Aarhus University
Department of Environmental Science

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HIGH RESOLUTION MODELLING OF ELEMENTAL CARBON FOR DENMARK

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Outline

- **Background/Motivation**
  - **Why EC?**
- **Methods**
  - **Measurements**
  - **Modelling set-up**
    - **Emissions**
- **Results**
  - **Timeseries / Scatter / time variation**
  - **4 stations**
- **Conclusions**

Harmonised concepts
Common tools:

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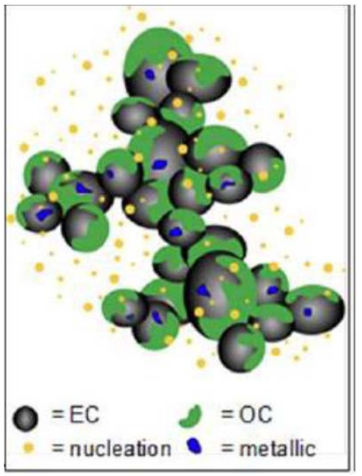
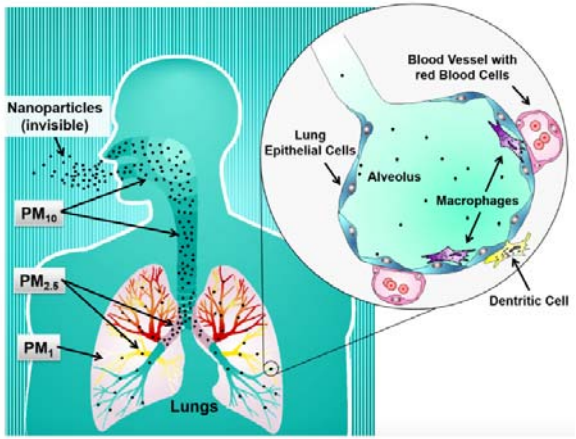
Background

- Elemental /Black carbon EC/BC similar in modelling terms
- Health effects (WHO, 2012, Janssen NAH et al. 2011)
  - Higher exposure-response function than PM 10/ 2.5
  - Revised AQ directive??
- Climate effect
  - Direct Warming effect
  - Via albedo



Maricq, 2007



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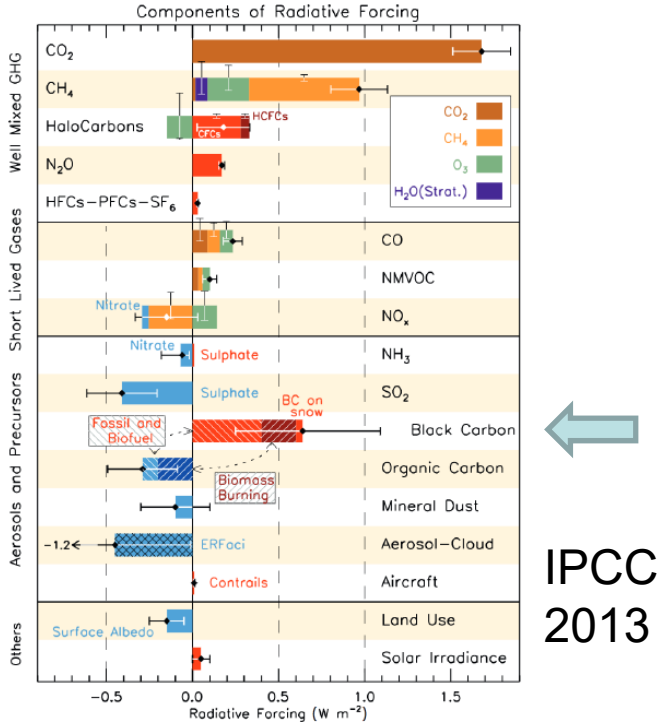


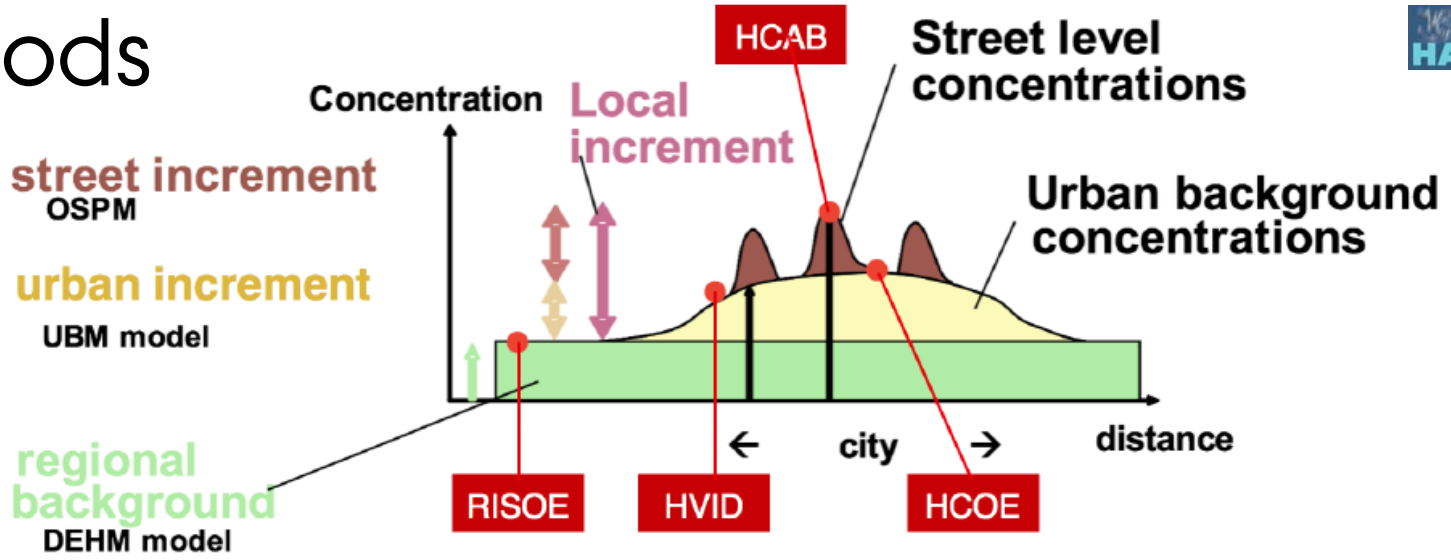
IPCC, 2013

Methods – measurements of EC

- NIOSH thermal-optical transmission method
- European EUSAAR2 temperature protocol

