Interpretation of data from the automatic weather stations Drescher and Filchner and Comparison with European Centre for Medium-Range Weather Forecasts (ECMWF) Analysis model results

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1 Abstract

Automatic weather stations (AWS) are due to the extreme cold conditions an attractive option to get more dense climatic data from Antarctica. These data is needed for weather forecast models or other climatic models. Data sets of the European Centre for Medium-Range Weather Forecasts (ECMWF) analysis model are used for comparison with AWS in the Weddell Sea. This region is of particular interest for the BRIOS2 (Bremerhaven Regional Ice-Ocean Simulations) model which produce results related to sea ice processes, water mass modifications and circulation patterns, all leading to a better understanding of the thermohaline ocean circulation in the Southern Ocean. Therefore, observations at AWS' can be used as a validation of the ECMWF model and can reveal sources for errors for climate models using a ECMWF forcing.

2 Introduction

The Antarctic continent is probably the most extraordinary place for climate observations on Earth. For most time of the year, the continent is surrounded by sea ice. The extreme cold makes Antarctica to one of the most unreal places to live. Due to the inaccessibility and the rough climate, running manned observatories is very expensive and arduously. Therefore, very few stations operate the entire year, and the locations are close to the coastline because of the difficult supply situation. Consequently, the locations may always be not appropriate to collect meaningful data. But climatological data is needed for many applications ranging from input data for weather forecasts models to long time global climate models. Hence, the installation of unmanned automatic weather stations (AWS) is very attractive to get a denser network of measured climatic records. Especially climate models require dense reliable data for their validation.

This report describes the data sets of two automatic weather stations, which have been maintained by the Alfred Wegener Institute in Bremerhaven (Germany) in the Weddell Sea region. The Drescher Station situated at the western edge of the Riiser Larsen ice shelf at 72°52'12"S 19°3'54"W started transmitting data on the 02.02.1992, while the Filchner AWS at the northern margin of the Ronne ice shelf at 77°4'16"S 50°6'32"W transmitted from 01.01.1991 until it was dismantled on 30.01.1999 (see Fig. 1). The reason for this was that due to a big calving event around the 13 October, 1998 the Filchner AWS was drifting on a tabular iceberg.

This report focusses firstly on the question whether automatic weather stations produce useful and reliable data, secondly on the presentation and interpretation of the data of the automatic weather stations Drescher and Filchner. In addition, do the measured and transmitted data fit into the general climatic characteristics of the Wedell Sea region? A comparison of the measured data with the European Centre for Medium-Range Weather Forecasts (ECMWF) analysis results is also conducted. Wind direction and air pressure are of special interests for the coupled ice-ocean BRIOS2 (Bremerhaven Regional Ice-Ocean Simulations) model. Seasonal variations of the sea-ice cover in the Southern Ocean represent one of the most pronounced signals in the annual cycle of the global climate system (Timmermann et al., 2002). But the BRIOS-2 results with respect to summer sea ice conditions do not agree perfectly with the observed sea-ice distribution. Since the BRIOS-2 model is forced with ECMWF analysis data, a comparison between ECMWF and the observed data could exclude or verify the ECMWF data as a possible source of error.

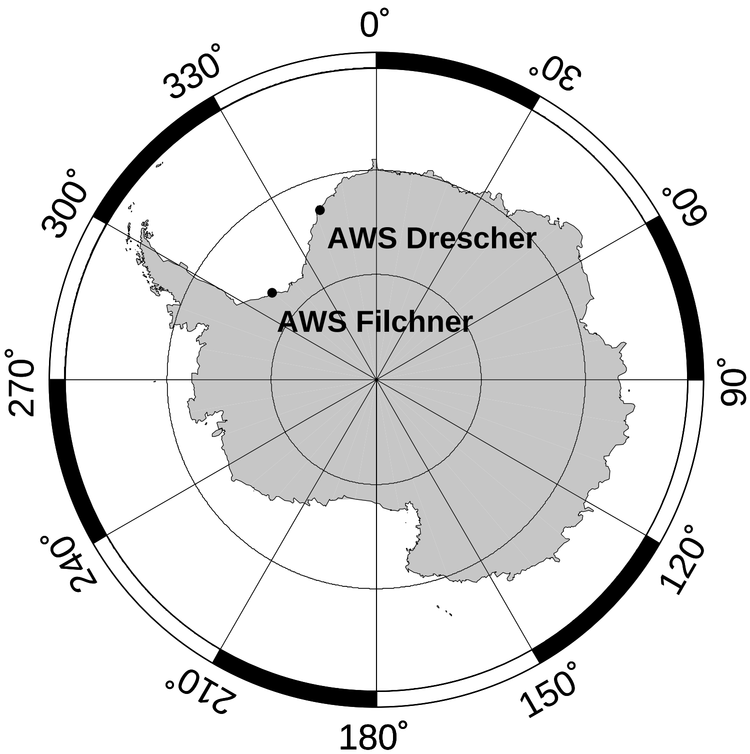


Figure 1: Location of the AWS Drescher and AWS Filchner

3 Data Acquisition and Processing

The stations were fitted with sensors for temperature, air pressure, relative humidity (Filchner since 06.02.1995, Drescher since 18.01.95), wind speed and wind direction(see Fig. 2). Additionally, the Drescher Station measured until 05.03.1995 the snow height but this data was never recorded (see Appendix D for technical details or Kottmeier and Lüdemann, 1996). The data is transmitted by the ARGOS system using two polar orbiting NOAA satellites. Each satellite needs about 102 minutes for orbiting the earth, so 20 to 28 contacts with the AWS's are possible per day for both. The data is transmitted every 200 seconds by a 8-bit word. In a first step the data is separated into the different parameters, outliers are eliminated and short gaps are interpolated. The received data sets are also transformed into a regular spaced time series with a resolution of 3 hours.

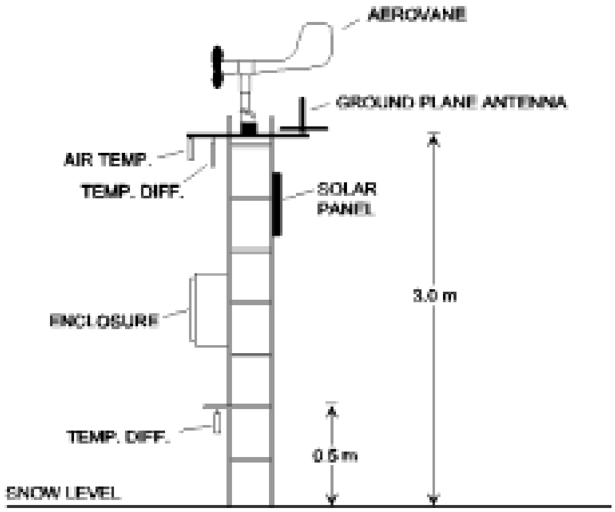


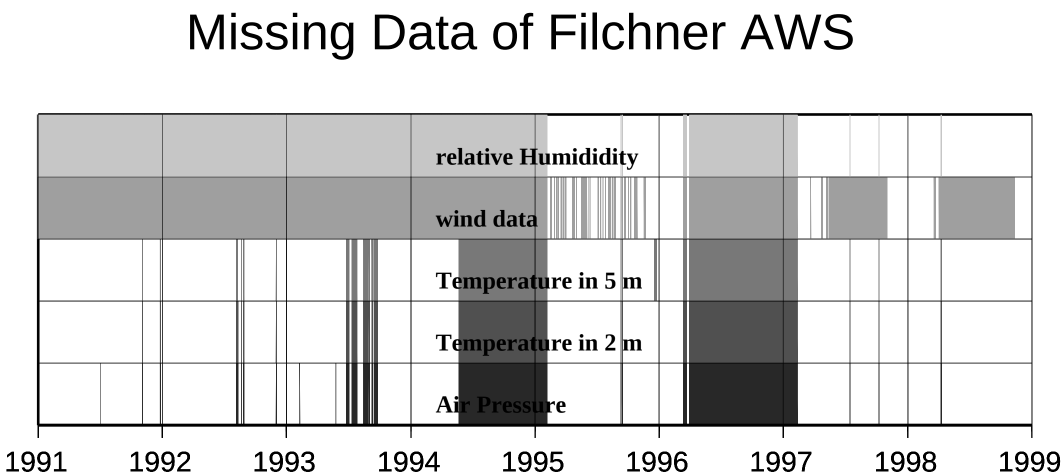
Figure 2: Layout of an automatic weather station used at the former German summer research station Filchner and at the Drescher inlet (University of Wisconsin: http://uwamrc.ssec.wisc.edu/gifs/awstower.gif)

4 Data presentation

The full data presentation is provided in Appendix A and B. Each parameter is plotted with a resolution of 3 hours, monthly means, annual means, and an average monthly mean. The recorded air pressure is reduced to mean sea level pressure (MSLP). The data integrity of the Filchner AWS for wind and humidity is not appropriate enough to calculate means, and, therefore plots for those are needless. Frequency wind roses of the Drescher AWS are presented, additionally subdivided into means for the entire measurement period, average winter and average summer months, and classified into wind speeds exceeding more than $10ms^{-1}$. As the minimum temperature occurs in August the winter months are July, August, and September while the summer months, in accordance to the classical division for the southern hemisphere, are December, January, and February.

5 ECMWF Data Processing

The ECMWF analysis data is provided in a regular spaced time series with a resolution of 6 hours on a grid of 1.125 degree in longitude and latitude. Only data for air pressure, temperature, and the two wind components are used for the comparison with the measured data. To interpolate the parameters for the exact position of the AWS', the four corner ECMWF grid points of the revolving square in which the AWS is located are weighted according to its distance. In order to get comparable data sets only every six hours a measured value is taken into account.



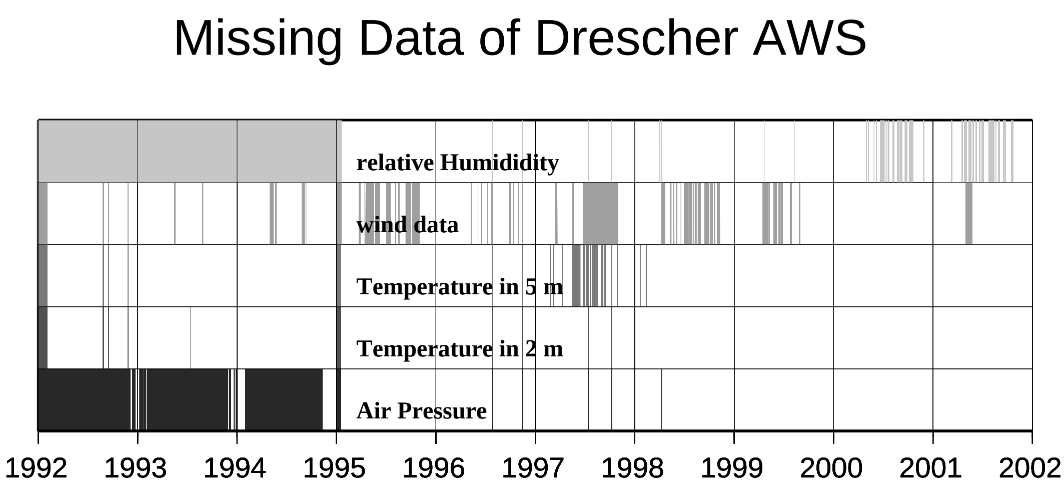


Figure 3: Missing data of the AWS Filchner and AWS Drescher. The grey area means no data has been provided.

6 Climatological Features of the Study Area

Antarctica detached from any other land mass by the Southern Oceans, is covered with 98% ice up to 4 km thick. This truncated position on the South Pole of our globe leads to special climate conditions. Unlike the Arctic, the Antarctic polar region shows a strong circumpolar low pressure trough around the 64°S latitude. North of this latitude westerly winds dominantes and to the south winds from the east prevail (König-Langlo et al., 1998). As the temperature gradient between the southern mid and high latitudes is strongest around the equinoxes, the low pressure trough shifts furthest south at these times (van Loon, 1966). The interior of the Antarctic continent which reaches an altitude of 4000m is dominated by the thermal polar high pressure area. The limited or, in winter absent insolation, the very high albedo, and the mostly unconfined outgoing long-wave radiation lead to a negative radiation budget. Therefore, a strong surface inversion occurs especially during the winter. Due to the orography and very smooth surface, katabatic winds transport cold air to the coastlines (Parish, 1988, Parish and Broomwich, 1991).

7 Interpretation of the Measured Data

Generally, data of automatic weather stations is less reliable then data of manned stations. Especially recording wind data at AWS's, where over years nobody looks after it, is unreliable. Deposits of rime ice at the cup anemometers denominates the biggest problem (Stearns et al. 1993). Wind tunnel experiments showed that icing extremely influences the measurements (Kimura et al. 2001). Particularly the Filchner data set shows big gaps of missing wind data during the Antarctic winter periods (see Fig. 3). Another source of errors is the accumulation of snow which reduces the distance between the sensors and the snow surfaces. If the logarithmic wind profile is assumed, the measured wind velocity is smaller than the one in the defined measurement height above ground. All in all, the air pressure sensor give the most reliable results, it can operate even if the sensor is snow-covered.

7.1 Temperature

The geographical position of the AWS's, high albedo values, and the not hinded outgoing long-wave radiation causes a negative radiation balance. Due to the stronger polar front and the Antarctic Circumpolar Ocean Current heat transfer from mid latitudes is not possible like in the Arctic. Both stations showed consistent low temperatures with the minima around August. The annual mean temperature at Filchner is -21,1°C due to a more southern location and the influence of very cold katabatic winds, Drescher with a more northern position and more affected by relative warmer air masses from north-east shows a higher mean temperature of -16.5°C (see Appendix A, Figs. 11,12; Appendix B, Figs. 19,20)

7.2 Air Pressure

The observed average annual mean sea level pressure at both stations varied between 985 and 995 hPa. At Filchner AWS a slightly higher air pressure is recorded which is due to the more southern location resulting in a greater distance to the circumpolar low pressure trough than the Drescher AWS. In addition, the Filchner AWS is closer to the thermal south pole high pressure area. Minima of air pressure can be found around March and September, especially at Drescher AWS. As mentioned, the Antartic circumpolar low pressure trough moves in a semi-annual cycle with the furthest shift to the south around March and September (van Loon, 1967). This effect is not so well represented at Filchner, again, due to the more southern location (see Appendix A, Fig. 13; Appendeix B, Fig. 21).

