SuperDARN Workshop 2026 Program

(June 7-12, 2026, Sakata-Hirata Hall, Nagoya University
Higashiyama Campus, Nagoya, Japan)

June 7 (Sunday)

Registration and icebreaker at chez Jiroud (1800 – 2000)

June 8 (Monday)

Greetings / Introduction of ISEE, Nagoya University (0900-0920)

1. Radar status reports, hardware developments, data handling

Chair: Nozomu Nishitani

0920 Review of the status of SuperDARN in 2026
G Chisham

0950 SuperDARN Data Analysis Working Group Report
Kevin T. Sterne, SuperDARN Data Analysis Working Group

1000 SuperDARN DDWG summary report
Fuli Ma

1010 Scheduling Working Group Report
Evan Thomas

1020 (break)

Chair: Jiaojiao Zhang

1045 Iceland SuperDARN Radar (ICW/ICE) Update
Simon G. Shepherd, Evan G. Thomas, William A. Bristow, David Flores

1105 Current status and future directions of the Wallops radar
Alex T. Chartier

1125 Recent developments of the SuperDARN Hokkaido East radar: implementation of the beam forming capability in the receiver system

Nozomu Nishitani, Yoshiyuki Hamaguchi, Tomoaki Hori, Atsuki Shinbori

1145 Preliminary results of the Spring 2026 SuperDARN-Arase conjunction campaign

Tomoaki Hori, K. Hosokawa, P. Ponomarenko, N. Nishitani, A. Shinbori, Y. Miyoshi, M. Teramoto, Y. Obana, A. S. Yukimatu

1205 (lunch)

Chair: Akira Sessai Yukimatu

1330 SuperDARN and ICEBEAR Calibration Techniques

Glenn Hussey, Brian Pitzel, Remington Rohel, Pasha Ponomarenko, Saif Marei, Draven Galeschuk, Devin Huyghebaert

1350 The SuperDARN Meteor Wind Product: A 31-year archive with modeled altitude contributions and validation

Alex T. Chartier

1410 Validating phase code modulation for sub-45 km range separation modes on the USRP-based SuperDARN system

Allison Pitzl, Kevin T. Sterne, Evan G. Thomas, J. Michael Ruohoniemi

2. Analysis techniques

Chair: Pasha Ponomarenko

1430 Post-processing tool to reprocess antennas IQ data with any averaging duration

Jordan Cho, Remington Rohel, Pasha Ponomarenko, Daniel Billet

1450 New SuperDARN data products of ionospheric vorticity and merge velocity vectors from mid-latitudes to the pole

Gareth Chisham, William A. Bristow, Glenn Hussey, J. Michael Ruohoniemi, Simon G. Shepherd

1510 Data assimilation into an emulator of a magnetosphere-ionosphere model for obtaining polar ionospheric potential map (invited)

Shin'ya Nakano, Ryuho Kataoka, Shigeru Fujita, Nilam Bhosale, Aoi Nakamizo, Akira Sessai Yukimatu

1530 (break)

3. Convection / substorms part I

Chair: William A. Bristow and Mariko Teramoto

1555 Unprecedented 2-D SuperDARN flows: unexpected fundamental elements of polar cap convection and substorm growth phase (invited)
Larry Lyons, Yukitoshi Nishimura, Katherine Davidson, Daniel Billet, Sneha Yadav, Pasha Ponomarenko, Remington Rohel, Nozomu Nishitani, Eric Donovan, Vassilis Angelopoulos

1615 Evolution of Reversed Convection Vortices Observed by SuperDARN during a Geomagnetic Storm
Jiaojiao Zhang, Xiyu Liu, Yiqun Yu, Nozomu Nishitani

1635 Mid-latitude SuperDARN systematically underestimates the storm-time ionospheric electric field
Maria-Theresia Walach

1655 A Superposed Epoch of SuperDARN Plasma Convection, THEMIS-All-Sky Auroral Brightness, and Their Covariance During Substorms
Matthew Flynn Wilcox

1715 Slow recovery of the plasmasphere during the May and October 2024 super geomagnetic storm
Atsuki Shinbori, Naritoshi Kitamura, Kazuhiro Yamamoto, Atsushi Kumamoto, Fuminori Tsuchiya, Shoya Matsuda, Yoshiya Kasahara, Mariko Teramoto, Ayako Matsuoka, Takuya Sori, Yuichi Otsuka, Michi Nishioka, Septi Perwitasari, Yoshizumi Miyoshi, Iku Shinohara

1735 (Session close)

PIs meeting at Research Institutes Building I, 3F Meeting Space (1900-)

June 9 (Tuesday)

4. Convection / substorms part II

Chair: Maria-Theresia Walach and Masakazu Watanabe

0900 A Statistical Study of Polar Cap Patch Occurrence and IMF Dependence Using GNSS TEC Maps
Qingyu Zhang, Yuzhang Ma, Beichen Zhang, Qinghe Zhang, Zanyang Xing, Huixin Liu,

Kjellmar Oksavik, Xiangcai Chen, Zejun Hu, Yong Wang, Jianping Wang

0920 Forecasting Polar Ionospheric Electrostatic Potentials Patterns Using Score-Based Diffusion Models and Solar Wind Drivers

Igino Coco, Francesco Pio Ramunno, Simone Mestici, Maria-Theresia Walach, André Csillaghy, Stefano Massetti

0940 A Statistical Picture of Dusk-Dawn Asymmetries in the Nightside Ionosphere

Jewel Abbey D. Relampagos, Adrian Grocott, Steve Milan

1000 Accounting for a Variable Flow Reversal Boundary Location in SuperDARN Convection Modelling

Adrian Grocott

1020 Updating ionospheric conductivity in an AI-based emulator through SuperDARN and SuperMAG data assimilation

Nilam Yashwant Bhosale, Ryuho Kataoka, Shinya Nakano, Shigeru Fujita, Akira Sessai Yukimatu, Aoi Nakamizo

1040 (break)

Chair: Atsuki Shinbori

1105 Mesoscale, short-lived Joule heating events are widespread in the polar ionosphere, and further statistics on their spatiotemporal characteristics.

Daniel Billett, Remington Rohel, Ian Mann, Glenn Hussey, Carley Martin

1125 Multi-Point Observations of Quarter-Wave Field Line Resonances Across the Magnetosphere–Ionosphere System with SuperDARN, Ground Magnetometers, Arase

Yuki Obana, Nozomu Nishitani, Keisuke Hosokawa, Tomoaki Hori, Mariko Teramoto, Atsuki Shinbori, Pavlo V. Ponomarenko, Akira S. Yukimatu, Colin L. Waters, Murray D. Sciffer, Glenn Hussey, Akimasa Yoshikawa, Yoshizumi Miyoshi, Ayako Matsuoka, Atsushi Kumamoto, Fuminori Tsuchiya, Shoya Matsuda, Yoshiya Kasahara, Iku Shinohara, Ian R. Mann, David K. Milling

1145 Stormtime electric fields at middle and low latitudes as observed by HF Doppler sounders and magnetometers during the super storm on May 10-11, 2024

Takashi Kikuchi, Kumiko Hashimoto, Keisuke Hosokawa, Tomizawa Ichiro, Ryuho Kataoka, Jaroslav Chum, Yusuke Ebihara, Yukitoshi Nishimura

1205 (lunch)

5. Subauroral / mid-latitude region processes

Chair: Alex T. Chartier and Joseph B.H. Baker

1330 Ionospheric convection during a low-latitude aurora event on Jan 1, 2025
Keisuke Hosokawa, Nozomu Nishitani, Tomoaki Hori, Atsuki Shinbori, Yuki Obana, Mariko Teramoto, Akira Sessai Yukimatu, Yoshizumi Miyoshi

1350 Distinguishing Global and Local Drivers of Low-Latitude Aurorae in November 2025
Tomotaka M. Tanaka, Nozomu Nishitani, Kiyoka Murase

1410 SuperDARN HOP Radars Observations of Ionospheric Convection Associated with Low-Latitude Auroras under Quiet Geomagnetic Conditions
Ryuki Yoda, Nozomu Nishitani, Tomoaki Hori, Atsuki Shinbori, Kazuo Shiokawa, Keisuke Hosokawa, Yuki Obana, Mariko Teramoto

1430 Auroral activity observed from unusual latitudes in China and its underlying significance
Jiaojiao Zhang, Xiang Deng, Jiyao Xu, Hui Li, Hang Li, Wei Wang, Jianyun Liang, Simon G. Shepherd, Evan G. Thomas, Ailan Lan, Jingye Yan, Zheng Wang, Qing-He Zhang, Ziqian Liu, Xinyue Wang, Fuqing Huang, Xianguo Zhang, Weiguo Zong, Chi Wang

1450 (break)

6. Special paper-I

Chair: Joseph B.H. Baker

1515 40 Years with HF Radar for Ionospheric Research: Experiences, Highlights, Fun Facts (invited)
John Michael Ruohoniemi

7. Neutral processes

Chair: Yuichi Otsuka and Jianjun Liu

1545 Occurrence Characteristics of Noctilucent Clouds from Japan: Mechanism of the Morning-Evening Asymmetry (invited)
Akiho Endo, Yoshihiro Tomikawa, Peter Dalin, Takuo Tsuda, Yuriko Nakamura,

Masahiro Omote, Nozomu Nishitani, Kazuyo Sakanoi, Kaori Sakaguchi, Satoshi Ishii, Katsushi Iwamoto, Hidehiko Suzuki

1605 OMTI-SuperDARN collaborative studies for the dynamics of the middle and subauroral latitude ionosphere
Kazuo Shiokawa, Nozomu Nishitani, Yuichi Otsuka, PWING Team, PBASE Team

1625 Electromagnetic conjugacy of TIDs after the 2022 HTHH volcanic eruption as seen in GNSS-TEC and SuperDARN Hokkaido pair of radars observations
Atsuki Shinbori, Yuichi Otsuka, Takuya Sori, Michi Nishioka, Septi Perwitasari, Takuo Tsuda, Nozomu Nishitani

1645 IMF Dependence of Midnight Bifurcation in the Thermospheric Wind Measured with FPI in Tromsø, Norway
Shin-Ichiro Oyama, Keisuke Hosokawa, Heikki Vanhamäki, Anita Aikio, Takeshi Sakanoi, Lei Cai, Ilkka I. Virtanen, Kazuo Shiokawa, Nozomu Nishitani, Atsuki Shinbori, Yasunobu Ogawa

1705 Investigating the Source and Characteristics of Winter Daytime MSTIDs Using the Chinese Dual Auroral Radar Network (CN-DARN)
Hang Li, Jiaojiao Zhang, Wei Wang, Yuting Wang, Yaxuan Li, Xiang Deng, Ailan Lan, Shengyang Gu, Yusong Qin, Jingye Yan, Chi Wang

1725 (session close)

DDWG meeting at Research Institutes Building I 3F Meeting Space (1900-)
DAWG meeting at Research Institutes Building I 4F Meeting Space (2000-)
SWG/SpaceWG meeting at Research Institutes Building I 5F Meeting Space (2100-)

June 10 (Wednesday)

8. Convection / substorms part III

Chair: Glenn Hussey

0900 Wave structures in ionospheric flow and their magnetospheric counterpart: Fall 2023 SuperDARN-Arase conjunction campaign

Tomoaki Hori, K. Hosokawa, N. Nishitani, A. Shinbori, Y. Miyoshi, M. Teramoto, Y. Obana, A. S. Yukimatu, K. Keika, S. Kasahara, S. Yokota, Y. Kasaba, A. Kumamoto, F. Tsuchiya, S. Matsuda, Y. Kasahara, A. Matsuoka, Y. Kazama, S.-Y. Wang, S. W. Y. Tam

0920 Reliability of Matching AMPERE Field-Aligned Current Boundaries With SuperDARN Lower Latitude Ionospheric Convection Boundaries During Geomagnetic Storm

Maria-Theresia Walach, Alexandra Fogg, John Coxon, Adrian Grocott, Steve Milan, Harneet Sangha, Kathryn McWilliams, Sarah Vines, Mark Lester, Brian Anderson

0940 Assimilative Mapping of SuperDARN and Complementary Observations for High-Latitude Ionospheric Electrodynamics

Tomoko Matsuo, Nicholas Bartel, John Michael Ruohoniemi, Bharat Kunduri, Shibaji Chakraborty

1000 New insights into subauroral polarization stream (SAPS) using multi-frequency SuperDARN HF radar observations

Evan G. Thomas, Simon G. Shepherd, Bharat S. R. Kunduri, J. Michael Ruohoniemi, Joseph B. H. Baker

1020 (break)

9. SuperDARN / satellites / rockets / other radars collaboration part I

Chair: Yuki Obana

1045 Arase–SuperDARN Collaborative Studies of Inner Magnetospheric Dynamics (invited)

Yoshizumi Miyoshi, Iku Shinohara, Takeshi Takashima, Kazushi Asamura, Kazuo Shiokawa, Tomoaki Hori, Atsuki Shinbori, Keisuke Hosokawa

1105 The GEOspace X-ray imager mission (GEO-X) (invited)

Yuichiro Ezoe

1125 LAMP and future sounding rocket experiment for investigation of energetic particle precipitation with pulsating aurora activities (invited)

Kazushi Asamura, Yoshizumi Miyoshi, Keisuke Hosokawa, Takeshi Sakanoi, Takefumi Mitani, Taku Namekawa, Masahito Nose, Mariko Teramoto, Yasunobu Ogawa

1145 (session close)

PM Schedule

Group photo
Lunchbox inside the bus
Tour to Gujo-Hachiman Castle and Traditional Town
Return to Mariott Associa Pergola (near Nagoya Station) for dinner

June 11 (Thursday)

10. SuperDARN / satellites / rockets / other radars collaboration part II

Chair: Tomoaki Hori

0900 Collaboration between SMILE mission and SuperDARN
Jiaojiao Zhang

0920 Recent advances in modeling the X-ray images expected by SMILE (invited)
Tianran Sun, Hyunju Connor, Andrey Samsonov, Steve Sembay, Chi Wang, Philippe Escoubet, Colin Forsyth

0940 Progress of the Ultraviolet Imager onboard SMILE (invited)
Fei He, Yongmei Wang

1000 (break)

11. Related programs

Chair: Akira Sessai Yukimatu

1025 Investigation of the IRI's auroral oval boundary model during the Mother's Day storm on 10-13 May 2024
Alicreance Hiyadutuje, Dieter Bilitza, Temitope Ojebisi, Malkia Kelelue, Solomon Degefa, Kibrop Webber

1045 Enhancing FAIRness of Data in SuperDARN: NSSDC's Efforts in Data Management and Services

Xin Xu, Fuli MA, Xiaoyan Hu, Qi Xu, Ziming Zou

1105 On multi-band echoes in SuperDARN range-time maps

Pasha Ponomarenko, Glenn Hussey, Thayananthan Thayaparan, Nozomu Nishitani

12. Ionospheric irregularities

Chair: Adrian Grocott

1125 GPS phase and amplitude scintillation at high latitudes during the extreme geomagnetic storm of May 2024

Paul Prikryl, Anthony C. M. McCaffrey, James M. Weygand, Reza Ghoddousi-Fard, Daniel Billet, Emma Spanswick, Joshua Houghton

1145 Exploring Machine Learning Approaches for the Classification of PMSE, F-region and TID Echoes in SuperDARN Observations

Jia Zhong, Li Fu Ma, Yan Xiao Hu, Ming Zi Zou

1205 (Session close)

13. Special paper-II

Chair: Pasha Ponomarenko

1330 Are E-region echoes a nuisance in SuperDARN experimentation? (invited)

Alexandre V. Koustov

14. HF wave propagation part I

Chair: Evan G. Thomas

1400 Collaboration between EISCAT_3D and SuperDARN (invited)

Yasunobu Ogawa, Advanced Radar Research promotion Center (ARRC) members

1420 Statistical Analysis of Geomagnetic Responses to EUV Radiation During Solar Flares at Kakioka

Ryosuke Okubo, Kyoko Watanabe, Satoshi Masuda, Akimasa Ieda, Hidekatsu Jin, Chihiro Tao, Shinnnosuke Kitajima

1440 Derivation of Ionospheric Parameter Contributing to HF Blackouts
Kyoko Watanabe, Shinnosuke Kitajima, Hidekatsu Jin, Chihiro Tao, Satoshi Masuda, Michi Nishioka

1500 Auroral Ionosphere Responses to Solar Wind Perturbations: A Case Study Utilizing the Polar Regions Monitoring Subsystem of the Chinese Meridian Project
Jianjun Liu, Xiangcai Chen

1520 (break)

1520-1700 poster session

P1 British Antarctic Survey Space Weather Observatory
Jo Cole

P2 The British Antarctic Survey's Falkland Island Radar
Nick Harker

P3 SENSU Syowa SuperDARN future plan towards Phase XI JARE project (2028-2034) and IPY-5
Akira Sessai Yukimatu, Nozomu Nishitani, Keisuke Hosokawa, Tomoaki Hori, Masakazu Watanabe, Hideaki Kawano, Yusuke Ebihara, Yoshimasa Tanaka, Ryuho Kataoka

P4 Future Plan for Space and Upper Atmospheric Research in JARE Phase XI
Yoshimasa Tanaka, Ryuho Kataoka, Takeshi Sakanoi, Akira Mizuno, Chihiro Kato, Akira Sessai Yukimatu, Yasunobu Ogawa, Tanakanori Nishiyama, Mizuki Fukizawa, Kiyoka Murase, Yusuke Ebihara, Yuki Hayashi, Masayoshi Kozai, Tomotaka M. Tanaka, Yukino Sato

P5 Development of a 20-Channel Imaging Receiver System for the SuperDARN Hokkaido East radar
Yoshiyuki Hamaguchi, Nozomu Nishitani

P6 Developing Automated SuperDARN Main-Array Calibration Using Mutual Coupling Measurements
Jordan Wiker, Alex T. Chartier

P7 MAHSSIV: a new project to globally estimate small scale plasma variability through the SuperDARN spectral width parameter
Emma E. Woodfield, Jade A. Reidy, Gareth Chisham, Daniel Whiter, Arianna Albayati

P8 The effect of virtual height models on SuperDARN data products and convection maps

Wout De Jonghe, Ben Reid, David Themens, Oliver Allanson

P9 A Statistical Study of the Dawnside Subauroral Polarization Streams Using SuperDARN Radars

Bianlong Zhao, Jiaojiao Zhang, Qinghe Zhang, Zanyang Xing, Yong Wang, Yuzhang Ma

P10 Westward ion flows in the dusk-side subauroral ionosphere: Role of wave-particle interactions

Shreedevi Porunakatu Radhakrishna, Yoshizumi Miyoshi, Yiqun Yu, Vania Jordanova

P11 High-Latitude Sudden Impulse Signatures of Negative Solar Wind Pressure Pulses: Observation and Global Modeling

Geetashree Kakoti, Kazuo Shiokawa, Dong Lin, Shreedevi P.R., Nozomu Nishitani

P12 Direct Comparison of MAGE-REMIX Simulated Ionospheric Potential with SuperDARN Line-of-Sight Observations

Tristen Wanner, Joseph B.H. Baker, Slava Merkin, Bharat Kunduri, J. Michael Ruohoniemi

P13 An Examination of Ionospheric Flow Dynamics During a SAR Arc - STEVE - SAR Arc Sequence Event

Veronica Romanek, Bharat Kunduri, Joseph B.H. Baker, J. Michael Ruohoniemi, Megan Gillies, Simon Shepherd, Evan Thomas

P14 How accurate are SuperDARN convection maps?

