Norwegian Meteorological Institute

Multi-model assessment of PM level changes over 1990-2010

Highlights from ED Trends study

On behalf of EDT Team presented by Svetlana Tsyro

TFMM 18-th meeting
Prague (CZ) May 3-5, 2017

Presentation Scope

- Components: **PM_{10}, $PM_{2.5}$**
- Periods:
  - **2001-2010** **5 (6) models** **& PM observations**
  - **1990-2000-2010** **8 models**

- Methods/tools
  - **EMEP, CHIMERE, LOTOS-EUROS, MATCH, MINNI, WRFF** (around the corner)
    for 1990 – 2010 (+ with 2010 emissions)
  - above & **CMAQB, POLYPHEMUS** (WRFC)
    for 1990, 2000, 2010 (+ 2010 meteorology)
  - **EMEP observations** (ebas): trend-sites **29 for PM10, 18 for PM2.5**
  - Mann Kendall test to detect the trend (significance level 0.1)
  - Theil-Sen's slope

- Questions
  - Can we see significant trends from model results? Observations?
  - How well the models reproduce observed trends? (Dis-) Agreements between the models?
  - Geographical differences? Seasonal differences?
  - Model calculated decadal differences to assess PM level changes
  - ……. effect of meteorology/ emissions, natural contribution,..??
- Summary

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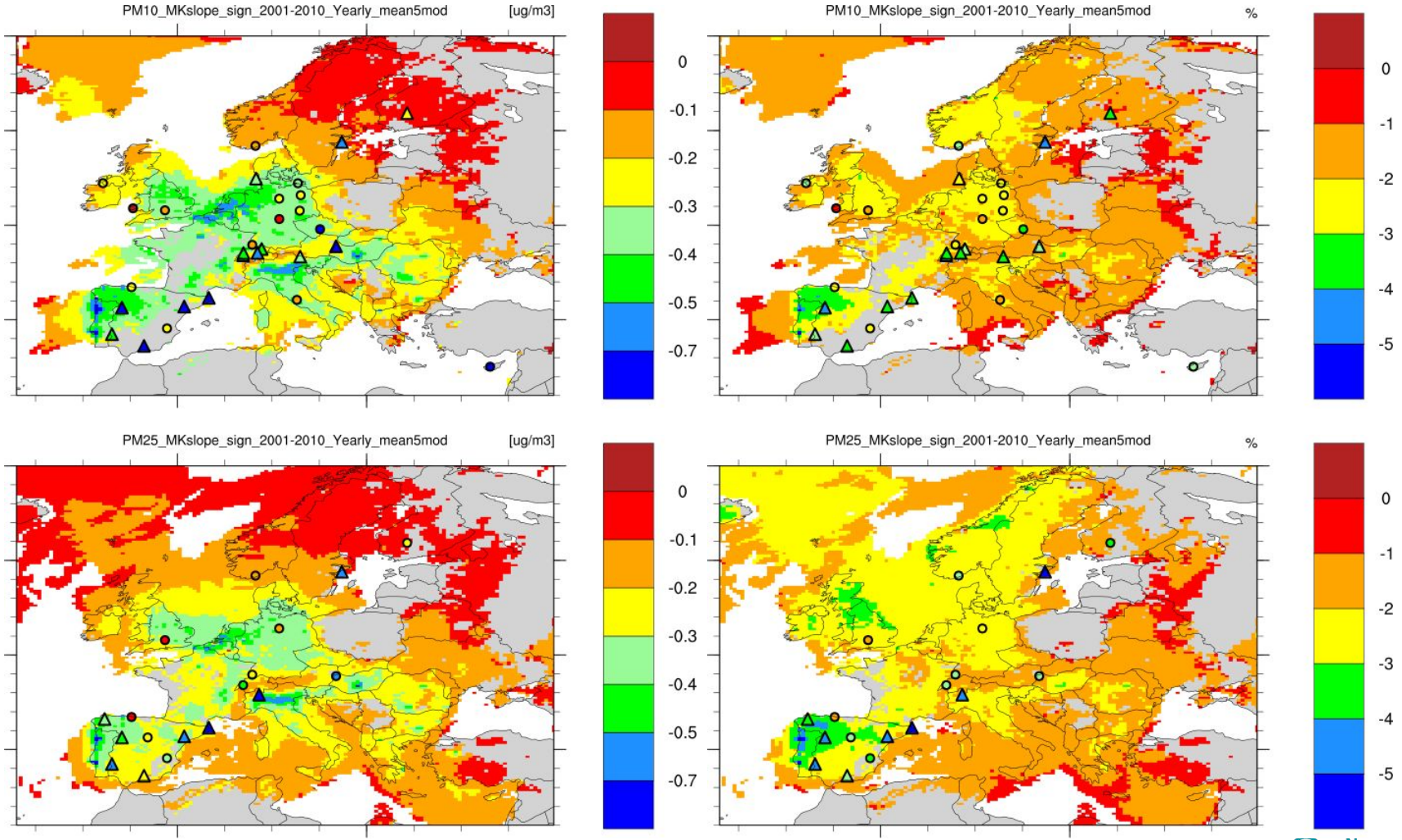
PM_{10} and $PM_{2.5}$ trends in 2001-2010 from 5-model ensemble and observations

µg m-3/yr

%/yr



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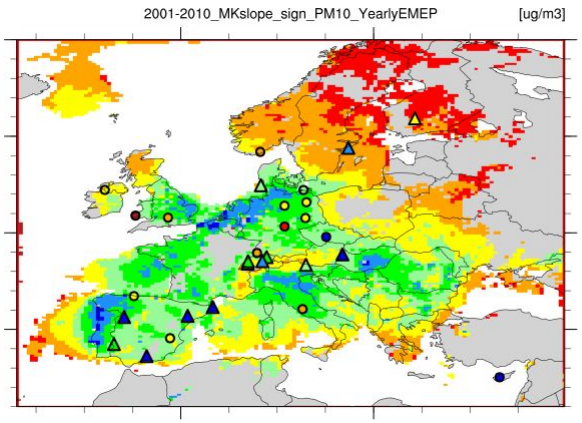
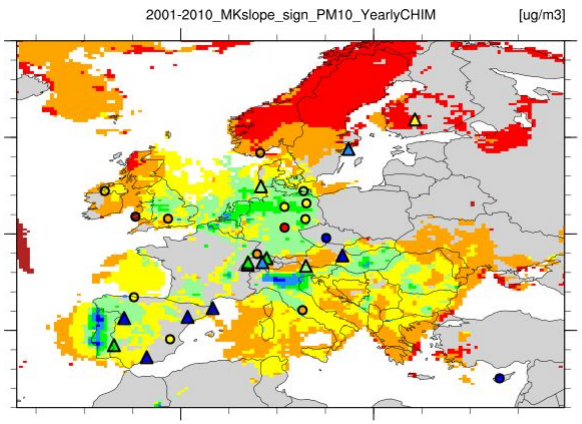
Modelled and observed PM_{10} trends in 2001-2010

