12. THE HORIZONTAL VISIBILITY AND FOG

12.1. The horizontal visibility

The horizontal visibility (VV) at Hornsund is recorded according to a marine scale of visibility with a scale of 0–9. The scale is non-linear, with short increases of visibility where overall visibility is low. As overall visibility increases, the intervals of horizontal extent are expanded rapidly[1]. For that reason calculating the means, e.g. mean monthly values of degree of visibility appear to have not great sense. Analysis of the periodic observations shows that during around 50% of days in a year the extent of visibility changes, often drastically (Fig. 12.1). In such a situation using as a measure the number of days with a given extent of visibility is also confusing.

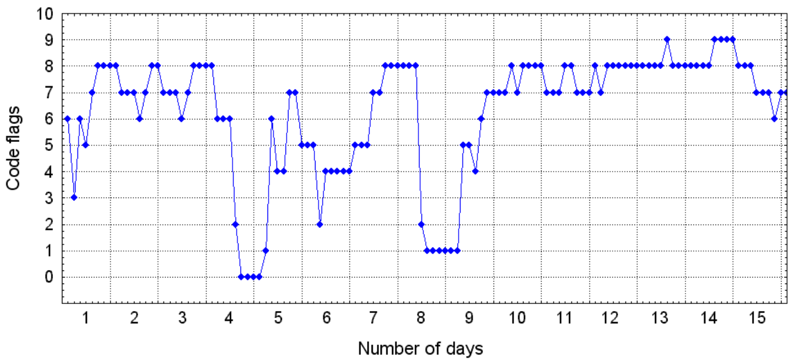

Fig. 12.1. The pattern of horizontal visibility at Hornsund in the first 15 days of January 1993.

Sharp changes of horizontal visibility from 8 (very good visibility; 22–50 km) to 0 (extent of visibility less than 50 m) or 1 (visibility from 50 to ~200 m) are seen on Fig. 12.1. A strong snowstorm (ww = 39) was the reason for the decrease of visibility by ~90 between January 4, 3 pm and January 5, 0 am, and similarly on January 8 and 9. Decrease of visibility on January 6 to VV = 2, and later to VV=4, was caused by continuous, and later by occasional, moderate and strong snowfall (ww = 73, 75 and 86). It draws attention to the fact that outside of precipitation periods and the big snowstorm, visibility was good and very good (VV = 7 and 8), and for moments even perfect (VV = 9).

[1] VV = 90 corresponds to extent of visibility below 50 m, VV = 91 – between 50 m and 0.1 NM (~200 m), VV = 92 – between 0.1 and 0.2 NM (~200–400 m), VV = 93 – between 0.2 and 0.3 NM (~400–600 m), VV = 94 – between 0.3 and 0.5 NM (~600–1000 m), but e.g. VV = 97 equals extent of visibility between 5 and 11 NM (~10–22 km), VV = 98 – between 11 and 28 NM (~22–50 km).

A survey of VV observations shows that on average in 46% of the measurements, VV was recorded as 8, that is the extent of horizontal visibility was greater than 22 km but not greater than 50 km (very good visibility). In around 17.5% of term observations extent of visibility was 9 ”extremely good visibility”, or ”perfect” (extent of horizontal visibility greater than 50 km). This may be interpreted to state that for around 63% of the year extent of visibility at Hornsund was greater than 22 km. Such extent of horizontal visibility on the southern Spitsbergen is connected with appearance of unusually transparent Arctic air here, in the summer mainly PAm (Arctic marine air), in the winter PAm and pac (Arctic continental air). Both have almost zero content of aerosols of lithospheric origin, and a low content of water vapour in the air, as well as the great frequency of occurrence of super-refraction, making the horizontal visibility so perfect here.

The main factors limiting the extent of horizontal visibility at Hornsund are the products of the condensation of water vapour. Other phenomena limiting extent of visibility such as dust gales or opacity of anthropogenic origin are unknown at Hornsund.

