Review of the status of SuperDARN in 2025

Gareth Chisham
With thanks to the PIs and working group chairs
Space Weather and Atmosphere Team
British Antarctic Survey

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE
FOR A SUSTAINABLE PLANET

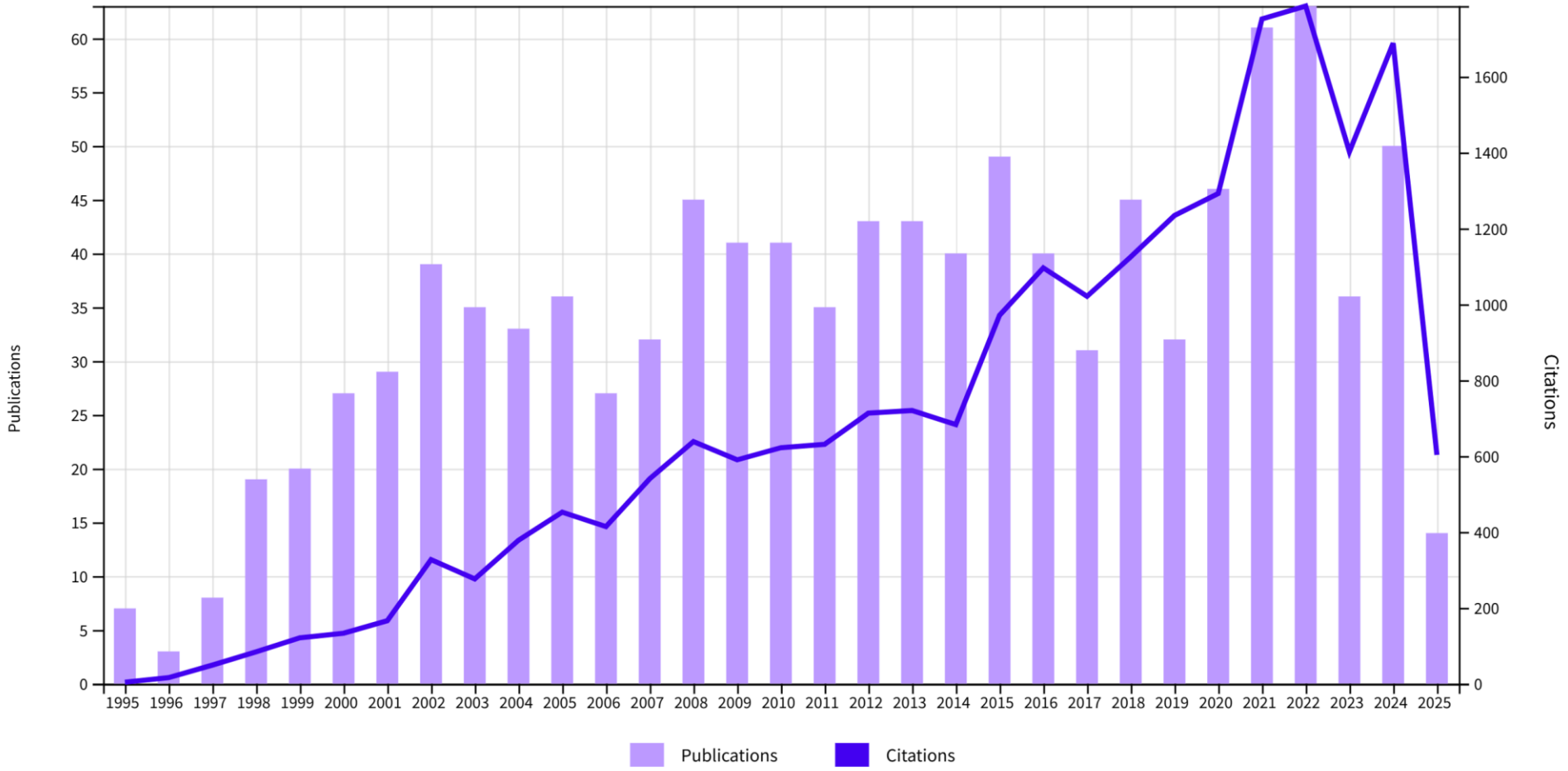
SuperDARN Workshop 2024

Successful Workshop in Beijing, China, hosted by Jiaojiao

SuperDARN workshop 2024 in Beijing.

SuperDARN Science

Sustained Relevance and Impact



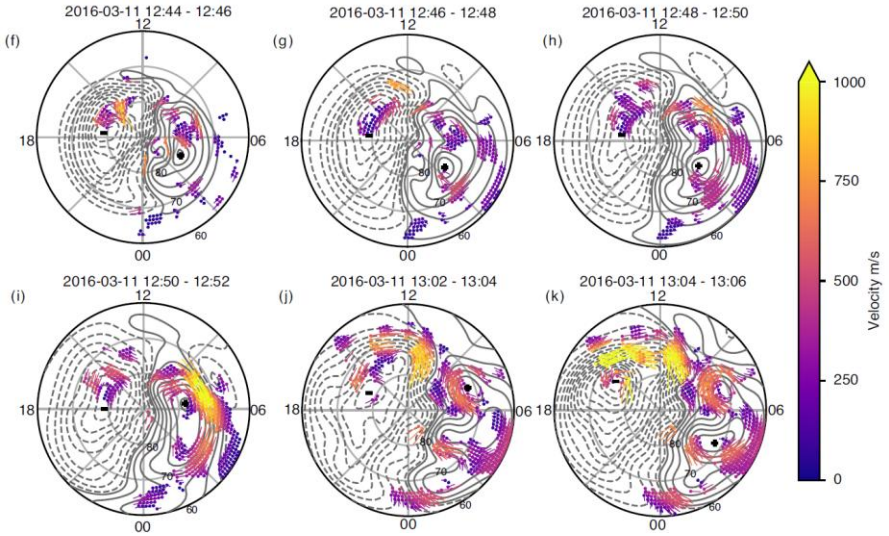
SuperDARN refereed publications from Web of Science

