Deliverable D17 (D3.2)

Methodology to improve European urban emission inventories

RI-URBANS

Research Infrastructures Services Reinforcing Air Quality Monitoring Capacities in European Urban & Industrial AreaS (GA n. 101036245)

By

NOA

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Deliverable D17 (D3.2): Methodology to improve European urban emission Inventories

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1. About this document

This document describes the methodology developed and employed to improve the European CAMS-REG emission inventory (spatial resolution of 0.1°x0.05° or ~6x6 km^2) over specific urban areas of Europe. The improvement is largely based on a spatial disaggregation approach to provide an increasing accuracy of the annual, anthropogenic emissions over the cities of interest. The spatial disaggregation of CAMS-REG is based on credible, open access, generic, contemporary, high-resolution (≤1 km^2) spatial datasets of the European area, which are transformed into the sector specific spatial proxies applied to the source categories of CAMS-REG. The approach -which is analytically described in the next sections- is incorporated into a fully automated tool that will produce the detailed mapping of industrial (point or at the spatial analysis of 1 km), transport (line or at the spatial analysis of 1 km) and residential, agricultural, and other (area, at the spatial analysis of 1 km) emission sources for all the pilot cities of the project. These products will directly be used as input for the AQ modelling at the urban scale (T3.3). The methodology will also be used to spatially disaggregate the 6x6km Ri-urbans European scale emission inventories developed in this task.

This document is a public document that will be distributed to all RI-URBANS partners for their use and submitted to European Commission as an RI-URBANS deliverable D17 (D3.2). **This document can be downloaded at** https://riurbans.eu/work-package-3/#deliverables-wp3 **in the folder deliverables.**

2. The emission downscaling approach

The developed approach to spatially improve the CAMS-REG dataset for high resolution air quality modelling, follows the generalized framework described in Figure 1. This framework can be applied in all the targeted European cities of RI-URBANS. Based on the urban centre definition[1] (found at JRC's Global Human Settlement Layer initiative), sector-specific spatial proxies are prepared based on publicly available datasets to distribute CAMS-REG (Kuenen et al., 2022) and E-PRTR emission datasets (https://industry.eea.europa.eu/) to area (1x1km^2), point and line sources. In line with the requirements of the high-resolution air quality models utilized in the frame of RI-URBANS, the emission datasets may be delivered in a gridded format, by attributing the line and/or point emissions to a grid with the spatial resolution of 1 km.

[1] An Urban Centre (UC) consists of contiguous grid cells with 1) population density of at least 1,500 inhabitants per km^2 OR 2) density of built-up area greater than 50% per km^2 AND 3) at least 50,000 total population.

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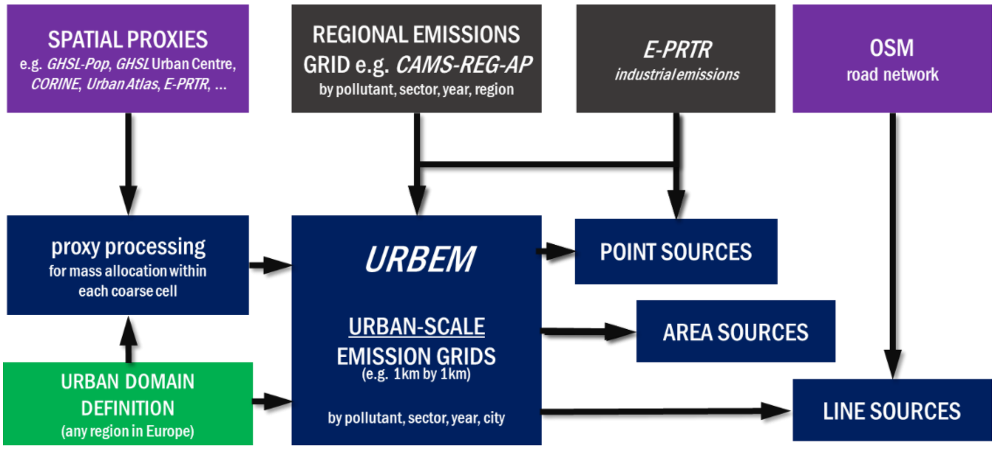

Figure 1. General methodology for the Urban Emissions downscaling framework. (Source: Ramacher et al., 2021).

The overall methodology includes first the general approach to prepare spatial proxies for different sectors (Sect. 2.1) and second, the application of these proxies in the downscaling approach (Sect. 2.2). A more detailed insight in the realization of the general methodology (Fig. 1) is given in Figure 2.

The application of this emission downscaling approach is realized as a software tool which is open source. Depending on the extent of the model domain, the preparation of proxies, the downscaling of emissions, and the creation of point, area and line source output files, the required computing time is about 5 minutes (for example for a 45 x 45 km domain, including 26000 line source elements and 20 point sources).

The emissions downscaling method described here is largely based on the existing and already published GIS-based tool, UrbEm (Ramacher et al., 2021). The tool was initially developed through the systematic collaboration of NOA and HZG in the frame of the European H2020 project SMURBS (official website: https://smurbs.eu/). UrbEm is an important component of the Portfolio of SMart URBan Solutions for air quality (https://smurbs.eu/solutions/), and has already supported and been evaluated through targeted city-scale CTM model applications. The current version of the downscaling method to support the RI-URBANS atmospheric modeling simulations has been optimized in collaboration with TNO. In particular, all point source emissions are at exact locations (lon, lat) rather than snapped to the grid cell, the OSM information for the shipping lanes is incorporated to spatially allocate GNFR G (shipping), the OSM information is directly used to spatially reallocate road transport emissions (rather than the intermediate use of population density), and the high-resolution spatial field of population density is applied as a backup proxy for all GNFR sectors. Additionally, the spatial disaggregation of emission subsectors using appropriate proxies was thoroughly examined, and found effective for the GNFR I (off-road), which is now performed differently for the mobile machinery for industrial activities (using industrial areas), mobile machinery for agricultural activities (using agricultural areas), railway emissions (using the OSM information for railways) and for all other machinery (using population density). Last, an optimization of the spatial re-allocation of the emitted mass to the 1 x 1km^2 cells is incorporated -namely an area coefficient approach- for those containing more than 1 cells of the CAMS inventory.

2.1 The utilized spatial datasets

As illustrated in Figure 1, the spatial disaggregation of the CAMS regional emission inventory CAMS-REG (Sect. 2.1.1) is performed with sector specific (following the GNFR nomenclature) spatial proxies (Sect. 2.1.2 - 2.1.5). These proxies are prepared with publicly available, well-established, contemporary spatial datasets of European (or Global) coverage. Table 1 introduces all anthropogenic activities based on GNFR classification, which are re-allocated within each coarse cell, according to the spatial information of the appropriate high-resolution spatial proxies. The latter are heavily dependent on the source type and are based on combinations of different data sources.

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Table 1: The spatial proxies (and their origin) used to disaggregate each anthropogenic activity (expressed as source sectors in GNFR) in the developed downscaling framework. More information on all spatial datasets used can be found in the next sections.

Anthropogenic activity (Source sector)	**High-resolution spatial proxy (dataset source)**	**Back up Spatial proxy (dataset source)**
Public Power and Refineries (GNFR A)	Industrial areas 1: Polygons hosting Public Power installations (E – PRTR and CLC 2018) *combined with* Land type characterized as 'Industry' (CLC 2018)	
Industrial Combustion and Processes (GNFR B)	Industrial areas 2: Polygons hosting installations of mineral or chemical industries and of production (and processing) of wood, paper, metals, animal and vegetable (E - PRTR and CLC 2018) *combined with* Land type characterized as 'Industry' (CLC 2018)	
Small Combustion (GNFR C)	(Residential) population Density (GHS-POP 2015)	
Fossil Fuel Production and Fugitive (GNFR D)	Industrial areas 3: Land type characterized as 'Industry' (CLC 2018)	(Residential) population Density (GHS-POP 2015)
Solvent and other use production (GNFR E)	(Residential) population Density (GHS-POP 2015)	Industrial areas 3: Land type characterized as 'Industry' (CLC 2018)
Road emissions (GNFR F)	Major Road Network (OSM) consisting of highways, trunks, primary & secondary roads and their links	
Shipping (GNFR G)	Shipping routes (OSM) *combined with* Land type characterized as 'Ports' (CLC 2018)	
Aviation (GNFR H)	Land type characterized as 'Airports' (CLC 2018)	
Off-road activities (GNFR I)	Land type characterized as 'Non-Road Mobile Sources' (CLC 2018) relevant to agricultural, industrial and construction activities, *combined with* Railway (OSM)	
Waste Treatment (GNFR J)	Arable and waste treatment areas: Polygons hosting waste management installations (E - PRTR and CLC 2018), *combined with* Land type characterized as 'Non-irrigated arable land' (CLC 2018) to allocate open waste	
Agriculture (GNFR K and GNFR L)	Land type characterized as 'Agriculture' (CLC 2018)	(Residential) population Density (GHS-POP 2015)

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2.1.1 The CAMS regional anthropogenic emissions (CAMS-REG)

CAMS provides sectoral annual emission totals for Europe (30°W – 60°E and 30°N – 72°N) for 2000-2018 (CAMS-REG-v5.1). The database involves annual emission rates of CH_4, CO, NH_3, NMVOC, NO_X, PM10, PM2.5 and SO_2 from road, air, rail transport, navigation, mobile machinery, fuel production, industrial activities (paper, cement, minerals, metals etc.), stationary combustion, agriculture, waste, solvent use and public power. The database is based on the GNFR sector classification and provides data at 0.1 x 0.05° (Kuenen et al., 2022).

