

History and progress of Japanese SuperDARN project

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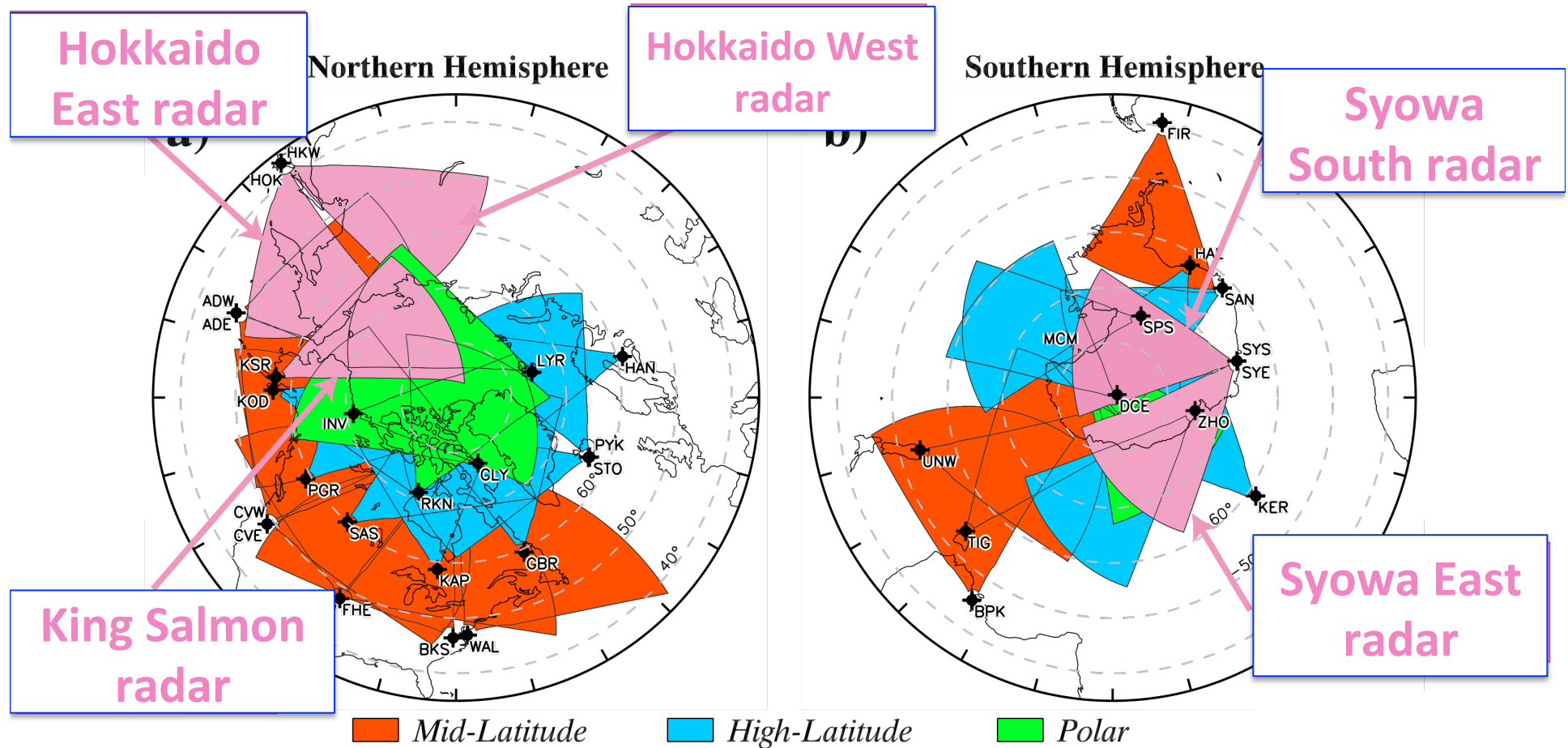
極地研
National Institute of Polar Research



名古屋大学
宇宙地球環境研究所
Institute for Space-Earth Environmental Research



Japanese contribution to SuperDARN



Number of operating HF radars: 36 (23 in the northern and 13 in the southern hemispheres) in Jan. 2019



Japanese SuperDARN radars

Syowa South



Syowa East



Currently 5
Japanese
SuperDARN radars
are running

King Salmon



Hokkaido East

Hokkaido West

Look back over the past

1983: Goose Bay radar



1995: Syowa South radar

**Important to
archive the
Historical
background**

1997: Syowa East radar

2001: King Salmon radar

2006: Hokkaido East radar

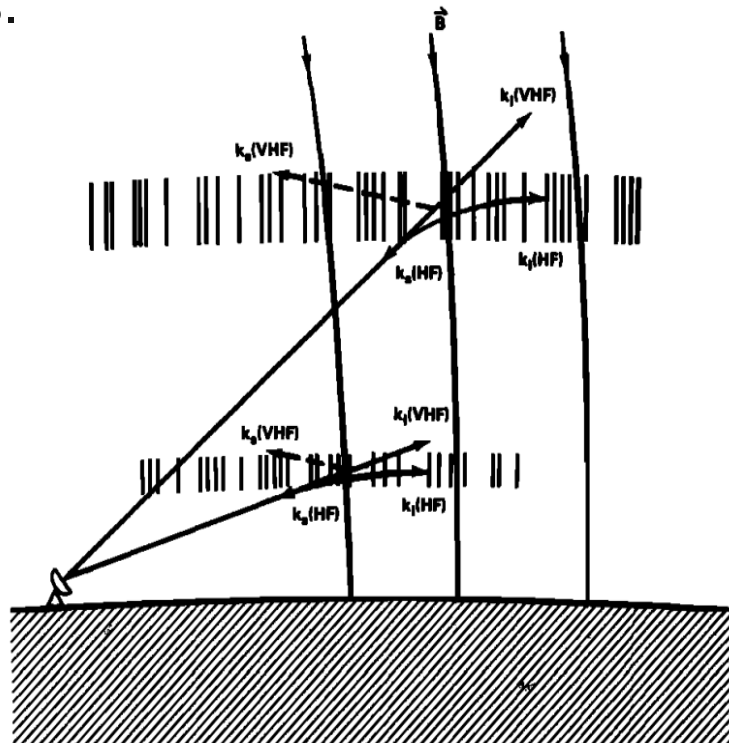
2014: Hokkaido West radar

Dr. Tadahiko Ogawa's historical contribution
to Japanese SuperDARN project (*Initiation of
Syowa radar experiment*)

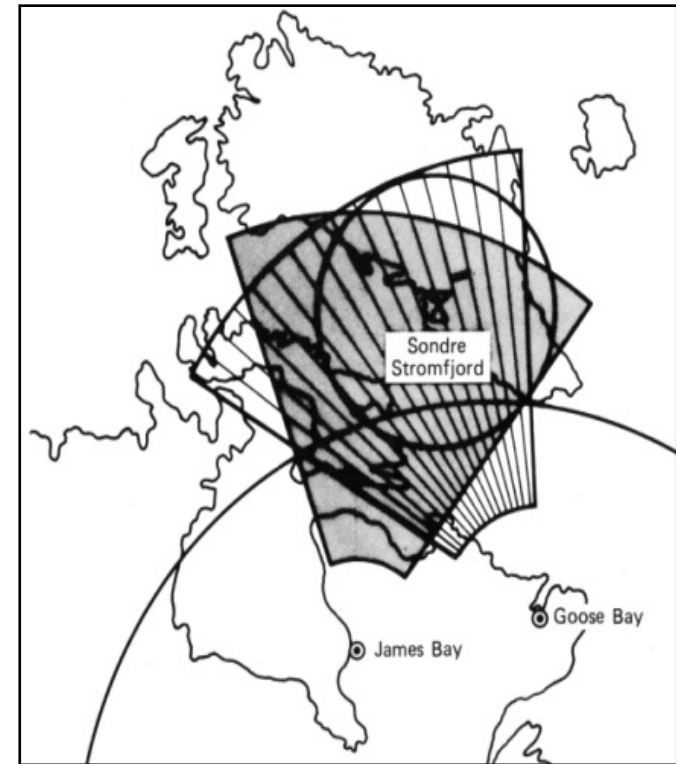


An HF Phased-Array Radar for Studying Small-Scale Structure in the High-Latitude Ionosphere
(Greenwald et al., Radio Sci., 1985)

Dr. Ogawa read this paper in 1986 and thought that this kind of HF radar should be installed at Syowa in addition to the existing VHF (50/112 MHz) radar to explore wide Antarctic ionospheric regions.



