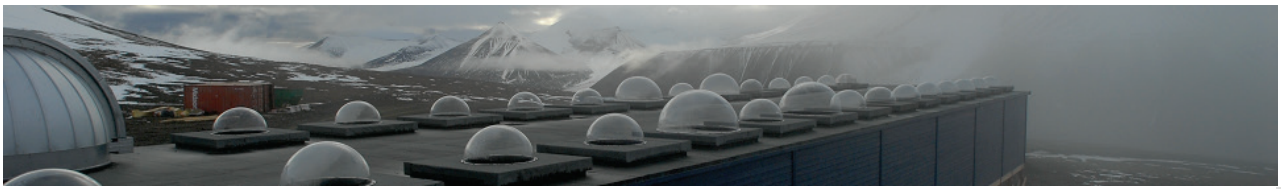

The Kjell Henriksen Observatory (KHO): Status and highlights - 2017

BIRKELAND CENTRE FOR SPACE SCIENCE

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Abstract

The following is a summary for the activity at the Kjell Henriksen Observatory (KHO) in 2017. The current active personnel of the observatory are presented together with the operational instruments. A brief summary of the progress of the newly constructed Super Dual Auroral Radar Network (SuperDARN) radar is given in addition to project highlights from the Boreal Aurora Camera Constellation (BACC). Near future activity is suspected to be high.

1. The observatory crew

The current crew of KHO is listed below. F. Sigernes headed and had the daily operational responsibility together with Mikko Syrjäsuo.

Name	UNIS position	E-mail
Fred Sigernes	Professor, Optics and atmospheric Research, Head of KHO, Leader Ground-based Instrumentation Group BCSS.	freds@unis.no
Mikko Syrjäsuo	Head engineer	mikkos@unis.no
Noora Partamies	Associate Prof. Middle atmospheric physics	noorap@unis.no
Dag Arne Lorentzen	Professor, Upper polar atmosphere, Head of the SuperDARN radar project, UNIS node leader of the BCSS	dagl@unis.no
Lisa Baddeley	Associate Professor, Radar applications, Head of the Doppler Pulsation Experiment C0-Investigator, SuperDARN radar project	lisab@unis.no
Xiangcai Chen	PhD candidate, Aurora physics	xiangcai.chen@unis.no
Pål Gunnar Ellingsen	Post Doc, Space physics	pale@unis.no
Emma Bland	Post Doc, Middle atmospheric physics	emmab@unis.no
Erkka Heino	PhD candidate, Middle atmospheric physics	Erkka.heino@unis.no
Katie Herlingshaw	PhD candidate, Upper atmospheric physics	katie.herlingshaw@unis.no

Table 1. The Kjell Henriksen Observatory crew (2017).

Our contact from the Norwegian Construction and Property Management Department in Longyearbyen Tommy Frantzen has started a new job and moved to Andøya at the mainland. Thanks for his excellent service. A new contact will be appointed to us soon.

2. 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. 1 shows students on excursion to KHO and SuperDARN. Here they trained on taking pictures and was introduced to the state-of-the-art facilities to do in-situ observations of the aurora.

Fig.1. AGF-216 students at Breinosa. YouTube Video by Pål Brekke.

The following 5 courses have used KHO as part of field work:

Code	Course name	ECTS
AGF-216	The Stormy Sun and the Northern Lights	5
AGF-301/801	The Upper Polar Atmosphere	15
AGF-304/804	Radar Diagnostics of Space Plasma	15
AGF-345/845	Polar Magnetospheric Substorms	10
AGF-210	The middle polar atmosphere	15

Table 2. UNIS courses using KHO as laboratory (2017)

A grand total of **60 ECTS** (European Credit Transfer and Accumulation System) have been taught.

3. Operational instrumentation

During the auroral winter season from November to the end of February, 25 optical instruments operate 24 hours a day. The 15 non-optical instruments run all-year-round 24 hours a day.

The instruments at KHO are grouped into mainly five 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

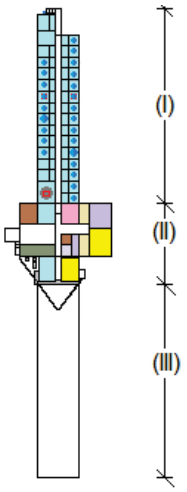


Fig. 2. Sketch of KHO: (I) Instrumental section, (II) Service section, and (III) Extended platform.

A detailed description of the performance and the scientific objective of each instrument are found online. 21 different institutions from 12 nations are present at KHO. Figures 3 and 4 show a map of where the instruments

are located. Table 3 lists all according to institution and category (#).

