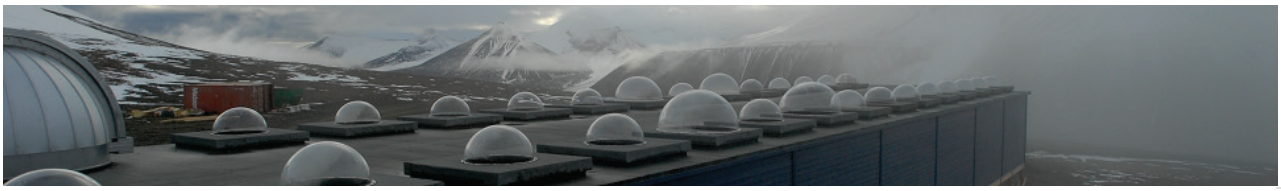

Status of the Kjell Henriksen Observatory 2006 – 2012

Fred Sigernes, Margit Dyrland, Silje Eriksen Holmen, Xiangcai Chen, Henrik Bjørklund, Lisa Baddeley and Dag Lorentzen

The University Centre on Svalbard (UNIS), N-9171 Longyearbyen, Norway.
Birkeland Centre for Space Science

Abstract

This paper is written as a response to the Norwegian Office of the Auditor General's (Riksrevisjonen) investigation on the use and exploitation of arctic research infrastructure in the period 2006-2012. A short presentation of the Kjell Henriksen Observatory (KHO) is given followed by the requested scientific achievements and outcome.

Ref: 2013/431 Riksrevisjonen: 2013/00686-22 Deferred public insight ref. law §18(2)

1. Introduction

The history of observatory dates back to the Auroral Station in Adventdalen (1978). Due to lack of space for new instruments and the increasing light pollution from Longyearbyen, it was, in 2007, moved up to Breinosa close to Mine 7 and the EISCAT radars. The site is 520 m above sea level and 12 km away from Longyearbyen. The move and construction was financed by the Royal Ministry of Education and Research in Norway. The observatory was officially opened in February 2008 and named after Prof. Kjell Henriksen from the University of Tromsø, who put a lot of work and soul into the Auroral Station in Adventdalen.

The observatory is the largest instrumental platform of its kind. It contains an instrumental section with 30 optical units, a service section and a platform for future extension. Each optical unit includes a control room and an instrument room with a transparent dome to view the sky. The field of view of each dome is 180^{o}. The service section contains tool shops, garage, kitchen, and living room. UPS power and a heat circulation system are also located in this section.

The observatory is owned by the Norwegian Construction and Property Management Department division North (Statsbygg Nord). The Geophysical department at UNIS has the responsibility to operate KHO, which includes safety, water supply, waste, electric power, heat, and internet access to all clients. KHO is connected to the internet by a fiber-optic cable to Longyearbyen. Transport of clients and instruments is conducted in the winter by a belt wagon from Mine 7. UNIS hires a garage from Store Norske at Mine 7.

2. Main purpose

KHO works as an optical site for ground-based observations of the dayside and night side aurora in the polar cap. The observatory is both in daytime and nighttime underneath the impact zone of energetic particles from the Sun, i.e. a green circular belt of auroral emissions around each geomagnetic pole. These belts are known as the auroral ovals. The two months of astronomical darkness at mid–winter makes the location the most ideal places for ground–based observations of the daytime aurora. Fig.1 shows the location of the auroral oval and the terminator for low geomagnetic or solar activity.

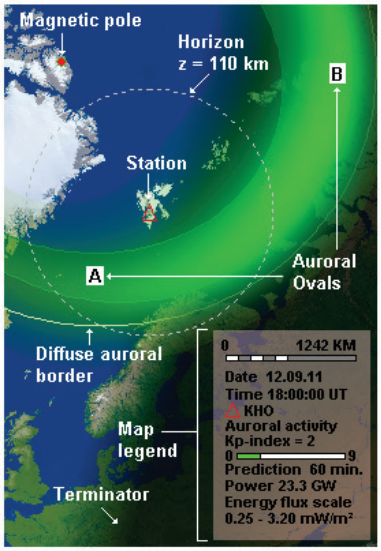

Fig. 1. The auroral oval (green)

The optical instruments at KHO are used to study a variety of questions / processes related to dayside and night side aurora, airglow, and dynamics of the thermosphere and mesosphere. Our goal is to get an overview of the Sun – Earth interaction in the magnetosphere to obtain a better understanding of upper atmospheric weather and how it connects to the lower atmosphere, and vice versa. The observatory attracts top world class scientific instrumental groups and serves an experimental laboratory for space physics at UNIS.

3. The observatory crew

The daily operations are handed by the crew listed below. They are employed by the Geophysical department at UNIS. All have personal scientific interest in KHO. They are all-year-round citizens of Longyearbyen.

Name	UNIS position	E-mail
Fred Sigernes	Professor, Optics and Atmospheric Research, Head of The Kjell Henriksen Observatory	freds@unis.no
Dag Arne Lorentzen	Professor, Upper polar atmosphere	dagl@unis.no
Lisa Baddeley	Associate Professor, Radar applications, Head of the Space Plasma Exploration by Active Radar (SPEAR)	lisab@unis.no
Margit Dyrland	Post Doc, Middle atmospheric physics	margitd@unis.no
Silje Eriksen Holmen	PhD candidate, Middle atmospheric physics	siljeh@unis.no
Xiangcai Chen	PhD candidate, Aurora physics	xiangcai.chen@unis.no
Henrik Bjørklund	Master candidate, Aurora physics	henribj@stud.ntnu.no

Table 1. The Kjell Henriksen Observatory crew (2013).

Our Norwegian Construction and Property Management Department in Longyearbyen contact is Tommy Frantzen (tofr@statsbygg.no).

4. Instrumentation

The instruments at KHO are grouped into mainly six categories (#):

A. All-sky cameras and narrow field of view imagers,
B. Meridian scanning photometers,
C. Spectrometers / spectrographs

D. Scanning / imaging interferometers
E. Radio or non-optical instruments
F. Active optical instruments (lasers)

Table 2 below lists all of the instruments according to institution and category (#).

	Instrument	Institution	#	Country
1	All-sky imager	University of Oslo (UiO)	A	Norway (NO)
2	All-sky intensified video camera	University Centre in Svalbard (UNIS)	A	NO
3	All-sky intensified camera	Finnish Meteorological Institute (FMI)	A	Finland
4	All-sky color camera	University College London (UCL)	A	England
5	All-sky video camera	UNIS	A	NO
6	All-sky DSLR camera	UNIS	A	NO
7	All-sky Airglow Imager	UNIS	A	NO
8	Auroral meridian spectrograph	National Institute of Polar Research (NIPR)	C	Japan
9	CCD spectrograph	Embry Riddle Aeronautical University (ERAU)	C	USA
10	Spectrographic Imaging Facility	The University of Southampton/UCL	C	England
11	Meridian-Scanning Photometer	University of Alaska Fairbanks/UNIS	B	USA/NO
12	1m S.Ebert-Fastie spectrometer	University of Alaska Fairbanks/UNIS	C	USA/NO
13	1m G.Ebert-Fastie spectrometer	University of Alaska Fairbanks/UNIS	C	USA/NO
14	1/2m B.Ebert-Fastie spectrometer	University of Alaska Fairbanks/UNIS	C	USA/NO
15	1/2m W.Ebert-Fastie spectrometer	University of Tromsø (UiT)	C	NO
16	Michelson Interferometer	ERAU	D	USA
17	Fabry-Perot interferometer	UCL	D	England
18	Scanning Doppler Imager	UCL	D	England
19	Ceilometer	Avinor	F	NO
20	Monochromatic Auroral Imager	Polar Research Institute of China (PRIC)	A	China
21	All-sky Airglow Imager	University of Electro-Communications (UEC)	A	Japan
22	Fluxgate magnetometer	UiT	E	NO
23	2-axis search coil magnetometer	Augsburg College/Univ. of New Hampshire	E	USA
24	Ionospheric Tomography receiver	University of Wales Aberystwyth (Aber)	E	England
25	Auroral Radio Spectrograph	Tohoku University	E	Japan
26	HF acquisition system	Institute of Radio Astronomy/UiT	E	Ukraine/NO
27	64xBeam Imaging Riometer	Danish Meteorological Institute (DMI)/UiT	E	Denmark/NO
28	Balloon Telemetry Station	Nobile/Amundsen - Stratospheric Balloon Center/Italian Space Agency	E	US/Italy
29	Hyperspectral tracker (Fs-Ikea)	UNIS	C	NO
30	All-sky hyperspectral camera	UNIS	C	NO
31	Narrow field of view tracker	UNIS	A	NO
32	Scintillation and TEC receiver	University of Bergen (UiB)	E	NO
33	Automatic weather station	UNIS	E	NO
34	4xWEB cameras (safety)	UNIS	A	NO
35	Celestron 4m Telescope	UNIS	A	NO

Table 2. Instruments at the Kjell Henriksen Observatory (2006-2012).

