2016
MID-TERM REPORT

BIRKELAND CENTRE
FOR SPACE SCIENCE

contents

mission

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 (UiB) 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:

1. When and why is the aurora in the two hemispheres asymmetric?

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

3. What are the effects of particle precipitation on the atmospheric system?

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

The BCSS is organized in four scientific groups focusing on each of these 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.

How is the Earth coupled

Highlights (from the first four years)

from the centre leader

This extended "annual" report covers the first four years of the Centre, from March 2013 to the end of 2016. Here is a brief overview of our major achievements during these years.

SCIENCE

By the end of 2016 we have published 152 papers in peer-reviewed journals. Ten of these papers have been cited more than 10 times. Yearly citations of our papers are increasing markedly. A paper in *Geophysical Research Letters* by *Østgaard et al.* (2013) was given a press release by AGU and an animation of the results on YouTube was downloaded more than 5300 times. We have had two front covers in *Journal of Geophysical Research* (*van der Meeren et al.*, 2014, *Han et al.*, 2015) and had one paper in *Science* (*Fear et al.*, 2014) with Steve Milan from BCSS as second author. Jesper Gjerløv from BCSS was a co-author on *Luhr et al.*, (2015), which was a Research Spotlight in *Geophysical Research Letters*. In recognition of our scientific achievements, the Centre leader was invited to the United Nations Office of Outer Space Affairs (UNOOSA) to give a presentation to the Committee on the Peaceful Uses of Outer Space (COPUOS) in Vienna (2017) on the Norwegian contribution to SCOSTEP/VarSITI.

AWARDS

Our students and senior members have received prestigious awards and prizes: the Fulbright and Peder Saether stipends, the Yara's Birkeland, Meltzer, and Martin Landrøs prizes, the EGU student award, and the AGU outstanding student award.

CONFERENCES AND LEADERSHP

The Centre has had a very strong presence at important international conferences. We have given about 400 presentations, of which more than 70 have been invited. We have organized special sessions at the European Geosciences Union (EGU) General Assembly and the American Geophysical Union (AGU) fall meetings every year. These are the two largest annual meetings for geo-sciences, with 15000 and 25000 attendees, respectively. We have also organized sessions at the Asian meeting, AOGS. In 2014, the SuperDARN workshop was organized by Centre members at UNIS.

We are active partners in several international networks (SCOSTEP, TEA-IS, SuperDARN, EISCAT, ICMA, ISSI workshops). Through TEA-IS, a European Science Foundation-funded network, we have organized summer schools. Nikolai Østgaard has been a member of one of the European Space Agency (ESA) expert advisory boards, Solar System Exploration Working Group. This group evaluates the scientific merits of ESA's future space missions.

In 2014, we initiated a collaboration with the Bjerknes Centre, bringing together space and climate researchers. This collaboration has led to the establishment of a cross-disciplinary course, "Solar effects on natural climate variability in the North Atlantic and Arctic," as part of the Norwegian Research School in Climate Dynamics (ResClim). To all our biannual workshops (8 so far), we have invited internationally recognized researchers, as well as the other space science groups in Norway which are not partners of our Centre.

INSTRUMENTS

In 2016, we delivered the Flight Model of the Modular X- and Gamma-ray Sensor (MXGS) – a part of ASIM – to be launched to the International Space Station in September 2017. MXGS will measure terrestrial gamma-ray flashes produced by electric discharges in thunderstorms. This ESA project has been the largest space instrumentation project ever undertaken by Norwegian academia. We have also built a smaller version of this instrument for an ER-2 aircraft flying at 20 km directly over thunderstorms. The first campaign is scheduled for April 2017. In October 2016, a new SuperDARN radar for probing plasma flow in the ionosphere was deployed at UNIS. SuperDARN is a global network of radars which provides very important data for several of Birkeland Centre's research groups.The Kjell

Highlights (from the first four years)

Henriksen Observatory (KHO) at UNIS now has 42 instruments in operation, and 4 new research groups have joined since 2013. Both KHO and SuperDARN are highlighted by the Norwegian Government as the hub of both national and international auroral research in their Svalbard White Paper. As of 2016, we have been involved in a new space mission called SMILE. This mission is a collaboration between ESA and the Chinese Academy of Science (CAS) and is scheduled for launch in 2022. For this mission, we will build parts of an X-ray telescope for measuring the solar plasma entrance to the Earth in both polar hemispheres. This is core science for the Birkeland Centre.

NEWLY-FUNDED PROJECTS

The Centre leader won an ERC Advanced Grant in 2013 and is also a partner in SAINT, a EU-funded Marie Skłodowska-Curie actions (ITN) starting in March 2017. Both these projects focus on terrestrial gamma-ray flashes. SOLENA, a proposal for studying the solar effects on climate variability, with Yvan Orsolini as PI, received RCN funding in 2015. We have also received EU funding to support the SWARM, an ESA satellite mission which provides unprecedented measurements of the Earth's magnetic field. Kjellmar Oksavik from BCSS played a central role in writing the successful Norwegian EISCAT-3D proposal that was approved in 2015.

EDUCATION & PUBLIC OUTREACH

Seven PhD students (4 female) and 40 master's students (14 female) have received their degrees so far. BCSS has also offered education to students from developing countries, via the Norwegian Quota Scheme. We have given lectures at a UN-supported Space Science regional schools both in Peru (2014) and in India (2016). The Facebook page for KHO has over 1000 followers, and messages posted there have reached 15000 people. At the end of 2016, the BCSS twitter account named "@BirkelandBCSS" has more than 5000 followers. Our EPO team have also been invited to be editors of the Space Physics Section of the Norwegian online encyclopedia entitled *Store Norske Leksikon*.

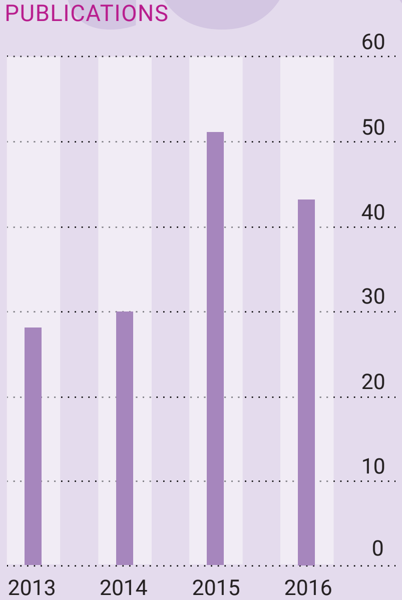
Finally, based on our achievements, we have attracted leading international scientists and signed contracts for two new professor positions: Martino Marisaldi from Italy (National Institute for Astrophysics, Bologna) and Michael Hesse from USA (NASA Goddard Space Flight Center).

I am proud to report such a broad range of success in our activity during these first years, something which has exceeded our own expectations. In this report you will find more details about our scientific achievements. I also want to take the opportunity to thank all the members of Birkeland Centre for Space Science for their excellent and hard work.

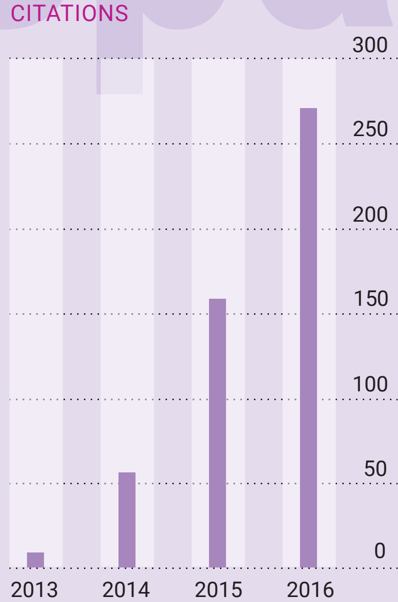
Nikolai Østgaard,
Leader of BCSS

dissemination data

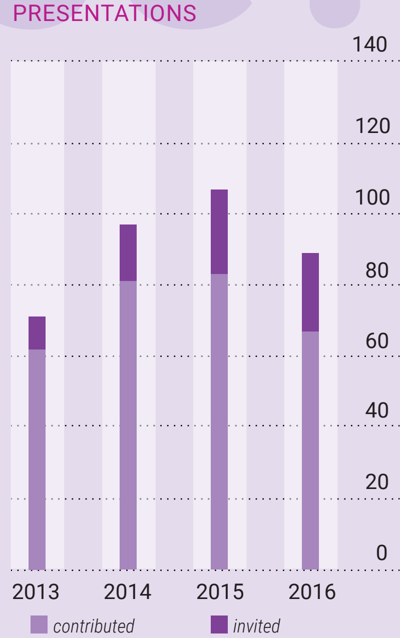
PUBLICATIONS



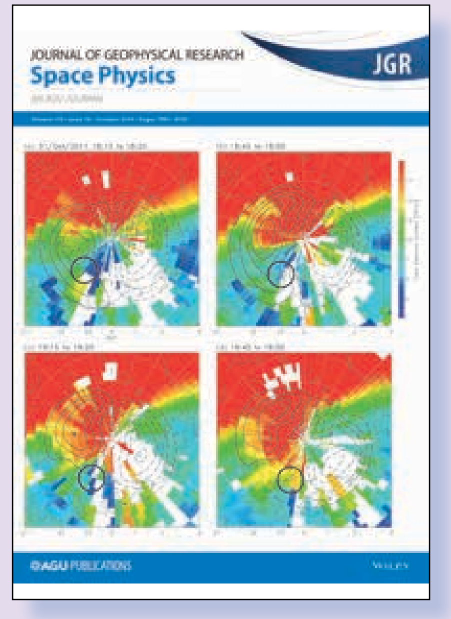
CITATIONS

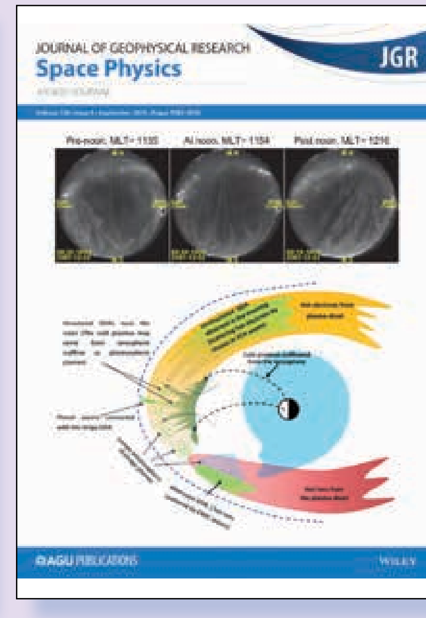


PRESENTATIONS

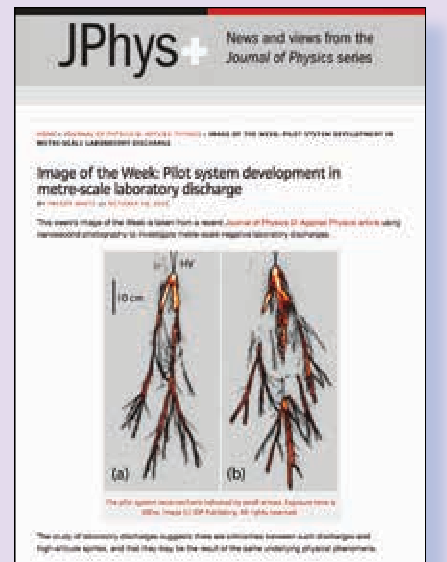


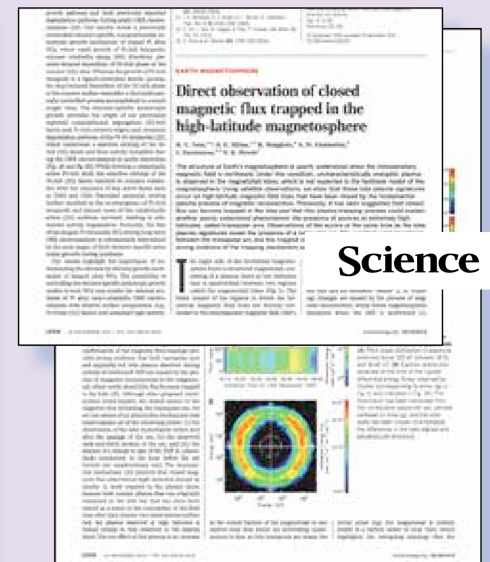
publication highlights



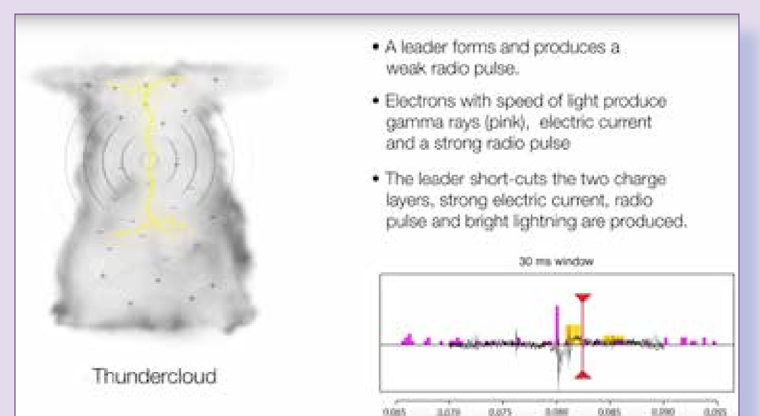


Cover pages from the *Journal of Geophysical Research:* (left) *van der Meeren et al., 2014,* (right) *Han et al., 2015*





(Left) *Kochkin et al., 2016,* about pilot systems in laboratory sparks, was highlighted as "image of the week" in *Journal of Physics, October 18, 2016.*
(Right) *Fear et al., 2014,* with Steve Milan as second author in *Science.*



In April 2013, one of our papers *(Østgaard et al., 2013)* was highlighted through an AGU press release. This led to 38 news articles worldwide and a video on YouTube that was downloaded more than 5300 times.

Highlights (from the first four years)

awards

Martin Landrøs Prize for Outstanding Master's Thesis
2015: Annet Eva Zawedde

Yara's Birkeland Prize
2014: Thomas Gjesteland,
Phd student

EGU Outstanding Student Poster
2013: Beate Krøvel Humberset,
Phd student
Fulbright Scholarship
2013: Nine months at
Johns Hopkins University/APL

EGU Outstanding Student Poster
2015: Christer van der Meeren,
Phd student

EGU Outstanding Student Poster
2016: Christoph Franzen,
Phd student

AGU Outstanding Student Award
2013: Nora Stray (née Kleinknecht),
Phd student

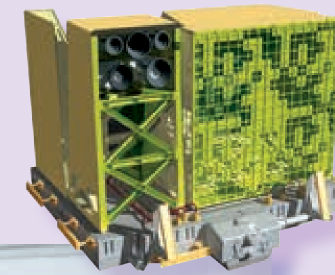
Peder Saether Stipend
2013: Jone Reistad, *Phd student*
Six months at SSL, UC Berkeley

Fulbright Scholarship
2013: Paul Tenfjord, *Phd student*
Nine months at UCLA

Fulbright Scholarship
2015: Martino Marisaldi, *Researcher*
Six months at Duke University

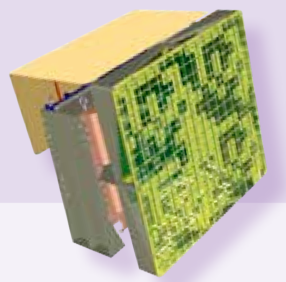
Fulbright Scholarship
2016: Kjellmar Oksavik,
Arctic Chair
Five months in 2017 at
Virginia Tech, USA

instrument highlights

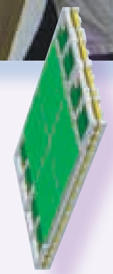


ASIM payload with MXGS instrument

ASIM: Ground Model delivered in November 2014
and Flight Model delivered during May - July 2015



X- and Gamma-ray detector (MXGS)



Low-Energy Detector (LED)

+

High-Energy Detector (HED)

SuperDARN: in operation from October 2016

Organisation (per December 2016)

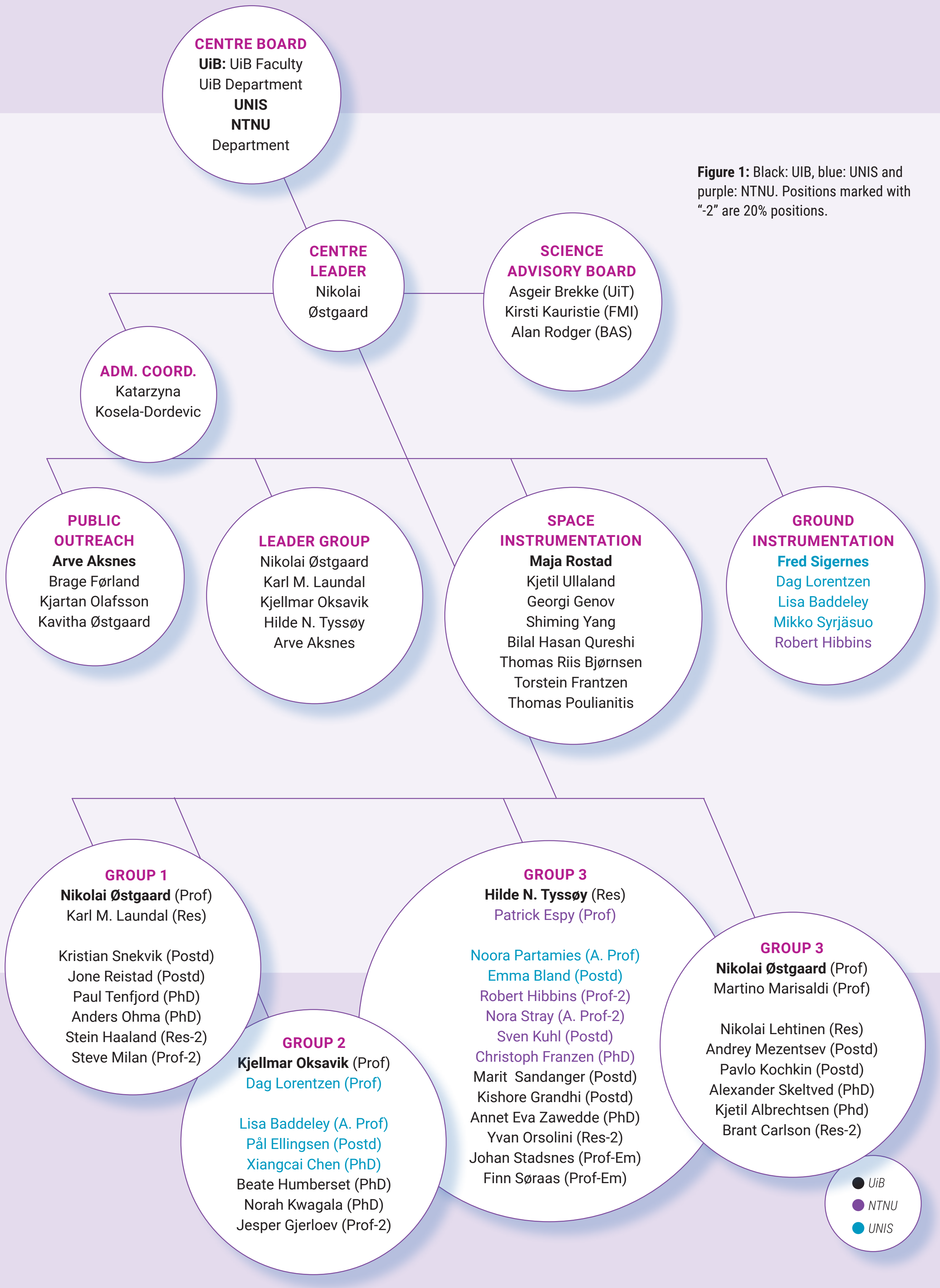
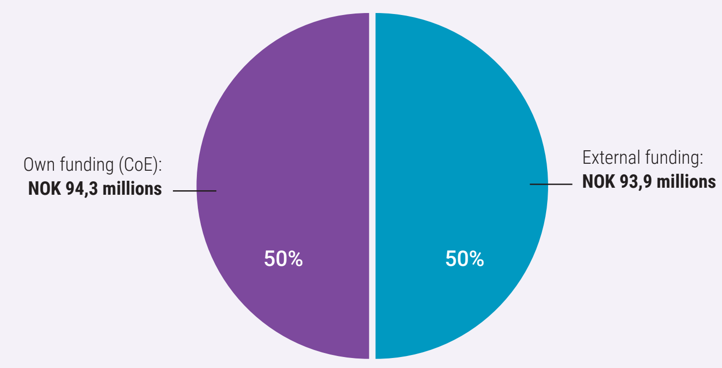
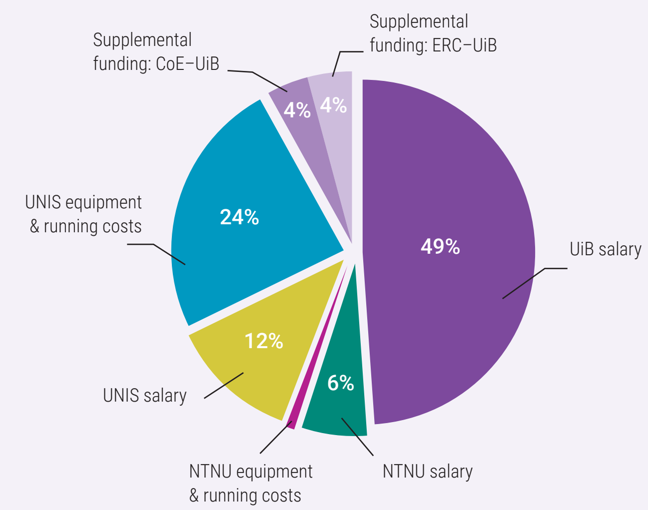


Figure 1: Black: UIB, blue: UNIS and purple: NTNU. Positions marked with "-2" are 20% positions.

