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Aerosol and Cloud Characterization at De La Salle University, Manila, Philippines

Edgar Vallar, Nesse Grace Resurreccion, Ofelia Rempillo, Jaime Raul Janairo, Everlyn Gayle Tamayo, Prane Mariel Ong and Maria Cecilia Galvez
Applied Research for Community, Health, and Environment Resilience and Sustainability (ARCHERS), Center for Natural Sciences and Environmental Research (CENSER)
De La Salle University – Manila
**Corresponding Author: edgar.vallar@dlsu.edu.ph*

Abstract: The paper introduces the research activities being conducted by the Applied Research for Community, Health, and Environment Resilience and Sustainability (ARCHERS) research group of the Center for Natural Sciences and Environmental Research (CENSER) of the College of Science of De La Salle University – Manila.

Key Words: air quality, environment, remote sensing, lidar, modelling

1. INTRODUCTION

ARCHERS researches are focused on studying the environment and its' effects on man. Research conducted by this unit examine the environment (air, water, land) by harnessing its interaction with light along with utilizing a host of passive and active sensors that may also serve as correlative sources of information. These multi-platform measurements provide more in-depth information on the environment. Thus, ARCHERS use passive and active remote sensing to study the environment. This allows us to remotely study the environment without physically being there to potentially interfere with the reactions occurring. In contrast with passive methods, active techniques mean that a light source is used. It is important to study the environment because we all live here so whatever we do to the environment will produce consequences that will affect us.

Whenever possible, we build instruments (e.g., sunphotometer, etc.) adapted to the Philippine setting to create a network of instruments that will yield not only baseline information on the environment but also provide continuous monitoring because we believe that "WHAT GETS MEASURED, GETS MANAGED". ARCHERS is also a founding member of RESearchers for Clean Air or RESCUEAIR, Inc. RESCUEAIR (http://www.rescueair.co.nr/) is a SEC-registered NGO non-government organization (NGO) composed of academicians and researchers from the Philippine's top research and educational institutions doing researches geared towards cleaner air. Dr. Vallar is currently the President of RESCUEAIR. Synergistic activities of ARCHERS include memberships in DOST–PCIEERD technical panels, DOST–SEI technical working group on climate change, DENR–EMB NCR Airshed Governing Board Execom, DepEd textbook review committee, and the Partnership for Clean Air (PCA, Inc.) NGO. The next sections provide a brief description of each research area. More information can be obtained from http://www.dlsu-earth.com/.

2. LIDAR (MIE + LED)

Figures and tables should be referred to in the tex LIDAR, an active remote sensing technique, is the acronym for Laser radar or LIght Detection And Ranging. LIDAR provides spatially–resolved and time–resolved information about the boundary layer, clouds and aerosols (e.g., particle size distribution, shape/sphericity, depolarization, optical thickness/depth, etc.).

We assembled our own MIE LIDAR using commercial instruments. A MIE LIDAR is a LIDAR that is designed to detect MIE scattered light meaning scattered light having the same wavelength as the transmitted light. The MIE LIDAR developed utilizes the 1064-, 532-, and 355-nm simultaneous outputs of Q-switched Nd:YAG laser as a light source. The laser outputs are directed/transmitted to the atmosphere to interact with clouds and aerosols. The laser light backscattered by clouds and aerosols is collected by a telescope. At the focal point of the telescope is an iris and a series of optics and detectors that convert the light into an electrical signal. The electrical signal is viewed using a digitizing storage oscilloscope which also digitizes the signal. The digitized signal is processed using a Labview–based application that we developed. The same application computes for the properties of the cloud and aerosol particles and saves the data for future use. The data acquisition process is also automated using another Labview–based application that we developed. This same system may also be employed for terrestrial (e.g., vegetation, DTM, etc.) and aquatic studies with some tweaks. Studies using this LIDAR system have been presented in many conferences here and abroad (Somekawa et al., 2013), (Galvez et al., 2004; 2006; 2008; 2010), (Vallar et al. 2002; 2003; 2004; 2006; 2008; 2010).

A LIDAR system is very expensive to build, bulky, and difficult to maintain as can be deduced from the previous paragraph. From the collaboration of Dr. Galvez with Chiba University in Japan, ARCHERS is now starting to develop an LED LIDAR system. The LED LIDAR system uses a superluminescent light-emitting diode (LED) as the light source. The LED LIDAR is cheaper to build than ordinary LIDARs and easier to maintain. More information about this will be provided in future presentations (Ong, 2017).