µg m-3/yr

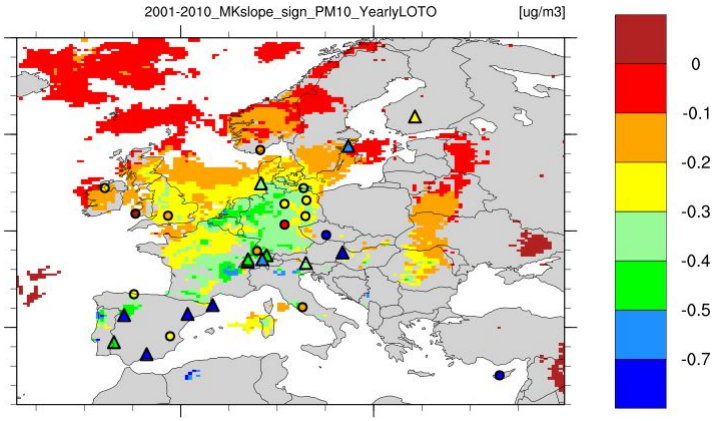
EMEP



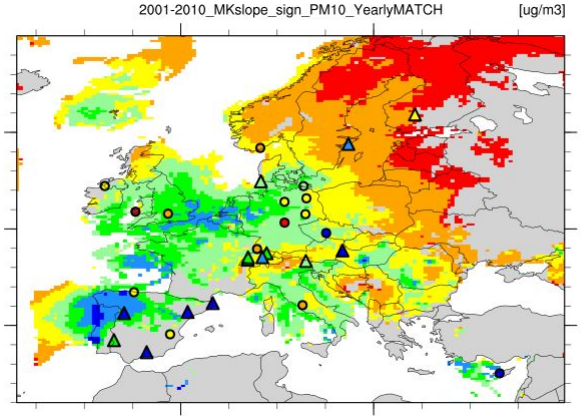
CHIM



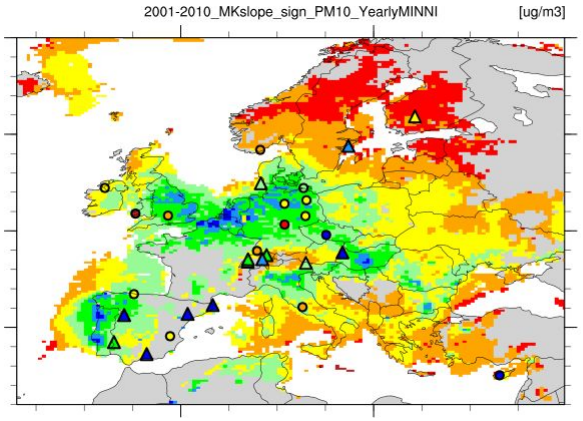
LOT



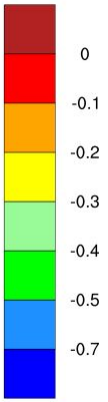
MATCH



MINNI



WRFF



Note rather irregular spatial coverage by Obs - has to be kept in mind when regarding the finding/conclusions

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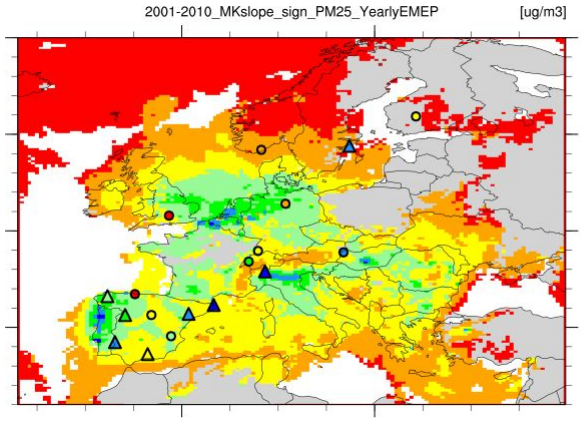
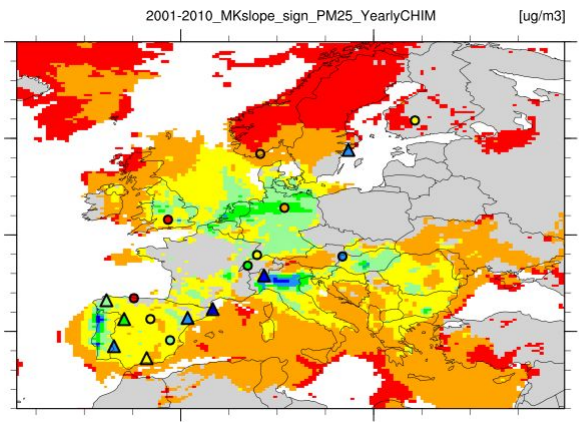
Modelled and observed $PM_{2.5}$ trends in 2001-2010

µg m-3/yr

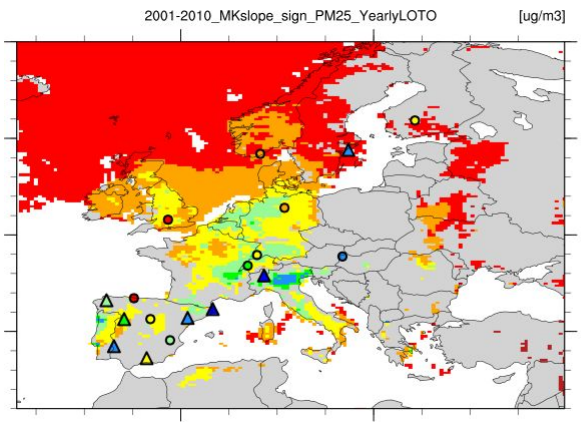
EMEP

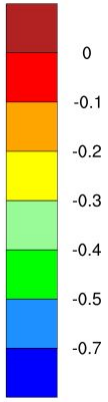


CHIM

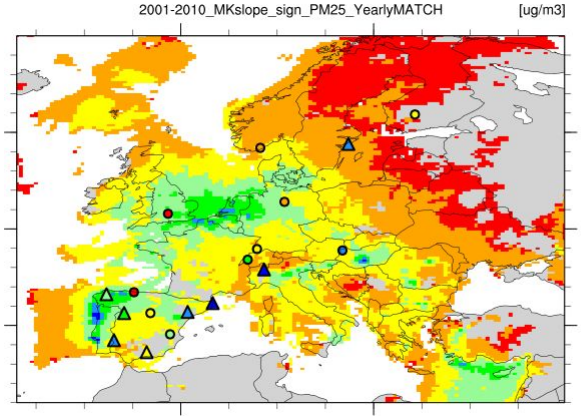


LOT

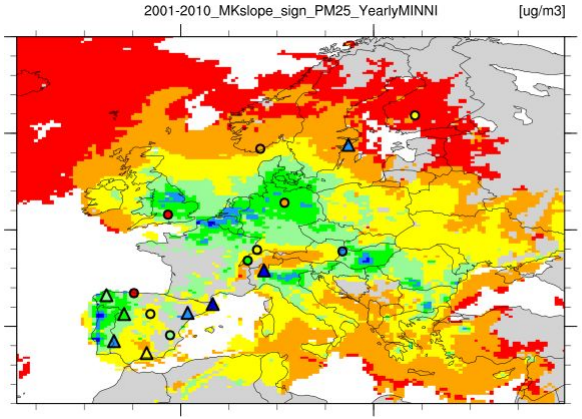




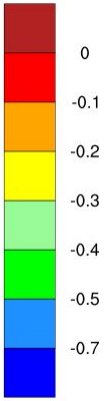
MATCH



MINNI



WRFN



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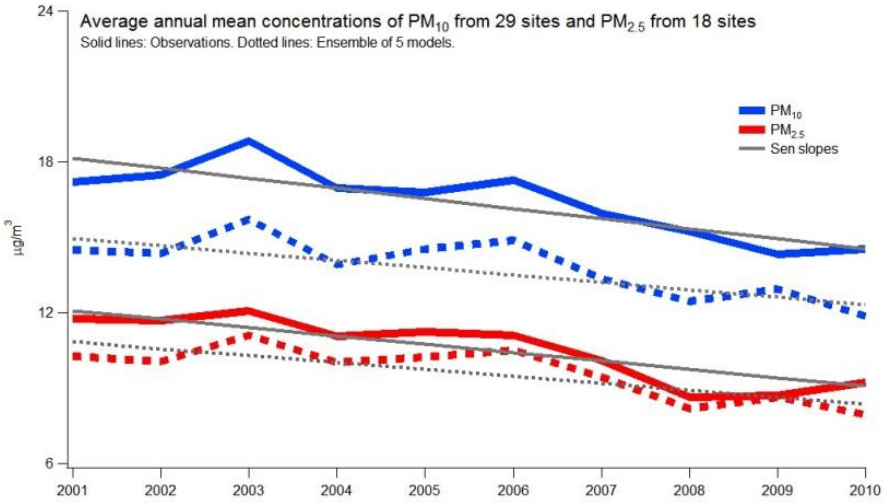
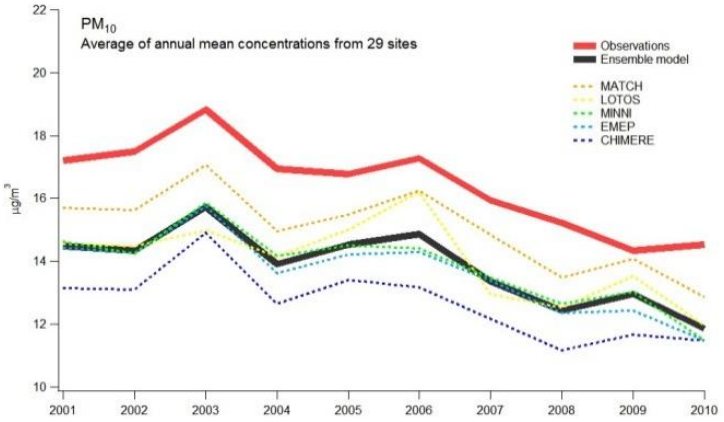
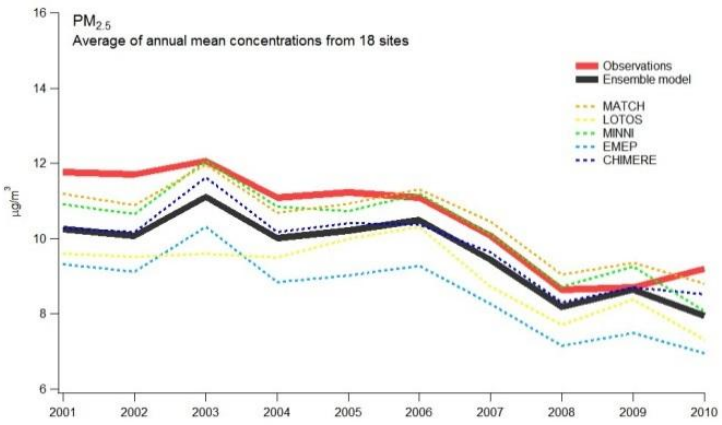
Annual mean series of PM_{10} and $PM_{2.5}$ from 2001 to 2010, averaged over 29 and 18 sites



