Assessment of the reported EMEP EC/BC emissions using EMEP WSC-W modelling and EC/eBC observations

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*The **revision of the Gothenburg Protocol** is expected to further strengthen efforts to reduce air pollution in Europe and North America..*
*.. will include, among others: …..**how to deliver further reductions of black carbon emissions**;*

EMEP TFMM, Potsdam 5-6 May 2025

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The scope of this assessment

EC/BC emissions have been submitted to EMEP since 2015. EC fractions of PM have been operationally used for EC assessments/SR in EMEP reports

To get a better insight into emissions' quality/consistency, we

- Compared different EC emission data sets
  - EMEP reported EC/BC (EMEP-EC)
  - EMEP model 'standard' (EMEP-Standard)
  - CAMS-TNO for 2022 (CAMS-REG v7.0 REF 2.2.1) - CAMS
- Run the EMEP model with the different emission data sets, for:
  - Year 2022
  - December 2017 - February 2018 IMP (EMEP/ACTRIS)
  - Long term 2015-2022 (only EMEP) - preliminary
- Compare to observations of EC and eBC, as well as source apportionment data of eBC (solid and liquid => residential and non-residential)

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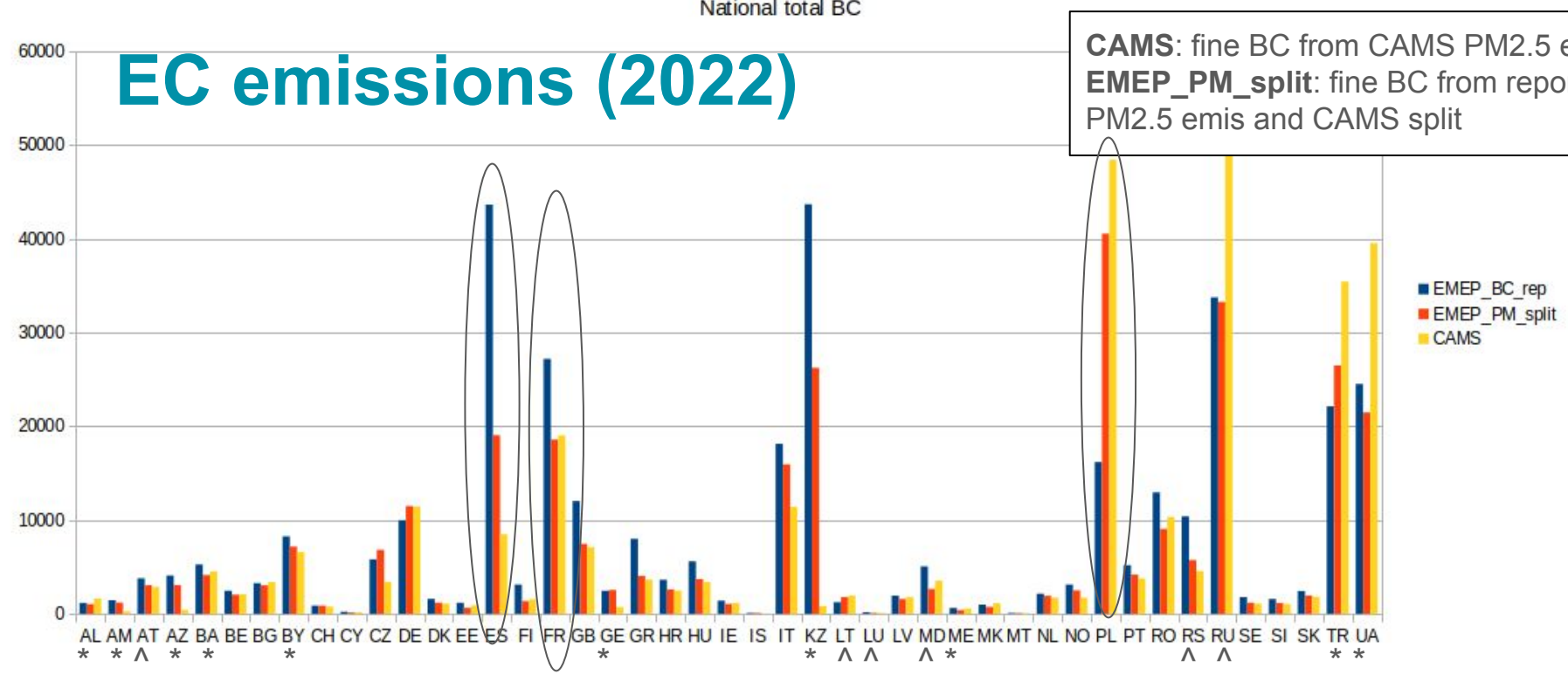
EC emissions (2022)

CAMS: fine BC from CAMS PM2.5 emis
EMEP_PM_split: fine BC from reported PM2.5 emis and CAMS split



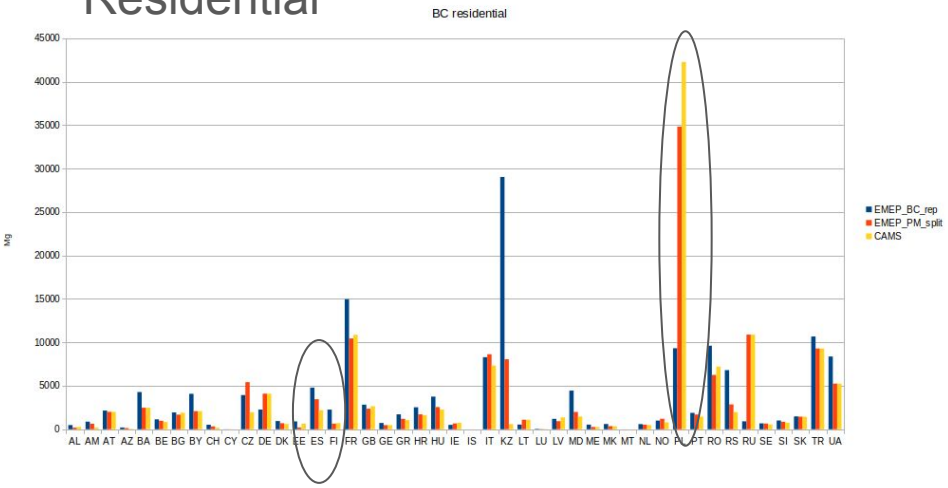
EMEP_BC_rep - tends to be higher (with exceptions), but large variability. NOTE:

BC reported by countries - unclear if it's in PM2.5 (most likely) or PM10 size fraction

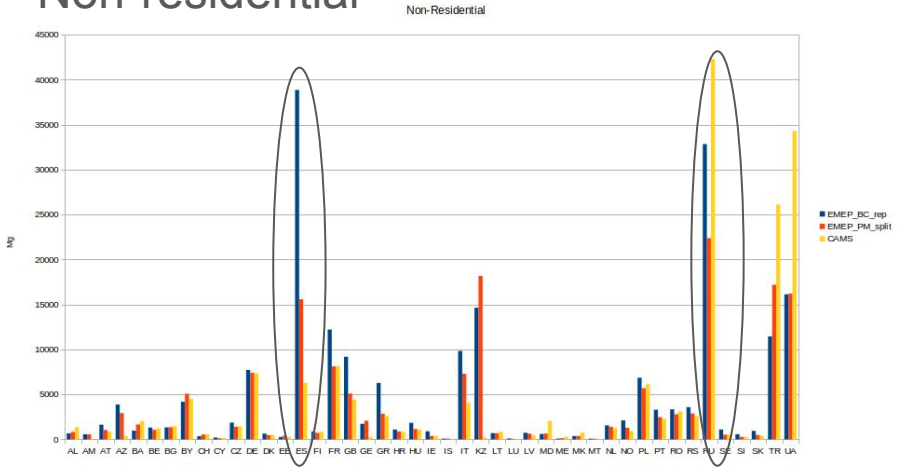
^ Gap-filled based on reported PM2.5 emissions and PM2.5 ratio from GAINS GP review,

* Gap-filled with data from GAINS GP review - EC in PM10

Residential

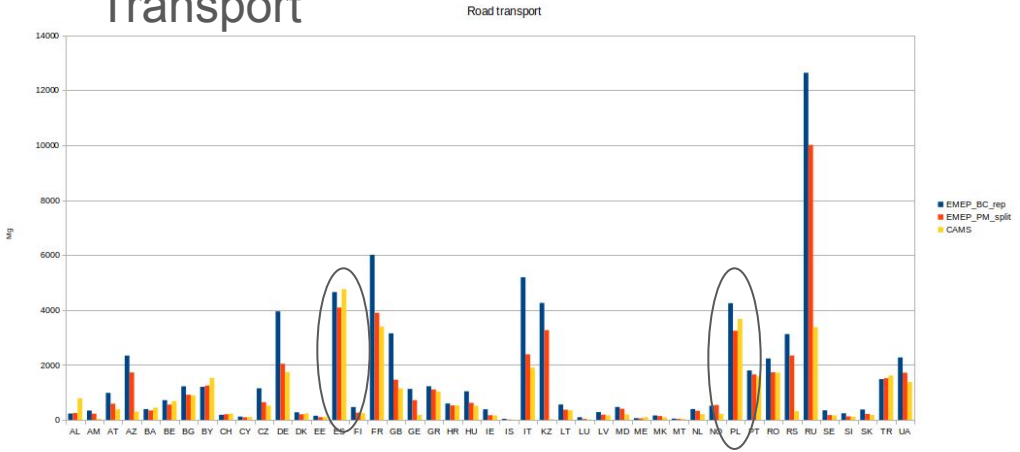


Non-residential



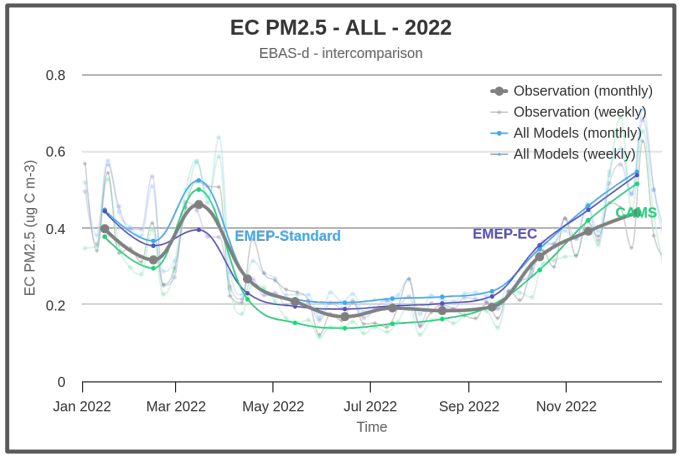
EC emissions per sector (2022)

