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OZONE MEASURING CAPABILITY OF GROUND-BASED, MILLIMETER WAVE SPECTROSCOPY

Millimeter wave spectroscopy of the rotational transitions of ozone is a powerful technique for measuring the stratospheric ozone distribution. This technique has the following characteristics:

1) The altitudes near 40 km where ozone depletion is first expected to manifest itself are those at which the technique works best. The altitude coverage of the technique is from approximately 23 to 67 km.

2) The calibration standards used in this technique are black body sources at known temperatures. These can be made to be highly reproducable as temperature is an easily maintained standard.

3) The millimeter wave data are not affected by the stratospheric aerosols which can make the results from scattered ultraviolet techniques such as Dobson/UMKEHR uncertain.

4) Millimeter wave emission observations can be carried out at any time of the day or night. This can, for example, facilitate intercomparison of the data with data from a satellite passing over the observing site.

5) The millimeter wave observations can be carried out at a sufficient variety of sites that full latitude coverage can be obtained.

6) The ozone altitude distribution is obtained from the spectral line profile by an inversion procedure that makes use of the pressure broadened nature of the spectral line. The pressure broadening coefficient has been well measured in the laboratory.

7) The instrument can be readily operated by a technician at a field location.

The power of the technique is best suggested by its application by the research group at the State University of New York to measurements of stratospheric trace constituents such as ClO and HO_2. These constituents produce spectral lines that are two orders of magnitude weaker than typical ozone lines. (See, for example, Parrish, et. al. Science, 211, 1158, 1981; deZafra, et. al., J. Geophys. Res., 89, 1321, 1984; and Solomon et. al., Science, 224, 1210, 1984.)

At Millitech, we have carried out an analysis of the millimeter wave ozone measurement technique and particularly the problem of recovering the altitude distribution from the spectral line profile. The results of this analysis are that the following specifications for stratospheric ozone measurements should be achievable using current millimeter wave technology:

Achievable Specifications for Measurements of Stratospheric Ozone

Time Requirement for Individual Observation:	20^{m} (for, e.g., line at 110.835 GHz.)[1]
Altitude Coverage	23 to 67 km.
Error in Determination of Altitude of Mixing Ratio Maximum:[2]	2 km.
Altitude Resolution: Full Width at Half Maximum if Hypothetical Stratosphere was Single Thin Layer	5 km.
Formal Altitude Resolution (Resolution of Two Thin Layers):[3]	8 km.
Measurement Precision:[4]	2%
Overall Absolute Calibration Accuracy	4%

Notes: 1) For a site with 2 mm precipitable water vapor.

2) For a typical ozone distribution similar to that in the U. S. Standard Atmosphere.

3) Defined as the minimum spacing between two infinitesimally thick layers of ozone for which the recovered altitude distribution will distinguish the presence of the two individual layers. This result is for a hypothetical distribution having these two layers only.

4) For an individual 20 minute observation with 5 km altitude bins.

The statistics developed by Frederick (Proceedings of the Ozone Correlative Measurements Workshop, Greenbelt, MD, 1983, NASA Conference Publication #2362) indicate that the 2% precision quoted above is more than adequate to detect an ozone trend of -0.1% per year if 200 measurements are made per year over a ten year span.

The resolution capabilities quoted above are set by the weighting functions for the ground based geometry. The resolution is adequate for direct intercomparison with the data from most other remote sensing techniques such as SBUV or for comparison with the results of theoretical models.

Millimeter wave spectroscopy is thus seen to be a feasible technique for detecting small trends in stratospheric ozone and is also one that is not affected by the calibration uncertainities that affect the scattered ultraviolet techniques that have been historically relied upon to obtain global ozone data.

Submitted by:
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