The development of long temperature and precipitation series for Ascension Island

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Abstract

Ascension Island has had a long intermittent record of instrumental weather recording. Here, we develop monthly records of mean temperature and precipitation totals (for 1924-2020 when an almost complete record is available) from the three principal recording sites: the capital Georgetown and two gauges at Wideawake Airfield. Although some of the data are in global climate databases, we have sourced as much data as possible from the primary sources in the United Kingdom, the United States and from the island itself. Air temperature shows statistically significant warming since 1950 of 0.54°C and since 1979 of 0.40°C, and agrees closely with sea surface temperatures, taken from the seas around the island, back to the start of the island series in 1924. Although the island is too small to be in Reanalyses, the warming trends of air temperatures from these products also agree, but the absolute air temperature values are about 1°C cooler than measured on the island. Annual precipitation on the island indicates it is very arid, with a long-term average of only 165mm. Occasionally, heavy monthly precipitation totals occur (always between February and June) which bring severe damage to the island's infrastructure and ecosystems. The heaviest monthly total was 334mm for April 1985.

1. Introduction

The purpose of this paper is to derive a long instrumental record of monthly temperature and precipitation change on Ascension Island. Although records are available in some global databases, many years have missing data, with more available in national sources and on the island. The study follows similar work on other South Atlantic Islands: St Helena (Feistel et al., 2003), Stanley on the Falkland Islands (Lister and Jones, 2015) and South Georgia (Thomas et al., 2018). On all the islands, the developed records have found uses in many projects, generally related to the often unique flora and fauna found on the islands. Hart-Davis (1973) provides a political history of Ascension together with a discussion of native flora and fauna, and some of the disastrous human introductions.

Ascension Island is only 88 square kilometres and is situated in the tropical South Atlantic (~8 degrees S, exact details in Table 1) roughly midway between Africa and South America. The highest point on the island is Green Mountain (869 m), a volcano in the mid-Atlantic ridge that last erupted over 500 years ago. The nearest land to the island is St Helena Island (~16 degrees S, 1295km to SSE of Ascension Island). The nearest point on the African continent is in Liberia, 1550 km to the north. The nearest point due east is 1950km on the Angolan coast, with NE Brazil 2250km away to the west. The Brazilian Island of Trinidade is slightly closer, 2100km to the south west of Ascension. Apart from being remote, Ascension Island is referred to as a 'Working Island'. This is a legal term, meaning that nobody has the right of residency, so that no-one can stay unless they or a dependent has a job. Everyone has a contract which lasts up to two years, which can be renewed. Very few stay beyond ten years. This is quite different from the three other British Islands in the South Atlantic (St Helena, Tristan da Cunha and the Falklands). Also in the 1990s, any agricultural enterprise was stopped.

The paper is structured as follows: Section 2 provides a history of recording on Ascension Island and the repositories of the basic raw data with Section 3 and 4 providing details of the development of the long temperature and precipitation records. For air temperature we compare with sea surface temperature from observations around the island and also with air temperature measurements from the location of Ascension in two of the latest Reanalyses, and discuss the issue of the island not being present as land. For precipitation, we also discuss some of the record wet days and months, which occur on the dry island, where the average precipitation is 165 mm. Section 5 concludes.

2. History of Recording

Brooks (1931) and Duffey (1964) provide an early history of instrumental recording on the island. Figure 1 shows a map of the island where various sites mentioned here are located. Some early records in 1815, 1834 and 1835 are mentioned, but more continuous recording of meteorological elements began at the main settlement called Georgetown (also referred to as Garrison) in August 1854 until April 1859, but still with some missing months. Meteorological measurements have also been summarised from HMS Tortoise for July 1860 to October 1865. The temperatures are clearly cooler, by about 1°C than those in the 1850s, so indicative that they were taken on board a ship anchored offshore.

Full meteorological measurements then recommenced in March 1923 at Georgetown and continued until the mid-1970s. It is unclear when they stopped there, but precipitation totals ceased with the December 1975 value. Monthly temperature averages at Georgetown also had many more missing months in the early 1970s. We have also found values for some months in 1917 and 1918 and all of 1919, probably from the Met Office publication *Reseau Mondial*. The original hand-written monthly sheets for November 1853 to April 1859 and for 1932-1936 and 1937-1946 have been scanned and are available (https://data.ceda.ac.uk/badc/corral/images/metobs/atlantic/Ascension_Island). These illustrate fully comprehensive weather recording of most of the variables expected at a weather station. Examples for August 1932 to August 1933 are available for the Second International

Polar Year, published by Met Office (1937). Some monthly precipitation totals are available from 1899 to 1913 and also for 1985 to 2011.

An airfield was developed on the island in 1942 by the United States, about 5-6km south of Georgetown at a site known as Wideawake Fairs, where there was a colony of sooty terns known locally as Wideawakes, because of their call. Continuous meteorological records from there are available from September 1957 to the present, with some earlier data for September 1942 to May 1947. This airfield site is known as Wideawake Field (by the US) or more recently as Airhead (by UK Met Office). In a later section we will discuss our combination of the series from Georgetown and those from the airfield, from both British and American sources. In global databases, the World Meteorological Organization (WMO) number for Georgetown was 61900 and that for Wideawake Field is 61902. The latter is currently operational, with the Georgetown number no longer in use.

Precipitation measurements were taken at both the Garrison site and on HMS Tortoise in the mid-19th century. They recommenced at the Garrison/Georgetown location in 1899, also with annual totals for 1895 to 1898. These continued until the end of 1975, but commenced again for 1985-2011. Gaps are evident though between 1914 and 1922, but the months in 1917-1919 available for temperature also provide monthly totals. An airfield site for precipitation starts in 1962 (referred to as Pan-Am) and continues until 2010. A second gauge starts recording at Airhead in 1984 and continues to the present.

Both the Garrison and Airhead sites occasionally experience heavy daily rainfall totals, but are generally very dry with a long-term annual averages of 165mm. The other precipitation record kept on the island is on Green Mountain (near the highest point of the island at 686m). Here precipitation is greater with a long-term average of about 660mm (value given in Brooks, 1931). Precipitation totals are available for this site for some months between 1859 and 1866, annual totals for 1884-1893, and monthly totals for 1894 to April 1922. Air temperatures were measured on Green Mountain during all of 1919 and comparisons can be made with Georgetown for this year (see Mathieson, 1990).

