N92-14507

A. Ground-Based Lidar Measurements of Stratospheric Ozone
The NASA/GSFC Stratospheric Ozone Lidar Trailer Experiment
"STROZ LITE"

RTOP #: 147-13-17-20

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C. Abstract of Research Objectives

The major research objective is the measurement of high precision vertical profiles of ozone between 20-40 kilometers. The precision is such that the instrument should be capable of detecting a small trend (on the order of less 1%/yr.) over a 5-10 year period. A measurement of temperature is also made between 30 and 365 km.

D. Summary

In fiscal 89 two ozone intercomparison campaigns were carried out, both at JPL's Table Mountain Facility in the San Gabriel Mountain just east of Los Angeles, California. In October-November 1988 the GSFC mobile lidar was installed at Table Mountain and a comparison between it and the permanent JPL lidar was made over the course of about 3 weeks. In addition ECC and ROCOZ sondes were launched from Pt. Mugu (about 100 miles from Table Mountain), and these were also a number of SAGE II overflights during the intercomparison. The major result was that the two lidars agreed very well between 20 and 40 km and under certain conditions up to 45-47 km. There were several anomalies noted during the course of the intercomparison which were followed very well by the two lidar. Agreement with the ROCOZ and ECC sondes was also very good however there were several instances showing differences which appear to be due to the spatial and temporal separation of the sondes and the lidars.

In July 1989, a much more formal intercomparison was held at Table Mountain. Again the Stroz Lite instrument was deployed at the Facility along with the JPL lidar. ECC sondes were launched at Table Mountain at the same times that the lidars were taking data. A microwave instrument, a Brewer instrument and a Dobson operated in the Umkehr mode were all in operation during the intercomparison, and were all located at Table Mountain. Additionally ROCOZ sondes were launched from San Nicholas Island (about 150 miles west of Table Mountain) and SAGE II had four overpasses. A preliminary look at the data indicates excellent agreement among the instruments. The GSFC instrument appears to have made excellent measurements between 20 and 42 km.

E. Publications

1. "STROZ Lite: NASA Goddards Stratospheric Ozone Lidar Trailer Experiment," T. J. McGee, R. Ferrare, J. J. Butler, P. Newman, D. Whiteman and J. Burris, NASA Technical Memorandum in Press 1989.

2. "Lidar Observations of Ozone Changes Induced by Sub-Polar Airmass Motion over Table Mountain (34.4°N)," T. J. McGee, R. Ferrare, J. Butler, P. Newman, D. Whiteman, J. Burris, S. Godin and I. S. McDermid, submitted to JGR, 1989.

3. "Measurement Intercomparison of the JPL and GSFC Stratospheric Ozone Lidar Systems," I. S. McDermid, S. M. Godin, L. O. Lindquist, T. D. Walsh, J. Burris, J. Butler, R. Ferrare, D. Whiteman and T. J. McGee, submitted to Applied Optics, 1989.

4. "A Mobile, Differential Absorption Lidar for the Measurement of Stratospheric Ozone and Temperature," T. J. McGee, D. Whiteman, R. Ferrare, J. Butler and J. Burris, submitted to JGR, 1989.

5. "A Lidar Measurement of Ozone in the Presence of a High Loading of Aerosol from the Launch of a Titan 34-D Rocket," T. J. McGee, R. Ferrare, J. Butler, J. Burris and D. Whiteman, submitted to GRL.

Biennial Report on
A MILLIMETER WAVE SYSTEM FOR REMOTE SENSING OF OZONE

Contract NAS5-30104
Jointly Funded by NSF Grant #ISI-8501016

Dr. Alan Parrish, Millitech Corp, Principal Investigator

Objective

The purpose of this work is to develop a millimeter wave spectroscopic instrument for the measurment of ozone in the middle and upper statosphere. The instrument observes the pressure-broadened spectral lines produced by rotational transitions of stratospheric ozone at 109.559 and 110.836 GHz, and is intended for use in the Network for Early Detection of Stratospheric Change.

Summary

A prototype version of the instrument was put into operation at the Millitech Corporation facility at South Deerfield, Massachussetts, in January, 1989. The next six months were devoted to tests and modifications as needed to prepare a completed instrument for delivery in June of 1989. The instrument was delivered to and is in operation at the Table Mountain Observatory of the Jet Propulsion Laboratory in Wrightwood, California. The instrument participated in the NASA-sponsored Stratospheric Ozone Intercomparison Campaign at Table Mountain from July 19-August 3, 1989.

A collaboration was arranged with Dr. Brian J. Connor of the NASA Langley Research Center for a scientific program using the instrument. Work being done under the resulting grant is described separately in this volume.

