

Using MAX-DOAS measurements of tropospheric NO₂ columns for MACC-II(I) validation

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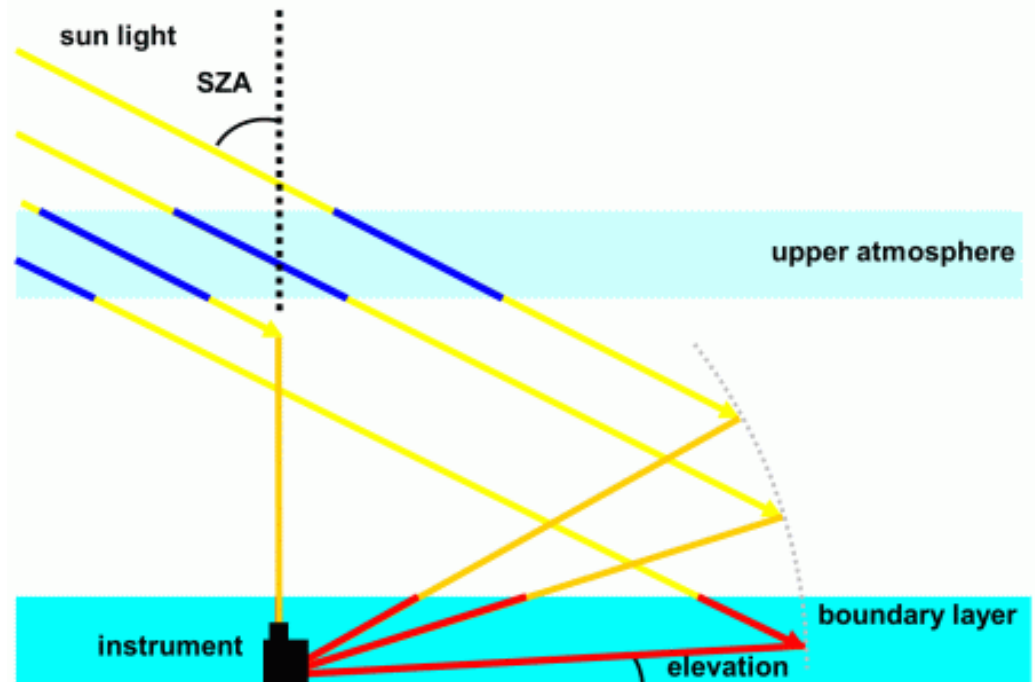
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- NO_2 is hazardous to human health, leads to O_3 and acid rain formation, eutrophication of ecosystems
- Accurate regional and global scale simulations and observations required
- MAX-DOAS data widely used for satellite validation, only Vlemmix et al. (2010) used it for model validation
- Investigate potential of using MAX-DOAS NO_2 measurements for MACC-II(I) and future COPERNICUS atmospheric service regional CTM validation

- Lotos-Euros (KNMI) regional model output compared to 4 different European stations:

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

- 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



- Lotos-Euros contributes to European regional ensemble of forecasts and reanalyses in MACC-II(I)
- Horizontal resolution: ~7 km, ~30 km (for OHP only)
- Driven by 3 hourly ECMWF weather forecasts, MACC global model as chemical boundary conditions
- MACC-II TNO anthropogenic emissions
- Hourly output, 4 vertical layers

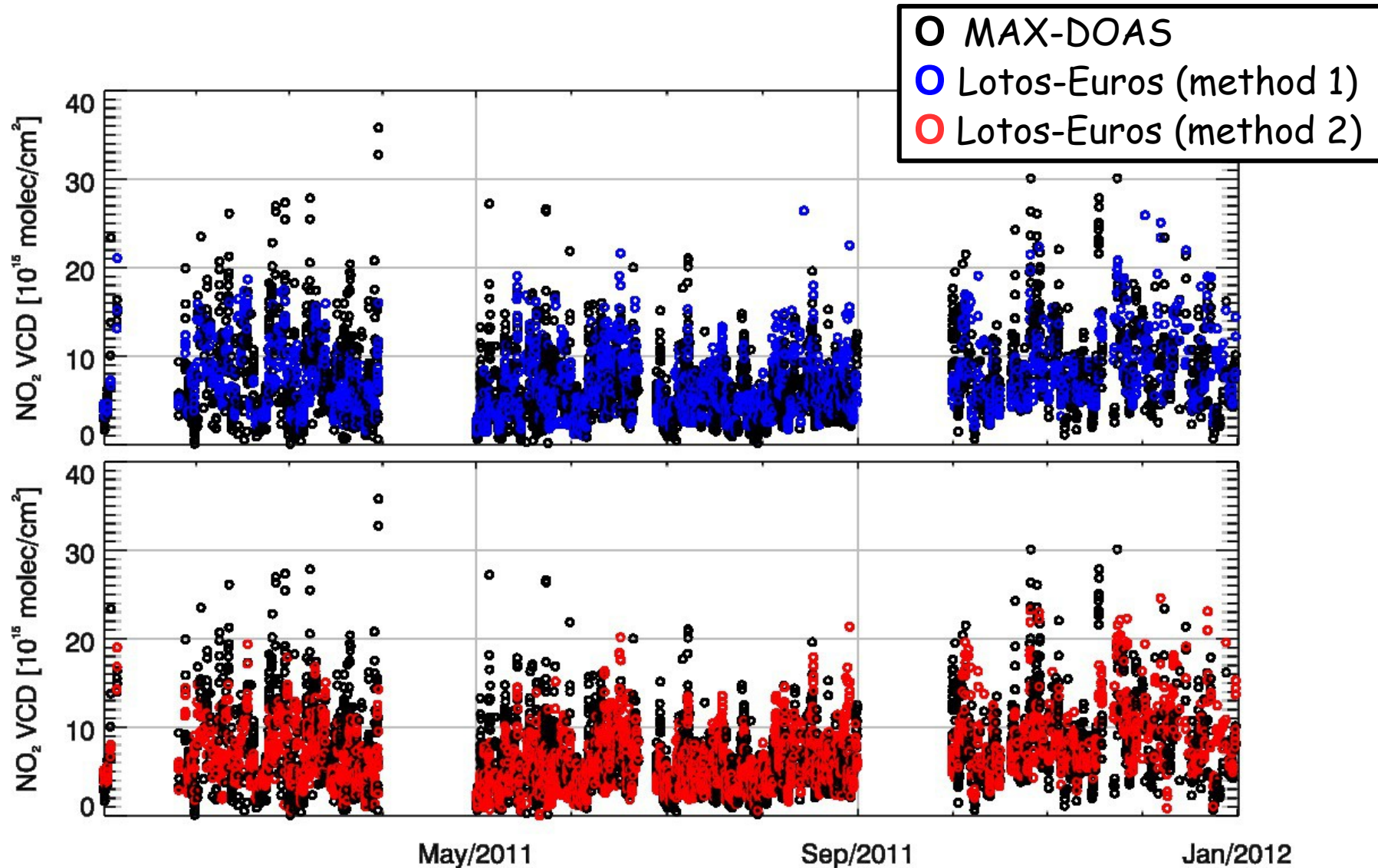
- Hourly model data sampled to closest measurement time
- Data derived on measurement altitudes assuming that model concentrations are constant within a model layer
- NO₂ VCDs from two methods:

$$VCD_{method1}^{model} = \sum_{i=1}^4 VCD_i^{model} \quad VCD_{method2}^{model} = \sum_{i=1}^N AVK_i * VCD_i^{model}$$

