NILU OR: 85/90

NILU OR : 85/90
REFERENCE : O-8336
DATE : NOVEMBER 1990
ISBN : 82-425-0219-6

Arctic Atmospheric Research Station on the Zeppelin Mountain (474 m a.s.l.) near Ny-Ålesund on Svalbard (78° 54'29"N, 11°52'53"E)

G.O. Braathen, Ø. Hov and F. Stordal

NILU OR : 85/90
REFERENCE: O-8336
DATE : NOVEMBER 1990
ISBN : 82-425-0219-6

ARCTIC ATMOSPHERIC RESEARCH STATION ON THE ZEPPELIN MOUNTAIN (474 M A.S.L.) NEAR NY-ÅLESUND ON SVALBARD (78° 54'29''N, 11° 52'53''E)

G.O. Braathen[1], Ø. Hov[2] and F. Stordal[1]

[1] NILU, Box 64, N-2001 Lillestrøm
[2] Department of Geophysics, University of Bergen, Allégaten 70, N-5007 Bergen

NORWEGIAN INSTITUTE FOR AIR RESEARCH
P.O. BOX 64, N-2001 LILLESTRØM
NORWAY

SUMMARY

A new atmospheric chemistry measurement station has been built on the Zeppelin mountain near Ny-Ålesund, Spitsbergen at 78° 54' 29"N and 11° 52'53"E. The altitude is 474 m a.s.l. The station has been in operation since October 1989, and several measurement programmes are or will be carried out:

- EMEP (European Monitoring and Evaluation Programme)
- TOR (Tropospheric Ozone Research, Eurotrac subproject)
- Greenhouse gases
- Stratospheric ozone
- Semivolatile chlorinated hydrocarbons
- Particles

The station is operated by the Norwegian Polar Research Institute in collaboration with NILU.

Long term measurements are carried out at the station, and international collaboration is welcomed.

CONTENTS

ARCTIC ATMOSPHERIC RESEARCH STATION ON THE ZEPPELIN MOUNTAIN (474 M A.S.L.) NEAR NY-ÅLESUND ON SVALBARD (78° 54'29''N, 11° 52'53''E)

1 BACKGROUND

Airborne and groundbased measurements have shown that polluted air is transported into the Arctic in particular during late winter and early spring. At times the pollution in the Arctic atmosphere is comparable to the level over Central Europe. Extensive measurements both in the European and American part of the Arctic (for summaries, see the special issue on Arctic air chemistry, Atmospheric Environment vol. 23, No. 11, 1989, and the special issue on Arctic haze, Arctic Gas and Aerosol Sampling Program II, Journal of Atmospheric Chemistry, vol. 9, Nos. 1-3, 1989) have shown that a permanent research station for long term, clean air (baseline) measurements can provide much needed data about a number of environmental problems of great significance:

Climate Change. To advance the understanding of the variability and trends in the atmospheric concentration of greenhouse gases, high quality measurements are required in a global network, where Ny-Ålesund will represent a region of the globe where no other sites are in operation. The site in Ny-Ålesund is of particular interest for the understanding of the sources and sinks of methane, where processes at high latitude are believed to influence the global distribution. Another important task is the measurement of the concentration of replacements for the chlorofluorocarbons regulated by the Montreal Protocol to the Vienna Convention for the protection of the ozone layer, most of which also are greenhouse gases.

Thinning of the ozone layer. The Airborne Arctic Stratospheric Expedition (AASE), carried out by NASA in January-February 1989, showed that ozone depletion of the same type as encountered in the so-called Antarctic ozone hole, also may take place

in the Arctic stratosphere under special circumstances. The measuring site in Ny-Ålesund can provide data both about the abundance of ozone depleting agents and the ozone concentration, and can be a corner stone in a site network set up to detect changes in the ozone layer and its controlling mechanisms. The station will play a central role in the European Arctic Stratospheric Ozone Expediton (EASOE) during the winter 1991/92.

Increase in surface ozone over Europe. There is evidence for a doubling of the surface-near ozone concentration over Europe during the last century, an increase which is thought to be controlled by the significant increase in anthropogenic NO_x-emissions in combination with the increase in methane. Also non-methane volatile organic compounds play a part, and the Ny-Ålesund site can provide boundary conditions for the European ozone distribution.

Acid deposition in Europe. Acid deposition in Europe is mainly due to emissions of SO_2 and NO_x in Europe, but emissions elsewhere may contribute to the acid deposition in Europe, at the same time as some of the sulphur and nitrogen pollution in Europe leaves the continent and is deposited elsewhere. The Ny-Ålesund site can provide boundary conditions for acid deposition in Europe.

Chlorinated hydrocarbons (industrial chemicals like PCB, and pesticides like DDT). The dispersion and deposition of persistent chlorinated hydrocarbons are not well known and it is an environmental problem of increasing significance to identify their global cycle. An Arctic site like Ny-Ålesund is remote from the sources and can provide background concentration data.

Particulate matter. Natural and anthropogenic particulate matter (aerosols) are important for cloud formation and precipitation chemistry. Heavy metals and acid components are found mainly in the particulate phase, and soil erosion and deserti-

fication also increase the load of particulate matter in the atmosphere.

Radioactivity. Ny-Ålesund is downwind of nuclear reactors on the Kola Peninsula, and radioactivity measurements there can provide early warning of nuclear accidents which otherwise may be unnoticed for longer times reducing the value of precautionary measures.