PM_{10} : MOD= -0.31 µg m^{-3} yr^{-1} (-2.0 % yr^{-1})
OBS= -0.42 µg m^{-3} yr^{-1} (-2.3 % yr^{-1})

$PM_{2.5}$: MOD= -0.28 µg m^{-3} yr^{-1} (-2.5 % yr^{-1})
OBS= -0.41 µg m^{-3} yr^{-1} (-3.2 % yr^{-1})





Good correlation between model and obs

PM_{10}: 0.85 (CHIM), 0.88 (EMEP), 0.62 (LOTO), 0.84 (MATCH), 0.80 (MINNI)

$PM_{2.5}$: 0.95(CHIM), 0.94(EMEP), 0.83(LOTO), 0.95 (MATCH), 0.90(MINNI)

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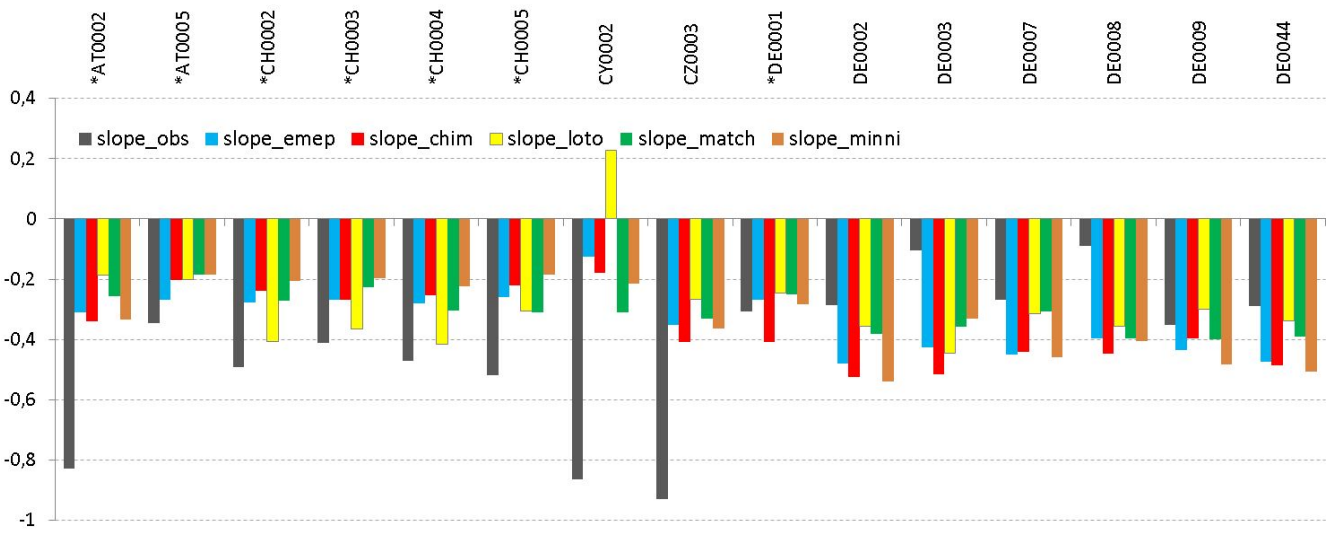
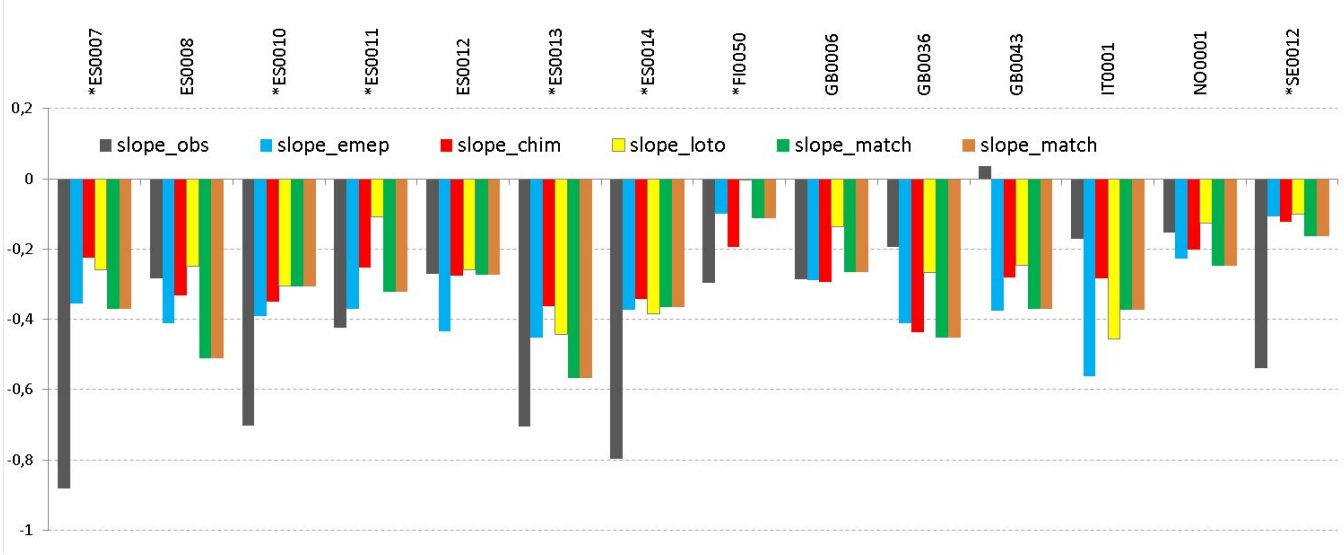
Mean PM_{10} trends at trend-sites ($\mu g\ m^{-3}yr^{-1}$)
Period: 2001-2010





