EISCAT

50 EISCAT

22nd EISCAT Symposium

&

49th Annual European Meeting on Atmospheric Studies by Optical Methods

24-28 August 2026

22nd EISCAT Symposium & 49th Annual European Meeting on Atmospheric Studies by Optical Methods

2026-08-24 Monday	2026-08-25 Tuesday	2026-08-26 Wednesday	2026-08-27 Thursday	2026-08-28 Friday
	8:00 Bus to campus	8:00 Bus to campus	8:00 Bus to campus	8:00 Bus to campus
	8:30 **Multi-instrument studies** Aula	8:30 **EISCAT** Aula	8:30 **Radar Techniques 1** Aula	8:30 **Space Weather & Upper Thermosphere** Aula
9:00 Bus to campus				
9:30 Registration				
10:00 **Opening session**	10:00 **Coffee break**	10:00 **Coffee break**	10:00 **Coffee break**	10:00 **Coffee break**
10:30 **Aurora studies 1** Aula	10:30 **Instrumentation & Poster Lightning talks** Aula	10:30 **Beynon medal award ceremony** Aula	10:30 **Radar Techniques 2** Aula	10:30 **Meteor & Space Debris** Aula
12:00 **Lunch** Atmosfären	12:00 **Lunch** Atmosfären	12:00 **Lunch** Atmosfären 12:00 Bus 1; 12:35 Bus 2	12:00 **Lunch** Atmosfären	12:00 **Lunch** Atmosfären
13:30 **Aurora studies 2** Aula	13:30 **Poster session** Aula	12:45 **Excursion to EISCAT_3D Kaiseniemi and visit to Naturum Abisko** !!! 12:45 Bus1 to Abisko !!! 13:15 Bus2 to E3D Buses will alternate at the visit places and they will be back to hotels at 17:45 - 18:15	13:30 **Ionosphere 1** Aula	Bus to airport/hotels
15:00 **Coffee break**	15:00 **Coffee break**		15:00 **Coffee break**	15:00
15:30 **Aurora studies 3** Aula	15:30 **Mesosphere - Lower Thermosphere** Aula		15:30 **Ionosphere 2** Aula	
17:30 Bus to hotels	17:30 Bus to hotels		17:30 Bus to hotels	
		18:45 Bus to Aurora		
		19:30 **Welcome drink (Aurora)**		
		20:00 **Banquet (Aurora)**		
		22:00 Bus to hotels		

https://eiscat.se/wp-content/uploads/2026/07/Abstract-book.pdf

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Detailed Schedule

Return to schedule or Programme schematic

Return to schedule or Programme schematic

2026-08-24 Monday

10:00 - 10:30 Opening Session

Opening of the Symposium, safety and organizational information. Program details will come in the week before the Symposium.

10:30 - 12:00 Aurora studies 1

What is GHOST aurora?

R. Dayton-Oxland [1,2], **N. Partamies** [1], **F. Ball** [2], **D. Whiter** [2], **S. Samaddar** [2], **M. Barthelemy** [3], **K. Herlingshaw** [1], **I. Virtanen** [4]

[1] *University Centre in Svalbard*
[2] *University of Southampton*
[3] *Universite Grenoble-des-Alpes*
[4] *University of Oulu*

GHOST aurora is a newly identified auroral continuum emission which occurs at high-latitudes. First detected using optical data from a full colour all-sky camera and spectrograph in Svalbard, GHOST appears as a pale white-mauve structure which follows auroral dynamics and particle precipitation. Spectral measurements show broadband emission across the whole optical range.

High-resolution spectra from HiTIES were analysed through fitting synthetic spectra, showing that the GHOST spectrum can be reproduced by hot, excited N_2, N_2^+, and O_2^+ which produce a pseudo-continuum of densely packed, overlapping vibrotational emission lines. Spectral fitting and EISCAT observations show high ion temperatures in the E and F regions.

We present the discovery and characterisation of GHOST aurora, multi-instrument measurements of GHOST and its background conditions, and we suggest a potential mechanism for the physical and spectral origin of GHOST aurora.

Conjugacy of pulsating auroras: conjugate observations of Syowa, Iceland, and Arase satellite

Y. Ito [1,2], Y. Ogawa [2,1,3], M. Fukizawa [2,1], A. Kadokura [2,3], Y. Tanaka [2,1,3], Y. Miyoshi [4], M. Ozaki [5], K. Hosokawa [6], Y. Kasahara [5], S. Matsuda [5], S. Kasahara [7], S. Yokota [8], K. Keika [7], T. Hori [4], A. Matsuoka [9], M. Teramoto [10], K. Yamamoto [4], I. Shinohara [11]

[1] *Graduate Institute for Advanced Studies, SOKENDAI, Japan*
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[4] *Institute for Space-Earth Environmental Research, Nagoya University, Japan*
[5] *Kanazawa University, Japan*
[6] *University of Electro-Communications, Japan*
[7] *University of Tokyo, Japan*
[8] *Osaka University, Japan*
[9] *Kyoto University, Japan*
[10] *Kyushu Institute of Technology, Japan*
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Tjörnes in Iceland and Syowa Station in Antarctica form one of the few geomagnetically conjugate point pairs. Both conjugate and non-conjugate pulsating auroras (PsAs) have been reported, but the mechanisms remain unclear due to the absence of magnetospheric observations. We proposed that magnetospheric density ducts, which may drive conjugacy of PsAs, control the high-latitude propagation of chorus waves, energetic electron precipitation, and patchy PsAs.

On 22 September 2018, similar PsAs were observed at both sites while the Arase satellite conducted magnetospheric in-situ observations at high magnetic latitudes (>22°), observing chorus waves along field lines and energetic electrons. These observations provide direct evidence that chorus waves from near the magnetic equator propagate to high latitudes and scatter electrons in both hemispheres. In this presentation, we report both similarities and differences between hemispheres and we discuss PsA conjugacy in relation to ducts.

On the diurnal distribution of auroral emission intensities

J. Ackroyd [1], **N. Partamies** [1], **H. Nesse** [2], **D. Whiter** [3], **M. Van De Kamp** [4]

[1] *University Centre in Svalbard (UNIS), Longyearbyen, Norway*
[2] *University of Bergen (UiB), Bergen, Norway*
[3] *University of Southampton, Southampton, UK*
[4] *Finnish Meteorological Institute, Helsinki, Finland*

This presentation outlines the development of an automated pipeline for generating pruned, absolute intensity time-series of optical auroral emission using all-sky camera (ASC) data from the MIRACLE network from multiple locations across Northern Fennoscandia and Svalbard. The study aims to characterise the diurnal distribution of the visible auroral emission intensities by converting raw image data into physical units. MIRACLE ASCs are typically calibrated every 1-3 years and the calibration coefficients produced allow for transformation of pixel brightness into absolute auroral emission intensities in Rayleighs. This project aims to further develop this process by applying the process to a pruned data set that excludes periods with no aurora or cloudy conditions resulting in a high-quality, long duration time-series suitable for in-depth statistical analysis. This serves to provide a foundation for deeper understanding of auroral energy output and morphology.

Dispersive Alfvén waves as an auroral acceleration process – insights from the VISIONS-2 rocket mission

E. Gavazzi [1], **A. Spicher** [1], **B. Gustavsson** [1], **J. Vierinen** [1], **J. Clemmons** [2], **R. Pfaff** [3], **R. Michell** [3], **D. Rowland** [3]

[1] *Department of Physics and Technology, UiT The Arctic University of Norway, Tromsø, Norway*
[2] *Department of Physics and Astronomy, University of New Hampshire, Durham, NH, USA*
[3] *NASA Goddard Space Flight Center, Greenbelt, MD, USA*

Alfvén waves with short perpendicular scales are dispersive and can support parallel electric fields. This enables them to capture and resonantly accelerate electrons to auroral energies down into the high-latitude ionosphere. These wave-particle interactions are thought to be the main acceleration mechanism behind small-scale, dynamic auroral structures, but their study remains challenging due to the short spatial and temporal scales involved.

We present measurements from one of the VISIONS-2 sounding rockets launched in December 2018 from Ny-Ålesund, Svalbard, which intersected active dayside aurora. Numerous energy–time and pitch-angle–time dispersed signatures in electron flux were observed by the high-resolution onboard instrumentation, indicative of Alfvénic acceleration. We present methods for analysing these structures and discuss how the inferred source-altitudes can be used to constrain plasma and wave conditions in the topside ionosphere and acceleration region.

Time-dependent electron-transport calculations of time-energy dispersed precipitation - conditions for bump-in-tail driven Langmuir turbulence and impacts for NEIALs

B. Gustavsson [1], **E. Gavazzi** [1], **O. Stalder** [1], **J. Clemmons** [2], **R. Pfaff** [3], **R. Michell** [3], **D. Rowland** [3], **A. Spicher** [1], **J. Vierinen** [1]

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Sometimes during dynamic aurora the backscatter from ion acoustic waves observed with IS radars can be enhanced by several orders of magnitude. It has been shown that both the up and down-shifted ion-line peaks can be enhanced in the same small, sub beam-width, volume aligned with the magnetic field with temporal variations on sub-second time-scales. One physical mechanism that can explain these observations are bump-in-tail driven Langmuir turbulence. In this presentation we will show time-dependent electron-transport calculations using measurements of energy–time and pitch-angle–time dispersed signatures in electron flux from one of the VISIONS-2 sounding rockets. The resulting high-energy tails of the electron phase-space densities show intermittent positive phase-space gradient during periods with rapidly varying precipitation, showing for the first time that bump-in-tail conditions arise in the auroral ionosphere. Impacts for Naturally Enhanced Ion Acoustic Lines as well a

Lunch

13:30 - 15:00 Aurora studies 2

Minimal scale size in Aurora

O. Stadler, B. Gustavsson

University of Tromsø

Auroral structures exhibit a remarkable range of spatial scales, from large arcs spanning hundreds of kilometres down to fine structures of tens of meters. The physical mechanisms responsible for the smallest structures remain debated. Here, a Monte Carlo simulation is used to determine the smallest possible extend of perpendicular structures in the aurora. Monoenergetic electrons with kinetic energies from 500 eV to 32 keV are initialised from a point source at 600 km altitude and propagated through the atmosphere using a Boris mover. A converging axially symmetric magnetic field captures the mirror force. The ionisation cloud from scattered electrons and secondaries serves as an approximation of the auroral emissions. We find the spatial extend of the aurora to be on the order of metres for low energy auroral precipitation to tens of metres for higher energies. Furthermore, we investigate magnetic mirroring as a possible explanation for enhanced aurora.

Fine-scale aurora over Skibotn

D. K. Whiter, K. Thillaimahrajan, S. Samaddar, R. Fear, K. Barton, N. Brindley
University of Southampton, UK

We have installed a high-resolution multi-spectral (4 camera) auroral imager called Embla in Skibotn, close to the EISCAT_3D site. Simultaneous imaging through a careful choice of narrow passband filters allows us to determine the energy and flux of the auroral precipitation, as well as measure the thermospheric neutral temperature at the altitude of the emission and estimate ionospheric electric fields, all at high temporal resolution (20-50 Hz). Embla operated throughout the 2025-2026 winter season, observing a wide variety of aurora including pulsating aurora, black aurora and substorm onset. A selection of observations and preliminary analysis of these events will be presented. We have recently streamlined and automated the process of calculating the energy and flux of the auroral precipitation, and in future seasons will provide a real-time feed of these parameters in the Skibotn magnetic zenith.

Altitude Structure and Morphological Differences of Aurora Using ALIS_4D

S. Nanjo [1], **T. Taki** [1], **T. Sergienko** [1], **U. Brändström** [1]

[1] *IRF Kiruna*

We present ground-based optical observations of aurora by ALIS_4D, a multi-point, multi-wavelength imaging system. By combining measurements at multiple wavelengths, we derive the altitude structure of auroral emissions and compare the results with electron transport model predictions. This comparison provides a quantitative assessment of how well current models reproduce the observed relationships between emission altitude, particle energy, and auroral morphology.