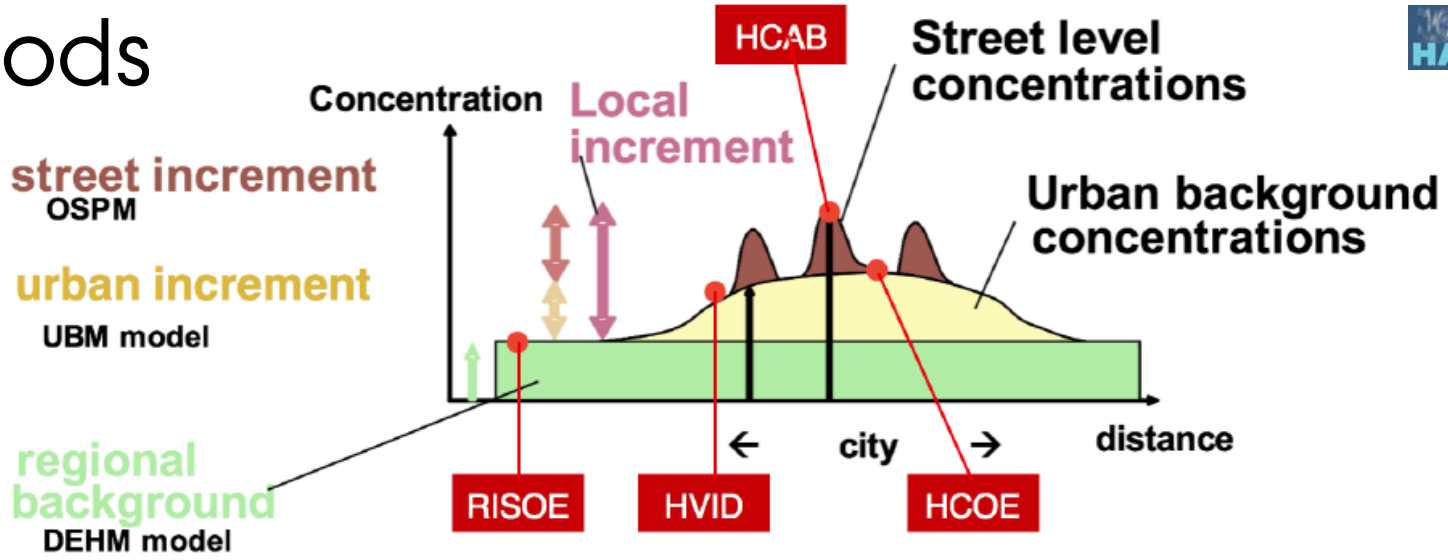
Nr	Station Name	Short Name	Description	Location	Time Period
1	Risø	RISOE	Rural Background	Lille Valby	2010 - 2016
2	Hvidovre	HVID	Suburb	Copenhagen	2015 - 2016
3	H.C. Ørsted Institute	HCOE	Urban Background	Copenhagen	2014 - 2016
4	H.C Andersens Boulevard	HCAB	Street (kerbside)	Copenhagen	2010 - 2016

Methods


HCAB
Street level concentrations
Concentration
Local increment
street increment
OSPM
urban increment
UBM model
Urban background concentrations
regional background
DEHM model
city
distance
RISOE
HVID
HCOE

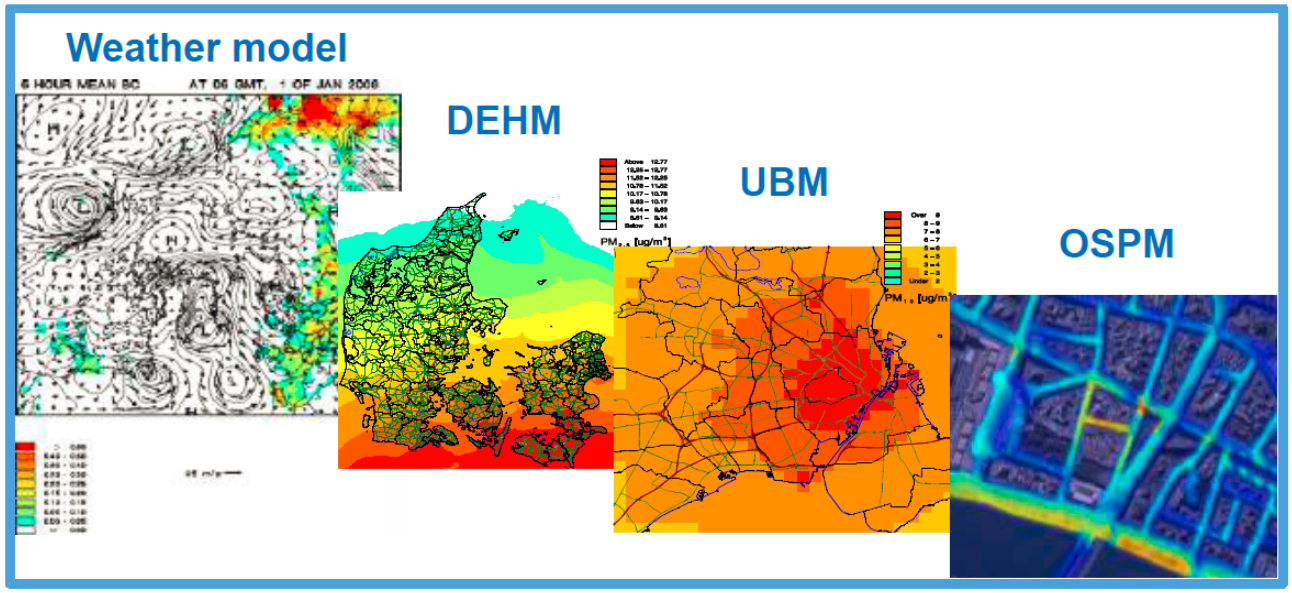

urban background
H.C. Ørsted Institute
Risø
rural background
H.C Andersens Boulevard
street (curbside)
Hvidovre
suburb

Methods



- **THOR system, www.au.dk/thor/**
  - **Weather prediction (WRF /MM5)**
  - **Danish Eulerian Hemispheric Model (DEHM)** for the Northern Hemisphere with a resolution 150 km x 150 km to 5.6 km x 5.6 km over Denmark (Brandt et al. 2012),
  - **Urban Background Model (UBM)** , Denmark domain at 1 km x 1 km resolution (Berkowicz 2000a, Brandt et al. 2001), and
  - **Operational Street Pollution Model (OSPM®)** for road traffic contribution in urban street locations (Berkowicz 2000b, Ketzel et al. 2012)

