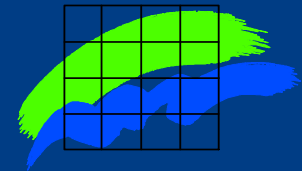




Tool for Exploratory Analysis of OSPM Model Performance for Long Time Series

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Outline

- Introduction on model evaluation
- Methods
 - The Model: OSPM
 - The Data sets
 - The Tool
- Results
- Conclusions and Outlook



Introduction

- ❑ “Harmo”-mission: pooling experiences, sharing tools and...
- ❑ ...model performance evaluation
 - ❑ uncertainty analysis
 - ❑ model validation
 - ❑ model intercomparison
- ❑ various model evaluation protocols and guidelines discuss mainly statistical analysis and metrics (FB, RMSE, Bias, FAC2, IA, Hit Rate ...)
 - ❑ MEG, Harmo, COST ...
- ❑ total model uncertainty
 - ❑ model uncertainty (model formulation, atmospheric dynamics, chemistry ...)
 - ❑ input data uncertainty (emissions, observed data, meteorology ...)
 - ❑ inherent variability (random nature of turbulence)



The model used: OSPM

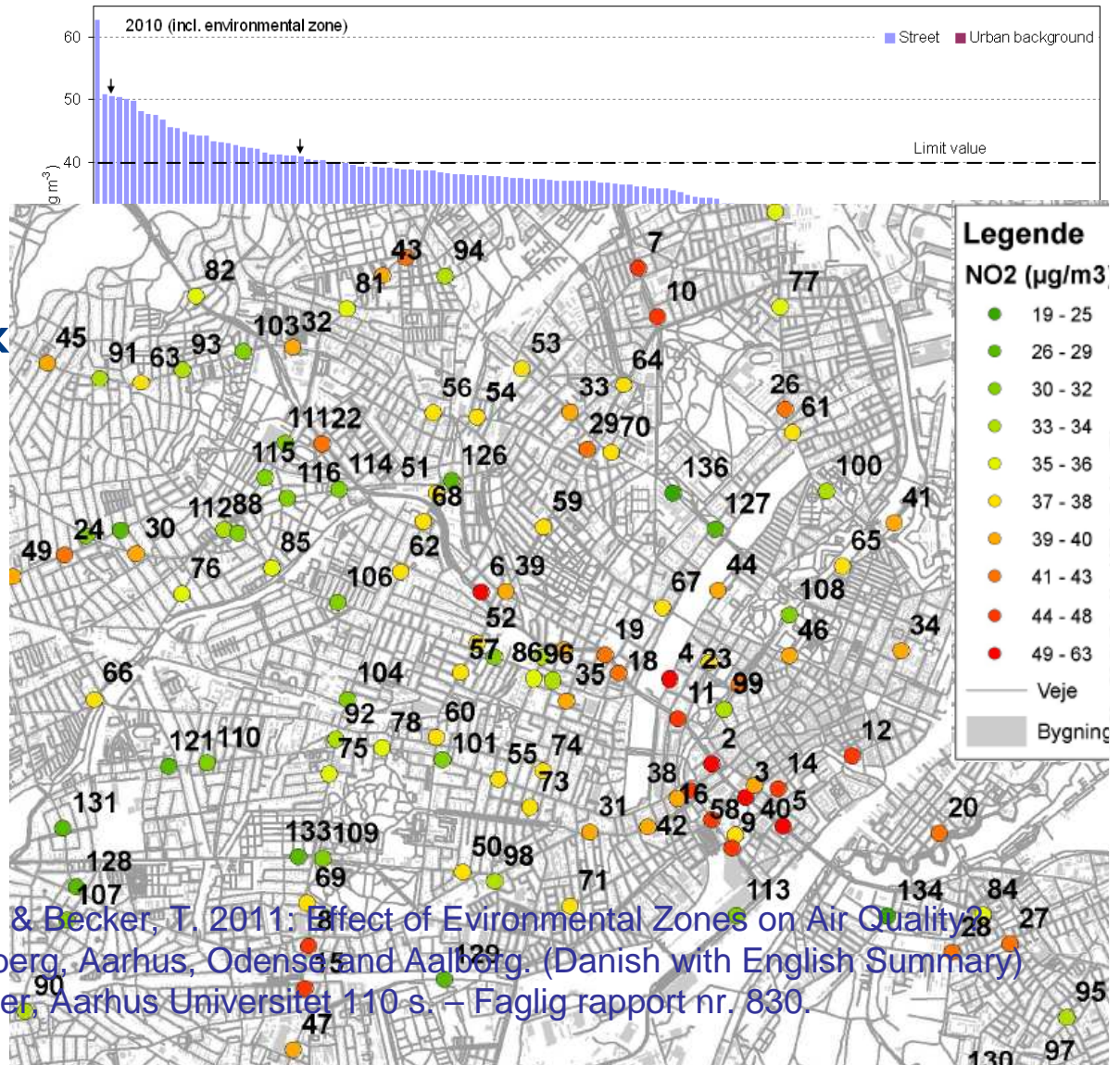
- > Has all relevant processes, is simple to apply and fast! - OSPM.dmu.dk
- > Frequently used; cities where OSPM has been applied/ validated:
- > emissions according to COPERT 4 method and actual Danish fleet



Kakosimos K.E., Hertel O., Ketzel M. and Berkowicz R. (2010): Operational Street Pollution Model (OSPM) - a review of performed validation studies, and future prospects. Environmental Chemistry, 7, 485-503.

Application of OSPM to many locations in DK

- › Selection of 265 streets in 4 mayor cities with ADT 10 000-65 000
- › Input using AisGIS.dmu.dk
- › Calculating the effect of environmental zones in 2010, 2015 and 2020
- › Mainly street canyons to identify potential compliance problems



Jensen, S.S., Ketzel, M., Nøjgaard, J. K. & Becker, T. 2011: Effect of Environmental Zones on Air Quality - Assessment for København, Frederiksberg, Aarhus, Odense and Aalborg. (Danish with English Summary) Slutrapport. Danmarks Miljøundersøgelser, Aarhus Universitet 110 s. – Faglig rapport nr. 830.
<http://www.dmu.dk/Pub/FR830.pdf>



Simple Evaluation for 5 street stations

> annual average for 2010

Station Name	Measurements		Model results		Relative difference	
	NO _x	NO ₂	NO _x	NO ₂	NO _x	NO ₂
	µg/m ³	µg/m ³	µg/m ³	µg/m ³	(%)	(%)
Coph.-HCAB	133	56	88	51	-35%	-10%
Coph.-Jagtvej	86	39	63	39	-26%	-1%
Odense	75	32	63	35	-16%	12%
Aarhus	87	39	65	36	-25%	-8%
Aalborg	104	39	53	30	-49%	-22%
	PM ₁₀	PM _{2.5}	PM ₁₀	PM _{2.5}	PM ₁₀	PM _{2.5}
Coph.-HCAB	28,1	17,4	30,0	19,4	7%	11%
Coph.-Jagtvej	26,7	17,8	27,7	18,3	4%	3%
Odense	26,0	-	27,8	17,7	7%	-
Aarhus	24,8	15,3	23,8	15,5	-4%	1%
Aalborg	-	18,3	23,8	13,8	-	-24%



