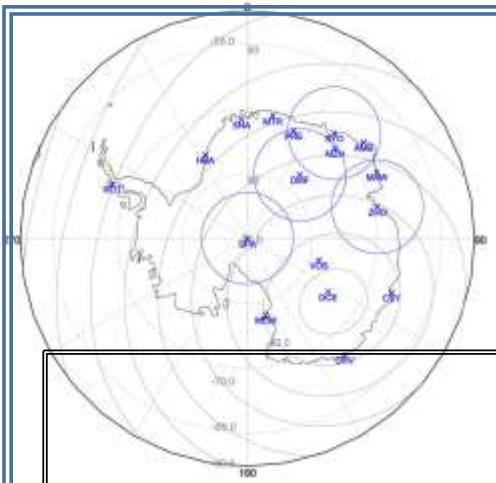
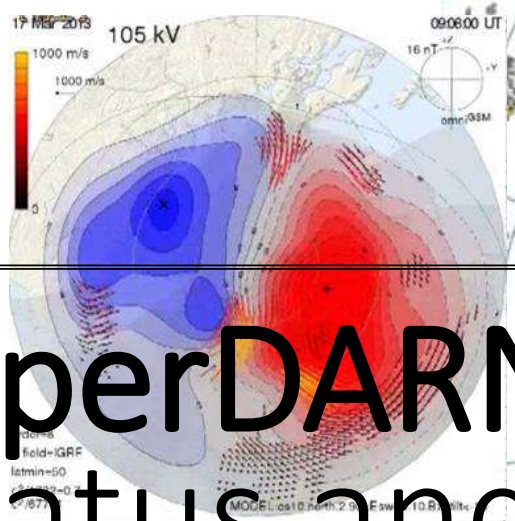
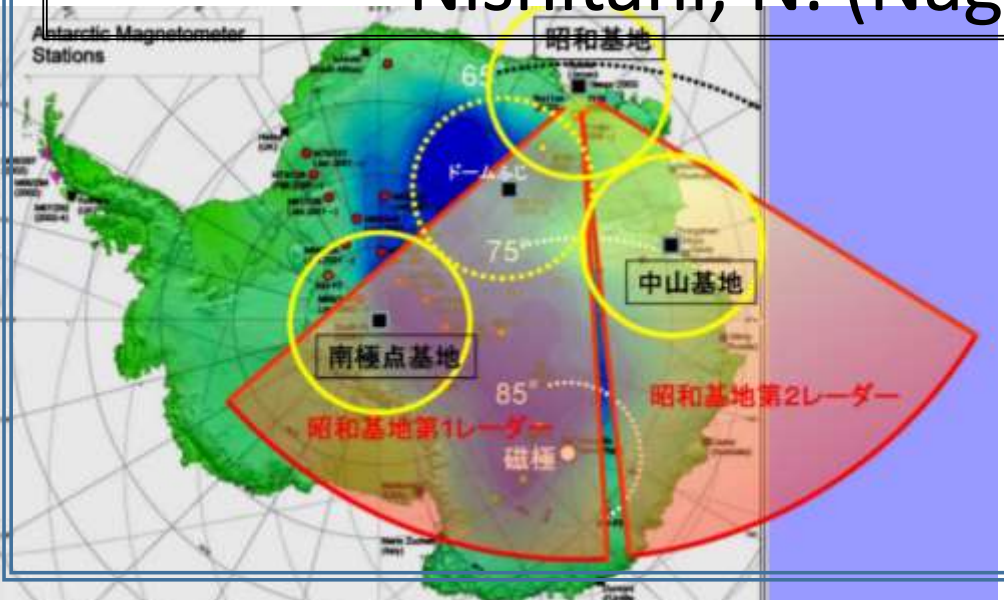
NIPR/ISEE FY2022 SuperDARN Research Meeting @NIPR+Online on 2023/03/09

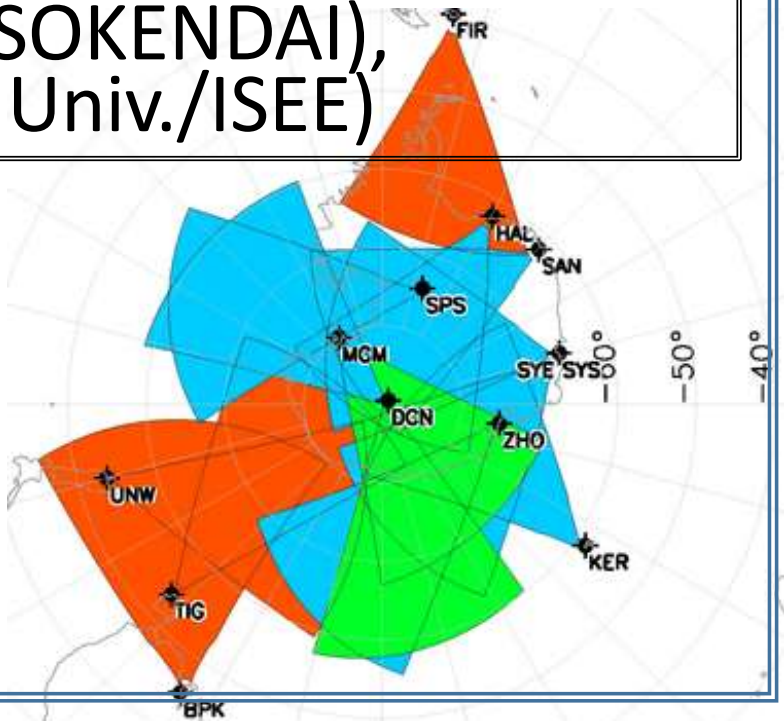




SuperDARN
current status and update

Yukimatu, A.S. (NIPR/SOKENDAI),
Nishitani, N. (Nagoya Univ./ISEE)



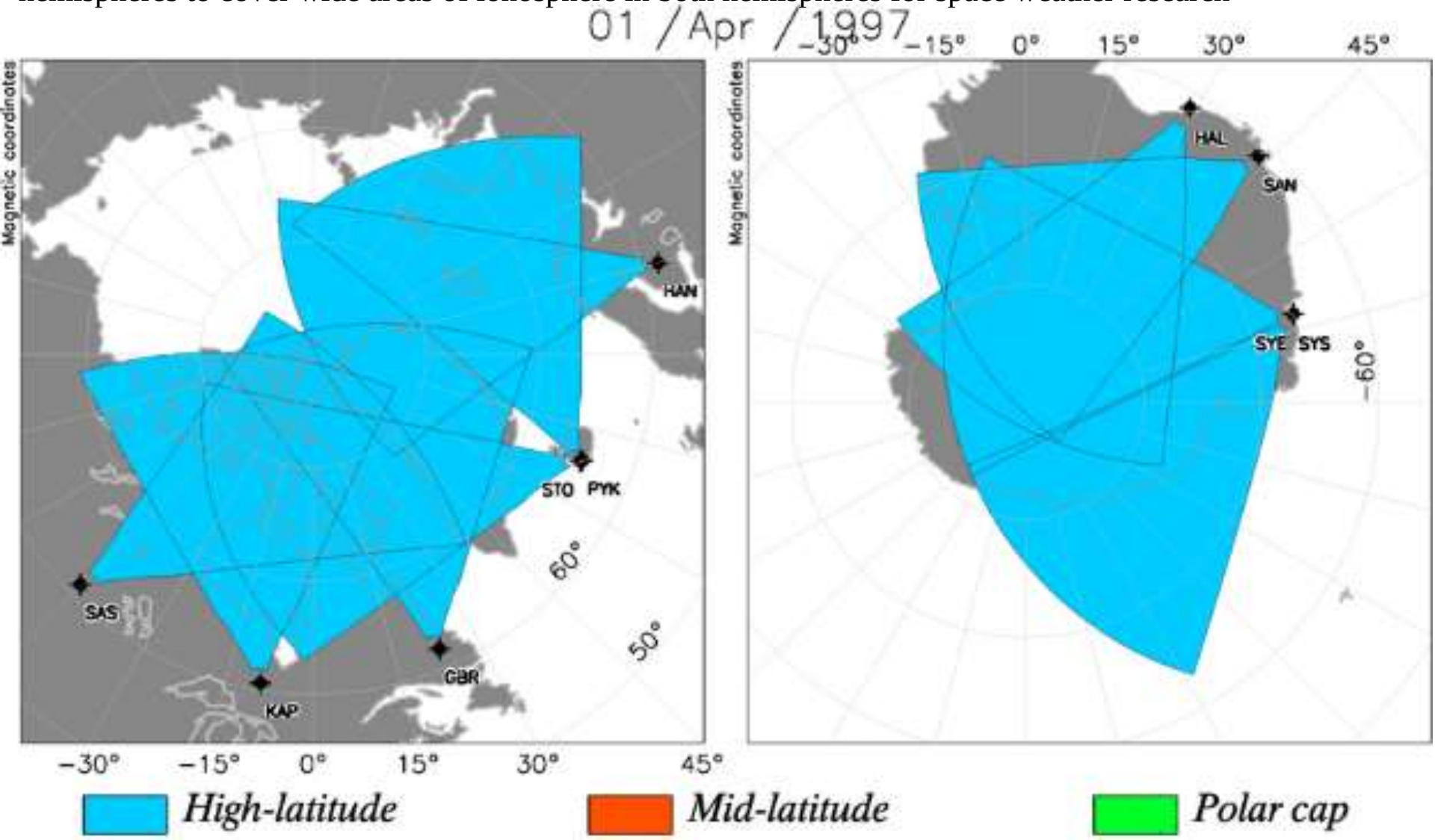


More data-more radars/FOVs

SuperDARN started in 1995…

1997

It is an international high frequency coherent radar network both in north and southern hemispheres to cover wide areas of ionosphere in both hemispheres for space weather research



SuperDARN計画

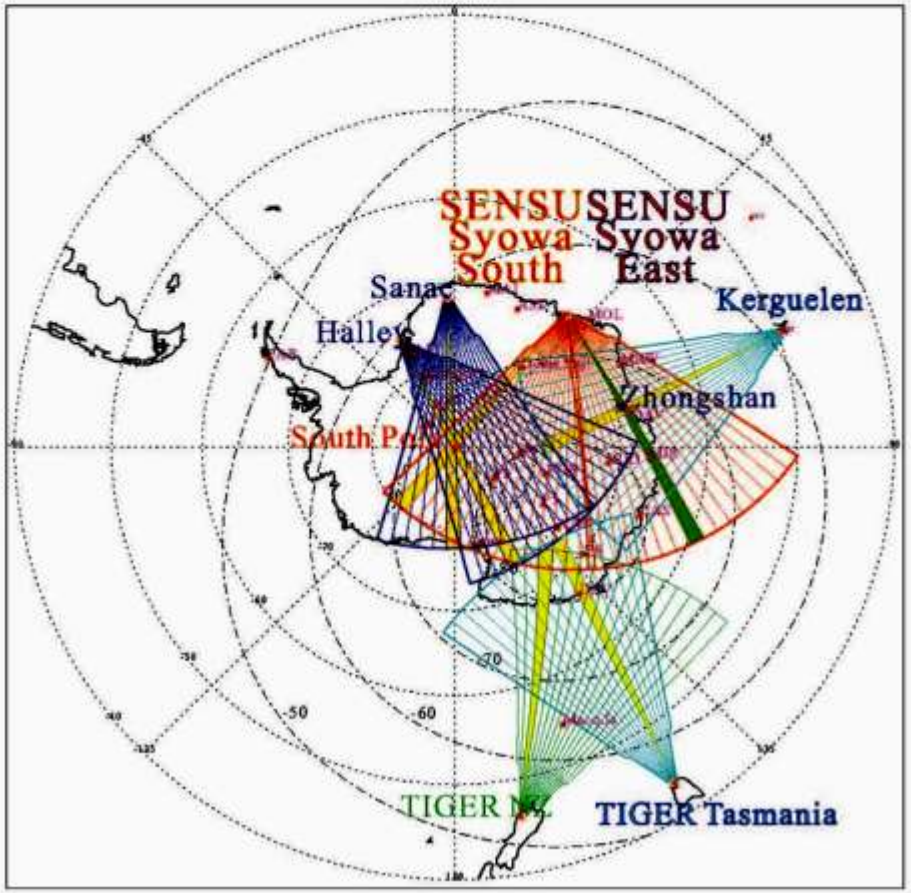
SuperDARN 2001

Southern Hemisphere Map

frang:180km /rsep:45km /nrang:75/height:400km

EPOCH: 2001/ 1/ 1 00:00:00 UTC (ys=0)

