023
Hungary (HU)	2024	English	EMEP/EEA 2023	EMEP/EEA 2023	EMEP/EEA 2023
Ireland (IE)	2024	English	EMEP/EEA 2023	EMEP/EEA 2023	No information
Iceland (IS)	2024	English	EMEP/EEA 2019	No information	No information
Italy (IT)	2024	English	EMEP/EEA 2019	No information	EMEP/EEA 2019

Country	Informative Inventory Report		1A4bi - Residential Stationary - Source of the BC in report	1B2C - Venting and Flaring - Source of the BC in report	3F - Field burning of agricultural residues - Source of the BC in report
	Submission year	Language			
Kazakhstan (KZ)	2024	English	No information	No information	No information
Liechtenstein (LI)	2024	English	EMEP/EEA 2019	No information	No information
Lithuania (LT)	2024	English	EMEP/EEA 2023	No information	No information
Luxembourg (LU)	2024	English	No information	No information	No information
Latvia (LV)	2024	English	EMEP/EEA 2019	EMEP/EEA 2019	No information
Monaco (MC)	2024	French	EMEP/EEA 2023	No information	No information
Montenegro (ME)	2024	English	EMEP/EEA 2023	No information	EMEP/EEA 2023
North Macedonia (MK)	2024	English	GB2023/ EMEP/EEA 23	No information	No information
Malta (MT)	2024	English	GB2023 / GAINS	No information	GB2023 / GAINS
Netherlands (NL)	2024	English	EMEP/EEA 2019	EMEP/EEA 2019	No information
Norway (NO)	2024	English	EMEP/EEA 2013	EMEP/EEA 2013	EMEP/EEA 2023
Poland (PL)	2024	English	EMEP/EEA 2019, 2023	EMEP/EEA 2023	GAINS
Portugal (PT)	2024	English	EMEP/EEA 2023	No information	EMEP/EEA 2019
Romania (RO)	2024	English	EMEP/EEA 2019	EMEP/EEA 2019	EMEP/EEA 2023
Serbia (RS)	2024	English	EMEP/EEA 2019	EMEP/EEA 2019	EMEP/EEA 2019
Russian Federation (RU)	2024	Russian	No information	No information	No information
Sweden (SE)	2024	English	No information	EMEP/EEA 2019	No information
Slovenia (SI)	2024	English	EMEP/EEA 2023	EMEP/EEA 2023	No information
Slovakia (SK)	2024	English	EMEP/EEA 2019	EMEP/EEA 2019	No information
Türkiye (TR)	2024	English	EMEP/EEA 2016	No information	No information
Ukraine (UA)	2024	English	No information	No information	No information

Time series of per capita BC emissions from sector 1A4bi - Residential Stationary

Observing reported data for sector 1A4bi - Residential Stationary there is a decrease in BC emissions over time for sector 1A4bi - Residential Stationary (Fig. 1). Although there is a peak present in 2012, 2013 and in 2021, total BC emissions from these countries have decreased in sector 1A4bi - Residential Stationary (Fig. 1). The following countries Austria, Armenia, Belarus, Canada, Moldova, Kazakhstan, Kyrgyzstan, Bosnia and Herzegovina, Russian Federation, Liechtenstein, Luxembourg, Türkiye, and Ukraine had incomplete or missing data and therefore could not be included in the graph.

Figure 1: Sum of Black carbon emissions (kt) across 36 countries (sector 1A4bi - Residential Stationary)



Data comparison between CEIP and GAINS

When analysing the BC emission estimates between CEIP and GAINS there are some significant differences for all GNFR sectors, where for certain countries either the values of CEIP emission estimates are higher or the values of GAINS emission estimates are higher. With the logarithmic scale, the smaller values are represented further down the axis, whilst larger values are higher up. Sectors K_Agriculture and M_Other were removed from the analysis as there was limited or no data for those sectors. Albania, Armenia, Austria, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kyrgyzstan, Kazakhstan, Luxembourg, Republic of Moldova, Montenegro, Serbia, Russian Federation, Türkiye, and Ukraine were gap-filled using GAINS data. Liechtenstein and Lithuania could not be included as their datasets were partially gap-filled. Therefore, no comparison was possible, in all data comparison between CEIP emissions estimates and GAINS emission estimates (CEIP, 2024b).

Figure 2: CEIP and GAINS BC emission estimates for the year 2020 for GNFR sectors A_PublicPower to B_Industry, for each country using a logarithmic scale.

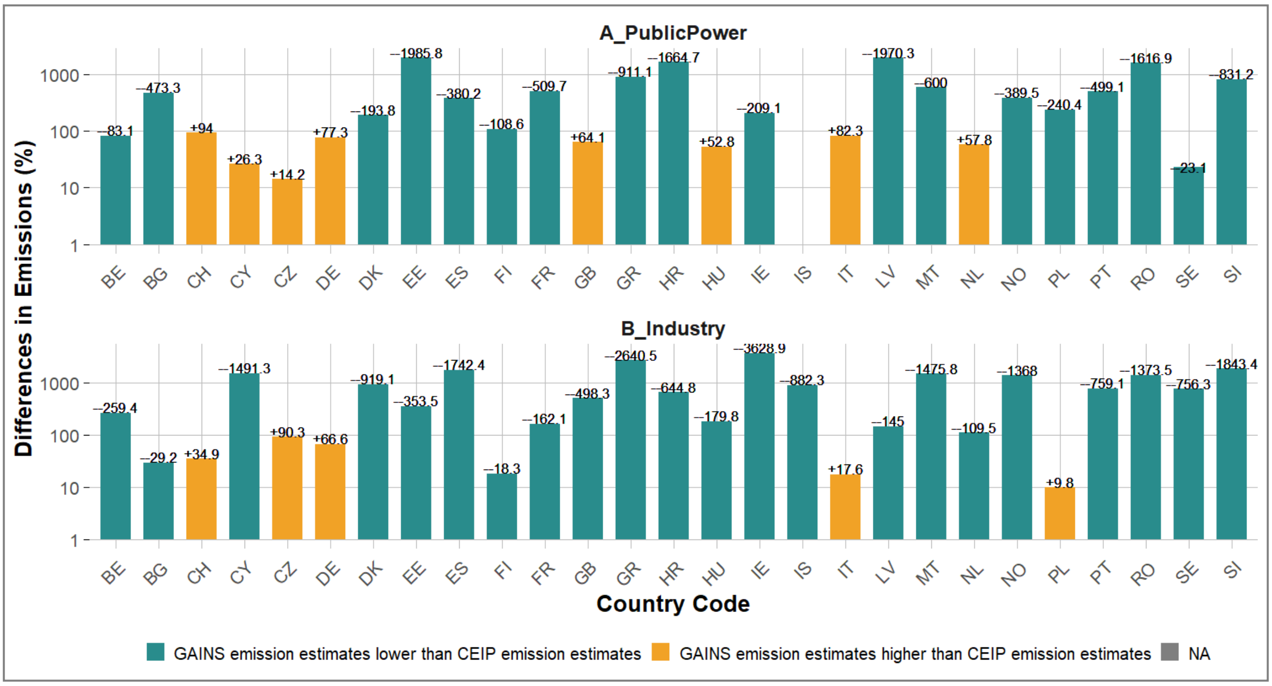


Figure 3: CEIP and GAINS BC emission estimates for the year 2020 for GNFR sectors C_OtherStatComb to D, for each country using a logarithmic scale.

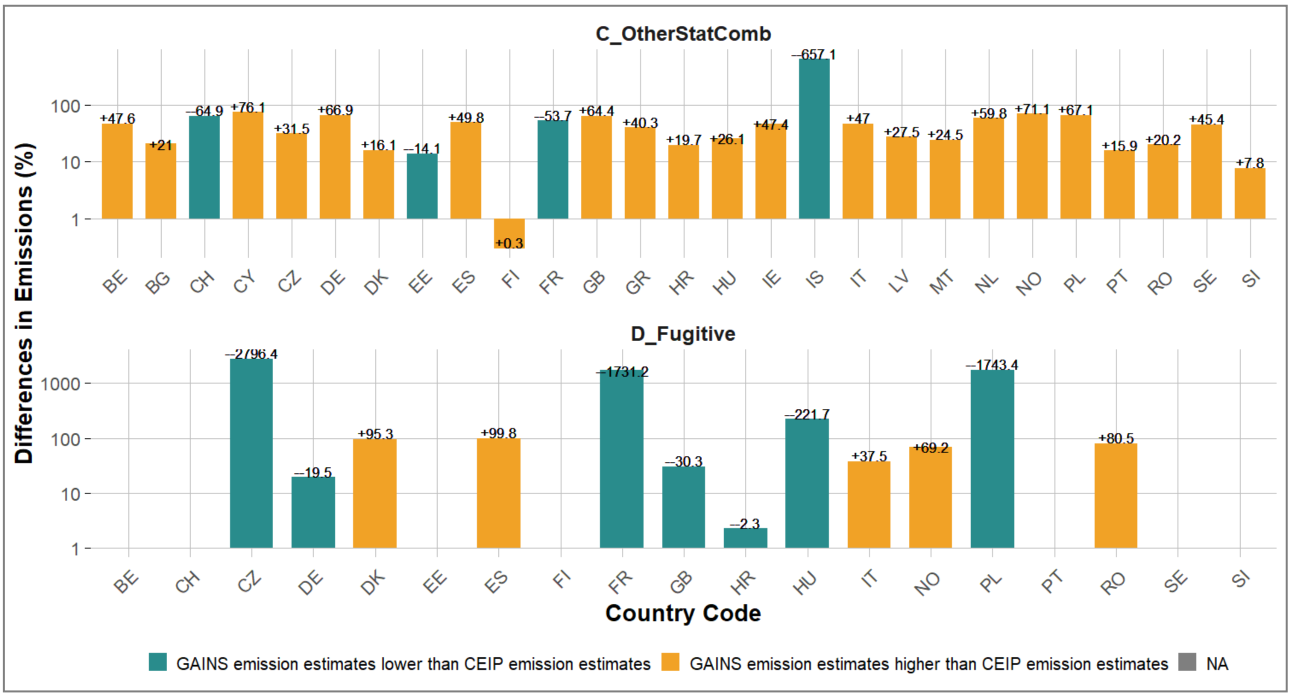


Figure 4: CEIP and GAINS BC emission estimates for the year 2020 for GNFR sectors E_Solvents to F_RoadTransport, for each country using a logarithmic scale.

