Intercomparison of GOME, Ozoneonde, and SAGE-II Measurements of Ozone: Demonstration of the Need to Homogenize Available Ozoneonde Datasets

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Abstract

We intercompare Stratospheric Column Ozone (SCO) and ozone profile retrievals from GOME data with ozonesonde and SAGE-II data for 1996-1999. GOME SCO over the altitude range -15-35 km usually agrees with ozonesonde SCO to within 2.5 DU (5.10%) over all stations using the carbon iodine method and most stations between 30N-30S. Evaluation with SAGE-II TOMS and Dobson data illustrates that biases mainly originate from ozonesonde underestimates in the stratosphere. GOME retrievals also show large positive biases of 36-68% at carbon iodine stations (except for Syowa) and of 20-55% for all the stations between 30N-30S except for Paramaribo and Easter Island (-10%) over -20-60 km, while biases relative to SAGE-II data over -15-20 km are usually 10-20%. The discrepancies over this altitude region reflect biases in GOME retrievals as well as ozoneonde measurements. In addition, GOME/ozonesonde biases vary from station to station and depend on ozonesonde technique, instrument type, sensor solution, and data processing, demonstrating the need to homogenize available ozoneonde datasets and standardize future operational procedures for reliable satellite validation.

1. Motivation

\textbullet Validate retrieved ozone profiles (especially in the stratosphere) and stratospheric column ozone from GOME (Liu et al., 2005, JGR)

\textbullet Investigate the sources of large and systematic biases in the stratosphere between GOME and sondes observations at some stations

\textbullet Approach: GOME vs. ozonesonde/SAGE-II

2. GOME, Ozoneonde, and SAGE-II Measurements of Ozone

GOME: retrieved from UV spectra using optimal estimation

\begin{itemize}
  \item 11 layers (-5 km thick, 2-3 layers in the stratosphere)
  \item Vertical resolution: 7-12 km in the stratosphere, 9-16 km in the troposphere
  \item Estimated uncertainties (random-noise errors and smoothing): 3-10% in the middle and upper stratosphere, 15-25% in the troposphere, -12% in SCD
  \item SCD resolution: normally 960-990 km.
\end{itemize}

3. Comparison Methodology

\textbullet GOME vs. SAGE-II

\textbullet Coincidence: same day, ±1.5 lat., ±5.0 lon.

\textbullet SAGE-II data: integrated column ozone, convolved with GOME retrieval AKs.

\textbullet SCO \textsubscript{SAGE-II}: stratospheric column ozone within layers 4-7/11 or ~15-25 km, summed up from transformed profiles

\textbullet GOME/SAGE-II overaration over a station’s use of coincidences within ±1.5 lat., ±40 km

4. GOME/SAGE-II SCO Comparison

\textbullet SCO: 5-9 DU with good core (Table 1)

\textbullet SCO over ozoneonde stations (Fig. 2)

\textbullet SCO: usually larger and varying biases: 5-20% for layer 4 and 20-55% for layer 3 (~15-35 km)

\textbullet SCO: for all the stations in 30ºN-30ºS (except Eastern Island and Paramaribo) over 10-20 km

\textbullet SCO: large positive biases of 30-60% over CI stations (except Syowa) and of 20-55% for all the stations between 30N-30S except for Paramaribo and Easter Island (-10%) over -20-60 km, while biases relative to SAGE-II data over -15-20 km are usually 10-20%.

\textbullet The discrepancies over this altitude region reflect biases in GOME retrievals as well as ozoneonde measurements. In addition, GOME/ozonesonde biases vary from station to station and depend on ozonesonde technique, instrument type, sensor solution, and data processing, demonstrating the need to homogenize available ozoneonde datasets and standardize future operational procedures for reliable satellite validation.

5. GOME/Sonde SCO Comparison

\textbullet SCO: similar trends and differences in early coinccidences

\textbullet Large differences in the tropics (Fig. 3)

\textbullet Positive SCO biases from 4-7 and SCO calibration error: usually within 3 DU in the bottom two layers (~10-20 km), positive at layers 4-5 (~15-25 km), and negative from layers 6 or 7 on upward.

\textbullet At Hohenpeißenberg (CI station), likely due to sensor solution change from SAGE-I to SAGE-II.

