5. THE ATMOSPHERIC PRESSURE

5.1. The annual course

Measurements of atmospheric pressure at Hornsund were started in July 1978. Pressure was measured every 3 hours with a mercury barometer placed at a height of 11 m a.s.l. In the study pressure values reduced to the sea level are used solely. Missing monthly means from January to June 1978 were completed by correlation with data from the Norwegian station Svalbard-Lufthavn in Longyearbyen and interpolated values from a set of re-analyzes NCEP/NCAR (NOAA 2007). For the period from July 1981 to July 1982 only mean daily data calculated by Mieczysław Sobik (University of Wrocław) from barograms were accessible: from comparison with the sources of data mentioned above it appears that these results are overestimated, therefore for monthly means from this period a correction of 1.6 hPa was used. Also, in the period between September 1984 and July 1989 it was found that barometer was reading 1.7 hPa too low, probably because of mercury loss. For this period a correction +1.7 hPa was thus used, set in July 1989 from comparison with a new barometer installed at the station. Mean monthly pressure values were also compared with data from the Norwegian stations, Björnöya, Svalbard Lufthavn and Ny Alesund.

Mean annual atmospheric pressure at Hornsund in 1978–2009 was 1009.2 hPa, with a standard deviation (σ_n) of ±2.1 hPa. In particular years these values varied from 1013.3 hPa in 1985 to 1004.9 hPa in 1989 (Fig. 5.1). The sequence of mean annual atmospheric pressures at Hornsund displays a weak negative trend. It amounts 0.041 hPa·yr^{-1} and is statistically not significant.

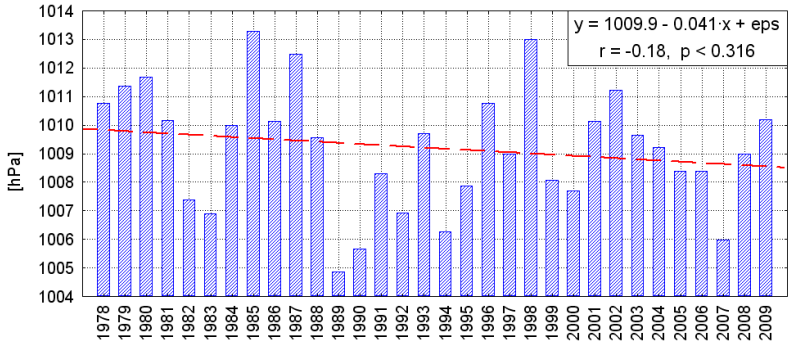

Fig. 5.1. Annual atmospheric pressure [hPa] reduced to the sea level at Hornsund in 1978–2009.

Over the course of the average year atmospheric pressure at Hornsund changes from 1002.8 hPa in January to 1016.3 hPa in May. Mean monthly values higher than the annual mean are noted from April to August (Fig. 5.2). The lowest mean monthly pressure of 986.6 hPa occurred in January 1993. At this time Spitsbergen was under the influence of a deep and vast low above

Björnöya. A similar situation occurred in January 2000 (see Fig. 4.4). The highest monthly mean of 1022.9 hPa occurred in April 1979 (see Fig. 4.11) when Spitsbergen was under the influence of the Greenland High.

Mean monthly pressure in December is characterized by the greatest changeability. This is proven by the highest standard deviation (σ_n) ±8.0 hPa (Fig. 5.2). In this month pressure was changing from 987.3 hPa in 2004 to 1017.2 hPa in 2009. The following months of the winter season are characterized by only slightly less changeability. The standard deviation σ_n was 7.3 hPa in January, 7.6 hPa in February and 7.1 hPa in March. Great variability of atmospheric pressure is connected with the differentiation of periods of occurrence of the longer lasting cyclonic situations in which systems of low pressure may be very deep. They are divided by wedges of the Greenland High. As a result mean monthly atmospheric pressure is low in these months. In the face of the fact that in consecutive years periods of highest pressure as well as intense escalation of winter cyclonic circulation may occur in different months, variability of mean monthly atmospheric pressure in winter is very great. More on this in Chapter 4.

