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Lessons learnt from the first EMEP intensive measurements: June 2006 and January 2007

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+ many others

TFMM workshop, JRC, 19-20 November 2009

EMEP Intensive measurement periods 2006-2007

- Focus on:
  - **PM mass closure**
  - **Artefact free measurements of gaseous and particulate nitrogen species**
  - **High temporal resolution data (diurnal variations)**

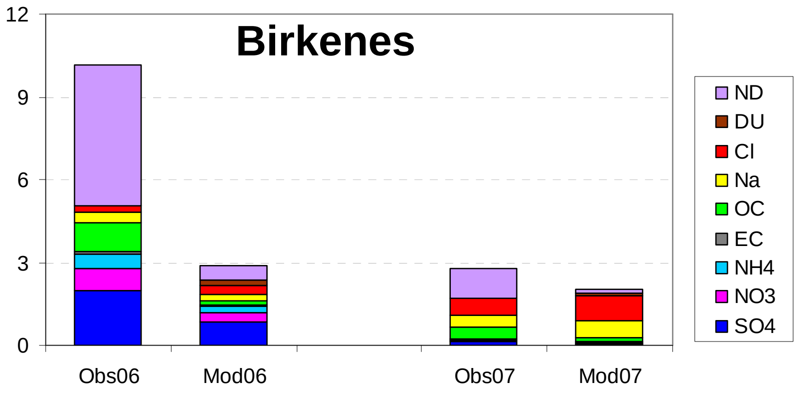
	mass	mass	daily						Intensive, hourly			
			Inorg		EC/OC		Crust		Inorg		EC/OC	
	June	Jan	June	Jan	June	Jan	June	Jan	June	Jan	June	Jan
AT02	PM10,PM2.5,PM1	PM10,PM2.5,PM1	FP	FP						SO4	PM2.5	
CH02	PM10,PM2.5,PM1	PM10,PM2.5,PM1	FP, PM10, PM1						AMS	AMS	PM2.5	PM2.5
CZ03	PM10, PM2.5	PM10,PM2.5			PM10	PM10						
DK41	PM10,PM2.5, PM1	PM10,PM2.5, PM1							NOx,O3	NOx,O3		
DE02	PM10,PM2.5,PM1	PM10,PM2.5,PM1	FP									
DE03	PM10, PM2.5	PM10, PM2.5	FP									
DE07	PM10,PM2.5	PM10,PM2.5	FP									
DE43	TSP	TSP	Berner								BC	BC
DE44	PM10,PM2.5,PM1 + Berner (5 sizes)		X	X	X	X				AMS		AMS (OM)
ES31	PM10,PM2.5, PM1	PM10,PM2.5, PM1	PM10 & PM2.5		TC	TC	PM10 & PM2.5					
FI17	PM10,PM2.5,PM1	PM10,PM2.5,PM1	X	X								
HU02	PM10				TC							
IE31									AMS		AMS	
IT01	PM10,PM2.5	PM10,PM2.5	X	X	X	X	X	X				
IT04	PM10,PM2.5	PM10,PM2.5	PM2.5	PM2.5	PM2.5	PM2.5			X	X		
NL11	PM10, PM2.5	PM10,PM2.5							X	X		
NO01	PM10,PM2.5,PM1	PM10,PM2.5,PM1	X	X	X	X						
SE12	PM2.5,PM1				X	X						
GB33									AMS		AMS (OM)	
GB36	PM10,PM2.5								X			
GB40									X	X		

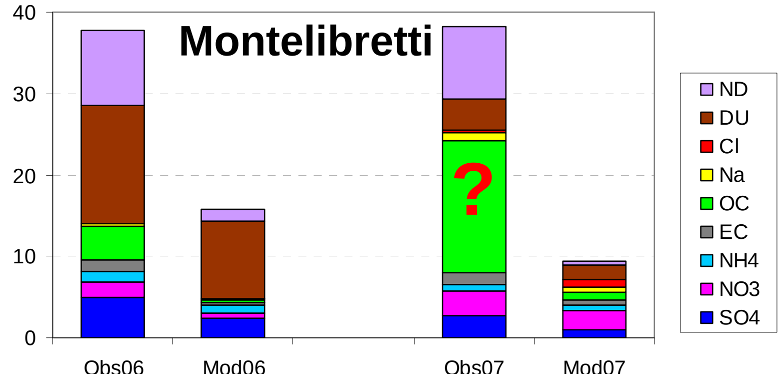
PM mass balance

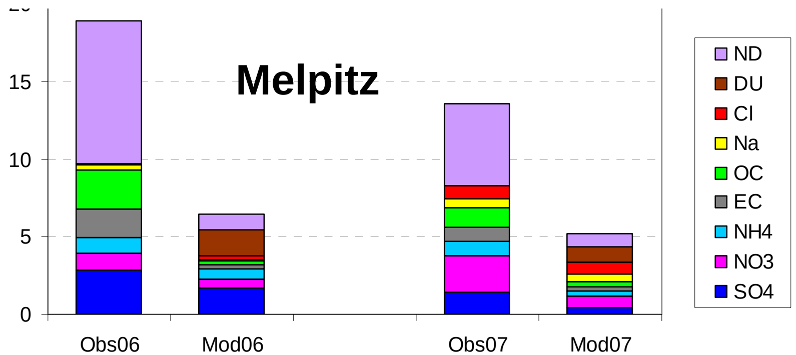
Mass closure for PM_{10} and $PM_{2.5}$ at four(5) sites with measurements of all inorganic and carbonaceous components:

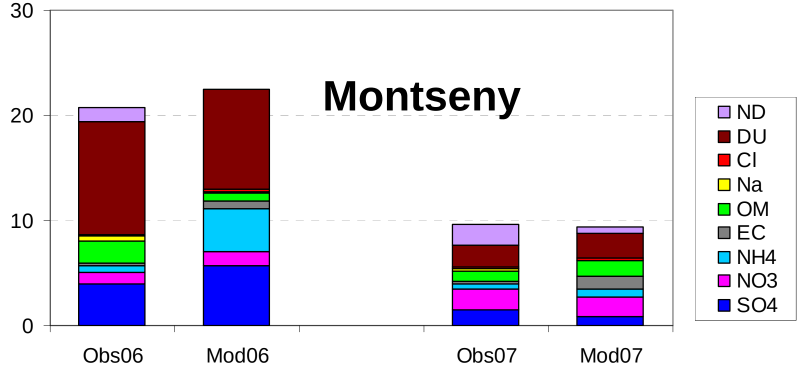
Birkenes, Melpitz, Montseny, Montelibretti, Ispra(PM2.5)

PM10 chemical speciation (μg/m³)