Obs - black

***) sites with observed significant trends**

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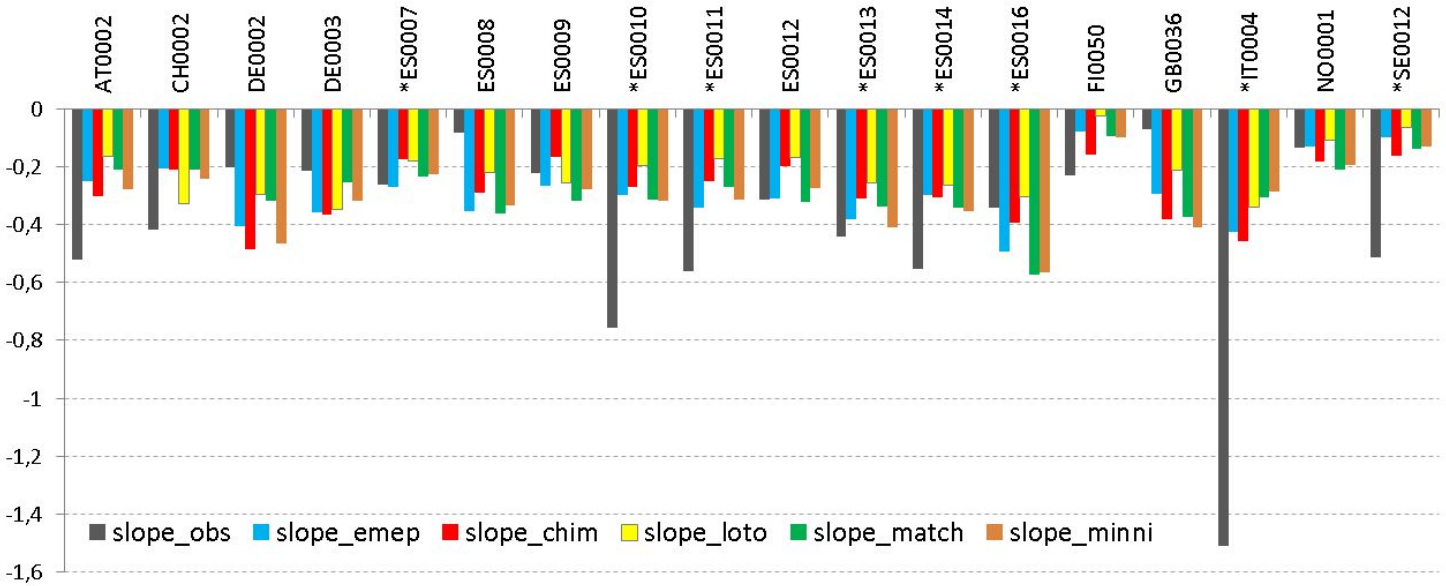
Mean $PM_{2.5}$ trends at trend-sites ($\mu g\ m^{-3}yr^{-1}$)
Period: 2001-2010



Obs - black

***) sites with observed significant trends**

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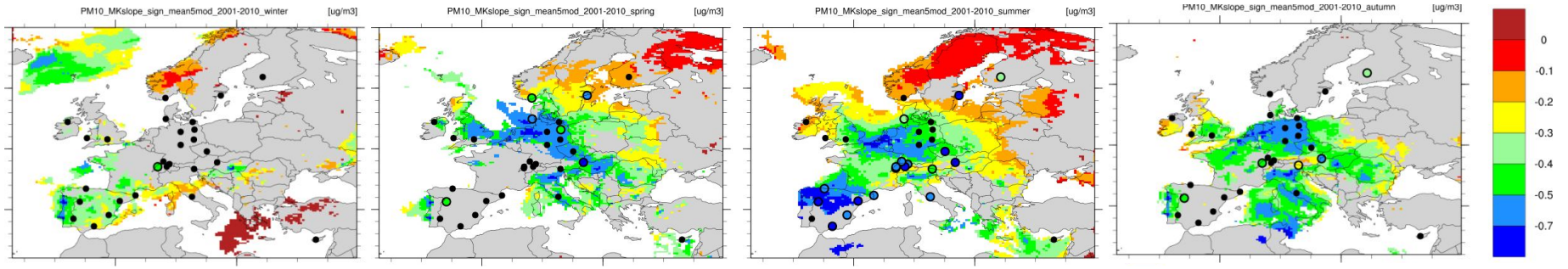
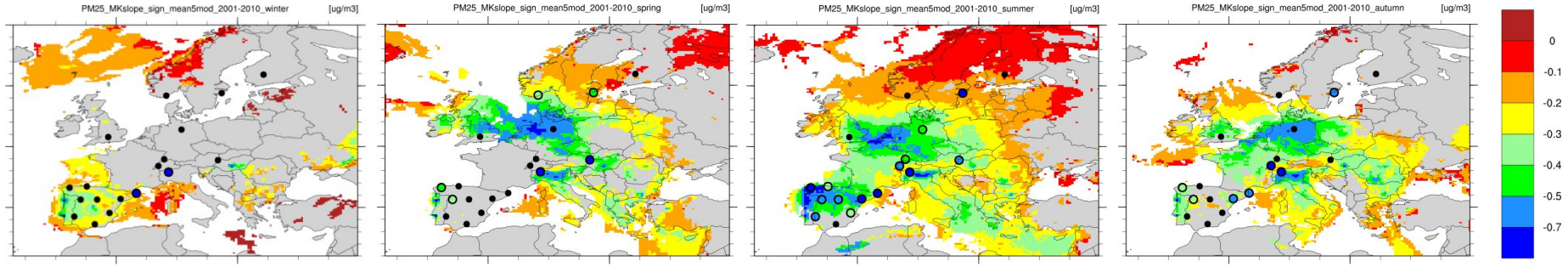
Seasonal mean trends in 2001-2010

winter spring summer autumn

PM10



PM2.5



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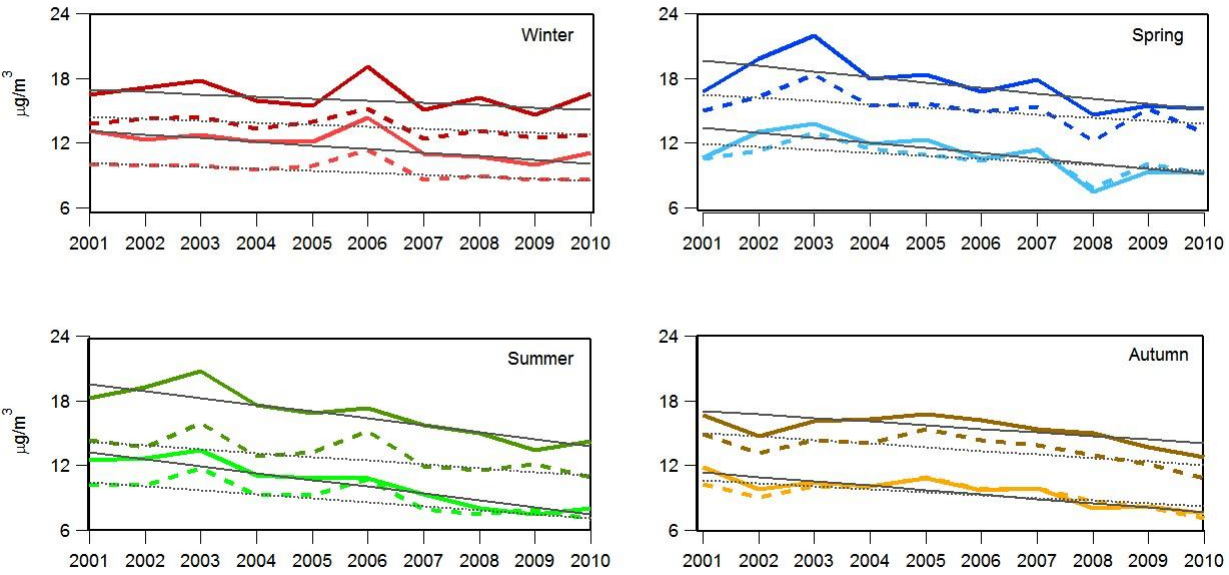
Mean seasonal trends in 2001-2010 (trend-sites)

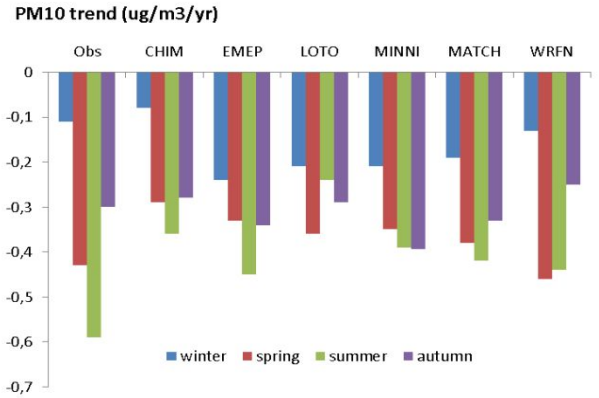
Seasonal mean PM_{10} and $PM_{2.5}$

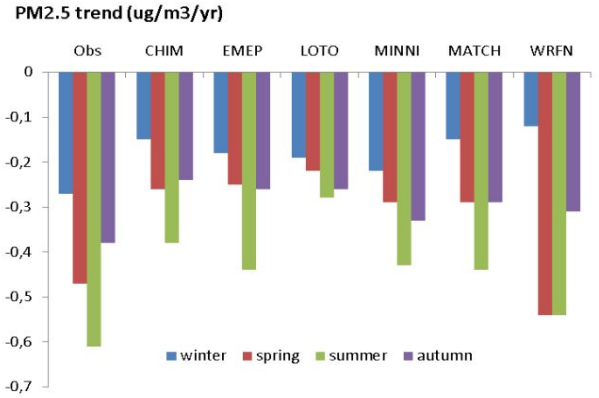
Average seasonal mean concentrations of PM_{10} from 29 sites and $PM_{2.5}$ from 18 sites

Solid lines: Observations. Dotted lines: Ensemble of 5 models.

