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Abstracts

Kiruna Atmospheric and Geophysical Observatory --- status report

U. Brändström, J. Kero, T. Leyser, D. Mikhaylova, P. Nilsson, U. Raffalski, M. Rönnfalk, T. Sergienko, L-H. Snow, M. Yamauchi

Swedish Institute of Space Physics (IRF), Sweden

Status report of observatory-activities (long-time monitoring) within IRF. Kiruna Atmospheric and Geophysical Observatory (KAGO) operates around 40 instruments in 12 different locations in Sweden, from Abisko in north to Tormestorp in the south. During the last year IRF again provides ionosonde data from three locations (Kiruna, Lycksele and Uppsala). ALIS_4D is extended from five to eight optical stations during this season. The talk also to some extent concerns Nordic observatory collaboration and interfacing observatory instruments as complementary instruments for EISCAT_3D.

Data handling in EISCAT and EISCAT_3D

Carl-Fredrik Enell, Harri Hellgren, and Juri Katkalov

EISCAT Scientific Association, Kiruna, Sweden

I will give an overview of the state of the legacy EISCAT data archives (portal and Madrigal) and discuss options for future EISCAT_3D data archives and access. Topics for discussion include:

1. Does authentication for access using EGI Checkin work for everybody?
2. Do we want to maintain the legacy EISCAT ISR and Dynasonde data archives, as well as future Svalbard radar data, separate from the EISCAT_3D archives?
3. Short summary of supporting projects (Pithia-NRF, Envri-FAIR, etc)

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Temporal and Spatial Variations of Total Electron Content during an HSS/CIR driven storm at high and middle latitudes

G. P. Geethakumari(1), A. Aikio(1), L. Cai(1), H. Vanhämaki(1), M. Pedersen(1), A. Coster(2), A. Marchaudon(3), P.-L. Blelly(3), V. Haberle(3), A. Maute(4), N. Ellahouny(1), I. Virtanen(1), J. Norberg(5), S. Oyama(6), and M. Grandin(7)

(1) Space Physics and Astronomy Unit, University of Oulu; (2) MIT Haystack Observatory, USA; (3) IRAP, University of Toulouse, France; (4)High Altitude Observatory, NCAR, USA; (5) Finnish Meteorological Institute, Helsinki; (6) ISEE, Nagoya University, Japan; (7) CoE in Sustainable Space, University of Helsinki

Solar wind interactions with the Earth's magnetosphere cause geomagnetic storms and thereby induce ionospheric storms. Many studies have been carried out for strong magnetic storms. Less has been explored about moderate or weak storms and their impacts on the ionosphere. This study investigates the spatio-temporal evolution of the ionospheric Total Electron Content (TEC) during a moderate (Sym-H index minimum: -63 nT) but long duration storm driven by two interacting solar wind high-speed streams (HSSs) and associated co-rotating interaction regions (CIRs) during 14-21 March 2016. The storm starts with a strong storm sudden commencement (SSC) with a peak close to 19 UT on 14 March 2016. The GNSS/TEC maps are obtained from the Madrigal database. The associated field-aligned currents (FACs) from AMPERE, ionospheric convection maps from SuperDARN, and the O/N2 ratio from TIMED/GUVI are also studied for understanding the physics behind the different features observed in TEC during the storm.

The study predominantly focuses on the changes of TEC at high and middle latitudes and the possible coupling between the two. The storm induced changes in the TEC were extracted by removing the quiet time background (mean of five quietest days of the month) from the TEC maps. Differential response of TEC variations are observed during different phases of the storm. During the initial phase, TEC enhancements and depletions are found mainly at high latitudes within the auroral oval and close to the cusp, plausibly associated with auroral precipitation and variations in the upward and downward field-aligned currents (FACs). After the onset of the main phase, the TEC is enhanced at mid-latitudes and auroral ovals with a maximum of ~10 TECU. Meanwhile, a significant decrease in TEC is observed in the polar cap region. During the main phase, we observe the evolution of a storm-enhanced-density (SED) plume and a transient enhancement of TEC in the polar cap. During the late main and the recovery phases, a strong TEC depletion at high and middle latitudes is found on the dayside and in the evening sector. The depletion of O/N2 ratio, triggered by Joule heating and atmospheric upwelling, could be a plausible reason for the TEC depletion. The possible physical mechanisms associated with the observed TEC variations will be discussed.

