MANILA OBSERVATORY

High-Definition Clean Energy, Climate, and Weather Forecasts for the Philippines

Annual Project Report

July 2021 to June 2022

Contents

Message from the Executive Director

We are pleased to report to you the highlights of our first year of work on the project titled "High-Definition Clean Energy, Climate, and Weather Forecasts for the Philippines" (ECW). These highlights include efforts at setting up the automated weather station (AWS) network, the high-resolution forecasting system and its continuing improvement, climate and weather risk assessment, long-term climate projections, outreach and publications.

When we began formally in July 2021, one of the first things we did was revive a part of the AWS network that was generously donated to us by Weather Philippines Foundation. Before this, the Manila Observatory had already been operating a number of AWSs in various parts of the country. To be honest, it has not been easy to operationalize the country-wide AWS network during this time of the pandemic. Despite the challenges of remote management however, we have managed to get more than half of the stations up and running and connected to our central database, realtime 24/7.

In parallel to the revival of this observation network, we began setting up our forecasting system that is designed to predict wind and solar power potential, as well as the usual weather variables of temperature and rainfall. This project has enabled us to acquire high performance climate computing systems to do the number crunching. Thus far, we have improved the system by (a) incorporating actual observations into our model forecasts in a process called data assimilation, and (b) increasing the confidence of these forecasts through an ensemble of model runs. Our web-based dashboard of five-day forecasts can now be accessed at https://panahon.observatory.ph/ecw.

Our efforts to generate climate and weather risk assessments are still a work in progress. This more complex exercise entails overlaying our geophysical forecasts with various types of exposure and social vulnerability factors that contribute to risk. In the past year, as a first step toward risk assessment and forecasting, the extreme weather bulletins we shared with various stakeholders already featured some exposure and vulnerability information to complement the actual extreme weather event itself.

The outputs of our work on long-term climate projection have already been posted at https://panahon.observatory.ph/climate. We have generated country-wide future climate profiles for various decades until the 2090s for temperature and rainfall. These profiles are based on moderate and high-emission scenarios, and will be further refined in the near future with more updated emission pathways.

This project has also enabled us to train and build the capacity of people. We know we cannot manage the AWS network by ourselves and so we see this as an opportunity to train others and work with them in doing whatever science and engineering is needed. Beyond the operational, this project has also helped us write scientific articles for publication in journals such as Environmental Research, Urban Climate, International Journal of Climatology, and the like.

We have learned so much in this first year alone. We know where and how we can become better. And our to-do list is still long. But no matter. The faces of the vulnerable, those at the margins, *las periferias*, are always before us. They stand to suffer the most in a warmer and more uncertain world.

As scientists working in the Jesuit tradition, we have been privileged to serve others through the talents God has given us. We celebrate the kindness of our platinum and gold partners, without whose generous benefaction our scientific ministry would not have been possible. We are truly grateful. With them, we have planted something that we hope to nurture in the coming years.

The imperative to sustain these efforts to care for our common home is clear. God and we willing, we shall "tame the tempest", as was once said of the mission that Jesuit scientists of the Manila Observatory in the 19th century in the time of Padre Faura took upon themselves. In the face of an impending climate emergency, we make this our mission too.

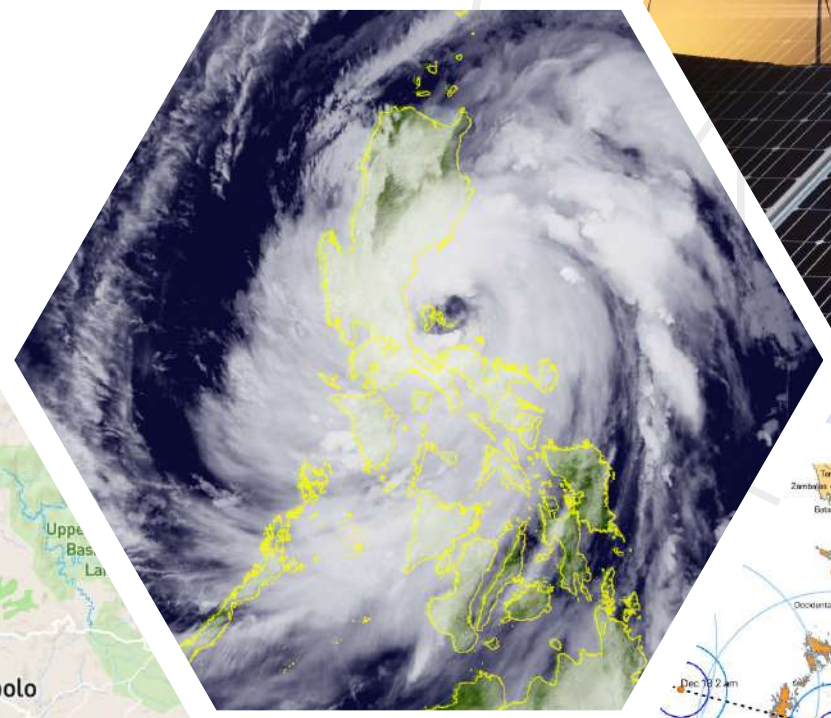
Jose Ramon T Villarin SJ PhD
Manila Observatory

Project summary

The High-Definition Clean Energy, Climate, and Weather Forecasts for the Philippines (ECW) project aims to respond to the global climate emergency by providing weather and climate information for clean energy development, and helping communities strengthen their resilience to climate and disaster risks. Information on real-time weather from the Automated Weather Station (AWS) network, and high-resolution hourly clean energy and weather forecasts over the entire country are made available. Furthermore, localized climate projections are generated for risk assessments to help vulnerable communities adapt to climate change.