Alexandre V. Koustov, Hayden Fast, Robert G. Gillies

P15 Nightside Severe Plasmaspheric Erosion Associated with SAPS: Evidence from Arase and SuperDARN HOK/HKW Observations

Yuki Obana, Naomi Maruyama, Atsuki Shinbori, Kumiko K. Hashimoto, Nozomu Nishitani, Tomoaki Hori, Akimasa Yoshikawa, Ayako Matsuoka, Yoshiya Kasahara, Yoshizumi Miyoshi, Iku Shinohara

P16 Intense magnetopause erosion at Earth during the May 2024 solar storm

Kazuhiro Yamamoto, Yoshizumi Miyoshi, Naritoshi Kitamura, Rumi Nakamura, Atsuki Shinbori, Ayako Matsuoka, Mariko Teramoto, Shoichiro Yokota, Satoshi Kasahara, Kunihiro Keika, Tomoaki Hori, Kazushi Asamura, Yoichi Kazama, Shiang-Yu Wang, Sunny Wing-Yee Tam, Tzu-Fang Chang, Bo-Jhou Wang, Iku Shinohara

P17 Excitation of storm-time Pc5 ULF waves using the GEMSIS magnetosphere-ionosphere coupled model: Comparison with GOES and

ground observations

Tomotsugu Yamakawa, Kanako Seki, Yoshizumi Miyoshi, Kazue Takahashi, Aoi Nakamizo, Kazuhiro Yamamoto

P18 Magnetic topology of the closed and interplanetary flux interlinkage in the magnetotail for northward IMF: Implications from MHD simulations

Masakazu Watanabe, Takashi Tanaka, Shigeru Fujita, Dongsheng Cai

P19 On the co-existence of dusk scatter echoes and ULF waves

Keisuke Hosokawa, Tomoaki Hori, Yuki Obana, Nozomu Nishitani, Mariko Teramoto, Pasha Ponomarenko, Atsuki Shinbori, Akira Sessai Yukimatu, Yoshizumi Miyoshi

P20 Observations and Mechanism Analysis of Unusual Continental Extended Poleward-Propagating Medium Scale Traveling Ionospheric Disturbances

Wei Wang, Jiaojiao Zhang, Junjie Chen, Fuqing Huang, Tong Dang, Jianyun Liang, Weijun Liu, Guoying Jiang, Hang Li, Yajun Zhu, Xiang Deng, Ailan Lan, Jingye Yan, Shunrong Zhang, Jiyao Xu, Chi Wang

P21 SuperDARN Hokkaido Pair of (HOP) radars observations of traveling ionospheric disturbances triggered by the Kamchatka Earthquake (on 22 July 2025)

Nozomu Nishitani, Tomoaki Hori, Atsuki Shinbori, Kota Noguchi, Pasha Ponomarenko

P22 Initial analysis result of thermospheric neutral density variations using Starlink Ephemerides

Takuya Sori, Mamoru Yamamoto

P23 Observation of shortwave fadeout events using Chinese Dual Auroral Radar Network (CN-DARN) during the severe solar storm in May 2024

Junjie Tong, Jiaojiao Zhang, Hang Li, Wei Wang, Bianlong Zhao, Wenqian Chen, Xiang Deng, Ailan Lan, Jingye Yan, Chi Wang

P24 The SuperDARN HF Radar Response to Spike Events over Kárhóll, Iceland

Xiangcai Chen

P25 Investigation of Neutral Wind Structure and Sporadic E Layer Formation Based on Meteor Echo Observations

Shinnosuke Okabe, Mariko Teramoto, Nozomu Nishitani

P26 Signatures of ULF-modulated energetic electron precipitation observed in OCTAVE VLF/LF transmitter signals

Kakeru Yoshii, Hiroyo Ohya, Fuminori Tsuchiya, Martin Connors, Nozomu Nishitani, Simon G. Shepherd, Hiroyuki Nakata

Banquet (1830 – 2030) at Conder House (near Fushimi Station)

June 12 (Friday)

15. HF wave propagation part II

Chair: Simon G. Shepherd

0900 Using oblique, bistatic receptions of SuperDARN signals to measure HF propagation in the auroral and polar cap regions
Riley Troyer, Jeffrey Holmes, Evan Thomas, Simon Shepherd, Eugene Dao, John Carilli, Eric Burnside, Kris Robinson

0920 Monitoring the ionospheric response to the upcoming August 2026 total solar eclipse
Evan G. Thomas, Simon G. Shepherd, Bharat S. R. Kunduri

0940 Sporadic E layer signatures in SuperDARN data
Pasha Ponomarenko, Glenn Hussey, Thayananthan Thayaparan, Nozomu Nishitani

1000 (break)

Chair: Gareth Chisham

Working group reports / PI's report / SuperDARN 2027 / etc. (1025-)

1145 Lunch - adjourn

Review of the status of SuperDARN in 2026

*Gareth Chisham[1]

1. British Antarctic Survey

This talk will present a review of the status of the radars in the network, and of the PI teams. It will also discuss the opportunities for the future, and the risks facing the continued operation of SuperDARN.

Keywords: SuperDARN, Review

SuperDARN Data Analysis Working Group Report

*Kevin T. Sterne[1], SuperDARN Data Analysis Working Group

1. Virginia Tech

An update on the SuperDARN Data Analysis Working Group's (DAWG) activities and main discussion topics over the last year as well as discussion topics to occur during a meeting at the workshop.

Keywords: working group

SuperDARN DDWG Summary report

*Fuli Ma[1]

1. CAS, national space science center, China

The SuperDARN DDWG summary report outlines recent developments and future plans regarding data management and distribution. Key updates include the integration of Dartmouth's sounding mode files into USASK and the restoration of Blackstone radar data, alongside the identification of timestamp errors in specific BPK files. The group has updated file checking strategies and the blocklist policy. Notably, the NSSC mirror adopted new pydarnio-based validation methods, confirming data gaps and releasing this data via FRDR, while also upating data from six NSSC radars. Future topics focus on finalizing policies for distributing sounding files, determining retention records, and synchronizing mirrors to ensure data quality.

Keywords: DDWG report

Scheduling Working Group Report

*Evan Thomas[1]

1. Dartmouth College

Report on the Scheduling Working Group activity since the last SuperDARN workshop.

Keywords: Scheduling

Iceland SuperDARN Radar (ICW/ICE) Update

*Simon G Shepherd[1], Evan G Thomas[1], William A Bristow[2], David Flores[2]

1. Thayer School of Engineering, Dartmouth College, 2. Dept of Meteorol & Atmos Sci, Penn State U

On May 4, 2025 the Iceland SuperDARN radars (ICW and ICE) were upgraded to the US USRP system: the digital USRP design developed by Bill Bristow and his groups at UAF and PSU, which have been operating successfully on the UAF/PSU radars (KOD, KSR, MCM, SPS) for many years. The Iceland radars, however, require additional control software to operate the two collocated radars. In particular, a clear frequency server, which can accommodate requests from multiple radars operating on multiple channels and provide reliable operating frequencies which are in low noise areas of the spectrum while maintaining sufficient separation between requesters and avoid restricted frequency bands, was missing. While the clear frequency server was being developed by the PSU group and tested on the Oregon dual-radar setup in our lab, we operated ICW as a stand-alone radar for serveral months.

Starting on July 24, 2025, we began testing the clear frequency server on the Iceland radars. During a period of continued development, the PSU and DC groups made significant improvements to the software. As of November 1, 2025, we have been running both radars (ICW and ICE) using many of the features that the USRP systems allow, including dual-channel operation, pulse-coding, wide-beam and frequency sounding. Our standard operating mode is a 5-baud, 500 microsecond pulse sequence on channel A, giving 15-km range resolution and a similar mode that steps through eight frequencies between ~9.5 to 16.6 MHz on channel B. Plans are being made to upgrade the Oregon radars (CVW and CVE) during the upcoming summer.

Keywords: USRP, dual-radar, clear frequency search, Iceland, Oregon

Current status and future directions of the Wallops radar

*Alex Chartier[1]

1. APL

We present the current status and future directions of the Wallops radar, including hardware upgrades, data processing advances and coordination with satellite HF receivers.

Keywords: Wallops, satellite, imaging, amplifiers

Recent developments of the SuperDARN Hokkaido East radar: implementation of the beam forming capability in the receiver system

*Nozomu Nishitani[1], Yoshiyuki Hamaguchi[1], Tomoaki Hori[1], Atsuki Shinbori[1]

1. ISEE, Nagoya University

We have been working on implementing imaging capability for the SuperDARN Hokkaido East radar, operated by Nagoya University. A typical SuperDARN operating mode is the normal scan program, which scans the entire radar field of view every 1 to 2 minutes. Conventional SuperDARN radars typically have a single receive channel (scanning one beam direction at one time). Therefore, the typical Nyquist frequency for conventional normal scan SuperDARN radar data is 4 to 8 mHz. This time resolution is not suitable for dealing with short-term variations such as Pi2 / Pc3 pulsations or space ionospheric disturbances. Recently, several SuperDARN radars have introduced imaging/beam-forming receiver systems that record multiple beam directions simultaneously (e.g., Bristow et al., 2019; McWilliams et al., 2023). Our group at ISEE, Nagoya University, is preparing this new capability for implementation at the SuperDARN Hokkaido East radar as well. This system utilizes the USRP-N210 SDR unit used in the remote receiver for the SuperDARN Hokkaido East radar signal in Nagoya (Nishitani et al., 2021). We have developed a 20-channel, full-specification system, which is currently being tested at the ISEE laboratory. We sent the receiver system to the radar site at the end of November 2025 and successfully conducted the test observation for a few days. In this presentation, we report on the initial results of this experiment. The new image receiver system is expected to acquire data with temporal and spatial resolutions several times higher than those of the existing systems. With the new system, we expect to deal with the following topics: (a) Study of a variety of scientific phenomena, such as ULF waves (e.g., Pi2 / Pc3) with periods shorter than 1 minute. (b) Transients excited by external (IMF / solar wind) and internal (e.g., onset of substorm expansion) environmental changes in the ionosphere and magnetosphere. (c) Ionospheric disturbances caused by sudden changes in the earth's surface, such as earthquakes and volcanic eruptions.

Keywords: SuperDARN Hokkaido Pair of (HOP) radars, imaging / beam-forming capability

Preliminary results of the Spring 2026 SuperDARN-Arase conjunction campaign

*Tomoaki Hori[1], K. Hosokawa[2], P. Ponomarenko[3], N. Nishitani[1], A. Shinbori[1], Y. Miyoshi[1], M. Teramoto[4], Y. Obana[5], A. S. Yukimatu[6,7]

1. ISEE, Nagoya Univ., 2. Univ. of Electro-Communications, 3. Univ. of Saskatchewan, 4. Kyushu Inst. of Tech., 5. Kyushu Univ., 6. National Inst. of Polar Research, 7. The Graduate Institute for Advanced Studies, SOKENDAI

We have been conducting a series of satellite-ground observation campaigns in Spring 2026, following the previous 2022 and 2023 campaigns, with SuperDARN radars and the Arase satellite. The purpose of the campaign is to coordinate conjunction observations of the radars and satellite primarily in the dusk to midnight sector targeting subauroral polarization streams (SAPS) and ultra-low frequency (ULF) waves including SAPS wave structure (SAPSWS). The current Spring 2026 campaign is scheduled to proceed from March to May 2026. Fortunately, several good conjunction observations, including those during magnetic storms, have been made so far during the campaign periods, in which the radars observed clear ULF wave signatures in ionospheric plasma flow with either westward or eastward propagation characteristics. Currently, detailed analysis of those ULF wave events is underway, and shortly Arase data should join this analysis, providing important clues about what was going on at conjugate sites in the inner magnetosphere. In the workshop, we will showcase some interesting observations and present the initial results based on the freshly obtained data.

Keywords: ULF wave, SAPS, Magnetosphere-Ionosphere coupling

SuperDARN and ICEBEAR Calibration Techniques

*Glenn Hussey[1], Brian Pitzel[1], Remington Rohel[1], Pasha Ponomarenko[1], Saif Marei[1], Draven Galeschuk[1], Devin Huyghebaert[2]

1. University of Saskatchewan, 2. Leibniz Institute of Atmospheric Physics

With respect to phase calibration, SuperDARN radars have typically been calibrated either by electrical measurements (spectrum analyser) on site and phase measurements between the main and auxiliary arrays. The ICEBEAR (Ionospheric Continuous-wave E-region Bistatic Experimental Auroral Radar) similarly used spectrum analyser measurements on site, but in both cases site visits are infrequent and the technique is challenged to properly account for antenna-based errors. The importance of phase calibration of the complete antenna path, on all unique antenna pairs, is critical for accurate and proper beam-forming (SuperDARN) and imaging (ICEBEAR) radar techniques. ICEBEAR has investigated using radar signals from aircraft as well as radio signals from the Cygnus A radio galaxy for improved calibration. The aircraft technique has also been applied to SuperDARN. This presentation presents and evaluates the current state of these receiver path-based phase calibration techniques for SuperDARN and ICEBEAR.

Keywords: ionosphere, magnetosphere, calibration

The SuperDARN Meteor Wind Product: A 31-year archive with modeled altitude contributions and validation

*Alex Chartier[1]

1. APL

We present a new 31-year archive (1993–2024) of meteor wind observations derived from the Super Dual Auroral Radar Network. While SuperDARN radars primarily observe the ionosphere, meteor echoes in standard operations provide continuous, all-local-time measurements of neutral winds in the mesosphere–lower thermosphere. A key limitation of these observations is the lack of height resolution. To address this, we develop an empirical model of the meteor altitude contribution function using meteor radar data, atmospheric models, and meteoroid flux estimates. The model is used to interpret SuperDARN winds and to enable quantitative comparisons with independent datasets.

Keywords: meteor, winds, mesosphere

Validating phase code modulation for sub-45 km range separation modes on the USRP-based SuperDARN system

Allison Pitzl[1], *Kevin T. Sterne[1], Evan G. Thomas[2], J. Michael Ruohoniemi[1]

1. Virginia Tech, 2. Dartmouth College

In March 2024, the Blackstone SuperDARN radar was upgraded to operate using software-defined radios (SDRs), enabling flexible transmit waveform generation. This work validates the operation of Pcodescan, a phase-coded pulse compression mode using Barker codes, on the upgraded system. Despite prior use, the mode had not been systematically tested on the new SDR-based hardware. In September 2025, experiments across all valid Barker code configurations revealed that certain bit length and multi-pulse increment combinations produced erroneous Doppler velocities during otherwise quiet ionospheric periods. The anomaly was replicated using a laboratory test radar in loopback configuration, where debugging revealed a sign error in the phase offset compensation of the USRP server baseband generation code. This error leaked into the velocity measurements, producing a false Doppler shift. A follow-on experiment in March 2026 confirmed the fix and validated correct velocity measurements across all modes.

Keywords: phase code modulation, software defined radio

Post-processing tool to reprocess antennas IQ data with any averaging duration.

*Jordan Cho[1], Remington Rohel[1], Pasha Ponomarenko[1], Daniel Billet[1]

1. University of Saskatchewan

The Borealis radar system designed by the SuperDARN Canada team allows for simultaneous sounding of the whole field of view by using a wide-beam transmission provided by non-linear phasing of the antenna array and narrow-beam reception performed by post-processing the received IQ signals from each antenna. We developed a tool to reprocess the IQ data to different averaging durations regardless of the initial averaging duration set during the radar operation. This was done because the latter may not be optimal if any ionosphere processes in the FOV are non-stationary during the averaging duration. In the new tool, the pulse sequences that are transmitted and received can be regrouped to fit the new desired averaging duration before further processing. To develop techniques to reprocess and find an averaging duration best suited for desired data, we will analyse data from the Clyde River radar. This analysis will be performed with the wide-beam ground scatter and ionosphere scatter data for several averaging durations ranging from 1 second to 1 minute for several 2-hour data periods.

Keywords: Widebeam Data, Averaging Duration/Integration Time, Post-processing

New SuperDARN data products of ionospheric vorticity and merge velocity vectors from mid-latitudes to the pole

*Gareth Chisham[1], William A Bristow[2], Glenn Hussey[3], J Michael Ruohoniemi[4], Simon G Shepherd[5]

1. British Antarctic Survey, 2. Penn State University, 3. University of Saskatchewan, 4. Virginia Tech, 5. Dartmouth College

New SuperDARN data products of ionospheric vorticity and merge velocity vectors have been produced for the epoch 2011-2016 inclusive extending from mid-latitudes (~50 degrees AACGM latitude) to the geomagnetic pole. These analyses make use of 4 SuperDARN radar pairs in the North American sector (INV/RKN, KOD/PGR, SAS/KAP, CVE/FHW). Recent statistical studies of ionospheric plasma flow vorticity have provided new insight into the nature of mesoscale plasma flow structures in the ionosphere, and how these vary with the ambient environmental conditions, and physical location in the system. The new vorticity data products allow the extension of these analyses to the polar and mid-latitude regions. This presentation will show a comparison between the initial analyses with this and previous vorticity data sets, and discuss planned future analysis. The same radar pairs have been used to produce a database of merge velocity vectors for the same time epoch. This presentation will show initial analyses of these data and discuss potential future usage of the new data product. Both data products are being given DOIs and will be made freely available to the community.

Keywords: SuperDARN, Ionospheric Vorticity, Merge Velocity Vectors

Data assimilation into an emulator of a magnetosphere-ionosphere model for obtaining polar ionospheric potential map

*Shin'ya Nakano[1,2], Ryuho Kataoka[3], Shigeru Fujita[1], Nilam Bhosale[3], Aoi Nakamizo[4], Akira Sessai Yukimatu[5]

1. The Institute of Statistical Mathematics, 2. Graduate University for Advanced Studies, SOKENDAI, 3. Okinawa Institute of Science and Technology, 4. National Institute of Information and Communications Technology, 5. National Institute of Polar Research

In order to globally reproduce the dynamics of the polar ionosphere, it is essential to consider the physical processes in the magnetosphere. However, a physical model of the magnetosphere is computationally demanding to solve the magneto-hydrodynamic (MHD) equation over the entire magnetosphere. We have developed a machine-learning-based emulator of an MHD model of the magnetosphere to efficiently obtain the temporal evolution of the polar ionosphere. This emulator provides an empirical prediction of the ionospheric variation as a result of the magnetospheric response to the solar wind variation. We then incorporate the SuperDARN data into the emulator to improve the realism of the prediction. Data assimilation of the line-of-sight velocity data by the SuperDARN radars is conducted by an algorithm which combines the ensemble transform Kalman filter with the importance sampling method to consider non-Gaussian features of the SuperDARN data. We compare compare the polar cap potential drop derived from the the estimated potential distribution with some geomagnetic indices. The result suggests some correspondences in variations between the polar cap potential drop and geomagnetic activity.

Keywords: emulator, data assimilation, ionospheric convection

Unprecedented 2-D SuperDARN flows: unexpected fundamental elements of polar cap convection and substorm growth phase

*Lyons Lyons[1], Yukitoshi Nishimura[2], Katherine Davidson[2], Daniel Billet[3], Sneha Yadav[1], Pasha Ponomarenko[3], Remington Rohel[3], Nozomu Nishitani[4], Eric Donovan[5], Vassilis Angelopoulos[1]

1. UCLA, 2. Boston University, 3. University of Saskatchewan, 4. Nagoya University, 5. University of Calagary

The new capability of resolving ionospheric flows in two-dimensions with high-spatial resolution, using the divergence-free condition, gives unprecedented opportunity to use SuperDARN to evaluate features of polar cap and auroral oval convection. Our preliminary survey indicates polar cap convection (dayside, nightside) at any given time may have important contributions from narrow flow channels that are poorly represented with previous large-scale convection pattern. Furthermore, there can large temporal variations, even under stable IMF conditions. If verified with more thorough analysis, these results would imply that the large-scale polar cap potential patterns should be viewed as long-term averages, but not representative of the actual structure of convection.
Fundamental understanding of what leads to the energy storage released during a substorm has not changed significantly since identification of the substorm growth phase by *McPherron* (1970). Based on 4 events, preliminary analysis indicates that, for some cases, first either: 1. an equatorward directed flow channel forms in the polar cap following prior weak convection or 2. an equatorward directed flow channel pre-exists within the polar cap. At a later time, the polar cap flow channel crosses into auroral oval (i.e., longitudinally localized nightside reconnection), this entry appearing not to be directly related to an IMF change. The entering flow channel then connects to a duskward-directed azimuthal flow. For cases with the auroral equatorward boundary detected with ASIs, this return flow was mostly equatorward of the auroral oval and was thus SAPS. This return flow/SAPS flow implies an increase in Region 2 (R2) downward currents, implying an increase in the partial ring current from the incoming flow channel. An increase in R2 currents using AMPERE was reasonably well-found using AMPERE, considering AMPERE’ s 10 min resolution and limitations from spherical harmonic fits used to obtain the currents.

Keywords: Convection, Flow channels, substorm growth phase, partial ring curren, Region 2 currents, SAPS

Evolution of Reversed Convection Vortices Observed by SuperDARN during a Geomagnetic Storm

*Jiaojiao Zhang[1], Xiyu Liu[2], Yiqun Yu[2], Nozomu Nishitani[3]

1. National Space Science Center Chinese Academy of Sciences, 2. Beihang University, 3. ISEE, Nagoya University

In recent years, six new SuperDARN radars have been constructed in China (CN-DARN), which have filled a major observational gap in mid-latitude coverage of the global SuperDARN network, enabling us to obtain the complete evolutionary picture of ionospheric convection during geomagnetic storms. In this study, we present an observation of evolution of reversed convection vortices by SuperDARN during the 1 December 2023 magnetic storm. By using comprehensive observation including SuperDARN convection, AMPERE maps of FACs and associated Iridium magnetic perturbations, in-situ Swarm observations of FACs, we identify a distinct counter-clockwise convection cell in the mid-latitude dusk sector of northern hemisphere, produced due to the intrusion of ring current wedge (RCW) into the lower-latitude Region-2 FAC area. Global magnetohydrodynamic (MHD) simulations further confirm that intense substorm injections disrupt both the tail current and ring current, forming spatially separated SCW and RCW structures. Their Region-1 sense FAC footprints exhibit latitudinal separation, enabling the observed counter-clockwise convection. These findings suggest the presence of a previously unrecognized wedge-shaped current system earthward of the SCW, fundamentally advancing our understanding of substorm magnetospheric dynamics.

Keywords: Reversed convection vortices, Chinese SuperDARN radars, Ring current wedge

Mid-latitude SuperDARN systematically underestimates the storm-time ionospheric electric field

*Maria-Theresia Walach[1]

1. Lancaster University

The Super Dual Auroral Radar Network (SuperDARN) infers the high-latitude ionospheric electro-static potential and electric field from line-of-sight velocities inferred from Doppler shift. These mappings, coded into the Radar Software Toolkit assume that the electric field is horizontal and the magnetic field is vertical. There is however an unaccounted physical constraint, that at mid-latitudes the magnetic field is significantly tilted from the vertical direction. This tilt becomes important especially during geomagnetic storms when the convection pattern expands to mid-latitudes. The horizontal-only assumption produces a direction-dependent underestimate of the inferred electric field, bounded by a geometrical factor, which mostly affects meridional flow.

