Statistical Modeling of Weekly Rainfall: A Case Study in Colombo City in Sri Lanka

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***Abstract*— The modeling of the weekly rainfall percentile is imperative for better understanding of rainfall patterns in any region. This study focuses on selecting the most appropriate probability distributions for weekly rainfall and use those to make reliable rainfall percentile with the 95% confidence intervals. Daily rainfall data of 56 years (1960-2015) during the South West Monsoon in Colombo City were used for this analysis. The three parameter Weibull distribution has been found most probable distribution for most of weekly rainfall totals. Weibull, two parameter Exponential, Exponential and Lognormal distributions were well fitted distributions for remaining totals. Based on the 95% confidence intervals of percentiles, the weeks 18-23, and 38-39 during SWM showed not only high rainfall, but also high rainfall variation results which caused high possibility to form extreme rainfall events. Heavy rainfall with great variation during the period of 30th April to 10th June and 17-30th of September was further confirmed by the result of running total of weekly rainfall.**

Keywords*— *Weekly Rainfall; Distribution; Colombo; Percentile; Confidence Intervals

I. INTRODUCTION

Rainfall percentiles are employed in designing of water related structures in many fields. Sound awareness about the rainfall pattern is vital to mitigate the various issues derived from heavy rainfall and long dry spell existence due to climate change. The probability distribution of the rainfall is essential to examine the pattern of rainfall specially in short range scale to get the maximum benefit from the rainfall by minimizing the damages which would be caused by changes of atmospheric behavior. Numerous people who live in urban areas are faced with many difficulties due to extreme rainfall events, especially from floods which occur from time to time [1]. Thus, prior knowledge of weekly rainfall behavior will be helpful to minimize such damages. By analyzing the rainfall characteristics on a weekly scale would be helpful to plan many activities which enclose with the urban areas, such as industrial, constructions, rain water harvesting, health and climate monitoring.

Sri Lanka is a tropical country which is vulnerable to climate change specially, from erratic rainfall events. The rainfall of Sri Lanka is strongly governed by the four seasonal varying monsoon system. Four major monsoon periods; First Inter Monsoon (FIM) from March to April, South West Monsoon (SWM) from May to September, Second Inter Monsoon (SIM) from October to November and North East Monsoon (NEM) from December to February can be identified in Sri Lanka [2].

Most of the researchers use point estimates derived from different theoretical probability distributions for rainfall percentiles and attempt to make inferences of rainfall amount. [3] used the Generalized Extreme Value distribution, Gamma and Log Pearson distributions for the maximum weekly rainfall in the monsoon period at the Pantnagar region in India to study the temporal variability of maximum weekly rainfall. According to the review of [4] the Weibull distribution is more likely fitted for describing weekly rainfall at Dehradun in India. Also, they used the probability distribution models for computing minimum assured amount of rainfall at different probability levels. Beta and Weibull distributions were fitted for the weekly rainfall during the monsoon and non monsoon periods, respectively, and those best fit distributions are employed for computing minimum assured amount of rainfall at different probability levels for the Command area by [5].

Moreover, many researchers have fitted theoretically probability distribution for the rainfall data at different time scales mainly monthly, seasonally and annually ([6], [7], [8] ,[9], [10]). However, extremely few studies were reported in Sri Lanka with respect to the rainfall variation at weekly scale. As noted in [11], weekly rainfall data were analyzed to investigate the change of the onset of FIM rain in coconut growing agro ecological regions in Sri Lanka.

However, it might be more risky depending on a single value formed from probability distributions to mitigate the circumstances which would be existed due to climate change. Confidence interval is one of the most popular technique that can be used to measure the uncertainty. Some researchers had made attempts to construct confidence intervals for rainfall amounts using different approaches such as Bootstrap and Bayesian. Bootstrap confidence intervals were made for the predicted rainfall quantities to show the effects of the Southern Oscillation Index Phase on rainfall quantiles by [12]. The three approaches; Bayesian, Bootstrap and Profile Likelihood were applied to construct confidence intervals of extreme rainfall quantiles by [13]. A study [14] was carried out to obtain reliable rainfall quantiles estimates for several return

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periods by using Wakeby Distribution with the method of L-moments estimates. Also, the 90% confidence intervals for the quantiles determined by Wakeby Distribution were constructed by using bootstrap resampling technique. To the best of the authors' knowledge, no study has been conducted for weekly rainfall quantiles in context of the parametric confidence interval approach in Sri Lanka.

