HARMO 17, 9-12 May 2016, Budapest

Estimating concentrations of B(a)P in Europe - population exposure and health effects

Cristina Guerreiro, NILU

Jan Horálek, CHMI

Frank de Leeuw, RIVM

Florian Couvidat, INERIS

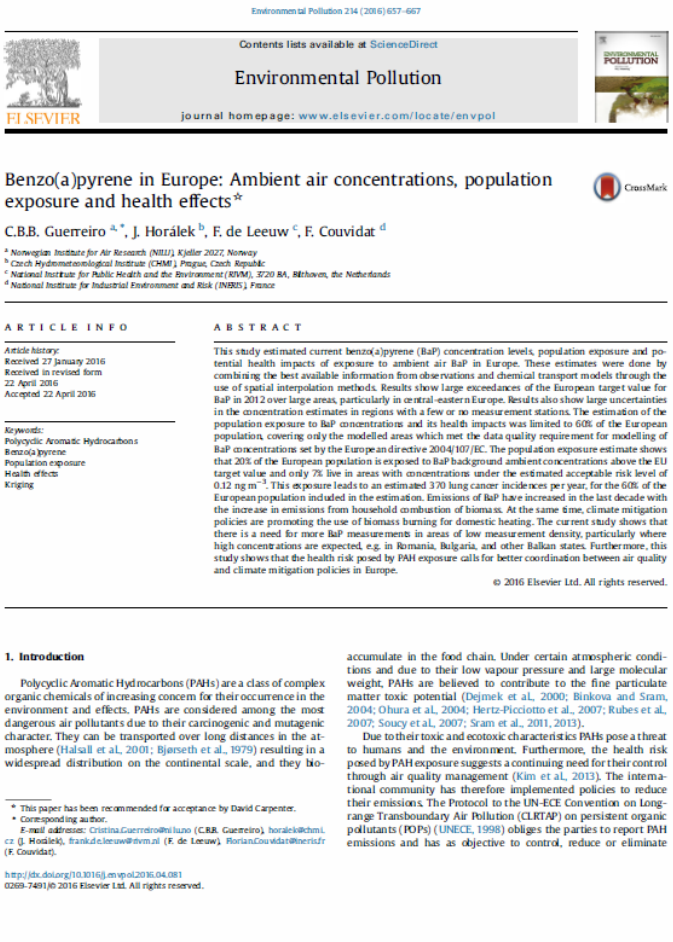
NILU

European Topic Centre
on Air Pollution and
Climate Change Mitigation

European Environment Agency

Outline of presentation

- Status BaP conc.
- Development in emissions
- Mapping methodology (BaP)
- Population exposure
- Health effects
- Discussion & conclusions
- CEN/TC264/WG43: MQO



Environmental Pollution 214 (2016) 657–667

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Benzo(a)pyrene in Europe: Ambient air concentrations, population exposure and health effects*

C.B.B. Guerreiro [a, *], J. Horálek [b], F. de Leeuw [c], F. Couvidat [d]

[a] Norwegian Institute for Air Research (NILU), Kjeller 2027, Norway
[b] Czech Hydrometeorological Institute (CHMI), Prague, Czech Republic
[c] National Institute for Public Health and the Environment (RIVM), 3720 BA, Bilthoven, the Netherlands
[d] National Institute for Industrial Environment and Risk (INERIS), France

ARTICLE INFO

Article history:
Received 27 January 2016
Received in revised form
22 April 2016
Accepted 22 April 2016

Keywords:
Polycyclic Aromatic Hydrocarbons
Benzo(a)pyrene
Population exposure
Health effects
Kriging

ABSTRACT

This study estimated current benzo(a)pyrene (BaP) concentration levels, population exposure and potential health impacts of exposure to ambient air BaP in Europe. These estimates were done by combining the best available information from observations and chemical transport models through the use of spatial interpolation methods. Results show large exceedances of the European target value for BaP in 2012 over large areas, particularly in central-eastern Europe. Results also show large uncertainties in the concentration estimates in regions with a few or no measurement stations. The estimation of the population exposure to BaP concentrations and its health impacts was limited to 60% of the European population, covering only the modelled areas which met the data quality requirement for modelling of BaP concentrations set by the European directive 2004/107/EC. The population exposure estimate shows that 20% of the European population is exposed to BaP background ambient concentrations above the EU target value and only 7% live in areas with concentrations under the estimated acceptable risk level of 0.12 ng m^{-3}. This exposure leads to an estimated 370 lung cancer incidences per year, for the 60% of the European population included in the estimation. Emissions of BaP have increased in the last decade with the increase in emissions from household combustion of biomass. At the same time, climate mitigation policies are promoting the use of biomass burning for domestic heating. The current study shows that there is a need for more BaP measurements in areas of low measurement density, particularly where high concentrations are expected, e.g. in Romania, Bulgaria, and other Balkan states. Furthermore, this study shows that the health risk posed by PAH exposure calls for better coordination between air quality and climate mitigation policies in Europe.

1. Introduction

Polycyclic Aromatic Hydrocarbons (PAHs) are a class of complex organic chemicals of increasing concern for their occurrence in the environment and effects. PAHs are considered among the most dangerous air pollutants due to their carcinogenic and mutagenic character. They can be transported over long distances in the atmosphere (Halsall et al., 2001; Bjørseth et al., 1979) resulting in a widespread distribution on the continental scale, and they bioaccumulate in the food chain. Under certain atmospheric conditions and due to their low vapour pressure and large molecular weight, PAHs are believed to contribute to the fine particulate matter toxic potential (Dejmek et al., 2000; Binkova and Sram, 2004; Ohura et al., 2004; Hertz-Picciotto et al., 2007; Rubes et al., 2007; Soucy et al., 2007; Sram et al., 2011, 2013).

