MANILA OBSERVATORY

2021 ANNUAL REPORT

MANILA OBSERVATORY ANNUAL REPORT 2021

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ANNUAL REPORT 2021

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RESEARCH ACTIVITIES

Introduction and Summary

In 2021, despite the continuing challenges of the pandemic such as limitations in internet connectivity, remote access to datasets and computing resources, remote project management, and other technical issues, **the Manila Observatory (MO) was still able to conduct substantial research, produce scientific papers, develop new projects, and engage stakeholders from government, the private sector, and civil society**.

Aside from several conference and webinar talks and presentations, a total of 17 journal publications, six book chapters, 14 technical reports, three policy papers, and two policy notes were written in 2021. In addition, a total of 3,664 maps on renewable energy and climate risk screening were produced in a span of two years (2020-2021)

17
JOURNAL PUBLICATIONS

6
BOOK CHAPTERS

14
TECHNICAL REPORTS

5
POLICY PAPERS & NOTES

3,664
MAPS of RENEWABLE ENERGY AND CLIMATE RISK

These publications and reports touched on the laboratories' respective expertise and on specific societal areas of concern in coordination with the MO collaboratories. A more detailed list is shown in Chapter 3 of this Annual Report.

1 RESEARCH ACTIVITIES

Science Laboratories

MO has five laboratories engaged in different and overlapping areas of scientific research. The newest to be created in 2021 is the Data and Sensor Development Laboratories. These laboratories are:

Regional Climate Systems (RCS), which does research on high-resolution climate change science and weather extremes using numerical modeling and data analysis to provide the science for climate resilience planning and adaptation, and disaster risk mitigation.

Geomatics for Environment and Development (GED), which applies remote sensing and geographic information systems (RS-GIS) to map social and environmental information that is needed to guide the sustainable development agenda of local communities.

Data and Sensor Development (DSD), which works on sensor development, data-management, systems integration, and data analytics research. DSD develops, operates, and maintains scientific instruments for environmental observations in coordination with the other laboratories.

Air Quality Dynamics (AQD), which aims to provide scientific guidance to air quality assessment and mitigation policy development through monitoring and modeling activities that form the scientific basis of effective air quality management.

Solid Earth Dynamics - Upper Atmosphere Dynamics (SED-UAD), which studies the behavior of electromagnetic radiation in the ionosphere and possible interactions with the lithosphere, magnetosphere, and heliosphere.

Aside from the five laboratories, MO also has two collaboratories that connect the science being done by the research laboratories to societal concerns. These are:

Resilience Collaboratory, which aims to promote the uptake and application of climate and disaster science in adaptation and climate resilient development, through stakeholder engagement in transdisciplinary research.

Energy Collaboratory, which serves as the policy arm of MO and is engaged in renewable energy knowledge production and management, energy access and energy information, policy and decision support for advocacy, education, and capacity building.

Three major research projects jointly undertaken by laboratories and collaboratories were the following:

1 **Access to Sustainable Energy Programme-Clean Energy Living Laboratories (ASEP-CELLs)**

ASEP-CELLs aims to achieve 100% rural electrification through renewable energy, and increase the share of renewable energy in the Philippines. Started in 2019, this project is funded by the European Union and implemented by the Ateneo School of Government, in partnership with MO, ICLEI-Local Governments for Sustainability - Southeast Asia Secretariat, Xavier University, and University of San Carlos. Term: 2019 to 2022.

2 **USAID Philippines Safe Water Project**

The USAID-funded Philippines Safe Water Project was executed by DAI in 2019. The purpose of this five-year initiative is to improve water security in water-stressed communities in the Philippines. It is envisioned that after five years, local government units, water service providers, and watershed councils in selected areas will have the information, incentives, and partnerships to identify and address barriers to a water-secure future. Term: 2019 to 2024.

3 **High Definition Clean Energy, Climate, and Weather Forecasts (ECW)**

This project aims to produce hourly clean energy and weather forecasts on a daily basis over the Philippines. Data from the Automated Weather Stations (AWS) of MO coupled with other satellite-based information are used to validate and improve these forecasts. Furthermore, existing local climate projections over the Philippines will be continually updated and incorporated into risk assessments to help vulnerable communities adapt to global climate change. Term: 2021 to 2026.

1 RESEARCH ACTIVITIES

Summary of activities & accomplishments

1 Regional Climate Systems

In 2021, the RCS Laboratory conducted local- and national-scale analyses of climate projections in the Philippines to examine future changes in climate including climate extremes, which will have impacts on renewable energy, water, infrastructure and cities. The RCS Laboratory also continued its efforts in generating and improving weather forecasts and climate projections at higher spatial resolutions to address the needs of end-users. Through ongoing collaboration with local and international research partners, RCS has produced 11 international journal publications, one technical report, as well as six book chapters mostly as part of Climate Change 2021: The Physical Science Basis (Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change). Research output has also been shared through virtual scientific conference presentations, as well as through online briefings and workshops with stakeholders.

2 Geomatics for Environment and Development

From 2020 to 2021, the GED Laboratory was involved in three projects, namely: (a) **ASEP-CELLs**, specifically, the process-oriented development of the Renewable Energy Decision Support System (RE DSS) which has led to the generation of 1,103 maps and five peer-reviewed working papers; (b) **ADB TA-9700**, in particular, the generation of 2,561 maps and various knowledge products for the Climate Risk Screening Decision Support System (CRS DSS), and (c) **USAID Philippines Safe Water Project**, which entailed the production of hazard, exposure and vulnerability (HEV) maps as well as reclassified land cover for five watersheds. In addition, a research monograph was published for the Philippine Center for Population and Development, in collaboration with the Office of Population Studies of the University of San Carlos.

3 Data and Sensor Development

As the newest laboratory established in October 2021, the DSD Laboratory has been working with other laboratories in areas such as weather data compilation and analysis, clean energy resource assessments, laboratory database and computing requirements. It has reconditioned 32 Lufft Automated Weather Stations (AWS) that are located within the National Capital Region, Region 3, and Region 4-A. Optimizations for running the Weather Research and Forecasting (WRF) model have been done on the two compute servers that are being utilized for daily weather forecasts. The database server for weather station data has been set up to facilitate internal access and quality assurance of weather observation data measured by the operational AWS. Real-time data from the AWS has been made accessible to the public by redesigning the Panahon website.

4 Air Quality Dynamics

As part of ASEP-CELLs, the AQD Laboratory was involved in quantifying the emission, transport, and dispersion of air pollution from a given coal-fired power plant in Cagayan de Oro. In another study, ambient levels of black carbon (BC) at the Port of Manila and at along East Avenue, Quezon City were measured. Also assessed were aerosol size distributions, BC mass concentration and chemical composition. Moreover, BC levels were compared for two jeepney routes in Quezon City. Median concentrations in both routes were found to be over three times higher than those reported in the US or Europe. The AQD Laboratory continued to provide ground-based meteorological and aerosol observations for the Cloud, Aerosol, Monsoon Processes Philippines Experiment. From these and other projects, five journal articles and two technical reports were produced.

5 Solid Earth Dynamics - Upper Air Dynamics

In October 2021, the SED-UAD Laboratory started a new project to study the behavior of the equatorial ionosphere in collaboration with the University of Colorado and the National Central University in Taiwan. In collaboration with colleagues from Kyushu University, SED-UAD continues to contribute to space weather studies through the hosting of magnetometers in various sites in the country. The Laboratory's ionospheric research has provided subject matter for the theses of several students from the ADMU Physics Department.

6 Resilience Collaboratory

In 2021, the Resilience Collaboratory conducted transdisciplinary research on climate and disaster risks with the Bataan Provincial Government and Bataan Peninsula State University under the Climate and Disaster Risk Assessment (CDRA) coaching and mentoring project, and with the watershed communities and councils of Bago and Malogo (Negros Occidental), Montible (Puerto Princesa City, Palawan), and Buayan-Malungon and Siguel (Sarangani) under the USAID Safe Water Project. Aside from virtual discussions that were held, three technical reports and one journal publication were also produced. The Resilience Collaboratory also organized and participated in various local and international outreach activities to engage diverse stakeholders (e.g. media, youth, academia, policy-makers) in important discussions surrounding climate change and how it stands to affect highly vulnerable communities in the Philippines.

7 Energy Collaboratory

Under the ASEP-CELLs Project, Energy Collaboratory produced three policy papers and two policy notes related to clean energy. As part of the Communication for COP and Just Transition, MO through this collaboratory is part of a consortium headed by the World Resources Institute. It was also a participant in the COP26 side event "How the COP26 Package Can Drive Ambition and Resilience With Solidarity and Justice". As the secretariat of OurEnergy2030, the Collaboratory's primary role is to communicate the transition to renewable energy and tools needed for its just transition. The Climate Justice Capacity Initiative was also established by the Energy Collaboratory in collaboration with Ateneo Law schools to enhance environment, energy, and climate law practice in the Philippines through capacity building, climate and environmental justice assistance, and policy and advocacy.

1 RESEARCH ACTIVITIES

Regional Climate Systems

SUMMARY

In 2021, the Regional Climate Systems (RCS) Laboratory conducted local- and national-scale analyses of climate projections in the Philippines to examine future changes in climate, including climate extremes, which will have impacts on renewable energy, water, infrastructure and cities. The RCS Laboratory also continued its efforts in generating and improving weather forecasts and climate projections at higher spatial resolutions to address the needs of end-users. Through ongoing collaboration with local and international research partners, RCS has produced 11 international journal publications, one technical report, as well as six book chapters, mostly as part of Climate Change 2021: The Physical Science Basis (Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change). Research output was also been shared through online briefings and workshops with stakeholders.

ASEP-CELLs

Regional or fine-scale climate projections were processed to examine future changes in climate variables relevant to solar, hydro and wind energy applications over the Philippines. This information was used in the risk analyses done by the GED Laboratory under this project. Results have been presented at an international conference, an international workshop, and to project funders. Climate downscaling simulations have also been done for the Cagayan de Oro site in collaboration with the AQD Laboratory for their dispersion modeling.

USAID Philippines Safe Water Project

Climate projections were used to describe the climate profiles of five watersheds, namely the Buayan-Malungon River Basin, Siguel Watershed, Bago Sub-Watershed, Malogo Watershed and Montible Sub-Watershed, as part of the preliminary risk analyses led by the Resilience Collaboratory in cooperation with the GED Laboratory.

Coordinated Regional Climate Downscaling Experiment - Southeast Asia (CORDEX-SEA)

The collaboration of MO with the CORDEX-SEA group continues under the second phase of the CORDEX-SEA project, “Southeast Asia Regional Climate Downscaling (SEACLID)/ CORDEX Southeast Asia Phase 2: High-resolution Analysis of Climate Extremes Over Key Areas in Southeast Asia”, with funding support from the Asia-Pacific Network for Global Change Research (APN). ***Started in 2017, this project aims to generate higher resolution climate change scenarios at 5-km resolution to examine climate extreme events over key areas in Southeast Asia, which have been identified based on exposure and vulnerability to climate extremes, in consultation with stakeholders.*** Mindanao was the chosen domain for the Philippines due to the high vulnerability of its population and agricultural economy to future climate change, particularly extreme events. In 2021, the 5-km resolution runs over Mindanao for the baseline (1971-2005) and far future (2079-2099) periods have been completed with ongoing simulations for the near-future (2021-2050) period. Results of the analysis were presented in an online workshop last November 2021. Furthermore, preparation for the downscaling of projections from the Coupled Model Intercomparison Project Phase 6 (CMIP6) global climate models is underway.

