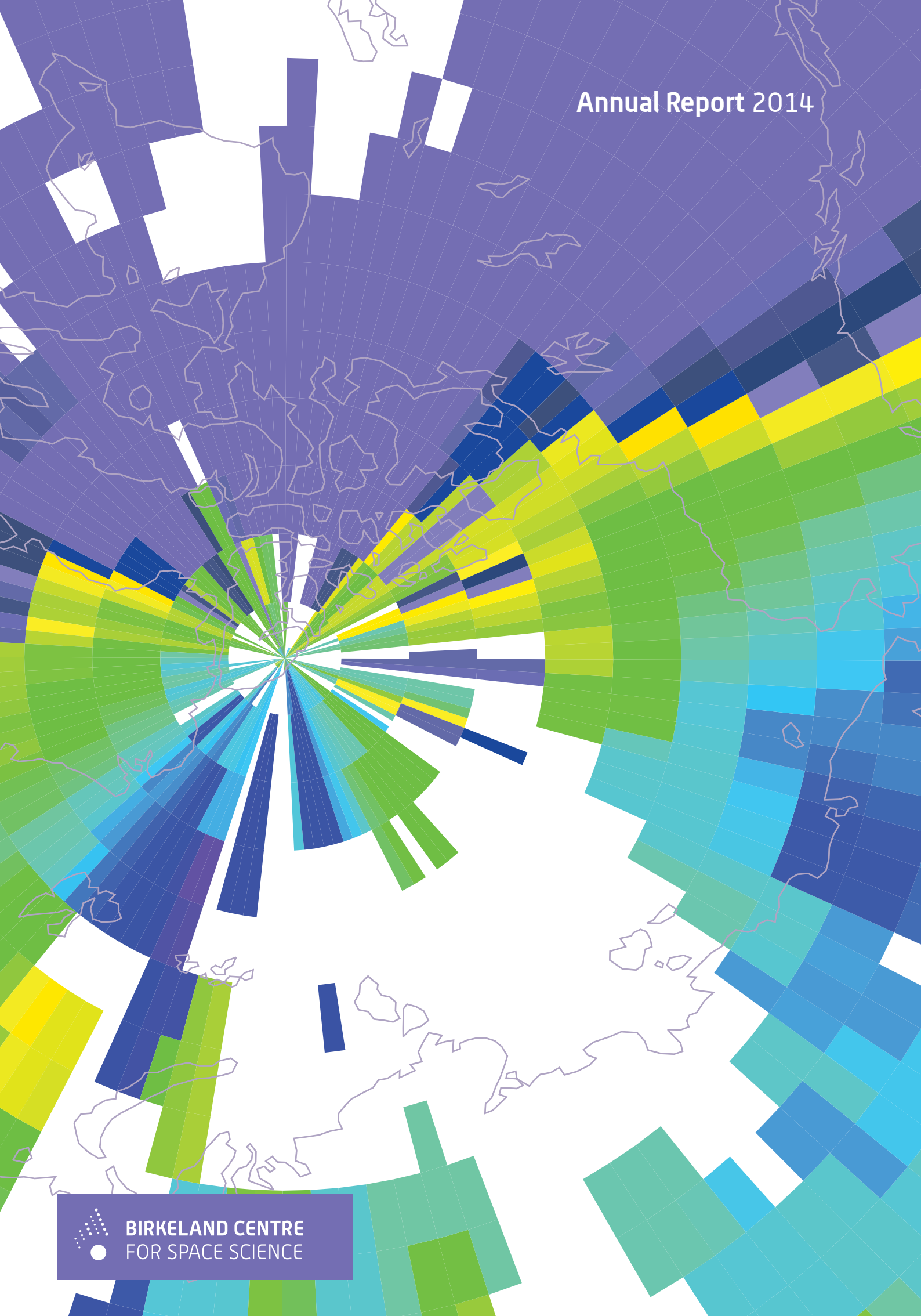
Annual Report 2014



BIRKELAND CENTRE
FOR SPACE SCIENCE

From the Centre Leader

The Birkeland Centre for Space Science (BCSS) started in March 2013. It is led from the Department of Physics and Technology at the University of Bergen with nodes at NTNU and UNIS. The overarching scientific objective of the BCSS is to understand "How the Earth is coupled to space". Under this title we have formulated four main questions where we have identified fundamental gaps in our knowledge:

Q1. When and why is the aurora in the two hemispheres asymmetric?
Q2. How do we get beyond the static large scale picture of the ionosphere?
Q3. What are the effects of particle precipitation on the atmospheric system?
Q4. What is the role of energetic particles from thunderstorms in geospace?

The BCSS is organized in scientific groups focusing on these four questions. In addition we have two groups to design, build and operate state-of-the art instrumentation, one for space and one for ground-based instrumentation. We also have a group for education and public outreach that is responsible for our visual identity.

During our second year, the Birkeland Centre for Space *Science* is keeping up the good momentum we had from the first year. We have published 29 papers in peer-reviewed journals. A highlight is the paper by Fear et al. (2014) in *Science*, with Steve Milan from BCSS as second author, about transpolar arcs. Another highlight is the paper by van der Meeren et al. (2014) about GPS scintillations and electron density irregularities, which was featured on the front page of *Journal of Geophysical Research*. Other highlights are the successful SuperDARN workshop at UNIS in May 2014 and the delivery of the Ground Model for ASIM. The collaboration with the Bjerknes Centre for Climate research has been initiated and the planning for aircraft campaigns over thunderstorm systems to search for terrestrial gamma ray flashes has started.

The young scientists at BCSS are doing very well. Thomas Gjesteland (UiB) was awarded the Yara Birkeland prize of 2014. The PhD students Jone Reistad and Paul Tenfjord were granted the Peder Sæther (6 months) and Fulbright (9 months) stipends to go to the University of California at Berkeley and Los Angeles, respectively.

We continue to have a strong presence at all the large international meetings. At EGU in Vienna we organized one session and gave 15 presentations, at AOGS we organized one session and gave six presentations, and at the AGU fall meeting we organized three sessions, gave five invited talks and 20 contributed presentations. Invited talks and presentations were also given at COSPAR Scientific Assembly, the URSI GASS 2014, 12th international conference on Substorms, as well as at other workshops and meetings (e.g., TEA-IS summer school, SuperDARN workshop, CEDAR).

Two PhD and nine master's theses have been produced. At the moment, we have nine master's students.

The two-year old Centre is still healthy and is doing fine.

Nikolai Østgaard,
Leader of BCSS

Q1 When and why is the aurora in the two hemispheres asymmetric?

The mechanisms producing the aurora are closely linked with the Birkeland currents, electric currents that flow along magnetic field lines. Birkeland currents flowing upward are largely carried by downward electrons, which can also excite auroral emissions if their energy is high enough. Interhemispheric asymmetries in Birkeland currents have been proposed as explanations for observations of differences in the auroras in two hemispheres *(Laundal and Østgaard, 2009; Reistad et al. 2013)*. For this reason, the Q1 group is currently working to understand asymmetric Birkeland currents.