During the auroral winter season from November to the end of February, 25 optical instruments operate 24 hours a day. The 10 non-optical instruments run all-year-round 24 hours a day. A detailed description of the performance and the scientific objective of each instrument are found online. 21 different institutions from 9 nations were present at KHO in the time period 2006-2012. A map of where the instruments are located can be downloaded here. Note that only 4 optical units are not used.

5. Teaching and courses

KHO serves as the main laboratory for hands on training and teaching of students in the Space physics group at UNIS.

Fig. 2 shows AGF-345 students on field work using both the EISCAT radar and KHO. They used state-of-the-art facilities to do in-situ observations of the aurora. In 2010 the students hit jackpot! For two nights, the aurora offered a spectacular night sky show that gave the students an excellent opportunity to collect data for their project work.

Fig.2. AGF-345 students in 2010. Photo: Njål Gulbrandsen

In the time period 2006-2012 the following 9 courses have used KHO as part of field work:

Code	Course name	ECTS
AGF-210	The Middle Polar Atmosphere	15
AGF-216	The Stormy Sun and the Northern Lights	5
AGF-215	Satellite Remote Sensing	9
AGF-218	Satellite and Sounding rocket Construction	15
AGF-301/801	The Upper Polar Atmosphere	15
AGF-304/804	Radar Diagnostics of Space Plasma	15
AGF-331	Remote Sensing and Spectroscopy	15
AGF-351	Optical methods in auroral physics research	7.5
AGF-345/845	Polar Magnetospheric Substorms	10

Table 3. UNIS courses using KHO as laboratory (2006-2012)

A grand total of **106.6 ECTS** (European Credit Transfer and Accumulation System) have been taught.

6. Annual accounts

	2007	2008	2009	2010	2011	2012
Income	60 100	206 000	336 000	279 870	384 000	288 000
Costs:						
Salary and social costs	694 106	703 093	822 067	837 847	851 972	947 145
House rent Statsbygg	0	2 062 000	2 075 399	2 198 690	2 207 495	2 198 743
Operating costs	130 830	511 827	791 244	336 817	626 879	552 766
Sum costs	824 936	3 276 929	3 688 710	3 373 354	3 686 346	3 698 654
Hence electric power	16 890	31 669	584 308	216 894	425 746	347 816

Table 4. KHO finance 2007-2012. All numbers are in NOK.

Comments / changes between years:

2007: Start-up. UNIS did not pay rent this year.
2009: Increase in operating costs due to no charge of electrical power for 2007 and 2008.
2011: Increase in operating costs due to too small estimated power consumption in 2010.
Salary and social costs: F. Sigernes + 30% in social costs.

7. Job promotions at UNIS due to KHO

1. Fred Sigernes, Full Prof. Optics and atmospheric research, 2007.
2. Dag Arne Lorentzen, Full Prof. Upper polar atmosphere, 2008.
3. Kjellmar Oksavik, Full Prof. Romfysikk, 2008
4. Lisa Baddeley, Post Doc. SPEAR project, 2009.
5. Lisa Baddeley, Assoc. Prof. Radar applications, 2012
6. Margit Dyrland, Post Doc. Middle atmospheric physics, 2010

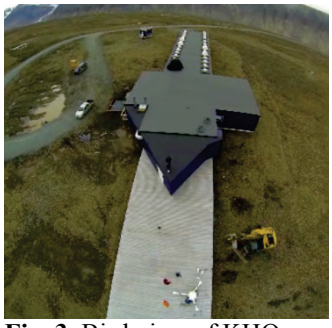

Fig. 3. Bird view of KHO

8. External funds Space physics group UNIS

#	Name of project	Finance	Year	Funds
1	Norwegian and Russian Upper Atmosphere Co-operation On Svalbard (NORUSCA)	Norwegian Science Council (NFR)	2006 - 2009	1 053 000
2	NORUSCA part 2	NFR	2010 - 2012	1 276 000
3	InfraSpace	NFR	2010 - 2014	8 200 000
4	Head of the Space Plasma Exploration by Active Radar (SPEAR)	NFR	2009 - 2012	6 617 000
5	Longyearbyen Dynamic Coherent Radar (LDCR)	ConocoPhillips	2011 - 2014	13 829 700
6	High Arctic Gravity waves and their effect on middle atmospheric circulation and temperature	NFR Frinat	2011 - 2014	3 244 000
			Total	34 219 700

Table 5. External Instrumental projects KHO-UNIS 2006-2014. All numbers are in NOK.

9. Supported sounding rocket campaigns

#	Name of rocket campaign	Information	Launch site	Time
1	Sounding of the Cusp Ion Fountain Energization Region - 2	SCIFER-2	Andøya	07:30 UT 18.01.2008
2	Investigation of Cusp Irregularities - 2	ICI-2	Ny-Ålesund	10:35 UT 05.12.2008
3	Rocket Experiment for Neutral Upwelling	RENU	Andøya	06:38 UT 12.12.2010
4	Investigation of Cusp Irregularities - 3	ICI-3	Ny-Ålesund	07:21 UT 03.12.2011

Table 6. Sounding rocket campaigns.

Note that all rockets are launched by Andøya Rocket Range (ARR). KHO has been used as launch decision site for both no. 1 and 3 in Table 6.

The SCIFER-2 rocket was a good test / exam for KHO, one month before it was officially opened. We passed the exam with flying colors according to Principal Investigator (PI) Prof. Paul Kintner from Cornell University, USA.

For the ICI-2 campaign, Prof. Jøran Moen launched the rocket from UNIS with live feed of data from both KHO and Ny-Ålesund. The data fiber connection between ARR, KHO and UNIS is essential for live feedback of data to the PI of the campaigns.