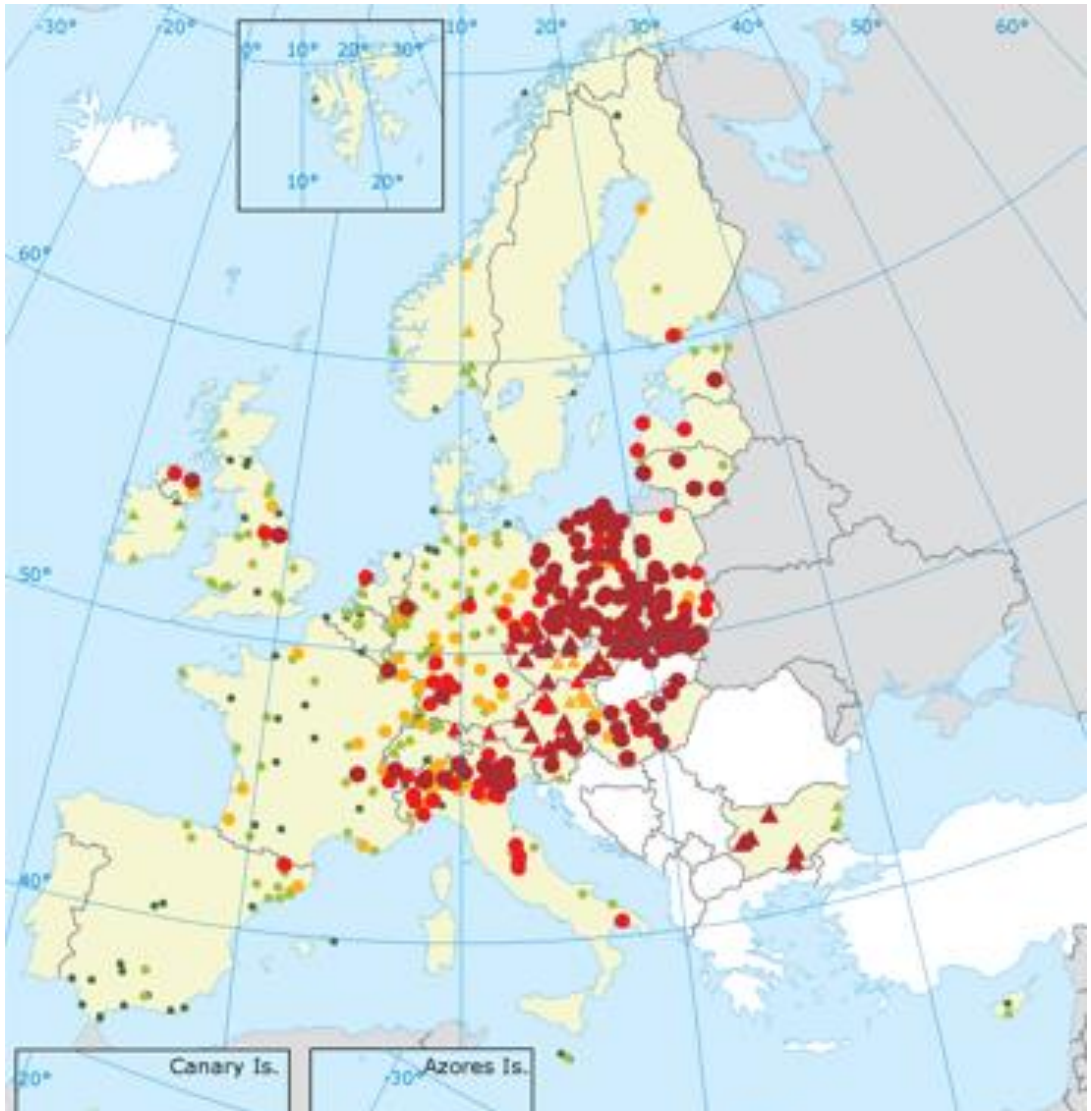
Due to their toxic and ecotoxic characteristics PAHs pose a threat to humans and the environment. Furthermore, the health risk posed by PAH exposure suggests a continuing need for their control through air quality management (Kim et al., 2013). The international community has therefore implemented policies to reduce their emissions. The Protocol to the UN-ECE Convention on Long-range Transboundary Air Pollution (CLRTAP) on persistent organic pollutants (POPs) (UNECE, 1998) obliges the parties to report PAH emissions and has as objective to control, reduce or eliminate

* This paper has been recommended for acceptance by David Carpenter.
* Corresponding author.
E-mail addresses: Cristina.Guerreiro@nilu.no (C.B.B. Guerreiro), horalek@chmi.cz (J. Horálek), frank.de.leeuw@rivm.nl (F. de Leeuw), Florian.Couvidat@ineris.fr (F. Couvidat).

http://dx.doi.org/10.1016/j.envpol.2016.04.081
0269-7491/

NILU

Status: 2012 BaP annual mean



BaP (ng/m^3)

- ≤ 0.12
- 0.12–0.40
- 0.40–0.60
- 0.60–1.00
- > 1.00
- No data
- Countries/regions not included in the data exchange process