In the core of CAMS methodology lies the National reports of emissions by year, pollutant and sector registered in and available through the Centre for Emission Inventories and Projections (http://www.ceip.at/). Supplementary sources include the Environmental European Agency (EEA), the Greenhouse gas ‐ Air pollution Interactions and Synergies model (GAINS), the Emissions Database for Global Atmospheric Research (EDGAR) and estimates by the Netherlands Organization for Applied Scientific Research (TNO). The spatial distribution of country total emissions from point sources is based on the E-PRTR database, while non-point sources are disaggregated through spatial proxies, such as total, rural and urban population, different land cover classes and Open Street Map.

A thorough report on the quality of the spatial data of the CAMS-REG inventory lies in Kuenen et al. (2022). Overall, uncertainties with respect not only in the National registrations but also in the spatial dis-aggregation proxies and methods used are present and difficult to quantify. With respect to the urban environment, indicative sources of errors include: i) the spatial dis-aggregation of vehicle emissions is performed for a single year (instead of annually), excluding, actual real-time road intensities and small road traffic volumes ii) power plant and industrial emission registrations include errors and inconsistencies, iii) building characteristics (e.g. type of building, level of insulation) are not taken into account for the spatial dis-aggregation of residential heating emissions, iv) occasional large construction sites are not taken into account for the construction of off-road machinery emissions.

2.1.2 European Pollutant and Transfer Register (E-PRTR)

E-PRTR (http://prtr.ec.europa.eu/) is the Europe-wide register that provides key environmental data for industrial facilities in European Union Member States and a few other countries and it provides annual emission totals for large sources i.e. for pollutants that exceed limit values. Besides the annual emission totals, the geographic location and sector for these sources is also defined. The official National data transmitted by the Member States to the European Environmental Agency (EEA) are subjected to a quality control through an automated validation tool developed by the EEA (2016).

The emissions of NO_X, SO_X, CO_2, NH_3 and particulate matter (PM10) from industrial facilities are utilized in this work. In addition, geo-locations from this database are selectively used for the spatial disaggregation of emissions from relevant sources (e.g. public power, see Table 1).

2.1.3 Corine Land Cover

The CORINE Land Cover (CLC) inventory (https://land.copernicus.eu/pan-european/corine-land-cover) was initiated in 1985 (reference year 1990). Updates have been produced in 2000, 2006, 2012, and 2018. It consists of an inventory of land cover in 44 classes. CLC uses a Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena and a minimum width of 100 m for linear phenomena. The Eionet network National Reference Centres Land Cover (NRC/LC) is producing the national CLC databases, which are coordinated and integrated by EEA. CLC is produced by the majority of countries by visual interpretation of high-resolution satellite imagery. The Sentinel 2 images used provide homogeneous, high quality multi-temporal imagery, to support high-quality identification of land cover changes in Europe (https://land.copernicus.eu/user-corner/technical-

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library/clc2018technicalguidelines_final.pdf) In a few countries semi-automatic solutions are applied, using national in-situ data, satellite image processing, GIS integration and generalization.

CLC has a wide variety of applications, underpinning various Community policies in the domains of environment, but also agriculture, transport, spatial planning etc. In this study, we applied CLC classes from the 2018 version as spatial proxies to distribute emissions to different sectors.

CORINE land use / cover (LULC) dataset is used as spatial proxy for the majority of source sectors (Table 1). Original LULC gridded data for 2018 (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018), with the spatial resolution of 100 m and 44 land types, are aggregated to 1 km^2 and reclassified into 12 generalized land types. Reclassified gridded data are either used as spatial proxies for sectors, such as industry and agriculture, or combined with other spatial information in order to create enhanced land use classes.

2.1.4 Global Human Settlement Layer

The Global Human Settlement Layer project of the European Commission's Joint Research Centre (Florczyk et al., 2019) contains spatially detailed information on population and settlements. The GHSL are offered as open and free data. The data range goes from global coverage datasets to pan-European built-up layers (the European Settlement Map) to analytical data (e.g., the Urban Centre Database). In this study, we apply the Global Human Settlement population grid (GHS-POP) and the Global Human Settlement Layer Urban Centres Database (GHS-UCDB).

The GHS-POP spatial raster dataset depicts the distribution of population, expressed as the number of people per cell (https://ghsl.jrc.ec.europa.eu/ghs_pop2019.php). Residential population estimates for target years 1975, 1990, 2000 and 2015 provided by CIESIN GPWv4.10 were disaggregated from census or administrative units to grid cells, informed by the distribution and density of built-up as mapped in the GHSL global layer per corresponding epoch. The available resolutions are 250m, 1km, 9 arcsec and 30 arcsec. In this study, we apply the GHS-POP layer for 2015 with resolution of 30 arcsec (WGS84) (GHS_POP_E2015_GLOBE_R2019A_4326_30ss_V1_0) to spatially distribute emissions that are connected to population activity, e.g., residential heating and as a back-up spatial proxy, i.e. where high-resolution information from the primary spatial proxy does not occasionally exist for some CAMS cells/emissions.

The GHS-UCDB is the most complete database on cities to date, publicly released as an open and free dataset. The database represents the global status on Urban Centres in 2015 by offering cities location, their extent (surface, shape), and describing each city with a set of geographical, socio-economic and environmental attributes, many of them going back 25 or even 40 years in time. Urban Centres are defined in a consistent way across geographical locations and over time, applying the "Global Definition of Cities and Settlements" developed by the European Union to the Global Human Settlement Layer Built-up (GHS-BUILT) areas and Population (GHS-POP) grids. A validation of the global human settlement through the Landsat imagery, as well as a quality control to ensure that all input population was disaggregated , and totals were preserved, have been successfully conducted (Pesaresi et la., 2016). In this approach, we apply the GHS-UCDB layer (GHS_STAT_UCDB2015MT_GLOBE_R2019A_V1_0) to identify the geographic extent of urban centres.

2.1.5 OpenStreetMap

OpenStreetMap (OSM, 2018) is a collaborative project to create a free editable map of the world. The geodata underlying the map is considered the primary output of the project. Created by Steve Coast in the UK in 2004, it was inspired by the success of Wikipedia and the predominance of proprietary map data in the UK and elsewhere. Since then, it has grown to over two million registered users, which may collect data using manual survey, GPS

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devices, aerial photography, and other free sources, or use their own local knowledge of the area. This crowdsourced data is then made available under the Open Database License. The site is supported by the OpenStreetMap Foundation, a non-profit organization registered in England and Wales. Quality assurance and quality control processes are performed to examine the completeness, consistency, accuracy, timeliness and accessibility of the data hosted in the platform.

The data from OSM can be used in various ways including production of paper maps and electronic maps (similar to Google Maps, for example), geocoding of address and place names, and route planning. OpenStreetMap data has been favourably compared with proprietary data sources. In this study, we apply OSM data to locate major road networks, which are used to distribute emissions from road traffic. Their surface attributes (lane number, length) is also used for the attribution of emissions.

The OSM data for ships are used to allocate the CAMS emissions from shipping overseas, while the railway data are used to allocate the railway emissions.

2.2 The spatial disaggregation method

The developed approach to downscale the regional emission inventory CAMS allows for the flexible creation of urban-scale emission inventories which can consist of any combination of area, line and point source information. The procedure allows to create emission inventories suitable for the high-resolution CTM simulations and enables considering the near field dispersion of pollutants for point and line sources. Nevertheless, the tool can also provide these two types of sources into the area dataset of 1x1km. The detailed insight in the updated realization of the general methodology (Figure 1) is given in Figure 2 and analytically described in the following subsections.