Philippine Climate Extremes

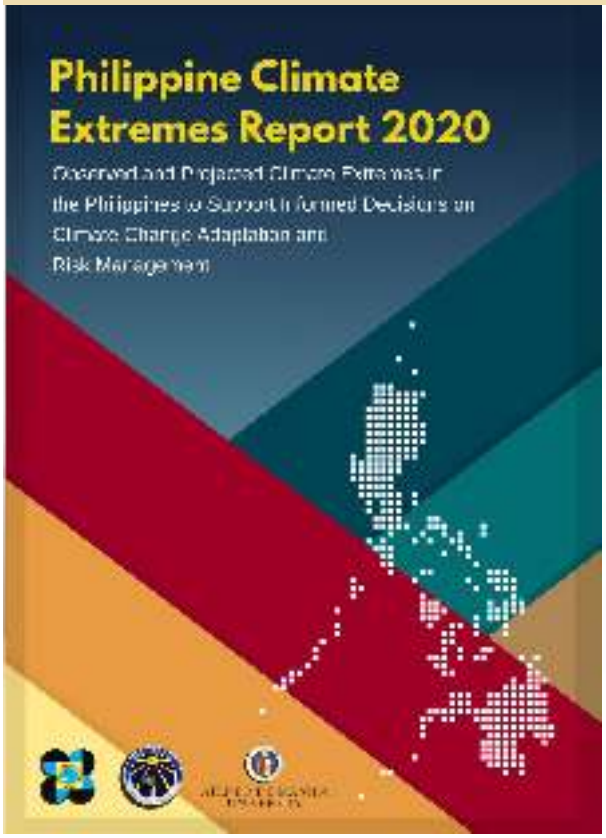
Among the projects that concluded in 2021 is the program "Analyzing CORDEX-SEA Regional Climate Simulations for Improved Climate Information over the Philippines: SST Influence, Variability and Extremes, Tropical Cyclone Activity" funded by the Department of Science and Technology - Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD). Started in 2018, this collaboration among MO, the Ateneo de Manila University (ADMU), and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (DOST-PAGASA) consisted of three projects, namely:

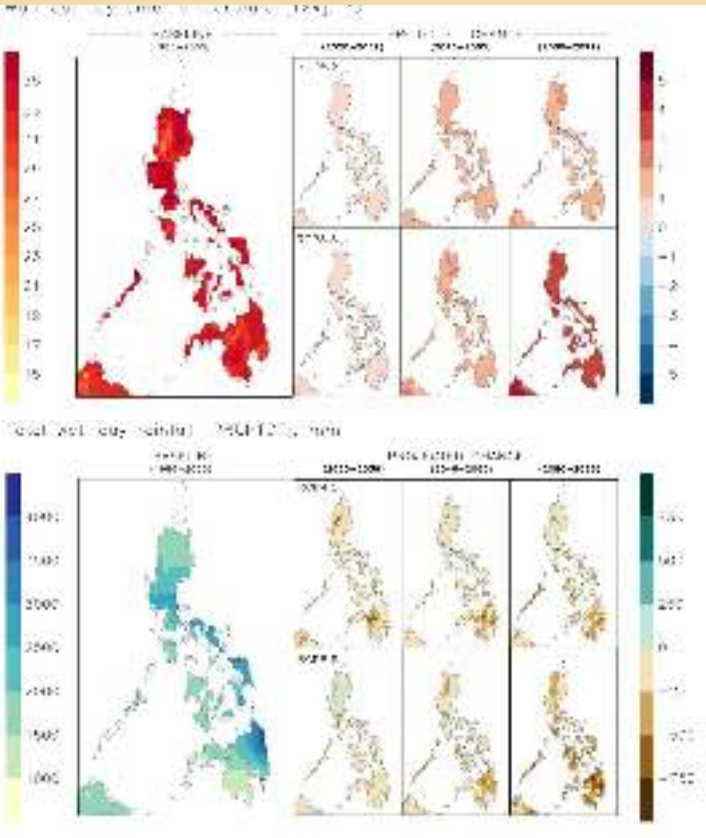
1. **Analysis of the Influence of Sea Surface Temperature (SST) Representation in Downscaled Regional Climate Using the SEACLID/ CORDEX-Southeast Asia Simulations**

2. **Multitemporal and Extremes Analysis of Modeled Climatology Over the Philippines in the SEA-CORDEX Domain**

3. **Detecting Tropical Cyclones in a Downscaled Regional Climate Model for CORDEX-SEA**

Sample maps of climate extremes indices from the Philippine Climate Extremes Report 2020





In this program, climate simulations over the Philippines from the SEACLID/CORDEX-SEA Phase 1 Project and from DOST-PAGASA were consolidated to create a 12-member multi-model ensemble.* These were then examined to understand relevant climate processes and their representation in climate models, and to characterize future changes, particularly in climate extremes. Projected changes in climate extreme indices based on temperature and rainfall under two Representative Concentration Pathways (RCP4.5 and RCP8.5) were documented in the "Philippine Climate Extremes Report 2020"[1]. This report was officially launched online last November 26, 2021. Data and maps can be accessed via an online interactive map[2]. These climate change projection scenarios can be used to support research on sectoral impacts, and policies for climate change adaptation and risk mitigation. Other research findings from this program have been documented in international peer-reviewed journal publications.

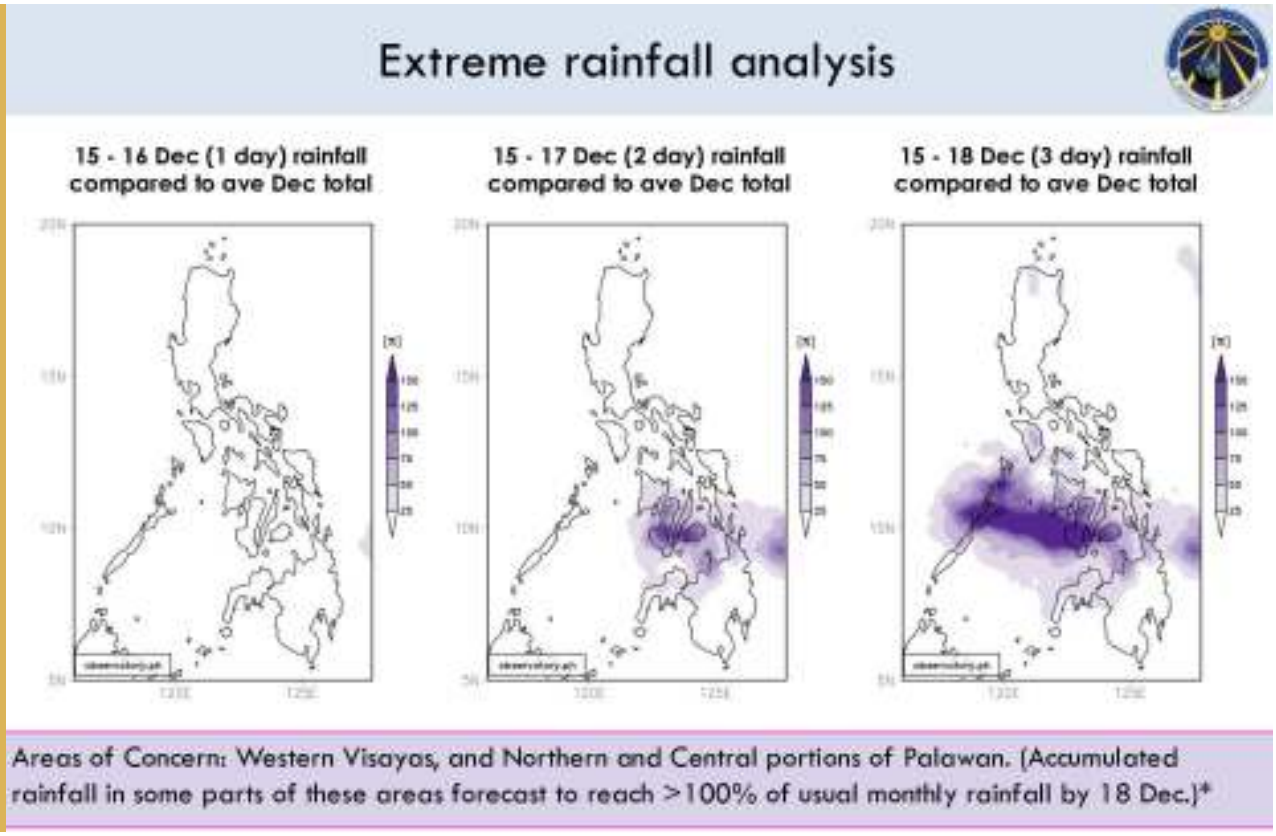
Local Climate Projections

A subset of the high resolution climate projections from the SEACLID/CORDEX-SEA Phase 1 Project was also analyzed in several projects that ended in 2021, in response to the needs of different stakeholders in the Philippines. In the Coastal Cities at Risk in the Philippines: Investing in Climate and Disaster Resilience Project (CCARPH), climate data for Metro Manila, Naga City and Iloilo City were examined to characterize the climate-related hazards that place these cities at risk, and used as input for the Climate and Disaster Risk Assessment (CDRA) led by the Resilience Collaboratory. Projected changes in rainfall and temperature were also analyzed for a climate change screening study for six river basins, namely Apayao-Abulug, Abra, Jalaur, Agus, Buayan-Malungon, Tagum-Libuganon, under the Infrastructure Preparation and Innovation Facility (IPIF) - 02 Water (Flood Control) Project.

**Resulting from a combination of three Regional Climate Models or RCMs forced with ten Coupled Model Intercomparison Project Phase 5 (CMIP5) General Circulation Models or GCMs.*

High Definition Clean Energy, Climate, and Weather Forecasts (ECW)

The RCS Laboratory continues its weather and climate research under the ECW Project. ***An automated weather forecast system was set up to support clean energy forecasting for solar and wind energy, which continues to be developed and refined.*** Extreme weather bulletins have also been produced to provide information on tropical cyclones forecast to make landfall in the Philippines, which are then disseminated to project partners and also made public via the MO Facebook page (https://www.facebook.com/manilaobservatory) and the Panahon website (https://panahon.observatory.ph). In addition to the ongoing work in downscaling climate projections, climate data is analyzed to support research on extremes indices to aid forecast risk communication. Results from the ongoing data analysis for the Clouds, Aerosols, and Monsoon Processes-Philippines Experiment (CAMP2Ex) with the AQD laboratory can also be used in the ECW project.



Analysis of extreme rainfall forecast highlighting areas of concern from MO Extreme Weather Bulletin for Typhoon Rai (Odette) issued on Dec 2021, 11am PHT.

Narisma Memorial

In the midst of the continued COVID-19 pandemic in 2021, the first quarter of the year had been particularly difficult for MO—especially for the RCS Laboratory—with the passing of Dr Gemma Teresa T. Narisma, who was Executive Director of MO and former head of the RCS laboratory. Dr Narisma's passion and dedication to climate science and in delivering science to society have been a source of inspiration for the laboratory in continuing its mission. Publications of RCS, as well as the Climate e-Learning Hub[3], have been dedicated to her memory.

Plans are also underway for the 2022 Gemma Teresa Narisma Memorial Lecture on Climate and Society, which will hopefully be an annual event to celebrate and continue the work started by Dr Narisma in bringing science to society, particularly to vulnerable communities.

[1] https://www.observatory.ph/climateelearning/report; http://bagong.pagasa.dost.gov.ph/climate/climate-change/dynamic-downscaling
[2] https://bagong.pagasa.dost.gov.ph/climate/climate-change/dynamic-downscaling/climap
[3] https://www.observatory.ph/climateelearning

1 RESEARCH ACTIVITIES

Geomatics for Environment and Development

SUMMARY

From 2020 to 2021, the GED Laboratory was involved in three projects, namely: (a) ASEP-CELLs, specifically, the process-oriented development of the Renewable Energy Decision Support System (RE DSS) which has led to the generation of 1,103 maps and five peer-reviewed working papers; (b) ADB TA-9700, in particular, the generation of 2,561 maps and various knowledge products for the Climate Risk Screening Decision Support System (CRS DSS), and (c) the USAID Philippines Safe Water Project, which entailed the production of hazard, exposure and vulnerability (HEV) maps as well as reclassified land cover for five watersheds. In addition, a research monograph was published for the Philippine Center for Population and Development, in collaboration with the Office of Population Studies of

