# Rainfall and Temperature Analyses for Select Stations in the Caribbean

**A Demonstration from
Training Attachment at the
Statistical Services Centre
University of Reading, U.K.**

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## DRY SPELLS

Even though the use of irrigation is increasingly popular, farming in the Caribbean remains predominantly rainfed. Agricultural droughts and dry spells are major causes of reduction of crop yield in the Caribbean, as water is seen as one of the most limiting and variable environmental factors on agricultural production in the region. Depending on the soil depth and retention capacity, dry spells[1] of about ten days or more can begin to reduce yield of many crops as water stress sets in. In shallow rooted crops, particularly in low water retaining soils, can experience water stress in less than 7 days. Deep rooted crops in high retaining soils can last up to 15 days or more before significant water stress sets in. Crops are particularly vulnerable if a dry spell presents itself when they are trying to get established – say for example in the first 30 days or so of its life cycle.

The graphs below (Figures 1 to 5) show the probabilities of having dry spells of 7, 10 or 15 days within 30 days of any chosen date of the year at select stations across the Caribbean. They strongly display the region's dry and wet seasons. In most of the region, the dry season is in January to May/June, but in Guyana from about February to April and from August to October. In general the graphs expectedly show that the probabilities of 7 day dry spells are much higher than 15 day ones, with 10 day spells somewhere in between. Unlike the other stations, Central Farms in Belize has high probability of 15 day spells – as high as about 0.75 in April. So one may reliably say that at least one dry spell of at least 15 days can be expected in 3 years out of 4.

[1] Dry spells are consecutive number of days with rainfall below a certain threshold, often used as 1 mm in tropical locations as less than this is rapidly evaporated from plant and soil surfaces with no effect on the plant as far as significant water needs are concerned

