MAX-DOAS tropospheric NO_2 column retrievals as a validation tool for MACC-III regional air quality models

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Motivation

- NO_2 is hazardous to human health, leads to O_3 and acid rain formation, eutrophication of ecosystems

- Accurate regional and global scale simulations and observations requiered

- MAX-DOAS data widely used for satellite validation, only Vlemmix et al. (2010) used it for model validation

- Investigate potential of using MAX-DOAS NO_2 retrievals for MACC-III and future CAMS regional model validation

What is MACC-III?

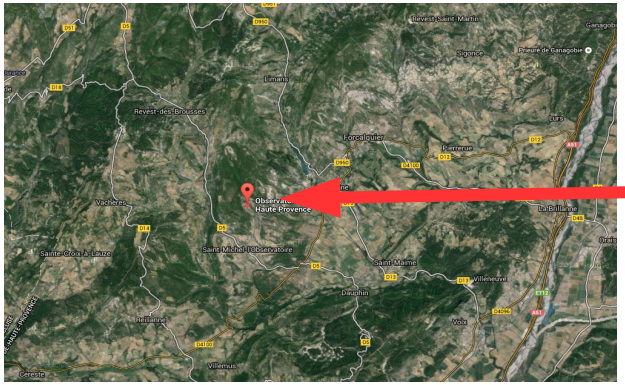
- **M**onitoring **A**tmospheric **C**omposition and **C**limate – **I**nterim **I**mplementation

- Current pre-operational **C**opernicus (European system for monitoring the Earth) **A**tmosphere **M**onitoring **S**ervice

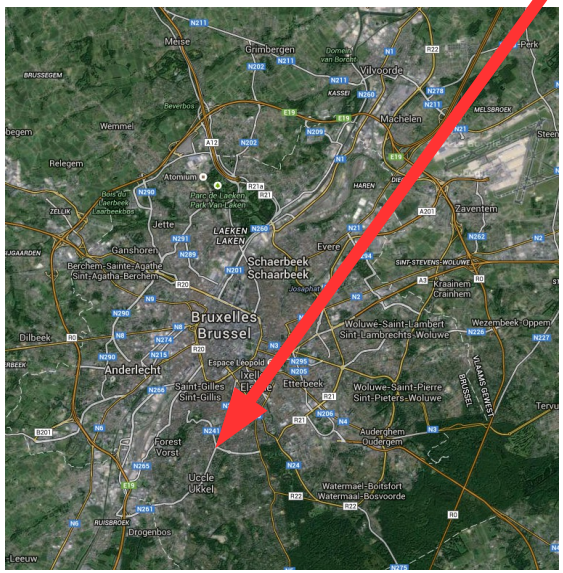
- Extension of ECMWF (Reading, UK) weather services to atmospheric composition

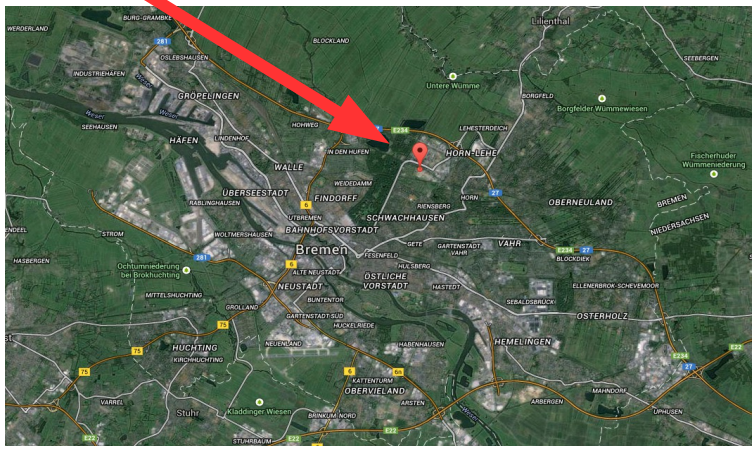
- Coordinated by ECMWF and operated by a 36-member consortium from …

MAX-DOAS measurement stations



Station	Institution	Quantity	Characterisation
OHP (France)	BIRA-IASB	column / profile	rural
Uccle (Belgium)	BIRA-IASB	column / profile	urban, local pollution
Bremen (Germany)	IUP-UB	column / profile	urban, local pollution





Regional air quality models

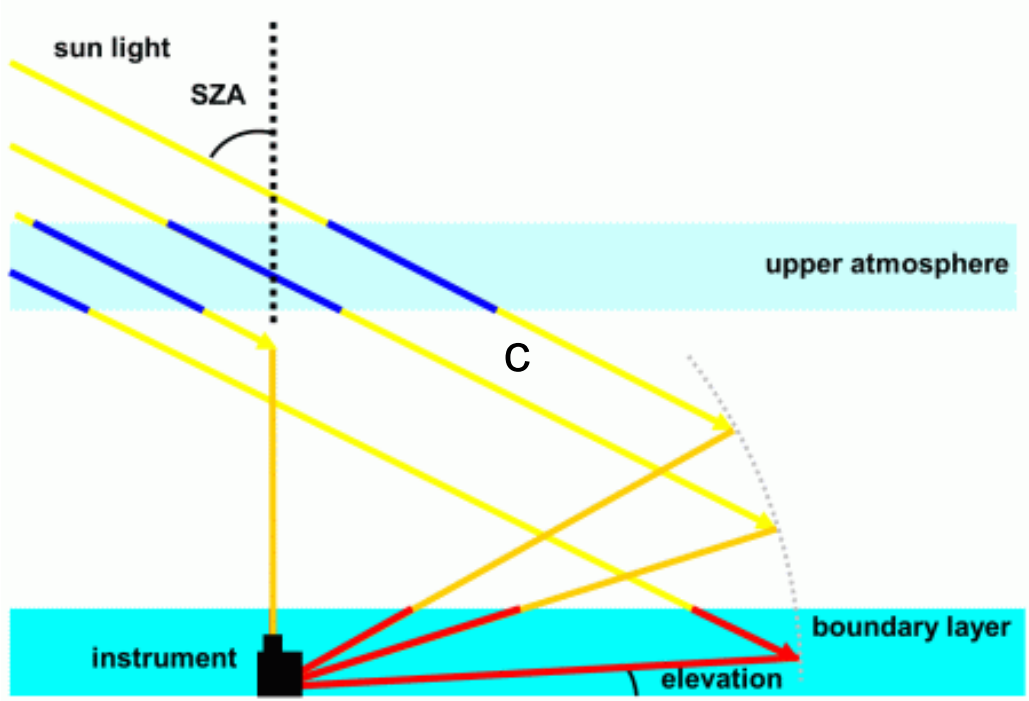
- Contribute to European regional ensemble of forecasts and reanalyses in MACC-III

