

Corrigendum: Central West Antarctica among the most rapidly warming regions on Earth

Contents

1	Revisions to Byrd temperatures from 1957-1975	1
1.1	Byrd temperature record in READER	1
1.2	Recalculation of the monthly mean temperatures	1
1.3	Remarks about specific months	2
1.4	Sources of temperature observations	3
1.5	References	3
1.6	Table and figures relevant to Section 1	3
2	Updated figures and tables from Bromwich et al. (2013)	7

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Section 1 provides details about the recalculation of the monthly temperatures from Byrd Station from the 1957-1975 period, including a table (Table S1) with the revised temperature values. Section 2 contains updated versions of the figures and tables shown in Bromwich *et al.* (2013) that were affected by the recalculation. The revised Byrd record is available online at http://polarmet.osu.edu/Byrd_recon/.

1 Revisions to Byrd temperatures from 1957-1975

1.1 Byrd temperature record in READER

The READER database¹ (Turner *et al.* 2004) is an important resource for high-quality, long-term (>10 years) surface and upper-air meteorological observations from Antarctic stations. This database was the source of monthly temperature observations used by Bromwich *et al.* (2013) in their reconstruction of the temperature record from Byrd Station. In READER, the temperature values for the early part of the record (1957-1975) were taken from the compilation of monthly temperature and pressure observations produced by Jones and Reid (2001). This compilation relied on monthly reports published in the *Monthly Climatic Data for the World* (MCDW) or *World Weather Records* (WWR). Jones and Reid (2001) themselves built upon the work of Jacka *et al.* (1984) and Jones and Limbert (1987).

Of concern for the temporal consistency of the Byrd temperature record was the uncertainty about the method used to calculate the monthly means. Our analysis revealed that the monthly temperatures reported for Byrd Station in MCDW and WWR were based on daily minimum and maximum temperatures, a method responsible for a cold bias in the results from October to March. As we explain below, the monthly reports suffer from additional issues, such as errors in temperature units or partial temporal coverage.

1.2 Recalculation of the monthly mean temperatures

We recalculated the monthly mean temperatures from 1957 to 1975 using the 6-hourly observations from the Integrated Surface Hourly Data set (DS 3505) found on the website of the National Climatic Data Center (NCDC). To our knowledge, these data have not been used in any of the compilations mentioned above nor in any publications over the past 20-plus years. Note that observations are available every 3

¹ <http://www.antarctica.ac.uk/met/READER/>

hours for most months until 1965, but only during austral summer thereafter. For consistency, we only used 6-hourly data in our calculation², as is done by READER (see Turner *et al.* 2004 for details).

In addition to the 6-hourly observations, NCDC also provides daily minimum and maximum temperatures (T_{\min} , T_{\max}) from Byrd Station as part of the Global Historical Climatology Network-Daily Data Set (GHCN-Daily). The temporal availability of the T_{\min} and T_{\max} data is generally greater than that of the 6-hourly data, that is, for certain days, only T_{\min} and T_{\max} are available. In such instances, we used a daily average temperature computed as $(T_{\min}+T_{\max})/2$ as a complement to the 6-hourly data. As explained in the main text, the “min/max method” introduces a cold bias (see Fig. S1) but the error is smaller than the uncertainty associated with the infilling method used by Bromwich *et al.* (2013) for the 1970s (uncertainty conservatively estimated at $\pm 2.5^{\circ}\text{C}$, but difficult to actually quantify because of the very small number of observations from Byrd during the entire 1970s decade).

The recalculated temperatures from 1957-1975 are shown in Table S1. The effect of this recalculation on the time series and trends is shown in Figs S2 and S3. It is noteworthy that, despite a revision of the Byrd temperature data set on READER’s website on 7 March 2013, some (small) differences now exist (as of August 2013) between our version and READER’s³. The differences pertain to the months discussed in Sections 1.3 and 1.4.

1.3 Remarks about specific months

Details about the temperature recalculation for a few specific months are given below. In particular, we explain why some monthly values have been changed, removed, or added compared to the Byrd temperature data set previously available on READER’s website (prior to 7 March 2013) and used by Bromwich *et al.* (2013). MCDW refers to the *Monthly Climatic Data for the World*.

