Chinese Journal of Polar Science, Vol.13, No.1, 67 - 74, June 2002

The Auroral Station in Adventdalen, Svalbard

F Sigernes[1], T Svenöe[1] and CS Deehr[2]

1 *The University Courses on Svalbard, N - 9171 Longyearbyen, Norway*

2 *Geophysical Institute, University of Alaska, Fairbanks, USA*

Received March 27, 2002

Abstract This paper describes the Auroral Station in Adventdalen near Longyearbyen, Svalbard (78°N, 15°E). The main instruments at the site are for optical observation of aurora and airglow, but magnetic and radar observations are also carried out. Emission spectra show the difference between the dayside and nightside optical aurora. A newly compiled mesospheric temperature series from the station is also presented, derived through 20 years of spectral measurements of the hydroxyl airglow layer.

Key words auroral optics, cusp, nightside and dayside aurora, airglow, hydroxyl emissions, triangulation, proton and electron precipitation.

1 Introduction

The Auroral Station in Adventdalen was built in 1978 and has worked as an optical site for ground - based observations of the dayside and nightside aurora in the polar cap. Figure 1 shows a photograph of the station together with a typical storm type aurora (Simmons *et al*. 1996). The station is in daytime located underneath the average dayside aurora oval. The two months of astronomical darkness at mid - winter makes the location to one of the most ideal places for ground - based observations of the daytime aurora.

The station has a fairly large group of high resolution, low light level optical instruments. Data from these instruments have been used widely in publications throughout the last two decades of auroral/space research. Sigernes (1997) determined the publication rate of the station to be about 1 paper per month. The number of graduated doctoral candidates using station as their main laboratory is 10.7 from the Optics Group at the Geophysical Institute, University of Alaska (UAF) and 3 through the Geophysical Department at the University Courses on Svalbard (UNIS). About 30 masters degree students from several institutions throughout the whole world have stayed to collect data for their thesis. Numerous scientific campaigns have been carried out with the station as headquarters. The University of Tromsö (UiTö) is the owner of the site, and the University of Alaska, Fairbanks contributes both with instruments and funds. The geophysics group at UNIS has become one of the new users of the station with both teaching and scientific objectives as primary goals. The Geophysical department at UNIS has the daily operational responsibility. A Scientific Station Board (SSB) is responsible for coordinating the experimental activity carried out at the station. UNIS leads SSB. Each user is requested to pay an annual fee to UiTö to cover the operating expenses of the station.

The main instruments at the site will be presented together with samples of data obtained

Fig.1. The Auroral Station in Adventdalen, Norway. Photograph of Storm – type aurora at 23:48 GMT on January 17, 1994 (Simmons *et al*. 1996).

from the station's last two decades of successful operation. Finally, we will give a present status report of the station followed by future recommendations.

2 Instrumentation

The optical instruments at the station are used to study a variety of problems including dayside and nightside aurora, airglow, and dynamics of the thermosphere and mesosphere. The instruments are grouped into mainly four categories: (1) all – sky cameras and narrow field of view imagers, (2) meridian scanning photometers, (3) spectrometers/spectrographs and (4) scanning/imaging interferometers.

During the auroral winter season approximately 25 instruments are operated at the station, 20 optical and 5 non – optical, respectively. A detailed description of the performance and the scientific objective of each instruments is found at the stations web server: http://haldde.unis.no.

