PRESENT AND FUTURE DAYSIDE CUSP PROGRAM AT SVALBARD

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Abstract: The present dayside cusp program at Svalbard is summarized. Our future plans are briefly reviewed. Comprehensive, complementary observations at selected sites are needed, including several chains of ground stations. Future cusp experiments also require larger diagnostic capabilities, and the need for multi-spacecraft programs is underscored.

1. Introduction

The magnetospheric cusp is a unique region for studies of physical and chemical reactions and processes in the upper atmosphere. The cusp is also a window for investigations of the coupling and interaction between the solar wind and magneto-ionic and thermospheric processes. In this note we will primarily concentrate on auroral emissions. For a broader summary the reader is referred to the paper by CARLSON *et al.* (1985).

The optical signatures seen by cameras, interferometers and photometers map the virtual motion of plasma features. The dynamics of polar region effects and their coupling to lower latitudes can, in part, be studied by chains of magnetic and optical ground stations.

The past few years have seen an increasing interest in the magnetospheric cusp region. The fundamental questions in relation to this region have now been recognized, but many of these remain unsolved.

2. The Dayside Cusp Program at Svalbard

One region in the Northern Hemisphere which satisfies the observational conditions for daytime aurora is the island group Svalbard. During December and January the sun is never higher there than 10° below the horizon, and the cusp region normally passes almost overhead (see Fig. 1).

Measurements of the Earth's magnetic field and auroral observations have been carried out at Svalbard, more or less continuously, since the turn of the century. Not until the International Geophysical Year (IGY) 1957–58, when all-sky cameras were

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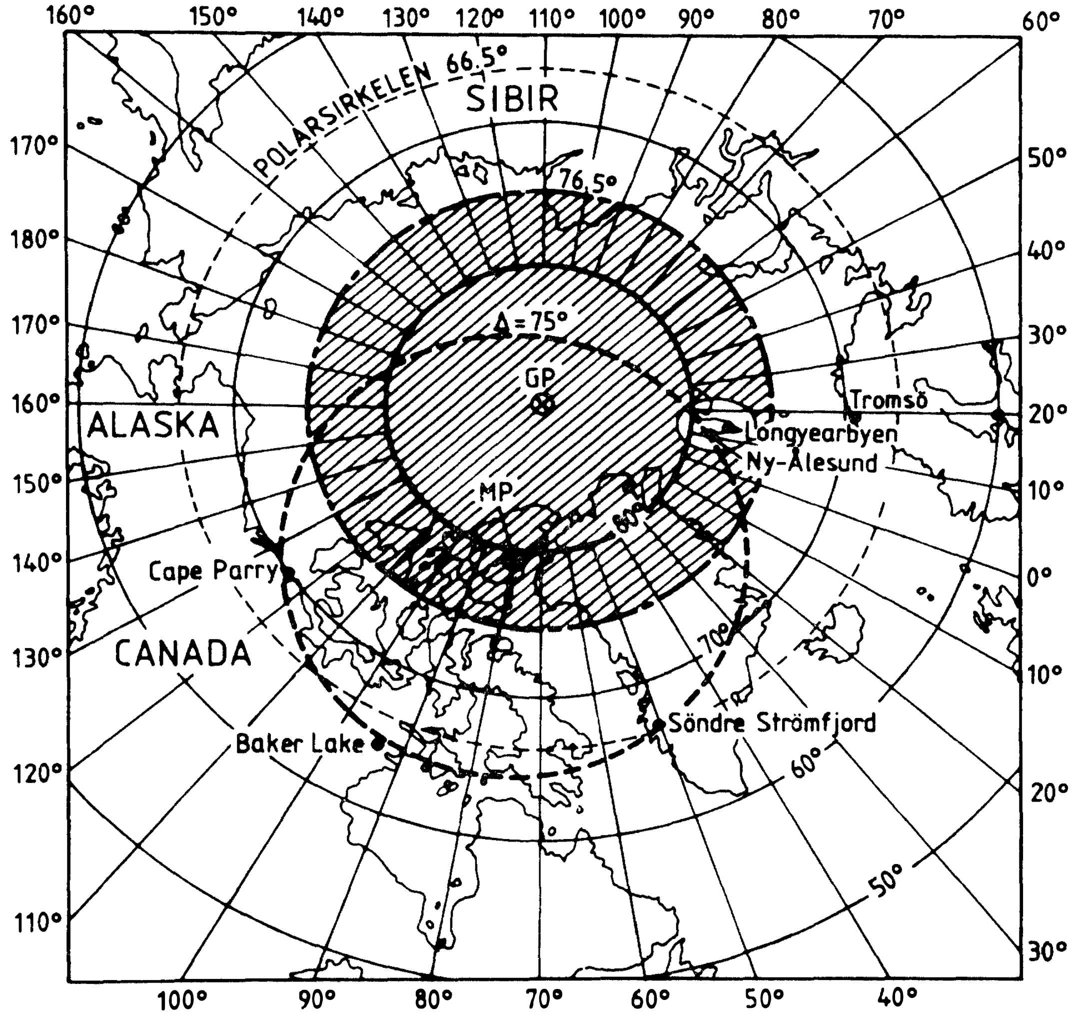

