Light pollution and Threats

BIRKELAND CENTRE FOR SPACE SCIENCE

Fred Sigernes, Lisa Baddeley, Mikko Syrjäsuo, Dag Lorentzen, Noora Partamies, Emma Bland, Erkka Heino, Katie Herlingshaw, Lindis Bjoland, Fasil Tesema Kebede and Nina Kristine Eriksen.

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

Abstract

Light pollution has become an exponential problem to the Kjell Henriksen Observatory (KHO). This document identifies the main polluters and possible solutions to the problem.

Introduction

In the late 90's it became necessary that we had to move our activity from the old *Nordlysstasjonen in Adventdalen* due to light pollution from Longyearbyen. Several sites were, at that point, evaluated for a new observatory. It was decided that the best course of action was to move the station to the furthest possible distance from Longyearbyen without the need to construct a large road to allow access to the site. The choice was Breinosa with co-location with the EISCAT Svalbard radars. Our wish to move was, after several media events, approved in May 2005 by the Minister of Education and Research, Kristin Clemet. On Budget (~25 MNOK), the new station was opened in January 2008 and named The Kjell Henriksen Observatory (KHO), dedicated to the late professor who had put a lot of work and soul into the old station in Adventdalen.

During the auroral winter season, from November to the end of February, 28 optical instruments operate around the clock. The 17 non-optical instruments run all-year-round, 24 hours a day. KHO serves as the main laboratory for hands on training and teaching of students in the Space physics group at UNIS. A grand total of **75 ECTS** (European Credit Transfer and Accumulation System) have been taught per year. We are currently 11 physicists permanently living in Longyearbyen that depends on successful operation of the observatory. In addition, 24 different institutions from 14 nations have optical instruments are at KHO. The observatory is the largest of its kind and is recognized as a world class research infrastructure.

It is the only place in the world capable of routinely making observations of the aurora, 24 hours a day, during the polar night. In addition, the infra-structure is of vital importance for ground support of NASA (USA), JAXA (Japan) and Norwegian scientific rockets.

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. Adjunct Prof. NTNU AMOS.	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 Geophysical Department, Principal Investigator (PI) SuperDARN radar project, UNIS node leader of the BCSS	dagl@unis.no
Lisa Baddeley	Associate Professor, Radar applications, Head of the Doppler Pulsation Experiment Co-Investigator (Co-I), SuperDARN radar project	lisab@unis.no
Emma Bland	Post Doc, Middle atmospheric physics	emmab@unis.no
Erkka Heino	Post Doc, Middle atmospheric physics	Erkka.heino@unis.no
Katie Herlingshaw	PhD candidate, Upper atmospheric physics	katie.herlingshaw@unis.no
Lindis Bjoland	Post Doc, Upper atmospheric physics	lindis.bjoland@unis.no
Fasil Tesema Kebede	PhD candidate, Middle atmospheric physics	fasil.tesema@unis.no
Nina Kristine Eriksen	PhD candidate, Upper atmospheric physics	NinaKristine.Eriksen@unis.no

Table 1. The Kjell Henriksen Observatory crew (2019).

Ida Asklund is our contact from the Norwegian Construction and Property Management Department in Longyearbyen who owns the building.

Operational instrumentation

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

A detailed description of the performance and the scientific objective of each instrument are found online. Figures 2 and 3 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; 5 are currently not in use.

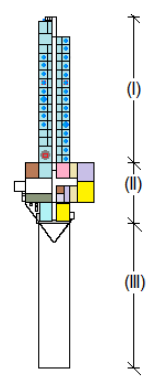

Fig. 1. Sketch of KHO: (I) Instrumental section, (II) Service section, and (III) Extended platform.

	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
41	3 axis induction magnetometer	PRIC	E	China
42	VHF base station	Kongsberg Satellite Service AS (KSAT)	E	NO
43	TESS-W photometer	University of Madrid (UCM)/UNIS	B	Spain/NO
44	2 x Tracker cameras	UNIS	A	NO

Table 2. Instruments at the Kjell Henriksen Observatory (2019).

