Temporal Disaggregation of Emissions Data for the Climate TRACE Inventory

Krsna Raniga[1,3], Dan Moore[1,3], Zoheyr Doctor[1,3], Christy Lewis[1,3], Lekha Sridhar[1,3], Peter Thomas[1,3], Ishan Saraswat[1,3], Gary Collins[2,3], April Nellis[2,3], Nicole Brown[2,3], Michael Pekala[2,3], Justin Rokisky[2,3], Elizabeth Reilly[2,3], Marisa Hughes[2,3], and Gavin McCormick[1,3]

1) WattTime, 2) Johns Hopkins University Applied Physics Laboratory, 3) Climate TRACE

1 Introduction

Greenhouse gas (GHG) emissions reporting inventories typically publish estimates at temporal granularities best suited to their specific expected use cases, with distinctions often made between scientific applications and regulatory accounting needs. For example, the Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines establish emissions reporting at the annual level as good-practice, consistent with its policy-driven objectives (IPCC, 2006). On the other hand, atmospheric and climate modeling use cases, supported by sources such as Emissions Database for Global Atmospheric Research (EDGAR), require data at finer timescales to capture sub-annual variability (Janssens-Maenhout et. al., 2019).

Up to its V3 release in 2023, the Climate TRACE inventory only provided GHG emissions data at an annual level. However, in the V4 release for 2024, Climate TRACE will publish monthly emissions data for CO_2, N_2O, CH_4, and non-greenhouse-gas (non-GHG) emissions, for all emissions sources and countries for years 2021-2024. This was done through a combination of native-monthly data as generated by Climate TRACE sector leads and external scale factors applied to any non-monthly data. This finer temporal resolution ensures completeness and consistency of the inventory for most arbitrary spatio-temporal analyses, while allowing insight into the effects of seasonality, economic fluctuations, and other driving factors of short-term emissions dynamics.

2 Materials and Methods

2.1 Datasets employed

The EDGAR Temporal Profiles (r1) dataset was used to disaggregate annual values to monthly values as shown in Figure 1. These profiles are available by country and by sector as defined in the IPCC 2006 guidelines (Crippa et. al, 2020). If a Climate TRACE sector natively reported their emissions at the monthly level, the data was not further modified.

The EDGAR r1 sectors were mapped to Climate TRACE (hereafter, “TRACE”) sectors manually, where the relationships could generally be many-to-many TRACE-to-EDGAR sectors (see supplementary materials, Section 6 Table 1, for mapping). For a given TRACE sector with such a relationship, its profile was initialized by taking an unweighted average of the constituent r1 sectors. For an r1 sector which mapped to multiple TRACE sectors, the same profile was applied to each TRACE sector without additional manipulation.

2.2 Source Methods

2.2.1 Temporal Granularity Cases

Based on start and end times for an entry for a given emissions source (point or area), its temporal granularity was computed to classify the timestamp as annual, quarterly, monthly, or other - where other signified some arbitrary timestamp which may have crossed month or year boundaries. The decision map for transformation to monthly emissions is shown in Fig. 1

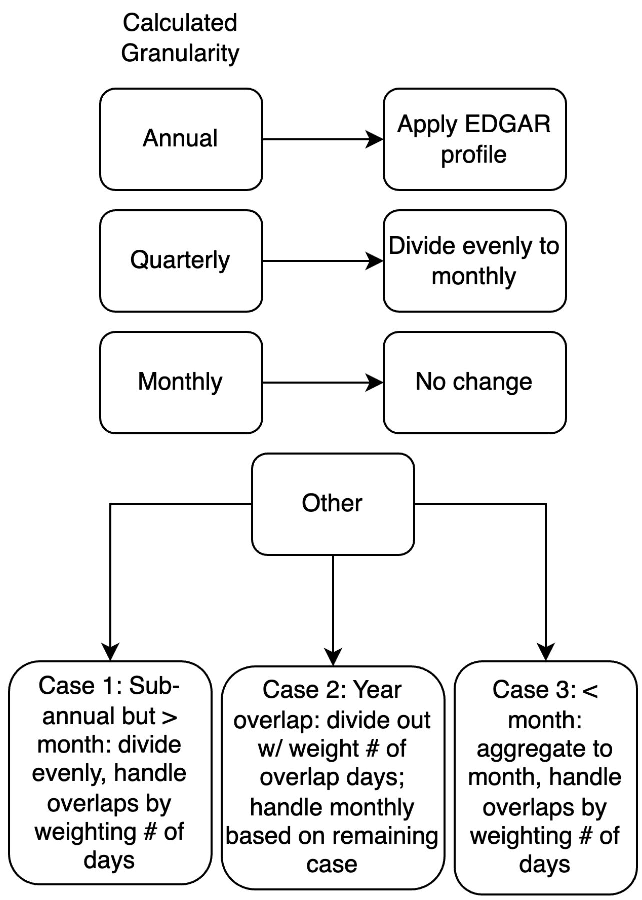

Fig. 1: Decision rule for handling different calculated temporal granularities.

For annual-to-monthly disaggregation cases, the TRACE-mapped r1 profiles were applied. Given the relationship between capacity (C), capacity factor (CF), activity (A), emissions factor (EF), and emissions (E) for the TRACE convention as shown below:

$$E = A * EF$$
$$A = C * CF$$

and differing relevant quantities by TRACE sector which operate as activity and capacity therein, a case-by-case mapping was needed for which variables were to be disaggregated or, in other words, which sectors' emissions factors, activities, capacity factors, and/or capacities were relevantly time-dependent to generate a temporally varying emissions quantity. Most sectors followed a convention of time-dependent capacities, constant capacity factors (better described as utilization in this case), time-dependent activities, and constant emissions-factors; necessarily, emissions values were always time-dependent for all gases.