Fig. 1. A map of the Northern Hemisphere. The shaded area centered on the geographic pole (GP) represents the region accessible for daytime auroral observations (i.e. where the sun is 10° below horizon during winter solstice.) The dashed circle is the typical location of the dayside aurora. This circle is centered on the 75° invariant latitude. As this map shows Svalbard and Franz Joseph Land is the only land region in the Northern Hemisphere with satisfactory observational conditions for dayside cusp auroral observations.

extensively used, was it concluded that aurorae occur frequently at Svalbard during daytime. Since then, standard magnetic and all-sky recordings have been carried out at Svalbard by The Auroral Observatory, University of Tromsø.

The possibility of carrying out simultaneous, coordinated optical measurements from two or more sites (Longyearbyen, 78.2°N, 15.6°E and Ny-Ålesund, 78.9°N, 11.9°E), on the same geomagnetic meridian and separated by 110 km, is another advantage at Svalbard (Fig. 2). In addition, the stations are in the transpolar meridian chain of auroral observatories extending from Alaska through Canada and into Europe through Scandinavia (see Fig. 1). This latter situation allows simultaneous day- and night-side observations on the same meridian.

A joint, multi-national cooperation for studies of optical dayside cusp signatures was started at Svalbard during the winter of 1978–79, and this program is still con-

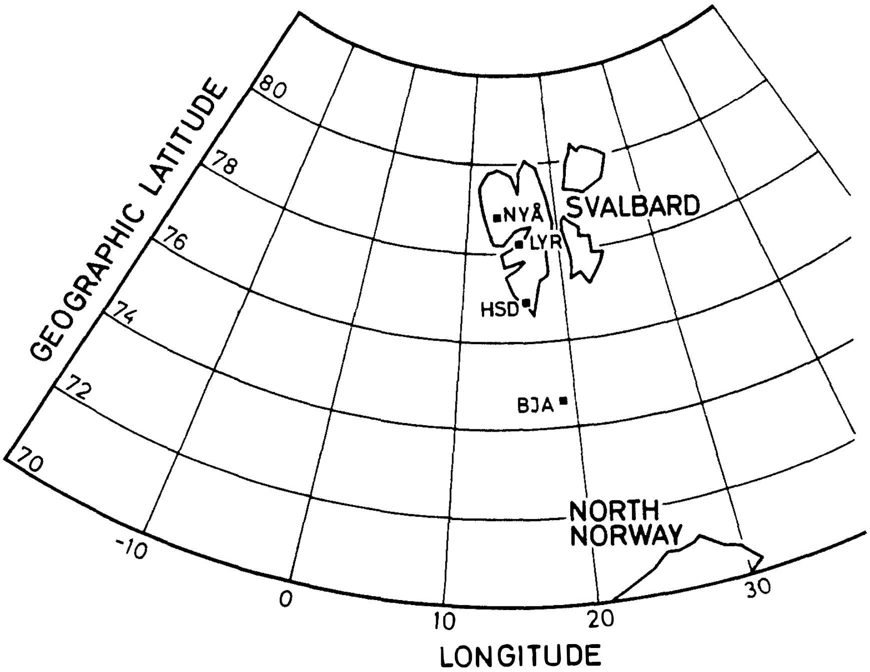

Fig. 2. A map showing the field sites of the dayside cusp recording stations in the Scandinavian sector (cf. also Table 2).

tinuing. An overview of the instrumental set-up and the participating research institutions are listed in Table 1.

A new, modern auroral station was built in Adventdalen, 5 km from Longyearbyen in 1983 with 120 m^2 of internal laboratory space plus a 40 m^2 outdoor raised platform.