Prof. Nikolai Østgaard, UiB
Team Leader and
Leader, Birkeland Centre for Space Science

Three mechanisms which could produce asymmetric Birkeland currents were summarized by Østgaard and Laundal (2012). One suggested mechanism producing such asymmetries is differences in field line tension following dayside reconnection when the interplanetary magnetic field (IMF) has a large component in the sun-Earth direction (B_X). In 2014, PhD student Jone Reistad and co-workers published a study that showed that there is indeed a statistically significant connection between the IMF B_X and the auroral intensity in the region where we expect this mechanism to operate (*Reistad et al., 2014*). The difference is not large, however, but considering that B_X is very frequently present in the IMF, this mechanism may play an important role in the total energy budget of the magnetosphere.

Apart from the ongoing work on asymmetries in Birkeland currents, the group has been part of other publications related to interhemispheric asymmetries in the auroral regions:

- Fear et al. (2014) published a paper in *Science*, showing particle distributions in the lobes which are characteristic of closed field lines. The regions where this was observed mapped to transpolar arcs, indicating that these auroral phenomena occur in both hemispheres simultaneously.
- Laundal and Gjerloev (2014) published a paper addressing longitudinal and interhemispheric differences in ground magnetic field perturbations which are due to variation in the Earth's main magnetic field. They showed that when comparing or mixing data from different longitudes and hemispheres, the main field will create systematic variations across the globe. These variations can be minimized if the data are properly represented in a reference frame taking a realistic model of the magnetic field into account.

The group has been very active in conferences in 2014, with presence at five conferences. There were four invited talks in the Q1 topic, three of these at the 2014 AGU Fall Meeting. We also organized a special session on interhemispheric asymmetries at the 2014 AGU Fall Meeting. Karl Magnus Laundal and Stein Haaland participated in an ISSI team on interhemispheric asymmetries. PhD student Paul Tenfjord was granted a Fulbright scholarship to go to University of California Los Angeles in 2015. PhD student Jone Reistad was granted the Peder Saether scholarship to go to the University of California, Berkeley in 2015. The Q1 group has held weekly team meetings in 2014, with remote members joining via telephone. One master's thesis has been produced.

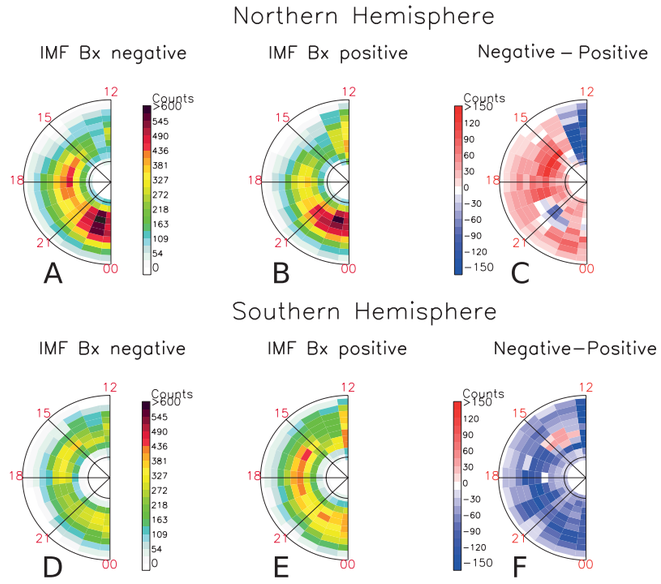


Figure 1: (Top) Auroral intensities for northern hemi-sphere, from left: IMF B_X negative, IMF B_X positive and difference between the two.

Figure 1: (Bottom) The same for southern hemispheres. Significant differences in the dusk sector consistent with the IMF B_X polarity and the expected signal from a more efficient solar wind current dynamo in the north for IMF B_X negative and in the south for IMF B_X positive *(Reistad et al., 2014)*.

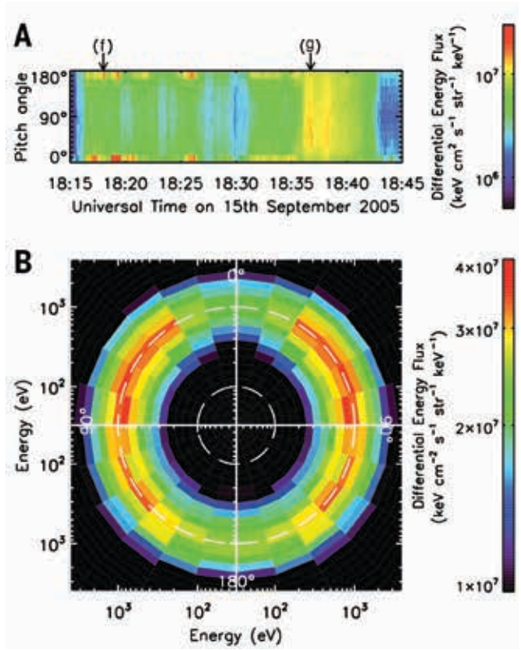


Figure 2: A: Pitch angle distribution of electrons from Cluster. Crossing the theta aurora is marked with (g).

B: Full energy distribution at (g), showing empty loss cones around 0° and 180° pitch angles, a strong indication that Cluster is measuring trapped particles on closed field lines *(Fear et al., 2014)*.

Team

Anders Ohma Master's student, UiB

Theresa Rexer Master's student, UiB

Jone Peter Reistad PhD candidate, UiB

Kristian Snekvik Post-doc, UiB

Paul Tenfjord PhD candidate, UiB

Steve Milan Professor II, UiB & Dept. of Physics & Astronomy, University of Leicester, UK

Stein Haaland Researcher II, UiB & Max Planck Institute for Solar System Research, Göttingen

Karl M. Laundal Co-leader, Researcher

Q²

How do we get beyond the large scale static picture of the ionosphere?

The science targeted by Q2 is an acknowledgement that the magnetosphere-ionosphere system is highly dynamic including processes with scale sizes from hundreds of meters to thousands of kilometers (at ionospheric altitudes). Despite this well-known fact, most published models make the assumption that observed variations are solely due to spatial gradients or, in other words, that the system is static. This crippling assumption is largely due to the inherent observational shortcomings of single satellite missions, which can-not separate spatial and temporal variations of a measured electromagnetic parameter. Progress, however, has been made possible by the recent launch of multi-point satellite missions (e.g. ESA SWARM, THEMIS and Cluster). These missions, as well as some ground-based observations, finally provide us the observational basis needed to advance our understanding of the coupling between the Earth and near space.

Dr. Jesper Gjerloev
Team Leader
UiB and Johns Hopkins University
Applied Physics Laboratory

The group has been productive in the past year and made progress on key questions. Below, we highlight two of the published papers of which one was selected for the cover page of the prestigious *Journal of Geophysical Research*.