Auroral ray dynamics retrieved by the 3D auroral tomography

T. Sergienko [1], T. Walther [2], and U. Brändström [1]

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[2] *Finish Meteorological Institute, Helsinki, Finland*

Auroral rays are one of the most dynamic and variable auroral forms. They can be observed as elements of active rayed auroral arcs and as individual forms, often characterised by a long height extension. The different forms of the auroral rays were studied using the results of the 3D auroral tomography. The data of the four imagers of the Auroral Large Imaging System (ALIS4D) were used for the reconstruction of the 3D structure of the aurora. This report presents the temporal and spatial variations of the characteristic energy and total energy flux across different types of auroral rays. The anti-correlation of the characteristic energy and the total energy flux was found in the dynamics of the rays forming the active auroral arc. The variation of the altitude profile of the separated auroral rays indicates that one is a result of the mixing of precipitation of the two different populations of the auroral electrons.

Auroral spectroscopy at Skibotn for EISCAT_3D: ASIS results and future developments

G. Cessateur [1], H. Lamy [1], M. Barthelemy [2], K. Hosokawa [3,4], S. Nanjo [5], M.G. Johnsen [6], R. Maggiolo [1]

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Skibotn is a key site for coordinated optical and radar studies in the EISCAT 3D era. This contribution presents an overview of current auroral spectroscopy activities, centered on the ASIS spectrograph and on the forthcoming Auror'Ex instrument. Recent ASIS results are summarized, including statistical variations of characteristic precipitation energy for diffuse auroras with magnetic local time, broader line-ratio studies, and dedicated analyses of proton aurora. Ongoing developments in spectral classification, including AI-based approaches to distinguish proton- and electron-dominated aurorae, are also briefly introduced. Particular emphasis is placed on Auror'Ex, presented as the next step in this effort, with planned deployment at multiple sites and latitudes to extend the spectral coverage and diagnostic capability available for future coordinated studies.

Coffee Break

15:30 - 17:00 Aurora studies 3

Hannes - ESA F3 Candidate Mission

M. Ivchenko [1], L. Roth [1], J. Perez-Coll Jimenez [1], M. Katrougkalou [1], H. Nilsson [2], S. Nanjo [2], E. Panov [3], O. Santolik [4], J. De Keyser [5], G. Cessateur [5], F. Darrouzet [5], K. Asamura [6], T. Sakanoi [7], Y. Ogawa [8], K. Hosokawa [9]; M. Yoshizumi [10], N. Partamies [11], T. Sarris [12], O. Marghitu [13], and the Hannes team

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[5] *BIRA-IASB, Belgium*
[6] *JAXA, Japan*
[7] *Tohoku University, Japan*
[8] *NIPR, Japan*
[9] *University of Electro-Communications, Japan*
[10] *Nagoya University, Japan*
[11] *UNIS, Norway*
[12] *Democritus University of Thrace, Greece*
[13] *Institute for Space Sciences, Romania*

A proposal for F-class mission, Hannes, has been submitted to ESA The mission will investigate dynamic cross-scale aurora plasma processes, and their impact on the magnetosphere-ionosphere-atmopshere coupling. Hannes will use twin satellites to resolve the spatio-temporal ambiguity, providing the first multipoint in situ observations of the small-scale (1-10 km) auroral physical processes, together with narrow field (<100 km) imaging.

Hannes will address the following core science questions

- What is the relationship between Alfvenic and quasi-electrostatic aurora?
- What is the role of small-scale structuring in diffuse and pulsating aurora?
- What is the role of current filamentation and electrostatic waves in the energetics of the magnetosphere-ionosphere-atmosphere coupling?
- How are plasma upflows from the topside ionosphere controlled by cross-scale processes?

The talk will present the mission concept.

Neutral Temperature Changes in Fine Scale Aurora

K. Barton[1,2], **D. K. Whiter**[1], **A. J. Kavanagh**[2], **S. Samaddar**[1]

[1] *University of Southampton, United Kingdom*
[2] *British Antarctic Survey, Cambridge, United Kingdom*

Joule heating from the dynamic electric fields in the aurora is a significant source of heat in the high latitude upper atmosphere. We present results from a new technique to measure neutral temperatures in fine-scale aurora at high spatial and temporal resolution ($\sim$0.2 s) using simultaneous images of emissions in two regions of the molecular nitrogen spectrum from the Auroral Structure and Kinetics (ASK) cameras in Svalbard. To separate local neutral temperature changes from spatial variation in emission altitude across each image, height profiles of the temperature are obtained by using a third image in an atomic oxygen emission to estimate the altitude of the temperature measurements. The resulting profiles show rapid neutral temperature changes between 95 km and 130 km on the order of 100 K. Cooler temperatures are often found in the brightest aurora, whereas higher temperatures are often associated with the edges of arcs where the electric fields are expected to be strongest.

F-region ion composition variations during an ICME driven storm estimated using EISCAT Tromsø UHF radar measurements

M. Yacoub [1], **I. Virtanen** [1], **A. Aikio** [1], **L. Cai** [1], **S. Oyama** [1,2,3], **Y. Ogawa** [3]

[1] *University of Oulu, Finland*
[2] *Institute for Space-Earth Environmental Research, Nagoya University, Japan*
[3] *National Institute of Polar Research, Japan*

Ion composition plays a crucial role in understanding the ionospheric structure, chemistry, and coupling with the magnetosphere. The dominant ion species vary with altitude, transitioning from molecular ions (NO^+ and O_2^+) in the E and lower F regions to atomic O^+ in the F2 region. This study investigates rapid variations in ion composition during the main phase of a geomagnetic storm on the night of 13 November 2012. During this night, multiple substorms occurred, causing auroral precipitation and Joule heating events. EISCAT UHF radar data from Tromsø were utilized to analyze ion composition changes with a temporal resolution of 10 seconds. The BAFIM-FlipChem analysis tool was applied to the radar data processing, helping to resolve the ambiguity of ion temperature and ion composition. These investigations were further supported by observations from optical instruments collocated with the radar. The transition altitude was found to vary between 179 km and 297 km during this night. Ion

Seeding of natural ionospheric Langmuir turbulence by high power radio transmissions during aurora

B. Isham [1], **V. Belyey** [2], **M. Rietveld** [3], **T. Leyser** [4]

[1] *Citizens of the Karst, San Juan, Puerto Rico, USA*
[2] *Private researcher, Oslo, Norway*
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[4] *Swedish Institute of Space Physics, Uppsala, Sweden (retired)*

Observations of enhanced Langmuir and ion-acoustic waves made during concurrent high-frequency (HF) radiowave pumping and natural auroral activity in the ionosphere show broad-band F-region Langmuir enhancements locked to the HF transmission frequency. The enhancements appear to start at a moment when both auroral particles and artificial HF radiowave pumping exist together. After the HF pump is turned off, the enhancements continue at frequencies near but not equal to the HF pump frequency. We conclude that the natural auroral conditions are active enough to maintain the enhanced wave activity, once initiated, or "seeded", by the catalytic effect of the combined natural and artificial pumps.

Electrodynamics of an isolated substorm: Currents and spectra of precipitating electrons

M. Myllymaa [1], A. Aikio [1], H. Vanhamäki [1], L. Cai [1], I. Virtanen [1], S. Oyama [2,3], and Y. Ogawa [3]

[1] *Space Physics and Astronomy Research Unit, University of Oulu, Finland*
[2] *ISEE, Nagoya University, Japan*
[3] *National Institute of Polar Research, Tachikawa, Japan*

We investigate an isolated substorm that took place on 7 November 2018. Our aim is to study the development of ionospheric currents during this event, with focus in the field-aligned currents (FACs). The main data sources are EISCAT UHF incoherent scatter radar and IMAGE. magnetometer network measurements. In general, FACs are hard to estimate from ground-based observations, but in this study, we determine them using two advanced methods: electron precipitation obtained from EISCAT electron density data with the ELSPEC method and SECS-based method to estimate the curl of the equivalent currents for IMAGE measurements. We also use NASA's OMNIWeb solar wind data and auroral all-sky cameras to support our findings. The two methods for estimating FACs give relatively similar results with enhancement in the upward FAC during increased electron precipitation. The most intense currents and auroras occur at the end of the expansion phase, along with a unique vortex structure seen in both.

2026-08-25 Tuesday

8:30 - 10:00 Multi-instrument studies

A multi-instrument case study of the dayside ionospheric behavior under varying IMF conditions

I. Frøystein [1], **A. Spicher** [1], **J. Vierinen** [1], **K. Oksavik**[2,3]

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[3] *Department of Arctic Geophysics, The University Centre in Svalbard, Longyearbyen, Norway*

The high-latitude, dayside ionosphere is a dynamic region characterized by particle precipitation due to the coupling to the solar wind-magnetosphere system. Four consecutive days in late November 2015 showcase this dynamic nature. During these four days, both EISCAT Svalbard radars (ESR) were running, providing information on the ionospheric parameters. Further, the ESR field-of-view is crossed by several satellites, including both Swarm and DMSP. In addition, optical auroral observations from Ny-Ålesund are available for two days. Finally, the IMF differs significantly between the four days. This diverse data set makes it possible to carefully investigate the dayside auroral region. Here we present a multi-instrument, multi-case study of the behavior of the dayside ionosphere under different IMF conditions.

Multi-Instrument Ground–Space Conjugate Observations of the Northern Magnetospheric Cusp and Merging Gap

F. M. Ball [1], R. C. Fear [1], K. Herlingshaw [2], Y. Bogdanova [3], A. Kavanagh [4], L. Clausen [5], A. Fazakerley [6], C. Forsyth [6], I. McCrea [3]

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[3] *RAL Space, Rutherford Appleton Laboratory, Science and Technology Facilities Council, UK Research and Innovation, Didcot, United Kingdom*
[4] *British Antarctic Survey, Cambridge, United Kingdom*
[5] *University of Oslo, Oslo, Norway*
[6] *Mullard Space Science Laboratory, University College London, Surrey, United Kingdom*

The polar cusps are vital areas of magnetospheric research because they couple the solar wind and magnetosphere through dayside reconnection. Yet a long-standing discrepancy remains between the in-situ cusp extent measured by spacecraft and the ionospheric merging gap inferred from ground observations. Ground signatures of reconnection, including pulsed ionospheric flows (PIFs) and poleward-moving auroral forms (PMAFs), often span several hours of magnetic local time (MLT), whereas in-situ estimates are of order 1–2 h MLT. We present an event study from 16 December 2017, when Cluster crossed the northern cusp during a dawn-dusk pass while the EISCAT Svalbard Radar operated in a conjugate campaign. All-sky imager, radar, and spacecraft observations show individual cusp extents of 2–4 h MLT, while simultaneous conjugate measurements reveal wider merging gap extents of 4.6 h and 5.4 h MLT. Overall, the combined observations of the merging gap span 7.2 h MLT.

Coordinated experiments with EISCAT and the HAIRS Super-DARN radar

D. M. Wright, T. K. Yeoman

Planetary Science Group, School of Physics and Astronomy, University of Leicester, Leicester, UK

The Hankasalmi Auroral Imaging Radar System (HAIRS) is a newly deployed state-of–the art digital imaging radar system which has a field of view centred over the Svalbard region, revealing the ionospheric cusp region electrodynamics at high spatial and temporal resolution over a 1 million square kilometre region of the ionosphere.

The EISCAT_3D field of view will lie within the region imaged by HAIRS and together these two instruments will provide studies of auroral electrodynamics at unprecedented resolution. Their digital capabilities will facilitate improved ways of investigating auroral phenomenon.

We will provide an update on HAIRS and some of the anticipated common science goals shared with EISCAT_3D, including the investigation of the temporal and spatial structuring of reconnection processes in the cusp in conjunction with the NASA TRACERS mission. In addition, recent results from multi-institution experiment campaigns for the DRIIVE programme will be presented.

New aspects of ionospheric irregularities based on joint observations by radar and lidar

W. Sun

Institute of Geology and Geophysics, Chinese Academy of Sciences

Ionospheric plasma bubbles refer to density depletion structures in the ionosphere, which are usually seen in the electron density profiles observed by radar, and have never been observed in the density profiles of metallic ions. In this letter, we report the first observation of plasma bubble signatures captured by lidar, manifested as depletion and bifurcation structures in the density profile of a Ca^+ patch appearing at F region height over low latitude. Different from majority of plasma bubbles observed by radar mainly seen in F region altitude, the bubble depletion signatures visualized by lidar at low latitude could be down to below the F layer bottom, i.e., valley region altitude $\sim$150 km. The results highlight the possibility of plasma bubbles to create depletion structures in metallic ion profiles appearing at F region, and provide a new method to investigate plasma bubbles by lidar.

