

Revisiting satellite derived tropospheric NO₂ trends

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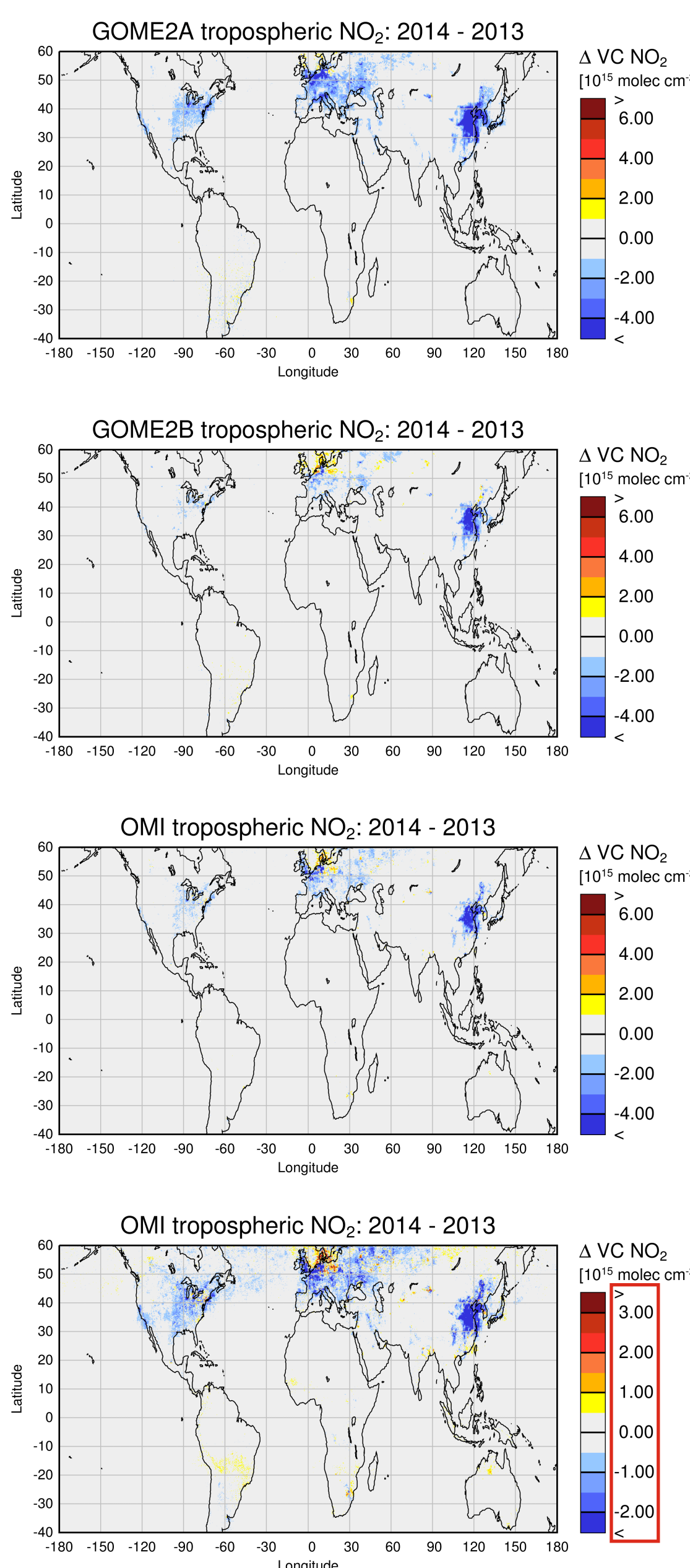
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Introduction

- NO₂ is a good indicator for tropospheric pollution
- satellite retrievals of tropospheric NO₂ 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 NO₂ decrease in 2014



Observations

- comparing the GOME2 A tropospheric NO₂ 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
- NO₂ 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 NO₂ 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