The first highlight of the efforts in Q2 was the appearance of a figure from a paper by van der Meeren et al. (2014) on the cover page of the JGR October 2014 issue. The study used a novel technique where spectrograms of 50 Hz raw phase from GPS signals were investigated to enhance our understanding of decameter-to-kilometer-scale irregularities in relation to plasma structures in the polar cap. Specifically, the study looked at plasma structuring at the front of a tongue of ionization (TOI) in the nightside polar cap over Svalbard, which had drifted across the polar cap from the sunlit dayside. The leading edges of plasma structures are, to a first approximation, stable against the gradient drift instability, which is a major instability generator in the polar cap. However, using the novel GPS phase spectrogram method, the study found that 1) the front of the TOI was indeed structured, 2) it was structured at different scale sizes at different locations on the edge, and 3) only the edge was structured, not the high-density plasma inside the TOI itself.

The second highlight was the study published by Luhr et al. (2014). They performed a statistical study of the temporal- and spatial-scale characteristics of different field-aligned current (FAC) types derived with the three-spacecraft ESA Swarm mission. From correlation analysis they concluded that the spatial morphology of the large-scale field-aligned currents is different on the dayside than on the nightside. On the nightside the longitudinal extension is on average 4 times the latitudinal width, while on the dayside, particularly in the cusp region, latitudinal and longitudinal scales are comparable.

The group has published seven papers plus six with Q1 and Q3, given seven invited talks, convened three special sessions at international meetings and hosted one conference. One PhD and three master's theses have been produced by Q2 group members in 2014.

Some highlights from presentations and sessions should also be mentioned. The 2014 SuperDARN meeting was successfully held at UNIS and the three special sessions were led by Dr. Gjerloev (one at AOGS in Sapporo and two at the 2014 Fall AGU Meeting in San Francisco).

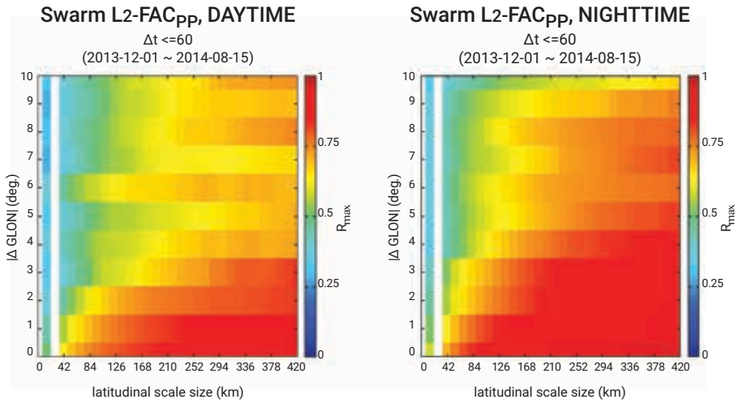


Figure 1: (Above) Analysis of FAC longitudinal correlation length. Correlations with Rmax <0.7 are considered insignificant. Dayside (left) and nightside (right).

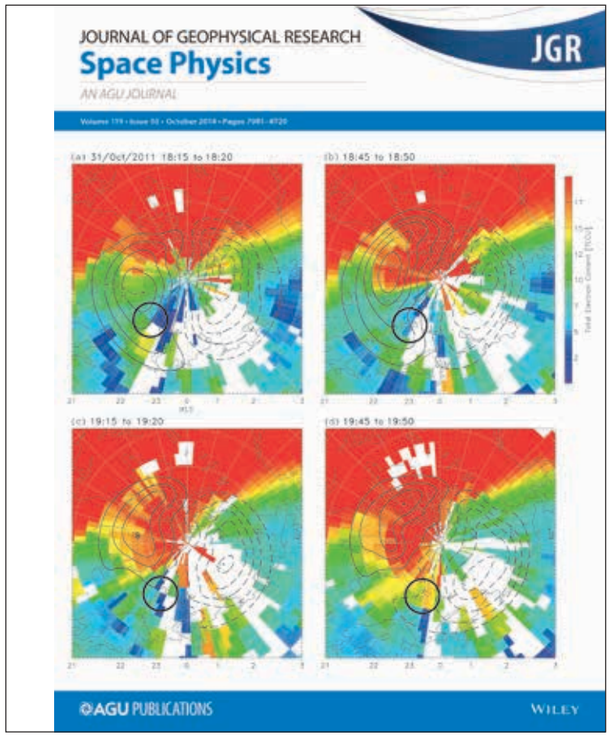


Figure 2: (Above) The image shows a tongue of ionization (TOI) stretching across the polar cap from the dayside ionosphere to the nightside over Svalbard (black circled). The study presents evidence of highly varied structuring at the front of the TOI as it passes over Svalbard.

Norah Kwagala Master's student, UiB

Xiangcai chen PhD candidate, UNIS

Christer van der Meeren PhD candidate, UiB

Beate Humberset PhD candidate, UiB

Finn Søraas Professor Emeritus, UiB

Lisa Baddeley Associate Professor, UNIS

Dag Lorentzen Co-leader, Professor, UNIS

Kjellmar Oksavik Professor, UiB *(not photographed)*

Team

Q3 What are the effects of particle precipitation on the atmospheric system?

Working with the impact of energetic particle precipitation (EPP) upon the atmosphere requires a cross-disciplinary approach. We need knowledge about the nature of the EPP in different types of events, in addition to the internal variability of the polar middle atmosphere as it forms the background against which perturbations due to EPP events must be measured. This duality was clearly exemplified by our first master's thesis. Zawedde (2014) showed that EPP-induced OH enhancement and subsequent O_3 depletion could be found even during weak and moderate geomagnetic storms. The spatial distribution of the enhancement was, however, strongly influenced by the seasonal dynamics.

Dr. Hilde Nesse Tyssøy, UiB
Team Leader

Meteor winds from a longitudinal chain of SuperDARN radars have been used to quantify the influence of planetary wave variability on the polar MLT (*Kleinknecht et al., 2014*) during summer (*Stray et al., 2014a*), winter (*Stray et al., 2015*) and autumn (*Stray et al., 2014b*) conditions. The Trondheim momentum flux meteor radar has been used to make the first measurements of the seasonal cycle of high latitude gravity wave forcing around 90 km (*de Wit et al., 2014a*). In addition, we have presented a combined observation and WACCM modelling study on the gravity wave forcing of the mesopause region during the 2013 major sudden stratospheric warming (*de Wit et al., 2014b*) and traced the extent of the influence of the winter stratospheric warming into the summer hemisphere using Aura Microwave Limb Sounder satellite temperature measurements (*de Wit et al., 2015*). We have, furthermore, continued to work on mesospheric ozone variability–a key constituent affected by EPP–using the WACCM model and observations.

We have also worked on quantifying the energy input deposited by both precipitating electrons and protons. With respect to the widely studied Solar Proton Events (SPEs), atmospheric models tend to oversimplify the distribution of the proton energy deposition. We have therefore provided a simple applicable cutoff latitude parameterization considering the physical mechanisms influencing the cutoff latitudes for both the day- and nightside using only the Dst index, the interplanetary magnetic field and solar wind pressure (*Nesse Tyssøy and Stadsnes, 2015*). The parameterization can be utilized on the GOES particle fluxes and the resulting energy deposition will improve the quantification of the total energy being deposited and capture the related day-night asymmetry during SPEs, as shown in Figure 1.

