NOTES AND CORRESPONDENCE

Hemispheric Surface Air Temperature Variations: Recent Trends and an Update to 1987

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ABSTRACT

The hemispheric mean land-surface air temperature series developed for both hemispheres by Jones et al. are updated through 1987. The global temperature estimate for 1987 is the third warmest on record, 1858–1987. Recent warming over the last 20 years (1967–86) is shown to be centered on middle latitude belts in both hemispheres.

1. Introduction

In 1986, Jones et al. (1986a,b; henceforth denoted as Jab) published a compilation of monthly mean surface air temperature data for the Northern and Southern Hemispheres based on land-based meteorological station data. The published data extend through December 1984. The purpose of this note is to improve the estimates for January 1981 through December 1984 and to update the series through December 1987. Using the grid point time series, we show the spatial patterns of recent warming over both hemispheres.

2. Data

The basic source of station data for the Northern and Southern Hemispheres is World Weather Records (WWR) [Smithsonian Institution 1927, 1934, 1947 and U.S. Weather Bureau 1959–82, available in digitized form from the National Center for Atmospheric Research (NCAR), Jenne 1975]. In Jab, this was supplemented considerably by additional data from sources detailed in Bradley et al. (1985) and Jones et al. (1985, 1986c).

For the 1981–84 period the density of station data fell in both hemispheres from the peak values during 1951–80 because some stations did not report their data on the Global Telecommunication System (GTS) regularly. For many countries these data are published up to 5–15 yr late. In Jab, for the years 1981–84, we relied on the GTS network augmented by additional data published in *Monthly Climatic Data for the World* (MCDW). This latter publication, published about 6 months behind time, includes most, but not all, GTS reporting stations. The extra delay enables station data not issued by GTS to be included.

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For most countries of the world during 1981–1984, Jab were able to use almost all stations that had been available during the 1971–80 period, allowing for a few station closures. There were, however, some exceptions to this, the most important of which occurred over Canada and the United States (see Appendix A).

The updated series for 1981 to 1987 are listed in Appendix B. Included are Table B1 (Northern Hemisphere; cf. Jones et al. 1986a); Table B2 (Southern Hemisphere 5°–60°S, SH60; cf. Jones et al. 1986b); Table B3 (Antarctica, 65°–90°S; cf. Raper et al. 1984) and Table B4 (Southern Hemisphere, 5°–90°S, cf. Jones et al. 1986b).

3. Discussion

a. Updated series

For the Southern Hemisphere series there are few changes to the earlier published series during the 1981–84 period except over Antarctica. Here, improvements have been made by obtaining almost all monthly data for the 15 stations that are used to form the area-weighted average for 1981–86. It is not possible to do this in real time and data for 1987 are provisional.

The most significant alterations to the already published series are for the Northern Hemisphere. The average increase in coverage is about 2% of the surface area of the Northern Hemisphere. The new value for 1981 is 0.04°C warmer than previously, with 1983 being 0.01°C cooler. The value for 1984 was 0.02°C warmer. Overall, the mean value for 1981 to 1984 with the new data is 0.01°C warmer at 0.26°C. The major increase in coverage was over Canada, north of 55°N. The changes primarily reflect the very large temperature anomalies that occurred in this region. Over northern Canada, 1981 was noticeably warmer than the 1951–70 normal while 1982 and 1983 were cooler.

