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OZONE PROFILE COMPARISON BETWEEN THE YORK-ISTS-AES DIAL AND SAGE II

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1 INTRODUCTION

In cooperation between York University, the Institute for Space and Terrestrial Science (ISTS) and the Atmospheric Environment Service of Canada (AES) a Differential Absorption Lidar (DIAL) has been measuring stratospheric ozone in Toronto (45° N, 80° W) since 1991 [1]. An almost identical system is operational since February 1993 at the NDSC Arctic-station in Eureka (80° N, 86° W). Here we report the comparison of DIAL ozone profiles taken in 1991 and 1992 in Toronto with SAGE II measurements [2]. Over most of the measurement range excellent agreement better than 5 % was found and presently no systematic bias between the two instruments can be resolved.

2 DATA SELECTION

SAGE II ozone profiles have participated in several comparisons (e.g. [3]), also with DIAL systems (e.g. [4]). The vertical resolution is about 3 km with typically 7 % accuracy. This is comparable to the range resolution of 1 to 5 km and accuracy of 1 to 10 % for the Toronto DIAL system. In other respects the two methods differ. Whereas the lidar takes a measurement at a fixed location over a whole night, SAGE II measures the ozone over a long horizontal path during sunset or sunrise. The tangent point of the SAGE II measurement almost never coincides with the lidar measurement. Figure 1 shows a typical situation.

For this comparison only SAGE II profiles taken within 1000 km of Toronto and within a few days of the DIAL measurements were selected [2]. In most cases the chosen SAGE II measurements bracket the DIAL measurement both in time and in latitude. This is desireable to reduce possible bias, because the ozone profile changes systematically with latitude (and also over time).

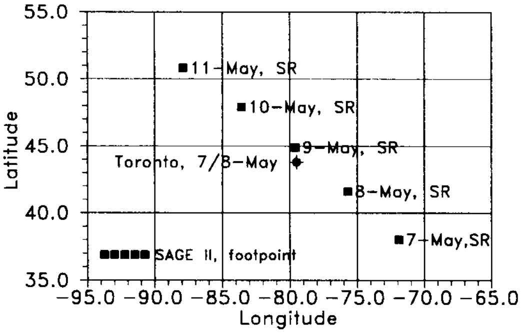

Figure 1: Tangent points of SAGE II measurements (squares) at sunrise for days before and after a lidar measurement (diamond) in May 1992.

3 SINGLE PROFILE COMPARISON

As an example Figure 2 shows a DIAL ozone profile (solid line) along with selected SAGE II profiles (symbols). Up to about 45 km the results look almost identical, only above that altitude a clear difference between the DIAL and SAGE II data can be seen. However, this difference is not surprising because above 45 km the uncertainty in the DIAL data (dashed line) be-

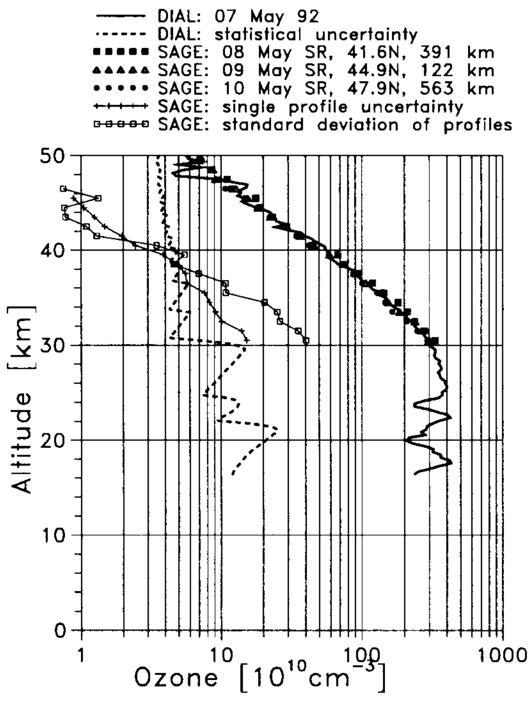

Figure 2: Comparison between one DIAL and three SAGE II ozone profiles in May 1992. The single profile uncertainties are shown for DIAL and SAGE II, for SAGE II the standard deviation of the profiles is given as well. Due to the presence of Pinatubo aerosol SAGE II data are not available below 30 km and the DIAL data are contaminated below 25 km.