Otherwise, as shown in Fig. 1, quarterly emissions values were divided evenly in each respective quarter, with no additional profiles applied. For timestamps overlapping multiple months, the emissions were attributed to each constituent month weighted by the fraction of overlapping days. Finally, emissions natively reported at monthly level were left unchanged.

2.2.2 Temporal Gap-Filling and Extrapolation

For emissions sources where any duration of time was missing across all entries between its first and last reported timestamps, e.g. if a month was missing an entry while all remaining months between 2021-2024 were reported, then the missing entry emissions and any associated metadata values are forward-filled then back-filled. This ensures that the next closest non-null value is used.

Emissions were extrapolated forward to the end of 2024 for all sectors, and each set of months which were not reported for that year or any year prior, emissions and associated metadata values from the equivalent month range of the last full reported year were used. Meaning, if January, February, and March 2022 were missing and January, February, and March 2021 were full, then 2021 values were used to fill in missing months in 2022. Similarly, if data did not extend back to January of 2021, then the analogous process was used to back-extrapolate data back to that minimum required initial timestamp.

2.3 Country Methods

For country-level emissions estimates, the method was analogous to that of Section 2.2, save for two differences:

1. For monthly-to-annual disaggregation: for each group of country, sector, gas, year, and month where any source emissions existed, such as individual facilities, land areas, or aggregated grid emissions, normalized monthly scale factors were backed out and then applied to the country-level emissions value. Where no sources existed, better described as "country-only" cases, whether as specific countries within a sector or entire sectors, the country-level emissions values were handled identically to the approach in Section 2.2.1.

2. For missing time periods: TRACE country emissions span 2015-2024, while monthly source-level emissions span 2021-2024 (though annual-level estimates do remain back to 2015 for some sectors). When this occurred and when the sum of source-level emissions exceeded country-level emissions in 2021-2024, then the average ratio between the two values for each country, gas and sector was calculated and multiplied by the 2015-2020 country emissions values. The purpose of this scale factor was to maintain any observed trends in country-level emissions prior to 2021 while ensuring that no apparent artificial increase manifested in any time series in the transition between 2020 and 2021.

2.4 Confidence and Uncertainty

For more information on adjusting confidence and uncertainty estimates, see *Bottom-up and Implicit Estimation of Emissions in Other Sub-sectors* in the "Post Processing for Global Emissions and Metadata Completeness" methodology directory.

All Climate TRACE data submitted by contributors had corresponding categorical confidence values ("very low", "low", "medium", "high", "very high"), which were downgraded by one level if any temporal disaggregation was undertaken. For any gap-filling and extrapolation cases, confidence values were defaulted to "very low".

For uncertainty estimates, an operating constraint that the variances of monthly values sum to the annual variance meant that the input variance was scaled by the monthly scale factors for the given sector.

3 Results

3.1 Temporal Disaggregation

Table 1 displays all sectors covered in Climate TRACE by their original granularity pre-intervention, level (source, country, or both), and appropriate intervention. Note that all sectors with any existing sources had a matching temporal granularity at the country-level but country-only sectors were all annual. The majority of TRACE sector data generated this year was annual, followed by month, then quarter.

Table 1: Summary of source-level sectors classified by temporal granularity (pre-disaggregation), level, and intervention in input data.

Input Granularity	Level	Intervention	Sectors
month	Source, country	None	aluminum, cement, chemicals, domestic-aviation, domestic-shipping, domestic-wastewater-treatment-and-discharge, electricity-generation, industrial-wastewater-treatment-and-discharge, international-aviation, international-shipping, iron-and-steel, pulp-and-paper, road-transportation, solid-waste-disposal, water-reservoirs
annual	Source, country	Disaggregation w/EDGAR Profile	bauxite-mining, coal-mining, copper-mining, cropland-fires, domestic-aviation, enteric-fermentation-cattle-pasture, food-beverage-tobacco, forest-land-clearing, forest-land-degradation, forest-land-fires, glass, international-aviation, iron-mining, lime, manure-left-on-pasture-cattle, net-forest-land, net-shrubgrass, net-wetland, oil-and-gas-production, oil-and-gas-refining, oil-and-gas-transport, other-chemicals, other-manufacturing, other-metals, petrochemical-steam-cracking, removals, rice-cultivation, shrubgrass-fires, synthetic-fertilizer-application, textiles-leather-apparel, wetland-fires
annual	Country -only	Disaggregation w/EDGAR Profile	biological-treatment-of-solid-waste-and-biogenic, crop-residues, enteric-fermentation-other, fluorinated-gases, heat-plants, incineration-and-open-burning-of-waste, manure-applied-to-soils, manure-management-other, other-agricultural-soil-emissions, other-energy-use, other-fossil-fuel-operations, other-mining-quarrying, other-onsite-fuel-usage, other-transport, railways, rock-quarrying, sand-quarrying, solid-fuel-transformation, wood-and-wood-products
quarter	Source, country	Even division	enteric-fermentation-cattle-operation, forest-land-clearing, forest-land-degradation, forest-land-fires, manure-management-cattle-operation, non-residential-onsite-fuel-usage, residential-onsite-fuel-usage, shrubgrass-fires, wetland-fires

Fig. 2 displays the different temporal variation based on cases present in the data for four example sectors' top 10 highest emitting sources from January 2021 to December 2024. For 'electricity-generation', the monthly estimates were produced natively by WattTime disaggregating annual estimates based on modeled monthly electricity demand (see Climate TRACE methodology, [Power sector: Emissions from Electricity Generation]). In contrast, for 'solid-waste-disposal', EDGAR uses a constant profile, so only annual step-changes are evident. For 'oil-and-gas-production', seasonal cycles with solstice-to-solstice periodicity are visible. Finally, the figure for 'enteric-fermentation-cattle-operation' illustrates the effect of even disaggregation of quarterly emissions, evident through quarter-wise step changes.