*** Station ***	[id:c]	Geo-Lat	Geo-Lon	Mag-Lat	Mag-Lon	Boresite	BeamSep
Halley	[04:h]	-75.5200	-26.6100	-51.3143	29.9187	-165.000	-3.24000
Sanae	[11:n]	-71.6800	-2.85000	-51.1752	43.2244	-75.2000	-3.24000
Syowa South	[12:s]	-69.0000	39.5800	-66.0755	71.8475	159.000	-3.33000
Syowa East	[13:n]	-69.0100	39.6100	-66.0866	71.8514	106.500	-3.33000
TIGER Tasmania	[14:r]	-43.3800	147.230	-54.4894	-133.431	140.000	-3.24000
Kerguelen	[15:r]	-49.3500	70.2500	-58.6676	121.828	158.000	-3.24000
TIGER NZ	[17:r]	-46.6000	170.000	-55.3478	-104.885	215.000	-3.24000

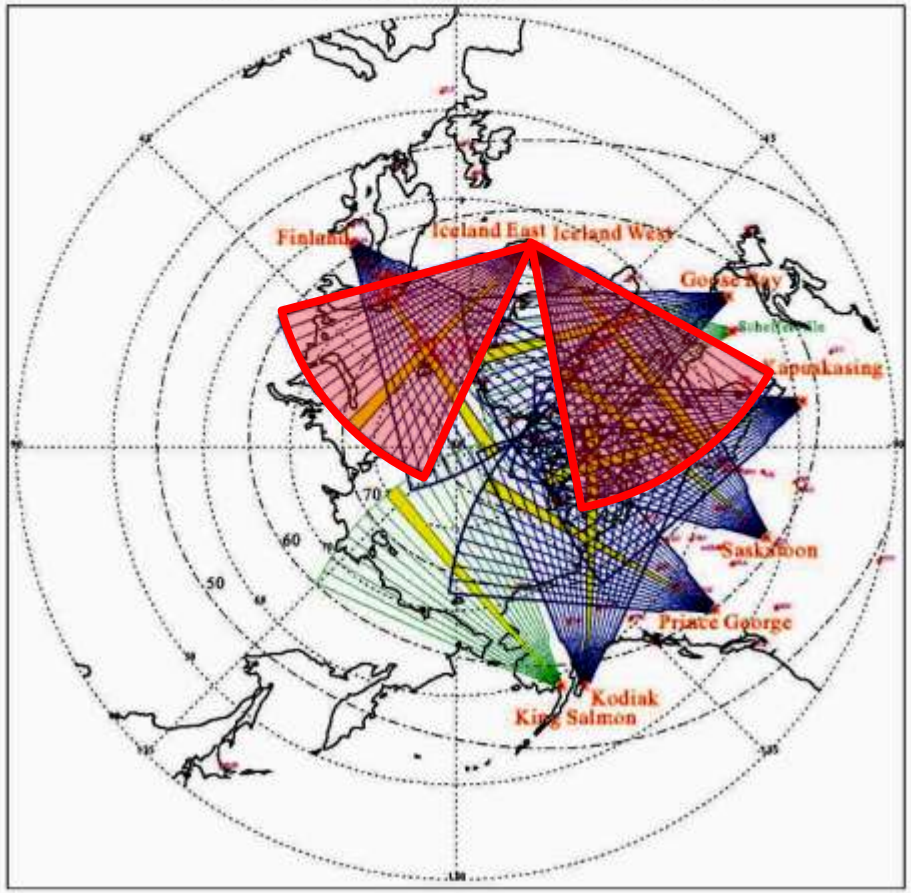


Northern Hemisphere Map

frang:180km /rsep:45km /nrang:75/height:400km

EPOCH: 2001/ 1/ 1 00:00:00 UTC (ys=0)

*** Station ***	[id:c]	Geo Lat	Geo Lon	Mag Lat	Mag Lon	Boresite	BeamSep
Goose Bay	[01:g]	53.3200	60.4600	61.7210	37.2090	5.00000	1.24000
Schefferville	[02:k]	54.8000	66.8000	64.1563	14.9280	7.0000	1.24000
Kapuskasing	[03:k]	49.3900	82.3200	60.6327	9.12758	12.0000	1.24000
Saskatoon	[03:s]	52.1600	256.930	61.1300	45.2610	23.1000	1.24000
Prince George	[04:g]	53.9000	122.900	59.8528	65.7709	5.90000	1.24000
Kodiak	[07:a]	57.6000	152.200	56.5378	96.3126	50.0000	1.24000
Iceland West	[08:w]	63.8600	22.0200	64.8175	67.3101	50.0000	1.29000
Iceland East	[09:e]	63.9700	20.5400	64.9813	68.4800	50.0000	1.24000
Finland	[10:f]	62.3200	26.6100	59.5453	104.858	12.0000	1.24000
King Salmon	[18:z]	58.6800	156.650	57.0917	101.332	20.0000	1.24000



SuperDARN

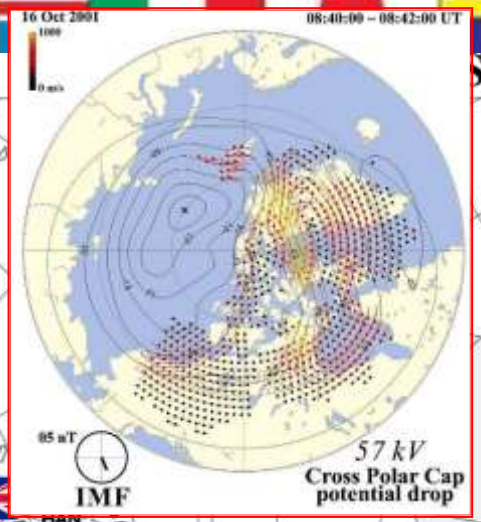
Super Dual Auroral Radar Network

Northern Hemisphere

Southern Hemisphere

HOP radars

ISEE



~2015

SENSU

Syowa radars

Magnetic coordinates

HOK HKW ADW ADE KSR KOD INV LYR HAN STO PYK CLY PGR RKN CVW CVE SAS GBR KAP FHW FHE BKS WAL

UNW TIG BPK MCM SPS HAL SAN ZHO KER

60° 50° 50°

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High–latitude Mid–latitude Polar cap