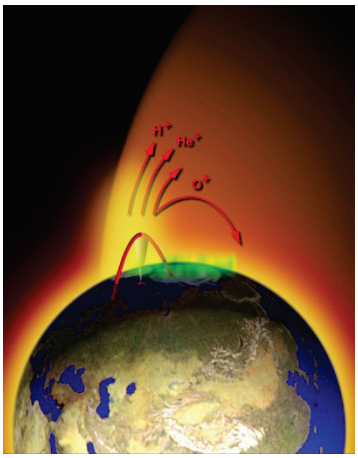

Fig.4 SCIFER-2 illustration

10. Graduated PhD students using KHO 2006 - 2012

1. C. Simon, Contribution to the study of energy inputs of solar origin in the ionosphere: Doubly-charged ions and proton kinetic transport - Application to the Earth and Titan, University of Grenoble, France, 2006.
2. E.A.K Ford, Gravity waves and small-scale structure of the high-latitude upper atmosphere, University of London, England, 2007.
3. A.S. Kashcheyev A.S. Remote sensing of wavelike disturbances in the ionosphere and on the sea surface at short wavelengths. Thesis for a candidate of physic-mathematics science degree in specialty 01.04.03 – Radio physics. – A. Usikov Institute for Radio physics and Electronics, National Academy of Sciences of Ukraine, Kharkiv, Ukraine, 2007.
4. J. Lunde, Particle Precipitation: Effects on Selected Ionospheric Phenomena, University of Tromsø, Norway, 2009.
5. Y. Obuchi, Study on dynamics of black aurora based on simultaneous optical and particle observations by REIMEI satellite, Tohoku University, Japan, 2008.
6. M. E. Dyrland, Multi-Instrument Derivation of Mesospheric Temperatures Over Svalbard, University of Tromsø, Norway, 2010.
7. H. Dahlgren, Multi-spectral analysis of fine scale aurora, KTH Electrical Engineering, Stockholm, Sweden, 2010.
8. Y. Sato, Auroral radio emissions in the MF and HF bands, Tohoku University, Japan, 2010.
9. M. Johnsen, The Dayside Open/Closed Field line boundary Ground-based optical determination and examination, University of Tromsø, Norway, 2011.
10. D. Whiter, Quantitative Analysis of Multi-Monochromatic Observations of Rapid Small Scale Aurora, University of Southampton, England, 2011.
11. E. T. Lundberg, Multipayload sounding rocket observations of velocity shear, VLF Hiss, and Alfvén Waves, Cornell University, USA, 2012.
12. M. Mella, In Situ Analysis of Measurements of Auroral Dynamics and Structure, Dartmouth College, USA, 2012.
13. H.-C.I. Yiu, Meso-scale studies of the polar cap thermosphere and ionosphere using the new Scanning Doppler Imager, University of London, England, 2013.
14. K. Hyomin, Development of Ground-Based Search-Coil Magnetometer Systems in the Polar Regions and Studies of ULF Pc1-2 Wave Propagation in the Ionospheric Waveguide, University of New Hampshire, USA, 2010.

11. SUMMARY

The overall operations and science outcome of the Kjell Henriksen Observatory (KHO) has been a success in the time period 2006 – 2012. 35 instruments from 9 nations (21 groups) have access to KHO. Since the move of 15 instruments from the old station in Adventdalen in 2007, we now have only 4 spaces left for new optical instruments. UNIS now owns ~40% of the instrumentation. 9 courses have been taught. 14 PhD students have graduated. External instrumental funding is ~34 million NOK. 4 large rockets are launched with support from us. The publication rate is close to 1.5 peer review paper per month*. 3 of our staff have been promoted to full professorship with 2 Post Docs and 1 Associate Prof. during the time period.

*See publication list 2006 – 2012.

12. Publications 2006 – 2012

The following publication list is compiled as a result of an e-mail sent to 38 scientists that are associated with KHO. 16 replied within the time frame of this report. They represent the principal investigators of KHO. The list contains 124 peer reviewed publications in the time period 2006 – 2012. The KHO publication rate is as a consequence close to 1.5 papers per month.

2006

1. Jean Lilensten, Cyril Simon, Mathieu Barthélémy, Joran Moen, Roland Thissen, D. A. Lorentzen, Considering the polarization of the oxygen thermospheric red line for Space Weather studies, Space Weather - The international Journal of Research and Applications, S11002, 2006.
2. Moen, J., H. C. Carlson, K. Oksavik, C. P. Nielsen, S. E. Pryse, H. R. Middleton, I. W. McCrea, and P. Gallop, EISCAT observations of plasma patches at sub-auroral cusp latitudes, Ann. Geophys., 24 (9), 2363-2374, 2006.
3. Pryse, S. E., R. W. Sims, J. Moen, and K. Oksavik, Ionospheric signatures of the low-latitude boundary layer under conditions of northward IMF and small clock angle, Ann. Geophys., 24 (8), 2169-2178, 2006.
4. Oksavik, K., J. M. Ruohoniemi, R. A. Greenwald, J. B. H. Baker, J. Moen, H. C. Carlson, T. K. Yeoman, Observations of isolated polar cap patches by the European Incoherent Scatter (EISCAT) Svalbard and Super Dual Auroral Radar Network (SuperDARN) Finland radars, and M. Lester, J. Geophys. Res., 111, A05310, doi:10.1029/2005JA011400, 2006.
5. Carlson, H. C., J. Moen, K. Oksavik, C. P. Nielsen, I. W. McCrea, T. R. Pedersen, and P. Gallop, Direct observations of injection events of subauroral plasma into the polar cap, Geophys. Res. Lett., 33, L05103, doi:10.1029/2005GL025230, 2006.
6. Ford, E. A. K.; Aruliah, A. L.; Griffin, E. M.; McWhirter, I., Thermospheric gravity waves in Fabry-Perot Interferometer measurements of the 630.0nm OI line, Annales Geophysicae, vol. 24, Issue 2, 555-566, 2006.
7. Griffin, Eoghan, Mike Kosch, Anasuya Aruliah, Andrew Kavanagh, Ian McWhirter, Andrew Senior, Elaina Ford, Chris Davis, Takumi Abe, Junichi Kurihara, Kirsti Kauristie, Yasunobu Ogawa, Combined ground-based optical support for the aurora(Delta) sounding rocket campaign, Earth, Planets and Space 58, 2006.
8. Kurihara, J.; Abe, T.; Oyama, K.-I.; Griffin, E.; Kosch, M.; Aruliah, A.; Kauristie, K.; Ogawa, Y.; Komada, S.; Iwagami, N., Observations of the lower thermospheric neutral temperature and density in the DELTA campaign,Earth, Planets and Space, Volume 58, p. 1123-1130, 2006.
9. Robertson, S. C., B. S. Lanchester, M. Galand, D. Lummerzheim, A. B. Stockton-Chalk, A. D. Aylward, I. Furniss, J. Baumgardner, First analysis of ground-based optical observation of H_β Doppler profiles near local solar noon in the cusp, Ann. Geophys., 24, 2543-2552, 2006.
10. Sullivan, J. M., N. Ivchenko, M. Lockwood, T. Grydeland, E. M. Blixt, B. S. Lanchester, Phase calibration of the EISCAT Svalbard Radar Interferometer using Optical Satellite Signatures, Ann. Geophys., 24, 2419-2427, 2006.
11. Lockwood, M., K. Throp, K., B. S. Lanchester, S. K. Morley and H. U Frey, Modelling the observed proton aurora and ionospheric convection responses to changes in the IMF clock angle: 2. The persistence of cusp proton aurora. J. Geophys. Res., 111, A02306, doi:10.1029/2003JA010307, 2006.
12. F. Sigernes and J. Holmes, Transmitting GPS position by an Iridium phone, Catalogue application, p. 47, Parallax Inc., Rocklin, CA 95765, USA, 2006.
13. Havnes, O., C. La Hoz, A. Aylward, E. Belova, T.W. Hartquist, M. J. Kosch, G. Morfill, L.I. Naesheim, M.T. Rietveld, M. Rubin-Zuzic, F. Sigernes, Observations of the overshoot effect during the 2004 EISCAT PMSE campaign, Advances in Space Research, Volume 38, Issue 11, p. 2344-2352, 2006.
14. Hall, C. M., T. Aso, M. Tsutsumi, J. Hoffner, F. Sigernes, and D. A. Holdsworth, Neutral air temperatures at 90 km and 70°N and 78°N, *J. Geophys. Res.,* Vol. 111**,** D14105, doi:10.1029/2005JD006794, 2006.