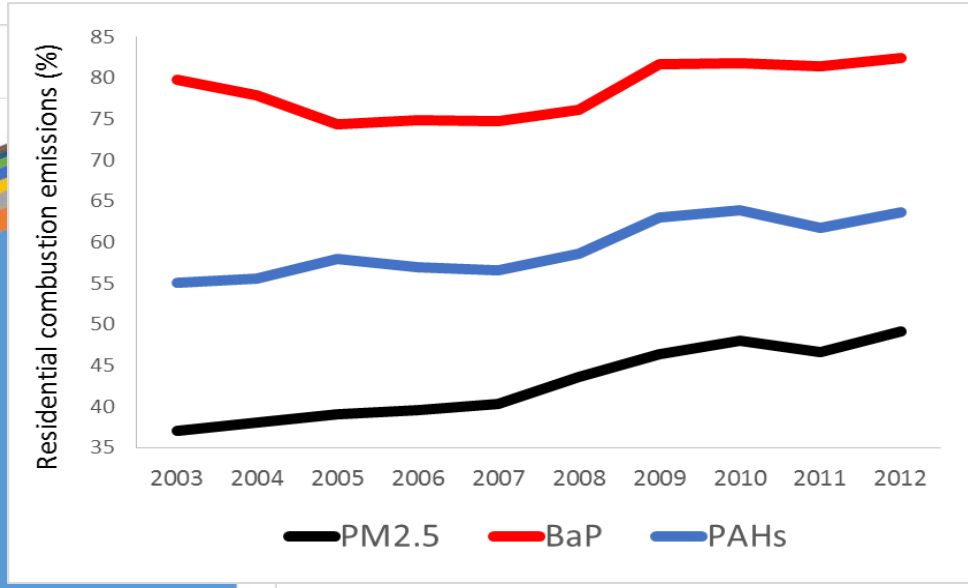
Source: EEA (2014)

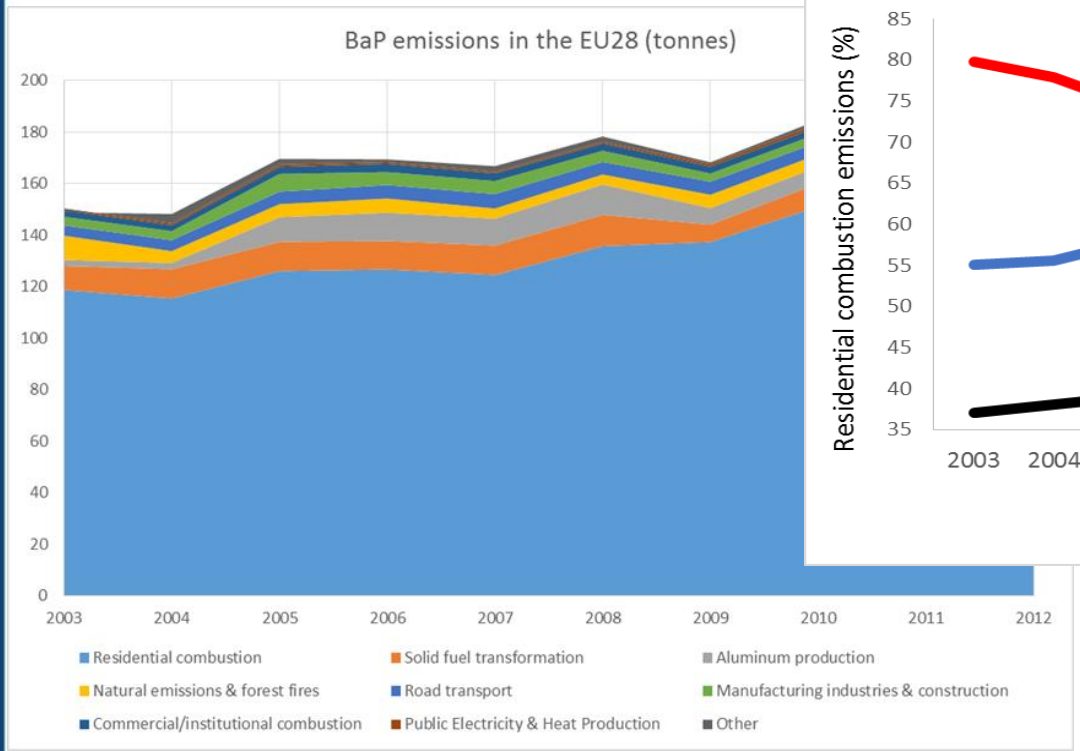
NILU

Development in emissions

- Residential combustion emits 82 % of BaP, 64% of PAHs, and 49% of PM2.5 total emissions in EU-28 in 2012
- Increasing trend 2003-2012: 25% BaP, 26% PAHs, 11% PM2.5

