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Global Three-Dimensional Distribution of LAWS Observations Based Upon Aerosols, Water Vapor and Clouds

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1.0 Introduction

A space-based Doppler Lidar Atmospheric Wind Sounder (LAWS) has been proposed by NASA as a facility instrument for the NASA Earth Observing System. Simpson Weather Associates, Inc. has developed LAWS Simulation Models (LSM) that are coupled with Global Circulation Models (GCM) to evaluate the potential impact of global wind observations on the basic understanding of the earth's atmosphere and on the predictive skills of current forecast models (GCM and regional scale). This paper uses the LSM to examine the three dimensional distribution of LAWS' observations over the globe. Such a study must consider the effects of atmospheric aerosols, molecular attenuation of the lidar signal, opaque clouds, and the presence of thin cirrus clouds.

2.0 LAWS Simulation Model

The LSM is a fully integrated simulation model that provides global three-dimensional simulated lidar winds. The major model components are for satellite location, laser scanner, atmospheric library, line of sight velocity, and the horizontal wind components. The atmospheric library model incorporates the effects of atmospheric aerosols, water vapor, opaque clouds and transparent cirrus clouds.

The LSM provides global aerosol backscatter via two methods; either tailored versions of the AFGL's FASCODE and LOWTRAN models or from probabilistic backscatter profiles based upon GLOBE data (LAWS baseline profiles). In our study we used the baseline maritime and continental aerosol backscatter profiles (Wood and Emmitt, 1991), as shown in Figure 1, in conjunction with European Center for Medium Range Weather Forecasting (ECMWF) relative humidity profiles to provide expected aerosol backscatter with natural variability.

The LSM uses the AFGWC Automated Cloud Analysis Model in conjunction with ECMWF data to infer global cloud cover. We find that the cloud model exaggerates the cloud coverage when compared to various satellite-derived cloud climatologies (Figure 2). We have taken several steps to empirically adjust the AFGL model so that the zonal distribution of total cloud coverage approximates that in Figure 3. The results are shown in Figure 4.

The LSM cirrus cloud model (Emmitt and Wood, 1991) is based upon a model obtained from Heymsfield (NCAR). The Heymsfield model computes a profile of cirrus cloud ice water content, along with cloud base and top altitudes, based upon a vertical atmospheric sounding taken with a rawinsonde. The LSM version of the Heymsfield model uses ECMWF profile data to supply atmospheric soundings as input to determine the presence of cirrus clouds.

3.0 Global Three-Dimensional LAWS Observations

Currently participation in the Observing System Simulation Experiments (OSSE) involves providing realistic LAWS simulation winds and observational errors for assimilation into NASA/GSFC and Florida State's GCMs (Atlas and Emmitt, 1991, Krishnamurti et. al., 1991). These OSSEs are addressing LAWS coverage issues. It is important to simulate in these experiments, both data quality and the data distribution (horizontal and vertical).

We have chosen to examine the global three-dimensional distribution of LAWS observations from the first day of our OSSE runs. Figures 5-7 depict the global averages of the number of LAWS shots in a 208X208 km target area as a function of altitude. The figures consider the effects of aerosols, aerosols and opaque clouds, and aerosols, opaque clouds and cirrus clouds, respectively.

4.0 References

Atlas, R. and G. D. Emmitt, 1991; Implications of Several Orbit Inclinations for the Impact of LAWS in Global Climate Studies. Paper presented at the AMS 71st Annual Meeting, Special Session on Laser Atmospheric Studies, New Orleans, LA, January.

Emmitt, G. D. and S. A. Wood, 1991; Simulating Thin Cirrus Clouds in Observing System Simulation Experiments (OSSE) for LAWS. Paper presented at the AMS 71st Annual Meeting, Special Session on Laser Atmospheric Studies, New Orleans, LA, January.

Krishnamurti, T., Xue, G. Rohallo, G. D. Emmitt, S. H. Houston and S. A. Wood, 1991; Using a Global Spectral Model in an Observing System Simulation Experiment (OSSE) for LAWS - An EOS Wind Measuring System. Paper presented at the AMS 71st Annual Meeting, Second Symposium on Global Change Studies, New Orleans, LA, January.

