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CENTRAL AUSTRALIA 20TH CENTURY TEMPERATURE TRENDS

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ABSTRACT: This work presents the computation of reliable warming trends for central Australia around Alice Springs within a circle of radius 1,000 km. Between 1880 and 2011, the average warming for the centre of Australia is +0.166 °C/century, slightly smaller than the warming of Alice Springs, that is +0.176 °C/century. Over a shorter time between 1910 and 2011, the centre of Australia is warming +0.794 °C/century, slightly more than the warming of Alice Springs, that is +0.719 °C/century.

Keywords: temperature records; homogenisation; pattern reconstruction; central Australia

1. INTRODUCTION

For spatial reconstructions of temperatures or other parameters, ideally equally spaced gridded data are needed over the full time of observation. Unfortunately, this is not available, as very few stations have data over the period of interest. Here we want to reconstruct the 20th century warming in the centre of Australia, where according to the local Bureau of Meteorology (BOM) there has been the largest warming in Australia. Figure 1 presents the temperature trends in Australia 1910 to 2016 according to the Australian BOM.

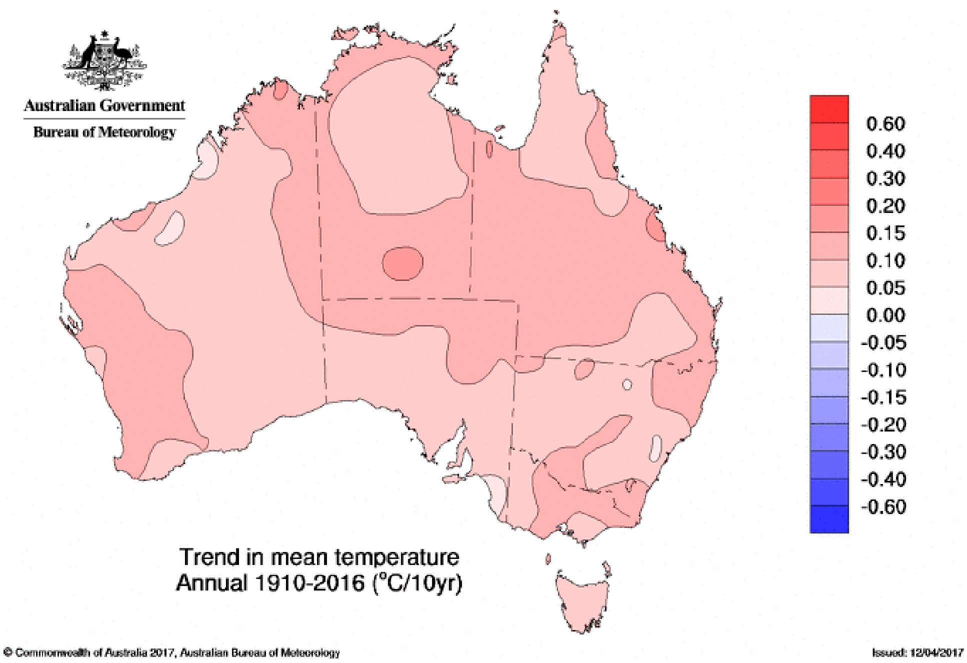

Figure 1 – Temperature trends in Australia 1910 to 2016 according to the Australian Bureau of Meteorology. Image is from Australian Government Bureau of Meteorology (2017a).

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However, according to independent studies such as Boretti, 2013; Mearns, 2015; Parker, 2014; Parker, 2015; Parker, 2016; Parker & Ollier, 2015; Parker & Ollier, 2017, there has been no warming at all.

When data are too few, and few gridded points have data covering different time windows, there is a significant uncertainty in the computed global trends, and almost anything can be obtained by using improper homogenizations. Theoretically, homogenization should remove urban heat island effects (i.e. artificial warming). Conversely, as used by the local Bureau of Meteorology, homogenization is used to create warming trends.