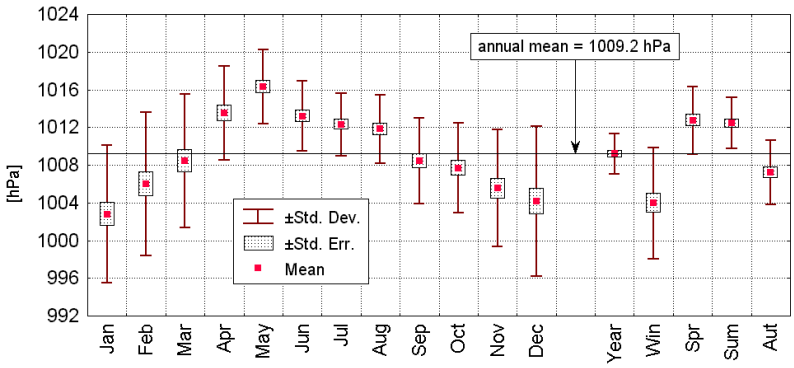

Fig. 5.2. Range of variability of mean monthly atmospheric pressure reduced to the sea level at Hornsund in 1978–2009. Win – winter (DJF), Spr – Spring (MAM), Sum – summer (JJA), Aut – autumn (SON)

The most stable mean monthly atmospheric pressure occurs in July when the standard deviation is only ±3.3 hPa. The multiannual mean is 1012.3 hPa pressure in this month, ranging from 1006.2 hPa in July 1995 to 1018.7 hPa in July 1993. Also the two other summer months, June and August, were characterized by comparatively little variability (σ_n = 3.7 hPa and 3.6 hPa, respectively). At this time the pressure field in the Spitsbergen region is often blurred, anticyclones are not so strong and are characterized by considerable stability. Further, in the face of diminished zonal contrasts between ground and troposphere temperatures cyclonal activity is moderate or weak. Low-pressure systems are relatively shallow and high-pressure wedges dividing them are broader than in winter. As a result the summer months are the most homogenous in mean monthly pressure.

At the nearby Svalbard Lufthavn station the annual course of atmospheric pressure is similar (Table 5.1). Differences in multiannual mean monthly pressures are never more than ±0.9 hPa. From October atmospheric pressure at Hornsund is lower than at the airport in Longyearbyen, and in summer slightly higher (for 0.6 hPa in July). The only greater difference (3.2 hPa) was in 2000.

In that year from April to November mean monthly pressure at Hornsund was for over 3 hPa higher than at Svalbard Lufthavn; the greatest difference (4.6 hPa) occurred in July. Mean annual pressure at Hornsund was only 0.3 hPa lower than at Longyearbyen. Atmospheric pressure at Ny Alesund was very close to the values recorded at Svalbard Lufthavn as well. In contrast Björnöya, situated on the route of Atlantic lows, has lower atmospheric pressures (Table 5.1). Difference in mean annual pressure in comparison with Hornsund amounted to 1.4 hPa. The big differences were from October to May, with the highest in February (2.3 hPa). In the summer months differences in pressure were insignificant.

Table 5.1. Comparison of the mean monthly and annual pressure at Hornsund and other stations in Svalbard in 1978-2009.

Month	Station *				Pressure difference:	
	Ny Alesund	Svalbard Lufthavn	Hornsund	Björnöya	Hornsund – Björnöya	Hornsund – Sval.-Luft.
January	1003.3	1003.6	1002.8	1000.7	2.1	–0.8
February	1006.5	1006.9	1006.0	1003.7	2.3	–0.9
March	1008.9	1009.3	1008.4	1006.2	2.2	–0.8
April	1013.9	1014.0	1013.5	1011.7	1.8	–0.6
May	1016.4	1016.4	1016.3	1015.2	1.2	–0.1
June	1013.0	1012.9	1013.2	1012.9	0.3	+0.3
July	1011.8	1011.7	1012.3	1012.3	0.0	+0.6
August	1011.6	1011.5	1011.8	1011.6	0.2	+0.3
September	1008.6	1008.5	1008.5	1007.5	0.9	–0.1
October	1008.5	1008.3	1007.7	1005.8	1.9	–0.6
November	1006.1	1006.2	1005.5	1003.9	1.7	–0.6
December	1004.7	1004.9	1004.2	1002.0	2.1	–0.7
Year	1009.4	1009.5	1009.2	1007.8	1.4	–0.3
Annual Range	13.1	12.8	13.5	14.5	–0.9	+0.8