15. Yeoman, T. K., L. J. Baddeley, R. S. Dhillon, T. J. T. Karhunen, T. R. Robinson, A. Senior and D. M. Wright, Range corrections for multi-hop backscatter from the SuperDARN HF radars, *Geophys. Res. Lett*, submitted, 2006
16. M. E. Wilson, M. E., T. K. Yeoman, L. J. Baddeley, and B. J. Kellet, A Statistical Investigation of the Latitude-Dependance of Unstable Magnetopsheric Particle Populations in Relation to High-m ULF Wave Generation *, Ann. Geophysicae,* 24, 11,:3027-3040 2006
17. Yeoman, T. K., D. M. Wright, and L. J. Baddeley, Ionospheric Signatures of ULF Waves: Active Radar Techniques, AGU monograph on magnetospheric waves, Geophysical Monograph Series 169, 2006
18. Scoffield, H. C., T. K. Yeoman, T. R. Robinson, L. J. Baddeley, R. S. Dhillon, D. M. Wright, T. Raita and T. Turunen, First results of artificial stimulation of the Ionospheric Alfvén resonator at 78°, *Geophys. Res. Lett*, 33, L19103, 2006
19. McKenna-Lawlor, S. M. P., M. Dryer, M. D. Kartalev, Z. Smith, C. D. Fry, W. Sun, C. S. Deehr, K. Kecskemety, and K. Kudela, Near real-time predictions of the arrival at Earth of flare-related shocks during Solar Cycle 23, J. Geophys. Res., 111, A11103, doi:10.1029/2005JA011162, 2006.

2007

20. Lorentzen, D. A., P. M. Kintner, J. Moen, F. Sigernes, K. Oksavik, Y. Ogawa, and J. Holmes, Pulsating dayside aurora in relation to ion upflow events during a northward interplanetary magnetic field (IMF) dominated by a strongly negative IMF BY, J. Geophys. Res., 112, A03301, doi: 10.1029/2006JA011757, 2007.
21. Sigernes, F., Holmes, J. M., Dyrland, M., Lorentzen, D.A., Chernouss, S. A., Svenøe, T., Moen, J. and Deehr, C. S., Absolute calibration of optical devices with a small field of view, Journal of Optical Technology, 74 (10), 669-674, 2007.
22. Dyrland, M. E., and F. Sigernes, An update on the hydroxyl airglow temperature record from the Auroral Station in Adventdalen, Svalbard (1980-2005), Can. J. Phys., (85), 2, 143-151(9), 2007.
23. Volent Z., G. Johnsen and F. Sigernes, Kelp forest mapping by use of airborne hyperspectral imager, Journal of Applied Remote Sensing, Vol. 1, 011503, 2007.
24. J. Moen, N. Gulbrandsen, D. A . Lorentzen, and H. C. Carlson, On the MLT distribution of F-region polar cap patches at night, Geophys. Res. Lett., L14113, 2007.
25. J.Lunde, B. Gustavsson, U.P. Løvhaug, D.A. Lorentzen and Y. Ogawa, Particle precipitations during NEIAL events: simultaneous ground based observations at Svalbard, Annales Geophysica, 1323-1336, 2007.
26. Kristen Frederick-Frost, Kristina Lynch , Paul Kintner , Eric Klatt , Dag Lorentzen , Joran Moen , Yasunobu Ogawa , M. Widholm, SERSIO: Svalbard EISCAT Rocket Study of Ion Outflows, A08307, JGR-Space Physics, 2007.
27. Rinne, Y., J. Moen, K. Oksavik, and H. C. Carlson, Reversed flow events in the winter cusp ionosphere observed by the European Incoherent Scatter (EISCAT) Svalbard radar, J. Geophys. Res., 112, A10313, doi:10.1029/2007JA012366, 2007.
28. Simon, C., J. Lilensten, J. Moen, J. M. Holmes, Y. Ogawa, K. Oksavik, and W. F. Denig, TRANS4: a new coupled electron/proton transport code – comparison to observations above Svalbard using ESR, DMSP and optical measurements, Ann. Geophys., 25 (3), 661-673, 2007.
29. Ford, E. A. K.; Aruliah, A. L.; Griffin, E. M.; McWhirter, High time resolution measurements of the thermosphere from Fabry-Perot Interferometer measurements of atomic oxygen, Annales Geophys., 25, 1269-1278, 2007.
30. Yeoman, T. K., N. Blagoveshchenskaya., V. Kornienko, T. R. Robinson, R. S. Dhillon, D. M. Wright, L. J. Baddeley, SPEAR: Early results from a very high latitude ionospheric heating facility, *Advances in Space Research,* 30, 3, 384 – 389, 2007
31. Baddeley, L. J., T. K. Yeoman , K. A. McWilliams, D. M. Wright, Global Pc5 wave activity observed using SuperDARN radars and ground magnetometers during an extended period of northward IMF, *Planet. and Space Sci*., 55, 6, 792-808, 2007.
32. Fry, C.D., T. Detman, M. Dryer, Z. Smith, W. Sun, C. Deehr, S. Akasofu, C.C. Wu, and S.M.P. McKenna-Lawlor, Real-Time Solar Wind Forecasting: Capabilities and Challenges, J. Atmos. Solar-Terr. Phys., 69, 109-115, 2007.

33. Intriligator, D.S., A. Rees, T. Horbury, W. Sun, T. Detman, M. Dryer, C. Deehr, and J. Intriligator, 3D modeling and turbulence: from the Sun to Voyager 1, in Turbulence and Nonlinear Processes in Astrophysical Plasmas - 6th International Astrophysical Conference, edited by D. Shaikh, and G.P. Zank, American Institute of Physics, 2007.

2008

34. Lilensten, J., J. Moen, M. Barthélemy, R. Thissen, C. Simon, D. A. Lorentzen, O. Dutuit, P. O. Amblard, and F. Sigernes, Polarization in aurorae: A new dimension for space environments studies, Geophys. Res. Lett., *35*, L08804, doi: 10.1029/2007GL033006., 2008.

35. Holmes, J. M., Kozelov, B. V., Sigernes, F., Lorentzen, D. A., Deehr, C. S., Dual site observations of dayside Doppler-shifted hydrogen profiles: preliminary results. Can. J. Phys., 86(5): 691–698, doi: 10.1139/P08-026, 2008.

36. Sigernes, F., J. M. Holmes, M. Dyrland, D. A. Lorentzen, T. Svenøe, K. Heia, T. Aso, S. Chernouss, and C. S. Deehr, Sensitivity calibration of digital colour cameras for auroral imaging, Opt. Express 16, 15623-15632 , 2008.

37. Carlson, H. C., K. Oksavik, and J. Moen, On a new process for cusp irregularity production, Ann. Geophys., 26, 2871-2885, 2008.

38. Moen, J., Y. Rinne, H. C. Carlson, K. Oksavik, R. Fujii, and H. Opgenoorth, On the relationship between thin Birkeland current arcs and reversed flow channels in the winter cusp/cleft ionosphere, J. Geophys. Res., 113, A09220, doi:10.1029/2008JA013061, 2008.

39. I. Sandahl, T. Sergienko, and U. Brändström, Fine structure of optical aurora, Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 70, 18, p. 2275–2292, 2008.

40. Amm, O., A. Aruliah, S.C. Buchert, R. Fujii, J.W. Gjerloev, A. Ieda, T. Matsuo, C. Stolle, H. Vanhamäki, and A.Yoshikawa, Understanding the electrodynamics of the 3-dimensional high latitude ionosphere: present and future, ISSI report published in Annales Geophys., 26, 3913-3932, 2008.

41. Ford, E. A. K.; Aruliah, A. L.; Griffin, E. M.; McWhirter, Statistical analysis of thermospheric gravity waves from Fabry-Perot Interferometer measurements of atomic oxygen, Annales Geophys., 26, 29-45, 2008.

42. Lühr, Hermann, Alan Aylward, Claudia Stolle, Tim Spain, Matthias Förster, Patricia Ritter, Anasuya Aruliah, Ionospheric Current Quantification and Modelling for Improved Magnetic and Electric Field Analyses for Swarm, (28.11.2008) ESTEC Report Contract No 20943/07/NL/JA, 2008.

43. D.K. Whiter, B.S. Lanchester, B. Gustavsson, N. Ivchenko, J.M. Sullivan and H. Dahlgren, Small-scale structures in flickering aurora, GRL, 35, L23103, doi:10.1029/2008GL036134, 2008

44. H. Dahlgren, N. Ivchenko, J. Sullivan, B. Lanchester, G. Marklund, D. Whiter, Morphology and dynamics of aurora at fine scale: first results from the ASK instrument, Ann. Geophys., 26, 1041-1048, 2008.