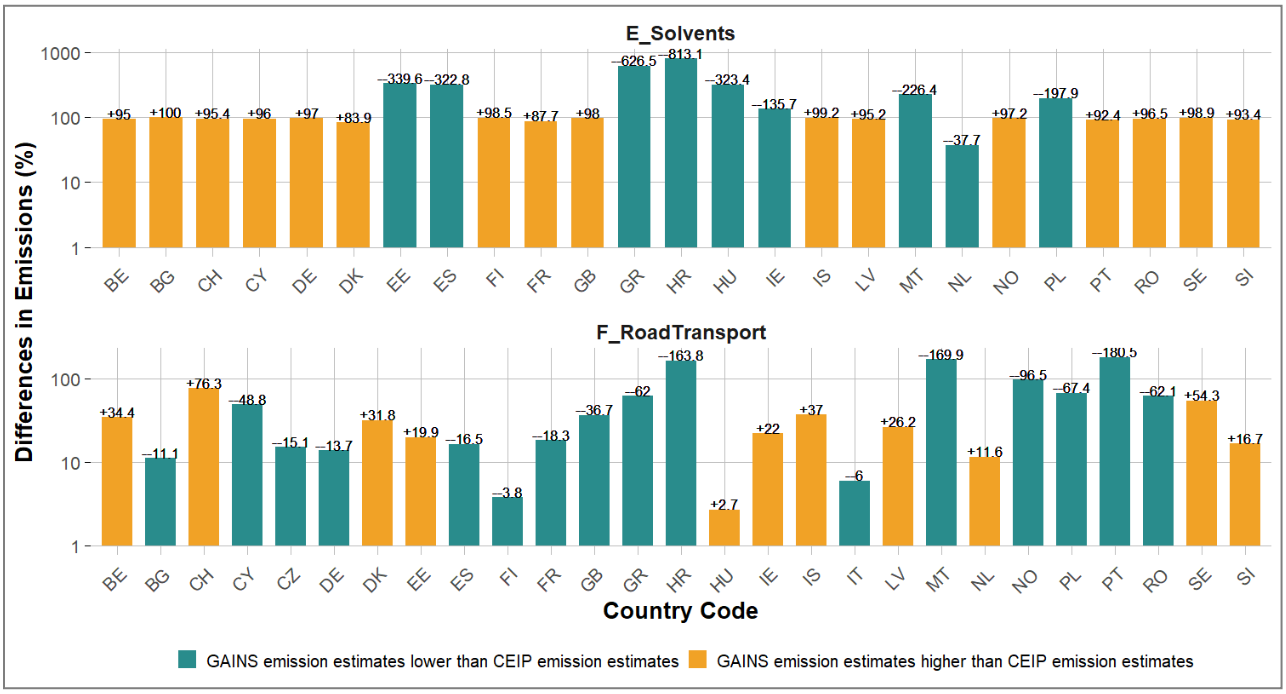


Figure 5: CEIP and GAINS BC emission estimates for the year 2020 for GNFR sectors G_Shipping to H_Aviation, for each country using a logarithmic scale.

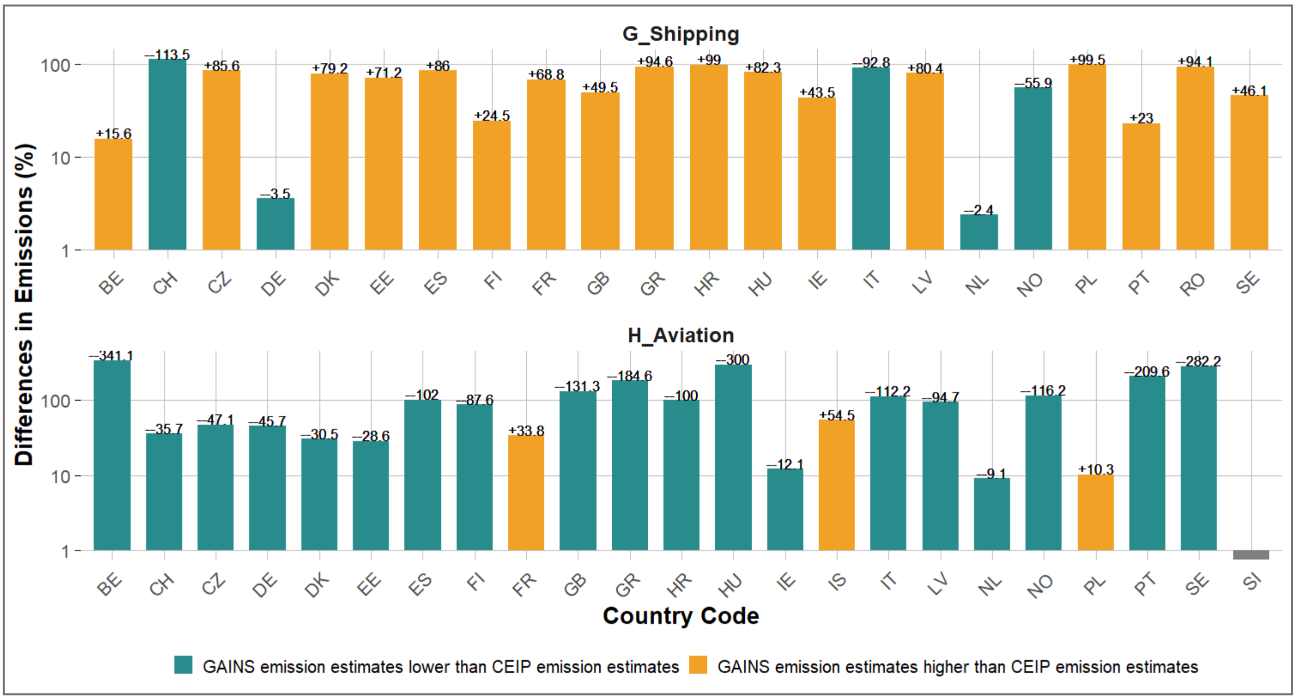


Figure 6: CEIP and GAINS BC emission estimates for the year 2020 for GNFR sectors I_Offroad to J_Waste, for each country using a logarithmic scale.

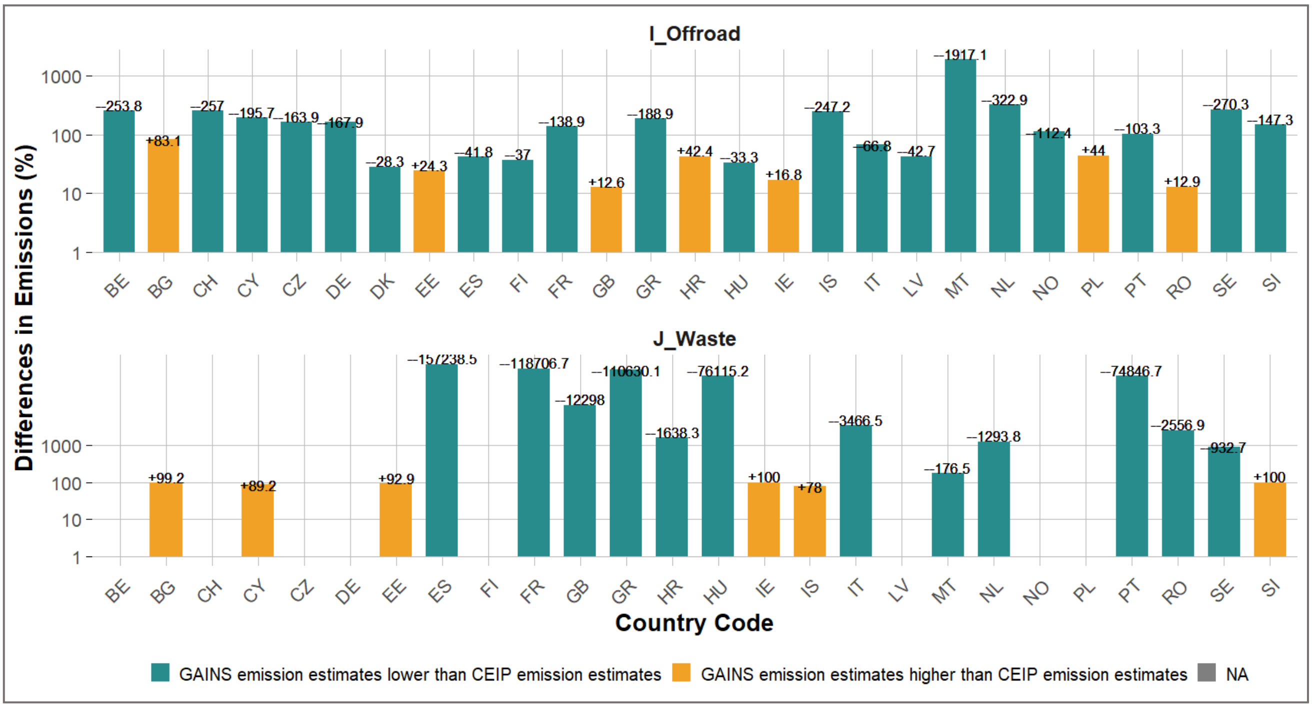
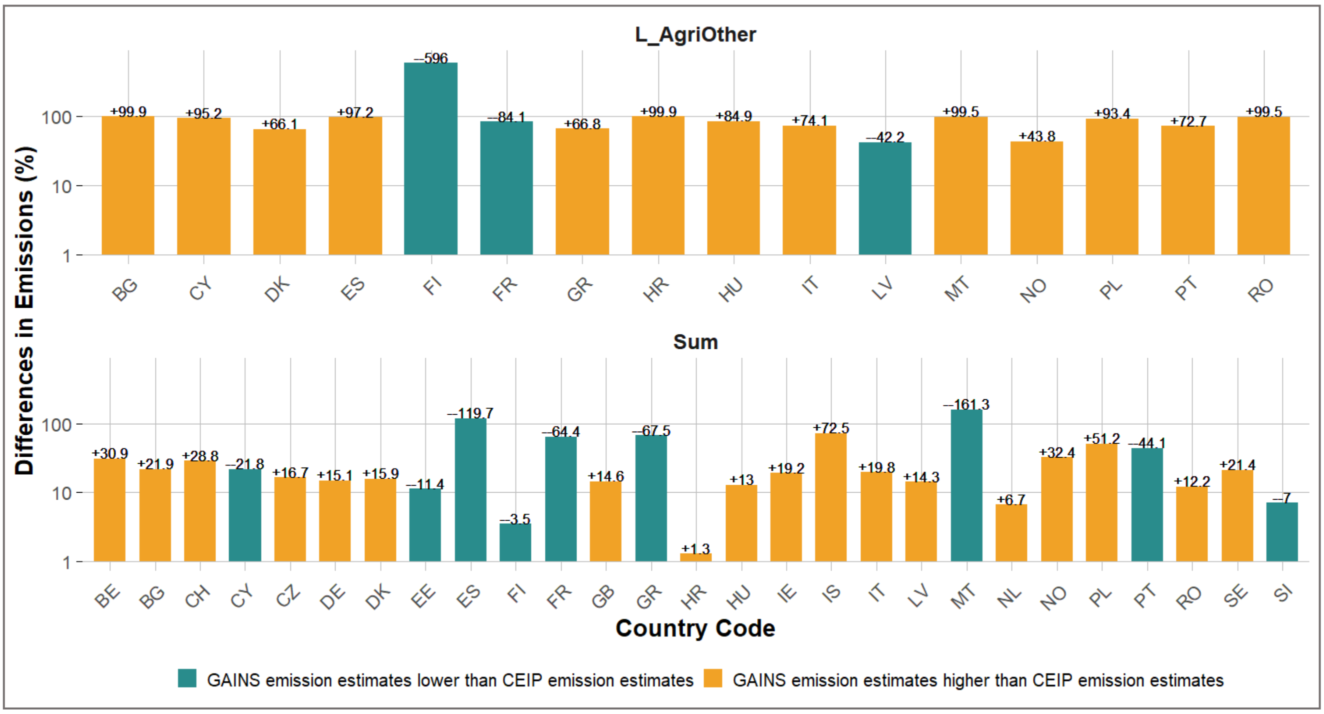


Figure 7: CEIP and GAINS emission estimates for the year 2020 for GNFR sectors L_AgriOther to Sum, for each country using a logarithmic scale.