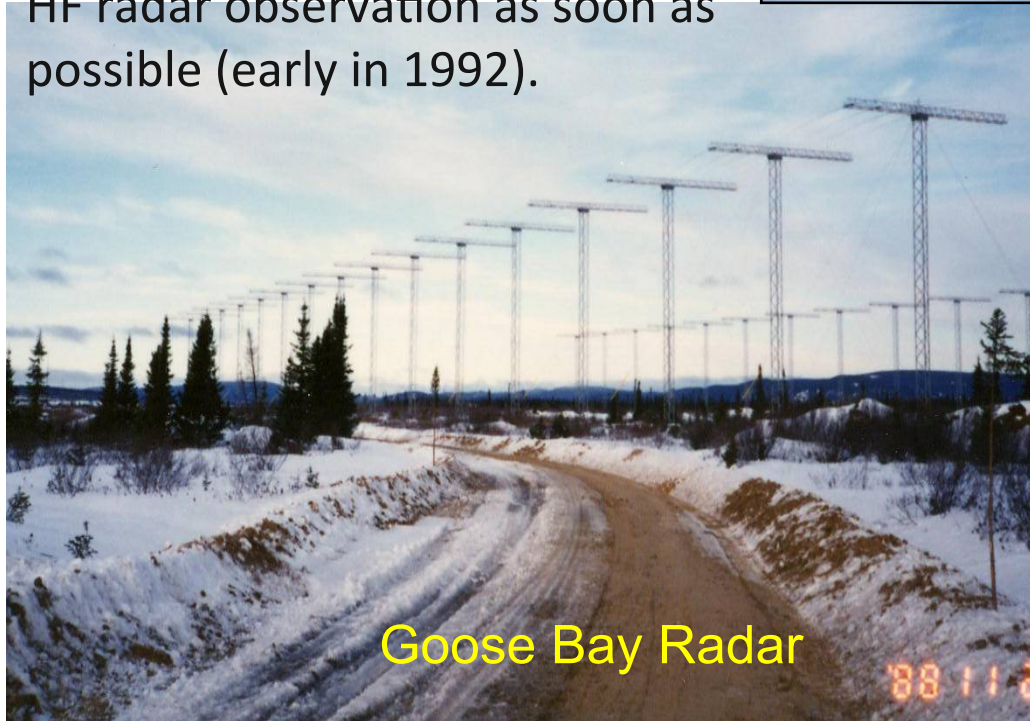
Ray paths of VHF and HF signals scattered into space by very high latitude E and F region irregularities.



Fields of view of the JHU/APL HF radar at Goose Bay and a planned French HF radar at James Bay.

Dr. Ogawa visited APL and
Goose Bay radar site in
November 1988

Ogawa visited APL to get information on the Goose Bay HF radar, and also visited the radar site to look the real system (!! very big !!). Greenwald, Baker (APL) and Dudeney (BAS/UK) recommended me to start Syowa HF radar observation as soon as possible (early in 1992).

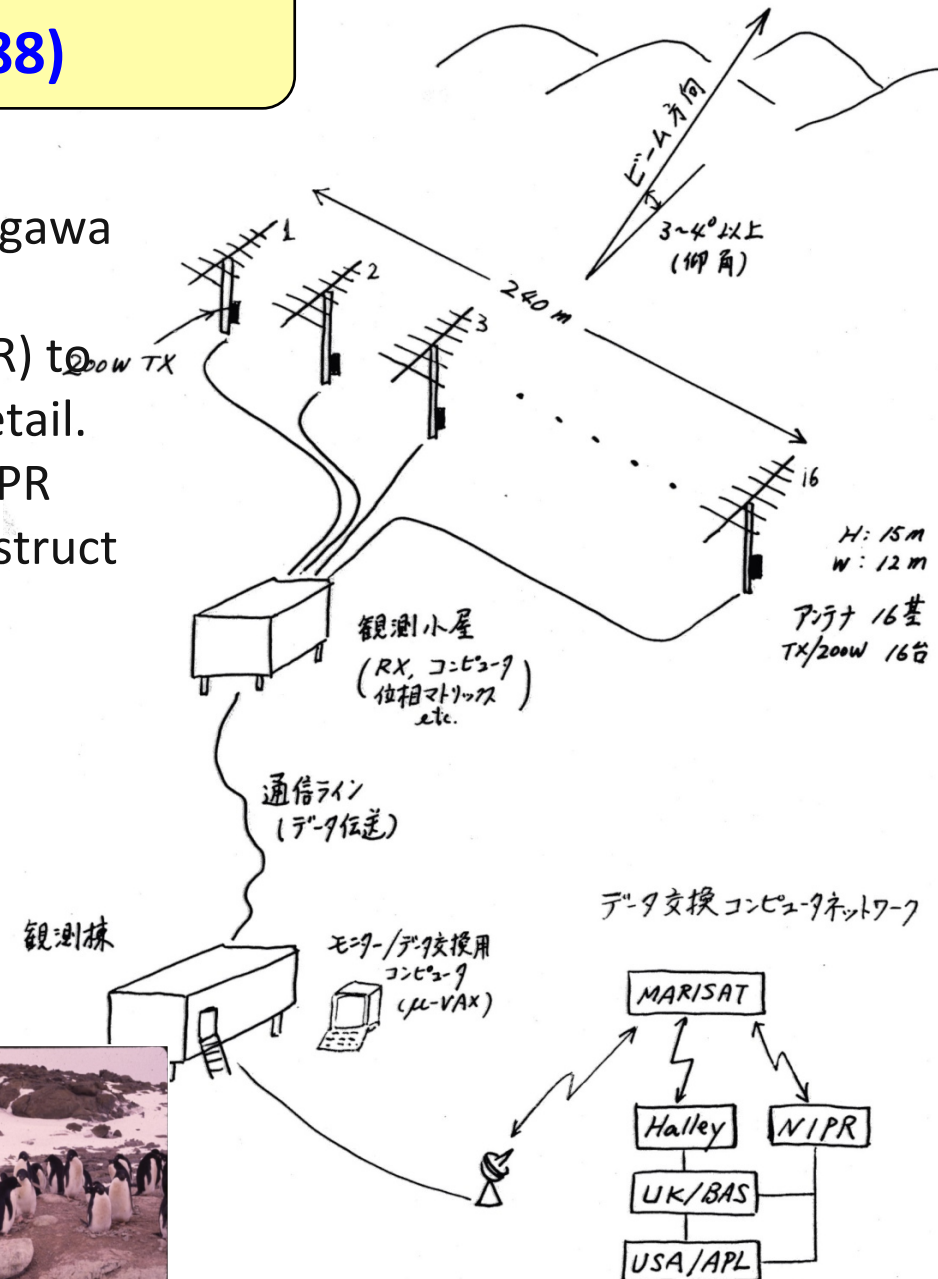


Goose Bay Radar



Proposal of Syowa HF radar experiment from Dr. Ogawa (Dec. 1988)

Based on the detailed and important information from Greenwald et al., Dr. Ogawa proposed the Syowa HF radar project to National Institute of Polar Research (NIPR) to explore the Antarctic ionosphere in detail. The upper atmosphere researchers of NIPR welcomed this project and hoped to construct the radar as soon as possible.



