

第X期6か年南極地域観測計画

SENSU Antarctic Syowa radars observation during coming Xth phase 6-year JARE project

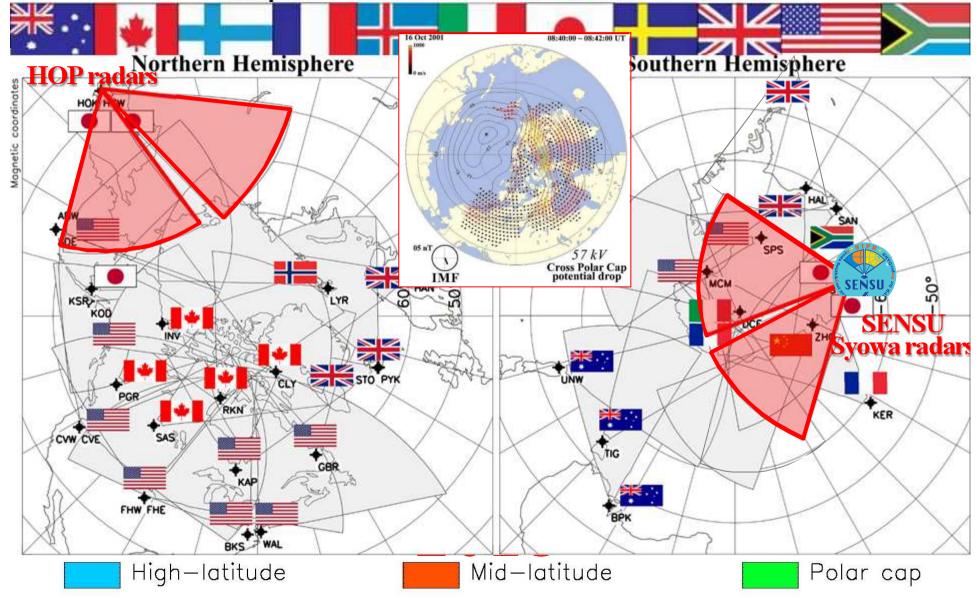
Yukimatu, A.S.^{1,2}, N. Nishitani³, T. Nagatsuma⁴, T. Hori³, K. Hosokawa⁵, M. Watanabe⁶, H. Kawano⁶, Y. Ebihara⁷, H. Maeno⁴, R. Kataoka^{1,2}, Y. Tanaka^{1,2,8}, K. Nishimura⁷, N. Sato¹ and Y. Kadowaki⁸

¹NIPR, ²SOKENDAI, ³ISEE/Nagoya U., ⁴NICT, ⁵UEC, ⁶ICSWSE/Kyushu U, ⁷RISH/Kyoto U., ⁸PEDSC/ROIS



SuperDARN Super Dual Auroral Radar Network





SD SENSU Syowa radars

Southern Hemisphere

for JARE X. SYS will restart soon.