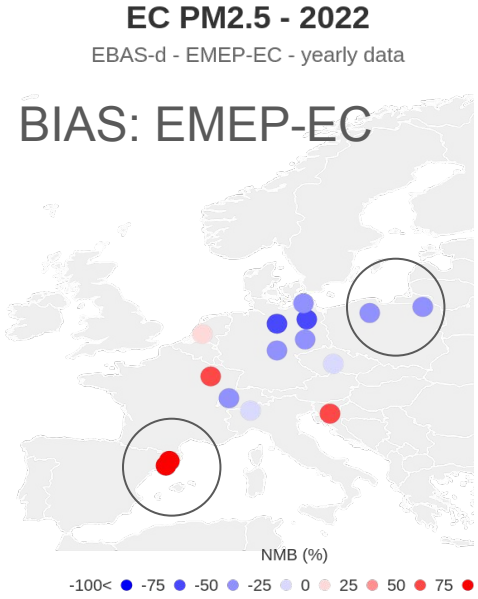
Transport

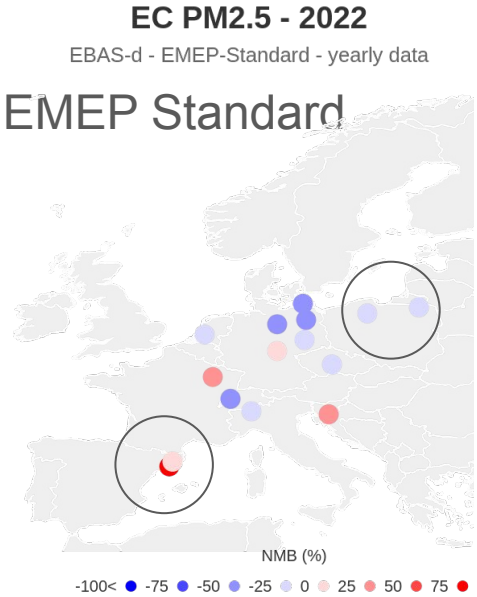


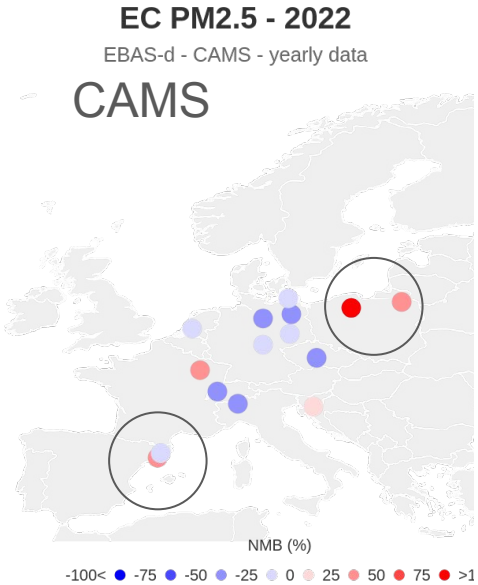
EC in $PM_{2.5}$ (2022)

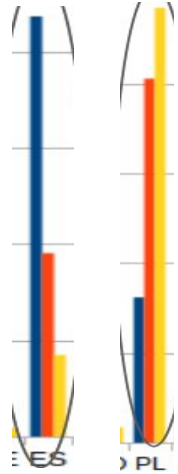
N=18	EMEP-EC	EMEP-Standard	CAMS
Bias (%)	5.9	14	-4.5
R^2 spatial	0.75	0.76	0.81











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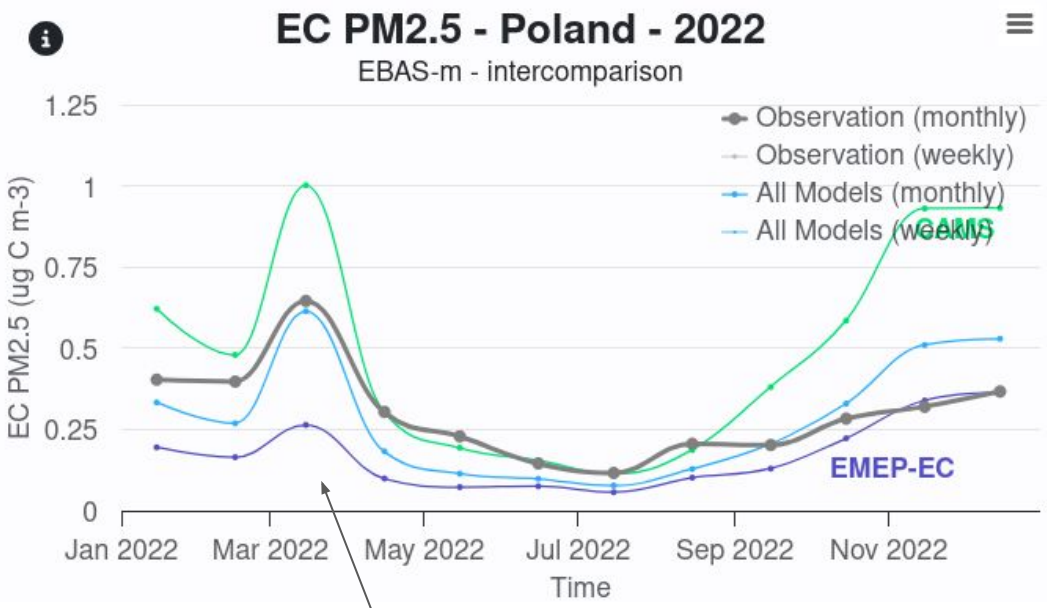
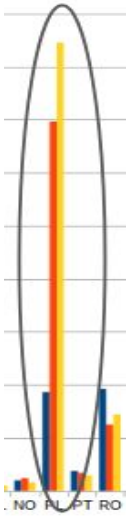
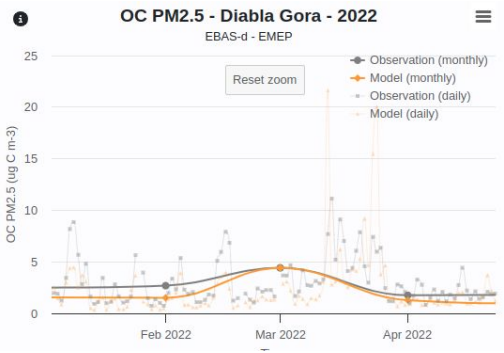
Larger difference at individual sites



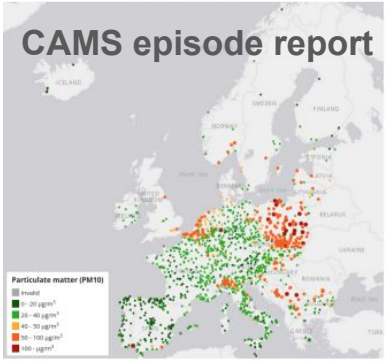
Can be explained by much smaller reported BC emissions from Residential heating



EMEP report



March 22



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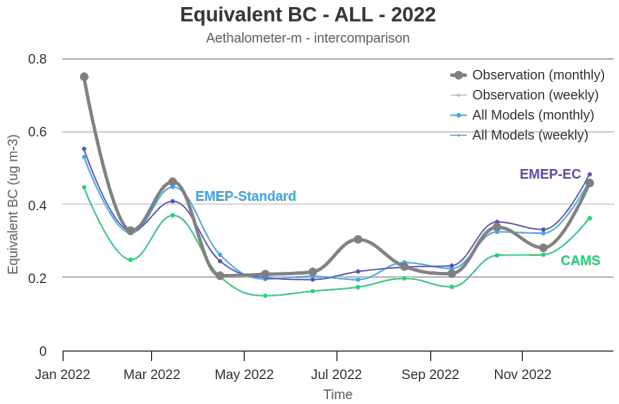
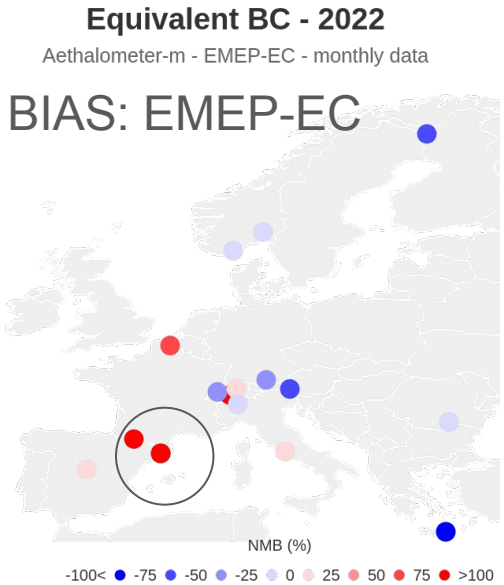
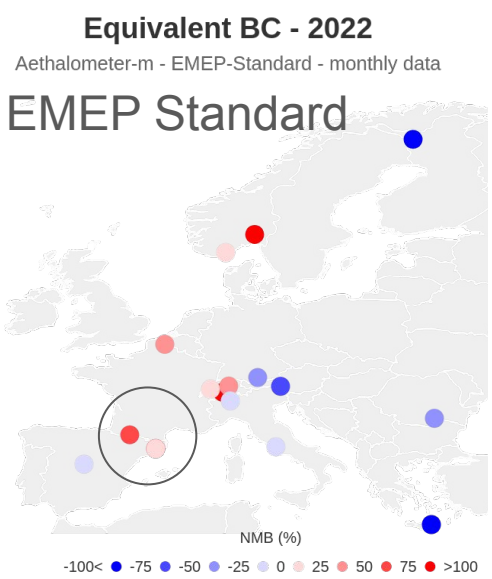
eBC (2022)