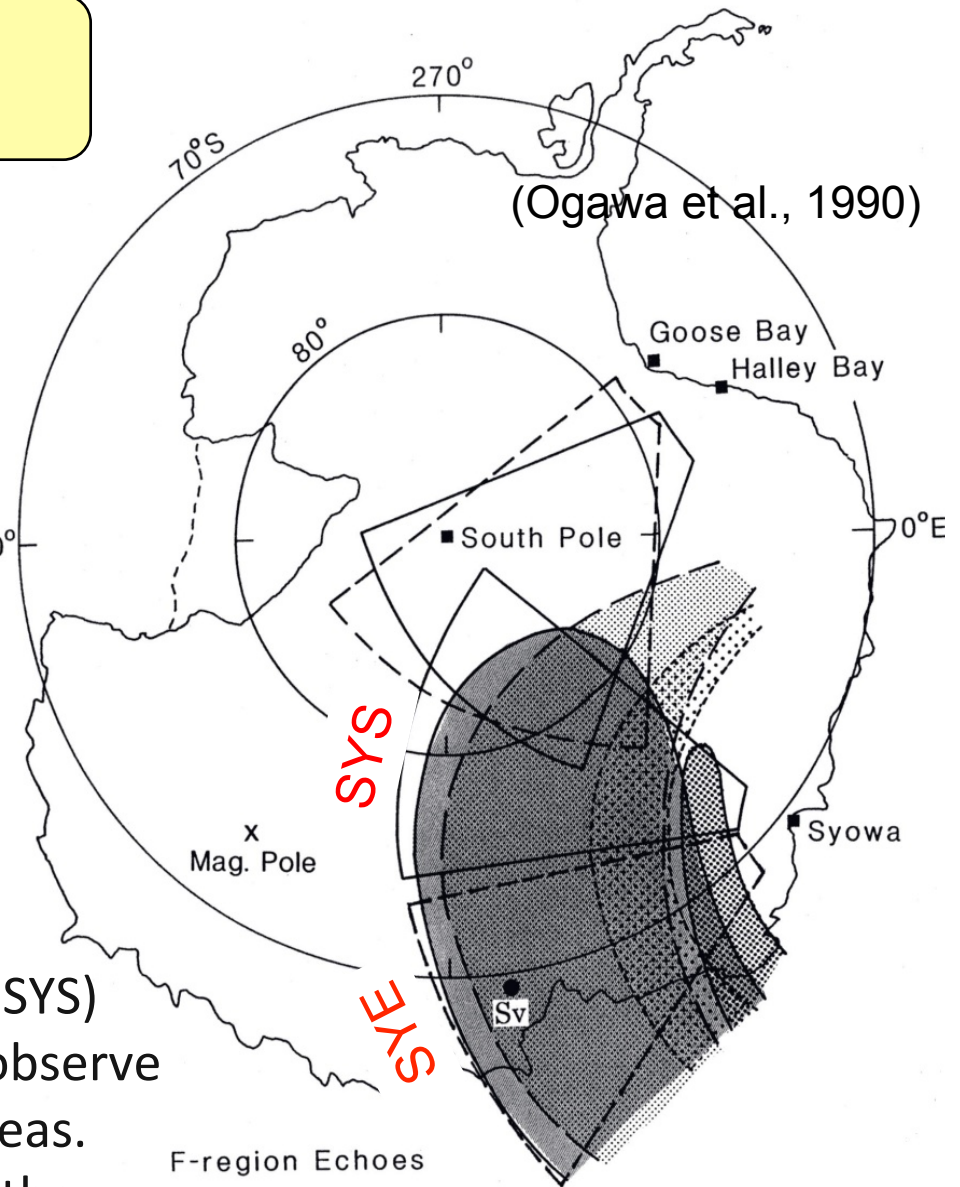
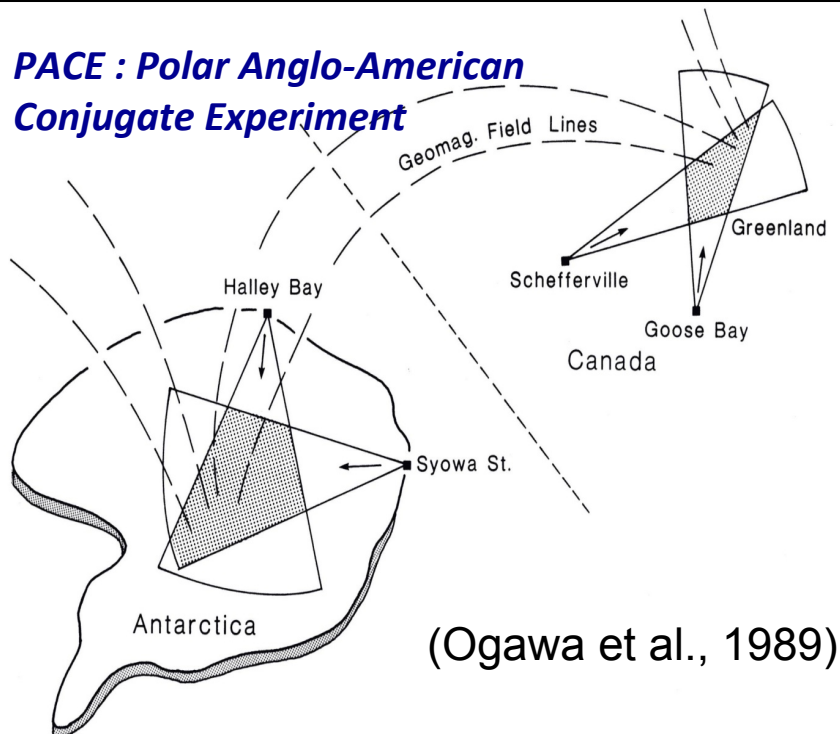
Syowa Station in Summer



Ogawa (1985)

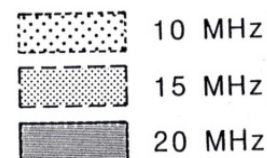
Proposal of Syowa HF radar experiment (Ogawa et al., 1989, 1990)

PACE : Polar Anglo-American Conjugate Experiment

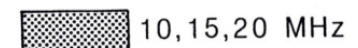


- Two Syowa radars, called Syowa-South (SYS) and Syowa-East (SYE), were planned to observe ionospheric irregularities over the wide areas.
- FOV of SYS overlaps partly with FOVs of the Halley Bay and Canadian radars.

F-region Echoes



E-region Echoes



Invitation letter from R. Greenwald to Prof. Hirasawa (1989)



THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY

Johns Hopkins Road, Laurel, Maryland 20707-6099
Telephone: (301) 953-5000 and 792-5000

February 24, 1989

Dr. T. Hirasawa
National Institute of Polar Research
9-10 Kaga 1-chrome
Itabasi-ku
Tokyo 173
Japan

Dear Dr. Hirasawa,

After a long period of waiting and much effort on the part of many scientists, the satellite mission known as ISTP/GGS has become a funded program. The satellites are being built, and in the early to mid-nineties they will be launched. Our goal is to use the data from these satellites and the ground-based coherent radar network, known to NASA as DARN, to provide new understanding of fundamental magnetospheric and ionospheric processes.

The original DARN proposal was based upon a global network of pairs of coherent VHF radars. Advances in technology and understanding over the past decade have resulted in new types of HF coherent radar systems capable of probing the ionosphere to very high magnetic latitudes, and to higher altitudes. These HF radar systems are presently located in Goose Bay, Labrador, Schefferville, Quebec, and Halley Bay, Antarctica. Recently, it has come to my attention that a fourth HF radar system is being considered for development by the National Institute of Polar Research in Japan. This radar is to be situated at Syowa Station, Antarctica where it will become an important complement to the other HF radars, Halley Bay in particular, and to the DARN experiment. Not only will the Syowa radar expand the field-of-view of the Halley radar, but it will also provide a second component to the doppler measurements in the latter's field-of-view. Together, the two radars will provide reliable plasma convection measurements over much of Antarctica.

It is important to consider how the new HF radar systems may be incorporated into the original DARN concept. For this reason, and also to reacquaint ourselves with the proposal that was written so many years ago, we are planning a two day meeting of the DARN team (co-investigators and/or designated interested parties) to be held in Cambridge, England on 24-25 April. Since a Japanese HF radar at Syowa would add significantly to the contributions of the DARN experiment to ISTP/GGS, I would like to invite you and Dr. T. Ogawa of the Japanese Radio Research Laboratory to attend this meeting and participate in the discussion. I also hope that you might be able to give the DARN investigators an update on your development plans at that time. If you are agreeable with this suggestion, I would plan to include your contribution on the first day of the meeting.

I believe that as well as to member we may be able to do that could be put spacecraft.

Local arrangements Dudeney of the British John is endeavoring accommodations for breakfast. If you can arrange this too on Monday evening. accommodations, the number in your party this address:

Alternatively, you can

Span:

If you wish need for your presence (country code) 301-9

I am looking forward to seeing you in Cambridge.

