Using EMEP data to evaluate COSMO-ART

Christoph Knote, Dominik Brunner - 13.05.2011
Laboratory for Air Pollution / Env. Technology

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Center for Climate Systems Modeling

EMPA
Materials Science & Technology

Motivation

Regional scale impacts of changing emissions
on air quality and climate

(title of PhD thesis)

climate

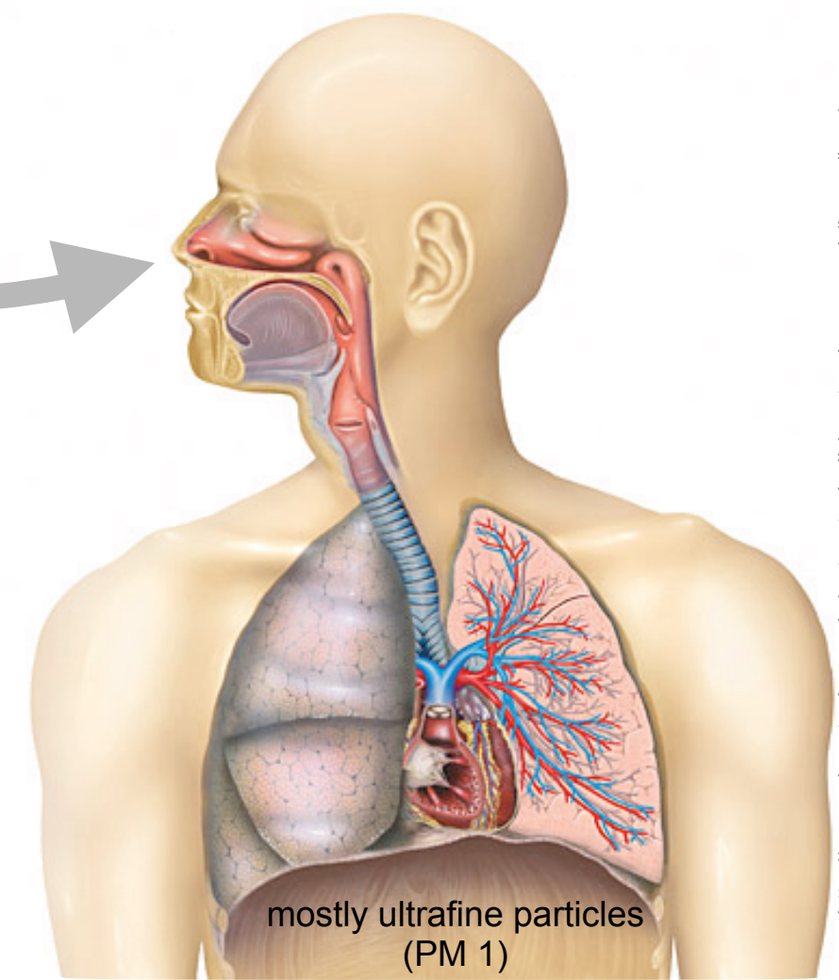
indirect effects

act as cloud condensation and ice nuclei

direct effect

aerosols

health



http://www.planet-wissen.de/natur_technik/anatomie_mensch/lunge/img/lunge_innen_dpa_g.jpg

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act as cloud condensation and ice nuclei

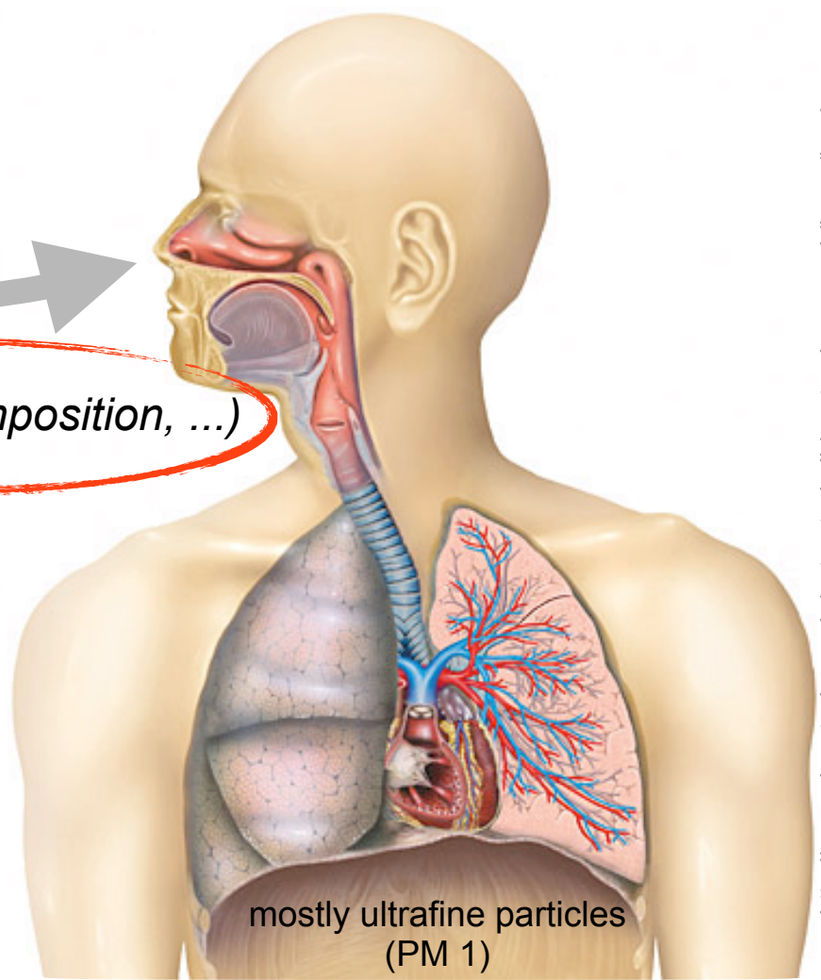
direct effect

aerosols

f(size, hygroscopicity, ...)

f(size, shape, composition, ...)

health



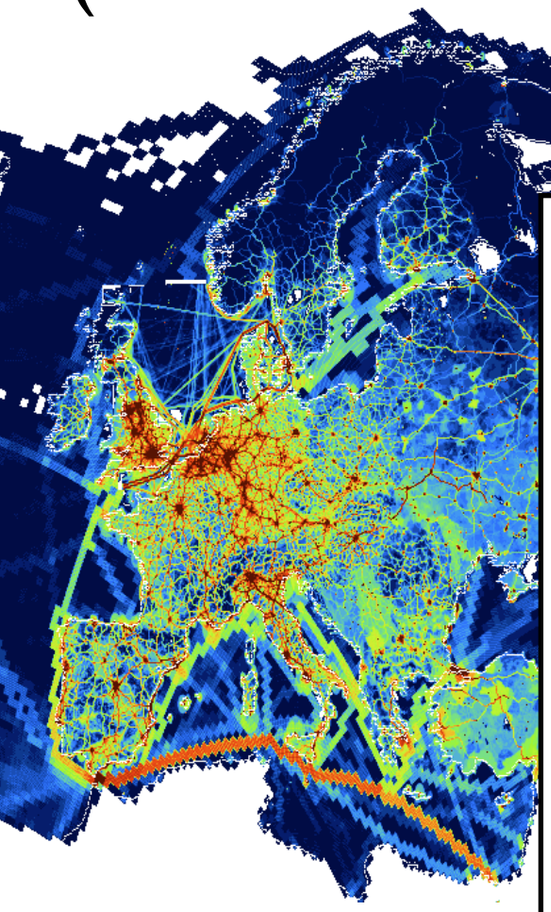
http://www.planet-wissen.de/natur_technik/anatomie_mensch/lunge/img/lunge_innen_dpa_g.jpg

We need a lot of information about aerosol characteristics!

Approach

detailed emissions dataset (TNO/MACC)

initial / bd. conditions (MOZART,IFS)



COSMO-ART

meteorology

COSMO
non-hydrostatic

preprocessor

INT2COSMO-ART
IC/BC, emissions

natural emissions

- BVOCs
- Sea salt
- Dust
- Pollen

SOA

SORGAM

inorganics

ISORROPIA

photolysis

PAPA
online calculation of photolysis rates

gas-phase

RADMK
extended RADM2
+ add. isoprene reactions
+ updated rate constants
+ hetero. N_2O_5 hydrolysis

MADEsoot
extended
6 modes
explicit soot aging

aerosols

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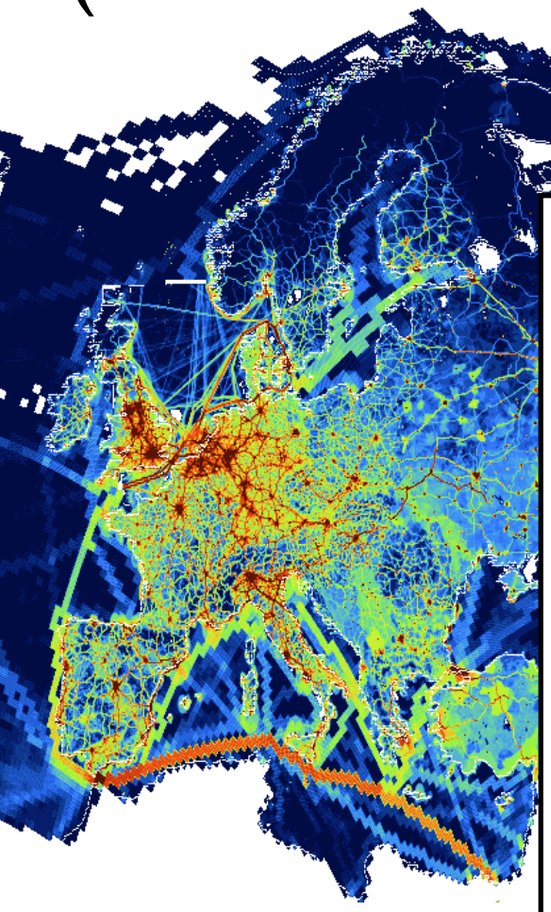

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MADEsoot
extended
6 modes
explicit soot aging

aerosols

comprehensive information on spatial and temporal distribution of

chemically-speciated, size-resolved aerosol characteristics

Setup

available data

spring	*summer*	*autumn*	*winter*	
				
✓	✓	✓	✓	EMEP standard
	✓			EIMP (AMS)
✓		✓		EUCAARI (AMS)
✓		✓		EUSAAR (D/SMPS)

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Setup

spring	*summer*	*autumn*	*winter*	*available data*
				
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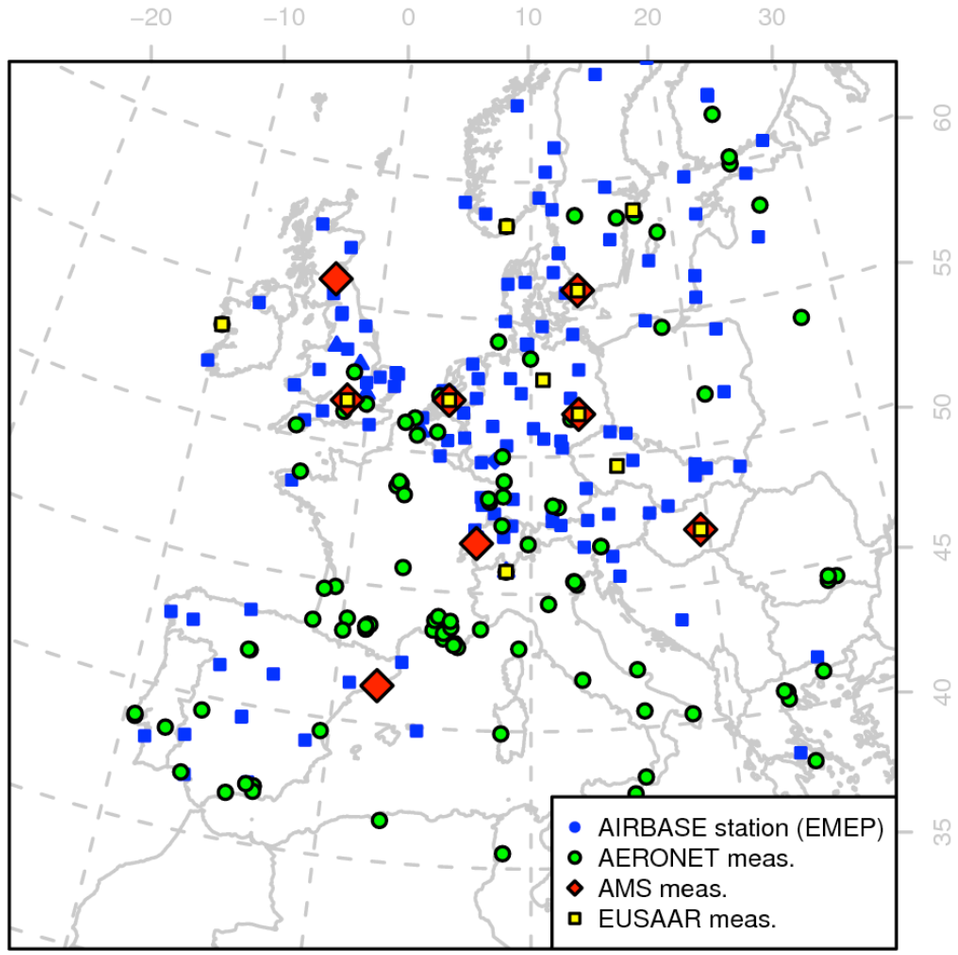