In addition, we have optimized the electron and proton measurement performed by the electron and proton detectors, MEPED, on the NOAA/POES and MetOp satellite system. The electron measurements are contaminated by low energy protons. The false counts can be subtracted as MEPED is measuring proton fluxes with the relevant energies. To do this accurately, we need to account for possible degradation of the proton detectors. We now have a consistent, robust method and result (*Sandanger et al.,* under review). We have also developed a method for calculating the flux versus pitch angle in the loss cone based on the measured electron fluxes and theoretical flux profiles based on wave-particle interaction, removing the measurement uncertainty associated to anisotropic fluxes.

The skills we have developed enable us to complement other research groups specializing in modelling and measuring chemical composition in the atmosphere. Several collaborations have been initiated in the last year. We are now actively taking part in the PhD study by Christine Smith-Johnsen at the Department of Geosciences at the University of Oslo where the Whole Atmosphere Community Climate Model (WACCM) is central. Together with the Department of Meteorology at Stockholm University we are investigating the direct impact of the electron precipitation production of NOx using measurements by the Swedish satellite Odin and the electron measurement from the NOAA/POES satellite. We have also initiated collaboration with Dr. Miriam Sinnhuber at the Karlsruhe Institute of Technology. However, first and foremost, we have started a collaborative project with the Bjerknes Center for Climate Research. This has resulted in the course "The Polar Winter Atmosphere from Troposphere to Mesosphere–coupling mechanisms, forcing and feedback" (Figure 2) as part of the Norwegian Research School in Climate Dynamics. Here, we found a common ground for a future collaboration where we intend to investigate the significance of a potential vertical coupling of the EPP impact on the middle atmosphere and surface temperature.

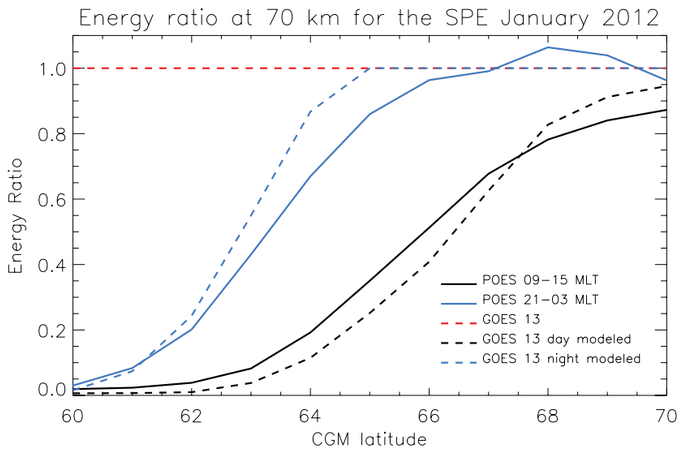


Figure 1: (Above) The estimated energy deposition at 70 km from the POES measurements for day (black) and night (blue) relative to the energy deposition estimated from GOES 13 measurements for the entire SPE January 2012. The red dashed line is the energy deposition from GOES 13 normalized to 1.0, while the black and blue dashed lines are the energy deposition when applying the day- and nightside cutoff parameterization to the GOES fluxes.

Figure 2: (Below) Dr. Annika Seppälä from the Finnish Meteorological Institute was one of ten lecturers teaching the course "The Polar Winter Atmosphere from Troposphere to Mesosphere".

Annet Eva Zawedde
Research assistant, UiB
Markus Marszalek
Master's student, UiB

Silje Holmen
PhD candidate, UNIS
Linn-Kristine Ødegaard
PhD candidate, UiB

Johan Stadsnes
Professor Emeritus, UiB

Marit Sandanger
Post-doc, UiB

Yvan Orsolini
Senior Scientist, NILU

Robert Hibbins
Professor, NTNU

Patrick Espy
Co-leader,
Professor, NTNU

Team

Q4 What is the role of energetic particles from thunderstorms in geospace?

It is now 20 years since it was discovered that thunderclouds emit very energetic particles into the near space environment. The energetic gamma bursts are called Terrestrial Gamma ray Flashes (TGFs) and they are the most energetic natural photon phenomenon in our atmosphere. Since then, it has also been found that energetic electrons and positrons are emitted from thunderstorms to space. The origin of these newly discovered phenomenona, and their effects on the near space environment, is the main science objective for our group.

Prof. Nikolai Østgaard, UiB
Team Leader and
Leader, Birkeland Centre for Space Science

In 2014 we have published three papers, given five invited talks and 17 contributed presentations at international meetings. Also this year, we organized sessions at the EGU and AGU meetings, and at the "Thunderstorm Effects on the Atmosphere-Ionosphere System"–TEA-IS summer school, we were represented by eight people and gave two of the invited lectures. One PhD and one master's theses have been produced by the Q4 group in 2014. Two new researchers have joined the group, Andrew Mezentsev and Nikolai Lehtinen. Thomas Gjesteland was awarded the Yara Birkeland Prize 2014.

There are two main competing theories for explaining the production of TGFs by electrons that have been accelerated in strong electric fields. One considers the strong local field in the leader tip of the lightning channel–often referred to as streamer-leader model–and the other considers acceleration and multiplication of electrons in the large ambient field between the two main charge regions, where a feed-back mechanism is also at work. Using the GEANT-4 tool-kit we have investigated the latter mechanism. Skeltved et al. (2014) found that the acceleration and multiplication of electrons were confirmed by the GEANT-4 model, but it is essential that the correct cross-sections of low energy electrons are used. They also found that a feed-back mechanism could increase the multiplication of electrons by many orders of magnitude. However, the electric field must be extremely high over short distance or the potential needs to be very high for larger distance between the charge layers. It is not obvious that such high electric fields or potentials are present in thunderclouds.

Nisi et al. (2014) examined the new catalogue of RHESSI TGFs (*Gjesteland et al., 2012*) and tropopause altitudes, and found that there was not a significant difference compared to the first catalogue. However, the study showed that the new RHESSI TGFs originated further away from the satellite footpoint.The most important result was that the fluence distribution of TGFs at source altitude seems to be softer when the production altitude is accounted for.

Fabró et al. (2015) presented a detailed analysis of the meteorological conditions conducive to TGF production over South America. Parameters like Cloud Top Altitude (CTA), Convective Available Potential Energy (CAPE), number of strokes, number of storms and Cloud Top Coverage area (CTC) have been analyzed for a large sample of passes of the AGILE satellite with or without TGF detection. The results basically confirm previous studies suggesting that high CAPE values, and extreme thunderstorm conditions in general, are favoured for TGF observations. On the contrary, the TGF / lightning flash ratio over South America, as obtained by ground observations by the World Wide Lightning Location Network (WWLLN), is lower with respect to other geographical regions, in contrast with previous results based on space observations of lightning by the LIS instrument onboard the TRMM satellite. This result may be related to the different type of lightning preferentially detected by ground and space instrumentation respectively, and deserves further investigation.