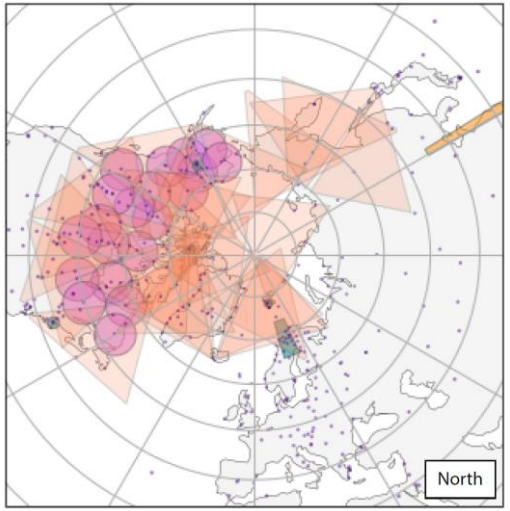
SuperDARN Science – 2024 Highlights

- Dai et al. (2024) – Global-scale magnetosphere convection driven by dayside magnetic reconnection, *Nature Communications*, 22 citations to date.

- Qu et al. (2024) – Estimation of ionospheric field-aligned currents using SuperDARN radar and DMSP observations, *JGR Space Physics*.

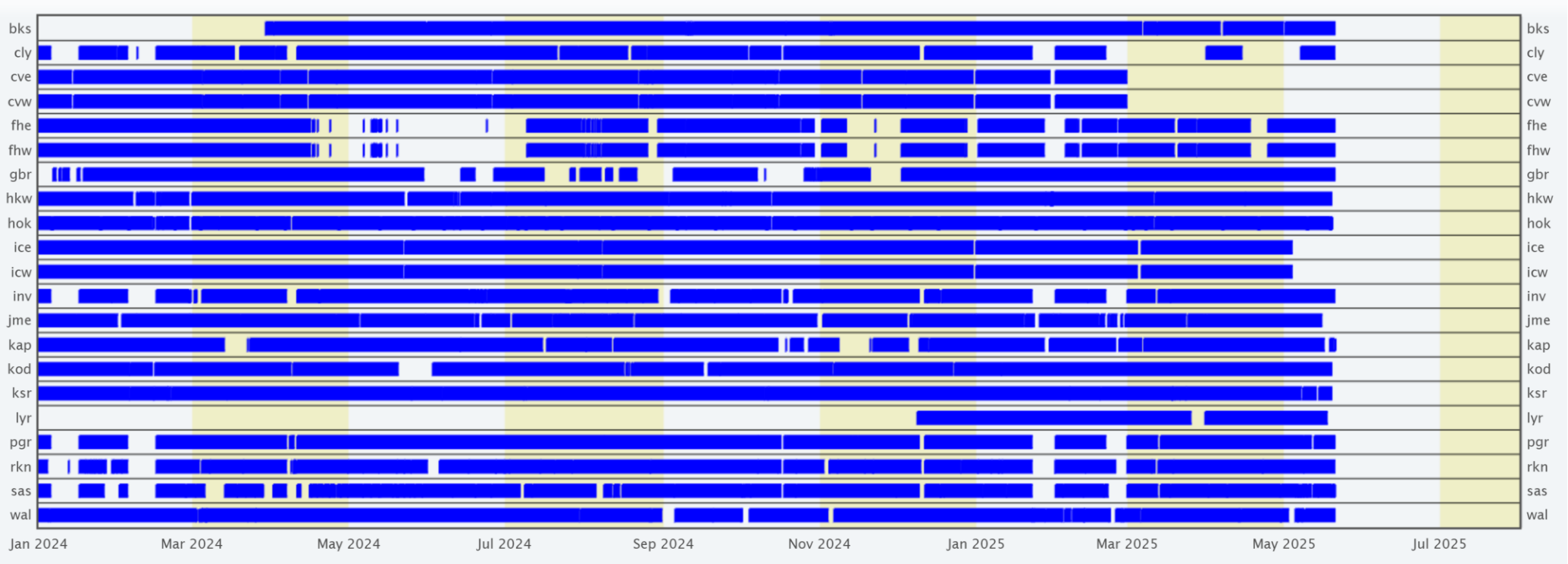
- Carter et al. (2024) – Ground-based and additional science support for SMILE, *Earth and Planetary Physics*.





Operational Radar Data Status

Northern Hemisphere (BAS data mirror)



- Good temporal coverage for nearly all Northern radars.
- Waiting to add recent Dartmouth data following resolution of a data issue.
- New Chinese radar data will be added soon.

Six New Chinese SuperDARN Radars

- Run by NSSC – PI Jiaojiao Zhang.
- HJE, HJW, LJE, LJW, SZE, SZW.
- These are now transferring data to the SuperDARN data mirrors.

