

Statistical Comparisons of Odin/OSIRIS Limb-Measured

Stratospheric Ozone Profiles with Satellite and Ozoneprobe Data

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Abstract. OSIRIS stratospheric ozone profiles (version 012) are statistically compared on a monthly basis with coincident POAM III, ozoneprobe and SAGE II profiles. Most of the time, the difference between monthly averaged OSIRIS ozone profiles and those measured by other instruments was within 7%-10% in the altitude range of 15 km – 40 km. However, during April – July 2002, November – December, 2002, February – May, 2003, and July 2003 periods, OSIRIS profiles appeared shifted downward by ~1 km introducing a difference of about 30% below 15 km and above 40 km.

Introduction

Odin was launched on February 20, 2001 into a polar, sun-synchronous orbit with the ascending node at 18:00 local time. A detailed description of the Odin mission has been given by *Murtagh et al.*, [2002] and *Llewellyn et al.*, [2003]. The Optical Spectrograph and Infrared Imager System (OSIRIS) scans the Earth's limb and measures scattered sunlight over the wavelength range 280 nm to 800 nm with ~1 nm spectral resolution. It has a field of view of 1.288 arc minutes in the vertical direction, equivalent to ~1 km of height at the tangent point. OSIRIS normally collects a spectral image approximately once every 2.5 seconds. The duration of each scan ranges from 70 to 130 seconds; that corresponds to the horizontal resolution of ~500 km to ~1000 km along the satellite track.

Ozone number density profiles are retrieved from the OSIRIS limb radiance spectra in the Chappuis absorption band between 10 km and 50 km on a 2 km grid using the inversion technique originally developed by *Flittner et al.* [2000] and *McPeters et al.* [2000] for the SOLSE/LORE experiment and adapted to OSIRIS by *von Savigny et al.* [2003].

OSIRIS – POAM III comparisons

OSIRIS stratospheric ozone profiles were compared on a monthly basis with coincident POAM III profiles for the time period between November 1, 2001 and September 30, 2003. The following coincidence criteria were chosen: 5 hours or less in Universal Time; 5° or less in latitude; 10° or less in longitude. The total number of monthly coincidences varied from 21 in September, 2002 to 304 in March, 2003, with the average number being around 100. Two examples of OSIRIS and POAM III monthly mean ozone profiles are shown in Figure 1 for May, 2003 (a) and September, 2003 (b). The total number of monthly coincidences in these examples was 66 and 68 respectively. The error bars indicate the standard deviation of the

fractional difference multiplied by the mean OSIRIS ozone profile at that height.

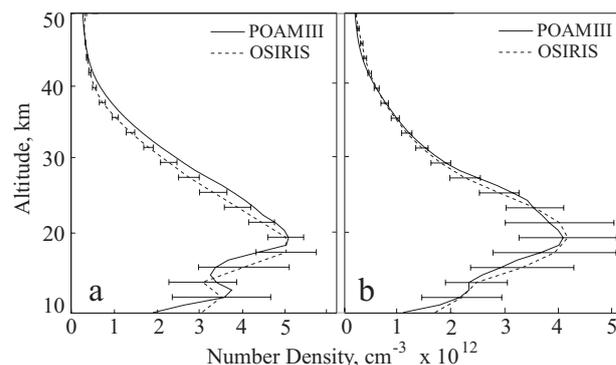


Figure 1. OSIRIS and POAM III monthly averaged coincident profiles for May, 2003 (a) and September, 2003 (b)

The overall difference between the two instruments in the altitude region of 15 km to 40 km was within 7% - 10%. However, as can be seen in Figure 1a, in May, 2003 there is a difference between the two data sets that shows as an apparent vertical shift of up to 1 km between the profiles. The same result was observed during April – July, 2002, November – December, 2002, February – May, 2003 and July, 2003 periods. However, many of the individual comparisons during these periods show no vertical shift.

OSIRIS – SAGE II comparisons

Each month, SAGE II and OSIRIS measure the same latitudinal region only during 2-4 days, and they do not have as many coincidences as POAM III and OSIRIS. Therefore, we compared zonally averaged SAGE II and OSIRIS ozone profiles that were measured during the same time period (usually 1-2 days) over separate latitude bands of 10° each. Two examples of OSIRIS and SAGE II zonally averaged ozone profiles are shown in Figure 2 for January, 2002 (a) and May, 2002 (b). The latitude bands are 40°S-50°S and 50°N-60°N respectively. The number of OSIRIS and SAGE II profiles in January, 2002 was 42 and 44 respectively, and in May, 2002 – 33 and 48 respectively. OSIRIS and SAGE II zonally averaged profiles were compared for the period of November, 2001 – July, 2002. As with the OSIRIS – POAM III comparisons, OSIRIS – SAGE II profiles generally agreed to within the difference of 5%-10%, and as in the previous case the OSIRIS profiles appeared to be shifted about 1 km down in altitude during April – July, 2002 period.