Wood, S. A. and G. D. Emmitt, 1991; A Reference Atmosphere for LAWS Trade Studies: An Update. Paper presented at the AMS 71st Annual Meeting, Special Session on Laser Atmospheric Studies, New Orleans, LA., January.

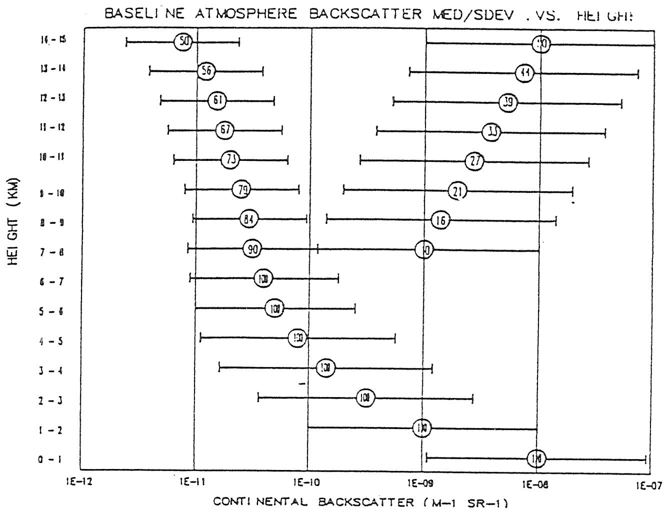

Figure 1a. Probabilistic continental backscatter profile where locations at the circles indicates the median value including data "drop outs" in the original WPL and JPL profiles. The number in the circle is the percentage of total observations associated with that median. The error bars +1 sigma in the log backscatter is based upon several hundred profiles. The cirrus mode above 7 km has been estimated.

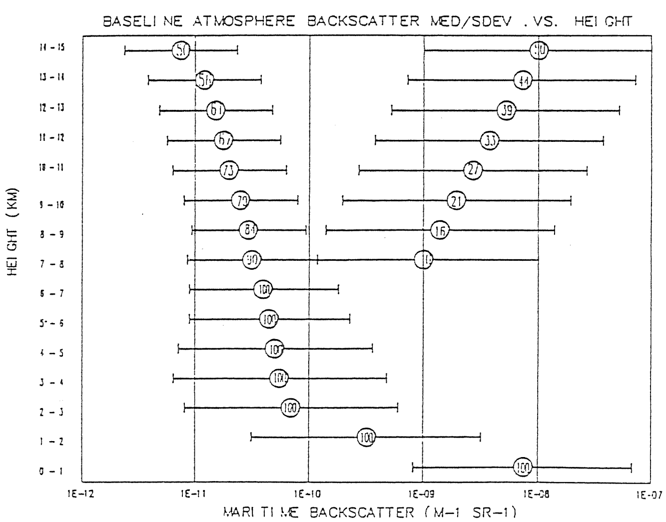

Figure 1b. Probabilistic maritime backscatter profile where locations at the circles indicates the median value including data "drop outs" in the original WPL and JPL profiles. The number in the circle is the percentage of total observations associated with that median. The error bars +1 sigma in the log backscatter is based upon several hundred profiles. The cirrus mode above 7 km and the low tropospheric aerosol mode have been estimated.

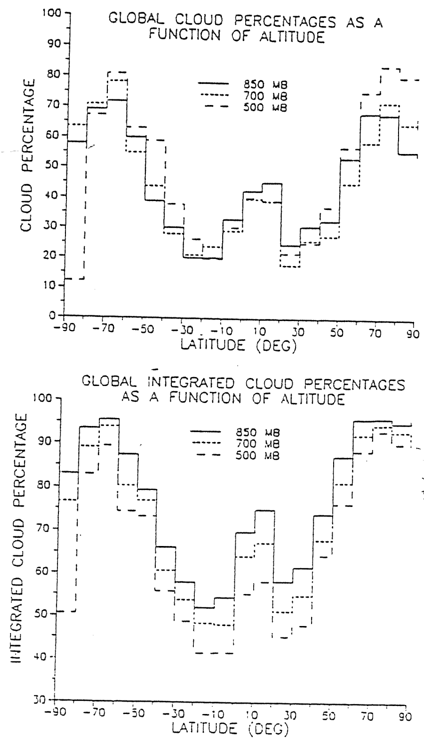

Figure 2. A) Global cloud percentages computed from the AFGL cloud model with ECMWF profile data from 11/10/79. Cloud percentages computed at 850, 700 and 500 mb levels. B) Cloud percentages integrated top-down to the 850, 700 and 500 mb levels.