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NO₂ trends above China

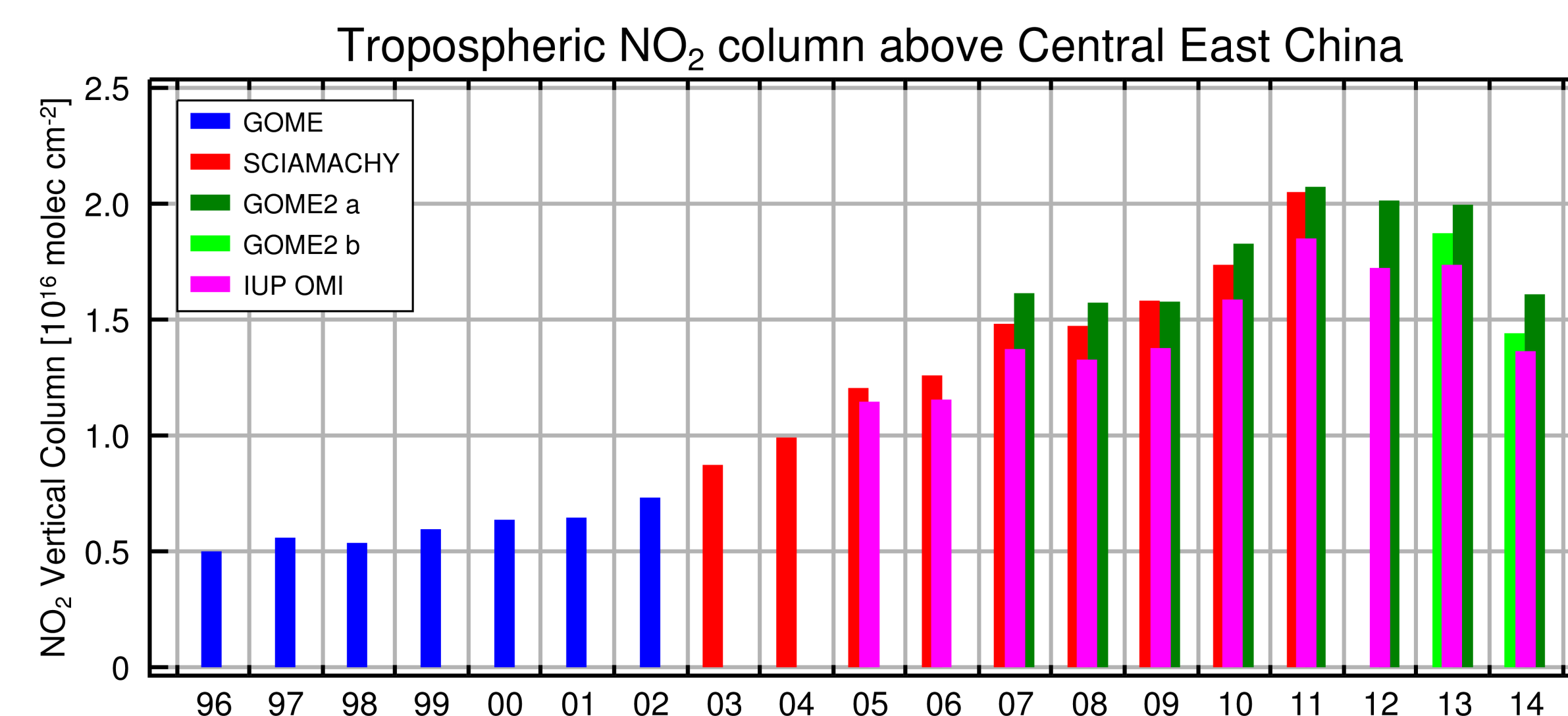


Figure 2: Tropospheric vertical columns of NO₂ retrieved from measurements of the GOME, SCIAMACHY, GOME2 A, GOME2 B and OMI instruments over East Central China (30°N - 40°N, 110°E - 123°E). All data are IUP retrievals using the same AMF and reference sector stratospheric correction and a cloud screening of 0.2.

- large increase observed in NO₂ 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?

