

# 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<sub>2.5</sub>

EU standards

WHO guidelines



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<sub>2.5</sub> in 2021 and 2022 in relation to the EU annual limit value and the WHO annual guideline level

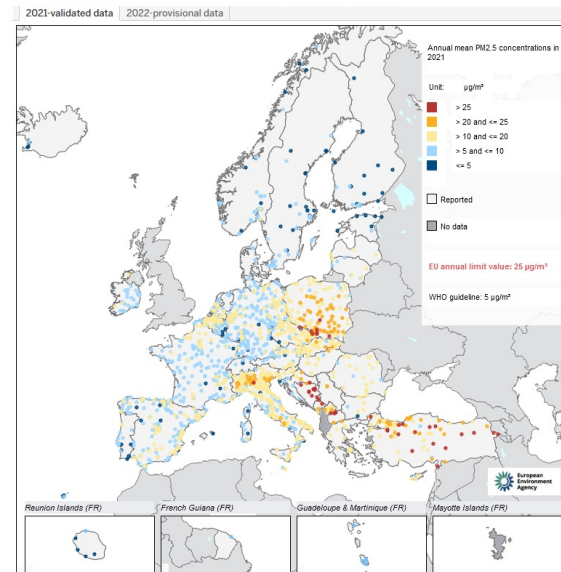
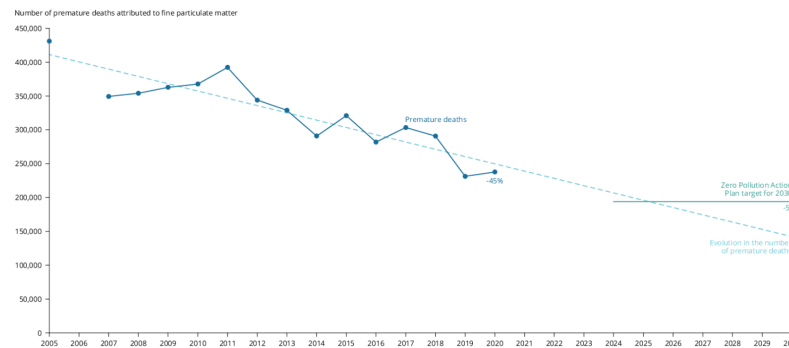
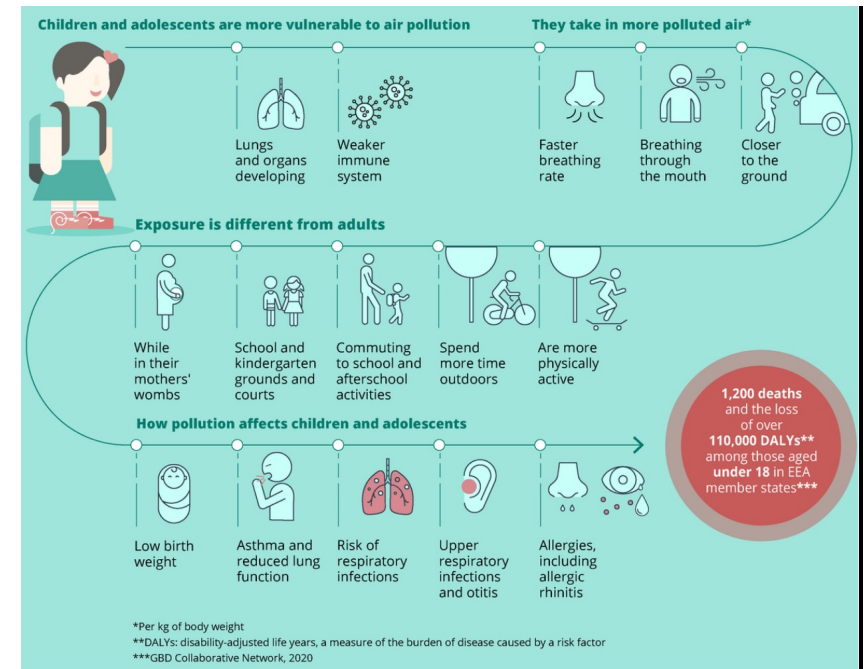


Figure 1. Premature deaths in the EU-27 due to PM<sub>2.5</sub> levels above the 2021 WHO guidelines and distance to the zero pollution target, 2005-2020