- Application of AVKs expected to show large influence on results

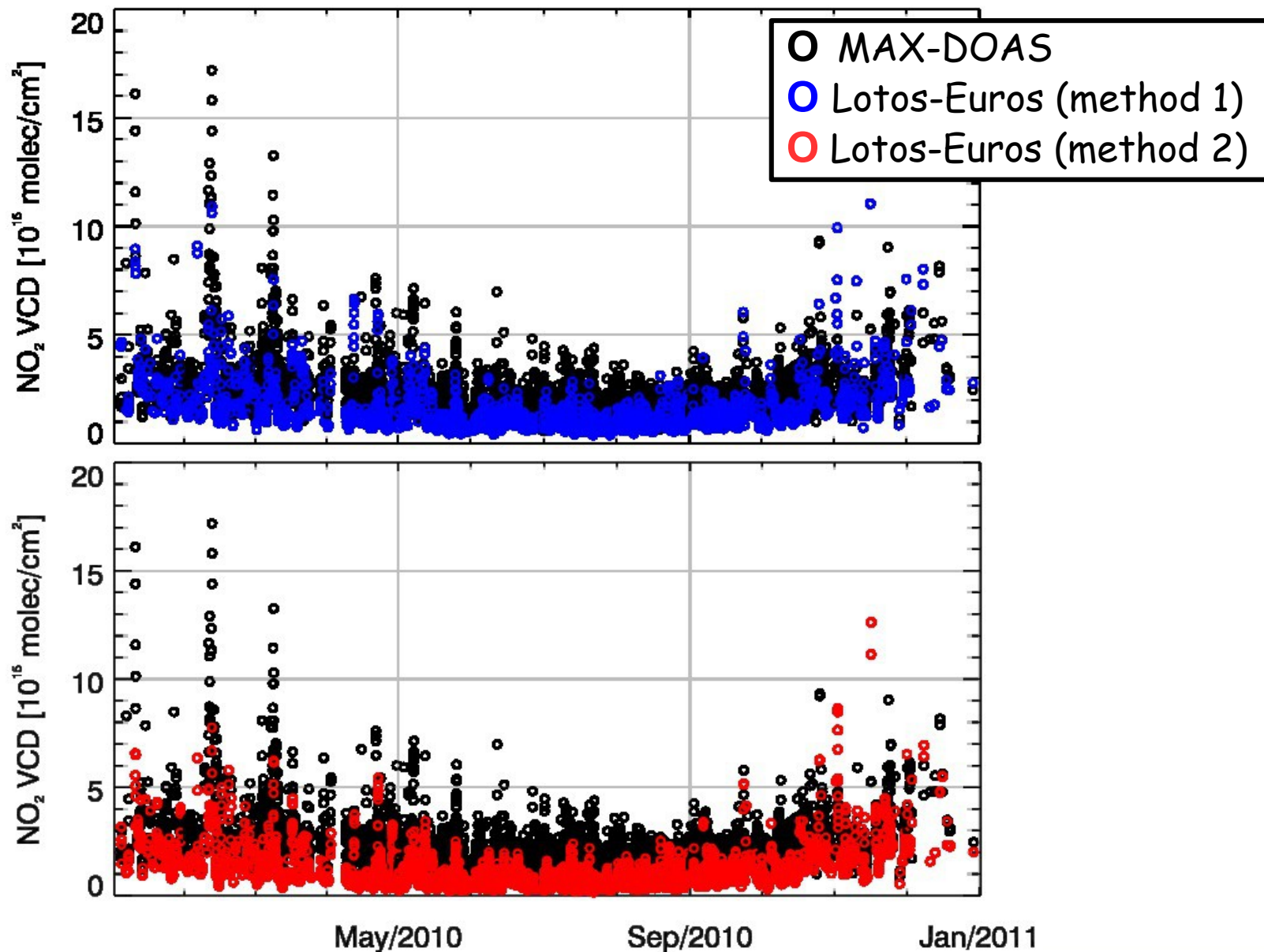
Time series - Bremen (urban)

