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THE VALIDATION OF OZONE MEASUREMENTS FROM THE IMPROVED STRATOSPHERIC AND MESOSPHERIC SOUNDER

Brian J. Connor
NASA Langley Research Center
Hampton, Va. 23681

Christopher J. Scheuer
Science and Technology Corporation
Hampton, Va. 23666

D.A. Chu
G & A Technical Software, Inc.
Hampton, Va. 23666

John J. Remedios, C.J. Marks, Clive D. Rodgers, and Fred W. Taylor
Oxford University
Oxford, England U.K. OXI 3PU

Abstract

We present preliminary results of the validation of ozone measurements from the Improved Stratospheric and Mesospheric Sounder (ISAMS). The indications are that the ISAMS provides ozone data which generally agrees with other experiments and climatological values, except in regions of large thermal gradients or high aerosol loading. Corrections for these effects will be included in future reprocessing of the data.

Introduction

The ISAMS is an infrared emission limb-scanner with both wideband and pressure-modulated radiometer channels between 4 and 16 μm. The measurement objectives for the ISAMS are temperature, CO, H_2O, N_2O, HNO_3, O_3, NO, NO_2, CH_4, N_2O_5, and aerosol. The ozone profiles will be used first to monitor the global ozone distribution between 20-60 km, and second to model ozone radiance in the other channels. After a brief description of the measurement, we present typical *early* results in the form of retrieved ozone cross sections, comparisons of ISAMS profiles measured at the same location at different times of the day, and comparisons with several other experiments. Finally, we make provisional estimates of the error in the ISAMS retrievals, and assess known problems with the data and prospects for its improvement. It should be stressed that all results are preliminary; substantial improvements can be expected after reprocessing of the data. All data presented here were produced by version 3.30 of the operational software, except as noted.

Measurement Description

The ISAMS ozone radiance measurement is provided by a wideband radiometer operating between 990-1010 cm^{-1}. The ozone measurement shares sampling time with temperature and HNO_3 measurements via a programa-ble rotating filter wheel. Approximately 25% of the filter wheel duty cycle is dedicated to ozone. A complete radiance profile (15-90 km) is made once per minute. The vertical resolution of the retrieval is approximately 2.5 km. Figure 1 shows the weighting function matrix for the ISAMS ozone radiance channel. The weighting function matrix gives a broad measure of the information content for a set of measurements.

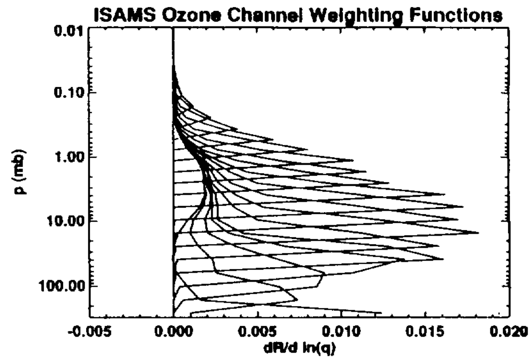

Fig. 1. Weighting functions for the measurement. Each function represents the contribution of ozone at all altitudes to the radiance at a single tangent point.

The ozone measurement is relatively free of interference from other molecular species, although it does include excited vibrational states. Volcanic aerosols from the Mt. Pinatubo eruption have severely impacted the ISAMS (and other UARS) ozone results. The ISAMS has a 12.1 μm atmosphere window channel specifically to help correct for this. The aerosol contamination has thus far constrained the bottom retrieval level to 10 mb (approx. 30 km). Progress on characterizing the aerosol extinction has been made (Lambert et al., these proceedings) and further improvements are expected. For now though, aerosol contamination is not included in the retrieval. When an adequate characterization of the aerosol extinction is derived it will be added to the software. We then hope to lower the bottom retrieval height limit to 100 mb.

Ozone Retrievals

The top of Figure 2 shows the zonal mean ozone values from 10.0 to 0.4 mb. The overall pattern is as expected and the values are reasonable. The bottom of Figure 2 depicts the scatter about the zonal mean. Values are generally between 8-15%, with higher values in the polar stratosphere. It is thought that the high polar stratosphere scatter may be due to strong temperature gradients near the edge of the polar vortex. Future versions of the software will correctly handle these gradients. Figure 3 shows the formal error estimate from the retrieval algorithm. These values are comparable to the standard deviation about the zonal mean. If the formal error estimate is realistic, this implies that the scatter about the zonal mean is primarily measurement error rather than real geophysical variation.

