Met Office

Case Study

Improving resilience to severe weather and climate change in the Philippines

Partnership with the Philippine National Meteorological Service; the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

Challenge

The geographical location of the Philippines, situated along the typhoon belt of the Pacific, means that it is particularly vulnerable to a range of natural disasters, including tropical cyclones (typhoons), earthquakes and volcanoes. As a low-lying island nation of over 7,000 islands dominated by coastal communities, it is also highly-susceptible to tsunamis, sea-level rise and storm surges which are associated with extreme weather events. Increasing urbanisation also poses a significant challenge to sustainable development, with over 40% of the population living in urban areas. This is expected to increase as the Philippine urban growth rate is higher than the national average.[1]

Most areas of the Philippines experience periods of torrential rain, flooding, landslides, high winds, thunderstorms and related storm surges, especially during the rainy season between June and November.

Typhoons are one of the most dangerous natural hazards. Every year, they cause considerable loss of life and immense damage to property. They are also notoriously difficult to predict. The effect of these hazards was witnessed in 2011's Typhoon Pedring (internationally known as Nesat), 2012's Typhoon Pablo (Bopha), and Super Typhoon Yolanda (Haiyan) in 2013, which was one of the most intense and deadly tropical cyclones on record.

The country is usually affected by around 21 cyclonic storms each year and directly struck by five to six. To make sure society is sufficiently resilient and prepared for such events requires the development and delivery of effective weather and climate services.

Met Office and PAGASA partnership - key dates

PRE 2012
Met Office contact with PAGASA via WMO and PRECIS*

JULY 2012
Launch of DOST research project (NOAH)

NOV 2013
UK aid humanitarian assistance following Typhoon Yolanda

UKaid
from the British people

*PRECIS - Providing REgional Climates for Impacts Studies
- regional climate modelling system from the Met Office Hadley Centre

Background

The Philippines is ranked as one of the world's most disaster prone countries, coming third out of 171 countries based on the number of disaster events in the last 10 years.[2] It is also among the top ten countries in the world in terms of victims of disasters.[3] Long-term average losses per year due to natural disasters are estimated to be 206 billion Philippine Pesos (US$4.6bn) or 1.8% of GDP in direct losses and 42.2 billion Pesos (US$941m) or 3.6% of total government expenditure in emergency losses.[4] Providing reliable, readily available and easily accessible weather and climate information has great potential to improve preparedness and response to natural disasters and extreme weather. It can provide an invaluable tool to improve resilience and support sustainable growth across various economic sectors, including health, transport, energy, construction and agriculture.

In 2012 the President of the Philippines gave instructions to put in place a responsive programme for disaster prevention and mitigation in relation to natural hazards for the Philippines. His aim was to provide weather warnings to the Philippine population at least six hours ahead of a potential weather event.

Several of the subsequent disaster risk reduction priorities required action from PAGASA and its parent department, the Philippine Department of Science and Technology (DOST).

The Met Office has a long history of working in partnership with PAGASA. This has included PAGASA using our regional climate modelling system, PRECIS[5], and collaborations through World Meteorological Organization (WMO) programmes. Implementing the President's 2012 priorities led to a closer partnership with PAGASA on several projects to develop weather and climate capability in the Philippines including:

- developing a suite of forecast products based on both the high-resolution Philippines model and operational global model forecasts for early warning systems;
- developing seasonal forecast products to improve forecasting complexity, resolution and skills;
- improving long-range climate predictions for climate resilience;
- training and enhancing technical capacity covering short-range forecasting through to long-range climate prediction; and
- building capacity with external stakeholders to improve awareness and uptake of PAGASA services.

JUNE 2014

Start of MetUM NWP Project: development phase for introduction of MetUM

JAN 2015

Launch of 'building resilience to climate extremes' project

UKaid
from the British people

JULY 2015

Start of transition phase for introduction of MetUM[6]

FEB 2016

Start of integrated iHPC project and installation of the MetUM at PAGASA

"Following Typhoon Haiyan we have been working closely with PAGASA to help enhance its scientific and technological capabilities. Together we have created an improved modelling, forecast, guidance and impacts service for the Philippines.