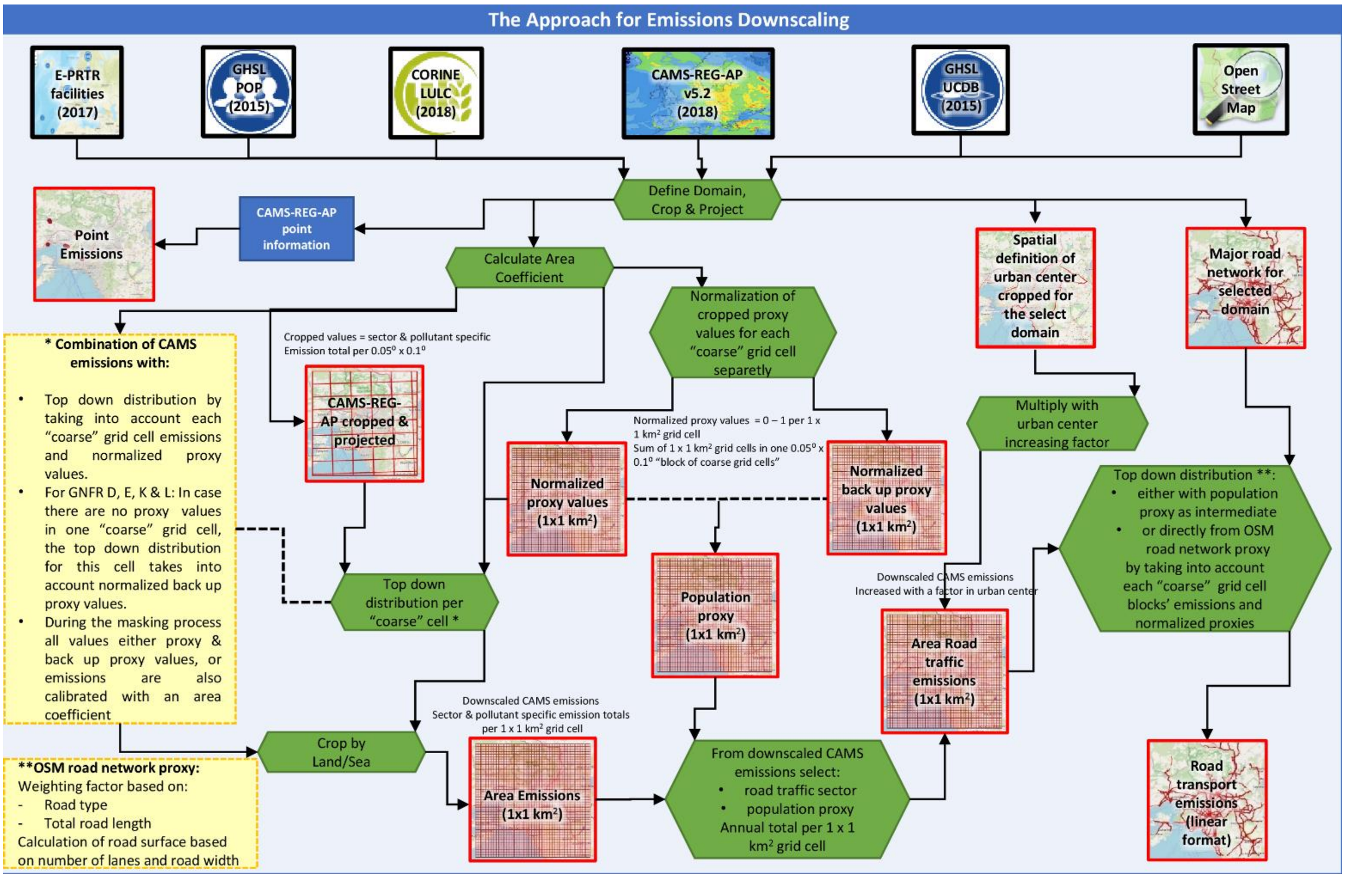

Figure 2. The detailed workflow for the improvement of CAMS emission dataset over cities.

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2.2.1 Processing of spatial proxies

The reclassified gridded data are combined with shipping or railway routes, and E-PRTR industrial information in order to create new added-value proxies, as evident from Table 1. In particular, OSM shipping routes, in vector format, are combined with LULC gridded ports and a complex proxy for shipping emissions is created. OSM railways are combined with LULC polygons characterized as non-road mobile sources, to attribute the emissions from off-road activities. E-PRTR point location information (2019) are combined with LULC vector Geo-database (2018) and reclassified LULC gridded data. E-PRTR location information, from around 24,000 industrial facilities, divided in 54 sectors and sub-sectors, are reclassified to two general categories, Waste Treatment and Other Industrial Activities and these are then spatially joined with the LULC polygons. These new land use classes are spatially joined with LULC reclassified gridded data in order to create enhanced proxies (Industrial areas 1, 2 and the waste treatment proxy) for Waste Treatment, Public power and refineries and Industrial Combustion and Processes emissions.

To further prepare the downscaling methodology of the gridded datasets, the sector-specific proxies are resampled (nearest neighbour), masked by the extent of the selected urban area and projected to the appropriate coordinate system (e.g., UTM Zones). The resampled sector-specific proxy grids are normalized per “coarse” grid cell (defined by the CAMS-REG resolution) separately, by forming the sum of all resampled “fine” grid cells (defined by the urban domain definition) that are within each “coarse” grid cell and then dividing each grid cell by this sum. Thus, the spatial distribution information of the “coarse” CAMS-REG grid is kept in the sector specific proxy grids, which follow the urban domain definition.

To account for the road traffic sector, Open Street Map vector data (line shape-files) were applied. We selected eight road types based on highway OSM data to construct the major road network of each urban area (motorway, motorway link, primary, primary link, secondary, secondary link, tertiary, tertiary link, trunk, trunk link). Thus, for each urban domain the major road network is represented.

2.2.2 Point industrial emissions

To create a point source emission inventory, the E-PRTR emissions register is applied to get the annual total emission values per sector and industrial unit as well as their spatial location and sectoral information. Therefore, the E-PRTR register for the whole of Europe is projected and cropped to a target urban domain definition. Then, the point source emission information is written into an output format that can be read by any CTM. It should be noted that for the purposes of RI-URBANS, all point source emissions are put at exact locations (lon, lat) rather than snapped to the grid cell, although the latter is an option for the models that accommodate only gridded emissions.

2.2.3 Area emission sources

To create area source emissions (Figure 2, central part), CAMS-REG emissions are combined with spatial datasets (Table 1) that are mapped to be used as sector specific spatial downscaling proxies (Figure 2). Based on the target urban domain’s extent, resolution and projection, the selected CAMS dataset is projected and cropped to the extent of the target urban domain. The result is a grid of annual emission totals, with the projection and extent of the target domain, but still with the coarse resolution of the regional CAMS emission inventory. In the next step, the corrected grids of annual emission totals are top-down distributed to the normalized grids of sector specific proxies. Thus, the spatial distribution information of the coarser CAMS grid is considered in downscaling to the high-resolution grid (e.g., 1 x 1km). In the cases that the high-resolution grid of the urban area of interest intersects with the coarse grid, thus a small cell contains more than one coarse cell, then the area coefficient approach is applied to the surfaces of the coarse cells so that the masses are attributed with accuracy. Also, for the coastal CAMS cells, all emissions from the land-based activities are attributed to the high-resolution cells over land, while shipping emissions are attributed to the high-resolution cells overseas. Last, where the boundaries of the domain intersect

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with the CAMS cells the amount of mass to be accounted for in the domain of interest is again calculated through an area coefficient.

2.2.4 Road transport emissions

To allocate emissions at a linear format, i.e. pollutants emitted from the road transport sector, CAMS is firstly downscaled to the high-resolution cells. This is either done with the use of the spatial proxy based on population density or without using any spatial proxy. Then, the mass is distributed to road links derived from OpenStreetMap (OSM) (Figure2, right section). The transformation of area sources for road transport to line sources generally requires spatial information on road networks as well as information on traffic density or annually averaged daily traffic volumes. Spatial data on traffic densities, vehicle and road types etc., have been considered through investing upon the spatial disaggregation of road transport emissions of the CAMS-REG inventory (Kuenen et al., 2021). The reason for this approach is the minimization of the need for explicit data requirements and the consistent creation of high-resolution emission inventories of all the pilot cities of RI-URBANS.

Before distributing road traffic area emissions to road-links, a factor to alter road traffic emissions in urban centres is applied. This is done to counteract the underestimations of road traffic emissions in urban areas, when downscaling regional emission inventories to the urban-scale. The studies of Kuik et al. (2018), Ramacher and Karl (2020) and Ramacher et al. (2021) have recognized this underestimation as one of the main causes of bias in modelled NO_X, PM10 and PM2.5 concentrations. Depending on the time and season the NO_X-emission correction factor derived by Kuik et al. ranges between a minimum of ca. 2 (midday in summer) and a maximum of ca. 4.5 (winter morning). For the applications of RI-URBANS we suggest the averaged emission correction factor of 3 (applied in the road traffic emissions which are within an area marked as urban centre), although this is very likely to vary from city to city and especially for each pollutant.