Note that out of 30 instrument domes; 6 are currently not in use.

	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 color camera	University College London (UCL)	A	England
4	All-sky video camera	UNIS	A	NO
5	All-sky DSLR camera	UNIS	A	NO
6	All-sky Airglow Imager	UNIS	A	NO
7	Auroral meridian spectrograph	National Institute of Polar Research (NIPR)	C	Japan
8	Spectrographic Imaging Facility	The University of Southampton/UCL	C	England
9	Meridian-Scanning Photometer	University of Alaska Fairbanks/UNIS	B	USA/NO
10	1m S.Ebert-Fastie spectrometer	University of Alaska Fairbanks/UNIS	C	USA/NO
11	1m G.Ebert-Fastie spectrometer	University of Alaska Fairbanks/UNIS	C	USA/NO
12	1/2m B.Ebert-Fastie spectrometer	University of Alaska Fairbanks/UNIS	C	USA/NO
13	1/2m W.Ebert-Fastie spectrometer	University of Tromsø (UiT)	C	NO
14	Fabry-Perot interferometer	UCL	D	England
15	Scanning Doppler Imager	UCL	D	England
16	Monochromatic Auroral Imager	Polar Research Institute of China (PRIC)	A	China
17	All-sky Airglow Imager	Kyoto University	A	Japan
18	Fluxgate magnetometer	UiT	E	NO
19	2-axis search coil magnetometer	Augsburg College/Univ. of New Hampshire	E	USA
20	Fluxgate magnetometer	PRIC	E	China
21	Auroral Radio Spectrograph	Tohoku University	E	Japan
22	HF acquisition system	Institute of Radio Astronomy/UiT	E	Ukraine/NO
23	64xBeam Imaging Riometer	Danish Meteorological Institute (DMI)/UiT	E	Denmark/NO
24	Balloon Telemetry Station	University of Rome	E	Italy
25	Hyperspectral tracker (Fs-Ikea)	UNIS	C	NO
26	All-sky hyperspectral camera	UNIS	C	NO
27	Narrow field of view tracker	UNIS	A	NO
28	Scintillation and TEC receiver	University of Bergen (UiB)	E	NO
29	Beacon Satellite receiver unit	Finnish Meteorological Institute (FMI)	E	Finland (FI)
30	Automatic weather station	UNIS	E	NO
31	4xWEB cameras (safety)	UNIS	A	NO
32	Celestron 4m Telescope	UNIS	A	NO
33	Internet radio link - Janssonhaugen	NORSAR	E	NO
34	UHF Ground station	National Institute for Aeronautics (LAPAN)	E	Indonesia
35	UHF Ground station	Technische Universität Berlin (TU)	E	Germany
36	All-sky Auroral Imager	Korea Polar Institute (KOPRI)	A	Korea
37	Boreal Auroral Camera Constellation	UNIS (KHO) and UiO (Ny-Ålesund)	A	NO
38	Meridian Imaging Spectrograph	UNIS	B	NO
39	HF Doppler Receiver	UNIS	E	NO
40	3 x GNSS Scintillation Receivers	Nagoya University	E	Japan

Table 3. Instruments at the Kjell Henriksen Observatory (2017).

One new group (#40) from Nagoya in Japan has installed an instrument at KHO in 2017.

