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Millimeter-Wave Radar Cloud Measurements and Data Analysis for Satellite Validation

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Final Report

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The University of Massachusetts operated a Cloud Profiling Radar System in Everglades City, Fla., for three weeks during September 1996. On-site calibration of the radar was performed with a trihedral corner reflector. Time-height measurements of reflectivity, Doppler mean velocity, Doppler velocity variance, and linear depolarization ratio were assembled into netCDF datafiles for further analysis and comparison with data from other sensors. The data were archived in the Phillips Laboratory Data Archive Center and were made available through the Worldwide Web on a university web site.

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Millimeter-wave Radar Cloud Measurements and Data Analysis for Satellite Validation

Contract No. F19628-96-C-0146

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1 INTRODUCTION

This final report details work completed by the University of Massachusetts Microwave Remote Sensing Laboratory (MIRSL) during the period from July 1, 1997 through September 30, 1997 under Contract F19628-96-C-0146. We also review the original tasks to be performed. This Contract supports data collection and analysis by the MIRSL Cloud Profiling Radar System (CPRS) in support of the SBIRS program.

2 REVIEW OF ACCOMPLISHMENTS

The work to be performed as originally stated in our proposal is listed below and broken up into measurement and analysis tasks.

ORIGINAL LIST OF TASKS TO BE PERFORMED:

1. **Data Collection:**
   - (a) Deploy and operate UMass Cloud Profiling Radar System (CPRS) in Key West, Florida for 2-3 weeks in September, 1996.
   - (b) Perform on-site calibration via trihedral 'corner' reflector to calibrate CPRS reflectivity measurements.
   - (c) Generate netCDF format computer files of data products collected, such as reflectivity, mean velocity, Doppler variance, linear depolarization ratio (LDR), etc.
   - (d) Generate netCDF format computer files of additional data products that might be collected as requested by Phillips laboratory.
2. **Data Analysis:**
   - (a) Assemble time-height and three-dimensional measurements into netCDF datafiles with convenient dimensions for further analysis and comparison with data from other sensors, such as the VIL and HSRL lidars.
   - (b) Comprehensive comparison between radar reflectivity, HSRL lidar optical depth measurements and other data such as soundings and in situ aircraft cloud microphysical measurements. Relationships between radar data and optical depth will be reported to Phillips Laboratory in the form of a technical report so that they may be used with Phillips Lab's TPQ-11 radar.
   - (c) Three-dimensional radar data will be converted to optical depths and cloud top maps. This data will be recorded in netCDF format and provided to Phillips lab via ftp or one of several magnetic tape formats.

All measurement tasks listed above have been accomplished. Aside form relocation of the measurement site from Key West, FL to Everglades City, FL the work performed is that stated above. 1996. The data has been archived in the Phillips Laboratory Data Archive Center (PDAC) and is also accessible via the World Wide Web at *http://abyss.ecs.umass.edu/cprs-web*.

Item (a) of the analysis tasks has been completed. Items (b) and (c) have not been completed since little quantitative HSRL data from the Everglades City Data collection is available from the University of Wisconsin. The original intent of our analysis was to estimate optical depth, τ, from radar reflectivities by comparison with University of Wisconsin High Spectral Resolution Lidar (HSRL) data. The meat of this analysis was to determine empirical relationships between lidar optical depth and radar backscatter. This would 'calibrate' the relationship between radar reflectivity and optical depth and permit optical depth estimation in optically thick clouds and precipitating clouds where lidar-derived optical depths are unavailable due to high extinction rates. Once this was accomplished application of these relationships was to be automated and applied to all measured data.

There are other interesting possibilities for estimating cloud optical depth, however this goes beyond the scope of our original proposal. Our Third Quarterly report explained how optical depth could be estimated using existing statistical relationships between ice mass content (IMC) and radar reflectivity. IMC is integrated vertically and multiplied by a cloud heating rate to derive cloud optical depth. It is difficult to place error bars on the optical depth estimates that result from this procedure because of the assumptions made. The only reliable method for reducing these uncertainties is direct comparison with optical depths measured by lidar. Without this 'calibration' optical depths derived by the method described above can be off by up to two orders of magnitude. The absolute error increases with radar reflectivity.