UN-GGIM Europe webinar
Earth Observation and SDGs: uses cases and workflows

Spatio-temporal enhancements of the air quality indicator SDG 11.6.2

"Annual mean levels of fine particulate matter in cities (population weighted)"

Evangelos Gerasopoulos - National Observatory of Athens/ Greek GEO Office

May 23, 2023

The ever growing importance of $PM_{2.5}$

The Ambient Air quality Directive 2008/50/EC is currently under revision to, among other things, align the EU standards more closely with the WHO recommendations (based on newer science).

Figure 5. Concentrations of $PM_{2.5}$ in 2021 and 2022 in relation to the EU annual limit value and the WHO annual guideline level

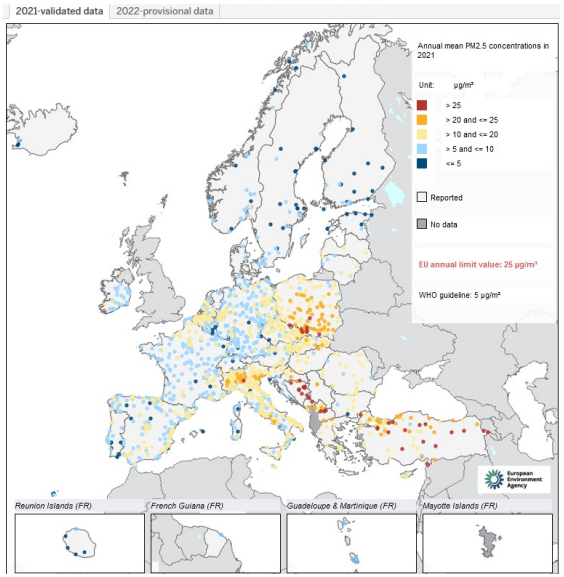
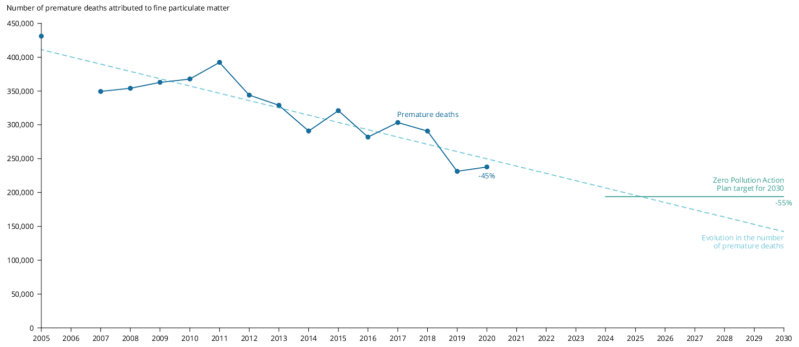
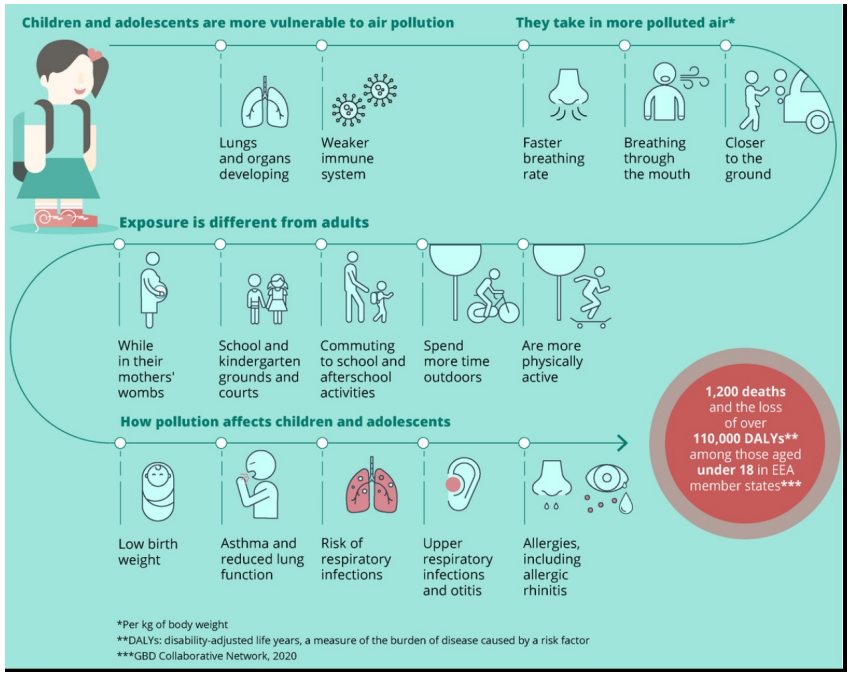


Figure 1. Premature deaths in the EU-27 due to $PM_{2.5}$ levels above the 2021 WHO guidelines and distance to the zero pollution target, 2005-2020