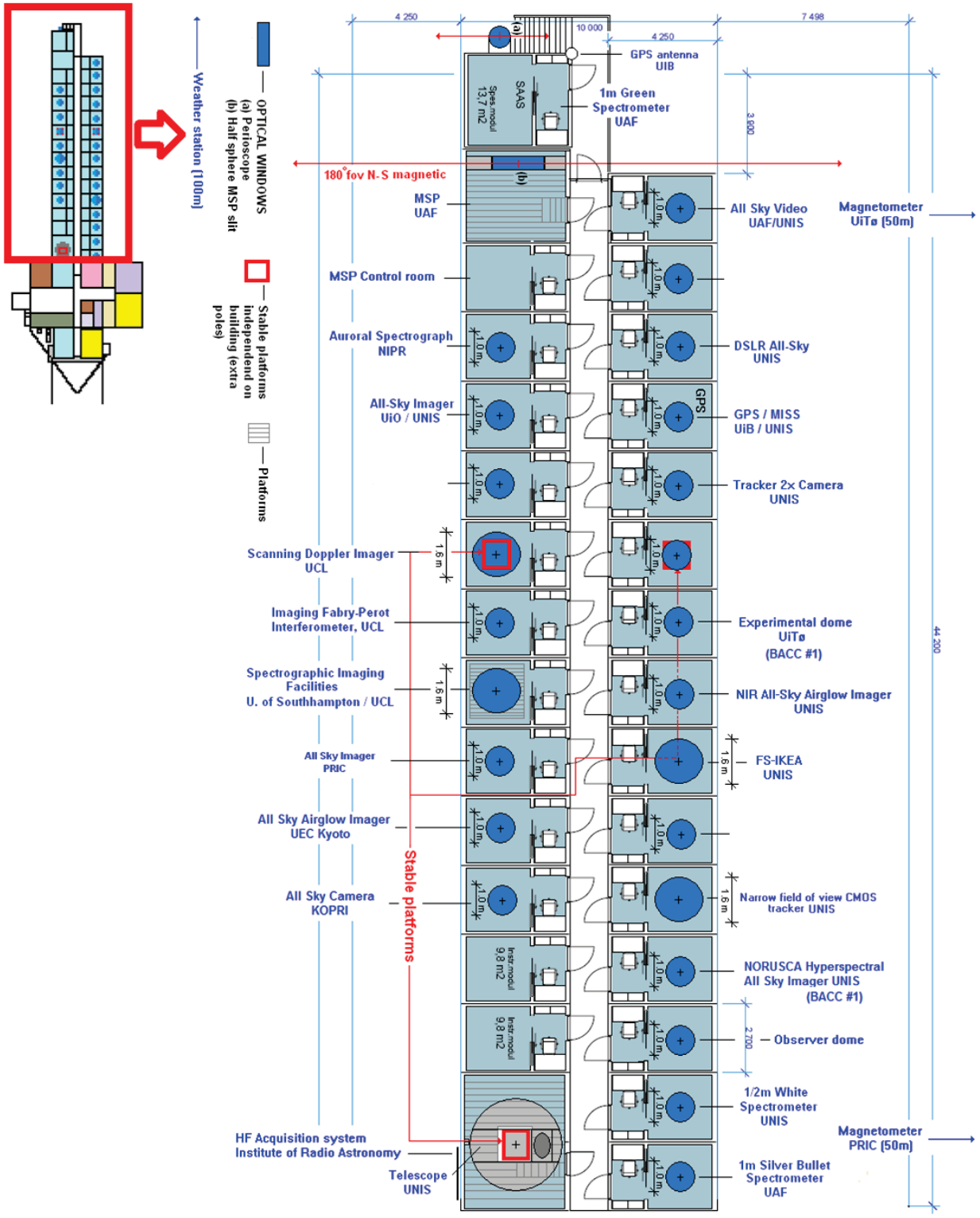


Fig.3. Map of the optical instruments at the Kjell Henriksen Observatory (2017).

