A McMurdo Station, Antarctica Climatology
With Special Emphasis on Fog

A report to the Antarctic Community

With support from the Office of Polar Programs
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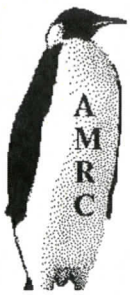

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This project is dedicated to my father, Anthony D. Lazzara, who has been a model for those maintaining a hand-written meteorological and climatological database for more than 30 years.

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A. Introduction

In 1999 the first Antarctic Meteorological Research Center (AMRC) meeting was held at The Ohio State University's Byrd Polar Research Center. A discussion among the attendees of the Antarctic research community on the status of the McMurdo Station weather observations and climatology concluded that its observations were of poor quality and limited availability. Since that time, discussions at various meetings (including the McMurdo Area User's Group (MAUG) part of the United States Antarctic Program (USAP)) and efforts to improve this situation have been attempted, both within the US and abroad.

In that same year, a fog studies project began at the University of Wisconsin - Madison in the form of a PhD thesis project by the author of this report. The project's objective was to diagnose the local fog events in the McMurdo Station region. Hence, the need for a McMurdo Station climatology was yet again of importance.

Since that time many researchers and logistic operators have requested McMurdo Station climatological information. One request of significant importance is the desire to have the best CLIMAT format reports both historically and in real-time be available from the station.

This effort is an overlapping start at satisfying these needs – first and foremost for the fog diagnostic study and next to be the starting point toward the effort to develop a more complete climatology of McMurdo Station, Antarctica for the broader research and operational Antarctic community.

B. Observational Data

The observations used for this project came from multiple sources. Efforts started here merge data from multiple groups. It is expected that this dataset will be used as the starting point to verify and check other archived records of McMurdo Station's observations from other sources in an effort to build a complete climatology of the station (including metadata). The results will be used for other proposed and future operational and research activities (e.g. historic CLIMAT message generation)

This study utilized McMurdo Station observational data from 1956 though mid-1998 from the British Antarctic Survey (BAS). This collection, primarily a by-product of the READER project (SCAR PACA READER Project, 2000), provided a ready-made, already quality controlled data set of 6 hourly observations of temperature, pressure (both sea level and station pressure), wind speed and direction along with u and v components of the wind. The BAS dataset was based off of data collected from the US National Climatic Data Center (NCDC), primarily. The BAS database however lacked fog observations. Hence, observations of fog came from a decoded NCDC database used by the USAP's Long Term Ecological Research (LTER) project. This database offered two sets of partially decoded DATSAV2 format McMurdo observations: one

with semi-coded observations of several fields from 1956 until 1966 and a second with all fields of information decoded from 1973 until mid-1998. This database was not quality controlled, and had observations at 6 hourly, 3 hourly and off-synoptic hours. This project selected the 6 hourly observations of fog from this collection and merged them with the BAS dataset. Observational data from mid-1998 until the end of 2004 came from the archives at the AMRC. This database of McMurdo Station observations, which are posted to the GTS (via the NOAAPORT broadcast received through the SSEC Data Center), provided the last collection of data needed to complete a greater than 30 year climatology record. This dataset was also not quality controlled, and was matched to the BAS dataset in temporal space – having only 6 hourly observations.

With this combined dataset, quality control checks were done on the data from 1998 through 2004. The year 1998 was used to verify that statistics here matched those computed by the READER project. Much of the quality control efforts focused on the removal of bad observations, primarily with regards to pressure observations. An independent dataset, actual monthly spreadsheets of observations direct from the McMurdo Station Weather Office, was spot checked, and there were some errors found. It is felt that once the database, that is the basis for these spreadsheets, is available from McMurdo Weather Office in the near future, a more complete cross-check of the data should be done (See Section F for more discussion on this).

A conscious choice was made to use 6 hourly observations, rather than all available observations. McMurdo Station's mode of operation during the winter season from early March until late August or September only has 6 hourly observations being taken, with 3 hourly observations taken during the rest of the year. It is felt that the use of the 3 hourly observations during the austral summer would skew the climatology results presented here. This is also the model followed by the READER project, and use of 6 hourly observations is the minimum standard for best climatology practice (WMO, 1983).

There are some periods during the record that lack observation data from any source. In particular, it appears that for much of the austral summer in 1998, there are no observations available from McMurdo Station. No agency or group that holds McMurdo Station observations has this missing data. Proposed future efforts to check the US National Archives, the holder of paper records and other documentation for the US military logistic support of the USAP, for any paper copies that might exist of this data, await funding. Hence, this analysis will not have any observations during this period.

One important finding during the quality control of the 1998 to 2004 data was the change in method used by the McMurdo Weather Office to compute sea level pressure. Prior to 1998, sea level pressure was computed using the US Standard Atmosphere as the basis for the computation. After mid-1998, the method was changed to using a computed R-value using the surface temperature and table provided the US Naval Detachment at the National Climatic Data Center (See section D, subsection 2, for more discussion). Although the R-value method calls for the computation to be done on sites that are only 50 feet in elevation, McMurdo Station, at an elevation of 109 feet or nearly 34 meters utilizes this method anyway. The data used in this analysis have been kept as reported, and not altered or adjusted at this time. Missing values of either sea level pressure or station pressure from 1998 to 2004 have not been replaced at this

time with computed values. Little impact has been seen or expected to the analysis discussed here. As a result of this finding, the station pressure alone has been used in the analysis.

The data used for this analysis can be found online at the following locations:

ftp://amrc.ssec.wisc.edu/pub/mcmurdo/combinedclimatology
ftp://ice.ssec.wisc.edu/pub/mcmurdo/combinedclimatology

C. McMurdo Station, Antarctica

McMurdo Station, Antarctica is located at 77 degrees 51 minutes South and 166 degrees 40 minutes East on the Hut Point Peninsula of Ross Island Antarctica (See Figure 1). The station, although located on sloping terrain, is at an elevation of 34 meters (109 feet), and is assigned the World Meteorological Organization (WMO) block identifier number 89664. Established in March of 1956, the station has been open continuously for the last 49 years. The publication of this document marks the 50th anniversary of the station.

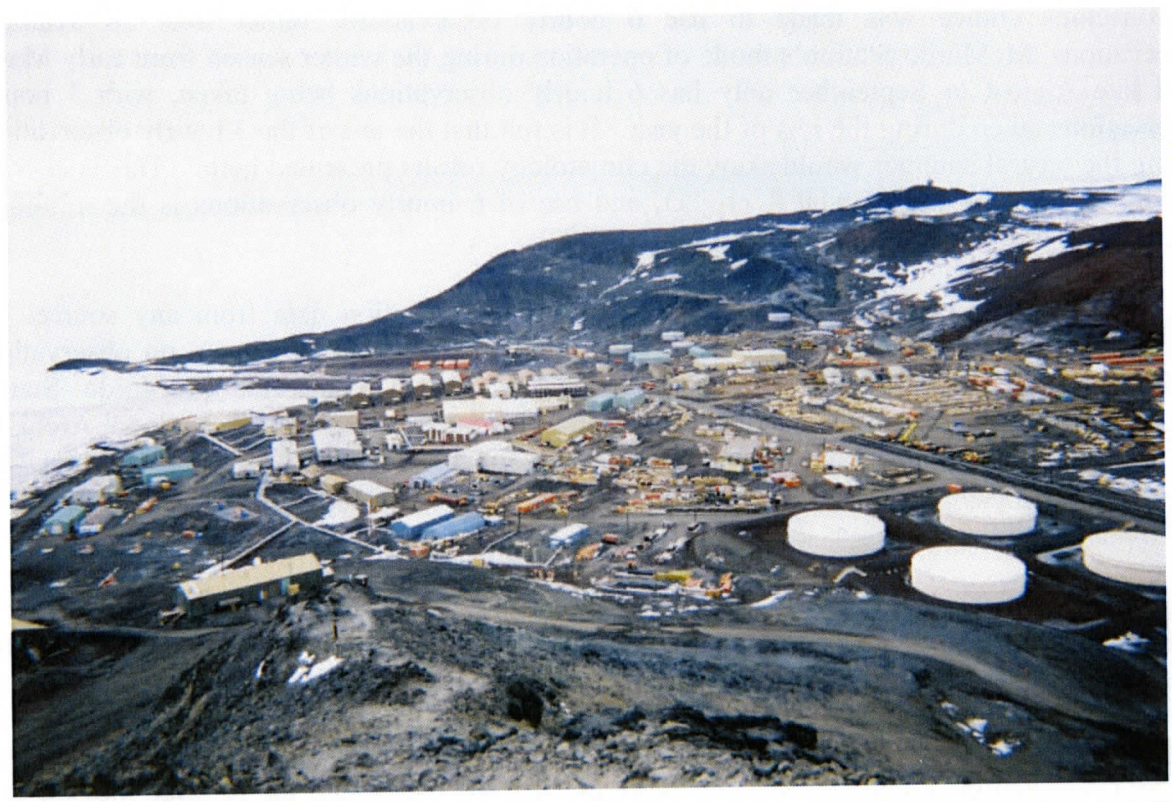

Figure 1. A view of McMurdo Station Antarctica as seen from Observation Hill, with Winters Quarter's Bay on the left side of the image, and Arrival Heights just outside the field of view of this photo to the right (*Photo Courtesy of the Author*).