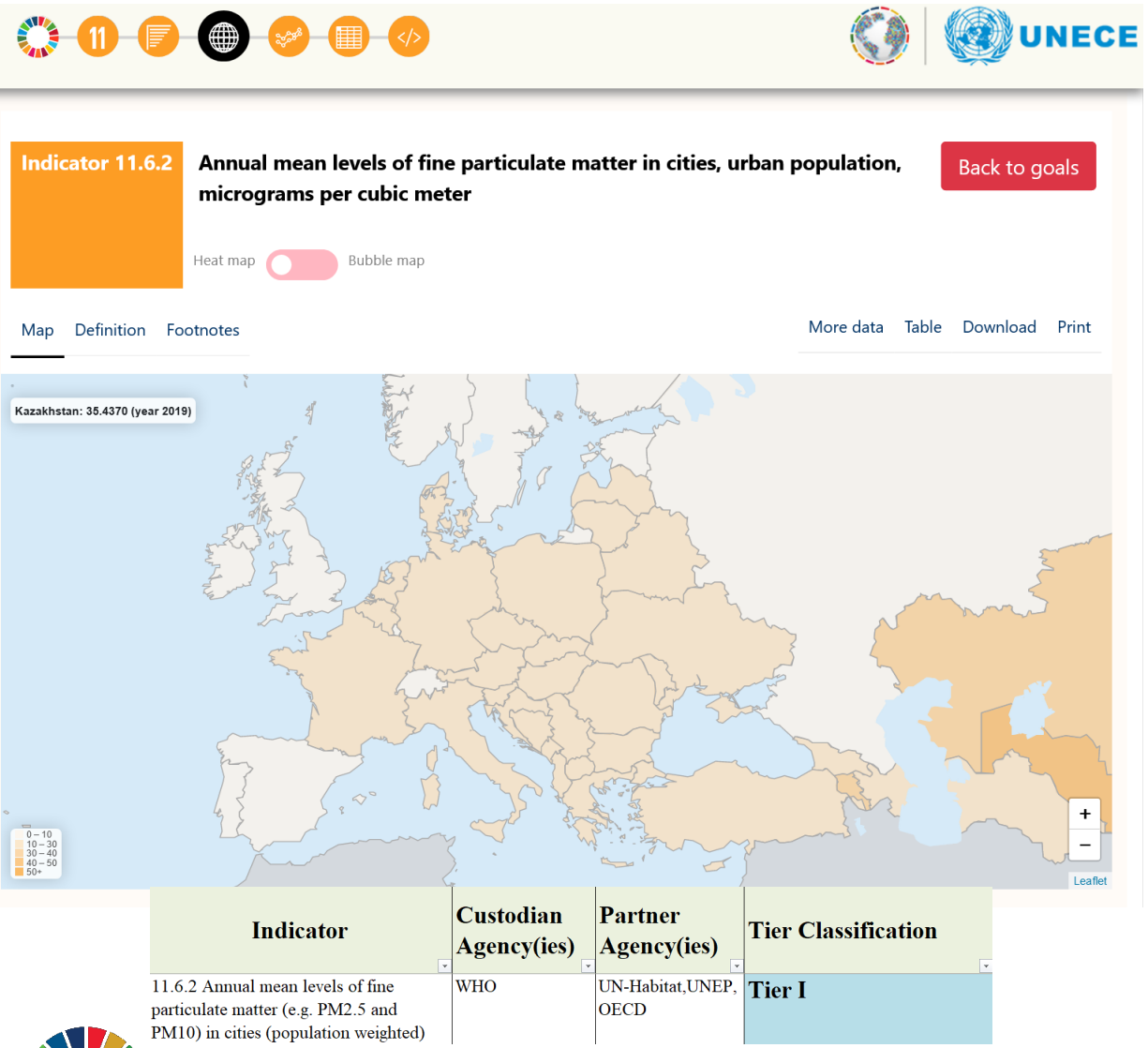


275000

from chronic exposure to fine particulate matter

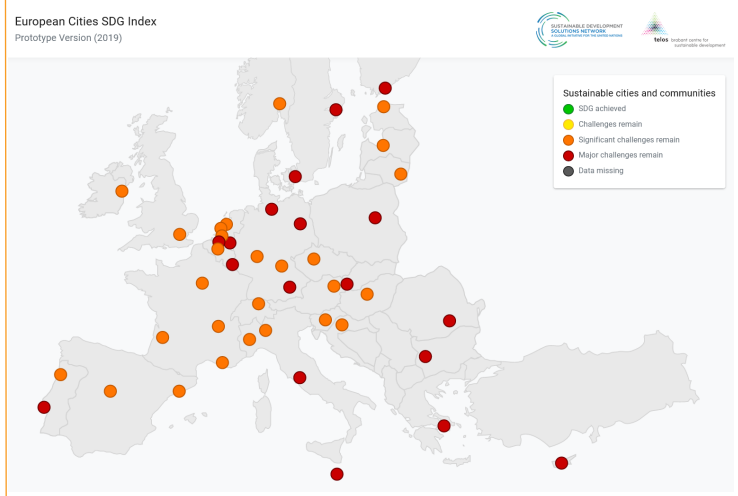


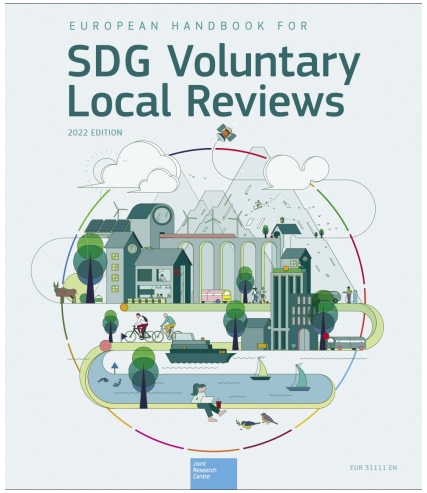
Tier 1, so why bother?