Methods



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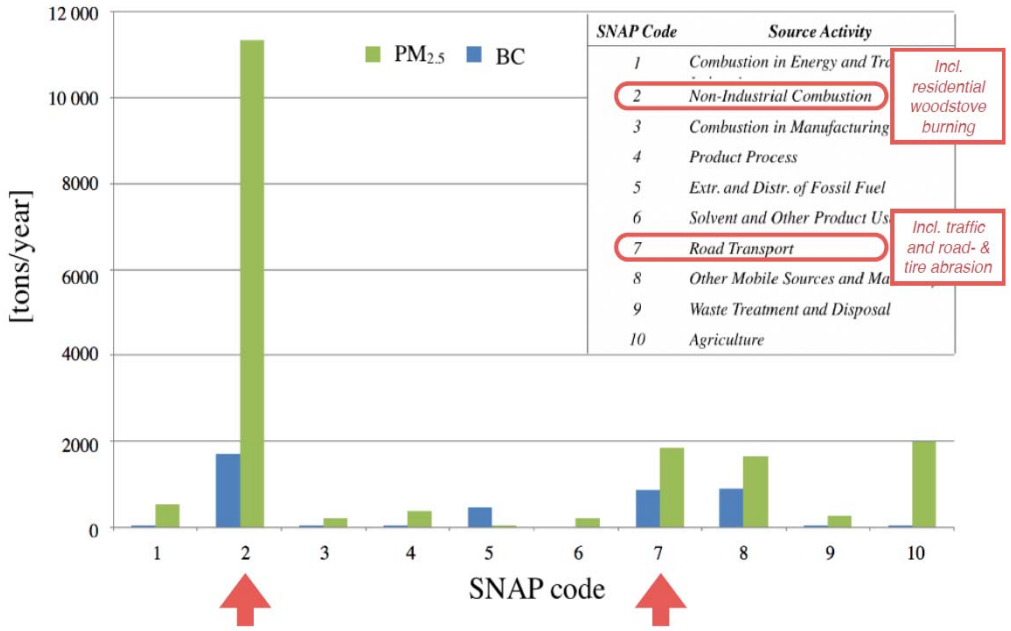
Methods - emissions

› PM exh factors + EC/PM2.5 ratios taken from COPERT

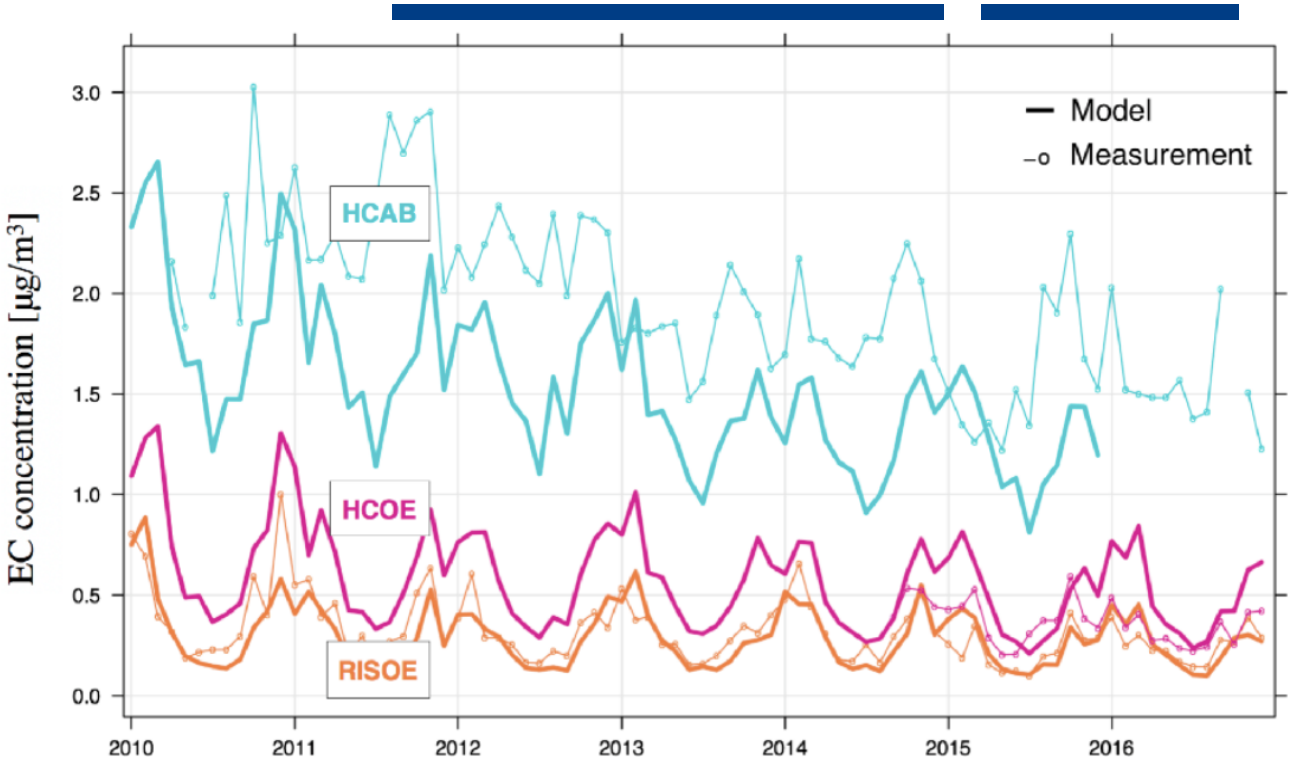
Køretøjskategori	Euro emissionsnorm	EC/$PM_{2.5}$ (%)	Usikkerhed (%)
Benzin person- og varebiler	PRE-ECE	2	50
	ECE 15 00/01	5	50
	ECE 15 02/03	5	50
	ECE 15 04	20	50
	Open loop	30	30
	Euro 1	25	30
	Euro 2	25	30
	Euro 3	15	30
	Euro 4	15	30
Diesel person- og varebiler	Konventionel	55	10
	Euro 1	70	10
	Euro 2	80	10
	Euro 3	85	5
	Euro 4	87	5
	Euro 3-5 Filter med brændstofsadditiv	10	50
	Euro 3-5 katalyseret partikelfilter	20	50
Diesel lastbiler og busser	Konventionel	50	20
	Euro I	65	20
	Euro II	65	20
	Euro III	70	20
	Euro IV	75	20
	Euro IV	75	20
	Euro VI	15	30

Sum of $PM_{2.5}$ and BC emissions in DK

- 10 source categories /SNAP code (Nielsen et al. 2015)
- Spatial distribution on 1 km x 1 km: Plejdrup, M.S. & Gyldenkærne, S. 2011: Spatial distribution of emissions to air – the SPREAD model.