7.3 Wind

As mentioned, wind is the most unreliable parameter. Detailed interpretation for the Filchner AWS is impossible because of the intermitted data recording. At the Drescher AWS, a bimodal wind field with high frequency of wind direction in the E to NE sector and lower frequency in the S to SW sector is observed. The same kind of pattern shows the data of Halley research station located in the same region(see Figs. 4 and 5). The higher speeds tend to be related to

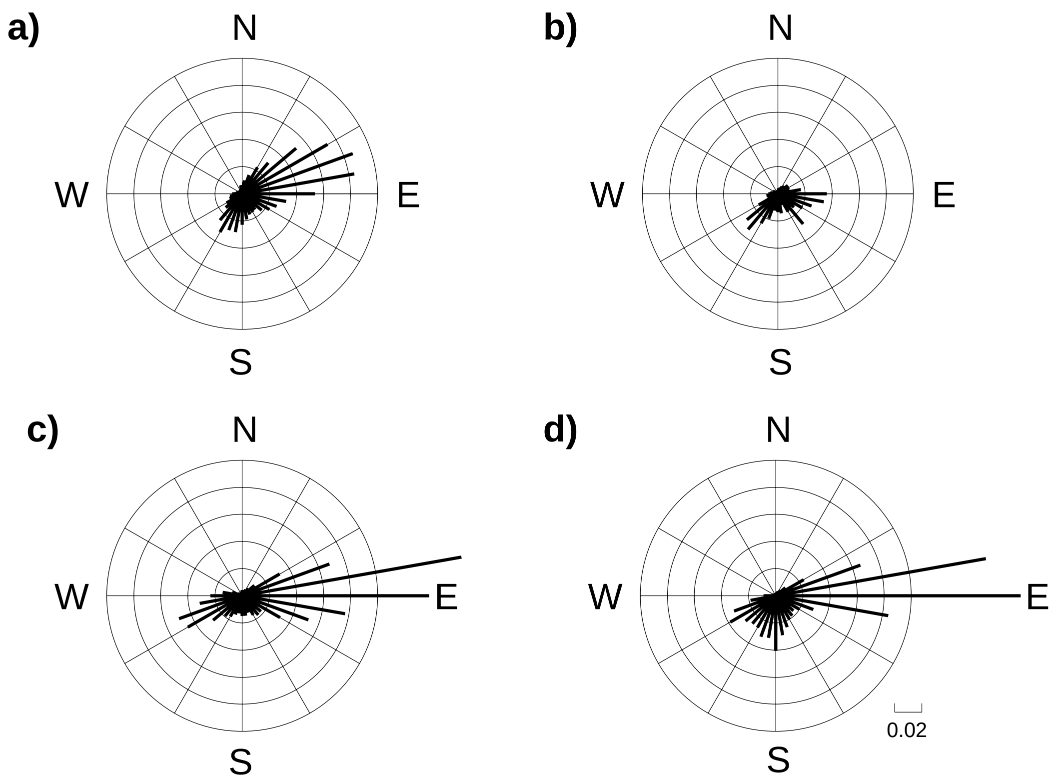


Figure 4: Frequency wind roses for different stations. Wind velocities not exceeding 1 m s^{-1} are negelcted. a)Drescher AWS, b)Filchner AWS, c) Halley, d) Neumayer. The windrose for Filchner AWS is based on very few data only (see Chapter 7.3).

winds from the east only (see Appendix A, Figs. 14-16,18). To the north of Drescher AWS low pressure areas migrate circumpolar eastwards. Due to the Coriolis force wind is diverted to the left for the southern hemisphere and hence the resultant geostrophic wind at the southern margin of the cyclone blows from the east. Katabatic winds increase the frequency of easterlies but cannot explain the south-western wind field component (Connolley and Cattle, 1994). One explanation for the southwestern component could be that cyclones migrate eastwards in the southern Wedell Sea. But own examinations about the location of the center of low pressure correspondent with Jones and Simmonds (1993) that cyclones do not track that far south. Some depressions move far south and reach the Weddellsea, but the density of cyclolysis is very high there, so the low pressure areas do not reach the Antarctic continent (King and Turner 1997). Another explanation is the so called super-geostrophic wind (see Fig. 6). For this situation a high pressure ridge extends far south into the Weddell Sea. Due to the curvature of the isobars centrifugal force occur. Considering a cyclone northwestwards of the Drescher Station the centrifugal force accelerates the wind because it opperates in the same direction. If only weather situations which

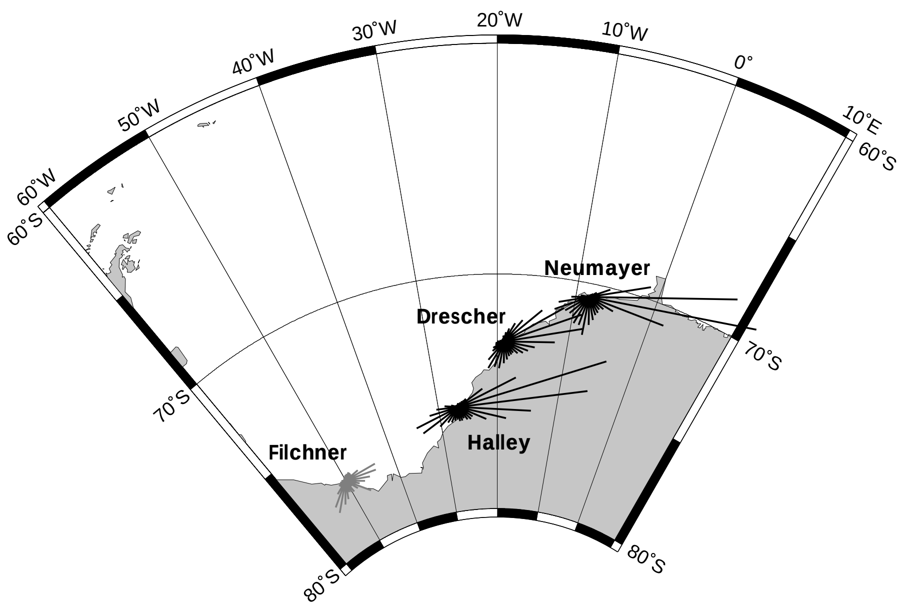


Figure 5: Frequency wind roses according to the position of observation. Wind velocities not exceeding 1 m s^{-1} are negelcted. The wind rose for Filchner is shown in grey, because the database is less reliable

match relatively good supergeostrophic weather conditions are considered the frequency wind rose for Drescher Station shows a dominant wind direction from the South-West (see Fig. 7). The peak of zonal wind speed around September is remarkable, caused by the shift of the circumpolar cyclones to the south (see Appendix A, Fig. 14).

7.4 Relative Humidity

Data for relative humidity is either erroneous or missing. For example, an instrument change at the Drescher AWS in January 1999 caused a tremendous change in the observed values. Nearly 100 % humidity was recorded for the period since 1999. The values at Filchner are more credible, but the time series is too short, and to many gaps make it more or less needless. Therefore no interpretation is done here (see Appendix A Fig 17).

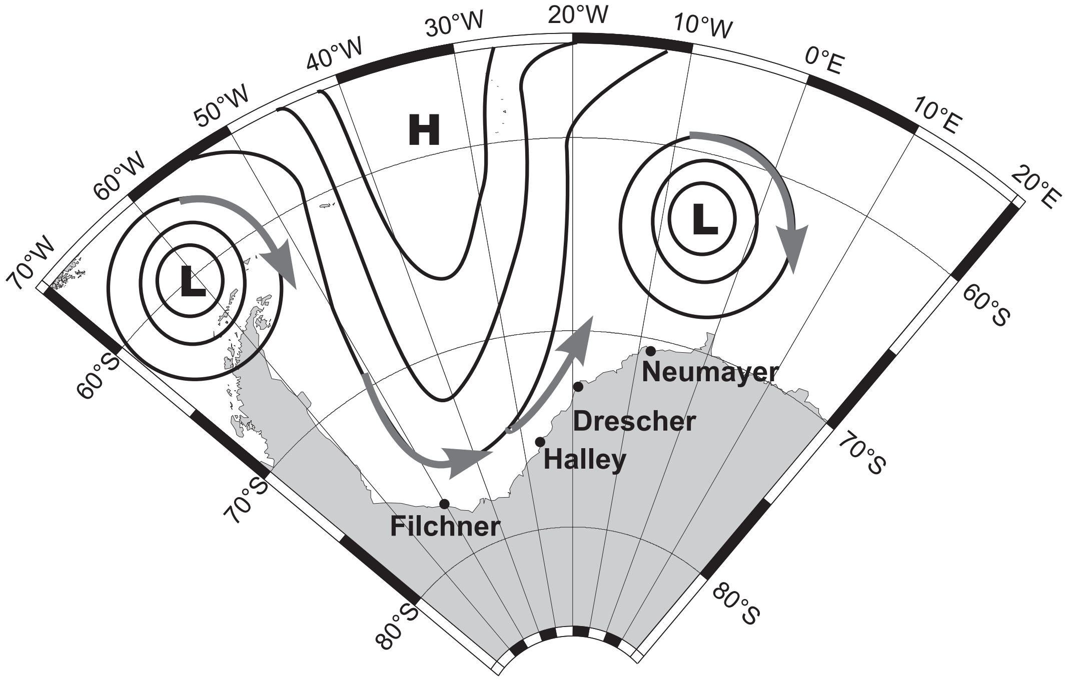


Figure 6: Theoretical isobars of MSLP for super-geostrophic weather conditions

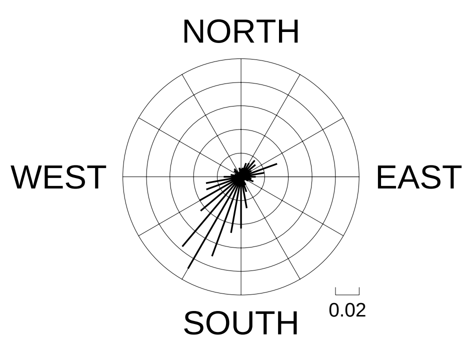


Figure 7: Frequency wind roses for Drescher and only for super-geostrophic weather situations. Wind velocities not exceeding 1 m s^{-1} are neglected.

8 Comparison of measured data with the ECMWF-analysis data

For the comparison of measured data with the ECMWF analysis data the data sets were transformed in order to make both data sets comparable (see Chapter 5). Wind data for Filchner is not taken into account for the comparison, because of the already mentioned erroneous and missing data. Positions of Drescher Station and the next ECMWF-grid points are shown in Figure 9. For a better interpretation, data sets of the manned stations Neumayer (Germany) and Halley (United Kingdom) are compared with the ECMWF analysis data as well. Generally, the best correlation can be found for air pressure. High r-square values can be founded for Filchner (0.89) and for Drescher (0.95). Due to data gaps at Filchner, Drescher generally shows a better correlation (see Appendix C, Figs. 24 and 25). Figure 10 shows the correlation coefficients for different methods used to interpolate ECMWF data to the position of the stations at Drescher, Halley and Neumayer. It seems that the influence of different interpolation methods is very low. Especially for the BRIOS ice-ocean model, it should be examined if remarkable, whether differences can be found for the ice grid point closest to the coast. However, it must be also considered that the observations are incorporated in the ECMWF-analysis.

8.1 Temperature

It seems hat the ECMWF-model overestimates the temperatures. But with correlation coefficients of 0.76 (Drescher) and 0.66 (Filchner) still reasonable values are reached. A notable temperature missmatch for measurement period until 1998 can be found at both AWS stations. Especially the cold winter temperature can be either not predicted by the ECMWF-model or the temperature sensors malfunctioned in very cold conditions. It is remarkable that the values of the same sensor match quite good with the ECMWF values since winter 1998 at Drescher AWS (see Appendix C, Figs. 26 and 30). But including data from Halley and Neumayer, the ECMWF analysis data tend to overestimates the temperature, particular if the temperatures are very low. All slopes of regressions are grater than 1. This ECMWF "warming" was described by several authors (Timmermann et al., 2002) and can be explained by an underestimation of winter surface temperature of the frozen Weddell Sea.

8.2 Air Pressure

As mentioned, the air pressure is the most reliable measured parameter of the automatic weather stations. The measured values fit very good with the modelled values at Drescher (see Appendix C, Fig. 27). At Filchner till 1994, the old sensor seemed to measure a slightly too high air pressure. Causing the average monthly values to differ by about 4 hPa (see Appendix C, Fig. 31). But overall, the ECMWF-values fit very good (see figure 19). A good coherence between ECMWF and observed data still exists if data from Neumayer and Halley stations are also compared.

8.3 Wind

Measured wind data of automatic weather stations is accompanied by many errors. It is difficult to draw conclusions from the wind data comparison of the Filchner AWS. It is notable that the meridional wind component does not match at all with the ECMWF database with a very small correlation coefficient of r^2=0.18. The zonal component is reflected better with a r^2 value of 0.52 (see Appendix C, Fig. 24). The relative low number of records, due to instrumental failures which can be considered for the correlation makes this result very vague. But even the Drescher data, where nearly five times more data can be used, only medium coherences of r^2=0.56 (zonal component) and r^2=0.58 (meridional component), are noted. The relative low regression slope can be best explained by instrumental failures due to icing and reduced distance to the surface. Figures 32 and 33 show frequency and wind speed roses for the original Drescher data, the interpolated ECMWF data for the Drescher position, for the ice-grid point of the BRIOS2 model, and the four surrounding ECMWF-grid points. Another effect is, that the average deviation of wind direction is not stable over time. At Drescher, till January 1995, the deviation is negative, afterwards it is positive (see Fig. 8). Together with the fact that exact at that time the station was replaced by a new one, it can be assumed that the Drescher Station was not pointed north accurately.

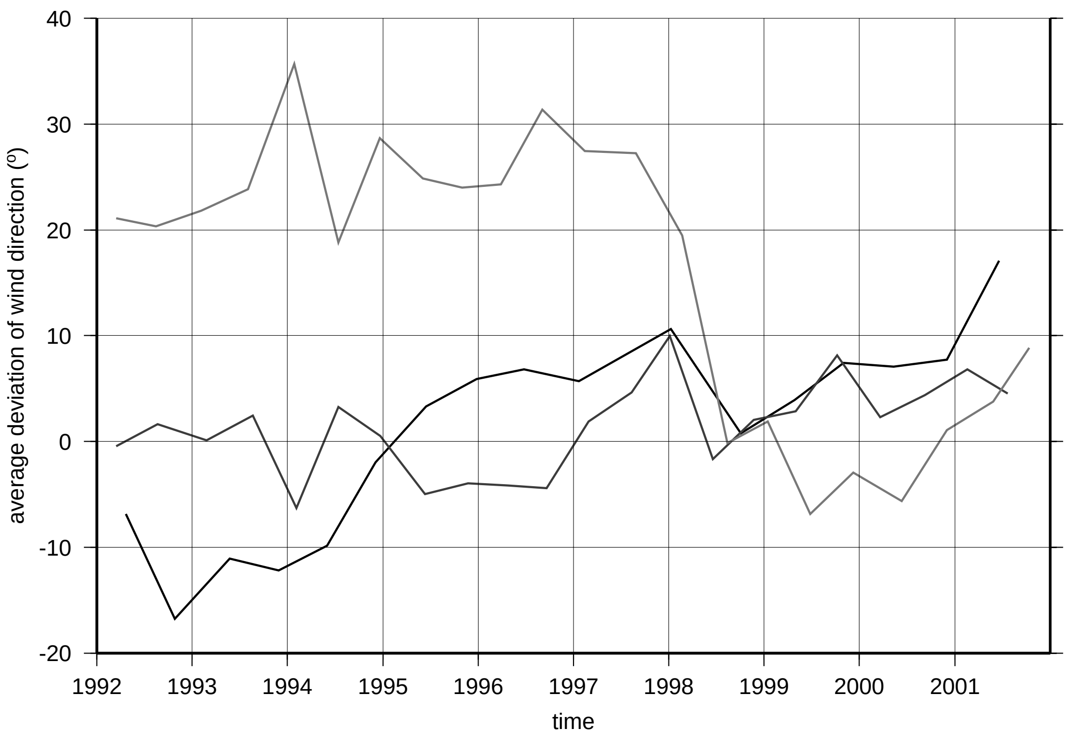


Figure 8: Deviation (running mean of 50 days) of wind direction between observered and ECMWF value for Drescher (black), Neumayer(dark grey), Halley(light grey).

