ANALYSIS OF THE MEAN AND EXTREME TEMPERATURE SERIES OF THE ARCTOWSKI ANTARCTIC BASE

Roberto Rodríguez, Carmen M. Llasat
Department of Astronomy and Meteorology, University of Barcelona

Stanisław Rakusa-Suszczewski
Department of Antarctic Biology, Polish Academy of Science, Warszawa

1. Introduction

The evolution of meteorological variables in the Antarctic is of special interest not only in explaining changes in glacial morphology but also in the climatic dynamics of the planet.

In this study, carried out within the framework of the ANT93E1312 project, the temperature series and mean, maximum and minimum temperatures, plus a parameter of special interest - the thermal interval (DTR) - have been analyzed for the Arctowski base. The Arctowski base is situated at an altitude of 2 metres on King George Island, facing Almirante Bay (62°10'S and 58°28'W). Features which differentiate it from other stations are its low altitude and its situation in a zone of forced ascents and Föhn phenomena, reducing relative humidity and increasing temperature (Bañon, 1991).

Table 1 presents the series analyzed, their characteristics and the cadence of the data. As can be observed, the series have been calculated on the basis of monthly means of the daily data. The DTR series was calculated on the basis of the difference between the mean monthly values of maximum and minimum temperature.

Table 1

Meteorological series analyzed
Cechy i rodzaje analizowanych serii Meteorologicznych

Series	Features	Values	Range	Data
Mean temperature	mean	monthly	1978-1992	daily
Maximum temperature	mean	monthly	1978-1991	daily
Minimum temperature	mean	monthly	1978-1991	daily
Diurnal temperature range	mean	monthly	1978-1989	calculated

2. Results and discussion

2.1. Continuity and homogeneity

The temperature data present two discontinuities in February and March 1990.

For the temperature series, extrapolation of data for neighbouring series was used, in this case from the Eduardo Frei base, using the criterion of Karl and Williams (1987) for resolution of discontinuities.

Given the shortness of the series, variance analysis was rejected for homogeneity analysis, and the analysis was carried out instead on the basis of the seasonal nature of its standard deviation with respect to time.

The series therefore present discontinuity and homogeneity.

2.2. Statistical description

2.2.1. Statistical parameters

A first step in analysis of the meteorological records is a statistical description thereof.

Noteworthy here is the high value of the variance (σ^2) and thus of the standard deviation (SD) in all the temperature series. This fact obliges us to consider as qualitative any numerical conclusion drawn from them. Also noteworthy is the high skewness and kurtosis values in the DTR series, which indicates that their distribution is markedly biased to the right and pointed.

The extreme values of the series, together with their temporal location are to be found in Table 2. This table shows 1982 as the year with extreme maximum temperature readings, while 1987 presented the minimum readings.

The minimum values obtained corroborate the rightward skew of the temperature distribution, given that their final values in both show a deviation from the mean value markedly higher than that recorded for the corresponding maximum values.

Table 2

Extreme values of the meteorological series
Zakres zmienności badanych serii meteorologicznych

Series	Unit.	Max.	Month	Year	Min.	Month	Year/s
Mean temperature	°C	3,7	January	1982	-13,2	July	1987
Maximum temperature	°C	1,6	January	1982	-17,8	July	1987
Minimum temperature	°C	9,5	March	1982	-7,9	July	1987
DTR	°C	10,6	July	1986	1,1	December	1989

2.2.2. Standard year

The term standard year is used to define the annual distribution of the monthly means of the series (Fig. 1). The definition of the standard year provides the order of magnitude of the monthly values of the variable studied. For this standard year, the mean temperature shows positive values in January, February, March, November and December, moving something of the order of 8°C. The minimum temperature mean shows positive values for the months of January and February, with a movement (11°C) greater than that of mean temperature. The maximum temperature shows positive values for 7 months - January, February, March, April, October, November and December with movement of 7°C. Finally, for the three foregoing distributions, July is the coldest month and January the warmest.

In consequence, given its definition, the standard year for the DTR presents the maximum and the minimum in the same months but in the reverse order: July is the month with a minimum in the annual DTR and January the month with the maximum. Its movement is 3°C.