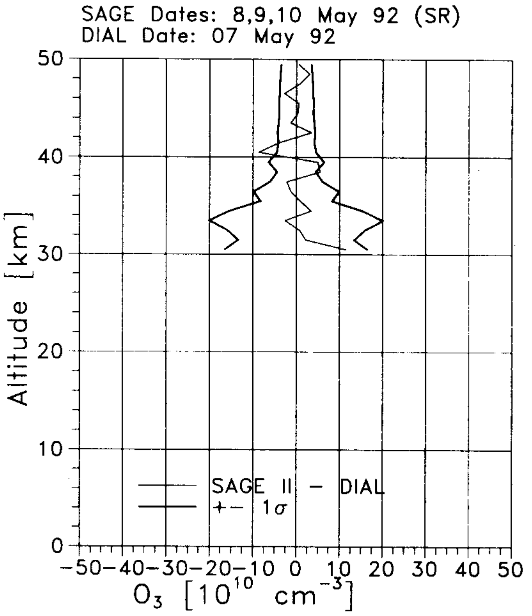

Figure 3: Absolute difference between DIAL and average SAGE II profile from Figure 2 (thin line). The ±1σ uncertainty margins due to natural variation and measurement uncertainty are shown as well (thick line).

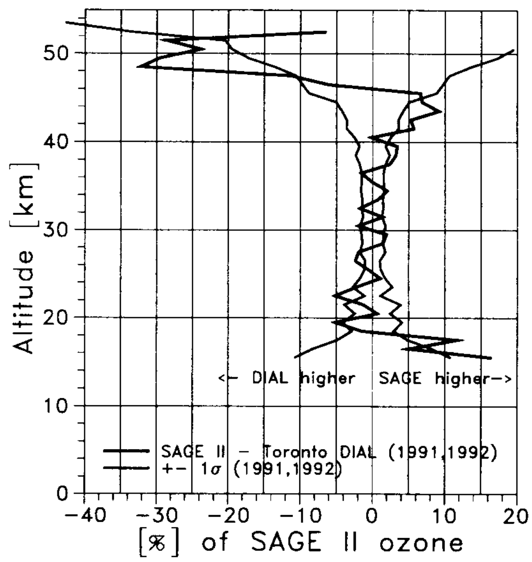

Figure 4: Relative difference between 41 DIAL and 88 SAGE II profiles (above 30 km) measured around Toronto in 1991 and 1992. Below 30 km only 9 DIAL and 20 SAGE II profiles in 1991 have been included, because of interference from Pinatubo aerosol. The thick line shows the relative difference of the arithmetic means, the two thin lines show the ±1σ standard deviation of the mean.

comes quite large.

The comparison between the DIAL and SAGE II data is complicated by the natural variation of ozone, since the two instruments are not measuring the same airmass. Below about 35 km the natural variation usually exceeds the single profile uncertainty. For comparison with a single DIAL measurement we therefore used the average SAGE II profile, with the standard deviation as an estimate for the natural variation.

Figure 3 shows the absolute difference between the DIAL profile and the average of the three SAGE II profiles from Figure 2 (thin line). The 1 σ uncertainty margins of the difference are indicated by the thick line. They were derived from the natural variability of the ozone (= standard deviation of the SAGE II profiles) and the DIAL single profile uncertainty . Almost nowhere are the 1 σ margins exceeded and so SAGE II and the DIAL agree within the natural limitations of the comparison. This is true for most of the comparisons in 1991 and 1992.

4 COMPARISON OF LONG TERM MEANS

Small but systematic differences between the instruments cannot be resolved by a single comparison, because they do not probe the atmosphere at the same time and place. By averaging over many cases, however, the natural variability will be reduced and even small biases between the instruments should become apparent. Figure 4 shows the average difference (arithmetic mean) between the comparable DIAL and SAGE II measurements in 1991 and 1992. Excellent agreement is found. Between 20 and 42 km differences are less than 5 %, for most altitudes even less than 3 %. They lie within the ±1σ uncertainty margin and no systematic bias can be resolved. Only above 47 km deviations significantly larger than 10 % are found. However, there the lidar reaches its upper measurement limit and the statistical uncertainty becomes large.

The agreement found between the Toronto DIAL and SAGE II is among the best reported, proving the quality of the Toronto DIAL data. It also shows that SAGE II can be very helpful in the validation of new DIAL systems, e.g. in the context of the NDSC.

References

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