COSMO-ART 4.17

200 x 190 grid points at 0.17° res.
40 vertical levels
= *1.520.000 grid cells*
Runge-Kutta time integration
Semi-lagrange tracer advection

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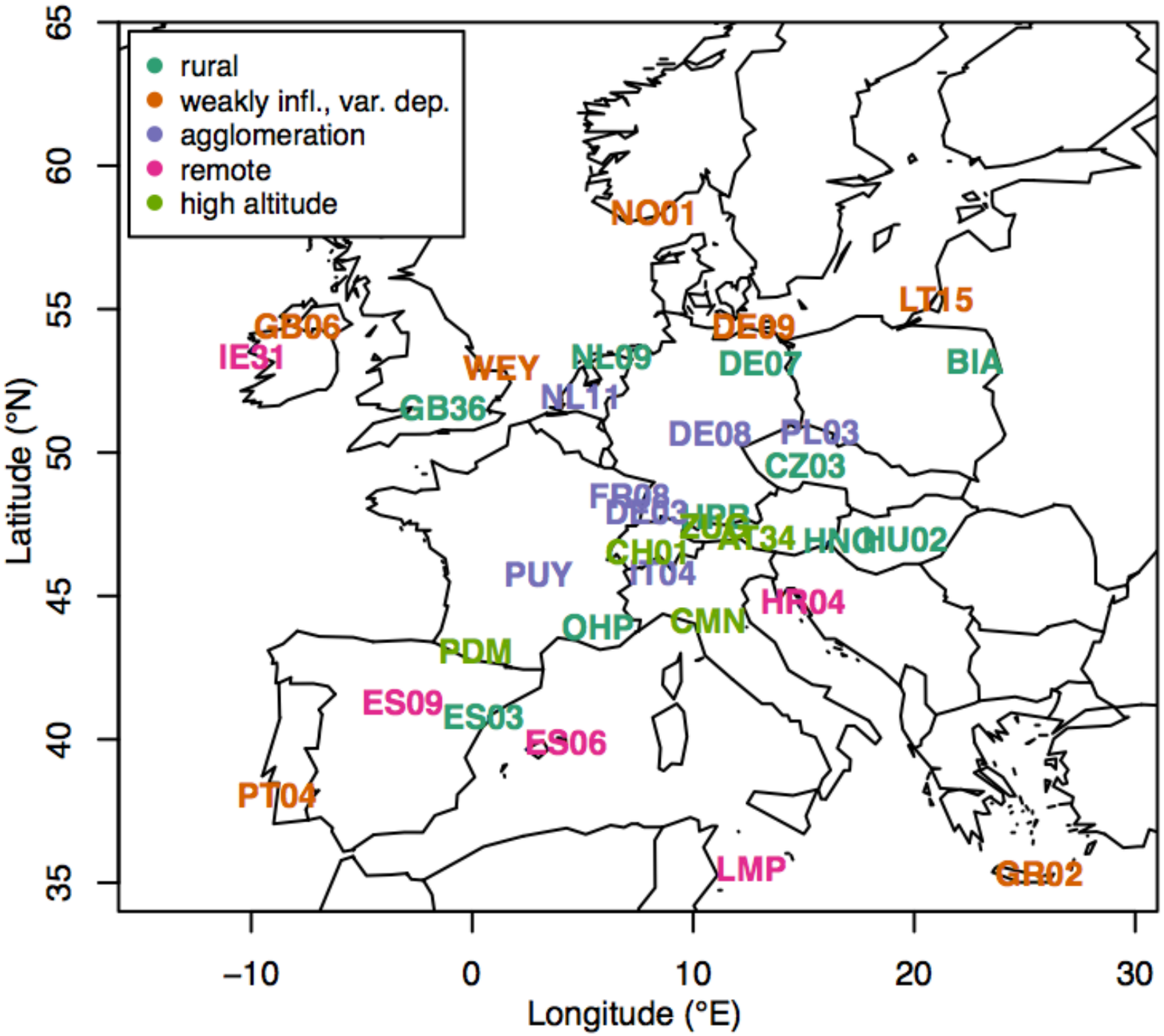
Classification of EMEP stations



4 subclasses
used in evaluation:

rural
rural/coastal
rural/remote
suburban

Henne, S., Brunner, D., Folini, D., Solberg, S., Klausen, J., and Buchmann, B.: Assessment of parameters describing representativeness of air quality in-situ measurement sites, Atmos. Chem. Phys., 10, 3561-3581, doi:10.5194/acp-10-3561-2010, 2010.

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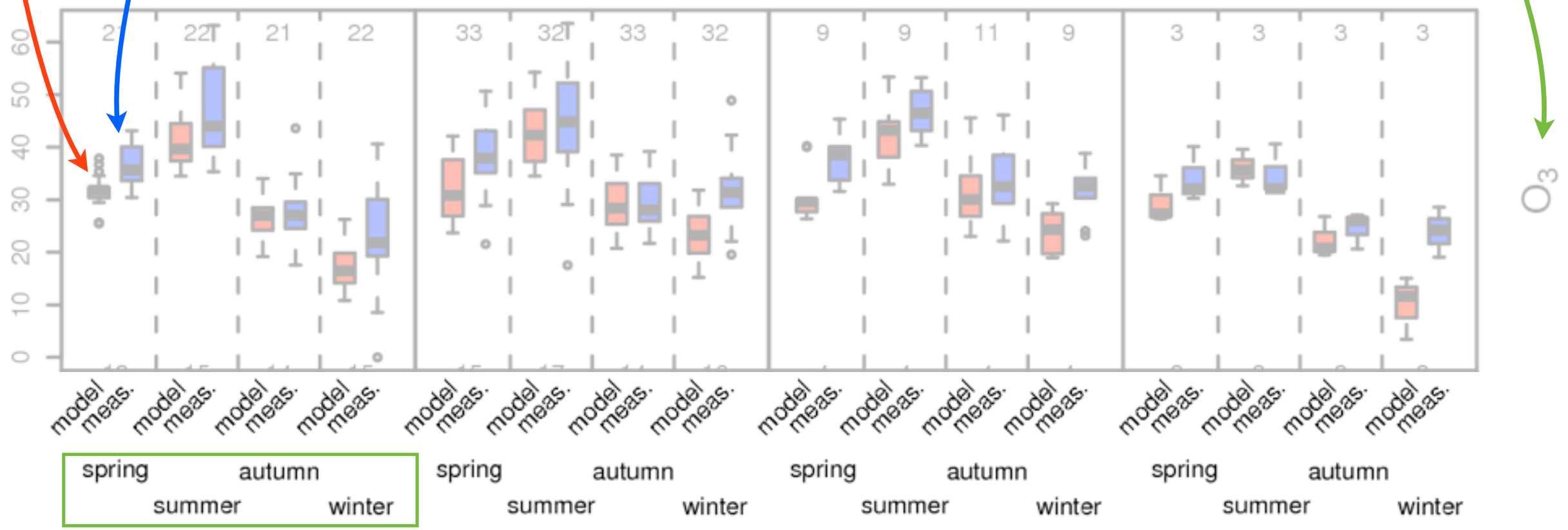
Evaluation of gas-phase

measurement

model

different subsets of EMEP stations

species



4 seasons

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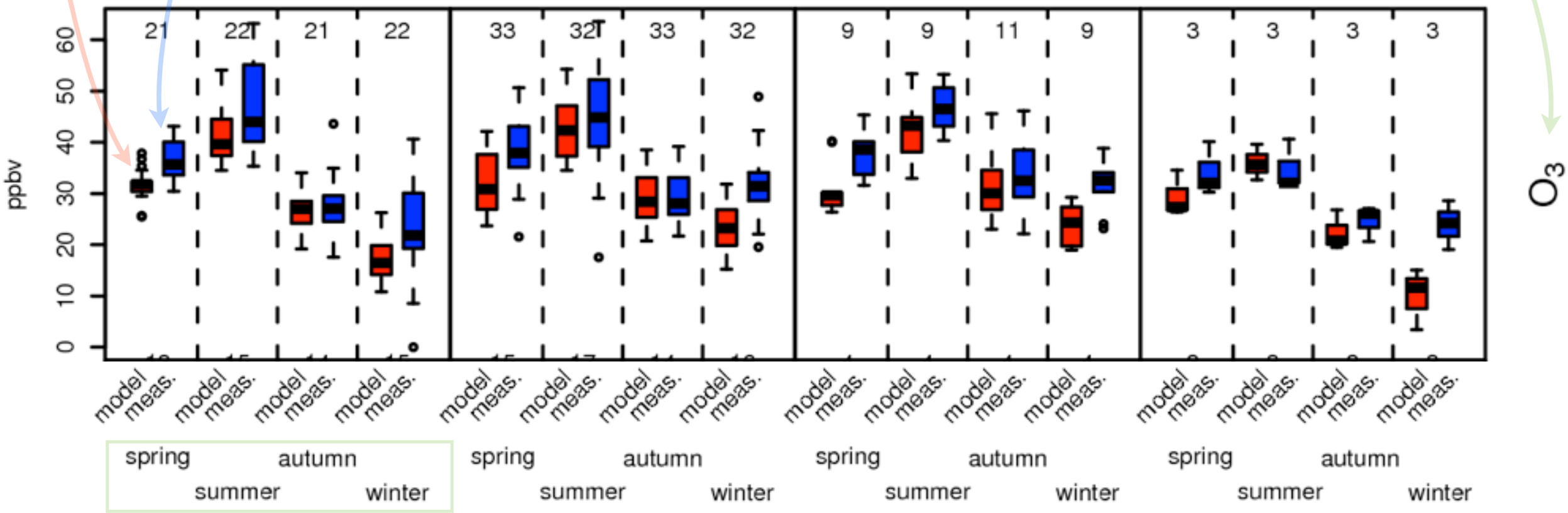

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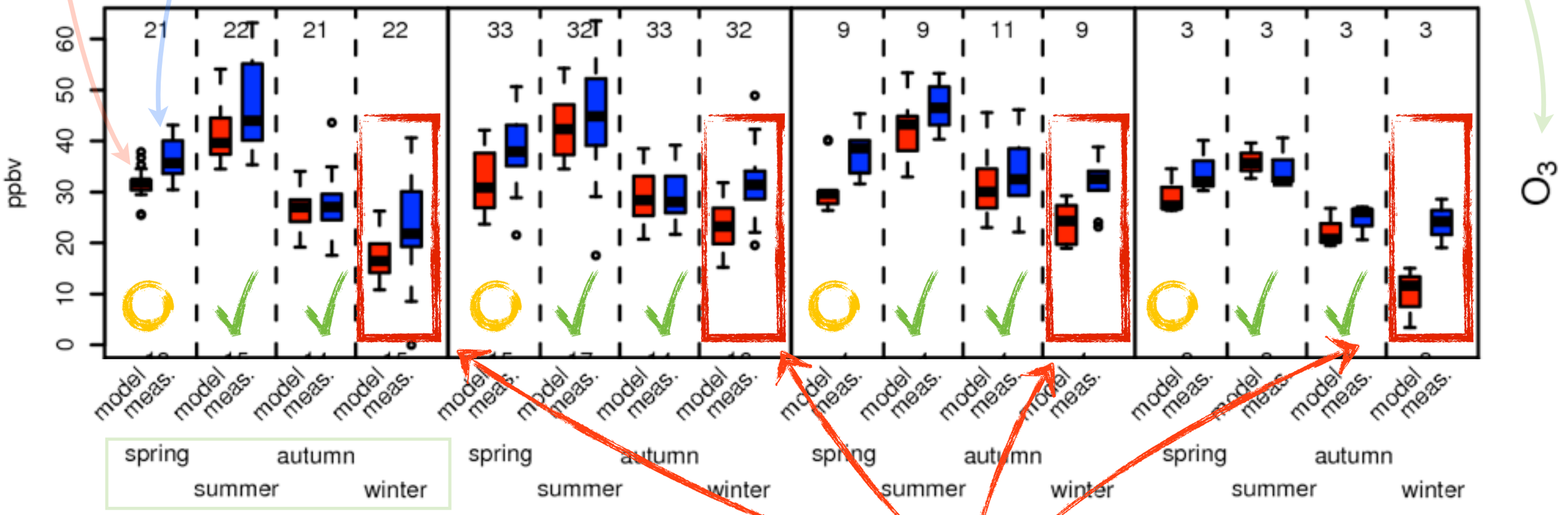

4 seasons

Jan/Feb 2006: high pollution episode with strong, persistent inversions - model struggles...