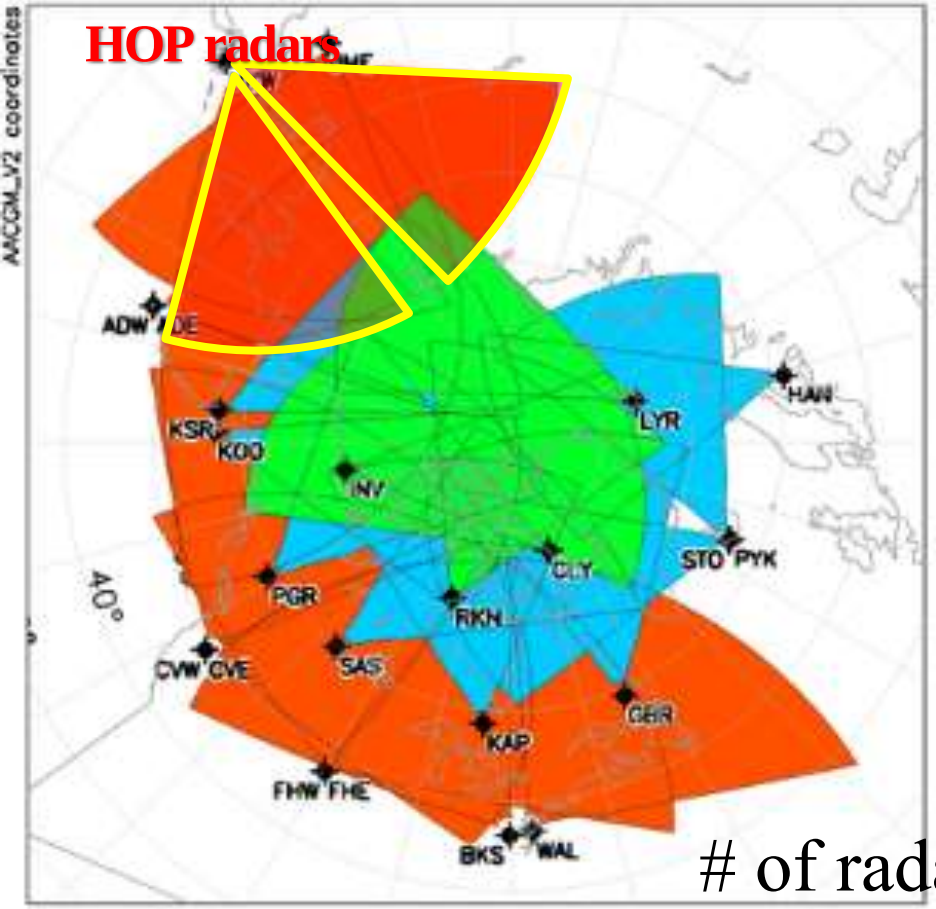
Japanese SD components

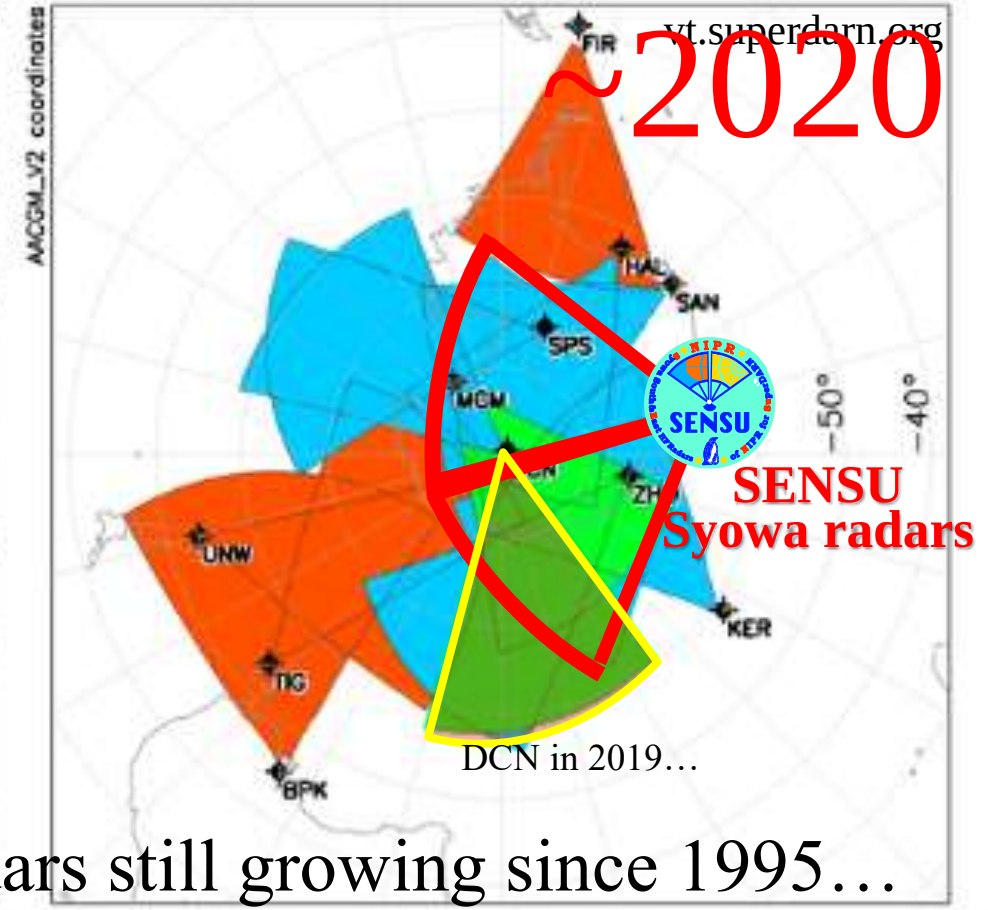
SuperDARN

Internat'l HF radar network

Northern Hemisphere

Southern Hemisphere





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~2020

SENSU
Syowa radars

DCN in 2019…

# of radars still growing since 1995…

High-latitude

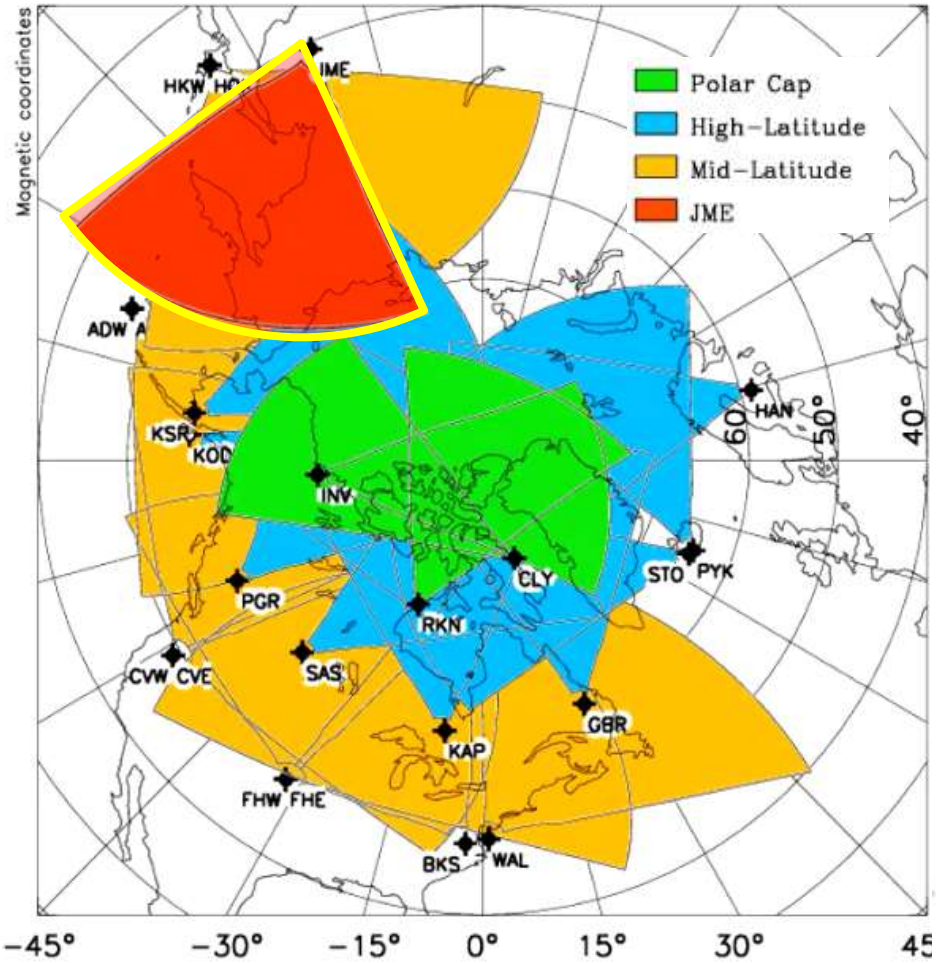
Mid-latitude

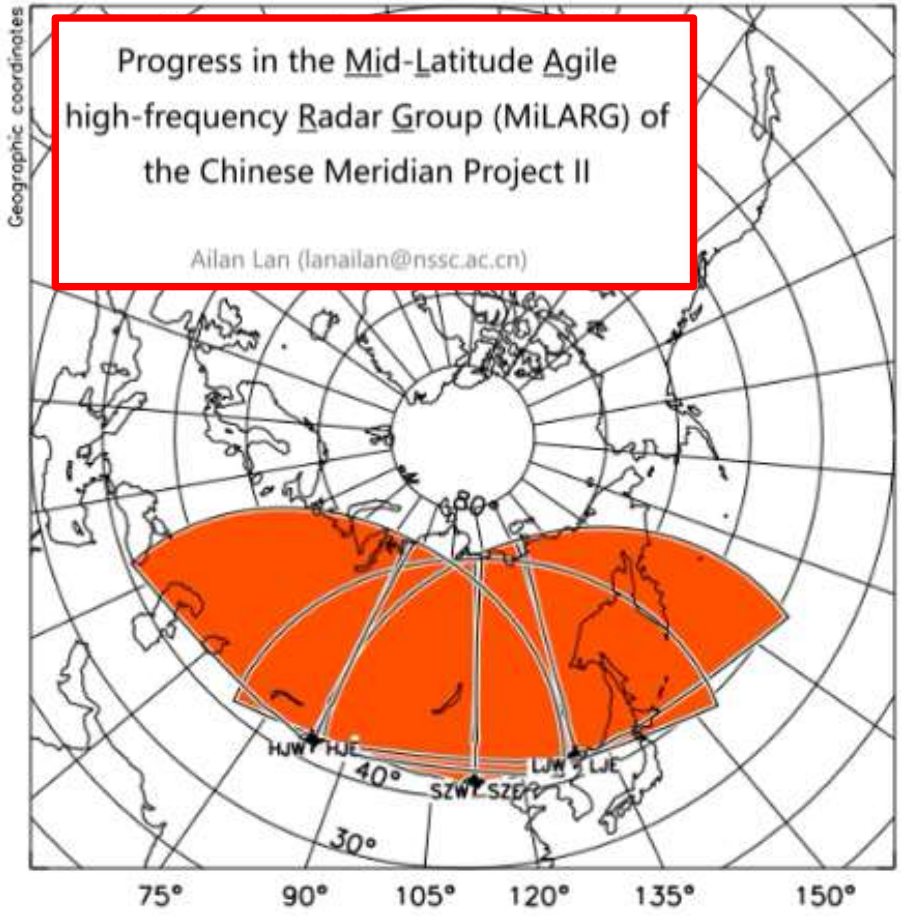
Polar cap

SuperDARN
Internat'l HF radar network

Northern Hemisphere

Southern Hemisphere





High-latitude *Mid-latitude* *Polar cap*

1 low lat. Chinese radar as well

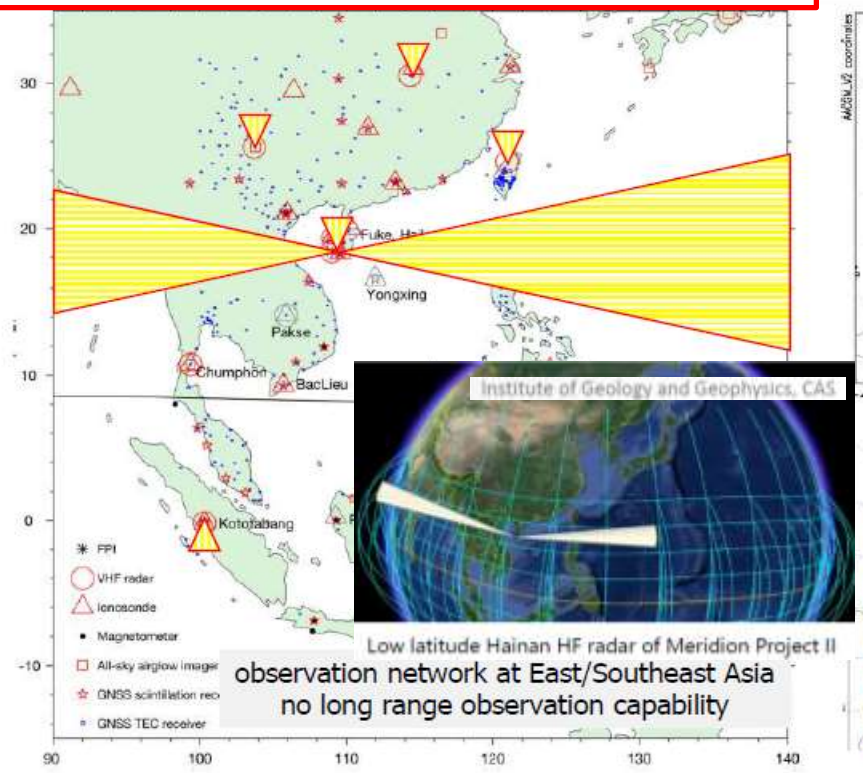
Low latitude Hainan HF radar:

Development and progress

Lianhuan Hu, Guozhu Li (PI), Baiqi Ning, Jianchang Zheng,
Wenzhi Chen, Zhi Wu, Xiukuan Zhao, Wenjie Sun, Haiyong Xie, Sipeng Yang

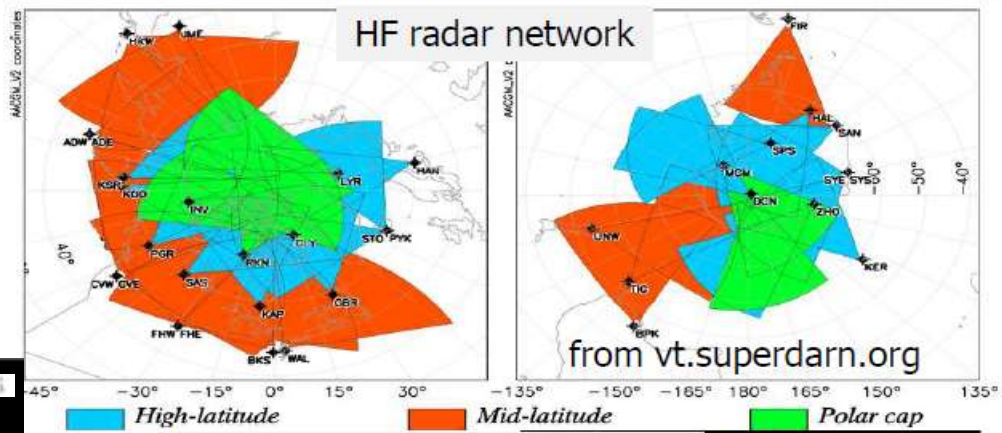
Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS)

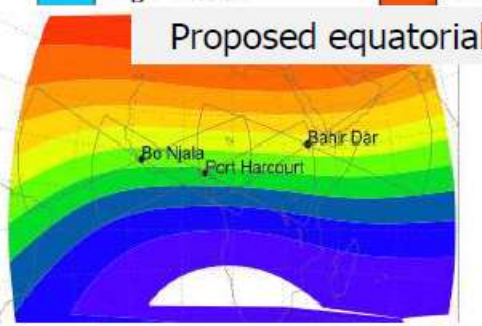
tional demand

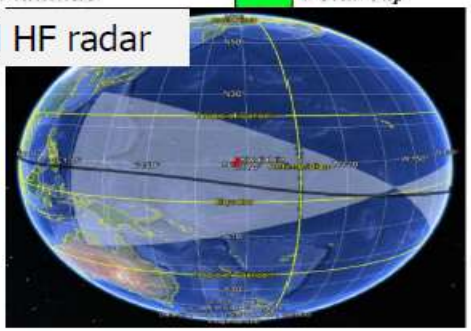


Low latitude Hainan HF radar of Meridion Project II

observation network at East/Southeast Asia
no long range observation capability







Li et al., Surveys in Geophysics, 2021 Michael et al., Radio sci., 2019 Parris et al., SD workshop 2019

SuperDARN Workshop 2022

- Radars: ~38 radars so far.→>40 (>45??) radars soon?!
- UK/BAS Falkland Is. radar will move to Halley or Sky Blue
- 2 New Iceland radars will be starting! (Dartmouth)
- **+6 new Chinese radars in northern mainland China** by CAS/NSSC as well as **new low lat SD (type?) radars** by NGG/CAS under construction and will start soon?!
- Unwin radar (Australian/NZ) – will be decommissioned
- UK **Finland** will be upgraded to new Borealis system!
- Planned French radar → to **Cyprus** hopefully soon?
- (African SD radar (Nigeria?) – no heard these days…?)
- Some old radars have variety of issues – to be solved
- COVID issues as well these 2 years