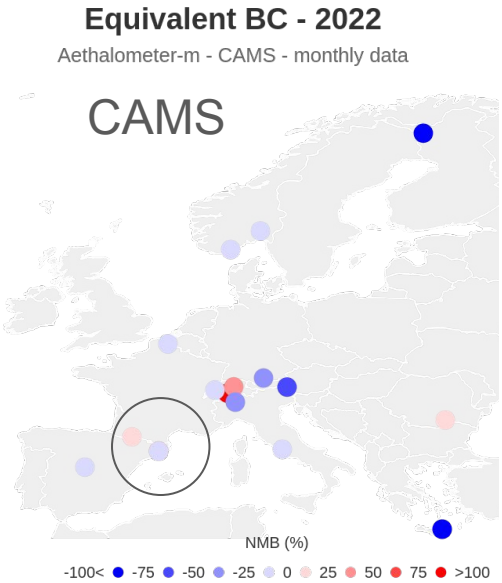
Thanks to Stephen Platt/CCC for eBC

N = 15	EMEP-EC*	EMEP-Standard**	CAMS**
Bias (%)	-7	-6.7	-25.9
R^2 spatial	0.69	0.66	0.73









*) EC ? (from emissions)

**) EC fine+EC coar

eBC - mixture of size cutoffs (PM1, PM2.5, PM10 and unknowns)

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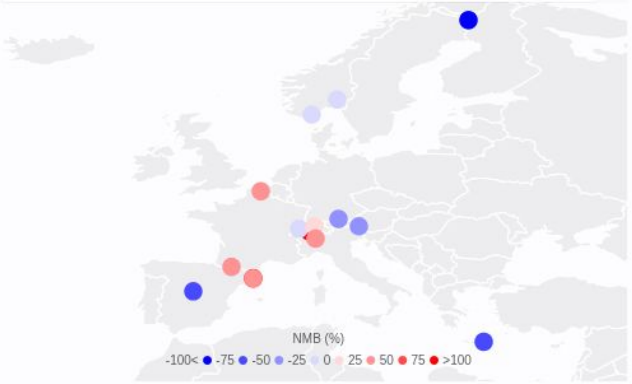
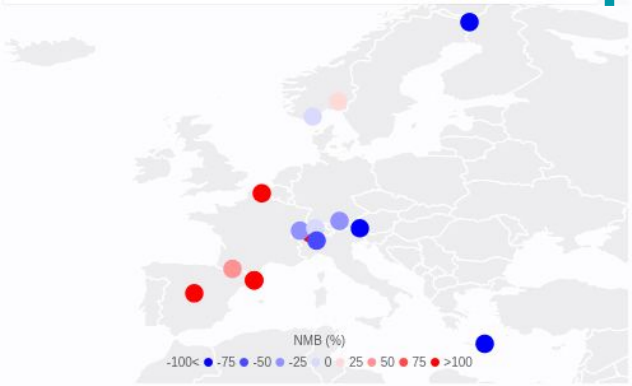
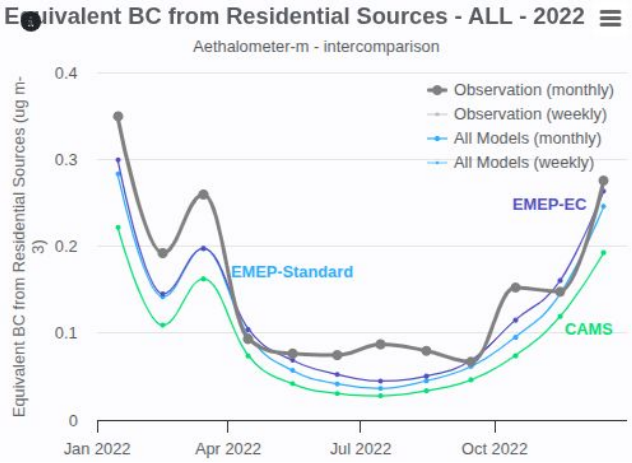
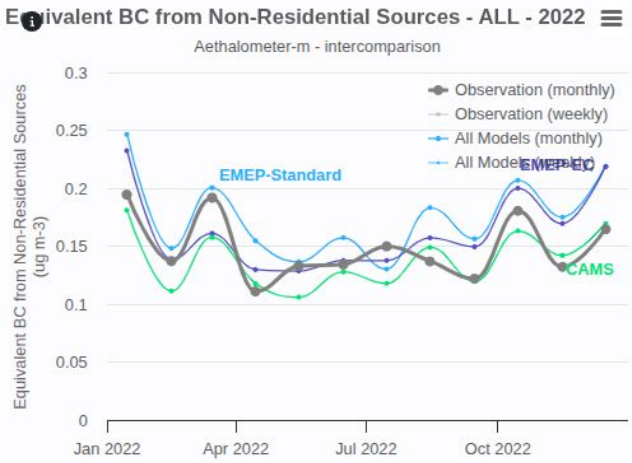
Modelled EC vs eBC:
residential -> solid fuel non-residential -> liquid

Bias









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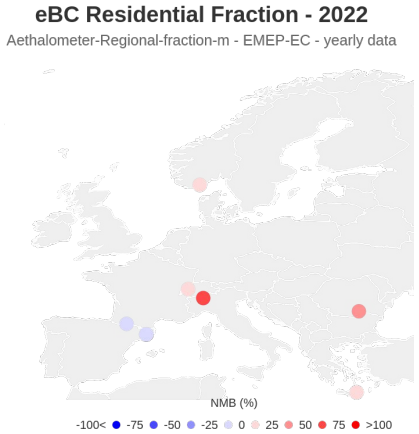
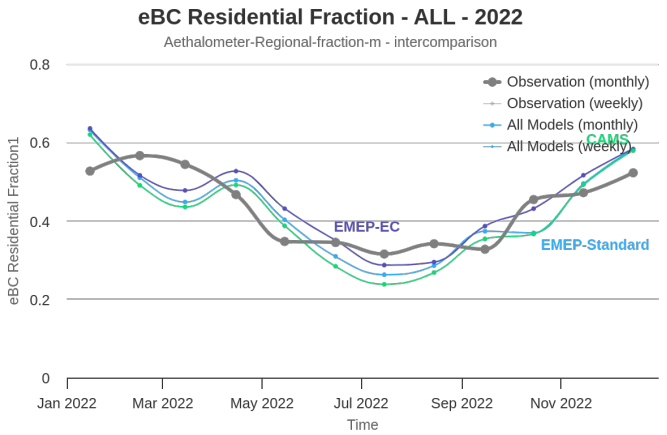
EC Residential fraction: EMEP EC emissions vs eBC