Rainfall usually reduces visibility to 4–10 km (VV = 96; moderate visibility), exceptionally from 2 to 4 km (VV = 95). This limited reduction is due to the low intensity of precipitation in general, only during events of greater intensity is the visibility decreased to below 4000 m. Mixed precipitation is the most frequently accompanied by notation VV = 95 (weak visibility). In cases of mixed precipitation with strong winds (Vw > 11 m/s) the extent of visibility is decreased at times to 1–2 km (VV = 94; weak visibility)[2]. Large variations in horizontal visibility were recorded in snowfalls, from 50 m to 10 km (VV from 1 do 6). During big snowstorms (block ww in the group $7wwW_1W_2$) visibility was strongly variable; in general it was recorded as VV = 4 (from 600 to 1000 m), only in few cases as VV = 3, 2, 1, and even 0 (Fig. 12.1). During the occurrence of weak snowstorms the extent of horizontal visibility was the most often 22 km and more (VV = 98).

Apart from heavy snowfall (ww = 74, 75), fog reduces the extent of horizontal visibility the most strongly. Because of the importance of limiting visibility by the fog, the problem will be discussed in a separate section below. Haze plays a lesser role than precipitation in limiting of VV at Hornsund, in the light of data contained in the observational registers, although this may result from the rules of the data coding[3].

In general, during a year at Hornsund up to 13 cases (observations) of the horizontal visibility extent smaller than 50 m were recorded, while maximum limitation of visibility did not occur every year. In the visibility scale between 1 and 4 (extent of visibility between 50 m and 2 km) from one dozen to a few dozens of cases of each value (1, 2, 3 and 4) were recorded. As a rule the sum of such cases, does not exceed 250, meaning that less than 10% of all observations record visibility below 2000 m. During a year around 370–400 observations are recorded on average during which estimates are of 2 to 10 km (VV = 5 and 6; weak to moderate visibility), comprising around 12–13% of all observations. Visibility 7 (extent of visibility from 10 to 22 km; good visibility) was recorded in around 500 observations per year on average, around 17% of all cases.

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2 In the marine scale of visibility normalized definition „weak visibility” corresponds to grades 4 and 5 (extent of visibility between 0.5 and 2 NM).

3 In the case of co-occurrence of different kinds of current weather, the observation book records the number (value) that is greater.

In particular years there were large, generally short-term, changes of horizontal visibility (Fig. 12.1 and 12.2). The short (a few hours', more seldom lasting one day), periods of weak to moderate visibility (VV from 4 to 6), were separated by longer periods of good visibility (7) and very good visibility (8), at times even perfect (9).

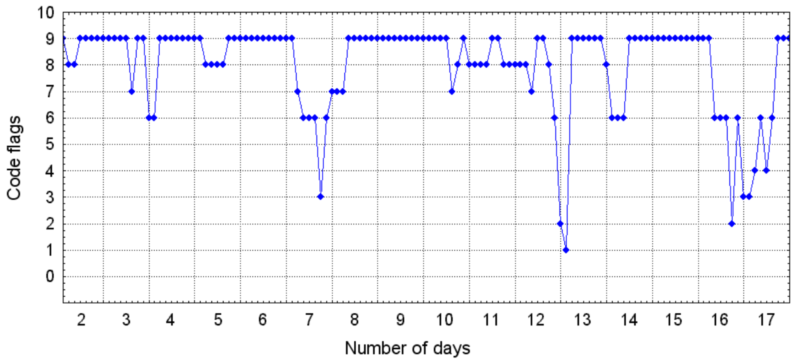

Fig. 12.2. The record of horizontal visibility at Hornsund, between July 2, 00 and July 18, 00 in 1993 (according to term observations).

The long period of the perfect visibility (VV = 9) was interrupted by a short, sudden drops of visibility extent. Horizontal visibility reaching 6, and next 3, from 6 am on July 7 was caused by haze and next by fog (Fig. 12.2). Decrease of visibility to 2 on July 12, and later to 1 was also caused by fog (ww = 45 and 46).