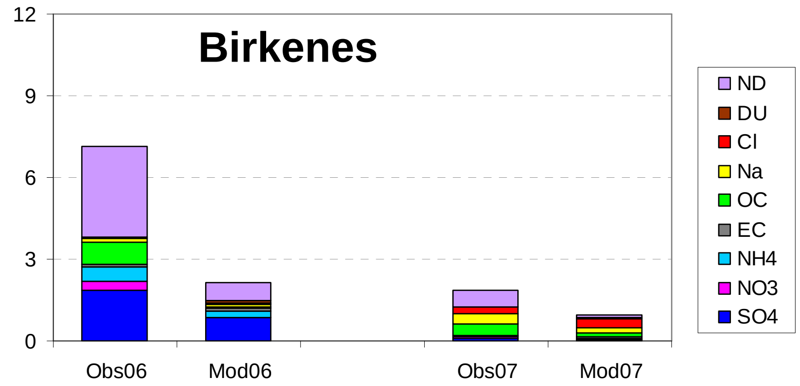


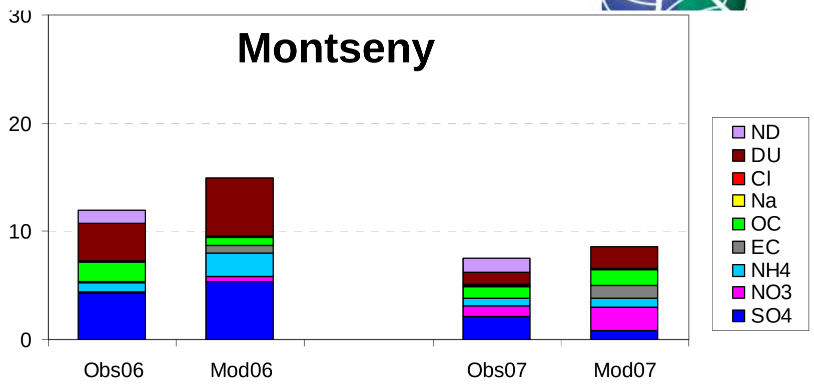


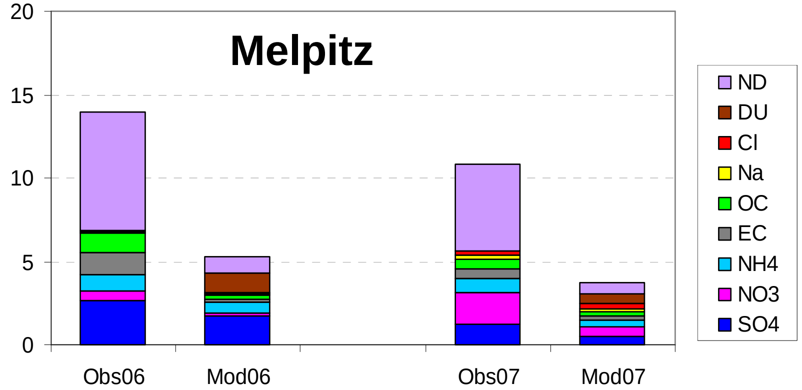


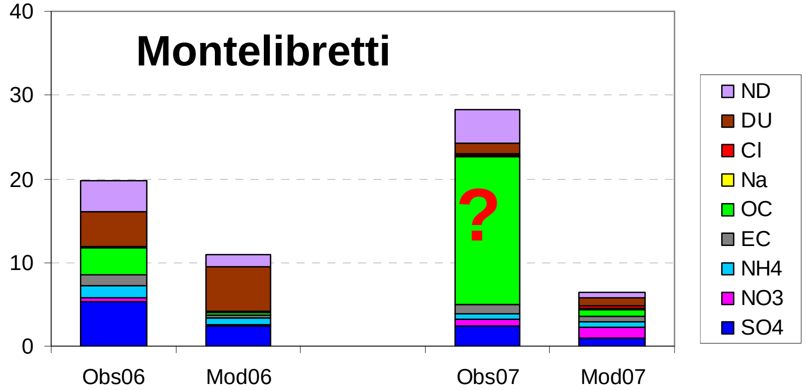
- **Model underestimates of PM_{10} *)… notice 20-30% of measured PM_{10} is "Not Determined" (50% at NO01 and DE44). Note! modelled OC = anthrop. primary OC**
- **The model tends to underestimate all PM components (exc. at ES17)**
- **Higher in summer than in winter (IT), larger difference for PM10 (but less pronounced in the model)**
- **Carbonaceous matter (EC + OC) main reason for underestimation of PM mass (ND)**

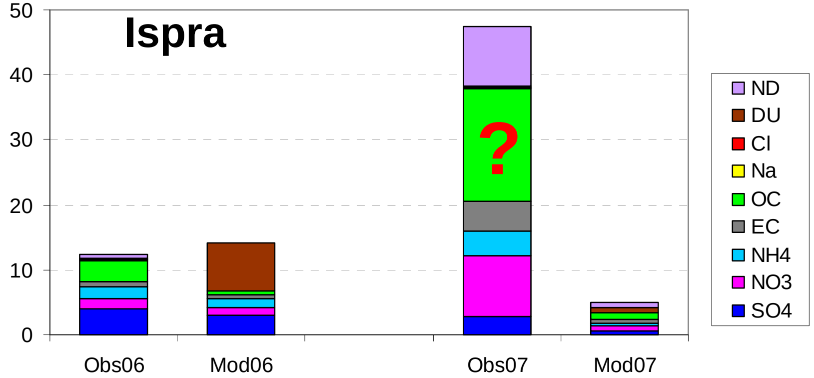
PM2.5 chemical speciation







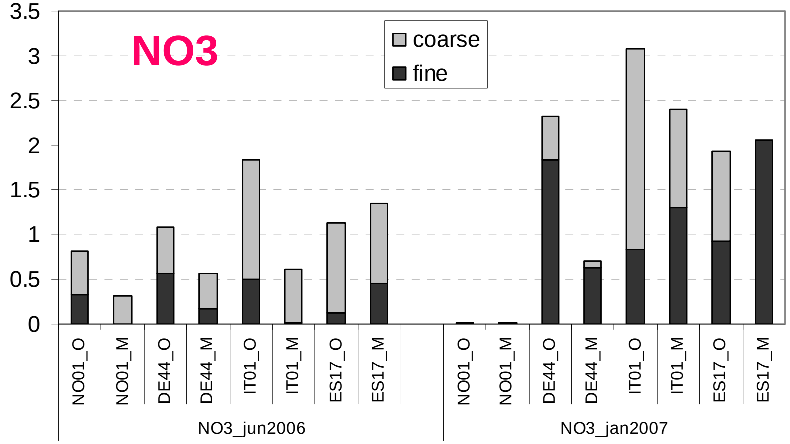


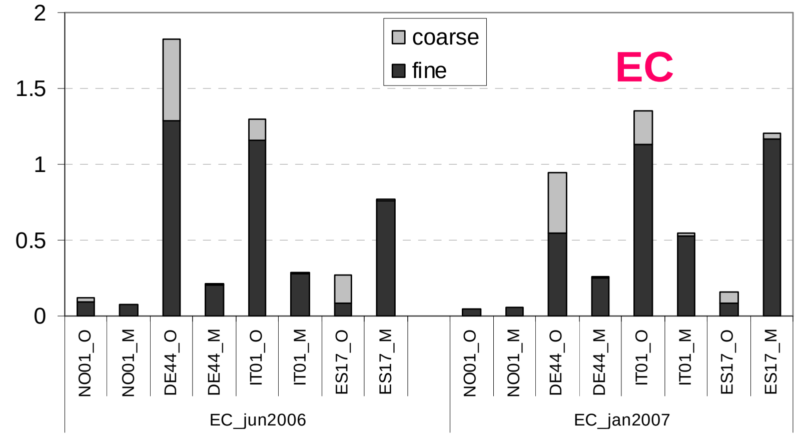


- **Smaller contribution from sea salt and mineral dust than in PM_{10}**
- **EC results consistent with EMEP EC/OC Campaign 2002**
- **Na+ underestimated, mostly in summer**
- **Mineral dust, mixed results, mostly within +-35%**

PM size distribution:

Distribution of NO3-, EC, between fine and coarse aerosols from model and measurements





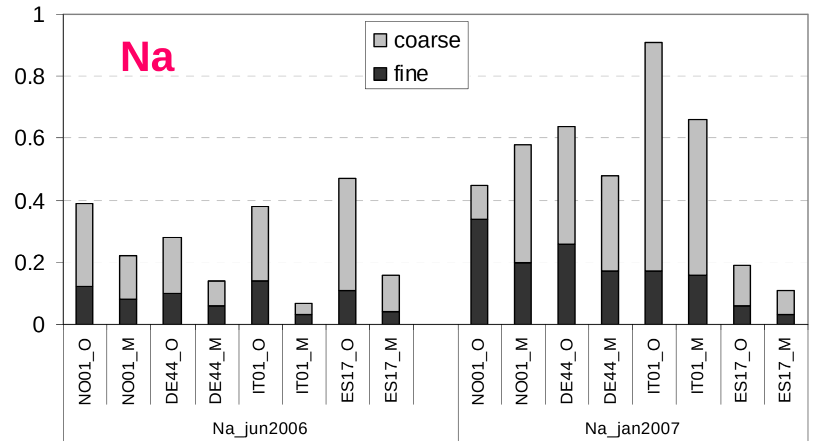
•In observations, a smaller NO3- mass occurs on fine aerosol in summer (between 10 and 50%) than in winter (between 30 and 80%) - reflected in the model results, but discrepancies can be significant for the individual sites.

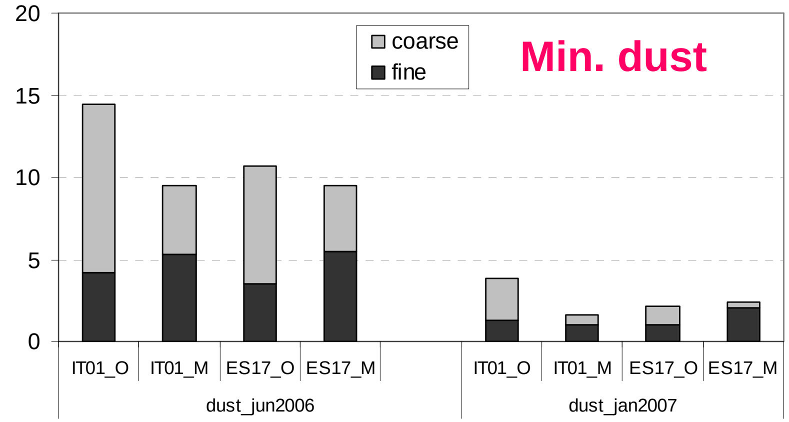
• Too little coarse EC in the model results compared to observation, which is due to large uncertainties (underestimation and missing sources) in emission data.

PM size distribution:

Distribution of Na+ and mineral dust between fine and coarse aerosols from model and measurements

- **Na+ size distribution is relatively well described by the model, with between 10 and 40% mass in the fine mode (probable measurement problems in January 2007 at NO01).**
- **For mineral dust, the model tends to underestimate the mass of coarse particles**





Artefacts and incompleteness in the measurement data complicates the analysis of results!