275000

from chronic exposure to fine particulate matter

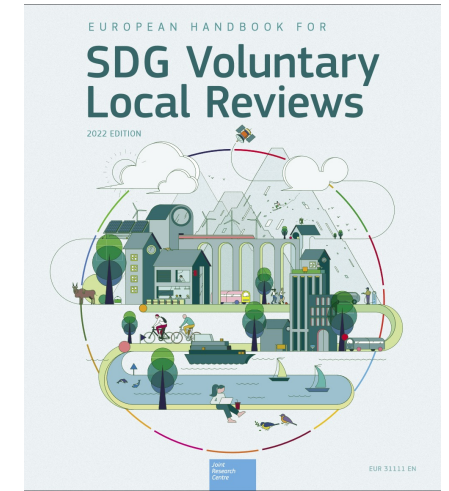
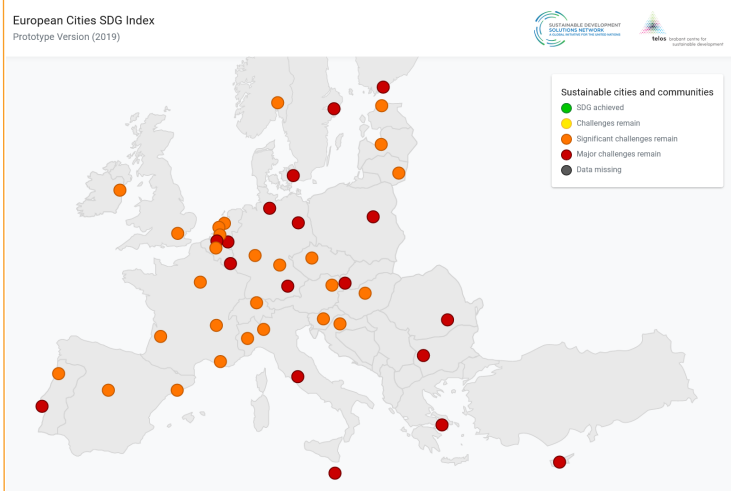


# Tier 1, so why bother?



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

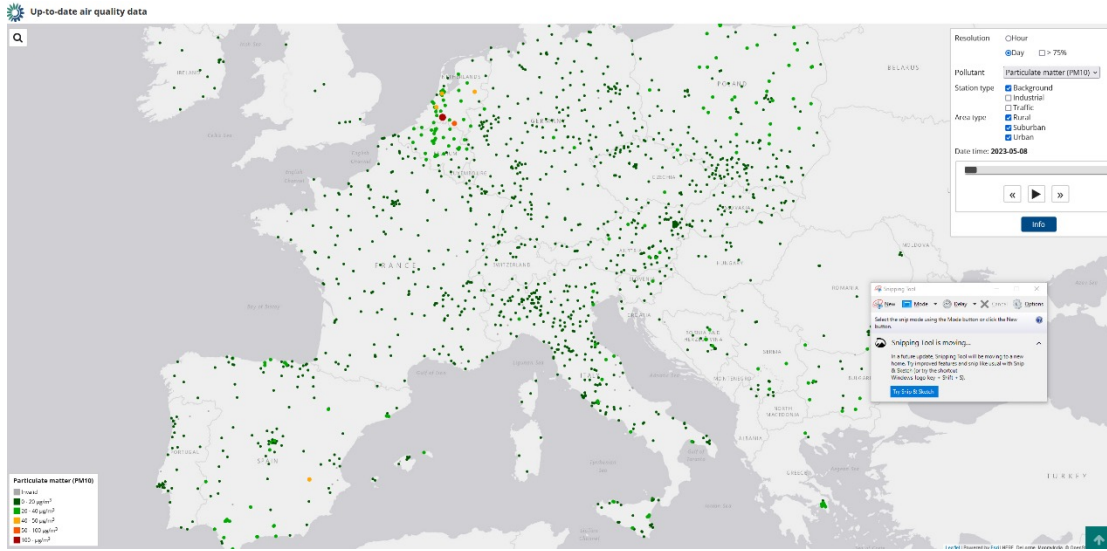
- ‘Our Struggle for Global Sustainability Will Be Won or Lost in Cities’, says Secretary-General ([2012](#))
- UN Decade of Action is underway → The need for *localization*



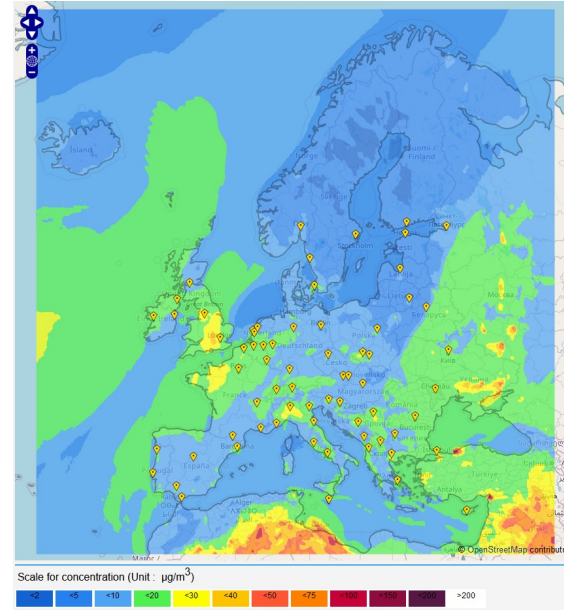
- Leave no One Behind (SDG, Green Deal, OECD) → *data needs*
- Smart City and full Earth Observation array for capturing *intra-urban variability*
- In line with UNGGIM Europe Scoping paper and SDG Territorial Dimension: *Recommendations (e.g. Use geospatial layers generated from Earth Observation data,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



