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A Manifestation of Climate Change? A Look at Typhoon Yolanda in Relation to the Historical Tropical Cyclone Archive

Carlos Primo C. David
Bernard Alan B. Racoma
Jonathan Gonzales
and Mark Vincent Clutario
Environment Monitoring Laboratory
National Institute of Geological Sciences
University of the Philippines Diliman

ABSTRACT

The IBTRACS world database of tropical cyclone(TC) tracks was analysed to determine potential historical trends in TC characteristics for the west Pacific basin. Trends are then related to the characteristics of Typhoon Yolanda to see if this individual event constitutes as a data outlier or is part of a trend that can be related to climate change. In terms of TC frequency, it is deduced that there is a decreasing pattern in tropical cyclone formation starting in 1970. It is also noted that while there is no trend observed in the annual mean maximum wind speed, a decrease in the number of high wind speed TCs is measured for the months of November and December. The location of TC formation has also been changing towards a higher latitude but closer to the Philippines in terms of longitude. Lastly, typhoons making landfall in the Visayas and Mindanao region have also become slightly more frequent in the last decade. Except for the last finding, the 2013 typhoon season does not fit in these general trends. This year may be the start of a new trend or shift in TC characteristics (which we will only know after a few more years) but is most likely part of the inherent annual variability of typhoon characteristics. Yolanda goes against perceived trends but its occurrence signifies that there is still much to learn about tropical cyclones and the impending impacts of climate change in general.

INTRODUCTION

On 8 November 2013, Super Typhoon Yolanda (International Name: Haiyan) made landfall in Guiuan, Eastern Samar. It was, by many accounts, the most powerful tropical cyclone (TC) that made landfall ever recorded in history. According to the

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Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the recorded maximum 10-minute sustained winds of Yolanda were 230 kilometers per hour (kph) with gustiness reaching 250kph shortly after landfall. The Joint Typhoon Warning Center (JTWC) calculated 1-minute maximum sustained windspeed of 315kph with gustiness reaching 380kph. The National Disaster Risk Reduction and Management Council (NDRRMC) report dated 16 December 2013 stated that 6,069 individuals perished while 1,779 are still missing because of Super Typhoon Yolanda. More than 5,000 of the casualties came from the province of Leyte and this was mainly due to the storm surge that affected its coastline. The estimated total worth of damages is pegged at PhP35.5 billion.

One question that often arises during discussions in the aftermath of the disaster is whether this extreme event can be considered to be the "new normal" and therefore attributable to climate change. Among meteorologists, the consensus is that the warming of ocean waters due to climate change will theoretically influence cyclogenesis, but the high level of uncertainty in results precludes any definitive cause-effect relationship (WMO 2006). The Intergovernmental Panel on Climate Change (IPCC) report conceded that the resolution of coupled ocean and atmospheric modelling is still too coarse to completely resolve climate change-related changes to tropical cyclone characteristics (IPCC 2007). Still, based on various modelling studies, the IPCC report projected a decrease in mid-latitude storms globally per year but an increase in average wind intensity. This statement was slightly revised in its Fifth Assessment Report (IPCC 2013) wherein it said that current datasets indicate no significant observed trends in global tropical cyclone frequency over the past century. Conflicting results were provided by McDonald and others (2005): they reported an almost insignificant decrease in the number of typhoons (6% decrease) but an increase in wind intensity. Still, Emoriet and others (2005) projected that both the number and intensity of cyclones in the northern Pacific basin will decrease but related precipitation will increase. One of the more recent works on tropical cyclone modelling was done by Knutson and others (2010), who projected that globally, the number of tropical cyclones will decrease by 6-34%, but the number of very intense cyclones will increase by about 20% by 2100. The same paper suggested a poleward shift in tropical cyclone formation.

Considering the apparent uncertainty of TC frequency and intensity trends from global climate models, the other technique that can be used in figuring out tropical cyclone trends is to analyze historical archives while looking at a single event, such as Yolanda, in relation to the typhoon database. This work aims to contribute to this form of analysis by looking at not only annual frequency and intensity trends but also other typhoon metrics by dissecting typhoon characteristics on a month-by-month scale.