Jointly with Dr. Connor, collaborations were arranged with Dr. William J. Wilson of JPL, and Dr. I Stuart McDermid of JPL Table Mountain Observatory to develop procedures for operation and maintainance of the instrument, and analysis of its data. Dr. Wilson's group is responsible for the operation and maintainance of the instrument, with day-to-day on site assistance from Dr. McDermid's group. Data analysis will primarily be performed at NASA Langley Research Center by Drs. Connor and Parrish. This arrangement is intended to serve as a model of a network having additional similar instruments at several field locations with data processed at Langley.

Publications

There were no publications from this task during this period. Preparation of publications regarding the instrument and data from the intercomparison campaign will begin shortly.

RESEARCH SUMMARY FOR

NASA UPPER ATMOSPHERE RESEARCH PROGRAM

1 SEPTEMBER 1989

A. TITLE: Microwave Measurements of Mesospheric Water Vapor

B. INVESTIGATORS/INSTITUTIONS: Dr. Charles L. Croskey
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C. ABSTRACT OF RESEARCH OBJECTIVES:

This research program is focused within three task areas, as follows. The first is to continue a series of ground-based microwave observations of water vapor in the mesosphere from Penn State. This unique data set spans five years and Penn State's is the only dedicated observatory of its kind. The second task is to continue the data analysis and interpretation for a great deal of this water vapor data in archive. The third task is to develop a second, more transportable microwave radiometer which can observe water vapor in the mid- and upper stratosphere as well as in the mesosphere. This second system would be used to obtain observations at other sites, especially different latitudes. It will collaborate in the NASA Network for the Detection of Stratospheric Change. Both radiometers will be used in correlative studies for the NASA Upper Atmospheric Research Satellite (UARS).

D. SUMMARY OF PROGRESS AND RESULTS:

1. The Penn State water vapor observatory has been in operation most of 1988 and 1989 (to date). In 1988, we made observations throughout late summer and early fall for the first time.

2. Most of the water vapor observations from 1984 - 1987 have been analyzed and the results have been presented in AGU meetings; they are being published, see section E. Analysis of these measurements has been addressed to questions of the roles of advective and diffusive transport in minor constituent vertical profiles, as well as the seasonal structure of H_2O. Observations from 1988 and early 1989 have undergone preliminary analysis.

3. The design of the second water vapor radiometer (cooled FET - solid state) is nearly complete and procurement of components is well along.

E. JOURNAL PUBLICATIONS:

1. "Mesospheric Water Vapor Measurements from Penn State: Monthly Mean Observations (1984 - 1987), Richard M. Bevilacqua, John J. Olivero, and Charles L. Croskey, Journal of Geophysical Research, in press, 1989.

2. "The Seasonal Variation of Water Vapor and Ozone in the Upper Mesosphere: Implications for Vertical Transport and Ozone Photochemistry", Richard M. Bevilacqua, Darrell F. Strobel, Michael E. Summers, John J. Olivero, and Mark Allen, Journal of Geophysical Research, accepted for publication, 1989.

BIENNIAL RESEARCH SUMMARY

A. TITLE: Ground-based Monitoring of Water in the Earth's Middle Atmosphere

B. INVESTIGATORS: P. R. Schwartz, R. M. Bevilacqua, and T. A. Pauls
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C. ABSTRACT OF RESEARCH OBJECTIVES:

Water vapor is the primary source of OH and other hydrogen compounds which are important in ozone photochemistry. It is also extremely infrared active and plays a central role in establishing middle atmosphere radiative balance. Finally, under some conditions, it is an excellent tracer of atmospheric motions and may be used to test multi-dimensional models. We have constructed, tested and will soon place in operation a 22 GHz ground-based radiometer for continuous measurements of water vapor in the stratosphere and mesosphere. This instrument has three unique features:

(1) it utilizes an all solid-state receiver based upon a high electron mobility FET (HEMT) amplifier,

(2) its multi-filter spectrometer is a modified version of the system designed for the Microwave Atmospheric Sounder and is thus rugged and ultra-stable, and

(3) it was designed for nearly automatic operation.

The design and construction of the instrument is based upon almost a decade of experience in middle atmosphere radio spectroscopy and utilizes tested and validated retrieval algorithms and techniques. This system will allow, for the first time, measurement of water vapor profile at altitudes of 20-70 km from the ground. An experimental program will be conducted with this instrument to test its performance as a remote system with the ultimate goal of using it as a part of a suite of ground-based middle atmosphere monitors.

D. SUMMARY OF PROGRESS AND RESULTS

This program started in June 1987 and progress during the first year was confined confined to design, engineering and procurement of the hardware. The following is a chronological summary of progress during 1988-9.