2 PERMANENT ATMOSPHERIC RESEARCH STATION ON THE ZEPPELIN MOUNTAIN

The need for a permanent site for atmospheric chemistry research on Svalbard was documented, and the planning of a clean air site was begun in 1987. Two requirements were of particular significance for the planning:

- the site should not be influenced by local pollution, on the other hand it should be accessible on a daily basis,

- it should be a permanent site intended for measurements over many years.

In May 1987 the Norwegian Ministry of Environment asked the Norwegian Institute for Air Research (NILU) to be responsible for the planning.

Ny-Ålesund is an old mining town on the west coast of Svalbard on Kongsfjorden, surrounded by mountains with tops about 5-600 m a.s.l. The mining operations stopped in 1963, and later the Norwegian Polar Research Institute (NP) has established a research station there, manned throughout the year. There is an airstrip in Ny-Ålesund where small aircraft and helicopters can land. See the local map of Ny-Ålesund and surroundings (Figure 1).

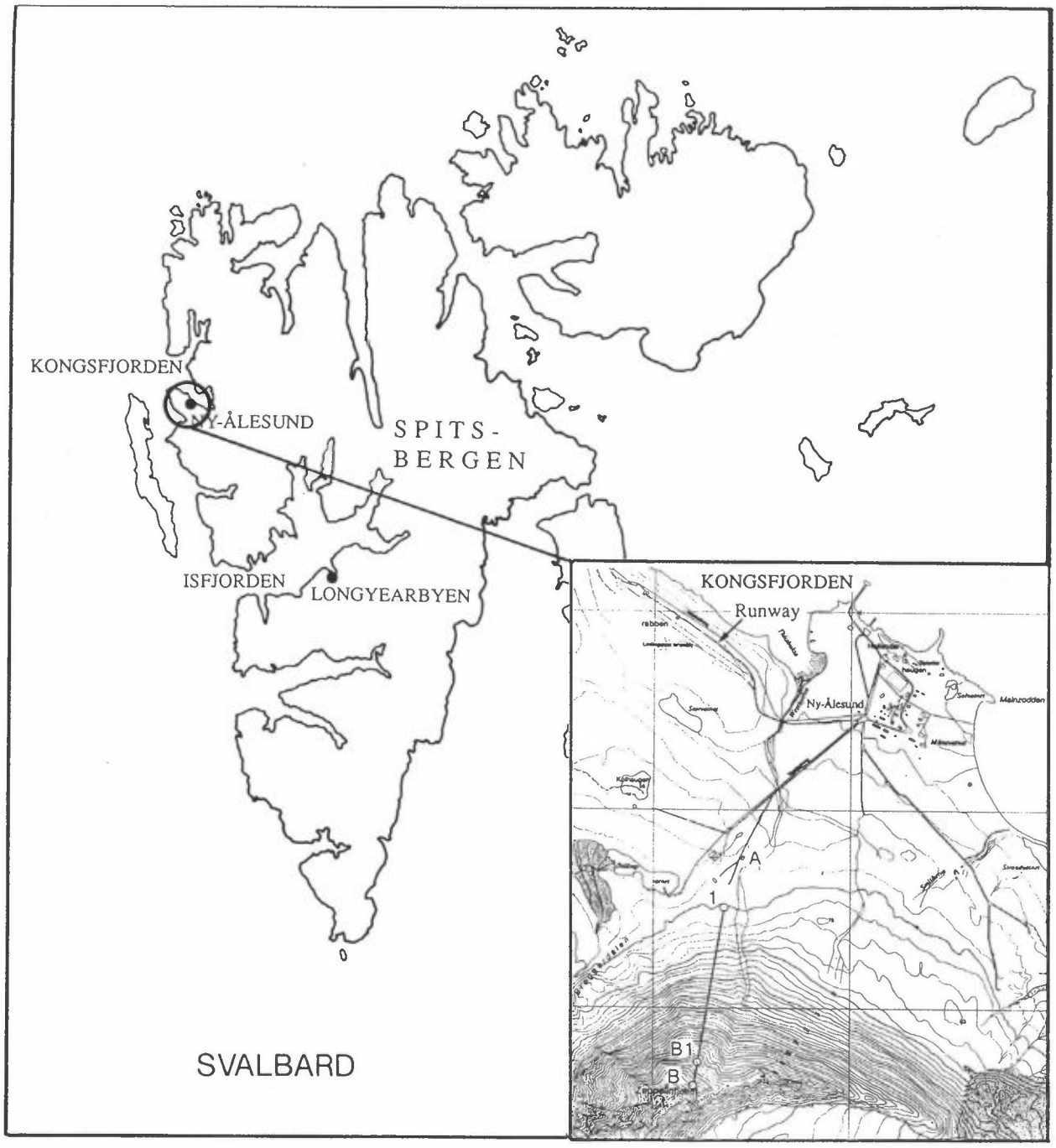


Figure 1: Maps of Ny-Ålesund, Svalbard and surroundings. The station is located at the circle designated with a B on the local map. The straight line from 1 to B shows the trajectory of the cable car.
The building marked with an A is the so-called "Gruvebadet" (Miners' Bath) where NILU has carried out measurements of SO_2 and SO_4^{2-} for many years. These measurements are still carried out in Gruvebadet in parallel with measurements on the Zeppelin Mountain to ensure continuity in the data series. The radioactivity measurements are also performed in Gruvebadet.

NILU has operated a measuring site for many years in Ny-Ålesund close to the community, but measuring sites on the valley floor are subject to local pollution at times, in particular during low wind and inversion conditions. To establish a clean air site with easy access from Ny-Ålesund, it was decided to build the station on the top of one of the mountains surrounding Ny-Ålesund, the Zeppelin Mountain, where a small plateau was selected as the site at 474 m a.s.l.

