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Lidar Research Activities in the Philippines

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I. Introduction

Lidar is a powerful tool used to study and investigate the atmosphere with high spatial and temporal resolution that can cover large geographical areas. Metro Manila being the center of political, administrative, and economic activities in the Philippines had become one of the most polluted cities in the world. Studies had shown that the air pollution is mainly from the number of vehicles roaming the metropolis. In 1994, a program for environmental monitoring of Metro Manila using lidar was proposed (Alarcon et al., 1994). The main objective of the program is primarily to assess and characterize the air quality in the Metropolis. As a first step in achieving this goal, a Mie Scattering Lidar System was constructed at the Ateneo de Manila University and this had been operational since 1996. Since then, group of researchers worked together to develop and increase the Lidar research in the Philippines. The purpose of this paper is to present the current and future Lidar research activities in the Philippines.

II. The Existing Lidar Systems in the Philippines

Shown in figure 1 are the two existing Lidar sites in the Philippines, which are both Mie scattering Lidars. The first Lidar station as mentioned above is located at the ADMU campus which is 14.94°N; 121.07°E. This is roughly 13 km from the second Lidar station located at the 4th floor of the Science & Technology Research Building (STRC) of De La Salle University (14.34°N, 120.60°E). The development and construction of the DLSU Lidar system, which started its operation early this year,

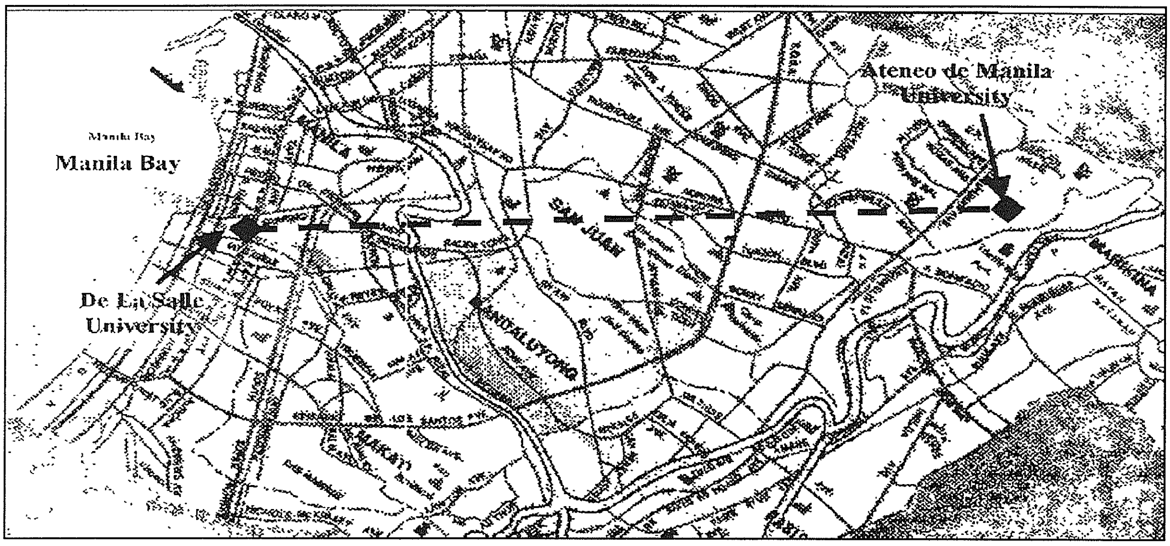

Figure 1. Partial map of Metro Manila showing the location of the two Lidar stations relative to one another.

was made possible through a research grant given by the DLSU The ADMU facility is located near the mountains and overlooking the Marikina Valley while the DLSU facility is 14 meters above sea level and 900 meters from Manila Bay Both systems are currently vertically pointing and operating in biaxial mode Further, both employ a commercial, pulsed frequency tripled Nd·YAG laser. Measurement are being taken regularly twice a week and three times a day (morning, afternoon, and evening).

III. Lidar Research Activities

A. Past and Current Lidar Research Activities

Observations have been carried out by both Lidar systems for the vertical distribution of clouds and aerosol, and depolarization ratio in the lower atmosphere using the 532-nm laser wavelength. The Lidar system at ADMU campus has been part of the Asian Lidar Network based in Chiba, Japan, which aims to coordinate all Lidar data on Asian aerosols, in order to understand the unique behavior of the clouds and aerosols in this part of the world. It has at least 2 years worth of data on cloud and aerosol extinction and optical depth properties. An example of a collection of earlier lidar measurements (in time-height-intensity map) done at the ADMU lidar between August to November 1996 is shown in figure 2 (Dorado, 1998). This period, which is considered to be a wet season in the Philippines, was marked by frequent occurrences below 2.5 km of low -lying cloud layers, which have relatively high backscatter intensity. It was marked by frequent occurrences below 2.5 km of low lying cloud layers, which have relatively high backscatter intensity. Multiple wavelength extinction measurements using the 1064-, 532-, and 355-nm simultaneous outputs of the Nd:YAG, as shown in figure 3, was also performed in this Lidar system (Galvez, 1998). This allowed the study on the wavelength dependence of cloud and aerosol extinction coefficient via the Angstrom relation. The obtained values of the Angstrom coefficient, δ, is between 1 to 3 for aerosols and –1 to 1 for low-altitude clouds. An example of the depolarization measurement of low-altitude clouds using the DLSU lidar system is shown in figure 4. The depolarization ratio was plotted in THI using the software developed by students at DLSU. The depolarization ratio of this cloud started at 0.1 at the cloud base and reached a value of upto 0.6 as the penetration depth increases. The clouds may be composed of liquid droplets mixed with irregulaly shaped particles such as dust. These depolarization measurements are also used to investigate the multiple scattering effect on the lidar return signal together with the Monte Carlo method (Vallar et al., 1999; Galvez et al., 1999). More