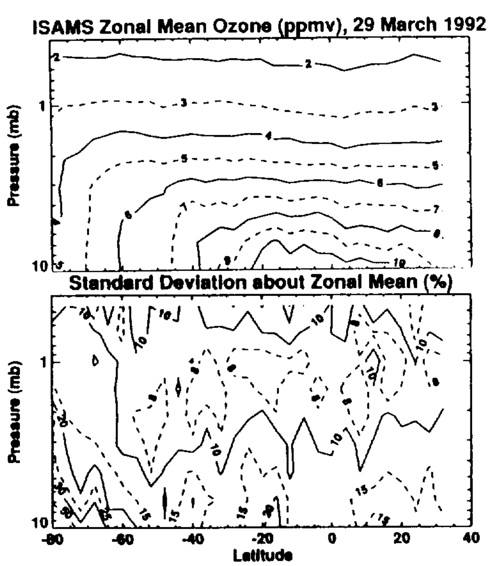

Fig. 2. Top: Zonal mean of ozone retrieved from individual radiance profiles.
Bottom: Scatter of the retrieved ozone about its mean.

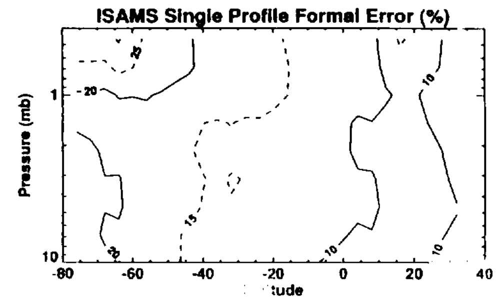

Fig. 3. Formal standard deviation of the retrieval.

Ascending and Descending Profile Comparisons

Comparisons between ascending and descending node profiles of ozone were made to provide an estimate of the internal consistency of the measurements. A dozen nearly coincident pairs of ascending/descending profiles were selected from the March 29, 1992
The ascending profiles were all daytime and the descending profiles nightime, allowing the opportunity to look for any diurnal variations. The top of Figure 4 shows the mean ascending and descending profiles. The bottom of Figure 4 shows the mean difference and standard deviation about the mean difference for the 12 pairs. No significant mean difference is evident and the scatter is approximately 10-20%. No diurnal variation is evident although a factor of 2 between night and day is expected at 60km. This is qualitatively consistent with the occurrence of non-LTE radiance during the day, an effect not yet included in the operational software.

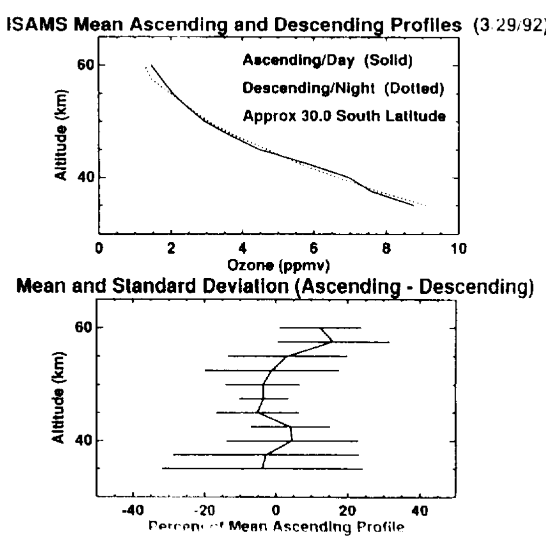

Fig. 4. Top: Mean of profiles measured on ascending and descending nodes of the orbit in coincident pairs.
Bottom: Difference (%) of the mean profiles and the standard deviation of the pairwise difference.