Here we analyse the data for the scattered network of measuring stations in Central Australia. All the stations within a circle of 1,000 km radius from Alice Spring are included in the analysis. The data are scattered and of unequal length. Here we use an approach where the annual temperature trends rather than simply the temperatures are shared between neighbouring stations.

The analysis is based on the GHCN v2 data set. As there is no reason why the effects of global warming should reduce the temperatures of the past up to one hundred years ago, this data set is superior to the latest data set GHCN v3 where the past temperatures in the individual locations have been arbitrarily redesigned nominally by homogenisation. Hence, our criticism of the adjustments and homogenization by BOM also applies to the adjustment and homogenizations by others such as GHCN in their v3 vs. v2. Figure 2 presents on the left the raw GHCN v2 data and on the right the GHCN v3 after adjustments and homogenization. Clearly, the temperatures of the past have been adjusted down by as much as 2 °C, significantly contributing to the apparent warming of Australia.

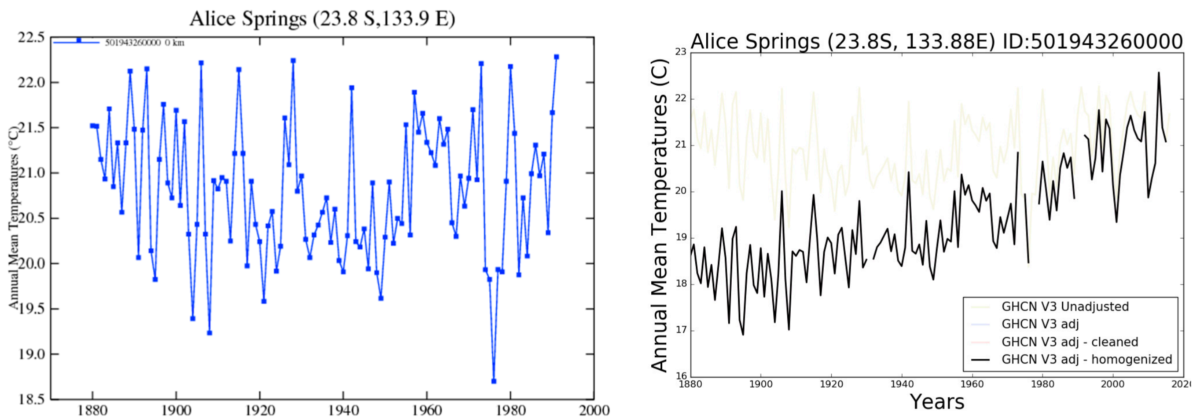

Figure 2 – Temperatures in Alice Spring before (left) and after (right) adjustments and homogeneizations. Images are from GISS Surface Temperature Analysis (2016, 2017).

Improper redefinitions of the past temperature records by the local Bureau of Meteorology are also treated in Abbot & Marohasy, 2017; Marohasy, 2017; Marohasy & Vlok, 2017; Marohasy & Abbot, 2016; Marohasy, 2016; Marohasy & Abbot, 2015. The tampering of temperatures by GISS

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/ GHCN is covered by Caryl, 2012; Gosselin, 2015; Goddard, 2012; Homewood, 2015 and many others.

2. METHODS

Temperature trends are computed by linear fitting of the measured monthly mean, minimum or maximum temperatures. If x is the time and y the temperature, by using a linear regression:

$$y = A + Bx \quad (1)$$

These values are averaged over the time window of the analysis.

For spatial reconstructions, equally spaced gridded data are ideally needed over the time of observation. If there are not enough data, and only few gridded points have data covering different time windows, the computed spatial trends are generally inaccurate.

Here we use two different approaches, homogenization of temperatures from neighbouring stations, as well as homogenization of temperature time gradients from neighbouring stations, to avoid producing spurious global trends.

Records having better quality are finally weighted more than scattered records.

3. RESULTS

3.1 – Stations Information

Alice Springs has temperature data from 3 stations (Australian Government Bureau of Meteorology, 2016). One now closed, Alice Springs Post Office, has data from March 1878 to December 1953. Another, Alice Springs Airport, has data since November 1941 and it is currently operational. A third one, Alice Springs Connellans, recorded less than 1 year of data from 1940 to 1941.

