20.2 THE SCAR READER PROJECT: ANTARCTIC CLIMATE CHANGE OVER THE LAST 50 YEARS

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1. INTRODUCTION

Understanding Antarctic climate variability and change is important because of the marked warming that has been observed over the Antarctic Peninsula in recent decades and the disintegration of a number of ice shelves in this area. At Faraday (recently re-named Vernadsky) station on the western side of the Peninsula the annual mean surface temperature has increased by about 2.5^o C since the 1950s, which is as large as any warming observed on Earth over this period. However, the region of marked warming appears to be quite limited, with the temperature rise at Signy, to the northeast of the tip of the Antarctic Peninsula, being only about half this value.

A major handicap in trying to examine recent Antarctic climate change has been the lack of a consistent data set of observations and climatological means. Some Antarctic operators make all their individual observations available via the Internet, while others provide summaries of monthly mean statistics on the Internet or publish tables of monthly mean data. However, many of the early individual observations are still only available via the meteorological registers, making it very difficult to check any suspect mean data. For these reasons it was decided to produce an improved data set of monthly mean Antarctic climate data attempting where possible to go back to the original synoptic reports and re-compute monthly and annual mean statistics. This project, which is known as READER (Reference Antarctic Data for Environmental Research), is being undertaken by the Scientific Committee on Antarctic Research (SCAR), which is a focus for most of the nations involved in Antarctic research.

2. DATA COLLECTION AND QUALITY CONTROL

The READER data set does not contain data for all stations that have operated in the Antarctic, but has concentrated on obtaining high quality data for stations with the longest records available. At present the data set contains only surface data, but it will be extended to include upper air data over the next two years.

To be included in the data set it was decided that a surface record from an occupied station must extend back at least 25 years, although not necessarily in a continuous period, or be currently in operation and have operated for the last 10 years. In addition, it was decided to include metadata on the changes that have taken place in the observing practices, station locations and instrumentation, in order that the possible impact of changes could be examined.

For an automatic weather station (AWS) to be included it must be operating now and have worked for the last 5 years, or for 10 years at some previous time, not necessarily in a continuous period.

Temperature, MSLP and station level pressure are the primary data held in the READER data base, but we have also included some wind information. The wind directions recorded at Antarctic stations are often heavily influenced by the local orography and are frequently not representative of the broad scale flow. Within the READER data base we have therefore only included mean wind speeds. All the monthly means were computed from 6 hourly synoptic reports where possible, but if these were not available CLIMAT means were used. Some recent means were computed from GTS observations, but these will be superseded by means computed from the synoptic data when they are available.

Quality control of the observations was carried out by comparing each observation of temperature, pressure or wind speed against the climatological mean for the month at a particular site and the known variability of the parameter at the location. In addition, physically unrealistic rapid changes in parameters were identified based on our existing knowledge of synoptic variability at various sites. The full READER data set is available via the project's World Wide Web site (http://www.antarctica.ac.uk/met/programs-hosted.html). The monthly mean data are provided as

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a series of tables, with each mean value also having the percentage of observations used to compute the statistic indicated in brackets. We also include simple tables (without percentages) of the means in text format, which will be easy to manipulate via a spreadsheet.

In the following section we provide a brief assessment of the temperature trends over the last few decades at 19 occupied Antarctic stations.

3. TRENDS IN THE TEMPERATURE DATA

Table 1 shows the annual and seasonal near-surface temperature trends (^oC (10 yr^{-1})) for 19 stations with long records. The trends are over the full period of each record.

The largest annual warming trends are found in the west central and northern parts of the Antarctic Peninsula, with Faraday/Vernadsky having the greatest statistically significant trend at +0.56 ^oC (10 yr^{-1}) over 1951-2000, a figure that is significant at <5% level. Rothera station, some 300 km to the south of Faraday, has a larger warming trend, but the shortness of the record and the large inter-annual variability of the temperatures means that the trend is not statistically significant. Although the region of marked warming extends from the southern part of the western Antarctic Peninsula to the South Shetland Islands, the rate of warming decreases away from Faraday, with the long record from Orcadas only having experienced a warming of +0.20 ^oC (10 yr^{-1}).

Around the rest of the Antarctic the annual temperature trends present a much more complex picture of change. The greatest warming outside the Peninsula region is at Scott base where temperatures have risen at a rate of +0.29 ^oC (10 yr^{-1}), although this change is not statistically significant.

The seasonal temperature trends in Table 1 indicate that at most of the coastal stations, and all the stations on the Antarctic Peninsula except Esperanza, the greatest warming has occurred during the winter. This is the time of year when air-ice feedback mechanisms are most effective and when a small reduction in sea ice will have a large impact on the air temperatures. From satellite-derived sea ice extent data sets, which start in the late 1970s, we know that the total area of Antarctic sea ice has increased over this period (Zwalley *et al.,* 2002), although there has been a marked decrease over the Amundsen-Bellingshausen Sea to the west of the Antarctic Peninsula. The winter season warming trends since the 1950s and 1960s at many of the coastal stations therefore point to more extensive sea ice in the earlier part of the period. This is also suggested by overlapping 30 year trends in the annual mean surface temperatures (not shown). For most stations, only 1961-1990 and 1971-2000 can be considered because of the shortness of the records, although three 30 year trends can be examined for Faraday, and the Orcadas record extends back to 1903. For all the continental stations, except Esperanza and Molodezhnaya, the warming trend was greater (or the cooling trend less) during the 1961-90 period compared to 1971-2000. This points to a possible recovery from more extensive sea ice conditions over the period 1960 to about 1980 and then relative stability in the record. Information on sea ice conditions in the pre-satellite era is very sparse, but King and Harangozo (1998) found a number of ship reports from the Bellingshausen Sea in the 1950s and 1960s when sea ice was well north of the locations found in the period of availability of satellite data.