ASEP-CELLs

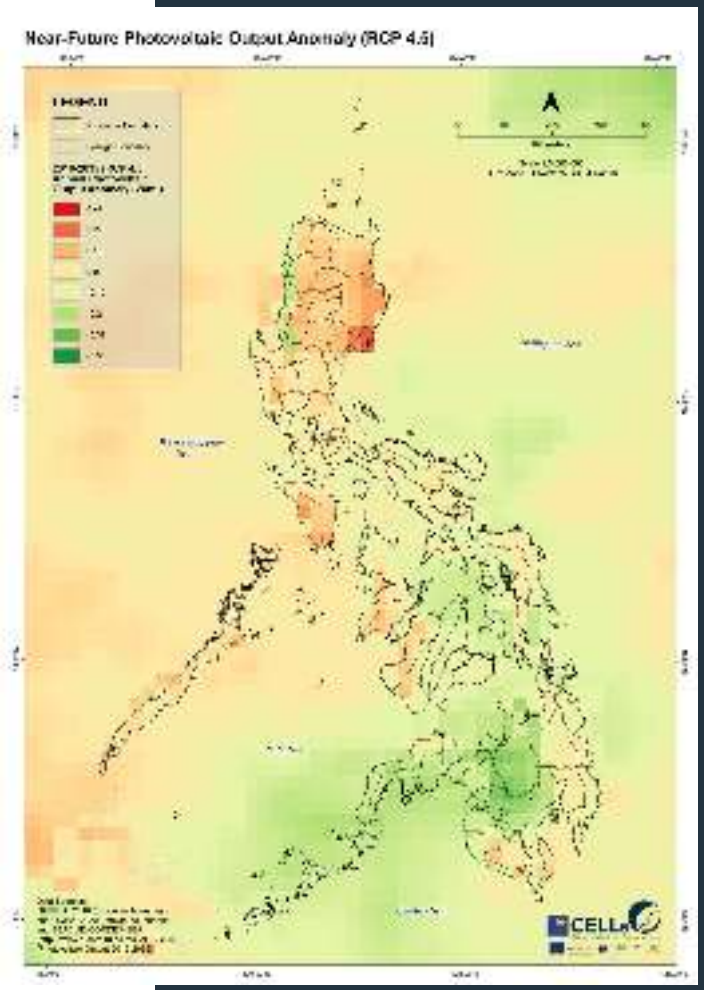
The development of a geomatics-based renewable energy decision support system (RE DSS) is one of the outputs expected of the GED Laboratory in this project. GED conceptualized and implemented the RE DSS in close coordination with the Department of Energy (DOE), a stakeholder of the ASEP-CELLs project. ***The main research thrust of the GED-led study is to map RE resource availability, site suitability, and the risks to these resources.*** The resulting RE DSS is process-oriented, given the need to facilitate the transition to greater use of renewables in the country. The application of remote sensing (RS) and geographic information (GIS) systems in developing the RE DSS contributes to the project's primary goals. These goals include increasing the share of RE in the Philippine energy mix, promoting energy efficiency and supporting sustainable development and inclusive growth.

1,103

TOTAL MAPS CREATED

hazards, exposures (resource availability), vulnerabilities, risks (to resources, facilities and systems, community and environment), site suitability, and climate

Sample map of potential changes in solar photovoltaic power density for the near-future (2016 to 2035) under RCP4.5 scenario. Values are relative to a baseline period (1986-2005).



A realignment meeting with the DOE - Renewable Energy Management Bureau (DOE - REMB) was initiated in June 2021 to further determine the objectives, design, and schedule of the map validationand strategic RE options workshop. Before the workshop proper, a preliminary activity with the agency was conducted. This involved the presentation of the RE DSS' interim results to obtain feedback on their relevance, validity, and usability. Furthermore, key informant interviews were conducted for the local case study in Naujan, Oriental Mindoro. These preparatory activities were followed by the national/regional and local map validation and strategic RE options workshops in October and November 2021. Feedback during these activities provided the team with essential insights on how to improve the maps and how these can be used by stakeholders in RE development and planning.

A total of five working papers were peer-reviewed and submitted. These are to be published solely in the project's research compendium. The Energy Consultant also presented the Philippine Renewable Energy Situationer. After drafting the initial outline for the technical/ descriptive narrative that would accompany the Renewable Energy Atlas, the team conducted monthly writing workshops. The first draft of the technical narrative was completed last December. The first draft of the working paper for the local case study was also submitted.

The maps were presented online to the European Union and project partners on September 17, 2021 in collaboration with the RCS Laboratory. The team also presented the risk and site suitability mapping results of the project in the International Council for Local Environmental Initiatives (ICLEI) webinar on sustainable energy best practices. MO also participated in the Accomplishments Presentation Event entitled, "A Transverse to a Brighter and Cleaner Philippines" last December 2021.

Sustaining Climate and Disaster Risk Resilient and Low Carbon Development in South Asia (ADB TA-9700)

ADB South Asia developing member countries (DMCs) require achievement and sustenance of compelling economic growth towards poverty reduction, fulfillment of the Sustainable Development Goals (SDGs) and multisectoral resilience in an age of intensified climate change and disaster risks. ADB's South Asia Department (SARD) is supportive of climate change mitigation, enhancing climate and disaster resilience, environmental sustainability, and reinforcing governance and institutional structures.

Pipeline projects mainstream strategic climate adaptation and mitigation options addressing risks, posed by climate change, extreme events, and natural hazards. SARD ensures this through:

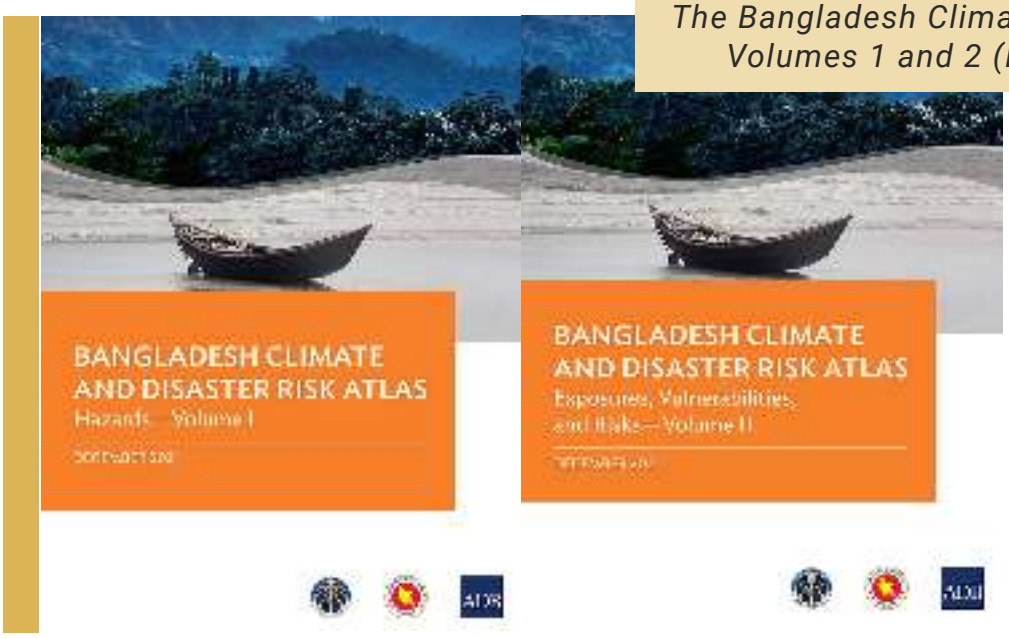
- **development of a remote sensing-geographical information system (RS-GIS) -based climate and disaster risk resilience decision support system,**
- **climate and disaster risk screening of, and climate finance estimation for, pipeline projects, and**
- **preparation and publication of knowledge products (Interim Report, 01/2022).**

Project funder is ADB SARD TA-9700. The term is from March 2019 to September 2022.

2,561 **MAPS *(hazards, exposure, vulnerabilities, risks, impacts, and climate data)* were produced as of December 2021 for *Bangladesh, Bhutan, India, Nepal, and Sri Lanka*.**

The downloading of data from secondary sources and the creation of the corresponding spatial databases were also completed last year. The former included climate data from CORDEX South Asia.

Maps were prioritized for the two-volume "Bangladesh: Climate and Disaster Risk Atlas", which was published in December 2021. In 2021, the ADB SARD also decided to publish a short Mountain Region Report entitled "Climate Change Risk Profile of the Mountain Region of Sri Lanka", which features eight maps. This is to be published in time for the ADB Annual Meeting to be hosted by the Government of Sri Lanka in May 2022. A longer Sri Lanka Mountain Region Report is underway, which will include 31 maps.



The Bangladesh Climate Risk Atlas, Volumes 1 and 2 (Dec 2021)

USAID Philippines Safe Water Project

In this project, the GED Laboratory contributed to the layout of base maps, the reclassification of land cover and the mapping of annual climate scenarios (from RCS Laboratory) in five watersheds, namely: Buayan-Malungon River Basin, Siguel Watershed, Bago Sub-Watershed, Malogo Watershed and Montible Sub-Watershed. GED together with Resilience Collaboratory led the preliminary risk analyses based on selected maps of hazard, exposure and vulnerability (H,E,V).

1 RESEARCH ACTIVITIES

Data and Sensor Development

SUMMARY

As the newest MO Laboratory established in October 2021, the DSD Laboratory has been working with other laboratories in areas such as weather data compilation and analysis, clean energy resource assessments, laboratory database and computing requirements. It has reconditioned 32 Lufft Automated Weather Stations (AWS) that are located within the National Capital Region, Region 3, and Region 4-A. Optimizations for running the Weather Research and Forecasting (WRF) Model have been done on the two compute servers that are being utilized for daily weather forecasts. The database server for weather station data has been set up to facilitate internal access and quality assurance of weather observation data measured by the operational AWS. Real-time data from the AWS has been made accessible to the public by redesigning the Panahon website.

The Data and Sensor Development (DSD) Laboratory was newly set up in October 2021. It was established from the former Instrumentation and Technology Development (ITD) Laboratory and with the transfer of information technology (IT) personnel from the Office of the Executive Director.

DSD is currently involved in the ECW Project together with the AQD and RCS Laboratories, and also handles the operation and maintenance of Automated Weather Stations (AWS) for the project.

Lastly, it is also responsible for developing the data management systems for MO projects, providing software optimizations for clean energy and weather forecasting, and web development.

High Definition Clean Energy, Climate, and Weather Forecasts (ECW)

DSD has been working on reconditioning the weather stations donated by Weather Philippines Foundation Inc (WPF). There are 32 Lufft AWS that are now operational — 31 are located at SM Malls and one in Pilipinas-Shell Foundation Inc Training Center in Pililla, Rizal. The AWS network that MO has been operating through Metro Weather, the Climate Resilience Network, and Ateneo partners is being maintained together with the AQD Laboratory. ***A database system has been developed for weather data from the different stations. Real-time weather observations are available at the Panahon website (https://panahon.observatory.ph).***

ECW web interface: https://panahon.observatory.ph/ecw

Metro Weather was a public-private partnership of Metro Manila Development Authority (MMDA), Chevron, MO, Globe Telecom, and ADMU that established a network of 30 AWS in Metro Manila. The Climate Resilience Network was a partnership between Shell Philippines Exploration B.V., Smart Communications, Inc., and MO that established an AWS network in select Shell depots and retail stations mostly in Cagayan de Oro City, Davao City/Davao Oriental, and Iloilo City.

Automated Weather Stations

The number of AWS to be operated and maintained by MO increased substantially in 2020 when WPF donated 163 Lufft weather stations. Prior to this, MO had been operating 96 weather stations around the country that were mostly located at partner sites, such as those of MetroWeather and the Climate Resilience Network. ***The maintenance of the 96-station network of MO was done by the former AQD-ITD Laboratory since weather monitoring is also important for air quality research.***

Due to pandemic restrictions, reconditioning the AWS network has been difficult. ***To date, there are 32 Lufft weather stations that have been reconditioned and six Davis weather stations that are still operational.*** The reconditioned AWS in SM Malls are located in Region 3, Region 4-A, NCR, and Rosales, Pangasinan. Initial discussion with Northwind was also done to facilitate the maintenance of the Lufft weather station in Bangui, Ilocos Norte.