2. Results



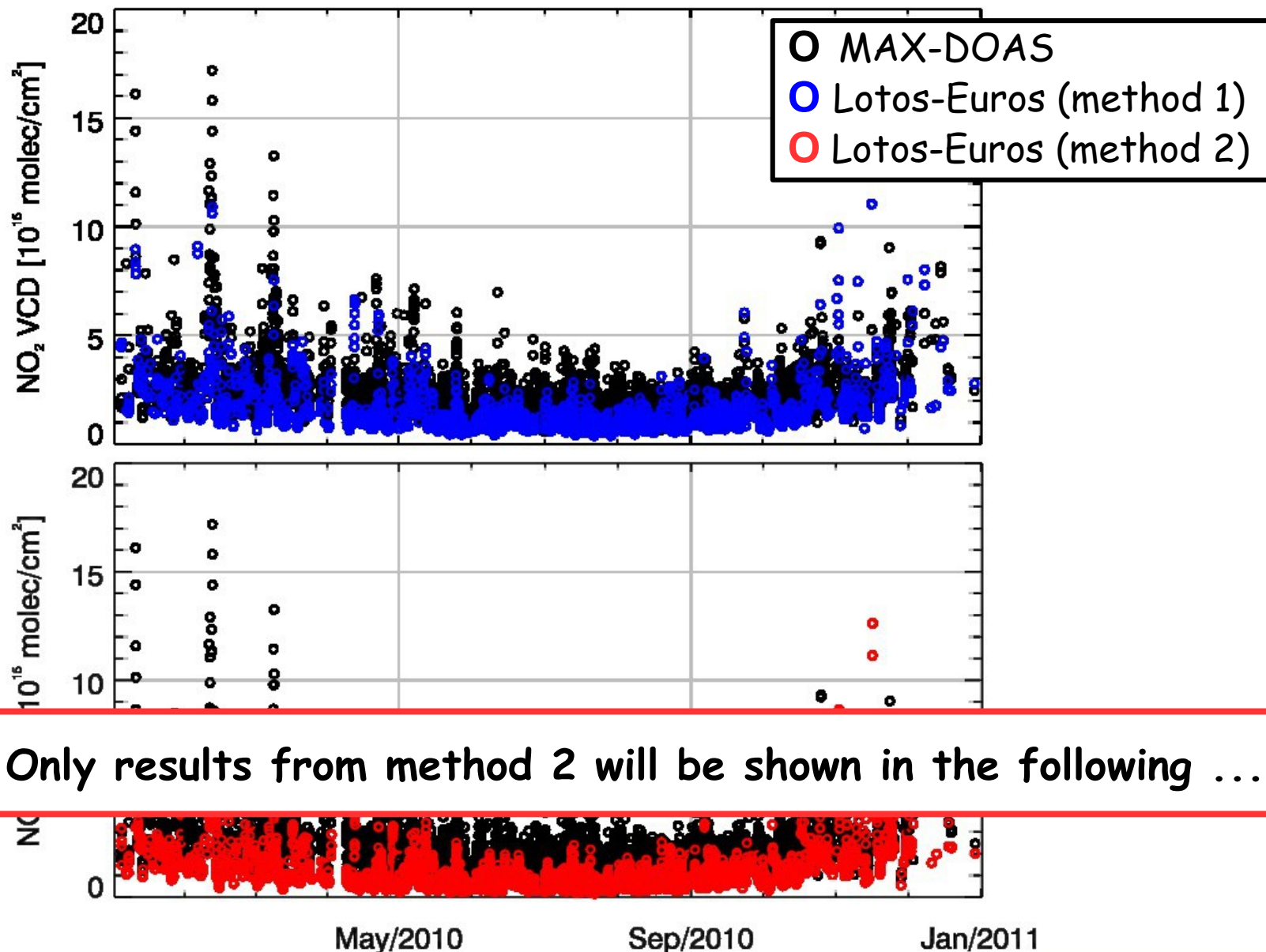
Time series - OHP (rural)

2. Results



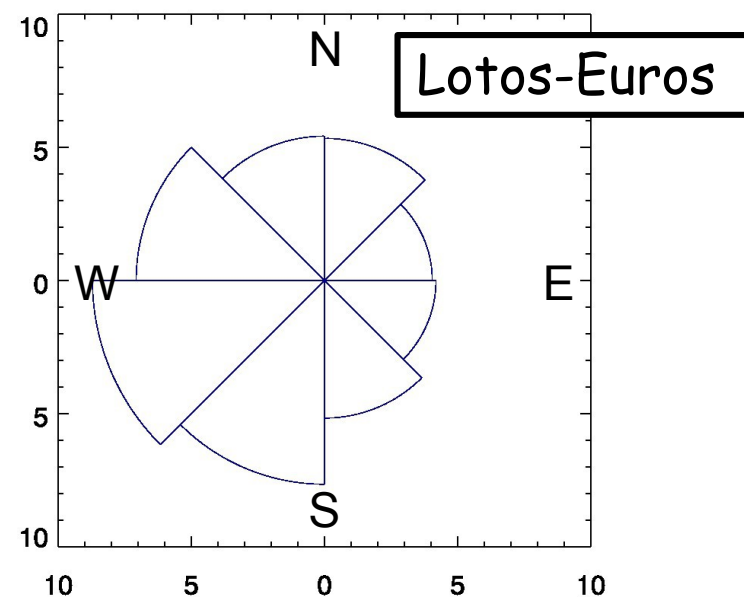
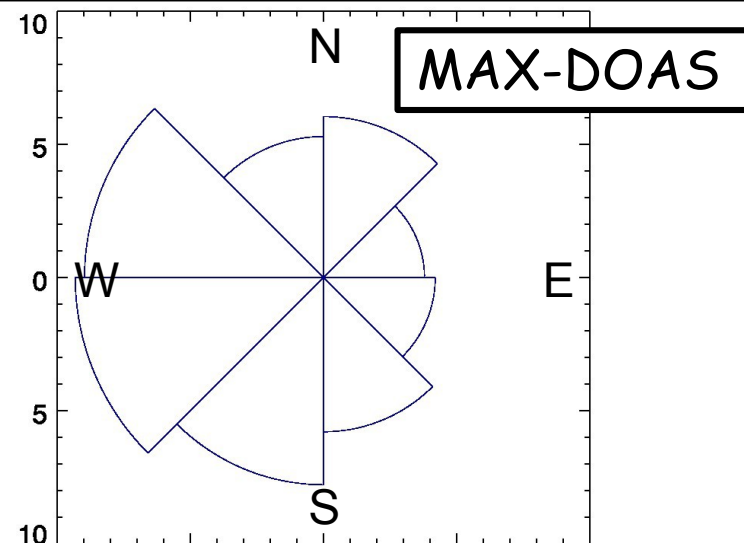
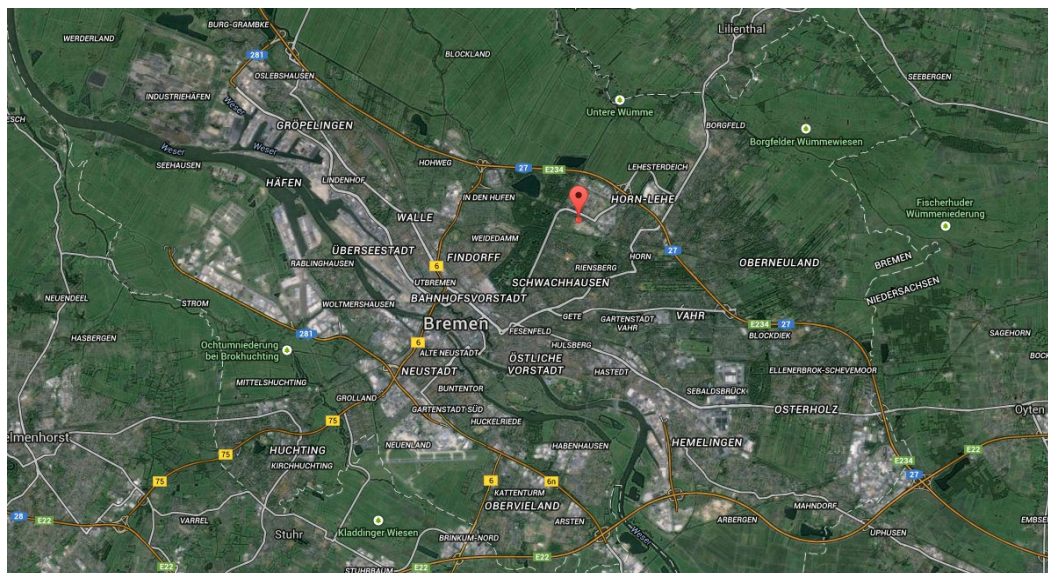
Time series - OHP (rural)