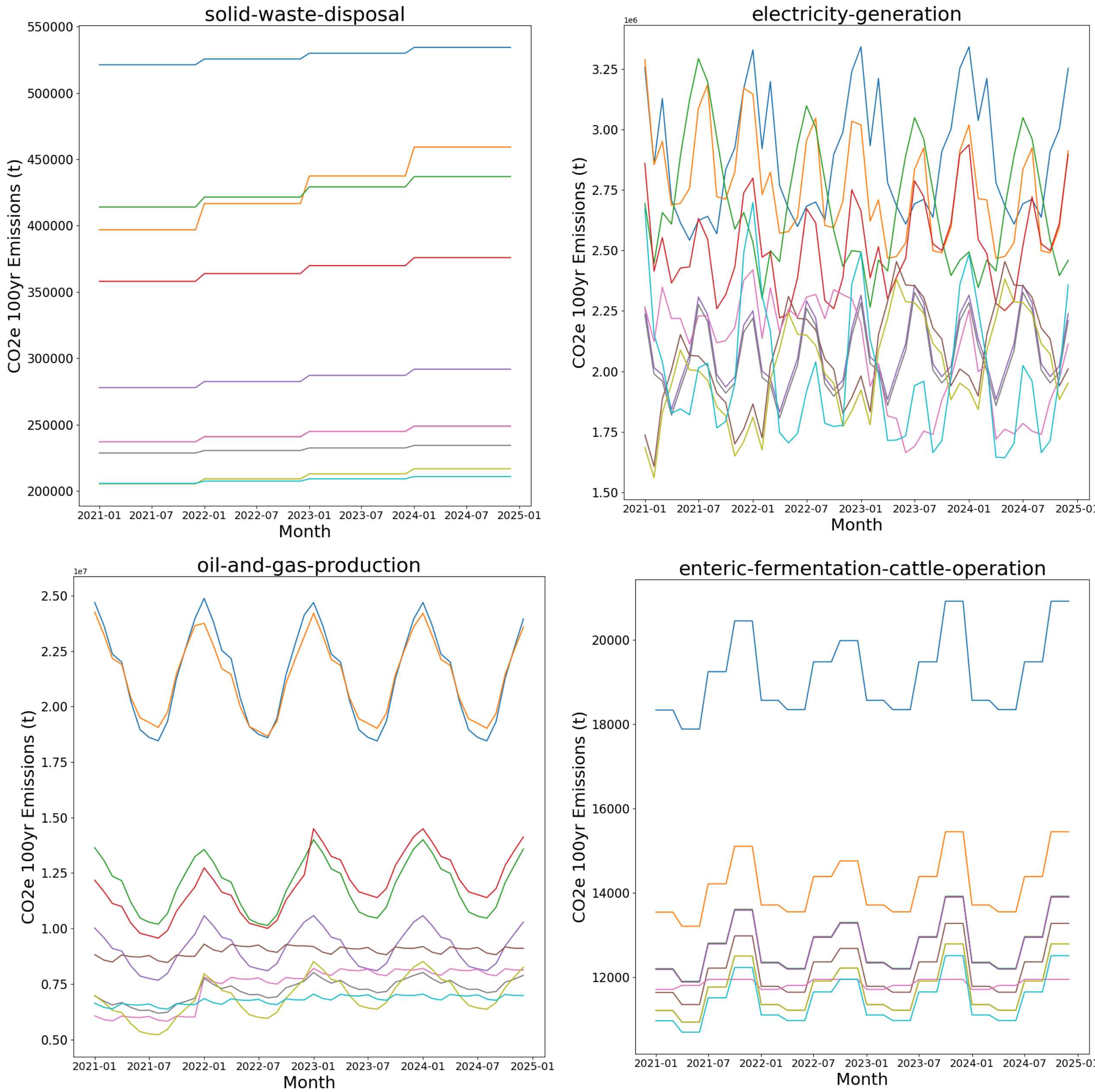

Fig. 2: Top 10 highest emitting sources for four sample sectors representing different temporal profiling cases. Top left: solid-waste-disposal, constant profile (divided annual emissions values by 4). Top right: electricity-generation, modeled monthly electricity from input data (no disaggregation/external profile applied on emissions values). Bottom left: oil-and-gas-production, non-constant EDGAR profile applied. Bottom right: enteric-fermentation-cattle operation, even disaggregation of quarterly (quarter emission values divided by 4).

3.2 Temporal Disaggregation uses in Atmospheric Modeling

For atmospheric modeling uses, due to the increased temporal granularity on top of fine-grained spatial and sectoral completeness, Climate TRACE can now better operate as a prior for inversion modeling. Fig. 3 highlights 4x5-degree gridded fossil-fuel CO_2 emissions over continental North America visualized as relative changes between sequential two-month increments in 2022. Though at a coarse resolution, one of the most apparent effects captured, having included native-monthly data from TRACE as well as EDGAR profiles where needed, is the relative decrease in emissions moving from winter to spring of 2022, a partial increase over the United States going into the peak of summer, a decrease again moving out of summer, and the similar increase in emissions moving into winter from autumn at the end of the year. Note, the differences are sensitive to the size of time-step in the Fig. 2 exercise, but the winter-to-spring and autumn-to-winter changes as seen below strongly persist nevertheless under different time-steps.