- **January 1957 (changed). Old value: -15.6°C . New value: -15.1°C .**
Meteorological observations at Byrd Station began on 10 January 1957. The monthly mean temperature previously (and still currently) reported by READER for that month is therefore based on observations from only 22 days. We filled in the 9-day data gap with the multi-year daily average temperatures for the first 9 days of January during 1958-1970. This data infilling resulted in a $+0.5^{\circ}\text{C}$ adjustment, reflecting the fact that the beginning of January is almost always warmer than the latter part of the month.
- **February 1970 (changed). Old value: -19.0°C . New value: -22.4°C .**
The value reported in READER was based on observations (T_{\min} , T_{\max}) from only 16 days (1-16 February 1970), as we concluded from an analysis of the GHCN-Daily data set. We replaced it with the monthly value found in MCDW.
- **October 1970 (added). Old value: none. New value: -26.3°C .**
The monthly mean temperature reported in MCDW (-15.3°C) was substantially higher than the multi-year average for October (-30.6°C for 1957-1969). As a result, it was not reported by Jacka *et al.* (1984), Jones and Limbert (1987), nor Jones and Reid (2001). We believe that the temperature in MCDW was mistakenly reported in degrees Fahrenheit instead of degrees Celsius. The monthly value recalculated from the 6-hourly observations (-26.3°C) is more consistent with the climatology.
- **November 1970 (added). Old value: none. New value: -22.3°C .**
Same problem as for October 1970 (value reported in MCDW: -7.0 , likely in $^{\circ}\text{F}$ instead of $^{\circ}\text{C}$). The monthly value was recalculated from the 6-hourly observations.

² The temporal frequency of the observations varies in the ISH/DS 3505 data set. For months with 3-hourly observations, we resampled the data to 6-hourly time series.

³ <http://www.antarctica.ac.uk/met/READER/surface/Byrd.All.temperature.html>

- **February 1971 (removed). Old value: -20.7°C. New value: none.**
The value reported by READER was based on observations from only 17 days (1-17 February 1970), as we concluded from an analysis of the GHCN-Daily data set. Since no monthly temperature was found in MCDW, we do not provide any monthly value for this particular month.
- **January 1973 (added). Old value: none. New value: -10.8°C.**
The monthly mean temperature was computed using a complete set of 6-hourly (94%) and T_{\min}/T_{\max} (6%) observations.
- **November 1974 (removed). Old value: -15.9°C. New value: none.**
The GHCN-Daily data set indicates that only 18 days of observations (13-30 November 1974) are available for this month. Since no monthly temperature was found in MCDW, we do not provide any monthly value for this particular month.

1.4 Sources of temperature observations

- 6-hourly temperatures:
 - Data set: Integrated Surface Hourly (ISH) (DS 3505)
 - Website: <http://www.ncdc.noaa.gov/doclib/>
- Daily minimum/maximum temperatures
 - Data set: Global Historical Climatology Network (GHCN) – Daily
 - Website: <http://www.ncdc.noaa.gov/oa/climate/ghcn-daily/>
- Monthly mean temperature reports
 - Data set: Monthly Climatic Data for the World (MCDW)
 - Website: <http://www.ncdc.noaa.gov/IPS/mcdw/mcdw.html>

1.5 References

- Bromwich, D. H. *et al.* Central West Antarctica among the most rapidly warming regions on Earth. *Nature Geosci.* **6**, 139–145 (2013).
- Jacka, T. H., Christou, L. & Cook, B. J. *A data bank of mean monthly and annual surface temperatures for Antarctica, the Southern Ocean and South Pacific Ocean.* Tech. Rep., Australian National Antarctic Research Expeditions Research Note 22 (1984). Available at <http://staff.acecrc.org.au/~jacka/temperature.html>.
- Jones, P. D. & Limbert, D. W. *A data bank of Antarctic surface temperature and pressure data.* Tech. Rep. Rep. TR038, U.S. Dept of Energy, Office of Energy Research, 52 pp (1987).
- Jones, P. D. & Reid, P. A. *A data bank of Antarctic surface temperature and pressure data.* Tech. Rep. Rep. ORNL/CDIAC-27, NDP-032, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Dept of Energy (2001). Available at <http://cdiac.esd.ornl.gov/epubs/ndp/ndp032/ndp032.html>.
- Turner, J. *et al.* The SCAR READER project: Toward a high-quality database of mean Antarctic meteorological observations. *J. Climate* **17**, 2890–2898 (2004).

