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Abstracts

Scandinavian Magnetometer Array recordings and the digitisation method

Otto Kärhä, Eija Tanskanen

Sodankylä Geophysical Observatory, University of Oulu

The International Magnetospheric Study (IMS) took place from 1977 to 1979. The Scandinavian Magnetometer Array (SMA), where a dense magnetometer chain was placed in the northern part of Scandinavia, was part of the IMS. This chain extended in north-south as well as east-west directions. The SMA-instruments contained a camera with 35mm film and three wire-suspended magnets.

The movement of the magnets were recorded optically on the film. Each film reel contains about two months of the data from one of the 36 magnetometer stations.

The total amount of available SMA data is 44000 days and 29km. In order to utilise the optical data recorded on the film, it must be digitised.

I will present the idea behind the custom-build digitisation device DigiMAG and show the examples of the recently digitised data.

Large GIC in Northwest of Russia

Ya. Sakharov, V.Selivanov

Polar Geophysical Institute, Kola Science Centre

We consider events with large amplitude of GIC at the nodes of the Northern Transit trunk transmission line (Russia) under various geomagnetic disturbances. The relationship between GIC events and conditions affecting the generation of currents in the power system, namely, the magnitude of the geomagnetic disturbance, the rate of change of the horizontal component of the geomagnetic field, the parameters of power lines are discussed.

Abstracts

Modelling of airborne Full Tensor Magnetic Gradiometry

Jouni Nevalainen, Elena Kozlovskaya, Jukka-Pekka Ranta

University of Oulu, Oulu Mining School

Magnetic technique has been a “backbone” mineral exploration method in geophysics from 17th century in Europe. In 1937, the first fluxgate sensors were developed that could measure three directional components of the magnetic field. This started the industrial wide use of magnetometers in mineral exploration. Now-a-days total field magnetic measurements are routinely done in ground, borehole and airborne surveys. Although magnetic signature for any material containing magnetic material is detectable using “common” total field intensity instrumentation, its modelling can be difficult due the potential field nature of magnetic field. In addition, presence of remanence magnetisation and/or magnetic material in side rock can make accurate modelling challenging. The complete description of the magnetic field through magnetic gradient measurements provide more information of the size, shape and material property of the magnetic rock mass. This is due that a specific magnetic objects effect is observed in all magnetic field gradients and thus constrain the number of possible magnetic models. During past decade highly sensitive magnetometers based in SQUID (Superconducting QUantum Interference Devices) technology has been successfully adopted in Full Tensor Magnetic Gradiometry airborne measurements, which has made magnetic methods a “new coming”. In this presentation the benefits of airborne FTMG Gradiometry through forward modelling and its comparison with airborne FTMG data measured in Northern Finland are discussed.

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Hybrid-Vlasov simulation of auroral proton precipitation in the cusps: Comparison of northward and southward interplanetary magnetic field driving

Maxime Grandin(1), Markus Battarbee(1), Maxime Dubart(1), Urs Ganse(1), Andreas Johlander(1), Yann Pfau-Kempf(1), Lucile Turc(1), and Minna Palmroth(1,2)

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We present the first hybrid-Vlasov simulations of proton precipitation in the polar cusps. We use two runs from the Vlasiator model to compare cusp proton precipitation fluxes during southward and northward interplanetary magnetic field (IMF) driving. The simulations reproduce well-known features of cusp precipitation, such as a reverse dispersion of precipitating proton energies, with proton energies increasing with increasing geomagnetic latitude, under northward IMF driving, and a non-reversed dispersion under southward IMF driving. The cusp location is also found more polewards in the northern IMF simulation than in the southern IMF simulation. In addition, we find that the precipitation takes place in the form of successive bursts during southward IMF driving, those bursts being associated with the transit of flux transfer events in the vicinity of the cusp. In the northward IMF simulation, dual lobe reconnection takes place. As a consequence, in addition to the high-latitude precipitation footprint associated with the lobe reconnection from the same hemisphere, we observe lower-latitude precipitating protons which originate from the opposite hemisphere's lobe reconnection site. The proton velocity distribution functions along the newly closed dayside magnetic field lines exhibit multiple proton beams travelling parallel and antiparallel to the magnetic field direction, which is consistent with published observations with the Cluster spacecraft. We suggest that precipitating protons originating from the opposite hemisphere's lobe reconnection site, albeit unfrequent, could be observed in a situation of dual lobe reconnection.