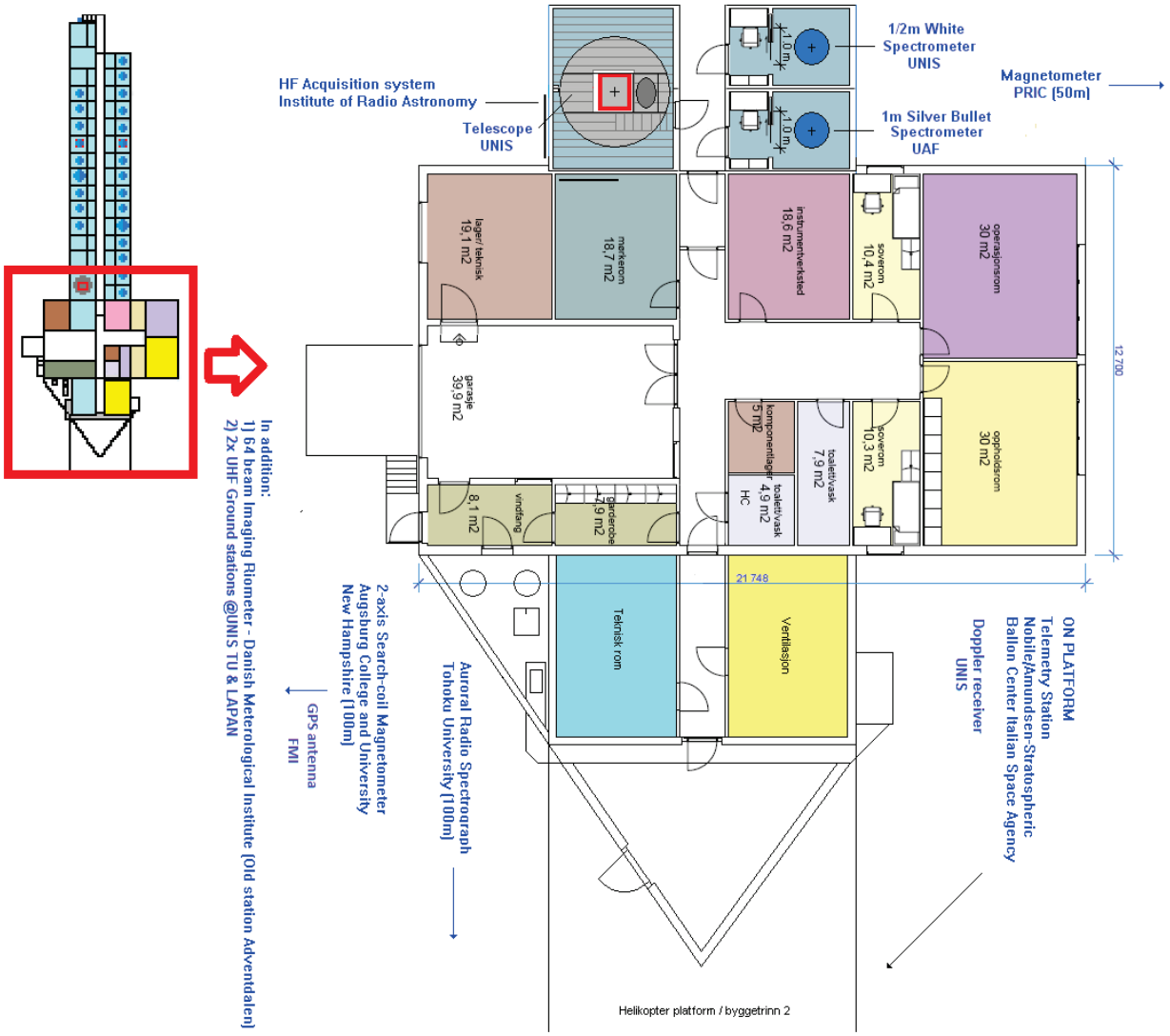


Fig.4. Map of the service section at the Kjell Henriksen Observatory (2017).

4. Major Highlight

Doctor Xiangcai Chen

28.02.2017

Salute! Xiangcai Chen has defended with success his PhD thesis titled: "A study of dayside open/closed field line boundary dynamics using simultaneous ground-based optical and HF radar observations". The defense was on Tuesday 28th of February 2017.

Read more

5. Public outreach

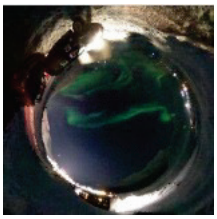
A large number of presentations, visits and interviews have been conducted at KHO. Visits from the local school in Longyearbyen and training on tourist guides have been popular activities.

The impacts of the TV shows from NRK about the Nordic winter and NHK (Nippon Hoso Kyokai) - Japan Broadcasting Corporation 360 recordings of dayside aurora are expected to be positive.

Fig.5. Longyearbyen school pupils visiting the roof of KHO. Photo: Mikko Syrjäsuo (2017).

The Aurora Forecast 3D app is rated as high as 4.2 and has reached over 12870 installs on Google Play for Android and 603 active users on iOS apple phones. The Facebook page for KHO has 1190 followers.

6. Other events



360 image of the aurora

03.03.2017

I finally got some time to play with the Ricoh Theta S camera. My first target is the substorm aurora above Svalbard on 3rd of Mars 2017. The exposure time is 3.5 second at ISO 1600. This is promising indeed!

View

Photo: F. Sigernes

Aurora Forecast 3D released

10.08.2017

The new auroral forecast is now finally released. It is a cross-platform app for both Apple and Windows computers. It is published on Google Play for Android and App Store for iOS phones. It forecasts the aurora oval up to +0, +1, and +4 hours ahead in time at any location on the planet using a 3D graphical layout.

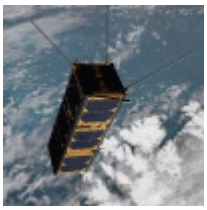
More info

In the spotlight!

18.12.2017

KHO have hosted two large TV productions in December. NRK is producing a documentary about the Nordic winter and NHK (Nippon Hoso Kyokai) - Japan Broadcasting Corporation is planning for the first time to broadcast the dayside aurora in 360 view.

More info



Spaceborn!