The main goal of this study is to select the most appropriate probability distribution of weekly rainfall and use those selected distributions to make reliable rainfall percentile with 95% confidence intervals.

II. Materials and Methods

The City of Colombo is the commercial capital of Sri Lanka. It is situated with latitudes 6^0 93′ N and Longitude 79^0 86′ E and is selected as the study site. Daily rainfall data of Colombo were collected from 1960 to 2015 from the Department of Meteorology, Sri Lanka for this study. Weekly rainfall pertaining to SWM is considered for this analysis due to this monsoon brings rainfall directly to the Colombo area during May to September. The Wald Wolfowiz test was used for the test of independence of weekly data series (Sharda and Das, 2005). Two goodness of fit test; Anderson Darling and Kolmogorov-Smirnov were used to identify the best fitted distributions for weekly rainfall data separately. Rainfall percentiles (P_{50}, P_{60}, P_{70}, P_{80} and P_{90}) were derived using best fitted distribution and constructed the 95% confidence bands for corresponding rainfall percentiles.

Furthermore, running totals of weekly rainfall were obtained to identify the pattern of weekly rainfall which start on any day during SWM. Moreover, 95% confidence intervals for percentiles based on the best fitted distributions of running totals were constructed.

A. Weekly Rainfall Data

The daily rainfall (mm) data has been converted into weekly rainfall by dividing a year into 52 weeks as Week 1, Week 2, Weeks 3 and others corresponding to 1-7 January, 8-14 January, 15-21 January and so on respectively. It is noted that the February 29th wasn't taken into account when marking 52 weeks. The weeks pertaining to SWM is presented in Table I. Also, running totals of weekly rainfall were obtained during SWM period with Week 1 of the running total corresponding to 30th of April to 06th of May, Week 2 represent the period, 1-7 May, Week 3 of the running total corresponding to 2-8 May, Week 4 related to 3-9 May and so on. It is calculated total of 148 running totals of weekly rainfall during the SWM.

B. Fittings the Probability Distributions

Weekly rainfall data as well as running weekly rainfall totals were fitted to various theoretical probability distributions such as Normal, Lognormal, Gamma, Weibull, Exponential, Smallest Extreme Value, Largest Extreme Value, Logistic, Log logistics and also tried different forms of some distributions such as 3- parameter Gamma, 2- Parameter Exponential, 3-Parameter Log logistic and 3-Parameter Weibull distributions.

TABLE I. Weeks pertaining to the SWM

Weeks	Date	Weeks	Date
18	April 30-May 06	29	July 16-22
19	May 07-13	30	July 23-29
20	May 14-20	31	July 30-August 05
21	May 21-27	32	August 06-12
22	May 28-June 03	33	August 13-19
23	June 04-10	34	August 20-26
24	June 11-17	35	August 27-September 02
25	June 18-24	36	September 03-09
26	June 25- July 01	37	September 10-16
27	July 02-08	38	September 17-23
28	July 09-15	39	September 24-30

Anderson Darling test and Kolmogorov-Smirnov test were used as goodness of fit tests for parametric distributions. The computations were done using statistical software, namely Minitab 17 and Stata 12.1. Selected probability distribution functions are described by considering X as a random variable representing weekly rainfall as presented in Table II. The formula used for the percentile and its variance calculation is also shown in Table III. Furthermore, Table IV depicts the formulas that were employed for the confidence bands of percentiles.

III. Results and Discussion

A. Modeling Weekly Rainfall

Histogram of dataset provides clear evidence that the distributions of the weekly rainfall are skewed to the right. Four randomly selected weeks 18, 24, 30 and 37 are depicted in Fig1. An almost similar pattern was observed in remaining data series also. Before fitting various probability distributions to data set, data were tested for normality using Anderson Darling test and it was revealed that, no data series followed a normal distribution. Furthermore, according to the result of the Wald-Wolfowitz test, there is no evidence to reject the null hypothesis which data are independent at the 5% level of significance for all week. Table V illustrates the best fitted distribution for weekly rainfall total with estimated maximum Likelihood estimators (MLE). Also the corresponding Anderson Darling test statistics (AD) and Kolmogorov-Smirnov test statistic (KS) were presented in the Table V. Same procedure was carried out for the running totals and obtained a similar result.