Some of the project's products and services include:

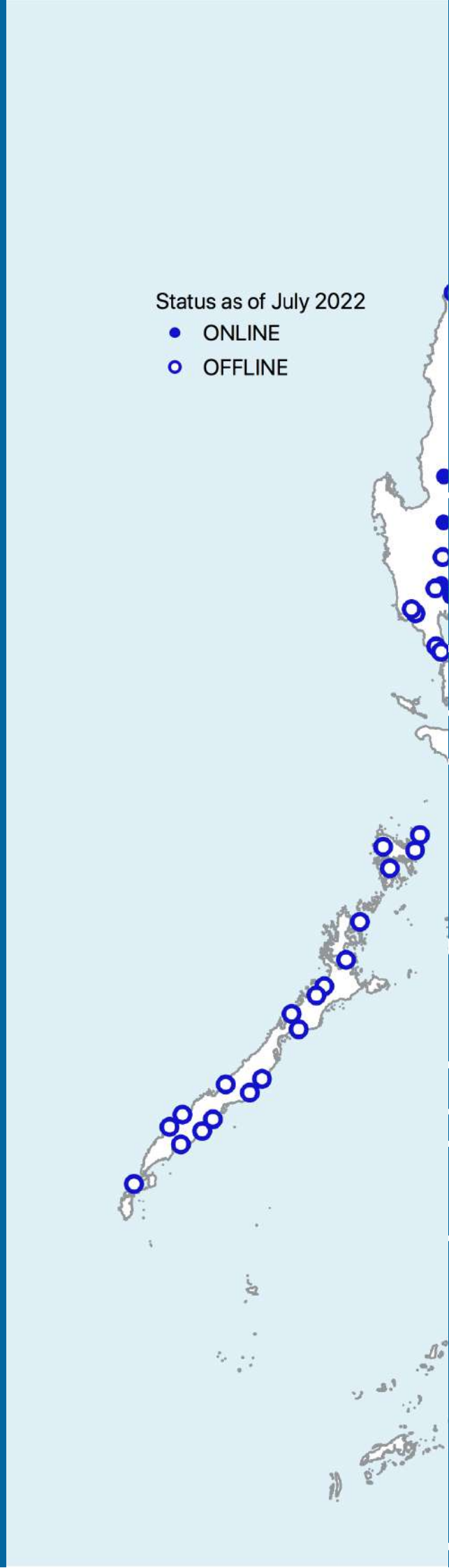
- Observational climate and weather datasets
- Climate and weather data analysis
- Extreme weather bulletins
- Climate change projections
- Clean energy forecasts
- Climate education and training

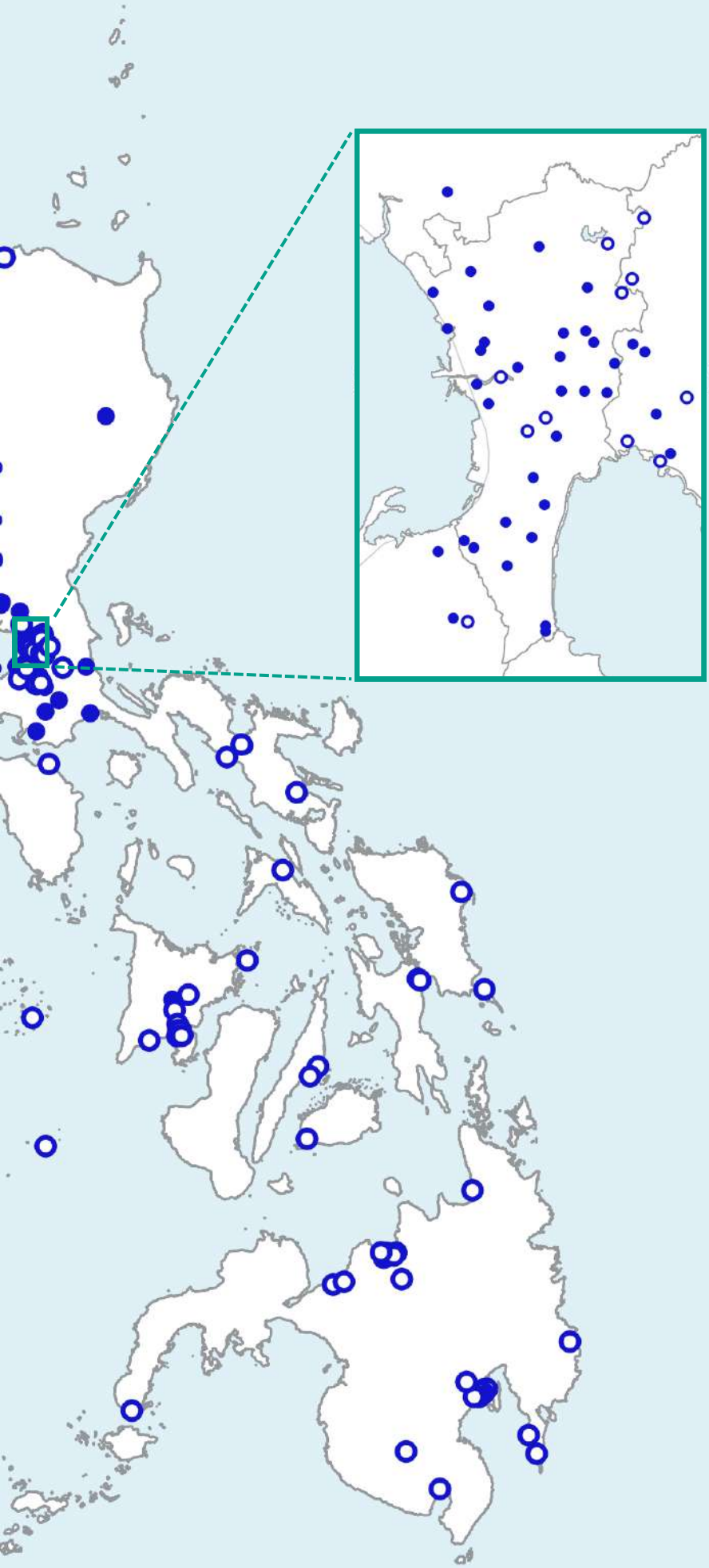


Automated Weather Station Network

Since 2012, the Manila Observatory has been operating and maintaining an automated weather station (AWS) network through partnerships with Metro Weather, the Climate Resilience Network, and Ateneo. In 2021, weather stations donated by Weather Philippines Foundation (WPF) were reconditioned and installed mainly in Metro Manila initially, given the constraints posed by the COVID-19 pandemic. Thus far, 42 Lufft AWS are now operational at SM malls and 23 Davis AWS are running in MO, Caltex stations, and Pilipinas-Shell Foundation training centers and partners.