Longyearbyen (LYR)

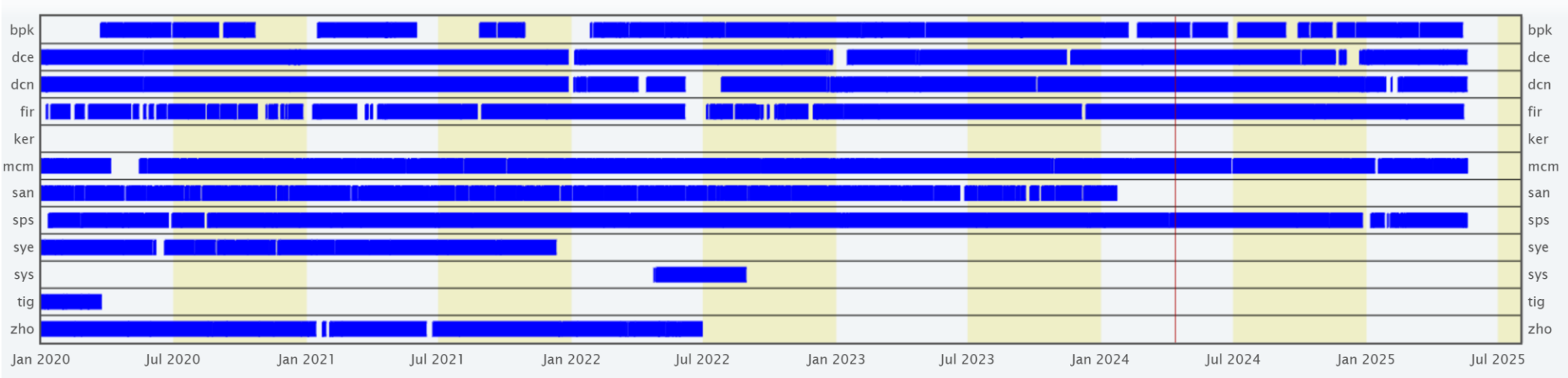
The LYR radar is now fully operational again (since December 2024)

Hankasalmi (HAN - Mk 2) - HAIRS

- The new Hankasalmi radar (renamed HAIRS) is almost ready to start operations.
- HAIRS will be running a Borealis system.

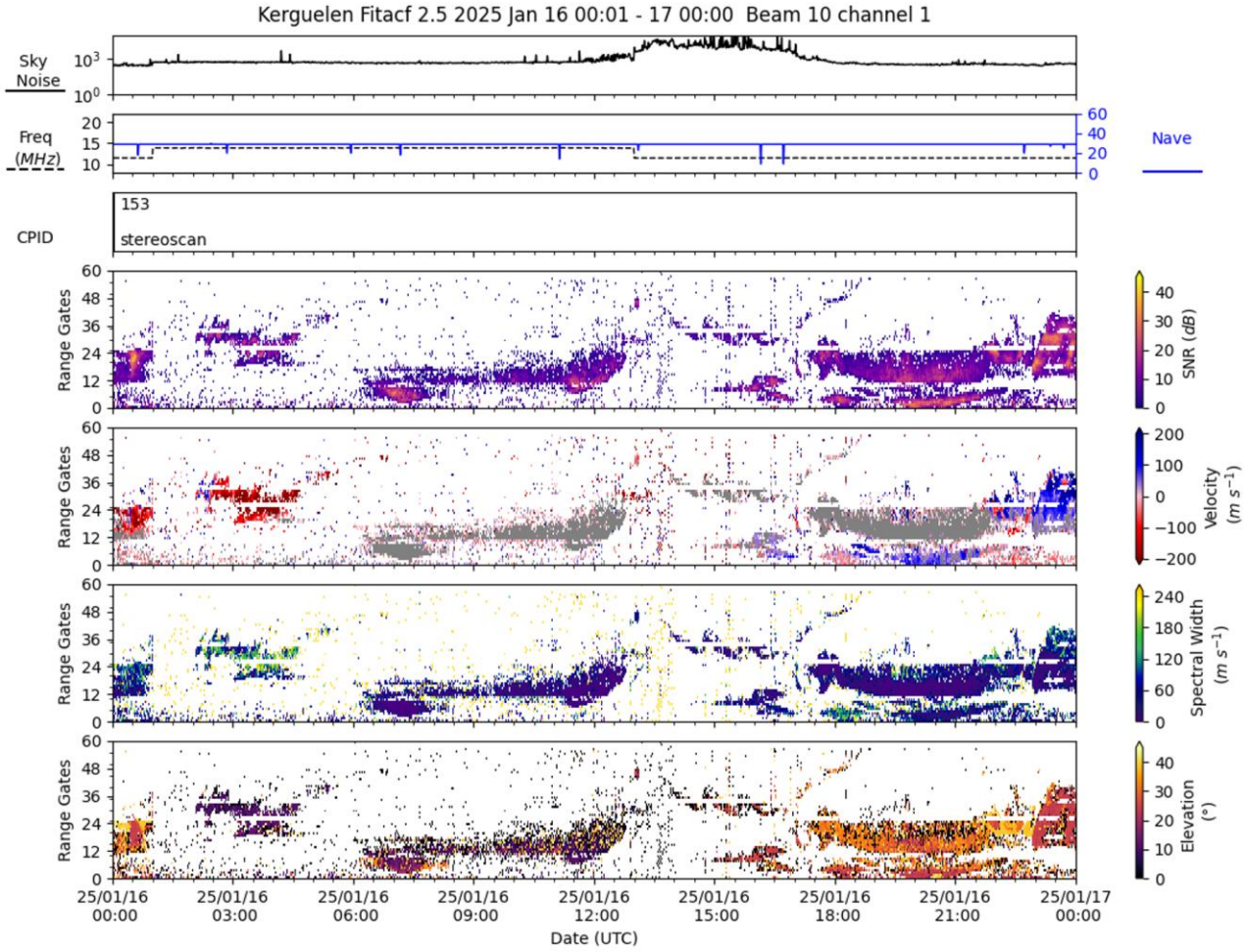
Operational Radar Data Status

Southern Hemisphere (BAS data mirror)



- Only 6 Southern radars with good up-to-date coverage.
- KER operating since January, data coming soon.
- TIG planned restart this year.
- SAN and ZHO operational but data catch-up needed.
- No information about the Syowa radars – SYE and SYS
- UNW will not return!

