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# Eurodelta-Carb exercise: intercomparison of modelled estimates of Benzo(a)pyrene (BaP) in Europe

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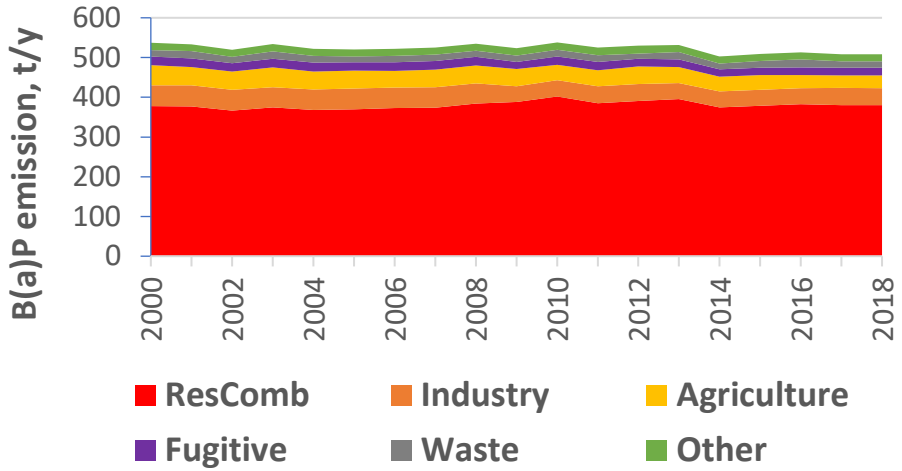
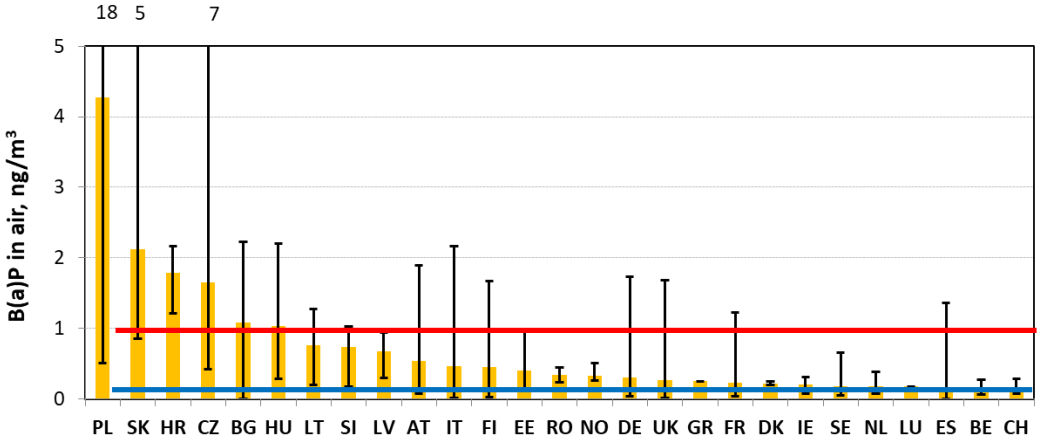
# Introductory remarks

- B(a)P is a semi-volatile reactive compound belonging to polycyclic aromatic hydrocarbons
- B(a)P has carcinogenic, mutagenic, and teratogenic properties that pose risk to human health and ecosystems
- B(a)P is mostly released to the environment as a result of incomplete combustion of biomass and fossil fuels
- B(a)P emissions do not change significantly in the EU countries over the past ~20 years
- Observed B(a)P levels still exceed EU target value and WHO reference level in Europe
- Available modelling approaches require refinement and harmonization (e.g. parameterizations of B(a)P gas-particle partitioning and degradation)