Monthly precipitation totals are also available for two sites between Georgetown and Green Mountain, Two Boats (April 1968 to May 1977) and at Traveller’s Rest (from 1985 to 2012).

Climatological summaries for Ascension Island (Georgetown and Green Mountain) are included in two of the UK Met Office's list of World Weather Averages, for 1889-1954 in Met Office (1958) and for the averages were updated for 1941-1970 for Georgetown in Met Office (1983).

3. Development of a Temperature Series

Temperature recordings have been made at two principal locations: Georgetown and Wideawake Field (also called Airhead). The locations of records at the two sites are given in Table 1 (see also Figure 1). Monthly averages for Georgetown (61900) are available in GHCNv4 and end in 1976. We also extracted the monthly averages from the UK MIDAS database, but this doesn't distinguish between the Georgetown site and the later airfield, although all values are missing from 1977 to 1988. For the UK source, the Georgetown site is near complete from 1923 to the early-1970s, but with many more missing months during the 1971-1976 period. This record is composed of monthly averages based on (Tx+Tn)/2, which is the standard practice in the UK. As mentioned in the history section a few earlier years (1917-1919 and 1854-1859) are available, and are stated to be based on (Tx+Tn)/2.

Records at the airfield began with September 1942 to May 1947 and continued from 1957 to 2019 with both taken by the US Air Force (USAF) and we obtained them from the National Centers for Environmental Information (NCEI in Asheville, NC, USA). These records are mostly taken at fixed hours 08 to 16 each day. More recent years have readings for every hour each day, indicative of automation. The exact location of these records is likely to be Cat Hill (see Figure 1). Records for a second airfield location (UK measurements referred to as Airhead from 1989 to 2020) are based on (Tx+Tn)/2. Monthly averages for an Airfield site (61902) are in GHCNv4 from 1957, but the values are often the same as Georgetown (61900) in the late 1960s and early 1970s, so we have focused on the more original MIDAS and USAF data rather than those in GHCNv4 or in CRU archives.

Both the Georgetown and Airfield locations are close to the sea, and as Ascension is in the tropical belt, variability from year to year is relatively small. The elevation of the Georgetown site is given numerous times over the years and is in the range 10-20m (and most recently as 20m above mean sea level). The Airfield sites are higher, 75m for the UK site and 85m for US one. So based on the height difference (55-65m) between Georgetown and the two Airfield sites, we'd expect Georgetown to be 0.4°C warmer, assuming a lapse rate of 0.006°C per metre. We address this assumption later, when issues of some extreme values and the differences in methods of calculating daily and monthly means at Georgetown and the US airfield site have been dealt with.

To develop a long composite record, we began by comparing monthly and annual series for Airhead (UK) based on (Tx+Tn)/2 and a second based on the hourly values from the US site. As the US readings changed the recording hours on a number of occasions, we determined that the 09 reading was always there when readings were taken so averaged those. Most months for the 1973-1975 and 1982-1984 periods are also limited to weekday measurements only, so a maximum of only 20 days in Februaries. We refer to these monthly averages as US09 and the UK ones as UKMO. Even though US09 are likely less robust than those based on (Tx+Tn)/2, they offer the only opportunity of infilling the gaps between 1971 and 1989.

Calculating daily and monthly means based on Tx and Tn values is the standard practice in the UK. A better estimate of the 'true' mean would be to use the mean of the 24 hourly readings each day, which have been available for the UK site since the measurements were automated. However, to be consistent with the measurements pre-automation, we have kept with the (Tx+Tn)/2 approach. These averages are also those transmitted over the WMO CLIMAT network, so allowing new values to be added to the station record, without any further adjustments.

Figure 2 shows a comparison of annual averages between UKMO and US09 for years from 1957 to 2019, of which UKMO is Georgetown from 1957 to 1970 and Airhead from 1989 to 2019. Georgetown is slightly warmer than Airhead as discussed earlier. 1971-76 is missing as no single year has a full set of 12 months for UKMO. Data are completely missing for 1977 to 1988. For 1990 to 2019, UKMO is about 1°C warmer than US09. Using these 30 years we developed monthly differences, which are given in Table 2. This shows only a slight seasonal cycle in the differences. The completely missing 1977-1988 period from UK sources is surprising as it includes the Falklands War period in 1982. Brenchley (1986) discusses the Mobile Meteorological Unit that was first deployed to Ascension in 1982, and additionally to Stanley on the Falkland Islands later in the year. Work continued on Ascension till 1984 and at Stanley until 1986. Weather records were taken at both sites, but the main purpose was more for real-time forecasting and any measurements made at either location have clearly not yet been added to the MIDAS database.

In Figure 2, the years 1969 and 1970 stand out clearly as being anomalously cold in the UKMO series. Looking at individual months, this anomalous behaviour starts with November 1968 and continues to December 1970. The values from MIDAS and also from GHCNv4 are the same values in both monthly archives for 61900 and 61902. We have an independent dataset of sea-surface temperatures (SSTs) from the grid box that surrounds Ascension Island from the HadISST2 dataset (Rayner et al., 2003). We will show this later, but 1968 and 1969 are not anomalously cold in the SST series. We suspect that the values in MIDAS and GHCNv4 for November 1968 to December 1970 which ought to have been taken at Georgetown might have been taken at one of the Airfield sites or not estimated using (Tx+Tn)/2. Either way they are too anomalous to leave in. The few monthly values from MIDAS in the 1971 to 1976 agree much better with US09 (values adjusted using Table 1), so we assume these were taken at Georgetown and have retained them.

For the long temperature record, therefore, we have infilled Georgetown data for all missing months between 1957 and 1976 with US09 adjusted as in Table 2, and also replaced November 1968 to December 1970 with US09 adjusted. For the Airhead site, the period from 1977 to 1989 is infilled with US09 adjusted, then the complete (Tx+Tn)/2 data are used up to the end of 2020. Finally, all the measured Georgetown data before 1977 are adjusted downwards by 0.4°C due to the height difference between the two locations. Infilled Georgetown data (from the adjusted US09 data) were not reduced by 0.4°C.

