Antarctic Meteorological Observations on the GTS during the FROST Project

STEVEN COLWELL AND JOHN TURNER

British Antarctic Survey, Cambridge, United Kingdom

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ABSTRACT

An assessment is made of the availability of Antarctic synoptic observations on the World Meteorological Organization (WMO) Global Telecommunication System (GTS) during the trial periods (5–9 July 1993 and 1–15 February 1994) and winter and summer special observing periods (SOPs) (July 1994 and January 1995) of the Antarctic First Regional Observing Study of the Troposphere project. The data collected at two nodes of the GTS—Melbourne, Australia, and Bracknell, United Kingdom—are considered. Data received at Melbourne were passed on to the Australian Bureau of Meteorology in Hobart and those received at Bracknell were passed similarly on to Cambridge. The trial periods showed that there were large differences in the number of surface observations received at the two nodes. Although Hobart always received more upper-air data than Cambridge, the reverse was true with automatic weather station (AWS) data. The experience from the SOPs indicates that there are now almost 50% more AWS observations on the GTS than surface observations from the staffed stations.

1. Introduction

Antarctica is one of the most data-sparse regions on Earth with only about 35 staffed surface reporting stations, 75 automatic weather stations (AWSs), and 11 upper-air stations (Turner et al. 1996). These provide routine meteorological observations for a region that covers about 14×10^6 km^2 or close to 10% of the land surface of the earth. It is important that the main meteorological centers produce high quality analyses for the region so that the medium- and long-range forecasts for the Southern Hemisphere do not suffer because of analysis errors emanating from this region. It is known that the forecasts for the Antarctic are not as accurate as those prepared for more northerly latitudes (Bourke 1994), despite the greater amounts of data that have become available in recent years. Southern Hemisphere observing system experiments show that observations such as satellite temperature soundings from polar orbiting spacecraft are able to extend the forecasting capability by about one day (Bengtsson 1989; Hart et al. 1993) but sounding data are very difficult to use over the Antarctic continent itself (Lutz et al. 1990) and are usually only employed at stratospheric levels.

Surface analysis over the Antarctic is therefore carried out using the observations from staffed stations and AWSs that have been deployed in recent years (Stearns and Wendler 1988). However, getting the observations from the Antarctic to the analysis centers is a major challenge as some centers are located in the Northern Hemisphere. Although satellite communication via geostationary satellites is now often employed, many stations lie on the transmission horizon of the satellites that have a southern limit of 81°, so there are periods when other means of communication must be employed. In addition, communication within the Antarctic via shortwave radio is very unreliable so that getting the observations to the collection centers can be difficult at times.

The First Regional Observing Study of the Troposphere (FROST) project (Turner et al. 1996), which involved periods of intensive data collection of Antarctic observations, offered an opportunity to assess how these observations are being transmitted on the World Meteorological Organization (WMO) Global Telecommunication System (GTS). FROST was based on three special observing periods (SOPs) (July 1994, 16 October 1994–15 November 1994, and January 1995). During these periods Antarctic observations were collected at the GTS nodes in Melbourne, Australia, and Bracknell, United Kingdom, and passed on to Hobart and Cambridge, respectively. However, before the SOPs there were three trial periods (5–9 July 1993, 1–15 February 1994, and 13–17 June 1994) during which Antarctic observations on the GTS were examined at a time when corrective action could be taken. The February 1994 trial period coincided with the WMO specific monitoring period for Antarctic data on the World Weather Watch system.

Corresponding author address: Steven Colwell, British Antarctic Survey, High Cross, Madingly Road, Cambridge CB3 0ET, United Kingdom.
E-mail: s.colwell@bas.ac.uk

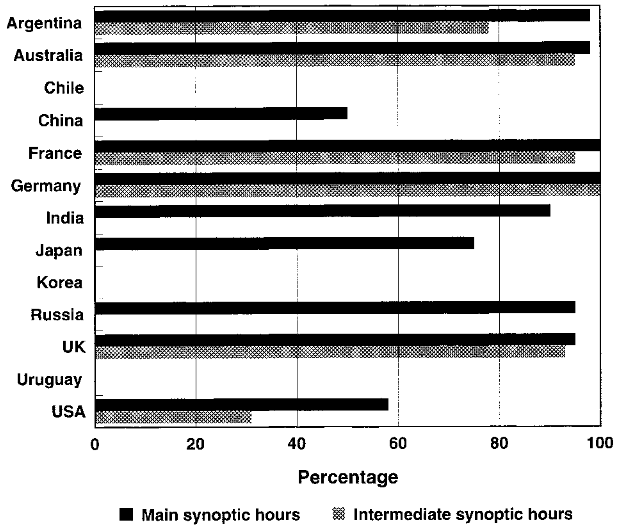

FIG. 1. Percentage of the total possible number of surface observations received in Cambridge from the Antarctic research stations by country for the first trial period of 5–9 Jul 1993.