Results



› Trends of monthly averages for observed and modelled EC (µg/m^3) at HCAB, HCOE and RISOE (2010 – 2016).
For RISOE - DEHM, for HCOE - UBM, for HCAB - OSPM.

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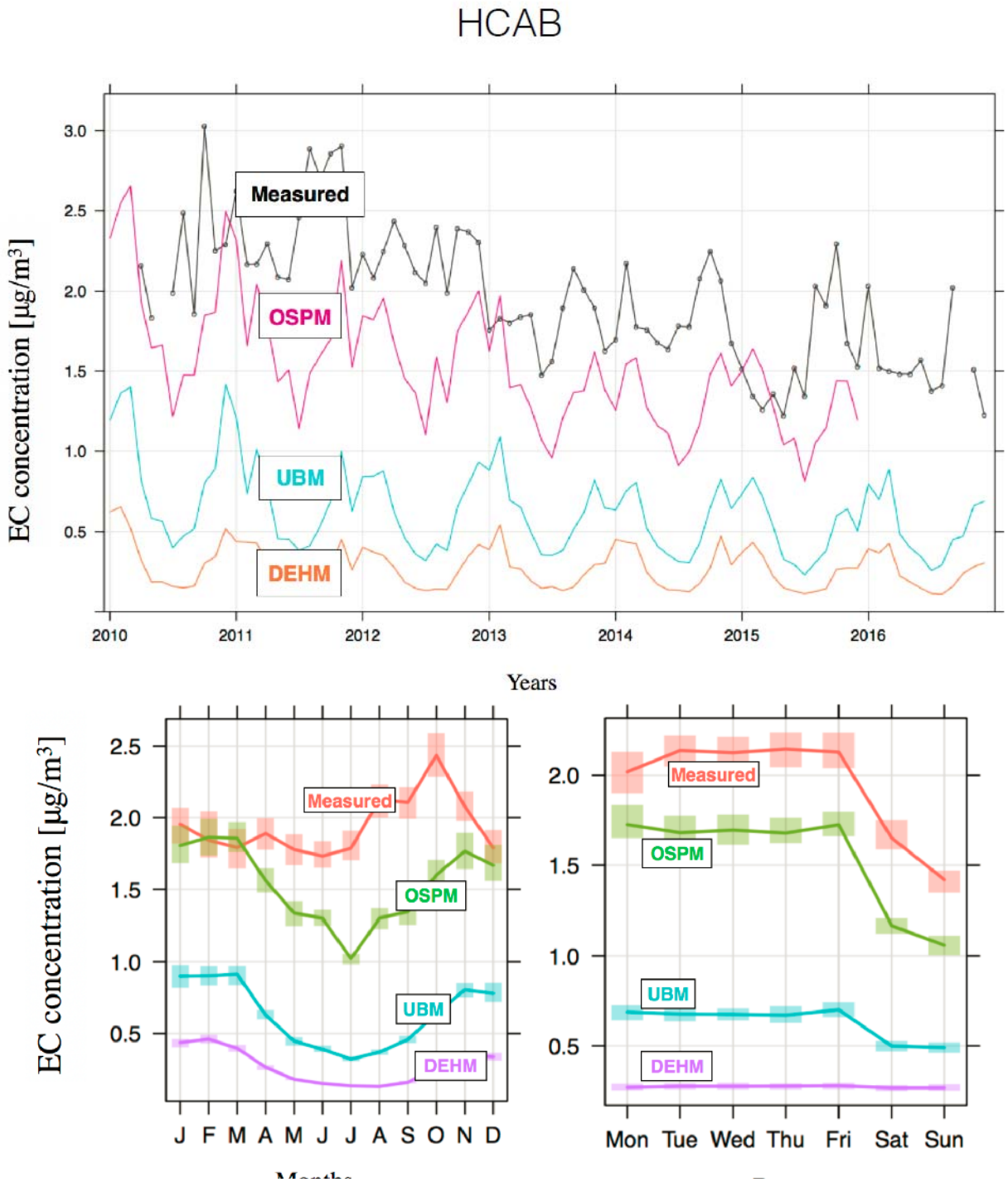
HCAB (street)

