HEALTH-RELATED CLIMATIC IMPACTS ON INCREASED CARCINOGENIC POTENTIAL RELATED TO BENZO(a)PYRENE ATMOSPHERIC LEVELS

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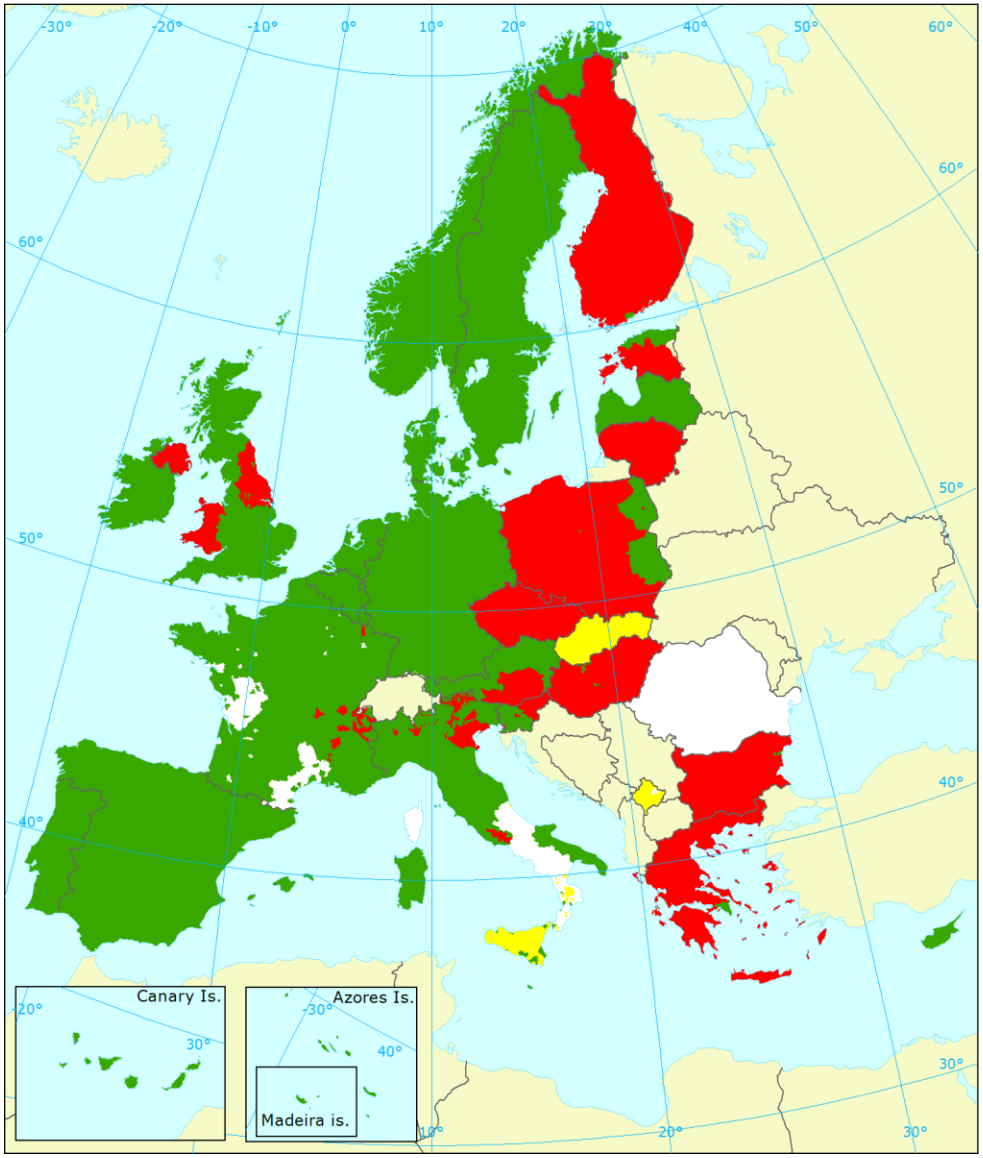
MOTIVATION:

A wide number of studies show that Europe exceeds some of the thresholds of air quality established in the legislation for several regulated pollutants.

Chemistry transport models (CTMs) play a key role in assessing and understanding the effects of emission mitigation plans.

BaP is the reference PAH for air quality guidelines and the only compound in this study to have legal limits in the atmosphere. It is arguably the most studied PAHs and one of the few SVOCs that are included in modelling strategies such as WFR-CHIMERE.

A number of atmospheric modelling studies have tried to characterise the levels and spatio-temporal patterns of PAHs (most of them focusing specifically on BaP) using CTMs both on global and regional scales, identifying a lack of field data in Europe to evaluate the behaviour of the CTMs against observations.



