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BRITISH ANTARCTIC SURVEY

WEATHER FORECASTING

MANUAL

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Revisions

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Version 5.0 February 2005

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Preface

This manual has been produced as an aid to those preparing weather forecasts for the Antarctic Peninsula region. Its primary use is to assist the operational forecasters based at Rothera Station, but it is hoped that it will also be of value to those involved in observing at other stations that receive forecasts from Rothera.

Many people have contributed to the success of the operation of the forecast office at Rothera. Steve Wattam was the first forecaster to be seconded from the Met. Office during the Austral summer of 1994-95 and much of the material used in the first version was supplied by him. Many of the forecasters from subsequent seasons have also made contributions to the handbook. The Rothera forecasters were:

1994-95	Steve Wattam
1995-96	Alison McClure
1996-97	Marc De Keyser
1997-98	Marc De Keyser
1998-99	Phil Reed
1999-2000	Steve Wattam
2000-01	Will Lang
2001-02	Phil Reed and Donald Ferguson
2002-03	David Lee and Will Lang
2003-04	Judith Rhodes and David Lee

The original system to transfer Met Office analyses and forecast products to Rothera was established and maintained by Richard Siddans, Russ Ladkin, Steve Leonard and Steve Colwell. Jon Shanklin handled the liaison with the communications section of the Met Office. Jon Shanklin installed the Horace system at Rothera and is the point of contact for technical issues on Horace.

SECTION 1

INTRODUCTION

The British Antarctic Survey (BAS) undertakes a wide range of atmospheric, biological and earth sciences research into the southernmost continent and surrounding sea areas. This is carried out from four research stations, by field parties in remote locations, and from aircraft and research vessels. The stations are all located in the Antarctic Peninsula/Weddell Sea area and their positions are shown in Fig. 1.1 along with locations of other places referred to in the text. Halley, which is on the Brunt Ice Shelf, carries out meteorological and upper atmosphere research and is the most southerly of the stations. Rothera, on Adelaide island, is the centre for BAS deep field operations and the station from where field parties concerned with glaciological, geological, geophysical and some life sciences research are deployed into the more remote areas of the continent. Meteorological and marine life sciences research also takes place at Rothera, while Signy (a summer only station) is involved in terrestrial and marine life sciences research. Bird Island is located at the western end of the sub-Antarctic island of South Georgia and, as the name implies, is another biological station. BAS also operates a station at King Edward Point on the North East of South Georgia on behalf of the South Georgia Government. In support of these activities BAS operates two ice strengthened vessels, the RRS *Ernest Shackleton* and RRS *James Clark Ross*, each operating in a dual research and re-supply role. BAS also operates four Twin Otter aircraft that are fitted with both wheels and skis, enabling them to use the crushed rock runway at Rothera and to land on snow and ice to deploy field parties. One or more of the Twin Otters are operated from Halley in most seasons in support of science and logistical activities. The Survey uses a Dash-7 aircraft to ferry scientists and supplies from the Falkland Islands to Rothera, enabling the maximum use to be made of the relatively short summer field season and to allow personnel to make brief visits to the Antarctic. The Dash-7 is also used to ferry fuel and equipment into the deep field, landing on blue ice runways. It is also used for conducting geophysical surveys. Although a limited amount of weather forecasting had been attempted in the past from South Georgia, BAS had never employed the services of a professional forecaster until the 1994/95 Antarctic field season. However, with the acquisition of a Dash-7 aircraft and an increase in the Twin Otter fleet to four, a decision was made to employ a forecaster, to be based at Rothera Research Station for the period of aircraft operations from early November until early March during each Austral Summer. Prior to the employment of a forecaster at the station, the briefing of aircrew and the provision of forecasts had been the responsibility of the Rothera meteorological observer. Since 2001/02 two forecasters have been employed, one for each half of the season.

This manual has been prepared for the benefit of forecasters at Rothera as an introduction to Antarctic meteorology and to BAS operations in the Antarctic. The document is revised periodically as experience and understanding of the weather of the Antarctic Peninsula region increases.

Fig. 1.1. A map of the Antarctic Peninsula area showing places referred to in text.

SECTION 2

THE CLIMATE OF THE BRITISH ANTARCTIC TERRITORY (BAT)

This section provides a brief overview of the meteorology and climatology of the Antarctic Peninsula region. For more details see King and Turner (1997).

2.1 Synoptic Scale Weather Systems

For many years it was thought that the Antarctic coastal region was an area of declining weather systems with few developments taking place. However, examination of satellite imagery shows that many cyclogenesis events took place on the synoptic and mesoscale with it being far more active than previously thought. During the summer months the main polar front is usually located well north of the Antarctic, between 50 and 60^o south. Many of the depressions that form on the front move in a southeasterly direction and become slow-moving in the Antarctic coastal region. However, depression tracks are very variable as shown in Fig. 2.1 (taken from Jones and Simmonds, 1993). Figs 2.2a and 2.2b show satellite imagery examples of synoptic scale depressions in the Bellingshausen Sea.

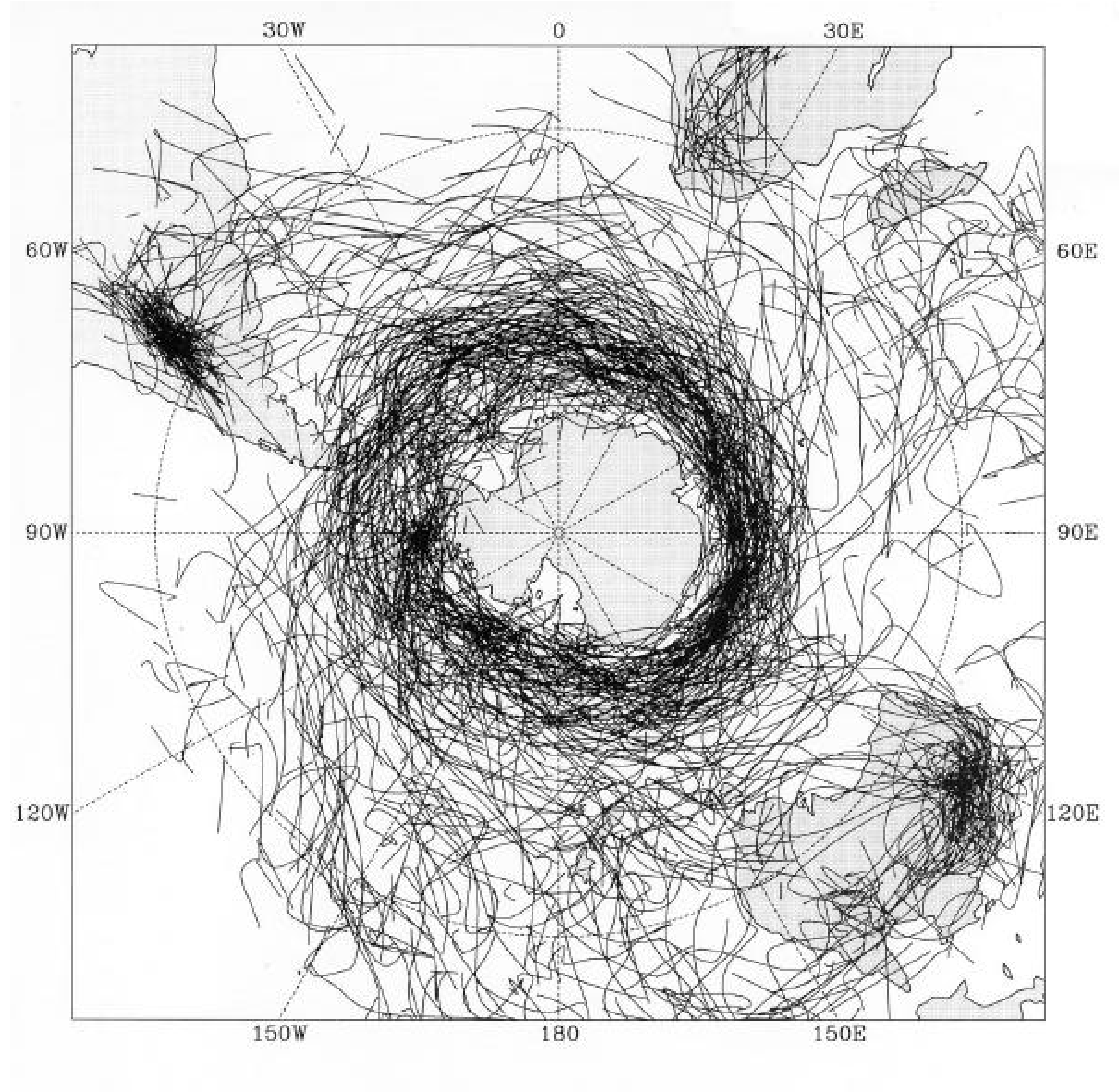

Fig. 2.1. Tracks and daily positions of cyclones during summer for the years 1985-89. From Jones and Simmonds (1993)

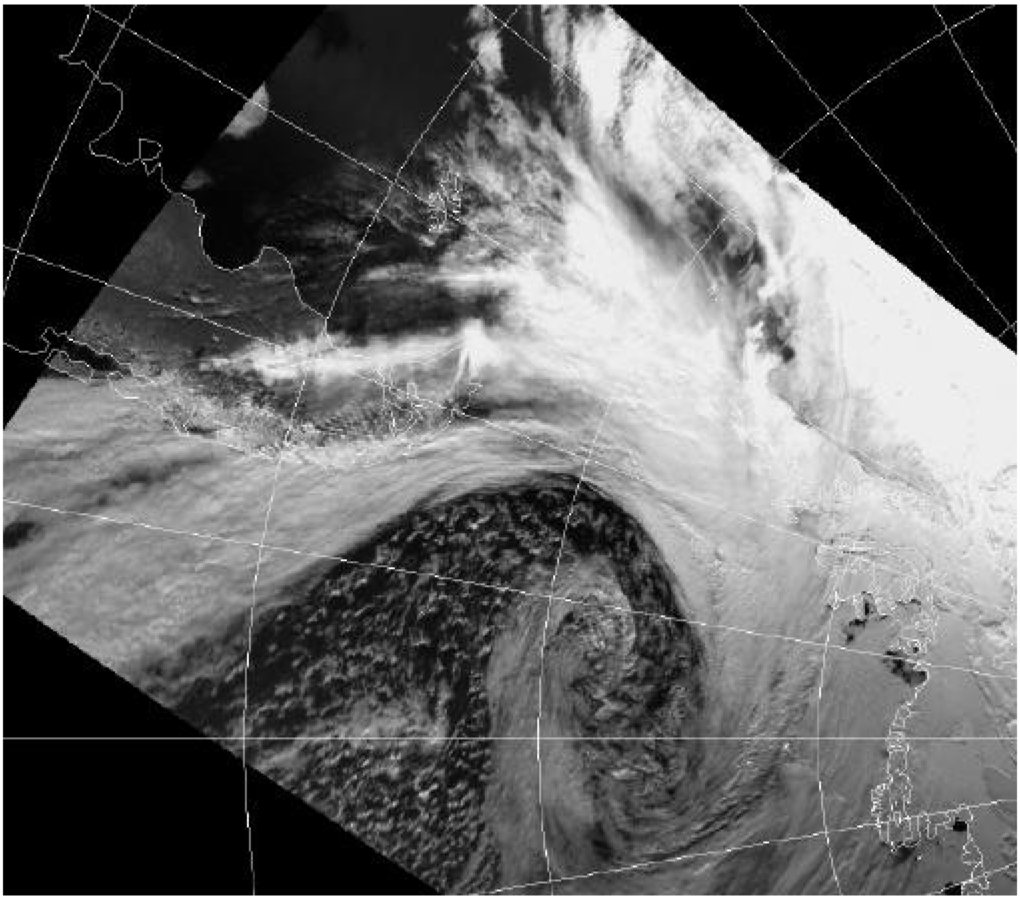

Fig. 2.2a. A visible AVHRR image of a major depression over the Bellingshausen Sea at 12:14 GMT 17 November 1993.

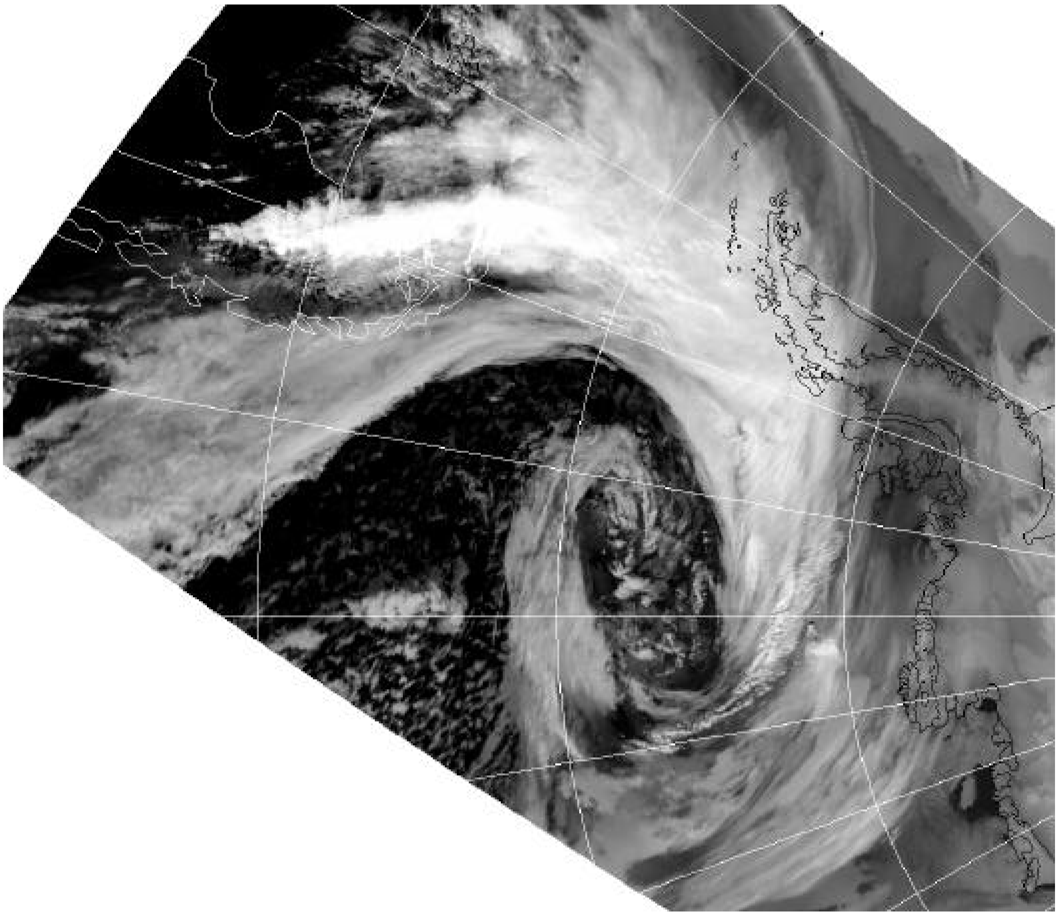

Fig. 2.2b. A thermal infra-red AVHRR image of a major depression over the Bellingshausen Sea at 12:14 GMT 17 November 1993

Because of the high north-south-oriented orography barrier of the Peninsula, which reaches over 2 km for most of its length, it is an effective barrier to the eastward movement of depressions, so that most become slow-moving in the Bellingshausen Sea, a favourite location being over or near Alexander Island. This gives a climatological mild northwesterly flow down the western side of the Peninsula, which is in contrast to the generally southerly winds experienced on the eastern side, which take the form of barrier winds (Schwerdtfeger, 1984). The barrier wind on the eastern side of the Peninsula results from the northward deflection of the climatological easterly flow found at the latitude of the Ronne Ice Shelf by this major orographic barrier. Most research stations are therefore situated on the western side, where early access can be achieved as the sea ice retreats in the November-December period. Some frontal systems appear to cross the Peninsula, moving into the Weddell Sea, often with a depression forming on the eastern side of the Peninsula. This lee cyclogenesis appears to be particularly common and vigorous to the east of the northern tip of the Peninsula, near James Ross Island. These developments are usually well-represented – at least qualitatively – by forecast models, though their activity can be considerably underestimated. Some depressions do penetrate the coastal area of the continent to the west of Alexander Island. One such event occurred on the 8/9th January 1995 and is shown in Fig. 2.3. The system retained its identity as far south as 80^{o} S.

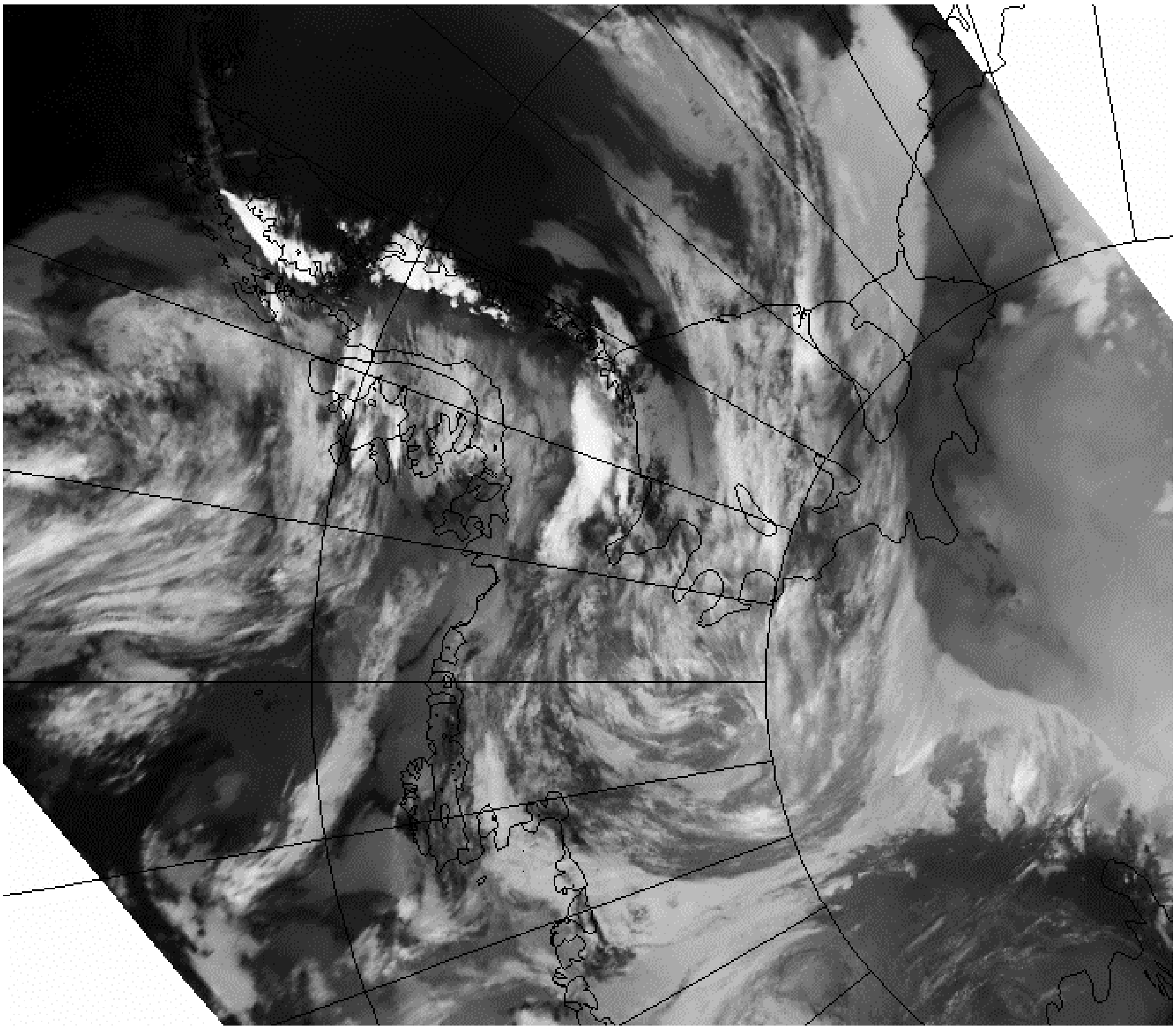

Fig. 2.3. An infrared satellite image from 9 January 1995 showing a low centred near the coast of the southern Bellingshausen Sea at 80° S.

Some of the depressions crossing the Peninsula tend to become complex, with circulations forming on both sides of the Peninsula. Timing the progress of lows as they cross the barrier is difficult. It seems that synoptic patterns vary markedly from year to year. A characteristic of the 2000-01 summer season, for example, was the relative frequency of depressions crossing eastwards through the Drake Passage or across the north Peninsula. The resulting prevailing easterly winds would bring extensive cloud to the eastern Peninsula, while western areas around Rothera enjoyed long periods of excellent weather. These easterly airflows seem to have been unusually persistent compared to previous seasons, however, highlighting the interannual variability of the climate of the region.

Model fields often increase their representation of the thermal gradient over the Bellingshausen and Weddell Seas, well south of the main thickness gradient associated with the polar front, giving an indication of the baroclinicity that can be found at higher latitudes. This thermal gradient is caused by cold (Antarctic) continental air meeting the less cold (Antarctic) polar air.

2.2 Mesoscale Disturbances

In contrast to the large occluding depressions, many smaller systems form at high latitudes and consist of small depressions with a horizontal scale of around 1,000 km or less ('mesocyclones'). These small depressions can take several different forms, including triple point lows, shallow vortices within low-level baroclinic zones, and minor depressions evolving out of large, quasi-stationary depressions that have multiple centres. Examples of mesocyclones observed around the Antarctic Peninsula are shown in Figs 2.4a and 2.4b.

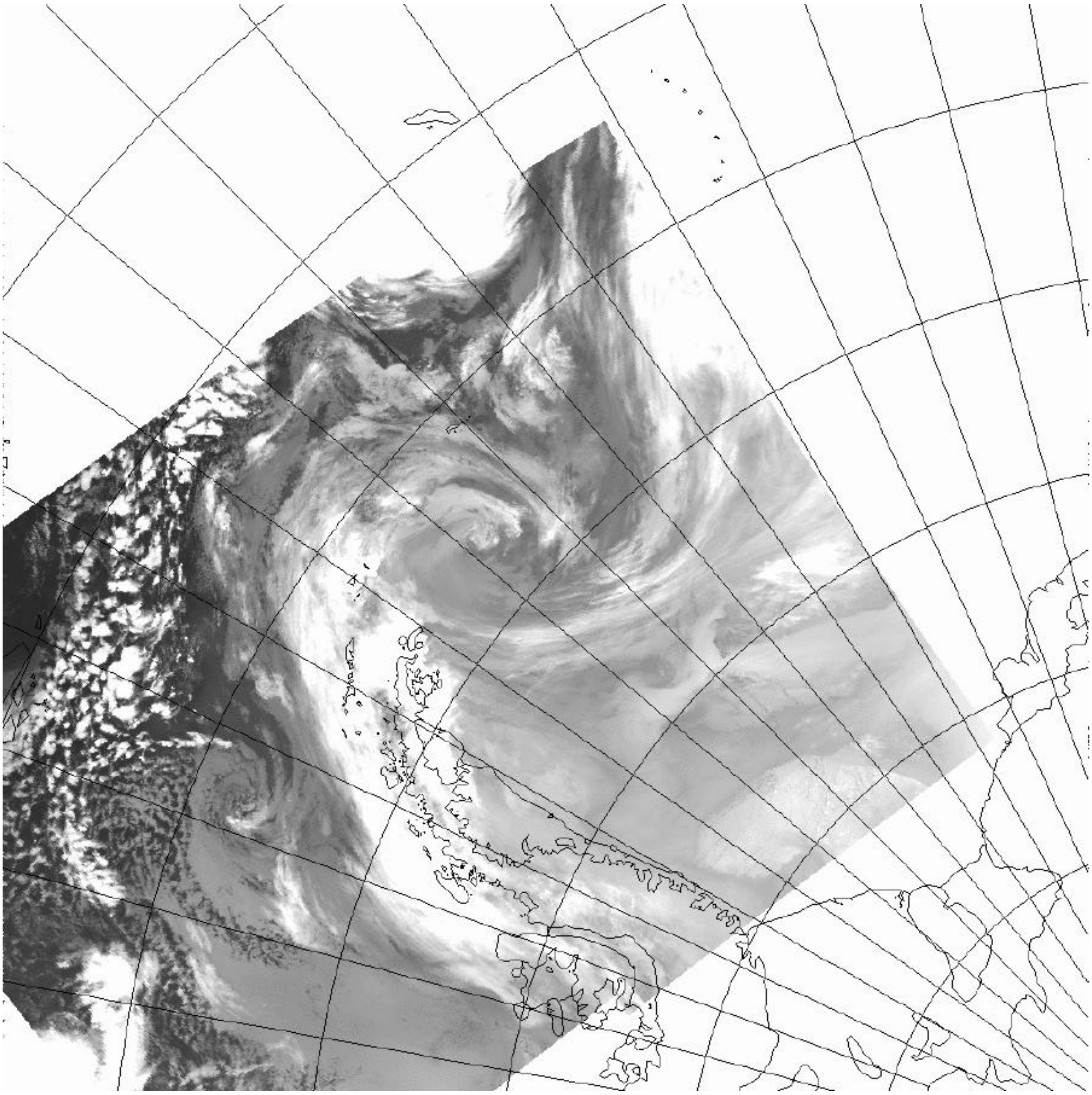

Fig. 2.4a. A mesocyclone to the west of the Antarctic Peninsula that formed in a southerly airflow west of a major depression.

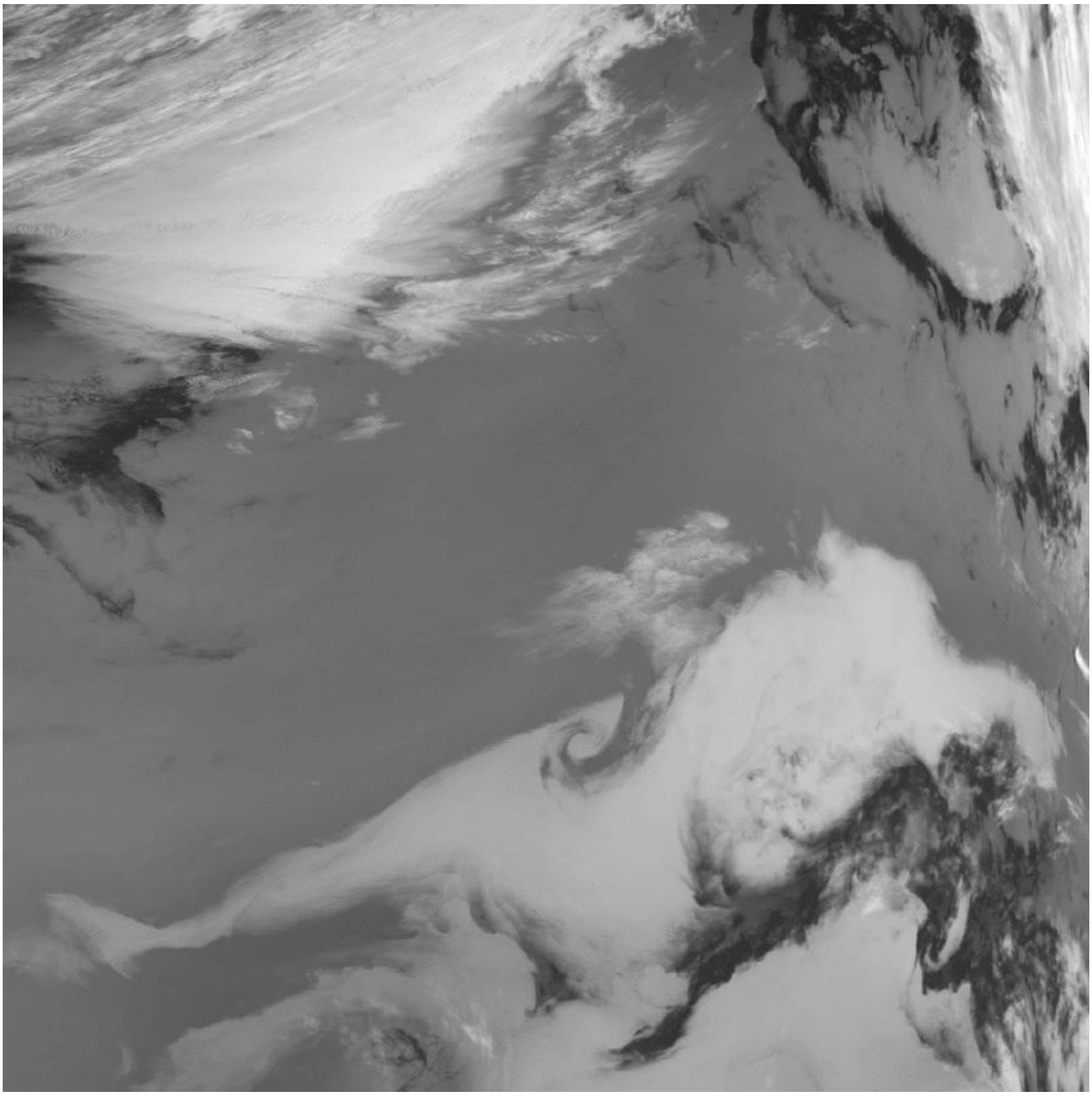

Fig. 2.4b. A small mesocyclone with a diameter of about 200 km that formed at the end of a cloud band.

In recent years satellite imagery has revealed the large number of mesocyclones forming around the coast of the Antarctic (Carleton and Carpenter, 1990) and case studies have shown the adverse effect that they can have on the weather at the research stations (Turner et al, 1993). Within the area considered here, mesocyclones are particularly common in the Bellingshausen Sea (Turner and

Thomas, 1994), in the coastal region of the eastern Weddell Sea, close to Halley Station (Heinemann, 1990) and on the Ronne Ice Shelf. The general frequency distribution of mesocyclone activity is shown in Fig 2.5 from Turner and Thomas (1994).

Many of the mesocyclones that affect the area of the Peninsula around Rothera and Fossil Bluff are associated with major, slow-moving depressions in the Bellingshausen Sea. These lows fragment into multiple vorticity centres as they occlude, which rotate around the old low centre in a 'merry-go-round' configuration. Small-scale surface cyclonic development is often associated with these short-wave troughs, sometimes in the form of 'comma clouds'. Model fields often contain a signal of such features, though they should not be relied upon to give accuracy in position or intensity of development. Satellite pictures displaying deep convection and occasional cumulonimbus clusters indicate the considerable degree of instability often present within these systems.

Much of the summer mesocyclonic activity near Halley occurs within the baroclinic zone formed along the Caird Coast as the prevailing cold easterly airflow off the Antarctic Plateau reaches the rather warmer airmass in the Weddell Sea. This frontal zone is relatively weak, though cyclonic development if often triggered, particularly in certain synoptic situations. Major lows to the east, off the coast in the vicinity of Neumayer tend to strengthen the easterly winds near Halley and bring cooler air down from the interior. This results in increasing baroclinicity along the coast, along with enhanced thermal and dynamical convergence within this zone. Mesoscale development is common in this situation. In contrast to mesocyclones near Rothera, those near Halley are typically shallower vortices, with cloud tops often not exceeding 10-15,000 ft. Forecast models usually give a signal for such developments, either via surface troughing or a tightening of the thermal gradient, though the formation and subsequent motion of mesocyclones near Halley is generally more subtle than those near Rothera, and extremely difficult to forecast with precision.

For more information on polar lows and mesocyclones see Rasmussen and Turner (2003).

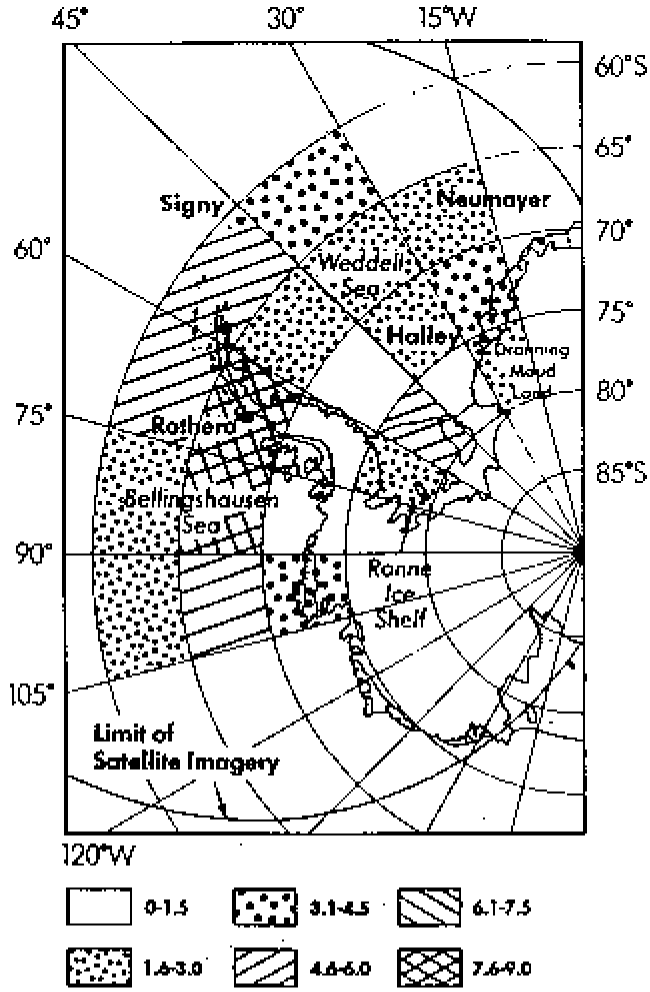

Fig. 2.5. The monthly spatial frequency of all mesoscale vortices for the period December 1983 to February 1984 normalized according to the available satellite imagery.

2.3 Precipitation

Precipitation mostly takes the form of snow, although it may fall as rain during the summer months as far south as Alexander Island. Showers are relatively common, but usually fall from stratocumulus rather than cumulus cloud. Intermittent light showers will usually result from broken or overcast layers of stratocumulus or altocumulus. As with in any mountainous location, orographic lifting and seeder-feeder mechanisms play an important part in producing these showers. In conditionally unstable airmasses convection is often triggered by orographic lifting and/or dynamical forcing (including low-level convergence) rather than surface heating although this can play a part in areas where there is exposed rock surface rather than ice. At Rothera, cumulus clouds are seen on a small number of occasions during the summer months, usually only over the peaks and islands and of little vertical extent. A diurnal element to these occurrences has been observed indicating that surface heating does play a role in their formation at Rothera. Cumulonimbus clouds giving strong gusts and moderate snow showers were observed at Rothera as a sharp upper-trough (and associated comma cloud) crossed Adelaide Island on 6 November 2000 although this was a very rare occurrence.

2.4 Visibility

Visibility in the central Peninsula area is usually good because of the lack of pollution sources, but mist and fog can occur when the wind velocity is low and a moist maritime air mass stagnates over the area. Visibility is most often reduced by precipitation with typical values of 500 – 3000 m in heavy snow, 3000 m – 8 km in moderate snow and 8 – 20 km in slight snow. Blowing snow during strong winds can also reduce visibility substantially, and a combination of moderate falling and blowing snow can result in visibilities of 500 m or less. Blowing snow can be a major cause of reduced visibility at Halley and on the Antarctic plateau often reducing the visibility to less than 100 m.

2.5 Wind

The wind speed and direction is largely dependent on the synoptic-scale circulation, although in some areas it is heavily influenced by orography, even with quite strong pressure gradients, and the effects of shelter or funnelling by mountains and valleys are marked in many places.

A selection of climatological data for the Antarctic Peninsula region is provided in Appendix C

SECTION 3

THE FORECASTING REQUIREMENT AND SCHEDULE OF OPERATIONS

3.1 Activities Requiring Weather Forecasts

3.1.1 Aircraft operations

The Dash-7 aircraft's primary role is to provide an airbridge between Rothera and Stanley in the Falkland Islands enabling field parties to be input into the Antarctic early in the season. There are therefore a number of round trips early and late in the season transporting personnel and cargo. During the mid-season period, rotations are at approximately monthly intervals. The Dash-7 aircraft operates at altitudes up to FL200.

In addition to the airbridge, the Dash-7 is used to transport fuel into the interior of the continent. This aircraft is not fitted with skis and hence operates to blue ice runways such as Sky-Blu, around 500 nm to the south of Rothera. The Dash-7 has in the past operated as far south as the Patriot Hills in the Ellsworth Mountains, though runway conditions there mean that further routine flights are unlikely.

The Dash-7 is also used for aeromagnetic survey flights. The meteorological conditions for these flights are quite stringent with good visibility and low turbulence being required over the survey area. Icing conditions must also be avoided as this affects the antennae on the aircraft. Icing may also affect aircraft performance with magnetometer pods installed.

The four Twin Otter aircraft operate virtually every day throughout the season when the weather permits. Their work consists of flights to input and recover field parties to remote locations, assessment of sea ice extent and form, aerial surveys, ferry flights to and from Halley station and the transfer of fuel and personnel to forward field stations at Fossil Bluff and Sky-Blu. The aircraft operate at altitudes of up to 14,000 ft.

The Twin Otters are also used for aerial photography at heights up to 14,000 feet. Such work requires cloudless conditions.

One or more of the Twin Otters are often based at remote sites, such as Sky-Blu or Halley for extended periods of survey or fieldwork support.

3.1.2 Ship operations

BAS operates two ships in Antarctic waters during the summer. The RRS James Clark Ross and the RRS Ernest Shackleton conduct marine scientific research and transfer personnel and cargo to the research stations. Wind can be particularly important to ships stuck in the sea ice. Swell/waves are also relevant during scientific cruises for trailing or deploying scientific instruments.

HMS Endurance may also operate in Antarctic waters during the summer. However, forecasts are not normally required as a Navy forecaster is usually onboard. Nevertheless, contact with the Rothera forecaster can be expected via HF radio and/or e-mail with an exchange of data taking place and also discussion of the current synoptic situation with the on board forecaster. On occasions HMS Endurance can be provided with copies of model output and satellite pictures.

3.1.3 Field Parties

Forecasts are only usually provided to field parties when an aircraft is with the party or planning to visit them. The forecaster will usually only speak to the pilot. Occasionally there may be a request for a forecast from a field party not expecting aircraft movements. In these cases only brief, qualitative forecasts are usually required with some indication of future trends. Field parties should be made aware before departure that they will have to add some ‘local knowledge’ themselves as forecasts are usually only an estimate of average conditions across their area, and are unlikely to be tailored towards their exact location.

Forecasts may also be requested by other BAS bases not already receiving a regular service, such as Signy. These will either be a ‘one off’ for a particular occasion, such as a ship coming in. The forecasts are sent via email or fax.

3.1.4 Other Nations and Operators

Forecasts are occasionally requested by other nations and operators who are involved in flying or shipping operations within the Antarctic. These may include flight forecasts between:

- Patriot Hills to Punta Arenas, Chile via Rothera.
- Punta Arenas to Rothera and then on to Halley, Neumayer, South Pole or McMurdo.
- South Pole and Rothera then Punta Arenas.

Notice of these flight is usually given in advance, however, forecasts may be required at short notice in an emergency e.g. an unforeseen medical evacuation (Medevac).

3.1.5 Non-Aviation Forecasts for Rothera Station

The Rothera Boating Officer requires a daily forecast to decide whether it is safe to put the boat in the water. The station Diving Officer will also use this information.

A daily briefing is provided to the Station Support Manager and the technical services staff unless other operational commitments dictate otherwise. This is required for planning outdoor base activities, such as snow clearing, painting and laying concrete, which are all temperature dependent.

A basic daily weather, wind and temperature forecast with outlook for the next day is written up on a board in the dining room for general use. This is much appreciated on the base.

3.2 Forecasts Provided

3.2.1 Work Schedule

The bulk of the forecasting workload is in the early morning, but forecasts can also be required at any other time according to operational flying requirements. Below is an example of a typical morning schedule:

0530– The timings of the main briefings usually requires the forecaster to start work around 0530 depending on the number of areas to be assessed.

0655 - Brief any pilots based at Halley via VOIP. The areas that forecasts are required for will have been discussed the day before and may include areas as far west as Berkner Island, as far east as Novolazarevskaya and as far south as the Pole. Note that pilots at Halley usually have access to HRPT satellite imagery and current PMSL charts (as per Rothera) but do not have the HORACE display system. Forecasters should attempt to be as detailed as possible, covering all the main elements of an aviation forecast, although information is very limited with satellite pictures being the main tool.

0700 – 0730 - Field sites 'scheds' via HF radio. Forecasts may be required for pilots at Fossil Bluff, Sky Blu or other field sites, although the requirement for these will vary during the season. The day's objectives will usually have been agreed the previous evening. Again, forecasts should be as detailed as possible when for aviation purposes, but satellite pictures may be the only source of information.

0745 - Rothera Daily Operations Brief

The Field Operations Manager (FOM) outlines the day's objectives based on operational requirements and a rough idea of the weather from the evening before. The Met brief then takes

place based around a briefing 'wall'.
Information placed on the wall include forecast upper wind charts (FL100 and FL180), field party actuals, Rothera TAF and observations for the last 2 hours in METAR form (these are for local use only, it is not necessary to complete a formal observation), satellite pictures of the relevant areas for the day and forecast MSLP charts for the day.

If necessary hand drawn surface charts can be prepared for 0000Z and 1200Z (there are usually too few obs at 0600Z and 1800Z) but it has been found that obs are very late coming in. Also 00Z and 12Z (2100 local the previous evening and 0900 local) are not very useful times in terms of the Rothera work schedule. The T+12 (0900 local) forecast chart is usually good enough to use as an 'analysis' and together with the T+24 (2100 local) provides reasonable guidance of the synoptic situation for the day. Any differences between the charts and reality can then be explained during the briefing.

The content of the briefing will include a general overview of the synoptic situation followed by detailed forecasts for Rothera and any other areas under consideration and an outlook for tomorrow.

The chief pilot and the FOM will then decide on the flying plans for the day.

0800 – Route forecasts for the Dash-7 between Stanley and Rothera, if required, should be available by 0800. The southbound route forecast is to be faxed or emailed to the BAS office in Stanley, this will usually be followed by a telephone or radio conversation with the pilots in Stanley who may require extra information or clarification and will then decide whether to fly or not.

The route forecast documentation will include a sig weather chart produced locally using Visio, model upper wind charts for FL100 and FL180 valid at 0900 local and 2100 local, TAFS and latest obs for Rothera, Marsh and MPA (southbound) or Rothera, Punta Arenas and MPA (northbound) including any explanation or comments deemed useful and an outlook for the following day.

0800 – 0830 (Mon – Sat) – Prepare forecast for Boating Officer. This should include general weather conditions for the day with wind speed and direction being particularly important for estimating the drift of sea ice. An outlook for the following day is included. A longer range outlook may be asked for occasionally.

0830 (Mon – Sat) – Technical Services brief. A brief, general overview of weather, wind and temperature for the day with an outlook for the following day. This briefing may sometimes be missed if decisions have yet to be made about whether the Dash-7 will fly, or for any other aviation commitments.

0600 – 0900 onwards – Any other written forecasts, such as those for Halley or the ships can be done when time permits or to any particular deadline that has been agreed. (may be best done in the evening)

After the aircraft have departed the weather is monitored and forecast updates are provided as and when required, updated information from the latest satellite images is often asked for when the aircraft are en-route.

For survey flying based at Rothera or a remote camp, flying and briefings may take place at any time of the day or night and is usually governed by GPS satellite geometry or quiet periods in the Earth's magnetic field.

3.2.2 CAVOK

When writing TAFs for Rothera remember the full CAVOK criteria.. Visibility must be =10 km as in the UK, but minimum cloud base will be more than 5000ft as it depends on the minimum sector altitude (MSA) of the area concerned. No official information has been found on values of MSA in Antarctica at the current time, however the definition of MSA is to be at least 1,000 ft above the highest ground in a non-mountainous area and 2,000 ft above the highest ground in a mountainous area.

Assuming the Peninsula area would be classed as mountainous and with highest peaks of around 9,000 ft it would seem sensible to set the CAVOK criteria to be no cloud below 11,000 ft. It should be remembered that this value is only a 'guestimate' and stands to be corrected at any time, it will also not be the same for other areas around Antarctica as highest ground heights vary.

3.2.3 Other Elements of the Forecast

It is not uncommon for pilots to ask for more information than would be required in non-Antarctic operations. The forecasting of contrast and horizontal definition is very important for aircraft operations but is also extremely difficult for remote sites with which the forecaster is not familiar and there are no observations available. The problems in forecasting for the Antarctic are well understood by the pilots and even when the forecast accuracy is thought to be low (such as when forecasting for an extended period ahead or when predicting cloud clearance) the forecasts are still valued, especially if an indication of the reliability can be given. Indeed, in addition to the usual short-period aviation forecasts, a major role the forecaster performs is to liase with the FOM and the Chief Pilot and to offer any information that may aid in operational planning up to a period of five days ahead. Information of this type is often necessarily qualitative in nature, but as a high proportion of operational decisions are made on the basis of weather alone, considerable time can be saved via such forecasts.

3.3 Forecaster Availability

The level of forecaster availability depends on the flying status:

If the Dash 7 is flying either to/from Sky Blu or Stanley the forecaster must be easily contactable e.g. carrying a VHF radio, and able to easily return to the office.

If the Dash 7 is on a PNR (point of no return flight – see Appendix E for PNR criteria) from Stanley to Rothera the forecaster must be available (in the building/in the tower) from when the point of no return has been reached until the aircraft lands. If the weather at Rothera is marginal or differs from the forecast, updates or advice may be required before PNR is reached in order to give the pilots enough information to make the decision to continue or turn around.

If only the Twin Otters are flying there are no restrictions on where the forecaster can be, although it is useful to be carrying a VHF radio, BUT if the runway cross wind component is greater than a mean of 20 kt then conditions go to ‘Dash 7 status’ and the forecaster must be available.

SECTION 4

DATA AVAILABILITY

4.1 Synoptic observations

The collective of South American (including TAFs for MPA, Punta Arenas etc), Antarctic and ship surface observations plus upper air data is continuously received on Horace via the Rothera – Cambridge satellite link. There is also an AFTN system for receiving TAFs/METARs in real time from MPA, Punta Arenas, Marsh etc. Upper air observations for Mount Pleasant, Halley, South Pole and Neumayer, and occasionally Marambio, are available.

There are three radio scheds each day when the 12, 18 and 00Z synoptic observations for Vernadsky and Fossil Bluff stations are received. These scheds are dealt with by the comms people or the met team and the forecaster does not need to be available for these.

There is an equivalent radio collection of all Argentinean and Chilean Antarctic stations every three hours throughout the day which is particularly useful for Marsh and Marambio but unfortunately takes place in Spanish. The data are, however, rebroadcast via text CQ transmission (5300 kHz) from Frei Met Centre at 00, 03, 06,…,18 and 21 Z which can be received via the Rothera ARQ system. Frei will include Marsh TAFs in this transmission on request.