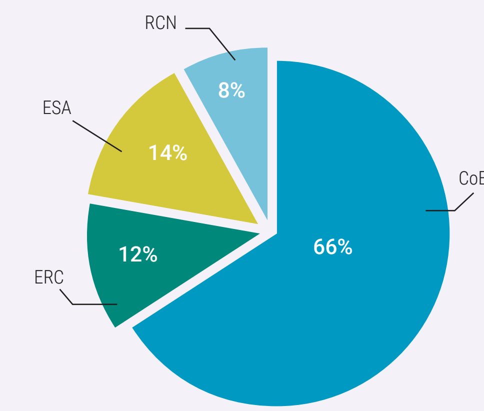
Funding Overview



FINANCE PLAN



OWN FUNDING



EXTERNAL FUNDING

European Research Council
Established by the European Commission

ERC funding is an ERC Advanced Grant–TGF-MEPPA, awarded to Nikolai Østgaard.

Boards (per December 2016)

centre board

MEMBERS
Anne Marit Blokhus *(board leader)*
Vice Dean, MN-faculty, UiB

Elisabeth Muller Lysebo
Deputy Director General, MN-faculty, UiB

Øyvind Frette
Head, Institute for Physics and Technology, UiB

Harald Ellingsen
Managing Director, UNIS

Erik Wahlström
Head, Department of Physics, NTNU

PARTICIPANTS
Nikolai Østgaard
Leader, Birkeland Centre for Space Science

Grete Kvamme Ersland *(board secretary)*
Head of Administration, Institute for Physics and Technology, UiB

Katarzyna Kosela-Dordevic
Administrative coordinator,
Birkeland Centre for Space Science

science advisory board

The Science Advisory Board has three members.

FROM 2013 - 2016/2017
Alan Rodger*
Former interim director of the British Antarctic Survey, UK (2013 -)

Margaret Chen
Associate Director of the Department of Space Sciences, Aerospace Corporation, USA (2013 - 2016)

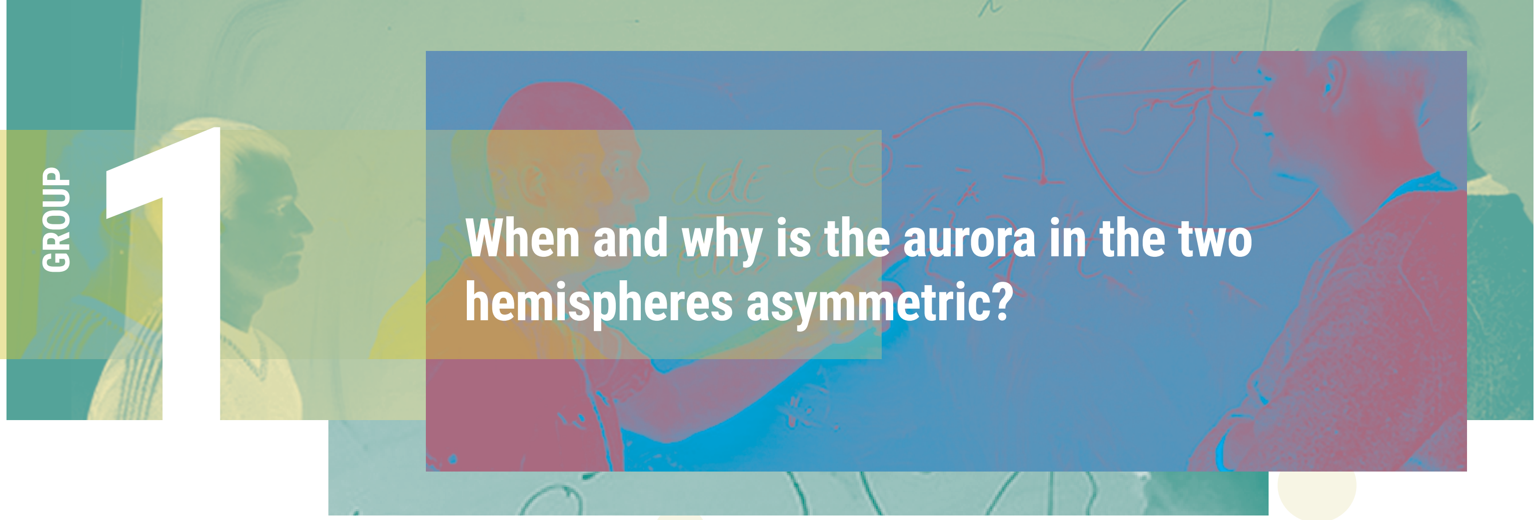
Asgeir Brekke
Professor Emeritus, University of Tromsø, Norway (2013 - 2017)

FROM 2017
Alan Rodger*
Former interim director of the British Antarctic Survey, UK (2013 -)

Kirsti Kauristie
Group Leader, Finnish Meteorological Institute (2016 –)

Herman Opgenoorth
Professor at Uppsala University, Sweden (2017 –)

* *Alan Rodger will be replaced in 2018.*



GROUP 1

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

Prof. Nikolai Østgaard, UiB
Team Leader

During the first four years we have focused on testing and understanding three mechanisms for producing asymmetric aurora and currents suggested by *Østgaard and Laundal* (2012): 1) asymmetric energy input to the ionosphere due to a radial (X) component in the interplanetary magnetic field (IMF), 2) asymmetric field-aligned currents and aurora as a result of an induced Y-component in the closed magnetosphere due to the transverse (Y) component of IMF, and 3) inter-hemispheric currents related to differences in ionospheric conductivity.

Our goal has been to verify/prove false the existence of these mechanisms as well as their relative importance. We have aimed at obtaining a consistent understanding of how the various parts of the entire system are dynamically coupled. Through this approach, we have also proposed correction to misconceptions that have been widely accepted by the community.

Our first attempt to understand the relative importance of the mechanisms was presented in *Reistad et al.* (2013) by studying 13 events with good imaging coverage of the aurora in both hemispheres. We found that most asymmetrically located features could be attributed to either the X- or Y-component of the IMF.

In *Tenfjord et al.* (2015), we explained how Birkeland currents can be produced when the IMF induces a Y-component in the closed magnetosphere. By theoretical considerations and numerical simulations, we presented a consistent explanation for how asymmetries in Birkeland currents are produced dynamically, as pressure and magnetic tension change the magnetospheric topology. In this paper we argue against the misconception that IMF penetrates the magnetosphere and that reconnection in magnetotail is necessary for explaining the observed asymmetries. We showed that a B_Y component is induced in the closed magnetosphere by the asymmetric loading of magnetic pressure in the lobes following the dayside reconnection geometry when IMF has a Y-component. We laid out, for the first time, a scenario of how an induced B_Y component leads to asymmetric magnetic footpoints and aurora and restoring symmetry leads to asymmetric currents consistent with observed plasma convection patterns. The results from this paper have received a lot of attention from the community and we have been invited to many international meetings to present these results. In a follow-up study, *Tenfjord et al.* (2017), found observational support for these results (see Figure 2). A superposed epoch analysis of IMF B_Y polarity changes and magnetic measurements at geosynchronous orbit revealed that a B_Y component was observed in the inner magnetosphere less than 10 minutes after IMF B_Y changed polarity and that the B_Y component was fully induced after less than 40 minutes. This is exactly what was predicted by *Tenfjord et al.* (2015).

The auroral signatures and plasma convection predicted by this scenario were further explored and confirmed by *Reistad et al.* (2016), who reported large asymmetries in field line footpoints when both the IMF B_Y and the tilt of the Earth´s magnetic dipole axis induce large B_Y component in the closed magnetosphere. We also showed that convection speed was different in the two hemispheres consistent with the restoring mechanism suggested by *Tenfjord et al.* (2015).

Østgaard and Laundal (2012) suggested, based on earlier theoretical studies, that the solar wind dynamo would lead to intensity differences in currents flowing in and out of the ionosphere in the two hemispheres, when IMF has a B_X component. The importance of this mechanism was explored statistically by *Reistad et al.* (2014) who found that the average intensity in electron precipitation is indeed slightly higher at dusk in the northern hemisphere when the IMF B_X is negative. The opposite was the case in the southern hemisphere. Although the differences were small, they were statistically significant. Current efforts are underway to utilise a technique developed by *Laundal et al.* (2016), to test if a similar asymmetry is seen in magnetic measurements of Birkeland currents.

The third mechanism, which is based on predictions of inter-hemispheric currents due to differences in sunlight conditions, has shown to be an elusive phenomenon. Such currents were predicted to occur due to ionospheric conductivity gradients, but no evidence of this was found by *Østgaard et al.* (2015), who used the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) to test this theory. While truly inter-hemispheric currents at high latitudes may therefore not be truly significant, seasonal differences in ionospheric currents are surely important. *Laundal et al.* (2015) showed, based on data and theory that the relationship between ground-based magnetometer measurements and the different parts of the ionospheric current system changes with the seasons. Simply put, in darkness, Birkeland currents become "visible" at polar latitudes, but in darkness their magnetic effects are canceled by horizontal Pedersen currents. Global patterns of the equivalent current were presented by *Laundal et al.* (2016), which confirmed these findings (see Figure 3).

In our efforts to understand inter-hemispheric asymmetries in the aurora, Group 1 has also been involved in several studies to investigate the effect of differences in the Earth's magnetic field in the two hemispheres. *Laundal et al.* (2016) reviewed how differences in the Earth´s magnetic field and sunlight exposure have significant effects on plasma drift, thermospheric winds, total electron content, ion outflow, currents and magnetic field perturbations, and the aurora in the two hemispheres. Effects on plasma drift due to differences in the Earth´s magnetic field were also explored in more detail by *Förster and Haaland* (2015). In a review of magnetic coordinate systems, *Laundal and Richmond* (2016) show the importance of proper use of non-orthogonal magnetic coordinate systems when studying ionospheric processes. This followed up the study by *Laundal and Gjerloev* (2014) who showed that common approximations lead to systematic errors, particularly in studies of subtle differences between hemispheres and longitudes.

Group 1 contributed to the results by *Fear et al.* (2014) published in *Science*, showing particle distributions, measured in the lobes of the magnetosphere, which were characteristic of closed field lines. The regions where this was observed mapped to transpolar arcs, indicating that this auroral phenomenon occur in both hemispheres simultaneously. The complex topology of the magnetic field lines during polar arcs is still an unresolved question and will be subject to further studies by our group.

To promote our own results and stimulate collaboration with other groups we have organized several sessions at the AGU fall meeting focused on hemispherical asymmetries of aurora, current and convection. We have participated in several ISSI working groups and research teams. During the first four years the group has produced three master's theses and one PhD thesis. Two of the Group's students have received prestigious stipends, the Fulbright and Peder Saether.

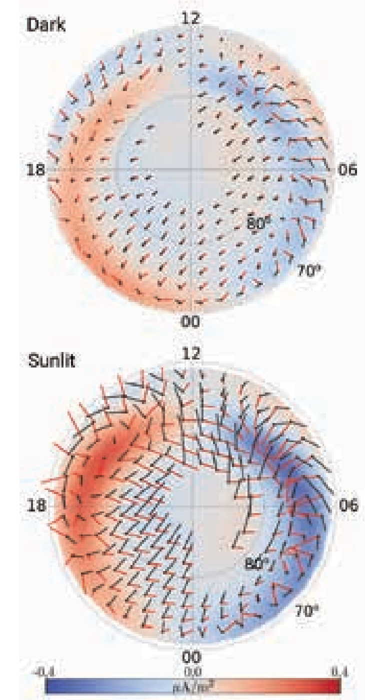


Figure 3: *Laundal et al. (2015)* showed that the Birkeland current system (colors in the background) relates differently to ground magnetic field perturbations in sunlight and darkness. In darkness, the current in the polar cap is likely very small, and the equivalent current, measured from ground (black vectors), is anti-parallel with the horizontal Birkeland closure currents (red vectors). In sunlight, Birkeland current signatures are largely invisible on ground.

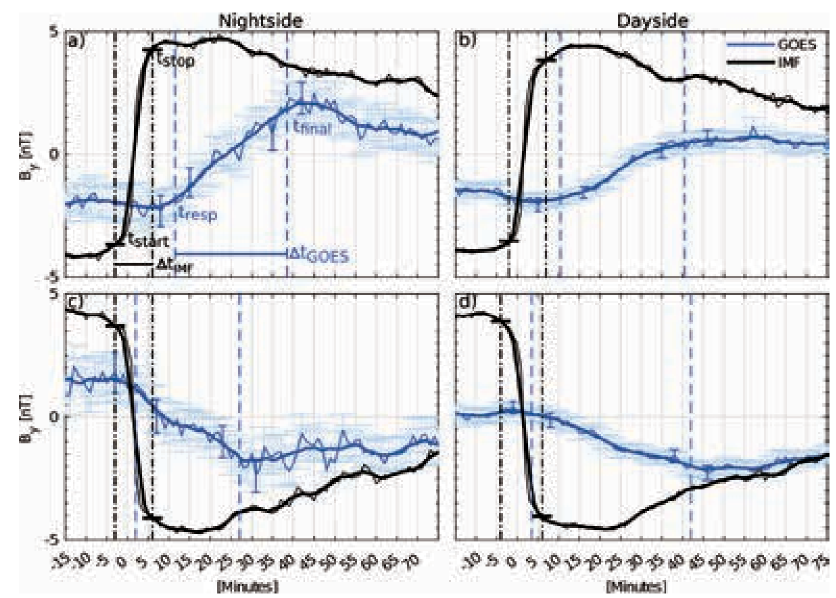
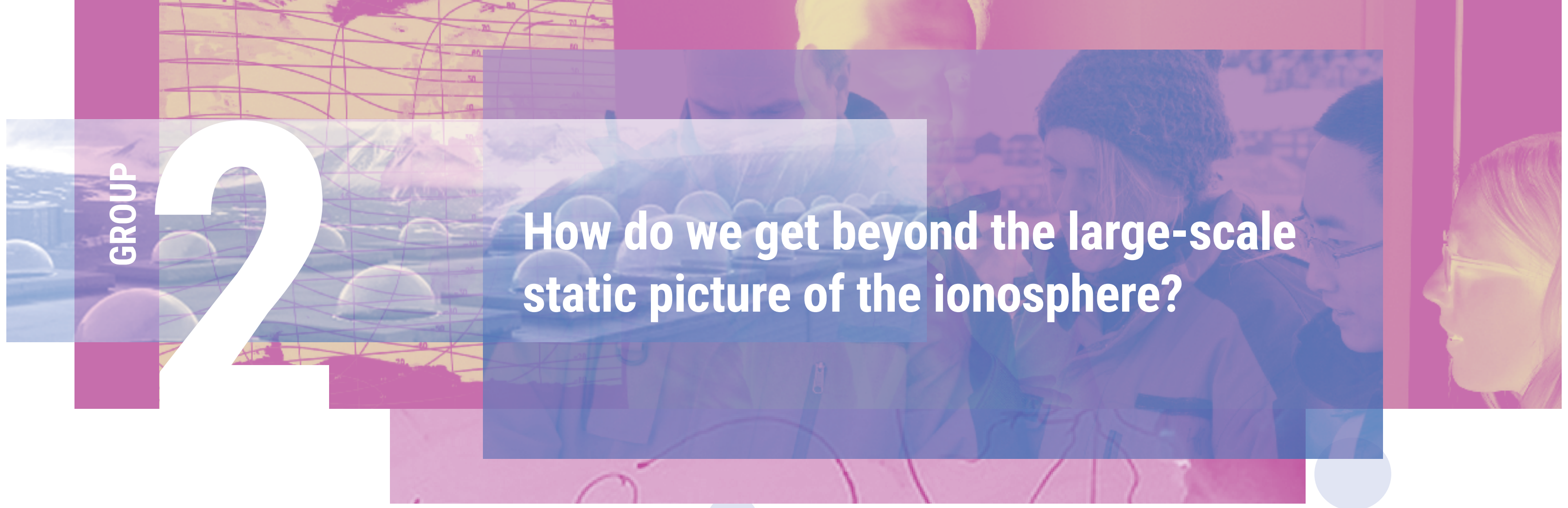


Figure 2: *Tenfjord et al.* (2017): A super epoch analysis of IMF By polarity changes and the induced By component at geosyncronous orbit. The first response is after 5-15 minutes and final reconfiguration is after 30-45 minutes, consistent with the scenario proposed by *Tenfjord et al.* (2015).



GROUP 2

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

Prof. Kjellmar Oksavik
Team Leader

The science targeted by Group 2 is an acknowledgement that the magnetosphere-ionosphere system is highly dynamic with processes ranging in scale size from hundreds of meters to thousands of kilometres (at ionospheric altitudes). Despite this well-known fact, most models assume 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 like single spacecraft missions, which cannot separate spatial and temporal variations of measured electromagnetic parameters. New multi-point observations offer a better observational basis for advancing our understanding of the coupling between the Earth and near space.

The Group has investigated plasma structuring in the ionosphere at small to meso-scales (<200 km) using multi-instrument studies based on data from spacecraft, EISCAT, SuperDARN, all-sky imagers, and a network of scientific navigation receivers, see Figure 4. In a series of publications (*van der Meeren et al., 2014, 2015, 2016; Oksavik et al., 2015*) we have revealed how plasma irregularities and signal scintillation can exist on the leading edge of the Tongue of Ionization (TOI), in Poleward Moving Auroral Forms (PMAFs), and in substorm aurora when plasma patches enter the nightside auroral oval. The observed plasma irregularities cover a wide range of temporal and spatial scale sizes, from decametre to several kilometres. There is also a high degree of localization, with significant variation over distances smaller than 100 km, and over time periods much less than one minute. A novel method was developed to produce spectrograms, which offer a more complete view of the structuring than traditional scintillation indices. It revealed for the first time that the most intense scintillations are observed when auroral emissions and polar cap patches coincide. This is essential for understanding the intensity and evolution of space weather, i.e. when and where there are problems for technology in Polar Regions.

One of our most important tools to monitor ionospheric convection globally is SuperDARN, but this over-the-horizon radar system has a fundamental challenge. Due to the refraction of the HF radio signals in the ionosphere, it is often difficult to determine the exact geographical location of SuperDARN radar echoes. In a series of publications (*Chen et al., 2015, 2016; Han et al., 2015*) we have used optical observations of the dayside aurora as a reference location. Through statistical analysis we identified for the first time that there was difference of up to 2° in latitude between the radar echoes and the aurora. The current SuperDARN ray-tracing method does not take into account the dynamics of a changing ionospheric density. We identify that the mapping accuracy can be improved by considering the level of solar activity, solar wind parameters, magnetic local time, season, and the radar operation frequency.

The magnetosphere and ionosphere (M-I) are coupled on a wide range of temporal and spatial scales, but models are still unable to describe the dynamics in the system. The Group has therefore begun to develop novel methods to trace patches of pulsating auroral emissions in all-sky images (*Humberset et al., 2016*) and reveal the lifetime of auroral emissions at different scale sizes (*Humberset et al., 2017*). In this way we provide objective and quantitative spatiotemporal characteristics of pulsating auroral patches and the nightside aurora at mesoscales (Figure 5). The spatial and temporal variations in this work are essential for quantifying the amount, location and time dependence of the energy deposition in the mesosphere-thermosphere-ionosphere system. Current models use input values that are significantly different from observations. This work aids to improve the quantitative input to M-I coupling models.

The Earth's magnetic field is key for M-I coupling, and the Group has used the very extensive data from the SuperMAG network to develop empirical models and global maps of ground magnetometer data (*Gjerloev and Hoffman, 2014; Waters et al., 2015*). The empirical model for the first time uses a two-wedge current system to describe the equivalent currents in the ionosphere during the peak of a bulge-type auroral substorm. The global SuperMAG maps offer an extension to areas that are poorly covered by ground-based instrumentation (e.g. over the oceans).

The Group benefits from a wide network of international collaborators. Some collaborative highlights include the first tracking of an auroral form all the way across the polar cap from the dayside to the nightside (*Nishimura et al., 2014*), the first spatial scale analysis of field-aligned currents from the SWARM spacecraft (*Lühr et al., 2015*), and the first network analysis of magnetometer data (*Dods et al., 2015*).

In four years, Group 2 has contributed to 145 presentations and 45 published papers. Two PhD and five master´s degrees have also been completed. Two papers were highlighted on the frontpage the Journal of Geophysical Research, and two of our students have received outstanding student paper awards from the European Geophysical Union. The Group has been actively involved in the national consortium supporting EISCAT_3D. The group has arranged several special sessions at international conferences, such as the Fall AGU and AOGS. In 2014 we hosted the international SuperDARN workshop, and on 20 March 2015 we participated in a live broadcast of the total solar eclipse on Svalbard which was aired to millions of TV viewers. One of our students won a PhD Fulbright stipend in 2013, and the group leader won a Fulbright Arctic Chair stipend in 2016.