Indicator	Custodian Agency(ies)	Partner Agency(ies)	Tier Classification
11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)	WHO	UN-Habitat,UNEP, OECD	Tier I

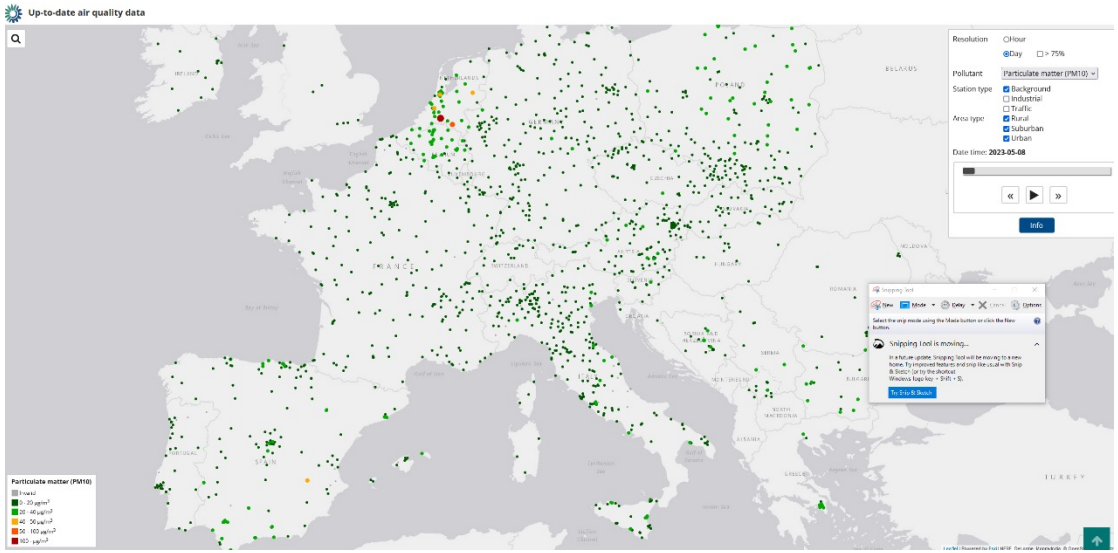
- 'Our Struggle for Global Sustainability Will Be Won or Lost in Cities', says Secretary-General (2012)
- UN Decade of Action is underway → The need for *localization*

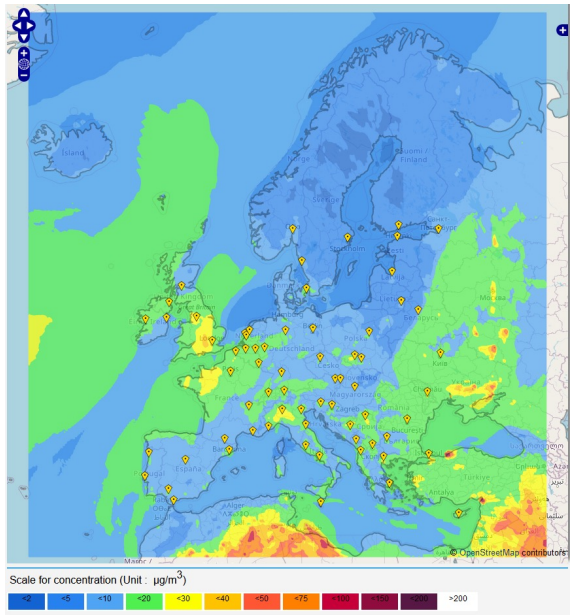




- Leave no One Behind (SDG, Green Deal, OECD)→ *data needs*
- Smart City and full Earth Observation array for capturing *intra-urban variability*
- In line with UNGGIM Europe Scoping paper and SDG Territorial Dimension: *Recommendations (e.g. Use geospatial layers generated from Earth Observation data, Implement consistent and stable sub-national spatial units)*