Development residential comb. share of total EU emissions



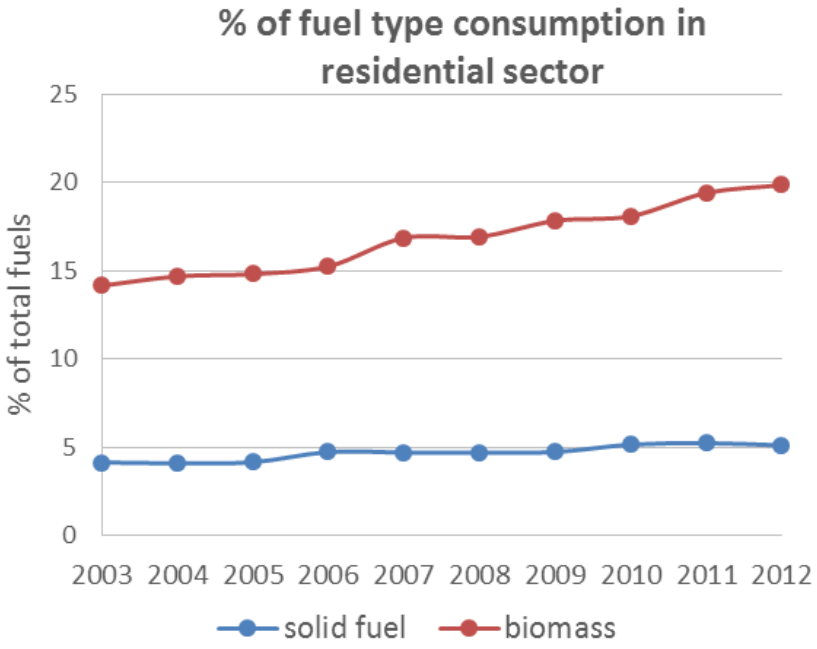


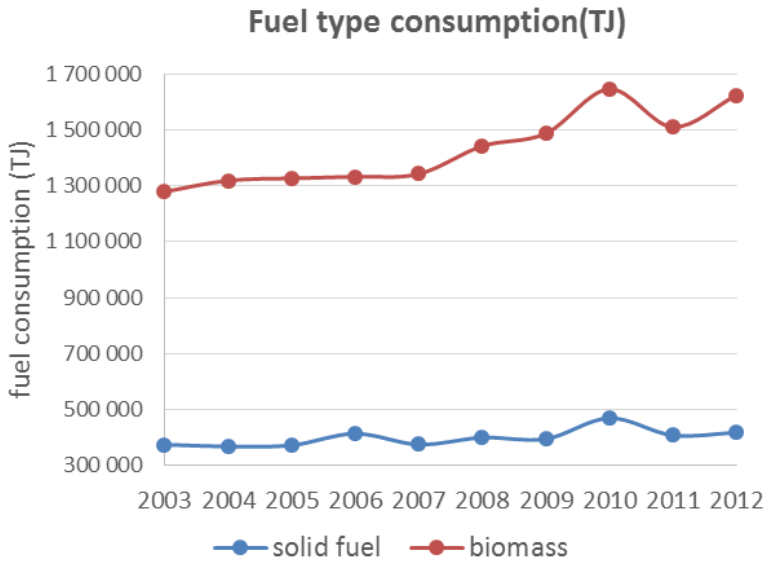
NILU

Development in emissions

- Residential combustion has seen an increase of:
  - 27% in the use of biomass (wood)
  - 12% if the use of solid fuels (coal)

  in EU-28 2003-2012





Population exposure in urban areas

% of urban popul exposed to conc. above EU/WHO values

Pollutant	EU reference value	Exposure estimate (%)	WHO AQG	Exposure estimate (%)
$PM_{2.5}$	year (25)	**10 – 14**	year (10)	**94 – 96**
PM_{10}	day (50)	**21 – 30**	year (20)	**69 – 89**
O_3	8-hour (120)	**14 – 17**	8-hour (100)	**97 – 99**
NO_2	year (40)	**8 – 13**	year (40)	**8 – 13**
BaP	year (1 ng/m^3)	**24 – 28**	year (0.12 ng/m^3)	**77 – 88**
SO_2	day (125)	**< 1**	day (20)	**37 – 42**
CO	8-hour (10)	**< 2**	8-hour (10)	**< 2**
Pb	year (0.5)	**< 1**	year (0.5)	**< 1**
Benzene	year (5)	**< 1**	year (1.7)	**10 – 12**

Estimate for 2010 – 2012. *Source: EEA (2014)*

NILU

European exposure: Methodology I
BaP concentration map

Primarily data:
- ★ measurement data

Secondary data:
- ★ dispersion model output (EMEP / CHIMERE)
- ★ altitude (rural map)
- ★ meteorology (FF- rural map, T- urban map)
- ★ population density

The secondary data for the ***linear regression model*** were selected based on their relation with measured AQ data. The ***Linear regression model is followed by kriging of its residuals (residual kriging)***

Measured and CTM data are ***logarithmically transformed***, due to the lognormal distribution of these data.

kriging – geostatistical method (i.e. knowledge of the spatial structure of air quality field is utilized, using variogram)

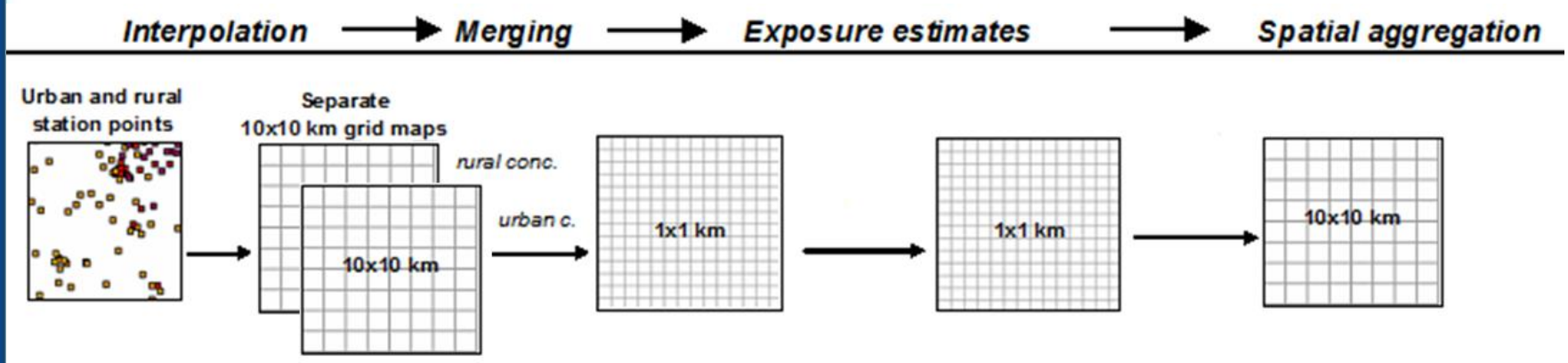
European Environment Agency

European exposure: Methodology II
BaP concentration map

Separate mapping of rural and urban air quality
due to different character of urban and rural air quality

