OZONE PROFILE CLIMATOLOGY PRODUCTS
FROM 8 YEARS OF NNORSY-GOME DATA SET

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Abstract

Within the ESA funded project "CHEOPS-GOME" (Climatology of Height-resolved Earth Ozone and Profiling Systems for GOME) several climatological ozone data products were done. Beside a total of 3 static look-up-table climatologies a new approach was followed to gain a software tool for the generation of climatological ozone profiles. This approach bases on neural network technique and can handle additional dynamic input parameters such as total ozone column, temperature or the combination of both.
All climatology products are available at http://nnorsy.zsw-bw.de.

DATA BASE

At ZSW a ozone retrieval approach based on neural networks was developed (Müller et al.). The Neural Network Ozone Retrieval System (NNORSY) was applied to TOVS (total columns) and GOME (ozone profiles) and resulted in a couple of ly2 and ly3 data products. The validated NNORSY-GOME V3.0 data set (De Clercq et al.) was used as data base for the generation of all ozone profile climatologies. It covers 8 years of global ozone profile data and consists of approximately 50 Millions single profiles (Fig. 1).

<table>
<thead>
<tr>
<th>Temporal coverage</th>
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<tbody>
<tr>
<td>Start Date: 09/01/1995</td>
</tr>
<tr>
<td>End Date: 05/31/2003</td>
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<tr>
<td>Number of Orbits/Profiles: 36694/48,579,769</td>
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<table>
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<tr>
<th>Level 2 Profiles</th>
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<tr>
<td>Minimum Altitude: surface</td>
</tr>
<tr>
<td>Maximum Altitude: 61 km</td>
</tr>
<tr>
<td>Vertical Sampling: 1 km</td>
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<tr>
<td>Ozone Number Density: 1e18/m³</td>
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<td>Ozone Error: %</td>
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Figure 1: Specification of NNORSY-GOME V3.0

The ozone profile chosen from NNORSY-GOME V3.0 data set cover the time range, when GOME spectra were availably globally.

USER CONCONSULTATION

A two-step user consultation was carried out at the beginning of CHEOPS-GOME resulting in the main specification of the climatology products. A total of 86 separate working groups attended. In the
following 2 examples of the user consultation results and how they influenced the final products are shown (Fig. 2 and 3).

**Figure 2: User consultation results for question 1.2.1 for the required “Temporal resolution”**

Daily and monthly temporal resolution was chosen by the majority of the users. This resulted in monthly climatological ozone profiles given in case of the LUTs and a daily resolution for the dynamic climatology.

**Figure 3: User consultation results for question 1.1 for the “Possible Input Parameters” (multiple selection)**

User preferred to have a longitudinal component within the climatology. Since the ozone profile is strongly correlated with the total ozone column and the temperature profile and because these data are often available they are respected as possible input for the dynamic approach.

**APPROACH 1: LOOK-UP-TABLE**

The NNORSY-GOME V3.0 ozone profiles were mapped and a simple averaging method was used to calculate the monthly climatological profiles. There are a total of 3 different LUTs available. While both LUT1 and LUT2 are given on a 2.5° longitude/ 10° latitude grid, LUT1 ozone profiles are offered as ozone number densities on altitude grid, LUT2 offers volume mixing ratios on pressure scale. Since some of the users already used the TOMS-V8 (published on the web) ozone climatology an analogous third LUT was provided, giving monthly means for 10 degree latitude bands. Here the profiles themselves are given as partial columns and are also total ozone classified.

**Figure 4: NNORSY-CLIMATOLOGY modes**

Mode 1 uses time, lat and lon for the generation of climatological ozone profile, according standard deviation and temperature information. With user provided total ozone column (mode 2) or temperature profile (mode 3) an improved ozone profile is delivered. If full input information is available, mode 4 generates a most realistic ozone profile.
APPROACH 2: DYNAMIC CLIMATOLOGY

In case of the dynamic NNORSY-CLIMATOLOGY neural networks were trained on ozone profiles from NNORSY-GOME V3.0, total ozone column resulting from integration of NNORSY-GOME V3.0 ozone profiles and on GEOS temperature profiles. Including error information for the named parameter a total of 10 neural networks comprise the software package of the NNORSY-CLIMATOLOGY.

The plot on the left hand side of figure 5 shows an ozone profile taken in the southern tropics (black) in November, when barely any dynamic features are affecting the ozone distribution. Here both climatologies agree quite well with the “real” retrieves one.

Yet in higher latitudes when ozone hole conditions are observed, it is seen, that with the additional information from the total ozone column and the temperature profile the generated “climatological” profiles are quite exactly following the retrievals and are able to represent the typical course of an ozone hole profile.

Figure 5: NNORSY-CLIMATOLOGY Mode 4 single ozone profiles
Retrieval ozone profiles (black) are compared to static climatological ozone profiles (green) (Fortuin et al) and to ozone profiles generated by the NNORSY-CLIMATOLOGY mode 4 (full input information)
Figure 6: NNORSY-CLIMATOLOGY mode 1 time series (Top: NNORSY-GOME retrieval time series, middle: ozone situation by NNORSY-CLIMATOLOGY mode 1, bottom: absolute differences)
Figure 7: NNORSY-CLIMATOLOGY Mode 4 time series (Top: NNORSY-GOME retrieval time series, middle: ozone situation by NNORSY-CLIMATOLOGY Mode 4, bottom: absolute differences)
Another way of showing the improvement in the profiles by using dynamic input information is to rebuild time series. Here ozone profiles from NNORSY-GOME retrieval are directly compared to climatological ozone profiles that were generated by the NNORSY-CLIMATOLOGY. If we take the retrieval ozone profile as the “truth” and therefore as a target value from retrievals or data assimilation, the climatological profiles represent the a priori or first guess. The deviation between the retrieval and climatological ozone profiles can be a measure for the usability of the different climatology modes. Figures 6 and 7 show the NNORSY-GOME ozone profile time series for Hohenpeißenberg time series from 1995 to 2003 at the top. For each ozone profile the NNORSY-CLIMATOLOGY tool was used to derive according climatological ozone profiles using no dynamical input parameter (Mode 1, Figure 6) and also using total ozone column and temperature profile (Mode 4, Figure 7). These time series are shown in the middle.

The retrieval time series shows realistic ozone patterns (De Clercq et al.) with rough yearly courses and short time fluctuations. Two strong dynamic features occur in late January 99 and in March 2003. While the static climatology mode 1 only uses day of the year and latitude/longitude as input parameters it shows a reoccurring yearly course and is therefore not able to capture these events. It really is a static climatology because the neural networks have no information about the current atmospheric state.

By providing information that represents the atmospheric state e.g. the according total ozone columns and temperature profiles, the climatological ozone profiles from mode 4 show a clear improvement towards the “real” ozone situation.

So in cases when a most realistic climatological ozone profile is needed and the accuracy of static latitudinal LUTs is not sufficient, the NNORSY-CLIMATOLOGY software would be a good choice.

**SUMMARY**

From the CHEOPS-GOME project a number of climatology products are available. Beside three look-up-tables a software climatology is offered, that is able to take respect for dynamic input parameters i.e. total ozone column and the temperature profile.

The advantages of the new climatology products lay not only in the homogenous NNORSY-GOME V3.0 data set that was used as data base. Especially the dynamic NNORSY-CLIMATOLOGY is able to deliver most accurate ozone profiles. It is available as a software package that can be integrated in models, retrieval systems and data assimilation processes in order to minimize the discrepancy of the a priori/first guess ozone profiles and the target profile.

**REFERENCES**


