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Validation of OMPS Ozone Profile Data with Expanded Dataset from Brewer and Automated Dobson Network.

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Abstract

❖ The first NPOESS satellite is scheduled to be launched in 2010 and will carry the Ozone Mapping and Profiler Suite (OMPS) instruments for ozone monitoring. Prior to this, the OMPS instruments and algorithms will be tested by flight on the NPOESS/NPP satellite, scheduled for launch in 2008.

❖ The heritage of satellite instrument validation (TOMS, SBUV, GOME, SCIAMACHY, SAGE, HALOE, ATMOS, etc) has always relied upon surface-based observations. While the global coverage of satellite observations is appealing for validating another satellite, there is no substitute for the hard reference point of a ground-based system such as the Dobson or Brewer network, whose instruments are routinely calibrated and intercompared to standard references.

❖ The standard solar occultation instruments, SAGE II and HALOE are well beyond their planned lifetimes and might be inoperative during the OMPS period.

❖ The Umkehr network has been one of the key data sets for stratospheric ozone trend calculations and has earned its place as a benchmark network for stratospheric ozone profile observations. The normalization of measurements at different solar zenith angles (SZAs) to the measurement at the smallest SZA cancels out many calibration parameters, including the extra-terrestrial solar flux and instrumental constant, thus providing a "self-calibrating" technique in the same manner relied upon by the occultation sensors on satellites. Moreover, the ground-based Umkehr measurement is the only technique that provides data with the same altitude resolution and in the same units (DU) as do the UV-nadir instruments (SBUV-2, GOME-2, OMPS-nadir), i.e., as ozone amount in pressure layers, whereas, occultation instruments measure ozone density with height.

❖ A new Umkehr algorithm will enhance the information content of the retrieved profiles and extend the applicability of the technique. Automated Dobson and Brewer instruments offer the potential for greatly expanded network of Umkehr observations once the new algorithm is applied.

❖ We discuss the new algorithm development and present preliminary results of comparisons between co-located Brewer and Dobson ozone profiles measured at Arosa station in Switzerland.

Features of the new Umkehr algorithm

- The *a priori* profiles have no impact on the monthly-mean anomaly (MMA)
  - simplifies interpretation of trends
- The algorithm is more linear
  - preserves the probability distribution function of the layer ozone which could otherwise bias the monthly means
- The measurements in the UMK04 (Petropavlovskikh et al, 2004) are given more weight than in the UMK92 (Mateer & DeLuisi, 1992)
  - total ozone information is part of the measuring system, rather than a part of a priori as in the UMK92.
- Information content of the lower layers in UMK04 is similar to other layers.
- Information in the upper layers is not degraded by changing the starting SZA to 70˚.

Current automated Dobson and Brewer Umkehr stations

Station	*Location*	*Inst. No.*	*Agency*
Fairbanks, AK	64.86N, 147.86W	DB 63	NOAA; U. of Alaska, USA
Haute Provence, France	43.93N, 5.71E	DB 85	NOAA, USA; CNRS, France
Boulder, CO	40.00N, 105.25W	DB 61	NOAA, USA
Mauna Loa, HI	19.53N, 155.58W	DB 76	NOAA, USA
Perth, Australia	31.92S, 115.96E	DB 81	NOAA; Australian Bureau of Meteorology
Lauder, New Zealand	45.04S, 169.68E	DB 72	NOAA, USA; NIWA, New Zealand
Arosa, Switzerland	46.80N, 9.70 E	Br 40	MeteoSwiss, Switzerland
Toronto, Canada	43.78N, 79.47W	Br 65	MSC, Canada
Thessaloniki, Greece	40.62N, 22.95E	Br 261	Aristotle University, Greece
Boulder, CO	40.00N, 105.25W	Br 67	NOAA, USA
Mauna Loa, HI	19.53N, 155.58W	Br 31	MSC, Canada