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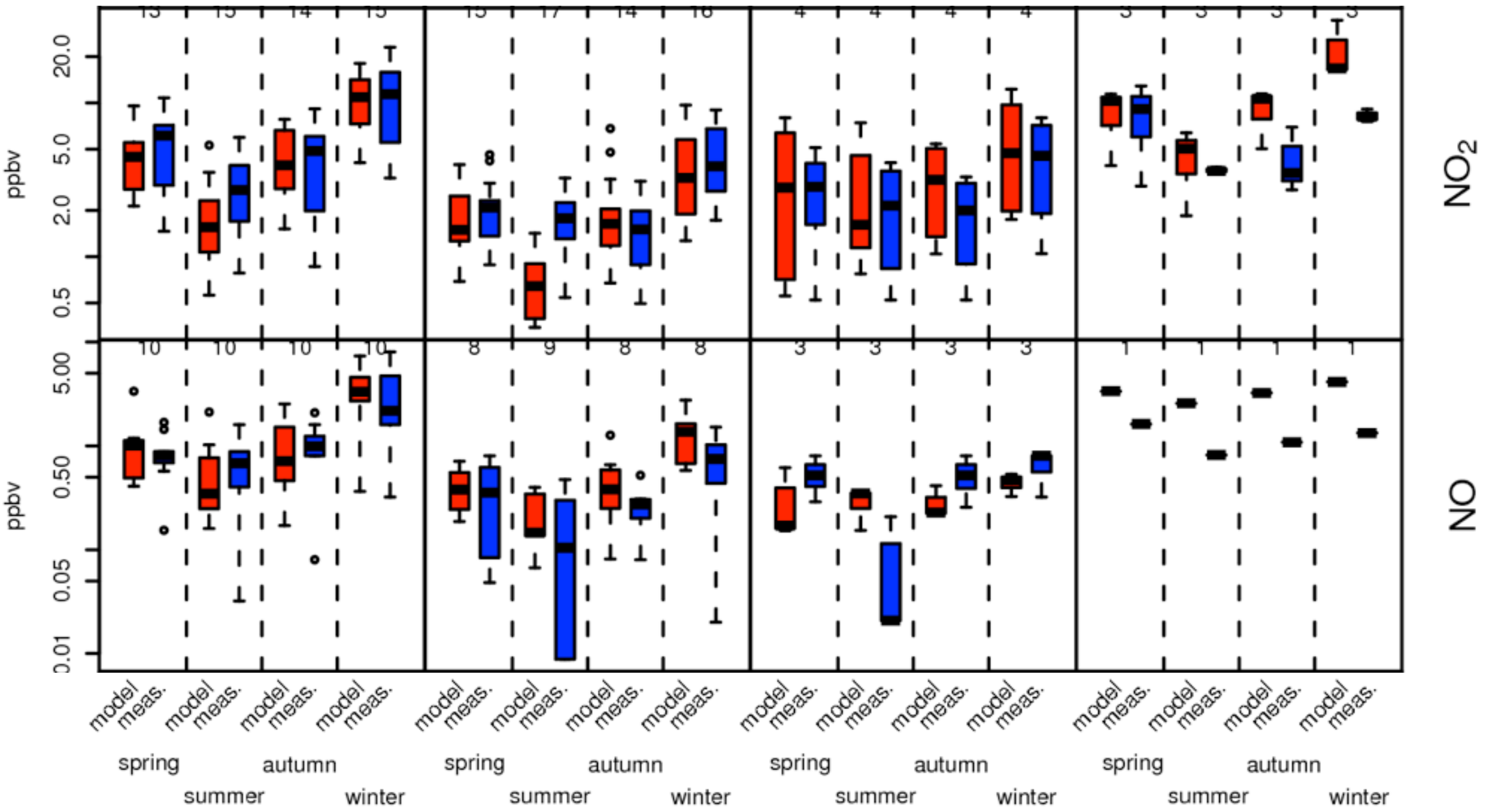
NO, NO_2



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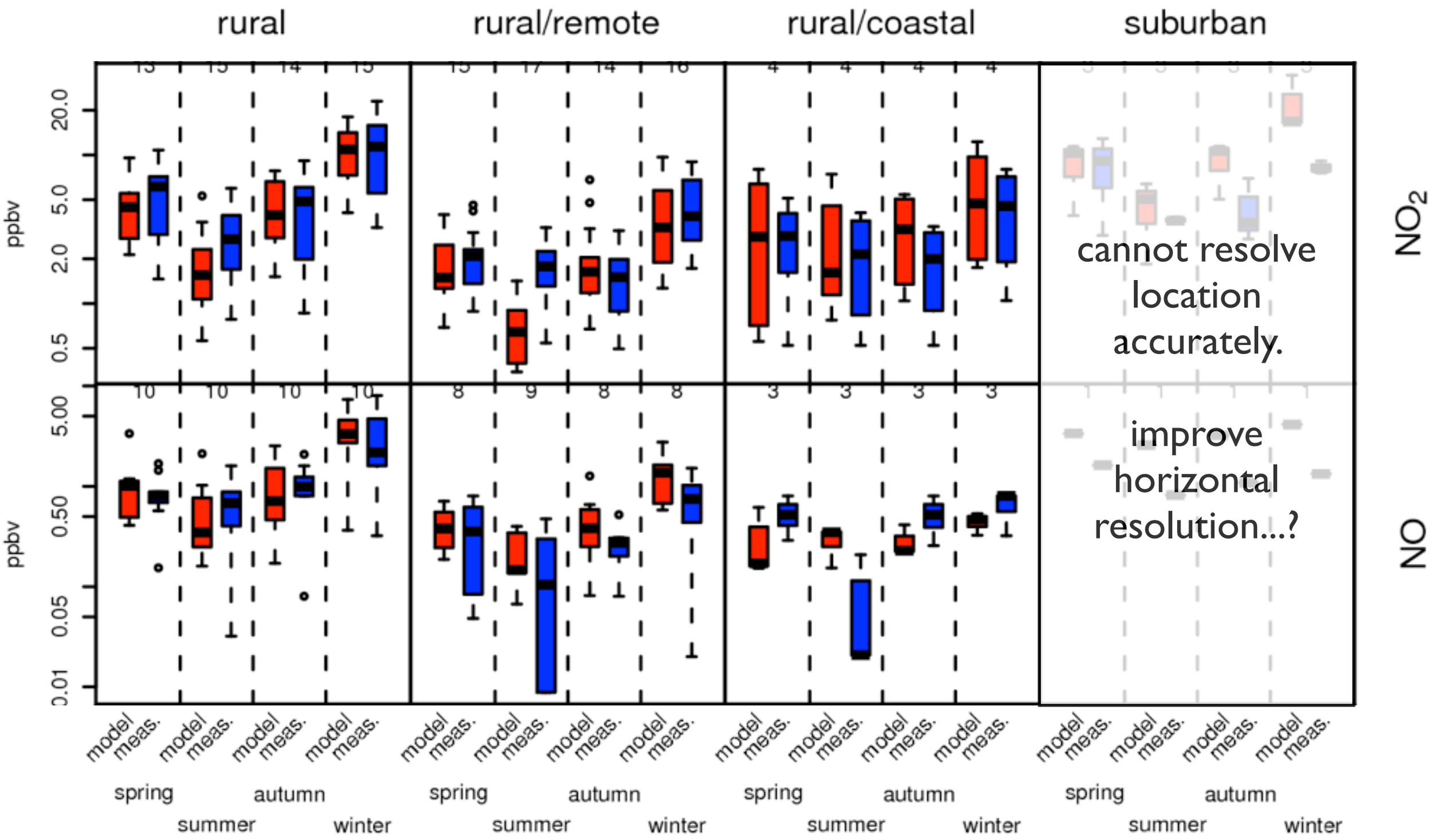

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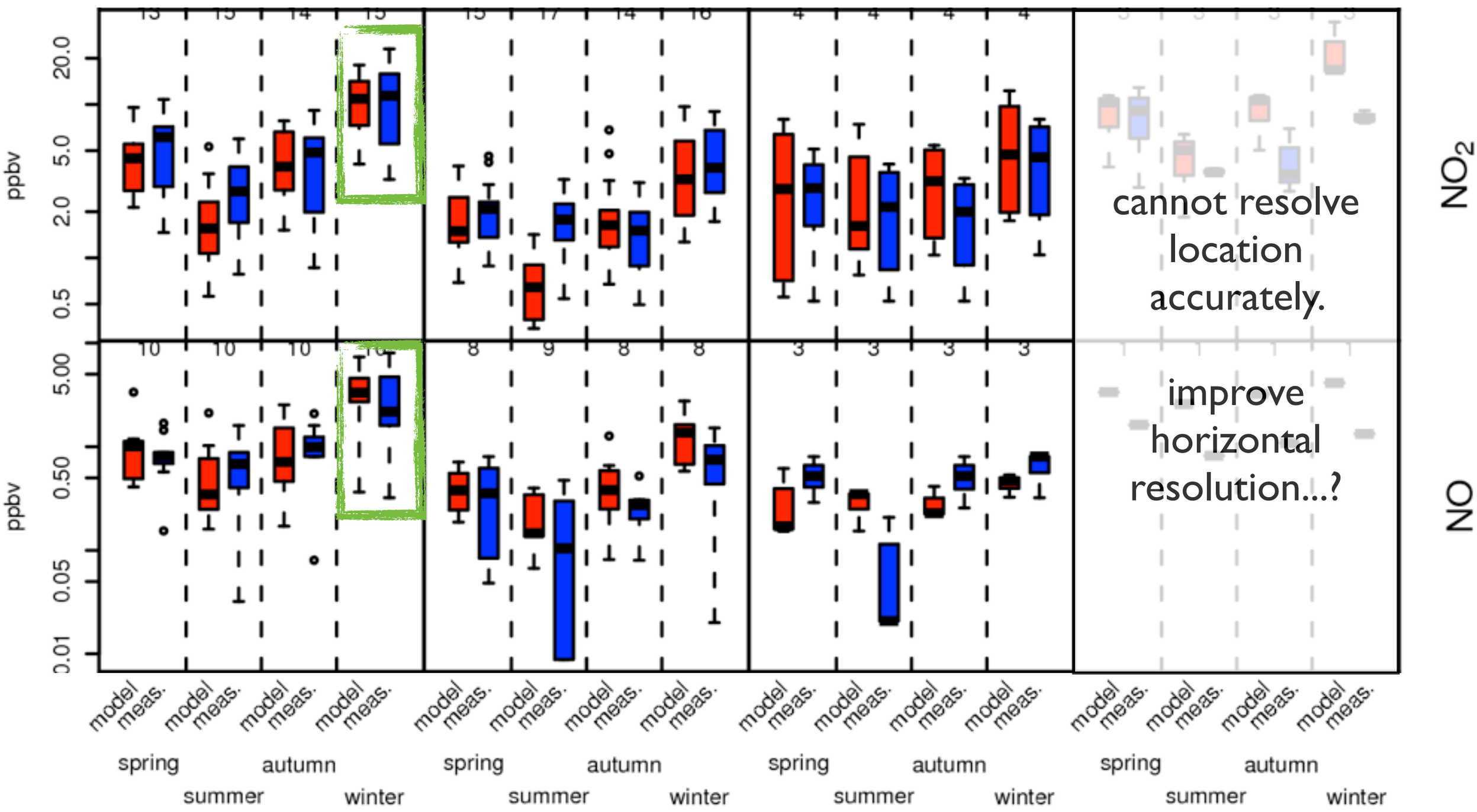
NO, NO_2

can represent NO_x during high pollution episode



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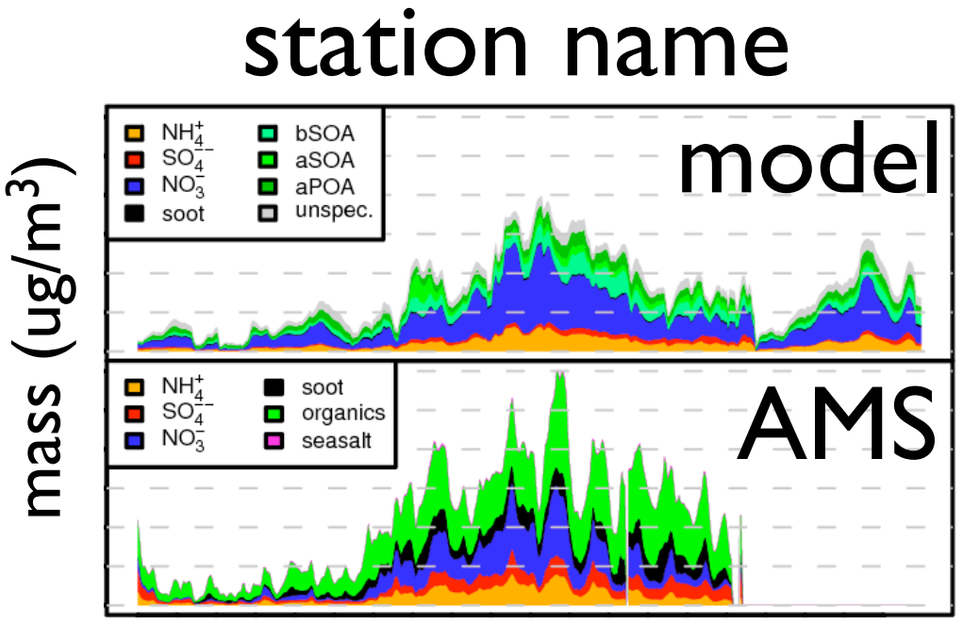
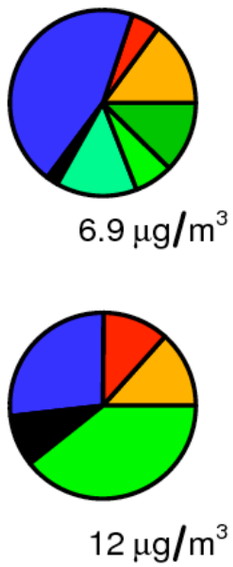
Aerosol chemical composition





mean composition
(only comparable species)