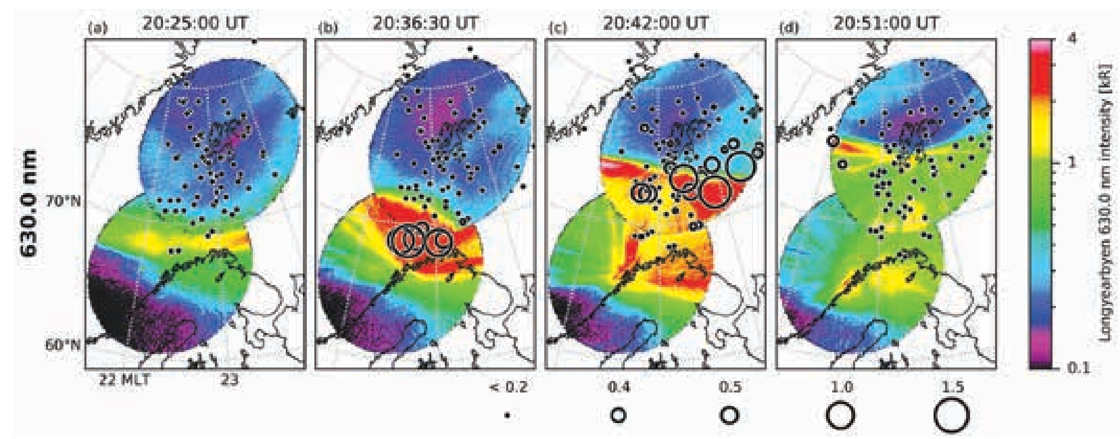


Figure 4: Auroral intensities over Scandinavia (bright colors). This study presents evidence of severe, localized and highly variable plasma structuring and scintillation (black circles) when a polar cap patch in light blue color enters the nightside auroral oval *(van der Meeren et al., 2015).*

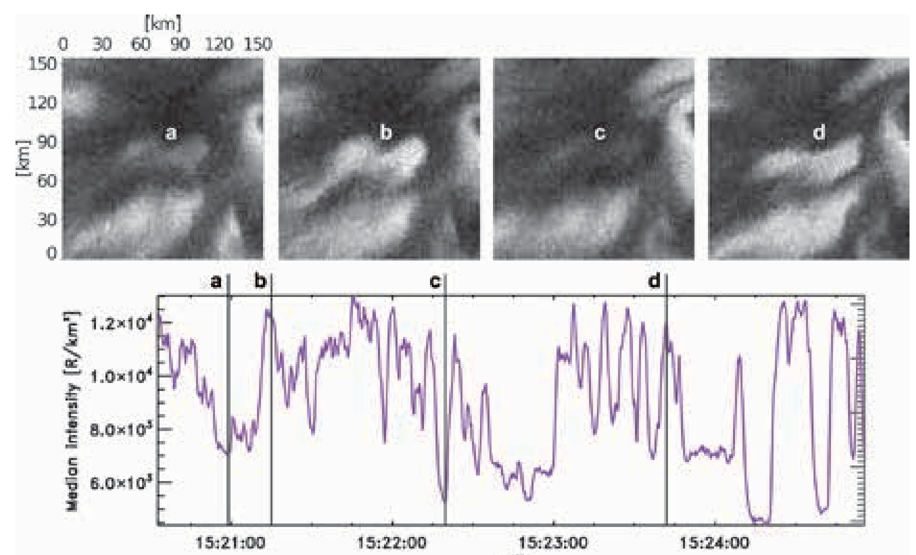


Figure 5: Example of a quantification of the highly variable auroral intensity inside a pulsating auroral patch (a-d). This study provides objective and quantitative characteristics of pulsating auroral patches that put observational constraints on suggested mechanisms in literature *(Humberset et al., 2016).*

GROUP 3

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

Dr. Hilde Nesse Tyssøy, UiB
Team Leader

The middle atmosphere is a boundary layer impacted both by waves from below, and particle forcing from above. Energetic particle precipitation (EPP) increases the production of NOx and HOx gases, causing a subsequent reduction of ozone. Ozone is an essential component of the middle atmosphere energy budget, and significant changes can influence the middle atmospheric dynamics *(Venkateswara Rao et al., 2015)*. Understanding the impact of EPP upon the atmosphere requires knowledge of both the nature of EPP as well as the internal variability of the polar atmosphere. Group 3 consists of scientists with a range of expertise, both within atmospheric and space physics. This cross-disciplinary approach has culminated in the work by *Zawedde et al.,* (2016) (see Figure 7). Here we found that during solar minimum, EPP-driven OH production is commensurate with background dynamical production. To quantify the EPP effect throughout the solar cycle, the background atmospheric dynamics, along with detailed knowledge of where and when the precipitation occurs, needs to be taken into account.

In contrast to previous work that attributed all OH production to EPP, here we found, for the first time, similar contributions to OH production from both wintertime planetary waves and EPP, and that both were required to explain the longitudinal distribution of OH. *Kleinknecht et al.* (2014) used meteor winds from a longitudinal chain of SuperDARN radars to provide the first un-aliased measurements of planetary wave structure and amplitude. Such measurements are not possible from single ground station or satellite observations. *Stray et al.* (2014a,b, 2015) used this technique to quantify the impact of naturally occurring changes due to planetary waves on the polar mesosphere and lower thermosphere (MLT) throughout the different seasons. To quantify the effects of short scale variability, de Wit et al. (2014a) used the Trondheim advanced meteor radar to make the first high temporal resolution measurements of the seasonal cycle of high latitude gravity wave forcing around 90 km. In addition, we have presented the first observations of the gravity wave forcing of the mesopause region during the 2013 major sudden stratospheric warming (*de Wit et al, 2014b*) by combining meteor radar observations and WACCM (Whole Atmosphere Community Climate Model) modelling. Subsequent work by *de Wit et al.* (2015) traced the extent of the influence of this winter stratospheric warming into the summer hemisphere using Aura Microwave Limb Sounder satellite temperature measurements.

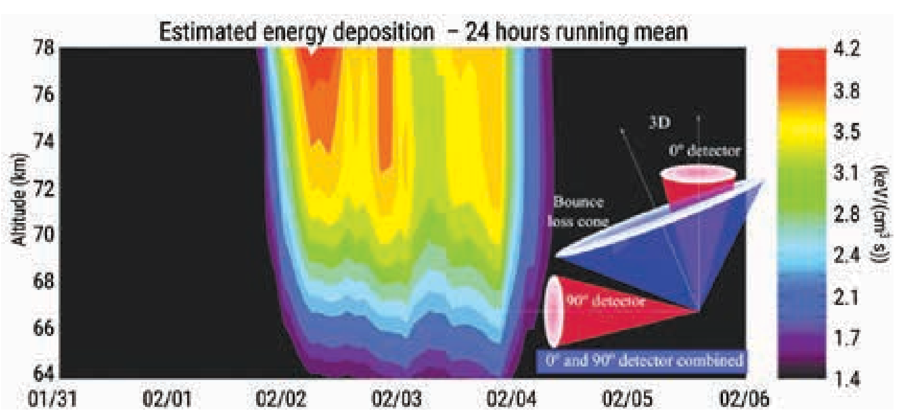


Figure 6: *Nesse Tyssøy et al. (2016):* By combining the measurements from two telescopes with the theory of wave-particle interactions in the magnetosphere, the total precipitated flux is constructed. This novel approach gives us full range coverage of electron energies that will be deposited at altitudes between 60 and 80 km.

Sudden stratospheric warmings with elevated stratopause events enhance transport of auroral NO from the MLT down into the stratosphere where it can destroy ozone in catalytic reactions. A detailed comparison with satellite observations of NO has revealed a remaining deficiency of WACCM in that respect (*Orsolini et al., 2017*). The respective roles of planetary, gravity and tidal waves in forcing such rapid NO descent has been investigated with WACCM, and the planetary waves (e.g., observed also by *Stray et al., 2015*) are found to be the main factor initiating this descent (*Limpasuvan et al., 2016*). In addition to chemical destruction of ozone, *Tweedy et al.* (2013) also showed that the secondary ozone layer could be enhanced during such elevated stratopause events. *Hendrickx et al.,* (2015) applied epoch analysis to study the general descent of EPP-produced NO based on observations. They showed that the direct production of NO occurs down to an altitude of 95-105 km and that NO enhancements have a 27-day recurrence that extends down to about 50 km during the northern hemisphere polar winter due to stratospheric sudden warming events, and to approximately 65 km during the southern hemisphere polar winter.

A reliable quantification of both the proton and electron forcing to be used for both modelling, statistical and case studies has been an essential objective that underpins the EPP research (*Nesse Tyssøy et al.,* 2013,2016; *Nesse Tyssøy and Stadsnes* 2015). To improve the long record of multiple spacecraft measurement by POES/MEPED we have developed a consistent and robust method to take into account the degradation of the proton detector (*Sandanger et al., 2015*; *Ødegaard et al., 2016*). As a consequence we can extend the validity of the measurements performed by both old and new satellites to cover more than three solar cycles. Furthermore, the energetic electron fluxes are often strongly anisotropic. By combining the measurements from both available telescopes with the theory of wave-particle interactions in the magnetosphere, the total precipitated flux can be constructed. This novel approach gives us full range coverage of electron energies that will be deposited at altitudes between 60 and 80 km. We have shown that this improves the estimate of the EPP-OH production by an order of magnitude (*Nesse Tyssøy et al., 2016*). It will further enable us to predict the direct production of NO within this altitude range.

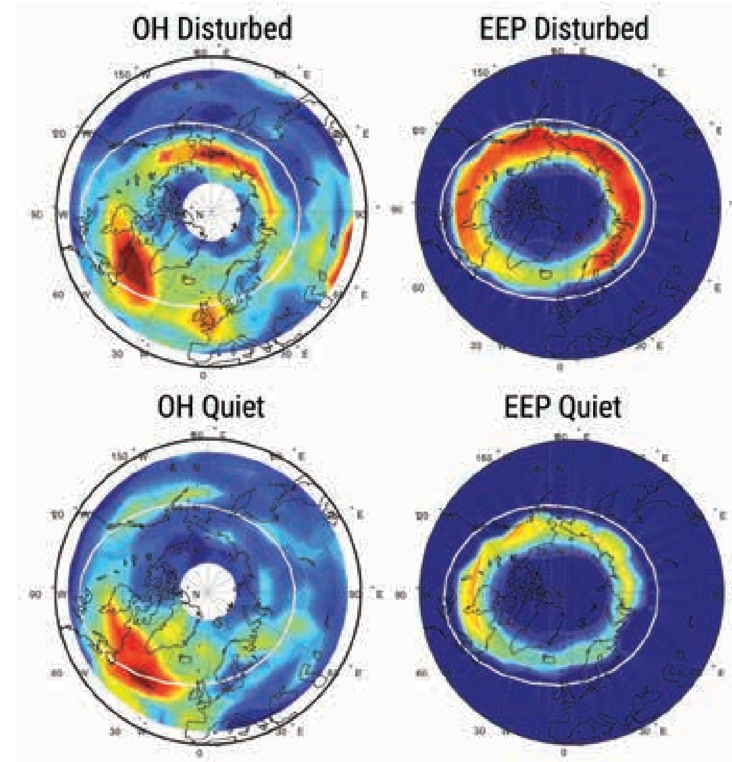
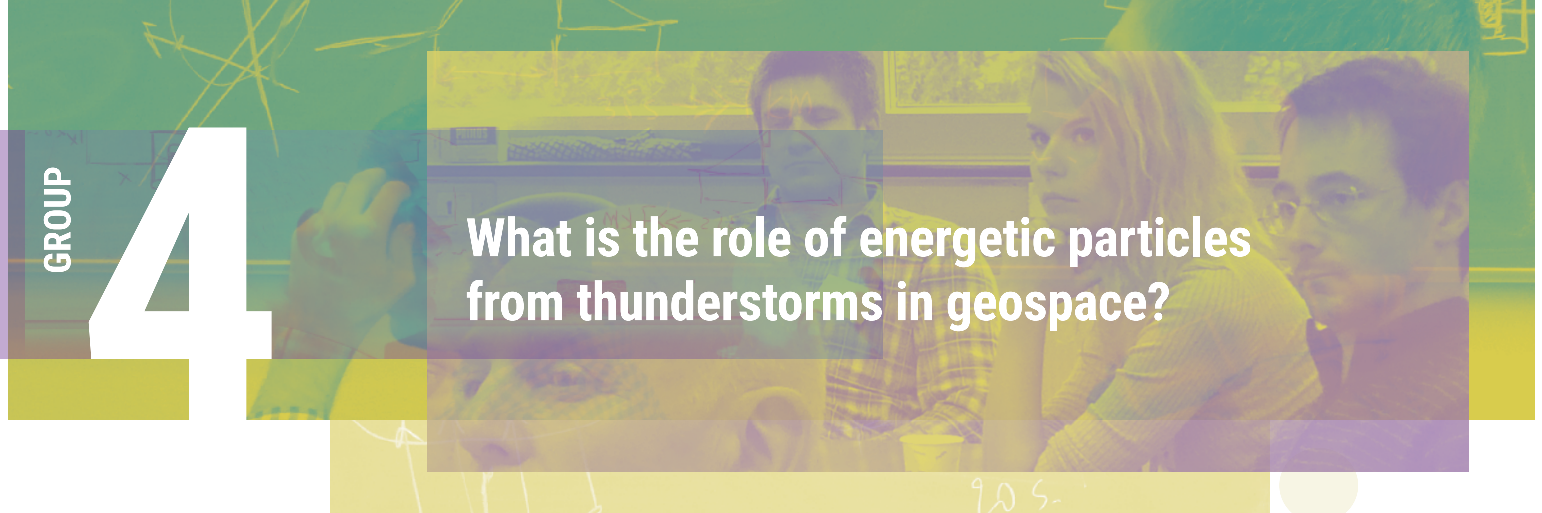


Figure 7: (Left) Mean nighttime OH during disturbed (top row) and quiet (bottom row) conditions at altitudes 75–78 km for winter (January February). (Right) Mean nighttime energy deposition during disturbed (top row) and quiet conditions (bottom row) at altitudes 75–78 km for winter (January–February). Mean values were calculated for each 5° latitude by 10° longitude bin between 40° to 80°N and longitudes 180°W to 180°E. The white line shows the approximate location of 55°N/S CGM latitude. (Adapted from *Zawedde et al., 2016*).

The relative importance of the direct and indirect NO production, as well as the improvement of the treatment of EPP in WACCM to include the total energy spectrum from auroral to relativistic energies, are topics for several ongoing and future studies (*Smith-Johnsen et al.*, PhD thesis, in preparation). It is also one of the subjects of our recent NFR grant, Full Range Energetic Particle Precipitation Impacting the Middle Atmosphere, with H. Nesse Tyssøy as PI. WACCM is also of high importance in another successful grant, Solar effects on natural climate variability in the North Atlantic and Arctic, with Yvan Orsolini as PI. With this proposal we have established collaboration with the Bjerknes Centre of Climate Research. It has also inspired a co-organized course as part of the Norwegian Research School in Climate Dynamics.

In defining the role of EPP upon the middle atmosphere, the leadership of the BCSS has been recognized within the peer community through a number of publications (42 as of 31 December, 2016) and invited talks. Yvan Orsolini has been elected as a member of the International Commission on the Middle Atmosphere (ICMA). The Group 3 UNIS node is part of the science collaboration Chemical Aeronomy in the Mesosphere and Ozone in the Stratosphere (CHAMOS). Hilde Nesse Tyssøy is co-leading the HEPPA-SOLARIS working group, "Medium Energy Electrons (MEE) Model-measurement intercomparison". Several BCSS memebers serve as national delegates, e.g. Hilde Nesse Tyssøy for the International Association of Geomagnetism and Aeronomy (IAGA) and Yvan Orsolini for Committee for Space Research (COSPAR). During the first four years 10 master´s and 4 PhD theses targeting our questions have been produced.



GROUP 4

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

Prof. Nikolai Østgaard, UiB
Team Leader

To answer the overarching question about the role of energetic particles from thunderstorms in the atmosphere and geospace we need to understand several sub-questions: How common are TGFs? How and at what altitude are TGF produced? How intense can they be? To address these questions we have used satellite observations from RHESSI and AGILE, and lightning data from aircraft as well as data from laboratory experiments of electric discharges we performed in Eindhoven in 2013. To explore the mechanism as well as the type of lightning that can produce TGFs, we have developed several models of streamers and leaders. We have explored the micro-physics of X-ray production from streamers in laboratory experiments. We believe these are the important building blocks of understanding how relativistic electrons and gamma photons are produced in the natural discharge process.

How common are TGFs? Are TGFs just rare, exotic phenomena or are they an intrinsic part of lightning discharges. All measurements from space are limited by detector size and sensitivity, and there might be weaker TGFs that we are unable to see with current detectors. In an effort to see if there are TGFs that we cannot identify by the current search algorithms, we used WWLLN lightning network to identify lightning in the field of view of the RHESSI detector. By correcting for propagation time from lightning to satellite, we stacked more than 740 000 RHESSI data strings from 2006 and 2012 centred around the time of lightning and found a significant signal indicating about 150 new TGFs in those two years. This was reported in *Østgaard et al., 2015* – a new population of TGFs (see Figure 8). An ongoing study exploring 12 years of WWLLN/RHESSI data has revealed more than 1200 new TGFs (*Albrechtsen et al., 2016* – AGU fall meeting). Optimizing the sensitivity of the AGILE instrument also indicates more TGFs. By optimizing the onboard software configuration, *Marisaldi et al.* (2015) reported that AGILE was able to detect ten times more TGFs than earlier in the mission. All these studies indicate that by improving our detector abilities and optimizing search algorithms, we are able to identify more and more TGFs.

How are TGFs produced? There are two main scenarios that have been proposed for TGF production: 1) produced in the large scale uniform field between main charge layers also involving feedback mechanisms, and 2) produced in the local field ahead of leaders. We have developed models to test both scenarios. *Skeltved et al.* (2014) validated the first mechanism which includes both relativistic run-away electron avalanche (RREA) as well as a feedback. We found that RREA will occur as long as there is >50 MV potential, but that the feedback mechanism requires very large and maybe unrealistic potentials (100s of MV) in the thundercloud. In *Skeltved et al.* (submitted 2016) we have tested the second scenario involving the local field ahead of the leader tip. We found that most modeling results so far have used unreasonable assumptions as well as simplified geometry. Using more realistic boundary conditions, we found that TGFs can indeed be produced ahead of leaders, but more detailed modeling needs to be performed to see if these mechanisms can produce the characteristic energy spectrum of TGFs as well as the most intense ones. Using Very Low Frequency radio waves for geolocation and observations of double-TGFs, *Mezentsev et al.* (2016) found very good support for TGFs being produced in the leader tip zone.

How intense can TGFs be? In *Gjestland et al.* (2015) we reported that RHESSI can observe TGFs from altitudes as low as 10 km, which also implies that the number of relativistic electrons produced is several orders of magnitude larger than previously reported.

Our laboratory experiments from Eindhoven were the focus of *Carlson et al.* (2015). During these discharge experiments, we measured energetic X-rays in more than half of the sparks. As these experiments only involve 1 MV compared to the 100 MV in a thundercloud, they are not one-to-one comparable to TGFs, but we can learn a lot about the micro processes involved in lightning. By performing a detailed statistical analysis of 900 laboratory sparks we determined the average energy of the X-ray photons to be 86 keV, which indicates that the energy of the electrons producing the X-rays is a few hundreds of keV. *Østgaard et al.* (2015) reported the first direct measurements of relativistic electrons from sparks in the laboratory. We found that ~ 300 keV electrons produced about 30–60 cm from the negative electrode were the most likely source of our measurements. The average energy of X-rays produced by these electrons would be 70 keV, consistent with the findings of *Carlson et al.* (2015). *Kochkin et al.* (2015) used a nanosecond-fast camera to explore the fine structure of streamer development in a spark. We found that a pilot-system develops from streamer beads created in the wake of negative streamer heads, and that these positive streamers will encounter the negative streamers closer to the electrode. These counter-streamers may be where the electric field increases sufficiently to produce relativistic electrons and X-rays.

The first five years of this BCSS Group have been funded by an ERC Advanced Grant: TGF – MEPPA. We have published 22 papers in peer-reviewed journals, given 8 invited talks and given 70 contributed presentations at international meetings. We have taken the lead in organising sessions each year at the EGU and AGU meetings, as well as organising summer schools through the European Science Foundation (ESF) funded TEA-IS network. Our team members have received important awards, such as the Fulbright, Meltzer and Yara's Birkeland Prize and we have given more than 15 interviews/public presentations. One of our papers *(Østgaard et al., 2013)* was highlighted by AGU and given a press release that was picked up by 38 sites world wide. In this paper we determined the sequence of radio signal, terrestrial gamma-ray flash and optical lightning, giving support to the idea that the electric field in the leader tip is important for the production of TGF. The TGF research is a young area of research and our Group has made many novel and important contributions. Our Group is considered to be one of the international leaders in this research.

Group 4 is working closely with the space instrumentation group and preparing for the ASIM mission as well as the aircraft campaign (FEGS) in the spring of 2017. Both instruments are specifically designed to detect TGFs and we expect that we will make significant progress in the next five years in answering both how common TGFs are and how they are produced. We are the largest group in the world working on TGFs research and have attracted some of the best young scientists. We are very well equipped and prepared to make a breakthrough in TGF research. From 2017 we will also be part of a Marie Skłodowska-Curie network, SAINT, supporting the ASIM mission.

