Summary for Policymakers

Synthesis of literature and available climate information to support resilience-building following Typhoon Haiyan (Yolanda) in the Philippines

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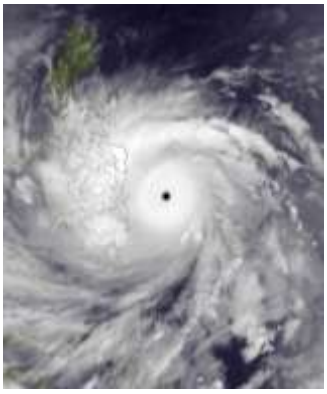
Rosanna Amato and Joseph Daron

Background Project Information

Typhoon Haiyan (locally named Yolanda) struck the Philippines in November 2013, causing significant damage and loss of life. In response, the UK Department for International Development (DFID) pledged support for the recovery and reconstruction effort. DFID is funding the Met Office, in partnership with the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), to help strengthen PAGASA's technical capabilities as well as provide state-of-the-art information to guide decisions and build resilience to future climate-related risks.

Typhoon Haiyan (Yolanda) was the most severe tropical cyclone to ever make landfall in the Philippines (right - NASA satellite image on November 7th, 2013). Maximum wind speeds peaked at 88 meters per second (197 miles per hour) and the storm travelled at twice the usual speed. The storm produced a very high storm surge with wave heights reaching 5 to 6 metres above normal in some regions of Leyte. Yolanda caused widespread devastation, killing over 6300 people and displacing over four million others. Other recent damaging typhoons in the Philippines include Typhoon Bopha (Pablo) in 2012 and Typhoon Rammasun (Glenda) in 2014.



What information is included in the literature review?

The review discusses key results from studies examining past and projected future climate extremes in the Philippines, with a focus on tropical cyclones. Information from the Intergovernmental Panel on Climate Change (IPCC), peer-reviewed scientific papers and relevant non peer-reviewed studies is summarised.

The review aims to:

- Assess the availability and reliability of regional climate information to support reconstruction efforts following Typhoon Yolanda
- Summarise information on past and future changes in tropical cyclones and sea level in the Philippines
- Identify the main constraints and opportunities for providing further information on future changes in tropical cyclones using regional climate model experiments

What is the current risk of tropical cyclones in the Philippines?

Tropical cyclones (TCs) are rotating storm systems that form over warm tropical waters. They bring very strong winds and large amounts of rainfall as well as the risk of coastal inundation from storm surges. TCs affecting the Philippines form in the western North Pacific Ocean, the most active area in the world for TCs, and gather strength as they move westward towards the Philippines. On average, 17 TCs (ranging from weak “tropical depressions” to intense “super typhoons”) pass through the Philippine Area of Responsibility (PAR) and seven TCs make landfall in the Philippines every year. However TC activity varies from year to year because of naturally occurring variability in the climate system. Between 1950 and 2013 the annual number of TCs entering the PAR varied between 11 and 27. TCs can occur at any time of year but most occur between July and October. Almost all of the Philippines is currently exposed to TCs, with a lower risk in the south (especially south Mindanao) and a higher risk further north.

What sources of historical and future climate information are available?

Observational climate records are available from meteorological stations across the Philippines since about the 1950s, although there are some temporal gaps in these records. Estimates of the climate can also be provided where stations do not exist (e.g. by using statistical methods to create gridded observational datasets). Satellite-based rainfall datasets, covering the period from the 1980s onwards, supplement ground-based observations. A number of TC datasets exist. The most

commonly used in the Philippines is the International Best Track Archive for Climate Stewardship (IBTrACS), which is a freely available global dataset providing information on TC frequencies, tracks and intensities. Sea level is monitored using a series of tide gauges around the Philippines as well as satellite-based radar altimeters.

Future climate projections come primarily from global climate model (GCM) simulations. More local scale projections are produced using regional climate models (RCMs), which better represent local scale atmospheric processes, and statistical downscaling methods. Recent projects providing downscaled future climate data for the region include the SEACAM project[1] and the SEACLID/CORDEX-Southeast Asia programme[2].

Has tropical cyclone activity in the Philippines region changed in the past?

Interpreting trends from historical observations of TCs in the western North Pacific Ocean is problematic because of changes in reporting methods over time and discrepancies between different datasets. However, there is some evidence for a slight increase in TC activity since 1970. A study by Kang and Elsner (2012) identified a trend towards fewer but more intense TCs in the region between 1984 and 2010. However, longer term historical trends are less apparent. A study by Kubota and Chan (2009) found no significant trends in TC activity or the number of landfalling TCs in the Philippines between 1902 and 2005. It is unclear whether human-induced climate change has affected TC activity in the western North Pacific region.