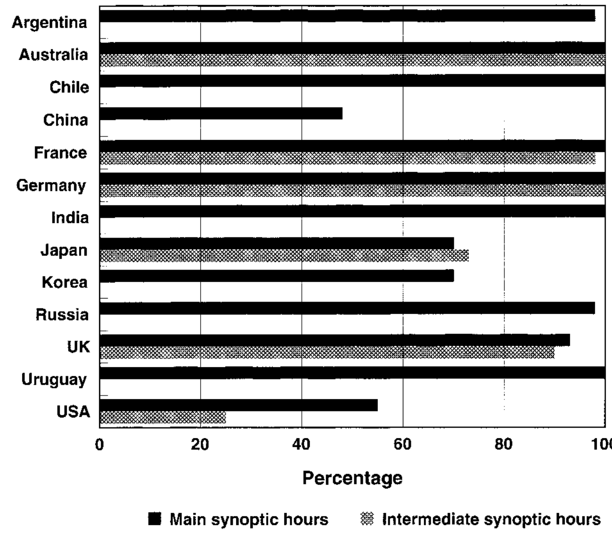

FIG. 2. Percentage of the total possible number of surface observations received in Hobart from the Antarctic research stations by country for the first trial period of 5–9 Jul 1993.

In this paper we examine the data received at Hobart and Cambridge during the trial periods and SOPs and consider how the amounts of data received compare with what should be expected based on the known observing programs. Following the SOPs the national bodies responsible for the observing stations were contacted so that any data not put onto the GTS could also be collected. This provided further information on periods when getting the observations out of the Antarctic via the usual communications routes was not possible.

In section 2 we provide a brief description of the GTS system and the different methods of putting data onto the GTS; section 3 considers the data collected during the winter and summer trial periods and highlights the important differences. In section 4 we examine the data collected during SOP-1 and SOP-3, observations that form the foundation of the FROST project. Section 5 considers the long-term trends in Antarctic observations on the GTS and in section 6 we discuss the reasons for data loss on the GTS and present some conclusions.

2. The GTS

The main source of synoptic data for FROST was the GTS, a communications system that was set up to exchange meteorological data between national weather services for use in forecasting and the assembly of climatological data. It links three World Meteorological Centres (WMCs), which are at Melbourne, Moscow, and Washington, and 15 Regional Telecommunication Hubs (RTHs) on the main telecommunication network of the GTS. In theory any data that are put onto the GTS via any of these entry points will be available at any of the others.

Data can be put onto the GTS from staffed stations and AWSs via three different routes. These are 1) via a data collection platform (DCP), which then transmits the synoptic data via a geostationary or a polar orbiting satellite to a ground station where the data are passed to either a WMC or an RTH (this also applies to drifting buoys); 2) via telex, using satellite communication systems, to either a WMC or an RTH (this also applies to ships); 3) via high-frequency (HF) telex to a national meteorological center (NMC) (U.K. Meteorological Office, National Centers for Environmental Prediction, Australian Bureau of Meteorology, and European Centre for Medium-Range Weather Forecasts), RTH, or WMC. The majority of the data are put onto the GTS via a DCP.

3. A summary of the data collected during the two trial periods

Figures 1 and 2 show the percentage of main and intermediate hour synoptic observations that were received at Cambridge and Hobart from Antarctic research stations staffed by the listed countries during the first trial period between 5 and 9 July 1993. The main synoptic hours are taken as 0000, 0600, 1200, and 1800 UTC and the intermediate hours as 0300, 0900, 1500, and 2100 UTC. In these figures the number of observations received is indicated as a percentage of the number that could theoretically be received depending on the usual reporting programs of the stations. The data received at Cambridge had to be requested from Bracknell and similarly the data received at Hobart had to be requested from Melbourne.