3 Data presentation

Out of the above assembly of instruments, there are 5 instruments that qualify as basic or key instruments in the daily operation of the station. Data from these instruments are fed to the station's main server which produce quick plots on the internet available to ongoing campaigns and the scientific community. The basic instruments are the Meridian Scanning Photometer (MSP), a All – Sky Camera (ALSC) and the 3 Ebert Fastie spectrometers. Auroral morphology is mapped by the camera followed up by the MSP to give intensity ratios between the different channels. The spectrometers give us the spectral information. As an example of data from the station, Fig.2 shows MSP data obtained from the SCIFER (Sounding of the Cleft Ion Fountain Energitization Region) sounding rocket campaign in 1995. The launch was from Andφya rocket range with the station as headquarters. The energetic electron trapping boundary is clearly located between the poleward edge of the pulsating aurora and the equatorial edge of the dayside auroral oval (discrete, poleward-moving auroral forms, first identified by Sandholt *et al*. 1986). These observations were confirmed by the particle data of the rocket. Another powerful technique is to triangulate with the MSP in Ny-Ùlesund, located 118 km geomagnetic north of the station (Sigernes *et al*. 1996c). Figure 3 shows the height distribution of the poleward moving auroral form which was the target of the rocket. The characteristic electron energy of the primary electrons was estimated by the red to green ratio to be around 0.3 keV. This is consistent with the rocket's particle data and the altitudes of maximum emissions, respectively. The main proton fluxes were observed poleward of the trapping boundary (Lorentzen *et al*. 1996). The proton signatures associated with dayside activity was first observed from ground by Henriksen *et al*. (1985). Sigernes *et al*. (1996a) confirmed these measurements and observed that the dayside proton precipitation have a bursty or pulsed nature. According to figure 4, the width and shape of the Doppler profile indicate that the initial energy of the precipitating protons are in the order of 1 keV (cf. Sigernes 1996b) and believed to be directly connected the reconnection process at the dayside magnetospause (Deehr *et al*. 1998).

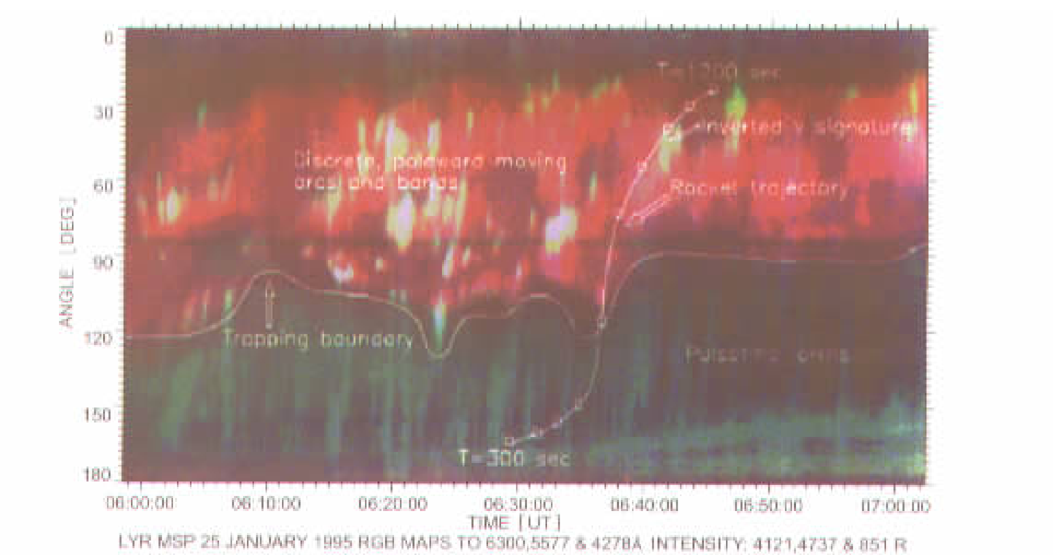

Fig. 2. Meridian Scanning Photometer (MSP) from the Auroral Station in Adventdalen 25 January 1995. The red, green and blue colors represents the auroral emissions 6300 [OI], 5577 Ù [OI] and 4278 Ù [N_2^+ ^{1}NG], respectively (Lorentzen *et al*. 1996).

Fig.5 and 6 show the typical difference between mid – day cusp aurora and night – time aurora, respectively. The molecular emissions are completely absent on the dayside. Indicating that the source particles do not have enough initial energy when entering the top of atmosphere to excite the molecular layers in the lower thermosphere, which is consistent with atomic emission height profiles of figure 3. Also note that, the night – time emissions are in the kR range while the daytime atomic line intensities are around tens of R.