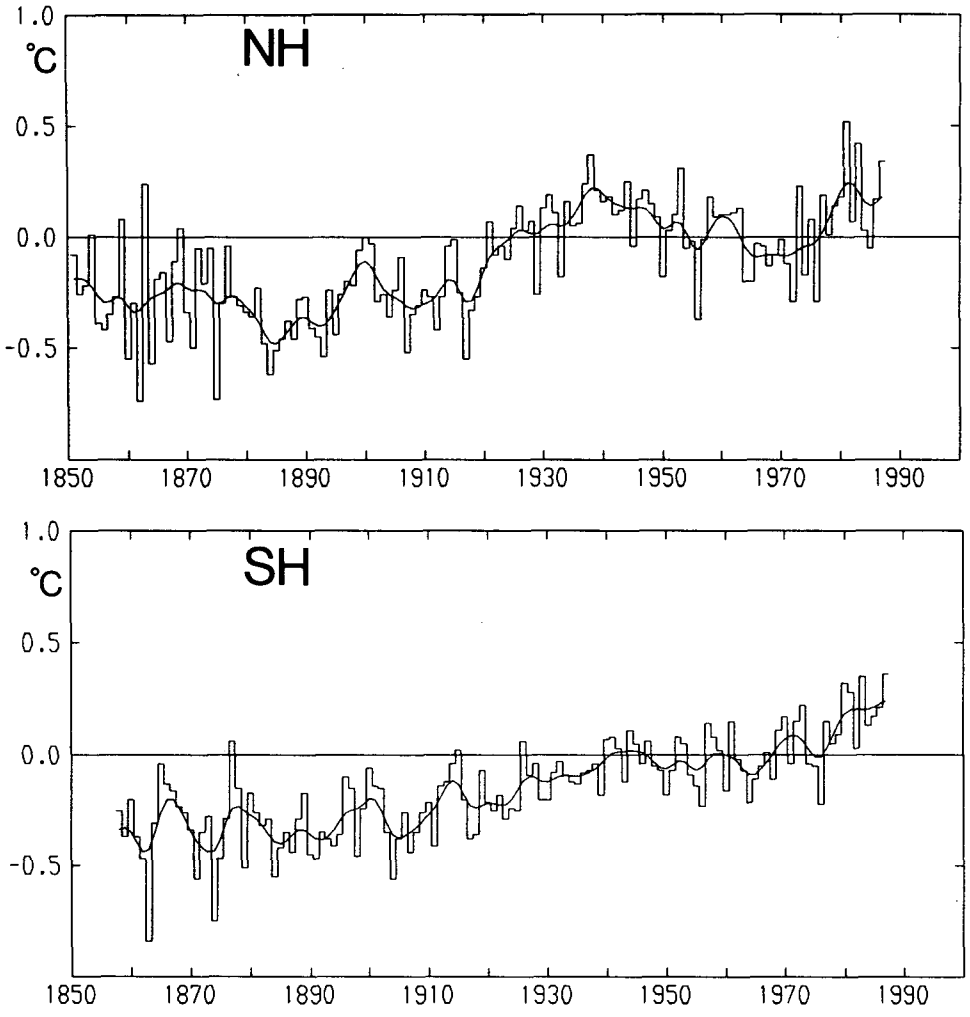

FIG. 1. Land-based annual mean surface air temperatures for the Northern Hemisphere (upper) and Southern Hemisphere (lower). Both series are expressed as departures from the reference period 1951–70. Smooth curves show 10 yr Gaussian filtered values.

The two hemispheric time series complete up to 1987 are shown in Fig. 1. The global value for 1987, based on an average of the two hemispheric values, is the third warmest year recorded since the start of the record in 1858. The warmth of 1987 is confirmed using global marine data from the United Kingdom Meteorological Office. Recently updated time series from Folland et al. (1984) also show 1987 to be the warmest year recorded, since the start of the record in 1856, in both their sea surface and nighttime marine air temperature series (Folland and Parker, personal communication).

b. Recent trends

Over the recent 20 yr period (1967–86), both hemispheres have experienced considerable warming: total trends of 0.36° and 0.23°C in the Northern and Southern Hemispheres (NH and SH), respectively. There has been concern expressed that this warming might be the result of increasing greenhouse gas concentrations. The magnitude of the warming appears to be too large to be explained by this effect alone, and assigning a particular cause with any confidence is impossible.

In order to look at the trend in more detail, maps of the spatial variations of the trend are shown in Fig. 2 (NH) and Fig. 3 (SH). A simple linear trend was fitted to each annual grid-point time series for the most recent 20 yr period (1967–1986). The trends are expressed in degrees centigrade per decade. Comparison can be made with the work of Jones and Kelly (1983) where similar linear trend maps have been presented for the Northern Hemisphere for the periods 1917–39, 1940–64 and 1965–80.