McMurdo Station is located on Winter Quarter's Bay next to Captain Robert Falcon Scott's first hut during the first of his several expeditions to Antarctica. Nearby is the New Zealand's Scott

Base located at Pram Point on the other side of Hut Point Peninsula. McMurdo Station and Scott Base are connected via a road through Bull Pass, a saddle point between Crater Hill and Observation Hill. Observation Hill, an extinct volcanic cone, lies at the very tip of Hut Point, Cape Armitage (See Figure 2).

Figure 2. An aerial photo of McMurdo Station on Hut Point Peninsula showing the ice runway as well as nearby New Zealand Scott Base at Pram Point, on the other side of Observation Hill and Cape Armitage (*Photographer Unknown*).

Three skiways/airfields are operated by the USAP nearby the station: the Ice Runway, Williams Field and Pegasus Field. Recently, these airfields have been assigned International Civil Aviation Organization (ICAO) identifiers NZIR, NZWD and NZPG. For many years prior to the 1990s, McMurdo Station was list as a Naval Air Facility, with the ICAO identifier NZCM. Some observations over the years from NZCM are indeed from the longest running airfield, Williams Field. Otherwise, today NZCM is reserved for reference to McMurdo Station proper.

At the station, synoptic and radiosonde observations are taken year round, while METAR (hourly surface observations) observations are taken (as of the last several years at least) at the airfields, when they are open during the operating field season (variable dates between late August and early March typically). It is noteworthy that as seen in figure 3, McMurdo Station's operating field season does come in line with the cycle of sun, and the duration of sunlight. It also points to how McMurdo Station has a limited diurnal variation, if any at all.

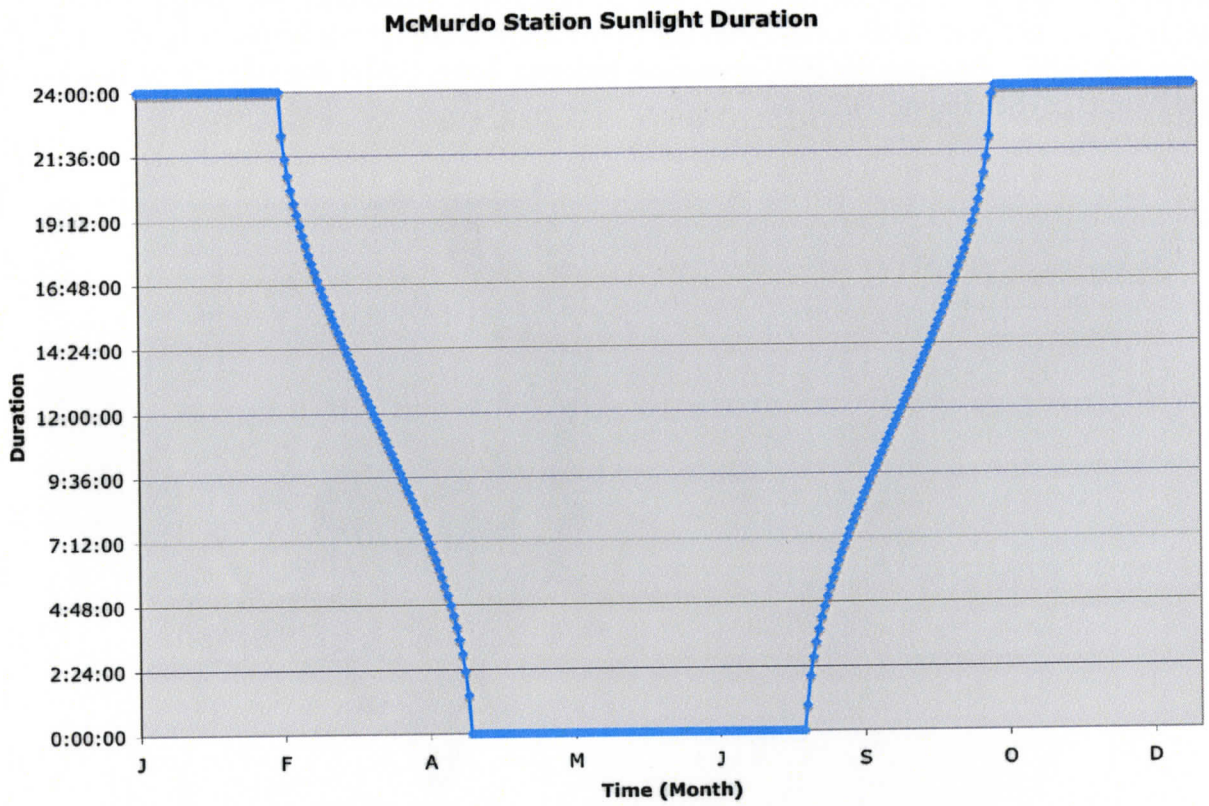

Figure 3 McMurdo Station's sunlight duration as depicted here reveals how the station does have long periods of 24 hour sunlight and 24 hour darkness, with two transition seasons.

Figure 4 An aerial photo graph of McMurdo Station from Operation Deep Freeze 1960 which shows the full Hut Point Peninsula with Mt. Erebus in the background, the active volcano at the heart of Ross Island, Antarctica. (*Photo courtesy of Operation Deep Freeze '60, Task Force 43*)

Weather observations taken at McMurdo Station occur at Building 165, jointly housing the McMurdo Weather Office (informally referred to as Mac Weather or Mac WX), and McMurdo Operations (Mac Ops), including air traffic control (Mac Center) (See Figure 5).

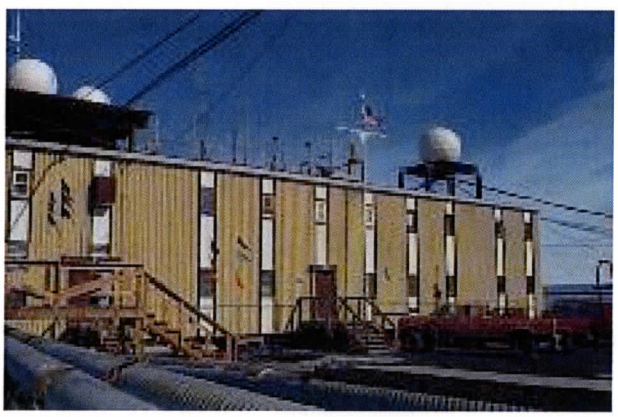

Figure 5 The weather instrumentation shown here atop building 165, McMurdo Operations and McMurdo Weather Office is the source of McMurdo Station's synoptic observations.

D. Data Analysis

The following section characterizes initial climatological findings for McMurdo Station, Antarctica from January 1, 1973 0 UTC through December 31, 2004 18 UTC. Included in this analysis are 41,096 observations. The subsection of the observations for the fog analysis includes only 721, roughly 1.8 percent of the total.

1. Temperature

a. All Observations

McMurdo Station Antarctica has an average temperature of -16.7 C (roughly 2 F) over the period studied, over all months, with a mode of -20 C (-4 F) and a median of -17.2 C (1 F). Figure 6 shows the variation of monthly mean temperature as well as the range of minima and maxima on a monthly basis studied over the time period as well. McMurdo's highest maximum temperature during this studied time period is 10.6 C (51 F) occurring on December 21, 1987 at 6 UTC. The lowest minimum temperature during this same timeframe is -47.8 C (54 F) taking place on August 4, 1975 at 0 UTC. The data revealed a standard deviation of 9.98 C. As a note, McMurdo Station's temperatures due reflect the kerlose or coreless winter, where the temperatures curve is "flat" during the winter months (Wendler and Kodama, 1993 and Stearns et al. 1993)

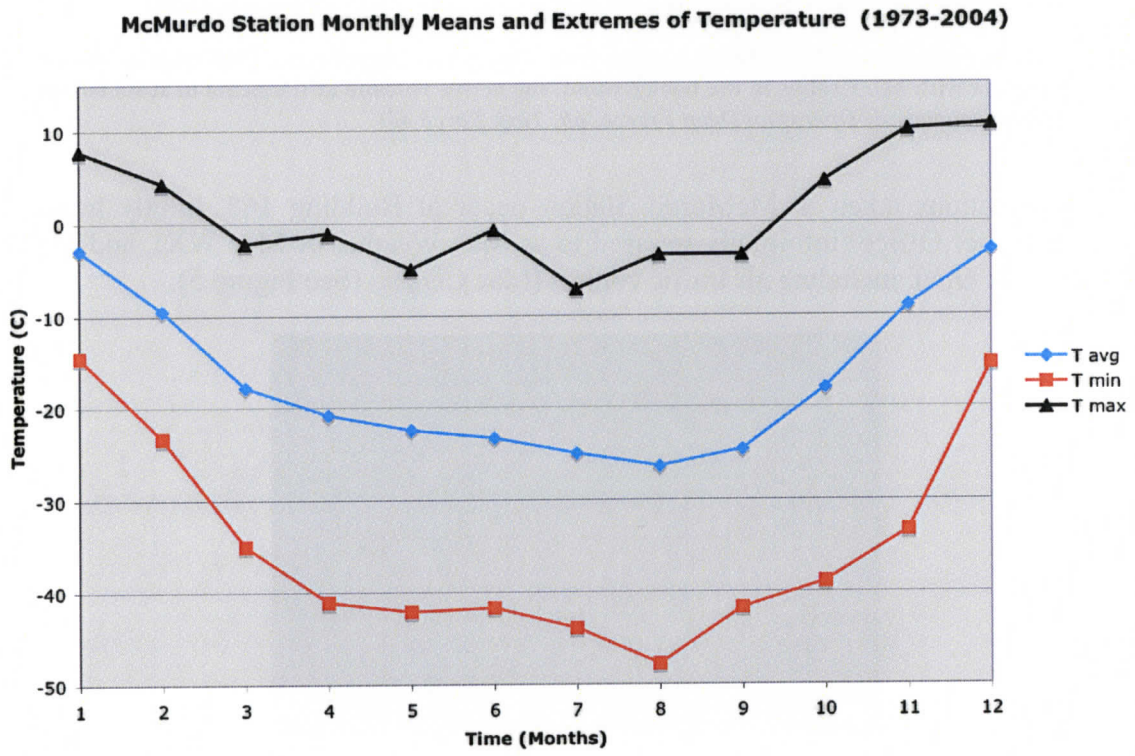

Figure 6. The monthly temperature means and extremes for McMurdo Station, Antarctica over the years 1973 though 2004.

b. Fog Observations

The average temperature that fog occurs at is -19.1 C (-2.4 F), over all months with a mode of -25.6 C (-14 F) and median of -20.9 C (-5.6 F). The minimum temperature at which fog has been recorded during the studied time frame is -47.2 C (-53 F) on August 4, 1978 at 12 UTC and the maximum temperature at which fog has been reported during this same period is 4.4 C (40 F) on December 26, 1984 at 6 UTC. The standard deviation of temperatures during fog occurrences is 11.4 C.