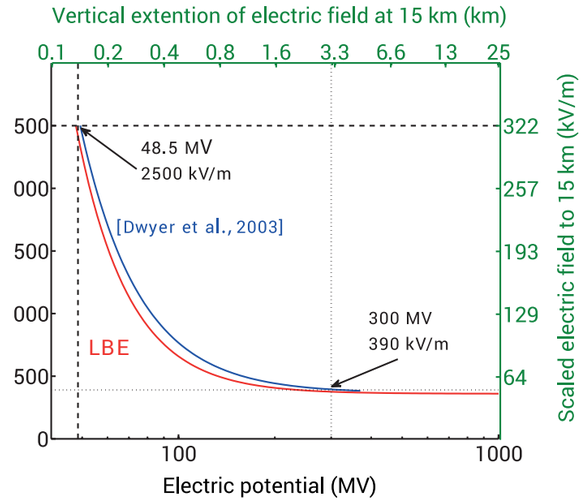


Figure 1: (Above) The threshold electric field and potential needed for the feedback mechanism to be efficient. For the mechanism to be efficient, fields and potentials have to be above the red or blue lines. Skeltved et al., (2014) is shown as LBE and compares well with Dwyer et al. (2003). The results show that very high electric fields are needed for short distances (2500 kV/m) and very large potentials are needed for larger distances (300 MV).

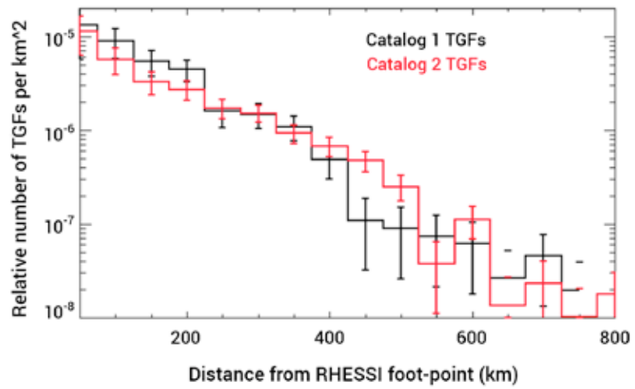


Figure 2: (Above) The distribution of the new RHESSI TGF from Catalog 2 *(Gjesteland et al. 2012)* compared with the Catalog 1 TGFs *(Grefenstette et al., 2009)*. The weaker TGF we have identified in Catalog 2 are mostly at larger distances from the RHESSI footpoint (400-500 km). The figure is from Nisi et al. (2014).

Team

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Vegard Aamodt, Kjetil Albrechtsen
Master's students, UiB

Alexander Skeltved
PhD candidate, UiB

Andrey Mezentsev
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Brant Carlson
Researcher II, UiB and Carthage College Wisconsin, USA

Nikolai Lehtinen
Researcher, UiB

Martino Marisaldi
Visiting Researcher, UiB
Researcher, INAF - IASF, Bologna

Thomas Gjesteland
Co-Leader,
Researcher, UiB

Space Instrumentation Group

The main task for the space instrumentation group in 2014 has been the Modular X-ray and Gamma Sensor (MXGS) instrument of the Atmosphere-Space Interactions Monitor (ASIM). ASIM is a spectroscopic mission, measuring optical (Transient Luminous Events: TLEs and lightning) and X -and gamma-ray emissions (Terrestrial Gamma-ray Flashes: TGFs). ASIM will be able to correlate, in space and time, the lightning, the TLEs and the TGFs by means of precise internal triggering and synchronization between optical instrumentation and the MXGS.

In June 2014 a new project, Fly's Eye GLM Simulator (FEGS), has been initiated. FEGS is a smaller version of ASIM to be flown on an aircraft (20 km).

Maja Rostad, UiB
Team Leader

ASIM

MXGS consists of two X- and Gamma-ray detectors. The Low Energy Detector (LED) is a detector array of 8 x 8 (64) Cadmium Zink Telluride (CZT) detector modules (DM) with dedicated read out electronics. This detector layer is pixelated, has a detection area of 1024 cm2 and will measure energies in the range of 15keV up to 400 keV. With a coded mask the LED will enable imaging of the TGFs. The High Energy Detector (HED) is 900 cm2 and consists of 12 Bismuth Germanate (BGO) crystals coupled to photomultiplier tubes with its dedicated read out electronics. It will cover energies extending up to 20 MeV.

The main milestones for ASIM in 2014 have been:

- **Passing the Critical Design Review**
  This is a major milestone, after which no design changes should be made.
- **Delivery of Ground Models**
  These models are electrically representative for the Flight Models and will be used on ground to understand problems during operation in space.
- **Building the Flight Models**
- **Vibration tests to qualify Flight Models**
- **Planning for transportation and qualification testing of the Flight Models at INTA in Madrid**
- **Calibration of the Low Energy Detector (LED) and High Energy Detector (HED) at various temperatures.**
- **Injected-noise and magnetic field testing**

FEGS

A new project, the Fly's Eye GLM Simulator (FEGS) was initiated in June 2014. This is a collaboration with Dr. Hugh Christian's group at the University of Huntsville in Alabama. As part of calibrating a lightning camera for a satellite mission at geosynchronous orbit, he will have access to NASAs ER-2 plane, a U-2 plane rebuild for science purposes. Dr. Hugh Christian will bring optical and electric field instruments and he has invited our group to bring X- and Gamma ray instruments. There will be several calibration campaigns over the next couple of years. This is an extremely good opportunity for both the Space Instrumentation Group and the Q4 group.

For FEGS we will use the same design as planned for COBRAT balloons (see annual report 2013) as the aircraft will fly at 20 km altitude compared to 30 km with COBRAT. Even better than COBRAT, the aircrafts have the ability to search for thunderstorm systems.

As the first FEGS campaign is already in 2015, we will not have the time to develop the full COBRAT design, but instead we will use one engineering model of the BGO detector from ASIM. The detector is more or less operational, but there is no read-out system since this is a separate unit in ASIM. Each flying campaign only lasts for a few hours, and without the constraints of space missions the read-out system can be simplified immensely, thus allowing us to fly the instrument already in the summer of 2015. Not only will this project give us much experience and knowledge that can be directly transferable to the COBRAT design, but it also gives us scientific data more than one year before ASIM is operational and we will learn much about the field operation of the BGO instrument itself.

For future aircraft campaigns we will use the more advanced design we originally developed for COBRAT. Work related to FEGS is also very helpful for the upcoming COBRAT mission, as this is an instrument that will also be built to be compatible with the ER-2 plane. As for the COBRAT design for FEGS, we have been in a meeting with CernTech who will design the electronics of this instrument, and a master student is working on adapting the firmware used on ASIM to COBRAT.

We are also responsible for a radio receiver, which is connected to the VLF/LF lightning detection network (LINET) run by the University of Munich.

Photo: Danish Technical University

Figure 1: (Above) The Ground Model of MXGS. The HED and LED are the two "silver"-boxes.

Photo: IFT, Universitet i Bergen

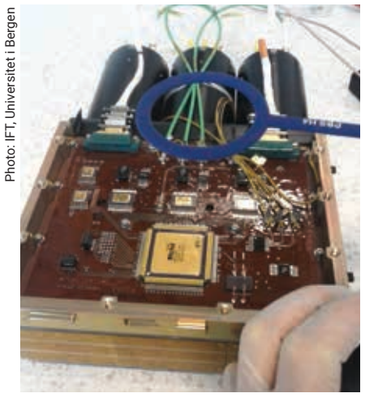

Figure 2: (Above) Sniffing magnetic field from the electronics of the HED.