3. SUNPHOTOMETER

Sunphotometry, a passive remote sensing technique. allows the measurement of aerosol optical thickness, turbidity, particle size distribution, columnar ozone, and water vapor. We developed our own two-axis sun tracker using stepper motors and a quadrant photodiode-based feedback system. Our Labview–based application automates the whole data acquisition and processing system. The commercial sunphotometer has four wavelengths, namely 368 nm, 500 nm, 675 nm, and 862 nm. The acquisition system tracks the sun using a conventional (employing the equation of motion of the sun) and a feedback loop (using a quadrant photodiode). The system reads the output of the quadrant photodiode. Once a user–defined threshold is exceeded, it means that it is sunny and the feedback loop is activated to align the sunphotometer to the sun. If it is cloudy, the conventional step is done for the alignment. After alignment is completed, data is gathered for the four wavelengths, stored and processed to yield the aerosol properties. A cloud–screening algorithm was also developed by our group to automatically remove data points that are "contaminated" by clouds. Journal publications and international conference presentations have been made using work involving the sunphotometer (Vergara, 2017; Vallar, 2010).

4. AIR SAMPLING: SCANNING ELECTRON MICROSCOPE WITH X-RAY MICROANALYSIS, GCMS AND AAS

Through collaborations with Howard University in Washington DC in the USA, the DLSU Chemistry, Chemical Engineering, and Biology departments, a six–stage cyclone impactor that can sample particles up to 0.65 micrometer in aerodynamic diameter is being used for air sampling at different sites (e.g., Taft Avenue roadside, selected sites in Meycauayan, Bulacan, hospitals, etc). The

six–stage sampler and a homemade personal sampler built by a former PhD student has also been used to study the exhaust from tailpipes of cars, buses, trucks, and tricycles for the thesis of our undergraduate students. 0.65–micrometer particles can penetrate the lungs, go into the bloodstream, and cause a host of diseases. Pre–weighed 49–mm diameter filters are placed inside each stage of the sampler. Particles are deposited on the filter according to the size-cut for that stage. After the sampling, a microbalance yields the concentration for the filter for each stage (given the sampling duration) while a Scanning Electron Microscope with X-ray Microanalysis (SEM/EDX) system provides the size, morphology and elemental composition. Chemical analysis of the air samples has also been performed by ARCHERS undergraduate students. Collaborative work with the DLSU Chemistry and Biology departments enable the conduct of bioaerosols studies at different sites using the six–stage sampler along with the SEM/EDX (Torres, 2012).

5. CHEMICAL ANALYSIS OF WATER HYACINTHS AND PLANTS

Water hyacinths and different plants have been studied by our group. SEM/EDX, GCMS and AAS were some of the instruments used to get information on how air and water pollutants affect them. This work has shown that plants can be used as bioindicators of air and water quality. Journal and conference publications have also resulted in this work (Galvez, 2015).

6. PM_{10}, $PM_{2.5}$, $PM_{1.0}$, SO_2, NO_2, OZONE, CO, AND BTX MEASUREMENTS + CORRE-LATION WITH HEALTH + LOCAL METEOROLOGY + VEHICLE TYPES

Collaboration with DENR–EMB has led to the installation of an Air Quality Monitoring Station (AQMS) by EMB at DLSU. Located near the DLSU Velasco Gate, the AQMS measures PM10, PM2.5, SO2, NO2, Ozone, CO, and BTX at 24/7. These criteria pollutants are mandated to be measured under the Philippine Clean Air Act (RA 8749). PM1.0 measurements have also been performed using the ARCHERS PM1.0 are sampler. Correlation of these data with health data for District 5 of Manila, local meteorological parameters (surface temperature, wind speed, wind direction, relative humidity, surface pressure, solar radiation and rainfall) and traffic flow yields a more in-depth analysis. Detailed traffic flow analysis will soon be made faster through a collaboration with the group of Dr. Joel Ilao of the DLSU College of Computer Studies. Traffic video will be processed to yield vehicle classification and counts. Meteorological data are obtained using an automated weather station located at the roof of Henry Sy Sr. Hall (HSSH). Papers analyzing these data are currently being written for publication. Collaborations with the group of Prof. Raouf Naguib of BIOCORE and Liverpool Hope University (LHU) yielded journal publications related to this field (Chinnaswamy, 2015; 2016). Conference presentations using these data have also been made (Vallar, 2015). Furthermore, the group will now start measuring indoor air quality such as in offices, school rooms, public utility vehicles, etc.