45. Sullivan, J. M., M. Lockwood, B. S. Lanchester, E. Kontar, N. Ivchenko, H. Dahlgren, D. K. Whiter, An optical study of multiple NEIAL events driven by low energy primary precipitation, Ann. Geophys., 26. 2435-2447, 2008.

46. Jokiaho, O., B. S. Lanchester, N. Ivchenko, G. J. Daniell, L. Miller, and D. Lummerzheim, Rotational temperature of N+2 (0.2) ions from spectrographic measurements used to infer the energy of precipitation in different auroral forms and compared with radar measurements, Ann. Geophys., 26, 853-866, 2008.

47. V.G. Galushko, A.V. Koloskov, V.V Paznukhov, B.W. Reinisch, G.S. Sales, Y.M. Yampolski, and A.V. Zalizovsky Self-Scattering of HF Heater Emission Observed at Geographically dispersed Receiving Sites. IEEE Antennas and Propagation Magazine. **Vol. 50**, No 6, p. 155-161, 2008.

48. Galushko, V. G., A. S. Kascheev, V. V. Paznukhov, Y. M. Yampolski, and B. W. Reinisch, Frequency-and-angular sounding of traveling ionospheric disturbances in the model of three-dimensional electron density waves, Radio Sci., 43, RS4013, doi:10.1029/2007RS003735, 2008.

49. Yeoman, T. K., L. J. Baddeley, R. S. Dhillon, T. R. Robinson, and D. M. Wright, Bistatic observations of large and small scale ULF waves in SPEAR-induced HF coherent backscatter, *Ann. Geophysicae*, 26, 2253-2263, 2008

50. Blagoveshchenskaya, N. F., T. D. Borisova, V. A. Kornienko, A. S. Janzhura, A. S. Kalishin, T. R. Robinson, T. K. Yeoman, D. M. Wright and L. J. Baddeley, The polar-ionosphere phenomena induced by high-power radio waves from the SPEAR heating facility, *Radiophysics and Quantum Electronices,* 51, 11, 2008

51. Yeoman, T. K., G. Chisham, L. J. Baddeley, R. S. Dhillon, T. J. T. Karhunen, T. R. Robinson, A. Senior, and D. M. Wright, Mapping ionospheric backscatter measured by the SuperDARN HF radars 2: Assessing SuperDARN virtual height models, *Ann. Geophysicae*, 26 , 4, 843-852, 2008

52. Grydeland, T., B. Gustavsson, L. Baddeley, E. M. Blixt, J. Lunde, Conditional integration of Incoherent Scattering in relation to flickering aurora, *Journal of Geophysical Research,* doi:10.1029/2008JA013039, 2008

53. Yeoman, T. K., H. C. Scoffield, D. M. Wright, L. J. Baddeley, A. N. Vasilyev, N. V. Semenova, Investigation of natural and artificial stimulation of the ionospheric Alfven resonator at high latitude, *Advances in Space Research,* 42, 5, 957 - 963, 2008

54. Sun, W., C. Deehr, M. Dryer, C.D. Fry, Z. Smith, and S. Akasofu, Simulated Solar Mass Ejection Imager and "Solar Terrestrial Relations Observatory-like" views of the solar wind following the solar flares of 27-29 May 2003, Space Weather, 6 (S03006), doi:10.1029/2006SW000298, 2008.

55. Smith, Z.K., T.R. Detman, W. Sun, M. Dryer, C.S. Deehr, and C.D. Fry, Modeling the arrival at Earth of the interplanetary shock following the 12 May 1997 solar event using HAFv2 and 3-D MHD HHMS models, Space Weather, 6, 2008.

56. McKenna-Lawlor, S.M.P., M. Dryer, C.D. Fry, Z.K. Smith, D.S. Intriligator, W.R. Courtney, C. Deehr, W. Sun, K. Kecskemety, K. Kudela, J. Balaz, S. Barabash, Y. Futaana, M. Yamauchi, and R. Lundin, Predicting interplanetary shock arrivals at Earth, Mars, and Venus: A real-time modeling experiment following the solar flares of 5-14 December 2006, J. Geophys. Res., 113 (A06101), 2008.

57. Zhang, Y., W. Sun, X. S. Feng, C. S. Deehr, C. D. Fry, and M. Dryer, Statistical analysis of corotating interaction regions and their geoeffectiveness during solar cycle 23, J. Geophys. Res., 113, A08106, doi:10.1029/2008JA013095, 2008.

2009

58. Jørgen Berge, Finlo Cottier, Kim S. Last, Øystein Varpe, Eva Leu, Janne Søreide, Ketil Eiane, Stig Falk-Petersen, Kate Willis, Henrik Nygård, Daniel Vogedes, Colin Griffiths Geir Johnsen, Dag Lorentzen, Andrew S. Brierley, Towards a new understanding of arctic marine ecosystems during the polar night, Biology Letters, Vol. 5, Numb. 1, 2009.

59. M.J.Engebretson, J. Moen, J.L.Posch, F. Lu, M.R. Lessard, H. Kim and D.A.Lorentzen, Searching for ULF signatures of the cusp: Observations from search coil magnetometers and auroral imagers in Svalbard, Journal of Geophysical Research, Vol. 114, 2009.

60. Hall, C. M., J. Röttger, K. Kuyeng, F. Sigernes, S. Claes, and J. Chau (2009), First results of the refurbished SOUSY radar: Tropopause altitude climatology at 78°N, 16°E, 2008, Radio Sci., 44, RS5008, doi:10.1029/2009RS004144., 2009.

61. Volent Z., G. Johnsen, and F. Sigernes, Microscopic hyperspectral imaging used as a bio-optical taxonomic tool for micro- and macroalgae, Appl. Opt. 48, 4170-4176, 2009.

62. Volent Z., G. Johnsen, and F. Sigernes, Microscopic hyperspectral imaging used as a bio-optical taxonomic tool for micro- and macroalgae, The Virtual J. for Biomed. Opt, Vol. 4, Iss. 9 – Sep.4, 2009.

63. Johnsen, G., Volent, Z., Sakshaug, E, Sigernes, F., and Petterson, L. H., Remote Sensing in the Barents Sea, Chapter 6: Eco System Barents Sea, pp. 139 – 166, Tapir Academic Press, Trondheim, ISBN 978-82-519-2461-0, 2009.

64. Sigernes, F., Dyrland, M., Peters, N., Lorentzen, D., Svenøe, T., Heia, K., Chernouss, S., Deehr, C., and Kosch, M., The absolute sensitivity of digital colour cameras, Opt. Express 17, No. 22, 20211-20220, 2009.

65. Holmes, J. M., B. V. Kozelov, N. J. Peters, C. S. Deehr, D. A. Lorentzen, and F. Sigernes, The ion velocity filter effect observed in dayside hydrogen aurora, Geophys. Res. Lett., 36, L23101, doi:10.1029/2009GL040972, 2009.

66. Mulligan, F. J., M. E. Dyrland, F. Sigernes, and C. S. Deehr, Inferring hydroxyl layer peak heights from ground-based measurements of OH(6-2) band integrated emission rate at Longyearbyen (78°N, 16°E), Ann. Geophys., 27, 4197-4205, 2009.

67. Griffin, E. M., A. L. Aruliah, I. McWhirter, H.-C. I. Yiu, and A. Charalambous, Upper thermospheric ion-neutral coupling from combined optical and radar experiments over Svalbard, Ann. Geophys., 27, 4293-4303, 2009.

68. Kurihara, J. S. Oyama, S. Nozawa, T. T. Tsuda, R. Fujii, Y. Ogawa, H. Miyaoka, N. Iwagami, T. Abe, K.-I. Oyama, M.J.Kosch, A. Aruliah, E. Griffin, and K. Kauristie, Temperature enhancements and vertical winds in the lower thermosphere associated with auroral heating during the Dynamics and Energetics of the Lower Thermosphere in Aurora (DELTA) campaign, J. Geophys. Res., 114, A12306, doi:10.1029/2009JA014392, 2009.