For the Northern Hemisphere, Fig. 2 is similar to the 1965–80 map of Jones and Kelly (1983). The coldness of the 1980s over Europe and some parts of the

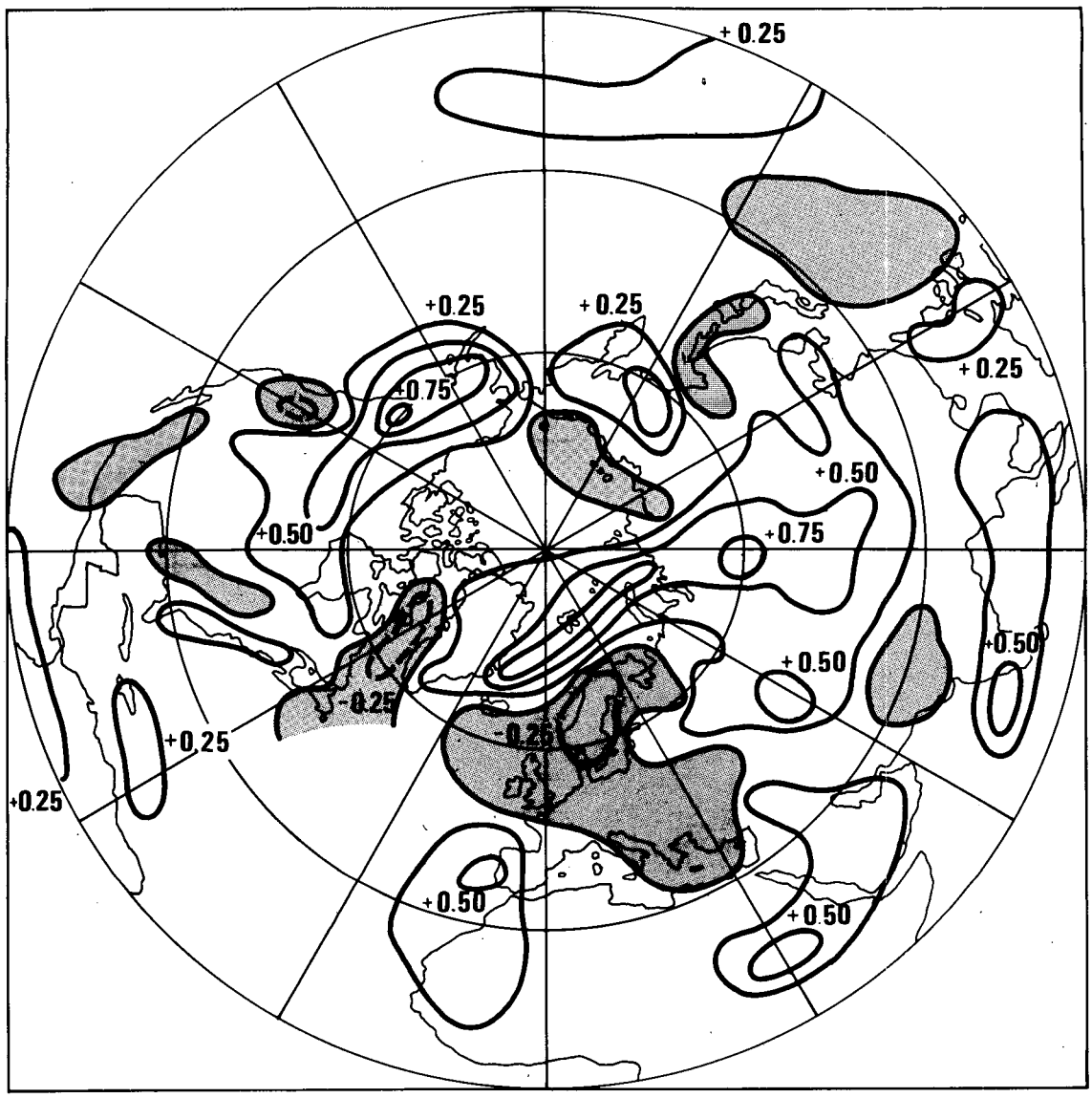

FIG. 2. Linear trend in Northern Hemisphere land-based annual mean surface air temperature over the 1967–86 period. Units °C decade^{-1} (e.g., +0.25°C decade^{-1} = 0.5°C warming over 1967–86). Shaded areas show cooling. Except where there are suitable islands, most oceanic areas are missing in this analysis.

southern United States, however, is a new feature. The areas of strongest warming are over Alaska, northwestern Canada, the Greenland Sea, most of the USSR, (especially western Siberia), parts of southern Asia, northern Africa and southwestern Europe. Cooling has occurred over extreme northeastern and eastern Canada, southwestern Greenland, and Europe (especially Scandinavia).