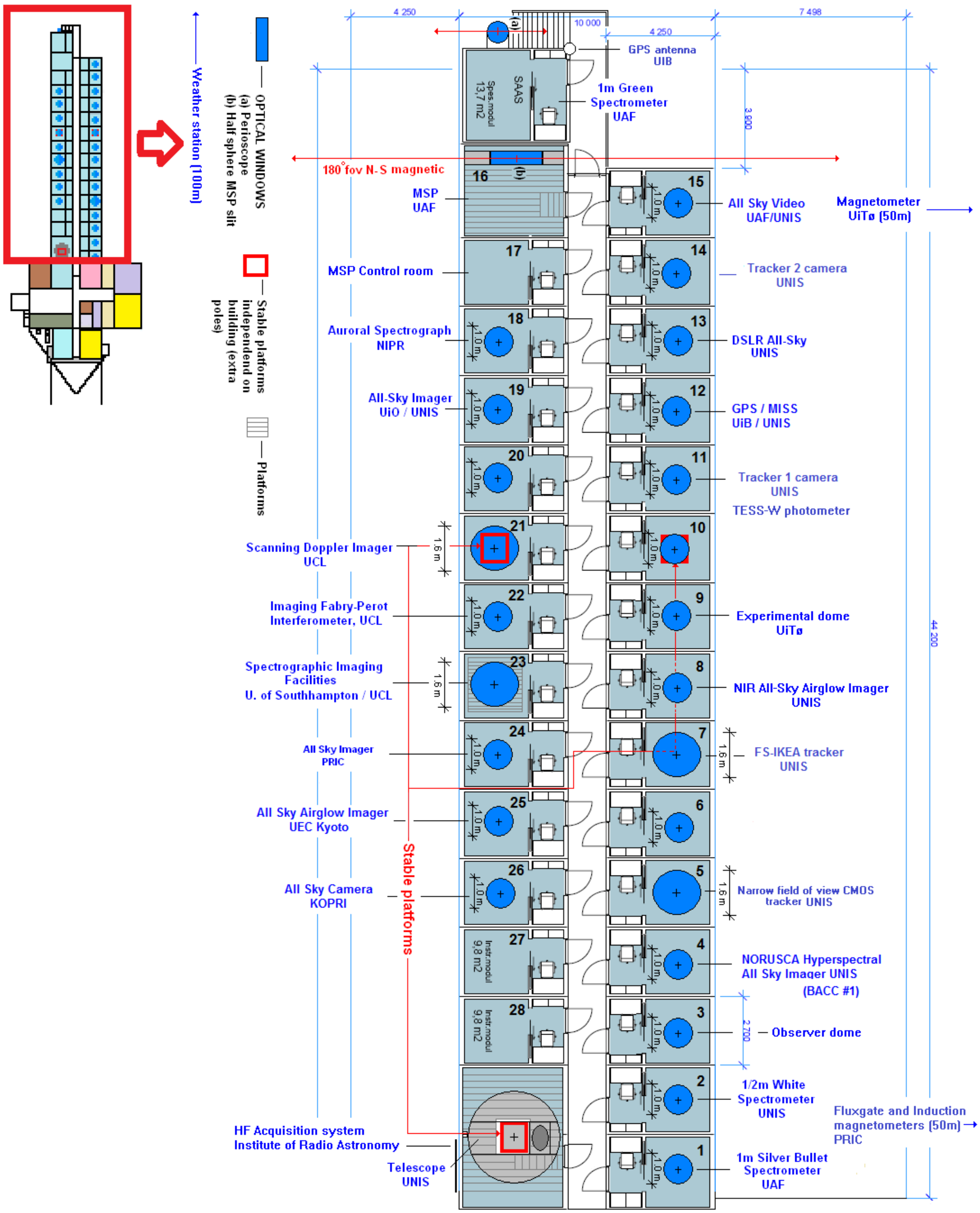

Fig.2. Map of the Instrumental section (I) at the Kjell Henriksen Observatory (2019).