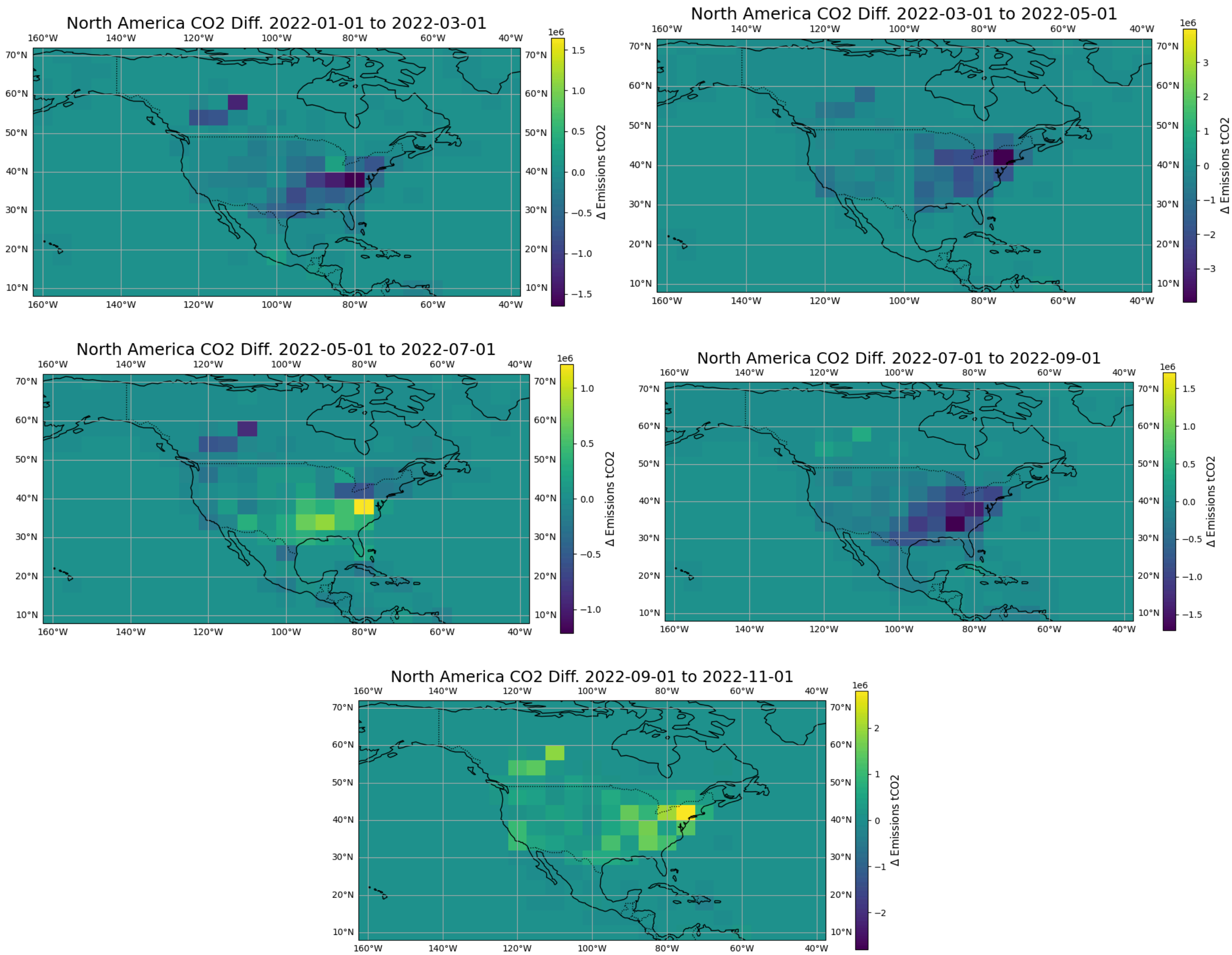

Fig. 3: 2-month interval *changes* in gridded CO_2 fossil-fuel emissions across 2022, for continental North America. Complete CO_2 fossil-fuel budget was generated by summing source emissions within each grid cell and disaggregating country-level remainders using spatial proxies (see *Spatial Disaggregation of Remainder Emissions* in the Climate TRACE methodology GitHub repo).

4 Discussion

Climate TRACE has adopted a standardized monthly temporal granularity for reporting both GHG and non-GHG emissions, alongside their related quantities including capacities, activities, and their multiplicative factors. This critical shift aligns with broader 2024 changes allowing for fine-grained completeness spatially, sectorally, and across gas species. For policy-driven decision-making, this temporal transformation enables detailed analyses of emissions in a given year to study impacts of total emissions from sources or aggregated regions of interest and allows for shorter-term evaluation of mitigation strategies. Moreover, monthly emissions are a critical step for atmospheric and climate modeling applications, serving to better integrate single-point observational measurements, while bridging the gap to even finer timescale disaggregation (e.g. 3-hourly).

The current methodology employs EDGAR's sector-wise temporal profiles to handle cases where monthly data is unavailable, either when:

- The TRACE contributor for a given sector could not themselves generate monthly values, typically due to limitations in input data frequency, or
- Estimates for a given sector were generated post-hoc to submissions from core contributing teams of the Climate TRACE coalition, based on asset, facility, or source locations and information derived from annual-reporting public databases

This approach ensures that there is always at least a preliminary estimate, or "prior," of monthly emissions for a given year, knowing that the uncertainty of a given estimate will necessarily increase with higher temporal granularity.

The next step begets integrating and/or generating additional temporal proxies for sector-wise and regional monthly profiling, while simultaneously robustly testing the validity of any such given proxy choice current or new. Approaches to handle this include:

1. Using monthly profiles from other emissions-specific inventories
2. Using globally comprehensive, spatially sensitive, and monthly-coherent data such as temperature, humidity, population density, etc. as single proxies or components of ensemble proxies
3. Using high-frequency estimates of ground-based plumes and/or atmospheric observations to generate full new profiles or perturb existing profiles for sector-region pairs of interest

Climate TRACE aims to generate independent, high-resolution emissions estimates that add value to both existing bottom-up and top-down accounting frameworks. The current temporal profiling status is a foundational step toward this goal, enabling broader domain coverage while supporting iterative and consistent improvement in accuracy and reliability.