Alice Springs Post Office and Alice Springs Airport are less than 10 km apart, and have more than a decade of overlapping measurements to permit alignment of the two records to produce a composite record of almost 140 years. The composite records show small or no warming over the period of observation (Boretti, 2013; Parker, 2014, 2015, 2016; Parker & Ollier, 2015).

It may be argued there is a need to homogenise the record of Alice Springs temperature record for removal of non-climatic deviations due to station relocations or changes in instrumentation and urban heat island (UHI) formation. This is far from simple for the data sets are scattered and incomplete.

A UHI is an urban area significantly warmer than its surrounding rural areas due to human activities. The main cause of UHI is from modification of land surfaces with waste heat a secondary contributor. UHI may eventually introduce more recent warming rather than cooling.

Homogenization is the removal of non-climatic changes of one station's time series from raw temperature records. As the raw records, may contain non-climatic deviations, these nonhomogeneities may be removed by homogenization comparing the temperature of the candidate station to a reference time series based on neighbouring stations. If the candidate and the reference stations experience about the same climate, the non-climatic deviations that happen only in one station can thus be identified and removed.

Within a 100-km radius, the only other station is Arltunga where less than 2 decades of data were recorded.

Within a 200-km radius, Ringwood also has less than 2 decades of recorded data, Palm Valley less than 1 decade of data, Territory Grape Farm about 2 decades of data, and Tempe Down 1 decade of data.

Within a 300-km radius, Papunya has less than 1 decade of data, Watarrka less than 3 decades, Mount Dare about 3 years of data, Willowra about 1 year of data. More than 4 decades of data are only available in Finke Post Office, Barrow Creek, Kulgera, Jervois, Yuendumu, Charlotte Waters and Curtin Springs. Finke Post Office, Barrow Creek, Kulgera have about 4 decades of data, Charlotte Waters and Jervois about 4½ decades of data, Yuendumu and Curtin Spring about 5 decades of data. The closest to Alice Springs of those stations with a minimum number of years recorded to be significant is Finke Post Office 219.4 km away. The start and end of recording and completeness of the records are strongly non-uniform.

For Alice Spring, homogenisation is a problem. There is no other station with usable data within 200-km. Furthermore, there are only 7 stations 200 to 300 km away with 40-50 years of data mostly from recent years. The scattered population of other stations of strongly variable completeness and length of the records makes any homogenisation procedures extremely unlikely to provide a meaningful result.

Looking at the individual temperatures of the neighbouring stations within a 300-km circle for the homogenisation does not help either.

Around Alice Springs itself the average daily maximum temperatures increases to the east, west, and especially north, while it is about constant to the south. Similar pattern is shown by the average daily minimum temperatures (Australian Government Bureau of Meteorology, 2017b). Homogenization using shorter and lower quality records from warmer areas introduces more inaccuracies and biases. Based on inadequate data, homogenization can only provide wrong patterns.

Moving further away from Alice Springs, over a circle of 1,000 km radius, few other stations are available, but none are of better quality than the composite Alice Springs record, as these stations also suffer from non-uniform quality and record length. Nevertheless, as was shown by Mearns

(2015), these individual records indicate a generally stable or minimally warming temperature rather than intense warming.

3.2 – Data Set Information

The analysis by Mearns (2015) was based on the GHCN v2 temperature data set (GISS Surface Temperature Analysis, 2016). This data set is considered more reliable than the subsequent version v3 of 2011 where past temperatures were subjected to administrative corrections. While the GHCN v2 time series are close to the actual temperature measurements for the individual stations of the "*Climate Data Online*" data set (Australian Government Bureau of Meteorology, 2016), the adjusted and homogenised GHCN v3 time series suffer from many arbitrary changes (Mearns, 2015; Goddard, 2012; Homewood, 2015).