SuperDARN

Internat'l HF radar network

Northern Hemisphere

Southern Hemisphere

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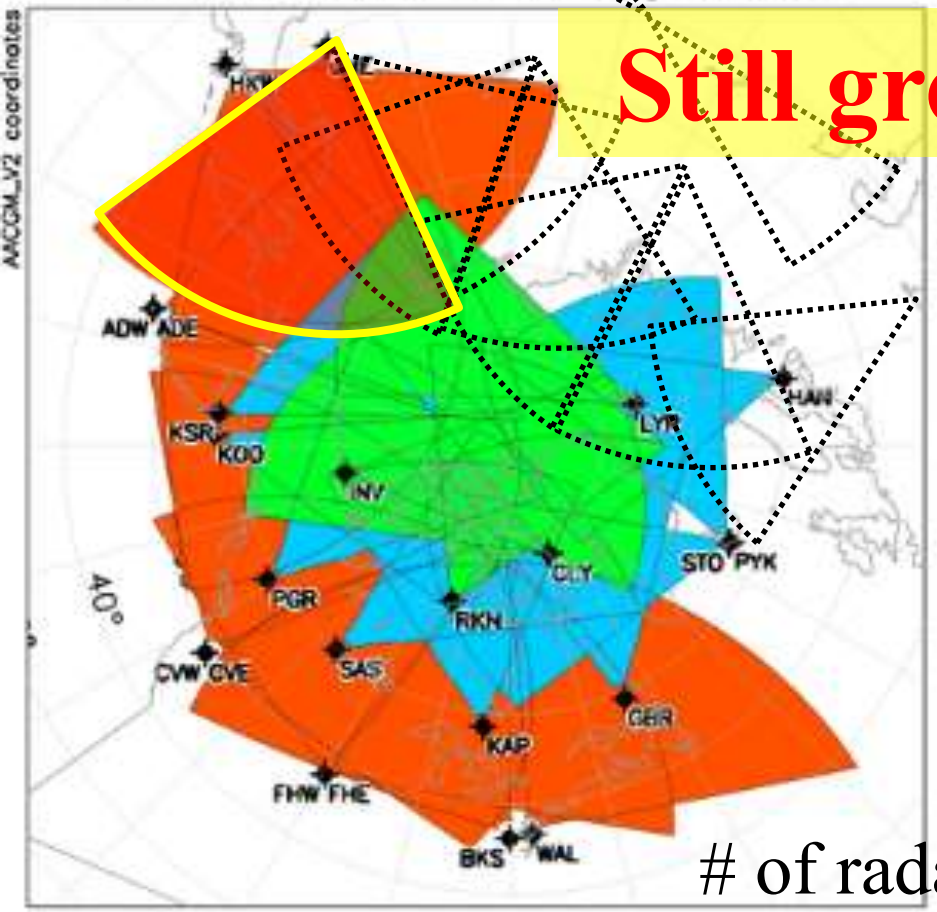
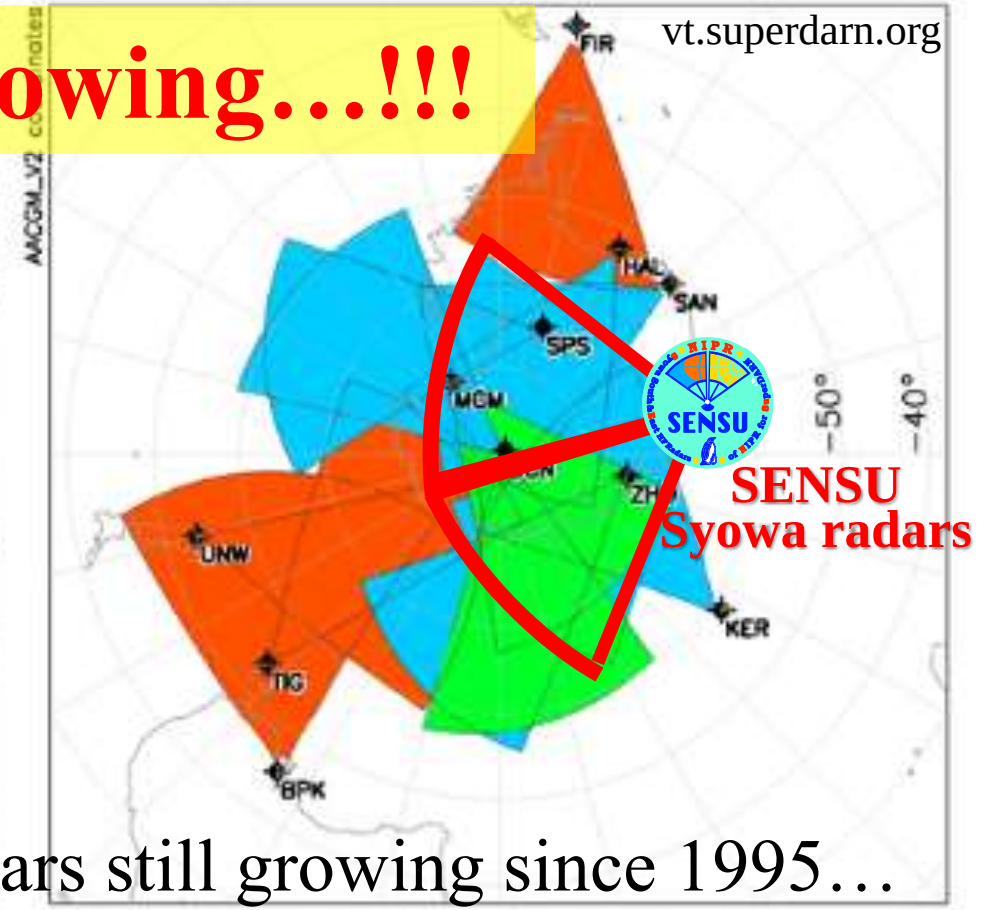
Still growing…!!!





SENSU
Syowa radars

# of radars still growing since 1995…

High-latitude *Mid-latitude* *Polar cap*

Older radar maintenance issues: sometimes fairly serious…

- New radars still increasing and expanding, but more number of older radars maintenance become harder…
- Tx/Rx Refurbishment (Ice W)
- Radio authority license issue
- Aged antenna (Iceland E, Syo)
- Budget
- Man power (inc. initial PIs retirement)
  French J-P. Villain: Ice W
  Australian, S.A.,…


Iceland East Feb. 2017

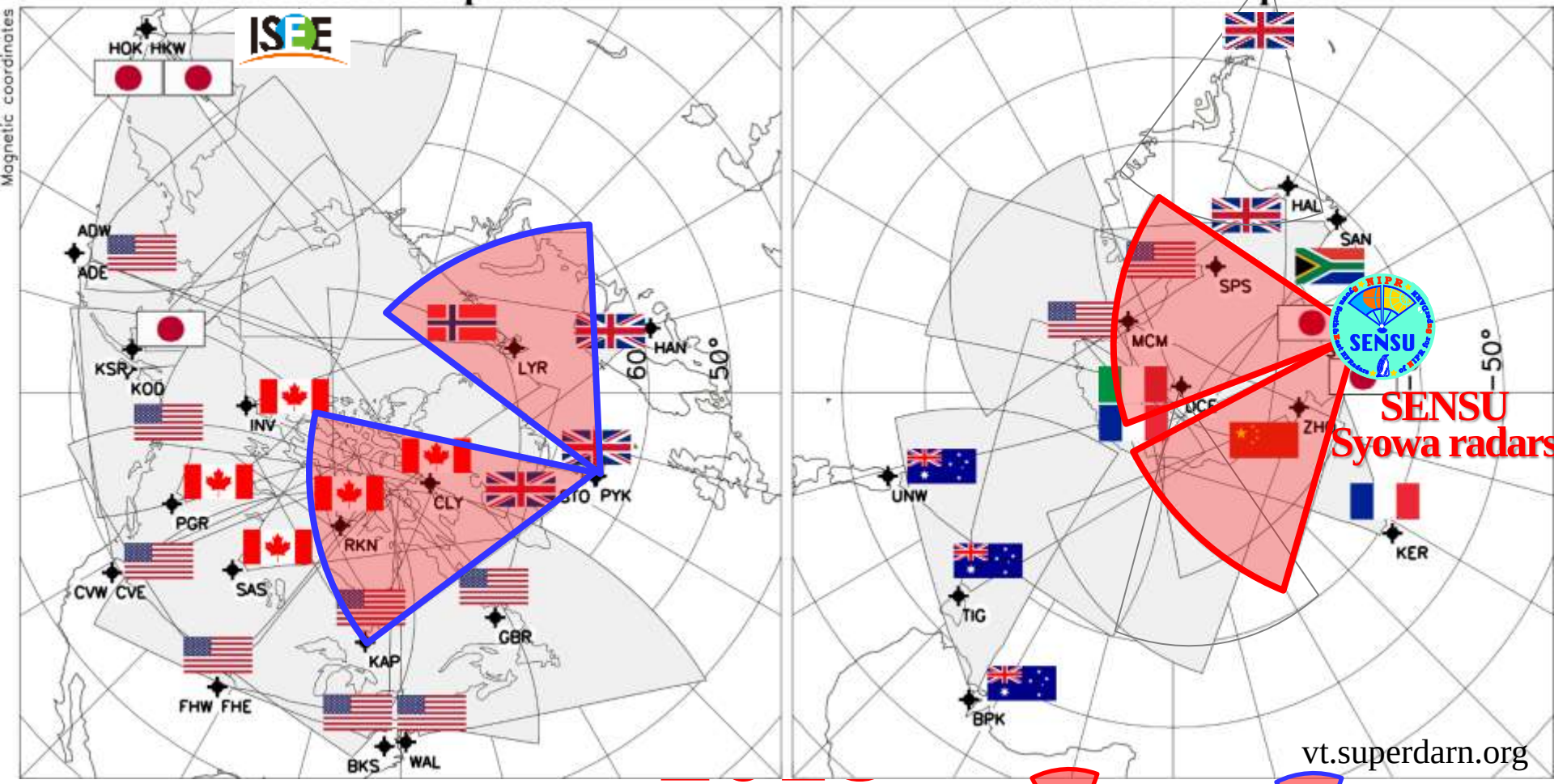
- Halley base (ice-shelf crack-evacuation) issue… (but Folk Island revived…) etc.
- All information tried to be shared, discussed, helped among us.