Benzo(a)pyrene 2012

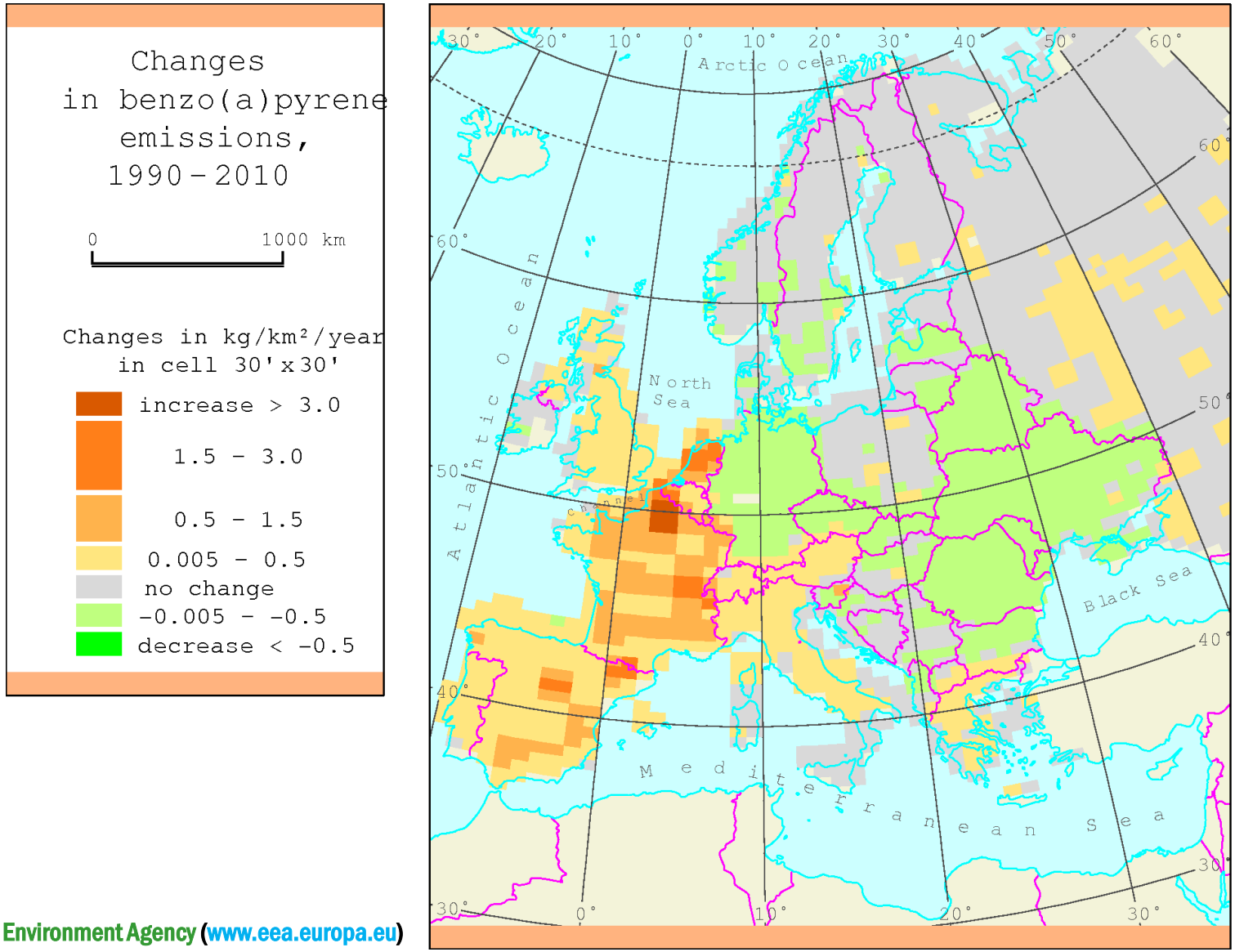
Annual target value
for the protection of human health

- Non-reporting Countries
- Zone designated, data misssing
- Area not designated
- <= target value
- > target value