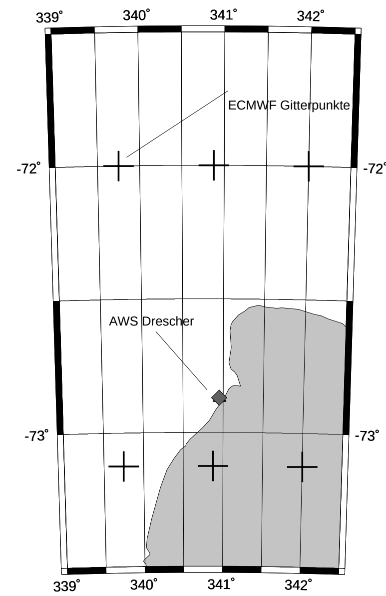


Figure 9: Position of the Drescher AWS and the closest ECMWF-Grid points. The diamond represent the next ice-grid point for the BRIOS2 model

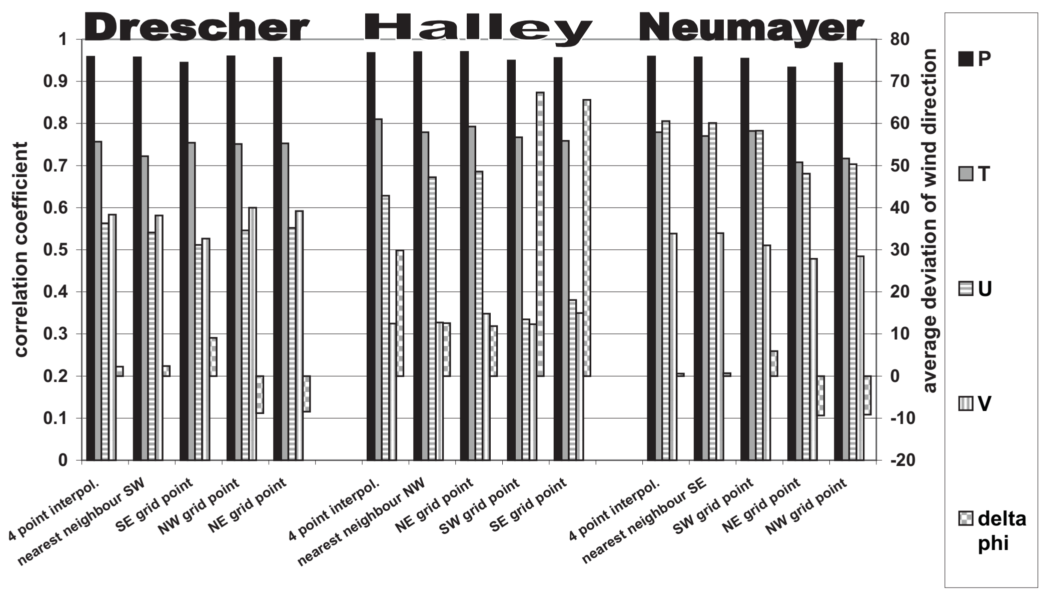


Figure 10: Different interpolation for the locations of Drescher AWS, Halley and Neumayer station. Shown are the correlation coefficient for main seal level pressure (P), temperature in 2m high (T), u-wind and v-wind component (U.V). The right axes belongs to the average deviation of wind direction (delta phi). The sequence of the next ECMWF gridpoints reflects the distance to the locations of observation.

9 Conclusions

The quality of data sets from automatic weather stations is less reliable. The extreme cold climate in Antarctica limits the use of these data. It becomes clear that with decreasing distances to the South Pole icing causes a dead loss of data during the winter period. Especially wind data must used very carefully. The most reliable parameter is air pressure. This report covers that wind direction shows a bi-modal structure with dominant winds from the E to NE. The most obvious explanation for the southwest wind direction observed by Drescher and Halley stations is a super-geostrophic weather situation. The comparison with the ECMWF analysis revealed that modelled air pressure agrees well with the observations in contrast to the temperature which deviates more during very cold periods. If wind data is used for interpretation one must keep in mind that maintenance of the stations does not happen for years and the measured height decreases due to further snow accumulation. The other result is that ECMWF-data for certain positions have to handle with care because it must be distinguished between locations over sea or land.

A Data presentation for Drescher

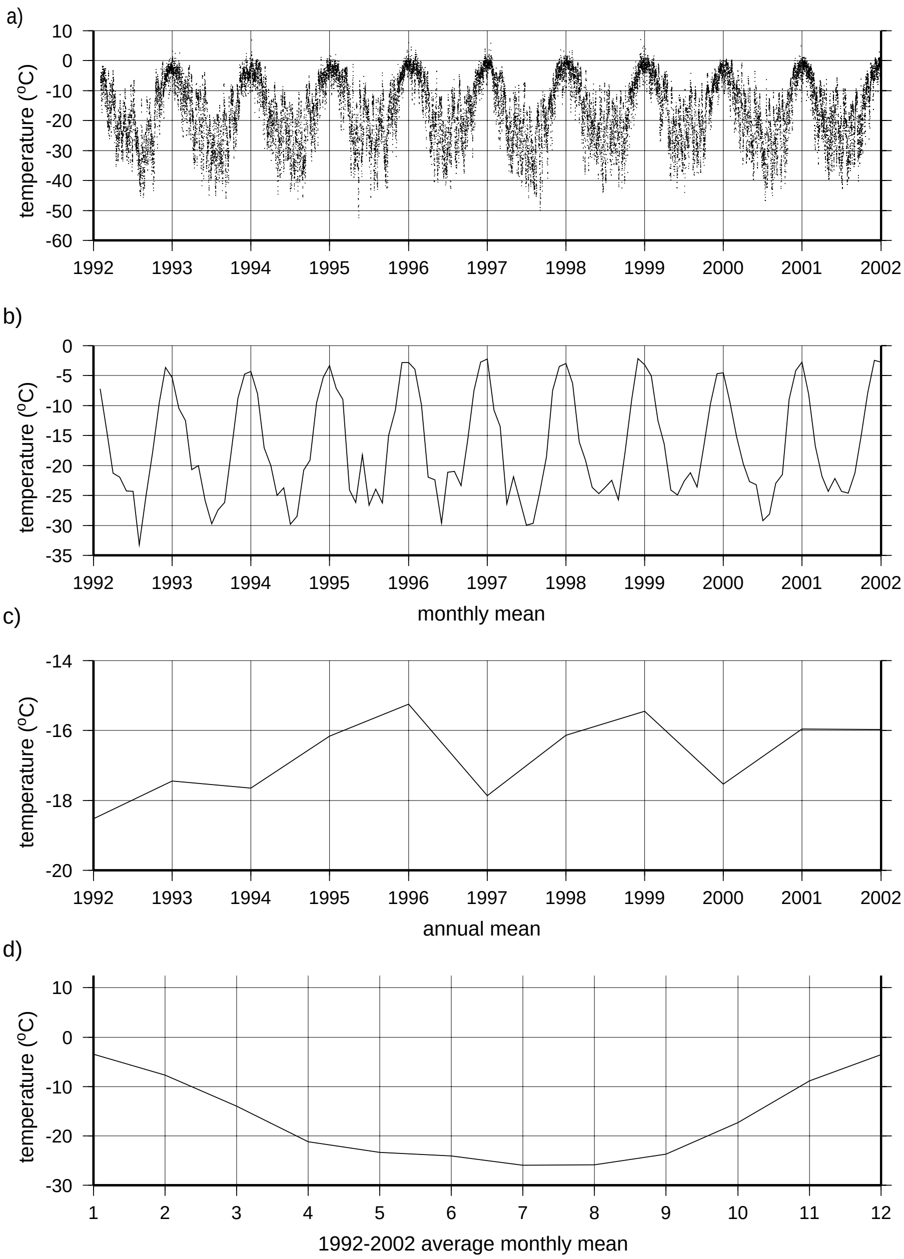


Figure 11: Temperature in 2m above surface for the Drescher AWS. Data interval 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

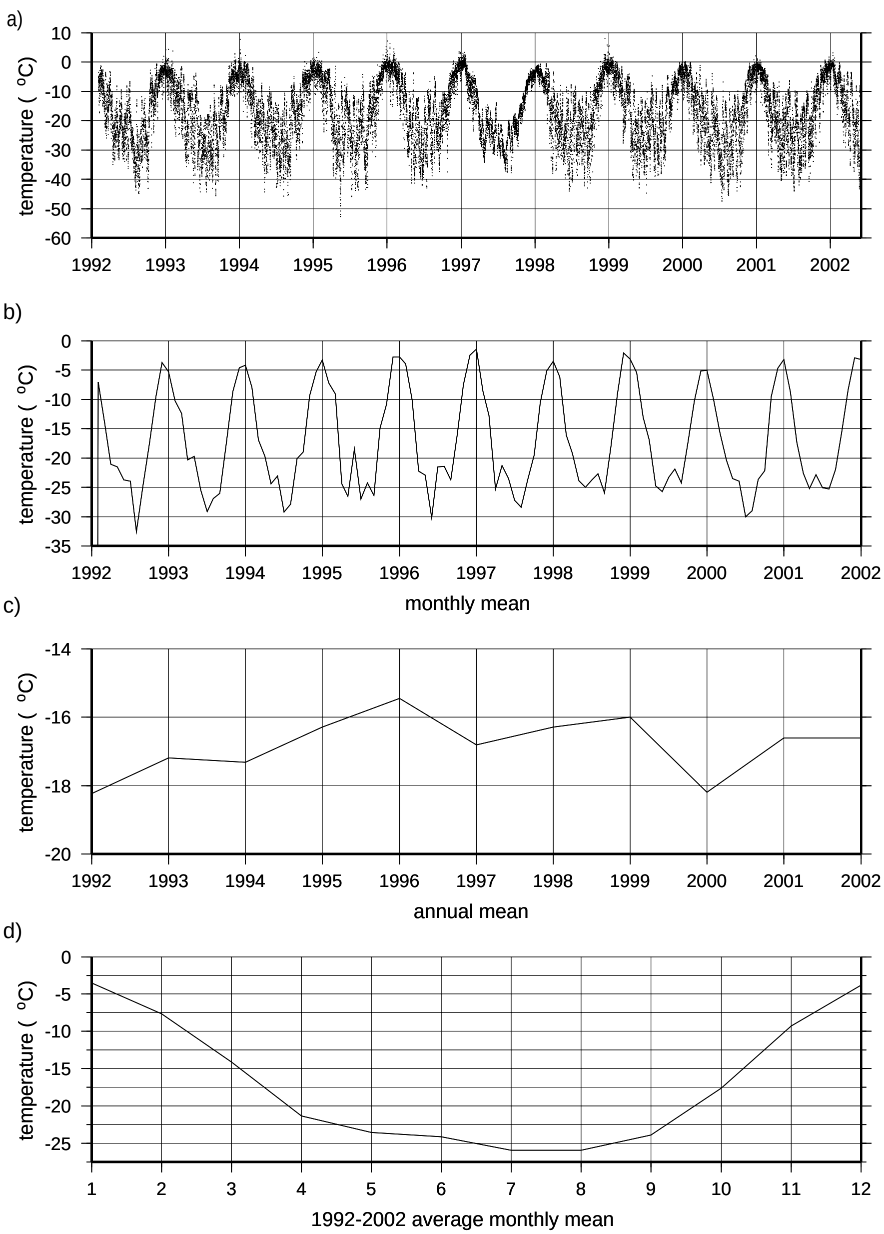


Figure 12: Temperature in 5m above surface for the Drescher AWS. Data interval 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

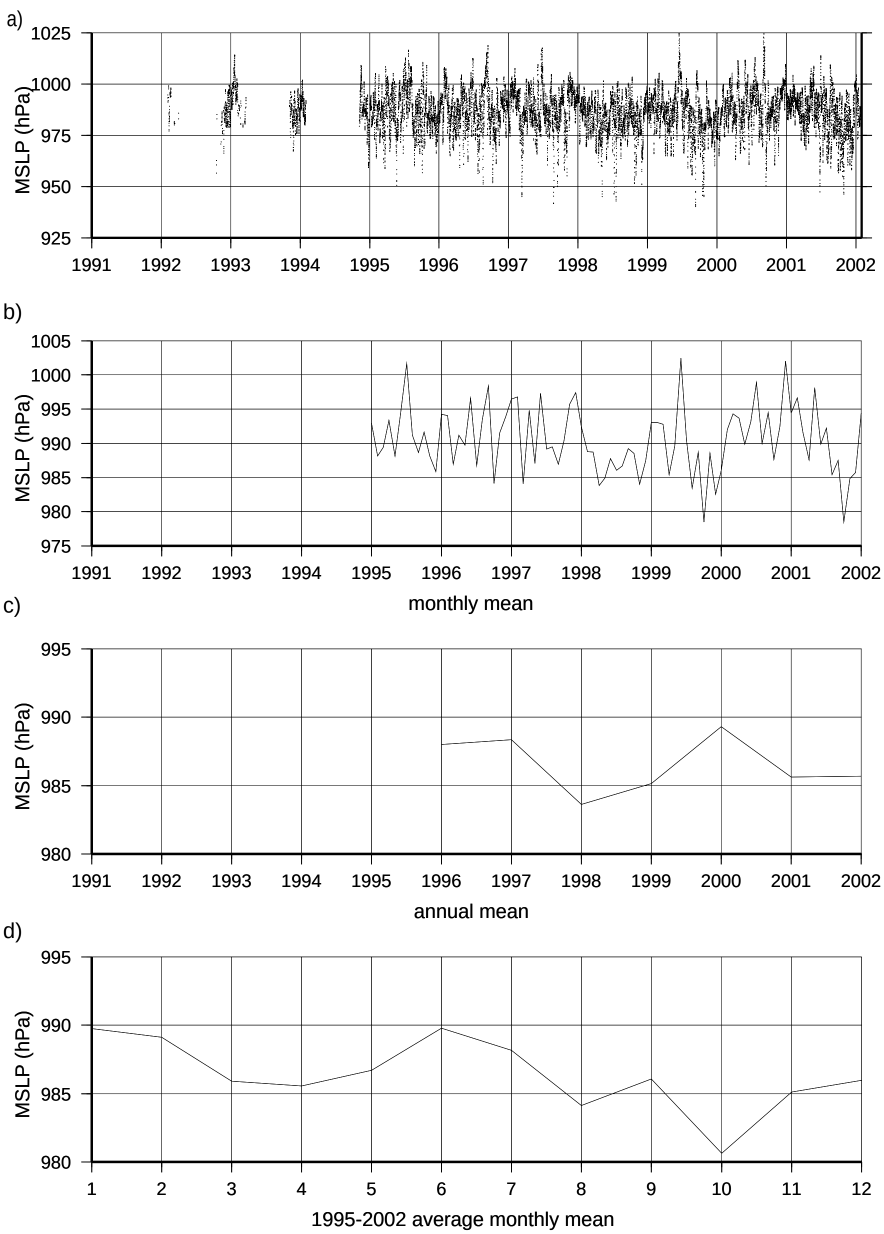


Figure 13: Mean sea level pressure (MSLP) for the Drescher AWS. Data interval 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