A database system has also been developed for observational and forecast data. Real-time weather observations are available at the Panahon website of the Observatory: https://panahon.observatory.ph.





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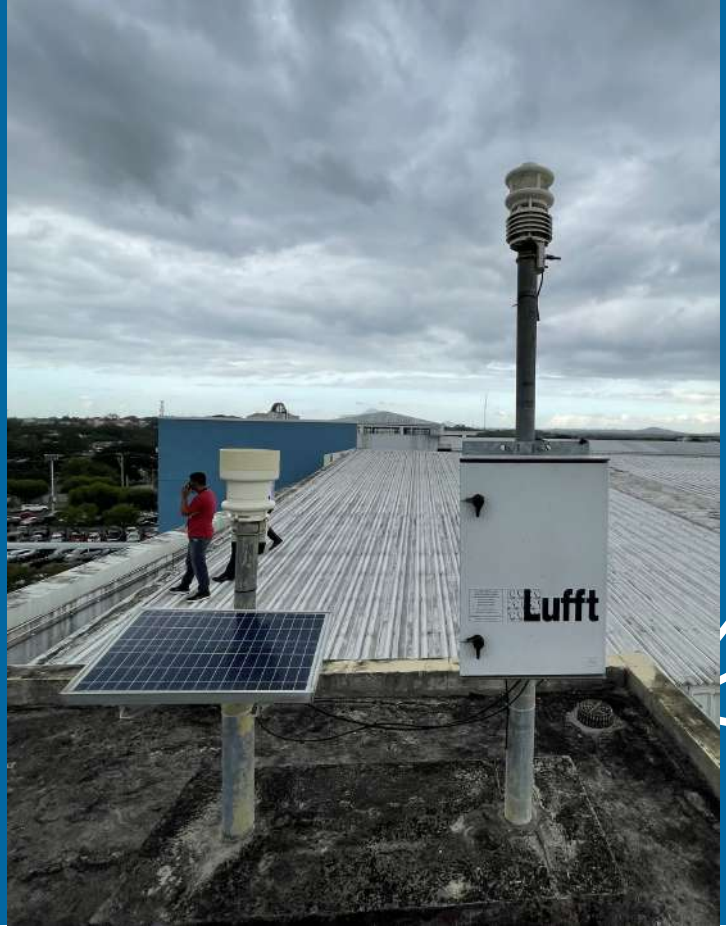

The LUFFT Compact Weather Sensor (WS 502) is an all-in-one sensor that measures meteorological variables like temperature, relative humidity, air pressure, wind direction, wind speed, and radiation. It has a built-in pyranometer to measure solar radiation and uses an ultrasonic anemometer to measure wind speed and direction. It uses a capacitative microelectromechanical system to measure humidity and air pressure. The WTB100 rain gauge measures precipitation through a tipping bucket mechanism.

Data is recorded by the Advance Remote Data-Acquisition (arQ) logger manufactured by DOST-ASTI, and is transmitted via GSM/GPRS.

The DAVIS Vantage Pro 2 Plus is a compact weather sensor that records near-real time data for temperature, relative humidity, wind speed, wind direction, rainfall, and rain rate. The Vantage Pro 2 Plus uses a mechanical anemometer and wind vane to record the wind speed and wind direction, and uses a tipping bucket mechanism to measure rainfall.

Data is automatically saved in and accessed from the cloud.

Clean Energy and Weather Forecasts

An automated weather forecast system has been up and running since 2021 to support clean energy forecasting (namely for solar and wind energy) for the entire Philippines. This system is continually refined with better methodologies and data on the ground.

Operational ensemble 5-day forecasts at 5-km spatial resolution are initialized every 12 hours (8:00 am and 8:00 pm local standard time). Forecasts can be viewed via the ECW website of MO: https://panahon.observatory.ph/ecw.


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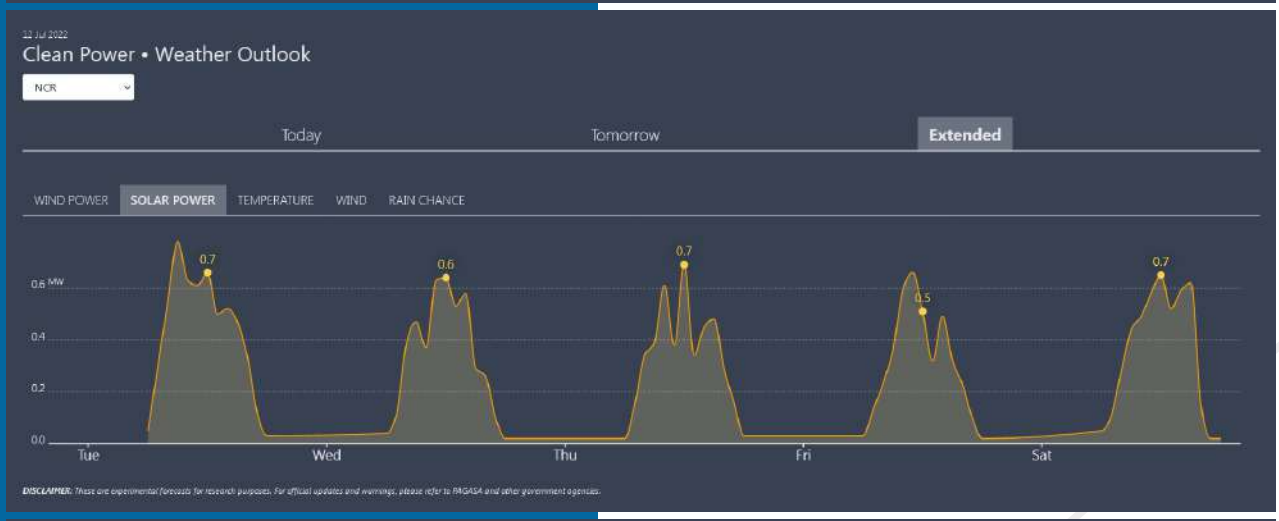
DISCLAIMER: These are experimental forecasts for research purposes. For official updates and warnings, please refer to PAGASA and other government agencies.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DISCLAIMER: These are experimental forecasts for research purposes. For official updates and warnings, please refer to PAGASA and other government agencies.