Earlier we mentioned that this elevation adjustment is simplistic. We have assessed the 0.4°C value with two other approaches. The first of these is a direct comparison of the Georgetown data with the adjusted US09 values (using Table 2) for monthly data during September 1957 to December 1967. Here the difference is 0.35°C based on the 124 months. The second approach uses data for the single year of 1919 taken at Georgetown and also on Green Mountain at an elevation of 686m. Both sets of averages are based on the (Tx+Tn)/2 method, and Georgetown elevation is stated to be 16m. The existence of this one year of data is mentioned in two of the sources, but only Mathieson (1990) gives the monthly averages. The difference in the annual means is 6.05° C, which gives a lapse rate of 0.009°C per meter for the 670m elevation difference. Using this for the 60m difference between Georgetown and the Airfield sites, gives a difference of 0.5°C. We therefore retained the 0.4°C value.

Figure 3 shows a comparison of the combined annual values from 1923 to 2020 against the SST series. This shows good agreement between warm and cold years. 1992 is likely quite cool because the Pinatubo dust cloud would have been at its strongest during this year. The major difference between the two series is in the year 1943, which was markedly cooler at Georgetown than the SST value. We have available the US09 data for September 1942 to May 1947, but these data are much more erratic and offset from the later US09 data (1957 onwards) suggesting they might have been taken at a different and unknown site. The SST series during WW2 may also be of lower quality as there were few observations during these years. So, the 1943 monthly values at Georgetown are retained.

Figure 4 shows our Ascension Island air temperature series against two of the most Reanalyses, ERA5 (Hersbach et al., 2020) and also 20CRv3 (Slivinski et al., 2019). Here we take the square of ocean where the island is, but note that Ascension Island is not land in either of these or any Reanalysis, as it is too small. ERA5 is a fully comprehensive Reanalysis, so takes in all available observations, which includes satellite data from the mid-1970s, radiosondes (which used to be launched from the island, but haven't for many years), surface observations and sea surface temperature (SST) fields. 20CRv3 includes only surface observations of station pressure and sea surface temperature fields. We took the air temperature values from both Reanalyses. Both indicate cooler air temperatures by almost 1°C. This is not surprising as the island isn't in the Reanalyses, but the year-to-year variability is similar driven by SST variability. In Figure 5, we show the SST and simulated Surface Air Temperature (SAT) from 20CRv3 and their difference which is approximately 1°C. This difference is remarkably stable, so estimated SAT in this Reanalysis varies in step with the input SST values. This provides support for the suggestion of Gillespie et al. (2021) that 20CRv3 could be used for the homogeneity assessment of measured surface air temperature series in remote locations. This difference between observations and Reanalyses in Figures 4 and 5 is also similar to that between the Garrison site and HMS Tortoise from the mid-19th century, mentioned in the Introduction.

As discussed in the Introduction, the nearest land to Ascension Island is St Helena Island, 1295 km to SSE. A record of monthly mean temperatures and one of monthly precipitation totals has been developed for St Helena by Feistel et al. (2003) and been updated regularly online (https://www.io-warnemuende.de/en_hix-st-helena-island-climate-index.html). We should caution readers not to expect much agreement because of the distance between the locations. In the well-used CRU_TS dataset (Harris et al., 2020) monthly temperature and precipitation data are interpolated to a regular half degree latitude/longitude grid, but stations beyond 1200km for temperature and 450km for precipitation are not used. St Helena is wetter and cooler, partly due to main observational site there being at 436m elevation. Despite this caution, the comparison in Figure 6 is better than we expected. Over the period 1950-2020, the correlation is 0.73, which is significant at the 95% level.

In Table 3, we give trends of these series together with SST over two periods: 1950-2020 (1950 is the current start year of ERA5) and 1979-2020 (the length of the satellite period). We also include the St

Helena trends. All five temperature series show statistically significant warming at the 95% level. At Ascension Island warming for the shorter recent period from 1979 is 0.40°C, and slightly more since 1950 at 0.54°C. Warming since 1979 is more consistent between our Island air temperatures and that shown by the SST data.

4. Development of a Precipitation Series

As with temperature, monthly precipitation totals have been measured at Georgetown for 1899-1913, 1924-1975 and 1985-2011. It is unclear whether the three periods of records were collected at the same location within Georgetown, but the settlement is relatively small often being referred to as a village. In an ideal world, more metadata about the history of recording with some pictures of the sites and instruments would be available. For the case of sites on Ascension Island these are just not in the archives at the Met Office in the UK, with the few earlier articles also providing little or no discussion of the quality of the data that was available. For precipitation, this study has sourced records directly from the island (James McGurk pers. comm.), but these only cover the period from about 1989. With these data, missing monthly values (during the 2001-2007 period) have been infilled, with only May and June 2007 still without values. More assessment locally has been undertaken with the precipitation data, presumably because of its greater importance due to the arid climate.

The UK Airhead site is complete from May 1984 to 2020, following receipt of daily precipitation totals directly from the island (for 2011-2019). About 20% of values after 2011 in the NCEI publication Monthly Climatic Data for the World (MCDW) are ten times too large, due to mm*10 values being submitted in monthly CLIMAT reports (where the total should be given in whole mm). This scale issue is much more common than it should be. In most parts of the world, this issue is corrected when the values are quality controlled, but Ascension has no neighbouring values and does have a large range of monthly totals from zero to over 300mm.

Monthly precipitation totals from the Pan-Am site (likely taken by USAF) are complete from 1962 to 2010, but these data are not included in the hourly data file from NCEI. We obtained these values also from James McGurk (pers. comm.). Figure 7 shows scatter plot comparisons of the Pan-Am site with Airhead for monthly and annual totals for the 1984-2010 common period. As they are in strong agreement, we have combined these two records to produce an airfield site record from 1962 to April 1984 (from Pan-Am) and Airhead from May 1984 to the present. Months and years with exceptionally high totals are discussed later in this section.

Figure 8 shows a similar scatter plot comparing monthly and annual totals for the Pan-Am site against Georgetown for the years from 1962 to 2000 (omitting values for 1976-1984 which were missing at Georgetown, so 30 years in total). Data for 2001-2010 were excluded due to the infilling at Georgetown discussed earlier. Georgetown and the Pan-Am/Airhead generally record similar amounts of annual precipitation, but even though there are only a few km apart, they occasionally differ by large amounts (in 1963 when the airfield was much wetter and 1994 when Georgetown was).

To adjust Georgetown (G) to the Airfield (A) for years before 1962, we used a simple regression based on monthly totals (Equation 1)

$$A = 0.8153*G + 4.39 \qquad (1)$$

If instead we had used the annual totals plotted in Figure 6, the equation would have been similar with A = 0.885*G + 42.7 mm.

