



Koninklijk Nederlands  
Meteorologisch Instituut  
*Ministerie van Verkeer en Waterstaat*

# OMI NO<sub>2</sub> algorithm & validation

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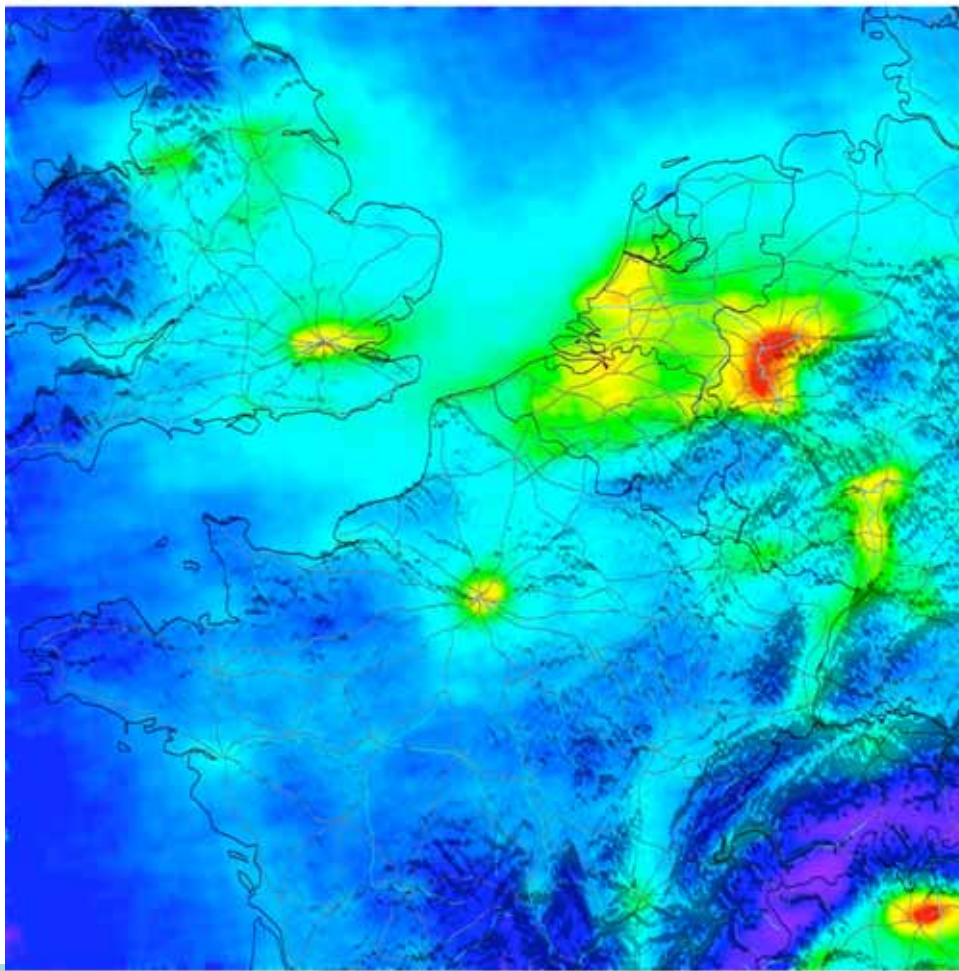
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- KNMI NO<sub>2</sub> retrieval algorithm
- Future algorithm improvements
- Comparisons with ground based data
- Validation campaigns

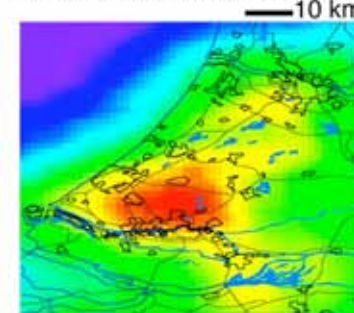


## OMI Tropospheric NO<sub>2</sub>, Dec 2004 until Nov 2005

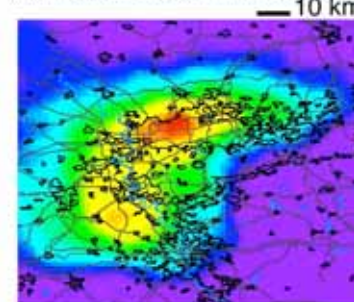
(a) Western Europe



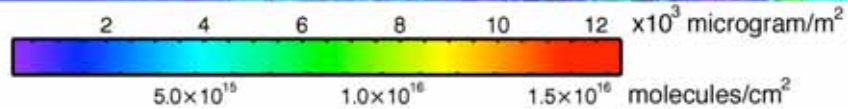
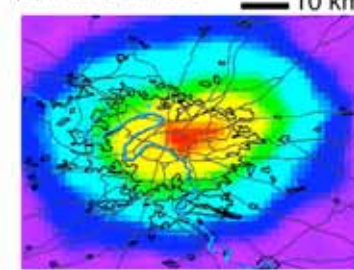
(b) Randstad, The Netherlands