Marsh airfield usually has an English speaking ATC between about 0900-1700 weekdays and some weekends who can also provide the latest Marsh weather and Marsh forecast. Forecasts can be arranged for other times in advance.

Synoptic observations are made at Rothera every three hours with aviation observations being carried out every hour when flying is taking place. Between hours, aviation observations are updated whenever significant weather changes take place, these are done by the met observers. The forecaster would not normally make observations. These observations are transmitted to the aircraft in a format described in the BAS Air Operations Manual (Howard, 1993 and updates).

An automatic measuring system (MILOS) operates at Rothera and updates continuously with all the usual observational information. Also available on this system are continuous traces of wind speed and direction, temperature, humidity and pressure. A laser cloud base recorder and present weather detector (PWD) are also installed giving continuous traces of cloud base and precipitation, and of visibility. The PWD also records type of precipitation (rain or snow) but this should not be relied on. Other observations are provided by field parties during the radio schedules and when aircraft are likely to visit their location. Some basic training in observing is given to sledge party members by the Rothera met observers before they are input into the field.

Reports from automatic weather stations are available on Horace and also directly from the polar orbiting satellites via the ARIES satellite receiving equipment which is installed at Rothera.

Radiosonde ascents at Rothera are normally flown around four times a week.

4.2 Model Charts

- All model fields out to T+144 are available on Horace
- The backup data link uses satellite from BAS HQ at Cambridge. Output from the UK Met Office Operational Global Model is transmitted to Rothera via Cambridge in GRIB code and is then re-projected onto polar stereographic charts. The model fields available consist of PMSL charts valid at T+0 to T+120
- 850hPa WBPT charts valid T+12 to T+48
- 1,000-500 hPa thickness charts
- 850,700 and 500hPa contour and wind feather charts
- Surface wind charts valid T+12 to T+48
- 700 hPa humidity charts valid for T+12 to T+36

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Examples of these charts are shown in Figs 4.1a to 4.1d.

If Horace fails the charts can be requested manually at any time and will take approx. 5 – 10 minutes to come through.

As in temperate latitudes the model will pick up most of the major synoptic systems and handle them quite well but will often miss the mesoscale systems and also tends to smooth out smaller features such as troughs. It seems to perform better in slow moving situations and may miss rapid cyclogenesis events out to the west due to the lack of data, although on the whole it usually has a good representation of the broadscale situation.

At the end of the summer 2003/04 the Horace system was installed at Rothera. Data available on Horace includes satellite pictures (not routinely), observations, including automatics and many model fields – MSLP, WBPT, wind and temperatures at all standard heights, snow/rainfall rates, cloud fields and visibility - all out to T+144.

MSLP (hPa) 12:00 29/07/97 (analysis).

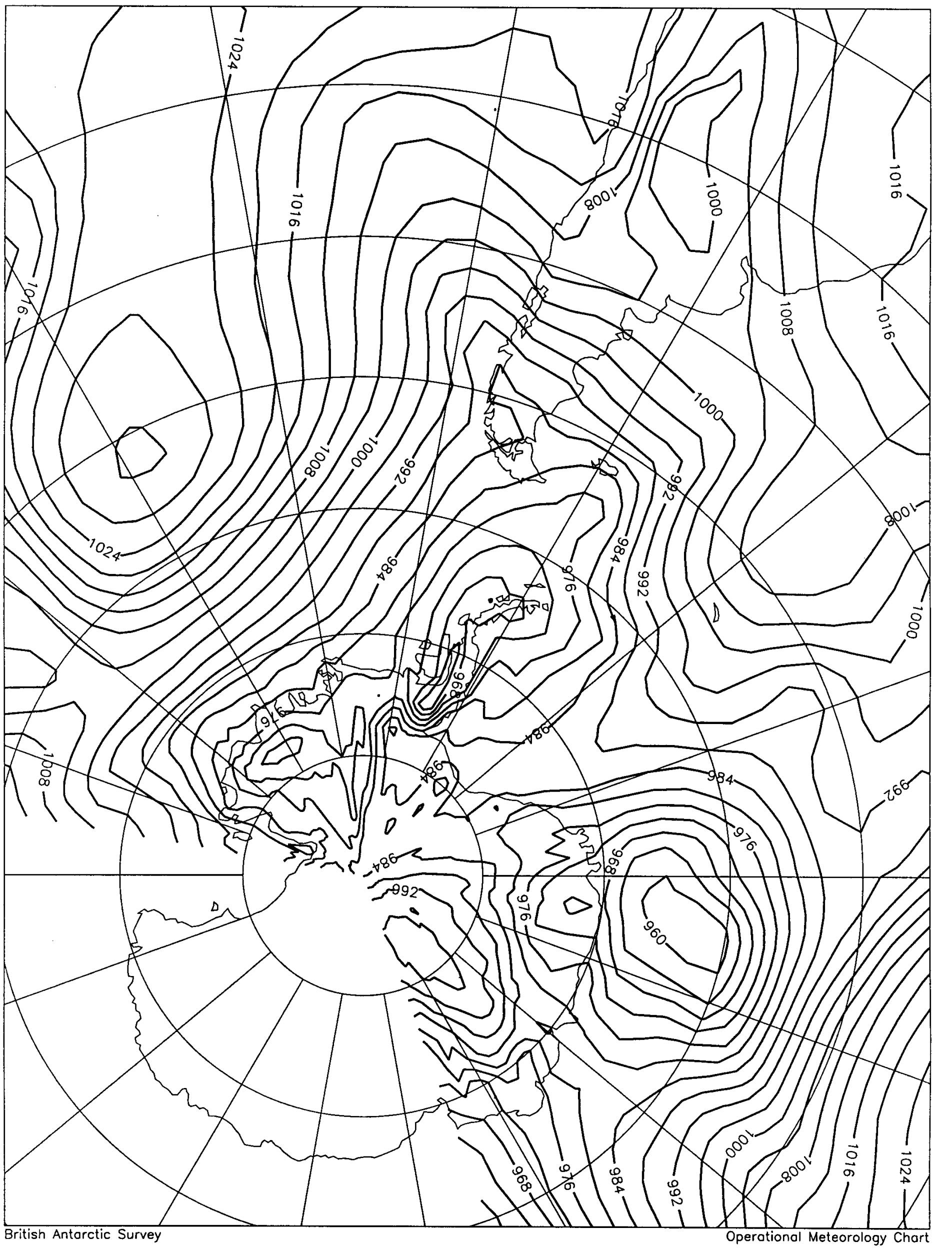
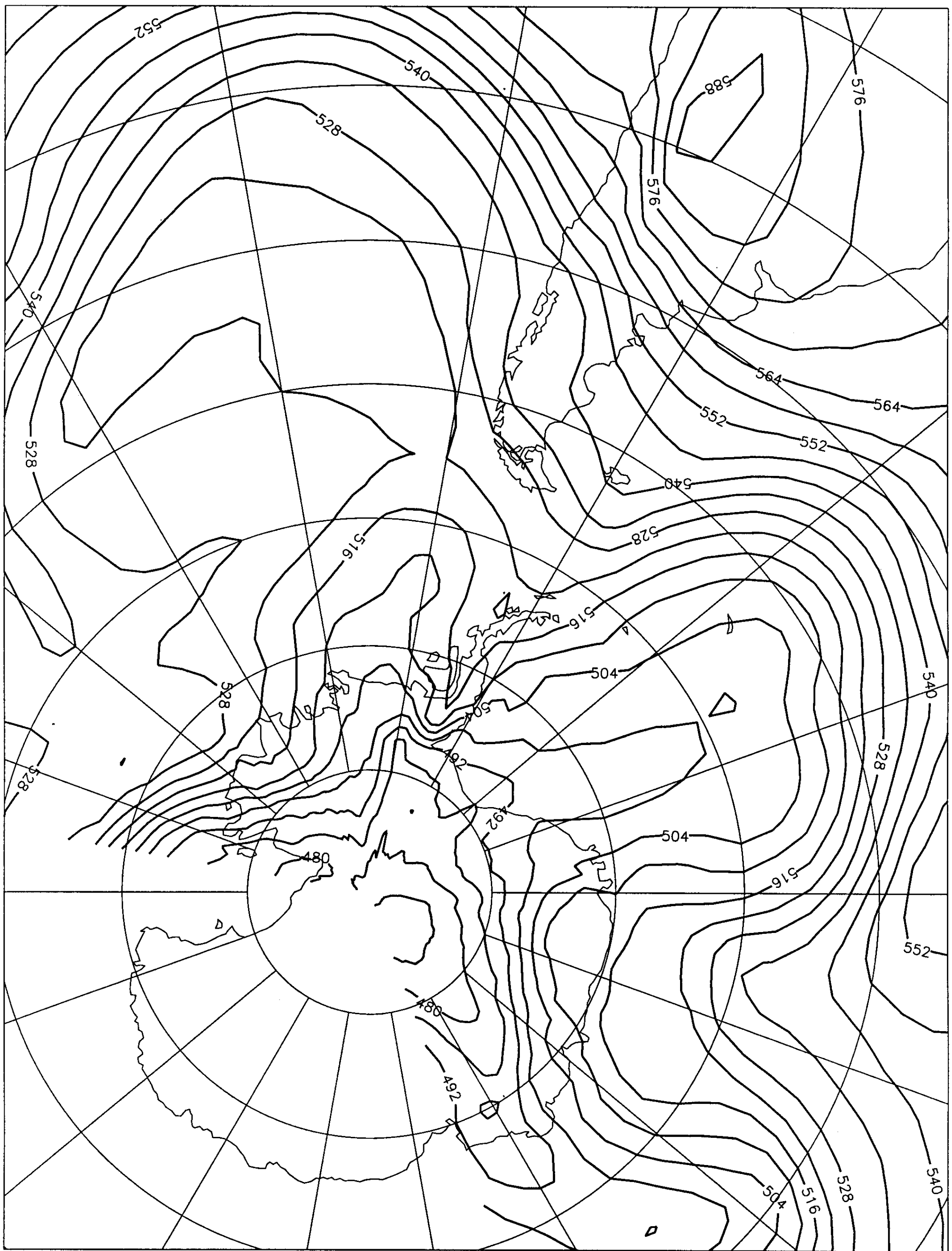


Fig. 4.1a. A PMSL field.

500/1000 HPa thickness (dm). 00:00 29/07/97 (analysis).



British Antarctic Survey

Operational Meteorology Chart

Fig. 4.1b. A 1,000-500 hPa thickness field.

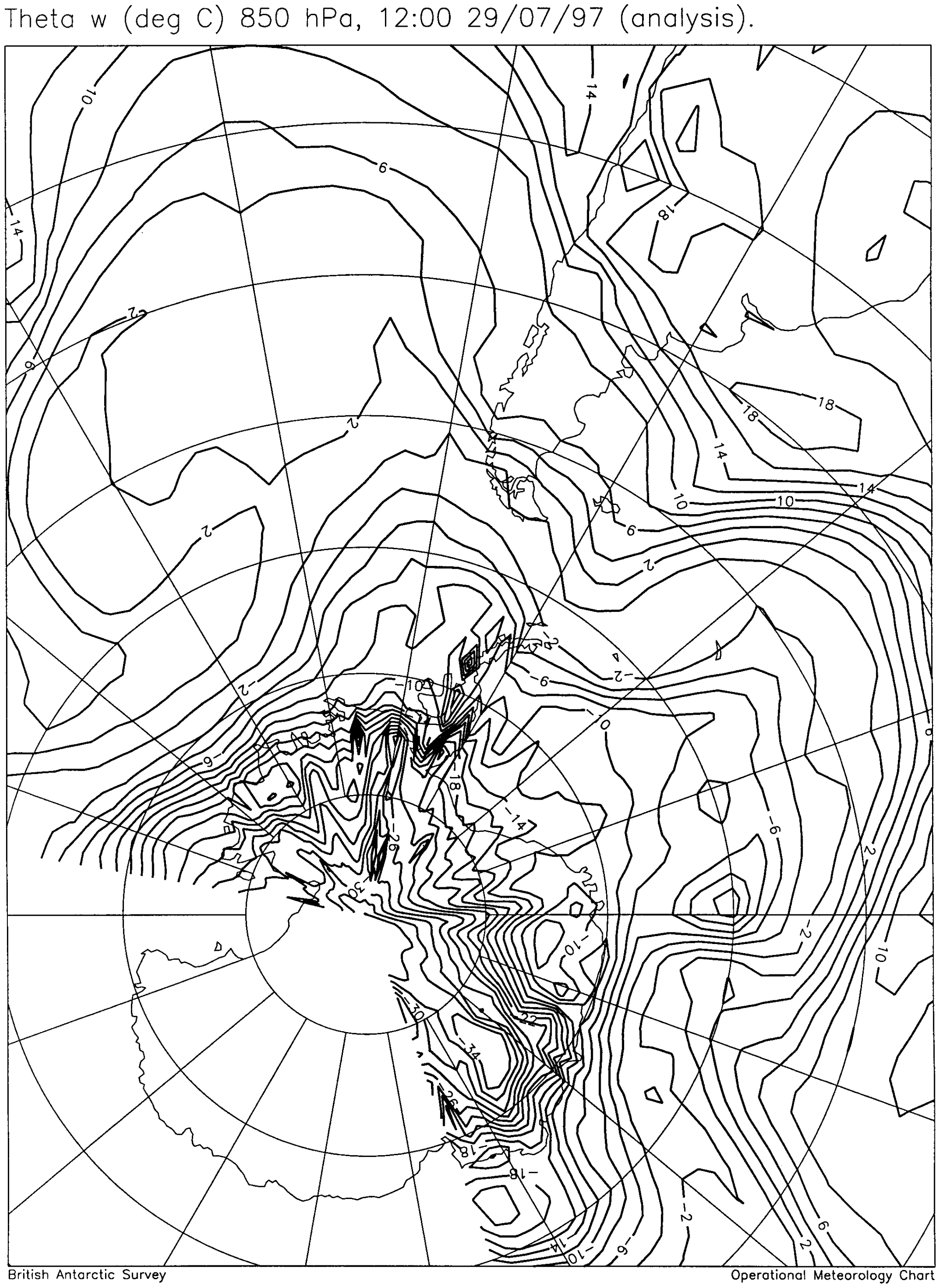


Fig. 4.1c. A wet bulb potential temperature field.

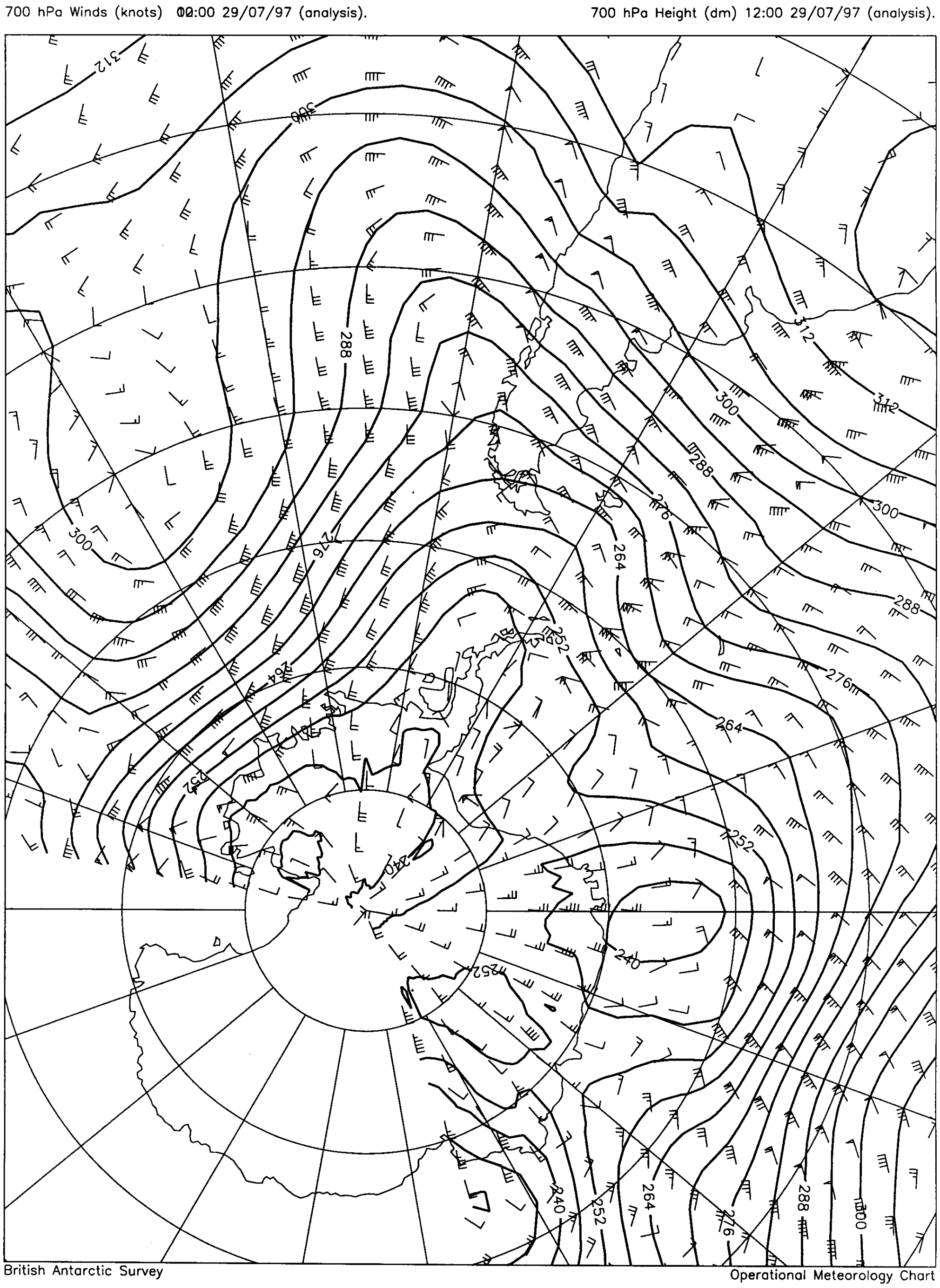


Fig. 4.1d A 700 hPa wind and contour field.

4.3 Satellite Imagery

Single AVHRR satellite images from the ARIES receiving system are available as well as a mosaic of the most recent passes. Imagery is available in the visible (channel 2), the infrared (channel 4) and also channel 3. HRPT systems are also installed at Halley and King Edward Point and on RRS Ernest Shackleton and RRS James Clark Ross.

Traditionally, channel 3 has sensed at 3.7 µm, this being a combination of emitted and reflected radiation and is particularly useful in detecting water droplet cloud over ice and snow which may be indistinguishable from the surface in the visible or infrared. At this wavelength ice and clouds consisting of water droplets with a diameter of greater than 10 µm (frontal clouds and cumulonimbus) appear black. However, clouds with water droplets with a diameter of less than 10 µm, such as low stratus, fog and relatively thin stratocumulus layers, appear white. If large droplets are present these clouds can result in aircraft icing. The channel appears very similar to infrared images during hours of darkness. Channel 3 at night is useful for distinguishing fog or low stratus from a clear surface. This is possible as the surface acts as a black body and its emissivity can be assumed to be 1, while the fog or stratus (with probably the same top temperature as the adjacent surface) has an emissivity of around 0.9.

During 2003 however a 'new' channel 3 was brought in which senses at 1.6 µm. This has been designed to distinguish between snow/ice surface and any cloud cover no matter what the cloud is composed of. This gives it a slightly different look to the 'old' channel 3 in that it shows up total cloud cover, not just low cloud/fog, so even cloud at altocumulus level will clearly show up rather than being black. Cirrus looks slightly different though, being all ice crystals it does usually look dark in the 1.6 µm range, although not completely black and some texture is visible to identify it as cloud rather than clear surface.

The satellites have been set so that the image that comes through labelled as channel 3 will not always be the same. Above approximately 60 degrees latitude, during darkness it will be the old 3.7 μm image (channel 3b), but during daylight it will be the new 1.6 μm image (channel 3a). This can lead to some confusion at the beginning and end of the Antarctic summer season when the channel is switching between day and night. During mid season though, with constant daylight, the channel 3 will always be the new 1.6 μm image, giving better continuity particularly during the crucial morning briefing period. See Appendix F for a fuller explanation of the theory behind channel 3a.

For each satellite pass an infrared reprojected ‘quick-look’ image is archived and can be printed (see Figs 4.2a and 4.2b) at a scale of 8 km/pixel and a transparent overlay can be used for gridding and coastline. This image is very small scale though and coastlines are difficult to place, it is not usually very useful. A better overview is the mosaic, a patchwork of the most recent passes which can be set to print out automatically at 0000Z and 1200Z, the last four mosaics can also be run as a loop. It should be noted though that some parts of this image may be at least 12 hours old in areas with infrequent satellite passes.

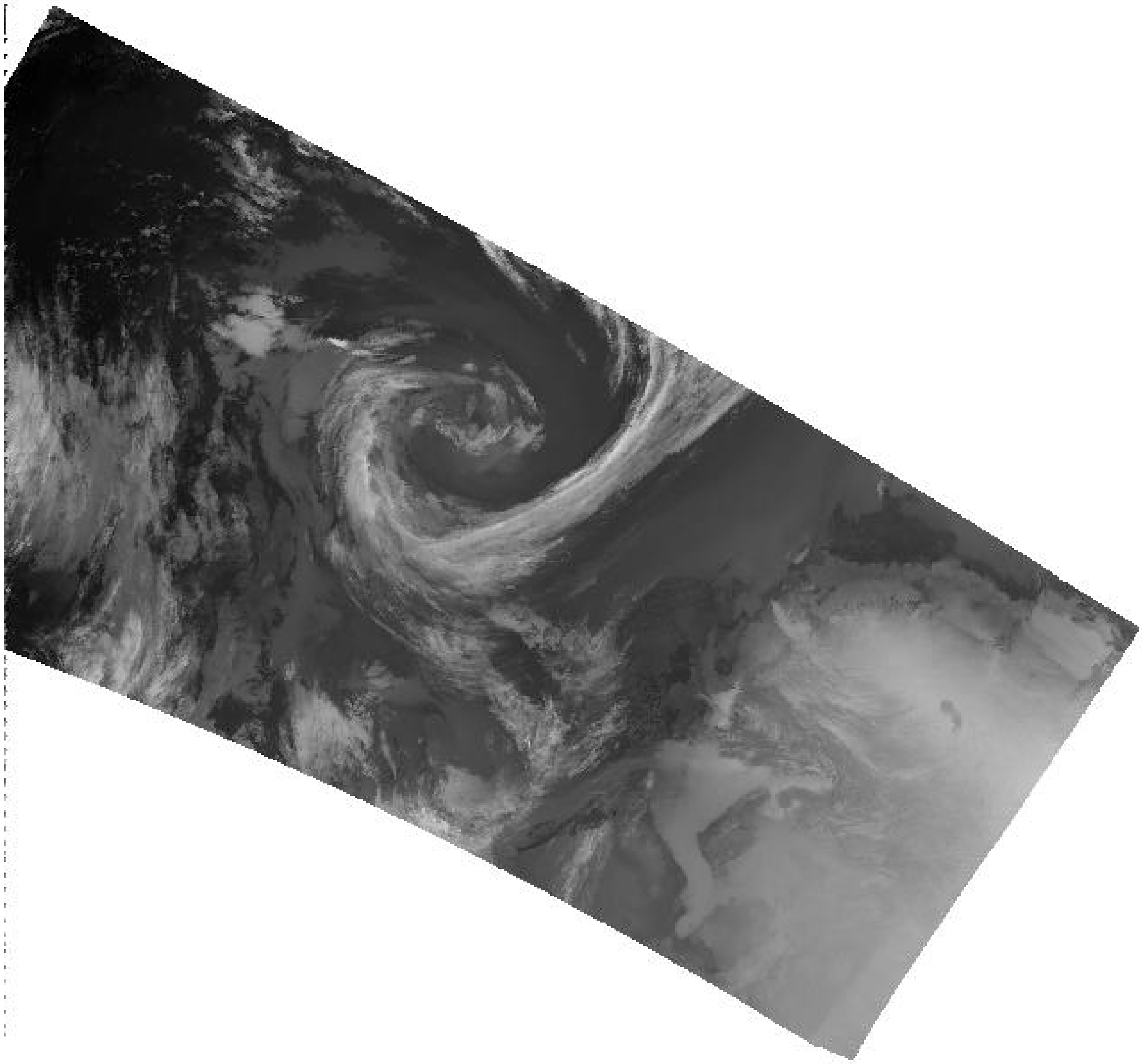
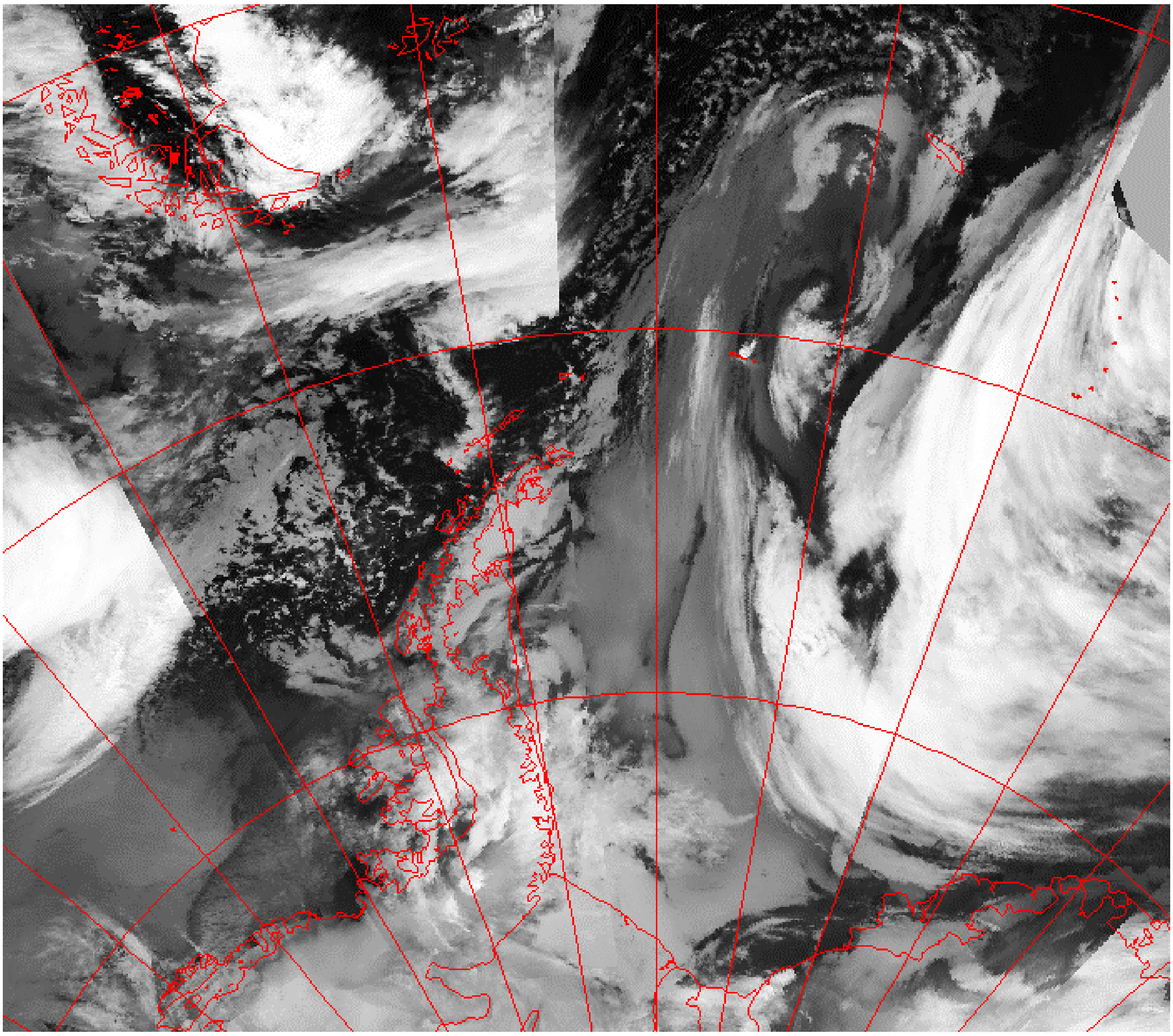


Fig. 4.2a. An example of an infrared, re-mapped ‘quick-look’ image.



AVHRR Ch. 4 Mosaic to 12 Nov 96 12:00 UTC

Fig. 4.2b. An example of an infrared, mosaic image which has the grid and coastline automatically included. Note that the grid and coastline is sometimes displaced slightly but this is usually easy to spot at some point in the image.

AVHRR imagery at 1 km resolution is also available covering 1,000 km squares. The areas covered by these high-resolution images are pre-set and relate to the areas of operation, but can be changed depending on requirements. Around 14 passes a day are received and processed, though most of these are obtained overnight, with no satellite data available for much of the day. Most satellite passes occur in the early morning and early evening but a handful of pictures are available during the day as well. Examples of cloud free images showing topography are shown in Figs 4.3a to 4.3g, along with examples of visual, channel 3 and IR images of cloud being shown in Figs 4.4a to 4.4f.

After the beginning of February the elevation of the sun becomes gradually lower so that the quality of the early, pre-briefing visible images deteriorates towards the end of the season. Consequently during this period only the infrared images are useful. This also applies at the beginning of the season.

Mid summer also has it’s problems. During the middle of the day with the relatively high, strong sun on an all white surface (be it cloud or ice) the features become indistinguishable on visible images due to the intense brightness and often these images become unusable areas of plain white where all texture has been lost.

Unlike in the UK, the surface below the cloud in Antarctica does have an effect on the look of the cloud on a satellite image. In coastal areas, due to the different strengths of the reflection upwards onto the base of the cloud from the ice and the sea, the coastline and patterns of the sea ice are often clearly visible, even though the cloud may be opaque when flying above or within it. This makes it difficult to determine the thickness of low level cloud in remote areas as it will often appear thinner than it actually is on the satellite picture. This effect can often be seen at Rothera where under full cover of opaque stratocumulus the outline of Adelaide island is often clearly visible on the satellite picture.

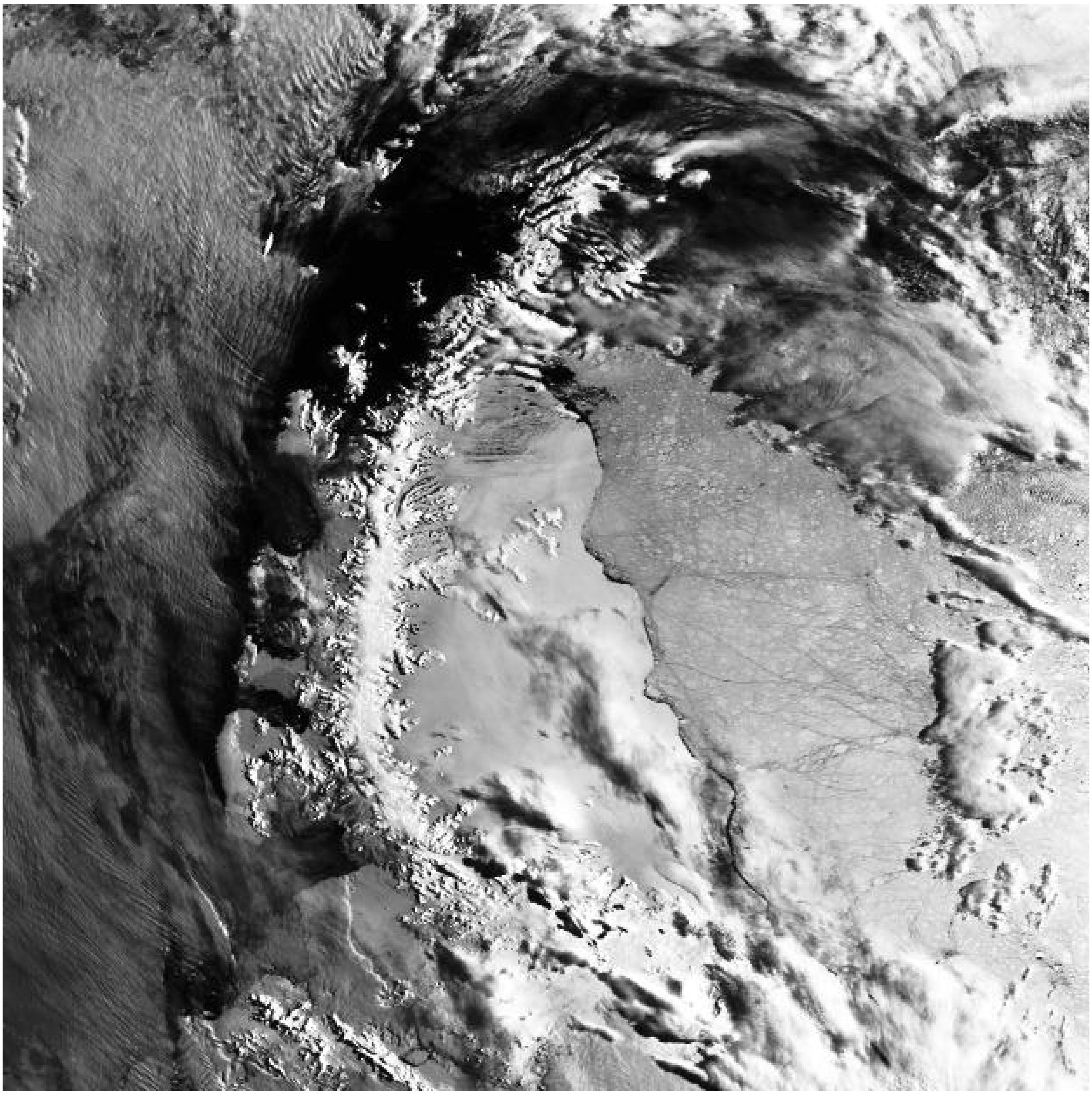


Fig. 4.3a. A 1 km resolution, visible image of the northern part of the Antarctic Peninsula. The Peninsula is largely cloud-free, but wave clouds are present near the northern tip. Extensive sea ice can be seen over the western Weddell Sea.

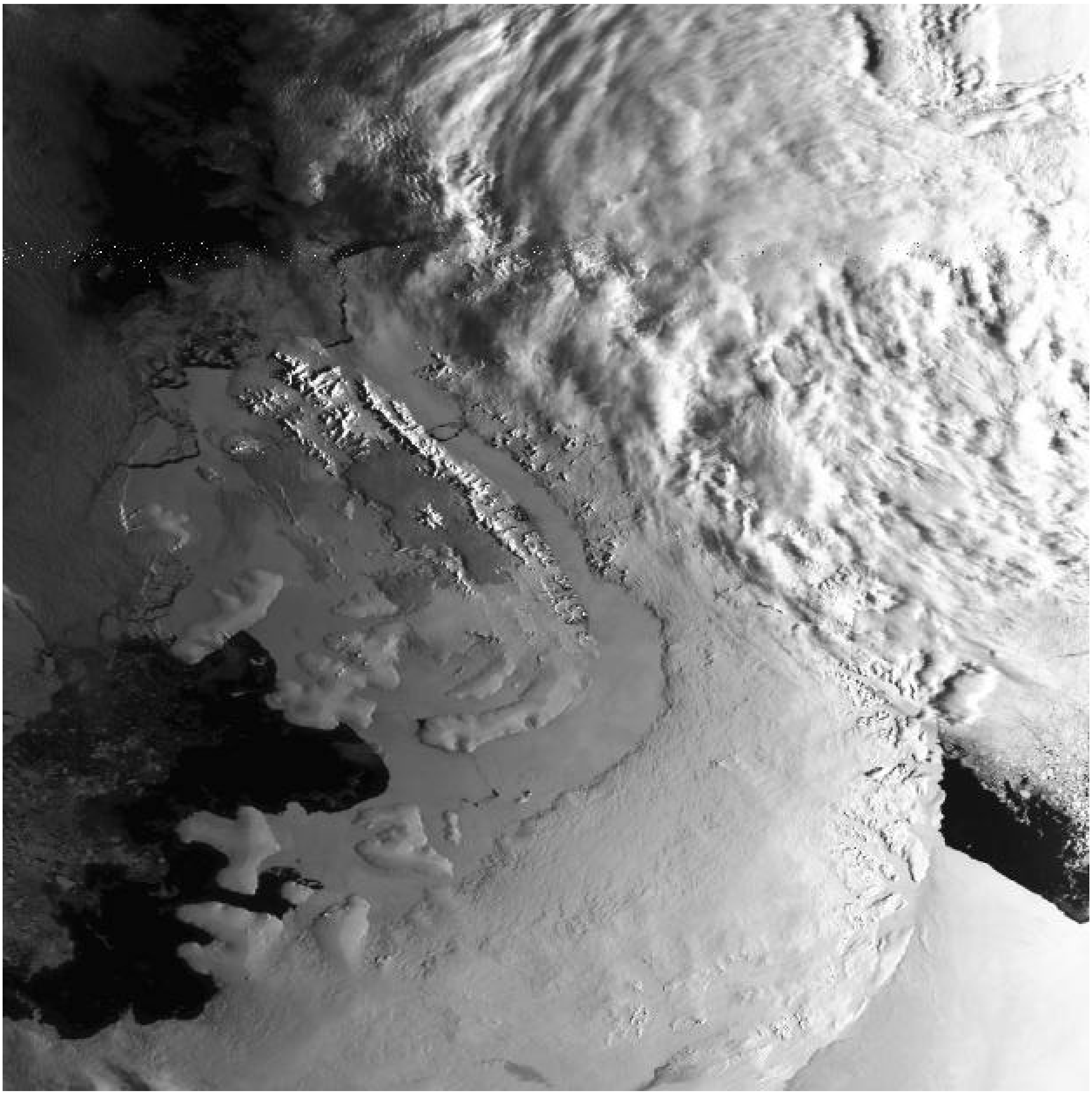


Fig. 4.3b. A 1 km resolution, visible image of Alexander Island, King George VI Sound and the base of the Antarctic Peninsula.

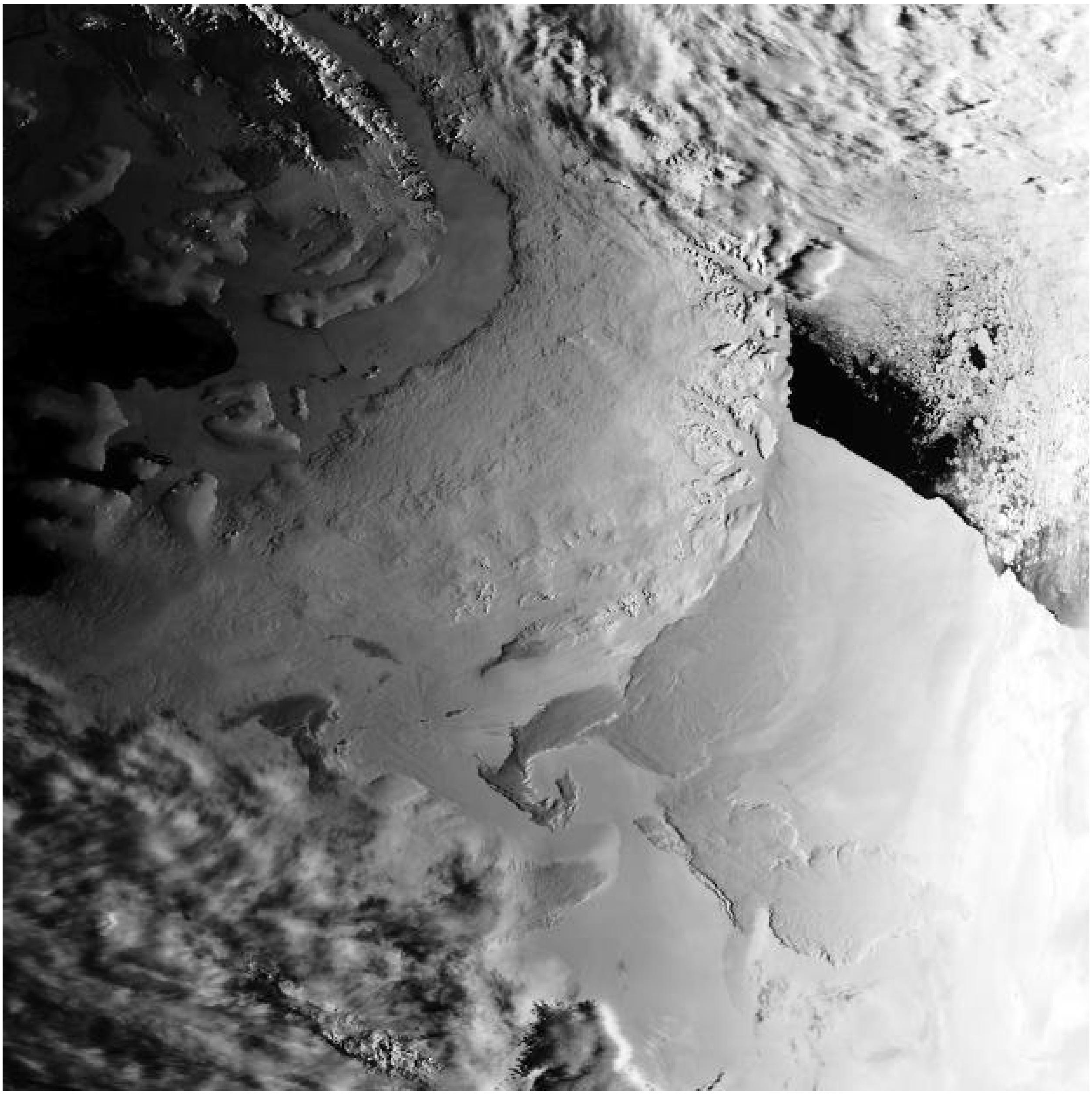


Fig. 4.3c. A 1 km resolution, visible image of southern Alexander Island, King George VI Sound and the western side of the Ronne Ice Shelf. The topography of the area around Sky-Blu is apparent.

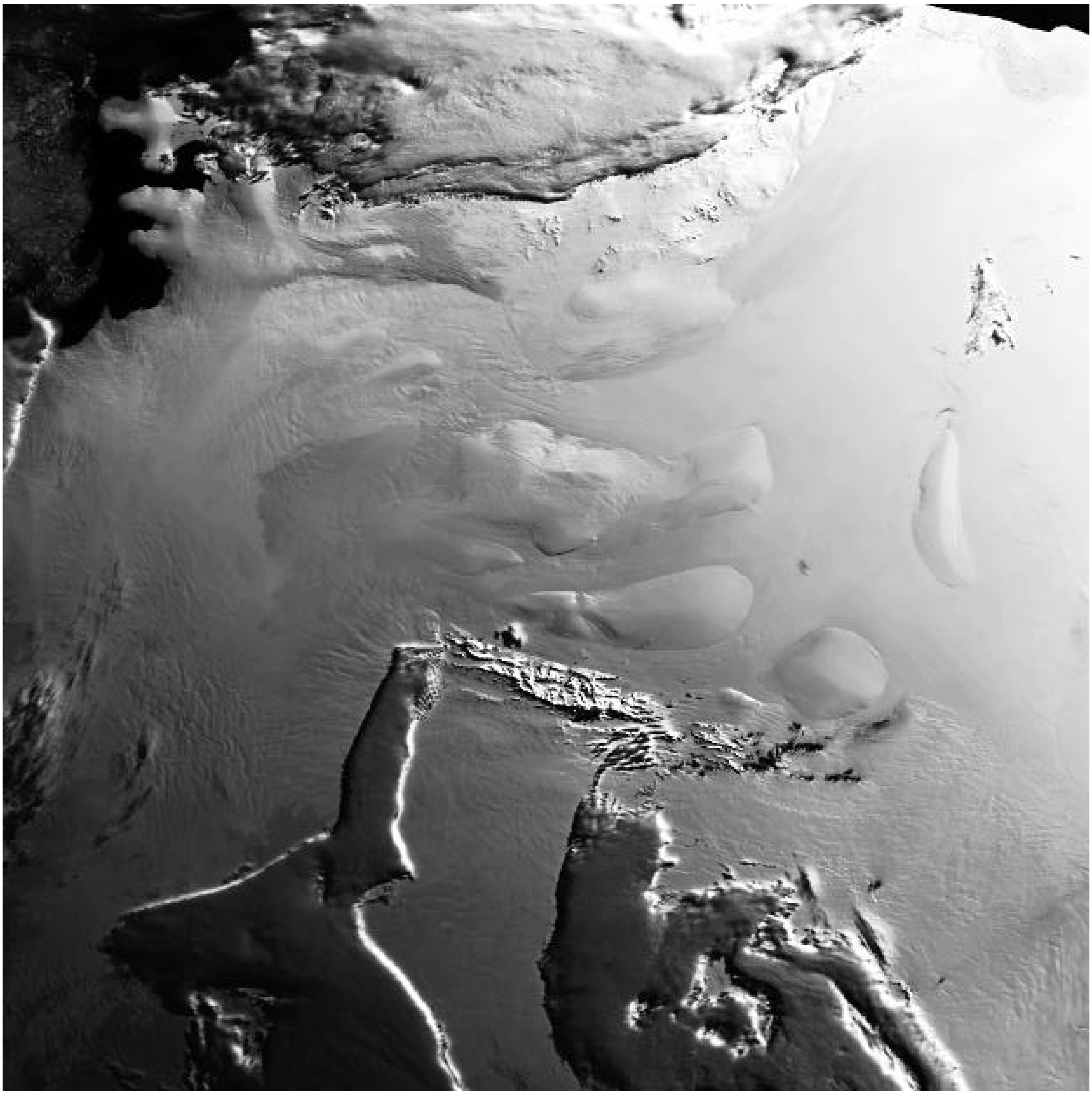


Fig. 4.3d. A 1 km resolution, visible image of the Ellsworth Mountains with the Fowler and Fletcher Ice Rises to the north. The topography around Haag Nunataks is apparent.

