IUGG 2011, M10, # 2488

Long-term observations of pollution from space

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Introduction

- pollution affects millions of people worldwide
- rapid changes in pollution levels took place over the last decade as result of population increase in cities, economic development, and environmental regulation changes
- pollution monitoring is well established in industrialised countries, but not yet in all parts of the world

- satellite observations provide measurements of key quantities for tropospheric pollution
- they have large uncertainties for individual observations but provide global coverage and consistent long-term data sets
- improved spatial resolution of current instruments allows observation on regional levels
- future instruments will provide data at resolutions enabling monitoring of pollution for individual cities

GOME, SCIAMACHY, and GOME-2

GOME:

- launched on ERS-2 in April 1995
- data 7.1995 - 6.2003
- 4 channel nadir viewing UV/visible spectrometer
- 320 x 40 km^2 pixel size
- global coverage: 3 days
- 10:30 LT equator crossing

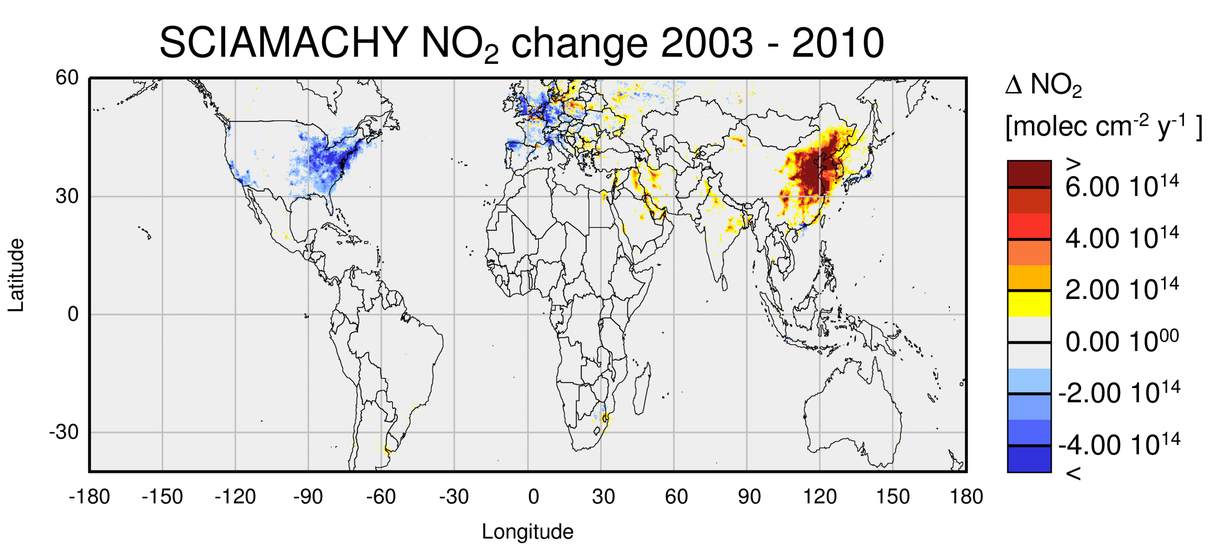
SCIAMACHY:

- 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: 6 days
- 10:00 LT equator crossing

GOME-2:

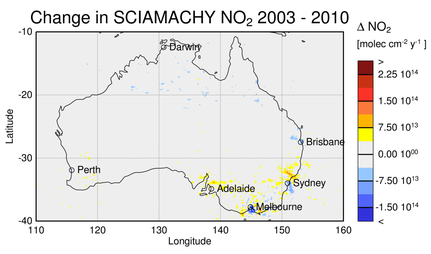
- launched on MetOp-A in October 2006
- data since January 2007
- 4 channel nadir viewing UV/visible spectrometer
- 80 x 40 km^2 pixel size
- global coverage:1.5 days
- 09:30 LT equator crossing
- first in a series of 3 instruments

Global change of NO_2

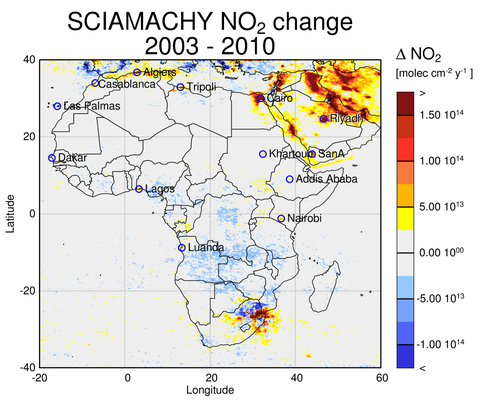


Observations

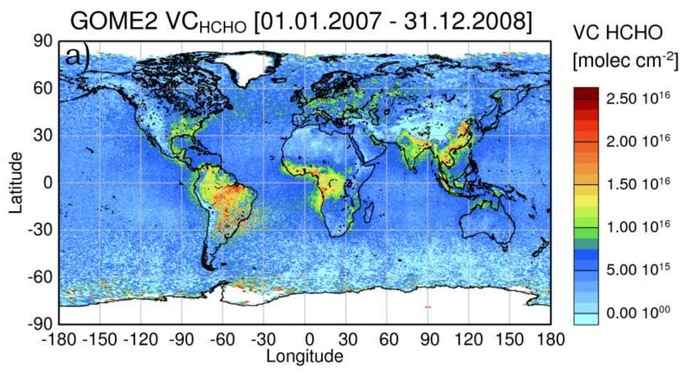
- large and systematic changes over last decade
- large increase in China as economy develops
- large decrease throughout the US
- decreases in Western Europe, but not as clear as in the US
- downward trends also in Japan, Hong Kong, and some cities in Australia

