P1-16 Optical Depth Measurements of Clouds in Manila (14.64N, 121.07E) Philippines

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1. Introduction

The optical properties of clouds are important elements of the global radiation balance. In particular, the optical depth distribution of clouds, which is derivable from extinction coefficients, is useful in modeling transport of radiation in the atmosphere (Pal et. al., 1992). In this part of the globe, not much is known of the optical properties of clouds. Thus, optical depth values are not known. This paper presents the calculated optical depths of clouds at 14.64 N, 121.07 E (Manila, Philippines) from the lidar backscattered lidar signals. The lidar station is located at the Ateneo de Manila University.

2. Optical Depth Measurements

A. The Lidar System

The lidar system is located at 14.64 N 121.07 E within the Manila Observatory. It is a fixed, vertically pointing system (Alarcon, 1996). The transmitting setup consists of a Q-switched Nd-YAG that transmits an expanded, collimated and linearly polarized 532-nm beam at 20Hz (Dorado, 1998). The backscattered signal is collected and focused by a 28-cm diameter Schmidt-Cassegraine telescope onto a photomultiplier tube (PMT) through a collimating lens and a bandpass filter. The analog voltage output of the PMT is digitized and averaged by the digitizing storage oscilloscope and stored in a computer.

B. Methodology

Computer software is developed in Xavier University, Cagayan de Oro to automate the extraction of the extinction coefficients from backscattered lidar signals. The extinction coefficient is computed using the equation below (Klett, 1981):

$$\alpha(r) = \frac{P(r)r^2}{\dfrac{P(r_m)r_m^2}{\alpha(r_m)} + 2\int_r^{r_m} P(r')r'^2\, dr'}$$

where P(r) is the backscattered signal; r is the altitude; r_m is the height at which the boundary value $\alpha(r_m)$ is applied.

The calculation of the extinction coefficient is basically dependent on the boundary value at a certain height. The boundary value $\alpha(r_m)$ is calculated using Klett's algorithm (1986). Briefly, the procedure assumes that the extinction coefficient is constant over $(0, r_m)$ and the average extinction over $(0, r_m)$ is the same as that over (r_o, r_m). The height r_o is the point of transmitter and receiver beam overlap. In the case of clouds, where the visibility is low, the boundary value is computed using the iteration of the equation

$$\Omega_m = \ln(1 + I\Omega_m)$$

where

$$\Omega_m = 2\alpha(r_m)[r_m - r_o]$$

and

$$I = (r_m - r_o)^{-1} \int_{r_o}^{r_m} \exp[S(r) - S(r_m)] dr.$$

If the iteration does not give $\alpha(r_m)$, the "default" equation is used that has the form

$$\Omega_m = (r_m - r_o) / r_o I.$$

From the said coefficient, the optical depth is calculated from the equation

$$\tau = \int_{r_1}^{r_2} \alpha(r) dr.$$

The choice of the points r_1 and r_2 is based on the lidar signal. The point r_1 is the height wherein the signal coming from the clouds start to rise. The point r_2 is the location wherein the signal is already decreasing and has a value comparable with r_1.

3. Results

Figures 1 and 2 show the optical depths of clouds with cloud base during the dry season, i.e., from March to May 1998 and during the wet season, i.e., from August to October 1998, respectively. The results show relatively higher optical depth values for wet season with low-lying clouds.

Furthermore, it was also observed that optical depth values are relatively high in the afternoon than in the morning. This is due to the fact that water vapor increases during the day as the temperature heats up and holds more vapor.

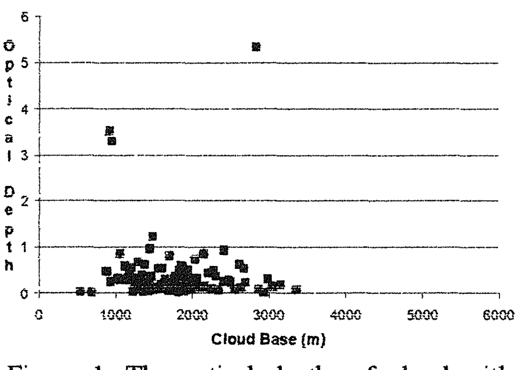

Figure 1. The optical depths of cloud with cloud base for dry months March to May 1998.

4. Summary

For the first time in the Philippines, the optical depths of clouds are determined. Though the results may not be representative of a more general picture of clouds, these values can serve as initial information about the clouds in this part of the world. The results also present the capability of the present lidar system to extract values of optical depth from lidar data.

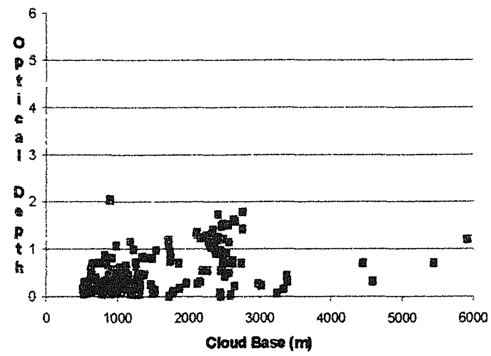

Figure 2. The optical depths of cloud with cloud base for wet months August to October 1998.

5. Acknowledgments

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References

Alarcon, M., S. Dorado, J. Holdsworth, B. Sychingiok, and D. McNamara. (1996). Mie Lidar Measurements in Metro Manila (14.64N, 121.07E). In 18th ILRC Proceedings, Berlin, Germany.

Dorado, S., N. Lagrosas, E. Agcopra, J. Canete, and M. Alarcon (1998). Mie Backscatter Intensity and Depolarization Measurements of Tropical Clouds, 14.64N, 121.07E in the Philippines. In 19th ILRC Proceedings, Annapolis, Maryland, USA.

Klett, J. (1981). Stable analytical inversion solution for processing lidar returns. *Applied Optics*. **20**, 211-220

Klett J. (1986). Extinction boundary value algorithm for lidar inversion. *Applied Optics*. **18**, 2462-2464

Pal, S. R., W. Steinbrecht, and A. I. Carswell. (1992). Automated method for lidar determination of cloud base-height and vertical extent. *Applied Optics*. **31**, 1488-1494