As noted by Humlum (2017), "*as the past does not change, any record undergoing continuing changes cannot describe the past correctly all the time*". Just because the true measurements available for the past are not compliant with some theoretical narrative, it is not acceptable to replace them with never-validated figures. Therefore, we take the GHCN v2 data as the most reliable source of temperature measurements for the area, and we discuss homogenization across the entire population.

The adjusted and homogenised GHCN v3 time series are obviously close to the adjusted and homogenised time series of the Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) data set (Australian Government Bureau of Meteorology, 2017c) the trend map of Figure 1 is hypothetically based on.

3.3 – This analysis

The 1,000-km radius circle around Alice Springs superimposed to the map of Australia is shown in Figure 3. To prevent any arbitrary adjustment or homogenization, the temperature records of all the 30 stations of GHCN v2 available in this circle of radius 1,000 km around Alice Springs are considered.

The surface of this circle is 3,141,592 km^2. Only Russia, Canada, United States, China and Brazil have a significantly larger total surface area, while India has about the same total surface area. It is would be most unreasonable, therefore, to expect similar temperatures across the whole area.

Figure 4 presents the temperature records of all the 30 stations $T_{i,k}$, with i=1,…,30 the station index and k the time index. These temperatures are the annual average temperature. If the classic linear fitting is applied to the Alice Springs record to compute the warming trend, this trend is +0.18 °C/century over the time window 1880-2011. The time series have variable record length, and many gaps. Alice Springs is the only station with recorded data spanning all the last century.

Figure 5 presents the number of stations operational at any time. This number increased continuously from 1 station only in 1880 to the 27 of 1970. Then the number of stations was drastically reduced to only 6 in 1993. Most of the stations operated during the years 1965 to 1992. Early 1970s to early 1990s was a period of temperature recovery after anomalous low temperatures in the early 1970s.

The individual annual average temperatures show that Alice Springs is cooler than most of the neighbouring stations.

Figure 3 – The 1,000-km radius circle around Alice Springs superimposed to the map of Australia from www.google.com/maps.