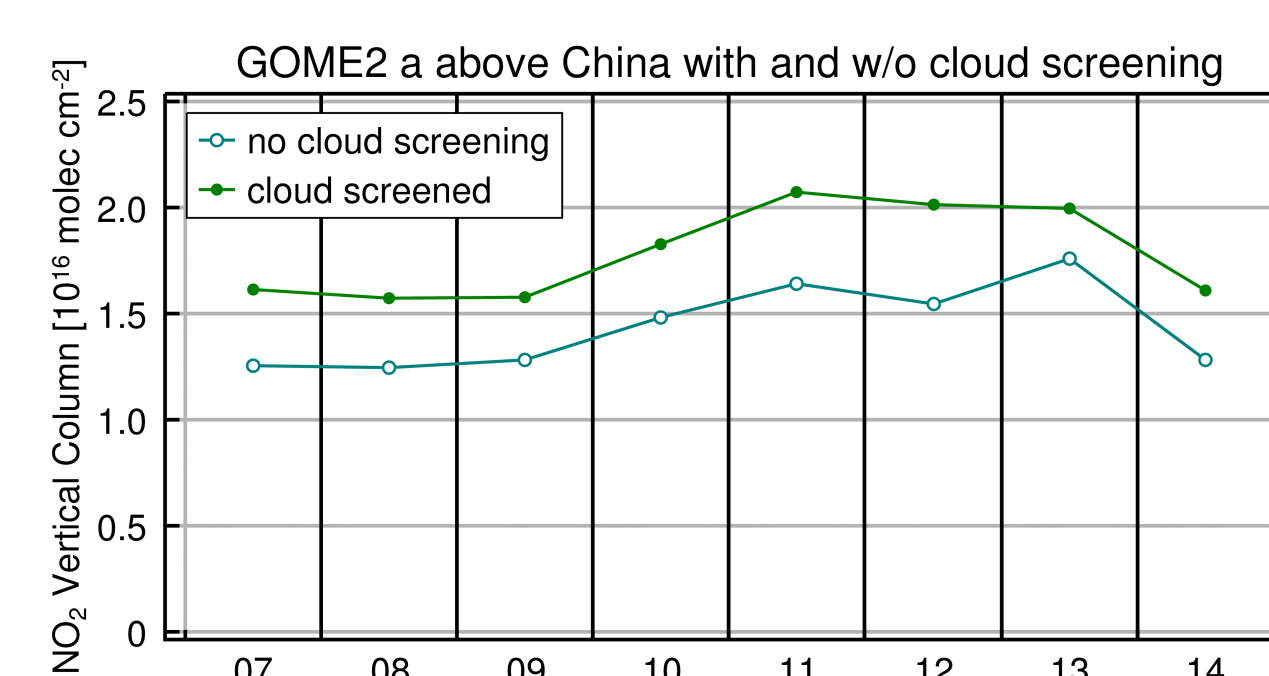


Figure 3: Comparison of annual GOME2 A tropospheric NO₂ vertical columns above east central China using two different analysis, the standard data (green) and a version using no cloud screening (blue curve)

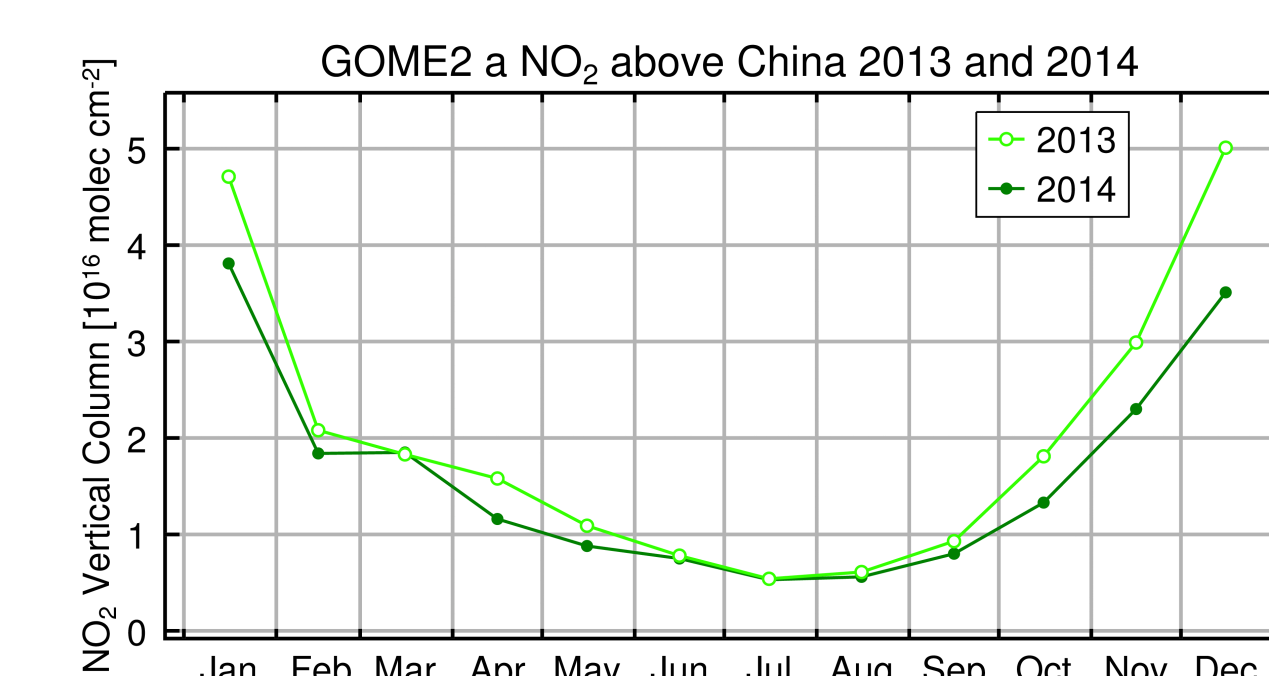


Figure 4: Direct comparison of monthly tropospheric NO₂ vertical columns above east central China for 2013 and 2014.