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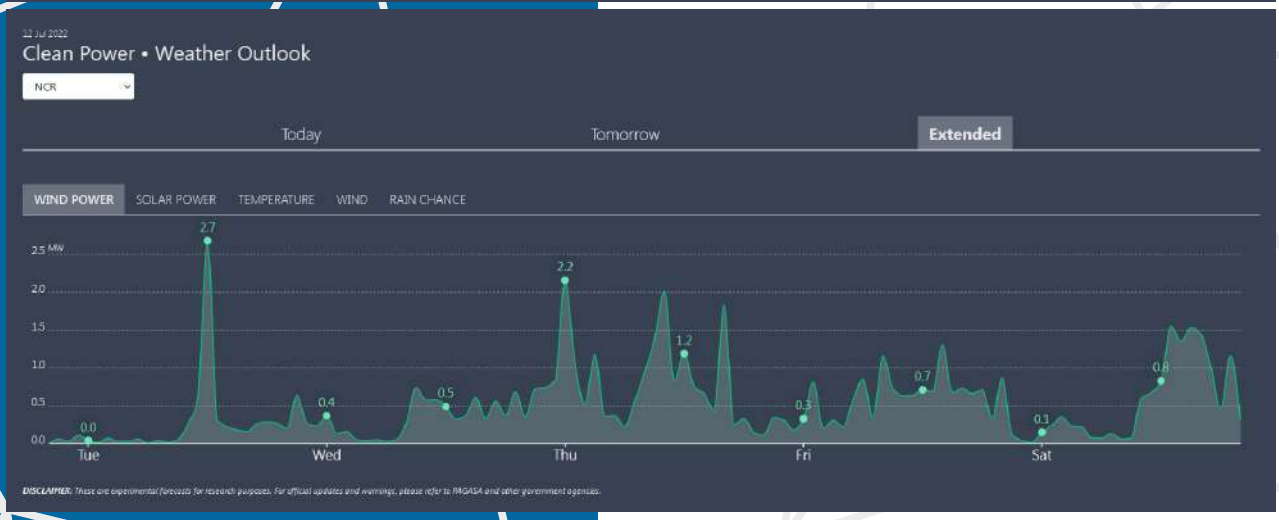
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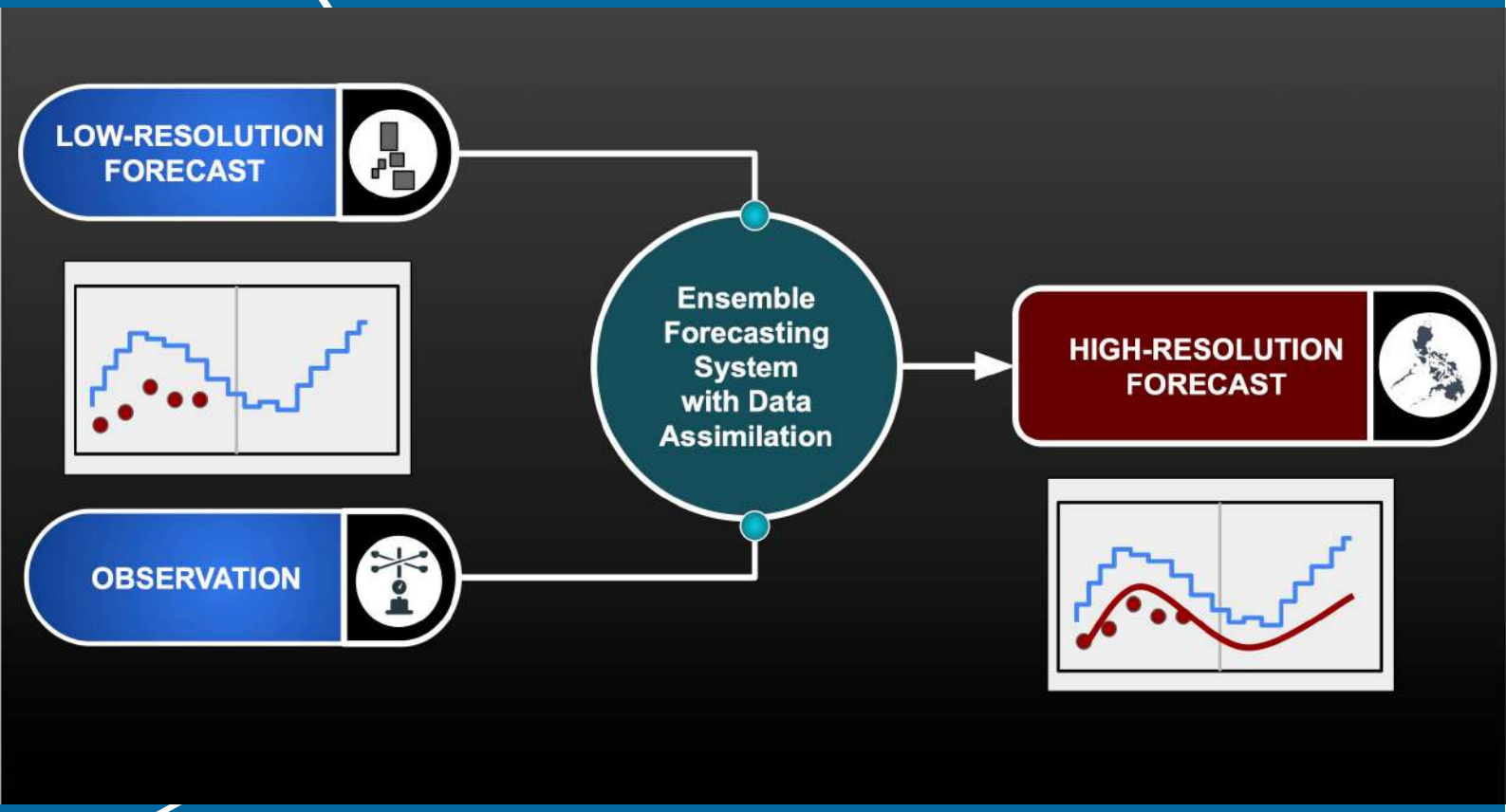