5 Acknowledgements

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6 Supplementary materials

Table 1 Map by sector for which metadata variables, between activity, emissions_factor, capacity, and capacity_factor have time-dependence as denoted by the "_is_temporal" flag for each value; choice of temporal disaggregation depends on units.

original_inventory_sector	activity_units	activity_is_temporal	emissions_factor_units	emissions_factor_is_temporal	capacity_units	capacity_is_temporal	capacity_factor_units	capacity_factor_is_temporal
aluminum	T of aluminum	TRUE	T of CO2 per T of aluminum (direct only)	FALSE	T of aluminum	TRUE	unitless	FALSE
bauxite-mining	T of bauxite ore	TRUE	T of CO2 per T of bauxite ore	FALSE	Tonnes	TRUE	unitless	FALSE
biological-treatment-of-solid-waste-and-biogenic	T of waste	TRUE	T of CO2 per T of waste	FALSE	population served or population equivalent	FALSE	T of waste per person	TRUE
cement	T of cement	TRUE	T of CO2 per T of cement (direct only)	FALSE	T of cement	TRUE	unitless	FALSE
chemicals	T of chemical	TRUE	T of CO2 per T of chemical (direct only)	FALSE	T of chemical	TRUE	unitless	FALSE
coal-mining	T of coal	TRUE	T of CO2 per T of coal extracted	FALSE	T of coal per year	FALSE	unitless	TRUE
copper-mining	T of copper ore	TRUE	T of CO2 per T of copper ore	FALSE	Tonnes	TRUE	unitless	FALSE
crop-residues	Tonnes	TRUE	Tonnes of CO2 per Tonnes of Crop residue	FALSE	area [ha]	FALSE	Tonnes per ha	TRUE
cropland-fires	area [ha]	TRUE	T of CO2 per ha burned	FALSE	area [ha]	FALSE	unitless	TRUE
domestic-aviation	T of fuel	TRUE	T of CO2 per T of fuel	FALSE	flights	TRUE	T of fuel per flight	FALSE
domestic-shipping	Nautical miles (nmi)	TRUE	T of CO2 per Nautical Miles (nmi)	FALSE	voyages and stays	TRUE	Nautical miles (nmi) per voyages and stays	FALSE
domestic-wastewater-treatment-and-discharge	population served	FALSE	T of CH4 per pop served	TRUE	population served or	FALSE	unitless	FALSE

original_inventory_sector	activity_ units	activity_is_ temporal	emissions_ factor_ units	emissions_ factor_is_ temporal	capacity_ units	capacity_ is_ temporal	capacity_ factor_ units	capacity_factor_ is_temporal
					population equivalent			
electricity-generation	MWh	TRUE	T of CO2 per MWh	FALSE	MW	TRUE	MWh per MW	FALSE
enteric-fermentation-cattle-operation	animal head(s)	FALSE	T of CO2 per animal head(s)	TRUE	animal head(s)	FALSE	unitless	FALSE
enteric-fermentation-cattle-pasture	animal head(s)	FALSE	T of CO2 per animal head(s)	TRUE	animal head(s)	FALSE	unitless	FALSE
enteric-fermentation-other	animal head(s)	FALSE	T of CO2 per animal head(s)	TRUE	animal head(s)	FALSE	unitless	FALSE
fluorinated-gases	Tonnes	TRUE	T of CO2 per T of F-gas produced	FALSE	Tonnes	TRUE	unitless	FALSE
food-beverage-tobacco	USD	TRUE	T of CO2 per USD	FALSE	USD	TRUE	unitless	FALSE
forest-land-clearing	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T CO2 / ha	FALSE	ha	TRUE
forest-land-degradation	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T CO2 / ha	FALSE	ha	TRUE
forest-land-fires	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T CO2 / ha	FALSE	ha	TRUE
glass	USD	TRUE	T of CO2 per USD	FALSE	USD	TRUE	unitless	FALSE
incineration-and-open-burning-of-waste	T of solid waste	TRUE	T of CO2 per T of solid waste	FALSE	T	TRUE	unitless	FALSE
industrial-wastewater-treatment-and-discharge	Tonnes of Product	TRUE	T of CO2 per T product	FALSE	Tonnes of Product	TRUE	unitless	FALSE
international-aviation	T of fuel	TRUE	To of CO2 per T of fuel	FALSE	flights	TRUE	T of fuel per flight	FALSE
international-shipping	Nautical miles (nmi)	TRUE	T of CO2 per Nautical Miles (nmi)	FALSE	voyages and stays	TRUE	Nautical miles (nmi) per voyages and stays	FALSE
iron-and-steel	T of steel	TRUE	T of CO2 per T of steel (direct only)	FALSE	T of steel	TRUE	unitless	FALSE

