A Protocol to Determine Interannual Variation of North-East Monsoon (*Maha* rainfalls): A Case Study in Anuradhapura, Sri Lanka

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Abstract
A protocol was developed to analysis the interannual variation of North-East monsoon (*Maha* rainfalls) and the protocol was validated with daily rainfall data of Anuradhapura for 1980–2010 period. Cumulative distribution of rainy days was plotted against the date of the year and a Gaussian model was fitted. The maximum positive and maximum negative curvatures of the Gaussian model were selected as the onset and the retreat of the North-East monsoon rainy season and the linear trends of onset, retreat and length of the growing season were checked for the significant deviation from zero. Accordingly, the mean onset and retreat of the period for 1981-2001was 22nd of October and 29th of January, respectively. The average length of the growing season was 97 days. Onset dates for 2002-2010 period varied from 13th of October (2008) to 15th of November (2009) with the mean of 26thOctober. The earliest and the most delayed retreat dates were 31st December (2006) and 8th March (2010), respectively. The length of the season varied from 58 days (2006) to 128 days (2010) with a mean of 90 days. The regression analysis revealed that there is a positive trend, i.e. delayed onset and retreat, and increased growing length in future though the interannual variation is not significant during 2002-2010.

Keywords: Interannual variation, Onset, Retreat, North-East monsoon
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Introduction

Sri Lanka, being predominantly an agricultural country, the seasonality of rainfall is very much important to the success of agriculture. Further, marked variability of seasonal rainfall also contributes to a negative impact on irrigation, availability of drinking water, livestock and wildlife, hydropower generation etc. Timely onset, retreat and the length of growing season are major determinants of type of crop, extent of cultivation, success of each growing stage and finally the yield. During the recent past, many claims (Sonnadara, 2015; Punyawardhana, 2002) have been made on the time of onset, retreat and length of growing season of both South-West (May to September) and North-East (December to February) monsoons. Comparing to South-West monsoon, North-East monsoon rainfall is important since it is the main source of moisture carrier to dry zone of the country which accounts about 60% of the total land area which has high potential for the cultivation of arable crops due to fertile soil, lack of rainfall and high evaporation constrain achieving higher yields (Punyawardena and Kulasiri, 1996). Therefore, determination of interannual variation of onset, retreat and growing season of North-East monsoon (*Maha* rainfalls) has a great benefit to achieve a higher yield through successful cultivation. The objective of this study was to develop a protocol to analysis the interannual variation of North-East monsoon and validate it with a selected data set.

Materials and Methods

The daily rainfall data for Anuradhapura was collected from the Department of Meteorology Sri Lanka for 1980 - 2010 period. A threshold value of 0.85 mm was selected to define a rainy day. The North-East monsoon (*Maha*season) falls between two years, therefore, the calendar was shifted by six months to capture the season in the middle of 365day year. Cumulative distribution method developed by Odekunle *et al*., (2005) that has been applied by Sonnadara (2015) for Sri Lankan North Eastern monsoonal conditions was used with modifications. First, the sum of the rainy days was calculated for 5day intervals followed by the computation of cumulative percentage of rainy days for 5-day intervals. To reduce the statistical fluctuations, five point moving average filter was applied (Sonnadara, 2015). Cubic spline interpolation was applied to interpolate into daily intervals and ten point moving average window was applied to further reduction of fluctuations. The first derivative of the cumulative percentage was plotted against the date and a Gaussian model was fitted. The maximum positive and maximum negative curvatures of the Gaussian model were selected as the onset and the retreat of the North-East monsoon rainy season respectively.

The linear trends of onset, retreat and length of the season were checked for the significant deviation from zero.

Results and Discussion

The following Gaussian model was fitted to the first derivate of the cumulative percentage and used to determine the onset, retreat and length of the North-East monsoonal rainy season at Anuradhapura (Figure 1).

$$y = ae^{\frac{-(x-b)^2}{2c^2}}$$

Where a, b and c are coefficients, e is mathematical constant (2.71828) and x is date of the year in 10^{-2}.

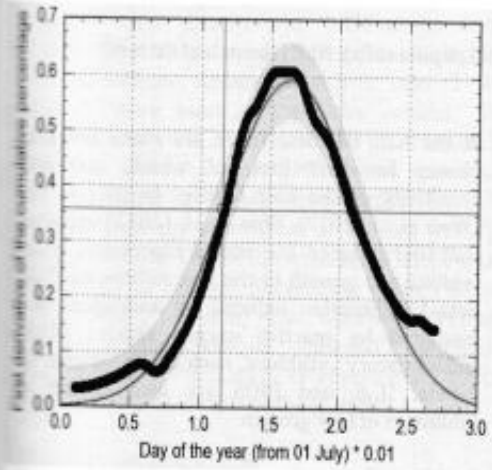

Figure 1: The Gaussian model (Dark line) developed to determine the onset, retreat and length of the season with its confidence interval (shaded area). The onset for 1981-2001 period is the place where two straight lines intercepts

According to the method developed, the mean onset and retreat of the season for 1981-2001 period was 22nd of October and 29th of January, respectively. The average length of the season for 1981-2001 period was 97 days. The observed mean length (13.86 weeks) was almost similar to the 14week length in North Central dry zone reported by Punyawadena (2002) for Maha season. Onset dates for 2002-2010 period ranged from 13th of October (2008) to 15th of November (2009) with the mean of 26thOctober. The earliest and the most delayed retreat dates were 31st of December (2006) and 8th of March (2010), respectively.

The length of the season varied from 58 days (2006) to 128 days (2010) with a mean of 90 days.

The results of regression analysis revealed that onset, retreat and length of the season have positive trends, i.e. delayed onset and retreat, and increased length can be observed in the future. But none of them were significantly different from zero. The steepest slope of the regression curve was for retreat of the season. The results agreed with the findings of Sonnadara (2015), who studied the variation of North-East monsoon at North and North-Eastern regions. Further validation of the protocol is needed for other regions across Sri Lanka and over South-West monsoon (*Yala* rainfall) season.

Conclusion

A new protocol, developed based on the cumulative distribution method and fitted using Gaussian model was successfully applied to Anuradhapura meteorological station to determine the onset, retreat and length of North-East monsoon rainy season. According to the new method, there is a positive trend, i.e. delayed onset and retreat, and increased growing length in future though the interannual variation is not significant during 2002 -2010.

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