Norwegian Meteorological Institute

Recent EMEP MSC-W model developments

to improve secondary inorganic aerosols

Presented by Svetlana Tsyro

TFMM 20-th meeting
Madrid, May 7-9, 2019

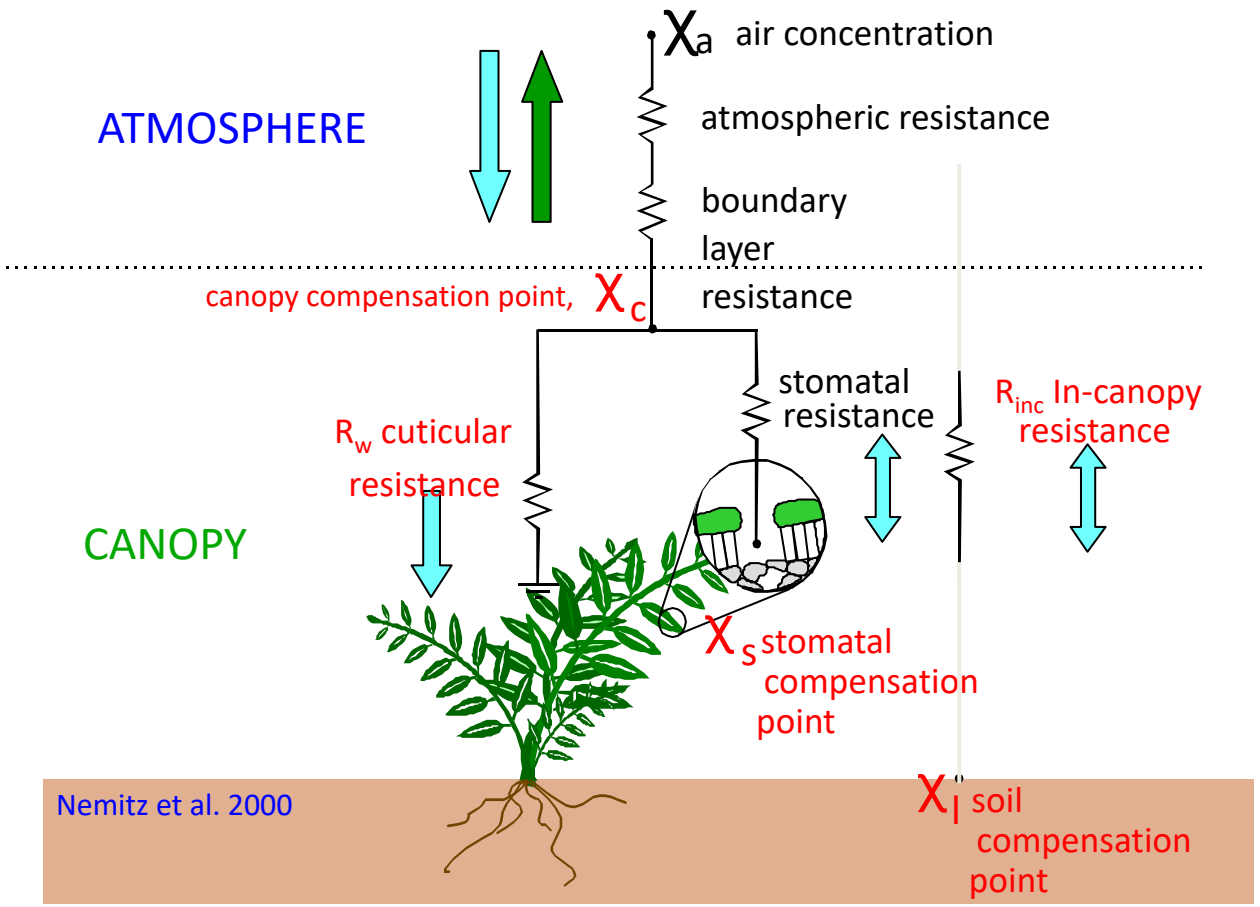
Recent and ongoing activities (which should be) contributing to SIA improvement

- **Finer model resolution:** 0.1x0.1° and 50m lowest layer
- **Finer resolution of national emissions** : 0.1x0.1°
- **Bi Directional Ammonia fluxes** (David Simpson in cooperation with TNO)
- **EQSAM4clim -** new thermodynamic equilibrium model

Norwegian Meteorological Institute

Bi-Directional exchange of NH_3

David Simpson & Roy Wichink Kruit

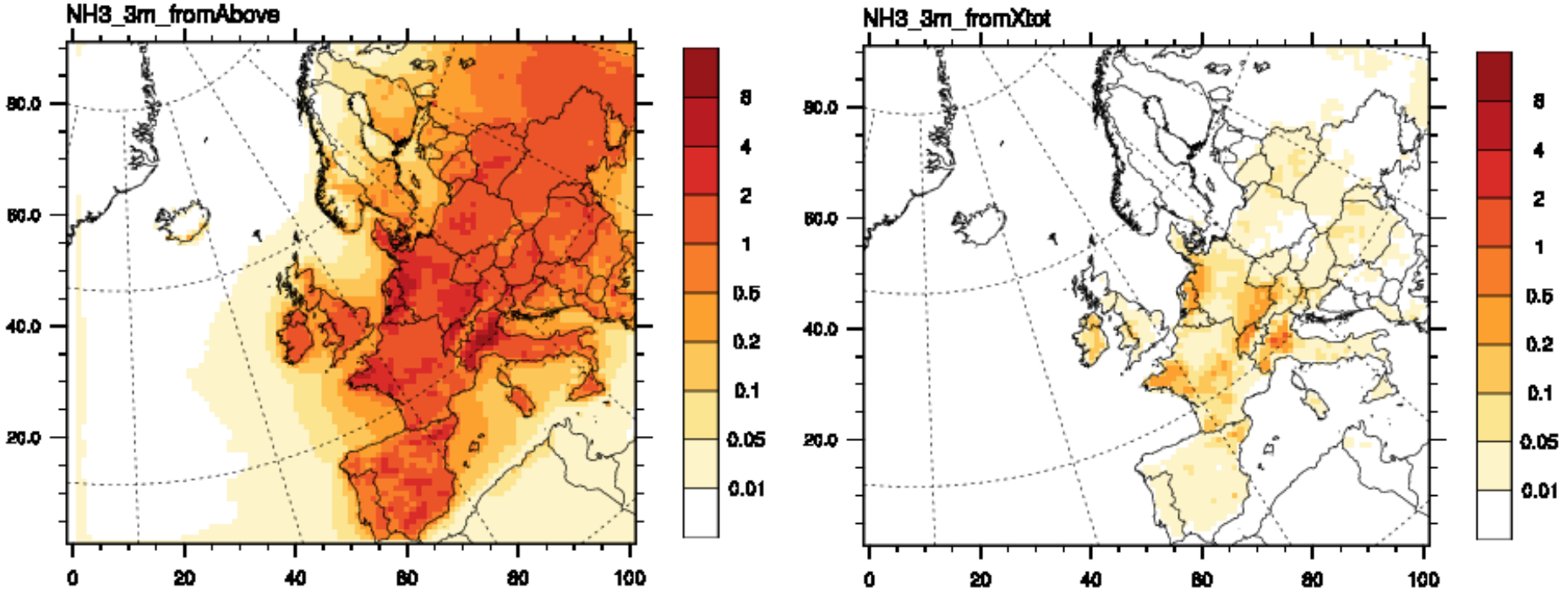


Norwegian Meteorological Institute

Towards Bi-Directional NH_3

On-going work:

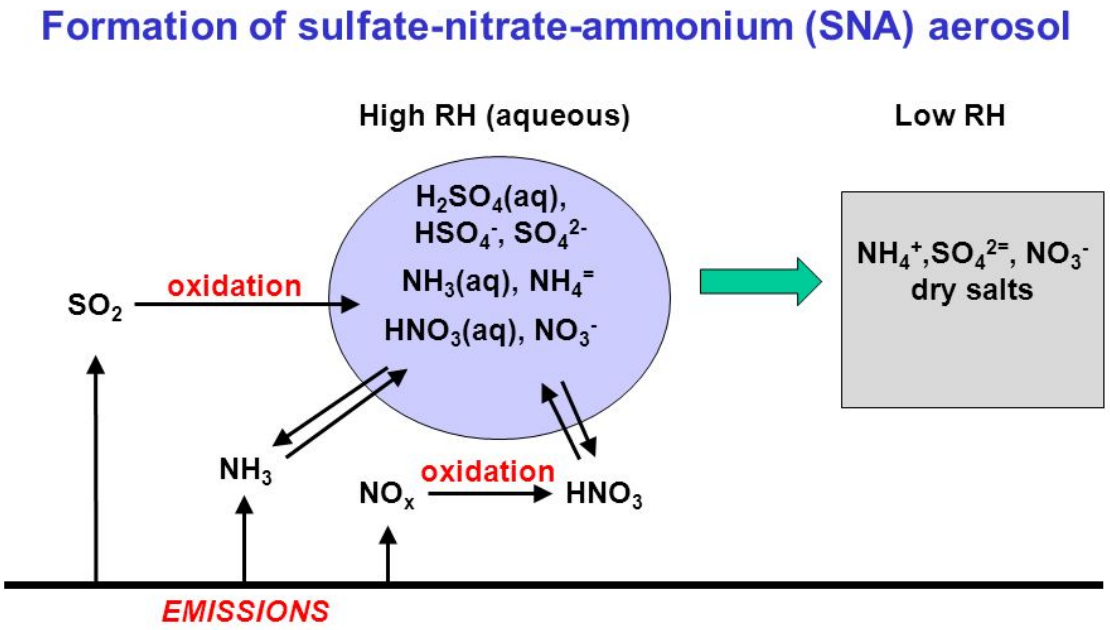
NH3 contributions, from ’above’ (left) and ’below’ (right)



Courtesy of David Simpson & Roy Wichink Kruit

Norwegian Meteorological Institute

SIA formation & Gas-aerosol partitioning



- Uptake of NH_3 and HNO_3 by sulfate aerosol follows thermodynamics
- This uptake affects the mass and phase of the aerosol

Thermodynamic equilibrium schemes for sulphate-nitrate-ammonium-water system

«Old» EMEP scheme: $(NH_4)_{1.5}\,SO_4$, simplified Kp = f(Rh, T)

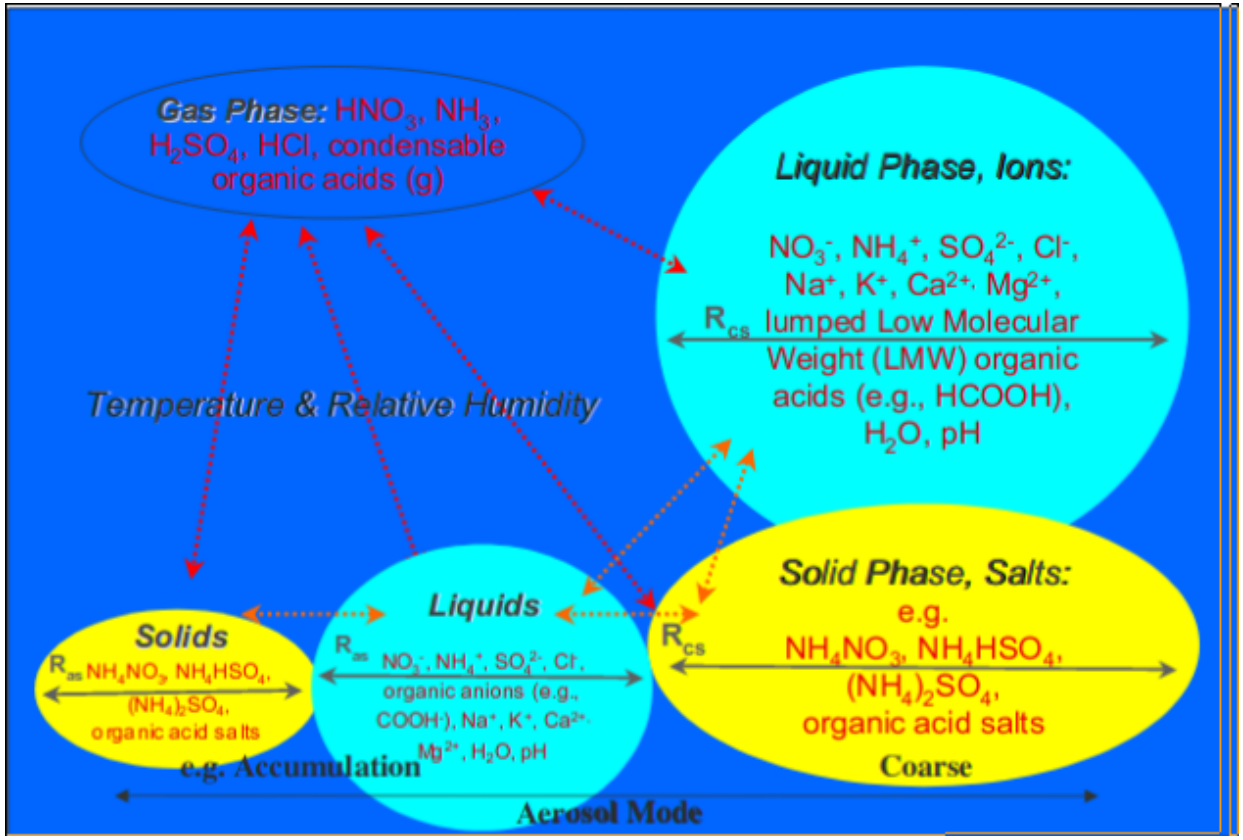
MARS (ARES): two regimes for NH_4 /SO_4, metastable aqueous aerosol