Current/Official (in situ) vs Modeling and Geospatial approach



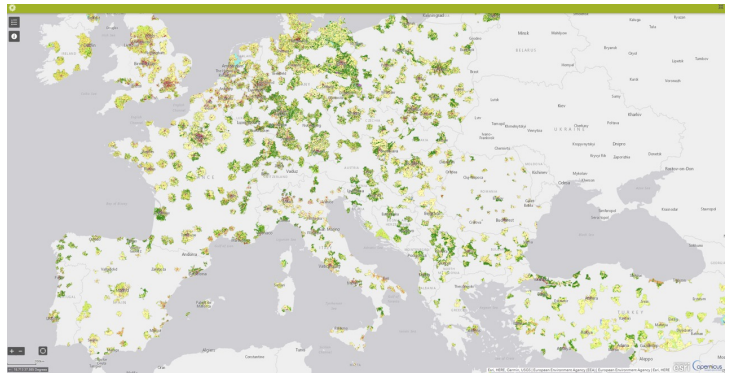


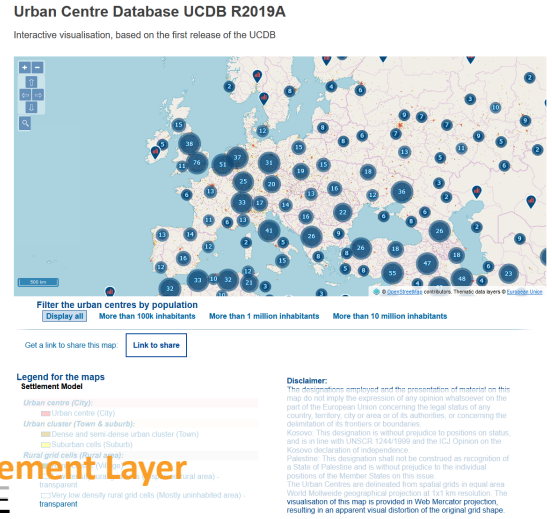
- Ensemble model
- Gridded data (~10km, 700 x 420 gridpoints)
- Operational and long-term
- Ever-improving
- 3-month evaluation
- Harmonized across Europe

UN Metadata: Countries with AQ monitoring networks provide the annual mean concentrations and *corresponding number of inhabitants* to derive the national population-weighted exposure to PM in cities using a generalized formula.

Additional data, such as satellite retrievals of aerosol optical depth, *chemical transport models*, topography, etc., can be utilized in the absence of ground measurements: **The Shaddick 2016-DIMAQ (Data Integration Model for Air Quality) workflow**.

Copernicus Atmospheric Modeling Service: European air quality reanalyses





Copernicus Land Monitoring : Urban Atlas & Emergency Management: Global Human Settlement Layer

The SMURBS 11.6.2 Platform: The low hanging Copernicus fruit

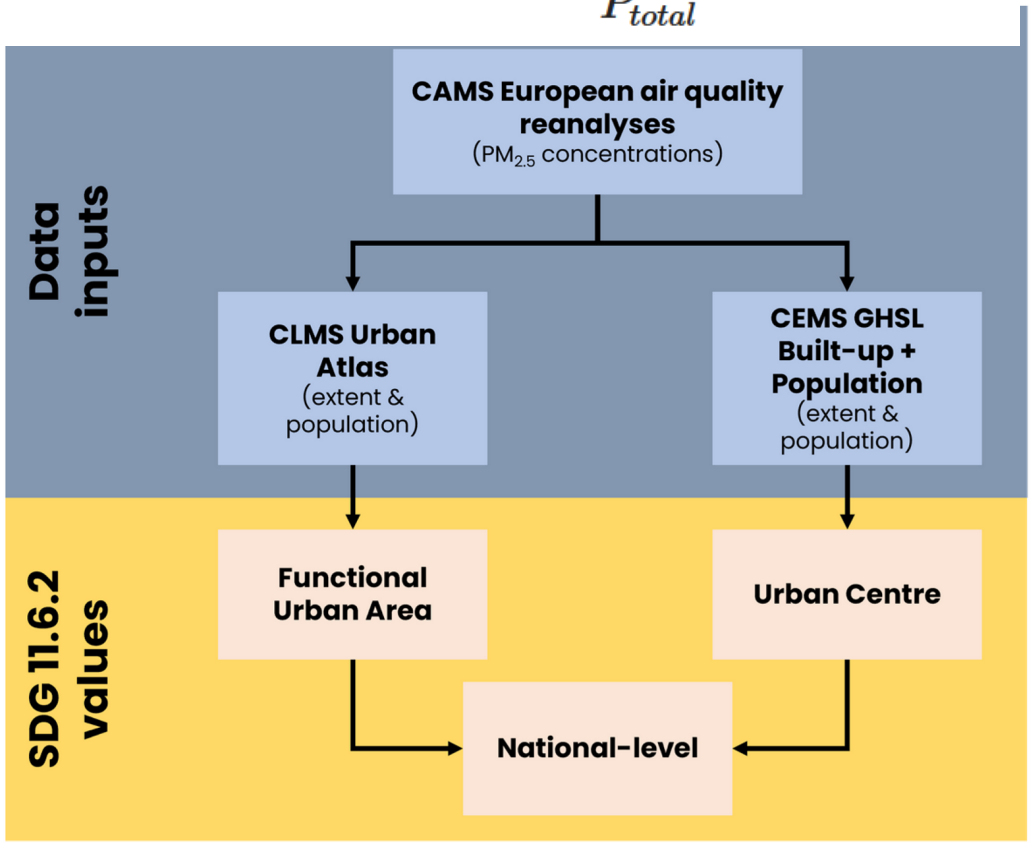
EuroGEO

ERA-PLANET

SMURBS

ERA-PLANET

$$Annual\ mean\ level = \frac{(C_{U1}P_{U1} + C_{U2}P_{U2} + \cdots + C_{Un}P_{Un})}{P_{total}}$$