Figure 9 shows the annual totals for Georgetown, the combined airfield record and the combined record from the late-19th century to the present. Annual precipitation totals show little trend throughout the almost 100-year record, but we have included annual trends in Table 3 for the same two periods as for the temperature series. The Airfield site has hardly any absolutely dry months, but Georgetown has many more, particularly before 1975. This might be due to more assiduous recording at the airfield sites. Also, some trace monthly totals are evident since 1989, but none beforehand. As with temperature, we also compare our Ascension Island annual precipitation total series with that from St Helena in Figure 10. As expected for precipitation due to the distance between the islands, there is little agreement between the two series.

Years with exceptionally high totals at Ascension Island, sometimes up to eight times the driest years, always contain very high daily and monthly totals, always in the February to June period. We commented earlier about the CLIMAT totals during 2012-2019 being entered erroneously in mm*10 units, so the island-based records are an important part of checking the values. These high totals cause significant damage in Georgetown, to roads and farmland across the island, and to the runway at the airfield, so we are confident that they happened. Hall (1989) listed heavy rainfall totals since 1831, occasionally noting events when there were no rain gauge records available in the 19th century. Duffey (1964) also gives a list, but only about half of the events up to 1934 are in common between the two articles. This second list often gives totals from the much wetter Green Mountain site, and more information about impacts across the island, especially on grass growth and the subsequent plagues of insects (cockroaches, locusts and mosquitos) after the 1924 and 1934 events.

No specific threshold was used in either publication, but all are daily or multi-day totals in excess of about 80 to 90 mm, totals which are almost twice the annual totals from the driest years, the driest of which was 1981 with 56.4 mm. The largest daily totals given by Hall (1989) are in the 200-350mm range, and his study focuses on their likely cause (westward moving disturbances), particularly events in March 1984 and April 1985. 1985 is the second wettest year on record with 494mm, of which 334mm fell in April 1985, a monthly total that is more than all bar the six wettest years. The wettest year since our combined series begins in 1899 is 1963 with 525mm. As noted earlier with respect to Figure 6, 1963 is one of two years where the Georgetown and Airfield sites differ by more than might be expected given the 30 common years of overlap. Since 1985, only 3 months have seen monthly totals above 100mm (April 1988 and April and June in 2011). The annual total in 2011 is the 4th wettest annual total with 448mm. The first, third, fifth and seventh wettest years are 1963, 1934, 1899 and 1924 and all contain very heavy daily and multi-day totals given by Duffey (1964) and Hall (1989).

5. Conclusions

We have developed a long monthly record of temperature and precipitation variations for the island. Although there are about 10 years of data from the 1850s and 1860s, air temperatures and precipitation totals have only been continuously recorded since 1923. We have included some earlier monthly values, where they were available. Measurements have been made at two locations: Georgetown, the island's capital and at two sites at the airfield, which was constructed in 1942. Although a record is available for the island in global climate databases, data from the different sites often appear the same, particularly during the 1960s to the 1980s. In this study we have accessed as much data as possible from original sources in the United Kingdom, the United States and from the island itself.

Air temperatures have warmed since 1950 by 0.54°C up to 2020, and by 0.40°C since 1979. The record has been compared with SSTs from the grid box where the island is in HadISST2 dataset. Agreement is excellent as would be expected as both sites are near the coast and the island is relatively small. The island is not large enough to be land in recent reanalyses (such as ERA5 and 20CRv3), but we extracted the air temperature series for the island's location. Agreement is good, as both the island air temperatures and the reanalyses are dependent on SST variations. The absolute are temperature values in both reanalyses are about 1°C cooler than those measured on the island, slightly more for ERA5 than 20CRv3. This difference is approximately the same as measurements made on the island during 1854-1859 compared to those made on board HMS Tortoise anchored offshore during 1860-1865.

A monthly precipitation record was developed from 1924, by combining the Georgetown and airfield measurement sites. Additionally, there are some earlier measurements for 1899-1909 from Georgetown, and two publications (Duffey, 1964 and Hall, 1989) are suggestive of more later 19th century measurements being taken that if found could link with the mid-19th century data. The record shows no long-term change in annual precipitation totals and is generally an arid island (164.7 mm average for 1924-2020). Despite this low average, heavy monthly totals occur in some years, always in the February to June months, causing 8 years since 1898 to have annual totals that are more than two to four times the long-term average. These much wetter years generally have one or two monthly totals in excess of 100mm, with the wettest month being April 1985 with 334mm, a total that is exceeded only by the six wettest years. The impacts of these wet periods across the island are discussed by Duffey (1964) and Hall (1989) with the latter paper discussing possible causes for the wet periods.

All the data collected during this study are available at https://sites.uea.ac.uk/cru/data (not until the paper is published) and the summaries will be sent to databases such GHCNv4.

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Table 1: Location of the recording sites in Georgetown, the island Airfield and St Helena

Station Name	Latitude (degrees S)	Longitude (degrees W)	Elevation (m)
Georgetown (Garrison)	7.933	14.3937	20
UKMO Airhead	7.967	14.4	75
Pan-Am (USAF)	7.9696	14.3937	85
St Helena	15.93	5.67	436

Table 2: Average differences between UKMO and US09 for the 1990-2019 period.

Month	UKMO-US09 (degrees Celsius)
January	1.0
February	1.1
March	1.0
April	1.0
May	0.8
June	0.9
July	1.0
August	0.9
September	0.8
October	0.7
November	0.7
December	0.8

Table 3: Annual trends of the series developed and used for Ascension Island for 1950-2020 and 1979-2020. All temperature trends (values are per decade) are statistically significant at the 95% level, but precipitation trends (in mm per decade) are not significant. For ERA5, the value for 2020 was incomplete, and 20CRv3 was only available to 2015.