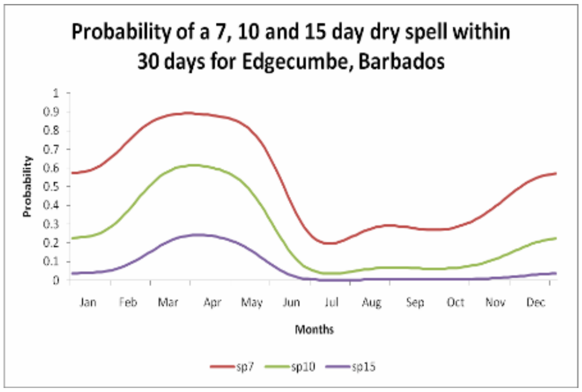


**Figure 1: Probability of a 7, 10 and 15 day dry spell within 30 days for Edgecumbe, Barbados**

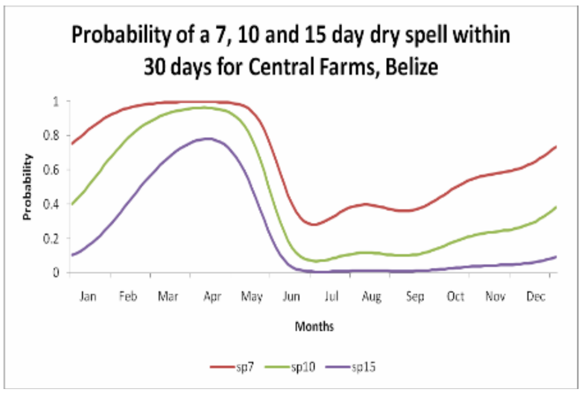


**Figure 2: Probability of a 7, 10 and 15 day dry spell within 30 days for Central Farms, Belize**

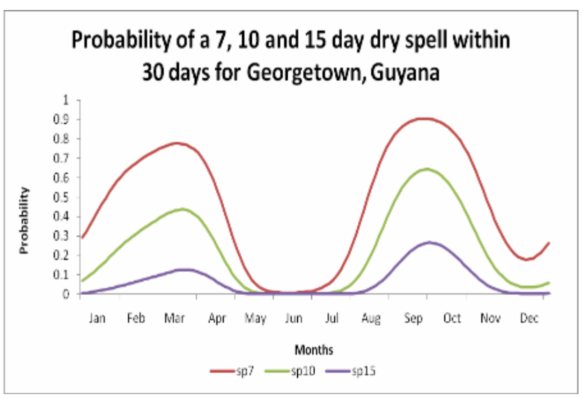


**Figure 3: Probability of a 7, 10 and 15 day dry spell within 30 days for Georgetown, Guyana**

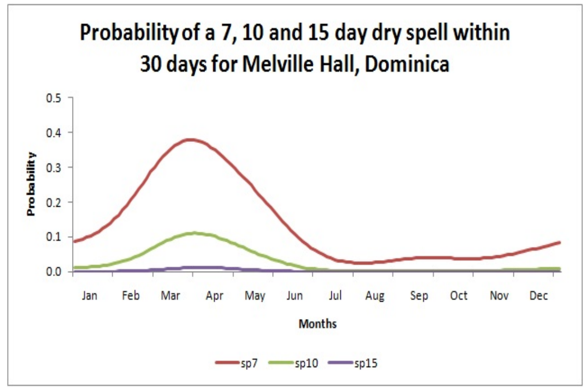


**Figure 4: Probability of a 7, 10 and 15 day dry spell within 30 days for Melville Hall, Dominica**

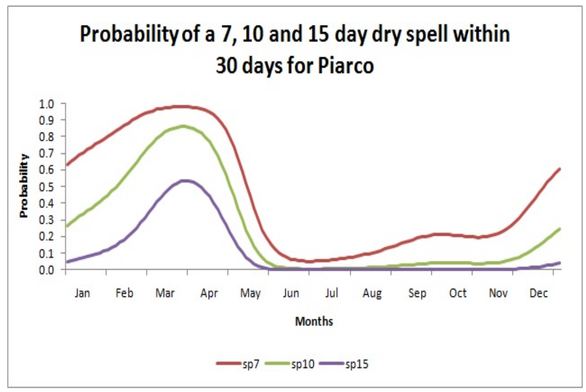


**Figure 5: Probability of a 7, 10 and 15 day dry spell within 30 days for Piarco, Trinidad**

Sufficiency, or insuffiency, of rainfall cannot only be ascertained by analysis of dry spells. It is possible to have insufficient rainfall for plant growth without having dry spells in the way defined above (i.e. as consecutive dry days). A location can in a month, for example, experience rainfall way below normal without a 7 day dry spell. Similarly, a location can have a significant dry spell but experience a rainfall total well above normal for the month. So it is important that analyses on both rainfall totals and dry spells be performed.

Assuming a potential evapotranspiration of about 4 to 5 mm per day (about the case for the Caribbean), Figures 6 to 10 show the probabilities of having 40 and 50 mm in a dekad (or 'ten day' period), whilst Figures 11 to 15 show the probabilities of having between 120 and 150 mm in a month (for those who may prefer or be more habitual in using monthly information). Both these ranges approximated 4 to 5 mm per day.

Figures 16 to 20 provide another way of looking at reliability of rainfall. In looking at percentiles, curves indicate the percentage of values less than a rainfall. For example, the 80$^{th}$ percentile suggests that 80 % of the rainfall in the dekad is less than a certain value. As an example of how percentiles can be used, if a farmer has irrigation, he may rely on the 20$^{th}$ percentile in his planning (i.e. with 80 percent of the times rainfall is greater than that value, you may be fairly certain that you can plan to receive that rainfall in 4 years out of 5.