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EISCAT_3D system development status

Harri Hellgren

EISCAT Scientific Association, Kiruna, Sweden

I will present EISCAT_3D system development status and discuss future plans for user interactions.

Investigating solar wind's effect on ground ULF power over SC24

R. Hynönen(1,2); E. I. Tanskanen (1)

(1) Sodankylä Geophysical Observatory, University of Oulu;
(2) School of Electrical Engineering, Aalto University

We study ultra-low frequency (ULF) wave power on the ground in IMAGE magnetometer chain over the course of the last solar cycle, and cross-examine it in relation to solar wind speed and other solar wind quantities like interplanetary magnetic field. We control for solar wind speed using a bootstrapping method, demonstrating that ULF power on the ground depends exponentially on the solar wind speed regardless of location and magnetic local time.

We show that while most of the dependence of ground ULF power over the solar cycle can be attributed to solar wind speed or dynamic pressure, magnetic field direction and the heliospheric current sheet influence seem to influence where the strongest fluctuations are detected on the ground.

Energetic particle precipitation signal found in the bromine acid observation

J. Jia(1,2), M. E. Szeląg(3), M. Höpfner(4), P. T. Verronen(3,5), and P. J. Espy(1,2)

(1) Norwegian University of Science and Technology (NTNU), Trondheim, Norway; (2) Birkeland Centre for Space Science (BCSS), Norway; (3) Space and Earth Observation Centre, Finnish Meteorological Institute, Helsinki, Finland; (4) Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research, Karlsruhe, Germany; (5) Sodankylä Geophysical Observatory, University of Oulu, Sodankylä, Finland.

Bromine acid ($BrONO_2$) is a major reservoir of the active bromine radicals that contribute to the formation of ozone hole. Energetic particle precipitation (EPP) generated NOx enhancement is known to lead to ozone loss in the mesosphere and upper stratosphere. In the lower stratosphere, however, this NOx enhancement is believed to restrain ozone depletion by 'locking' the active chlorine and bromine species to the reservoir forms (HCl/HBr and ClONO2/BrONO2). In this study we report $BrONO_2$ response to EPP for the first time, using the latest BrONO2 measurement data from the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on Envisat. We report a positive and significant correlation between BrONO2 and EPP Ap index above 30km in Arctic. In addition, the Whole Atmosphere Community Climate Model with D-region ion chemistry (WACCM-D) was used to characterise the EPP contribution to $BrONO_2$ formation.

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Metsähovi Radio Observatory in the 2020s

J. Kallunki and J. Tammi

Metsähovi Radio Observatory, Aalto University, Kylmälä, Finland

Aalto University Metsähovi Radio Observatory has gotten a major facelift over the past three years. The observatory has new premises, and the old buildings are renovated. The protective radome of the 14-metre radio telescope is renewed, and the radio telescope steering system is upgraded with modern servo drives. In the instrumentation section, a prototype of the water vapour radiometer was installed in the spring of 2022, and a new aurora camera is now operational. Furthermore, the first new MCA radio telescope (5.5-metre dish at frequency range of 4-8 GHz) started regular observations in the summer 2022, and the telescope has already been used for hands-on education and to launch a methanol maser monitoring programme; the second MCA radio telescope is being constructed. Finally, we are in the process of purchase a new triple-band (K-, Q- and W-bands) radio astronomical receiver for the 14-metre radio telescope for next-level radio astronomy.