EU target value 1 ng $m^{-3}$

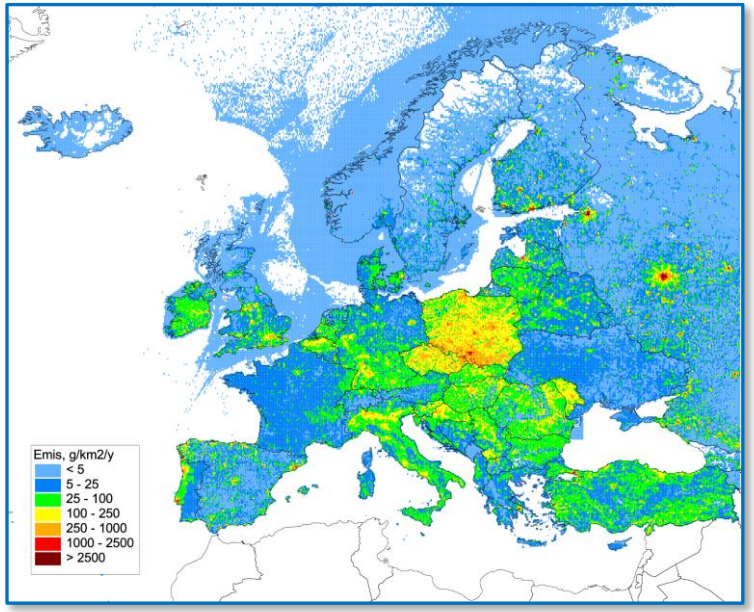
WHO ref level 0.12 ng $m^{-3}$

# Eurodelta-Carb multi-model study of B(a)P pollution in Europe

**Contribution to EMEP/TFMM Eurodelta-Carb multi-model multi-pollutant project**

## Objectives:

- Multi-model assessment of spatial distribution of B(a)P and exceedances of air quality guidelines
- Analysis of model predictions for B(a)P and reasons of differences between the models and with measurements
- Contribute to further development of B(a)P modelling approach




Annual B(a)P emissions within Eurodelta-Carb modelling domain (2018)

## Participating models:

| *Model* | *Institution* |
|---|---|
| CHIMERE | CIEMAT (Spain), INERIS (France) |
| GLEMOS | EMEP/MSC-E |
| MINNI | ENEA (Italy) |
| SILAM | FMI (Finland) |

# Eurodelta-Carb multi-model study of B(a)P: setup details

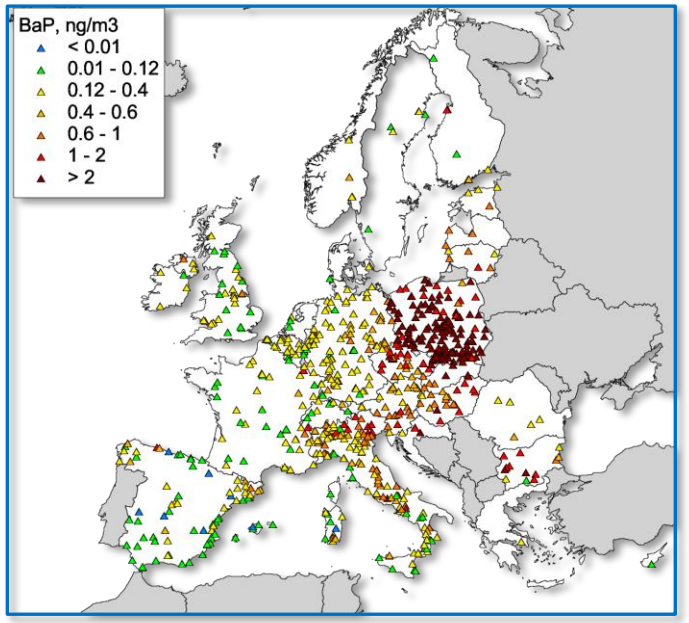
- **Temporal coverage:**
  From 1 Dec 2017 to 31 Dec 2018

- **Emissions of B(a)P:**
  EMEP/CEIP emission inventory for 2018 (submission of 2021)

- **Emissions of non-B(a)P species (SOx, NOx, PM2.5,…):**
  Recommendation to use CAMS-REG-AP/REF2.1 emission inventory

- **Model simulations:**
  Base case model run
  Sensitivity model runs – ongoing work

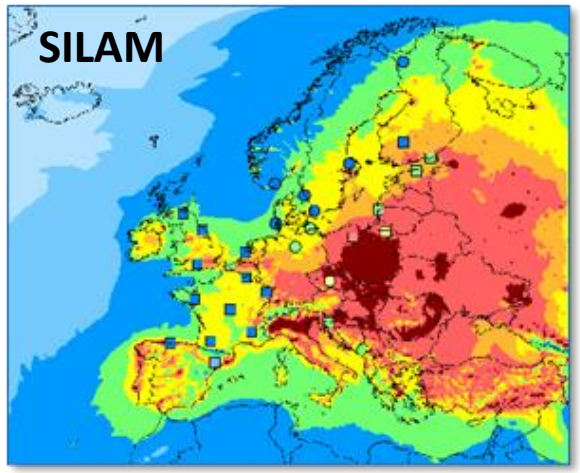
- **Observations:**
  EMEP and EEA AQ e-reporting measurement data for 2017/2018
  EMEP/ACTRIS/COLOSSAL intensive monitoring campaign for winter 2017/2018