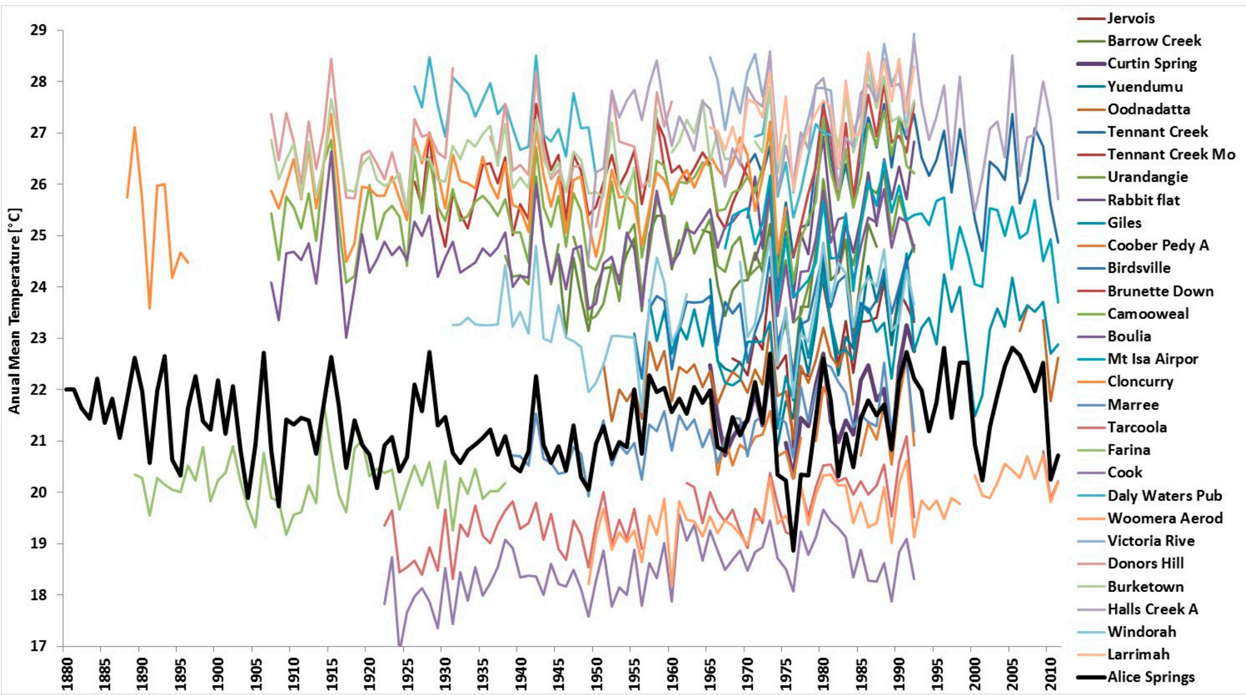

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Figure 4 - Annual mean temperature time series for Alice Springs and all the neighbouring stations within the circle from GHCN v2. Data is from GISS Surface Temperature Analysis (2016).

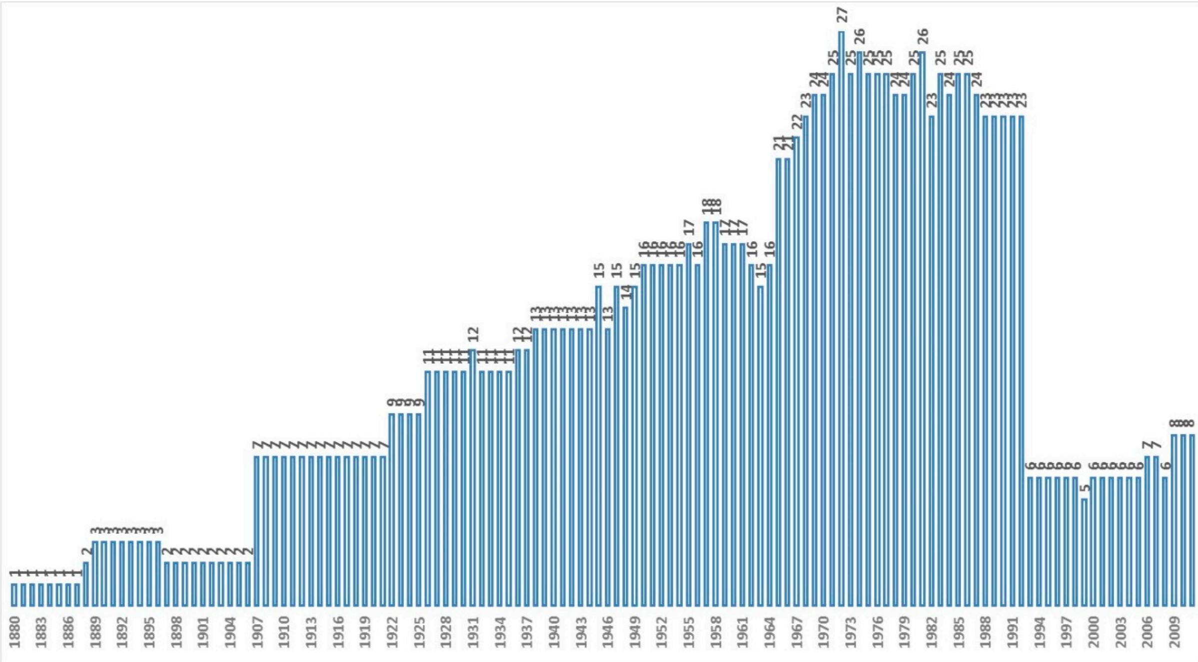

Figure 5 - Number of stations operational at any time within the circle from GHCN v2. Data is from GISS Surface Temperature Analysis (2016).

Unfortunately, the 30 stations have never been operational together, and for only one year, 1972, 27 of the 30 stations were-operational at the same time. Only from 1965 to 1992 have there been more than 20 of these 30 stations operational. The population is clearly scattered and strongly variable with time.

The average record length is 52 years, the longest record is 132 years (Alice Spring) and the shortest record is 23 years. Only 11 stations have a record length of more than 60 years. As many stations have significant gaps, the actual number of years with recorded data is much smaller. The individual trends are generally not significant as they do not cover a sufficiently long-time window to account for decadal and multi-decadal variability.

