Presented at the DLSU Research Congress 2015
De La Salle University, Manila, Philippines
March 2-4, 2015

Weather Projections for De La Salle University - Manila Using Statistical Downscaling

Juan Carlos Tamayo[1,*], Rechel Arcilla[1], Edgar Vallar[2], Maria Cecilia Galvez[2]
[1] *Mathematics Department, De La Salle University*
[2] *Physics Department, De La Salle University*
**Corresponding Author: juan.tamayo@dlsu.edu.ph*

Abstract: Statistical downscaling is a method in which small-scale or local-scale weather data can be generated using statistical relationships derived from Global Climate Models (GCMs). It is often used in weather data forecasting as a tool for connecting the global forecasts of the GCMs to the regional / local scale. This paper focused on using statistical downscaling for weather forecasting at De La Salle University - Manila. Results showed that the months of June, July, August and September have the highest number of wet days and the highest average amount of precipitation throughout the year. Results also showed that the simulated data had an identical statistical distribution as that of the original data. Forecasts made for the simulated data were used as forecasts for the original data since it was shown that the original and simulated data sets had the same distribution. The forecasts were then used as insights for future climate scenarios.

Key Words: Weather Forecasting; Statistical Downscaling; Weather Generator; LARS-WG; Global Climate Models

1. Introduction

Weather forecasting is a much needed tool for our society in today's lifestyle. It helps us make decisions on our daily activities. For instance, it helps farmers make decisions regarding their crops, and it helps people plan their daily traffic routes. Furthermore, it is necessary for a country that depends on its agricultural production to have an accurate weather forecast so that it can manage its agricultural production and investments better. But more importantly, it helps plan for emergency situations (i.e. flooding) and prevents such situations from happening. It is imperative that a country has a self-sufficient weather forecasting branch that can accurately predict and forecast weather conditions before it even happens so that people can prepare for any natural calamities that can come their way.

The Philippine Atmospheric, Geophysical, & Astronomical Services Administration (PAGASA), the government agency that is tasked to deal with weather forecasting and flood control, has done its job in trying to forecast the weather in the country. However, local government units (LGUs) need small-scale forecasts so that they can make proper decisions. Thus, a localized type of weather forecasting should be made.

Global Climate Models (GCMs) is a mathematical representation of the global climate. It is designed so that scientists can simulate future weather and environment conditions on a global scale. It usually uses large area grids ranging from about 110 – 500 km by 110 – 500 km. Thus, the accuracy of these models decline when used for regional or local impact assessments due to their inherent coarse spatial resolution (Bachelet, 2011). Also, local climate may differ from the regional climate due to geographical terrains such as deep valleys and mountains. Thus, methods have been developed that can appropriately create models for impact assessment on a smaller, regional or local, scale.

The statistical downscaling technique is the dominant technique used by scientists for small scale impact assessment of the weather conditions. The method was developed on the view that two factors, namely the local physiographic features of the land and the large scale climactic state, affected the local climate (Wilby et al, 2004). This technique generates local weather data using the statistical relationships found in the GCMs.

De La Salle University (DLSU) is often included in the list of the top universities in the Philippines. However, weather factors such as precipitation often hinder its students in getting the best out of their education. Proper localized weather information should be generated so that this may be avoided. Thus, there is a need for a localized study that will derive the necessary weather information.

This study aims to project future weather conditions using statistical downscaling. Specifically, it aims to be able to simulate future weather data using temperature and precipitation readings from DLSU. Also, it aims to project the future amount of rainfall that is due for the academic years 2014 - 2019 using statistical downscaling.

The localized weather forecasts can help in the decision-making of the administration during tropical storms and typhoons. This is significant since the university will be able to make faster and timelier decisions with regards to the suspension of classes preventing unnecessary hardships for the La Sallian community.

The statistical relationships developed for the current climate may not hold true for future climates (Wilby et al, 2004). Thus, the usefulness of the results and conclusions may only be true for a few years. In addition, the usefulness of the study only extends to a small (50 km) circumference of the area that was used since statistical downscaling only provides information for area grids of 50 km or less (Wilby et al, 2004).

Furthermore, the study used only one GCM since there was a lack of readily available GCMs in the software. Also, the study only made use of 3 years' worth of data.