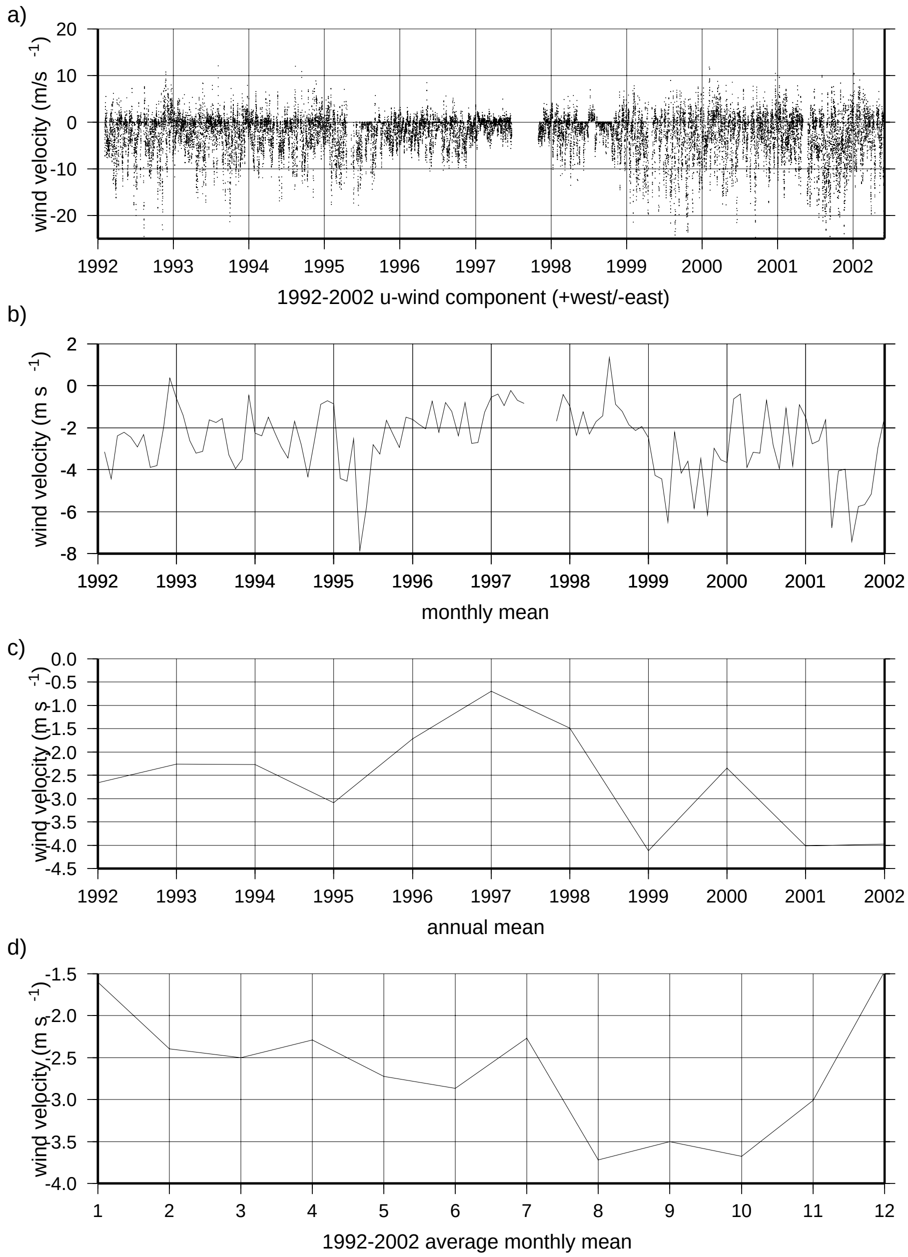


Figure 14: Wind velocity for the u-component for the Drescher AWS. Positive values represent west wind, negative east wind respectively. Data interval 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

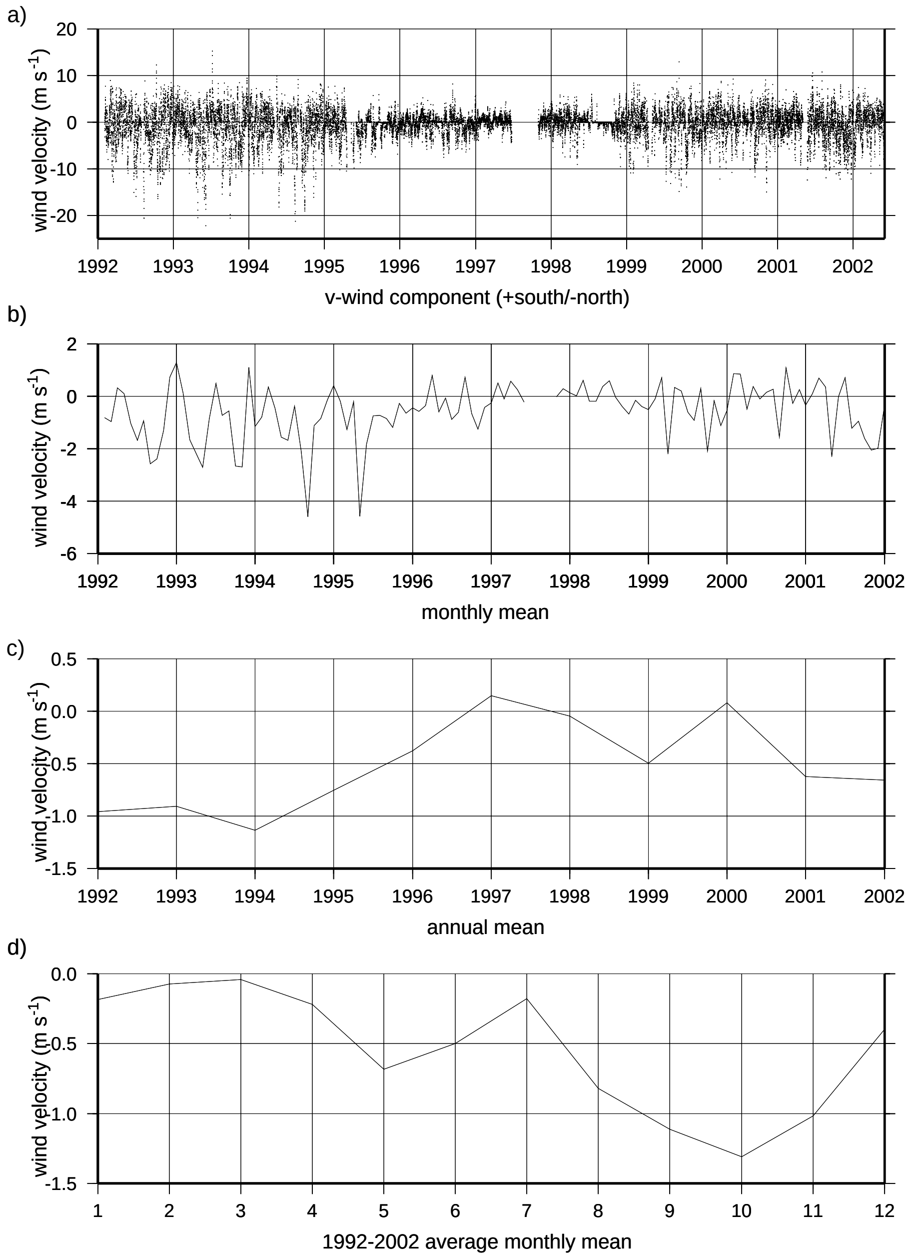


Figure 15: Wind velocity for the v-component for the Drescher AWS. Positive values represent north wind, negative south wind respectively. Data intervall 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

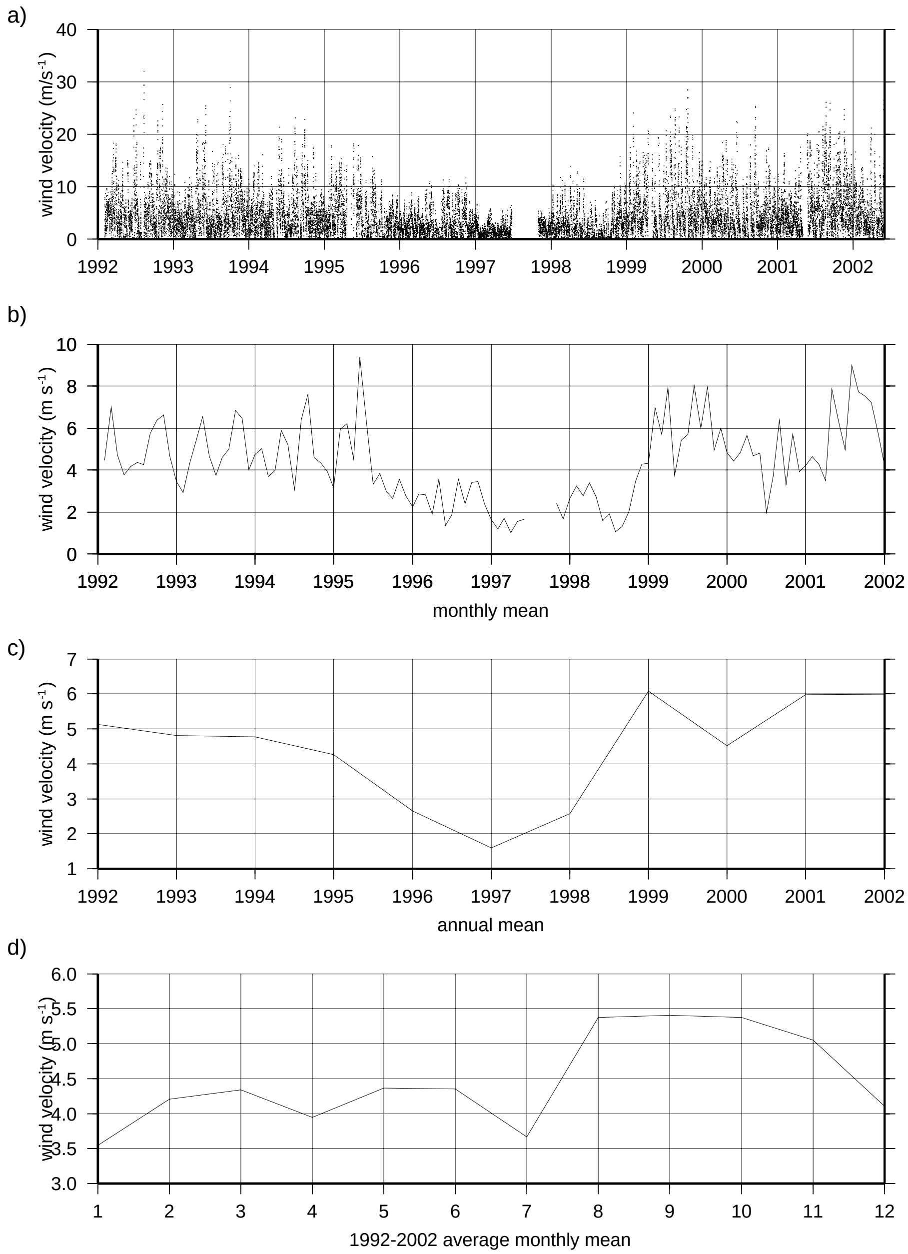


Figure 16: Scalar wind velocity for the Drescher AWS. . Data interval 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

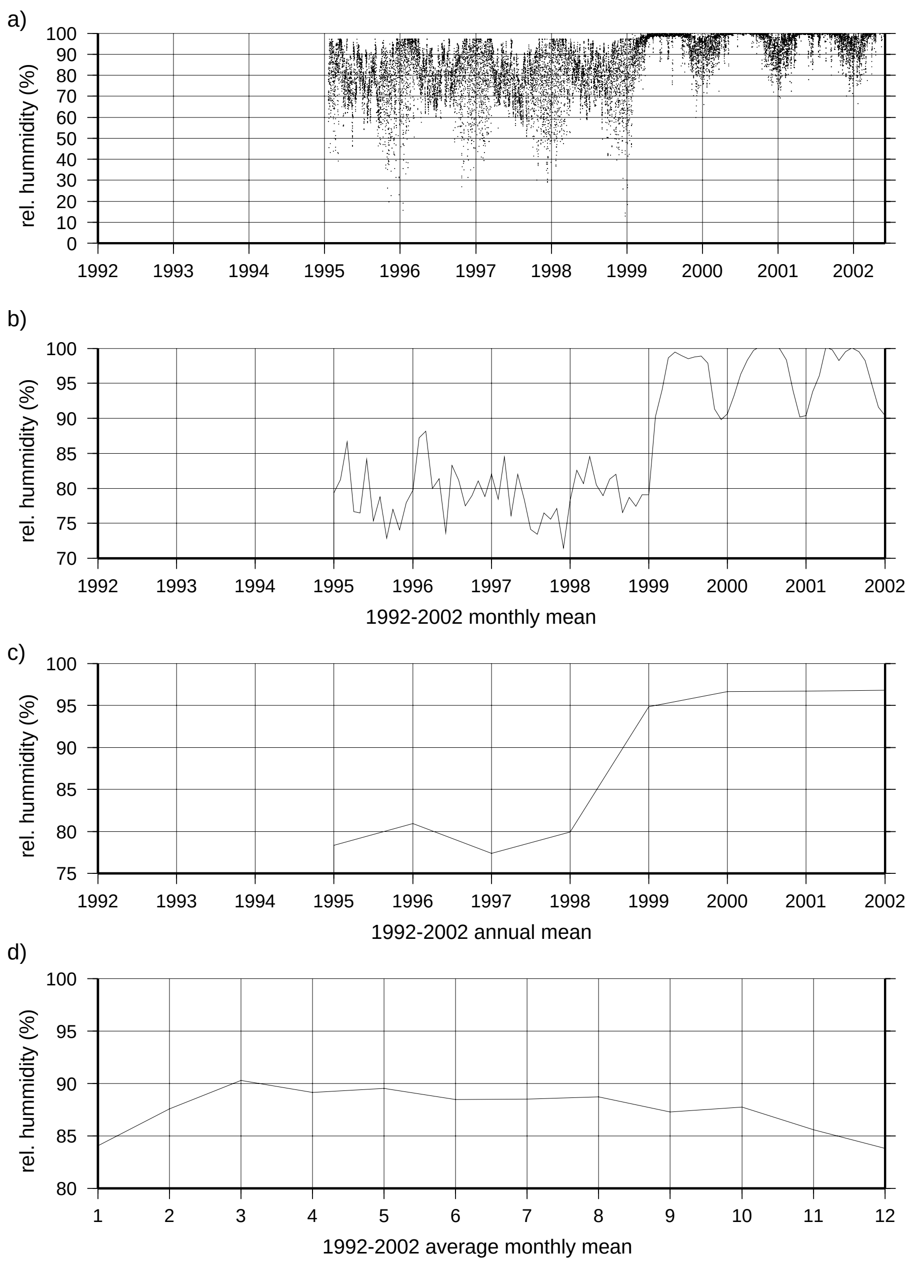


Figure 17: Relative Humidity for the Drescher AWS. Data intervall 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