(c) Ruhr area, Germany



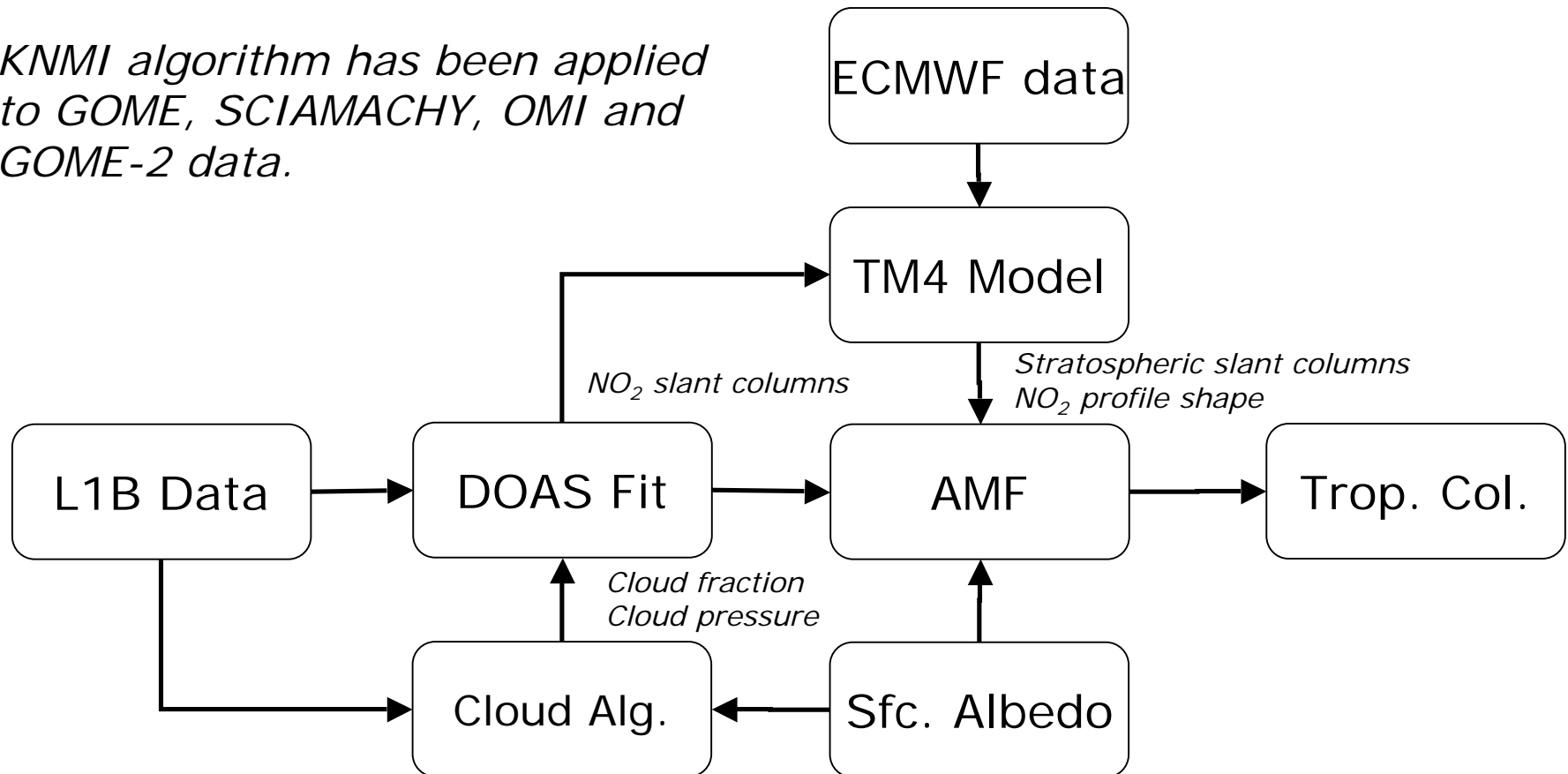
(d) Paris, France





## KNMI Retrieval Algorithm

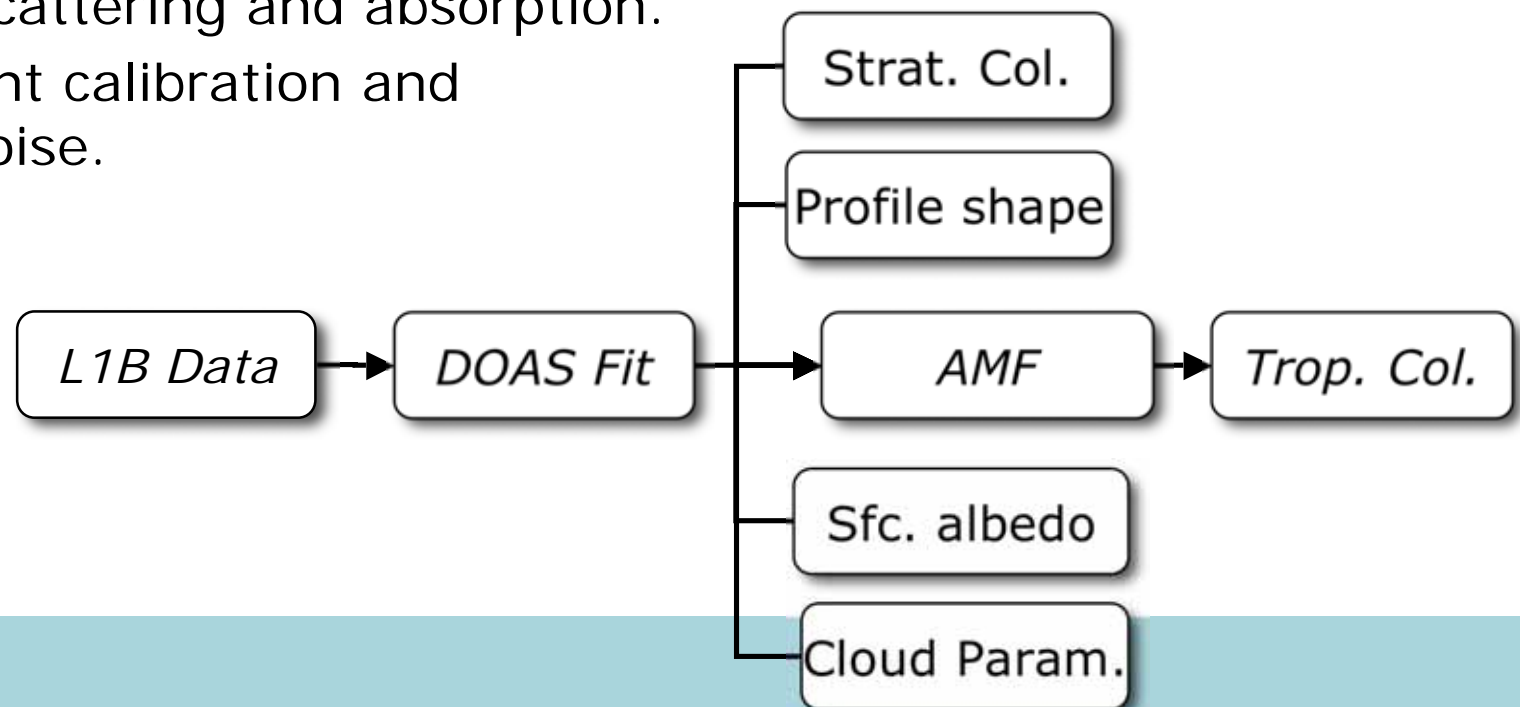
*KNMI algorithm has been applied to GOME, SCIAMACHY, OMI and GOME-2 data.*