In Fig. 3, the main warming in the Southern Hemisphere is evident over Australia, southern South Africa, the southern tip of South America and the Antarctic Peninsula, and the Australian sector of Antarctica. The warming is strongest at the island stations in the 45°–55°S belt. Cooling in the Southern Hemisphere is apparent over tropical parts of Brazil, Madagascar, coastal parts of Antarctica near 60°E, and central parts of the Antarctica continent.

In both hemispheres there are large regions where cooling predominates. Over Scandinavia, annual temperatures during this period have cooled by 0.6°C over the 1967–1986 period. Over Antarctic coasts near 60°E, the total cooling is around 1°C. In contrast, the maximum warming is 2.0°C over northwestern Canada, 1.6°C over western Siberia and 1.1°C over the extreme south of South Africa.

The consensus view of the pattern of warming expected due to a doubling of atmospheric CO_2 concentration (Schlesinger and Mitchell 1985) is for warming

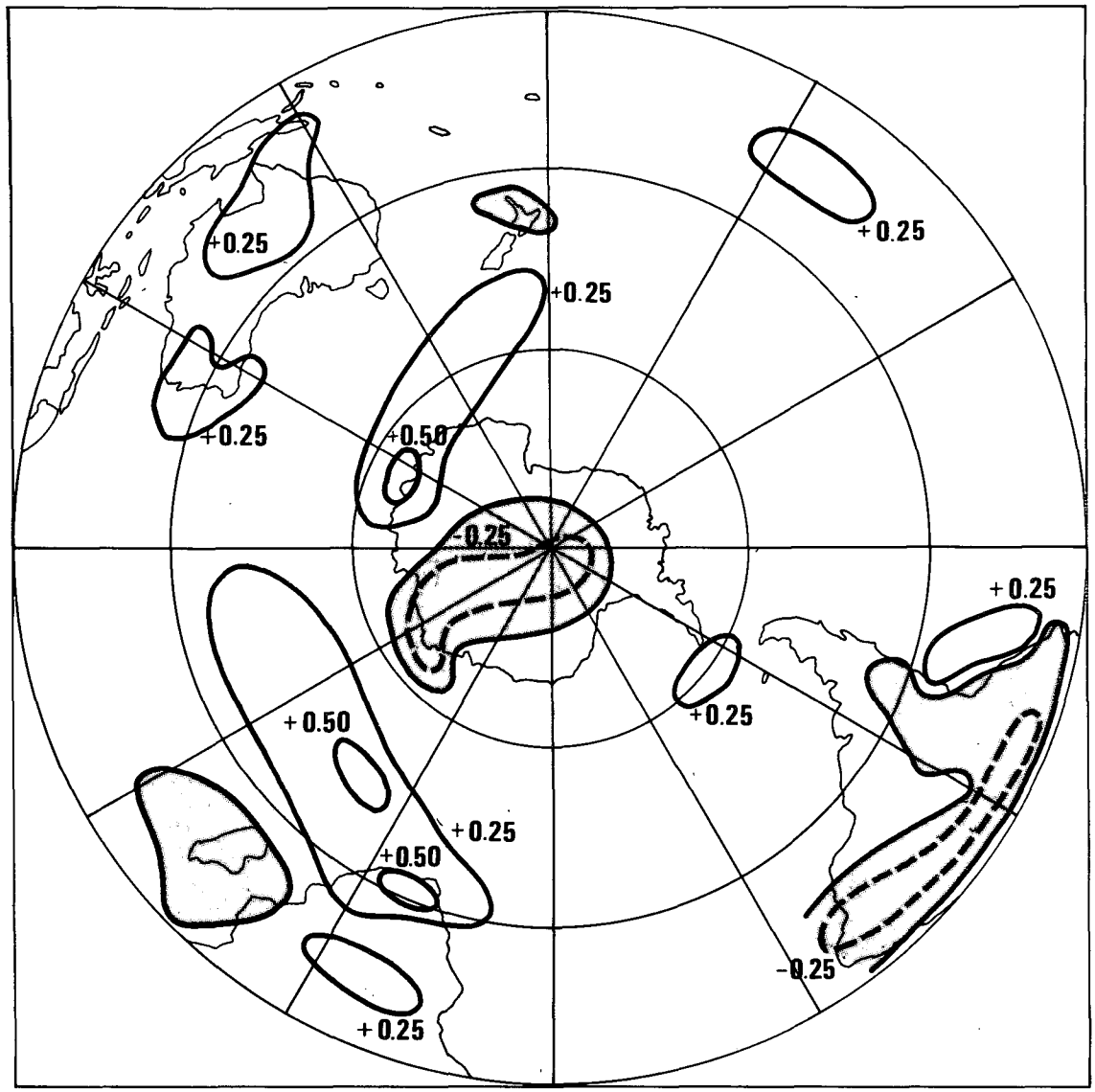

FIG. 3. Linear trend in Southern Hemisphere land-based annual mean surface air temperature over the 1967–86 period. Units °C decade^{-1} (e.g., +0.25°C decade^{-1} = 0.5°C warming over 1967–86). Shaded areas show cooling. Except where there are suitable islands, most oceanic areas are missing in this analysis.

everywhere with amplification in polar latitudes. While the transient response patterns may differ from this picture (see, e.g. Wigley et al. 1986 for a review), it is interesting to note that the area-average trend for 1967–86 for the polar regions indicates little change. The main area of warming in both hemispheres has taken place in the middle latitude belt between 30° and 60°. The only major region of cooling in this latitude belt occurred over northern and eastern Europe.

4. Conclusions

The hemispheric mean surface air temperature series for the Northern and Southern Hemispheres developed by Jones et al. (1986a,b) are updated through 1987. Averaging the two hemispheres together shows that 1987 is the third warmest global temperature recorded since 1858. The values for 1981 and 1983 were warmer. Over the marine areas of the globe, however, 1987 was the warmest year (Folland and Parker, personal communication).