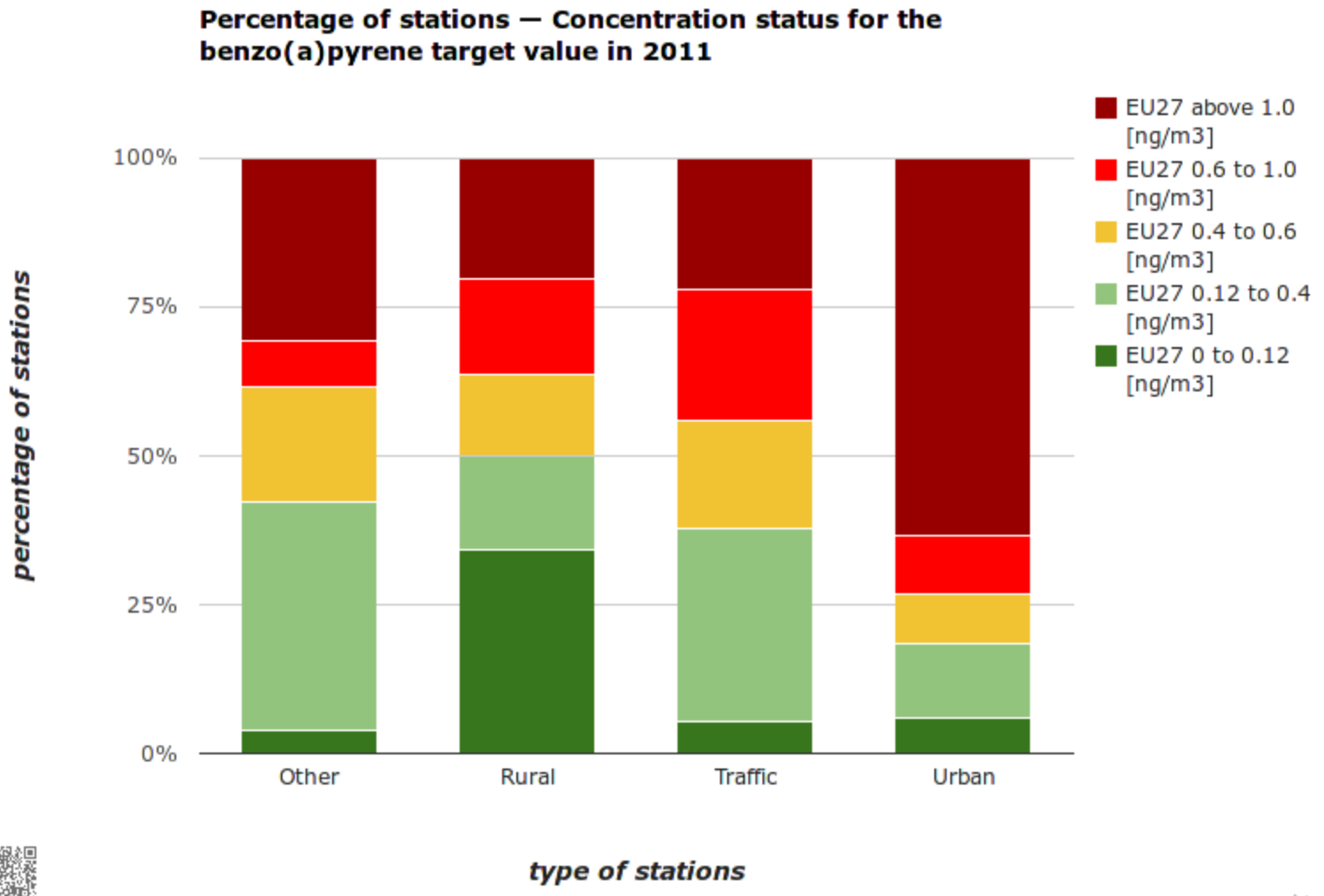
The BaP annual mean value may not exceed 1 ng m^{-3}.

The target value entered into force in 31.12.2012.

Source: European Environment Agency (www.eea.europa.eu)

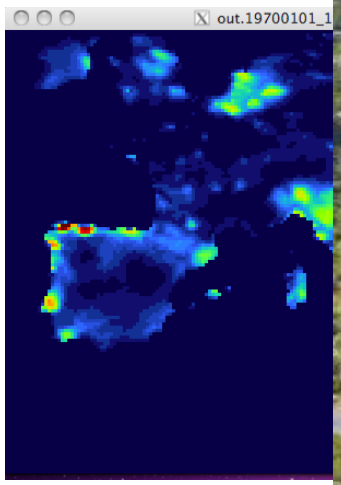


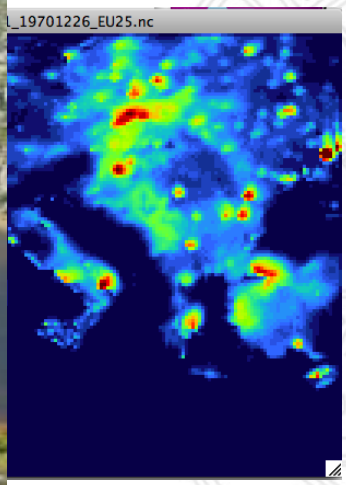
Source: European Environment Agency (www.eea.europa.eu)



Source: European Environment Agency (www.eea.europa.eu)

Human health + Climate change = INCREASED CONCERN ?





OBJECTIVE:

The main objective of this work is to provide adequate responses to the following questions:

1. Can we establish a **BaP climatology covering a European domain** using modelling approaches?

2. Are these approaches powerful enough to address **health-related issues**?

3. How will **climate change influence** both the climatologies and parameters of human health concern?

Question 1:

Can we establish a **BaP climatology covering a European domain** using modelling approaches?