Calibration of all-sky cameras resumed

M van de Kamp

Finnish Meteorological Institute, Helsinki

The FMI all-sky camera in Kilpisjärvi had last been calibrated in September 2016. After that, the calibration was skipped a couple of years, and also other cameras were calibrated less frequently than before. In order to get the calibrations back on track, in September 2022, the Kilpisjärvi and Abisko cameras were calibrated by Tero Raita and Max van de Kamp at the calibration tools at SGO. As part of the same session, Urban Brändström calibrated the calibration tools using the radioactive phosphor sources. It is planned that from this moment onward, the calibrations will again be performed regularly. At least, the current calibration results will enable the quantitative analysis of Kilpisjärvi aurora pictures of the past few years.

EISCAT/EISCAT_3D meteor and space object, current and planned, research at IRF

D Kastinen and J Kero

Swedish Institute of Space Physics

The current EISCAT systems have historically and continue to contribute to research on the topics of meteors and space objects such as space debris. With the construction of EISCAT_3D a slew of new and exciting research is foreseen, but will undoubtedly also emerge as the system begins to operate. In order to fully utilise EISCAT/EISCAT_3D and the surrounding research infrastructure it is important to coordinate research efforts. This coordination enables us to utilise each other's development (to not reinvent the wheel), but also to use duplicated efforts as validation. We will present current and planned research at IRF, using EISCAT/EISCAT_3D and complementary instruments, on the topics of meteors, space debris, and near-Earth objects.

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Ground based validation of the particle forcing used in CMIP climate models

A. Kero(1), N. Thomas(1), and Pekka Verronen(1,2)

(1) Sodankylä Geophysical Observatory, University of Oulu;
(2) Finnish Meteorological Institute

In this presentation, we evaluate various EPP forcing models (see https://doi.org/10.1029/2021JA029128) proposed for the CMIP climate models against the EISCAT VHF data. This work is part of the on-going HISSA project.

EISCAT_3D and complementary instruments: an inventory of research infrastructure needs

J. Kero, D. Kastinen, and U. Brändström

Swedish Institute of Space Physics (IRF), Kiruna, Sweden

The Swedish Research Council (VR) carries out a prioritisation of needs related to research infrastructure of national interest in a recurrent cyclical process over two years. The first stage consists of a needs inventory, with an upcoming call during 2023. The outcome of the needs inventory is then used as the basis of a targeted call for applications in 2024.

We would like to discuss needs related to EISCAT_3D in order to: a) facilitate the deployment, operation, and combined usage of current and new complementary instruments, b) enable user-friendly access to interdisciplinary and multi-instrument data, and c) coordinate and gain access to EISCAT_3D observation time and data processing. The aim is to bring together and significantly develop existing resources into a research infrastructure where all component parts are of national/international interest and the bringing together of them results in clear added value for research within the field.

Origins of extreme solar particle events

L. Kocharov

Sodankylä Geophysical Observatory, University of Oulu

Energy range of protons emitted by solar eruptions, flares and coronal mass ejections (CMEs), into the interplanetary medium may extend in extreme events up to the rigidities (energies) ~1-10 GV (433 MeV – 9.1 GeV). Solar nucleons with energy >300 MeV/nucleon can generate a nuclear cascade in the Earth's atmosphere, whose byproducts can be eventually registered by ground-based detectors as neutron monitors (NMs), causing a ground-level enhancement (GLE) event.

Over the past 25 years, it has been widely believed that solar energetic particles of major events are accelerated in the MHD shocks driven by CMEs on open magnetic field lines of the solar wind. We show that for the >300 MeV protons, such fait contradicts both theoretical modelling and multi-wavelength analysis of the solar electromagnetic emissions associated with GLEs. Our results indicate that production of the high-energy solar protons is triggered in the large-scale coronal magnetic field structures by the flare pulse and continues then in the solar corona, well behind the CME travelling in the solar wind

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Multiproxy reconstructions of integral energy spectra for extreme solar particle events of 7176 BCE, 660 BCE, 775 CE and 994 CE

S. Koldobskiy(1,2), F. Mekhaldi(3,4), G. Kovaltsov(1), I. Usoskin(1,2)

(1) Space Physics and Astronomy Research Unit, University of Oulu, Finland;
(2) Sodankylä Geophysical Observatory, University of Oulu, Finland;
(3) Department of Geology-Quaternary Sciences, Lund University, Lund, Sweden;
(4) British Antarctic Survey, Ice Dynamics and Paleoclimate, Cambridge, UK

Extreme solar particle events (ESPEs) are rare and the most potent known processes of solar eruptive activity.