2. Results



Average NO₂ VCD in 45° wind direction bins - Bremen

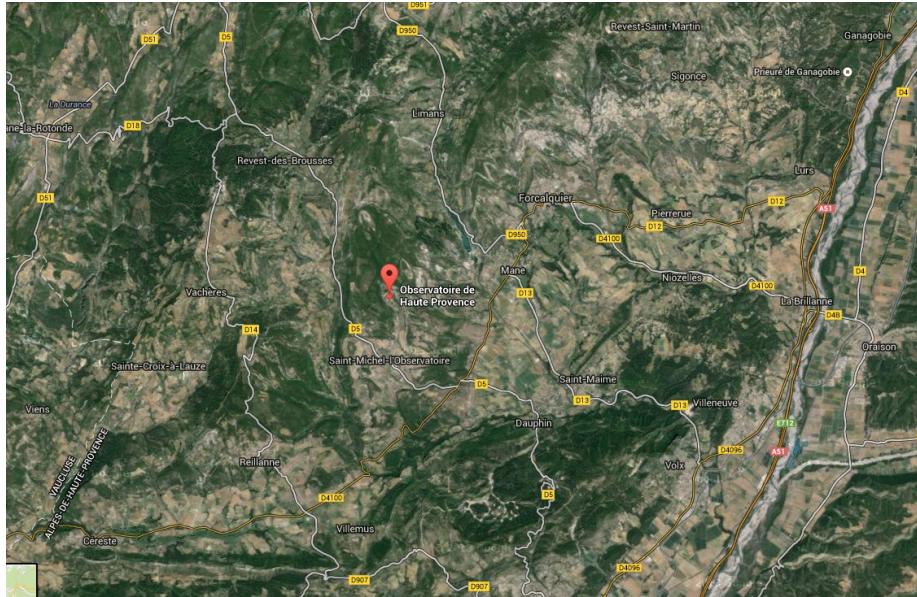
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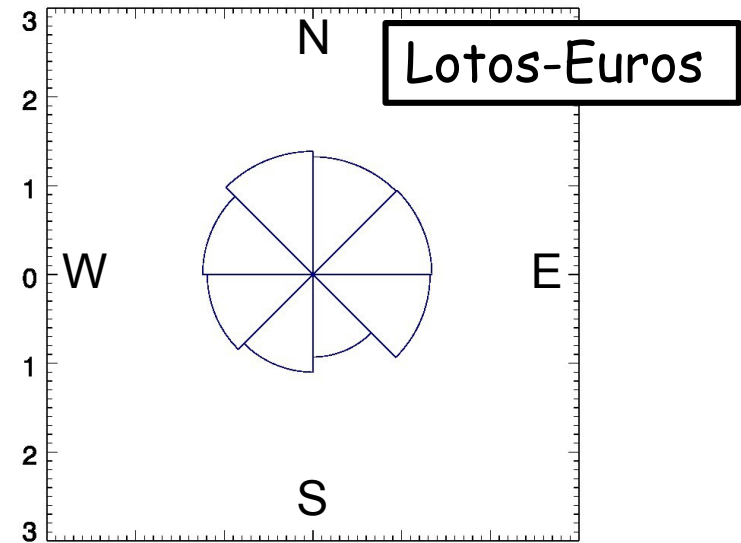
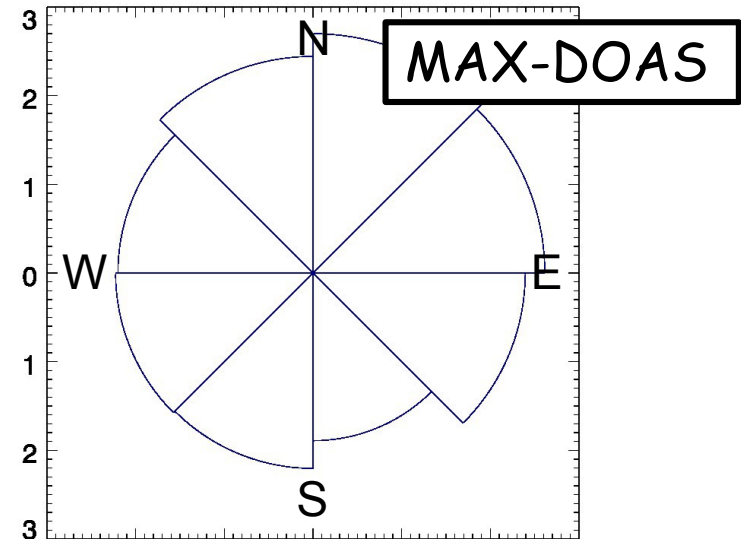
... wind direction taken from the model