In early 1988, the Norwegian Ministry of Environment decided to go ahead with the construction of the site, including a cable car to secure easy access, and Statens Bygge og Eiendomsdirektorat (SBED, a public agency for construction of public buildings) was given the responsibility to carry out the necessary construction work on behalf of the Ministry of Environment. This work was carried out during the summers of 1988 and 1989, and the first measuring instruments were in place in September 1989.

The total cost for the station and the cable car was nearly 11 million NOK. In addition comes the instrument acquisition, where The Royal Norwegian Research Council for Science and Technology (NTNF) made a 3 million NOK contribution to the Norwegian research institutions using the station. In Figure 2 photographs of the station are shown.

Figure 2: The Zeppelin Mountain station (upper picture with a view to the west, lower picture to the east over Kongsfjorden).

3 THE WEATHER IN NY-ÅLESUND COMPARED WITH OTHER ARCTIC RESEARCH SITES

Locating the station at 474 m a.s.l. means that the site is above any local inversion most of the time. Surface inversions are common in Ny-Ålesund during winter and spring, but they are seldom deeper than 3-400 m. On the other hand, in particular in summer the Zeppelin Mountain can be enveloped by stratus clouds or orographic clouds. In the Table below, monthly weather data averaged for the time period 1971-1980 for Ny-Ålesund are shown (Steffensen, 1982).

Table 1: Monthly weather data for Ny-Ålesund averaged over the years 1971-1980 (Steffensen, 1982)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Relative humidity (%)													
Mean	77	79	79	78	81	85	87	87	85	71	68	69	79
Precipitation, mm:													
Monthly average	31	34	39	19	22	13	33	42	39	47	35	31	385
Max. 24 h	26	23	18	13	17	9	35	40	23	30	34	20	
Number of days with:													
More than 0,1 mm	11.9	12.0	12.2	9.5	9.2	6.3	9.5	12.1	12.6	12.8	9.3	11.1	128.5
" " 1,0 mm	6.8	7.9	8.4	5.7	5.5	3.0	6.9	6.9	8.7	9.1	6.0	7.8	82.7
" " 10,0 mm	0.6	0.6	0.7	0.2	0.4	-	0.5	1.1	1.1	1.0	0.9	0.8	7.9
" " 0,1 mm rain	1.4	1.2	2.1	0.8	2.8	5.0	9.5	11.7	7.8	3.2	2.3	1.4	49.2
" " 0,1 mm snow	11.7	11.8	12.0	9.5	8.5	3.9	1.0	2.0	8.3	11.9	8.6	10.8	100.0
Clouds and visibility:													
Mean. octas	4.8	4.9	4.9	4.3	5.4	5.9	6.2	6.5	6.3	6.0	4.5	4.7	5.4
Number of clear days	6.1	6.1	4.9	7.2	4.6	2.2	2.0	0.9	1.4	2.4	7.1	7.1	52.0
" " cloudy days	12.6	12.6	12.4	9.5	15.4	16.1	19.0	18.7	18.0	17.9	11.0	12.1	175.3
Frequency fog (%)	-	0.1	0.6	0.3	0.9	3.0	1.6	2.5	0.4	-	-	-	0.8
Horizontal visibility:													
<1 km	0.6	2.0	2.8	1.1	1.2	3.3	1.1	2.2	1.5	1.3	0.4	0.2	1.6
<4 km	5.3	11.2	11.0	8.9	5.3	7.5	4.5	3.7	4.1	10.5	11.9	12.7	8.4
Lowest cloud base:													
<100 m	0.4	0.9	1.5	0.6	0.8	1.1	6.2	4.1	0.9	1.1	0.2	0.2	1.5
<300 m	1.0	3.0	4.5	7.3	8.1	17.3	18.5	11.9	8.7	6.3	2.8	0.6	7.4
Global radiation													
cal/cm^3 1975/79	-	57	1766	7439	13734	14217	10785	5986					

The precipitation is very low (385 mm annual average for 1971-1980) with a fall maximum and a summer minimum. The number of overcast days is 175.3 with a summer maximum of 19.0 in July and a minimum of 9.5 in April. The frequency of fog is 0.8% on an annual basis, with a July maximum of 3.0%. The frequency of horizontal visibility less than 1 km is 1.6% on an annual basis, with a March maximum of 2.8% and a December minimum of 0.2%. Clouds with base height below 300 m occur 7.4% of the time on an annual basis, with an August maximum of 11.9% of the time and a December minimum of 0.6% of the time.

A comparison of the local weather in Ny-Ålesund and at other Norwegian Arctic locations is made in Figure 3 (from Steffensen, 1982) where the frequency of fog on a monthly basis for 6 Norwegian Arctic meteorological stations, averaged over 10 years or more, is shown. The locations of the stations are shown in Figure 4. The frequency of fog is much higher at the sites located on small islands (Jan Mayen, Hopen and Bjørnøya) than for the Svalbard sites (Isfjord Radio, Ny-Ålesund and Longyearbyen), and on Svalbard, the frequency of fog is higher at Isfjord Radio than at the other sites.