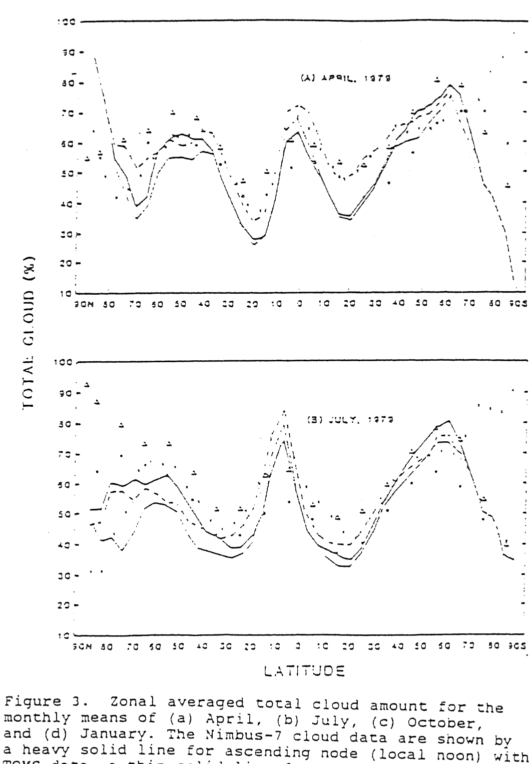

Figure 3. Zonal averaged total cloud amount for the monthly means of (a) April, (b) July, (c) October, and (d) January. The Nimbus-7 cloud data are shown by a heavy solid line for ascending node (local noon) with TOMS data, a thin solid line for ascending node without TOMS data, and a dashed line for descending node. Also shown in the figure are Berlyand and Strokina's (1980) 30 year cloud climatology ( ); the Air Force 3D-Nephanalysis cloud data for 1979 (X, compiled by Hughes and Henderson-Seilers, 1985); and London's (1957) multiyear averaged cloud climatologies (.).

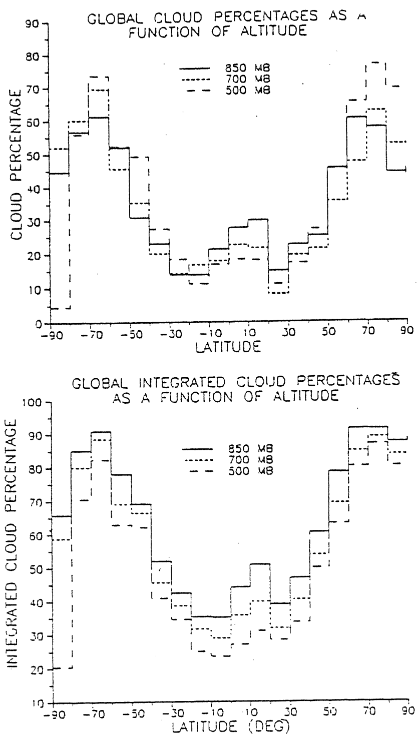

Figure 4. A) As for Fig 2(a) except empirically adjusted. B) As for Fig 2(b) except empirically adjusted.