Average NO_2 VCD in 45° wind direction bins - OHP

2. Results



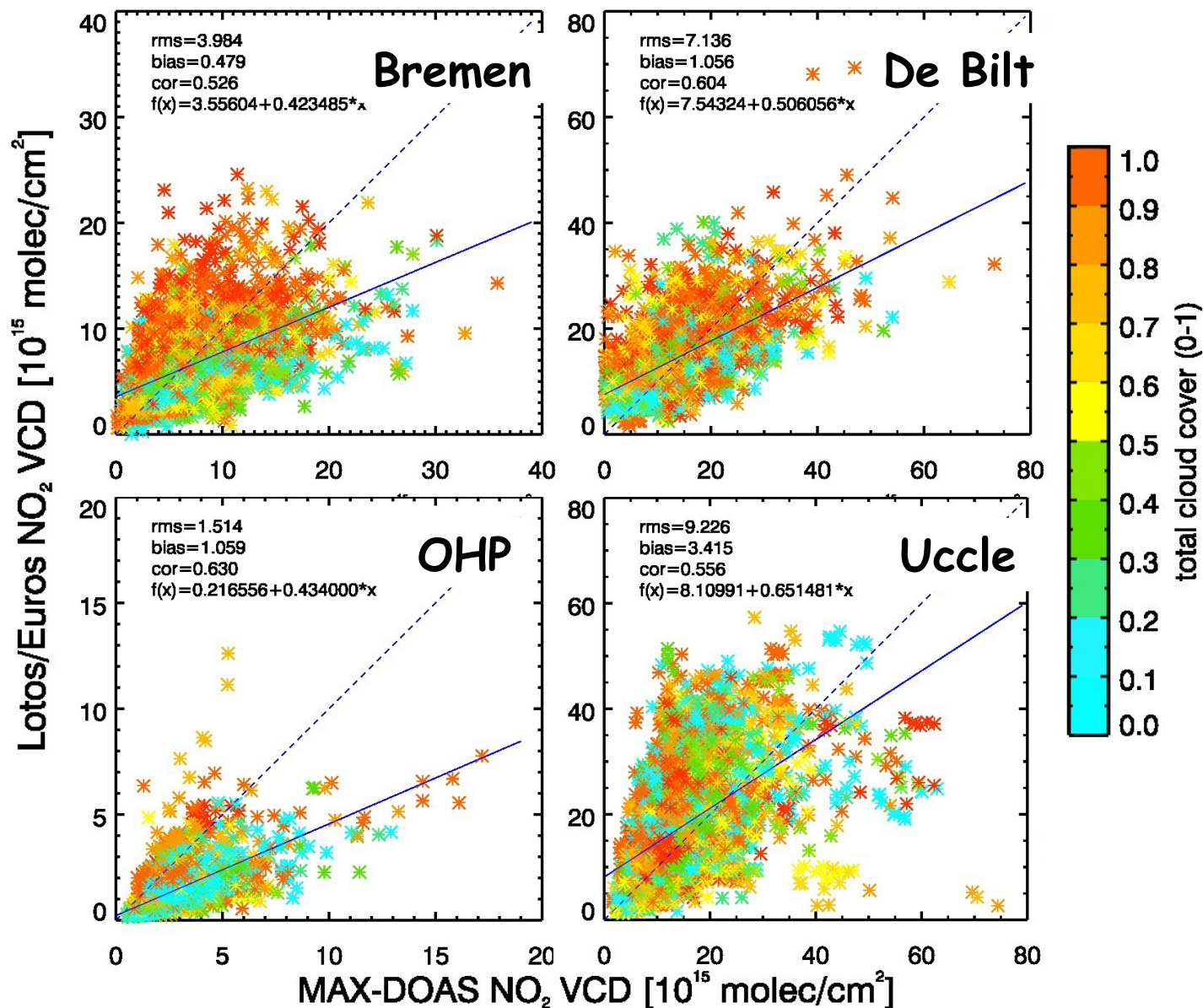
... wind direction taken from the model



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

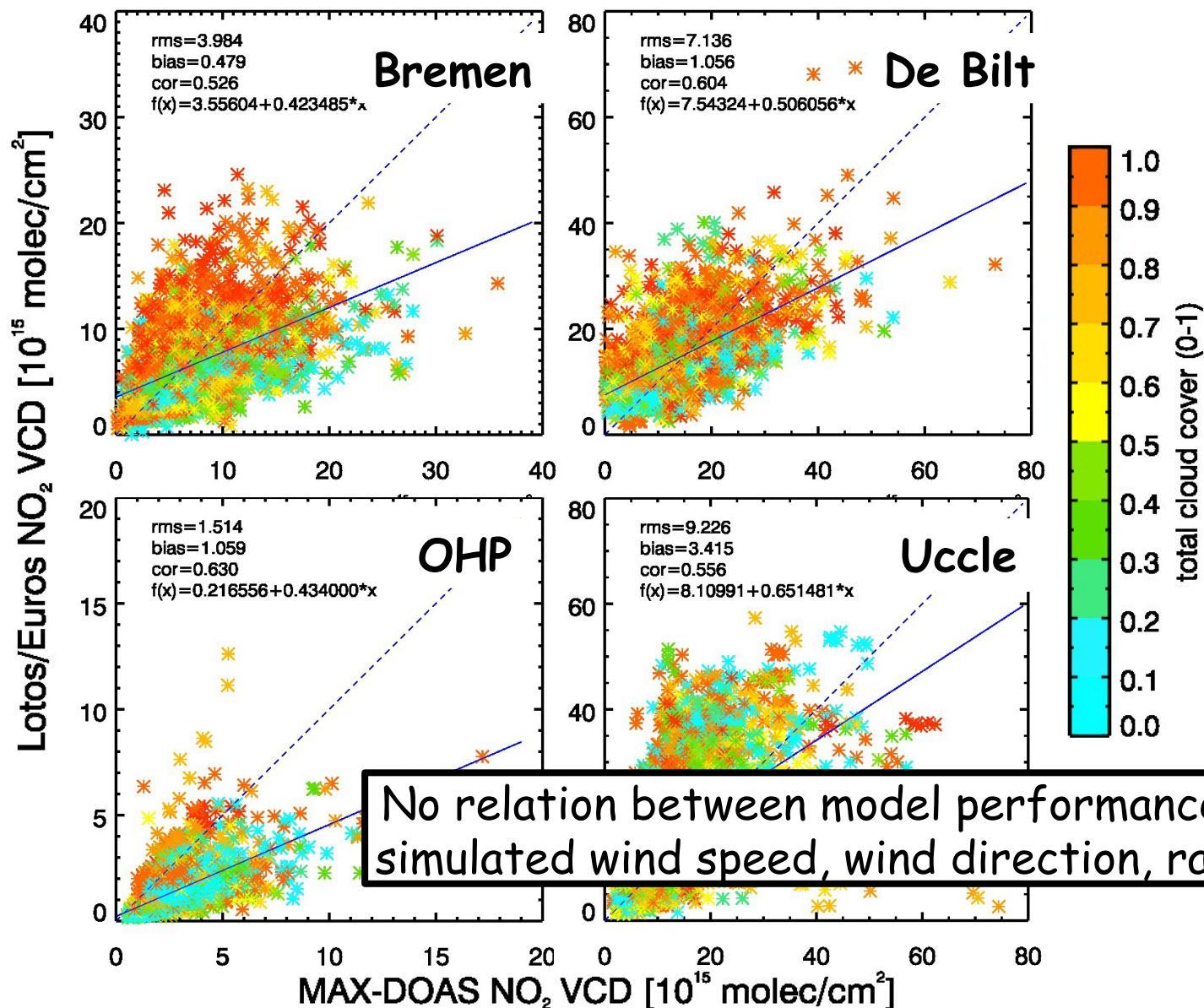
Scatterplots - color: model total cloud cover