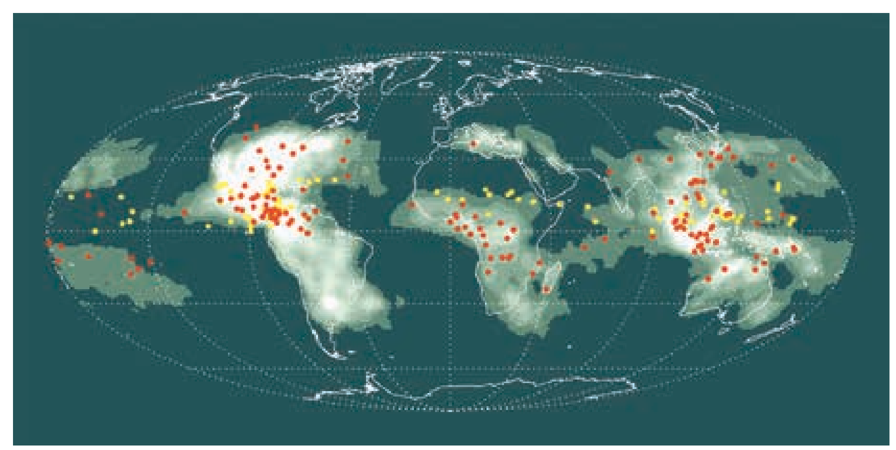
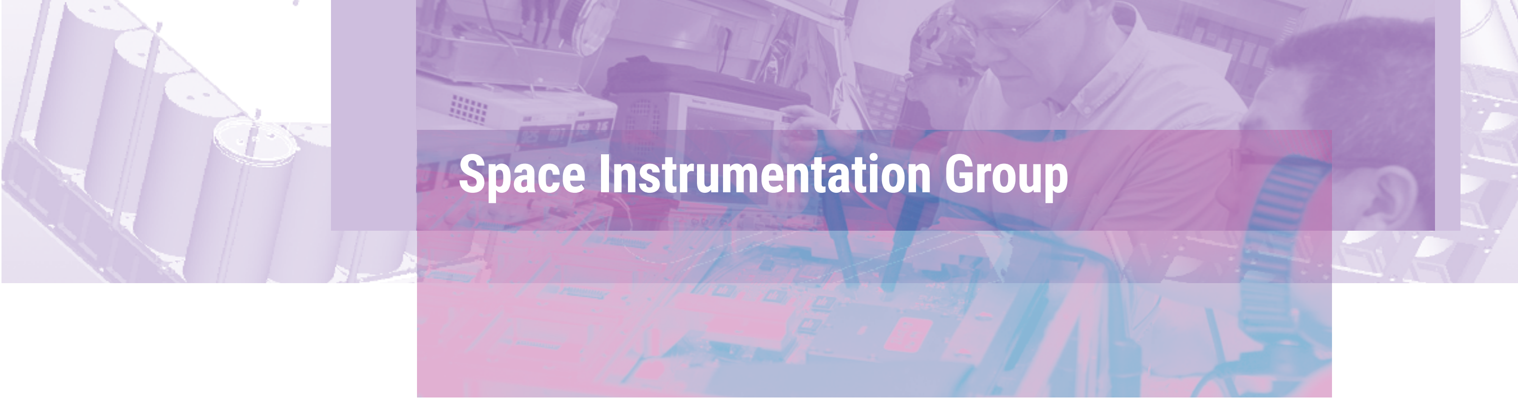


Figure 8: The already-known TGFs are shown in yellow. The new population is shown in red *(Østgaard et al., 2015)*.



Space Instrumentation Group

Maja Rostad, UiB
Team Leader

The main tasks of the space instrumentation-group for the time period 2013-2016 have been to finalize the Modular X-ray and Gamma Sensor (MXGS) instrument of the Atmosphere-Space Interactions Monitor (ASIM), build a detector for FEGS, start our involvement in the SMILE mission and develop a particle detector, DEEP.

ASIM

ASIM is a European Space Agency (ESA) mission to the International Space Station in which we got involved in 2004. ASIM will measure 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. ASIM is a complex project requiring expertise on Product Assurance requirements, procurement, ITAR regulations and formal documentation. During this project we have enhanced our expertise significantly and are now in a good position to get involved in new space missions such as SMILE (see below).

Our responsibility has been to develop the detector and readout electronics for MXGS, which consists of two X- and Gamma-ray detectors. The Low Energy Detector (LED) is a 1024 cm^2 pixelated detector of CZT (Cadmium Zinc Telluride) with dedicated read-out electronics. LED will measure energies in the range of 15 keV up to 400 keV. With a coded mask, the LED will enable imaging of the TGFs. The High-Energy Detector (HED) is 900 cm^2 of BGO (Bismuth Germanate Oxide) crystals coupled to photomultiplier tubes with their dedicated read-out electronics. It extends the energy range up to 20 MeV.

We have developed three models of the instrument and for each step there have been extensive review processes. From 2013 to 2016, we passed the following milestones: 1) Finalizing and testing the Engineering Model of LED and HED and delivered the document package for the Critical Design Review (2013-2014). This is a major milestone, after which no design changes can be made. 2) Delivery of the Ground Models (2014) which are electrically representative for the Flight Models (FM) and will be used on-ground to understand problems during operation in space. 3) Building, testing and calibration of the Flight Model started immediately after that and was delivered in late 2015. In 2016 we delivered the final HED and LED Data Package for the Preliminary Acceptance Review adding up to more than 440 documents. All tests of MXGS have been successfully performed.

MXGS is now fully integrated on the CEPA platform together with all other subsystems of ASIM and after system testing, ASIM will be ready for launch in late September 2017. ASIM is the largest space instrumentation project ever undertaken by Norwegian academia. The total budget for our involvement (including in-kind contribution) is about 70 MNOK.

Figure 9: The ER-2 aircraft (FEGS project)

FEGS

The Fly's Eye GLM Simulator (FEGS) is a project of the University of Alabama in Huntsville with the main mission of calibrating the Global Lightning Monitor which is flying on a geostationary satellite. FEGS will fly on NASA's ER-2 aircraft to perform a series of flights over thunderclouds at an altitude of 20-22 km. We have been invited to have a gamma-ray detector on FEGS.

For the first flights, we will use a spare BGO detector (225 cm^2) from ASIM. New read-out electronics–including power supply and a data processing unit–have been built for this instrument. First test flights were run in November 2016 and the first scientific flight campaign is planned for 100 flight hours in March-May 2017.

For future aircraft campaigns, we plan to develop a new version of this instrument (FEGS2) to fit inside the same thermally controlled box. This instrument will probably have a larger detector area and use faster detectors and electronics, but the results from the first FEGS campaign will guide us in optimizing the design.

SMILE

The Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) mission is a joint mission between ESA and the Chinese Academy of Science (CAS) led by UK. The main instrument is the Soft X-ray Imager (SXI), which will be able for the first time ever to remotely detect the entry of plasma from the Sun into the Earth's magnetosphere.

Based on expertise we have developed through the ASIM project, we have been asked to deliver the door mechanism which protects the CCD camera of the SXI. It will otherwise be exposed to radiation during perigee passage. The door will also be activated in case of severe solar storms. This project started in 2016. Launch is scheduled for 2021.

Our involvement in SMILE has a budget of about 16 MNOK.

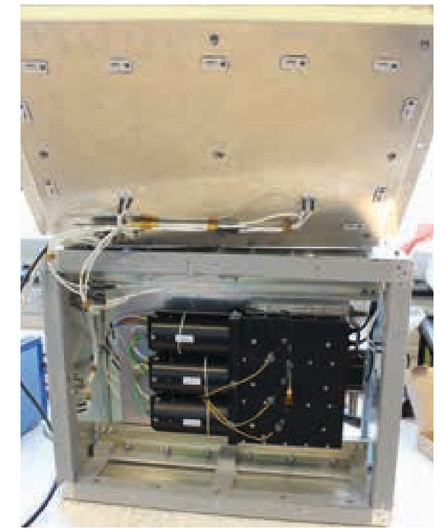
DEEP INSTRUMENT

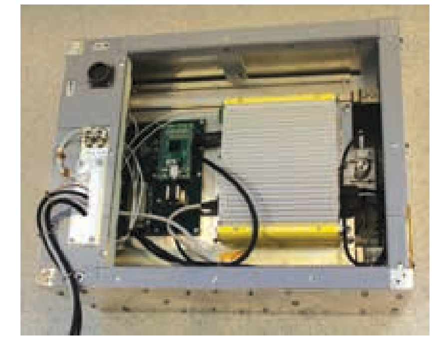
(Distribution of Energetic Electron and Proton) Lack of accurate measurements of energetic particle precipitation (EPP) is an important limitation for studying effects of EPP, such as changing chemistry and dynamics of the atmosphere. It is further of interest for geomagnetic storms and solar proton events and their associated space weather effects.

We have therefore decided to develop a prototype particle instrument that can detect electrons (30-500 keV) and protons (30 keV-10 MeV). Our goal is to have this detector flying on one of the Norwegian micro-satellites. The precipitation of energetic particles will be monitored during the whole orbit, thus giving a measurement of the total energy input to the Earth's upper atmosphere. The measurements will be performed with excellent energy, pitch angle and time resolution thanks to dedicated Silicon detectors developed at SINTEF and read-out electronics developed by our group.

LINET

We have maintained the Bergen LINET station, which is a VLF/LF radio receiver that is part of the lightning detection network LINET. The LINET network is run by the University of Munich. The combined use of ASIM and LINET data will be the focus of a PhD project at BCSS, part of the SAINT project. SAINT is a Marie Curie network with 10 partners.





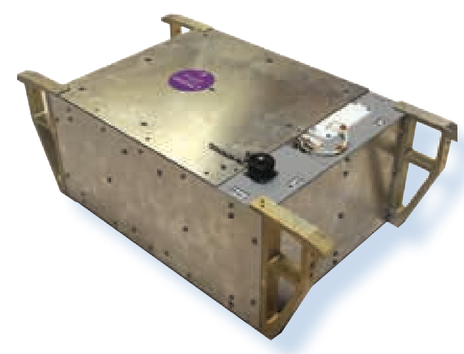


Figure 10: The FEGS instrument:
(Top) The instrument with bottom cover open.
(Bottom)The instrument with top cover open.
(Left) The instrument ready for mounting on the rack.

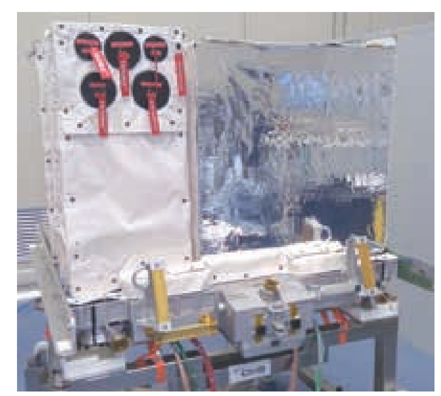


Figure 11: The ASIM instrument mounted on CEPA. MXGS is on the right (silver cover), MMIA is on the left.

Figure 12: The integration of HED into MXGS FM

Ground Instrumentation Group

Prof. Fred Sigernes, UNIS
Team Leader

The ground-based instrumentation group is running and maintaining the research infrastructure. This includes the Kjell Henriksen Observatory (KHO) and the SuperDARN radar at Svalbard, the BCSS Scintillation and Total Electron Content (TEC) network, NTNU's meteor radar with optics at Dragvoll campus in Trondheim, and the SuperMAG worldwide magnetometer chain. This section reports on the main activity in the period 2013-2016.

KJELL HENRIKSEN OBSERVATORY

There are now 21 different institutions from 13 nations at the Kjell Henriksen Observatory (KHO). 42 instruments are operative. Four new groups have joined KHO since 2013. During the auroral winter season from November to the end of February, 28 optical instruments operate 24 hours a day. The 14 non-optical instruments run all-year-round 24 hours a day. KHO has been used as headquarter and support for 3 large rocket campaigns (see Figure 13); 1) 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, 2) the University of Oslo scientific sounding rocket ICI-4 mission and 3) the Rocket Experiment for Neutral Upwelling 2 (RENU2) campaign. KHO was also operative during the total eclipse on Svalbard 20th of March 2015. A grand total of 240 ECTS (European Credit Transfer and Accumulation System) have been taught using the observatory as the main laboratory. One PhD student and five master's students have graduated.

Her Royal Majesty Queen Sonja of Norway visited KHO in 2013 and 2015. KHO was featured at 60 minutes TV show and Euronews. The old Auroral Forecast (2012) app has reacted over 50k downloads on Google Play. Our new Aurora Forecast 3D (2016) is rated high and has reached over 1000 downloads in less than a month. The Facebook page for KHO has over 1000 followers and posts that have reached 15000 people.

SUPERDARN

A SuperDARN (Super Dual Auroral Radar Network) HF Radar is operational in Svalbard. Permission for the facility was awarded in May 2014 and construction began in October 2014. The antenna masts were mounted in August 2015. Main power and optical fiber connections were also installed in 2015. First radar functionality tests were carried out in November 2015 and routine operations started in the autumn of 2016. The radar is configured with stereo capabilities, meaning that it can operate two channels simultaneously with different frequencies. It also has an interferometer array, which is used to calculate the elevation angle of the received signal.

The new SuperDARN radar provides 24 hour data coverage of the ionospheric conditions to the North East of Svalbard (see Figure 12). The field of view is orientated along the auroral oval providing observations of auroral conditions before they rotate into the field of view of the optical instruments at the KHO (facilitating possible improvements to the auroral forecast). The primary data product from the system is the ionospheric convection velocity. The data is stored both locally and at the SuperDARN data storage facility at the British Antarctic Survey where it is utilized to produce global ionospheric convection maps in real time.

UNIS held Norway's first international SuperDARN meeting in May 2014, with 50 scientists from 11 countries attending.

NTNU GROUND-BASED INSTRUMENTS

The main ground based instrument at NTNU, the new generation Skiymet momentum flux meteor radar, has operated with minimal interruption since summer 2012. Data from this instrument have been used in two PhD projects and a number of masters and technical physics specialization projects at NTNU since 2013. Data have also been used to complement student projects on atmospheric wave variability using meteor wind data from the mid- to high-latitude chain of northern hemisphere SuperDARN radars. The radar forms a key part of the high-latitude instrument cluster of the ARISE2 collaborative infrastructure design study project funded by the European Commission H2020. In addition, profiles of electron density and ionization rate derived from the EISCAT radar are being used to validate the thermospheric ionization rates derived from the SSUSI satellite. Once validated, these satellite data will play a key element in quantifying the thermospheric production of nitric oxide, leading to improved parameterization of the direct effect of energetic particle precipitation on the chemistry and dynamics of the neutral atmosphere.

Optical instrumentation at NTNU has been used in PhD student Christoph Franzen's project. He has initiated a new collaboration with the Nordic Optical Telescope on La Palma, developing a novel technique to measure the variability of the low-latitude mesopause region from archived astronomical data. These low-latitude data will be used in conjunction with data from the Trondheim near-IR spectrometer to deduce the relative influence of solar UV and solar particle precipitation on the chemistry and dynamics of the mesosphere and lower thermosphere.

GNSS RECEIVER 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 network operated nominally in 2013.

SUPERMAG

SuperMAG is a worldwide collaboration of organizations and national agencies that currently operate more than 300 ground based magnetometers. SuperMAG provides easy access to validated ground magnetic field perturbations in the same coordinate system, identical time resolution and with a common baseline removal approach. SuperMAG has established its position as the single point of access of ground based magnetometer data. With more than 100 thousand downloads / year, >1000 registered users and recognized as a USA National Science Foundation facility it has become an integrated part of the worldwide heliophysics science community. SuperMAG provides a long list of tools for easy data access and publication quality plots, >40 years of data, and the inclusion of satellite footprints (ESA SWARM and NASA RBSP satellites).

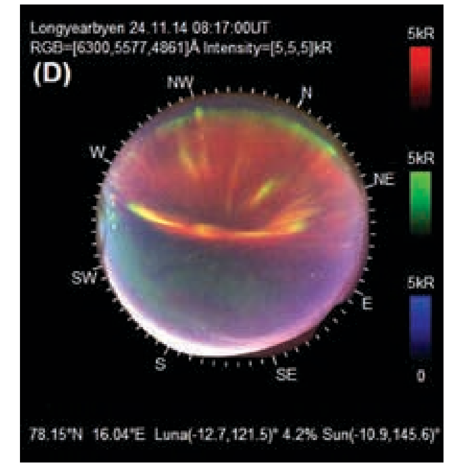


Figure 13: C-REX ground-based data. The Red, Green and Blue color channels are from center wavelengths of 6300, 5577 and 4861 Å, respectively.

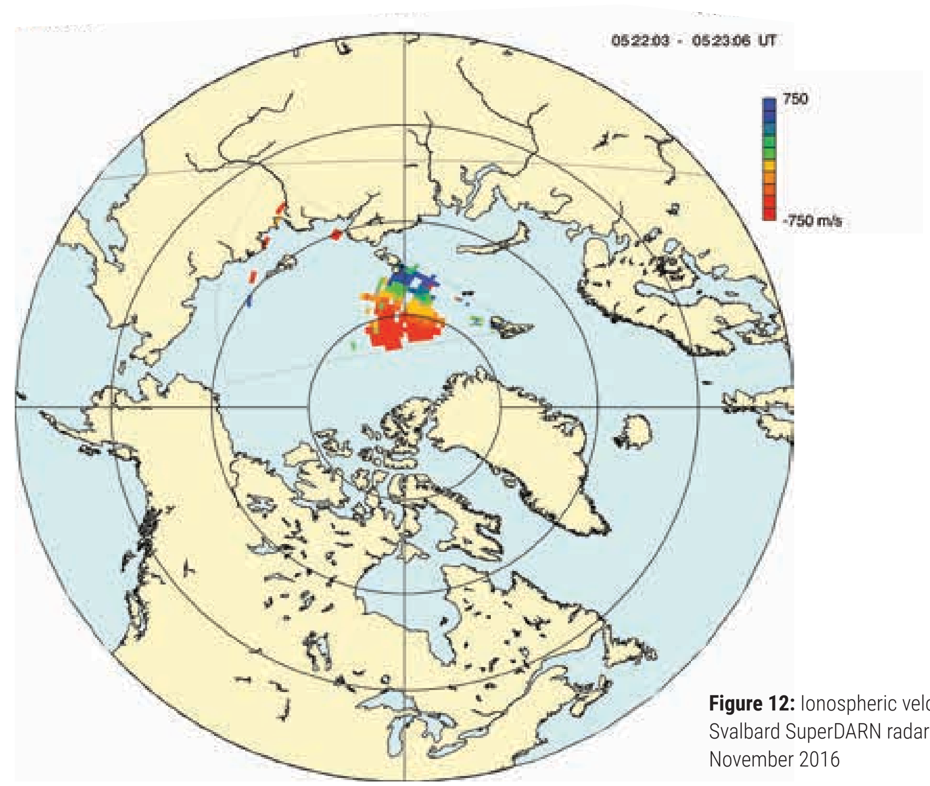


Figure 12: Ionospheric velocity plot from the Svalbard SuperDARN radar on the 27th of November 2016

Research Training

BCSS GRADUATE COURSES

The research training at BCSS is given as regular graduate courses, specialized courses as well as direct supervision of PhD and post-docs. In addition, we have initiated a cross-disciplinary course with climate researchers at the Bjerknes Centre for Climate Research.

In addition, we give introductory courses that are important for recruiting young students into our space science programs at the undergraduate level.

UiB courses

Course	Name	ECTS
PHYS 350	Space Plasma Physics	10
PHYS 352	Selected Topics in Ionospheric Physics	10
	Special Course: Lightning and terrestrial gamma-ray flashes	10
	Research School: Solar effects on natural climate variability in the North Atlantic and Arctic *(part of ResClim, the Norwegian Research School in Climate Dynamics)*	5

UNIS courses

Course	Name	ECTS
AGF 801	The Upper Polar Atmosphere	15
AGF 804	Radar Diagnostics of Space Plasma	15
AGF 845	Polar Magnetospheric Substorms	10

NTNU courses

Course	Name	ECTS
FY8902	Atmospheric Physics and Climate Change	7,5
FY8504	Advanced Experimental Physics	7,5

PHD DISSERTATIONS TO DATE

Student	Gen.	Inst.	Year	Dissertation Title
Ragnhild *(Schrøder Hansen)* Nisi	F	UiB	2014	Constraining the properties of Terrestrial Gamma-ray Flashes
Jone Reistad	M	UiB	2016	Mechanisms responsible for asymmetric aurora between the conjugate hemispheres
Linn Kristine Ødegaard	F	UiB	2016	Energetic particle precipitation into the middle atmosphere
Christer van der Meeren	M	UiB	2016	Mesoscale ionospheric plasma irregularities and scintillation over Svalbard
Teferi Dejene Demissie	M	NTNU	2013	The vertical structure and source regions of large and small scale waves in the middle atmosphere
Nora Stray *(née Kleinknecht)*	F	NTNU	2014	Planetary waves in the northern MLT: Vertical coupling and effects
Silje Holmen Eriksen *(Part of BCSS during her PhD project)*	F	UNIS/ UiT	2016	Trends and variability in polar mesopause region temperatures attributed to atmospheric dynamics and solar variability

MASTER'S THESES COMPLETED BY DECEMBER 2016

Gender	UIB	NTNU	UNIS	TOTAL
F	7	5	2	14
M	9	14	3	26
	16	19	5	40

At the moment, we have 9 PhD students (UIB: 7, NTNU: 1 and UNIS: 1)

In the original proposal, we promised that 20 PhD and 80 master's students would be graduated after 10 years. We are on schedule.

Research Collaboration within the Centre

Although the BCSS is organized in four independent research groups and two instrumentation groups, there has been extensive collaboration as well as collaborative projects between all the groups.