Then, each grid cell of the downscaled road traffic area emissions is separately intersected with downloaded OSM road links, which are tagged as motorway, trunk, primary, secondary and tertiary roads. The intersecting OSM road links' lengths are used to calculate the total road length of all intersecting road links. The total road link length is used to derive a first weighting factor for each intersecting road link. A second weighting factor is derived, based on the different road types of each road link intersecting the grid cell, to account for generic traffic densities of different road types, following the work of Ibarra-Espinosa et al. (2018). The combination of both weighting factors allows for top-down distribution of the grid cell emission value to all intersecting road lengths, considering length and road type. This is repeated for all grid cells of the road traffic area emissions grid. Thereby, all road traffic area emissions are distributed to OSM road links (line emission sources). The integration of road sector emissions into the area dataset is optional.

3. Preliminary results

The previous version of the described methodology has already been applied for the urban areas of Athens (Greece), Ioannina (Greece), Hamburg (Germany), Helsinki (Finland) in the frame of several research projects (SMURBS, e-shape, PANACEA). Results are already published in a scientific paper (Ramacher et al., 2021) and in several scientific conferences (e.g. AGU, COMECAP, UAQ).

The current version, which contains several upgrades (see Sect. 2) has been applied in two of the pilot cities of RI-URBEMS (Helsinki and Athens). In order to identify the spatial differences between the CAMS dataset and the high-resolution data representative species of each GNFR sector are mapped for both cities (Figures 3-12). Emission totals for the urban domains are also given for both datasets to ensure the mass consistency of the method, while the high-resolution proxy used to spatially disaggregate the CAMS mass rate per cell is also provided using isopleths.

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Differences in the spatial distribution provided by the two approaches are briefly discussed. The two cities act as demonstrators of the value of the current development for the high resolution CTM applications.

3.1 Public power and refineries (GNFR A)

As expected for all coastal cities, the spatial allocation of this source type is greatly improved for the coastal areas, allocated at the industrial zones inland, when the 1x1 km grid is applied. Also, their peaks at the power plant areas of each city are better captured, both in space and absolute values, through the use of the emission downscaling approach.

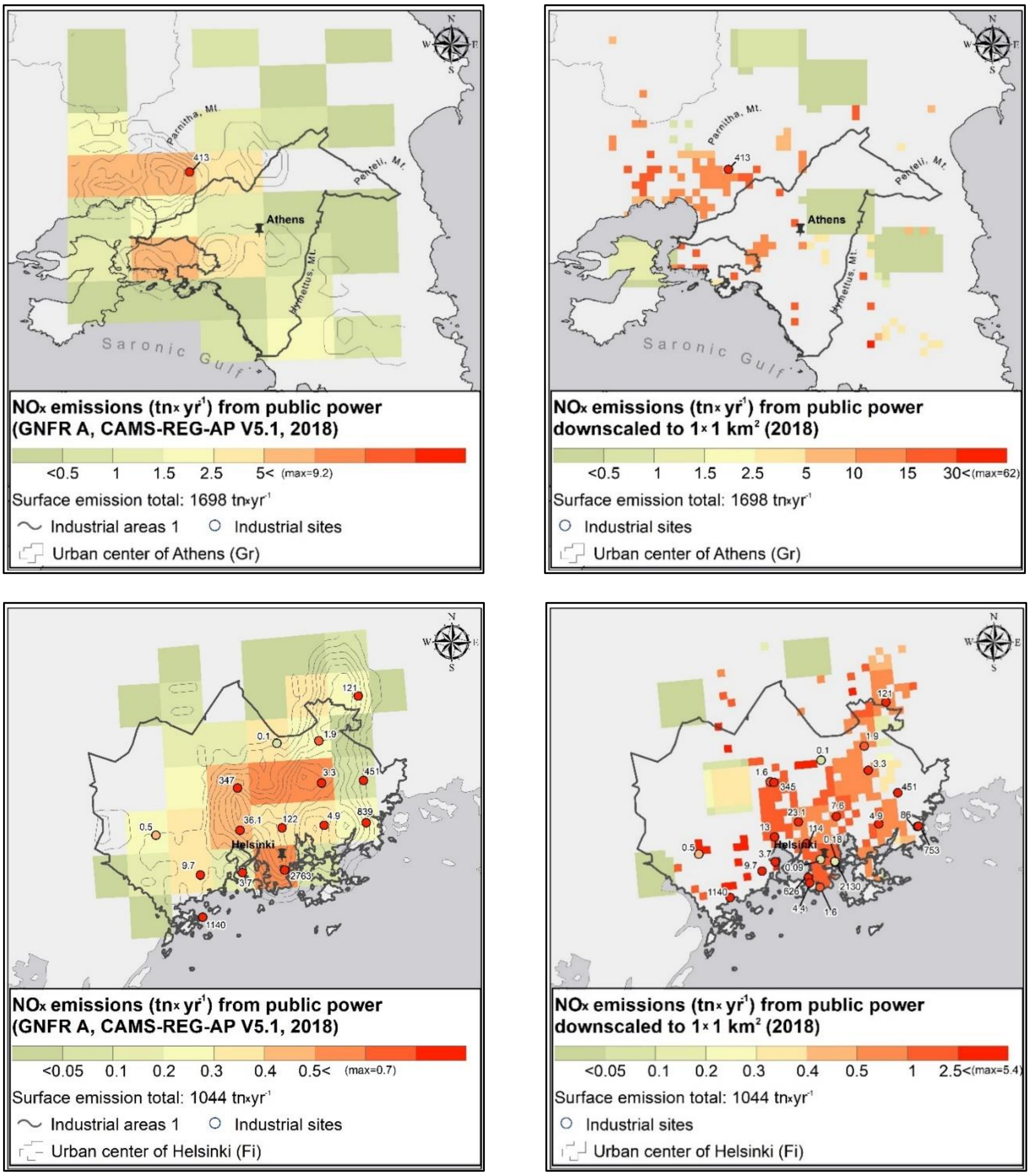

Figure 3. The spatial distribution of annual (2018) NOx emissions (tn y^{-1}) from public power (GNFR A) derived from the CAMS (v5.1) emission database (left) and after their spatial refinement (right). Indicative results are shown for the urban areas of Athens (top) and Helsinki (bottom).

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3.2 Industrial combustion and processes (GNFR B)

Following the pattern of the industrialized areas in both cities, when the spatial disaggregation is applied, emissions are confined and peak in those areas, in contrast to the more homogeneous fields followed by CAMS resolution.