## Uncertainties in the NO<sub>2</sub> Retrieval

- Cloud parameters: fraction, optical thickness, altitude.
- Spectral surface reflectivity
- NO<sub>2</sub> profile shape.
- Aerosol scattering and absorption.
- Instrument calibration and signal to noise.







## Improved Surface Albedo Climatology

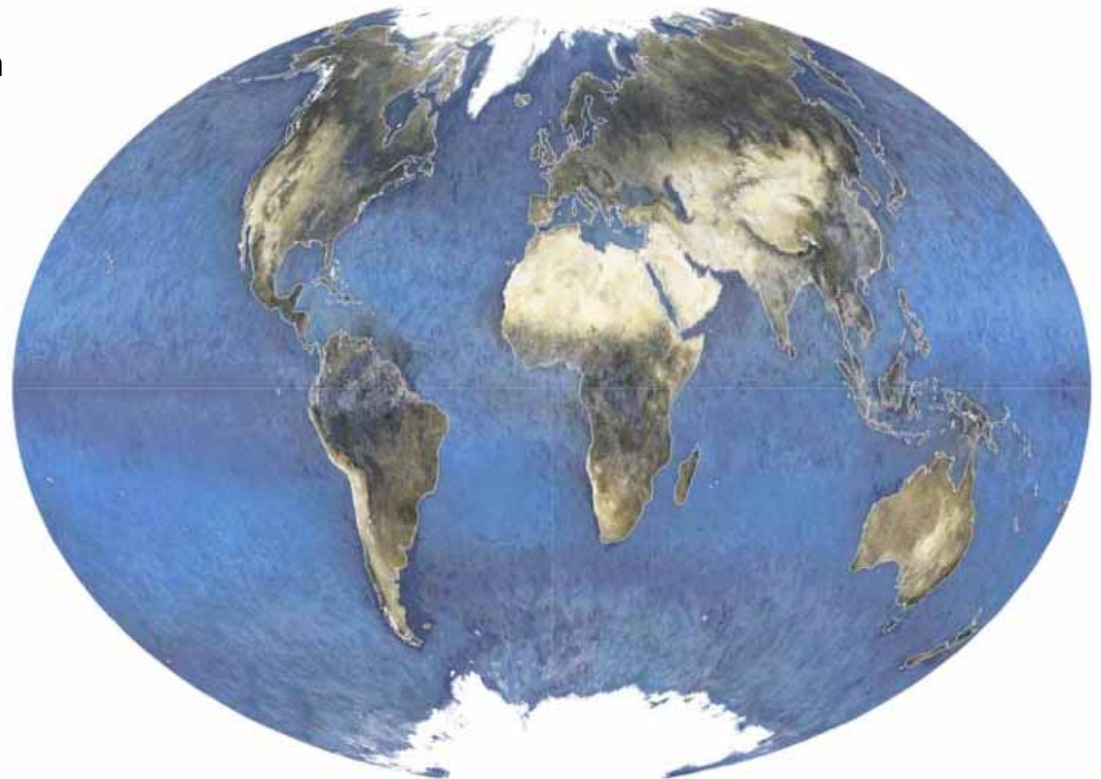
Monthly surface albedo database  
derived from 3 years OMI data for 23  
wavelengths between 330 and 500 nm

Spatial resolution 0.5x0.5 degrees.

Better statistics than the Koelmeijer  
et al. GOME climatology allow new  
retrieval techniques for the LER.