32 **LUFFT WEATHER STATIONS**	SM Malls and Shell Training Center in Pililla, Rizal
6 **DAVIS WEATHER STATIONS**	MO premises, Caltex Station in Parañaque, Iloilo City Hall, and Xavier University

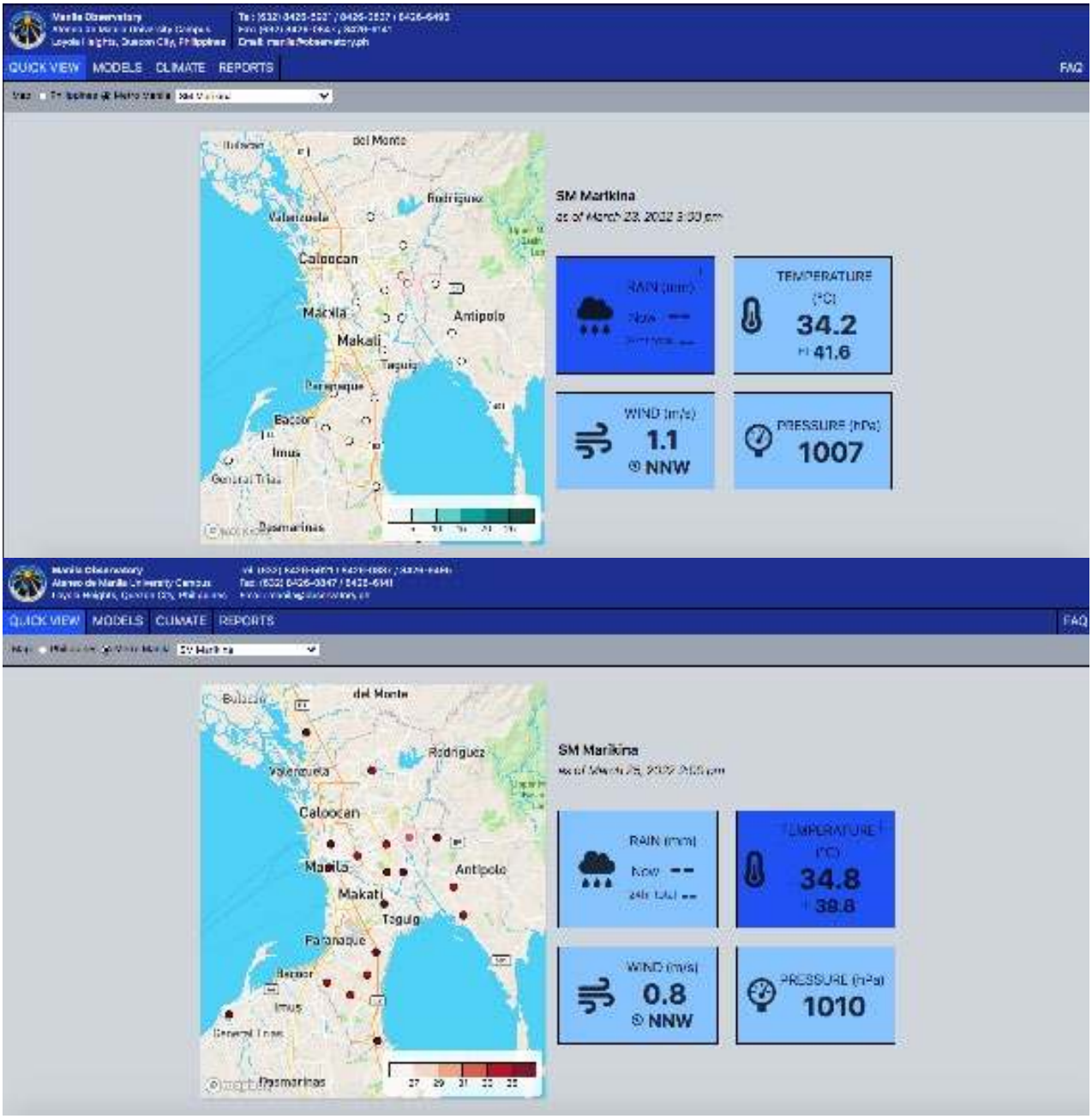
In order to hasten the reconditioning and ensure the long-term sustainability of the AWS network, project partners of ECW and research collaborators are being tapped for the regular maintenance of the weather stations. Several memoranda of agreement have been signed with partners such as SM, Ayala, and Shell. These three have shown interest in orienting their technical personnel on basic maintenance of weather stations. As such, on February 21, 2022, Pilipinas Shell Foundation Inc. (PSFI) organized an onboarding event for their people who are involved in the project. The project team discussed the importance of the project and how it can benefit their business units as well as the local communities in their vicinity. It was also conveyed that the ECW project is the continuation of the Climate Resilience Network project with Shell Philippines Exploration B.V. and Weather Philippines Foundation Inc AWS network.

Xavier University (XU) and Ateneo de Davao University (AdDU) have also expressed interest in the ECW Project and wish to pursue studies related to the project, in addition to helping with the operation and maintenance of the AWS network in their areas. A formal agreement has been made with XU for this collaboration and the agreement with AdDU is being formalized through the Center for Renewable Energy and Appropriate Technologies (CREATE) and Tropical Institute for Climate Studies (TropICS).

Reconditioning of Lufft weather station at SM Malls

Computing and Information Systems

The ECW project has obtained two compute servers for clean energy, climate, and weather forecasting. Each server has a 96-core computing capacity and is optimized for running the Weather Research and Forecasting (WRF) Model. Daily model runs have been automated to generate the forecasts. The forecasts from these servers are processed and uploaded to the ECW project website (https://panahon.observatory.ph/ecw).



Real-time weather data at select locations (https://panahon.observatory.ph)

Some of the servers in MO have been repurposed to be the web server for the ECW project and data processing. These have been essential in the automation of simulations for forecasting and retrieving data from weather station observations. Cloud-based systems such as Linode are also being used for redundancy of web servers and for processing short messaging service (SMS) from Lufft weather stations through the Globe Labs systems. A database server for weather station data has been set up using the AQD network-attached storage (NAS) systems for consolidating data management of scientific data in MO. The database currently stores weather observations every ten minutes from the 32 Lufft weather stations.

To view the real-time data from the AWS, the Panahon website has been redesigned. It is now able to access the database and post real-time station readings on the web. A new website for the weather and clean energy forecasts is now also available with a simple interface aimed for the general public. A development page for model runs and a station database management page have also been created internally for system evaluation and maintenance.

1 RESEARCH ACTIVITIES

Air Quality Dynamics

SUMMARY

As part of ASEP-CELLs, the AQD Laboratory was involved in quantifying the emission, transport, and dispersion of air pollution from a given coal-fired power plant in Cagayan de Oro. In another study, ambient levels of black carbon (BC) at the Port of Manila and along East Avenue, Quezon City were measured. Also assessed were aerosol size distributions, BC mass concentration and chemical composition. Moreover, BC levels were compared for two jeepney routes in Quezon City. Median concentrations in both routes were found to be over three times higher than those reported in the US or Europe. The AQD Laboratory continued to provide ground-based meteorological and aerosol observations for the Cloud, Aerosol, Monsoon Processes Philippines Experiment. From these and other projects, five journal articles and two technical reports were produced.

ASEP-CELLs

This study aims to quantify the emission, transport, and dispersion of air pollution from a given coal-fired power-generating facility located in Cagayan de Oro (CDO). Two analyses from receptor and dispersion modeling were done.

Particulate matter (PM2.5) samples were collected in Brgy. Alae, Bukidnon from February 24 to May 3, 2021. The sampling site was located about 20 km from two coal-fired power plants in Villanueva, Misamis Oriental, namely STEAG State Power Inc and Filinvest Development Corporation Utilities Inc. Filter samples were analyzed for mass, elemental species, BC content, and water-soluble ions. Daytime (7:00 am - 7:00 pm) and nighttime (7:00 pm - 7:00 am) sampling enabled the characterization of diurnal differences in the level of different chemical components of PM. Initial results showed that 87% (121 out of 138) of the total number of samples had PM levels exceeding the 24-hour WHO guideline value. PM2.5 mass and BC showed higher concentration at night, while secondary aerosols and crustal-related elements had higher levels at daytime.

Top left: Assembly preparation of the Davis automated weather station (AWS)
Top right: Configuration and set-up of the AWS console
Bottom left: Installation of two Tactical Air Samplers (TAS) for daytime and nighttime PM2.5 measurements
Bottom right: Demonstration of how the instruments work to barangay officials (Brgy. Alae, Manolo Fortich, Bukidnon)

For dispersion modeling, the dispersion of pollutants from the two power plants was simulated using CALPUFF. This complemented the receptor modeling results since it showed where and how these pollutants were dispersed from the power plants. The simulation was initially run in March 2021, but the final model run was from April 2020 to April 2021. These runs gave an idea of average concentrations of the pollutants, as well as the concept of intake fraction (i.e. the fraction of emitted pollutants that is inhaled by people) which is used to determine exposure. Initial results indicated that the pollutant concentrations were strongly affected by the diurnal sea breeze and that nearby population centers (e.g. CDO and Villanueva) accounted for most of the intake fraction.

Clean Air for a Sustainable Future: A Transdisciplinary Approach to Mitigate Emissions of Black Carbon in Metro Manila, Philippines (TAME-BC)

Metro Manila experiences high levels of air pollution, which are a threat to both human health and the environment. Previous studies have shown unusually high black carbon (BC) concentrations in the megacity. Black carbon, a component of PM2.5, is known to be capable of absorbing harmful substances and depositing them deep within the respiratory tract.

The AQD Laboratory worked on two of four TAME-BC work packages of the project:

WP 1: BC levels at the Port of Manila and at East Avenue, Quezon City were measured using a container laboratory from our partners at Leibniz Institute for Tropospheric Research. Quantities measured included aerosol particle size distributions, BC mass concentrations, and chemical composition.

WP 2: Spatiotemporal distributions of BC were obtained and compared for two Public Utility Jeepney (PUJ) routes in Quezon City from January to February 2020. One PUJ route is characterized by heavy traffic in the city center (Arayat-QMC route), while the other route is situated inside a state university campus (University of the Philippines - Diliman). Since little is known about the health effects of prolonged exposure to BC, the results of this analysis are expected to feed into the simultaneous study at the Lung Center of the Philippines to determine the health impacts of such exposures on the participating PUJ drivers.

For the whole sampling period in each route, concentrations in the city route had a median of 50.4 µg m^{-3}, with an interquartile range (IQR) of 27.49 µg m^{-3} to 87.85 µg m^{-3}; while concentrations in the university route had a median of 31.0 µg m^{-3}, with an IQR from 41.53 µg m^{-3} to 53.72 µg m^{-3}. Median concentrations found in both routes were over three times higher than those reported in the US or Europe. The spatiotemporal patterns of BC were associated with route conditions that increase traffic density, such as vehicle volume and anthropogenic activity within the area.

Among the challenges encountered were learning to use sampling instruments supplied by partners from Leibniz Institute for Tropospheric Research (TROPOS), optimizing data analysis, coordinating our sampling with partners from different groups, and learning to integrate transdisciplinary perspectives into our work.

Top left: TROPOS mobile sampling backpack containing aethalometer, dryer, computer, and particle counter
Top right: Typical sampling setup inside the jeepney with intake pointed towards the driver
Bottom left: Sampling position including the driver
Bottom right: Used masks after one whole day of sampling (about 6-8 hours outdoors)

Cloud, Aerosol, and Monsoon Processes-Philippines Experiment (CAMP2Ex)

The Cloud, Aerosol, Monsoon Processes Philippines Experiment (CAMP2Ex) and CAMP2Ex IMPACT-PH provided intensive meteorological and aerosol in-situ and remote sensing observations over the Philippines in the tropics since 2018. CAMP2Ex IMPACT-PH, as the ground-based observation field campaign funded by Ateneo SOSE ARISE, continued to measure and analyze aerosol properties from state-of-the art instruments. These instruments include the following:

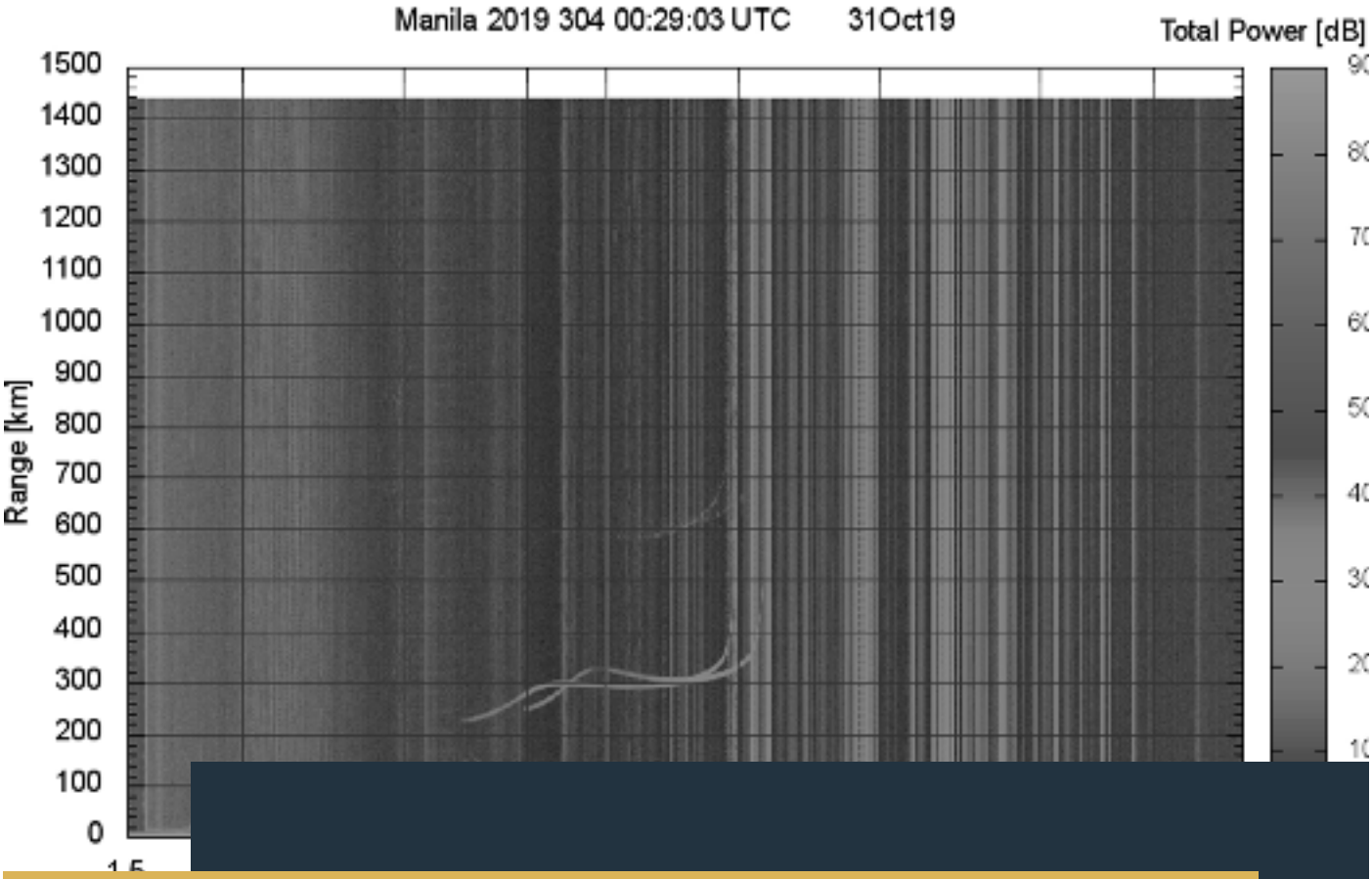
1. **Sunshine Pyranometers, Solar Spectral Flux Radiometer (SSFR) from US NRL and University of Colorado**
2. **Disdrometer, All-sky Camera, Beta Attenuation Monitor, DustTrak, Tactical Air Sampler (TAS), Particle Soot Absorption Photometer (PSAP) from US NRL**
3. **High Spectral Resolution Lidar (HSRL) from University of Wisconsin-Madison**
4. **Micro-Orifice Uniform Deposit Impactor (MOUDI) from University of Arizona**

The measurements from MOUDI provided a unique dataset that enabled size-resolved characterization of PM, and the examination of several topics related to PM chemistry and its implications. Several papers were produced using the MOUDI dataset, which were collected from July 2018 to February 2021. On the other hand, the HSRL measurements provided the first in-depth seasonal and diurnal characterization of cirrus clouds as well as vertical information on the extent of pollution in Metro Manila. Results were presented at the CAMP2Ex Science Team Meeting last September to October 2021.

Top left: High Spectral Resolution Lidar (HSRL)
Top right: Disdrometer
Bottom left: Sunshine Pyranometers, Solar Spectral Flux Radiometer (SSFR)
Bottom right: Tactical Air Sampler (TAS)

1 RESEARCH ACTIVITIES

Solid Earth Dynamics-Upper Atmosphere Dynamics



SUMMARY

In October 2021, the SED-UAD Laboratory started a new project to study the behavior of the equatorial ionosphere in collaboration with the University of Colorado and the National Central University in Taiwan. In collaboration with colleagues from Kyushu University, SED-UAD continues to contribute to space weather studies through the hosting of magnetometers in various sites in the country. The Laboratory's ionospheric research has provided subject matter for the theses of several students from the ADMU Physics Department.

Equatorial Plasma Bubbles over Manila

This study looks at the dynamics of the equatorial ionosphere at 120°E longitude between Taiwan and the Philippines and focuses on the formation of Equatorial Plasma Depletions, which leads to ionosphere plasma structuring and causes scintillation of radio waves passing through this region of the ionosphere.

This is a cooperative international research project involving the University of Colorado, the National Central University in Taiwan, and MO in the Philippines. From March to August 2021, the research proposal application requirements were completed and submitted to the Office of Naval Research and it was approved on October 6, 2021.

The project duration is for three years from October 1, 2021 to September 30, 2024. The principal investigator is Dr. Justin Mabie of the Cooperative Institute for Research in Environmental Sciences (CIRES) Research and Innovation Office of the University of Colorado with Dr. Terence Bullet as research scientist. Mr. Clint Dominic Bennett is the sub-principal investigator.

Magnetic Data Acquisition System (MAGDAS)

The UAD continues to host MAGDAS magnetometers from the International Center for Space Weather Science and Education (ICSWSE) of Kyushu University. These instruments are housed in Davao and Muntinlupa.

UNDERGRADUATE THESES

Ionospheric physics-related thesis work is ongoing with Dr. Quirino Sugon Jr. and undergraduate physics students from the ADMU Department of Physics. They are:

1. **Maria Cheska Pabilona, Undergraduate Student, 4 BS PS, "Taal Volcano Eruptions of Jan 12, 2020: Spectrogram Analysis of Traveling Ionospheric Disturbances (TIDs) at Muntinlupa and Davao MAGDAS Stations"**

2. **Jose Carlo Leyesa, Undergraduate Student, 4 BS APS-MSE, "Finding Magnetic Precursors to the 2010 Moro Gulf Quake via DBSCAN Analysis of MAGDAS Davao Data"**

3. **Christian Louie Cornista, 3 BS APS-MSE, "Multiple Reflections Inside Cylindrical Plasma Bubbles: Quantization Conditions For Antiparallel Incident and Backscattered Rays"**

2

SOCIETAL ENGAGEMENT

3 SOCIETAL ENGAGEMENT

Resilience Collaboratory

SUMMARY

In 2021, the Resilience Collaboratory conducted transdisciplinary research on climate and disaster risks with the Bataan Provincial Government and Bataan Peninsula State University under the CDRA coaching and mentoring project, and with the watershed communities and councils of Bago and Malogo (Negros Occidental), Montible (Puerto Princesa City, Palawan), and Buayan-Malungon and Siguel (Sarangani) under the USAID Philippines Safe Water Project. Aside from virtual discussions that were held, three technical reports and one journal publication were also produced. The Resilience Collaboratory also organized and participated in various local and international outreach activities to engage diverse stakeholders (e.g. media, youth, academia, policy-makers) in important discussions surrounding climate change and how it stands to affect highly vulnerable communities in the Philippines.

Climate and Disaster Risk Assessment: Coaching and Mentoring

To build the capacity of local governments and universities in the Philippines for conducting Climate and Disaster Risk Assessment (CDRA), the Resilience Collaboratory developed a Coaching and Mentoring module that avoids the traditional top-down expert-driven approach to risk assessment, and focuses on the need to increase stakeholder participation so as to facilitate learning. Through this module, a transdisciplinary approach to risk assessments is applied, which aims to engage local governments and universities as active partners in identifying local risk priorities and data needs, consolidating and validating geospatial data, mapping risk, analyzing climate and disaster risks, and formulating climate change adaptation and disaster risk reduction strategies. Experts from communities of practice also remain important partners in this transdisciplinary process, especially as they offer practical knowledge and experience that may enhance the understanding of risk, and facilitate the forging of evidence-informed action by different stakeholders.

In 2021, the Resilience Collaboratory carried out CDRA coaching and mentoring in Bataan Province. The RCS Laboratory provided downscaled climate projections for the province, while the GED Laboratory produced climate maps, while also guiding Bataan's Provincial Planning and Development Office in producing hazard - exposure - vulnerability (HEV) maps. Building on these data and tools, the Resilience Collaboratory developed processes for facilitating stakeholder engagement in risk assessment.

In particular, the Resilience Collaboratory designed and facilitated a participatory online integrated risk analysis workshop where, guided by HEV and climate maps, local stakeholders identified risk priority areas in Bataan province, explored the possible root causes of vulnerability, and enumerated appropriate climate change adaptation and disaster risk reduction options in the short-, medium- and long-term. Furthermore, it facilitated the co-production of the "Bataan Province Risk Profile" together with the 1Bataan Resilience Council and the NRC Technical Working Group. The report was turned over to the Provincial Government of Bataan in March 2022.

CDRA coaching and mentoring, March 2022. Ceremonial turnover of Bataan Province Risk Profile to Governor Albert Garcia.

Safe Water

MO carried out preliminary climate risk analyses for five watersheds under the Safe Water Project: Bago and Malogo (Negros Occidental), Montible (Puerto Princesa City, Palawan), Buayan-Malungon and Siguel (Sarangani). RCS produced downscaled climate projections for each watershed, while GED produced land cover, HEV and climate maps. Based on these various datasets and maps, the Resilience Collaboratory posed the following research questions:

1. **Which areas are most likely affected by the hazard?**
2. **Within these affected areas, what specific physical, social, environmental and economic elements exist?**
3. **Will average rainfall and temperature increase or decrease in the future?**
4. **How will climate change affect the nature of hazards and degree of disaster impacts?**

The results of the preliminary climate risk analysis were presented and validated through a series of webinars organized from February 2 to 4, 2021 for Negros Occidental, Puerto Princesa, and Sarangani. Participants included local stakeholders such as local governments, water service providers, and watershed communities.

During the webinars, MO outlined the basics of climate change, summarized projected changes in rainfall and temperature in the watersheds, introduced the risk framework, and presented the key findings of the preliminary risk analysis together with sample maps. Interactive polls and open discussions were also held with local stakeholders regarding changes they have observed in the local climate, and impacts they expect specifically on the water sector as a result of these changes. Through a breakout group activity, stakeholders were also asked to detail the potential direct and indirect impacts of climate change on their watershed, and to share their initial thoughts on possible adaptation options. Taking into account the inputs of local stakeholders from the webinars, MO produced a summary report detailing the results of the preliminary risk analyses.

MO through the Resilience Collaboratory also conducted a baseline assessment of climate information uptake and usability among local stakeholders from selected water service providers, watershed communities and councils, and local government units (LGUs) within the Safe Water Project sites. The questionnaire survey covered five key thematic areas: (1) socio-demographic profile of the local stakeholders; (2) their knowledge of and attitude toward climate change; (3) climate change adaptation and mitigation practices; (4) climate and water governance; and (5) climate information uptake and use. Based on the survey results, the Resilience Collaboratory produced a science communication plan for the project that outlined strategies for promoting climate information uptake and usability for a resilient water sector in the Philippines.

USAID Safe Water Project, February 2021.
Webinar series on climate risk in five watersheds.

OUTREACH ACTIVITES:

CONFERENCES

1. **Sustainability Research and Innovation Congress (SRI) 2021. L. Jamero as Early Career Champion for the theme "Resilience"**

2. **26th Session of the Conference of Parties. United Nations Framework Convention on Climate Change. Green Zone Exhibitor: "Racing the King Tide" (360 film on island resilience). Glasgow, UK, 2021. L. Jamero as film producer**

MEETINGS

1. **Meeting with the Ambassador of Canada to the Philippines on climate resilience and environmental sustainability. Cebu, Philippines. November 2021. L. Jamero as local interlocutor.**

2. **Local Conference of the Youth (LCOY) Philippines: 2021 National Meeting. Virtual. September 4, 2021. L. Jamero as keynote speaker.**

WEBINARS

1. **Highlights of the latest IPCC climate science report: A briefing by Manila Observatory Scientists. Virtual. August 20, 2021.**

2. **ASEAN Climate Leadership Program. October 2021. L. Jamero as mentor.**

3. **Promoting Climate Security in the 21st Century. Chiang Mai University. October 12, 2021. L. Jamero as resource speaker.**

4. **Climate Tracker Asia Round Table Discussion. Virtual. September 27, 2021. L. Jamero as resource speaker.**

5. **Oscar M. Lopez Center (OML Center) Climate Media Labs: Webinar 01 on Climate Change Impacts. Virtual. September 2, 2021. L. Jamero as resource speaker.**

6. **"MapaKalamidad.ph Women and Disasters: Perspectives from Government, Civil Society and Academe." Virtual. March 13, 2021. L. Jamero as resource speaker.**

3 SOCIETAL ENGAGEMENT

Energy Collaboratory

SUMMARY

Under the ASEP-CELLs Project, the Energy Collaboratory produced three policy papers and two policy notes related to clean energy. As part of the Communication for COP and Just Transition, the Collaboratory is part of a consortium headed by the World Resources Institute. It was also a participant in the COP26 side event "How the COP26 package can drive ambition and resilience with solidarity and justice". As the secretariat of OurEnergy2030, its primary role is to communicate the transition to renewable energy and the tools needed for its just transition. The Climate Justice Capacity Initiative was also established in collaboration with Ateneo Law schools to enhance environment, energy, and climate law practice in the Philippines through capacity building, climate and environmental justice assistance, and policy and advocacy.