Methodology

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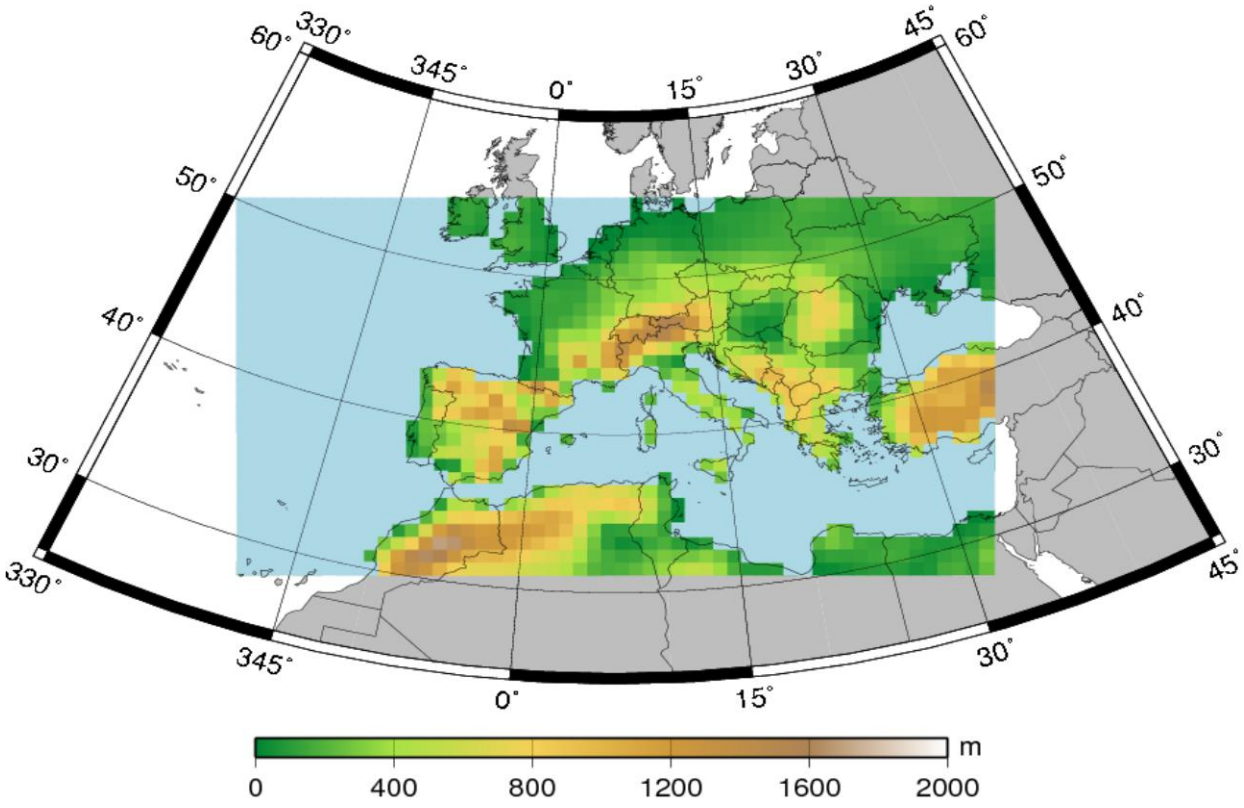
The regional model MM5-CHIMERE applied with a resolution of 25 km covering most of Europe and northern Africa was used:



Methodology

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MM5 Community Model

Chimere

The **parameterisations** include:

MM5:

Microphysics → **Simple Ice**

Cumulus → **Grell**

PBL → **MRF**

Radiation → **RRTM**

Soil → **Noah LSM**

CHIMERE:

Chemical Mechanisms → **MELCHIOR2**

Aerosol chemistry → Inorganic (thermodynamic equilibrium with **ISORROPIA**) and organic (**MEGAN SOA** scheme) aerosol chemistry

Natural aerosols → **dust, re-suspension and inert sea-salt**

Boundary Conditions → **LMDz-INCA+GOCART**

EMEP anthropogenic emissions

Results

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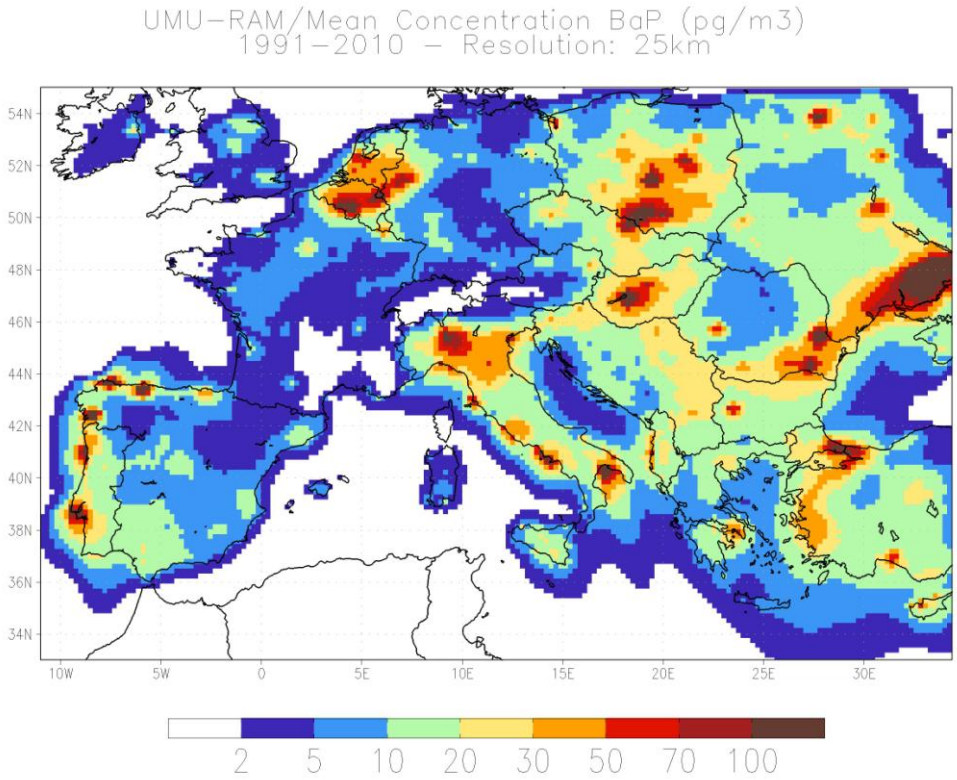
BaP air climatologies (1991-2010), pg m^{-3}