Of particular interest is the cloudiness since vertical sounding optical instruments and in particular those based on infrared absorption, depend on a clear sky for operation. In Figure 5 is shown the monthly average cloud cover in octas (based on visual observation of the cloud cover in units of 1/8 or octa, complete cloud cover = 8) averaged over many years for 9 Arctic meteorological stations, 4 in the Norwegian part (Jan Mayen, Bjørnøya, Hopen and Ny-Ålesund), and 5 on Greenland run by the Danish Meteorological Institute (Nord, Narsarsuaq, Thule Airbase, Danmarkshavn and Søndre Strømfjord). The locations of the stations are shown in Figure 4. The data for the Danish sites on Greenland were provided by the Danish Meteorological Institute. It can be seen that the sites in the Norwegian Arctic are more cloud covered than the sites on Greenland. On Greenland, the site close to the southern tip

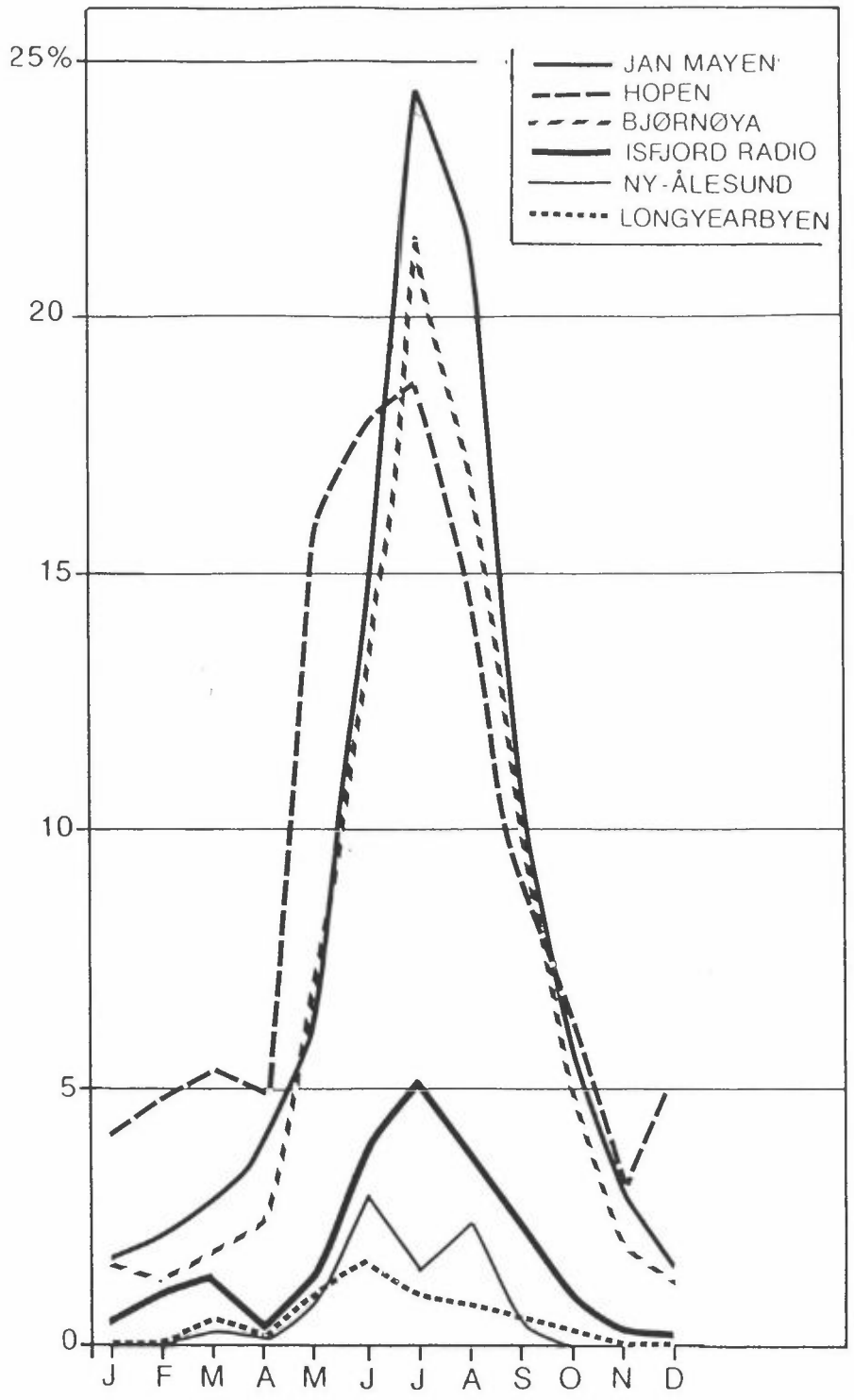


Figure 3: Average monthly frequency of fog on Norwegian Arctic meteorological stations (Steffensen, 1982)

