Satellite observations of biomass burning NO_2

A. Richter, J. Leitão, A. Hilboll, A. Zien and J. P. Burrows
Institute of Environmental Physics/Remote Sensing, University of Bremen,
FB 1, P.O. Box 330440, D-28334 Bremen, Germany
Email: Andreas.Richter@iup.physik.uni-bremen.de

ife

Why care for NO_2 from fires?

- nitrogen oxides (NOx = NO_2 + NO) are important trace gases in the troposphere
- they are a key component in tropospheric ozone formation
- through reaction with OH, they form HNO_3 contributing to acidification

- in regions with small anthropogenic emissions, fires can be the largest source of NOx
- through pyro-convection, NOx from fires can be injected into higher layers where the life-time is longer and transport more rapid
- together with other emissions from biomass burning, NOx produces ozone downwind of fires

- biomass burning varies from year to year in response to meteorological conditions (e.g. El Nino) and land needs (forest clearing, agriculture)
- as climate changes, the intensity of fires is expected to change

SCIAMACHY and GOME-2

SCIAMACHY:

- launched on ENVISAT in March 2002
- data since August 2002
- 8 channel nadir and limb viewing UV/visible/NIR spectrometer
- 60 x 30 km^2 pixel size
- global coverage in 6 days
- 10:00 LT equator crossing

GOME-2:

- launched on MetOp-A in October 2006
- data since January 2007
- 4 channel nadir viewing UV/visible spectrometer
- first in a series of three identical instruments
- 80 x 40 km^2 pixel size
- global coverage in 1.5 days
- 09:30 LT equator crossing

Data analysis:

Differential Optical Absorption Spectroscopy (DOAS), correction of stratospheric NO_2 with reference sector method, tropospheric airmass factor, cloud screening, no cloud correction

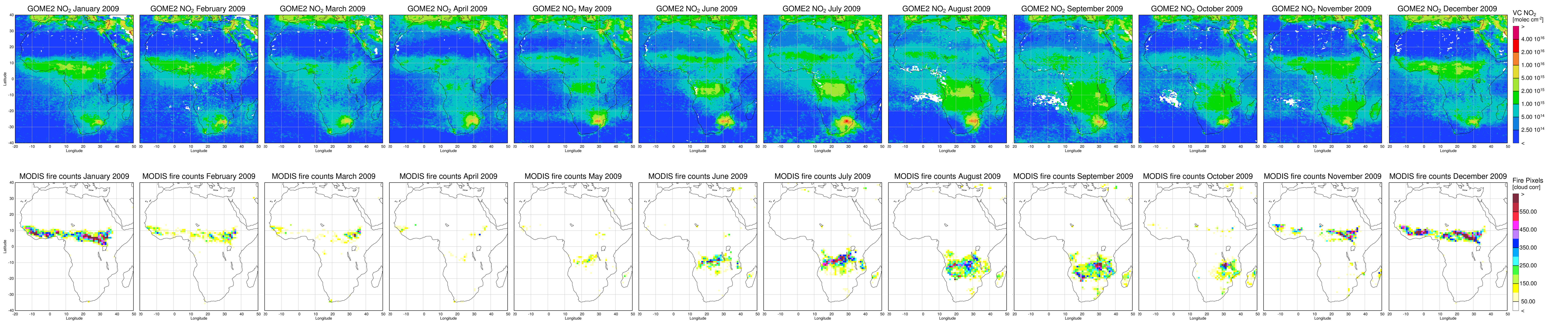
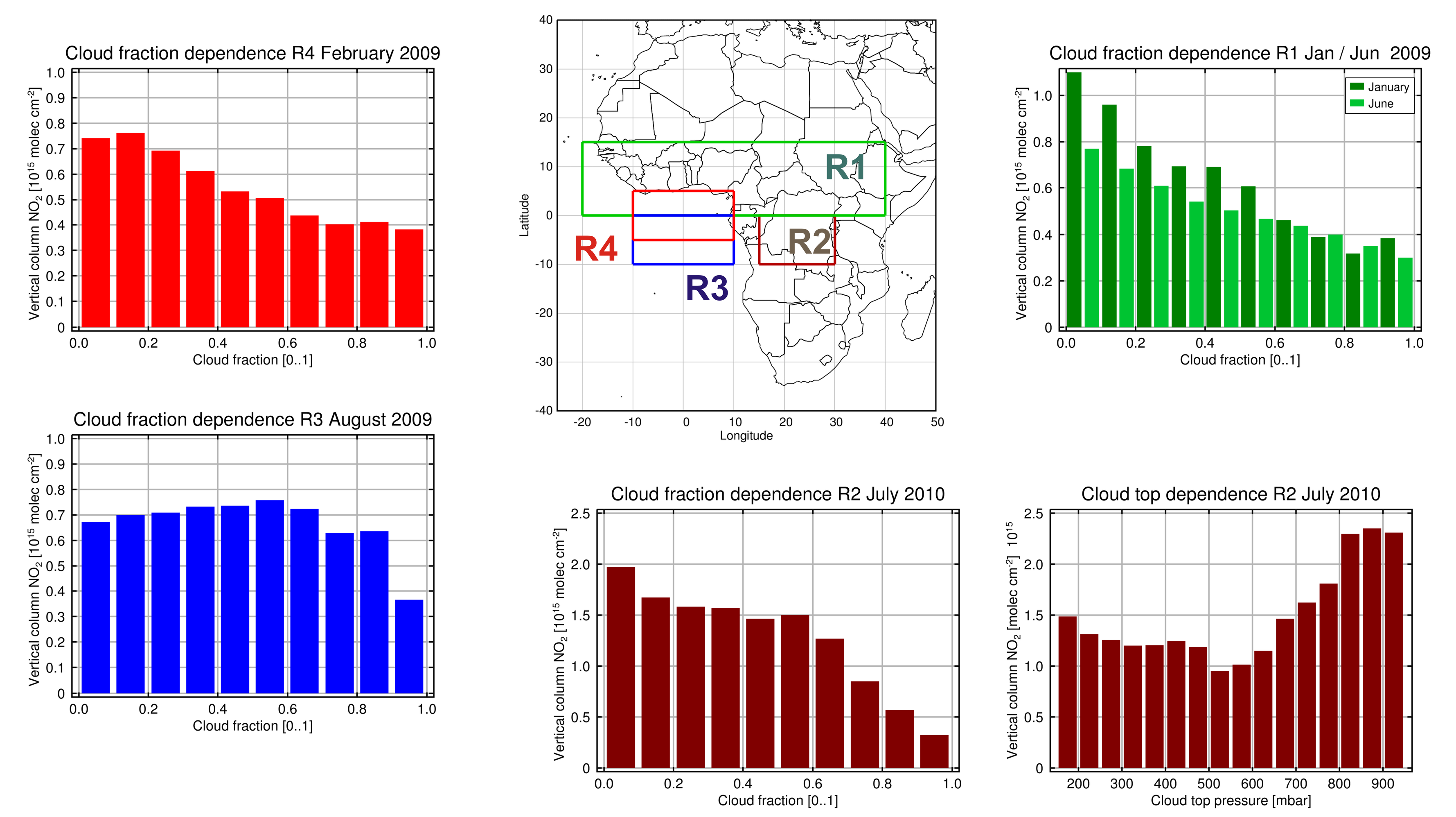