1.6 Table and figures relevant to Section 1

Table S1
Figures S1–S3

Table S1. Recalculated monthly mean temperature observations from Byrd Station (1957-1975). As explained in Section 1.2, small differences exist (as of August 2013) between the table below and its version on READER's website⁴.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1957	-15.1	-20.9	-30.1	-35.3	-36.5	-33.3	-40.8	-29.2	-30.4	-26.7	-20.6	-12.2
1958	-14.8	-15.0	-28.3	-30.9	-27.2	-40.8	-40.6	-41.7	-40.4	-30.2	-21.4	-17.5
1959	-18.2	-18.1	-25.1	-23.1	-33.5	-33.2	-33.8	-38.5	-35.4	-33.8	-22.9	-14.8
1960	-15.5	-23.7	-31.2	-30.2	-32.8	-30.5	-34.0	-40.3	-34.2	-27.2	-24.5	-14.9
1961	-12.9	-19.0	-29.1	-24.2	-36.2	-34.2	-35.4	-36.6	-33.1	-36.6	-21.8	-15.9
1962	-15.1	-23.3	-28.2	-36.5	-29.5	-40.2	-35.3	-35	-43.2	-32.7	-21.6	-15.2
1963	-14.4	-20.5	-30.6	-29.8	-33.8	-28.3	-39.7	-35.4	-36.6	-26.9	-18.7	-16.6
1964	-16.8	-21.9	-24.7	-30.2	-30.3	-32.2	-31.8	-40.6	-34.8	-30.7	-19.4	-14.2
1965	-13.9	-18.6	-28.3	-26.9	-37.7	-34.5	-30.0	-32.5	-38.6	-28.0	-18.5	-12.7
1966	-14.4	-17.4	-25.5	-26.0	-34.0	-28.7	-34.5	-39.8	-34.4	-30.5	-19.7	-13.2
1967	-12.9	-14.7	-25.6	-33.7	-27.6	-32.0	-38.6	-31.3	-37.6	-33.6	-22.8	-13.7
1968	-13.3	-16.3	-24.5	-28.9	-36.3	-41.6	-36.5	-38.7	-42.7	-29.6	-20.8	-14.6
1969	-14.8	-22.6	-24.1	-33.1	-30.5	-38.1	-33.5	-37.4	-33.4	-30.3	-23.1	-13.9
1970	-11.6	-22.4	-21.6	-26.1	-35.0	-30.1	-33.9	-33.8	-35.3	-26.3	-22.3	-13.3
1971	-12.5	-19.2	-	-	-	-	-	-	-	-30.6	-22.0	-14.9
1972	-16.5	-16.5	-	-	-	-	-	-	-	-	-	-
1973	-10.8	-17.3	-	-	-	-	-	-	-	-	-	-13.7
1974	-11.9	-16.0	-	-	-	-	-	-	-	-	-16.6	-13.2
1975	-14.7	-	-	-	-	-	-	-	-	-	-	-

Legend:

- **Black:** All 6-hourly observations are available.
- **Black underlined:** 6-hourly observations are partially available. For days without 6-hourly data, the daily mean temperature is computed as $(T_{\min}+T_{\max})/2$, using T_{\min} and T_{\max} data from the GHCN-Daily data set. The combination of 6-hourly and T_{\min}/T_{\max} data provides observations for $\geq 90\%$ of the days.
- **Blue:** The monthly mean temperature is taken from MCDW except for Aug 1970, for which the temperature in MCDW is missing. Here, the monthly value for this month is reported as in Jones and Reid (2001).
- **Red:** Observations (either 6-hourly or T_{\min}/T_{\max}) are available for fewer than 90% of the days. The monthly mean temperature is not used in our reconstruction. The only exception is January 1957 (see details in Section 1.3).