Solar cycle variation of simple and complex active regions

Shabnam Nikbakhsh(1) and Eija Tanskanen(2)

(1) Aalto University; (2) SGO, University of Oulu

Solar active regions emerge on the Sun's photosphere and they frequently produce flares and coronal mass ejections (CMEs) which are among major space weather drivers. Therefore studying ARs can improve space weather forecast.

The Mount Wilson Classification groups ARs according to their magnetic structures from the less complex, Alpha class, to the more complex one, Beta-Gamma-Delta class. In this study, we investigated the daily Mount Wilson magnetic classification of ARs.

We showed that the abundance of Simple ARs (SARs) follows very closely the sunspot number. In addition, we found that in both cycle 23 and 24, the abundance of SARs peaks during the sunspot maximum. On the other hand, the abundance of Complex ARs (CARs) reaches its maximum value two years after solar maximum in both cycles. We also studied the latitudinal distributions of the different magnetic complexity classes, and found out that, independent of the complexity type, the northern and southern distributions are the same.

Abstracts

Radiation Belt Electron Impact on Polar Atmospheric Ozone: a Simulation Study on Importance of Magnetic Local Time Dependency

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The radiation belts are regions in the near-Earth space where solar wind electrons are captured by the Earth's magnetic field. A part of these electrons is continuously lost into the atmosphere where they cause ionisation and chemical changes. Driven by the solar activity, electron forcing displays a decadal cycle which leads to ozone variability in the polar regions. Understanding possible dynamical connections to regional climate is an on-going research activity which supports the assessment of greenhouse gas driven climate change by better definition of the solar-driven variability. In the context of the Coupled Model Intercomparison Project Phase 6 (CMIP6) and the coming IPCC report, energetic electron and proton precipitation is included in the solar forcing recommendation for the first time. For radiation belt electrons, CMIP6 forcing is from a daily, zonal mean proxy model which is driven by the geomagnetic Ap index and provides a forcing data set extending back to 1850. This zonal mean model thus ignores the well-known dependency on magnetic local time (MLT), i.e. the diurnal variability. Here we use the Whole Atmosphere Community Climate Model with lower ionospheric chemistry extension (WACCM-D) to study the effect of MLT-dependency of electron forcing in polar ozone response. We analyse simulations with MLT-dependent and MLT-independent forcing, and contrast ozone responses in monthly mean data as well as in monthly means of individual local time sectors. We consider two cases: 1) year 2003 and 2) extreme, long-duration forcing. Our results indicate that the ozone responses to MLT-dependent and MLT-independent forcings are very similar, and the differences found are relatively small compared to overall uncertainties in electron forcing. Therefore, the fact that the CMIP6 electron forcing ignores MLT dependency should not create any significant error in long-term climate simulations.

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Long term ozone observations at Sodankylä

Rigel Kivi

Finnish Meteorological Institute

At Sodankylä ozone measurement programs were established in late 1980s, soon after the discovery of the Antarctic ozone hole. A Brewer spectrophotometer with serial number #037 has been taking regular total ozone measurements since early 1989. In addition, since 1990, total ozone and nitrogen dioxide columns have been obtained both at sunrise and sunset on a daily basis using a SAOZ spectrometer (Système D'Analyse par Observations Zénithales). First ozone sondes were also flown in late 1980s at Sodankylä. There is a continuous record of ozone soundings since 1989. At Sodankylä site electrochemical concentration cell (ECC) ozonesondes have been flown since the start of the measurements. Main instrumental change took place in February 2006. In order to assess the impact of change from SPC to EN-SCI sondes, a series of dual sonde launches was performed. In dual sonde payloads an EN-SCI ozonesonde was flown using a 0.5 % KI sensing solution and a SPC ozonesonde using 1% KI solution. The comparison flights showed an average agreement better than 2 % in the stratosphere. Therefore it is possible to assume that the sonde data set can be used for trend studies. Comparison of integrated sonde data with total column observations by Brewer spectrometer was also performed. No biases during the long term measurements were found. Regarding the sonde comparisons with satellite borne (Microwave Limb Sounder (MLS) and the Ozone Monitoring Instrument (OMI)) profile retrievals there has been a positive bias above 10 hPa of altitude and a negative bias at around 30 hPa. However, sonde total column comparisons with the OMI total ozone measurements have shown good agreement.

