19. SNOW COVER AT THE HORNSUND STATION

There is snow cover (SC) on the tundra at Hornsund for 244 days in a year on average. During the 32 years of record at the station SC persisted for the longest time in 2008, when it was present for 272 days; in 1996 it was just five days shorter, 267 days. The shortest duration was in 1993, 203 days (Fig. 19.1, Table 18.35). Snow nearly always lasted from November through May (Fig. 19.2), and was most permanent in March and April. During 1978–2009 there was no snow-free period recorded in these two months (Table 19.1). In the month of May snow-free days were recorded only twice: seven days in 2006 and six days in 1989. Snow-free conditions occurred sometimes also between December and February, but very rarely (Table 18.35). During the months of November 1993 to January 1994, there was negligible SC because of limited precipitation and very strong winds which blew the snow off of the tundra. Hence January 1994, despite low air temperatures, was exceptionally poor in SC (only three days). In all the other January records there was SC always and every day. Another exception was February 2003 when there was SC for only 17 days.

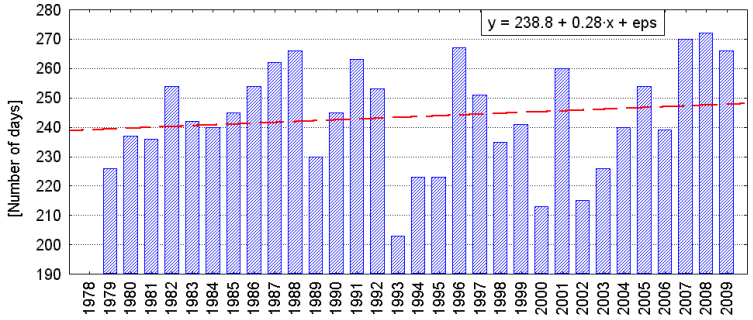

Fig. 19.1. The annual number of days with snow cover at Hornsund in 1978–2009.

Table 19.1. Mean monthly, annual and standard deviation (σn) as well as maximum (Max) and minimum (Min) numbers of days with snow cover at Hornsund, 1978–2009.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean	30.1	27.9	31.0	30.0	30.6	14.6	0.1	0.5	3.5	18.9	27.5	29.9	243.6
σn	5.0	2.1	0.0	0.0	1.6	9.1	0.2	1.6	4.1	9.6	4.5	3.1	18.1
Max	31	29	31	30	31	30	1	8	15	31	30	31	272
Min	3	17	31	30	24	0	0	0	0	0	13	17	203

Quite frequently SC was only transient in the month of September; September 1978 was the longest spell in the record, when there was SC during half of the month. In October 1978, 1987 and 2006 SC was continuous throughout the month. The only October without SC was in 2002. Full melt of SC occurred mainly in June, when the snow cover lingered for just over the half of the

days on average. Only twice was there full melt a month earlier, in May of 1989 and 2006. Three times SC persisted throughout June (in 1981, 1996 and 2008). In June and October there was snow on the tundra for 15–19 days on average, and these months were characterized by the greatest range of variability of number of days with SC at Hornsund (Fig. 19.2). Sporadically, single days with SC may occur also during the summer, in July and August. In July a day of snow cover occurred twice in the record, in 1996 and 2008, whereas in August snow cover has been recorded five times, in 1982 (for as long as eight consecutive days), in 1994, 1996, 1999 and 2007.

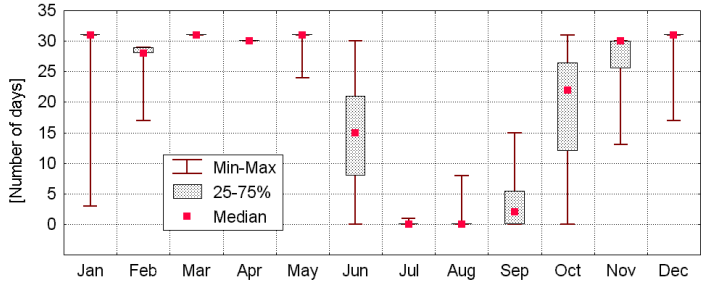

Fig. 19.2. Range of variability of monthly number of days with snow cover at Hornsund, 1978–2009.

Over the full period of record, 1979–2009, there is a small, statistically insignificant, trend of increase of SC days at the rate of three days per 10 years. However, before 2006 the trend was for a decrease, also statistically insignificant. Increasing SC contributes to increase of albedo and decreasing absorption of solar radiation by the tundra.