The mesosphere may be the least known parts of our atmosphere, partly because of the problem of obtaining direct in situ observations. On the other hand it appears that this part of the

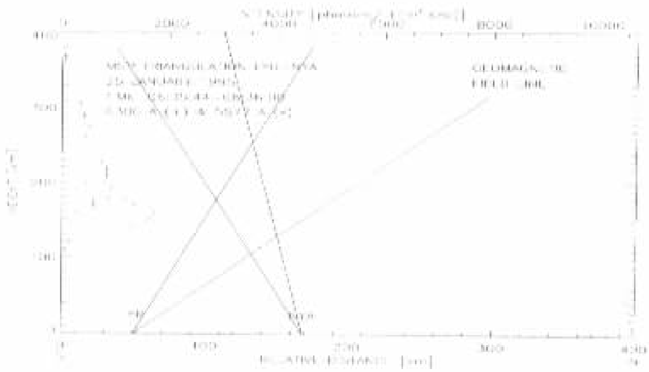

Fig. 3. The volume emission rate as a function of altitude 25 January 1995 from Ny– Ùlesund (NYA) and the Auroral Station in Adventdalen (LYR). The [OI] 6300 Ù is plotted as (+) and the [OI] 5577 Ù as (*).

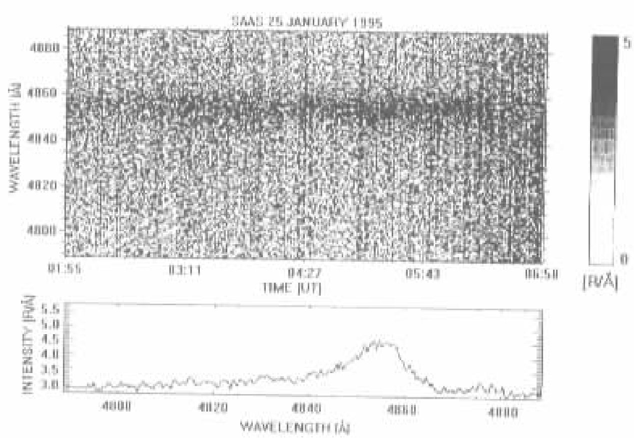

Fig. 4. Upper panel shows a spectrometer grayscale plot as function of wavelength and time for 25 January 1995 from the Auroral Station in Adventdalen. The scaled bar to the left indicates intensities per Ùngstrom in Rayleighs. Lower panel shows the corresponding time averaged Doppler profile of H_{β} 4861 Ù.

atmosphere may be most, and first, affected by changes in the atmospheric content of greenhouse gases. There are clear signs that these parts of the atmosphere have changed profoundly at least during the last three decades (Gadsden 1990). Mid latitude rocket measurements by Golitsyn *et al*. (1996) reports a negative temperature trend of -30 K since 1957. On the other hand, direct observations by the falling sphere technique, which give temperatures up to approximately 95 km, does not give any negative or positive trends of the polar mesopause temperatures during summer (Lübken 2000). Clearly, there is need for more long term temperature measurements from different locations and by different methods.

Atmospheric temperature measurements obtained from OH emission spectra have been car-

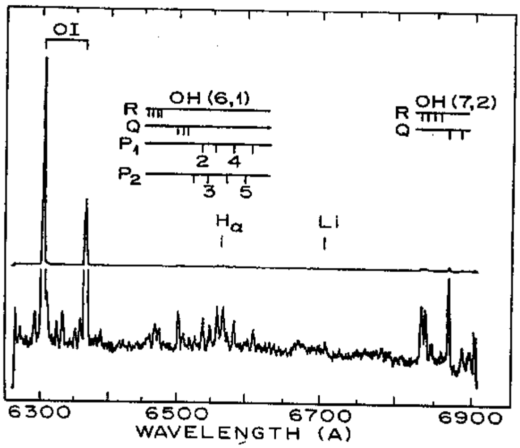

Fig.5. Mid – day cusp auroral spectra from the Auroral Station in Adventdalen. Note the weak OH(6 – 1) emissions and the narrow H_α profile.