In addition to the optical program, naturally occurring electromagnetic emissions and magnetic micropulsations have been recorded continuously at Svalbard for more than ten years by Institute of Physics, University of Oslo. As the noise background level is low, Svalbard is well located for high quality recordings of ULF, ELF and VLF emissions. The main purpose of this study is to:

a) map the occurrence of ULF, ELF and VLF activity as function of latitude and time,

b) correlate this activity with dayside cusp aurora, and

c) study propagation and generation characteristics.

A large amount of Svalbard data, both optical and geomagnetic as well as electromagnetic wave measurments, have been presented (*e.g.* DEEHR *et al.*, 1980; SANDHOLT *et al.*, 1983; HOLTET *et al.*, 1983; SIVJEE, 1985; HENRIKSEN *et al.* 1985; SMITH, 1985). In addition, we will also mention the Proceedings from the Lillehammer ASI-meeting, May 1984 on The Morphology and Dynamics of the Polar Cusp by HOLTET and EGELAND, 1985.

Dr. H. C. CARLSON, Jr. (AFGL, Hanscom, Mass. USA) and coworkers have loaned us an all-sky imaging photometer which has been operated at Longyearbyen since November 1983. A group from University of Tokyo—headed by Prof. T. OGUTI—started both optical, ELF/VLF and micropulsations recordings at Ny-Ålesund in the fall of 1984.

Table 1. Instrument type, deployment and purpose for the Svalbard expedition 1978–79.

	Instrument	Institution*	Location**	Purpose
1.	All-sky camera (35 mm B & W)	GI	LYR	Location and orientation of auroral arcs and bands.
2.	All-sky camera (16 mm color)	UT	NYÅ	
3.	Meridian scanning photometer (all inc)	GI	LYR	Mapping of local time position of red (6300 Å) cusp and discrete bands and associated characteristic energy of precipitating particles.
4.	Meridian scanning photometer (4278 Å N_2^+)	US	LYR	
5.	Meridian scanning photometer (6300 Å)	NIKF	NYÅ	
6.	Meridian scanning photometer (OI and 4861 Å H beta)	GI	PKR, FYU	
7.	Zenith LLLTV	NIKF	LYR	Morphology of fast-moving bands.
8.	Fabry-Perot interferometer (6300 Å)	UP	LYR	Doppler wind and temp of neutral *F*-region.
9.	1-m spectrophotometer (3000–87000Å)	GI	LYR	Spectroscopic studies of various atmospheric emissions.
10.	1/2-m spectrophotometer	GI	LYR	
11.	Magnetometer	UT	NYÅ	Determination of substorm-related effects.
12.	Magnetometer	UT	BJØ	
13.	Magnetometer	UT	TOS	
14.	Magnetometer chain (7 instruments in Alaska chain)	GI	AK	

				Location coordinates			
				Geographic		Geomagnetic	
				Lat.	Long.	Lat.	Long.
		**NYÅ–	Ny-Ålesund	78.9	15.6	75.4	114.7
*GI–	Geophysical Institute	LYR–	Longyearbyen	78.2	11.9	74.4	129.4
NIKF–	Norwegian Institute of Cosmic Physics	BJØ–	Bjørnøya	74.5	19.2	71.1	110.5
UP–	Ulster Polytechnic	TOS–	Tromsø	69.7	19.0	66.0	105.2
US–	University of Saskatchewan	AK–	Alaska Chain	63 to 80	~150	62.9 to 89	~260
UT–	University of Tromsø	PKR–	Poker Flat	64.9	148.0	64.9	260.3
		FYU–	Fort Yukon	66.6	145.3	67.0	260.7

The Polar Geophysical Institute, Appatity, USSR, operates a geophysical observatory at Barentsburg, roughly 40 km from the station at Longyearbyen.

3. Future Plans for Dayside Cusp Studies at Svalbard

The cusp research program at Svalbard will be continued and in several aspects extended and up-graded during the next five years. In addition to the Ny-Ålesund and Longyearbyen stations, two more sites—Hornsund and Bjørnøya (Fig. 2)—will be actively used. The planned instrumental set up at these four observatories together with coordinates are listed in Table 2. Furthermore, better living and working quarters for scientists in Longyearbyen are planned.

The following main projects will have priority:

Table 2. Ground based station and instrumental set up at the Svalbard Archipelago.