2. Results



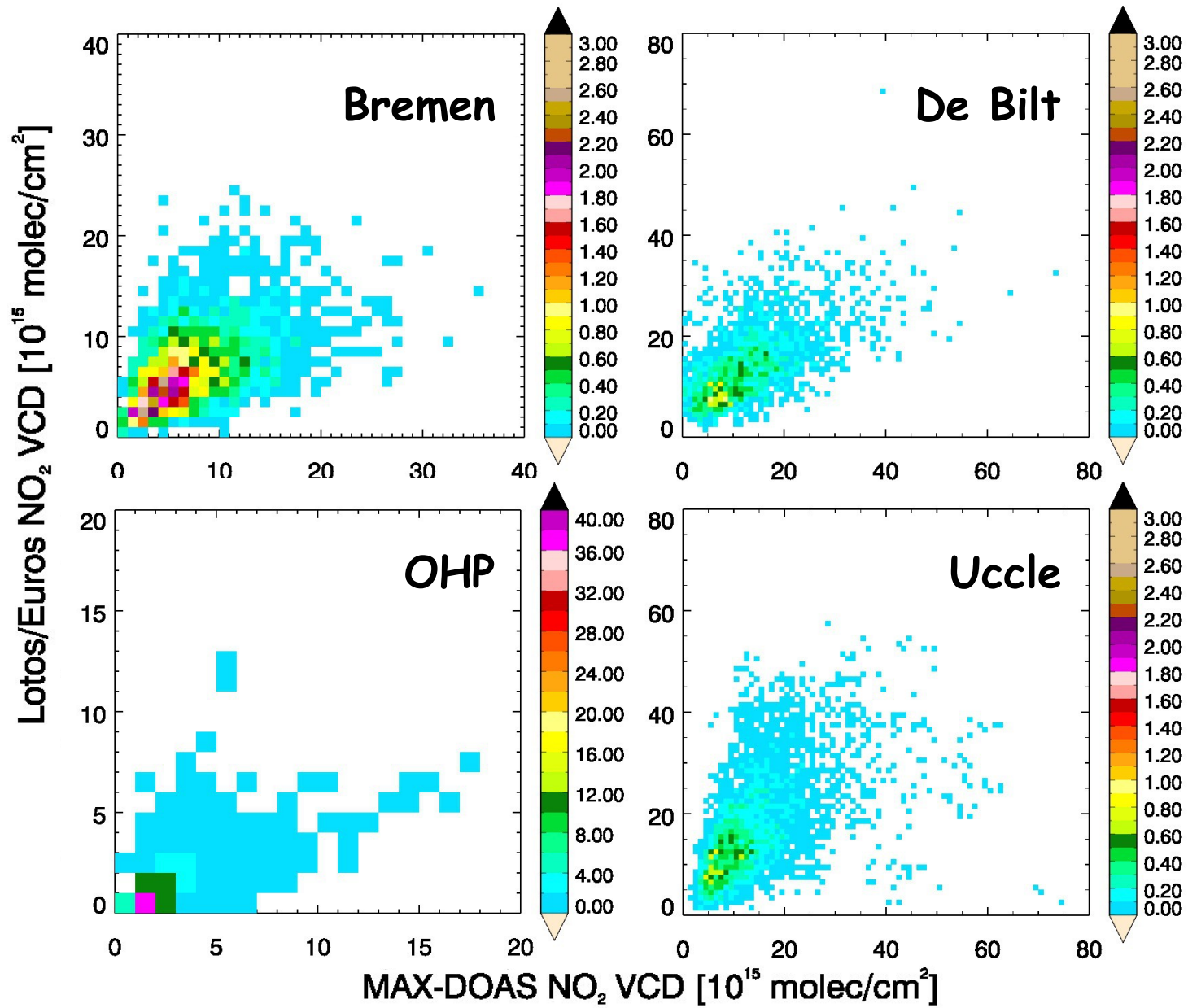
Scatterplots - color: model total cloud cover

2. Results



Scatterplots - color: data percentage per 1×10^{15} molec/cm² bin

2. Results



Summary and outlook

- Good agreement with respect to magnitude of values and wind directional distribution for all urban stations (underestimation for OHP)
- Temporal correlations ~ 0.6
- No big differences between method 1 and method 2 VCDs, although MAX-DOAS sensitivity much larger close to surface
- Model tends to underestimate VCDs for low simulated cloud cover possibly linked to photochemistry (no dependency on simulated wind speed, wind direction, rain)
- Extended comparisons to follow (weather observations, surface concentrations, diurnal cycle, other regional models ...)