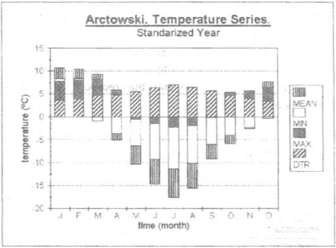

Fig 1. Standard year for the mean, minimum and maximum temperature and DTR series
Zmienność średnich miesięcznych, minimalnej i maksymalnej oraz amplitudy dobowej temperatury powietrza w roku standardowym

2.2.3. Lineal correlation

The correlation between the various series allows us to make an initial approximation to the interdependencies between them. Table 3 shows their respective coefficients of correlation.

It is important to note the high correlation which exists between the minimum and mean temperature series (r = 0.98), very high for this type of series (Jones, 1990), a fact notable, too, in other series from other Antarctic bases, such as those for the Chilean Navy base on Arturo Prat (Rodríguez and Llasat, 1994). This indicates a greater dependency of the mean temperaure compared with the minimum temperature, of more homogeneous distribution with respect to the more dispersed maximum. The lowest correlation index, on the other hand, is presented by the minimum and maximum series, with r = 0.93. It may therefore be stated that while mean and minimum temperatures are in accordance with regional characteristics, maximum temperature is affected by the local features of each station.

Table 3

Pearson correlation coefficient of the temperature series
Wartości współczynników korelacji Pearsona dla ciągów temperatur minimalnych i maksymalnych

X-series	Y-series	r (Pearson)
Minimum	Mean	0,98
Maximum	Mean	0,96
Minimum	Maximum	0,93

2.3. Temporal analysis

2.3.1. Moving average

The first technique used in temporal analysis is the moving average. This consists in successive calculation of the arithmetic mean on moving temporary windows of constant length. Given the length of the series analysed, five-year windows were used, with a cadence of one month.

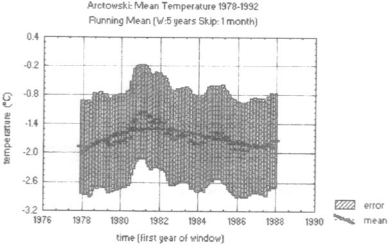

Fig. 2. Moving average of the mean temperature.
Średnia miesięczna temperatura powietrza na Stacji Srctowskiego.
Średnie ruchome 5-letnie

Figure 2 shows the moving average for the mean temperature series. It reveals the existence of a particularly high temperature interval for the 1981-1985 and 1982-86 windows, attaining mean values exceeding -1.3°C, with an increase of 0.6°C over the average level of the previous windows. The moving average decreases from the 1982-1986 window, with a slight recovery of same centred on the 1985-1989 window, at -1.6°C, to end up fluctuating on -1.8°C, which corresponds to the mean value for the entire series. This evolution is parallel to that of other South Shetlands bases (Rodríguez, 1995), (Fig.3), so that, extrapolating in time, a rising trend of the moving average of the same order of magnitude - 0.04°C/year - may be assumed.

The minimum temperature series (Fig. 4) shows a temporal evolution of the mean almost identical to that of the foregoing series. The intervals of ascent and decrease are the same, reaching values exceeding -3.6°C in the first interval (1981-1985), with an increase of 1.0°C over the previous interval, while the second shows a decrease of -6°C. The final values are around -4.4°C.

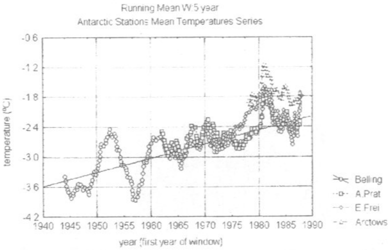

Fig. 3. Moving average of the mean temperature of the Arctowski, E. Frei, A. Prat and Belligshausen series.