Series	1950-2020	# of years	1979-2020	# of years
Ascension Air Temperature (°C)	0.0765	71	0.0964	42
SST (°C)	0.1006	71	0.1051	42
ERA5 (°C)	0.1045	70	0.1301	41
20CRv3 (°C)	0.1128	66	0.1267	37
St Helena (°C)	0.1183	71	0.0806	42
Ascension Precipitation (mm)	0.0681	71	3.749	42

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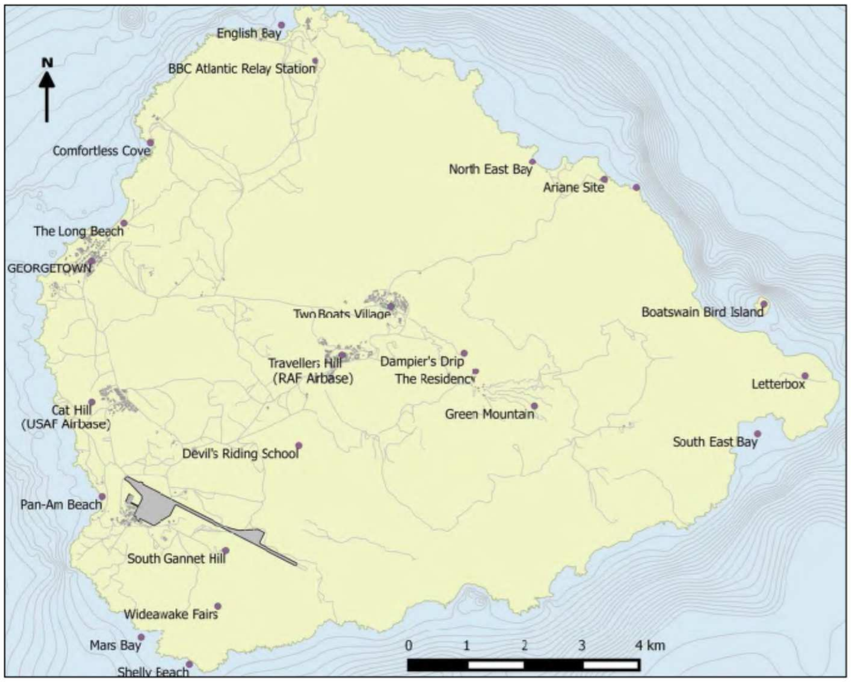

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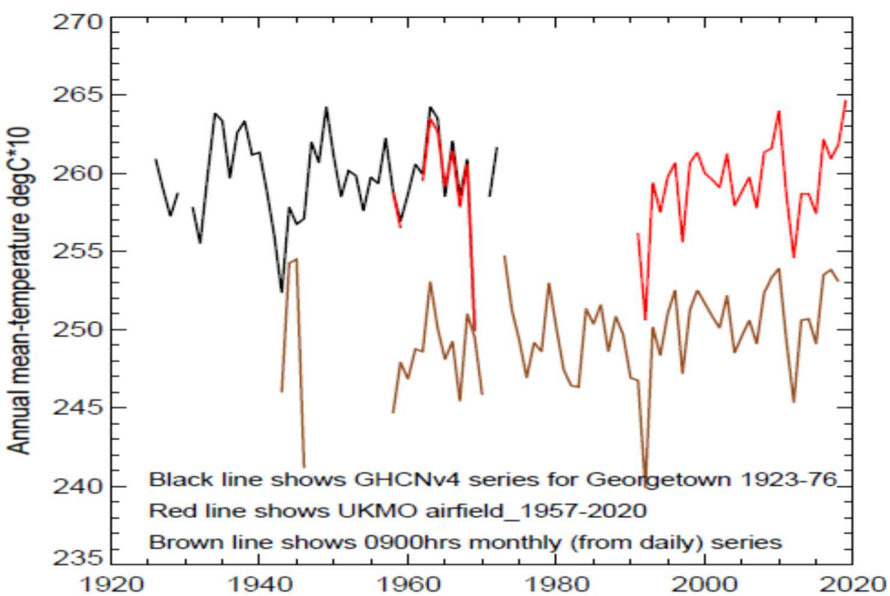

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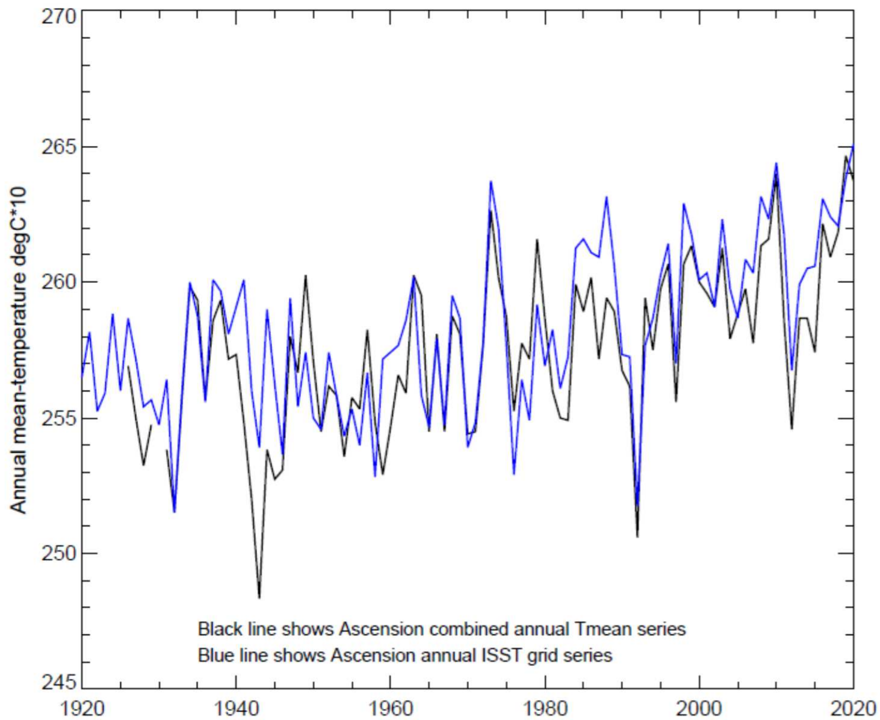