Examples:

Rather poor data coverage at ES17 (between 1 and 6 days during each of the campaign periods) and not the same for the different components.

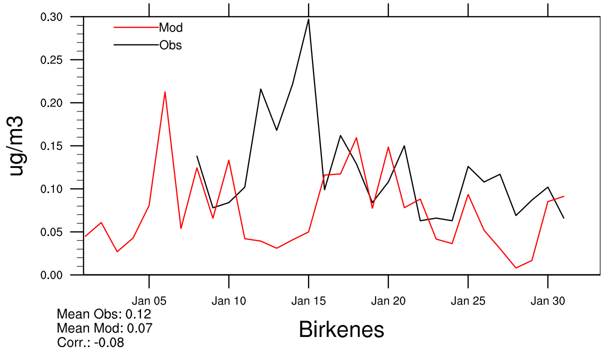
See problem with the SO_4, NO_3 and NH_4 measurements for January 2007 at NO01: PM.25 and PM10 measurements correlate poorly with the regular filter pack measurement going in parallel. The filter pack measurements correlate better with the EMEP model.

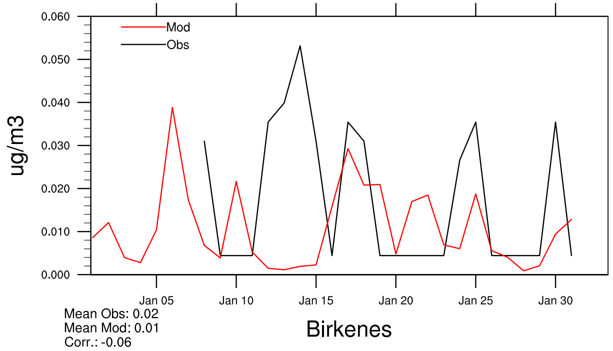
Extremely high the winter levels of OC at the Italian sites which are much higher than any of the other sites and 2-5 times higher than the level in summer, both in PM10 and PM2.5

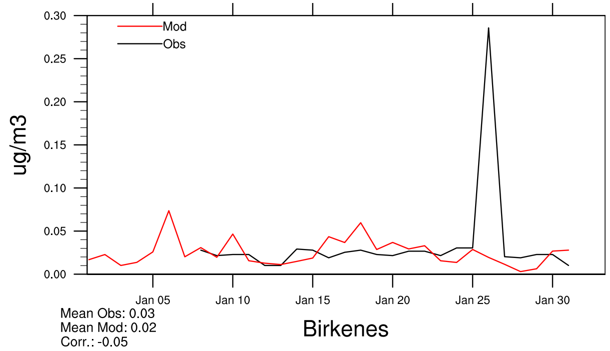
Probable artefact in the chloride measurements due to evaporation of HCl, as the Na/Cl ratio is often much higher than the sea salt ratio

Inconsistent measurement data at Birkeness

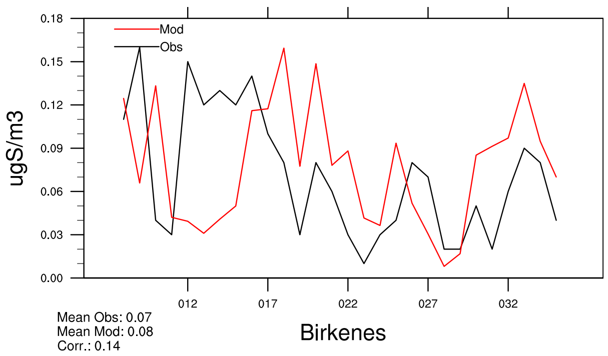
Intensive measurements

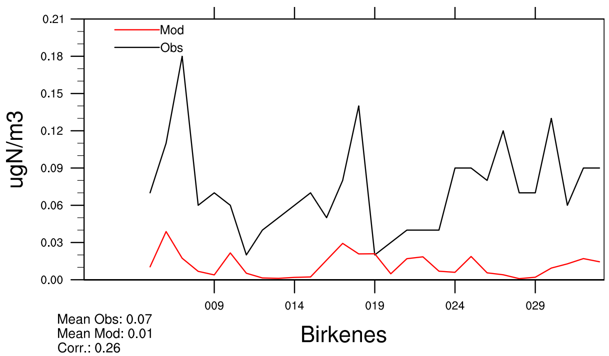


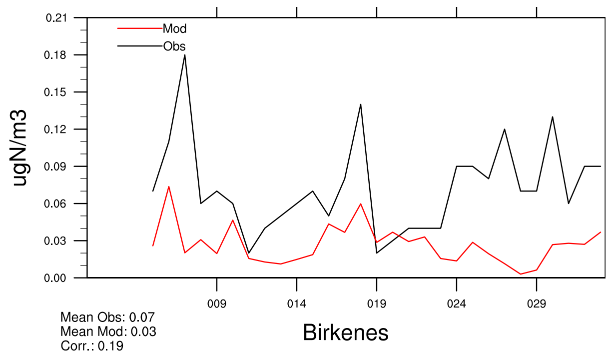




EMEP network (filter pack)







SO_4^{2-} **NO_3^-** **NH_4^+**

Artefacts and incompleteness in the measurement data complicates the analysis of results!

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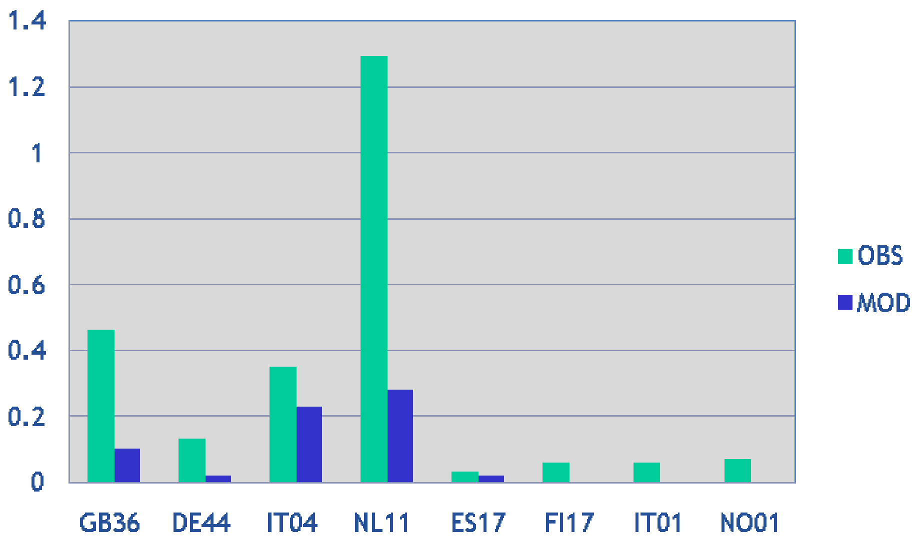
Probable artefact in the chloride measurements due to evaporation of HCl, as the Na/Cl ratio is often much higher than the sea salt ratio

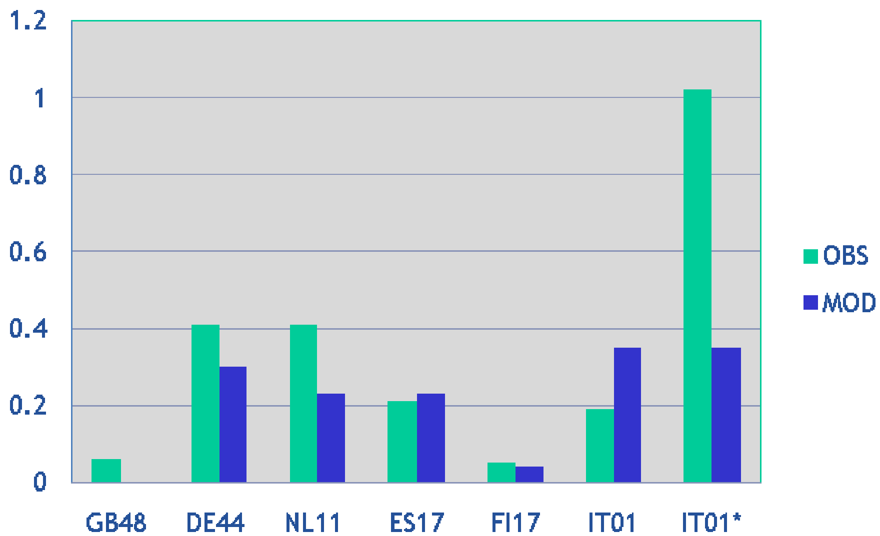
Aerosol/gas partitioning:

- NH_3-NH_4^+ split modelled well both in summer and winter
- More problems with nitrate

Fine nitrate ($PM_{2.5}$)