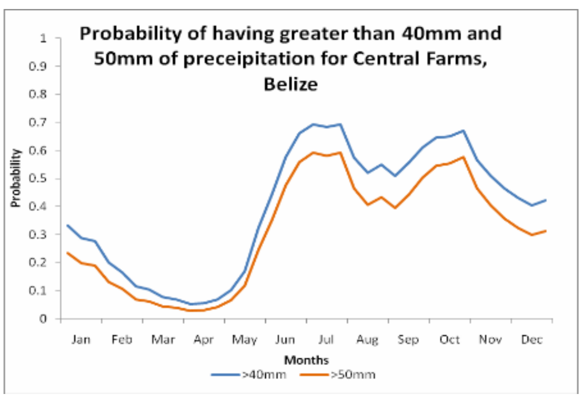


**Figure 6: Probability of having greater than 40mm and 50mm of rainfall at Central Farms, Belize**

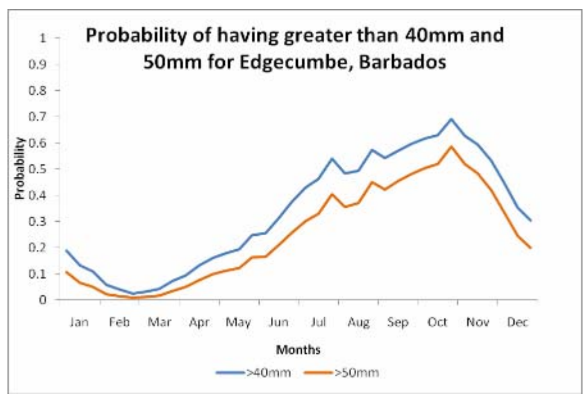


**Figure 7: Probability of having greater than 40mm and 50mm of rainfall at Edgecumbe, Barbados**

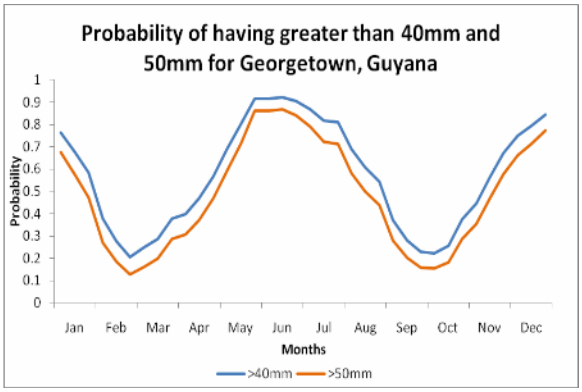


**Figure 8: Probability of having greater than 40mm and 50mm of rainfall at Georgetown, Guyana**

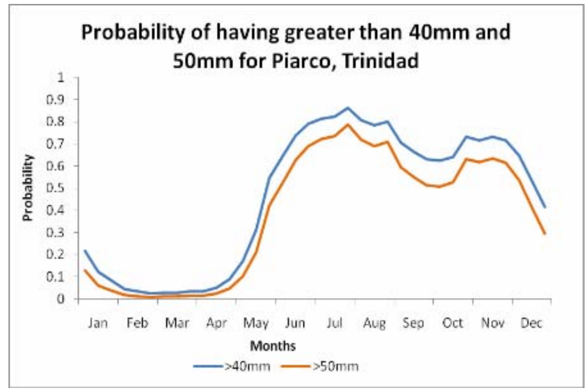


**Figure 10: Probability of having greater than 40mm and 50mm of rainfall at Piarco, Trinidad**

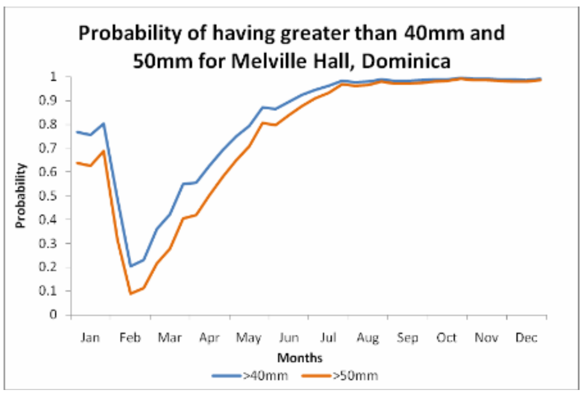


**Figure 9: Probability of having greater than 40mm and 50mm of rainfall at Melville Hall, Dominica**

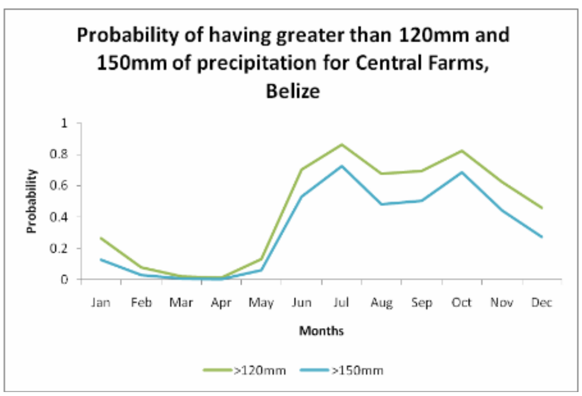


**Figure 11: Probability of having greater than 120mm and 150mm of rainfall at Central Farms, Belize**

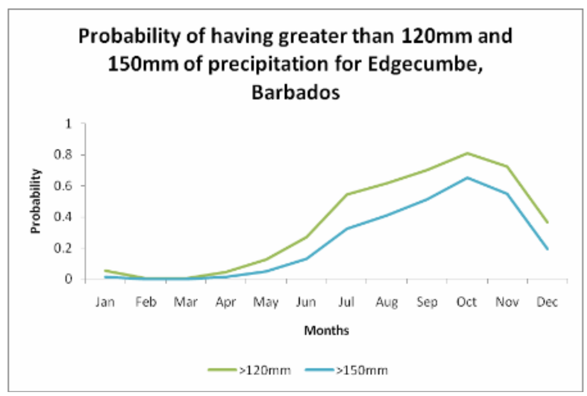


**Figure 12: Probability of having greater than 120mm and 150mm of rainfall at Edgecumbe, Barbados**

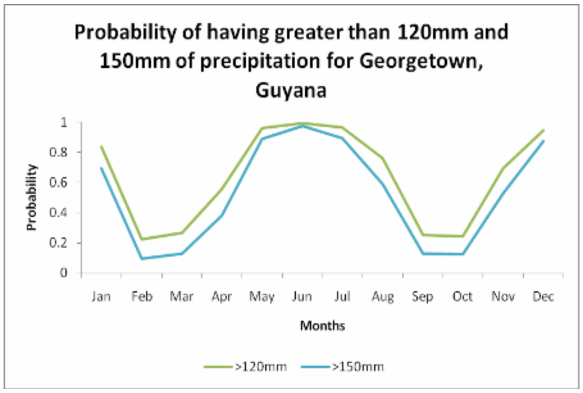


Figure 13: Probability of having greater than 120mm and 150mm of rainfall at Georgetown, Guyana

