NDSC Lidar Intercomparisons and Validation: OPAL and MLO3 Campaigns in 1995

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Introduction: The Network for the Detection of Stratospheric Change (NDSC) has developed and adopted a Validation Policy [1] in order to ensure that the results submitted and stored in its archives of are of a known, high quality. As a part of this validation policy, blind instrument intercomparisons are considered an essential element in the certification of NDSC instruments and a specific format for these campaigns has been recommended by the NDSC-Steering Committee. Some of the key elements of the Instrument Intercomparisons Protocol [1] are that the campaign is under the control of an impartial referee who ensures, as far as possible, that the participants do not see each others results during the campaign so that a true, blind intercomparison is achieved. The referee also has many other responsibilities including collecting the results from the participants during the campaign, making, the comparisons and analyses, and preparing the conclusions for reporting and publication, The comparisons of stratospheric ozone profile measuring instruments held at Lauder, New Zealand, during April 1996 and at Mauna Loa, Hawaii, during August 1996 both followed the formal protocols for a NDSC blind intercomparison.

OPAL NIWA, Lauder, New Zealand Referee: Stuart McDermid / JPL	
RIVM-Lidar	*NIWA-Sondes*
J. B. Bergwerff	I. S. Boyd
E. J. Brinksma	W. A Matthews
F. T. Ormel	*LaRC-Microwave*
D. P. J. Swart	B. Connor
GSFC-Lidar	A. Parrish
R. Farmer	J. J. Tsou
M. R. Gross	*SAGE II-Satellite*
P. Kimvilakani	P. H. Wang
T. J. McGee	J. Zawodny
U. Singh	

MLO3 NOAA, Mauna Loa, Hawaii Referee: Richard McPeters / GSFC	
JPL-Lidar	*NOAA-Sondes*
R. W. Sirko	D. Hofmann
I. S McDermid	B. Johnson
T. D. Walsh	*LaRC-Microwave*
GSFC-Lidar	B. Connor
R. Farmer	A. Parrish
M. R Gross	J. J. Tsou
P. Kimvilakani	*SAGE II-Satellite*
T. J. McGee	J. Zawodny
U. Singh	

Table **1.** Participants in the stratospheric ozone profile comparison components of the OPAL and MLO3 campaigns, and other co-authors for this paper.

OPAL: The Ozone Profiler Assessment at Lauder was carried out at the primary NDSC station located at the National Institute of Water and Atmosphere (NIWA) facility at Lauder, New Zealand (45.05°S, 169.68°E) from April 15 to 29, 1996. One of the primary goals of this campaign was to evaluate and validate the new differential absorption lidar system from RIVM [2] that was first constructed in Holland and

Day	Date	GL GSFC	MM LaRC	NZ NIWA	RL RIVM	SA SAGE
1	4/15/95	√ √	√	√	√ √	
2	4/16/95	√	√	√	√	
3	4/17/95	√ √	√	√	√ √	
4	4/18/95		√			√
5	4/19/95	√	√			√
6	4/20/95	√	√	√	√	√
7	4/21/95	√ √	√	√	√	√
8	4/22/95	√	√	√	√ √	
9	4/23/95	√	√	√	√	
10	4/24/95		√			
11	4/25/95	√		√	√	
12	4/26/95	√		√	√	
13	4/27/95		√			
14	4/28/95	√	√		√	
15	4/29/95	√	√		√	

Table 2. Measurements during OPAL. Each √ represents one profile measured.

then moved to Lauder in October 1994. The microwave ozone radiometer [3] had recently been re-installed at Lauder, following a period of intercomparison at Table Mountain, and required validation. The other instruments participating in this campaign were the mobile DIAL system from GSFC [4] and the balloon ECC sondes that were part of the ongoing program at NIWA. Additionally, there were several reasonably close overpasses of the SAGE II satellite instrument and of HALOE onboard UARS, although the latter have not yet been incorporated into the intercomparisons and neither satellite measurements are truly part of the blind dataset.

OPAL **Results:** All of the results presented in this paper are from the blind part of the campaign and the final date set for acceptance of results was the day after the last of the measurements. Any results submitted after that day become part of a revised data set that will also be intercompared but which was not carried out as a blind experiment. As an example of the results obtained during the OPAL campaign, figure 1 shows the profiles obtained by all of the instruments on day 6 (4/20) which was one of the days when all instruments had measurements. The first measurement on this night was from the SAGE II satellite which made a sunset (06:34) (Note all times are UT) measurement at a tangent point of 47.3°S, some 905-km from the Lauder site. The ECC sonde was launched at 12:28 and made measurements up to its burst altitude of 34.8-km which it reached at 14:13. The two lidars cannot be operated simultaneously due to interference of the backscattered light. The GSFC lidar operated first on this night, running from 13:10 to 14:33; the RIVM lidar then followed at 15:12 until 17:50. The microwave instrument obtained a profile from an integration through most of the night, from 13:59 to 17:55. Thus, with the exception of the SAGE II measurement all of the measurements were made very close together in time.

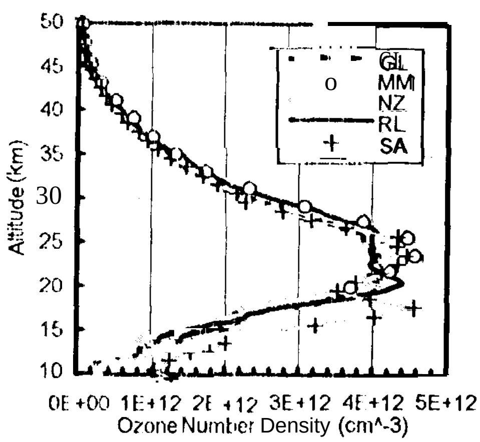

Figure 1. OPAL ozone profiles for 4/20/96.