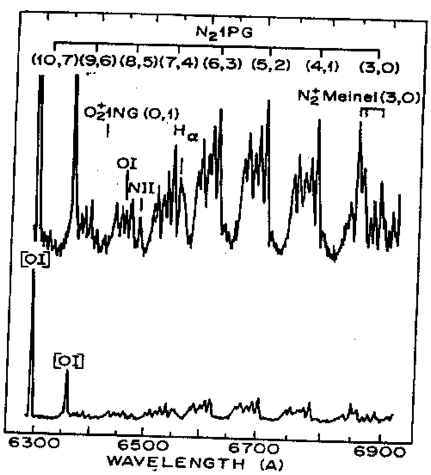

Fig.6. Night – time auroral spectra from the Auroral Station in Adventdalen. Note the strong N_2, O_2^+ and N_2^+ emissions.

ried out at the Auroral Station since 1980. The temperature is inferred from the relative photon emission rates of various lines in the OH(6 – 2) band by constructing synthetic spectra that best match the observations. The basis for calculating these spectra is given by Herzberg (1950) with term values from Krassovsky *et al*. (1962) and Einstein coefficients from Turnbull and Lowe (1989). The uncertainty of the above method is approximately ± 2 K (Viereck and Deehr 1989). The OH(6 – 2) daily mean rotational winter temperature from 1980 to 2001 is plotted in Fig.7. Large variations in the temperature may occur within each daily average. The temperature may change more than 20 K within an hour due to the interaction of gravity waves with the emitting layers. The annual behavior is a relatively low temperature in late December followed by a warm period in early January as first reported by Myrabϕ(1986), but further analysis is necessary in order eliminate the effects of longer term trends. Nevertheless, there appears to be no dramatic changes in the winter temperatures of the polar mesospause over the past twenty years.

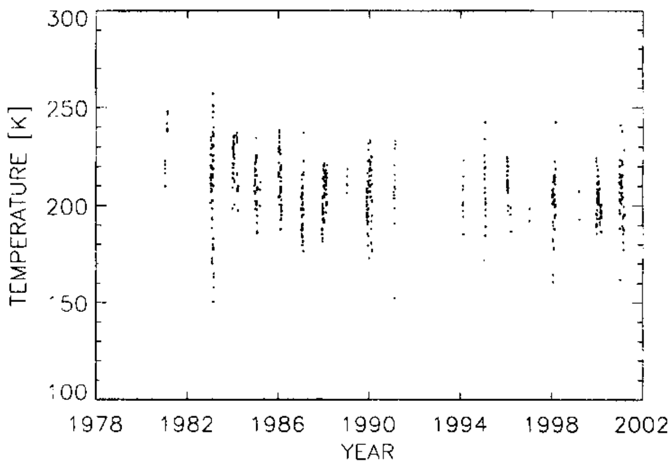

Fig.7. Seasonal mesospheric OH(6 – 2) airglow winter temperature over Svalbard 1980 – 2001.

4 Present status

New instruments are being tested and compared to the basic ones described above. Both the spectral and spatial resolution will be improved. A new Ebert-Fastie spectrometer from the University of Tromsö will soon replace the one we have planned to be moved to Ny – Ùlesund. This project involves dual spectral measurements of hydrogen emissions from our station and Ny – Ùlesund in order to study the velocity filter effect of the dayside protons. A new scintillation antenna will be built behind the station by the University of Oslo and the US Air Force Research Laboratory. It will used to study sub – km scale irregularities in the dayside and night side auroral oval – PIS (Polar Ionospheric Scintillation). Near future plans also involve construction of a control link to the polar orbiting TUBSAT (Technical University of Berlin Satellite) satellite. It carries 3 monochromatic cameras and is gyro stabilized to track objects. The aim is to get a bird watch of the aurora as we track the station operating from the other side.

The activity at the station has steadily increased during the past decade. The SSB has not been able to accommodate all requests for research activity. The need for more and better space will very soon limit further expansion. For that reason we have been forced to expand our outdoor platform to make space to a new French group that will operate a Michelson interferometer PIS (Etudes Polaires per Intererometrie a Svalbard).