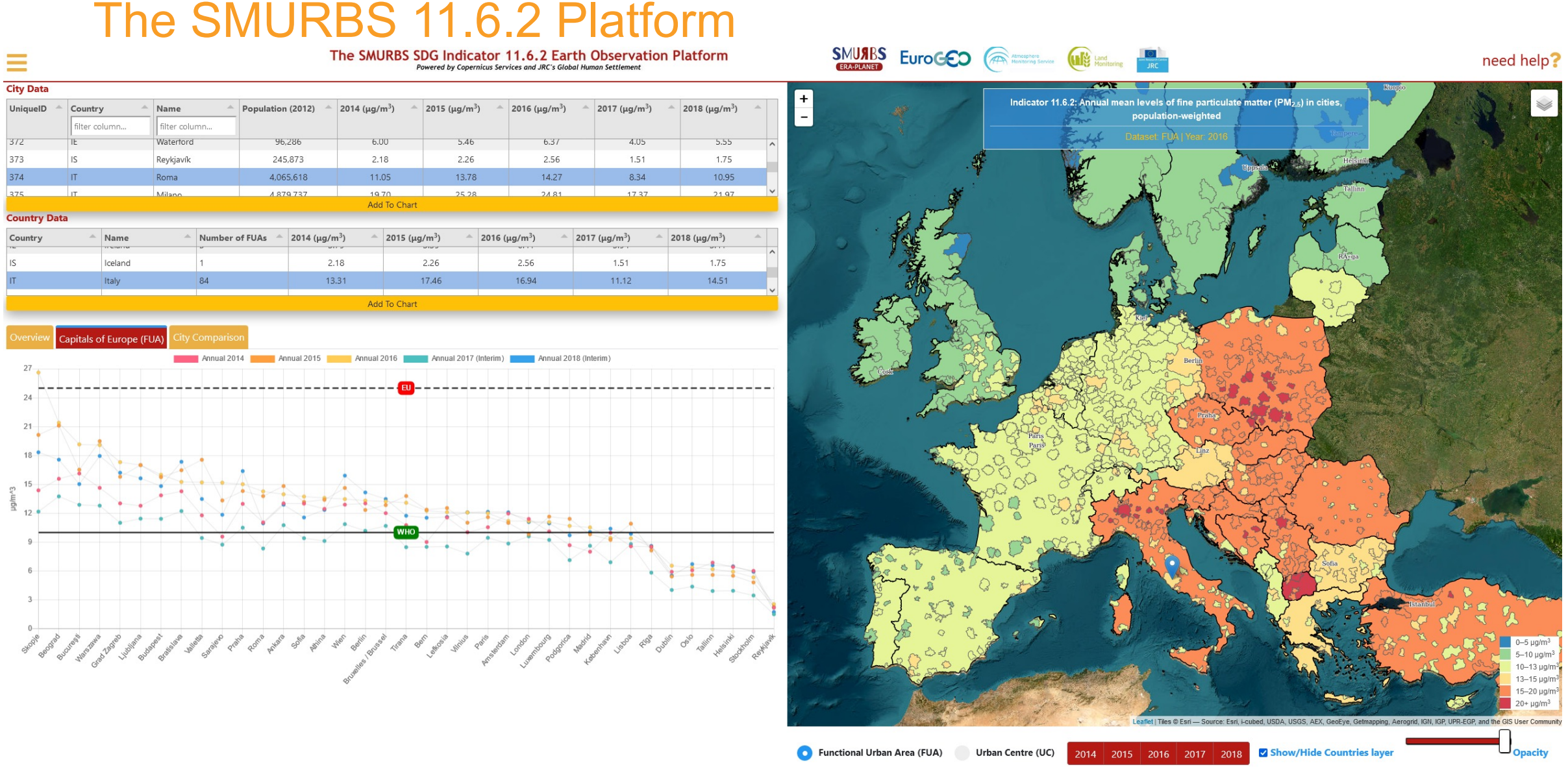


Atmosphere Monitoring

Land Monitoring

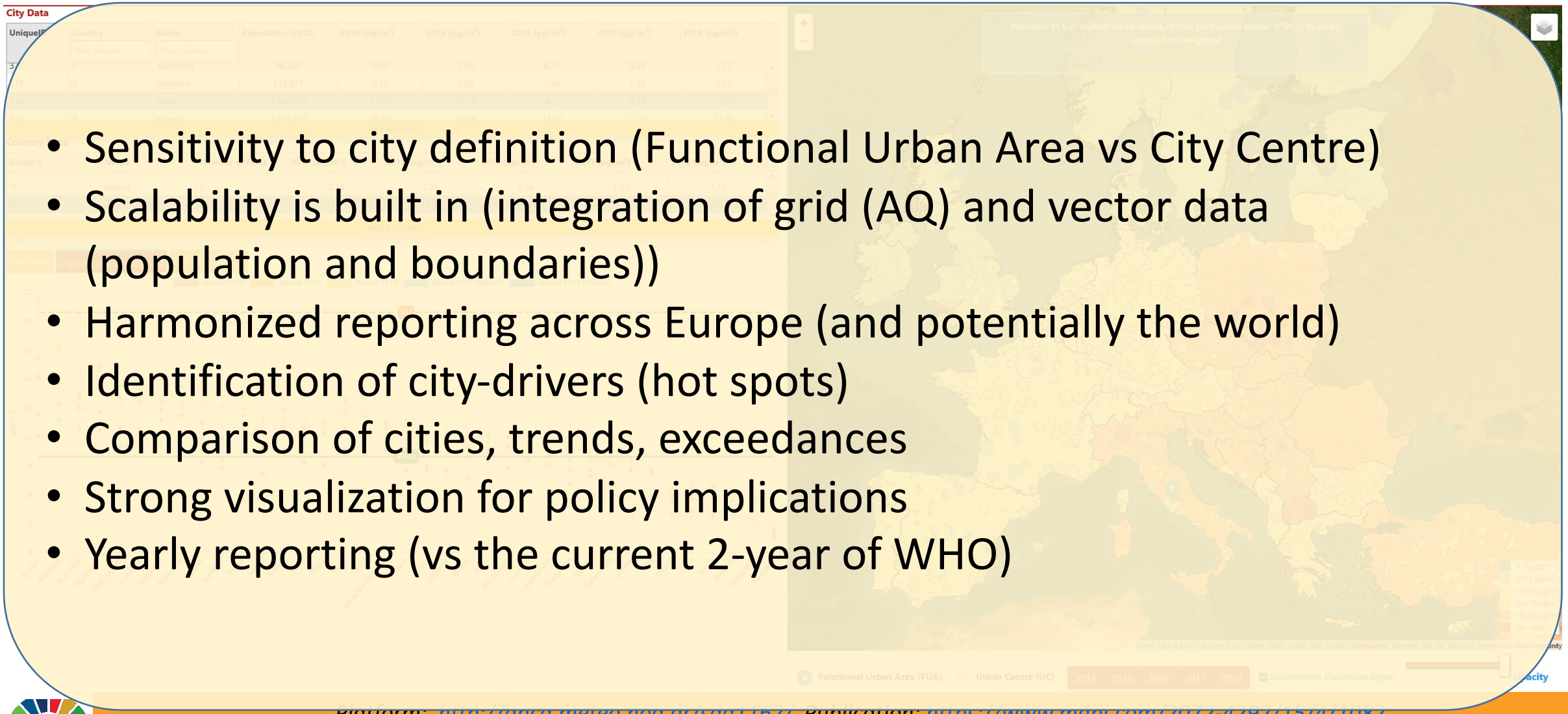
Emergency Management

The SMURBS 11.6.2 Platform



Platform: http://apcg.meteo.noa.gr/sdg1162/ *Publication:* https://www.mdpi.com/2072-4292/15/4/1082

The SMURBS 11.6.2 Platform

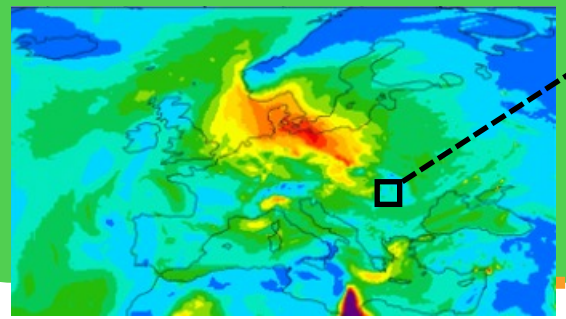


- Sensitivity to city definition (Functional Urban Area vs City Centre)
- Scalability is built in (integration of grid (AQ) and vector data (population and boundaries))
- Harmonized reporting across Europe (and potentially the world)
- Identification of city-drivers (hot spots)
- Comparison of cities, trends, exceedances
- Strong visualization for policy implications