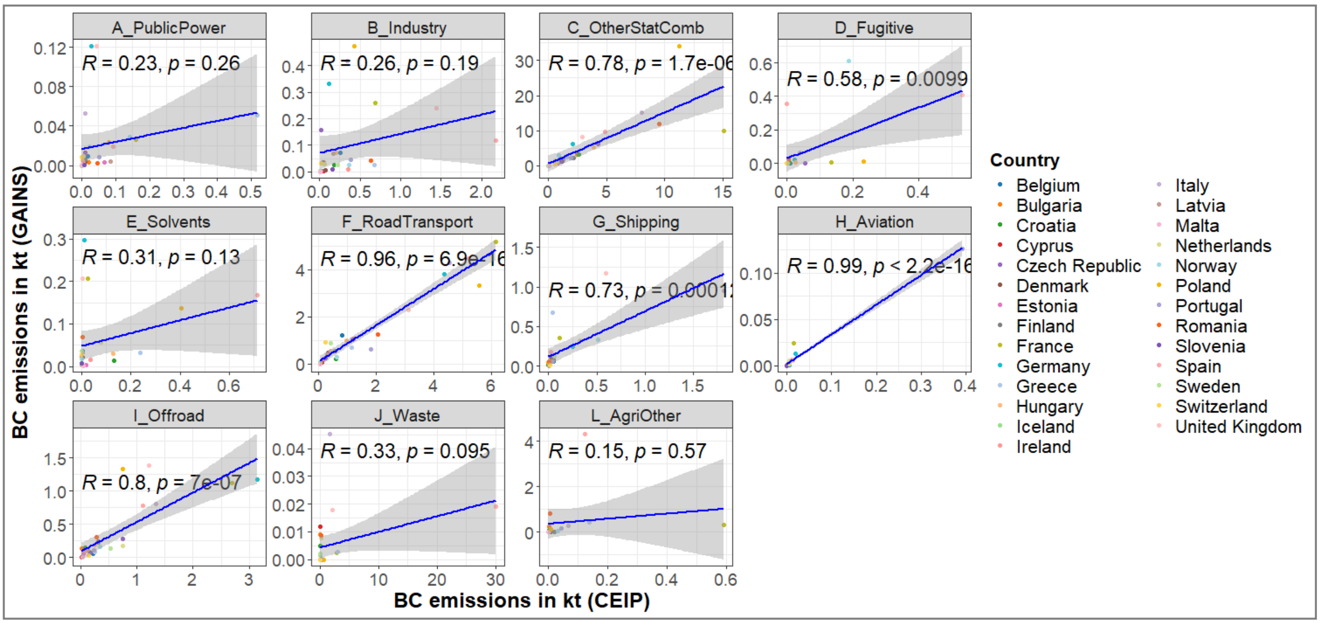


The data comparison between GAINS emission estimates and CEIP emission estimates shows that there are more countries where GAINS emission estimates are lower than CEIP emission estimates for sector A_PublicPower, B_Industry, D_Fugitive, F_RoadTransport, H_Aviation, I_Offroad and

J_Waste (Fig. 2-7). Whilst for sectors C_OtherStatComb, E_Solvents, G_Shipping, L_AgriOther and the Sum of emission estimates, there are more countries where GAINS emission estimates are higher than CEIP emission estimates (Fig. 2-7). Notably, sectors C_OtherStatComb, F_RoadTransport, G_Shipping, H_Aviation, L_AgriOther and the Sum of emission estimates show most differences in emissions estimates below 100% whereas sectors A_PublicPower, B_Industry, D_Fugitive, E_Solvents, I_Offroad and J_Waste exhibit differences in emission estimates above 1000% (Fig. 2-7). Analysing the sum of emission estimates for CEIP and GAINS, most countries have low discrepancy values (< 35%), with Croatia having the lowest difference (1.3%) and Malta having the highest (-161.3 %) (Fig. 7).

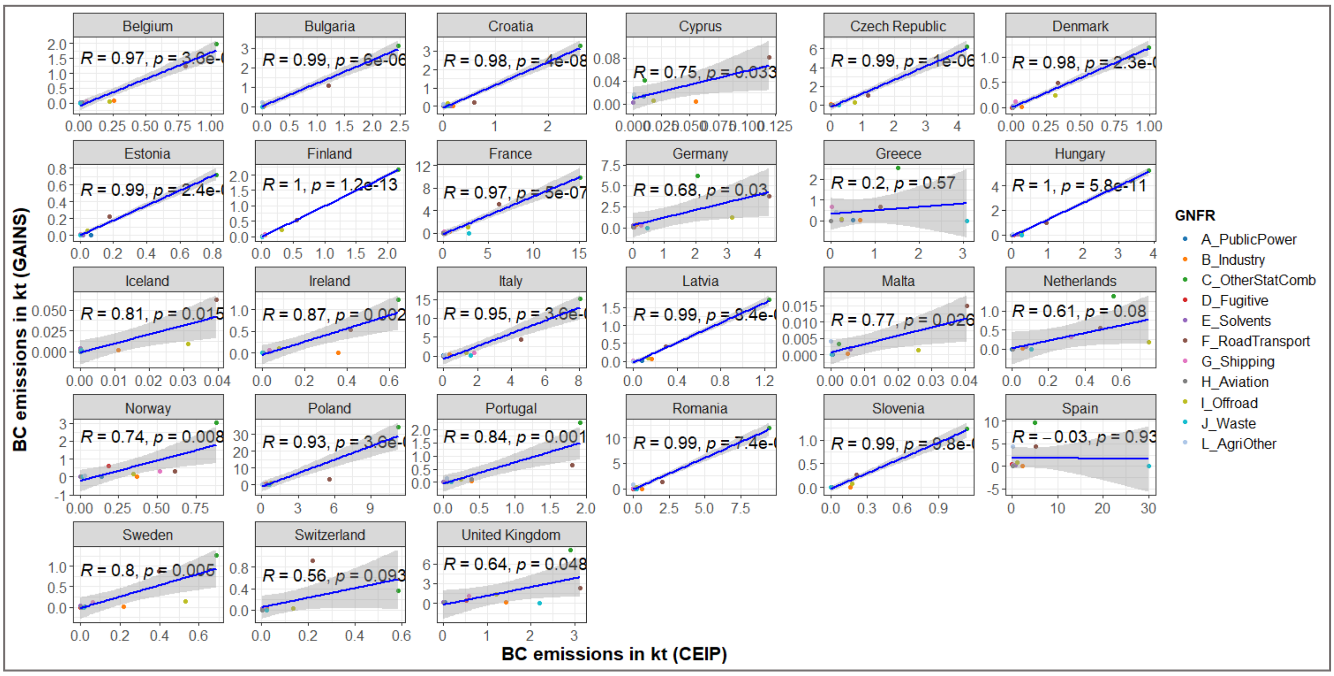
The data reveals a strong correlation between CEIP and GAINS emission estimates in specific sectors, as indicated by high correlation coefficients (R values) (see Fig. 8). These sectors include C_OtherStatComb (R= 0.78), D_Fugitive (R=0.58), F_RoadTransport (R=0.96), G_Shipping (R=0.73), H_Aviation (R=0.99) and I_Offroad (R=0.88), where the correlation coefficients indicate a close relationship between the datasets. In contrast, other sectors, such as A_PublicPower (R=0.23), B_Industry (R=0.26), E_Solvents (R=0.31) and J_Waste (R=0.33) display a weaker correlation between CEIP and GAINS emission estimates (Fig. 8). Sector L_AgriOther shows the lowest correlation between CEIP and GAINS (R=0.15) (Fig. 8). These findings suggest that, while CEIP and GAINS emission estimates are well aligned in certain sectors, there are notable sector-specific variations in the strength of the correlation, with some sectors displaying only modest positive correlations.

Figure 8: Pearson correlation coefficient of CEIP and GAINS BC emission estimates by GNFR sector and country.



The correlation between CEIP and GAINS emission estimates by GNFR sector varies across different countries. Countries such as Cyprus (R=0.75), Germany (R=0.68), Greece (R=0.2), Iceland (R=0.81), Ireland (R=0.87), Malta (R=0.77), Netherlands (R=0.61), Norway (R=0.74), Poland (R=0.93), Portugal (R=0.84), Spain (R=-0.03), Sweden (R=0.8), Switzerland (R=0.56) and the United Kingdom (R=0.64) all have R values below 0.95. Although most of these R values still indicate a strong correlation between CEIP and GAINS emission estimates they are lower compared to the rest of the countries (Fig. 9), with Spain exhibiting the weakest correlation (R=-0.03) and Greece showing the second lowest (R=0.2).

Figure 9: Pearson correlation coefficient of CEIP and GAINS BC emission estimates by country and GNFR sector.



Data comparison between CEIP, GAINS & CAMS

When comparing the BC emission estimates of CEIP, GAINS and CAMS certain sectors show lower differences in emission estimates than other sectors for certain countries (Fig. 10-19). For instance, CEIP emission estimates are lower than CAMS emission estimates for more countries in sectors A_PublicPower, D_Fugitive, J_Waste and L_AgriOther, while CEIP estimates are higher than CAMS for more countries in sectors B_Industry, C_OtherStatComb, F_RoadTransport, G_Shipping, I_Offroad and Sum of emission estimates (Fig. 10-19). Regarding GAINS emission estimates, for more countries, they are lower than CAMS estimates in the following sectors A_PublicPower, B_Industry, D_Fugitive and J_Waste, whereas GAINS estimates are higher than CAMS for more countries in sectors C_OtherStatComb, F_RoadTransport, G_Shipping, I_Offroad, L_AgriOther and Sum of emission estimates (Fig. 10-19).

For the differences between CEIP and CAMS emission estimates, sectors B_Industry, C_OtherStatComb, F_RoadTransport, I_Offroad and the Sum of emission estimates show the majority of differences under 100%, whilst sectors A_PublicPower, D_Fugitive, G_Shipping, J_Waste and L_AgriOther have differences in emission estimates above 1000% (Fig. 10-19). Similarly, for the differences between GAINS and CAMS emission estimates, sectors F_RoadTransport, G_Shipping, L_AgriOther and the Sum of emission estimates have a majority of differences in emissions estimates under 100%, whilst sectors A_PublicPower, B_Industry, C_OtherStatComb, D_Fugitive, I_Offroad and J_Waste have differences in emission estimates above 1000% (Fig. 10-19).

Sectors E_Solvents, H_Aviation and K_AgriLivestock have no CAMS emission estimates for analysis (Fig. 10-19). Albania, Armenia, Austria, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kyrgyzstan, Kazakhstan, Luxembourg, Republic of Moldova, Montenegro, Serbia, Russian Federation, Türkiye, and Ukraine were gap-filled using GAINS data. Liechtenstein and Lithuania could not be included as their datasets were partially gap-filled. Therefore, no comparison was possible, in all data comparison between CEIP emissions estimates and GAINS emission estimates (CEIP, 2024b).

Figure 10: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector A_PublicPower, for each country using a logarithmic scale.