5 Recommendation

The plans for a new station were made almost 6 years ago. The long period of uncertainty has limited the growth of the station at it 's current location. In addition, light pollution from Longyearbyen is an increasing problem. A new station should be built in order to be able to welcome new scientist/groups and to secure auroral optics at this unique location in the northern hemisphere.

Acknowledgements The Auroral Station in Adventdalen is owned by the University of Tromsö. The University Courses on Svalbard (UNIS) operates the station. We deeply appreciate the support of the Optical group at the Geophysical Institute, University of Alaska, who owns most of the instruments. The American program at the observatory is supported by the Atmospheric Science Division of the National Science Foundation.

References

Deehr CS, Lorentzen DA, Sigernes F(1998): Dayside auroral hydrogen emission as an aeronomic signature of magnetospheric boundary layer processes. Geophys. Res. Lett., 25: 2111.

Gadsden M(1990): A secular change in noctilucent cloud occurrence. J. Atmos. Terr. Phys., 52: 247 - 251.

Golitsyn GS, Semenov AL, Shefov NN, Fishkova LM, Lysenko EV, Perov SP(1996): Long - term temperature trends in the middle and upper atmosphere. Geophys. Res. Lett., 23: 1741 - 1744.

Henriksen K, Fedorova NI, Totunova GT, Deehr CS, Romick GJ, Sivjee GG(1985): Hydrogen emissions in the polar cleft. J. Atm. Terr. Phys., 47: 1051 - 1056.

Herzberg G(1950): Spectra of Diatomic Molecules. NewY.: D. Van Nostrad co., inc.

Krassovsky VI, Shefov NN, Yarin VI(1962): Atlas of the Airglow Spectrum 3000 - 12400 Ù. Planet. Space Sci., 9: 883 - 915.

Lorentzen DA, Deehr CS, Minow JI, Smith RW, Stenbaek - Nielsen HC, Sigernes F, Arnoldy RL, Lynch K(1996): SCIFER - Dayside auroral signatures of magnetospheric energetic electrons. Geophys. Res. Lett., 23: 1885.

Lübken FJ(2000): Nearly zero temperature trend in the polar summer mesosphere. Geophys. Res. Lett., 27: 3603 - 3606.

Myrabö HK(1986): Winter - season mesopause and lower thermosphere temperatures in the northern polar region. Planet Space Sci., 34: 1023 - 1029.

Sandholt PE, Deehr CS, Egeland A, Lybekk B, Viereck R, Romick GJ(1986): Signatures in the dayside aurora of plasma transfer from the magnetosheat. J. Geophys. Res., 91: 10063.

Sigernes F(1997): Auroral Spectroscopy? A status report to the Auroral Observatory. University of Tromsö, 1 - 30.

Sigernes F, Fasel G, Deehr CS, Smith RW, Lorentzen DA, Wetjen LT, Henriksen K(1996a): Calculations and Ground - based Observations of Pulsed Proton Events in the Dayside Aurora. J. Atm. Terr. Phys., 58: 1281.

Sigernes F(1996b): Estimation of initial auroral proton energy fluxes from Doppler profiles. J. Atm. Terr. Phys., 58: 1871.

Sigernes F, Moen J, Lorentzen DA, Deehr CS, Smith R, ö ieroset M, Lybekk B, Holtet J(1996c): SCIFER - Height measurements of the midmorning aurora. Geophys. Res. Lett., 23: 1889.

Simmons DAR, Sigernes F, Henriksen K(1996): Weather, twilight, and auroral observing from Spitsbergen in the polar winter. Polar Record, 32(182): 217 - 228.

Turnbull DN, Lowe RP(1989): New hydroxyl transition probabilities and their importance in airglow studies. Planet. Space Sci., 37 (6): 723 - 738.

Viereck RA, Deehr CS(1989): On the interaction between gravity waves and the OH Meinel (6 - 2) and O_2 atmospheric (0 - 1) bands in the polar night airglow. J. Geophys. Res., 94: 5397.