When Typhoon Hagupit reached land in December 2014, many lives were saved as a result of such improved weather warnings and forecast information as well as consistent communication of the weather event to the Philippine Government. It is testament to the value of 'partnership', that PAGASA is now seeking to become a MetUM[6] Associate, and we look forward to many years of collaboration."

Julian Menadue
Strategic Partnership Manager, Met Office

Working together to improve early warning systems

The strength of our partnership with PAGASA was demonstrated when Typhoon Hagupit (locally named Ruby) hit in December 2014. It was the second most intense tropical cyclone of the year and brought high winds and heavy rain.

As the storm formed over the Pacific, we worked closely with PAGASA to predict its track and assess its intensity. The Met Office global weather forecasting model, along with other leading global modelling systems, identified the development of Typhoon Hagupit four days ahead of it making landfall. However the storm's track proved difficult to predict as different global models gave different forecasts of the typhoon's track.

As it became increasingly clear that Typhoon Hagupit was a significant threat, we undertook additional, more detailed model runs. These included high-resolution ensemble outputs which enabled some level of confidence to be applied to the expected landfall time and location. Attention was focussed on the variance between a slow moving and a fast moving track of the typhoon towards the Philippines (figure 1), and the related impacts of each.

These more optimised forecast outputs were made available to PAGASA and were used to complement other data sources in early warnings and advice from PAGASA to the Philippines Government and the wider population.

On 6 December, Hagupit made landfall in the Philippines, then tracked across the country passing south of the capital Manila. Throughout the storm's development and passage we also provided relevant and timely advice to decision makers within the UK's Department for International Development and Foreign and Commonwealth Office. This advice was used by UK Government to support decision-making on the early deployment of humanitarian assistance.