The land areas of both hemispheres have undergone considerable warming during the last 20 yr period, 1967–1986. The spatial pattern shows that the recent warming has been strongest in middle latitude belts between 30° and 60°, with the important exception of Europe. Little, if any, warming has occurred over polar latitudes during this time.

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APPENDIX A

Additional Data Sources

1. North America

For 1981–84, Jab used approximately 50% of the 1970s station network for Canada and only 10% for the United States. For the United States in the 1970s, Jab used between 5 and 49 stations for each grid point on a 5° latitude by 10° longitude grid. During 1981–84 this reduced to one–two stations per grid point, but no grid point was omitted.

Over Canada, the situation was somewhat different due to the country's more northerly position and the grid used. The gridding algorithm in Jab associated each station with its nearest grid point and did not allow a station to influence more than one grid point. The reduction in stations used here not only reduced station density but also markedly reduced the number of grid points for which values could be assigned. Overall, the reduction in coverage between the 1970s and 1981–84 was just under 2% of the total area of the hemisphere, or roughly 4% of the griddable area.

To rectify the problem for Canada, data for 1981–85 were obtained for as many of the 1970s station network as possible. In addition, for 1986 and 1987, the GTS reporting stations in Canada have been supplemented by 28 additional stations published in *Climatic Perspectives* within 3 weeks of the end of the month. For the contiguous United States MCDW began publishing, in January 1987, station information for about three times as many stations as before. Of these new stations, 53 had previously been used by Jab up to 1980. Data for these stations were obtained for the 1981–86 period.

These improvements over North America increase the number of stations used for Canada from 40 to 68 and for the contiguous United States from 40 to 93.