Station name	Ny-Ålesund (NYÅ)	Longyearbyen (LYR)	Hornsund (HSD)	Bjørnøya (BJA)
Geographic latitude	79.00	78.20	77.0	74.50
Geomagnetic latitude	75.44	74.36	73.54	71.1
L-value	16.5	14.4	13.1	9.5
Magnetic midday (UT)	0830	0830	0830	0830
Magnetometer*	x	x	x	x
Riometer	x		x	x
All-sky camera	x	x	x	
Meridian scanning photometer**	x	x	P	P
Auroral spectrometer	P	x		
Fabry-P. interferometer	x	x		
Auroral TV camera	P	x		
ELF/VLF emission	x	P	x	
Micropulsation	x		x	P
Ionosonde	P			
Ozone	P	x		

* Plan to install three new magnetometer stations in addition to those listed.
** Intensified ASC (630 nm) exist. x: Existing, P: planned.

1) In order to map the height, location, latitudinal width and dynamics of the dayside cusp aurora *vs.* time and ionospheric/magnetospheric activity, multichannel meridian scanning photometers and/or all-sky imaging photometers, as well as auroral TV cameras will be operated at all stations. (This will be done in cooperation with scientists from AFGL/USA and University of Tokyo, Japan, in addition to the ongoing cooperation (Table 1).) A close coordination by similar observations carried out simultaneously on the night-side is an important part of the ongoing cooperation.

2) The study of the midday auroral spectrum will continue and be extended into the infrared (*i.e.* from 0.3 to 3 μm) (SIVJEE, 1985). The future program includes: the $O^+(^2D)-N_2$ charge exchange process, variations in the N, and O abundances in the polar atmosphere, non-LTE vibration distributions of thermospheric molecules, and wave-induced perturbations of N, OH, and O_2-emissions. The measurements will be compared with synthetic spectra and used as data for model calculations.

3) Helium abundance in the polar atmosphere using the He I emission at 1083 nm will be correlated with the 587.6 nm (He I). Spectrometric measurements will be extended to the OH-band which will be used to monitor mesospheric temperature. The slowly varying solar depression angle at Svalbard is excellent for twilight studies of resonance emissions, especially the alkali metals in the mesopause. The program will also include measurements of the solar spectrum from 290 to 900 nm for biological, climatological and medical purposes. New optical instruments such as auroral lidar and/or infrared Michelson interferometer have been proposed.

4) The *F*-region in the vicinity of the cusp plays a large role in the general thermospheric circulation. Optical interferometric observations yielding ion and neutral winds will continue to be coordinated with both optical and radiowave observations of the dayside aurora during the months immediately adjacent to the winter solstice. Other special studies to be undertaken include ion-neutral coupling, Joule heating and

their relationship to auroral magnetospheric processes, and also to the Interplanetary Magnetic Field (IMF). Recent Fabry-Perot measurements and associated theoretical studies have indicated that the cusp region has a critical role in the overall polar thermospheric neutral circulation due to the convergent geometry of the ion convection near the dayside auroral zone and the dominant importance of ion drag forcing the thermospheric momentum balance. This has been convincingly demonstrated by the discovery of the dependence of the neutral thermospheric wind on the IMF.

5) The OH and O_2 airglow near the mesopause shows high intensities and large changes in temperature at 78°N latitude. These changes are related to transport processes associated with atmospheric disturbances. Three spectrometers will be used to determine the directional onset and decay of atmospheric disturbances such as gravity waves at the mesopause. It appears that these observations can be made in less than 5 min at the high levels of airglow intensity found in the winter polar region.

6) Beginning with the 1984–85 winter observations, the three northern stations will be equipped to record micropulsations, ULF, ELF, and VLF emissions. The ELF/VLF receiver at Ny-Ålesund will be upgraded and will be included in the global net for monitoring ULF-VLF noise and wave activity.

In addition, there are plans to install a digital ionosonde at Ny-Ålesund.

Coordination will be particularly significant with the VHF/UHF incoherent scatter radar (EISCAT) in Northern Scandinavia and polar orbiting satellites such as HILAT and VIKING will be important. In addition, a dayside auroral-cusp sounding rocket program from Svalbard has been proposed. Coordination of ground and satellite data have already started, but this type of activity will be greatly extended in the near future.

4. Conclusions

Though much recent progress has been made, many new questions have been raised and there is a clear need to map and quantify further the various coupling and interaction processes occurring in the region associated with the polar cusp.

Comprehensive studies of processes unique to the dayside cusp region have been proposed at Svalbard and we would welcome the cooperation and participation of other research groups in this program. In particular, we believe there is a large need for closer cooperation, both in data collection and interpretation, between groups working at Svalbard and the South Pole (CARLSON *et al.*, 1985). Further progress will strongly dependent on thorough planning, coordination, and cooperation.

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(Received January 31, 1985)