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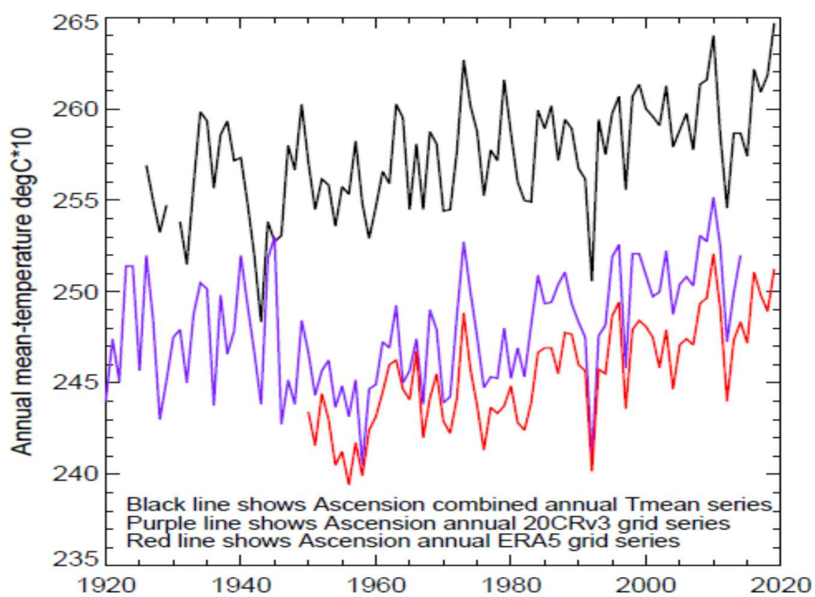

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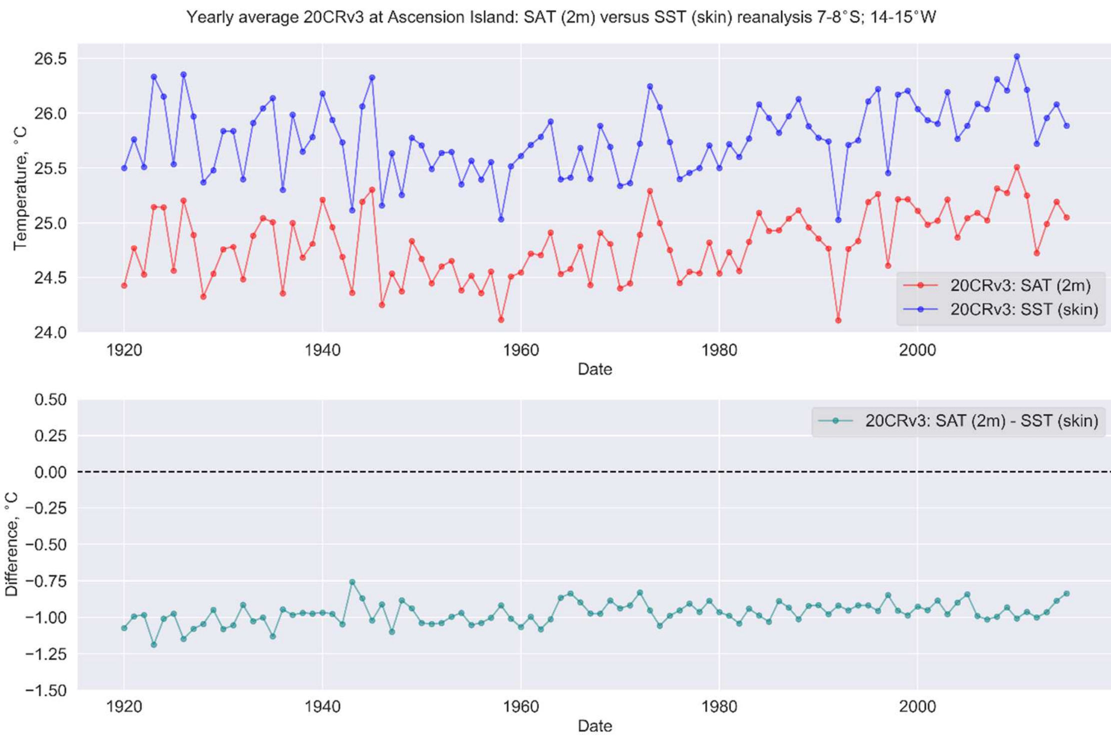

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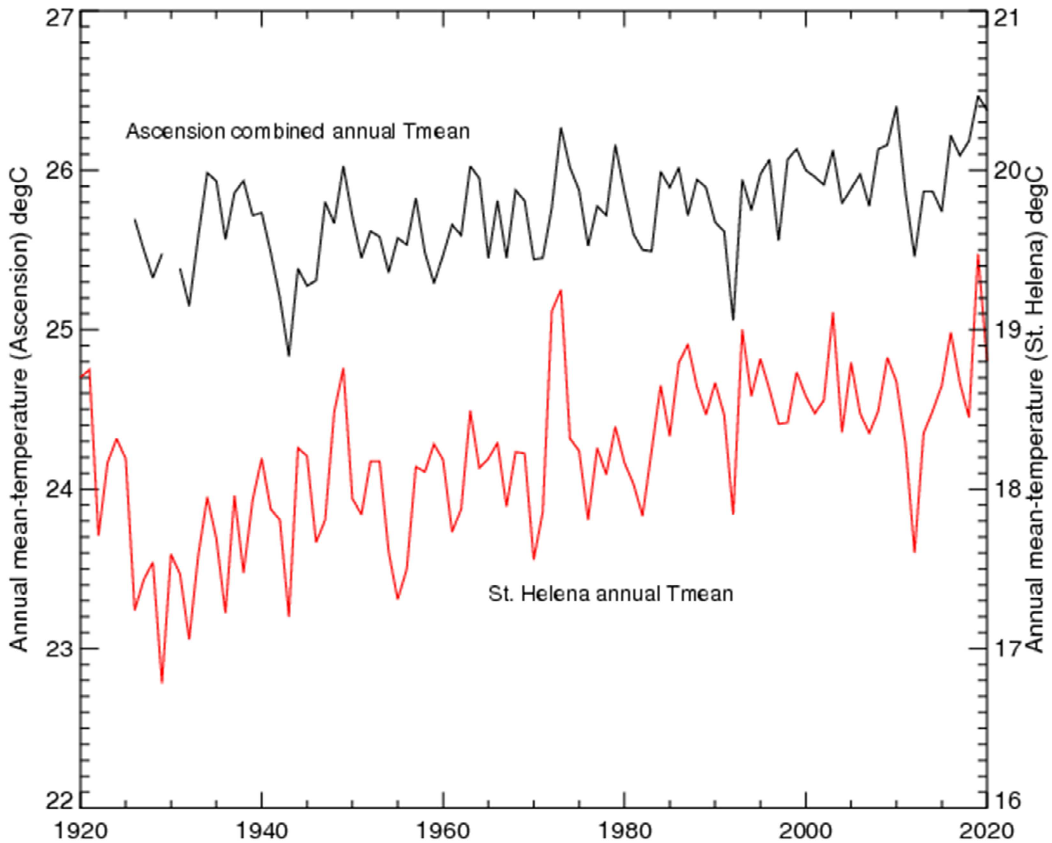