23.12.2017

We are proud to announce that KHO is part in the satellite proposal of **NTNU AMOS** that just got funded by the Norwegian Research Council. Our knowledge of hyperspectral imaging will fly into space!
Video

7. The Svalbard SuperDARN (Super Dual Auroral Radar Network) HF Radar

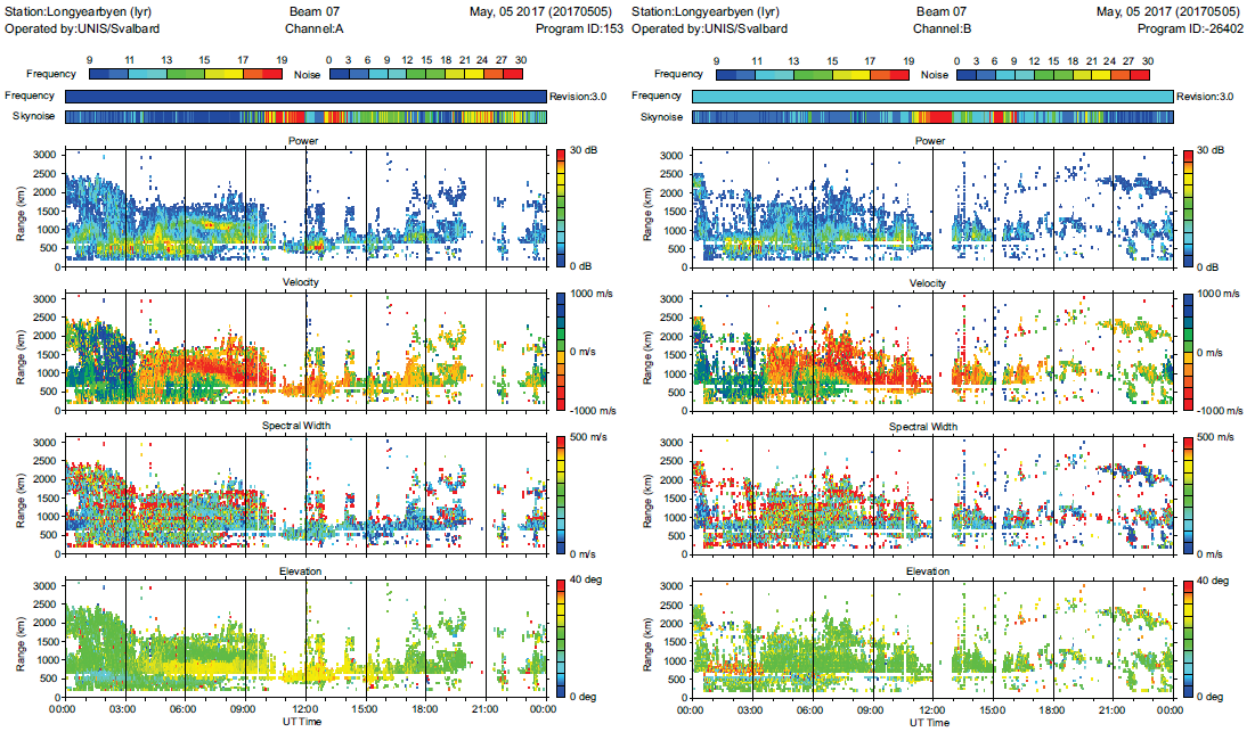


Fig. 6. Range-Time diagram showing 24 hours of stereo data from channel A and channel B using beam 7 (of a total of 16 beams). The panels show from top to bottom, received radar power, particle line of sight velocity, spectral width and the elevation of the return signal using the interferometer array. The high velocity component seen in both channels from about 06 to 10 UT is the cusp region.

Routine operations for the SuperDARN radar started in the late autumn of 2016, and the radar has been running with 24 hours/day coverage throughout 2017. The radar has performed very good for its first full year of operation, and has provided an extensive amount of good quality data.

The radar is a so called stereo radar, which means that it operates on two frequencies – or channels - simultaneously. It consist of a main antenna array, used for send and receive, and an interferometer array, used for calculating the return signal elevation angle. It has a 52 degree field of view looking North-East, with a typical range of more than 3000 km, thus covering a large portion of the Arctic Ocean. The radar is a part of a global network of similar radars, and

data – apart from being stored locally - are streamed to two international servers on a daily basis, one located at the British Antarctic Survey (BAS) in Cambridge UK, and the other at Virginia Tech in Blacksburg, VA, USA. One of the main data products from the combined set of radars are global convection maps of the ionosphere.