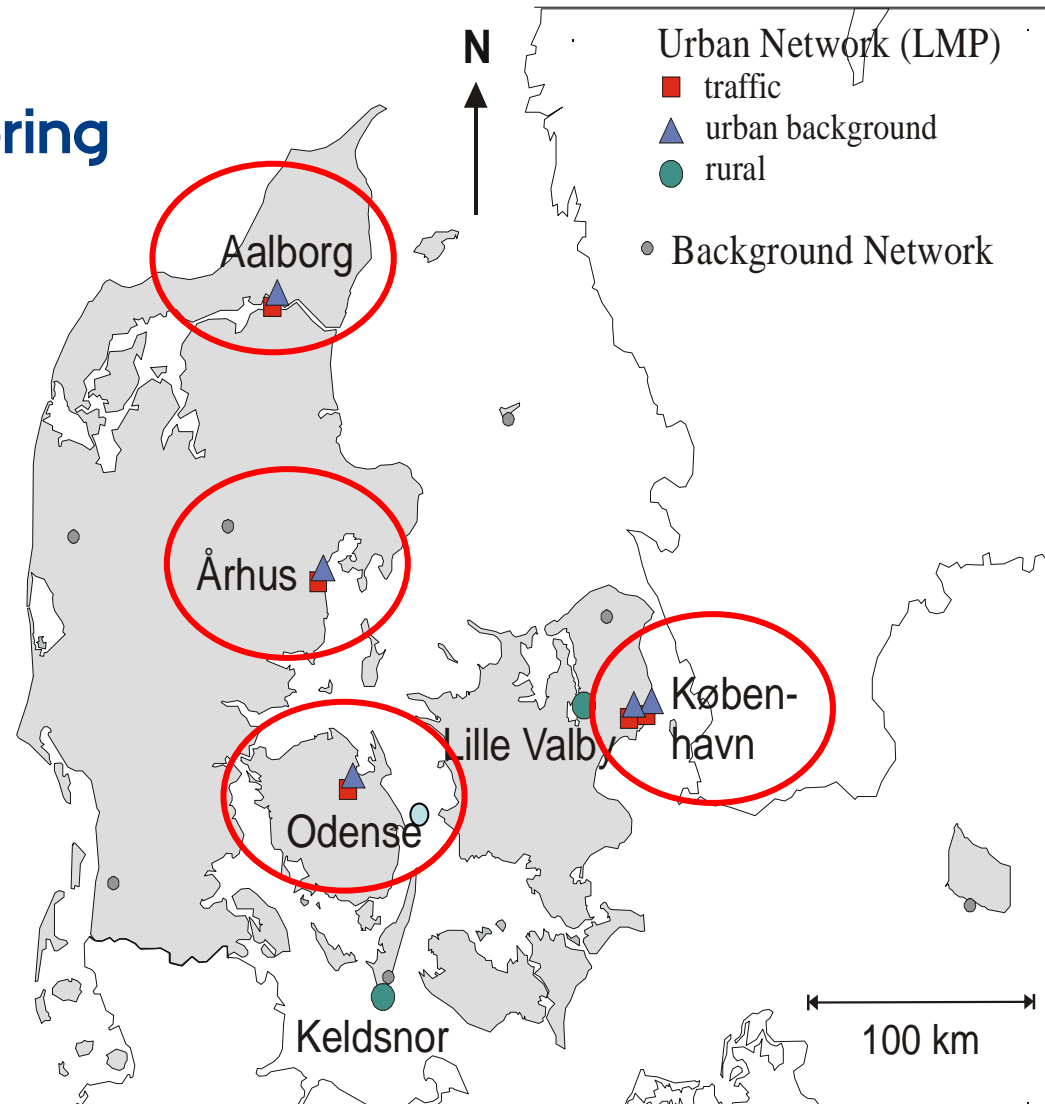
Motivation

- › **Maybe model is ‘right for the wrong reasons’??!!**
- › **statistical analysis might obscure deficiencies of the model**
- › **combination of statistical analysis and ”exploratory data analysis” has been proven very useful before (e.g. MUST exercise under COST 732)**
- › **analyse as many years of data for many stations**
- › **need for a tool to do this**



The data set

- > **Danish Air Quality Monitoring Programme**
- > **5 street stations and 4 urban background stat.**
- > **up to 17 years of data**
- > **compounds:**
 NO_x , O_3 , CO , PM_{10} $\text{PM}_{2.5}$



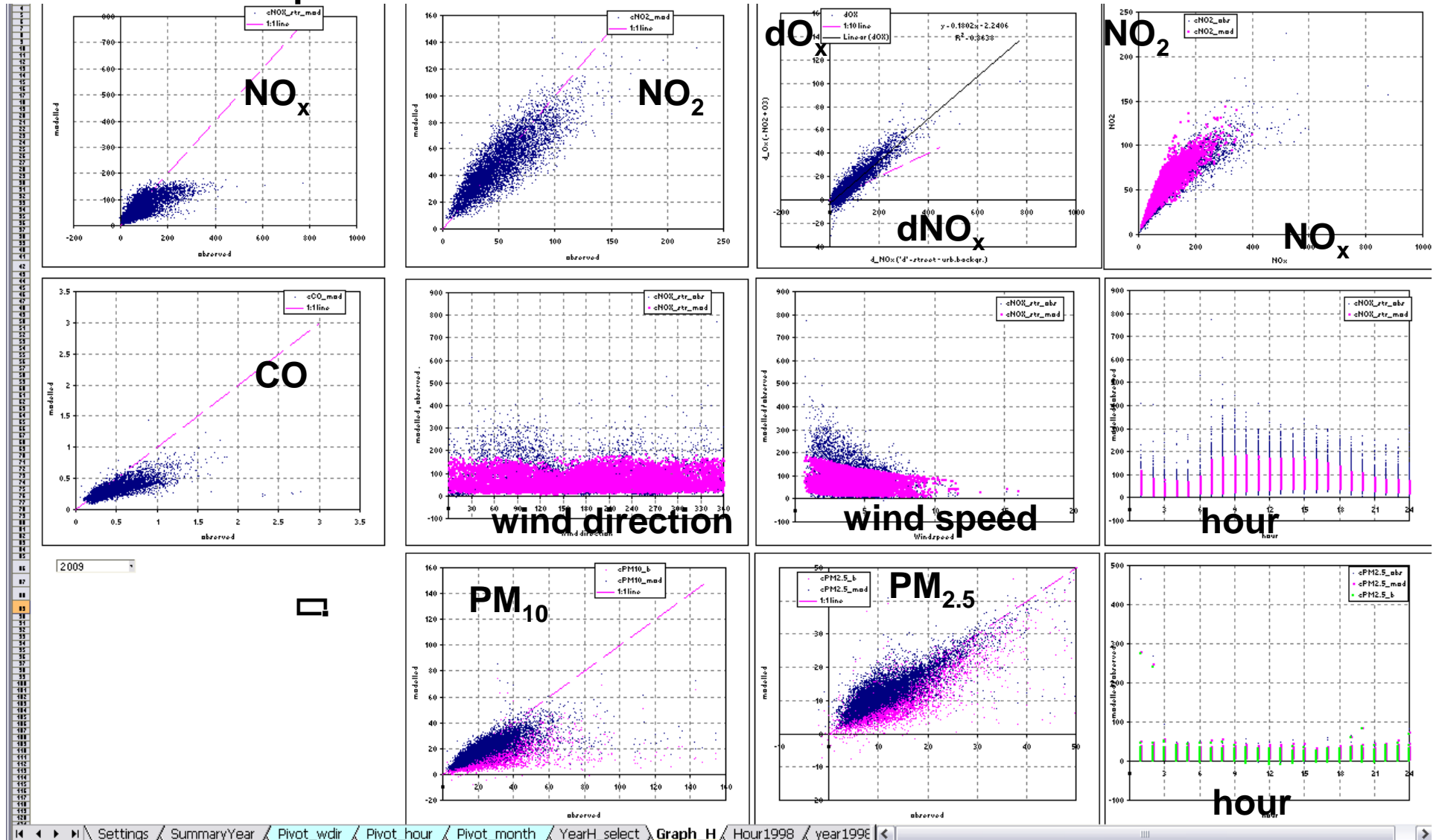


The Tool

- › **based on Excel 2003 + including graphics, filters, pivot tables, VBA macros,**
(briefly tested for Excel 2010)
- › **easy graphical inspection of data through:**
 - › scatter plots (model vs. observation) of hourly data
 - › trends of annual averages
 - › plot of aggregated averages versus independent parameters (hour, month, wind direction)
- › **can handle large amount of data, e.g. hourly time series for 17+ years**
- › **WinOSPM writes output directly into Excel files**