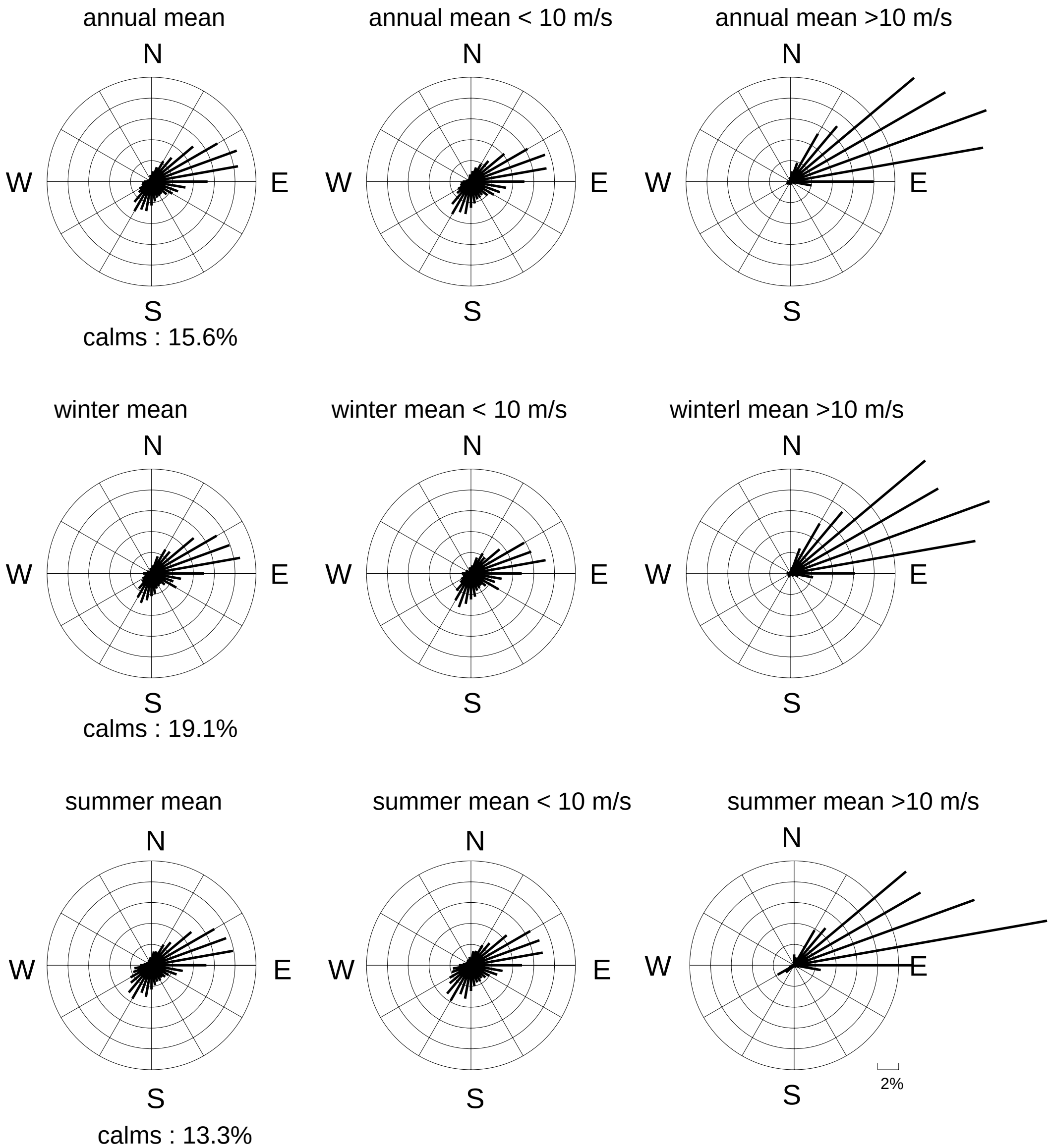


Figure 18: Wind roses for relative frequency of wind direction for the Drescher AWS. Wind speed below $1ms^{-1}$ is assumed as calms.

B Data presentation for Filchner

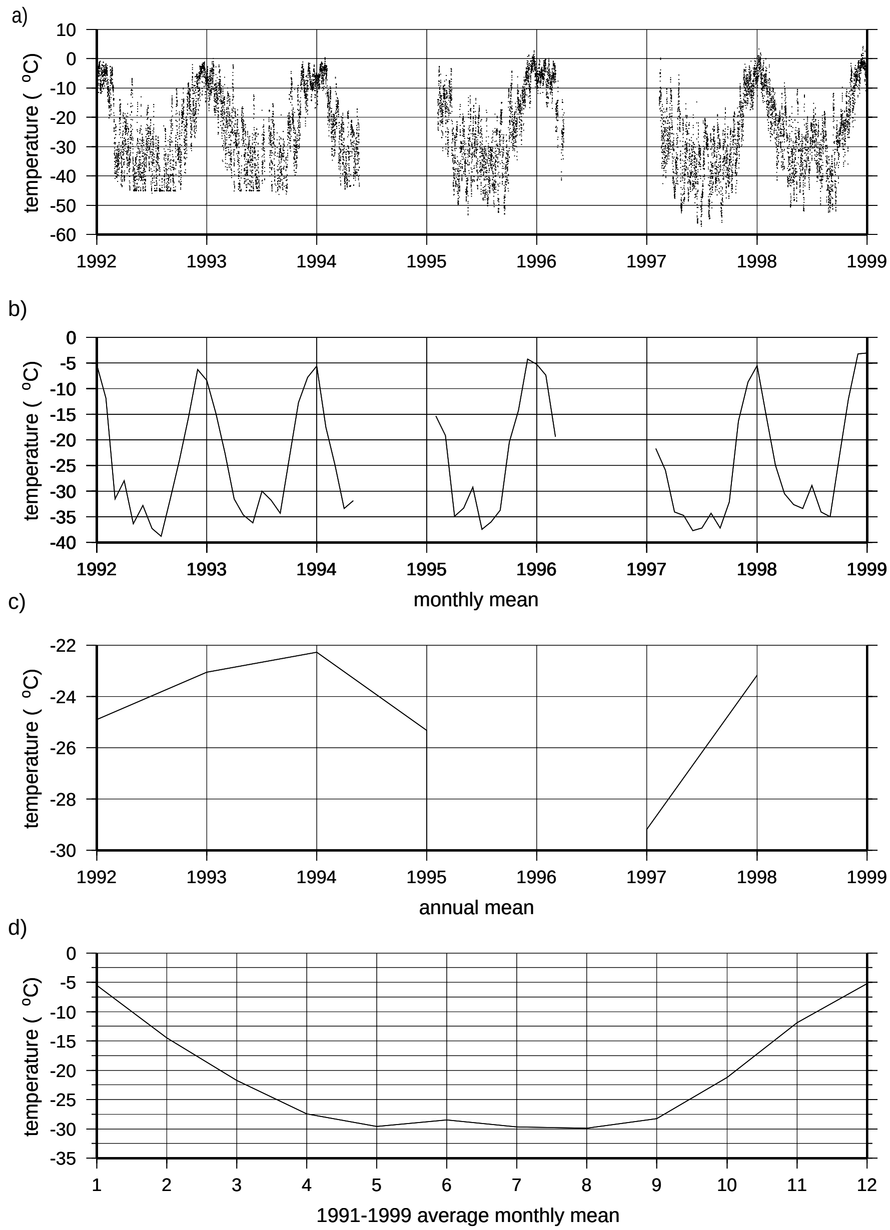


Figure 19: Temperature in 2m above surface for the Filchner AWS. Data intervall 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

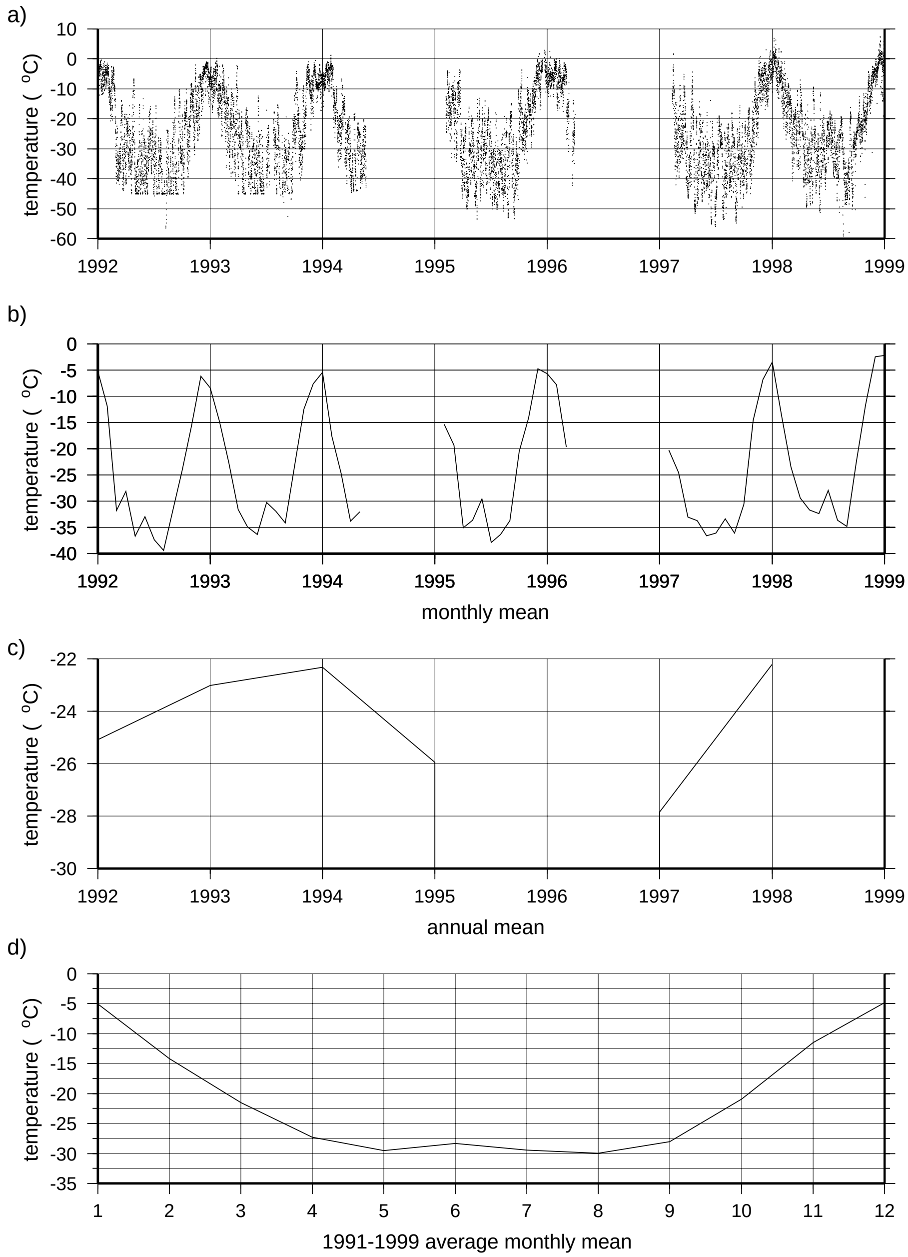


Figure 20: Temperature in 5m above surface for the Filchner AWS. Data intervall 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

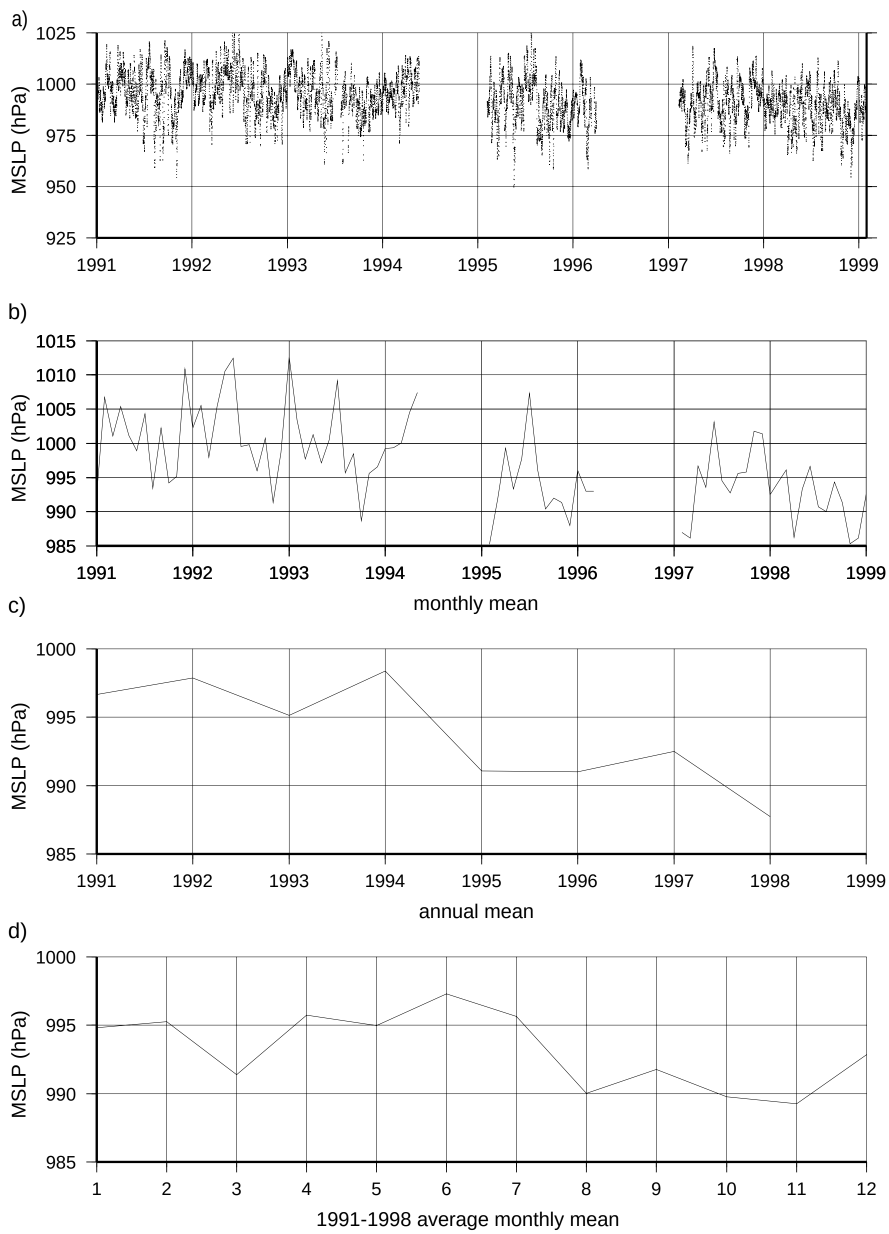


Figure 21: Mean sea level pressure (MSLP) for the Filchner AWS. Data intervall 3 hours. a): all recorded values b) monthly means c): annual means d) average monthly means