Figures 3 and 4 show the percentage of main and intermediate synoptic hour observations that were received from each country at Cambridge and Hobart dur-

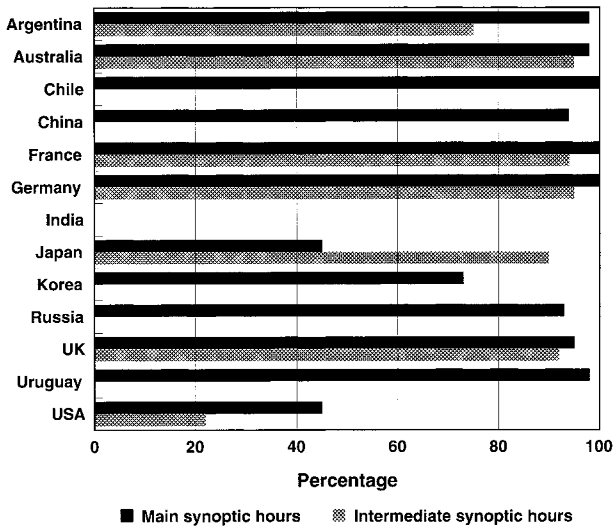

FIG. 3. Percentage of the total possible number of surface observations received in Cambridge from the Antarctic research stations by country for the second trial period of 1–15 Feb 1994.

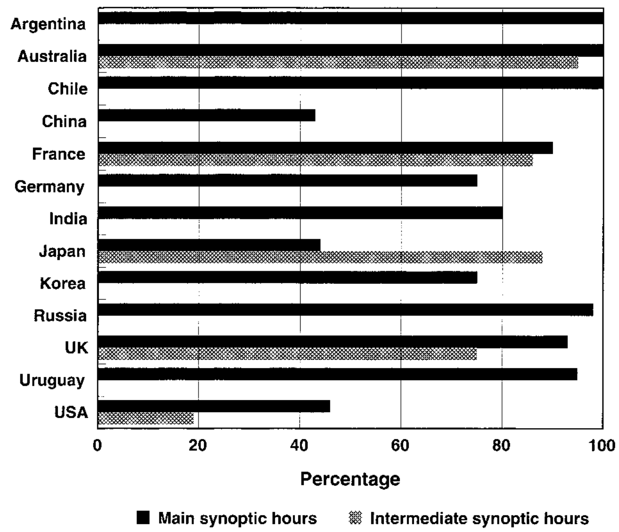

FIG. 4. Percentage of the total possible number of surface observations received in Hobart from the Antarctic research stations by country for the second trial period of 1–15 Feb 1994.

ing the second trial period between 1 and 15 February 1994.

In general, the overall percentage of observations received during the second trial period (64%) was greater than that received during the first (61%). This is not surprising since more stations are open during the austral summer than in the winter. If looked at in more detail, it can be seen that 63% of possible observation were received at Hobart for the first trial period, which then fell to only 60% during the second period, and in Cambridge it went up from 59% to 67%. The important differences are as follows.

1) Only the main synoptic reports were received at Hobart from the Argentine bases during the first and second trial periods, whereas about 75% of the intermediate reports along with the majority of the main synoptic reports were received at Cambridge.
2) During the first trial period no reports were received from the Chilean bases at Cambridge but all the main synoptic reports were received at Hobart. All the reports were received at Cambridge during the second trial period.
3) No reports were received from the Chinese station Great Wall (89058) at either Hobart or Cambridge during the first trial period during the winter. The majority of reports were received from Zhong Shan (89573) at both Hobart and Cambridge. During the second trial period all the reports from Great Wall were received at Cambridge but still none were received at Hobart.
4) In excess of 90% of all the main synoptic reports were received from the Indian station during the first trial period. Hobart still received 80% of the reports during the second trial period but no reports were received at Cambridge.
5) Only the main synoptic reports were received from the Japanese station Syowa (89532) at Cambridge during the first trial period whereas Hobart received both the main and intermediate synoptic reports. During the second trial period both the main and intermediate reports were received at both Cambridge and Hobart. However, the upper-air data from Syowa stopped being received at both of the two locations during the second trial period. Flights resumed on 1 April 1994 and were received during the SOPs.
6) No reports were received from the Korean station King Sejong (89251) at Cambridge during the first trial period but they were received at Hobart. During the second trial period the reports were received at both sites.
7) During the first trial period no reports were received from the Uruguayan station Dinamet (89054) at Cambridge but the reports were received at Hobart. During the second trial period the reports were received at both sites.
8) The reports from the American station Amundsen-Scott (89009) were patchy with only about 30% of reports being received at Cambridge and Hobart during both of the trial periods. Also of note is the lack of data received at Hobart from the American AWSs (89108, 89705, 89799, 89873, 89327, and 89879). The majority of the data from these AWSs were received at Cambridge.