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

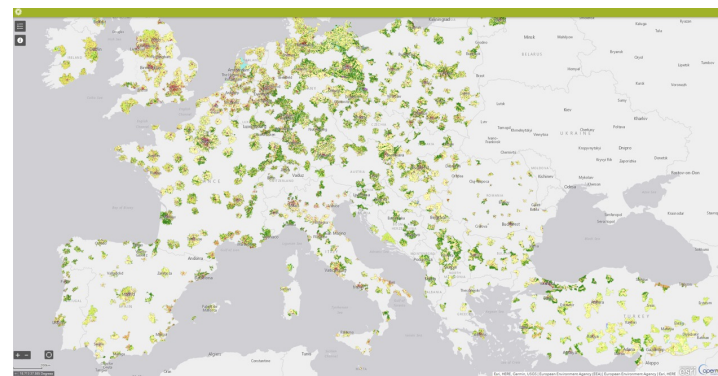


**UN Metadata:** Countries with AQ monitoring networks provide the annual mean concentrations and *corresponding number of inhabitants* to derive the national population-weighted exposure to PM in cities using a generalized formula. Additional data, such as satellite retrievals of aerosol optical depth, *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.**

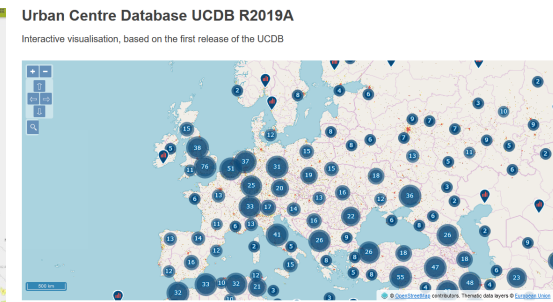


## Copernicus Atmospheric Modeling Service: European air quality reanalyses

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



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



Urban Centre Database UCDB R2019A  
Interactive visualisation, based on the first release of the UCDB

Filter the urban centres by population  
 Display all  
 More than 100k inhabitants  
 More than 1 million inhabitants  
 More than 10 million inhabitants

Get a link to share this map [Link to share](#)

**Legend for the maps**  
**Settlement Model**  
 Urban centre (City)  
 Urban cluster (Town & suburb)  
 Suburban centre (Rural)  
 Rural grid cells (Rural area)  
 Non-urban area (Rural area)  
 Non-urban area (Rural area)

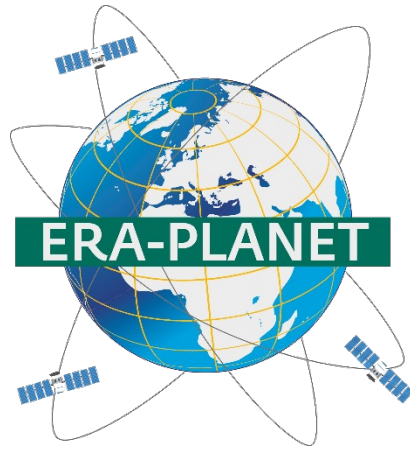
**Disclaimer:**  
 The designations employed and the presentation of material on this map do not imply the recognition of any specific whatsoever on the part of the European Union concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.  
 Kosovo: This designation is without prejudice to positions on status, and is in line with UN Security Council Resolution 1244 and the ICJ Opinion on the Kosovo declaration of independence.  
 Palestine: The designation does not constitute an recognition of a State of Palestine and is without prejudice to the individual positions of the Member States on this issue.  
 The Urban Centres are delineated from spatial grids in equal area World Mercator projection and are not intended to represent the actual shape of the urban centres. The visualisation of this map is provided in Web Mercator projection, resulting in an apparent visual distortion of the original grid shape.



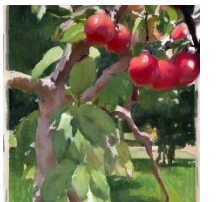
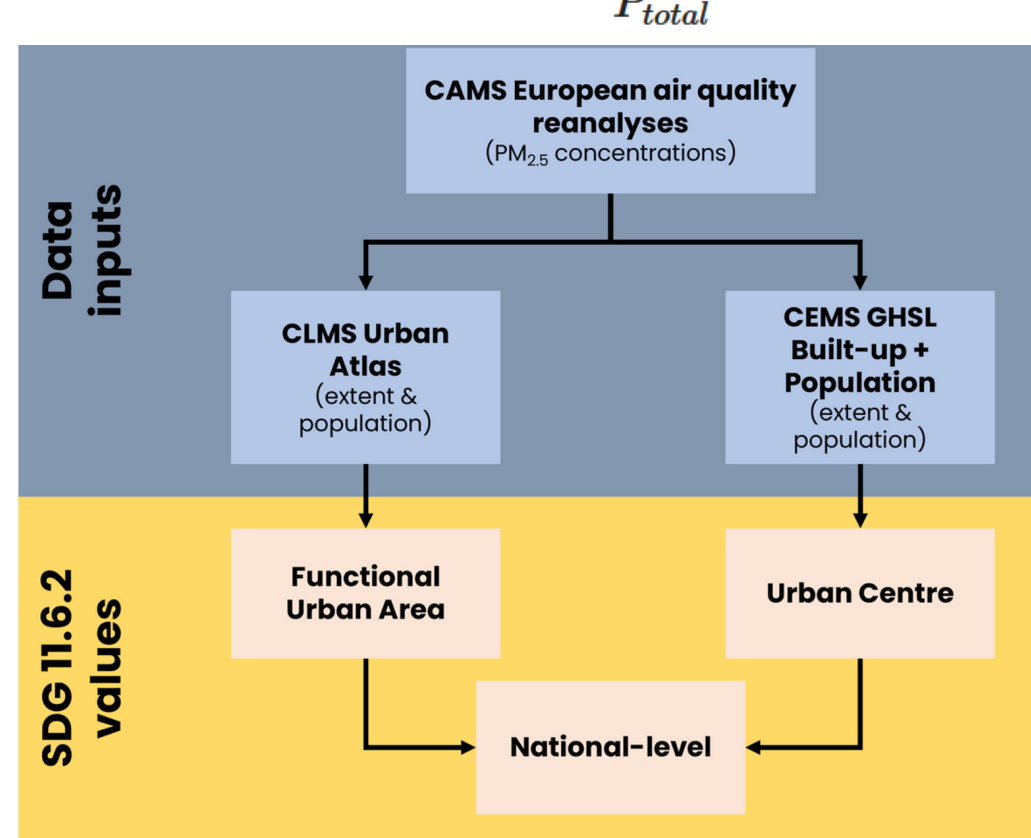
Spatio-temporal enhancements of the air quality indicator SDG 11.6.2