mean mass of those
components

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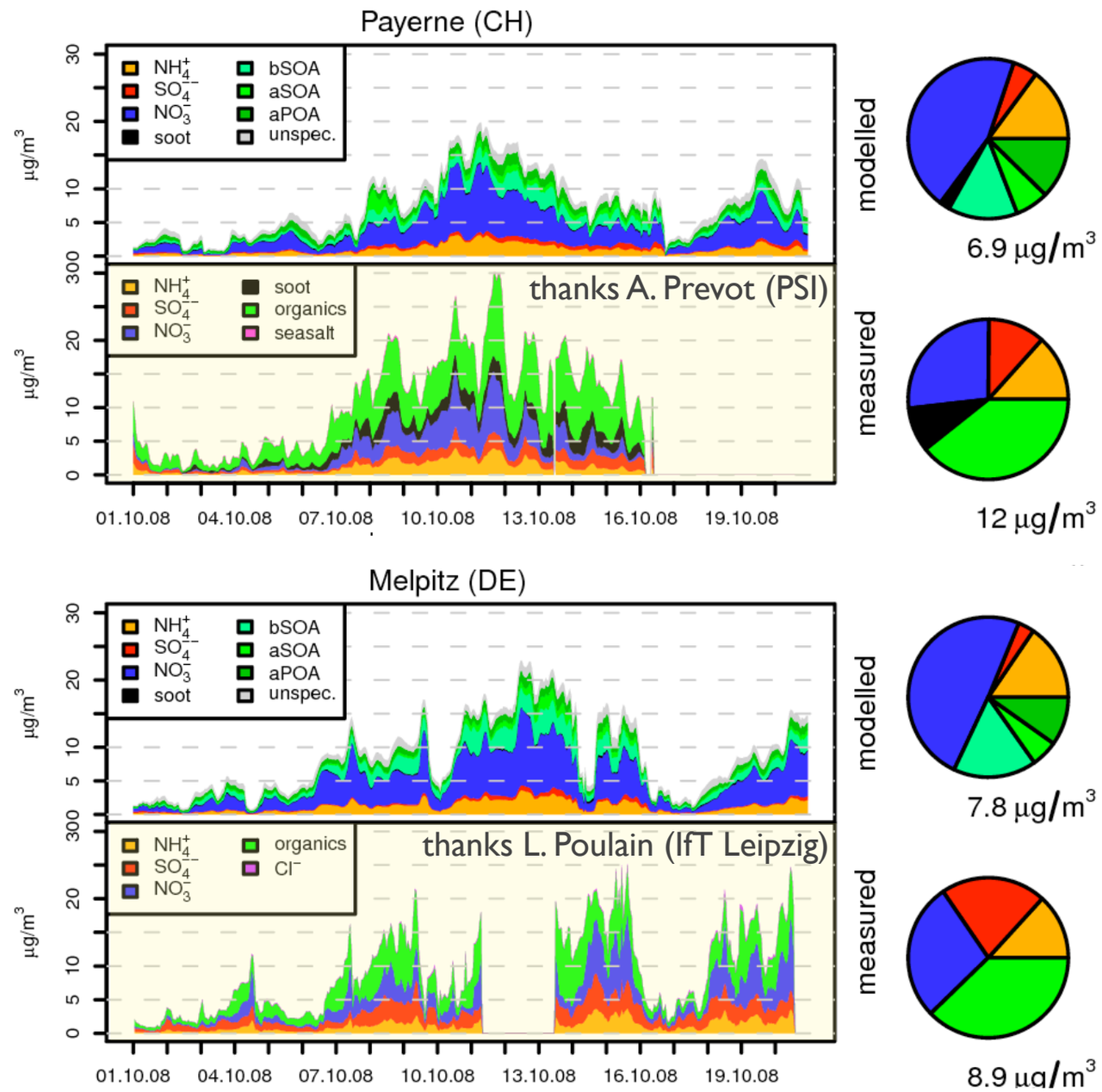
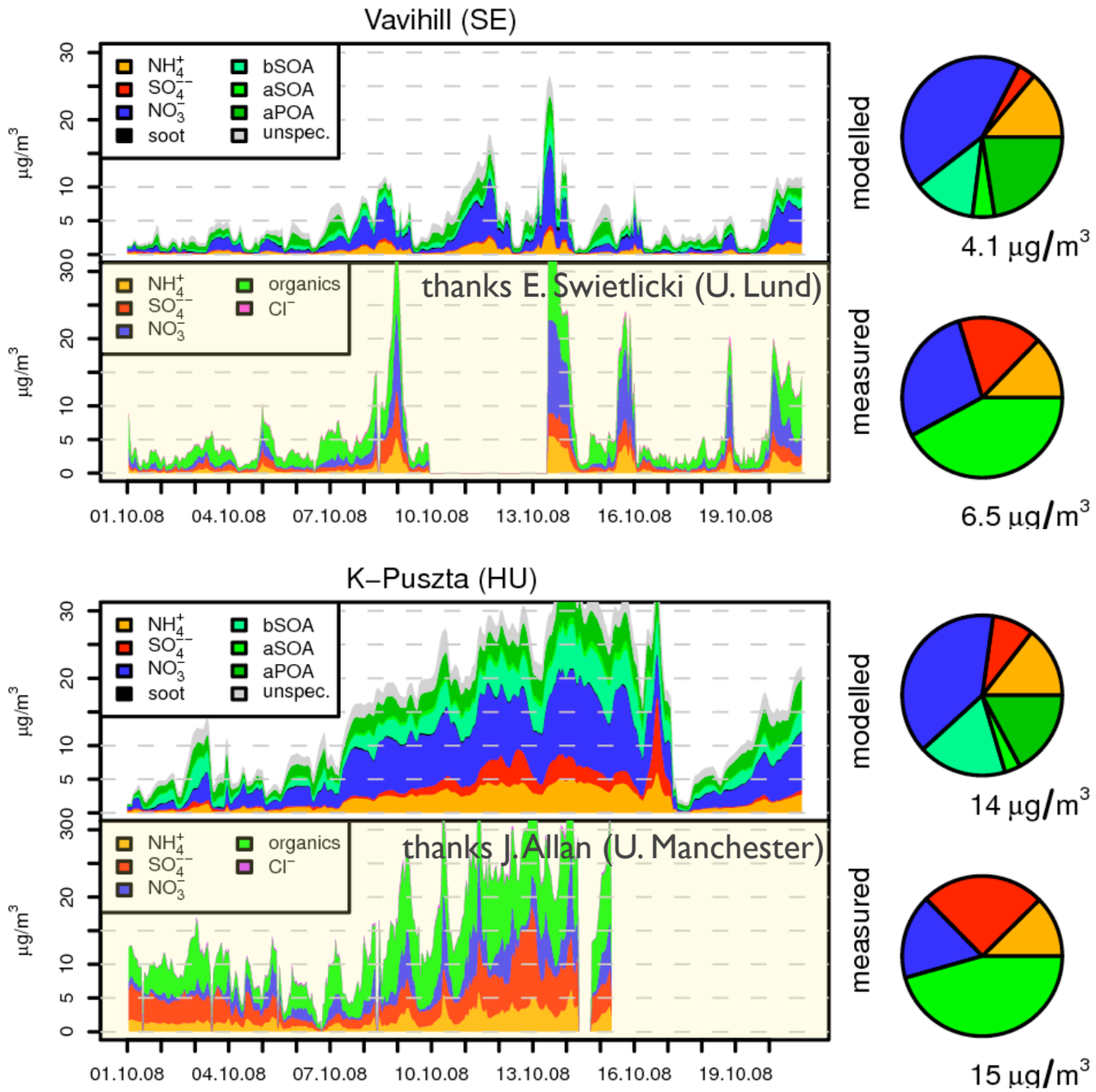
simulated period:
October 2008 (20 days)

Aerosol chemical composition





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simulated period:
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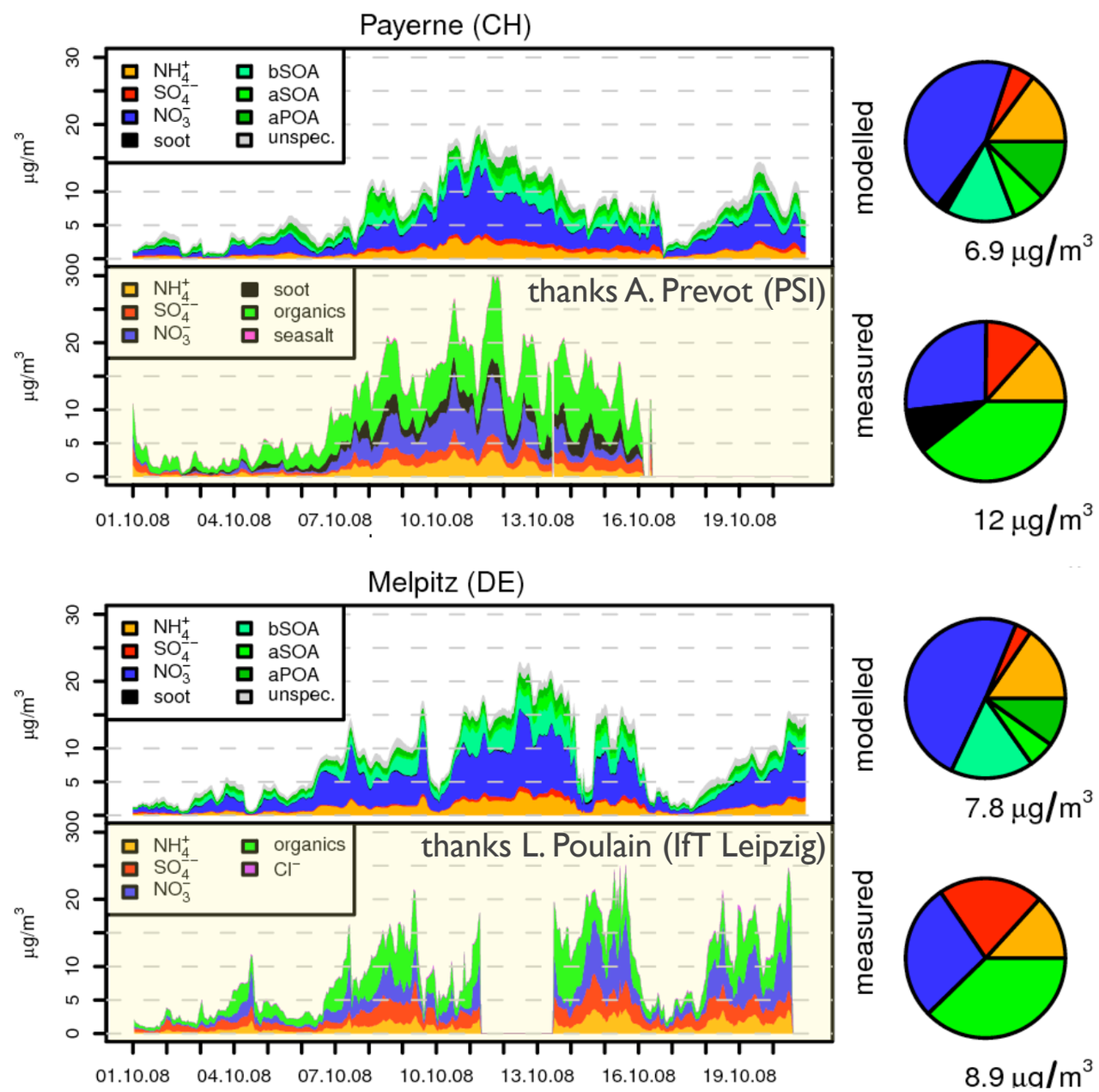
Aerosol chemical composition

peaks are resolved



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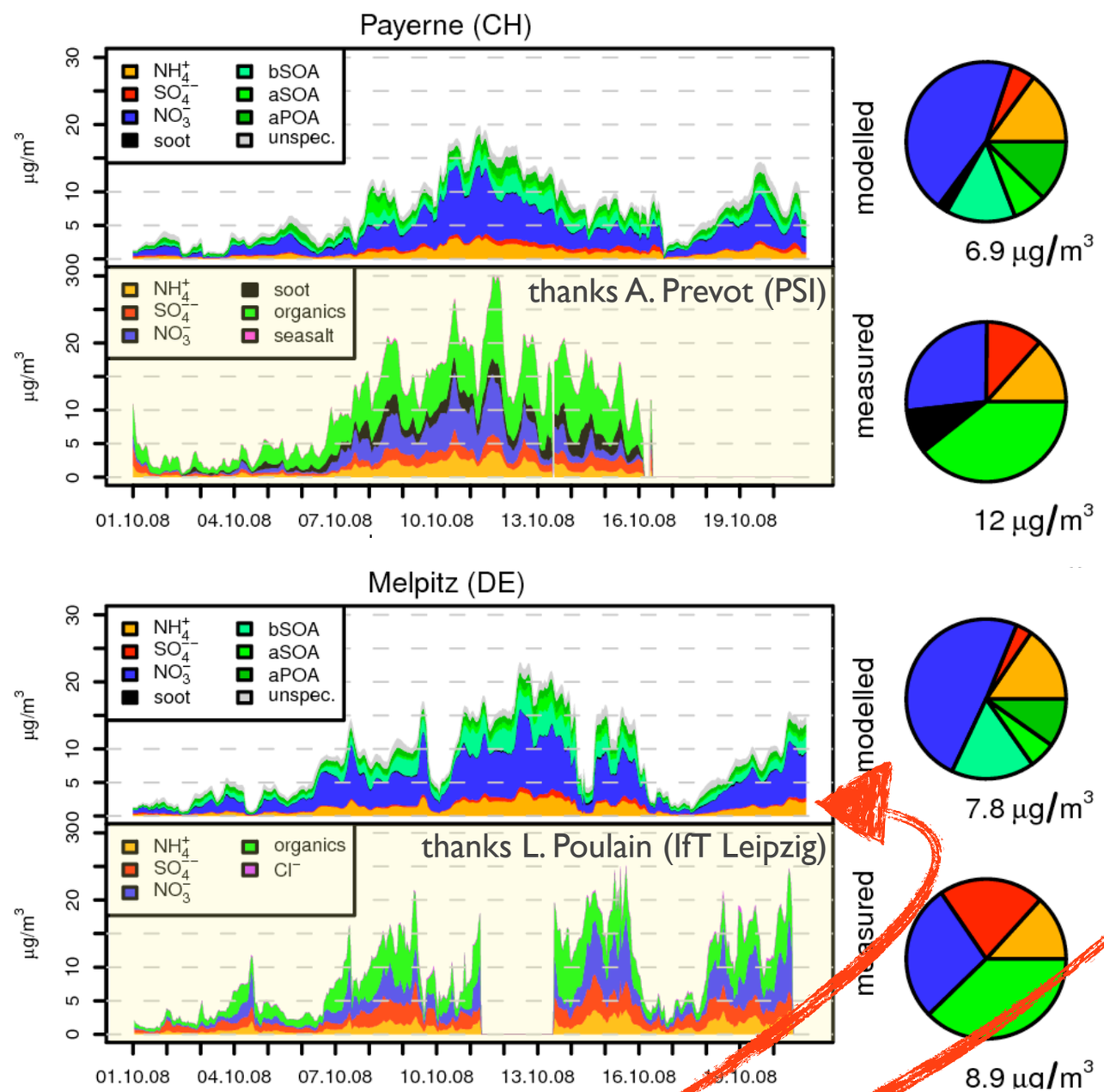