Umkehr measurement background and availability of data

- **There are 3 types of operational Umkehr systems: traditional Dobson, automated Dobson and Brewer (single and double)**
- **Umkehr data have been processed and archived at WOUDC from only two of these systems (traditional and automated Dobson) using UMK92 algorithm.**
- **Only the C-pair data from the automated Dobsons are used, even though they also take A- and D-pair measurements.**
- **The algorithm for Brewer Umkehr had been recently developed similar to the Dobson UMK04 algorithm**
- **Brewer data are available through direct contacts with Brewer operators**
- **SAG Ozone is in the process to develop procedures for centralized Brewer data archiving**

No major discord was found Between SBUV and Umkehr independent measurements from 1979 through 2001 time period (Petropavlovskikh et al. 2005).

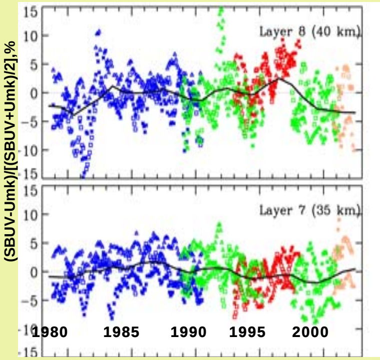
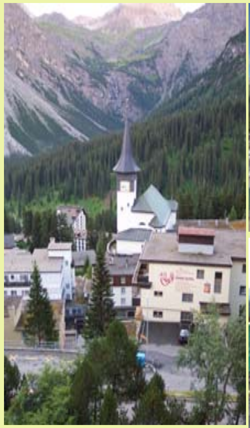


Figure 1. Monthly Mean Anomalies (MMA) in matched SBUV-Umkehr for Arosa, Boulder and Tateno Dobson stations (BUV satellites are Nimbus 7, NOAA-09, NOAA-11, NOAA-16, **5 month smooth).**

Umkehr layer system

Layers	Layer Boundary (km)	Pressure limits (hPa)
0+1	0 - 10	1013 - 253
2+3	10 - 20	253 - 63
4	20 –25	63 – 32
5	25 - 30	32 –16
6	30 – 35	16 – 8
7	35 - 40	8 -4
8	40 - 45	4 - 2
9	45 -50	2 – 1
8+	40 – top of atmosphere	4 - 0

Dobson and Brewer data are collected on regular bases at Arosa, Switzerland, ground station since 1989



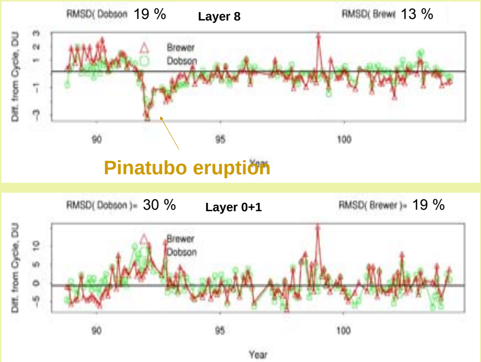


Figure 2. Time series of the ozone in two layers retrieved from co-incident Dobson and Brewer data at Arosa station. Nearly the same inter-annual ozone variability is observed by the two systems in both the lower and upper atmosphere.

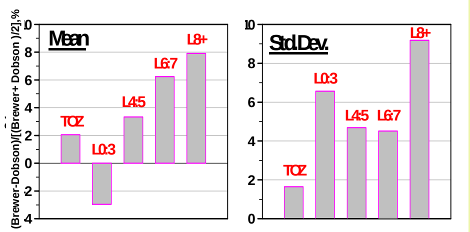


Figure 3. Comparisons between retrieved ozone profiles from co-incident Brewer and Dobson measurements at Arosa station: bias (left panel) and standard deviation (right panel). The future work includes assessment of the "stray light" contribution in Dobson/Brewer measurements (possible explanation of existing bias).

Investigation of three critical areas of OMPS performance

Pre-Launch Validation

Goal: Create a new dataset (algorithm included) with daily ozone profiles from an expanded number of location and broad latitude range for validation of the NPOESS ozone profile products.