8. Status: The Boreal Aurora Camera Constellation (BACC)

The BACC project is starting to grow forming a constellation of low cost high sensitive all-sky color cameras monitoring the aurora oval at multiple sites. Two camera stations have already been tested at the Kjell Henriksen Observatory (KHO) (2015-2017) and in Ny-Ålesund (2016-2017). Two new stations are under construction. These will be deployed by the Finnish Meteorological Institute (FMI) to Kevo and Muonio in northern Finland. The plan is to utilize existing auroral boreal infrastructure to create a constellation of cameras. A detailed description of the system is found here.

A major setback in the project was discovered after 1 year of operation of the Ny-Ålesund camera. The USB connectivity to the camera was simply lost. We still struggle to find this bug that seems to be related to Windows 7 and PC hardware. Three new Lenovo Think Station Tiny with Core i7 processors running Windows 10 seem to have solved the problem.

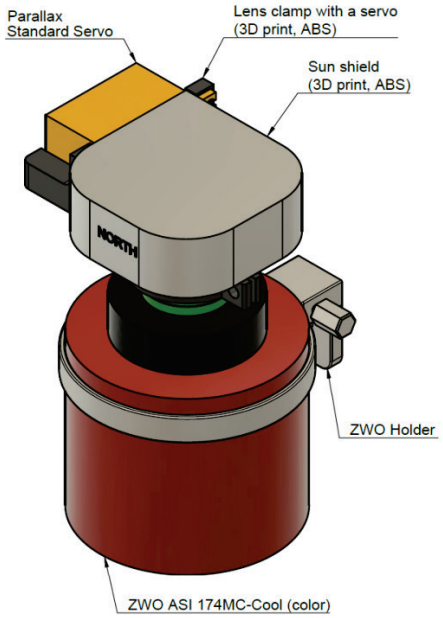


Fig. 7. Drawing of the new cooled version of BACC with Sun protection.

The cameras are now protected from direct Sun light by a 3D printed lid / shutter, controlled by an Arduino microcomputer and a standard Parallax servo. Fig. 7 shows the technical drawing of the new shutter protection system. The servo and the microcomputer are both powered by a second USB port. Serial communication via the USB port is used to open and close the shutter according to the maximum solar elevation angle allowed at the site. A typical solar elevation angle of 10 degrees below the horizon is a safe limit to avoid overexposure and damage to the sensors.

The cameras will be very useful during future rocket and radar campaigns. We now finally very soon have identical cameras at multiple sites. Keograms are available at the KHO data page.

9. Status of the building

The building needs a new layer of paint. KHO is the highest operative building in Svalbard at an altitude of 520m above sea level with extreme wind and low temperature conditions. The most important and urgent thing that needs attention is the water leaks from the domes. The domes need to be re-mounted with proper weather proof in-between rings between dome and roof (hatch plate). According the Svalbard Bygg AS who fixed the roof that blew off the service

section in 2016, the dome mounting screws are in addition losing their grip due to waterlogged hatch plates. The leaks have caused one personnel accident due to water damage of a power supply leading to electrical shortcut and shock. This accident was reported and as a response an electrical safety course was held with the observatory crew by the former head of the power plant in Longyearbyen, Knut Flå.

10. Governmental white paper on Svalbard

Our work has been positively noted in the Norwegian governmental white paper on Svalbard (Meld. St. 32, 2016):

> *"Norge er ledende i nordlysforskningen, og Kjell Henriksen-observatoriet (KHO) utenfor Longyearbyen er kjernen i norsk og internasjonal nordlysforskning. Sammen med rakett- og satellittmålinger, samt radaranleggene EISCAT og SuperDARN, utgjør dette en unik forskningsinfrastruktur på Svalbard. Denne forskningsinfrastrukturen stiller Norge i en sterk posisjon for å delta i internasjonalt samarbeid på feltet.»*

In English this means that we are on track after 10 years of operation.

11. Summary

The Kjell Henriksen Observatory (KHO) is part of The Birkeland Centre for Space Science (BCSS) and the activity has been normal 2017 with several events. Two TV production teams visited us in December with focus on the Polar winter (NRK) and the Dayside aurora (NHK). Our cross platform Aurora Forecast 3D app is published at Apple Store. The major highlight was Xiangcai Chen's defense in February. Our SuperDARN (Super Dual Auroral Radar Network) radar provides after one year of successful operation real time data to the rest of the world. One instrumental group has joined KHO. The Nagoya University from Japan has installed 3 new GNSS scintillation receivers to measure drift velocity of the plasma irregularities in the ionosphere. Our Boreal Camera Constellation (BACC) continues to grow. Five UNIS courses have used KHO as the main laboratory for teaching and 1 PhD student has graduated with flying colors.