With best regards,

Raymond A. Greenwald

RAG:me

DARN WORKSHOP

24/25 April 1989

International workshop to
discuss the Dual Auroral
Radar Network input to
the NASA GGS/ISTP Mission

British Antarctic Survey
Cambridge, England

N. SATO

DARN Workshop, April 1989 at Cambridge

FUTURE DIRECTIONS

- Transmitter upgrade will begin this summer. The new transmitters will provide greater reliability and increased transmitting power at the higher operating frequencies.
- PACE will be part of the ground based system for the ISTP/GGS project. The coherent scatter radar observations for ISTP are known as DARN (Dual Auroral Radar Network). The PACE radars will be complemented by the STARE radars (Germany and Finland), the SABRE radar (UK), the SHERPA radar (Schefferville, Quebec), and the BARS radar (Canada) and probably a new HF radar which will be built at Syowa, Antarctica (Japan).

Project member of Syowa radar

Organization of the Syowa Station HF Radar Experiment

in 1989

Principal Investigator: Prof. Takeo Hirasawa (National Institute of Polar Research, Japan)

Co-Investigators: Dr. Tadahiko Ogawa (Communications Research Laboratory, Japan)

Prof. Masaki Ejiri (NIPR)

Prof. Natsuo Sato (NIPR)

Dr. Hisao Yamagishi (NIPR)

Dr. Ryoichi Fujii (NIPR)

Mr. Kiyoshi Igarashi (CRL)

Natsuo Sato, *in charge of* **PI**

Hisao Yamagishi, *in charge of* **Hard ware**

Sessai Yukimatu, *in charge of* **Software** from 1993

Preparation of radar system

Purchase problem between NIPR and APL

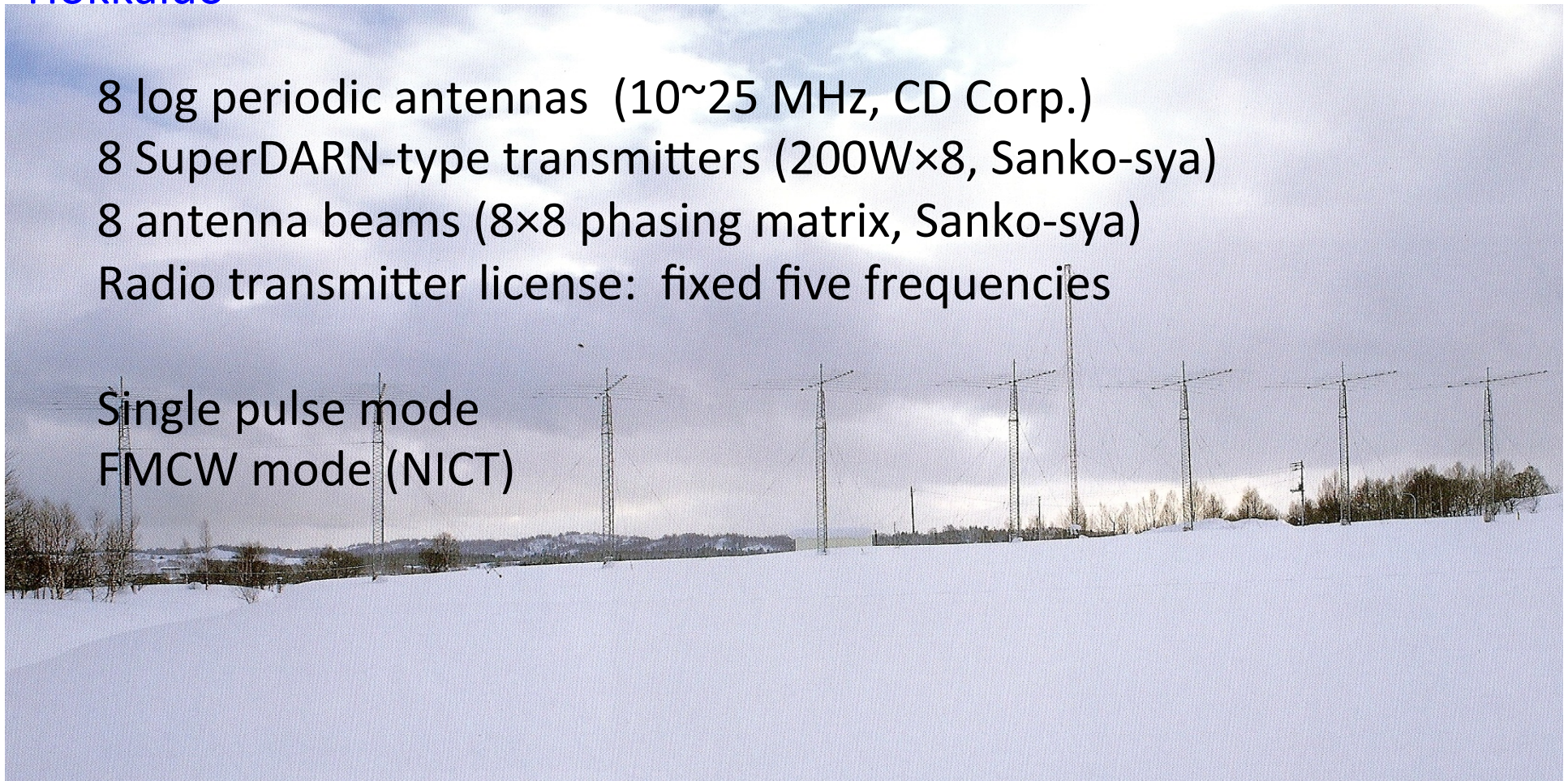
- In 1989, Sato, N and Fujii, R visited APL and met with Greenwald (Dudeny, Pinock), and discussed how to prepare the Syowa radar system
- Original plan of NIPR (government institution) was to buy the system from APL via private trading company, not direct trading with APL.
- It was “Problem”!!
- APL can not make contract with private trading company
- So, how to solve this big problem?
- R. Greenwald proposed that APL will offer all the circuit diagram of transmitter and receiver, etc.
- So please produce the system in Japan.

Preliminary experiment of Syowa radar at Moshiri, Hokkaido carried mainly by Dr. Yamagishi

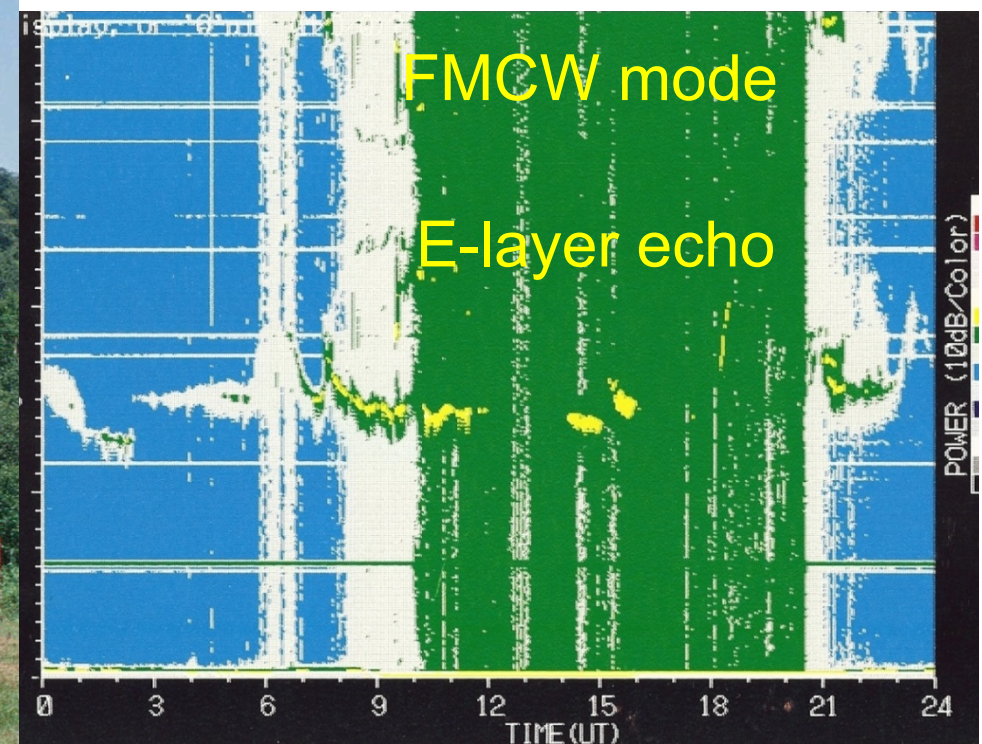
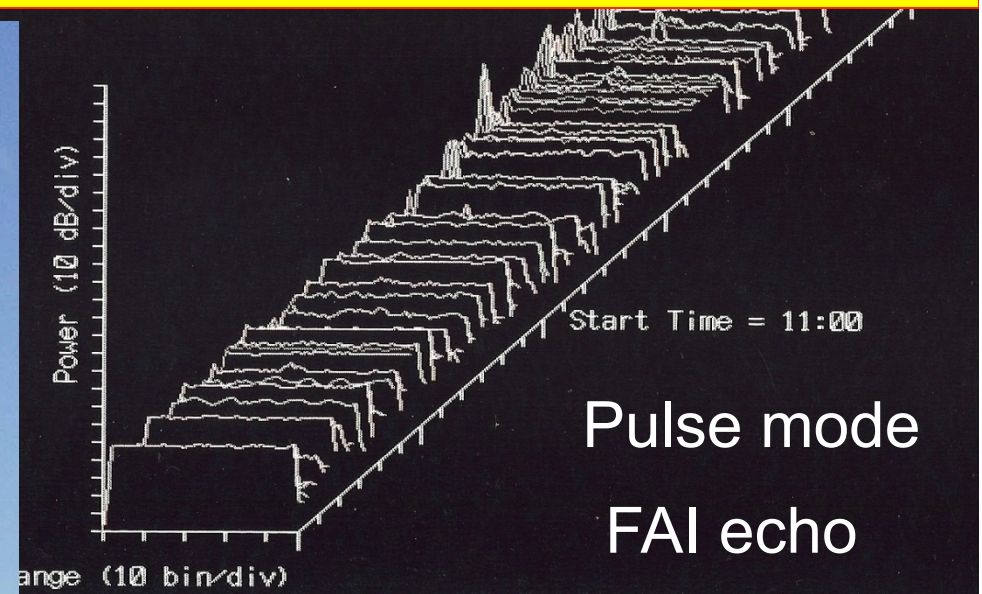
Based on the circuit diagram offered by APL, NIPR (Japanese small company) produced a preliminary HF radar system, and tested at Hokkaido