Ideally, for a proper computation of the spatial distribution of the warming trends over the period of observation, one should consider the complete time series spanning the complete time window 1880 to 2011 for a sufficiently large number of equally spaced gridded points. We cannot do this as we only have data from few locations, which are of strongly variable length and completeness.

3.3.1 – Temperature anomaly approach

A first opportunity to couple together these 30-time series to infer at least a naïve averaging warming trend is to consider the individual stations' temperature anomalies against reference temperatures measured over the same reference time window and average these anomalies. As there is no common time window for all the stations, this "*anomaly*" approach is difficult to apply. We may still define a "*reference*" temperature as the average of all the measured temperatures for a given location. Figure 6 presents the annual mean temperature anomaly time series for Alice Springs and all the neighbouring stations within the circle. The lack of warming is very clear. The warming rate in Alice Spring is +0.176 °C/century 1880 to 2011 and +0.719 °C/century 1910 to 2011. The naïve average warming is slightly smaller, +0.140 °C/century 1880 to 2011 and +0.451 °C/century 1910 to 2011.

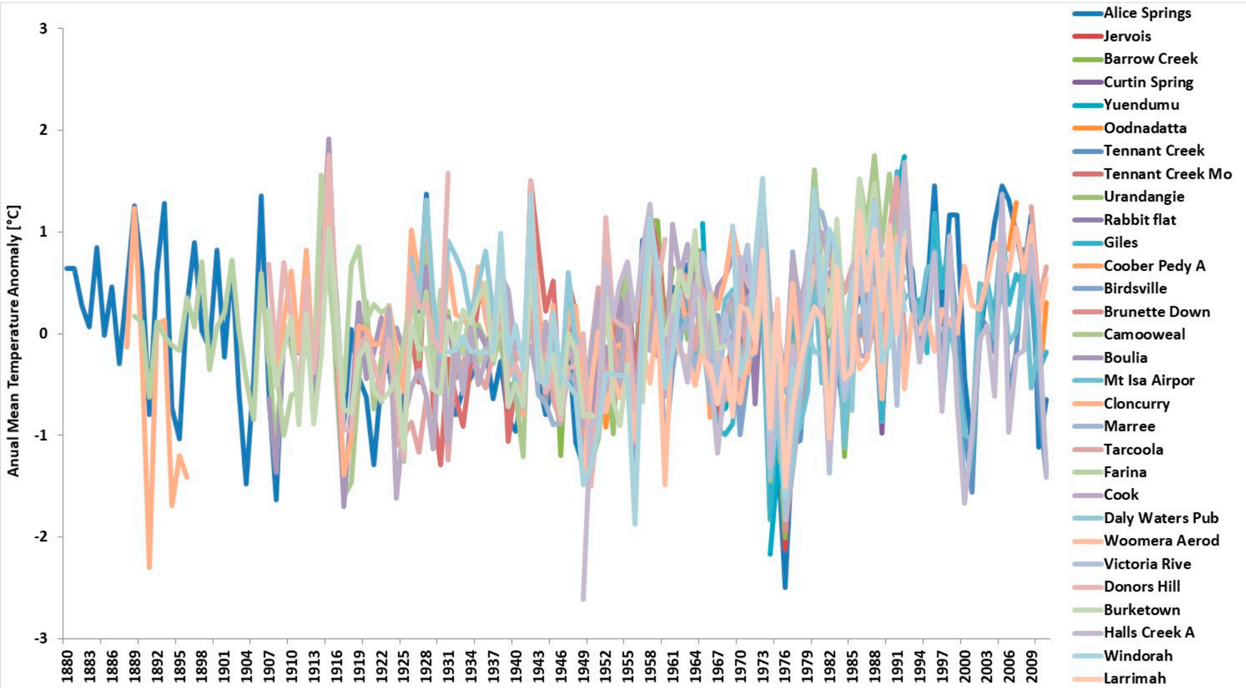

Figure 6 - Annual mean temperature anomaly time series for Alice Springs and all the neighbouring stations within the circle from GHCN v2. Data is from GISS Surface Temperature Analysis (2016).

