Long-term Monitoring of OClO and NO_2 from Space

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Why OClO and NO_2?

- stratospheric polar ozone depletion in both hemispheres continues to occur each winter & spring
- slow recovery is expected and needs to be monitored
- links to climate change are not yet fully understood, could go both ways (impact of lower T on chemistry and PSC formation, possible changes in dynamics)

- OClO at twilight can readily be observed with UV/vis absorption spectroscopy from the ground and from space; long-term data sets exist
- OClO concentrations depend on ClO and BrO abundance which are key substances in catalytic ozone destruction
- NO_2 plays multiple roles in ozone depletion, both as a catalyst in the NO_x cycle and in the formation of reservoir species such as $ClONO_2$ and $BrONO_2$
- NO_2 can also be monitored by UV/vis observations and serve as an indicator of denoxification and denitrification

How to measure from Space?

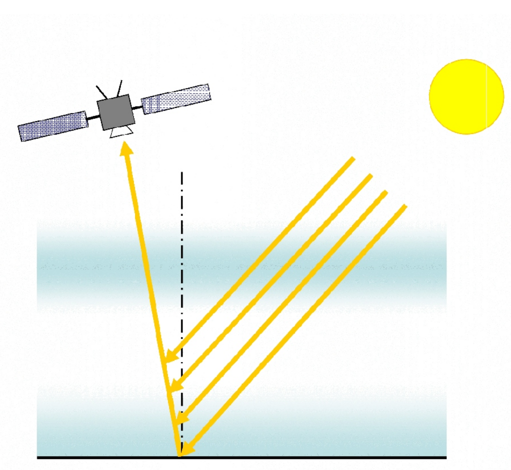


Fig 1: Cartoon of the measurement geometry. The light observed by the satellite is either reflected on the surface or scattered back from the atmosphere. At twilight, the sensitivity to the stratosphere is largest and similar to that of ground-based zenith-sky

Measurement Technique:

- Differential Optical Absorption Spectroscopy (DOAS) on UV/visible sun light scattered back and reflected from the atmosphere and surface
- use of Lambert-Beer's law to determine the absorption along the effective light path
- use of radiative transfer simulations to determine the effective light path
- evaluation of data at 90° solar zenith angle (SZA) for constant photochemical conditions and highest sensitivity in the stratosphere

Instruments used:

GOME
- data from 9.95 - 6.2003
- 320 x 40 km^2 pixels
- global coverage 3 days
- 10:30 LT equator crossing

SCIAMACHY
- data since 8.2002
- 60 x 30 km^2 pixels
- global coverage 6 days
- 10:00 LT equator crossing

GOME-2
- data since 3.2007
- 80 x 40 km^2 pixels
- global coverage 1.5 days
- 09:30 LT equator crossing