8 log periodic antennas (10~25 MHz, CD Corp.)
8 SuperDARN-type transmitters (200W×8, Sanko-sya)
8 antenna beams (8×8 phasing matrix, Sanko-sya)
Radio transmitter license: fixed five frequencies

Single pulse mode
FMCW mode (NICT)



Preliminary experiment of Syowa radar at Moshiri, Hokkaido



Design concept of Syowa SuperDARN radar

Three-year budget was approved.

Field test on full system was not permitted in Japan.

**Main concept is to install two radars with adjacent FOV
to have wide observation area.**

The first radar system can be used for the field test.

*The result will be used to improve the design of
the second radar.*

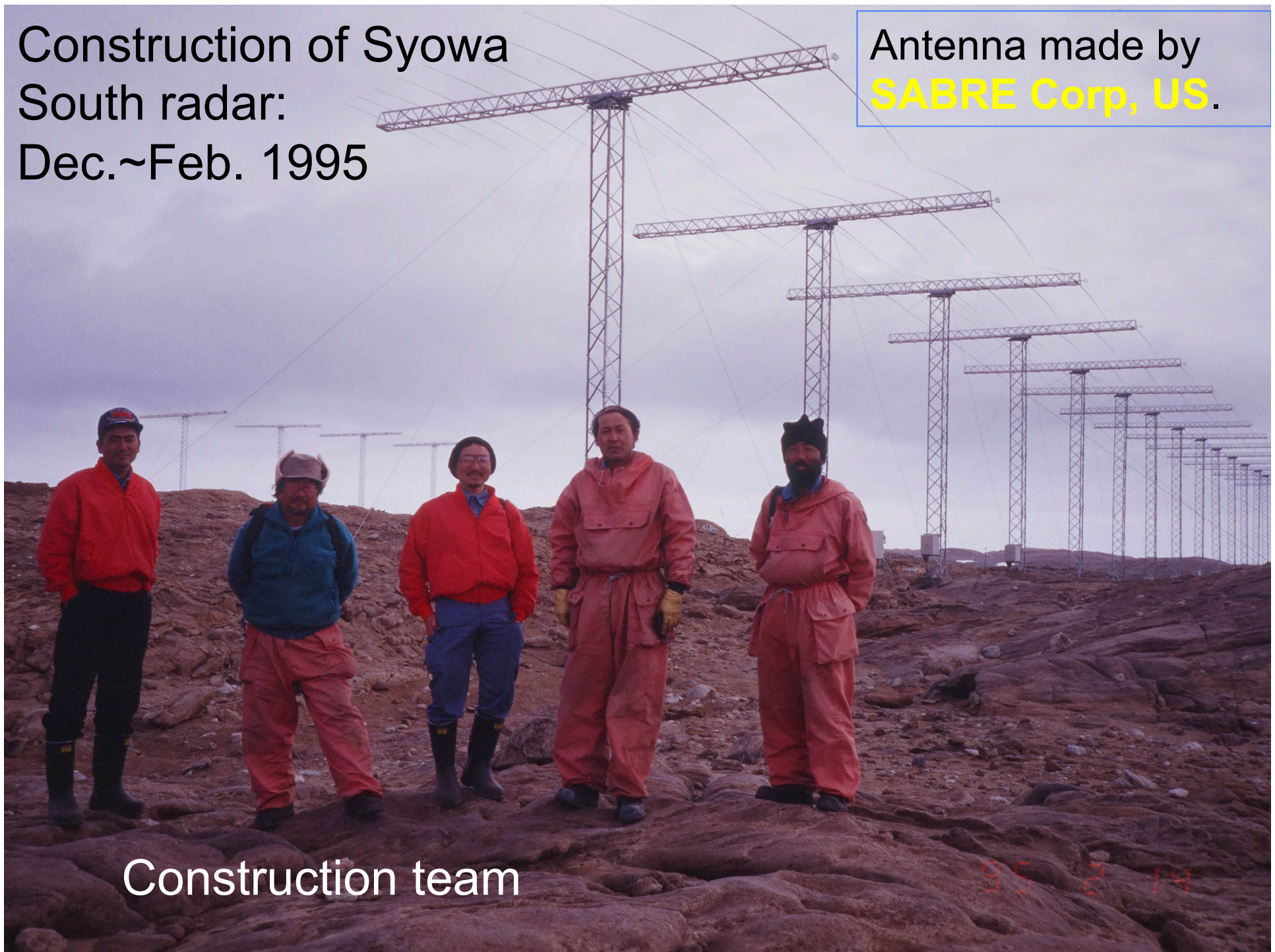
**As a result, the second radar (Syowa East) showed good
performance,
while the first radar (Syowa South) needed improvements
afterward.**