In comparing all observations and all non-fog observations to all fog observations temperatures during fog occurrences are on average colder than the mean (See Figure 7). In any case, the trend tracks very closely with the average of all observations. In comparing fog occurrence minimum and maximum temperatures with all observations of extremes, (see Figure 8), the minimum temperatures during fog occurrences are comparable to minimum temperatures over all observations, while there is a marked difference in maximum temperatures between fog occurrences and all observations.

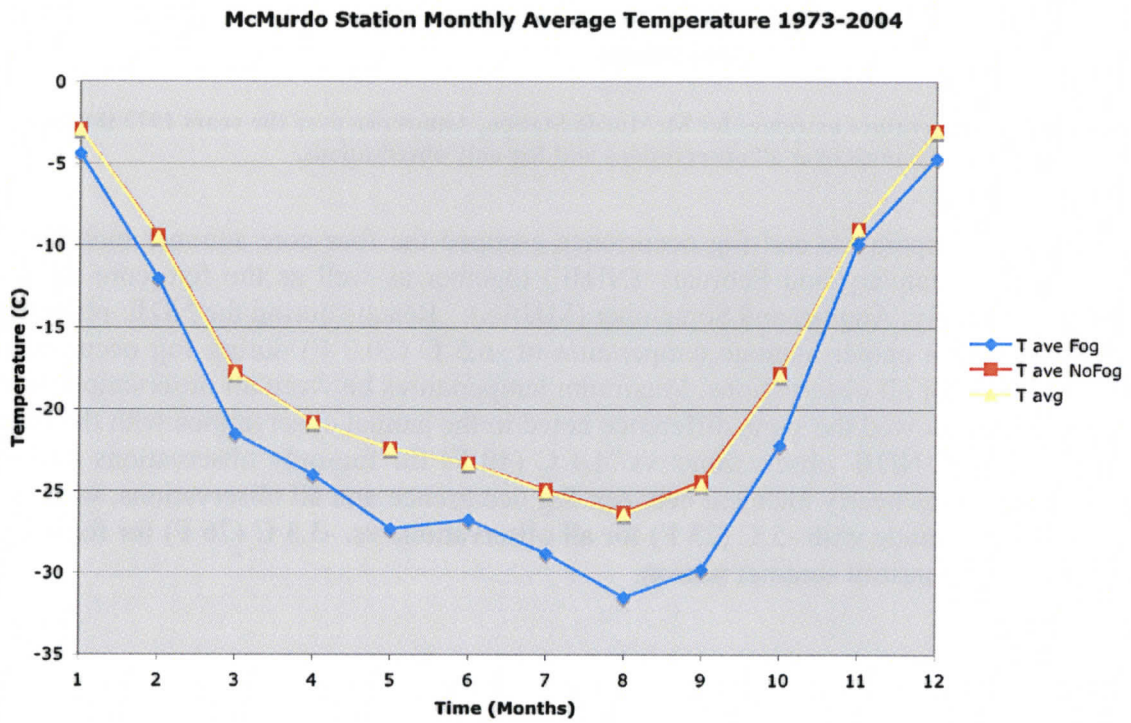

Figure 7. The monthly temperature means for McMurdo Station, Antarctica over the years 1973 through 2004 separated into temperature means over all observations, over non-fog observations and fog-only observations.

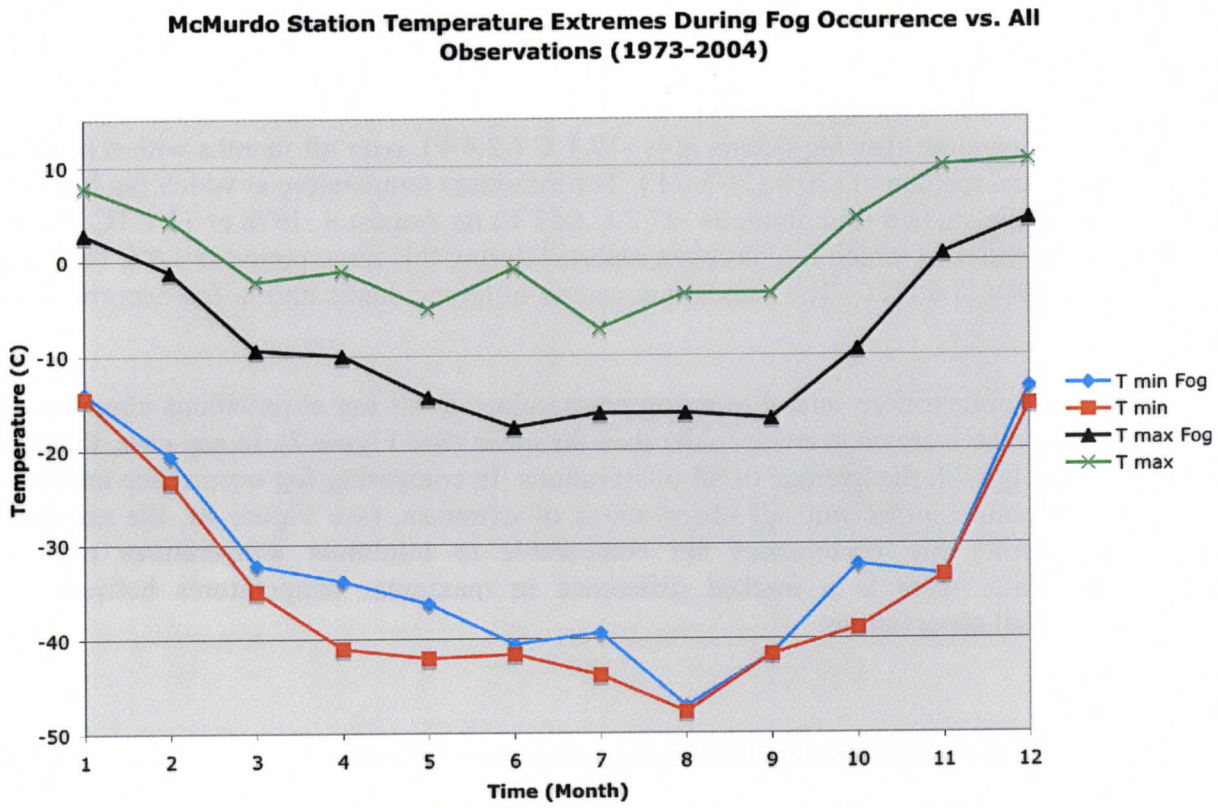

Figure 8. The monthly temperature extremes for McMurdo Station, Antarctica over the years 1973 through 2004 for minimums and maximums over all observations and fog-only observations.

Seasonal analysis of temperature and fog occurrence grouped the four core summer months of November, December, January and February (NDJF) together as well as the five core winter months of May, June, July, August, and September (MJJAS). Results during the NDJF reflected the annual results with a cooler average temperature of -6.5 C (20.3 F) during fog occurrence verses -5.9 C (21.3 F) for all observations. Maximum temperatures between all observations and fog-only observations showed the same difference noted in the annual observations with the max at 10.6 C (51 F) for all NDJF observations vs. 4.4 C (40 F) for fog-only observations during NDJF. All other measures nearly matched between fog occurrence and all observations, with the minor exception of the mode with -5 C (23 F) for all observations vs. -3.3 C (26 F) for fog-only observations during this austral summer season.

2. Pressure

a. All Observations

McMurdo Station's station pressure average, mode and median are all 986.1 mb during the study time frame. The extreme maximum is 1035.2 mb occurred on August 9, 1974 at 0 UTC,

while the extreme minimum is 937.5 mb on July 19, 1993 at 18 UTC. The standard deviation is 10.7 mb.

As noted in the data description section, sea level pressure computation methods prior to 1998 used the United States Standard Atmosphere. After 1998, the method utilized involved the use of R-values computed by the Fleet Numerical Meteorology and Oceanography Detachment/Air Force Combat Climatology Center (AFCC) at the National Climatic Data Center. More information on this can be found at AFCC web site https://www2.afccc.af.mil/html/rapid_rfactor.html. The preliminary data analysis here looked at the sea level data as found in the source data sets. No attempt was made to compute the sea level pressure in a consistent manner. Thus, this report does not include those results, as they may not be significant. A moderate level of quality control was conducted on the pressure observations in the AMRC dataset from 1998 through 2004, screening for obvious errors, spikes (as seen graphicly) and removal of bad values.