We quantify this bias using IGRF geometry, real storms (e.g. St Patrick's Day 2015) and direct line-of-sight measurements, tested against AMISR vector velocities. We find that mid-latitude radars systematically underestimate inferred the electric field magnitude by 4–6 % at storm peak, with the per-cell maximum reaching the geometric ceiling of 17 % at the equatorward Heppner–Maynard boundary. When used for space weather estimates, the introduced bias propagates quadratically into Joule heating, where Hokkaido East loses ~12 % of its inferred storm-time energy deposition rate.

Keywords: mid-latitude, magnetic field direction, electric field

A Superposed Epoch of SuperDARN Plasma Convection, THEMIS-All-Sky Auroral Brightness, and Their Covariance During Substorms.

*Matthew Flynn Wilcox[1]

1. Penn State University

Joule heating, driven by the interaction of electric fields and ionospheric conductivity, is a primary cause of thermospheric expansion during geomagnetic activity. This expansion increases atmospheric drag on Low-Earth-Orbit (LEO) satellites, potentially reducing their lifetimes. Accurate Joule heating estimates require precise knowledge of the electric field, derived from plasma convection, and conductivity which is proportional to auroral brightness. Using plasma convection data from the Super Dual Auroral Radar Network (SuperDARN) and auroral brightness data from NASA’s Time History of Events and Macroscale Interactions during Substorms (THEMIS) All-Sky Imagers (ASI), we performed a superposed epoch analysis of 10 auroral substorm events from solar cycle 24, the most recent completed solar cycle. This analysis characterizes the typical temporal and spatial evolution of plasma velocity, auroral brightness, and their covariance during substorms. The superposed epoch shows that brightening and expansion of the auroral arc are broader and weaker than in individual events. Plasma velocities are lower than in individual events, but persist to the west and equatorward of onset, while negative covariance emerges near substorm onset, strengthening and spreading with the brightest auroral regions. Although not yet applied in empirical models, the covariance quantity provides a practical constraint for predicting electric field and conductivity in the auroral zone, which could ultimately improve Joule heating calculations, improving forecasts of thermospheric expansion and helping mitigate the risk of premature satellite reentry due to increased atmospheric drag.

Keywords: Joule Heating, Thermospheric Expansion, Auroral Substorm, Plasma Convection, Ionospheric Conductivity, SuperDARN, THEMIS ASI, Covariance

Slow recovery of the plasmasphere during the May and October 2024 super geomagnetic storm

*Atsuki Shinbori[1], Naritoshi Kitamura[1], Kazuhiro Yamamoto[1], Atsushi Kumamoto[2], Fuminori Tsuchiya[2], Shoya Matsuda[3], Yoshiya Kasahara[3], Mariko Teramoto[5], Ayako Matsuoka[4], Takuya Sori[4], Yuichi Otsuka[1], Michi Nishioka[6], Septi Perwitasari[6], Yoshizumi Miyoshi[1,7], Iku Shinohara[8]

1. Nagoya University, 2. Tohoku University, 3. Kanazawa University, 4. Kyoto University, 5. Kyushu Institute of Technology, 6. Institute of Information and Communications Technology, 7. Kyung Hee University, 8. Institute of Space and Astronautical Science, Japan Aerospace eXploration Agency

To elucidate the main cause of the slow recovery of the plasmasphere during the May and October 2024 super storms, we analyzed Global Navigation Satellite System (GNSS) - total electron content (TEC) and Arase satellite observation data. To identify the electron density variation in the ionosphere, we calculated the ratio of the TEC difference (rTEC), which is defined as the difference from the 10-quiet-day average TEC divided by the average value. Additionally, we estimated the electron density in the plasmasphere and inner magnetosphere from the upper frequency limit of the upper hybrid resonance (UHR) waves observed by the Arase satellite. Consequently, an L-t plot of the electron density showed that the plasmasphere contracted from L = 7.0 to L = 1.5–2.5 within 9 h after a sudden commencement of both geomagnetic storms. During the storm recovery phase, the plasmapause gradually shifted to a higher L-shell. The electron density in the plasmasphere recovered the quiet-time level on a 3 or 4-day scale. The timescale of the plasmaspheric refilling was much longer than that of other coronal mass ejection (CME)-driven storms during the Arase era. The rTEC in the Northern Hemisphere showed that an enhancement in the rTEC value occurred at high latitudes (60°–70° in magnetic latitude (MLAT)) in the daytime (10–14 in magnetic local time (MLT)), approximately 1 h after the storm onset. Subsequently, a tongue of ionization (TOI) formed in the polar cap owing to the effect of the solar wind and magnetosphere in driving horizontal flows in the ionosphere. The rTEC was globally depleted during the storm recovery phase. The depletion indicates the occurrence of a negative storm owing to a neutral composition (O/N_2) change driven by the energy input from the magnetosphere in the high-latitude thermosphere. The coincidence of the long refilling timescale of the plasmasphere and the depletion of the rTEC suggests that a strong negative storm impedes plasmaspheric refilling.

Keywords: May 2024 super geomagnetic storm, Plasmasphere, Ionosphere, Negative storm, GNSS-TEC, Arase satellite, Plasmaspheric refilling, Composition change of neutral atmosphere

A Statistical Study of Polar Cap Patch Occurrence and IMF Dependence Using GNSS TEC Maps

*Qingyu Zhang[1,2,3], Yuzhang Ma[1], Beichen Zhang[2,4], Qinghe Zhang[5,1], Zanyang Xing[1], Huixin Liu[3], Kjellmar Oksavik[6,7], Xiangcai Chen[2,8,9], Zejun Hu[2,8], Yong Wang[1], Jianping Wang[10]

1. Shandong Key Laboratory of Space Environment and Exploration Technology, Institute of Space Sciences, Shandong University, 2. MNR Key Laboratory for Polar Science, Center for Space Physics and Astronomy, Polar Research Institute of China, 3. Department of Earth and Planetary Sciences, Kyushu University, 4. Antarctic Zhongshan Ice and Space Environment National Observation and Research Station, Polar Research Institute of China, 5. State Key Laboratory of Solar Activity and Space Weather, National Space Science Center, Chinese Academy of Sciences, 6. Department of Physics and Technology, University of Bergen, 7. Arctic Geophysics, University Centre in Svalbard, 8. Arctic Yellow River Earth System National Observation and Research Station, Polar Research Institute of China, 9. State Key Laboratory of Lunar and Planetary Sciences, Macau University of Science and Technology, 10. Instistute of Physics and Optoelectronics Technology, Baoji University of Arts and Sciences

We present an automated algorithm for identifying the two-dimensional distribution of polar cap patches from GNSS Total Electron Content (TEC) maps, combining dynamic thresholding with a set of physical constraints. The performance of the algorithm is validated using a well-documented event, showing close agreement with manual identification in both timing and spatial morphology. Using GNSS TEC data from 2020–2024, we analyze the seasonal, universal time (UT), and Interplanetary Magnetic Field (IMF) dependencies of patch occurrence in the northern polar cap. The resulting patterns are generally consistent with previous studies, with results from solar-maximum years being more reliable. Focusing on the solar-maximum year 2023, we further examine the relationship between patch formation and the preceding IMF variations. The statistical analysis reveals that both rapid and large-amplitude variations in the IMF By and Bz components are closely associated with patch formation, with these IMF fluctuations typically preceding patch formation by about 10–15 minutes. This suggests that IMF-driven modulation of the convection pattern plays an important role in polar cap patch formation. These results provide new statistical evidence linking IMF variations to patch formation and demonstrate the capability of TEC-based methods for statistical patch studies.

Keywords: Polar cap patches, GNSS TEC maps, Plasma convection

Forecasting Polar Ionospheric Electrostatic Potentials Patterns Using Score-Based Diffusion Models and Solar Wind Drivers

*Igino Coco[1], Francesco Pio Ramunno[2], Simone Mestici[3], Maria Walach[4], André Csillaghy[2], Stefano Massetti[5]

1. INGV, 2. FHNW, 3. Roma "La Sapienza" Univ., 4. Lancaster Univ., 5. INAF-IAPS

We present a preliminary study on forecasting electrostatic potential maps in the polar ionosphere using external drivers, including the interplanetary magnetic field (IMF) and solar wind velocity (SWV). We employ advanced machine learning techniques, focusing on score-based diffusion models, which are capable of generating realistic data by reversing a noise-corruption process and are well suited for capturing complex spatial patterns.The model is trained on a dataset of two-dimensional ionospheric potential maps derived from SuperDARN observations in the Southern Hemisphere (years 2020-2025, 2-minute cadence), combined with corresponding IMF and SWV measurements. Using a 30-minute input window, the model directly predicts future map sequences while enforcing physical consistency through the inclusion of solar wind conditions.Results show high predictive accuracy on short timescales (a few minutes), successfully reproducing both spatial structures and global indicators such as the Cross Polar Cap Potential. Performance degrades beyond 10-20 minutes, reflecting the intrinsic dependence of ionospheric dynamics on future external conditions. However, by incorporating upstream measurements at L1 and accounting for propagation delays, the model enables forecasts with up to ˜1 hour lead time.These findings demonstrate the potential of diffusion models for ionospheric prediction, while highlighting fundamental limits in system predictability and the need for improved solar input characterization and expanded training datasets.

Keywords: Polar cap potential patterns, Deep learning model

A Statistical Picture of Dusk-Dawn Asymmetries in the Nightside Ionosphere

*Jewel Abbey Relampagos[1], Adrian Grocott[1], Steve Milan[2]

1. Lancaster University , 2. University of Leicester

Previous work has reported on the IMF control of asymmetric (east-west) flows observed in the high-latitude nightside ionosphere by SuperDARN (Grocott et al., 2008). However, since 2010, SuperDARN has undergone expansion in the Northern Hemisphere, with the inclusion of mid-latitude radars (StormDARN) and polar-latitude radars (PolarDARN). As a result, significant changes may be introduced in the ionospheric convection map data due to increased spatial coverage in the mid-latitude regions. In addition to this, the use of newer statistical models and improved data analysis procedures will also contribute to changes in the produced convection patterns.

Using SuperDARN Northern Hemisphere observations from 1999 to 2023, we build upon earlier results to explore the consequences of these developments. We extend the analysis to assess the validity of the Grocott et al. (2008) results, and compare the occurrence of these fast flows with other geophysical parameters such as the auroral electrojet index. We also compare the flows to field-aligned current boundaries derived from the AMPERE dataset to investigate the magnetospheric origins of the flows.

Keywords: Ionosphere Plasma Convection , Ionosphere-Magnetosphere Coupling , SuperDARN, AMPERE

Accounting for a Variable Flow Reversal Boundary Location in SuperDARN Convection Modelling

*Adrian Grocott[1]

1. Lancaster University

SuperDARN convection models are typically parameterised by the upstream IMF conditions, with all flow data for a given specification of the IMF orientation and magnitude (or solar wind electric field) being combined to produce the best-fit pattern for those conditions. This approach neglects the fact that the size of the convection pattern is largely controlled by the solar wind and magnetospheric time-history, not the instantaneous driving conditions. Hence, a given model pattern may contain data within the same geographical region that corresponds to very different geophysical regions. Chisham et al. (2025, doi:10.1029/2025GL115265) recently addressed the impact of this issue on the ionospheric vorticity, using IMAGE FUV auroral boundaries to define an adaptive coordinate system for interpreting the vorticity data. They found that an auroral boundary-based coordinate system better organised the vorticity data. We consider whether the flow can be better organised using a similar approach. Rather than using an independent dataset (such as auroral imagery) to order the data, we test how well the flow data can order itself using the dusk and dawn flow reversal boundaries.

Keywords: Convection, Boundary

Updating ionospheric conductivity in an AI-based emulator through SuperDARN and SuperMAG data assimilation

*Nilam Yashwant Bhosale[1], Ryuho Kataoka[1], Shinya Nakano[2], Shigeru Fujita[2], Akira Sessai Yukimatu[3], Aoi Nakamizo[4]

1. Okinawa Institute of Science and Technology, Japan, 2. Institute of Statistical Mathematics, Tachikawa, Tokyo, Japan, 3. National Institute of Polar Research, Tachikawa, Tokyo, Japan, 4. National Institute of Information and Communication Technology , Tokyo, Japan

Ionospheric electrodynamics is characterized by temporal variations and spatially non-uniform electric potential, conductivity, and auroral currents, especially in the auroral region, where particle precipitation and field-aligned currents produce spatially varying conductance and current systems. We examine these electrodynamic variations using the Surrogate Model for REPPU Auroral Ionosphere (SMRAI), an AI-based emulator trained on ionospheric outputs from the REPPU global MHD simulation (Kataoka et al., 2023, 2024). SuperDARN line-of-sight plasma drift observations are assimilated to update the two-dimensional electric potential pattern, which is referred to as SMRAI-SD (Nakano et al., 2025). After SuperDARN data assimilation, SMRAI-SD better reproduces the temporal variability and AE indices than the original SMRAI results. We further use SuperMAG magnetic perturbations together with the SuperDARN-updated potential to estimate Hall conductivity. The resulting Hall conductivity and Hall current maps show more spatially non-uniform structures than those derived using the original SMRAI potential. During the substorm interval, the combined SuperDARN–SuperMAG update shows localized nightside conductivity enhancement. This result suggests that SuperMAG data assimilation, when combined with the SuperDARN-updated electric potential can modify the conductivity pattern. However, the physical validity of the updated conductivity distribution and its role in reproducing auroral currents require further investigation.

Keywords: AI emulator , Ionospheric Electordynamics, Auroral region, Ionospheric Conductivity

Mesoscale, short-lived Joule heating events are widespread in the polar ionosphere, and further statistics on their spatiotemporal characteristics.

*Daniel Billett[1], Remington Rohel[1], Ian Mann[2], Glenn Hussey[1], Carley Martin[1]

1. University of Saskatchewan, 2. University of Alberta

The SuperDARN Canada radars (INV, PGR, SAS, CLY, RKN) have carried out numerous coordinated wide-beam runs (3.7s temporal resolution scans) over the past couple of years, resulting in over 100 days of high temporal resolution measurements with uncompromised spatial coverage. We have used these runs to make high-temporal resolution convection maps over Canada, called the Fast Borealis Ionosphere (FBI).

In this study, we examine the FBI maps through the lens of Joule heating generated by the convection electric field. We present statistics that simultaneously examine the spatial scale and temporal longevity of Joule heating events, showing that short-lived, mesoscale events are extremely common. About 50% of the total Joule heating power is dissipated on spatial scales below ~800km and timescales below ~3 minutes.

No other instrument (ground or space-based) comes close to the simultaneous spatial coverage and temporal fidelity offered by the SuperDARN wide-beam convection patterns. It has enabled the first data-driven proof that Joule heating is dominated by variability on mesoscales and short temporal scales, a longstanding problem within the space physics community.

Keywords: joule heating, convection, superdarn

Multi-Point Observations of Quarter-Wave Field Line Resonances Across the Magnetosphere–Ionosphere System with SuperDARN, Ground Magnetometers, Arase

*Yuki Obana[1], Nozomu Nishitani[2], Keisuke Hosokawa[3], Tomoaki Hori[2], Mariko Teramoto[4], Atsuki Shinbori[2], Pavlo V. Ponomarenko[5], Akira S. Yukimatu[6], Colin L. Waters[7], Murray D. Sciffer[7], Glenn Hussey[5], Akimasa Yoshikawa[1], Yoshizumi Miyoshi[2], Ayako Matsuoka[8], Atsushi Kumamoto[9], Fuminori Tsuchiya[9], Shoya Matsuda[10], Yoshiya Kasahara[10], Iku Shinohara[11], Ian R. Mann[12], David K. Milling[12]

1. i-SPES, Kyushu University, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. The University of Electro-Communications, 4. Kyushu Institute of Technology, 5. University of Saskatchewan, 6. National Institute of Polar Research, 7. The University of Newcastle, 8. Kyoto University, 9. Tohoku University, 10. Kanazawa University, 11. Institute of Space and Astronautical Science, JAXA, 12. University of Alberta

A distinct Pc5-band (~2.4 mHz) ultra-low-frequency (ULF) wave was detected in the duskside subauroral region by two Canadian SuperDARN radars between 00:00 and 02:00 UT on 23 November 2022 under exceptionally quiet geomagnetic conditions. The wave exhibited a periodic Doppler velocity signature resembling a "caterpillar," characterized by northeastward (anti-sunward) propagation and an azimuthal wave number of ~12. Ground magnetometer observations showed latitudinal variations in wave amplitude and phase consistent with field line resonance (FLR), with a peak near 66° magnetic latitude. SuperDARN observations further revealed detailed ionospheric structures and propagation characteristics of the FLR.Simultaneously, the Arase satellite, whose ionospheric footprint traversed the caterpillar-wave region, detected toroidal oscillations in both electric and magnetic fields at magnetically conjugate locations in the inner magnetosphere. These oscillations showed strong coherence with the ground observations. The electric field led the magnetic field by ~45° in phase, indicating that the wave contained both standing and propagating components carrying energy toward the northern ionosphere.Electron densities of ~21-25 cm^{-3} inferred from upper hybrid resonance (UHR) frequencies observed by PWE/HFA yielded an expected fundamental half-wave resonance frequency of ~3.9 mHz, significantly higher than the observed frequency (~2.4 mHz). This discrepancy suggests that the wave is more consistent with a quarter-wave mode, whose resonance frequency is typically 1.5-1.7 times lower than that of the half-wave mode.Numerical simulations using a 2.5-dimensional dipole magnetosphere model reproduced key characteristics of quarter-wave modes. Previous studies suggested that quarter-wave resonances are preferentially excited during geomagnetically quiet conditions and under strong interhemispheric asymmetry in ionospheric Pedersen conductance. Both conditions were satisfied during this event, supporting the quarter-wave interpretation.In this presentation, we extend the analysis to additional events. We present multi-point observations of quarter-wave FLRs, with particular emphasis on diagnosing FLR properties from ionospheric signatures observed by SuperDARN.

Keywords: ULF wave, field line resonance, quarter-wave

Stormtime electric fields at middle and low latitudes as observed by HF Doppler sounders and magnetometers during the super storm on May 10-11, 2024

*Takashi TK Kikuchi[1], Kumiko Hashimoto[2], Keisuke Hosokawa[2], Tomizawa Ichiro[2], Ryuho Kataoka[3], Jaroslav Chum[4], Yusuke Ebihara[5], Yukitoshi Nishimura[6]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. University of Electro-Communications, 3. Okinawa Institute of Science and Technology, 4. Institute of Atmospheric Physics of the Czech Academy of Sciences, 5. Research Institute for Sustainable Humanosphere, 6. Center for Space Physics, Boston University

The Mother’ s day storm on May 10-11, 2024 provided us with opportunities to find new properties of ionospheric electric field and currents from mid-latitudes to the equator. Mid-latitude geomagnetic sudden commencement (SCx,y in Bx or By component) is bipolar as composed of the preliminary impulse (PI) and main impulse (MI). It is shown that the mid-latitude SCx,y is SCx(+ -) and SCy(- +) in the morning, and SCx(- +) and SCy(+ -) in the afternoon. The equatorial SCx is SCx(- +) during the day and SCx(+ -) during the night. The SCx,y meets the DP2 currents composed of two-cell Hall current vortices at high-middle latitudes surrounding the foot of field-aligned currents (FACs) and of Pedersen-Cowling currents between the FACs and equatorial ionosphere. It is shown that the PI started instantaneously at midlatitude and equator with the resolution of 1 sec. During the storm main phase (MP), midlatitude Bx/By are MPx(-) and MPy(+) in the morning and MPx(+) and MPy(-) in the afternoon, and the equatorial MPx is MPx(+) during the day and MP(-) during the night, consistent with the DP2 currents. Electric fields were observed by HF Doppler sounders in Japan, Czechia and Argentina in three local time zones. The electric fields of the PI/MI in the day and night are in opposite direction to each other. The day-night reversal of the electric fields are consistent with electric potentials transmitted by the TM0/TEM mode in the Earth-ionosphere waveguide/transmission line. The electric field of the MP is the dawn-to-dusk convection electric field, while the overshielding occurred a few hours after the SC and in the beginning of the storm recovery phase. During the recovery phase of the storm on May 11 2024, several substorm positive bays occurred at mid-latitudes during the night, which were accompanied by DP2 currents on the dayside and westward convection electric fields on the nightside, which suggests that the stormtime substorms provided the convection electric fields to the middle latitude ionosphere.

Keywords: Storm on May 10-11, 2024, Convection and overshielding electric fields during storm main phase, Ionospheric electric field and currents of SC , Stormtime substorm electric field and currents, TM0/TEM mode in Earth-ionosphere waveguide/transmission line

Ionospheric convection during a low-latitude aurora event on Jan 1, 2025

*Keisuke Hosokawa[1], Nozomu Nishitani[2], Tomoaki Hori[2], Atsuki Shinbori[2], Yuki Obana[3], Mariko Teramoto[4], Akira Sessai Yukimatu[5], Yoshizumi Miyoshi[2]

1. University of Electro-Communications, 2. ISEE, Nagoya University, 3. Kyushu University, 4. Kyushu Institute of Technology, 5. National Institute of Polar Research

On the night of the new year day of 2025, which corresponded to the main phase of an intense magnetic storm (minimum Dst of -200 nT), continuous appearance of reddish aurora was captured by a color digital camera at Rikubetsu, Hokkaido (Glat: 43.53N, Glon: 143.61E, Mlat: 36.76N, and L-value of 1.558). During this extended interval of auroral display at mid-latitude, relatively large substorms (AE index of as large as 2000 nT) occurred three times with a separation of several hours. Following these substorm events, the aurora observed from Hokkaido got intensified, while the Super Dual Auroral Radar Network (SuperDARN) radars installed in the same place simultaneously observed an increase of the plasma convection in the longitudinal direction. During these intensifications, the region of reddish auroral emission showed longitudinal drift: during the first two intensification events before midnight, the aurora moved westward, while the final intensification observed in the morning side showed eastward movement. The directions of these auroral drift well corresponded to the east-west drift velocities measured by SuperDARN. During the third intensification event, ultraviolet aurora observations by DMSP/SSUSI confirmed that the reddish aurora seen from Hokkaido had migrated southward to approximately 50 MLAT. Furthermore, the region of enhanced plasma convection observed by SuperDARN was found to be located slightly equatorward of the aurora structure. In the presentation, we will discuss the relationship between the plasma convection observed by SuperDARN and the velocities of the drifting motion of aurora, as well as the mechanism by which substorms cause intensification of mid-latitude auroras and corresponding enhancement of the background ionospheric convection.