- Yearly reporting (vs the current 2-year of WHO)

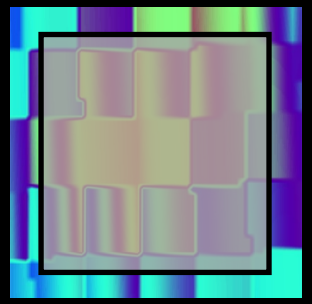
Platform: http://apcg.meteo.noa.gr/sdg1162/ Publication: https://www.mdpi.com/2072-4292/15/4/1082

Increasing the localization (from CAMS to intra-urban)

CAMS European-scale AQ interim reanalysis from model



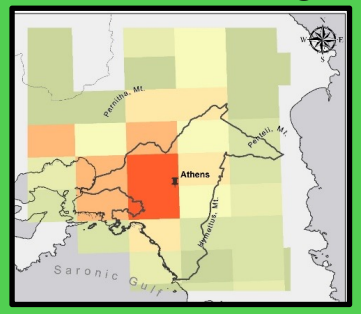
WRF model meteorological simulations



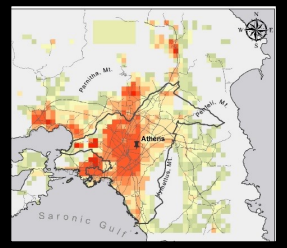
Boundary air pollution conditions

Atmospheric meteorological parameters

CAMS-REG-AP: regional anthro pogenic emissions

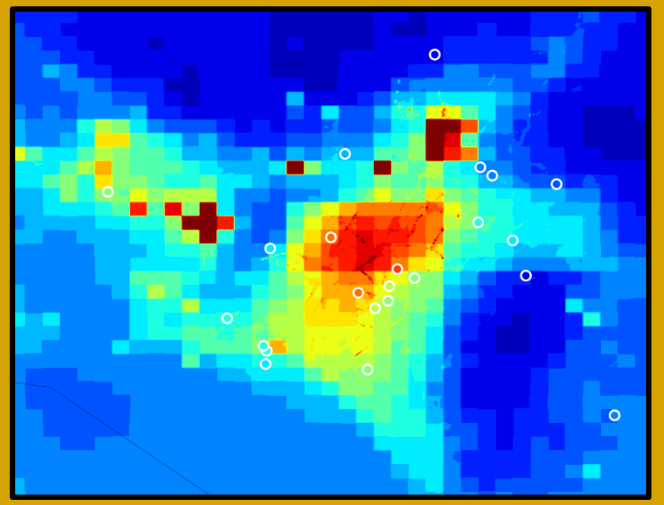


UrbEm spatial disaggregation tool



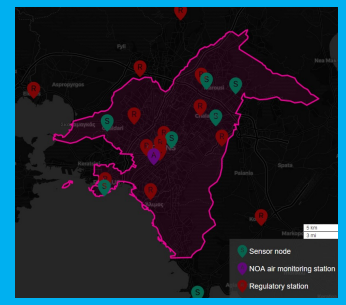
High resolution Anthropogenic air pollution emissions

