Long-term Monitoring of OClO and NO₂ from Space

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Why OClO and NO₂?
- 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
- NO₂ plays multiple roles in ozone depletion, both as a catalyst in the NO₂ cycle and in the formation of reservoir species such as ClONO₂ and BrONO₂
- NO₂ can also be monitored by UV/vis observations and serve as an indicator of denitification and denitrification

How to measure from Space?
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 km² pixels
- Global coverage: 3 days
- 10:30 LT equator crossing
- SCIAMACHY: data since 8.2002
- 60 x 30 km² pixels
- Global coverage: 6 days
- 10:00 LT equator crossing
- GOME-2: data since 3.2007
- 80 x 40 km² 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
- NO₂ determined by photochemistry and denitification/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 results of different local time of overpass

Results:
- OClO and NO₂ behaviour in the SH similar in most years
- 2002 (split vortex): lower OClO, early recovery of NO₂
- 2006 large OClO and unusually low NO₂ until end of winter
- 2007 unusually low OClO from mid July but increasing values by mid September
- 2007 NO₂ unusually large in early August but decreasing until September
- Vortex asymmetry? less PSC in early vortex?

Conclusions and Outlook

- UV/visible satellite measurements of OClO and NO₂ provide valuable long-term data sets
- OClO columns are large in the SH vortex for all years but highly variable in the NH
- NO₂ 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 NO₂ and higher OClO in the early phase but appears to have stabilized in September
- OClO and NO₂ time series will be continued by the GOME-2 instruments on MetOp (see Fig 5)

Selected References

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

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