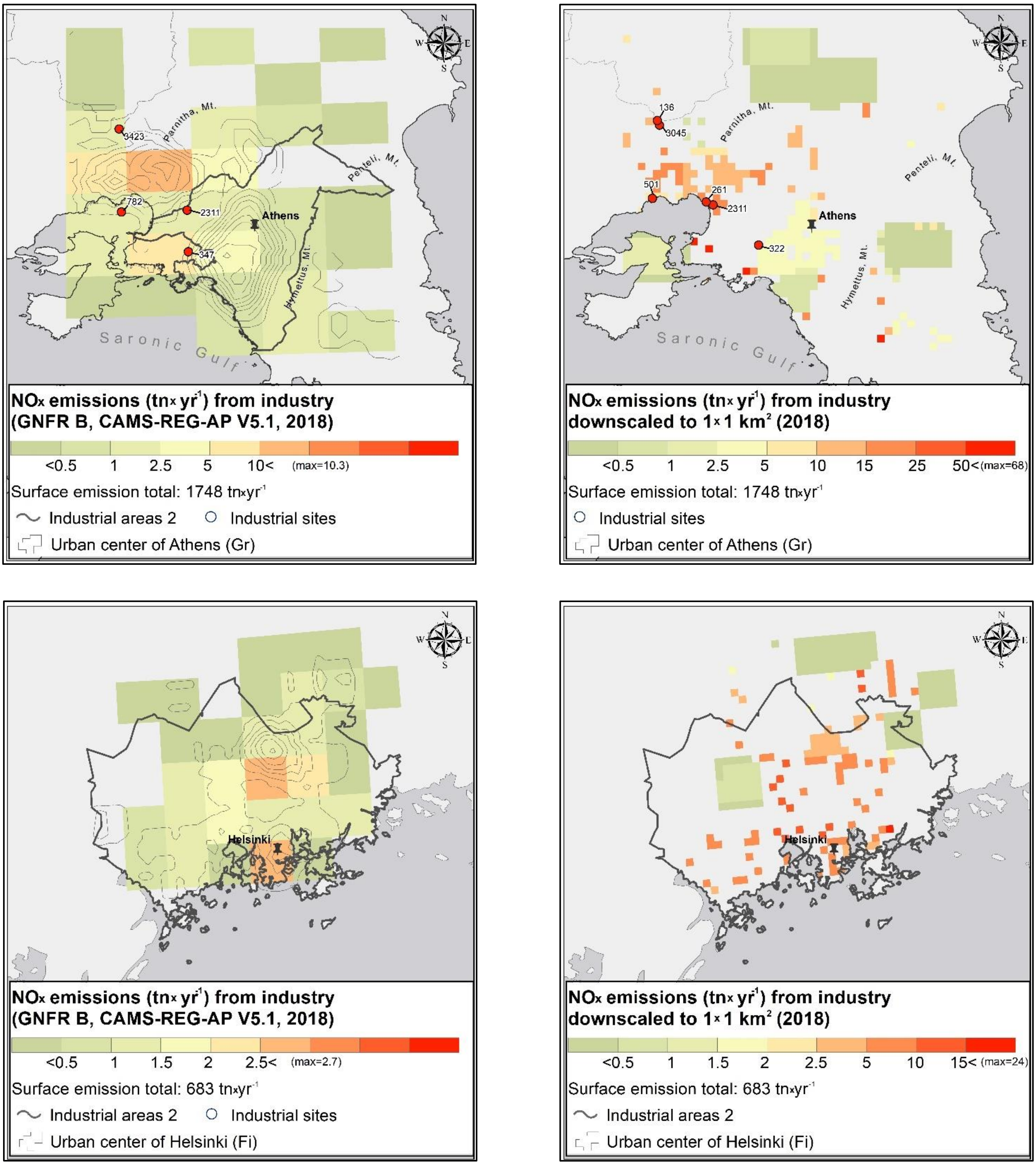

Figure 4, Same as in Figure 3, but for GNFR B.

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3.3 Small combustion (GNFR C)

In the fields of small combustion for Athens, an improvement when the spatial allocation is applied, occurs at the mountainous non-residential areas. In this source sector, the spatial disaggregation is based on residential population density.

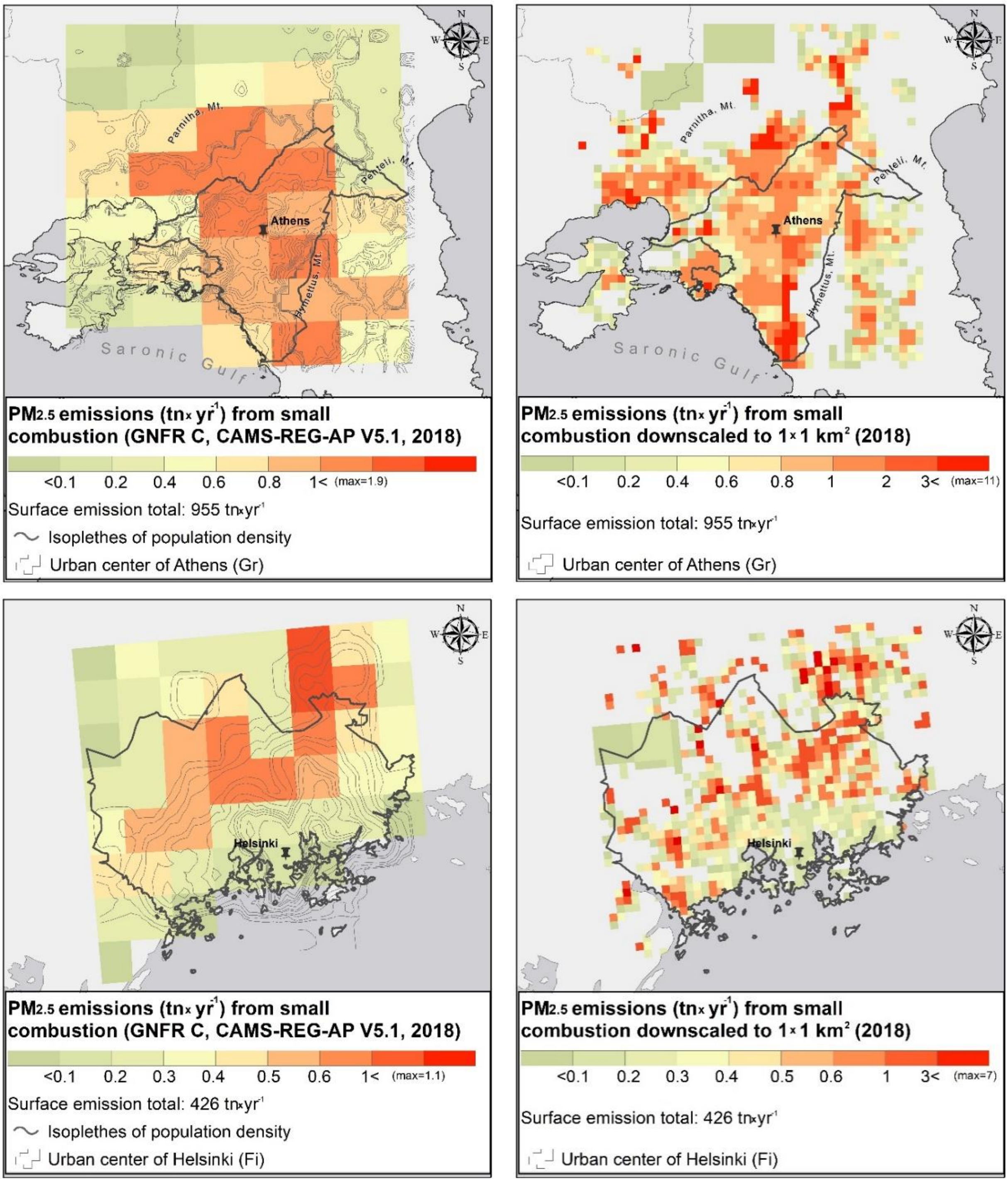

Figure 5. Same as in Figure 3, but for GNFR C.

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3.4 Fossil fuel production and fugitives (GNFR D)

Similarly, to the other industrial source sectors, emissions from this source sector are again spatially confined and peak at the industrialized areas of the cities. In the case of Athens, it is noted that point emissions are allocated through the exact E-PRTR locations, instead of using the original CAMS database.

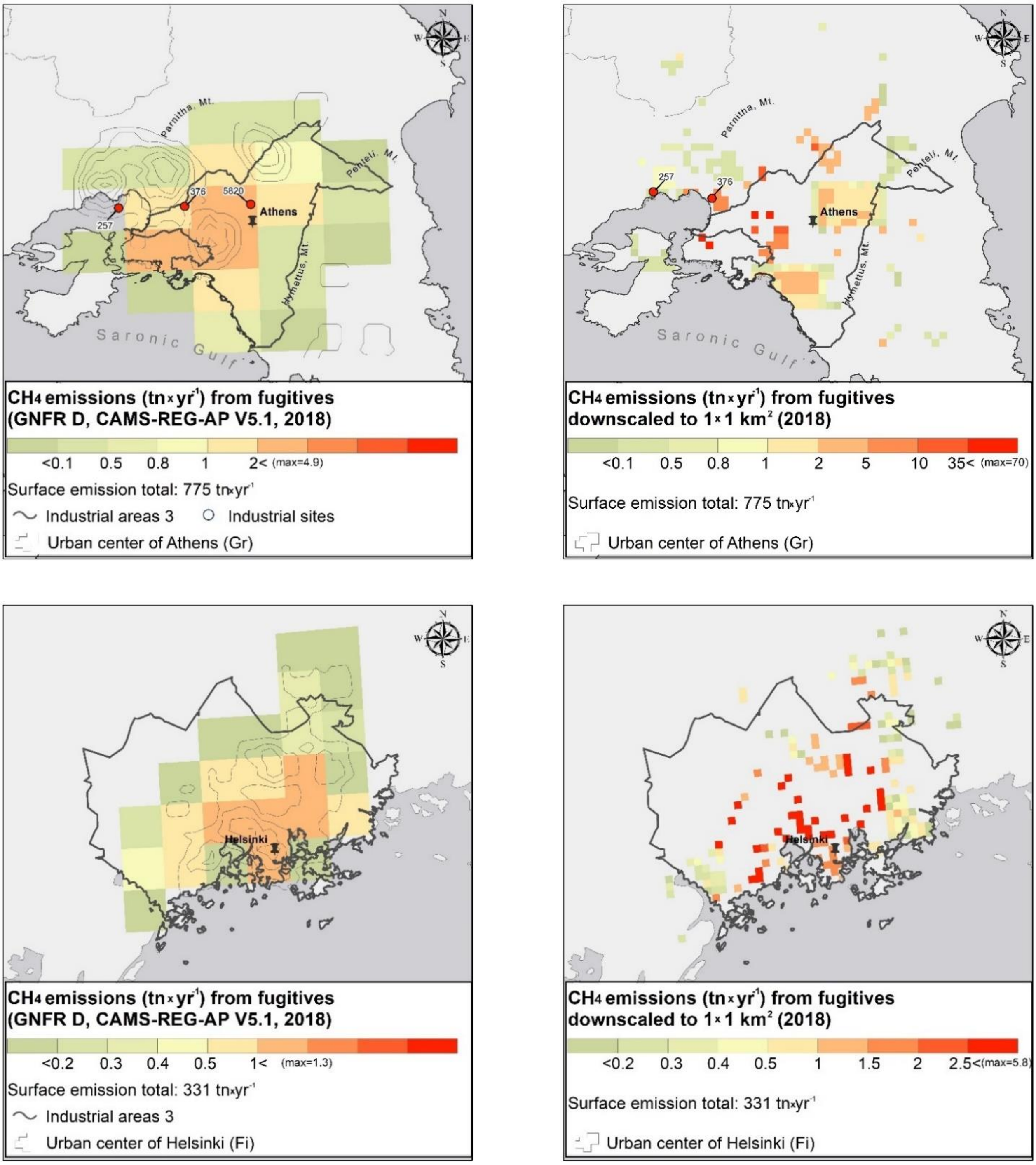

Figure 6. Same as in Figure 3 but for GNFR D.