Construction of Syowa
South radar:
Dec.~Feb. 1995

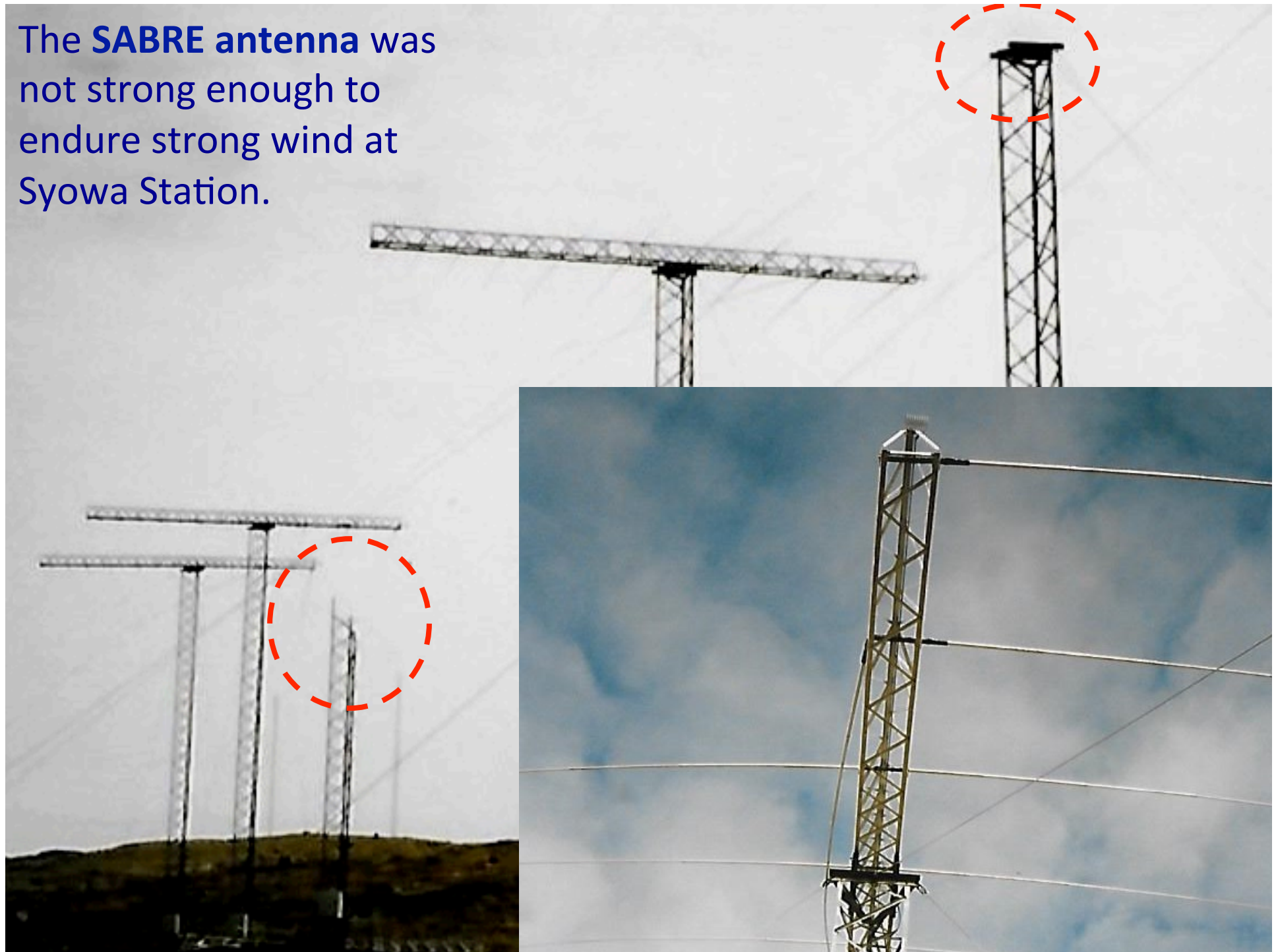
Antenna made by
SABRE Corp, US.

Construction team

95 2 14



The **SABRE antenna** was not strong enough to endure strong wind at Syowa Station.



Construction of East radar

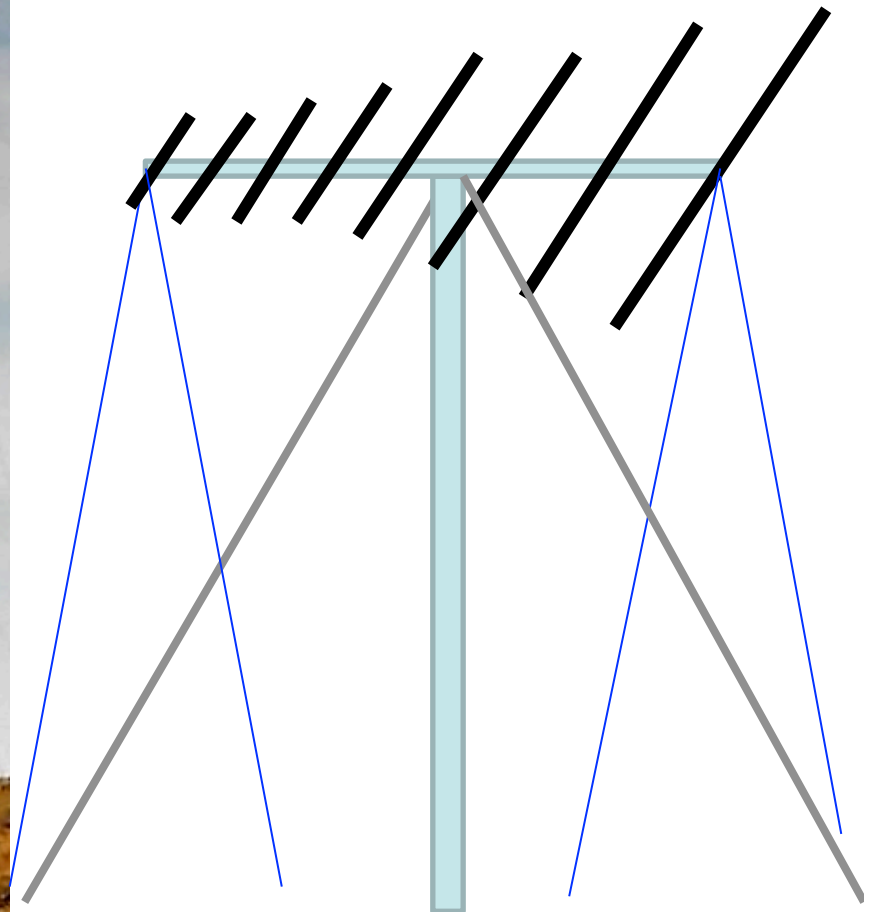
January 1997

Different type antenna was selected

Antenna: made by
Create Design Corp.



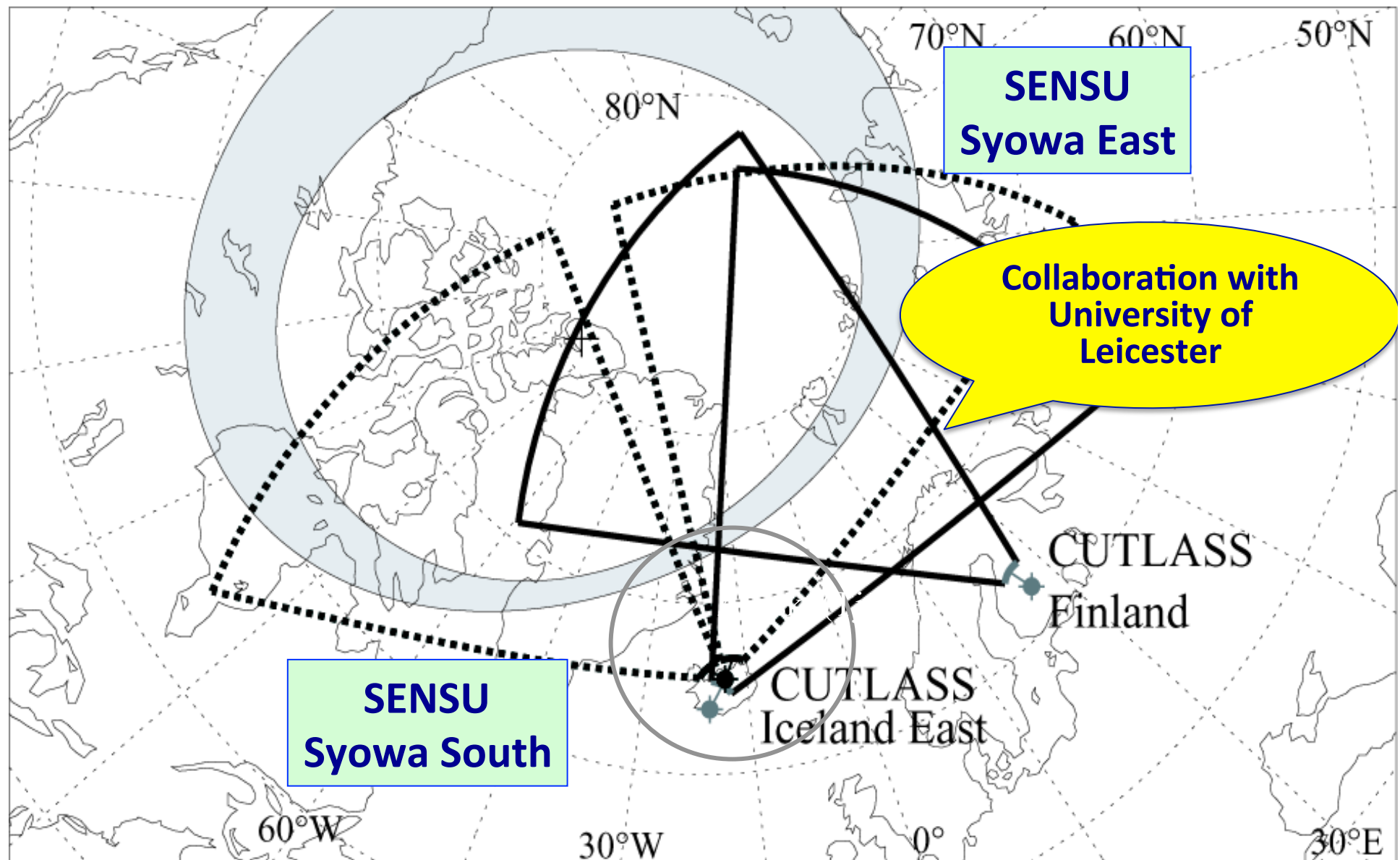
Prepare for the strong wind,
anti-rotation guy ropes were attached at
both ends of the antenna boom



Collaboration with ground-based observation in Antarctica



Characteristics of SENSU Syowa radar: *Conjugate field of views of CUTLASS and SENSU*



1995 Cambridge SuperDARN Workshop

Report on the SuperDARN Workshop

Cambridge, UK - 2/3/4 May 1995



Natural Environment Research Council
British Antarctic Survey, High Cross, Madingley Rd., Cambridge, CB3 0ET, U.K.