EQSAM-3: parameterized version of ISORROPIA

EQSAM4clim: most recent version

Norwegian Meteorological Institute

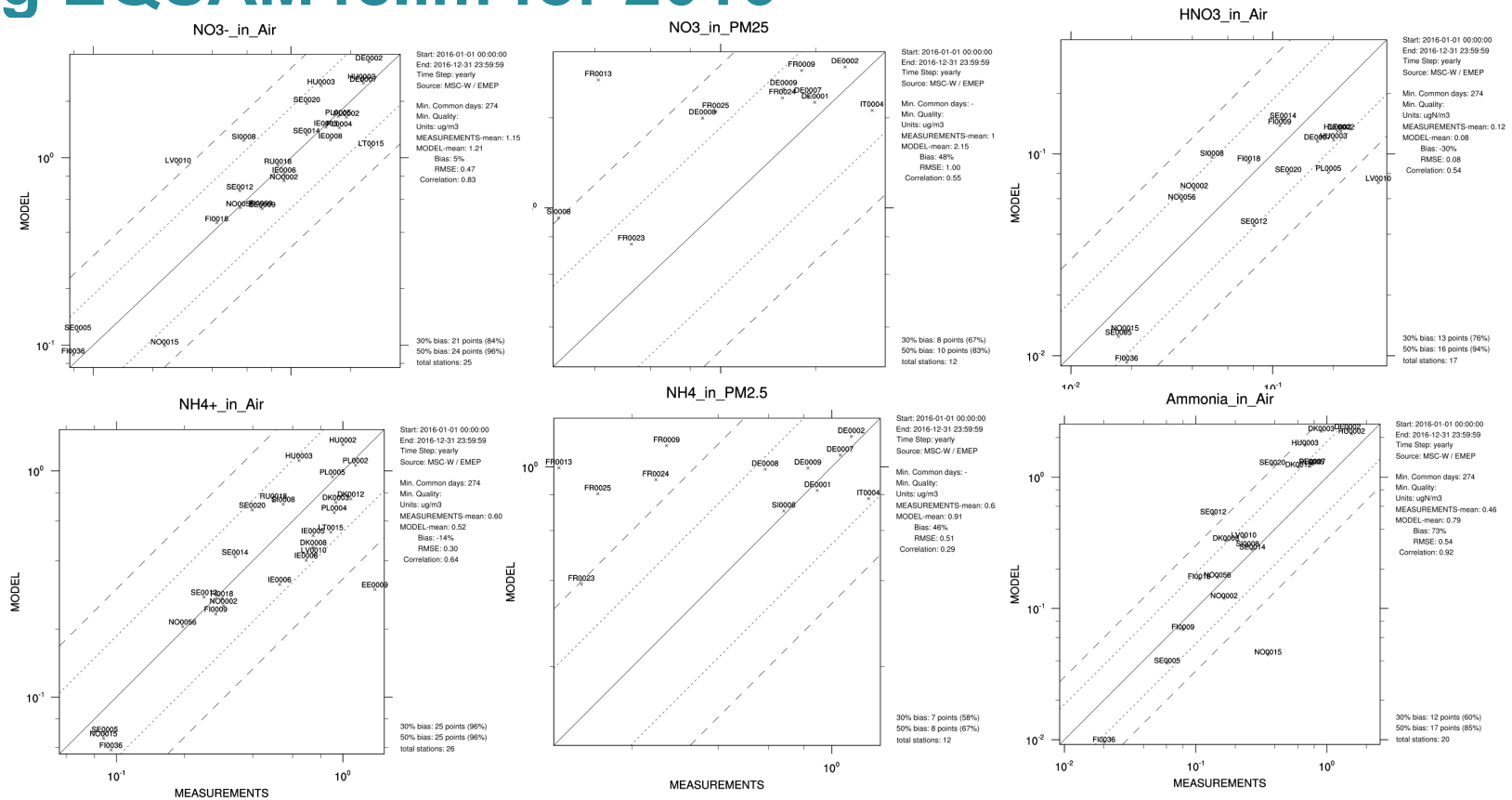
EQSAM4clim



Implemented in the EMEP MSC-W model, in close cooperation with Swen Metzger (www.researchconcepts.io, www.eco-serve.de)

Thoroughly compared against ISORROPIA, evaluated with in-situ and satellite observations (AOD) on global scale (Metzger et al., ACP (2018, 2016, 2012, 2006)