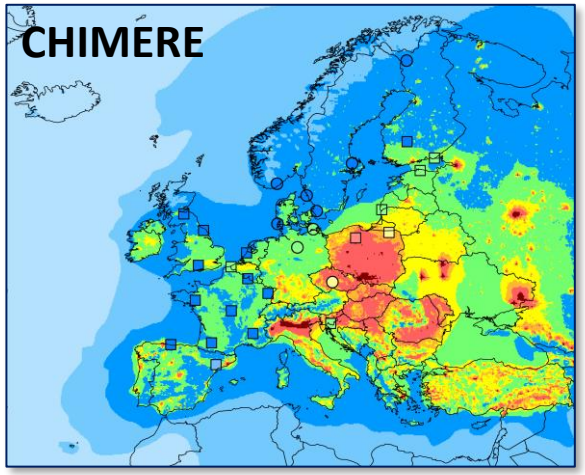


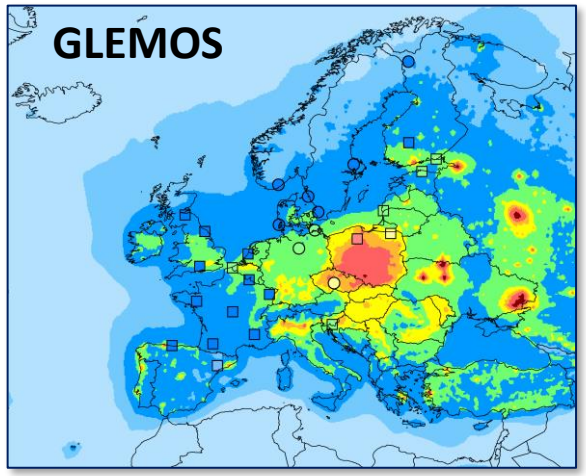

EMEP and EEA AQ e-reporting B(a)P measurements (2018)

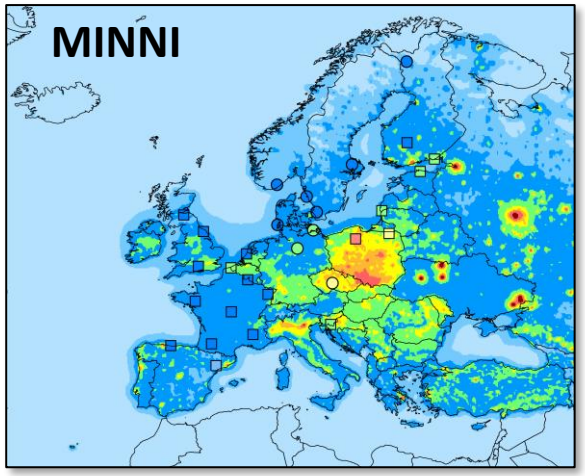
# Spatial distribution of modelled and observed B(a)P