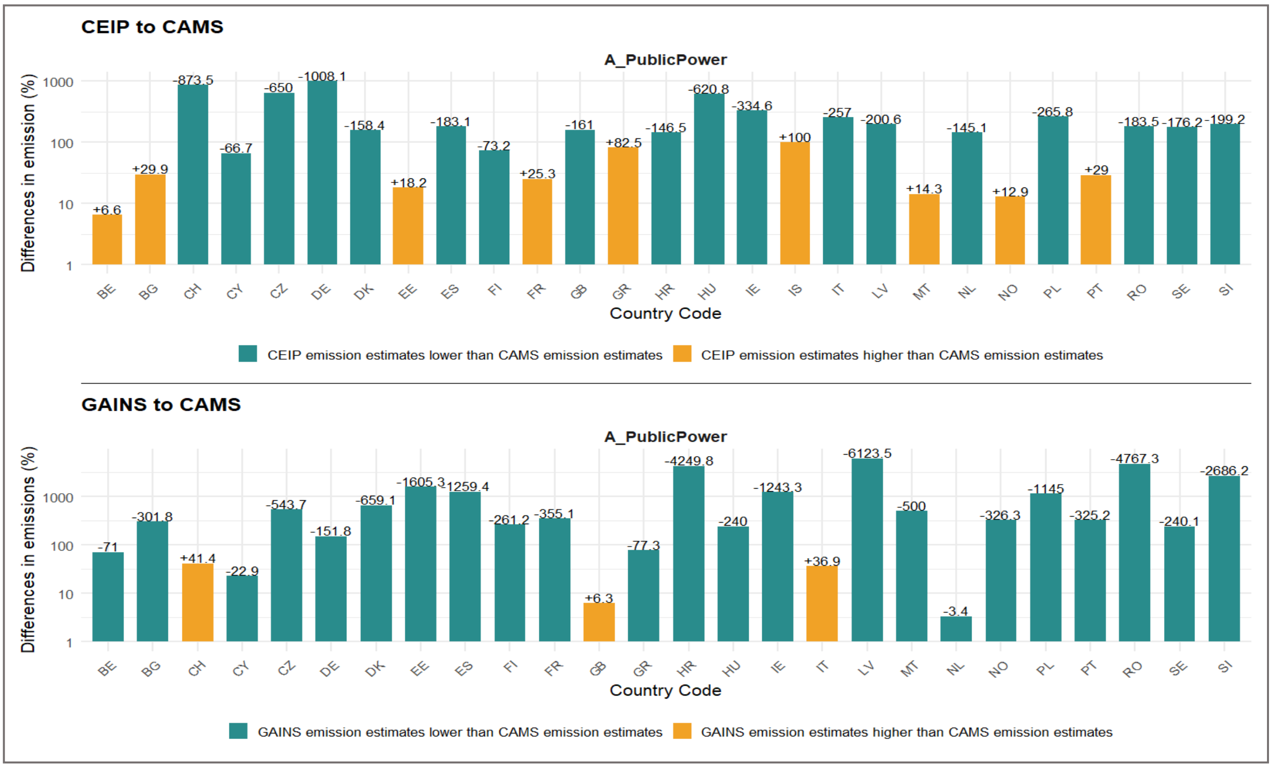


Figure 11: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector B_Industry, for each country using a logarithmic scale.

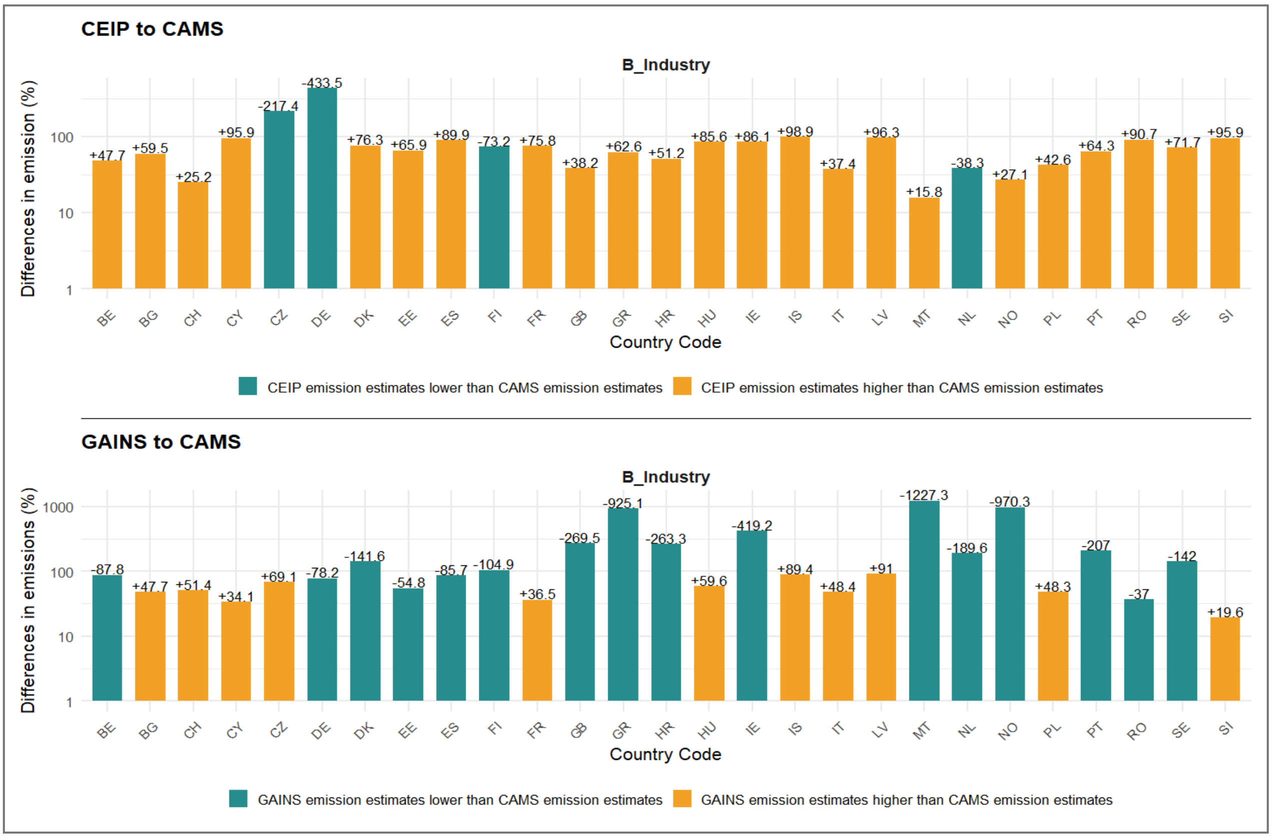


Figure 12: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector C_OtherStatComb, for each country using a logarithmic scale.

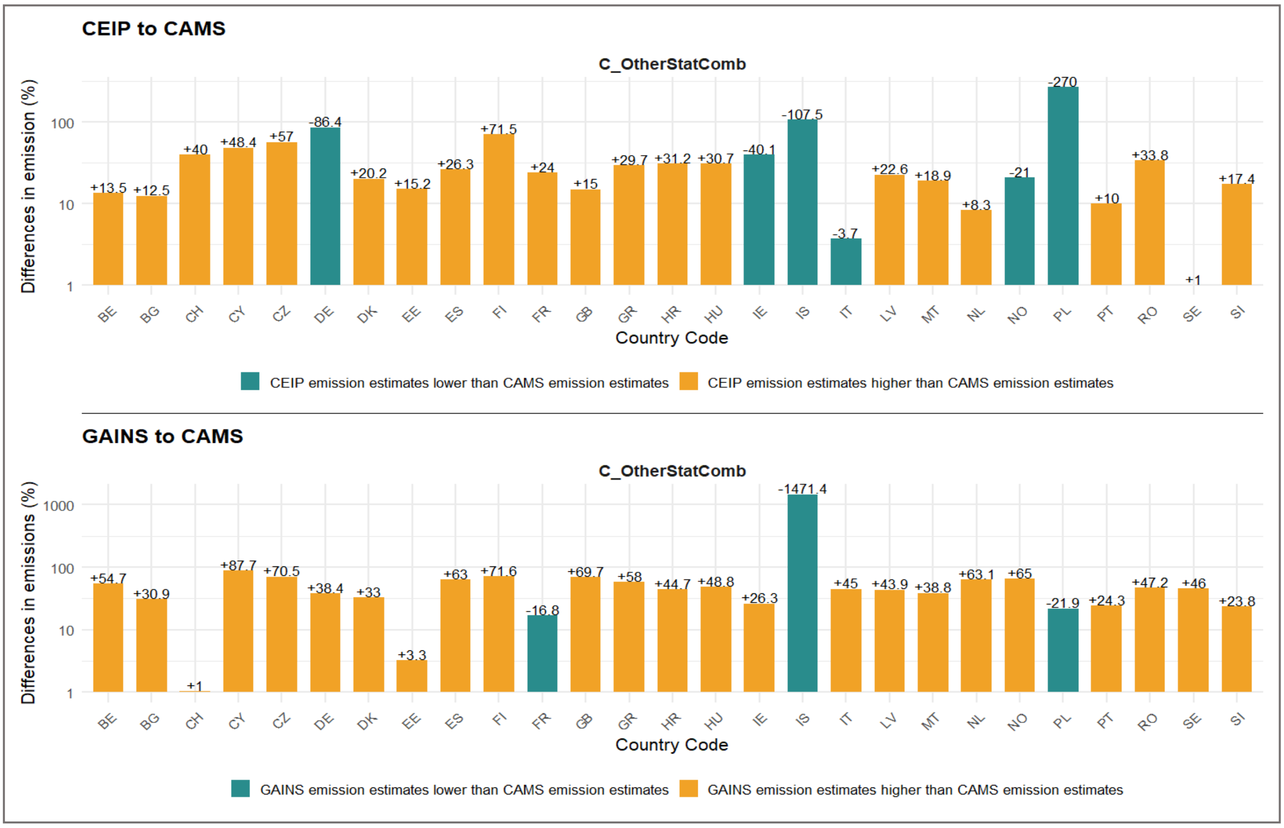


Figure 13: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector D_Fugitive, for each country using a logarithmic scale.

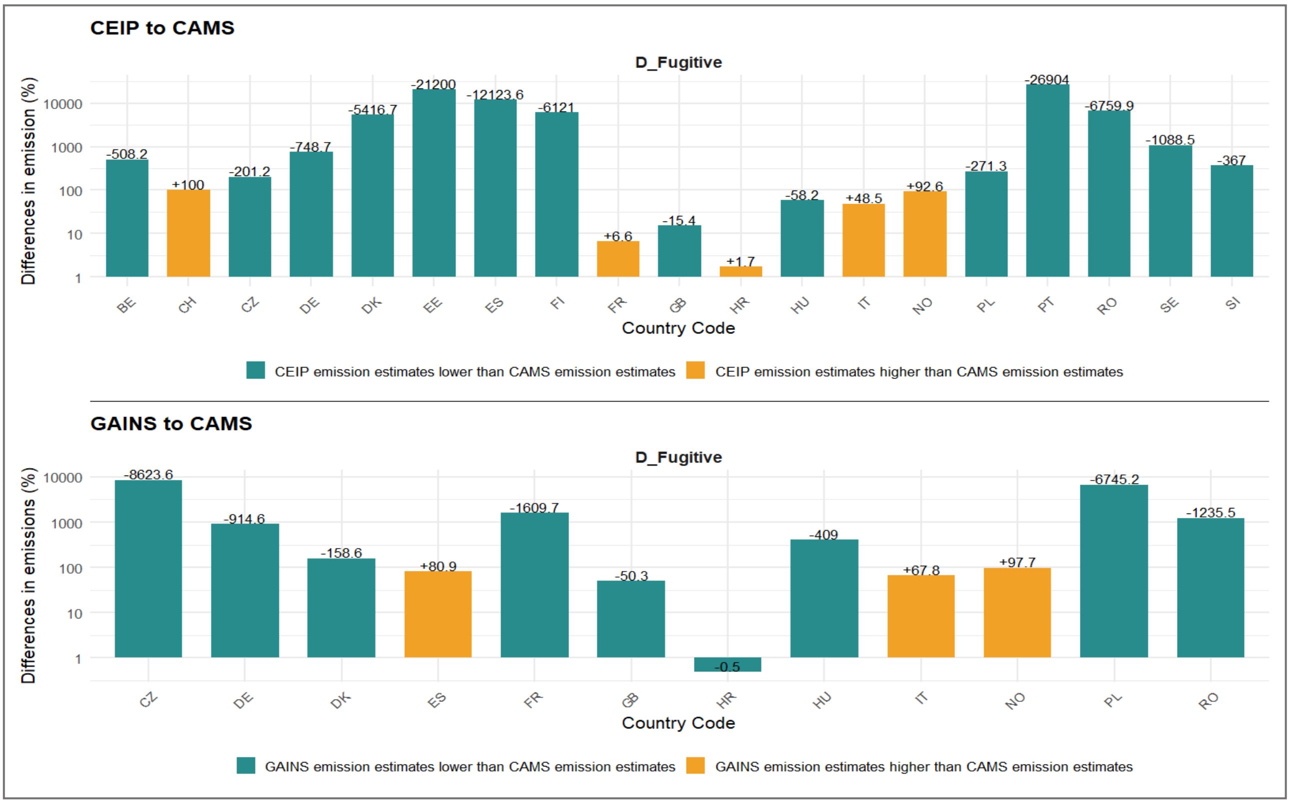


Figure 14: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector F_RoadTransport, for each country using a logarithmic scale.