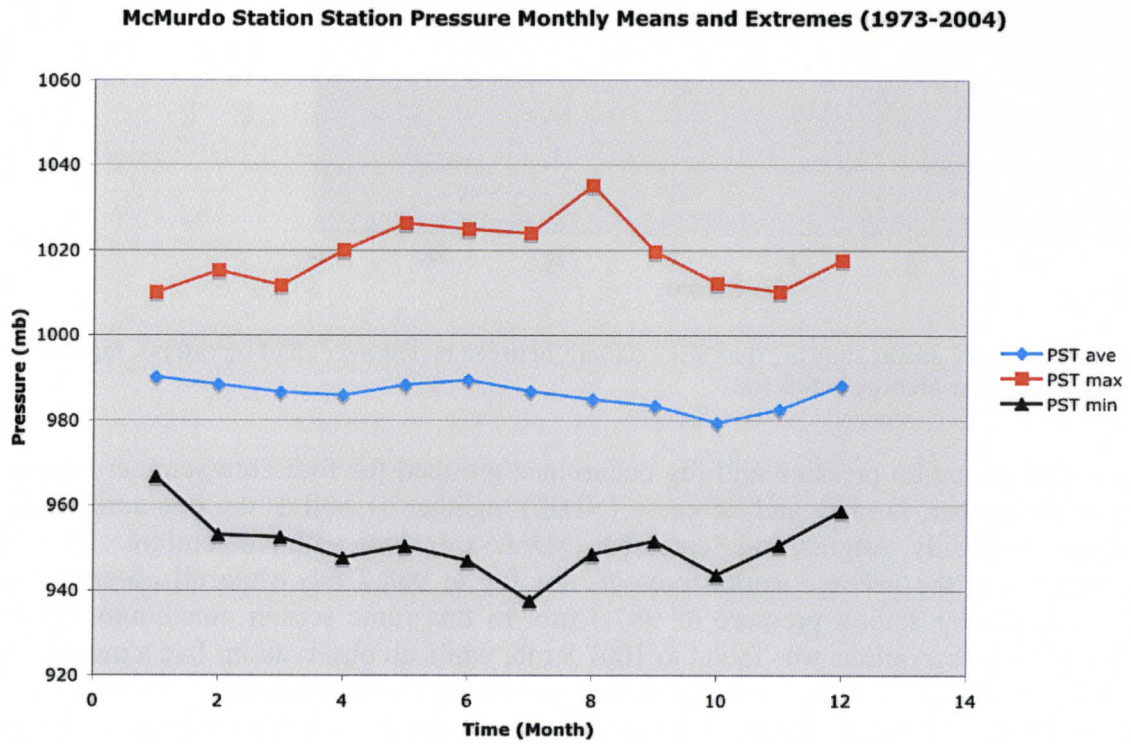

Figure 9 McMurdo Station monthly means and extremes of station pressure of all observations from 1973 through 2004.

b. Fog Observations

In reviewing fog occurrence and station pressure, the averages are practically identical with the average for all observations at 986.3 mb while for fog only observations at 986.1 mb. This is reflected in a comparison of the month-to-month averages as seen in Figure 10. In agreement with comments from McMurdo Weather Office forecasters, the maximum and minimum

extremes during fog for station pressure are clearly well within the range of all observations extremes (See Figure 11).

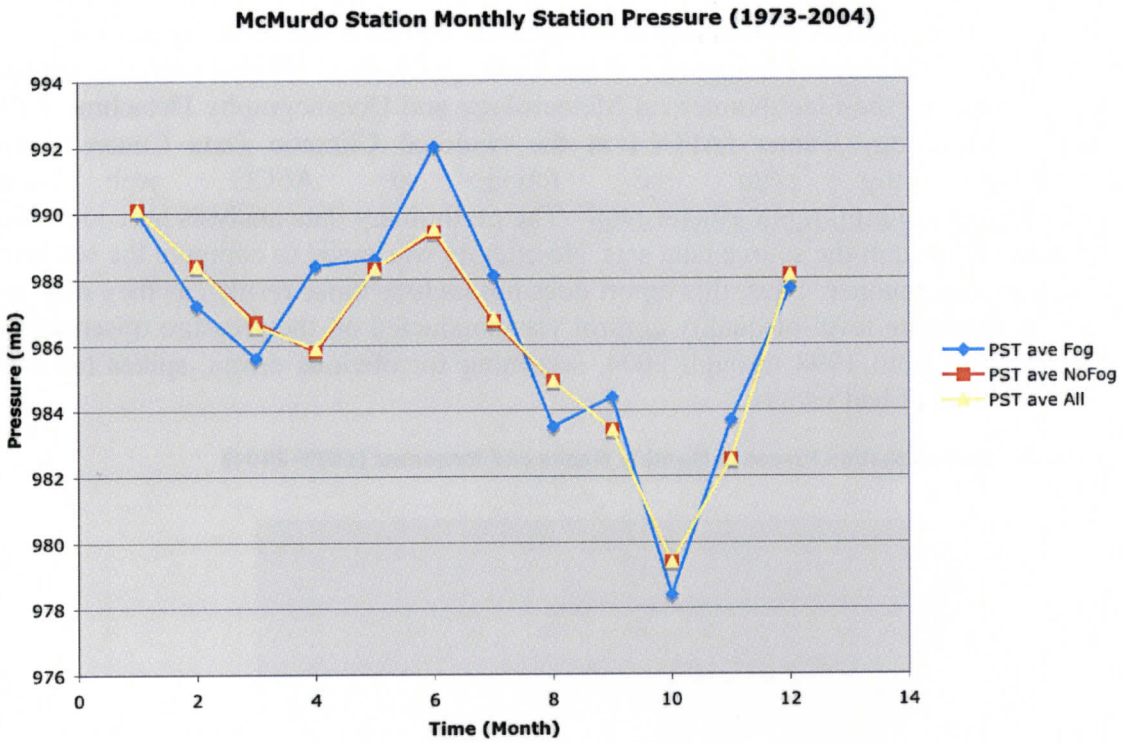

Figure 10 Station pressure means showing the close relations between means over all observations, fog-only and no-fog observations at McMurdo Station.

Seasonal analysis of station pressure and fog occurrence grouped the four core summer months of November, December, January and February (NDJF) together as well as the five core winter months of May, June, July, August, and September (MJJAS), as done with temperature. Results during the NDJF had the average station pressure for fog at 988.2 mb while all observations averaged a very similar station pressure of 987.3 mb. In this same season, maximum station pressure during fog observations was found to 1007.8 mb, while all observations had a maximum at 1017.6 mb. During the NDJF season, minimum pressure during fog occurrence observation is 962.7 mb, while it is 950.6 mb for all observations. Results during the MJJAS season have a similar behavior: Average station pressure is 986.5 mb for all observations, while it is 985.8 mb for fog-only observations, Maximum station pressure is 1035.2 mb for all observations, while it is 1009.8 mb for fog-only observations, Minimum station pressure is 937.5 mb for all observations, while it is 954.3 mb for fog-only observations.

Other measures such as median values, track very close by for, of all observations vs. fog-only observations (for NDJF, 987.6 mb vs. 988.3 mb respectively and for MJJAS, 986.1 mb vs. 985.1 mb, respectively). However, differences are noted with mode values for all observations vs. fog-only observation (for NDJF, 988.1 mb vs. 992.5 mb, respectively and for MJJAS, 981 mb vs. 988.8 mb).

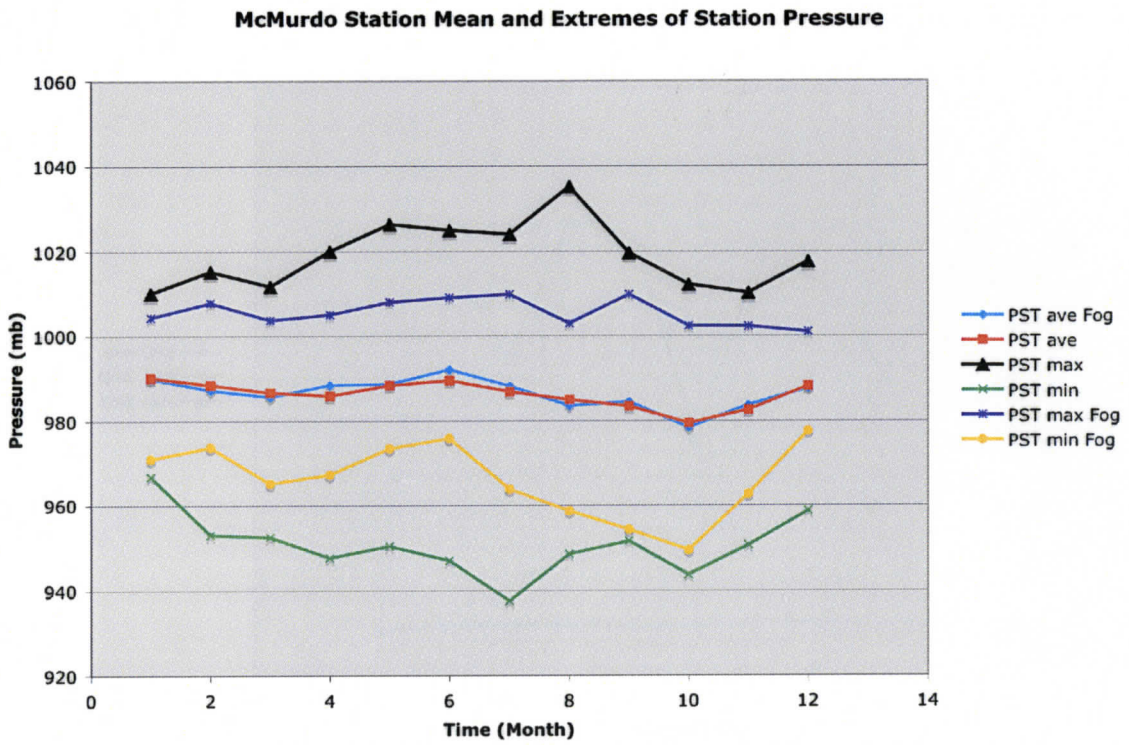

Figure 11 McMurdo Station extremes for Station Pressure for all observations and fog only occurrence observations depicting how fog will not occur at the extremes in pressure, but rather much closer to the means.