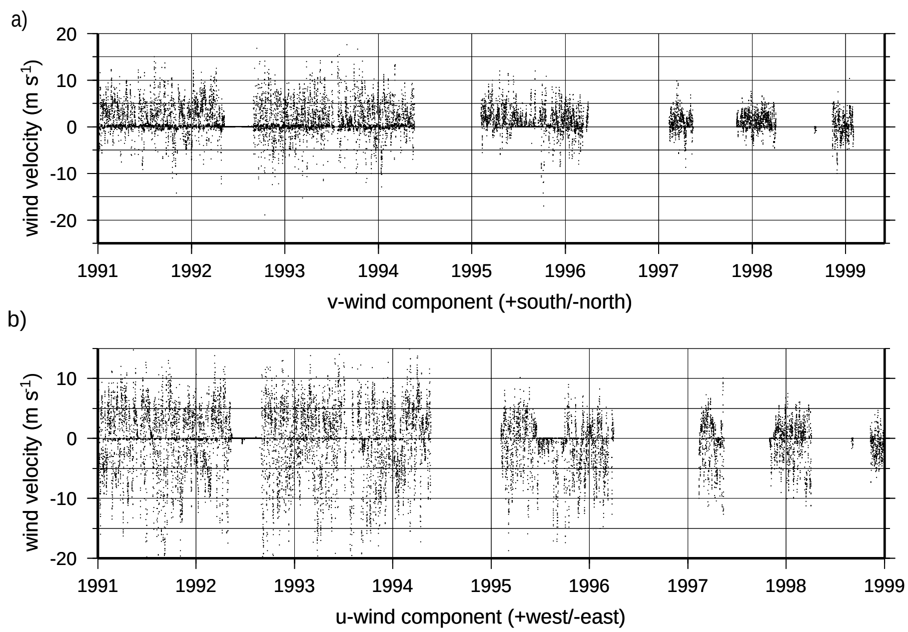


Figure 22: Windvelocity for the v-component (a) and u-componenet (b) for the Filchner AWS. Positive u-values represent west wind, negative east wind. Positive v-values represent north wind, negative south wind respectively. No means are calculated due to the lack of data. hours.

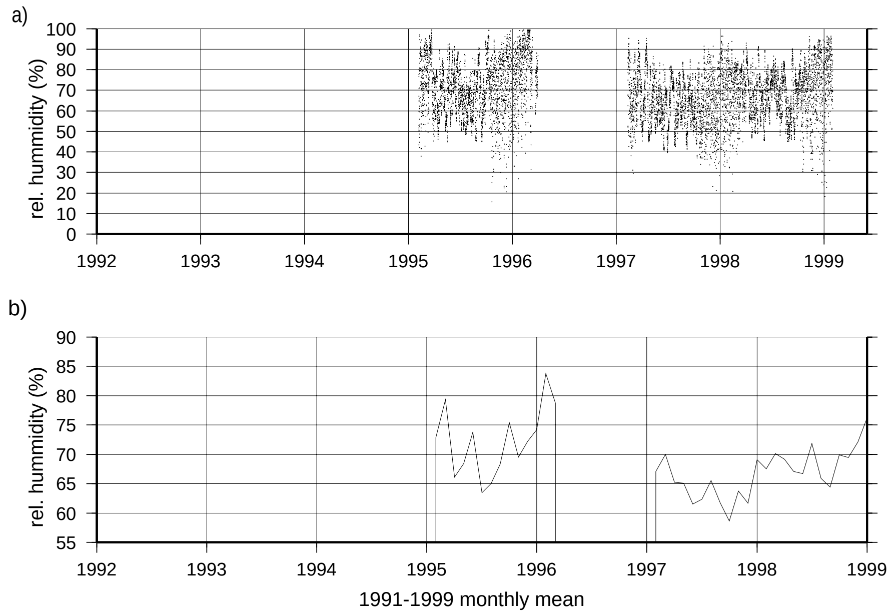


Figure 23: Relative Humidity for the Filchner AWS. Data interval 3 hours. a): all recorded values b) monthly means Other means are calculated due to the lack of data.

C Comparison with the ECMWF-analysis data

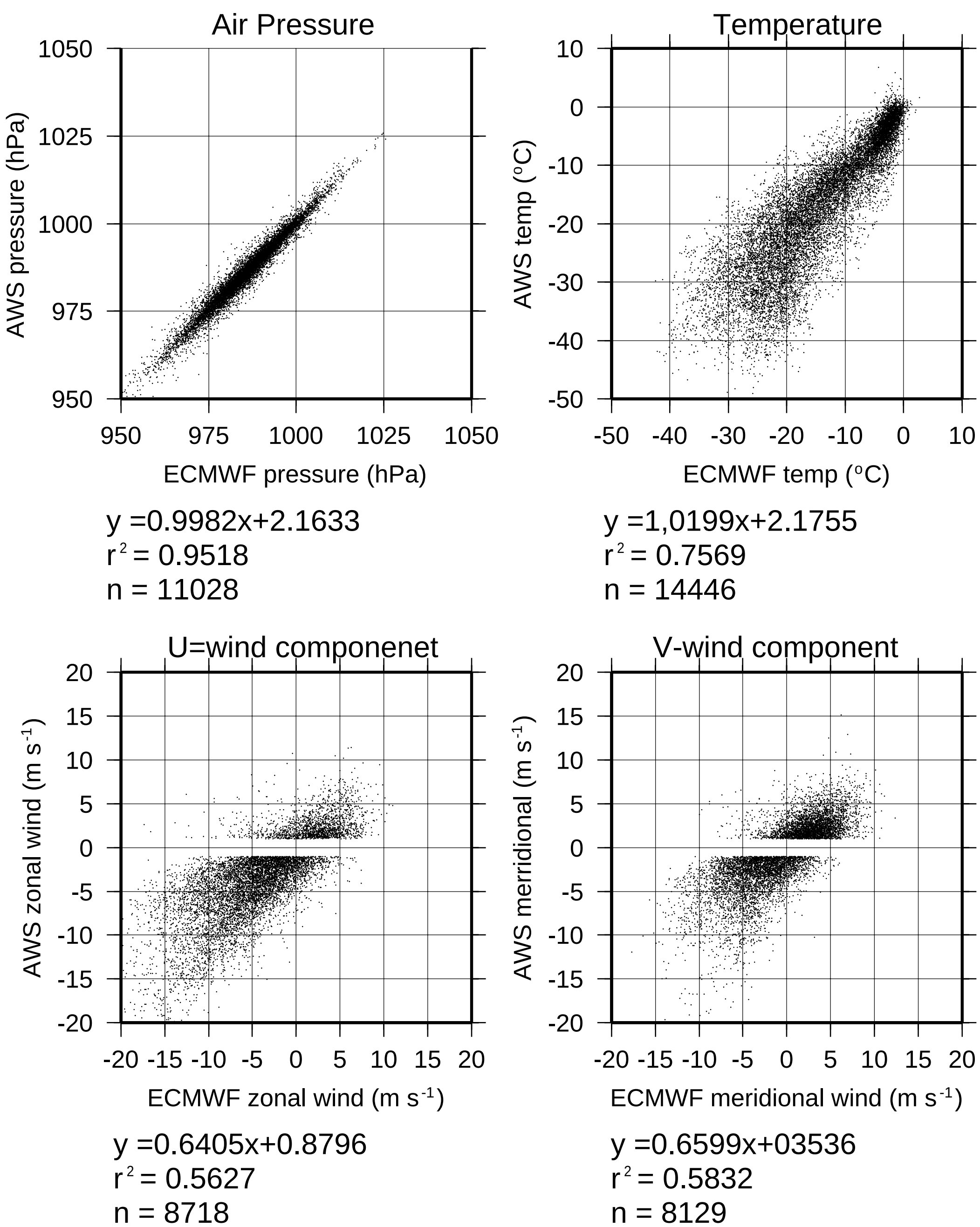


Figure 24: Correlations between the original measured data of the Drescher AWS and for the same position interpolated ECMWF-data

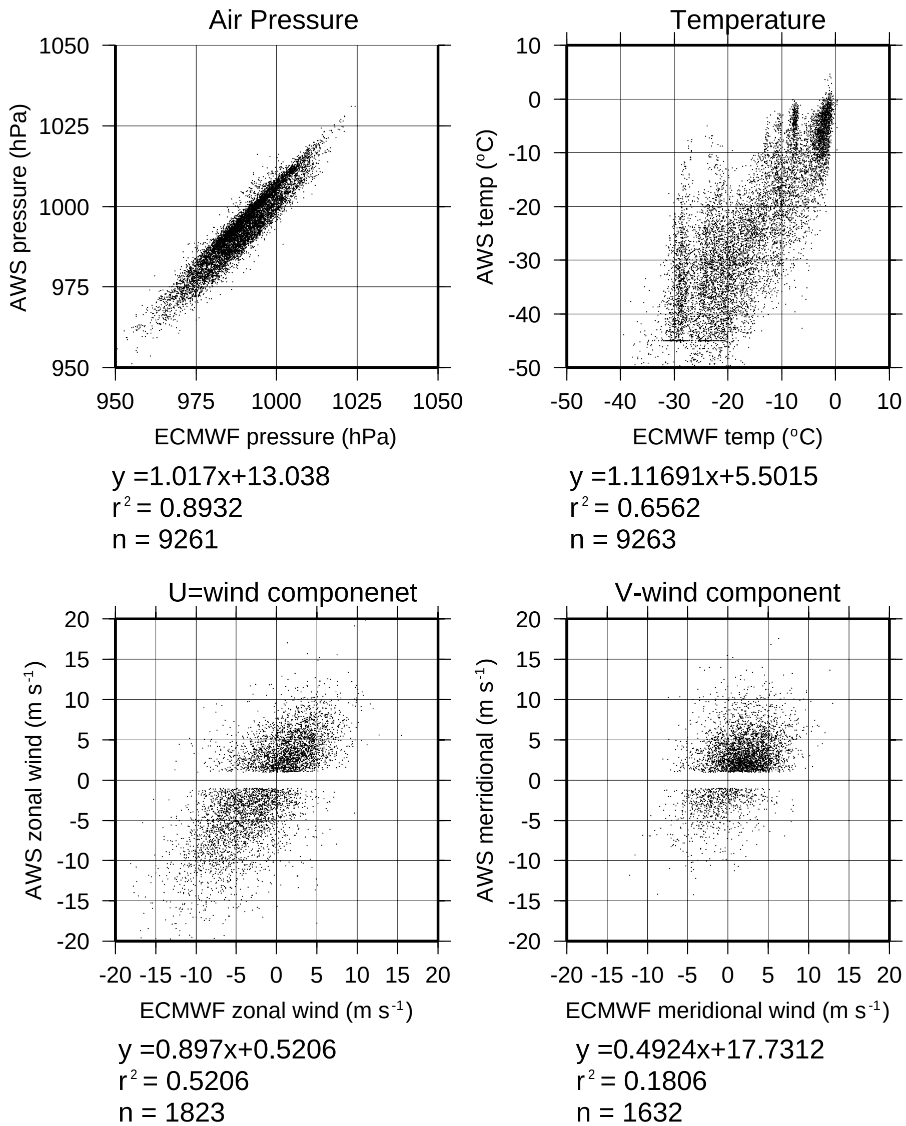


Figure 25: Correlations between the original measured data of the Filchner AWS and for the same position interpolated ECMWF-data

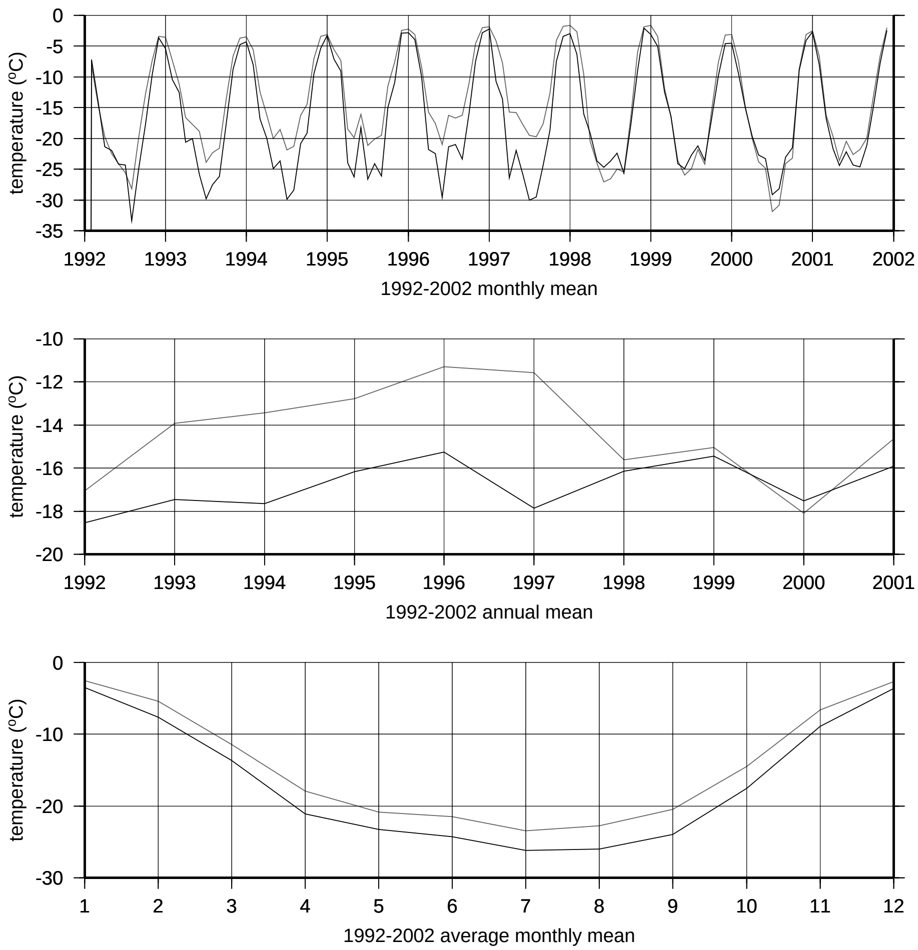


Figure 26: Comparison between the plot of temperature for Drescher AWS and the interpolated ECMWF-data (grew)