original_inventory_sector	activity_units	activity_is_temporal	emissions_factor_units	emissions_factor_is_temporal	capacity_units	capacity_is_temporal	capacity_factor_units	capacity_factor_is_temporal
iron-mining	T of iron ore	TRUE	T of CO2 per T of iron ore	FALSE	Tonnes	TRUE	unitless	FALSE
lime	T of lime	TRUE	T of CO2 per T of lime	FALSE	T of lime	TRUE	unitless	FALSE
manure-applied-to-soils	kg of N	TRUE	T of CO2 per kg of N	FALSE	area [ha]	FALSE	kg of N per ha	TRUE
manure-left-on-pasture-cattle	animal head(s)	FALSE	T of CO2 per animal head(s)	TRUE	animal head(s)	FALSE	unitless	FALSE
manure-management-cattle-operation	animal head(s)	FALSE	T of CO2 per animal head(s)	TRUE	animal head(s)	FALSE	unitless	FALSE
manure-management-other	animal head(s)	FALSE	T of CO2 per animal head(s)	TRUE	animal head(s)	FALSE	unitless	FALSE
net-forest-land	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T CO2 / ha	FALSE	ha	TRUE
net-shrubgrass	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T CO2 / ha	FALSE	ha	TRUE
net-wetland	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T CO2 / ha	FALSE	ha	TRUE
non-residential-onsite-fuel-usage	TBD	TRUE	T of CO2 per TBD	FALSE	TBD	TRUE	TBD	FALSE
oil-and-gas-production	High, Medium Low	TRUE	License restricted	FALSE	N/A	TRUE	N/A	FALSE
oil-and-gas-refining	BBL	TRUE	T of CO2 per BBL	FALSE	BBL per day	FALSE	days	TRUE
oil-and-gas-transport	High, Medium Low	TRUE	License restricted	FALSE	N/A	TRUE	N/A	FALSE
other-agricultural-soil-emissions	area [ha]	FALSE	T of CO2 per ha	TRUE	area [ha]	FALSE	unitless	FALSE
other-chemicals	Factories	FALSE	T of CO2 per factory	TRUE	Factories	FALSE	unitless	FALSE
other-energy-use	J	TRUE	T of CO2 per J	FALSE	Joules	TRUE	unitless	FALSE
other-fossil-fuel-operations	T of fuel	TRUE	T of CO2 per T of fuel	FALSE	T of fuel	TRUE	unitless	FALSE
other-manufacturing	Factories	FALSE	T of CO2 per factory	TRUE	Factories	FALSE	unitless	FALSE

original_inventory_sector	activity_units	activity_is_temporal	emissions_factor_units	emissions_factor_is_temporal	capacity_units	capacity_is_temporal	capacity_factor_units	capacity_factor_is_temporal
other-metals	Factories	FALSE	T of CO2 per factory	TRUE	Factories	FALSE	unitless	FALSE
other-onsite-fuel-usage	TBD	TRUE	T of CO2 per TBD	FALSE	TBD	TRUE	TBD	FALSE
other-transport	Joules	TRUE	T of CO2 per J	FALSE	Joules	TRUE	unitless	FALSE
petrochemical-steam-cracking	Tonnes	TRUE	T of CO2 per T of ethylene produced	FALSE	T of ethylene	TRUE	unitless	FALSE
pulp-and-paper	T of pulp & paper	TRUE	T of CO2 per T of Pulp & Paper (direct only)	FALSE	T of pulp & paper	TRUE	unitless	FALSE
railways	Joules	TRUE	T of CO2 per J	FALSE	Joules	TRUE	unitless	FALSE
removals	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T CO2 / ha	FALSE	ha	TRUE
residential-onsite-fuel-usage	TBD	TRUE	T of CO2 per TBD	FALSE	TBD	TRUE	TBD	FALSE
rice-cultivation	area [ha]	TRUE	T of CO2 per harvested ha	FALSE	area [ha]	FALSE	unitless	TRUE
road-transportation	Vehicle* km	TRUE	T of CO2 per (Vehicle * km)	FALSE	km	FALSE	vehicles in a month	TRUE
rock-quarrying	T of rock	TRUE	T of CO2 per T of rock	FALSE	Tonnes	TRUE	unitless	FALSE
sand-quarrying	T of sand	TRUE	T of CO2 per T of sand	FALSE	Tonnes	TRUE	unitless	FALSE
shrubgrass-fires	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T CO2 / ha	FALSE	ha	TRUE
soil-organic-carbon	Tonnes	TRUE	Tonnes of CO2 per total Tonnes of soil organic carbon change	FALSE	area [ha]	FALSE	Tonnes per ha	TRUE
solid-fuel-transformation	T of fuel	TRUE	T of CO2 per T of fuel	FALSE	T of fuel	TRUE	unitless	FALSE

original_inventory_sector	activity_units	activity_is_temporal	emissions_factor_units	emissions_factor_is_temporal	capacity_units	capacity_is_temporal	capacity_factor_units	capacity_factor_is_temporal
solid-waste-disposal	Tonnes of waste	TRUE	T of CO2 per T of waste	FALSE	m2	FALSE	Tonnes per m2 of waste	TRUE
steel	T of steel	TRUE	T of CO2 per T of steel (direct only)	FALSE	T of steel	TRUE	unitless	FALSE
synthetic-fertilizer-application	kg of N	TRUE	T of CO2 per kg of N	FALSE	area [ha]	FALSE	kg of N per ha	TRUE
textiles-leather-apparel	USD	TRUE	T of CO2 per USD	FALSE	USD	TRUE	unitless	FALSE
water-reservoirs	m2	TRUE	T of CO2 per m2	FALSE	m2	FALSE	fraction	TRUE
wetland-fires	T C in living biomass	TRUE	Emission efficiency factor (unitless)	FALSE	T C / ha	FALSE	ha	TRUE

Table 2 Sector-mapping from Climate TRACE sectors to EDGAR r1 temporal profile sectors based on IPCC 2006 categories.