1995 Cambridge SuperDARN Workshop

Signed on Original PI Agreement



D. Walker

J-P. Villain

1998 SuperDARN Workshop in Tokyo



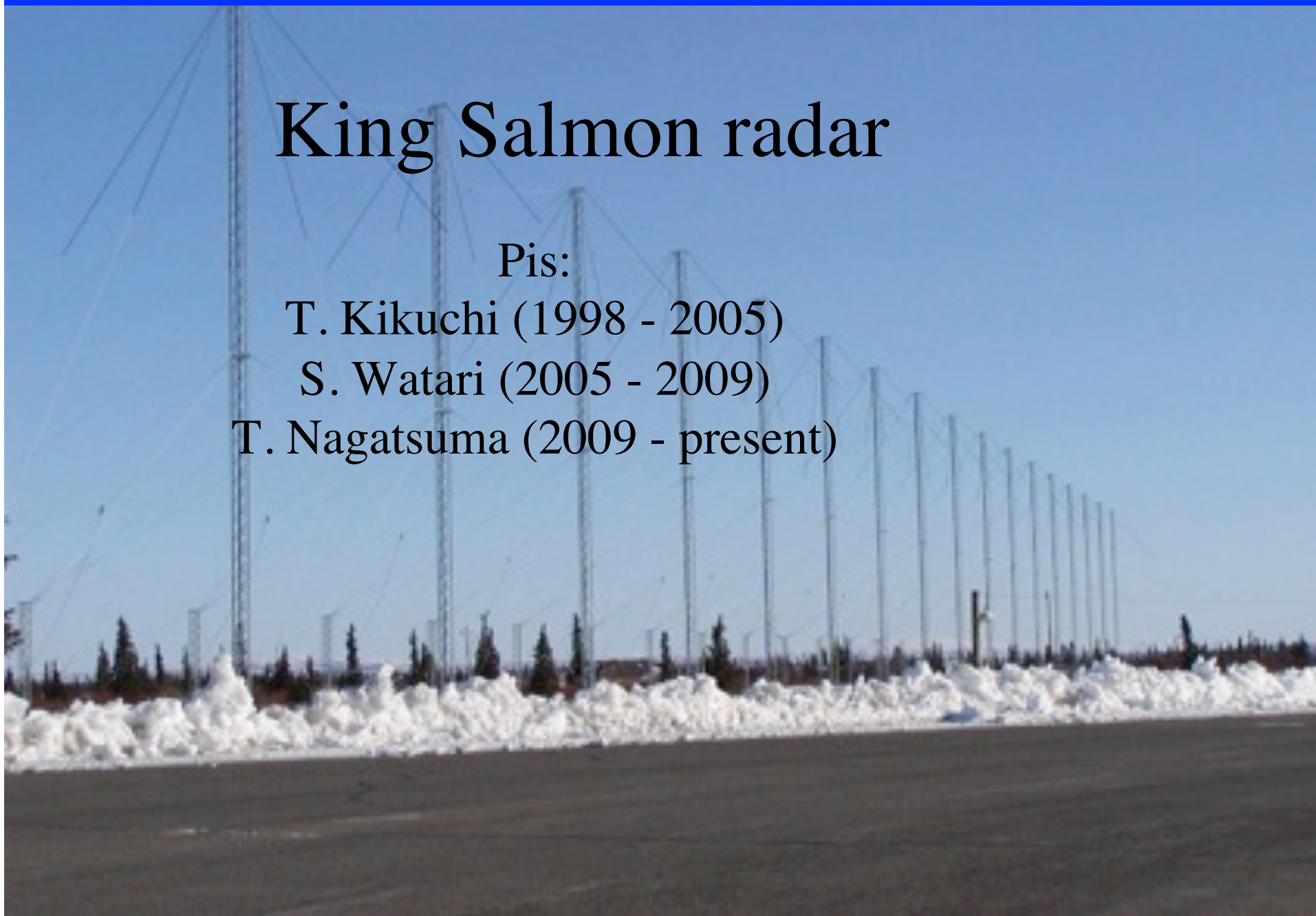
King Salmon radar

Pis:

T. Kikuchi (1998 - 2005)

S. Watari (2005 - 2009)

T. Nagatsuma (2009 - present)



Construction of the King Salmon radar

- **Dec 1997:** King Salmon Airforce Base was proposed at the meeting in SF. *Members: T. Kikuchi (CRL), W. Bristow, S. Akasofu, R. Smith (UAF) and R. Greenwald (APL).*
- **March 1998:** Kikuchi and Bristow surveyed King Salmon Airforce Base.
- **July 1998:** CRL joined SuperDARN community (PI: T. Kikuchi).
- **Oct 1999:** Kikuchi and Bristow explained the plan of the KS radar to the commander at Elmendorf AFB in Anchorage and to residents in Bristol Bay at the public meeting.
- **June 24-July 8 2001:** Installation of the radar and cables *by T. Kikuchi, K. Nozaki, K. Hashimoto, M. Shinohara, W. Bristow, C. Thomas, (Thornhill, R. Barnes via the internet).*
- **July 1 2001: First light of operation**
- **July 7 2001:** Online data to APL

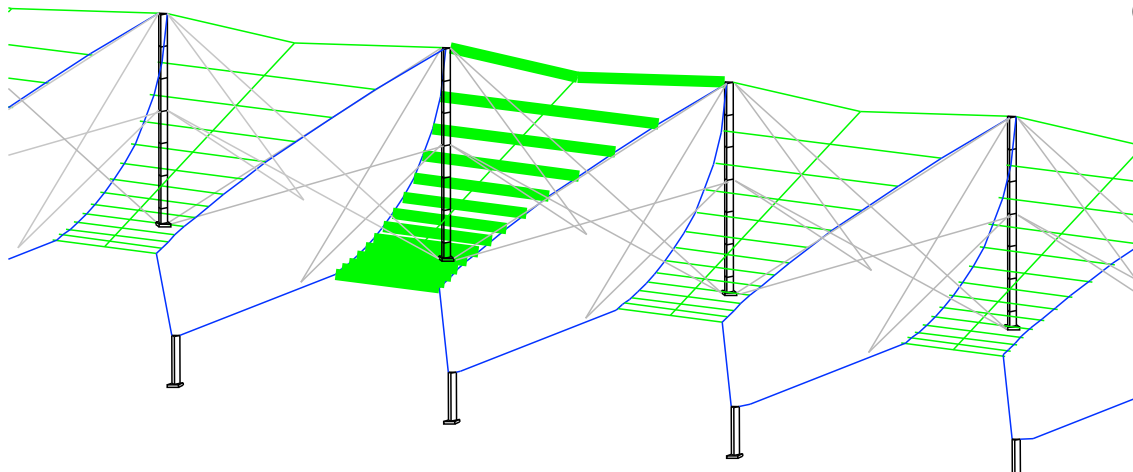
Wire element log periodic antenna



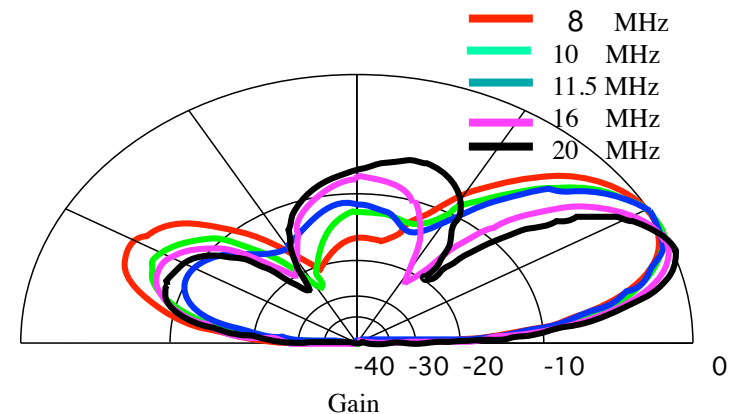
Alumoweld wire is good for a long time observation, easy to construct and maintain, and tolerant for severe winds.