How might tropical cyclone activity change in the future?

Rising atmospheric greenhouse gas concentrations are increasing the energy in the climate system, causing ocean temperatures to rise and altering other aspects of the climate system that affect TCs. Although uncertain, future climate projections from the IPCC show that, by 2100, the overall number of TCs in the region may decrease but the TCs that do occur may become more intense on average, with increases in wind speeds and rainfall. High resolution modelling studies project increases of up to 20% in rainfall from TCs in the western North Pacific region.

Current evidence suggests that, irrespective of whether overall TC numbers and intensities increase or decrease, year-to-year variability will remain high. This variability is largely influenced by natural climate variations on global and continental scales, such as the El Niño Southern Oscillation (ENSO). During an El Niño event TCs are typically more intense, but they are also more likely to re-curve northward and miss the Philippines. Conversely, during a La Niña event (the opposite phase to El Niño) TCs are typically less intense but they follow straighter tracks, increasing the risk of landfall in the Philippines. There is some evidence that climate change may bring more El Niño like conditions in the Pacific Ocean. This could lead to more intense TCs in the region but favour TC formation further south-east, lowering the risk of landfalling TCs in the Philippines.

How confident are we in future projections of tropical cyclones?

Based on current understanding, the IPCC has stated that an increase in the frequency of the strongest storms in the region is ‘more likely than not’. Providing more confident statements about how TCs might change in a changing climate is extremely challenging. Climate models are an important tool for generating climate change projections, and GCMs can provide information about

[1] http://precisrcm.com/SEACAM.pdf
[2] http://www.observatory.ph/2015/04/12/seaclidcordex-southeast-asia/

relevant changes at the large scale. However, these models are unable to produce realistic TC intensities because they are not able to use the high spatial resolutions (a computationally demanding task**)** required to accurately represent relevant atmospheric processes. Yet a number of recent GCM studies have been able to simulate annual numbers of TCs and their geographical distribution of formation in the region that are consistent with the observations. This provides a solid basis for downscaling GCMs to higher spatial resolutions.

How is the sea level changing and what are the future risks of coastal inundation?

The global average sea level has risen by approximately 22 cm between 1870 and 2014, primarily due to thermal expansion of the ocean and increased melting of land-based glaciers and ice sheets. Between 1993 and 2012 the sea level in the western North Pacific Ocean increased at a rate of 10mm/year, approximately three times faster than the global average of 3mm/year. The difference is due to regional factors, such as the influence of natural modes of ocean variability on regional ocean circulation patterns. In Manila the sea level increase has been compounded by human-induced land subsidence (e.g. due to extensive groundwater extraction) of up to 1 metre per decade over the same period. Globally, the IPCC projects a sea level rise of between 0.52 and 0.98 metres by 2100 and an increase in the rate (presently at 3mm/year) to between 8 and 16 mm/year. There are currently no reliable projections of regional scale sea level rise for the Philippines.

The Philippines is highly vulnerable to the impacts of coastal storm surges. A study by Brecht et al. (2012) projects that 16 million people will be exposed to storm surge risk in the Philippines by 2100 compared to 10.6 million people in the year 2000, primarily due to rising coastal populations. The IPCC states, with high confidence, that extreme storm surges will increase with sea level rise at the global scale but there is low confidence in region-specific projections. The height of future surges will depend on regional sea level variations, TC intensity changes and changing coastlines.

The literature review constitutes an initial phase of the DFID funded project. Building on the information gathered in the review, as well as insights gained through further work in developing stakeholder relationships and understanding the needs of decision makers in the Philippines, the project will develop new science to improve understanding of tropical cyclone risks and climate extremes. Ultimately the project aims to inform decisions to increase resilience to climate risks and improve livelihoods in the Philippines.

Further work in the project will:

- Conduct high resolution climate model experiments to improve our understanding of tropical cyclone risks in the Philippines
- Explore the multiple related impacts that affect vulnerability and exposure to climate risks in the region, including sea level rise, extreme winds and intense rainfall
- Enhance the interactions between PAGASA, the Met Office and different stakeholder groups to develop climate products that help address climate risks and improve resilience

Met Office
FitzRoy Road, Exeter
Devon EX1 3PB
United Kingdom

Tel (UK): 0370 900 0100 (Int): +44 1392 885680
Fax (UK): 0370 900 5050 (Int): +44 1392 885681
enquiries@metoffice.gov.uk
www.metoffice.gov.uk