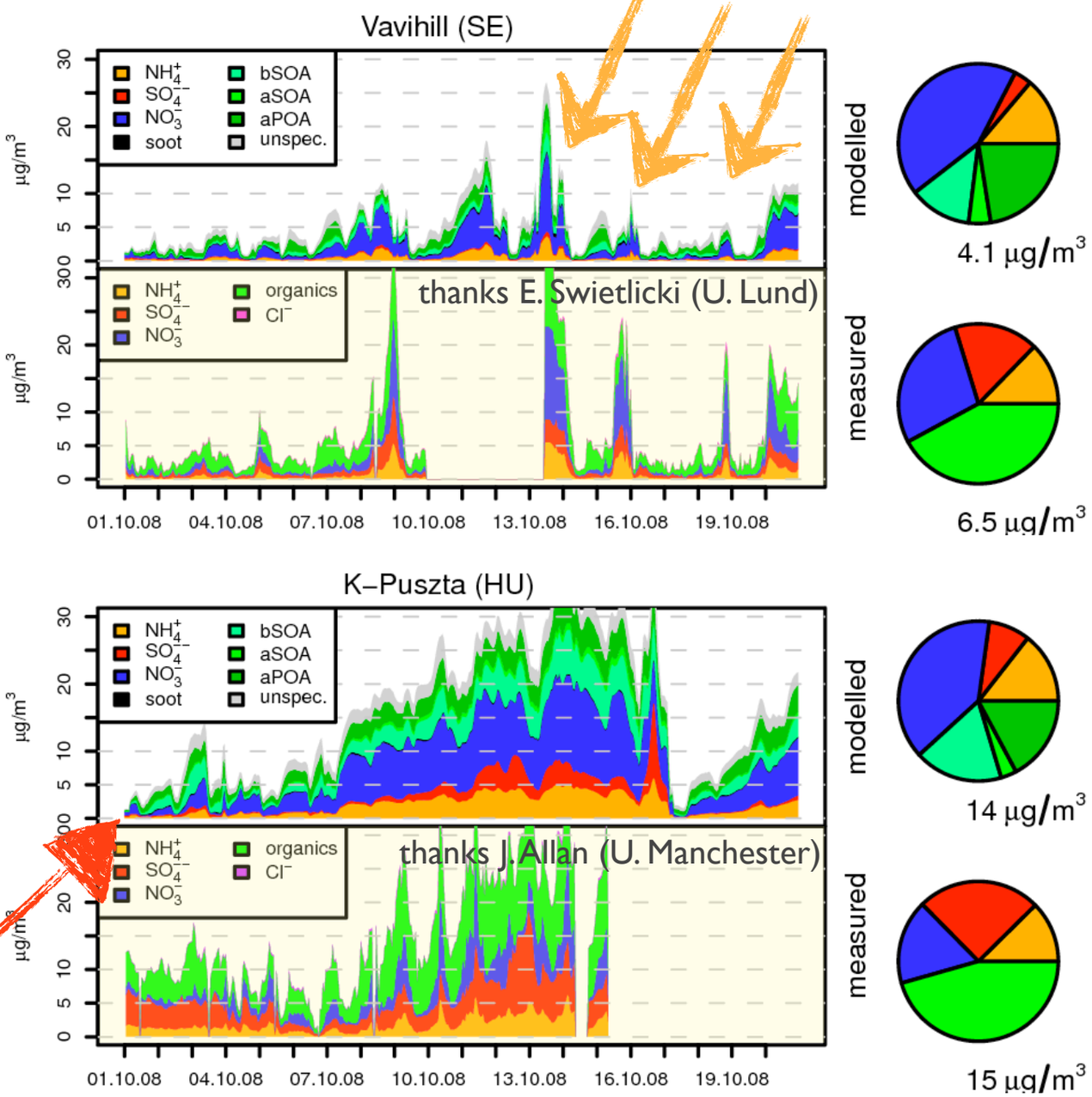

too low sulfate (missing aq.-phase ox. / bd.-conditions)
leads to nitrate overestimation

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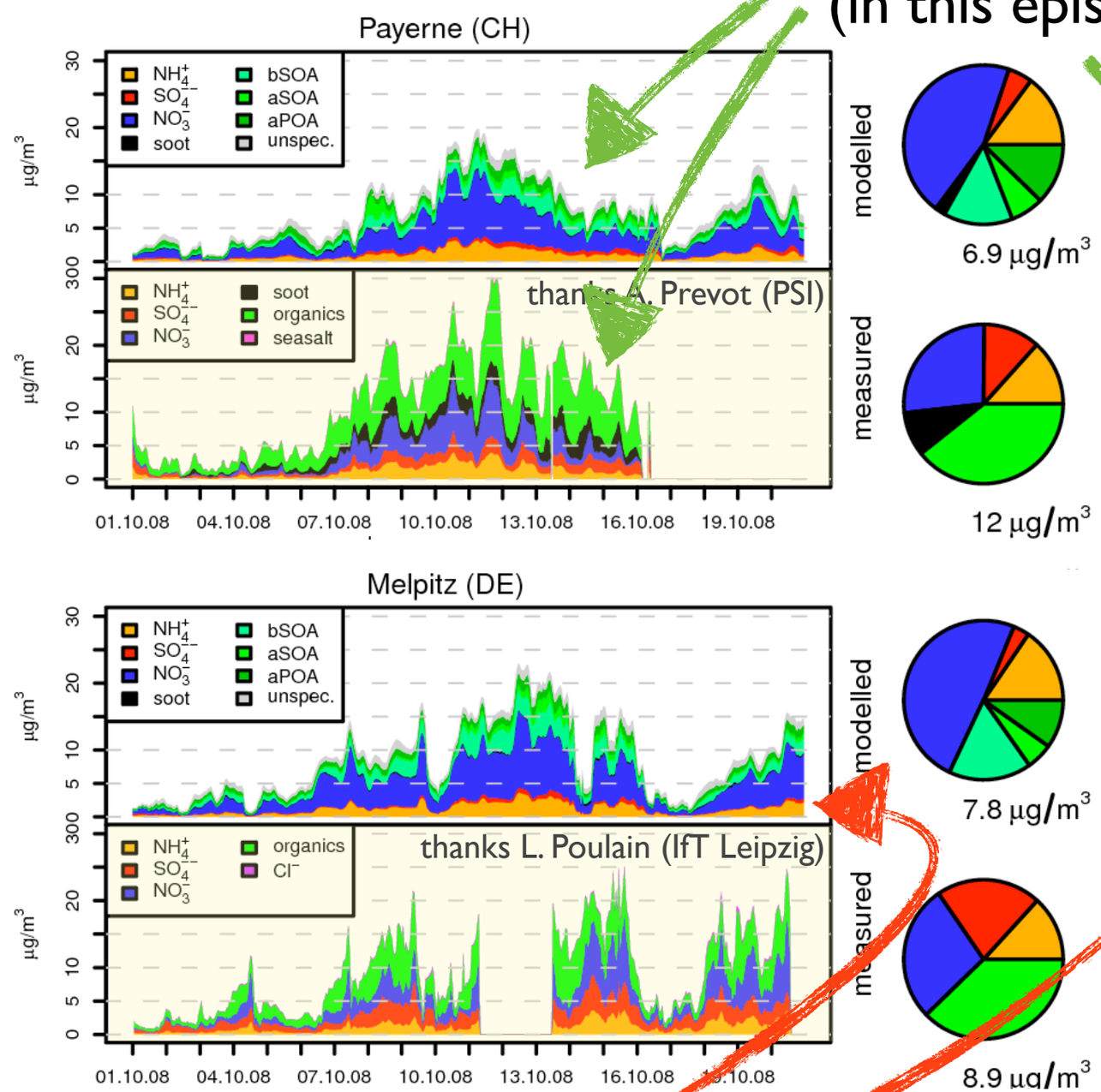
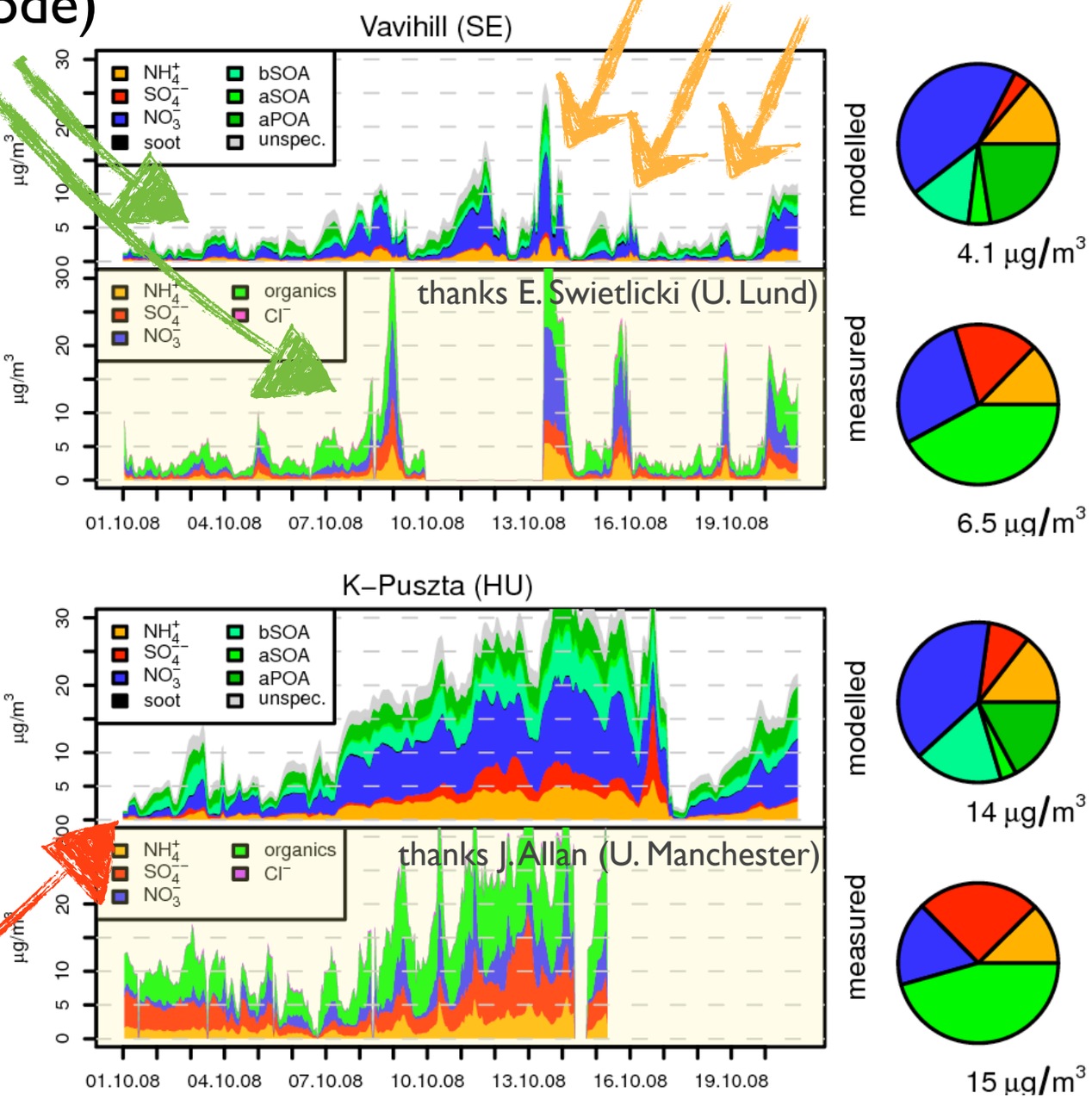
simulated period:
October 2008 (20 days)

Aerosol chemical composition

organics are not the problem
(in this episode)

peaks are resolved





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leads to nitrate overestimation