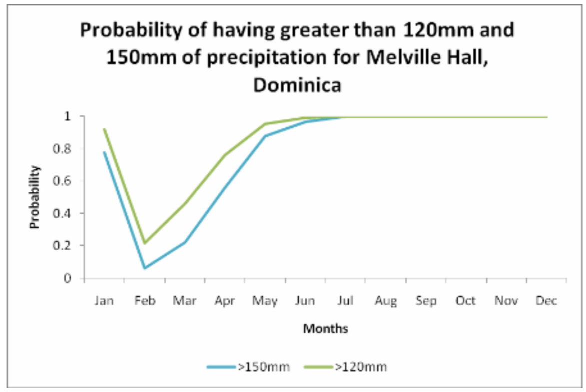


Figure 14: Probability of having greater than 120mm and 150mm of rainfall at Melville Hall, Dominica

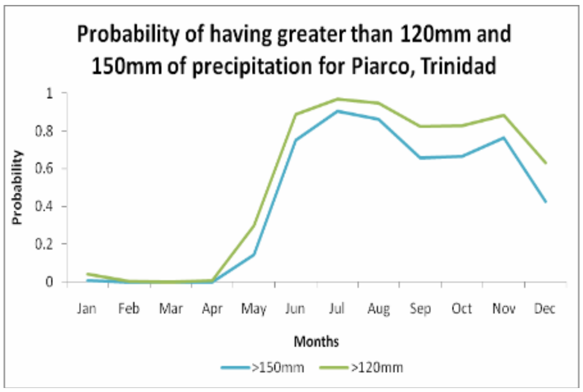


Figure 15: Probability of having greater than 120mm and 150mm of rainfall at Piarco, Trinidad

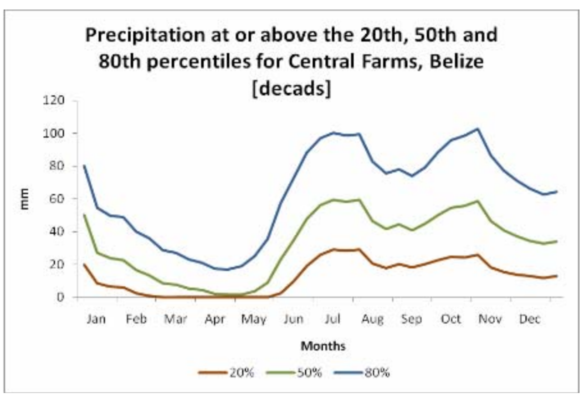


Figure 16: Precipitation at the 20th, 50th and 80th percentiles for Central Farms, Belize

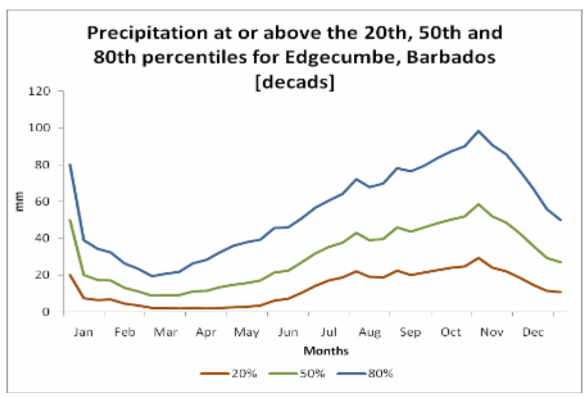


Figure 17: Precipitation at the 20th, 50th and 80th percentiles for Edgecumbe, Barbados