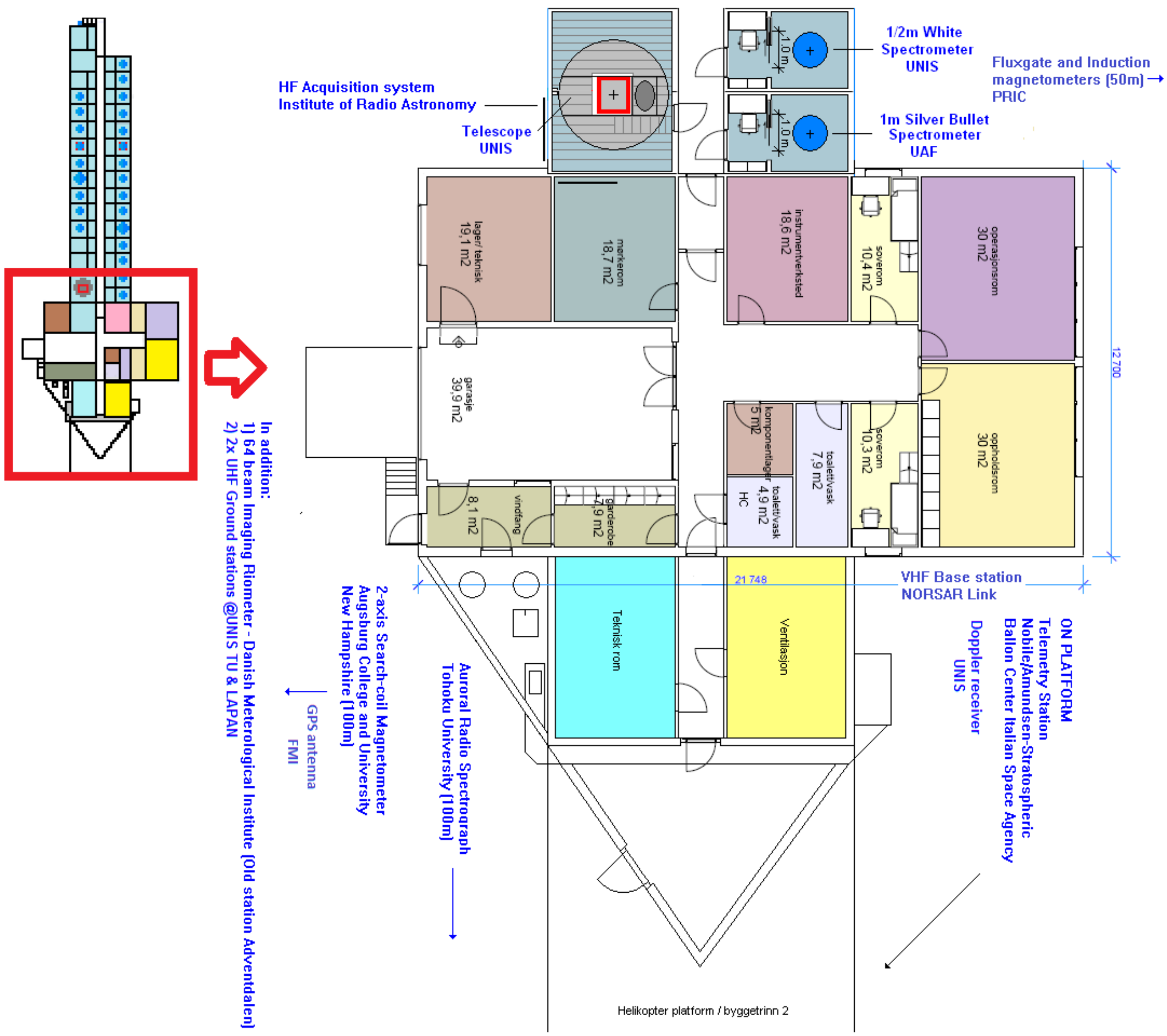

Fig.3. Map of the Service section (II) at the Kjell Henriksen Observatory (2019).

Light pollution and threats

Since the opening of the KHO in 2008, the light pollution has increased exponentially. The source is mainly due to growing number of dog yards by the foot of the mountain into the Bolterdalen valley. When driving from Longyearbyen into Adventdalen the illumination from these yards look like a small city. Numerous attempts through Svalbardposten to encourage people to at least turn OFF the lights when they are not in use have failed. Dialog is not working even though we have a political consensus from the local government that light pollution should be kept to a minimum. Figures 4 to 12 identifies the main polluters.