- Modelled BaP climatologies do not show defined spatial patterns
- Several areas in Europe exceed 100 pg m^{-3} as annual averages (Portugal, Spain, Netherlands, Germany, Italy or Poland), reaching more than 500 pg m^{-3} over some areas in Poland
- The highest concentrations are found in urban (e.g. Lisbon, Portugal) and industrial settings (Ruhr area, Germany)

Question 2:

Are these approaches powerful enough to address **health-related issues**?

Methodology

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When setting the target value for BaP in the Directive 2004/107/EC (average limit of 1 ng m^{-3} over one year), a Quantitative Risk Assessment (QRA) method* was based on studies focusing on the increased risk of lung cancer due to industrial exposure to PAHs.

Using this method and the World Health Organisation unit risk of lung cancer estimate for PAHs (87 x 10^{-6} BaP m^{-3} for lifetime exposure), the EU calculated the increased risk for three possible target values:

(1) **0.01 ng m^{-3}** with an associated increased life-time risk of $1x10^{-6}$
(2) **0.1 ng m^{-3}** with an associated increased life-time risk of $1x10^{-5}$
(3) **1 ng m^{-3}** with an associated increased life-time risk of $1x10^{-4}$

(Source: cancersymptoms.org)

*Butterfield, D.M. and Brown, R.J.C. (2012). Polycyclic aromatic hydrocarbons in Northern Ireland. National Physical Laboratory Report AS66, Teddington, Middlesex, UK

Results

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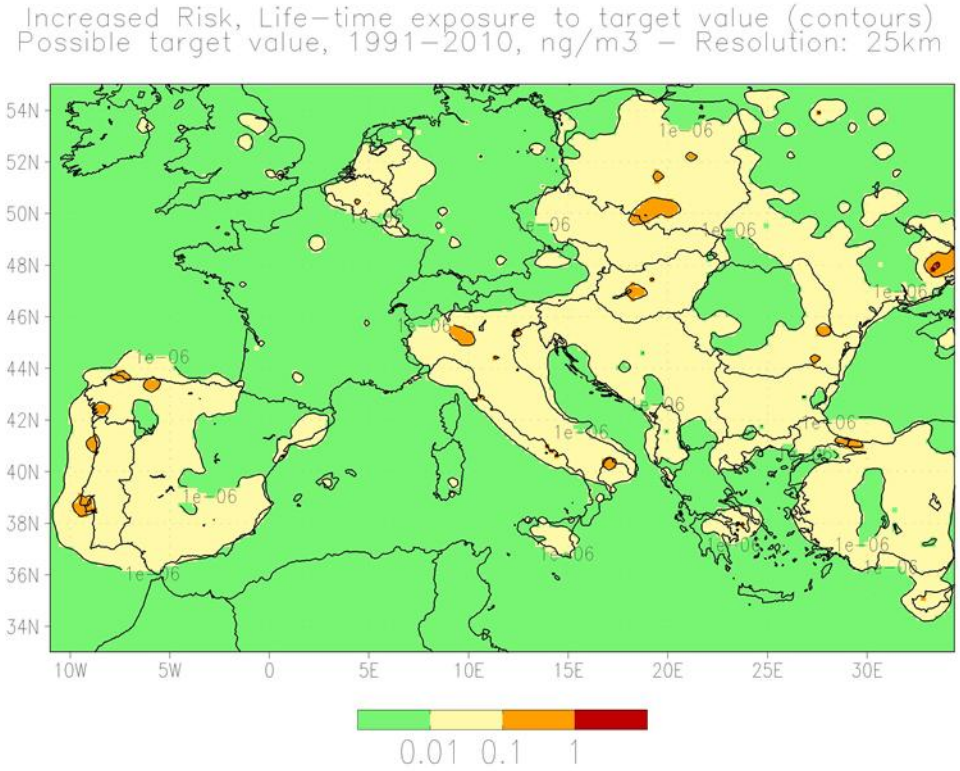
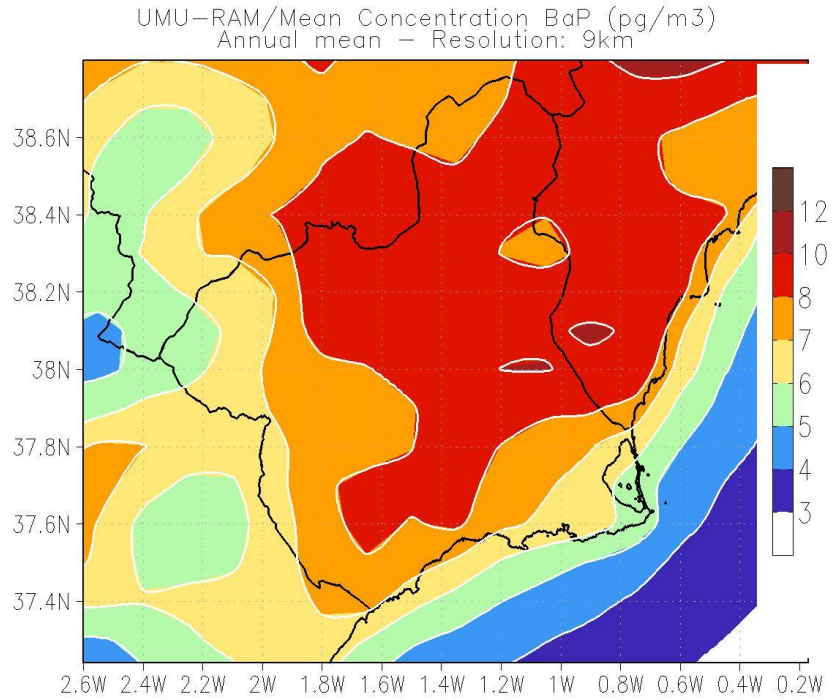
Increased risk of lung cancer (1991-2010), pg m^{-3}