A more detailed breakdown of the number of observations received from each of the stations and AWSs over the two trial periods can be found on the FROST Web site (http://www.nerc-bas.ac.uk/public/icd/FROST/).

In Tables 1 and 2 the percentages of the total possible

TABLE 1. Percentage of observations received during the first trial period.

	Hobart	Cambridge
Percentage of possible synoptic reports from staffed stations	64	61
Percentage of possible upper-air reports	94	74
Percentage of possible reports from AWSs	32	42

number of observations are shown for Cambridge and Hobart for the first and second trial periods. It should be noted that no differentiation is made between main and intermediate synoptic observations and the total percentage received may only be 50% where all the main synoptic observations were received but none of the intermediate ones.

It can be seen that during the first trial period Hobart received more surface synoptic observations than Cambridge, although the position was reversed in the second period. On the other hand, Hobart always received more upper-air data than Cambridge. The greatest number of AWS observations was received at Cambridge where around 10% more of the AWS data were received than at Hobart.

After the trial periods two main conclusions could be drawn.

1) Another source needed to be found for the AWS data as only about 50% of the observations were being received via the GTS. The countries responsible for the AWSs were contacted directly to obtain a copy of their data.
2) A merged dataset needed to be produced for the actual SOPs that combined the data that were received in Hobart and Cambridge. This also allowed more rigorous error checking to be carried out by comparing the observations received at the two sites.

4. Data received during the FROST SOPs

The majority of the meteorological data for the FROST SOPs were received over the GTS but some observations were collected later from the countries that operate the different stations or AWSs. The data received at Cambridge and Hobart were compared and any errors were either corrected or the observation was deleted. A merged dataset was then produced from the data received at Cambridge and Hobart. A summary of the data received during SOP-1 and SOP-3 are shown in Tables 3 and 4.

The data from SOP-2 (16 October 1994–15 November 1994) will only be collated if there is sufficient interest in this period.

It is impossible to work out the percentage of reports received from ships as it is not known how many ships are south of 50°S at any given time and not all the ships in the area send meteorological data on the GTS. However, for the other forms of data a percentage of the possible data that could be received is given.

The data collected for SOP-1 and SOP-3 are now as complete as possible and these observations are available via the FROST Web site (see section 3). The FROST Web site also contains online GIF images of pressure, temperature, and wind speed for all the stations and AWSs used within the FROST project.

Tables 3 and 4 show that very similar percentages of surface and upper-air data were received during the two SOPs. The greater number of surface reports collected during SOP-3 is a result of additional stations being open during the summer months. The difference between the seasons is especially marked with the ship data, since very few research vessels operate in the Antarctic during the winter and the data that were collected were from commercial vessels passing just south of the northern limit of data collection at 50°S. For both SOPs it was found that few observations could be obtained from the national operators to supplement the data collected via the GTS. With the upper-air data this was usually because an ascent had been missed as a result of severe weather or hardware problems. The exception was with the AWS data where many of the observations failed to be put on the GTS and it was necessary to contact the AWS operators to get a reasonable coverage of data. This was particularly the case during the winter SOP when over twice as many observations were obtained after the event than were available on the GTS.

5. Long-term trends

The long-term performance of the GTS over the past eight years was also examined by taking 30 stations in Antarctica that have been operating for the entire period and looking at the percentage of observations from the main synoptic hours (0000, 0600, 1200, and 1800 UTC) that have been received at Cambridge over the GTS. From Fig. 5 it can be seen that the percentage of ob-

TABLE 2. Percentage of observations received during the second trial period.

	Hobart	Cambridge
Percentage of possible synoptic reports from staffed stations	62	75
Percentage of possible upper-air reports	81	74
Percentage of possible reports from AWSs	39	53

TABLE 3. The number of observations received during SOP-1.

	Cambridge	Hobart	Late obs	Total	% possible
Surface	5563	5381	184	7020	92
Upper air	827	849	66	952	76
Ship	63	39	0	81	—
AWS	5893	5121	5997	11 721	74
Buoy	6924	4338	0	7110	41

TABLE 4. The number of observations received during SOP-3.