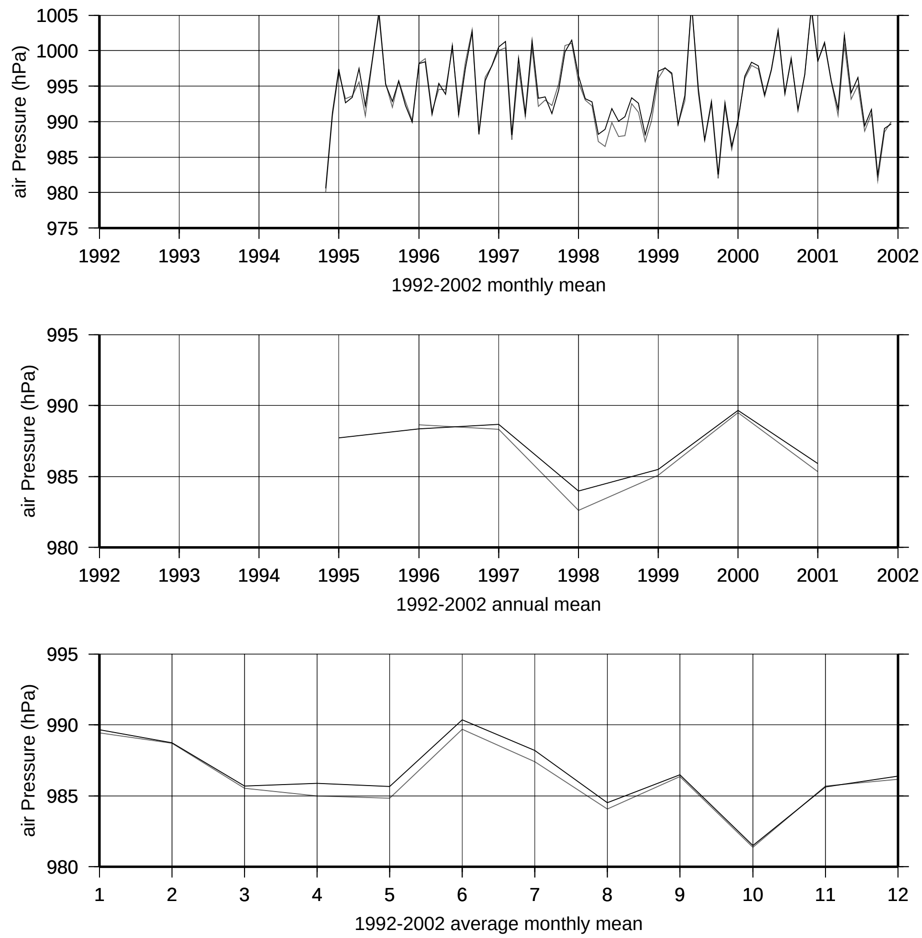


Figure 27: Comparison between the plot of mean seal level pressure for Drescher AWS and the interpolated ECMWF-data (grew)

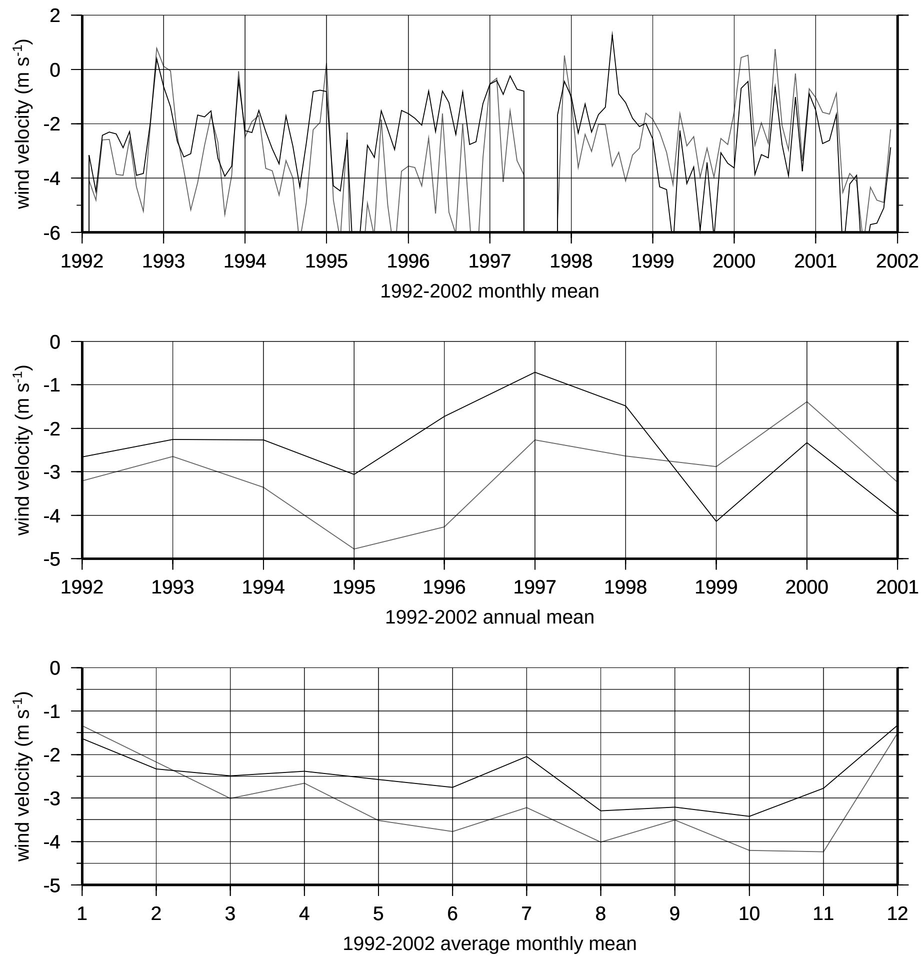


Figure 28: Comparison between the plot of zonal wind component for Drescher AWS and the interpolated ECMWF-data (grew)

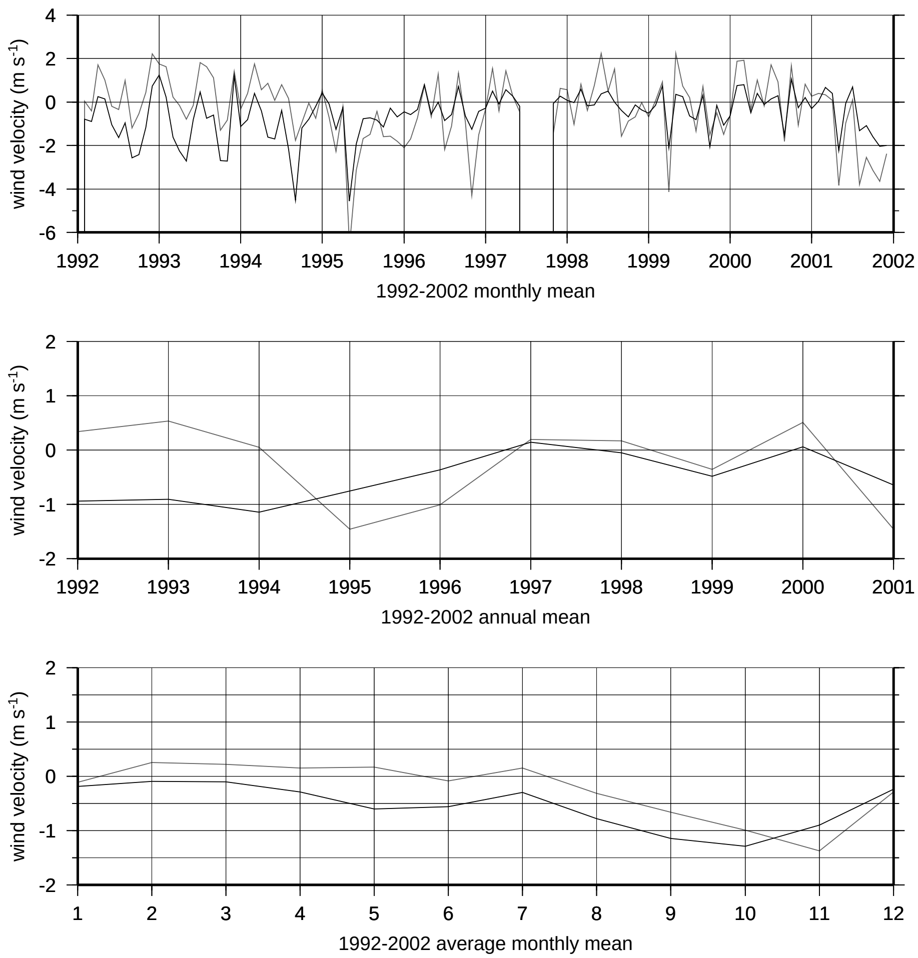


Figure 29: Comparison between the plot of meridonal wind component for Drescher AWS and the interpolated ECMWF-data (grew)

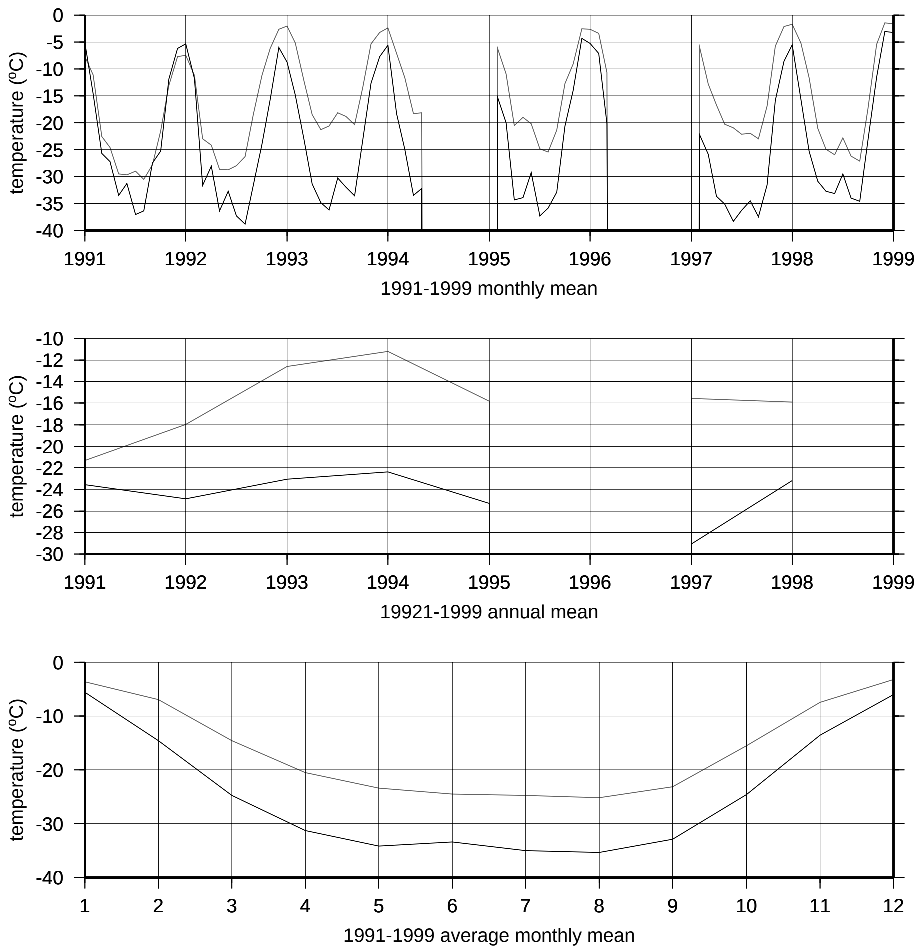


Figure 30: Comparison between the plot of temperature for Filchner AWS and the interpolated ECMWF-data (grew)

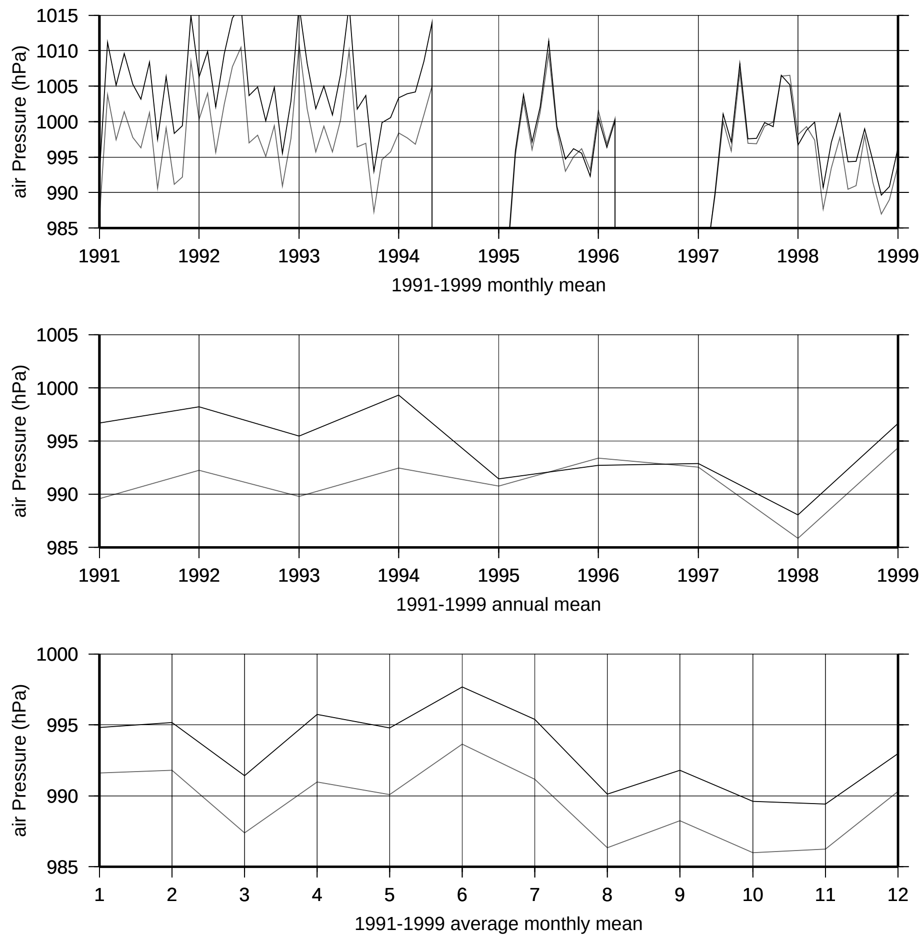


Figure 31: Comparison between the plot of mean sea level pressure for Filchner AWS and the interpolated ECMWF-data (grew)