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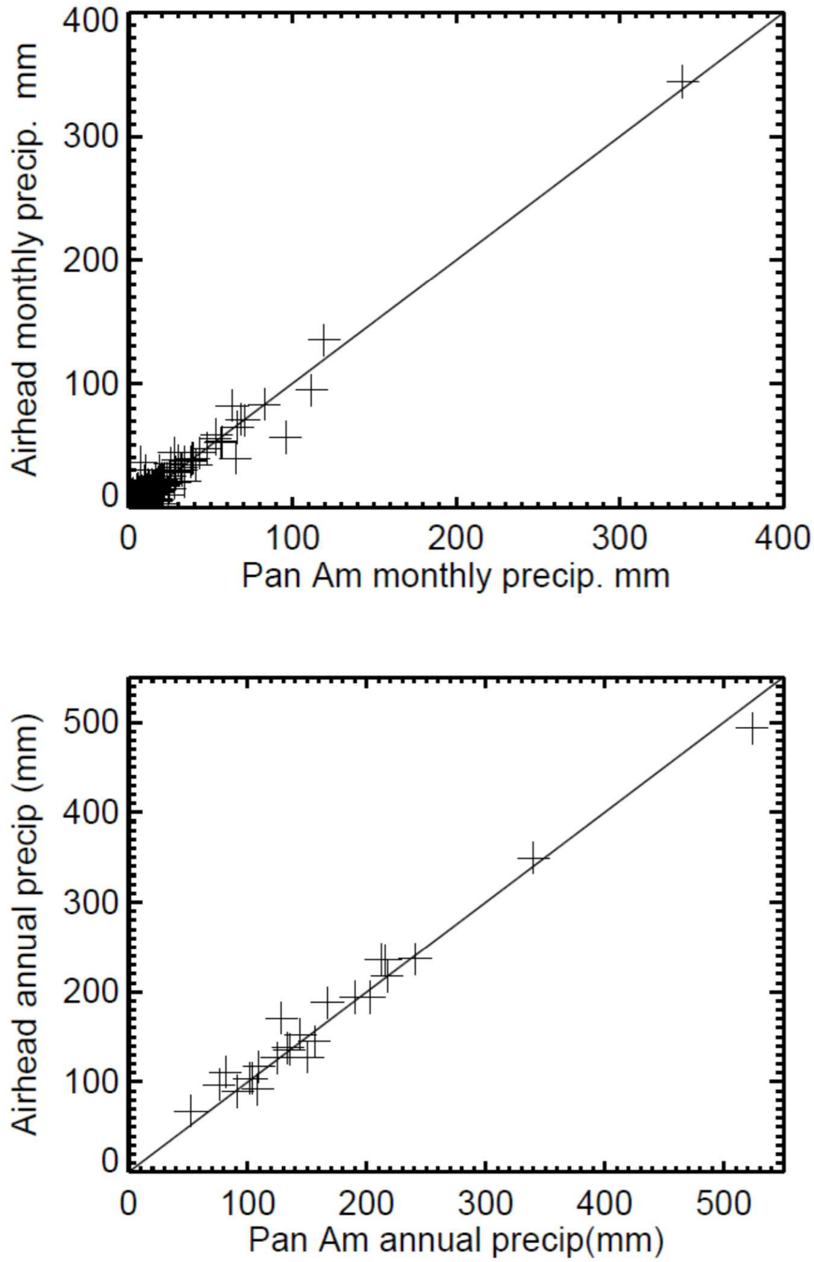

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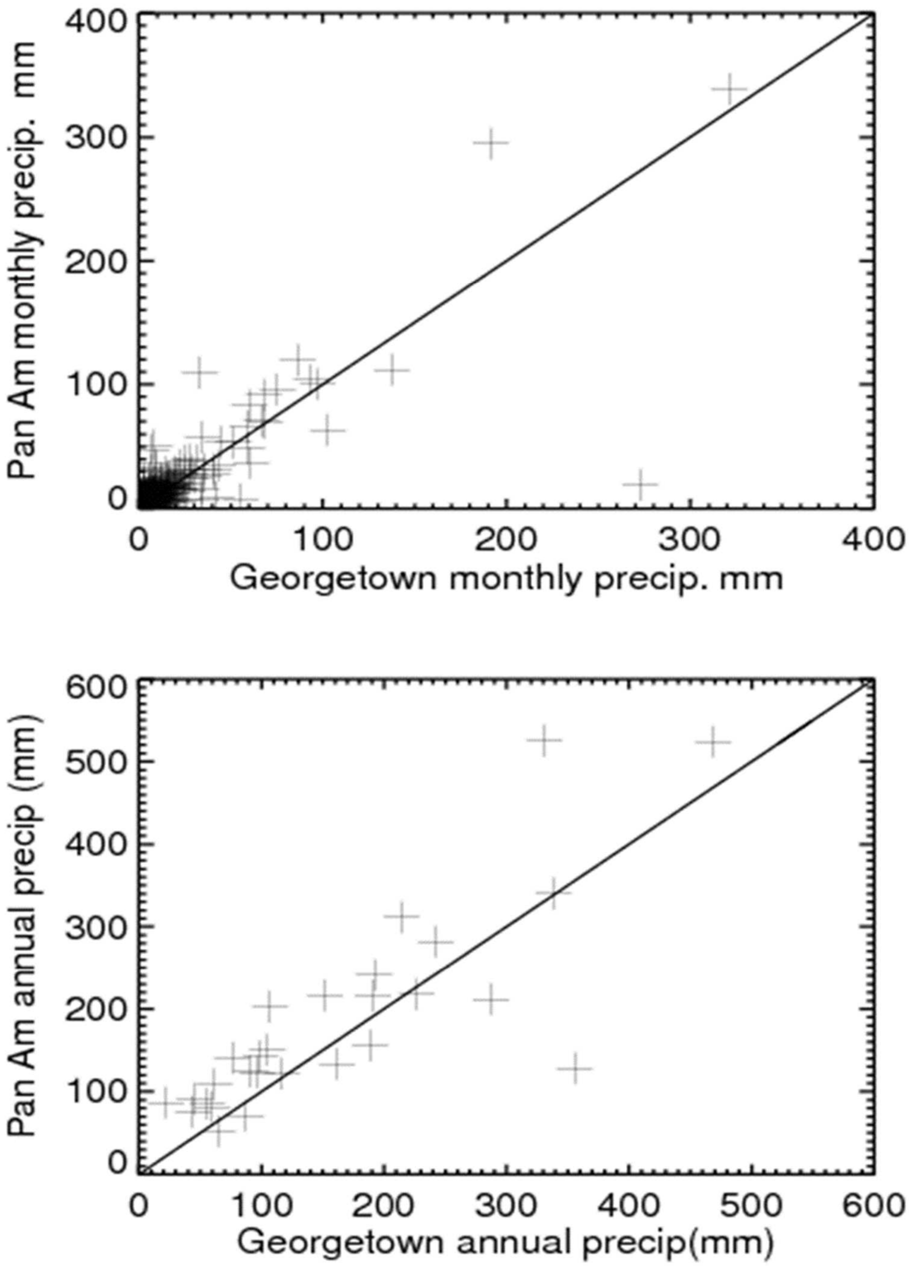