**Results of the base case model run for 2018**



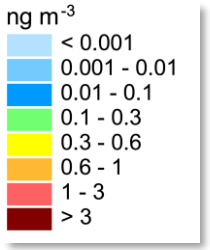




- Annual mean modelled B(a)P concentrations

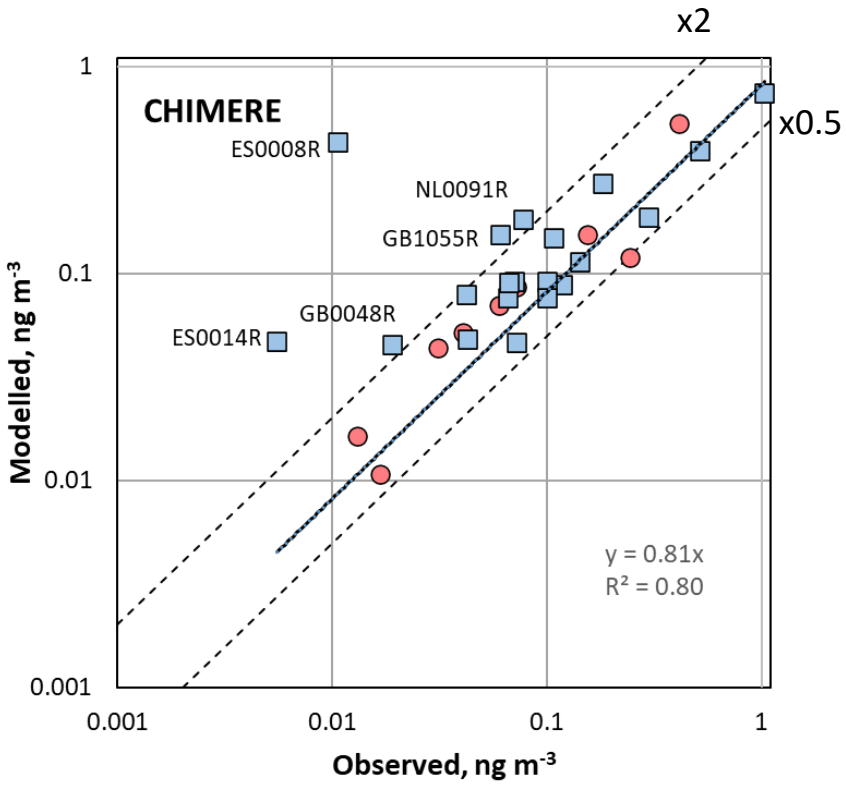
- Measurements of 29 EMEP stations:
  - 9 measured gas+aerosol B(a)P (circles)
  - 20 measured aerosol B(a)P (squares)
  - high altitude stations were excluded

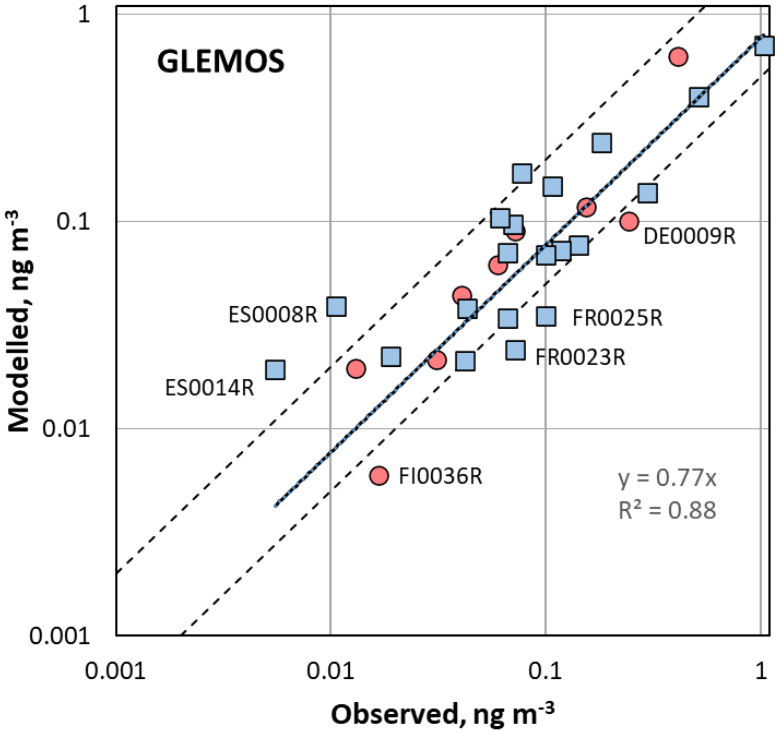
Modelled B(a)P concentrations:
SILAM > CHIMERE > GLEMOS > MINNI