⁴ <http://www.antarctica.ac.uk/met/READER/surface/Byrd.All.temperature.html>

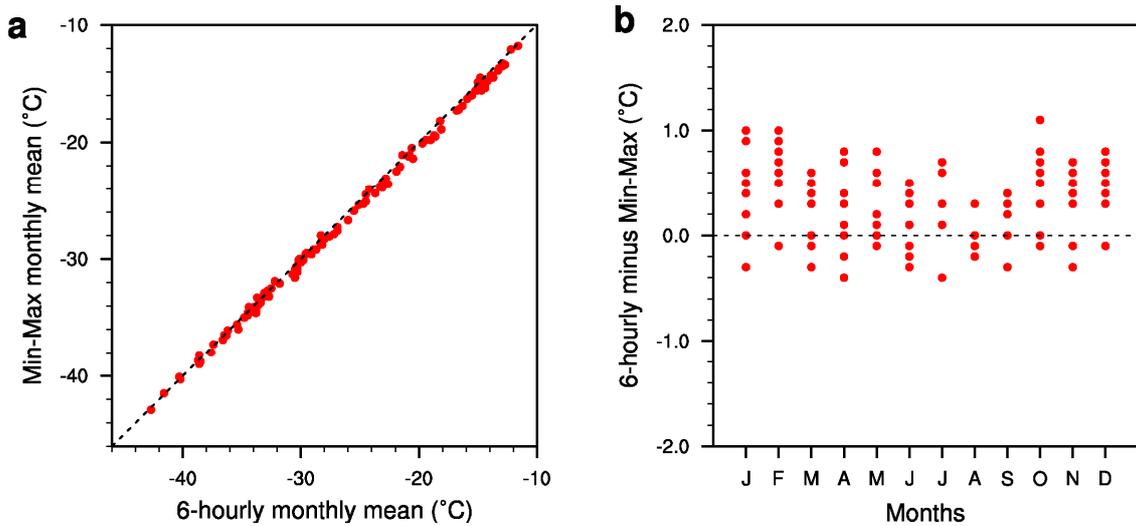


Figure S1. Comparison between monthly mean temperatures based on 6-hourly data from the ISH data set and monthly mean temperatures based on $(T_{\min}+T_{\max})/2$ from the GHCN-daily data set (see section 1.4 for details about the two data sets). The data span 1957-1975 and are limited to months with complete observations.

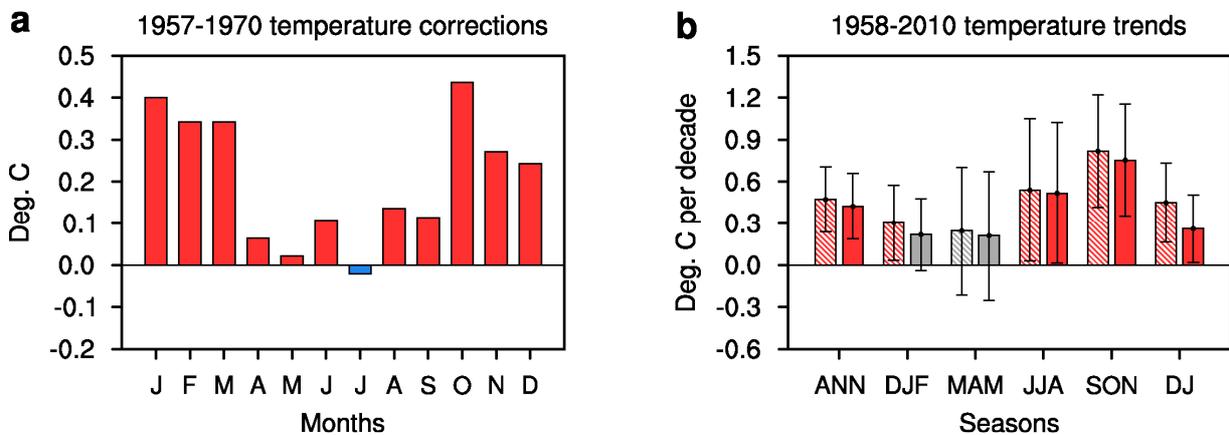


Figure S2 | a, Differences between the recalculated monthly mean temperatures and the monthly mean temperatures originally used by Bromwich *et al.* (2013). The differences are averaged over the 1957-1970 and shown for each calendar month. **b,** Linear temperature trends for the 1958-2010 period reported by Bromwich *et al.* (hatched fill) and recalculated after revision of the 1957-1975 monthly mean temperatures (solid fill). The error bars denote the 95% confidence interval of the trends.