Figure 15: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector G_Shipping, for each country using a logarithmic scale.

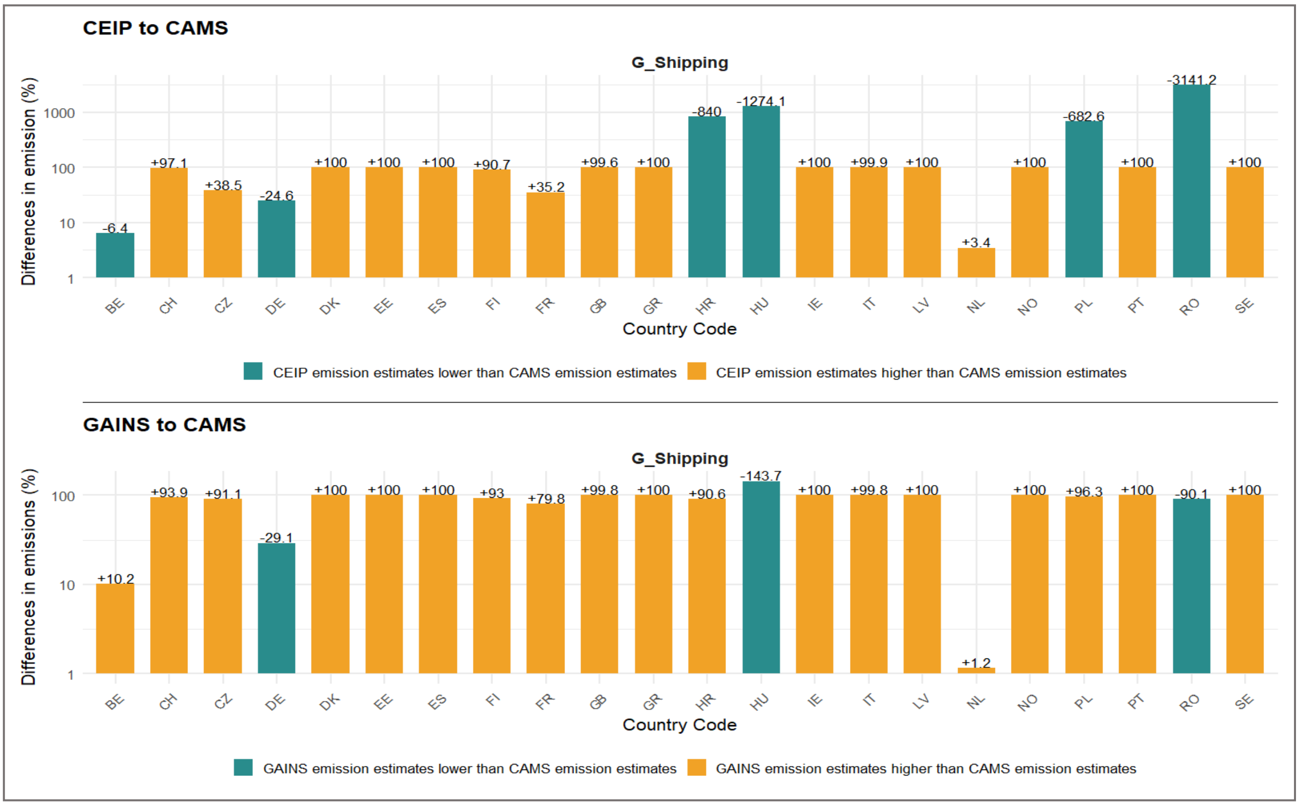


Figure 16: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector I_Offroad, for each country using a logarithmic scale.

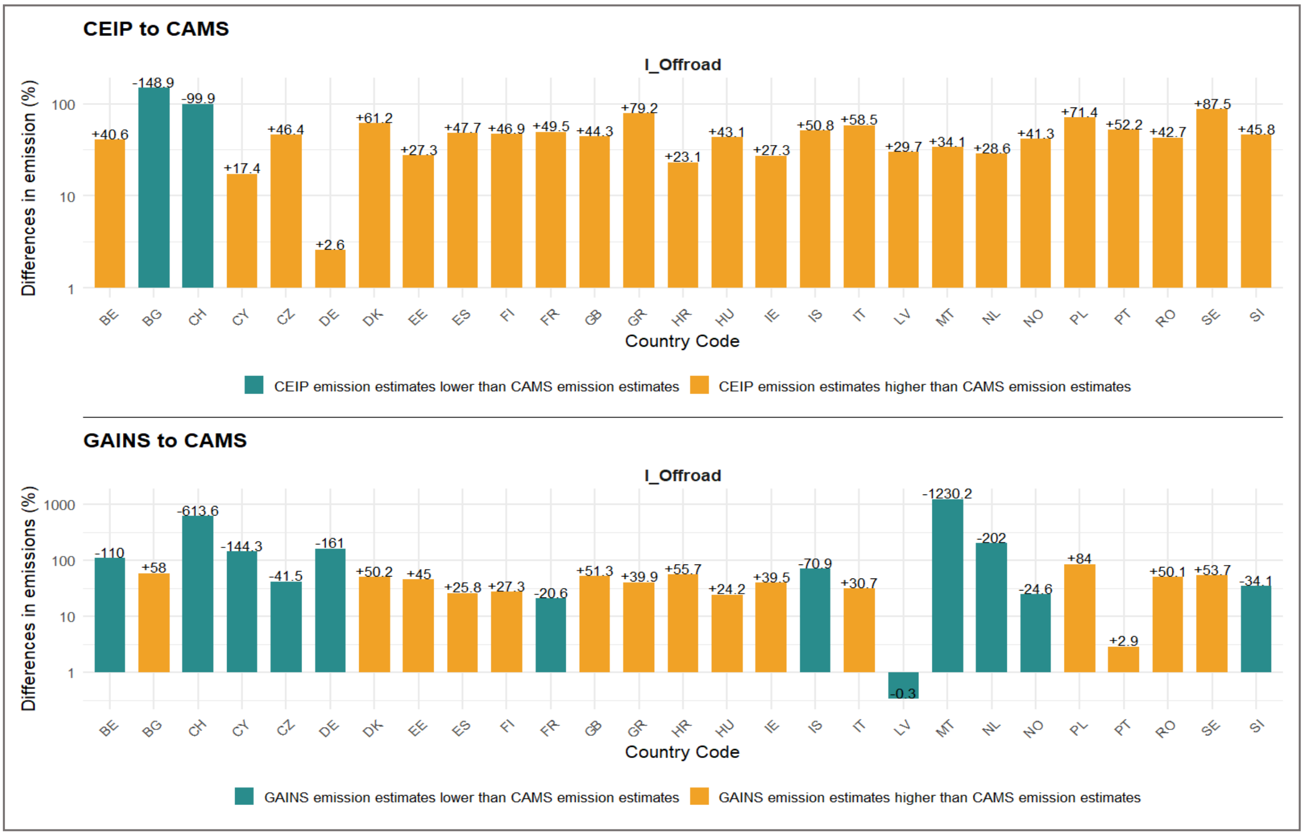


Figure 17: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector J_Waste, for each country using a logarithmic scale.

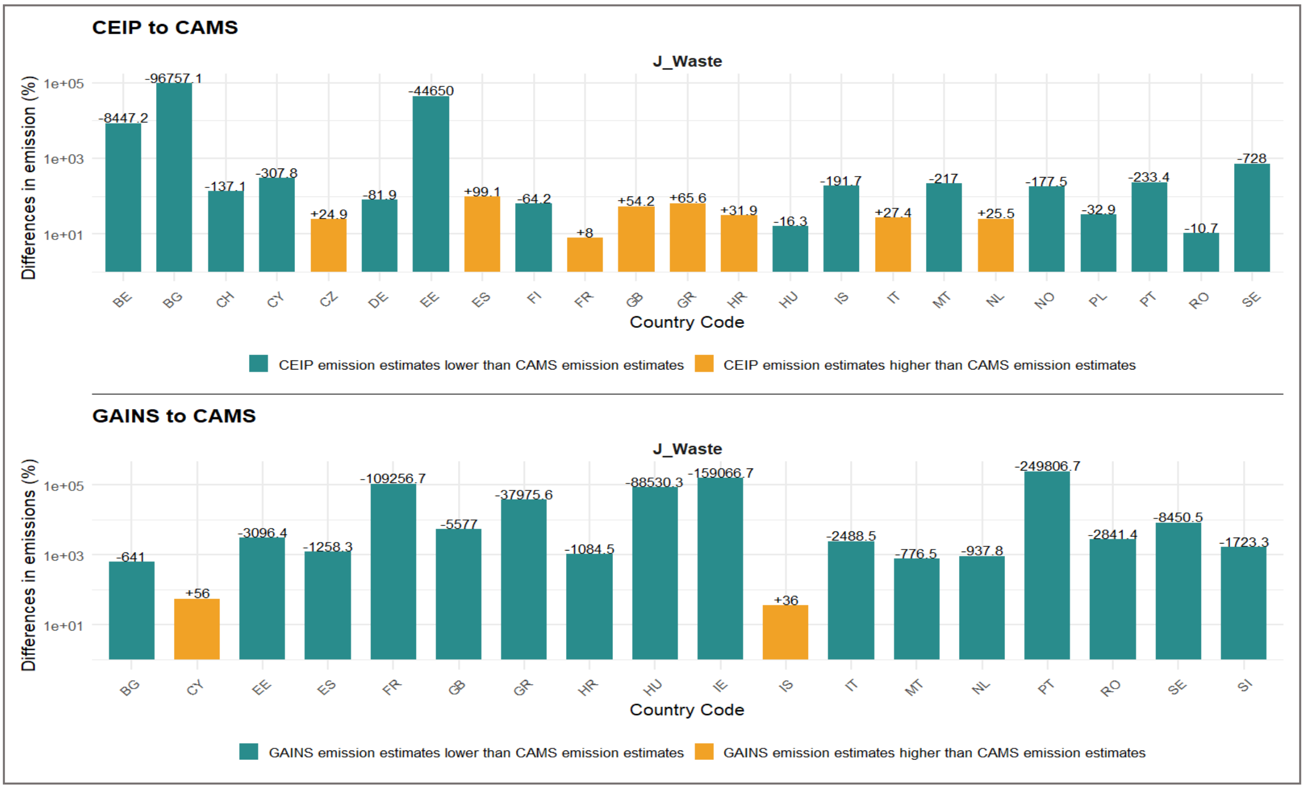


Figure 18: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR sector L_AgriOther, for each country using a logarithmic scale.