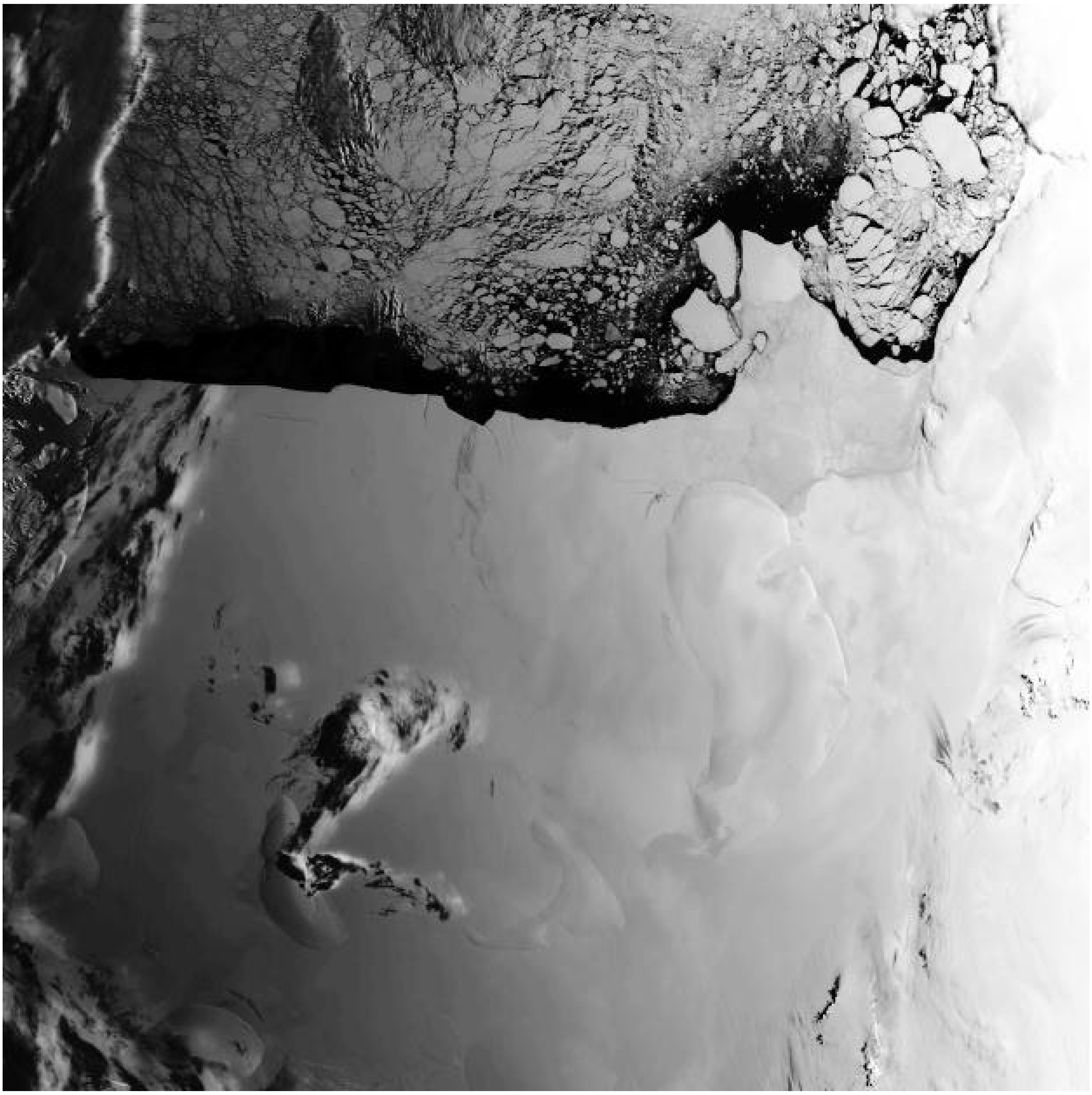


Fig. 4.3e. A 1 km resolution, visible image of the Ronne/Filchner Ice Shelf, showing Berkner Island and the icebergs that broke away from the shelf linked by fast ice. The topography around the Ronne Ice Shelf and Berkner Island is apparent.

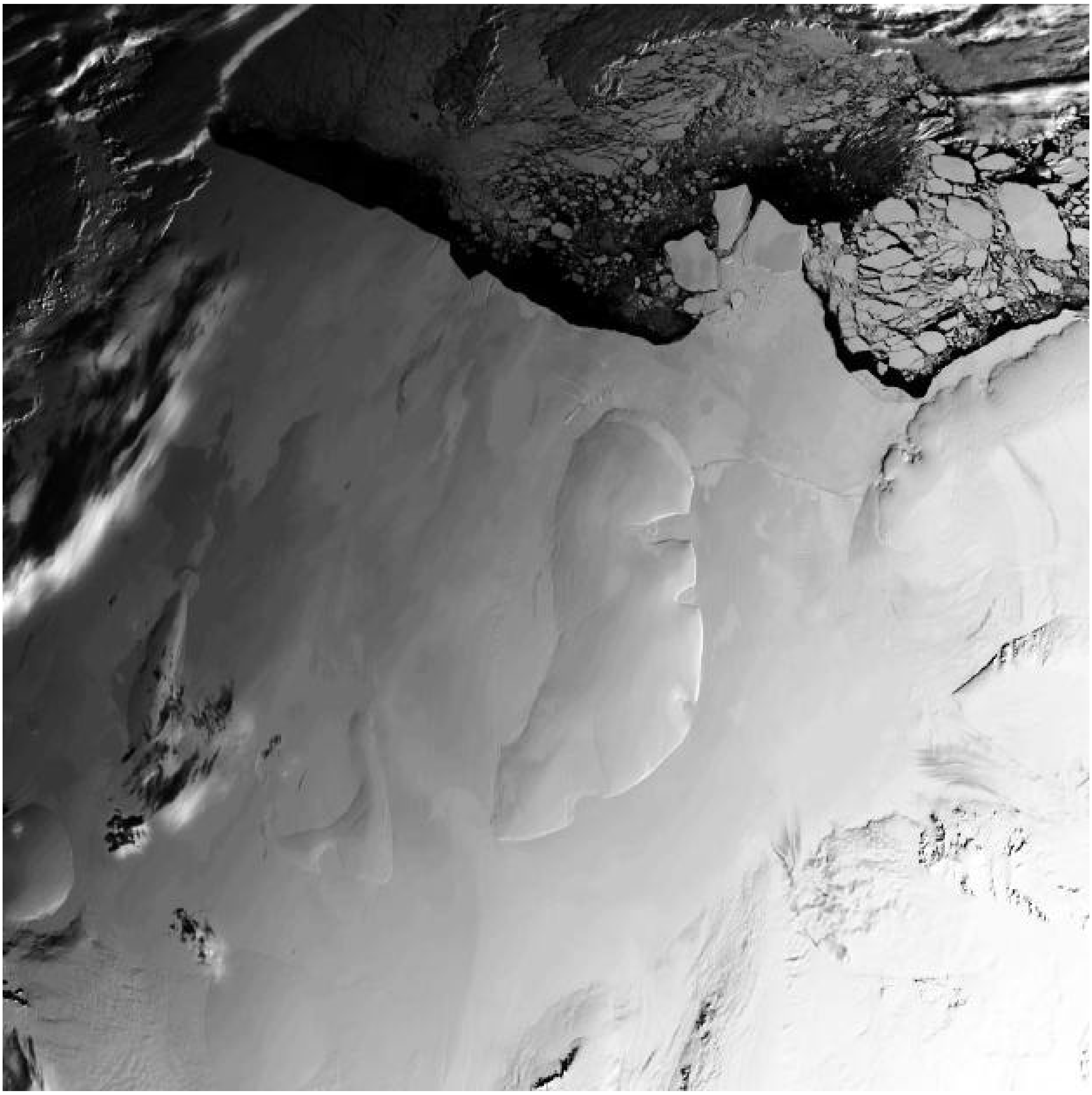


Fig. 4.3f. A 1 km resolution, visible image of Berkner Island and the eastern Ronne Ice Shelf showing the topography.

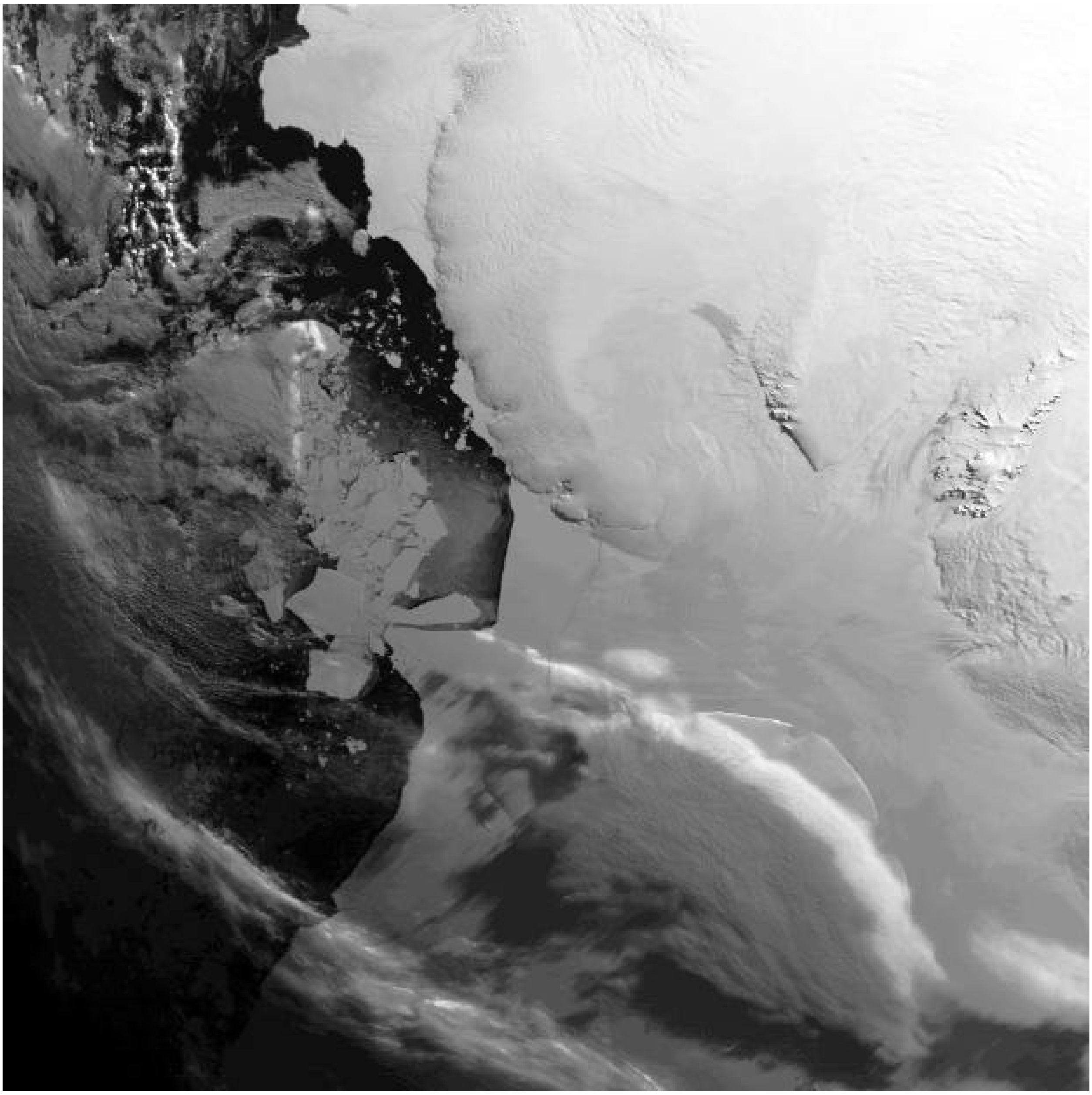


Fig. 4.3g. A 1 km resolution, visible image of Halley, Dronning Maud Land and the eastern Ronne Ice Shelf showing the topography and the Shackleton Mountains.

Fig. 4.4a. A 1 km resolution, visible image of Alexander Island, King George VI Sound and the Adelaide Island.

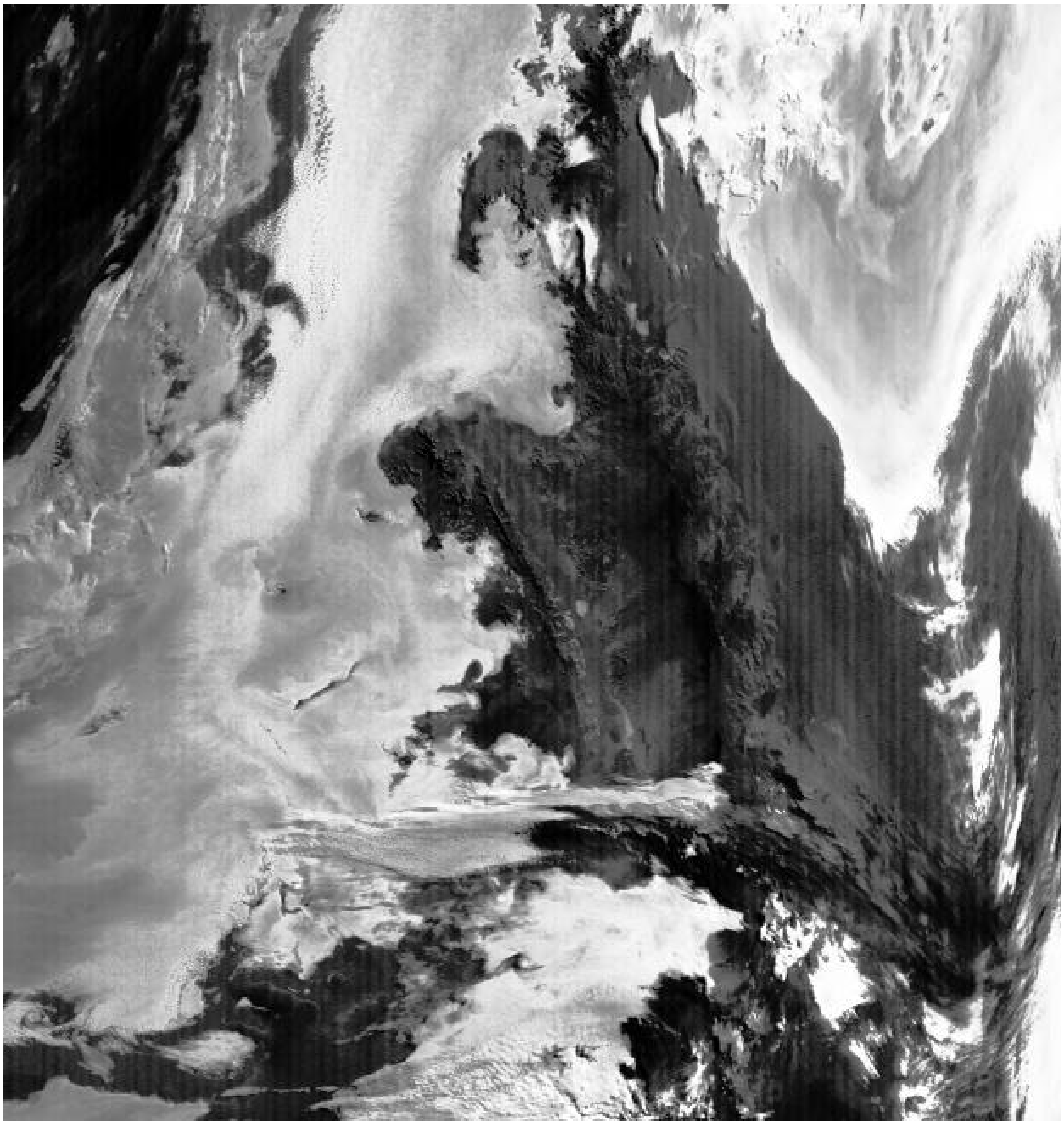


Fig. 4.4b. A 1 km resolution, channel 3 (3.7 µm) image for the same time as that in Fig. 4.4a. Cloud composed of water droplets appear light, while ice cloud and the ice surface appear black.

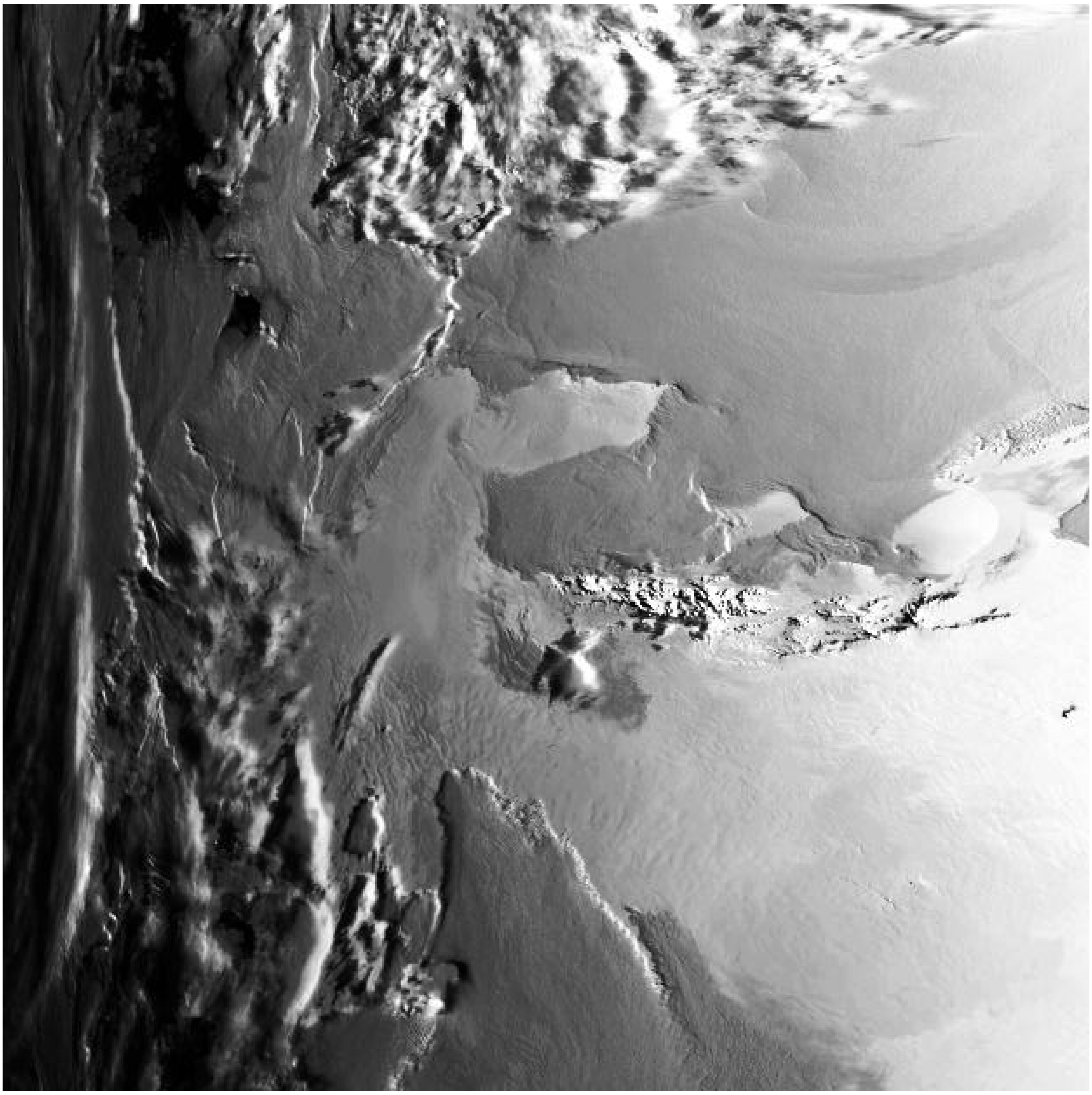


Fig. 4.4c. A 1 km resolution, visible image of the Ellsworth Mountains region. The mountains have the highest reflectance while the surrounding ice appears darker. The low cloud, like many clouds in the Antarctic, is darker than the snow surface, since the cloud droplets are large.

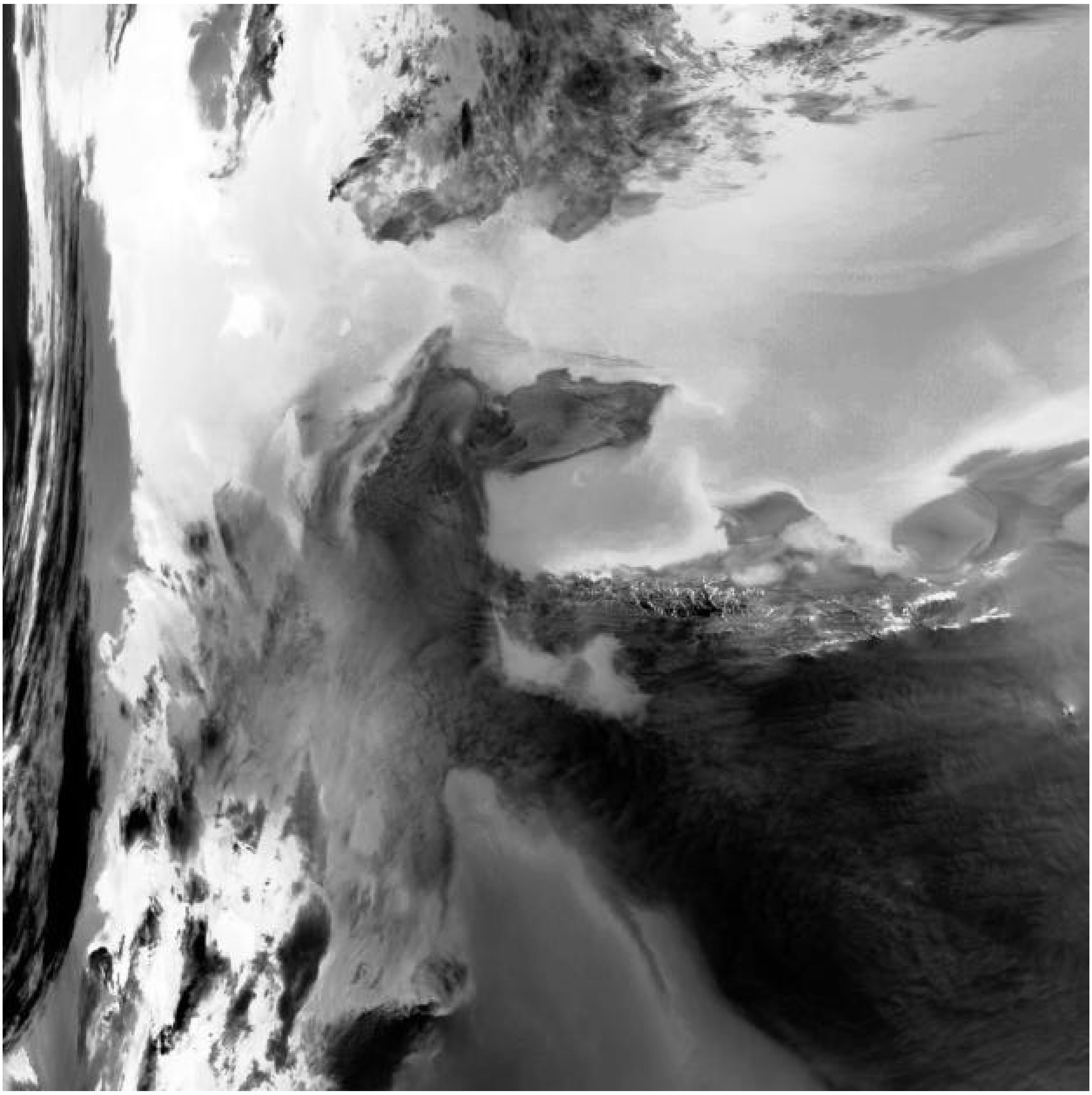


Fig. 4.4d. A 1 km resolution, channel 3 (3.7 µm) image for the same time as that in Fig. 4.4c. The high reflectance of the cloud indicates that it is composed of super cooled water droplets.

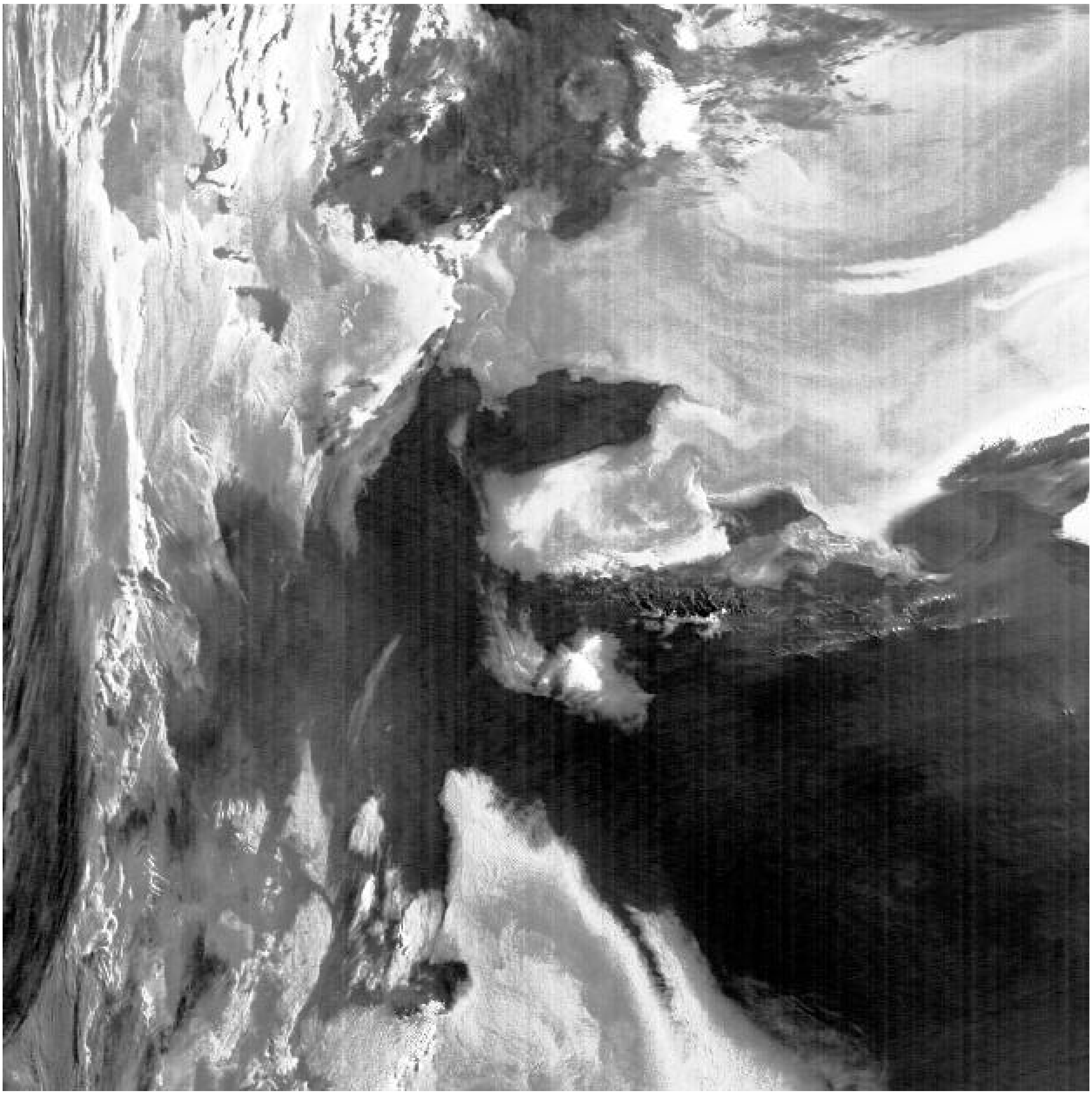


Fig. 4.4e. A 1 km resolution, infrared image for the same time as that in Fig. 4.4c. The cloud appears light, indicating that it is colder than the ice surface. However, the coldest cloud is on the western side of the image.

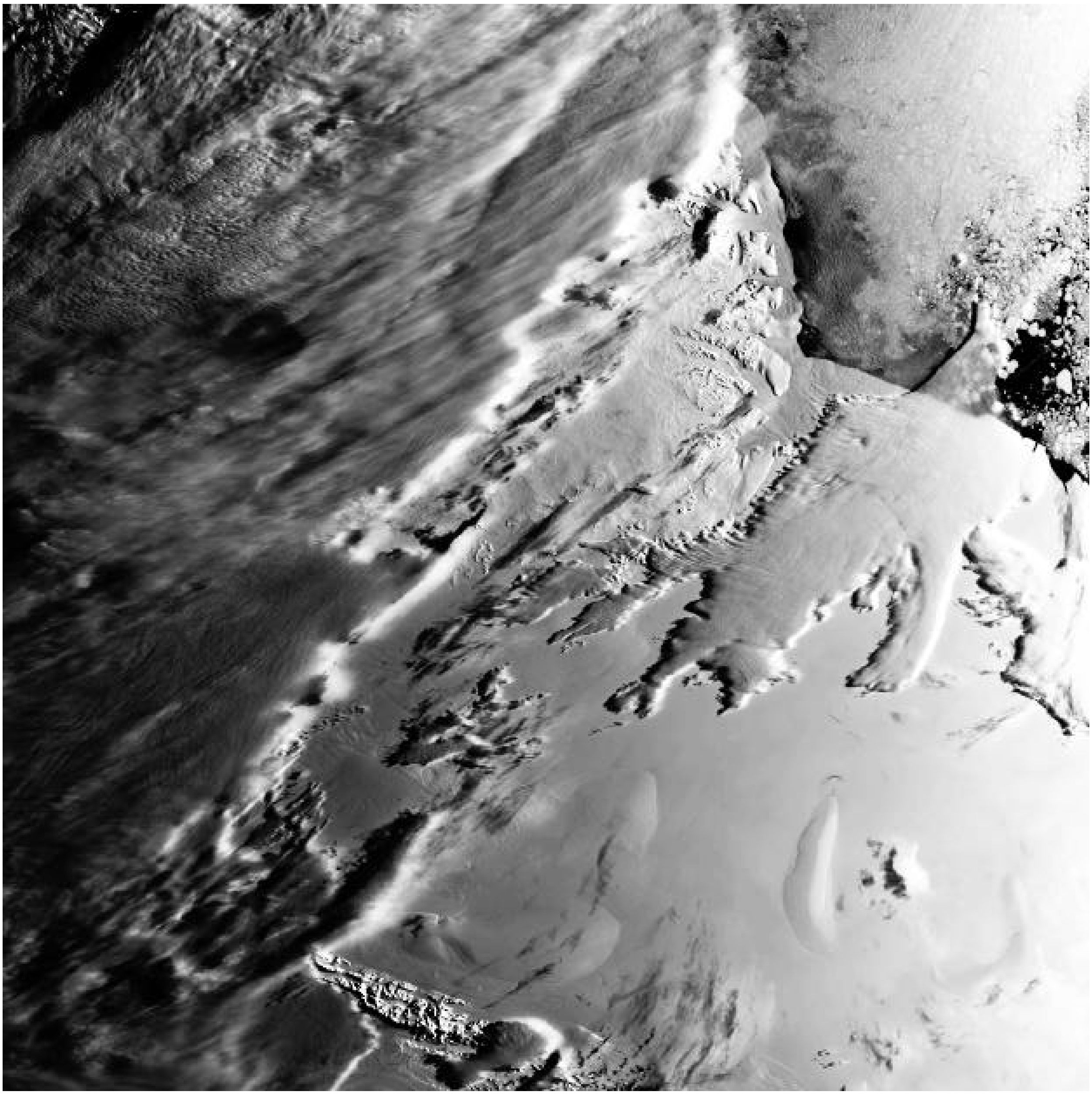


Fig 4.5a A visual image showing the southern part of the Peninsula around Sky-Blu. The extent of the lower level cloud is rather difficult to determine from this image.

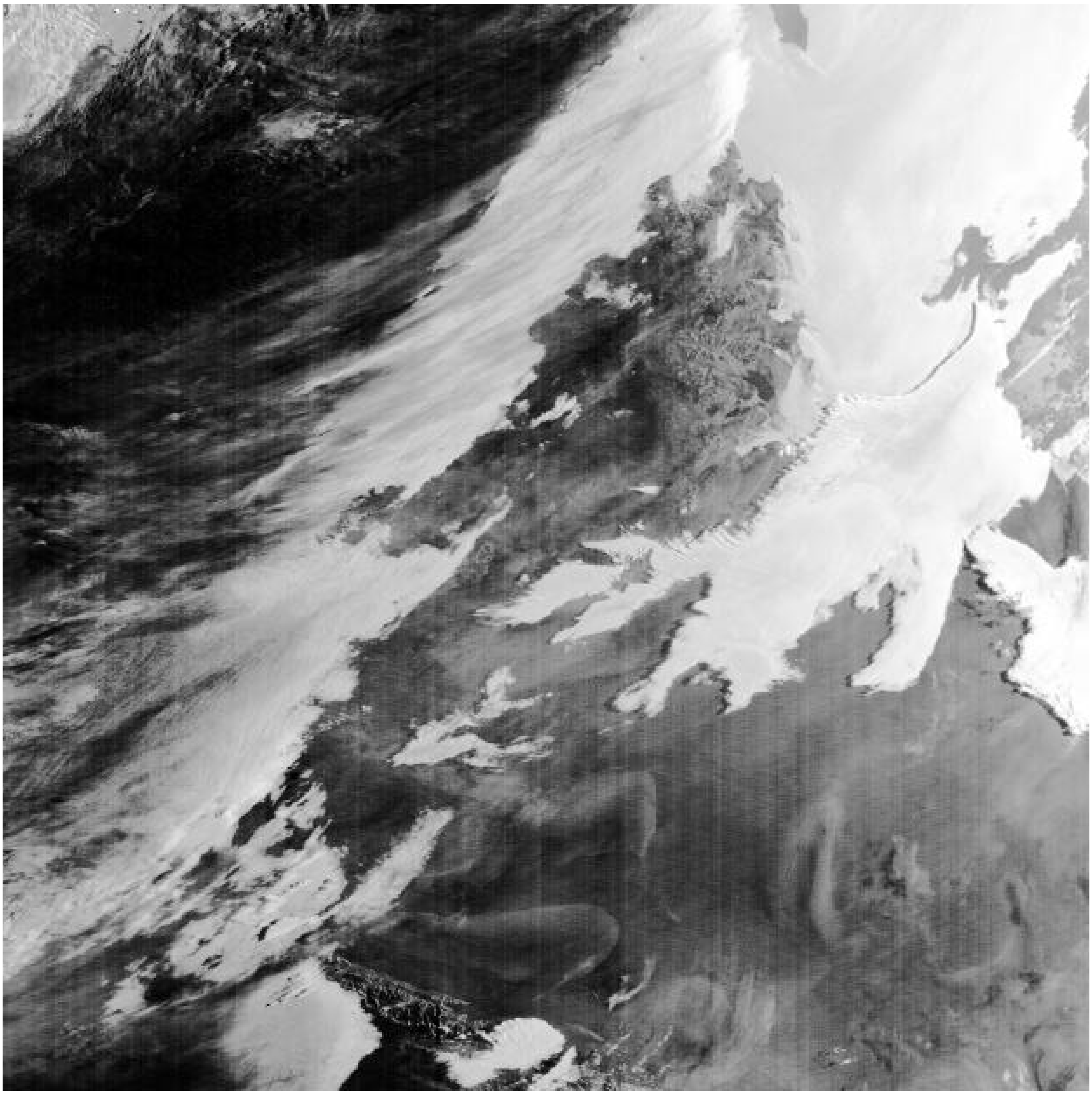


Fig 4.5b A channel 3 image showing the same area as Fig 5.2a but this time the extent of the lower cloud is much easier to determine, even through cirrus is present.

SECTION 5

FORECASTING FOR THE ANTARCTIC PENINSULA AREA

5.1 Synoptic Scale Depressions

Large pressure systems are generally handled well by the model. Although the topography of the Peninsula is crudely represented in the model, it does recognise it as a barrier and often doesn't correctly move depressions across the Peninsula but instead develops a new system on the Weddell Sea side. Often depressions to the west of Rothera will move east-southeast to become slow moving near Alexander Island where they steadily fill, although areas of snow/showers can still be generated by these old lows, even when in their death throes and leave a lot of cloud to the west of the Peninsula. Although not common, depressions can cross the coast into the continent and remain as identifiable features for days. One of these occasions was on the 8-9 January 1995 when a low moved south, to the west of Sky-Blu, producing 50-60 kt winds at both Fossil Bluff and Sky-Blu and still remained identifiable as a vortex at 80° S. It subsequently filled very quickly but left a legacy of rather persistent cloud for the field parties to endure. This event is shown in Fig 2.3.

5.2 Mesoscale Systems

Some of the heaviest and most persistent precipitation in summer has come from mesoscale systems, which on more than one occasion produced significant snowfall at Rothera such that runway clearance was necessary. However, the occurrence of very active mesoscale systems is very variable from year-to-year. Sometimes the global model can pick up or develop these small-scale systems. Otherwise the model often hints at the areas where these systems may develop by producing locally increased thickness gradients poleward of the main polar front and small thermal troughs, which at first may appear to be almost random drawing of the thickness lines, particularly in the area around the southern Peninsula. An example of a small cold pool that gave precipitation is shown in Fig 5.1. Experience would suggest that these small thermal troughs should not be ignored as several mesoscale systems have developed in association with them. Once the likely area of development has been identified then confidence in a forecast can increase if cloud development is seen on satellite imagery. Without these hints from the model it is almost impossible to say which cloud on the satellite images will produce precipitation.

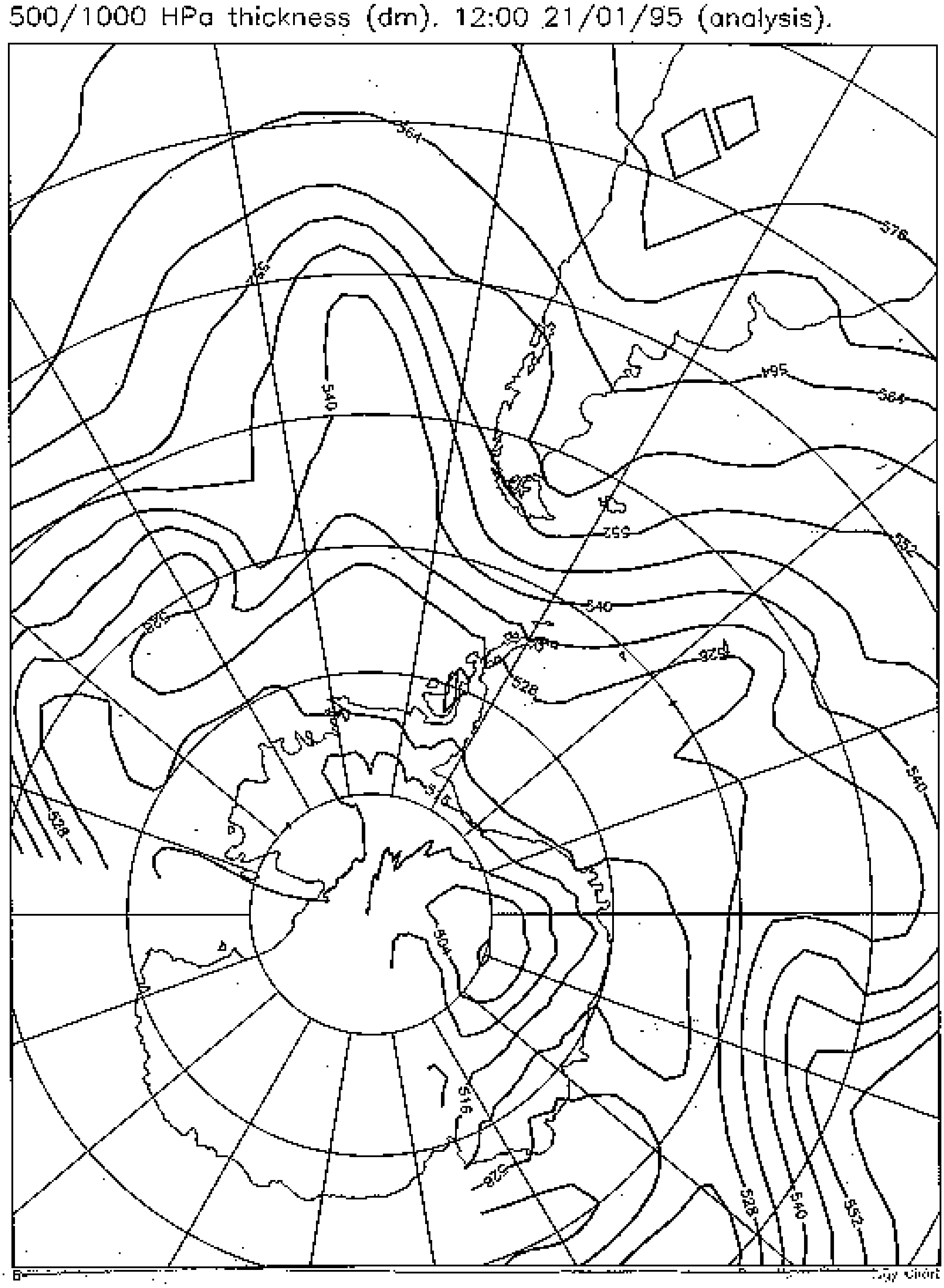


Fig. 5.1. The 1,000-500 hPa thickness chart for the occasion when a small cold pool and thermal trough over Alexander and Adelaide Islands resulted in significant snowfall at Rothera.

5.3 Fronts

Some large-scale fronts give enough precipitation to reduce visibility and cloud base to affect aircraft operations, e.g. 12-14 November 1995. Although fronts will move across the Peninsula, they have, on several occasions, left a band of cloud on the western side which has prolonged the precipitation and delayed frontal clearance by several hours. An example of this situation is shown in Fig. 5.2. The delayed frontal clearance can sometimes allow the next front to reach the Peninsula before the previous one has cleared. On the other hand, some fronts do clear readily. Further research needs to be done to determine which fronts are likely to clear quickly and which will leave a residual band of cloud and precipitation on the west side of the Peninsula.

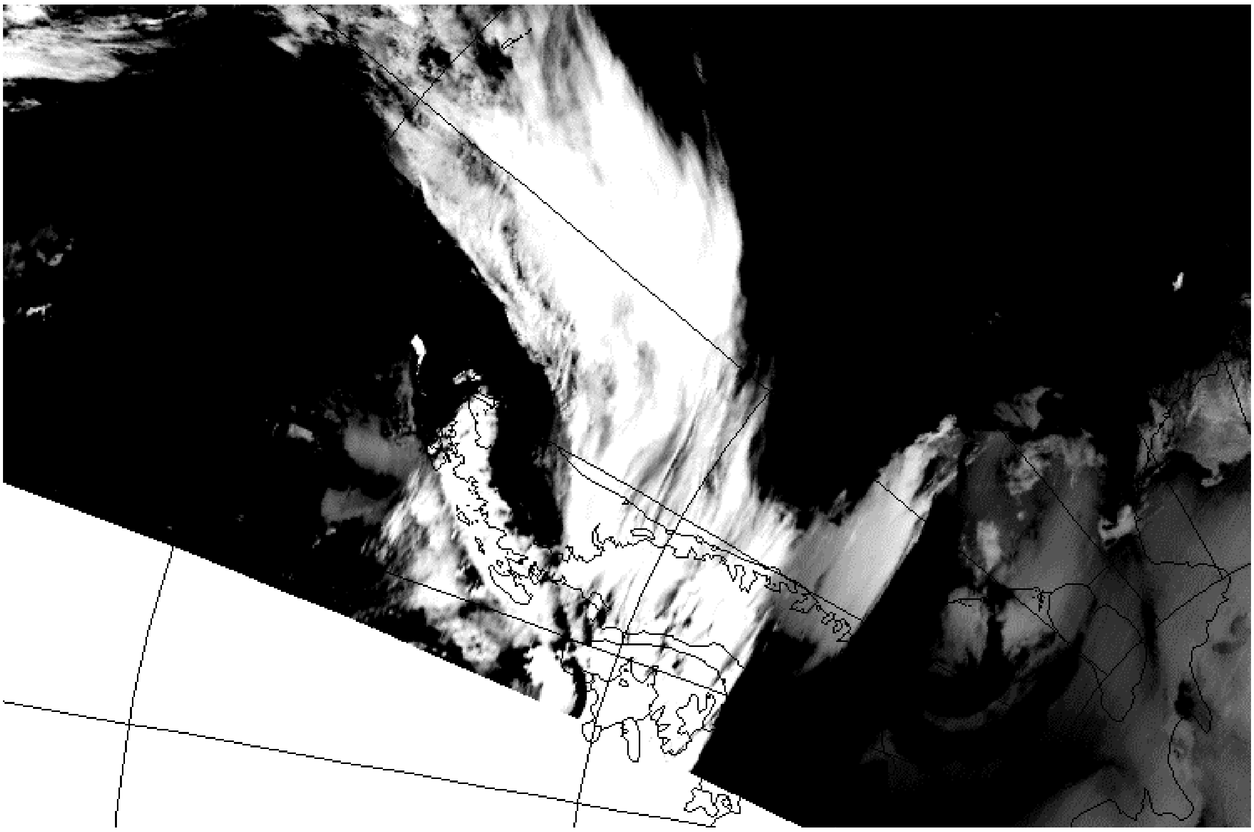


Fig 5.2 An infrared image from 21:47 GMT 19 January 1995 showing a band of cloud trapped on the western side of the Peninsula after the passage of a cold front. This cloud produced a good deal of precipitation and delayed the cold frontal clearance by several hours.

5.4 Predicting the Main Weather and Oceanographic Elements

5.4.1 Winds

Generally speaking northerly winds bring mild, moist air southwards, whereas southerly winds tend to bring dry, cold air northwards. However, a lookout needs to be kept for returning maritime air on a southerly or returning continental air on a northerly. Figure 5.3 is an example of returning continental air from the north which brought improving conditions southwards down the western side of the Peninsula, particularly at Fossil Bluff where there had been quite poor conditions for some days. It should be noted that the cold front caused even poorer conditions, in terms of cloud lowering to the surface and visibility falling to fog limits for a time at Fossil Bluff as the front moved southwards.