In the beginning of the period, 1979–1988, a regular increase of number of SC days was observed, from 226 to 266 days (Fig. 19.1). In 1985–1992, this index was above the 30-year mean with the exception of 1989 (230 days). From the recorded minimum of 203 days in 1993 up to 2006, despite significant fluctuations, number of days with SC was above the average only in four years, and was lower in seven years. There were low numbers of SC days in 2000 (213) and 2002 (215) also. During the final three years (2007–2009) SC persisted for very long times, more than 260 days, with the maximum cover for whole investigated period occurring in 2008 (272 days).

The mean thickness of snow cover calculated as the monthly or annual quotient of thickness of lasting snow and number of days with SC over the year amounted to only 20 cm (Table 19.2 and Table 18.36). In the greatest snow year, 1998, this value attained 43 cm, but in 1999 amounted to only 10 cm (Fig. 19.3). Most often the mean annual thickness of snow on the tundra was in the range of 10–15 cm (9 cases). Somewhat more seldom (7 cases) it was somewhat bigger at 20–25 cm. In only five years was the mean annual thickness of SC at or above 30 cm (Table 18.36).

Table 19.2. Mean, monthly, annual and standard deviations (σn) plus maximum (Max) and minimum (Min) thickness of snow cover [cm] at Hornsund, 1978-2009.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean	18.3	23.5	27.8	31.2	29.4	14.5	0.1	0.3	1.6	4.4	8.0	12.2	20.1
σn	11.5	11.9	12.5	13.7	16.0	11.4	0.4	0.8	2.3	3.1	5.5	8.3	7.8
Max	46.0	49.3	58.7	64.3	67.9	43.0	2.0	3.3	9.0	14.0	21.4	39.9	43.0
Min	1.8	3.3	5.5	9.8	5.2	0.0	0.0	0.0	0.0	0.0	2.1	2.4	9.6

In the course of the year, there is a net increase of SC (snow pack) thickness from the beginning of winter to a culmination in April (31 cm) on average (Fig. 19.4). The mean thickness of SC in May was not much less (29 cm). May 1998 (68 cm) was among the months with the highest mean thickness: it was 4 cm greater than in April that year. In that exceptionally snowy year mean monthly thickness in June was equal to the annual mean, 43 cm. In the average June, when in general the snow pack disappears rapidly, the average thickness of SC is only half (14 cm) of the thickness in May. For the beginning of winter mean monthly multiyear thicknesses of SC greater than 10 cm appeared only in December (12 cm), and a twofold increase of this thickness was delayed on average until February (24 cm).

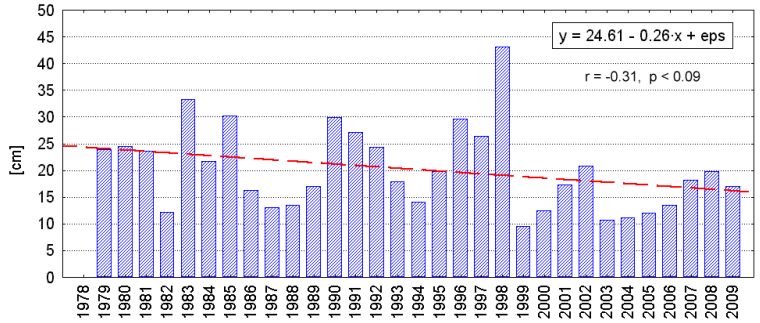

Fig. 19.3. The mean annual thickness of the snow cover [cm] at Hornsund, 1978–2009.

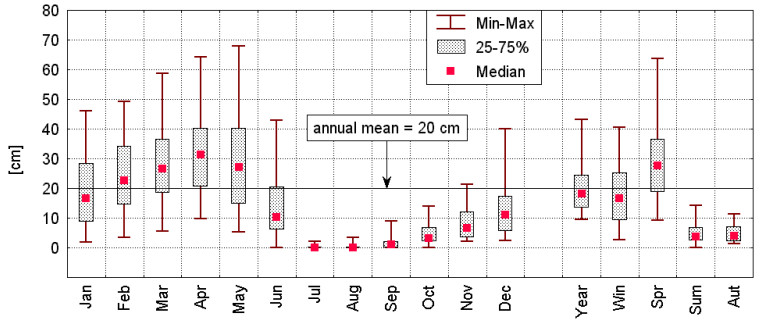

Fig. 19.4. Range of variability of the mean monthly and seasonal snow cover thickness [cm] at Hornsund, 1978–2009. Win – winter (DJF), Spr – spring (MAM), Sum – summer (JJA), Aut – autumn (SON).