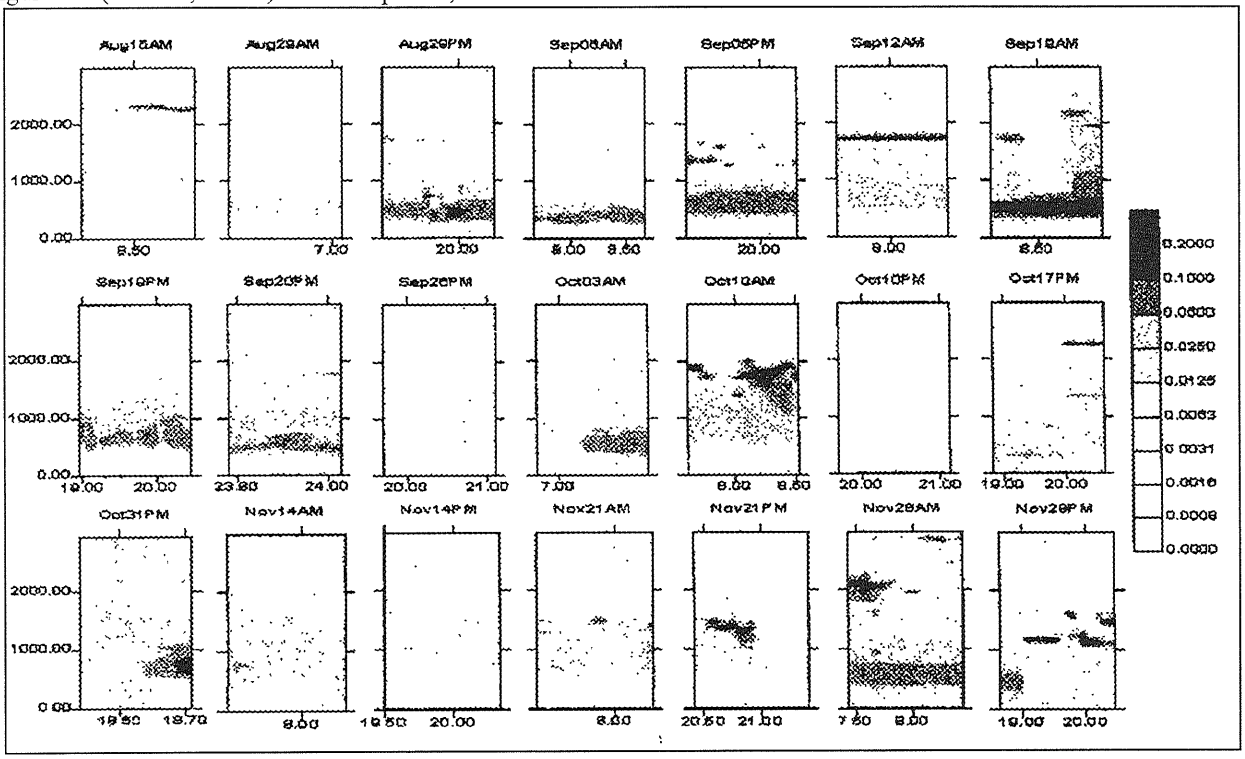

Figure 2. An example of the time-height-backscatter intensity (THI) profiles of lidar measurement acquired on 1996 during the wet season (August - November).

experimental results from both lidar systems are described in detail in two other papers presented in this conference (Vallar et al., 1999; Lagrosas et al., 1999).

The ADMU Lidar is currently being developed as a scanning Mie Lidar system to study the urban boundary layer, e.g. turbulence, etc. (Tubal, et al., 1998) This scanning Lidar system will be used to determine meteorological parameters such as wind direction and speed, and to study particulate transport in the boundary layer. Whereas, the DLSU Lidar is at present being modified to provide three-wavelength measurement at 355-, 532-, and 1064-nm, including two-wavelength depolarization measurement for 532- and 1064-nm wavelengths. Algorithm analyses are currently being developed to determine the particle size using the information contained in the multiple wavelength extinction measurement. The effect of multiple scattering within the aerosol and cloud layers is also being investigated using the Monte Carlo method and depolarization Lidar method. Initial studies are also being conducted together with a group of people from the Chemistry Department of DLSU to investigate the possible application of Lidar in detecting the early stages of red tide and its concentration.