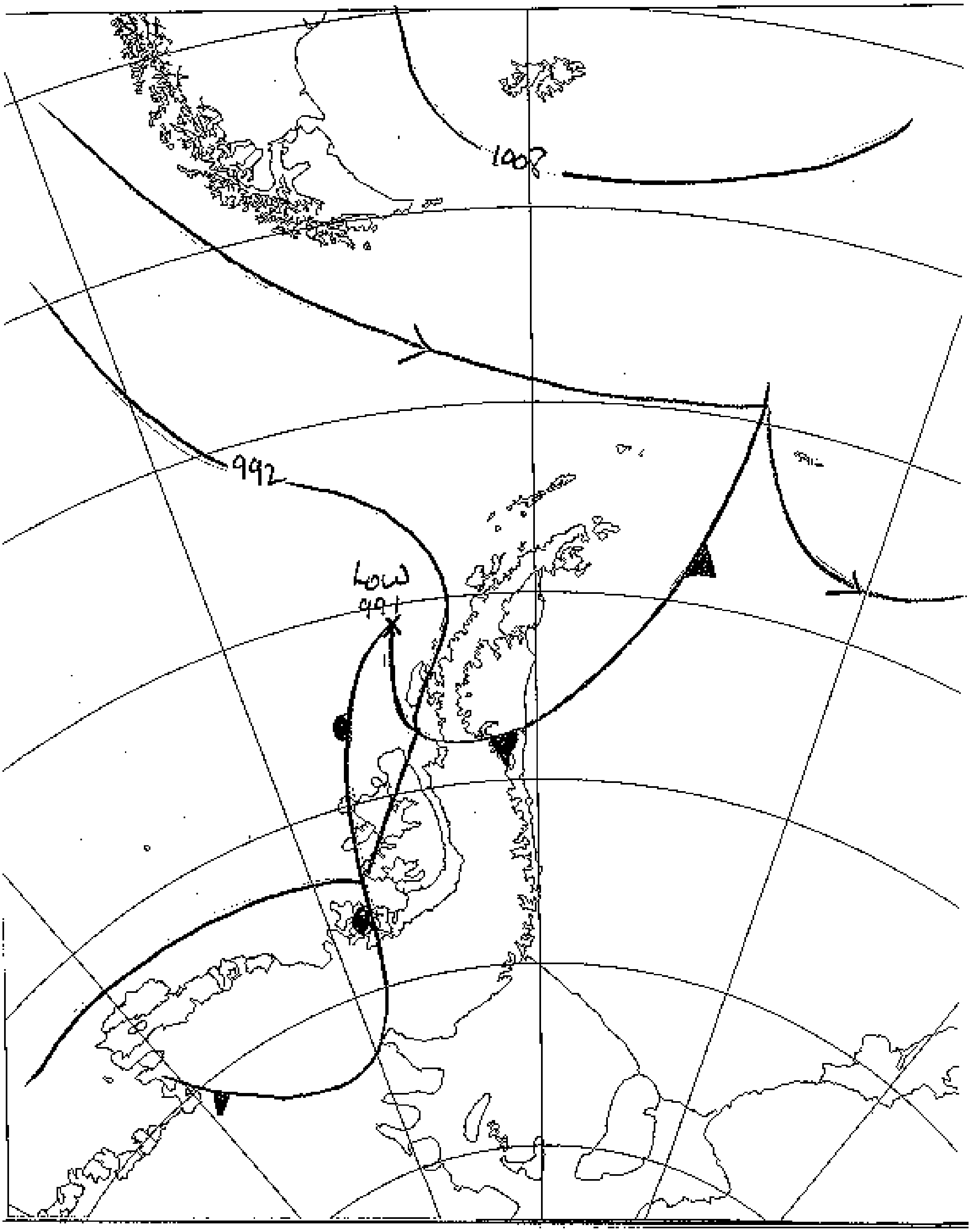


Figure 5.3. Surface analysis at 1200 GMT 3 December 1994.

Needless to say winds are heavily influenced by the local topography and it is almost impossible to accurately forecast winds for a particular locality without detailed local knowledge and experience. Hence in field party forecasts only general winds can be given, based on the synoptic flow predicted by model MSLP fields. Additional information may be gained via careful analysis of high-resolution satellite images. Cloud movement and wave effects in cloudsheets will give an indication of the current wind.

Barrier winds are a phenomenon on the eastern side of the Peninsula and are well described by Schwerdtfeger (1984). This barrier wind effect is a result of the piling up of cold low-level air created over the Ronne and Filchner Ice Shelves and then advected towards the Peninsula on the climatological easterly winds that affect Antarctic coastal areas. The resulting thermal and pressure gradients create a surface wind parallel, in a generally southerly sense, to the mountain barrier of the Peninsula.

Katabatic winds are common, particularly down the numerous glaciers. Foehn winds are less common but do occur, quite strongly at times, on the western side of the Peninsula as again described by Schwerdtfeger. They are less common in the east. Normally the air on the eastern side of the Peninsula is very cold and dense and on most occasions is prevented from reaching the west due to the topography of the Peninsula. However, Schwerdtfeger suggests that even in these conditions a Foehn wind can develop down western slopes, providing that the pressure difference across the Peninsula is at least 8 hPa and this having been maintained for 12 hours. Foehn Winds also develop under different circumstances i.e. when depressions become slow-moving near the tip of the Peninsula (see Fig 5.4), advecting warm and less dense air southwards down the eastern side of the Peninsula, resulting in a quite strong wind developing down the western slopes, helped by the general easterly gradient across the Peninsula. (see Section 6.1). An easterly gradient can give locally very strong surface winds on the western slopes, with ‘mistral’-type winds developing as the wind funnels down through the valleys and fjords running roughly perpendicular to the spine of the Peninsula, examples of which occur both at Rothera and at San Martin.

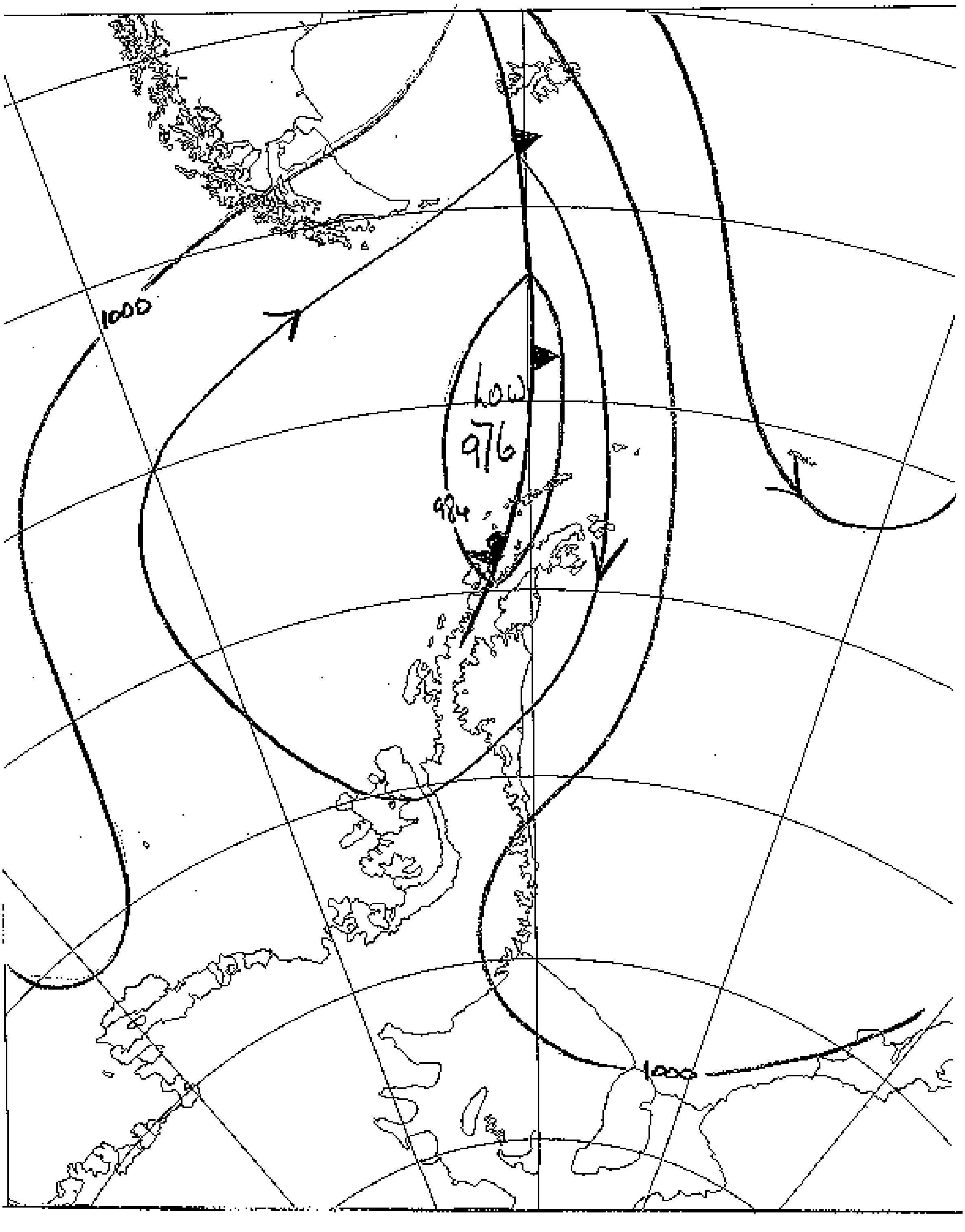


Fig. 5.4. Surface analysis at 1200 GMT 31 January 1995.

5.4.2. Clouds

Although some balloon ascent data are available, the obvious tool for forecasting cloud is the satellite imagery. Cloud tops are subjectively estimated from their temperatures on infrared images. Again topography plays a major part in the generation of cloud. The only way detailed cloud forecasts can be provided is by studying the high-resolution imagery available from the ARIES system and using a nowcasting approach combined with knowledge of the larger scale synoptic developments from the modelled fields available on Horace.

The most common type of cloud observed around the Peninsula is stratocumulus, with a base of around 2,000 to 6000 ft AMSL and tops of 5,000 to 8,000 ft. Stratiform cloud is also very common at all levels between the surface and 10,000 to 15,000 ft although the layers are often thin. Dense frontal cloud affects the Peninsula at times, particularly in the north, though dense upper cloud above 18,000 ft is uncommon. The topography of the Peninsula plays an important role in determining cloud heights, particularly when the prevailing wind is zonal. For instance, in an easterly wind it is very unlikely that significant cloud will form below the level of the mountains on the western side, due to subsidence and subsequent drying of the air.

The wave pattern apparent in cloud sheets indicates lenticular clouds, which can be a very valuable guide to where turbulence is present.???

Cumulus cloud does seem to be a little more common in the Peninsula area than perhaps one would think. Cumulus cloud streets can be seen on satellite pictures over the sea when cool continental air flows out over the warmer sea. Well-developed convective cloud can sometimes be seen on satellite pictures, and cumulonimbus clouds have been observed at Rothera (Fig 5.5) and at Vernadsky. *A thunderstorm was recorded at Vernadsky on 1995 January 27.* The tephigram for 2 March 1995, shown in Fig. 5.6, illustrates the degree of instability that can be present as far south as Rothera. On the 11 February 2001 satellite imagery showed convective cells with cloud tops at around –50° C near the Haag nunataks, associated with a minor mesocyclone, demonstrating that such cloud can be found some way inland on rare occasions.

Fig 5.5 Cumulonimbus observed from Rothera on 6 November 2000.

Cloud top heights are derived from the cloud top temperature facility on ARIES. When forecasting for mid-latitude regions (e.g. for flights to and from the Falklands), the CTTs can be compared with model fields on Horace, radiosonde data or with a standard atmosphere to derive heights. Otherwise the technique used is to compute the temperature difference (ΔT) between the surface and the cloud top and divide this by a mean lapse rate of 0.6^{o} per 100 m (or roughly $2°$ per 1000 ft) e.g. with a temperature difference of 12^{o} C the height is taken to be 2,000 m. Care must be taken to assume a sensible sea surface temperature as the CTT of a sheet of cloud extending from an ice shelf over the sea remains the same although the surface temperature changes significantly. The pilots confirm that heights computed by this method are generally correct.

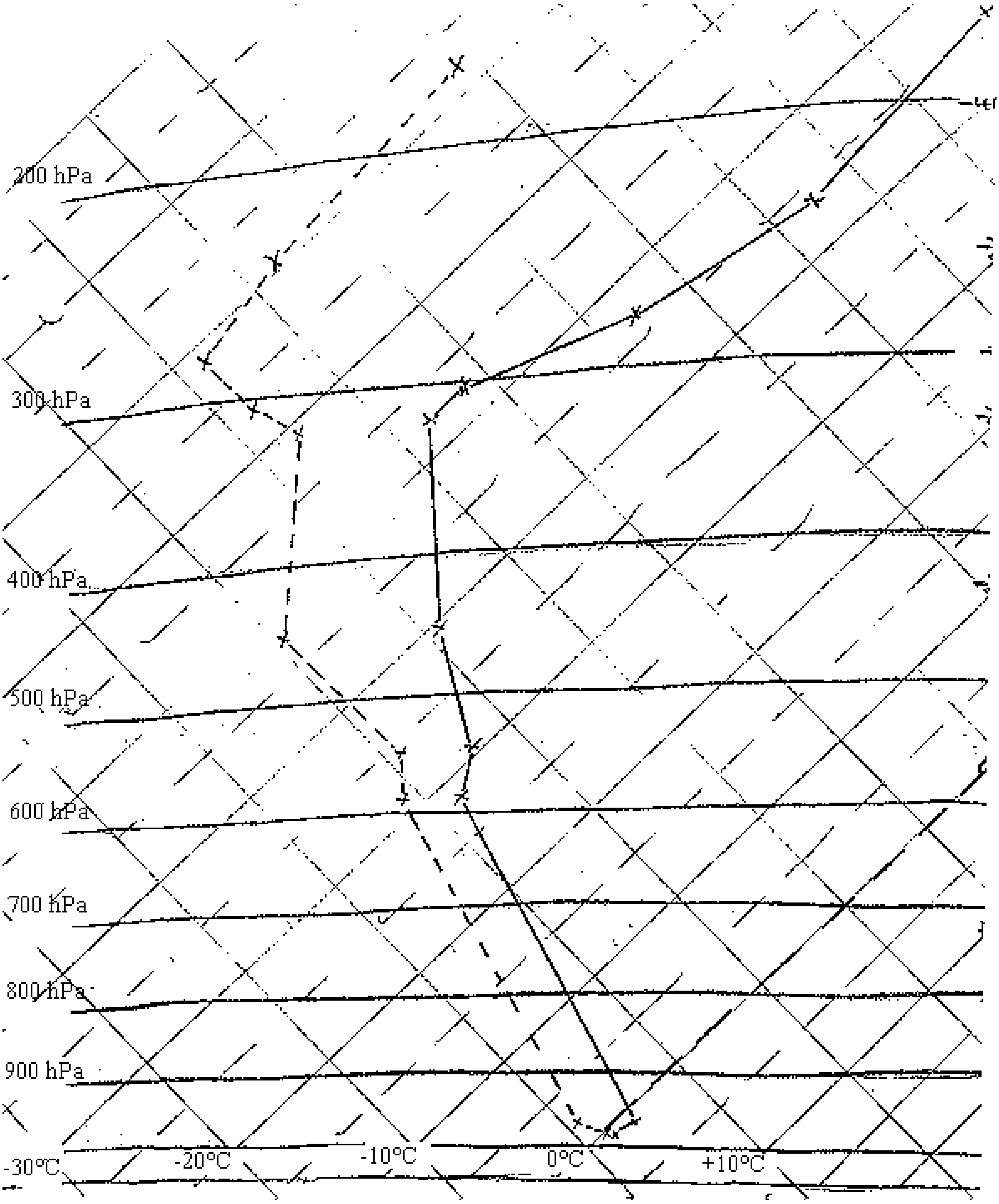


Fig 5.6 Tephigram showing unstable air to 600 hPa at Rothera at 2000 GMT on the 2 March 1995.

5.4.3. Visibility

Visibility is generally extremely good, so much so that the judging of distance is very difficult with mountains and islands appearing much nearer than they actually are.

Fog is common around the northern parts of the Peninsula but even in the south fog will form during periods of light winds and clear skies when maritime air has been advected from the north and then stagnates. Fog can also occur in a returning maritime airmass from the south (unlike a true southerly continental). Such a case is shown in Fig 5.7.

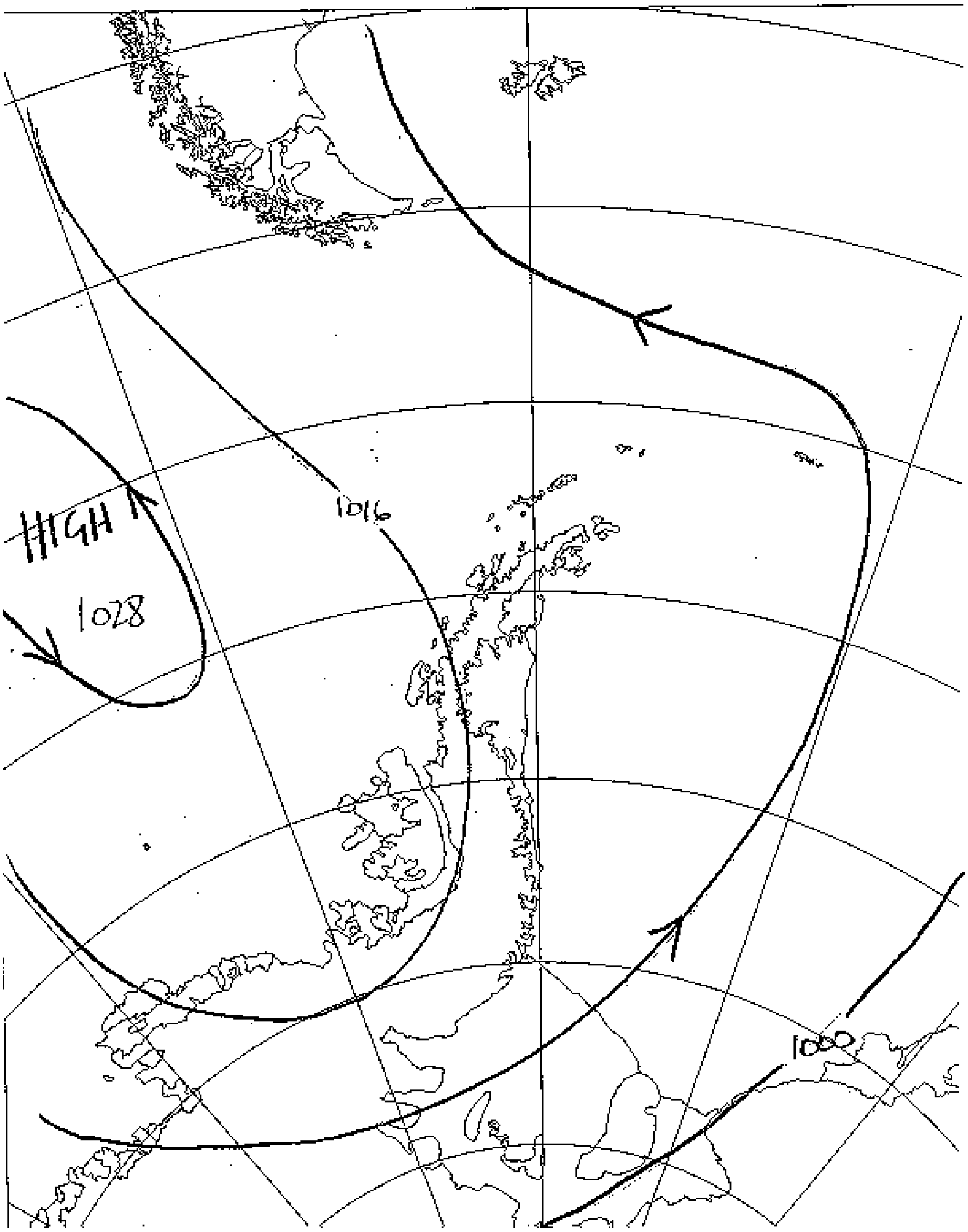


Figure 5.7. Surface analysis for 1200 GMT 20 February 1995 showing returning maritime air along the western side of the Peninsula, which resulted in extensive fog under light gradient conditions.

Blowing snow will also affect the visibility quite markedly, into fog limits at times, but only to a relatively shallow depth of a few tens of feet and the airborne visibility will remain quite good, providing there is no falling snow. To determine if snow is actually falling during a period of blowing snow is often very difficult, but very important from an aviation point of view and indeed from a meteorological point of view. However, with your back to the wind and with careful observation it is often possible to see some larger flakes of snow amongst the smaller but more numerous elements of the blowing snow, indicating that snow is actually falling from the cloud above. It is also possible to hear the larger snowflakes hitting your hood. As a rough guide, blowing snow i.e. snow blowing above head height (snow below head height is classed as drifting snow) can be expected to begin with speeds of 20 kts or more, although greater wind speed is needed to lift snow from a warm surface.

Visibility is predicted for the ships in very much the same way as for any other ocean area, taking into account the sea surface and air temperatures, wind speed and continuity. The Antarctic Convergence, where there can be a rapid change in sea surface temperature over a fairly small meridional distance, is particularly prone to fog.

5.4.4. Precipitation

Precipitation over the Antarctic Peninsula is most frequent in the spring and autumn, while summer and winter are relatively drier. Precipitation is usually in the form of snow in the south but often as rain in the north in summer. However, it should be noted that rain can occasionally occur in winter as far south as Rothera. The only real guide to precipitation type is the thickness field, with values of greater than 528 dm indicating rain. During summer this proves to be a reliable way of predicting whether precipitation would be of rain and snow. Values as high as 540 dm can occur during most summers, with rain falling under such conditions.

As already stated, cumulus cloud is perhaps not as rare as one might think. Certainly genuine showery airstreams have been identified as far south as Rothera on south westerly, westerly and north westerly airstreams.

Most solid precipitation is in the form of snowflakes although on the odd occasion precipitation has been in the form of snow grains, diamond dust or soft hail. Light snow can fall out of cloud as thin as 1,000ft. This seems to mainly occur in light wind situations. Freezing rain and drizzle is relatively common across the far north of the Peninsula (e.g. on King George Island), but is rare occurrence further south.

5.4.5. Other elements

The surface contrast - the ease with which surface features can be distinguished - is a very important parameter, not only from the aviation point of view but also for field parties travelling through crevassed areas or areas where there are relatively large sastrugi. The cloud cover affects the quality of the contrast. An opaque layer of water droplet cloud produces the worst conditions, often called 'white out'. Drum-lines or flags at some landing sites help to alleviate the problems caused by poor contrast.

Horizontal definition is the ease with which the boundary between the ground and the sky can be determined. It is a parameter most appropriate over ice shelves or areas where there are no mountains or nunataks visible. As with surface contrast, the horizontal definition is affected by the cloud cover with an opaque layer of water droplet cloud producing the worst conditions. The presence of clear water leads off an ice shelf may be an important element in enhancing the horizontal definition in these areas.

Most cases of low contrast and horizontal definitions occur in snow-covered areas without surface features, though it should be noted that under certain conditions, definition can be lost between sea and sky also. See Appendix A for definitions of the levels of contrast and horizontal definition.

The cloud below cirrus levels is mixed phase clouds composed of both water droplets and ice crystals. Even in very low cloud and fog as far south as the Ronne Ice Shelf usually contains water droplets. Hence airframe icing is common, but because of the low temperatures and hence generally low water content of the cloud, most icing seems to be light. However, moderate icing is not uncommon, indeed severe icing has been encountered in the past in shallow low cloud with a temperature of -20^{o} C over the Ronne Ice Shelf. Although the -20^{o} C isotherm is often used in temperate latitudes as the limit for moderate icing, anything colder being regarded as producing only a light icing risk, it has been suggested that -30^{o} C may be more appropriate in the Antarctic. Nevertheless, limited observational data would suggest that significant icing conditions can occur in conditions not normally associated with moderate or severe icing in temperate latitudes. One severe icing event occurred between Sky-Blu and Fossil Bluff in the 1996-97 season when a Twin Otter reported quickly picking up 4-5 cm of clear ice as it descended towards the Fossil Bluff Skiway. The thickness chart showed a cold airmass (514 dm) over the Peninsula and there was a surface temperature of $-14°$ C. The thickness chart for 12 GMT 11 February indicated the invasion of a warm airmass from the northwest. This airmass moving over the colder and denser air in the lower levels introduced multilayered clouds with precipitation. This precipitation formed in the warm air and fell as liquid droplets through the colder air below, so becoming supercooled. When these droplets collided with the aircraft (or surface) they turned immediately to clear ice.

Overall, however, layered stratiform clouds dominate the Peninsula, hence aircraft are usually able to climb or descend to avoid any moderate icing encountered.

Temperature is the least important parameter as far as operations are concerned, but it is an element that can fluctuate by a surprising amount. Diurnal variations at Rothera in mid-summer, in sunny conditions, are of the order of 4-5 deg C. Advection, of course, also contributes to temperature change and most of the temperature forecasting is done subjectively based on airmass type.

5.4.6 Waves and Swell

Wind waves are computed from the model surface wind speed, and fetch or duration. Swell has to be estimated using knowledge of wind and wave conditions over the previous few days and the few available swell observations. A diagram allowing the estimation of deep water wave height from information on wind speed, fetch length and wind duration is shown in Fig. 5.8. Wave etc field information is available on Horace.

In practice, however, the mobility of systems over much of the forecast area (and certainly through the Drake Passage) often renders attempts to estimate wave height using simple nomogram techniques unrealistic without a lot of experience.

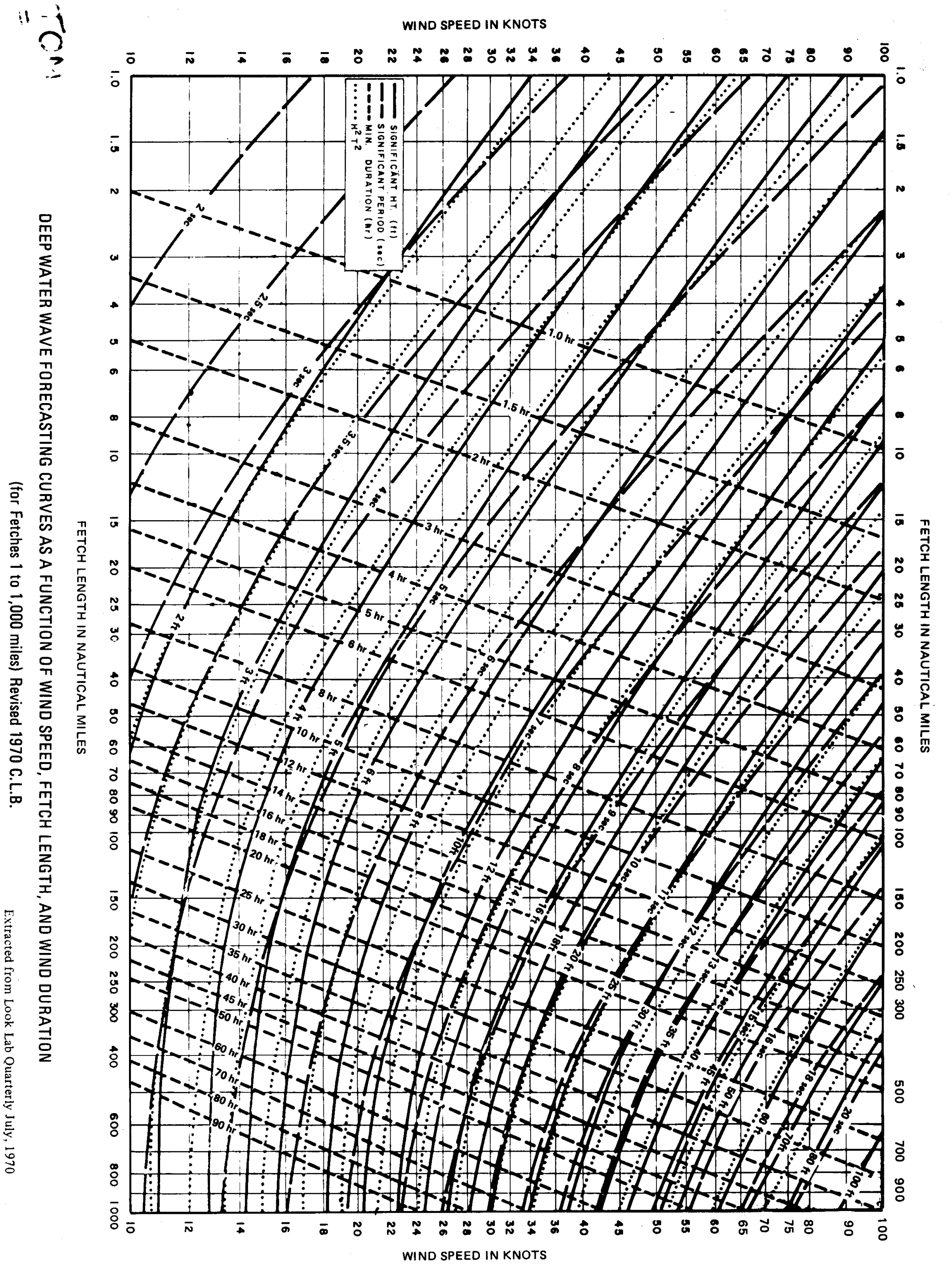


Figure 5.8 A diagram allowing the calculation of deep water wave height from information on wind speed, fetch length and wind duration.

SECTION 6

CHARACTERISTICS OF SPECIFIC AREAS VISITED BY BAS AIRCRAFT

The ski equipped Twin Otter aircraft may land almost anywhere there is flat crevasse-free terrain, but the following is a guide to conditions at some of the most often visited locations. Wind roses for places from which data are available are shown in Figs 6.1 to 6.7.

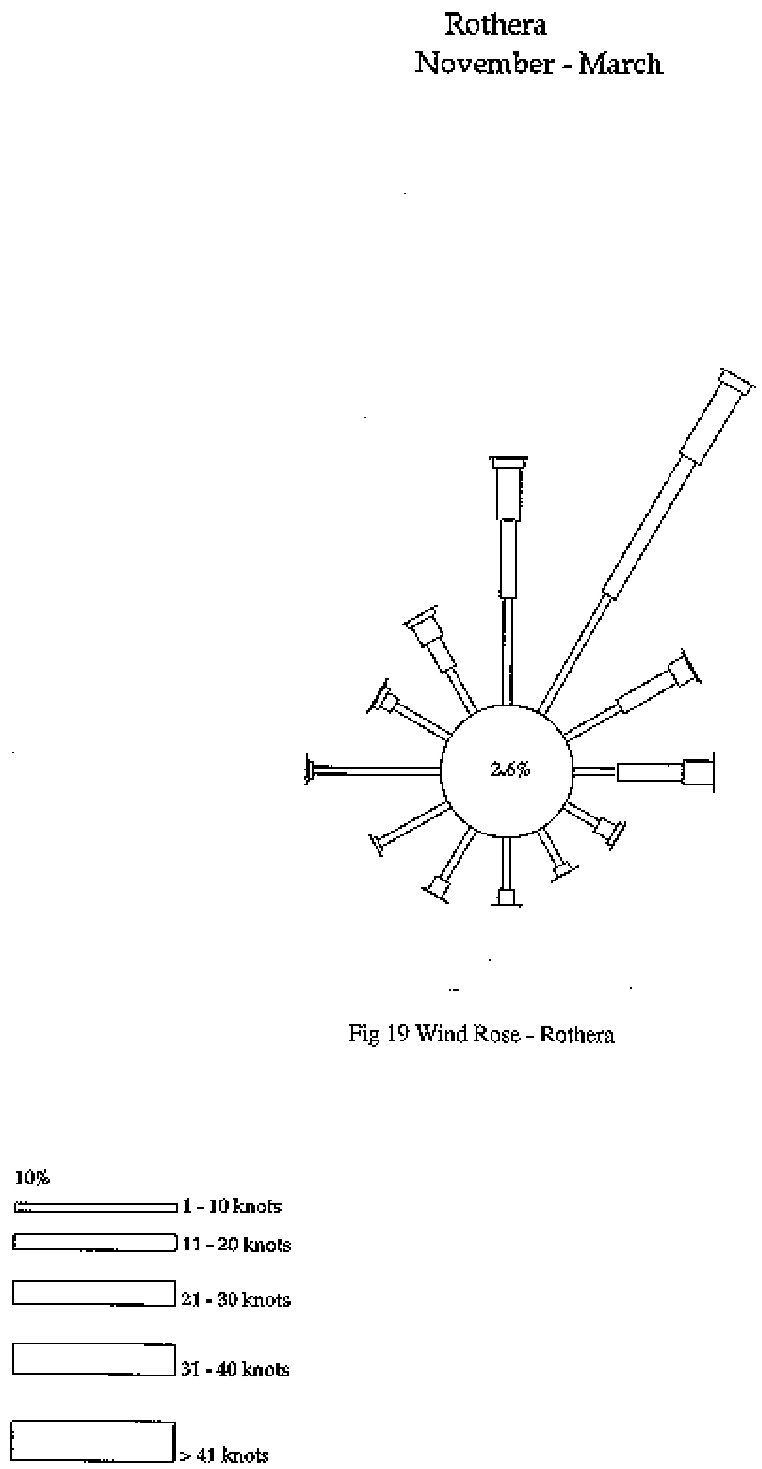


Figure 6.1. Wind rose for Rothera (November to March) based on data from all years.

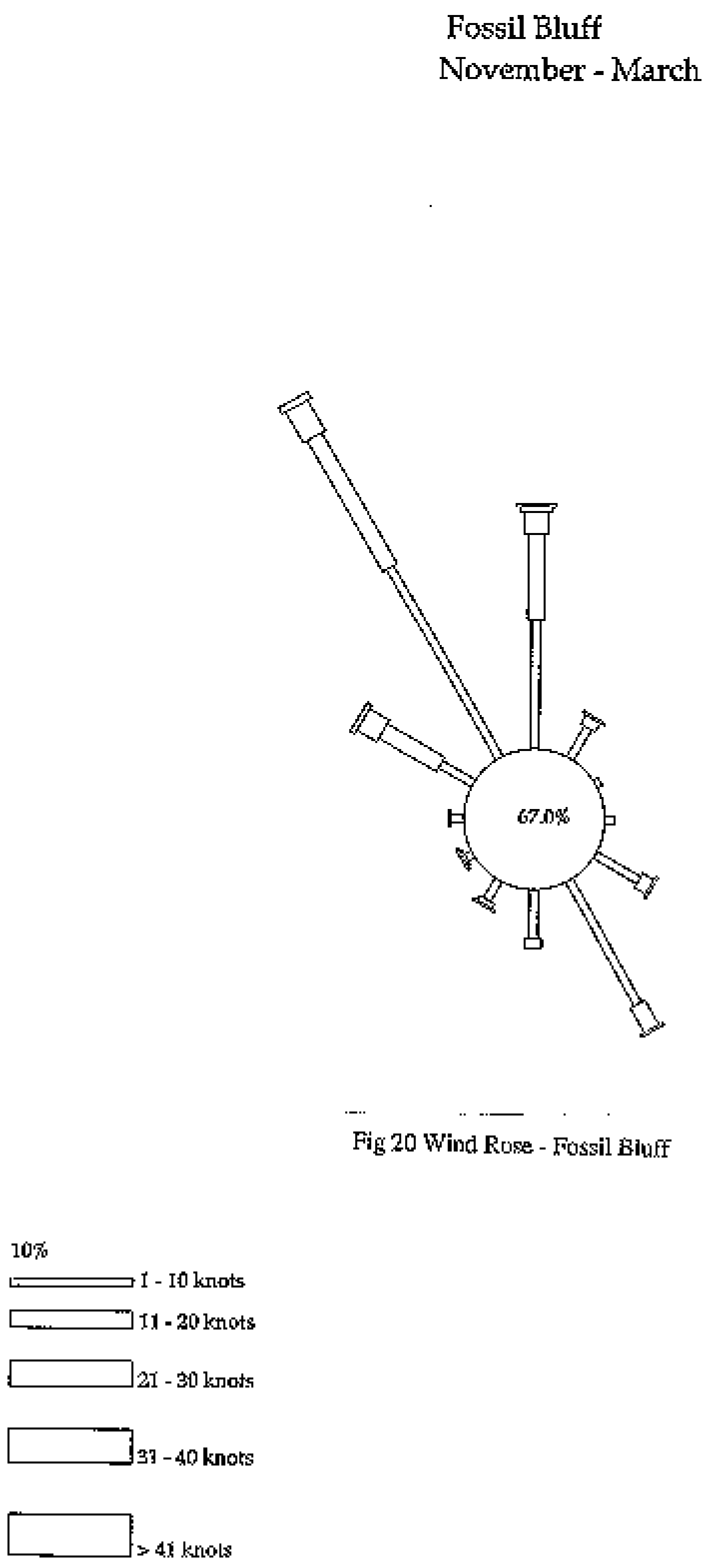


Figure 6.2. Wind rose for Fossil Bluff (November to March) based on data from all years.

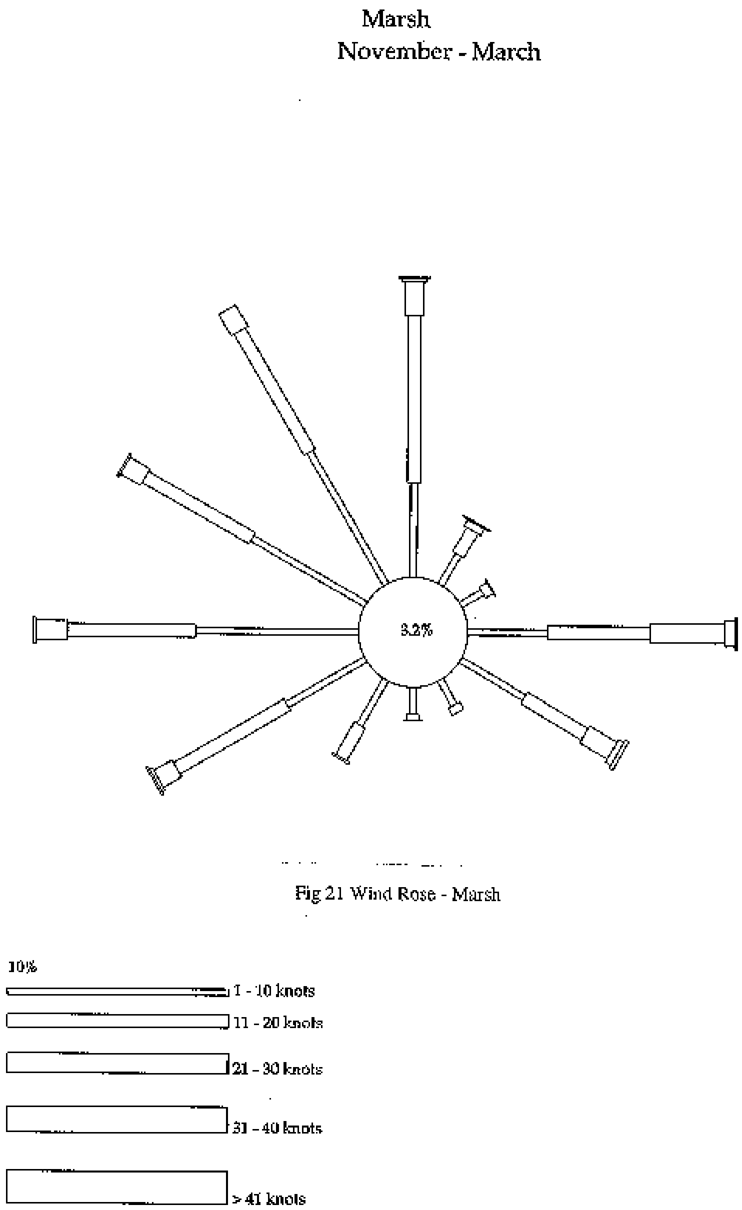


Figure 6.3. Wind rose for Marsh (November to March) based on data from all years.

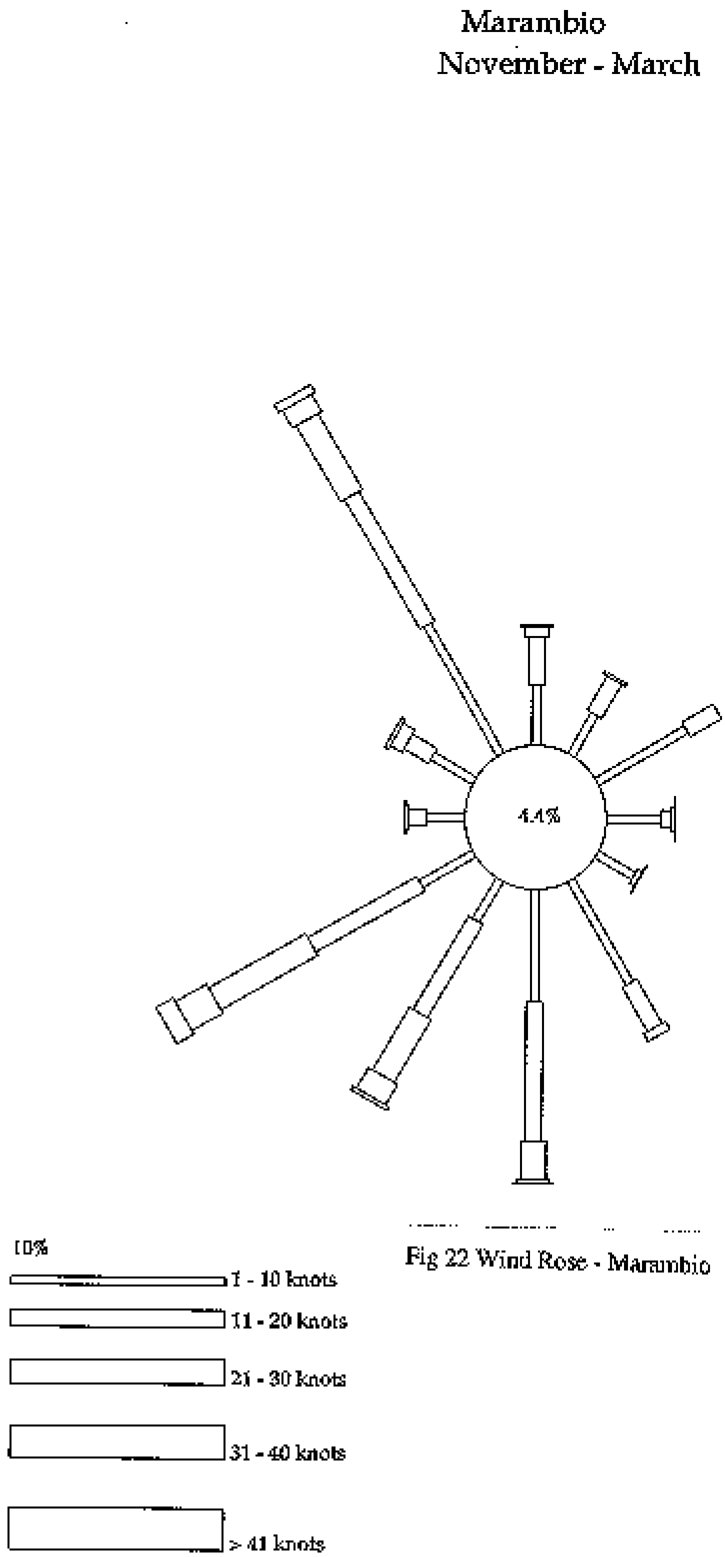


Figure 6.4. Wind rose for Marambio (November to March) based on data from all years.

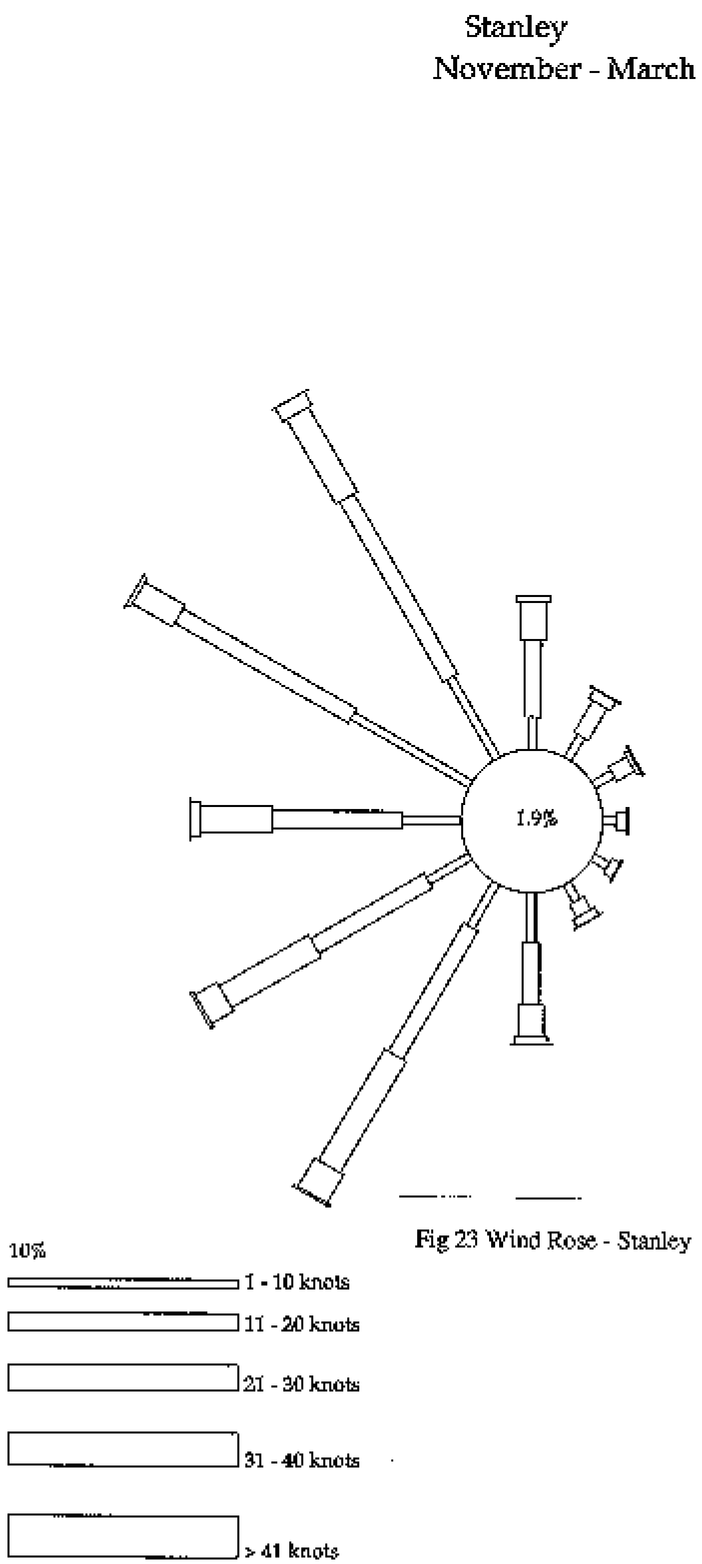


Figure 6.5. Wind rose for Stanley, Falkland Islands (November to March) based on data from all years.