During ESPEs, a vast amount of cosmogenic isotopes (CIs) Be10, Cl36 and C14 can be produced in the Earth's atmosphere and deposited in natural stratified archives.

CI measurements in these archives allow us to evaluate particle fluxes during ESPEs.

Here we present a new method of ESPE integral flux reconstruction based on modern modelling advances, allowing to fit together different CI data within one model.

We represent the ESPE fluxes as an ensemble of scaled flux reconstructions for ground-level enhancement events registered by the neutron monitor network since 1956 coupled with satellite and ionospheric data.

Reconstructed ESPE fluences appear softer in its spectral shape than earlier estimates, leading to significantly higher estimates of the low-energy ($E < 100$ MeV) fluence. This makes ESPEs even more dangerous for modern technological systems than previously believed.

Investigating Radiation at Flight Altitudes Using Modern Techniques and Tools

Nicholas Larsen (1,2), Alexander Mishev (1,2), Ilya Usoskin (1,2)

(1) Sodankylä Geophysical Observatory, University of Oulu, Finland
(2) Space Physics and Astronomy Research Unit, University of Oulu, Finland

Solar eruptions can send large amounts of charged particles towards the Earth. These charged particles can, given enough energy, penetrate the magnetosphere and enter the Earth’s atmosphere. The increase in precipitating particles at flight altitude can lead to an increase in radiation dose experienced by aircraft crew and passengers. In order to mitigate any danger that these solar eruptions can cause it is important to be able to accurately compute the radiation at flight altitudes. One way to do this is to use a combination of tools one which can compute the trajectory of these charged particles to determine spectral and angular characteristics, and another to take these values and compute the radiation dose.

Here, we will explain the method used to obtain the radiation dose values as well as present early results produced using a combination of the new OTSO tool, used to compute the propagation of charged particles in the magnetosphere, and the radiation dose method developed in-house at the University of Oulu.

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First observations from new VLF receiver at OUJ

J Manninen(1), C Martinez-Calderon(2), T. Rantala(1), and A. Nikiforou(1)

(1) Sodankylä Geophysical Observatory, Sodankylä, Finland;
(2) Institute for Space-Earth Environmental Research, Nagoya University, Japan

Japanese wide-band VLF receiver was installed at Oulujärvi station (OUJ) in mid-October 2022. It belongs to Japanese PWING network containing 8 VLF receivers near 60° MLAT on northern hemisphere. In this presentation we will show the first observations from OUJ receiver.

Study of space weather effects under worst case scenario during extreme SEP

A. Mishev(1), S. Panovska(2), I. Usoskin(1)

(1) Sodankylä Geophysical Observatory, University of Oulu; (2) GFZ Potsdam, Germany

Study and quantification of the cosmic-ray-induced effects in the atmosphere and the corresponding space weather effects is specifically important during ground-level enhancements (GLEs). A specific space weather effect, the focus in this study, is the exposure to radiation at aviation altitudes, which also represent an important threat. Here, we focus on a specific class of events due to solar energetic particles (SEPs), viz. GLEs with cosmogenic imprints, i.e. that have been registered by ^{14}C records. We present results and application of an analysis of SEPs using neutron monitor (NM) records, namely study of their spectra and subsequent assessment of space weather effects. We assessed the space weather effect during the strongest indirectly reconstructed historical extreme SEP event, that is, 774 AD. The possible implications are discussed.