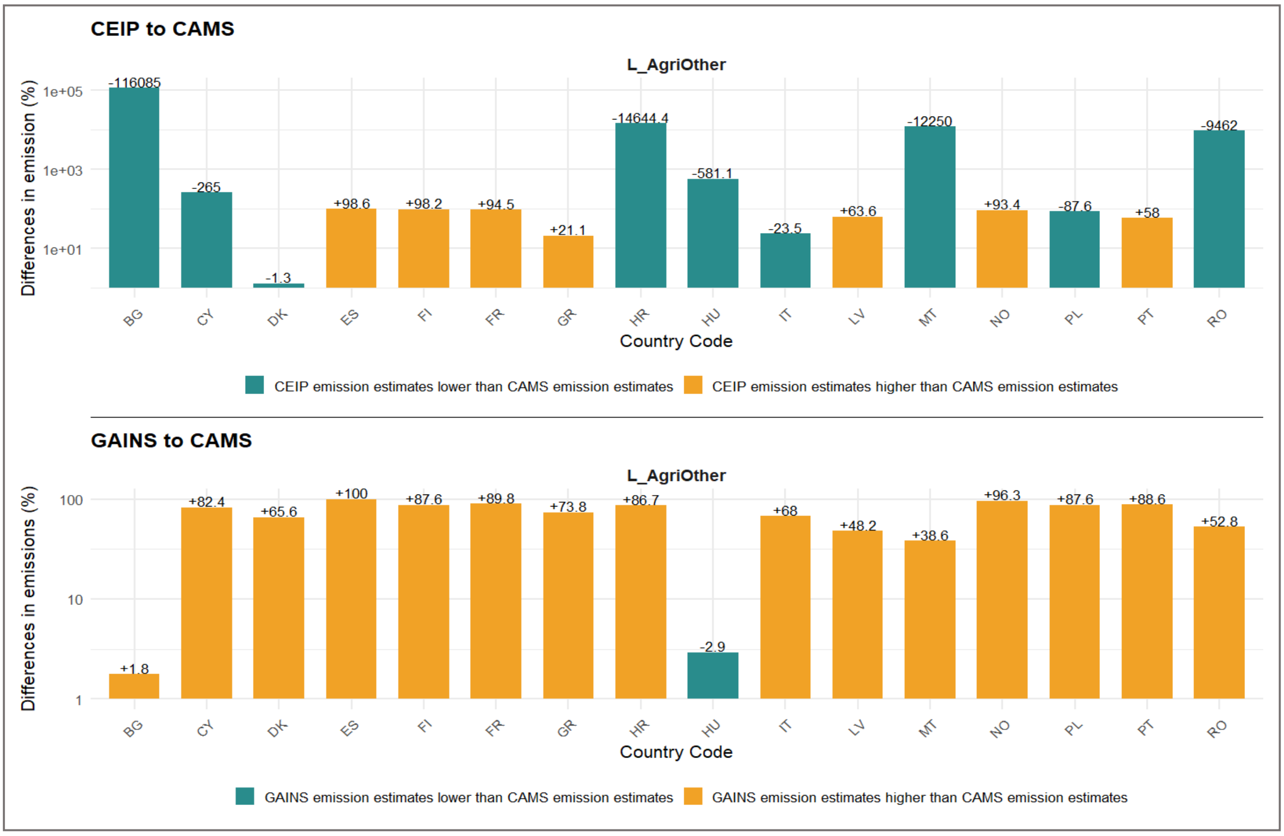
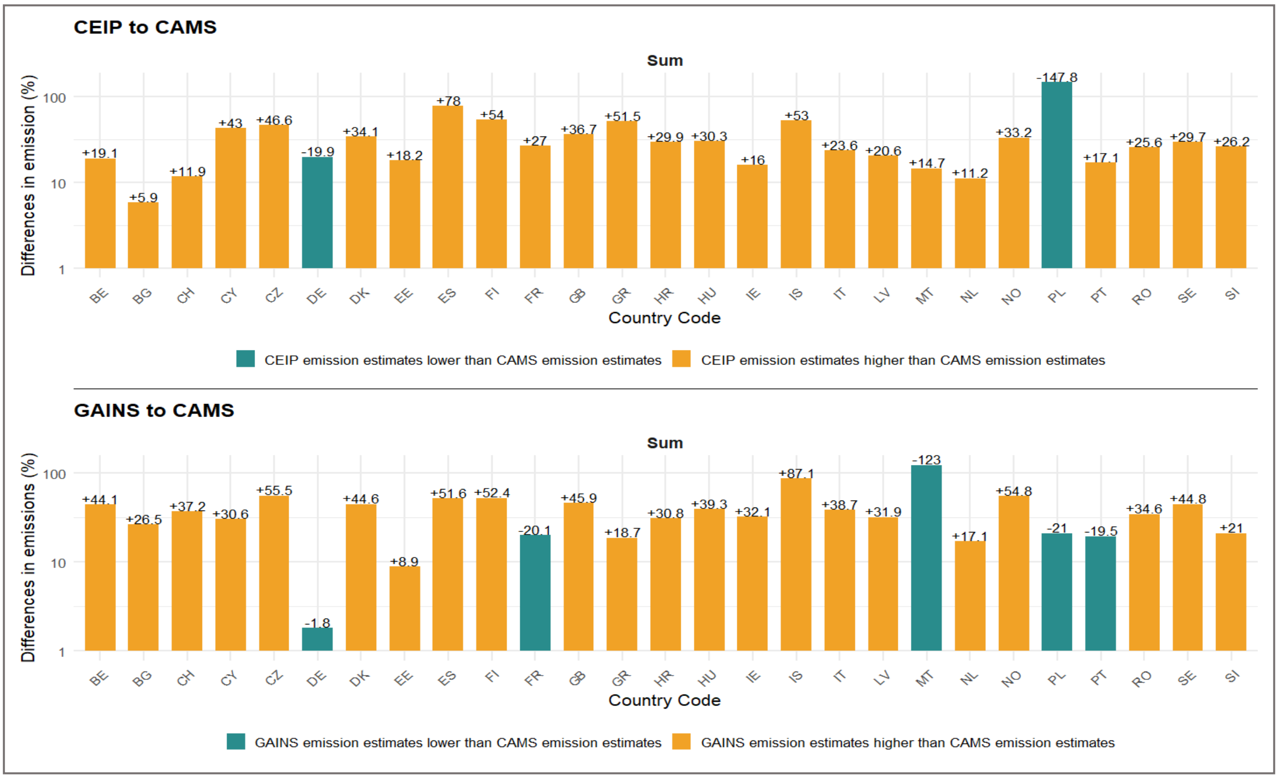


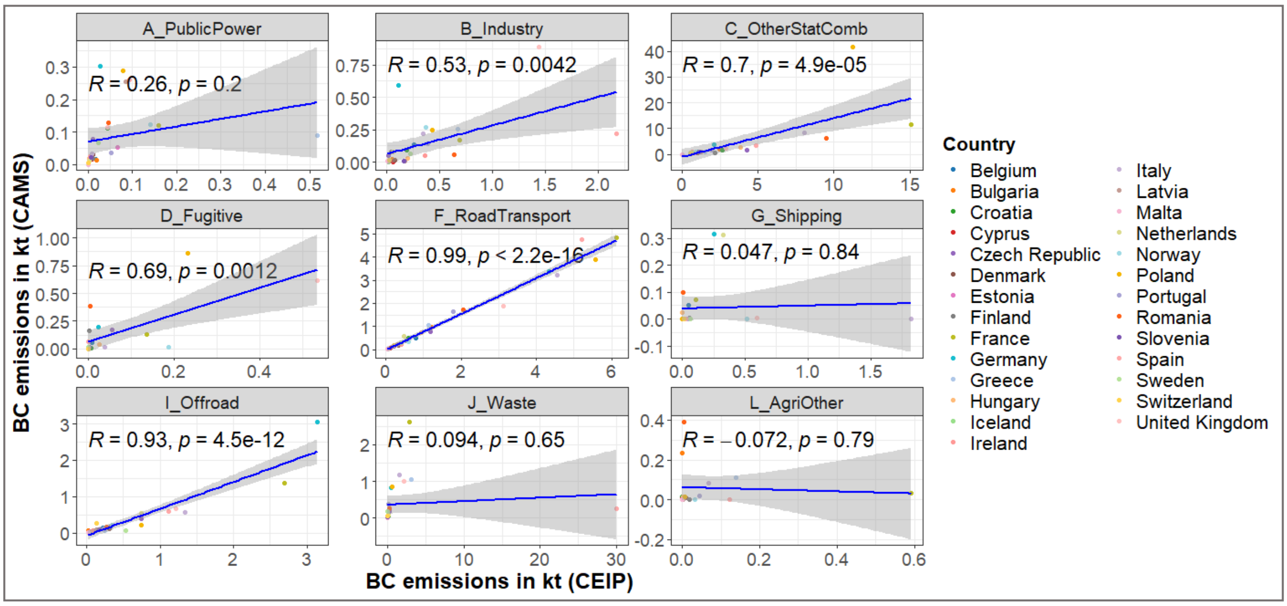
Figure 19: CEIP-CAMS and GAINS-CAMS emission estimates for GNFR the Sum of sectors, for each country using a logarithmic scale.



Analysing the Sum of sectors of emission estimates for CEIP and CAMS, there are only two instances where CEIP emission estimates are lower than CAMS emission estimates with Germany and Poland (Fig. 19). The lowest difference between CEIP emission estimates and CAMS emission estimates is attributed to Bulgaria (5.9 %), whilst Poland has the highest (-147.8 %) (Fig. 19). Comparing the Sum of sectors of emission estimates for GAINS and CAMS there are only five instances where CEIP emission estimates are lower than CAMS emission estimates with Germany, France, Malta, Poland, and Portugal (Fig. 19). The lowest difference between GAINS emission estimates and CAMS emission estimates is attributed to Germany (-1.8 %), whilst Malta has the highest (-123 %) (Fig. 19).

Some sectors show high correlation between CAMS and CEIP emission estimates while the same sector shows low correlation between CAMS and GAINS emission estimates (Fig. 8, 20-21). Five sectors C_OtherStatComb (R=0.7), D_Fugitive (R=0.69), F_RoadTransport (R=0.99) and I_Offroad (R=0.93) have the highest correlation between CAMS and CEIP. While sectors A_PublicPower (R=0.26), B_Industry (R=0.53) have low correlations between the emission estimates. G_Shipping (R=0.047), J_Waste (R=0.094) and L_AgriOther (R=-0.072) have little to no correlation between CAMS and CEIP emission estimates, especially L_AgriOther (Fig. 20). E_Solvents, H_Aviation and K_AgriLivestock have no CAMS emission estimates for analysis (Fig. 20).

Figure 20: Pearson correlation of CAMS and CEIP values by GNFR sector for each country.



Analysing the emission estimates between GAINS and CAMS, there are four sectors B_Industry (R=0.57), C_OtherStatComb (R=0.94), F_RoadTransport (R=0.96) and I_Offroad (R=0.65) which have the highest correlation. While A_PublicPower (R=0.45), D_Fugitive (R=0.12) and J_Waste (R=0.27) have a low correlation for the BC emission estimates between GAINS and CAMS. With G_Shipping (R=0.03) and L_AgriOther (R=0.042) having the lowest, to no correlation (Fig. 21). E_Solvents, H_Aviation and K_AgriLivestock have no values CAMS for analysis (Fig. 21).