SGO Observations – Towards a Nordic Observatory Roadmap

Thomas Ulich, Urban Brändström, and the Nordic Observatory Collaboration Team

SGO, KAGO/IRF Kiruna, FMI, TGO, PGI, ISEE/U Nagoya

We will give an overview of the status of SGO's Observational Programme and report on the progress of the Nordic Observatory Collaboration. Specifically, we will discuss the Roadmap for Observatories which is envisaged by the collaboration. The Roadmap is intended to serve as an overview of plans for instrumentation maintenance, upgrade, and possible needs for new kinds of instrumentation, which allows interested parties to find synergies and identify areas to collaborate in these developments. Also an inventory of the current instrumentation and their locations is being finalised by the team.

Abstracts

Geomagnetic observations at SGO

T Raita, T Rantala, and P Lakkala

Sodankylä Geophysical Observatory, University of Oulu

Sodankylä Geophysical Observatory has 106 years history of geomagnetic measurements. The longest time series are from basic parameters (hourly means and geomagnetic activity indexes). The digital era started in mid 1980's and digital induction coil measurements started in 1995. This talk will present the status of SGO geomagnetic observations including status of new 250Hz induction magnetometers.

Cosmic ray measurements by SGO: status report

Stepan Poluianov and Ilya Usoskin

Sodankylä Geophysical Observatory, University of Oulu,
Space Physics and Astronomy Unit, University of Oulu

This conference contribution covers the status of real-time measurements of cosmic rays by Sodankylä Geophysical Observatory. The cosmic ray variability is measured by neutron monitors located in Oulu, Finland and at station Concordia, Antarctica. In 2019, there were a major electronics upgrade of Antarctic neutron monitors and introduction of a dedicated data server to the Oulu cosmic ray stations. The results of the upgrades are presented.

Abstracts

Statistical survey of Energetic Electron Precipitation events using coordinate observations from Arase and ground Riometer network

Neethal Thomas1, Antti Kero1, Miikka Hyötylä1, Kazuo Shiokawa2, Yoshizumi Miyoshi2, Yoshiya Kasahara3, Satoshi Kasahara4, Shoichiro Yokota5, Kunihiro Keika4, Tomo Hori2, Shiang-Yu Wang6, Yoichi Kazama6, C-W. Jun2, Sunny Wing-Yee Tam7, Tzu-Fang Chang7, Bo-Jhou Wang6, Kazushi Asamura5, Ayako Matsuoka5, and Iku Shinohara6

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The energetic electrons present in the radiation belt and that injected into the nightside magnetosphere in association with substorm intervals are known to accelerate and precipitate into the Earth's atmosphere under favourable conditions. The resonant interactions of the energetic electrons with different plasma waves and the ultra-low frequency pulsations in the magnetosphere are considered as the possible candidates for the Energetic Electron Precipitation (EEP) events. In order to understand the characteristic nature of the EEP events and its dependence on different generation mechanisms, we have performed a statistical analysis employing coordinate observations from ground riometer network and inner-magnetospheric satellite mission, Arase. We have analysed over one year of data between March 2017 to June 2018. EEP events are firstly identified by the ground riometer network (located between Geographic Latitude: 60°N to 77°N and Geographic longitude: 15°E to 28°E) operated by Sodankylä Geophysical Observatory over northern Finland by estimating the cosmic noise absorption. The events for which Arase has ionospheric footprints near the riometer locations are considered in this study. The riometer observations are then compared with the comprehensive dataset of plasma waves/flux and the electric and magnetic fields observations obtained from Arase satellite. The study aims to quantify the source mechanisms, its dependence on the energy of the penetrating electrons, the MLT dependence of the EEP events, etc. The statistical results along with case studies will be presented.