\textbullet Large bias change at American Samoa (CI station), opposite biases at Hohenpeißenberg and Payerne.

\textbullet Large biases (10-15 DU) at Tateno & Kagoshima (CI stations), opposite biases at Hohenpeißenberg and Payerne.

\textbullet Systematic positive biases at Naha (CI station), similarly at Tateno and Kagoshima.

\textbullet Large biases (10-15 DU) at Tateno & Kagoshima (CI stations), opposite biases at Hohenpeißenberg and Payerne.

\textbullet Large bias change at American Samoa (CI station), opposite biases at Hohenpeißenberg and Payerne.

\textbullet American Samoa and Tahiti, biases increase 11-15% over 0.25 km and 6-10% over 2-5 km, switching to 2%-unbuffered sensor solution.

\textbullet The altitude-dependent correction and correlation to ozonesonde model, and processing.

\textbullet Uncorrected altitude hysteresis in ozoneonde data introduces an error of 5.

\textbullet Inhomogeneity exists in ozoneonde datasets, making it difficult to perform a reliable and accurate validation without considering ozoneonde operational characteristics.

6. GOME/Ozoneonde Profile Comparison

\textbullet GOME retrievals show similar altitude-dependent calibration error: usually within 3 DU in the bottom two layers (~10-20 km), positive at layers 4-5 (~15-20 km), and negative from layers 6 or 7 on upward.

\textbullet At Hohenpeißenberg (CI station), likely due to sensor solution change from SAGE-I to SAGE-II.

\textbullet Large bias change at American Samoa (CI station), opposite biases at Hohenpeißenberg and Payerne.

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Conclusions

\textbullet GOME Stratospheric Column Ozone (SCO) over the altitude range -15-35 km usually agrees with SAGE-II SCO to within 2.5 DU (1.5%) without significant spatiotemporal dependence.

\textbullet GOME SCO is systematically larger than ozonesonde SCO by 8-20 DU (5-10%) over Carbon Iodine (CI) stations and most stations between 30N-30S.

\textbullet Large biases of 10-20 DU mainly originate from ozonesonde underestimates in the stratosphere.

\textbullet GOME shows large positive biases of 30-40% over CI stations (except Syowa) and of 20-55% for all the stations in 30N-30S (except Eastern Island and Paramaribo) over 10-20 km.

\textbullet The discrepancies over this altitude region reflect biases in GOME retrievals and ozonesonde measurements.

Acknowledgements

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Table 1: GOME/SAGE-II SCO comparison (a. mean, b. raw)

<table>
<thead>
<tr>
<th>Lat. Range</th>
<th>SCO a.</th>
<th>SCO b.</th>
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<tr>
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<td>2382</td>
<td>2382</td>
</tr>
<tr>
<td>30N-30S</td>
<td>2063</td>
<td>2063</td>
</tr>
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<td>20N-20S</td>
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<td>2312</td>
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<td>0N-0S</td>
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<td>2300</td>
</tr>
<tr>
<td>10S-10P</td>
<td>2333</td>
<td>2333</td>
</tr>
<tr>
<td>20S-20P</td>
<td>2333</td>
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<tr>
<td>30S-30P</td>
<td>2333</td>
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<tr>
<td>40S-40P</td>
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</table>

Fig. 1: Locations of ozoneonde stations

Fig. 2: Mean biases for GOME/SAGE-II SCO4-7 (~15-35 km) and SCO8-11 (~35-60 km) at ozoneonde stations during 1996-1999.

Table 2: Comparison of GOME, ozonesonde, and SAGE-II SCO measurements of ozone.

<table>
<thead>
<tr>
<th>Station</th>
<th>GOME SCO4-7</th>
<th>SAGE-II SCO4-7</th>
<th>Ozoneonde SCO4-7</th>
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<tr>
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<td>Moscow</td>
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</tbody>
</table>

Fig. 3: Comparison of GOME, ozonesonde, and SAGE-II SCO measurements of ozone.

Fig. 4: Comparison of GOME, ozoneonde, and SAGE-II SCO measurements of ozone.

Fig. 5: Absolute columnar ozone over GOME layer 4 (~15-20 km) and layer 5 (~20-25 km) between GOME and SAGE-II/Sonde in 1996-1998.