BaP – urban/suburban concentrations are in general higher than the rural concentrations

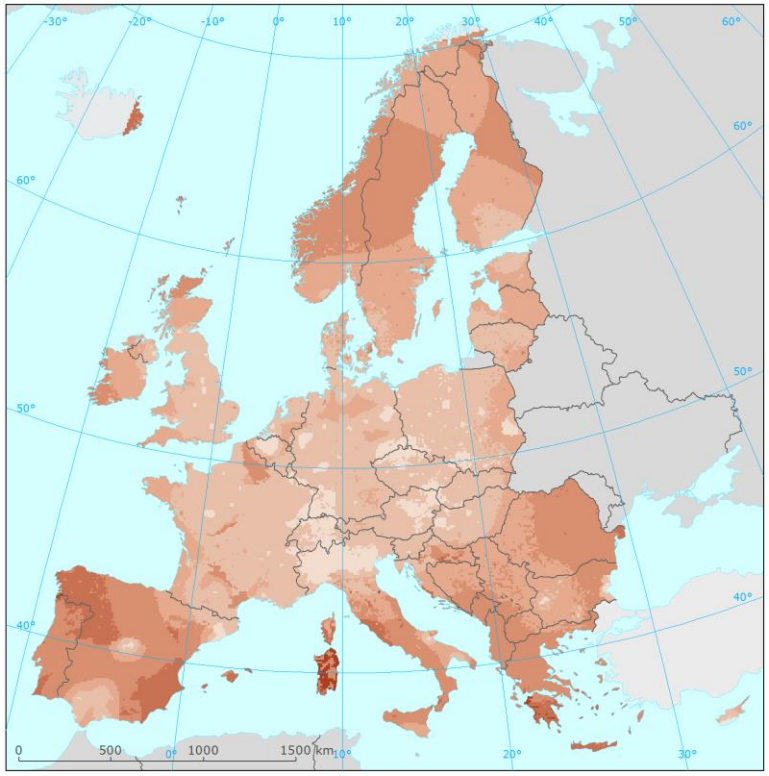
Rural map – based on rural background stations
Urban background map – based on urban and suburban backgr stations
Final maps are created by merging rural and urban background maps, using *population density*.



Uncertainty estimates

cross-validation – the spatial interpolation is calculated for each measurement point from all available information except from the point in question.

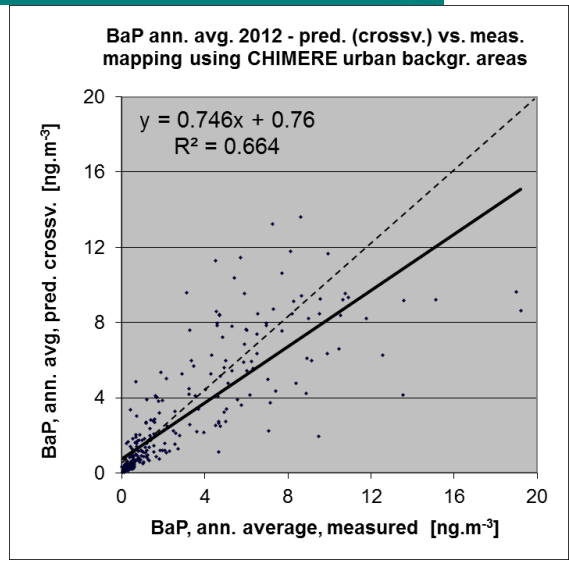
Interpolation rel. standard error – should be < 0.6



Benzo(a)pyrene
Annual Average
Relative Standard Error

Reference Year: 2012
Combined Rural and Urban Background Map
Model Used in Mapping: CHIMERE
Resolution: 10x10 km

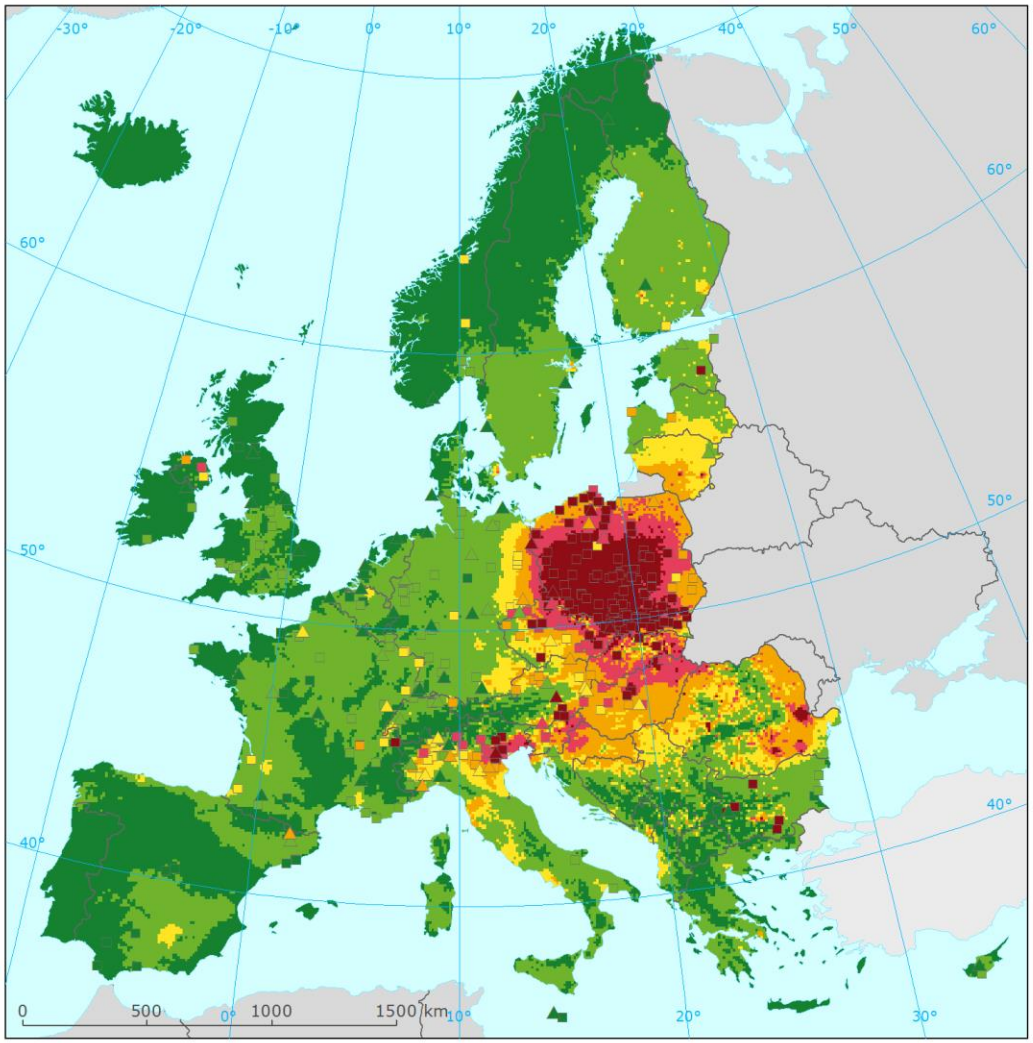
- 0 – 0.4
- 0.4 – 0.6
- 0.6 – 0.8
- 0.8 – 1
- 1 – 1.2
- 1.2 – 1.8
- outside data coverage
- poor data coverage