Średnia miesięczna temperatura powietrza na stacjach Arctowski, E.Frei, A.Prat i Bellingshausen. Średnie ruchome 5-letnie

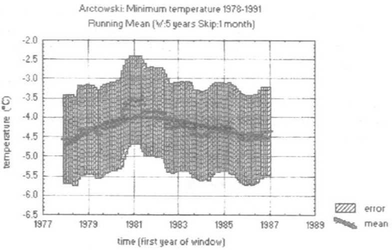

Fig. 4. Moving average of the minimum temperature.
Średnie ruchome 5-letnie minimalnej temperatury powietrza na Stacji Arctowskiego

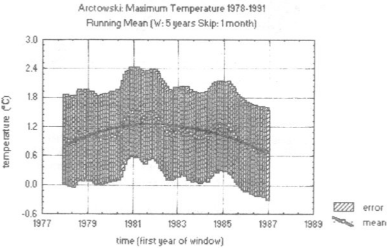

Fig. 5. Moving average of the maximum temperature.
Średnie ruchome 5-letnie maksymalnej temperatury powietrza na Stacji Arctowskiego

The maximum temperature in the 1981-1985 window shows values of 1.5°C. The decrease in the moving average from that window on is notable, reaching the minimum value of 0.6°C by the end of the series (1987 - 1991), (Fig. 5).

The evolution of the moving average for the thermal interval, DTR, shows a clear decrease in the extreme intervals, with movement of -0.3°C. The interval from the 1982-1986 window up to 1985-1989 shows a practically constant evolution, on 5.4°C (Fig. 6).

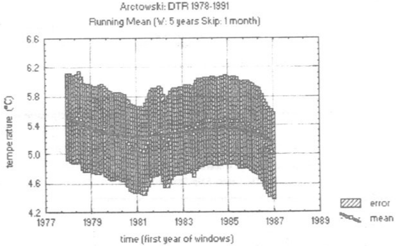

Fig. 6. Moving average of the DTR.
Średnie ruchome 5-letnie dobowej zmienności temperatury (DTR)

2.3.2. Temporal evolution of the trend

The trend is defined as the rate of variation of the magnitude studied with respect to time, that is, the gradient of the regression line. The magnitude is clearly no more than an estimate, being larger the shorter the length of the signal to be analyzed, since the specific weight of a new record is high in percentage terms and, therefore, the degree of destabilization of the trend is also high. Hence the interest of observing the trend, not only over the entire window to be studied, but also in terms of its temporal evolution from the start of same, in function of the accumulated trend (Rodríguez and Llasat, 1994), taking account of evaluation of its typical error

$$\frac{\Delta T}{\Delta t}(\tau) = \frac{\sigma_{xt}(\tau)}{\sigma_x^2(\tau)} \qquad \tau = 1,2,....N$$

where $\sigma_{xt}(\tau)$ is the covariance of the variable with respect to time and $\sigma_x(\tau)$ the standard deviation of the series, calculated on windows of increasing length L=1,τ. The temporal increase is of 1 year, both annually and seasonally. The general method is to implement the analysis on the basis of stabilization of the variance of said evolution, the interval of equilibrium. Nevertheless, in view of the length of the series, it is implemented from the 1978-1987 regression.

In general terms, the trends obtained are spectacularly high, with values exceeding 0.10°C/year, which, were they to be maintained, would result in 10°C/century. This fact results from the scant length of the series, which leads to a high variance, a weak correlation and therefore a typically high error. Winter is the season which presents the highest typical error in all the series, while the summer is the season with the lowest value. We might note, too, although they lie outside the interval of equilibrium, the maximums recorded in the winter series of mean and maximum temperature between 1978 and 1985.

The evolution of the mean annual temperature trend fluctuates around 0.00°C/year from 1987, without presenting any clear permanence of positive or negative values. The fall presents a clear permanence of negative values, fluctuating on the value 0.15±0.07°C/year (Fig. 7). The evolution of the trend for winter and spring, on the other hand, presents a permanence of positive values, though not in such a clear manner, the mean values being 0.10±0.15°C/year and 0.07 ± 0.05°C/year, respectively. Summer is the season which shows the lowest variance in the evolution of its trend, which is slightly negative, with a mean value of 0.02±0.02°C/year.

The evolution of the trend of annual minimum temperature shows fluctuation around the value of 0.00°C/year, with a typical error of ± 0.06°C.