› 3 model contributions



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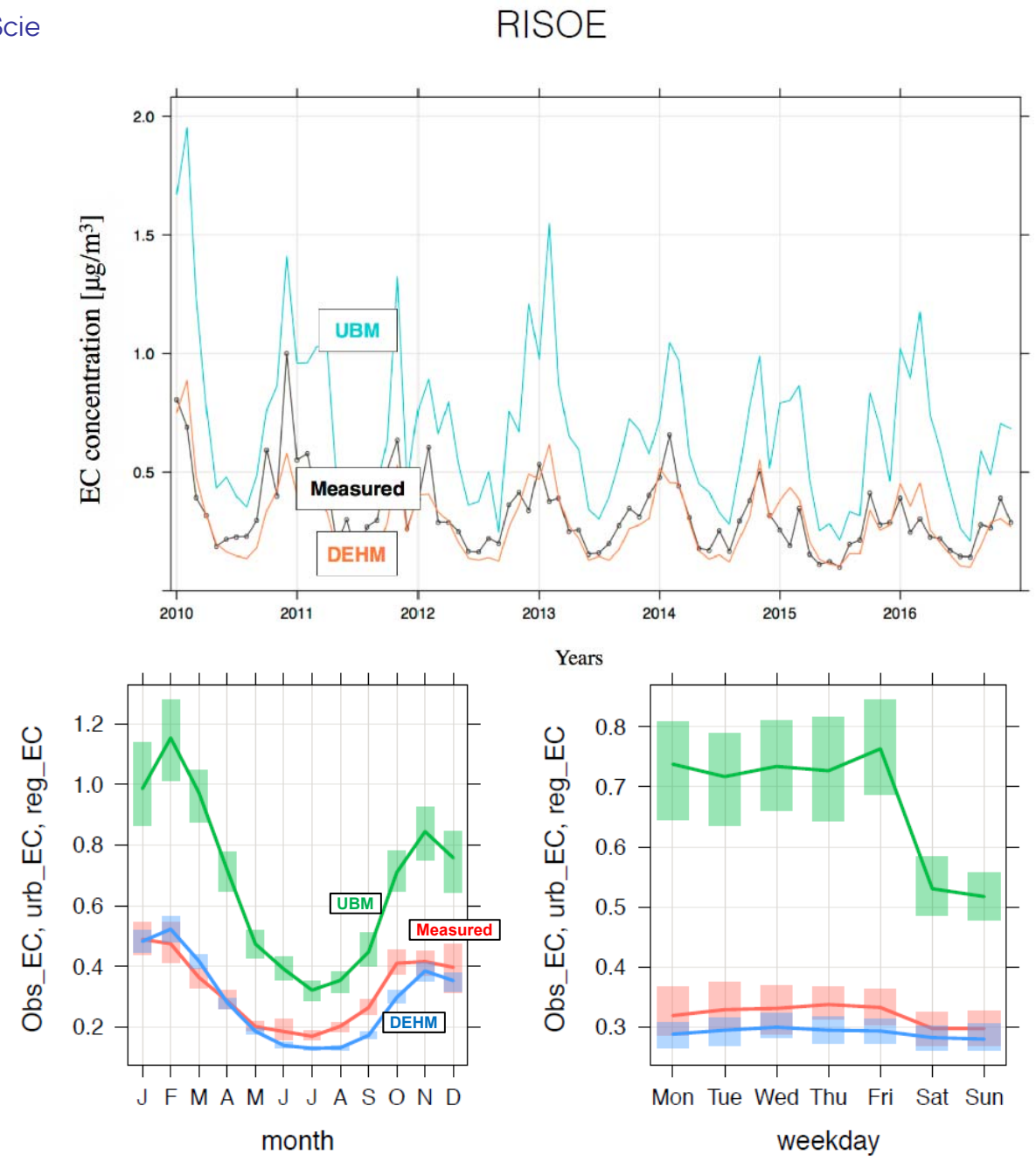
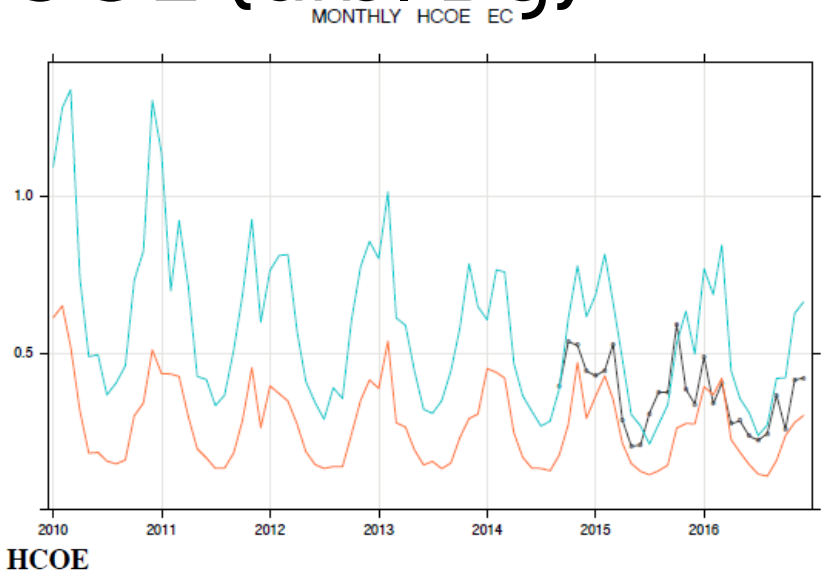
openair R

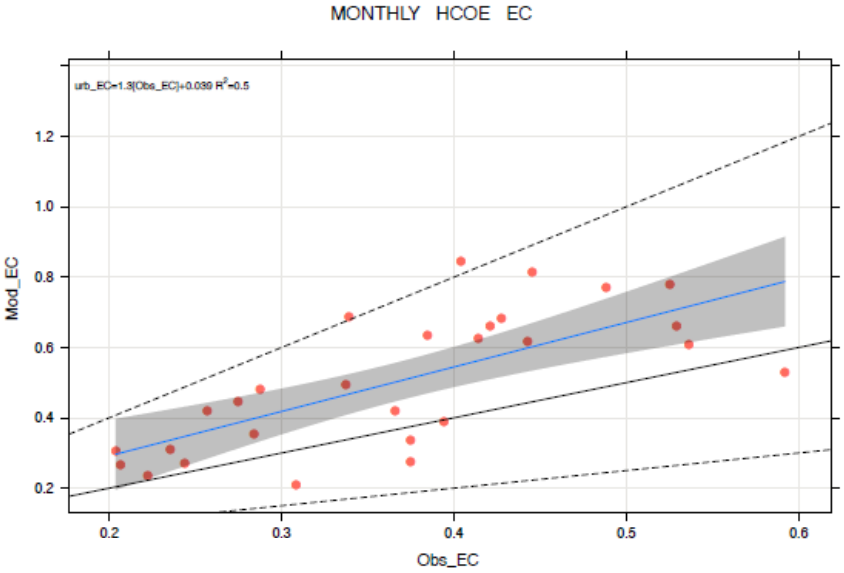
RISOE (rural)

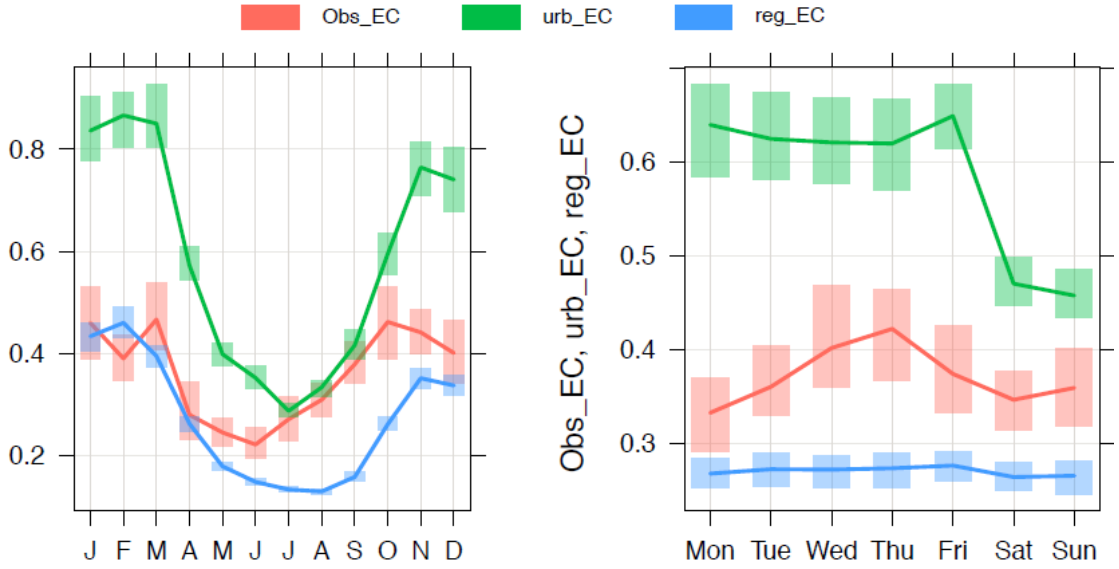
- UBM contirbutes too much
- Hmix issue



HCOE (urb. Bg)