Guerreiro et al., 2015

NILU

Interpolated BaP map (EMEP)



Benzo(a)pyrene
Annual Average

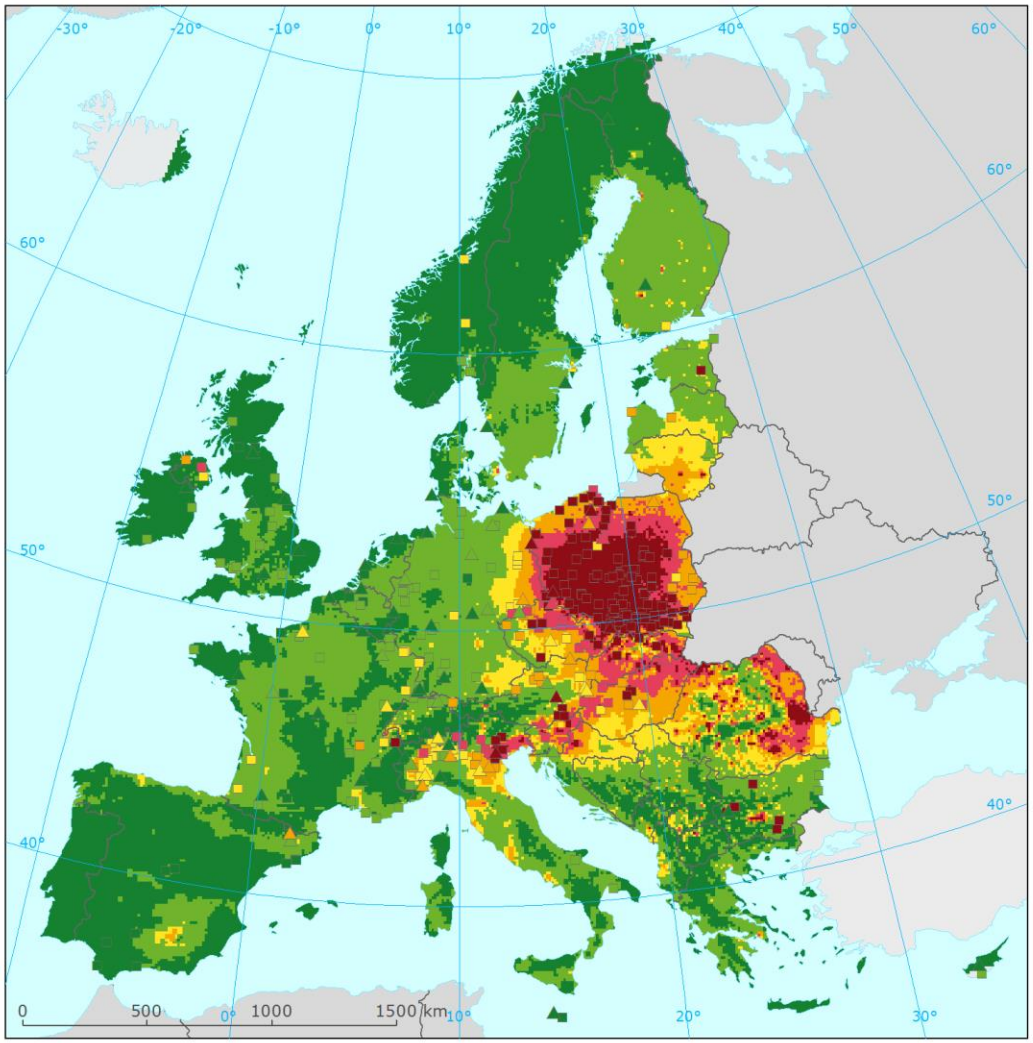
Reference Year: 2012
Combined Rural and Urban Background Map
Model Used in Mapping: EMEP
Resolution: 10x10 km