Darker colours: PM_{10}. Lighter colours: $PM_{2.5}$. Grey lines: Sen slopes.







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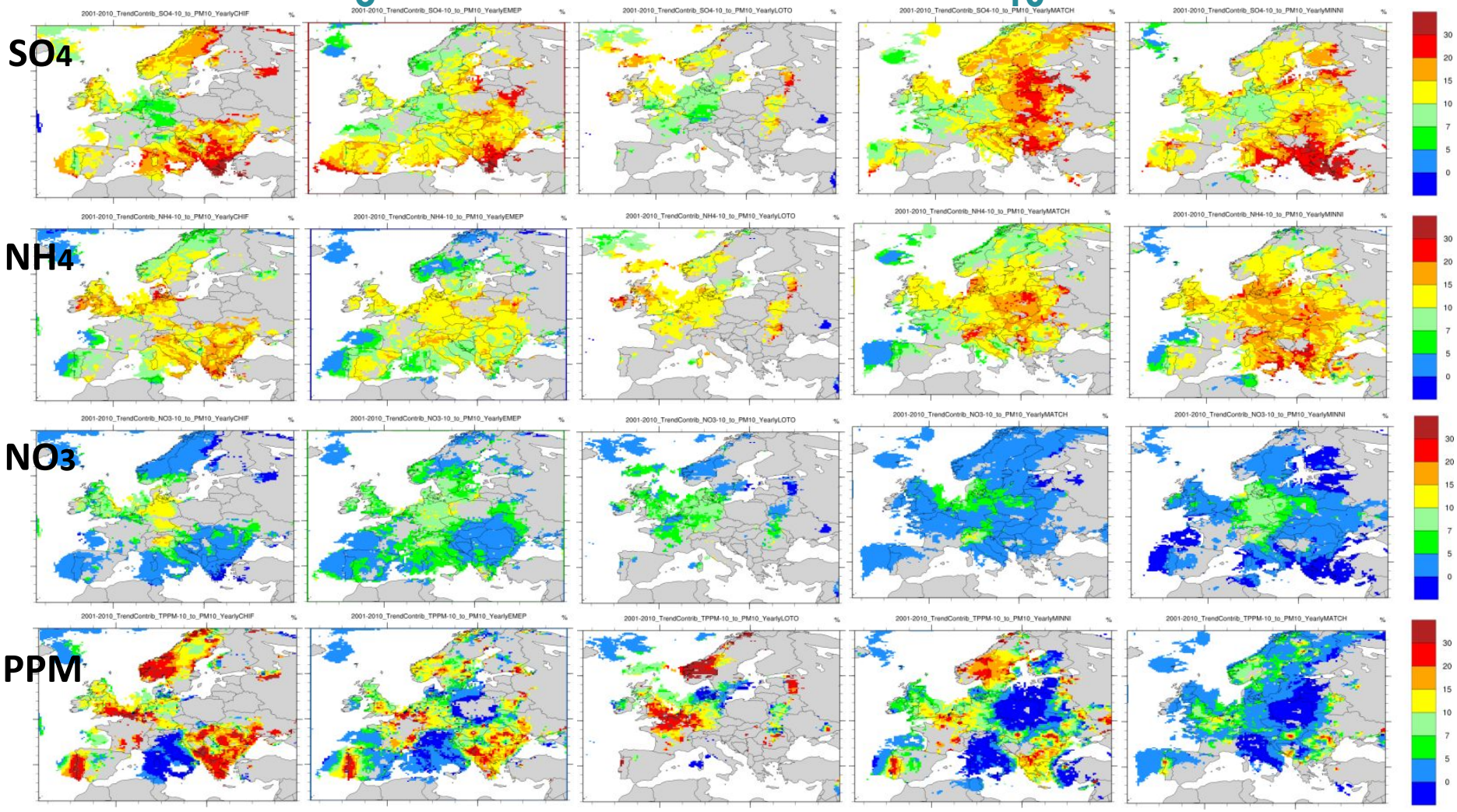
Relative contributions of (downwards) SO_4, NH_4, NO_3 and primary PM to PM_{10} trends



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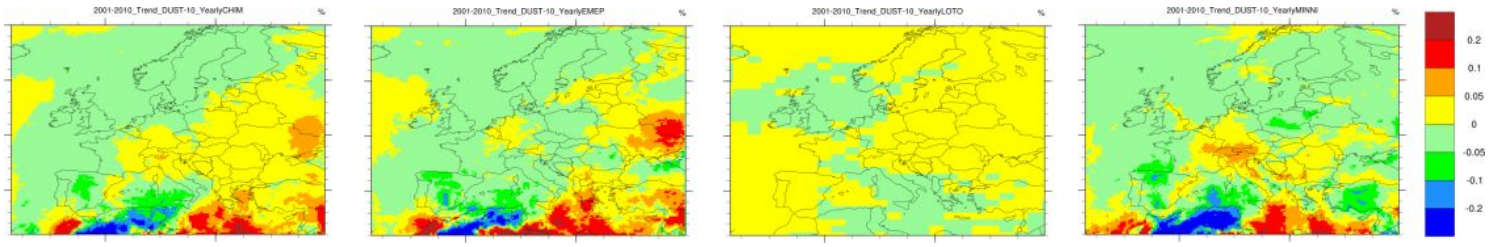
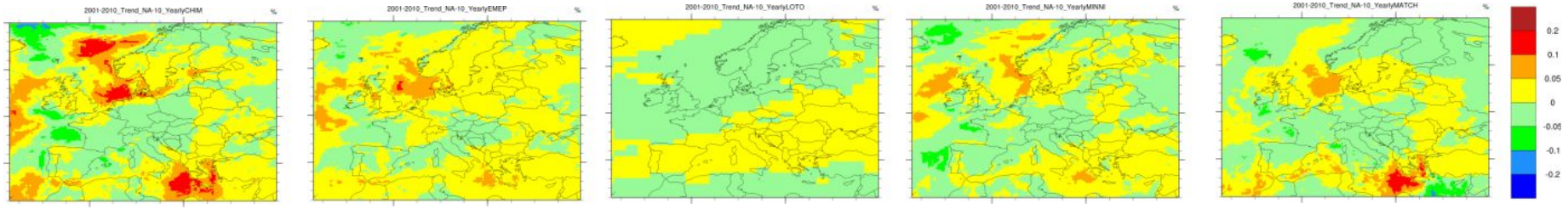
Relative contributions of natural aerosols to PM_{10} trends