* – data from the Norwegian Meteorological Institute

The multiannual (long-term) behaviour of atmospheric pressure at these stations is very similar so the Hornsund station represents changes of this parameter in Spitsbergen very well (Fig. 5.3). In 1978–2009 three distinct maxima of atmospheric pressure may be distinguished, occurring in 1979–1980, 1985-1987 and in 1998. In the latter year mean pressure at the Svalbard Lufthavn station reached 1013.7 hPa. Minima in mean annual pressure occurred in 1983 (Björnöya 1004.7 hPa, Hornsund 1006.9 hPa), 1989–1990 (Björnöya 1004.1 hPa, Hornsund 1004.9 hPa) and lately in 2007 (Björnöya 1004.7 hPa, Hornsund 1006.0 hPa).

5.2. Extreme values and interdiurnal variability

The full range of atmospheric pressure changes at Hornsund in 1978–2006 amounted to nearly 95 hPa (Table 5.2). The highest pressure of 1044.2 hPa was noted on April 10, 1996 at 00 UTC. The lowest pressure of 949.4 hPa occurred on January 31, 1993 at 09 UTC. The greatest variability was in the period from October to April, when absolute ranges exceeded 80 hPa, and differences between the mean maximum and minimum were higher than 40 hPa. The smallest

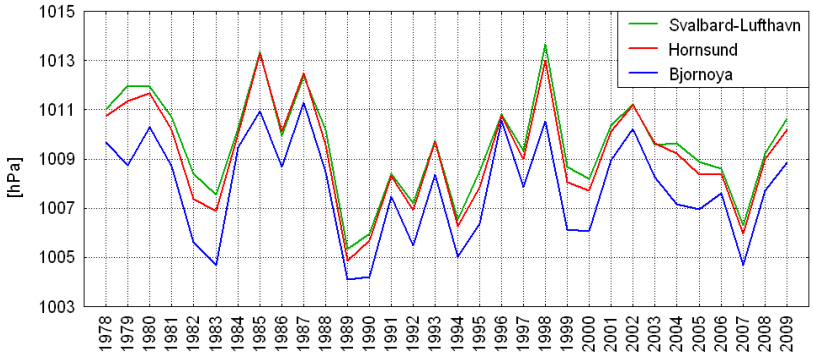

Fig. 5.3. Multiannual variability of mean annual atmospheric pressure at the selected stations in 1978-2009.

Table 5.2. Extreme values of atmospheric pressure reduced to the sea level [hPa] and the range of variability at Hornsund (July 1978 – June 1981, September 1982 – December 2009)

Month	Avg. max	Max	Year	σn	Avg. min	Min	Year	σn	Range max–min	Avg. max–avg. min
January	1025.0	1038.1	1979	6.4	973.1	949.4	1993	11.9	88.7	51.9
February	1027.5	1040.1	2007	7.8	978.9	958.3	1993	9.1	81.8	48.6
March	1030.5	1042.8	1979	8.7	981.4	958.0	1997	12.3	84.8	49.2
April	1031.8	1044.2	1996	7.0	988.0	953.3	1990	9.6	90.9	43.8
May	1029.7	1040.6	1993	4.8	996.3	980.3	1992	6.8	60.3	33.4
June	1026.8	1034.9	1998	4.2	994.9	980.9	2006	8.0	54.0	31.9
July	1024.1	1030.2	2008	3.6	997.7	979.8	1995	6.1	50.4	26.4
August	1023.8	1029.7	1987	3.7	993.9	978.8	1994	6.8	50.9	29.9
September	1025.2	1034.3	1992	4.4	986.7	967.2	1999	7.7	67.1	38.5
October	1026.5	1039.2	1987	6.2	982.9	956.0	1986	10.9	83.2	43.6
November	1025.9	1036.9	1998	5.8	979.7	955.8	1996	11.4	81.1	46.1
December	1026.7	1040.7	1996	6.9	972.7	951.8	2007	11.8	88.9	54.0
Annual	1027.0	1044.2	1996	2.1	985.4	949.4	1993	2.9	94.8	41.6