Characterising Ion-Neutral Coupling During Geomagnetic Disturbances using EISCAT, Dynasonde, and FPI

S. Mandal [1], **C. Scott** [2], **A. Aruliah** [3], **J. Reidy** [1], **M. Wild** [4], **A. J. Kavanagh** [1]

[1] *British Antarctic Survey, United Kingdom*
[2] *University of Reading, United Kingdom*
[3] *University College London, United Kingdom*
[4] *Rutherford Appleton Laboratory, United Kingdom.*

The neutral dynamics defining the baseline conditions of the coupled ionosphere-thermosphere (I-T) region are well understood on global scales. However, localised meso-scale behaviours, which significantly influence thermospheric composition and drive subsequent ionospheric changes remain difficult to characterise due to observational gaps and model limitations. We have characterised such meso-scale changes induced by space weather events using a comprehensive multi-instrument dataset spanning over three decades from the Scandinavian region. By combining ionospheric measurements from EISCAT and Dynasonde with neutral winds and temperatures from Fabry-Pérot Interferometers (FPIs), we quantify the perturbations in the I-T system during geomagnetically disturbed periods. We will present key findings from these analyses, detailing the causal mechanisms of high-latitude ion-neutral coupling.

Coffee Break

10:30 - 12:00 Instrumentation & Poster Lightning talks

An update on the status of US aeronomy instrumentation supporting EISCAT-3D

K. Branning [1], **M. Conde** [1], **D. Hampton** [1], **A. Ridley** [2], **S. Oyama** [3]

[1] *University of Alaska Fairbanks*
[2] *University of Michigan*
[3] *Nagoya University*

This presentation provides an update to the instrument status and plans for the upcoming seasons for the TITAN-3D network (Tristatic Ionosphere-Thermosphere Aeronomy Network). This project previously established three long-term observatories in Abisko (Sweden), and Aakenus & Kevo (Finland) with the objective of operating alongside the EISCAT-3D radar, to support studies of ion-neutral coupling. Due to logistical difficulties, the network did not operate at full capacity during the 2025/2026 winter, but we expect normal operation from the fall of 2026 onwards. We present early results from the observatories including comparisons of vertical wind measurements between instruments and locations, long-duration temperature time series including comparison with MSIS model predictions, detection of gravity wave, and examples of four-dimensional wind observations. These results highlight the ability to provide dense, multi-instrument data sets to support EISCAT-3D operations.

An exact solution to the problem of field of view and optimal bearing direction grid for interferometric image inversion

V. Belyey [1], **B. Isham** [2]

[1] *Private researcher, Oslo, Norway*
[2] *Citizens of the Karst, San Juan, Puerto Rico, USA*

Interferometric imaging using antenna arrays is rapidly becoming an important technique in radio and radar observations of the ionosphere. The principal unaliased field of view of a measurement is determined by the antenna array geometry and the desired principal direction of observation. The bearing direction grid, which specifies for the image processing algorithm the number and positions of the pixels in the image, is traditionally determined in an ad-hoc fashion, for example, with pixels chosen to be uniformly distributed in angle or space.
Here we present a procedure which, for a given array geometry, principal direction of observation, and desired phase interval between pixels, calculates the unaliased field of view and a bearing direction grid having a phase difference between pixels which is uniform and equal to a desired value. Examples are given from current ionospheric research projects using radio and radar imaging.

Coupling modeling and optical observations to reconstruct the precipitating particle fluxes and the ionosphere dynamics: new observations and uses of RGB images

M. Barthelemy[1,2], **G. Cessateur**[3], **H. Lamy**[3], **S. Reboud**[1,2], **E. Robert**[2]

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Optical observations of the aurora from space and from the ground give key information for auroral physics studies. They however often need to be coupled with simulations to give their quintessence. In our works, we use imagery, spectroscopy and polarimetry instruments to observe the auroras and combine these observations with a 1D kinetic code of the ionosphere thermosphere named Transsolo to get both the precipitation particles characteristics and the dynamics. Recent developments allow to get the full synthetic spectra of the aurora both in the FUV (120-200 nm) and in the visible (380-900 nm). By running the code at different locations on a grid it is then possible to map the precipitation using different parameters of the particle distributions, especially the total flux, the mean energy of the distribution(s) and their widths. By integrating over RGB filters bandpass, it is also possible to use RGB images to reconstruct these precipitating characteristics. This last activity being

Evaluation of new LEO PNT beacon transmitter opportunities for ionospheric tomography and data assimilation

R. S. Creed, C. N. Mitchell, R. J. Watson

University of Bath, UK

Improvements in real-time ionospheric monitoring provide more information for the effective mitigation of space weather disruptions to systems sensitive to space weather. Proposed LEO satellite constellations with GPS-like transmissions from commercial companies such as XONA, and recent European Space Agency initiatives, offer new opportunities for monitoring via tomography and data assimilation. Presented is a simulation tool for validating the end-to-end use of new LEO signals for ionospheric specification. Receiver geometries were used from existing GNSS global networks to assess reconstruction algorithms under varying ionospheric conditions, including monitoring medium-scale Travelling Ionospheric Disturbances (TIDs) modelled over a background electron density above North America. Results show that LEO GNSS constellations enhance spatial resolution and temporal sampling. Future work will integrate optical data from FUV photometers and ISR data to validate reconstructions.

Poster Lightning talks

Lunch

13:30 - 15:00 Poster session

Estimation of F1 Region Ion Composition Using Incoherent Scatter Plasma Line Data

T. Bag [1], **I. Virtanen** [1], **M. Gupta** [2], **P. Guio**[2,3] **and B. Gustavsson** [2]

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[3] *Department of Physics and Astronomy, University College London (UCL), United Kingdom*

The F region O^+ ion fraction [O^+/Ne] is routinely taken from the International Reference Ionosphere (IRI) model in EISCAT data analysis. However, the model is subject to substantial uncertainties, particularly in active conditions when the ion composition varies rapidly. The biased O^+ ion fractions will consequently bias also ion and electron temperature estimates due to strong error correlations between these plasma parameters. The O^+ ion fraction can be fitted to incoherent scatter spectra alongside the other plasma parameters using smoothness priors and chemistry modeling. However, validating these results has been challenging due to lack of model-independent ion composition measurements. In this work, we apply a model-independent technique to estimate F1-region ion composition [O^+/Ne] using EISCAT plasma-line and ion-line observations. We present initial results, assess the method's sensitivity to power calibration, and discuss its potential limitations.

Identification of field-aligned current boundaries using optical methods

N. Brindley, D. Whiter

University of Southampton, UK

Spacecraft data pertaining to field-aligned currents above the aurora is sampled along a 1D trajectory through rapidly evolving structures, resulting in significant spatio-temporal ambiguity. Due to the orbital speed, it is also not generally possible to observe temporal evolution with a single spacecraft. We present an optical only method for identifying and observing field-aligned currents at high spatial and temporal resolution. The method uses auroral observations from the ASK instrument, alongside the existing Southampton ionospheric model, to estimate the characteristic energy, energy flux, and number flux for each pixel. In this pilot study, the boundary between two current regions is identified in bivariate lognormal mixture model fits to 2D probability distributions of the energy and energy flux. The auroral forms observed between the two current regions are qualitatively similar to those expected for the tearing instability.

Calibration of the Faraday Rotation Effect in Sanya Incoherent Scatter Radar Observations

Y. Cai, X. Yue, J. Wang, M. Li, N. Zhang, F. Ding

Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS)

Southward observations by the Sanya Incoherent Scatter Radar are significantly affected by the Faraday rotation effect, resulting in the daily observation of anomalous multi-layered ionospheric structures, as circularly polarized signals become elliptically polarized at low elevation angles and the southward beam is more closely aligned with the magnetic field lines. Starting from antenna theory and radar equations, we derived an expression for received power that accounts for the Faraday rotation effect. By combining this with the relationship between the Faraday rotation angle and the path-dependent TEC and magnetic field strength, we successfully calculated how the Faraday rotation angle varies along the path. Finally, we performed the necessary corrections, thereby restoring the normal ionospheric observation structure. This method can be applied to correct for the Faraday rotation effect in all incoherent scatter radar systems.

Imaging auroral polarization: first-light results from the POLAR camera

G. Cessateur [1], H. Lamy [1], J. Lilensten [2], A. G. Ortega [3], L. Bosse [4], O. Katz [2], M. G. Johnsen [5], M. Barthelemy [2]

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[3] *Universidad de Alcalá, Madrid, Spain*
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Auroral polarimetry is a promising observable for probing upper-atmosphere dynamics, but its physical origin remains unclear. We present first-light results from the POLAR camera, developed for spatially resolved imaging polarimetry of auroral emissions. A first dataset at 557.7 nm, acquired in Skibotn in February 2026, is compared with simultaneous Corbel CRU measurements and provides a first validation of the instrumental convention and temporal behaviour. The POLAR images reveal a structured polarization field: DoLP is more closely linked to auroral intensity, while AoLP often remains coherent over most of the field of view. The evolution in the (q,u) plane suggests a strong scene-wide component, with additional local intensity-dependent variations. Future observations at 427.8 and 630.0 nm will test the wavelength dependence of the signal.

Toward AI-based classification of ground-based auroral emission spectra

G. Cessateur [1], **M. Le Lain** [2], **H. Lamy** [1], **S. Lefèvre** [2,3], **M.G. Johnsen** [4], **M. Barthelemy** [5], **G. Bertrand** [6]

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[6] *STAROS, Antibes, France*

Machine learning has been widely applied to auroral imagery for detection and morphology classification, but, to our knowledge, automated classification of 1D ground-based auroral emission spectra remains largely unexplored. Spectra carry direct physical information: each wavelength bin traces a specific atomic or molecular transition.

This contribution presents a first unsupervised study of auroral emission spectra, aimed at identifying proton- and electron-related signatures and mixed cases in low-resolution optical spectra. We use an approach based on feature extraction and clustering to assess whether physically meaningful spectral classes emerge without imposed labels, and compare results to a supervised baseline. The work also includes the preparation of a dedicated spectral library for AI applications, combining labeled auroral spectra with non-auroral astrophysical spectra.

Auroral monitoring at Princess Elisabeth Antarctica Station

G. Cessateur [1], **H. Lamy** [1], **M.G. Johnsen** [2], **S. Nanjo** [3], **A. Calegaro** [1]

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[2] *Tromsø Geophysical Observatory, Faculty of Science and Technology, UiT the Arctic University of Norway, Tromsø, Norway*
[3] *Swedish Institute of Space Physics, IRF Kiruna, Sweden*

Princess Elisabeth Antarctica provides a valuable platform for optical monitoring of high-latitude auroral activity from the Antarctic sector. This contribution presents first results from a new all-sky camera data set, with emphasis on AI-based classification of auroral forms inspired by the approach of Nanjo et al. (2022). Initial tests focus on automated identification of auroral occurrence and main auroral morphological classes in order to support future statistical studies at the site. The presentation also outlines future instrumental developments, including the planned deployment of an Auror'Ex spectrograph, which will complement the all-sky imagery by adding spectral information on auroral emissions and precipitation-related processes.

Towards a physical classification of meteor head echoes from long-term EISCAT VHF observations

A.D. Løkke [1], D. Huyghebaert [2,1], A. Kvammen [1], A. Spicher [1], and Y. Yokoyama [1], I. Mann [1]

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[2] *Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany*

Cosmic dust entering Earth's atmosphere ablates and produces particles that affect the atmosphere, but the entry and accumulation processes remain poorly understood. We introduce an ∼1M-event catalogue of meteor head echoes from vertical-beam EISCAT VHF observations (2014–present), extracted using software developed by Huyghebaert et al. (2025). These echoes, produced by sub-millimetre microgram meteoroids, are analysed via temporal and spatial evolution of SNR and line-of-sight Doppler velocity to partition events into five classes: ordinary ablation, differential ablation, fragmentation, ambiguous head echoes, and non-head echo signals. A small subset of events is manually labelled to guide semi-supervised classification of the full dataset. Preliminary results show clear clustering by radar signature, suggesting physically distinct populations. Statistical analyses of the labelled dataset may refine estimates of meteoroid composition and the processes governing atmospheric entry.