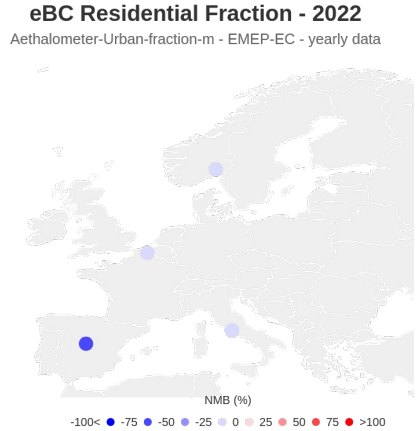
Bias

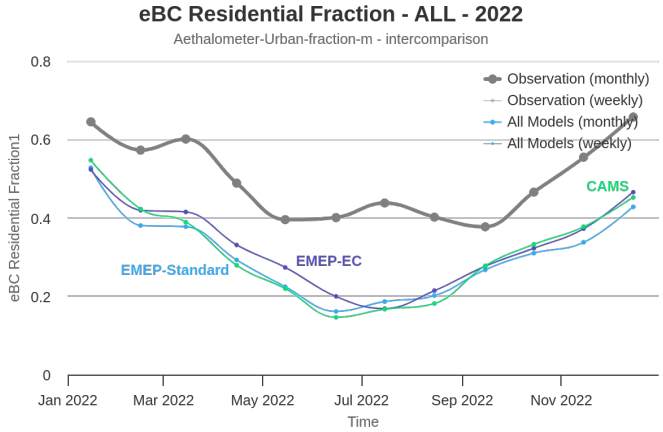
Regional





Urban





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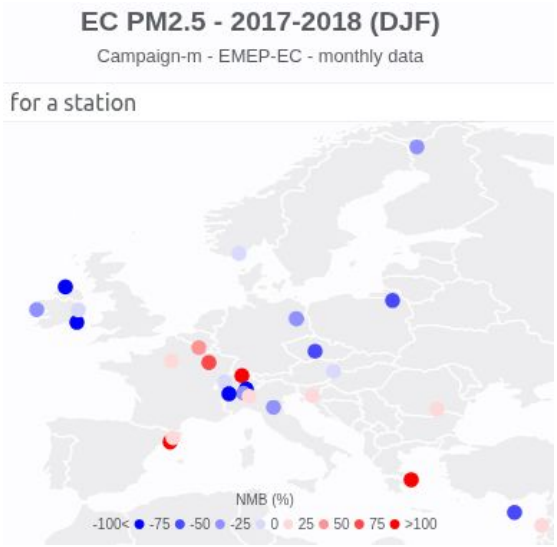
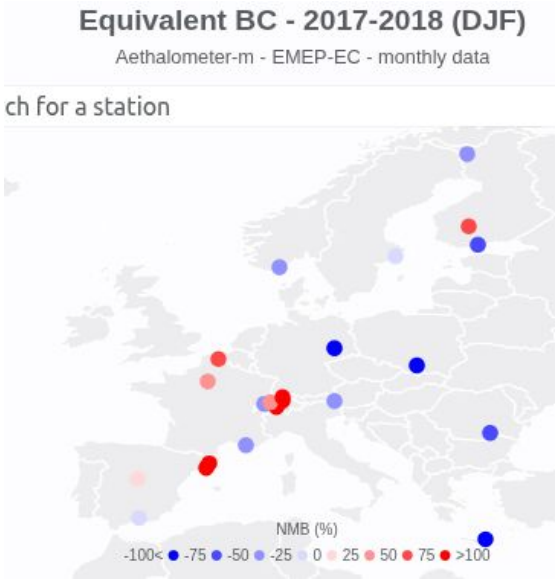
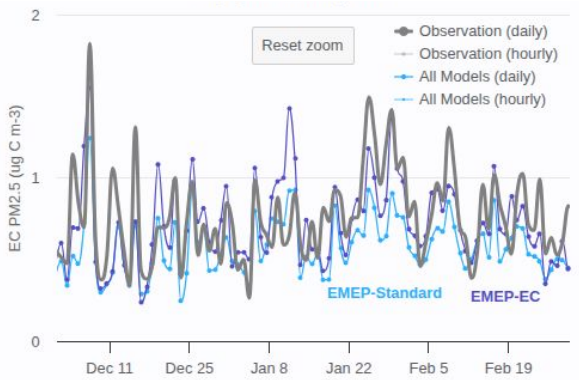
EC2.5 and eBC Dec 2017- Feb 2018 IMP

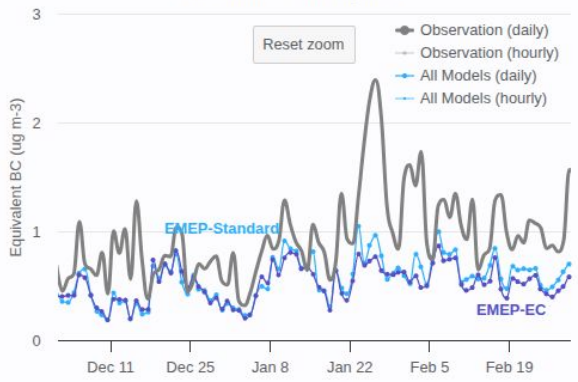
EC and eBC appear to stronger underestimate obs, but the data set is different from from 2022 (more C/E European sites)

Some difference btw EMEP-EC and EMEP_Std

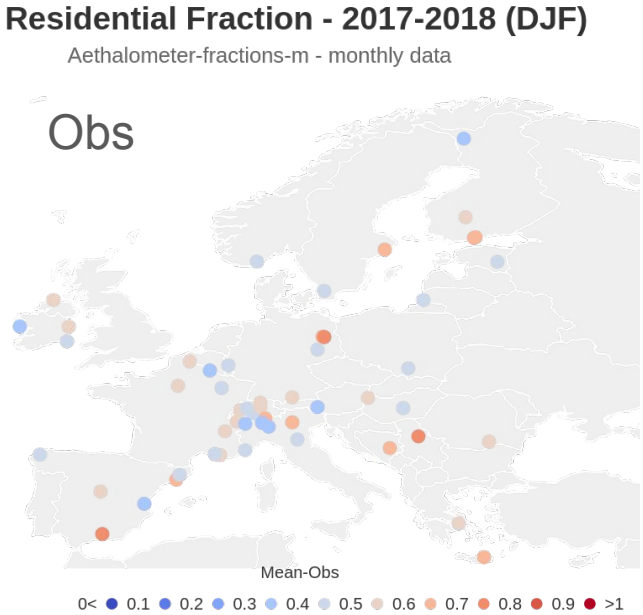


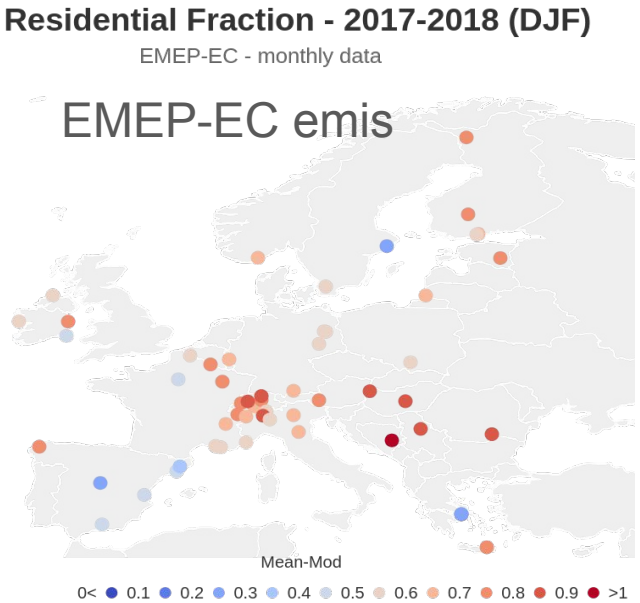




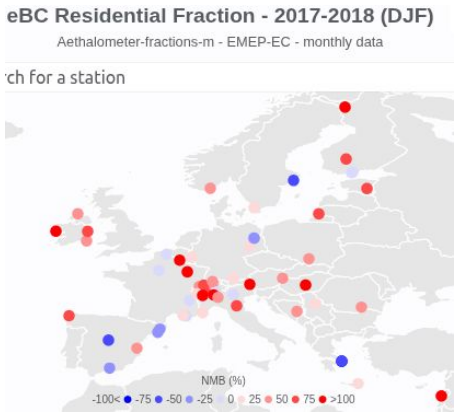


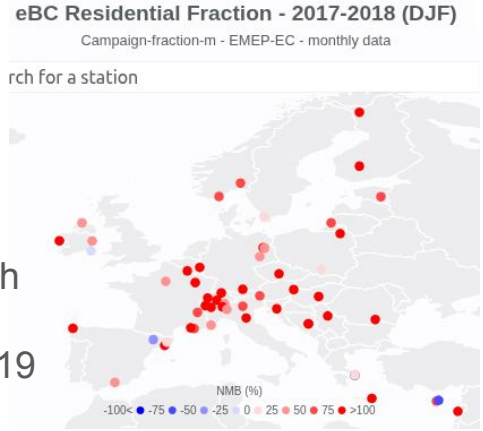
‘Residential fraction’ of EC, 2017/2018 winter





Bias

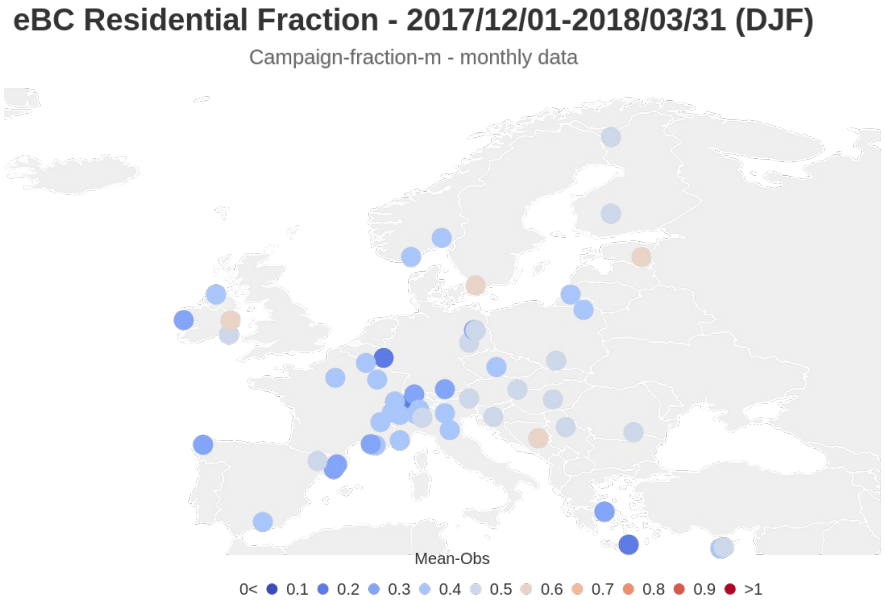




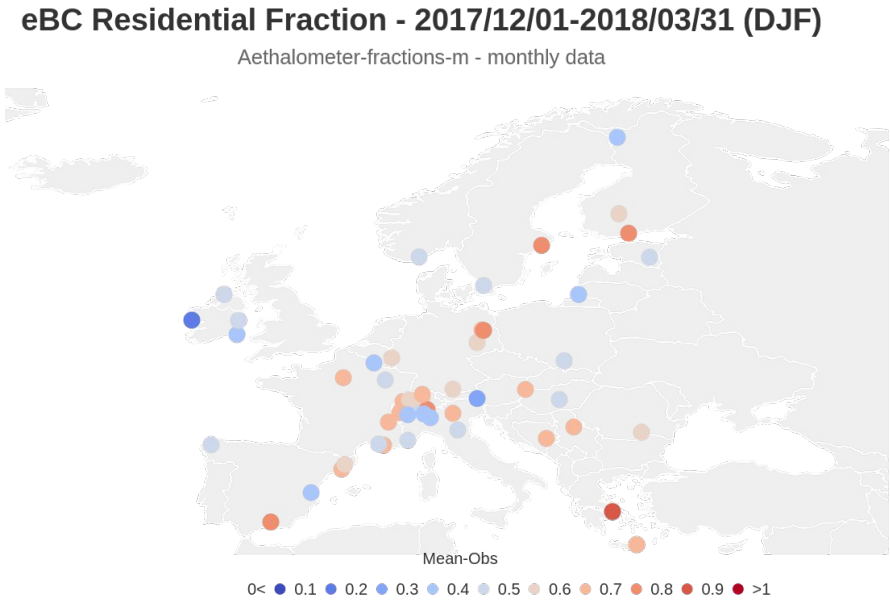
Systematically higher residential heating fraction from EMEP w/EC emissions, somewhat smaller overestimation by EMEP-Standard