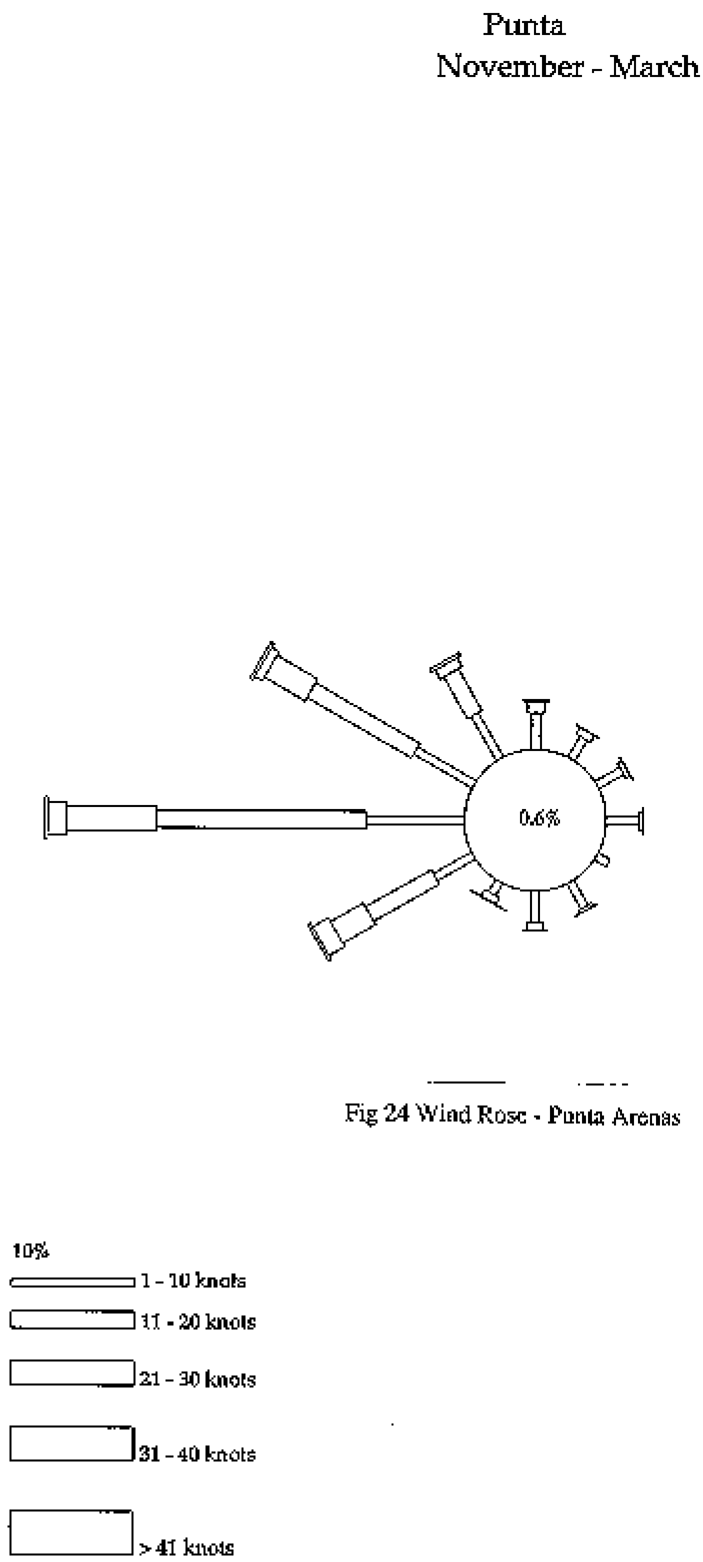


Figure 6.6. Wind rose for Punta Arenas, Chile (November to March) based on data from all years.

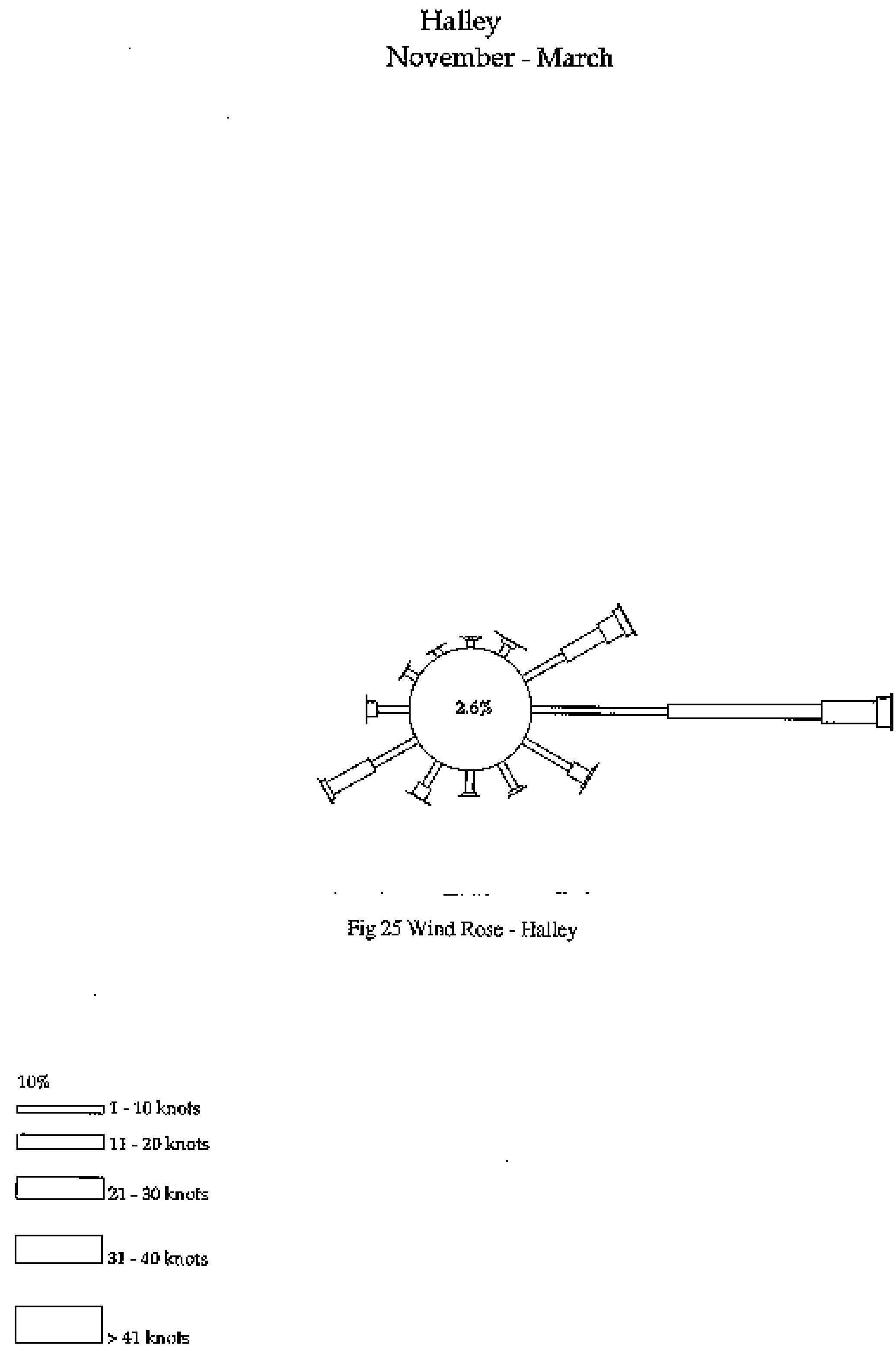


Figure 6.7. Wind rose for Halley Station (November to March) based on data from all years.

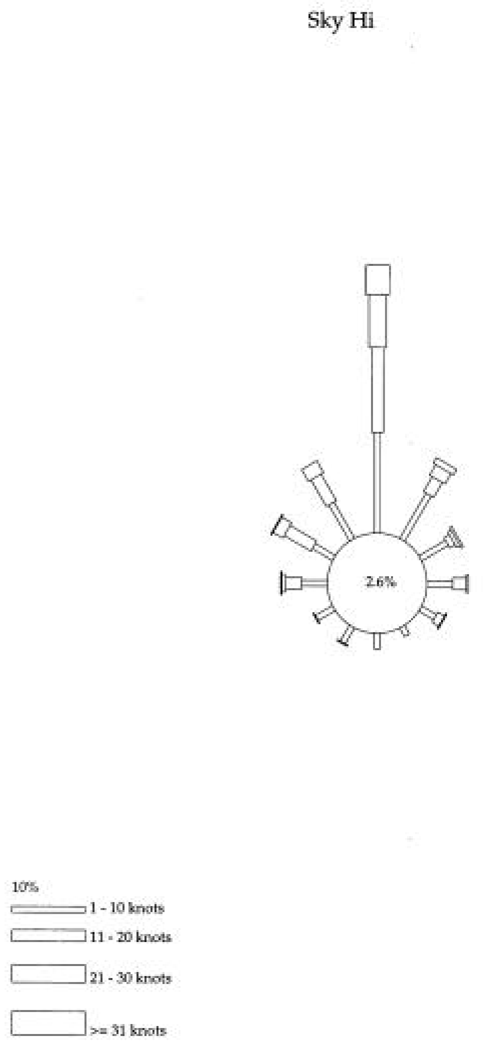


Figure 6.8 Wind rose for Sky-Hi (November to March) based data from all years. Sky-Blu data not yet available.

6.1. Rothera (see Fig. 6.9)

At Rothera, the surrounding terrain dictates that winds tend to be northerly or southerly, with northerly (340-040) being the most frequent direction. Certain directions within this range are favoured, with winds from 020 or 340 degrees true particularly common. The wind speed is often stronger with northerlies than the pressure gradient, or compared with speeds at other bases might suggest. There are two reasons for this:-

1. Funnelling through the Gullet and along the northern part of Marguerite Bay.
2. With pressure falling from the west and the Peninsula topography acting as a barrier to air movement, the pressure gradient between the mountains of the Peninsula and Adelaide Island may become stronger than indicated by the large-scale pressure field. This seems to be a frequent occurrence when the pressure gradient suggests a west or northwesterly wind the wind direction was often directly from the north.

Strong northerly winds usually result from major depressions in the Bellingshausen Sea. There have been occasions, however, when a strong west-east pressure gradient has failed to produce significant winds in these situations. This is presumably due to the shelter afforded by Adelaide Island from certain gradient wind directions, with different stability situations enhancing or diminishing this effect. Mountain wave activity can produce surges of wind speed.

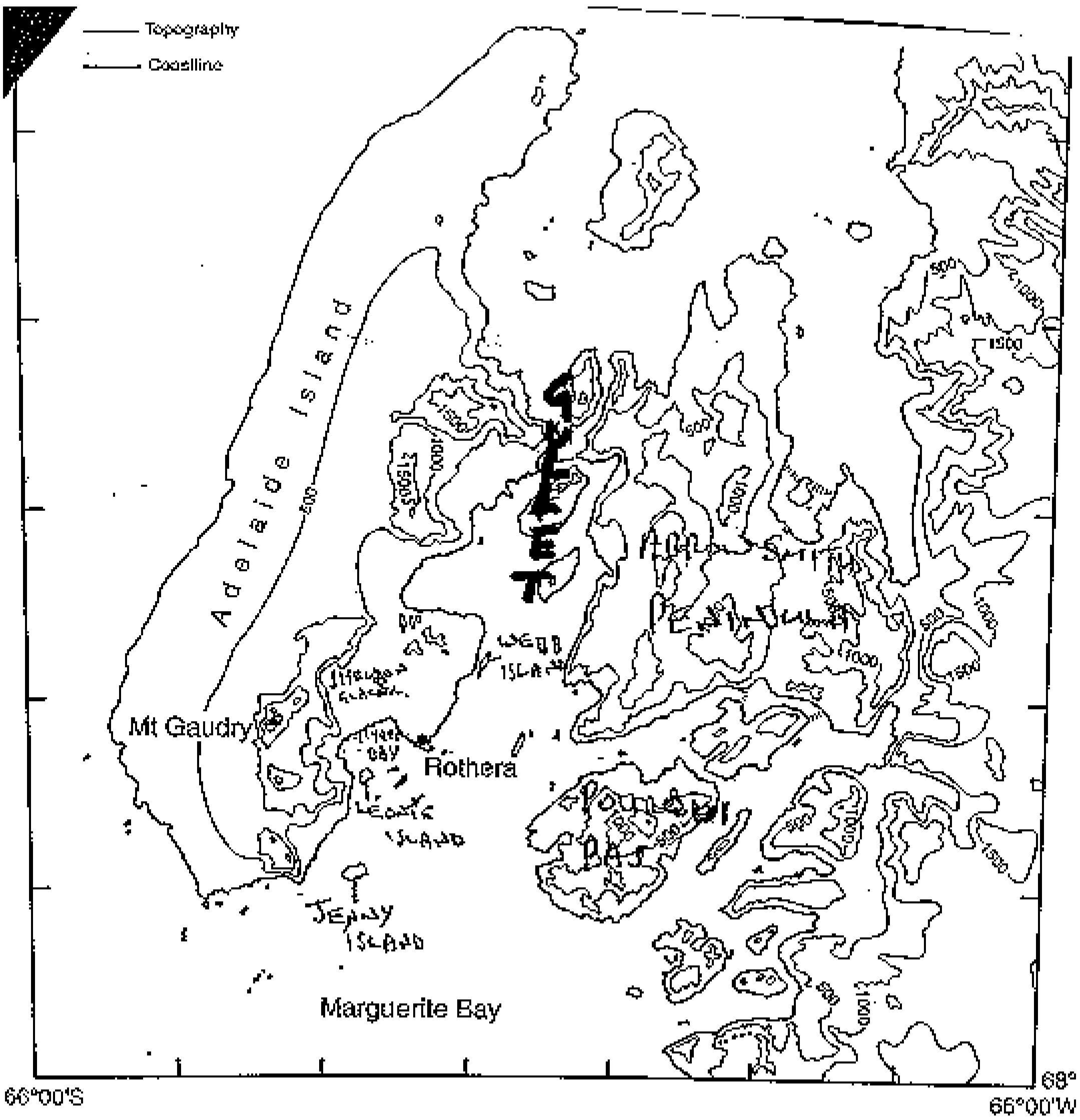


Fig 6.9 Map of Adelaide Island and environs.

Even with a southwesterly gradient the surface wind may well be north or northeasterly. On at least one occasion, in the 1994-95 season cloud at 1,000 ft was moving from the northeast, in the opposite direction to the gradient wind. A similar phenomenon occurred during the 2000-01 season. Winds can increase rapidly when backing from north-northeast through to northwest and particularly when they are between 330 and 350. This direction allows the air to funnel through the McCallum Pass and come tumbling down the glacier side as a particularly gusty wind, which will be considerably in excess of the gradient. Early March 2004 saw an example when gusts reached 60Kt with a gradient of no more than 40Kt. North to northeast winds can also often spring up unexpectedly when the gradient would not merit the actual wind speed. The wind can die again just as suddenly. This is probably due to subtle changes in the wind direction causing funnelling due to the local topography.

In the absence of strong pressure gradients, a light katabatic westerly flow (5-10 kts) down from the Island will often prevail, but generally the high ground to the west means strong westerlies are rare.

Strong easterly winds can occur when an easterly gradient funnels down through Bigourdan Fjord and over Pinero Island at 080 degrees true. In this synoptic situation, San Martin will often experience even stronger localised winds from 050 degrees. Such winds were common in the 2000-01 season. Light winds would usually result from a slowing, veering northeasterly gradient wind, though as soon as the direction reached 080 degrees, speeds would increase to between 20-30 kts. Dewpoints would rapidly drop to between –7 and –12^{o} C within minutes, rapidly clearing any low cloud affecting Rothera. Thus the wind clearly has Foehn characteristics despite no rise in temperature. This wind also resembles a 'mistral'-type valley wind as it is very localised to the fjord and the Rothera area. Winds on the traverse and Reptile Ridge, for example, usually remain light giving an alternative landing site for the Twin Otters at the ski-way if necessary.

Strong easterly surface winds can also occur suddenly and without warning in very slack pressure systems with very little, or no discernable easterly gradient. These are the result of cold air building up to the east of the peninsula and spilling westwards. Model fields may be able to help in predicting an increased likelihood of a significant easterly happening by monitoring the temperature at 5000FT. In these cases the temperature always drops when the easterly winds begin suggesting a katabatic element to the flow.

Wind direction remains remarkably constant in both these situations, typically 090 20 kt gusting 30 kt, these winds usually begin very suddenly and once set in can persist for many hours (see Fig. 6.10).

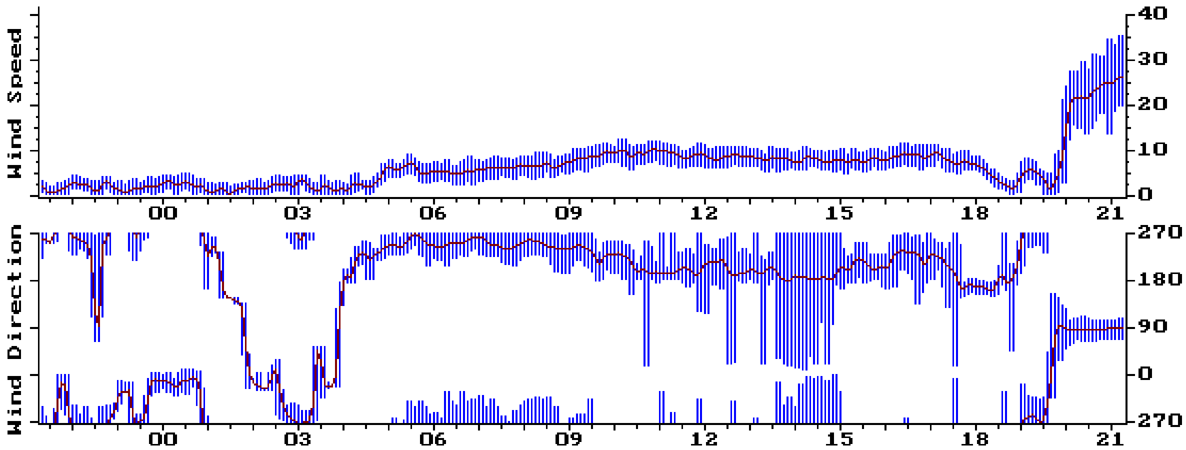


Fig. 6.10. Graphs showing the beginning of an episode of strong easterly winds which occurred on 7 November 2003 – Note how suddenly the wind changed and how steady the direction became. General aviation conditions in the Rothera area are excellent in an easterly, though runway turbulence and wind shear combined with the strong crosswind component can be problematic. On this occasion a Twin Otter crashed on landing approximately half an hour after the easterly winds had begun, although this was an exceptional event, safe take-offs and landings are often made at Rothera in similar wind conditions.

Sometimes mountain wave activity may contribute to this effect and a strong easterly gradient will enhance it. On one occasion during the 2000-01 season easterly winds suddenly increased to 30 kts with gusts of 45 kts every 10 minutes or so, with this situation persisting for 2-3 hours. Foehn winds may develop as the result of warm air being advected south down the eastern side of the Peninsula by a slow-moving depression to the north (see Fig. 5.4). On another occasion a small low was centred immediately to the north-northwest of Rothera, as shown in Fig 7.11.

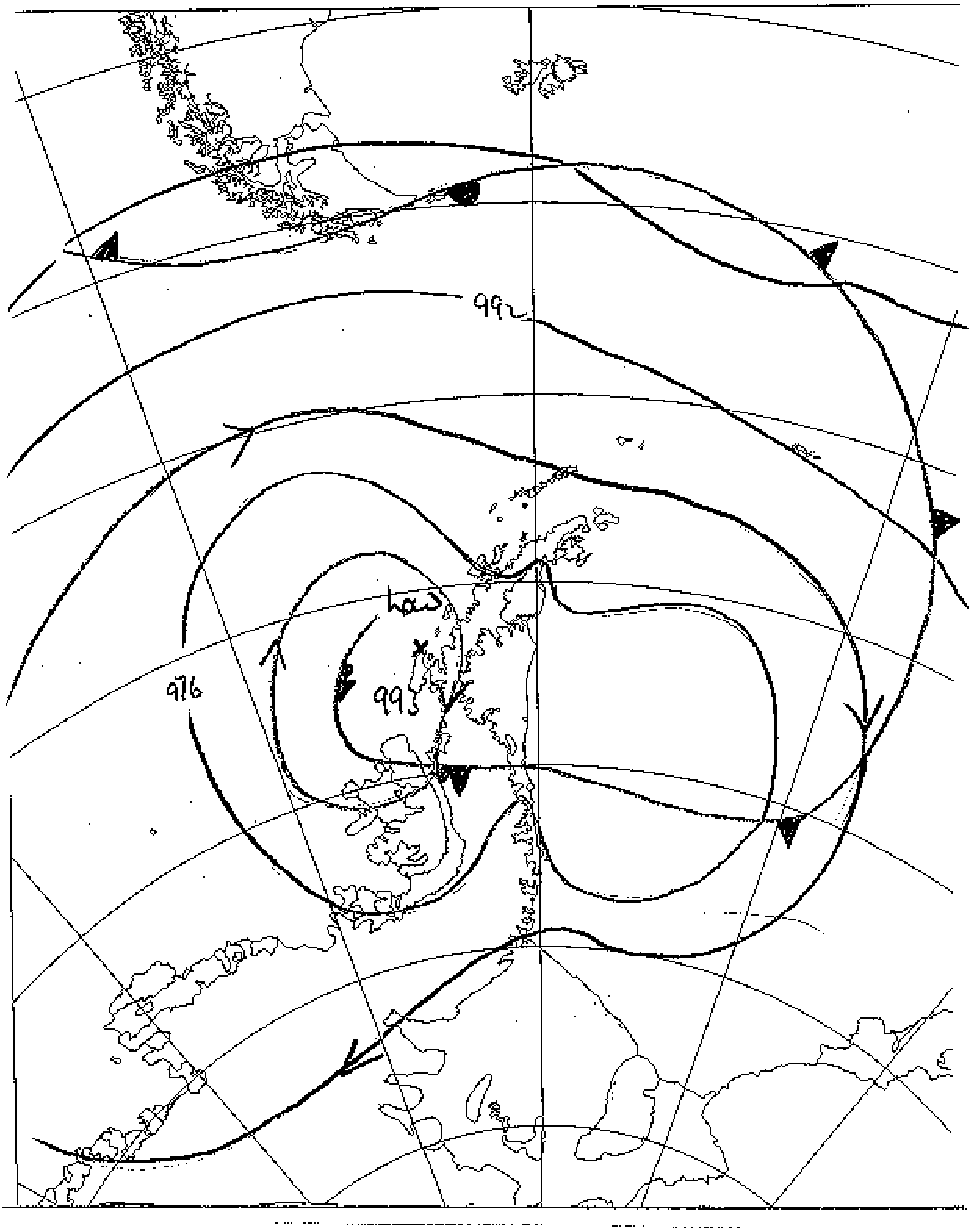


Figure 7.11. The surface analysis for 1200 GMT 12 February 1995.

There are two wind measuring systems at Rothera. One is used for the synoptic reports and is situated on higher ground immediately to the east of the base and one is situated alongside the north-south runway. There is frequently a large difference between runway wind and the met tower wind, sometimes as much as 90 degrees. In easterly winds, the runway sensor is sheltered by the base and the Point, and the frequent 10-15 kt difference in speed with the met tower sensor is indicative of the wind shear experience by pilots when landing on the southern end of the runway. The magnetic variation at Rothera is 21°E.

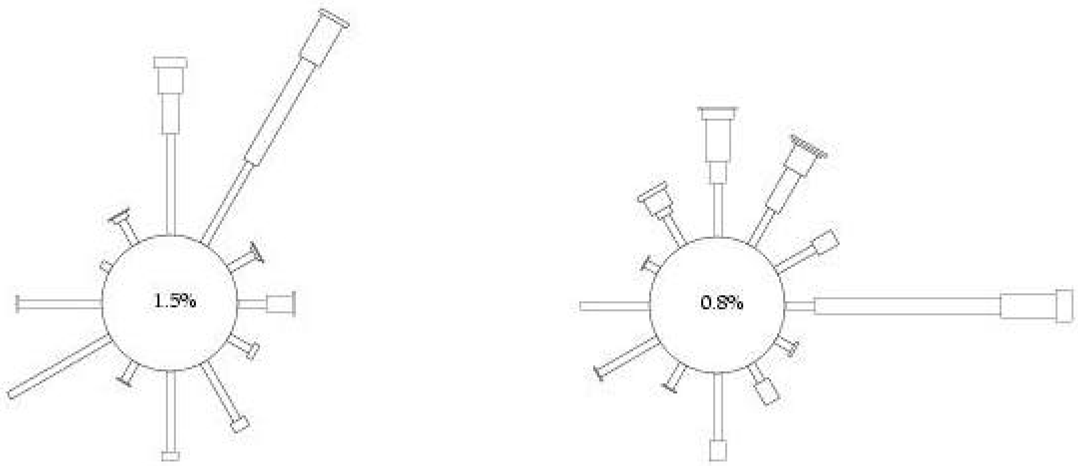
The airfield is generally well protected from very low cloud by the high mountains on three sides. When major frontal systems cross the airfield a combination of high winds and the shelter effect generally keeps the cloud base above a level where it would effect aircraft operations. Pilots have often reported heavier precipitation, worse visibility and lower cloud base in Marguerite Bay than at Rothera. Visibility can be reduced markedly by blowing snow at the beginning and end of the season, but falling precipitation is the main reason for reduced visibility when the snow around the base has melted. The worst visibility and cloud base problems seem to be in light airs. Once the sea ice melts, there is available moisture from the surrounding water to modify the air in stagnant conditions. Sometimes there can be a day of sunshine in a col or a ridge, before low cloud (or occasionally fog) drifts across the airfield. The low cloud or fog can sometimes be detected on the satellite imagery in Marguerite Bay before it reaches the airfield, although you need to look carefully at the channel 3 imagery with the sun up. Fog is not uncommon over the sea when maritime/returning maritime air stagnates under clear skies. It does seem very reluctant to advect onto the runway, even with a southerly breeze, although this cannot be relied upon. Strong northerly winds also seem to cause a reduction in visibility to the south even in the absence of precipitation, and 'mank' (see Appendix A) in Ryder Bay can frequently reduce visibility to 5-7 km to the south of the station, though the reason for this is not clear.

Precipitation is mainly in the form of snowflakes but rain does occur. Continuous moderate rain can occur when forecast thickness values are of the order of 540 DM.

Genuine showery airstreams affect Rothera on southwest, west and northwesterly airflows where the air has been of continental origin.

The diurnal temperature range can be of the order of 4-5 deg C on sunny days in mid-summer. Similar temperature changes can occur as a result of advection.

Interannual variability in the weather at Rothera and the Antarctic region as a whole is high so it is hard to define ‘normal’ or ‘extreme’ conditions. See Fig. 6.12 for just one example of how different conditions can be from one year to the next.



November 2002 November 2003

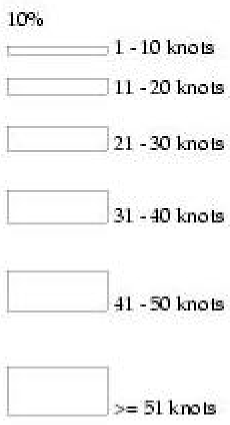


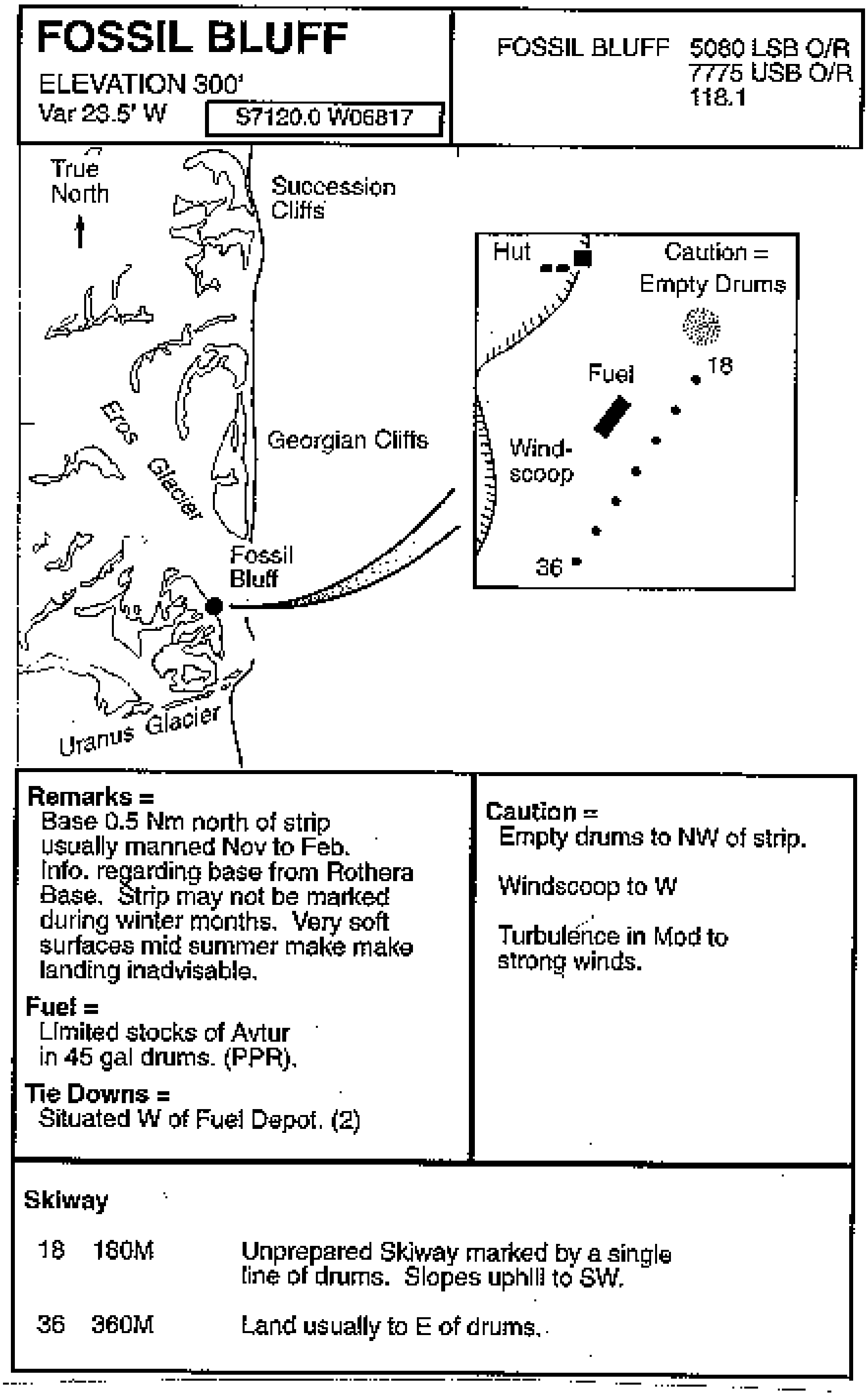
Fig. 6.12. Although these two months show very marked differences and 2003 does have an unusual frequency of easterlies, neither one of them is extreme in the context of the record as a

whole as Rothera wind patterns tend to show big differences from year to year.

6.2 Fossil Bluff

This forward field station is manned throughout the summer and is situated on Alexander Island overlooking the King George VI Sound at 71.20^o S, 68.17^o W. The Sound itself is an ice shelf up to 200 m thick. Aircraft visit Fossil Bluff almost every day if the weather permits.

Winds generally tend to be from the north or south due to funnelling down the Sound, though this effect does not significantly strengthen a northerly wind as at Rothera. The wind speed as measured at the accommodation hut may be different to that at the skiway (see Fig. 6.13).



FOSSIL BLUFF

ELEVATION 300'

Var 23.5' W   S7120.0 W06817

FOSSIL BLUFF 5060 LSB O/R
7775 USB O/R
118.1

Remarks =
Base 0.5 Nm north of strip usually manned Nov to Feb. Info. regarding base from Rothera Base. Strip may not be marked during winter months. Very soft surfaces mid summer make make landing inadvisable.

Fuel =
Limited stocks of Avtur in 45 gal drums. (PPR).

Tie Downs =
Situated W of Fuel Depot. (2)

Caution =
Empty drums to NW of strip.

Windscoop to W

Turbulence in Mod to strong winds.

Skiway

18	180M	Unprepared Skiway marked by a single line of drums. Slopes uphill to SW.
36	360M	Land usually to E of drums.

Figure 6.13. Map showing the relationship between the hut at Fossil Bluff and the skiway.

The wind is often a north-northwesterly at the hut (where most of the observations are made) due to the flow down the Eros glacier.

Low cloud distribution is very variable due to the complex topography of the surrounding area with regions of quite low stratus (200-500 ft) in some places whilst it may be completely clear in others. The Bluff is fairly well protected. Sometimes with extensive stratus over the Sound the skiway may be in the clear as it is approximately 200 ft above the Sound. Stratus seems to be more extensive in the middle to late summer. This is probably due to the formation of melt pools in the Sound. When the Sound is frozen there is less available moisture, so stratus would have to advect in, rather than form *in situ.*

Fog over the Sound tends to be rather reluctant to clear in light winds, particularly if temperatures are around zero or above and melt pools have developed. Stratus and fog in the Sound can quickly thicken to give fog at the hut or the skyway, particularly as diurnal cooling becomes more significant late in the season.

The Bluff is often well protected from precipitation and snow-stake data suggest that the Sound generally has low precipitation. Several large depressions near western Alexander Island failed to produce any precipitation at the Bluff, although the northern half of the Sound suffered precipitation and low cloud. Some of the heaviest and most prolonged precipitation events have been associated with mesoscale features. Slow-moving fronts can also produce precipitation. A spell of northerlies with a slow-moving front to the west will advect low cloud and precipitation into Fossil Bluff. Precipitation is usually in the form of snow or sleet, although rain has been reported.

Contrast often improves during the summer with the development of large meltpools which take on a blue or turquoise colour.

The magnetic variation at Fossil Bluff is 23.5^{o} E.

6.3 Sky-Blu

Sky-Blu is an area of blue ice near a nunatak some 12 km from the former BAS depot at Sky-Hi at an altitude of around 5,000 ft, and some 500 miles to the south of Rothera. The camp is manned permanently from late November until mid-February, and the blue ice runway enables the Dash-7 to land to depot fuel in support of field parties and Twin Otter operations. Fig. 6.14 is a schematic diagram of Sky-Blu. The ice runway is aligned north-south and crosswinds are a major consideration for Dash-7 operations, with a crosswind limit of 10 kts. Generally, Sky-Blu is a windy area, hence the blue ice. Winds come predominantly from the north and generally the model MSLP fields give reasonable guidance as to direction and often the 2000FT wind is nearest the reported wind strength. An AWS is located to the north of the nunatak, and measurements from this are broadly in line with the expected 'area wind' from the model. Winds at the runway itself are frequently rather different, with direction usually more northerly and speeds often subject to rapid variations due to turbulence and rotor activity caused by the nunatak. Pilots have reported potentially hazardous short-period and sudden fluctuations in wind speed along the runway, usually at times when the AWS reads 20-30 kts while mean runway speeds have been light and variable.

The model fields are mainly reliable, but south of 70^{o} S they have to be used with care, particularly as the surface elevation gradually increases. Sky-Blu, for example, is at approximately 5,000 ft, so surface winds should correspond with the 850 hPa level winds. In practice, however (probably due to the simplified orography of the model Peninsula), these winds are often too light and 2000FT or 950 hPa winds appear to give a better representation of Sky-Blu winds, however models do not capture the occurrence of the not unusual 40KT northerly.

Beyond the nunatak, a pronounced ridge (at 6,000 ft AMSL) marks the 'backbone' of the southern Peninsula some miles to the north. This ridge often marks the limit of low cloud coming from the north. Hence Sky-Blu is usually well-sheltered from stratus rising from King George Sound, though old frontal systems can become slow-moving in the area and cloud base may become low due to continuous precipitation. The Ronne Ice Shelf lies down a gradual slope to the south, and low cloud or fog can readily rise from the Ronne to give rapid deterioration in conditions, particularly in southerly winds. Usually these conditions reach Sky-Blu as the Ronne 'fills up' with cloud under the influence of a northeasterly airflow, though low cloud and fog can form purely from the upslope motion of previously cloud-free air from the south. Conversely, as the Ronne clears again (due to winds veering southerly for example), low cloud on the slope below Sky-Blu can persist for rather longer than expected due to the upslope component to the flow.

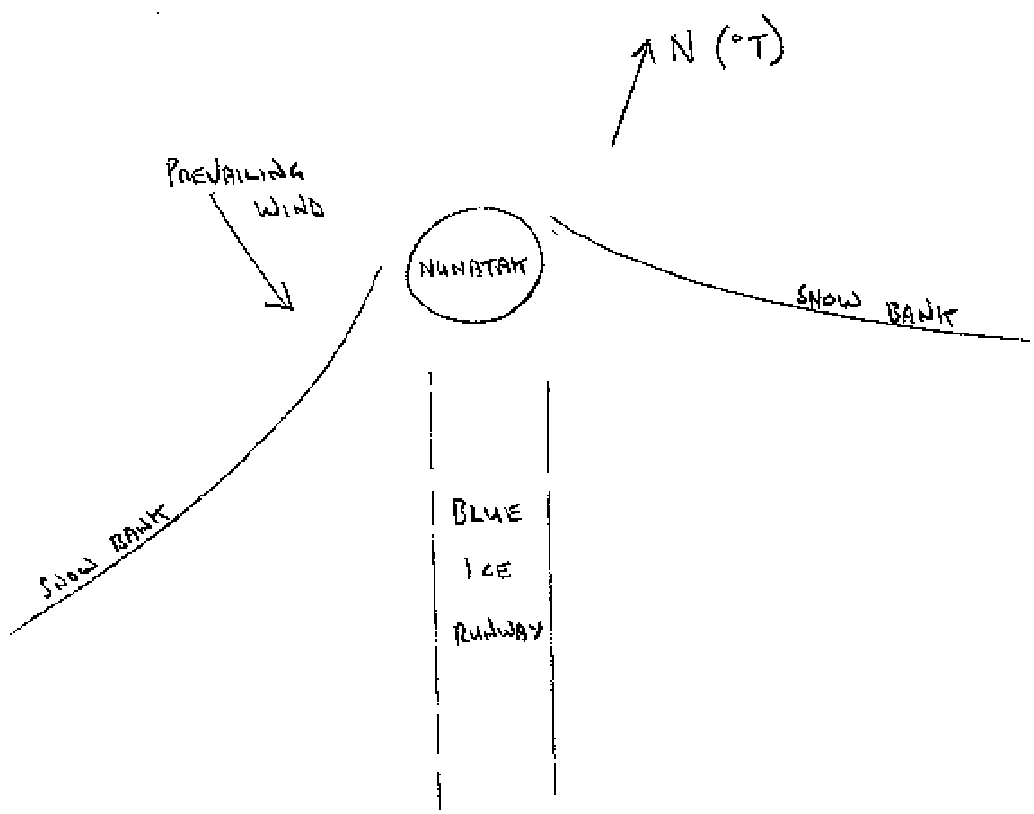


Fig. 6.14. Sketch map of Sky Blue

Moderate or good contrast and horizontal definition are essential for Dash-7 operations, as the blue ice runway cannot be seen in poor contrast. See the figures below.

Fig. 6. 15. Summer 2002/03 - Dash 7 coming in to land at Sky Blu with good visibility and contrast.

Fig. 6. 16. Summer 2002/03 - Dash 7 at the end of the runway with 'Lanzarote' nunatak behind.

The magnetic variation at Sky-blu is 25° E.

6.4 Shelf and New Ronne Depots

Shelf depot is an unmanned fuel depot on the edge of the Ronne Ice Shelf. A further depot (New Ronne) was established further southeast near the ice front during the 1998-99 season. Aircraft do not visit Shelf and New Ronne Depots very often but they are bolthole for aircraft flying to and from Halley, Berkner Island etc.

The winds at Shelf Depot seem to be predominately from the south, under the influence of the barrier winds up the eastern Peninsula.

The Ronne Ice Shelf is often affected by large sheets of stratus and stratocumulus. Large areas of shallow low stratus or fog are not uncommon, particularly when a northeasterly wind brings moisture in off the Weddell Sea. If the onshore flow persists, especially in combination with pressure falls, the cloud on the Ronne will continue to increase and thicken, with layers forming above with tops sometimes in excess of 10,000 ft. Low pressure systems in the southern Weddell Sea may also drift south and become slow-moving on the Ronne, also bringing extensive cloud.

The low cloud/fog is usually composed of water droplets and hence can be picked up on the channel 3 (3.7 µm) imagery quite readily (see Figs. 6.17a and b). Severe airframe icing has occurred in low cloud/fog over the Ronne in the past, with a pilot reporting severe ice build up on descent through the cloud in just 3 minutes with temperatures of –20° C. Often, the shelf edge is visible through the cloud on satellite images, though note that this does not necessarily imply that and aircraft flying within or above the cloud will be able to see the ground, it merely highlights the different strengths of the reflection upwards onto the base of the cloud from the ice and the sea, making cloud appear thinner than it actually is.

Mesoscale lows are common across the Ronne, though generally seem smaller and less active than those to the east towards Halley, with severe weather and strong winds relatively uncommon. They generally manifest themselves as swirls of deeper stratiform cloud embedded within stratocumulus cloudsheets, and usually serve to cause enhancement and prolonging of periods of light to moderate snow.

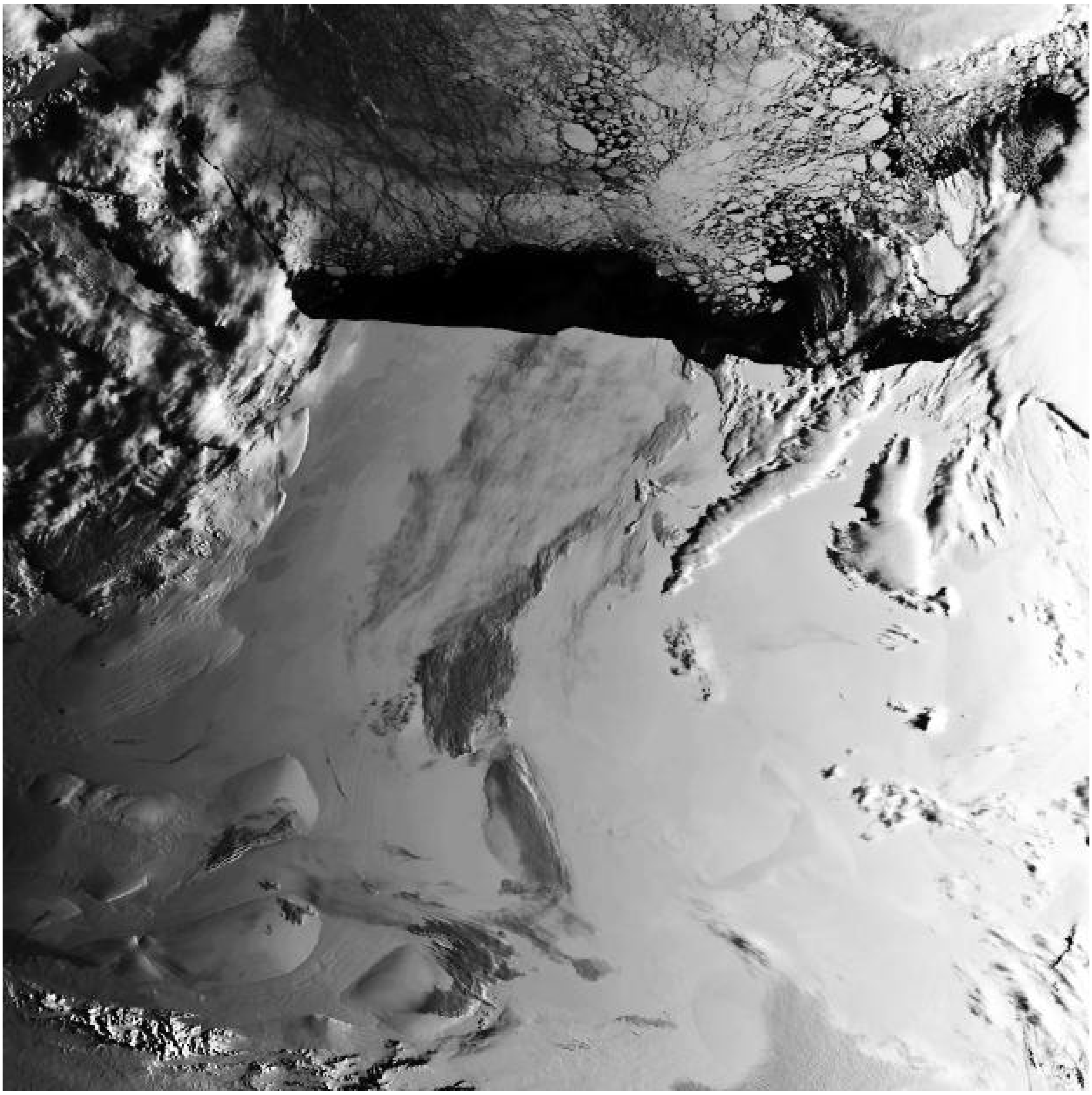


Fig 6.17a A visual satellite image of a lead of clear water off the Ronne Ice Shelf. Some low cloud is also evident.

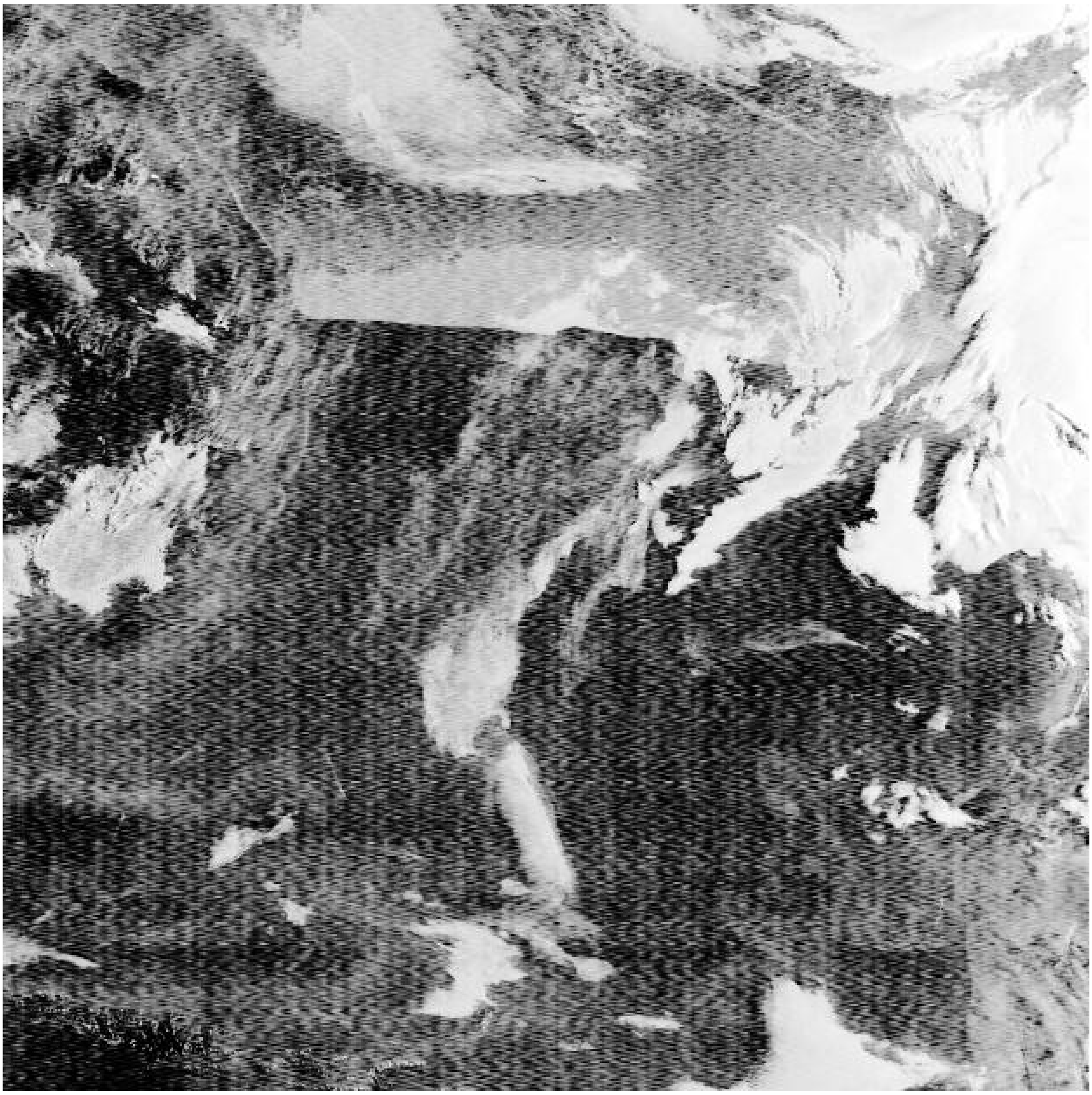


Fig 6.17b A channel 3 (3.7 μm) image for the same area and time as Fig 6.17a. The extent of the low cloud is more evident, particularly over the open water.