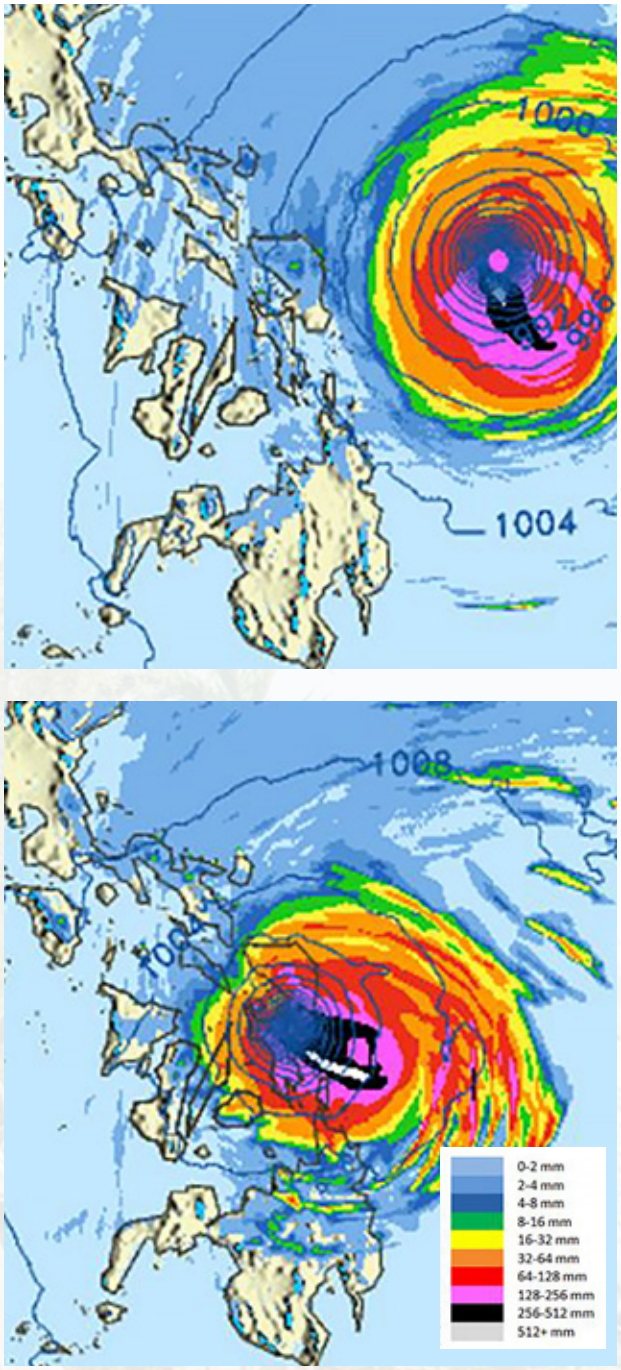

Figure 1: T+72 hour forecast of 12 hour precipitation accumulations of a more northerly slow moving track (top) and a more southerly fast moving track (bottom) from 15Z 07 December 2014.

" We would like to extend our sincerest gratitude for the valuable assistance that the Met Office officials and staff have given PAGASA – DOST during the passage of Typhoon Hagupit in the Philippines. The guidance documents and invaluable insights that you have provided were really very helpful and guided us to better understand Typhoon Hagupit's behaviour and validate our forecast. This heightened our capacity to assess the different models and provided the opportunity to enhance our capability in weather forecasting."

Dr Vicente Malano
PAGASA Acting Administrator

Building resilience to weather and climate extremes

Following Typhoon Yolanda (Haiyan) in 2013, the UK government immediately provided humanitarian support funded by UK aid from the Department for International Development (DFID), followed up with a technical assistance programme to help recovery and reconstruction in the Philippines. One component of this programme was building resilience to climate extremes, which was managed by the Met Office in partnership with PAGASA.

The 2015/16 project involved:

- developing regional climate model simulations to assess the impacts of climate change on future tropical cyclone activity; and
- building capacity to utilise existing/future climate information, by providing training activities to PAGASA and working with local government to develop processes to inform local planning and decision-making.

The project started with a comprehensive review and consultation with over 300 stakeholders on the issues around current information provision and uptake. This identified barriers and opportunities, including under-utilised historical climate risk information, a lack of capacity at local government level to translate existing complex information, and access to information by end-users. This work led to the development of two pilot projects to improve uptake of climate risk information in local planning, which are summarised in the case study across the page.

A central component of the wider project was generating and analysing high-resolution future climate simulations, using a regional climate model (HadGEM3-RA) developed by the Met Office. PAGASA also produced new simulations, by using a co-produced and consistent methodology with the regional climate modelling system PRECIS. The simulations provide insights into the variable and changing nature of typhoon frequency and intensity and other significant climate extremes in the Philippines over the next century, focusing on changes by the mid-21st century to inform resilience building and planning decisions. Modelling outputs have also contributed to PAGASA's new national climate projections which will be released in 2017.

A final component of the project focused on developing regional sea-level projections using a tool developed by the Met Office and collaboration with PAGASA scientists through secondments to the UK. The approach builds on the existing global projections of sea-level change over the next century, provided by the Intergovernmental Panel on Climate Change (IPCC), to estimate different contributions to regional sea-level rise in the Philippines such as melting glacier ice, gravitational effects, and ocean dynamics. The projections are available for different regions of the Philippines and they grow current knowledge, providing a first step towards more localised sea-level projections to inform long-term coastal planning decisions.

Learning from the project has helped develop a roadmap and an action plan identifying what is required to make climate information part of mainstream national and local planning and decision-making over the short- to medium-terms (2017-2022).

Continued work with PAGASA is intended to further support developing climate resilient planning practices across the Philippines. This will include assessing impacts of climate change across vulnerable sectors such as health, agriculture, energy, transport and other critical infrastructure, industrial development and transportation networks. An understanding of these will help to better inform climate resilient city planning as well as the ongoing management and operational efficiency of urban and rural areas and their infrastructure. The supply of high quality climate information will be critical to supporting resilient investment, innovation and development.

Case studies – Greater Metro Manila Area (GMMA)

Heavy rainfall pilot project – high resolution forecasting

Manila is the capital and second largest city in the Philippines, with a population of 12 million. Manila can be directly affected by tropical cyclones and also experiences a South West monsoon that can focus thunderstorm activity over the metropolitan area, triggering widespread floods and increased risk of landslides.