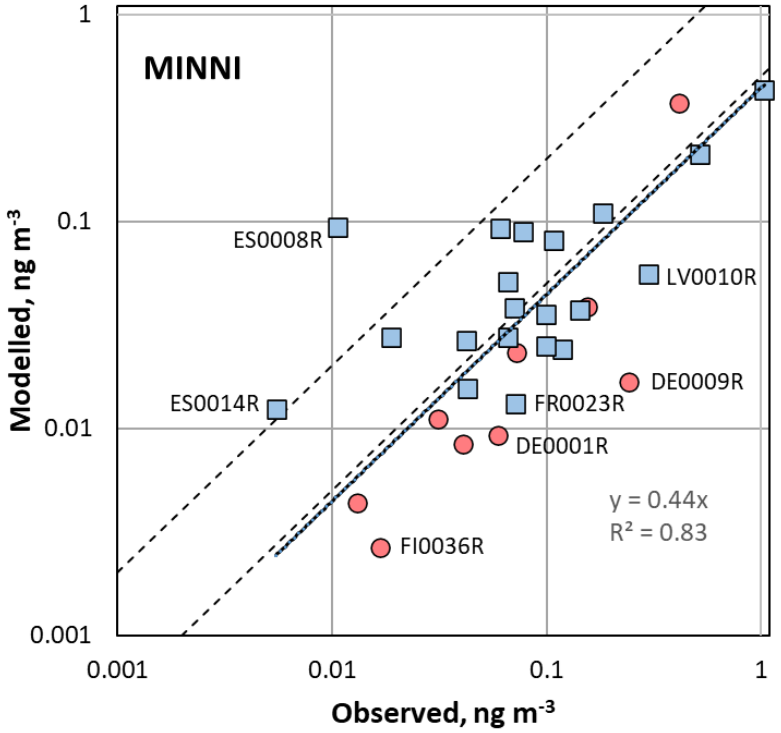


# Base case model run: modelled vs observed (EMEP stations)

**Annual mean B(a)P concentrations (2018), 29 EMEP stations**




gas+aerosol phase B(a)P

aerosol phase B(a)P

# Base case model run: modelled vs observed (EMEP stations)

**Statistical metrics, calculated on the basis of annual mean total and particulate phase BaP air concentrations**

| Models | Mean | NMB (%) | R | RMSE | F2 (%) | F3 (%) |
|---|---|---|---|---|---|---|
| Total B(a)P concentrations (9 stations), mean observed 0.116 ng $m^{-3}$ | | | | | | |
| **CHIMERE** | **0.120** | **3.9** | **0.93** | **0.058** | **89** | **100** |
| **GLEMOS** | 0.121 | 4.3 | 0.91 | 0.087 | 78 | **100** |
| **MINNI** | 0.054 | -53.3 | 0.86 | 0.090 | 11 | 22 |
| Particulate B(a)P concentrations (20 stations), mean observed 0.156 ng $m^{-3}$ | | | | | | |
| **CHIMERE** | **0.170** | **8.9** | 0.84 | 0.128 | **80** | **90** |
| **GLEMOS** | 0.126 | -19.3 | **0.96** | **0.095** | 70 | 85 |
| **MINNI** | 0.075 | -52.1 | 0.93 | 0.168 | 40 | 70 |

**Possible reasons of discrepancies:**

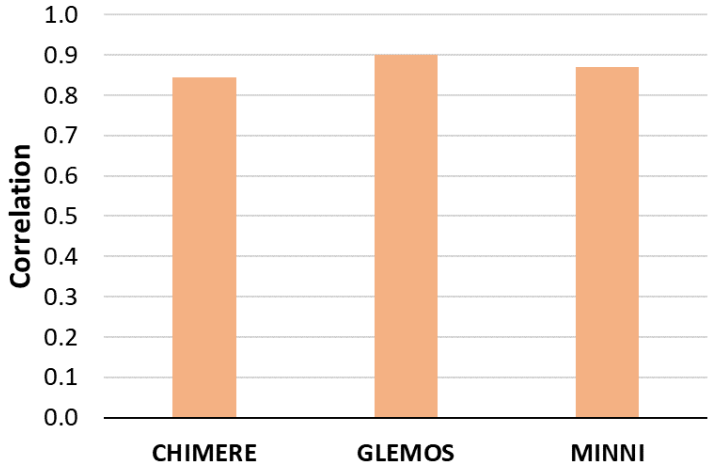
- uncertainties in modelling approach (e.g. degradation rates of B(a)P in aerosol phase)
- uncertainties in temporal profiles and sector distribution of B(a)P emissions
- uncertainties in measurements (e.g. outliers, values below detection limits)