A similar situation is noted with standard deviation of station pressure between the seasons. There is some agreement between all observations and fog-only observations for standard deviation (for NDJF, 8.9 vs. 7.3 and for MJJAS, 11.9 vs. 10.8).

3. Wind Speed and Direction

a. All Observations

Wind observations at McMurdo Station show an average speed of 10.1 knots; however, the resultant wind speed average is 6.8 knots. The maximum wind speed observation made at the station during the period study is 112.3 knots recorded on February 27, 1998 at 0 UTC. With regards to u and v components of the wind, the average u-component is -6.75 knots and v-component is 0.9 knots. This points to a preferred direction with a significant percentage of the winds come from the East as seen in the wind rose in figure 13. The resultant wind direction is 82.4 degrees with constancy of 0.67.

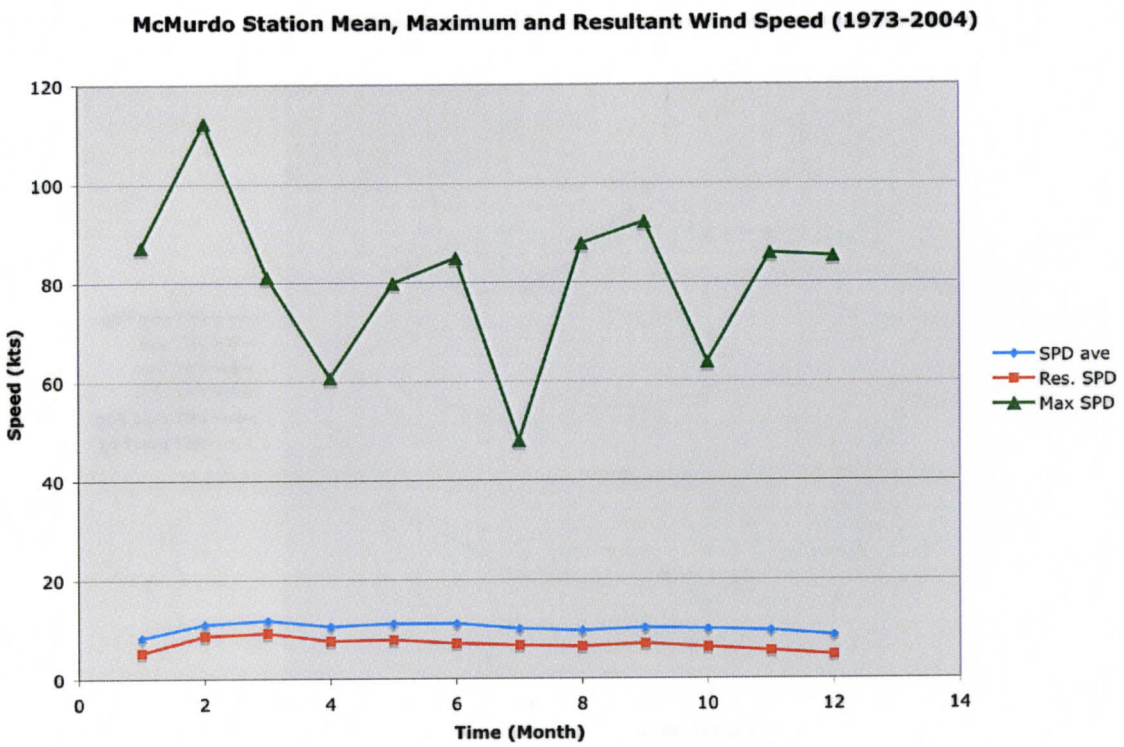

Figure 12. Wind speed averages, resultant wind speed and maximum wind speed on a month by month basis for McMurdo Station.

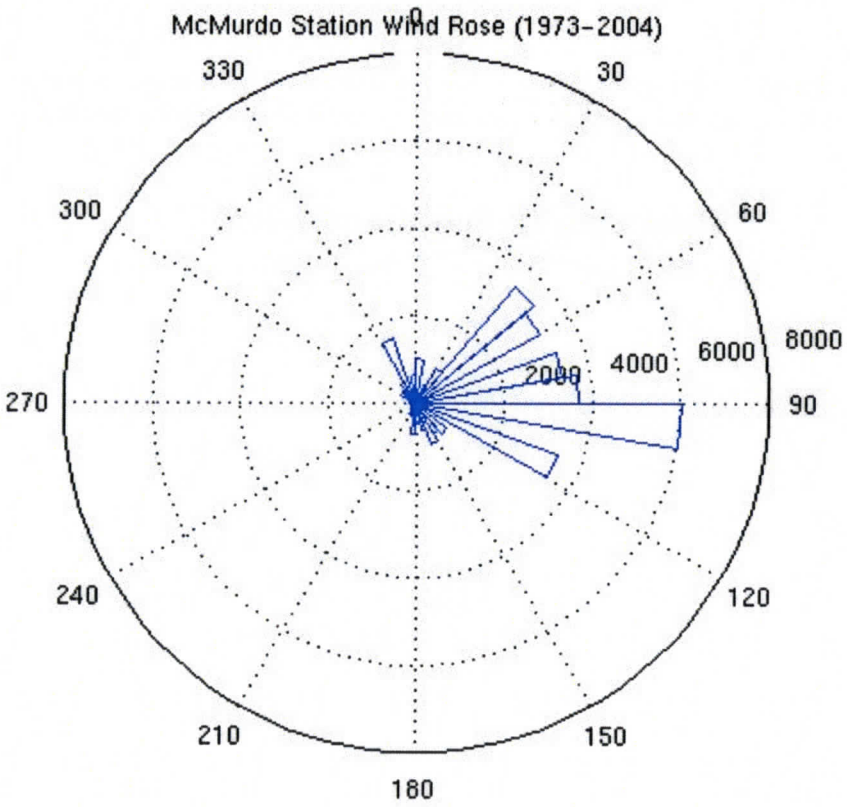

Figure 13 A wind rose for McMurdo Station, Antarctica using all observations that shows how Easterly the winds are at the station (calm winds reported as 0 knots and 0 degrees have been removed from this display). This display has 10 degree bins for the wind direction and the circular rings are in 2000 observation increments.

b. Fog Observations

During fog occurrences, wind directions are extremely close to that of McMurdo's general climatology, as can be seen in figure 14. Additionally, the resultant wind is 79.7 degrees with a resultant average speed of 7.6 knots the average mean speed is 9.3 knots – fairly close to McMurdo's general climate for wind. The constancy for fog occurrence winds was 0.81 – larger than the 0.67 for the general climate. All other statistics including modes, medians, standard deviation, and minimum speeds were all small values (such as minimums and modes of 0 knots), or values very similar between all observations and fog-only observations.

In comparing seasons, it is interesting to see how wind statistics are similar between the two seasons for all observations. During NDJF, average speeds are 9.3 knots, while for MJJAS they are 10.4 knots. For resultant wind direction and speed, they are 82 degrees at 5.9 knots during NDJF vs. 82 degrees at 6.9 knots during MJJAS. However, fog-only observations did have one or two noticeable differences between seasons. Fog occurrences in MJJAS had a bit less of a wind speed average at 7.8 knots, while for NDJF it is 9.2 knots. Wind constancy ran on the

order of 0.82 in MJJAS vs. 0.75 in NDJF. Other statistics such as resultant wind direction and speed show greater similarity MJJAS has 76 degrees at 6.4 knots, while NDJF has 80 degrees at 6.9 knots. All other statistics including modes, medians, and standard deviations all showed values relatively close to each other between the fog-only observations and all observations in each seasons.