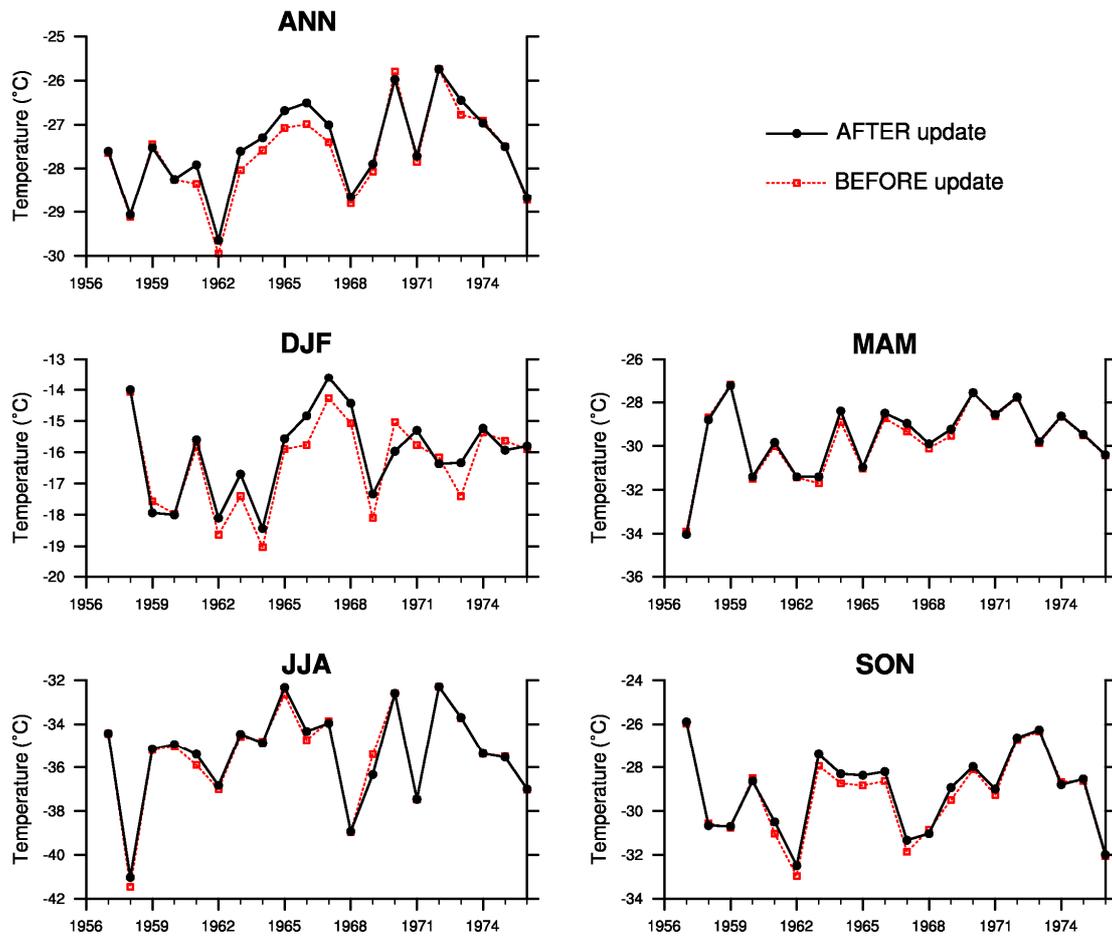


Figure S3 | Comparison between the updated Byrd temperature record (solid black line) and the Byrd record used by Bromwich *et al.* (2013) (dashed red line). The changes are limited to the 1957-1975 portion of the record, which is why the time series do not extend beyond 1976.

