# Revisiting satellite derived tropospheric $NO_2$ trends

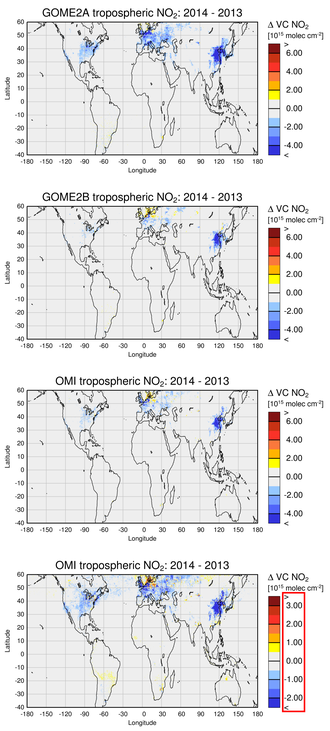
EGU2015-10674
AS3.14
B72

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

## Introduction

- $NO_2$ is a good indicator for tropospheric pollution
- satellite retrievals of tropospheric $NO_2$ are available since 1996, providing now nearly 20 years of data
- consistency between trends derived from different satellite instruments is good
- large trends have been reported in these data with mostly decreases in industrialised countries and increases in countries with rapidly growing economies, in particular China
- some unexpected changes appear to have happened recently

## The unusual $NO_2$ decrease in 2014




### Observations

- comparing the GOME2 A tropospheric $NO_2$ columns from 2014 and 2013, there is a marked downward trend over most of the northern hemisphere
- the same (although less pronounced) can be found in GOME2 B data and OMI retrievals
- using a zoomed in colour scale, it is apparent that also OMI sees a decrease over a large fraction of the NH
-

### Discussion

- the similarity between data from all three instruments makes an instrumental problem very unlikely, although GOME2 A trends appear to be biased high
- an artefact from the use of reference sector stratospheric correction can be excluded as it would not be limited to polluted regions
- $NO_2$ reductions from emission controls and weak economic development may be part of the explanation but the effect appears too uniform and over China also too large

=> we do not have a good explanation yet!

**Figure 1**: Differences of annual mean tropospheric $NO_2$ columns for 2014 - 2013. From top to bottom: GOME2 A, GOME2 B, OMI, OMI with zoomed in colour scale. All retrievals are IUP fits with simple reference sector stratospheric correction

- Funding by the University of Bremen and the EU FP7 program PANDA is gratefully acknowledged
- GOME and SCIAMACHY lv1 data were provided by ESA through DLR, GOME-2 lv1 data were provided by EUMETSAT, OMI lv1 data by NASA

## $NO_2$ trends above China

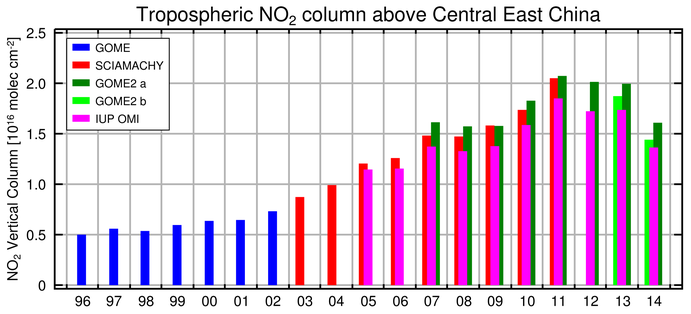



**Figure 2**: Tropospheric vertical columns of $NO_2$ retrieved from measurements of the GOME, SCIAMACHY, GOME2 A, GOME2 B and OMI instruments over East Central China (30°N - 40°N, 110°E - 123°E). All data are IUP retrievals using the same AMF and reference sector stratospheric correction and a cloud screening of 0.2.

- large increase observed in $NO_2$ columns over central eastern China from 1996 to 2011
- good overall consistency between different satellite instruments
  - OMI columns lower because of noon overpass time
  - GOME2 A data seem to be biased high for unknown reasons
  - stagnation / some reduction after 2011
- very clear reduction in 2014 seen by all three instruments
  - emission control effects?
  - economic downturn?
  - interannual variability?