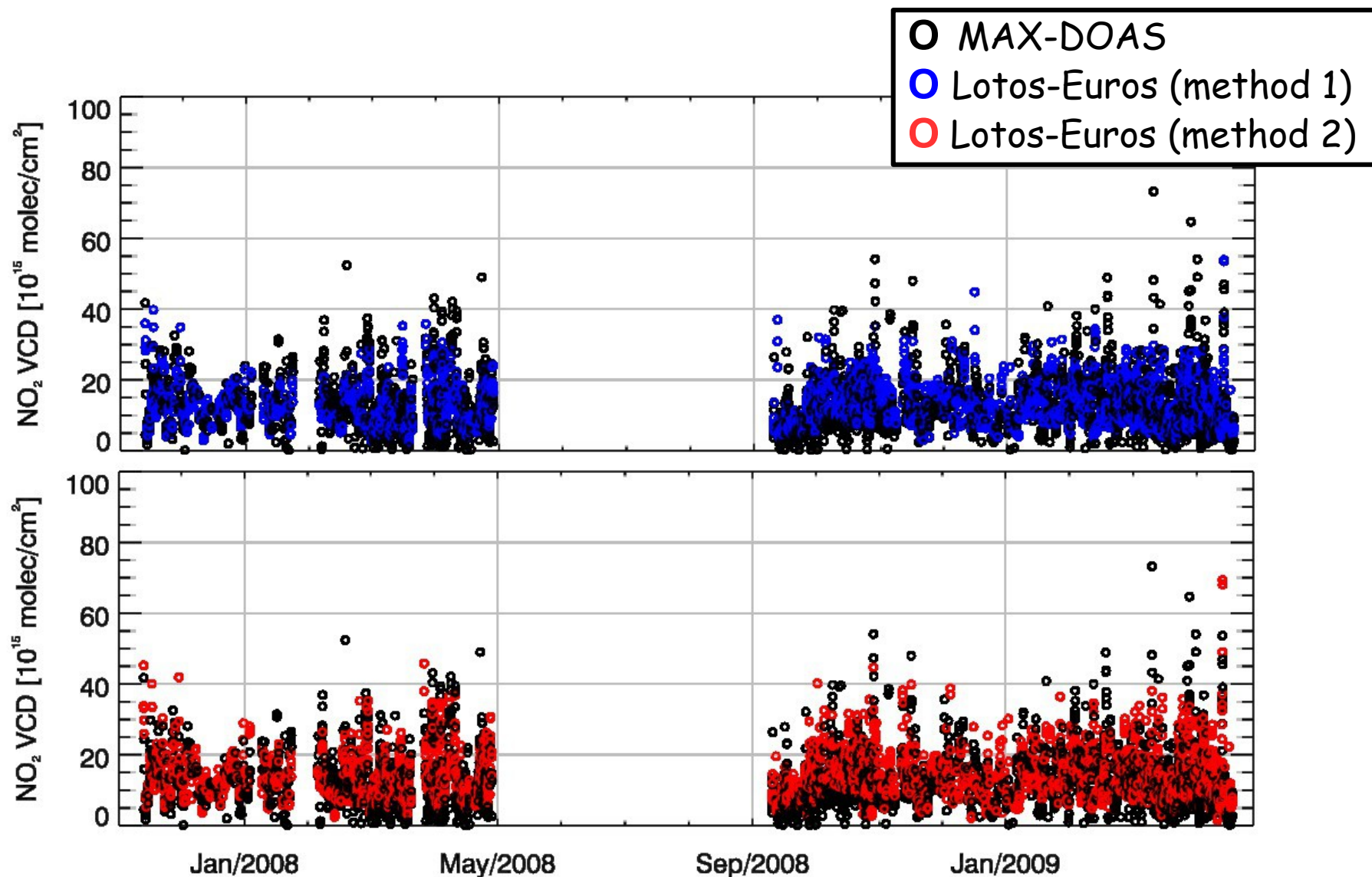
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Appendix

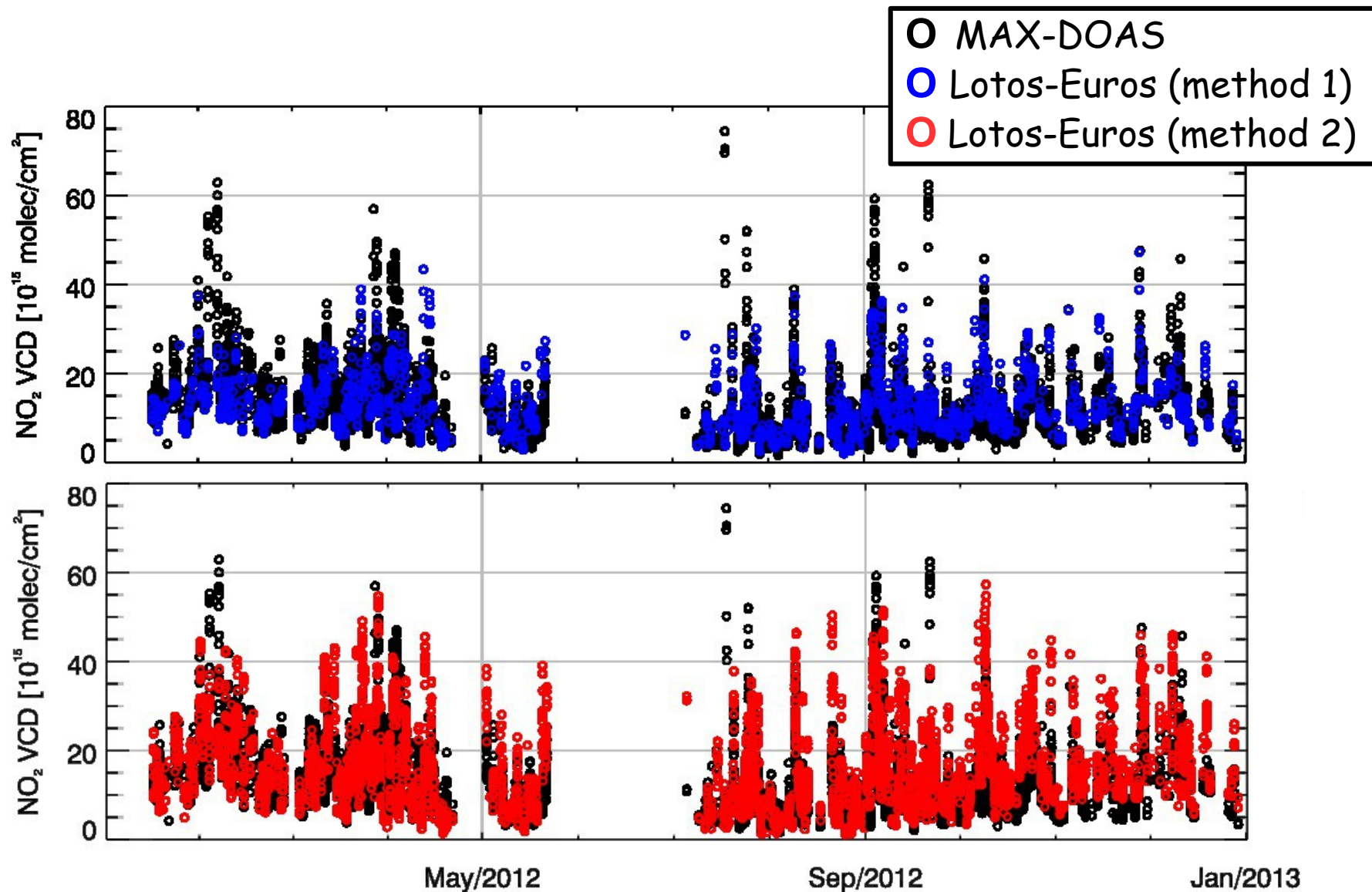
Time series - De Bilt (urban)