Analysis of SuperMAG data has been a continuous collaboration between Groups 1 and 2. SuperMAG provides the most important data set for remotely measuring ionospheric currents systems globally in both hemispheres. However, a collaborative effort by Dr. Laundal (Group 1) and Prof. Gjerloev (Group 2) explored the systematic errors introduced by using common approximations for coordinate transformations, particularly in studies of subtle differences between hemispheres and longitudes *(Laundal & Gjerloev, 2014)*. This study was followed up by *Laundal and Richmond (2016)* who showed the importance of using non-orthogonal magnetic coordinate systems when studying ionospheric processes. All studies performed using SuperMAG data performed by BCSS are now using the non-orthogonal magnetic coordinate system. Drs. Haaland (Group 1) and Gjerloev (Group 2) used the SuperMAG data to explore dawn-dusk asymmetries in ring current intensity.

The PhD project for Jone Reistad was also a collaborative project between the two groups, where Prof. Oksavik (Group 2) was the supervisor and Prof. Østgaard (Group 1) was the Co-supervisor. Besides extensive use of auroral imaging of the two hemispheres, this project also utilized SuperDARN network *(Reistad et al., 2016)*. Knowledge about the measurement technique, processing and limitation is crucial to utilize these data fully. The collaboration between Group 1 and Group 2 is of great importance for achieving this knowledge and these data are crucial to address the main questions for both Group 1 and Group 2. In 2016, also Group 3 initiated a project (Dr. Bland) using SuperDARN data.

One of the great achievements of Group 3 has been to develop a data processing scheme to obtain a complete pitch angle distribution of electron energies from NOAA data *(Nesse Tyssøy et al., 2016)*. This implies a detailed calibration scheme to adjust for the degradation of the detectors *(Sandanger et al., 2015)*. This effort has been a collaborative effort between Group 3 and Group 2 (Prof. Oksavik).

Although Group 4 and Group 1 have quite different scientific questions to address, the mathematical expertise of Dr. Lehtinen from Group 4 was crucial to solving complex mathematical integrals for the study of *Laundal et al.* (2015).

Large collaborative projects between Groups 1, 3, 4 and the Space Instrumentation Group have been very important for developing the ASIM and FEGS projects (Group 4), the SMILE project (Group 1) and the DEEP project (Group 3). Both Group 1, Group 2 and Group 3 work closely with the Ground-Based Instrumentation Group on utilizing KHO, SuperDARN, EISCAT, SuperMAG, GNSS receivers as well as the NTNU ground based instruments.

International Collaboration

Of our 152 publications, more than 40% have BCSS members as first author. The large majority of the first author papers have international co-authors. The more than 50% of the published papers with international collaborators as first author reflect the large international collaborative network of BCSS. Table 1 lists the co-authors sorted by countries. In the following, we want to highlight some of the international collaborative efforts that have been subject to special international attention.

Laundal and Richmond (2016) is an example of one of our young leaders (Dr. Laundal) collaborating with a highly recognized scientist (Dr. Richmond) from NCAR, Boulder, US to publish a review paper on the importance of using proper coordinate systems when analyzing magnetic ground based data. *Fear et al.* (2014) is an example where Prof. Milan from BCSS was the second author of a paper in ***Science***, showing that precipitating particles producing theta aurora/polar cap arcs are on closed field lines.

Luhr et al. (2015) with Dr. Gjerloev from BCSS as co-author about field aligned currents measured by the SWARM mission that made it to a research spotlight in *Geophysical Research Letters*. Two other collaborative papers *(van der Meeeren et al., 2014; Han et al., 2015)* both made the front cover of the *Journal of Geophysical Research.*

Hendricx et al. (2015) is another important paper resulting from collaborative efforts. The paper reported the 27-day recurrence (solar rotation) of NO enhancements associated with energetic particle precipitation.

Our featured papers on TGF research *(Østgaard et al. , 2013)* has been a collaborative effort between BCSS and groups in the US (Prof. S. Cummer; Dr. H. Christian; Prof. D. Smith).

BCSS is also part of a number of collaborative projects and organizations. TEA-IS (2013-2016) was an ESF funded network, where most of the European scientists in TGF research were involved. This is now followed up with the SAINT project, a Marie Curie network starting in 2017, also for TGF research. We have participated in a number of ISSI workshops and teams during 2013-2016. We are part of the international networks for EISCAT 3D, SuperDARN and SuperMAG. We are co-leading the SPARC SOLARIS/HEPPA and represent Norway in IAGA, ISWI and SCOSTEP. We also have a close collaboration with Dr. Niels Olsen at DTU, Denmark for analyzing SWARM data, and with Dr. Brian Anderson at JUAPL for analyzing AMPERE data.

The hardware projects are all large international collaborations. ASIM is a collaboration between Spain, Denmark, Norway, Italy and France. The aircraft campaign, FEGS, is a joint effort by the US and BCSS. The SMILE project involves a number of countries: UK, China, Canada, USA, Austria, Belgium, the Czech Republic, Hungary, Spain and Norway. As the facilities in Eindhoven Technical University are no longer available, we have initiated collaboration with Barcelona.

Table 1: Collaborators by countries
(Source: ISI Web of Knowledge)

Country	Papers	%
Norway	142	99
USA	68	47
England	37	25
Germany	32	22
Finland	16	11
France	16	11
Canada	15	10
Italy	13	9
Japan	13	9
Russia	13	9
Sweden	11	7
Belgium	10	7
Netherlands	9	6
South Africa	7	5
People's Rep. China	6	4
Spain	6	4
Brazil	5	3
Denmark	5	3
Czech Republic	3	2
Poland	3	2
Australia	2	1
Austria	2	1
India	2	1
Switzerland	2	1

Following is a list of BCSS' most important international collaborators in the period 2013-2016.

Table 2: BCSS international collaborators 2013-2016

Institute/Agency	Collaborator(s)	Group(s)
Univ. of California, Los Angeles, US	R. Strangeway	G1
Univ. of Calgary, Canada	E. Donovan, E. Spanswick	G1
Univ. of California, Berkeley, US	S. Mende, H. Frey	G1
GFZ, Potsdam, Germany	M. Förster	G1
Lancaster University, UK	A. Grocott, M. Kosch	G1, G2
Johns Hopkins Univ./APL, US	S. Ohtani, B. Anderson, P. Newell, L. Paxton	G1, G2
Univ. of Leicester, UK	S. Sembay, M. Lester	G1, G2
Nat. Inst. of Polar Res., Tokyo, Japan	Y. Ogawa	G1, G2
Virginia Tech., Virginia, US	M. Ruohoniemi, J. Baker	G2
Univ. of New Hampshire, US	M. R. Lessard	G2
Univ. of Warwick, UK	S. Chapman	G2
Inst. of Physics of the Earth, Russia	V. Pilipenko, E. Fedorov	G2
Polar Research Inst., China	D.-S. Han, Z.-J. Hu, Y. Liu, Q. Qiu, J.-M. Liu, H.-Q. Hu, H.-G. Yang, R. Shi	G2
Stockholm Univ., Sweden	L. Megner	G3
NASA Jet Propulsion Laboratory, US	G. Manney, M. Santee	G3
NASA Langley Reseach Center, US	M. Mlynczak, C. J. Mertens	G3
Hampton Univ., Virginia, US	J. Russell III	G3
LASP, Univ. of Colorado, US	C. Randall	G3
Coastal Carolina Univ., US	V. Limpasuvan	G3
NCAR, Boulder, Colorado, US	D. Marsh, R. Garcia, A. Smith, A. Richmond	G3, G1
British Antarctic Survey, UK	R. Horne, M. Clilverd, D. Newnham, M. Freeman, I. Cnossen	G3, G1
Univ. of Bath, UK	N. Mitchell, M. Füllekrug	G3, G4
LPCE, CNRS, Orleans, France	N. Huret, J.-B. Renard, S. Celestin	G3, G4
Danish Technical Univ. Denmark	T. Neubert, N. Olsen	G4, G1
Univ. of Alabama, Hunstville, US	H. Christian	G4
Naval Research Laboratory , US	E. Grove	G4
SRC, Warsaw, Poland	P. Orleanski	G4
Univ. of Valencia, Spain	V. Reglero, P. Conell	G4
Univ. Politec. de Catalunya, Spain	J. Montanya	G4
Eindhoven Univ., Netherlands	L. van Deursen, U. Ebert	G4
Univ. of Munich, Germany	H. D. Betz	G4
Duke Univ., US	S. Cummer	G4
INAF - Natl. Inst. for Astrophys., Italy	C. Labanti, M. Tavani	G4

Dissemination and Communication

Dr. Arve Aksnes, UiB
Team Leader

From 2013 to 2016 BCSS research has led to the publication of 152 articles in top, peer-reviewed journals. BCSS has also organized more than 10 sessions at AGU and EGU meetings, and given about 400 presentations at international meetings, of which more than 70 have been invited.

Our key currency of dissemination is through publication in top, peer-reviewed journals and through presentations to other researchers in the space science community. Participation in international meetings is also essential to create opportunities for exchange of ideas and collaborations with top-notch scientists in the field. To strengthen the public outreach work, BCSS has from the beginning established an Education and Public Outreach (EPO) group. The work of this EPO group has been guided by the following prioritized goals:

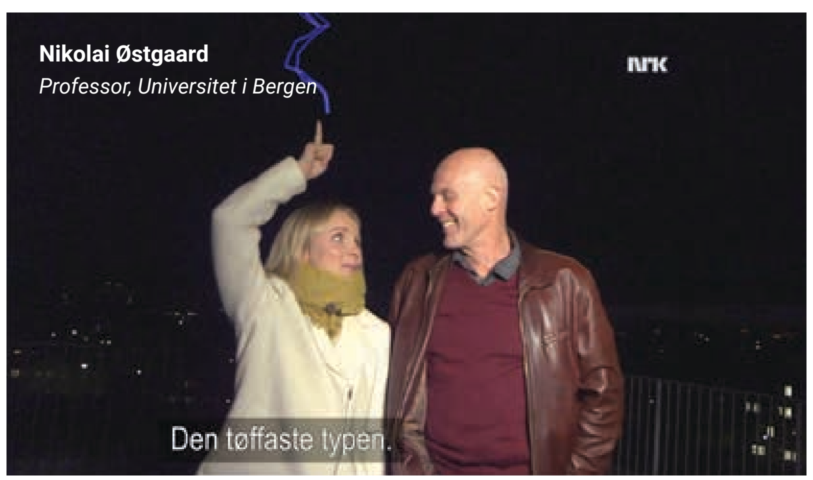
1.To present BCSS research results to an international and domestic audience

2.To promote the Centre's major achievements (funding, large hardware, stipends etc.) to an international and domestic audience

3.To create a feeling of pride, ownership, and a sense of belonging within BCSS in order to create a more cohesive community

4.To recruit bachelor's students to our master's program and to recruit high school students to higher education (university level) in physics

Figure 14: Centre leader Nikolai Østgaard presents recent findings on lightning on the poplar science TV program "Schrødingers Katt".



BCSS research results and the Centre's major achievements are publicised on the Centre's website and through social media channels (Twitter and Facebook). During the Centre's first four years, 44 news articles aimed at a public audience have been highlighted on the BCSS webpage. In addition, 127 external media articles involving BCSS research results and/or the Centre have been produced.

In the case of extraordinary research results, extra steps have been taken to reach an even wider audience. One example is the paper by *Østgaard et al.* (2013) entitled "Simultaneous observations of optical lightning and terrestrial gamma ray flash from space" that identified for the first time a sequence of radio pulses, TGF and optical emissions. A 2-minute animation was created in order to make the results more accessible to a general public. This prompted the American Geophysical Union (AGU) to make a press release of these findings. After the publication of the paper, many media sources around the world picked up the AGU story, which resulted in 38 news articles worldwide. We had more than 500 external visitors to the Centre's homepage. The animation that was part of AGU's press release packet (prepared by us) was seen more than 5300 times on YouTube.

A successful opportunity for the publicising of one of the Centre's major achievements came with the appearance of Centre Leader Nikolai Østgaard on the TV science show *Schrødingers Katt* in the beginning of 2016. *Schrødingers Katt* is an award winning programme with an average viewer base of 500,000 that brings popular science and technology to a lay audience. On the show, Østgaard was able to explain the significance of the launch of the Atmosphere Space Interactions Monitor (ASIM) payload and its subsequent role on the International Space Station (ISS). Østgaard explained occurrences of blue jets and red sprites in the upper atmosphere and how the ASIM instrument would help increase our knowledge regarding such physical phenomena.

During the first year as a Centre of Excellence, it was important to establish the Centre's identity – both externally and internally. A website for the Centre was developed, an external portal to ensure an up-to-date listing of the research group's publications and presentations and newsworthy happenings. Various brand identity materials were also produced. In addition, Twitter and Facebook accounts for the Centre were established. At the end of 2016, our twitter account, named "@BirkelandBCSS", has more than 5000 followers.

Internally, reorganizing the 4th floor of the Department of Physics and Technology building in Bergen (the BCSS headquarters), where about 75% of the BCSS members are based, was a priority throughout 2014. An important purpose of making the Centre's research results more visible and accessible was to encourage interaction within groups and perhaps also across groups at the Centre/Institute. Profiles of individual PhD students and postdocs were created and exhibited to promote greater familiarity and pride among junior group members and attract new PhD students. Large TV screens placed at the entrance to the Centre show both real-time space weather information and films that explore the research being done. These have proved to be a natural meeting place for Centre members and non-members alike.

In both 2015 and 2016, a recruitment event was arranged in the beginning of the year. Students were invited to learn more about space science and to interact with staff and students. The events attracted more than 20 students, and the steady stream of master's students to BCSS suggests that this recruitment strategy works.

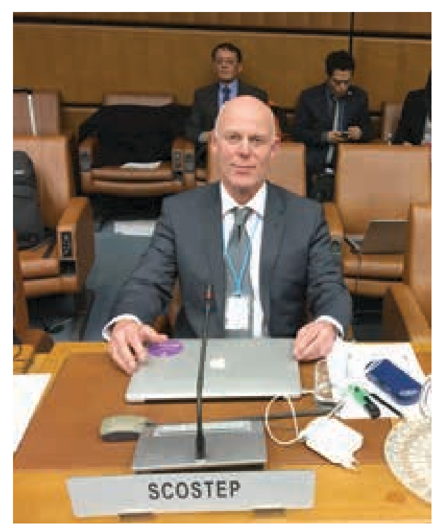
Geography has been one of the challenges of creating a feeling of community among the Centre's far-flung member groups. To counteract this, workshops that bring all members together have been organized every sixth month. While the workshops in the fall have been arranged in Bergen, other workshops have been arranged in Svalbard (UNIS) and Trondheim (NTNU) in order to familiarize all Centre members with each other's work environments.

Every year BCSS participates in Research Days, the annual science fair that takes place in downtown Bergen. In particular, the event known as "Forskningsdagene UNG" has been of great interest: this event targets high school students, making it possible to actively engage with our desired target group.

Photo: forskning.no

Figure 16: (Left)
Prof. Kjellmar Oksavik on Svalbard during the solar eclipse.

Figure 15: (Below) Nikolai Østgaard made a presentation to the UN Committee on the Peaceful Uses of Outer Space (COPUOS)



Figures 17: (Below) Research Days 2015, Festplassen, Bergen.

Photo: Kjartan Olafsson

Project Funding

Birkeland Centre for Space Science: CoE Funding 160 MNOK; Total Funding over ten years 440 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		
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.	P.I. Nikolai Østgaard; 2.85 MEUR
Strategic Core Activities for the Space Physics group at the University of Bergen (SCASP-UIB) | Project nr: 216872/F50–RCN/Program for Space Research		
2012-2015	A project to support TGF research and Cluster studies – one PhD student	P.I. Nikolai Østgaard; 3 MNOK
Norwegian Research Council Program for Space Research | Project nr: 208028/F50		
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	P.I. Nikolai Østgaard; 4.86 MNOK
Norwegian Research Council Program for Space Research | Project nr: 230956/F50		
2014-2017	**The Norwegian Cluster studies** A small project to support the Norwegian collaboration using Cluster data	P.I. Nikolai Østgaard; 600 KNOK
Norwegian Research Council Program for Space Research | Project nr: 212014/F50		
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 campaigns at Svalbard	P.I. Kjellmar Oksavik; 1.3 MNOK
Norwegian Research Council Program for Space Research | Project nr: 195385/F50		
2010-2015	**Infrastructure for space physics related research on Svalbard** A project to develop new space related infrastructure on Svalbard	P.I. Dag Lorentzen; 8.2 MNOK
Norwegian Research Council Program for Space Research | Project nr: 191747/V30		
Dec. 2009 - Feb. 2013	**Gravity-wave sources and scales in the Polar Regions and their effect on Polar Mesospheric Clouds**	P.I. Patrick J. Espy; 2.523 MNOK full cost
Norwegian Polar Institute Researcher | Project-NARE		
2011-2013	**Observation of carbon monoxide and ozone in the Antarctic and Arctic:** Implications for the inter-hemispheric coupling of vertical motions	P.I. Patrick J. Espy; 2.566 MNOK full cost
UK Natural Environment Research Council standard grant | NE/G018707/1		
Aug. 2009- July 2013	**A new radar for integrated atmospheric science in the southern hemisphere** British Antarctic Survey / University of Leicester	P.I. Steve Milan, Co-I: Robert Hibbins; Full economic cost £686K
UK Natural Environment Research Council standard grant | NE/H009760/1		
April 2010- Mar. 2013	**Wave dynamics of the mesosphere** British Antarctic Survey / University of Bath	P.I. Robert Hibbins; Full economic cost £588K
UK Natural Environment Research Council standard grant | NE/I010173/1		
April 2011- Mar. 2016	**Solar wind connection to regional climate** British Antarctic Survey	Co-I. Robert Hibbins; Full economic cost £457K
Norwegian Research Council FRINAT Program | Project nr: 191628		
2009-2014	**SPEAR – a high power ionospheric modification facility for Svalbard**	P.I. Lisa Baddeley; 6617 KNOK
Norwegian Research Council Program for Space Research | Project: 255276/E10		
2016-2019	**SOLENA –** Solar effects on natural climate variability in the North Atlantic and Arctic. Collaboration between the Bjerknes Centre for Climate Research, the Dept. of Geosciences, UiO, and the Geophysical Institute, UiB.	P.I. Yvan Orsolini; 11374 KNOK
SuperMAG | ESA PRODEX funding | Contract: 4000104152		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.	160 KEUR
Tech. Support for ESA SWARM SuperMAG Activity | ESA PRODEX funding | Contract: 4000114432/15/NL/FF/ah		P.I.s Jesper Gjerloev, Nikolai Østgaard
2015-2016	**SuperMAG –** is a worldwide collaboration of organizations and national agencies that currently operate more than 300 ground-based magnetometers.	120 KEUR

Publications

152) Browett, S.D., R.C. Fear, A. Grocott, **S.E. Milan** (2016), Timescales for the penetration of IMF By into the Earth's magnetotail, *J.Geophys. Res. Space Phys*, doi: 10.1002/2016JA023198 [pdf]

151) **N. Østgaard, J. P. Reistad, P. Tenfjord, K. M. Laundal, K. Snekvik, S. E. Milan, S. Haaland** (2016), Mechanisms that Produce Auroral Asymmetries in Conjugate Hemispheres, *AGU Geophysical Monograph 215*, Auroral Dynamics and Space Weather, Editors: Y. Zhang and L. Paxton, doi:10.1002/9781118978719.ch10

150) Ursi, A., **M. Marisaldi,** M. Tavani, D. Casella, P. Sano, S. Dietrich (2016) Detection of multiple terrestrial gamma-ray flashes from thunderstorm systems, *J. Geophys. Res.–Biogeosciences*, doi:10.1002/2016JA023136

149) Ursi A., P. Sanò, D. Casella, **M. Marisaldi,** S. Dietrich, and M. Tavani (2016), A pipeline to link meteorological information and TGFs detected by AGILE, *J. Geophys. Res.*, doi:10.1002/2016JA023137

148) Sonnerup, **S. Haaland,** G. Paschmann, T. Phan, and S. Eriksson (2016), Magnetopause, reconnection layer bounded by switch-off shocks 2: Pressure anisotropy, *J. Geophys. Res. Space. Phys.*, doi:10.1002/2016JA023250

147) **Tenfjord P., N. Østgaard**, R.J. Strangeway, **S. Haaland, K. Snekvik, K.M. Laundal, J.P. Reistad,** and **S.E. Milan** (2016), Magnetospheric response and reconfiguration times following IMF By reversals, *J. Geophys. Res.*, 121, doi:10.1002/2016JA023018

146) **Kwagala, N. K., K. Oksavik, D. Lorentzen,** and M. Johnsen (2016) On the contribution of thermal excitation to the total 630.0 nm emissions in the northern cusp ionosphere, *JGR - Space Physics*, doi: 10.1002/2016JA023366

145) Liu, Z., K.L. Koh, **A. Mezentsev**, S.-E. Enno, J. Sugier, and M. Füllekrug (2016), Variable phase propagation velocity for long-range lightning location system, *Radio Science*, doi: 10.1002/2016RS006058

144) Malhotra, G., J. M. Ruohoniemi, J. B. H. Baker, **R. E. Hibbins**, and K. A. McWilliams (2016), HF radar observations of a quasi-biennial oscillation in midlatitude mesospheric winds, *J. Geophys. Res. Atmos.*, 121, doi:10.1002/2016JD024935

143) Prikryl, P., R. Ghoddousi-Fard, J. M. Weygand, A. Viljanen, M. Connors, D. W. Danskin, P. T. Jayachandran, K. S. Jacobsen, Y. L. Andalsvik, E. G. Thomas, J. M. Ruohoniemi, T. Durgonics, **K. Oksavik**, Y. Zhang, E. Spanswick, M. Aquino, and V. Sreeja (2016), GPS phase scintillation at high latitudes during the geomagnetic storm of March 17-18, 2015, *J. Geophys. Res. Space Physics*, 121, doi:10.1002/2016JA023171