Hale cycle in solar hemispheric radio flux: Evidence for a relic magnetic field oriented opposite to solar rotation

K Mursula

Space Climate Group, Space Physics and Astronomy Research Unit, University of Oulu

We study solar 10.7 cm radio fluxes in the northern and southern hemispheres using three F10.7 index versions at different average heliographic latitudes. We find that maximum radio flux in each odd solar cycle is larger in the north than in the south while southern fluxes are larger in even cycles. Hemispheric differences at cycle maxima are typically 20%. Radio fluxes normalised by solar activity level depict a dominant Hale cycle variation in both hemispheres, with an opposite phase and overall amplitude of about 5% in the north and 4% in the south.

These results are naturally explained by a weak relic magnetic field remaining in the Sun from times of the birth of the solar system. We can also determine orientation of the toroidal component of the relic field to be opposite to the direction of solar rotation. We also find that times of large hemispheric asymmetry and high solar activity coincide because they are produced by the relic field shifted away from the solar equator.

Abstracts

Modelling a non-Maxwellian electron velocity distribution in the ionospheric D-region during artificial radio wave heating

M. Myrvang(1), B. J. Gustavsson(1), A. Kero(2)

(1) UiT The Arctic University of Norway;
(2) Sodankylä Geophysical Observatory, University of Oulu

Current models most likely overestimates the effect of artificial heating in the D-region compared to observations. The ionospheric D-region varies in altitude range from about 50 km to 100 km. In this part of the ionosphere, the electron density is low and the neutral density is relatively high. Artificial heating increases the electron temperature by transferring the energy of high power radio waves into thermal energy of electrons. The electron velocity distribution may influence the modelling of electron temperature in the D-region during heating. A previous study by Stubbe (1981) demonstrated the non-Maxwellian electron velocity distribution during heating. However, most following studies assumed a Maxwellian distribution. In another study, the authors speculate that the assumption of the Maxwellian electron velocity distribution may cause the discrepancy between model and observations (A. Senior et al., 2010). We are now implementing the non-Maxwellian distribution from Stubbe (1981) with updated cross sections for the following neutral species: rotational and vibrational excitation of molecular nitrogen and molecular oxygen, electronic excitation and fine structure excitation of atomic oxygen.

[1] A. Senior et al. (2010): «Diagnosing radio plasma heating in the polar summer mesosphere using cross modulation: Theory and observations». Journal of geophysical research, vol. 115, A09318.
[2] P. Stubbe (1981): «Modifying effects of a strong electromagnetic wave upon a weakly ionized plasma: A kinetic description». Radio Science, Volume 3, page 417-425.

Abstracts

Satellite-Borne Observations of Ozone Impact by the November 2001 Solar Proton Event

K. Nilsen(1), A. Kero(1), P. T. Verronen(1,2), M. E. Szeląg(2)

(1) Sodankylä Geophysical Observatory, University of Oulu;
(2) Space and Earth Observation Centre, FMI Helsinki

The November 2001 Solar Proton Event (SPE) is one of the strongest events in the era of satellite observations. However, no observational case study of this exceptional event's impact on atmospheric chemistry has been reported. In this paper, we use satellite-based observations from Optical Spectrograph and Infrared Imaging Systems (OSIRIS) to quantify the SPE impact on middle atmospheric O_3 in the southern hemisphere during summertime conditions. The results show a relatively modest, yet detectable, O_3 depletion in the upper stratosphere and lower mesosphere. Compared to the observations, the Whole Atmosphere Community Climate Model (WACCM-D) simulates somewhat lower O_3 levels before the event but captures well the relative ozone depletion. The largest depletion is seen on November 6th, after the Geostationary Operational Environment Satellite observed the peak proton fluxes. On this day, the O_3 depletion was observed and simulated from the pole to 55°S geographic latitude. The daily polar cap (poleward of 60°S geographic latitude) averaged O_3 profiles show a maximum depletion of 16.6±2.2% at 1 hPa and 18.8±3.3% at 1.5 hPa altitude, by OSIRIS and WACCM-D, respectively. After the SPE, an enhancement in NOx is simulated by the results of the model within altitudes of the observation, which is well correlated with the observed and modelled O_3 depletion. Challenges related to the detection of SPE impact on O_3 in the summer hemisphere are discussed. We find that a careful analysis of simulation results can be essential when isolating the SPE impact from background variation.