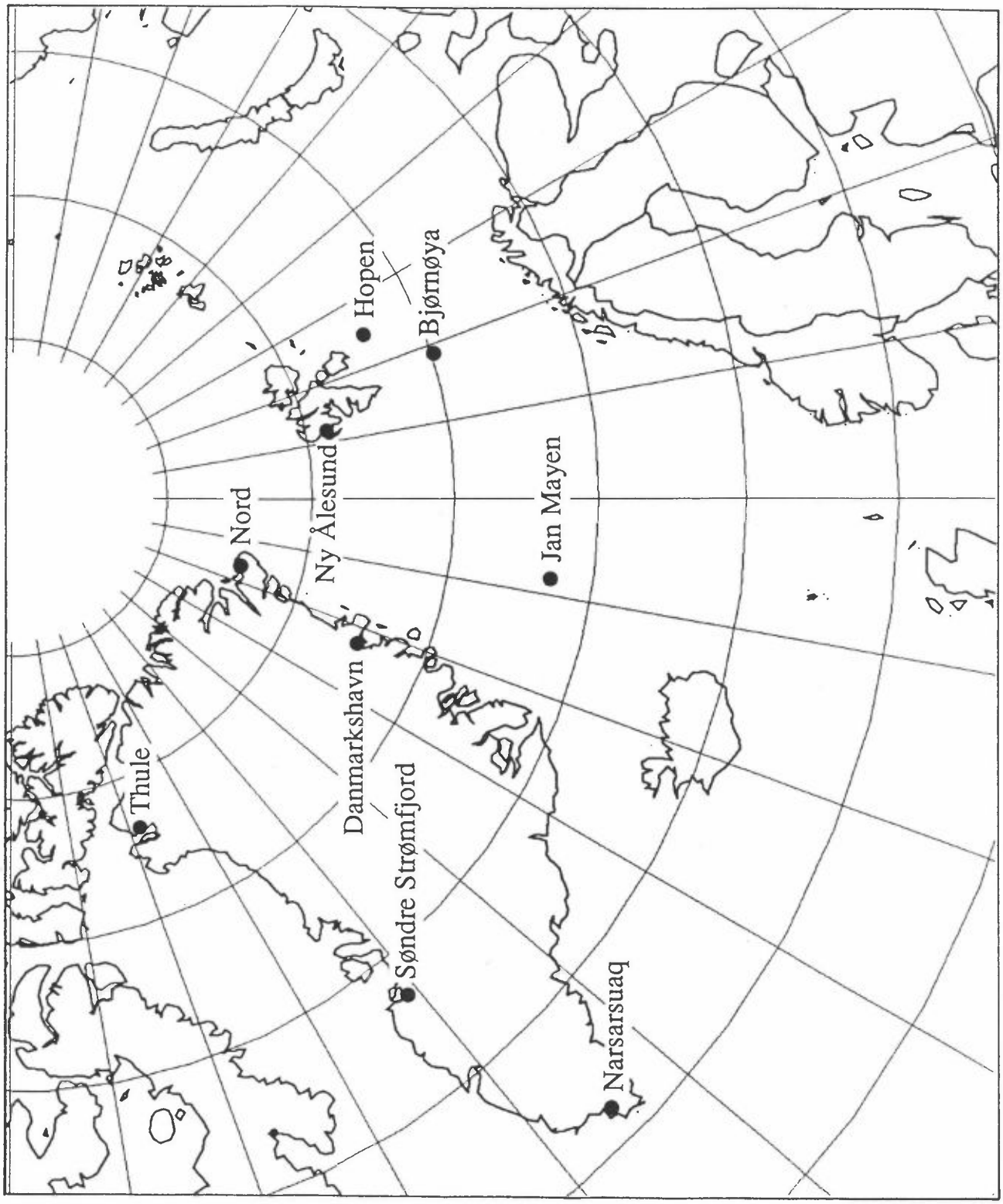


Figure 4: Map of the Arctic region with meteorological stations in the Norwegian Arctic (run by the Norwegian Meteorological Institute) and Greenland (run by the Danish Meteorological Institute)