69. O. Jokiaho, B. S. Lanchester, N. Ivchenko, Resonance scattering by auroral N_2^+: steady state theory and observations from Svalbard, Ann. Geophys., 27, 3465-3478, 2009.

70. M. Ashrafi, M., B. S. Lanchester, D. Lummerzheim, N. Ivchenko, and O. Jokiaho, Modelling of $N_2$1P emission rates in aurora using various cross sections for excitation, Ann. Geophys., 27, 2545-2553, 2009.

71. Lanchester, B. S., M. Ashrafi, and N. Ivchenko, Simultaneous imaging of aurora on small scale in OI (777.4 nm) and $N_2$1P to estimate energy and flux of precipitation, Ann. Geophys., 27, 2881–2891, 2009.

72. Dahlgren, H., N. Ivchenko, B. S. Lanchester**,** M. Ashrafi, D. Whiter, G. Marklund, J. Sullivan, First direct optical observations of plasma flows in the metastable O^+ ion in discrete aurora, J. Atmos. Solar Terr. Phys., 71, 228–238, 2009.

73. S.B. Kascheev, A.V. Zalizovski, A.V. Koloskov, V.G. Galushko, I. I. Pikulik, Y.M. Yampolski, V.I. Kurkin, G.I. Litovkin, and A. I. Orlov. Frequency Variations of HF Signals at Long-Range Radio Paths during a Solar Eclipse. Radio Physics and Radio Astronomy, **14,** #4, p. 353-366, 2009.

74. D.M. Wright, R.S. Dhillon, T.K. Yeoman, T.P. Robinson, E.C. Thomas, L.J. Baddeley, and S. Imber, Excitation thresholds of field-aligned irregularities and associated ionospheric hysteresis at very high latitudes observed using SPEAR-induced HF radar backscatter, *Ann. Geophysicae,* 27, 2623-2631, 2009

75. N.F. Blagoveshchenskaya, T.D. Borisova, V.A. Kornienko, A.S. Kalishin, T.R. Robinson, T.K. Yeoman, D.M. Wright and L.J. Baddeley, SPEAR-induced field-aligned irregularities observed from bi-static HF radio scattering in the polar ionosphere, *J. Atmos. and Solar-Terrestrial Phys.,*71, 11 - 20, 2009

76. T. D. Borisova, N. F. Blagoveshchenskaya, V. A. Kornienko, A. S. Yanzhura, A. S. Kalishin, T. R. Robinson, T. K. Yeoman, L. J. Baddeley,Peculiarities of Artificial Ionospheric Radiation under the Action of Higher_Power HF Radiowaves, Emitted by the SPEAR Facility, on the Sporadic *E* Layer of the Polar Ionosphere, *Geomagnetism and Aeronomy,* DOI: 10.1134/S0016793209060176, 2009.

77. Pilipenko, V. O. Chugunova, M. Engebretson, T. Yeoman, and M. Vellante, Mechanisms of the cusp-related Pc 3-4 waves, in “Physics of Auroral Phenomena,” Proc. 32nd Annual Seminar, Apatity, 89-92, 2009.

2010

78. Dyrland, M. E., F. J. Mulligan, C. M. Hall, F. Sigernes, M. Tsutsumi, and C. S. Deehr, Response of OH airglow temperatures to neutral air dynamics at 78°N, 16°E during the anomalous 2003–2004 winter, *J. Geophys. Res.*, 115, D07103, doi:10.1029/2009JD012726, 2010.

79. Dyrland, M. E., C. M. Hall, F. J. Mulligan, M. Tsutsumi, and F. Sigernes, Improved estimates for neutral air temperatures at 90 km and 78°N using satellite and meteor radar data, *Radio Sci.*, 45, RS4006, doi:10.1029/2009RS004344, 2010.

80. D.A. Lorentzen, J. Moen, K. Oksavik, F. Sigernes, Y. Saito and M.G. Johnsen, In-situ measurement of a newly created polar cap patch, Journal of Geophysical Research - Space Physics, 115, DOI: 10.1029/2010JA015710, 2010.

81. J. K. Burchill, D. J. Knudsen, J. H. Clemmons, K. Oksavik, R. F. Pfaff, C. T. Steigies, A. W. Yau, and T. K. Yeoman, J., Thermal ion upflow in the cusp ionosphere and its dependence on soft electron energy flux, Geophys. Res., 115, A05206, doi:10.1029/2009JA015006, 2010.

82. Aruliah, A. L., Griffin, E. M., Yiu, H.-C. I., McWhirter, I., and Charalambous, A.: SCANDI . an all-sky Doppler imager for studies of thermospheric spatial structure, Ann. Geophys., 28, 549-567, 2010.

83. Kosch, M.J., C. Anderson, H-C. I Yiu, R. Makarevich, A. Aruliah, M. Conde, T. Davies, I. McWhirter, P. Dyson, First observations of simultaneous inter-hemispheric conjugate high-latitude thermospheric winds, J. Geophys. Res, Space Physics, 115, A09328, doi:10.1029/2009JA015178, 2010.

84. D. K. Whiter, B. S. Lanchester, B. Gustavsson, N. Ivchenko, H. Dahlgren, Using multispectral optical observations to identify the acceleration mechanism responsible for flickering aurora, Journal of Geophysical Research - Space Physics , Vol. 115, A12, 2010.

85. S.B. Kascheev, A.V. Koloskov, A.V. Zalizovskiy, V.G. Galushko, I.I. Pikulik, Yu.M. Yampolski, V.I. Kurkin, G.I. Litovkin, A.I. Orlov, P.V. Petko. Experimental Investigation of Spectral Characteristics of HF Signals on Long and Ultra-Long-Range Radio Paths. Radio Physics and Radio Astronomy, v. 1, №2, pp. 125-136., 2010.

2011

86. F. Sigernes, E. Lundberg, Å. Skjæveland, J. M. Holmes, M. Dyrland, N. Peters, D. A Lorentzen, K. Oksavik, M. Mella, K. Lynch, Y. Ogawa, M. R. Lessard, and P. M. Kintner, The Stellacam II as an all-sky imager during the SCIFER 2 rocket campaign, Physics of Auroral Phenomena, Proc. XXXIII Annual Seminar, Apatity, pp. 41-45, 2011.

87. F. Sigernes, M. Dyrland, P. Brekke, E. K. Gjengedal, S. Chernouss, D. A. Lorentzen, K. Oksavik and C. S. Deehr, Real time aurora oval forecasting – SvalTrackII, Optica Pura y Aplicada (OPA), 44, 599-603, 2011.

88. C. M. Hall, G. Hansen, F. Sigernes, and K. M. Kuyeng Ruiz, Tropopause height at 78N 16E: average seasonal variation 2007–2010*, Atmos. Chem. Phys.*, 11, 5485 - 5490, 2011.

89. F. Sigernes, M. Dyrland, P. Brekke, S. Chernouss, D.A. Lorentzen, K. Oksavik, and C.S. Deehr, Two methods to forecast auroral displays, Journal of Space Weather and Space Climate (SWSC), Vol. 1, No. 1, A03, DOI:10.1051/swsc/2011003, 2011.

90. Barthélémy, M.; Lilensten, J.; Pitout, F.; Wedlund, C.S.; Thissen, R.; Lorentzen, D.A.; Sigernes, F.; Moen, J.I.; Gronoff, G.: McCrea, I.W.; Rothkael, H.; Ménager, H.; Aruliah, A.. Polarisation in the auroral red line during coordinated EISCAT Svalbard Radar/optical experiments., Annales Geophysicae , Vol. 29 (6) s. 1101-1112, DOI: 10.5194/angeo-29-1101-2011, 2011.