Keywords: Convection, Aurora, Sub-auroral region

Distinguishing Global and Local Drivers of Low-Latitude Aurorae in November 2025

*Tomotaka M. Tanaka[1,2], Nozomu Nishitani[3], Kiyoka Murase[4]

1. The Graduate University for Advanced Studies, 2. National Institute of Polar Research, 3. Institute for Space–Earth Environmental Research, Nagoya University, 4. Kitami Institute of Technology

The occurrence of low-latitude aurorae has been discussed in relation to global geomagnetic indices such as AE, Dst, and SYM-H. It is known that the visible latitude of these aurorae tends to decrease as geomagnetic activity intensifies (e.g., larger AE and more negative Dst/SYM-H). A recent study found that an increase in ASYM-H—an indicator of ring current asymmetry—contributes to low-latitude occurrences, suggesting the presence of local factors that cannot be explained solely by global disturbances. Despite this, there have been no previous cases directly comparing the differences and individual contributions of global fluctuations and local structures in events where both were observed simultaneously. To elucidate the triggers of low-latitude aurorae, categorizing and examining them as "global factors" and "local factors" is considered an essential clue. Therefore, this study analyzes and compares the characteristics of both factors during the low-latitude aurora event on November 12, 2025.For the analysis, we used Doppler velocity data from the SuperDARN Hokkaido West HF radar and aurora camera data from the Rikubetsu radar site. Optical observations captured a diffuse, large-scale red aurora lasting for several hours, whereas a red aurora with a striated structure appeared in a localized region for a short duration of less than several tens of minutes. Doppler echoes, likely representing westward plasma convection, were simultaneously observed during the period when the striated aurora was visible. The diffuse, long-lasting, large-scale aurora is consistent with characteristics of a SAR arc, typically caused by the proximity of the ring current and the plasmapause. In contrast, the short-lived appearance of the striated aurora and the associated westward plasma convection suggest that FACs associated with conductivity gradients may contribute to their formation. This presentation will discuss the mechanisms of low-latitude aurorae from the perspectives of global and local factors in geomagnetic activity.

Keywords: Low-Latitude Aurora

SuperDARN HOP Radars Observations of Ionospheric Convection Associated with Low-Latitude Auroras under Quiet Geomagnetic Conditions

*Ryuki Yoda[1], Nozomu Nishitani[1], Tomoaki Hori[1], Atsuki Shinbori[1], Kazuo Shiokawa[1], Keisuke Hosokawa[2], Yuki Obana[3], Mariko Teramoto[4]

1. ISEE, Nagoya University, 2. UEC, 3. Kyushu University, 4. Kyushu Institute of Technology

During Solar Cycle 25, which reached its maximum in 2024, increased solar activity has led to multiple geomagnetic storms. As a result, several instances of aurora emission have been observed in Rikubetsu, Hokkaido, Japan (geomagnetic latitude: 37 degrees). Among these, we focused on the auroral event observed on March 26, 2025, despite low geomagnetic activity (with the Dst of -60 nT). This event is particularly interesting because most of the other auroral events were associated with much stronger geomagnetic activity, typically with minimum Dst values below -100 nT.

Analysis using the SuperDARN HOP (Hokkaido Pair of) radars revealed localized flow intensification (at 55 to 65 degrees geomagnetic latitudes) associated with auroras, equatorward expansion of the auroral oval boundary, together with southward convective flows originating from the high-latitude regions poleward of 70 to 80 degrees geomagnetic latitude.

This study aims to capture changes in ionospheric convection associated with low-latitude auroras using the SuperDARN HOP radar. By comparing these changes with other auroral events at Rikubetsu, we investigate how they are related to geomagnetic activity. Furthermore, we seek to elucidate the factors driving these convective changes and auroral emission.

Keywords: SuperDARN HOP raders, low-latitude aurora, ionospheric convection, geomagnetic activity dependence, Hokkaido Rikubetsu

Auroral activity observed from unusual latitudes in China and its underlying significance

*Jiaojiao Zhang[1,2,3], Xiang Deng[1,3], Jiyao Xu[1,2,3], Hui Li[1], Hang Li[1,2,3], Wei Wang[1,3], Jianyun Liang[1], Simon G. Shepherd[4], Evan G. Thomas[4], Ailan Lan[1], Jingye Yan[1], Zheng Wang[1], Qing-He Zhang[1], Ziqian Liu[1], Xinyue Wang[1], Fuqing Huang[5], Xianguo Zhang[1], Weiguo Zong[6], Chi Wang[1]

1. National Space Science Center Chinese Academy of Sciences, 2. University of Chinese Academy of Sciences, 3. Siziwang Observatory of Space Weather, 4. Dartmouth College, 5. University of Science and Technology of China, 6. National Satellite Meteorological Center

Auroras have been observed at unusual latitudes of China over the past couple of years, which may be a direct result of the north magnetic pole’ s drift and intense solar activity. However, the specific impact on the Asian space environment remains unclear. Here, we present auroral activities recorded in southern Inner Mongolia (~37.2° N in magnetic latitude) and the resulting ionospheric environmental changes detected by the Chinese Dual Auroral Radar Network (CN-DARN) during a recent severe geomagnetic storm. Leveraging the wide spatial coverage and continuous high time resolution monitoring capabilities of the CN-DARN, comprehensive analysis of ground-based and space-based multi-source data reveals that CNDARN has captured the spatiotemporal evolution characteristics of dawnside subauroral polarization streams (SAPS). The study identifies a direct link between auroral intensification and dawnside SAPS acceleration for the first time, establishing a mechanistic connection between auroral activity and ionospheric convection dynamics in subauroral region. Moreover, the observations show that the ionospheric irregularities with high velocity of 1,000 m/s induced by the dawnside SAPS have propagated to Mohe (~ 48.6° N in magnetic latitude), the northernmost region of China. The research also reveals that intense auroral particle precipitation caused severe degradation of high-frequency (HF) communications in the Asian region. This study represents the first comprehensive investigation of auroral activity observed at unusual latitudes of China, unraveling the impact of auroral activities on the ionospheric environment of Asian mid-to-high latitudes. It also showcases the critical capabilities of the Chinese Meridian Project in addressing space environmental challenges of Asia.

Keywords: auroral activities, dawnside SAPS, CN-DARN radars

40 Years with HF Radar for Ionospheric Research: Experiences, Highlights, Fun Facts

*John Michael Ruohoniemi[1]

1. Virginia Tech

Before SuperDARN there was a bold idea to apply HF frequencies to study the auroral ionosphere using coherent backscatter techniques and phased array antennas. Ray Greenwald and colleagues installed the first radar at Goose Bay, Labrador in 1983. I joined his group at JHU/APL as a postdoctoral fellow in January, 1986, and was promptly thrown into the front line…hauling transmitters on and off the towers at Goose Bay at -30 C in a brisk northwest wind as Ray sought to boost transmitter power from 100 W to 2 kW. The project was collaborative from the beginning with personnel and equipment shared on the Goose Bay project and on radar builds carried out by the French at Schefferville, Québec, and by the British at Halley Bay, Antarctica. Early scientific successes led to the concept of a larger effort based on international cooperation and the sharing of data, and finally to the SuperDARN collaboration. Many of the standards (such as transmitter power) associated with SuperDARN were set by the early, even pre-SuperDARN, experiences. In this retrospective presentation I will give my personal view of the evolution of the HF radar technique and of SuperDARN, with personal recollections and an accounting of some of the key technical and scientific developments.

Keywords: SuperDARN, History

Occurrence Characteristics of Noctilucent Clouds from Japan: Mechanism of the Morning-Evening Asymmetry

*Akiho Endo[1], Yoshihiro Tomikawa[3,4], Peter Dalin[2], Takuo Tsuda[5], Yuriko Nakamura[1], Masahiro Omote[1], Nozomu Nishitani[6], Kazuyo Sakanoi[7], Kaori Sakaguchi[8], Satoshi Ishii[9], Katsushi Iwamoto [10], Hidehiko Suzuki[1]

1. Meiji University, 2. Swedish Institute of Space Physics (IRF), 3. National Institute of Polar Research (NIPR), 4. The Graduate University for Advanced Studies (SOKENDAI), 5. University of Electro-Communications (UEC), 6. Institute for Space-Earth Environment Research (ISEE), 7. Komazawa University, 8. Space Environment Laboratory Radio Propagation Research Center Radio Research Institute, 9. Rikkyo University, 10. Monbetsu city

Noctilucent clouds (NLCs) are the highest clouds in the Earth’ s atmosphere and are typically observed during summer in high-latitude regions (50°–60° in latitude). In recent years, NLC occurrences have been reported to expand toward lower latitudes. Particularly, the number of NLC detections from midlatitudes (below 50°) is increasing.
In Japan, the NLC imaging network has been updated since the first NLC detection from Hokkaido in 2015. Four more events were observed in 2020, one in 2021, and four in 2025, resulting in a total of 10 NLC observations at present. Except for one case, all events in Hokkaido occurred in the early morning hours (2:00–3:00 LST), indicating a strong asymmetry in the morning and evening occurrence of NLCs.
In this study, we investigated the occurrence characteristics of NLCs from Hokkaido and their relationship with the background atmospheric conditions. By analyzing the NLC formation environment and advection history using temperature and water vapor data from Aura/Microwave Limb Sounder (MLS) and temperature and meridional wind data from the JAGUAR-DAS Whole neutral Atmosphere Reanalysis (JAWARA). In the longitudinal sector including Hokkaido, a low-temperature condition favorable for NLC conservation is formed by atmospheric tidal waves prior to the morning hours. This tidal activity creates a distinct observational advantage for morning NLC observations, consistent with the fact that most events in this study were observed in the morning.
In this presentation, we will introduce the latest observational results from Japan and discuss the atmospheric background conditions that enable NLC existence at mid-latitudes.

Keywords: Noctilucent cloud (NLC), Polar mesospheric cloud (PMC), Upper mesospheric region, JAWARA, Hokkaido

OMTI-SuperDARN collaborative studies for the dynamics of the middle and subauroral latitude ionosphere

*Kazuo Shiokawa[1], Nozomu Nishitani[1], Yuichi Otsuka[1], PWING Team, PBASE Team

1. Institute for Space-Earth Environmental Research, Nagoya University

The Optical Mesosphere Thermosphere Imagers (OMTIs) consists of more than 20 aurora and airglow imagers, six airglow photometers, and five Fabry-Perot interferometers, measuring dynamical variation of the mesosphere, thermosphere, and ionosphere, through airglow emissions. There have been several collaborative studies using OMTIs and the SuperDARN radars for the dynamics of the middle and subauroral latitude ionosphere, for 1) medium scale traveling ionospheric disturbances (MSTIDs) (e.g., Shiokawa et al, 2008; Ogawa et al., 2009; Suzuki et al., 2009; Koustov et al., 2009), 2) large-scale traveling ionospheric disturbances (LSTIDs) (e.g., Shiokawa et al., 2008), 3) penetrating electric field during storm-time substorms (Morita et al., 2025), and 4) STEVE and SAR arcs (Sugimura et al., 2025). In this presentation, we will review these various collaborative studies using OMTIs airglow images and SuperDARN ionospheric parameters.

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Keywords: Optical Mesosphere Thermosphere Imagers, MSTID, LSTID , penetrating electric field, STEVE, SAR arc

Electromagnetic conjugacy of TIDs after the 2022 HTHH volcanic eruption as seen in GNSS-TEC and SuperDARN Hokkaido pair of radars observations

*Atsuki Shinbori[1], Yuichi Otsuka[1], Takuya Sori[2], Michi Nishioka[3], Septi Perwitasari[3], Takuo Tsuda [4], Nozomu Nishitani[1]

1. Nagoya University, 2. Kyoto University, 3. National Institute of Information and Communications Technology, 4. The University of Electro-Communications

To elucidate the characteristics of electromagnetic conjugacy of traveling ionospheric disturbances (TIDs) just after the 15 January 2022 Hunga Tonga-Hunga Ha’ apai volcanic eruption, we analyze global navigation satellite system-total electron content data and ionospheric plasma velocity data obtained from the Super Dual Auroral Radar Network Hokkaido pair of radars. Further, we use thermal infrared grid data with high spatial resolution observed by the Himawari 8 satellite to identify lower atmospheric disturbances associated with surface air pressure waves propagating as a Lamb mode. After 07:30 UT on 15 January, two distinct TIDs propagating in the westward direction appeared in the Japanese sector with the same structure as those at magnetically conjugate points in the Southern Hemisphere (SH). Corresponding to these traveling ionospheric disturbances observed in the SH, the plasma flow direction in the F region changed from southward to northward. At this time, the magnetically conjugate points in the SH were located in the sunlit region at a height of 105 km. The amplitude and period of the plasma flow variation are ~100–110 m/s and ~36–38 min, respectively. Further, there is a phase difference of ~10–12 min between the total electron content and plasma flow perturbations. This result suggests that the external electric field variation generates the TIDs observed in both Southern and Northern Hemispheres. The origin of the external electric field is an E region dynamo driven by the neutral wind oscillation associated with atmospheric acoustic waves and gravity waves. Finally, the electric field propagates to the F region and magnetically conjugate ionosphere along magnetic field lines with the local Alfven speed, which is much faster than that of Lamb mode waves.

Keywords: 2022 Hunga Tonga-Hunga Ha’ apai volcanic eruption, Electromagnetic conjugacy of traveling ionospheric disturbances, Super Dual Auroral Radar Network Hokkaido pair of radars, E-region dynamo electric field, Atmospheric acoustic waves and gravity waves, Global navigation satellite system-total electron content, Himawari 8 satellite, Surface air pressure waves, F-region

IMF Dependence of Midnight Bifurcation in the Thermospheric Wind Measured with FPI in Tromsø, Norway

*SHIN-ICHIRO OYAMA[1,2,3], Keisuke Hosokawa[4], Heikki Vanhamäki[3], Anita Aikio[3], Takeshi Sakanoi[5], Lei Cai[3], Ilkka I. Virtanen[3], Kazuo Shiokawa[1], Nozomu Nishitani[1], Atsuki Shinbori[1], Yasunobu Ogawa[2]

1. ISEE, Nagoya University, 2. National Institute of Polar Research, 3. Space Physics and Astronomy Research Unit, University of Oulu, 4. The University of Electro-Communications, Chofu, 5. Tohoku University

A thermospheric wind dataset from a Fabry-Perot interferometer (630 nm) and ion velocity from a Dynasonde in Tromsø, Norway, was analyzed across nine winters to study thermospheric and F-region ionospheric dynamics at auroral latitude. This study examined bifurcation in zonal neutral wind and ion velocity at midnight and its dependence on the Y component of the interplanetary magnetic field (IMF). Ionospheric plasma convection patterns are imprinted on thermospheric wind variations through westward and eastward accelerations at dusk and late morning. The zonal wind bifurcates before midnight for IMF By < 0, but for By > 0, it inverts into the postmidnight sector. Neutral wind streams from higher latitudes may cause this dependence due to anti-sunward plasma flow distorted in the polar cap.

Keywords: Thermosphere, Ionosphere, Fabry-Perot Interferometer, ion drag, Joule heating

Investigating the Source and Characteristics of Winter Daytime MSTIDs Using the Chinese Dual Auroral Radar Network (CN-DARN)

*Hang Li[1], Jiaojiao Zhang[1], Wei Wang[1], Yuting Wang[1], Yaxuan Li[1], Xiang Deng[1], Ailan Lan[1], Shengyang Gu[2], Yusong Qin[2], Jingye Yan[1], Chi Wang[1]

1. National Space Science Center, Chinese Academy of Sciences., 2. Wuhan University

Medium-scale traveling ionospheric disturbances (MSTIDs) are important wave-like perturbations in the ionosphere. Although some previous studies have been conducted, the source of winter daytime MSTIDs remains unclear. Using joint observations from the Chinese Dual Auroral Radar Network (CN-DARN) of the Chinese Meridian Project Phase two, the Atmospheric Infrared Sounder (AIRS),and ERA5 Reanalysis data, this study provides observations linking stratospheric polar vortex variability, GW activity, and daytime MSTIDs over the Asian mid-latitudes. We analyzed an exceptionally strong polar vortex event in February 2025. The observation of pronounced MSTIDs activity by CN-DARN was accompanied by remarkably intense gravity wave activity during the same event. In contrast, we examined the same period in 2024, which was a typical polar vortex breakdown event. We found that gravity wave activity was weak, and the occurrence rate of MSTIDs was very low. The analysis results show that daytime MSTIDs propagated predominantly southward during February 2025. Comparative analysis suggests that polar vortex activity is likely a source of wintertime daytime MSTIDs. We performed WACCM-X simulations to investigate daytime neutral winds at 200 km altitude during different polar atmospheric activities in winter. The simulation results indicate that stronger northward neutral winds occur at middle and high latitudes during polar vortex events than during polar vortex breakdown events, which favors the propagation of southward MSTIDs.This study establishes a link between the polar vortex, GWs, and MSTIDs in the Asian sector, advancing understanding of MSTID sources and characteristics.

Keywords: MSTIDs, Polar Vortex

Wave structures in ionospheric flow and their magnetospheric counterpart: Fall 2023 SuperDARN-Arase conjunction campaign

*Tomoaki Hori[1], K. Hosokawa[2], N. Nishitani[1], A. Shinbori[1], Y. Miyoshi[1], M. Teramoto[3], Y. Obana[4], A. S. Yukimatu[5], K. Keika[6], S. Kasahara[6], S. Yokota[7], Y. Kasaba[8], A. Kumamoto[8], F. Tsuchiya[8], S. Matsuda[9], Y. Kasahara[9], A. Matsuoka[10], Y. Kazama[11], S.-Y. Wang[11], S. W. Y. Tam[1,12]

1. ISEE, Nagoya University, 2. Univ. of Electro-Communications, 3. Kyushu Inst. of Tech., 4. Kyushu Univ., 5. National Inst. of Polar Research, 6. The University of Tokyo, 7. Osaka Univ., 8. Tohoku Univ., 9. Kanazawa Univ., 10. Kyoto Univ., 11. ASIAA, Academia Sinica, 12. National Cheng-Kung University

Plasma convection intensifies in the sub-auroral to auroral region during geomagnetically disturbed periods, typically forming a fast westward flow channel on the dusk side including subauroral polarization stream (SAPS). Recent radar and satellite observations have revealed that such an enhanced westward flow sometimes shows flow variations propagating in the same azimuthal direction of the background flow. In particular, those found in SAPS are referred to as SAPS wave structure (SAPSWS). Although the wavy flow structure was extensively studied using ionospheric radars and low-altitude satellites, its magnetospheric counterpart in the ring current and plasma sheet has not yet poorly understood due to lack of good conjugate observations. To examine those magnetosphere-ionosphere coupled phenomena, we conducted a series of campaign observations using SuperDARN and Arase during October to December in 2023, primarily targeting the subauroral to auroral region on the night side. The wavy flow structure was successfully observed by the radars during several events of the campaign with near-conjugate magnetospheric observations of Arase. Preliminary analyses of the conjunction events show that wavy flow variations at (sub)auroral latitudes are associated with energetic electron and ion injections or dipolarization of the magnetic field in the inner magnetosphere. Interestingly, in a conjunction event, Arase was located just inside the plasmasphere and did not see any injection signatures while a wavy flow structure showed up clearly at slightly higher latitudes of the satellite’s ionospheric footprint. These observations suggest that the magnetospheric counterpart may be located in the ring current region outside the plasmapause, not penetrating into the plasmasphere. In the presentation, we examine detailed characteristics of plasma and field variations observed by Arase and discuss what part of the magnetospheric signatures would correspond to azimuthally-propagating structure of ionospheric flow.