3.3.2 – Temperature difference approach

In addition to the "*anomaly*" approach, we may also try to infer a naïve average warming trend by looking at the local annual differences of temperature year after year.

The annual temperatures may differ more than 10 ºC from one location to another. The annual temperature rises (or falls) are conversely usually much closer. There may be some sort of synchronization of the oscillations even when the area under study is quite large.

We can always say if the temperature of one year is higher or lower than the temperature of the year before. We may then build a homogenization procedure based on the rate of change of the temperatures and not the temperatures themselves.

The difference between maximum, minimum and average values of $T_{i,k}$ across the population are obviously much larger than the difference between maximum, minimum and average values of annual differences of temperature

$$(dT/dt)_{i,k}= (T_{i,k}- T_{i,k-1})/ (t_k-t_{k-1}) \quad (2)$$

In this equation, t is the time.

Even when the area under study is large, there is a certain extent of synchronization of warming and cooling. Values of $(dT/dt)_{i,k}$ are often all positive and negative across the population. As a result, the annual temperature difference for Alice Springs and the average of the population match each other very well.

If the analysis of the naïve averages of the $T_{i,k}$ at any time as done by Mearns (2015) may be questioned as a proper approach to compute a warming trend (but the subjective homogenisation for compliance with narratives is certainly worse), the analysis based on the naïve averages of the $(dT/dt)_{i,k}$ at any time provides a more reliable estimate of the warming trend across the area

Integrating the time series of the naïve average dT_k permits computation of the naïve average warming rate by considering

$$T_k=T_{k-1}+(t_k-t_{k-1})\cdot (dT/dt)_{i,k} \quad (3)$$

The time series of the naïve average of the $dT_{i,k}$ from all the stations of the area and the dT_k of Alice Springs are very close each other, similarly close is their integral representing the time anomalies vs. their 1880 value, Figure 7.