The greatest thickness of SC at Hornsund amounted to 80 cm and was measured on May 14, 1998. During the 32 years of the record, a maximum thickness >50 cm was noted only in 11 years (Fig. 19.5, Table 18.37). The smallest maximum thickness was measured in 1999 (28 cm). Over the year thick snow cover generally occurred between January and June (Table 19.4). Maximum SC thickness recorded in December was 45 cm in 1982, and in November was 41 cm in 1979. In October the thickest snow cover was 25 cm in 1989.

During the research period, mean annual thickness of the lasting snow (snow pack) decreased by around 2.6 cm per ten years. This trend is not statistically significant ($p = 0.106$), but there were

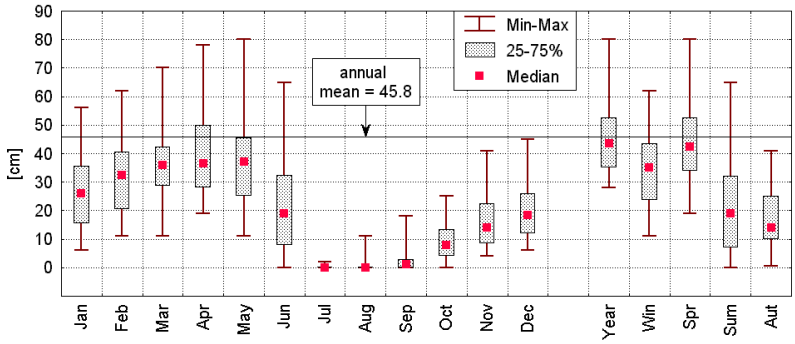

Fig. 19.5. Range of variability of maximum monthly and seasonal thickness of the snow cover [cm] at Hornsund, 1978–2009. Win – winter (DJF), Spr – spring (MAM), Sum – summer (JJA), Aut – autumn (SON).

Table 19.4. Mean monthly, annual and standard deviations (σn) thicknesses of the snow cover [cm] at Hornsund in 1978-2009, plus the highest (Max) and the lowest (Min).

Element	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean	27.2	32.5	37.4	39.9	37.7	23.0	0.1	0.6	2.5	9.3	16.5	20.1	45.8
σn	13.8	14.5	14.0	13.7	16.0	17.7	0.4	2.1	3.9	6.6	9.7	10.6	13.2
Max	56	62	70	78	80	65	2	11	18	25	41	45	80
Min	6	11	11	19	11	0	0	0	0	0	4	6	28

statistically significant negative trends of mean snow cover thickness recorded for May and June (Fig. 19.6). In May decrease of snow pack thickness amounted to 6.4 cm per 10 years, and in June 5.9 cm per 10 years. This means that during the 32 years of observations at Hornsund, mean thickness of the snow cover decreased by 20 cm in May, and by 19 cm in June in total. This significant reduction of the snow pack in May and June was also accompanied by a decrease in the number of days with snow cover that, however, was not statistically significant. If this trend continues, in the near future at Hornsund we might expect snow-free conditions to appear earlier. However, this annual scale reduction of the snow pack has not been accompanied by a reduction of number of SC days but rather with an increase.

Over 1978–2009 some decrease of maximum snow pack thickness at Hornsund was also evident. It was strongest between February and June, and in April, May and June reached statistical significance at: –6.3 ($p = 0.019$), –6.5 ($p = 0.040$) and –7.9 ($p = 0.024$) cm per 10 years, respectively. Annual maximum thickness of SC is characterized by a statistically insignificant decreasing trend of 1.9 cm per 10 years. In the case of maximum thickness as well as mean thickness, the clearly seen reduction after 1998 is worthy of notice (Fig. 19.3). Since that time the mean annual snow cover exceeded 20 cm only once (21 cm in 2002), and the maximum in as many as five years did not exceed 30 cm. Earlier such low maxima had occurred only twice, in 1987 and 1994.