Explanation: Extreme values were chosen from measurements made every 3 hours.
Avg. max – mean values from monthly maximum, Max – the highest value in month or year, σn – standard deviation, Avg. min – mean values from monthly minimum, Min – the lowest value in month or year.

changes were in the summer. The extreme range of fluctuations decreased in July to 50.4 hPa, and the mean to 26.4 hPa.

Variability of pressure maxima is distinctly smaller than that of minima (Table 5.2). The smallest changes were noted in summer, in July the standard deviation being only ±3.6 hPa. The biggest fluctuations of pressure maxima occurred between October and April and the highest standard deviation was in March (±8.7 hPa). On average the highest maxima of pressure were noted in April (1031.8 hPa) and the lowest maxima in August (1023.8 hPa). In August absolute maximum pressure did not exceed 1030 hPa (1029.7 hPa in 1987) during the period investigated. In contrast, from December to May atmospheric pressure exceeding 1040 hPa may occur.

Variability of pressure minimum was greatest between October and April, when the standard deviation usually exceeded ±10.0 hPa, reaching ±12.3 hPa in March. From May to September

this variability was almost two times smaller and in July mean standard deviation decreased to ±6.1 hPa. Mean pressure minima reached the lowest values in December (972.8 hPa) and in January (973.1 hPa). In contrast, from May to August pressure was higher than 994 hPa and reached in July 997.7 hPa. Absolute minimum pressure between October and April fell below 960 hPa. Between April and May there is significant increase in pressure minima values. In May and June falls of pressure below 980 hPa were not noted in the investigated period.

During 1978-2009 the annual amplitude of atmospheric pressure showed a tendency to decrease (Fig. 5.4). The linear trend was -1.1 hPa/10 years in absolute amplitude and –0.4 hPa/10 years in mean amplitude. The biggest annual amplitude, 92.0 hPa, was recorded in 1993. High values also occurred in 1996 (88.4 hPa) and 2007 (88.3 hPa). The smallest annual amplitudes in atmospheric pressure were in 1985 (62.7 hPa) and 2009 (63.6 hPa).

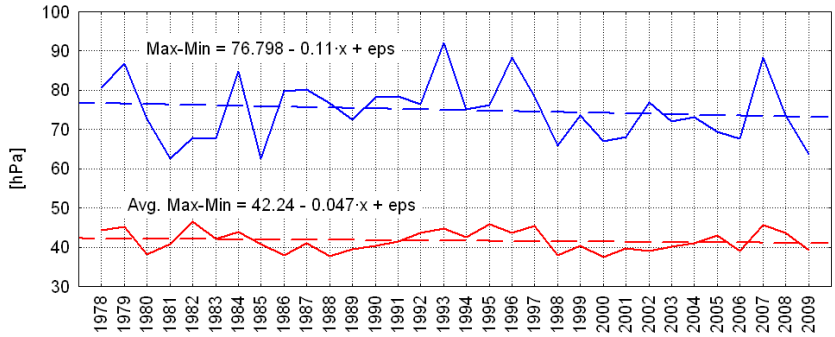

Fig. 5.4. Long-term variability of absolute annual range of atmospheric pressure (Max-Min) and average annual range (Avg. Max – Avg. Min) at Hornsund (1978–2009).