91. Oksavik, K., J. I. Moen, E. H. Rekaa, H. C. Carlson, and M. Lester, Reversed flow events in the cusp ionosphere detected by SuperDARN HF radars, J. Geophys. Res., 116, A12303, doi:10.1029/2011JA016788, 2011.

92. I. Sandahl, U. Brändstöm, T. Sergienko, and T. Leyser, Networks of people and infrastructure for ground-based auroral research, Optica Pura y Aplicada, 44(4), 581-591, 2011.

93. T. I. Pulkkinen, E. I. Tanskanen, A. Viljanen, N. Partamies, K. Kauristie, Auroral electrojets during deep solar minimum at the end of solar cycle 23, Journal of Geophysical Research, Vol. 116, A4, 2011.

94. N. Partamies, L. Juusola, E. Tanskanen, K. Kauristie, J. M. Weygand, and Y. Ogawa, Substorms during different storm phases, Ann. Geophys., 29, 2031-2043, 2011.

95. Kosch, M.J., I. Yiu, C. Anderson, T. Tsuda, Y. Ogawa, S. Nozawa, A. Aruliah, V.Howells, L.J. Baddeley, I.W. McCrea, J.A. Wild, Meso-scale observations of Joule heating near an auroral arc and ion- neutral collision frequency in the polar cap E-region, JGR, J. Geophys. Res., 116, A05321, doi:10.1029/2010JA016015, 2011.

96. Lanchester, B. S., O. Jokiaho, M. Galand, N.Ivchenko, D. Lummerzheim, J. Baumgardner, S. Chakrabarti, Separating and quantifying ionospheric responses to proton and electron precipitation over Svalbard, J. Geophys. Res., 116, A09322, doi:10.1029/2011JA016474, 2011.

97. Archer, J., H. Dahlgren, N. Ivchenko, B.S. Lanchester, G.T. Marklund: Dynamics and characteristics of black aurora as observed by high resolution ground-based imagers and radar, Int. J. Remote Sens., 32, 2973-2985, doi:10.1080/01431161.2010.541517, 2011.

98. H. Vickers and L. J. Baddeley, An alternative estimation of the RF-enhanced plasma temperature during SPEAR artificial heating experiments: Early Results,, *Journal of Geophysical Research*, 116, DOI: 10.1029/2011JA016795, 2011

99. D. Teodosiev, E. Yordanova, P. Nenovski, T. Nikolova, D. Danov, G. Crowley, L. Baddeley, S. Buchert, Ion temperature distribution in the high latitude region (EISCAT UHF radar observations): What it the field-aligned currents influence?, Comptes Rendus De L'Academie Bulgare Des Sciences, 64, 5, 729-736, 2011

100. M.J. Kosch, I. Yiu, C. Anderson, T. Tsuda, Y. Ogawa, S. Nozawa, A. Aruliah, V.Howells, L. J. Baddeley, I. McCrea, J. Wild, Meso-scale observations of Joule heating near an auroral arc and ion-neutral collision frequency in the polar cap E-region, *Journal of Geophysical Research*, 116, DOI: 10.1029/2010JA016015, 2011.

101. N. F. Blagoveshchenskaya, T. D. Borisova, T. K. Yeoman, M. T. Rietveld, I. M. Ivanova and L.J. Baddeley, Artificial small-scale field-aligned irregularities in the high latitude F region of the ionosphere induced by an X-mode HF heater wave, *Geophys. Res. Lett*., 38, DOI: 10.1029/2011GL046724, 2011.

2012

102. E. J. Lund, M. R. Lessard, F. Sigernes, D. A. Lorentzen, P. M. Kintner, K. A. Lynch, D. H. Huang, B. C. Zhang, and H. G. Yang, Electron temperature in the cusp as measured with the SCIFER-2 sounding rocket, Journal of Geophysical Research - Space Physics, Vol. 117, A06326, 7 pp., DOI: 10.1029/2011JA017404, 2012.

103. B. U. E. Brandstrom, C.-F. Enell, O.Widell, T. Hansson, D. Whiter, S. Makinen, D. Mikhaylova, K. Axelsson, F. Sigernes, N. Gulbrandsen, N. M. Schlatter, A. G. Gjendem, L. Cai, J. P. Reistad, M. Daae, T. D. Demissie, Y. L. Andalsvik11, O. Roberts, S. Poluyanov, and S. Chernouss, Results from the intercalibration of optical low-light calibration sources 2011, Geosci. Instrum. Method. Data Syst., ISSN 2193-0856., 1(1), s 91-97, DOI: 10.5194/gid-1-91-2011, 2012.

104. F. Sigernes, Y. Ivanov, S. Chernouss, T. Trondsen, A. Roldugin, Y. Fedorenko, B. Kozelov, A. Kirillov, I. Kornilov, V. Safargaleev, S. Holmen, M. Dyrland, D. Lorentzen, and L. Baddeley, Hyperspectral all-sky imaging of auroras, Opt. Express, Vol. 20 (25), 27650-27660, DOI: http://dx.doi.org/10.1364/OE.20.027650, 2012.

105. Holmen S.E., Dyrland M.E., and F. Sigernes, Mesospheric temperatures derived from three decades of hydroxyl airglow measurements from Longyearbyen, Svalbard (78°N), Acta Geophysica. In press.

106. Hall, C.M., M. E. Dyrland, M. Tsutsumi, and F. J.Mulligan, Temperature trends at 90 km over Svalbard, Norway (78°N 16°E), seen in one decade of meteor radar observations, J. Geophys. Res., 117, D08104, doi:10.1029/2011JD017028, 2012.

107. M. G. Johnsen, D. A. Lorentzen, J. M. Holmes, and U. P. Løvhaug, A model based method for obtaining the open/closed field line boundary from the cusp auroral 6300 ångstrøm [OI] red line, Journal of Geophysical Research - Space Physics, Vol. 117, A03319,DOI: 10.1029/2011JA016980, 2012.

108. M. G. Johnsen and D. A. Lorentzen, The dayside open/closed field line boundary as seen from space- and ground-based instrumentation, Journal of Geophysical Research - Space Physics, Vol. 117, A03320, DOI: 10.1029/2011JA016983, 2012.

109. M. G. Johnsen and D. A. Lorentzen, A statistical analysis of the optical dayside open/closed field line boundary, Journal of Geophysical Research - Space Physics, Vol. 117, A02218, DOI: 10.1029/2011JA016984, 2012.

110. Oksavik, K., J. Moen, M. Lester, T. A. Bekkeng, and J. K. Bekkeng, In situ measurements of plasma irregularity growth in the cusp ionosphere, J. Geophys. Res., 117, A11301, doi:10.1029/2012JA017835, 2012.

111. Young, M. A., M. Lessard, M. Engebretson, J. R. Woodroffe, and K. Oksavik, Spectral enhancements associated with Pi1B events observed at high latitude, J. Geophys. Res., 117, A09314, doi:10.1029/2012JA017940, 2012.

112. Moen, J., K. Oksavik, T. Abe, M. Lester, Y. Saito, T. A. Bekkeng, and K. S. Jacobsen, First in-situ measurements of HF radar echoing targets, Geophys. Res. Lett., 39, L07104, doi:10.1029/2012GL051407, 2012.