Comparisons With Other Experiments

The ISAMS ozone was compared against a number of other results. The top of Figure 5 shows the difference between zonal means for ISAMS and the 1979 measurements from the Limb Infrared Monitor of the Stratosphere (LIMS) (Gille and Russell, 1984). The agreement is approximately 10-20% with the LIMS accuracy estimated at 10-15%. The bottom of Figure 5 shows a similar comparison between the ISAMS and the Microwave Limb Sounder (MLS). The MLS measurements are from the the 205 GHz channel and the results are preliminary (J. Waters, private comm. 1992). Typically ISAMS and MLS agree within 10% except in the polar regions where differences exceed 30%. Note the similarity of the ISAMS/LIMS and ISAMS/MLS comparisons. Figure 6 shows the rms of the difference between individual ISAMS and MLS profiles. Values are generally 10-15% with higher values found in the polar stratosphere and above 0.7mb. Figure 7 shows a 12 hour time series of ozone at 10mb. The measurements are highly correlated, tracking each other well through ozone variations of greater than a factor of 2, however the ISAMS exhibits greater scatter and some unrealistically high values.

Figure 8 shows comparisons with HALOE (J.M. Russell III, private comm. 1992) and Figure 9 shows comparisons with ground-based lidar (Mc Dermid et al., 1990) and microwave measurements (Parrish et al., 1992). These look generally reasonable, but extended series of comparisons will be necessary before quantitative conclusions can be drawn. Comparisons with CLAES and SAGE II are also needed.

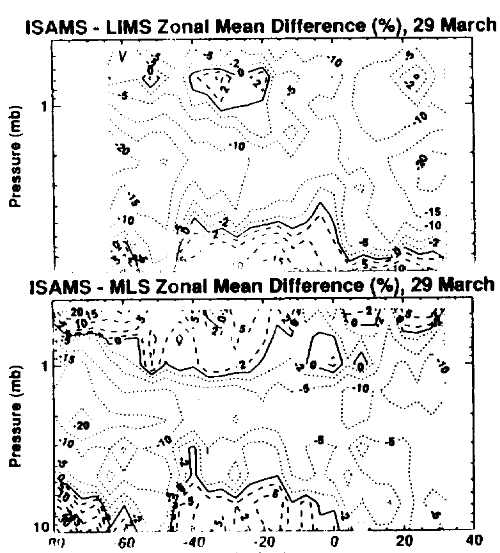

Fig. 5. Top: Difference (%) of the ISAMS and LIMS zonal means for 29 March. (LIMS measurements from 1979, ISAMS from 1992.)
Bottom: As above, but for ISAMS and MLS.

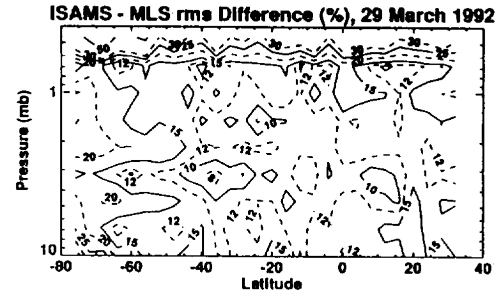

Fig. 6. Rms difference (%) of coincident pairs of ISAMS and MLS observations.

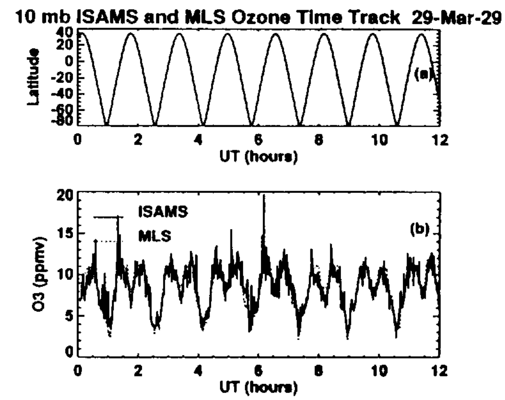

Fig. 7. Top: Tangent point latitude vs. time. Bottom: ISAMS and MLS ozone at 10 mb vs. time.