METHODOLOGY

The US National Oceanic and Atmospheric Administration (NOAA) maintains a database that archives all recorded tropical cyclones by various weather agencies. The International Best Track Archive for Climate Stewardship (IBTRACS) boasts of more than 300,000 tropical cyclone-related entries, one-third of which are western Pacific cyclones (Knapp and others 2010). The dataset covers the years 1884-2012, and includes TC tracks (6-hourly), calculated wind speed and barometric pressure, among other information. The IBTRACS has been endorsed by the World Meteorological Organization as an official archiving program for tropical cyclone information. The present analysis primarily uses the IBTRACS data; however, the 2013 TC data from JTWC are included, whenever applicable, for completeness.

The IBTRACS data is parsed using the Python programming language and Microsoft Excel, and plotted using ESRI's ArcGIS. In many of the interpreted data, a 10-year moving average is employed to reduce annual variability and highlight the longer term changes in the parameters measured. Statistical analysis is performed to confirm any possible trends from the dataset.

RESULTS AND DISCUSSION

Tropical cyclone frequency

Figure 1 shows tropical cyclone formation in the west Pacific basin on an annual basis. Evident in this plot is the increase in TCs recorded from the start of the dataset until around the 1970s wherein the highest total number of typhoons recorded was 61 in 1971; the 10-yr moving average in 1971 was 47.7 typhoons per year. The apparent 300% increase over the 86-year period is partly due to incomplete tropical cyclone reporting in the early years; reports were based on data dependent on the density of shipping vessels reporting such weather disturbances (Knuttson and others 2010). Higher ship density started in the 1960s and satellite-based reporting only became operational in 1966. Starting in 1970, a decreasing trend spanning 43 years is recorded in the 10-year moving average. The current 10-year average stands at 28.4 typhoons per year.

Typhoon Yolanda was the 34th of 35 tropical cyclones that formed in the west Pacific basin in 2013. With seven more typhoons than the 10-year average, 2013

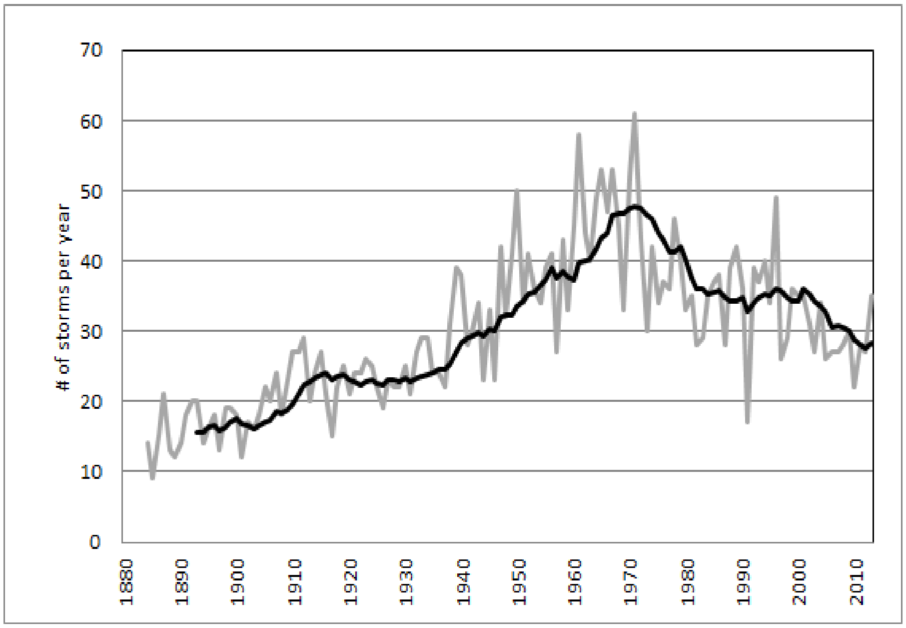


Figure 1. Number of tropical cyclones recorded annually in the west Pacific basin. The black line is the 10-yr moving average.

has the highest recorded number of TCs in the last 12 years and constitutes a 3-year increasing trend starting in 2010.