SuperDARN

Super Dual Auroral Radar Network

Northern Hemisphere

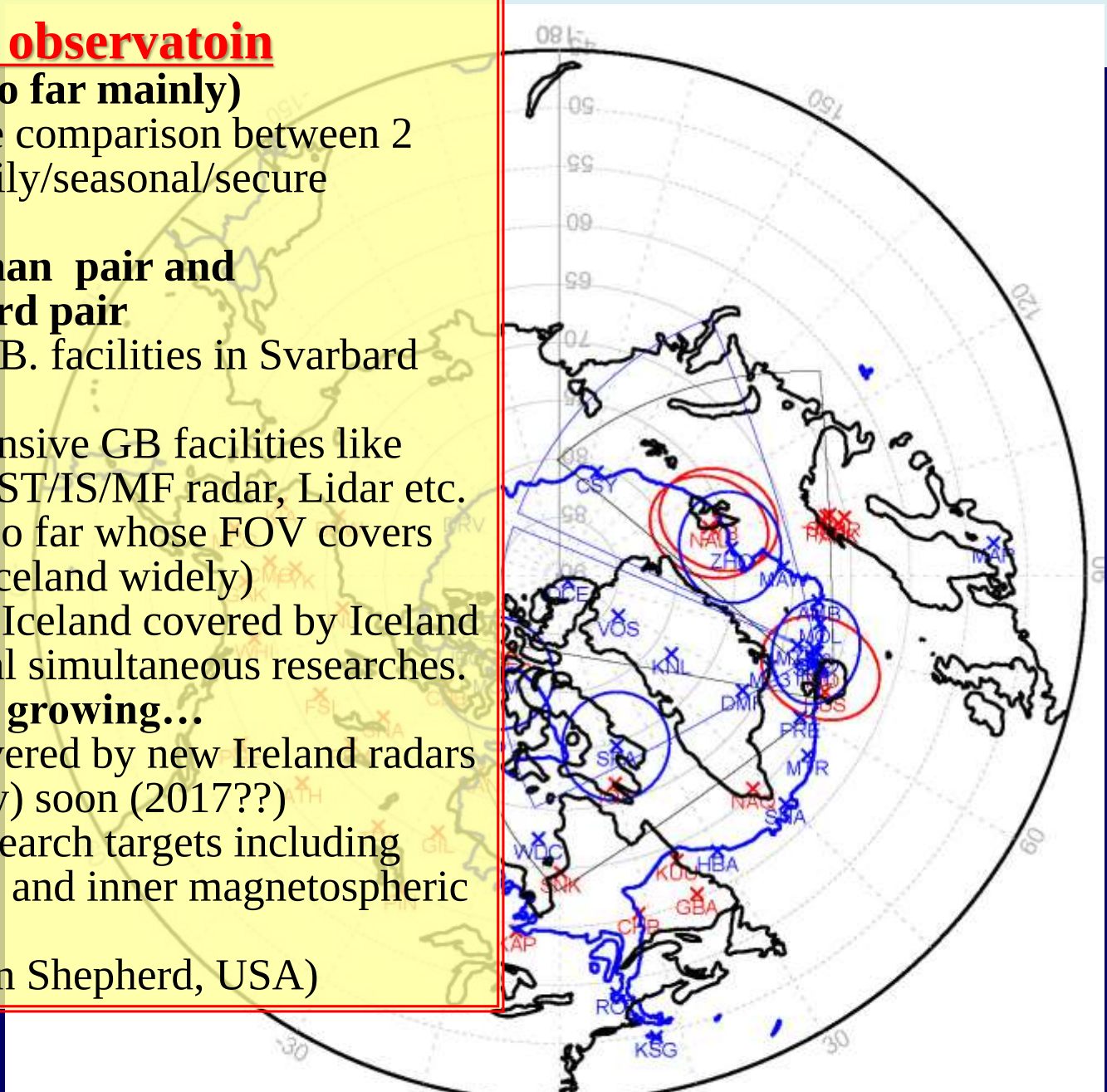
Southern Hemisphere



Future conjugate observation

Wide area conjugate observatoin

- **Syowa-Iceland pair (so far mainly)**
  - Limited area – fine comparison between 2 points but large daily/seasonal/secure variation.
- **Syowa East +Zhongshan pair and Iceland East – Svalbard pair**
  - Comprehensive G.B. facilities in Svarbard and Zhongshan
  - Syowa : comprehensive GB facilities like Many opt. inst., MST/IS/MF radar, Lidar etc. But no SD radars so far whose FOV covers over Syowa (and Iceland widely) though Tjornes on Iceland covered by Iceland East – many optical simultaneous researches.
- **However,… SD is still growing…**
  - Iceland will be covered by new Ireland radars possibly (hopefully) soon (2017??)
  - Many potential research targets including auroral, subauroral and inner magnetospheric studies… (proposal by Simon Shepherd, USA)



New Iceland W&E SD radars

- **Iceland West (Stokkseyri) radar**

  geog +63.86N 22.02W boresite: -59.0° bs3.29 bm#16 →53°

  run by French CNRS/LPCE (PI: J.P. Villain)

  →moved to UK Leicester→Lancaster U. (PI: J. Wild)→ceased

  →**new Iceland West: first light in Jan 2023!** (@IceE site)

  by US Dartmouth Col. (PI: Simon Shepherd)

  geog +63.77$_{39}$N 20.54$_{61}$W boresite: -52.0° bs3.24 bm#24 →78°

- **Iceland East (Pykkvibaer) radar**

  geog +63.77N 20.54W boresite: +30.0° bs3.24 bm#16 →52°

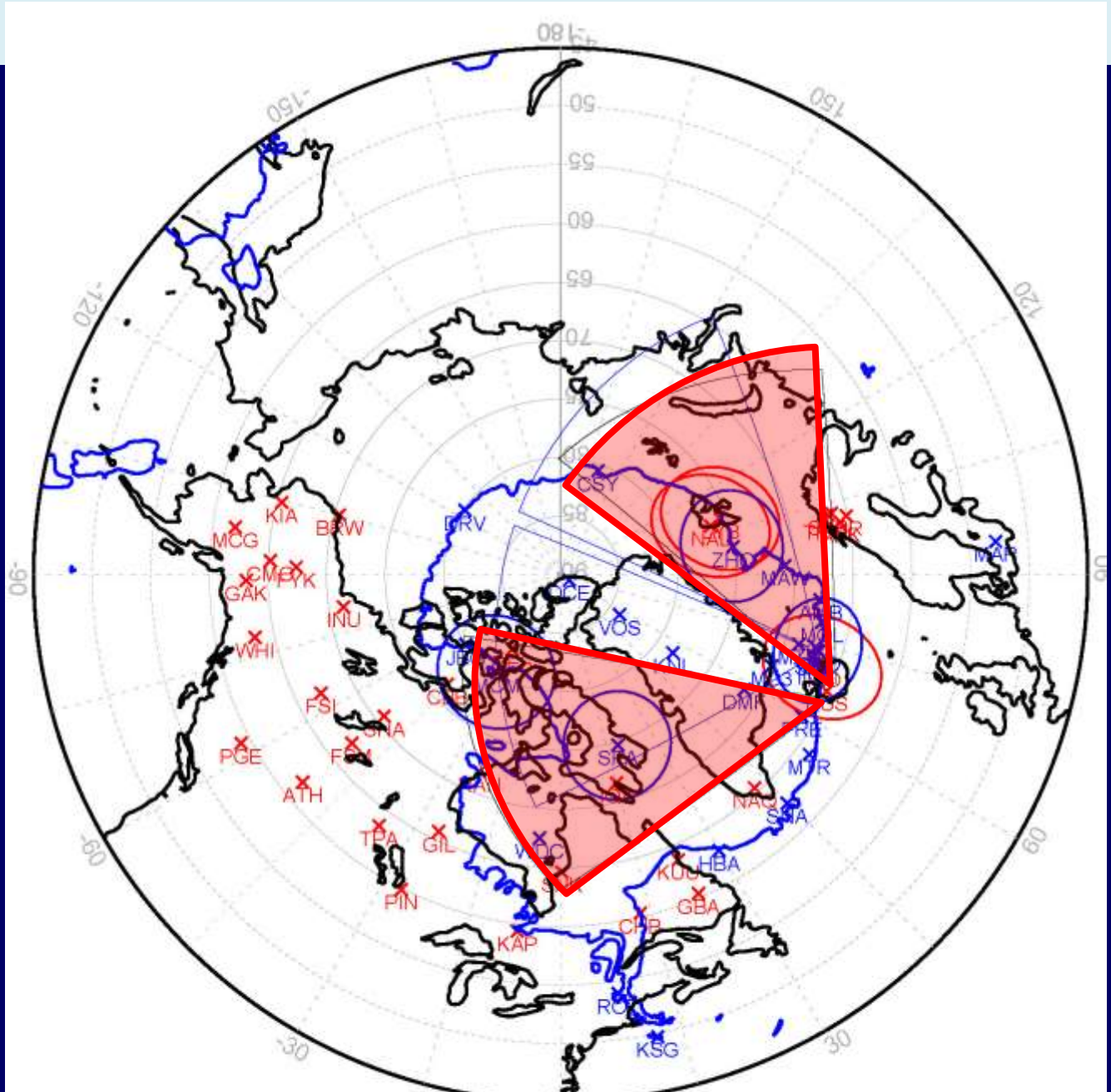
  run by UK Leicester (CUTLASS type) (PI: M. Lester) →ceased

  →**new Iceland East: first light in Jan 2023!** (@IceE site)

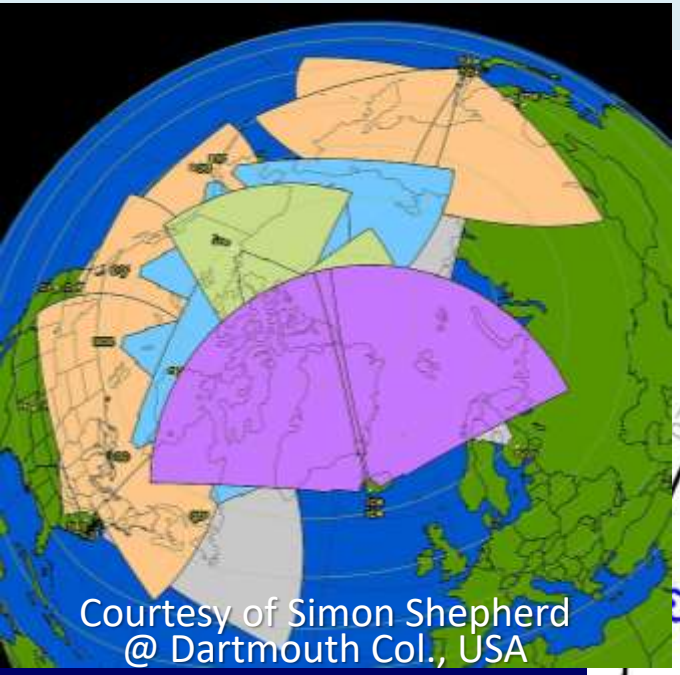
  geog +63.77$_{44}$N 20.54$_{18}$W boresite: +23.0° bs3.24 bm#24 →78°

  by US Dartmouth Col. (PI: Simon Shepherd)

Future conjugate observation



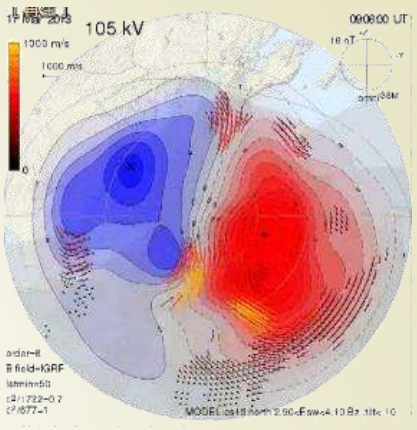
Future conjugate observation



- **Wider coverage over Iceland and higher latitude area w/o gaps between 2 SD radars**
- **FOVs over EISCAT/EISCAT-3D from Iceland to be recovered (Finland SD radar will also be revived soon hopefully)**
- Syowa-Iceland conjugate study as well as SD-EISCAT-3D collaboration with simultaneous observation/campaign also with other instruments (e.g. satellite/GB optical) will be enhanced.

SuperDARN 2021-2023 PIEC issues

PIEC meeting in 2021-2022



- **PI agreement – Data Policy**
  - **1. Data Management & Standard**
    -Level 0: IQ, L1: rawACF, L2: fitacf, grd, map..
  - **2. data access, sharing and re-use**
    -open data use policy, acknowledgement, NC,
    - data embargoes (ST/DT)
    - data distribution (DDWG) https://github.com/SuperDARN/DDWG
      quality check, security & preservation (multiple data hub @ different locations)
    -documentations (data & software): https://radar-software-toolkit-rst.readthedocs.io/en/latest/
  - **2.5 Data Access Via Published Datasets (SD OL data repository w/DOIs)**
    - FRDR (Federal Research Data Repository) @ https://www.frdr-dfdr.ca/repo/collection/superdarn
    - DOIs: immutable – suitable for citation
      each year of data assigned a unique DOI
    - No sooner than one year after collected for data quality control & embargo to expire

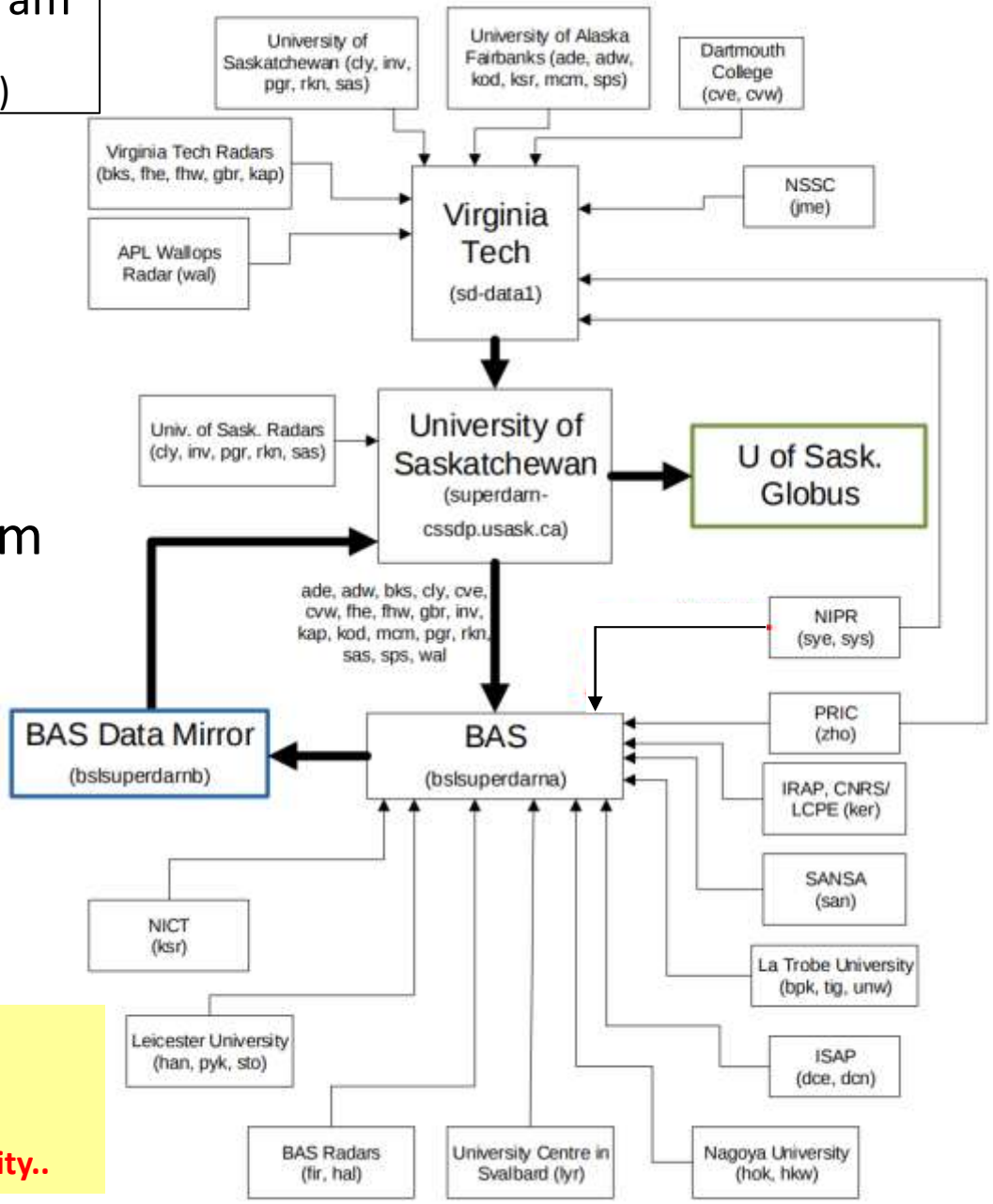
New PI agreement will hopefully be signed in SD 2023 workshop in S.A.!