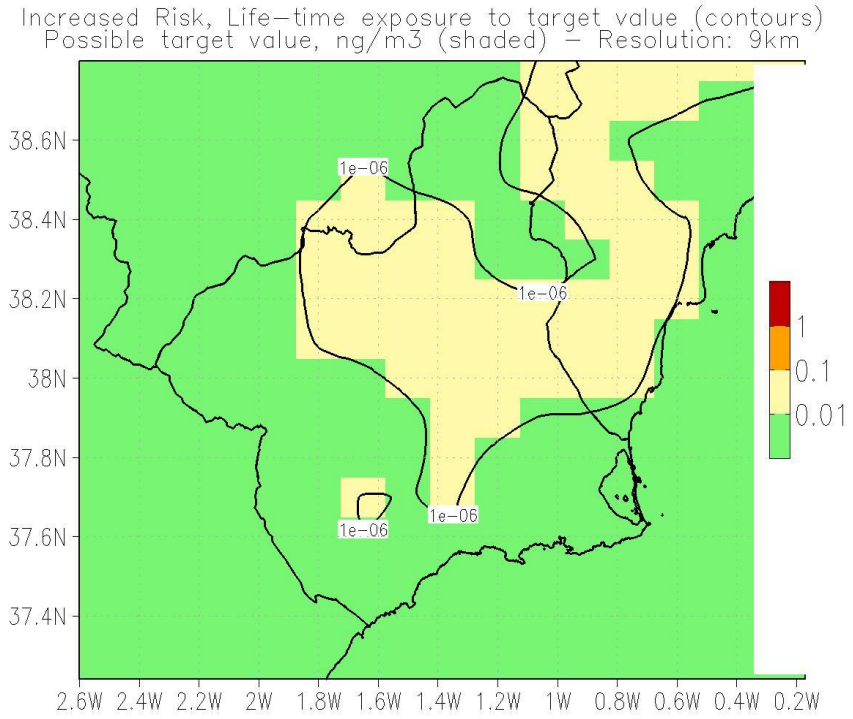


- The highest target value for present-day climatologies is only exceeded in Ukraine
- Some areas surpass 0.1 ng m^{-3} with associated increased risk of 1 x 10^{-5} for lung cancer (Lisbon and Porto, some areas in northern Spain and Poland and the Po Valley in Italy), the rest of Europe falls under it (below 0.1 ng m^{-3} in southern and eastern Europe and 0.01 ng m^{-3} in most of Europe)
- This involves increased risks of lung cancer under 1 x 10^{-5} and 1 x 10^{-6}, respectively

For a smaller domain...



The maximum climatic BaP value is under 0.1 ng m^{-3}, with some areas exceeding the target value of 0.01 ng m^{-3}



Therefore, an increased life-time risk of 1 x 10^{-6} is exceeded in several areas of our domain

Question 3:

How will **climate change influence** both the climatologies and parameters of human health concern?