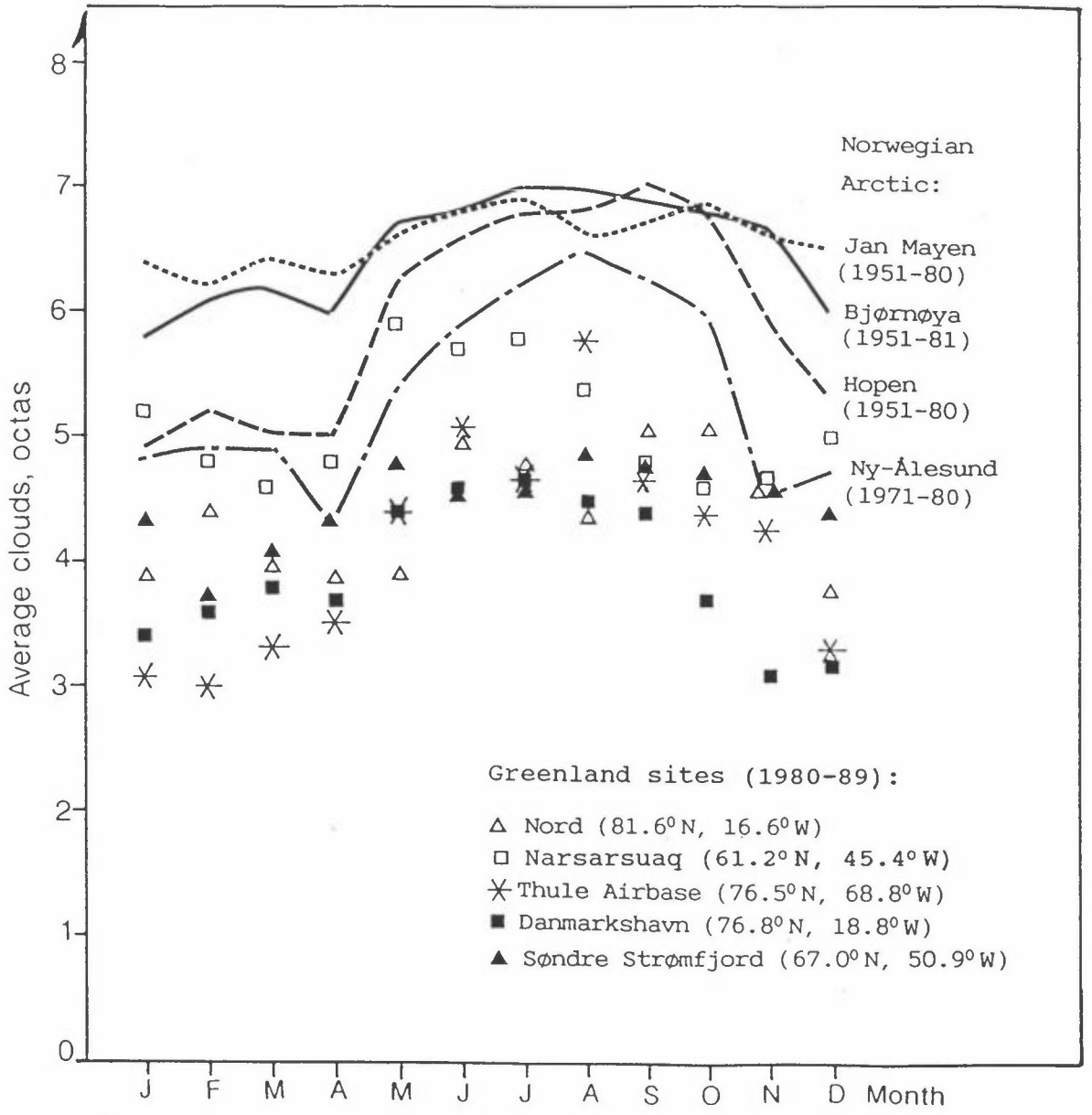


Figure 5: Average monthly cloud cover at meteorological stations in the Norwegian Arctic (Steffensen, 1982) and on Greenland (provided by the Danish Meteorological Institute).

(Narsarsuaq) has more cloud cover than the sites further to the north. The cloud cover in Narsarsuaq is quite similar to the cloud cover in Ny-Ålesund, while the cloud cover on the northernmost sites on Greenland (Thule Airbase and Nord) is much lower (on an annual basis about 4 octas). The annual average cloud cover in Ny-Ålesund is 5.4 octas, on Jan Mayen 6.6 octas.

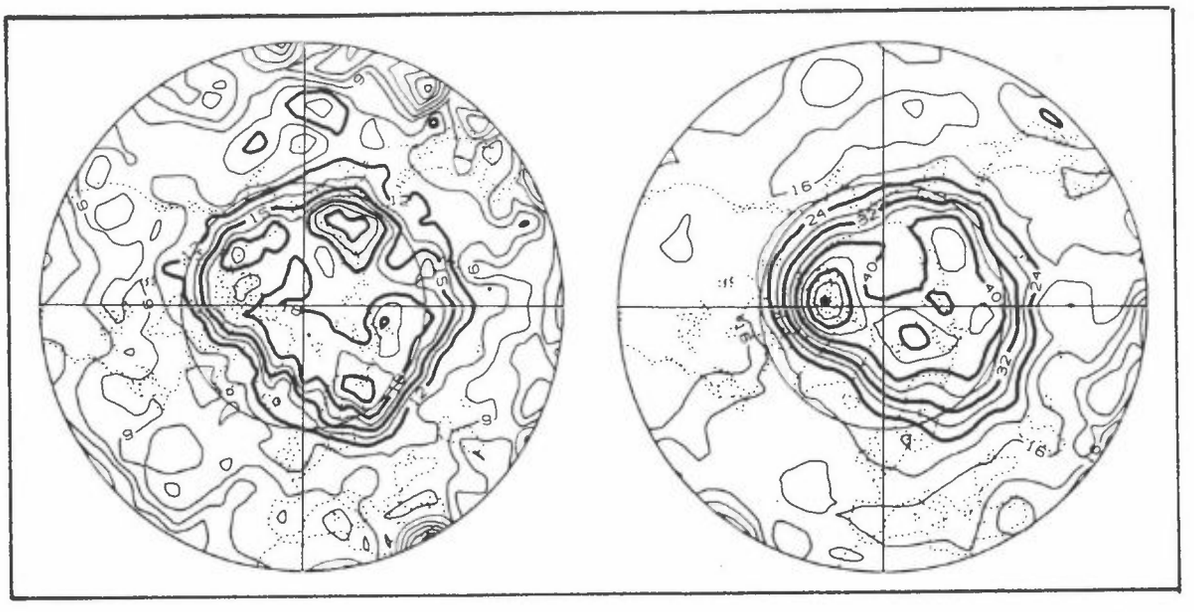
4 THE POLAR VORTEX OVER NY-ÅLESUND

The measurement site at Ny-Ålesund is usually located within the strong vortex which persists in the Arctic during the winter season. Since the exchange of airmasses between the inside and the outside of the vortex is very slow, heat transport into the vortex is prohibited, yielding very low temperatures in the lower stratosphere due to radiative cooling. PSCs are frequently observed in the region.

During the Arctic Airborne Stratospheric Expedition (AASE) in January and February 1989 Ny-Ålesund was inside the polar vortex or near the edge of the vortex the entire period, until the warming that started in the middle of February and lead to the breakdown of the vortex (see Figure 6 for one selected day). The temperatures in the lower stratosphere were frequently measured to be below -78^0 C (Figure 7) which is the approximate temperature limit for the occurance of Polar Stratospheric Clouds (PSCs). PSCs were observed in the 17-24 km region with the lidar instrument at Ny-Ålesund in 50% of the cases when the cloud conditions (tropospheric clouds) permitted observations (Figure 7).

Several AASE flights with the ER-2 plane passed Svalbard. Chemically disturbed conditions were observed in many cases in this region, in the sense that the partitioning within the nitrogen and chlorine families was highly distorted when compared with the conditions outside the polar vortex. In particular high levels of the ozone depleting constituent ClO were detected.

Although the winter of 1989, from which data has been presented in this section, was colder than normal (zonally averaged), the areal extent of temperatures low enough to allow formation of PSCs was similar to other years. PSCs have been detected from satellite instruments (SAGE) to occur regularly during the winter in the Arctic.



