National report The Netherlands

Systematic observations:
Surface networks and capacity building

- Brewer measurements in the Netherlands

The Brewer measurements at the station “De Bilt” by KNMI have been continued. Brewer #100 has been replaced by Brewer #189. “De Bilt” has the longest record of ozone measured with an MKIII instrument in the WOUDC database. The #100 has been refurbished, and transferred to Antarctica.

- Brewer measurements in Suriname

Measurements at the station “Paramaribo” with Brewer #159 have been continued. After careful cleaning, the dataset has now been submitted to WOUDC and NDACC. (The variability in de ozone data in this tropical station is low, and interference by clouds is a significant problem at this site.)

- Ozone sondes in the Netherlands

The ozone sounding program at station “De Bilt” by KNMI has been continued, with at least one launch per week, and more when special events occurred.

- Ozone sondes in Surinam

The ozone sounding program in Paramaribo has been continued with one launch per week. Paramaribo station is part of the SHADOZ network. Problems with the balloons and batteries at this site are still under investigation. The observations at Paramaribo are performed by staff of the Meteorological Service of Surinam and the bilateral cooperation with KNMI includes capacity building at the Anton de Kom University.

- Lidar measurements in New-Zealand

RIVM has continued the operation of the stratospheric ozone lidar at the NDACC station in Lauder, New-Zealand where first measurements started in 1994. The ozone and temperature profile observations are currently performed about four times per month. The data are available at the NDACC and ESA calibration/validation databases and have been used in various validation studies and also for trend analyses.

- UV-monitoring in the Netherlands

RIVM has continued spectral UV-monitoring on the Bilthoven location. A 17 year data-record has been achieved in 2010. Over 20000 spectral UV-readings are performed yearly and QC-checked UV-index data are reported live on the webpage www.rivm.nl/zonkracht (in Dutch). Yearly sums of the UV-doses are calculated and long term trends and variations are analysed. RIVM data are also used in the WMO/UNEP ozone assessment and RIVM lead-authored a publication on long term changes in the UV-climate at eight European UV-stations.

Satellite networks

The Netherlands has been involved in satellite ozone measurements from several instruments: GOME, SCIAMACHY, OMI and GOME-2. These are UV-visible satellite spectrometers, from which ozone and several other trace gases, like NO2, SO2, HCHO, are determined. All four instruments are operational, although the global coverage of GOME is lost since 2003.

SCIAMACHY is contributed by Germany, the Netherlands, and Belgium to ESA's Envisat satellite. SRON is the Dutch co-PI of SCIAMACHY. OMI is a contribution from the Netherlands and Finland to NASA's EOS-Aura satellite. KNMI has the PI-role for OMI. TROPOMI is the successor instrument of OMI and SCIAMACHY. TROPOMI is approved by the Netherlands and ESA, and will fly on the ESA Sentinel-5 Precursor mission, to be launched end of 2014. KNMI has the PI-role of TROPOMI.

Ozone data processing and users

At KNMI near-real time data processing of satellite ozone columns and ozone profiles is taking place; see Table 1. Also data assimilated products are made. Most of the products are being delivered to users via the web portal www.temis.nl.

The OMI ozone products are being delivered via the GSFC Data and Information Services Center (DISC). GOME-2 data processing at KNMI is performed in the framework of the Ozone and Atmospheric Chemistry Monitoring Satellite Application Facility (O3MSAF) of EUMETSAT. Data delivery of near-real-time ozone profile products is done via EUMETCast broadcasting. Fig. 2 gives an example of GOME-2 profiles derived for the Antarctic in 2008.

There are many users of the satellite ozone data; for example, SCIAMACHY and OMI ozone column data is being delivered in near-real-time to ECMWF for assimilation in the model. The EU MACC project is also a user of KNMI satellite ozone data.

Table 1: Near-real-time and offline satellite ozone products made by KNMI.