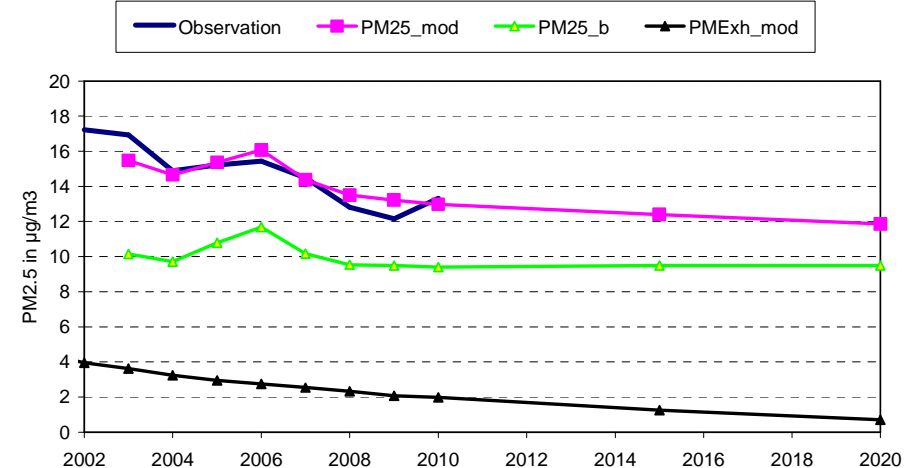
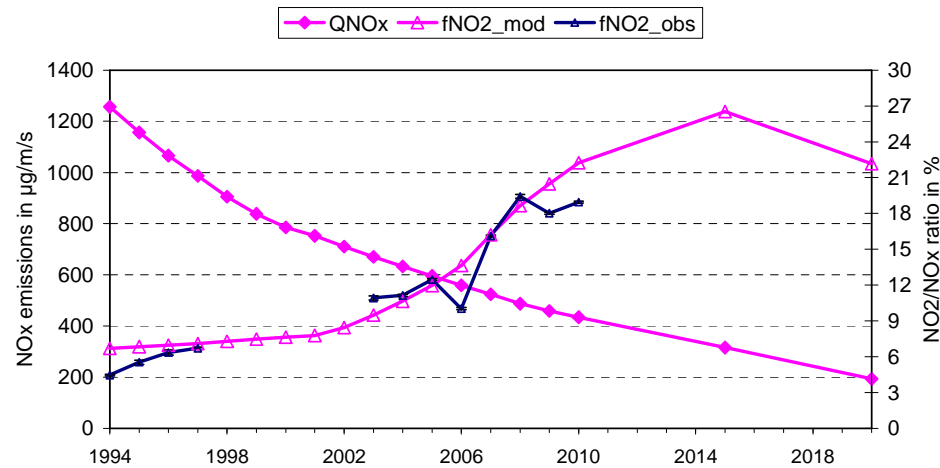
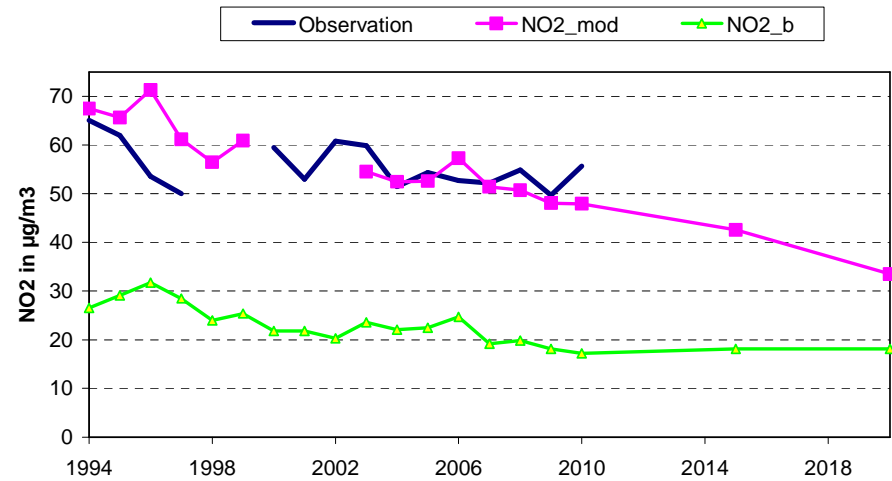
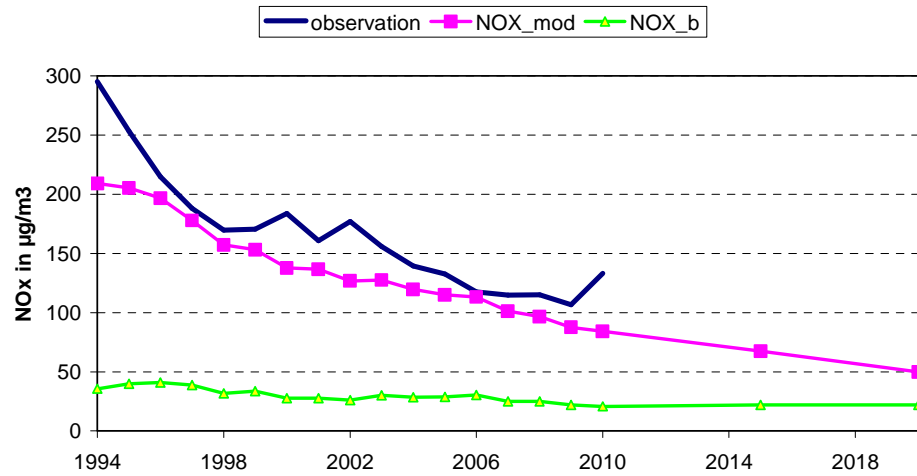