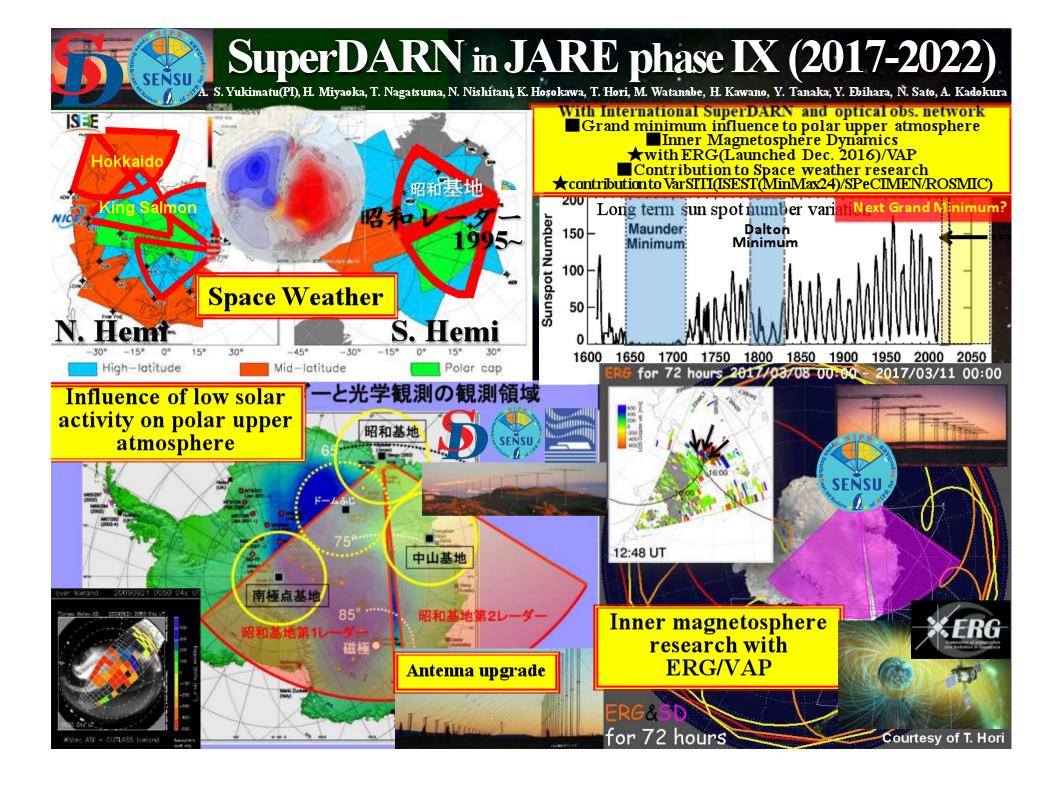
History:

- ▶ 1995: SuperDARN established, Syowa South started
- 1997: Syowa East started operation
- 2001: started precise meteor wind measurement with IQ raw tingerseries
- 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.

 SYE stops for maintenance in 2022
- Main achievements are summarized in next slide...

Main achievements w/ SENSU/SuperDARN

▼Phase IV(JARE33-37/1992-1996)-Phase V(JARE38-42/1997-2002): JARE: Japanese Antarctic NIPR joined SuperDARN when SD established in 1995 SENSU Syowa South installed in 1995, Syowa East installed in 1997. **Research Expedition** 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 <u>Ionosphere-Magnetosphere mapping</u> – <u>development of plasmapause detection at ionosphere</u> • Discovery of new MHD wave phenomena associated with SC events. • Discovery on PMSE echoes, MSTIDs, and Na layer in thermosphere **▼Currently ongoing Phase IX(2017-2022/JARE58-62):** 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 15 • Enabled high energy particle precipitation with SD noise data (Bland, et al., 2019) NIPR • near range echoes studies with modern interferometer calibration • Polar Science journal Special Issue on SuperDARN after SDWS2019 - finally published in 2021



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 provided to the property of SuperDARN papers & citations 1994 - 2021.5 No of Control 1994 -

■ Many productive scientific papers and citations

■Contribution to Space/Astronomical/Fundamental physics etc.

Syowa - unique location under auroral region w/comprehensive obstools

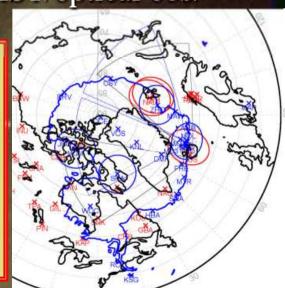
Hemispheric conjugate/non CJG study in global scale

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 (and Iceland widely)

though Tjornes on Iceland covered by Iceland East – many optical simultaneous researches.