Model-based forecasts without actual observed data are mostly guesswork. The ECW ensemble forecasting system assimilates or incorporates data from the AWS network, satellites, and other observation networks to increase confidence in the accuracy of clean energy and weather prediction.

While operational forecasts for clean energy and weather are ongoing, research is also being done to solve problems and continually improve the ECW forecasting system.

Climate and Weather Extremes

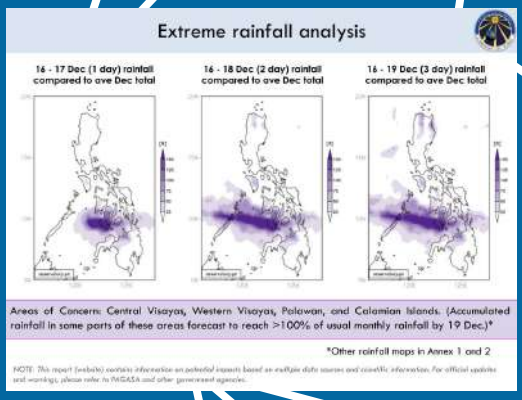
Extreme weather bulletins (EWBs) provide people with information about extreme events such as tropical cyclones (TCs), extreme rainfall or heat, and potential risks to vulnerable areas exposed to such hazards.

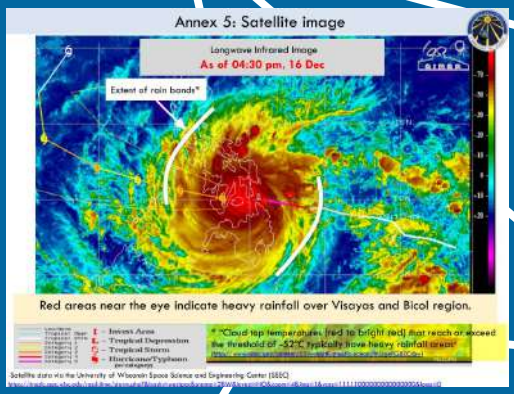
Five EWBs on TCs that made landfall in the Philippines have been released since 2021, starting with TC Dujuan (Auring) in February 2021 until TC Megi (Agaton) in April 2022.

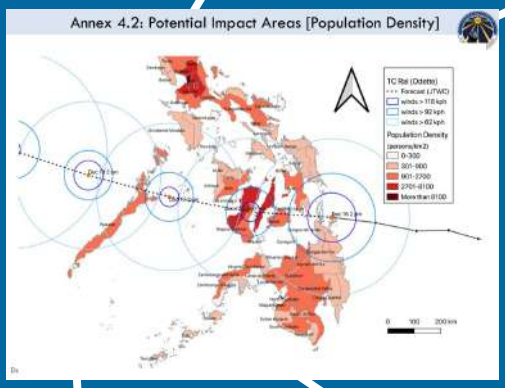
An EWB was released in July 2021 to warn of the enhanced Habagat rainfall and wind brought about by TC In-fa, which did not make landfall yet severely affected local weather in the Philippines.

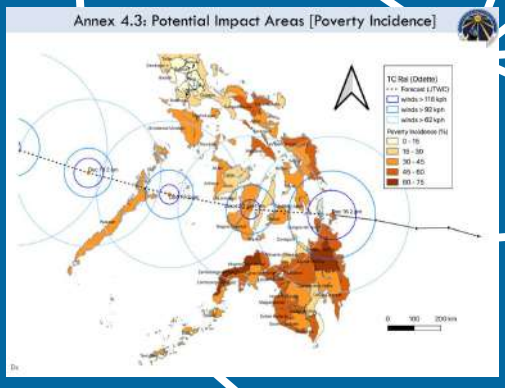
Two EWBs were also released to warn of extreme rainfall associated with storms that did not further intensify (Tropical Storm Crising in May 2021 and Tropical Depression Lannie in October 2021).

An EWB on heat was also released on May 8, 2022 in anticipation of the extreme heat that was forecast to happen prior to the 2022 national election.



