Recent Trends of Minimum and Maximum Surface Temperatures over Sri Lanka

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Introduction

Global warming becomes one of the most important environmental problems in the 21st century. The assumption that increased greenhouse gas concentrations may leadto a rise in global temperatures first emerged in the 1960s (Peterson et al., 2008). The concentration of carbon dioxide in the atmosphere has increased by more than 30 percent since 1750 (Schaefer & Domroes, 2009). The great majority of climate scientists now agree that the evidence for anthropogenic globalwarming is strong (Rosenberg et al., 2010) and, as a result, they impact other parts of the climate system. It is commonly accepted that the global average surface air temperatures have risen by 0.74 ± 0.18 ^{0}C [0.56 ^{0}C to 0.92 ^{0}C] over the last 100 yr from 1906 - 2005 (IPCC, 2007).

Although the temperature increase is widespread over the globe, spatial and temporal characteristics of temperature trends can be found with highest values in northern latitudes and land regions have warmed faster than the oceans (IPCC, 2007). Therefore, climate change and its impacts are an issue of a great and rapidly accelerating concern since the 1990s. Because of the spatial and temporal distinctions of temperature trends, it is very important to analyze station data for a better understanding of trend behaviors on regional and local scales.

Research Problem

What is the trend of minimum and maximum surface temperatures over Sri Lanka during the period, 1951 – 2012?

Objectives of the Study

The objective of this paper is to identify the trends of minimum and maximum surface temperatures over Sri Lanka.

Theoretical Considerations and Empirical Evidence

So far, some researchers have analyzed temperature records of recent years in Sri Lanka and they have identified a general warming in the country. The study which was done by Schaefer (2009) using data from thirteen stations over Sri Lanka indicates an increasing annual mean temperature trend for the period, 1901-2000. De Silva and Sonnadara (2009) also noted an increasing temperature trend in their study performed for data in five stations over the country. De Costa (2008) has shown an increasing trends of monthly temperature in Sri Lanka using data from seven stations from the period 1869 - 2007. Basnayake et al. (2002) whose analysis was done for 1900-2000 period using data at ten stations in Sri Lanka also reported an increasing temperature trend.

Methodology

The data for this particular study was collected by the Department of Meteorology of Sri Lanka. Monthly minimum and maximum temperature data from 15 meteorological stations within wet zone, dry zone and intermediate zone was collected for the period from 1951-2012.The linear trend analysis was computed to measure the magnitude of long term trends. The regression coefficients are given in ^{0}C. As a measure of significance the trend-to-noise-ratio (T/N) was calculated. The trend value is divided by the noise, where the noise is represented by the standard deviation of the data. If T/N values are higher than the value 1.96 (T/N >1.96)it can be regarded as statistically significant (95%) (Sneyers, 1990). Further, a non – parametric Mann Kendall test was applied by a positive/ negative Z value which indicates upward or downward trend. If Z values > 1.96 can be regarded as significant (95%).

Key Findings and Conclusion

This study focused on analyzing the trend of monthly mean minimum and maximum temperature recorded during 1951-2012 for fifteen meteorological stations over Sri Lanka. The long term analysis indicates that the monthly mean minimum and maximum temperature has a considerable year to year variation at all selected stations in Sri Lanka. According to the analysis, all locations show an increasing trend from 0.0005 ^{0}C to 0.0239^{0}C in annual mean minimum temperature during the examined period (1951–2012).Twelve locations (Anuradapura, NuwaraEliya, Colombo, Diyatalawa,

Ratmalana, Katunayaka, Galle, Puttalam, Ratnapura, Badulla, Batticaloa and Hambantota) show high trend of warming during the period while Trincomaalee, Kurunagala and Kandy show lower increasing trend.The lowest increasing trend shows at Trincomalee(0.0005^{0}C annually) and the highest increasing trend shows at Anuradapura (0.0239 ^{0}C annually). The positive trends of warming are in some cases strictly linear (Anuradapura, NuwaraEliya, Colombo, Diyatalawa, Katunayaka and Ratmalana) (T/N values > 1.96), and in most cases significant (Z values > 1.96; see table 01)indicating the high standard deviation and underlining the high inter annual variability of monthly mean minimum temperature. There are three stations where the monthly mean minimum temperature were greater than the global average (global monthly mean minimum temperature average 0.0204 ^{0}C annually). They areAnuradapura(0.0239 ^{0}C), NuwaraEliya(0.0235 ^{0}C) and Colombo (0.0207 ^{0}C).

According to the monthly mean maximum temperature data analysis, all locations except NuwaraEliya show an increasing trend in monthly mean maximum temperature during the examined period (1951 – 2012). NuwaraEliya shows a decreasing trend (-0.0024 ^{0}Cannually) but it is not linear or significant. While Ratnapura and Katunayaka show lower increasing trend, the rest of others show higher trend. Badulla (0.0280^{0}C annually) and Ratmalana (0.0280^{0}C annually) show the highest warming rate during the examined period.