Scatter plots



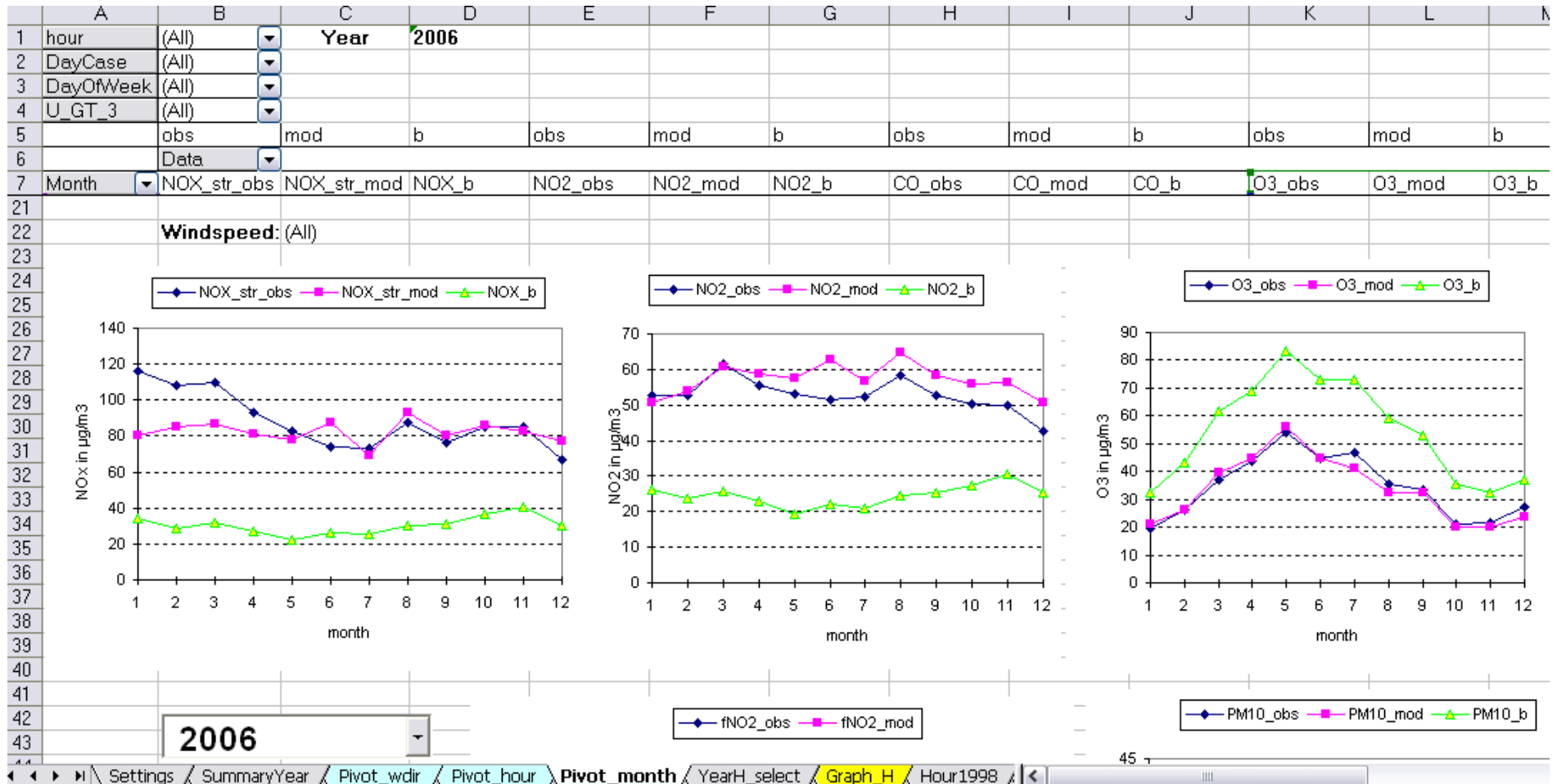


Annual Trends





Monthly variation

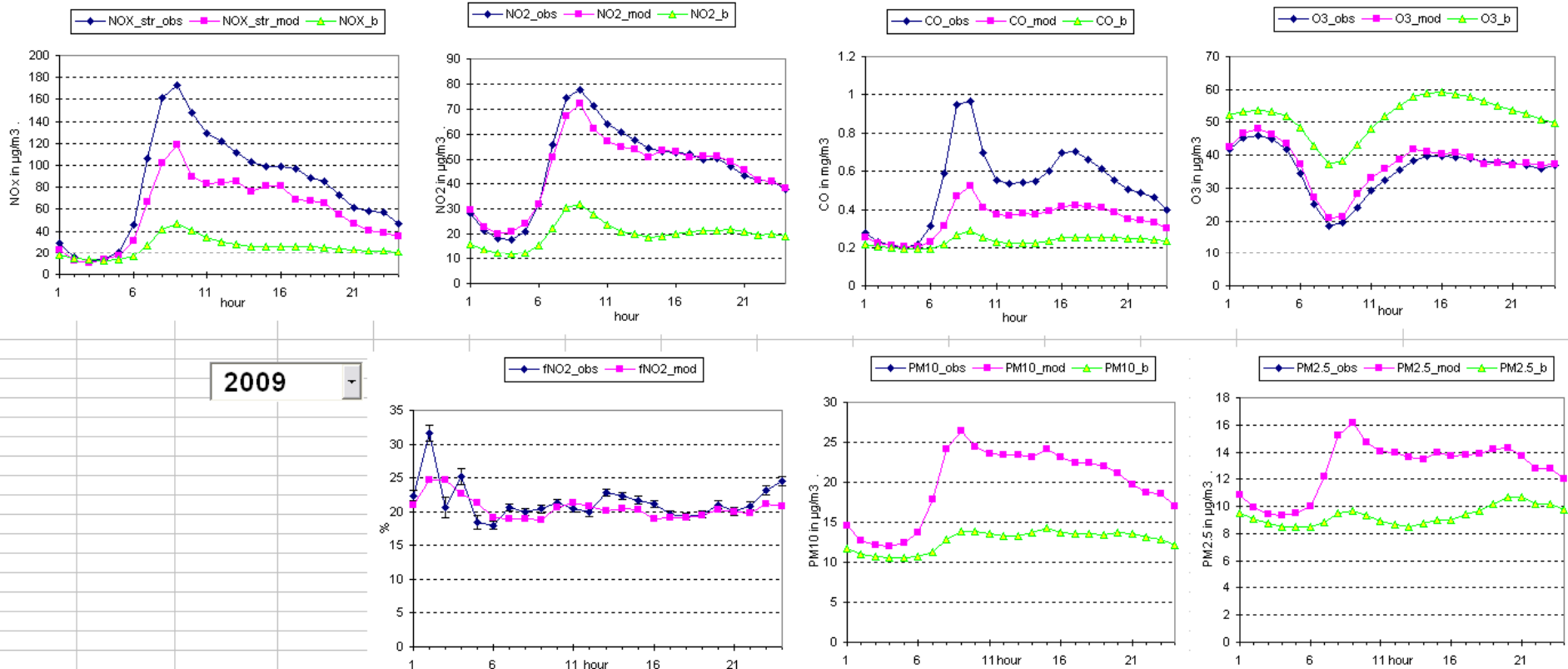




Diurnal variation - DayCase 1 (Mo-Fr)

Month	(All)	Year	2009												
DayCase	1														
Day_of_Week	(All)														
U_GT_3	(All)														
	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod	
Data															
hour	NOX_str_obs	NOX_str_mod	NOX_b	NO2_obs	NO2_mod	NO2_b	CO_obs	CO_mod	CO_b	O3_obs	O3_mod	O3_b	PM10_obs	PM10_mod	
24	47.04288639	35.08058756	21.05997054	37.70765955	38.42288794	19.13622501	0.399728777	0.307384117	0.239026452	36.87023915	37.22656231	49.87967922		16.9967615	
Grand Total	81.42925068	58.1823761	25.1622209	46.80161065	45.47284987	20.12141006	0.523037377	0.349068558	0.236470712	35.70288683	37.34840507	51.6546282		19.6946663	

Windspeed: (All)