2. Methodology

2.1 Data

The data used in this study was taken from the Environment And RemoTe Sensing ResearcH (EARTH) laboratory of the Physics Department of DLSU. This laboratory primarily deals with studies geared towards obtaining more information about the environment and protecting it. The site for their weather station is on the rooftop of the Br. Andrew Gonzales Hall Building. The site takes a reading every 30 minutes each day, thus having 48 readings per day. A usual day starts at 12:30 AM and ends at 12:00 AM. The site's record from 9:30 AM of March 14, 2011 to 12:00 AM of July 19, 2014 was used in the study. It included variables such as the minimum and maximum temperatures of the day, the daily amount of rainfall, and the daily percentage of humidity around the site. The observations started from 9:30 AM of March 14, 2011 because this was the first observation that the weather station took and ended at 12:00 AM of July 19, 2014 since this was the day that the data was extracted from the site.

Only daily amount of rainfall and minimum and maximum temperatures were used in this study. Numerous articles and journals suggested that temperature and precipitation are good variables for statistical downscaling (Semenov and Barrow, 2002; Wilby et al, 2004; Walsh, 2011).

A record for the suspension of classes was also taken from the twitter history of "De La Salle University". The twitter account named "De La Salle University" is the official twitter account of De La Salle University – Manila. This data will be used for the interpretation of the downscaled data.

2.2 Analysis

Statistical downscaling was applied to the data using the weather generator approach. In particular, the LARS-WG was used since it was able to give more accurate estimates than the Statistical DownScaling Model (SDSM), another approach that makes use of the regression method (Lansigan et al., 2013). The data was summarized so that its statistical characteristics such as its mean, standard deviation, and semi-empirical distribution were derived. These characteristics were used to generate simulated data. The Kolmogorov – Smirnov, t- and F- tests were used to check for any significant differences between the simulated data and the original data. The GCM was then used in order to simulate future weather conditions.

All analyses were performed using LARS – WG. A 1% level of significance was used in the hypothesis testing.

3. Results and Discussion

3.1. Summary of Observed Data

The summary of the amount of precipitation recorded from March 14, 2011 to July 19, 2014 (original data) by the EARTH laboratory in DLSU is detailed from Tables 1 through 4. These tables detail necessary statistics such as the length of dry/wet spells within a particular month and the amount of precipitation within that same month.

Results showed that the months of June, July, August, and September are the months that have the highest average amount and highest maximum amount of precipitation (Table 1, Figure 2). These months are, coincidentally, the rainy months of the year for the country and are expected to have the highest mean amount of precipitation throughout the year.

Table 1 also shows that some months have standard deviations higher than its corresponding means. This simply means that there is a high variability for rainfall during these months. Take the month of April to be an example of such behaviour. There could be some instances wherein the month of March would have little to no rain for one year and would have high amounts of rain for the next.

Table 1. Statistics from the original data for total amount of precipitation for each month (in mm)

Month	Max	Mean	S.D.
January	32.9	18.667	16.560
February	84.3	47.553	40.857
March	80.9	35.700	37.204
April	36.3	11.802	16.496
May	184.4	108.980	60.700
June	606.4	300.210	214.559
July	530.0	331.958	135.220
August	817.6	430.247	379.955
September	591.3	395.863	231.443
October	291.2	226.197	56.339
November	173.1	92.090	79.597
December	153.9	68.033	75.624

Available information for the lengths of the wet and dry series for each month was also summarized. Table 2 presents the statistics for the wet series while Table 3 presents the statistics for the dry series.