Tropical cyclone intensity

Tropical cyclone intensity is measured via the maximum wind speed each TC system has attained during its lifetime. The IBTRACS database has a record of historical wind speeds between the years 1977 and 2012. The measure of wind speed is based on the 10-minute maximum sustained winds, which is similar to PAGASA's signal system but different from the Storm category system used in the United States. The latter is based on a 1-minute maximum sustained winds measurement.

Figure 2 shows the annual maximum wind data obtained from the IBTRACS dataset. Average annual maximum wind speeds do not show any definite trend; if at all, there is a slight decrease in mean typhoon intensity in the 25th to 75th percentile of annual typhoons since 2007. Typhoon Yolanda's 230kph matches 2010's Typhoon Juan (International Name: Megi) wind speed. The 2013 maximum wind speed average falls within historical range despite recording five typhoons that exceeded 185kph maximum wind speeds (two made landfall in the Philippines: Odette and Yolanda).

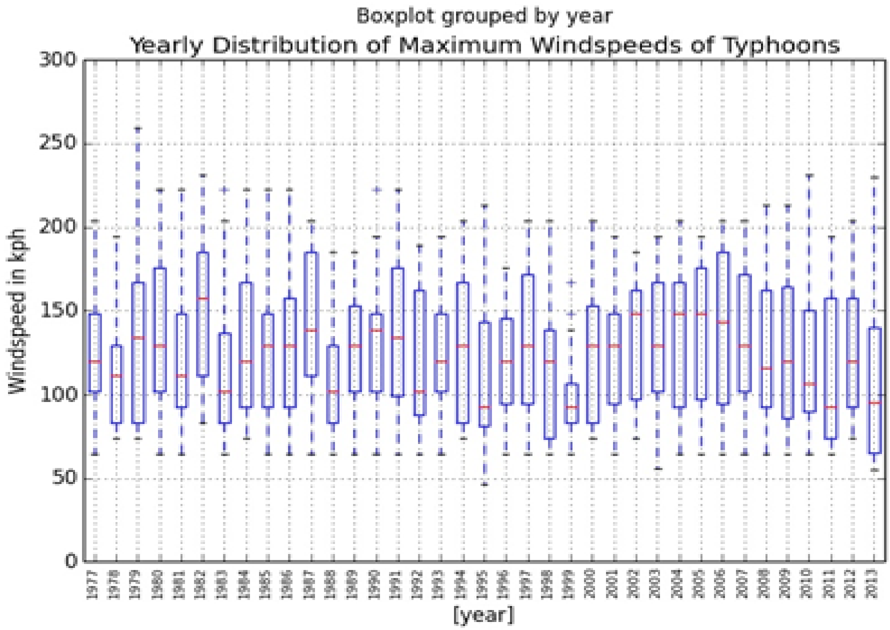


Figure 2.Maximum wind speed data. The dashed line shows the range of wind speeds per year, the box denotes the range of typhoons falling within the 25th to 75th percentile (interquartile range) and the horizontal line inside the box represents the mean of the annual maximum wind speeds.