12. New plans KHO – near future

KHO gives vital support to the Grand Challenge Initiative. 7 rockets will be launched in to the cusp over Svalbard over the next 2-3 years. Ground-based data is essential in order to provide the Primary Investigators (PIs) with the right launch decision criteria.

The planned rocket mission time tables gives us time to tune up our existing instruments and plan for new ones. The Meridian Imaging Svalbard Spectrograph (MISS) is finished and only needs operational software to contribute. Figure 8 shows the first produced RGB coded keogram from the instrument. Our tracker system need to be tuned up and tested. For the CREX 2 campaign, it is essential to select the optimal center wavelengths for the NORUSCA cameras.

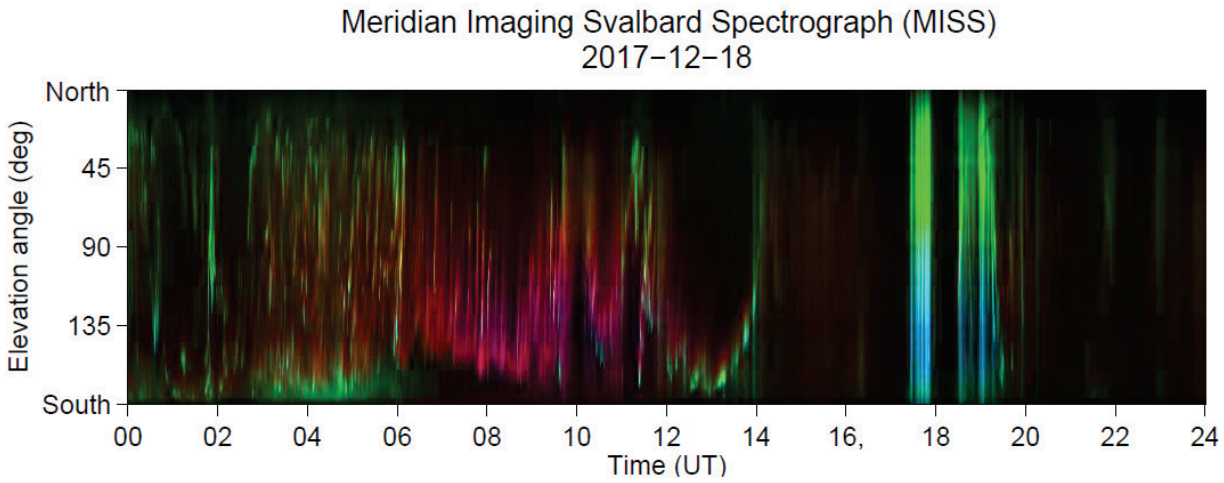


Fig. 8. Meridian Imaging Svalbard Spectrograph (MISS) RGB coded keogram. The color red, green and blue intensities correspond to auroral emission wavelengths 630, 557.7 and 487.2 nm. Hemispheric geomagnetic North to South slices of sky intensities are stacked as a function of time to get an overview of auroral activity. The read region from 06 to 11 UT is the dayside cusp.

In cooperation with the Norwegian Centre of Excellence named NTNU AMOS we have successfully, applying our knowledge of spectroscopy, constructed a small light weight push broom Hyper Spectral Imager (HSI) for drone operations. The next step is to design, develop and test a new prototype for CubeSat satellites aimed at detecting various oceanic targets.

Our new BACC partner is the Finnish Meteorological Institute (FMI). Two new stations are under testing and final calibrations. These will be deployed by the Finnish Meteorological Institute (FMI) to Kevo and Muonio in northern Finland. This will support and extend our forecast service in latitude.

The internal research funding of UNIS is of vital importance in future plans. It enables us to preserve the instrumental momentum and helps us keep track of new technology as it arrives. It seeds our research plans and proposals and is as a consequence strategically important to us. This must not be underestimated compared to our external funding which is more tied up or locked to predefined proposal tasks.

Graduated students

1. Xiangcai Chen, PhD, A study of dayside open/closed field line boundary dynamics using simultaneous ground-based optical and HF radar observations, University of Oslo / UNIS, Norway, February 24, 2017.

Presentations 2017

1. Fred Sigernes, Mikko Syrjäsuo, Pål Gunnar Ellingsen, Bjørn Lybekk, Espen Trondsen, Lasse Clausen, Jøran Moen, Jyrki Mattanen and Kirsti Kauristie, Status: The Boreal Aurora

Camera Constellation (BACC), The 44th Annual European Meeting on Atmospheric by Optical Methods, Barcelona, Spain, 4 - 8 September, 2017.