Compared with dataset from EMEP Rep2019

eBC residential fractions from ‘old’ PMF method and ‘new‘ aethalometer method



Old data (from 2019)



Latest data

Systematically different results

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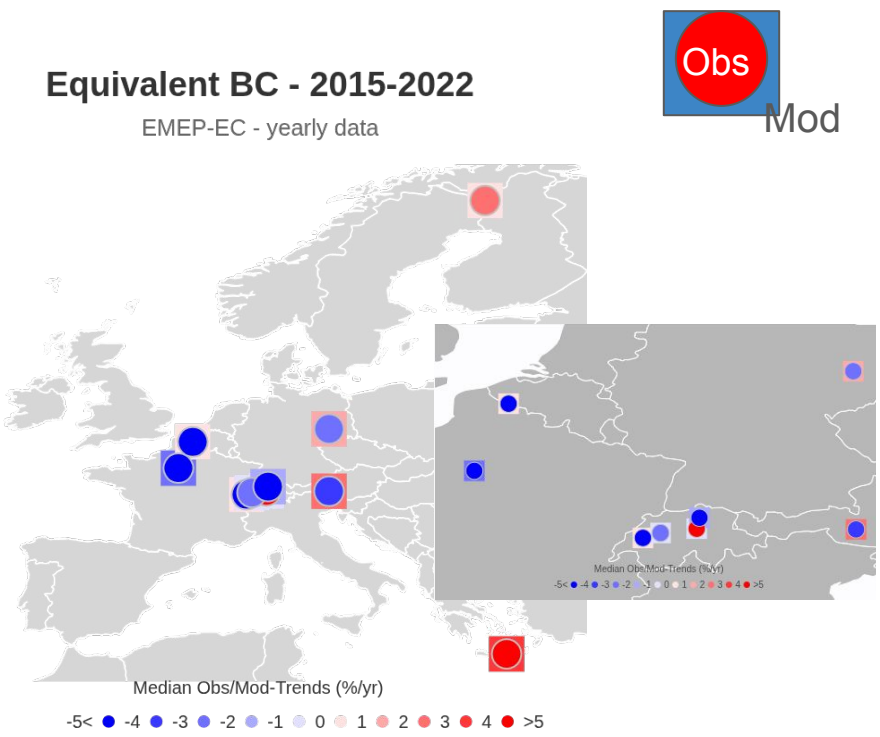
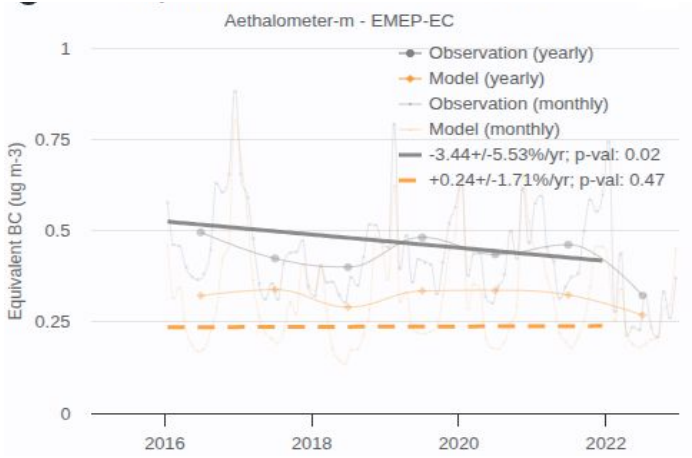
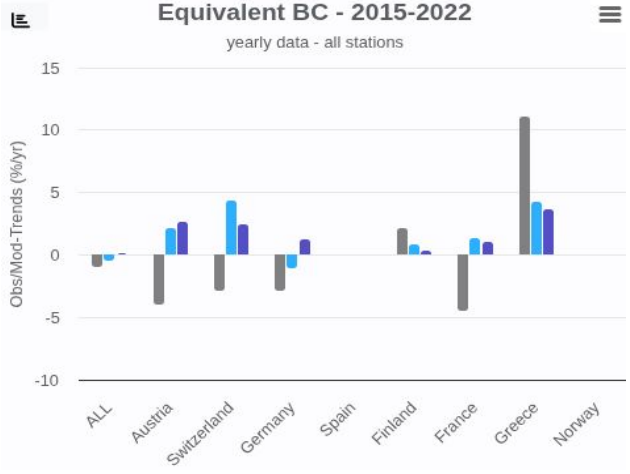
Multi-year results (“Trends”) for EC vs eBC







Obs: -3.44 %/yr - significant

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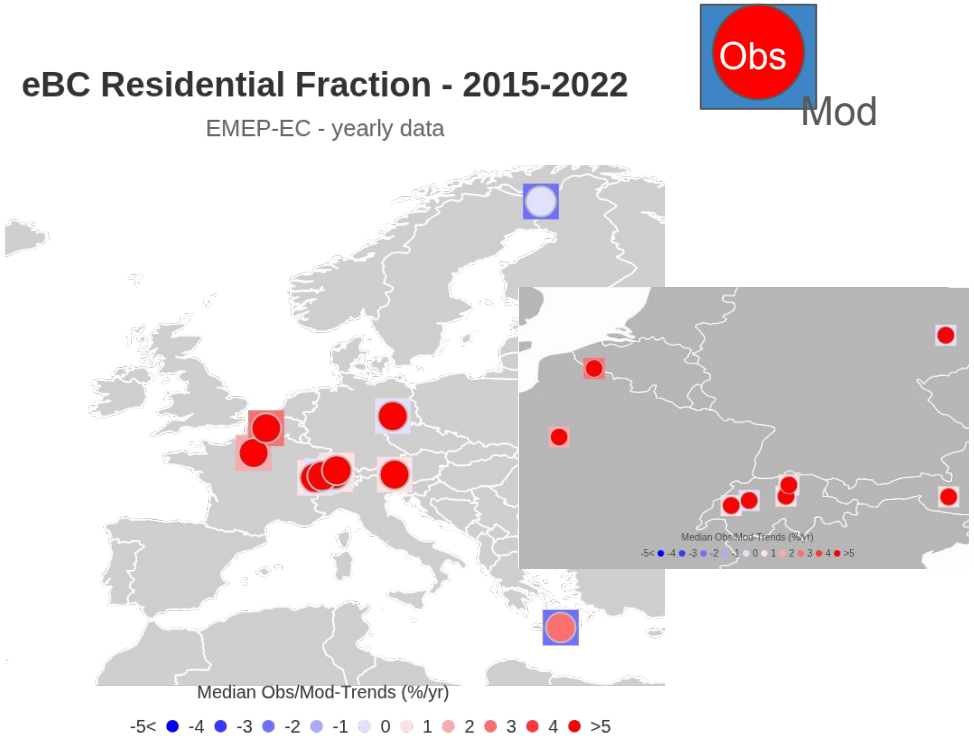
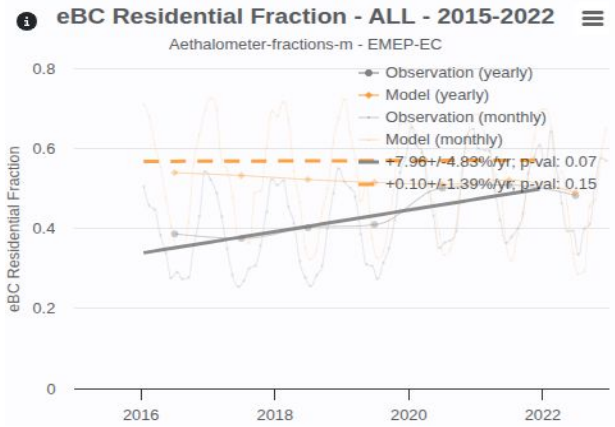
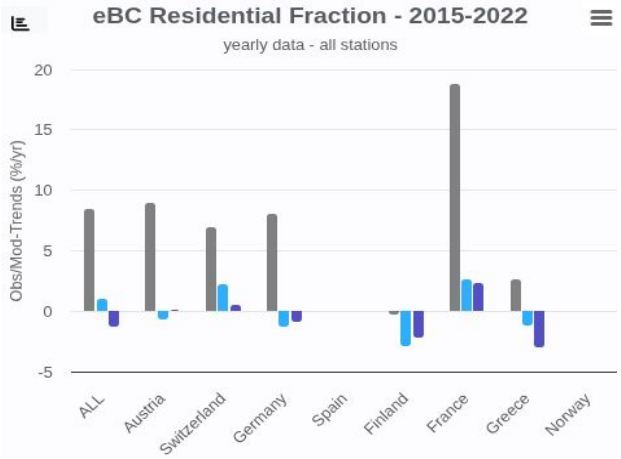
Multi-year results (“Trends”) for residential fraction of EC vs eBC