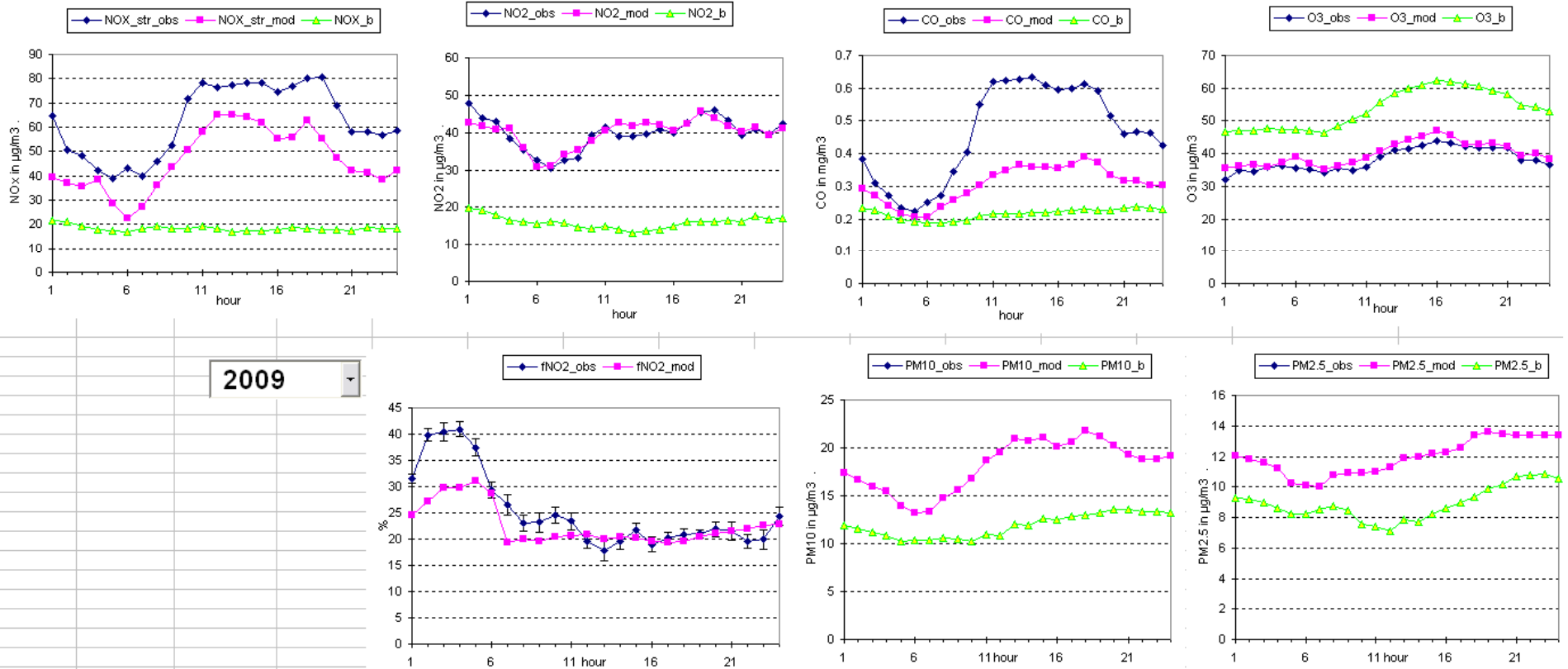




Diurnal variation - DayCase 2 (Sa)

Month	(All)	Year	2009														
DayCase	2																
DayOfWeek	(All)																
U_GT_3	(All)																
	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod
Data																	
hour	NOX_str_obs	NOX_str_mod	NOX_b	NO2_obs	NO2_mod	NO2_b	CO_obs	CO_mod	CO_b	O3_obs	O3_mod	O3_b	PM10_obs	PM10_mod			
24	58.7281362	42.36720374	18.22550913	42.1972668	41.1592108	17.04465748	0.424353294	0.30278237	0.229875753	36.44516911	38.34142193	52.76211283					19.11748996
Grand Total	62.46264916	46.44470644	18.31799681	39.79176063	39.87931896	15.96631517	0.462112988	0.305583301	0.216087435	38.1159124	39.95023389	53.67144473					18.08085594

Windspeed: (All)

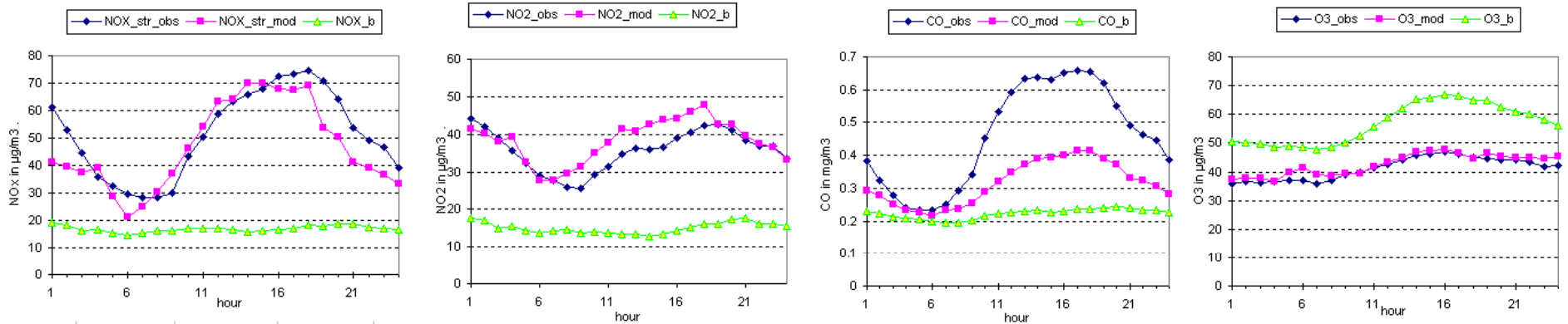




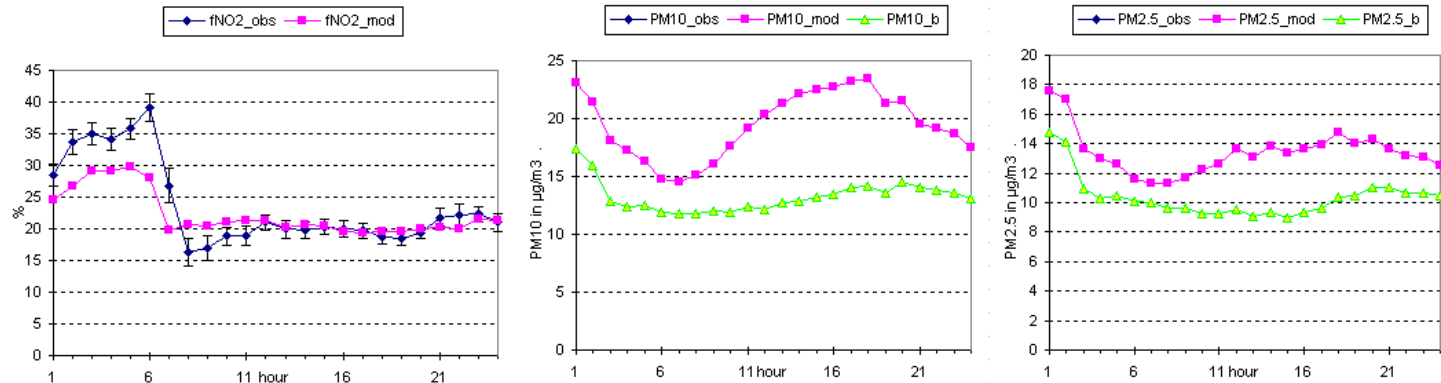
Diurnal variation - DayCase 3 (So)