Kerguelen (KER)



Kerguelen data for beam 10 – 16 January 2025

- The newly-reconditioned Kerguelen radar has been operational since January 2025.
- It is now operating in STEREO.

Falkland Islands Radar (FIR)

- Construction and testing of a new lightweight transmission antenna (3-D printed parts and carbon fibre poles).
- Can be more easily deployed to a range of Antarctic locations.

New SuperDARN PIs

- Glenn Hussey (University of Saskatchewan) has been appointed Director of SuperDARN Canada, and SuperDARN PI responsible for the radars at Saskatoon (SAS), Prince George (PGR), Inuvik (INV), Clyde River (CLY), and Rankin Inlet (RKN).

- Stefano Massetti (INAF-IAPS, Rome) is the new Italian PI, responsible for the radars at Dome-C in Antarctica (DCE, DCN).

New SuperDARN Appointments

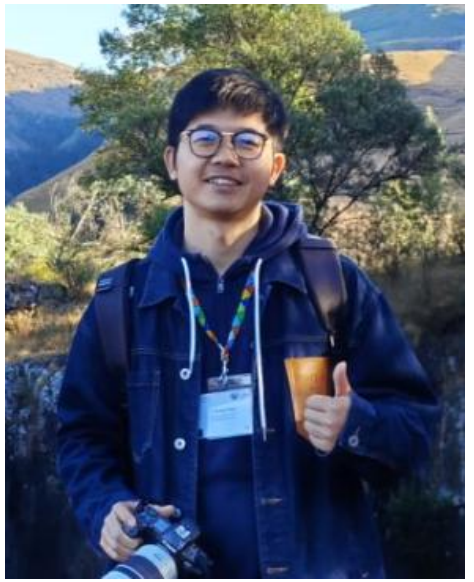
- Dan Billett has been appointed to a new SuperDARN faculty position at the University of Saskatchewan (start 1 July 2025).

- Jo Cole has joined the Space Weather team at the British Antarctic Survey (BAS) as the Space Weather Instrument Scientist, with SuperDARN operational responsibilities.

Promotion of SuperDARN Personnel

- Ex-SuperDARN PI Mervyn Freeman has been promoted to a Band G scientist at BAS.

- Xiang Deng has been promoted to senior engineer at NSSC.



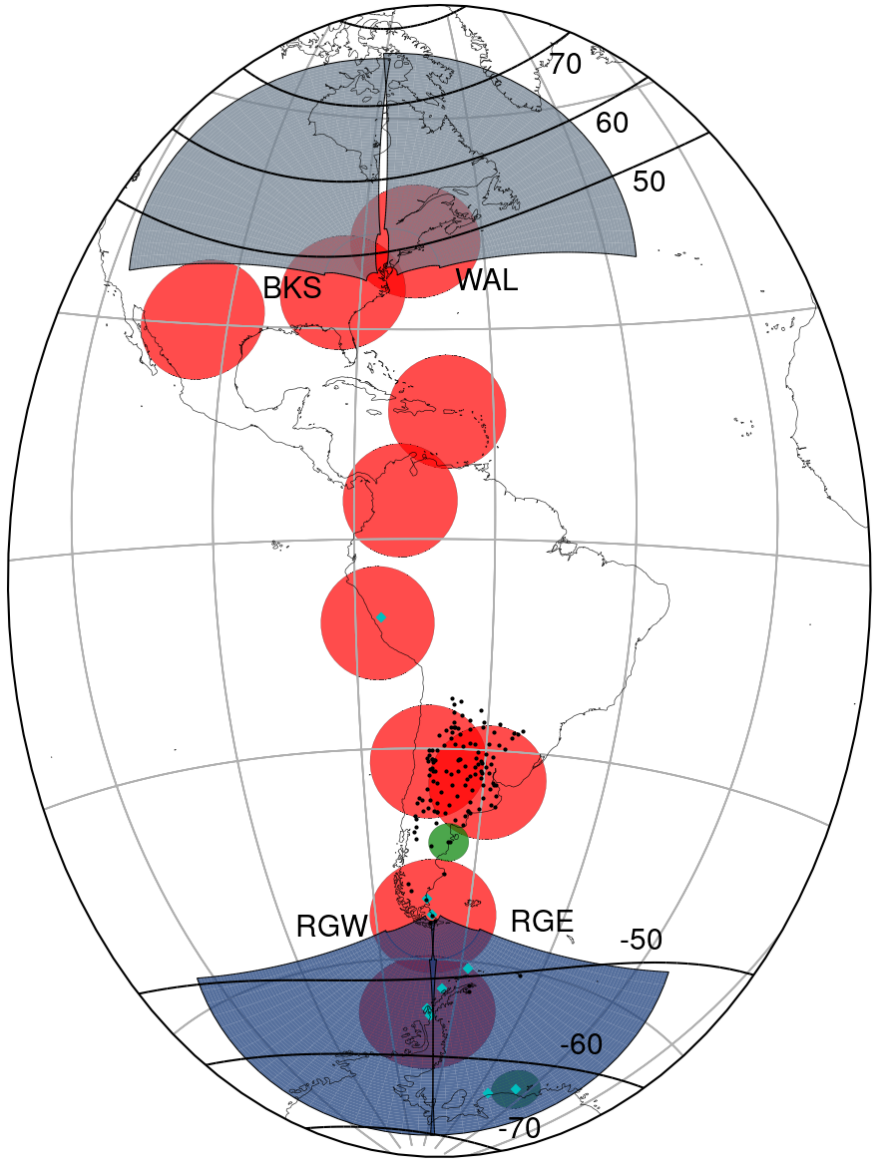
- Bharat Kunduri is in line for promotion to Research Associate Professor at VT.