Atmospheric pressure at Hornsund has not shown regularities at the diurnal scale. Changes of pressure have characteristically irregular fluctuations over the period of a few days, depending on the passage of systems of high or low pressure. At times, particularly in the winter half of the year when low-pressure systems are passing as well as frontal systems, sudden changes of pressure exceeding ±10 hPa in three hours may occur. As an example of such changes of pressure at Hornsund, the period January 1 – February 10 1993 is presented in Fig. 5.5. During this period fluctuations of pressure were associated with passage of lows until at the end Spitsbergen came under the influence of a deep high-pressure system. It was in this time at Hornsund that the lowest pressure, 949.4 hPa on January 31, 1993, was recorded, as noted above.

The second example (Fig. 5.6) shows the variability of pressure during a period dominated by high-pressure systems. Changes of pressure from April 1 to May 10 1996 were gentler than in the case of great cyclonic activity. After six days of low pressure there was a rapid increase to the highest noted value of 1044.2 hPa on April 10, 1996. On April 9 – 10, 1996 a centre of high pressure was located over Spitsbergen. High pressure (mainly types Ea and Ka) was maintained for around two weeks. Finally, a drop of pressure occurred on April 26–27, 1996 because a shallow baric low-pressure system formed over Spitsbergen.

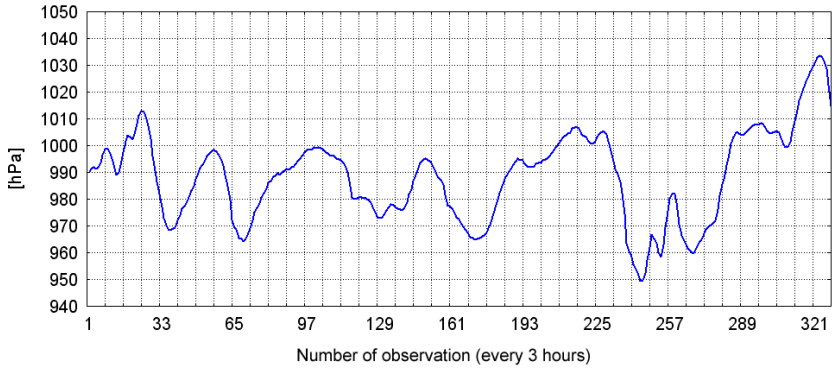

Fig. 5.5. Atmospheric pressure at Hornsund in the period from January 1 to February 10, 1993. On the X-axis: 1 – January 1, 1993, 00 UTC, 241 – January 31, 1993, 00 UTC, the smallest graduation corresponds to 24 hours (8 measurements at three-hour intervals).

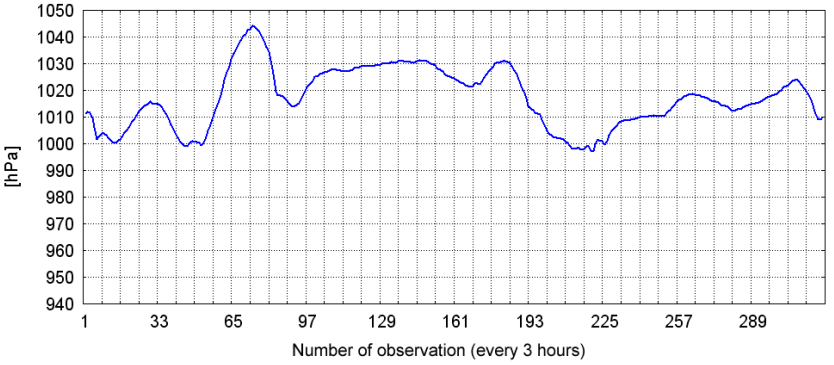

Fig. 5.6. Atmospheric pressure at Hornsund in the period from April 1 to May 10, 1996. On the X-axis: 1 – April 1, 1996, 00 UTC, 241 – May 1, 1996, 00 UTC, the smallest graduation corresponds to 24 hours (8 measurements at three-hour intervals).