Available at <http://www.knmi.nl/omi>

### Yearly Minimum LER



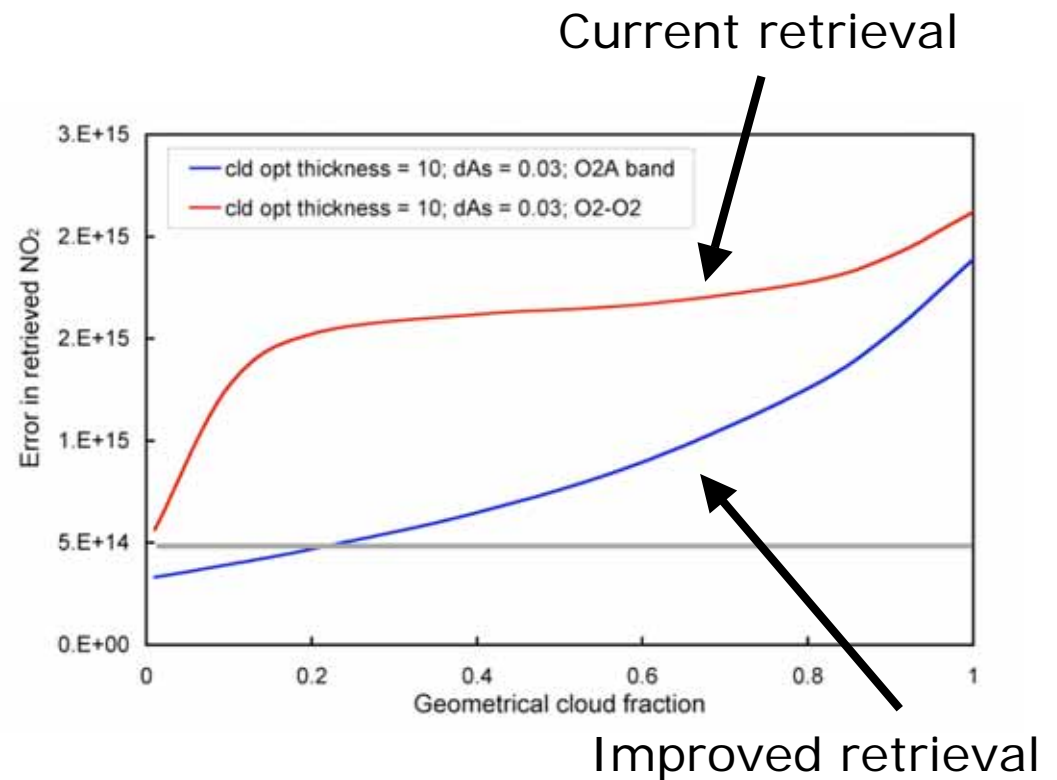
Kleipool Q. L., et al., (2008), Earth surface reflectance climatology  
from 3 years of OMI data, J. Geophys. Res., 113, D18308,  
doi:10.1029/2008JD010290.

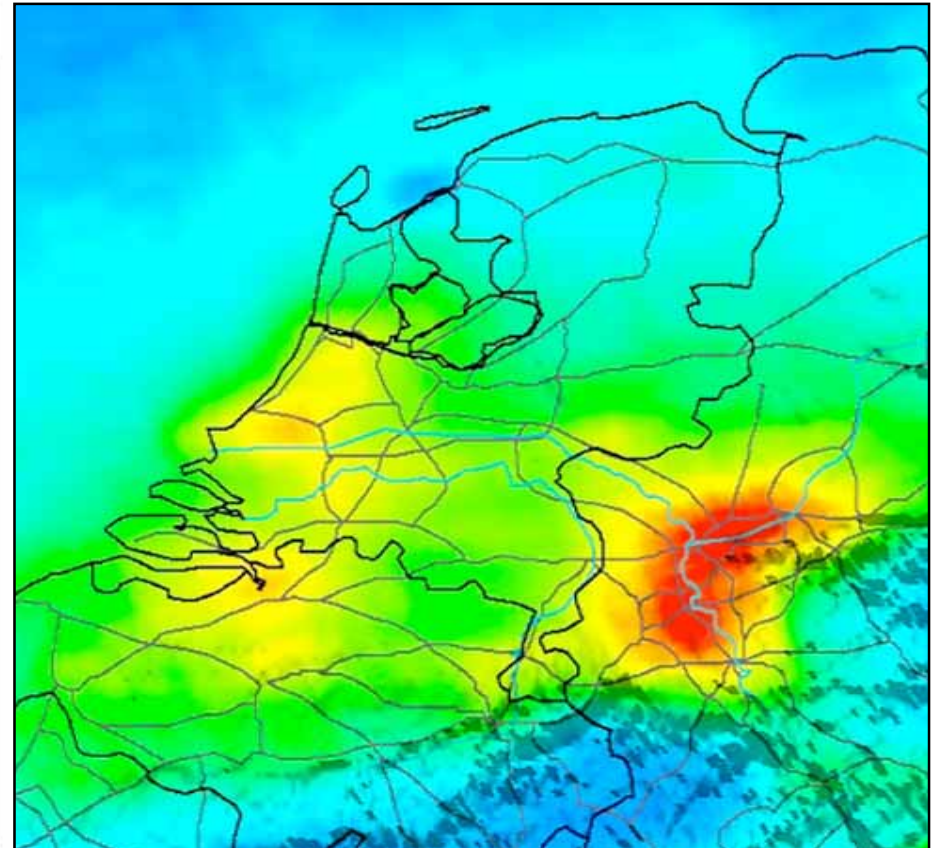
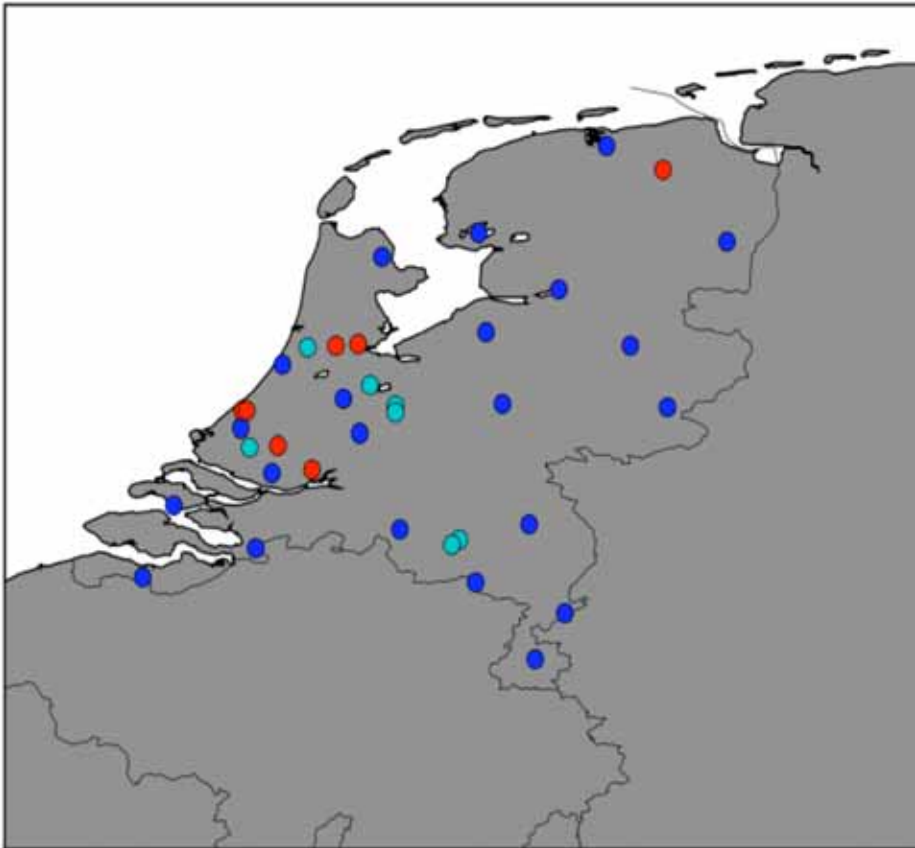


