IDENTIFICATION OF CRITICAL DESIGN POINTS FOR THE EAP OF A SPACE-BASED DOPPLER LIDAR WIND SOUNDER

G.D. Emmitt and S.A. Wood
Simpson Weather Associates, Inc.
Charlottesville, VA 22902

The feasibility of making tropospheric wind measurements with a space-based Doppler Iidar has been studied by a number of agencies over the past 10-15 years.
Currently NASA has a plan to launch such an instrument, the Laser Atmospheric Wind Sounder (LAWS), within the next decade.

The design of the LAWS continues to undergo a series of interactions common to most instruments targeted for a space platform. In general, the constraints of available platform power, weight allowance and project funds continue to change. With these changes the performance and design specifications also must change.

One of the most basic design considerations is the Energy Aperture Product (EAP) which is directly related to the weight and power constraints. The power requirements are scaled to the energy of the laser pulse and its average pulse repetition frequency (prf), The weight of the instrument is determined in part by the energy of the laser and its prf and in part by the size (aperture) of the optics. While not linearly, costs also scale to both the laser energy and telescope diameter.

One of the more critical trades being performed is that of the observations (number and accuracy) returned as a function of EAP. Lidar returns are obtained from aerosols, transparent cirrus, and the tops of opaque clouds. The accuracy of the line-of-sight (LOS) measurement is dependent upon the signal-to-noise ratio (SNR). The accuracy or representativeness of the wind information within a specific volume containing several LOS samples depends upon both the SNR and the number of samples.

The distribution of the observational opportunities can be described in terms of a log. normal distribution of aerosol backscatter with a median near 3-5 x 10 In-I sr-l for
9.11 gm plus a broad distribution of high backscatter from clouds, desert dusts and

PBL aerosols with a median around 10-7 m^{a} sr-l (see Figure l).

Our ability to detect useful information (sufficient SNR and number of samples) can be expressed in terms of a consensus algorithm which is shown schematically in Figure lb. Note that approximately 8 dB spans the gap between < 5% useful returns to > 95% useful returns. Overlaying Figure 1b on Figure la presents a clear picture of several or the critical regions for performance - one in the region less than 10-10 and the other greater than 10 ^{8}.

In our presentation we will explore the sensitivity of the performance of a spacebased Doppler Iidar to a range of EAPs given a realistic distribution of observation opportunities around the globe. A GCM will be used in a simulation experiment to produce performance profiles in terms of the source of backscattered information (see Figures 2 and 3 for examples). Critical design points for the EAP vs backscatter will be identified in terms of marginal performance.

Acknowledgement

This work has been supported under NASA contract NAS8-38559.