Comparison of field-aligned currents responses to geomagnetic storms

M N Pedersen, H Vanhamäki, A T Aikio

Space and Astronomy Research Unit, University of Oulu, Finland

The time delay from an interplanetary driver arriving at the magnetopause to the response in the ionosphere has not been quantified separately for different types of storm drivers. This study investigates the delay for storms driven by high speed streams and associated stream interaction regions (HSS/SIR), sheaths and magnetic clouds (MC). It is found that the total FAC and SME index lag the Newell coupling function (NCF) by 40±10 min during storms driven by HSS/SIR and sheaths, while the delay is 60±10 min for MCs. Furthermore, the correlation coefficient between FAC and NCF increases as NCF is averaged over larger time windows up to 60 min for sheath, 100 min for HSS/SIR and 120 min for MC storms.

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Raspberry Pi computers in remotely controlled neutron monitors DOMC/DOMB in Antarctica

S Poluianov (1,2)

(1) Sodankylä Geophysical Observatory, University of Oulu, Finland;*
(2) Space Physics and Astronomy Research Unit, University of Oulu, Finland

Neutron monitors DOMC/DOMB operated by SGO at the research station Concordia (Dome C, Antarctica) got a major upgrade of electronics in 2019. The core of the new data acquisition system of the instrument is the Raspberry Pi 3 single-board computer. The new design significantly expanded the capability and flexibility of the system. Here we present the technical features not related to the scientific quality of the data, which can be summarised as the following: (1) neutron monitors became stand-alone Linux servers; (2) remote control of important operation parameters (e.g., high-voltage, pulse thresholds), (3) custom extended telemetry from the instruments, (4) additional short-term storage of data files. However, we also got new tasks to run the neutron monitors reliably, namely supporting the system and updating the custom-built software. It is a challenging task due to a very limited internet connection with the remote Antarctic station.

Sub-GLE event candidates found in archive data of the South Pole and Vostok neutron monitors

S. Poluianov(1,2), O. Batalla(3), A. Mishev(1), S. Koldobskiy(1), I. Usoskin(1,2)

(1) Sodankylä Geophysical Observatory, University of Oulu, Finland;
(2) Space Physics and Astronomy Research Unit, University of Oulu, Finland;
(3) National Autonomous University of Mexico, Mexico

Strong solar energetic particle storms can be registered by ground-based neutron monitors causing so-called Ground-Level Enhancements (GLE) in their data. In addition to that, there is a sub-class of such events called “sub-GLE” for ones seen only by high-altitude polar neutron monitors with exceptionally high sensitivity to low-energy cosmic ray particles and not observed at all other stations. So far, we had only one sub-GLE occurred on 29-10-2015, when two high-altitude polar stations Dome C and South Pole were in operation, and three sub-GLE candidates in 2012 and 2014. Before that, no such events could be found due to the lack of a pair of high-sensitivity neutron monitor setups, except for a short period from 1964 to 1972, when the South Pole and Vostok stations were working. Here we present our survey of the South Pole and Vostok data for that period. Two more sub-GLE event candidates were found (on 09-06-1968 and 27-02-1969), they were confirmed by particle measurements from satellites and observations of the flare activity on the Sun.