Urban scale CTM modeling



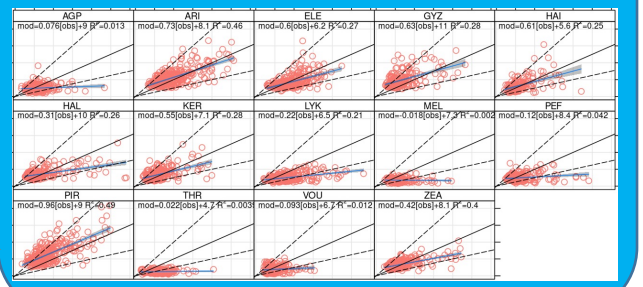
Episode-CityChem

In situ &



Citizen observatory Air pollution measurements

Model evaluation



Health-related levels of air pollution per pixel/ municipality

Spatio-temporal enhancements of the air qu

Increasing the localization (and other indicators)

Figure 8. Annually averaged $PM_{2.5}$ concentrations for the 30,000 × 30,000 m^2 Hamburg domain with a resolution of 100 × 100 m^2, as simulated with the EPISODE-CityChem model.

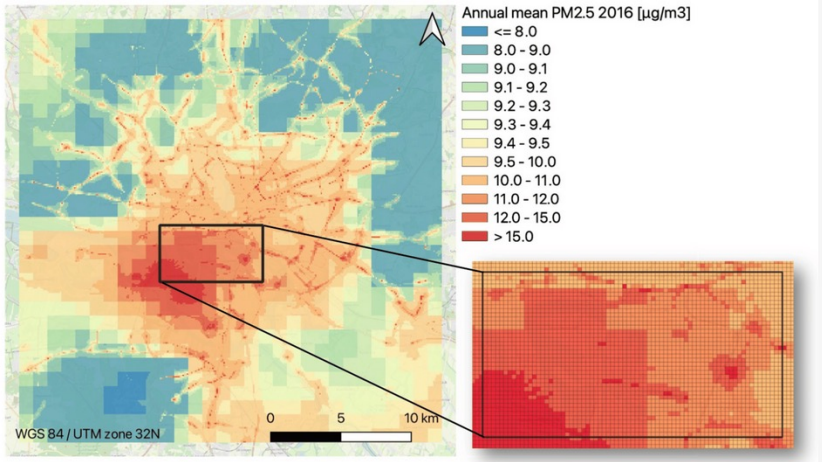


Figure 9. Annual mean $PM_{2.5}$ concentrations in districts (**a**) and neighbourhoods (**b**) for Hamburg, 2016, as simulated with EPISODE-CityChem. Bivariate plots for normalized mean $PM_{2.5}$ concentrations and normalized population density in districts (**c**) and neighbourhoods (**d**) for Hamburg, 2016. The SDG 11.6.2 value for the urban area, deriving from district and neighbourhood aggregations and calculations provided at the bottom.