Testing EQSAM4clim for 2016

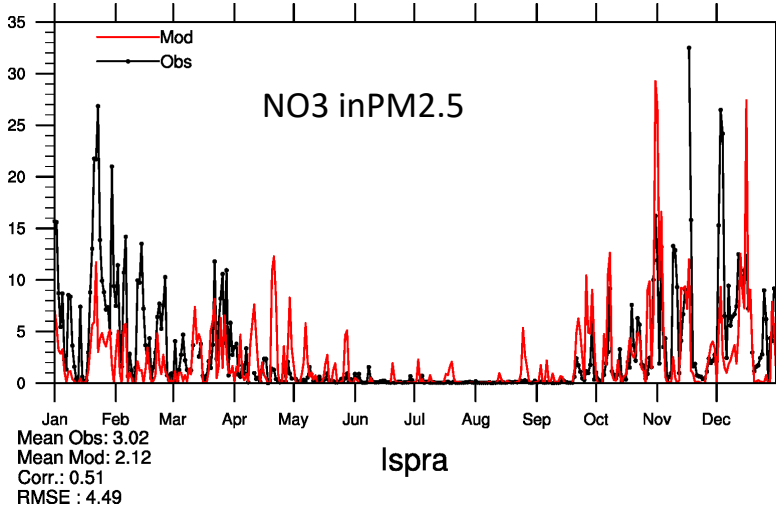


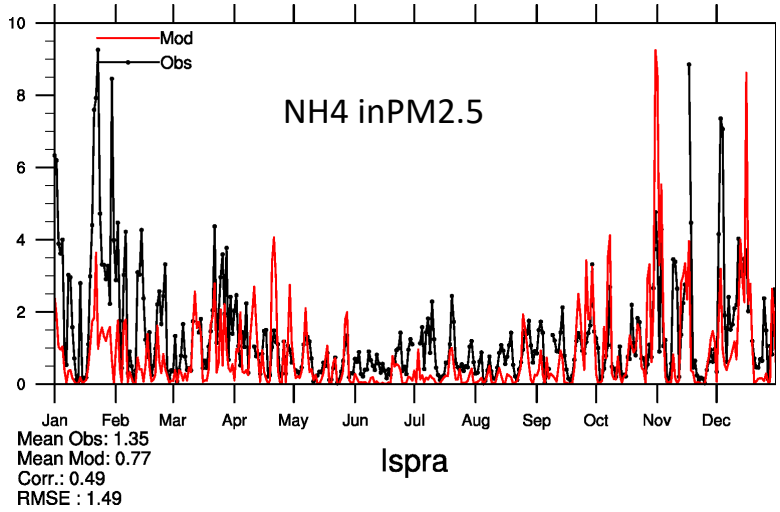
	NO3			NH4			HNO3	NH3	PM10	PM2.5
	Bias-y	R-y	IOA-yd	Bias-y	R-y	IOA-yd	Bias-y (%)			
MARS	9 %	0.82	0.89	-12 %	0.65	0.80	-22	66	-17	-14
Eq4clim	5 %	0.83	0.90	-14 %	0.64	0.79	-30	73	-24	-20
Rep18	13 %	0.83	0.90	-11 %	0.65	0.80	-31	68	-22	-18