UN-GGIM E

# The SMURBS 11.6.2 Platform: The low hanging Copernicus fruit



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



# The SMURBS 11.6.2 Platform

The SMURBS SDG Indicator 11.6.2 Earth Observation Platform  
Powered by Copernicus Services and JRC's Global Human Settlement



need help?

**City Data**

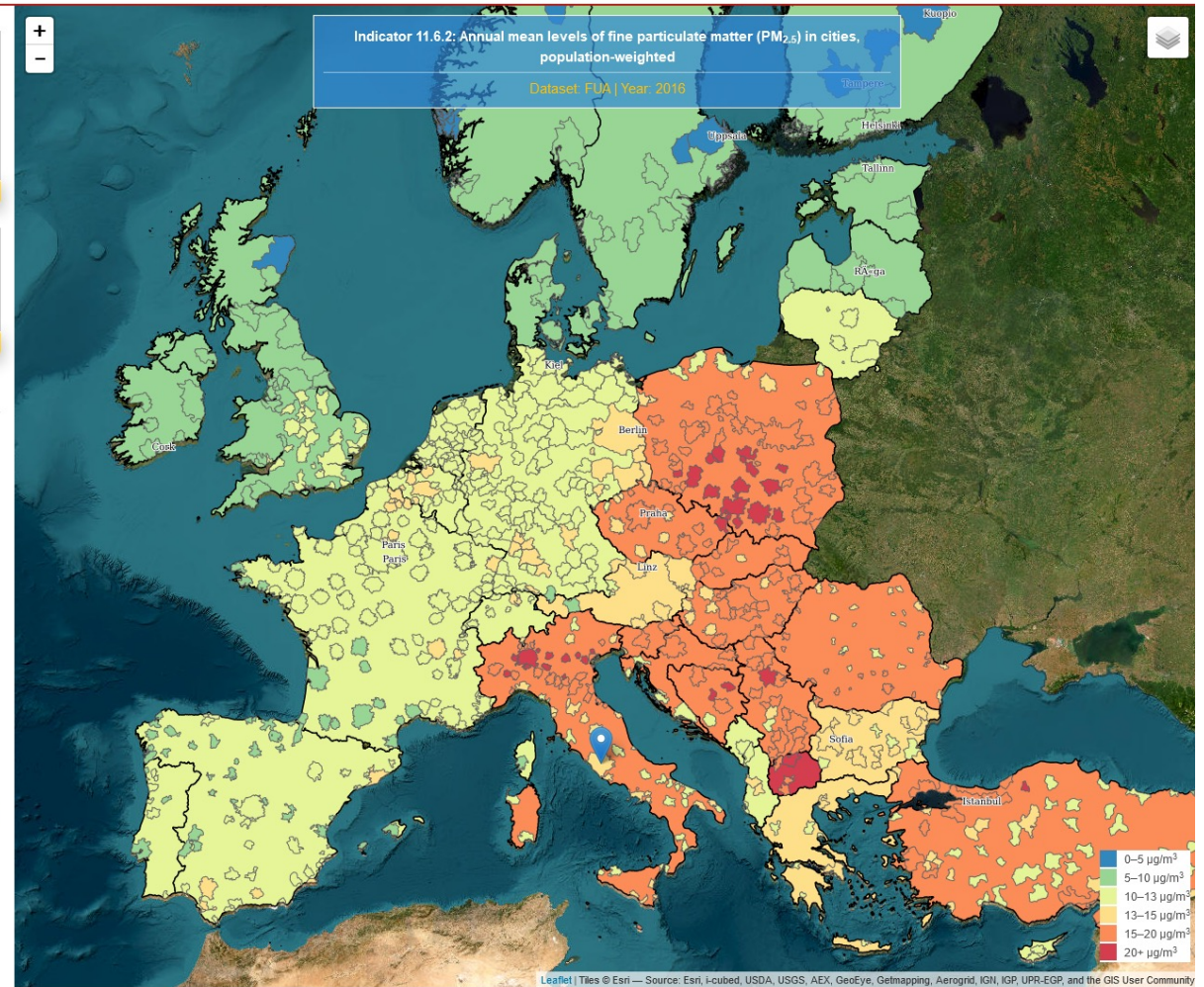
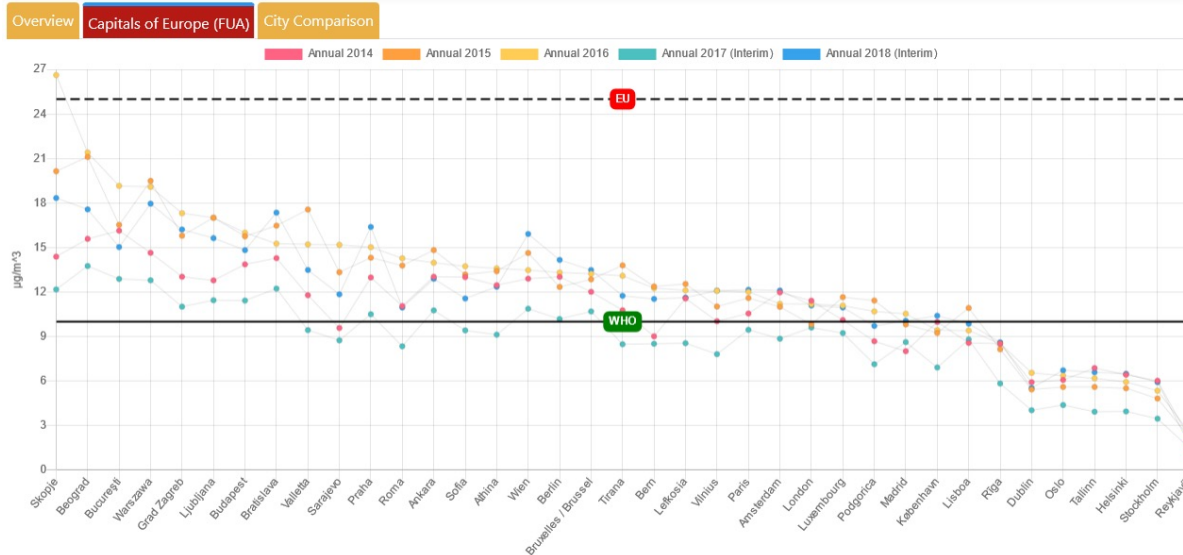
UniqueID	Country	Name	Population (2012)	2014 ( $\mu\text{g}/\text{m}^3$ )	2015 ( $\mu\text{g}/\text{m}^3$ )	2016 ( $\mu\text{g}/\text{m}^3$ )	2017 ( $\mu\text{g}/\text{m}^3$ )	2018 ( $\mu\text{g}/\text{m}^3$ )
372	IE	Waterford	96,286	6.00	5.46	6.37	4.05	5.55
373	IS	Reykjavik	245,873	2.18	2.26	2.56	1.51	1.75
374	IT	Roma	4,065,618	11.05	13.78	14.27	8.34	10.95
375	IT	Milano	4,879,737	19.70	25.28	24.81	17.37	21.97