## Future Algorithm Improvements

Simulation studies based on the VIS and NIR ( $O_2$  A-Band)

Significant improvement can be achieved, especially for partly cloudy conditions.





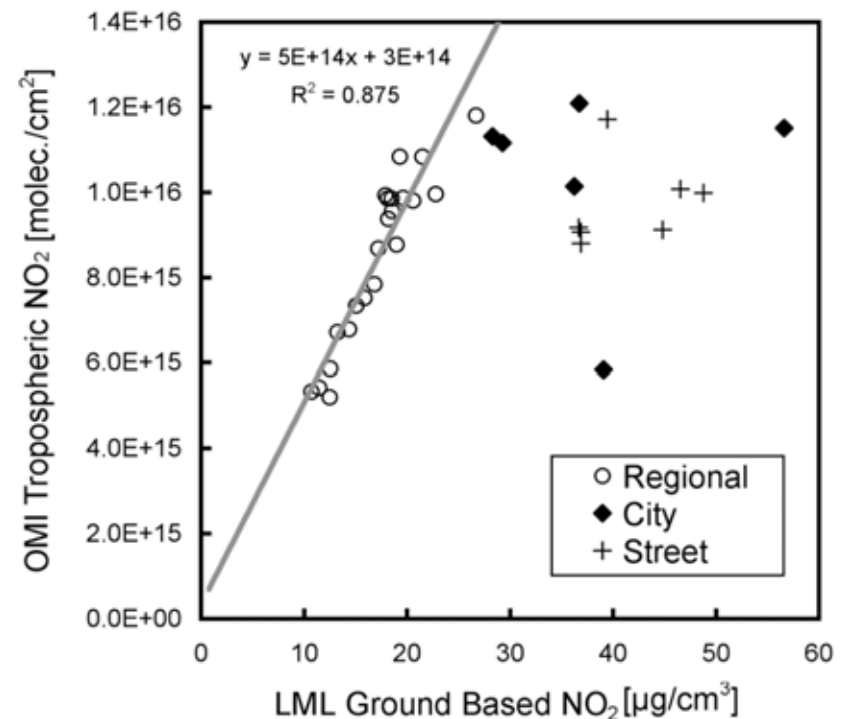
LML Dutch air quality network, [www.rivm.nl/lml](http://www.rivm.nl/lml)  
Regional, City and Street stations  
Mean yearly value per station for 12:00 to 14:00 hrs





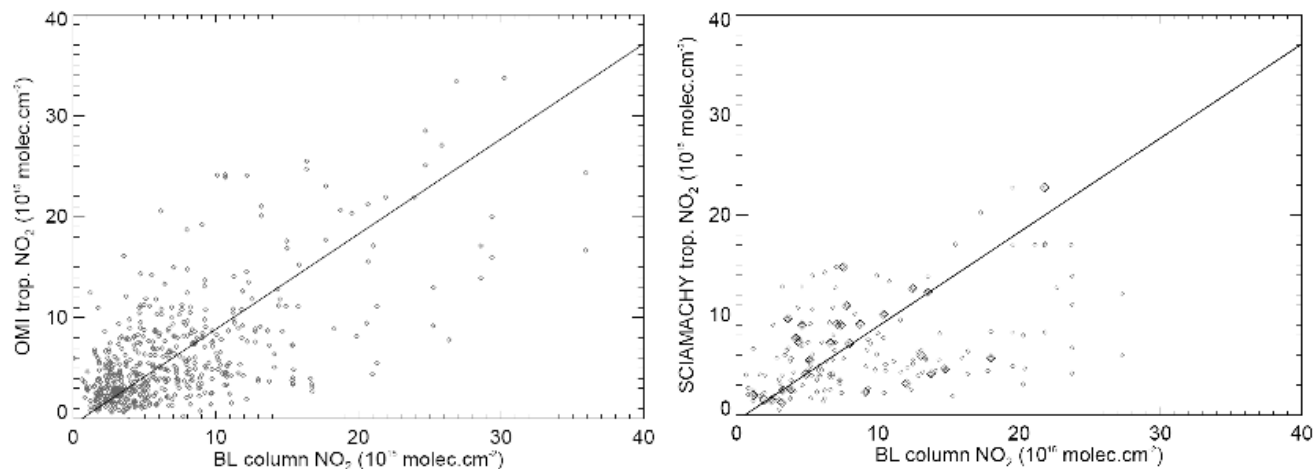
## Relationship with ground based measurements

- Linear relationship between ground based measurements and satellite observations of the average  $\text{NO}_2$ .
- This relationship does not hold for stations close to  $\text{NO}_2$  sources.
- $\text{NO}_2$  yearly or seasonal  $\text{NO}_2$  budget can be derived from satellite measurements.