y – yearly, d - daily

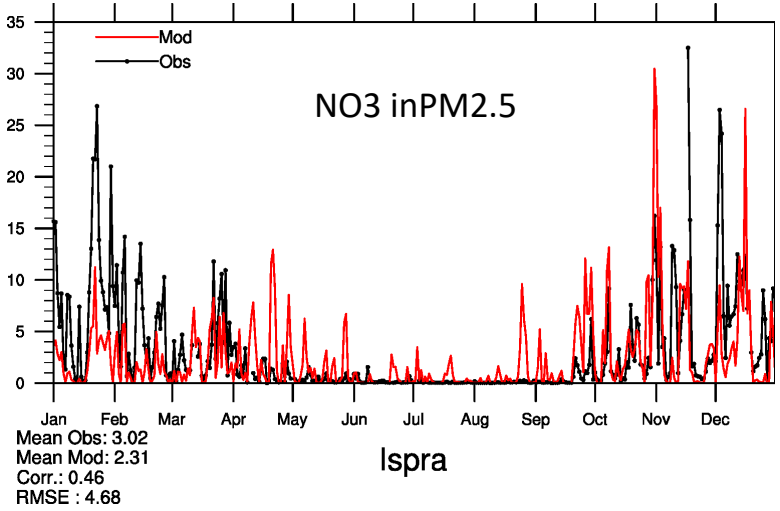
Meteorological Institute

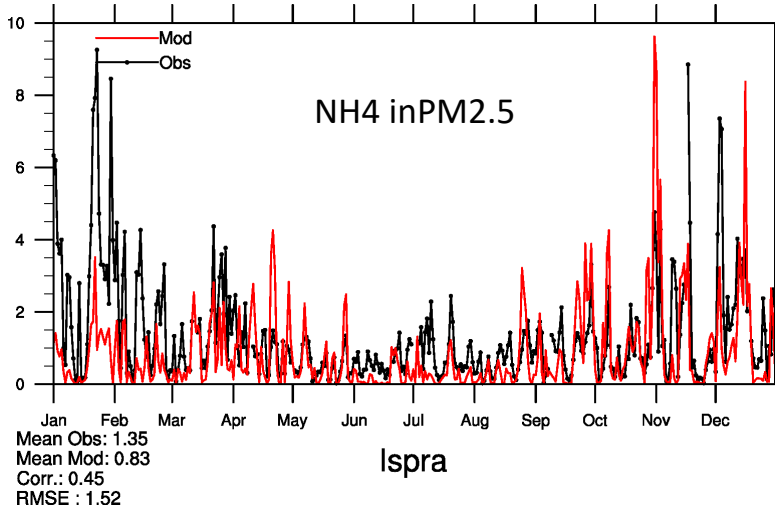
EQSAM4clim





MARS





Norwegian Meteorological Institute

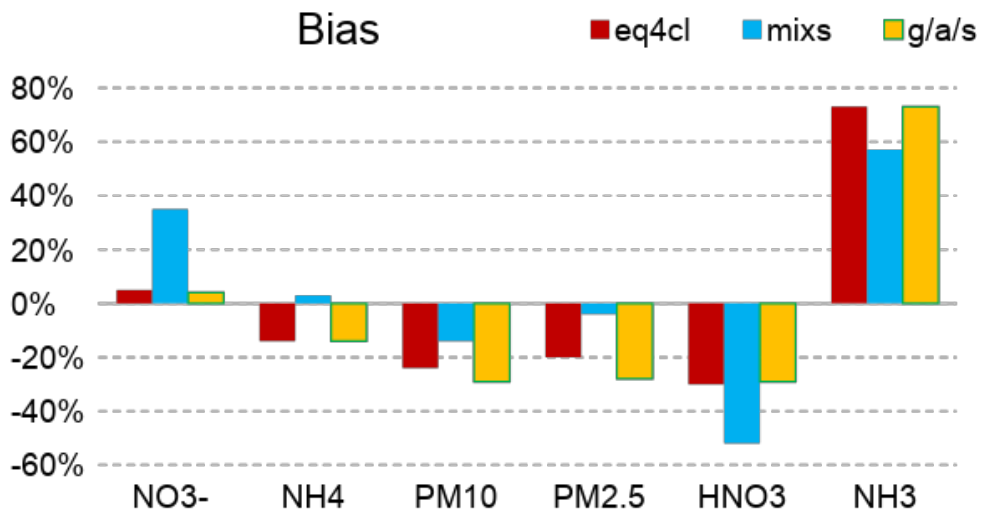
NO_3^- in $PM_{2.5}$

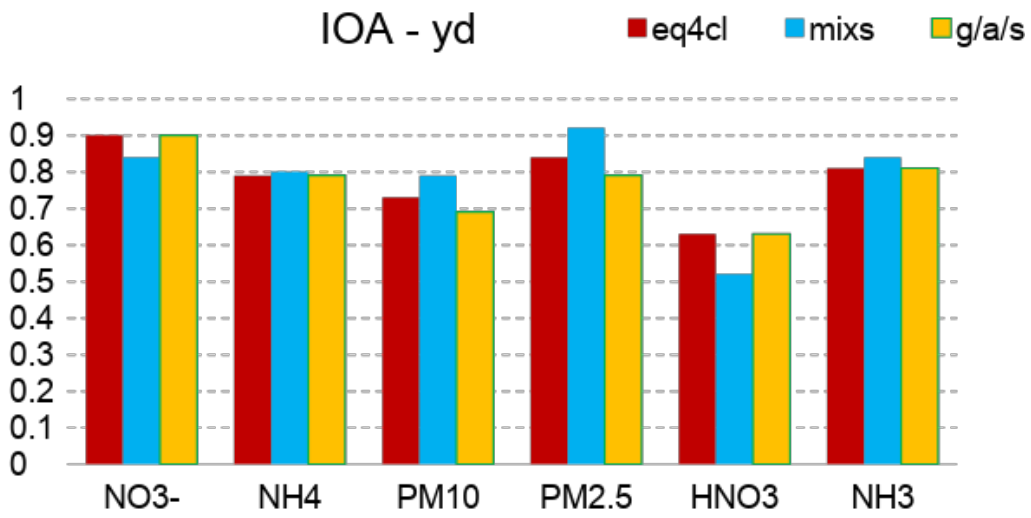
	OBS	eq4cl	mars	R eq4cl	R mars
DE01	**1.99**	**2.25**	2.44	**0.39**	0.34
DE02	**2.48**	**2.95**	3.13	**0.49**	0.46
DE08	**1.58**	**2.50**	2.69	**0.41**	0.37
FR09	**1.81**	**2.88**	2.97	**0.23**	0.20
FR24	**1.57**	**2.33**	2.44	**0.46**	0.46
SI08	**0.31**	**0.93**	0.93	**0.49**	0.48

Similarly, some improvement is found for NH_4^+ in $PM_{2.5}$

Norwegian Meteorological Institute

EQSAM4clim: testing setups





EQSAM4clim allows flexibility wrt included processes and gas/aerosol components (cations and anions) and variable degree of complexity..

Ideally, all major cation/anions should be included for best result

Presently, base cations from mineral dust are not accounted for

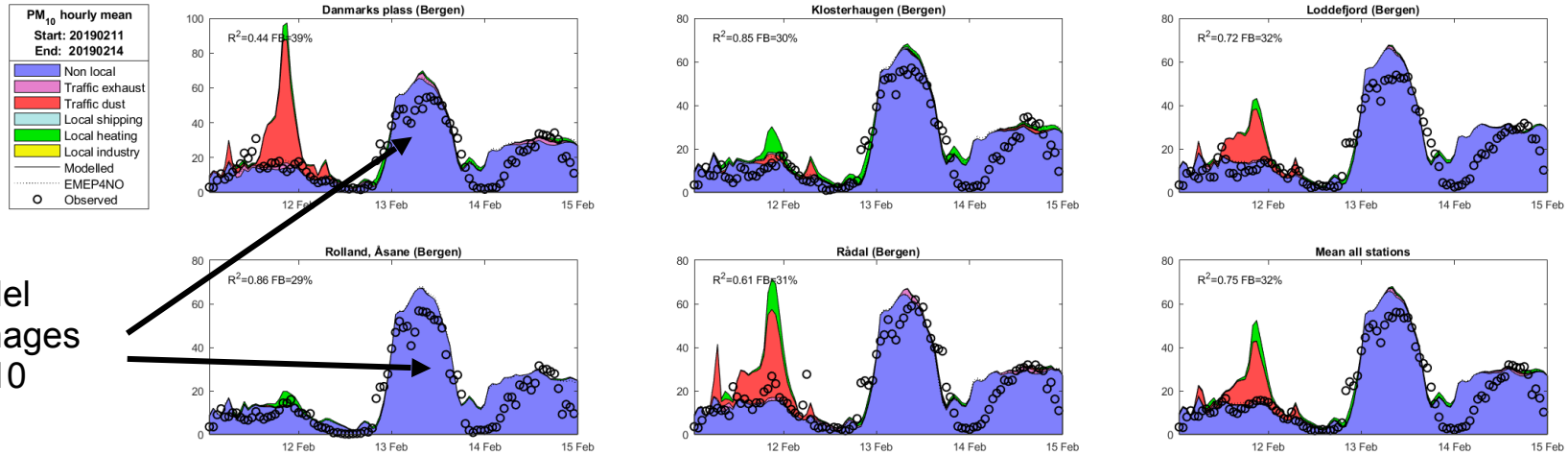
eq4cl – metastable aqueous aerosols, gas/aerosol partitioning (as in MARS)

mixs – equil. dissociation constant Kp for NH_4NO_3 not only f(RH, T), but also f(composition): decreases with increasing $(NH_4)_2SO_4$) content

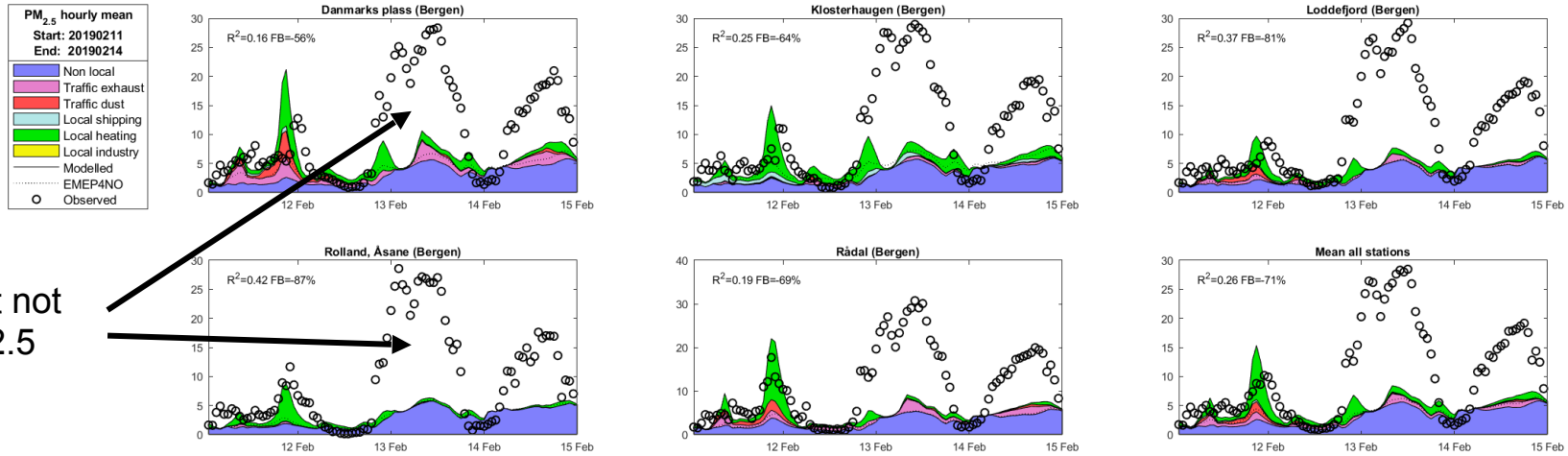
g/a/s – full gas/aerosol/solid equilibrium