142) Fedorov, E., N. Mazu, V. Pilipenko and **L. Baddeley** (2016) Modeling the high-latitude ground response to the excitation of the ionospheric MHD modes by atmospheric electric discharge, *J. Geophys. Res.Space Physics*, doi: 10.1002/2016JA023354

141) Mishin, E., B. Watkins, **N. Lehtinen**, B. Eliasson, T. Pedersen, S. Grach (2016) Artificial ionospheric layers driven by high-frequency radiowaves: An assessment, *J. Geophys. Res.-Space phys.*, doi: 10.1002/2015JA021823

140) J. C. Coxon, **S. E. Milan**, J.A. Carter, L. B. N. Clausen, B. J. Anderson and H. Korth (2016) Seasonal and diurnal variations in AMPERE observations of the Birkeland currents compared to modeled results, *J. Geophys. Res.: Space Phys.*, doi: 10.1002/2015JA022050

139) **P. Kochkin**, C. Köhn, Ut. Ebert and L. van Deursen (2016) Analyzing x-ray emissions from meter-scale negative discharges in ambient air, *Plasma Sources Sci. Technol.*, doi:10.1088/0963-0252/25/4/044002

138) Lyu, F., S.A. Cummer, M. Briggs, **M. Marisaldi,** R. J. Blakeslee, E.C. Bruning, J. G. Wilson, W. Rison, P. Krehbiel, G. Lu, E. Cramer, G. Fitzpatrick , B. Mailyan, S. McBreen, O. J. Roberts, and M. Stanbro (2016), Ground detection of terrestrial gamma ray flashes from distant radio signals, *Geophys. Res. Ltr.*, doi: 10.1002/2016GL070154

137) **Kochkin, P., N. Lehtinen**, A.P.J. van Deursen and **N. Østgaard** (2016) Pilot system development in metre-scale laboratory discharge, *J. Phys. D: Appl. Phys.*, doi: 10.1088/0022-3727/49/42/425203

136) Shukhtina, M.A., E. I. Gordeev, V. A. Sergeev, N. A. Tsyganenko, L. B. N. Clausen, and **S. E. Milan** (2016) Magnetotail magnetic flux monitoring based on simultaneous solar wind and magnetotail, observations, *J. Geoph. Res–Space Phys.*, doi: 10.1002/2016JA022911

135) Füllekrug, M., Z. Liu, K. Koh, **A. Mezentsev,** S. Pedeboy, S. Soula, S.-E. Enno, J. Sugier, and M. J. Rycroft (2016) Mapping lightning in the sky with a mini array, *Geophys. Res. Ltrs.*, doi: 10.1002/2016GL070737

134) Rutjes, C., D. Sarria, **A. Broberg Skeltved**, A. Luque, G. Diniz, **N. Østgaard**, and U. Ebert (2016), Evaluation of Monte Carlo tools for high energy atmospheric physics, *Geosci. Model Dev. Discuss.*, doi:10.5194/gmd-2016-147

133) Dunlop, M., **S. Haaland**, C. Escoubet, and X.-C. Dong (2016), Accessing 3-D currents in space: Experiences from Cluster, *J. Geophys. Res. Space Physics*, 121, Issue 8, doi:10.1002/2016JA022668

132) Sonnerup, B., Paschmann, **G., Haaland**, S., Phan, T., Eriksson, S. (2016), Reconnection layer bounded by switch-off shocks: Dayside magnetopause crossing by THEMIS D, *J. Geophys. Res. Space Physics*, 121, Issue 4, doi:10.1002/2016JA022362

131) Woodroffe, J. R., S. K. Morley, V. Jordanova, M. G. Henderson, M. M. Cowee, and **J. W. Gjerloev** (2016), The Latitudinal Variation of Geoelectromagnetic Disturbances During Large (Dst≤-100 nT) Geomagnetic Storms, *Space Weather*, 14, doi:10.1002/2016SW001376

130) Newell, P. T., K. Liou, **J. W. Gjerloev**, T. Sotirelis, S. Wing, E. J. Mitchell, Substorm probabilities are best predicted from solar wind speed, *J. Atm. Solar-Terrest.Phys.*, Vol. 146, August 2016, Pages 28–37

129) Hajra, R., B. T. Tsurutani, E. Echer, W. D. Gonzalez, and **J. W. Gjerloev** (2016), Supersubstorms (SML < -2500 nT): Magnetic Storm and Solar Cycle Dependences, J. Geophys. Res. Space Physics, 121, doi:10.1002/2015JA021835

128) **Laundal, K. M.**, C. C. Finlay, N. Olsen (2016), Sunlight effects on the 3D polar current system determined from low Earth orbit measurements, *Earth Planets Space*, doi: 10.1186/s40623-016-0518-x

127) **Laundal, K. M.**, I. Cnossen, **S. E. Milan, S. E. Haaland**, J. Coxon, N. M. Pedatella, M. Förster, **J. P. Reistad** (2016), North-South asymmetries in Earth's magnetic field – Effects on high-latitude geospace, *Space Sci. Rev.*, doi:10.1007/s11214-016-0273-0

126) **Laundal, K. M.**, and A. D. Richmond (2016), Magnetic coordinate systems, *Space Sci. Rev.*, doi:10.1007/s11214-016-0275-y

125) **Humberset, B. K., J. W Gjerloev**, M. Samara, R. Michell, I. R. Mann (2016), Temporal Characteristics and Energy Deposition of Pulsating Auroral Patches, *J. Geophys. Res.*, doi: 10.1002/2016JA022921

124) Mezentsev, A., **N. Østgaard, T. Gjesteland, K. Albrechtsen, N. Lehtinen, M. Marisaldi**, D. Smith and S. Cummer (2016), Radio emissions from double RHESSI TGFs, J. Geophys. Res.: Atmos., doi: 10.1002/2016JD025111

123) **van der Meeren, C., K. Oksavik, D.A. Lorentzen**, L.J. Paxton, L.B.N. Clausen (2016), Scintillation and irregularities from the nightside part of a sun-aligned polar cap arc, *J. Geophys. Res.*, doi: 10.1002/2016JA022708

122) **J. P. Reistad, N. Østgaard, P. Tenfjord, K. M. Laundal, K. Snekvik, S. Haaland, S. E. Milan, K. Oksavik**, H. U. Frey, A Grocott (2016), Dynamic effects of restoring footpoint symmetry on closed magnetic field-lines, *J. Geophys. Res.*, 121, doi: 10.1002/2015JA022058

121) **Zawedde, A. E., H. Nesse Tyssøy, R. Hibbins, P. J. Espy, L.-K. G. Ødegaard, M. I. Sandanger and J. Stadsnes** (2016), The impact of Energetic Electron Precipitation on Mesospheric Hydroxyl During a Year of Solar Minimum, *J. Geophys. Res.*, doi: 10.1002/2016JA022371

(continued on next page)

Publications (continued)

120) **Nesse Tyssøy, H., M .I. Sandanger, L.-K. G. Ødegaard, J. Stadsnes, A. Aasnes, and A. E. Zawedde** (2016), Energetic Electron Precipitation into the Middle Atmosphere: Constructing the Loss Cone Fluxes from MEPED POES. *J. Geophys. Res.*, doi: 10.1002/2016JA022752

119) **Ødegaard, L.-K. G., H.N. Tyssøy, M. I. J. Sandanger, J. Stadsnes and F. Søraas** (2016), Space Weather Impact on the Degradation of NOAA POES MEPED Proton Detectors, *J. Space Weather & Space Climate*, doi: 10.1051/swsc/2016020

118) **Chen, X.-C., D. A. Lorentzen**, J. I. Moen, **K. Oksavik, L. J. Baddeley**, and M. Lester (2016), F-region ionosphere effects on the mapping accuracy of SuperDARN HF radar echoes, *Radio Science*, 51, doi:10.1002/2016RS005957

117) Jin, Y., J. I. Moen, W. J. Miloch, L. B. N. Clausen, and **K. Oksavik** (2016), Statistical study of the GNSS phase scintillation associated with two types of auroral blobs, *J. Geophys. Res. Space Physics*, 121, doi:10.1002/2016JA022613

116) de Wit, R. J., D. Janches, D. C. Fritts, and **R. E. Hibbins** (2016), QBO modulation of the mesopause gravity wave momentum flux over Tierra del Fuego, *Geophys. Res. Lett.*, 43, doi:10.1002/2016GL068599

115) Limpasuvan, V., **Y. J. Orsolini**, A. Chandran, R. R. Garcia, and A. K. Smith (2016), On the Composite Response of the MLT to Major Sudden Stratospheric Warming Events with Elevated Stratopause, *J. Geophys. Res. Atmos.*, 121, doi:10.1002/2015JD024401

114) **Østgaard, N., B. E. Carlson**, R. S. Nisi, **T. Gjesteland**, Ø. Grøndahl, **A. Skeltved, N. G. Lehtinen, A. Mezentsev, M. Marisaldi, and P. Kochkin** (2016), Relativistic electrons from sparks in the laboratory, *J. Geophys. Res. Atmos.*, 121, doi:10.1002/2015JD024394

113) **Laundal, K.M., J.W. Gjerloev, N. Østgaard, J. P. Reistad, S. Haaland, K. Snekvik, P. Tenfjord**, S. Ohtani and **S. E. Milan** (2016), The impact of sunlight on high-latitude equivalent currents, *J. Geophys. Res. Space Physics*, 121, doi:10.1002/2015JA022236

112) **Milan, S.E.**, S.M. Imber, J.A. Carter, M.-T. Walach and B. Hubert (2016), What controls the local time extent of flux transfer events?, *J. Geophys. Res.*, doi: 10.1002/2015JA022012

111) Goldstein, J., D. V. Bisikalo, V. I. Shematovich, J.-C. Gérard, **F. Søraas**, D. J. McComas, P. W. Valek, K. LLera, and J. Redfern (2016), Analytical Estimate for Low Altitude ENA Emissivity, *J. Geophys. Res. Space Physics*, 121, doi:10.1002/2015JA021773

110) Savolainen, T., D. K. Whiter, and **N. Partamies** (2016), Automatic segmentation and classification of seven-segment display digits on auroral images, *Geosci. Instrum. Method. Data Syst. Discuss.*, doi:10.5194/gi-2015-28

109) Kauristie, K., M. Myllys, **N. Partamies**, A. Viljanen, P. Peitso, L. Juusola, S. Ahmadzai, V. Singh, R. Keil, U. Martinez, A. Luginin, A. Glover, V. Navarro, and T. Raita (2016), Forecasting auroras from regional and global magnetic field measurements, *Geosci. Instrum. Method. Data Syst. Discuss.*, doi:10.5194/gi-2015-33

108) Hettrich, S., Y. Kempf, N. Perakis , J. Górski, M. Edl, J. Urbár, M. Dósa, F. Gini, O. W. Roberts, S. Schindler, M. Schemmer, D. Steenari, N .Joldzic, **L.-K. G. Ødegaard**, D. Sarria, M. Volwerk, and J. Prak (2015) Atmospheric Drag, Occultation 'N' Ionospheric Scintillation(ADONIS) mission proposal, Alpbach Summer School 2013 Team Orange, *J. Space Weather Space Clim.*, doi: 10.1051/swsc/2015004 jastp.2014.12.003

107) **Stray, N.H., P.J. Espy,** V. Limpasuvan, and R.E. Hibbins (2015) Characterisation of quasi-stationary planetary waves in the Northern MLT during summer, *J. Atm. And Solar-Terrest. Phys.*, doi:10.1016/j.jastp.2014.12.003

106) Fear, R. C., **S. E. Milan**, J. A. Carter, and R. Maggiolo (2015), The interaction between transpolar arcs and cusp spots, *Geophys. Res. Lett.*, 42, 9685-9693, doi: 10.1002/2015GL066194

105) Ganushkina, N.Y., M.W. Liemohn, S. Dubyagin, I.A. Daglis, I. Dandouras, Iannis, D.L. De Zeeuw, Y. Ebihara, R. Ilie, R.M. Katus, M.V. Kubyshkina, **S. Milan**, S. Ohtani, **N. Østgaard, J.P. Reistad, P. Tenfjord**, F.R. Toffoletto, S.G. Zaharia, O.A. Amariutei (2015), Defining and resolving current systems in geospace. *Annales Geophysicae 2015*; Vol 33. (11) s. 1369-1402

104) **Haaland, S**., A. Eriksson, M. André, L. Maes, **L. Baddeley**, A. Barakat, R. Chappell, V. Eccles, C. Johnsen, B. Lybekk, K. Li, A. Pedersen, R. Schunk, and D. Welling (2015), Estimation of cold plasma outflow during geomagnetic storms, *J. Geophys. Res.*, 120, 021810, doi:10.1002/2015JA021810

103) Hall, C. M., **S. E. Holmen**, C. E. Meek, A. H. Manson, and S. Nozawa (2015), Change in turbopause altitude at 52 and 70 N, *Atmos. Chem. Phys. Discuss.*, 15, 20287-20304, doi: 10.5194/acpd-15-20287-2015

102) **Holmen, S. E.**, C. M. Hall, and M. Tsutsumi (2015), Neutral atmosphere temperature change at 90 km, 70 N, 19 E, 2003-2014, *Atmos. Chem. Phys. Discuss.*, 15, 15289-15317, doi: 10.5194/acpd-15-15289-2015

101) Tanaka, Y., Y. Ogawa, A. Kadokura, **N. Partamies**, D. Whiter, C.-F. Enell, U. Brändström, T. Sergienko, B. Gustavsson, A. Kozlovsky, H. Miyaoka, and A. Yoshikawa (2015), Eastward-expanding auroral surges observed in the post-midnight sector during a multiple-onset substorm, *Earth Planets and Space*, 67:182, doi:10.1186/s40623-015-0350-8

100) Oliveira, D. M, J. Raeder, and **J. W. Gjerloev** (2015), Effects of Interplanetary Shock Inclinations on Nightside Auroral Power Intensity, *Braz. J. Phys.*, doi: 10.1007/s13538-015-0389-9

99) Waters, C. L., **J. Gjerloev**, M. Dupont, R. J. Barnes (2015), Global maps of ground magnetometer data, *J. Geophys. Res.*, doi: 10.1002/2015JA021596

98) Tereshchenko, E. D., R. Y. Yurik and **L. Baddeley** (2015), Stimulated electromagnetic emission polarization under different polarizations of pump waves, *Ann. Geophys.*, 33, 295-300, doi:10.5194/angeo-33-295-2015

97) **Østgaard, N.**, K. H. Albrechtsen, T. Gjesteland, A. Collier (2015), A new population of Terrestrial Gamma-ray Flashes in the RHESSI data, *Geophys. Res. Letter*, doi: 10.1002/2015GL067064

96) **Tenfjord, P., N. Østgaard, K. Snekvik, K. M. Laundal, J. P. Reistad, S. E. Haaland, S. E. Milan** (2015), How the IMF B_y induces a B_y component in the closed magnetosphere and how it leads to asymmetric currents and convection patterns in the two hemispheres, *J. Geophys. Res.*, doi: 10.1002/2015JA021579

95) C. Forsyth, I.J. Rae, J. C. Coxon, M.P. Freeman, C.M. Jackman, **J. Gjerloev**, A.N. Fazakerley (2015), A New Technique for Determining Substorm Onsets and Phases from Indices of the Electrojet (SOPHIE), *J. Geophys. Res.*, doi: 10.1002/2015JA021343

94) **Milan, S. E.**, J. A. Carter, H. Korth, and B. J. Anderson (2015), Principal Component Analysis of Birkeland currents determined by the Active Magnetosphere and Planetary Electrodynamics Response Experiment, *J. Geophys. Res. Space Physics*, 120, doi:10.1002/2015JA021680

93) **Gjesteland, T., N. Østgaard**, S. Laviola, M.M. Miglietta, E. Arnone, **M. Marisaldi**, F. Fuschino, A.B. Collier, F. Fabro, J. Montanya (2015), Observation of intrinsically bright terrestrial gamma ray Flashes from the Mediterranean basin, *J. Geophys. Res.*, doi:10.1002/2015JD023704

92) **van der Meeren, C., K. Oksavik, D. A. Lorentzen**, M. T. Rietveld, and L. B. N. Clausen (2105), Severe and localized GNSS scintillation at the poleward edge of the nightside auroral oval during intense substorm aurora, *J. Geophys. Res. Space Physics*, doi:10.1002/2015JA021819

91) Han, D.-S., **X.-C. Chen**, J.-J. Liu, Q. Qiu, K. Keika, Z.-J. Hu, J.-M. Liu, H.-Q. Hu, and H.-G. Yang (2015), An extensive survey of dayside diffuse aurora based on optical observations at Yellow River Station, *J. Geophys. Res. Space Physics*, 120, 7447–7465, doi:10.1002/2015JA021699

90) **Sandanger M. I., L.-K. Ødegaard, H. Nesse Tyssøy, J. Stadsnes, F. Søraas, K. Oksavik**, K. Aarsnes (2015), In flight calibration of NOAA POES proton detectors - derivation of the MEPED correction factors, *J. Geophys. Res.*, doi: 10.1002/2015JA021388

89) **Chen, X.-C., D. A. Lorentzen, J. I. Moen, K. Oksavik and L. J. Baddeley** (2015), Simultaneous ground-based optical and HF radar observations of the ionospheric footprint of the open/closed field line boundary along the geomagnetic meridian, *J. Geophys. Res.*, doi:10.1002/2015JA021481

88) Cohen, I. J., M. R. Lessard, R. H. Varney, **K. Oksavik**, M. Zettergren, and K. A. Lynch (2015), Ion Upflow Dependence on Ionospheric Density and Solar Photoionization, *J. Geophys. Res.*, doi:10.1002/2015JA021523

87) **Marisaldi, M.**, A. Argan, A. Ursi, **T. Gjesteland**, F. Fuschino, C. Labanti, M. Galli, M. Tavani, C. Pittori, F. Verrecchia, F. D'Amico, **N. Østgaard,** S. Mereghetti, R. Campana, P. W. Cattaneo, A. Bulgarelli, S. Colafrancesco, S. Dietrich, F. Longo, F. Gianotti, A. Rappoldi, M. Trifoglio, A. Trois (2015), Enhanced detection of Terrestrial Gamma-Ray Flashes by AGILE, *Geophys. Res. Lett.*, doi: 10.1002/2015GL066100

86) **Carlson, B. E., N. Østgaard, P. Kochkin**, Ø. Grøndahl, R. Nisi, K. Weber, Z. Scherrer, K. LeCaptain (2015), Meter-scale spark x-ray spectrum statistics, *J. Geophys. Res.*, doi: 10.1002/2015JD023849

85) **Venkateswara Rao, N., P. J. Espy, R. E. Hibbins**, D. C. Fritts, and A. J. Kavanagh (2015), Observational evidence of theinfluence of Antarctic stratosphericozone variability on middle atmospheredynamics, *Geophys. Res. Lett.*, 42, doi:10.1002/2015GL065432

84) **Oksavik, K., C. van der Meeren, D. A. Lorentzen, L. J. Baddeley**, and J. Moen (2015), Scintillation and loss of lock from poleward moving auroral forms in the cusp ionosphere, *J. Geophys. Res.*, doi:10.1002/2015JA021528

83) Hendrickx, K., L. Megner, J. Gumbel, D. E. Siskind, **Y. J. Orsolini, H. Nesse Tyssøy** and M. Hervig (2015), Observation of 27-day solar cycles in the production and mesospheric descent of EPP-produced NO, *J. Geophys. Res.*, doi:10.1002/2015JA021441

82) Dods, J., S. C. Chapman and **J. W. Gjerloev** (2015), Network Analysis of Geomagnetic Substorms Using the SuperMAG Database of Ground Based Magnetometer Stations, J. Geophys. *Res. Space Physics*, doi:10.1002/2015JA021456

81) **Laundal K. M., S. E. Haaland, N. Lehtinen, J. W. Gjerloev, N. Ostgaard, P. Tenfjord, J. P. Reistad, K. Snekvik, S. E. Milan**, S. Ohtani, B. J. Anderson (2015), Birkeland current effects on high-latitude ground magnetic field perturbations, *Geophys. Res. Lett.*, doi:10.1002/2015GL065776

80) Kabirzadeh, R., **N. G. Lehtinen**, and U. S. Inan (2015), Latitudinal dependence of static mesospheric E fields above thunderstorms, *Geophys. Res. Lett.*, 42, 4208–4215, doi:10.1002/2015GL064042

79) Semenov, V. S. , D. I. Kubyshkina, M. V. Kubyshkina, I. V. Kubyshkina, and **N. Partamies** (2015), On the correlation between the fast solar wind flow changes and substorm occurrence, *Geophys. Res. Let.* 42, 5117-5124, doi:10.1002/2015GL064806

78) Myllys, M., **N. Partamies** and L. Juusola (2015), Latitude dependence of long-term geomagnetic activity and its solar wind drivers, *Annales Geophysicae*, 33, 573-581, doi: 10.5194/angeo-33-573-2015

77) Juusola, L., K. Kauristie, M. van de Kamp, E. I. Tanskanen, K. Mursula, T. Asikainen, K. Andréeová, **N. Partamies**, H. Vanhamäki, A. Viljanen (2015), Solar wind control of ionospheric equivalent currents and their time derivatives, *J. Geophys. Res.* 120, doi:10.1002/2015JA021204