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Mesospheric temperature estimation using meteor wind radar

E. Sarkar and Th. Ulich

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On theory, the reflected radio signal from the ablating meteor train in the mesosphere can be used to continuously monitor atmospheric parameters (temperature, density etc) at 90 km altitudes. In practice, complication arises to the measurement errors in the system as well as the persistent effect of natural variability (size, mass, velocity, entry angle) in meteoroids property. The long-standing hypothesis that needs to be debated: Is the assumed equality between atmospheric scale height (H_KT) and the effective diffusion scale height (H_D) of meteor trails valid for these data? In this study, it is argued that such an equality is not a theoretical necessity. Furthermore, long-term trend analysis showed that the discrepancy between H_KT and H_D varies nonlinearly with seasons. Once this bias is quantified at a given radar site, the atmospheric temperature at 90 km be measured continuously for all time of the year, which otherwise, have not been possible with any other existing methodology.

Implementation of Deep Learning for Ionogram Images Recognition and Parameters Scaling

R. Sherstyukov, Th. Ulich, A. Kozlovsky, S. Moges

Sodankylä Geophysical Observatory, University of Oulu, Sodankylä, Finland

The Sodankylä ionosonde produces ionograms with 1-minute cadence (1440 ionograms/day), however careful parameter scaling takes time, therefore the scaler processes only 1 ionogram/hour. This time resolution is insufficient to investigate fast ionospheric phenomena such as meteor-induced Es layers with several minutes lifetime and medium scale travelling ionospheric disturbances (MSTIDs) with typical 20-70 minute periods.

Therefore, a deep learning approach was implemented to recognise the ionogram patterns and scale the minute-by-minute ionogram parameters. Convolutional neural networks (CNN) are at the core of most state-of-the-art computer vision solutions for a wide variety of tasks. The recognition accuracy of CNN highly depends on the depth of CNN (number of convolution layers) and the complexity of its architecture. Several architectures of deep CNN were tested to solve a task of ionogram recognition.

The dataset used for CNN training contains 86,500 ionograms for 2010-2020 years with ground truth parameters for each ionogram. Classification task to recognise the presence of F1, F2, E, and 6 types of Es layers (f, l, h, r, k, c, a) on ionogram, as well as regression task to define certain ionospheric parameters foF1, foF2, foE, foEs, h'E, h'F, fmin, M3000 are solved. The accuracy of multi-class layer prediction and errors (MAE, RMSE) of ionogram parameter scaling are presented.

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EISCAT and EISCAT 3D – The road ahead

A Steuwer

EISCAT Scientific Association

With EISCAT 3D construction and assembly now in full swing, a handover of the EISCAT Directorship on 1 January 2024, and a likely change of the legal status for the EISCAT Scientific Association in order to maintain long-term stability, there are many changes, challenges, as well as exciting opportunities on the road ahead. In this presentation I will give an update on recent developments, and outline some of the key milestones ahead.

Ozone impact from solar energetic particles cools the polar stratosphere

M. E. Szeląg(1), D. R. Marsh (2,3), P. T. Verronen (1,4), A. Seppälä(5), N. Kalakoski(1)

(1) Space and Earth Observation Centre, Finnish Meteorological Institute, Helsinki, Finland;
(2) Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, Boulder, CO, USA; (3) Faculty of Engineering and Physical Sciences, University of Leeds, Leeds, UK;
(4) Sodankylä Geophysical Observatory, University of Oulu, Sodankylä, Finland;
(5) Department of Physics, University of Otago, Dunedin, New Zealand

Understanding atmospheric impacts of solar energetic particle precipitation (EPP) remains challenging, from quantification of the response in ozone, to implications on temperature. Both are necessary to understand links between EPP and regional climate variability. Here we use a chemistry-climate model to assess the importance of EPP on late winter/spring polar stratosphere. In transient simulations, the impact on NOy, ozone, and temperature is underestimated when using EPP forcing from the current recommendation of the Coupled Model Intercomparison Project (CMIP6). The resulting temperature response is largely masked by overall dynamical variability. An idealised experiment with EPP forcing that reproduces observed levels of NOy results in a significant reduction of ozone (up to 25%), cooling the stratosphere (up to 3 K) during late winter/spring. Our results unravel the inconsistency regarding the temperature response to EPP-driven springtime ozone decrease, and highlight the need for an improved EPP forcing in climate simulations.