Photo: Prototech AS

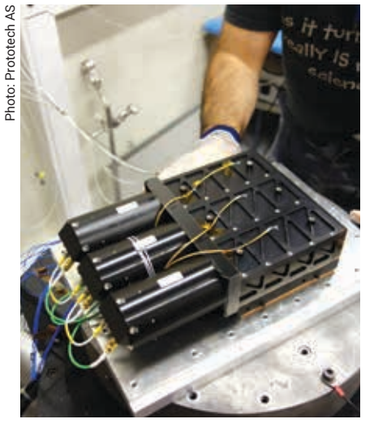

Figure 3: (Above) A BGO DAU, which will be used for FEGS.

Image: IFT, Universitet i Bergen

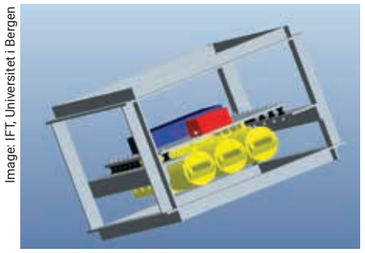

Figure 4: (Above) The BGO DAU mounted in a box, with power supply and read-out electronics.

Kjetil Ullaland
Professor, UiB

Thomas Poulianitis
Chief Engineer, UiB

Bilal Qureshi
Chief Engineer, UiB

Thomas Bjørnsen
Chief Engineer, UiB

Shiming Yang
Chief Engineer, UiB

Georgi Genov
Senior Engineer, UiB

Team

Ground-based Instrumentation Group

The ground-based instrumentation group is running and maintaining the research infrastructure (KHO, SPEAR and the new SuperDARN radar). This considerable effort includes a long duration campaign of 5 months every year. This section reports on the main activity in 2014 at The Kjell Henriksen Observatory (KH0), the new node to the Super Dual Auroral Radar Network (SuperDARN) , the BCSS Scintillation and Total Electron Content (TEC) network , instruments on NTNU's Dragvoll campus in Trondheim and SuperMAG.

Prof. Fred Sigernes, UNIS
Team Leader

2014 Highlights

1. C-REX launched successfully!
KHO was a central part of the Cusp Region EXperiment (C-REX), a NASA sounding rocket mission that released a large constellation of artificial clouds into the ionosphere above the Greenland Sea. The rocket was launched from Andøya Space Centre at 08:05 UT on 24th of November, 2014.

2. SuperDARN
The Super Dual Auroral Radar Network (SuperDARN) is currently on target to have the facility operational by October 2015. Planning permission for the facility was awarded in May 2014 and construction on site began in October 2014. The antenna masts are currently in storage at UNIS and will be deployed on site in summer 2015. Mains power and optical fiber connections will also be installed in summer 2015. The transmitter units will arrive in summer 2015 and will be connected at the site in September 2015.

UNIS held Norway's first international SuperDARN meeting in May 2014. We had 50 upper atmospheric / auroral scientists from 11 countries attending the meeting.

3. The total eclipse
The preparations for the total eclipse of 20th of March 2015 have started with both airborne and ground-based campaigns planned. The totality of the event is only 147 seconds beginning at ~11:10 LT.

4. New HF transmitter
A new HF transmitter was deployed to Hornsund research base in April to study gravity waves (with the help of the sea ice group within AGF). The receiver will be deployed at KHO this summer.

5. SPEAR
Results from a collaborative experiment with colleagues in Barentsburg has just been accepted for publication in *Annales Geophysicae*. The experiment detailed artificial ionospheric emissions detected by radio receivers in Barentsburg which were generated using the SPEAR facility.

6. GPS network
BCSS operates scintillation and total electron content receivers at four sites in Svalbard: Ny-Ålesund, Longyearbyen, Hopen and Bjørnøya. Each receiver records detailed information about the amplitude and phase of navigation signals from GPS, GLONASS and GALILEO. The data are used to understand how navigation signals are affected by plasma irregularities on their way through the ionosphere. The project has resulted in twelve scientific publications, 45 presentations at conferences, two master theses, and several interviews in news media.

7. NTNU radar system
Ground-based observational facilities running during 2014 in support of BCSS activities at NTNU's Dragvoll campus in Trondheim include a new generation 30 kW Skiymet meteor radar system and a near-IR Andor spectrometer. Data from these instruments have been used in three masters projects at NTNU during 2014 together with four papers that were a part of two PhD programmes at NTNU.

8. SuperMAG
SuperMAG is a worldwide collaboration of organizations and national agencies that currently operate more than 350 ground-based magnetometers (Figure 2). Through a user-friendly website it provides measurements of magnetic field perturbations from all available stations in the same coordinate system, with identical time resolution and a common baseline removal approach. This high quality dataset enables continuous and nearly global monitoring of the ionospheric current system and its coupling to the magnetosphere.

The worldwide Heliophysics community has embraced SuperMAG. In 2014 the registered users (>700 as of February 2015) downloaded >22.000 data products and produced 30 peer reviewed papers. Dr. Brage Førland (UiB) is the SuperMAG lead programmer.

The flow of energy between the magnetosphere and the ionosphere is primarily via electric current, electromagnetic waves and the precipitation of charged particles along magnetic field lines. Ionospheric currents have received considerable attention over many years of research since they are the dominant phenomenon at ionospheric altitudes compared to all other phenomena pertaining to magnetosphere-ionosphere coupling, involving many times more energy dissipation than particle precipitation. Thus one of the major efforts in gaining an understanding of the overall solar wind-magnetosphere-ionosphere system is through studies of these parameters, especially at times of substorms and magnetic storms.

Photo: Xiangcai Chen/UNIS

Figure 1: (Above) The SuperDARN workshop group in front of the Kjell Henriksen Observatory (KHO).

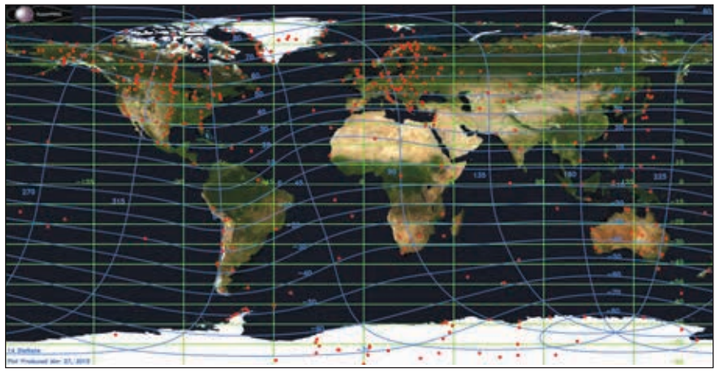

Figure 2: (Below) Ground-based magnetometers provide unique continuous and global coverage. Red dots indicate 413 ground stations (green lines are geographic coordinates and blue ones are geomagnetic coordinates).