Norwegian Meteorological Institute

PM episode due to sea salt in Bergen (Norwegian west coast) 13.02.2019



Model manages PM10

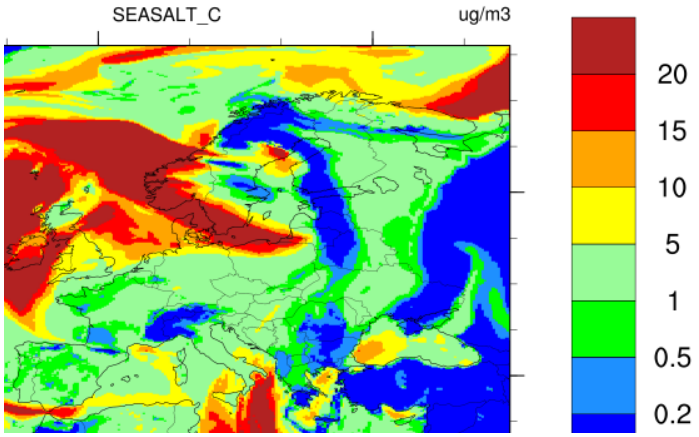


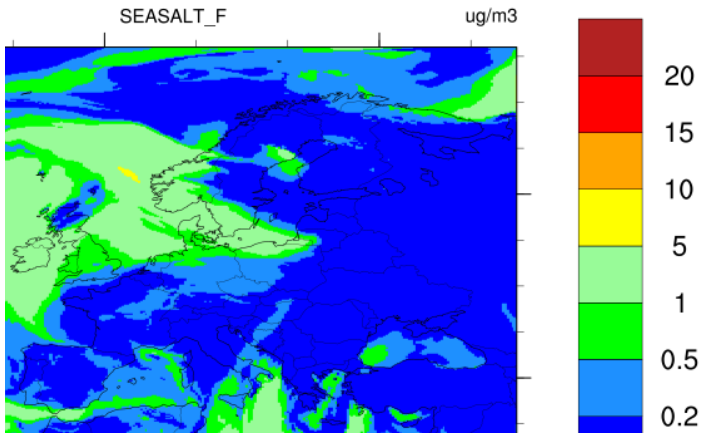
..but not PM2.5

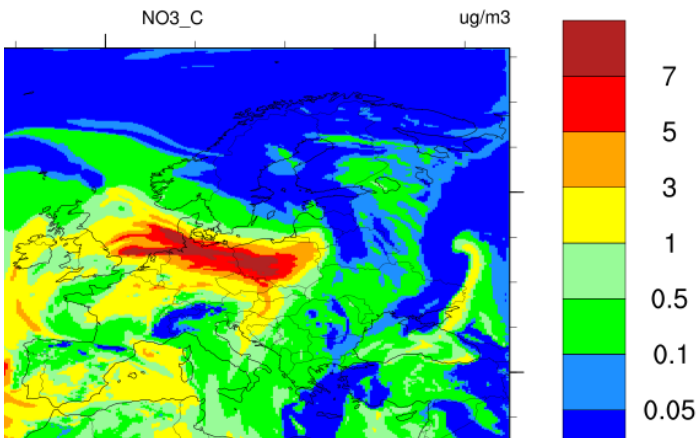
Norwegian Meteorological Institute

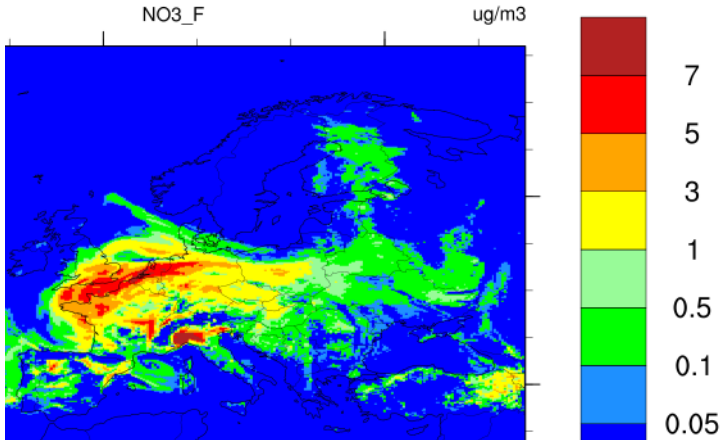
PM episode in Bergen (Norwegian west coast) 13.02.2019

air quality forecast using MARS









Coarse NO_3 ($NaNO_3$) formation, but not $NaNO_3$ on fine sea salt

Also Na_2SO_4 is formed (actually preferential wrt $(NH_4)_2SO_4$)

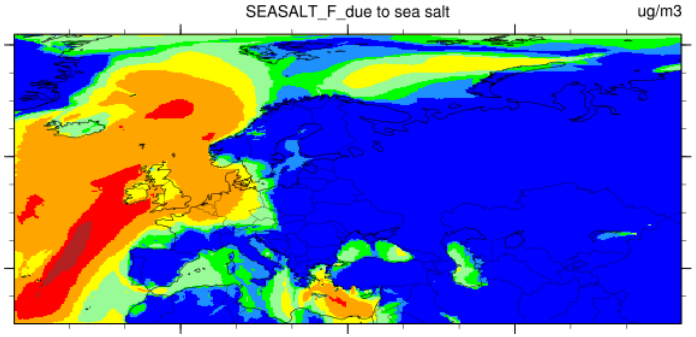
Could this (partly) explain the model failure????