- cloud effects and / or problems with cloud retrieval could be one possible explanation for the reduced NO₂ 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

- direct comparison of GOME2 A data from 2013 and 2014 shows that NO₂ 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 NO₂ trends

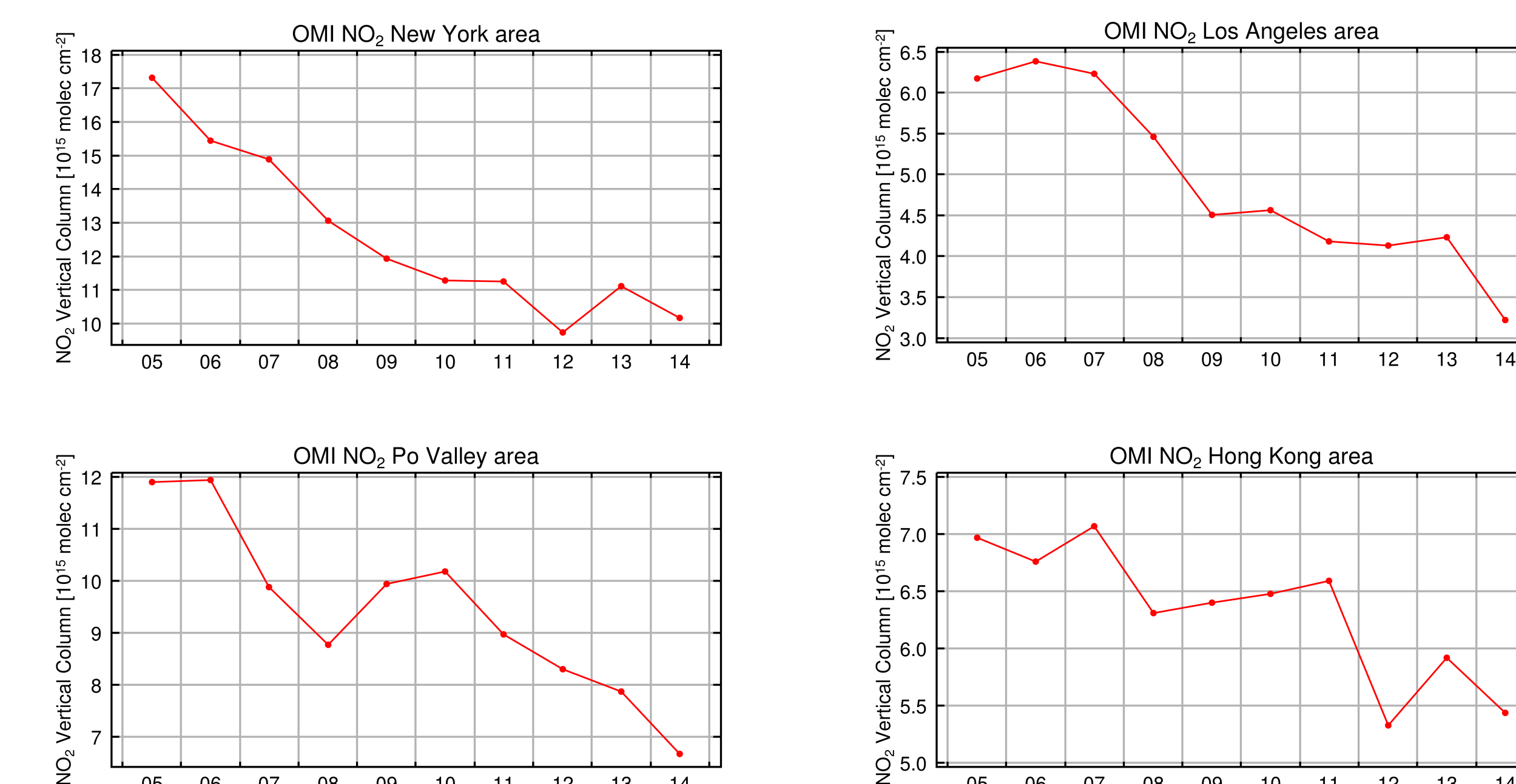


Figure 5: Time series of OMI tropospheric NO₂ vertical columns over selected agglomerations

- continuous downward trends in NO₂ 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 NO₂ columns started already in the early 2000
- the year 2014 stands out in some but not all time series

Conclusions

- the satellite NO₂ 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 NO₂ 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

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