Figur 6: Ertel's potential vorticity on the 400 K (approximately 16 km altitude, left hand side) and 460 K (approximately 20 km, right hand side) surfaces. The edge of the vortex is in the region with the steepest gradients in the vorticity, showing that Svalbard is located inside the vortex, in this particular case, January 23, 1990 (from Newman et al.,1989).

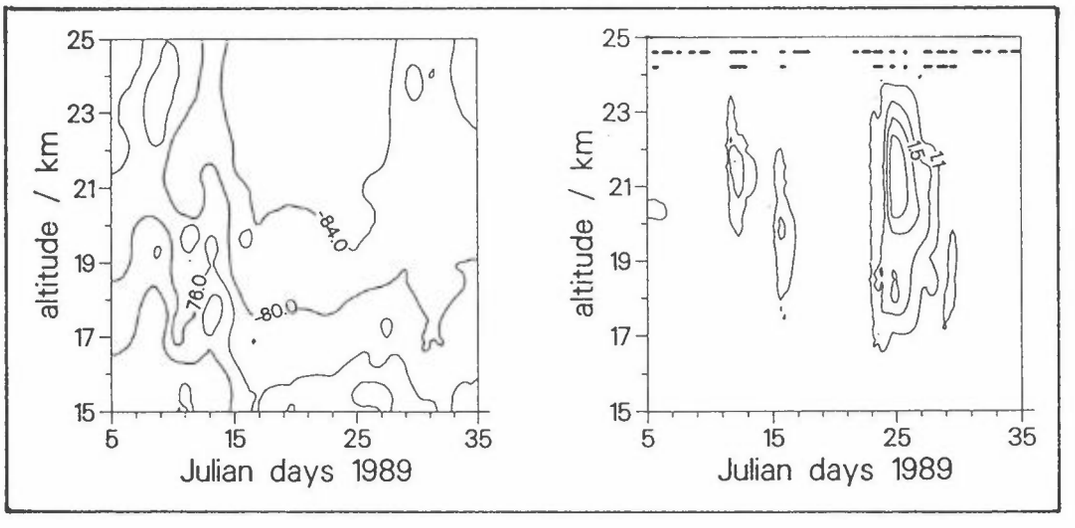


Figure 7: Lower stratospheric temperatures (left hand side) and scattering ratios (right hand side, the upper line of bars at the top of the panel shows the times when lidar observations were made, the lower line the times of PSC observations), measured with the lidar instrument at Ny-Ålesund (after Krüger, 1990).

5 INSTRUMENTATION AND ACCESS

The station can be accessed by airplane or helicopter from Longyearbyen to Ny-Ålesund and via cable car to the station. The station building is 40 m^2 and the electric power supply is 80kW. Below follows a description of measurement programmes being carried out at the station. The funding agencies of the measurement programmes are also mentioned.

EMEP (European Monitoring and Evaluation Programme):

Funded by SFT (the Norwegian State Pollution Control Authority).

Tropospheric ozone (continuous measurement, UV absorption).
NO_2, daily average, filter method (KI impregnated).
SO_2, daily average, filter method.
Sum nitrate in air, daily average, filter method.
Sum ammonium in air, daily average, filter method.
Sulphate aerosol, daily average, filter method.
Nitrate in precipitation, weekly average (the rain amount is very low).
Ammonium in precipitation, weekly average.
Sulphate in precipitation, weekly average.
Other ions in precipitation, weekly average.

Tropospheric Ozone Research (TOR), EUROTRAC subproject:

Funded by the Norwegian Research Council for Science and the Humanities (NAVF) and the Royal Norwegian Research Council for Science and Technology (NTNF).

Tropospheric ozone, continuous, UV-absorption.

C_2-C_9 hydrocarbons, every second day, spot samples taken in stainless steel bottles, analysis by gas chromatography/flame ionization detection.

Peroxyacetyl nitrate (PAN), continuous (4 samples per hour), automatic GC-electron capture detection (ECD) analysis.

Halocarbons, every second day, spot samples in steel flasks, analysis by GC-ECD.

NO and NO_2, continuous, chemiluminescence detection (soon in place).

CO, continuous, photometric detection (soon in place).

Photolysis rate coefficients for NO_2 and ozone, continuous, photometric method (planned for 1991).

Greenhouse gases:

Funded by NAVF.

Carbon dioxide, continuous, infrared absorption, operated by MISU (University of Stockholm).

Methane, every second day, spot samples in stainless steel bottles.

Chlorofluorocarbons, every second day, stainless steel bottles.

Tropospheric ozone, continuous, UV-absorption.

Particles, continuous, condensation nuclei counter, operated by MISU (University of Stockholm).

A technique for measuring N_2O using stainless steel bottle sampling and GC-EEC analysis is being developed.

Stratospheric ozone:

Funded by SFT.

A diode array (SAOZ, UV/visible) spectrometer for measurement of column densities of ozone, NO_2, O_4, H_2O and possibly OClO and BrO was installed in September 1990.

An ozone lidar is operated by Alfred Wegener Institut in Bremerhaven. Ozone sondes are launched in Ny-Ålesund by Alfred Wegener Institut at times in collaboration with the Finnish Meteorological Institute, on a regular basis from October 1990.

Polychlorinated hydrocarbons (pesticides, PCB, etc.):

A programme for measuring polychlorinated hydrocarbons will start in January 1991. Sampling will be by glassfiber filters (particles) and polyurethane plugs (PUR vapor phase).

Particles:

Filters sampled with a high volume sampler will be analysed for heavy metals. Sampling of different size fractions by a Hauke cascade impactor will soon start, and the filters will be analysed at the University of Gent. Condensation nuclei concentration is measured by MISU (University of Stockholm).