Overview over OClO Measurements

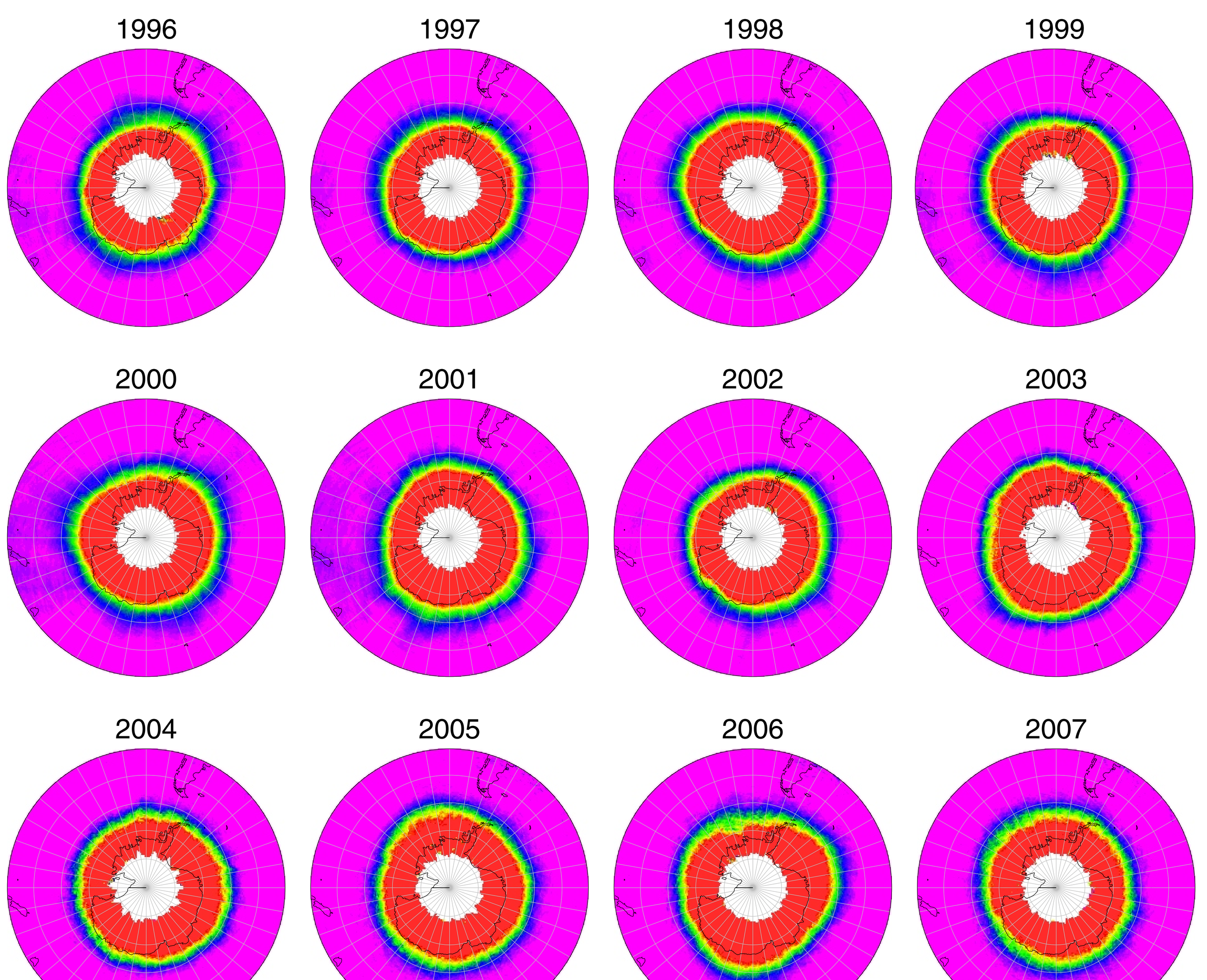
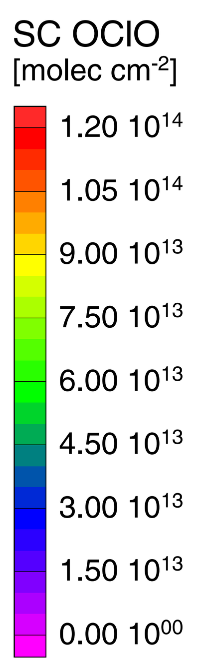


Fig 2: GOME (1996 - 2002) and SCIAMACHY (2003 - 2007) OClO slant columns for August in the Southern Hemisphere