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3.5 Solvents and other use production (GNFR E)

In this source factor, the spatial disaggregation of emissions results in their more accurate conferment to the urban area of both cities.

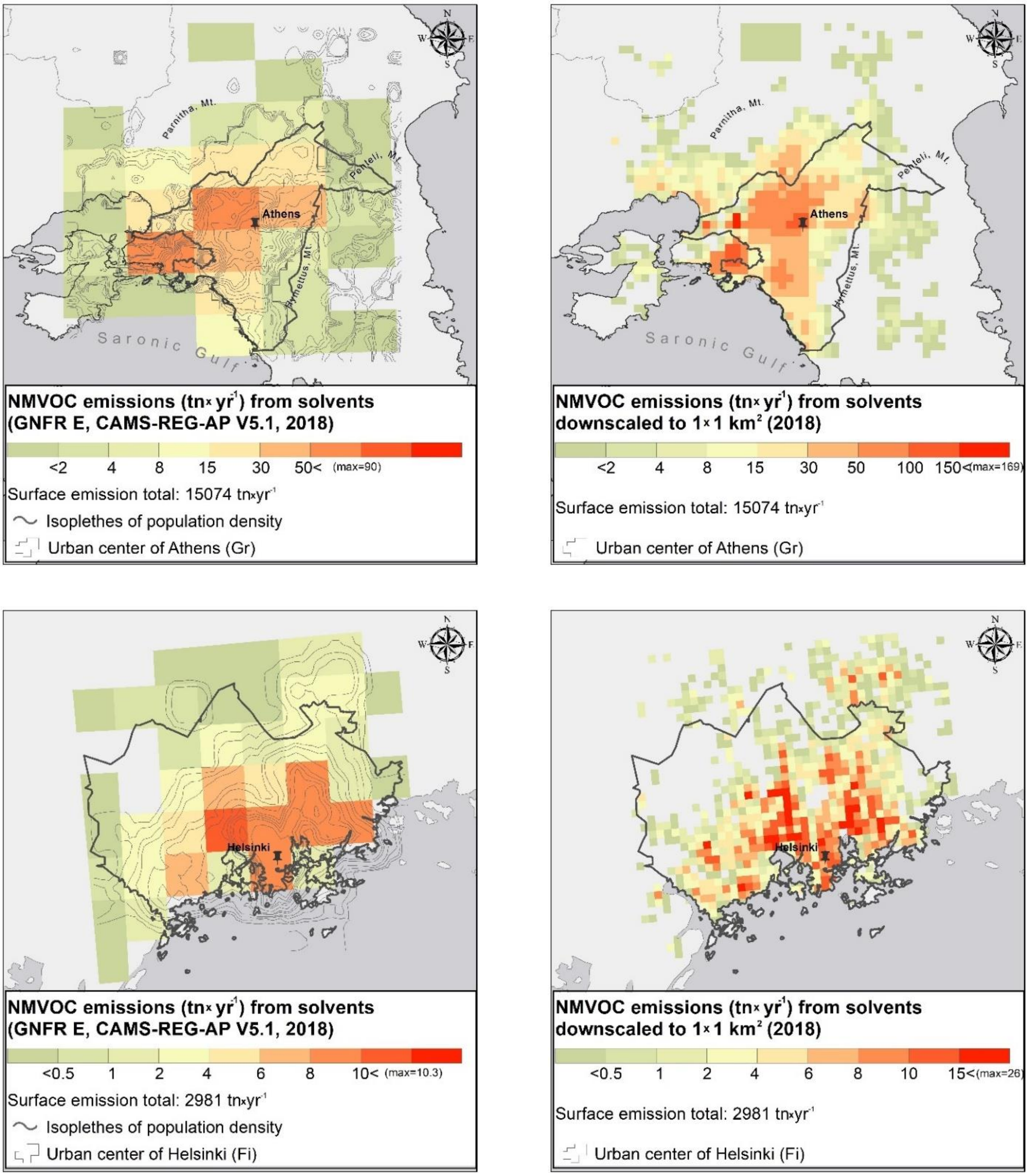

Figure 7. Same as in Figure 3, but for GNFR E.

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3.6 Road transport (GNFR F)

The biggest spatial improvement occurs for emissions from road transport. Through the applied methodology, the mass in each CAMS cell is attributed to its road network. In the below plots the mapping through the direct allocation to the network is given. Similar maps (and data), when the population density is first used for the high-resolution area mapping, are also available but not shown.

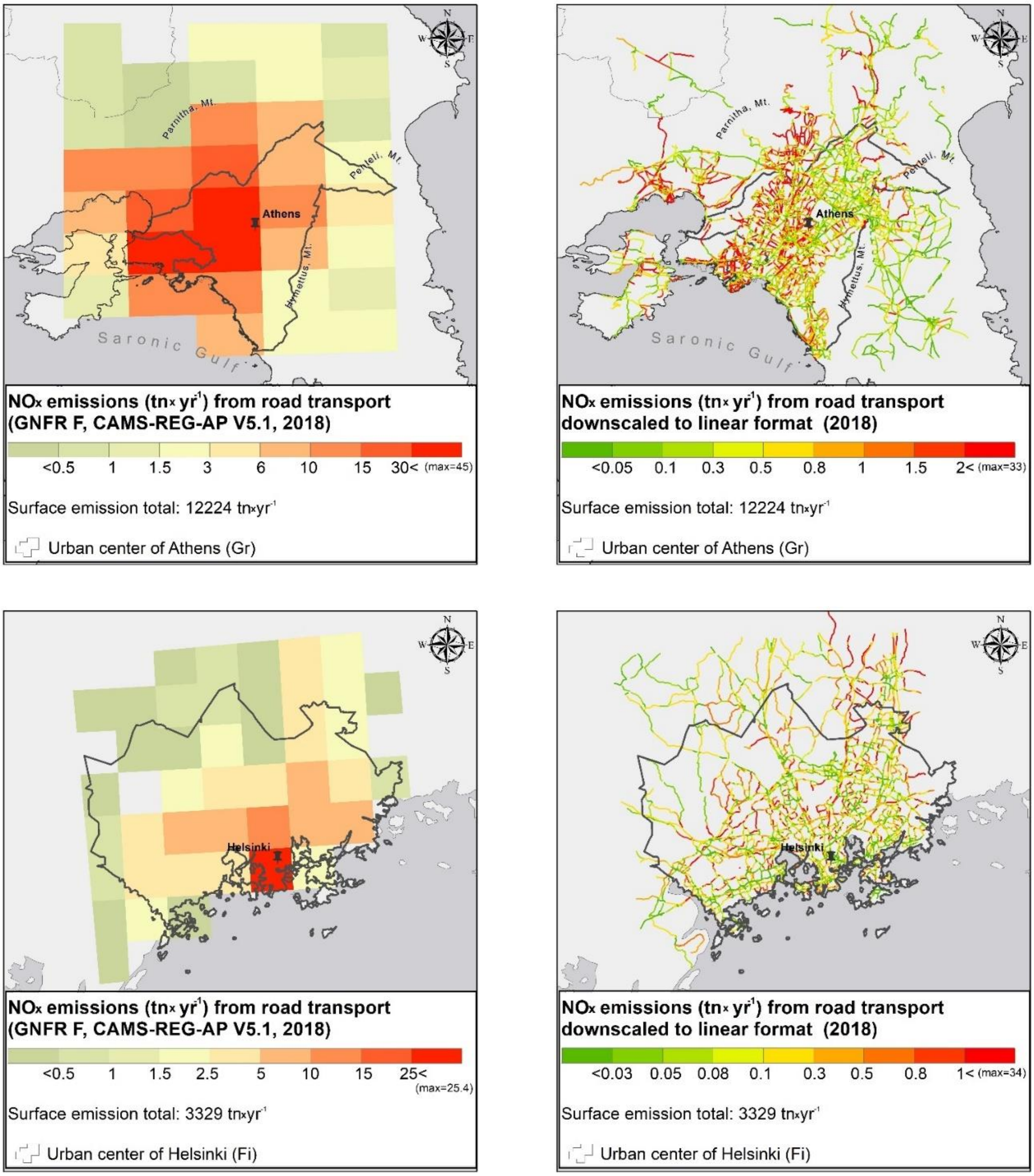

Figure 8.Same as in Figure 3 but for GNFR F, which is allocated to the road network (right).