Obs: +8 %/yr - significant





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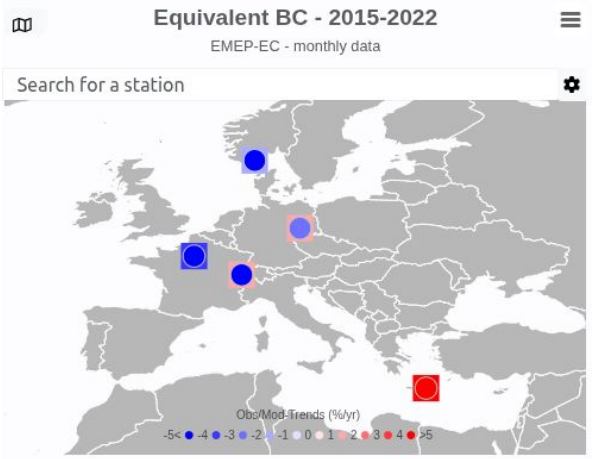
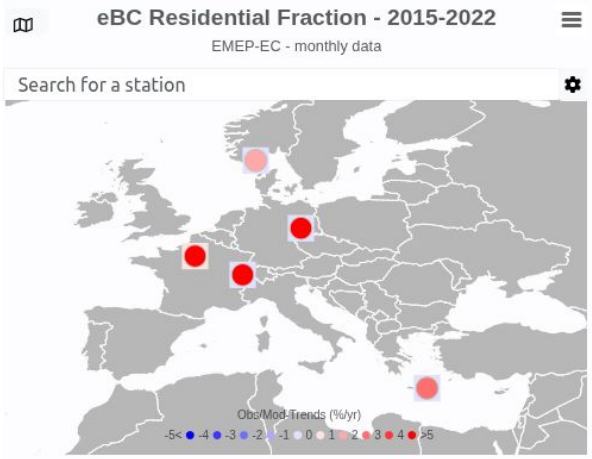
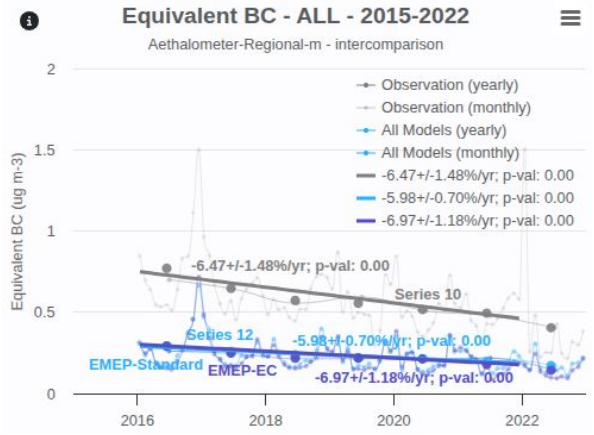
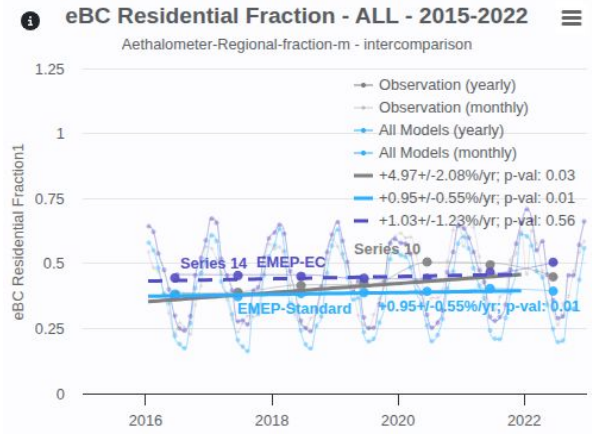
“Trends” for modelled EC vs eBC at regional sites









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Summary of our assessment of EC emissions

- **EC reported emissions**: large differences vs those derived from EMEP and CAMS PM2.5 emissions found for some countries and sectors
  - overall tends to be larger, but unclear wrt EC size ($PM_{2.5}$ or PM_{10}) - to be clarified!
- Comparison of **modelled EC with observations (EC and eBC)**
  - EMEP w/EC emissions - fairly good overall for 2022 (also Residential & non-Residential)
  - but also considerable deviations at individual sites/in some countries - a review of EC emissions could be recommended, e.g. Spain, Poland, France
- **Fractions** of residential/non-residential (solid/liquid) :
  - Fair agreement of residential EC fractions at regional sites, underestimation at urban (2022)
  - Observed Residential fractions tend to be higher than modelled in summer
  - Winter 2017-18 IPM - model underestimates observed EC and eBC and overestimates residential EC in C/E Europe
  - accuracy of eBC fractions aethalometer data??
- Observations indicate significant decreasing “trend” in eBC and increasing in relative contribution of residential eBC

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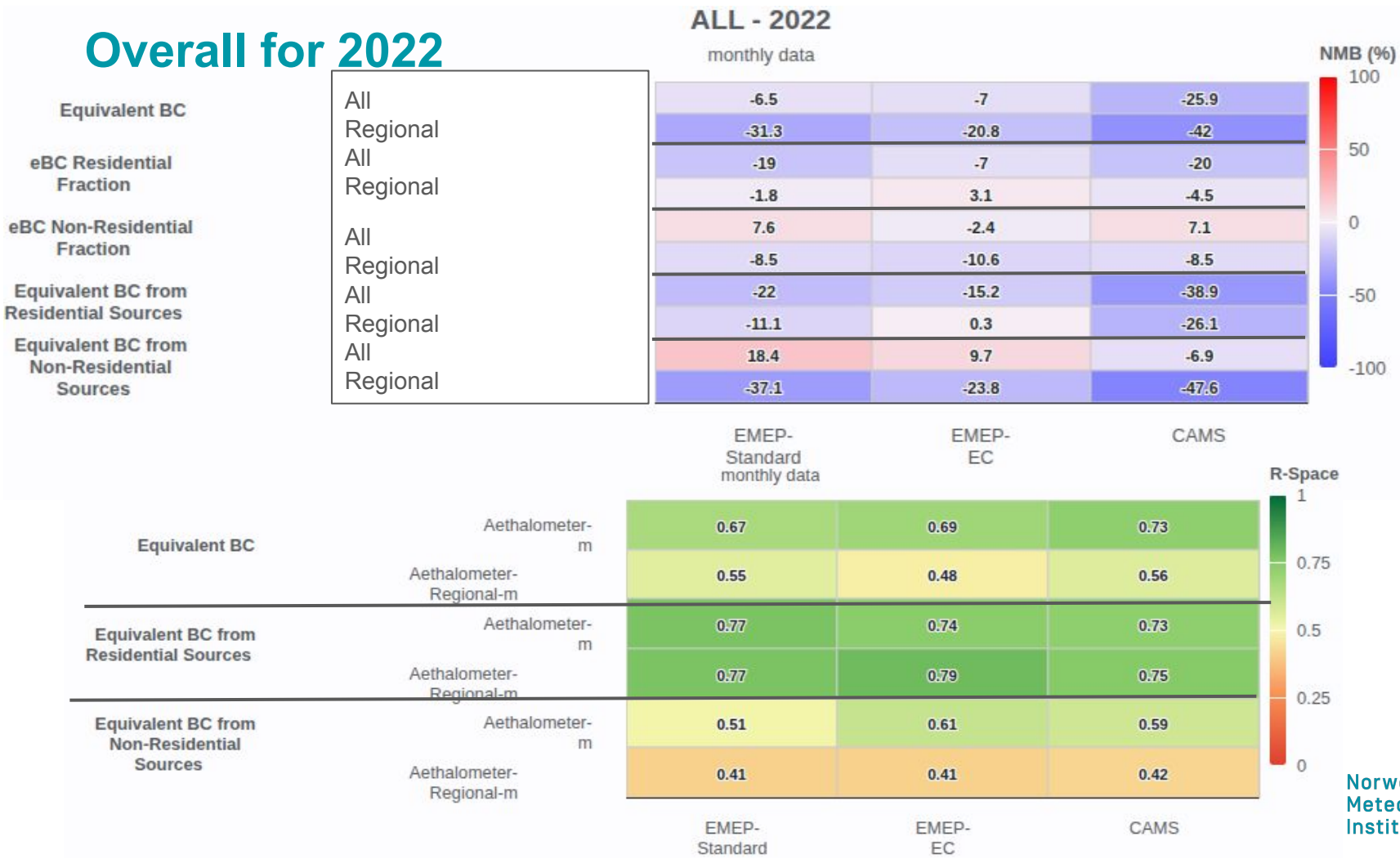
Overall for 2022



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Thank you for your attention!