Lisa Baddeley
Associate Professor, UNIS

Robert Hibbins
Professor, NTNU

Dag Lorentzen
Professor, UNIS

Team

Education and Public Outreach

The Education and Public Outreach Group (EPO) is responsible for making BCSS research results accessible to interested public. During the first months of 2014, we finished the design and implementation of the BCSS website (https://birkeland.uib.no/). After launching the new webpage on March 7, we have continuously updated the information provided to the public. This includes about 20 news articles written by the EPO group during the year. In addition to these BCSS news items, 25 media articles involving our researchers were produced in 2014.

Dr. Arve Aksnes, UiB
Team Leader

Designing the BCSS headquarters

Designing the 4th floor of the Department of Physics and Technology building in Bergen, where about 75% of the BCSS members are working, has been a priority throughout 2014. Figure 2 is from the hallway, where posters describing BCSS science are presented. One of the group's goals in 2014 has been to provide the members of the different BCSS groups—as well as other researchers in the building—the possibility to become aware of each other's research. To this end, we renovated the space available for exhibiting posters. New linoleum boards now stretch from doorway to doorway along the entire corridor space, providing ample space for the exhibition of 25+ large-format posters.

We have also developed poster templates to ensure that the Centre's identity is consistently applied. Recent BCSS research is shown at the beginning of the hallway entrance next to the vestibule, while the research history from earlier times is found at the end.

Research profiles of PhD students and post-docs at BCSS are presented on the wall in the vestibule that is facing the hallway. The goal of these profiles is to create a feeling of inclusion among the students at the Centre as well as to challenge our PhD students and post-docs to take ownership of their research. The presentations are attached to a glass-magnetic board.

On the main wall of the vestibule, we are currently in the process of installing two information screens. We intend the information shown on these screens to be an invitation to engage in active discussion. Students, group members and visitors will have the opportunity to see live space weather data. Our goal is to create a forum for discussion among experts and non-experts alike.

SuperMAG-based teaching program

In order to encourage and inspire young people, we started to develop a teaching program in 2014 that includes use of SuperMAG data. SuperMAG has been developed by Q2-leader Jesper Gjerloev, and is a worldwide collaboration involving data from more than 300 ground-based magnetometers. The purpose of SuperMAG is to provide easy access to measurements of the Earth's magnetic field for both researchers and the general public. Our teaching program is aimed at high school students in both physics and natural sciences and we plan to launch it in the course of 2015.

The space suitcase

In 2007, Kjartan Olafsson of the Department of Physics and Technology at UiB, developed a project called "The Space Suitcase" whose objective was to engage students and teachers at the high school level in the study of space physics. The suitcase in question was filled with instruments and instructions on how to use them. Schools across the country could borrow the suitcase and conduct experiments. During 2014, we have upgraded the instrument package of the space suitcase to include a pyranometer, solar cells, data loggers and computer software.

We have also developed several projects and assignments that will fit nicely with the curriculum for high school students. On February 6, 2015, Kjartan Olafsson and Arve Aksnes presented the space suitcase to 50 high school teachers at an event called "Faglig-pedagogisk dag" in Bergen. The space suitcase is now ready to be lent out to high schools in Norway.

Bringing space science directly to the public During the Research Days 2014, the BCSS participated in two of the events in Bergen. At "Festplassen" on Saturday the 20th of September, we had a stand titled "Festplassen: Calling space!" This event at Festplassen is known as "Forskningstorget" and attracts people of all age groups (Figures 3 and 4).

Photo: Silje Eriksen Holmen

Figure 1: (Left) The image at left appears in an article in the newspaper *Nordlys*. In the article, professor Dag Lorentzen of UNIS explains a rare phenomenon that lights up the sky when hot air from the Earth cools down to below -78 degrees Celsius.

Figure 2: (Left) View of the new bulletin boards in the vestibule

Photo: Kjartan Olafsson

Figure 3: (Above) Forskningstorget

Photo: Kjartan Olafsson

Figure 4: (Above) BCSS master's students at Forskningsdagene UNG

Kjartan Olafsson
Associate Professor, UiB

Kavitha Østgaard
Senior Consultant, UiB

Brage Førland
Chief Engineer, UiB

Team

Projects supporting BCSS 2014

Birkeland Centre for Space Science (2013-2022): Funding 160 MNOK; Additional funding from UiB: 20 MNOK

European Research Council Advanced Grant | Grant Agreement Nr. 320839

P.I. Nikolai Østgaard

2013-2018

Terrestrial Gamma Flashes–the Most Energetic Photon Phenomenon in our Atmosphere
A 5 year project to support TGF research. The project comprises both data analysis, modeling and experiments. The goal is to understand what processes are involved in the TGF production. The experiments will be performed from space, balloons, aircraft and in the laboratory.

2.49 MEUR
Additional 623 KEUR (25%) funding was given by the University of Bergen

Atmosphere-Space Interaction Monitor (ASIM) | ESTEC Contract Ref. 40000101107/10/NL/BJ | Terma-DTU Contract TER-SPACE-CON-DTU_SPACE-002_rev2

P.I. Nikolai Østgaard

2010-2016

Phase C and D, sub-sub-contract between DTU Space and University of Bergen
This project started September 2010 and is an ESA contract to design and build the front-end electronics and detector arrays for Modular X- and Gamma-ray Monitor (MXGS). ASIM is a payload for the International Space Station and is planned for launch in 2016.

2.85 MEUR

Strategic Core Activities for the Space Physics group at the University of Bergen (SCASP-UIB) | Project: 216872/F50–NFR/Prog. for Space Research

P.I. Nikolai Østgaard

2012-2015

A project to support TGF research and Cluster studies – one PhD student

3 MNOK

Norwegian Research Council Program for Space Research | Project: 208028/F50

P.I. Nikolai Østgaard

2010-2016

Terrestrial Gamma Flashes—the Most Energetic Photon Phenomenon in our Atmosphere
Project to support TGF research, PhD student, engineer and balloon instruments/campaigns

4.86 MNOK

Norwegian Research Council Program for Space Research | Project: 230956/F50

P.I. Nikolai Østgaard

2014-2016

The Norwegian Cluster studies
A small project to support the Norwegian collaboration using Cluster data

600 KNOK

Norwegian Research Council Program for Space Research | Project: 212014/F50

P.I. Kjellmar Oksavik

2012-2014

Space weather effects in the upper atmosphere on navigation signals
A small project to investigate how the upper atmosphere affects satellite communication and navigation signals using a set of GNSS scintillation receivers and EISCAT c**ampaigns at Svalbard**

1.3 MNOK

Norwegian Research Council Program for Space Research | Project: 195385/F50 | NFR/Infrastruktur

P.I. Dag Lorentzen

2010-2015

Infrastructure for space physics related research on Svalbard
A project to develop new space related infrastructure on Svalbard

8.2 MNOK

UK Natural Environment Research Council standard grant | NE/I010173/1

Co-I. Robert Hibbins

April 2011-
Mar. 2014

Solar wind connection to regional climate
British Antarctic Survey

Full economic cost £457K

Norwegian Research Council FRINAT Program | Project: 191628

P.I. Lisa Baddeley

2009-2014

SPEAR – a high power ionospheric modification facility for Svalbard

6617 KNOK

SuperMAG | ESA PRODEX funding

P.I. Jesper Gjerloev

2012-2014

SuperMAG – is a worldwide collaboration of organizations and national agencies that currently operate more than 300 ground-based magnetometers.