ASEP-CELLs

The Energy Collaboratory was charged with the overall management of this project for MO and served as the information dissemination arm. Policy Papers and policy notes were produced for the use of partners and a research compendium is being prepared for present and future stakeholders. The following policy papers were produced:

1. **The Philippine Climate Change Commitments and the Energy Transition to a Low-Carbon Future;**
2. **Energy and Climate Nexus: The Contribution and Vulnerability of the Global and Philippine Energy Sector to Climate Change; and**
3. **Philippines Roadmap: Policies and Laws Needed to Reduce Greenhouse Gas Emissions Pursuant to its Nationally Determined Contribution**

These papers were accompanied by two policy notes on (i) Policy Energy Gap and (ii) Transitioning to Renewable Energy. In addition, two policy notes are currently being developed alongside the possibility for a cross-cutting policy paper which delves into the scientific research produced by the other laboratories. The climate papers have been likewise presented during the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) 26 last November 2021.

Alliance for Climate Transformation 2025 (ACT2025)

Through the Energy Collaboratory, MO is part of a consortium headed by the World Resources Institute (WRI), with partners from Asia, the Caribbean, Latin America, and Africa. In the first quarter of 2021, MO attended a consortium retreat which laid down the benchmarks of success and conducted a background press briefing in April 2021[4].

In July 2021, Dr. Tony La Viña as representative of MO was invited to speak at the Asia Pacific Climate Week Side Event of WRI Indonesia.

Throughout the year, relevant materials that contribute to the development of the communications advocacy of the consortium were provided, including publication of think pieces in Rappler[5]; a limited podcast series in preparation for the COP26 where Dr. Tony La Viña talked about Rules and Architecture[6] and the release of an Alliance Statement ahead of the UNGA and COP27.

The Energy Collaboratory also participated in the COP26 side event “How the COP26 Package Can Drive Ambition and Resilience with Solidarity and Justice”.

OurEnergy2030:

The Energy Collaboratory, representing MO, has been a member of this coalition since 2019. In 2020, it served as secretariat and main partner of the European Climate Foundation which hosts Tara, a regionally-led grant-making initiative to accelerate energy transformation in Asia. The primary role of OurEnergy2030 is to communicate the renewable energy transition and tools for its just transition. Digital products were created to align with OurEnergy2030's Core Demands in the areas of research and communications. In line with this, Design and Delivery of Leadership & Skills Deep-dive Training to Youth & Student Leaders were conducted. The first cohort is already done and is currently producing post-project activities such as technical outputs. This training has been delivered with coalition partners New Energy Nexus and ICLEI. LGU engagements are also in the pipeline. The second cohort will be held in 2022.

Support for Clean Energy Investment Accelerator (CEIA)'s Green Energy Option Program (GEOP) Sessions are also continuously being held. Also launched was the Vision 20/30 Platform, which is a tri-annual press conference for a multi-sectoral and bipartisan coalition for a decisive, coherent, and complete energy transformation in the Philippines. This platform fosters political engagement across national, local, and party-list leadership lines.

Climate Justice Capacity Initiative

This project is a collaboration with Ateneo Law Schools to enhance environment, energy, and climate law practice in the Philippines through legal education. It has three main elements: (1) capacity building; (2) climate and environmental justice assistance; and (3) policy and advocacy.

Memorandums of Agreement (MOAs) have been signed with Ateneo de Naga, Ateneo de Davao, Ateneo de Zamboanga, Ateneo de Manila, and Xavier University.

Currently, the Energy Collaboratory is preparing the Training Needs Assessment modules for the legal clinics. Baselines were provided from Focus Group Discussions with key informants from various sectors. Preparations of videos and other training materials for the legal clinics are also in the works.

[4] https://www.wri.org/initiatives/allied-climate-transformation-act2025
[5] https://www.rappler.com/voices/thought-leaders/opinion-imperatives-june-climate-negotiations/
[6] https://www.wri.org/initiatives/allied-climate-transformation-act2025/act2025-podcast

3 SOCIETAL ENGAGEMENT

Regional Climate Systems

ONLINE WORKSHOP, BRIEFING WITH STAKEHOLDERS

1. *CORDEX Southeast Asia Outreach and Capacity Building Workshop, 15-17 November 2021*

    a. *Oral presentation: "AR6 Report, Regional Atlas, CORDEX-SEA contributions and relevance to Southeast Asia", T. Ngo-Duc and F. Cruz*

    b. *Oral presentation: "Future Climate Extremes in the Philippines", F. Avila and T. Cinco*

    c. *Oral presentation: "Climate Change Impacts on Renewable Energy Resources in the Philippines", F. Cruz*

    d. *Oral presentation: "CORDEX-SEA 5km Simulations over Mindanao, Philippines", J. Dado*

2. *Philippine Climate Extremes Report Launch, 26 November 2021 (in collaboration with DOST-PAGASA, Ateneo de Manila University and the Climate Change Commission)*

3. *Participation of F. Cruz at the Approval Session of the IPCC AR6 WGI, 26 July - 6 August 2021, and in regional events hosted by the IPCC at the UN Climate Change*

INTERNSHIPS

1. *Five BSc Applied Physics students of the Department of Physics, Ateneo de Manila University, 28 June - 6 August 2021*

2. *L. Olaguera, J. Dado and F. Avila as resource speakers for the short course on Introduction to Numerical Weather Prediction, College of Science, Bicol University, July 2021*

3

RESEARCH OUTPUT

2 RESEARCH OUTPUT

Regional Climate Systems

JOURNAL PUBLICATIONS

1. *Olaguera, L. M., J. Matsumoto, J. M. B. Dado, and G. T. T. Narisma, 2021. Non-Tropical Cyclone Related Winter Heavy Rainfall Events Over the Philippines: Climatology and Mechanisms. Asia Pacific Journal of Atmospheric Sciences. https://doi.org/10.1007/s13143-019-00165-2.*

2. *Tibay, J., F. Cruz, F. Tangang, L. Juneng, T. Ngo-Duc, T. Phan-Van, J. Santisirisomboon, P. Singhruck, D. Gunawan, E. Aldrian, and G. T. Narisma, 2021. Climatological Characterization of Tropical Cyclones Detected in the Regional Climate Simulations Over the Cordex-Sea Domain. International Journal of Climatology. https://doi.org/10.1002/joc.7070.*

3. *Villafuerte, M. Q. II, J.C.R. Lambrento, K.I. Hodges, F.T. Cruz, T.A. Cinco, G.T. Narisma, 2021. Sensitivity of Tropical Cyclones to Convective Parameterization Schemes in RegCM4. Climate Dynamics. https://doi.org/10.1007/s00382-020-05553-3.*

4. *Magnaye, A.M.T., Narisma, G.T., Cruz, F.T., Dado, J.M.B., Tangang, F., Juneng, L., Ngo-Duc, T., Phan-Van, T., Santisirisomboon, J., Singhruck, P. and Gunawan, D., 2021. Potential Influence of Sea Surface Temperature Representation in Climate Model Simulations over CORDEX-SEA Domain. International Journal of Climatology. https://doi.org/10.1002/joc.7440.*

5. *Bañares, E., G. T. T. Narisma, J. B. B. Simpas, F. T. Cruz et al., 2021. Seasonal and Diurnal Variations of Observed Convective Rain Events in Metro Manila, Philippines. Atmospheric Research. https://doi.org/10.1016/j.atmosres.2021.105646.*

6. *Manalo, J.A., Matsumoto, J., Takahashi, H.G., Villafuerte, M.Q., Olaguera, L.M.P., Ren, G. and Cinco, T.A., 2021. The Effect of Urbanization on Temperature Indices in the Philippines. International Journal of Climatology. https://doi.org/10.1002/joc.7276.*

7. *Olaguera, L.M.P., Caballar, M.E., De Mata, J.C., Dagami, L.A.T., Matsumoto, J. and Kubota, H., 2021. Synoptic Conditions and Potential Causes of the Extreme heavy rainfall event of January 2009 over Mindanao Island, Philippines. Natural Hazards. https://doi.org/10.1007/s11069-021-04934-z.*

8. *Olaguera, L.M.P., Matsumoto, J., Kubota, H., Cayanan, E.O. and Hilario, F.D., 2021. A Climatological Analysis of The Monsoon Break Following The Summer Monsoon Onset Over Luzon Island, Philippines. International Journal of Climatology. https://doi.org/10.1002/joc.6949.*

9. *Nguyen-Thuy, H., Ngo-Duc, T., Trinh-Tuan, L., Tangang, F., Cruz, F., Phan-Van, T., Juneng, L., Narisma, G. and Santisirisomboon, J., 2021. Time of Emergence of Climate Signals Over Vietnam Detected from the CORDEX-SEA Experiments. International Journal of Climatology. https://doi.org/10.1002/joc.6897.*

10. *Nguyen-Thi, T., Ngo-Duc, T., Tangang, F.T., Cruz, F., Juneng, L., Santisirisomboon, J., Aldrian, E., Phan-Van, T. and Narisma, G., 2021. Climate Analogue and Future Appearance of Novel Climate in Southeast Asia. International Journal of Climatology. https://doi.org/10.1002/joc.6693.*

11. *Nguyen-Ngoc-Bich, P., Phan-Van, T., Ngo-Duc, T., Vu-Minh, T., Trinh-Tuan, L., Tangang, F.T., Juneng, L., Cruz, F., Santisirisomboon, J., Narisma, G. and Aldrian, E., 2021. Projected Evolution of Drought Characteristics in Vietnam Based on CORDEX-SEA downscaled CMIP5 data. International Journal of Climatology. https://doi.org/10.1002/joc.7150.*

BOOK CHAPTER

1. *Arias, P. A., N. Bellouin, E. Coppola, R. G. Jones, G. Krinner, J. Marotzke, V. Naik, M. D. Palmer, G-K. Plattner, …, F. Cruz, et al., 2021, Technical Summary. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, et al. (eds.)]. Cambridge University Press. In Press.*

2. *Gutiérrez, J.M., R.G. Jones, G.T. Narisma, et al., 2021: Atlas. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, et al. (eds.)]. Cambridge University Press. In Press.*

3. *Gutiérrez, J.M., R G. Jones, G.T. Narisma, et al., 2021: Atlas Supplementary Material. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, et al. (eds.)]. Available from https://www.ipcc.ch/*

4. *Ranasinghe, R., A. C. Ruane, R. Vautard, N. Arnell, E. Coppola, F. A. Cruz, S. Dessai, A. S. Islam, M. Rahimi, D. Ruiz Carrascal, J. Sillmann, M. B. Sylla, C. Tebaldi, W. Wang, R. Zaaboul, 2021, Climate Change Information for Regional Impact and for Risk Assessment. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [MassonDelmotte, V., P. Zhai, A. Pirani, S. L. Connors, et al. (eds.)]. Cambridge University Press. In Press.*

5. ***Ranasinghe, R., A. C. Ruane, R. Vautard, N. Arnell, E. Coppola, F. A. Cruz, S. Dessai, A. S. Islam, M. Rahimi, D. Ruiz Carrascal, J. Sillmann, M. B. Sylla, C. Tebaldi, W. Wang, R. Zaaboul, 2021, Climate Change Information for Regional Impact and for Risk Assessment Supplementary Material. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, et al. (eds.)]. Available from https://www.ipcc.ch***