2 Updated figures and tables from Bromwich et al. (2013)

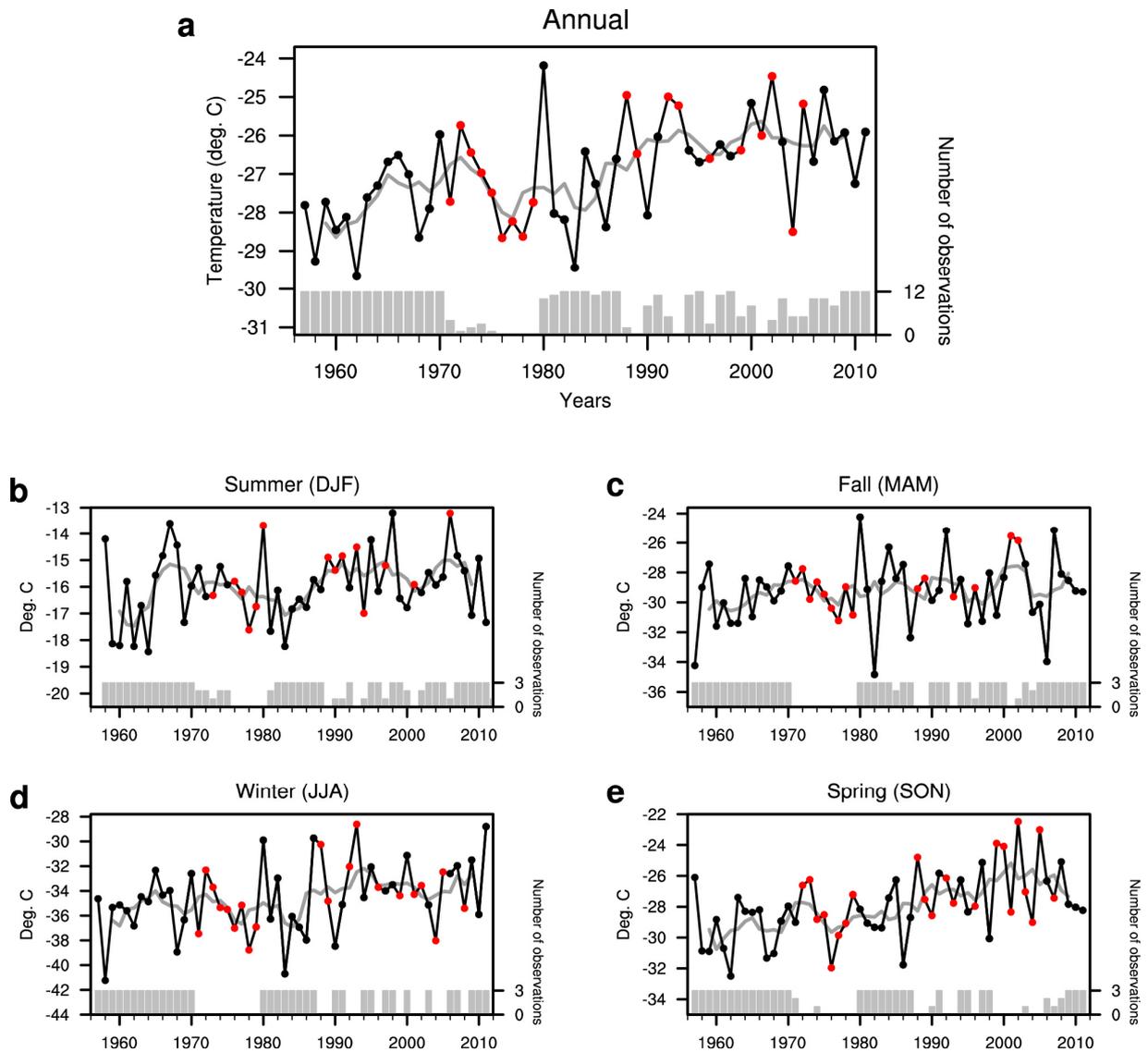


Figure S4 | Updated Figure 2 from Bromwich *et al.* (2013).