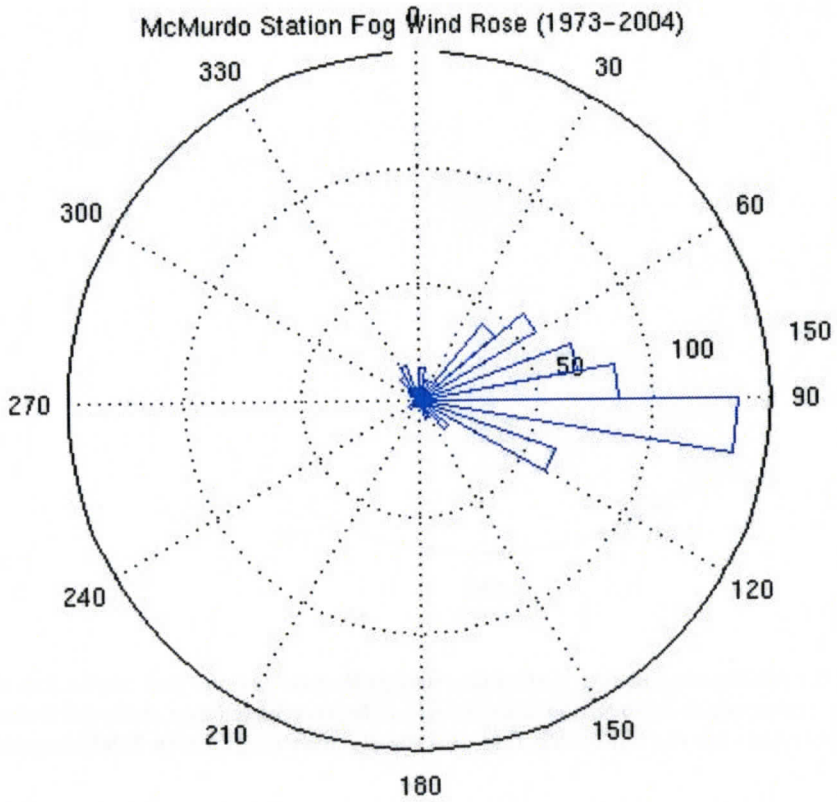

Figure 14 A wind rose for McMurdo Station during fog occurences only also showing the very Easterly component.

4. Fog

One of the first analyses of fog at McMurdo Station is a comparison with observations made at nearby skiways/airfields, such as Williams Field, Pegasus Field and the Ice Runway. On initial look at observations taking during the season when one or more of the skiways/airfields are open in the McMurdo Sound area show that McMurdo Station only has a small number of fog occurances, as compared to the skiways/airfields (See Figure 15 and 16). Hence, the general climatology of fog as depicted at McMurdo is a subset of events that occur in the Ross Island and McMurdo Sound region of Antarctica.

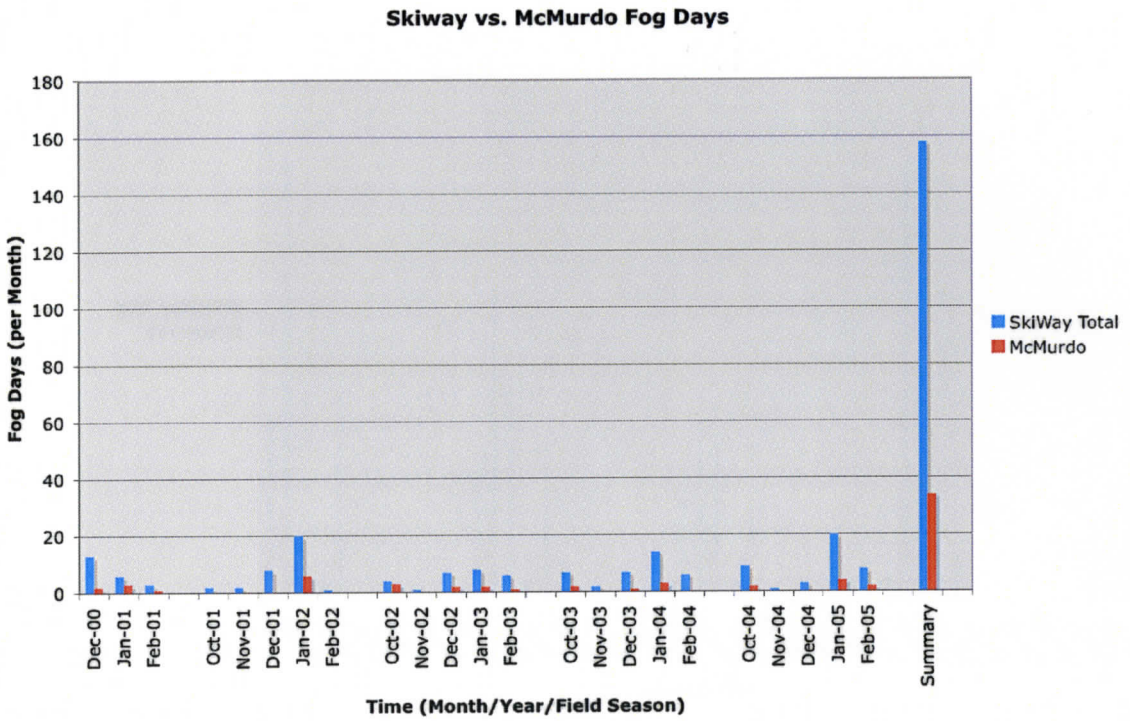

Figure 15 A graph showing McMurdo Station fog occurrences is only experience 18 percent of the fog events in the McMurdo Sound Basin, when comparing with fog occurrences at the three nearby Skiways: Ice Runway, Williams Field and Pegasus Field for late 2000 through the 2005 field season. Please note the Skiway totals do not have any duplicate data.

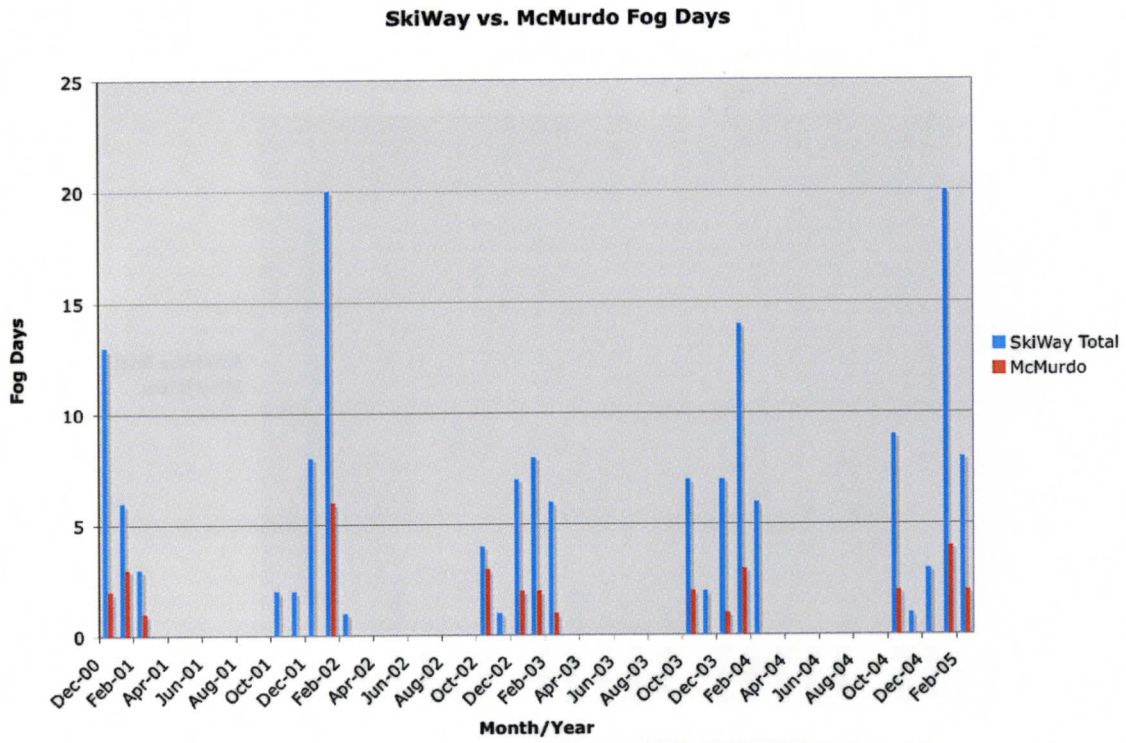

Figure 16 Same as in Figure 11, without the summary columns.

In reviewing the fog occurrences at McMurdo Station, a classification of fog days was done to quantity the fog occurrences for this analysis. A fog day is defined as being a day when at least one hour of the day has a report of fog (both as current weather or as past weather). Figures 17 and 18 below show the fog days as a time series as well as organized by month. The data used for this analysis utilized all observations including all 3 hourly observations, when available.

The series over the time period studied as seen in figure 17 shows that McMurdo has had periods of significant fog affecting McMurdo – as much as 17 days in a single month. The 1990s have significantly fewer fog events per month. Figure 18 shows the same information for the same period of time, but in this case on a month-by-month basis. There are two clear seasons for fog in McMurdo: One in the late winter peaking in September, and one in middle of summer, peaking in January. Minimums are found in early winter in May-June as well as in spring in November. The only break in the progression occurs in February, with an unexpected decrease in fog events as compared to January and March. One possible reason for this may be due to the fact that February has the highest snowfall at McMurdo Station (See Figure 19) as reported as a part of NCDC's International Station Meteorological Climate Summary (ISMCS) climatology dataset. This initial climatology study did not include a detailed precipitation analysis (See Section F for more on this). These findings warrant further investigation.