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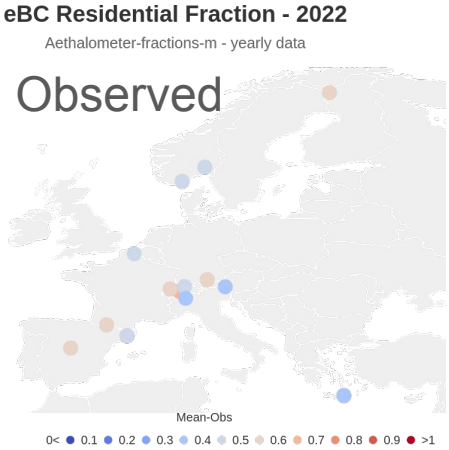
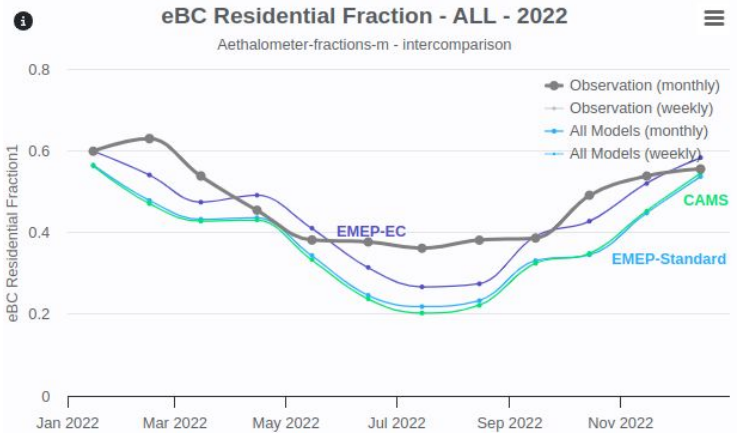
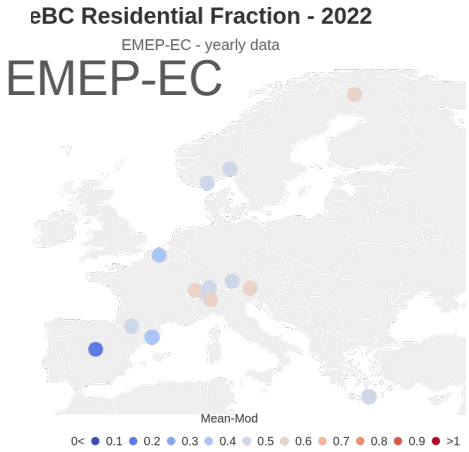
MAIN QUESTION: Are the reported EMEP EC emissions of high enough quality so that EC can be included in the revised Gothenburg Protocol?

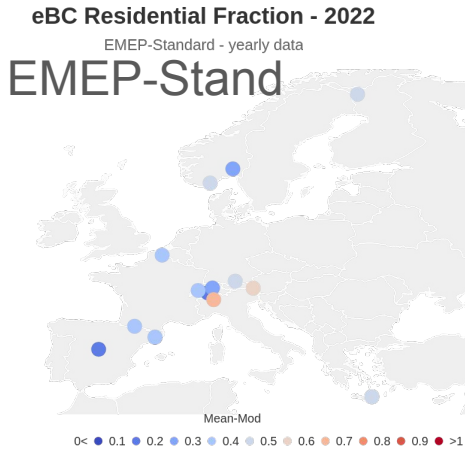
1. What do we know about the different emission inventories:
    a. Different totals, different share of sectors, different share of fine/coarse?
    b. Where do they come from (including gridding)?
2. Are the results qualitatively & quantitatively different with different emission inventories? (e.g. in reproducing ff/tot and bb/tot, or total conc etc)
3. Do we reproduce the ff/bb - what does that tell us about the emission sectors
4. Are different areas in Europe different?
5. Can we reproduce trends in (sectoral) emissions?
6. Are trends & other results different when compared to urban/rural sites and what does that tell us? (EC in cities comes mostly from traffic and EC in rural areas mostly from wood burning, I think)

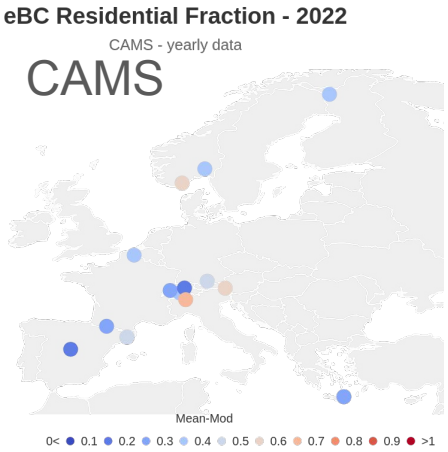
EC residential fraction vs eBC from solid fuel, 2022











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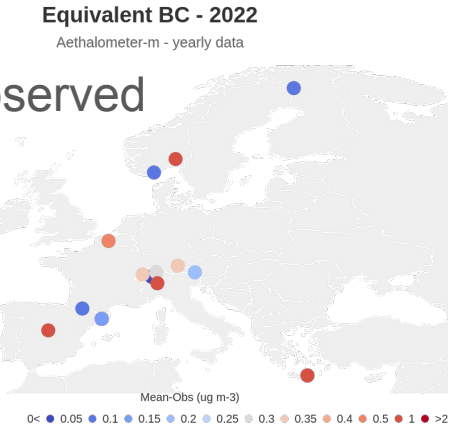
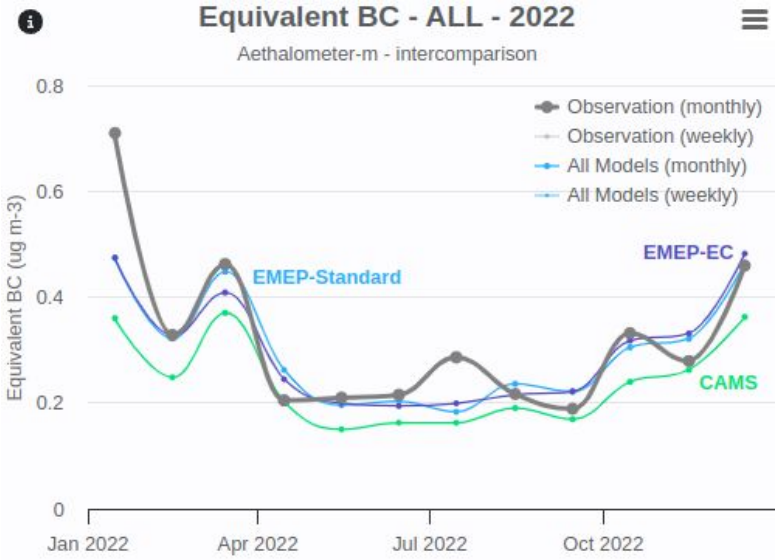
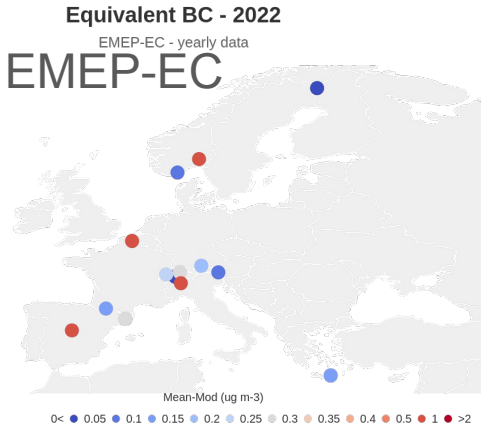
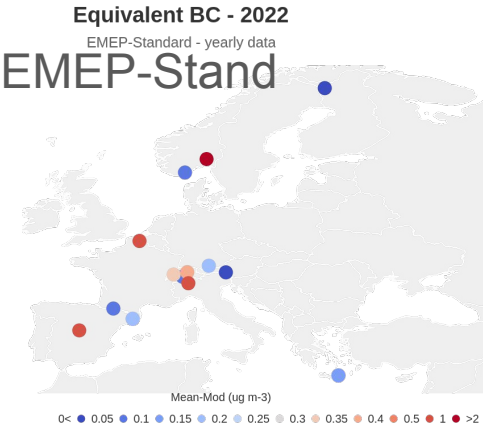
eBC, 2022


Equivalent BC - 2022
Aethalometer-m - yearly data
Observed
Mean-Obs (ug m-3)
0< 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.5 1 >2


Equivalent BC - ALL - 2022
Aethalometer-m - intercomparison
Observation (monthly)
Observation (weekly)
All Models (monthly)
All Models (weekly)
Equivalent BC (ug m-3)
0.8
0.6
0.4
0.2
0
EMEP-Standard
EMEP-EC
CAMS
Jan 2022
Apr 2022
Jul 2022
Oct 2022


Equivalent BC - 2022
EMEP-EC - yearly data
EMEP-EC
Mean-Mod (ug m-3)
0< 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.5 1 >2