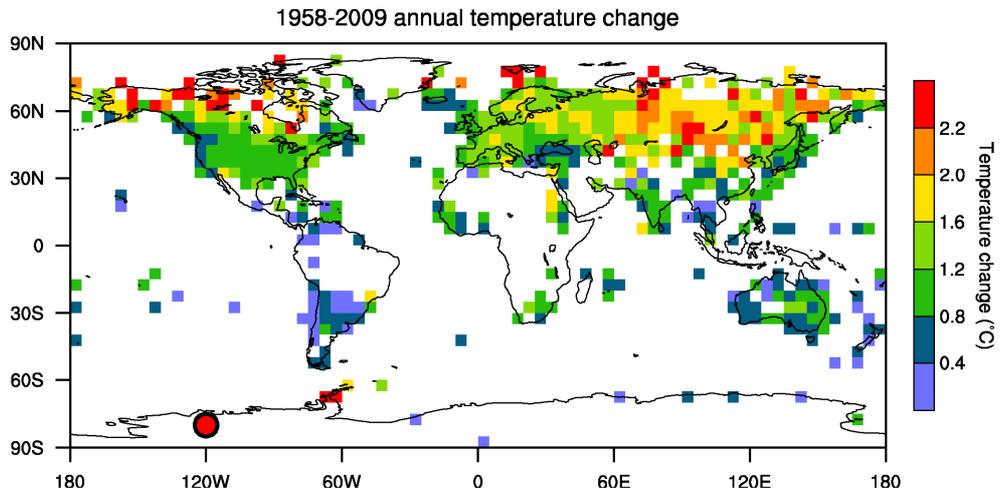


Figure S5 | Updated Figure 3c from Bromwich *et al.* (2013).

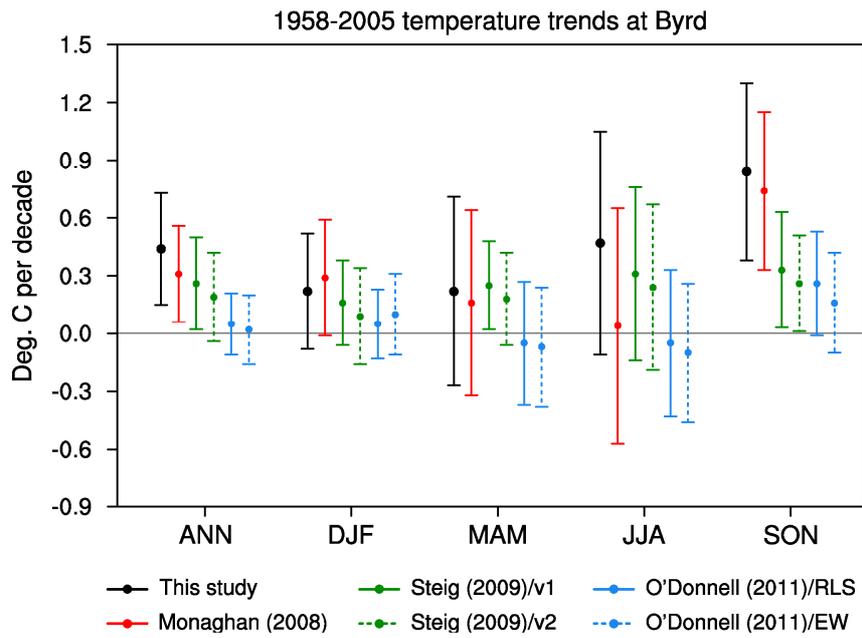


Figure S6 | Updated Figure 4 from Bromwich *et al.* (2013).

Table S2 | Updated Table S1 from Bromwich *et al.* (2013). The original Table S1 contained a calculation error for December-January. This error has been corrected in the values given below (highlighted in gray).