Keywords: SAPS, ULF wave, Magnetosphere-Ionosphere coupling, Ring current

Reliability of Matching AMPERE Field-Aligned Current Boundaries With SuperDARN Lower Latitude Ionospheric Convection Boundaries During Geomagnetic Storms

*Maria-Theresia Walach[1], Alexandra Fogg[2], John Coxon[3], Adrian Grocott[1], Steve Milan[4], Harneet Sangha[5], Kathryn McWilliams[6], Sarah Vines[7], Mark Lester[4], Brian Anderson[8]

1. Lancaster University , 2. Dublin Institute for Advanced Studies, 3. Northumbria University, 4. University of Leicester, 5. UK Space Agency, 6. University of Saskatoon, 7. Southwest Research Institute, 8. Johns Hopkins University Applied Physics Laboratory

High-latitude ionospheric convection is a useful diagnostic of solar wind-magnetosphere interactions and nightside activity in the magnetotail. For decades, the high-latitude convection pattern has been mapped using the Super Dual Auroral Radar Network (SuperDARN), a distribution of ground-based radars which are capable of measuring line-of-sight (l-o-s) ionospheric flows. From the l-o-s measurements an estimate of the global convection can be obtained. As the SuperDARN coverage is not truly global, it is necessary to constrain the maps when the map fitting is performed. The lower latitude boundary of the convection, known as the Heppner-Maynard boundary (HMB), provides one such constraint. In the standard SuperDARN fitting, the HMB location is determined directly from the data, but data gaps can make this challenging. In this study we evaluate if the HMB placement can be improved using data from the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE), in particular for active time periods when the HMB moves to latitudes below 55°. We find that the boundary as defined by SuperDARN and AMPERE are not always co-located. SuperDARN performs better when the AMPERE currents are very weak (e.g., during non-active times) and AMPERE can provide a boundary when there is no SuperDARN scatter. Using three geomagnetic storm events, we show that there is agreement between the SuperDARN and AMPERE boundaries but the SuperDARN-derived convection boundary mostly lies ~ 3° equatorward of the AMPERE-derived boundary. We find that disagreements primarily arise due to geometrical factors and a time lag in expansions and contractions of the patterns.

Keywords: HMB, equatorial FAC boundary, geomagnetic storms

Assimilative Mapping of SuperDARN and Complementary Observations for High-Latitude Ionospheric Electrodynamics

*Tomoko Matsuo[1], Nicholas Bartel[1], John Michael Ruohoniemi[2], Bharat Kunduri[2], Shibaji Chakraborty[3]

1. University of Colorado Boulder, 2. Virginia Polytechnic Institute and State University, 3. Embry-Riddle Aeronautical University

The Assimilative Mapping of Geospace Observations (AMGeO, https://amgeo.colorado.edu/) is a collaborative data science platform for the geospace science community that integrates diverse, heterogeneous observations—such as those from SuperDARN, AMPERE, and SuperMAG—to produce comprehensive maps of high-latitude ionospheric electrodynamics for scientific discovery and space weather research. The platform is an open-source Python software and web application service that facilitates data acquisition and preprocessing, which are typically labor-intensive. To reduce barriers for users, it retrieves data directly from providers' servers via Application Programming Interfaces (APIs). This presentation highlights our recent efforts to improve the integration of SuperDARN data products, along with our plans to extend AMGeO to mesoscales.

Keywords: SuperDARN, Assimilative Mapping, High-latitude Ionospheric Electrodynamics

New insights into subauroral polarization stream (SAPS) using multi-frequency SuperDARN HF radar observations

*Evan G. Thomas[1], Simon G. Shepherd[1], Bharat S. R. Kunduri[2], J. Michael Ruohoniemi[2], Joseph B. H. Baker[2]

1. Dartmouth College, 2. Virginia Tech

The expansion of Super Dual Auroral Radar Network (SuperDARN) coverage to mid-latitudes over the past 20 years has greatly improved our understanding of subauroral ionospheric phenomena. In particular, the mid-latitude radars have been an invaluable tool for detecting and monitoring the evolution of high-velocity, westward plasma flows located equatorward of the nightside auroral oval. These subauroral polarization streams (SAPS), previously characterized using single-point measurements from low-altitude spacecraft and incoherent scatter radars, can span more than 12 hours of magnetic local time and are closely coupled to dynamics in the inner magnetosphere. We present results from the network-wide, multi-frequency sounding experiments conducted each month since early 2023, during which many SAPS events have been observed by the participating mid-latitude radars. We demonstrate how the detection of SAPS-associated ionospheric irregularities in the single-frequency normalscan data can be significantly improved using multi-frequency measurements, raising questions about our understanding of SAPS onset and formation mechanisms in the coupled magnetosphere-ionosphere system.

Keywords: SAPS

Arase–SuperDARN Collaborative Studies of Inner Magnetospheric Dynamics

*Yoshizumi Miyoshi Miyoshi[1], Iku Shinohara[2], Takeshi Takashima[2], Kazushi Asamura[2], Kazuo Shiokawa[1], Tomoaki Hori[1], Atsuki Shinbori[1], Keisuke Hosokawa[3]

1. Nagoya University, 2. JAXA, 3. The University of Electro-Communications

The Arase (ERG) satellite, launched in 2016, has provided comprehensive observations of the inner magnetosphere, covering wide energy ranges of electrons (~50 eV–4 MeV) and ions (10 eV/q–180 keV/q), together with electromagnetic field measurements over broad frequency bands. These measurements enable detailed investigations of wave–particle interactions responsible for the acceleration and loss of energetic particles and plasma in the inner magnetosphere. A key strength of the Arase project is its extensive coordination with ground-based observations. In particular, collaboration with the SuperDARN radar network has opened a unique opportunity to connect global ionospheric convection and electric fields with plasma processes observed in the magnetosphere. Through conjugate observations, SuperDARN provides large-scale context of high-latitude convection patterns and ULF wave activity, which are essential for understanding energy transport and coupling processes between magnetosphere and ionosphere. Since the start of operations, a large number of Arase–SuperDARN conjunction events have been identified. These coordinated observations have revealed how mesoscale and global electric field structures control particle transport, and plasma structure. In this presentation, we review recent progress in Arase–SuperDARN collaborative studies, focusing on the linkage between ionospheric convection, magnetospheric wave activity, and plasma/particle dynamics. We also discuss future directions, including data-driven modeling, and further integration with multi-satellite observations to advance predictive understanding of the geospace environment.

Keywords: Arase, international collaboration, inner magnetosphere

The GEOspace X-ray imager mission (GEO-X)

*Yuichiro Ezoe[1]

1. Tokyo Metropolitan University

We report on the GEO-X (GEOspace X-ray imager) mission, a novel Japanese small satellite designed to advance our understanding of solar wind-magnetosphere interactions through soft X-ray imaging of the dayside magnetospheric boundary, particularly the magnetosheath and cusp regions (Ezoe et al. 2023 J. Astron. Telesc. Instrum. Syst., 9, 034006). The interaction between the solar wind and Earth's magnetosphere, encompassing the transport processes of mass, momentum, and energy, represents a critical scientific theme not only in solar-terrestrial science but also in astronomy and space weather research. By utilizing solar wind charge exchange X-ray emission (e.g., Sibeck et al. 2018 Space Science Reviews, 214, 79), a phenomenon established through X-ray astronomy missions such as Suzaku, Chandra and XMM-Newton, GEO-X will enable global imaging of the magnetosphere. The spacecraft will be deployed via a rideshare and subsequently perform orbital maneuvers to conduct magnetospheric observations. GEO-X will offer a global perspective, as demonstrated by magnetohydrodynamic simulations (e.g., Momose et al., 2025, Geophys. Res. Lett., 52, e2024GL114342), while contributing to a deeper understanding of the SWCX emission as a foreground emission for X-ray astronomical observations. Through collaboration with other X-ray imaging missions such as SMILE, stereo observations of the magnetospheric structures will be realized. Equipped with a propulsion system to perform orbital maneuvers, GEO-X holds engineering significance as a deep-space exploration small satellite.

Keywords: X-rays, solar wind charge exchange, global imaging of the magnetosphere

LAMP and future sounding rocket experiment for investigation of energetic particle precipitation with pulsating aurora activities

*Kazushi Asamura[1], Yoshizumi Miyoshi[2], Keisuke Hosokawa[3], Takeshi Sakanoi[4], Takefumi Mitani[1], Taku Namekawa[5], Masahito Nose[6], Mariko Teramoto[7], Yasunobu Ogawa[8]

1. JAXA, 2. Nagoya University, 3. The University of Electro-Communications, 4. Tohoku University, 5. National Institute of Information and Communications Technology, 6. Nagoya City University, 7. Kyushu Institute of Technology, 8. National Institute of Polar Research

LAMP sounding rocket was launched in Alaska on March 5, 2022 to investigate generation mechanisms of sub-relativistic electron precipitation under pulsating aurora (PsA) activities. The rocket has successfully flown in PsA patches which contain internal modulations (~3Hz) on their emission intensity. During the flight, the electron instruments (HEP and EPLAS) detected energy-time dispersions on precipitating electrons with energies from 6.7 to 580 keV. With the help of numerical simulations, we concluded that the observed signatures could be formed by pitch-angle scattering of electrons due to chorus waves propagating from low to high latitude in the inner magnetosphere. The onboard magnetometer (MIM) detected distinct deviations on observed magnetic field from IGRF model when LAMP was inside the PsA patch. We have also successfully determined the current structure inside the PsA patch under assumptions of ionospheric conductivities and applied electric field vector inside / outside the patch.

We are planning to conduct a new sounding rocket experiment. LAMP has identified the precipitation of sub-relativistic electrons generated by chorus waves. But, in case of LAMP, the observations were made just at one specific location inside the PsA patch. Therefore we plan to launch a new rocket from Esrange, Sweden, so that it can fly through the field-of-view of EISCAT_3D radar. EISCAT_3D will provide 3D structure of ionospheric electron density, from which we can infer spatial scale of high-energy electron precipitation and its source region, in contrast to the rocket observations which are single point measurement in principle.

We expect that the newly-re-deployed SuperDARN Finland radar, which covers the rocket flight area, will be available during the launch campaign. It is useful since it observes background ionospheric electric field, which can help constrain the structure of current system inside the PsA parch,

We will present the results obtained by LAMP, and plan for the next sounding rocket experiment.

Keywords: sounding rocket, energetic electron precipitation, pulsating aurora, EISCAT_3D, SuperDARN Finland radar

Collaboration between EISCAT_3D and SuperDARN

*Yasunobu Ogawa[1], Advanced Radar Research promotion Center (ARRC) members[1]

1. National Institute of Polar Research

EISCAT AB, the successor to the European Incoherent Scatter (EISCAT) Scientific Association, is leading the development of the EISCAT_3D radar in northern Scandinavia. The first stage of international collaborative operation is scheduled to begin around 2027. The EISCAT_3D radar is expected to be used for various scientific studies, including the investigation of the transport of energy and mass from the solar wind and magnetosphere to the ionosphere and atmosphere (McCrea et al., 2016). Concentrated observations of various plasma parameters in the upper atmosphere over a range of several hundred kilometres, primarily using EISCAT_3D, are highly effective in investigating energy and mass transport, conversion and dissipation. On the other hand, network observations, such as those from SuperDARN radars, are important for understanding phenomena occurring across the broader polar regions of the upper atmosphere. Thus, observations from both systems are complementary. Furthermore, simultaneous observations of ion velocities within the same field of view using the SuperDARN radars in Finland (Hankasalmi) and Iceland (Stokkseyri), which resumed operations in recent years, and EISCAT_3D, are indispensable for verifying the measured plasma parameters.
This paper reports on the latest status of the EISCAT_3D project and discusses the potential for future international collaborative research between the EISCAT_3D radar and SuperDARN.

Keywords: EISCAT, EISCAT_3D, Upper atmosphere

Collaboration between SMILE mission and SuperDARN

*Jiaojiao Zhang[1]

1. National Space Science Center Chinese Academy of Sciences

SMILE (Solar wind Magnetosphere Ionosphere Link Explorer) is a joint space mission developed by the European Space Agency (ESA) and the Chinese Academy of Sciences (CAS). Planned for launch in April 2026, it employs soft X-ray and ultraviolet imagers, together with in-situ detectors, to conduct global observations of Earth’ s magnetosphere and aurora. Its key scientific objectives are to investigate the dynamic coupling between the solar wind, magnetosphere, and ionosphere, explore the generation and evolution of geomagnetic storms and substorms, and enhance the understanding and forecasting of space weather. SuperDARN observes magnetosphere-ionosphere convection from the ground and will serve as an ideal partner for SMILE to reveal magnetosphere-ionosphere (M-I) coupling dynamics. In this report, after analyzing the respective capabilities of the two devices (SuperDARN and the SMILE mission), I will propose potential future cooperation directions in light of my research experience, so as to fully exert their respective advantages and promote in-depth collaborative research.

Keywords: SMILE, SuperDARN, Collabration

Recent advances in modeling the X-ray images expected by SMILE

*Tianran Sun[1], Hyunju Connor[2], Andrey Samsonov[3], Steve Sembay[4], Chi Wang[1], Philippe Escoubet[5], Colin Forsyth[3]

1. National Space Science Center, Chinese Academy of Sciences, 2. NASA Goddard Space Flight Center, 3. University College London, 4. University of Leicester, 5. European Space Agency

The Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) mission provides global imaging of the Earth’ s magnetosphere using soft X-ray observations. We present recent progress on the modeling of SMILE Soft X-ray Imager (SMILE-SXI) and its capability to capture large-scale magnetospheric structures. SMILE-SXI remotely senses regions such as the magnetopause and cusps through solar wind charge exchange emissions. Recent work includes improved imaging and reconstruction techniques, as well as new insights into magnetosheath X-ray emission processes. This talk highlights results demonstrating the potential of SMILE-SXI for studying solar wind–magnetosphere interactions. The study supports the development of global observational approaches in space physics and complements ground-based measurements from the Super Dual Auroral Radar Network (SuperDARN), facilitating coordinated analyses between SMILE and SuperDARN to advance our understanding of coupled magnetosphere–ionosphere dynamics.

Keywords: magnetosphere–ionosphere coupling, SMILE, X-ray imaging

Progress of the Ultraviolet Imager onboard SMILE

*Fei He[1], Yongmei Wang[2]

1. Institute of Geology and Geophysics, Chinese Academy of Sciences, 2. National Space Science Center, Chinese Academy of Sciences

The aurora is the optical manifestation of the global magnetospheric dynamics. Optical imaging of aurora provide insight into the large-scale convections and wave-particle interactions in the magnetosphere, thus provide important information on the mass and energy flow in the solar wind-magnetosphere coupling system. The Ultraviolet Imager (UVI) onboard the Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) satellite will image the entire auroral oval in N2 Lyman-Birge-Hopfield (LBH) band (160–180 nm) while effectively mitigating contamination from dayglow, achieving a spatial resolution of approximately 100 km or better. The SMILE spacecraft operates in a highly eccentric orbit characterized by an orbital period of approximately 50 hours. This orbit configuration is particularly well-suited for long-term continuous monitoring of northern auroras. The coordinate observations from SMILE and SuperDARN will significantly enhance our research into energy deposition processes occurring within the ionosphere and upper atmosphere during solar wind-magnetosphere interactions. Here, we will introduce in detail the instrument, laboratory calibrations, in-flight calibration plan, and data products of SMILE UVI.

Keywords: Aurora, UVI, SMILE

Investigation of the IRI's auroral oval boundary model during the Mother’s Day storm on 10-13 May 2024

*Alicreance Hiyadutuje[1], Dieter Bilitza[2,3], Temitope Ojebisi[4], Malkia Kelelue[5], Solomon Degefa[6], Kibrop Webber[5]

1. South African National Space Agency, 2. Department of Physics and Astronomy, George Mason University, 3. Heliospheric Laboratory, NASA Goddard Space Flight Center, 4. Bamidele Olumilua University of Education, Science and Technology, Ikere, 5. Kenya Space Agency, 6. Ethiopian Space Science and Technology Institute

In this study, we assessed the performance of the International Reference Ionosphere (IRI) auroral oval boundary (AOB) model during the Mother’s Day storm that occurred on 10-13 May 2024. Different models, such as the Oval variation Assessment, Tracking, Intensity, and Online Nowcasting (OVATION) Prime (OP), POES-DMSP fitted data, and the Kp-based model, were compared with IRI’s model outputs. The IRI’s AOB model was investigated during a G4 storm that occurred on 10-12 October 2024. To validate the models, we used the SWARM satellites' AOB measurements and found that the IRI model deviated by 1.6 and 2.9%, while other models deviated by 11.4 and 21.3%. All AOB models showed the nonlinear equatorward expansion during these storms.

Reference
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1. Hiyadutuje, Alicreance, et al. "Assessment of the performance of the IRI’s auroral oval boundary model as applied to the Mother’s Day G5 storm during 10–13 May 2024." Advances in Space Research (2025). https://doi.org/10.1016/j.asr.2025.04.003

Keywords: IRI, Ovation Prime, Auroral oval boundary, POES and DMSP satellite data, SWARM satellite data

Enhancing FAIRness of Data in SuperDARN: NSSDC’ s Efforts in Data Management and Services

*Xin Xu[1], Fuli MA[1], Xiaoyan Hu[1], Qi Xu[1], Ziming Zou[1]

1. National Space Science Center, Chinese Academy of Sciences (NSSC, CAS)

Under the global paradigm of Open Science, scientific data has emerged not only as a primary achievement of researchers but also as a fundamental catalyst for technological innovation. The National Space Science Data Center (NSSDC) has proactively integrated these principles into the development and operation of the SuperDARN China mirror site and its dedicated data service portal.
SuperDARN China officially commenced operations in May 2022, spearheaded by Dr. Zhang Jiaojiao, Chief Scientist of the Jiamusi High-Frequency Radar, and supported by the SuperDARN Executive Committee. Currently, NSSDC is responsible for its technical construction and long-term maintenance. In its design and implementation, NSSDC prioritizes the unique operational patterns of SuperDARN, focusing on data distribution stability, time efficiency, and robust security.
To ensure data FAIRness, NSSDC has established a robust technical infrastructure characterized by: (1) assigning Persistent Identifiers (PIDs) to ensure every dataset is uniquely discoverable and trackable; (2) providing automated PID registration alongside standardized citation formats to promote academic integrity; and (3) releasing all metadata under Creative Commons licenses to offer a transparent, standardized framework for global copyright permissions.
Building on this established infrastructure, NSSDC is advancing a more comprehensive data governance framework to further enhance the quality and usability of scientific resources. Our roadmap involves a strategic transition toward full-lifecycle data management, beginning with the implementation of automated format validation and rigorous quality control at the point of ingestion to ensure the highest levels of data integrity. Furthermore, by developing advanced metadata curation techniques, we aim to bridge the gap in semantic interoperability, ultimately evolving the mirror site into a more intelligent, value-added ecosystem that fosters interdisciplinary collaboration.

Keywords: Data Governance, SuperDARN China, FAIR Principles

Seeing Magnetic Fields as Geometry: A Three-Direction Field-Aligned Frame Approach for the Multi-Point Observation Era

*Akimasa Yoshikawa[1,2,3]

1. Faculty of Science, Kyushu University, 2. Quantum and Spacetime Research Institute, Kyushu University, 3. International Research Center for Space and Planetary Environmental Science, Kyushu University

For more than four decades, Kyushu University has developed ground-based multi-point observation networks to investigate magnetosphere–ionosphere coupling. These observations provide a powerful way to capture the ionospheric projection of electromagnetic structures in near-Earth space. At the same time, in-situ magnetic field observations are entering a new era of multi-point and eventually high-density constellation measurements. In this transition, it becomes essential to reconstruct not only the magnetic field vector, but also its first- and second-order spatial derivative structures.

In this talk, I introduce a three-direction field-aligned extended frame for describing magnetic field variations as geometry. A local orthonormal triad is defined by the magnetic field direction, the normal direction of the magnetic field line, and the binormal direction. By extending this frame not only along the field line but also in the normal and binormal directions, magnetic structures can be analyzed in terms of curvature, torsion, non-integrability, connection, and curvature forms. This framework interprets the magnetic field as a three-directional geometric fabric that bends, twists, spreads, and breaks.
The magnetic gradient tensor provides information on current, twist, bend, and splay. The magnetic Hessian further reveals second-order structures such as directional sharpness, sheet-like deformation, tube-like geometry, and mixed spatial variations. While the magnetic vector Laplacian is closely related to the rotational structure of the current, the remaining trace-free Hessian components contain anisotropic information that is not captured by conventional current-based diagnostics.

This framework aims to connect large-scale ionospheric structures observed from the ground with local magnetic derivative structures measured by multi-point spacecraft. It provides a common geometric language for interpreting both visual ionospheric patterns and in-situ magnetic field variations, and may help extend magnetosphere–ionosphere coupling studies from the analysis of intensity and distribution toward the analysis of shape and geometry.

Keywords: next-generation constellation measurement, magnetosphere–ionosphere coupling, current-curl structure, twist–bend geometry, generative geometry and measurement geometry

GPS phase and amplitude scintillation at high latitudes during the extreme geomagnetic storm of May 2024

*Paul Prikryl[1], Anthony C. M. McCaffrey[1], James M. Weygand[2], Reza Ghoddousi-Fard[3], Daniel Billet[4], Emma Spanswick[5], Joshua Houghton[5]

1. Physics Department, University of New Brunswick, 2. Earth, Planetary, and Space Sciences, University of California, 3. Canadian Geodetic Survey, Natural Resources Canada, 4. Physics Department, University of Saskatchewan, 5. Department of Physics and Astronomy, University of Calgary

The May 2024 geomagnetic storm was the most intense in recent decades, significantly affecting the Earth magnetosphere and ionosphere. We investigate GPS amplitude and phase scintillation during the main and recovery phases of the storm using GPS receivers including the specialized scintillation receivers of the Canadian High Arctic Ionospheric Network (CHAIN). The 30-s scintillation indices using GPS receivers sampling at a 50 Hz rate or higher are complemented by 1-Hz GPS receivers providing a proxy scintillation index. The occurrence of GPS scintillation is studied in the context of ionospheric convection observed by SuperDARN, horizontal equivalent ionospheric currents and estimated vertical current amplitudes derived from the magnetic field measurements by ground magnetometers using the spherical elementary current method, as well as riometer-measured ionospheric absorption, which serves as indicators of energetic particle precipitation. During the main phase of the storm both phase and amplitude scintillation significantly increased following the impact of the interplanetary shocks due to coronal mass ejections. The most immediate response was observed at very high latitudes in the cusp region, spreading to auroral and nominally sub-auroral latitudes as the interplanetary magnetic field turned southward. The ionospheric pierce points of strong GPS scintillation were largely collocated with eastward or westward electrojet currents associated with ionospheric convection or mapped near the edges of electrojet regions. In relation to vertical current amplitudes, strong scintillation is mapped mostly near the reversal boundaries between downward and upward currents or collocated with the upward currents. In the recovery phase of the storm, when the geomagnetic disturbances on the nightside were associated with riometer-measured absorption due to auroras, strong phase and moderate amplitude scintillation were observed, particularly when computed for 1-s window to detect short-lived diffractive scintillation.