Results from CHIM, EMEP, LOTO, MINNI, MATCH

Mineral dust



Na^+ from sea salt



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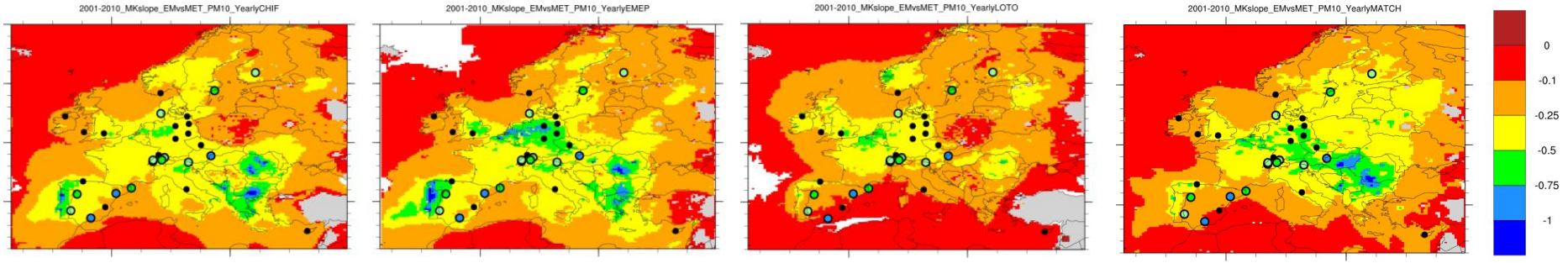
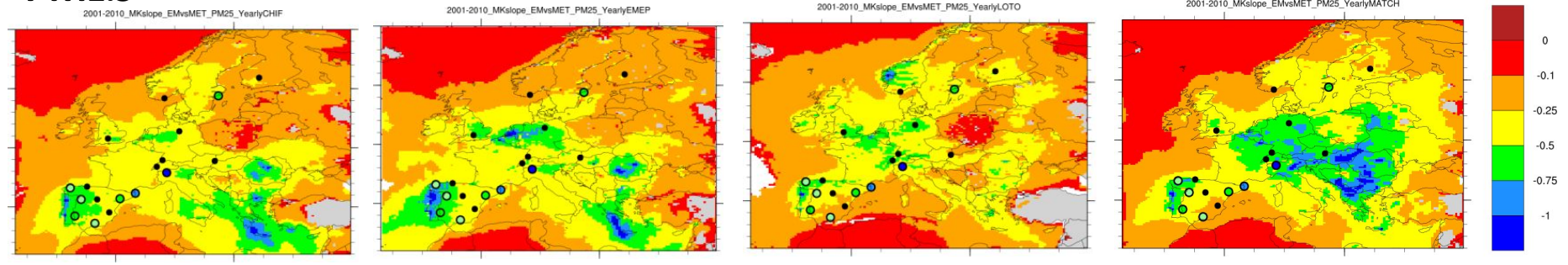
Relative effects on PM trends (2001-2010) due to emission changes and meteorological variability

Sen (Tier3A-Tier3B) / STD(Tier3B)

PM10



PM2.5



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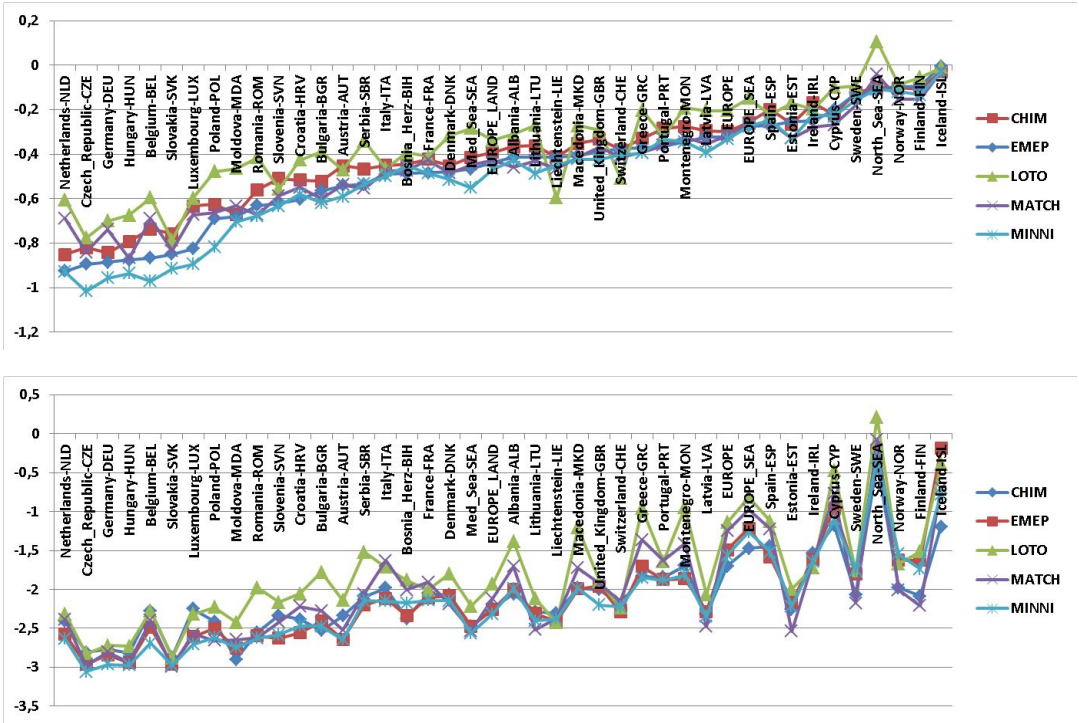
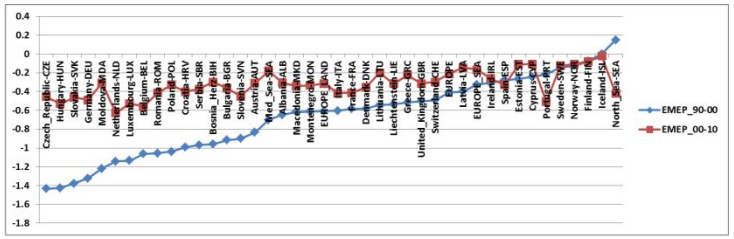
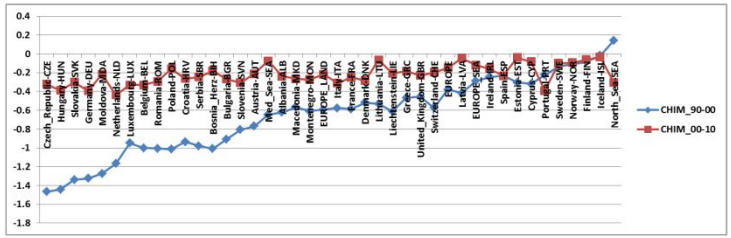
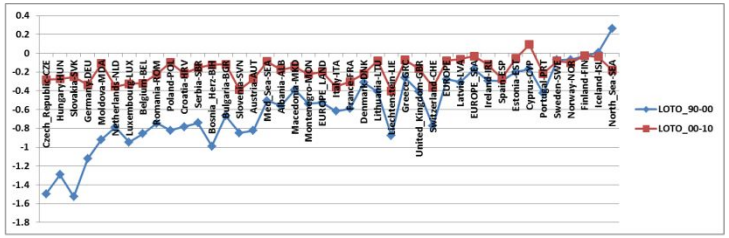
PM_{10} trend slope for 1990-2010

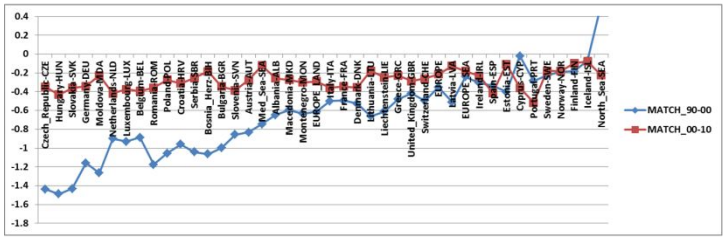
absolute (µg m3 yr-1) and relative to 1990 (perc m-3 yr-1)

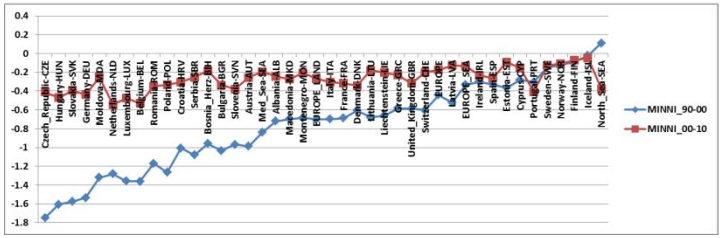












PM_{10} trend slopes for 1990-2000 and 2000-2010

(µg m-3 yr-1)