Activity sector description	IPCC_2006_source_category	climate_trace_sector
Energy industries (gas)	1.A.1	electricity-generation
Energy industries, Pumped storage of electricity	1.A.1	
Energy industries (biofuels)	1.A.1	electricity-generation
Energy industries (coal)	1.A.1	electricity-generation
Energy industries, Nuclear in Pumped storage of electricity	1.A.1	
Energy industries (oil)	1.A.1	
Energy industries (other fuels)	1.A.1	other-energy-use
Manufacturing industry, Iron and steel industry	1.A.2.a	iron-and-steel
Manufacturing industry, Chemical industry (combustion)	1.A.2.c	chemicals, other-chemicals
Manufacturing industry, Food and tobacco (combustion)	1.A.2.e	food-beverage-tobacco
Manufacturing industry, Construction (combustion)	1.A.2.k	other-manufacturing
International aviation	1.A.3.a.i	international-aviation
Domestic aviation	1.A.3.a.ii	domestic-aviation
International shipping	1.A.3.d.i	domestic-shipping, international-shipping
Inland waterways	1.A.3.d.ii	N/A
Fuel combustion in petroleum refineries	1.B.2.a.iii.4	oil-and-gas-refining
Fuel transformation in petroleum refineries	1.B.2.a.iii.6	other-fossil-fuel-operations
Manufacturing industry, Iron and steel industry	1A2a	iron-and-steel
Manufacturing industry, Non-metallic minerals (combustion)	1A2b	other-manufacturing

Activity sector description	IPCC_2006_source_category	climate_trace_sector
Manufacturing industry, Non-ferrous metals (combustion)	1A2b	other-metals
Manufacturing industry, Paper, pulp and print (combustion)	1A2d	pulp-and-paper
Manufacturing industry, Non-specified industry (combustion)	1A2f	other-manufacturing
Manufacturing industry, Textiles (combustion)	1A2f	other-manufacturing
Manufacturing industry, Transport equipment (combustion)	1A2f	textiles-leather-apparel
Manufacturing industry, Machinery (combustion)	1A2f	other-manufacturing
Manufacturing industry, Mining (combustion)	1A2f	bauxite-mining, copper-mining, iron-mining, rock-quarrying, sand-quarrying, other-mining-quarrying
Manufacturing industry, Wood and wood products (combustion)	1A2f	other-manufacturing
Road transport	1A3b	road-transportation
Road transport evaporative emissions	1A3b v	N/A
Rail transport	1A3c	railways
Other non-road transport	1A3e	other-transport
Pipeline transport	1A3e	N/A
Small combustion	1A4	residential-onsite-fuel-usage, non-residential-onsite-fuel-usage, other-onsite-fuel-usage
Production of coal/gas/peat	1B	N/A
Transformation industry, Chemical heat for electricity production	1B	N/A
Transformation industry, coal mines	1B1	coal-mining
Transformation industry, Fuel transformation coal liquefaction plants	1B1	solid-fuel-transformation
Transformation industry, Fuel transformation coke ovens	1B1	solid-fuel-transformation
Transformation industry, Fuel combustion Peat Briquettes plants	1B1	solid-fuel-transformation
Transformation industry, Fuel transformation gasification plants for biogas	1B1	solid-fuel-transformation
Transformation industry, Peat Briquettes plants	1B1	solid-fuel-transformation
Transformation industry, Fuel transformation charcoal production plants	1B1	solid-fuel-transformation
Transformation industry, Fuel combustion charcoal production plants	1B1	solid-fuel-transformation
Transformation industry, Fuel combustion Liquefaction/Regasification plants	1B1	solid-fuel-transformation
Transformation industry, Fuel combustion gasification plants for	1B1	solid-fuel-transformation

Activity sector description	IPCC_2006_source_category	climate_trace_sector
biogas		
Transformation industry, Fuel combustion non-specified transformation activity	1B1	solid-fuel-transformation
Transformation industry, Fuel combustion coke ovens	1B1	solid-fuel-transformation
Transformation industry, Fuel combustion coal liquefaction plants	1B1	solid-fuel-transformation
Transformation industry,Blast furnaces	1B2	N/A
Transformation industry, Transformation in Gas to liquids plants	1B2	N/A
Transformation industry,Fuel combustion patent fuel plants	1B2	N/A
Transformation industry,Fuel combustion oil and gas extraction	1B2	oil-and-gas-production, oil-and-gas-transport
Transformation industry, Petrochemical industry	1B2	petrochemical-steam-cracking
Transformation industry, Fuel combustion blast furnaces	1B2	N/A
Transformation industry, Electric boilers	1B2	N/A
Transformation industry, For blended natural gas	1B2	N/A
Transformation industry, Fuel transformation in gas works	1B2	N/A
Transformation industry, Fuel transformation Liquefaction/Regasification plants	1B2	N/A
Transformation industry, Non specified transformation activity	1B2	N/A
Transformation industry, Heat pumps	1B2	N/A
Transformation industry, Gas works	1B2	N/A
Transformation industry, Fuel transformation patent fuel plants	1B2	N/A
Transformation industry, Distribution losses in transformation processes	1B2	N/A
Production of oil	1B2	oil-and-gas-production, oil-and-gas-transport
Crude steel production	2.C.1	iron-and-steel
Iron and steel production: Pellet production	2.C.1	iron-and-steel
Ferro Ally production	2.C.2	other-metals
Food production	2.H.2	food-beverage-tobacco
Production of non-metallic minerals, Cement production	2A1	cement
Production of non-metallic minerals, Lime production	2A2	lime
Production of non-metallic minerals, Glass bottles	2A3	glass
Production of non-metallic minerals, Glass production	2A3	glass
Production of non-metallic minerals, Limestone and Dolomite Use	2A3, 2A4	other-manufacturing
Production of non-metallic minerals, Soda ash production and use	2A3,2A4	other-manufacturing