Add To Chart

**Country Data**

Country	Name	Number of FUAs	2014 ( $\mu\text{g}/\text{m}^3$ )	2015 ( $\mu\text{g}/\text{m}^3$ )	2016 ( $\mu\text{g}/\text{m}^3$ )	2017 ( $\mu\text{g}/\text{m}^3$ )	2018 ( $\mu\text{g}/\text{m}^3$ )
IS	Iceland	1	2.18	2.26	2.56	1.51	1.75
IT	Italy	84	13.31	17.46	16.94	11.12	14.51

Add To Chart



Functional Urban Area (FUA)
  Urban Centre (UC)
 2014 2015 2016 2017 2018
  Show/Hide Countries layer
  Opacity



Platform: <http://apcg.meteo.noa.gr/sdq1162/> Publication: <https://www.mdpi.com/2072-4292/15/4/1082>

Spatio-temporal enhancements of the air quality indicator SDG 11.6.2

UN-GGIM Europe Webinar 23<sup>rd</sup> May 2023

# The SMURBS 11.6.2 Platform

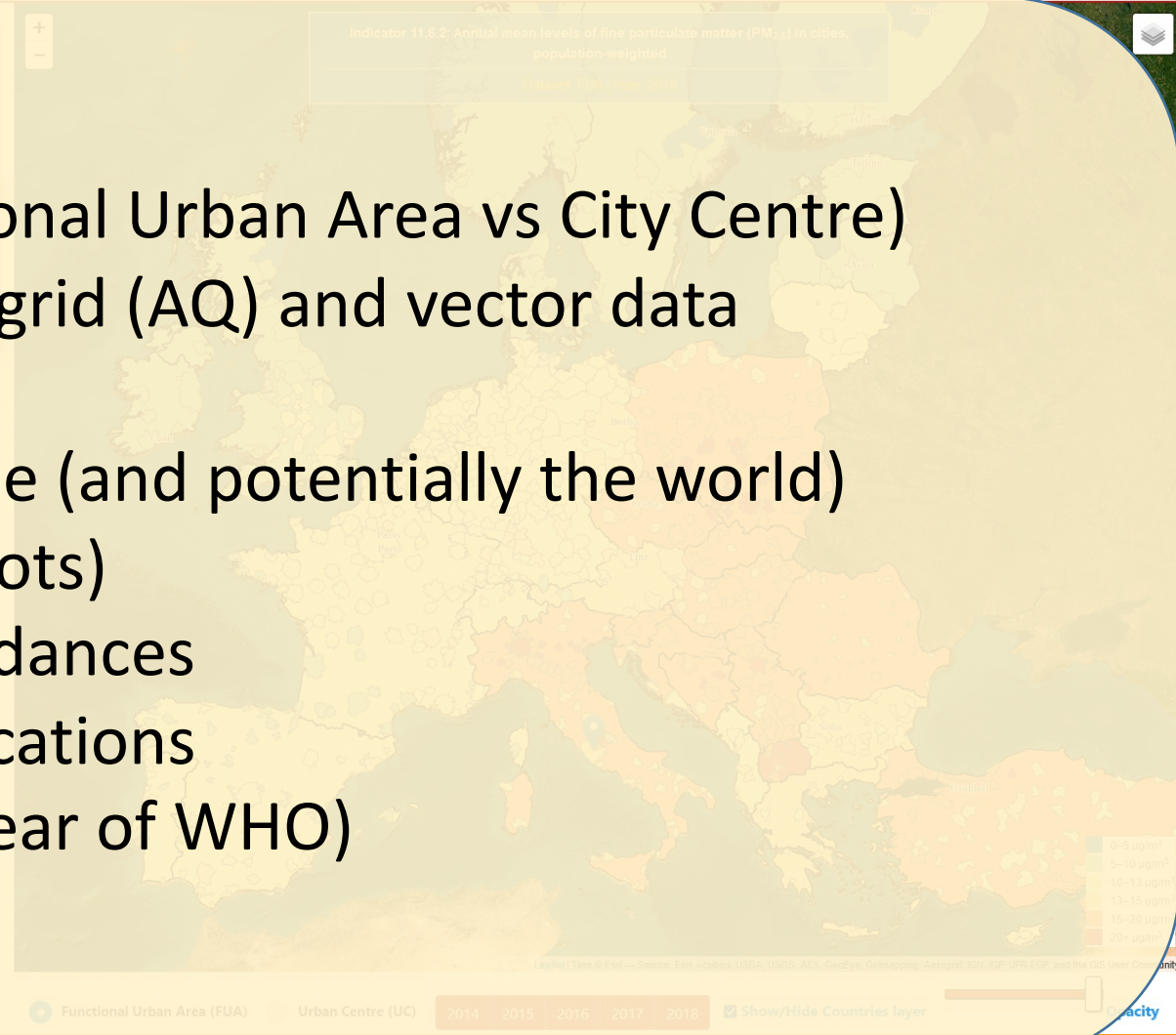
The SMURBS SDG Indicator 11.6.2 Earth Observation Platform  
Powered by Copernicus Services and JRC's Global Human Settlement



need help?

City Data

UniqueID	Country	Name	Population (2012)	2014 (µg/m³)	2015 (µg/m³)	2016 (µg/m³)	2017 (µg/m³)	2018 (µg/m³)
3	DE	Waldbrunn	96,206	6.00	5.46	6.97	4.05	5.55
15	PL	Reykjavik	245,075	2.18	2.26	2.56	1.51	1.75
174	IT	Rome	4,065,616	11.05	13.76	14.27	8.34	10.95