7. MICROTOPS: TOTAL COLUMN OZONE, PRECIPITABLE WATER VAPOR (PWV) AND AEROSOL OPTICAL DEPTH (AOD)

A commercial, handheld ozonemeter is also being used by ARCHERS to obtain measurements of total column ozone, precipitable water vapor and aerosol optical depth. Using a tripod, students go to the roof of the Science & Technology Research Center (STRC) and manually point the ozonemeter to the sun to get the data every minute for 5 minutes at 30–

minute intervals. Data is only obtained when the sun is not visibly obscured by clouds. Total column ozone is important to measure because it can give information on stratospheric ozone and ground–level ozone. Each type of ozone plays a significant role in the atmosphere and our health. AOD gives an idea of the level of pollution in the atmosphere. High AODs mean that the atmosphere is hazy or polluted. As implied in its name, PWV is the amount of water vapor in that atmosphere that can become rain. Aside from affecting the hydrological cycle, water vapor also affects climate, weather (e.g., surface temperature), and the attenuation of electromagnetic radiation in the atmosphere. Thus, it is useful for climate change studies. ARCHERS studies in this area has led to journal publications and conference presentations (Plando, 2017).

8. SATELLITE REMOTE SENSING + LOW–LATITUDE IONOSPHERIC TOMOGRAPHY NETWORK (LITN)

Satellite remote sensing data are currently being analyzed ARCHERS students and correlated with the DENR–EMB AQMS measurements. The LITN study of ARCHERS was made possible via a collaboration with National Central University (NCU) in Taiwan. Dr. Ernest Macalalad, now with Mapua Institute of Technology, studied for his PhD at NCU and continues to collaborate with ARCHERS for this study along with the PWV work that makes use of satellite and other ground–level measurements. An MS Physics student published her LITN study in a journal recently (Francisca, 2015). Another MS Physics student also recently published her PWV study (Carnicer, 2017).

9. DEVELOPING INEXPENSIVE AND ROBUST ATMOSPHERIC INSTRUMENTS FOR NETWORK APPLICATIONS

Instruments used in ARCHERS studies mentioned earlier are expensive, difficult to operate and bulky. Realizing this, ARCHERS students are developing micro–controller based instruments capable of measuring criteria pollutants and meteorological parameters at 24/7 and have wireless/ethernet data transmission. Collaboration with Mr. Cesar Llorente of the DLSU ECE department helps resolve problems with both software and hardware. A journal publication was produced from this collaboration (Llorente, 2015).

10. WEATHER AND AIR POLLUTION MODELING

The increasing need to know the weather and air quality for disaster preparedness and other activities has motivated the ARCHERS group to go into this field. Dr. Gerry Bagtasa, a former student who studied for his PhD in Chiba University, is collaborating with ARCHERS in developing our capabilities in this area. ARCHERS students are currently doing their thesis in this area. A paper on this field is being prepared for publication.

11. HEALTH EFFECTS OF PARTICULATE MATTER

Most of the researches done by ARCHERS so far are on measurements and characterization of pollutants and their effects on plants. ARCHERS have just embarked on determining in more detail the health effects of particulate matter on humans. In collaboration with Prof. Nilda Muñoz of the St. Luke's College of Medicine, one student group will determine the where in the respiratory system of a mouse will PM2.5 be most likely to deposit. Another thesis group is working with the Philippine Nuclear Research Institute (PNRI) to find out mutations caused on human blood by PM2.5. Journal publications are planned after each study.

12. MONETARY VALUATION OF THE EFFECTS OF POOR AIR QUALITY

ON HEALTH AND THE ECONOMY EALTH EFFECTS OF PARTICULATE MATTER

Knowing how air quality becomes poor and the health effects of poor air quality is not enough. Political and administrative policy related to air quality can be made better if it is science–based. Thus, determining the economic costs of poor air quality is important. Poor air quality affects not only the health of the citizens in a community but also the economy of the country and the household expenditures. In collaboration with the US Environmental Protection Agency (EPA), ARCHERS students are doing their thesis on this field. The EPA continues to train ARCHERS students in this topic.

13. MANILA AEROSOL CHARACTERIZATION EXPERIMENT: MACE 2015

MACE 2015 is a collaborative aerosol characterization campaign undertaken by ARCHERS with other research institutes in the Philippines, Partnership for Clean Air, RESCUEAIR, and the Leibniz Institute for Tropospheric Research (TROPOS) in Leipzig, Germany (http://wiki.tropos.de/index.php/The_Manila_Aerosol_Characterization_). Journal publications have just been submitted giving some of the results for this campaign. A second and more intensive campaign is being planned for 2018–2019. Funding for this second campaign was discussed in a meeting last 1st week of May 2017 in Leipzig.

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