Sometimes tropical storms missing Manila to the north can enhance the South West monsoon and increase its intensity. This happened in August 2014 with tropical cyclone Halong, and twice in September 2014 with tropical cyclone Kalmaegi and an unnamed tropical depression in the South China Sea.

In all three instances we provided PAGASA with high-resolution Numerical Weather Prediction (NWP) outputs which meant they could be used for early warning of severe weather within the Manila metropolitan area. In each case PAGASA issued a yellow 'take action' weather warning which alerted people to the risk of flooding.

Impact-based forecasts, as opposed to a general weather forecast that people have to interpret themselves, have helped to improve preparedness for adverse weather and protect the homes, lives and livelihoods of the Philippine population.

"In line with the capacity building that the project has brought to PAGASA, I am very happy to inform you that our team won the Best Innovation outstanding award for 2016. The award is held annually and is participated in by different groups within PAGASA. Our team wants to extend our deepest appreciation to the Met Office in general, and to your science and business teams in particular. We would also like to share the award with the entire team!"

Thelma Cinco
Climatology and Agrometeorology Division
PAGASA

Supporting climate resilient city planning

Following the recommendations of the stakeholder review under the DFID project, two pilot projects at Local Government Unit (LGU) level were progressed with the aim of improving the use of climate information in local planning and decision-making. Two regions were chosen with contrasting characteristics; one urban (Three Cities in Greater Metropolitan Manila) and one rural (municipality of Salcedo, Eastern Samar).

These focused on selected climate sensitive sectors (for example health, local businesses, agriculture and fisheries) across the "supply chain" of climate information, covering information production, translation into risks and impacts, and communicating risk information to end-users. The pilots adopted a novel user-needs-based approach involving multiple interactive workshops to ensure the process was a collaborative effort between the producers and users of climate information. Participants included local planners, people working in disaster risk reduction and the health sector, and housing officers and community level (Barangay) officers. Outputs included providing training to over 100 local community members on how to use climate information, and developing a clear process to integrate climate information into local and sectoral planning and decision-making.

The pilot process provided valuable insights and learning to support the improved production, communication and uptake of climate information in local decision-making in the Philippines. The user-needs-based approach involving multiple interactive workshops ensured this was a collaborative effort between the producers and users of climate information and has greatly improved PAGASA's understanding of their end-user needs. LGUs have also become much more effective at incorporating climate information into planning and decision-making processes to improve resilience to climate and weather extremes.

Learning from this process and the products developed will support wider testing and development in other LGU areas. The pilot projects have improved interactions and understanding between PAGASA, as the national provider for climate information, and key departments responsible for local planning, disaster risk reduction and climate adaptation.

Further information is available at **http://www.metoffice.gov.uk/research/applied/international-development/philippines.**

Recent model improvements

Tropical cyclones are notoriously difficult to predict. But improvements to the Met Office forecasting model and our partnership with the Philippines are helping improve forecast accuracy and mitigate what can be devastating impacts.

In December 2013, Typhoon Yolanda (Haiyan) wreaked havoc across the Philippines, leaving over 6,000 people dead and millions displaced. It was one of the most powerful tropical cyclones ever recorded.

While the storm's track was predicted accurately using a global forecasting model, its intensity was underestimated. This is an issue for any global model – while their resolution is improving as increased computer power becomes available, it is still not enough to replicate the conditions at a tropical cyclone's typically compact centre, where winds can reach 190 mph and pressure as low as 900 millibars.

Major upgrades to our global model have already improved tropical cyclone intensity predictions since 2013, with tracking predictions improved by almost nine percent.

A more recent change has taken advantage of the observational estimates made by tropical cyclone warning centres around the world. Assimilating this data into the global model has improved tracking predictions by another six percent. The simulations produced as part of the building climate resilience project also provide insights into the variable and changing nature of typhoons and other significant climate extremes in the Philippines.

Strength in partnership

The continued partnership between the Met Office and PAGASA has delivered notable successes.