It is noted that the most of the week belongs to the SWM were well fitted with the 3 parameter Weibull distribution. However, weeks 22-24, Exponential, Lognormal and Weibull distributions were found to be most appropriate distributions. Two parameter Exponential distributions were most probable distribution for the Weeks 26, 29, 31 and 34. Moreover, 68% of the running weekly totals are well fitted with the 3 parameter Weibull distribution while 22% are fitted with the two parameter Exponential distribution and the remaining are well fitted with the Exponential, Largest Extreme Value, Weibull and Lognormal distributions.

TABLE II. PROBABILITY DENSITY FUNCTIONS

Distribution	Probability Density Function	Parameters
Lognormal	$f(x)=\frac{1}{\sigma x\sqrt{2\pi}}\ \exp\left(-\frac{(\ln x-\mu)}{2\sigma^2}\right)$	μ - Location Parameter, σ -Scale Parameter $\mu \geq 0$, $\sigma > 0$, $X \geq 0$
Exponential	$f(x)=\frac{1}{\alpha}\ \exp\left(-\frac{x}{\alpha}\right)$	α -Scale Parameter $\alpha > 0$
2 Parameter Exponential	$f(x)=\frac{1}{\alpha}\ \exp\left(-\frac{(x-\lambda)}{\alpha}\right)$	α -Scale Parameter, λ -Threshold parameter $\alpha > 0$, $\lambda < X$
Largest Extreme Value	$f(x)=\frac{1}{\sigma}\exp\left[\left(\frac{x-\mu}{\sigma}\right)\right]\exp\left\{-\exp\left(\frac{(x-\mu)}{\sigma}\right)\right\}$	μ - Location Parameter, σ -Scale Parameter $\mu \geq 0$, $\sigma > 0$, $X \geq 0$
Weibull	$f(x)=\frac{\beta}{\alpha^{\beta}}x^{\beta-1}\ \exp\left(-\left(\frac{x}{\alpha}\right)^{\beta}\right)$	α -Scale Parameter, β -Shape Parameter $\alpha > 0$, $\beta > 0$, $X \geq 0$
3-Patarameter Weibull	$f(x)=\frac{\beta}{\alpha^{\beta}}(x-\lambda)^{\beta-1}\ \exp\left(-\left(\frac{x-\lambda}{\alpha}\right)^{\beta}\right)$	α -Scale Parameter, β -Shape Parameter, λ -Threshold parameter $\alpha > 0$, $\beta > 0$, $\lambda < X$

TABLE III. THE FORMULAS USED FOR PERCENTILES AND VARIANCE ESTIMATES

Distribution	Percentiles $\left(\hat{X}_p\right)$	Variance of Percentile Var $\left(\hat{X}_p\right)$
Lognormal	$\hat{\mu}+z_p\,\hat{\sigma}$	$Var(\hat{\mu})+{z_p}^2\,Var(\hat{\sigma})+2Z_p Cov(\hat{\mu},\hat{\sigma})$
Exponential	$-\ln(1-p)\,\hat{\alpha}$	$[-\ln(1-p)]^2\,Var(\hat{\alpha})$
2 Parameter Exponential	$\hat{\lambda}+[-\ln(1-p)\,\hat{\alpha}]$	$Var(\hat{\lambda})+[-\ln(1-p)]^2\,Var(\hat{\alpha})+2[-\ln(1-p)\,]Cov\,(\hat{\lambda},\hat{\alpha})$
Largest Extremes Value	$\hat{\mu}+z_p\,\hat{\sigma}$	$Var(\hat{\mu})+{z_p}^2\,Var(\hat{\sigma})+2Z_p Cov(\hat{\mu},\hat{\sigma})$
Weibull	$\hat{\alpha}\,[-\ln(1-p)]^{1/\hat{\beta}}$	$\frac{\hat{X}_p^2}{\hat{\alpha}^2}Var(\hat{\alpha})+\frac{\hat{X}_p^2}{\hat{\beta}^4}{z_p}^2\,Var(\hat{\beta})-2Z_p\,\frac{\hat{X}_p^2}{\hat{\alpha}\,\hat{\beta}^2}Cov(\hat{\alpha},\hat{\beta})$
3-Parameter Weibull	$\hat{\lambda}+\hat{\alpha}\,[-\ln(1-p)]^{1/\hat{\beta}}$	$Var(\hat{\lambda})+\hat{\omega}^2\,Var(\hat{\alpha})+\frac{\hat{\alpha}^2}{\hat{\beta}^4}\hat{\omega}Z_p^2\,Var(\hat{\beta})-2\frac{\hat{\alpha}}{\hat{\beta}^2}\hat{\omega}^2{z_p}^2\,Cov(\hat{\alpha},\hat{\beta})+2\,\hat{\omega}Cov(\hat{\alpha},\hat{\lambda})-2\frac{\hat{\alpha}}{\hat{\beta}^2}Z_p\hat{\omega}\,Cov(\hat{\beta},\hat{\lambda})$