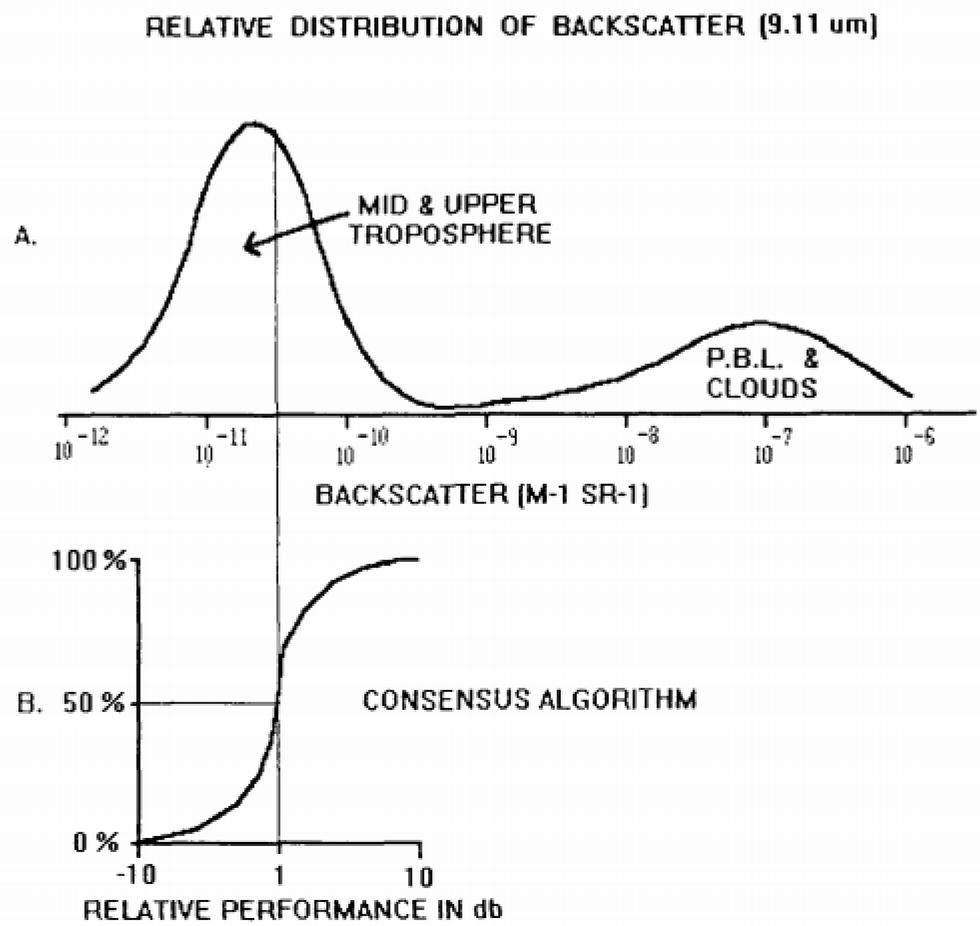

FIGURE 1

Figure l : (a) Schematic distribution of backscatter opportunities for a space-based Iidar Wind sounder. (b) Schematic of a signal processing algorithm based upon the consensus of 8 independent observations along the LOS.