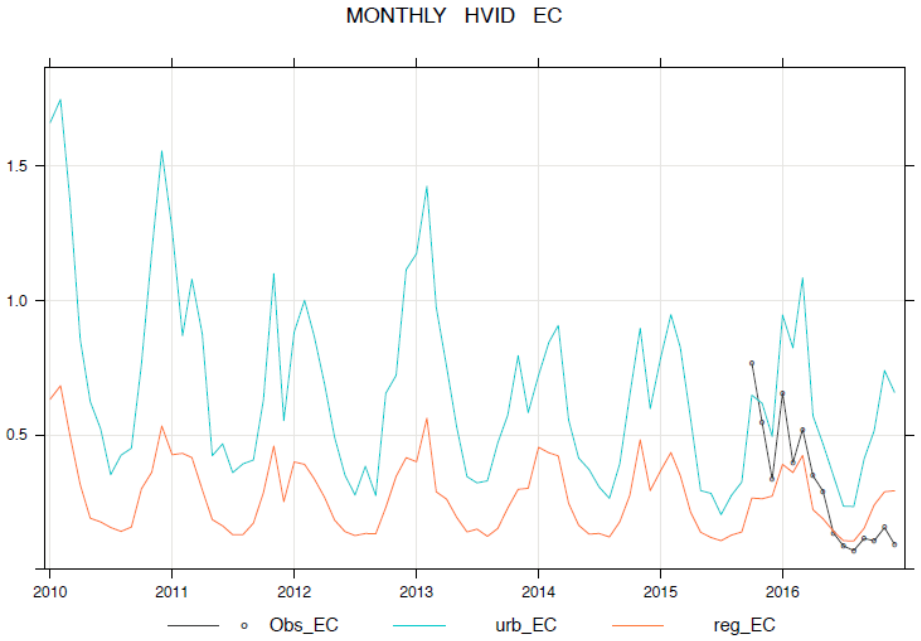

MONTHLY HCOE EC
1.0
0.5
2010
2011
2012
2013
2014
2015
2016
HCOE

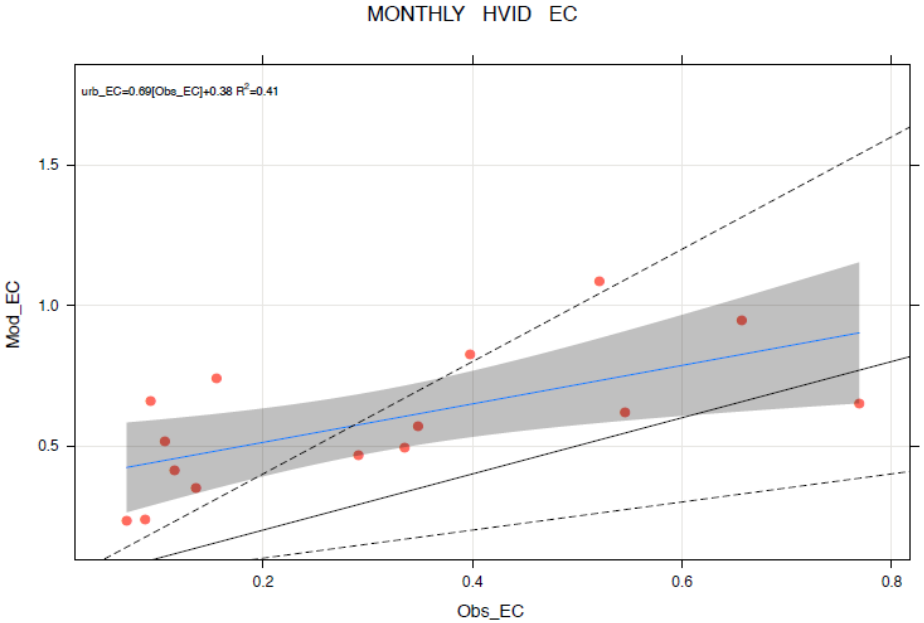

MONTHLY HCOE EC
urb_EC=1.3[Obs_EC]+0.039 R²=0.5
1.2
1.0
0.8
0.6
0.4
0.2
Mod_EC
0.2
0.3
0.4
0.5
0.6
Obs_EC


Obs_EC
urb_EC
reg_EC
0.8
0.6
0.4
0.2
J F M A M J J A S O N D
Obs_EC, urb_EC, reg_EC
0.6
0.5
0.4
0.3
Mon Tue Wed Thu Fri Sat Sun

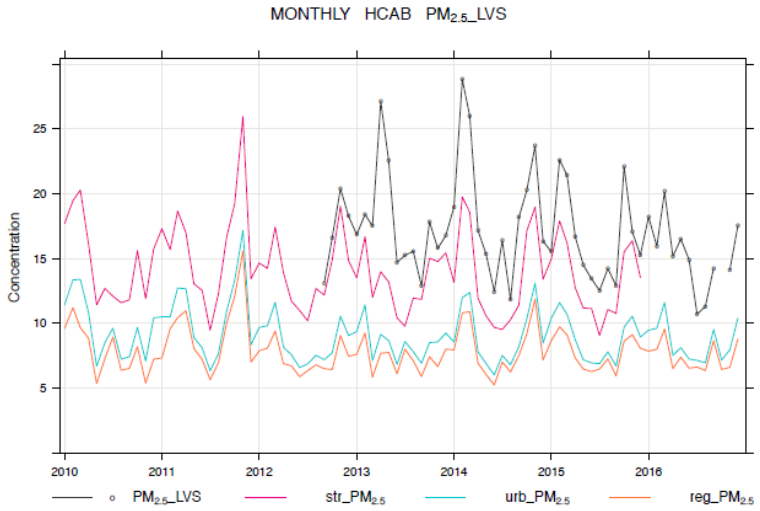
HVID (suburban)