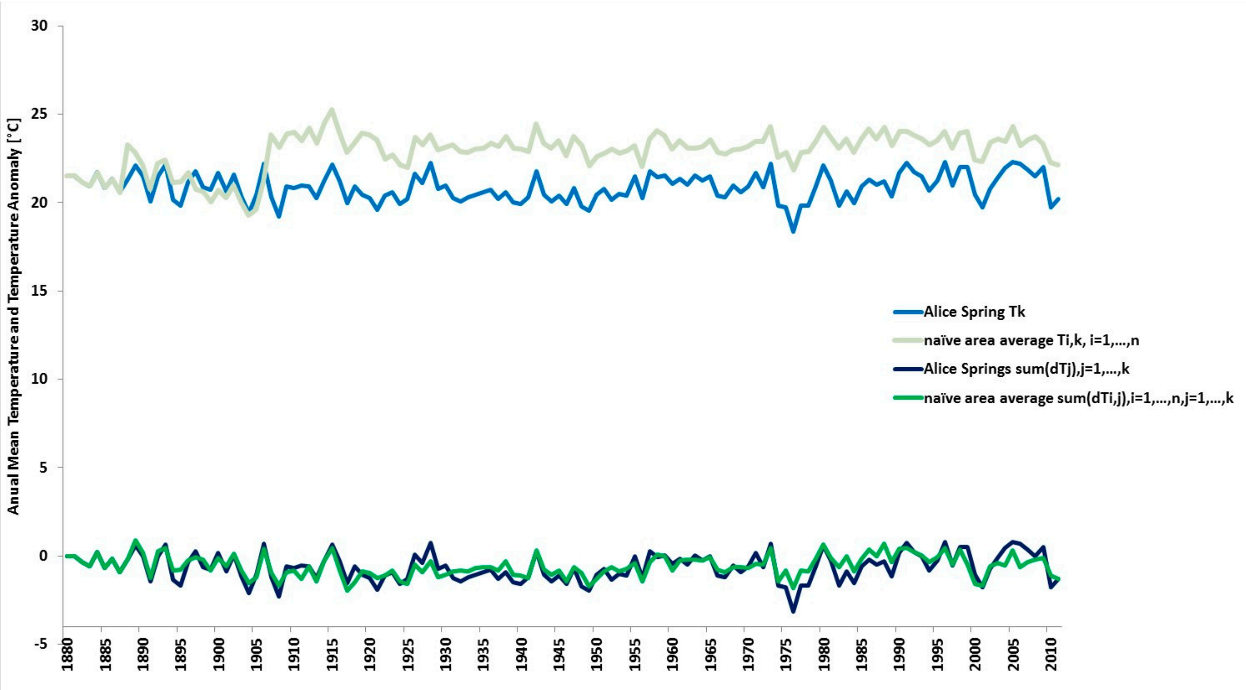

Figure 7 – Mean annual temperature for Alice Springs and mean annual temperature anomaly for Alice Springs and naïve area average.

The figure also shows the naïve average mean annual temperature over the area as done by Mearns (2015), as well as the mean temperature of Alice Springs. The jump about 1910 is due to the inclusion of stations from warmer areas. 1910 2011, the naïve average mean annual temperature over the area is almost de-trended, slightly negative, -0.023 °C/century.

By computing the warming trend from the naïve average of the temperature differences, 1880 to 2011 the centre of Australia is warming +0.166 ºC/century, slightly less than the warming of Alice Springs which is +0.176 ºC/century, but similarly insignificant.

Over a shorter time-window 1910 to 2011, the centre of Australia is warming +0.794 ºC/century, slightly more than the warming of Alice Springs, that is +0.719 ºC/century.

4. DISCUSSION AND CONCLUSIONS

The popular global temperature reconstructions such as GISS Temp show a large global warming since 1880. We maintain that these global reconstructions are not based on actual measurements, but are subjective interpretations based on temperatures that never were collected, or equally subjective interpretation of the temperature that were collected but modified for some excuse.

If we look at the sea surface temperature, there are no gridded data 1880 to present to be used for the reconstruction. Until a few decades ago, there were no data at all for the most part of the seas.

If we look at the land temperatures, the situation is only marginally better. The spatially scattered data do not cover all the time window, and they often suffer from the urban heat island (UHI) effect. In the example we considered, the large area centred on Alice Springs the individual temperature records and their averaging and extension for spatial reconstructions do not provide the same results of the GISS reconstructions.

The area we are considering is 2,000 km diameter, with a surface area about the size of India. We use all the data from all the stations in this large area that has a tiny UHI effect.

The Australian Bureau of Meteorology, consistently with GISS but inconsistently with the raw data and the homogenization proposed here, claims that around Alice Spring there is the largest warming rate of Australia. This opinion appears to be completely subjective, and the BoM never disclose the method by which their conclusion was reached.

In complete contrast the raw data of the individual stations, Figure 4, the Alice Spring data, Figure 6 and 7, and the area average data, Figure 7, all support a very small warming.

It must be mentioned that products of much better quality than GISS Temp such as the RSS or UAH satellite lower troposphere temperature show a warming drastically reducing moving southwards, with the largest warming at the north pole and the smallest warming, a cooling, at the south pole. Hence the need to introduce extreme adjustments and homogenizations to prove that the southern hemisphere in general and Australia is subjected to global warming. From the thermometer measurements, the warming of the central part of Australia has been minimal over the time window 1880-2011.

From the data of GHCN v2 data set, from 1880 to 2011, the average warming for the centre of Australia is +0.166 °C/century, slightly smaller than the warming of Alice Springs which is +0.176 °C/century, but similarly insignificant.

Over the shorter time window 1910 to 2011, the warming of the central part of Australia has been larger. The average warming for the centre of Australia is +0.794 °C/century, slightly larger than the warming of Alice Springs, that is +0.719 °C/century.

Claims of warming for Alice Spring well more than 2 °C/century are gross exaggerations.

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