After aggregating the observations into diurnal and into multiannual monthly means, it is found that changes of horizontal visibility during a year are small. The large number of factors influencing the extent of horizontal visibility allows them to become complementary (e.g. during the winter the frequency of obscuring fog decreases but frequency of obscuring snowfall increases), and as a consequence no clear annual cycle of visibility can be observed. During a year on average somewhat „better" than mean annual visibility characterizes May and June. The most improvement of visibility appears in May in some years; in others in June. In July and August on average there is some worsening of visibility because of increase of fog and rainfalls. In some years September is also like this, especially if air temperatures drop rapidly. Besides the fog and rains of greater intensity, mixed precipitation and snowfalls appear then, strongly reducing visibility.

Characteristics of horizontal visibility at Hornsund presented here is correct only for areas in the vicinity of the station, not higher than 75–100 m a.s.l. Together with increase of elevation, frequency of occurrence of fog will abruptly increase, in substantial part being dense to very dense. This fog differs little from clouds (Photo 12.2), the base of which may be very low.

12.2. Fog

Fog is a phenomenon occurring relatively frequently in the region of the Hornsund station. During the year 32 days with fog are recorded on average. The smallest recorded number of days with fog in any year was 12 in 2007, and the greatest was 55 days in 2004. The interannual variability of number of days with fog is substantial (σ_n = 11.1).

Occurrence of fog at Hornsund shows a distinct rhythm in the annual cycle, quite accurately reflecting the annual behaviour of air temperature, and therefore the annual pattern of water vapour pressure. Mean monthly number of days with occurrence of fog at Hornsund are compiled in Table 12.1. Data for particular years are placed in Table 18.32.

Table 12.1. Mean monthly number of days with occurrence of fog at Hornsund (Mean), standard deviation (σn) and minimum (Min) and maximum (Max) number of days with fog recorded in month, in 1978–2009.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean	0.2	0.3	0.8	1.1	1.8	4.7	8.8	7.1	4.0	1.2	1.1	0.4
σn	0.6	0.7	1.2	1.2	2.1	3.5	5.1	4.0	3.2	1.6	1.7	0.8
Min	0	0	0	0	0	0	2	1	0	0	0	0
Max	3	3	5	4	7	12	23	15	12	6	7	3

Data in Table 12.1 show that occurrence of fog at Hornsund, between October and March was of very low probability although conceivable (Fig. 12.3). Median fog frequency was zero in these months. However once in a few years occurrence of a day or days with fog in these months is possible. Frequency of fog increased from April to reach an unquestionable maximum in July (most often 8-9 days in this month, the observed maximum amounting 23 days in 1994 !). In August the number of days with fog insignificantly decreases in relation to July (most often 7 days in this month), the greatest observed number of days with fog also decreased clearly. July and August are months in which probability is very large that there will appear be at least one day with the fog at Hornsund.

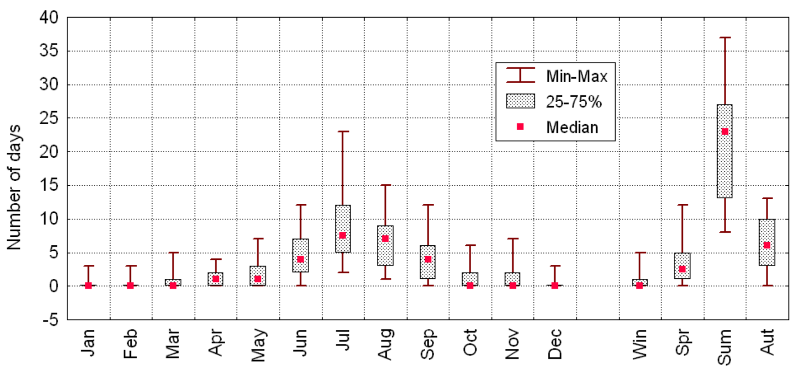

Fig. 12.3. Range of variability of number of days with fog (VV= 0–4) at Hornsund, 1978–2009.
Win – Winter (DJF), Spr – Spring (MAM), Sum – Summer (JJA), Aut – autumn (SON).