Figure: GOME-2 cloud screened tropospheric NO_2 columns for 2009 compared to MODIS cloud corrected fire counts. While there is a large degree of similarity in the spatial and temporal evolution, there are clearly also other NOx sources (soil emissions, anthropogenic activities) and evidence for transport from the fires to other regions including the ocean.

Cloud effects



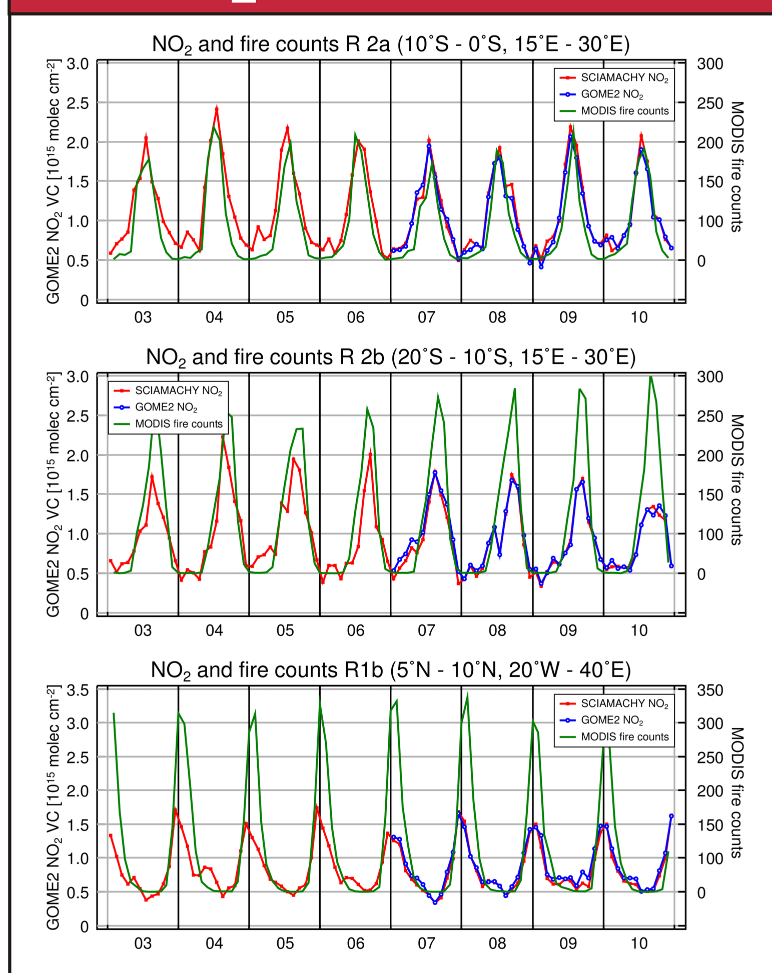
Background

- IUP Bremen NO_2 data is only screened, not corrected for cloud effects
- reduction through shielding and enhancement from albedo effect and light path enhancement should be reflected in vertical columns

Observations

- columns over region 1 show clear shielding effect, both during biomass burning (January) and for soil emissions (June) => clouds are above NO_2
- columns over region 4 also show shielding although over the ocean => low NO_2
- columns over region 2 show some shielding but mainly for very large and very small cloud fractions => some NO_2 is above and within clouds
- for partially cloudy scenes (cloud fraction > 0.1) NO_2 columns increase for cloud top heights below 600 mbar => most of the NO_2 is below this altitude
- columns over region 3 show very little cloud dependence => NO_2 is higher up in the troposphere, above low clouds

NO_2 and fire counts



Observations

- NO_2 columns in the selected regions follow the seasonality of MODIS fire counts indicating that fires are the main NOx source
- NO_2 columns from SCIAMACHY and GOME2 agree very well, indicating that there is no drift in SCIAMACHY data
- in region 2a, the interannual variability of fire counts is reflected in the variability of the NO_2 columns
- this is not the case for other regions, in particular R2b where fire counts have been increasing while NO_2 decreased
- the amount of NO_2 per fire count varies between the regions

=> retrieval problems or real differences ?

Conclusions

- in many regions, NOx emissions from fires dominate satellite observed NO_2 columns
- the seasonal pattern of NO_2 follows that of MODIS fire counts
- interannual variability of fire counts is not in all regions reflected in NO_2 variability
- there is indication for injection of NO_2 into higher layers in central Africa from the dependence of NO_2 columns on FRESCO cloud fraction and cloud top height
- depending on region, NO_2 transported over the ocean is found either below or above clouds

Acknowledgements

GOME-2 radiances have been provided by EUMETSAT
This project has been funded by the University of Bremen
MODIS fire counts have been retrieved from
ftp://neespi.gsfc.nasa.gov/data/s4pa/Fire/MOD14CM1.005/

Selected References

Koelemeijer, R. B. A., P. Stammes, J. W. Hovenier, and J. F. de Haan, A fast method for retrieval of cloud parameters using oxygen A band measurements from the Global Ozone Monitoring Experiment, *J. Geophys. Res.* **106**, 3475-3490, 2001

Leitão, J., Richter, A., Vrekoussis, M., Kokhanovsky, A., Zhang, Q. J., Beekmann, M., and Burrows, J. P.: On the improvement of NO2 satellite retrievals – aerosol impact on the airmass factors, *Atmos. Meas. Tech.*, **3**, 475-493, 2010

Richter, A., Burrows, J. P., Nüß, H., Granier, C, Niemeier, U., Increase in tropospheric nitrogen dioxide over China observed from space, *Nature*, **437**, 129-132, doi: 10.1038/nature04092, 2005

Richter, A., Begoin, M., Hilboll, A., and Burrows, J. P.: An improved NO2 retrieval for the GOME-2 satellite instrument, *Atmos. Meas. Tech. Discuss.*, **4**, 213-246, doi:10.5194/amtd-4-213-2011, 2011

Richter, A. and J.P. Burrows, Retrieval of Tropospheric NO2 from GOME Measurements, *Adv. Space Res.*, **29**(11),1673-1683, 2002

Wang, P., Stammes, P., van der A, R., Pinardi, G., and van Roozendael, M.: FRESCO+: an improved O2 A-band cloud retrieval algorithm for tropospheric trace gas retrievals, *Atmos. Chem. Phys.*, **8**, 6565-6576, doi:10.5194/acp-8-6565-2008, 2008

Universität Bremen

see also: www.iup.uni-bremen.de/doas