2. Antarctica

In order to update the mean Southern Hemisphere air temperature series it is necessary to update the Antarctic series produced by Raper et al. (1984). Much of the data necessary to do this were obtained by personal contact because both GTS and MCDW are particularly poor in this region. All 29 time series for station temperature and pressure, up to 1986, are given by Jones and Limbert (1987).

3. Other regions

For other regions of the world, improvements over the GTS data used in Jab have been made for 1985 to 1987 using MCDW, *Die Witterung in Übersee,* and published monthly and annual national reports, particularly for Mexico, the PRC and New Zealand (for many South Pacific islands).

Finally, a small number of station data errors in the Jab dataset have been detected using satellite data (Jones et al. 1988) and corrected by checking with the original source.

APPENDIX B

Updated Series

TABLE B1. Surface air temperature for the Northern Hemisphere. Departures in degrees Celsius, from the reference period (1951–70) mean. The figures in parentheses give the spatial coverage of the network as a percentage of the maximum possible area, which includes ocean areas.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	1.17	0.96	1.25	0.55	0.17	0.32	0.20	0.28	0.12	0.11	0.36	0.73	0.52
	(47)	(48)	(48)	(47)	(46)	(45)	(46)	(46)	(45)	(46)	(46)	(46)	
1982	−0.31	0.22	−0.01	0.12	0.06	−0.08	0.20	−0.09	0.15	0.03	−0.11	0.60	0.07
	(45)	(46)	(45)	(45)	(46)	(46)	(45)	(46)	(45)	(45)	(46)	(46)	
1983	1.05	0.60	0.72	0.43	−0.01	0.04	0.29	0.42	0.34	0.22	0.93	0.04	0.42
	(42)	(43)	(44)	(43)	(44)	(44)	(43)	(42)	(44)	(43)	(44)	(46)	
1984	0.33	0.10	0.32	0.16	0.33	0.13	0.01	0.12	−0.25	0.02	−0.21	−0.72	0.03
	(44)	(44)	(44)	(45)	(43)	(44)	(44)	(45)	(44)	(44)	(44)	(44)	
1985	−0.03	−0.53	0.10	0.12	0.19	−0.17	−0.15	0.03	−0.07	0.05	−0.20	0.10	−0.05
	(48)	(46)	(48)	(47)	(47)	(47)	(46)	(47)	(45)	(47)	(47)	(47)	
1986	0.74	0.27	0.43	0.37	0.22	0.14	−0.03	−0.02	−0.06	−0.02	−0.09	0.18	0.18
	(46)	(48)	(47)	(47)	(47)	(46)	(47)	(46)	(47)	(47)	(47)	(46)	
1987	0.35	1.00	0.00	0.21	0.23	0.18	0.39	0.20	0.53	0.15	0.12	0.89	0.35
	(47)	(46)	(47)	(47)	(46)	(46)	(46)	(47)	(47)	(47)	(46)	(45)	

TABLE B2. Surface air temperature for the Southern Hemisphere (SH60: 2.5°–62.5°S). Departures in degrees Celsius, from the reference period (1951–70) mean. The figures in parentheses give the spatial coverage of the network as a percentage of the area of the whole hemisphere, which includes ocean areas.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	0.20	0.22	−0.03	0.53	0.46	0.00	0.15	0.16	0.13	−0.04	0.10	0.35	0.19
	(23)	(23)	(24)	(23)	(23)	(24)	(23)	(23)	(24)	(22)	(23)	(22)	
1982	0.36	0.11	−0.02	0.02	0.29	−0.22	−0.08	0.35	0.02	−0.20	0.15	0.46	0.10
	(21)	(21)	(22)	(21)	(21)	(22)	(21)	(22)	(22)	(22)	(22)	(22)	
1983	0.50	0.67	0.46	0.49	0.58	0.30	0.23	0.10	0.27	0.23	0.28	0.38	0.37
	(21)	(21)	(23)	(23)	(22)	(22)	(21)	(21)	(22)	(23)	(22)	(21)	
1984	0.00	0.14	−0.02	−0.09	0.16	−0.16	0.07	−0.09	0.10	0.28	0.05	0.00	0.04
	(22)	(23)	(20)	(21)	(21)	(22)	(22)	(22)	(21)	(21)	(21)	(22)	
1985	0.39	0.22	0.26	0.15	0.19	0.11	0.20	0.20	0.03	0.03	0.21	0.35	0.20
	(21)	(22)	(22)	(23)	(22)	(21)	(22)	(21)	(21)	(21)	(22)	(21)	
1986	0.21	0.22	0.17	0.44	0.49	0.28	0.05	0.05	0.01	0.06	0.07	0.27	0.19
	(22)	(21)	(21)	(22)	(22)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	
1987	0.45	0.37	0.33	0.72	0.33	0.41	0.64	0.24	0.23	0.45	0.65	0.48	0.44
	(21)	(22)	(21)	(22)	(21)	(21)	(21)	(21)	(21)	(22)	(21)	(17)	