Instrument	**Product**	**Period**	**Data delivery**
GOME	Ozone column	1995 – now (global until 2003)	http://www.temis.nl
SCIAMACHY	Ozone column	2002 – now	http://www.temis.nl
OMI	Ozone column, Ozone profile, Assimilated ozone column	2004 – now	http://www.temis.nl http://disc.sci.gsfc.nasa.gov/Aura
GOME-2	Ozone profile, Assimilated ozone column	2007 – now	http://www.temis.nl http://o3msaf.fmi.fi EUMETCast

Consistency and complementarity of data sets

Recent developments in OMI ozone data retrievals and validation

The quality of the second data collection of the Ozone Monitoring Instrument (OMI) flying aboard the NASA EOS-Aura platform was published in the 2007/2008 JGR Special Issue on Aura Validation. It was reported that both the OMI-TOMS and OMI-DOAS total ozone column data products showed remarkable agreement with ground based Dobson and Brewer reference data for the 2004-2007 data record. The validation results show a globally averaged agreement of better than 1% for OMI-TOMS data and better than -2% for OMI-DOAS data with the ground-based observations. The OMI-TOMS data product is shown to be of high overall quality with no significant dependence on solar zenith angle or latitude. However, the OMI-TOMS data product contains interferences from atmospheric sulfur dioxide originating from strong volcanic eruptions, it reveals cloud structures originating from employing a cirrus contaminated cloud top pressure climatology, and it reveals non-physical jumps originating from retrieval setting changes with solar zenith angle and slant column. The OMI-DOAS data product shows no significant dependence on latitude except for the high latitudes of the Southern Hemisphere where it systematically overestimates the total ozone value. In addition a significant dependence on solar zenith angle is found between OMI-DOAS and ground-based data. In the third data collection the issues with OMI-TOMS have been addressed and solved; sulfur dioxide contaminated pixels are flagged more thoroughly, actual cloud top pressure data from the OMI-Raman cloud algorithm is employed and the jumps no longer occur. For OMI-DOAS the dependence on solar zenith angle has been reduced by half as a result of calibration improvements, however the challenge remains to solve this issue. Current developments on OMI-TOMS focus on the combined retrievals of both total ozone column and sulfur dioxide column. Current developments on OMI-DOAS focus on the use of improved absorption cross sections, an improved wavelength calibration and optimizing the sampling of the various look-up-tables by spline interpolation. In September of 2009 the last operational OMI data product came online; vertical ozone profiles operationally retrieved from the UVVIS nadir observations by OMI. Validation against a multitude of ground based and space based reference data sources reveals that OMI stratospheric ozone profiles agree within 20% with correlative data except for both the polar regions during local spring. For ozone in the troposphere OMI shows a systematic positive bias versus the correlative data sets of order 60% in the tropics and 30% at mid-latitude regions. The largest source of error is identified as the spectral stray light fit in our operational algorithm which is currently updated.

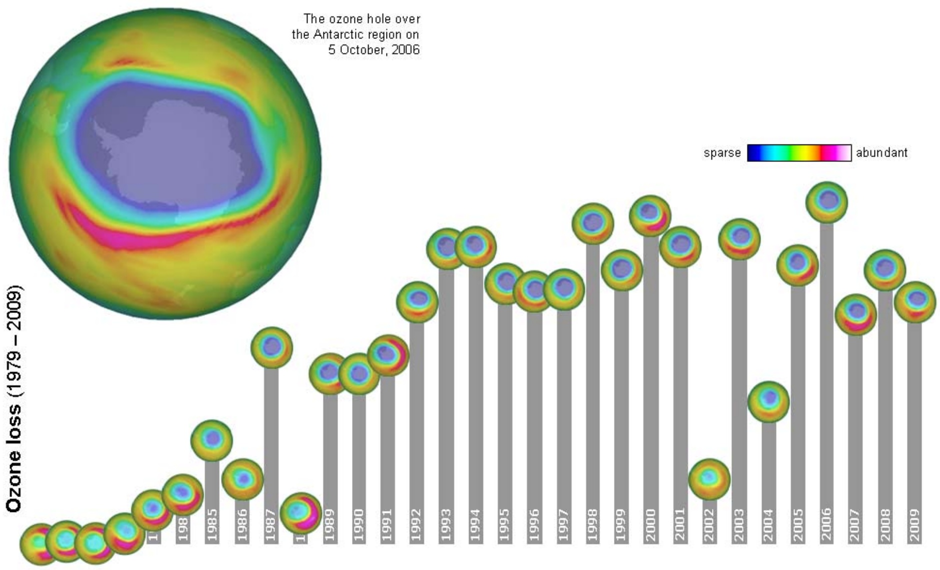

Fig. 1: Thirty-year time series of the Antarctic ozone hole, derived from the multi-sensor reanalysis data set of Van der A et al. (2010).