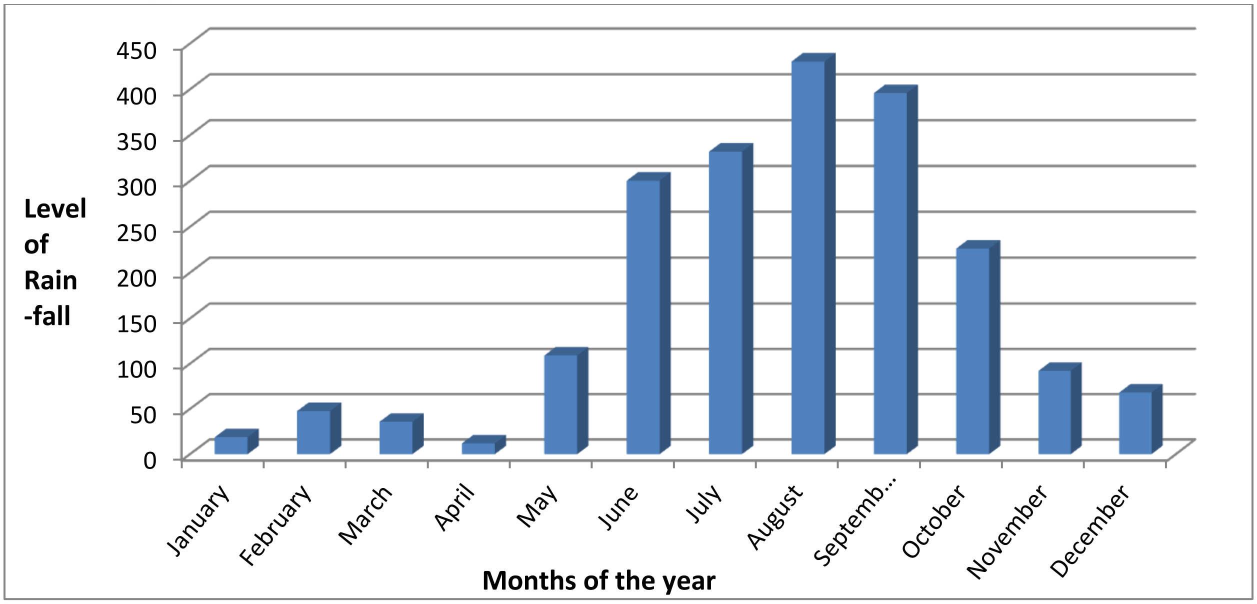

Figure 1. Bar graph of the monthly mean amount of precipitation from the original data (in mm)

Table 2. Statistics from the original data for the length of the wet series for each month (in days)

Month	Max	Mean	S.D.
January	3.00	2.00	0.71
February	3.00	1.33	0.67
March	6.00	1.77	1.31
April	2.00	1.17	0.37
May	10.00	3.00	2.37
June	10.00	3.85	2.83
July	15.00	5.40	4.30
August	12.00	4.80	3.92
September	19.00	6.25	5.54
October	10.00	2.56	2.24
November	7.00	2.53	1.68
December	7.00	2.00	1.66

Table 2 presents the average number of wet days in all the months. Based on the table, the months that have the highest average number of wet days are the months of June, July, August, and September which is in agreement with the earlier findings. Table 2 also shows that there is a high variability for the length of the wet series for each month. Again, there could be some instances wherein the months would have longer lengths of wet days for one year and would have short lengths of wet days for another.

On the other hand, the average number of dry days per month is highest in the months of January, February, March, and April (Table 3). These months are known as the summer months of the country and are expected to have the most number of dry days.

Table 3. Statistics from the original data for the length of the dry series for each month (in days)

Month	Max	Mean	S.D.
January	31.00	7.40	9.50
February	14.00	6.89	3.63
March	26.00	6.57	6.88
April	23.00	14.71	8.31
May	10.00	3.00	2.32
June	4.00	2.32	0.98
July	7.00	1.60	1.54
August	5.00	1.64	1.23
September	3.00	1.30	0.64
October	9.00	2.71	2.19
November	20.00	3.35	4.50
December	6.00	3.23	1.80

Furthermore, the month of November recorded a dry series of 20 days and has the highest average of dry days after the summer months. However, no conclusions can be made for the dry series for November since it varies inexplicably year-by-year. This may be caused by the "El Niño" phenomenon that happened during 2012 and 2013 (Anonymous, 2014). The "El Niño" phenomenon causes the country to have below normal precipitation and, thus, having longer dry spells within the year.

The records for the suspension of classes from the twitter history of "De La Salle University" were then used to cross-reference the date of the suspension of classes and its corresponding amount of precipitation from the weather station. The results of this procedure are summarized in Table 4.

Table 4. List of all suspended days for the years 2011 – 2014 and their respective levels of precipitation (in mm)

Date	Amount of rain
7/3/2012	85.1
7/30/2012	21.3
8/1/2012	5.3
9/15/2012	110.7
10/3/2012	57.4
6/18/2013	2.8
8/12/2013	28.7
8/19/2013	154.7
8/20/2013	263.1
10/14/2013	10.7
11/9/2013	1.3
7/15/2014	40.9
7/16/2014	108.5
7/17/2014	5.3

The largest amount of precipitation that was recorded was during the month of August 2013 which recorded a precipitation level of 263 mm (Table 4). This extreme point resulted from the entry of severe tropical storm Trami, also known as Typhoon Maring, in the Philippine area of responsibility last August 18, 2013. Maring was infamous for causing the floods that affected over half of the city of Manila and for the floods along South Luzon Expressway (SLEX).