The positive trends of warming are in some cases strictly linear (Ratmalana, Galle, Batticaloa, Badulla, Kandy, Puttalam and Diyatalawa) (T/N values > 1.96). The others indicating the high standard deviation and underlining the high inter annual variability of monthly mean maximum temperature. According to the Mann Kendall test, most cases are significant (Z values > 1.96; see table 01).

There are nine stations where the monthly mean maximum temperature were greater than the global average (global monthly mean maximum temperature average 0.0141 ^{0}C annually). They are Badulla (0.0280^{0}C), Ratmalana (0.0280 ^{0}C), Galle (0.0249 ^{0}C), Batticaloa (0.0201 ^{0}C), Kurunagala (0.0188 ^{0}C), Trincomalee (0.0172 ^{0}C), Kandy (0.0160 ^{0}C), Puttalam (0.0162 ^{0}C), Anuradapura (0.0150^{0}C), NuwaraEliya (0.0235 ^{0}C) and Colombo (0.0207 ^{0}C).

According to the global level data (from 1950 to 2004) analysis, Vose et al. (2005); IPCC (2007); Zhou et al. (2008) have identified that, the minimum air temperature has been increasing faster than the maximum air temperature (0.204vs. 0.141^{0}C dec^{-1}). The same trend can be identified in Sri Lanka.

Wet zone								
Station name	**Annual Mean Minimum Temperature Trend** (1951-2012)				**Annual Mean Maximum Temperature Trend** (1951-2012)			
	Linear Trend Statistics		Mann Kendall Statistics		Linear Trend Statistics		Mann Kendall Statistics	
	Linear Trend (Annual)	T/N ratio	Sen's Slope Estimate Q (Annual)	Z value	Linear Trend (Annual)	T/N ratio	Sen's Slop e Estimate Q (Annual)	Z value
Colombo	0.0207	2.74	0.215	6.79	0.0128	1.18	0.0167	4.94

Galle	0.0161	1.93	0.0153	4.85	0.0249	2.87	0.0243	7.12
Ratnapura	0.0089	1.79	0.0081	3.86	0.0009	0.14	0.0000	-0.30
Kandy	0.0052	0.75	0.0077	2.45	0.0160	1.99	0.0151	4.00
NuwaraEliya	0.0235	2.79	0.0250	6.61	-0.0024	0.35	0.0000	-0.37
Ratmalana	0.0195	2.23	0.0193	5.21	0.0280	2.96	0.0267	6.71
Katunayaka	0.0186	2.58	0.0235	7.47	0.0092	1.02	0.0088	1.68

Table 1: The Monthly Mean Minimum and Maximumtemperature Trend During 1951-2012 and Continues Warming Period, the Trend, Trend to Noise-S3]Ratios (T/N) and Mann Kendall Statistics.

Dry zone								
Station name	**Annual Mean Minimum Temperature Trend** (1951-2012)				**Annual Mean Maximum Temperature Trend** (1951-2012)			
	Linear Trend Statistics		Mann Kendall Statistics		Linear Trend Statistics		Mann Kendall Statistics	
	Linear Trend (Annual)	T/N ratio	Sen's Slope Estimate Q (Annual)	Z value	Linear Trend (Annual)	T/N ratio	Sen's Slope Estimate Q (Annual)	Z value
Puttalam	0.0092	1.49	0.0083	3.15	0.0162	1.99	0.0167	4.43
Trincomalee	0.005	0.083	0.0000	0.35	0.0172	1.14	0.0247	5.00
Hambantota	0.0094	1.83	0.0095	4.34	0.0113	1.12	0.0171	5.14
Anuradapura	0.0239	2.90	0.0236	7.39	0.0150	1.07	0.0198	4.74
Batticaloa	0.0088	1.67	0.0085	3.97	0.0201	2.46	0.0200	6.10

Inter-mediate zone								
Station name	**Annual Mean Minimum Temperature Trend** (195-2012)				**Annual Mean Maximum Temperature Trend** (1951-2012)			
	Linear Trend Statistics		Mann Kendall Statistics		Linear Trend Statistics		Mann Kendall Statistics	
	Linear Trend (Annual)	T/N ratio	Sen's Slope Estimate Q (Annual)	Z value	Linear Trend (Annual)	T/N ratio	Sen's Slope Estimate Q (Annual)	Z value
Kurunegala	0.0049	0.71	0.0053	1.58	0.0188	1.90	0.0183	4.33
Badulla	0.0087	1.58	0.0087	3.75	0.0280	2.29	0.0333	6.22
Diyatalawa	0.0200	2.21	0.194	4.40	0.0138	1.98	0.0125	4.65

Keywords: Climate Change; Global Warming; Sri Lanka ;Temperature

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