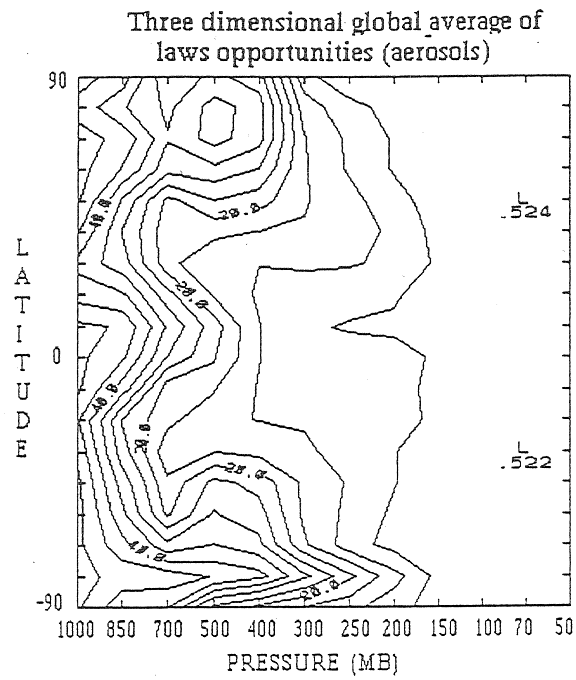

Figure 5. Global average of the number of LAWS opportunities in a 208 X 208 km area as a function of altitude. Only aerosol effects are considered.

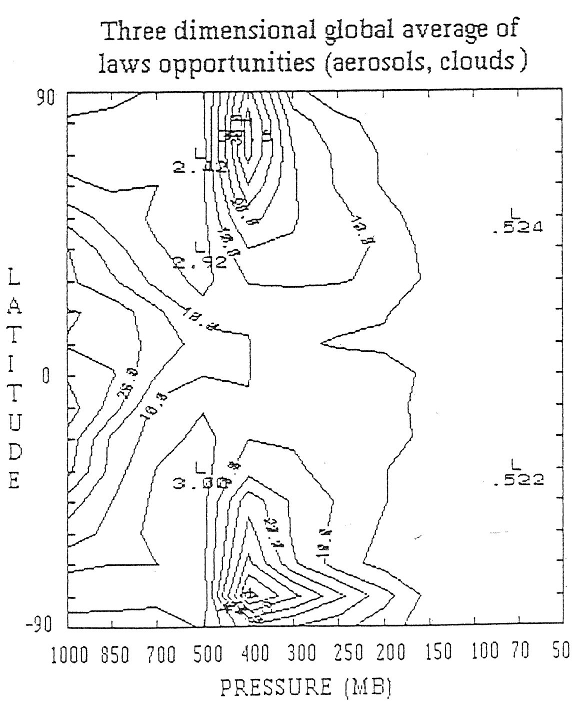

Figure 6. Global average of the number of LAWS opportunities in a 208 X 208 km area as a function of altitude. Only aerosol and opaque cloud effects are considered.

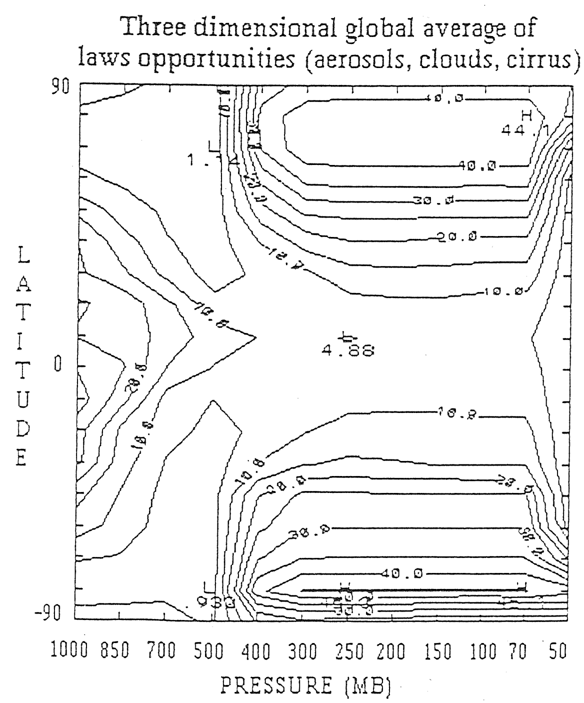

Figure 7. Global average of the number of LAWS opportunities in a 208 X 208 km area as a function of altitude. Aerosol, opaque cloud and cirrus effects are considered.