2. Fred Sigernes, The Aurora Forecast 3D, The 44th Annual European Meeting on Atmospheric by Optical Methods, Barcelona, Spain, 4 - 8 September, 2017.
3. Emma Bland, E- and F-region electron density measurements over Svalbard, SuperDARN Workshop 2017, San Quirico d'Orcia, Italy, 4-9 June 2017.
4. Emma Bland, SuperDARN radar observations of ionospheric electron density and D-region attenuation, CHAMOS Workshop 2017, Helsinki, Finland, 30 October - 3 November 2017.

Publications 2017*

1. F. Sigernes, P. G. Ellingsen, N. Partamies, M. Syrjäsuo, P. Brekke, S. E. Holmen, A. Danielsen, B. Olsen, X. Chen, M. Dyrland, L. Baddeley, D. A. Lorentzen, M. A. Krogtoft, T. Dragland, H. Mortensson, L. Smistad, C. J. Heinselman and S. Habbal, Video cascade accumulation of the total solar eclipse on Svalbard 2015, Geosci. Instrum. Method. Data Syst. Discuss., 6, 9-14, 2017.
2. F. Sigernes, Aurora Forecast 3D, iOS app in Apple Store, August 9, 2017.
3. Xiangcai Chen, PhD thesis, A study of dayside open/closed field line boundary dynamics using simultaneous ground-based optical and HF radar observations, University of Oslo, ISSN 1501-7710, 2017.
4. Partamies, N., D. Whiter, A. Kadokura, K. Kauristie, H. Nesse Tyssøy, S. Massetti, P. Stauning, and T. Raita, Occurrence and average behavior of pulsating aurora, *J. Geophys. Res. Space Physics,* doi: 10.1002/2017JA024039, 2017
5. Partamies, N., J.M. Weygand, and L. Juusola, Statistical study of auroral omega bands, *Ann. Geophys., 35,* 1069-1083, 2017.
6. N. Yagova, N. Nosikova, L. Baddeley, O. Kozyreva, D. Lorentzen, V. Pilipenko, and M. G. Johnsen, Non-triggered auroral substorms and long-period (1–4 mHz) geomagnetic and auroral luminosity pulsations in the polar cap, Accepted Ann. Geophys., 2017.
7. Xiaoyan Zhou, Gerhard Haerendel, Joran I. Moen, Espen Trondsen, Lasse Clausen, Robert J. Strangeway, Bjorn Lybekk, Dag A. Lorentzen, Shock-Aurora: Field-Aligned Discrete Structures Moving along the Dawnside Oval, Accepted, JGR 2017.
8. X. -C. Chen, D. -S. Han, D. A. Lorentzen, K. Oksavik, J. I. Moen, and L. J. Baddeley, Dynamic Properties of Throat Aurora Revealed by Simultaneous Ground and Satellite Observations, Accepted for publication, JGR, 2017.
9. Baddeley, L.J., D. A. Lorentzen, N. Partamies, W. Denig, V. A. Pilipenko, K. Oksavik, X. Chen, and Y. Zhang (2017), Equatorward Propagating Auroral Arcs Driven by ULF Wave Activity: Multipoint Ground and Space Based Observations in the Dusk Sector Auroral Oval, J. Geophysi. Res. Space Phys., 122, doi:10.1002/2016JA023427
10. V. B. Belakhovsky, V. A. Pilipenko, Ya. A. Sakharov, D. A. Lorentzen and S. N. Samsonov, Geomagnetic and ionospheric response to the interplanetary shock on January 24, 2012, Earth, Planets and Space , 69:105 DOI 10.1186/s40623-017-0696-1, 2017.
11. N. Yagova, N. Nosikova, L. Baddeley, O. Kozyreva, D. Lorentzen, and V. Pilipenko Non-triggered auroral substorms and long-period (1-4 mHz) geomagnetic and auroral

luminosity pulsations in the polar cap, submitted to Ann. Geophys. 35,3, 365-376, 10.5194/angeo-35-365-2017, 2017.

12. V.A. Pilipenko, O.V. Kozyreva, L. Baddeley, D.A. Lorentzen, V.B. Belakhovsky, Suppression of the dayside magnetopause surface modes, Solar-Terrestrial Physics – V. 3, No. 4, P. 17–25, DOI, 10.12737, 2017.

*Listed presentations and publications do not include all instrumental groups at KHO, only from the KHO crew.