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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

JARE phase X & beyond

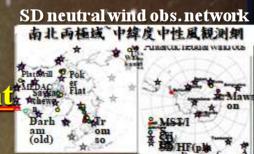
to provide HQ essential space weather data stably to wide sci. comm. as an important component of international SD project

to construct global neutral wind obs. Network

■to monitor long-term env. change variation

■ to promote domestic/internat'l res. collaboration

Long-term and stable observation is important → move to JARE Monitoring obs. category



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

世話人:川村賢二

- 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 「過去と現在の南極から探る将来の地球環境システム」

<サブテーマ>

環境の変動

"Oldest Ice"

南極地域観測第X期6か年計画

Sea – Ice interaction

サブテーマ2 世話人:田村岳史

最古級のアイスコア採取を軸とした古

環境研究観測から探る南極氷床と全球

氷床―海氷―海洋結合システムの統合研究観測から探る東南極氷床融解メカニズムと物質循環変動

Atm. Gen. Circ. & Space W. effect

サブテーマ3 世話人: 堤雅基

大型大気レーダーを中心とした観測展開から探る大気大循環変動と宇宙の 影響

and atmospheric response explored from the **polar cap**

課題1-1 川村賢二

最古級のアイスコア取得を目指す第3期ドームふじ深層掘削

課題1-2 菅沼悠介

東南極氷床変動の復元と急激な氷床融解メカニズムの解明

課題2-2 杉山慎(北海道大学)

急激な氷床質量損失を駆動する氷河・接地線・棚氷の変動 とそのメカニズム

課題2-1 溝端浩平(東京海洋大学)

東南極の氷床-海氷-海洋相互作用と物質循環の実態解明

課題2-3 猪上淳

南大洋上の雲形成メカニズムの解明と大気循環の予測可能 性の向上

課題3-1 堤雅基

大型大気レーダーを中心とした観測展開から探る大気大循環変動

課題3-2 **片岡龍峰** 極冠域から探る宇宙環境変動と地球大気への影響



第X期6か年計画 重点研究観測計画案 2022.4~

課題名:極冠域から探る宇宙環境変動と地球大気への影響

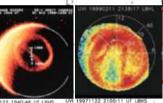
Space environmental changes and atmospheric response explored from the polar cap

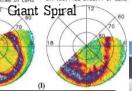
SD (moni): one of important components **Objectives:**

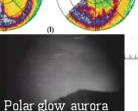
- ★Condition for Xth period (2022-2028):
- solar activity started to be weakened in long-term perspective after about a half century of high activity period since IGY
- New 11-year solar cycle 25 started from eoy2019-2020
- Next (weak?) solar max is expected in 2025 (mid. of phase X)
- Good timing for 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? Ouantitatively 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