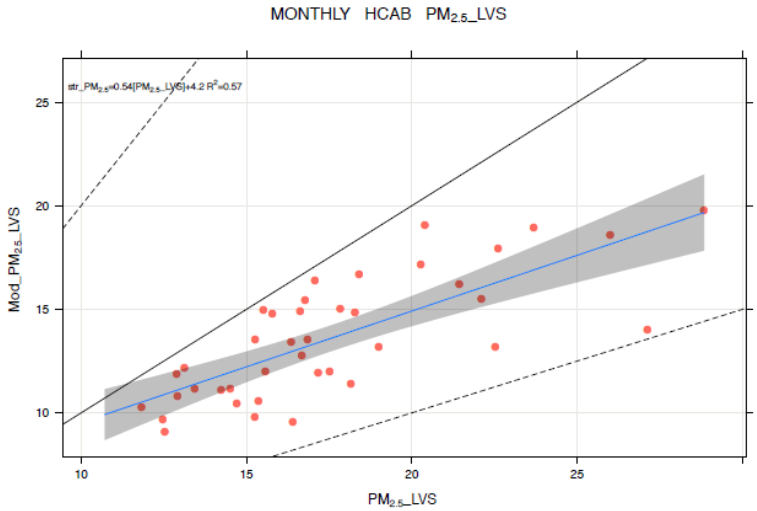
- time series too short
- Year to year variation of emissions?