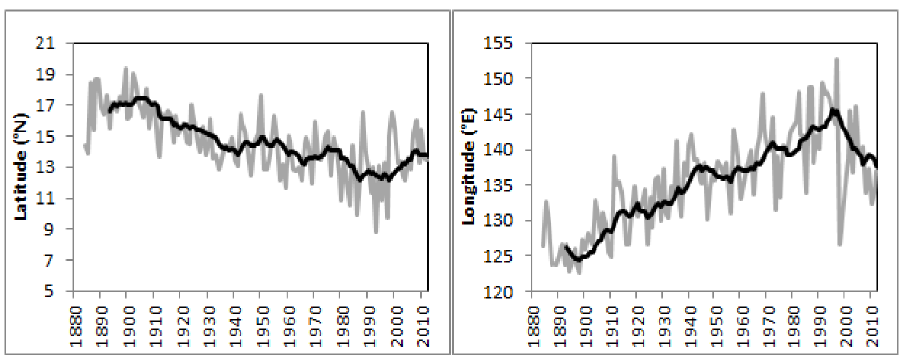
The IBTRACS dataset is further analysed to determine monthly trends for typhoon intensity. Table 1 shows the average number of significant typhoons (>150kph) that formed in the west Pacific basin for each month per decade. August and September record the most number of significant typhoons and the number is increasing throughout the decades. Significant typhoons in November and December show a decreasing trend.

Table 1. Average frequency of significant typhoons per decade (>150kph)

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot
1977-1979	0.3	0.0	0.0	0.0	0.0	0.7	1.0	1.7	1.7	1.7	2.0	1.0	10
1980-1989	0.2	0.2	0.3	0.5	0.4	1.1	2.1	2.2	3.0	2.9	1.8	0.8	16
1990 - 1999	0.0	0.0	0.1	0.3	0.5	1.0	1.4	2.4	3.2	2.4	1.4	0.3	13
2000-2009	0.0	0.1	0.4	1.2	1.3	1.5	2.4	3.3	3.3	2.0	1.1	0.4	17
2010-2013	0.0	0.0	0.0	0.3	0.5	1.0	1.5	2.8	3.8	2.5	0.5	0.3	13
average	0.1	0.1	0.2	0.5	0.5	1.1	1.7	2.5	3.0	2.3	1.4	0.6	14

Location of formation

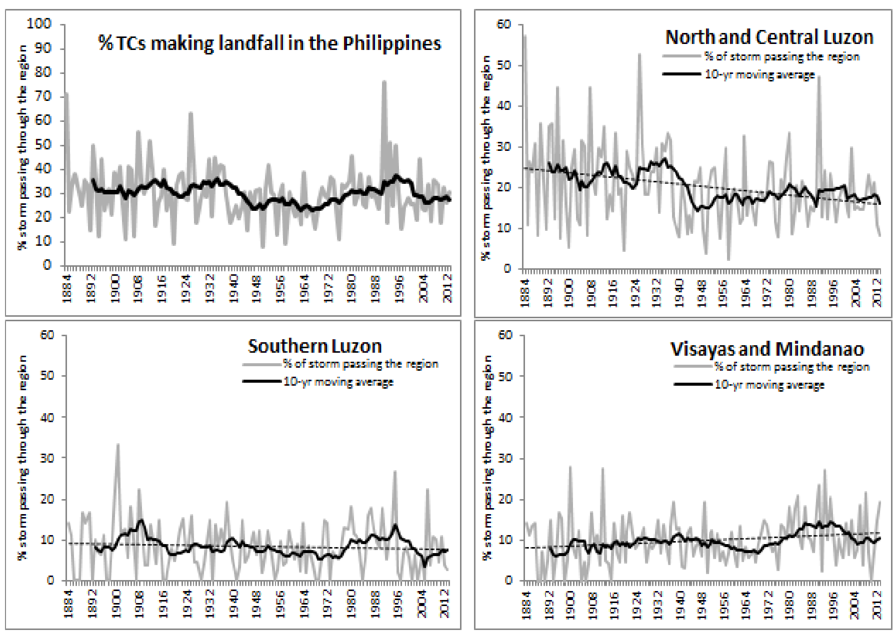
The location of tropical cyclone formation will indirectly have a bearing on whether or not typhoons will make landfall in the Philippines. With a general west-northwest typhoon track, the higher the formation latitude and further east longitude, the lower the chance of the typhoon passing by our country. The Philippines is located at latitude 5pN to 20pN and longitude 117pE to 127pE. This latitude range is roughly the same range as the western Pacific typhoon formation. Figure 3a shows a definite shift in annual mean latitude of formation from about 17pN to as low as 12pN in the mid-1990s. This is coupled with an increase in annual mean formation longitude (farther east from the Philippines) from 125pE to 145pE (Figure 3b). Since then, however, a shift back to higher latitudes but closer longitude of formation is recorded in the last 18 years. This means that on average, typhoons have been more recently forming nearer the Philippines but at a higher latitude equivalent to Metro Manila. This is despite the fact that significant typhoons within the recent past have originated from very near the equator. Typhoon Sendong (International Name: Washi) became a tropical depression at 6p north; Typhoon Pablo (International Name: Bopha), at 5p north; and Typhoon Yolanda, at 7pN of the equator.