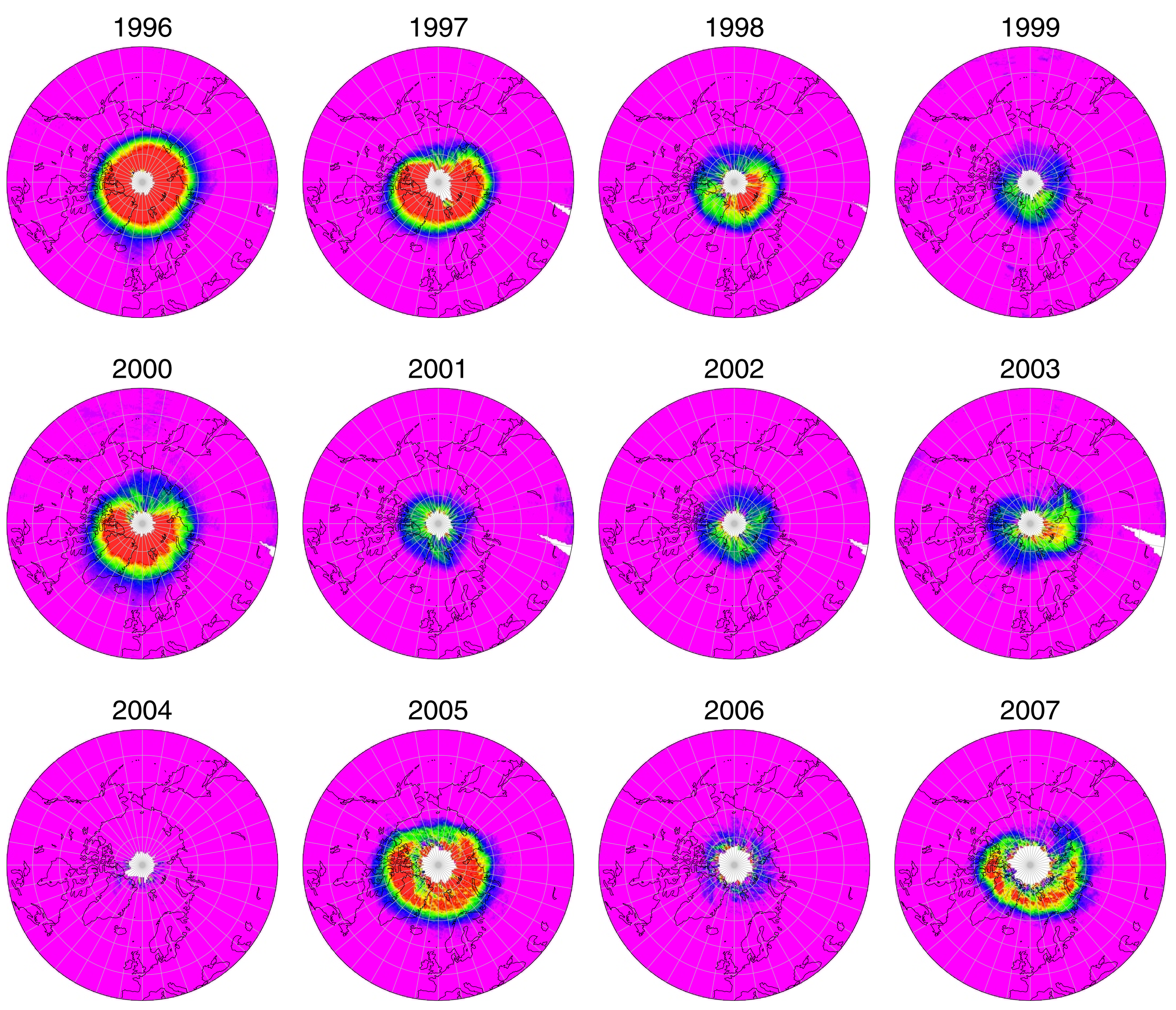
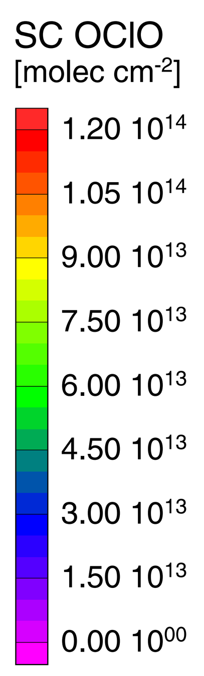


Fig 3: GOME (1996 - 2002) and SCIAMACHY (2003 - 2007) OClO slant columns for February in the Northern Hemisphere



Comparison between years

Measurements:

- OClO determined by photochemistry (rapid photolysis) and availability of ClO and BrO
- NO_2 determined by photochemistry and denoxification / denitrification
- use of 90° SZA values makes measurements comparable
- over the season, the 90° SZA measurements move from higher to lower latitudes
- vortex asymmetries can impact on results
- comparison between instruments (GOME, SCIAMACHY, OMI, GOME-2) difficult as result of different local time of overpass

Results:

- OClO and NO_2 behaviour in the SH similar in most years
  2002 (split vortex): lower OClO, early recovery of NO_2
  2006 large OClO and unusually low NO_2 until end of winter

- 2007 unusually low OClO from mid July but increasing values by mid of September
- 2007 NO_2 unusually large in early August but decreasing until September

=> vortex asymmetry? less PSC in early vortex?