Keywords: Ionospheric irregularities, Ionospheric currents , GPS phase and amplitude scintillation, Geomagnetic storm, Space weather

Exploring Machine Learning Approaches for the Classification of PMSE, F-region and TID Echoes in SuperDARN Observations

*Jia Zhong[1,2], Li Fu Ma[1,2], Yan Xiao Hu[1,2], Ming Zi Zou[1,2]

1. National Space Science Center, Chinese Academy of Sciences, 2. National Space Science Data Center

SuperDARN (Super Dual Auroral Radar Network) radars, as a global network of high-frequency radars, play a crucial and irreplaceable role in observing ionospheric dynamics, particularly in the polar regions. The accurate and automatic classification of radar echoes is not only essential for distinguishing different physical processes in the polar ionosphere but also a key prerequisite for realizing large-scale, high-efficiency analysis of SuperDARN observation data. This work focuses on the automatic classification of three typical and important types of SuperDARN radar echoes using advanced machine learning techniques, namely Polar Mesospheric Summer Echoes (PMSE), F-region echoes, and Traveling Ionospheric Disturbance (TID) echoes—all of which are closely related to polar ionospheric structure and dynamic changes. First, the key characteristics of the three types of echoes are systematically analyzed in detail, including their temporal variation patterns, spectral characteristics (such as Doppler shift and spectral width), and spatial distribution features, which lay a solid foundation for subsequent feature extraction and model training. Then, the main challenges existing in echo classification are deeply discussed, such as the overlap of feature parameters between different types of echoes, the interference of background noise and instrumental errors in radar data, and the lack of sufficient labeled samples for model training. To address these challenges, a preliminary classification framework is proposed, covering the steps of echo data preprocessing, key feature selection and optimization, appropriate machine learning model selection and preliminary validation ideas based on limited sample data. This study aims to provide a feasible and efficient technical approach for the automatic identification of typical SuperDARN radar echoes, thereby promoting the efficient mining and analysis of large-scale SuperDARN observation data, deepening the understanding of polar ionospheric dynamic processes, and providing technical support for subsequent related research on ionospheric variation and space weather.

Keywords: Machine learning, Automatic classification, Super dual auroral radar network (SuperDARN), Polar mesospheric summer echoes (PMSE), F-region echoes, Traveling ionospheric disturbance (TID) echoes

Are E-region echoes a nuisance in SuperDARN experimentation?

*Alexandre V Koustov[1]

1. U of Saskatchewan

The SuperDARN experiment grew from E-region (electrojet) studies with the 144-MHz STARE radars in Northern Europe. Since it was realized that the velocity of STARE echoes was often not the ExB drift component, the original SuperDARN design (1993) automatically excluded them from consideration. However, subsequent introduction of the Potential Fit Technique (1998) with utilization of the line-of-sight (LOS) velocities opened up opportunities to involve the echoes in the construction of global-scale convection maps. Since then, utilization of E-region velocities has swung back and forth, from unconditional inclusion to total rejection.

In this presentation, I will first describe the essence of the problem and shortly review the results of theoretical and experimental studies on the velocity of electrojet irregularities. I will then go over several SuperDARN publications relevant to the problem, including my work with colleagues and graduate students, and highlight challenges for convection mapping with E-region echoes. Other aspects of E-region detection useful in SuperDARN applications will be discussed. I hope that the presentation will convince everyone of the usefulness of E-region SuperDARN data and of the need to invigorate research in this area.

Keywords: E-region echoes , ExB drift, SuperDARN plasma flow map

On multi-band echoes in SuperDARN range-time maps

*Pasha Ponomarenko[1,2], Glenn Hussey[1], Thayananthan Thayaparan[3], Nozomu Nishitani[2]

1. University of Saskatchewan, Saskatoon, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. Defence Research and Development Canada, Ottawa

For many years SuperDARN researchers have observed multiple bands of strong echoes with ground scatter characteristics (low velocity and narrow spectral width). While these signatures were provisionally attributed to reflections from the sporadic E-layer, to date no detailed tests of this attribution have been performed. In this work, we present a systematic study of such multi-band echoes (MBE) observed by SuperDARN Canada radars. The results, which cover spatio-temporal morphology, dependence on the radar frequency, diurnal/seasonal/solar cycle climatology, and latitudinal variations, allowed us to clarify the MBEs' origins and to determine their value for ionospheric diagnostics.

Keywords: Ionospheric HF propagation

Statistical Analysis of Geomagnetic Responses to EUV Radiation During Solar Flares at Kakioka

*Ryosuke Okubo[1], Kyoko Watanabe[1], Satoshi Masuda[2], Akimasa Ieda[2], Hidekatsu Jin[3], Chihiro Tao[3], Shinnnosuke Kitajima[4]

1. National Defense Academy of Japan, 2. ISEE/Nagoya University, 3. NICT, 4. JASDF Fuchu Base

The solar flare effect (SFE) is a geomagnetic variation caused by enhanced ionospheric currents during solar flares. It primarily reflects flare variations in solar soft X-ray and extreme ultraviolet (EUV) emissions. Hudson et al. (2025) demonstrated the utility of hodogram analysis in representing the temporal evolution of the SFE using geomagnetic vectors. By using hodogram, we can easily identify the character difference of electric current system between Sq (Solar quiet day variation) and SFE. Then we statistically analyzed SFE magnitudes and hodograms using high time-resolution Kakioka (KAK) geomagnetic data and Solar Dynamics Observatory (SDO)/Extreme ultraviolet Variability Experiment (EVE)’ s EUV data. By comparing solar spectral variations with geomagnetic vector evolution, we aim to clarify the driving ionospheric current systems and their physical mechanisms for SFE.
We analyzed 21 X-class flares from 2011–2014. SFE amplitudes in all components (X, Y, Z) strongly correlated (correlation coefficients (CC) > 0.6) with the solar quiet (Sq) daily variation, confirming a local time dependence. However, only the Y-component correlated significantly (CC > 0.5) with soft X-ray peak intensity of flare (flare class).
Horizontal (X-Y) hodograms revealed abrupt changes in the geomagnetic vector direction during flare. This vector change coincides with the transition from EUV-dominated (e.g., He II 30.4 nm, Lyα 121.5 nm) to soft X-ray-dominated phases. Soft X-rays and EUV penetrate the ionosphere to different depths. Soft X-rays penetrate into the lower E region (peaking at ~105 km), where Hall conductivity peaks. In contrast, EUV emissions are absorbed at higher altitudes in the upper E region (~ 130 km), where Pedersen conductivity is dominant. We therefore infer that soft X-rays and EUV primarily drive the enhancements of Hall and Pedersen currents, respectively. Because these solar emissions peak at different times during a flare, the two currents are enhanced with a temporal phase shift. This time-differenced activation of altitude-dependent currents directly modulates the direction of the integrated magnetic vector observed on the ground. This indicates that the SFE is a result of superposition of multiple current systems with distinct altitude-dependent responses.

Keywords: Geomagnetic Solar Flare Effect, solar EUV/X-ray, Electric conductivity

Derivation of Ionospheric Parameter Contributing to HF Blackouts

*Kyoko Watanabe[1], Shinnosuke Kitajima[1], Hidekatsu Jin[2], Chihiro Tao[2], Satoshi Masuda[3], Michi Nishioka[2]

1. National Defense Academy of Japan, 2. National Institute of Information and Communications Technology, 3. Institute for Space–Earth Environmental Research, Nagoya University

Shortwave fadeouts (SWF) are sudden disruptions of high-frequency (HF) radio communication caused by enhanced solar X-ray emission during flares. Traditionally, the magnitude of SWF has been estimated empirically based on the peak solar X-ray flux and the solar zenith angle. However, this flare-centric approach often fails to accurately predict the severity of ionospheric absorption, particularly when distinguishing between simple absorption enhancements and complete blackouts. Recent observations have revealed that ionospheric conditions before flare critically modulate the impact of flares, and this effect appears to be particularly pronounced during ionospheric negative storms.
We performed a comprehensive statistical analysis using a long-term dataset spanning over 40 years (1981–2023) obtained from four ionosonde stations in Japan. From this analysis, we derived a new ionospheric susceptibility parameter, “f_B,” defined as the ratio of the background F2-layer critical frequency (foF2) to the difference between foF2 and the minimum frequency (f_{min}).
The f_B exhibits distinct seasonal and diurnal variations independent of the solar cycle, quantitatively representing the background ionosphere's vulnerability to blackouts. Furthermore, we found that a high f_B value significantly lowers the flare intensity threshold required to trigger a blackout. By incorporating f_B into a new empirical model, the accuracy of blackout prediction improved significantly, with the Area Under the Curve (AUC) increasing from 0.75 to 0.82 compared to conventional methods. These findings demonstrate that monitoring f_B enables real-time, pre-flare risk assessment, providing a robust foundation for improving operational space weather forecasting.

Keywords: Shortwave fadeouts (SWF), Dellinger phenomenon, Solar flare, Ionosphere, X-ray emission, Ionosonde, Space Weather

Auroral Ionosphere Responses to Solar Wind Perturbations: A Case Study Utilizing the Polar Regions Monitoring Subsystem of the Chinese Meridian Project

*Jianjun Liu[1], Xiangcai Chen[1]

1. Polar Research Institute of China

The Earth's polar regions serve as a natural conduit for solar wind energy and momentum, transferring this energy into the geospace and driving complex magnetosphere-ionosphere-thermosphere coupling processes that have significant global space weather and space climate impacts. Continuous, coordinated observations from these remote locations are essential for investigating these dynamical processes. To address this need, the Chinese Meridian Project has equipped a Polar Regions of High Latitudes Monitoring Subsystem, deploying space physics multi-instruments at year-round research stations in both the Arctic and Antarctic region. This subsystem utilizes observatories at Great Wall Station and Zhongshan Station (ZHO) in Antarctica, as well as Longyearbyen (LYR) in the Arctic. Magnetic coordinates of these observatories provide the ideal geographical conditions for conducting optical, radio, and magnetic measurements. Furthermore, a feature of this monitoring subsystem is the magnetic conjugacy between the Antarctic ZHO and Arctic LYR station pair, which facilitates the simultaneous study of interhemispheric space environmental phenomena. To date, the routine operation of the subsystem has provided comprehensive and continuous monitoring of phenomena such as auroral activity, ionospheric status, atmospheric dynamics, and plasma wave variations. By presenting initial observational results centered on a single disturbed space weather event, this paper provides detailed observational capabilities and scientific objectives, demonstrating its capacity to supply significant data for advancing our understanding of polar space weather and its role in the global solar-terrestrial environment.

Keywords: polar ionosphere, magnetic storm

Using oblique, bistatic receptions of SuperDARN signals to measure HF propagation in the auroral and polar cap regions

*Riley Troyer[1], Jeffrey Holmes[2], Evan Thomas[3], Simon Shepherd[3], Eugene Dao[2], John Carilli[2], Eric Burnside[1], Kris Robinson[1]

1. SDL, 2. AFRL, 3. Dartmouth

SuperDARN is an international collaboration of polar pointing over-the-horizon radar systems in both the northern and southern hemispheres. These systems transmit at relatively high-power outputs to allow for a detectable backscatter from small scale plasma irregularities. The transmitting power also enables the high frequency (HF) signals to propagate large distances with multiple hops through the ionosphere. In this study, we developed custom software to detect and process obliquely propagating signals from the Iceland SuperDARN system. We measure these signals with passive HF receivers located at the Pituffik Space Base in Greenland, and at the Summit Station in central Greenland. To conduct this study, we operated both SuperDARN systems in a special mode with a limited beam configuration and frequency sweeps between 9 and 13 MHz on each of those beams. By processing the signals from each beam, we can compare differences in Doppler velocity and propagation path length across the beams. We can then compare these differences to time-of-year, geomagnetic conditions, models of the auroral region, and to SuperDARN measurements of the convection pattern. Additionally, both receivers are comprised of 8 receiving antenna, which allows us to derive an angle-of-arrival for the received signals. Our initial results indicate that there is significant off great circle path propagation at both the Summit Station and Pituffik receivers. In this presentation, we show these initial results, a comparative analysis between both stations, and preliminary statistics with the data we have collected so far. We also discuss challenges, solutions, and lessons learned from installing HF receivers in the harsh arctic environment. Approved for public release; distribution is unlimited. Public Affairs release approval #AFRL-2025-1506

Keywords: bistatic, hf propagation, signal of opportunity

Monitoring the ionospheric response to the upcoming August 2026 total solar eclipse

*Evan G. Thomas[1], Simon G. Shepherd[1], Bharat S. R. Kunduri[2]

1. Dartmouth College, 2. Virginia Tech

On 12 August 2026, a total solar eclipse will pass between Iceland and Greenland before traveling equatorward over Spain. While the path of totality is primarily in the European sector, significant obscuration will also occur over North America and so eclipse effects should be visible to many of the Super Dual Auroral Radar Network (SuperDARN) radars in the Northern Hemisphere. Many of the Northern Hemisphere radars have also recently been upgraded to use digital USRP-style hardware, enabling new observational capabilities. In this presentation, we describe results from two recent solar eclipses passing over North America in October 2023 and April 2024 when several SuperDARN radars operated a special mode to monitor high frequency (HF) propagation conditions before, during, and after the eclipse at multiple frequencies spanning from 9.5-17.5 MHz along selected azimuthal beam directions at a 1-min temporal cadence. Based on these previous results, we suggest experimental modes and solicit community feedback to maximize observations of the ionospheric response to this upcoming space weather event. Finally, we describe plans using two down-range HF receivers deployed at Summit Station and Pituffik Space Base in Greenland to monitor transmissions from the Iceland West SuperDARN radar during the eclipse.

Keywords: eclipse

Sporadic E layer signatures in SuperDARN data

*Pasha Ponomarenko[1,2], Glenn Hussey[1], Thayananthan Thayaparan[3], Nozomu Nishitani[2]

1. University of Saskatchewan, Saskatoon, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. Defence Research and Development Canada, Ottawa

As the ionospheric E-layer has a significant effect on HF radio wave propagation, it is important to characterise it as accurately as possible. In this respect, SuperDARN represents a well-suited instrument for such characterisation due to its continuous operations covering a wide range of latitudes. While the regular E-region echoes in SuperDARN data have been studied in detail for over three decades, information about their sporadic counterparts is notably missing from the literature, with only a couple of discernible case-study publications. To fill this gap, in we utilised a multi-year data set from SuperDARN Canada radars to identify fingerprints of the sporadic E layers, which allowed us to reconstruct the layer's climatology and to analyse its effects on HF propagation at high latitudes.

Keywords: Sporadic E layer

Closing summary by the Chair of the SuperDARN PI Executive Council

*Gareth Chisham[1]

1. British Antarctic Survey

This talk will provide a summary of the meeting, in particular, of the discussions and decisions of the PI executive council.

Keywords: SuperDARN, Summary

British Antarctic Survey Space Weather Observatory

*Jo Cole[1]

1. British Antarctic Survey

The British Antarctic Survey (BAS) operates 45 space weather instruments across the Southern Hemisphere, 44 of which are located in Antarctica. The Space Weather Observatory (SWO) plays a vital role in monitoring and understanding rare and extreme space weather events that can have significant impacts on critical infrastructure, including satellites and power grids.
We operate the Falkland Islands Radar (FIR) SuperDARN, alongside a range of Antarctic instruments to observe the complex chain of Sun to Earth processes driving space weather. By combining complementary datasets, we can better assess the impacts of severe space weather events, supporting improved forecasting capabilities and the development of mitigation guidelines for industry and government.
All SWO data are openly available, and we actively seek engagement and collaboration to make meaningful contributions to the global space weather community.

Keywords: Instrumentation, Antarctica

The British Antarctic Survey's Falkland Island Radar

*Nick Harker[1]

1. British Antarctic Survey

The British Antarctic Survey (BAS) runs its current SuperDARN instrument from Goose Green on the Falkland Islands (-51.831 Latitude, -58.979 Longitude). The main instrument consists of 16 log-periodic antennas, driven by SD Tiger 3 Transceivers and has been collecting data reliably over and around the Antarctic Peninsular region for the last 9 years. It is also used to trial new instrumentation. Currently a light weight reflectorless three element log-periodic antenna supported on a carbon fibre frame is being tested, which if successful would be a suitable option for installation at remote and hard to access sites.

Keywords: antenna

SENSU Syowa SuperDARN future plan towards Phase XI JARE project (2028-2034) and IPY-5

*Akira Sessai Yukimatu[1,2], Nozomu Nishitani[3], Keisuke Hosokawa[4], Tomoaki Hori[3], Masakazu Watanabe[5], Hideaki Kawano[5], Yusuke Ebihara[6], Yoshimasa Tanaka[7,1,2], Ryuho Kataoka[8,1]

1. ROIS/NIPR, 2. SOKENDAI, 3. ISEE, Nagoya Univ., 4. Univ. of Electro-Communications, 5. i-SPES, Kyushu Univ., 6. Kyoto Univ., 7. PEDSC/ROIS-DS, 8. OIST

NIPR has joined the SuperDARN project since its establishment in 1995 and run 2 SENSU SuperDARN radars, Syowa South and Syowa East radars (SENSU stands for "Syowa South & East HF Radars of NIPR for SuperDARN") in Japanese Antarctic Syowa station (69.00 S, 39.58 E) in polar auroral zone. Both radars have substantially contributed to the SuperDARN project and scientific researches, such as studies on various types of auroral phenomena, geomagnetic pulsations, substorms, reconnection, precise neutral wind observation around mesopause region, studies on polar mesospheric summer echoes (PMSEs), magnetosphere-ionosphere-neutral atmosphere vertical coupling, studies on influence of low solar activity or grand minimum on geospace space weather with a various observational and theoretical collaborative research. Due to the importance of the obtained basic physical parameters widely used and referred, and also of the long-term observation, this project moved to JARE monitoring observation since current phase X 6-year JARE project (2023.2-2029.1) with close collaboration with AJ1007 prioritized project for space weather/space climate research. We here summarise our important achievements so far and will discuss on issues remaining unresolved, ways forward and the future perspective and strategies regarding the scientific direction of our SENSU SuperDARN research and long-term stable operation towards phase XI JARE period (2028-2034), IPY-5 (2032-2033) and beyond.

Keywords: SuperDARN, Space Weather, Space Climate, Japanese Antarctic Research Project, International Polar Year (IPY), Antarctic Syowa station

Future Plan for Space and Upper Atmospheric Research in JARE Phase XI

*Yoshimasa Tanaka[1,8,9], Ryuho Kataoka[2,1], Takeshi Sakanoi[3], Akira Mizuno[4], Chihiro Kato[5], Akira Sessai Yukimatu[1,9], Yasunobu Ogawa[1,8,9], Tanakanori Nishiyama[1,9], Mizuki Fukizawa[1,9], Kiyoka Murase[6], Yusuke Ebihara[7], Yuki Hayashi[5], Masayoshi Kozai[8], Tomotaka M. Tanaka[9,1], Yukino Sato[9]

1. National Institute of Polar Research, 2. Okinawa Institute of Science and Technology, 3. Tohoku University, 4. Institute for Space-Earth Environmental Research, Nagoya University, 5. Shinshu University, 6. Kitami Institute of Technology, 7. Research Institute for Sustainable Humanosphere, Kyoto University, 8. Polar Environment Data Science Center, ROIS-DS, 9. The Graduate University for Advanced Studies (SOKENDAI)

During the Japanese Antarctic Research Project Phase X Six-Year Plan (FY2022–FY2028), one of the prioritized research projects, “Space environmental changes and atmospheric response explored from the polar cap (AJ1007)”, called the “auroraXcosmic” project, has been conducted. One of the key features of this project is the deployment of an all-sky imager network across the polar cap as well as auroral zones in Antarctica. Based on international collaboration, these imagers are currently operated at eight manned stations and two unmanned stations, and are utilized together with the SuperDARN to investigate solar wind –magnetosphere - ionosphere interactions. In addition, several instruments have been installed at Syowa Station, including cosmic ray detectors (a muon detector and a neutron monitor), a millimeter-wave spectrometer, and a spectral riometer, to study the effects of energetic particles from space on the polar upper atmosphere.
In Phase XI (FY2028-FY2034), we will further advance studies of solar wind–magnetosphere–ionosphere interactions by effectively utilizing the observational network established during Phase X. We plan to use the Starlink communication system to enable prompt transmission of multi-point imager data. By applying machine learning techniques, we will perform data assimilation with the high-resolution MHD simulation model REPPU, thus advancing space weather research. We will also investigate the impacts of energy input from space on the atmosphere through coordinated observations based on Syowa Station. A newly proposed observation is near-infrared spectroscopic measurements of metastable orthohelium density, atmospheric temperature, and wind velocity in the altitude range of 300 - 1000 km. Furthermore, Phase XI will coincide with planned crewed lunar exploration missions and various planetary exploration programs. In this context, by utilizing the internationally unique co-located neutron and muon observations at Syowa, we aim to further develop remote-sensing techniques for interplanetary space and establish a foundation for future heliospheric diagnostics.