- ≤ 0.12 ng.m^{-3}
- 0.12 - 0.4 ng.m^{-3}
- 0.4 - 0.6 ng.m^{-3}
- 0.6 - 1 ng.m^{-3}
- 1 - 1.5 ng.m^{-3} (1 = TV)
- > 1.5 ng.m^{-3}
- outside data coverage
- poor data coverage
- △ rural background station
- □ urban/suburban background station

Guerreiro et al., 2015

NILU

Interpolated BaP map (CHIMERE)



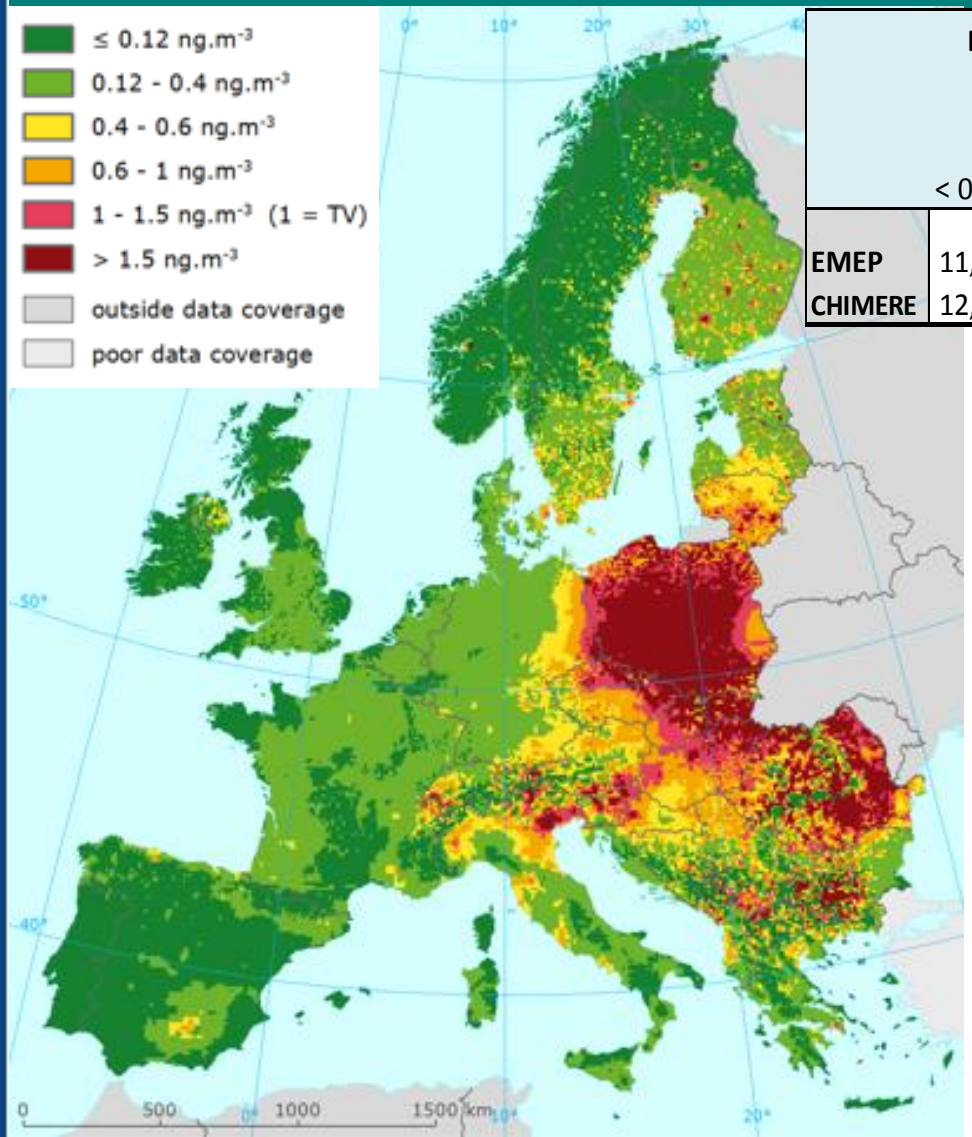
Benzo(a)pyrene
Annual Average

Reference Year: 2012
Combined Rural and Urban Background Map
Model Used in Mapping: CHIMERE
Resolution: 10x10 km

- ≤ 0.12 ng.m^{-3}
- 0.12 - 0.4 ng.m^{-3}
- 0.4 - 0.6 ng.m^{-3}
- 0.6 - 1 ng.m^{-3}
- 1 - 1.5 ng.m^{-3} (1 = TV)
- > 1.5 ng.m^{-3}
- outside data coverage
- poor data coverage
- △ rural background station
- □ urban/suburban background station

Guerreiro et al., 2015

Population exposure to BaP



	BaP - annual mean, exposed population (%)						BaP popul. weighted conc. (ng/m^3)
		> Target value			> TV		
	< 0.12	0.12-0.4	0.4-0.6	0.6-1.0	1.0-1.5	> 1.5	
EMEP	11,66	46,73	10,44	10,71	6,82	13,64	0,84
CHIMERE	12,57	46,12	9,78	11,00	6,14	14,28	0,92

- Only 12 % of the European population live in areas with BaP conc. under ref. level of 0.12 ng/m^3 (increased cancer incidence 1 /10^5 inhabitants)
- 20% live above the TV
- Estimated lung cancer incidence:

  550 - 600 in Europe

Guerreiro et al., 2015

Underestimated PAHs health impacts

- PAHs have several health impacts: **lung cancer**, skin and bladder cancer, genotoxicity and mutagenicity; affects children's' cognitive development, & linked to cardiovascular morbidity and mortality;
- *BaP is* a marker for total exposure to carcinogenic PAHs & only contributes to *part of the total carcinogenic potential of PAHs*;
- Airborne PAHs are deposited on soil and water and may be bioaccumulated in the food chain. In addition to inhalation *humans are also exposed to airborn PAHs through consumption of food and water*;
- *Concentrations and exposure to BaPs are underestimated* in this study, mainly due to the lack of measurement data.