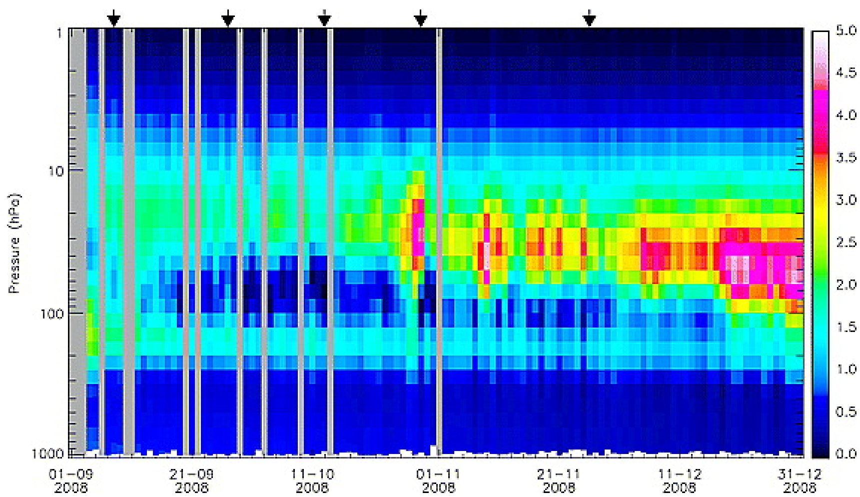

Fig. 2: Vertical structure of the Antarctic ozone hole in 2008 observed by GOME-2 (from Van Peet et al., 2008).

Use of NDACC lidar profiles for validation

Furthermore, RIVM has performed the ozone and temperature profile validation project VALID for ESA. In this project satellite the quality of the satellite-derived ozone profiles (with a focus on GOMOS, MIPAS, and SCIAMACHY measurements) was assessed with NDACC lidar profiles [van Gijsel et al., 2009, van Gijsel et al., 2010, Keckhut et al., 2010].

Re-evaluation of data-records

A major effort has been the multi-sensor re-analysis of total ozone performed with the TM3-DAM model (Van der A et al, 2010). This effort created a single coherent total ozone dataset from all available ozone column data measured by polar orbiting satellites in the near-ultraviolet Huggins band in the last thirty years. Fourteen total ozone satellite retrieval datasets from the instruments TOMS (on the satellites Nimbus-7 and Earth Probe), SBUV (Nimbus-7, NOAA-9, NOAA-11 and NOAA-16), GOME (ERS-2), SCIAMACHY (Envisat), OMI (EOS-Aura), and GOME-2 (Metop-A) were used. It is used to document the evolution of the Antarctic ozone hole (fig. 1).

Reconstruction of erythemal ultraviolet radiation levels in Europe
RIVM has led a large scale study to reconstruct the past UV-radiation levels in Europe by combining several reconstruction techniques and UV-monitoring data from eight European stations. Data from the RIVM site are included in the analysis. For this site the data-record now covers just over 17 years (period 1994-2011). For the combined European sites an increase in yearly UV-doses of around 4-6 % is found (se fig 3) in the past 25 years. Results from this analysis were also included in the WMO/UNEP Scientific assessment report (chapter 2, co-authored by den Outer).

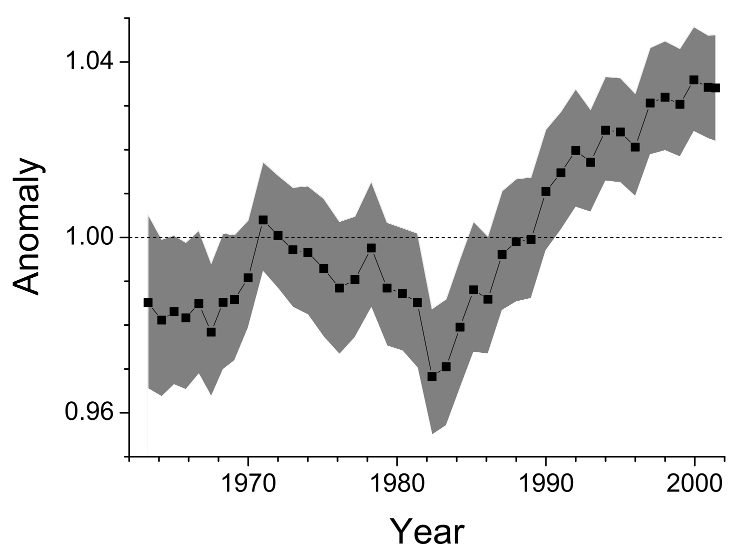

Fig. 3: The combined result for the 10 year running average of the relative yearly UV-doses for eight European sites. Prior to averaging, each reconstructed time series is normalized with respect to the 1983–2004 average. The gray area depicts the estimated uncertainty in the result.