Data Distribution: Exabyte 8mm tapes, CDs, DVDs, USB-HDD & OL now

SuperDARN data transfer block diagram
(tentative, from SuperDARN DDWG
(Data Distribution Working Group) github)

rawacf format data are distributed between the SuperDARN institutes.

fitacf format data are created by each institute (some of them distribute them to the general scientific community – e.g., Virginia Tech, ERGSC etc.).



- **Saskatchewan and BAS (also VT) are primary hubs**
- **3rd Hub has started at NASC, China**
- **ISEE/NIPR also try to establish 4th hub(s), which could largely contribute to SD and science community..**

2021/9～SuperDARN data with DOIs now

SuperDARN (rawacf) data have been assigned doi's!

(https://www.frdr-dfdr.ca/repo/collection/superdarn?order=DESC&sort=1)

- SuperDARN 2021: https://doi.org/10.20383/102.0677
- SuperDARN 2020: https://doi.org/10.20383/103.0573
- SuperDARN 2019: https://doi.org/10.20383/102.0558
- SuperDARN 2018: https://doi.org/10.20383/101.0290
- SuperDARN 2017: https://doi.org/10.20383/101.0289
- SuperDARN 2016: https://doi.org/10.20383/102.0446
- SuperDARN 2015: https://doi.org/10.20383/102.0447
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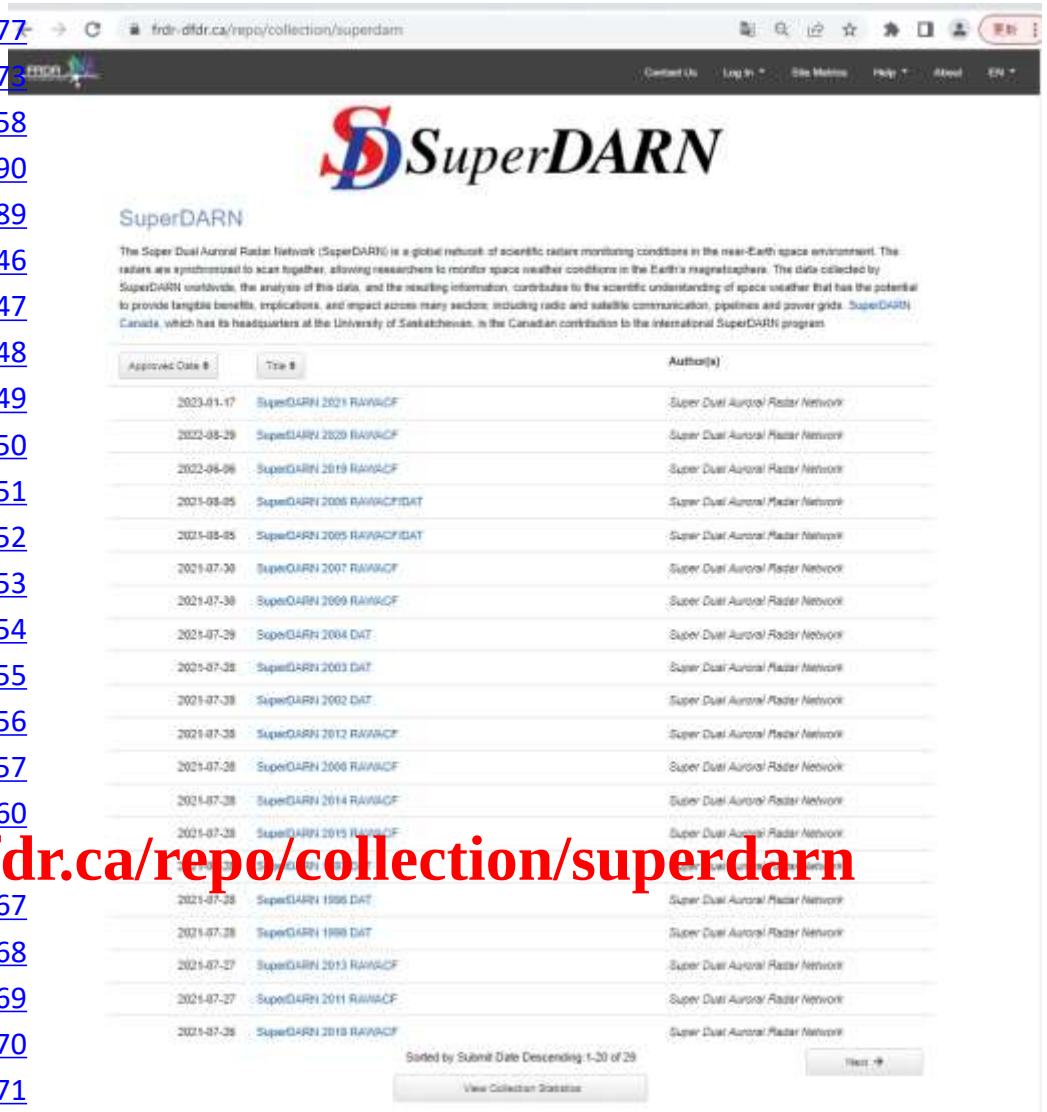
- SuperDARN 2005: https://doi.org/10.20383/102.0457
- SuperDARN 2004: https://doi.org/10.20383/102.0460
- ---
- SuperDARN 1997: https://doi.org/10.20383/102.0467
- SuperDARN 1996: https://doi.org/10.20383/102.0468
- SuperDARN 1995: https://doi.org/10.20383/102.0469
- SuperDARN 1994: https://doi.org/10.20383/102.0470
- SuperDARN 1993: https://doi.org/10.20383/102.0471

https://www.frdr-dfdr.ca/repo/collection/superdarn



Number of SuperDARN papers & citations

No of Papers 1991 – 2022.5

1119 publications

(average # of citations per item was 17.71)

63 publication in 2021 in WoS – highest so far!

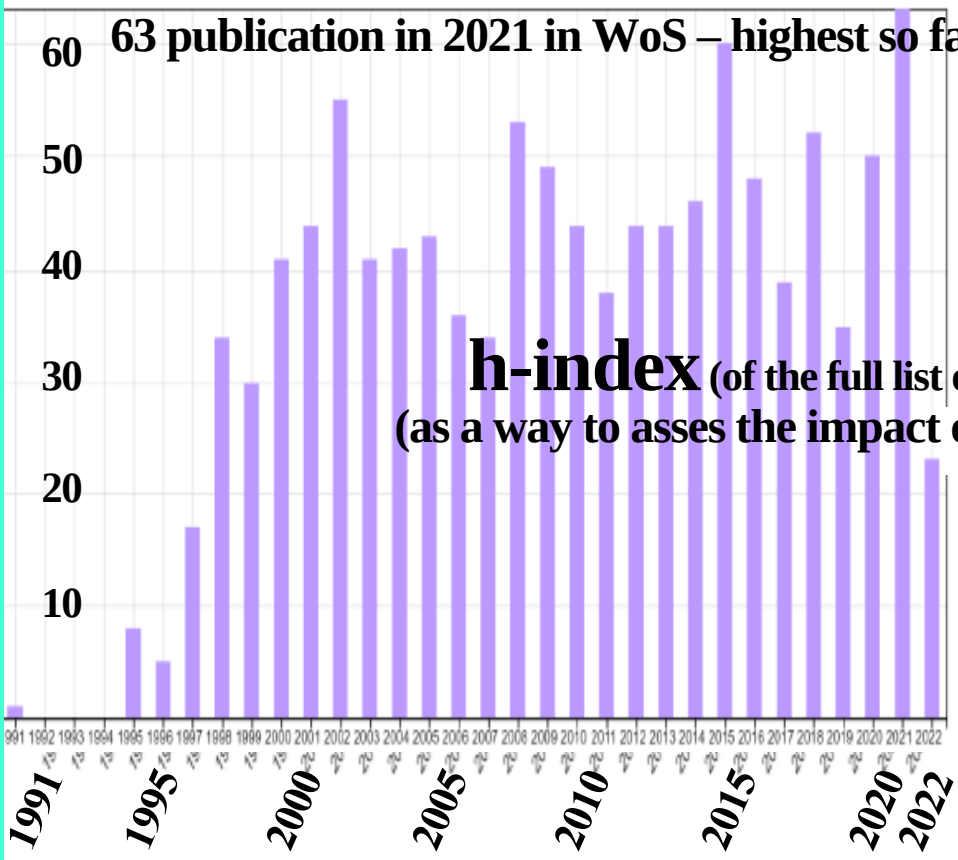


Figure 1a. Number of SuperDARN papers published on an annual basis since 1991, including 2019. The data query of the Web of Science database was performed on 2nd June, 2020.

h-index (of the full list of pubs) = 52

(as a way to asses the impact of the SD network)