Like the mean temperature, it shows clearly negative values for the fall (-0.15 ± 0.05°C/year) and positive for the winter and spring, although, as stated above, the former presents high variance and high typical error, which detracts from its quantitative character. The mean values are, respectively, 0.15 ± 0.20°C/year and 0.10 ± 0.07°C/year (Fig. 8). The summer shows a mean trend of 0.02 ± 0.02°C/year.

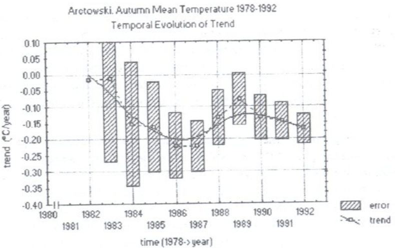

Fig. 7. Temporal evolution of the trend of the annual mean temperature series
Zmienność czasowa trendu średniej rocznej temperatury powietrza

Although it has a mean value of 0.00 ± 0.07°C/year, the maximum temperature trend shows a clearly decreasing evolution. The fall also shows negative values, at -0.15 ± 0.07°C/year. Winter has a high typical error band of ± 0.15°C/year and a positive mean value of 0.15°C/year. As in the previous series, the spring retains its positive character, at 0.07 ± 0.05°C/year, while the summer shows clearly negative values, at -0.05 ± 0.05°C/year (Fig. 9).

In both the annual and the seasonal series the evolution of the stable interval of the DTR trend is clearly decreasing, with negative final values in all cases equal to or lower than -0.05 ± 0.03°C/year. The values reached in summer are noteworthy, with the trend being significantly lower than in the other seasons, reaching a final value of -0.09 ± 0.03°C/year (Fig. 10), thus corroborating the trend observed by Karl et al. (1993) at hemispheric level.

Table 4

Qualitative estimate of the seasonal trends

Ocena jakościowa sezonowych trendów temperatury powietrza

Series/season	Fall	Winter	Spring	Summer	Yearly
Mean	-	+	+	-	+
Minimum	-	+	+	-	+
Maximum	-	+	+	-	-
DTR	-	-	-	-	-

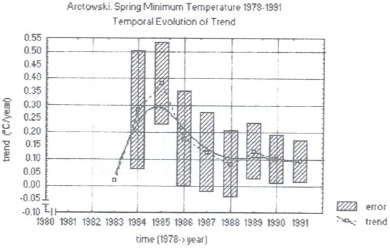

Fig. 8. Temporal evolution of the trend of the spring minimum temperature seasonal series

Zmienność czasowa trendu wiosennych minimalnych temperatur powietrza

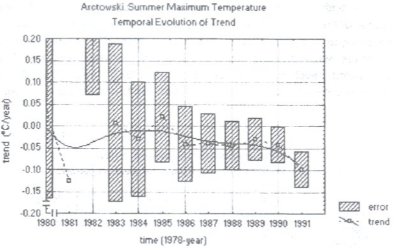

Fig. 9. Temporal evolution of the trend of the summer maximum temperature seasonal series.

Zmienność czasowa trendu letnich maksymalnych temperatur powietrza

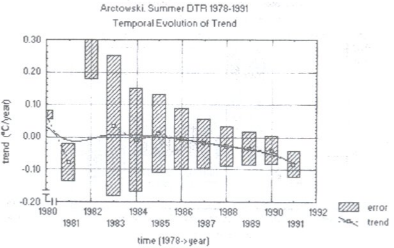

Fig. 10. Temporal evolution of the trend of the summer DTR seasonal series.

Zmienność czasowa trendu dobowych amplitud temperatury powietrza (DTR) w okresie lata

2.3.4. Thermal anomalies

In order to be able to assess the temporal evolution of a meteorological variable, the records must be capable of providing for interpretation of the disturbing effect of the natural annual distribution of same. In order to mitigate said effects, standardized or typified variables are used in accordance with the following expression:

$$z(y)_m = \frac{x_m(y) - x_m}{\sigma_m}$$

where m is the month of the record, y is the year, $z(y)_m$ is the typified datum, x(y), x_m the arithmetic mean of the corresponding month and σ_m its standard deviation.