2. Results



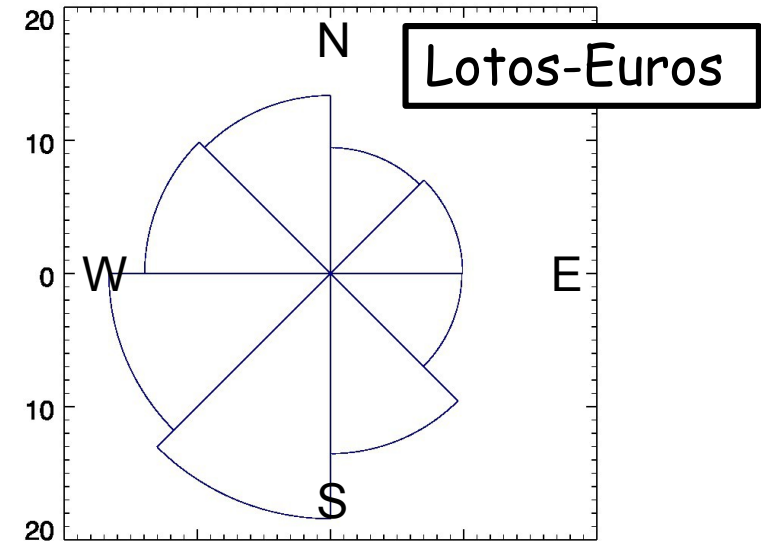
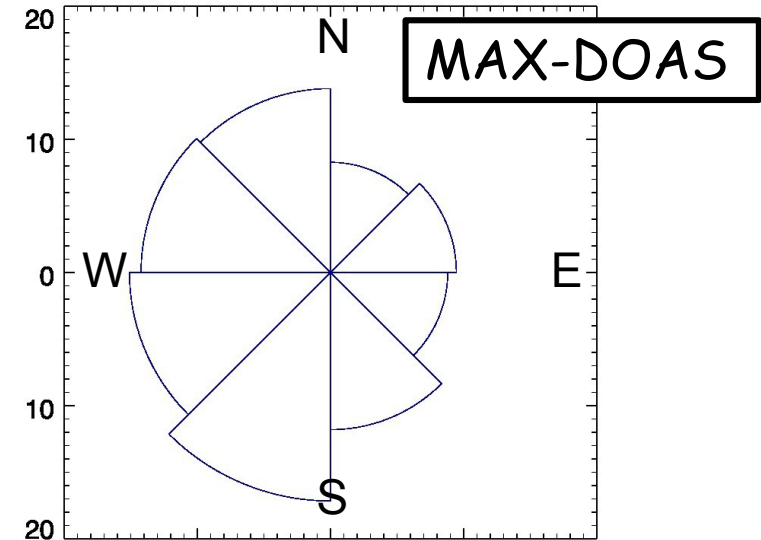
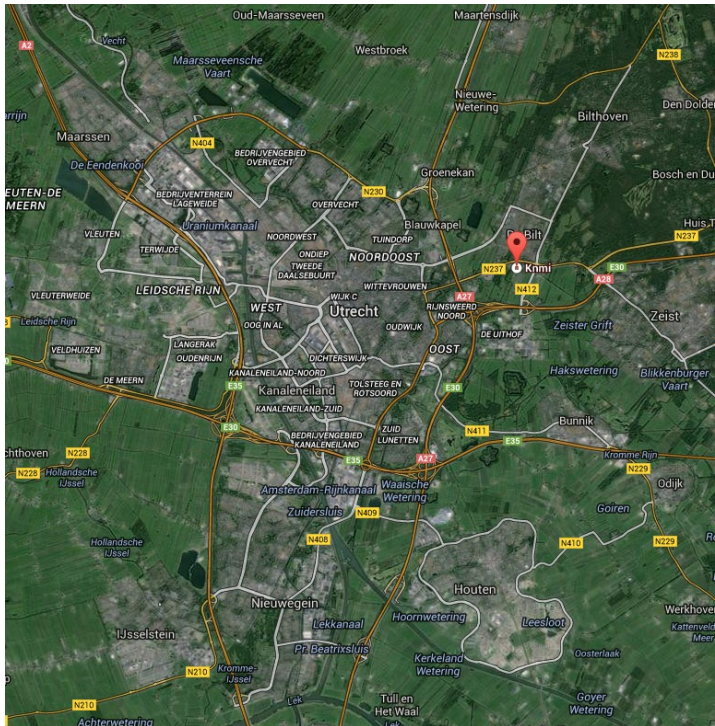
Time series - Uccle (urban)

2. Results



De Bilt - average NO_2 VCD in 45° wind direction bins

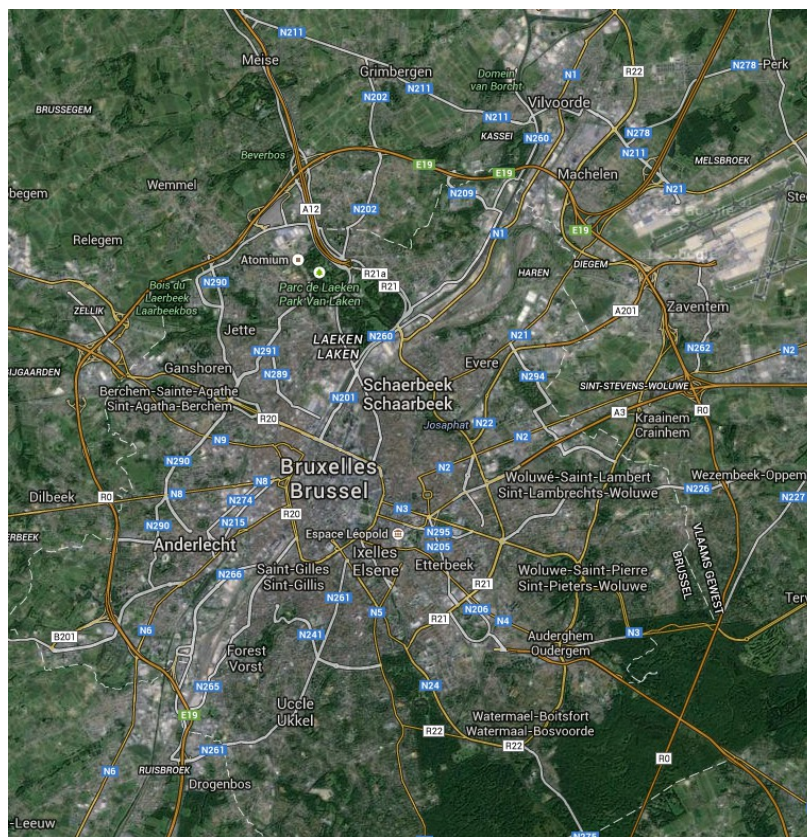
2. Results



... wind direction taken from the model

Uccle - average NO_2 VCD in 45° wind direction bins

2. Results



... wind direction taken from the model