	Cambridge	Hobart	Late obs	Total	% possible
Surface	6092	6535	356	9582	92
Upper air	571	827	25	971	75
Ship	573	719	0	795	—
AWS	3703	4419	9627	13 515	91
Buoy	5855	5634	0	6416	62

servations received dropped between 1988 and 1992, going down from 70% to 43%. Since 1992 there has been a rapid increase in percentage of possible data received up to a maximum of 85% in 1994, which seems to have stayed constant since that time. While this increase cannot be attributed wholly to FROST, it is hoped that the efforts made by the nations who operate in the Antarctic to contribute to this project resulted in some problems of data transmission being solved.

6. Discussion and conclusions

This study has shown that the number of reports received from the stations is reasonable but it is still not 100%. A number of reasons why all of the reports do not reach the nodes of the GTS were examined.

1) Some of the observations miss their time slots. This problem occurs when the data are sent via a DCP. The problem can occur for two reasons. First, the operator may not be able to send the observation to the DCP in time for it to be transmitted. Second, if the time on the DCP is not set correctly to within a few seconds, then the DCP transmits at the wrong time and the transmissions can then be blocked at the ground station. This can be corrected by more rigorous checks on the DCP time by the observers at the station.
2) Some observations are incorrectly typed in by the observers. This is a problem that is difficult to overcome. If the observation is incorrectly typed, then decoding software may not be able to handle it and may discard the data as being corrupt.
3) Some data are corrupted while they are being transmitted to the satellite. This problem should only occur where geostationary satellites are being used as they are only just above the horizon when viewed from Antarctica. There is no real solution to this problem but the data could be sent two or even three times and this would help to ensure that at least one of the observations arrived uncorrupted.
4) Some data are corrupted or lost between the computer that the observation was entered on and DCP. This problem can be resolved by logging and checking the data that is put onto the DCP.
5) If the observations are transmitted via radio, then there can be transmission problems due to interference.
6) Errors can occur due to the telex operator not using the numeric shift while typing in the observations.
7) The final problem is that not all the data that were received in Cambridge and Hobart were the same. Most of the data were the same but there were quite a number of observations that were received in Cambridge but were not received in Hobart or vice versa. The data that are received at Hobart and Cambridge must be requested from the WMCs and NMCs. This was thought to be the reason for the difference in the number of observations received during the first trial period. Before the second trial period it was ensured that all the possible meteorological data were being requested for Cambridge and Hobart but it was found that there was still a difference in the number of observations arriving at the two sites. The only conclusion that can be drawn from this is that data are being lost somewhere on the GTS network.

In conclusion it can be stated that the GTS is a valuable source of meteorological data from Antarctica but care must be taken when using these data as corruptions do occur and problems at particular locations can occur, resulting in data loss for some users of the system. For this assessment it was not possible to explain all the differences in data availability that were found at Hobart and Cambridge. When a particularly serious problem was identified, such as all the data from one station not arriving at a particular node, and a detailed investigation was carried out, then it was sometimes possible to trace

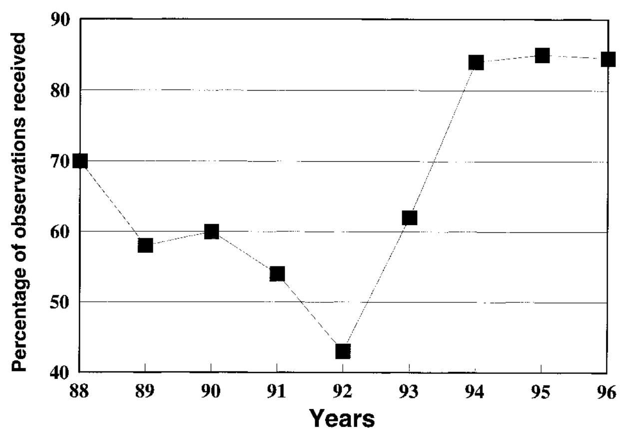

FIG. 5. Long-term annual percentage of surface observations that reached Cambridge from 30 staffed stations in Antarctica.

the problem to the forwarding of certain messages at one location. In this situation action could be taken to correct the problem, but our experiences during the project are that problems such as this occur quite frequently on the GTS and the flow of data needs to be monitored on a near-continuous basis if a large percentage of the observations are to be collected.

Only about 85% of observations get through on the GTS so the data cannot be used to calculate long-term averages. The data from the GTS should be considered as a source of information for short-term study periods and for any longer periods of study the relevant countries should be contacted to get a complete dataset.

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