Keywords: Antarctica, polar cap, imager network, Japanese Antarctic Research Expedition, solar wind - magnetosphere - ionosphere interactions

Development of a 20-Channel Imaging Receiver System for the SuperDARN Hokkaido East radar

*Yoshiyuki Hamaguchi[1], Nozomu Nishitani[1]

1. ISEE, Nagoya University

We have developed a 20-channel imaging receiver designed to operate in conjunction with an HF radar. Transmission is handled by the pre-existing HF radar, while reception is performed by operating both the HF radar and the 20-channel imaging receiver simultaneously. The 20-channel imaging receiver utilizes 10 USRPs (2 channels per unit) to receive signals from all 16 main antennas and 4 interferometer antennas. Beamforming and other processing are performed during post-processing of the data. We conducted a test operation last November, connecting the system to the SuperDARN Hokkaido East HF Radar and running it continuously for four days, during which we successfully acquired 20-channel I/Q data without problems. Transmission was conducted in standard normalscan mode, fixed to Beam 7 mode, and wide-angle mode. In standard normalscan mode, it was confirmed that the power distribution of the HF radar and that of the 20-channel imaging receiver matched. This confirmed that the 20-channel imaging receiver system, including data processing, is operating as designed. Details of the experiment and future perspective will be presented.

Keywords: Imaging Receiver System, USRP

Developing Automated SuperDARN Main-Array Calibration Using Mutual Coupling Measurements

*Jordan Wiker[1], Alex T Chartier[1]

1. JHUAPL

Accurate per-antenna amplitude and phase calibration is increasingly important for SuperDARN beamforming, interferometry, and cross-site consistency, but most operational calibration methods still rely on manual measurements, external targets, or hardware-specific procedures. We present a software-driven mutual coupling calibration method (MCCM) being developed for Borealis and prepared for first tests at the Wallops SuperDARN radar. The approach transmits on one main-array antenna at a time while receiving on the remaining active channels, then repeats the sweep across the full array to build a redundant matrix of pairwise complex responses. From these measurements we estimate a receive-side complex correction vector that can be applied to compensate channel-to-channel phase and amplitude offsets. The method is designed to use existing radar hardware and site configuration metadata, so it can be adapted to different SuperDARN installations without requiring external targets or permanent added calibration hardware. The initial implementation includes conservative low-power qualification steps, configuration-driven antenna selection, geometric ordering of test pairs from farthest to nearest separation, capture quality-control metrics from antennas_iq data, and a receive-side solver that reports correction factors and residual consistency. Planned results for the workshop will include first qualification measurements from Wallops, evaluation of safe operating levels for the calibration mode, and an assessment of whether MCCM can provide a practical path toward repeatable, automated main-array calibration for SuperDARN radars.

Keywords: Antenna Calibration, Borealis, SuperDARN, HF Radar, Mutual Coupling Calibration

MAHSSIV: a new project to globally estimate small scale plasma variability through the SuperDARN spectral width parameter

Emma E Woodfield[1], Jade A Reidy[1], *Gareth Chisham[1], Daniel Whiter[2], Arianna Albayati[1]

1. British Antarctic Survey, 2. University of Southampton

Accurate estimation of energy transfer within the ionosphere-thermosphere system is critical to calculations of the expansion and contraction of the Earth’ s atmosphere. The consequent changes in atmospheric density have a major impact on the altitude of low-Earth orbiting satellites and debris. A significant source of upper atmospheric heating is global plasma motion in the ionosphere which causes heating to occur through friction with the neutral atmosphere, including Joule heating from electrical currents. Most methods of tracking this heat input rely on large scale observations that miss the contribution from smaller scale variability, which can be substantial, double that estimated from large scale observations. MAHSSIV (Missing Atmospheric Heating from Small Scale Ionospheric Plasma Variations) is a new UK funded 4-year project to capture the global importance of small-scale variation using SuperDARN, specifically using the spectral width parameter as a link to small-scale plasma variability. Spectral width is affected by two main processes: plasma motion within the measurement cell area, and the lifetime of plasma density irregularities. Higher spectral width values have been linked to velocity variations rather than target lifetime through analysis of SuperDARN raw data. We will use collocated data from SuperDARN, ASK (a very high resolution auroral imager on Svalbard) and EISCAT data to establish an empirical link between spectral width and plasma variability which we will then carefully extend to the global reach of SuperDARN radars bearing in mind geophysical conditions. We will also investigate possible additional information on the small-scale variability via the SuperDARN raw data. The final goal of the project is to produce an open-source tool for the community to be able to estimate the amount of small-scale variability and its effect on Joule Heating in both hemispheres using historical and future SuperDARN data.

Keywords: SuperDARN, Spectral Width, Joule Heating

The effect of virtual height models on SuperDARN data products and convection maps.

*Wout De Jonghe[1], Ben Reid[1], David Themens[1], Oliver Allanson[1]

1. Univ. of Birmingham

The geolocation of scatter points is a crucial step in the processing of SuperDARN data. Yet, calibration errors in the elevation angle of the returned beam have made accurate positioning a major problem since the inception of the radar network. Virtual height models were created as a solution to this problem: by estimating the virtual height upon reflection, the elevation angle can be reverse engineered. Although recent efforts have drastically improved the trustworthiness of elevation angle measurements, even in historical datasets, the virtual height models remain widely used. The "Standard Virtual Height" and "Chisham" models are most common, as they are implemented in the Radar Software Toolkit (RST). Both models use the group range alone to estimate the virtual height, making their validity questionable. There have been studies about the resulting impact on providing correct geolocation, but how the virtual height models affect the final products (convection maps, cross polar cap potential…) is less explored. This study aims to fill that knowledge gap. We use the RST to generate convection maps for a 5-year period between 2021-2026, extracting the cross polar cap potential (CPCP) and the Heppner-Maynard Boundary (HMB) for quantitative analysis. We also introduce our own virtual height model that uses raytracing methods to find the virtual height, gaining accuracy at the cost of a longer runtime. We find that the CPCP and HMB show relatively small deviations between the different virtual height models, although a difference up to 10% in the CPCP is common. The convection maps are shown to deviate more strongly, with large visual differences in drift velocities and dipole locations, especially during active periods. A case study shows that the virtual height model that implements raytracing has the potential to automatically eliminate erroneous data or radar noise, as it finds no suitable path for those beams.

Keywords: Virtual height models, Convection maps, Raytracing

A Statistical Study of the Dawnside Subauroral Polarization Streams Using SuperDARN Radars

*Bianlong Zhao[1,2], Jiaojiao Zhang[2], Qinghe Zhang[2,1], Zanyang Xing[1], Yong Wang[1], Yuzhang Ma[1]

1. Shandong University, 2. National Space Science Center

The Harang discontinuity (HD) is a common and prominent feature in the electric and magnetic fields of the high-latitude auroral region, playing a crucial role in substorm dynamics. As a key component of the HD return flow, the subauroral polarization stream (SAPS) is closely associated with the HD, and their intrinsic relationship as well as current characteristics are critical for understanding substorm evolution. However, constrained by the performance of observational instruments, previous studies have not reached a consistent conclusion regarding the detailed relationship between the HD and SAPS, and the characteristics of their corresponding field-aligned currents (FACs) remain unclear. In this study, we investigated the characteristics and spatio-temporal evolution of the HD using observations from the SuperDARN and Swarm satellites, analyzed the impact of substorms on the HD, and explored the relationship between the HD and SAPS. The main results are as follows: (1) The upward FACs on the high-latitude side of the HD reverse to downward FACs on the low-latitude side, and the eastward flow at high latitudes reverses to westward flow at low latitudes. (2) The HD is closely linked to substorms: no HD exists before substorm onset; the HD forms during the substorm growth phase, moves toward the dawnside and equatorward during the expansion phase, and dissipates during the recovery phase. The dawnward/ duskward extension position of the HD is related to the interplanetary magnetic field (IMF) By component, while its poleward/ equatorward extension position is associated with the substorm. (3) The SAPS and the westward flow within the auroral oval together constitute the return flow on the equatorward side of the HD. The SAPS forms after the HD and dissipates following the disappearance of the HD.

Keywords: Harang Discontinuity, Subauroral Polarization Streams, Field-Aligned Current

Westward ion flows in the dusk-side subauroral ionosphere: Role of wave-particle interactions

*Shreedevi Porunakatu Radhakrishna[1], Yoshizumi Miyoshi[1], Yiqun Yu[2], Vania Jordanova[3]

1. ISEE Nagoya University, 2. School of Space and Environment, Beihang University, 3. Los Alamos National Laboratory, Los Alamos, USA

Subauroral polarization streams (SAPS) are fast westward plasma flows observed in the dusk-to-midnight sector during geomagnetic storms, often exhibiting structured features such as multiple velocity peaks. However, the physical mechanisms responsible for this structuring remain unclear. We combine DMSP observations with global simulations using the RAM-SCB model to investigate the role of electromagnetic ion cyclotron (EMIC) wave-particle interactions in modifying SAPS. DMSP observations during the 17 March 2013
storm show multiple SAPS velocity peaks co-located with enhanced ion precipitation. Simulations including EMIC waves reproduce additional peaks, whereas those without EMIC waves produce a single broad SAPS channel. Simulations demonstrate that EMIC wave-driven proton precipitation enhances ionospheric Pedersen conductance, producing localized conductance gradients that redistribute the electric field and generate multiple westward flow peaks in the subauroral ionosphere. These results establish EMIC wave-driven proton precipitation as a key mechanism responsible for structuring SAPS and highlight its role in magnetosphere-ionosphere coupling. Future observations using the SuperDARN could test this mechanism by identifying multiple, narrow westward flow channels and their temporal evolution in association with regions of enhanced particle precipitation during geomagnetic storms.

Keywords: Geomagnetic storms, SAPS, Particle Precipitation, Wave-particle interactions

High-Latitude Sudden Impulse Signatures of Negative Solar Wind Pressure Pulses: Observation and Global Modeling

*GEETASHREE KAKOTI[1], Kazuo Shiokawa[1], Dong Lin[2], Shreedevi P.R.[1], Nozomu Nishitani[1]

1. Institute for Space-Earth Environmental Research (ISEE), Nagoya University, 2. Clemson University, South Carolina, USA

Sudden decreases in solar wind dynamic pressure drive rapid magnetospheric expansion and produce negative sudden impulses (SIs) recorded in ground magnetic field observations. These transient events can significantly perturb the magnetosphere-ionosphere (M-I) system, driving reconfiguration of high-latitude convection and redistribution of ionospheric current systems. This study examines the spatiotemporal evolution of negative SIs during two negative solar wind dynamic pressure pulse events: a strong event on 23 March 2023 (~20 nPa drop at 14:33 UT) and a moderate event on 27 September 2022 (~10 nPa drop at 05:31 UT) under northward interplanetary magnetic field (IMF) conditions. High-resolution ground magnetometer data are used to systematically characterize the preliminary reverse impulse (PRI) and main impulse (MI) phases, examining their amplitude, timing, and magnetic local time (MLT) dependence. This is complemented by SuperDARN radar observations that reveal transient vortices and flow perturbations, and the associated high-latitude ionospheric convection response during both the PRI and MI phases. To interpret the observed SI features and elucidate the underlying physical mechanisms, we use the Multiscale Atmosphere-Geospace Environment (MAGE) model, which successfully reproduces the key SI signatures and their dusk-dawn asymmetries. Since the observed characteristics of SIs are closely associated with the formation and redistribution of field-aligned currents (FACs), MAGE outputs are then used to diagnose the origin and evolution of newly formed FACs, driven by pressure pulses. Together, the high-resolution observations and MAGE simulations advance our understanding of the physical processes governing negative SI events and pressure-driven M-I coupling.

Keywords: Negative Solar Wind Pressure Pulses, Sudden Impulse, Field-aligned currents, MAGE

Direct Comparison of MAGE-REMIX Simulated Ionospheric Potential with SuperDARN Line-of-Sight Observations

Tristen Wanner[1], *Joseph B.H. Baker[1], Slava Merkin[2], Bharat Kunduri[1], J. Michael Ruohoniemi[1]

1. Virginia Tech, 2. Johns Hopkins University Applied Physics Laboratory

Accurate modeling of ionospheric electrodynamics is crucial for understanding Earth’s near-space environment and for the space weather forecasting necessary to support mitigation of its impacts on critical infrastructure. This study introduces an observational operator method to validate REMIX (REdeveloped Magnetosphere-Ionosphere Coupler Solver), the ionospheric electrodynamics component of the MAGE (Multiscale Atmosphere-Geospace Environment) framework, using SuperDARN (Super Dual Auroral Radar Network) data, focusing on ionospheric plasma convection. This technique utilizes the REMIX-calculated electrostatic potential to compute ExB drifts, which are then interpolated to SuperDARN range gate locations. By projecting the modeled ExB convection onto radar beam look directions, we derive synthetic Doppler velocities that can be directly compared with SuperDARN observations of F-region plasma convection. This provides an approach to identify discrepancies between the model and observations, providing valuable insights for improving the accuracy and reliability of REMIX and enhancing our understanding of magnetosphere ionosphere coupling. Initial comparisons highlight the potential for characterizing model performance quantitatively and for investigating different parameterization schemes.

Keywords: MAGE, REMIX, Model-Data Comparison

An Examination of Ionospheric Flow Dynamics During a SAR Arc - STEVE - SAR Arc Sequence Event

Veronica Romanek[1], Bharat Kunduri[1], *Joseph B.H. Baker[1], J Michael Ruohoniemi[1], Megan Gillies [2], Simon Shepherd[3], Evan Thomas[3]

1. Virginia Tech, 2. Mount Royal University, 3. Dartmouth College

Strong Thermal Emission Velocity Enhancement (STEVE) and Stable Auroral Red (SAR) arcs are two distinctive features of the sub-auroral ionosphere. STEVE events are associated with "extreme" Subauroral Ion Drifts (SAIDs) with speeds expected to exceed 4-5 km/s, whereas SAR arcs are primarily linked to magnetospheric heat conduction. Previous studies have shown that SAR arcs can also be linked with SAID related heating in the mid-latitude trough region. More recent observations have shown that SAR arcs can occur in the vicinity of STEVE, often times prior to STEVE's occurrence, likely acting as a pre-cursor mechanism to STEVE. However, we are yet to fully understand how large-scale plasma convection on the nightside contributes to the development of SAR arc - STEVE sequence events. In this study, we examine ionospheric flow dynamics during a SAR arc - STEVE - SAR arc sequence observed on April 10, 2022 by the all-sky imager in Lucky Lake, Canada. During this event, several US mid-latitude SuperDARN radars were making continuous observations of plasma convection collocated with the optical observations made by the Lucky Lake all-sky imager. We analyze the dynamics of both auroral and sub-auroral plasma flows on the nightside to examine the nature of magnetosphere-ionosphere coupling during this SAR arc - STEVE sequence. In particular, we examine the temporal variability in speed, direction, and latitudinal extent of plasma flows and their relation to the mid-latitude trough and field-aligned currents to test and validate our current understanding of magnetosphere-ionosphere coupling during such intervals.

Keywords: SAR Arc, Steve, SAID

How accurate are SuperDARN convection maps?

*Alexandre V Koustov[1], Hayden Fast[1], Robert G Gillies[2]

1. U of Saskatchewan, 2. U of Calgary

Over the years, the original SuperDARN plasma flow mapping by Ruohoniemi and Baker (1998) has undergone a few improvements, and alternative approaches have been proposed. But the accuracy of the obtained maps, in terms of both their overall configuration and their local velocity magnitudes and directions, has never been addressed. Besides the line-of-sight (LOS) velocity reduction due to the index of refraction effect, the median filtering of measured velocities, and combining and fitting them into a global flow pattern, can introduce additional inaccuracies in the resultant velocity vector magnitude and direction.

In this study, SuperDARN map velocity vectors (based on Thomas and Shepherd, 2018) are compared with ExB plasma flow components measured by incoherent scatter radars RISR-N and RISR-C at Resolute Bay (Canada) by projecting the map velocity vectors onto the direction of the respective RISR beam at nearly collocating points. More than 90,000 joint measurements indicate that, on average, the map velocities are about half of the ExB components in various RISR beam directions. The “reduction” effect is larger for cases in which map vectors are oriented across RISR beams, during dawn and dusk hours, and at large positive IMF Bz. The reduction effect is particularly strong when the flows, according to RISR, are fast, above ~1000 m/s.

Keywords: SuperDARN plasma flow map, ExB drift, Incoherent Scatter Radar RISR

Nightside Severe Plasmaspheric Erosion Associated with SAPS: Evidence from Arase and SuperDARN HOK/HKW Observations

*Yuki Obana[1], Naomi Maruyama[2], Atsuki Shinbori[3], Kumiko K. Hashimoto[4], Nozomu Nishitani[3], Tomoaki Hori[3], Akimasa Yoshikawa[1], Ayako Matsuoka[5], Yoshiya Kasahara[6], Yoshizumi Miyoshi[3], Iku Shinohara[7]

1. i-SPES, Kyushu University, 2. LASP, University of Colorado Boulder, 3. Institute for Space–Earth Environmental Research, Nagoya University, 4. The University of Electro-Communications, 5. Kyoto University, 6. Kanazawa University, 7. Institute of Space and Astronautical Science, JAXA

We investigate the role of subauroral polarization streams (SAPS) in driving extreme plasmaspheric erosion during the September 2017 geomagnetic storm by combining nightside Arase observations with SuperDARN radar measurements. A previous study (Obana et al., 2019) based on dayside Arase data reported unusually deep plasmapause erosion down to L ~ 1.6 - 1.7 and suggested that sustained penetration of convection electric fields to low latitudes may have played a key role. However, the contribution of localized subauroral electric fields, such as SAPS, remains unclear.

In this study, we analyze electron density profiles derived from the upper hybrid resonance observed by Arase during its nightside passes. We find that, at times corresponding to or immediately following strong SAPS activity identified by the SuperDARN Hokkaido East (HOK) and Hokkaido West (HKW) radars, a pronounced depletion of electron density occurs in the inner magnetosphere at L ~ 1.7 - 2.2. This depletion is significantly sharper and extends to lower L-shells than that observed during the preceding orbital pass, indicating rapid erosion of the plasmasphere on the nightside.

The timing and location of this erosion are consistent with enhanced westward plasma flows associated with SAPS, which imply a strong northward electric field capable of driving strong anti-corotation (westward, dawn-to-dusk) E ~B convection in the subauroral region. These results suggest that SAPS may contribute to localized, rapid erosion of plasmaspheric flux tubes on the nightside and that these eroded flux tubes subsequently rotate toward the dayside, consistent with the deep erosion reported by Obana et al. (2019).

We will further examine the temporal evolution and spatial extent of SAPS using SuperDARN HOK/HKW observations, and assess their relationship to plasmapause location and midlatitude ionospheric trough dynamics. By integrating nightside and dayside observations, this study aims to clarify the role of SAPS in magnetosphere-ionosphere coupling processes leading to extreme plasmaspheric erosion.

Keywords: SAPS, plasmasphere, Arase

Intense magnetopause erosion at Earth during the May 2024 solar storm

*Kazuhiro Yamamoto[1], Yoshizumi Miyoshi[1,2], Naritoshi Kitamura[1], Rumi Nakamura[3], Atsuki Shinbori[1], Ayako Matsuoka[4], Mariko Teramoto[5], Shoichiro Yokota[6], Satoshi Kasahara[7], Kunihiro Keika[7], Tomoaki Hori[1], Kazushi Asamura[8], Yoichi Kazama[9], Shiang-Yu Wang[9], Sunny Wing-Yee Tam[10], Tzu-Fang Chang[10], Bo-Jhou Wang[9], Iku Shinohara[8]

1. Institute for Earth-Space Environmental Research, Nagoya University, 2. Kyung Hee University, 3. Space Research Institute, Austrian Academy of Sciences, 4. Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University, 5. Graduate School of Engineering, Kyushu Institute of Technology, 6. Department of Earth and Space Science, Graduate School of Science, Osaka University, 7. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 8. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 9. Academia Sinica Institute of Astronomy and Astrophysics, 10. Institute of Space and Plasma Sciences, National Cheng Kung University

Earth’s main magnetic field forms the magnetosphere, a barrier against solar wind plasmas. A southward magnetic field carried by the solar wind makes the magnetosphere smaller, which is termed “magnetopause erosion.” This process leads to equatorward extension of the polar region, where solar wind plasmas directly intrude into the magnetosphere. Although previous studies have suggested that magnetopause reconnection causes magnetopause erosion, the erosion mechanism during super geomagnetic storms remains controversial owing to a lack of *in situ* measurements. Here, we report a magnetopause crossing by the Arase satellite at 4.96 R_E during the May 2024 super geomagnetic storm, which is one of the innermost magnetopause crossings ever detected by magnetospheric spacecraft. An unexpected decrease in the magnetic field intensity extended from the inner magnetosphere to the magnetopause, indicating that magnetospheric currents reduced Earth’s main magnetic field on a global scale. Consequently, the solar wind pushed the weakened magnetosphere further toward the Earth, resulting in the severe erosion of the magnetosphere. This shrinkage led to a significant equatorward penetration of solar energetic particles on the dayside, suggesting that the magnetospheric currents can increase the risk of aircraft exposure to solar energetic particles at mid-latitudes.