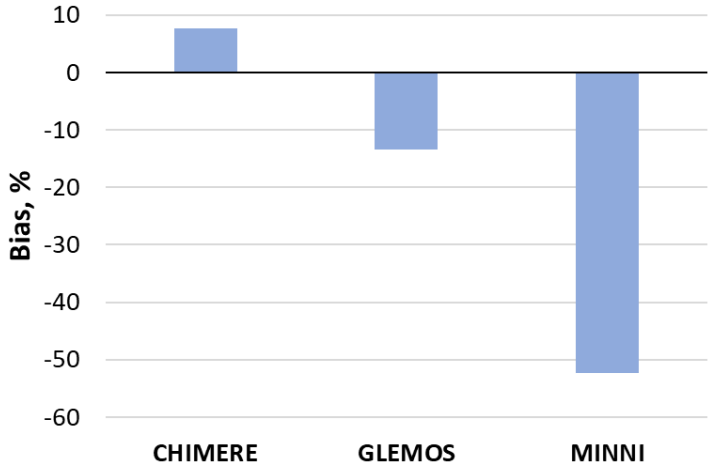
# Base case model run: modelled vs observed (EMEP stations)

- High spatial correlation of modelled and measured B(a)P air concentrations
- Significant differences between model biases (due to different parameterizations of B(a)P degradation)