Methodology

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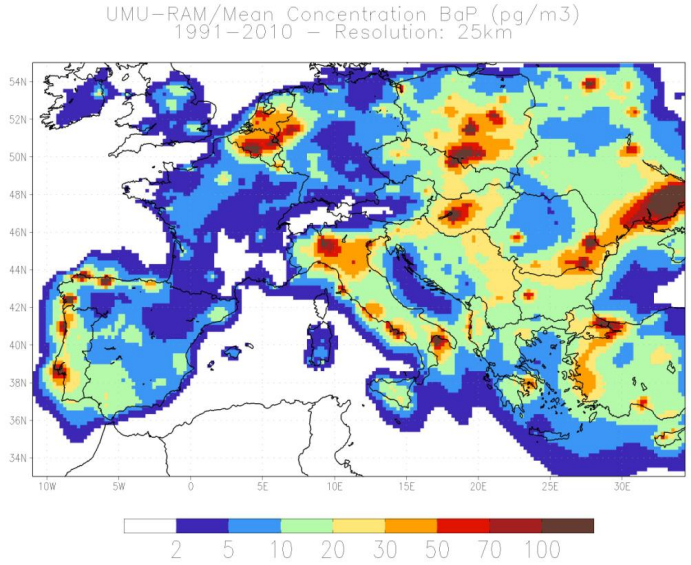
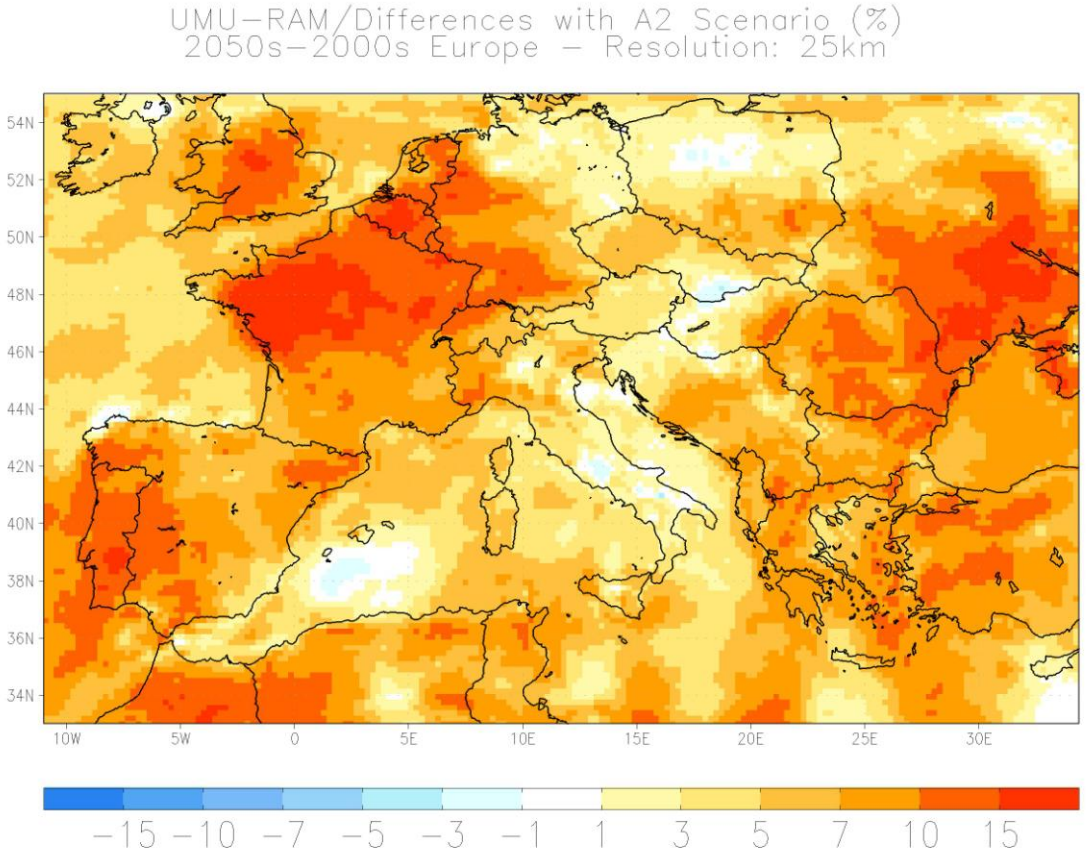
- Simulations for present-day climatologies (1991-2010) were compared to a time slice covering 2031-2050, using the future SRES A2 scenario
- In order to isolate the possible effects of climate change on the ground concentrations of air pollution, unchanged anthropogenic emissions are assumed (derived from the EMEP database)
- Natural emissions depend on climate conditions, and consequently are the only parameter to vary between reference and future climate simulations (Jiménez-Guerrero et al., 2012)
- Biogenic emissions were generated dynamically using MEGAN (Model of Emissions of Gases and Aerosols from Nature) with the parameterised form of the canopy environment model.
- The model estimates these emissions as a function of hourly temperature and ground level shortwave radiation from MM5-RCM.

Jiménez-Guerrero, P.; Montávez, J.P.; Gómez-Navarro, J.J.; Jerez, S. and Lorente-Plazas, R. (2012). Atmospheric Environment, 55, pp. 483–495.