Forecasting improvements at all timescales include:

- Producing visualised forecasts for use by PAGASA forecasters.
- Improved forecast representation of the low pressure associated with tropical storms - assisting with forecasting storm intensity.
- Improved initialisation resulting in about a 10% increase in forecast accuracy of tropical cyclone tracks at landfall. This has pushed the timeline of forecasting tracks within a 100 km envelope out from ~24 hours to ~36 hours.
- Producing convective scale forecasting at 2 km resolution initially for use across the GMMA (see Heavy rainfall project case study).
- Developing a prototype forecast model for the Angat Dam (the associated reservoir supplies the Manila metropolitan area).
- Developing seasonal forecast products to improve forecasting complexity, resolution and skills.
- New high-resolution climate models to support climate resilience planning.

Operational enhancements:

- Heightened activity during significant events, for example Haiyan (Yolanda) and Hagupit (Ruby), when more detailed forecast runs were produced by the Met Office including ensembles with the focus on cyclone track, landfall location/time and intensity.
- Sharing of our operational practices, including working practices and systems for forecasting and warning of severe weather, through hosting PAGASA forecasters at the Met Office head office in the UK.

Training and workshops:

- Training and workshops on the Met Office Unified Model (MetUM) at the Met Office in the UK for PAGASA and University of Philippines staff.
- Training on impact forecasting resulting in clearer messaging to the public and other stakeholders.
- Training on engaging with stakeholders to develop sector-specific impact forecasts.
- A joint workshop on convective scale modelling hosted by PAGASA.
- 'Train the trainer' approach to ensure that learning is sustained.

Stakeholder engagement:

Outputs of the DFID project have greatly enhanced awareness of PAGASA's service among stakeholders and are expected to provide a number of benefits by:

- providing a common understanding of opportunities, barriers and actions required to improve climate-related risk information delivery by PAGASA and uptake at various levels; and
- paving the way for strengthening collaborations between PAGASA and different government departments, to improve resilience and ultimately benefit Philippine society.

Stakeholder engagement workshop during pilot projects – building resilience to weather and climate extremes.

Next steps

Working closely with PAGASA has and will continue to produce further developments in the messaging of both weather impacts and climate projections to the Philippines stakeholder community and its population in general.

The Met Office and PAGASA continue to collaborate, and the Met Office is supporting PAGASA with the installation of an integrated High Performance Computer (iHPC). A Cray XC40 supercomputer is being installed in 2017 within a data centre at PAGASA's Head Office in Manila. As part of this project, the Met Office is providing research and development services on the MetUM which will lead to PAGASA becoming a MetUM associate.

[1] https://www.adb.org/sites/default/files/publication/42817/philippines-national-urban-assessment.pdf
[2] World Risk Report 2016, United Nations University – Institute for Environment and Human Security (NHU-EHS), and Bundnis Entwicklung Hilft (Alliance Development Works) http://weltrisikobericht.de/english/
[3] Centre for Research on the Epidemiology of Disasters (CRED), Université catholique de Louvain Brussels - Belgium, EM-DAT: The OFDA/CRED- International Disaster Database, http://www.emdat.be
[4] World Bank 2014
[5] PRECIS - Providing REgional Climates for Impacts Studies - regional climate modelling system from the Met Office Hadley Centre
[6] The Met Office Unified Model (MetUM) is the numerical modelling system developed and used at the Met Office for all weather and climate applications.

Who we are

The Met Office is a global centre of excellence in weather and climate science, and the UK's national weather service. Founded in 1854, the Met Office pioneered weather forecasting. Ever since then we have been at the forefront of developments in weather and climate science.

Our international development work

We draw on our scientific and operational strengths to offer practical advice and specialist consultancies. Our wide range of skills and expertise enables us to support countries around the globe in developing and enhancing their weather and climate services.

What makes us different?

As an international organisation, we are exposed to many challenges and have a reputation of meeting and exceeding expectations. Our strong track record includes:

- experience of working in over 150 countries;
- a pool of internationally-experienced specialist staff;
- World Meteorological Organization (WMO) accredited training;
- a thorough understanding of how weather and climate are linked to development goals and policies;
- design of impact-based forecasting for WMO policy;
- supercomputing capacity for sophisticated modelling;
- developing one of the most accurate regional meteorological models in the world, now adopted by Australia, South Africa, South Korea and Thailand.

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