Multi Sensor Reanalysis (MSR) of total ozone and ozone profiles

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Introduction

MSR version 1:
• Total ozone data record 1979-2008
• van der A et al. ACP, 2010

MSR version 2:
• Total ozone data record extended to 1970-2012
• van der A et al. AMT, 2015

Operational MSR updates:
• Part of Copernicus Climate Change Service (C3S-ozone)
• Will start soon
Methodology:
Constructing the Multi-Sensor Reanalysis of ozone
Multi Sensor Reanalysis (MSR) of ozone

Assumption:
• The ground observations are on average a good approximation for the true values.

Procedure:
• All UV-VIS satellite data in the period 1970-2012 is used.
• Step 1: Correct satellite data to avoid biases. The reference data that is chosen are ground data observations from reliable WOUDC stations.
• Step 2: Satellite data is assimilated in a chemical-transport model to achieve complete global and temporal coverage.

Availability:
• Multi Sensor Re-analysis (MSR) data available at www.temis.nl
• Published in:

Reference data

Reference data set:

- From WOUDC 91 ground stations are selected with a long and reliable dataset (*Fioletov et al.*, 2008)
- Dobson & Brewer instruments
- Dobson data corrected for temperature dependence (*Kerr et al.*, 2002)
# Corrections satellite data

Expected dependencies of satellite data:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Physical mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar zenith angle</td>
<td>Light path</td>
</tr>
<tr>
<td>Viewing zenith angle</td>
<td>Scan mirror</td>
</tr>
<tr>
<td>Effective temperature</td>
<td>O3 cross-section</td>
</tr>
<tr>
<td>Time (trend)</td>
<td>Instrument degradation</td>
</tr>
<tr>
<td>Offset</td>
<td>Calibration</td>
</tr>
</tbody>
</table>

- Generate time series of the satellite data sets for all stations.
- Fit all time series as function of the 5 parameters.
- Apply corrections as function of the fit parameters to construct the Multi-Sensor Reanalysis (MSR) level 2 data
Correction of level 2 data

Satellite minus Brewer observations for the Uccle ground station
Data assimilation of the MSR level 2 data

- Level 2 data is on satellite footprint. Location measured on irregular times. Regions without observations exist.

Therefore, data assimilation used to create a homogeneity data record

Data assimilation:
- Kalman-type data assimilation scheme using the TM model
- Meteo: ECMWF ERA-interim winds, temperatures
- Stratospheric chemistry parametrizations (Cariolle v. 2.9)
- Starting in 1970 by including BUV data. The reanalysis period is 43 years (!).

- Output:
  - Total ozone field every 6 hours
  - Spatial grid is 1 x 1 degree (resolution is 0.5 degree)
  - Daily local time ozone field at noon (for UV index)
Analysis of results for the MSR version 2
Examples of error fields for
- 26-06-1971 (BUV)
- 26-06-1984 (TOMS)
- 26-06-2006 (almost all sat.)
OmF, OmA as function of latitude and solar zenith angle in January 2008
OmF of the Multi-Sensor Reanalysis (MSR2)

Gridded for January 2008
MSR 2 extended with Dobson

ground observations

MSR2

MSR2 extended with Dobson
October monthly mean 1970-2015 (MSR2+)
Comparison to AC&C/SPARC database
Comparison of MSR and AC&C/SPARC

ECV ozone comparison for 1980-2010:
• Ozone satellite observations: MSR2
• Ozone database from AC&C/SPARC (for CMIP5)
  – No dynamics included
  – Zonal averaged stratosphere
Intercomparison with SPARC data over the Antarctic (Sep.-Nov.)
AC&C SPARC ozone versus MSR2
(annual zonal mean)
BAMS climate report 2015

NH March (60°N-90°N)

SH October (60°S-90°S)

DU

WOU DC
SBUV V8.6 NASA
SBUV V8.6 NOAA
GOME/SCIA GSG
GOME/SCIA GTO
MSR2
preliminary WOU DC data in 2015

1. Application to ozone profiles
2. Conclusions
We apply a similar method to ozone profiles

• Reference is ozone sonde database (WOUDC)
• Correction per layer as function of SZA, VZA, and time
• 3D data assimilation of simultaneous instruments.
• To be processed within O3-CCI project:
  1995-2012 (GOME, GOME2, OMI, SCIA, IASI)
First results of 3D ozone field (1)

Examples of retrieved ozone layers on 7 January 2008

Ozone in 0-6 km layer

Ozone in 25-30 km layer
Monthly mean ozone of January 2008 in 0-6 km layer
Summary

Multi Sensor Reanalysis (MSR2) of total ozone:

- 18 total ozone data sets from BUV, TOMS, SBUV, GOME, SCIAMACHY, OMI and GOME-2 are corrected by comparison with Brewer and Dobson data (WUDC).
- An improved data assimilation scheme has been developed and verified by detailed OmF analysis.
- The MSR data record is extended to the period **1970-2012** on a 1x1 degree grid (0.5 degree resolution) and 6 hour time steps.
- A similar method has been applied to nadir ozone profiles. First results are available.

Outlook

- MSR-methodology applied to ozone profiles observed by satellite (results available via CCI-ozone project)
- Operational MSR updates via the Copernicus Climate Change Service (C3S)