## Comparisons of Individual for 6 Stations in Israel



**Fig. 2.** Left panel: OMI tropospheric versus interference-corrected boundary layer  $\text{NO}_2$  columns ( $10^{15}$  molecules  $\text{cm}^{-2}$ ) at 13:30–14:00 h at 6 Israeli stations. The solid line indicates the result of a RMA regression ( $r=0.63$ , slope=0.93). OMI measurements have been taken under mostly clear conditions (cloud radiance fraction <50%) and with pixel centres within  $0.1^\circ$  of the stations. Right panel: same, but now for SCIAMACHY and boundary layer  $\text{NO}_2$  columns at 10:00 h. The solid line indicates the RMA regression to SCIAMACHY (cloud radiance fraction <50%) observations within  $0.1^\circ$  of the stations, indicated by the larger diamonds ( $r=0.54$ , slope=0.94). The smaller diamonds indicate coincidences where SCIAMACHY pixel centers were within  $0.25^\circ$  of the stations.



## Cabauw Intercomparison Campaign of Nitrogen Dioxide measuring Instruments

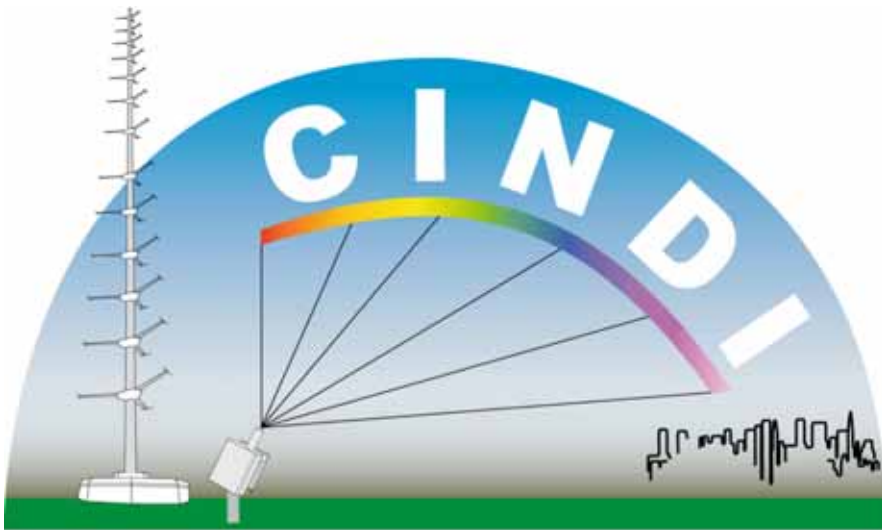
A CEOS, GEOMON and NDACC initiative

- CINDI is the largest NO<sub>2</sub> field campaign ever: more than 20 group will participate.

- CINDI campaign will take place in Cabauw, The Netherlands in June-July 2009

- The CINDI campaign will make an significant step in understanding the accuracy of ground based NO<sub>2</sub> remote sensing observations

- In addition a large validation dataset will be obtained, also addressing the representation error.



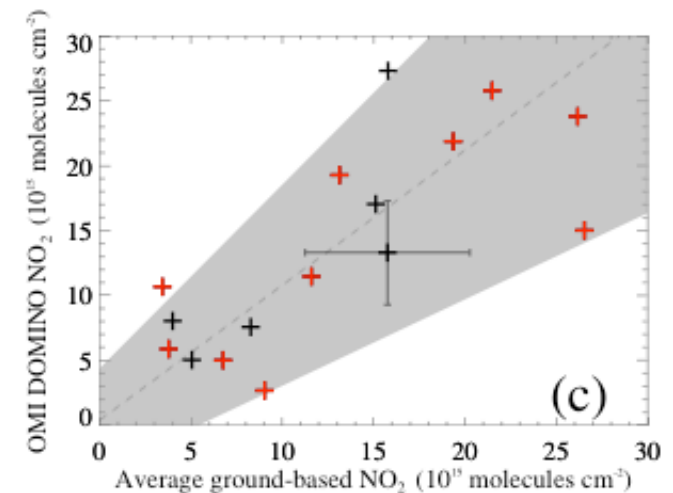
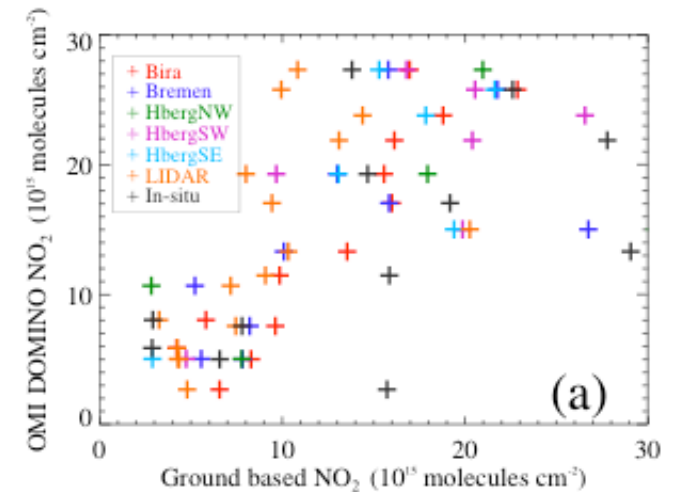


## Validation: Dandelions

Comparison with ground based *in situ* and remote sensing measurements.