- Neil Cobbett has been promoted to a Band F engineer at BAS.

SuperDARN Opportunities

Potential for new
SuperDARN radars

- Cyprus (Haris Haralambous)
- Argentina (Bill Bristow)

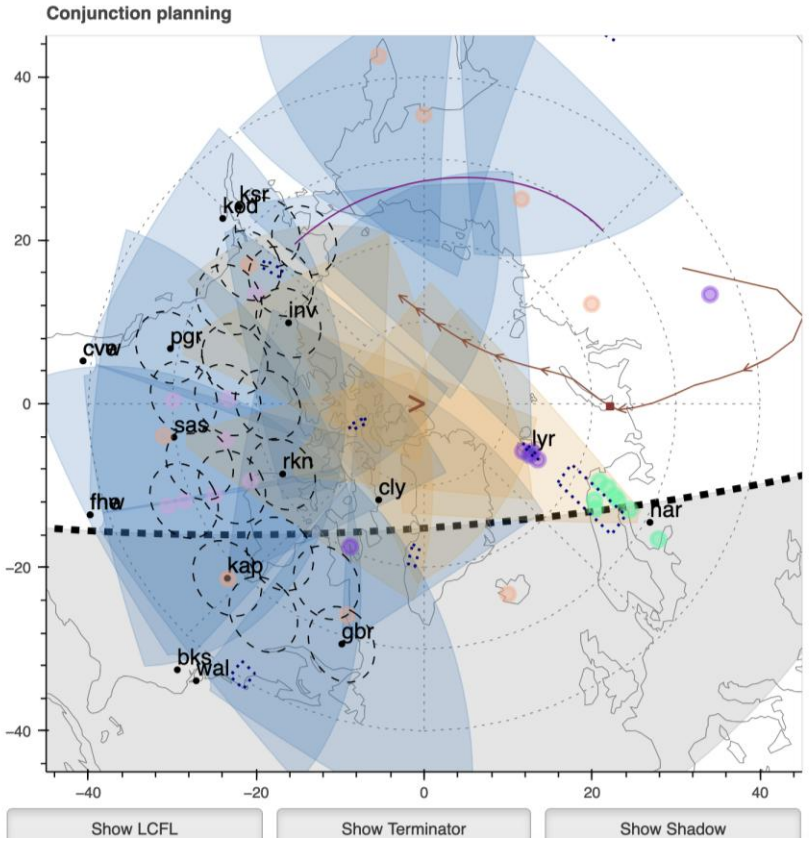


Courtesy: Bill Bristow

SuperDARN Opportunities

Future Collaboration with Satellite Missions

- SuperDARN has a vital role to play in collaboration with future spacecraft missions, e.g., SMILE, GDC, Dynamic.