113. Sato, Y., T. Ono, N. Sato, and Y. Ogawa, First observations of 4fce auroral roar emissions, Geophys. Res. Lett., 39, L07101, doi:10.1029/2012GL051205, 2012
114. Taguchi, S., K. Hosokawa, Y. Ogawa, T. Aoki, and M. Taguchi, Double bursts inside a poleward-moving auroral form in the cusp, J. Geophys. Res., 117, A12301, doi:10.1029/2012JA018150, 2012.
115. Young, M. A., M. Lessard, and M. Engebretson, Pi1B propagation in the high-latitude ionosphere, *J. Geophys. Res.*, *117,* A03322, doi:10.1029/2011JA017127, 2012.
116. Berthomier, M. et al., Alfvén: Magnetosphere-Ionosphere Connection Explorers, Exp Astron, 33:445.489, DOI 10.1007/s10686-011-9273-y, 2012.
117. Carlson, H. C., T. Spain, A. Aruliah, A. Skjaeveland, and J. Moen, First-principles physics of cusp/polar cap thermospheric disturbances, Geophys. Res. Lett., 39, L19103, doi:10.1029/2012GL053034, 2012.
118. Scholz, T., C.O. Asma, and A. Aruliah, Recommended set of models and input parameters for the simulations of orbital dynamics of the QB50 cubesats, ESA report, 2012.
119. B. Lanchester, Auroral Phenomenology and Magnetospheric Processes: Earth and other planets, Geophys. Monogr. Ser., vol. 197, edited by A. Keiling et al. 171–182, AGU, Washington, D. C., doi:10.1029/2011GM001161, 2012.
120. H. Dahlgren, N. Ivchenko, B. S. Lanchester, Monoenergetic high-energy electron precipitation in thin auroral filaments, Geophys. Res. Letters, 39, L20101, doi:10.1029/2012GL053466, 2012.
121. Tereshchenko, E. D., R.Yu. Yurik, L. Baddeley, Observations of the Stimulated electromagnetic Emmision at the High Latitudes under the different modes of the heating facility, Vestnik KSC RAS. N2, p16-21, 2012
122. Borisova T.D., Blagoveshchenskaya N.F., Kalishin A.S., Oksavik K., Baddeley L., and T. Yeoman. Effects of Modification of the Polar Ionosphere with High-Power Short Wave Extraordinary-Mode HF Waves produced by the SPEAR heating facility, *Radiophysics and Quant. Electr.*, 55, No.s 1-2, June 2012
123. L.J. Baddeley, I. Haggstrøm, T. K. Yeoman, M. Rietveld, First Observations of SPEAR-induced top and bottomside sporadic E-layer heating observed using the EISCAT Svalbard and SuperDARN radars, *Journal of Geophysical Research*, 117, DOI: 10.1029/2011JA017079, 2012
124. Yeoman, T. K., D. M. Wright, M. J. Engebretson, M. R. Lessard, V. A. Pilipenko, and H. Kim (2012), Upstream-generated Pc3 ULF wave signatures observed near the Earth's cusp, J. Geophys. Res., 117, A03202, doi:10.1029/2011JA017327, 2012.

13. Question and Answers (Q&A)

The questions are based on Riksrevisjonen original questions. Note that the unit *per month and per year* is not relevant. It makes no meaning to us, because the instruments operate 24 hours per day throughout the auroral season and the observatory is fully automatic operated through our fiber connection. We have no means of counting the time each institution use on operating the instruments through the fiber connection. As a consequence, some questions are rephrased to fit the operational modus of KHO.

1. Documentation on use and utilization in the period 2006-2012

a) How many planned runs/measurements/projects do you have per year?

Answer: The answer to the question depends on type of instrument and on the auroral season. The auroral season in Svalbard starts on the 1st November and ends on the 28th February. The plan is then to run all 25 optical instruments 24 hours per day. The rest of the optical year is used to calibrate, analyze and report the data from the optical instruments/projects. This includes writing scientific papers and travel to conferences. The non-optical instruments are set up to run all-year-round 24/7. Total number is then 35 per year. Data is based on section 4.

b) How many runs/measurements/projects are actually executed per year?

Answer: All 35.

c) What is the most common reason that runs/measurements/projects are not executed?

Answer: Power failure is the most common reason and these occur a few times a year for periods of a few hours. However, this rarely affects the KHO due to the backup UPS system which is installed. The power failures themselves are not as a result of any internal problems with the KHO but are due to issues at the Longyearbyen power station.

d) How many days have you installation not been running per year?

Answer: Zero

e) What is the number of 24-hours-scientist-days per year?

Answer: There are 21 institutions from 9 nations present at KHO. On average each institution sends ~2 persons up to KHO for ~14 day per year to setup and calibrate their instruments prior to the auroral season. Excluding UNIS this gives 20 x 2 x 14 = 560 days per year in client preparation time. During rocket campaigns we have 10-15 extra days per year. The head of the station uses 40% of his time at KHO. This equals to approximately 146 days per year. The rest of the crew uses at UNIS uses on average 30 days per person, which gives us 150 days per year. The total number of 24-hours-scientist-days per year is then roughly estimated to be 871.

f) What is the number of graduated PhD that has used data from KHO in the period from 2006 to end of 2012?

Answer: 14. See section 10.

g) Is there other data on use and utilization of KHO in units per year?

Answer: KHO is used as a laboratory for teaching students basic skills in ground-based remote sensing. See section 5. 9 courses at UNIS have used KHO in the time period 2006-2012. This gives an average of 106 ECTS / 7 years = 15 ECTS per year of teaching.

2. Goals and plans for use and utilization

a) Describe how goals and plans for use and utilization is conducted and approved.

Answer: Goals and plans are discussed within the Space physics group at UNIS and depends on plans for new instrumentation and external funding. The group also actively travels to scientific meetings to present our projects and to discuss new possibilities with other scientists. Here we also attract other groups, both from within our own research field of Space Physics and from other research areas. The instrumental rent or fee is 20kNOK per year. This is a rate affordable by academic institutions, which serves as an important additional incentive for new groups to place instruments there. A new group will have to sign a standard contract with KHO.

b) What is goal and plans for use and utilization in 2013?

Answer: Our main goal this season is to support the ICI-4 rocket in December. The observatory must be, as always, fully operational with all optical instruments active by 1st November. Each instrument has its own scientific objective and will be operating throughout the auroral season. See section 2 and 4.

c) Have goals and plans for use and utilization changed in the period 2006-2012?

Answer: No.

3. Assessment of use and utilization

a) Which factors affects utilization of the KHO?

Answer: Our work to attract new groups is the most important factor. It is vital to conduct high quality research to show others that there are new possibilities by using KHO. Other factors are purely economic such as electrical power costs and the general economic situation of our clients. These are mostly from the university sector where funding has been low the last decade, especially in Europe.

b) Has there been unused capacity of KHO since 2006?

Answer: Yes. KHO was constructed to house more instruments and to get away from the light pollution of Longyearbyen. In 2007 all 15 instruments from the Auroral Station in Adventdalen were moved up to KHO. That is 50% capacity. Since then there has been a steady increase of instruments. For the 2013 season we only have 4 modules left for new optical instruments.

c) What is the reason for this unused capacity?

Answer: It takes time to fill all optical units both by attracting new group and to get funding

for new instruments. Note that KHO was constructed with 50% overcapacity to be able to accommodate future instruments and groups.

d) What is the overall evaluation of the utilization?
Answer: Good to Excellent. New non-optical instrument groups have increased more than we expected.

e) Are there other investigations or evaluations of the use and utilization of KHO?
Answer: No. This is the first one since it was opened in 2008.

4. Readings, duty, supervision and maintenance of instruments from client institutions
a) What is the number of client instruments KHO is responsible for in 2013?
Answer: 22

b) Who owns these instruments?
Answer: See section 4 (Table 2).

c) How many hours per month have been used on this in 2013?
Answer: All instruments at KHO are fully automatic and upload data to their home institutions through the internet. This means that, under normal operational circumstances, almost no daily support needed. 4 new radio groups have visited to install instruments. We have used ~1 week of installation help and support in 2013 or ~4 hours per month.

d) How is the number of client instruments developed since 2006?
Answer: The number has linearly increased from 15 up to 22.

5. Research results
a) How many scientific papers have been written based on research at KHO in the time period 2006-2012?
Answer: 124. See section 12.

6. Data availability
a) Is data from KHO free for others?
Answer: Yes through real time Quicklooks on our web server: http://kho.unis.no. If more detailed data is required, then we forward the request to the PI of the instrument in question.

7. Running costs
a) What is the annual running costs (including salary to technical personnel), specified for the years 2006-2012?
Answer: See Table 4 section 6.

b) What is the cause of change between the years?
Answer: See section 6.