Only two stations from the interior of the Antarctic have long temperature records so it is not possible to make any clear statement about change over this vast area. However, the data from Vostok does not show any statistically significant change over a record that extends back over 40 years. At Amundsen-Scott there is a cooling in all seasons, but only the annual trend of –0.17 ^oC (10 $yr)^{-1}$ is statistically significant at the 10% level. However, it should be noted that it has not been possible to obtain much metadata for the station and the study of Hogan et al., (1993) has highlighted changes in the nature of the temperature record around the time of the relocation of the station in December 1974. Clearly the South Pole temperature record requires further investigation.

4. REFERENCES

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Table 1. Annual and seasonal surface temperature trends ($^oC\ (10\ yr)^{-1}$) at selected Antarctic stations with long records. [a]= Significant at the 1% level. [b]= Significant at the 5% level. [c]= Significant at the 10% level. Trends included if 90% of the observations are available. S = synoptic data, C = CLIMAT, G = GTS.

Station	Annual	Spring	Summer	Autumn	Winter	Period	Data used
Novolazarevskya	+0.25 ± 0.27[c]	+0.25 ± 0.41	+0.19 ± 0.34	+0.08 ± 0.46	+0.44 ± 0.66	1962-2000	S & C
Syowa	+0.01 ± 0.35	+0.01 ± 0.48	–0.01 ± 0.27	–0.12 ± 0.67	+0.14 ± 0.58	1960-61, 1967-2000	S
Molodezhnaya	–0.06 ± 0.29	–0.18 ± 0.50	–0.14 ± 0.32	–0.21 ± 0.43	+0.30 ± 0.77	1964-95, 1997-98	C & G
Mawson	–0.11 ± 0.23	–0.04 ± 0.33	–0.09 ± 0.26	–0.30 ± 0.40	+0.03 ± 0.58	1955-2000	S & G
Davis	+0.03 ± 0.35	+0.05 ± 0.50	+0.05 ± 0.30	–0.26 ± 0.60	+0.15 ± 0.67	1958-63, 1970-2000	S & G
Mirny	–0.01 ± 0.26	+0.09 ± 0.46	–0.14 ± 0.30	–0.28 ± 0.45	+0.31 ± 0.56	1956-2000	S & G
Vostok	–0.02 ± 0.34	-0.11 ± 0.51	+0.13 ± 0.42	–0.32 ± 0.63	+0.14 ± 0.85	1958-2000	C & G
Casey	+0.01 ± 0.40	+0.13 ± 0.50	–0.09 ± 0.30	–0.14 ± 0.90	+0.22 ± 0.83	1962-2000	S & G
Dumont d'Urville	+0.02 ± 0.27	+0.23 ± 0.45	0.00 ± 0.31	–0.34 ± 0.35[c]	+0.17 ± 0.60	1956-2000	S & C
Scott Base	+0.29 ± 0.36	+0.34 ± 0.68	+0.05 ± 0.38	+0.18 ± 0.65	+0.43 ± 0.71	1958-2000	C
Rothera	+1.01 ± 1.42	+1.06 ± 1.53	+0.36 ± 0.57	+1.37 ± 1.46	+1.73 ± 2.79	1978-2000	S
Faraday/Vernadsky	+0.56 ± 0.43[b]	+0.25 ± 0.4.4	+0.24 ± 0.17[a]	+0.63 ± 0.60[b]	+1.09 ± 0.88[b]	1951-2000	S
Bellingshausen	+0.35 ± 0.46	–0.10 ± 0.47	+0.30 ± 0.20[a]	+0.51 ± 1.05	+0.58 ± 0.97	1969-2000	S
Esperanza	+0.41 ± 0.42[c]	-0.07 ± 0.57	+0.43 ± 0.34[b]	+0.82 ± 1.11	+0.51 ± 0.82	1961-2000	C
Marambio	<90%	-0.8 ± 10.5	<90%	<90%	+0.81 ± 1.53	1971-2000	C
Orcadas	+0.20 ± 0.10[a]	+0.15 ± 0.14[b]	+0.15 ± 0.06[a]	+0.21 ± 0.16[a]	+0.27 ± 0.24[b]	1904-2000	C
Halley	–0.11 ± 0.47	0.00 ± 0.53	+0.12 ± 0.28	–0.56 ± 0.81	+0.02 ± 0.76	1957-2000	S
Neumayer	–0.13 ± 1.03	–0.01 ± 1.69	–0.02 ± 1.25	–1.37 ± 1.32[b]	+0.30 ± 2.23	1982-2000	S
Amundsen-Scott	–0.17 ± 0.21[c]	–0.12 ± 0.63	–0.21 ± 0.49	–0.19 ± 0.45	–0.20 ± 0.50	1958-2000	S