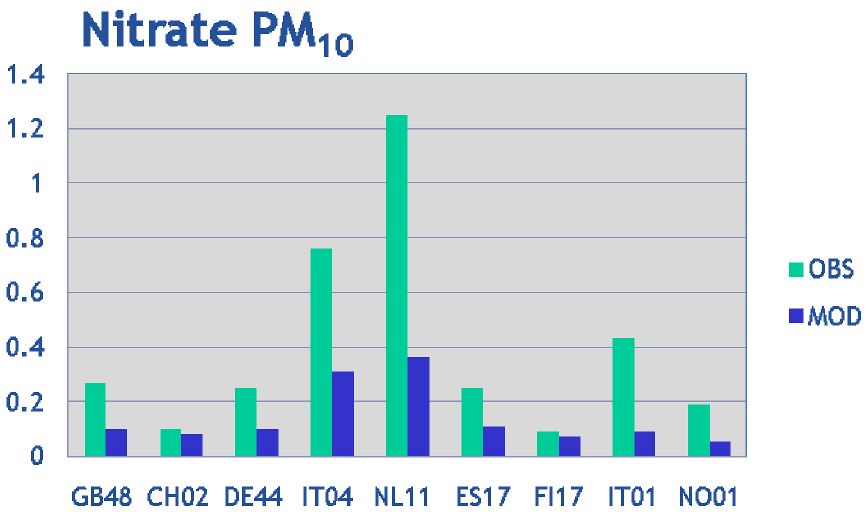
June 2006

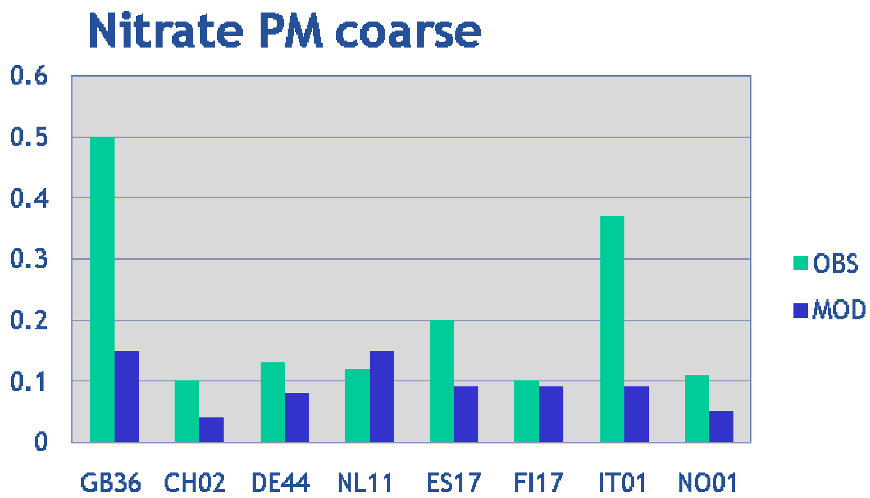


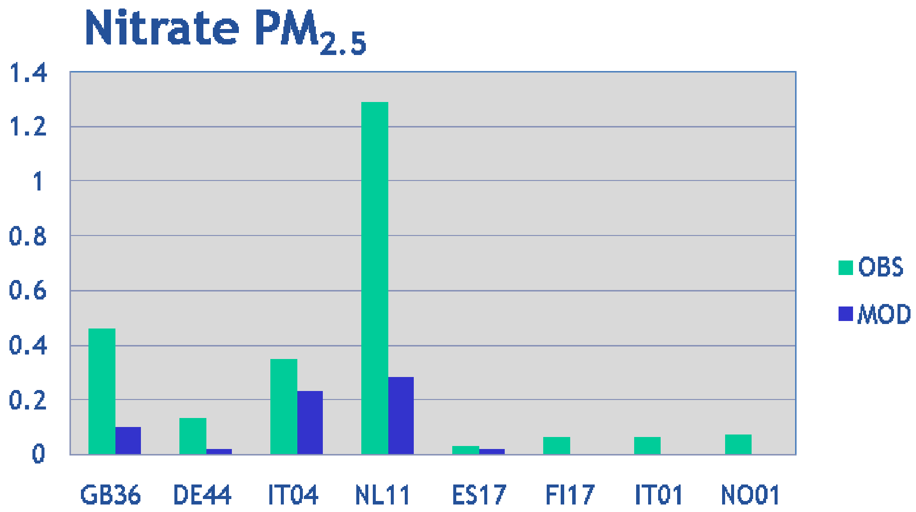
January 2007

- Underestimation in summer and mixed in winter
- HNO_3 mixed in summer, low in winter

Nitrate in different size fractions



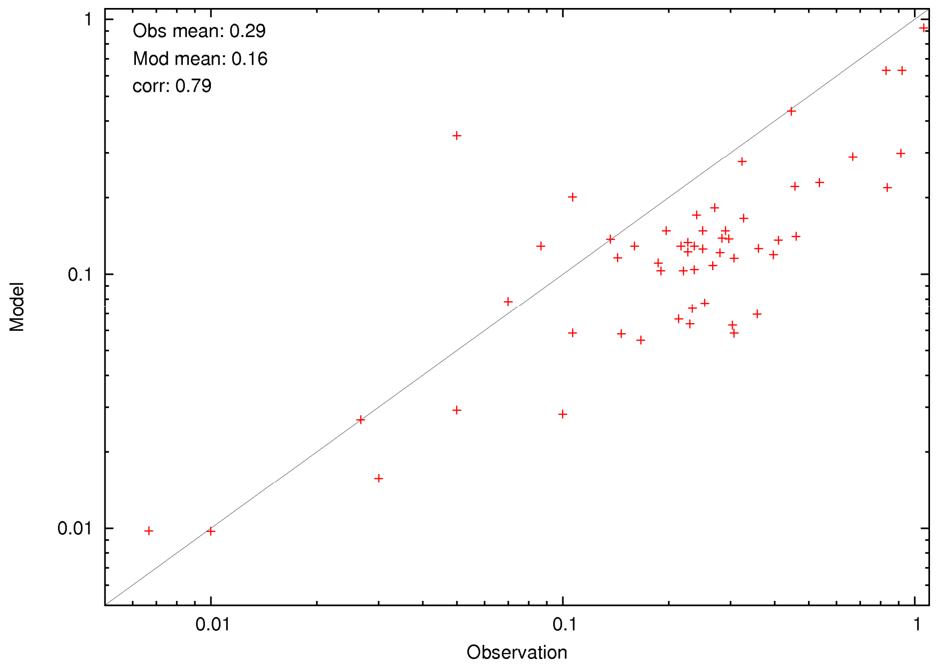




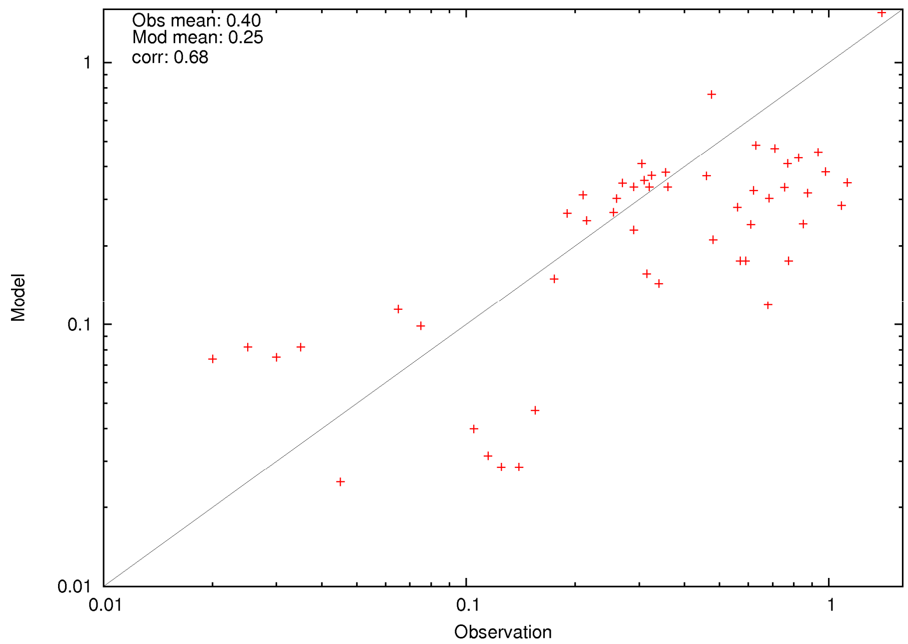
PM_{10} nitrate underestimated, mostly because of underestimation of fine nitrate