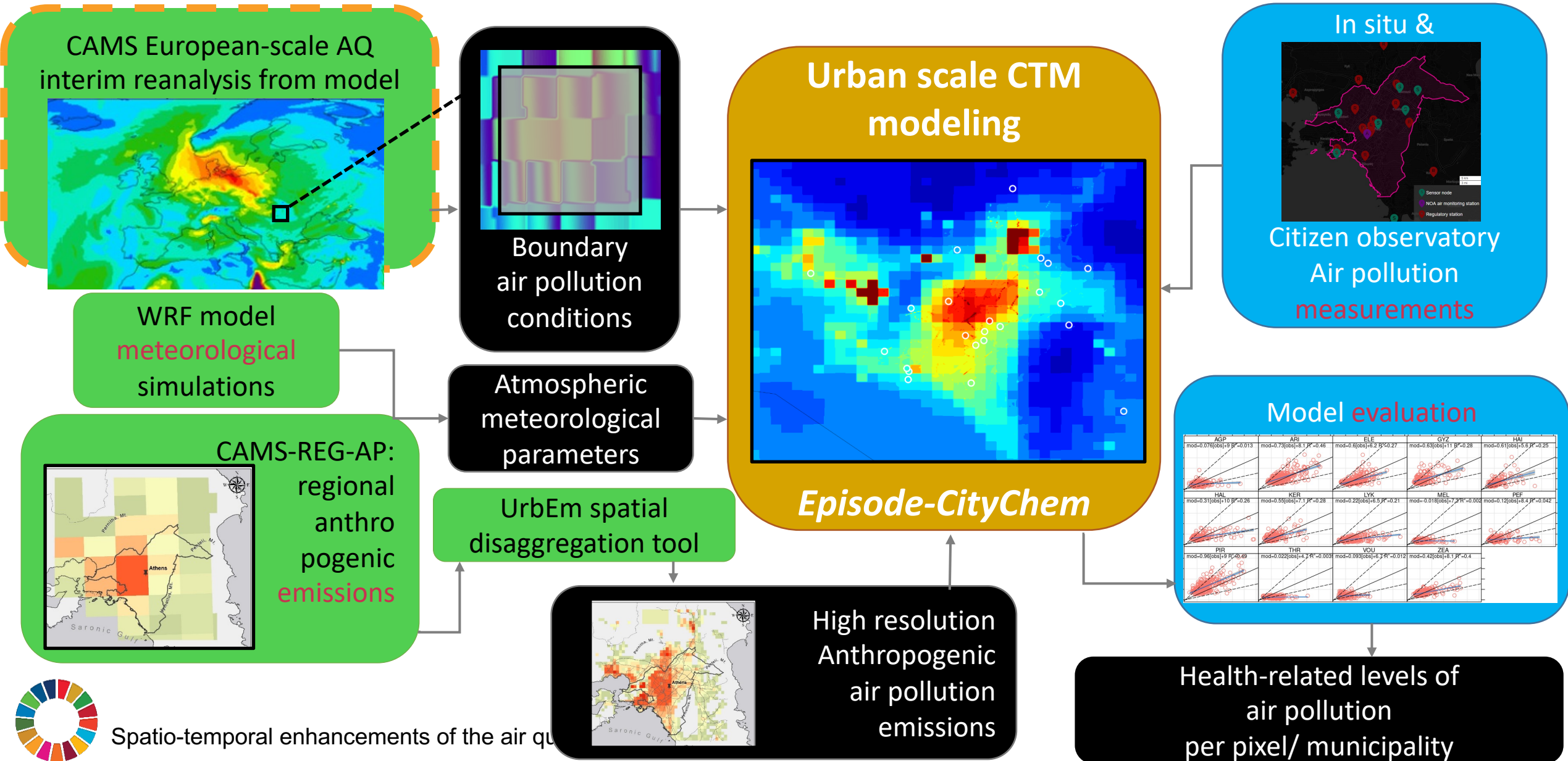


- Sensitivity to city definition (Functional Urban Area vs City Centre)
- Scalability is built in (integration of grid (AQ) and vector data (population and boundaries))
- Harmonized reporting across Europe (and potentially the world)
- Identification of city-drivers (hot spots)
- Comparison of cities, 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.mapi.com/2072-4292/15/4/1082>



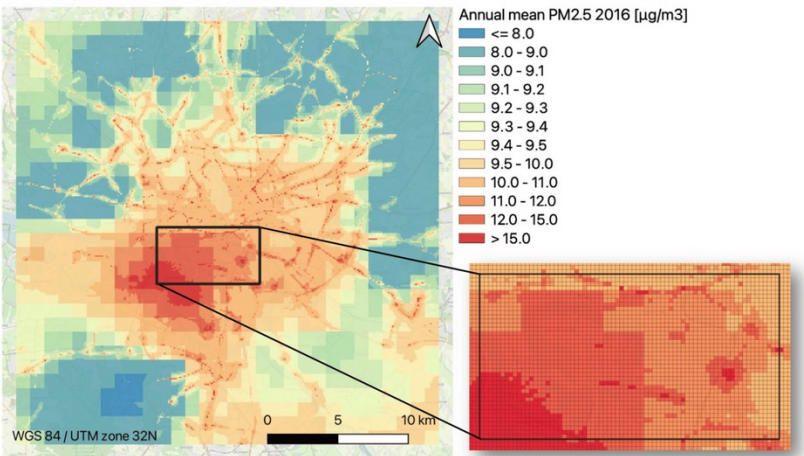
# Increasing the localization (from CAMS to intra-urban)