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Mega-constellations vs. Astronomy - International Law and the right to see the stars

Stefan Kirchner

University of Lapland, Arctic Centre

For untold generations, the view of the starry night sky has sparked the human imagination, but already today, the experience of a clear night sky full of stars is restricted to rural and remote areas with little light pollution and children growing up in urban areas today might not be aware of the wonders of the night sky. Light pollution as a problem has often been considered a regional issue and a necessary byproduct of urbanisation and economic and technological development. In recent months, though, a new threat has emerged, which already affects ground-based astronomy. Large-scale satellite constellations, like SpaceX's Starlink threaten to make ground-based astronomy difficult, especially the search for moving objects such as small near-Earth objects. Currently, space activities are a growing concern for the Arctic academic community and large-scale satellite constellations can also affect scientific research in the Nordic region. It is argued by some that the disturbance might only be temporary, but this appears to be far from clear and the question nevertheless requires a clear solution. The currently prevailing legal opinion appears to be that there is very little in international space law which might prevent private actors from launching a large number of satellites in low earth orbits, despite the impact it has on astronomy, and that space-based observatories are the future. n this presentation the problem of decreased observability of the night sky is discussed from the perspective of international law, in particular international space law and the right to conduct scientific research with the aim of reconciling the interests of New Space enterprises with the interest of future generations to be able to see the stars.

NOSWE - The Norwegian Centre for Space Weather

Raisa E. Leussu and Daniel Martini

Norwegian Centre for Space Weather (NOSWE), Tromsø Geophysical Observatory (TGO),
UiT - The Arctic University of Norway

The Norwegian Centre for Space Weather (NOSWE) is a unit established under Tromsø Geophysical Observatory (TGO) at UiT – the Arctic University of Norway, in Tromsø – a junction point for industries affected by space weather including the oil industry and auroral tourism. NOSWE has been formally appointed by the responsible government body (The Norwegian Space Agency) as the regional space weather warning centre in Norway, and as of 2019, formally accepted as part of the International Space Environment Services as the regional warning centre in Norway.

NOSWE acts as the contact point for, most importantly, government directorates and industries in issues concerning space weather, but also for the general public with related questions. We present our work in increasing the national preparedness for space weather events in Norway, the background of NOSWE's establishment, and some key areas for future development.

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New software radio and FPGA based general purpose radio signal sampler introduction

M Lehtinen, M Suovula, M Fletcher, T Tallkvist, N Asplund

SGO, Inverpolis Oy, Holmark Oy, RF-shamaanit Oy

This is an introduction to our developments for a family of software radio and FPGA based radio instruments. The steps so far taken include ready made robust and field-deployable products for ionospheric radio tomography, spectral riometers and imaging array radar systems. Special emphasis is on the planned second generation, further integrating the processing computers together with the FPGA using Xilinx ultrascale technology SoC (System on Chip) family of Zynq chips.

Superb scientific data by mitigation of environmental radio interference

Michael Fletcher

RF-shamaanit Oy

Pre-emptive site survey work is imperative for recovering weak radio phenomena when using state of the art software defined scientific radio equipment. Determining optimal installation location is a combination of maximum access to the direction of observation, but also minimising interference coupled from Electro-Magnetic Interference sources in the vicinity. The latter more often than not, requires extra work on nearby other instrumentation in order to remove or at least effectively reduce EMC radiation not identified earlier.

Software defined scientific radio instruments for harsh conditions

Tomas Tallkvist

RF-shamaanit Oy

Generic hardware solutions enable cost effectiveness along with repeatable radio performance over wide temperature ranges and extremely variable weather conditions. Very careful radio frequency design provides practically non-existent self-interference whilst also allowing excellent performance amidst the legitimate spectral energy of todays communications services.