Model	Institution	Grid resolution
Lotos-Euros	TNO	~7x7 km
MOCAGE	Météo-France	~15x22 km
EMEP	MetNo	50x50 km
EMEP-MACCEVA	MetNo	~18x14 km
CHIMERE	LISA-CNRS/ UPEC/UPD	~18x28 km (2010/2011) ~7x11 km (2012)
SILAM	FMI	~15x22 km (2010/2011) ~10x15 km (2012)

all driven by ECMWF meteorology

Multi AXis Differential Optical Absorption Spectroscopy

- Measures scattered sunlight at different elevation angles
- Horizon viewing direction for tropospheric measurements
- SCDs of absorbers derived from Lambert-Beer's law
- VCD = SCD / AMF
- **Sensitivity much larger close to the surface**



Model data processing for intercomparison

- Hourly model data sampled to closest measurement time

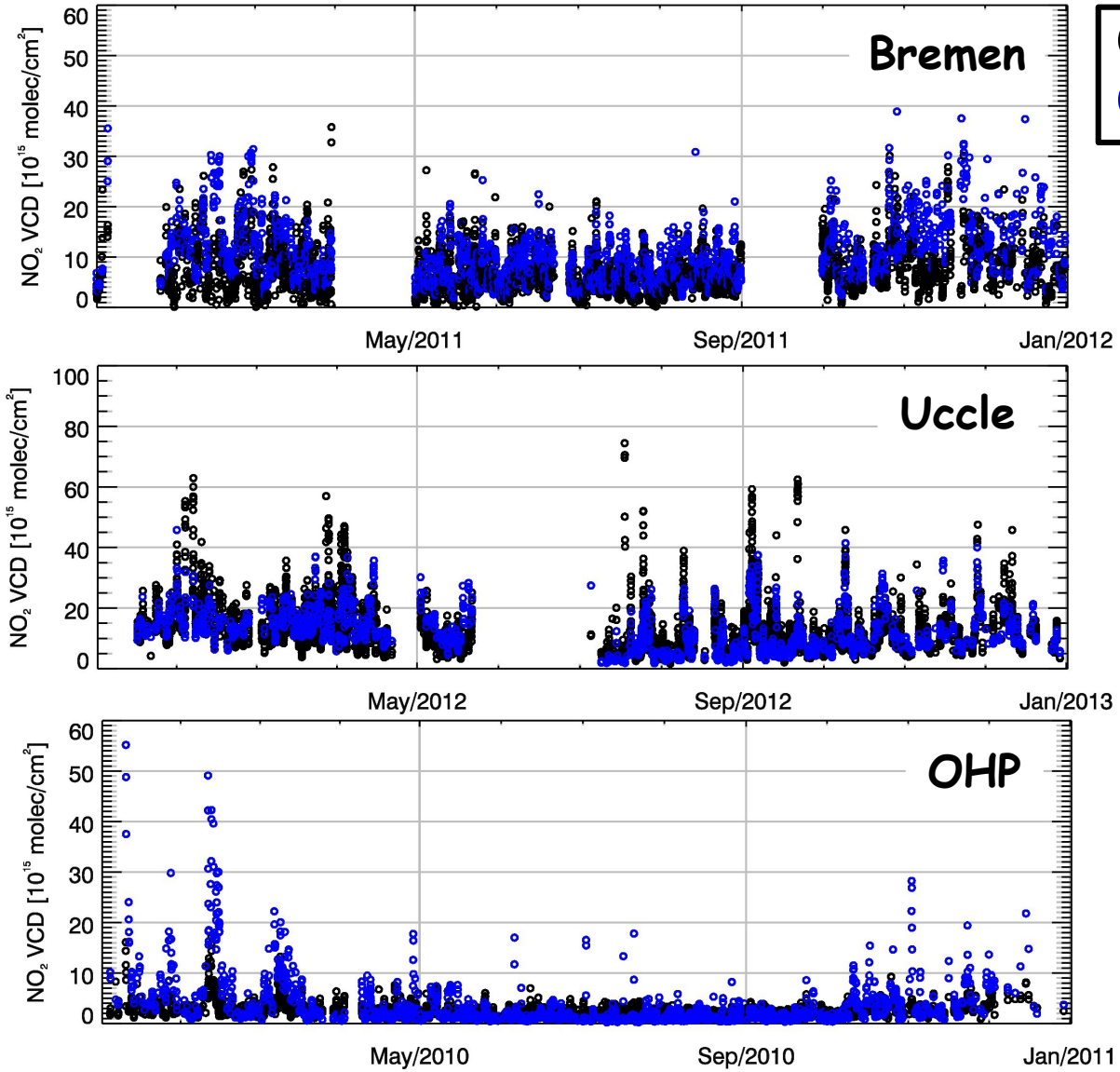
- Data derived on measurement altitudes assuming that model concentrations are constant within a model layer

- NO_2 VCDs from two methods:

$$VCD_{method1}^{model} = \sum_{i=1}^{N_{model}} VCD_i^{model} \qquad VCD_{method2}^{model} = \sum_{i=1}^{N_{obs}} AVK_i * VCD_i^{model}$$