Month	(All)	Year	2009														
DayCase	3																
DayOfWeek	(All)																
U_GT_3	(All)																
	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod
Data																	
hour	NOX_str_obs	NOX_str_mod	NOX_b	NO2_obs	NO2_mod	NO2_b	CO_obs	CO_mod	CO_b	O3_obs	O3_mod	O3_b	PM10_obs	PM10_mod			
24	39.0747249	33.16312312	16.5866715	33.52568297	33.31212092	15.44379226	0.385640332	0.283632123	0.225524354	42.36320978	45.2565998	56.12461681		17.47197498			
Grand Total	51.56808984	46.96063753	16.9702586	35.68101995	38.33261376	15.08353642	0.45756915	0.315716773	0.22284152	41.22122438	42.62746567	56.80699277		19.45789117			

Windspeed: (All)



2009

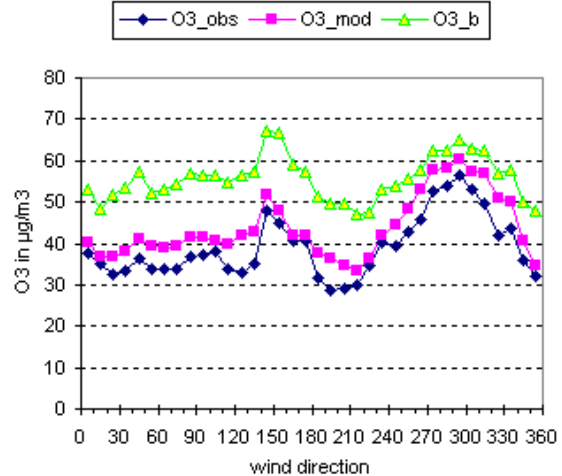
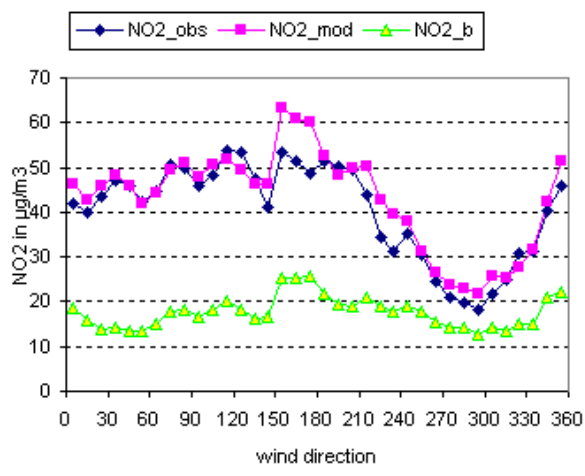
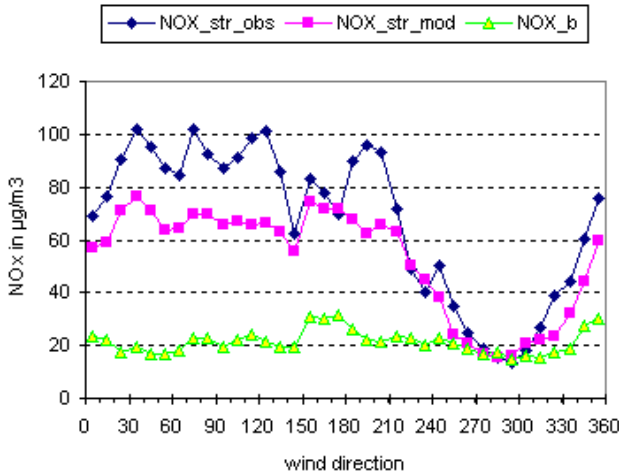




Dependence on wind direction

Month	(All)	Year	2010										
DayCase	(All)												
DayOfWeek	(All)												
U_GT_3	(All)												
	obs	mod	b	obs	mod	b	obs	mod	b	obs	mod	b	
	Data												
Wdclass	NOX_str_obs	NOX_str_mod	NOX_b	NO2_obs	NO2_mod	NO2_b	CO_obs	CO_mod	CO_b	O3_obs	O3_mod	O3_b	

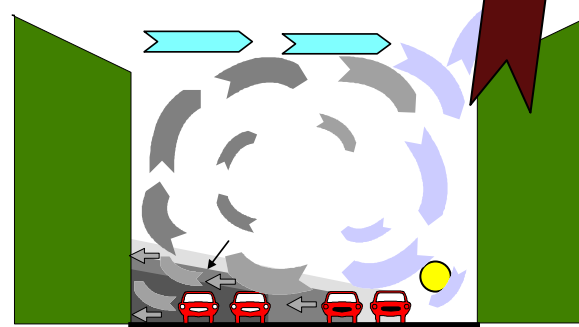
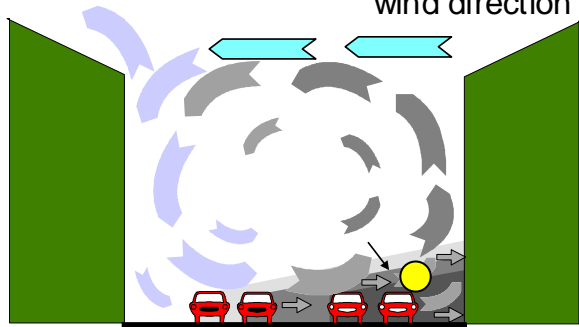
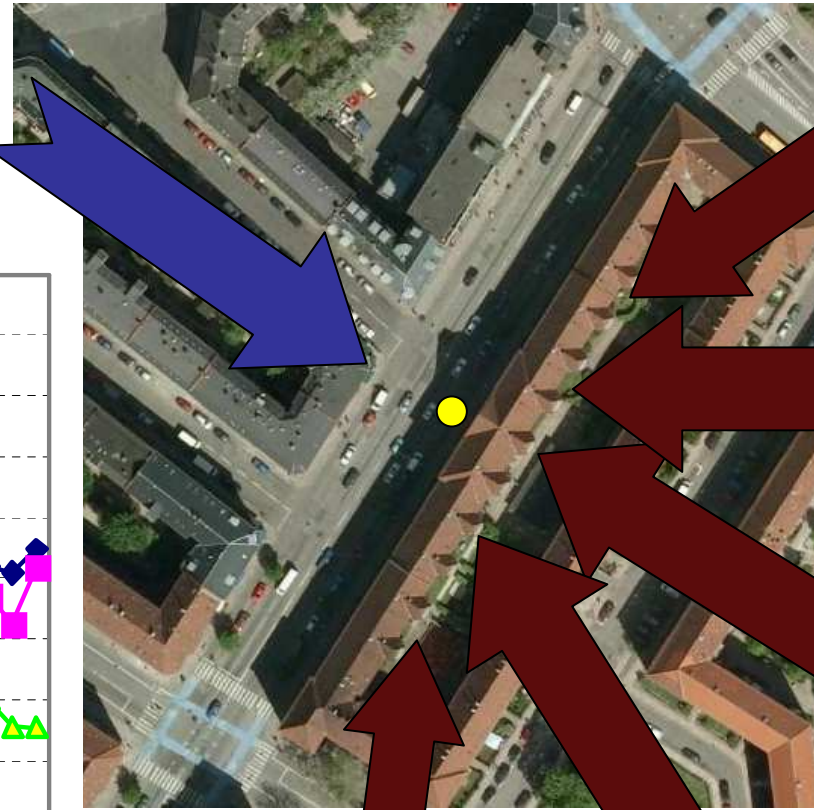
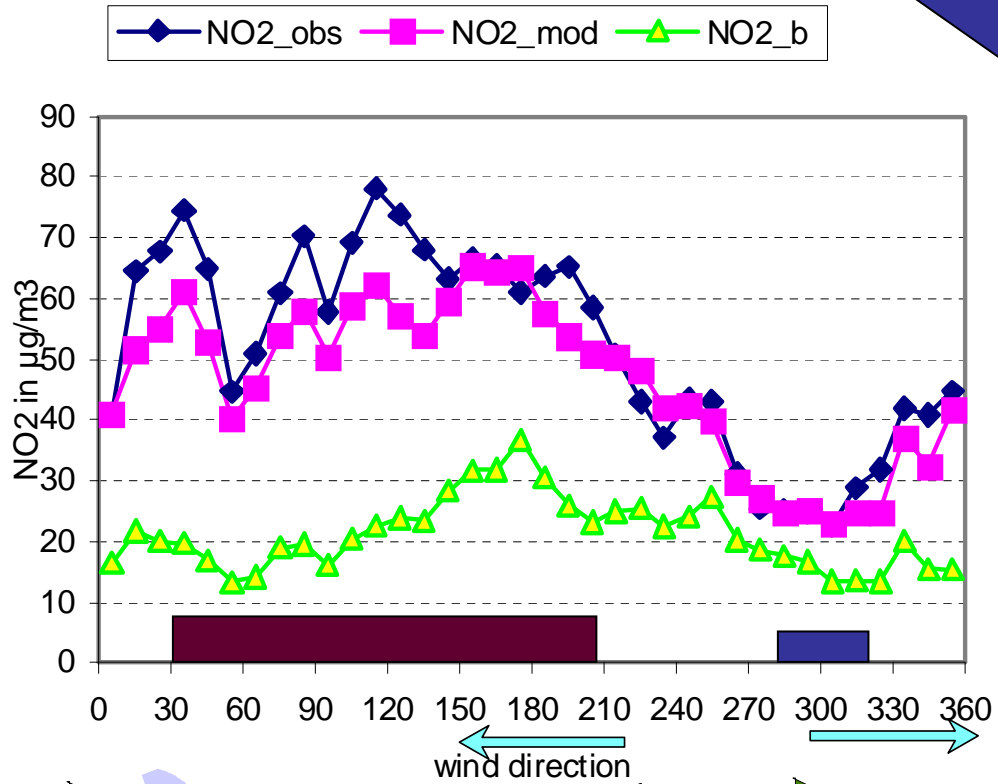
Windspeed: (All)