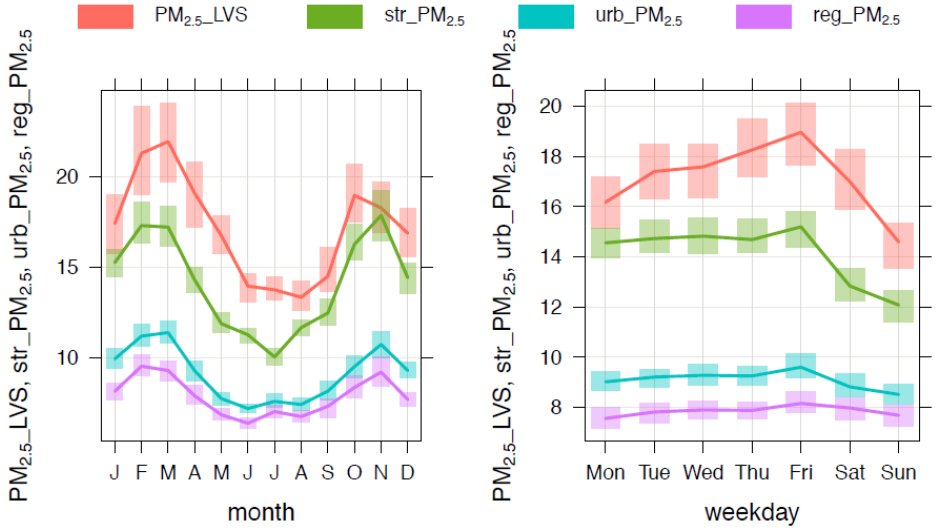




HCAB (street) PM2.5

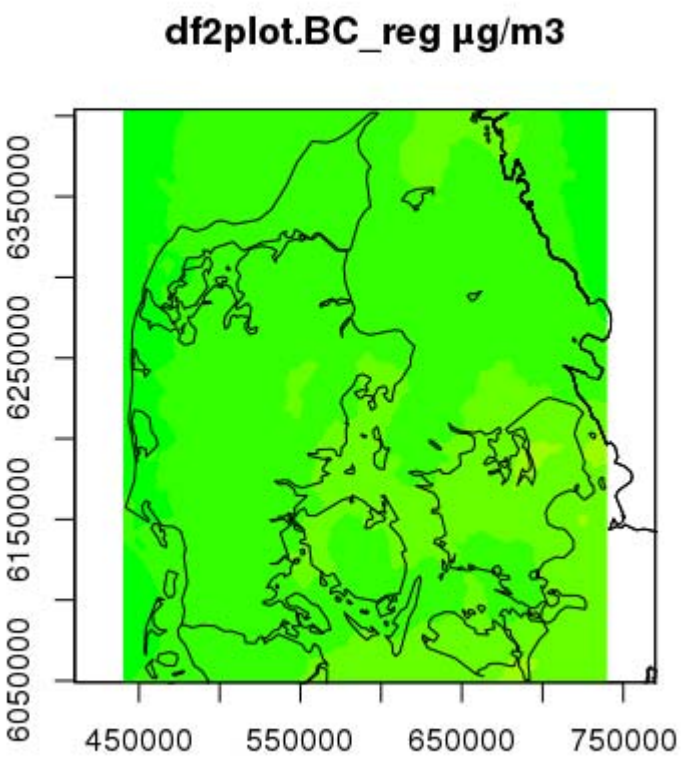


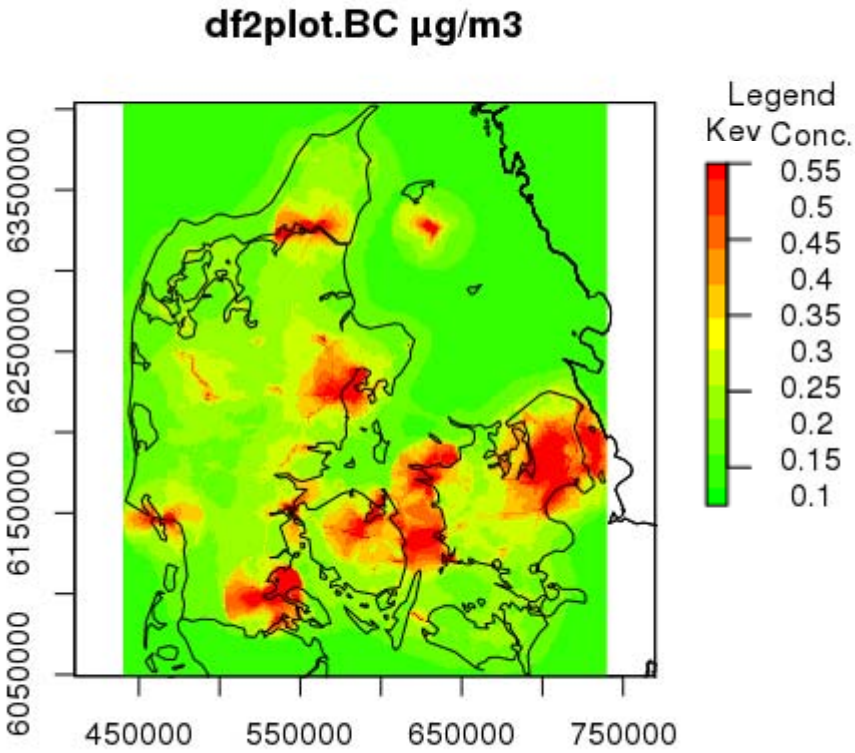




Annunal average of EC for 2015

› **DEHM 5.6x5.6 km^2 and DEHM + UBM in 1x1 km^2**





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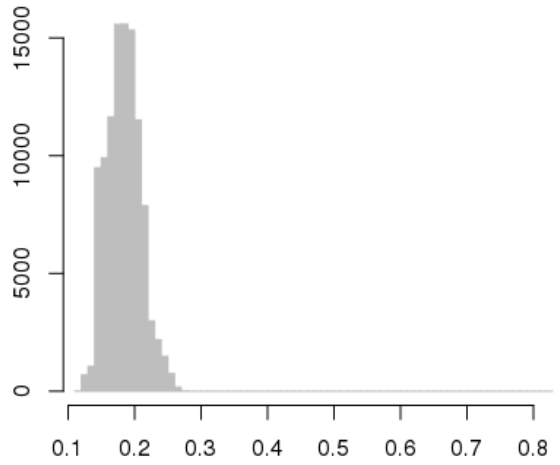
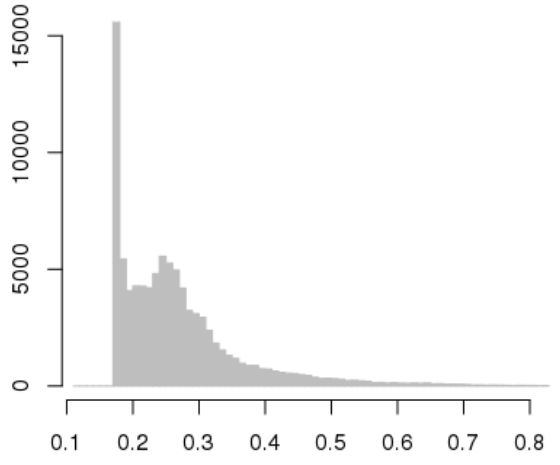
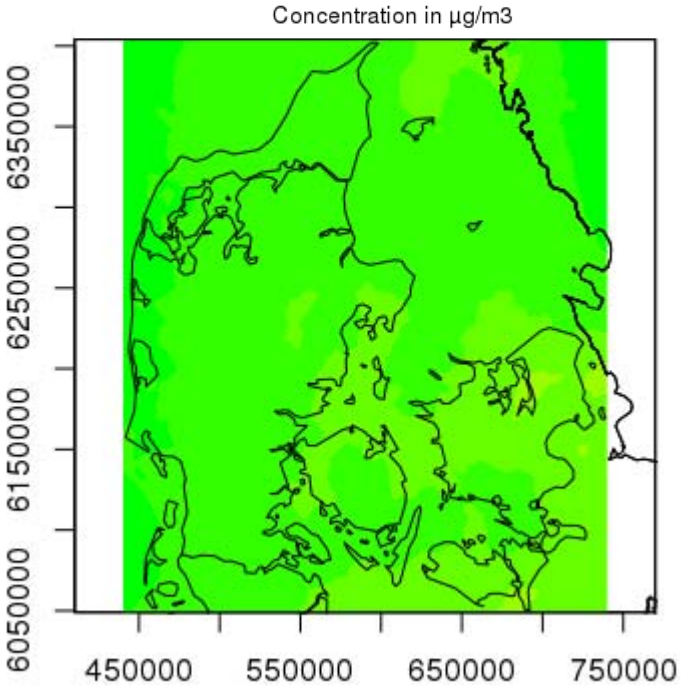
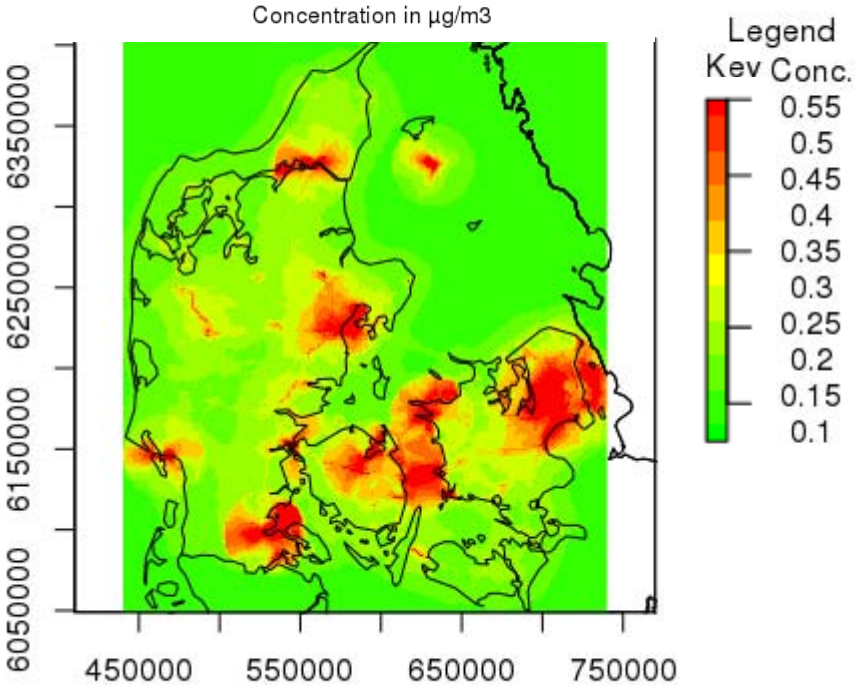
› DE and km²









Conclusions

- first time modelled EC concentrations over the whole of Denmark modelled in a fine spatial resolution of 1 km x 1 km
- Different types of plotting (time series plots, scatter plots, average time variation) identifies areas for improvements
- General levels of EC concentration well reproduced by the models at all 4 stations
- Also the annual and weekly variation in concentrations, with a few exceptions:
  - HCAB (street location) under-prediction in the summer months
  - RISOE (rural station), unrealistic low mixing heights in the UBM model
  - HCOE (urb. bg), over-predition in winter
- Future: More analysis EC meas., check emissions

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