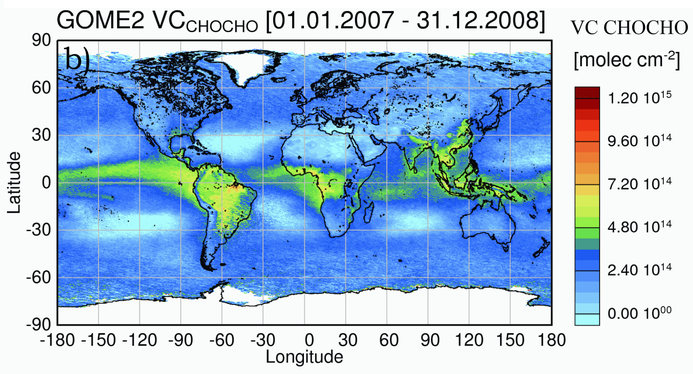


- mixed situation in Eastern Europe / Russia
- systematic and large increases in the Arabian countries and in India, but much more localised than in China
- clear upward trends in cities in Central and South America, as well as in Africa



VOCs - HCHO and CHOCHO





Formaldehyde

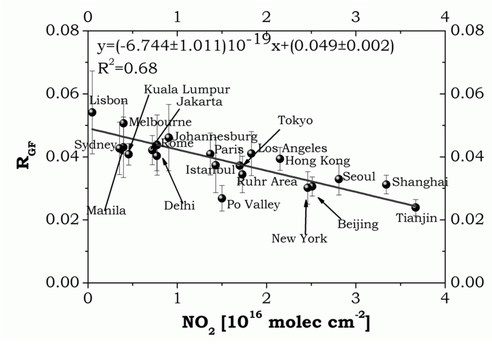
- signal is dominated by biogenic sources
- some contributions from biomass burning, mainly seen over individual large fire areas
- some coastal areas with enhanced HCHO over the ocean

Glyoxal

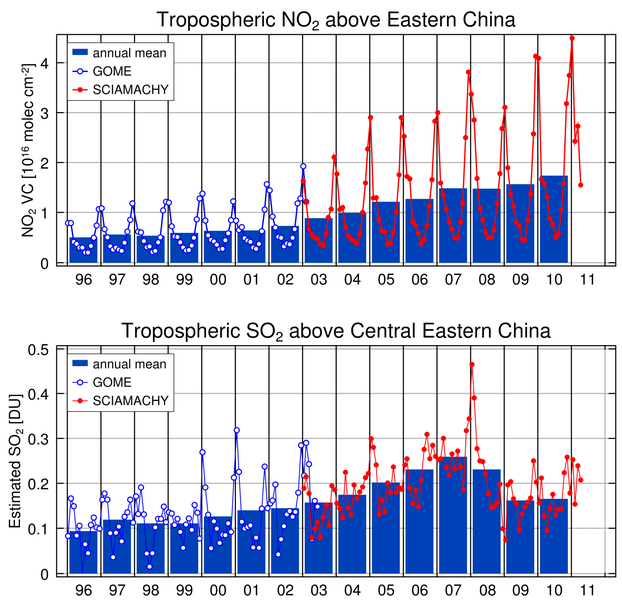
- dominated by biogenic sources
- clearly enhanced over fires
- some higher values over anthropogenic pollution
- high values over tropical oceans - indication for oceanic source?

Ratio Glyoxal / Formaldehyde

- HCHO and glyoxal global distributions are similar
- ratio of glyoxal to HCHO should depend on sources
- different ratios are observed over biomass burning, biogenic emissions, and anthropogenic sources
- a very clear correlation is found for the ratio over large cities if plotted as function of NO_2 (marker for anthropogenic pollution)



NO_2 and SO_2 Changes over China



Observations

- NO_2 columns in the selected region show a strong annual increase with the exception of the 2008 / 2009 period (Olympics, economic downturn)
- reasons: increased use of fossil fuels for energy production and transportation as economy grows
- large seasonality in NO_2 columns (photochemistry, emissions)
- excellent agreement between GOME and SCIAMACHY in the overlapping time period
- SO_2 columns also show increase, but only until 2007 when flue gas desulphurisation became mandatory for power plants

Conclusions

- Long-term satellite observations provide consistent data sets to monitor pollution
- NO_2 columns have changed significantly over the last decade, with large increases over China and in many developing cities and decreases over the US, Europe and Japan
- Environmental regulations show effect in China where the increase in SO_2 values has stopped and even reversed in 2007
- Although global VOC fields are dominated by biogenic emissions, ratios of glyoxal to formaldehyde show strong correlation to NO_2 over large cities indicating anthropogenic emission sources

Acknowledgements

- GOME-2 radiances have been provided by EUMETSAT, GOME and SCIAMACHY radiance by ESA through DLR
- This project has been funded by the University of Bremen, the European Union through the CITYZEN project and the DFG via INTA

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