Keywords: magnetopause, cusp, Arase satellite, May 2024 super geomagnetic storm, magnetosphere-ionosphere coupling

Excitation of storm-time Pc5 ULF waves using the GEMSIS magnetosphere-ionosphere coupled model: Comparison with GOES and ground observations

*Tomotsugu Yamakawa[1], Kanako Seki[2], Yoshizumi Miyoshi[1], Kazue Takahashi[4], Aoi Nakamizo[3], Kazuhiro Yamamoto[1]

1. Nagoya University, 2. The University of Tokyo, 3. National Institute of Information and Communications Technology, 4. Johns Hopkins University Applied Physics Laboratory

Pc5 ultra-low-frequency (ULF) waves play a key role in the dynamics of ring current ions and radiation belt electrons through wave-particle interactions. The waves can modulate field-aligned currents and ionospheric electric fields through magnetosphere-ionosphere coupling. However, where and how storm-time Pc5 waves are generated by ring current ions remain under debate. Previous studies [e.g., Yamakawa et al., 2022] demonstrated the excitation of storm-time Pc5 waves using the GEMSIS magnetosphere-ionosphere coupled model. However, those simulations assumed simplified and static conditions for Region-1 field-aligned-current (FAC) and ion injection on the nightside, which are not realistic for the inner magnetosphere. The purpose of this study is to investigate ring current evolution and the excitation of ULF waves during a magnetic storm under time-varying Region-1 FAC and ion injection. We focus on the 22 July 2009 magnetic storm. During this event, Dst decreased to nearly -80 nT around 07:00 and 10:00 UT. The excitation of ULF waves is investigated by GEMSIS coupled model (GEMSIS-RC + GEMSIS-POT), GOES satellites, and ground observations. GEMSIS-RC model is a drift-kinetic and self-consistent model for ring current ions, while GEMSIS-POT is a 2-D ionospheric potential solver.Poloidal ULF waves were observed by GOES satellites and ground stations from 02:50 to 03:40 UT in the premidnight region. Wave frequency of observed ULF waves was in the range of 1.3–1.8 mHz, and the m number (azimuthal wave number) was relatively small, ranging from -3 to -6, propagating westward. The GEMSIS coupled simulation reproduces the excitation of storm-time Pc5 waves in the premidnight region, with similar frequency and m number with observations.The simulation results suggest that the waves are generated through the drift resonance with ring current ions at 50-200 keV and inward gradient of ion PSD contributes to the wave growth. These results indicate that the GEMSIS coupled model is capable of providing the excitation mechanism and global distribution of observed ULF waves. The results also imply a potential impact on ionospheric electrodynamics through magnetosphere–ionosphere coupling, providing a basis for future comparisons with SuperDARN observations.

Keywords: ULF waves, ring current, drift resonance, drift-kinetic simulation

Magnetic topology of the closed and interplanetary flux interlinkage in the magnetotail for northward IMF: Implications from MHD simulations

*Masakazu Watanabe[1], Takashi Tanaka[1], Shigeru Fujita[2], Dongsheng Cai[3]

1. Kyushu University, 2. The Institute of Statistical Mathematics, 3. Nagoya University of Commerce & Business

In global magnetohydrodynamic simulations for northward interplanetary magnetic field (IMF), interlinkage of closed and interplanetary magnetic flux sometimes appears in the magnetotail. The basic magnetic topology of the magnetosphere is what we call the “2-null, 2-separator structure,” in which one negative (type A) null in the Northern Hemisphere and one positive (type B) null in the Southern Hemisphere are connected by two separators threading the dayside and nightside of the magnetosphere. The interlinkage indicates that the basic 2-null, 2-separator structure is locally broken. Using a geodesic level-set method to trace the magnetic surface emanating from the null (referred to as a fan or Σ surface), we analyzed the magnetic topology of the interlinkage structure. We found that the original null in each hemisphere multiplexes to form a null cluster (or a null region) in which the nulls have the same sign and are located on the same Σ surface. The simplest model that can explain such a topology is the “4-null, 8-separator structure” we newly propose here. The original Σ_A surface emanating from the type A null in the Northern Hemisphere duplicates in the Southern Hemisphere. The same thing occurs for the Σ_B surface emanating from the type B null in the Southern Hemisphere. As a result, the total number of nulls also doubles (four), with the total number of separators quadrupling (eight). The total number of topological regions separated by separatrices becomes ten (originally four). We also discuss reconnection sequences leading to the interlinkage magnetic flux. A key reconnection process is IMF-lobe reconnection that occurs simultaneously in both hemispheres (the so-called dual lobe reconnection, DLR). Normally, IMF-lobe reconnection and its consequent flux circulation occur independently in the two hemispheres. However, the DLR mixes the two magnetic flux circulations.

Keywords: magnetic topology, MHD simulation, magnetic flux interlinkage

On the co-existence of dusk scatter echoes and ULF waves

*Keisuke Hosokawa[1], Tomoaki Hori[2], Yuki Obana[3], Nozomu Nishitani[2], Mariko Teramoto[4], Pasha Ponomarenko[5], Atsuki Shinbori[2], Akira Sessai Yukimatu[6], Yoshizumi Miyoshi[2]

1. University of Electro-Communications, 2. ISEE, Nagoya University, 3. Kyushu University, 4. Kyushu Institute of Technology, 5. University of Saskatchewan, 6. National Institute of Polar Research

During a four-month period spanning from October to December 2023, special time observations were conducted, with approximately 9 days per month, in support of Arase conjunctions. These observations were targeted to observe auroral and subauroral phenomena on the nightside and dusk-side. One of the targets of this special time experiments is ULF waves in the auroral/subauroral latitudes. In actual, during this special observation period, many echoes were obtained in the dusk-side subauroral region. In particular, echoes known as Dusk Scatter Echoes (DUSE: Ruohoniemi et al., 1988) were observed almost daily near the evening-side terminator possibly in association with the mid-latitude trough (Hosokawa et al., 2001), and many of these showed Doppler velocity oscillations associated with ULF waves even during quiet intervals. In this study, a small statistical analysis was conducted to determine how frequently these evening-side echoes contained ULF waves. Detection of ULF waves was performed visually based on quick-look RTI plots of all the North American radars. The results indicated that approximately 70% of DUSEs observed by auroral-zone radars contained ULF wave signatures. Additionally, it was found that long-lasting echoes were observed at the subauroral latitudes (i.e., by the mid-latitude radars) throughout the entire nightside MLT sector, not limited to the dusk sector, and these echoes frequently contained ULF wave signatures. In the presentation, we show the occurrence characteristics of ULF waves within DUSE and discuss the source (or excitation process) of such waves in association with the generation of radar echoes (i.e., irregularities) in the auroral/subauroral regions.

Keywords: ULF waves, Subauroral irregularities

Observations and Mechanism Analysis of Unusual Continental Extended Poleward-Propagating Medium Scale Traveling Ionospheric Disturbances

*wei wang[1,2,3], Jiaojiao Zhang[1,2,3], Junjie Chen[4], Fuqing Huang[5], Tong Dang[5], Jianyun Liang[1], Weijun Liu[1], Guoying Jiang[1,3,6], Hang Li[1,2,3], Yajun Zhu[1,2,3], Xiang Deng[1,2], Ailan Lan[1,2], Jingye Yan[1,3], Shunrong Zhang[7], Jiyao Xu[1,3], Chi Wang[1,3]

1. National Space Science Center (NSSC), Chinese Academy of Sciences, Beijing, China, 2. Siziwang Observatory of Space Weather, Chinese Academy of Sciences, 3. University of the Chinese Academy of Sciences, 4. DeDpartment of Earth Sciences, University of Hong Kong, 5. Deep Space Exploration Laboratory/School of Earth and Space Sciences, University of Science and Technology of China, 6. Hainan National Field Science Observation and Research Observatory for Space Weather, 7. MIT Haystack Observatory

The newly established Chinese Dual Auroral Radar Network (CN-DARN) consists of six high-frequency coherent scattering radars, extending over 10,000 km in longitude and 4,000 km in latitude, thereby offering a powerful platform for MSTIDs observations. In this study, we report the first observation of an unusual continental extended poleward-propagating medium-scale traveling ionospheric disturbance event (MSTID) on May 10, 2024, based on measurements from CN-DARN radars. This event was initially detected after sunset by the easternmost radar of CN-DARN. As the terminator moved westward, it was subsequently continuously tracked and monitored from east to west throughout the entire network. The synchronous observations of the CN-DARN Hejing pair of radars and the nearby all-sky airglow imager indicated that this disturbance propagated northeastward, with a phase velocity of approximately 270 m/s and a period of about 30 minutes. The combined measurements of atmospheric gravity waves and neutral winds strongly suggest that the filtering effect of neutral winds on gravity waves generated near the terminator is the direct cause of this MSTID event. Further numerical simulations using the Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIEGCM) indicate that enhanced space weather activities drive the strong southwestward neutral winds at summer night to extend from high latitudes to middle latitudes, thereby triggering this unusual event. This work highlights the role of space weather conditions in driving continental extended poleward-propagating MSTID events.

Keywords: poleward-propagating MSTIDs, Chinese Dual Auroral Radar Network, Space weather effects, Neutral wind filtering

SuperDARN Hokkaido Pair of (HOP) radars observations of traveling ionospheric disturbances triggered by the Kamchatka Earthquake (on 22 July 2025)

*Nozomu Nishitani[1], Tomoaki Hori[1], Atsuki Shinbori[1], Kota Noguchi[1], Pasha Ponomarenko[2,1]

1. ISEE, Nagoya University, 2. University of Saskatchewan

We report on the SuperDARN Hokkaido Pair of (HOP) radars observations of traveling ionospheric disturbances triggered by the Kamchatka Earthquake (Mw=8.8) on July 22, 2025, which occurred off the eastern coast of the Kamchatka Peninsula. The initial disturbance at the epicenter began at 2324 UT. The HOP radars, located in Hokkaido and operated by ISEE, Nagoya University, began seeing the coseismic ionospheric disturbances at 2336 UT. The SuperDARN Hokkaido West radar was operating with 'stereoscan' mode, with channel A scanning through the whole field of view with a 1-minute interval, and channel B monitoring the fixed beam direction (beam 10) every 3 seconds. In addition, channel A was scanning from west to east, in the opposite direction to the propagation of the disturbances, allowing the point of intersection between the scanning beam and the disturbance to be determined with an accuracy of 3 seconds. Moreover, since channels A and B operate at different radar frequencies (10.81 MHz vs 9.15 MHz), it is possible to discuss the vertical and horizontal propagation speeds of the disturbance. The time difference between the start times of channels A and B is 9 seconds. It appears relatively short if we assume virtual reflection altitudes at two frequencies based on the Secant Law, but the ray-tracing analysis of HF propagation indicates that the actual reflection-point altitude difference between the channels A and B is within 10 km, consistent with the typical upward propagation velocity of acoustic waves (a few hundred m/s). Initial results of the analysis of this event and the preliminary interpretation of the propagation characteristics of the coseismic ionospheric disturbance will be presented.

Keywords: SuperDARN Hokkaido Pair of (HOP) radars, Kamchatka Earthquake, coseismic ionospheric disturbance

Initial analysis result of thermospheric neutral density variations using Starlink Ephemerides

*Takuya Sori[1], Mamoru Yamamoto[1]

1. Research Institute for Sustainable Humanosphere, Kyoto University

In the upper atmosphere, neutral particles are ionized by the Extreme Ultraviolet from the Sun, forming the plasma. As the ionization is partial, the plasma density is much smaller than the neutral density. At the E region height, the neutral density is approximately 10^6 times larger than the plasma density. The neutral atmosphere can affect spatiotemporal variations of the plasma density in the ionosphere. We need to understand the spatiotemporal variations in neutral density in the thermosphere to better understand Ionosphere–Thermosphere coupling. However, it is difficult to observe the neutral particles in the thermosphere from the ground because they do not interact with radio (electromagnetic) waves through radar observations. Although direct observations using sounding rockets and satellites can probe the neutral atmosphere, their coverage is limited.Recently, a large number of satellites have been launched into space by private companies. For example, SpaceX operates Starlink satellites in the thermosphere, and the number of satellites has reached ~10,000 as of Mar. 2026. In this study, we investigate the thermospheric density derived from the Starlink Ephemerides in Nov. 2025 using the analysis method of Yamamoto [2026] to confirm the accuracy of the tomography results of the thermospheric density. Spatial variations of the thermospheric density at an altitude of 482 km were approximately consistent with those calculated by models (MSIS2.1 and GAIA) during geomagnetically quiet periods. During the main phase of the geomagnetic storm, the thermospheric density was largely enhanced compared with that from MSIS2.1. An enhancement of the thermospheric density derived from GAIA was comparable to that by the tomography analysis. The thermospheric density from the tomography analysis, however, showed significant decrease after the enhancement. This behavior was not found in either MSIS2.1 or GAIA. The main difference between the tomography and MSIS2.1/GAIA results appears in the nighttime sector in the spherical distribution of the thermospheric density. During the geomagnetic storm, the thermospheric density from MSIS2.1/GAIA exhibits a local enhancement at the nightside equator, while the tomography analysis did not enhance but decreased. We need further analysis to improve the problem.

Keywords: Thermospheric neutral density, Starlink Ephemerides, Geomagnetic storms

Observation of shortwave fadeout events using Chinese Dual Auroral Radar Network (CN-DARN) during the severe solar storm in May 2024

*Junjie Tong[1,2], Jiaojiao Zhang[1,2,3], Hang Li[1,2,3], Wei Wang[1,3], Bianlong Zhao[1,4], Wenqian Chen[1,2], Xiang Deng[1,3], Ailan Lan[1,2,3], Jingye Yan[1,2], Chi Wang[1,2]

1. Key Laboratory of Solar Activity and Space Weather, National Space Science Center, Chinese Academy of Sciences, 2. University of Chinese Academy of Sciences, 3. Siziwang Observatory of Space Weather, National Space Science Center, Chinese Academy of Sciences, 4. Shandong Provincial Key Laboratory of Optical Astronomy and Solar-Terretrial Environment, Institude of Space Sciences, Shandong University

Shortwave fadeout (SWF) is a typical dayside HF radio disturbance caused by solar flare-induced ionospheric ionization enhancement. Using newly built Chinese Dual Auroral Radar Network (CN-DARN) observations, we investigate two X-flare-driven SWFs during the May 2024 geomagnetic superstorm (SYM-H = -518 nT), on 10 May (pre-storm) and 11 May (storm main phase). Comparative analysis reveals strong ionospheric negative storm modulations on SWF characteristics: a prominent Doppler flash (line-of-sight velocity peak 150 m/s, exceeding prior records) preceded the pre-storm SWF, but none was detected for the storm-phase event. The latter showed layered radar backscatters (E- vs. F-region reflections) with divergent interruption durations (~20 min vs. ~80 min); F-region backscatters had abnormally prolonged recovery (>3 h to quiet-time levels), while E-region signals and the pre-storm SWF recovered in ~1 h. We also find radar transmission frequency and local time impact SWF observations. These results highlight ionospheric negative storm effects on flare-induced SWFs, clarify their characteristics in complex ionospheric conditions, and support their accurate forecasting.

Keywords: Shortwave fadeout, CN-DARN radars, Solar storm in May 2024, Solar flare

The SuperDARN HF Radar Response to Spike Events over Kárhóll, Iceland

*Xiangcai Chen[1]

1. Polar Research Institute of China

Spike events, characterized by short-duration, intense cosmic noise absorption (CNA) enhancements observed by riometers, are often associated with transient particle precipitation during magnetospheric disturbances. In this study, we investigate the corresponding signatures of spike events in the HF radar backscatter measured by the SuperDARN Iceland East (SIE) radar. By analyzing simultaneous observations from the China-Iceland Arctic Observatory riometer and the SIE radar, we identify spike events and examine the concurrent HF radar responses, including changes in backscattered power, Doppler velocity, and spectral width. Some results show that spike events are typically accompanied by pronounced enhancements in HF radar backscattered power and a broadening of the spectral width, indicative of increased ionization in the D-region ionosphere and enhanced irregularity generation in the E-region. The temporal evolution of these radar signatures relative to the spike onset suggests a close coupling between the precipitating particle flux and the modification of the HF propagation conditions. This study highlights the potential of combining riometer and SuperDARN observations to better understand the impulsive particle precipitation mechanisms and their impact on the high-latitude ionospheric dynamics.

Keywords: Ionospheric Absorption, Spike Event

Investigation of Neutral Wind Structure and Sporadic E Layer Formation Based on Meteor Echo Observations

Shinnosuke Okabe[1], *Mariko Teramoto[1], Nozomu Nishitani[2]

1. Kyushu Institute of Technology , 2. Nagoya University

Sporadic E (Es) layers are transient electron density layers formed in the ionospheric E region at an altitude of around 100 km. They are important phenomena because they significantly affect shortwave radio communication and radar observations. Previous studies have suggested that the accumulation of metallic ions caused by vertical wind shear in the neutral atmosphere plays a key role in the formation of sporadic E layers. However, direct observations of neutral winds in the mesosphere and lower thermosphere are limited, and observational studies investigating neutral wind structures during sporadic E layer formation remain insufficient. In this study, near-range echoes observed by the Hokkaido Rikubetsu SuperDARN radar, a high-frequency radar system for observing the high-latitude ionosphere, were analyzed. Meteor echoes were extracted from the radar data to estimate the vertical structure of neutral winds at altitudes between 60 and 120 km. SuperDARN data obtained during 2024 were used in this analysis. Meteor echoes were selected under the following conditions: altitude range of 60–120 km, signal intensity greater than 15 dB, Doppler velocity between −60 and 60 m/s, and spectral width less than 6 m/s. In addition, three sporadic E layer events were identified using ionosonde observations, which measure ionospheric altitude and electron density using radio waves. The altitude distributions of neutral winds associated with these events were analyzed. In the first event, vertical wind shears with velocity differences of 18.02 m/s in the north–south direction and 60.63 m/s in the northeast–southwest direction were observed. In the second event, velocity differences of 42.64 m/s and 69.95 m/s were observed, respectively. In the third event, velocity differences of 38.59 m/s and 31.31 m/s were identified. These neutral wind structures are consistent with the wind shear theory of sporadic E layer formation and indicate that the conditions required for sporadic E layer generation were confirmed through actual observations. This study demonstrates that neutral wind observations using meteor echoes are effective for understanding the formation processes of sporadic E layers and are expected to contribute to future studies of sporadic E layers and the mesosphere–lower thermosphere region.

Keywords: Sporadic E layer, Neutral wind shear, Meteor echo observations

Signatures of ULF-modulated energetic electron precipitation observed in OCTAVE VLF/LF transmitter

*Kakeru Yoshii[1], Hiroyo Ohya[1], Fuminori Tsuchiya[2], Martin Connors[3], Nozomu Nishitani[4], Simon G. Shepherd[5], Hiyoyuki Nakata[1]

1. Graduate School of Science and Engineering, Chiba University, 2. Planetary Plasma and Atmospheric Research Center (PPARC), Tohoku University, 3. Center for Science, Athabasca University, 4. Institute for Space-Earth Environmental Research (ISEE), Nagoya University, 5. Dartmouth College

Ultra low frequency (ULF, <5 Hz)-modulated energetic electron precipitation (EEP, 100 keV to 1 MeV) occurs during substorms in the Athabasca sub-auroral zone (Miyashita et al., 2018), and that ULF-modulated EEP also occurs due to a lowering of the mirror point during geomagnetically quiet time (Brito et al., 2012; Tanaka et al., 2022). However, the underlying mechanism remains unclear. In this study, we investigate oscillations in the amplitude and phase of very low frequency (VLF, 3–30 kHz) and low frequency (LF, 30–300 kHz) transmitter signals associated with EEPs. The aim is to elucidate the generation mechanism of ULF-modulated EEP by comparing with ground-based magnetic field data and ionospheric plasma dynamics observed by the Super Dual Auroral Radar Network (SuperDARN) HF radar. We investigated an EEP event that occurred during the recovery phase of a geomagnetic storm on May 29, 2017. VLF/LF amplitude oscillations with a period of 132.8 s were observed on multiple propagation paths over North America. In particular, anti-phase variations were found between the NDK (transmitter frequency: 25.2 kHz)–Athabasca (ATH) and WWVB (60.0 kHz)–ATH paths. Furthermore, SuperDARN observations showed significant Doppler velocity perturbations to the east of ATH, accompanied by moving echoes detected across multiple beams. The Doppler velocity also exhibited periodic variations corresponding to the VLF/LF oscillations, suggesting an EEP-related ionospheric response. We interpret that enhanced ionization within the precipitation region may generate a localized electric field opposite to the background ionospheric convection electric field, leading to a reduction of the effective convection and thus weaker Doppler velocities (Shinnkai et al., 2003). Ground magnetometer data further showed magnetic field variations of up to 8 nT at stations located at similar latitudes to the VLF/LF propagation paths, with 128 s periodic oscillations. The azimuthal wave number (m number) estimated from pairs of nearby stations indicates westward propagation between VIC-NEW, whereas eastward propagation was found between GLYN-HRIS. Further details will be discussed in the session.

Keywords: EEP, ULF-modulated