Activity sector description	IPCC_2006_source_category	climate_trace_sector
Production of non-metallic minerals, Other uses of carbonate	2A4	other-manufacturing
Production of non-metallic minerals, Other non-metallic minerals	2A4	other-manufacturing
Production of chemicals, Ammonia production	2B1	chemicals
Production of chemicals, Nitric acid production	2B2	other-chemicals
Production of chemicals, Adipic acid production	2B3	other-chemicals
Production of chemicals, Calcium carbide production	2B4	other-chemicals
Production of chemicals, Sulphuric acid production	2B5	other-chemicals
Production of chemicals, Bulk chemicals production	2B5	other-chemicals
Production of chemicals, Specialities production	2B5	other-chemicals
Production of chemicals, Silicon carbide production	2B5	other-chemicals
Production of chemicals, Caprolactam production	2B5	other-chemicals
Production of chemicals, N-fertilizer production	2B5	other-chemicals
Production of chemicals, Glyoxylic acid production	2B5	other-chemicals
Production of chemicals, Glyoxal production	2B5	other-chemicals
Production of chemicals, Titanium oxide production	2B6	other-chemicals
Steel casting	2C1	iron-and-steel
Pig iron production	2C1	iron-and-steel
Sinter production	2C1	iron-and-steel
Production of non-ferrous metals, Aluminium production	2C3	aluminum
Production of non-ferrous metals, Magnesium production	2C4	other-metals
Production of non-ferrous metals, Lead production	2C5	other-metals
Production of non-ferrous metals, Zinc production	2C6	other-metals
Production of non-ferrous metals, Copper production	2C7	other-metals
Production of non-ferrous metals, Gold production	2C7	other-metals
Production of non-ferrous metals, Mercury production	2C7	other-metals
Production of non-ferrous metals, Other non-ferrous production	2C7	other-metals
Production of non-metallic minerals, Brick production	2C7	other-metals
Non energy use of fuels in industry, transformation industry	2D	N/A

Activity sector description	IPCC_2006_source_category	climate_trace_sector
Non energy use of fuels in petrochemical industry	2D	petrochemical-steam-cracking
Non energy use of fuels in transport sector	2D	N/A
Other non energy use of fuels	2D	N/A
Other solvents use	2D	N/A
Pulp and paper production	2D	pulp-and-paper
Solvents in rubber and plastics industry	2D	other-manufacturing
Solvents in vegetative oil extraction	2D	other-manufacturing
Solvents in paint	2D	other-manufacturing
Solvents in pesticides	2D	other-manufacturing
Solvents in chemical industry	2D	other-manufacturing
Solvents in dry cleaning	2D	other-manufacturing
Solvents in glues and adhesives	2D	other-manufacturing
Solvents in households products	2D	other-manufacturing
Solvents in industrial degreasing	2D	other-manufacturing
Solvents in leather production	2D	textiles-leather-apparel
Solvents in graphic arts	2D	other-manufacturing
Production and use of other products	2G	fluorinated-gases
Enteric fermentation of ruminants	3.A.1	enteric-fermentation-cattle-operation, enteric-fermentation-cattle-pasture, enteric-fermentation-other
Forest Land Remaining Forest Land	3.B.1.a	N/A
Forest to grassland conversion	3.B.1.b.ii	N/A
Large scale biomass burning	3.C.1	forest-land-fires, shrubgrass-fires, wetland-fires
Agricultural waste burning	3.C.1.b	cropland-fires
Agricultural soils, Limestone use	3.C.2	other-agricultural-soil-emissions
Agricultural soils, CO2 from urea fertilization	3.C.3	other-agricultural-soil-emissions
Agricultural soils, animals	3.C.4	other-agricultural-soil-emissions
Agricultural soils, N-fixing crop	3.C.4	other-agricultural-soil-emissions
Agricultural soils, histosols	3.C.4	other-agricultural-soil-emissions

Activity sector description	IPCC_2006_source_category	climate_trace_sector
Agricultural soils, crop residues	3.C.4	other-agricultural-soil-emissions
Agricultural soils, application of nitrogen fertilizers	3.C.4	synthetic-fertilizer-application
Indirect N2O from NOx and NH3	3.C.5	other-agricultural-soil-emissions
Indirect N2O emissions	3.C.5	other-agricultural-soil-emissions
Manure management	3A2	manure-left-on-pasture-cattle, manure-management-cattle-operation, manure-management-other
Manure as fertilizer	3C4	other-agricultural-soil-emissions
Rice cultivation	3C7	rice-cultivation
Solid waste disposal: composting, landfills, hazardous, other	4A, 4B	solid-waste-disposal, biological-treatment-of-solid-waste-and-biogenic
Solid waste disposal: incineration	4C	incineration-and-open-burning-of-waste
Waste Water Treatment	4D	domestic-wastewater-treatment-and-discharge, industrial-wastewater-treatment-and-discharge
Hydroelectric dam reservoir emissions	5.B	water-reservoirs
Fossil fuel fires: gas and oil fires	5.B	N/A
Fossil fuel fires: Coal fires underground	5.B	N/A

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Geographic boundaries and names (iso3_country data attribute): The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases on Climate TRACE are generated from the Global Administrative Areas (GADM) project (Version 4.1 released on 16 July 2022) along with their corresponding ISO3 codes, and with the following adaptations:

- HKG (China, Hong Kong Special Administrative Region) and MAC (China, Macao Special Administrative Region) are reported at GADM level 0 (country/national);
- Kosovo has been assigned the ISO3 code 'XKX';
- XCA (Caspian Sea) has been removed from GADM level 0 and the area assigned to countries based on the extent of their territorial waters;
- XAD (Akrotiri and Dhekelia), XCL (Clipperton Island), XPI (Paracel Islands) and XSP (Spratly Islands) are not included in the Climate TRACE dataset;
- ZNC name changed to 'Turkish Republic of Northern Cyprus' at GADM level 0;
- The borders between India, Pakistan and China have been assigned to these countries based on GADM codes Z01 to Z09.

The above usage is not warranted to be error free and does not imply the expression of any opinion whatsoever on the part of Climate TRACE Coalition and its partners concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders.

Disclaimer: The emissions provided for this sector are our current best estimates of emissions, and we are committed to continually increasing the accuracy of the models on all levels. Please review our terms of use and the sector-specific methodology documentation before using the data. If you identify an error or would like to participate in our data validation process, please [contact us].

7 References

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