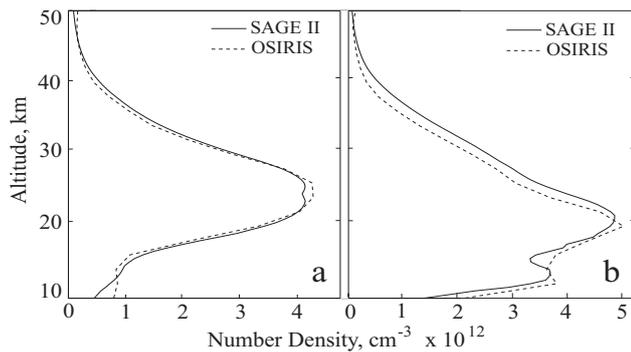


Figure 2. OSIRIS and SAGE II zonally averaged ozone profiles for January, 2002 (a) and May, 2002 (b)

OSIRIS – ozonesonde comparisons

OSIRIS ozone profiles were compared with coincident ozonesonde measurements for the one year period between November 2001 and October 2002. Since ozonesonde stations typically measure ozone profiles once a day or less, we broadened the time range in our coincidence criteria: ≤ 20 hours in UT, $\leq 5^\circ$ in latitude and $\leq 10^\circ$ in longitude. Ozonesonde data were obtained from the World Ozone and Ultraviolet Radiation Data Center (WOUDC). The number of coincidences varied from 5 in November, 2001 to 39 in March, 2002. Table 1 presents names and coordinates of ozonesonde stations, and the total number of coincidences with each station.

Table 1. Names and coordinates of ozonesonde stations, and the total number of coincidences with each station

Ozonesonde Station	Coordinates		Number of coincidence <i>s</i>
	Lat., °N	Lon., °E	
Alert	82.5	-62.3	2
DeBilt	52.1	5.2	9
Eureka	80.0	-85.9	3
Goose Bay	53.3	-60.3	1
Huntsville	35.3	-86.6	1
Irene	-25.9	28.2	3
Isfarhan	32.5	51.7	1
Kagoshima	31.6	130.6	15
Lauder	-45.0	169.7	22
Naha	26.2	127.7	14
Newmayer	-70.7	-8.3	10
Payerne	46.5	6.6	46
Praha	50.0	14.5	18
Santa Cruz	28.5	-16.3	16
Sapporo	43.1	141.3	13
Stonyplain	53.6	-114.1	1
Syowa	-69.0	39.6	12
Tateno	36.1	140.1	18

Examples of the OSIRIS – ozonesonde monthly averaged coincident profiles are shown in Figure 3 for May, 2002 (a) and October, 2002 (b). The error bars indicate the standard deviation of the fractional difference multiplied by the mean OSIRIS ozone profile at that height. Overall, OSIRIS – ozonesonde monthly averaged profiles agree within a difference of 5%-7%, except for the April – July, 2002 period when they had an apparent downward shift of $\sim 0.5 - 1$ km.

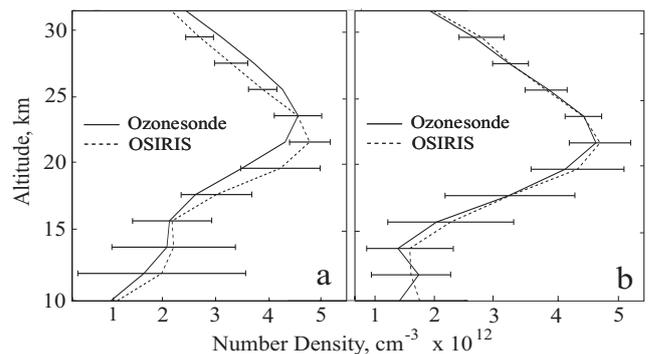


Figure 3. OSIRIS – ozonesonde monthly averaged coincident profiles for May, 2002 (a) and October, 2002 (b)

Conclusion

OSIRIS stratospheric ozone profiles are statistically compared with the coincident POAM III and ozonesonde profiles and also with all SAGE II profiles measured at the same time in the same latitude regions. All comparisons start at the beginning of November, 2001 and end at different times: comparisons with SAGE II goes until the end of July, 2002; with ozonesondes – until the end of October, 2002, and with POAM III – until the end of September, 2003. The agreement between all instruments in the altitude range of 15 km – 40 km is within 7%-10% except for the April – July, 2002, November – December, 2002, February – May, 2003 and July, 2003 periods, when there is an apparent downward shift of up to 1 km. This shift increases the difference between the instruments of about 30% below 15 km and above 40 km. The reason for the apparent altitude offset has not yet been found, but could be due to attitude registration issues or because of systematic errors within the current operational inversion algorithm.

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References

- Flittner, D.E., P.K. Bhartia, and B.M. Herman, O₃ profiles retrieved from limb scatter measurements: Theory, *Geophys. Res. Lett.*, 27, 2601-2604, 2000.
- Llewellyn, E.J., et al., First Results from the OSIRIS Instrument on-board Odin, *Sodankylä Geophysical Observatory Publications*, 92, 41-47, 2003.
- McPeters, R.D., et al., The Retrieval of O₃ profiles from Limb Scatter Measurements: Results from the Shuttle Ozone Limb Sounding Experiment, *Geophys. Res. Lett.*, 27, 2597-2600, 2000.
- Murtagh, D.P., et al., An Overview of the Odin Atmospheric Mission, *Can. J. Phys.*, 80, 309-319, 2002.
- von Savigny, C., et al., Stratospheric Ozone Profiles Retrieved from Limb Scattered Sunlight Radiance Spectra Measured by the OSIRIS Instrument on the Odin Satellite, *Geophys. Res. Lett.*, 30, 1755-1758, doi:10.1029/2002GL016401, 2003.