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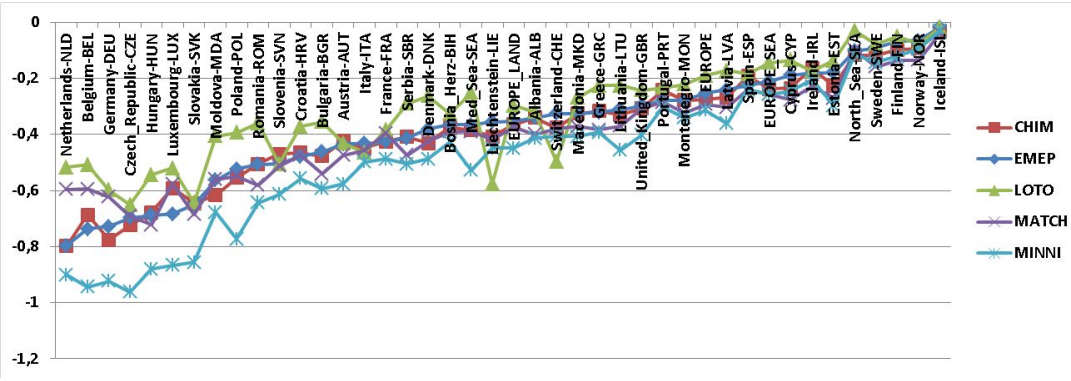
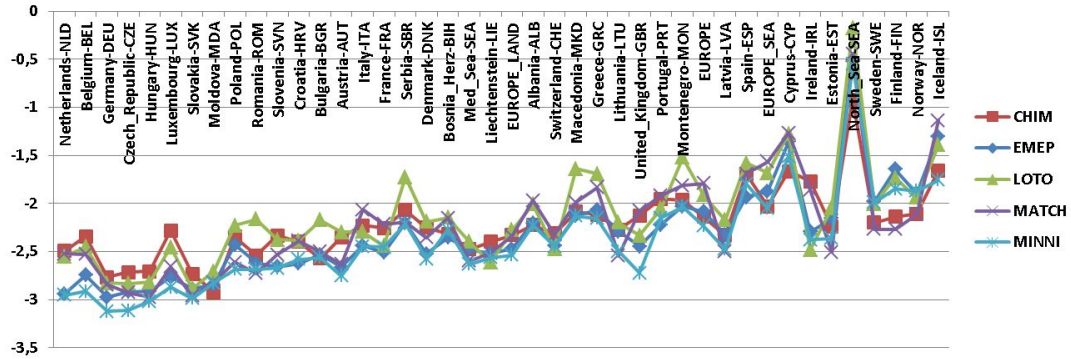
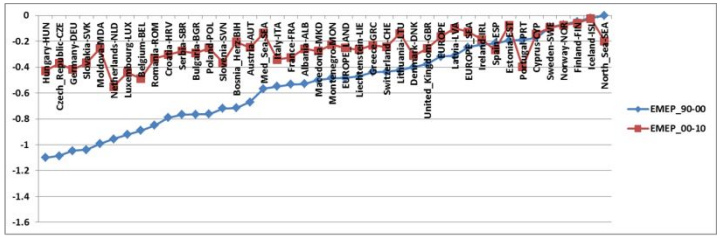
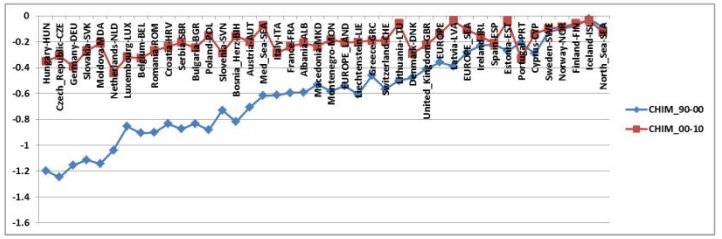
$PM_{2.5}$ trend slope for 1990-2010

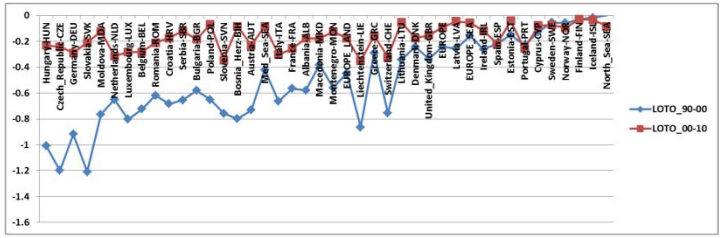
absolute (µg m3 yr-1) and relative to 1990 (perc m-3 yr-1)

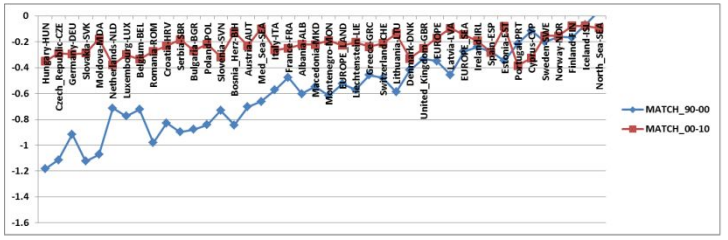


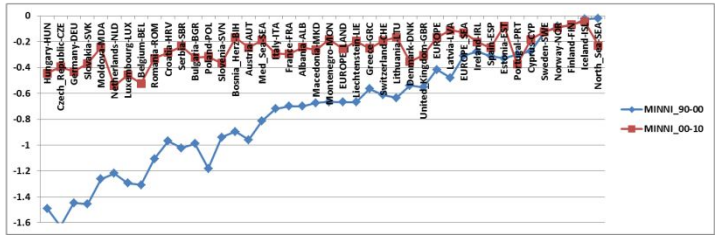












PM_{10} trend slopes for 1990-2000 and 2000-2010

(µg m-3 yr-1)

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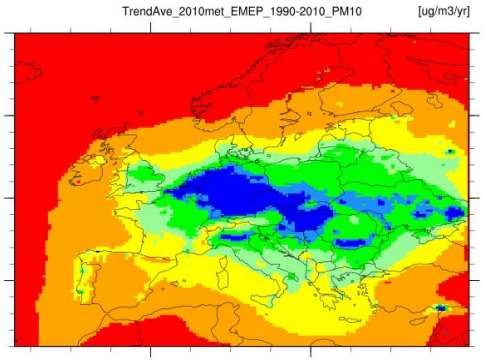
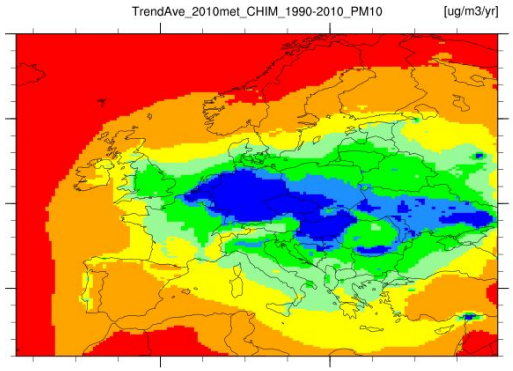
PM10 change (µg m-3 yr-1) from diffs 1990-2010 (2010 meteorological conditions)