The positive values of the typified variable are called positive anomalies, while the negative are called negative anomalies. We show these on a scalar map on annual-monthly axes, thus providing the temporal distribution of thermal anomalies.

In general, the distribution of thermal anomalies in the mean, minimum and maximum temperature series shows positive and negative intervals extending over all the months of year, so that certain intervals can be characterized as entirely positive or negative.

Regarding the thermal anomalies of the mean temperature series (Fig. 11), notable for its intensity of $z > 1.5$ is the two-year period 1988-89, anomalously positive, and recorded also at other South Shetlands stations (Rodríguez, 1995) and in practically the entire Antarctic continent (Jacobs & Comiso, 1993; Jones, 1995). The 1978-79 interval is also of note in showing positive anomalies over all months of the year, of the order of z ¸ 1.0. The 1982-83 and 1983-84 intervals show positive anomalies of the same order of magnitude, extending over the first and second semesters, respectively.

The negative anomalies, in their turn, show themselves in three intervals of practically annual length and of similar intensity, occasionally reaching values exceeding $z > -3.0$. These are 1980-81, 1986-87 and 1990-91.

The distribution of anomalies in the minimum temperature series (Fig. 12) is very similar to that of mean temperature. It shows practically the same anomalous intervals and of the same positive-negative sign, while we might note the reduction in the length of the positive anomaly in the 1986-87 interval, where it is confined to the second and third quarters.

As opposed to neighbouring stations, the maximum temperature also shows a distribution of anomalies coinciding with the previous ones (Fig. 13). It nevertheless shows a high intensity in all the positive anomalous in- tervals, with values of z > 1.5. The first quarter of 1982 is of note, with values exceeding z > 2.0.

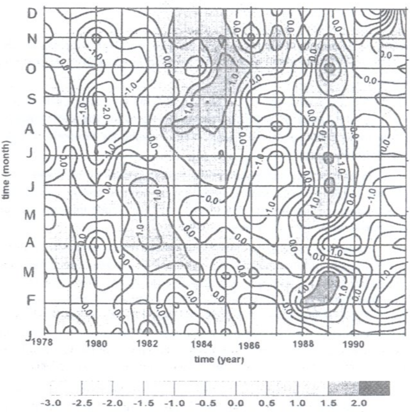

Fig. 11. Thermal anomalies of the mean temperature series.
Anomalie średniej miesięcznej temperatury powietrza na Stacji Arctowskiego

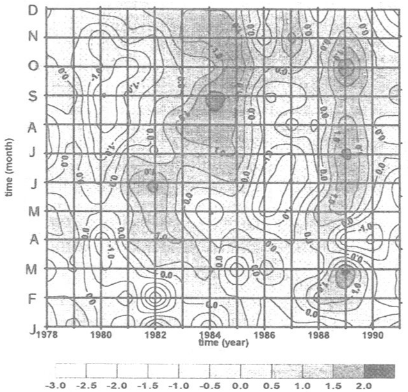

Fig. 12. Thermal anomalies of the minimum temperature series.
Anomalie średniej miesięcznej minimalnej temperatury powietrza na Stacji Arctowskiego

In comparison with the series for A. Prat and E. Frei, the interval 1988-1989 is notable in the distribution of DTR anomalies in that, while these other stations present a concentration of negative anomalies (Rodríguez, 1995), Arctowski has an interval without any marked positive or negative concentration. This fact is due to the parallel behaviour of the anomalies in the series of maximums and minimums remarked upon above. Both present positive anomalies in this interval, and the thermal interval therefore remains practically constant.