76) **Partamies, N.**, L. Juusola, D. Whiter and K. Kauristie (2015), Substorm evolution of auroral structures, *J. Geophys. Res.* 120, doi:10.1002/2015JA021217

75) McCrea, I., A. Aikio, L. Alfonsi, E. Belova, S. Buchert, M. Clilverd, N. Engler, B. Gustavsson, C. Heinselman, J. Kero, M. Kosch, H. Lamy, T. Leyser, Y. Ogawa, **K. Oksavik**, A. Pellinen-Wannberg, F. Pitout, M. Rapp, I. Stanislawska, and J. Vierinen (2015), The science case for the EISCAT_3D radar, *Progress in Earth and Planetary Science*, 2:21, doi:10.1186/s40645-015-0051-8

74) Engebretson, M. J., J. L. Posch, J. R. Wygant, C. A. Kletzing, M. R. Lessard, C.-L. Huang, H. E. Spence, C. W. Smith, H. J. Singer, Y. Omura, R. B. Horne, G. D. Reeves, D. N. Baker, M. Gkioulidou, **K. Oksavik**, I. R. Mann, T. Raita, and K Shiokawa (2015), Van Allen probes, NOAA, GOES and ground observations of an intense EMIC wave event extending over 12 hours in MLT, *J. Geophys Res. Space Physics*, 120, doi:10.1002/2015JA021227

73) Pitout, F., A. Marchaudon, P.-L. Blelly, X. Bai, F. Forme, S. C. Buchert and **D. A. Lorentzen** (2015), Swarm and ESR observations of the ionospheric response to a field-aligned current system in the high-latitude midnight sector, *Geophys. Res. Lett.*, 42, doi: 10.1002/2015GL064231

72) M. Förster and **S. Haaland** (2015), Interhemispheric differences in ionospheric convection: Cluster EDI observations revisited, *J. Geophys. Res., Space Physics*, Volume 120, Issue 6, doi:10.1002/2014JA020774

71) Maes, L., R. Maggiolo, J. De Keyser, I. Dandouras, R. C. Fear, D. Fontaine and **S. Haaland** (2015), Solar illumination control of ionospheric outflow above polar cap arcs, *Geophys. Res. Let.*, Volume 42, Issue 5, doi:10.1002/2014GL062972

70) Dorville, N., **S. Haaland**, C. Anekallu,G. Belmont, and L. Rezeau (2015), Magnetopause orientation:Comparison between generic residue analysis and BV method, *J. Geophys. Res. Space Physics*, 120, Issue 4, doi:10.1002/2014JA020806

69) Kronberg, E. A., E. E. Grigorenko, **S. E. Haaland**, P. W. Daly, D. C. Delcourt, H. Luo, L. M. Kistler, I. Dandouras (2015), Distribution of energetic oxygen and hydrogen in the near-Earth plasma sheet, *J. Geophys. Res.*, Space Physics, Volume 120, Issue 4, DOI: 10.1002/2014JA020882

68) Tsurutani, B. T., R. Hajra, E. Echer and **J.W. Gjerloev** (2015), Extremely intense (SML ¾2500 nT) substorms: isolated events that are externally triggered?, *Ann. Geophys.*, 33, 519-524, doi:10.5194/angeo-33-519-2015

67) **Carlson, B. E.,** C. Liang, P. Bitzer and H. Christian (2015), Time domain simulations of preliminary breakdown pulses in naturallightning, *J. Geophys. Res. Atmos.*, 120, 1–18, doi:10.1002/2014JD022765

66) Knipp, D. J., L. M. Kilcommons, **J. Gjerloev**, R. J. Redmon, J. Slavin, and G. Le (2015), A large-scale view of Space Technology 5 magnetometer response to solar wind drivers, *Earth and Space Science*, 2, doi:10.1002/2014EA000057

65) de Wit, R.J., **R.E. Hibbins, P.J. Espy**, and E.A. Hennum (2015), Coupling in the middle atmosphere related to the 2013 major Sudden Stratospheric Warming, *Ann. Geophys.*, 33(3), 309-319, doi:10.5194/angeo-33-309-2015

64) Bjoland, L. M., **X. Chen**, Y. Jin, A. S. Reimer, Å. Skjæveland, M. R. Wessel, J. K. Burchill, L. B. N. Clausen, **S. E. Haaland**, and K. A. McWilliams (2015), Interplanetary magnetic field and solar cycle dependence of northern hemisphere F region Joule heating, *J. Geophys. Res.*, doi: 10.1002/2014JA020586

63) Fabró, F., J. Montanyà, **M. Marisaldi**, O. A. van der Velde, and F. Fuschino (2015), Analysis of global Terrestrial Gamma Ray Flashes distribution and special focus on AGILE detections over South America, *J. Atmos. Solar Terr. Phys.*, doi: 10.1016/j.jastp.2015.01.009

62) Lühr, H., J. Park, **J. W. Gjerloev**, J. Rauberg, I. Michaelis, J. M. G. Merayo, and P. Brauer (2015), Field-aligned currents' scale analysis performed with the Swarm constellation, *Geophys. Res. Lett.*, 42, doi:10.1002/2014GL062453

61) Goodwin, L., B. Iserhienrhien, D. M. Miles, S. Patra, **C. van der Meeren**, S. C. Buchert, J. Burchill, L. B. N. Clausen, D. J. Knudsen, K. McWilliams, J. I. Moen (2015), Swarm *in situ* observations of F-region polar cap patches created by cusp precipitation, *Geophys. Res. Lett.*, doi: 10.1002/2014GL062610

(continued on next page)

Publications (continued)

60) **Stray, N.H.**, **Y.J. Orsolini**, **P.J. Espy**, V. Limpasuvan, and **R.E. Hibbins** (2015), Observations of planetary waves in the mesosphere-lower thermosphere during stratospheric warming events, *Atmos. Chem. Phys.* 15, 4997-5005, doi:10.5194/acp-15-4997-2015

59) **Nesse Tyssøy, H.** and **J. Stadsnes** (2015), Cutoff latitude variation during Solar Proton Events: Causes and Consequences, *J. Geophys. Res.*, doi: 10.1002/2014JA020508

58) Kronberg, E. A., **S. E. Haaland,** P. W. Daly, E. E. Grigorenko, L. M. Kistler, M. Fränz, and I. Dandouras (2014), Correction to "Oxygen and hydrogen ion abundance in the near-Earth magnetosphere: Statistical results on the response to the geomagnetic and solar wind activity conditions", *J. Geophys. Res. Space Phys*., doi:10.1002/2013JA019703

57) Walsh, A.P., **S. Haaland**, C. Forsyth, A. M. Keesee, J. Kissinger, K. Li, A. Runov, J. Soucek, B. M. Walsh, S. Wing, and M. G. G. T. Taylor (2014) Dawn–dusk asymmetries in the coupled solar wind–magnetosphere–ionosphere system: a review, *Ann. Geophys.*, doi:10.5194/angeo-32-705-2014

56) C. Liang, B. Carlson, **N. Lehtinen**, M. Cohen, R. A. Marshall, and U. Inan (2014) Differing current and optical return stroke speeds in lightning, *Geophys. Res. Ltr.*, doi:10.1002/2014GL059703

55) Shi, R., Z.-J. Hun, B. Ni, D. Han, **X.-C. Chen**, C. Zhou, and X. Gu (2014), Modulation of the dayside diffuse auroral intensity by the solar wind dynamic pressure, *J. Geophys. Res.*, 119, DOI: 10.1002/2014JA020180

54) **Stray, N.H.**, **P.J. Espy**, V. Limpasuvan, and R.E. Hibbins (2014), Characterisation of quasi-stationary planetary waves in the Northern MLT during summer, *J. Atmos. Solar Terr. Phys.*, doi:10.1016/j.jastp.2014.12.003

53) **Sigernes, F.**, **S. E. Holmen**, D. Biles, H. Bjørklund, **X. Chen**, M. Dyrland, D. A. Lorentzen, L. Baddeley, T. Trondsen, U. Brändström, E. Trondsen, B. Lybekk, J. Moen, S. Chernouss, and C. S. Deehr (2014), Auroral all-sky camera calibration, *Geosci. Instrum. Method. Data Syst.*, 3, 241-245, doi:10.5194/gi-3-241-2014

52) Holmes, J. M., Johnsen, M. G., Deehr, C. S., Zhou, X. Y. and **Lorentzen, D. A.** (2014), Circumpolar ground-based optical measurements of proton and electron shock aurora, *J. Geophys. Res.*, 119, doi: 10.1002/2013JA019574

51) **Reistad, J. P., N. Østgaard, K. M. Laundal, S. Haaland, P. Tenfjord, K. Snekvik, K. Oksavik, S. E. Milan** (2014), Intensity asymmetries in the dusk sector of the poleward auroral oval due to IMF Bx, *J. Geophys. Res.*, 119, doi:10.1002/2014JA020216

50) Fear, R. C., **S. E. Milan**, R. Maggiolo, A. N. Fazakerley, I. Dandouras, S. B. Mende (2014), Direct observation of closed magnetic flux trapped in the high-latitude magnetosphere, *Science*, Vol. 346, 1506-1510, doi: 10.1126/science.1257377

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

48) **Haaland, S., J. Reistad, P. Tenfjord, J. Gjerloev**, L. Maes, J. DeKeyser, R. Maggiolo, C. Anekallu, and N. Dorville (2014), Characteristics of the flank magnetopause: Cluster observations, *J. Geophys. Res. Space Physics*, 119, doi:10.1002/2014JA020539

47) **van der Meeren, C., K. Oksavik, D. Lorentzen**, J. I. Moen, and V. Romano (2014), GPS scintillation and irregularities at the front of an ionization tongue in the nightside polar ionosphere, *J. Geophys. Res. Space Phys.*, 119, doi:10.1002/2014JA020114

46) **Skeltved, A. B., N. Østgaard, B. Carlson, T. Gjesteland**, and S. Celestin (2014), Modeling the Relativistic Runaway Electron Avalanche and the feedback mechanism with GEANT4, *J. Geophys. Res.*, doi:10.1002/2014JA020504

45) Demissie, T.D., **P. J. Espy,** N. H. Kleinknecht, M. Hatlen, N. Kaifler, and G. Baumgarten (2014), Characteristics and sources of gravity waves observed in NLC over Norway, *Atmos. Chem. Phys.*, 14, 12133–12142, doi:10.5194/acp-14-12133-2014

44) de Wit, R.J., **R.E. Hibbins**, and **P.J. Espy** (2014), The seasonal cycle of gravity wave momentum flux and forcing in the high-latitude northern hemisphere mesopause region, *J. Atmos. Solar Terr. Phys.*, doi: 10.1016/j.jastp.2014.10.002

43) **Kleinknecht, N. H., P. J. Espy**, and **R. E. Hibbins** (2014), The climatology of zonal wave numbers 1 and 2 planetary wave structure in the MLT using a chain of Northern Hemisphere Super-DARN radars, *J. Geophys. Res. Atmos.*,119, doi:10.1002/2013JD019850

42) **Laundal K. M., and J. W. Gjerloev** (2014), What is the appropriate coordinate system for magnetometer data when analyzing ionospheric currents?, *J. Geophys. Res., Space Physics*, doi:10.1002/2014JA020484

41) Nisi, R. S., **N. Østgaard, T. Gjesteland,** and A. B. Collier (2014), An altitude and distance correction to the source fluence distribution of TGFs, *J. Geophys. Res. Space Physics*, 119, doi:10.1002/2014JA019817

40) **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

39) Kozyra, J. U., M. W. Liemohn, C. Cattell, D. De Zeeuw, C. P. Escoubet, D. S. Evans, X. Fang, M.-C. Fok, H. U. Frey, W. D. Gonzalez, M. Hairston, R. Heelis, G. Lu, W. B. Manchester IV, S. Mende, L. J. Paxton, L. Rastaetter, A. Ridley, **M. Sandanger, F. Søraas**, T. Sotirelis, M. W. Thomsen, B. T. Tsurutani, and O. Verkhoglyadova (2014), Solar filament impact on 21 January 2005: Geospace consequences, *J. Geophys. Res. Space Phys.*, 119, 5401–5448, doi:10.1002/2013JA019748

38) Nishimura, Y., L. R. Lyons, Y. Zou, **K. Oksavik**, J. I. Moen, L. B. Clausen,E. F. Donovan, V. Angelopoulos, K. Shiokawa, J. M. Ruohoniemi, N. Nishitani, K. A. McWilliams, and M. Lester (2014), Day-night coupling by a localized flow channel visualized by polar cap patch propagation, Geophys. Res. Lett., 41, 3701-3709, doi:10.1002/2014GL060301

37) Reisin, E., J. Scheer, M. Dyrland, C. Deehr, F. Sigernes, C. Schmidt, K. Höppner, M. Bittner, P. Ammosov, G. Gavrilyeva, J. Stegman, V. Perminov, A.I. Semenov, P. Knieling, R. Koppmann, K. Shiokawa, R.P. Lowe, M. J. López-González, E. Rodríguez, Y. Zhao, M. Taylor, R. Buriti, P. Espy, W. French, K.-U. Eichmann, J. Burrows, C. von Savigny (2014), Traveling planetary wave activity from mesopause region airglow temperatures determined by the Network for the Detection of Mesospheric Change (NDMC), J. Atmos. *Sol. Terr. Phys.*, 119, pages 71-82

36) **Venkateswara Rao**, N., N. Balan, and A. K. Patra (2014), Solar rotation effects on the Martian ionosphere, *J. Geophys. Res. Space Phys.*, 119, doi:10.1002/2014JA019894

35) **Stray, N. H.**, R. J. de Wit, **P. J. Espy**, and **R. E. Hibbins** (2014), Observational evidence for temporary planetary-wave forcing of the MLT during fall equinox, *Geophys. Res. Lett.*, 41, 6281–6288, doi:10.1002/2014GL061119

34) de Wit, R.J., **R.E. Hibbins, P.J. Espy, Y. Orsolini**, V. Limpasuvan, and D. Kinnison (2014), Observations of gravity wave forcing of the mesopause region during the January 2013 major Sudden Stratospheric Warming, *Geophys. Res. Lett.*, 41(13), 4745-4752, doi:10.1002/2014GL060501

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

32) **Holmen, S.E.**, M.E. Dyrland, and **F. Sigernes** (2014), Mesospheric temperatures derived from three decades of hydroxyl airglow measurements from Longyearbyen, Svalbard (78°N), *Acta Geophysica*, Vol 62, No 2, pp. 302-315, doi: 10.2478/s11600-013-0159-4

31) **Marisaldi, M.**, F. Fuschino, M. Tavani, S. Dietrich, C. Price, M. Galli , C. Pittori , F. Verrecchia, S. Mereghetti, P. W. Cattaneo, S. Colafrancesco, A. Argan, C. Labanti, F. Longo, E. Del Monte, G. Barbiellini, A. Giuliani, A. Bulgarelli, R. Campana, A. Chen, F. Gianotti, P. Giommi, F. Lazzarotto, A. Morselli, M. Rapisarda, A. Rappoldi, M. Trifoglio, A. Trois, S. Vercellone (2014), Properties of terrestrial gamma ray flashes detected by AGILE MCAL below 30 MeV, *J. Geophys. Res.*, doi: 10.1002/2013JA019301

30) Motoba, T., S. Ohtani, A. Kadokura, and **J. W. Gjerloev** (2014), Interrelationship between pre-onset auroral and magnetic signatures at a geomagnetically conjugate Iceland-Syowa pair, *J. Geophys. Res.*, 119, 761–769, doi:10.1002/2013JA019512

29) **Daae, M.**, C. Straub, P. J. Espy, and D. A. Newnham (2014), Atmospheric ozone above Troll station, Antarctica observed by a ground based microwave radiometer, Earth Syst. Sci. Data, 6, 105-115, doi:10.5194/essd-6-105-2014

28) Newnham, D.A. , **P.J. Espy,** M. A. Clilverd, C. J. Rodger, A. Seppälä, D. J. Maxfield, P. Hartogh, C. Straub, K. Holmén and R. B. Horne (2013) Observations of nitric oxide in the Antarctic middle atmosphere during recurrent geomagnetic storms, *J. Geophys. Res. Space Phys.*, doi:10.1002/2013JA019056

27) Motoba, T., K. Takahashi, **J. Gjerloev**, S. Ohtani and D. K. Milling (2013) The role of compressional Pc5 pulsations in modulating precipitation of energetic electrons, *J. Geophys. Res. Space Phys.*, doi:10.1002/2013JA018912

26) **Haaland, S.**, and **J. W. Gjerloev** (2013), On the relation between asymmetries in the ring current and magnetopause current, *J. Geophys. Res.*, 118 (D12), 7593, doi: 10.1002/2013JA019345

25) Li, K., **S. Haaland**, A. Eriksson, M. André, E. Engwall, Y. Wei, E. A. Kronberg, M. Fränz, P. W. Daly, H. Zhao, Q. Y. Ren (2013), Transport of cold ions from the polar ionosphere to the plasma sheet, *J. Geophys. Res.*, 118 (D9), 5467, doi: 10.1002/jgra.50518

24) Carlson, H. C., **K. Oksavik**, and J. I. Moen, Thermally excited 630.0nm O(1D) emission in the cusp: A frequent high-altitude transient signature (2013), *J. Geophys. Res.*, 118, doi:10.1002/jgra.50516

23) Demissie, T.D., K. Hosokawa, N.H. Kleinknecht, **P.J. Espy**, **R.E. Hibbins** (2013), Planetary wave oscillations observed in ozone and PMSE data from Antarctica, *J. Atmos. Sol. Terr. Phys.*, Vol. 105-106, pages 207-213

22) de Wit, R.J., **R.E. Hibbins**, **P.J. Espy**, and N.J. Mitchell (2013), Interannual variability of mesopause zonal winds over Ascension Island: coupling to the stratospheric QBO, *J. Geophys. Res.*, 118 (D21), 12052, doi: 10.1002/2013JD020203

21) **Tenfjord, P.**, and **N. Østgaard** (2013), Energy transfer and flow in the solar wind-magnetosphere-ionosphere system: A new coupling function, *J. Geophys. Res.*, 118 (D9), 5659, doi: 10.1002/jgra.50545

20) Goldstein, J., D. J. McComas, P. Valek, J. Redfern, **F. Søraas**, and D. Bazell (2013), Local-time-dependent low-altitude ion spectra deduced from TWINS ENA images, *J. Geophys. Res.*, 118 (D6), 2928, doi: 10.1002/jgra.50222

19) **Milan, S. E.** (2015), Sun et Lumière: Solar wind-magnetosphere coupling as deduced from ionospheric flows and polar auroras, in D. Southwood et al. (eds.), Magnetospheric Plasma Physics: The Impact of Jim Dungey's Research, *Astrophysics and Space Science Proceedings 41*, Springer International Publishing Switzerland, doi: 10.1007/978-3-319-18359-6_2

18) **Milan, S. E.** (2013), Modelling Birkeland currents in the expanding/contracting polar cap paradigm, *J. Geophys. Res.*, 118 (D9), 5532, doi:10.1002/jgra.50393

17) Tweedy, O. V., V. Limpasuvan, **Y. J. Orsolini**, A. K. Smith, R. R. Garcia, D. Kinnison, C. E. Randall,O.-K. Kvissel, F. Stordal, V. L. Harvey and A. Chandran (2013), Nighttime secondary ozone layer during major stratospheric sudden warmings in specified-dynamics WACCM, *J. Geophys. Res.*, 118 (D15), 8346, doi:10.1002/jgrd.50651

16) Mitchell, E. J., P. T. Newell, **J. W. Gjerloev**, and K. Liou (2013), OVATION-SM: A model of auroral precipitation based on SuperMAG generalized auroral electrojet and substorm onset times, *J. Geophys. Res.*, 118 (D6), 3747, doi:10.1002/jgra.50343

15) Cohen, I. J., M. R. Lessard, S. R. Kaeppler, S. R. Bounds, C. A. Kletzing, A. V. Streltsov, J.W. Labelle, M. P. Dombrowski, S. L. Jones, R. F. Pfaff, D. E. Rowland, B. J. Anderson, H. Korth, and **J.W. Gjerloev** (2013), Auroral Current and Electrodynamics Structure 1 (ACES) observations of ionospheric feedback in the 2 Alfven resonator and model responses, *J. Geophys. Res.*, 118 (D6), 3288, doi:10.1002/jgra.50348

14) Paschmann, G., **S. Haaland**, B.Sonnerup and T. Knetter (2013), Discontinuities and Alfvenic fluctuations in the solar wind, *Ann. Geophys.*, 31, 871-887, doi:10.5194/angeo-31-871-2013

13) Munteanu, C., **S. Haaland**, B. Mailyan, M. Echim, and K. Mursula (2013), Propagation delay of solar wind discontinuities: Comparing different methods and evaluating the effect of wavelet denoising, *J. Geophys. Res.*, 118 (D7), 3985, doi:10.1002/jgra.50429

12) Demissie, T. D., N.H. Kleinknecht, **R.E. Hibbins**, **P. J. Espy** and C. Straub (2013), Quasi-16-day period oscillations observed in middle atmospheric ozone and temperature in Antarctica, *Ann. Geophys.*, 31, 1279-1284, doi:10.5194/angeo-31-1279-2013

11) Straub, C., **P.J. Espy, R.E. Hibbins,** and D.A. Newnham (2013), Mesospheric CO above Troll station, Antarctica observed by a ground based microwave radiometer. *Earth Syst. Sci. Data*, 5, 199-208, doi:10.5194/essd-5-199-2013