When a gap of ice-free sea opens up between the ice shelf and the sea ice (see Figs. 6.17a and b), sea smoke may occur and even develop into cumulus cloud. This is also an area for the development of fog if winds are light.

6.5 Berkner - North Dome

Another unmanned fuel depot on the Northern Dome of Berkner Island at 78.18^{o} S, 46.17^{o} W. Very little information is available about the weather at this depot, other than it does not seem to be a very windy place. A drilling team there during the 1994-95 season reported no more than about 10 kts. A good deal of clear weather was experienced there during the 1994-95 season but upslope stratus can be a problem, resulting in fog on the Dome. This usually results either from a northerly airflow off the sea, or from a general thickening of stratus/fog on the Ronne or Filchner Ice Shelves.

During a flight from Rothera to Halley via Berkner Island on 16 January 1997 a strong (20-25 kt) upslope (west to east) wind was encountered along the western side of the island. This strong wind was not related to the broadscale synoptic pressure gradient. This airflow caused moderate to severe airframe icing. It is believed that the strong wind was a result of damming of cold dense and moist air on the western side of the island.

6.6 Halley

Halley is situated on the Brunt Ice Shelf at approximately 75^{o} 35’ S, 26^{o} 36’ W.

The wind is predominately easterly at 10-20 kts and stratus is not uncommon, with a base of 500-1,000 feet. Fog will sometimes develop over the clear water leads in the sea ice and occasionally advects into Halley on a light westerly or northerly wind. Model MSLP and surface wind fields usually give good guidance for the forecaster, though significant errors can occur due to the effects of mesoscale lows in the area.

Occasionally depressions move southwest down the coast towards Halley or they form in the Weddell Sea, often after a low has approached the western parts of the Peninsula and begins to fill. These depressions are capable of producing strong easterly winds at Halley with mean speeds of around 30 kts or more. Several occasions have been reported of occlusions advecting around a low in the Weddell Sea became slow-moving as they approached Halley. This gives stronger easterly winds than the gradient suggested, probably because of squeezing against the plateau to the south. This can give prolonged periods of gales and blowing and falling snow. Mesocyclones developing along the coast have been known to produce severe weather (e.g. Christmas 1995) at Halley but although they are a relatively common occurrence the severe weather is quite rare.

The magnetic variation at Halley is 1°W.

6.7 Haag Nunataks

A small unmanned fuel depot at approximately 77° S, 78° W at an altitude of around 4,000 ft and with a magnetic variation of 30° W. The predominant wind direction is southwest to southeast (based on field party reports during the 1994-95 and 1995-96 seasons).

Cloud associated with old fronts will often penetrate as far south as Haag and may be quite persistent. Satellite imagery has shown organised deep convective cloud in the area in association with a small mesocyclone during February 2001. Fog is probably most likely with a southerly wind. Although extensive low cloud may develop over the Evans Ice Stream (see below), it does not always affect Haag. In the 1995-96 season Haag had periods of up to two weeks of cloud and high winds, but also a few periods of light winds and sunshine. Changes of type seemed to be over a period of days, as opposed to hours further north in the Peninsula. Solar halos were frequent and usually heralded a period of bad weather.

During the 1998-99 season this area was very prone to long periods of extensive low cloud cover and greatly enhanced southeasterly winds, with blowing snow a persistent problem.

6.8 The Epica site

Epica is located on the Plateau to the south of Halley and conditions there are broadly representative of those at other depots and science sites (e.g. AGOs) in the area. Field reports indicate that the primary source of poor weather is cloud advecting or forming up the slope in a northerly or westerly wind. Low cloud on the Filchner Ice Shelf may thicken sufficiently to reach the area. Sheets of shallow stratocumulus move erratically over the Plateau, causing reduction in contrast, but cloud bases are invariably higher when these have advected from the higher ground to the south or east.

6.9 The Rutford and Carlson Ice Streams

Weather in these areas is strongly influenced by conditions on the Ronne and the synoptic situation to the north across the Peninsula. Low cloud and fog can frequently spread up from the Ronne in southeasterly winds, and cloud can thicken sufficiently to give periods of moderate snow at times, particularly in association with minor mesoscale vortices.

Winds are primarily from the southeast, and can be strong and give poor conditions which persist for several days. This is usually associated with strong easterly or northeasterly gradients from the Weddell Sea onto the southeast Peninsula. Some of this air is forced to flow around the southern edge of the Peninsula, only to then funnel strongly up the ice streams to the west. The model usually signals these strong wind events well in advance by increasing the easterly or southeasterly gradients in MSLP fields in the area between the South Peninsula and the Ellsworth Mountains.

6.10 The Evans Ice Stream

The Evans Ice Stream is notorious for rather worse weather than the Rutford or Carlson, and indeed other surrounding areas such as Sky-Blu. Similar ideas apply, in that low cloud frequently spreads up from the Ronne, and substantial funnelling effects may give persistent strong southeast winds in certain synoptic situations. The Evans is also sufficiently far north to be affected by lows to the north, for example those that become slow-moving in the southern Bellingshausen Sea or over Alexander Island. The area also seems to be considerably cyclogenetic, and mesoscale systems often appear to develop or become reactivated in the area, with the potential for extended periods of precipitation as well as strong winds.

6.11 Patriot Hills

Adventure Network International (ANI) operate a summer-only base in the Patriot Hills, at the southeastern end of the Ellsworth Mountains. BAS keeps a limited supply of fuel there, which will occasionally be used by BAS Twin Otters. A C130 regularly flies there from Punta Arenas, landing on a blue ice runway, which has also been used by the BAS Dash-7 in the past. Chartered Twin Otters are used to transport tourists and other commercial customers to places such as the Pole and Vinson Massif.

Weather at Patriot Hills is also influenced strongly be conditions on the Ronne Ice Shelf, and cloud on the Ronne can frequently spread into the area, sometimes in the form of low stratus. Little is known about the prevailing winds at present, though there are considerable local effects which may give very different conditions between the camp, the skiway and the blue ice runway. These localised winds appear to be katabatic in nature and can be very strong and variable at times.

SECTION 7

NOTES ON DIVERSION AIRFIELDS FOR DASH-7

During Dash-7 rotations to Stanley and flights to Sky-Blu or survey work, two diversion airfields are used at the northern tip of the Peninsula although Marambio is rarely considered as an option.

7.1 Marsh

Marsh is a Chilean base on King George Island, which is situated in the South Shetland Islands and is really the only suitable diversion for the Dash 7 when en-route from Stanley to Rothera. Marsh is at an altitude of 156 ft. Note that Marsh (SCRM) is the military runway, while Frei (SCEF) is the met station.

Weather here is often poor with overcast skies and fog not uncommon, due to cold sea temperatures and generally moist and relatively mild air. The general wind is from the northwesterly quadrant and may be very strong at times. Winds from the west and northwest often produce the worst conditions, which usually improve as the wind backs towards the south and colder and drier air is brought northwards. Local shelter from very poor conditions may be afforded in northeasterly winds. Colder, drier air can sometimes be advected in from the Weddell Sea on east or southeasterly winds. These winds however appear to be uncommon with the wind rose suggesting a figure of 15%. The 850 hPa θw chart usually gives good guidance on changes of airmass and so deteriorations or improvements in conditions at Marsh. From subjective observations θw values of around 0 or below tend to give moderate to good conditions at Marsh, θw values of around 2 or greater usually indicate marginal or poor conditions.

At the time of writing (Feb 2004) there is some difficulty in the agreement between BAS and the authorities at Marsh over the routine use of the airfield as a diversion for the Dash 7. Although it cannot currently officially be called a diversion it can be used in any emergency. A runway diagram for Marsh is shown in Figure 7.1.

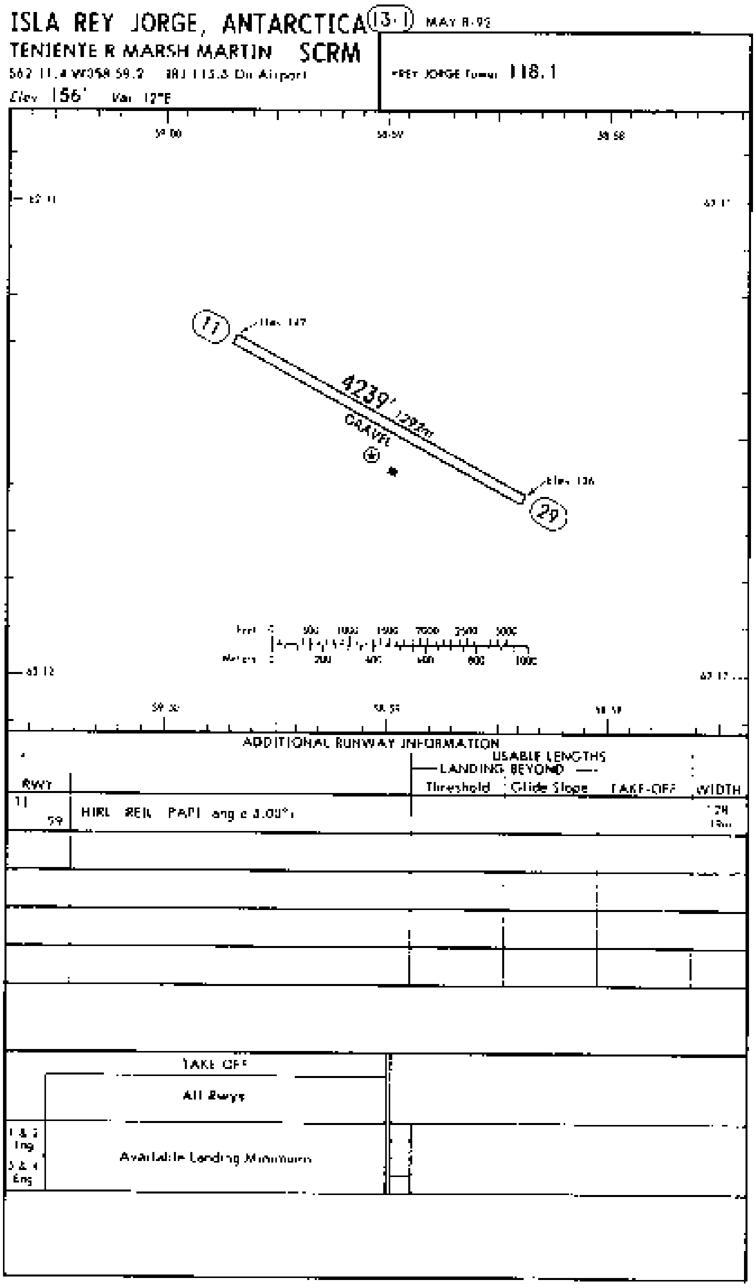


Figure 7.1. A runway diagram for Marsh.

7.2 Marambio

Marambio is an Argentinean base and generally has similarly poor weather to Marsh. The base is situated on Seymour Island, a small island just east of James Ross Island. It is at an altitude of 650 ft. The base is no longer used as a routine Dash-7 diversion due to poor runway conditions, but may be considered in case of emergency in the future.

Significant protection from low cloud in west or northwesterly winds is afforded by the high ground of the Peninsula. However, a veer to the north or northeast may well bring in extensive low cloud. South or southeasterly winds will bring in cold, perhaps showery conditions from the Weddell Sea, but if close to the southwestern flank of a depression low cloud may produce fog on the airfield. The station is particularly exposed during occasional situations of rapid lee cyclogenesis just to the east of the tip of the Peninsula. On one occasion during February 2001, the area experienced hurricane force southwesterly/southerly winds from such a development. Experience suggests that the model can seriously underestimate the depth of these lows, and hence winds may be much stronger than the model implies.

A runway diagram for Marambio is shown in Fig. 7.2.

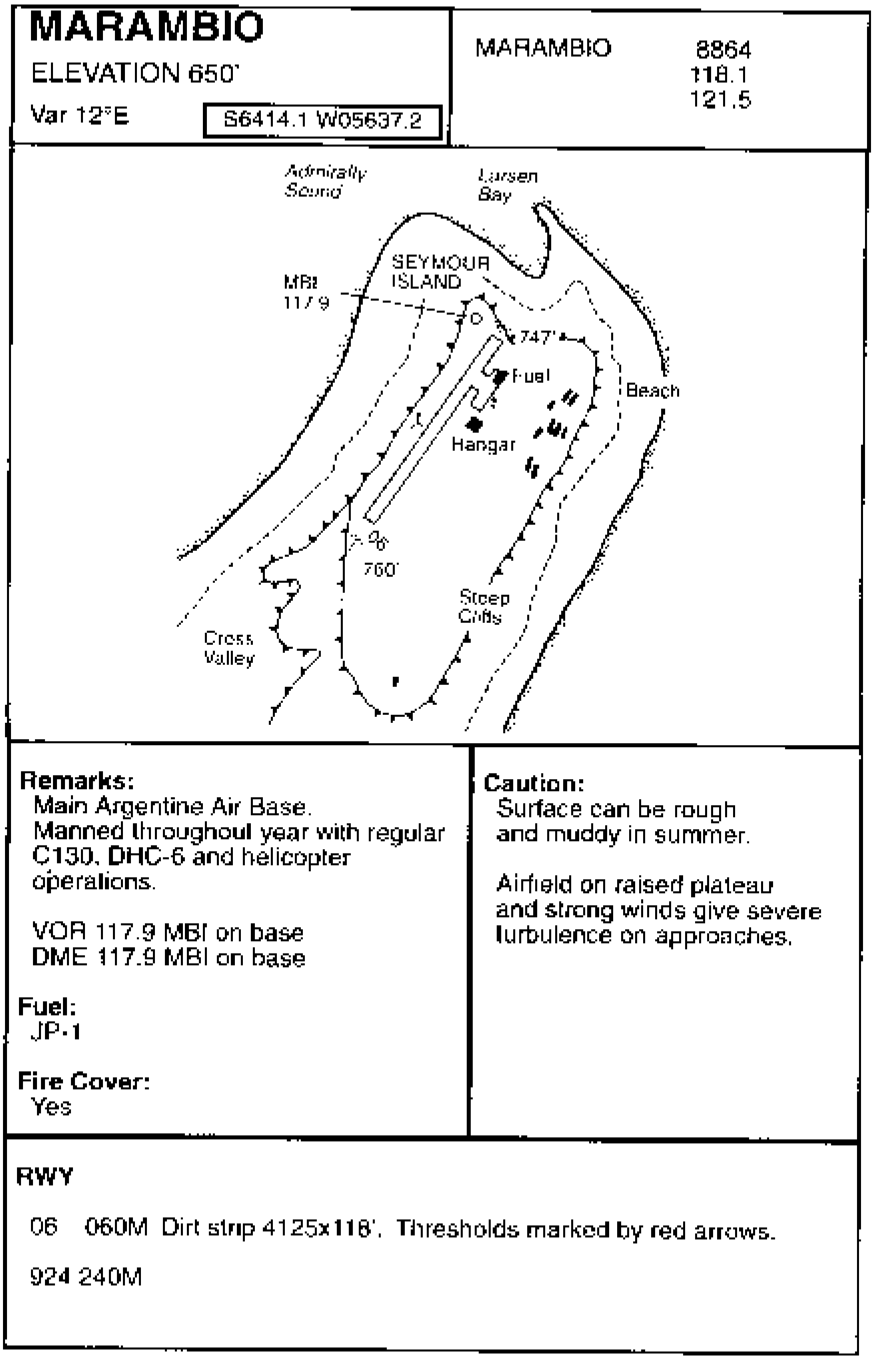


Figure 7.2. A runway diagram for Marambio.

7.3 Punta Arenas, Chile

This airfield is situated near to the tip of South America at an altitude of 37 m. It is under the influence of prevailing westerly winds, which can often be strong, although it is protected to some extent by the mountains to the west. The cloud base is rarely below 2,000 ft and the cloud is usually broken. Conditions are often showery and the wind gusty. Visibility is rarely below 10 km and there is often significant turbulence as the approach is over cliff tops from the east. The airfield is nearly always useable as an alternate. There is usually a daily TAF issued.

7.4 Ushuaia, Argentina

This airfield is at an altitude of 14 m, to the south of Punta Arenas, with generally similar weather patterns. Weather reports are less frequent than for Punta Arenas, with Metars probably only being reported when traffic is expected.

There is also a Chilean airfield at Puerto Williams just to the south of Ushuaia which is the closest South American airfield to the Peninsula, but weather reports have not been received and no contact made.

7.5 Climate statistics for Marsh and Marambio

Statistics have been compiled for Marsh and Marambio from reports received at Cambridge over the Global Telecommunications System (GTS), which are available on Horace at Rothera. Percentages of the total observations are given for the following criteria:

a) Visibility equal to or greater than 10 km.

b) Wind speed less than 30 kts.

c) Lowest reported cloud above 1000ft.

d) No present weather at the station, within sight or during the preceding hour including precipitation, fog, drifting or blowing snow.

	Marsh	Marambio	Rothera[1]
November	34%	39%	57%
December	42%	43%	71%
January	38%	39%	72%
February	38%	43%	66%
March	43%	49%	58%
Mean	39%	43%	65%

Notes

1) The percentages given for Rothera do not include weather within sight of the station or during the preceding hour; neither do they include any restriction on lowest reported cloud. See note 2 on cloud below.

2) Lowest reported cloud is part of the coding for Met. Reports. This does not necessarily reflect the level of the main cloud base. This can be especially misleading at Rothera where around 10 percent of observations report cloud below 1,000 feet but this is often due to an isolated patch adjacent to the surrounding mountains, having little impact on flying operations. Therefore this cloud criterion has been excluded from the Rothera figures.

3) In total, far less observations are received from Marambio. This amounts to around two thirds of the number received from Marsh.

4) These data are only based on GTS data, not data received directly from the stations via HF radio.

5) No account has been taken of hours of darkness or restricted operating hours of Marsh or Marambio.

6) The data are from actual weather reports. No account has been taken of weather forecasts issued or grouping the observations into extended periods of ‘good’ weather.

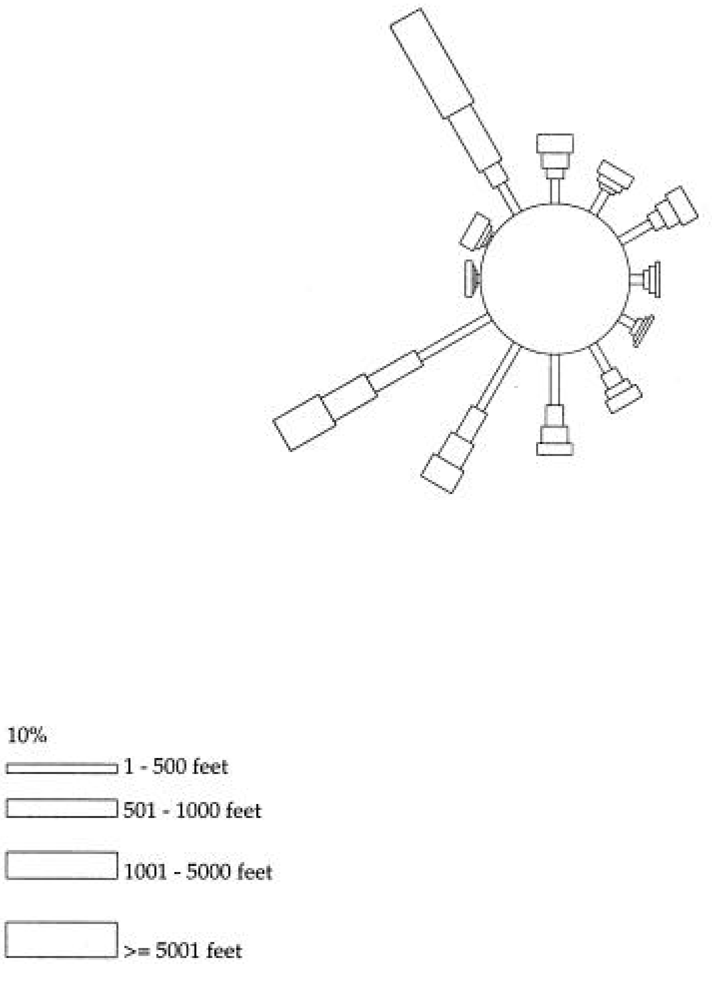
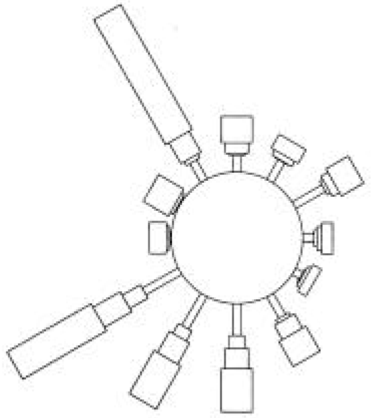


Figure 7.3. Marambio. Lowest reported cloud classed by wind direction for November to March including data from all years.



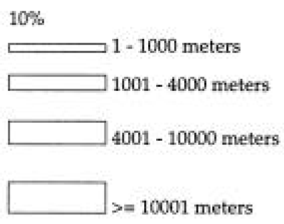


Figure 7.4. Marambio. Visibility classed by wind direction for November to March including data from all years.

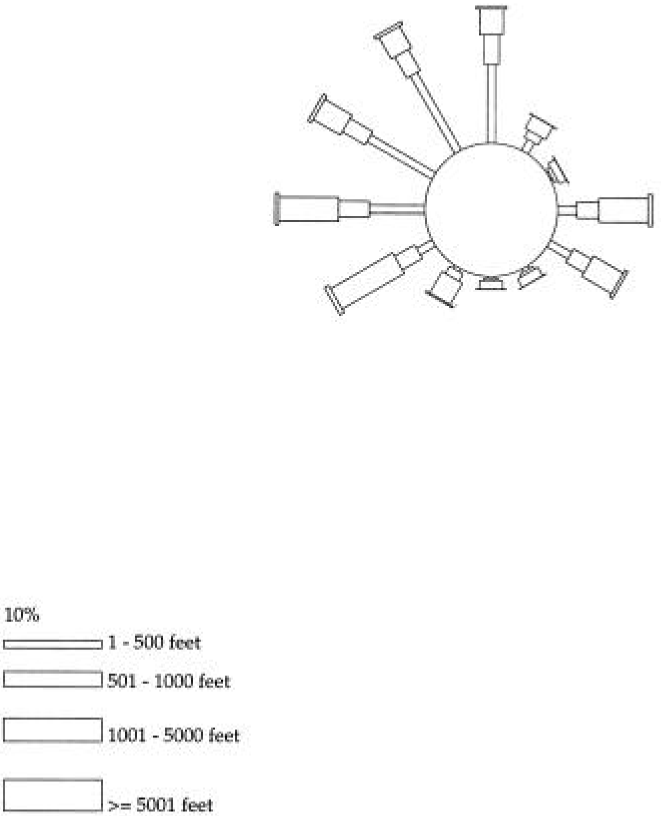
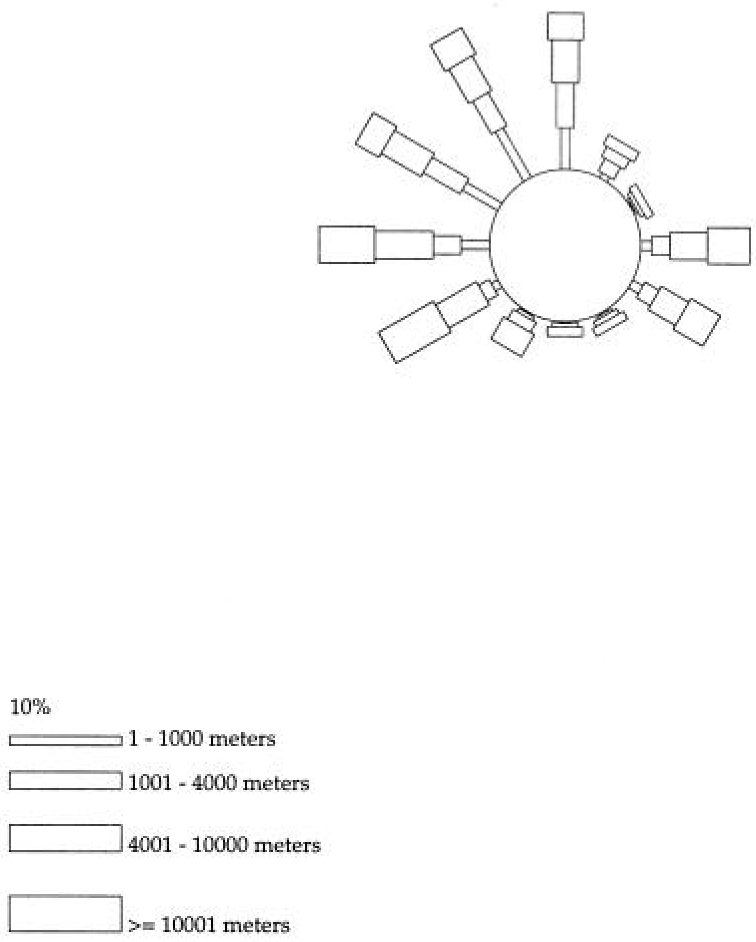


Figure 7.5. Marsh. Lowest reported cloud classed by wind direction for November to March including data from all years.



7.6. Marsh. Visibility classed by wind direction for November to March including data from all years.

APPENDIX A

NOTES AND DEFINITIONS

BLUE ICE	An area where the wind is usually strong and blows away the snow to reveal an area of blue ice. Alternatively it can occur where the ablation exceeds the precipitation. These areas are usually found in the lee of nunataks.
DINGLE	A BAS term denoting clear skies and good visibility. N.B. the words Dingle and Mank are 'BAS speak' and may mean different things to different people and should not be used in forecasts.
FAST ICE	Sea ice that forms and remains attached to the shore, an ice shelf or even grounded icebergs.
ICE SHELF	A floating ice sheet attached to the coast, which may be several hundred metres thick. This ice is of glacial origin and is maintained by continuing glacial flow and by local accumulation.
MAGNETIC VARIATION	All field party reports of wind direction are in degrees magnetic. The magnetic variation within the normal area of operation is quite large, from near zero at Halley to 40^{o} east at the Ellsworth Mountains. The variation at Rothera is around 20^{o} east. In order to obtain degrees true it is necessary to ADD the variation to the reported wind direction given by the field parties.
MANK	A BAS term for very low cloud or fog or generally unpleasant weather. N.B. the words Dingle and Mank are 'BAS speak' and may mean different things to different people and should not be used in forecasts.

NUNATAK	A mountain or hill top protruding through the ice and snow.
PACK ICE	A term used in a wide sense to include any area of sea ice, except fast ice.
SASTRUGI	Hard ridges of ice and snow which lie parallel to the prevailing wind direction and hence are a good indication of the recent predominant wind in remote areas. If they are quite large they present a hazard to aircraft operations and also to overland travel.
SEA ICE	Frozen sea (of which there are several different categories)
SURFACE CONTRAST	The degree of surface contrast is the ease with which features on a snow surface i.e. sastrugi, skidoo tracks can be defined. Increasing cloud amount and thickness will diffuse the available sunlight and reduce the contrast.

The following definitions are used:-

NIL	Footprints, skidoo tracks, etc. become indistinct at more than 50 metres.
POOR	Footprints, skidoo tracks, etc. become indistinct at more than a few kilometres.
MODERATE	Surface features are visible as far as the eye can see, but not clearly defined.
GOOD	Surface features are visible as far as the eye can see and are clearly defined.

If the contrast is varying as clouds pass overhead, or if the contrast it falls between two of the above definitions, it may be reported as "moderate to poor", etc.

HORIZONTAL DEFINITION	More applicable in non-mountainous areas, such as those where there are no other features to show the horizon. Basically the ease with which the horizon can be defined. As with surface contrast the following terms are used:-
NIL	Sky and land appear as one, no horizon visible.
POOR	Sky can be discriminated from the land but no distinct horizon is visible.
MODERATE	Horizon is visible but no significant difference in the appearance of land and sky.
GOOD	Distinct horizon with obvious difference between land and sky.

Horizontal definition can be given for specific compass directions

APPENDIX B

REFERENCES

Carleton A. M. and Carpenter D. A. 1990, 'Satellite Climatology of Polar Lows and Broadscale Climatic Associations for the Southern Hemisphere. Int. J. Climatol, 10(3), 219-246.

Heinemann G. 1989, 'Mesoscale Vortices in the Weddell Sea Region (Antarctica). Mon. Wea. Rev. 118(3), 779-793.

Howard, J. 1993. 'British Antarctic Survey Air Operations Manual' : Cambridge, British Antarctic Survey.

Jones D. A. and Simmonds I., 1993, 'A Climatology of Southern Hemisphere Extratropical Cyclones', Climate Dynamics 9:131-145.

King, J. C. and Turner, J. 1997. 'Antarctic Meteorology and Climatology' : Cambridge, Cambridge University Press, 409 pp.

Rasmussen, E. A. and Turner, J. (Eds.) 2003. ‘Polar Lows: Mesoscale Weather Systems in the Polar Regions’ 612 pp. Cambridge, Cambridge University Press.

Schwerdtfeger W. 1984, 'Weather and Climate of the Antarctic' Amsterdam, Elsevier, 261 pp.

Turner J., Lachlan-cope T. A., Warren D. E. and Duncan C. N. 1993, 'A Mesoscale Vortex over Halley Station, Antarctica', Mon Wea Rev 121 1317-1336.

Turner J. and Thomas J. P., 1993, 'Summer-Season Mesocyclones in the Bellingshausen-Weddell Region of the Antarctic and Links with the Synoptic-Scale Environment', Int. J. Climatol, 14

871-894.

APPENDIX C

CLIMATOLOGICAL DATA FOR ROTHERA

In this appendix a number of histograms are included to indicate the frequency of various visibility conditions as a function of wind direction. Information on the relationship between cloud base and wind speed is also provided. An idea of the mean and extreme conditions at Rothera can be obtained from the data in Table C.1.

Temperature

	November	December	January	February	March
Absolute max.	6.1	7.8	8.5	8.1	7.1
Average monthly max.	4.0	6.0	7.0	5.9	5.1
Mean daily max.	0.5	2.5	3.8	2.9	0.6
Average daily mean	-1.9	0.5	1.5	0.8	-1.4
Mean daily min.	-4.0	-1.3	-0.3	-1.1	-3.1
Average monthly min.	-10.5	-4.3	-2.9	-4.1	-7.5
Absolute min.	-14.5	-7.3	-5.4	-6.6	-9.6

Table C.1a. Rothera temperature data

Wind Speed

	November	December	January	February	March
Mean speed	12.7	9.9	9.5	10.5	11.3
Highest daily mean	56.0	43.0	52.0	37.0	46.0
Average monthly gust	48.0	39.8	34.1	39.7	50.5
Highest gust on record	65.3	59.7	63.0	57.0	67.0

Table C.1b. Rothera wind speed data

Number of Days With

	November	December	January	February	March
Gale	4.7	2.6	2.0	1.2	3.5
Snow falling	20.4	15.7	14.6	14.5	21.4
Rain falling	1.8	4.5	7.2	6.7	3.6
Fog	1.0	1.3	1.3	1.1	0.9

Table C.1c. Rothera weather frequency data

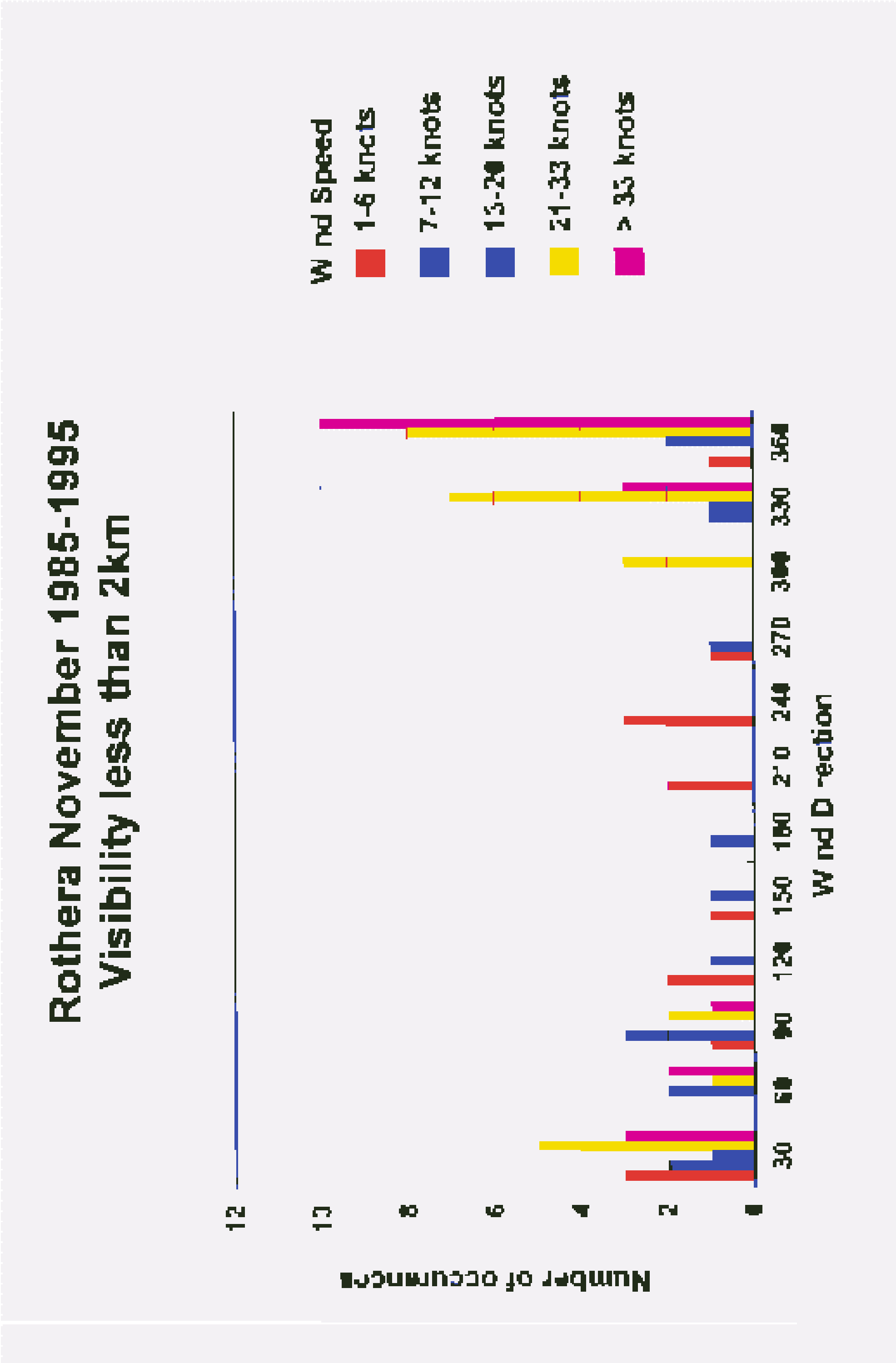


Fig. C.1d. Rothera visibility in November less than 2 km as a function of wind direction. Period 1985-95.

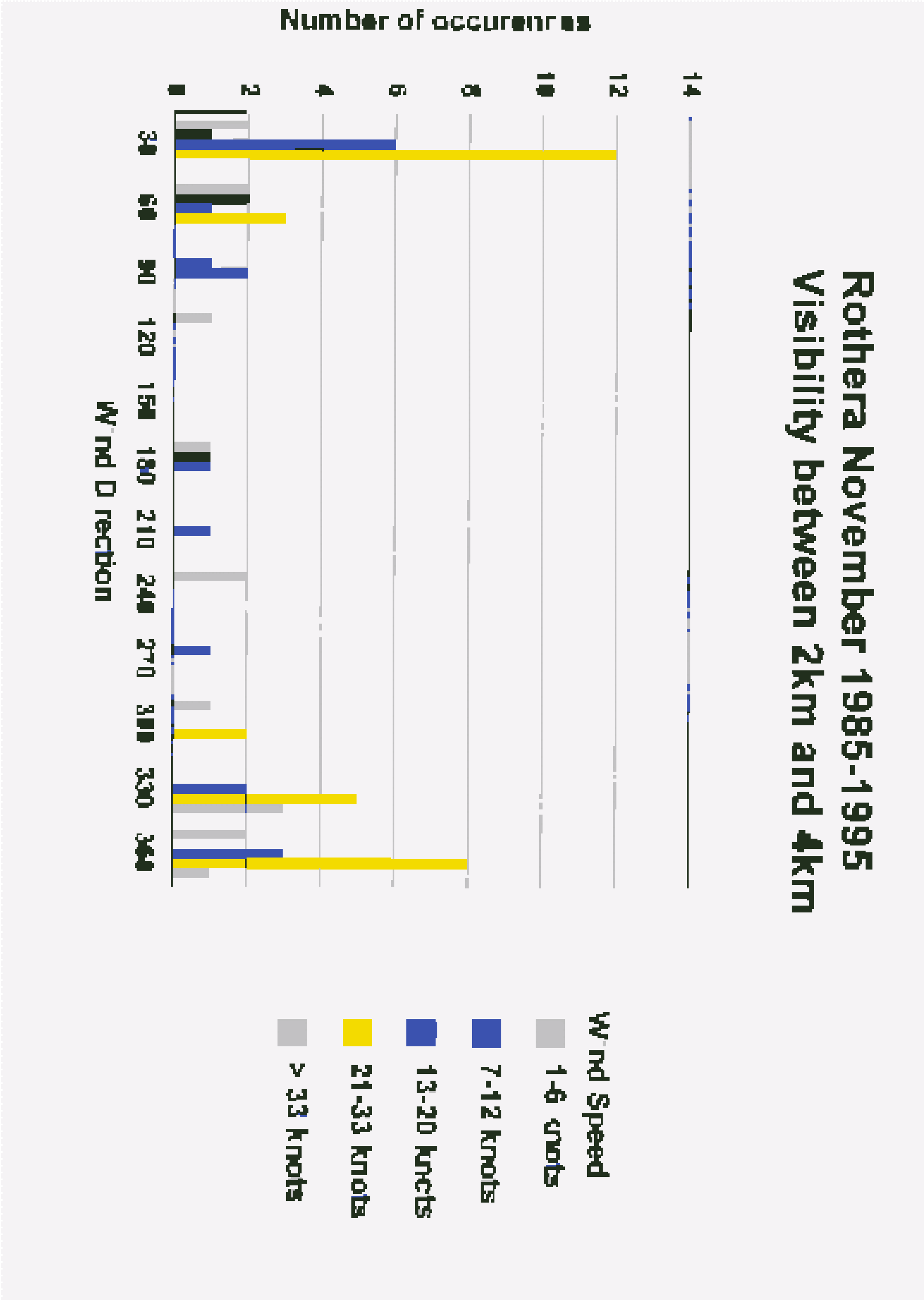


Fig. C.2. Rothera visibility in November between 2 km and 4 km as a function of wind direction. Period 1985-95.

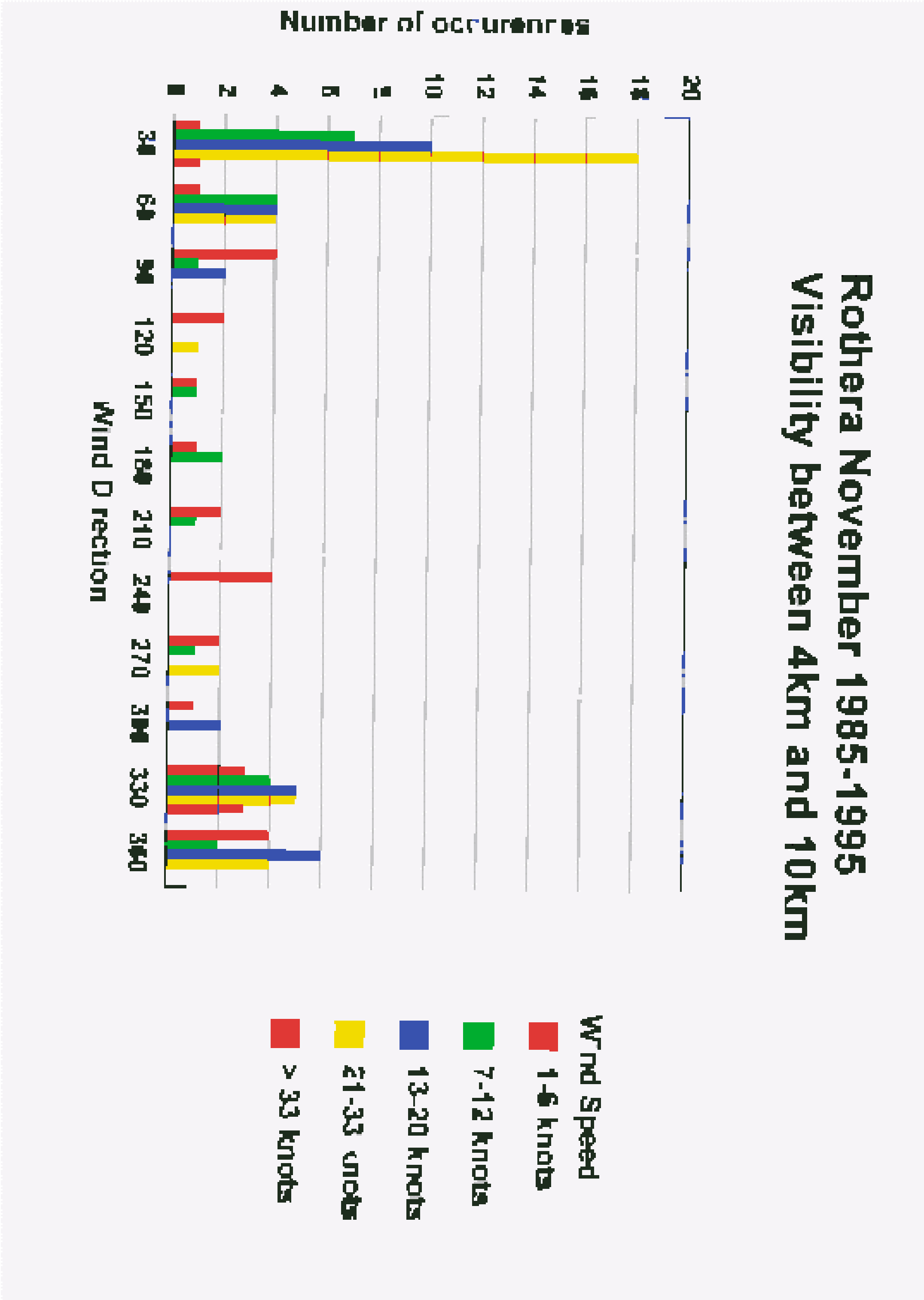


Fig. C.3. Rothera visibility in November between 4 km and 10 km as a function of wind direction. Period 1985-95.

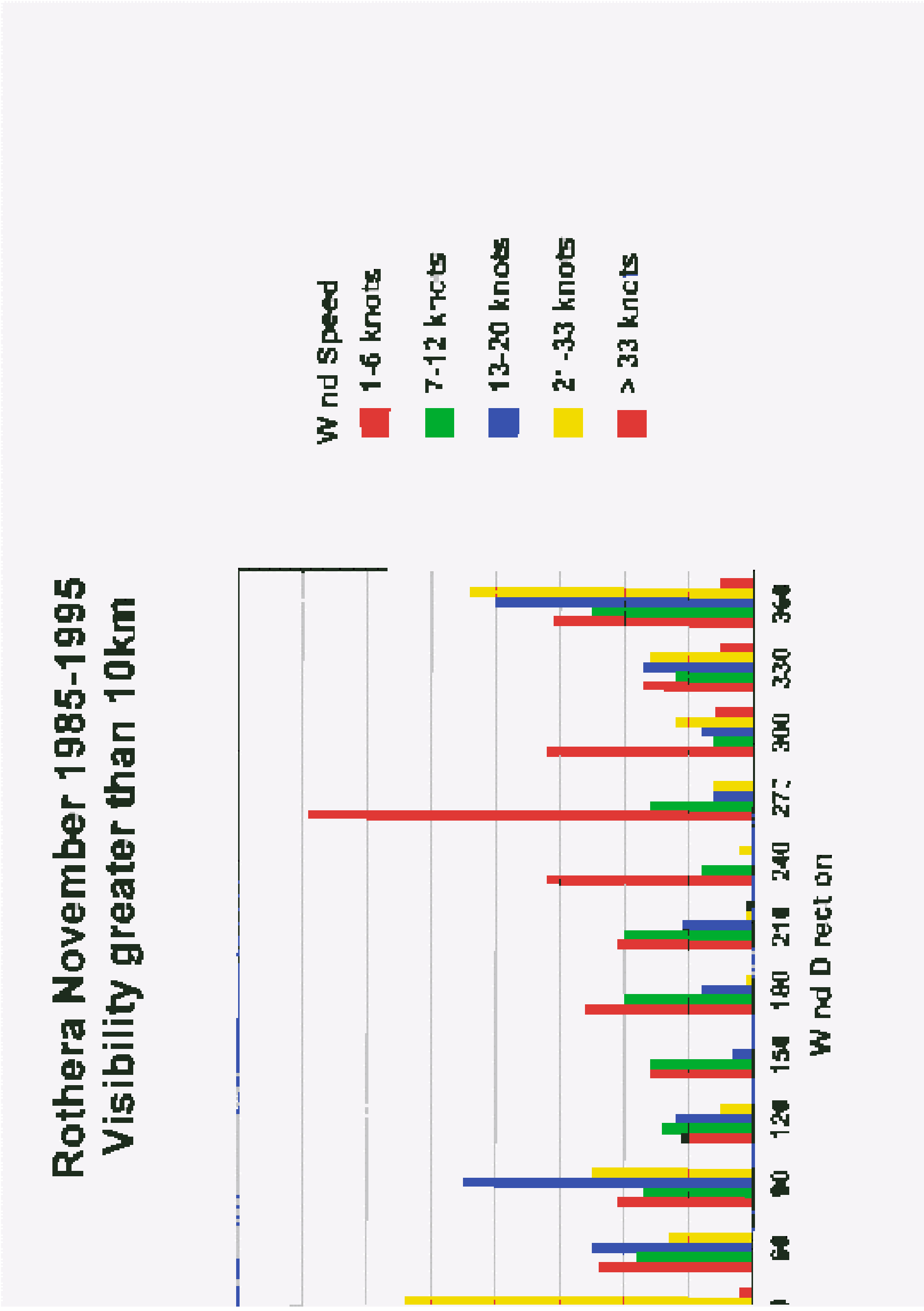


Fig. C.4. Rothera visibility in November greater than 10 km as a function of wind direction. Period 1985-95.