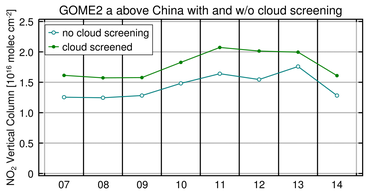



**Figure 3**: Comparison of annual GOME2 A tropospheric $NO_2$ vertical columns above east central China using two different analysis, the standard data (green) and a version using no cloud screening (aqua curve)

- cloud effects and / or problems with cloud retrieval could be one possible explanation for the reduced $NO_2$ in 2014. However, comparison with an analysis using all data (no cloud screening) shows a similar decrease.
- in 2013, the difference between cloud screened and not screened data is smaller as cloud screening removed part of the intense pollution episode in January 2013

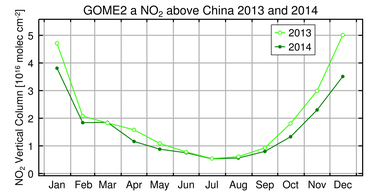



**Figure 4**: Direct comparison of monthly tropospheric $NO_2$ vertical columns above east central China for 2013 and 2014.

- direct comparison of GOME2 A data from 2013 and 2014 shows that $NO_2$ in 2014 was lower than in 2013 for every single month
- differences are smaller in summer than in winter
- OMI and GOME2 B data (not shown) exhibit the same behaviour

## More $NO_2$ trends

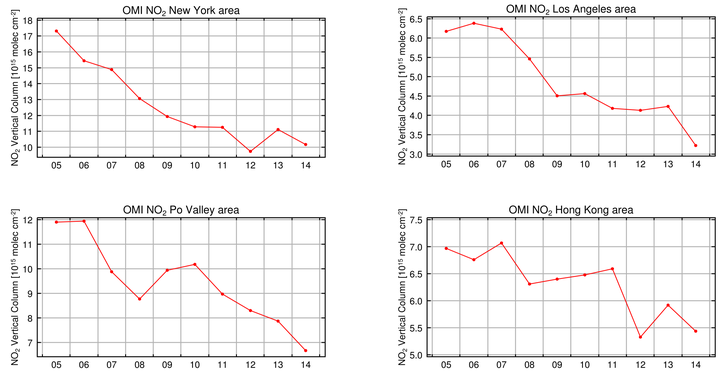



**Figure 5**: Time series of OMI tropospheric $NO_2$ vertical columns over selected agglomerations

- continuous downward trends in $NO_2$ can be found in many regions of the world, in particular in the US but also in Europe
- Hong Kong is an exception to the rest of China in that the downturn in $NO_2$ columns started already in the early 2000
- the year 2014 stands out in some but not all time series

## Conclusions

- the satellite $NO_2$ column trends above east central China have stopped to increase and in 2014, a clear downturn is observed
- the change in trend is consistent between all satellite instruments used
- continuing downward trends are also observed in other parts of the world, in particular the US
- the year 2014 appears to be special in that $NO_2$ columns were significantly lower than in 2013 in most of the northern hemisphere in several satellite products
- instrumental effects can only explain part of the 2014 effects
- cloud issues also seem not to be the explanation
- this unexpected result needs more investigation

## Selected references

Hilboll, A., Richter, A., and Burrows, J. P.: Long-term changes of tropospheric NO2 over megacities derived from multiple satellite instruments, *Atmos. Chem. Phys.*, **13**, 4145-4169, doi:10.5194/acp-13-4145-2013, 2013.

Richter, A., Burrows, J. P., Nüss, H., Granier, C. and Niemeier, U.: Increase in tropospheric nitrogen dioxide over China observed from space, Nature, 437(7055), 129–32, doi:10.1038/nature04092, 2005.

Schneider, P., Lahoz, W. A., and van der A, R.: Recent satellite-based trends of tropospheric nitrogen dioxide over large urban agglomerations worldwide, Atmos. Chem. Phys., 15, 1205-1220, doi:10.5194/acp-15-1205-2015, 2015.

Van der A, R. J., Peters, D. H. M. U., Eskes, H., Boersma, K. F., Van Roozendael, M., De Smedt, I. and Kelder, H. M.: Detection of the trend and seasonal variation in tropospheric NO2 over China, J. Geophys. Res. Atmos., 111(x), 1–10, doi:10.1029/2005JD006594, 2006.

Universität Bremen



www.doas-bremen.de