Other contributions

Netherlands scientists have contributed to several chapters of the 2010 UNEP/WMO Scientific assessment report, e.g. to the coordination of chapter 8 (Daniel and Velders, 2010).
A new assessment study has led to an important update of the projected future contribution to climate warming by HFCs (Velders et al., 2009).

References

A, R.J. van der, M.A.F. Allaart and H.J. Eskes (2010): Multi *sensor reanalysis of total ozone,*
Atm. Chem. Phys., **10**, 11277-11294, doi:10.5194/acp-10-11277-2010.

Daniel, J.S., G.J.M. Velders (Coordinating lead authors of Chapter 8), *A Focus on Options and Information for Policymakers*, in UNEP/WMO Scientific assessment of ozone depletion: 2010, World Meteorological Organization, Global Ozone Monitoring Project - Report No. **52**, WMO, Geneva.

Den Outer, P.N., H. Slaper, H., A. Lindfors, J. Kaurola, A. Bais, A Kazantzidis, U. Feister, J. Junk, M. Janouch, W. Josefsson .(2010), *Reconstructing of erythemal ultraviolet radiation levels in Europe for the past four decades*, J. Geophys. Res., 115, D10102, doi:10.1029/2009JD012827

Mijling, B., O.N.E. Tuinder, R.F. van Oss and R.J. van der A (2010): *Improving ozone profile retrieval from spaceborne UV backscatter spectrometers using convergence behaviour diagnostics*, Atmospheric Measurement Techniques, **3**, 1555-1568, doi:10.5194/amt-3-1555-2010.

Laat, A.T.J. de, R.J. van der A and M. van Weele (2009): *Evaluation of tropospheric ozone columns derived from assimilated GOME ozone profile observations*, Atm. Chem. Phys., **9**, 8105-8120

Peet, J.C.A. van, R.J. van der A, A.T.J. de Laat, O.N.E. Tuinder, G. Koenig-Langlo and J. Wittig (2009): *Height resolved ozone hole structure as observed by the Global Ozone Monitoring Experiment–2*, Geophys. Res. Lett., **36**, doi:10.1029/2009GL038603.

Kroon, M., J.P. Veefkind, M. Sneep, R.D. McPeters, P.K. Bhartia and P.F. Levelt (2008): *Comparing OMI-TOMS and OMI-DOAS total ozone column data*, J. Geophys. Res., **113**, doi:10.1029/2007JD008798.

Kroon, M., I. Petropavlovskikh, R. Shetter, S. Hall, K. Ullman, J.P. Veefkind, R.D. McPeters and P.F. Levelt (2008): *OMI total Ozone Column Validation with Aura-AVE CAFS Observations*, J. Geophys. Res., **113**, doi:10.1029/2007JD008795.

Struijs, J., A. Van Dijk, H. Slaper, H.J. Van Wijnen, G.J.M. Velders, G. Chaplin, M.A.J. Huijbregts (2010), *Spatial- and time-explicit human damage modelling of ozone depleting substances in Life Cycle Impact*, Environ. Sci. Technol. 44, 204–209.

Van Gijsel et al. (2009): *Global validation of ENVISAT ozone profiles using lidar measurements*, International Journal of Remote Sensing 30(15), 3987-3994.

Van Gijsel et al. (2010): *GOMOS ozone profile validation using ground-based and balloon sonde measurements*, Atmospheric Chemistry and Physics 10, 10473-10488.

Velders, G.J.M., D.W. Fahey, J.S. Daniel, M. McFarland, S.O. Andersen (2009): *The large contribution of projected HFC emissions to future climate forcing*, Proc. Natl. Acad Sci., 106, 10949-10954, doi: 10.1073/pnas.0902817106.