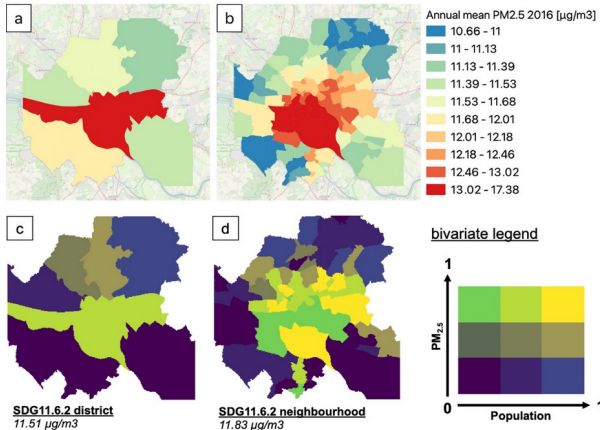


# Increasing the localization (and other indicators)

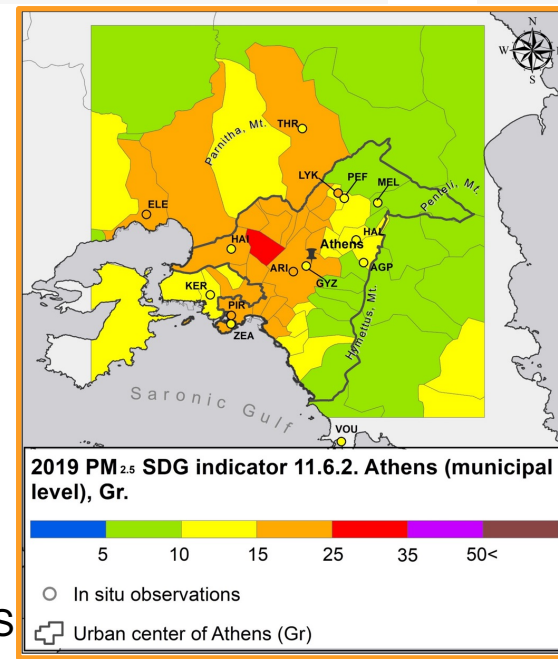
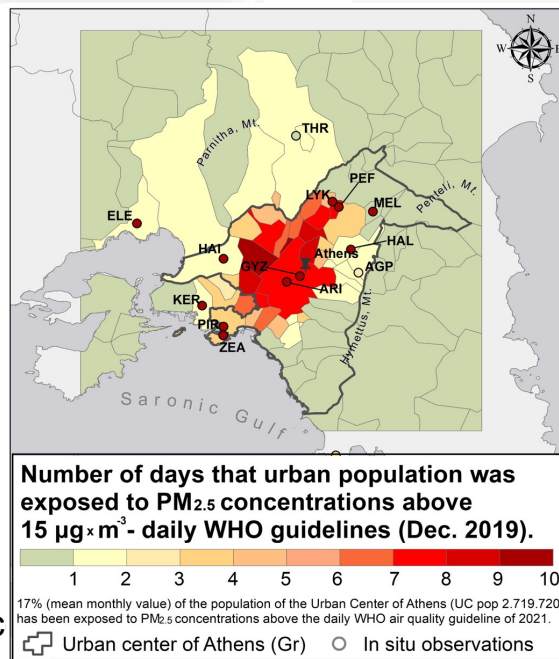
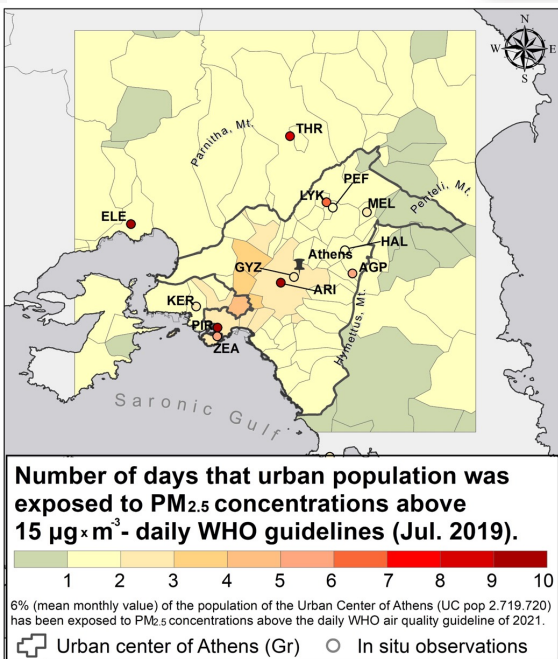
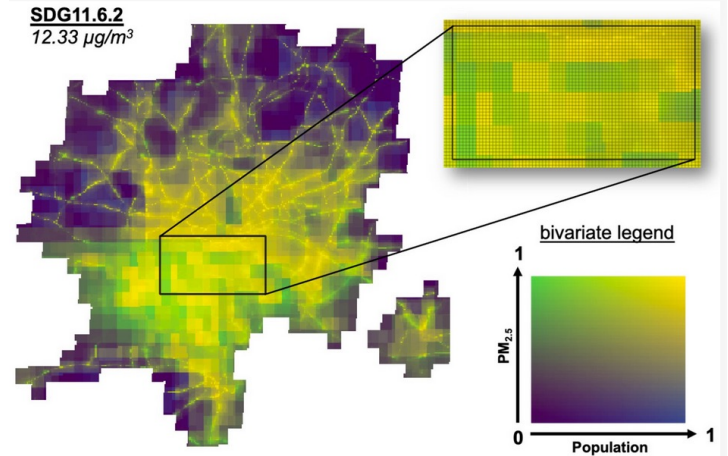
**Figure 8.** Annually averaged PM<sub>2.5</sub> concentrations for the 30,000 × 30,000 m<sup>2</sup> Hamburg domain with a resolution of 100 × 100 m<sup>2</sup>, as simulated with the EPISODE-CityChem model.



**Figure 9.** Annual mean PM<sub>2.5</sub> concentrations in districts (a) and neighbourhoods (b) for Hamburg, 2016, as simulated with EPISODE-CityChem. Bivariate plots for normalized mean PM<sub>2.5</sub> 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<sub>2.5</sub> 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<sub>2.5</sub> sensors can enhance the AQ fields especially within cities (and SDG 11.6.2)



# References

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