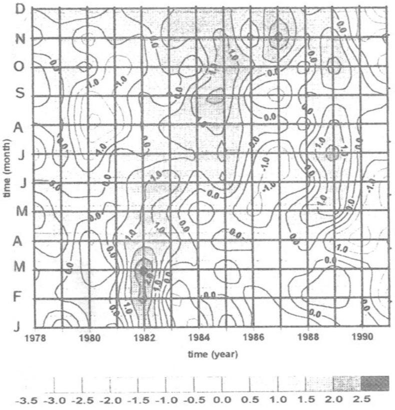

Fig. 13. Arctowski. Thermal anomalies of the maximum temperature series.
Anomalie średniej miesięcznej maksymalnej temperatury powietrza na Stacji Arctowskiego

The first quarter of 1982 and from April to December of the 1986-1987 interval are notable for being positively anomalous. In respect of negative anomalies, the second quarter of the 1983-84 interval is of special significance. At the end of the series, from 1988 there is a zone dominated by negative anomalies, though without any marked concentration.

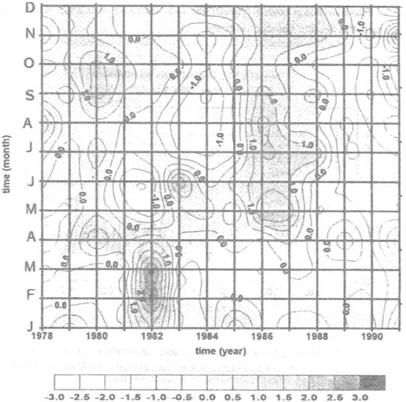

Fig. 14. Arctowski. Thermal anomalies of the DTR.
Anomalie średniej miesięcznej dobowej amplitudy powietrza na Stacji Arctowskiego

2.4. Spectral analysis

The application of this type of analysis to short series has little relevance, all the more so where the aim is to obtain information concerning possible periodicities in zones of low frequencies. Nevertheless, given the high correlation between the Bellingshausen (British Antarctic Survey) and Arctowski series (r = 0.98), a study was made of the extrapolated mean temperature series 1944-1992. The results of this extrapolation show discordance with the mean temperatures in the 1948-1960 interval obtained by Martianov & Rakusa-Suszczewski (1990) for this series (T = 0.3°C). From 1960, however, the results coincide entirely.

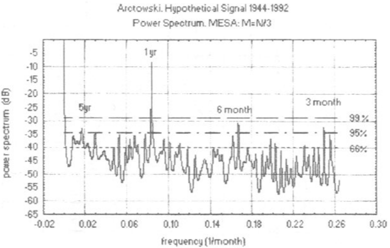

Fig. 15. Power spectrum of the extrapolated 1944-1990 Arctowski series.
Gęstość widmowa średniej miesięcznej temperatury powietrza na Stacji Arctowskiego ekstrapolowanej na okres 1944-1990

The power spectrum (Fig. 15) was calculated using the maximum entropy method, MESA, with an error protection filter M = N/3, which is the one which provides a better spectral resolution-variance ratio (Rodríguez, 1992) with a high frequential resolution, 16 times its natural resolution. In the zones of high frequencies it can be observed that, above the normal level of confidence of 95%, notable quarterly, semestral and annual maximums can be observed, explained by the trivial periodicities. In the zone of low frequencies, above the aforesaid level of confidence, we can note the maximum corresponding to a five-year periodicity which exceeds the biennial period in intensity, which, taking account of the evolution of the thermal anomalies in intervals of opposite signs and of biennial and triennial length, is corroborated.

3. Conclusions

The Arctowski temperature series, although they can be evaluated individually, cannot be considered in themselves, but must be viewed rather in the context of the meteorological series of the South Shetlands Antarctic bases since, like other regionizable series of short length, they represent a time differential within their own temporal function.

The regionability of mean and minimum temperatures can be observed, with correlation coefficients exceeding 0.95 alongside other neighbouring series, while the maximum temperature is a function of the local characteristic of each station.

The correlation between the different series reveals a clear interdependence between the mean, minimum and maximum temperatures, with the correlation between the mean and minimum temperatures being highest.

Bi-annual mean length intervals of thermal anomalies, whether positive or negative, follow each other, particularly significant being the positive thermal anomaly located in 1989 in the mean and minimum temperature series, in accordance with observations from other Antarctic bases.

For all the temperature series, the winter is the season which shows the greatest thermal variation, increasing with time and of the order of 0.1°C/year. The fall is, on the other hand, the season which shows the largest decrease, of the order of 0.1°C/year. Spring shows a rising trend and summer a falling trend in all the temperature series, although with noticeably more moderate rates. There is a trend towards reduction of the annual thermal variation.

