The influence of global warming on tropical cyclone characteristics and their impacts in the Philippines

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ABSTRACT

Tropical cyclones (TCs) are among the deadliest and most destructive natural hazards in the Philippines. With global warming and climate change, it is important to have a better understanding of how TCs have changed and might change in the future, particularly the most damaging events. This study has analyzed how the characteristics and potential impacts of the most damaging TC events in the Philippines might change under different climate conditions.

First, the ability of the Weather Research and Forecasting (WRF) Model was evaluated in simulating observed TC case in the Philippines wherein a high level of sensitivity to cumulus schemes, with a trade-off between using Kain-Fritsch and Tiedtke schemes have been found. The TC intensity is also sensitive to the surface flux options used; while the simulated track is most sensitive to cumulus scheme and spectral nudging. Our study also revealed low sensitivity to the initial and boundary conditions, having less spread than the simulations using different parameterization schemes.

Next, an idealised set of simulations were performed using the chosen WRF setup to examine the response of three of the most damaging TC cases in the Philippines - Typhoons Haiyan (2013), Bopha (2012), Mangkhut (2018) - to changes in sea surface temperature (SST) and atmospheric temperature. Changes in SSTs resulted in changes in TC track, with the simulated TCs' track to shift northwards, and an increase (decrease) in SSTs resulted in an increase (decrease) in TC intensity, size, and rainfall. The increase in atmospheric temperature profile with the increase in SST resulted in more intense TCs.

Finally, simulations were performed using the Pseudo-Global Warming (PGW) Technique and the WRF model at 5km resolution with cumulus convection parameterization (5kmCU) and at 3km without cumulus parameterization (3kmNoCU), with climate conditions for the pre-industrial and future periods derived from a selection of the latest CMIP6 models. Simulations of the three TC cases under the pre-industrial climate, showed that global warming has so far weakly influenced the intensity of the TC cases, but did not have much influence on the TC cases' track, size, and translation speed. We found that re-forecasting the three TCs under future warming scenarios leads to more intense TCs in terms of peak winds and rainfall, further increasing the wind-related cyclone damage potential (CDP) of Typhoons Haiyan, Bopha and Mangkhut in the future. The increase in the CDP ranges from ~1% to up to 37% in the future under the SSP5-8.5 scenario, primarily due to the increase in maximum winds. With the projected increases in TC-associated rainfall, TC-related damages due to flooding and landslides are also expected to increase in the future. There are relatively small changes in TC tracks, size and translation speed under the future climate. This will have great implications in terms of disaster risk management and climate change adaptation in the future.