Methods:

✓Characterize Brewer and automated Dobson instrument measurements for accuracy and precision.

✓Develop an improved algorithm for the Brewer and automated Dobson ozone profile retrievals. Utilize additional wavelength information in Umkehr measurements to validate NPOESS ozone information in the upper stratospheric region.

✓Test the accuracy and precision of the new Brewer/automated Dobson retrievals against other established ground-based networks (ozone-sonde, lidar and microwave) and through NPP and NPOESS validation field campaigns.

✓Establish a baseline of Umkehr measurements using the new algorithm in time for the NPP launch.

Post-Launch validation

Goal: Investigate the quality of the post-launch OMPS nadir and limb profiles using pre-tested validation methods.

Methods:

✓Provide new Brewer and automated Dobson data to the IPO to expand geographical coverage and frequency of ground-based ozone dataset currently available for NPP and NPOESS OMPS validation.

✓Validate OMPS nadir profiler, which can subsequently be used to check the calibration of the Limb Profiler. Quantify resolution and accuracy of the OMPS nadir measurement.

Post-Launch algorithm stability evaluation

Goal: Evaluate long-term stability of the nadir and limb ozone profile algorithm retrievals

Methods:

✓Systematically process, improve and archive Brewer and automated Dobson ground-based observations for NPOESS validation needs.

✓Quantify the stability of the OMPS instrument by providing a calibration reference with expanded Umkehr Brewer and automated Dobson network.

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Plans to evaluate quality of existing data

✓ Perform an analysis and survey the minimum capabilities and station distribution needed for the ground Brewer/Dobson networks

✓ Participate in the upcoming validation campaign in Finland, in spring 2006 (no cost) to demonstrate how the Umkehr technique and algorithm can be improved

✓ Conduct regular inter-comparisons with other ground-based measurements (ozone-sonde, lidar, microwave) at selected NDSC sites and the NOAA MLO site.

Potential Umkehr Brewer stations

Station Name	Country	Agency	Location (lat/long)	Station Name	Country	Agency	Location (lat/long)
Alert	Canada	MSC	82.50 N, -62.30 E	Montreal	Canada	MSC	45.47 N, -73.75 E
Eureka	Canada	MSC	80.05 N, -86.43 E	Longfengshan	China	CHN	44.73 N, -127.6 E
Resolute Bay	Canada	MSC	74.72 N, -94.98 E	Halifax (Dartmouth)	Canada	MSC	44.73N, -83.77 E
Yakutsk	Russia	RHM	62.02 N, -129.63 E	Sapporo	Japan	JMA	43.05 N, 141.34 E
Sodankyla	Finland	FMI	67.37 N, 26.63 E	Beijing	China	CHN	39.95 N, -116.32 E
Jokioinen	Finland	FMI	60.82 N, 23.50 E	GSFC	U.S.A.	NASA-GSFC	38.99 N, -76.84 E
Churchill	Canada	MSC	58.75 N, -94.00 E	Tsukuba (Tateno)	Japan	JMA	36.05 N, 140.14 E
Edmonton (Stony Plain)	Canada	MSC	53.55 N, -114.10 E	Kagoshima	Japan	JMA	31.55 N, 130.56 E
Goose Bay	Canada	MSC	53.32 N, -60.30 E	Naha	Japan	JMA	26.20 N, 127.69 E
Saskatoon	Canada	MSC	52.11 N, -106.71 E	Taipei	Thailand	TWN	25.03 N, -121.52 E
De Bilt	Netherlands	KNMI	52.10 N, 5.18 E	Minamitorishima	Japan	JMA	24.30 N, 153.97E
Regina	Canada	MSC	50.21 N, -104.67 E	Chengkung	Thailand	TWN	23.1 N, -121.37 E
Winnipeg	Canada	MSC	49.91 N, -97.24 E	Paramaribo	Surinam	KNMI	5.81 N, -55.21 E
Saturna Island	Canada	MSC	48.78 N, -123.13 E	Syowa Station	Antarctica	JMA	69.00 S, 39.59 E