The trend of the minimum temperature is towards an increase, while that of the maximum temperature is towards a slight decrease, which has an effect on reduction of the DTR over time.

The thermal interval, DTR, shows a mean value of 4.9°C, reaching its extreme values in winter. Towards the end of the series, there is a clear reduction of mean values for all stations, with a trend of around -0.05°C/year at all, except in summer, which shows a noticeably higher value in terms of absolute value, at -0.09°C/year.

In the extrapolation of the Arctowski series compared with the Bellingshausen series, a spectral maximum corresponding to a period of 5 years can be observed.

References

Bańón M., 1991. El clima en las Shetland del Sur, el Norte de la Península Artártica.

Caso de la B. A. E. Juan Carlos I. Actas del IV simposio español de estudios antárticos. 25-34.

Jacobs S.S., Comiso J.C., 1993. A Recent Sea-Ice retreat west of Antarctic Peninsula, Geophys. Res. Letters, **20**, N12, 1171-1174.

Jones P.D., 1990. Antarctic Temperatures over the Present Century. A Study of the Early Expedition Record. Am. Met. Soc. 1193-1203.

Jones P.D., 1995. Recent Trends in Maximum and Minimum Temperature in the Antarctic. Geoph. Res. Letters (in rev.)

Karl T.R., Jones P.D., Knight R.W., Kukla G., Plummer N., Razuvayev V., Gallo K.P., Lindseay J., Charlson R.J., Peterson T.C., 1993. Asym-m etric Trends of Daily Maximum and Minimum Temperature. Bull. Am. Meteor. Soc. **74**, 1007-1023.

Karl T.R., Williams C.N., 1987. An Approach to adjusting climatological time series for discontinuous inhomogeneities. J. Climate Appl. Meteor., **26**, 1744-1763.

Rodríguez R., 1992. Análisis Armónico de Series Meteorológicas. First-Deree thesis. University of Barcelona. 130 pp.

Rodríguez R., Llasat M.C., 1994. Análisis de las Series de Temperatura de la Base Arturo Prat. Actas del V simposio español de estudios antárticos (in press).

Rodríguez R., 1995. Análisis de Series Meteorológicas: Evaluación del Cambio Climático. Doctoral Thesis. University of Barcelona. 273 pp.

Martianov V., Rakusa-Suszczewski S., 1990. Ten years of climate observations at the Arctowski and Bellingshausen stations (King George Is., South Shetland, Antarctic). In: Global change regional research centres. Seminar papers and IGBP WG 2 report, Ed. Breymeyer Inst. Geogr. Spatial Org. PAS, 80-87.

Acknowledgements

We would like to thank the Fundacja im. Henryka Arctowskiego Warszawa for the welcome they accorded us and the facilities they made available to carry out this study. We are also grateful to the Dynamic Geology team of the University of Barcelona, and especially to Dr. Francesc Sabat, Dr. Jaume Cabret and Dr. Jordi Corbera, for their scientific assistance. We also thank Rosa Mary Lanceta for her help in digitalizing over 14,000 pieces of data from the Arctowski base. Thanks, too, to Thomas J. Molloy for the translation of this paper.

ANALIZA ŚREDNICH I EKSTREMALNYCH WARTOŚCI TEMPERATURY POWIETRZA NA STACJI ARCTOWSKIEGO

Streszczenie

W ramach programu ANT93E1312 dokonano analizy zmienności temperatury powietrza mierzonej na Stacji Arctowskiego. Na podstawie wielkości średnich dobowych obliczono: średnie temperatury miesięczne dla lat 1978-92, średnie miesięczne maksima i minima dla lat 1978-91 oraz średnie miesięczne wielkości dobowej zmienności temperatury powietrza (DTR, różnica między średnią miesięczną wielkością maksimum i minimum temperatury powietrza).

Obliczone średnie miesięczne zawierają się w przedziale od 3.7°C (styczeń 1982) do -13.2°C (lipiec 1987). Lata 1982 i 1987 były tymi, w których obserwowano ekstremalne wartości również w odniesieniu do wartości średnich maksymalnych i minimalnych (tab.2).