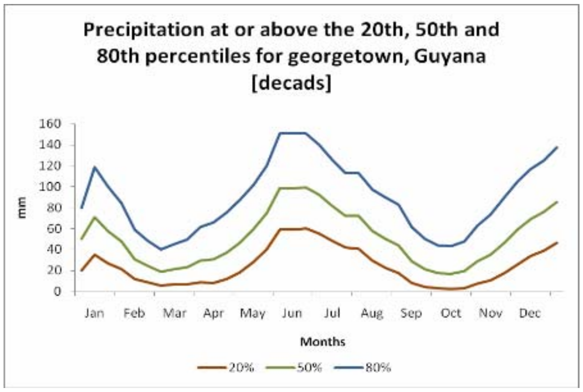


**Figure 18: Precipitation at the 20th, 50th and 80th percentiles for Georgetown, Guyana**

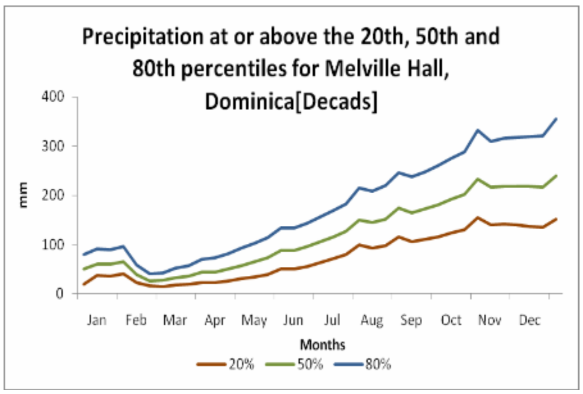


**Figure 19: Precipitation at the 20th, 50th and 80th percentiles for Melville Hall, Dominica**

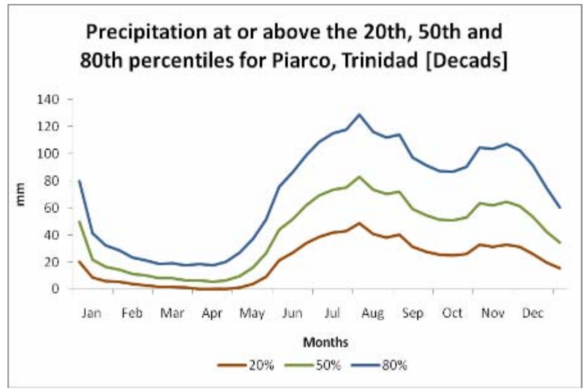


Figure 20: Precipitation at or above the 20th, 50th and 80th percentiles for Piarco, Trinidad

## Return Periods

Based on the climatology of a location, the return periods provide the frequency with which a rainfall amount is received. For example a fifty year return period for rainfall is the amount received once every fifty years. It is important that these be tempered in light of changes in future climate. Rains with the frequencies in Table 1 below have potential for flooding to varying degrees.

Similar to return periods for rainfall, maximum-temperature return periods provide the frequency at which a particular temperature is reached. Such high temperatures can be detrimental to crops and cause heat stress in animals. As an example of how the tables can be read, Table 2 of annual temperature return periods suggests that once in every 20 years the temperature at CIMH would reach 34.8 $^{o}$C (at some time during the year).

**Table 1: Return periods of daily (24 hour) rainfall**

| Return Period (Years) | Barbados (CIMH) | | | Belize (Central Farms) | | | Guyana (Georgetown) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Level | Confidence Limits | | Level | Confidence Limits | | Level | Confidence Limits | |
| | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| 2 | 82.1 | 69.0 | 95.1 | 83.0 | 68.1 | 97.9 | 96.6 | 87.2 | 106.0 |
| 5 | 111.1 | 89.1 | 133.2 | 106.3 | 87.7 | 124.9 | 119.6 | 105.5 | 133.7 |
| 10 | 133.5 | 98.4 | 168.6 | 120.7 | 95.9 | 145.6 | 135.6 | 114.9 | 156.3 |
| 20 | 157.6 | 101.0 | 214.1 | 133.9 | 97.1 | 170.8 | 151.5 | 120.1 | 183.0 |
| 50 | 193.1 | 92.5 | 293.7 | 150.1 | 89.8 | 210.4 | 173.1 | 120.5 | 225.7 |
| 100 | 223.4 | 75.2 | 371.5 | 161.5 | 78.9 | 244.1 | 189.9 | 115.9 | 264.0 |

**Table 2: Return periods daily maximum temperature**

| Return Period (Years) | Barbados (CIMH) | | | Belize (Central Farms) | | | Guyana (Georgetown) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Level | Confidence Limits | | Level | Confidence Limits | | Level | Confidence Limits | |
| | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| 2 | 32.7 | 32.4 | 33.0 | 38.6 | 37.7 | 39.4 | 32.9 | 32.6 | 33.3 |
| 5 | 33.5 | 32.9 | 34.1 | 40.0 | 38.9 | 41.1 | 33.6 | 33.2 | 34.0 |
| 10 | 34.1 | 33.0 | 35.1 | 40.8 | 39.4 | 42.2 | 34.0 | 33.5 | 34.5 |
| 20 | 34.8 | 33.0 | 36.6 | 41.6 | 39.7 | 43.4 | 34.3 | 33.8 | 34.9 |
| 50 | 36.0 | 32.6 | 39.5 | 42.4 | 39.6 | 45.3 | 34.7 | 34.0 | 35.5 |
| 100 | 37.1 | 31.8 | 42.5 | 43.0 | 39.2 | 46.9 | 35.0 | 34.1 | 35.9 |

## TRENDS

Trends in rainfall, and in particular temperature, can indicate varying climate patterns due to climate change (whether natural or anthropogenic). Detecting trends in the data may be useful in decision making at the policy level in agriculture and food security.

It is suggested that the Caribbean region could experience an increase in temperature by up to 2-3 $^{o}$C by 2100. It is also suggested that annual rainfall totals can decline by as much as 20-30 % also in this time frame. From this there is the likelihood of increased water deficiency for agriculture production and food processing, combined with more frequent intense rains with potential for flooding and soil erosion. There is also the likelihood of increased number of heat waves, as in particular, the minimum (night time) temperatures increase at relatively rapid rates.

It is still uncertain as to how Caribbean rainfall will be altered in the future. The certainty is however greater for temperature, with the minimum (night time) temperatures expected to increase at a faster rate than the maximum (daytime) temperatures. The graphs below, Figures 21 to 25, show upward trends at some stations over the past few decades, albeit not all statistically significant. Figures 26 to 30, which indicate the difference between maximum and minimum temperatures, illustrate a trend that that the minimum temperatures are increasing at a faster rate, as with time, the temperature range is decreasing apart from at Georgetown, Guyana. Rainfall trends in the Caribbean, as seen from Figures 31 to 35 are mixed with no clear trend of any of the 5 stations being statistically significant.