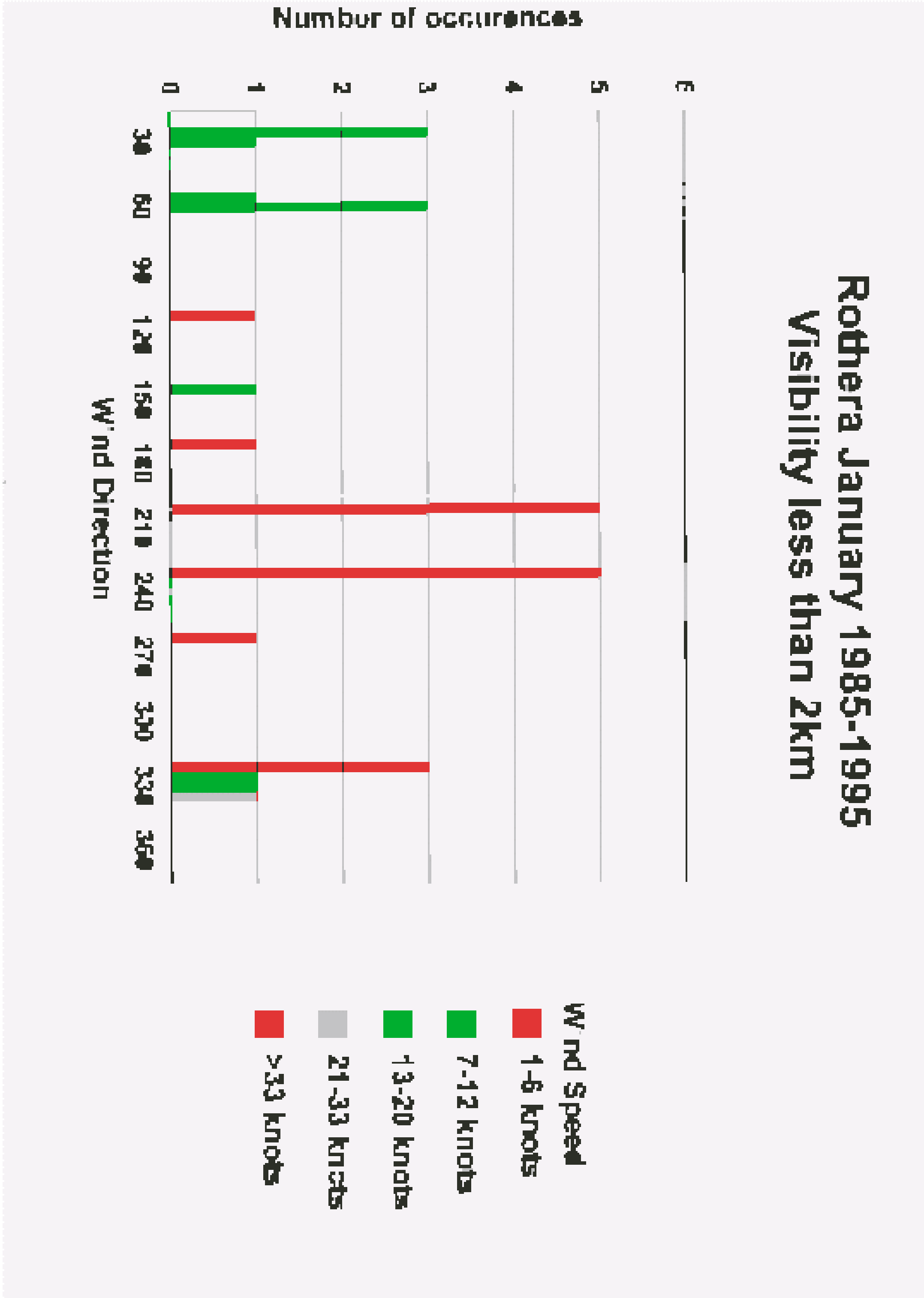


Fig. C.5. Rothera visibility in January less than 2 km as a function of wind direction. Period 1985-95.

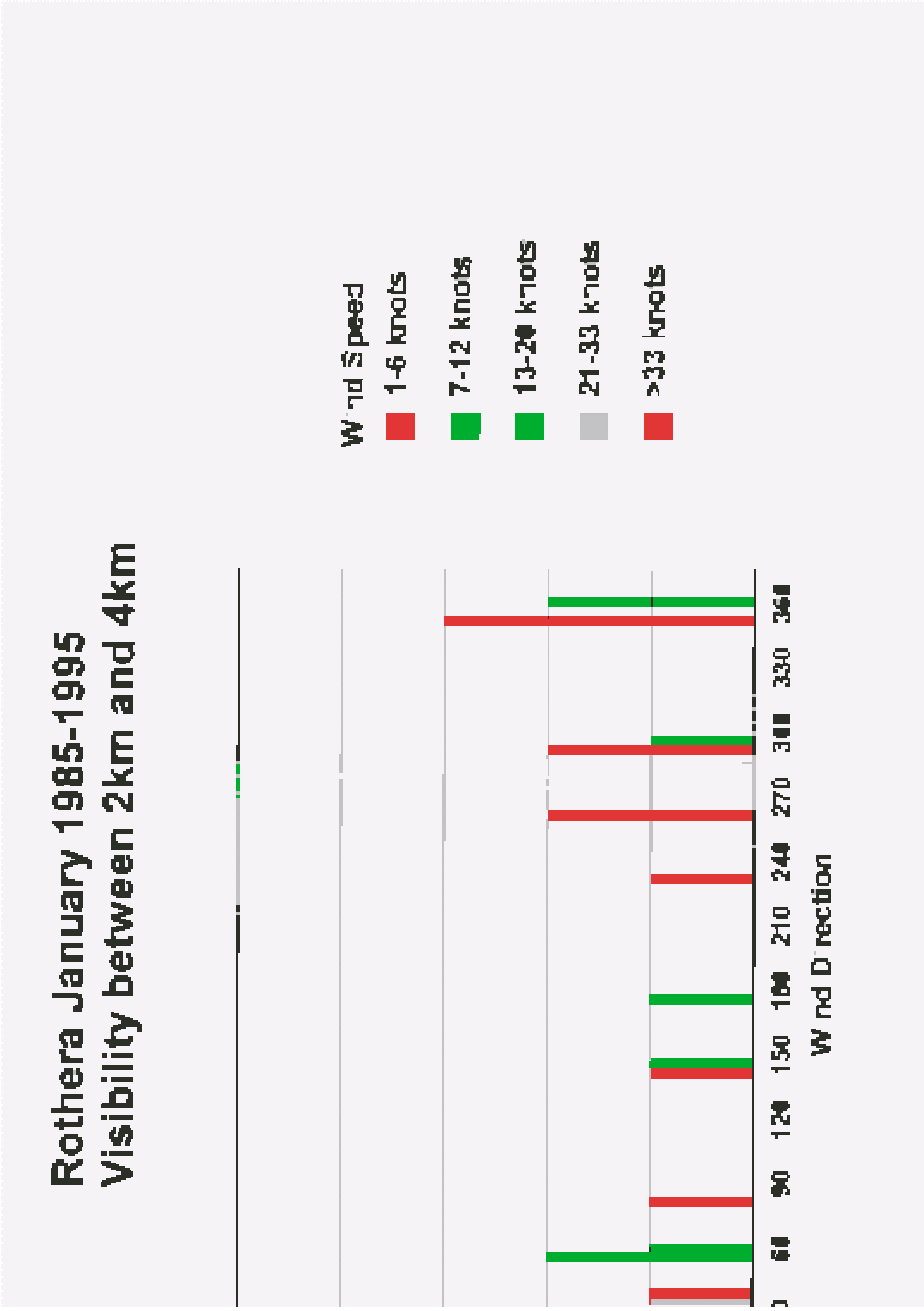


Fig. C.6. Rothera visibility in January between 2 km and 4 km as a function of wind direction. Period 1985-95.

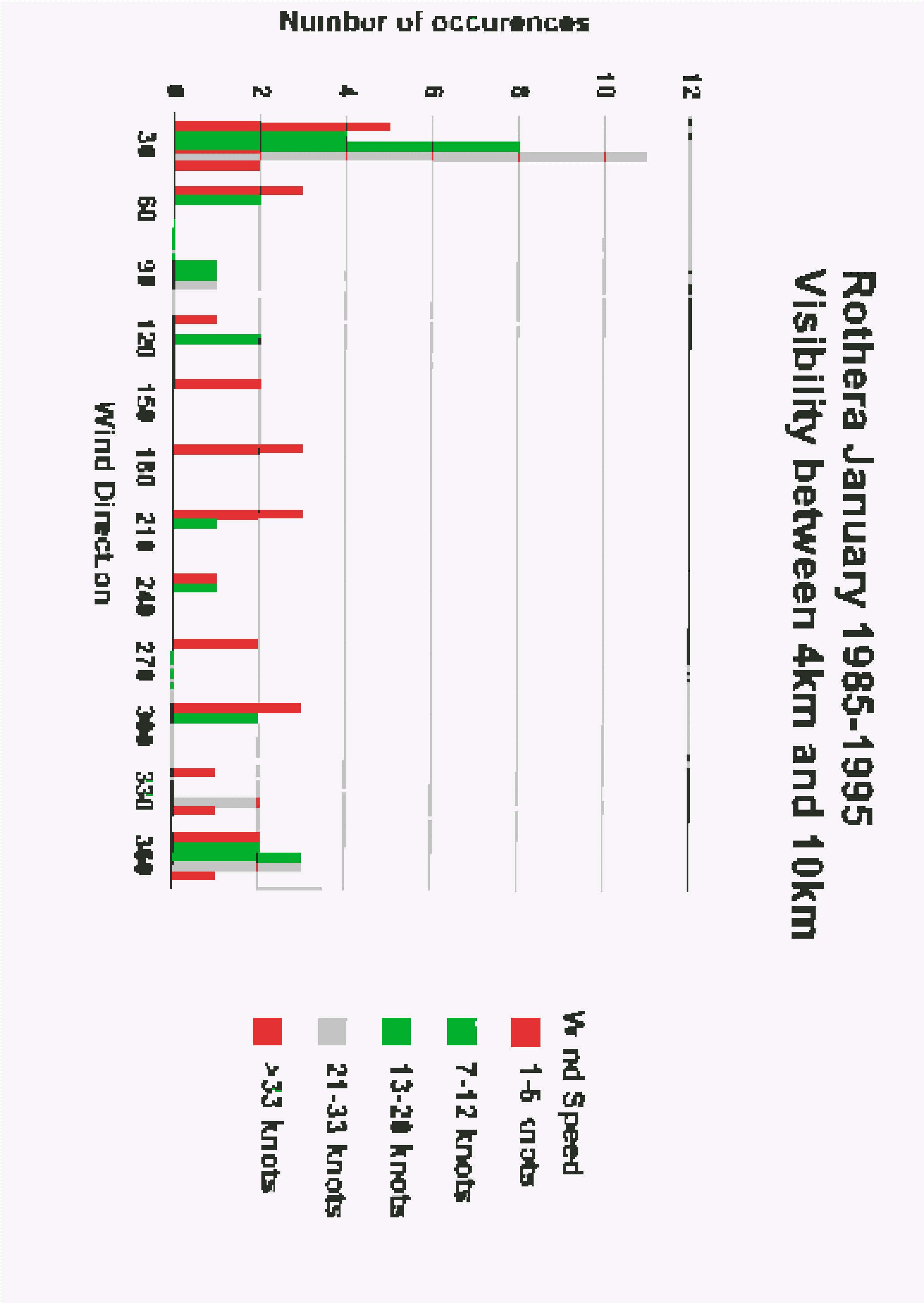


Fig. C.7. Rothera visibility in January between 4 km and 10 km as a function of wind direction. Period 1985-95.

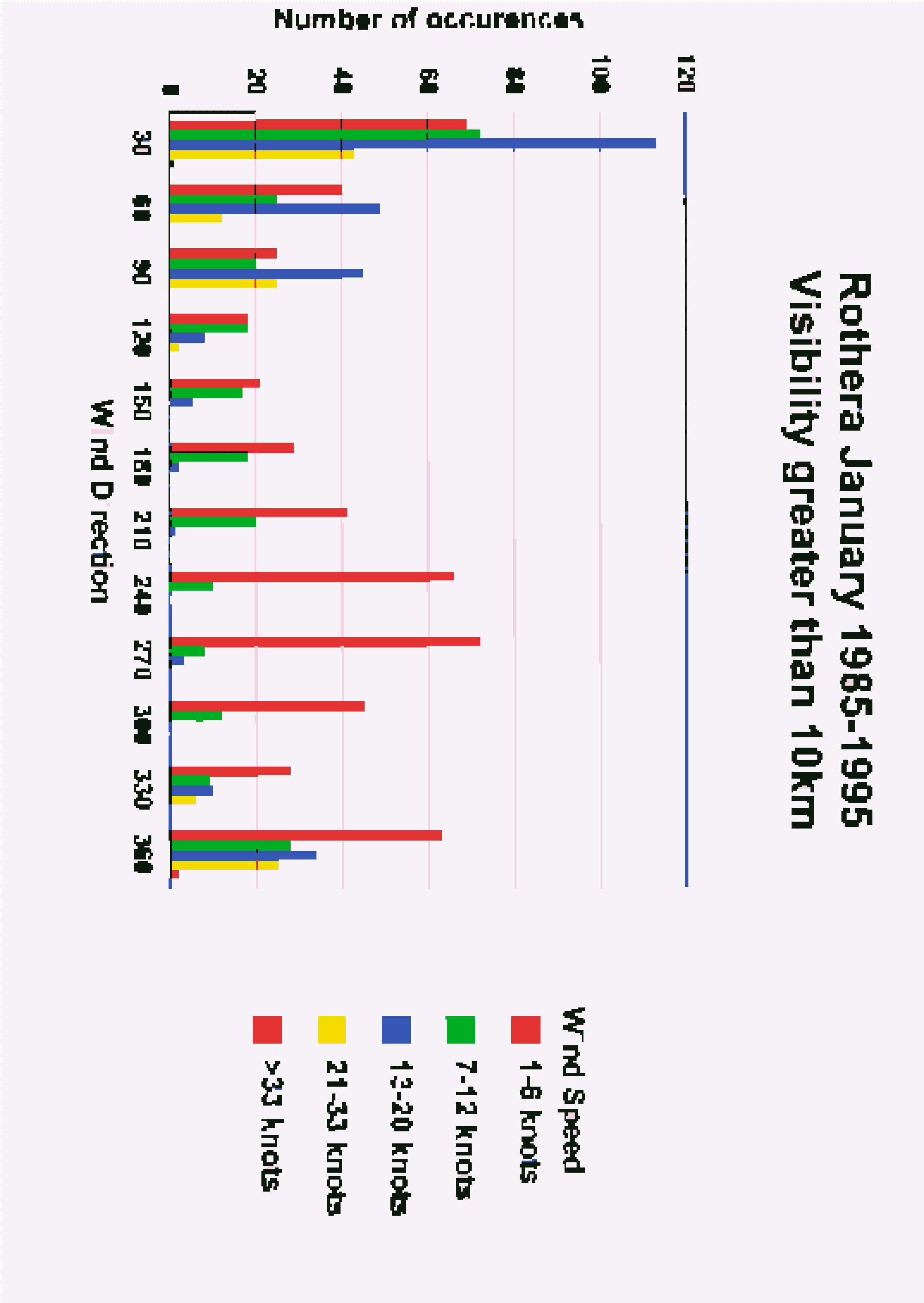


Fig. C.8. Rothera visibility in January greater than 10 km as a function of wind direction. Period 1985-95.

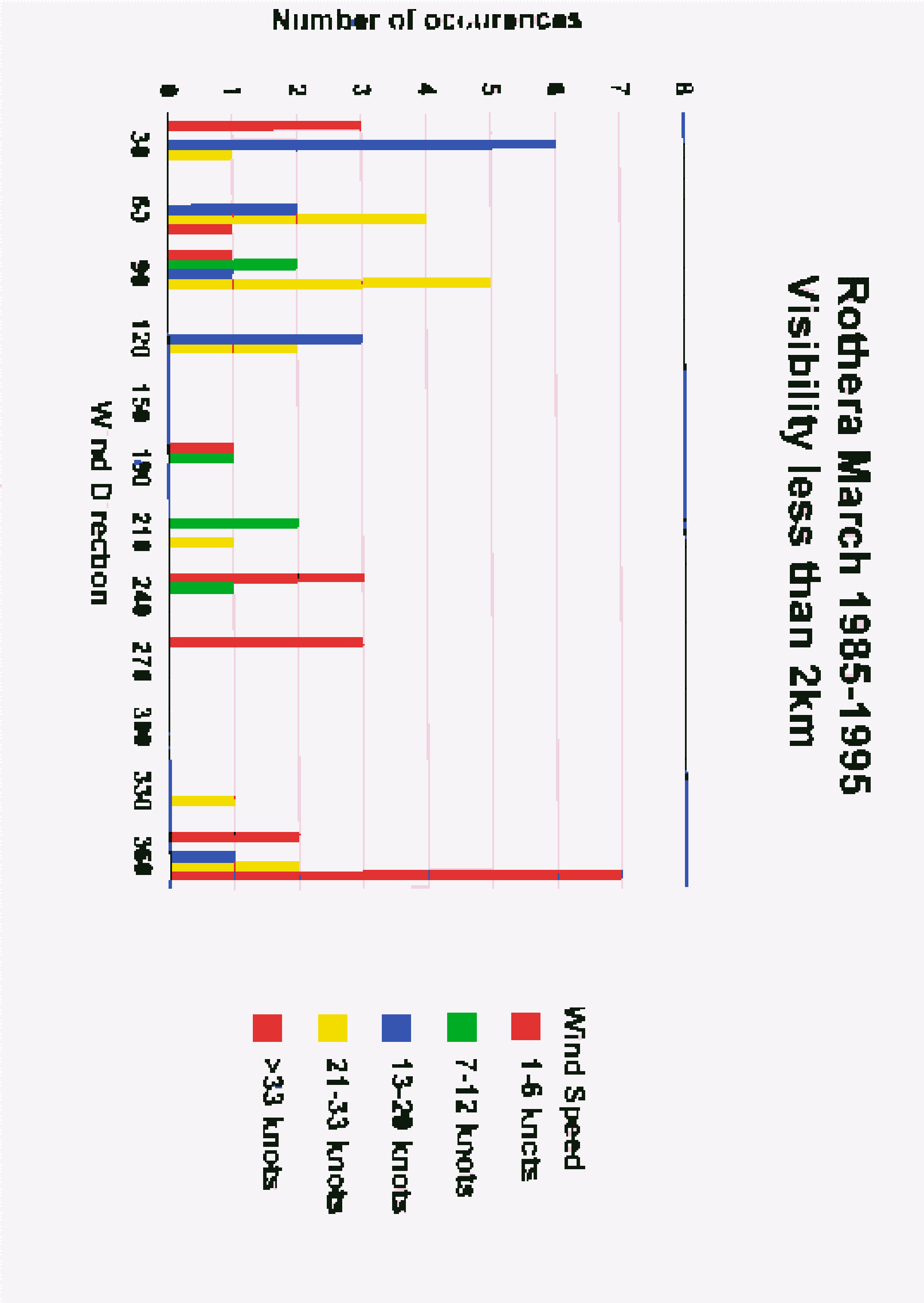


Fig. C.9. Rothera visibility in March less than 2 km as a function of wind direction. Period 1985-95.

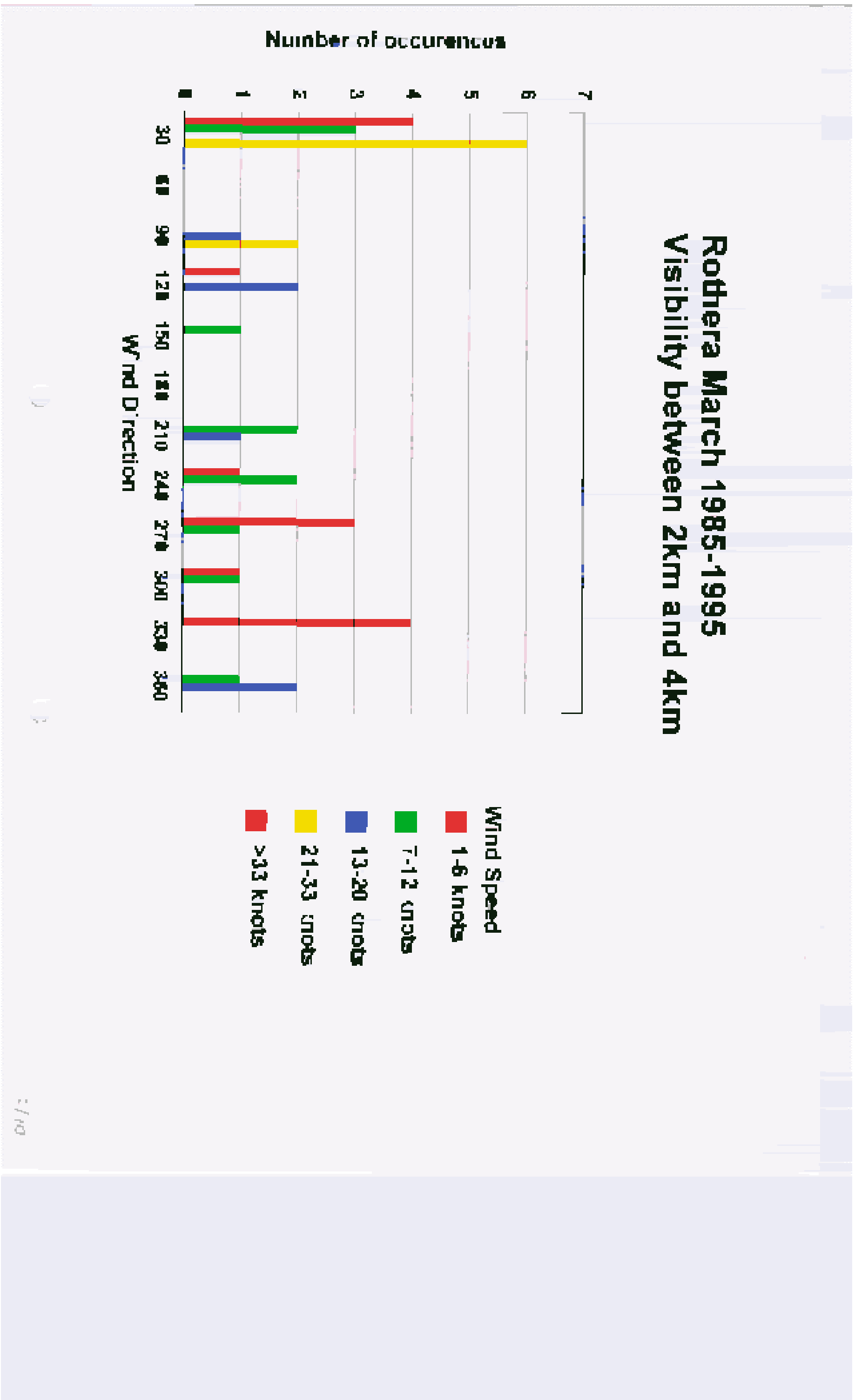


Fig. C.10. Rothera visibility in November between 2 km and 4 km as a function of wind direction. Period 1985-95.

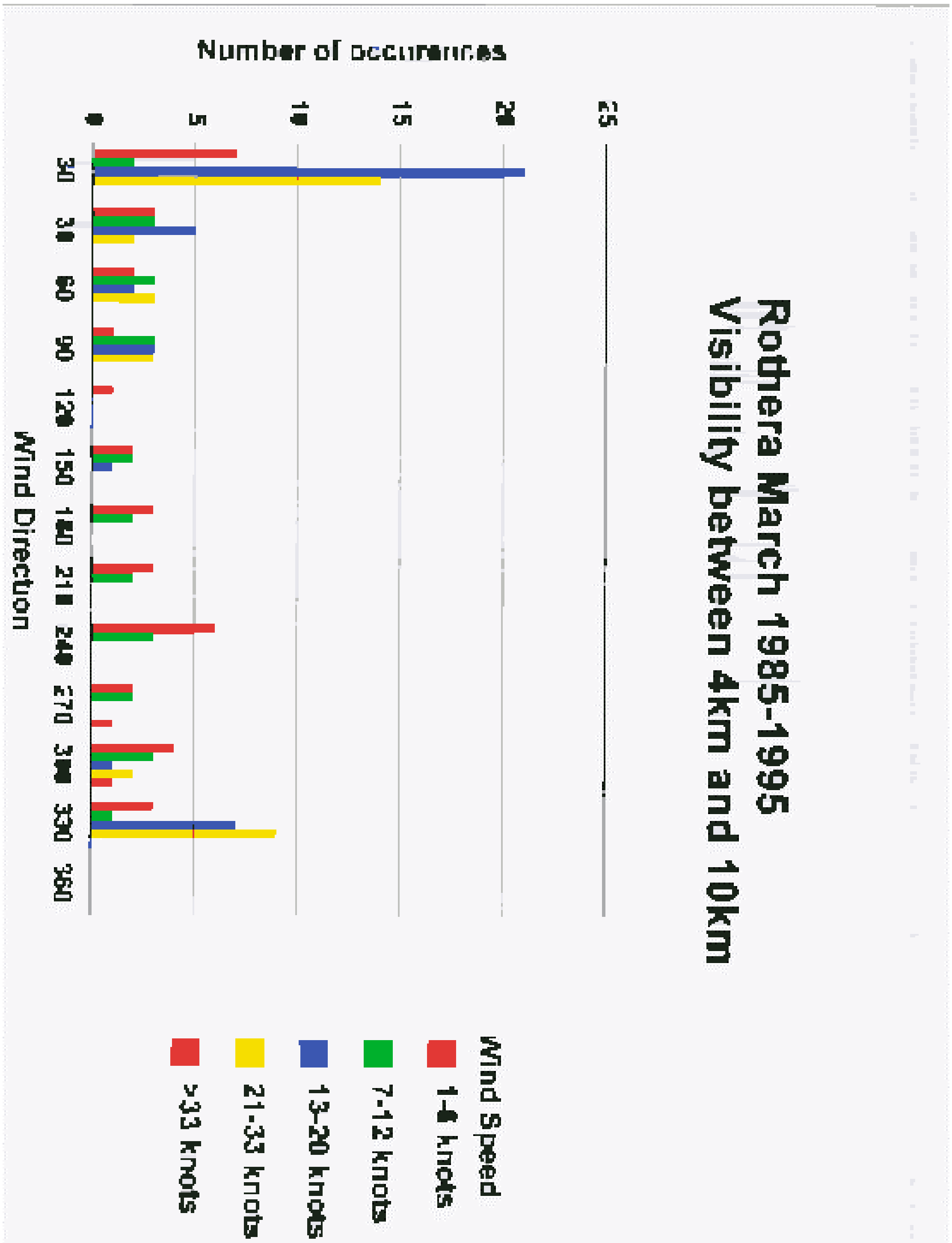


Fig. C.11. Rothera visibility in March between 4 km and 10 km as a function of wind direction. Period 1985-95.

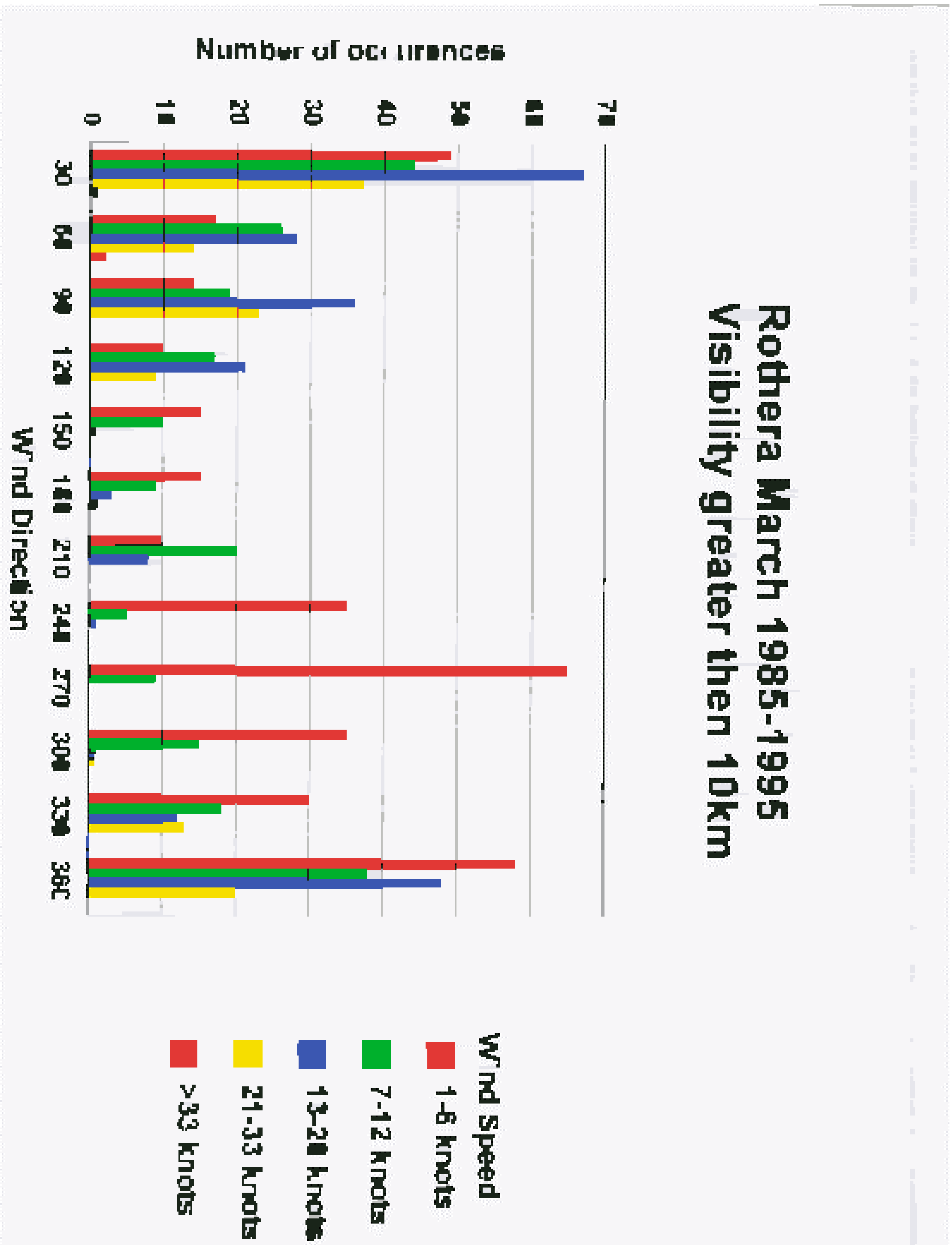


Fig. C.12. Rothera visibility in March greater than 10 km as a function of wind direction. Period 1985-95.

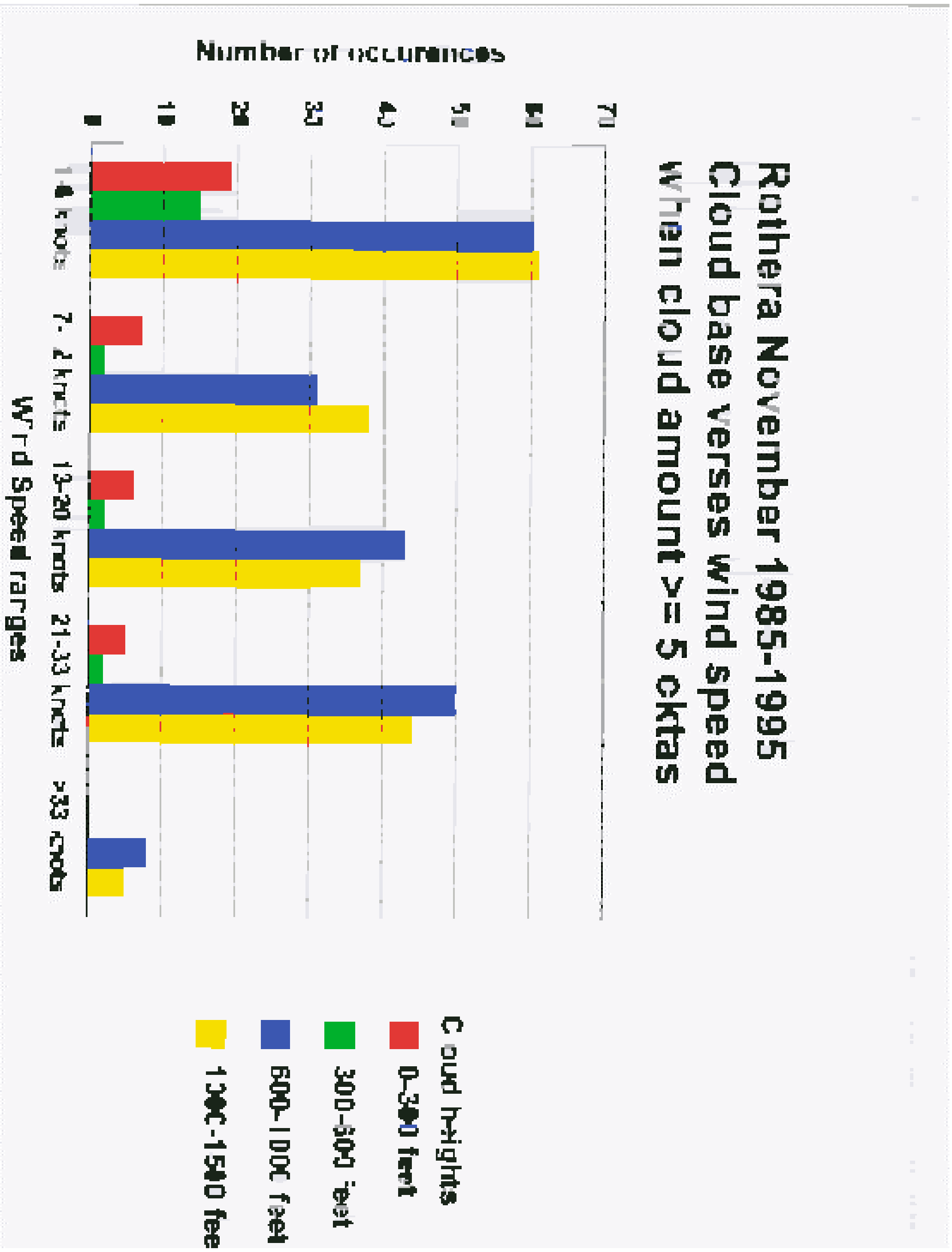


Figure C.13. Cloud base verses wind speed at Rothera in November when cloud amount greater than or equal to 5 oktas.

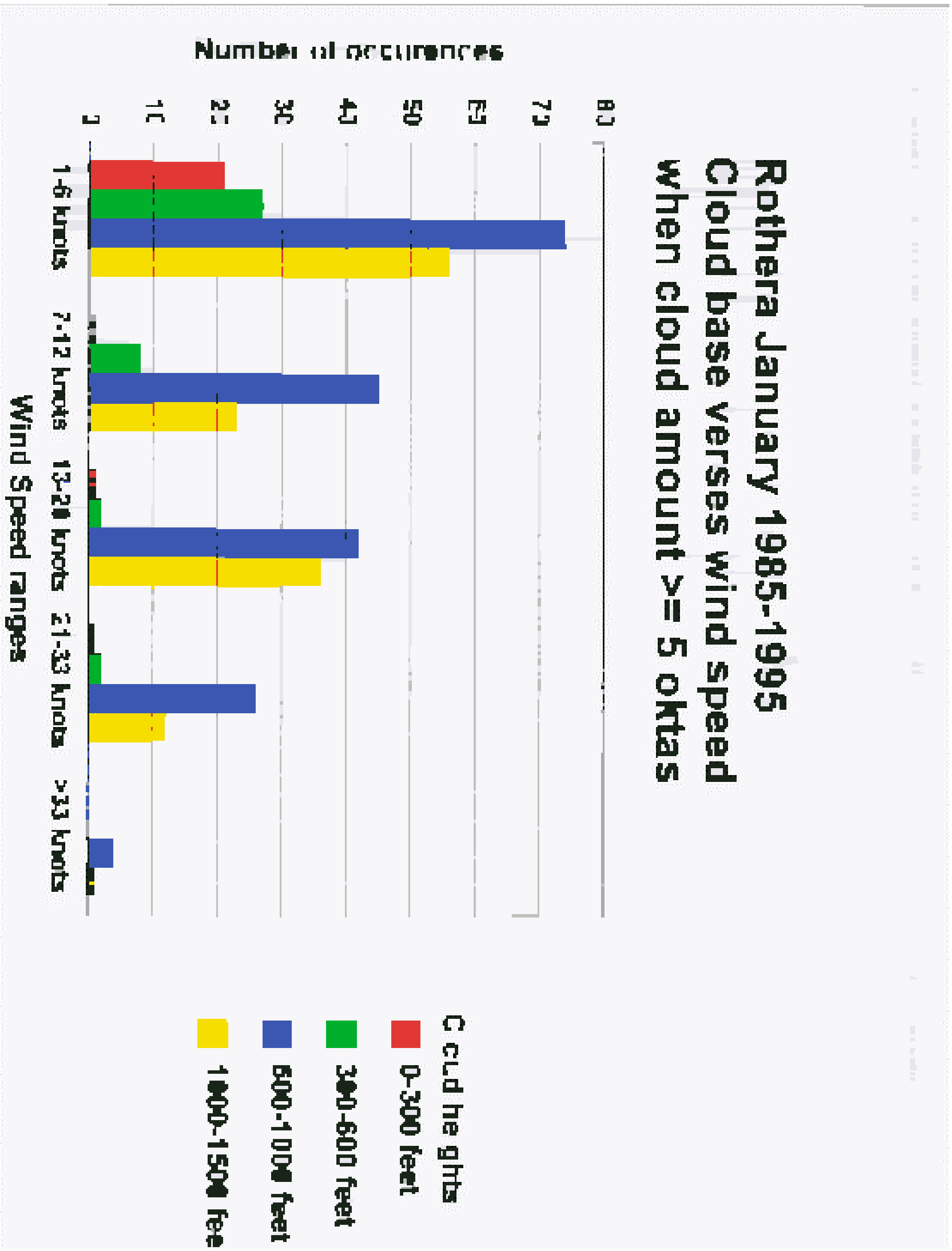


Figure C.14. Cloud base verses wind speed at Rothera in January when cloud amount greater than or equal to 5 oktas.

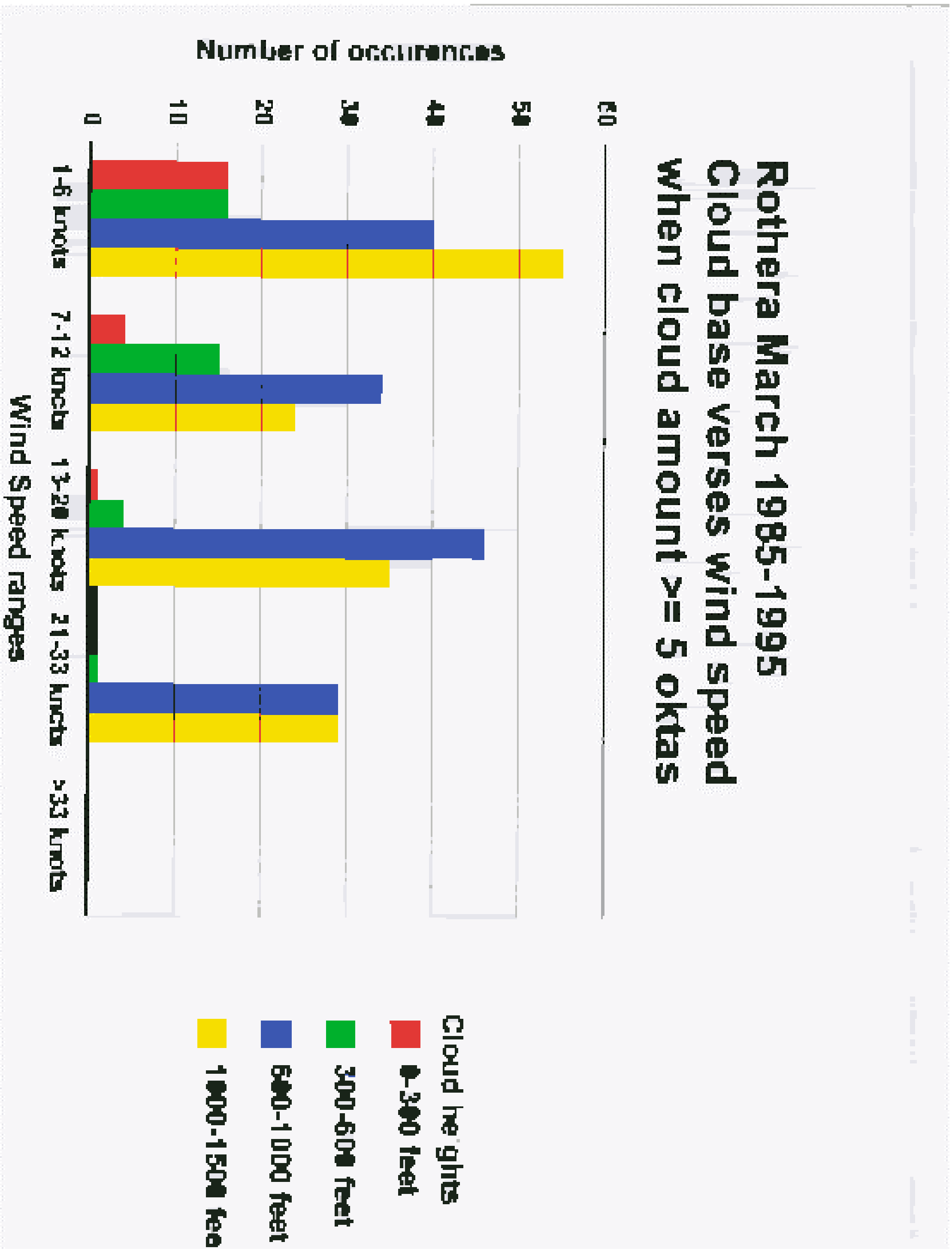


Figure C.15. Cloud base verses wind speed at Rothera in March when cloud amount greater than or equal to 5 oktas.

APPENDIX D

Forms used at the Rothera forecast office

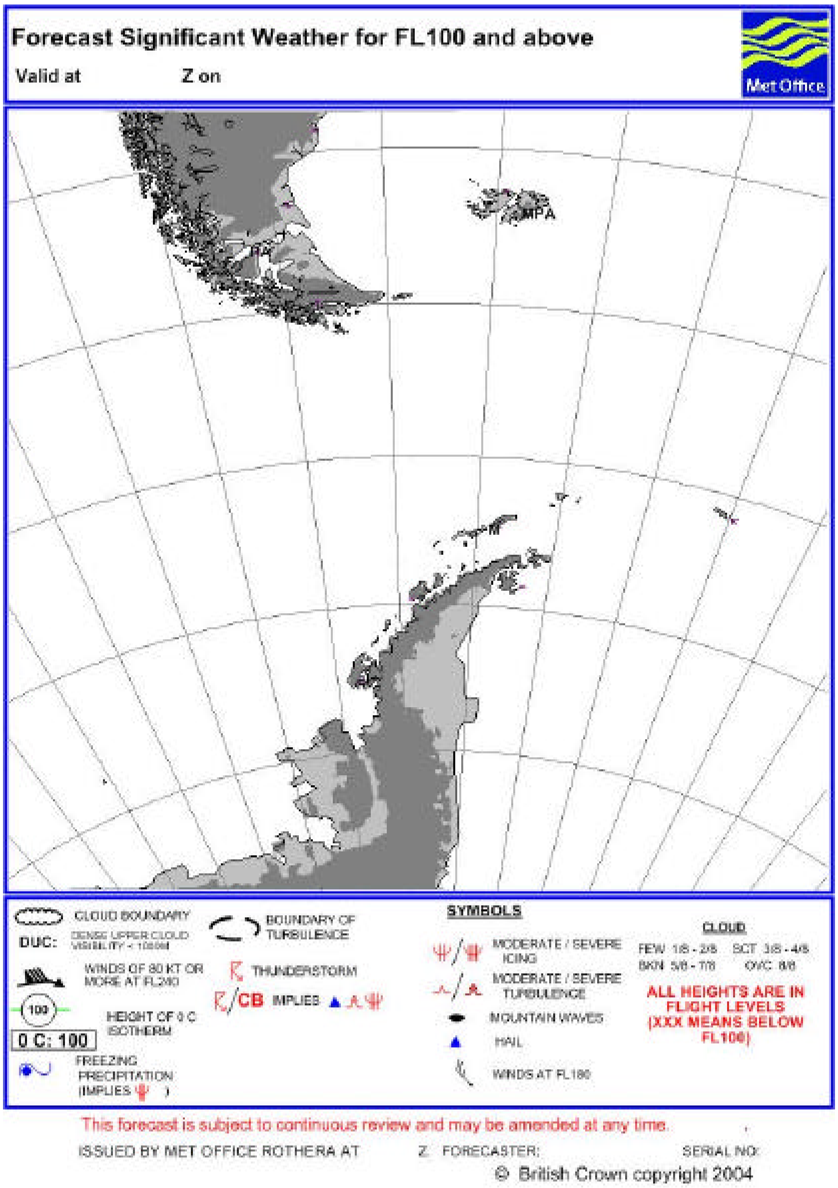


Fig. D.1. Forecast significant weather chart for FL 100 and above.