Seasonal performance, nitrate

Summer



Winter

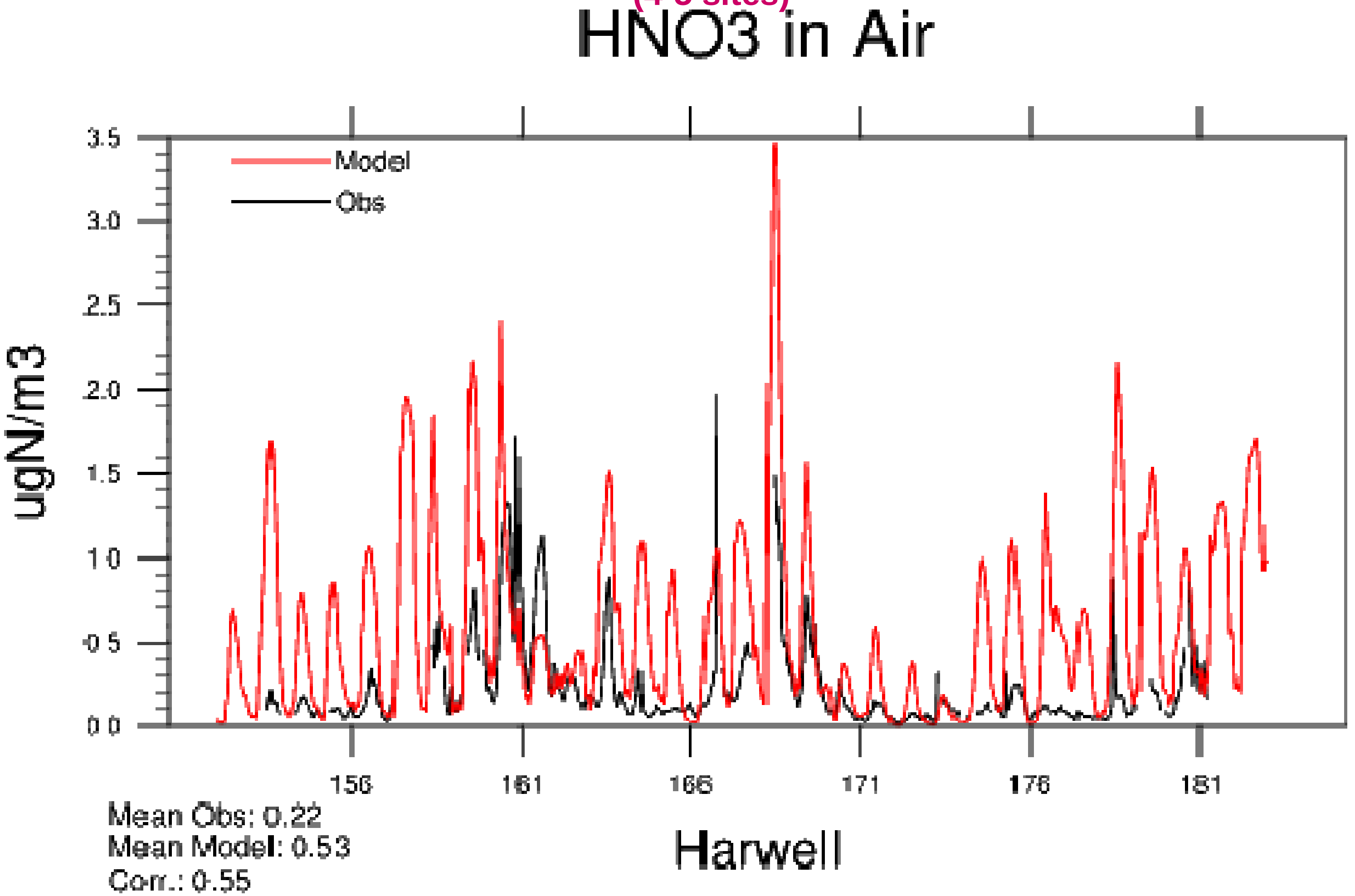


NitroEurope IP

- Summer more under estimated than winter

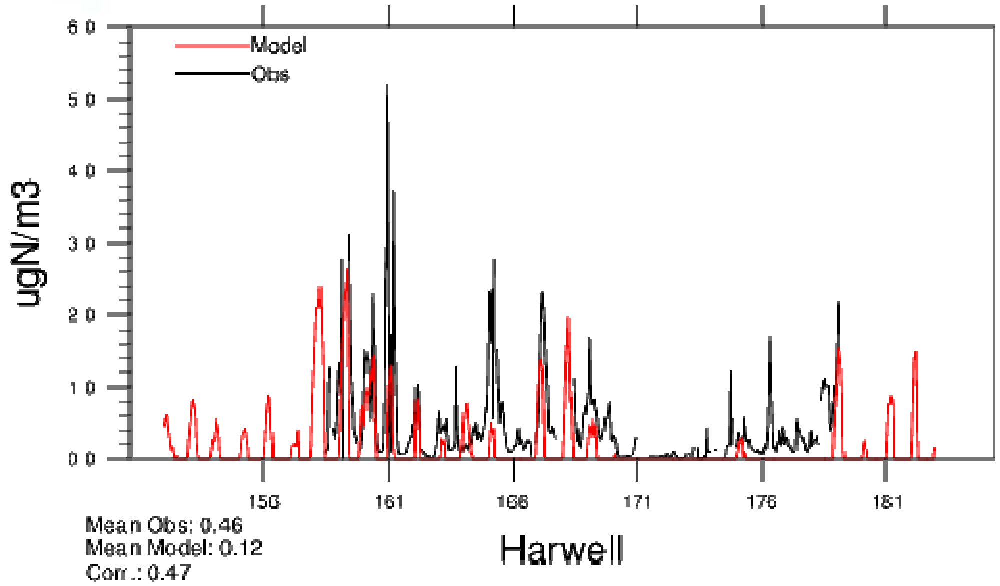
Evaluation of diurnal variations

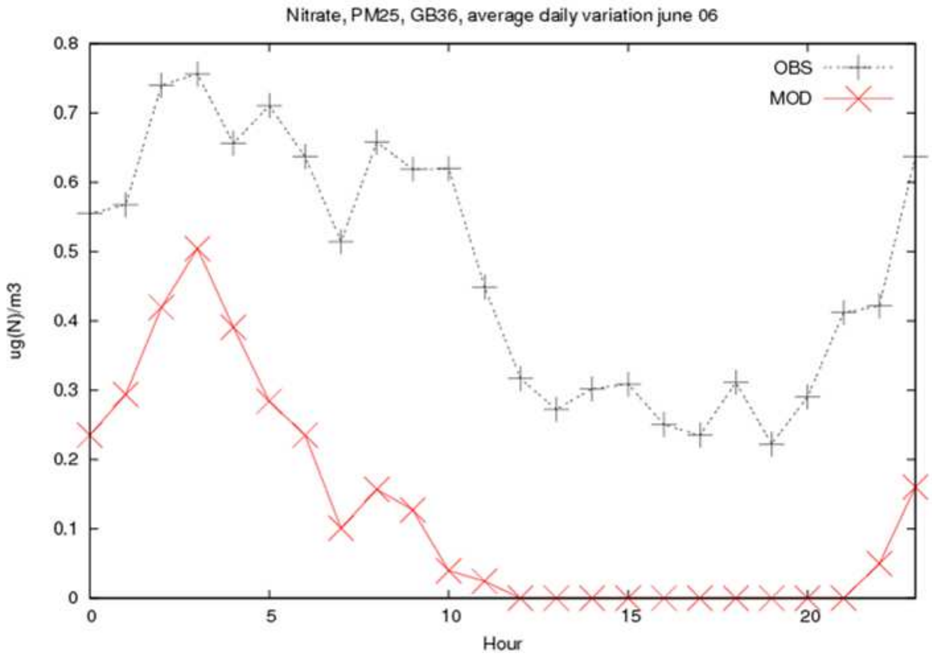
(4-5 sites)