Abstracts

Diversity of the auroral-subauroral ionosphere and thermosphere during very low Kp condition

Shin-ichiro Oyama, Anita Aikio, Heikki Vanhamaki, Yasunobu Ogawa, Atsuki Shinbori, Mike Rietveld, Mirjam Kellinsalmi, Abiyot Workayehu, Marcus Pedersen

ISEE Nagoya Univ., Univ. of Oulu, NIPR, EISCAT, FMI

The Kp index has been widely used for representing global-scale geomagnetic activity. The lowest number of 0, however, may not mean auroral energy inputs would completely be terminated from the Magnetosphere into high latitudes. This study will present an event at Kp=0, analysing ionospheric and thermospheric data obtained with various instruments on the ground and the space. Many phenomena, which can be typically seen at auroral and sub-auroral latitudes, were identified in this event but confined into the poleward area from the common location of these phenomena during more active conditions. The auroral oval and the ionospheric trough were located at 73-79N and 69-71N, respectively, in the Scandinavian sector. In the trough, westward high-speed ion flow and westward Thermospheric-wind acceleration were developed with downward FAC around a pseudo-substorm onset time. The current system embedded between the auroral oval and the trough was characterised by many fine structures, which may not have been focused in the previous studies. The event also showed that Ionospheric/Thermospheric changes in the trough had tight connection with those in the auroral oval. This suggests importance of wide latitudinal coverage of measurement for the Magnetosphere-Ionosphere-Thermosphere coupling.

Abstracts

Characteristics of an HSS-driven magnetic storm in the high-latitude ionosphere; A case study of 14th of March 2016 storm

Nada Ellahouny (1), Anita Aikio (1), Marcus Pedersen (1), Heikki Vanhamäki (1), Ilkka Virtanen (1), Johannes Norberg (2), Maxime Grandin (3), Alexander Kozlovsky (4), Tero Raita (4), Kirsti Kauristie (2), Aurelie Marchaudon (5), Pierre-Louis Blelly (5)

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Solar wind High-Speed Streams (HSSs) affect the auroral ionosphere in many ways, and several separate studies have been conducted of the different effects seen e.g. on aurora, geomagnetic disturbances, F-region behaviour, and energetic particle precipitation. In this presentation, we study an HSS event in the current solar cycle (24), which was associated with a co-rotating interaction region (CIR) that hit the Earth's magnetopause at about 18:30 UT on 14 March 2016. The associated magnetic storm lasted for eight days, and the Dst index reached -56 nT. We use a very comprehensive set of measurements to study the whole period of this storm, following day by day for the magnetic indices and solar wind parameters and relating its consequences on ionospheric plasma parameters. We use EISCAT radar data from Tromsø and Svalbard stations to see the response in plasma parameters at different altitudes, riometer data for cosmic noise absorption, and IMAGE magnetometers to see the intensities of auroral electrojets. TomoScand ionospheric tomography provides us with electron densities over a wide region in Scandinavia and AMPERE data the global field-aligned currents. We identified 13 local substorms in the Scandinavian sector from the IL (MAGE lower) index. Altogether, there were 11 global substorms, for which the AE index reaches 1000 nT. We discuss the development of currents, as well as E and D region precipitation during the course of this long-duration storm and compare local versus global behaviour.

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Occurrence and altitude of the non-specular long-lived meteor trails during meteor showers

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The meteor radar observations at Sodankylä Geophysical Observatory during 2008-2019 were used to study occurrence and height distributions of the long-lived non-specular (LLNS) meteor echoes which are received from the non-field-aligned irregularities generated along traces of relatively large meteoroids. The LLNS meteor echoes constitute about 2% of all meteor radar detections, however during some showers (Geminids, Perseids, Quadrantids, Arietids or/and Daytime ζ-Perseids, and Lyrids) the percentage of LLNS echoes is noticeably higher (of the order of 6, 5, 4, 4, and 3%, respectively). The LLNS meteor echoes typically occur ~2 km higher than other echoes (except June-July when the height difference is ~1 km). Because of that, larger percentage of LLNS during some meteor showers is manifested as upward shift of the height distribution of meteor trails. Moreover, during some showers (Lyrids, η-Aquariids, Perseids, Orionids, and Leonids) the LLNS echoes occur noticeably (up to 3-6 km) higher than other trails. Thus, enhanced heights of meteor detections during major meteor showers (Quadrantids, Lyrids, η-Aquariids, Arietids or/and Daytime ζ-Perseids, Perseids, Orionids, Leonids, and Geminids) are predominantly due to long-lived non-specular echoes from the non-field-aligned irregularities associated with large meteoroids.