Results

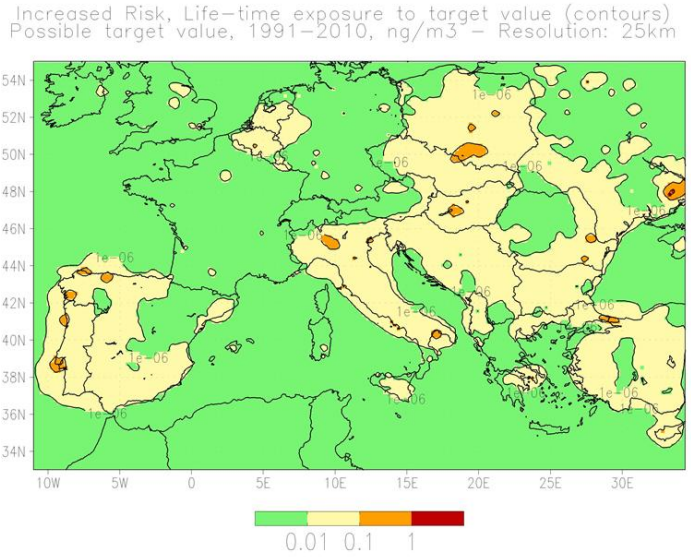


BaP air climatologies (2031-2050), pg m^{-3}

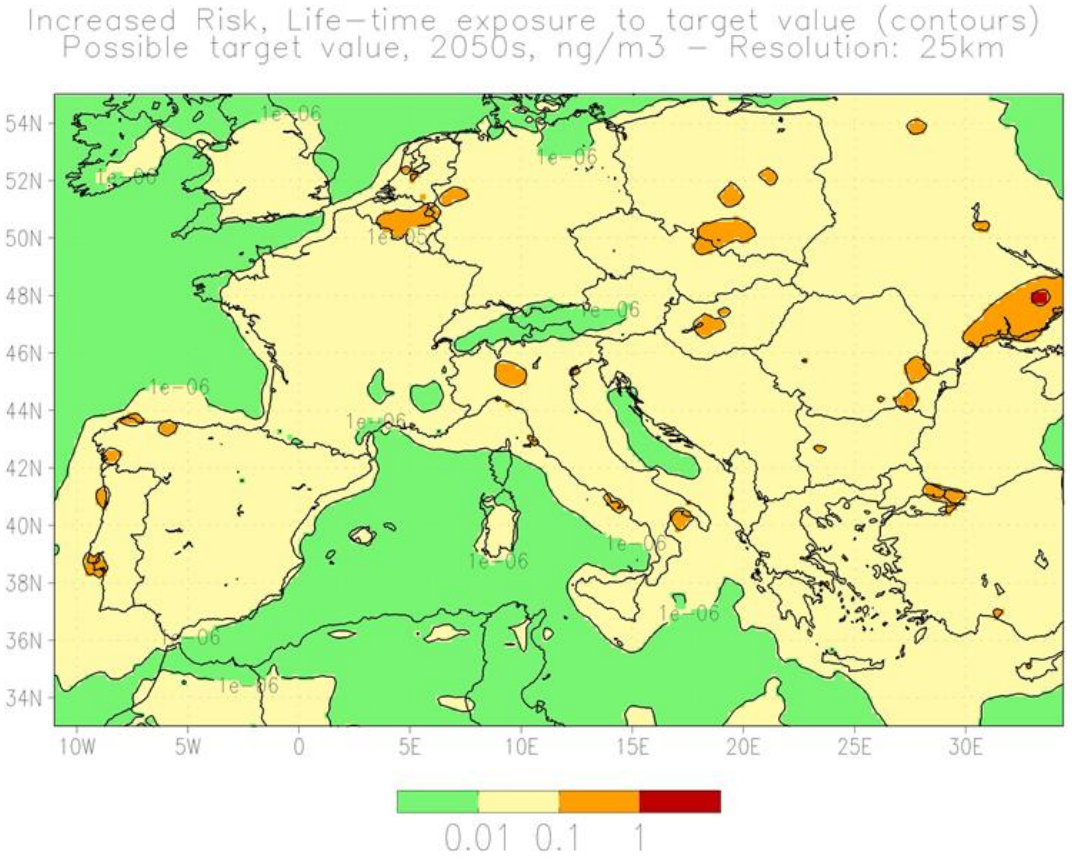


- The highest increases are up to 25% over western France. This region presents very low levels of BaP currently, so climate change alone is not reflected in high levels of this pollutant
- Significant rises (around 15%) are modelled over eastern Europe (mainly Ukraine) and western Iberian Peninsula, coinciding with the highest BaP concentrations
- Strong decreases in precipitation modelled for the Iberian Peninsula for future climates (e.g. Jiménez-Guerrero et al., 2012) imply a significant increase in its atmospheric concentration

Results



Increased risk of lung cancer (2031-2050), pg m^{-3}



- For SRES A2-driven simulations, the risks of lung cancer increase substantially all over Europe
- While the 1 ng m^{-3} target is only surpassed in Ukraine, a much larger number of areas exceeding the 0.1 ng m^{-3} threshold is found with respect to present-day climatologies (e.g. over the Ruhr Valley in Germany or the Netherlands)

CONCLUSIONS:

- A regional climate modelling system (coupling MM5-RCM and CHIMERE chemistry transport model) was applied to a simulation covering a present-climate condition (1991-2010) and the future SRES A2 scenario (2031-2050) in order to obtain regional distributions PAHs concentrations.

- Chemistry transport models (CTMs) identify areas with levels higher than established by regulations for BaP in the actual conditions and increases up to 25% in future projections.

- The general increased risk of lung cancer over land in Europe (1×10^{-6} for the present scenario) is turned into an order of magnitude higher (1×10^{-5}).

- It is important to characterise and reduce the uncertainties of model projections by having a better idea of the regional air pollution meteorology (especially related to temperature and precipitation, which influences considerably the difference between simulations of particulate material such as BaP).

Acknowledgements:

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