Studies of noctilucent clouds from the stratosphere during the TRANSAT balloon flight

P. Dalin [1], H. Suzuki [2], N. Pertsev [3], V. Perminov [3], L. Megner [4], J. Kero [1], P. Voelger [1], J. Hedin [4], G. Baumgarten [5]

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[5] *Leibniz Institute of Atmospheric Physics, Rostock University, Kühlungsborn, Germany*

A transatlantic balloon flight (TRANSAT) was conducted between in June 2024. The TRANSAT balloon, operated by the French Space Agency (CNES), floated in the stratosphere at approximately 40 km altitude between Esrange (Sweden) and Baffin Island (Canada) for about 3.8 days. The scientific payload comprised nine scientific instruments, including an optical imager for noctilucent cloud (NLC) studies and infrasound instrument from the IRF. The NLC imager consisted of three identical visible-range optical cameras, one of which operated successfully throughout the entire flight, capturing thousands of NLC images. The TRANSAT balloon campaign was supported by ground-based lidar measurements and spaceborne observations from the Swedish MATS satellite. We present technical characteristics of the balloon experiments and present early results. Among others, nearly continuous observations of NLC were obtained during the entire flight. An intrusion of warm air mass in the mesopause was identified.

EISCAT in RI-Scale

C.-F. Enell [1], T. Ulich [1], G. Kovács [2], M. Liwicki [2], M. Guimaraes [3] and M. Santos [3]

[1] *EISCAT AB, Sweden*
[2] *Luleå University of Technology, Sweden*
[3] *Neuraspace Portugal*

EISCAT has an archive of incoherent scatter radar data from almost 45 years, and as EISCAT 3D begins to produce data, the volumes of data will expand to require new analysis methods utilizing high performance computing.

EISCAT is a partner in the EU project *Unlocking Research Infrastructure Potential with Scalable AI and Data* (RI-Scale), which aims to develop AI/machine learning methods for large datasets. We take part in and provide EISCAT data to two scientific use cases together with Luleå University of Technology and Neuraspace.

The core of RI-Scale are the Data Exploitation Platforms (DEP) which provide unified access to data and resources via
*Access control with the EGI Checkin identity broker
*Data management by Rucio/FTS, the data management system developed for LHC/Atlas
*Selection of machine learning models from an AI Model Hub

Joule Heating Associated with Mesoscale Auroral Structures Observed by All-Sky Imagers and EISCAT UHF Radar

M. Fukizawa[1,2], **Y. Ogawa**[1,2,3]

[1] *National Institute of Polar Research, Japan*
[2] *The Graduate University for Advanced Studies, SOKENDAI, Japan*
[3] *Research Organization of Information and Systems, Japan*

Joule heating in the high-latitude ionosphere is governed by electric fields and conductance. In discrete auroral arcs, enhanced conductance in bright regions is associated with reduced electric fields, leading to suppressed heating within the arc and enhanced heating in adjacent darker regions. Its applicability to mesoscale auroral structures such as omega-band aurora remains unclear.

We analyze events observed by all-sky imagers and the EISCAT UHF radar. Discrete arcs show reduced electric fields in bright regions and enhanced heating in adjacent dark regions, consistent with previous studies. In contrast, omega-band structures exhibit Joule heating variability depending on spatial scale, with enhanced heating often occurring in surrounding dark regions. These results indicate that strong Joule heating occurs in darker regions and boundaries. Joule heating associated with omega-band aurora in the post-midnight to morning sectors is therefore important for high-latitude energy input.

Laboratory Radar Investigation of Lunar Regolith Simulant with Water Ice

M. Li, X. Yue, W. Yang, Y. Fan

Institute of Geology and Geophysics, Chinese Academy of Sciences

Water ice in lunar permanently shadowed regions is critical for future exploration. Radar remote sensing offers advantages, but distinguishing ice from rocks remains ambiguous due to similar circular polarization ratio (CPR) responses. The Coherent Backscatter Opposition Effect (CBOE)—where CPR peaks at backscatter and decays with increasing bistatic angle—maybe can discriminate ice from rocks. However laboratory radar measurements are lacking. We propose a laboratory experiment using S-band (2-4 GHz) and X-band (8-12 GHz) radars to measure CBOE curves from lunar regolith simulant mixed with ice and rocks. A well-designed device has been deployed. It can adjust incident angle and bistatic angle to study CBOE peak response. Preliminary results show rocks reduce CBOE peak amplitude and broaden width compared to ice fragments, consistent with theory. This study provides a reference for interpreting bistatic radar data and supports ice resource assessment and lunar landing site selection.

MATS and EISCAT_3D - Can we make it happen?

L. Megner, J. Gumbel, O. M. Christensen, B. Linder, D. P. Murtagh, N. Ivchenko, L. Krasauskas, J. Hedin, J. Dillner, G. Giono, G. Olentsenko, L. Kern, and J. Stegman

Department of Meteorology, Stockholm University

MATS (Mesospheric Airglow/Aerosol Tomography and Spectroscopy) is a Swedish satellite launched in 2022 to study gravity waves at the mesopause. Observations of O_2 airglow and Noctilucent clouds enable 3D reconstruction of temperature fields and cloud structures.

Here we discusses the scientific potential of co-measurements of MATS and other instruments, in particular EISCAT_3D, and how these can be achieved.

EISCAT_3D electron density observations can resolve the smallest atmospheric structures. Combined with MATS, gravity wave structures from mesoscale down to $\sim$100 m can be captured. Simultaneous wind fields — often the missing key — further improve our understanding of wave propagation and energy deposition. The combination also enables studies of neutral-ionosphere coupling and gravity wave modulation, a largely unexplored research area.

Finally, we provide a status update on MATS, which has faced significant challenges since 2023 but is expected to resume operations in summer 2026.

Aurora and airglow observations at Bear Island, Svalbard

Y. Ogawa [1], **M. G. Johnsen** [2], **Y. Tanaka** [1]

[1] *National Institute of Polar Research, Japan*
[2] *Tromsø Geophysical Observatory Faculty of Science and Technology UiT, The Arctic University of Norway, Norway*

We initiated aurora and airglow observations at Bear Island (74.43°N, 19.03°E) in September 2024. Located between northern Scandinavia and Svalbard—key sites for EISCAT and optical measurements—Bear Island is within the field of view of F-layer observations, while E-layer measurements have been limited. To address this, we developed a four-camera system based on a modified Watec setup, enabling stable data acquisition without internet connectivity. The system observes at 427.8, 557.7, and 630.0 nm, with dual exposure (1 s, 4 s) at 630.0 nm to capture both aurora and airglow patches. Combined with observations from Longyearbyen, Tromsø, and Skibotn, this enables wide-area coverage across $\sim$20° latitude. These observations support studies of auroral substorm dynamics and airglow transport. Data from the 2024–2025 season are being processed and released via AQVN.

ATISE Wind: Auroral Thermosphere Ionosphere Spectrometer Experiment - Wind measurement

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[2] *univ Grenoble Alpes, CSUG, 38000 Grenoble France*

Solar activity poses a critical threat to terrestrial and orbiting infrastructure, yet a lack of high-resolution dynamic data in the upper atmosphere hinders accurate mitigation. To bridge this gap, the ATISE Wind project introduces a static interferometer designed to measure thermospheric and ionospheric winds with better temporal resolution than previous wind measurement instruments.
Unlike traditional Fabry Perot devices constrained by mechanical optical path differences scanning (often exceeding one minute), the ATISE Wind instrument utilizes a Fizeau-based architecture. Eliminating moving parts enables direct interferogram measurements in just a few seconds. Successfully demonstrated during a 2026 ground-based campaign in Skibotn, the system proved its potential for near-future high efficiency even under low sky brightness conditions (≈15 kR). Exposure time down to 1s could be used to determine such wind speeds for the red (630 nm) and green lines (557 nm). Future

Optimizing Scanning Patterns for Multi-Beam Incoherent Scatter Radar

T. Rexer, B. Gustavsson, A. Spicher, A. Kvammen

UiT The Arctic University of Norway

The multi-beam capabilities of EISCAT 3D enable measurements of ionospheric electron densities resolved in space and time.
However, as beam scanning always is sequential, this introduces temporal inconsistencies that affect the derived plasma parameters when the ionophere evolves on timescales comparable to the scan cycle. Here, we investigate how scanning pattern choice affects the quality of multi-point electron density estimates.
Using GEMINI simulations of the electron densities above Skibotn, we compare different scanning patterns. Each scanning pattern produces a distinct spatiotemporal sampling distribution, and we assess how reconstruction of the electron densities varies across patterns and inter-beam distances.
Our results show that scanning order significantly affects the accuracy of the inferred electron density and motivates careful beam pattern design for future EISCAT 3D common programs and campaigns.

TNA possibilities at atmospheric and space weather research facilities

A. Tjulin, M. Tjulin, T. Ulich

EISCAT AB, Kiruna, Sweden

EISCAT is involved in two EU funded projects that will start up during the second half of 2026, RAISEARTH and ATMO-SERV. Both projects will include possibilities for Trans-National Access (TNA) to research facilities of the highest standard.

RAISEARTH is a collaboration supporting frontier research in heliophysics and space weather. It will offer TNA to instruments (such as radars, ionosondes, GNSS arrays, magnetometers, radio telescopes), and Virtual Access to FAIR datasets, event catalogues, and model outputs spanning the Sun-Earth system.

ATMO-SERV brings together European atmospheric research infrastructures to integrate the full spectrum of atmospheric observations, from the Earth's surface to the upper atmosphere, as well as the human exposure research, addressing the intertwined challenges of climate change, air quality, extreme events and health impacts. The project will provide TNA to a large number of state-of-the-art facilities and digital services.

Access to EISCAT services – EISCAT Virtual Organization: Identity and Access management for scientific community

M. Tjulin, I. Häggström

EISCAT AB, Kiruna, Sweden

The present era of rapid technological advances creates a challenge to create and maintain FAIR data and services. The need for identity and access management arises for the organizations providing the services. EISCAT services like EISCAT Portal and EISCAT tools with GUISDAP on EGI notebooks need to be made available to the present and future EISCAT users, while preserving the commitments of EISCAT to data availability and accessibility stipulated in its data policy. To achieve these goals, EISCAT Virtual Organization (VO) was created with the use of Perun system. In connection with the Single Sign-On service EGI Check-in, it offers a solution for identity and access management to services while enabling users to still use their institutional and scientific accounts. This poster will introduce EISCAT services and EISCAT VO together with the information about how to access, troubleshoot and take advantage of this infrastructure for access to EISCAT data and services.

EISCAT Sodankylä

T. Ulich[1,2], **J. Markkanen**[1,2], **M. J. Postila**[3], **T. Iinatti**[2], **A-L. Piippo**[3]

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[3] *EISCAT Sodankylä, Sodankylä Geophysical Observatory, Sodankylä, Finland (retired)*

The EISCAT Scientific Association was established in 1975 and registered in Sweden from 1st January 1976. In 1977, the Finnish EISCAT site was established at the Sodankylä Geophysical Observatory, and the first staff members were hired. Also the foundations of the UHF receiver antenna were constructed. In 1978, the 32 m parabolic UHF. receiver antenna was built by Toronto Iron Works (TIW) and their local subcontractors. The antenna was handed over to EISCAT on 3rd November 1978. The first Finnish "Special Programme" (SP) experiment was carried out 5th-6th June 1982. The Sodankylä UHF operations continued until the 930 MHz frequency band suffered too much from RFI due to GSM network. The antenna was converted to VHF 224 MHz in 2012 to allow for continued tri-static operations. With the EISCAT_3D radar taking shape, the remote sites were discontinued and the Sodankylä antenna was removed in April 2025.

Topside–bottomside decomposition of STEC for physics-informed GNSS error estimation in polar regions

L. Zuili [1,2], **F. Ginisty** [2], **M. Meftah** [1]

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[2] *Augura Space, Paris, France*

Under disturbed ionospheric conditions, frequent at high latitudes, the underlying assumptions of models used by GNSS augmentation systems may break down, leading to increased positioning errors or reduced confidence.

We propose a physics-informed framework for GNSS positioning error estimation that explicitly decomposes STEC into topside and bottomside contributions. Total STEC is derived from dual-frequency GNSS observations, while the topside contribution is obtained from the neural-network model of Smirnov et al. (2023). The residual between observed STEC and modeled topside content is then used as a proxy for bottomside electron content.

We use EISCAT Scientific Association observations at Tromsø as a high-quality reference for bottomside contribution.

These descriptors are used as inputs to a deep learning model for predicting GNSS positioning error.

We assess whether this decomposition improves accuracy and interpretability under polar disturbed ionospheric conditions.