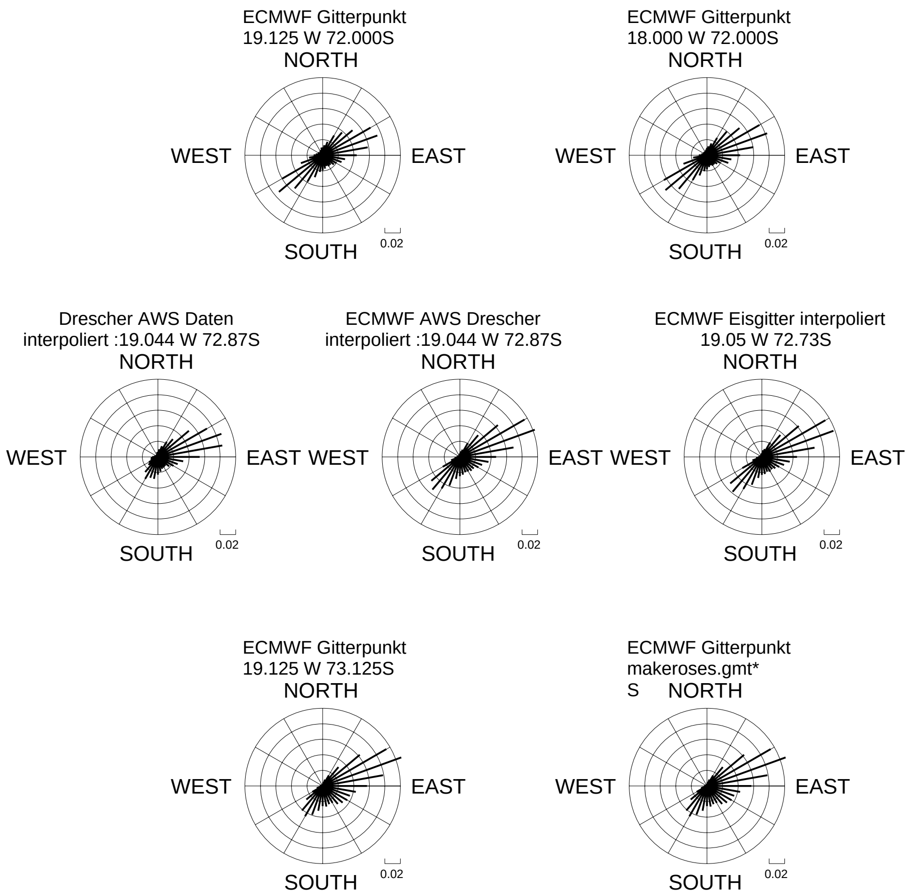


Figure 32: Frequency wind rose for Drescher AWS, the interpolated ECMWF-data for the location of Drescher AWS and the next ice-gird point of the BRIOS2-model and seperatly for the four sourunding ECMWF-grid points

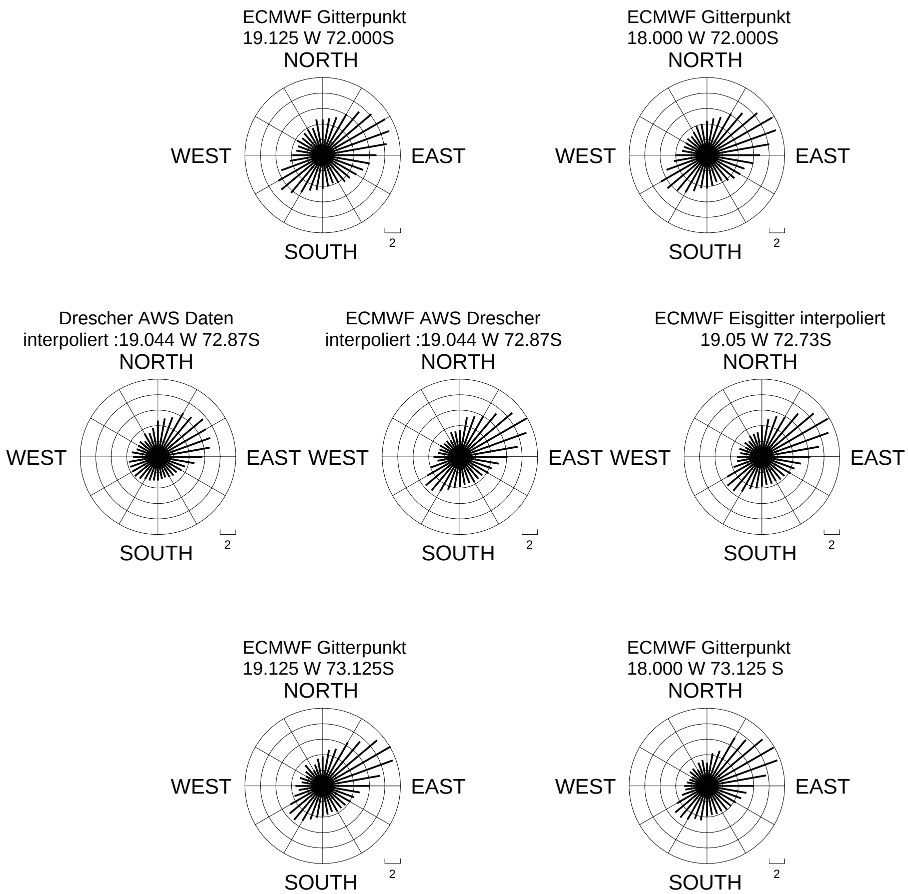


Figure 33: Velocity wind rose for Drescher AWS, the interpolated ECMWF-data for the location of Drescher AWS and the next ice-gird point of the BRIOS2-model and separately for the four surrounding ECMWF-grid points

D Sensor specifications

AWS Filchner 3315

operating time:	Jan 1990 - 22.05.94
location :	77.087S 50.214W Elevation a.s.l. 40m
manufacturer:	Defense Systems Inc., USA, University Hanover, Germany

sensors

Air Pressure Company:	Paroscientific, Inc.
Sensor:	Digiquartz transducer 215
Accuracy	+/- 0.2 hPa
Resolution:	10 bit -> 15 hPa
Range:	900 - 1053.5 hPa
Sensor location:	approx. 3m above ice surface

Air Temperature

Company:	Yellowsprings
Sensor:	44020
Accuracy	+/- 0.2°C
Resolution:	8 bit -> 0.2°C
Range:	-44°C - +6°C
Sensor location:	1. Sensor approx. 5m above ice surface 2. Sensor approx. 3m above ice surface

Wind

Company:	R.M. Young
Sensor:	Wind Monitor-RE
Accuracy	Speed: +/- 0.2 kn Direction: +/- 5°
Resulution:	Speed: 8 bit -> +/- 0.5 kn Direction: 8 bit -> +/- 1.5°
Range:	Speed: 0 - 127.5 m s^-1 Direction: 0 - 360 °
Sensor location:	approx. 5m above ice surface

AWS Filchner 3312	
operating time:	06.02.95 - 30.03.96
location :	77.071S 50.109W Elevation a.s.l. 40m
AWS Filchner 3313	
operating time:	11.02.97 - 30.01.99
location :	77.071S 50.109W Elevation a.s.l. 40m
AWS Drescher 3310	
operating time:	18.01.95 - 24.01.99
location :	72.870S 19.048W Elevation a.s.l. 34m
manufacturer:	Defense Systems Inc., USA, University Hanover, Germany

sensors	
Air Pressure	
Company:	Paroscientific, Inc.
Sensor:	Digiquartz transducer 215A-102
Accuracy	+/- 0.2 hPa
Resolution:	16 bit -> 0.05 hPa
Data Sampling	Interval 10 min
Sensor location:	approx. ice surface
Air Temperature Difference	
Resolution:	12 bit -> 0.125°C
Range:	-100°C - +412°C
Data Sampling	Interval 10 min
Sensor location:	approx. 3m above ice surface
Vertical Difference	
Resolution:	8 bit -> 0.0625°C
Range:	-5.125°C - +10.8125°C
Data Sampling	Interval 10 min
Sensor location:	approx. 3m and 1m above ice surface
Humidity	
Company:	Vaisala
Sensor:	HMP35A
Accuracy	2% rel humidity in the range of 0-90% 3% rel humidity in the range of 90-100%
Resolution:	8 bit -> 0.4%
Range:	0 - 102%
Data Sampling	Interval 20 min
Sensor location:	approx. 3m above ice surface
Wind	
Company:	Belfort
Sensor:	Model 123 aerovane
Accuracy	Speed: +/- 0.2 kn Direction: +/- 5°
Resolution:	Speed: 8 bit -> +/- 0.25 m s^{-}1 Direction: 8 bit -> +/- 1.4 °
Range:	Speed: 0 - 64 m s^{-1} Direction: 0 - 356 °
Sensor location:	approx. 3m above ice surface

AWS Drescher 3317

operating time:	02.02.92 - 05.03.95
location :	72.879S 19.021W Elevation a.s.l. 35m
manufacturer:	Defense Systems Inc., USA
sensors	
Air Pressure	
Company:	Paroscientific, Inc.
Sensor:	Digiquartz transducer 215AT-073
Accuracy	+/- 0.2 hPa
Resolution:	10 bit -> 0.1 hPa
Range:	920 - 1022.3 hPa
Data Sampling:	Cycle: 4 s, Average 12 min Interval 12 min
Sensor location:	approx. 1.5m above ice surface
Air Temperature	
Company:	Yellowsprings
Sensor:	44020
Accuracy	+/- 0.2°C
Resolution:	8 bit -> 0.2°C
Range:	-44°C - +6°C
Data Sampling:	Cycle: 4 s, Average 12 min Interval 12 min
Sensor location:	1. Sensor approx. 5m above ice surface 2. Sensor approx. 3m above ice surface
Wind	
Company:	R.M. Young
Sensor:	Wind Monitor-RE
Accuracy	Speed: +/- 0.2 kn Direction: +/- 5°
Resolution:	Speed: 8 bit -> +/- 0.5 kn Direction: 8 bit -> +/- 1.406°
Range:	Speed: 0 - 127.5 m s^{-1} Direction: 0 - 360 °
Data Sampling:	Cycle: 4 s, Average 12 min Interval 12 min
Sensor location:	approx. 5m above ice surface
Snow Height	
Company:	Campbell Scientific Corp.
Sensor:	Ultrasonic Depth Gauge, UDG 01
Accuracy	+/- 1cm
Resolution:	15 bit -> 0.125cm
Range:	0 - 265cm
Data Sampling:	Cycle: 15 s, Average 12 min Interval 12 min

AWS Drescher 3317

operating time:	24.01.99 -
location :	72.864S 19.065W Elevation a.
s.l. 35m	
manufacturer:	Sellmann & Kruse GbR, Germany

sensors

Air Pressure

Company:	Paroscientific, Inc.
Sensor:	Digiquartz transducer 216B
Accuracy	+/- 0.2 hPa
Resolution:	10 bit -> 0.1 hPa
Range:	920 - 1022.3 hPa
Data Sampling:	Interval 200s
Sensor location:	approx. ice surface

Air Temperature

Company:	R. M. Young
Sensor:	Model 41342 (PTA1000)
Resolution:	10 bit -> 0.1°C
Range:	-50°C - +50°C
Data Sampling:	Interval 200s
Sensor location:	1. Sensor approx. 5m above ice surface
	2. Sensor approx. 2m above ice surface

Humidity

Company:	Vaisala
Sensor:	HMP35A
Accuracy	2% rel humidity in the range of 0-90%
	3% rel humidity in the range of 90-100%
Resolution:	8 bit -> 0.4%
Range:	0 - 102%
Data Sampling	Interval 200s
Sensor location:	approx. 5m above ice surface

Wind

Company:	R.M. Young
Sensor:	Wind Monitor-RE
Resolution:	Speed: 8 bit -> +/- 0.16 m s^{-1}
	Direction: 8 bit -> +/- 1.406°
Range:	Speed: 0 - 40.8 m s^{-1}
	Direction: 0 - 358.33 °
Data Sampling:	Cycle: 4 s, Average 12 min
	Interval 200s
Sensor location:	approx. 5m above ice surface

E References

Connolley, W. M. and H. Cattel, The Antartic climate of the UKMO Unified Model, *Antarctic Sciences*, **6**, 115-122, 1994.

Jones, D. A. and I. Simmonds, A climatology of southern Hemisphere extratropical cyclones, *Climat Dynamics*, **9**, 131-145, 1993.

Kimura, S., K. Abe, K. Tsuboi, B. Tammelin and K. Suzuki, Aerodynamic charachteristics of an iced cup-shaped body, *Cold Regions Sciences and Technology*, **33**, 45-58, 2001.

King, J. C. and J. Turner, Antarctic Meteorology and Climatology, *Cambridge Atmospheric and Space Sciences Series*, Cambridge 1997.

Kottmeier, Ch. and J. Lüdemann, Meeresbojen 1986-1995 / Technische Dokumentation, *Berichte aus dem Fachbereich Physik*, **69**, Alfred Wegener Institut, 1996.

Loon van, H., The half yearly oscillations in middle an high southern latitudes and the coreless winter, *Journal of the Atmospheric Sciences*, **24**, 472-486, 1967.

Parish, T. R., Surface winds over the Antarctic continent: A review, *Review of Geophysics*, **26(1)**, 169-180, 1988.

Parish, T. R. and D. H. Bromwich, Continent-scale simulation of the katabatic wind regime, *Journal of Climate*, **4**, 135-146, 1991.

Stearns, C. R., L.M. Keller, G.A. Weidner and M.Sievers, Monthly mean climatic data for Antarctic weather station, in *Antarctic Meteorology and Climatology: Studies based on Automatic Weather Stations, Antarctic Research Series*, **61**, 1-21, 1993.

Timmermann, R., A. Beckmann and H. H. Hellmer, The role of sea ice in the fresh-water budget of the Weddell Sea, Antarctica, *Annals of Glaciology*, **33**, 419-424, 2001.

Timmermann, R., A. Beckmann and H. H. Hellmer, Simulations of ice-ocean dynamics in the Weddell Sea. 1. Model configuration and validation, *Journal of Geophysical Sciences*, **107, C3**, 10.1029/2000JC000741, 2002.

University of Wisconsin: http://uwamrc.ssec.wisc.edu/gifs/awstower.gif