  - CHIMERE: no degradation of B(a)P in aerosol phase

  - MINNI has higher rate of B(a)P degradation in aerosol phase than GLEMOS



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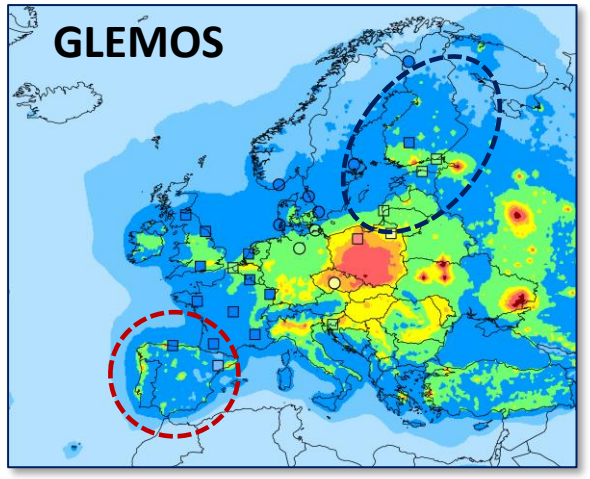
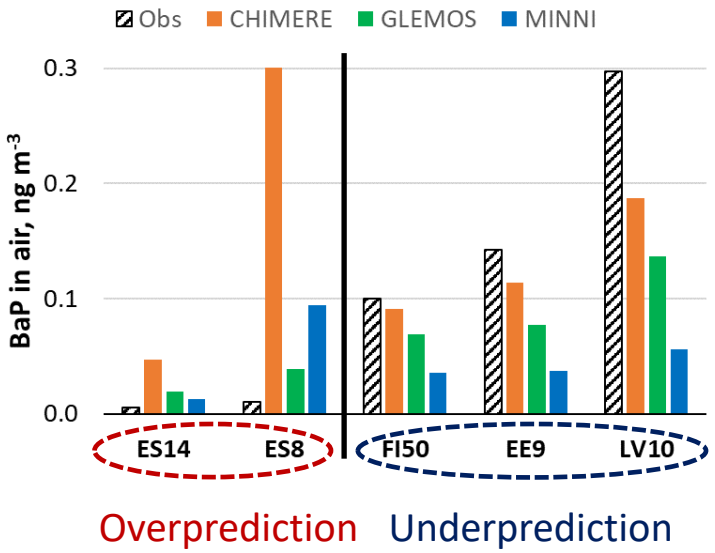
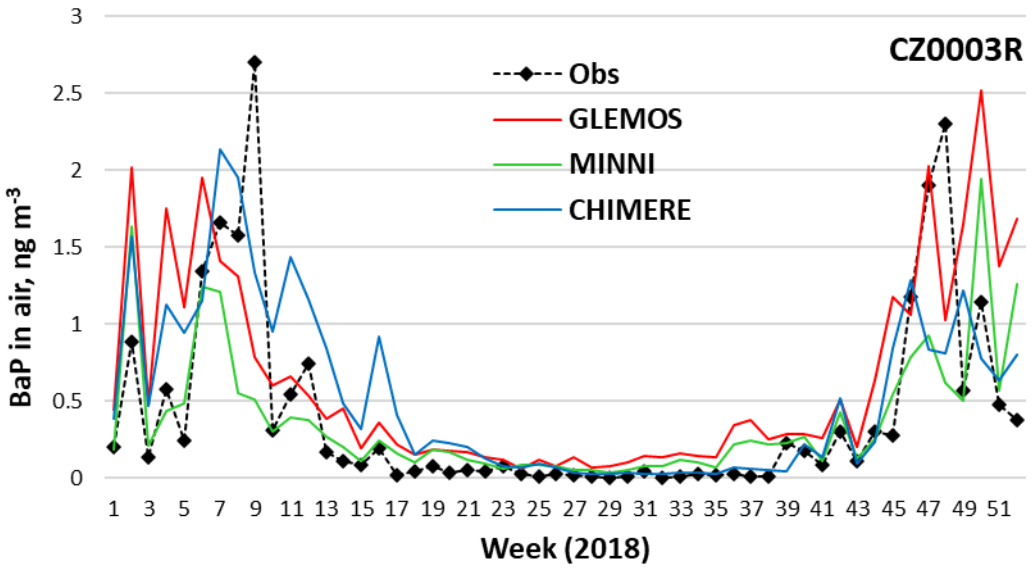
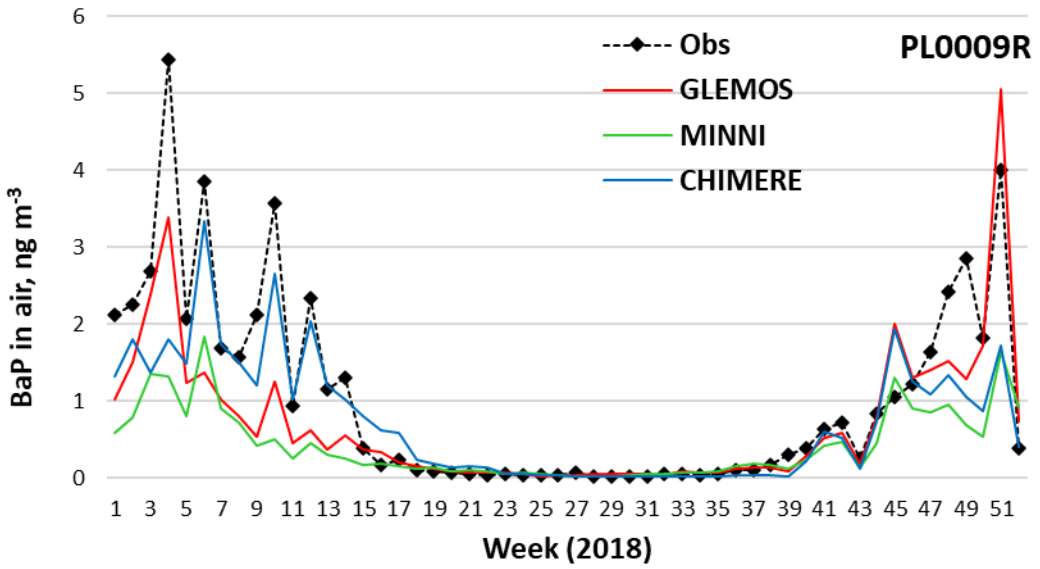
- Models overpredict observed concentrations in Spain and underpredict in Finland, Latvia, Estonia (due to possible uncertainties in national B(a)P emission inventories)



# Base case model run: B(a)P intra-annual variations




- High correlation with observed intra-annual variability of B(a)P air concentrations
- Differences between the models for particular months due to different factors of emission temporalization used in the models
- Other possible factors: differences in meteorological data and concentrations of atmospheric reactants

# Concluding remarks and further activities

- Preliminary intercomparison of model simulations with prescribed officially reported B(a)P emissions demonstrates a generally reasonable level of agreement between the models and with measurements (spatial correlation, intra-annual variability)

- For some of the stations, modelled B(a)P concentrations significantly deviated from the observed values indicating possible uncertainties in emission estimates, modelling approaches and measurements

- Model-to-model differences of B(a)P concentrations indicate high sensitivity of the models to the implementation of B(a)P degradation in the atmosphere

- Next stage of the study will focus on sensitivity analyses (e.g. for B(a)P degradation, emission temporalization, meteorological drivers) and on analysis of other model outputs (B(a)P concentrations in precipitation, deposition fluxes, and concentrations of species affecting B(a)P chemical transformations in the atmosphere)