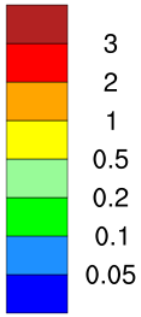
Norwegian Meteorological Institute

EQSAM4clim

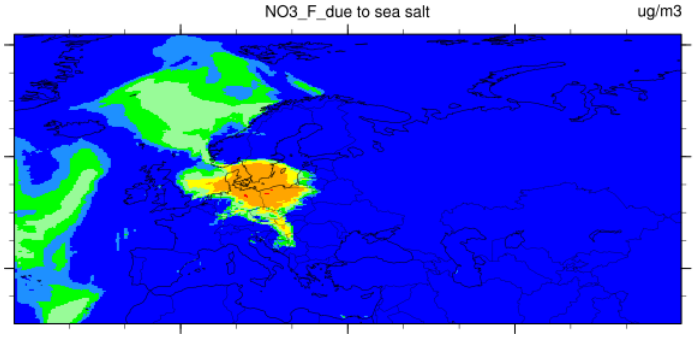
Formation of fine NO_3^+ due to fine sea salt

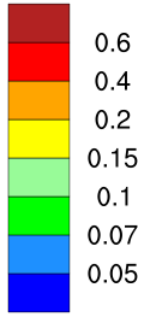
Sea salt

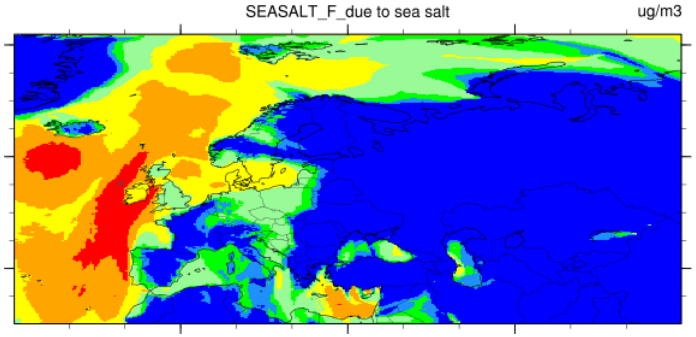


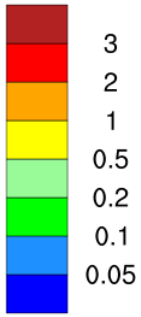


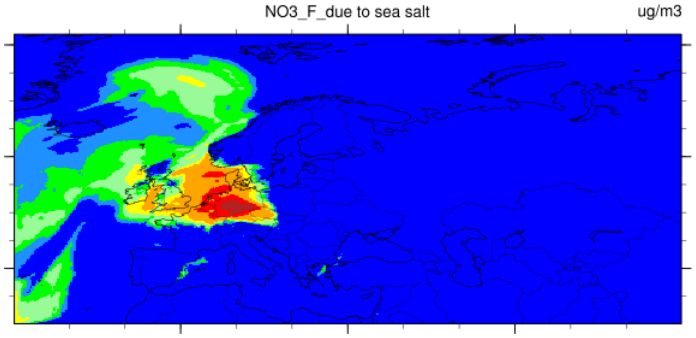
NO_3^+

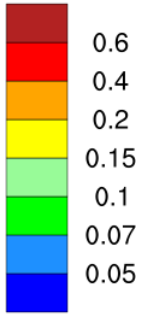












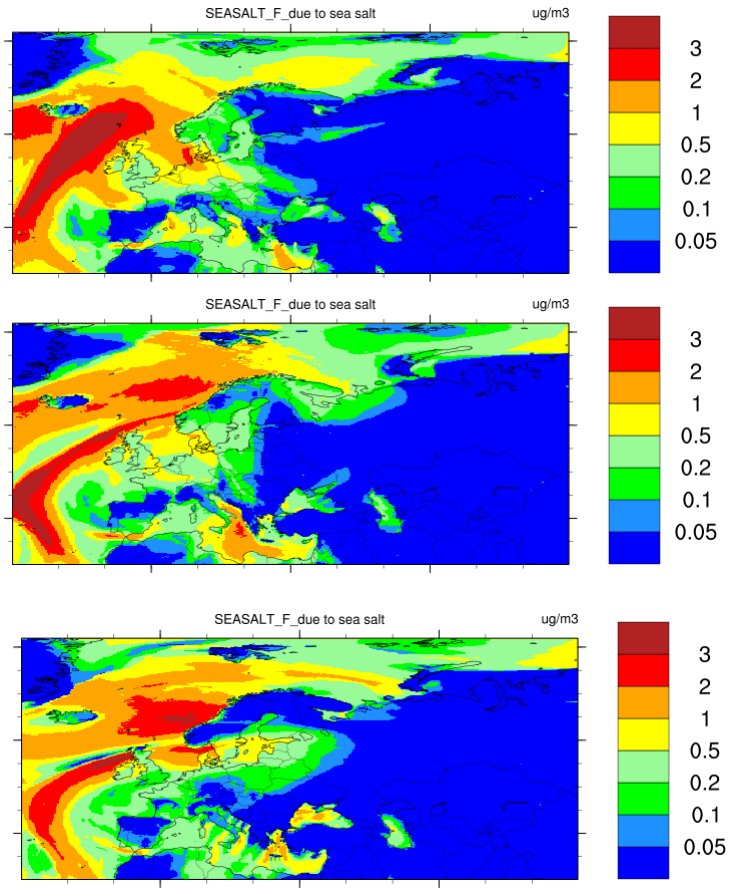
23-24 January 2016

Norwegian Meteorological Institute

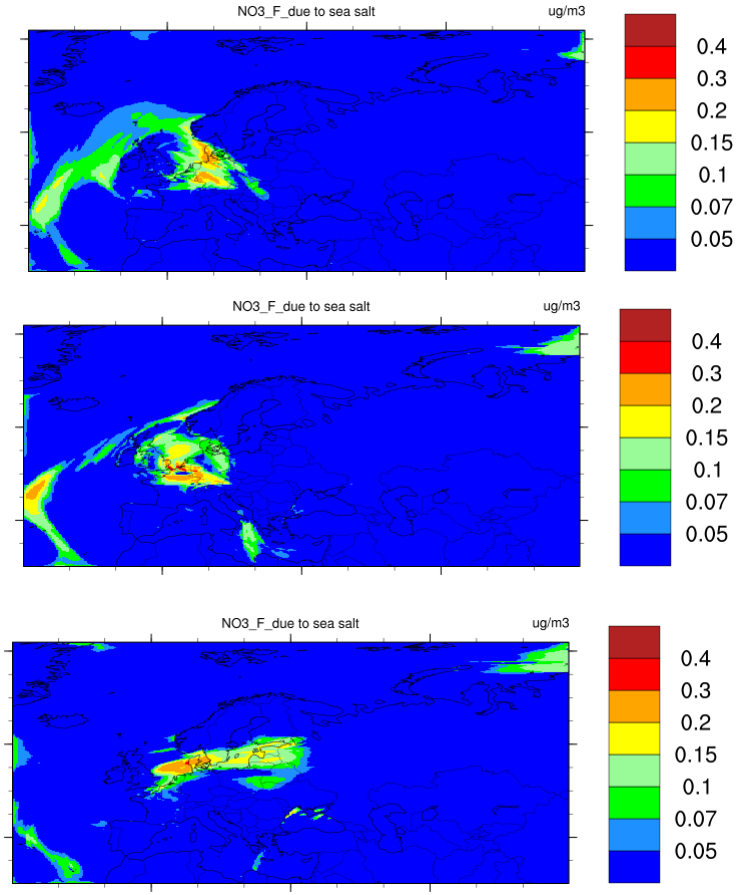
EQSAM4clim

Formation of fine NO_3^+ due to fine sea salt

Sea salt



NO_3^+



28-30 December 2016

Norwegian Meteorological Institute

Summary and outlook

★ **The latest version of EQSAM - EQSAM4clim - has been implemented in the EMEP MSC-W model**