It can simplify the analysis if the profiles measured by the different instruments can be individually compared to some reference profile. In STOIC[5], for example a reference profile was created by averaging together all the measurements made by all of the instruments during the campaign. However, for OPAL, it was decided that there were not sufficient measurements that this might not cause undue bias. A reference profile was obtained by averaging all SAGE II measurements made within 1000-km and 5° latitude of Lauder during the years 1985-1991. Figure 2 shows the difference between the average of the profiles measured by each instrument and this SAGE II climatology. It appears that below about 15-km the actual profile during the OPAL campaign was quite different to the climatological profile. However, with the exception of SAGE II, the instruments at Lauder agree very well with each other in this region. In fact, the altitude range for agreement within ±10% extends from approximately 10-km to 45-km, again with the exclusion of SAGE II. Above 45-km the lidar differences rapidly increase and this is perhaps the upper limit for the lidar profiles during this campaign. Both the RIVM lidar team and the microwave team are reprocessing their results using improved algorithms and these revised results will also be considered in the final analysis.

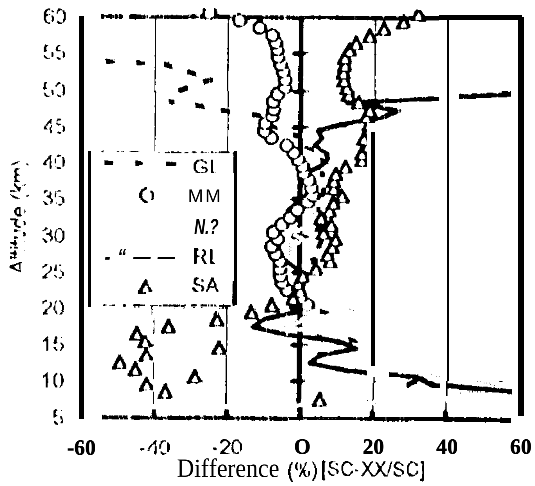

Figure 2. OPAL average differences from SAGE II climatology (Pre-Pinatubo).

MLO3: The MLO3 campaign was carried out at the NOAA Manna Loa Observatory (19.5°N, 155.6°W) primary NDSC station between August 15 and September 1, 1996. This campaign was very like OPAL, with a similar group of instruments participating. Following OPAL the GSFC mobile DIAL system was transported to MLO. The JPL lidar, LaRC microwave ozone, and ECC son-

Day	Date	GL GSFC	JL JPL	MM LaRC	NS NOAA	SA SAGE
1	8/15/95	√	√	√	√	
2	8/16/95	√	√	√	√	
3	8/17/95	√	√	√	√	
4	8/18/95	√	√	√	√	
5	8/19/95	√	√	√	√	
6	8/20/95	√	√	√	√	
7	8/21/95	√	√	√	√	
8	8/22/95	√	√	√	√	
9	8/23/95	√	√	√		
10	8/24/95	√	√	√	√	
11	8/25/95	√	√	√	√	
12	8/26/95	√	√	√	√	
13	8/27/95			√		
14	8/28/95	√	√	√	√	√
15	8/29/95	√	√	√	√	√
16	8/30/95	√	√	√	√	√
17	8/31/95	√	√	√	√	
18	9/1/95	√	√	√	√	

Table 3. Measurements during MLO3.

dcs arc all part of the ongoing NDSC measurements at Ml (). 1 xcept for some preliminary assessment at '1'able Mountain, where it was built, the JPL lidar had 1101 previously participated in any validation campaigns.

As can bc seen from table 3 all of the instruments were able 10 make a large number of measurements during MLO3. The results are summarized in figure 3 which shows the mean of all of the profiles for each instruments. In general the agreement is slightly better than was observed for OPA1. with good agreement extending to well above 50-km altitude. At the bottom of the profile the JPL lidar results started to diverge from the group and these results were clearly in error although at the top of the profile the agreement with the microwave and SAGE II results was very good even above 55-km. Following the campaign this problem was investigated and traced to an overload problem in the receiver which was subsequently corrected, Further informal intercomparisons with the same group of instruments confirm that this problem has been resolved While it is somewhat difficult to see in figure 3, above 25-km the ECC results were consistently higher than the group but below this point the agreement between the sondes GSFC lidar and SAGE II was very good.

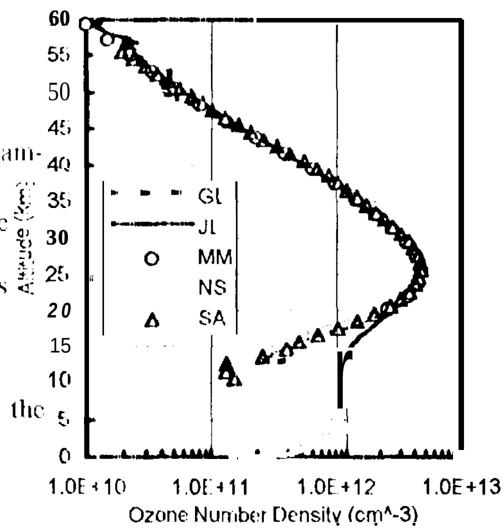

Figure 3. MLO3 mean profiles.

Acknowledgments: The work described in this paper was earl ied out, in part, at the Jet Propulsion Laboratory, California Institute of Technology, and at the Goddard Space Flight Center, under agreements with the National Aeronautics and Space Administration, We are grateful to 111 staff at the Lauder and Mauna Loa facilities for their hospitality and assistance in ensuring the success of these campaigns.

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