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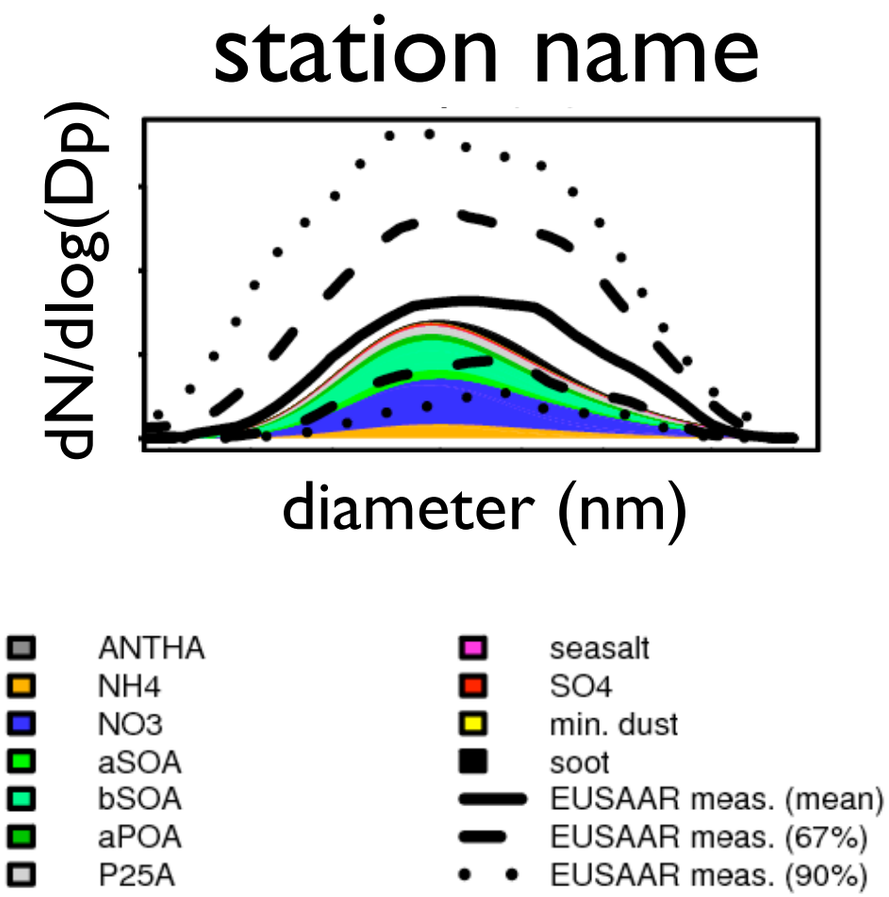
Aerosol size distribution

comparison against
homogenized, statistical number size
distribution dataset for several
European stations

measured:
(Asmi et al, ACPD, 2011)

solid line:
median
dashed lines:
67% of values
dotted lines:
90% of values



modelled:

colored area:
size-resolved
chemical composition
(20 days mean,
sum of all modes)

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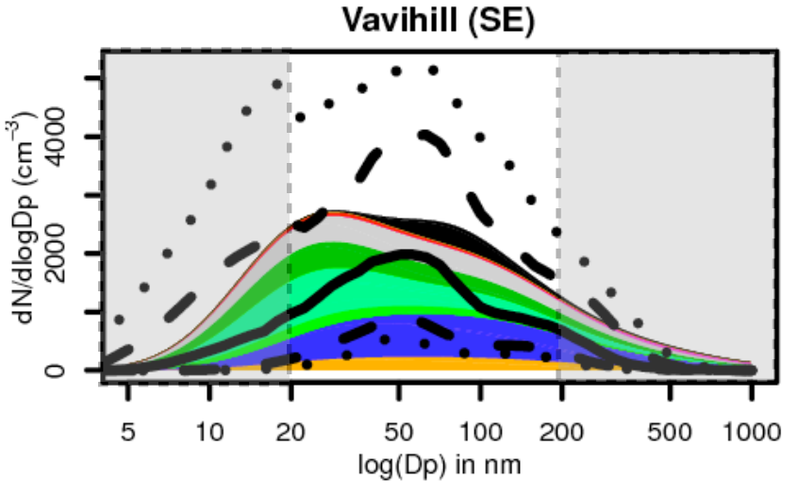
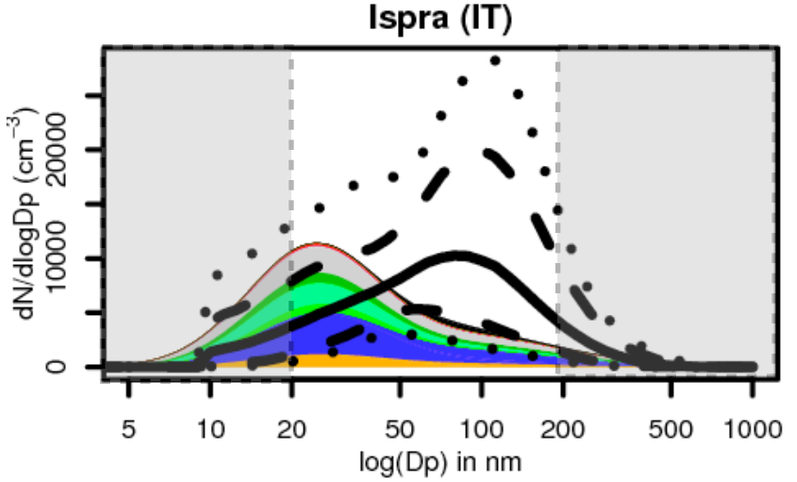
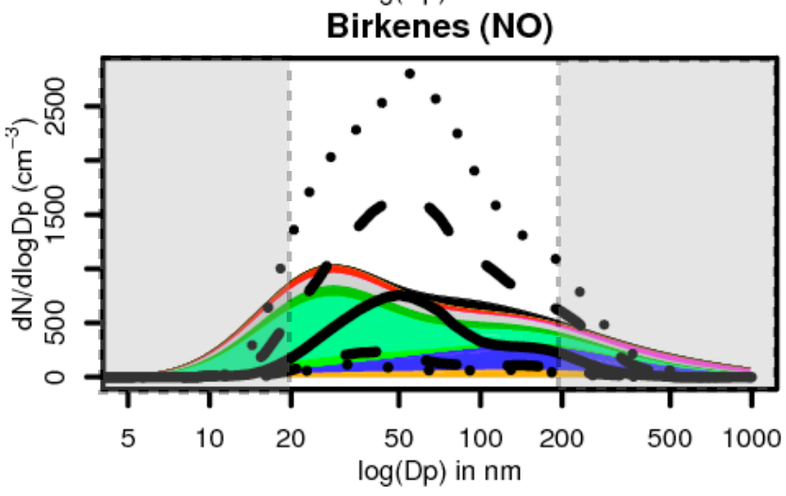
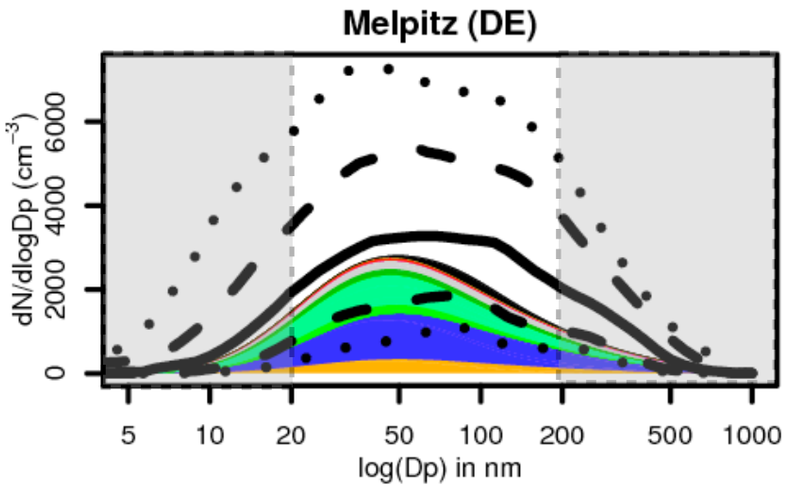
simulated period:
October 2008 (20 days)

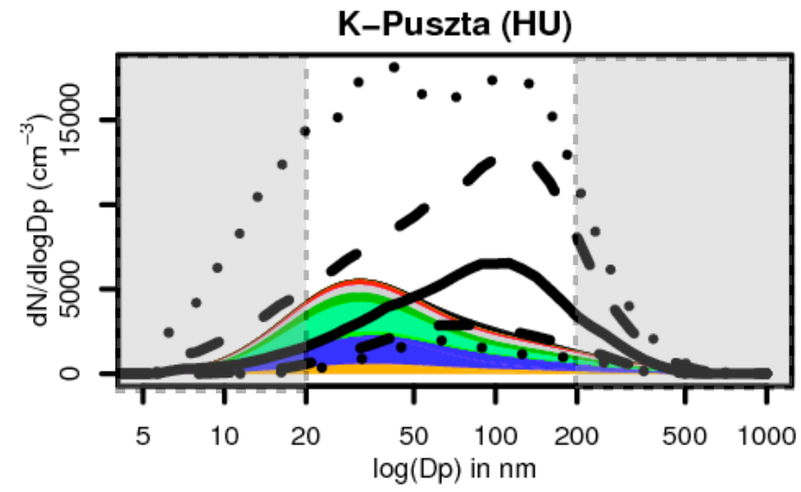
Aerosol size distribution

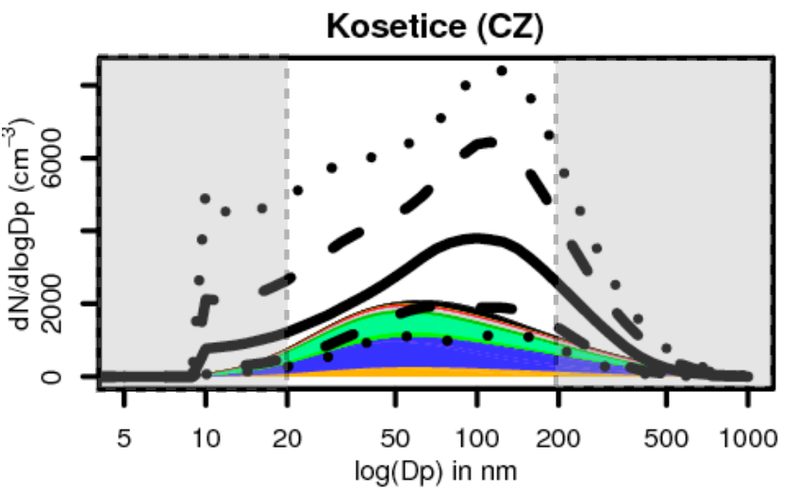


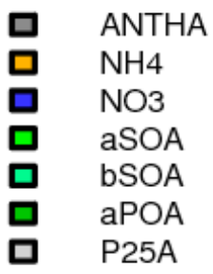


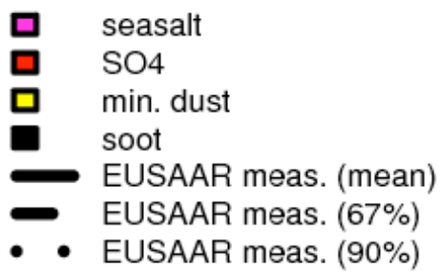


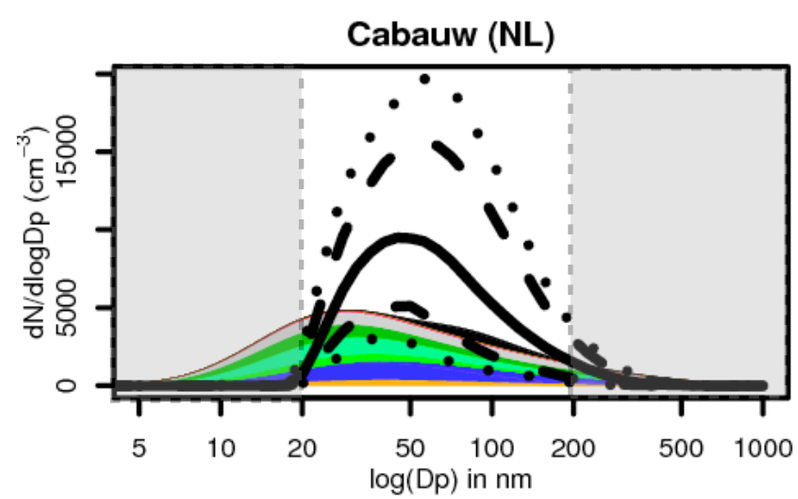












EUSAAR data from Asmi et al., 2011, ACPD

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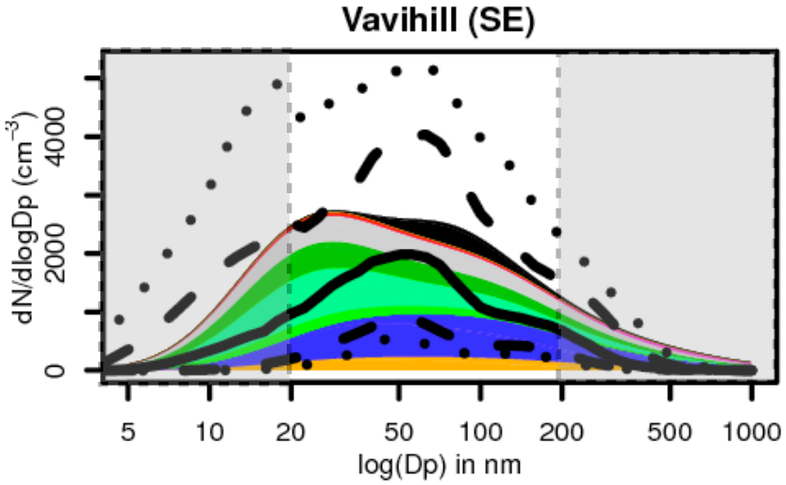