The fog appearing at Hornsund is the most often typically advective, forming during the inflow of warm and humid air over ground with a temperature lower than the dew point of the arriving air (Photo 12.1). This fog then generally fills all of the fjord. The fog is formed on its forefield (over the Greenland Sea) and is carried into Hornsund Fjord. The fog is accompanied by the inflow of air from the western sector (220–280°) with very low wind velocity (1–3 m·s^{-1}).

Photo 12.1. Advective fog at Hornsund. Photo taken in Isbjörnhamna, looking direction NW (August 2005). Fog occurs both over water and over land, the sky is invisible. The extent of horizontal visibility is 0.3–0.5 NM; weak fog (Photo A.A. Marsz).

Photo 12.2. Bands of orographic clouds in the region of the Hornsund station (in foreground), recorded as fog (ww = 40). In such situations fog occurs solely over the land, fog is not observed over the water of fjord. Photo from Isbjörnhamna, July 2005 (Photo A.A. Marsz)

The second type of fog in its frequency of occurrence is orographic fog. This fog is formed during air inflow from particular directions (usually from 240 to 130°). The fog is characterized by its large variability over short periods of time and its clearly banded structure. From the sea (fjord, where such fog does not occur), bands of low orographic clouds are seen clearly, with the base resting on the land, forming and slowly moving over the terrace on which station is located and over slopes of Ariekammen and Fugleberget. When they are over the station or in the field of observers' view during observations these bands are recorded as fog (Photo 12.2). Similar fog, of an orographic – statically stable character may form also over the waters of the fjord, covering its coastal parts and the marine terrace (Photo 12.3), merging into orographic clouds higher over the land. Such type of fog occurs during the slow inflow of air from the southern to western sectors, the most often in the summer. Occurrence of fog is not observed along the southern shores of Hornsund during inflow of air from the northern sector.

Photo 12. 3. Orographic– statically stable fog spreading along the western shores of Hornsund.
Photo from Isbjörnhamna in the eastern direction, July 2003 (Photo A. Styszyńska).

During a polar night, with weak wind or calm, and with relatively thin sea ice on the fjord, during advection of strongly cooled air (the temperature around –12°C and less) theoretically ice fog could form (Utaaker 1974). Single observations of current weather (ww) show the possibility of occurrence of instances of such fog (e.g. between January 4, 1988 at 6 pm and January 5, 1988 at 9 am, when air temperature was in the range between –17.8 and –20.1°C; record ww = 40 (fog or ice fog ... occurring in some distance from the site during the observations...).

During the winter, fog from evaporation forms, named "steaming of the sea" (Photo 12.4). This type of fog is formed more frequently than ice fog, over the parts of fjord free of sea ice, and at strong drops of air temperature. Such fog occurs when air temperature is lower for at least 8–10°C than the sea surface temperature. This fog becomes denser and its vertical extent increases together with increase of the differences between water and air temperature. The fog from "steaming of the sea" may deposit rime when flowing in over the land. However, the probability that such fog may be carried over the station is greater only when a bigger sheet of clear water appears directly in front of the station vicinity. Neither ice fog nor fog from "steaming of the sea" occurs during the warm season of the year.

Photo 12.4. Fog from evaporation forming over ice-free water in Hornsund Fjord.
Photo from the shore of Isbjörnhamna, March 2004 (Photo L. Buchert)

Earlier research on the occurrence of fog at Hornsund and its associations with the types of atmospheric circulation defined by Niedźwiedź was made by Pietroń (1987), based on the data from the seasons, 1957–1958, 1978 –1980 and 1981–85. Basic features of the temporal distribution of fog at Hornsund, in the shorter and longer time periods are very similar – in both series the summer maximum (in July and August) is marked. The number of days with fog changed significantly. In the longer period the mean number of days with fog during the average year increased (from 25.7 to 31.1 of day). Days with fog in December, not recorded earlier, appeared also.