Mission to collaborate with SD	Agency, lead(s)	SCWG and SD point of contact	Mission start	Orbit info	Expected duration	SD considerations
TRACERS	NASA	Yasir Soobiah, Tim Yeoman	Summer 2025	~550 km circular, RAAN ~Noon, 2 s/c formation	~1 year	Operational from MLT ~10.5 h to 14.5 h to cover cusp regions HAIRS to support TRACERS, upgrades to system May 2025
EZIE	JHU/APL, Jesper Gjerloev, Sam Yee	?	March 2025 so operational	420 km to 630 km, 3 x s/c formation	18 months	Routine, given fast orbital period?
SMILE	ESA/CAS	Jenny Carter, Maria-Theresia Walach	Expected >Feb 2026	Apogee ~20 R_E, above NH, approx. 51 h orbit,	3 years 7 years maximum	Convection and EP maps pipeline at Leicester to feed SMILE Data Fusion Facility; in development
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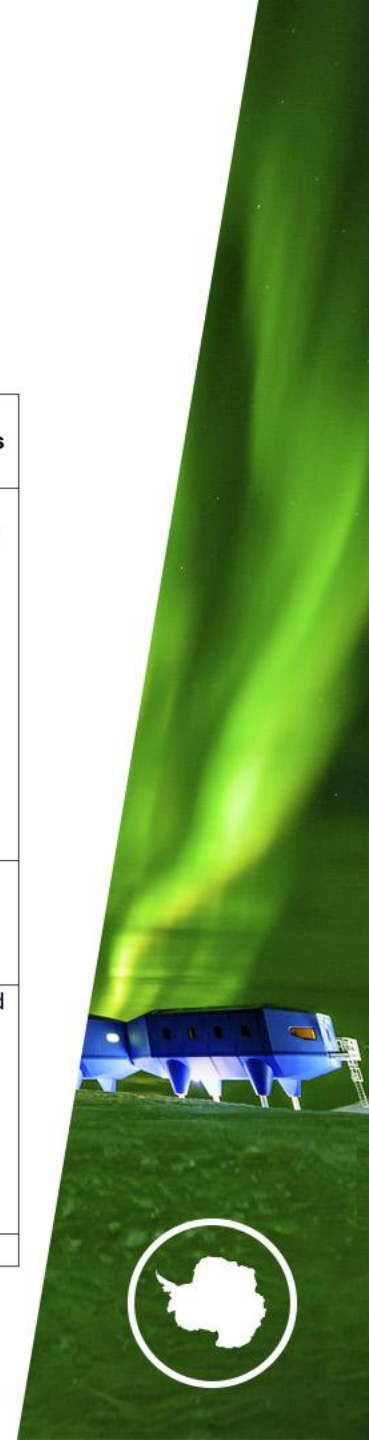
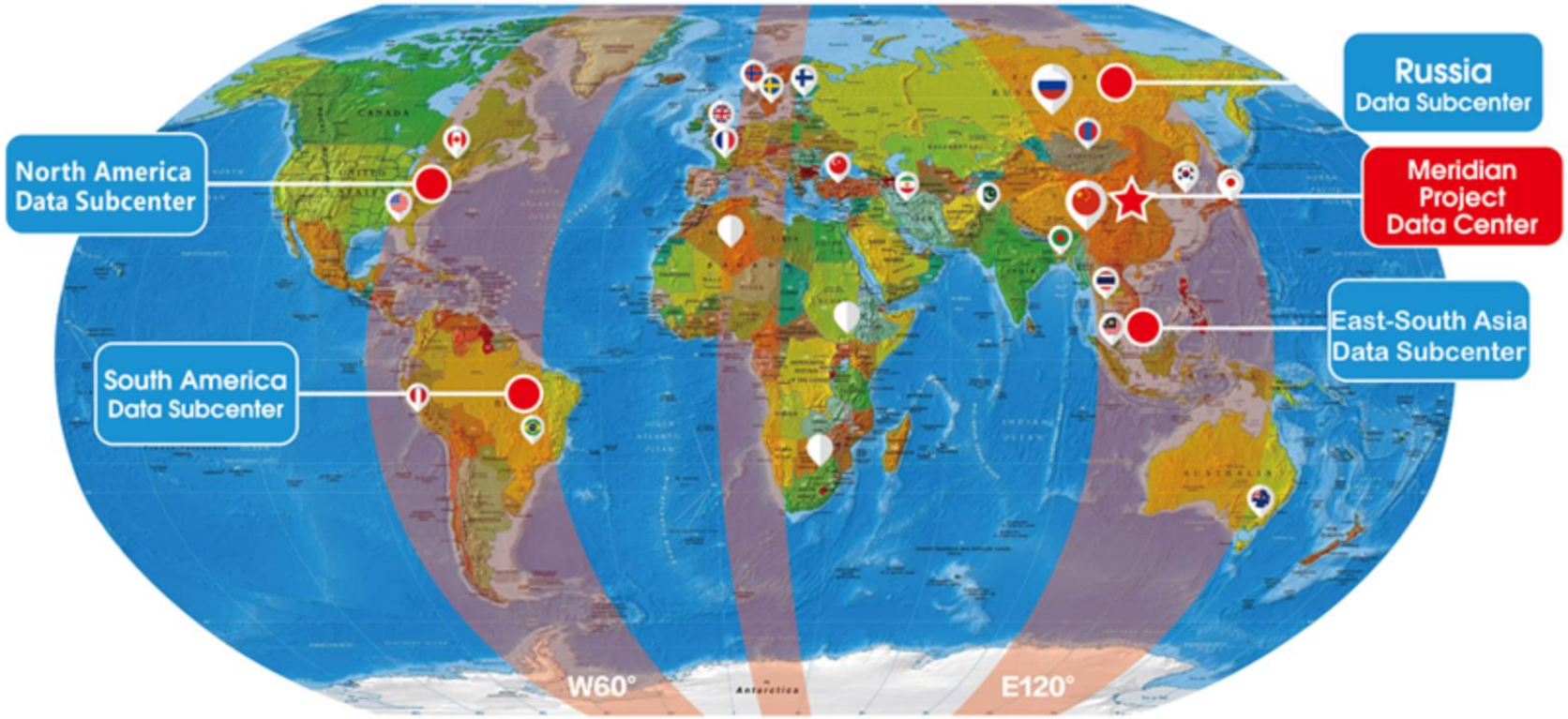
Courtesy: Jenny Carter



SuperDARN Opportunities

International Meridian Circle Program (IMCP)