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3.7 Shipping and aviation (GNFR G and GNFR H)

Similarly, to the road sector, shipping and aviation emissions are also greatly improved once projected to the high-resolution grid through the applied methodology. The shipping lines are followed, while aviation is put as a point source.

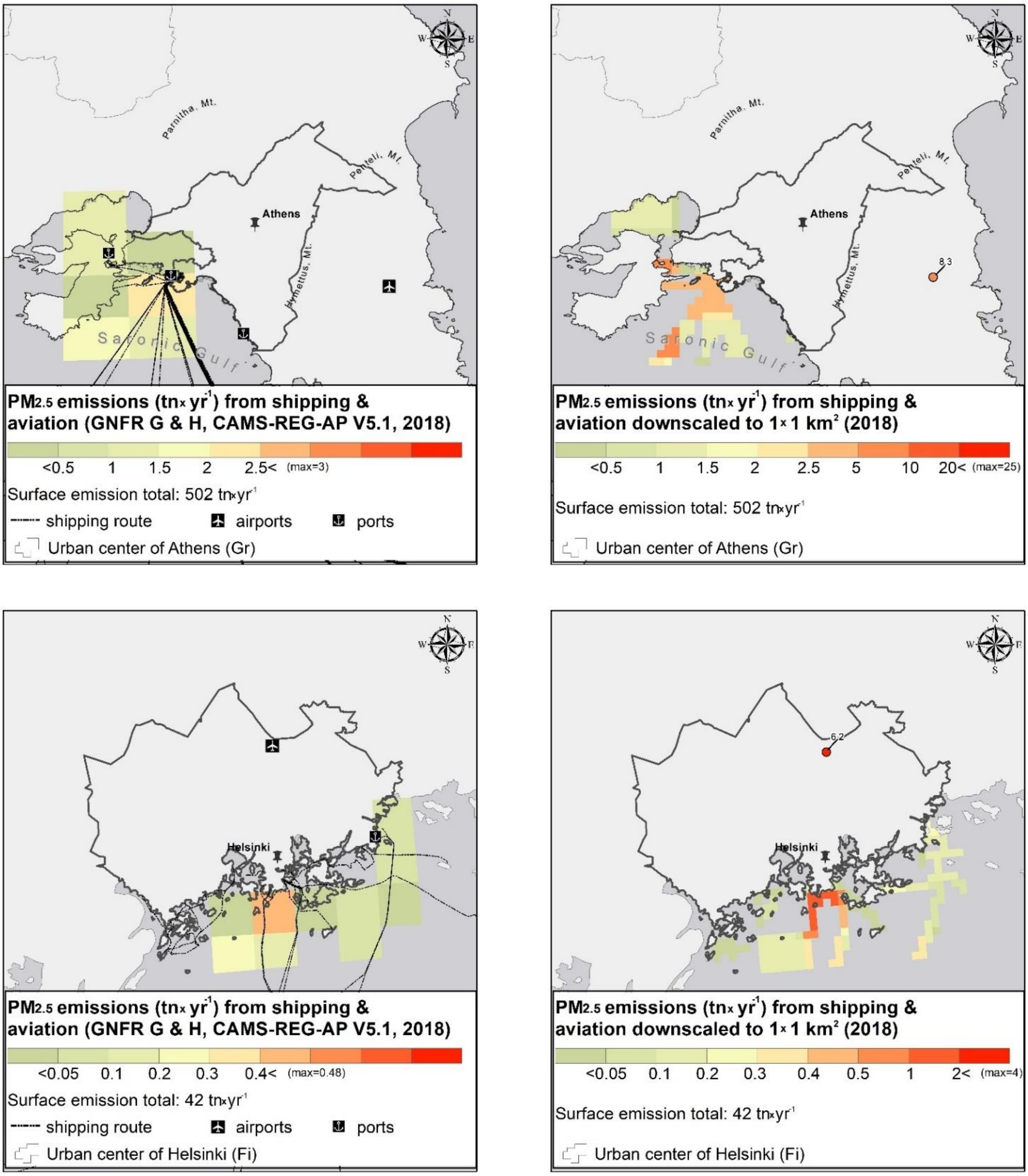

Figure 9. Same as in Figure 3, but for GNFR G and GNFR H.

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3.8 Offroad activities (GNFR I)

This is the only sector where the spatial allocation of its four subsectors was performed through the use of different spatial proxies. Again, railway emissions are nicely allocated, while confined peaks of other offroad activities are revealed through the spatial disaggregation.

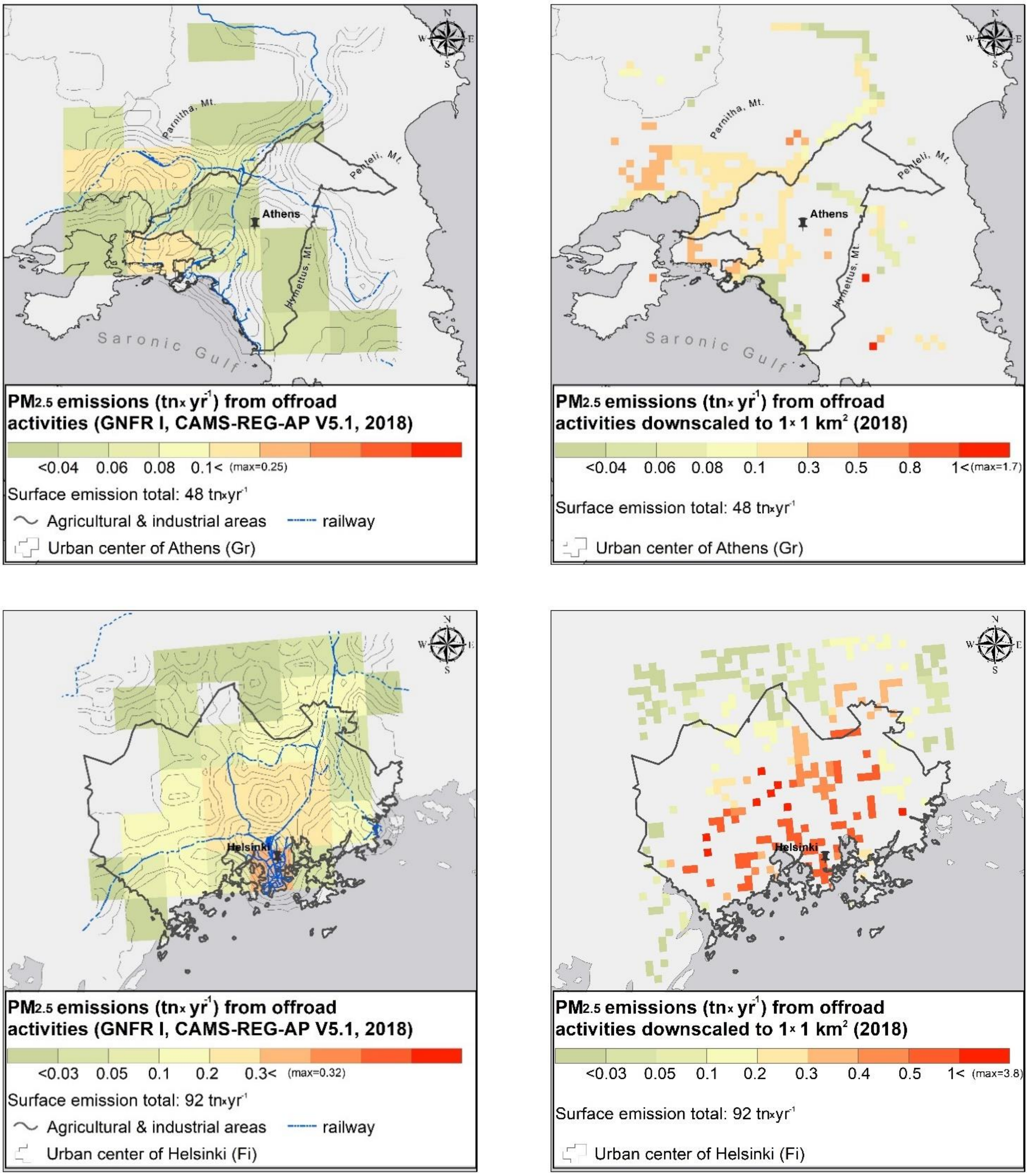

Figure 10. Some as in Figure 3, but for GNFR I.