Not much information is available on snow pack thicknesses at other Spitsbergen stations. The fullest series of data for 1978–2009 are from the Svea and Svalbard-Lufthavn stations. These are accessible in the database eKlima of the Norwegian Meteorological Institute. Comparing mean SC thickness at Hornsund with that at the Svea station located in the interior of Van Mijen Fjord

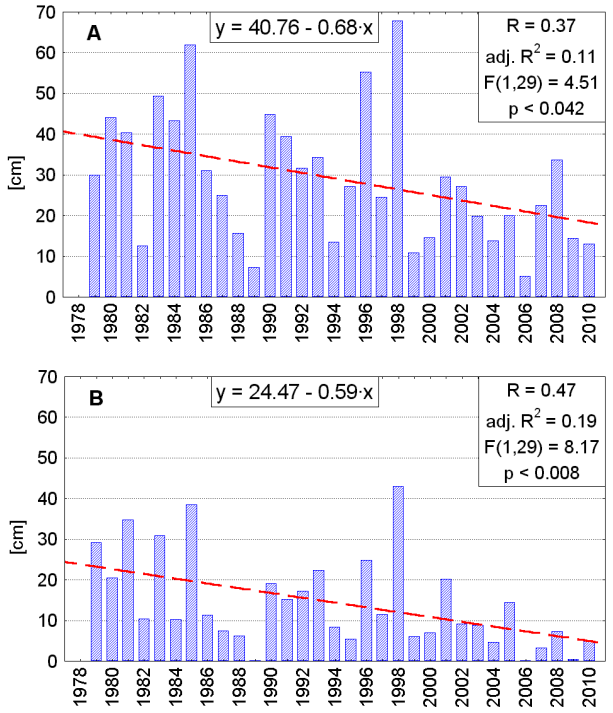

Fig. 19.6. Changes of snow cover thickness [cm] in May (A) and June (B) and the trends, 1979–2010.

(Tables 19.3 and 19.4) one should note that during the winter (December-April) SC at Hornsund is only half as great. Only in June does the snow thickness there become on average somewhat bigger than in the central parts of middle Spitsbergen represented by Svea. Between December and April, the monthly precipitation totals at Hornsund and Svea are similar. However, the mean wind velocities at Hornsund are around 1.5 $m \cdot s^{-1}$ greater than at Svea, indicating that the big differences of snow pack thickness are associated with the effectiveness of wind scour. Statistically significant associations between changes of SC thickness at Hornsund and Svea occurred only in

Table 19.3. Monthly snow cover thickness [cm] at the Hornsund and Svea stations, 1982–2002.

Station	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Svea*:												
Mean	**44.0**	**54.3**	**59.6**	**63.1**	**45.3**	**6.2**	**0.0**	**0.0**	**0.2**	**3.7**	**11.5**	**22.6**
Max	96	101	84	90	88	39	0	0	1	9	33	75
Min	14	26	22	24	12	0	0	0	0	0	1	3
Hornsund:												
Mean	**20.3**	**24.6**	**28.8**	**32.2**	**31.8**	**15.5**	**0.1**	**0.4**	**1.9**	**4.8**	**8.7**	**12.9**
Max	46	49	59	64	68	43	2	3	9	14	21	40
Min	2	3	6	10	7	0	0	0	0	0	2	2
Svea–Hornsund	23.7	29.7	30.8	30.9	13.5	–9.3	–0.1	–0.4	–1.7	–1.1	2.8	9.7

* – data from the Norwegian Meteorological Institute (eKlima)

Table 19.4. Monthly snow cover thickness [cm] at the Hornsund, Svalbard-Lufthavn and Svea stations in 1978–1993

Station	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Svea*	47.2	54.5	63.6	69.8	51.9	12.1	0.0	0.0	0.3	4.4	10.4	24.3
Svalbard-Luft.*	13.7	18.0	22.0	25.5	12.4	0.6	0.0	0.0	1.0	4.3	8.4	9.7
Hornsund	18.1	24.9	30.5	34.7	34.1	18.2	0.0	0.2	1.8	4.9	7.5	11.3

* – data from the Norwegian Meteorological Institute (eKlima)

September ($r = 0.57$, $p = 0.005$) and December ($r = 0.50$, $p = 0.019$). Given the quite short distance between these two stations this shows that local features of environment can exert a big influence on SC thickness.

At the Svalbard-Lufthavn station, which is also located in central Spitsbergen and deep in the interior of a fjord like Svea, SC thickness is smaller than at Hornsund (Table 19.4). The biggest differences occurred during the spring (May-June) when SC at Hornsund was up to 18–20 cm thicker than at Svalbard-Lufthavn. Wind velocities recorded at this station were lower than at Hornsund, therefore smaller thickness of winter SC at Svalbard-Lufthavn should be due to lesser precipitation totals there.