TABLE IV. THE FORMULAS USED FOR CONFIDENCE LIMITS FOR PERCENTILES

Distribution	Confidence Bands
Lognormal Exponential Weibull	$\left\{\exp\left[\ln(\hat{X}_p)-Z_{\alpha/2}\frac{\sqrt{Var(\hat{X}_p)}}{\hat{X}_p}\right],\exp\left[\ln(\hat{X}_p)+Z_{\alpha/2}\frac{\sqrt{Var(\hat{X}_p)}}{\hat{X}_p}\right]\right\}$
2-Parameter Exponential 3- Parameter Weibull	If $\lambda<0$ $\left\{\hat{X}_p-Z_{\alpha/2}\sqrt{Var(\hat{X}_p}\ ,\quad \hat{X}_p+Z_{\alpha/2}\sqrt{Var(\hat{X}_p}\ \right\}$ $\lambda>0$ $\left\{\hat{X}_p-Z_{\alpha/2}\sqrt{\frac{Var(\hat{X}_p)}{\hat{X}_p}}\ ,\quad \hat{X}_p+Z_{\alpha/2}\sqrt{\frac{Var(\hat{X}_p)}{\hat{X}_p}}\right\}$
Largest Extreme Value	$\left\{\hat{X}_p-Z_{\alpha/2}\sqrt{Var(\hat{X}_p}\ ,\quad \hat{X}_p+Z_{\alpha/2}\sqrt{Var(\hat{X}_p}\ \right\}$