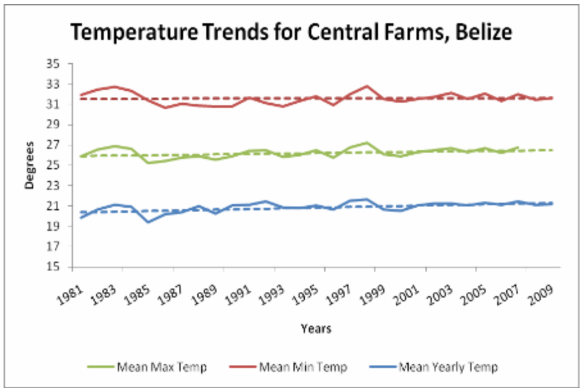


**Figure 21: Temperature trends [Central Farms, Belize]**

*Mean Max Temp* $y = 25.6 + 0.0030 * yr$ $p = 0.823$
*Mean Min Temp* $y = -46.6 + 0.03380 * yr$ $p = 0.001$
*Mean Yearly Temp* $y = -16.1 + 0.0212 * yr$ $p = 0.075$

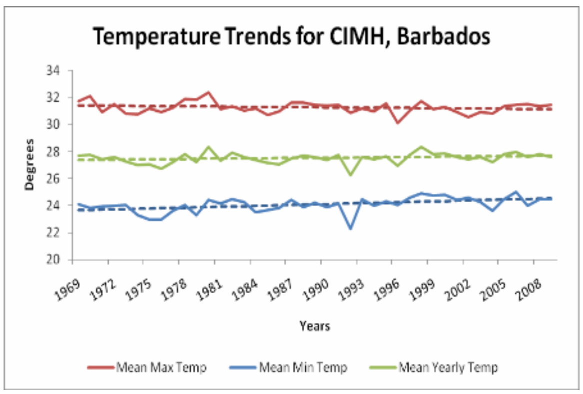


**Figure 22: Temperature trends [CIMH, Barbados]**

*Mean Max Temp* $y = 21.90 + 0.00404 * yr$ $p = 0.270$
*Mean Min Temp* $y = -20.0 + 0.02217 * yr$ $p = 0.002$
*Mean Yearly Temp* $y = 12.0 + 0.00781 * yr$ $p = 0.136$

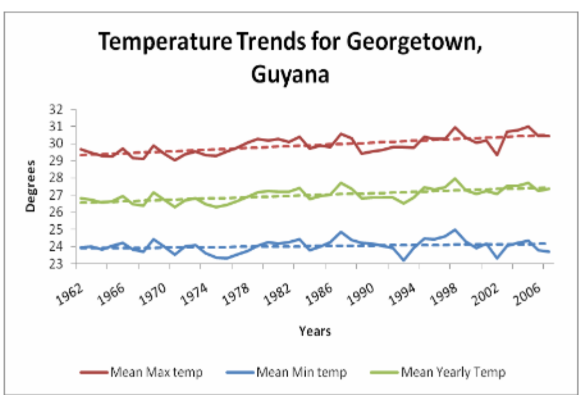


**Figure 23: Temperature trends [Georgetown, Guyana]**

*Mean Max Temp* $y = -21.82 + 0.02607 * yr$ $p < 0.001$
*Mean Min Temp* $y = 12.22 + 0.00595 * yr$ $p = 0.164$
*Mean Yearly Temp* $y = -12.21 + 0.01976 * yr$ $p < 0.001$

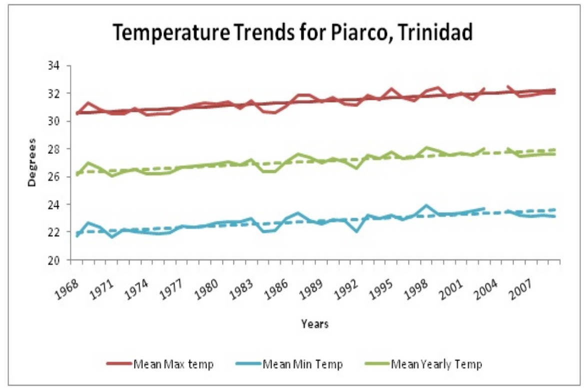


**Figure 24: Temperature trends [Piarco, Trinidad]**

*Mean Max Temp* $y = -48.79 + 0.04033 * yr$ $p < 0.001$
*Mean Min Temp* $y = -53.92 + 0.03857 * yr$ $p < 0.001$
*Mean Yearly Temp* $y = -51.29 + 0.03942 * yr$ $p < 0.001$