120 KEUR

Publications 2014

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21. **Holmen, S. E., M. E. Dyrland, and F. Sigernes** (2014), Long-term trends and effect of solar cycle variations on mesospheric winter temperatures over Longyearbyen, Svalbard (78°N), *J. Geophys. Res. Atmos.*, 119, doi: 10.1002/2013JD021195

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19. Newell P. T. and **J. W. Gjerloev** (2014), Local Geomagnetic Indices and the Prediction of Auroral Power, *J. Geophys. Res. Space Physics*, doi: 10.1002/2014JA020524

18. **Gjerloev, J. W.**, and R. A. Hoffman (2014), The large-scale current system during auroral substorms, *J. Geophys. Res. Space Physics*, 119, 4591–4606, doi:10.1002/2013JA019176

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Personnel 2014

Summary

	TOTAL	UiB	NTNU	UNIS	MEN	WOMEN
Professors	9	5	2	2	8	1
Professors Emeriti	2	-	-	-	2	-
Scientists / Postdocs	14	11	1	2	11	3
PhD Candidates	10	7	1	2	5	5
Technicians	9	10	-	-	7	3
Master's Students	18	11	7	0	11	7

Science Advisory Board (SAB)

Margaret Chen, *Aerospace Cooperation, Los Angeles*	USA
Alan Rodger, *Former Director of British Antarctic Survey*	UK
Asgeir Brekke, *Professor Emeritus, University of Tromsø*	NOR

BCSS Team

Centre Leader	Nikolai Østgaard	UiB
Adm. Coordinator	Anja Hegen	UiB
Centre Board	Jarl Giske, *Vice-Dean , Faculty of Math. & Natural Sciences*	UiB
	Bjørn Åge Tømmeråsa, *Dir. of Faculty, Faculty of Math. & Natural Sciences*	UiB
	Head, Dept. of Physics and Technology Geir Anton Johansen (until May 2014) Øyvind Frette (as of May 2014)	UiB
	Erik Wahlström, *Head, Department of Physics*	NTNU
	Ole Arve Misund, *Managing Director*	UNIS
	Nikolai Østgaard, *Leader, BCSS*	UiB
	Anja Hegen, *Administrative Coordinator, BCSS*	UiB

Engineering Team

Lisa Baddeley	UNIS
Thomas Riis Bjørnsen	UiB
Margit Dyrland	UNIS
Georgi Genov	UiB
Robert Hibbins	NTNU
Dag Lorentzen	UNIS
Kåre Njøten	UiB
Fred Sigernes	UNIS
Thomas Poulianitis	UiB
Bilal Qureshi	UiB
Maja Rostad	UiB
Kjetil Ullaland	UiB
Shiming Yang	UiB

Education and Public Outreach Team

Arve Aksnes, PhD, *Team Lead*	UiB
Kavitha Becker, *Senior Consultant*	UiB
Brage Førland, PhD, *Chief Engineer*	UiB
Kjartan Olafsson, PhD, *Associate Prof.*	UiB

Scientific Team

Lisa Baddeley	Associate Professor	UNIS
Patrick Espy	Professor	NTNU
Jesper Gjerloev	Professor, *20% UiB*/JHAPL	UiB
Robert Hibbins	Professor	NTNU
Dag Lorentzen	Professor	UNIS
Steve Milan	Professor, *20% UiB*/Univ. of Leicester	UiB
Kjellmar Oksavik	Professor	UiB
Johan Stadsnes	Professor *Emeritus*	UiB
Finn Søraas	Professor *Emeritus*	UiB
Kjetil Ullaland	Professor	UiB
Nikolai Østgaard	Professor	UiB
Brant Carlson	Sr. Researcher *20% UiB*/Carthage Coll.	UiB
Margit Dyrland	Post-doc	UNIS
Pål Ellingsen	Post-doc	UNIS
Thomas Gjesteland	Researcher	UiB
Stein Haaland	Researcher *20% UiB*/ISSI	UiB
Karl Laundal	Researcher	UiB
Nikolai Lehtinen	Researcher	UiB
Martino Marisaldi	Visiting scientist, Univ. of Bologna	UiB
Andrey Mezentsev	Post-doc	UiB
V. Rao Narukull	Post-doc	NTNU
Yvan Orsolini	Senior scientist *20% UiB*/NILU	UiB
Marit Sandanger	Post-doc	UiB
Kristian Snekvik	Post-doc	UiB
Hilde Nesse Tyssøy	Researcher	UiB
Xiangcai Chen	PhD candidate	UNIS
Marianne Daae	PhD candidate (resigned April 2014)	NTNU
Ragnhild Hansen	PhD candidate (finished June 2014)	UiB
Silje Eriksen Holmen	PhD candidate	UNIS
Beate Humberset	PhD candidate	UiB
Jone Reistad	PhD candidate	UiB
Alexander Skeltved	PhD candidate	UiB
Paul Tenfjord	PhD candidate	UiB
Christer van der Meeren	PhD candidate	UiB
Linn Kristine Ødegaard	PhD candidate	UiB

Major Achievements 2014

December 2014	Steve Milan was co-author of a *Science* paper by Fear et al. (2014) entitled "Direct observation of closed magnetic flux trapped in the high-latitude magnetosphere". PhD student Paul Tenfjord at UiB was granted the Fulbright Scholarship (9 months) to go to the University of California, Los Angeles. Impressive BCSS presence at the AGU Fall Meeting 2014, where we organized 3 sessions, gave 5 invited talks and had 20 contributed presentations.
October 2014	One of the figures in the paper by Christer van der Meeren entitled «GPS scintillation and irregularities at the front of an ionization tongue in the nightside polar ionosphere» was used on the front cover of *Journal of Geophysical Research.*
September 2014	Thomas Gjesteland was awarded the Yaras Birkeland prize of 2014.
August 2014	Strong BCSS presence at the AOGS Annual Meeting 2014, where we organized 1 session and gave 6 presentations.
June 2014	PhD student Jone Peter Reistad at UiB was granted the Peder Sæther (6 months) stipend to go to the University of California, Berkeley.
May 2014	UNIS hosted this year's SuperDARN 2014 workshop from 25th - 30th May. Nikolai Østgaard gave an invited talk about BCSS, and the workshop was attended by members from all three institutions (UiB, NTNU, UNIS) which make up BCSS.
April 2014	Strong BCSS presence at the EGU Meeting 2014, where we organized 1 session and gave 15 presentations.
February 2014	Research group Q2 was responsible for a special session at the AOGS conference in Sapporo, Japan.
February 2014	Research group Q3 initiated a collaboration with the Bjerknes Centre for Climate Research.
January 2014	BCSS delivered the ground model for ASIM.The purpose of this model is to verify the functionality of the electronics design before building the actual flight model.

Cover: Inspired by C. van der Meeren's *Journal of Geophysical Research* cover image (page 7).

Photos: Unless otherwise mentioned, all photographs by C. van der Meeren.