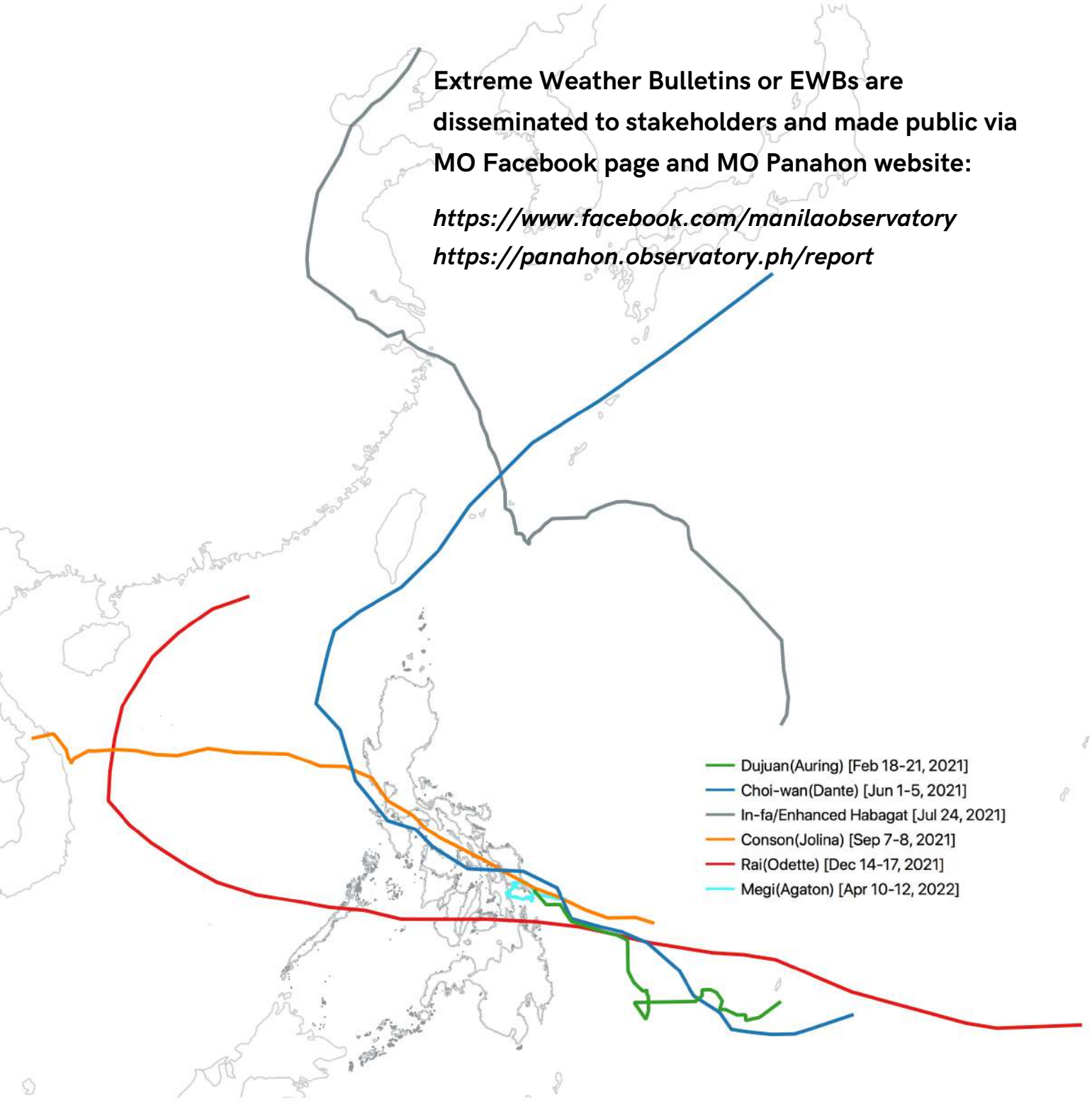






Extreme Weather Bulletins or EWBs are disseminated to stakeholders and made public via MO Facebook page and MO Panahon website:

https://www.facebook.com/manilaobservatory
https://panahon.observatory.ph/report

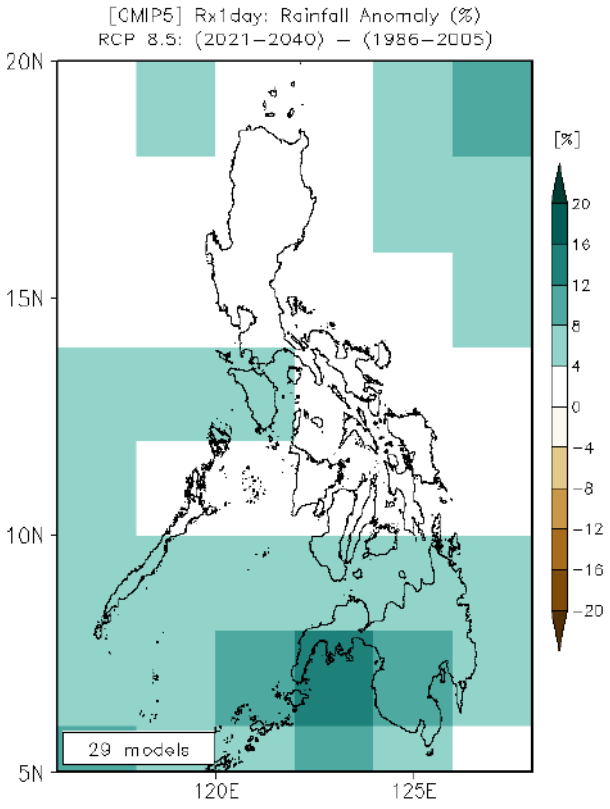


The EWB includes the latest available information and forecast of the climate or weather hazard as well as the exposure and vulnerability of potential impact areas. At present, risk is only roughly estimated as overlaid maps of hazard, exposure, and vulnerability factors at sub-national scales. Ongoing research focuses on developing appropriate climate and weather risk indices and forecasts at finer scales that can be used by communities adversely affected by extreme events.

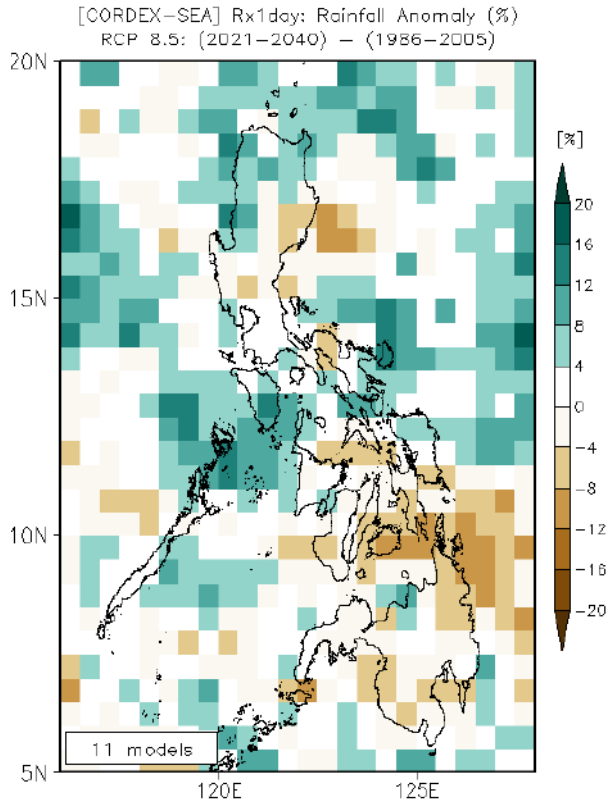
High-resolution Climate Projections

Climate information generated by global climate models (GCMs) are typically too coarse to account for the variations in Philippine climate and topography. Dynamical downscaling using regional climate models (RCMs) is an effective but computationally intensive method to generate high-resolution projections for regions of complex topography and marine conditions such as those in Southeast Asia.