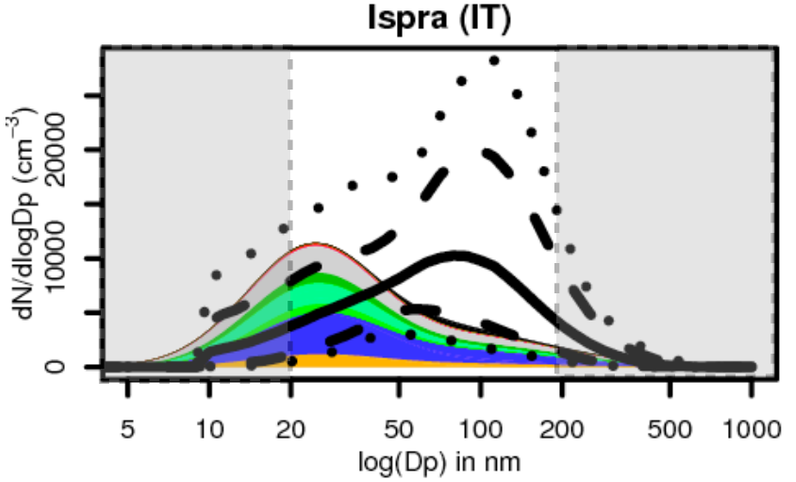

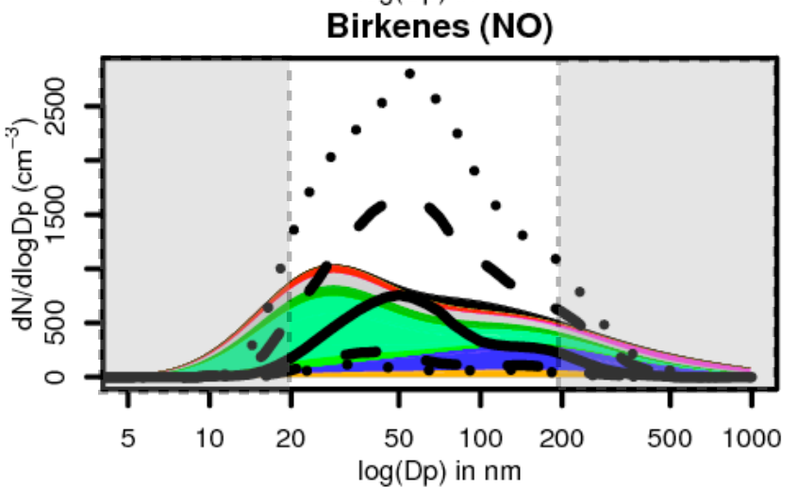

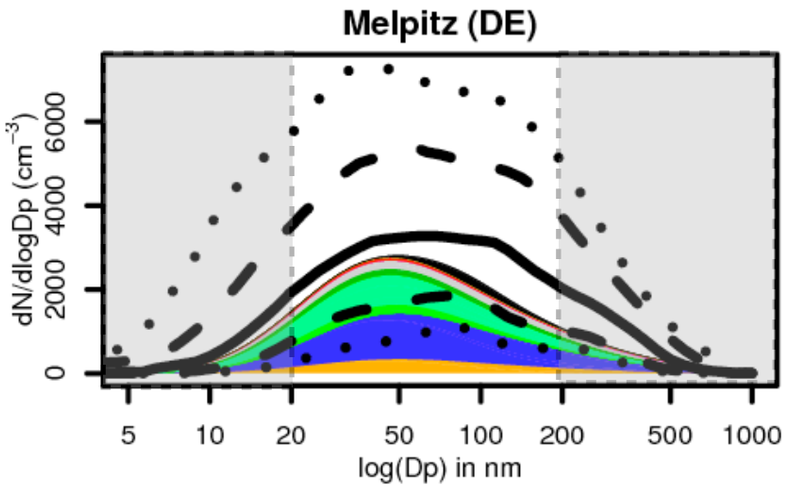

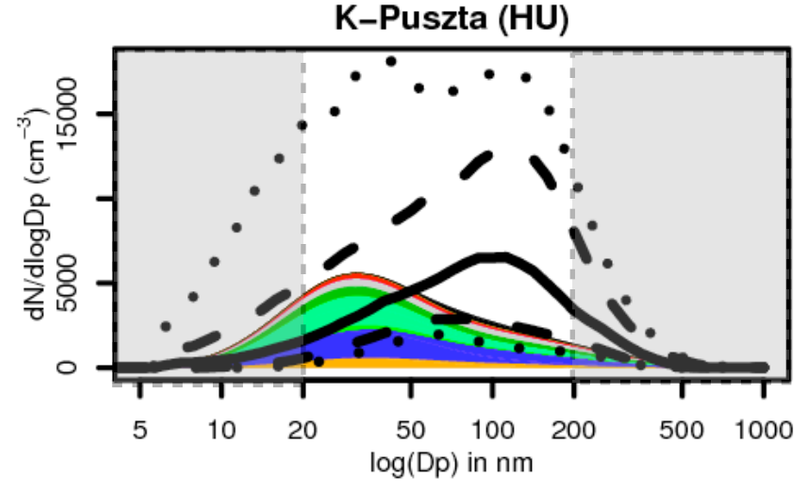

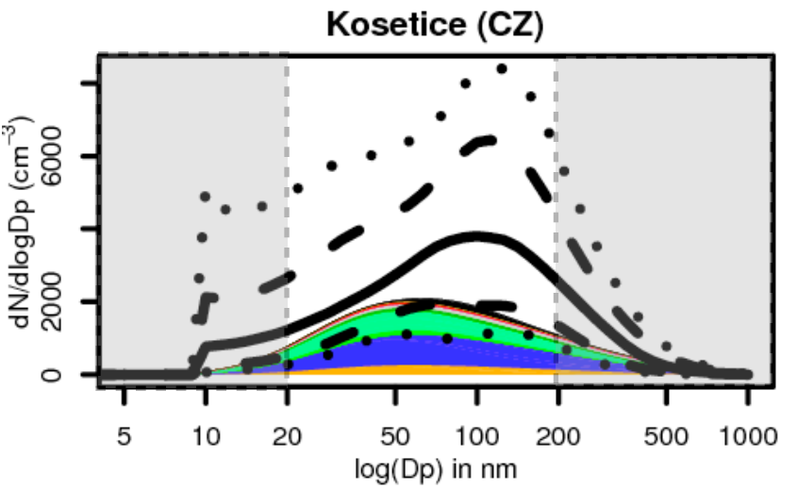

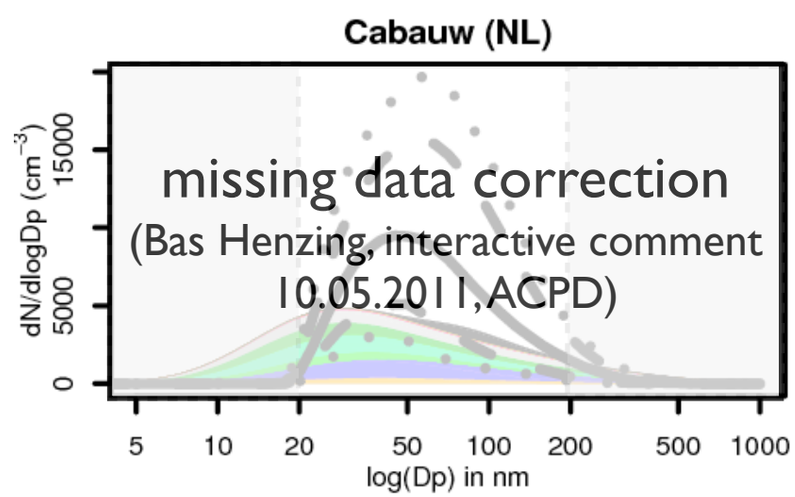

EUSAAR data from Asmi et al., 2011, ACPD

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simulated period:
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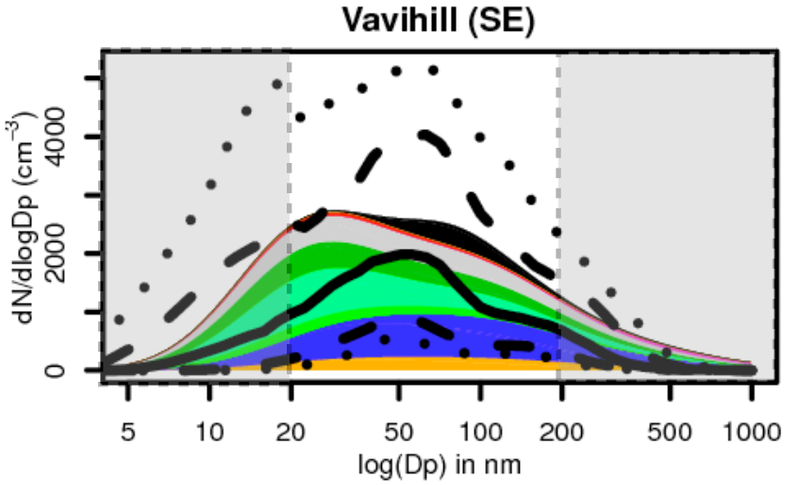
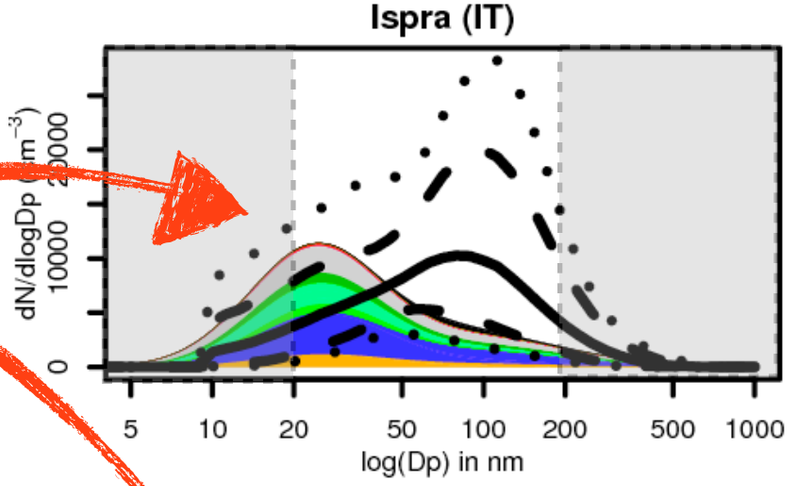
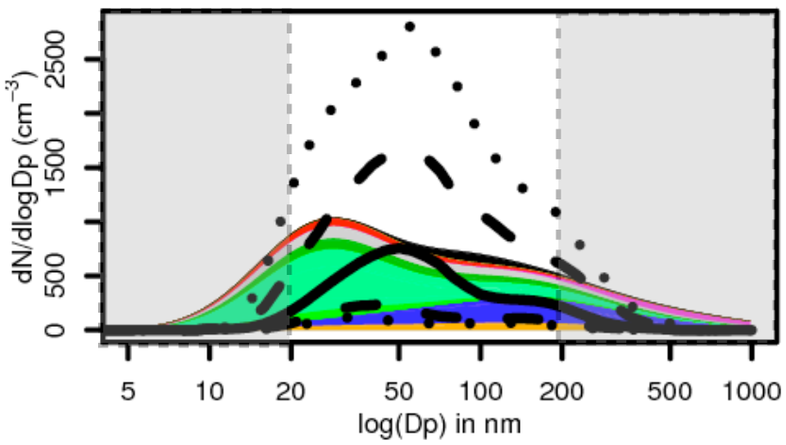
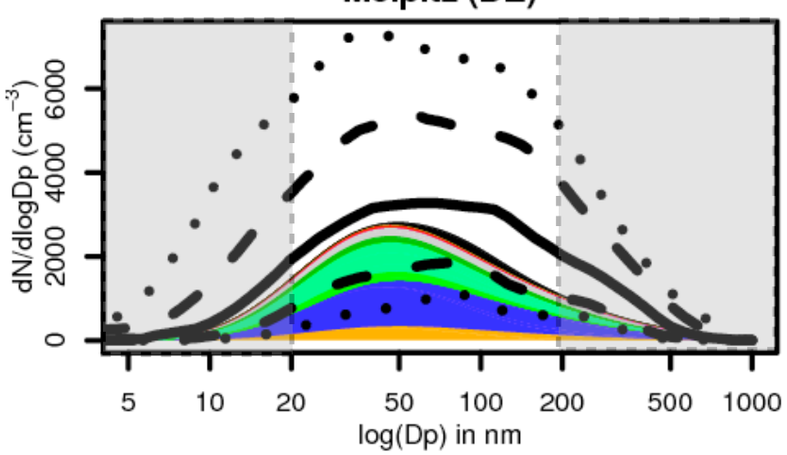
Aerosol size distribution

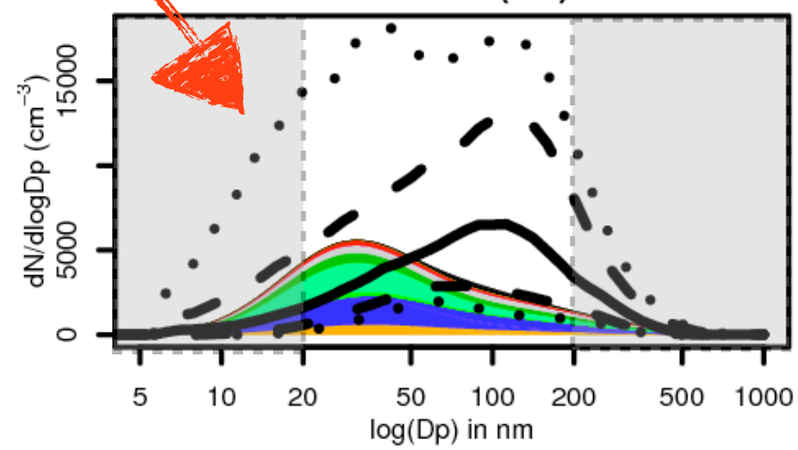
strongly polluted sites.
wrong aging / wrong
emission sizes?