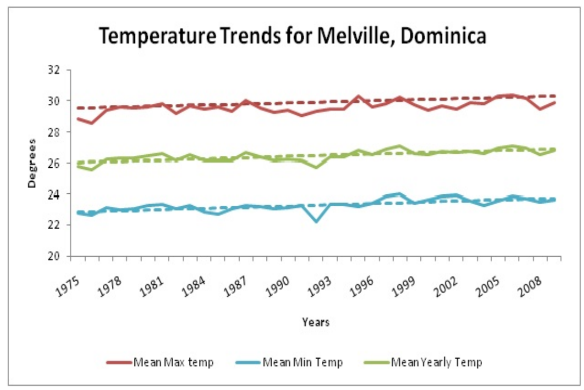


**Figure 25: Temperature trends [Melville Hall, Dominica]**

*Mean Max Temp* $y = 16.4 + 0.02307 * yr$ $p < 0.001$
*Mean Min Temp* $y = -29.32 + 0.02641 * yr$ $p < 0.001$
*Mean Yearly Temp* $y = -22.87 + 0.02476 * yr$ $p < 0.001$

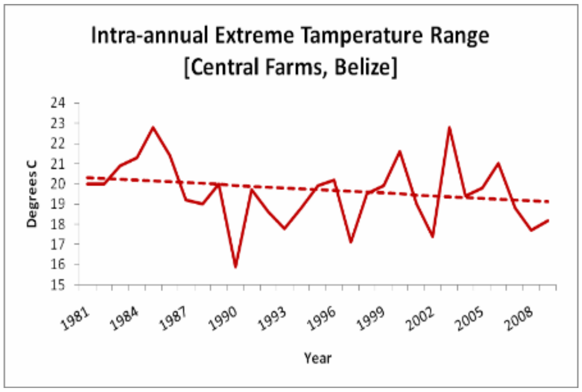


**Figure 26: Intra-annual temperature range [Central Farms, Belize]**

***y = 106.1 – 0.04333 *yr   p= 0.230***

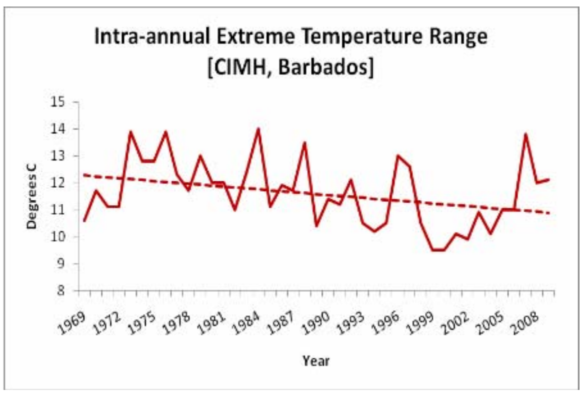


**Figure 27: Intra-annual temperature range [CIMH, Barbados]**

***y =80.4 – 0.0346 *yr   p= 0.0333***

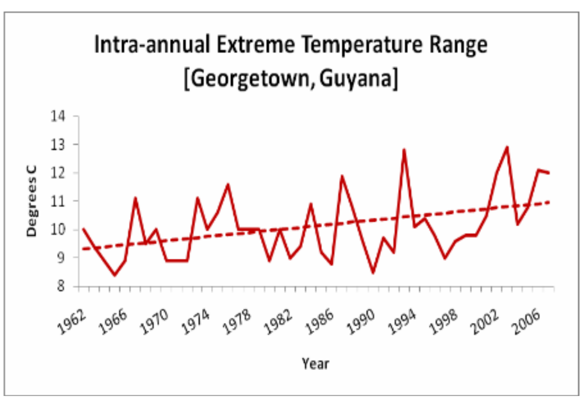


**Figure 28: Intra-annual temperature range [Georgetown, Guyana]**

***y = -61.9 + 0.0363 *yr   p= 0.003***

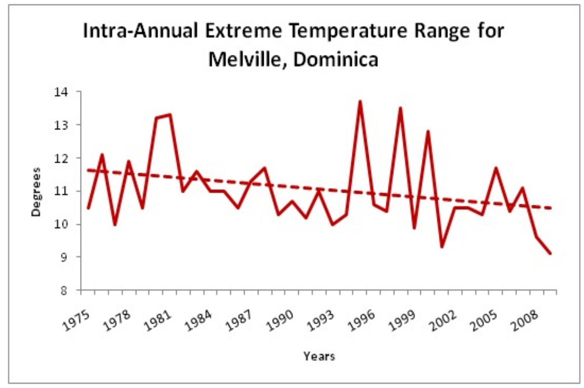


**Figure 29: Intra-annual temperature range [Melville Hall, Dominica]**

***y = 77.4 – 0.0333*yr   p= 0.088***

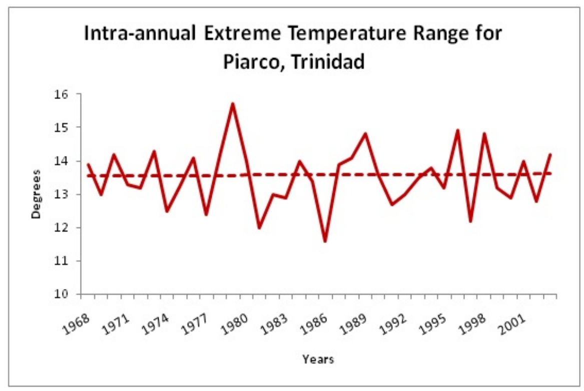