6. ***Tangang, F., J.X. Chung, Supari, S.T. Ngai, E. Salimun, F. Cruz, G. Narisma, T. Ngo-Duc et al. 2021. Progress in Climate Change Downscaling Simulations in Southeast Asia. In: Kaushik A., Kaushik C.P., Attri S.D. (eds) Climate Resilience and Environmental Sustainability Approaches. Springer, Singapore. https://doi.org/10.1007/978-981-16-0902-2_2***

TECHNICAL REPORT

1. ***DOST-PAGASA, Manila Observatory and Ateneo de Manila University, 2021. Philippine Climate Extremes Report 2020: Observed and Projected Climate Extremes in the Philippines to Support Informed Decisions on Climate Change Adaptation and Risk Management. Philippine Atmospheric, Geophysical and Astronomical Services Administration, Quezon City, Philippines, 145 pp.***

CONFERENCE PRESENTATION

1. ***18th Annual Meeting of the Asia Oceania Geosciences Society (AOGS), 2-6 Aug 2021***
    a. ***Poster presentation: "Preliminary Analysis of Wind Energy Projections in the Philippines Based on CORDEX-SEA Ensemble", A. Lagrama, F. Cruz, and J. Dado***
    b. ***Poster presentation: "Projected Changes in Surface Solar Radiation and Temperature from CORDEX-SEA Simulations and their Impact on Future Photovoltaic Output in the Philippines", D. Loqueloque, F. Cruz, and J. Dado***
    c. ***Poster presentation: "Projecting Hydropower Generation Using a Process-Based Flow Duration Curve Model and CORDEX-SEA Simulations", E. Pillas, F. Cruz, and J. Dado***

2. ***CAMP2Ex Science Team meeting (virtual), 29-30 Sep 2021***
    a. ***Oral Presentation: "Manila Observatory CHECSM site", J.B. Simpas, M.O. Cambaliza, S.M. Visaga, L.G. Aragon, A.M. Magnaye, P.A. Bañaga, G. Betito, F.A. Cruz, J.M. Dado, M.P. Ibañez, L.M. Olaguera, L.P. Tonga, V. Topacio, G.T. Narisma***

3. ***Philippine Meteorological Society Meeting, 29-30 March 2021***
    a. ***Oral Presentation: "On the Spatio-Temporal Characteristics of the Dry Rainy Season During 2020 Over Luzon Island, Philippines", L.M. Olaguera, J. Manalo, J. Matsumoto, A.L. Solis***

2 RESEARCH OUTPUT

Geomatics for Environment and Development

KNOWLEDGE PRODUCTS/MONOGRAPH

1. *Asian Development Bank (2020). The Multihazard Risk Atlas of Maldives: Geography—Volume I, Climate and Geophysical Hazards—Volume II, Economy and Demographics—Volume III, Biodiversity—Volume IV, and Summary—Volume V. DOI: https://dx.doi.org/10.22617/TCS200049*

2. *Vicente, M. C. T. M., Gultiano, S., Narisma, G. T., Borja, J. R. B., del Castillo, M. F. P., Carba, D. B., Bas, I. N., Carreon, S. V. U., Dayawon, R. S., Discar, A. C., Gozo, E. C. and Soria, G. C. (2021). GIS-based Climate Change Vulnerability and Adaptation (V&A) and Disaster Risk Assessments For Metro Cebu (research monograph). Manila Observatory, Office of Population Studies - University of San Carlos and Philippine Center for Population Development, Inc.*

3. *Asian Development Bank (2021). Bangladesh Climate and Disaster Risk Atlas: Hazards—Volume I and Exposures, Vulnerabilities, and Risks—Volume II. DOI: https://dx.doi.org/10.22617/TCS210518*

WORKING PAPERS

1. *Familara, A.D.F., Reyes, S.R.C., Sebastian, A.V.C., and Vicente, M.C.T.M. Mapping Biomass Resource, Biomass Power Plants Site Suitability, and Associated Risks.*

2. *Austria, R.V., Familara, A.D.F., Muzones, D.M., Reyes, S.R.C. and Vicente, M.C.T.M. Mapping Risks to Renewable Energy: A Value-Added Feature of a Space-Based Decision Support System.*

3. *Biguerras, M.G., Dimain, M.R., Montajes, J. T., Reyes, S.R.C., and Vicente M.C.T.M. Mapping Risks to Renewable Energy: A Value-Added Feature of a Space-Based Decision Support System*

4. *Agad, A, Jacela, J., Reyes, S. R. C. and Vicente, M. C. T. M. Wind Energy in the Philippines – Resource and Associated Risks: A Review of Existing Literature*

5. *Biguerras, M.G., Dimain, M.R., Montajes, J. T., Reyes, S.R.C., and Vicente M.C.T.M. State of Hydropower in the Philippines: Key Issues and Challenges in Harnessing the Power of Water*

2 RESEARCH OUTPUT

Air Quality Dynamics

JOURNAL PUBLICATIONS

1. *Gonzalez, M. E., Stahl, C., Cruz, M. T., Bañaga, P. A., Betito, G., Braun, R. A., Azadi Aghdam, M., Cambaliza, M. O., Lorenzo, G. R., MacDonald, A. B., Simpas, J. B., Csavina, J., Sáez, A. E., Betterton, E., & Sorooshian, A. (2021). Contrasting the Size-Resolved Nature of Particulate Arsenic, Cadmium, and Lead Among Diverse Regions. Atmospheric Pollution Research, 12(3), 352–361. https://doi.org/https://doi.org/10.1016/j.apr.2021.01.002*

2. *Hilario, M. R. A., Crosbie, E., Bañaga, P. A., Betito, G., Braun, R. A., Cambaliza, M. O., Corral, A. F., Cruz, M. T., Dibb, J. E., Lorenzo, G. R., MacDonald, A. B., Robinson, C. E., Shook, M. A., Simpas, J. B., Stahl, C., Winstead, E., Ziemba, L. D., & Sorooshian, A. (2021). Particulate Oxalate-To-Sulfate Ratio as an Aqueous Processing Marker: Similarity Across Field Campaigns and Limitations. Geophysical Research Letters, 48(23), e2021GL096520. https://doi.org/https://doi.org/10.1029/2021GL096520*

3. *Hilario, M. R. A., Crosbie, E., Shook, M., Reid, J. S., Obiminda L. Cambaliza, M., Bernard B. Simpas, J., Ziemba, L., Digangi, J. P., Diskin, G. S., Nguyen, P., Joseph Turk, F., Winstead, E., Robinson, C. E., Wang, J., Zhang, J., Wang, Y., Yoon, S., Flynn, J., Alvarez, S. L., … Sorooshian, A. (2021). Measurement Report: Long-Range Transport Patterns into the Tropical Northwest Pacific During the CAMP2Ex Aircraft Campaign: Chemical Composition, Size Distributions, and the Impact of Convection. Atmospheric Chemistry and Physics, 21(5), 3777–3802. https://doi.org/10.5194/acp-21-3777-2021*

4. *Lorenzo, G. R., Bañaga, P. A., Cambaliza, M. O., Cruz, M. T., AzadiAghdam, M., Arellano, A., Betito, G., Braun, R., Corral, A. F., Dadashazar, H., Edwards, E.-L., Eloranta, E., Holz, R., Leung, G., Ma, L., MacDonald, A. B., Reid, J. S., Simpas, J. B., Stahl, C., Visaga, S.M., and Sorooshian, A. (2021). Measurement Report: Firework Impacts on Air Quality in Metro Manila, Philippines, During the 2019 New Year Revelry. Atmospheric Chemistry and Physics, 21(8), 6155–6173. https://doi.org/10.5194/acp-21-6155-2021*

5. *Stahl, Connor, Crosbie, E., Bañaga, P. A., Betito, G., Braun, R. A., Cainglet, Z. M., Cambaliza, M. O., Cruz, M. T., Dado, J. M., Hilario, M. R. A., Leung, G. F., MacDonald, A. B., Magnaye, A. M., Reid, J., Robinson, C., Shook, M. A., Simpas, J. B., Visaga, S. M., Winstead, E., … Sorooshian, A. (2021). Total Organic Carbon and the Contribution from Speciated Organics in Cloud Water: Airborne Data Analysis from the CAMP2Ex Field Campaign. Atmospheric Chemistry and Physics, 21(18), 14109–14129. https://doi.org/10.5194/acp-21-14109-2021*

TECHNICAL REPORTS

1. ***New Year's Eve 2021 Particle Pollution Measurements in Metro Manila http://www.observatory.ph/2021/02/25/new-years-eve-2021-particle-pollution-measurements-in-metro-manila/***

2. ***Prodigalidad, 2021. Impacts of the COVID–19 Pandemic on the Air Quality in Metro Manila, Philippines and in the Southeast Asian Region (Internship output)***

CONFERENCE PRESENTATION

1. ***CAMP2Ex Science Team Meeting and Composition Working Group, Presentations by: James Bernard Simpas, Maria Obiminda Cambaliza, Shane Marie Visaga, Paola Angela Bañaga, Grace Betito, Xzann Garry Vincent Topacio***
    a. ***"Manila Observatory CHECSM site", 29-30 Sep 2021***
    b. ***"Planetary Boundary Layer height, wind and traffic volume effects on PM2.5 surface concentrations over Metro Manila Philippines", 21 Oct 2021***

2. ***2021 Advanced Institute on Health Investigation and Air Sensing for Asian Pollution (HI-ASAP) October 12-15,19, 2021, "HI-ASAP Research Update from the Philippines" Presentation by Maria Obiminda L. Cambaliza and Melliza T. Cruz***

ADDITIONAL NOTES ON AQD TEHNICAL REPORTS

Status of Air Quality during the COVID-19 pandemic

Air quality in Metro Manila and other parts of the world has been impacted by changes in human activities due to the COVID-19 pandemic. A technical report is being prepared to assess the status of air quality in Metro Manila by analyzing filter-based, continuous PM measurements and satellite measurements of NO2.

Initial results show a decline in PM2.5 in the early months of the Enhanced Community Quarantine (ECQ) but gradually increased upon transitioning to less strict quarantine classification. Diurnal change in PM2.5 concentration was also observed possibly due to the changes in people's daily routine.

New Year's Eve air quality during the pandemic

Since 2003, MO has continuously monitored air pollution during the New Year's Eve celebration in different locations in Metro Manila. In New Year 2021, we deployed MiniVol samplers for 24-hour sampling at seven sampling sites: (1) MO, Quezon City; (2) Barangka, Marikina; (3) Nangka, Marikina; (4) Mambugan, Antipolo; (5) Valle Verde, Pasig; (6) South Bay Gardens, Parañaque; and (7) San Jose del Monte, Bulacan. AS-Lung personal samplers for real-time continuous sampling were installed at nine sites: (1) MO, Quezon City; (2) Barangka, Marikina; (3) Nangka, Marikina; (4) Mambugan, Antipolo; (5) Valle Verde, Pasig; (6) South Bay Gardens, Parañaque; (7) San Jose del Monte, Bulacan; (8) Katipunan Avenue, Quezon City; and (9) Fortune, Marikina. Also installed in MO is the University of Arizona's Micro-Orifice Uniform Deposit Impactor (MOUDI) for size-segregated PM measurement.

The 24-hour PM2.5 measurements for 2021 have shown improved air quality, from "unhealthy" levels of PM2.5 concentrations in 2020 to "moderate" levels due to COVID-19 restrictions in the greater Metro Manila. The decreased levels of PM were also observed in the size-segregated PM mass, showing lesser influence from fireworks and traffic emissions. Furthermore, a significant increase in real-time PM2.5 measurements was still observed after midnight, which can be attributed to residual firework activities and vehicles racing their engines to create noise.