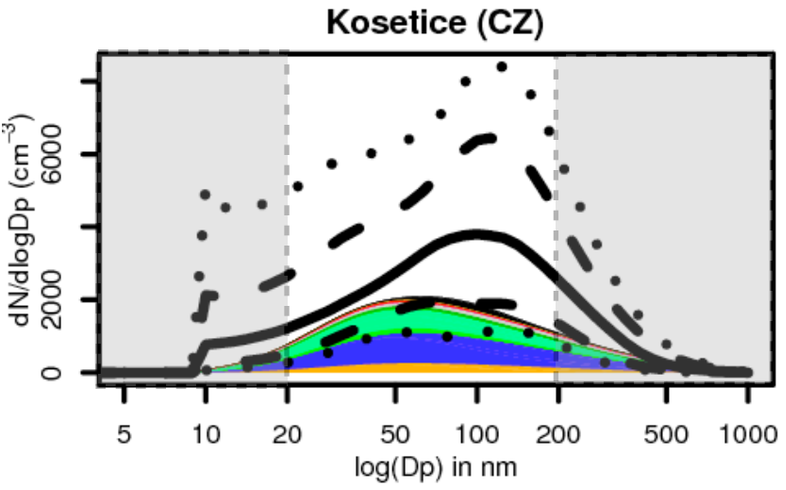


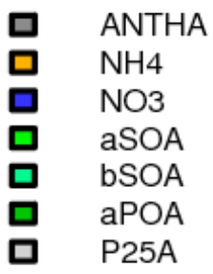


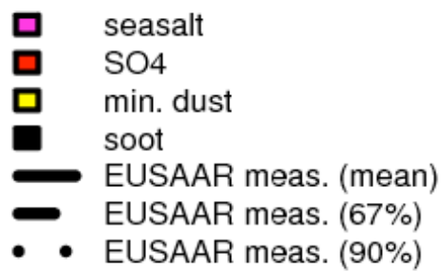


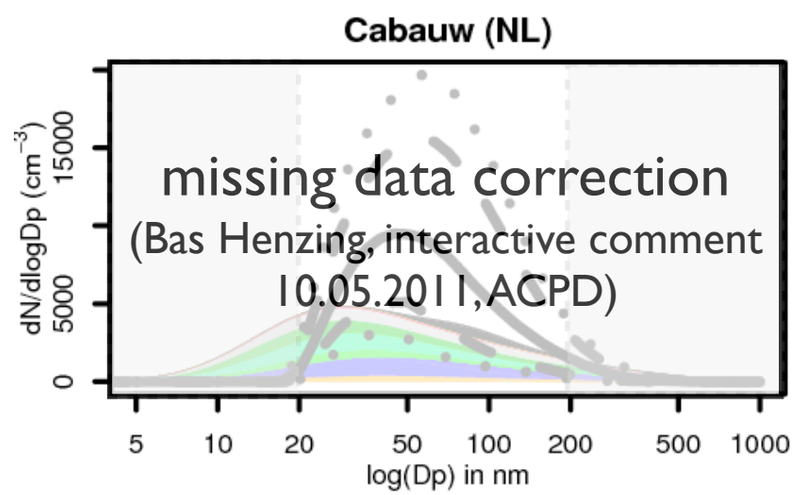












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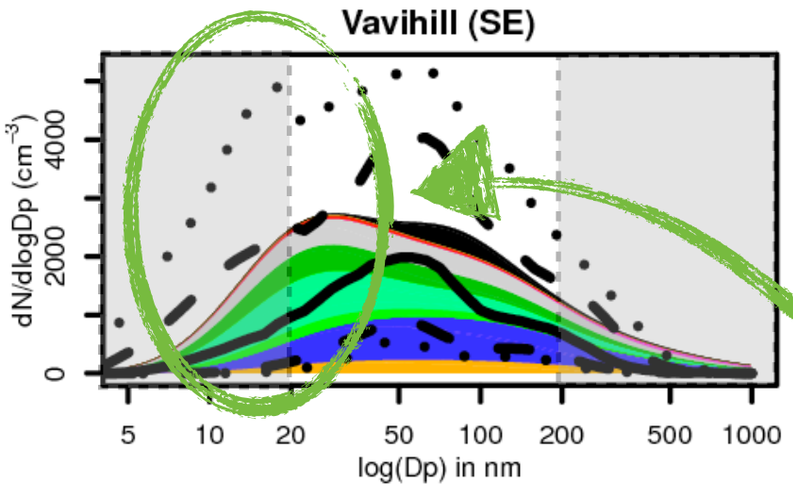
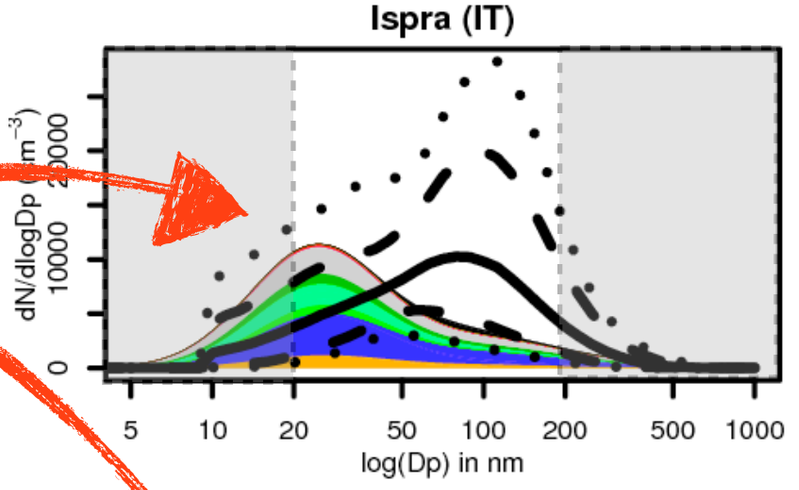
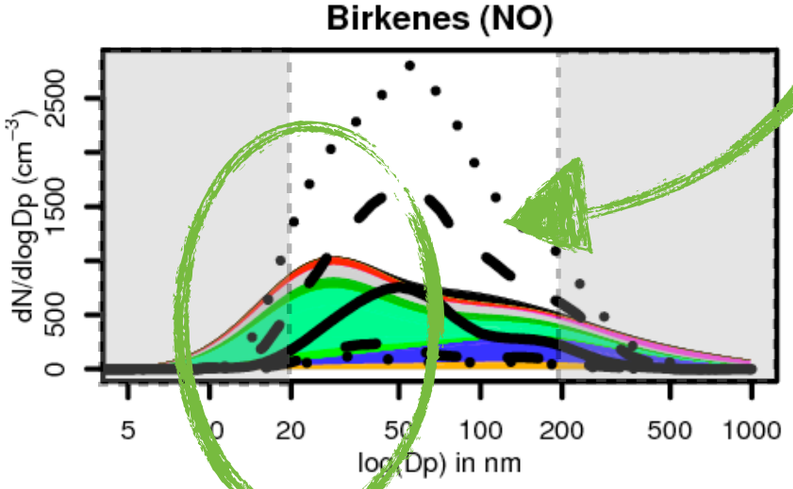
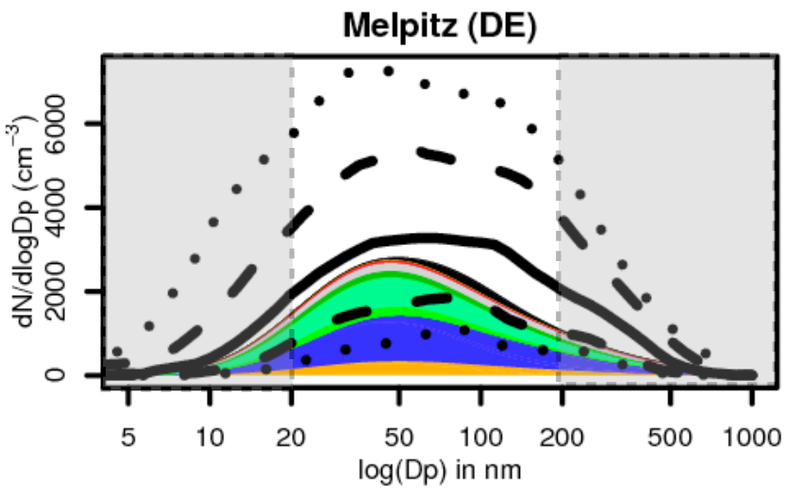
emission sizes?

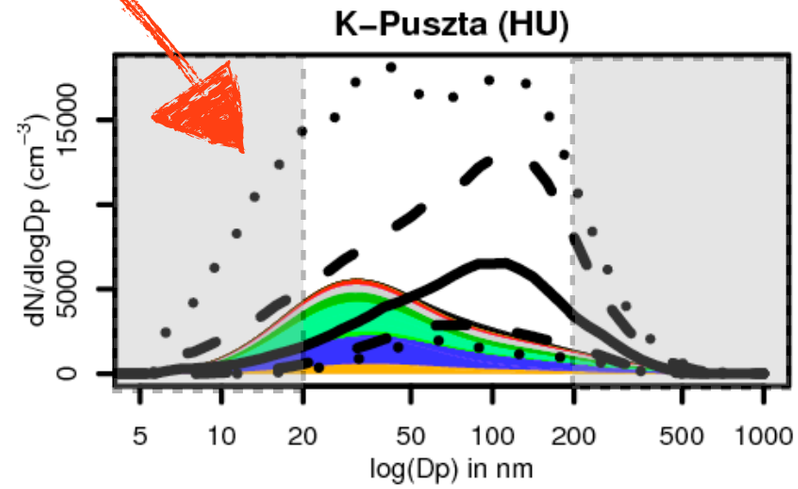
strong bSOA contribution

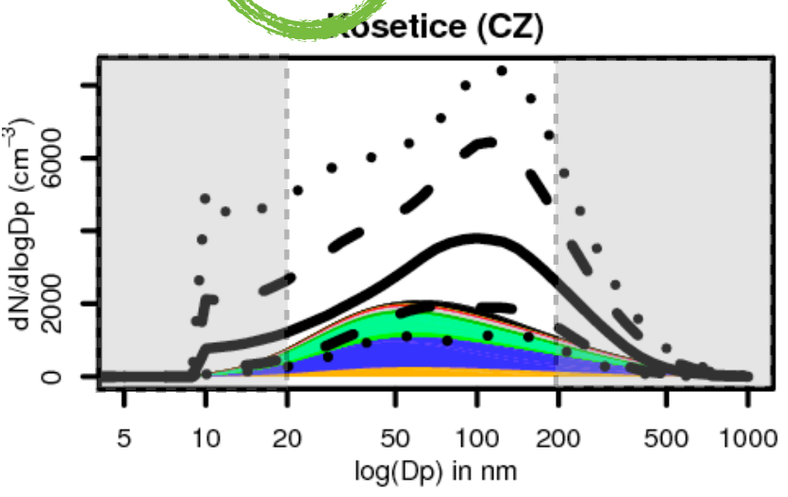


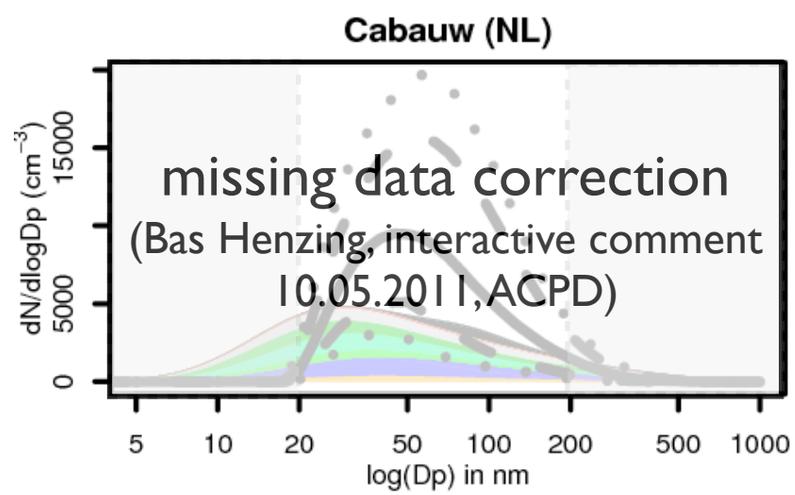












EUSAAR data from Asmi et al., 2011, ACPD

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Conclusions

- newly available datasets from recent projects (EUCAARI/EUSAAR) connected to EMEP are **invaluable for our evaluation**
- our **modeling system can represent complex aerosol characteristics well** during different seasons
- EMEP data helps to **identify model deficiencies** and choose the appropriate measures:
  - inclusion of aqueous-phase chemistry (SO_2 oxidation)
  - improvements on aerosol boundary conditions
- evaluation results allow to **quantify biases in climate feedback simulations** (number of CCN, hygroscopicity, optical properties)

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Thanks for your attention