- The EMEP model reproduce the peak around noon

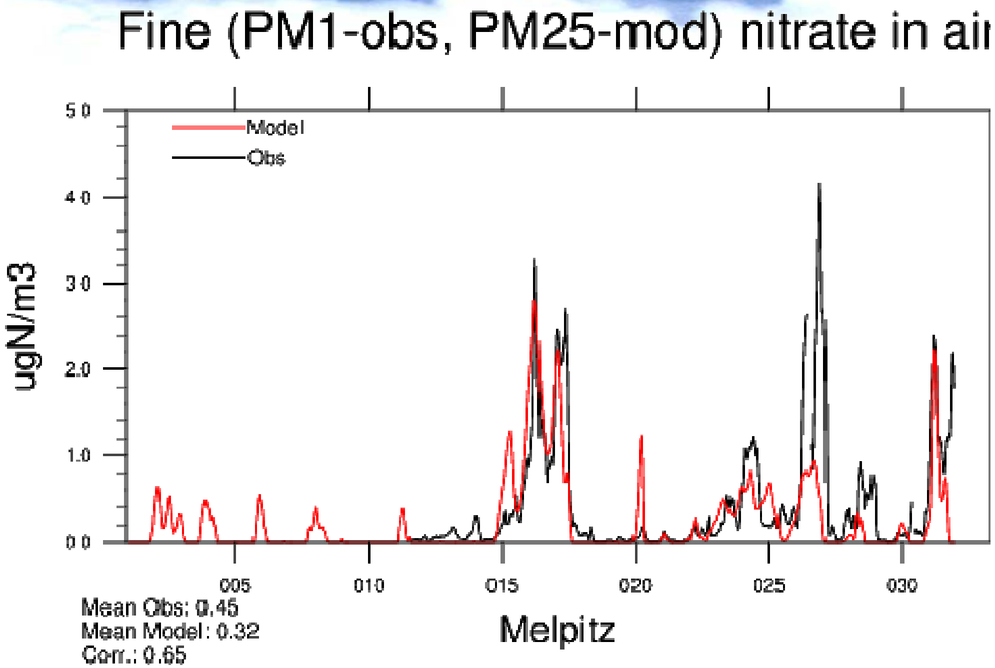
Fine (PM25) nitrate in air

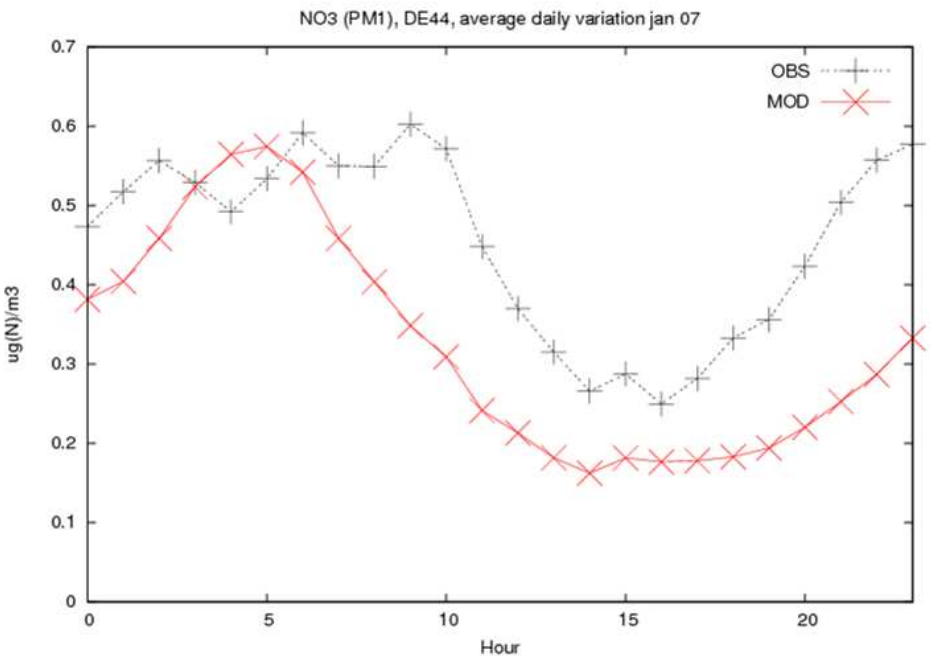




Fine nitrate, summer:

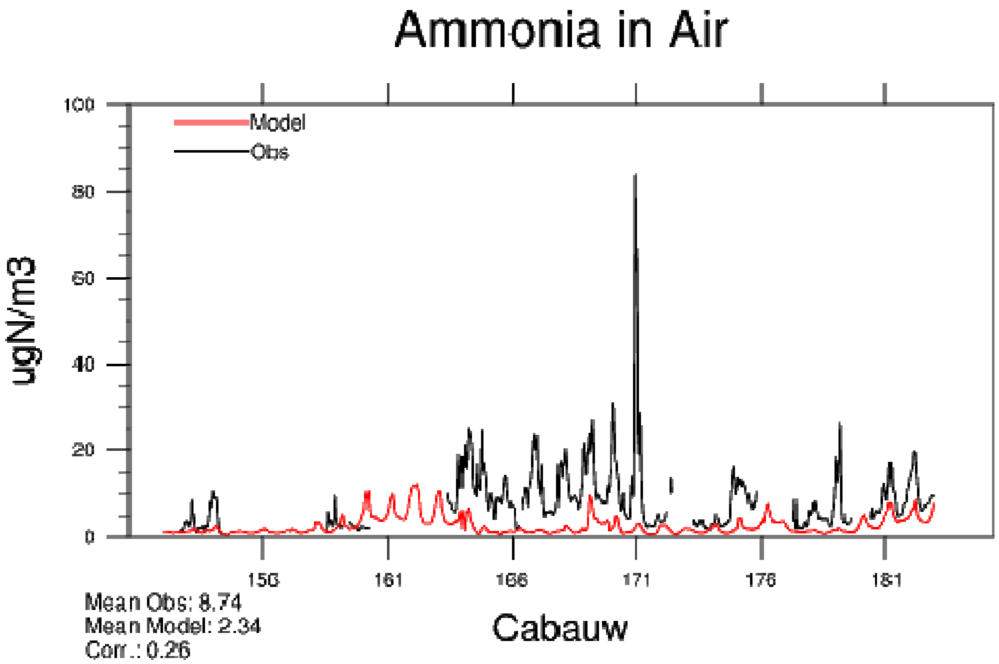
- NH4NO3 completely evaporates during day
- Absolute levels low

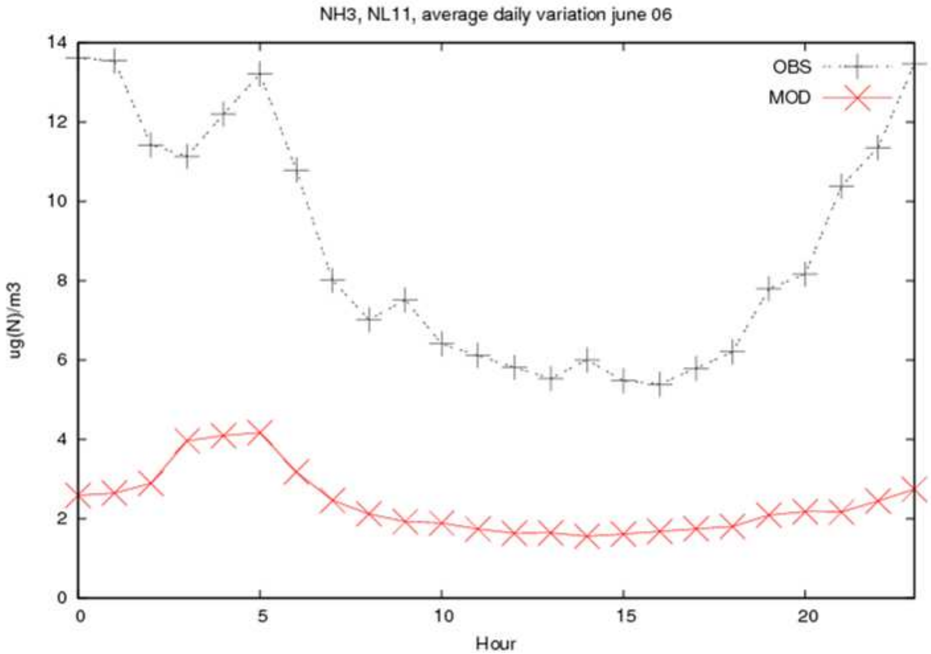




Fine nitrate, winter:

- The EMEP model reproduce morning peak
- Absolute values ok



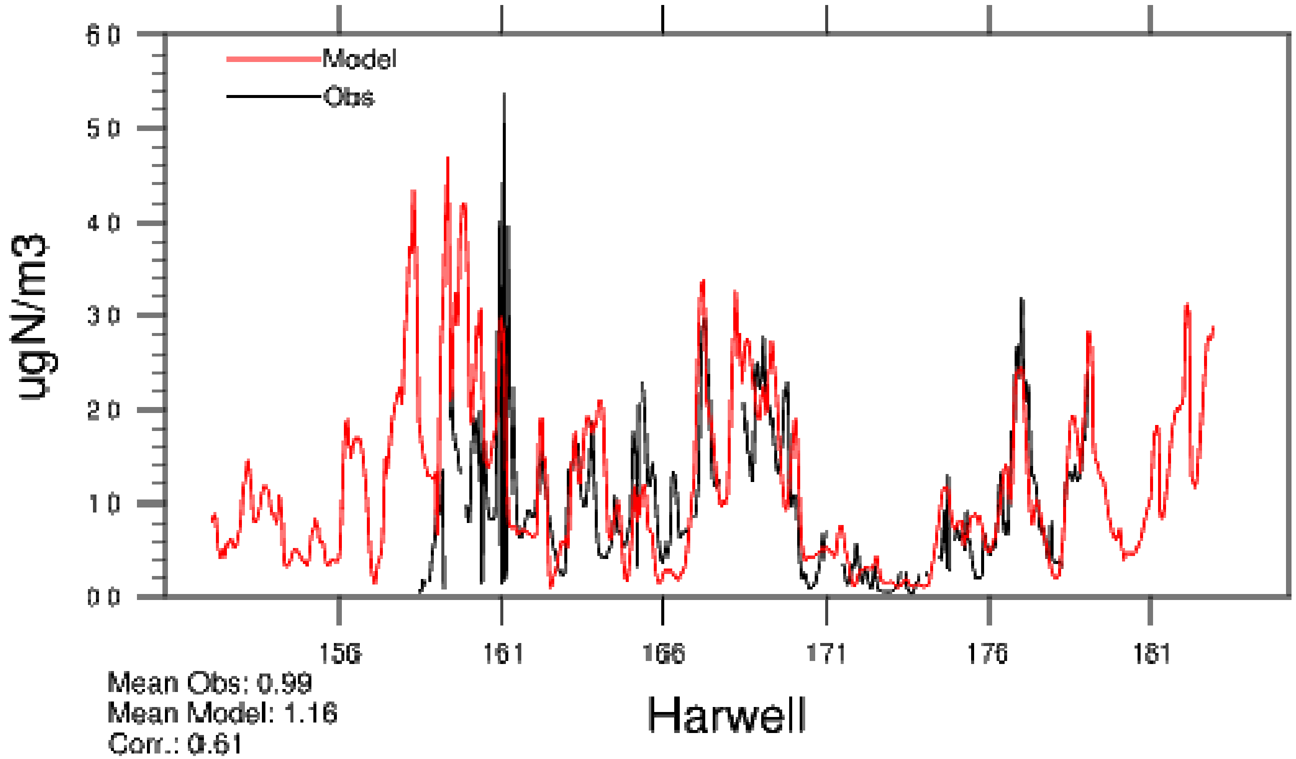


Diurnal variation NH3 determined by:
- •Emissions
- •Stability/dry deposition
- •Conversion to ammonium

Cabauw June 06: model and obs gives qualitatively same diurnal variation

The EMEP model always gives night time maximum:
-diurnal variation of NH3 emissions
-need dynamical NH3emission module

NH4+ (PM25) in Air



- Ammonium modelled well both in summer and winter

Conclusions

- The campaign data have been very valuable for evaluating the (missing) PM mass closure – missing carboneous matter..
- Evaluation of N gas-particle: problem in summer formation of fine nitrate
- Diurnal profile of NH3 in many cases wrong; because of the lack of emission coupling to meteorology?

Model – measurements comparison for PM2.5

			$PM_{2.5}$	SO_4^{2-}	NO_3^-	NH_4^+	EC	OC*)	Na^+	Miner.
IT01	2006	Bias	-45	-53	-92	-39	-76	-94	-79	25
		R	*0.71*	*0.63*	*-0.03*	*0.69*	*0.55*	*0.56*	*0.30*	*0.67*
	2007	Bias	-78	-62	57	71	-53	-95	-6	-18
		R	*0.30*	*0.10*	*0.11*	*-0.19*	*0.35*	*0.59*	*0.42*	*0.16*
IT04	2006	Bias	-10	-27	-21	-15	-34	-81	-82	
		R	*0.75*	*0.63*	*0.74*	*0.59*	*0.85*	*0.84*	*-0.21*	
	2007	Bias	-90	-79	-92	-89	-86	-94	-80	0
		R	*0.42*	*0.60*	*0.55*	*0.67*	*0.04*	*0.25*	*-0.11*	*0.24*
DE44	2006	Bias	-62	-36	-70	-32	-81	-92	-40	
		R	*0.55*	*0.79*	*0.03*	*0.44*	*0.60*	*0.54*	*0.80*	
	2007	Bias	-66	-64	-64	-57	-55	-49	-35	
		R	*0.35*	*0.59*	*0.58*	*0.58*	*0.63*	*0.50*	*0.65*	
NO01	2006	Bias	-70	-55	-100	-51	-22	-86	-33	
		R	*0.72*	*0.88*	*-0.06*	*0.48*	*0.89*	*0.79*	*0.51*	
	2007	Bias	-48	-36	-	0	20	-69	-41	
		R	*0.08*	*-0.09*	-	*0.36*	*0.25*	*0.14*	*0.46*	

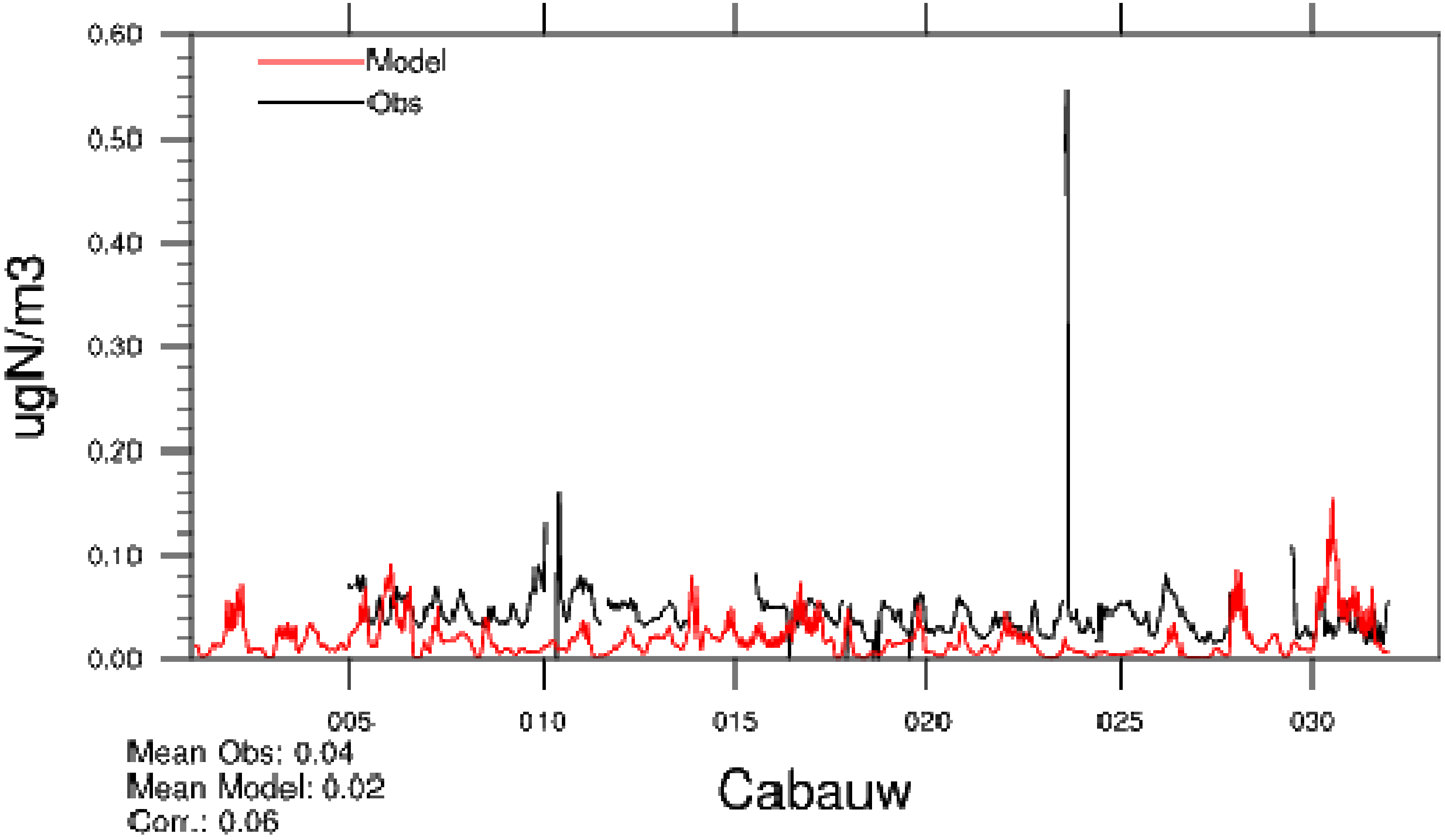
Results for different components

- Carbonaceous matter: main reason for underestimation of C (especially in June 06), SOA + biogenic missing
- Results for EC/OC consistent with comparison against EMEP EC/OC data: underst. EC in central/south (especially summer), overestimate in northern Europe in summer
- Na+ underestimated, mostly in summer
- Mineral dust, mixed results, mostly within +-35%