No of Citations 1994 – 2022.5

19818 citations

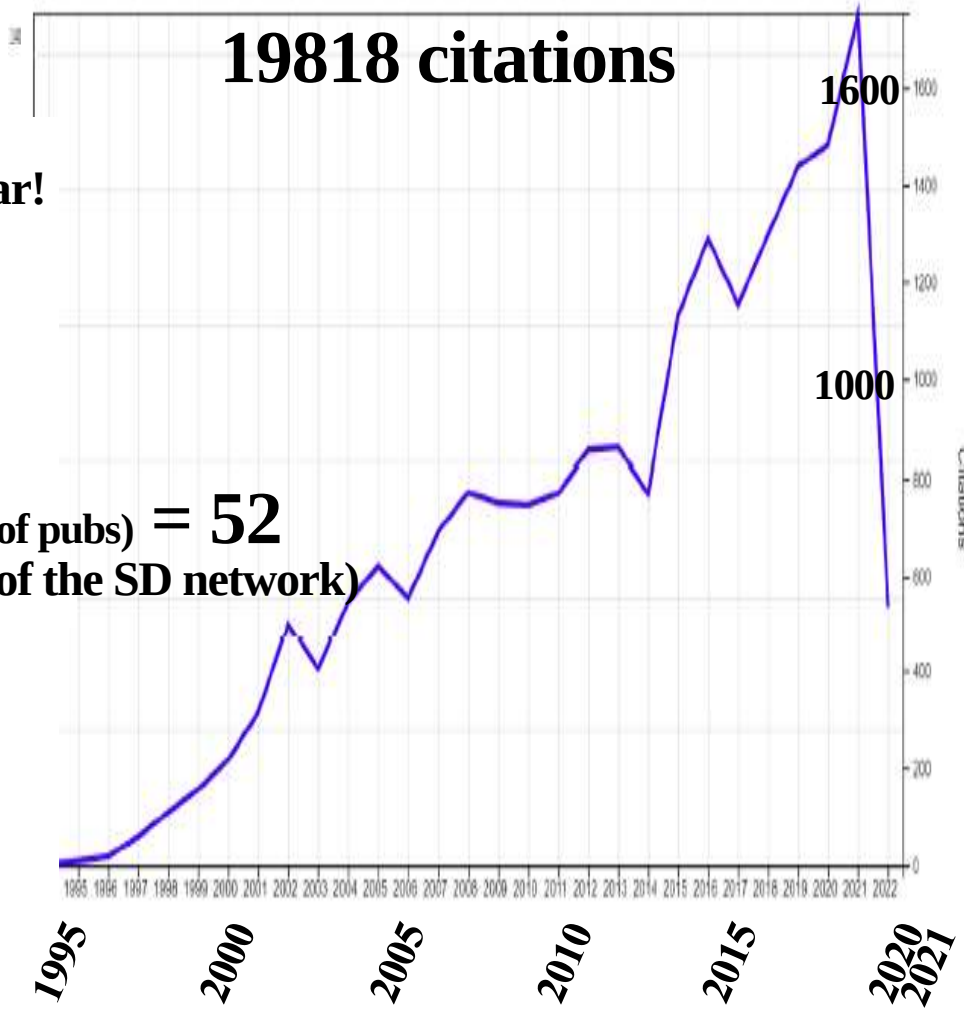
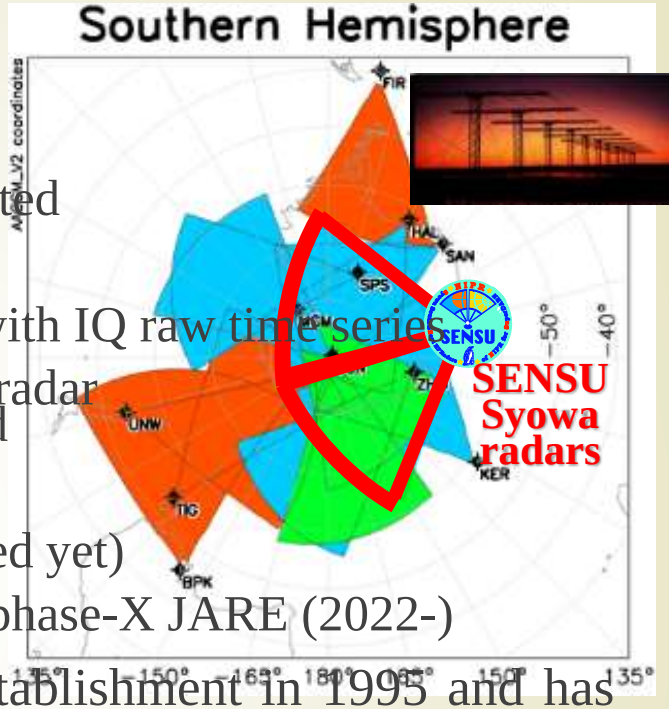


Figure 1b. Number of citations for SuperDARN papers on an annual basis derived from the query of the Web of Science database.

McWilliams, SD2022

SuperDARN data – widely used in science and applications

SD SENSU Syowa radars



- **History:**
  - 1995: SuperDARN established, Syowa South started
  - 1997: Syowa East started operation
  - 2001: started precise meteor wind measurement with IQ raw time series
  - 2005: Syowa South upgraded to Leicester Stereo radar
    Syowa East interferometer capability added
  - 2008: digital Rx introduced to Syowa South
  - 2017: antenna upgrade work started (not completed yet)
  - 2021: plan to move to monitoring observation in phase-X JARE (2022-)
- NIPR has joined SuperDARN project since its establishment in 1995 and has been running 2 SENSU SuperDARN radars, Syowa South and Syowa East radars, in Antarctic Syowa station (69.00 S, 39.58 E) in the polar auroral zone as a project in JARE (Japanese Antarctic Research Expedition).
- Both radars have substantially contributed to the international project, e.g., studies on auroral phenomena and storms/substorms, geomagnetic pulsations, precise neutral wind measurement around the mesopause region, polar mesospheric summer echoes (PMSEs), magnetosphere-ionosphere-neutral atmosphere vertical coupling, and influence of low solar activity or grand minimum on space weather.
- Main achievements are summarized in next slide..

SYE stops for maintenance in 2022
for JARE X. SYS restarted Apr. 2022

Main achievements w/ SENSU/SuperDARN

JARE: Japanese Antarctic Research Expedition

▼**Phase IV(JARE33-37/1992-1996)-Phase V(JARE38-42/1997-2002):**
NIPR joined SuperDARN when SD established in 1995
SENSU Syowa South installed in 1995, Syowa East installed in 1997.
Revealed dynamics of Pc3-5 MHD waves with simultaneous GEOTAIL satellite observation.
Discovery of ionospheric phenomena just prior to tail reconnection
First Neutral wind altitude profile around mesopause region with SD underdense meteor echoes

▼**Phase VI(2002-6/JARE43-47):**
PMSE first SuperDARN observation by Syowa SENSU radar
Increasing tendency of PMSE year-to-year occurrence rate indicated cooling in mesopause region corresponding to possible global warming

▼**Phase VII(2007-2010/JARE48-51):collaboration with IPY2007-2008/ICESTAR/IHY**
Discovery of synchronization of pulsating aurora (PsA) and electric field around PsA
Discovery of dipolarization electric field during passage of break-up aurora
technical establishment of high temporal resolution (1~2 sec) 2-D plasma vectors
Improvement of neutral wind measurements with meteors using FDI (freq. domain interf.) & oversampling

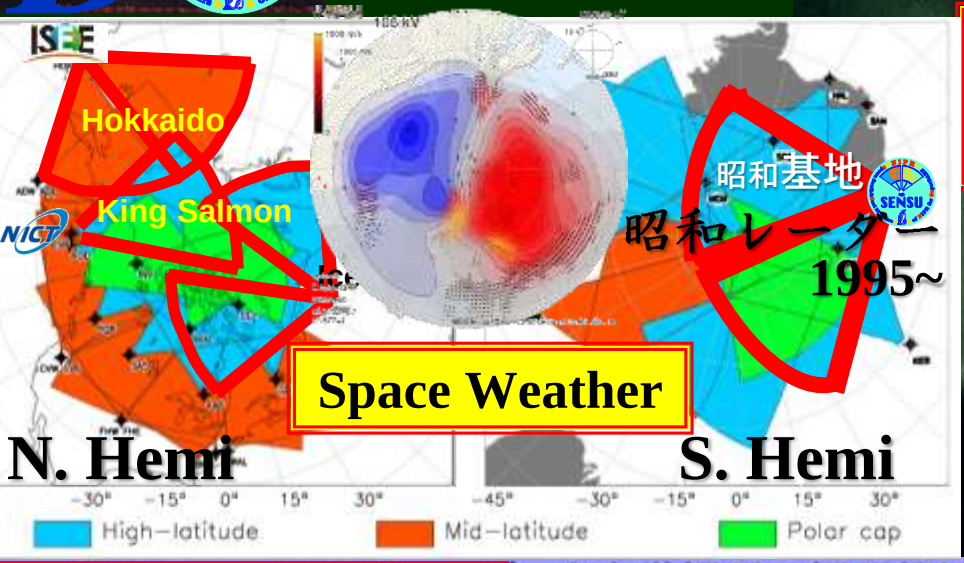
▼**Phase VIII(2011-2016/JARE52-57)**: AP39
- success of validation of model on dynamics of aurora/convection/waves associated SSC/SI phenomena
- new discovery on relationship and generation mechanism of PsA related ionospheric electric field
- Development of new sounding modes for inner-magnetosphere studies in collaboration with ERG/VAP missions
- New Ionosphere-Magnetosphere mapping – development of plasmapause detection at ionosphere
- Discovery of new MHD wave phenomena associated with SC events.
- Discovery on PMSE echoes, MSTIDs, and Na layer in thermosphere

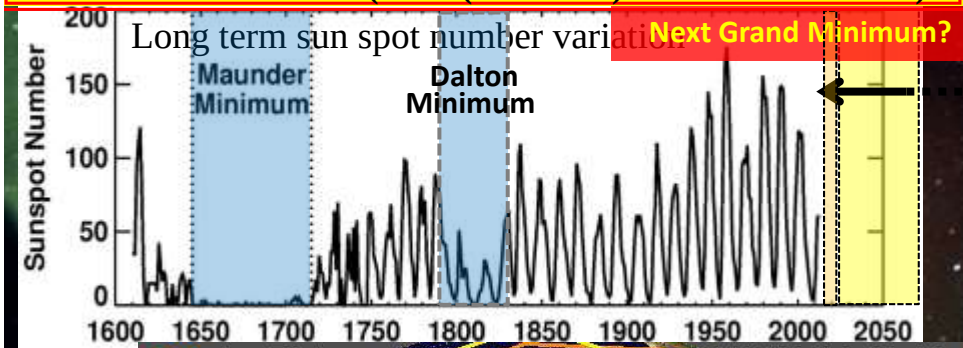
▼**Phase IX(2017-2023.1/JARE58-63)**: AP0904/AP0928 - **(see next slide…)**
- Inner magnetosphere research with ERG(Arase)/VAP satellites with GB network
- New discovery and theoretical simulation on magnetospheric response - enhancement of ionospheric convection during solar wind with very small IMF
- Enabled high energy particle precipitation with SD noise data (Bland, et al., 2019)
- near range echoes studies with modern interferometer calibration
- **Polar Science journal Special Issue on SuperDARN after SDWS2019** – finally published in 2022 thanks!!

SuperDARN in JARE phase IX (2017-2022)

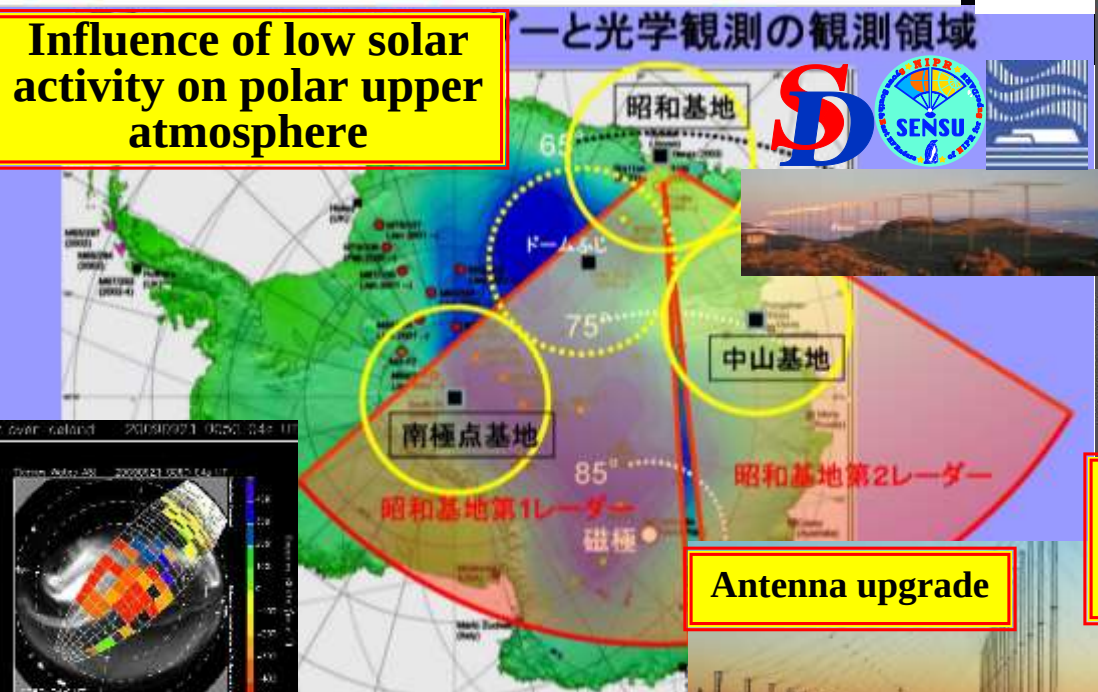
A. S. Yukimatu(PI), H. Miyaoka, T. Nagatsuma, N. Nishitani, K. Hosokawa, T. Hori, M. Watanabe, H. Kawano, Y. Tanaka, Y. Ebihara, N. Sato, A. Kadokura