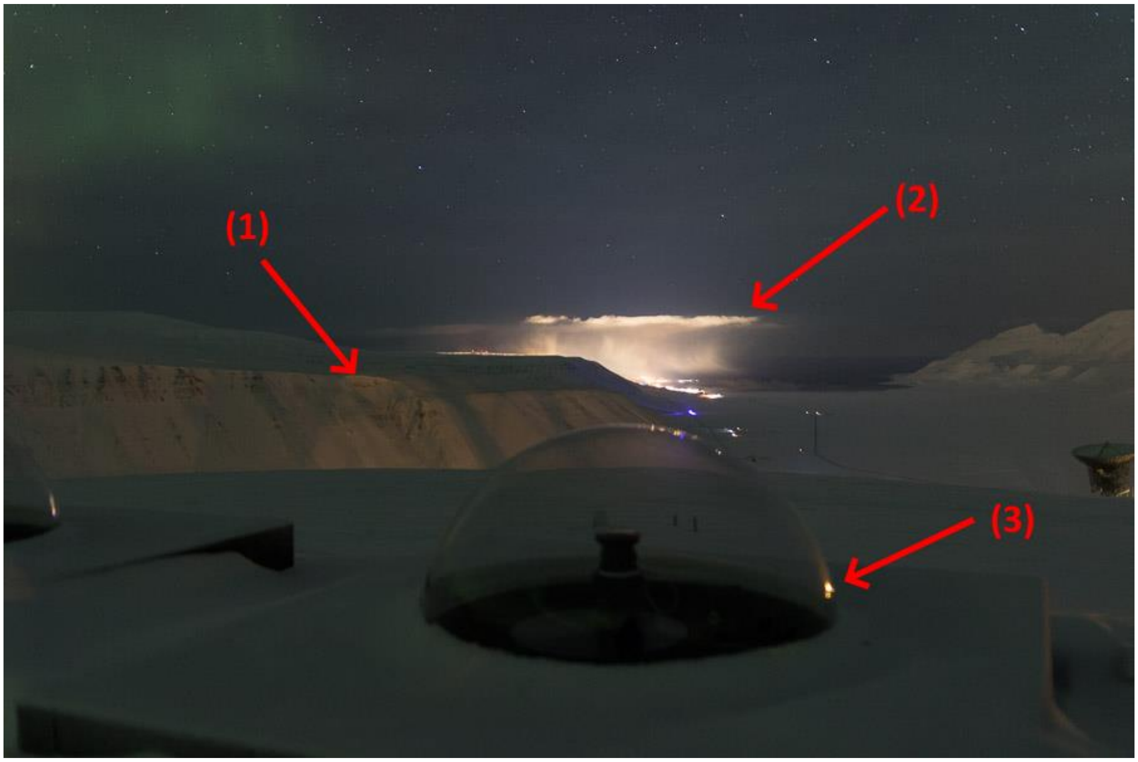

Fig.4. . Image by Mikko Syrjäsuo (2017)**.** Light pollution from (1) Dog yards, (2) Longyearbyen and (3) Mine 7.

Fig.5. Image by Stefan Claes (2019) showing main light polluters as seen from across the Adventdalen Valley.

Fig.6. Image by Mikko Syrjäsuo (2019) of Dog yard #1.

Fig.7. Image by Mikko Syrjäsuo (2019) of Dog yard #3.

Fig.8. Image by Mikko Syrjäsuo (2019) of Dog yard light pollution on the mountain side.

Fig.9. Image by Mikko Syrjäsuo (2019) of dog yards.

Fig.10. Image by Mikko Syrjäsuo (2019) of Mine 7.

Fig.11. Image by Mikko Syrjäsuo (2019) of increasing establishment of Dog yards close to KHO.

Fig.12. Image by Mikko Syrjäsuo (2019) aurora and light pollution from Dog yards.

Note that the above images have been taken by a regular DSLR camera without any processing to increase image intensity. The optical instruments at KHO are about 100 times more sensitive and detect the pollution even at high elevation angles to the horizon. See Figure 13. Such pollution can have serious consequences in regards to the scientific integrity of the data from the instrumentation as well as limiting their capabilities.