TABLE B3. Antarctic mean monthly temperature anomalies relative to the 1957–75 reference period, formed by areally averaging gridded data from 65° to 90°S.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	−0.04	0.50	1.27	−0.36	−0.62	0.95	4.23	4.56	0.29	0.44	−0.77	−0.07	0.80
1982	−0.32	−0.19	−2.27	−0.85	0.85	0.27	1.33	−2.39	−1.99	−0.40	1.32	0.72	−0.33
1983	0.57	−0.27	−0.72	−0.97	2.45	0.72	−1.55	1.40	2.46	−1.03	−1.42	−0.69	0.24
1984	0.52	−0.53	1.23	0.27	2.71	−2.22	0.90	2.07	1.82	−1.20	0.04	1.29	0.57
1985	0.21	−0.69	0.71	0.74	−1.51	1.42	−0.68	1.59	0.67	−0.26	−0.93	−0.97	0.03
1986	−0.15	3.02	1.11	0.07	−0.57	−1.52	0.01	1.27	0.24	0.14	−0.09	−0.29	0.28
1987	1.08	0.34	0.01	0.84	−1.56	2.38	0.59	−3.37	−1.28	−0.01	0.14	0.39	−0.04

TABLE B4. Surface air temperature for the Southern Hemisphere (SHT: 2.5°–90°S): departures from the reference period (1951–70) mean. The figure in parentheses gives the spatial coverage of the network as a percentage of the area of the whole hemisphere, which includes ocean areas.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	0.18	0.26	0.17	0.39	0.29	0.15	0.79	0.85	0.15	−0.11	−0.04	0.28	0.28
	(28)	(27)	(29)	(28)	(27)	(28)	(27)	(28)	(29)	(26)	(27)	(26)	
1982	0.24	0.06	−0.39	−0.13	0.39	−0.14	0.16	−0.10	−0.31	−0.23	0.34	0.50	0.03
	(25)	(26)	(26)	(26)	(25)	(25)	(26)	(26)	(27)	(27)	(26)	(26)	
1983	0.51	0.51	0.27	0.57	0.89	0.37	−0.07	0.32	0.63	0.03	0.00	0.20	0.35
	(25)	(26)	(27)	(27)	(26)	(26)	(26)	(25)	(26)	(27)	(26)	(25)	
1984	0.08	0.03	0.20	−0.03	0.59	−0.50	0.21	0.27	0.39	0.03	0.05	0.21	0.13
	(26)	(27)	(25)	(26)	(25)	(26)	(26)	(26)	(25)	(25)	(26)	(26)	
1985	0.36	0.07	0.03	0.24	−0.09	0.33	0.06	0.43	0.14	−0.02	0.02	0.12	0.17
	(25)	(27)	(27)	(27)	(26)	(25)	(26)	(26)	(25)	(25)	(26)	(25)	
1986	0.15	0.70	0.33	0.38	0.33	−0.03	0.04	0.24	0.06	0.09	0.04	0.18	0.21
	(26)	(25)	(26)	(26)	(25)	(25)	(26)	(25)	(25)	(24)	(24)	(25)	
1987	0.56	0.36	0.28	0.74	0.03	0.70	0.63	−0.35	−0.03	0.36	0.57	0.47	0.36
	(25)	(26)	(25)	(26)	(25)	(24)	(25)	(25)	(23)	(22)	(22)	(20)	

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