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New space situational awareness capabilities and assets at SGO

Eija I. Tanskanen

Sodankylä Geophysical Observatory, University of Oulu

Sodankylä Geophysical Observatory provides world-class capabilities for space and Arctic situational awareness non-stop around the clock. The Observatory's Situational Awareness Centre produces real-time 24/7 information about the geosphere, atmosphere, space conditions and solar storms, and provides space situational awareness information for the different national and international actors. Main actors include international networks providing space-related services, scientists, data centres and other customers from a wide variety of fields.

New assets by the on-going and recently started projects produce improved situational awareness capabilities. Aurora project "Revot" extends the all-sky camera network which was started to get built at Earth-Space Research Ecosystem, E2S transmitter gives new space situational information, and EU funded project PITHIA will enable monitoring of the pulsation power at the auroral zone.

News from SGO

Th Ulich, T Raita

Sodankylä Geophysical Observatory

We report on the latest developments of SGO's observatory activities and future plans. SGO is part of the Nordic Observatory Collaboration and we will provide updates related to SGO activities within NOC.

Update of the cosmic-ray station operation through 2022

Ilya Usoskin

University of Oulu, Finland

A traditional annual review of the results, achievements and problems of the SGO cosmic-ray group in 2022 will be presented along with plans and prospectives for future research and collaborations.

Abstracts

The BIOSPACE: Resilience control via atmospheric integration of space and biophysics by the biome level Pico/nanobiointeractome signalling mechanism?

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One of the functions of the earth spheres, is to silence the cosmic ray air showers so that in most part the ionising radiation would not reach the life stock for DNA mutations. Natural events are now known to involve a universal pico-, nano- and microlevel system for communication within species and between them. This communication system transfers also to air the essential molecules, namely DNA, RNA, proteins, lipids, sugars and metabolites for biochemical resilience control and represent natural compartmentalisation process. Such species secreted extracellular vesicles (EVs) elements provide wealth of biochemical surfaces and grounds to increase our understanding atmospheric biophysics. Charles Darwin speculated in his Pangenesis theory that Gemmules particles would mediate widely bio interactions. The EVs are in line with these speculations. Putative roles of cosmic ray air showers as a driver of biological novelty and integration to the (EV/molecular) bio space will be discussed in light of the experimental evidence in the laboratory and in the field.

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Abstracts

Mysterious geomagnetic response to minor solar wind disturbance: Observations

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On 15 April 2022, Kiruna magnetometer detected isolated geomagnetic spike of 400 nT with rising time 2 minutes. This is the same level of large sudden commencement (historically largest one is about 1000 nT in Kiruna), but this event was not followed by any magnetic storm or substorm. In this sense, the observed 400 nT spike is unique in the history of Kiruna magnetometer (more than 30 years of digital data). At the same time, Kiruna riometer detected strong absorption with short rise time, indicating a sudden increase of the electron density.

The world-wide geomagnetic observations available at IMAGE, SuperMAG and INTERMAGNET geomagnetic network, show isolated localised geomagnetic spike in the dawn sector in both hemispheres, but not dusk sector, gradually moving toward midnight with decreasing intensity. Detailed analyses of geomagnetic deviation in the norther hemisphere indicates strong shear in the ionospheric Hall current with the sense of downward field. Considering its location and electron density increase, this field-aligned current is most likely caused by the ring current particles, as is indicated by DMSP data.

The solar wind velocity is constant and no specific variation that can cause such a unique event. However, multi-spacecraft observations by SOHO, DSCOVR, ACE, Cluster and MMS suggest a possibility of very localised IMF structure.

We thank magnetic stations of IMAGE, SuperMAG and INTERMAGNET network, and SOHO, DSCOVR, ACE, Cluster, DMSP and MMS team for providing data.