TABLE V. BEST FITTED STATISTICAL MODELS AND MAXIMUM LIKELIHOOD ESTIMATES FOR WEEKLY RAINFALL DURING SWM

Week No.	Best Fitted Distribution	AD	KS	Estimated Parameters (MLE)
18	3 - Parameter Weibull	0.317 (0.501)	0.0782 (0.884)	$\alpha = 77.061$, $\beta = 0.878$, $\lambda = -0.838$
19	3 - Parameter Weibull	0.131 (0.520)	0.0526 (0.996)	$\alpha = 82.249$, $\beta = 0.888$, $\lambda = -0.935$
20	3 - Parameter Weibull	0.247 (0.510)	0.0684 (0.956)	$\alpha = 67.331$, $\beta = 0.804$, $\lambda = -0.508$
21	3 - Parameter Weibull	0.362 (0.461)	0.1027 (0.596)	$\alpha = 73.570$, $\beta = 1.086$, $\lambda = -1.752$
22	Exponential	0.457 (0.540)	0.0857 (0.773)	$\alpha = 68.989$
23	Lognormal	0.319 (0.526)	0.0700 (0.928)	$\mu = 3.518$, $\sigma = 0.912$
24	Weibull	0.291 (0.257)	0.0691 (0.934)	$\alpha = 43.645$, $\beta = 1.267$
25	3 - Parameter Weibull	0.498 (0.222)	0.0752 (0.910)	$\alpha = 34.182$, $\beta = 0.884$, $\lambda = -0.383$
26	2- Parameter Exponential	0.912 (0.103)	0.1099 (0.110)	$\alpha = 40.204$, $\lambda = -0.718$
27	3 - Parameter Weibull	0.275 (0.521)	0.073 (0.926)	$\alpha = 32.535$, $\beta = 0.887$, $\lambda = -0.269$
28	3 - Parameter Weibull	0.531 (0.186)	0.069 (0.952)	$\alpha = 24.822$, $\beta = 0.741$, $\lambda = -0.131$
29	2- Parameter Exponential	0.873 (0.107)	0.1813 (0.182)	$\alpha = 37.875$, $\lambda = -0.676$
30	3 - Parameter Weibull	0.596 (0.210)	0.1066 (0.548)	$\alpha = 16.711$, $\beta = 0.626$, $\lambda = -0.038$
31	2- Parameter Exponential	0.841 (0.126)	0.1823 (0.232)	$\alpha = 19.853$, $\lambda = -0.355$
32	3 - Parameter Weibull	0.617 (0.113)	0.1002 (0.627)	$\alpha = 15.263$, $\beta = 0.602$, $\lambda = -0.029$
33	3 - Parameter Weibull	0.445 (0.531)	0.094 (0.706)	$\alpha = 23.975$, $\beta = 0.651$, $\lambda = -0.067$
34	2- Parameter Exponential	0.694 (0.101)	0.1193 (0.194)	$\alpha = 29.964$, $\lambda = -0.535$
35	3 - Parameter Weibull	0.607 (0.120)	0.1186 (0.410)	$\alpha = 22.408$, $\beta = 0.698$, $\lambda = -0.089$
36	3 - Parameter Weibull	0.544 (0.328)	0.0888 (0.770)	$\alpha = 26.012$, $\beta = 0.602$, $\lambda = -0.049$
37	3 - Parameter Weibull	0.246 (0.531)	0.0662 (0.967)	$\alpha = 40.709$, $\beta = 0.838$, $\lambda = -0.366$
38	3 - Parameter Weibull	0.438 (0.315)	0.0979 (0.656)	$\alpha = 57.303$, $\beta = 0.855$, $\lambda = -0.261$
39	3 - Parameter Weibull	0.397 (0.394)	0.0679 (0.958)	$\alpha = 81.654$, $\beta = 0.863$, $\lambda = -0.831$

* The value in parenthesis represent the corresponding P value

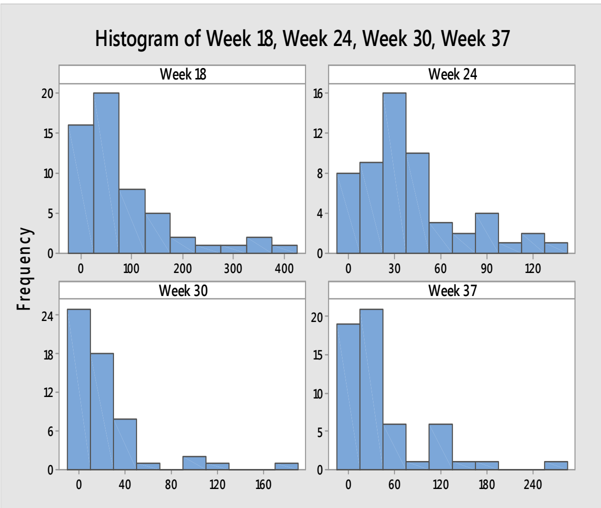

Fig. 1. Histograms of Weeks 18, 24, 30 and 37

B. Percentile and confidence intervals

Weekly rainfall percentiles and the corresponding 95% confidence intervals are presented in Table VI. Those intervals were made for the weekly rainfall percentiles at 50, 60, 70, 80 and 90 based on the probability distributions which were selected as best fitted for corresponding weeks.

The result indicated that there was much heavy rainfall at the begins of the SWM. Also, Weeks 18-23 marked considerable rainfall with high variability. It is noted that 90^{th} percentiles of Weeks 18-23 varies between 108.4mm to 209.6 mm which bring a greater amount of rainfall to this region. According to the Table VI, there is a 90% chance to have 209.6 mm maximum rainfall, during the 19^{th} week and this value can be varied between 144.2 mm and 274.9 mm at 95% confidence level. However, a clear decreasing pattern of weekly rainfall can be identified after the 23^{rd} week.