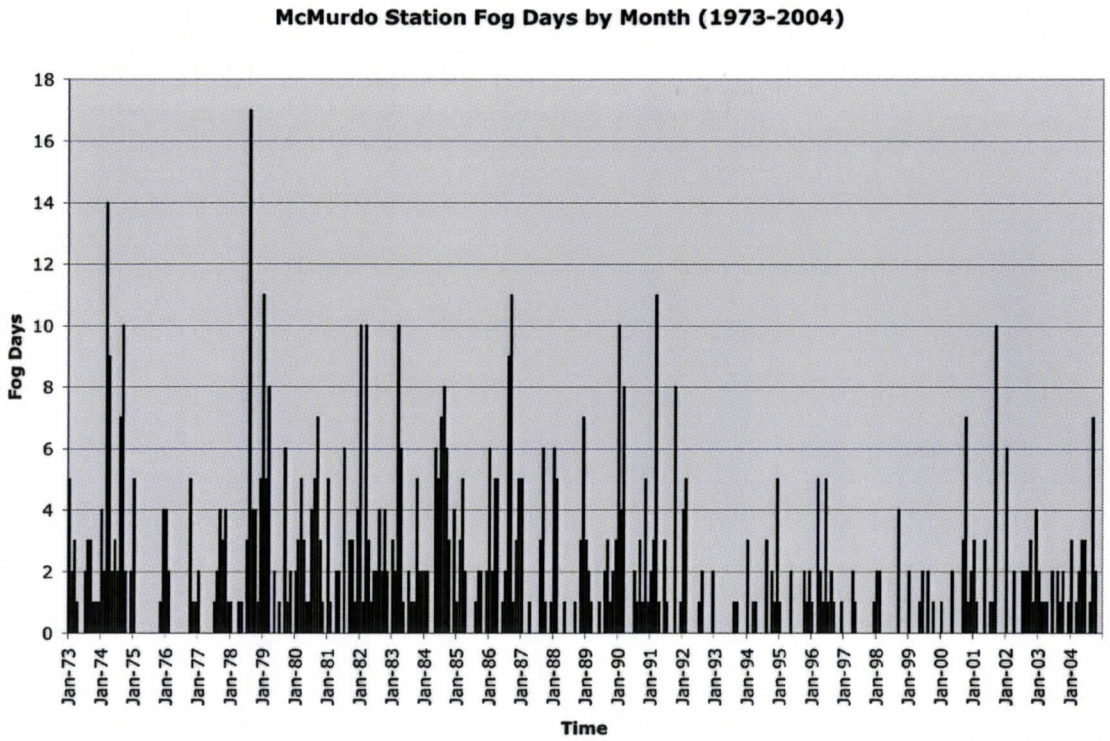

Figure 17. The number of fog days per month from 1973 through 2004 at McMurdo Station, Antarctica.

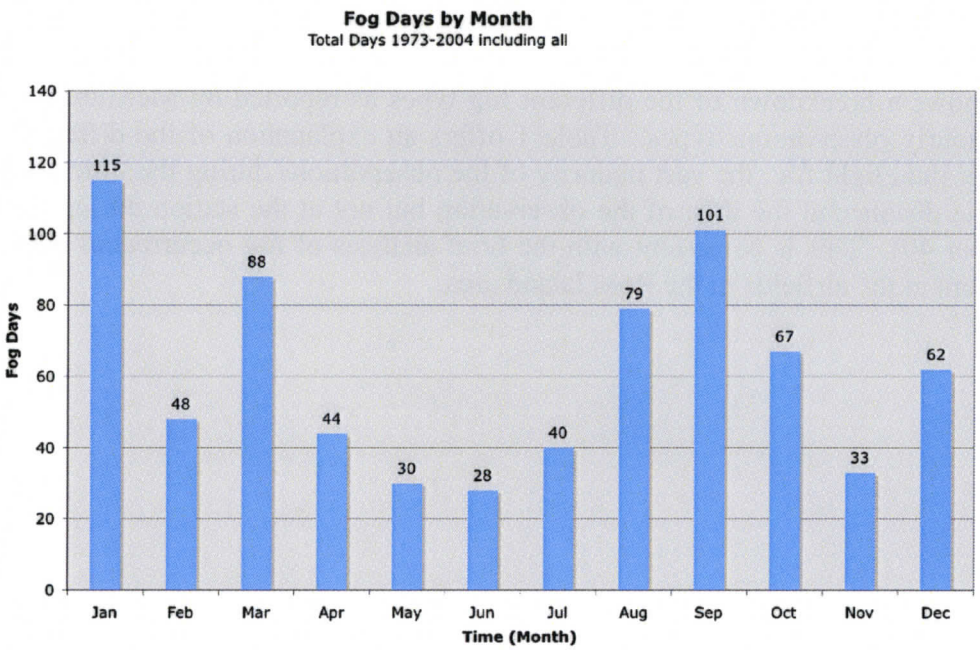

Figure 18. A summary of all fog observations (includes 3 and 6 hourly observations) by month.

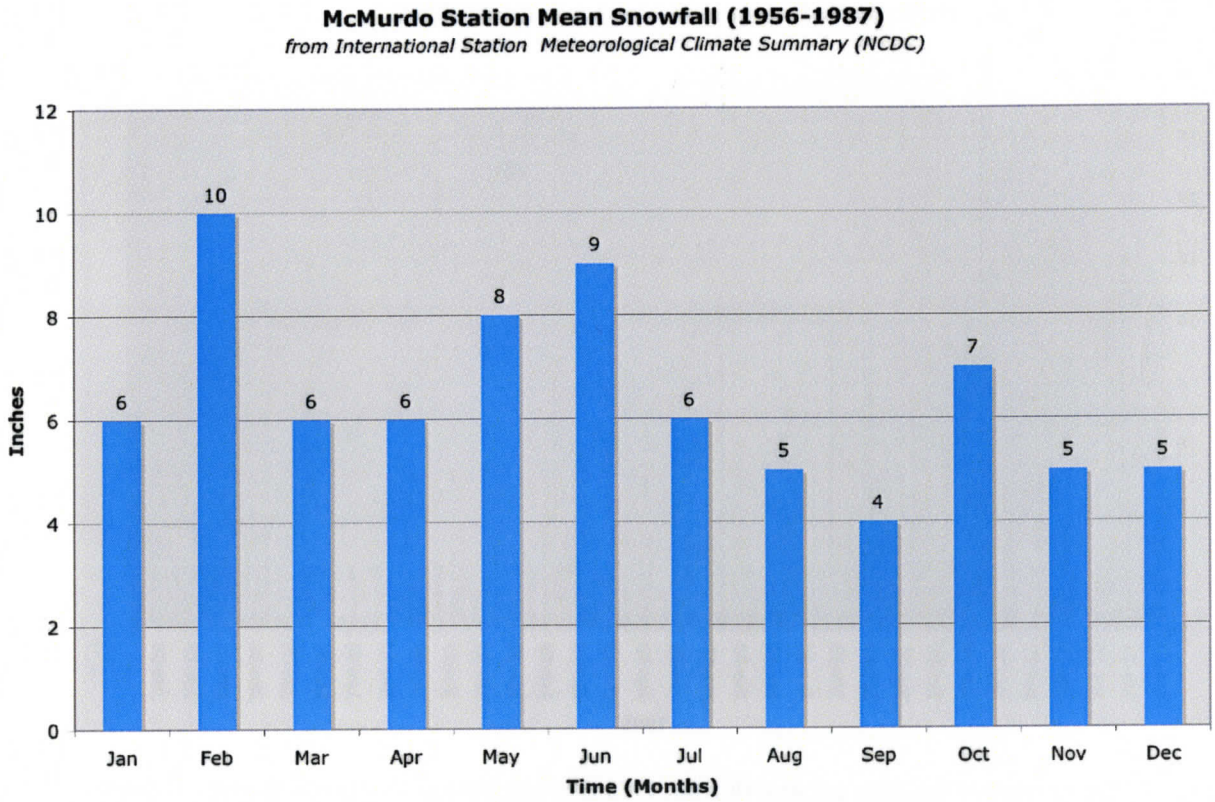

Figure 19. The mean monthly snowfall at McMurdo Station Antarctic from the NCDC International Station Meteorological Climate Summary.

Figure 20 shows a breakdown of the different fog types as reported by McMurdo Station over only the 6-hourly observations types. Table 1 offers an explanation of the different types and codes. Other than light fog, the vast majority of the observations during the time period studied are fog in the distance at the time of the observation but not at the station during the past hour (Type number 40). This is consistent with the brief analysis of fog occurrences being so much more prevalent at the airfields in the Ross Island area.

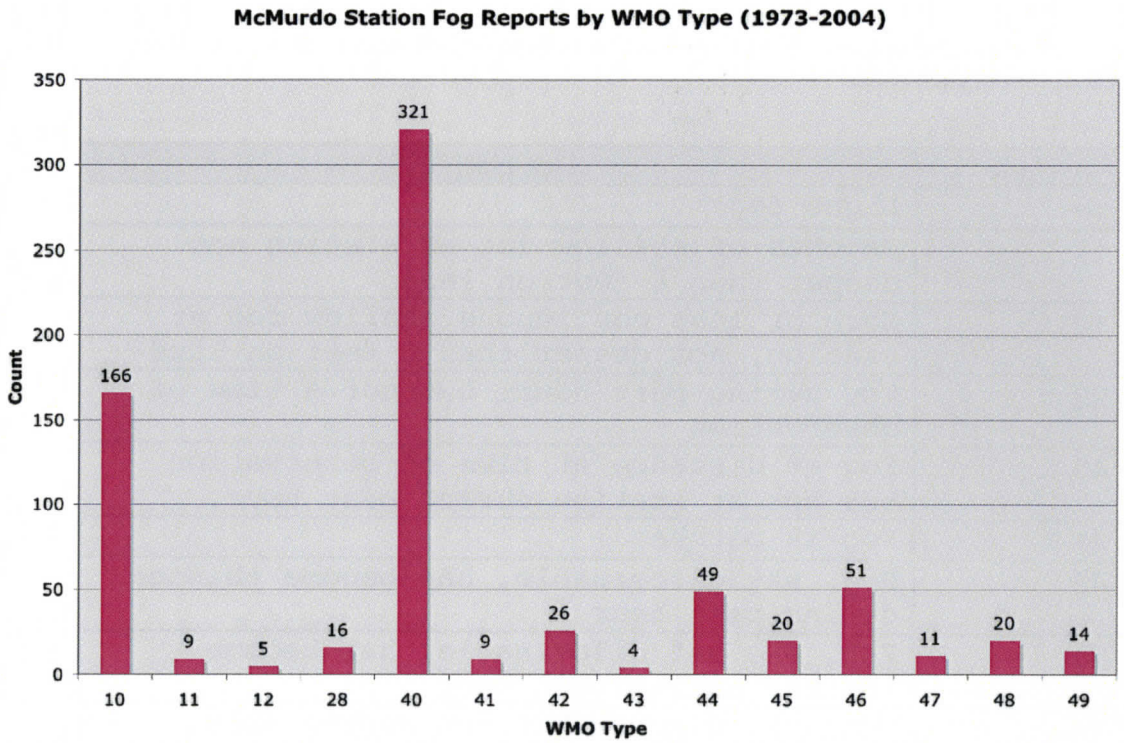

Figure 20. The number of reports of fog used in this analysis is shown here broken down by WMO classification.