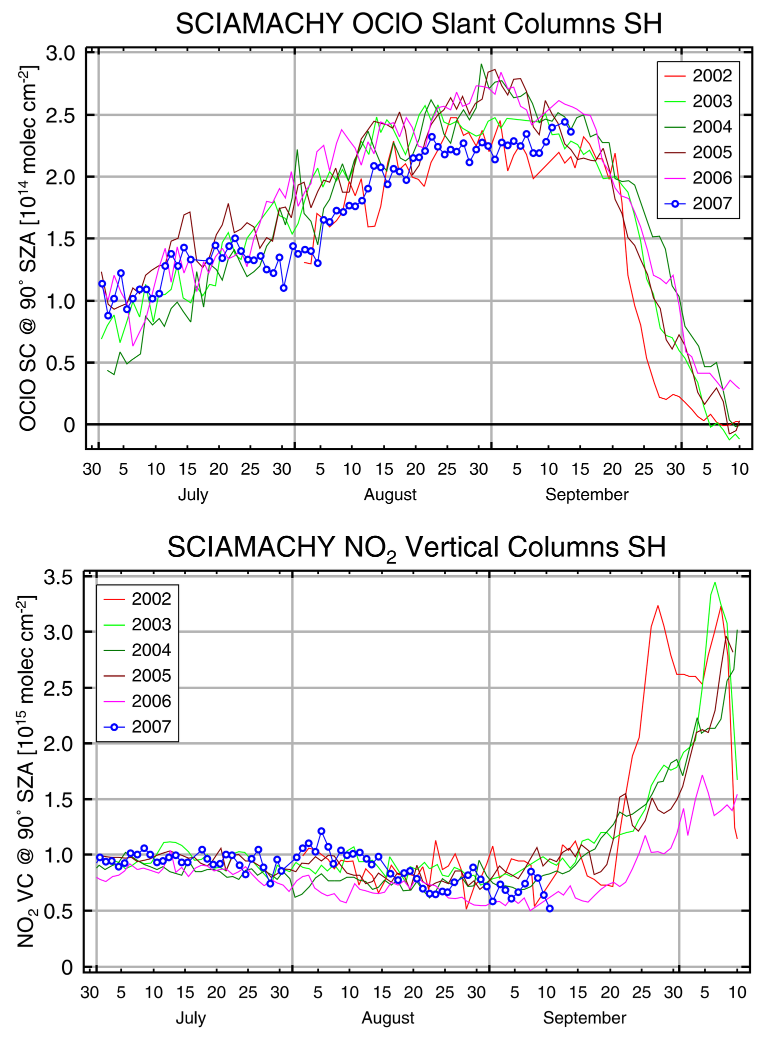


Fig 4: Measurements of OClO slant columns (upper plot) and NO_2 vertical columns (lower plot) at 90° SZA in the Southern Hemisphere. Part of the variability observed is the result of sampling of the deformed vortex by the satellite measurements

Conclusions and Outlook

- UV/visible satellite measurements of OClO and NO_2 provide valuable long-term data sets
- OClO columns are large in the SH vortex for all years but highly variable in the NH
- NO_2 columns are very similar from year to year until the recovery period where large variations occur, in particular in the SH
- SH winter 2007 has lower OClO and higher NO_2 in the early phase but appears to have stabilized in September

- OClO and NO_2 time series will be continued by the GOME-2 instruments on MetOp (see Fig. 5)

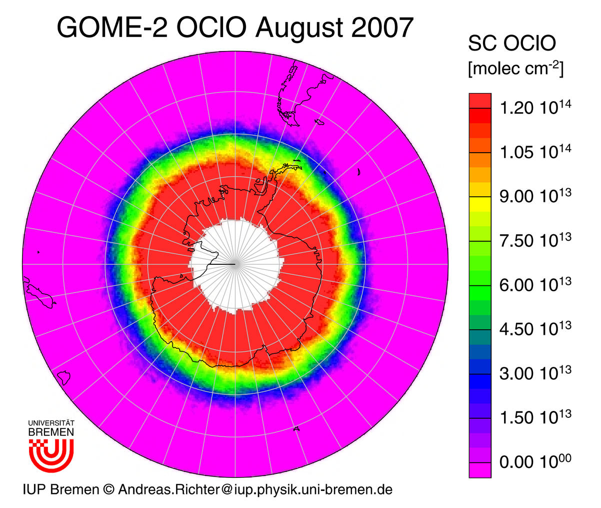


Fig. 5: Prelimary OClO columns from the new GOME-2 instrument

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