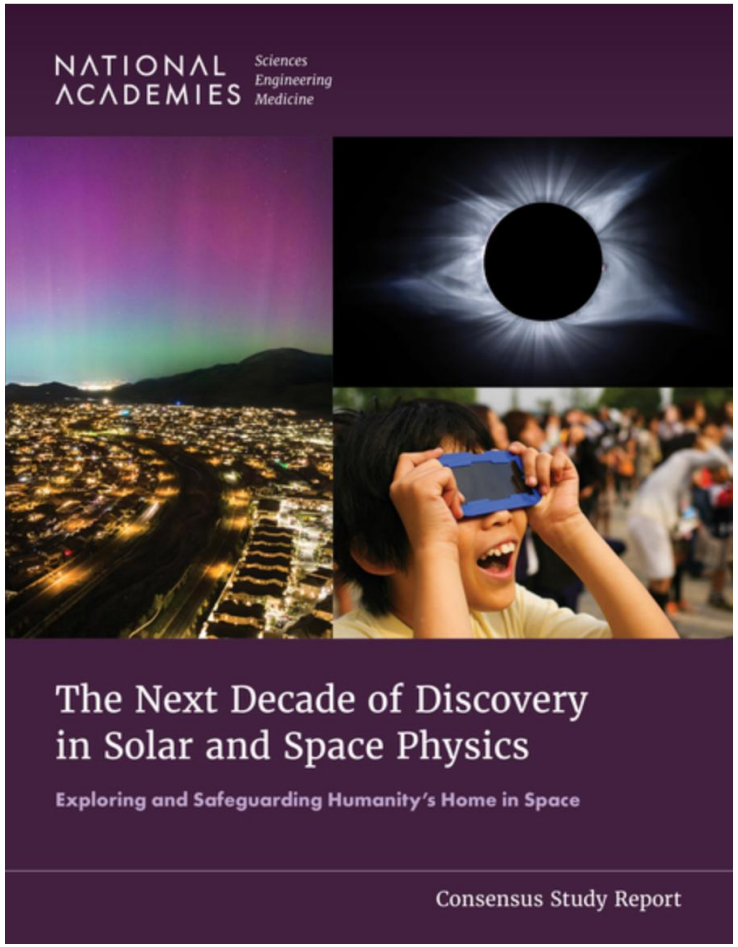


- Large scope for collaborations between SuperDARN and IMCP.
- Opportunities of support to produce higher-level data products.

SuperDARN Community Issues

Funding

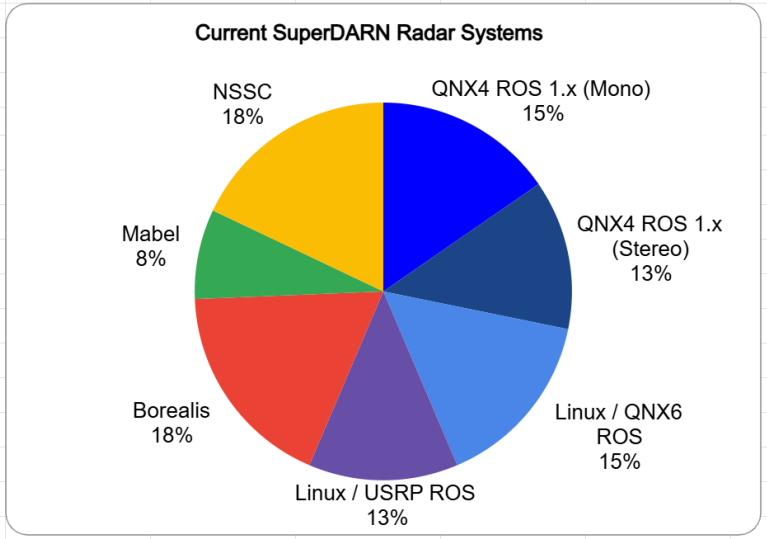
- Long-term funding presently secure in Canada, China, and France, and for the short term for most other groups.
- Future funding situation most uncertain in USA and UK – BUT US decadal survey outlines how the research community values SuperDARN, specifically calling for continued support for operation, expansion and development of new analysis techniques.
- What can we do as a community to address funding issues?
- Many are aware of the importance of SuperDARN for visualising convection (amongst many other things), BUT are reluctant to devote time or resources to its operation – Are we a victim of our own success – people think SuperDARN no longer needs support?



SuperDARN Community Issues

Hardware and Software Divergence

QNX4 ROS 1.x (Mono)	6	DCE, DCN, GBR, HOK, KAP, SYE
QNX4 ROS 1.x (Stereo)	5	HKW, KER, LYR, SYS, ZHO
Linux / QNX6 ROS	6	CVE, CVW, FHE, FHW, ICE, ICW
Linux / USRP ROS	5	BKS, KOD, KSR, MCM, SPS
Borealis	7	CLY, HAN, INV, PGR, RKN, SAS, WAL
Mabel	3	BPK, FIR, SAN
NSSC	7	JME, HJE, HJW, LJE, LJW, SZE, SZW
Total	**39**	
Offline / Decomissioned	6	ADE, ADW, PYK, STO, TIG, UNW
		11 radars using QNX4-era ROS
		6 radars using QNX6-era ROS
		5 radars using USRP-style ROS
		7 radars using USRP-style Borealis
		3 radars using FPGA-style Mabel
		7 radars using FPGA-style NSSC design



Courtesy: Evan Thomas

Strengths: Additional capability; Increased reliability; Increased resolution…

Impacts: Less hardware crossover; Reduced collaboration between teams; Reduced support for underfunded groups; Reduced data compatibility…

SuperDARN Community Issues

Accessibility and Availability of Data and Software

Complexity of SuperDARN data and software is an issue for non-experts

RAWACF files (for experts only) – This is the main data set we make available!

↓

Three commonly used methods for fitting ACFs (FitACFv2.5, FitACFv3.0, lmfit)

FITACF files (more accessible but still requires an element of expertise)

↓

Geolocation: Two virtual height models (standard and Chisham); Elevation angles (for experts)

For mapping: Multiple gridding and mapping options

Higher level data products (more accessible for the community)
BUT no universally-agreed SuperDARN products freely available

SuperDARN Community Issues

Accessibility and Availability of Data and Software

- Lack of coherence of where to access data – 3 data mirrors providing RAWACF files, and other sites providing processed data – Standardization?
- Multiple websites giving access to data and browsing plots – Standardization?
- Presently no agreed distribution of higher-level data products (e.g., map files) – should we as a community be doing this?
- Presently little capability for real-time data to support nowcasting and forecasting models – is this likely to change in the near term? Would this benefit from concerted community effort?