2010

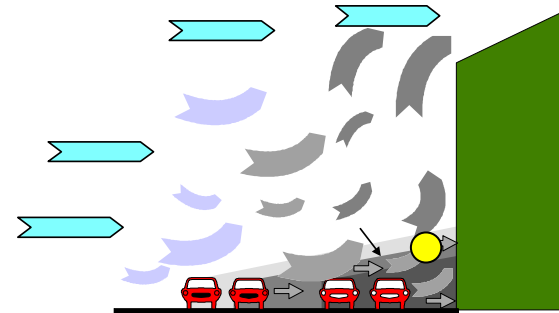
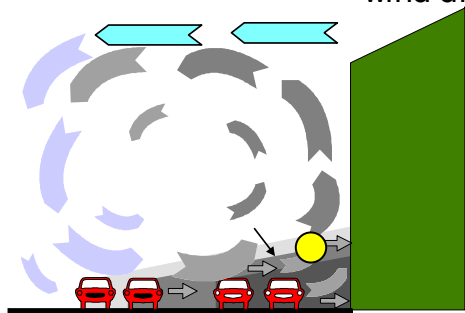
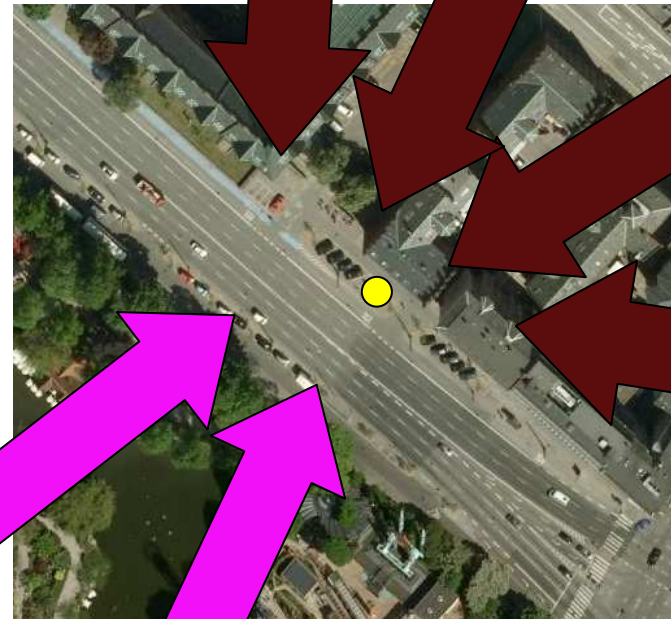
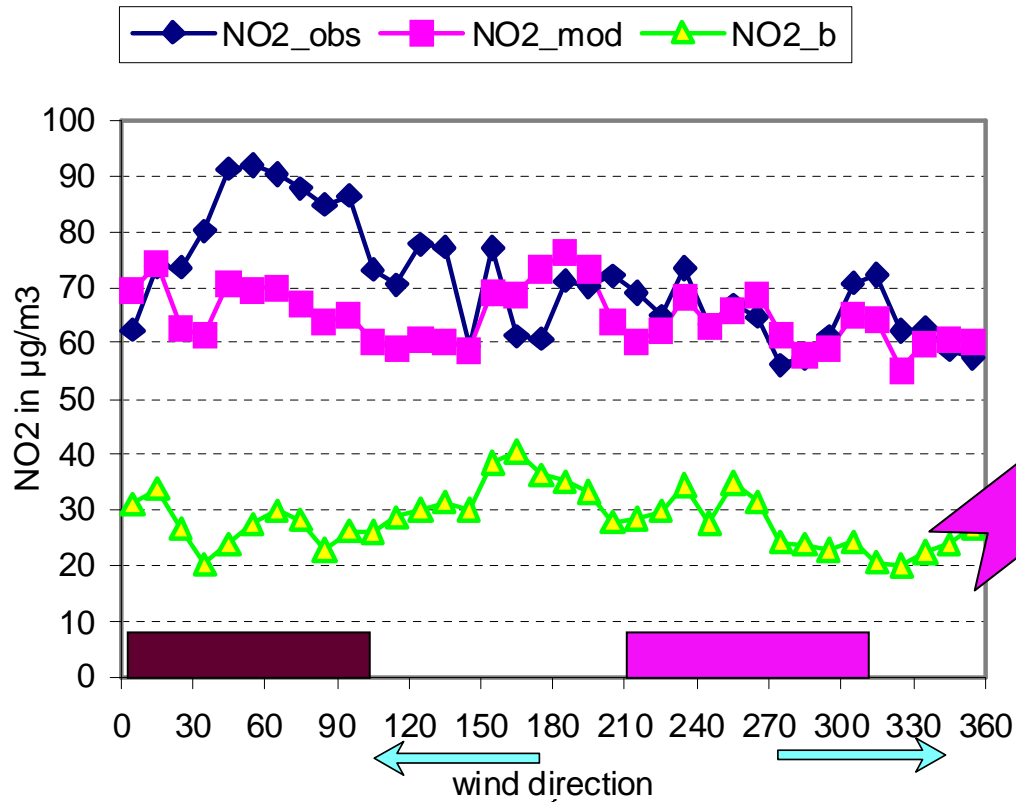