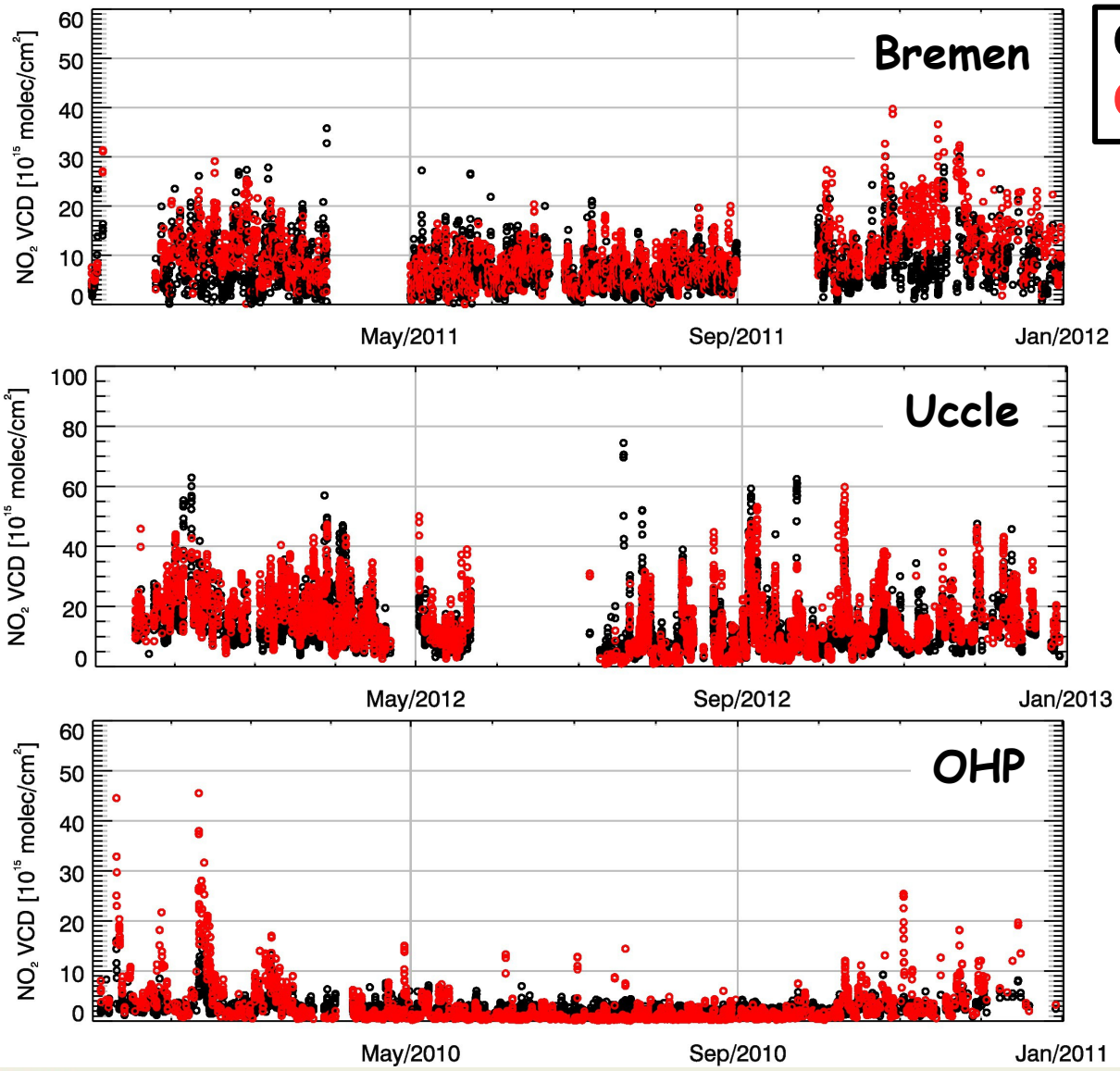
- Application of AVKs expected to show large influence on results

Time series



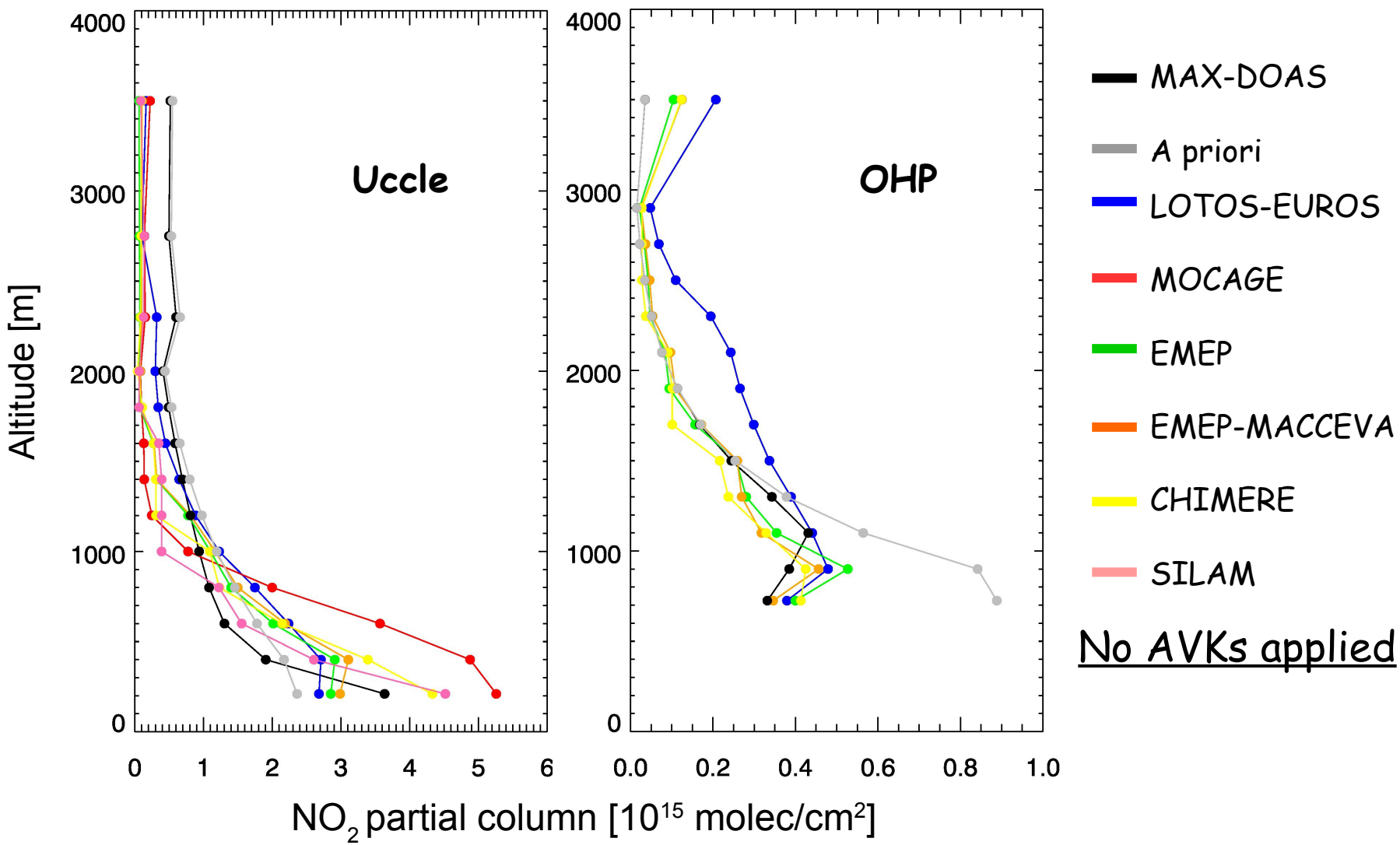
O MAX-DOAS
O Lotos-Euros (method 1)