Table 1. The listing of World Meteorological Organization International Codes on present weather for fog types with description of each code.

Fog Type Code	Description
10	Light fog
11	Patches of shallow fog at station not deeper than 6 feet on land
12	More or less continuous shallow fog at station, not deeper than 6 feet on land
28	Fog during past hour, but not a time of observation
40	Fog at distance at time of observation, but not at station during past hour.
41	Fog in patches
42	Fog, sky discernable, has become thinner during past hour
43	Fog, sky not discernable, has become thinner during past hour
44	Fog, sky discernable, no appreciable change during past hour
45	Fog, sky not discernable, no appreciable change during past hour
46	Fog, sky discernable, has begun or become thicker during past hour
47	Fog, sky not discernable, has begun or become thicker during past hour
48	Fog, depositing rime, sky discernable
49	Fog, depositing rime, sky not discernable

E. Summary

In reviewing the findings, McMurdo Station sees a typical range of temperatures, pressures and winds for this location in the Antarctic region in the Polar Easterly wind regime. Fog occurrences at the station are indeed embedded in this climatological flow pattern. However, McMurdo Station proper only sees a fraction of the fog events when compared with nearby skiways and airfields. Fog is an regional phenomenon in the Ross Island and McMurdo Sound region. A summary of the highlights of McMurdo Station climatology is outlined in Table 2 and Table 3.

Variable	Value	Date (if applicable)
Maximum Temperature	10.6 °C (60 °F)	06 UTC December 21, 1987
Minimum Temperature	-47.8 °C (-54 °F)	00 UTC August 4, 1975
Maximum Station Pressure	1035.2 mb	00 UTC August 9, 1974
Minimum Station Pressure	937.5 mb	18 UTC July 19, 1993
Maximum Wind Speed	112.3 knots	00 UTC February 27, 1998
Average Temperature	-16.7 °C (1.9 °F)	
Average Station Pressure	986.1 mb	
Average Wind Speed	10.1 knots	
Resultant Wind Speed	6.8 knots	
Resultant Wind Direction	82 degrees (East)	
Constancy	0.67	

Table 2. A summary of key climatological values are shown here for all observations from McMurdo Station from 00 UTC January 1, 1973 through 18 UTC December 31, 2004.

Variable	Value	Date (if applicable)
Maximum Temperature	4.4 °C (40 °F)	06 UTC December 26, 1984
Minimum Temperature	-47.2 °C (-53 °F)	12 UTC August 4, 1978
Maximum Station Pressure	1009.8 mb	06 UTC July 29, 1980 12 UTC July 29, 1980 18 UTC September 12, 1980
Minimum Station Pressure	949.5 mb	00 UTC October 9, 1993
Maximum Wind Speed	33.1 knots	18 UTC February 18, 1992
Average Temperature	-19.1 °C (-2.4 °F)	
Average Station Pressure	986.3 mb	
Average Wind Speed	9.4 knots	
Resultant Wind Speed	7.6 knots	
Resultant Wind Direction	80 degrees (East)	
Constancy	0.81	

Table 3. A summary of key climatological values are shown here for fog-only observations from McMurdo Station from 00 UTC January 1, 1973 through 18 UTC December 31, 2004.

F. Future Efforts

As touched upon in the prior sections, there is more work to be done to bring the McMurdo Station observational dataset and resultant climatology into a climate data record of one of Antarctica's long-term weather monitoring stations. Three cross checking efforts need to be conducted to bring this dataset to the best-merged collection possible. First, with newer versions of NCDC database available to the educational community (since the one used in this

study), a re-verification check should be done for this dataset against NCDC data holdings. Next, the McMurdo Station Weather Office database needs to be crosschecked against this dataset as well. A third check will be with the Carbon Dioxide Information Analysis Center (CDIAC) at the Oak Ridge National Laboratory (ORNL). This group hosts a combined collection of data and analysis of McMurdo Station observations from NCDC and the Climate Research Unit at the University of East Anglia, UK. (As a side note, datasets such as these have become the basis of other Internet sites offering this class of information, such as www.worldclimate.com). Some variables will need extra care, such as precipitation (Figure 21), where information from a variety of sources is in wide disagreement, rendering the dataset nearly unusable. During these efforts, the list of meteorological variables to be analyzed needs to be expanded to include as many as possible. Additionally, the database can be extended back to the opening of the station in 1956 (which is already in the BAS READER database, but not include here as part of this effort).

The resulting product will provide the foundation for the back generation of CLIMAT format messages from 1956 until the present. It will be critical in the computing of these messages to have the temperature averages computed using at least the 6 hourly observations available, and not using the widely used average of the extreme daily temperatures. The method of using the daily extremes only for temperature averages results in incorrect values, and possible distorted trends during the transition seasons (Keller, Pers. Comms, 2005). Another effort that is pending funding as of this writing, would be to search the US National Archives, which holds historic information on the United States Antarctic Program. The archives should be searched for the existence of any missing data and perhaps as important, any metadata about the weather observing program at McMurdo Station, Antarctica (along with other US stations).

One last effort will be to have this well-groomed dataset be provided to data centers world wide as the official climatological database for McMurdo Station Antarctica. Providing it in a variety of formats used by the operational and scientific communities (CLIMAT, ASCII Text, spreadsheets, netCDF, etc.) will ensure that this effort will be a solid foundation upon which a continuous and valuable record can continue.

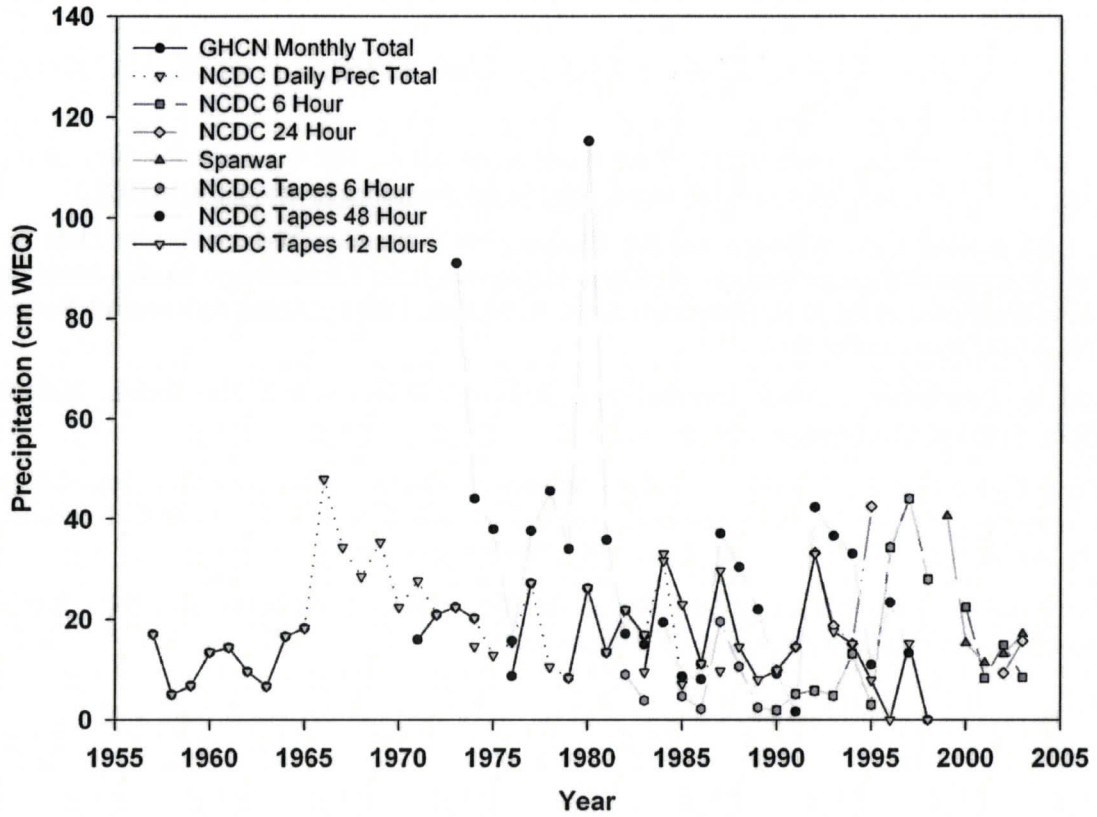

Figure 21 McMurdo Station's Precipitation reports from a variety of sources, as depicted here, shows the disagreement between datasets that needs to be resolved in future climatological analysis. (*Courtesy of T. Nylen*)

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