TABLE VI. PERCENTILES OF WEEKLY RAINFALL AND THE CORRESPONDING 95% CONFIDENCE INTERVAL DURING SWM IN COLOMBO

Week Number	**PERCENTILES**				
	P_{50}	**P_{60}**	**P_{70}**	**P_{80}**	**P_{90}**
18	49.9 *(32.1, 67.7)*	68.9 *(46.5, 91.4)*	94.4 *(65.4, 123.3)*	131.7 *(92.1, 171.3)*	198.5 *(136.3, 260.7)*
19	53.5 *(34.6, 72.4)*	73.6 *(49.9, 97.3)*	100.45 *(70.0, 130.9)*	139.7 *(98.1, 181.2)*	209.6 *(144.2, 274.9)*
20	42.2 *(25.9, 58.5)*	59.9 *(38.7, 81.0)*	84.3 *(56.2, 112.4)*	121.2 *(81.5, 160.9)*	189.5 *(124.5, 254.6)*
21	50.8 *(35.9, 65.6)*	66.1 *(48.5, 83.8)*	85.5 *(64.1, 107.0)*	112.3 *(84.8, 139.8)*	156.8 *(116.8, 196.8)*
22	47.8 *(36.8, 62.1)*	63.2 *(48.6, 82.1)*	83.1 *(63.9, 107.9)*	111.0 *(85.4, 144.3)*	158.9 *(122.3, 206.4)*
23	33.72 *(26.6, 42.8)*	42.5 *(33.3, 54.1)*	54.4 *(42.1, 70.2)*	72.6 *(55.0, 95.9)*	108.4 *(78.5, 149.8)*
24	32.7 *(25.6, 41.7)*	40.7 *(32.6, 50.9)*	50.5 *(41.0, 62.3)*	63.5 *(51.7, 78.2)*	84.3 *(67.8, 104.8)*
25	22.2 *(14.3, 30.1)*	30.6 *(20.7, 40.4)*	41.8 *(29.1, 54.5)*	58.2 *(40.8, 75.6)*	87.4 *(59.8, 115.1)*
26	27.2 *(19.9, 34.4)*	36.1 *(26.5, 45.8)*	47.7 *(35.0, 60.4)*	64.0 *(47.0, 80.9)*	91.9 *(67.6, 116.1)*
27	21.3 *(13.8, 28.7)*	29.2 *(19.8, 38.6)*	39.8 *(27.8, 51.9)*	55.4 *(38.9, 71.8)*	83.0 *(57.1, 108.9)*
28	15.0 *(8.7, 21.3)*	21.9 *(13.6, 30.3)*	31.8 *(20.3, 43.2)*	47.0 *(30.3, 63.8)*	76.4 *(47.6, 105.2)*
29	25.5 *(18.7, 32.5)*	34.0 *(24.9, 43.1)*	44.9 *(33.0, 56.9)*	60.3 *(44.3, 76.2)*	86.5 *(63.7, 109.4)*
30	9.3 *(4.7, 13.8)*	14.5 *(8.0, 21.0)*	22.5 *(12.9, 32.0)*	35.7 *(20.7, 50.7)*	63.4 *(35.1, 91.6)*
31	13.4 *(9.8, 17.0)*	17.8 *(13.1, 22.6)*	23.6 *(17.3, 29.8)*	31.6 *(23.2, 40.0)*	45.4 *(33.4, 57.3)*
32	8.3 *(4.0, 12.5)*	13.2 *(7.0, 19.3)*	20.8 *(11.6, 29.9)*	33.6 *(18.9, 48.3)*	61.0 *(32.7, 89.2)*
33	13.6 *(7.1, 20.0)*	20.9 *(11.9, 29.9)*	31.8 *(18.8, 44.8)*	49.8 *(29.6, 69.9)*	86.4 *(49.1, 123.6)*
34	20.2 *(14.8, 25.7)*	26.9 *(19.7, 34.1)*	35.5 *(26.1, 45.0)*	47.7 *(35.1, 60.3)*	68.5 *(50.4, 86.5)*
35	13.2 *(7.3, 19.0)*	19.7 *(11.7, 27.6)*	29.2 *(18.0, 40.3)*	44.2 *(27.6, 60.9)*	74.0 *(44.4, 103.5)*
36	14.1 *(6.9, 21.3)*	22.5 *(12.0, 32.9)*	35.4 *(19.8, 51.0)*	57.3 *(32.3, 82.3)*	103.9 *(155.6, 152.2)*
37	25.9 *(16.3, 35.6)*	36.3 *(24.0, 48.7)*	50.4 *(34.3, 66.6)*	71.5 *(49.0, 93.9)*	109.8 *(73.6, 146.0)*
38	37.1 *(23.6, 50.5)*	51.5 *(34.4, 68.6)*	70.9 *(48.7, 93.1)*	99.7 *(69.1, 130.3)*	151.7 *(103.1, 200.3)*
39	52.6 *(33.6, 71.6)*	73.0 *(48.9, 97.0)*	100.4 *(69.3, 131.6)*	140.9 *(97.8, 184.0)*	213.7 *(144.6, 282.8)*