Time series



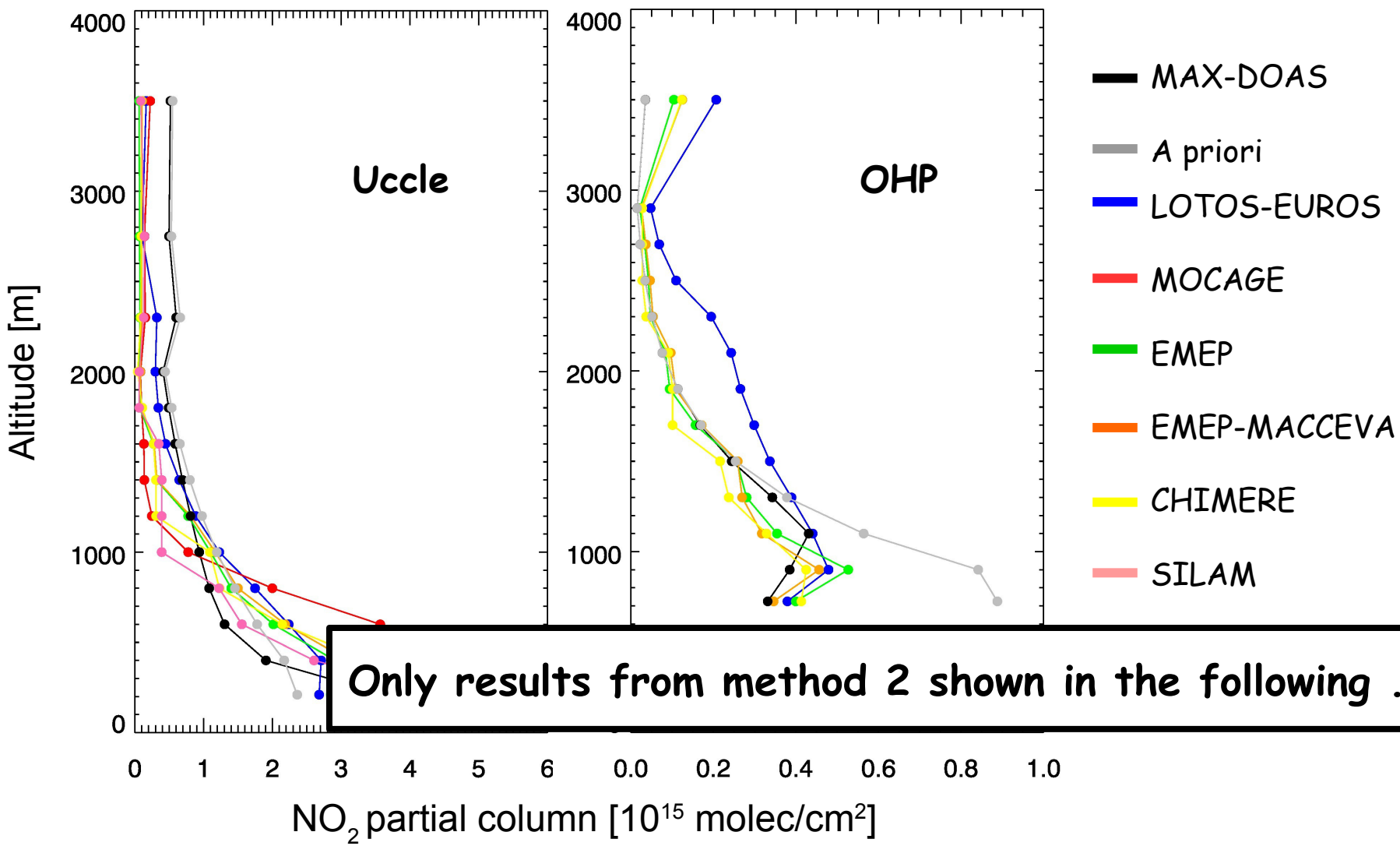
O MAX-DOAS
O Lotos-Euros (method 2)

Vertical profiles averaged over time series



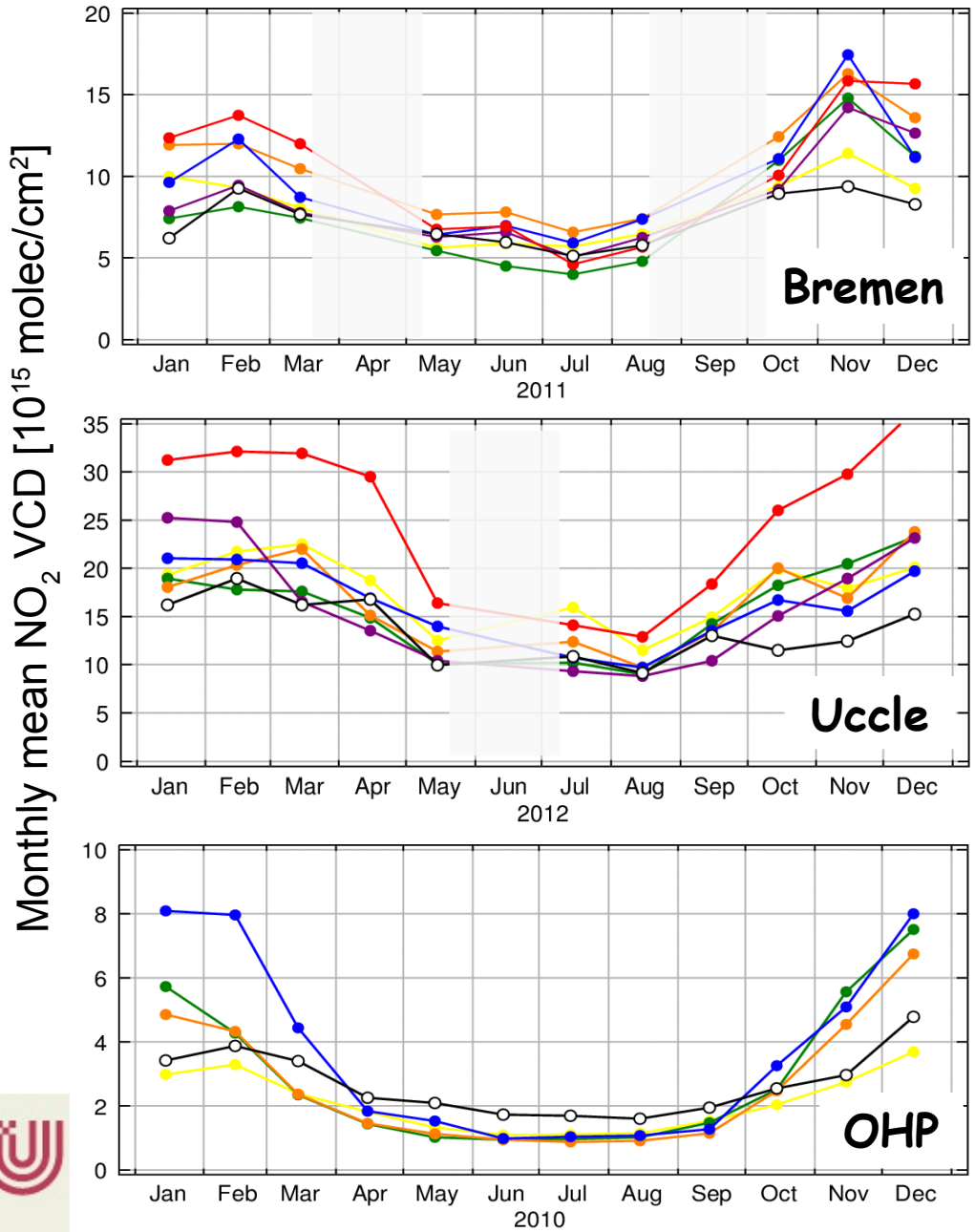
No AVKs applied

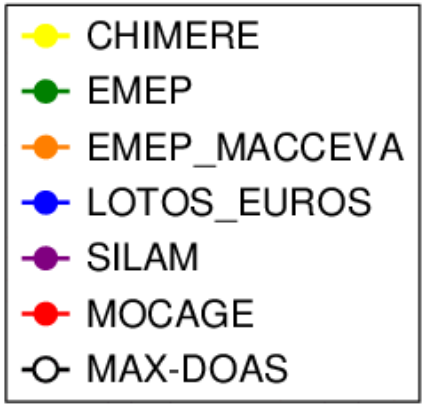
Vertical profiles averaged over time series



Only results from method 2 shown in the following ...