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3.9 Waste treatment (GNFR J)

Waste treatment is heavily allocated to the respective land uses, or to the arable land, assuming waste combustion. In the case of Athens, the main waste treatment site on a small island, is been attributed with the respective CAMS emissions.

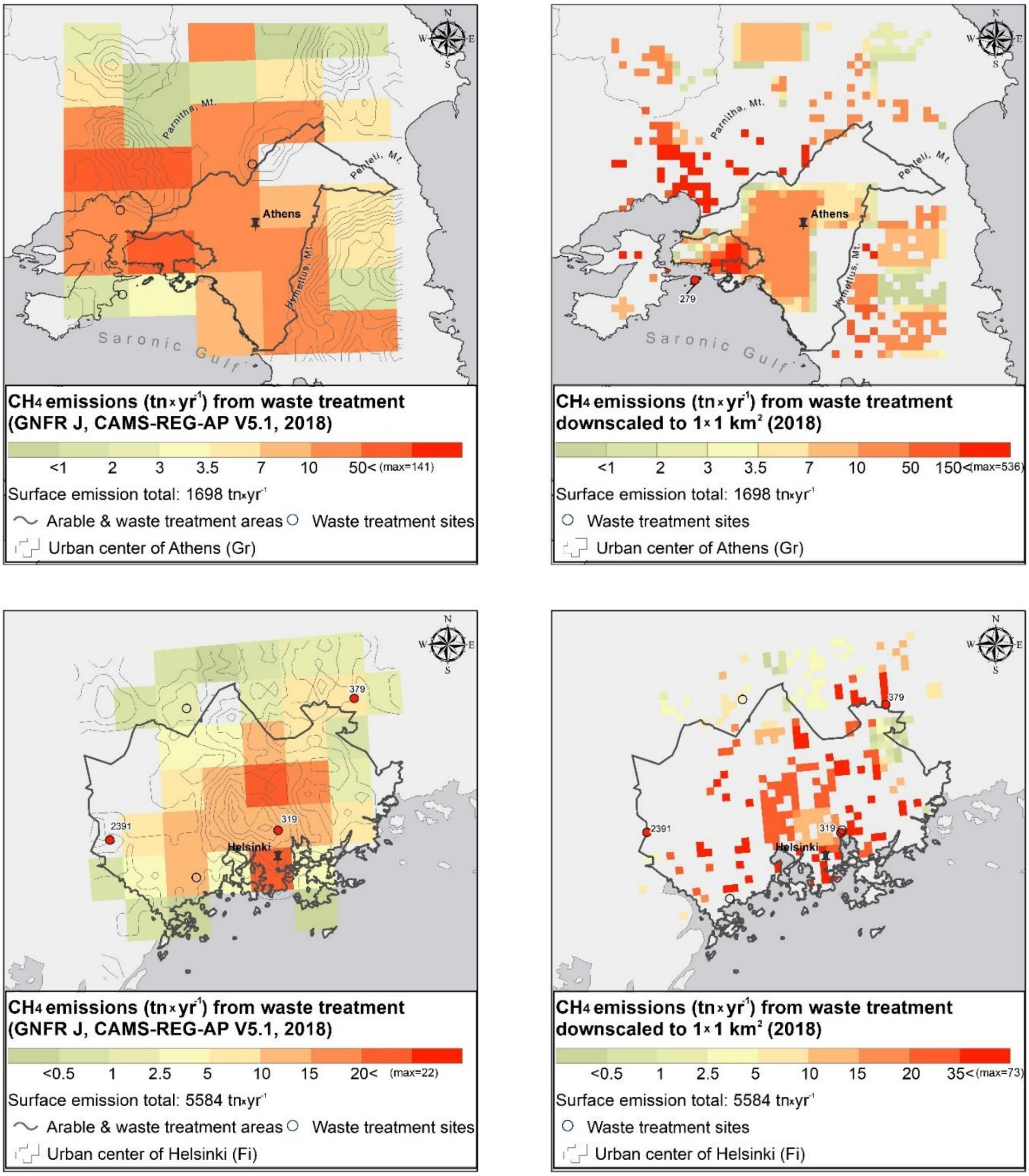

Figure 11. Same as in Figure 3, but for GNFR J.

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3.10 Agriculture (GNFR L and GNFR K)

The spatial reallocation of emissions from agriculture gives their mapping mainly outside the city centers, while the population density manages their allocation for the few CAMS areas in the urban center.

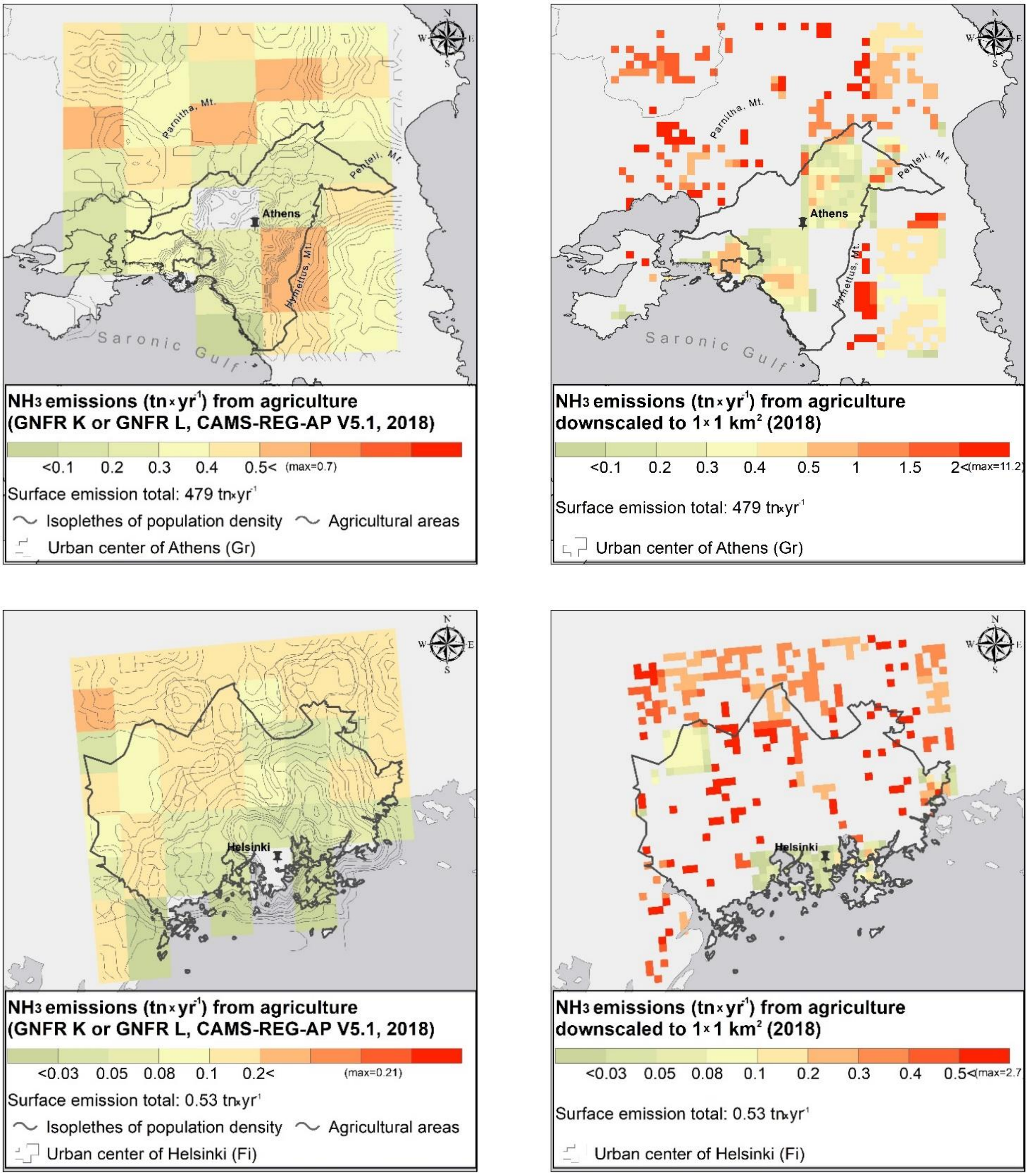

Figure 12. Same as for Figure 3., but for GNFR K and L.

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4. Summary

This deliverable describes the spatial disaggregation method to improve CAMS regional emissions over the pilot cities of RI-URBANS. The method will incorporate all additional species and sources that will occur in the frame of this task. In addition, the method will be evaluated and optimized once the comparison of available bottom up emission datasets over cities occur. Then, the method will be applied in all pilot cities of RI-URBANS, so that inputs are available for the high resolution CTM applications.

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