Figures 3a and 3b. Mean latitude and longitude of typhoon formation per year.

Number and location of landfall

Figure 4a shows that annually a range of 8-76% of TCs that form in the west Pacific basin make landfall in the Philippines. The historical average is 30.3% with the highest recorded percentage happening in 1991 and culminating in the highest 10-yr average of 37.7% in 1995. However, since then, this percentage has gone down to 28%, with 2013 recording only 31.4% of the TCs making landfall in the country. To determine whether typhoon tracks are changing through time, the number of TCs making landfall in Northern Luzon, Southern Luzon-Bicol, and Visayas-Mindanao are plotted (Figures 4b-d). Northern Luzon still accounts for most TCs making landfall (20.2% of all TCs formed), followed by Visayas-Mindanao (9.8%) and Southern Luzon-Bicol (8.4%). However, noticeable in these plots is the slight decrease in TCs entering Luzon and Bicol and increase in the percent of TCs entering Visayas-Mindanao, which is up by 0.8% to 10.6%. The peak occurred in the 1990s when 12-15% of TCs passed by Visayas-Mindanao. The 2013 typhoon season recorded 7 of 11 tropical cyclones making landfall in Visayas or Mindanao. This also constitutes 20% of all TCs that formed in the west Pacific basin, double the 10.6% average for the region.



Figures 4a-d. Percent of tropical cyclones formed that made landfall in the Philippines. The dark line shows the 10-year moving average for the dataset.

CONCLUSIONS

There are evident tropical cyclone trends as shown by the analyses of the IBTRACS database. These include: the decreasing number of TCs forming in the west Pacific basin, the increase in latitude (and decrease in longitude) of mean TC formation, the decrease in the number of significant storms in November and December, and the increase in TCs entering Visayas and Mindanao. Further analyses of the IBTRACS database are already underway, including the separation of apparent linear trends relatable to climate change with possible inter annual cyclical occurrences such as the El Nino Southern Oscillation.

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REFERENCES

Emori S, Hasegawa A, Suzuki T, Dairaku K. 2005. Validation, parameterization dependence, and future projection of daily precipitation simulated with a high-resolution atmospheric GCM. Geophys. Res. Lett. 32 L06708. DOI: 10.1029/2004GL022306.

[IPCC] Intergovernmental Panel on Climate Change. 2007. Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL, editors. Cambridge, UK and New York, USA: Cambridge University Press.

[IPCC] Intergovernmental Panel on Climate Change. 2013. Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Stocker TF, Qin D, Plattner GK, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM, editors. Cambridge, UK and New York, USA: Cambridge University Press. In press.

Knapp KR, Kruk MC, Levinson DH, Diamond HJ, Neumann CJ. 2010. The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying tropical cyclone best track data. Bull. Amer. Meteor. Soc. 91: 363-376.

Knutson TR, McBride JL, Chan J, Emmanuel K, Holland G, Landsea C, Held I, Kossin JP, Srivastava AK, Sugi M. 2010. Tropical cyclones and climate change. Nature Geosci. 3: 157-163. DOI 10.1038/NGEO779.

[WMO] World Meteorological Organization. 2006. WMO International Workshop on Tropical Cyclones Statement on Tropical Cyclones and Climate Change. Available from: http://www.wmo.int/pages/prog/arep/tmrp/documents/iwtc_statement.pdf