Figure 21: Pearson correlation of CAMS and GAINS values by GNFR sector for each country

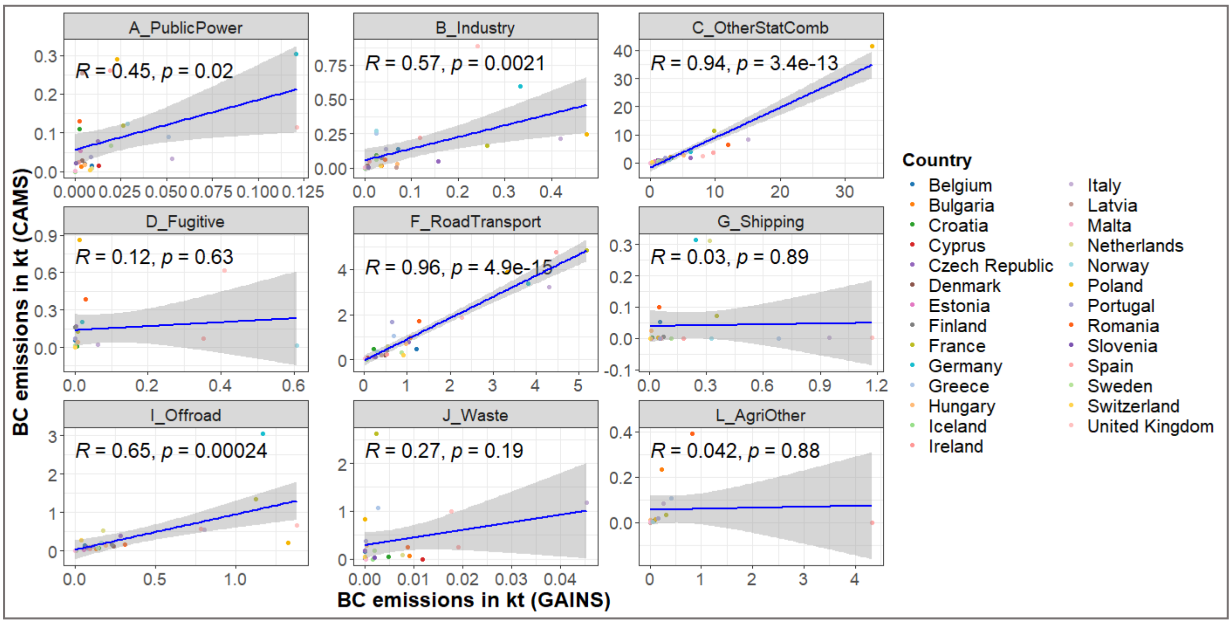
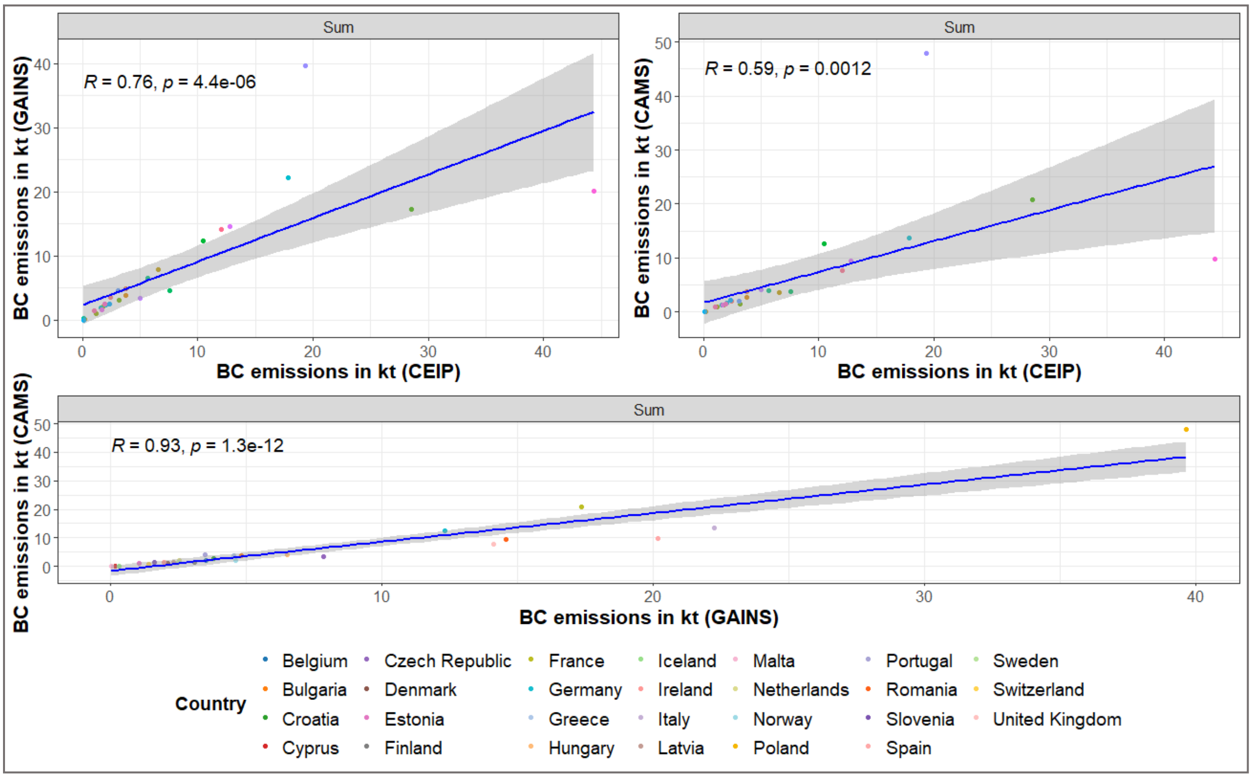


Figure 22: Pearson correlation coefficient of CAMS, CEIP and GAINS sum values for each country.



Whilst CAMS and CEIP emission estimates seem to be relatively correlated to each other, CAMS and GAINS emission estimates are much more correlated than CAMS and CEIP emission estimates (Fig. 22). With the sum of CAMS and GAINS emission estimates having the highest correlation (R=0.93) (Fig. 22), the sum of CEIP and GAINS emission estimates having the second highest correlation (R=0.76) (Fig. 22) and lastly the sum of CEIP and CAMS emission estimates having the lowest correlation (R=0.59) (Fig. 22).

Discussion

Analysis of the methods used to calculate BC emissions

Though BC is not a mandatory pollutant for reporting 42 countries reported BC emissions for 2022. The analysis of three different sectors—1A4bi - Residential Stationary, 1B2C - Venting and Flaring, and 3F - Field burning of agricultural residues—provided a comprehensive overview of the status of black carbon (BC) emissions data submitted by various countries. For the analysis important sectors for the BC emissions were chosen with 1A4bi - Residential Stationary certainly being the most important key source for BC emissions across the EMEP region. For all countries reporting BC emissions under the Air Convention for 1A4bi – residential heating, this source contributes on average 43.75% of total BC emissions in the year 2022. While 1B2C - Venting and Flaring with an average contribution of 0.76% of total BC emissions in the year 2022 on average is a much smaller source, it is an important source for oil and gas producing countries 1B2C - Venting and Flaring, e.g. in Norway and Canada it contributed 6% and 5% to national total BC emissions in 2022. Black carbon emissions from 3F - Field burning of agricultural residues are a minor source, as indicated by the reported data, with an average contribution of 0.5% to the national total emissions in 2022 across all countries that provided data for this source. However, there is satellite-based evidence that BC emissions are underestimated in national reporting in some countries (Amann et al. 2017).

The availability of BC data and the information about the methods applied to derive the data varies across different sectors and countries, reflecting the importance of the sector and the availability of data. A substantial proportion of countries reported BC emissions using Tier 1 and Tier 2 methods, with Tier 1 being the most used across all three analysed sectors. Most countries used a Tier 2 methodology for reporting in sector 1A4bi - Residential Stationary, indicating a relatively high level of BC reporting and more comprehensive information on methodologies. In contrast, Tier 1 methodology was more common in sector 1B2C - Venting and Flaring, as it is a minor source in several countries. Reporting in sector 3F - Field burning of agricultural residues, however, was notably sparse, suggesting that BC emissions in this sector are not well documented by many countries (Table 1). The analysis of the methodologies used to calculate BC emission data also shows a quite high reliance on the EMEP/EEA guidebook with relatively few countries using country specific methods. Out of the 42 countries with available IIRs, Canada, Switzerland, Spain, Finland, Croatia, Latvia and the United Kingdom, demonstrated the highest use of higher tiered methodology across all three sectors (Annex II).

Comparison of CEIP and GAINS and CAMS datasets

Despite sector-specific discrepancies, the overall correlation between GAINS and CAMS was the highest (R = 0.93), while the CAMS-CEIP comparison showed a lower yet still significant correlation (R = 0.76) (Fig. 22). This suggests that, while sector- and country-level differences exist, for most countries and sectors the alignment between the datasets remains strong.

It has to be kept in mind that the three datasets are not completely independent. CEIP data is based on national reported data and gap-filled data. The reported data is mostly based on the EMEP/EEA Guidebook and country specific methods. The gap-filled data is based on GAINS data and interpolations. If the gap-filled data completely relied on GAINS data, it was excluded from the comparison. GAINS uses a bottom-up modelling framework with standardized activity data and emission factors. The CAMS emissions are based on various existing data sets that include the national reported emission inventories (like the CEIP dataset) and also other alternative datasets including the GAINS dataset.

A few countries exhibit very low correlations between the datasets. In these cases, the low or even negative correlations likely reflect fundamental differences in sectoral allocation, activity data selection, or emission factor choice rather than random deviations. Such anomalies highlight the need for targeted review efforts during the annual inventory review process.

Large differences in emission estimates, exceeding 1000% in some sectors and countries, are primarily observed in A_PublicPower, D_Fugitive, J_Waste and L_AgriOther. Like for differences between countries reasons for these discrepancies are differences in sectoral allocation, activity data selection, or emission factor choice.

Future studies could delve deeper into the reasons behind low correlations in certain sectors or countries, potentially identifying areas where data collection methodologies or emission models could be refined. This could lead to more consistent and accurate reporting, thereby improving the reliability of emissions inventories for both regulatory and research purposes.

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Annex I: Crosswalk between NFR and GNFR sectors

Table A 1: Legend explaining the code names of the NFR sectors for source-sector level emissions reporting under the LRTAP Convention and the aggregated GNFR sectors to which they belong

GNFR Code	NFR Code	NFR Long name	Additional Notes
A_PublicPower	1A1a	Public electricity and heat production	
B_Industry	1A1b	Petroleum refining	
B_Industry	1A1c	Manufacture of solid fuels and other energy industries	
B_Industry	1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	
B_Industry	1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	
B_Industry	1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	
B_Industry	1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper, and Print	
B_Industry	1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages, and tobacco	
B_Industry	1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	
I_Offroad	1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	
B_Industry	1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	
H_Aviation	1A3ai(i)	International aviation LTO (civil)	
H_Aviation	1A3aii(i)	Domestic aviation LTO (civil)	
F_RoadTransport	1A3bi	Road transport: Passenger cars	
F_RoadTransport	1A3bii	Road transport: Light duty vehicles	
F_RoadTransport	1A3biii	Road transport: Heavy duty vehicles and buses	
F_RoadTransport	1A3biv	Road transport: Mopeds & motorcycles	
F_RoadTransport	1A3bv	Road transport: Gasoline evaporation	
F_RoadTransport	1A3bvi	Road transport: Automobile tyre and brake wear	
F_RoadTransport	1A3bvii	Road transport: Automobile Road abrasion	
I_Offroad	1A3c	Railways	
G_Shipping	1A3di(ii)	International inland waterways	
G_Shipping	1A3dii	National navigation (shipping)	
I_Offroad	1A3ei	Pipeline transport	
I_Offroad	1A3eii	Other (please specify in the IIR)	
C_OtherStationaryComb	1A4ai	Commercial/institutional: Stationary	
I_Offroad	1A4aii	Commercial/institutional: Mobile	
C_OtherStationaryComb	1A4bi	Residential: Stationary	
I_Offroad	1A4bii	Residential: Household and gardening (mobile)	
C_OtherStationaryComb	1A4ci	Agriculture/Forestry/Fishing: Stationary	
I_Offroad	1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	
I_Offroad	1A4ciii	Agriculture/Forestry/Fishing: National fishing	
C_OtherStationaryComb	1A5a	Other stationary (including military)	
I_Offroad	1A5b	Other, Mobile (including military, land based and recreational boats)	
D_Fugitive	1B1a	Fugitive emission from solid fuels: Coal mining and handling	
D_Fugitive	1B1b	Fugitive emission from solid fuels: Solid fuel transformation	