Season or month	Linear temperature trends (°C per decade)			
	1958-2010	1980-2010	1958-2010 (no infill. 1970s)	1958-2010 (uncorrected)
ANN	0.42±0.24 (99.9)	0.50±0.52 (93.1)	0.42±0.21 (99.9)	0.48±0.25 (99.9)
DJF	0.22±0.26 (89.1)	0.37±0.55 (79.6)	0.23±0.25 (91.3)	0.42±0.27 (99.6)
MAM	0.21±0.46 (61.9)	0.14±1.09 (20.4)	0.22±0.46 (64.7)	0.23±0.45 (67.1)
JJA	0.52±0.50 (95.0)	0.68±1.18 (72.7)	0.49±0.48 (94.6)	0.49±0.51 (93.0)
SON	0.75±0.40 (99.9)	0.84±1.15 (82.6)	0.76±0.41 (99.9)	0.82±0.40 (99.9)
DJ	0.26±0.24 (95.6)	0.29±0.53 (70.6)	0.28±0.24 (97.1)	0.47±0.27 (99.8)
Jan	0.33±0.32 (95.0)	0.60±0.68 (90.5)	0.34±0.32 (95.8)	0.56±0.40 (98.9)
Feb	0.08±0.58 (21.0)	0.51±1.73 (42.8)	0.04±0.57 (10.3)	0.26±0.61 (58.2)
Mar	0.40±0.70 (72.4)	1.21±1.65 (83.2)	0.45±0.71 (77.7)	0.52±0.77 (79.8)
Apr	-0.05±0.82 (9.2)	-0.22±1.62 (21.2)	-0.10±0.83 (18.7)	-0.06±0.81 (12.1)
May	0.28±0.68 (57.0)	-0.55±1.55 (51.1)	0.31±0.68 (62.4)	0.23±0.67 (49.4)
Jun	0.67±0.71 (93.1)	0.71±1.53 (62.9)	0.69±0.69 (94.2)	0.66±0.70 (92.9)
Jul	0.52±0.84 (76.5)	0.93±2.12 (59.9)	0.45±0.83 (70.4)	0.47±0.85 (71.4)
Aug	0.36±0.92 (55.6)	0.39±2.06 (28.4)	0.33±0.94 (50.5)	0.33±0.92 (51.2)
Sep	1.12±0.81 (99.0)	1.30±1.97 (78.6)	1.06±0.82 (98.3)	1.08±0.82 (98.5)
Oct	0.72±0.69 (95.2)	0.33±1.75 (28.3)	0.72±0.71 (94.0)	0.83±0.72 (96.7)
Nov	0.41±0.44 (93.0)	0.90±1.21 (83.0)	0.48±0.43 (96.8)	0.55±0.46 (97.5)
Dec	0.21±0.25 (89.3)	-0.05±0.60 (13.8)	0.20±0.25 (87.5)	0.40±0.27 (99.3)

Table S3 | Updated Table S2 from Bromwich *et al.* (2013).

Period	Season	Linear temperature trends (°C per decade)						
		This study	Chapman & Walsh (2007)	Monaghan <i>et al.</i> (2008)	Steig <i>et al.</i> (2009)		O'Donnell <i>et al.</i> (2011)	
					v1	v2	RLS	E-W
1958 to 2005	ANN	0.43± 0.29	-	0.31±0.25	0.26±0.24	0.19±0.23	0.05±0.16	0.02±0.18
	DJF	0.22± 0.30	-	0.29±0.30	0.16±0.22	0.09±0.25	0.05±0.18	0.10±0.21
	MAM	0.22± 0.50	-	0.16±0.48	0.25±0.23	0.18±0.24	-0.05±0.32	-0.07±0.31
	JJA	0.47± 0.58	-	0.04±0.61	0.31±0.45	0.24±0.43	-0.05±0.38	-0.10±0.36
	SON	0.84± 0.47	-	0.74±0.41	0.33±0.30	0.26±0.25	0.26±0.27	0.16±0.26
1958 to 2001	ANN	0.48± 0.33	0.07±0.19	0.25±0.29	0.29±0.29	0.27±0.25	0.05±0.19	0.03±0.22
	DJF	0.23± 0.34	0.03±0.16	0.16±0.37	0.18±0.26	0.16±0.26	0.05±0.21	0.13±0.25
	MAM	0.24± 0.59	0.03±0.38	0.09±0.57	0.31±0.25	0.29±0.25	-0.05±0.38	-0.06±0.36
	JJA	0.62± 0.66	0.11±0.47	0.15±0.69	0.42±0.51	0.39±0.46	0.04±0.44	-0.04±0.42
	SON	0.84± 0.47	0.11±0.30	0.60±0.45	0.28±0.38	0.26±0.33	0.19±0.30	0.10±0.31