Coffee Break

15:30 - 17:00 Space Weather & Upper Thermosphere

Deciphering the Nightglow: The Synergy of Atmospheric Observations, Modeling Calculations, and Laboratory Experiments

K. S. Kalogerakis

Center for Geospace Studies, SRI International, Menlo Park, California, USA

Throughout the night, various chemical reactions, energy transfer, and other excitation processes in Earth's upper atmosphere contribute to a weak light emission known as the nightglow. Space- and ground-based observations, atmospheric models, theoretical calculations, and laboratory experiments are routinely used to investigate the underlying processes and advance the state of knowledge about this relatively poorly understood atmospheric region in which space meets the Earth's atmosphere.

We will use our studies of the mechanisms regulating the mesospheric OH Meinel band nightglow emission as examples that highlight the synergy of atmospheric observations, modeling, and laboratory experiments. Each one of these subdisciplines of upper atmospheric science has an important role and their interplay is essential for progress. The latter is inevitable, even though it invariably appears frustratingly slow, as if going nowhere in infinitely small steps!

Odin 25 years

J. Gumbel [1], C. von Savigny [2], D. P. Murtagh [1,3], J. Stegman [1], D. A. Degenstein [4], A. E. Bourassa [4], and the Odin Team

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[2] *University of Greifswald, Germany*
[3] *Chalmers University of Technology, Sweden*
[4] *University of Saskatchewan, Canada*

In February 2026, we celebrated the 25th anniversary of the Odin satellite in orbit. At the end of April, Odin finished scientific observations. With its orbit now rapidly declining, Odin will turn into space debris in the Fall of 2026. This presentation will be an homage, highlighting in particular some optical achievements by OSIRIS, the Optical Spectrograph and Infrared Imager System onboard Odin. We will also discuss plans of creating a systematic OSIRIS airglow database.

The ORIGIN rocket project – old and new sources of oxygen nightglow

J. Hedin [1], J. Gumbel [1], L. Megner [1], J. Stegman [1], J. Dillner [1], N. Ivchenko [2], D. P. Murtagh [1,3], K. Kalogerakis [4], B. Strelnikov [5], S. Löhle [6], I. Hoerner [6], S. Fasoulas [6], U. Brändström [7], P. Dalin [7], C. S. Patel [8], S. Chakrabarti [8]

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[8] *University of Massachusetts (UML), Lowel, USA*

The ORIGIN (Oxygen and its Role In Generating and Influencing Nightglow) sounding rocket campaign was conducted at Esrange Space Center in 2025, comprising both a sounding rocket, satellite and ground-based measurements. The ORIGIN project focus on atomic oxygen (AO) in the Mesosphere/Lower Thermosphere (MLT) region of the Earths atmosphere and the ability to determine AO from measurements of the major nightglow emissions O2 Atmospheric Band, O Green Line, and OH Meinel. Thus, three important techniques for remote sensing of AO are directly compared, while at the same time assessing underlying photochemical mechanisms and performing independent measurements of key species and atmospheric background conditions. AO is the major carrier of chemical energy in the MLT, thus controlling much of the chemistry, energy budget and radiative properties here. The ability to accurately measure the local distribution of AO is thus crucial. I will present the project and first results.

Probing Mid-Latitude Thermospheric and Ionospheric Disturbances via Ground-Based Airglow Observations

T. Lhereux [1], **F. Pitout** [1], **K. Shiokawa** [2]

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Following a coronal mass ejection (CME) or solar flare, charged particles interact with Earth's geomagnetic field, are guided along field lines toward the magnetic poles, and deposit energy into the upper atmosphere. This energy input locally raises temperatures, reducing atmospheric density and triggering buoyancy-driven oscillations. The resulting traveling atmospheric disturbances (TADs) propagate equatorward, passing over mid-latitude regions. To detect and characterize these perturbations, we operate a network of three ground-based all-sky cameras equipped with narrowband interference filters, targeting specific airglow emission lines diagnostic of the thermosphere and ionosphere. Airglow is produced by radiative de-excitation of atmospheric constituents following daytime UV photoabsorption. This instrumental setup is based on low-cost CMOS camera technology, offering a cost-effective alternative to conventional airglow imagers while maintaining sufficient sensitivity for upper atmospheric monitoring. We present here our first observational results and discuss the potential of this low-cost instrumental approach for monitoring mid-latitude upper atmospheric dynamics during solar events.

EISCAT and rocket data validation of the EPP models used in climate models

A. Kero [1], **N. Thomas** [1], **P. Verronen** [1,2], **M. van de Kamp** [2], **J. Fadiji** [1]

[1] *Sodankylä Geophysical Observatory, University of Oulu, Finland*
[2] *Finnish Meteorological Institute, Finland*

Energetic particle precipitation (EPP) forcing is included into the recent CMIP climate modelling recommendations. According to these simulations, the impact of inclusion of the medium energy electrons to the ozone variability was estimated to be 12-24% in the mesosphere and 5-7% in the stratosphere. However, to obtain a continuous particle forcing required for these multi-decadal simulations, the precipitating particle flux spectrum was parameterised by the magnetic Ap index to match statistically to the POES satellite's MEPED particle detector data. This rather simple approach has several uncertainties, but the most critical one is that the existing satellite-borne particle detectors, including the MEPED instrument, struggle to separate the loss cone populations from trapped particles, leading to biases in EPP forcing especially in the relativistic energies. In this presentation, we evaluate the modelled electron densities against the EISCAT VHF and rocket datasets.

2025-08-26 Wednesday

8:30 - 10:00 EISCAT

EISCAT and EISCAT_3D

P. Påhlsson and the EISCAT Staff

EISCAT AB, Kiruna, Sweden

EISCAT is currently building EISCAT_3D, the World's most advanced 3-dimensional imaging radar for atmospheric, ionospheric and near-Earth space investigations. EISCAT_3D will be capable of tracking satellites as well as observe meteors and asteroids. The fully steerable, tri-static, phased-array incoherent scatter radar is located in Skibotn (Norway), Karesuvanto (Finland), and Kaiseniemi (Sweden). It is foreseen that EISCAT_3D will be able to make first science observation with a subsystem of the Skibotn radar (NO-7) with 637 kW. Thereafter, EISCAT_3D will gradually expand to fully tri-static operations. EISCAT_3D is a European Strategy Forum for Research Infrastructures (ESFRI) Landmark in the Environment domain. Here we will give an overview of the current status of EISCAT and EISCAT_3D and it's future use for ionospheric as well as space object/space debris work.

The Polar Geospace Observatory – a new facility on Svalbard?

L. J. Baddeley [1], L. Clausen [2], J. Chau [5], S. Sartori [2], B. Babar [2], T. Ulich [6], D. A. Lorentzen [1], J. Vierinen [3], A. Spicher [3], I. Solheim [3], N. Gulbrandsen [4], M. Johnsen [4], D. Huyghebaert [5], T. Renkwitz [5], J. Reidy [7], A. Kavanagh [7], L. Alfonsi [8], A. Strømme [9], C. Heinselman [10]

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[2] *University of Oslo, Norway*
[3] *Department of Physics and Technology, The Arctic University of Norway, Tromsø, Norway*
[4] *Tromsø Geophysical Observatory, The Arctic University of Norway, Tromsø, Norway*
[5] *Leibniz Institute of Atmospheric Physics (IAP), Germany*
[6] *EISCAT AB, Sweden*
[7] *British Antarctic Survey, UK*
[8] *Istituto Nazionale di Geofisica e Vulcanologia (INGV), Italy*
[9] *European Space Agency, Italy*
[10] *University of Fairbanks, Alaska*

The current EISCAT Svalbard Radar (ESR) has provided the scientific community with unprecedented observations of the cusp and polar cap regions since 1994 and has been instrumental in expanding our understanding of the coupling between the IMF and geomagnetic field. The aging, un-replaceable technology puts a finite lifetime on the system taking it (optimistically) into the early 2030s. Here we present an overview of a recently submitted proposal to the EU Horizon program for a 3-year design study for the next generation observatory on Svalbard – The Polar Geospace Observatory (PGO). We envisage this being a state-of-the-art system, serving a far wider community than the current ESR, powered by renewable energy sources. The project has representatives from the ionospheric, atmospheric, radio astronomy and renewable energy research communities. We welcome suggestions and input for the facility from the community here at the symposium.

Present and Future of Heating with EISCAT

Heating Workgroup

UiT The Arctic University of Norway

The Heating Workgroup will present an overview of its activities, progress, and outcomes since the last symposium. This talk summarizes key developments and ongoing work, including a recent paper, the results of a community petition, and two applications submitted to the International Space Science Institute (ISSI). The session will close with the current status of EISCAT Heating and an open discussion about the next steps, priorities, and the future of Heating.

Messaging Extraterrestrial Intelligence (METI) with the EISCAT Tromsø UHF Radar

D. A. Vakoch [1], **J. Richards** [1], **R. B. Kerr** [2], **I. Ribas** [3]

[1] *METI International, San Francisco, USA*
[2] *Computational Physics, Inc., Springfield, USA*
[3] *Institute of Space Sciences, Barcelona, Spain*

The EISCAT Tromsø UHF radar was used to transmit information-rich signals to nearby stars for Messaging Extraterrestrial Intelligence (METI), an active counterpart to the Search for Extraterrestrial Intelligence (SETI). Multiple stars were targeted each session, timed to prioritize a combination of 1) the nearest stars, 2) stars with known exoplanets, 3) Sun avoidance, 4) minimal atmospheric dispersion, and 5) minimal slew time between stars. Using signals modulated in phase and frequency, an encoded message indicated preferred time of a reply signal, coordinated with the summer solstice—an astronomically observable phenomenon. As a future development, we encourage commensal METI strategies in which 1) aeronomists analyze data collected during METI experiments, and 2) aeronomists track stars during traditional ionospheric and atmospheric radar transmissions, yielding technosignatures distinct from Earth's leakage radiation, even if the radar signals encode no additional information.

Coffee Break

10:30 - 12:00 Beynon medal award ceremony

Award ceremony of Beynon medal to Dr. Craig Heinselman. Detailed information will come in the week before the Symposium.

Lunch

12:45 - 17:45 Excursion

For more information see:
Information about Buses, Lunches, Excursion and Banquet

19:30 - 22:00 Banquet

For more information see:
Information about Buses, Lunches, Excursion and Banquet

2025-08-27 Thursday

8:30 - 10:00 Radar Techniques 1

Reevaluation of EISCAT plasma parameters during the May 2024 geomagnetic storm using O^+ ratios from AMIE-driven SD-WACCM-X

F. Günzkofer [1], **A. Tjulin** [2], **Gang Lu** [3], **Hanli Liu** [3], **G. Stober** [4,5]

[1] *Institute for Solar-Terrestrial Physics, German Aerospace Center (DLR)*
[2] *EISCAT AB*
[3] *High Altitude Observatory, National Center for Atmospheric Research (NCAR)*
[4] *Institute of Applied Physics, Microwave Physics, University of Bern*
[5] *Oeschger Center for Climate Change Research, Microwave Physics, University of Bern*

Inferring Level 2 plasma parameters from incoherent scatter radar measurements requires a priori assuming certain quantities. Previous studies suggested that the ratio of atomic oxygen ions (O^+) is the parameter with the largest impact on the inferred plasma parameters, and especially under geomagnetic storm conditions, the applied IRI ion composition deviates from realistic conditions. Several approaches to this problem have been investigated in the past, and we present a new approach, making use of a data assimilative geomagnetic forcing technique (AMIE). We apply O^+ ratios given by an AMIE-driven WACCM-X model run of the May 2024 geomagnetic storm for a reevaluation of the EISCAT Svalbard Radar measurements of this event. We show that the level 2 parameters are altered by up to 15% (electron density) and 40% (ion and electron temperatures) in this reevaluation. The possibility of an empirical correction model is discussed.

2D F-region Ion Composition Fits to EISCAT Svalbard Radar Meridional Scan Measurements

A. Nigusie [1], **I. Virtanen** [1], **H. Vanhamäki** [1], **L. Roininen** [2,3]

[1] *Space Physics and Astronomy Research Unit, University of Oulu, Oulu, Finland*
[2] *School of Engineering Sciences, Lappeenranta-Lahti University of Technology, Lappeenranta, Finland*
[3] *Clare Hall, University of Cambridge, United Kingdom*

Ion composition is a key parameter for determining energy exchange and recombination rates, studying ion upflow and outflow and ion–neutral chemistry, and accurate electron and ion temperature fits to incoherent scatter (IS) spectra. F-region O^+ ion fraction fits to geomagnetic field-aligned IS radar measurements were enabled previously using Bayesian filtering, correlation priors, and chemistry modeling. We combine the technique with an analysis technique for multistatic multibeam radars and bin data from multiple beam directions in magnetic latitude and longitude to extend the technique to 2D/3D plasma parameter fits. We apply the new technique to make 2D plasma parameter fits to the EISCAT Svalbard radar meridional scan measurements and study 2D variations of O^+ ion fraction during Joule heating and precipitation events. The technique is designed to make 3D plasma parameter fits to volumetric EISCAT3D measurements and will be applied when the system becomes available.