The ground based measurements show considerable variations.

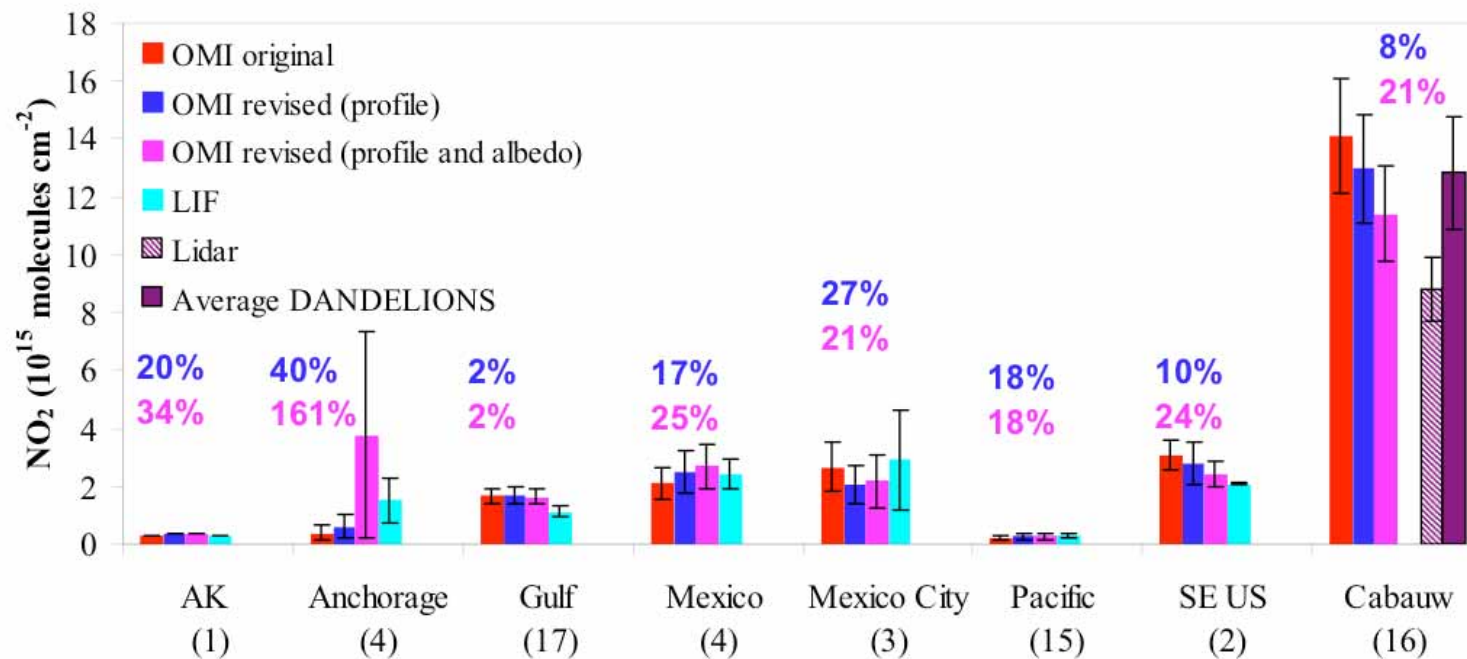
The results show 20-30% differences between the ground based and the satellite measurements.



Upper plot all comparisons.  
Lower plot averaged per day.



## Validation of Tropospheric NO<sub>2</sub>



*Validation results depend on the a-priori information on the profile shape and the surface albedo.*