Jagtvej



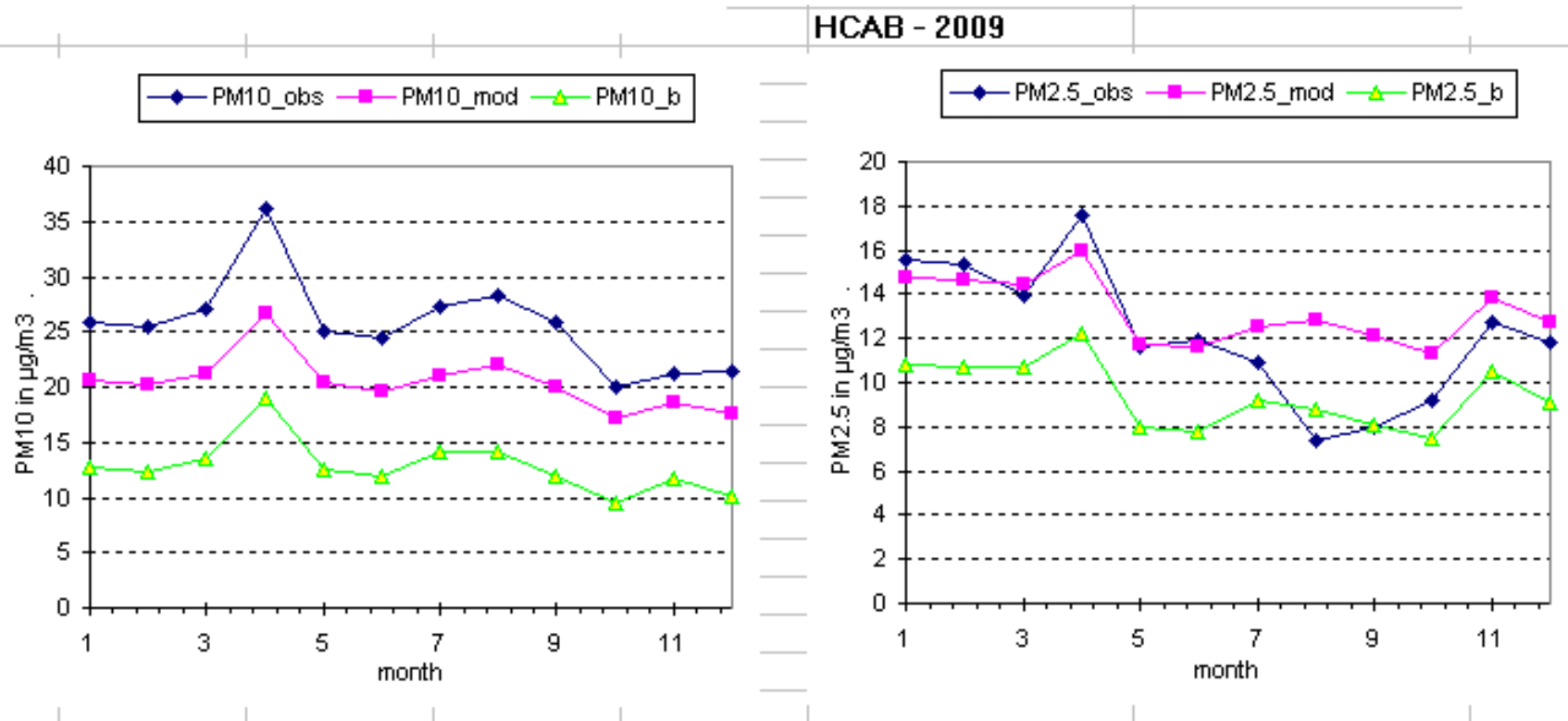


H.C. Andersens Boulevard



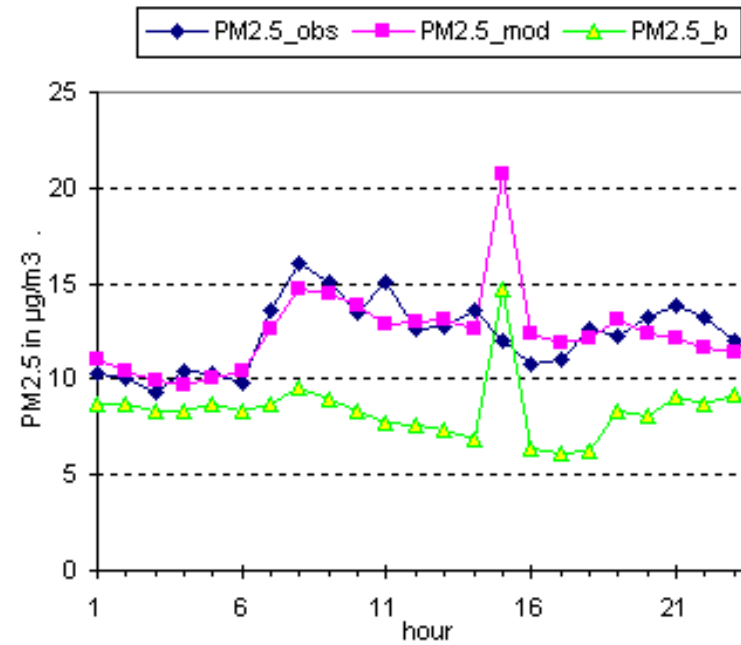
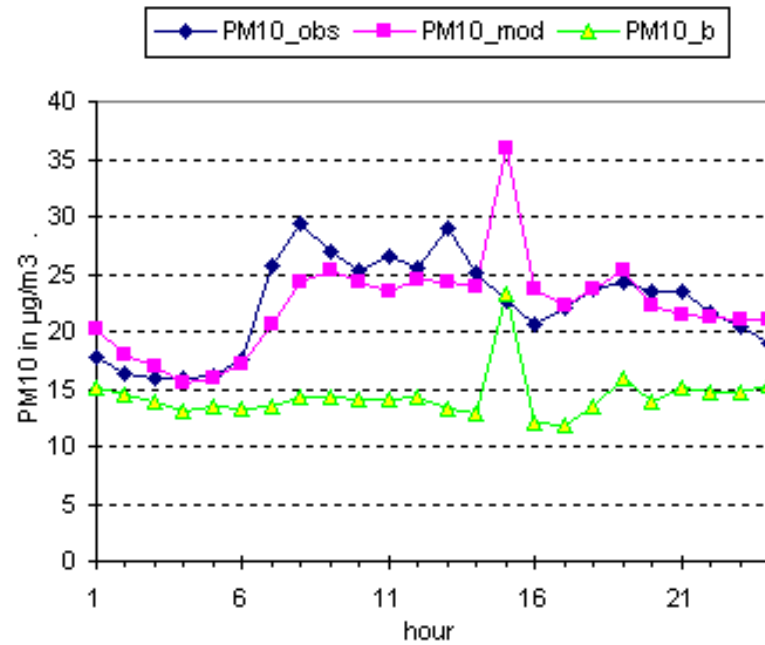


Example for finding errors in observations





Example for finding errors in observations



HCAB - 2008



Conclusions and Outlook

- ❑ exploratory data analysis is essential in addition to statistical model evaluation in order to:
 - > show that your model is “right for the right reason”
- ❑ can help to identify and systematically investigate
 - > shortcomings in the model
 - > errors in the model input data
 - > inconsistencies in the measurements
- ❑ OSPM applied to 5 long-term data sets from Denmark
 - > good results for most compounds, but certainly room for improvement
- ❑ easy-to-use-tool is available from: OSPM.dmu.dk
- ❑ Interaction of the OSPM user community possible via:
http://en.wikipedia.org/wiki/Operational_Street_Pollution_Model
(*Google: Wiki OSPM*)