10) **Nesse Tyssøy, H., J. Stadsnes, F. Søraas**, and M. Sørbø (2013), Variations in cutoff latitude during the January 2012 solar proton event and implication for the distribution of particle energy deposition, *Geophys. Res. Lett.*, 40 (D16), 4149, doi: 10.1002/grl.50815

9) **Reistad, J. P., N. Østgaard, K. M. Laundal** and **K. Oksavik** (2013), On the non-conjugacy of nightside aurora and their generator mechanisms, *J. Geophys. Res.*, 118 (D6), 3394, doi:10.1002/jgra.50300

8) **Østgaard, N., T. Gjesteland, B. E. Carlson**, A. B. Collier, S. Cummer, G. Lu, and H. J. Christian (2013), Simultaneous observations of optical lightning and terrestrial gamma ray flash from space, *Geophys. Res. Lett.*, 40 (D10), 2423, doi: 10.1002/grl.50466

7) Engebretson, M. J., T. K. Yeoman, **K. Oksavik, F. Søraas, F. Sigernes**, J. I. Moen, M. G. Johnsen, V. A. Pilipenko, J. L. Posch, M. R. Lessard, B. Lavraud, M. D. Hartinger, L. B. N. Clausen, T. Raita, and C. Stolle (2013), Multi-instrument observations from Svalbard of a traveling convection vortex, electromagnetic ion cyclotron wave burst, and proton precipitation associated with a bow shock instability, *J. Geophys. Res.*, 118 (D6), 2975, doi:10.1002/jgra.50291

6) Ribeiro, A. J., J. M. Ruohoniemi, P. V. Ponomarenko, L. B. N. Clausen, J. B. H. Baker, R. A. Greenwald, K. Oksavik, and S. de Larquier (2013), A comparison of SuperDARN ACF fitting methods, Radio Science, 48 (D3), 274, doi:10.1002/rds.20031

5) Hansen, R. S., **N. Østgaard**, **T. Gjesteland**, and **B. Carlson** (2013), How simulated fluence of photons from Terrestrial Gamma ray flashes at aircraft and balloon altitudes depends on initial parameters, *J. Geophys. Res.*, 118 (D5), 2333, doi: 10.1002/jgra.50143

4) **Østgaard, N., B. K. Humberset, K. M. Laundal,** and **J. P. Reistad** (2013), Correction to "Evolution of auroral asymmetries in the conjugate hemispheres during two substorms", *Geophys. Res. Lett.*, 40 (D3), 471, doi:10.1002/grl.50123

3) **Søraas, F., K. M. Laundal,** and M. Usanova (2013), Coincident particle and optical observations of nightside subauroral proton precipitation, *J. Geophys. Res.*, 118, 1, doi:10.1002/jgra.50172

2) M. Förster, Y. I. Feldstein, L. I. Gromova. L. A. Dremukhina, A. E. Levitin, and **S. E. Haaland** (2013), Some aspects of modelling the high-latitude ionospheric *convection from Cluster/EDI data,* Geomagnetism and Aeronomy, Vol. 53 (1), 85-95

1) Moen J., **K. Oksavik**, L. Alfonsi, Y. Daabakk, V. Romano, and L. Spogli (2013), Space weather challenges of the polar cap ionosphere, *J. Space Weather Space Clim.*, 3, A02, DOI: 10.1051/swsc/2013025, 2013

Personnel (as of December 2016)

Summary

	TOTAL	UiB	NTNU	UNIS	MEN	WOMEN
Professors	8	5	2	1	9	0
Professors Emeriti	2	2	-	-	2	-
Scientists / Postdocs	19	14	2	3	14	5
PhD Candidates	14	11	1	2	8	6
Technicians	10	8	-	2	9	1
Master's Students	9	8	-	1	6	3
Administration	3	3	-	-	1	2

Science Advisory Board (SAB)

Margaret Chen, *Aerospace Corporation, 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	Katarzyna Kosela-Dordevic	UiB
Centre Board	Anne Marit Blokhus, *Vice-Dean, Faculty of Math. & Natural Sciences*	UiB
	Elisabeth Müller Lysebo *Dep. Dir. Genl., Fac. of Math. Nat. Sci.*	UiB
	Øyvind Frette *Head, Dept. of Physics and Technology*	UiB
	Erik Wahlström, *Head, Dept. of Physics*	NTNU
	Harald Ellingsen, *Managing Director*	UNIS
	Grete K. Ersland, *Head of Admin., IFT Board Secretary*	UiB

Engineering Team

Thomas Riis Bjørnsen	M	UiB
Torstein Frantzen	M	UiB
Brage Førland	M	UiB
Georgi Genov	M	UiB
Thomas Poulianitis	M	UiB
Bilal Qureshi	M	UiB
Maja Rostad	F	UiB
Fred Sigernes, *Professor*	M	UNIS
Mikko Syrjäsuo	M	UNIS
Kjetil Ullaland, *Professor*	M	UiB
Shiming Yang	M	UiB

Education and Public Outreach Team

Arve Aksnes, *PhD, Leader*	M	UiB
Brage Førland, *Chief Engineer*	M	UiB
Kjartan Olafsson, *Assoc. Prof.*	M	UiB
Kavitha Østgaard, *Sr. Consultant*	F	UiB

Scientific Team

Lisa Baddeley	Assoc. Professor	F	UNIS
Patrick Espy	Professor	M	NTNU
Jesper Gjerloev	Professor II	M	UiB
Robert Hibbins	Professor	M	NTNU
Dag Lorentzen	Professor	M	UNIS
Martino Marisaldi	Assoc. Prof.	M	UiB
Steve Milan	Professor II	M	UiB
Kjellmar Oksavik	Professor	M	UiB
Noora Partamies	Assoc. Professor	F	UNIS
Johan Stadsnes	Professor *Emeritus*	M	UiB
Nora Stray	Assoc. Prof. II, 20% UiB	F	NTNU
Finn Søraas	Professor *Emeritus*	M	UiB
Kjetil Ullaland	Professor	M	UiB
Nikolai Østgaard	Professor	M	UiB
Brant Carlson	Researcher II	M	UiB
Pål Ellingsen	Post-doc	M	UNIS
Kishore Kumar Grandhi	Post-doc	M	UiB
Stein Haaland	Researcher II	M	UiB
Pavlo Kochkin	Post-doc	M	UiB
Sven Olav Kühl	Post-doc	M	NTNU
Karl Laundal	Researcher	M	UiB
Nikolai Lehtinen	Researcher	M	UiB
Andrey Mezentsev	Post-doc	M	UiB
Yvan Orsolini	Researcher II	M	UiB
Jone Reistad	Post-doc	M	UiB
Marit Sandanger	Post-doc	F	UiB
Kristian Snekvik	Post-doc	M	UiB
Hilde Nesse Tyssøy	Researcher	F	UiB
Kjetil Albrechtsen	PhD candidate	M	UiB
Xiangcai Chen	PhD candidate	M	UNIS
Christoph Franzen	PhD candidate	M	NTNU
Silje Eriksen Holmen	PhD, 2016	F	UNIS
Beate Humberset	PhD candidate	F	UiB
Norah Kwagala	PhD candidate	F	UiB
Anders Ohma	PhD candidate	M	UiB
Jone Reistad	Phd, 2016	M	UiB
Alexander Skeltved	PhD candidate	M	UiB
Paul Tenfjord	PhD candidate	M	UiB
Christer van der Meeren	PhD, 2016	M	UiB
Annet Eva Zawedde	PhD candidate	F	UiB
Linn Kristine Ødegaard	PhD, 2016	F	UiB

Former BCSS Employees

Marianne Daae	PhD, 2014	F	NTNU
Nora Stray (Kleinknecht)	PhD, 2014	F	NTNU
Ragnhild S. Hansen (Nisi)	PhD, 2014	F	UiB
Margit Dyrland	Post-doc, until 2014	F	UNIS
Anja Hegen	Adm. Coordinator, until 2015	F	UNIS
Dominik Fehlker	Engineering team, until 2013	M	UiB
Geir Anton Johansen	Engineering team, until 2013	M	UiB
Kåre Njøten	Engineering team, until 2015	M	UiB
Thomas Gjesteland	Researcher, until 2015	M	UiB
Theresa Rexer	PhD candidate	F	UiB
V. Rao Narukull	Post-doc, until 2014	M	NTNU
Teferi Dejene Demissie	PhD, 2013	M	NTNU

Major Achievements

December 2016

Instrumentation: ASIM is fully integrated and ready to be launched in September 2017.

Award: Kjellmar Oksavik is awarded the prestigious Fulbright Arctic Chair stipend for 2017. He will visit Virginia Tech from August to December 2017.

Special invitation: In recognition of the scientific achievements by BCSS, the Centre Leader Nikolai Østgaard has been invited (2017) to the United Nation, Office of Outer Space Affairs, Vienna. Here he presents the Norwegian contribution to SCOSTEP/VarSITI to one of the Scientific and Technical Subcommittees (UNCOPUOS/STSC).

Research grant: The proposal "Full Range Energetic Particle Precipitation Impacting the Middle Atmosphere (FREPPIMA))" is accepted for funding by the Research Council of Norway. PI: Hilde Nesse Tyssøy

Outreach: Fred Sigernes publishes a new cell phone app in Google Play that allows lay people to learn where the auroral oval is most likely located right now, in one hour, and in four hours. The app is called "Auroral Forecast 3D".

New PhD: Silje Eriksen Holmen successfully defends her PhD thesis "Trends and variability of polar mesopause region temperatures attributed to atmospheric dynamics and solar activity".

November 2016

Outreach: Nikolai Østgaard lectures at SCOSTEP/ISWI, Sangli, India.

October 2016

Instrumentation: The new SuperDARN radar in Svalbard is officially opened.

Media: An image taken by Pavlo Kochkin is selected as the picture of the week in the *Journal of Physics D: Applied physics*. The picture shows a discharge phenomenon called pilot system, which may have a similarity with sprites triggered by lightning.

New PhD: Christer van der Meeren successfully defends his PhD thesis "Mesoscale ionospheric plasma irregularities and scintillation over Svalbard".

September 2016

Award: A bust of Yuri Gagarin is awarded to the Birkeland Centre for Space Science by the organization "Dialogue of Cultures" to honour the 55th year anniversary of Gagarin's famous space flight.

New PhD: Linn-Kristine Glesnes Ødegaard successfully defends her PhD thesis "Energetic particle precipitation into the middle atmosphere – optimization and applications of the NOAA POES MEPED data".

June 2016

New PhD: Jone Peter Reistad successfully defends his PhD thesis "Mechanisms responsible for asymmetric aurora between the conjugate hemispheres".

May 2016

Award: The European Geosciences Union (EGU) awards Christoph Franzen the EGU Outstanding Student Poster (OSP) award for his poster entitled "Single vs multi-level quenching of the hydroxyl airglow".

April 2016

Media: Auroral research at the Kjell Henriksen Observatory is featured on the largest European news channel *Euronews* in a program series called "Learning World". This TV program has been translated into 13 languages; Arabic, English, French, German, Greek, Hungarian, Italian, Persian, Portuguese, Russian, Spanish, Turkish and Ukrainian.

Media: The Australian TV news magazine *60 Minutes* broadcasts a program with Fred Sigernes at the Kjell Henriksen Observatory about the origin of the aurora.

February 2016

Instrumentation: BCSS becomes part of a new space mission called SMILE. This is a collaborative mission between ESA and the Chinese Academy of Sciences scheduled for launch in 2021. BCSS will build a shutter system for the SXI soft X-ray telescope, which will measure the entry of solar wind plasma into the Earth's magnetosphere.

December 2015

Research grant: The proposal "Solar effects on natural climate variability in the North Atlantic and Arctic (SOLENA)" is accepted for funding by the Research Council of Norway. PI: Yvan Orsolini

November 2015

Publication is highlighted: Jesper Gjerloev is a co-author on a paper by *Dods et al.* (2015) which reports on how SuperMag magnetometers behave like a social network by "talking" to each other through vectors. The paper is highlighted in *Science Newsline*.

September 2015

Publication is highlighted: Xiangchai Chen is a co-author on a paper by *Han et al.* (2015). One of the figures from this paper is featured on the cover of the *Journal of Geophysical Research*.

Outreach: Hilde Nesse Tyssøy is one of the authors of the Norwegian science anthology book *Stjerneklart*.

August 2015

Funding: A SWARM-SuperMAG project with Jesper Gjerloev as Principal Investigator receives funding from ESA.

Outreach: Kjartan Olafsson and Arve Aksnes are invited to be editors of the Space Physics Section of the Norwegian online encyclopedia entitled *Store Norske Leksikon*.

(continued on next page)

Major Achievements (continued)

June 2015	**Funding:** UiT/The Arctic University of Norway is awarded NOK 288 million for EISCAT_3D, with Kjellmar Oksavik as co-investigator. The award from the Research Council of Norway (RCN) will be used to build the first stage of the most advanced 3D imaging radar system in the world. **Award:** Annet Eva Zawedde is awarded the Martin Landrøs Prize for outstanding master's thesis. Thesis: "Weak to Moderate Recurrent Storms and their Influence on the Middle Atmosphere Composition in 2008". Thesis supervisor: Hilde Nesse Tyssøy.
May 2015	**Award:** The Solar-Terrestrial Sciences (ST) Division of the European Geosciences Union (EGU) awards PhD candidate Christer van der Meeren the EGU Outstanding Student Poster (OSP) award for his poster entitled "Observations of simultaneous multi-constellation GNSS scintillation in nightside aurora over Svalbard".
April 2015	**Publication is highlighted:** A January 2015 article in *Geophysical Research Letters* by Lühr et al.—with Jesper Gjerloev as co-author—is selected as a "Research Spotlight" by the journal's editors. **Award:** Martino Marisaldi of BCSS and INAF - IASF Bologna wins the Fulbright Research Scholar Grant to spend a six month research period starting in October 2015 at the Dept. of Electrical and Computing Engineering at Duke University, Durham, North Carolina, USA.
March 2015	**Media:** The UNIS team contributes with instruments and expertise during the total solar eclipse on Svalbard on the 20th of March, an event that is broadcasted live to millions of TV-viewers all over the world.
December 2014	**Publication is highlighted:** Steve Milan is co-author on a *Science* paper by *Fear et al.* (2014) entitled "Direct observation of closed magnetic flux trapped in the high-latitude magnetosphere". **Award:** Paul Tenfjord is granted the Fulbright Scholarship (9 months) to go to the University of California, Los Angeles.
October 2014	**Publication is highlighted:** 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" is used on the front cover of *Journal of Geophysical Research.*
September 2014	**Award:** Thomas Gjesteland is awarded Yara's Birkeland prize of 2014.
June 2014	**Award:** Jone Peter Reistad is granted the Peder Sæther (6 months) stipend to go to the University of California, Berkeley. **New PhD:** Ragnhild Schrøder Nisi successfully defends her PhD thesis "Constraining the source properties of TGFs".
May 2014	**Conference:** UNIS hosts the 2014 SuperDARN workshop from 25th - 30th May.
February 2014	**Collaboration:** Collaboration is initiated with the Bjerknes Centre for Climate Research.
January 2014	**Instrumentation:** UiB delivers 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.
2014 - 2016	**Special invitation:** Nikolai Østgaard becomes a member of the Solar System Exploration Working Group (ESA).
December 2013	**Award:** Outstanding Student Paper Award is given to Nora Kleinknecht, NTNU, for her poster presentation at the AGU Fall Meeting 2013.
October-November 2013	**Outreach:** Nikolai Østgaard lectures at SCOSTEP/ISWI, Nairobi, Kenya.
August 2013	**Award:** Jesper Gjerloev is awarded observation time at the Arecibo radar–featured in movies like *Golden Eye* (James Bond) and *Contact.* The Arecibo radar will now be used by BCSS to get beyond the large scale static picture of the ionosphere.
May 2013	**Award:** Beate Krøvel Humberset is awarded the EGU Outstanding student poster (OSP) award for her poster presentation "Untangling the space-time ambiguity of pulsating aurora", abstract N° EGU2013-833 in session ST3.2. S
24 April 2013	**Media:** A press release entitled "Scientists detect dark lightning linked to visible lightning" is published by AGU, based on a *GRL*-paper by Nikolai Østgaard, Thomas Gjesteland and Brant Carlson from the Birkeland Centre for Space Science. Other authors include A. B. Collier, S. A. Cummer, G. Lu, and H. J. Christian. A video is also uploaded to the AGU YouTube site. The press release results in many news articles around the world.

Glossary

A – C

AGILE	Astrorivelatore Gamma a Immagini Leggero
AGU	American Geophysical Union
AMPERE	Active Magnetosphere and Planetary Electrodynamics Response Experiment
AOGS	Asia Oceania Geosciences Society
ARISE2	Atmospheric dynamics Research InfraStructure in Europe
ASIM	Atmosphere-Space Interactions Monitor
BAS	British Antarctic Survey
BCSS	Birkeland Centre for Space Science
BGO	Bismuth Germanate Oxide
C-REX	Cusp Region EXperiment
CAS	Chinese Academy of Science
CCD	Charge-Coupled Device
CEPA	Columbus External Payload Adapter
CGM	Corrected GeoMagnetic
CHAMOS	Chemical Aeronomy in the Mesosphere and Ozone in the Stratosphere
CoE	Centre of Excellence
COPUOS	Committee on the Peaceful Uses of Outer Space
COSPAR	Committee for Space Research
CZT	Cadmium Zinc Telluride

D – F

DEEP	Distribution of Energetic Electron and Proton
DTU	Technical University of Denmark
ECTS	European Credit Transfer and Accumulation System
EGU	European Geosciences Union
EISCAT	European Incoherent Scatter Scientific Association
EISCAT_3D	EISCAT three-dimensional imaging radar project
EPO	Education and Public Outreach
EPP	Energetic Particle Precipitation
ERC	European Research Council
ESA	European Space Agency
ESF	European Science Foundation
EU	European Union
FEGS	Fly's Eye GLM Simulator
FM	Flight Model
FMI	Finnish Meteorological Institute
FREPPIMA	Full Range Energetic Particle Precipitation Impacting the Middle Atmosphere

G – I

GALILEO	European global navigation satellite system
GLM	Geostationary Lightning Mapper
GLONASS	Russian global navigation satellite system
GNSS	Global Satellite Navigation System
GPS	Global Positioning System
HED	High-Energy Detector
HEPPA	High-Energy Particle Precipitation in the Atmosphere
HF	High frequency
HOx	Hydroxides
IAGA	International Association of Geomagnetism and Aeronomy
ICMA	International Commission on the Middle Atmosphere
IMF	Interplanetary Magnetic Field
ISS	International Space Station
ISSI	International Space Science Institute
ISWI	International Space Weather Initiative
ITAR	International Traffic in Arms Regulations
ITN	Innovative Training Networks

J – M

JGR	Journal of Geophysical Research
JHUAPL	Johns Hopkins University Applied Physics Laboratory
KHO	Kjell Henriksen Observatory
LED	Low-Energy Detector
LINET	LIgtning detection NETwork
LF	Low Frequency
M-I	Magnetosphere and Ionosphere
MEE	Medium Energy Electrons
MEPED	Medium Energy Proton and Electron Detector
MEPPA	Most Energetic Photon Phenomenon in our Atmosphere
MLT	Mesosphere and Lower Thermosphere
MMIA	Modular Multi-Imaging Assembly
MN-faculty	Faculty of Mathematics and Natural Sciences
MXGS	Modular X- and Gamma-ray Sensor

N – Q

NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NFR	Norges Forskningsråd
NO	Nitric Oxide
NOx	Nitrogen Oxides
NOAA	National Oceanic and Atmospheric Administration
NTNU	Norwegian University of Science and Technology
OH	Hydroxide
OSP	Outstanding Student Poster
PhD	Philosophiae Doctor
PI	Principal Investigator
PMAFs	Poleward Moving Auroral Forms
POES	Polar Orbiting Environmental Satellites

R – S

RBSP	Radiation Belt Storm Probes
RCN	Research Council of Norway
RENU2	Rocket Experiment for Neutral Upwelling 2
ResClim	Research School in Climate Dynamics
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Image
RREA	Relativistic Run-away Electron Avalanche
SAINT	Science And INnovation with Thunderstorms
SCOSTEP	Scientific Committee on Solar Terrestrial Physics
SFF	Senter for Fremragende Forskning
SMILE	Solar Wind Magnetosphere Ionosphere Link Explorer
SOLARIS	Solar Influences
SOLENA	Solar effects on natural climate variability in the North Atlantic and Artic
SPARC	Stratospheric-tropospheric Processes And their Role in Climate
SPEAR	Space Plasma Exploration by Active Radar
SSL	Space Sciences Laboratory
SSUSI	Special Sensor Ultraviolet Spectrographic Imager
ST	Solar-Terrestrial Sciences
SuperDARN	Super Dual Auroral Radar Network
SuperMAG	Observations of the global magnetic field
SWARM	European satellite mission to study the Earth's magnetic field
SXI	Soft X-ray Imager

T – W

TEA-IS	Thunderstorm Effects on the Atmosphere-Ionosphere System
TEC	Total Electron Content
TLEs	Transient Luminous Events
TOI	Tongue of Ionization
TGF	Terrestrial Gamma-ray Flash
UC Berkeley	University of California, Berkeley
UCLA	University of California, Los Angeles
UiB	University of Bergen
UiT	UiT – Arctic University of Norway
UK	United Kingdom
UN	United Nations
UNIS	University Centre in Svalbard
UNOOSA	United Nations Office of Outer Space Affairs
US	United States
VarSITI	Variability of the Sun and Its Terrestrial Impact
VLF	Very Low Frequency
WACCM	Whole Atmosphere Community Climate Model
WWLLN	World Wide Lightning Location Network


n/s