At present, the highest resolution for long-term climate change projections in the Philippines is 25 km. This information is already available as part of the Coordinated Regional Climate Downscaling Experiment-Southeast Asia (CORDEX-SEA). The downscaled projections are based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) dataset, using moderate and high emission scenarios called representative concentration pathways (RCP) 4.5 and 8.5, respectively.



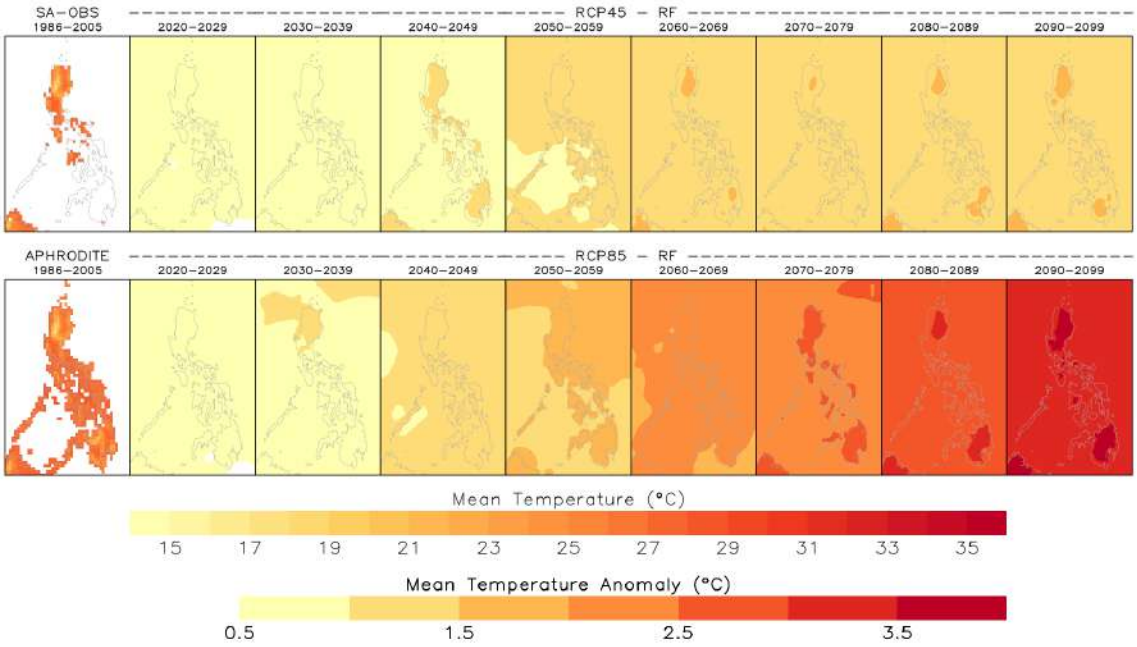
Low resolution



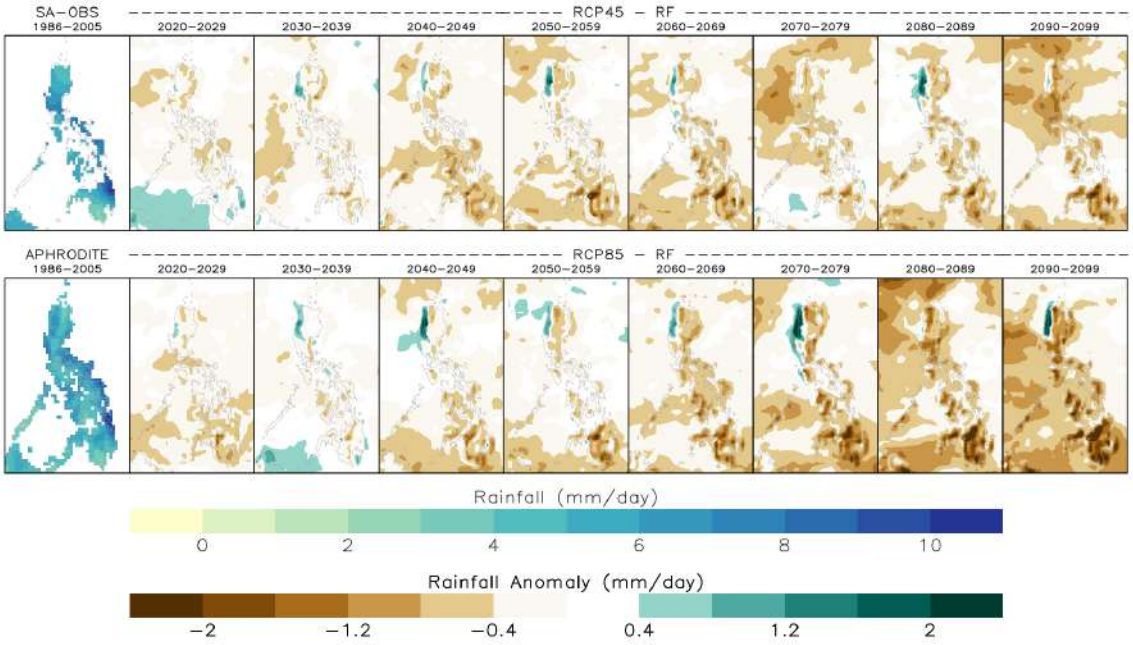
High resolution

Decadal projections of the changes in Philippine climate are also available on the web: https://panahon.observatory.ph/climate.