W standardowym roku, dodatnie wartości średniej miesięcznej temperatury powietrza wystąpiły w 5 miesiącach: styczniu, lutym, marcu, listopadzie i grudniu (ryc. 1). W tych miesiącach średnie dobowe mogą sporadycznie przekraczać 8°C. Średnie miesięczne minimalne temperatury powietrza, dodatnie wartości wykazują w styczniu i lutym i mogą być wtedy nawet o 11 deg wyższe od średniej. Średnie miesięczne maksima dodatnie są aż w 7 miesiącach: styczniu, lutym, marcu, kwietniu, październiku, listopadzie i grudniu. Na podstawie przeanalizowanych danych można stwierdzić, że na Stacji Arctowskiego lipiec jest miesiącem najzimniejszym, a styczeń najcieplejszym.

Pomiędzy temperaturami średnimi i ekstremalnymi istnieje bardzo duża zależność (tab. 3). Wartości współczynnika korelacji (Pearsona) r mieszczą się w przedziale od 0.93 do 0.98.

Zmiany analizowanych wielkości w czasie przedstawiono za pomocą średnich ruchomych 5-letnich. Charakter zmienności przedstawiają ryc. 2-6. Na wszystkich rycinach wyraźnie widoczne są wyższe wartości średnich miesięcznych w początkowym okresie obserwacji (1981-1985) niż w okresie późniejszym. Średnia wielkość trendu wynosi 0.1°C/rok. Linie trendu dla roku i wybranych pór (wiosna, lato) przedstawiono na ryc. 7-10. Jesienią i latem - trendy wszystkich 4 badanych serii temperatur są ujemne (tab. 4), a zimą i wiosną - dodatnie. Jesienią wielkość trendu wynosi -0.15±0.07°C/rok, zimą +0.10±0.15°C/rok, wiosną +0.07±0.05°C/rok, latem zaś oscylują koło 0°C/rok.

Innym sposobem oceny zmienności danego parametru w czasie może być określenie wielkości odchyleń od średniej. Rozkład anomalii temperatury średniej miesięcznej i wielkości ekstremalnych oraz DTR, w okresie 1978-1991 przdstawiają ryc. 11-14. Wśród wielkości średnich, dodatnie anomalie (>1.5 deg) stwierdzono we wszystkich miesiącach 1978 i 1979 roku, a w latach 1982-83 i 1983-84 - w miesiącach drugiej połowy roku. Wyraźnie ujemne anomalie średnich miesięcznych temperatur powietrza wystąpiły w okresach: 1980-81, 1986-87 i 1990-91 (> -3.0 deg).

Rozkład anomalii temperatur minimalnych jest bardzo podobny do rozkładu anomalii temperatur średnich (ryc. 11 i 12). Śledząc odchylenia maksymalnej temperatury powietrza (ryc. 13) zwraca uwagę bardzo duża (>2.0 deg) dodatnia anomalia występująca na początku 1982 roku (luty-marzec). W tym samym okresie zaznacza się również najwyższa dodatnia anomalia DTR (ryc. 14).

Ze względu na niewielką długość serii obserwacyjnych ze Stacji Arctowskiego oceny zmienności temperatury powietrza mierzonej na tej stacji lepiej dokonać na tle innych stacji położonych na Szetlandach Południowych. Ponieważ seria ze Stacji Arctowskiego wykazuje bardzo dużą korelację z ciągiem Deception-Bellingshausen (1944-90, British Antarctic Survey) - r=0.98 - to w celu wyznaczenia okresowości zmian, ciąg Stacji Arctowskiego, ekstrapolowany do okresu 1944-92, poddano analizie widmowej. Analiza spektralna takiej serii średniej miesięcznej temperatury powietrza (ryc. 15) wykazuje występowanie wyraźnej cykliczności 5-letniej. Nieco słabiej zaznacza się periodyczność 2- i 3-letnia. Okresowości jednoroczne, półroczne i kwartalne nie mają większego znaczenia.