Automated Guisdap initialization and off-line ionospheric parameter estimation from EISCAT raw voltage data

P. Gallop [1], **B. Isham** [2], **P. Guio** [3]

[1] *Private researcher, Reading, UK*
[2] *Citizens of the Karst, San Juan, Puerto Rico, USA*
[3] *University of Tromsø, Tromsø, Norway*

We discuss the automated initialization of Guisdap for long pulse raw voltage data, the near-real-time computation of LPMs from raw data files, followed by the estimation of ionospheric parameters using Guisdap. This work is specifically aimed at the "LT" special programmes, designed for high-time-resolution observations of Langmuir turbulence and other energetic events. Automated initialization is of interest to be able to easily work with changes to the details of the data files which were made as the data-taking programs evolved during testing and use. A stand-alone application was developed with a flexible approach to generating LPM's outside of the EISCAT system, i.e. outside of filan. Preliminary parameter computations from the LT special programme data will be discussed.

The EISCAT LT observing programs and external contributions to science at EISCAT

B. Isham [1], **V. Belyey** [2], **A. Stramkals** [3], **P. Guio** [4], **M. Rietveld** [5], **P. Gallop** [6], **J. Bergman** [7]

[1] *Citizens of the Karst, San Juan, Puerto Rico, USA*
[2] *Private researcher, Oslo, Norway*
[3] *Uppsala University, Uppsala, Sweden*
[4] *University of Tromsø, Tromsø, Norway*
[5] *EISCAT Scientific Association, Ramfjordmoen, Norway (retired)*
[6] *Private researcher, Reading, UK*
[7] *Swedish Institute of Space Physics, Uppsala, Sweden*

The EISCAT LT Special Programme radar control and data recording codes are an attempt to approximate full spectrum incoherent scatter measurements at high time resolution with maximum flexibility via recording of the fundamental complex voltage samples, combined with real-time and post-processing analysis in any way desired.
The LT special programmes are a step in a continuous and diverse process aimed at enabling the full technical potential of EISCAT and other radar systems and achieving the maximum scientific return from the measurements. It is also an example of an external contribution to EISCAT. The LT programmes will be discussed, along with examples of other external contributions to EISCAT.

On optimal measurement and data analysis techniques for EISCAT3D

I. Virtanen [1], **A. Nigusie** [1], **T. Bag** [1], **S. Hatch** [2], **N. Thomas** [3], **A. Kero** [3]

[1] *Space Physics and Astronomy Research Unit, University of Oulu, Finland*
[2] *Department of Physics and Technology, University of Bergen, Bergen, Norway*
[3] *Sodankylä Geophysical Observatory, University of Oulu, Sodankylä, Finland*

EISCAT3D will introduce both unprecedented flexibility and completely new challenges in terms of incoherent scatter (IS) radar experiment design and data processing. While IS radars have traditionally relied mainly on analysis of core transceiver site data from each radar beam separately, the multiple beam remote receivers of EISCAT3D will enable measurement techniques not available with monostatic radars or single-beam remote receivers. Additional improvements may be available from plasma line and Faraday rotation data in favorable conditions, and from advanced transmission coding techniques. We use modeling tools and synthetic data to estimate how much one may be able to improve accuracy of the plasma parameter estimates, as compared to conventional analysis of the core site ion line data measured with conventional transmission modulations. In addition to accuracy of Ne, Te, Ti and Vi, we consider also F region ion composition and E/D region ion-neutral collision frequency fits.

Coffee Break

10:30 - 12:00 Radar Techniques 2

MAARSY-3D: Multi-static Interferometric Radar Measurements of MLT Phenomena and Dynamics

D. Huyghebaert [1], **R. Latteck** [1], **T. Renkwitz** [1], **M. Hafteh** [1], **J. Vierinen** [2,1], **J. M. Urco** [3], **J. L. Chau** [1]

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[3] *Pontificia Universidad Catolica del Peru, Lima, Peru*

The Middle Atmosphere Alomar Radar System (MAARSY) is a 53.5 MHz phased array radar that operates with a peak power of ≈800 kW with interferometric radar imaging capabilities. The main site is located in Andenes, Norway, and in recent years the radar has been expanded to be multi-static, with a now operational 48-antenna receiver site located near Stø, Norway, and a planned second receiver site to be installed this summer (2026). During the summer of 2025, both the primary site and the Stø MAARSY-3D1 receiver site were operated continuously in a 5 transmit beam experiment mode. This provides an extensive 3-month dataset of multi-static PMSE. measurements at altitudes of 80-90 km that can be used to investigate dynamics in the MLT with multiple line-of-sight velocity vectors in high spatio-temporal resolution (≈1 km, 30 s). The presentation will provide an overview of the MAARSY-3D system, including some results from the 2025 campaign.

High-frequency radar imaging of the ionosphere from Puerto Rico

B. Isham [1], **T. Bullett** [2], **B. Gustavsson** [3], **E. Polisensky** [4], **A. Stramkals** [5], **V. Belyey** [6], **C. Brum** [7], **J. Vierinen** [3], **J. Bergman** [8], **R. Livingston** [9]

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[2] *Front Range Radio, Berthoud, Colorado, USA*
[3] *University of Tromsø, Tromsø, Norway*
[4] *U.S. Naval Research Laboratory, Washington, DC, USA*
[5] *Uppsala University, Uppsala, Sweden*
[6] *Private researcher, Oslo, Norway*
[7] *Christiano Brum, University of Central Florida, Orlando, Florida, USA*
[8] *Swedish Institute of Space Physics, Uppsala, Sweden*
[9] *Scion Associates, Port Townsend, Washington, USA*

We are developing a 2 to 25 MHz antenna array for radar and radio imaging of the ionosphere. The array is located at the United States Geological Survey (USGS) San Juan Observatory in Cayey, Puerto Rico, and consists of 9 fixed antennas and up to 16 temporary antennas, each of which is an active crossed electric dipole. Elements in the array are arranged in a partly ordered and partly semi-random pattern, providing a good distribution of baseline vectors. Relocatable cable-less antenna elements will also be included.

Project goals include the development of radio sounding, polarization, interferometric, and imaging techniques, and student training. Scientific objectives include studies of space weather, ionospheric structure and dynamics, plasma processes, lightning, meteors, and radio wave propagation. Efforts to restore HF capabilities at Arecibo are under discussion; high-power HF transmissions would allow investigations of the geometry of stimulated radio emissions.

First Detection of the Enigmatic Low Latitude 150-km Echoes in the UHF Band

X. Yue, J. Wang, Y. Wang, Y. Cai, F. Ding, N. Zhang, M. Li, B. Ning, J. L. Chau
Institute of Geology and Geophysics, Chinese Academy of Sciences; IAP

Through applying a 4-MHz linear frequency modulation waveform, which has high range resolution and signal intensity, we successfully detected for the first time the ionospheric 150 km echo enhancement at 430–450 MHz of the Ultra-High-Frequency (UHF) band using the newly built Sanya Incoherent Scatter Radar (SYISR). The obtained low signal enhancement (less than 0.5 dB) explains why previous UHF. experiments did not detect them. We also found that our measured fine structure shows a much wider forbidden region than previous results and covers a much larger altitudinal and local time region. In comparison with recent upper-hybrid instability theory and simulation, our results confirmed the predicted higher altitude occurrence, wider gaps between enhancements, the turn corner feature around sunrise, and perhaps the weak enhancement, which provide an independent evaluation of the newly proposed mechanism in UHF. band. Future UHF. experiments could further improve the physical understanding of

Statistical characteristics of HF radar echoes from the rebuilt Longyearbyen SuperDARN radar: occurrence, velocity, and echo height distribution

D.A. Lorentzen, L.J. Baddeley, and M. Syrjäsuo
The University Centre in Svalbard (UNIS), Norway

The Longyearbyen (LYR) SuperDARN radar samples the high-latitude ionosphere from the dayside cusp and polar cap through to the nightside auroral zone. Its boresight oriented at 23.7 degrees geographic north - is designed to maximize cusp and polar cap coverage as the station rotates beneath the auroral oval. Following a comprehensive hardware rebuild, the radar data has been publicly available since Dec 2024. Here we present a statistical characterization based on recent data. We examine echo occurrence, LOS velocity, and spectral width as functions of MLT, MLAT, season and IMF orientation. The virtual height distribution reveals distinct E- and F-layer propagation modes with clear MLT dependence, and strong seasonal contrasts. IMF Bz/By sorting reveals the solar wind influence on echo occurrence and convection in the cusp sector. Co-located with EISCAT and optical instrumentation on Svalbard, LYR SD provides valuable context for multi-instrument studies of cusp aurora and convection.

Scalable and flexible analysis of raw ionospheric radio and radar voltage data with Python, Xarray, and Zarr

A. Stramkals [1], **J. Bergman** [2], **B. Isham** [3], **P. Guio** [4], **V. Belyey** [5]

[1] *Uppsala University, Uppsala, Sweden*
[2] *Swedish Institute of Space Physics, Uppsala, Sweden*
[3] *Citizens of the Karst, San Juan, Puerto Rico, USA*
[4] *University of Tromsø, Tromsø, Norway*
[5] *Private researcher, Oslo, Norway*

Raw ionospheric radio and radar complex voltage data can be produced and consumed in different scenarios, from a classroom experiment with a single radio receiver to a research project involving multiple radar receiving antennas. These environments have different operating constraints and requirements. For data analysis, a student might run off-the-shelf software on commodity hardware, while a researcher might wish to tailor the software to their specific research goals.
Building on top of technologies with first-class support for parallel computing, a flexible platform can be created for analysis of complex voltage samples. We give an overview of a Python software prototype that can execute standard analyses of raw complex voltage data on commodity hardware such as a student laptop and scale to more powerful workstations, cloud storage systems, or HPC clusters. Figures derived from voltage samples recorded using the EISCAT Tromsø VHF radar system will also be presented.

Lunch

13:30 - 15:00 Ionosphere 1

An Abrupt Decrease in Electron Temperature Inside the Ionospheric Density Holes During the Launches of Carrier Rockets

L. Zhao, F. Ding, X. Yue, Y. Cai, J. Wang

Institute of Geology and Geophysics, Chinese Academy of Sciences

Previous observations have demonstrated that rocket exhaust can trigger ionospheric electron density holes and cause electron temperature enhancements during launches. Using high-precision measurements from the Sanya incoherent scatter radar, we discovered a previously overlooked decrease in electron temperature. We report a daytime event and a nighttime event. During daytime, the electron temperature first decreased sharply by $\sim$650 K within 5.5 min, then increased by $\sim$1000 K before gradually recovering over $\sim$1 hr. Multi-beam observations indicated that this cooling was localized near the rocket trajectory, much narrower than the accompanying electron density depletion. Moreover, the ion temperature increased by 550 K. The nighttime electron and ion temperatures decreased by $\sim$450 K and $\sim$150 K, respectively, without subsequent electron temperature increase.

Plasma temperature variability during the 2025 and 2026 DRIIVE/FINESSE Campaigns

I. W. McCrea [1], **A. J. Kavanagh** [2], **Y. V. Bogdanova** [1], **M. P. Freeman** [2]

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Two UK EISCAT campaigns in support of the DRIIVE and FINESSE NERC consortium grants took place from December 14-20 2025 and March 16-22 2026. The campaigns, which used both the EISCAT UHF and VHF radars, covered a wide range of geophysical conditions from Kp 0 to 7. As well as very interesting variations in the morphology of the plasma density, highly dynamic behaviour was observed in both the electron and ion temperatures, displaying both correlation and anti-correlation with auroral precipitation. Of particular interest are some of the apparently strong but comparatively short-lived electron temperature enhancements seen in the topside ionosphere. While these appear to be related to the E-region density variability observed at the same time, we will examine whether these events could have a plasma physical explanation, which might affect their standard interpretation as bulk temperature increases.