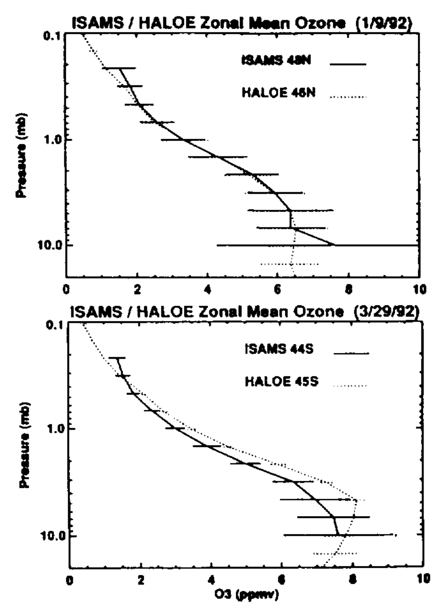

Fig. 8. Top: ISAMS and HALOE zonal mean profiles for 9 Jan. near 47deg N. The latitude is dictated by the HALOE occultation geometry. Horizontal bars show the standard deviation of individual profiles. Bottom: As above, for 29 March near 45degS.

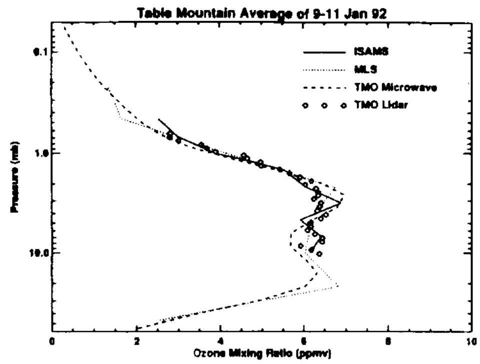

Fig. 9. Average ozone profiles measured by four instruments near Table Mountain, California (34degN, 118degW) during 9-11 Jan. 1992.

Error Estimates

For single profiles, the formal error estimates from the operational algorithm are broadly consistent with both the internal consistency checks and comparisons to other experiments. In particular, note the similarity between the combined ISAMS and MLS single profile formal errors (Top of Fig. 10) and their rms differences (Fig. 6). Thus we provisionally adopt the formal error estimates for single profiles, e.g. Fig. 3.

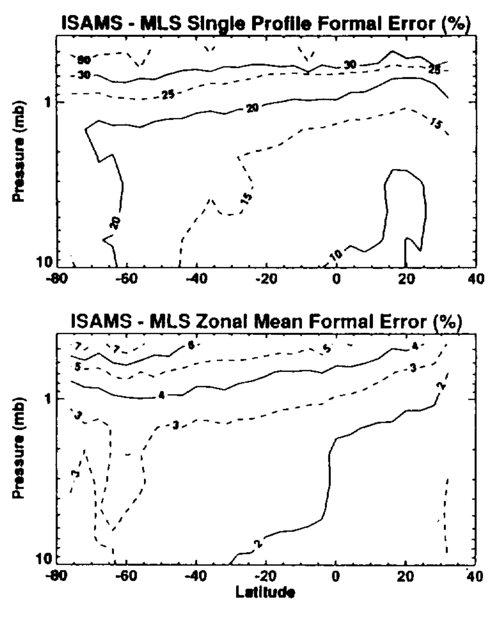

Fig. 10. Top: Error expected in comparing single ISAMS and MLS profiles, based on uncertainties derived by the operational algorithms.
Bottom: Error expected in comparing zonal mean profiles, assuming the single profile errors are random.

For zonal means however, the difference of ISAMS from LIMS and MLS is much larger than would be expected if the single profile errors were random (Bottom of Figure 10 shows the expected zonal mean differences from MLS). Furthermore, the similarity of the comparisons to MLS and LIMS suggests a systematic bias in the ISAMS zonal means of typically 10% or less, but larger in some regions, particularly the polar mid-stratosphere.

Problems and Future Prospects

The ozone retrieval is very sensitive to temperature. At 30 km the effect is about 5.5%/degree. Line-of-sight (LOS) temperature gradients have been found to be important and at times extreme, especially near the poles. Including LOS gradients in the temperature retrieval eliminates many unrealistic ozone values and improves the comparison with other measurements, especially in the polar mid-stratosphere. Gradients in ozone along the LOS may also be important. This is currently under investigation. Aerosol contamination in the temperature and ozone channels has been found to be especially important below 10mb and higher still in the tropics. It may be responsible for the bias with respect to MLS observed in the tropics. Attempts to correct for the contamination have not yet yielded a satisfactory result. Scatter in the data is higher than expected based on radiance signal-to-noise. This is also being investigated. Errors due to elevation-dependent stray light have been noted and corrections are being developed. Finally, calibration errors in the sun-side view are being studied.

Acknowledgements

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