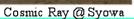




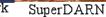






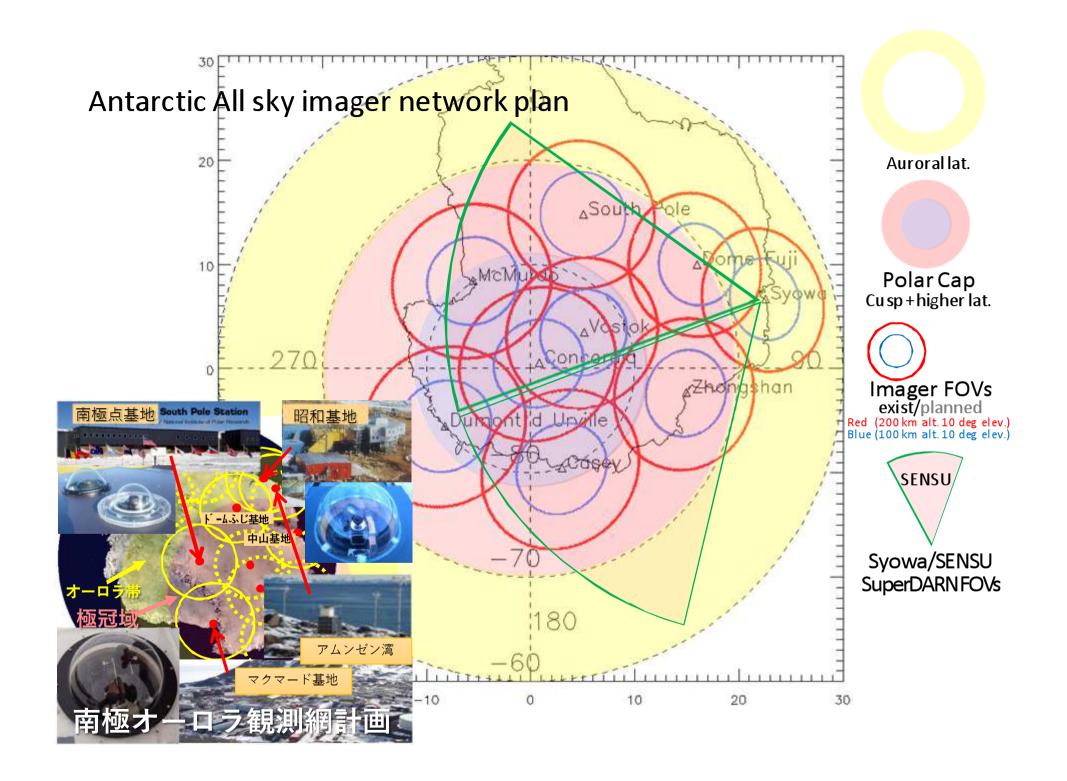


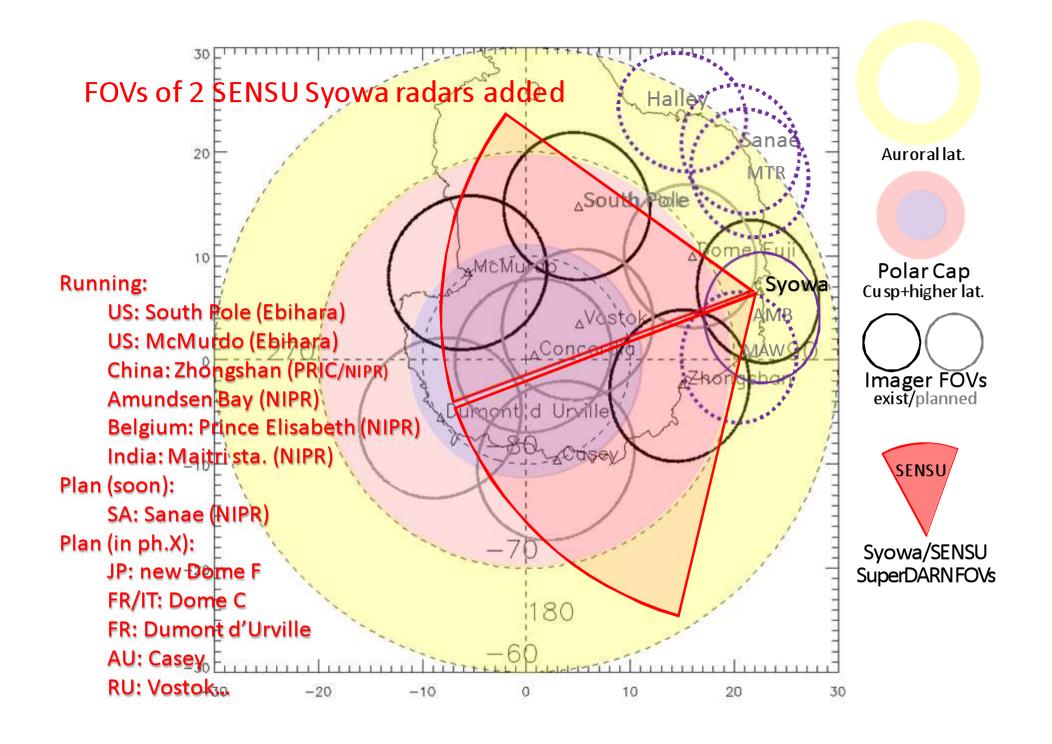


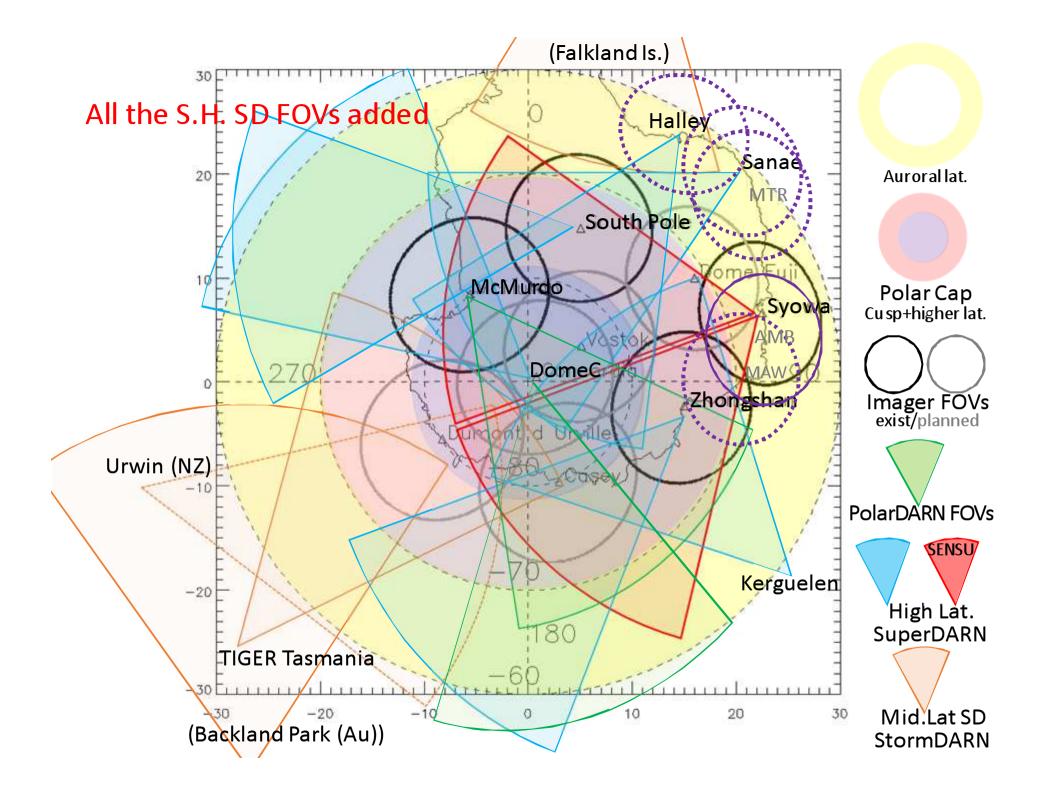




Cosmic Ray @ Syowa Mm-wave spectroscopic obs. New Spectrum Riometer







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 Syowa - unique location under auroral region w/comprehensive obsitools Hemispheric conjugate/non CJG study in global scale Conduct many collaboration with satellite/IS/MST/optical obs. network, theory/simulation research JARE phase X & beyond — move to JARE Monitoring obs. Long-term and stable observation is important to provide essential data to wide scientific community Contribution to Prioriterised 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 •Qualitative improvement with higher precision obs. more dev. of Ionosphere-Magnetosphere mapping Antenna and Tx upgrade for sustainable operation

Summary



SENSU S	yowa radars pro	iect and achiev	vements so far:
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NIPR/SENSU radar group and Syowa South and Syowa East radars joined SuperDARN since its establishment in 1995. 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.

SENSU research plan for coming phase X 6-year JARE project:

Since basic data obtained by SuperDARN has been increasingly important in wider community and it is therefore of great importance to keep this observation going on a long-term basis and to provide those valuable and fundamental data to the community. We decided to maintain and even accelerate SuperDARN as an essential long-term scientific monitoring observational research from the upcoming phase X JARE project for long-term stable contribution to broader coverage of research and applications.

SENSU SD radars will also contribute as an important component to the prioritised research project on space weather and space climate research driven by Kataoka, where several ASI FOVs plan to fill in mostly whole polar cap regions by international collaboration and the FOVs are under SH SD FOVs so that we can promote abundant scientific research on polar cap, SW-M-I coupled system and space weather/space climate and its impact on earth's environment.

Current and Future issues to be resolved:

Syowa radars have several issues to be resolved: Need to upgrade aged antenna arrays with metal fatigue requiring hard maintenance work. Need to modify and refurbish transmitters. Best effort will be made during the coming phase X period for more stable long-term operation with less-maintenance cost.