B. Future Research Plans of the Lidar Group of the Philippines

a. Aerosol and boundary layer studies in view of their role in climate forcing. These include studies on atmospheric boundary layer structure related to air pollution phenomena and structure of sea breeze front using aerosol as a tracer. These entail a modification of the existing DLSU Lidar system to also have a scanning capability, just like what the ADMU Lidar is doing right now for cooperative research especially in transport studies in Metro Manila where air pollution especially due to mobile sources is a very big problem. The modification of the DLSU Lidar is being presently undertaken in collaboration with the Manufacturing Engineering Department of DLSU.
b. Trace gas measurement in the urban or remote atmosphere and measurements of stratospheric ozone using a mobile Differential Absorption Lidar and/or similar systems like DOAS and remote FTIR. Due to lack of available data on the concentration of pollutant gases in the atmosphere such as SO_2, etc., a mobile DIAL will be an indispensable tool for air quality monitoring and government policy making. The last study, thus far, conducted by the DENR regarding the present level of pollutant gases in the urban atmosphere using chemical analysis method was in 1992. The study indicated that the levels of pollutant gases and particulate emissions from both mobile and stationary sources exceed the Philippine Guidelines.
c. Lidar measurement in the middle atmosphere, especially that Mayon Volcano, one of the volcanoes in the Philippines, just had a minor eruption last June 22, 1999.

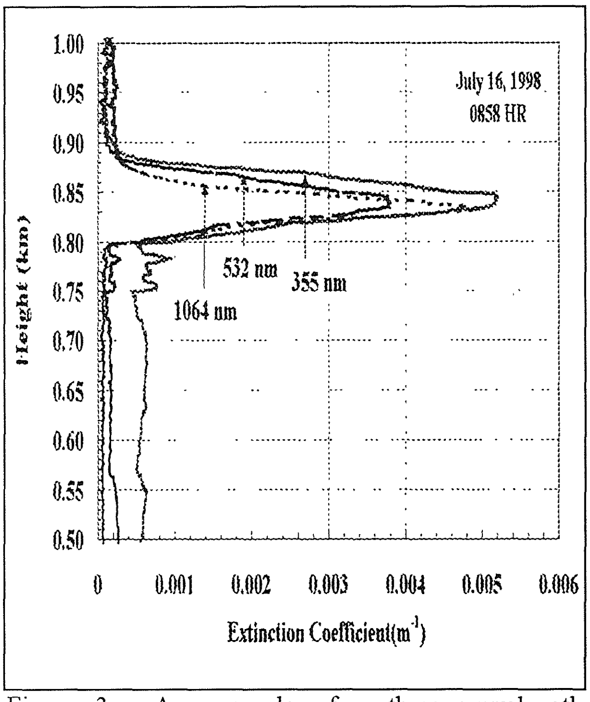

Figure 3. An example of a three wavelength extinction measurement at the ADMU lidar site.

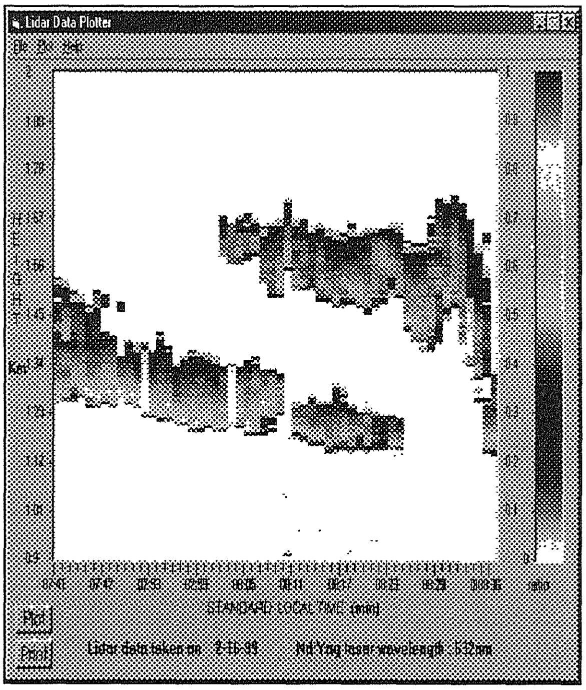

Figure 4. A THI map of the depolarization ratio of low-atltitude clouds measured at the DLSU lidar site.

d. Application of Lidar technique for wind, atmospheric temperature and density measurement.
e. Development of Lidar system for ocean and agricultural studies.
f. Establishment of a Lidar Network in the Philippines These include the establishment of more Lidar sites and have as many people as possible to be involved with the project. This includes not only people from the academe but also people from the government such as the Department of Environment and Natural Resources (DENR), and also the military, especially the Philippine Navy and the Philippine Air Force, for the development of shipborne or airborne Lidar systems for ocean and atmospheric studies. At present, there's a plan to develop another Lidar system in Mindanao, particularly, at General Santos City, which is becoming one of the major cities in the Mindanao (Dorado et al., 1999).
g. Participation in international Lidar network.

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