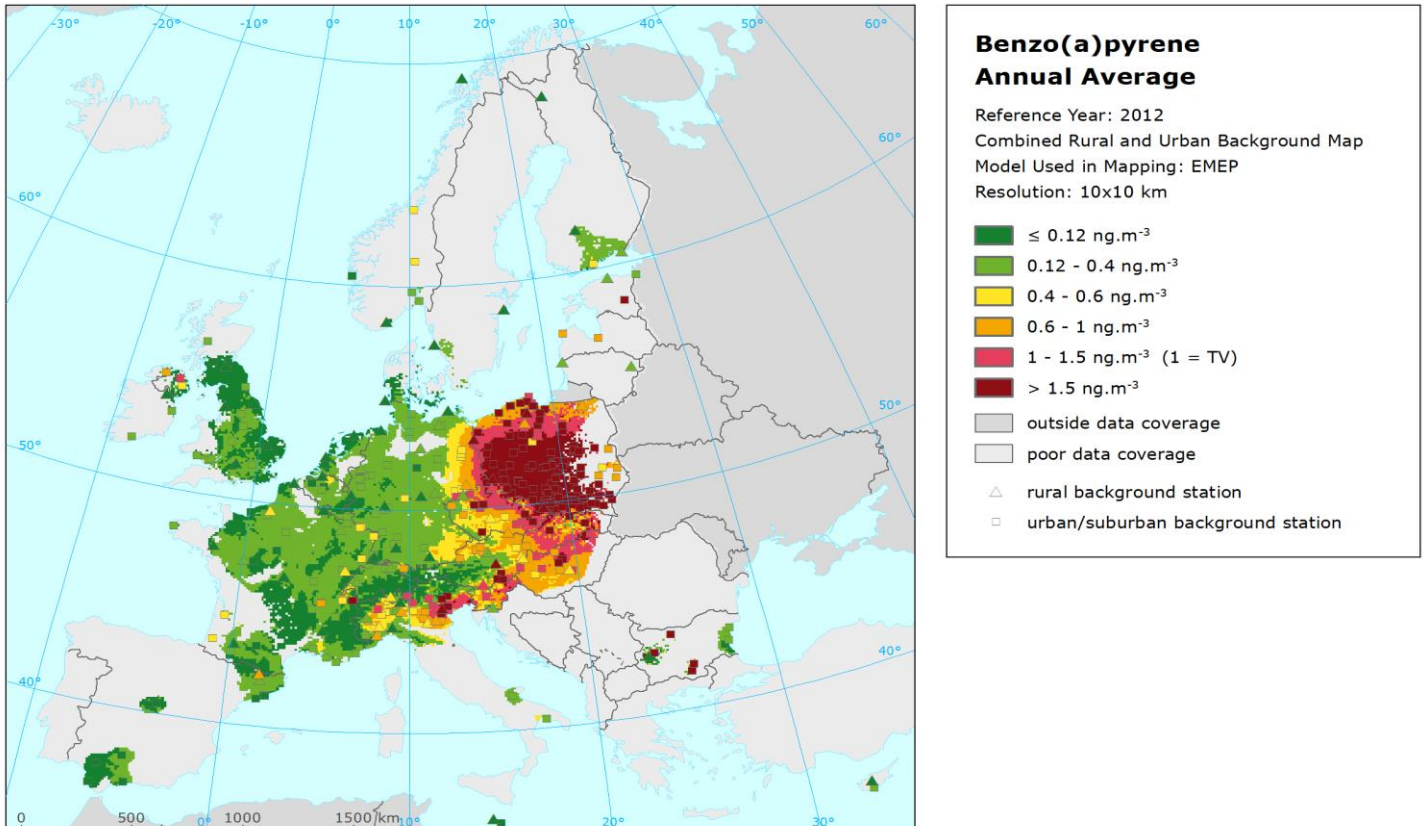
Discussion

- Biomass for domestic heating was the main renewable energy technology in 2012 in EU28 (43% of RES).
- Biomass heating plays a very important role in meeting EU's "20-20-20" targets.
- The residential combustion sector is a ***main contributor to exceedances of BaP and PM2.5*** TVs in Europe.
- These emissions ***significantly increase the risk of*** respiratory ***disease*** *(e.g. lung cancer)*, chronic obstructive pulmonary disease and cardiovascular disease.

NILU

Conclusion

- There is a need to **better spatial coverage of BaP measurements**, especially in countries with expected high concentrations and few/no stations



New CEN/TC 264/WG 43: Modelling Quality Objectives

Deliverable:

Technical Specification describing the methodology to define and calculate:

- Modelling Quality Objectives (MQO) and
- Modelling Performance Indicators (MPI)

where these can be calculated on the basis of measurements

Scope:

- **Assessment** purposes in the context of the AQ Directive
- Pollutants covered **$PM_{2,5}$, PM_{10}, NO_2, O_3**

MS represented: AT, BE, DE, DK, FI, FR, NL, NO, SE, UK

Thank you for your attention!

Cristina Guerreiro (cbg@nilu.no)

Guerreiro, C., Horálek, J., de Leeuw, F., Couvidat, F. (2016) Benzo(a)pyrene in Europe: Ambient Air Concentrations, Population Exposure and Health Effects. J. of Environmental Pollution, DOI: 10.1016/j.envpol.2016.04.081
http://authors.elsevier.com/authorforms/ENPO8670/d9c5760d253207b5e6c976bb2c210863