Resilience Collaboratory

JOURNAL PUBLICATIONS

1. *Jamero, M.L, Vicente, M.C., Perez, R., Cruz, F., Dimain, M. R.,Dela Paz, M.A., Gozo, E., Plopenio, J., Tejada, M., Defiesta, G., Agudo, F.A., Dator-Bercilla, J., Yulo-Loyzaga, M.A., and Porio, E. "Transdisciplinary Approach to Climate and Disaster Risk Assessment in the Philippines: Coaching and Mentoring." Manuscript submitted to Environmental Science and Policy last Dec 2021, currently under review.*

TECHNICAL REPORTS

1. *Jamero, M. L., Vicente, M.C., Cruz, F., Perez, R., Dela Paz, M.A., Dimain, M.R., and Gozo, E. Bataan Province Risk Profile. CDRA Coaching and Mentoring Project, March 2022.*

2. *Jamero, M. L., Vicente, M.C., Cruz, F., Perez, R., Dimain, M.R., Dela Paz, M.A., and Gozo, E. Preliminary Climate Risk Analysis for Bago and Malogo (Negros Occidental), Montible (Puerto Princesa City, Palawan), Buayan-Malungon and Siguel (Sarangani) Watersheds. USAID Safe Water Project, February 2021.*

3. *Dineros, A. and Jamero, M. L. Climate Information Uptake and Usability for Resilient Philippine Water Sector. USAID Safe Water Project, March 2021*

2 RESEARCH OUTPUT

Energy Collaboratory

POLICY PAPERS

1. ***The Philippine Climate Change Commitments and the Energy Transition to a Low-Carbon Future***

2. ***Energy and Climate Nexus: The Contribution and Vulnerability of the Global and Philippine Energy Sector to Climate Change***

3. ***Philippines Roadmap: Policies and Laws Needed to Reduce Greenhouse Gas Emissions Pursuant to its Nationally Determined Contribution***

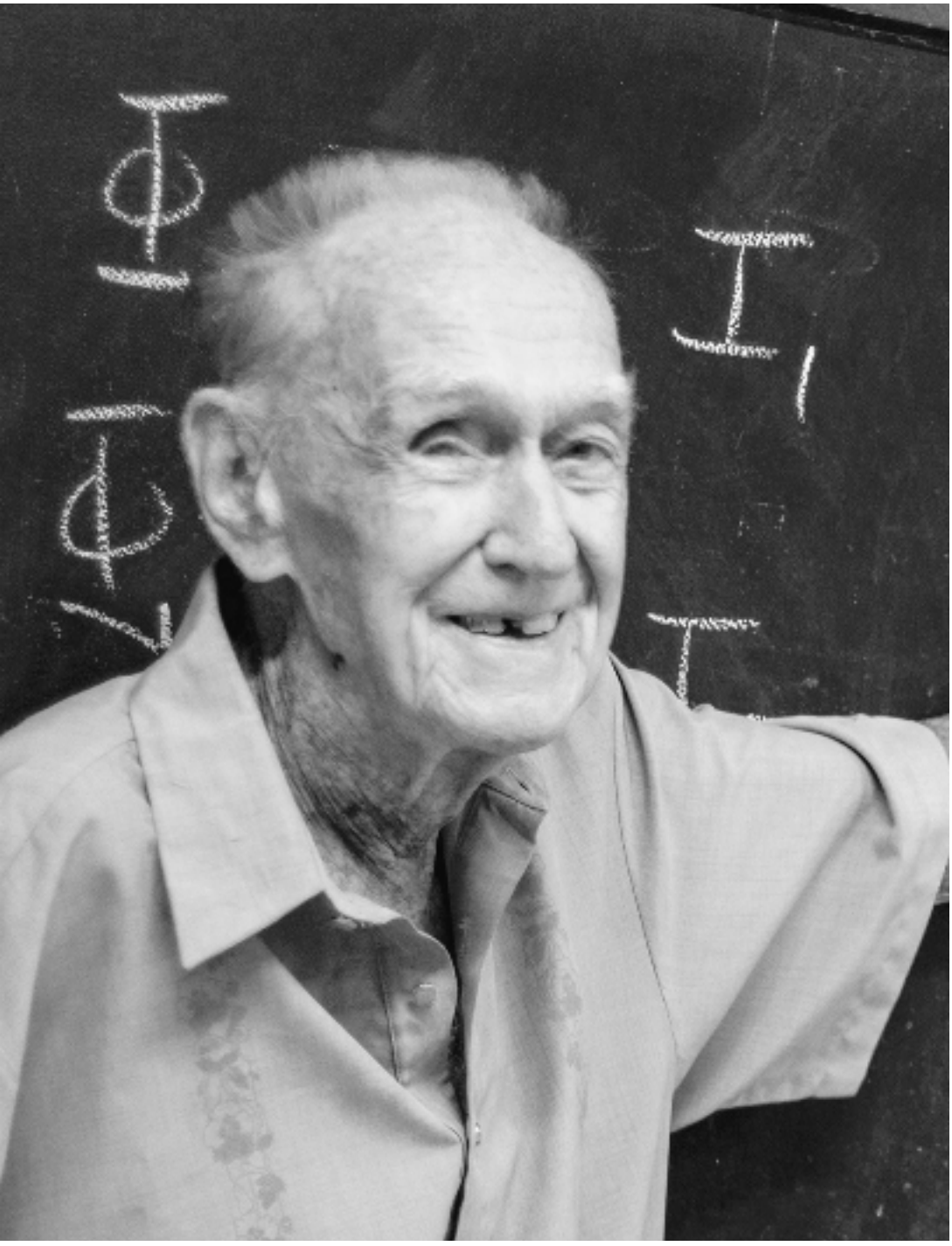
POLICY NOTES

1. ***Policy Energy Gap***

2. ***Transitioning to Renewable Energy***

IN MEMORIAM

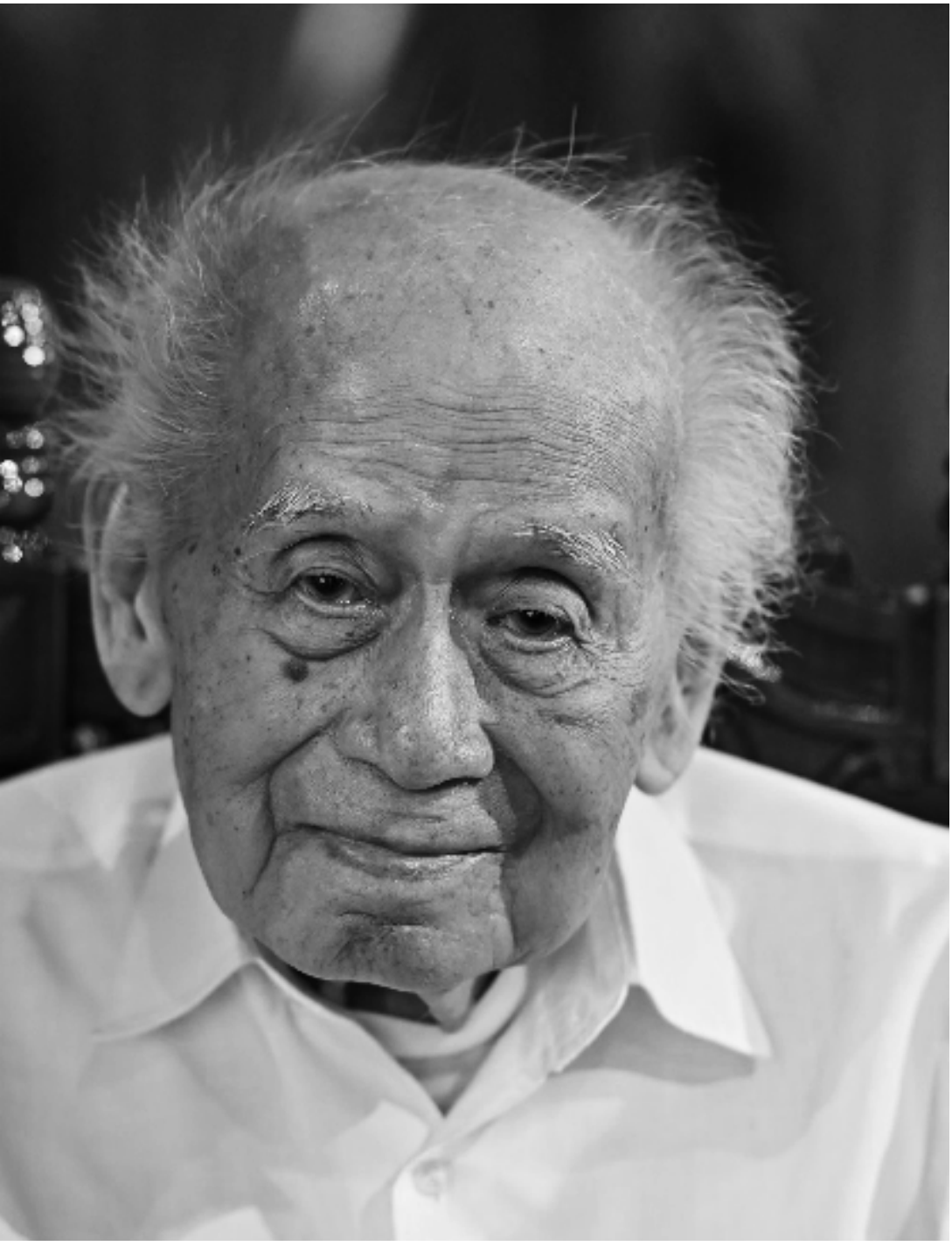
Fr Francisco Glover SJ PhD
Physicist, MO Director
(1925 - 2021)



"The quest continues. Physicists are still turning outward toward space, and inward toward the nucleus, the heart of the atom, still seeking to know more and more of the world about us, ever striving to come to a deeper understanding and appreciation of the wonderful works of God."

IN MEMORIAM

Fr Sergio Su SJ PhD
Geophysicist
(1922 - 2021)



“and you will deny me my own Jacob’s ladder?”

In his 90s, when offered to transfer his lab from the second floor to the ground floor of the Manila Observatory.

IN MEMORIAM

Gemma Teresa Narisma PhD
Atmospheric Scientist, MO Director
(1972 - 2021)

"I pray that we will have the heart and inspiration, faith, and courage, to continue this tradition of science, rooted in love, undaunted by the uncertainties that we face, and with the goal of providing excellent science that is timely and responsive to current challenges, and grounded in humility and encounters with those who are truly in need."

Acknowledgements

We are truly grateful to our partners and benefactors for their generous support of our work as an environmental observatory that shares in the urgent mission to care for our common home.

PROJECT PARTNERS & DONORS

Inter-laboratory Projects

European Union, ASEP CELLs Project
DAI, USAID Safe Water Project
IDRC Canada, CCARPH Project

Geomatics for the Environment and Development (GED) Laboratory

Asian Development Bank - South Asia Department
Group on Earth Observation (GEO) Microsoft (MS) Planetary Computer Programme
The UK Royal Society and UK Research Institute Global Challenges Research Fund (GCRF) and the British Geological Survey Alliance for Resilient Urban South East Asia (ARUSEA)+Bridge for Billions Incubation Programme
Sentinel Asia (SA)
International Disaster Charter (IDC)
Ateneo de Manila University
National Resilience Council
Xavier University Engineering Resource Center (XUERC)

Air Quality Dynamics (AQD) Laboratory

NASA (CAMP2Ex)
Dr. James Crawford, NASA Langley Research Center
University of Winsconsin

Regional Climate Systems (RCS) Laboratory

CORDEX Southeast Asia
Asia-Pacific Network for Global Change Research
Department of Science and Technology - Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST - PCIEERD)
Egis International

Upper Atmosphere Dynamics (UAD) Laboratory

University of Colorado

Data and Sensor Development (DSD) Laboratory

Clean Energy, Climate and Weather (ECW) Project donors:
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- ***La Filipina Uy Gongco Group***
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- ***Pilipinas Shell Foundation***

ECW partner:
- ***Xavier University***

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Chiang Mai University
Samdhana
Oscar M. Lopez Foundation
UP Los Banos Center for Integrated Natural Resources and Environmental Management

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Ateneo de Manila University
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Ateneo de Zamboanga University
Xavier University

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National Academy of Science and Technology
National Mapping and Resource Information Authority (NAMRIA)
Bataan - Office of the Governor
DOST - Philippine Atmospheric, Geophysical and Astronomical Services Administration (DOST - PAGASA)
Philippine Council for NGO Certification (PCNC)
Philippine Institute of Volcanology and Seismology (PHIVOLCS)
Climate Change Commission (CCC)

We also thank the following for composing this report:

Ms. Jennifer Tibay for the layout
Ms. Anne Nilo for proofreading

Laboratory and Collaboratory heads for the content:
Dr. Celine Vicente (GED)
Dr. James Simpas (AQD)
Dr. Faye Cruz (RCS)
Mr. Clint Bennett (SED-UAD)
Dr. Niño Uy (DSD)
Dr. Lau Jamero (Resilience Collaboratory)
Atty. Yla Paras (Energy Collaboratory)