The second long term threat is the lifetime of Mine 7, which is expected to operate for a maximum of 20 more years. There are several scenarios that should be evaluated and discussed. If we stay co- located with the EISCAT Svalbard radar, the access to the mountain (keeping the road up the mountain open all year), will most probably double or triple the operational costs. If we have to move due to light pollution, then we will need a new road and infrastructure further away from Longyearbyen and Bolterdalen. One alternative could be to move deep into Adventdalen. Note that this is not compatible with the environmental plan to make inner Adventdalen a conservation area.

On positive note, the light pollution from Longyearbyen itself has decreased. The main reason for this is that the street lights have been changed from gas discharge tubes (orange, Sodium emission) to blue LED lights that are only illuminating the roads and are crucially, not directing light up into the atmosphere (directional illumination). The blue lights from the LEDs are dimmed by air and distance more effectively than the orange Sodium emission lines from the tubes. The Sodium lines were long range visible and the pollution was high. We, at KHO, and the auroral scientific community would like to thank Lokalstyret for the new street light solution in Longyearbyen.

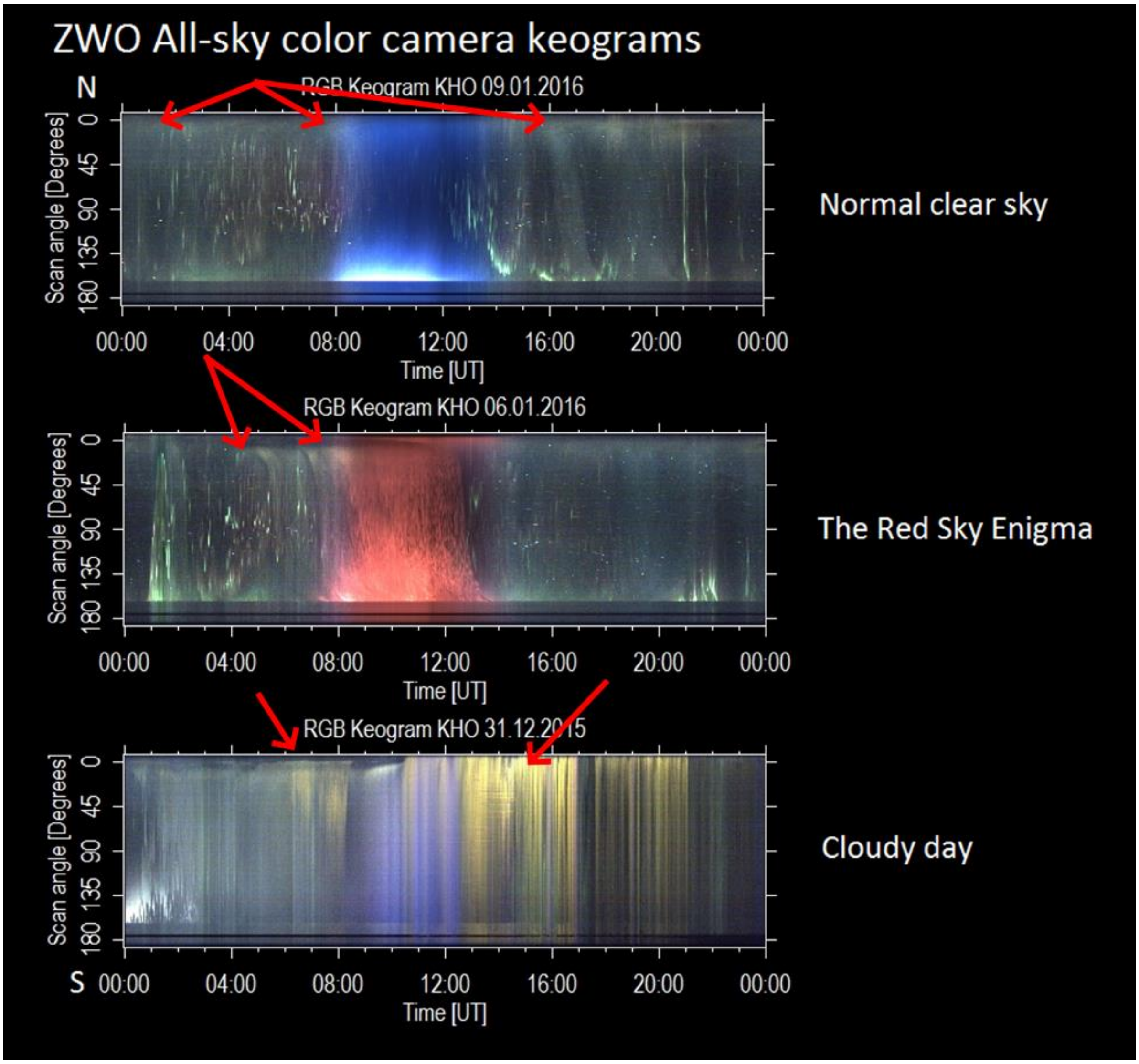

Fig. 13. Daily all-sky color camera Keograms along the North – South magnetic meridian from the Kjell Henriksen Observatory (KHO) illustrating normal clear sky (top), the Red Sky enigma (middle) and cloudy conditions (bottom) at 9th, 6th and 31st of December 2015, respectively. Red arrows mark diffuse areas of light pollution. Note the strong light pollution is clearly seen on cloudy days.

Figure 13 shows three all-sky color camera keograms from KHO. A keogram is just a time stack of the center image column intensities from our all-sky cameras aligned North-South in geomagnetic coordinates. The main purpose is the see the overall activity during one day. Top panel shows a clear day with lots of aurora. The middle panel shows red colored Sun illuminated stratospheric ice clouds that appear mid-day in the winter. It is known as the Red Sky Enigma effect. The bottom panel shows a typical cloudy day.

Solutions?

Since our current attempts to discuss the matter further with the local community has failed then we feel it is necessary to propose more stringent measures to reduce the light pollution. These could be measures such as:

- Installing light switches with automatic timers (such as the ones at the town dog yard) which will ensure the lights are switched off when they are not needed
- Ensure that all steps are done to keep any illumination down to a minimum such as the use of LED bulbs and that all lights should be pointed towards the ground (where they are needed) and not up into the sky. Such directional illumination is recommended by the EU project named STARS4ALL