Equivalent BC - 2022
EMEP-Standard - yearly data
EMEP-Stand
Mean-Mod (ug m-3)
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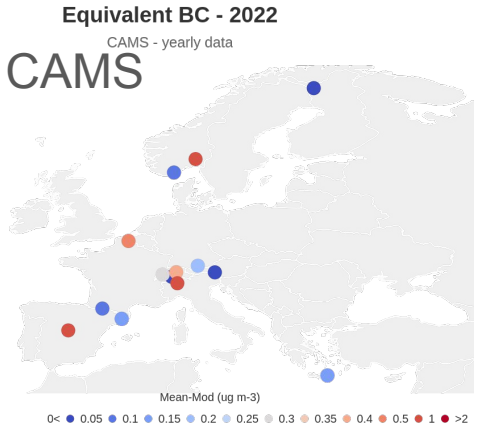
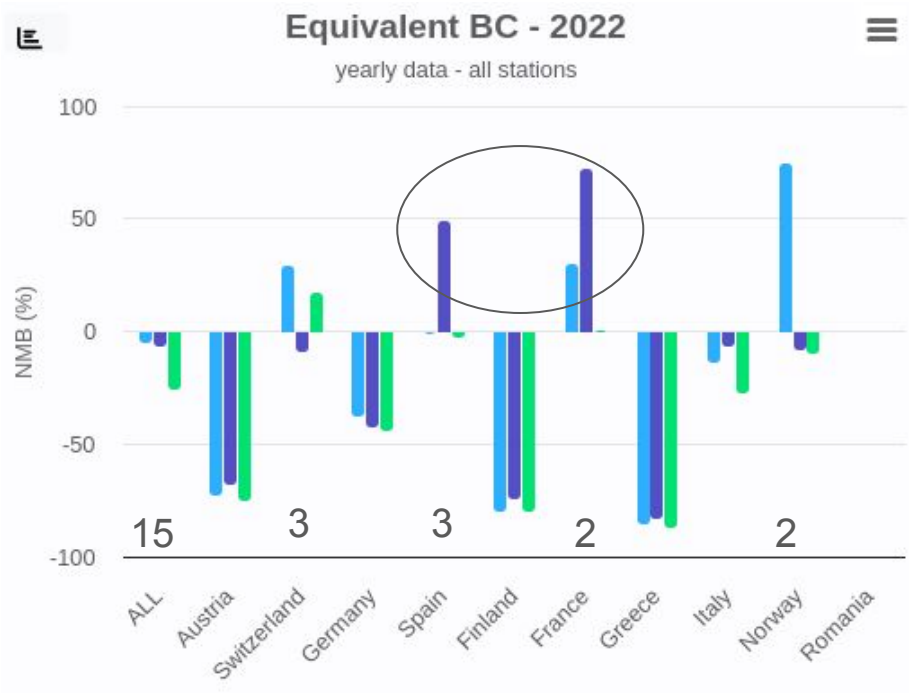
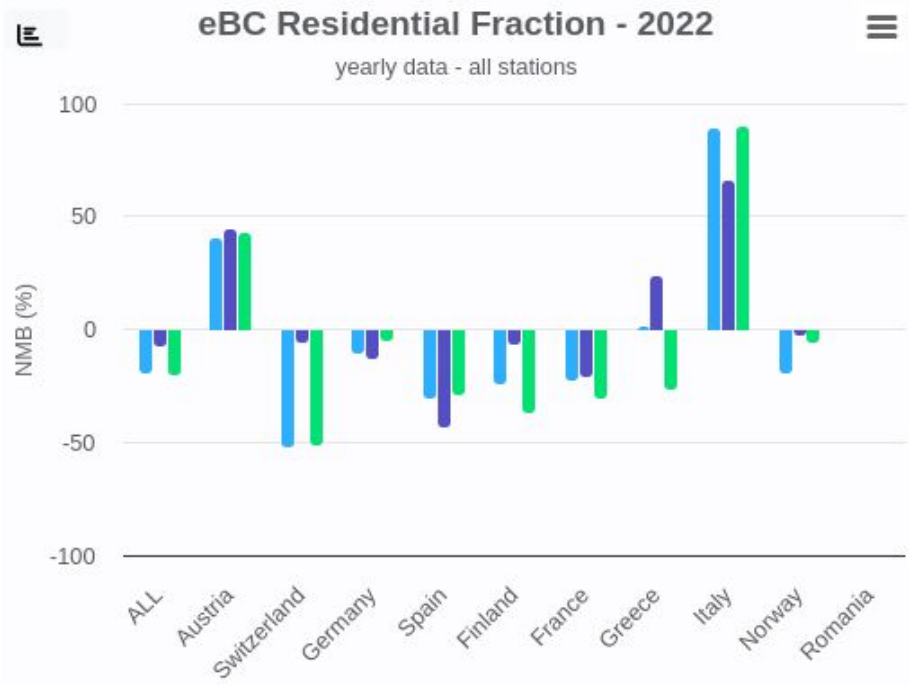

Equivalent BC - 2022
CAMS - yearly data
CAMS
Mean-Mod (ug m-3)
0< 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.5 1 >2

Modelled EC vs eBC, 2022 - per country





EMEP-Standard EMEP-EC CAMS

Rather large variation

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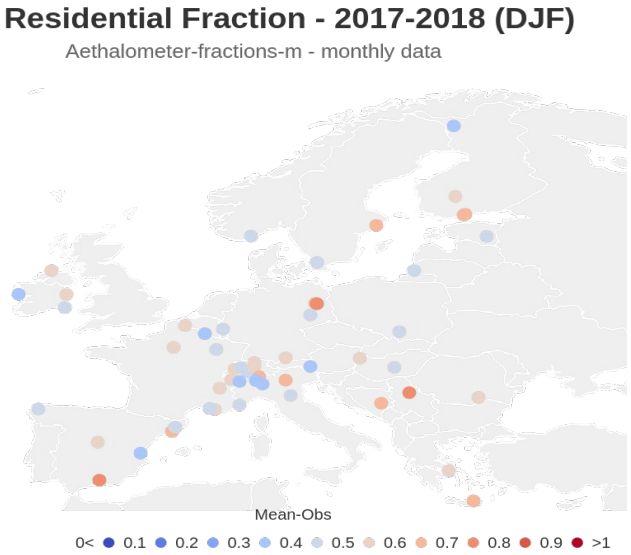
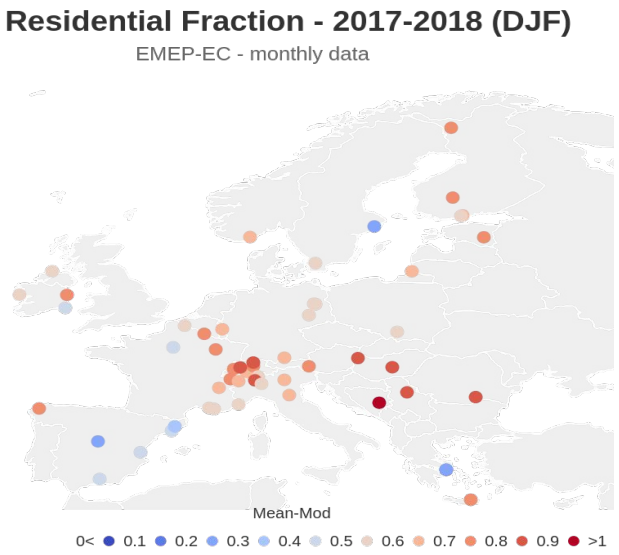
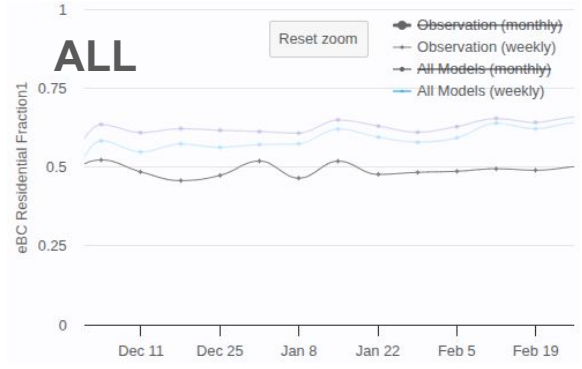
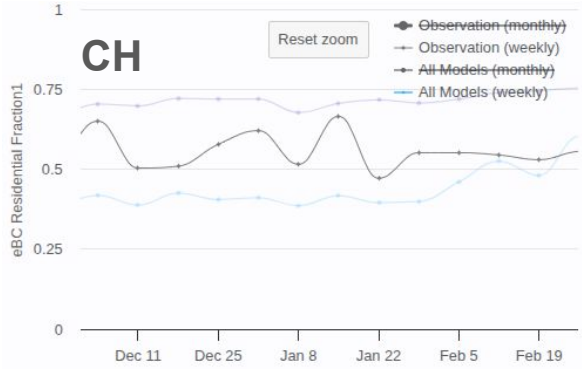
‘Residential fraction’ of EC, 2017/2018 winter









Systematically higher residential heating fraction from EMEP w/EC emissions, somewhat less overestimation by EMEP-Standard

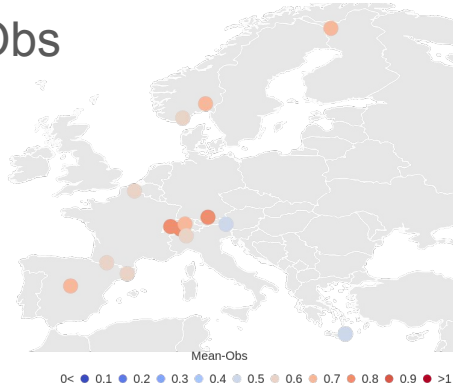
Norwegian Meteorological Institute

‘Residential fraction’ of EC, 2022 winter

eBC Residential Fraction - 2022 (DJF)

Aethalometer-fractions-m - monthly data

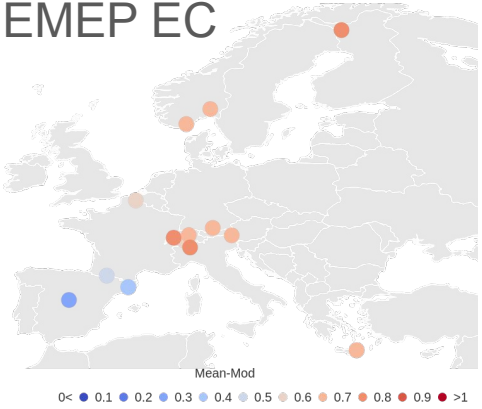
Obs



eBC Residential Fraction - 2022 (DJF)

EMEP-EC - monthly data

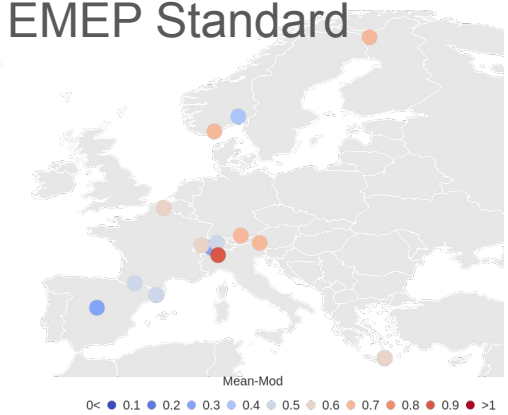
EMEP EC



eBC Residential Fraction - 2022 (DJF)

EMEP-Standard - monthly data

EMEP Standard



eBC Residential Fraction - 2022 (DJF)

CAMS - monthly data

CAMS