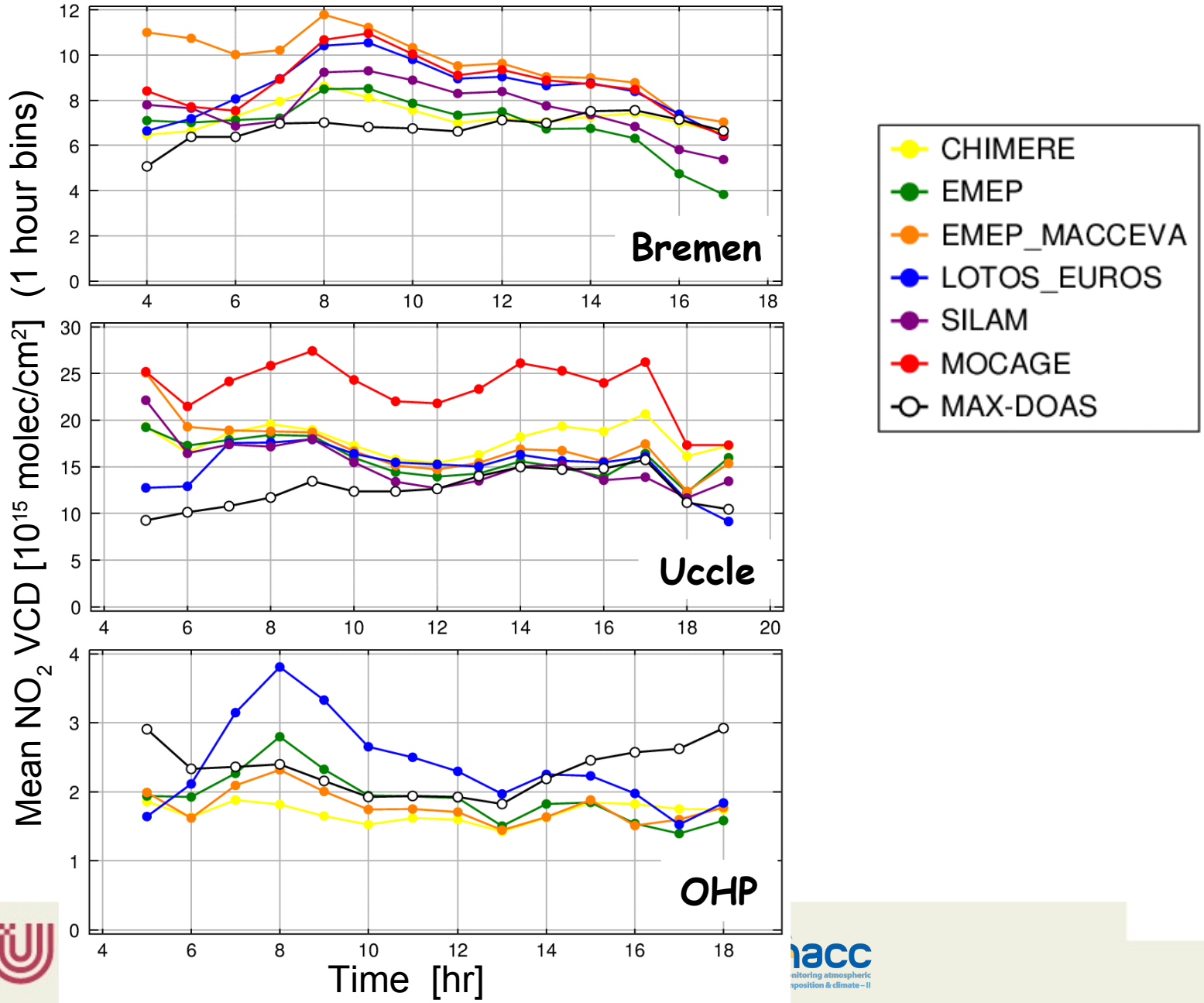
Seasonal cycles



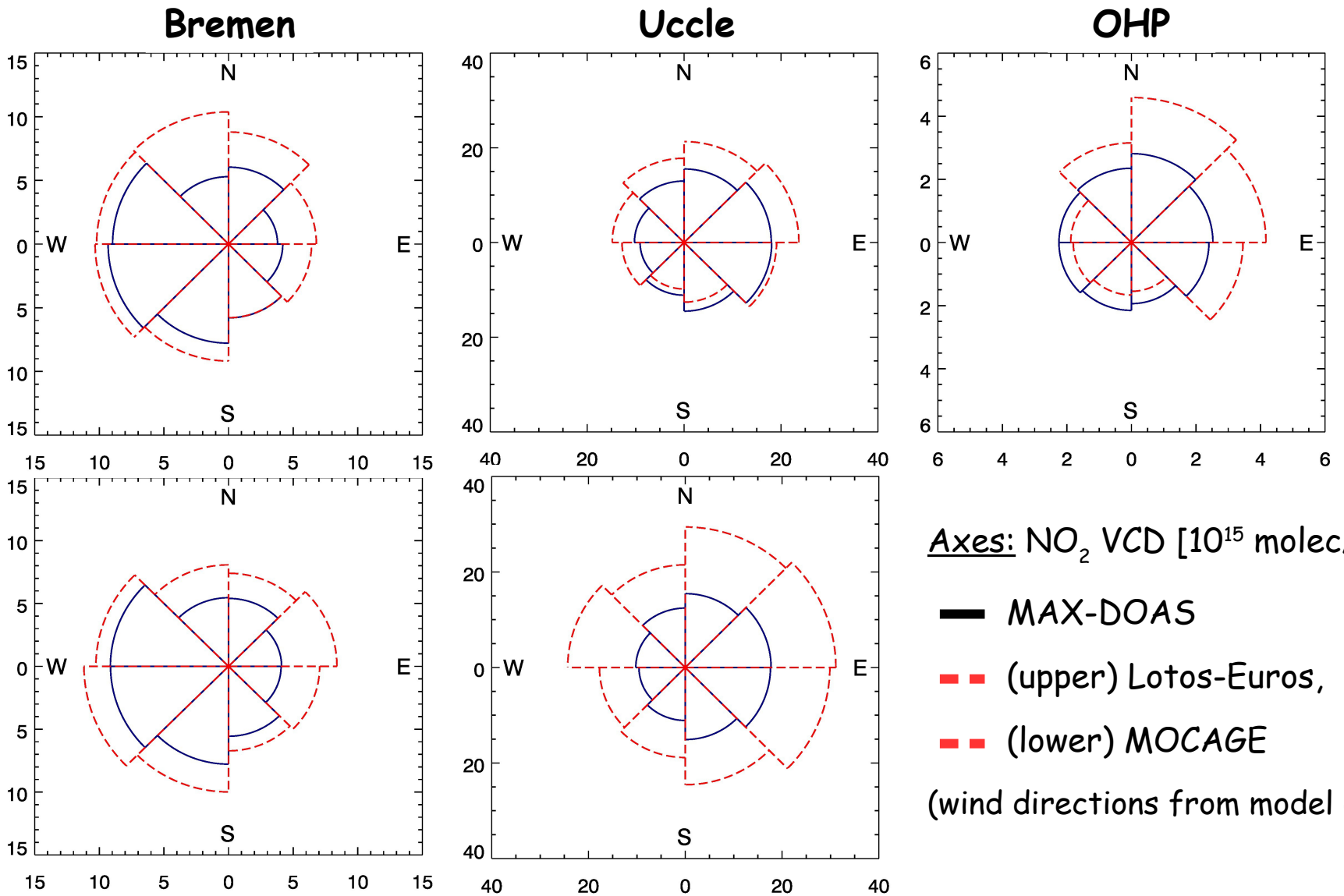


Gray boxes: no measurements

Diurnal cycles



Average NO_2 VCDs in 45° wind direction bins



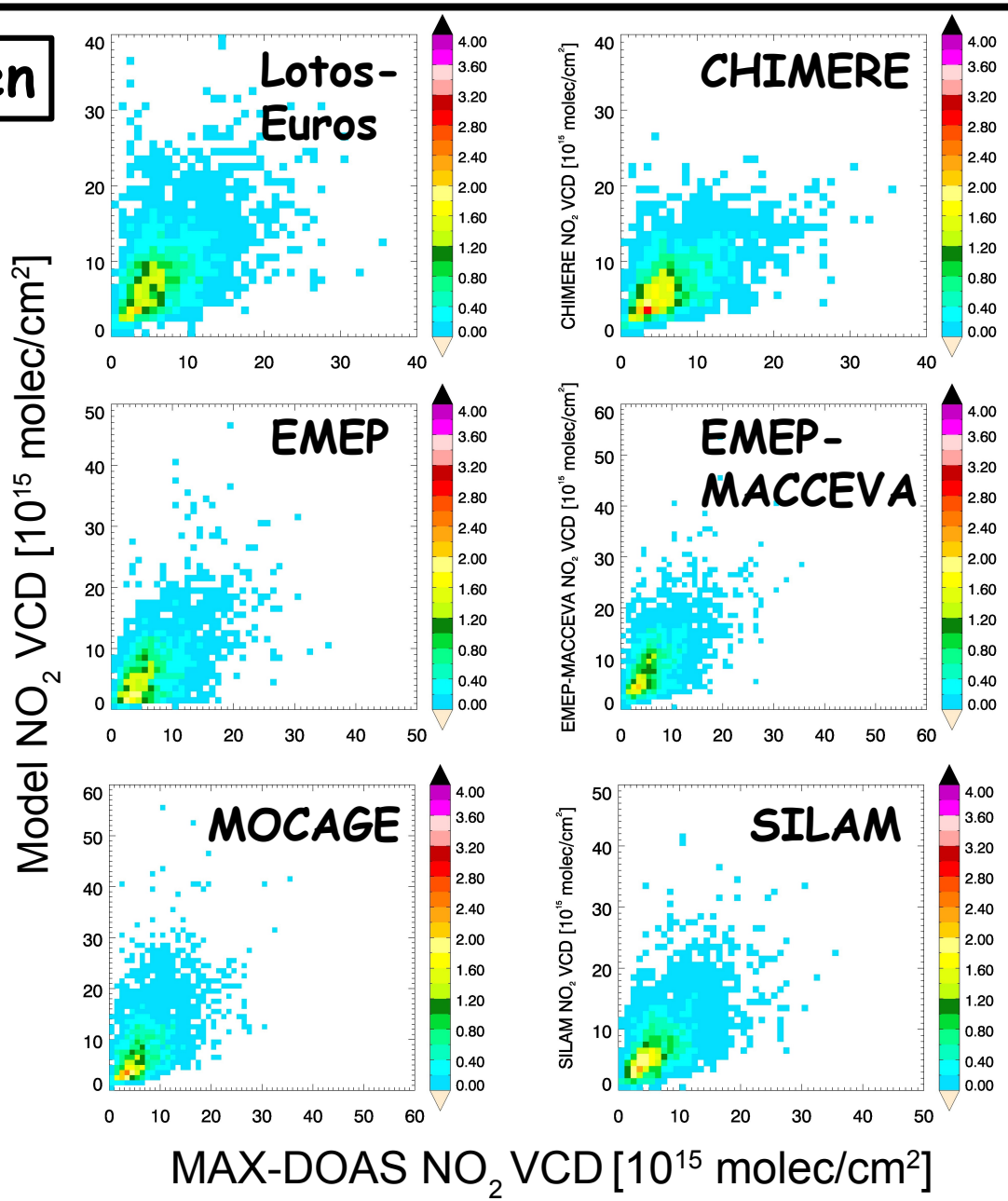
Axes: NO_2 VCD [10^{15} molec/cm^2]

- MAX-DOAS
- (upper) Lotos-Euros,
- (lower) MOCAGE

(wind directions from model data)

Scatterplots – color: data percentage per 1 x 10^{15} molec/cm^2 bin

Bremen



Summary for all stations:

Correlations:

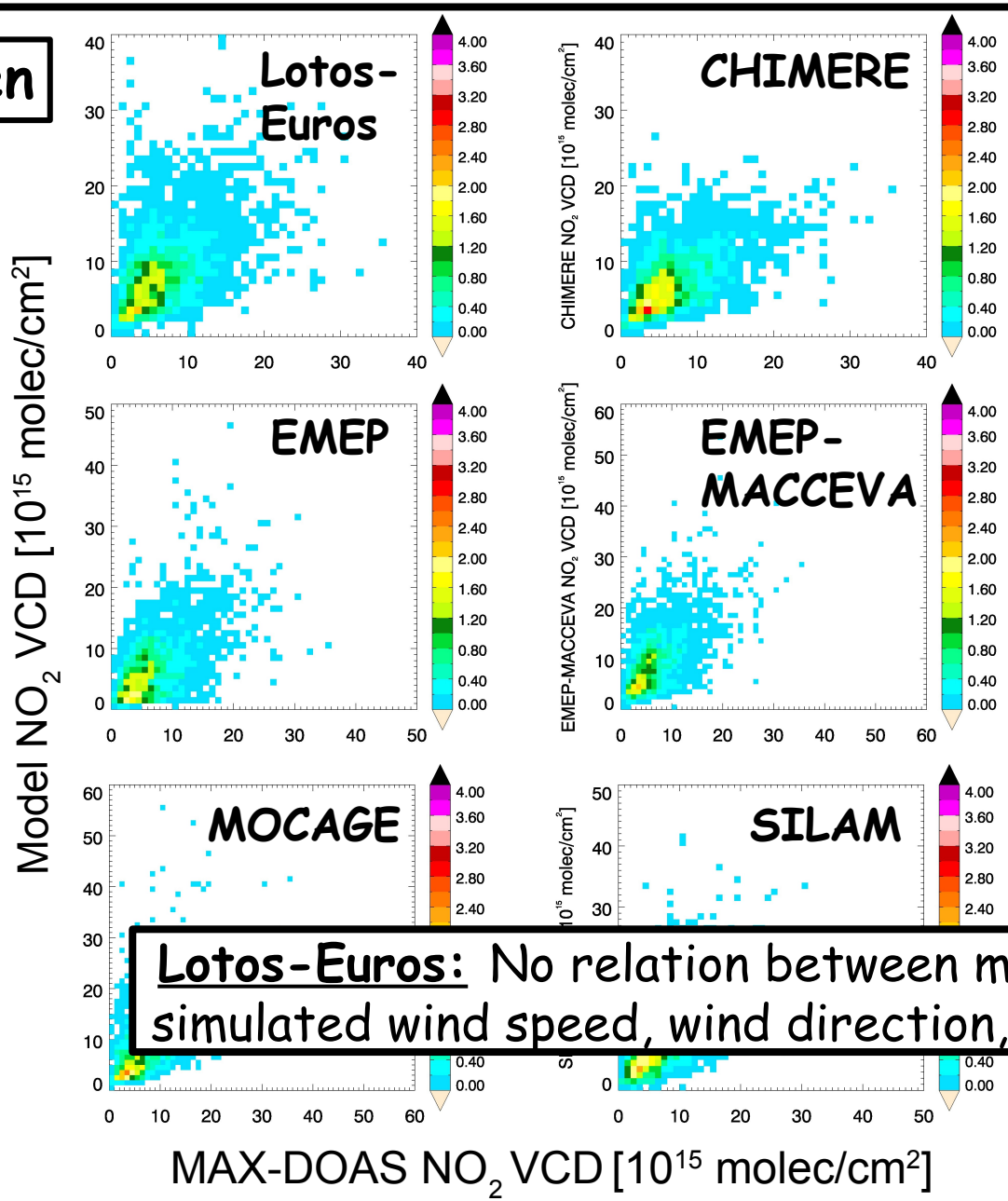
50-65 %

RMS:

1-15 x 10^{15} molec/cm^2

Scatterplots – color: data percentage per 1 x 10^{15} molec/cm^2 bin

Bremen



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Lotos-Euros: No relation between model performance and simulated wind speed, wind direction, rain

Summary and outlook

- No big differences between method 1 and method 2 VCDs, although MAX-DOAS sensitivity much larger close to surface

- Models tend to overestimate retrievals

- Moderate temporal correlations: 50-65 %

- Large differences for seasonal and diurnal cycles

- Good agreement for wind directional distributions

- More comparisons to follow (weather observations, surface concentrations, weekly cycle ...)

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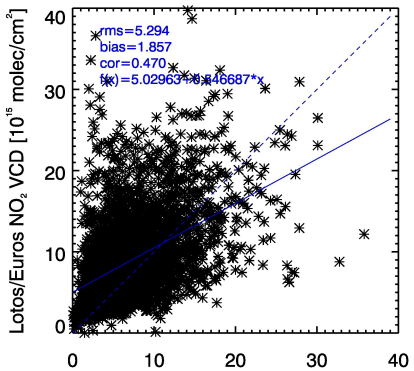
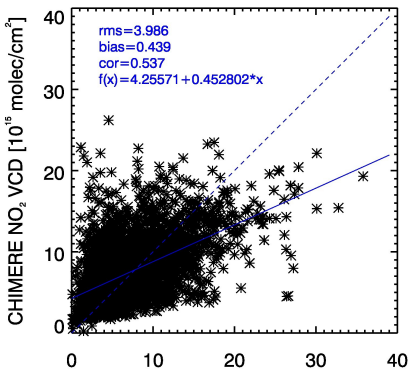
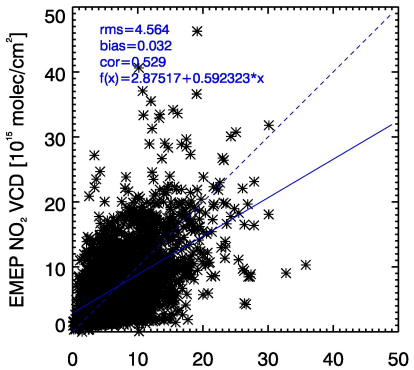
... *thank you :-)*