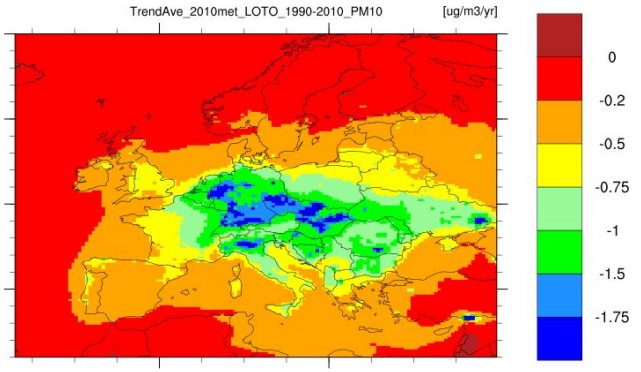
EMEP



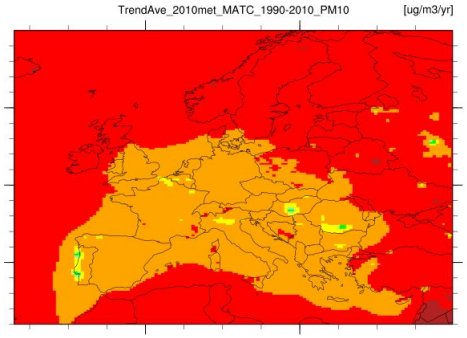
CHIM



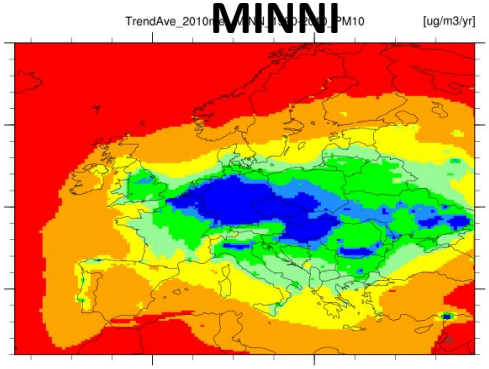
LOTO



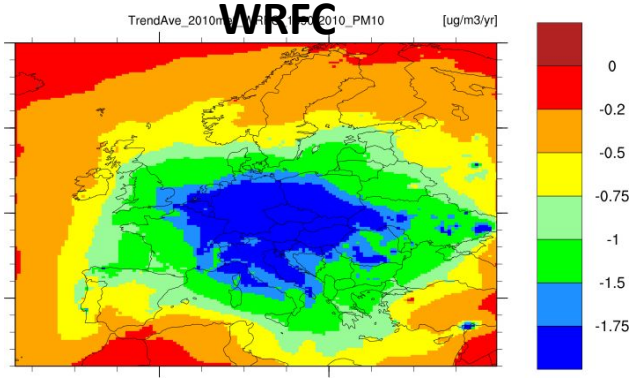
MATCH



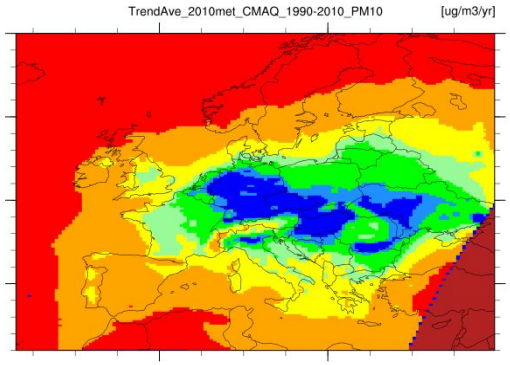
MINNI



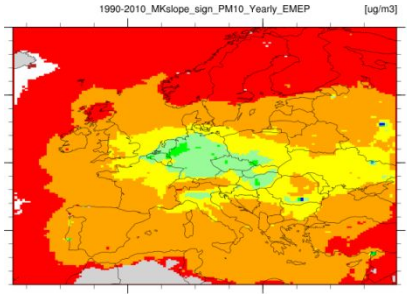
WRFC



CMAQB



For comparison: PM10 trend from EMEP 1990-2010



Good overall correspondence between the models;
PM changes per year derived from 1990-2010 differences are larger compared to average trends

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SUMMARY

- On average, the models underestimate PM10 by 14%, PM2.5 by 11% (+/- 5-10% variation)
- The model results are quite consistent in terms of mean trends over Europe, though some differences exist
- Compared to observations, the models calculate significant PM10 and PM2.5 trends in 2001-2010 for more regions/sites, but the modelled trends are on average smaller: MOD -0.31 and -0.28; OBS= -0.42 and 0.41 $\mu g\ m^{-3}\ yr^{-1}$
- Somewhat larger differences between model calculated trends for individual PM components (PM composition change)
- PM trends are largest in summer and smallest in winter - observations and models agree
- Significant reduction of emission reduction effect on PM trends due to interannual meteorological variability
- PM trends vary in EMEP countries and source regions (largest C. Europe, smaller S/E and N. Europe)
- Differences based on model results for 1990, 2000 and 2010 are applied to estimate PM level changes (calculations with constant meteorology)

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Děkuji za pozornost
Děkuji všem za vaši pozornost

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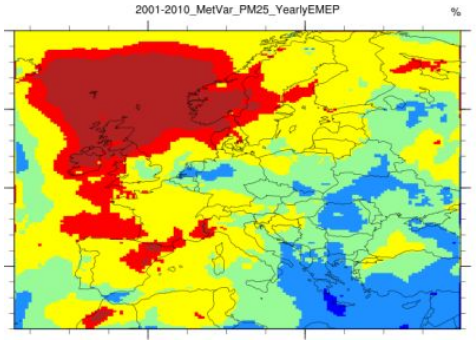
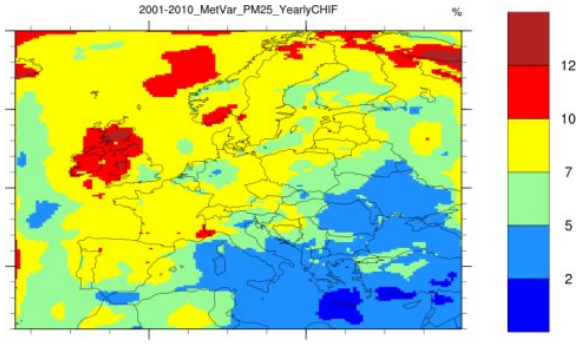
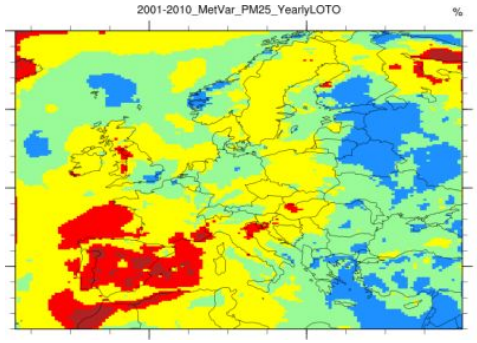
Relative annual variability of PM2.5 (STD/Mean) due to meteorological variability

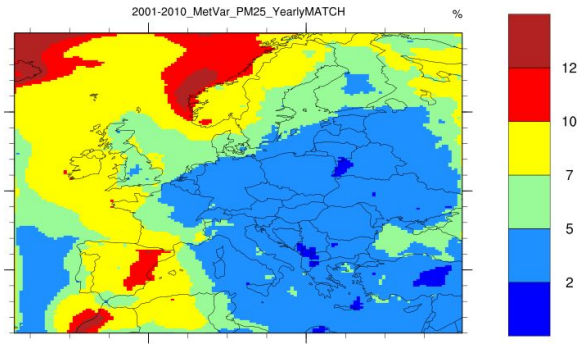
PM10





PM2.5





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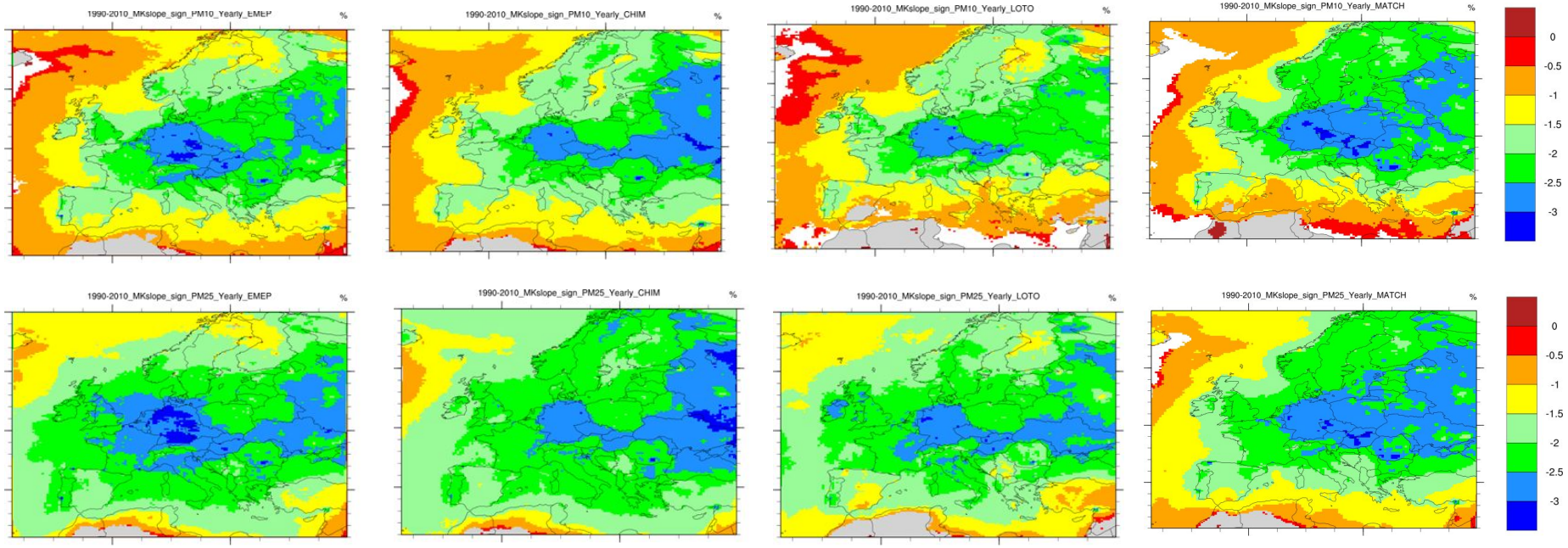
Mean PM trends (in % per year) relative to the PM level in 1990

EMEP

CHIM

LOTO

MATCH



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