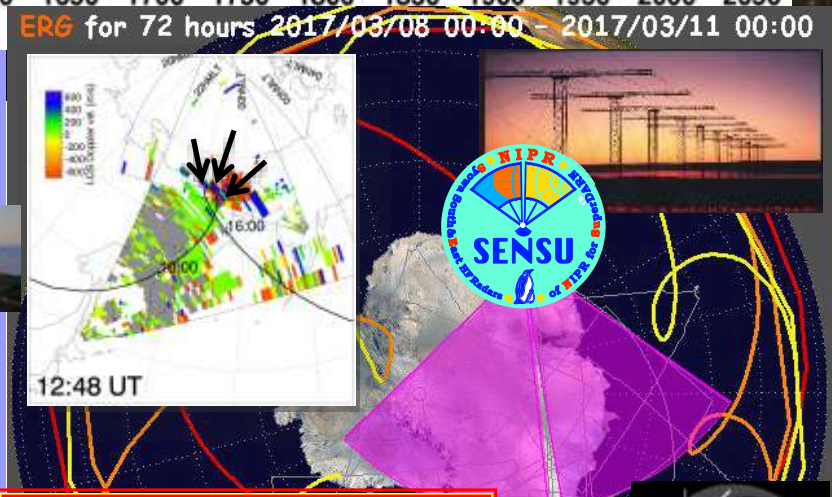
With International SuperDARN and optical obs. network
■Grand minimum influence to polar upper atmosphere
■Inner Magnetosphere Dynamics
★with ERG(Launched Dec. 2016)/VAP
■Contribution to Space weather research
★contribution to VarSITI(ISEST(MinMax24)/SPeCIMEN/ROSMIC)





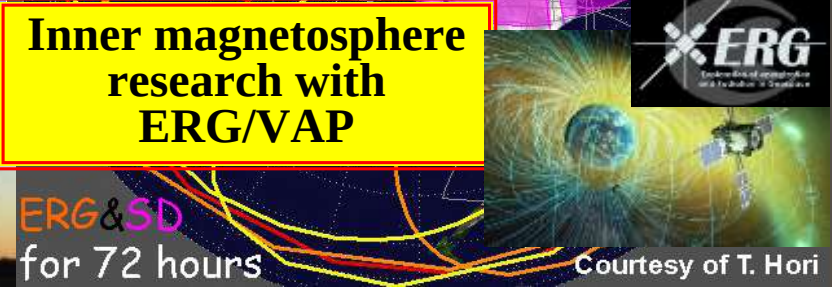
Influence of low solar activity on polar upper atmosphere





Antenna upgrade

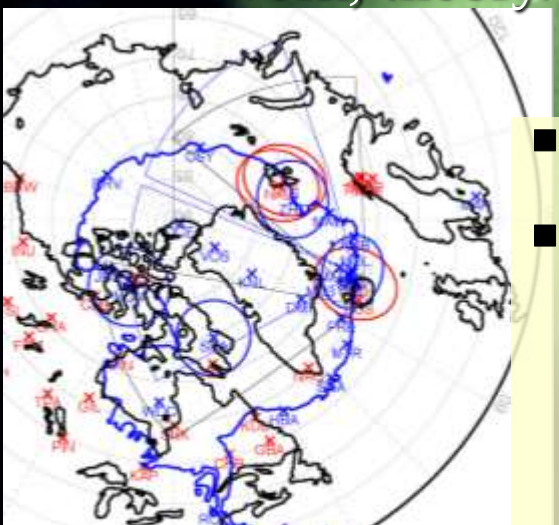
Inner magnetosphere research with ERG/VAP



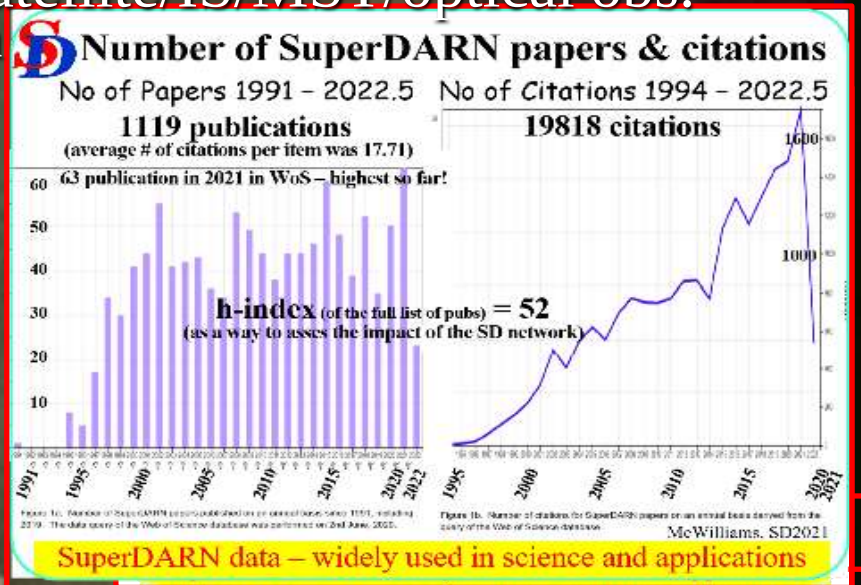
SuperDARN JARE Phase X plan (2022-2028)

Importance of Antarctic/Syowa SuperDARN observation

- **SD** - Unique tool for providing global upper atmosphere data - not only global plasma convection and electric potential map but also neutral wind distribution and PMSEs etc.
- Provide unique and important basic data to understand Space Weather & Upper Atmosphere inc. ion-neutral vertical coupling
- Fundamental obs. network like global magnetometers
- Internationally well-recognized unique & important project
- Many productive scientific papers and citations
- Contribution to Space/Astronomical/Fundamental physics etc.
- **Syowa** - unique location under auroral region w/comprehensive obs tools
- Hemispheric conjugate/non CJG study in global scale
- Conduct many collaboration with satellite/IS/MST/optical obs. network, theory/simulation research



- **Syowa-Iceland pair (so far mainly)**
  - Limited area – fine comparison between 2 points but large daily/seasonal/secure variation.
- **Syowa East +Zhongshan pair and Iceland East – Svalbard pair**
  - Comprehensive G.B. facilities in Svarbard and Zhongshan
  - Syowa : comprehensive GB facilities like Many opt. inst., MST/IS/MF radar, Lidar etc. But no SD radars so far whose FOV covers over Syowa (& Iceland widely) though Tjornes on Iceland covered by Iceland East – many optical simultaneous researches.



SuperDARN JARE Phase X plan (2022-2028)

- **JARE phase X & beyond – move to JARE Monitoring obs.**
  - **as long-term and stable observation is important**
    to provide essential data to wide scientific community
- **Contribution to Prioritised Research Project on Space Weather/Climate**
  by Kataoka et al. with cosmic ray and optical obs. network under SD FOV esp. under newly started unique lower solar activity period
- **Main theme of JARE X Prioritized Research Project**
  「Future Earth env. system explored from past and present Antarctica」

極地研 JARE Phase X 6yr Prioritised project on S.W. 2022.4~

Space environmental changes and atmospheric response explored from the polar cap by R. Kataoka

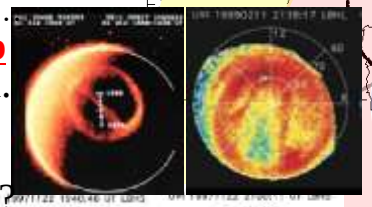
Objectives: SD (moni): one of important components

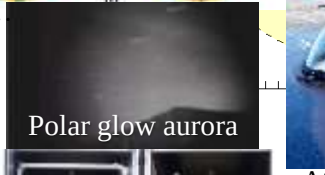
★Condition for Xth period (2022-2028):
- **solar activity** started to be **weakened** in long-term perspective after about a half century of high activity period since IGY
- New 11-year solar cycle 25 started from eoy2019-2020
- Next (weak?) solar max is expected in 2025 (mid. of phase X)
  - Good timing for new SW/C res. with internat'l activities
  e.g. Parker Solar Probe, Solar Orbiter, BepiColombo, FACTORS,..
- auroral oval expected to be shrunk – importance of **polar cap**
- unknown space weather/climate phenomena expected as well.

★to understand…
- how open the earth env. is? - Direct SW-M-I coupled system
- how will space environmental change influence on earth env.?
  Quantitatively evaluate the total atm. impact from space…
  →elucidate basic energies in multi-scale complex auroras in whole PC.
- how will low solar activity affect earth atmosphere env.?
- variety of unknown and/or new polar cap phenomena
  (e.g., **SAA/TPA**, **PMPCA**, **polar-glow** aurora(PCA), **giant spiral**(CME), polar hole, ..
  ref: Hosokawa et al., 2020, Rosenqvist, 2007, Simmons & Henriksen, 1995, …)
  (e.g., convection enhancement under low IMF |B| (Iwaki et al. presented 2015) …)
- how can we predict future space weather and climate?
  What will happen when SW disappears? – contribute to SW/SC research
- any possible application to interdisciplinary research, e.g. on astrophysical and planetary science? (e.g. Mars diffuse aurora)

★Strategy:
- Filling blank areas in polar cap inc. OCB – impossible in Arctic
- Strong international collaborations in Antarctica
- provide ground-truth to closely working **global simulation**
  - space weather **re-analysis data study** by REPPU group


UAO


Giant Spiral


Polar glow aurora


ASI Polar Cap Network


SuperDARN


Cosmic Ray @ Syowa


Mm-wave spectroscopic obs.


New Spectrum Riometer

AuroraXcosmic project @ https://polaris.nipr.ac.jp/~aurorax/

Antarctic All sky imager network plan w/ SENSU FOVs +All the S.H. SD FOVs added

Running:
- US: South Pole (Ebihara)
- US: McMurdo (Ebihara)
- China: Zhongshan (PRIC/NIPR)
- Amundsen Bay (NIPR)
- Belgium: Prince Elisabeth (NIPR)
- India: Maitri sta. (NIPR)

Plan (soon):
- SA: Sanae (NIPR)

Under planning & negotiation (in ph.X):
- JP: new Dome F
- FR/IT: Dome C
- FR: Dumont d'Urville
- AU: Casey
- RU: Vostok...

(Falkland Is.)
Halley
Sanae
MTR
South Pole
McMurdo
Dome Fuji
Syowa
AMB
Vostok
DomeC
MAW
Zhongshan
Dumont d'Urville
Casey
Kerguelen

Auroral lat.

Polar Cap
Cusp+higher lat.

Imager FOVs
exist/planned

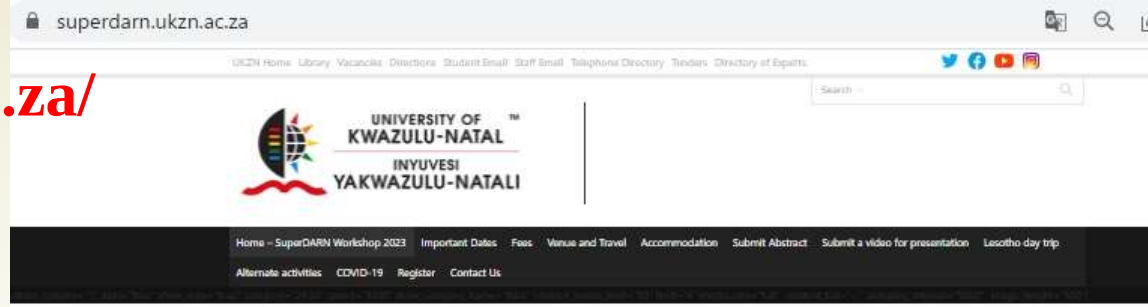
PolarDARN FOVs

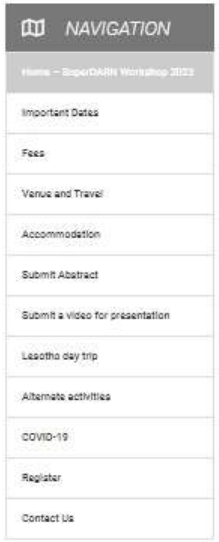
SENSU
High Lat.
SuperDARN

Mid.Lat SD
StormDARN

https://superdarn.ukzn.ac.za/

SuperDARN Workshop 2023
will be held in South Africa!!
during May 29th to June 2nd
Please join us!!





Due Dates

Submit Abstract: 1st May 2023

Upload Video presentation if not attending workshop: 19th May 2023

ALL Payments must be completed by 8th May 2023

Early Bird Registration: 14th April 2023

Late Bird Registration: 1st May 2023