D_Fugitive	1B1c	Other fugitive emissions from solid fuels	
D_Fugitive	1B2ai	Fugitive emissions oil: Exploration, production, transport	
D_Fugitive	1B2aiv	Fugitive emissions oil: Refining / storage	
D_Fugitive	1B2av	Distribution of oil products	
D_Fugitive	1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	
D_Fugitive	1B2c	Venting and flaring (oil, gas, combined oil, and gas)	
D_Fugitive	1B2d	Other fugitive emissions from energy production	
B_Industry	2A1	Cement production	
B_Industry	2A2	Lime production	
B_Industry	2A3	Glass production	
B_Industry	2A5a	Quarrying and mining of minerals other than coal	
B_Industry	2A5b	Construction and demolition	
B_Industry	2A5c	Storage, handling, and transport of mineral products	
B_Industry	2A6	Other mineral products (please specify in the IIR)	
B_Industry	2B1	Ammonia production	
B_Industry	2B2	Nitric acid production	
B_Industry	2B3	Adipic acid production	
B_Industry	2B5	Carbide production	
B_Industry	2B6	Titanium dioxide production	
B_Industry	2B7	Soda ash production	
B_Industry	2B10a	Chemical industry: Other (please specify in the IIR)	
B_Industry	2B10b	Storage, handling, and transport of chemical products (please specify in the IIR)	
B_Industry	2C1	Iron and steel production	
B_Industry	2C2	Ferroalloys production	
B_Industry	2C3	Aluminium production	
B_Industry	2C4	Magnesium production	
B_Industry	2C5	Lead production	
B_Industry	2C6	Zinc production	
B_Industry	2C7a	Copper production	
B_Industry	2C7b	Nickel production	
B_Industry	2C7c	Other metal production (please specify in the IIR)	
B_Industry	2C7d	"Storage, handling and transport of metal products (please specify in the IIR)"	
E_Solvents	2D3a	Domestic solvent use including fungicides	
B_Industry	2D3b	Road paving with asphalt	
B_Industry	2D3c	Asphalt roofing	
E_Solvents	2D3d	Coating applications	
E_Solvents	2D3e	Degreasing	
E_Solvents	2D3f	Dry cleaning	
E_Solvents	2D3g	Chemical products	
E_Solvents	2D3h	Printing	
E_Solvents	2D3i	Other solvent use (please specify in the IIR)	
E_Solvents	2G	Other product use (please specify in the IIR)	
B_Industry	2H1	Pulp and paper industry	
B_Industry	2H2	Food and beverages industry	
B_Industry	2H3	Other industrial processes (please specify in the IIR)	
B_Industry	2I	Wood processing	
B_Industry	2J	Production of POPs	
B_Industry	2K	"Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)"	
B_Industry	2L	Other production, consumption, storage, transportation, or handling of bulk products (please specify in the IIR)	
K_AgriLivestock	3B1a	Manure management - Dairy cattle	
K_AgriLivestock	3B1b	Manure management - Non-dairy cattle	
K_AgriLivestock	3B2	Manure management - Sheep	

K_AgriLivestock	3B3	Manure management - Swine	
K_AgriLivestock	3B4a	Manure management - Buffalo	
K_AgriLivestock	3B4d	Manure management - Goats	
K_AgriLivestock	3B4e	Manure management - Horses	
K_AgriLivestock	3B4f	Manure management - Mules and asses	
K_AgriLivestock	3B4gi	Manure mangement - Laying hens	
K_AgriLivestock	3B4gii	Manure mangement - Broilers	
K_AgriLivestock	3B4giii	Manure management - Turkeys	
K_AgriLivestock	3B4giv	Manure management - Other poultry	
K_AgriLivestock	3B4h	Manure management - Other animals (please specify in IIR)	
L_AgriOther	3Da1	Inorganic N-fertilizers (also includes urea application)	
L_AgriOther	3Da2a	Animal manure applied to soils	
L_AgriOther	3Da2b	Sewage sludge applied to soils	
L_AgriOther	3Da2c	"Other organic fertilisers applied to soils (including compost)"	
L_AgriOther	3Da3	Urine and dung deposited by grazing animals	
L_AgriOther	3Da4	Crop residues applied to soils	
L_AgriOther	3Db	Indirect emissions from managed soils	
L_AgriOther	3Dc	Farm-level agricultural operations including storage, handling, and transport of agricultural products	
L_AgriOther	3Dd	Off-farm storage, handling, and transport of bulk agricultural products	
L_AgriOther	3De	Cultivated crops	
L_AgriOther	3Df	Use of pesticides	
L_AgriOther	3F	Field burning of agricultural residues	
L_AgriOther	3I	Agriculture other (please specify in the IIR)	
J_Waste	5A	Biological treatment of waste - Solid waste disposal on land	
J_Waste	5B1	Biological treatment of waste - Composting	
J_Waste	5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities	
J_Waste	5C1a	Municipal waste incineration	
J_Waste	5C1bi	Industrial waste incineration	
J_Waste	5C1bii	Hazardous waste incineration	
J_Waste	5C1biii	Clinical waste incineration	
J_Waste	5C1biv	Sewage sludge incineration	
J_Waste	5C1bv	Cremation	
J_Waste	5C1bvi	Other waste incineration (please specify in the IIR)	
J_Waste	5C2	Open burning of waste	
J_Waste	5D1	Domestic wastewater handling	
J_Waste	5D2	Industrial wastewater handling	
J_Waste	5D3	Other wastewater handling	
J_Waste	5E	Other waste (please specify in IIR)	
M_Other	6A	Other (included in national total for entire territory) (please specify in IIR)	

Annex II: Tier analysis for each country for 1A4bi, 1B2C and 3F

Table A 2: Legend explaining the Tier methodology for the three NFR sectors for each country

CLRTAP Parties	**Informative Inventory Report**		**Tier methodology for 1A4bi**	**Tier methodology for 1B2C**	**Tier methodology for 3F**
	Submission year	Language			
Albania (AL)	2024	English	Tier 1	Tier 1	Tier 1
Armenia (AM)	2024	English	Tier 1	No information/NA	No information/NA
Belgium (BE)	2024	English	Tier 2	No information/NA	No information/NE
Bulgaria (BG)	2024	English	Tier 1	Tier 1	Tier 1
Canada (CA)	2024	English/French	Tier 2	Tier 2	Tier 2
Switzerland (CH)	2024	English	Tier 2	Tier 3	No information/NA
Cyprus (CY)	2024	English	Tier 1	Tier 1	Tier 1
Czechia (CZ)	2024	English	Tier 2	Tier 1	No information/NE
Germany (DE)	2024	English	Tier 2	No Information /NE	No information/NE
Denmark (DK)	2024	English	Tier 1	Tier 2	No information/NE
Estonia (EE)	2024	English	Tier 2	No information / NE	No information/NE
Spain (ES)	2024	English	Tier 1/Tier 2	Tier 1/Tier 2	Tier 2
Finland (FI)	2024	English	Tier 2	Tier 2	Tier 2
France (FR)	2024	French	Tier 1	Tier 1	Tier 2
UK (GB)	2024	English	Tier 1/Tier 2	Tier 1/Tier 2	Tier 1
Greece (GR)	2024	English	Tier 1	Tier 1	No information/NA
Croatia (HR)	2024	English	Tier 2	Tier 1	Tier 2
Hungary (HU)	2024	English	Tier 2	Tier 1	Tier 1
Ireland (IE)	2024	English	Tier 2	Tier 1	No information/NA
Iceland (IS)	2024	English	Tier 1	No information/NA	No information/NA
Italy (IT)	2024	English	Tier 2	No information/ NA	Tier 1

Kazakhstan (KZ)	2024	English	No information/NA	No information/NA	No information/NA
Liechtenstein (LI)	2024	English	Tier 1	No information/NA	No information/NA
Lithuania (LT)	2024	English	Tier 2	No information/NA	No information/NA
Luxembourg (LU)	2024	English	No information/ NA	No information/NA	No information/NA
Latvia (LV)	2024	English	Tier 2	Tier 2	No information/NA
Monaco (MC)	2024	French	Tier 1	No information/NA	No information/NA
Montenegro (ME)	2024	English	Tier 1	No information/NA	Tier 1
North Macedonia (MK)	2024	English	Tier 1	No Information/ NA	No information/ NA
Malta (MT)	2024	English	Tier 1/Tier 2	No information/NA	Tier 1
Netherlands (NL)	2024	English	Tier 1/Tier 2	Tier 1	No information/NA
Norway (NO)	2024	English	Generalized Tier 1	Generalized Tier 1	Tier 1
Poland (PL)	2024	English	Tier 2	Tier 1	Tier 1
Portugal (PT)	2024	English	Tier 1/Tier 2	No information /NE	Tier 1
Romania (RO)	2024	English	Tier 1	Tier 1	Tier2
Serbia (RS)	2024	English	Tier 1	Tier 1	Tier 1
Russian Federation (RU)	2024	Russian	No information/NA	No information/NA	No information/NA
Sweden (SE)	2024	English	No information/NA	Tier 1	No information/NA
Slovenia (SI)	2024	English	Tier 2	Tier 1	No information/NA
Slovakia (SK)	2024	English	Tier 2	Tier 1	No information/NA
Türkiye (TR)	2024	English	Tier 1	No information/NA	No information/NA
Ukraine (UA)	2024	English	No information/NE	No information/NE	No information/NA

Annex III: Pearson R values CAMS, CEIP and GAINS

Table A 3: Legend explaining the R values between CAMS, CEIP and GAINS for all GNFR sectors (except sum).

CLRTAP Parties	CEIP / GAINS correlation (R value)	CEIP / CAMS correlation (R value)	CAMS / GAINS correlation (R value)
Belgium (BE)	0.97	0.96	0.98
Bulgaria (BG)	0.99	0.99	0.99
Croatia (HR)	0.98	1	0.98
Cyprus (CY)	0.75	0.88	0.86
Czechia (CZ)	0.99	0.99	0.96
Denmark (DK)	0.98	0.98	0.98
Estonia (EE)	0.99	1	0.99
Finland (FI)	1	0.91	0.91
France (FR)	0.97	1	0.97
Germany (DE)	0.68	0.9	0.87
Greece (GR)	0.2	0.85	0.54
Hungary (HU)	1	1	0.99
Iceland (IS)	0.81	0.97	0.86
Ireland (IE)	0.87	0.85	0.98
Italy (IT)	0.95	0.97	0.98
Latvia (LV)	0.99	0.97	0.96
Malta (MT)	0.77	0.97	0.88
Moldova (MD)	0.97	0.59	0.58
Netherlands (NL)	0.61	0.95	0.69
Norway (NO)	0.74	0.82	0.9
Poland (PL)	0.93	0.93	1
Portugal (PT)	0.84	0.97	0.83
Romania (RO)	0.99	0.99	0.99
Slovenia (SI)	0.99	0.99	1
Spain (ES)	-0.03	0.082	0.75
Sweden (SE)	0.8	0.77	0.94
Switzerland (CH)	0.56	0.89	0.53
UK (GB)	0.64	0.94	0.8

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