★ **Initial tests give positive results:**

- evaluation for 2016 - similar compared to MARS

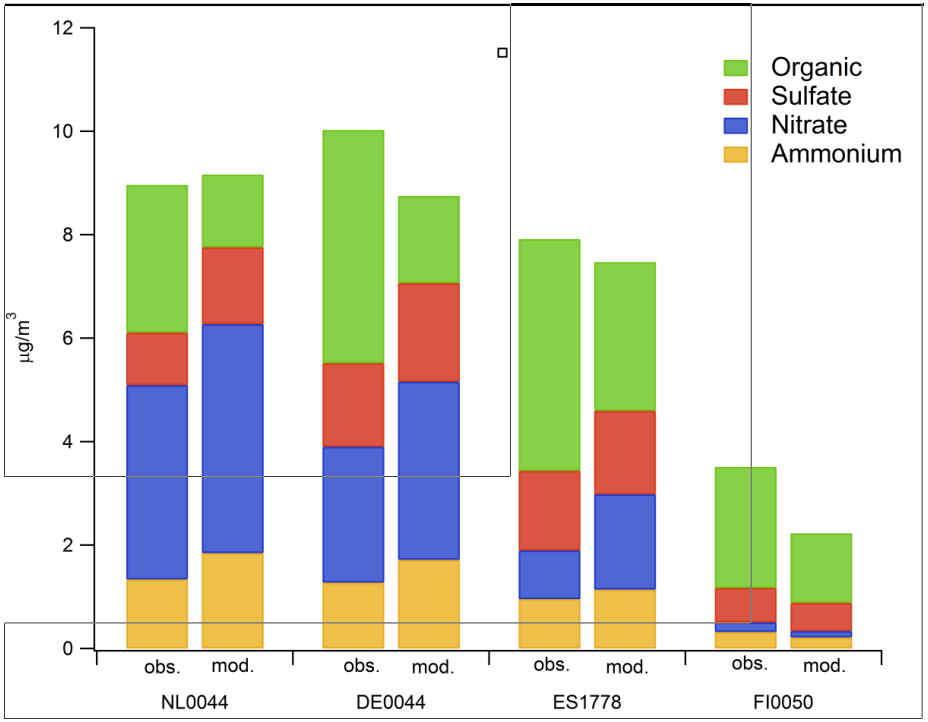
- inclusion of sea spray NaCl in the equilibrium allows formation of Na_2SO_4 and $NaNO_3$ (which can be important in coastal sea salt influenced regions)

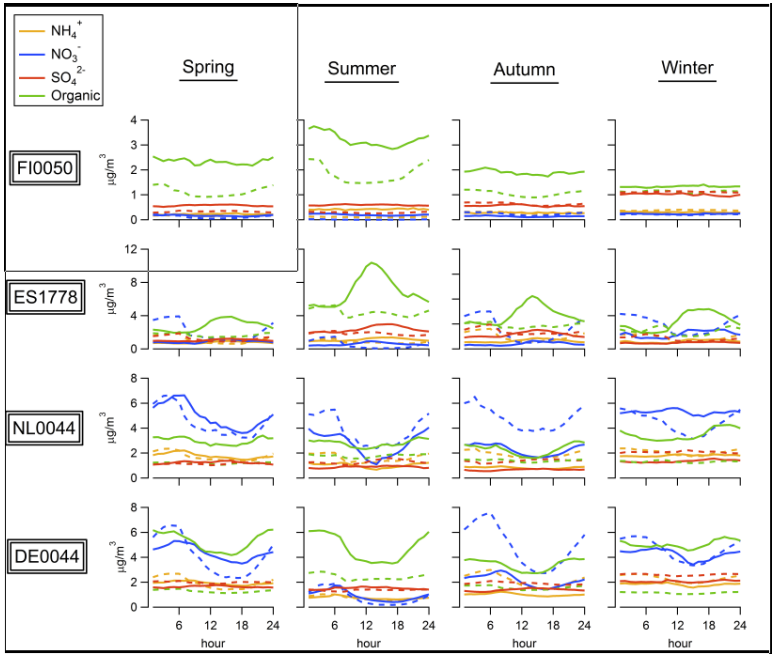
- several setups for equilibrium system complexity are tested - needs more study for diff regions (episodes!!), evaluation with observations (ACSM data, gas/aerosol)

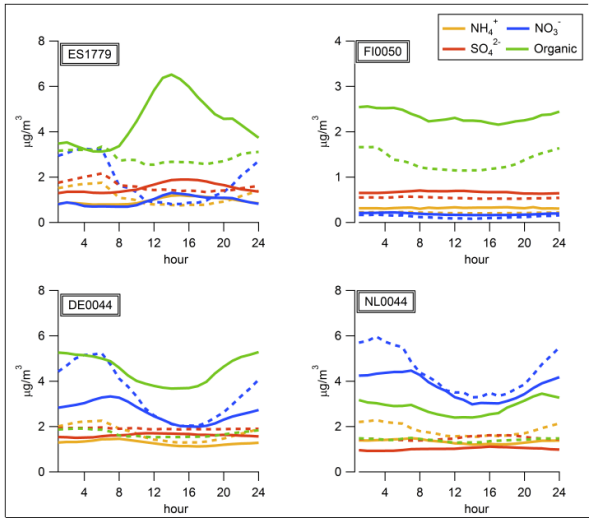
- more accurate calculation of PM water is expected, but depends on the setup (=completeness of cation/anion system)

Norwegian Meteorological Institute

Aerosol evaluation with ACSM (2012-2013)







EMEP Report 1/2017

Norwegian Meteorological Institute

Summary and outlook

★ **EQSAM4clim will be one of the options to solve SIA in the Open Source (May 2019?) and after some testing next weeks will likely be used in model calculations for Report 2019**

Further work

★ **Extending to base cations (Ca^{2+}, Mg^{2+}, K^{+}) from windblown and anthropogenic dust**

★ **Testing EQSAM4clim for coarse aerosols??**

Many thanks go to Swen Metzger

ResearchConcepts Io

for his assistance with EQSAM4clim implementation and consultancy regarding thermodynamics

Norwegian Meteorological Institute

Muchas gracias!

Norwegian Meteorological Institute