Meteorological measurements:

Wind speed and direction, humidity, temperature and pressure are measured. UV and total radiation is measured by the Norwegian Polar Research Institute.

Instruments:

Operating institutions in parantheses: NILU=Norwegian Institute for Air Research, MISU=The Meteorological Institute, University of Stockholm, NP=Norwegian Polar Research Institute.

Continuous ozone monitor, Monitor Lab (NILU).
Sequential filter samplers, NILU type EK and FK (NILU).
High volume filter sampler (NILU).
Polyurethane plug sampler (NILU).
Gas chromatograph for detection of PAN, NILU PANalyzer (NILU).
Condensation Nuclei Counter, TSI-3020 (MISU).
Condensation Nuclei Counter, TSI-3760 (MISU).
Nephelometer for visibility at 550 nm, MISU type (MISU).
Filter sampler for analysis of soot, ions and metals (MISU).
CO_2 analyzer (MISU).
Weather station, Aanderaa Instruments (wind, temperature, humidity, pressure) (NILU).
Rosemount wind meter (MISU).
PT-100 outdoor thermometer (MISU).
Atmos Equipment SAOZ for total ozone, NO_2 and other species (NILU).

To be installed late in 1990:

Hauke cascade impactor (NILU).
Tecan Cranox System for NO, NO_2 and NO_y (NILU).
CO monitor (NILU).
J_{NO2} instrument (NILU).
Siemen Ersking Net Radiometer (NP).
Kipp & Zonen Pyranometer (NP).
Eppley Ultraviolet Radiometer (NP).

As mentioned above the instruments run by NILU and NP have been funded by NTNF. Most of the instruments are or will be connected to automatic dataloggers which can be called by telephone and modem from NILU for automatic transfer of data.

6 INTERNATIONAL COLLABORATION

The station is operated by the Norwegian Polar Research Institute (NP) in collaboration with NILU. A joint committee is set up between NILU and NP to organize the daily work at the station. An engineer is employed by NP in Ny-Ålesund with the responsibility to carry out the daily duties in connection with the measuring activities. The basic running costs for the station are provided by the Norwegian Ministry of Environment through the Norwegian Polar Research Institute, while the cost involved in carrying out specific research projects has to be covered in the normal way through grants from research councils or through other channels.

The station is ideal for long term measurments, while the infrastructure in Ny-Ålesund is not sufficient to carry out intensive campaigns involving many research groups and much equipment. In particular the transportation between Longyearbyen and Ny-Ålesund is a bottle neck, and heavy equipment may have to be shipped in by boat. Ny-Ålesund is usually accessible by boat only during the summer months.

The station is open for international collaboration, and research plans can be communicated both to NILU and to the Norwegian Polar Research Institute for consideration. Research plans should be joint projects involving a Norwegian partner.

Responsible scientist at NILU: Geir Ole Braathen, NILU, Box 64, N-2001 Lillestrøm, telephone +47-6-814170, fax +47-6-819247, E-mail: geir@nilu.no (Internet).

Responsible scientist at the Norwegian Polar Research Institute: Thor Siggerud, Norsk Polarinstitutt, Rolfstangveien 12, N-1330 Oslo Lufthavn, Telephone: +47-2-123650, fax +47-2-123854

7 ACKNOWLEDGEMENT

The authors are grateful to Dr. Torben S. Jørgensen, Danish Meteorological Institute, for providing the meteorological data from Greenland.

8 REFERENCES

Krüger, B.C. (1990) Observations of polar stratospheric clouds in the Arctic winter 1989 at 79N, Geophys.Res.Lett., 17, 365-368.

Newman, P.A., Lait, L.R., Schoeberl, M.R., Nagatani, R.M. and Krueger, A.J. (1989) Meteorological atlas of the Northern Hemisphere lower stratosphere for January and February 1989 during the Airborne Arctic Stratospheric Expedition, Technical Memorandum 4145, NASA.

Steffensen, E. (1982) The climate at Norwegian Arctic stations. Klima nr. 5, DNMI.

NORSK INSTITUTT FOR LUFTFORSKNING (NILU)
NORWEGIAN INSTITUTE FOR AIR RESEARCH
POSTBOKS 64, N-2001 LILLESTRØM

RAPPORTTYPE OPPDRAGSRAPPORT	RAPPORTNR. OR 85/90	ISBN-82-425-0219-6	
DATO SEPTEMBER 1990	ANSV. SIGN.	ANT. SIDER 21	PRIS NOK 45,-

TITTEL	PROSJEKTLEDER
Arctic atmospheric research station on the Zeppelin Mountain (474 m a.s.l.) near Ny-Ålesund on Svalbard (78°54'29"N, 11°52'53"E)	G.O. Braathen
	NILU PROSJEKT NR. O-8336

FORFATTER(E)	TILGJENGELIGHET *
Geir O. Braathen Øystein Hov Frode Stordal	A
	OPPDRAGSGIVERS REF.

OPPDRAGSGIVER (NAVN OG ADRESSE)
Norsk institutt for luftforskning
Postboks 64
2001 LILLESTRØM

3 STIKKORD
Atmospheric research | baseline station | global change

REFERAT
A new atmospheric research station is built on the Zeppelin Mountain near Ny-Ålesund on Svalbard. The station is equipped with instruments measuring acid compounds and photochemical oxidants including precursors, greenhouse gases, gases that deplete the ozone layer, chlorinated hydrocarbons, particulate matter and meteorological parameters. The site is open for international collaboration.

TITLE

ABSTRACT

* Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C