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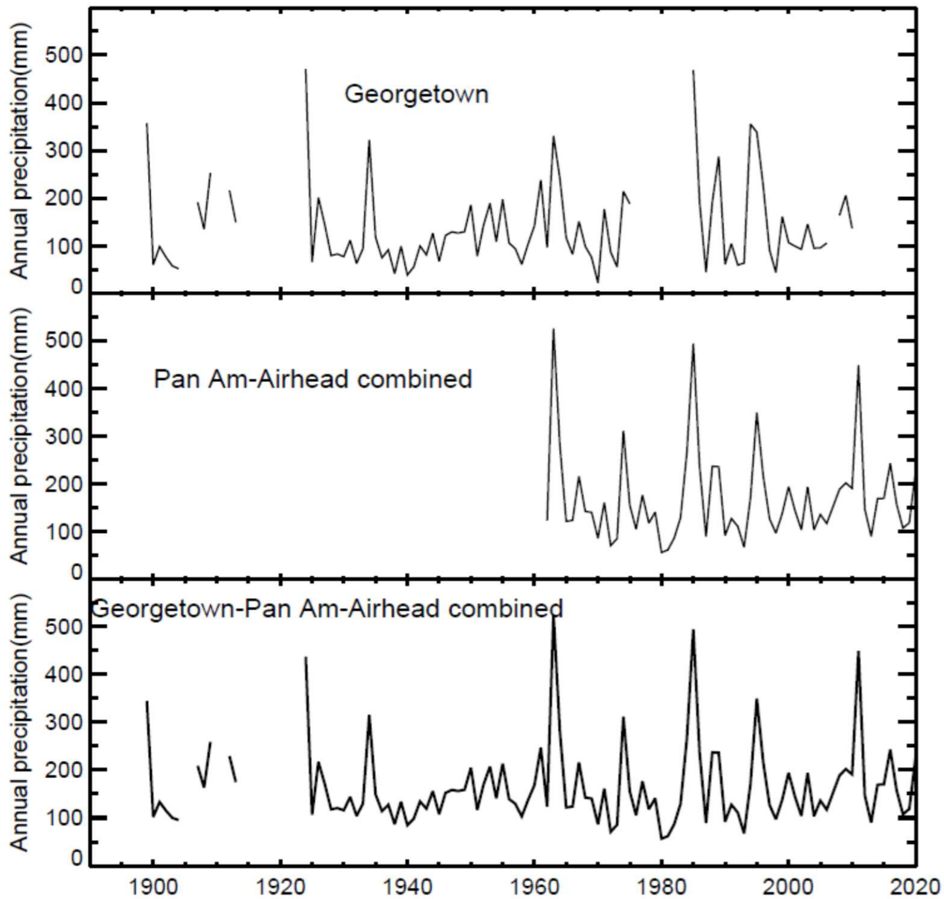

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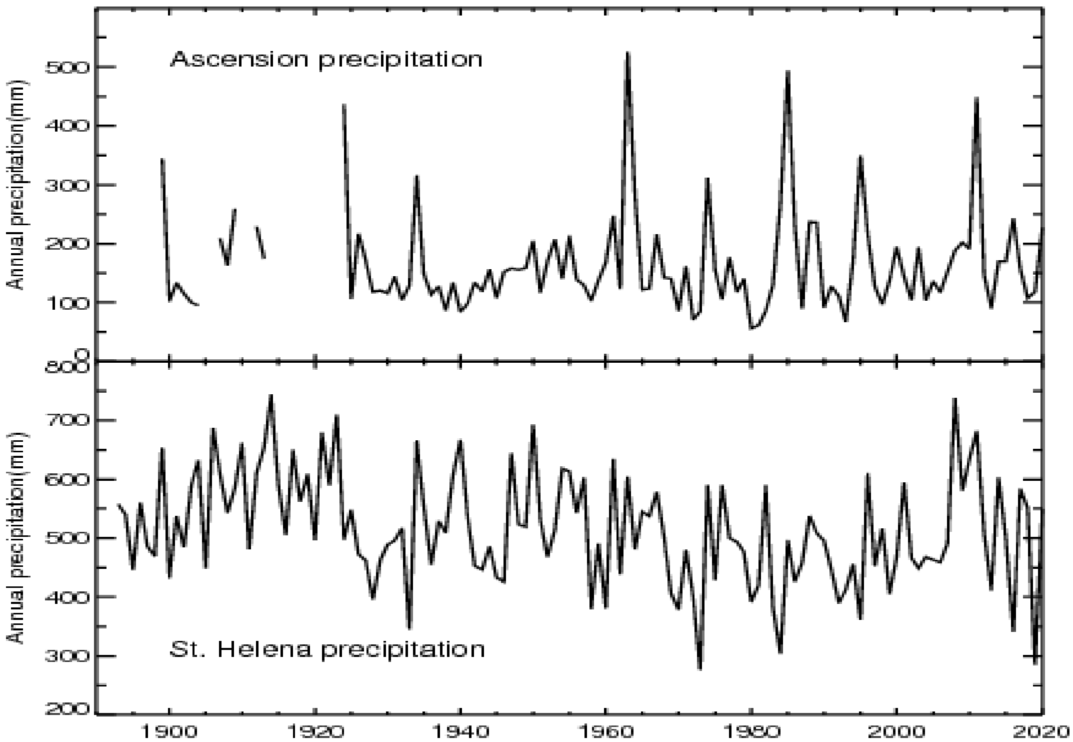

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