The Weeks 31 and 32 marked lower rainfall amount than others during SWM. After 35th week, again it can be seen an increasing trend of weekly rainfall till the end of the season. The Week 39 records the highest rainfall amount in the SWM. The median rainfall of the 39th weeks was 52.6 mm while the 70th percentile of this week marked more than 100 mm rainfall amount which is a large quantity for the area. Week 38 also brings much heavy rainfall with noticeable variation in this season for this region.

The rainfall percentiles and corresponding 95% confidence intervals for running totals of weekly rainfall were constructed during the SWM in Colombo. Fig.2 represented only 90th percentile of running total and its 95% confidence bands. It also depicts the high rainfall variation with the arrival of SWM. Also, Fig.2 illustrates the much heavy rainfall due to the withdrawal of the SWM. Based on the result of the running total of the weekly rainfall, it can be further confirmed that there was heavy rainfall with great variation during the period of weeks 18-23 (30th April to 10th June) and weeks 38-39 (17th-30th of September).

IV. CONCLUSION

Weekly rainfall data pertaining to SWM is skewed with a longer tail extending to the right. One probability distribution has not been found to represent all the week. However, three parameter Weibull distribution was well fitted with the most of the week. Two parameter Exponential distribution, Exponential, Weibull and Lognormal are the other best fitted probability distributions for weekly rainfall data. Based on the percentiles and corresponding 95% confidence intervals which were derived using selected probability distributions, much heavy rainfall during the weeks 18-23 and 38-39 can be expected. Founded on the analysis of running weekly totals of rainfall, it can be further confirmed that there is a high possibility of extreme rainfall events forming within this period. Based on the analysis of past extreme rainfall events in Colombo area during SWM, it can be identified that the many floods occurred in the months May and June. Most recently (on 15 May 2016) Sri Lanka was hit by a severe tropical storm that caused heavy flooding in Colombo. Furthermore, floods occurred in Colombo in the past years; 1975, 1989, 1992, 2008 from May to June period [15].

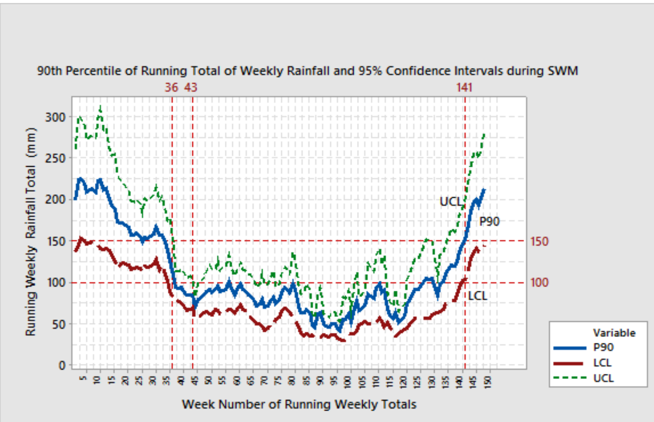

Fig. 2. 90th Percentiles of running total of weekly rainfall and 95% confidence intervals during SWM in Colombo

As shown Fig 2, much heavy variation in weekly rainfall can be identified with the arrival of the monsoon. Thus, the time onset of the monsoon is also important to mark extreme rainfall events.

However, we cannot be satisfied about the length of the 95% confidence intervals of rainfall percentiles as the intervals are somewhat wider. Small sample size and strongly skewed distribution pattern might be a one of the reasons for wide confidence bands. Furthermore, heavy skewed distributions have deviated from the normal distribution which can affect intervals bands as those are calculated based on the normality assumption. As an alternative, parametric bootstrapping approach with an optimal confidence level which can be made by bootstrapping calibration can be employed.

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