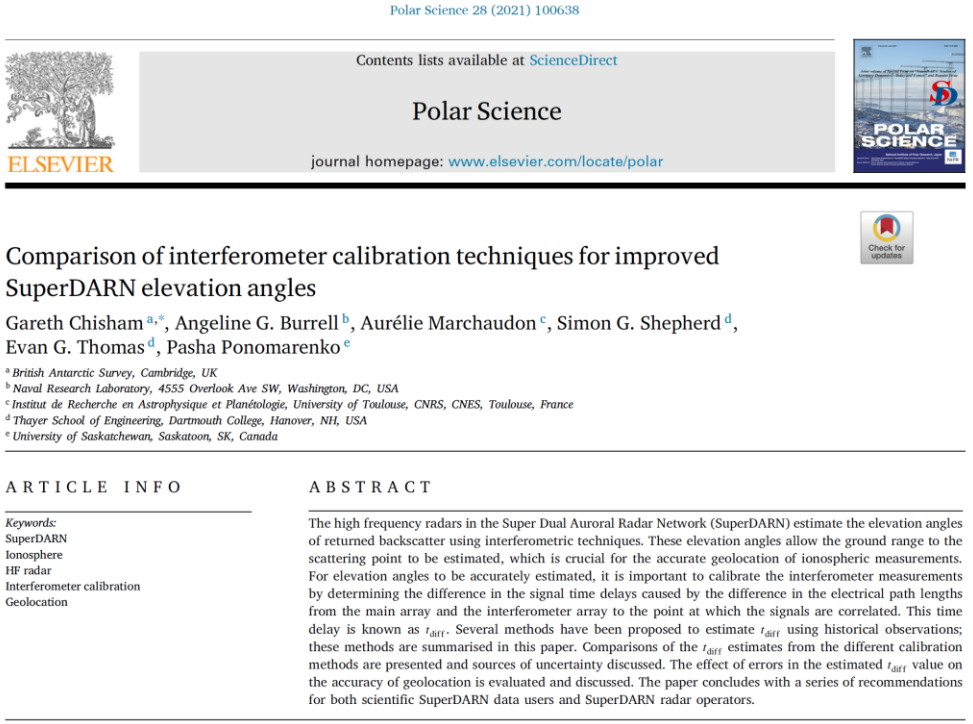
SuperDARN Community Issues

Succession Planning

- Need this to ensure continuity and sustainability of the network.
- Mike Ruohoniemi (5 radars) stepping down soon – Clear succession plan
- Bill Bristow (4) approaching retirement – No presently agreed succession plan
- Nozomu Nishitani (2) retiring 2028 – No presently agreed succession plan
- Akira Sessai Yukimatu (2) retiring soon – Unknown
- Mike Kosch (1) retiring 2026 – Short term succession plan
- Tim Yeoman (1) retirement pending – No presently agreed succession plan
- Australia (2) – All key staff retired and running on fumes! – No science team pushing the future of SuperDARN Australia

Regenerating SuperDARN Collaboration and Co-operation

- Many things we do need to be done at a community collaborative level.
- BUT require real buy-in and allotted time to make them successful.
- Example: TDIFF task force:
  - Originated at Tuscany workshop in 2017
  - Real outputs in terms of improvement of geolocation of data and understanding of elevation angle data.
  - Key software and papers.
  - BUT took significant commitment (often unrewarded).
- Need younger people in the community to engage with and commit to these projects.



Polar Science 28 (2021) 100638

Contents lists available at ScienceDirect

Polar Science

journal homepage: www.elsevier.com/locate/polar

Comparison of interferometer calibration techniques for improved SuperDARN elevation angles

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ARTICLE INFO

Keywords:
SuperDARN
Ionosphere
HF radar
Interferometer calibration
Geolocation

ABSTRACT

The high frequency radars in the Super Dual Auroral Radar Network (SuperDARN) estimate the elevation angles of returned backscatter using interferometric techniques. These elevation angles allow the ground range to the scattering point to be estimated, which is crucial for the accurate geolocation of ionospheric measurements. For elevation angles to be accurately estimated, it is important to calibrate the interferometer measurements by determining the difference in the signal time delays caused by the difference in the electrical path lengths from the main array and the interferometer array to the point at which the signals are correlated. This time delay is known as t_{diff}. Several methods have been proposed to estimate t_{diff} using historical observations; these methods are summarised in this paper. Comparisons of the t_{diff} estimates from the different calibration methods are presented and sources of uncertainty discussed. The effect of errors in the estimated t_{diff} value on the accuracy of geolocation is evaluated and discussed. The paper concludes with a series of recommendations for both scientific SuperDARN data users and SuperDARN radar operators.

Regenerating SuperDARN Collaboration and Co-operation

- The core SuperDARN community is aging!
- How do we attract the younger generation to SuperDARN? More accessible data sets?
- What more can we do to retain younger scientists? Increased recognition of all outputs, not just science?
- How can we give more recognition to those who commit to SuperDARN projects?

Summary

- The use, and the value, of SuperDARN data for science and modelling is at an all-time high.
- BUT there are cracks in the SuperDARN infrastructure.
- The number of key personnel at the core of SuperDARN is decreasing.
- There are opportunities for younger scientists and engineers to make a difference working with SuperDARN.
- Feel free to contact me: gchi@bas.ac.uk