**Figure 30: Intra-annual temperature range [Piarco, Trinidad]**

***y = 10.6 + 0.0015*yr   p= 0.894***

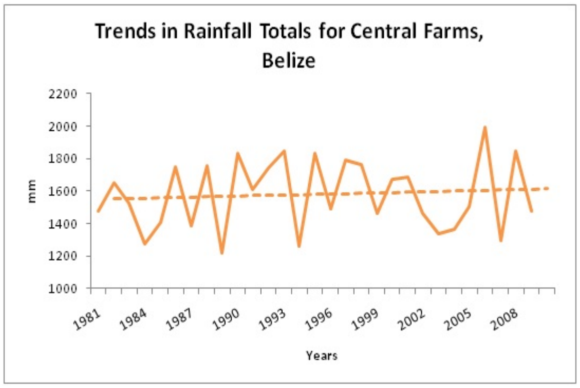


**Figure 31: Trends in rainfall totals for Central Farms, Belize**

***y = -2806 + 2.20 * yr*** ***p = 0.651***

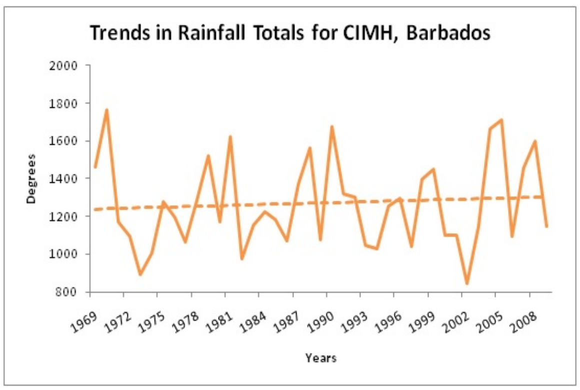


**Figure 32: Trends in rainfall totals for CIMH, Barbados**

***y = -1931 + 1.61 * yr*** ***p = 0.613***

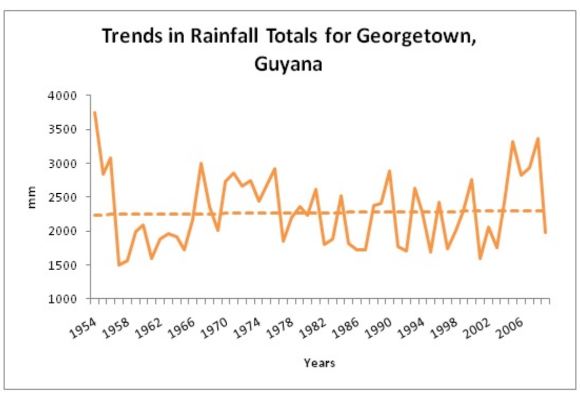


**Figure 33: Trends in rainfall totals for Georgetown, Guyana**

*y = 92 + 1.11 * yr* *p = 0.800*

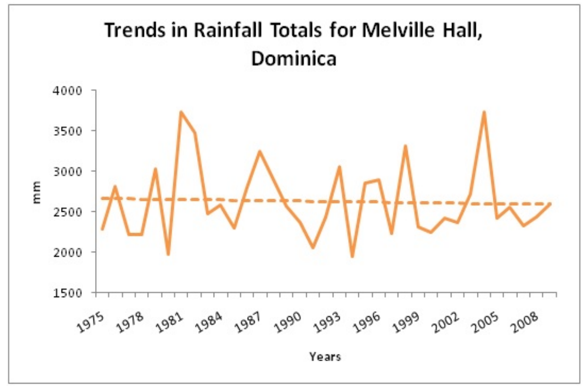


**Figure 34: Trends in rainfall totals for Melville Hall, Dominica**

***y = 6950 – 2.17 * yr*** ***p = 0.783***

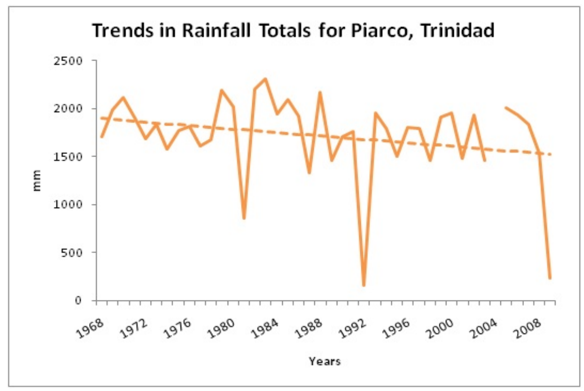


**Figure 35: Trends in rainfall totals for Piarco, Trinidad**

***y = 19667 – 9.03 * yr*** ***p = 0.118***