Determination of the O^+-O Collision Frequency Factor from the Sanya Incoherent Scatter Radar Measurements

N. Zhang [1,4], **J. Lei** [2], **X. Yue** [1,4,5], **Y. Cai** [1,4], **J. Wang** [1,4], **Y. Wang** [1,4,5], **F. Ding** [1,4,5], **Y. Zhu** [3,5], **B. Ning** [1,4]

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[5] *College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, China*

Collisions between oxygen atoms and oxygen ions play a crucial role in the momentum and energy exchange between the ionosphere and the thermosphere. However, direct measurement of O^+-O collision frequency or parameterizing this factor has been challenging over years. By utilizing the newly built Sanya incoherent scatter radar wind profiles, we have proposed a new method to calculate the O^+-O collision frequency factors, i.e., Burnside factor, for the first time from the whole year SYISR dataset. Our results show that the mean Burnside factor is 1.31, although it ranges from 1.07 to 1.41 as a function of local time and from 1.19 to 1.41 with respect to the seasons. The reliability of the method has been validated through an independent estimation by a co-located FPI and SYISR winds. To our knowledge, this is the first comprehensive analysis of Burnside factor, which are of great importance in collision frequency parameterization.

Fast magnetotail plasma sheet flows and ionospheric equivalent currents

V. Koikkalainen [1], L. Juusola [2], M. Grandin [2], N. Partamies [3], L. Pänkäläinen [1], A. Workayehu [1], M. Palmroth [1,2]

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[2] *Finnish Meteorological Institute, Finland*
[3] *The University Centre in Svalbard, Department of Arctic Geophysics, Norway*

Fast Earthward plasma flows, such as bursty bulk flows (BBFs), are often observed in the Earth's magnetotail and have been associated with ionospheric signatures in the form of North-South-aligned current channels or changes to the westward electrojet.

We study the ionospheric effects of fast (> 400 km/s) Earthward flows in the magnetotail by identifying such events from Cluster, MMS, and THEMIS data during conjunctions with Fennoscandia in the years 2001–2025. We derive the equivalent currents in the ionosphere by applying the Spherical Elementary Current System (SECS) method to IMAGE. ground-based magnetometer observations, and study their temporal evolution when a conjugated fast Earthward flow is observed by the satellite in the magnetotail.

We find different types of fast flow characteristics create distinct ionospheric responses, and explore the connection between dipolarization in the tail and the intensification of the westward electrojet.

Ionospheric Responses to the High-Latitude Solar Eclipse of 10 June 2021

H. Sato, G. Nykiel, F. Günzkofer, T. Kodikara, J. A. Cahuasquí, M. Hoque

German Aerospace Center (DLR), Institute for Solar-Terrestrial Physics, Neustrelitz, Germany

We present a multi-instrument investigation of the ionospheric response to a high-latitude solar eclipse, combining EISCAT radar data with GNSS and in-situ satellite measurements. A solar eclipse causes a local reduction in ionospheric density due to diminished solar radiation, and the recovery phase often remains prolonged after the eclipse ends. We analyze altitude-dependent plasma variations during the 10 June 2021 eclipse using EISCAT radar data and relate them to depletion and recovery in TEC derived from GNSS. Electron density and temperature show distinct responses, with density exhibiting strong altitude asymmetry. Higher-altitude density responds more slowly, leading to delayed TEC depletion and recovery. The plasma pressure gradient and subsequent density diffusion explain the delayed response and sustained depletion, potentially enhanced by reduced neutral density-

Coffee Break

15:30 - 17:00 Ionosphere 2

Moderate geomagnetic storm effects on the ionosphere - thermosphere

A. Aikio [1], **L. Cai** [1], **G. Geethakumari** [1], **J. Norberg** [2], **K. Kauristie** [2], **S. Käki** [2]

[1] *University of Oulu, Finland,*
[2] *Finnish Meteorological Institute*

On 26 March 2025, a moderate geomagnetic storm was initiated, following a solar wind high-speed stream hitting the Earth's magnetopause. The storm was measured by several incoherent scatter radars as a part of the World Day campaign, Tromsø EISCAT UHF, Millstone Hill, Poker Flat and Resolute Bay North. In this talk, we focus on the effects in the Scandinavian sector. The storm produced several previously observed features, such as high-latitude F region electron density depletion and signatures of temporarily varying Joule heating. Of specific interest are the large-scale traveling ionospheric disturbances (LSTIDs), that were launched in the beginning of the storm main phase at high latitudes and propagated toward lower latitudes. The mid-latitude ionospheric trough, identified by the GNSS total electron content maps and 3D ionospheric tomography, had a pronounced effect on the LSTID propagation. The different aspects of ionosphere-thermosphere coupling during this storm are discussed.

Advance in incoherent scatter observations of the ionospheric D region

E. Turunen, N. Thomas, A. Kero

Sodankylä Geophysical Observatory, University of Oulu

Incoherent scatter radar is know to be the most powerful single tool in ionospheric measurements. However, in the lower part of the ionosphere, i.e. in the collision dominated plasma, where electron concentration may be extremely low, development of the technique has been slow after the first measurements already some decades ago. In this talk we make review of recent advance, which show higher resolutions in observations, connections to other measurements, specially by satellites, new analysis of old data and most notably, availability of the modern phased-array techniques. This review should guide planning of new D-region experiments, which we soon expect to be available by the EISCAT-3D radar, once the measurements can be done with sufficiently high signal-to-noise ratios.

Four-dimensional Observations for the Low-latitude Sporadic E. Layer by Sanya Incoherent Scatter Radar

J. Wang [1], X. Yue [1], X. Zhou [1], Y. Cai [1], F. Ding [1], J. L. Chau [2], D. C. Fritts [3], J. Vierinen [4], A. Z. Liu [5]

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[3] *GATS Inc., Boulder, Colorado, USA*
[4] *UiT The Arctic University of Norway, Tromsø, Norway*
[5] *Center for Space and Atmospheric Research (CSAR) and Department of Physical Sciences, Embry-Riddle Aeronautical University, Daytona Beach, FL, USA*

Sporadic E (Es) layer plays essential role in ionosphere-atmosphere coupling. Sanya Incoherent Scatter Radar (SYISR), employing a wide-bandwidth chirp signal, now enables the spatiotemporal resolutions of 37.5 m in range and 50 s in time. We have applied the new capability for observations of Es layer in the low-latitude ionosphere. Direct observational evidences for the mesoscale GW modulations and Kelvin-Helmholtz instability are firstly obtained by four-dimensional electron density detections. Our results reveal how these atmospheric dynamics influence the behaviors of Es layer and also highlight the capabilities of SYISR to detect the coupling between atmospheric dynamics and electrodynamical processes in the low-latitude lower thermosphere.

Characteristics of Medium Scale Traveling Ionospheric Disturbances using EISCAT VHF measurements

S. Moges [1], **T. Ulich** [2,3], **A. Kozlovsky** [3], **R. Sherstyukov** [3], **S. Lasanen** [3], **H. Tesfaw** [4]

[1] *Swedish Institute of Space Physics, Kiruna, Sweden*
[2] *EISCAT AB, Kiruna, Sweden*
[3] *Sodankylä Geophysical Observatory, University of Oulu, Finland*
[4] *Space Physics and Astronomy Research Unit, University of Oulu, Finland*

The vertical profiles of medium scale traveling ionospheric disturbances (MSTID) characteristics in the ionospheric E and bottomside F regions using multiple daytime runs of EISCAT VHF measurements are revealed with manda experiment mode. Spectral analysis is applied to identify the dominant wave amplitudes and periods, while a cross-correlation method is used to determine the vertical wavelength, λz. It is observed that the dominant relative amplitude (δNe/Ne) reveal both seasonal and height variations. The amplitudes of MSTIDs observed during winter are approximately 5-10 times larger compared to other seasons.

3D Reconstruction of a Westward Traveling Surge Event and Conductivity Distribution Analysis

T. Hoshino [1], Y. Tanaka[1,2,3], M. Fukizawa[1,2], Y. Ogawa[1,2,3], T. Nishiyama[1,2], K. Hosokawa [4], K. Kauristie [5], T. Hoppe [5], A. Kozlovsky [6], T. Raita [6]

[1] *Polar Science, Graduate Institute for Advanced Studies*
[2] *National Institute of Polar Research*
[3] *Research Organization of Information and Systems*
[4] *The University of Electro-Communications*
[5] *Finnish Meteorological Institute*
[6] *Sodankyla Geophysical Observatory, University of Oulu*

Auroral substorms exhibit rapid expansion, including the westward traveling surge (WTS). Vortex plasma flows in WTS may be driven by sharp conductivity gradients at the surge front, but these occur on small spatial and temporal scales and are difficult to observe directly.

In this study, we apply auroral tomography to reconstruct the three-dimensional structure of WTS from multi-point optical observations. This enables estimation of electron density and conductivity distributions, which can be validated using EISCAT radar data.

We present results from a WTS event on February 16, 2018, using 427.8 nm images from Tromsø, Abisko, and Kilpisjärvi, including energy flux, average energy, and 3D distributions of emission rate, electron density, and conductivity.

2025-08-28 Friday

8:30 - 10:00 Mesosphere - Lower Thermosphere

Secular shifts in the Earth's magnetic field and its consequences for auroral boundaries

L. M. Bjoland [1], **F. S Barros** [2,3,4], **S. Haaland** [5], **A. Santos** [2], **A. Schillings** [6]

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[2] *Artificial Intelligence and Computer Science Laboratory, University of Porto, Portugal*
[3] *Institut de Recherche en Astrophysique et Planétologie, France*
[4] *Instituto de Astrofísica e Ciências do Espaço, Portugal*
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This study examines long-term variations in the geomagnetic field and their consequences for the auroral oval, as observed in Svalbard. Using satellite data, we show that both the poleward and equatorward boundaries of the auroral oval are slowly, but consistently shifting equatorward. To investigate if this equatorward shift results in a lower chance of observing aurora, we have developed automated methods for identifying auroral boundaries in EISCAT Svalbard radar data. Observations from the EISCAT Svalbard radar seems to confirm this equatorward trend, though further analysis is needed to draw definitive conclusions.

Omega bands as a space weather hazard

R. M. Hodnett [1], **S. E. Milan** [1], **S. K. Vines** [2], **J. W. Gjerloev** [3], **L. J. Paxton** [3], **S. Nozawa** [4]

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Omega bands are a dawn sector auroral structure with wave-like morphology. They consist of upward and downward field aligned currents (FAC) and are formed between the region 1 and region 2 FAC boundary. As they drift eastward, omega bands produce ground-based magnetic perturbations which can have large dB/dt values and hence are a potential source of geomagnetically induced currents (GICs). GICs are space weather hazard as they can damage infrastructure such as power grids. In this study, we examine multiple case studies of omega bands with various instrumentation including all sky camera data, magnetometers and EISCAT data. Measurements from the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) are used to study the FACs of different events. We provide a study of omega band electrodynamics and aim to understand what causes different case studies to have larger dB/dt values and hence which type of event contribute most to space weather hazards.

Variability of Thermospheric Helium over the 2024–2026 Winter Seasons: Ground-Based Optical Observations at Longyearbyen, Svalbard

T. Nishiyama[1,2], **M. Kagitani**[3], **T. Bag**[4], **T. T. Tsuda**[5], **Y. Ogawa**[1,2], **F. Sigernes**[6]

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[2] *Department of Polar Science, The Graduate University for Advanced Studies, SOKENDAI, Tokyo, Japan*
[3] *Planetary Plasma and Atmospheric Research Center, Tohoku University, Sendai, Japan*
[4] *University of Oulu, Oulu, Finland*
[5] *University of Electro-Communications, Tokyo, Japan*
[6] *University centre in Svalbard, Norway*

This study investigates the temporal variability of orthohelium, He(23S), in the polar region across multiple timescales. Forming between 250 km and 800 km, the orthohelium layer is a vital tracer for upper thermospheric and lower exospheric dynamics. However, its response to geomagnetic disturbances remains poorly understood.

We analyzed continuous He(23S) airglow brightness at 1083 nm from the 2024–2025 and 2025–2026 winter seasons using the NIRAS-2 spectrograph at the Kjell Henriksen Observatory, Svalbard (78.1°N). The data exhibit clear seasonal variations, including the "helium winter bulge," and a strong solar zenith angle dependence. Crucially, we identified sudden brightness enhancements linked to magnetic storms and solar proton events. This presentation discusses these findings through a detailed comparison with TIE-GCM simulations to elucidate the physical mechanisms driving helium variability in the high-latitude thermosphere.