The multi-filter spectrometer filter electronics modules were completed in April 1988. These were a 10 x 40 MHz and 20 x 2 MHz unit (a so-called W/I module) and a 30 x 200 KHz (N module). The board computer processor and data acquisition system was also completed and tested at this time. The software in the processor is identical to the FEB software used in the MAS experiment so that no development was required. A Compaq-plus computer was selected as the central processor for the monitoring system. These units are portable, rugged and sufficiently inexpensive that several spares can be purchased. The processor software is written in PASCAL and contains a menu driven observing program which allows several different observing sequences to be used. Separate software modules control data taking, firing the calibration noise diode, and switching the receiver front-end. These units were bench tested and then used in a field experiment on the roof of Building 209 at NRL in May 1988.

The purpose of the NRL experiment was to test the spectrometer system and software using a radio astronomy receiver borrowed from the Maryland Point

Observatory. The noise temperature of the radio astronomy system was expected to be in the range 200-250K (as opposed to <100K for the final system) so we anticipated testing only the 40MHz and 2MHz filter receivers since the signal-to-noise ratio on the 200KHz filters will be very poor. Several problems were encountered using this set up. (1) The radio astronomy receiver system actually had a noise temperature closer to 300K. (2) The bandwidth of the radio astronomy front-end is limited by a filter which is narrower than the 10x40MHz bandwidth so that some channels receive no signal. (3) A spurious signal from the phase-lock system interferes with the 10x40MHz filters. Never-the-less, atmospheric water vapor spectra were obtained in May 1988. An successful attempt was made to retrieve profiles from these spectra using the software package developed for this purpose. The retrieval technique is described in Bevilacqua et al. 1983 J.Geophys.Res. 88, 8523.

The key hardware elements including the wideband, low loss cryogenic circulator and HEMT amplifier were delivered in the winter 1988-9. The cryogenic HEMT amplifiers for this project were constructed by NRAO. Integration of an amplifier into a dewar also containing the cryogenic circulator switch and a cold balance noise source was completed in April 1989. The remaining receiver components consisting of the mixer, L.O. module and an IF driver module were completed by June 1989 and the entire system moved to a roof top location at NRL for another test. The intention is to carry out tests and atmospheric measurements at NRL to validate performance before moving the system to a final location on Table Mountain in California. The overall system noise performance has been verified and other engineering tasks accomplished but, unfortunately, the poor Washington summer weather has not permitted actual measurements (as of August 1989).

Location of the final receiver system for a long series of experiments at Table Mountain California at a site operated by JPL was discussed with W.J. Wilson, C. Ruf and W. Ricketts of JPL. A plan for siting and operation of both the H_2O system and the millimeter-wave O_3 system constructed by MilliTech at the same location has been agreed upon. The current timetable calls for moving to this site during the first week of October 1989. During the initial stages of this experiment, different sky switching schemes will be investigated including the use of a quasi-optic beam chopper being designed by JPL. Data acquisition will be automated and data stored on floppy disks at the sites. These will be picked up and electronically mailed to NRL by JPL personnel. Processing of data from floppy disks and retrievals will be done periodically at NRL.

E. PUBLICATIONS

The following two publications related to retrieval and interpretation of water vapor data were partially supported by this program:

Bevilacqua, R. M. and Olivero, J. J. "Vertcal Resolution of Middle Atmospheric Measurements by Ground-based Radiometry" J.Geophys.Res. 93, 9463 (1988).

Bevilacqua, R. M., Strobel, R. F., Summers, M.E., Olivero, J. J., Allen, M. "The Seasonal Variation of Water Vapor and Ozone in the Upper Mesosphere: Implications for Vertical Transport and Ozone Photochemistry" J.Geophys.Res. accepted for publication.

A. Development of a UV-Visible Spectrograph and Data Analysis System for Measurements of Stratospheric Trace Gases as Part of a New Global Ground-Based Network for Long-Term Measurements

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C. The unique property of ozone in absorbing biologically damaging ultraviolet radiation from the sun has motivated a great deal of research directed towards a better understanding of the factors influencing the global distribution and temporal variability of ozone. A new global network for early detection of stratospheric change is being built under NAA/NOAA auspices. We are constructing a new UV-visible spectrograph and data analysis system (which guilds on our current system) to measure ozone and nitrogen dioxide and other trace gases in the stratosphere as part of the new global network. The new system consists of a new double spectrograph, new telescope system, and a new state of the art reticon array detector system that surpasses the current reticon array system we are currently using.

D. Funding was received only for FY 1988. Results for that fiscal year are:

1. optical design of the spectrograph completed,
2. detailed mechanical design of the spectrograph completed,
3. optical design of telescope begun,
4. start of prototype spectrograph construction begun,
5. prototype data acquisition software begun,
6. prototype array detector system designed and parts breadboarded.