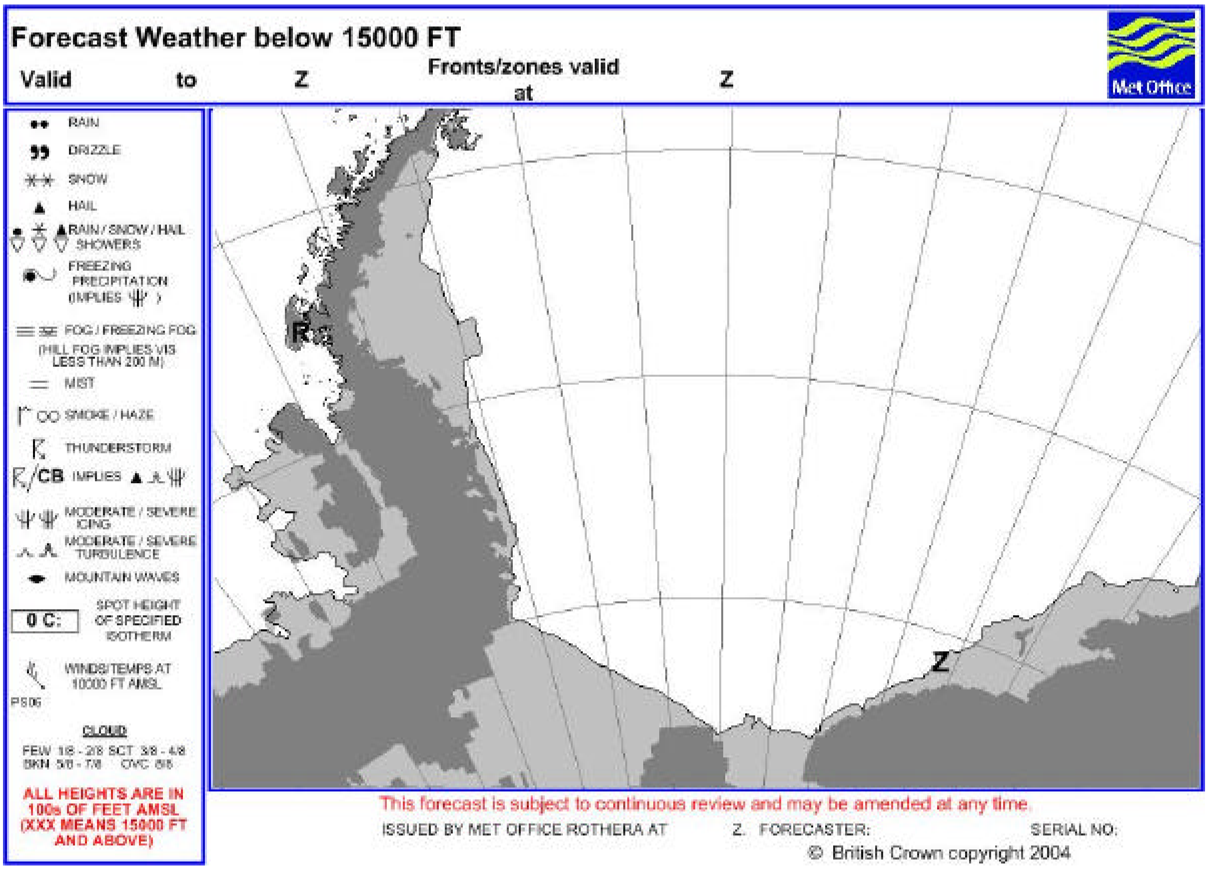


Fig. D.2. Forecast significant weather chart for levels below 15000 ft.

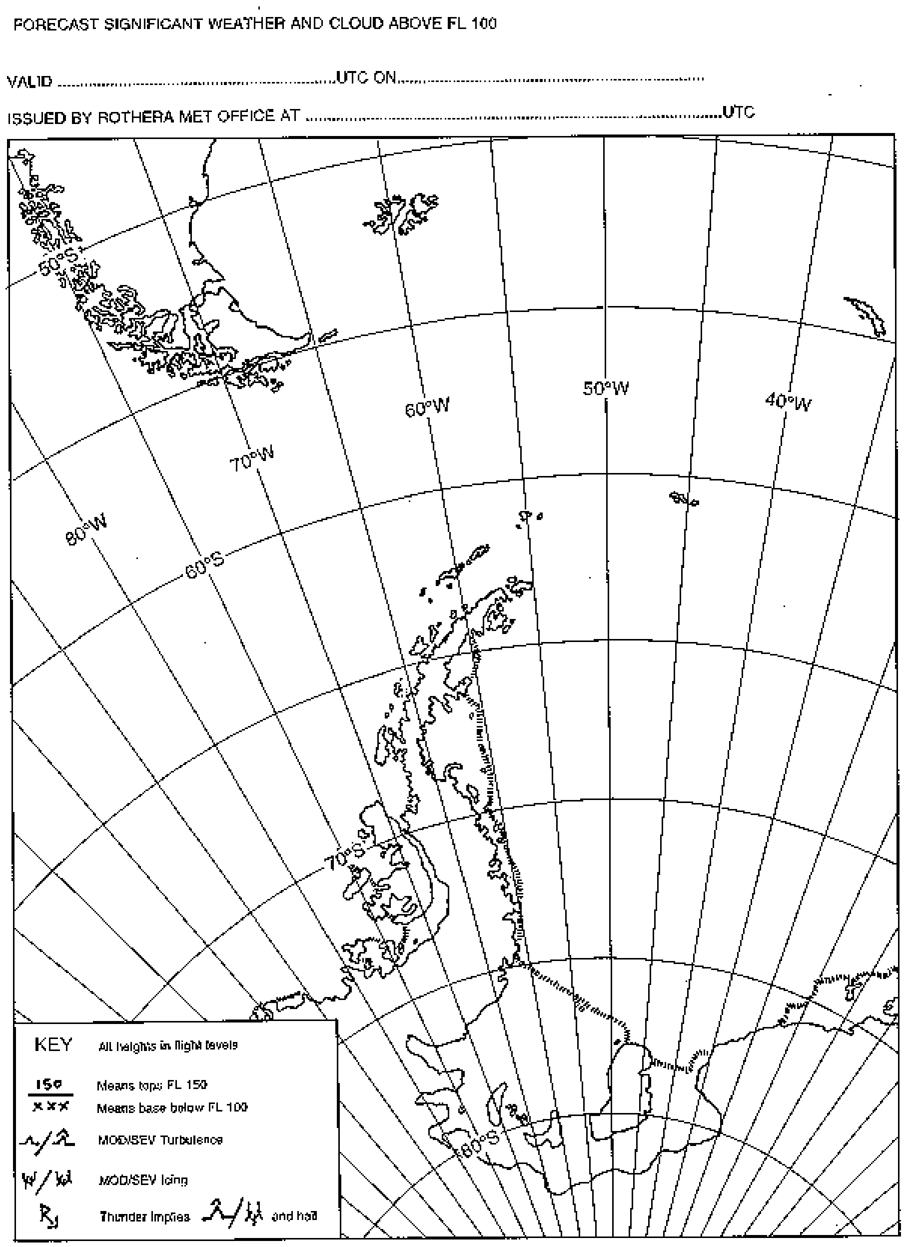


Fig. D.3. Forecast significant weather and cloud above FL 100 (hand drawn version). Chart used when the Visio version is not available as a result of a computer failure.

APPENDIX E

Dash 7 PNR Flight Criteria

If no suitable diversion is available the Dash 7 is said to be on a PNR flight. A PNR flight will only be considered as an option if the following criteria are met:

Weather at Rothera

Cloud	Ceiling not below 2000 ft, no more than one okta of lower level cloud.
Wind	If wind is southerly then not less than 15 kt (based on the risk of fog moving in from this direction). Easterly and Westerly winds not greater than 30 kt. Northerly wind not greater than 40 kt. No light and variable winds allowed.
Visibility	Greater than 25 km, no risk of fog or mist.
TEMPO	‘TEMPO’ deteriorations below these criteria in a TAF is acceptable.
Precipitation	No greater than slight.

Note: These weather limitations are flexible and are currently under review (Feb 2004), every potential flight is considered on a case by case basis.

Other Limitations

No less than 4400lbs of fuel forecast overhead at Rothera. The point of no return must be within 90 minutes of Rothera.
This is dependant on the upper winds, an average head wind component for the route of 45 kt or more will lead to a flight with only restricted cargo load. With an average head wind component of 55 – 60 kt the flight will not take place.

Other considerations

Sky Blu to give hourly met obs throughout the flight.

No movements of aircraft or heavy vehicles is allowed on the runway after PNR has been reached, small vehicles eg. Gators, may still cross.

APPENDIX F

The AVHRR Channel 3 (1.6 µm) Imagery

The National Operational Hydrologic Remote Sensing Center (NOHRSC; National Weather Service, NOAA) uses NOAA Polar Orbiting (AVHRR) and Geostationary (GOES) satellite data to map snow and clouds throughout the United States. Daily map products are generated to support operational hydrologic forecast models and numerical weather prediction models. To map snow and clouds, NOHRSC analysts use a supervised image classification algorithm that uses multi-band (wavelength) satellite data. The reflectance of snow and clouds is similar in the wavelengths measured by GOES channel 1 and AVHRR channels 1 and 2 (Figure F.1), therefore discrimination between snow and clouds using these channels is difficult.

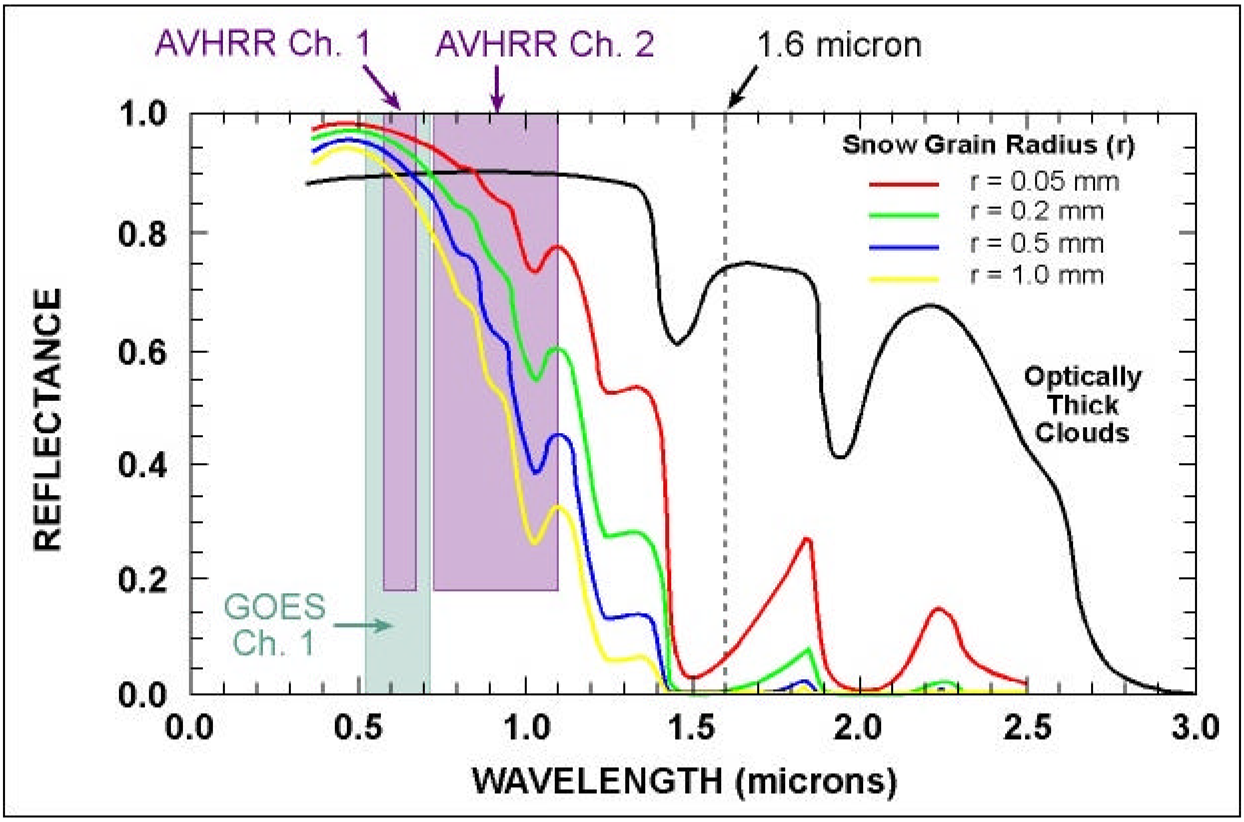


Figure F.1. Satellite channel wavelengths in microns (m), and typical reflectance spectra for snow and clouds.

Snow Can be Distinguished From Cloud at 1.6 m

The 1.6 m wavelength allows significantly improved discrimination between snow and clouds. At 1.6 m, snow has very low reflectance, while the reflectance of clouds remains high (Figure 1). Therefore, both cirrus and optically thick clouds can be directly classified and distinguished from snow at the 1.6 m wavelength (Warren, 1982). This has been clearly demonstrated using the operational Landsat Thematic Mapper satellite, which has a channel centered near 1.6 m (channel 5; 1.57-1.78 m) (Dozier, 1987; Baglio, 1989).

AVHRR Channel 3a Demonstrates Effectiveness of 1.6 m

The NOAA-15 Polar Orbiting Advanced Very High Resolution Radiometer (AVHRR) satellite sensor includes a 1.6 m channel (Ch. 3a) that was turned on for testing between March 20 - April 22, 1999. Analysts at the NOHRSC evaluated the effectiveness of the 1.6 m AVHRR data for mapping snow cover (Figure 2).

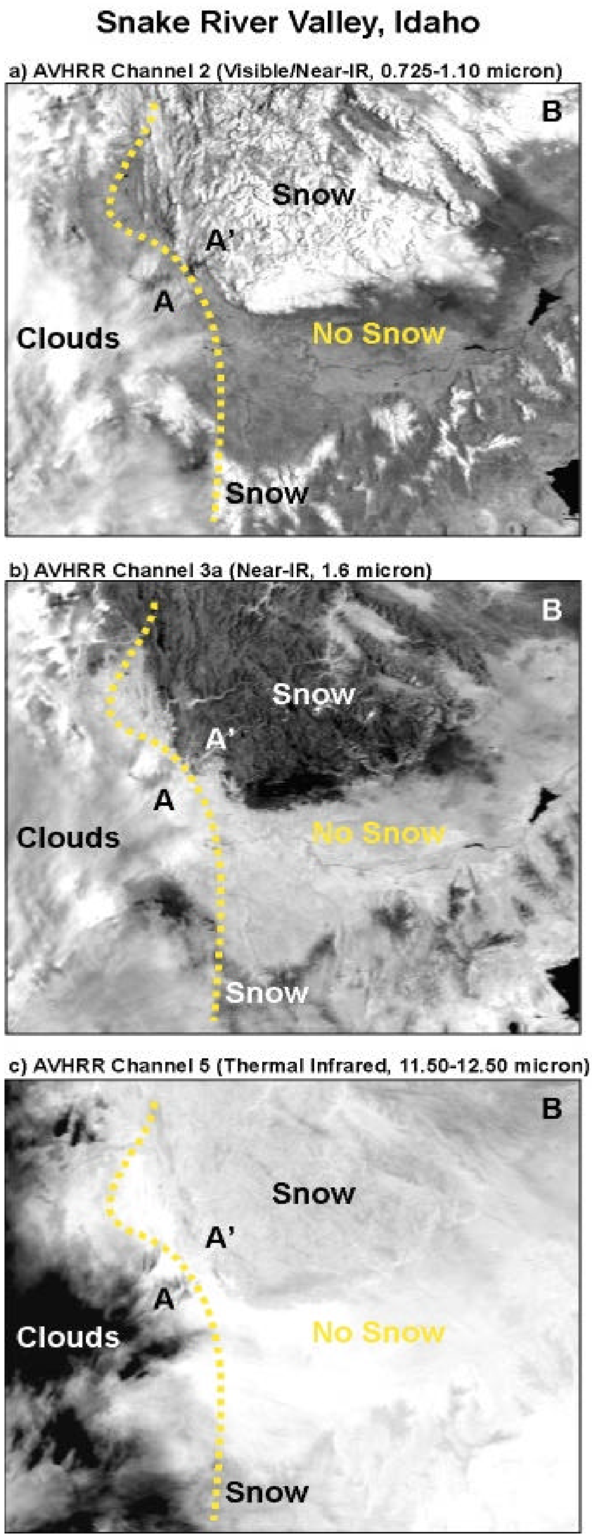


Fig. F. 2. NOAA-15 AVHRR imagery of the vicinity of the Snake River Valley, Idaho, March 24, 1999.

AVHRR Chanels 2, 3a, and 5 illustrate the reflectance of clouds and snow in these three wavelength regions (Figure 2). Channel 2 includes portions of the visible and near-infrared spectrum (e.g. Figure 1). The image contains significant cloud cover on the left side of the dotted line. The clouds are transparent in some areas and opaque in others. Clouds and snow have similar reflectance in this wavelength region. For example, the brightness of transparent cloud cover at point A is similar to the brightness of snow at points A' and B. Although the two features can be discriminated visually based on their different textures, their similar brightness in this channel does not readily permit discrimination between the two features using numerical classification techniques.

Channel 3a is the 1.6 µm test channel. The low reflectance of snow at this wavelength, indicated in Figure 1, is clearly apparent here. Cloud reflectance remains relatively high. For example, point A is significantly brighter than points A' and B. The darkest areas in the 3a image are unforested, snow-covered areas. The dark areas further north are also snow covered, but are less dark because of increased reflectance of forest cover at 1.6 m. The large difference in snow and cloud reflectance at 1.6 m even permits identification of snow beneath thin transparent clouds, as evident in the small dark area directly below point A.

Channel 5 lies in the thermal infrared portion of the spectrum, and brightness in this channel is related to the temperature of the cloud and land surfaces. In this case, the more opaque clouds have much cooler temperatures than the land surface, while the more transparent cloud and snow temperatures are similar (e.g. at A and A'). The ability to discriminate between clouds and snow using this channel is complicated by the variable temperatures of both clouds and snow, and their often similar temperatures.

The relative abundance of snow, clouds, and forest cover were determined using the1.6 m 3a channel and linear spectral unmixing techniques (Figure 3a, c, and e) using AVHRR Channels 1,2, 3a, 4, and 5. The relative abundance of each feature in a pixel is depicted as

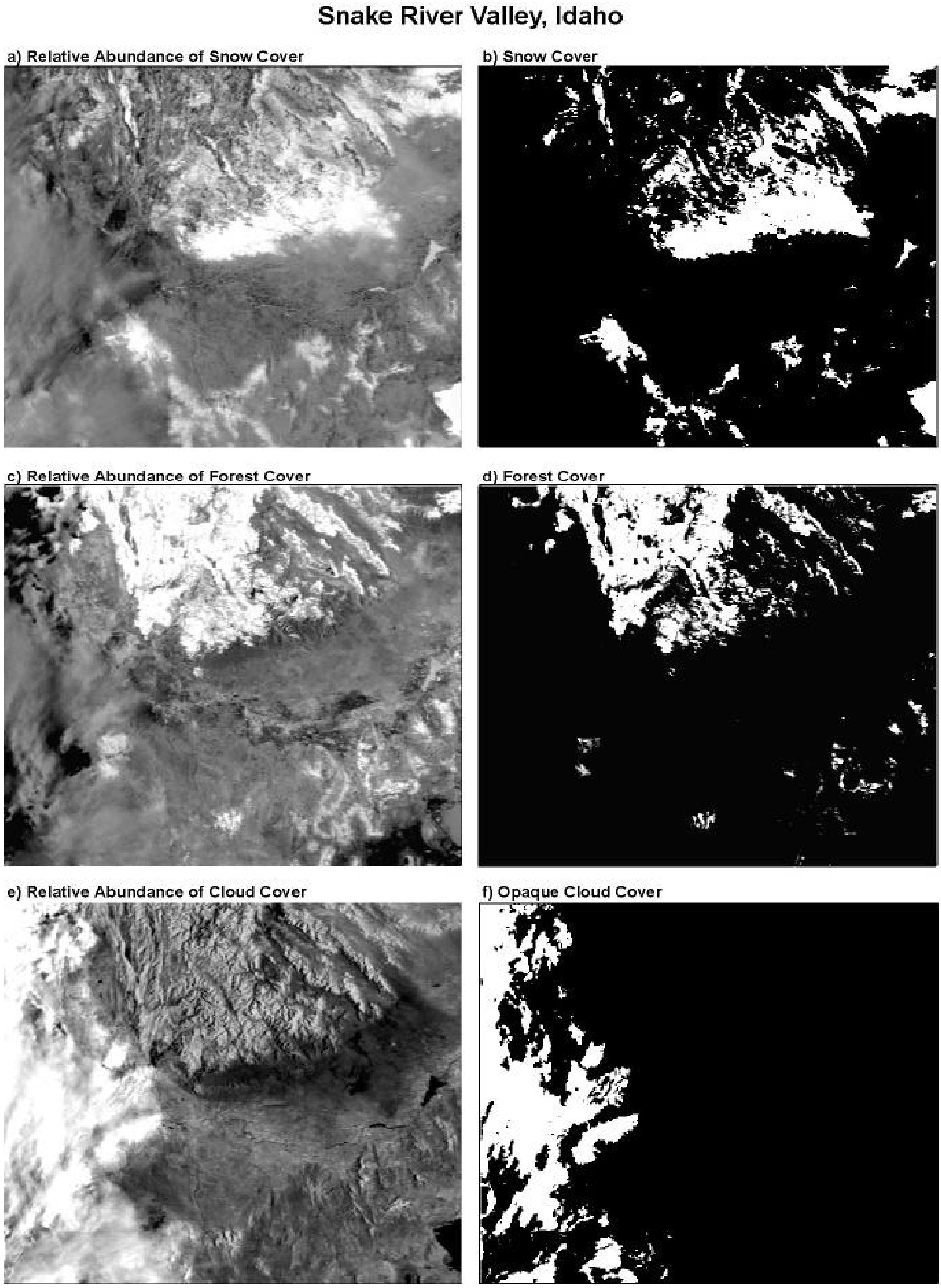


Fig. F.3. Relative abundance and threshold classification of (a,b) snow cover, (c,d) forest cover, and (e,f) cloud cover determined using linear spectrral unmixing.

shades of gray, with darker shades indicating less abundance and lighter shades indicating more abundance. Images (a) and (c) indicate that both forest and snow cover contribute to the reflectance of individual pixels in the northern part of the image. Images (a) and (e) illustrate areas with transparent clouds, where the land surface features (e.g. snow) contribute to the pixel reflectance. These relative abundance images were classified using a simple threshold (Figure 3 b, d, and f) to illustrate the benefit of the 1.6 m channel for snow/cloud discrimination.

AVHRR 1.6 m Channel Improves Snow and Cloud Classification

Under normal AVHRR operations (without the 1.6 m channel), snow and cloud classification is based on information illustrated by channels 2 and 5 in Figure 2. Classification is based on all five channels, but channels 1 and 2 are highly correlated with each other, as are channels 4 and 5. AVHRR channel 3 (3.55 - 3.93 m) adds little or no useful information for snow/cloud discrimination. The different reflectance characteristics between snow and clouds at 1.6 m significantly improve snow and cloud discrimination (Table 1).

Table 1. Assessment of AVHRR Channel 3a for operational snow and cloud mapping tasks.	**AVHRR with Normal Ch. 3**	**AVHRR with 1.6 m Channel**
Snow/Opaque Cloud Discrimination	Fair	Improved
Snow/Tranparent Cloud Discrimination	Poor	Improved
Identification of Snow beneath Transparent Cloud	Poor	Improved

References

Baglio, J.V., and Holroyd, E.W., 1989. Methods for operational snow cover area mapping using the advanced very high resolution radiometer: San Juan Mountains Test Study, *Research Technical Report*, U.S. Geological Survey, Sioux Falls and U.S. Bureau of Reclamation, Denver.

Dozier, J., 1989. "Remote sensing of snow in visible and near-infrared wavelengths," *Theory and Applications of Optical Remote Sensing*, G. Asrar, ed., John Wiley and Sons, New York.

Warren, S., 1982. Optical properties of snow, *Reviews of Geophysics and Space Physics*, 20, 67.

APPENDIX G

List of stations and AWS sites in the BAS operational area
List updated 2005 February 23

	WMO/ARGOS NUMBER	LAT	LON	HEIGHT metres	NAME	Country
***	85889	46°50'S	75°36'W	40	Cabo Raper Light House	Chile
	85892	47°15’S	72°35’W	196	Cochrane	Chile
***	85896	47°43'S	74°55'W	22	Isla San Pedro Light House	Chile
	85930	52°24'S	75°06'W	52	Islotes Evangelistas Light House	Chile
R	85934	53°00'S	70°51'W	37	Punta Arenas (Carlos Ibanez)	Chile
	85972	56°36'S	68°43'W	42	Isla Diego Ramirez	Chile
***	87880	48°47'S	70°10'W	360	Gobernador Gregores	Argentina
***	87903	50°20'S	72°18'W	220	Lago Argentino Aero	Argentina
	87904	50°15’S	72°03’W	204	El Calafate Aero	Argentina
	87909	49°19'S	67°19'W	60	San Julian Aero	Argentina
***	87912	50°01'S	68°34'W	113	Santa Cruz Aero	Argentina
	87925	51°37'S	69°17'W	19	Rio Gallegos Aero	Argentina
***	87934	53°48'S	67°45'W	22	Rio Grande	Argentina
***	87936	54°42’S	67°15’W	105	Tolhuin	Argentina
	87938	54°48'S	68°19'W	14	Ushuaia	Argentina
	88878	51°19’S	59°36’W	16	Pebble Island	UK AWS
	88883	51°54’S	60°55’W	17	Weddell Island	UK AWS
R	88889	51°49'S	58°27'W	73	Mount Pleasant Airport	UK
	88897	52°26’S	59°05’W	15	Sea Lion Island	UK AWS
	88900	54°00’S	38°03’W	3	Bird Island	U.K. AWS
***	88903	54°16'S	36°30'W	3	Grytviken	UK
***	88958	67°46’S	68°55’W	?	Carvahal	Chile
	88963	63°24'S	56°59'W	24	Esperanza	Argentina
	88968	60°44'S	44°44'W	8	Orcadas	Argentina
***	88970	64°58'S	60°04'W	32	Matienso	Argentina
***	88981	56°17'S	27°35'W	113	Zavodovski Island	SA AWS
	88986	59°27'S	27°19'W	286	South Thule Island	SA AWS
*	89001	70°18'S	2°21'W	62	S.A.N.A.E.	SA
R	89002	70°40'S	8°15'W	50	Neumayer	Germany
	89004	71°42’S	2°48’W	815	SANAE	S A. AWS
Int	89014	73°03'S	13°23'W	?	Nordenskiold	Fin. AWS
***	89020	75°35’S	26°10’W	30	Brunt	UK AWS
***	89021	75°36’S	25°45’W	30	Chasm	UK AWS
R	89022	75°35'S	26°36'W	39	Halley	UK
*	89034	77°52'S	34°37'W	256	Belgrano II	Argentina
*	89042	60°43'S	45°36'W	6	Signy	UK
***	89049	85°40’ S	46°23’W	1860	AGO-2	USA AWS
	89050	62°12'S	58°56'W	16	Bellingshausen	Russia
	89053	62°14'S	58°38'W	11	Jubany	Argentina
	89054	62°10'S	58°50'W	10	Dinamet	Uruguay
R Occ	89055	64°14'S	56°43'W	200	Marambio	Argentina
	89056	62°25'S	58°53'W	10	Frei	Chile
	89057	62°30'S	59°41'W	5	Arturo Prat	Chile
	89058	62°13'S	58°58'W	10	Great Wall	China
	89059	63°19'S	57°54'W	10	O'Higgins	Chile

	89061	64°46'S	64°05'W	8	Palmer	USA
R	89062	67°34'S	68°08'W	16	Rothera	UK
	89063	65°15'S	64°16'W	11	Vernadsky	Ukraine
	89064	62°40'S	60°23'W	?	Juan Carlos	Spain
	89065	71°20'S	68°17'W	55	Fossil Bluff	UK
	89066	68°07'S	67°08'W	7	San Martin	Argentina
	89214	72°52'S	19°02'W	20	Drescher	D. AWS
	89250	62°05'S	58°24'W	267	King George Island	Braz. AWS
	89251	62°13'S	58°45'W	10	King Sejong	Korea
	89253	63°11'S	55°24'W	75	Joinville Island	Braz. AWS
	89257	75°55'S	59°16'W	40	Limbert (also known as Shelf)	US AWS
***	89259	83°10'S	59°35'W	165	Filchner-Ronne Schelfice	D. AWS
	89261	64°16'S	61°54'W	17	Racer Rock	USA AWS
	89262	67°01'S	61°33'W	17	Larsen Ice Shelf	USA AWS
	89263	66°00'S	66°08W	20	Biscoe Islands	Braz. AWS
	89264	71°22'S	68°48'W	753	Uranus Glacier	USA AWS
	89266	72°12'S	60°10'W	205	Butler Island	USA AWS
***	89269	64°47'S	64°04'W	8	Bonaparte Point	USA AWS
	89272	74°48'S	71°29'W	1510	Sky Blu	USA AWS
	8910	64°58'S	65°40'W	25	Santa Claus Island	USA AWS

Notes:
* Station closed or no longer undertaking observations.
** Station damaged, awaiting repair.
*** Data not currently present on Horace.
R Radiosonde station.
Occ Occasional
Int Intermittent

Aerodrome designators

EGAR	Rothera
EGYP	Mount Pleasant
SAWB	Marambio
SAWH	Ushuaia
SCCI	Punta Arenas
SCGZ	Puerto Williams
SCRM/SCEF	Marsh/Frei
SFAL	Stanley

Ship Identifiers

DBLK	RV Polarstern	
GXRH	HMS Endurance Not reporting 2005	
LOAI	Almirante Irizar	
PDZS	Europa (Dutch ice strengthened tall ship!)	
UCJP	Kapitan Dranitsyn	
UCKZ	Akademic Federov	
WCX7445	Laurence M Gould (USA)	Not reporting 2005
WBP3210	Nathaniel B Palmer (USA)	Not reporting 2005
ZDLS1	Ernest Shackleton	
ZDLP	James Clark Ross	
ZSAF	S.A. Agulhas	

Appendix H

Horace technical information

H.1 Operation

For normal use login as horace, password horace and role as chief. Rothera should report all problems to Jon Shanklin <jdsh@pcmail.nerc-bas.ac.uk>. DO NOT MAKE ANY CHANGES TO SYSTEM SETTINGS. These must be done from Cambridge so that they are properly documented. Only documented changes will be implemented in system upgrades.

Charts can be emailed by saving as gifs and then clicking on the mail icon. Only outgoing mail in enabled. You can print charts, however Horace will only use the default printer, usually set as the most convenient laser jet. Use full colour rather than line drawing for output, even on a black and white laser. If other printers are enabled, you can print to these from Konqueror etc.

a) To start Graphic Visualiser:
Bottom right hand side 2nd icon (Browse: graphical) and start graphic visualiser
It initially starts with a global map.

b) To change map:
Maps | display user maps | BAS Antarctic or whatever
A left mouse click zooms in, shift left zooms out
Shift centre rotates
Control centre scrolls
or run one of the macros.

c) To plot fields:
Press top left hand side 2nd icon (Display NWP data) (isobar icon)
Click on UKMO –
The default is global | main | selected levels | original
you may need to click on amended then back to original to see current available fields
sea state data is in wave | global | model levels | original
derived data is in global | main | derived | original
Select what you want. Load derived fields first.

d) To plot obs:
Press top left hand side 3rd button (Display plotted observations)
Select SYNOP, METAR, SHIP and TEMP
You can chose time at top – press now, then adjust to a main or intermediate synoptic hour

e) To create imagery:
Start the Dartcom SIAMIV programme and run:

HRPT | import | Dundee | Import [select hrpt<n> | Close
The data is imported to c:\dart32\siamiv_viewer. Older files are archived in Arch01 etc.
HRPT | decommutate | Decommutate | Close [you can go back to an older file if you want]
HRPT | Subsample | Select all | Create | Save as hrpt_sampled | Close
The data is saved to c:\Dart32\workarea

Navigation | Polar navigate
If the navigation isn't right (sometimes the case if the pass goes over the pole) select a smaller area to subsample that doesn't include the pole or reject the image.
Navigation | Projection transform | Transform | Save as hrpt_reprojected | Close
[The transform area is set to –68/60, 4/1200/1000]
File | Export | Data | Channels 1 to 5 | Close
[At night only bother with the infra-red channels 3 to 5, and possibly only 5]

Whilst it might be possible to configure MacroPro to processes the stages after decommutation automatically [See Dartcom manual], in practice it is best to have user choice over which images to process. Some are flawed, either at the copying stage or on transmission from the satellite (particularly NOAA 16).

Once processed, start WinSCP2, session hor2 (or hor1 if bas1 is running) and copy the channel data (HRPT channel <n> calibrated values.bin) from c:\dart32\workarea to /home/hor_adm/bas/aries on Horace by double clicking. A cron job on both machines (running every five minutes) will then rename the files and copy them to be processed for display. It only takes a couple of minutes to process each file, so if you are doing the morning block at 12 Z, just process channel 5 and instead of accepting the automatic name each time, change 5 through the sequence 5, 4, 3 etc. This won't affect where the file goes, but does prevent it being overwritten by the newer file.

f) To plot imagery
There are two programs to display the satellites images: graphic visualiser as above and Imagery (started from the same service button), which is a cut down version of the visualiser, but which starts with the animation buttons on view. For either choose a map and then click the leftmost icon with the satellite dish on it. Select Channel 4 (which actually has channel 5 data) or Channel 2 (actually channel 1) and mercator projection. This should show the available frames. Select the frames one at a time or select a series for an animation.

g) To produce five-day forecast
Bottom right hand side 6th icon (Browse: Product_Creation/) and start 5_Day_Forecast
Select NWP (isobar icon)
Enter station id
Press monitor icon

H.2 Problems

On occasion a run of the Met Office model encounters problems and the automatic download copies a partial run. First check to see if anything has come in after the automatic run, then manually run the download if required. Type the following from a horace terminal window:

a) login to bas ftp site:
ftp ftp.bas.ac.uk
metftp
met_456
b) issue commands:
cd horace
cd nwp
ls -alrt
c) check that the most recent bas1_nwp_south.... file is larger than 35Mb and is after 08:15 or 20:15 as appropriate. Exit from ftp (bye). If it is:
d) Login as hor_adm (password wessex1) by typing
su hor_adm
e) issue commands
cd ~/bas/routines
./get_bas_nwp.ksh
f) once it has run, logout by typing exit. Depending on how busy codis is, it will take 20 - 90 minutes to download the files.

H.3 Macros

The following local macros have been developed for BAS operational use:

a) Obs:

This displays the latest observations available.
Most stations only report at 3 hourly intervals
1. Click on date and time icon on toolbar
2. Adjust time in the top left hand box backwards to the nearest time divisible by 3.
3. Move the second year box down on the right to 2005.
4. Click on TV icon in bottom left hand corner.
This will give the latest observations for the most recent 'main' hour.

b) Main:

This gives details for Rothera and surrounding area for 6 days.

Fields are as follows:

1. 10,000FT humidity with areas above 80% (likely cloud) coloured red.
2. Snow showers.
3. General snow.
4. General rain.
5. Rain showers.
6. Surface temperature.
7. Surface pressure (isobar chart).
8. Surface winds.

c) LL Wind & Temp:

Fields are as follows:

1. Surface wind.
2. Wind at 2000FT.
3. Wind at 5000FT.
4. Temperature at 5000FT.

d) Halley:

Same as Main but for the Halley area.

e) GFS2:

A south polar view of the general circulation can be used for comparing with the American model (http://www.antarctica.ac.uk/met/jds/avn/tkavnsh.html or from http://www.wetterzentrale.de/topkarten/fsavnsh.html) or just looking at New Zealand and southern parts of Australia.

Fields are as follows:

1. Essentially colours represent warmer of colder air (orange warm, purple cold)
2. White lines are surface pressure.

f) Graeme:

Low, medium and high cloud fields and associated winds for lidar or optical studies.

g) Brief Chart & Brief Winds:

Macros for morning briefing in Summer.

h) Jon

Low, medium, high and convective cloud fields with a rather more pessimistic setting than for Graeme- for astronomical studies.

j) Ozone

This plots the 100 hPa temperature field on a pole centred map and colours in the area colder than –70°C. Temperatures below –80°C are near the centre of the ozone hole.

H.4 Known features

Macros:
If you try and select latest for the second or more data layers it remains unselected and reverts to select at run time. Choose predefined and then latest and it is OK.

Metwatch: Once a Metwatch action is started it remain active until the machine is rebooted. This means that processes can accumulate and in particular generate lots of warning messages. Metwatch won't watch out for a TEMP message.

Ingest of images stops after editing files SatelliteDataSource.dat or SatelliteSourceType.dat in /usr/horace_linux/operational/d_base/resources/static_data. It also does the same thing once it decides a file is **bad**. You must then reboot the system.

Wind arrows change size depending on size of window frame.

Macros don't change NWP fill colour, but just use the last scheme set.

Satellite image ingestion uses the last modified date, not the time received date.

The Dartcom Siamiv program reverses the grey-scale of the images and restricts the range giving rather poor images. The problem appears to lie in the Siamiv export, which gives the wrong value to the maximum scale value, and then also compresses the available range. Eg a temperature range of +3 to –55 is assigned a range of +3 to –273 and then coded into +3 to –30.

The profiler won't print profiles – solution – save the profile as a gif and print from the web browser, or mail as an attachment. Both browser and mail have folders for GV Products.

Horace will only print to the default printer.

The intensity of precipitation as shown by symbols changes with window size.

H.5 Data feed

Data from the Met Office is sent by ftp to the BAS site at ftp.nerc-bas.ac.uk (user metftp, pw met_456). Data specifically for Horace is sent to the metftp horace subdirectory, which has further subdirectories of nwp (for numerical forecast data), dpds (for observational and image data), rothera (for data for Rothera) and Cambridge (data for Cambridge).

a) General data from the GTS comes to BAS in a continuous stream of small files which are received every five minutes or so at the metftp root site. The data flow includes observational data and the GRIB data, but these GRIBs aren't handled properly by Horace. The files are named BASyyyymmddhhmmssA.DAT, but the gribs are extracted and the files are renamed to syBASyyyymmddhhmmssA.DAT and copied to ftp/metftp/Horace/rothera and ftp/metftp/Horace/cambridge by the script get_new running under cmet on bsucena at /users/icd/cmet/NEW_MET_OFFICE_DATA which uses ftp with user hor_adm. This is than processed on Horace by move_DPDS.ksh.
b) Specific GTS data files for Horace, are sent by the Met Office to ftp/metftp/horace/dpds on bsuitsb (and moved by us to ftp/metftp/horace/rothera & cambridge), but they only cover the north-west Atlantic area. Rothera will not need this data. The files are named syamBE_hhmm.dat.gz and are copied to /usr/horace_linux/operational/d_base/incoming by another cron job on bsucena. Further processing by Horace is then automatic. Data on the ftp site older than 12 hours is deleted by BAS.
c) The nwp data is received between 05 to 08 UT and 17 to 20 UT, with initial transmissions containing partial information, so it is best to wait until 8 am/pm. The files are:
   bas1_nwp_south_yyyymmddhhmm.tar.gz 35Mb
   bas1_wave_south_yyyymmddhhmm.tar.gz 1Mb
   These files appear in the ftp/metftp/Horace/nwp directory. They are transferred by Horace to /usr/horace_linux/operational/d_base/incoming/transfer ($TRANSDIR) by a cron job running every five minutes (data_receive.ksh) which unpacks them and sends the data file to the destination specified in Dest.txt, which is in the tar file. Data on the ftp site older than two days is deleted by BAS.
d) Image data, which begins L*.DAT.gz (eg LINR37d_hh00.DAT and LVNR37d_hh00.DAT) goes into ftp/metftp/horace/rothera, but you can ignore this. Only images centred on Bermuda are received so these aren't much use operationally, but are being taken. ARIES images are converted to AUTOSAT (Horace) format using the Dartcom SIAMIV system.

The transfers are done using cron jobs. These check that files haven't already been copied and only copy new ones. At Rothera bas1 is currently set up to collect the data from Cambridge and copy it to bas2, however if bas1 isn't running bas2 will do the collection. The Cambridge Horace runs in the same way, but looks at a different directory at the metftp site for the dpds data.

H.6 General system information

Rothera should report all problems to Jon Shanklin <jdsh@pcmail.nerc-bas.ac.uk>. DO NOT MAKE ANY CHANGES TO SYSTEM SETTINGS. These must be done from Cambridge so that they are properly documented. Only documented changes will be implemented in system upgrades. Problems are then reported to helpdesk@metoffice.com, with copies to Phil Dominy <phil.dominy@metoffice.com> and Andy Cooper <Andrew.l.cooper@metoffice.com>. Phil will usually pass on queries to the relevant experts.

The Rothera printer is ljet4, which is the ops room printer.

The images that are generated (gifs, png etc) from GV are in
/usr/horace_linux/operational/d_base/generated_products/local/graphics/gpe

There are lots of links which get you to similar places – use the command env or set to inspect what is set.
For example the following appear to be similar:
/usr == /data/bas<n>

The following are useful shortcuts
$top_dir == /usr/horace_linux/operational
$DBASE == /usr/horace_linux/operational/d_base
$DBASE_INCOMING == /usr/horace_linux/operational/d_base/incoming
$TRANSDIR == /usr/horace_linux/operational/d_base/incoming/transfer
$DBASE_STATIC_FILES == /usr/horace_linux/operational/d_base/resources/static_data

Horace does an automatic mirror of the system to the other machine (/disk/bas<n>/backup/bas<n>/operational) at 01:00 every day. This only copies the Horace system files in Horace_linux, it does not copy the user files for hor_adm or Horace.

The d or compare12 commands from hor_adm will list some of the differences between the two systems.

If text is blurry on the screen you need to check the monitor settings. Press " menu | picture quality | OPQ " and select picture or text.

H.6.1 hor_adm/bas/routines:

The machines are configured so that bas1 is the primary and bas2 is the secondary. If bas1 is not running, then the routines run on bas2. Routines for bas use are in /home/hor_adm/bas/routines, with working directories of aries, dpds, images and nwp. Documentation from various sources is in docs and temporary working files are in temp

Get_bas_nwp.ksh
This routine copies the latest nwp data from basftp/met/Horace/nwp to /hor_adm/bas/nwp and then uses scp to copy them to bas2:$TRANSDIR before moving them to $TRANSDIR.

get_bas_dpds.ksh
This routine copies all syBAS files on basftp/met/Horace/rothera to /hor_adm/bas/dpds and then uses scp to copy them to bas2:$DBASE_INCOMING_DPDS before moving them to $DBASE_INCOMING_DPDS.

get_bas_images.ksh
This routine copies all L*.gz files on basftp/met/Horace/rothera to bas1:/hor_adm/bas/images and then uses scp to copy them to bas2:hor_adm/dpds before moving them to hor_adm/dpds. It is normally switched off as the files are for North America.

Move_aries.ksh
The routine simply renames 'HRPT channel <n> calibrated values.bin' to I<c>II01d.DAT (see below) and then copies them to /usr/horace_linux/operational/d_base/incoming/unprocessed/SATELLITE on both machines. For the moment it is also copying them to Cambridge.

Get_bas_wx.ksh
This just gets weather.txt from the BAS ftp site at metftp/Horace/rothera and copies it to both machines.

Local BAS macros and standard BAS maps are available on all machines.
GV Macros are in /home/Horace/gui_data/gv_macros/default.
Imager maps are in /home/Horace/gui_data/images
GV maps are in /home/Horace/gui_data/softcopy
NWP settings are in /home/Horace/gui_data/config/GV_NWPstyle_default.cfg however these change at the drop of a hat and so aren't worth copying.

It is possible to run Horace remotely using PCAnyWhere, however when running on a PC overlay of fields doesn't work. Running directly using the remote_GV.ksh [macro] command is impractical with the present speed of the Codis link. The script lives in /usr/Horace_linux/operational/exec/applications/app_scripts/
A macro to plot MSLP, 10 metre winds and swell will have to be set up.

H.6.2 Image files

The L<x>NR37d_<hh>00.DAT (where <x> is I or V) files are processed to give a name like yyymmddhhmm_NR_autosat_ps_ADC_<yy> (where <yy> is IR or VI). The date/time is found inside the file as are the keys L<x>NR (where NR is the region). The raw files are copied to /usr/horace_linux/operational/d_base/incoming/unprocessed/SATELLITE and are then processed to /usr/horace_linux/operational/d_base/incoming/images/satellite

The Aries ingest PC copies the latest raw data file to p:\aries\transfer\hrpt.tmp and then renames it hrpt.dat. [arun.bat was modified to do this after copying to dlt]. On the forecaster PC, the program hrpt.exe (icon 'Check satellite' in the folder 'aries to horace') runs in the background and copies hrpt.dat to a rolling archive of hrpt<n>.dat in c:\aries and also generates the associated files of hrpt<n>.txt and hrpt<n>.tle. It is loaded on startup on the PC, so doesn't need to be run again, equally do not close it down.

A series of processes updates c:\aries\weather.txt on a daily basis. First a process running on cmet (actually currently on jdsh) on bsucena gets the file from http://www.celestrak.com/NORAD/elements/weather.txt. This is the file newpred.dat that Steve sends, but it musn't have blank lines in it, so it should be copied as a binary. This is copied to ftp.nerc-bas.ac.uk/metftp/Horace/rothera and a cron job on Horace then copies it to /home/hor_adm/bas/routines. The hrpt.exe program that copies the image then runs an ftp command once a day to copy it from there to c:\aries. Once codis can access the outside world this could be done directly.

From Siamiv you choose which of the rolling archive files you want to process and these are modified in c:\dart32\workarea. Copy the autosat format files created by Siamiv (HRPT channel <n> calibrated values.bin) to hor_adm/bas/aries using WinSCP. After this the process becomes automatic again and a cron job renames them to I<c>II01d.DAT where <c> is P, Q, R, S or T corresponding to channel 1, 2, 3, 4, 5. Internally the keys are <yy> = C1, VI, C3/CA/CB, IR, C5. The three files are copied to /usr/horace_linux/operational/d_base/incoming/unprocessed/SATELLITE and are then processed to /usr/horace_linux/operational/d_base/incoming/images/satellite with names like yyyymmddhhmm_II_autosat_mc_AVHRR_<yy>. A current feature of the Dartcom software is that only VI and IR work, with VI being channel 1 or 2 and IR the rest.