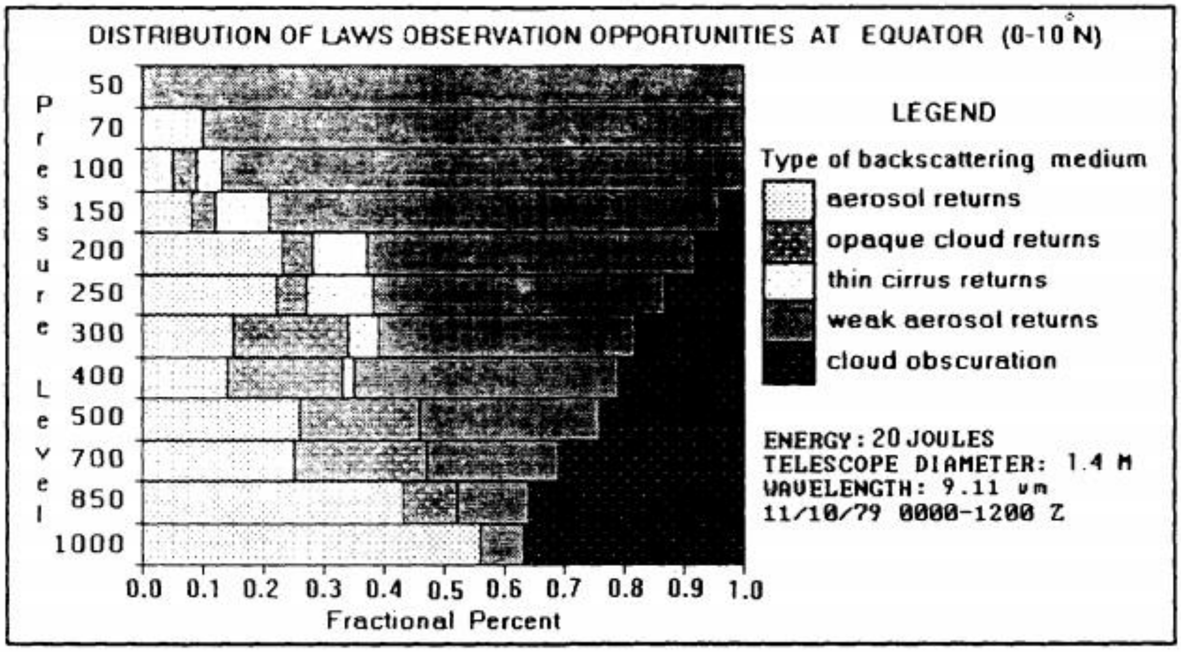

FIGURE 2

Figure 2: Summary plot of the distribution of backscatter returns from the equator to 10 ^{0} N band for a 20 joule laser with a 1.45 meter diameter telescope and in a 500 km orbit during a 12 hour period simulated with a global general circulation model (GCM). This summary indicates the percentage of time the Lidar system can make a useful wind measurement in terms of the backscatter conditions clouds, thin cirrus, aerosols or no returns due to obscuration by higher clouds.

In the GCM based simulation experiment opaque cloud returns are derived from Nimbus 7 climatology and the GCM. Upper tropospheric thin cirrus are obtained from SAGE statistics. The aerosol returns are based upon a 9.11 gm backscatter profile derived from recent GLOBE data and the LAWS baseline

9.11 gm backscatter profile. The usefulness of a measurement is judged in terms of the SNR, the number of shots into a 200x200 km area and the resulting observational uncertainty, co. A threshold value of = 5 m s -l is used above 300 mb while a value between I and 5 m ^{L} is used below that level. Fractional cloud coverage is used to calculate the number of shots (out of 26) that succeed in passing through to lower layers.

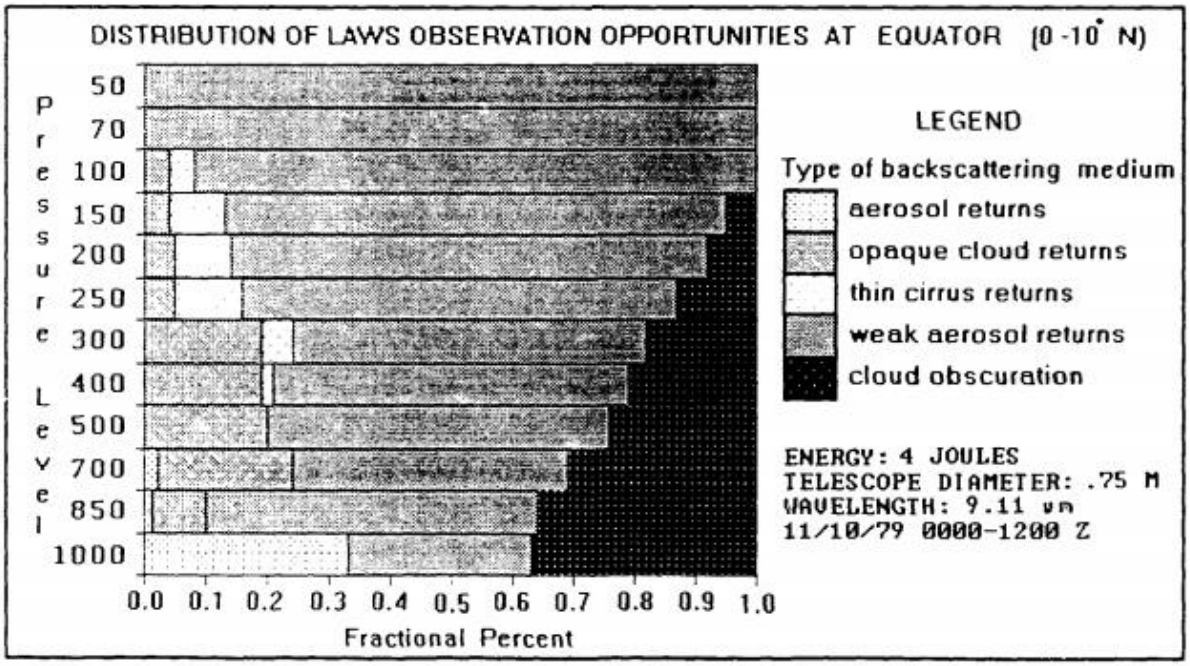

FIGURE 3

Figure 3: Same as Figure 2 except for a 4 joule .75 meter telescope system.