Analysis of the dynamical evolution of the Quadrantid meteoroid stream

G. E. Sambarov and T. Yu. Galushina

Research Institute of Applied Mathematics and Mechanics, Tomsk State University

We investigate numerically the dynamical evolution of simulated meteoroid stream of the Quadrantids ejected from the parent body of the asteroid (196256) 2003 EH1. The main goal of this work is to identify mean motion and secular resonances and to study the mutual influence of resonance relations and close encounters with the major planets. Since the dynamics of this asteroid is predictable only on short time intervals, and not only close and/or multiple close encounters with major planets, but also the presence of at least one unstable resonance can lead to chaotic in motion of test particles, we studied their resonant dynamics. The dynamical evolution of the test particles expects possible scenario for resonant motion. We conjecture that the reasons of chaos are the overlap of stable secular resonances and unstable mean motions resonances and close and/or multiple close encounters with the major planets. The estimate of the stability of orbits in which the particles in simulations moved was carried out by analysing the behaviour of the parameter MEGNO (Mean Exponential Growth factor of Nearby Orbits). The larger part of the identified resonances is stable. We found a peculiar behaviour for this stream. Here, we show that the orbits of some ejected particles are strongly affected by the Lidov–Kozai mechanism that protects them from close encounters with Jupiter. Lack of close encounters with Jupiter leads to a rather smooth growth in the parameter MEGNO and the behaviour imply the stable motion of simulation particles of the Quadrantids meteoroid stream.

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The effects of Aerosols and solar activity on the Global Atmospheric Electrical Circuit in a changing Climate

Marzieh Khansari and Eija Tanskanen

Sodankylä Geophysical Observatory

Monitoring and researching the global electric circuit (GEC) is crucially important due to its links with climate change. They are connected by lightning activity, which itself is a measure of the GEC. Furthermore, it is known that space weather affects the Earth's lightning, therefore the GEC might prove to be a critical tool in examining climate change in terms of solar and lightning activity.

In a warming climate, it is entirely possible that lightning activity could increase. Many variables can be obtained by researching lightning activity; surface temperature, tropical deep convection, rainfall, upper troposphere water vapour content and other important parameters, which clearly affect the global climate system and are affected by climate change.

Another increasingly important question is whether or not aerosols will contribute significantly to the Earth's radiation budget, whether it be cooling or warming the climate. In a warming climate aerosol loading could alter and increase lightning activity, which in turn can lead to a positive feedback due to generation of NO_x and thus O_3 in the troposphere, a potent greenhouse gas.

Utilising state-of-the-art in-situ and remote sensing instruments and data sets for example from NASA, NOAA and Sodankylä observatory, the linkage between the global electric circuit, aerosols, space weather and climate will be investigated."

Ground-based observation of banded-structure VLF emissions in the 5-39 kHz frequency range at subauroral latitudes

Edith L. Macotela[1], Jyrki Manninen[1], Kazuo Shiokawa[2], Claudia Martinez-Calderon[2], Mitsunori Osaki[3], Shin-Ichiro Oyama[2], Martin Connors[4], Akira Kadokura[5], Tauno Turunen[1]

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Analysis of very low frequency (VLF) radio waves provides us with an outstanding possibility of investigating the response of both the lower ionosphere and magnetosphere to a diversity of transient and long-term physical phenomena originating on Earth (e.g. atmospheric waves) and/or from space (e.g. solar flares). In this work, data obtained by four VLF radio receivers, which are part of the PWING network, located in northern Finland (Kannuslehto, magnetic latitude: 64.5N), Canada (Athabasca, 61.3N), Alaska (Gakona, 63.0N), and Iceland (Husafell, 64.9N) are used to look for banded structures in natural VLF emissions observed in the 5-39 kHz frequency range. Analysing the time window between November 2017 and February 2018, we observed banded structure emissions that occur mostly during the evening local time. We found that some of the events occur before substorms while others occur during substorm activity. This study shows the first evidence in which banded-structure VLF emissions are observed at subauroral latitudes.