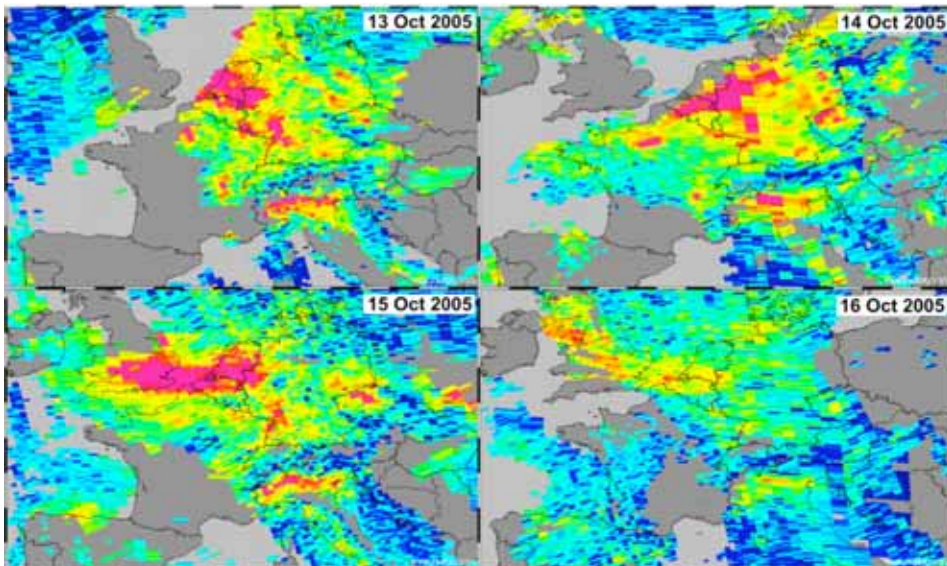




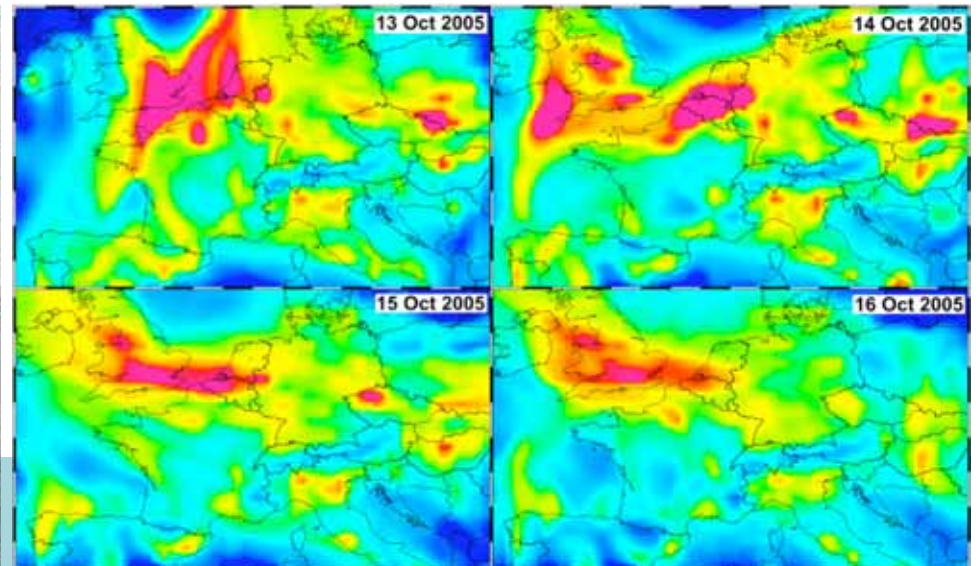
## Model Comparisons

- The representation errors in model-satellite comparisons are less important
- Model-satellite comparisons provide large statistics.

OMI



CHIMERE



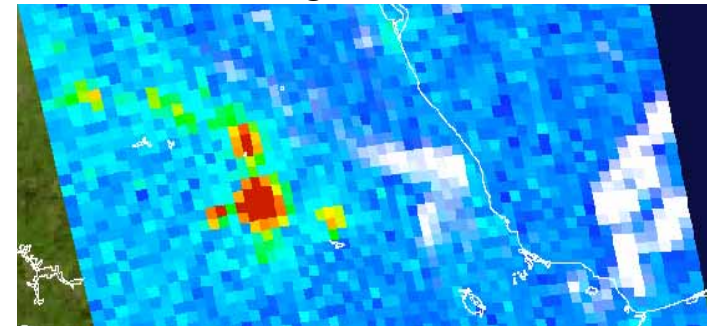


## New Mission: TROPOMI

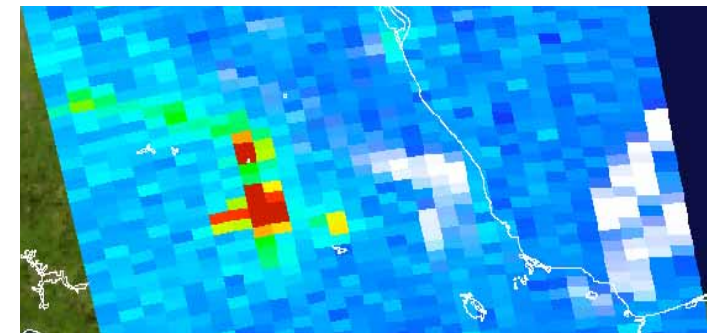
- Spatial resolution  $< 10 \times 10 \text{ km}^2$ .
- Improved SNR as compared to OMI.
- Planned launch 2014 on the Sentinel 5 Precursor in an afternoon orbit.
- Diurnal information can be derived by combining TROPOMI and GOME-2

*TROPOMI resolution will be higher than the OMI zoom mode.*

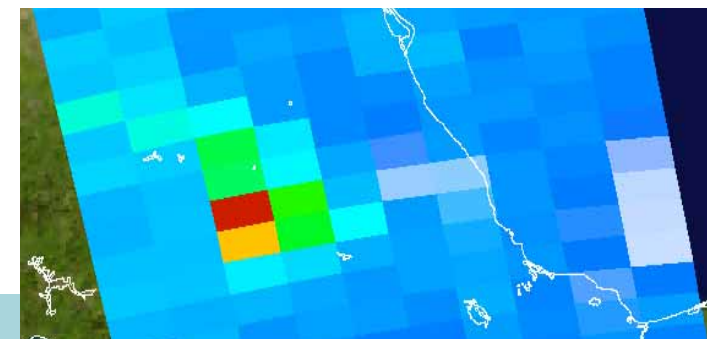
Mexico City, Jan. 20, 2005



OMI Zoom  $12 \times 13 \text{ km}^2$



OMI  $24 \times 13 \text{ km}^2$



Approx. GOME-2  $72 \times 39 \text{ km}^2$



## Summary

The KNMI NO<sub>2</sub> products are available from GOME, SCIAMACHY, OMI and GOME-2 and are available from [www.temis.nl](http://www.temis.nl) .

Validation results show errors in the 20-30%. Comparisons with ground based instruments contain a large representation error.

Comparisons with yearly averaged *in-situ* measurements show that the satellite measurements are representative for regional stations, but not for stations close to emission sources.

Model-satellite comparisons do not suffer from a large representation error and are a good tool for better understanding of both model and satellite accuracies.

Simulations show that algorithms can be improved significantly, especially for partly cloudy conditions.

With improved spatial resolution and signal-to-noise ratio, TROPOMI will make a next step forward for NO<sub>2</sub> air quality applications.