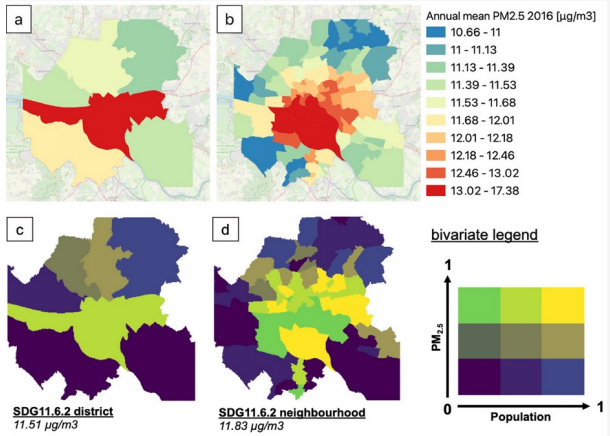
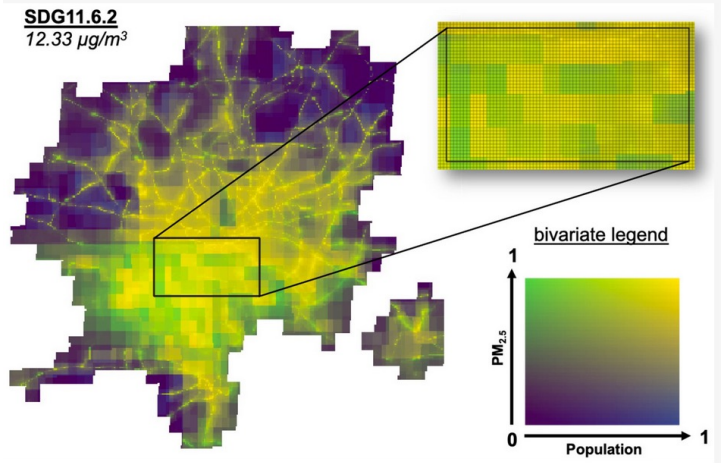
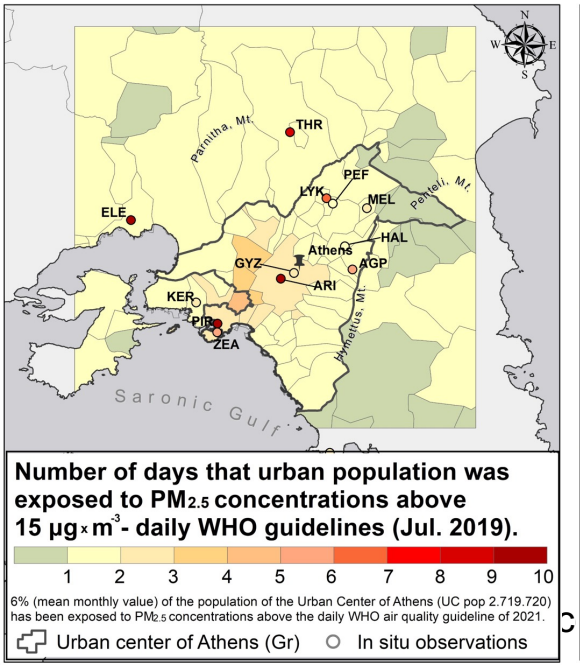
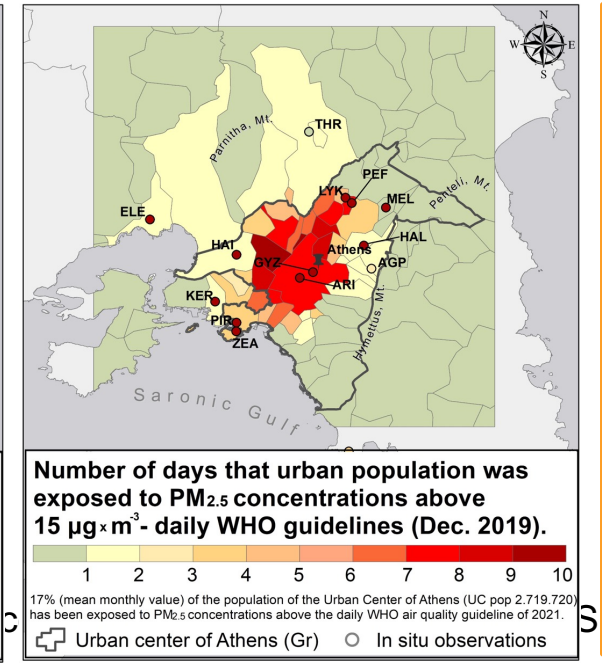
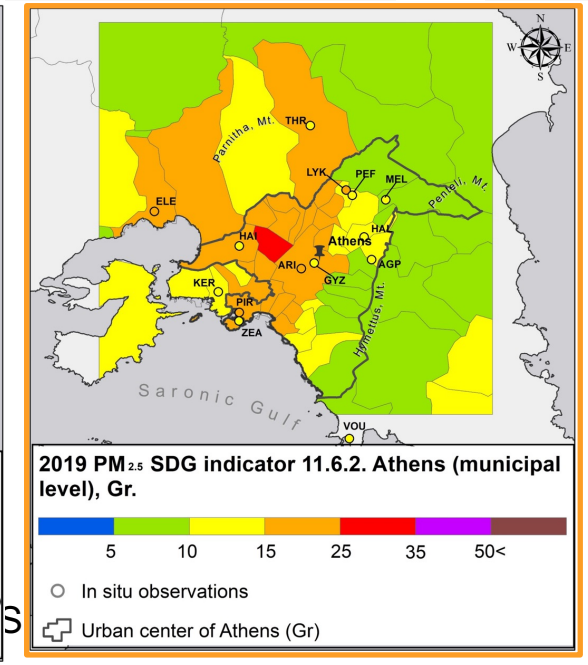


Figure 10. Bivariate map that combines population from GHS POP and simulated $PM_{2.5}$ concentrations (normalized values) to identify hotspots of population exposure to particulate matter pollution (yellow) or highly polluted but not populated areas (green), in comparison to low polluted areas, with low (purple) or high (blue) population density.









- Modelling workflow entirely based on Copernicus and other open data
- Gridded data and hourly concentrations enable various aggregations
- Seasonality is captured (e.g. summer vs winter)
- Intra-urban hot spots are identified (enabling efficient mitigation measures)
- Enables exposure, health and environmental disparity studies (enabling just mitigation measures)

Insights

- Complementarity to current workflow
- The main added value of EO is the spatio-temporal disaggregation
- More open socio-economic data (e.g. High value datasets, census data) will enhance the leave no one behind paradigm (e.g. dynamic exposure)
- Copernicus and other open data ensure applicability across Europe (Shaddick 2021 also utilizes the CAMS global reanalysis in DIMAQ)
- Harmonized reporting is ensured (AQ+City definition)
- A useful approach in under-monitored areas (e.g. EU's small giants)
- Low-cost $PM_{2.5}$ sensors can enhance the AQ fields especially within cities (and SDG 11.6.2)

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