Model – measurements comparison for PM10

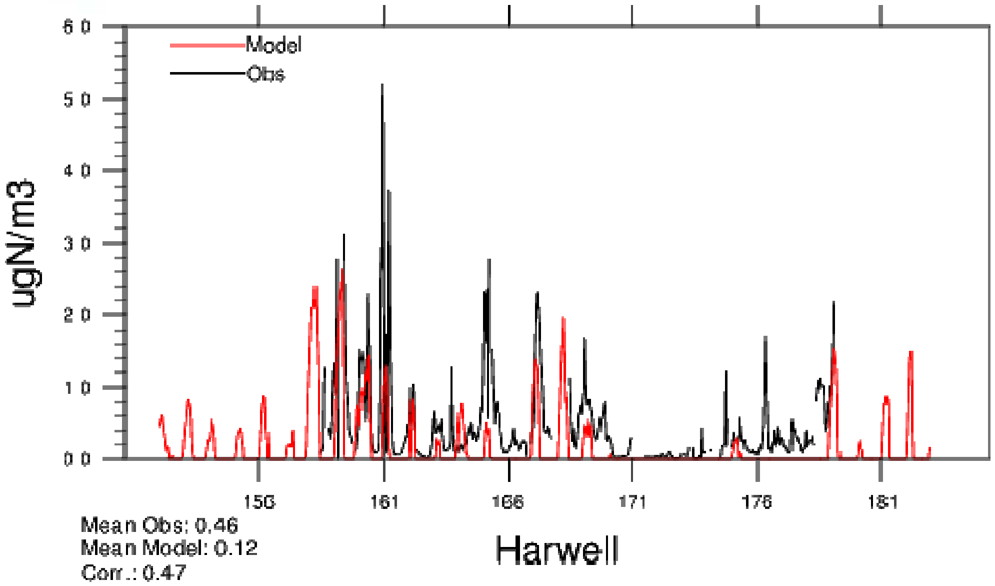
			PM_{10}	SO_4^{2-}	NO_3^-	NH_4^+	EC	OC*)	Na^+	Miner.
IT01	2006	Bias	-58	-51	-67	-32	-78	-94	-82	-34
		R	*0.85*	*0.63*	*0.33*	*0.62*	*0.60*	*0.49*	*0.02*	*0.84*
	2007	Bias	-75	-65	-22	57	-59	-94	-27	-57
		R	*-0.03*	*0.10*	*-0.11*	*0.10*	*0.50*	*0.62*	*0.53*	*0.21*
DE44	2006	Bias	-66	-40	-49	-32	-88	-92	-40	
		R	*0.37*	*0.77*	*0.06*	*0.33*	*0.73*	*0.45*	*0.87*	
	2007	Bias	-62	-68	-68	-60	-72	-75	-25	
		R	*0.37*	*0.58*	*0.62*	*0.56*	*0.55*	*0.48*	*0.66*	
NO01	2006	Bias	-72	-57	-62	-48	-42	-88	-44	
		R	*0.78*	*0.83*	*0.45*	*0.76*	*0.87*	*0.65*	*0.79*	
	2007	Bias	-26	-42	-50	-33	20	-68	29	
		R	*0.01*	*-0.08*	*-0.06*	*-0.05*	*0.65*	*0.16*	*0.31*	
ES17	2006	Bias	-10	44	19	269	182	-69	-64	21
		R	*0.32*	*0.72*	*-0.66*	*0.92*	*-0.24*	*-0.24*	*0.53*	*0.54*
	2007	Bias	-3	-42	-6	51			-45	-1
		R	*0.66*	*0.77*	*0.54*	*0.45*			*0.57*	*0.4*

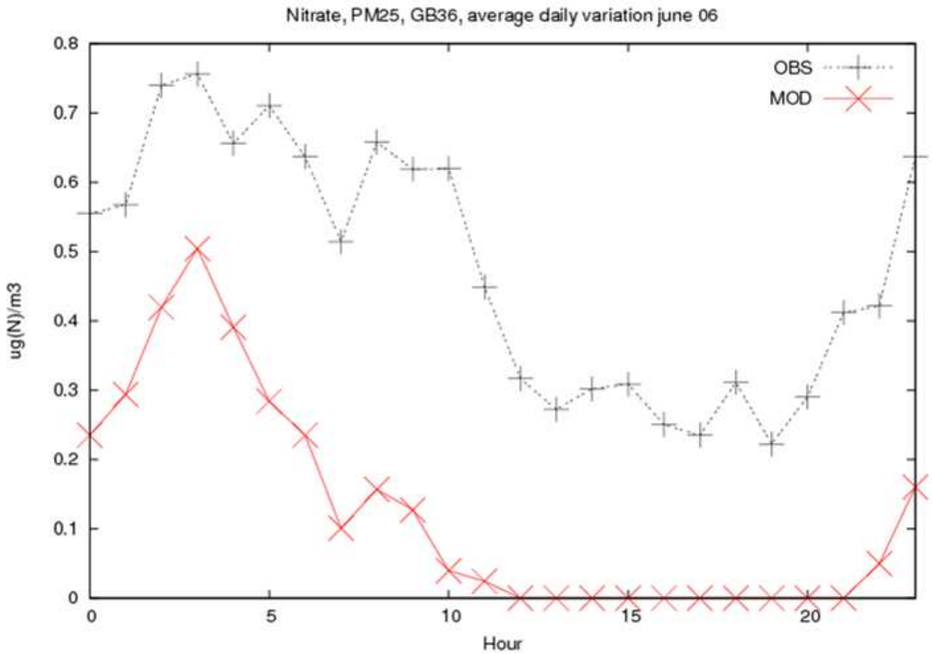
HNO3 in Air



Winter: Much less pronounced diurnal variation. Weaker correlation between obs and model

Fine (PM25) nitrate in air



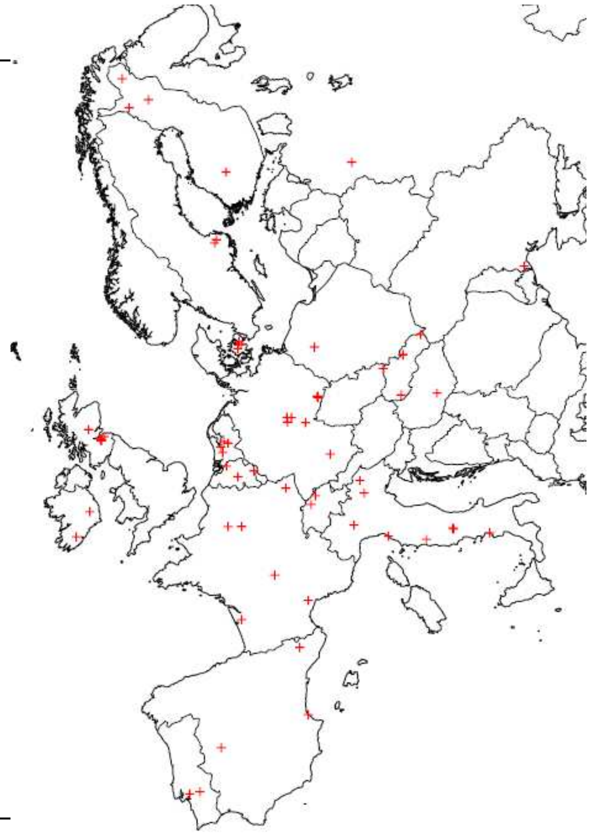


Fine nitrate, summer:

- NH4NO3 completely evaporates during day
- Absolute levels low

NitroEurope data versus EMEP data, 2007

Component	Ns	Obs	Bias (%)	Corr
NEU data				
NH_3 ($\mu g(N)\ m^{-3}$)	58	1.64	-13	0.47
NH_4^+ ($\mu g(N)\ m^{-3}$)	57	0.91	-26	0.67
HNO_3 ($\mu g(N)\ m^{-3}$)	*57*	*0.25*	*-46*	*0.66*
NO_3^- ($\mu g(N)\ m^{-3}$)	57	0.48	-27	0.79
EMEP data				
NH_3 ($\mu g(N)\ m^{-3}$)	16	1.78	-34	0.93
NH_4^+ ($\mu g(N)\ m^{-3}$)	30	0.78	-29	0.63
HNO_3 ($\mu g(N)\ m^{-3}$)	13	0.17	-29	0.49
NO_3^- ($\mu g(N)\ m^{-3}$)	25	0.41	-29	0.73



Stations from NitroEurope

NitroEurope IP

Mass distribution between fine and coarse aerosols

- **In observations, a smaller NO3- mass occurs on fine aerosol in summer (between 10 and 50%) than in winter (between 30 and 80%) - reflected in the model results, but discrepancies can be significant for the individual sites.**

- **Too little coarse EC in the model results compared to observation, which is due to large uncertainties (underestimation and missing sources) in emission data.**

- **Na+ size distribution is relatively well described by the model, with between 10 and 40% mass in the fine mode (probable measurement problems in January 2007 at NO01).**

- **For mineral dust, the model tends to underestimate the mass of coarse particles**

Analysis is made of

- Geographical distribution (northern/central/southern Europe)
- Temporal variability (summer/winter)
- Comparison between model calculated and measured concentrations of the PM components
- The distribution of aerosol mass between fine and coarse particles