- Run a community awareness campaign about light pollution at the beginning of the dark season each year.
- Provide a forum for KHO scientists and the tourist industry to formally discuss issues pertaining to light pollution.
- Aim for the Longyearbyen area to be designated as an International Dark Sky Place (https://www.darksky.org/our-work/conservation/idsp/become-a-dark-sky-place/).
- Prohibit new construction in the Breinosa/Bolterdalen area so that light pollution cannot increase further. Or require that proposals for new construction include specific measures to minimize light pollution.
- Introducing a higher electricity tariff for those in the valley who have commercial activities
- …

Some solutions could be achieved with minimal disruption (such as installing timers and LED bulbs with directional illumination). Alternatively, they could, for example, be enforced as an operational necessity by Lokalstyret. Even more strictly, all lights could be controlled by the power plant. It should also be noted that the light pollution means that the tourist industry in town, which operates any 'auroral tours', could be being forced to drive further and further into the valley. This in turn will increase their running costs (in terms of petrol for the bandwagon) which will have a knock on effect. An action plan is definitely needed or KHO will have to move if the situation continues. It is also a paradox that some in the tourist industry do not seem to understand the value of dark skies and aurora. Especially, since it is the strong public interest in the aurora that leads to visitors. Lots of people use the all-sky camera data from KHO and our Aurora Forecast 3D app to help them catch the aurora.

Summary
KHO is the world's largest optical auroral observatory and represents a large investment from the Ministry of Education and Research. Light pollution threatens this investment. The light pollution from human activities close to Breinosa has increased dramatically during the last decade since KHO was opened in 2008. If the KHO is to continue to be recognized as a world class facility for auroral studies, attracting scientists from around the world, it is vital for it to operate under minimum light pollution conditions. We hope our concerns are taken seriously in order to secure our mandate from the Norwegian Parliament to operate an auroral observatory for the nation, and respect the taxpayer's contribution to our activity.

Governmental white papers
1) Environmental protection on Svalbard: Section 3.1 of the Svalbard Environmental Protection Act defines light as a type of pollution (https://www.regjeringen.no/en/dokumenter/svalbard-environmental-protection-act/id173945/)

2) Norwegian governmental white paper on Svalbard: Section 9.4.4 (Meld. St. 32 (2016-2016) https://www.regjeringen.no/en/dokumenter/meld.-st.-32-20152016/id2499962/