Mean Daily Temperature (°C)



Daily Rainfall (mm/day)



Outreach

ACEN Weather and Climate Learning Series

Lecture Series 1: Introduction to Philippine Weather and Climate (March 17, 2022)

- "The Weather and Climate of the Philippines: Local Drivers and Variability" (Speaker: Lyndon Mark P Olaguera PhD)
- "Introduction to Philippine Climate Extremes" (Speaker: Francia B Avila PhD)

Lecture Series 2: Basics of Weather and Climate Data and Modeling (June 16, 2022)

- "Measuring Weather Conditions" (Speaker: Sherdon Niño Y Uy PhD)
- "Introduction to Weather and Climate Modelling" (Speaker: Julie Mae B Dado PhD)

SM Prime Holdings, Inc. Disaster Risk Resilience Knowledge Series

Session 1: The Automated Weather Station (AWS) Training (March 28, 2022)

- "Basic AWS Operation and Maintenance" (Speakers: Jerson Samson, Paola Bañaga, and Rene Toledo)

Session 2: Typhoon Resilience: Tools and Technology at the Tip of your Fingertips (June 7, 2022)

- "Tropical Weather Systems" (Speaker: Rosa T Perez PhD)
- "High-Definition Clean Energy, Climate, and Weather Forecasts for the Philippines Project" (Speaker: Sherdon Niño Y Uy PhD)

Presentations

- Tonga LP, Olaguera LMP, Magnaye AMT, 2021. Validation of WRF-Solar forecasts over Manila Observatory using SPN1 pyranometer. CAMP2Ex 2021 Virtual Science Team Meeting.

- Aragon LG, Dado JM, 2021. fdir-S* validation using SPN1 pyranometer for Wet Bulb Globe Temperature (WBGT) estimation. CAMP2Ex 2021 Virtual Science Team Meeting.

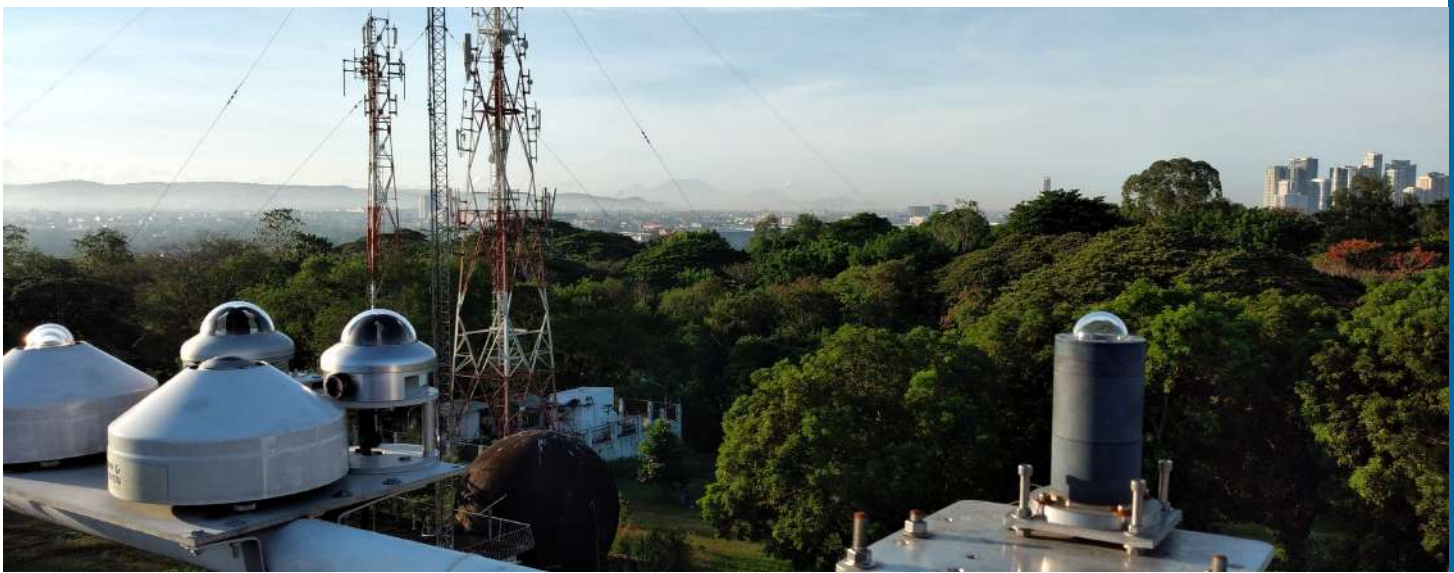
Publications

- Aragon LG, Dado JM, Cruz F, Villarin JR, Simpas JB, Cambaliza MO, Bañares E, Visaga SM, 2022. Spatio-temporal characteristics of heat stress indices in a tropical megacity in the Philippines. *Environmental Research* (in preparation)

- Llorin AG, Olaguera LMP, Magnaye AMT, Cruz F, Dado JMB, Gozo EC, Topacio XGVM, Uy SN, Simpas JBB, Villarin JRT, 2022. Quantifying the influence of updated land use/land cover in simulating urban climate: a case study of Metro Manila, Philippines. *Urban Climate* (under review)

- Olaguera, LMP, Magnaye AMT, Visaga SMA, Cruz FT, Villarin JRT, Matsumoto J, 2022. Regional characterization of diurnal cycle of precipitation during the southwest monsoon season in the Philippines. *International Journal of Climatology* (under review)

- Olaguera LMP, Cruz FT, Dado JMB, Villarin JRT, 2022. Complexities of extreme rainfall in the Philippines. In Extreme Natural Events: Sustainable Solutions for Developing Countries. *Springer Nature Singapore*



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Pilipinas Shell Foundation, Inc.

OXFAM

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- Angela Monina T Magnaye
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- Xzann Garry Vincent M Topacio
- Sherdon Niño Y Uy PhD
- Jose Ramon T Villarin SJ PhD

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