Energy conversion in the upper thermosphere based on 9-year measurements from FPI and Dynasonde in Tromsø, Norway

S. Oyama[1,2,3], **H. Vanhamäki**[3], **L. Cai**[3], **K. Hosokawa**[4], **and K. Shiokawa**[1]

[1] *Institute for Space-Earth Environmental Research, Nagoya University, Nagoya, Japan*
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[3] *Space Physics and Astronomy Research Unit, University of Oulu, Oulu, Finland 4The University of Electro-Communications, Chofu, Japan*

This research has studied how energy moves from the ionospheric plasma to the thermospheric neutral gas of Earth at high latitudes. This study analyzed measurements conducted over nine years in Tromsø, Norway. Normally, to study the energy transfer, complex formulas have been combined involving ionospheric electric conductivity. This study, however, introduced a simpler method by calculating a ratio R, which compares two types of energy transfer: Joule heating rate and electromagnetic energy transfer rate. R was determined using ion velocity and neutral wind measured with a Dynasonde and Fabry-Perot interferometer, respectively. (1) $0 < R < 1$: This is a case of energy transfer from kinetic energy of the ionospheric plasma to heat (Joule heating) and motion (wind acceleration by Lorentz force) of the thermospheric neutral particles, which occurs under moderately active geomagnetic conditions at dusk to pre-midnight. (2) $R < 0$: This is a case of negative work by Lorentz force throughout

Recent Mid and High latitude Observations of Thermospheric Winds

Q. Wu [1] **, H. Wu** [1]**, W. Wang** [2]**, M. Connors** [2]**, R. Kerr** [3]**, P. Dandenault** [4]**, G. Jee** [5]**, C. Lee** [5]

[1] *NCAR, Boulder, USA*
[2] *Unversity of Athabasca, Athabasca, Canada*
[3] *CPI, Lowell, USA* [4] *APL, Laural, USA*
[5] *KORPI, Incheon, S. Korea*

In recent years, more ground-based Fabry Perot interferometers (FPI) in the American Sector (Athabasca, AB, Canada; Easton, ME; Millstone Hill, MA; Boulder, CO and others) have been deployed to observe thermospheric winds. At the same time, there are also high latitude observations from Svalbard, Norway. The current solar maximum cycle also provides a great opportunity to examine the thermospheric winds from high to mid latitudes during very strong geomagnetic storms. Some FPIs are deployed very close to the sub-auroral region for examination of the sub-auroral polarization streams (SAPS) effect on the thermospheric winds. The observations have been compared with the NCAR TIEGCM simulations. As polar cap expands during geomagnetic storms, some of the mid latitude stations become inside the polar cap where the dynamic driving processes of the thermospheric winds are different from those in subauroral regions. Having stations separated in small latitude range can help determine the expa

Coffee Break

10:30 - 12:00 Meteor & Space Debris

Fireball and Space Debris Observations with the BRAMS Network

H. Lamy, H. Joly, M. Anciaux, A. Calegaro, J. Laur , S. Calders
Royal Belgian Institute for Space Aeronomy

BRAMS (Belgian RAdio Meteor Stations) is a Belgian forward-scatter radio network dedicated to the detection and characterization of meteors entering the Earth's atmosphere. It comprises a dedicated beacon at 49.97 MHz (340 W) and 51 receiving stations, including two interferometers. Its main strengths are the large number of stations, allowing full coverage of the meteoroid path, and a high sampling rate of about 6 kHz. Recently, meteoroid trajectory and velocity reconstruction has been achieved using time delays between echoes recorded at different stations, combined with pre-t0 phase measurements. In this talk, the current status of the network will be presented, together with first results on fireballs and observations of the uncontrolled Starlink re-entry of 27 August 2024. Future work on fireballs and space debris with BRAMS will also be discussed.

Observations of space debris re-entry by the Odin satellite

P. Noble [1], **Ch. von Savigny** [2], **L. Megner** [1], **J. Gumbel** [1]

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[2] *University of Greifswald, Institute of Physics, Greifswald, Germany*

The rate of satellite launches is increasing rapidly and is only expected to continue growing. To limit the accumulation of space debris at orbital altitudes, satellites and rocket stages are routinely de-orbited and allowed to burn up in the atmosphere. However, the potential atmospheric impacts of the ablation of anthropogenic material remains very poorly understood. For example, the impact on ozone chemistry, aerosol microphysics, and radiative balance are all unknown. Modelling studies have been able to simulate possible scenarios but these have been largely unconstrained by observations.

In this work, we present the first satellite observations of a space-debris re-entry event using the OSIRIS instrument onboard the Odin satellite. The observations reveal signatures consistent with mesospheric metal pollution from re-entering debris and demonstrate that such events can be detected from space. Observations over successive satellite overpasses provide further insight into the evolution and transport of the resulting atmospheric pollution. These results highlight the large potential of satellite-based observations of space debris pollution in (1) actively monitoring new pollution and accumulation and (2), providing constraints for modelling studies on the atmospheric impact.

The Nordic Space Tracking Radar (NOSTRA)

J. Kero [1], D. Kastinen [1], T. Grydeland [2], S. Lasanen [3], L. Macotela [2], M. Leinonen [3], B. Kårtveit [2], T. Teppo [3]

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[2] *Norwegian Research Centre (NORCE), Norway*
[3] *University of Oulu, Finland*

Earth is currently surrounded by approximately 17 000 satellites and a large population of space debris, with a total mass exceeding 15 000 tonnes. Fragmentation events have produced more than one million objects larger than 1 cm, posing increasing risks to space operations. The EISCAT_3D system will detect debris down to a few centimetres, and determine trajectories using tristatic observations, significantly enhancing EISCAT's contribution to space situational awareness. The Nordic Space Tracking Radar (NOSTRA) is a complementary initiative aiming to establish a Nordic capability for routine monitoring of space debris and satellites. It will consist of three S-band (2–4 GHz) transmitter–receiver stations in northern Fennoscandia, arranged in a $\sim$500 km triangle and enabling MIMO radar operation. Together, EISCAT_3D and NOSTRA will provide complementary capabilities for characterizing space objects, enabled by their differing operating frequencies and system architectures.

Ionospheric corrections for EISCAT space object observations

J. Aricoche [1], **D. Kastinen** [1], **J. Kero** [1], **A. Tjulin**[2,1]

[1] *Swedish Institute of space Physics(IRF), Kiruna, Sweden*
[2] *EISCAT AB, Kiruna, Sweden*

The number of active satellites is growing at an unprecedented rate. The improved observation capacity for small space debris particle is hence important for space situational awareness. In this study, EISCAT's radar measurements of electron densities have been used to correct orbit measurements of space objects for ionospheric effects on wave propagation. A forward model based on geometric optics in an inhomogeneous, anisotropic, lossy plasma has been employed for this purpose.
EISCAT's VHF and UHF simultaneous measurements were analyzed for space object detection. We compared the estimated position using UHF measurements with the actual locations obtained from the Precise Orbit Determination (POD) from available satellites. We have also compared the corrections based on electron density from physical models of the ionosphere and quantified the uncertainties that these different approaches introduce into the orbit measurements results.

Maxidusty-2 in-situ measurements and sample collection in NLC/PMSE layers

I. Mann [1], S. V. Olsen [1], Y. Eilertsen [1], Y. Yokoyama [1], J.-C. Tinguely [1], A. Spicher [1], J. Hedin [2], J. Gumbel [2], B. Strelnikov [3], K. Schueler [3], G. Baumgarten [3], R. Latteck [3], D. Huyghebaert [3], T. Renkwitz [3], E. Trondsen [4], L. Clausen [4]

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The mesosphere–lower thermosphere (MLT) contains ice particles and dust of refractory composition suppposedly formed in meteors. Ice particles are observed in summer at mid and high latitudes in noctilucent clouds, NLC, and polar mesospheric summer (radar) echoes, PMSE NLC and PMSE abundences increased over recent decades indicating possible changes in these layers. The Maxidusty-2 (MXD2) rocket was launched from Andoya, Norway into a layer with NLC and PMSE. The payload included four dust detectors, a neutral gas instrument, Langmuir probes and a Faraday rotation experiment to measure electrons. Two independent instruments collected dust particles. Initial analysis shows that the dust properties differ in two PMSE layers and that the infered dust charges are different from those measured with similar instruments during a 2016 campaign. Collected samp

Lunch

Information about Buses, Lunches, Excursion and Banquet

Bus:

There will be buses providing transportation to and from Space Campus where the Swedish Institute of Space Physics (IRF) and EISCAT HQ are located. The transportation will be provided each day. The buses will have a sign EISCAT/IRF. Bus 1 will take a route through Old city center and surroundings and Bus 2 through New city center as follows:

BUS 1 to Space Campus					
Bus Stop	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Camp Ripan	9:00	8:00	8:00	8:00	8:00
Norrmalm/Nikkaluoktaexpressen (Arctic Eden)	x	x	x	x	x
Sporthallen	x	x	x	x	x
Kiruna Stormarknad (Hotell E10)	9:10	8:10	8:10	8:10	8:10
IRF	x	x	x	x	x

(x = the bus stops for boarding or alighting; - = the bus doesn't stop)

BUS 1 to Hotels					
Bus Stop	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
IRF	17:30	17:30	*	17:30	12:50
Airport (only Friday flight 14:00)	-	-		-	x
Kiruna Stormarknad (Hotell E10)	x	x		x	x
Sporthallen	x	x		x	x
Norrmalm/Nikkaluoktaexpressen (Arctic Eden)	x	x		x	x
Camp Ripan	x	x		x	x

(x = the bus stops for boarding or alighting; - = the bus doesn't stop; * see Excursion)

BUS 2 to Space Campus					
Bus Stop	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Hagelstigen (Kiruna City Studios)	9:00	8:00	8:00	8:00	8:00
Stadshustorget	9:05	8:05	8:05	8:05	8:05
IRF	x	x	x	x	x

(x = the bus stops for boarding or alighting; - = the bus doesn't stop)

BUS 2 to Hotels					
Bus Stop	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
IRF	17:30	17:30	*	17:30	13:30
Airport (only Friday flight 16:00)	-	-		-	x
Stadshustorget	x	x		x	x
Hagelstigen (Kiruna City Studios)	x	x		x	x

(x = the bus stops for boarding or alighting; - = the bus doesn't stop; * see Excursion)

Lunch:

Lunch will be provided in the Atmosfären restaurant at IRF. Because of the seating limitations the participants will have to split to two groups and space out the lunch over the provided time-slot.

Excursion:

Please remember that Kiruna and Kaiseniemi/Abisko are located in the polar region. Average day temperatures in August are around 10°C, light jacket against the wind/rain and some warmer layer will be most probably needed for the excursion. The participants will take lunch based on if they belong to Bus 1 or Bus 2 as Bus 1 is leaving Space Campus earlier. Excursion is happening the following way:

BUS 1		**BUS 2**	
IRF	12:45	IRF	13:15
Abisko	14:00-15:15	Kaiseniemi	14:15-15:15
Kaiseniemi	15:45-16:45	Abisko	15:45-17:00
Camp Ripan	17:45	Hagelstigen	18:15
Norrmalm/Nikkaluoktaexpressen (Arctic Eden)	x	Stadshustorget	x
Sporthallen	x		
Kiruna Stormarknad (Hotell E10)	x		
IRF/Space campus (only alighting)	x		

(x = the bus stops for boarding or alighting; - = the bus doesn't stop)

Banquet:

Banquet will take place in Aurora Kultur och Kongress (New city centre). Bus transportation from hotels to the venue and back is provided by Bus 1 as follows:

BUS 1 (to banquete)		BUS 1 (to hotels)	
Camp Ripan	18:45	Stadshustorget	23:15
Norrmalm/Nikkaluoktaexpressen (Arctic Eden)	x	Hagelstigen (Kiruna City Studios)	x
Sporthallen	x	Kiruna stormarknad (Hotel E10)	x
Kiruna stormarknad (Hotel E10)	18:55	Sporthallen	x
Hagelstigen (Kiruna City Studios)	x	Norrmalm (Arctic Eden)	x
Stadshustorget	x	Camp Ripan	x

(x = the bus stops for boarding or alighting; - = the bus doesn't stop)

More detailed information about buses with bus-stop maps will come in the week before the Symposium together with other necessary information about lunches, banquet and excursion if any will be needed.