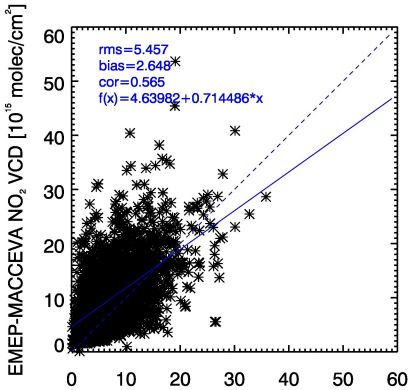
Appendix

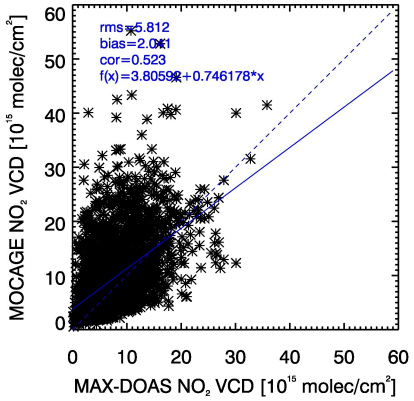
Scatterplots - Bremen

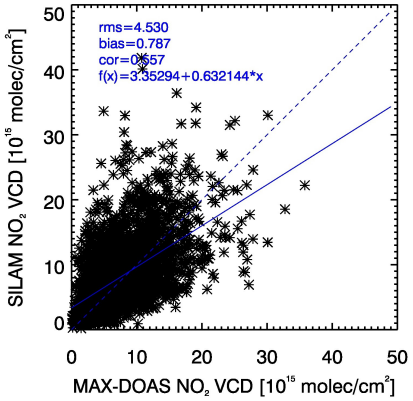




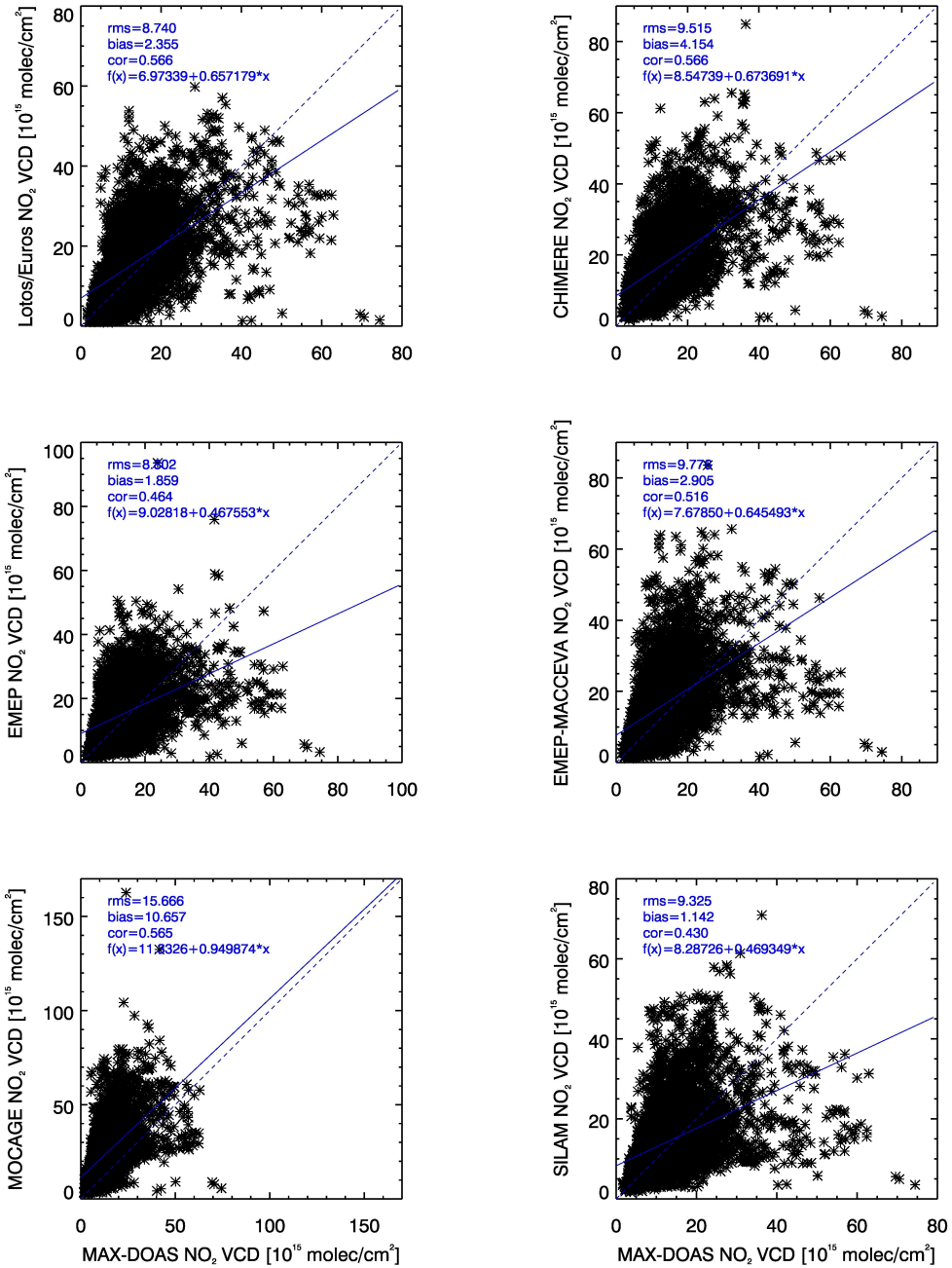




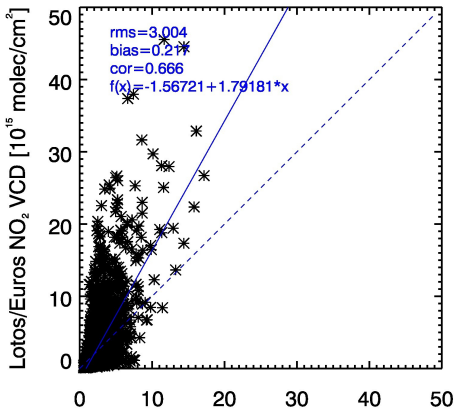


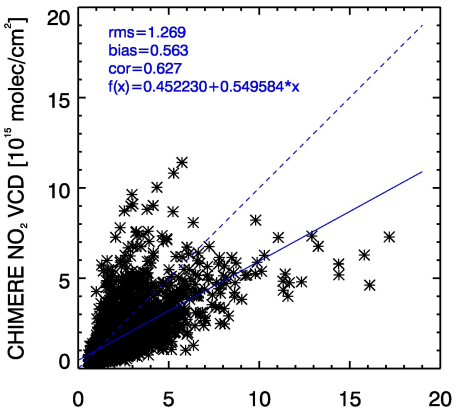


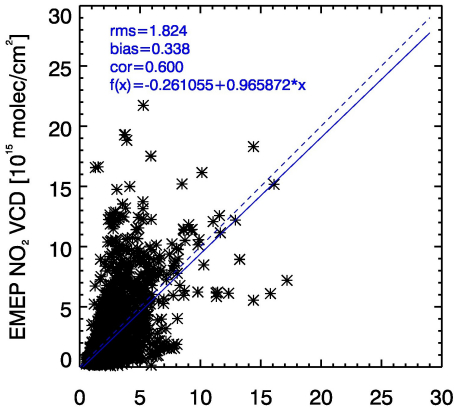
Scatterplots - Uccle

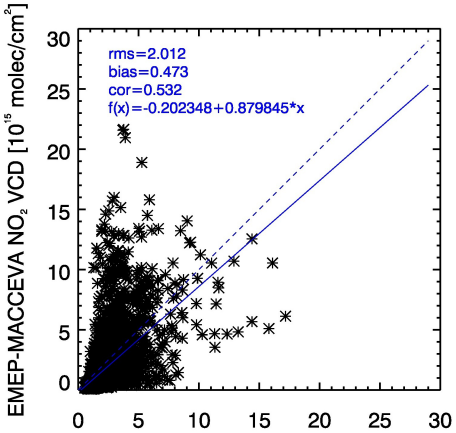


Scatterplots - OHP









Profiles at different observed cloud conditions