It can also be shown that the bulk of the suspension of classes had precipitation levels of more than 40 mm (Table 4). Thus, it can be established that the threshold for the amount of precipitation needed in order to suspend classes, for this paper, would be 40 mm.

3.2. Projections for 2014 – 2016

Future values of precipitation were then simulated. The simulated future amounts of daily precipitation for the next academic years for the area of De La Salle University are presented in Table 5. Take note that the data presented in Table 5 are only the dates that exceeded the minimum threshold of 40 mm.

These projections can be used as insights, or "indicators", to see what future weather climates are like. For example, a "Red Warning" flood around the middle of March 2015 is expected since the data shows that there is a high projected amount of precipitation for this time. A "Red Warning" flood indicates that more than 30mm of precipitation have been dropped within the past hour. A "Red Warning" usually results to evacuation for low lying areas (Panela, 2012). Thus, the projection can be used in order to prepare for and prevent the future weather complication that will happen during that time.

Table 5. Projected values of precipitation for Academic Years 2014 to 2019 (in mm)

Date	Amount of rain	Date	Amount of rain
9/17/2014	43.7	1/14/2016	66.1
9/19/2014	41.1	1/19/2016	67.2
9/20/2014	43.1	1/24/2016	108.5
1/8/2015	110.2	1/13/2017	143.7
1/31/2015	82.1	1/21/2017	42.8
2/7/2015	54.7	1/28/2017	88.8
2/10/2015	78.9	2/6/2016	72.4
2/26/2015	54.5	3/4/2016	219.3
3/16/2015	58.6	3/14/2016	41.6
3/18/2015	169.1	3/19/2016	133.9
4/4/2015	107	3/21/2016	80.9
4/7/2015	104.6	12/3/2016	47
1/3/2016	89.3		

In addition, results showed that there would be floods that are half as devastating as Typhoon Ondoy which recorded precipitation levels of 454.9 mm. According to the simulations, there would be one typhoon during the first quarter of 2016.

3.3. Post-Hoc Observations

Since the original period of the data used in this study is from June 2011 – July 2014, it is possible to make post-hoc observations for the dates that go beyond July 2014 to try to see if the projected amount of precipitation is viable. One notable time period is the period of September 17–20, 2014. These dates are notable since these are the dates that Typhoon Mario was in the Philippine Area of Responsibility (Anonymous, 2014). From the projections in Table 5, it is shown that the dates of

September 17, 19, and 20 of 2014 are likely to have amounts of precipitation that go beyond the minimum threshold of 40 mm. Thus, it can be said that the paper predicted that there would be a weather disturbance for that time period.

4. Conclusion

Statistical downscaling provided a different approach on how to forecast for amount of precipitation and maximum and minimum temperatures for a local area. This technique generates localized data that can be used for small-area risk assessment.

Using the weather generator approach, this study has forecasted for future values of the aforementioned variables. Since the approach does not need any kind of assumption for it to work, the method is easily applied and no transformations were needed. The software that was elected to be used in the study is the LARS-WG.

Descriptive statistics showed that the months that recorded the highest number of wet days and, subsequently, recorded the highest amount of precipitation are the months of June, July, August and September. These months are commonly considered to be the "rainy" months of the Philippines.

Forecasted values were then created and were shown to have extreme outliers. These outliers should be taken note of for future reference since these can act as insights for future possible weather scenarios. In general, all the days that has precipitation values that are greater than 40 mm should be taken note of.

5. Recommendation

Future researchers can look into longer series of weather data in order to have greater accuracy. Future studies may also divulge in using multiple GCM outputs so as to cross-reference their forecasts using different GCMs. Using multiple GCMs may also result to greater accuracy in the forecasts.

Temperature may also be considered in future studies for other areas. Temperature forecasting is useful for farm areas since temperature is important in crop production and forestry.

New techniques such as temporal downscaling may also applied so that sub-daily weather information could be generated in the study. Studying such techniques will lead to valuable information and would give new perspectives when it comes to weather forecasting and statistical downscaling.

6. Acknowledgement

The researchers would like to thank Dr. Edgar Vallar and Dr. Maria Cecilia Galvez of the EARTH laboratory for providing the data that was used in the study and for sharing some of their findings in their laboratory.

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