Log periodic elements are pulled up by winches between towers.

Plastic rope guys to avoid interference to neighboring air surveillance radar.



Constant take of angle for frequency change.



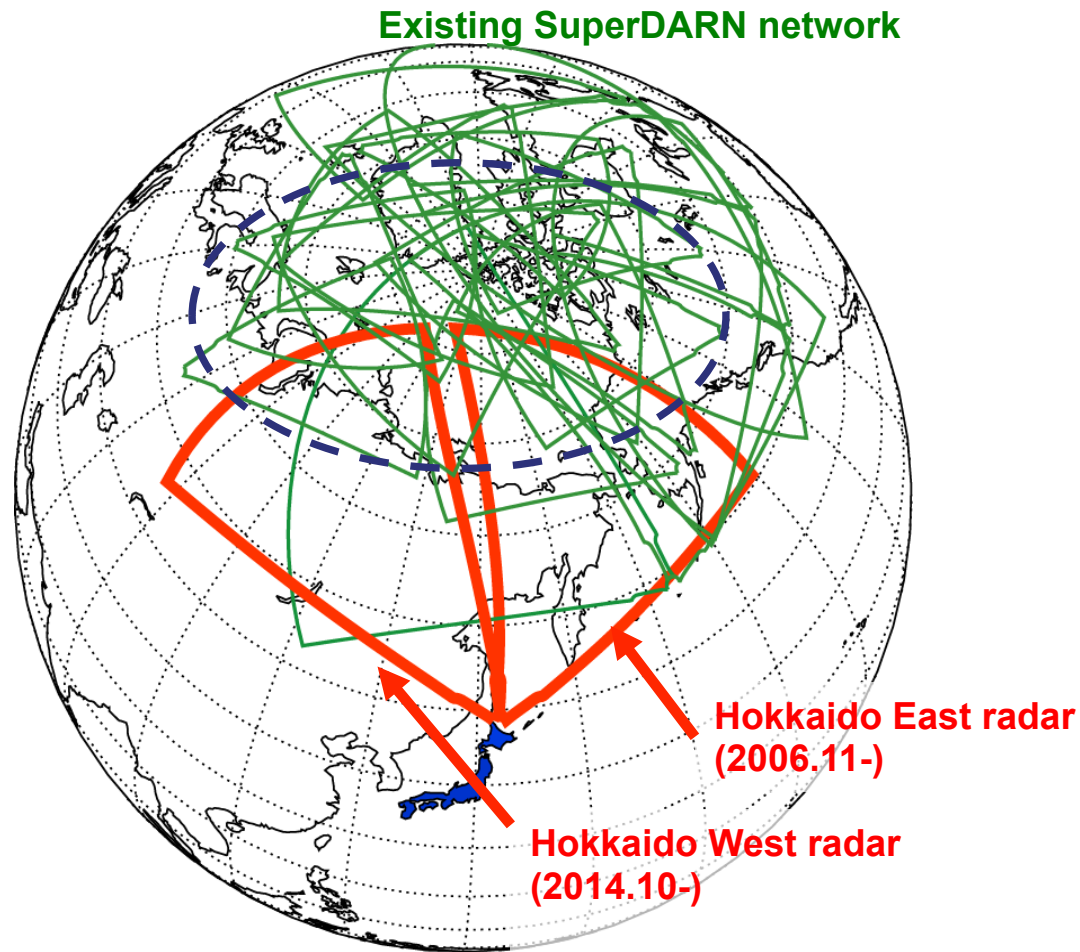
Installed CUTLASS radar system by University of Leicester



First light on July 1, 2001

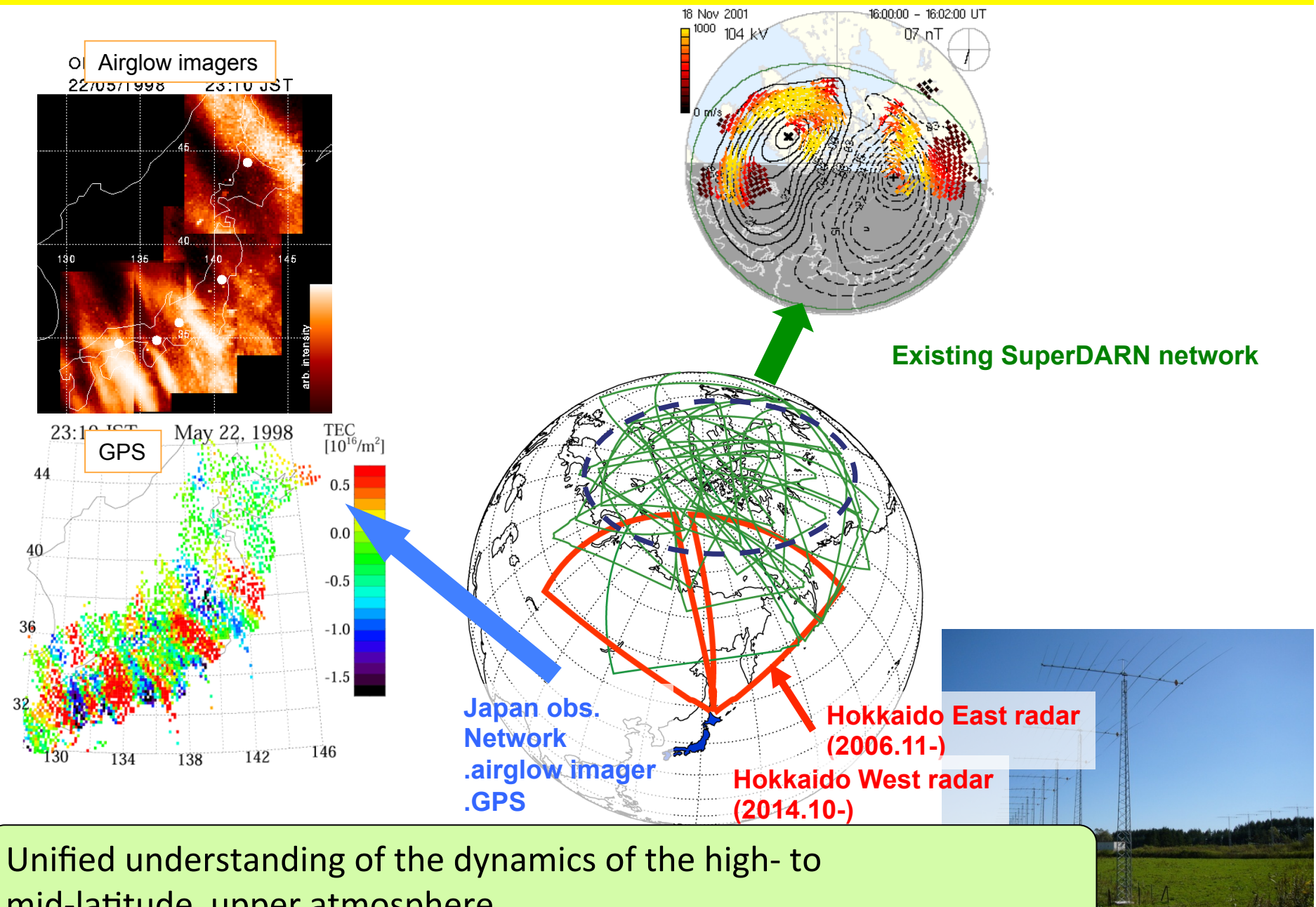


SuperDARN Hokkaido Pair of (HOP) radars (2006.11-)



The Hokkaido radar (at lowest geo-magnetic latitude) covers 38-80 geomag. lat, Corresponding to $L = 1.6$ to 33

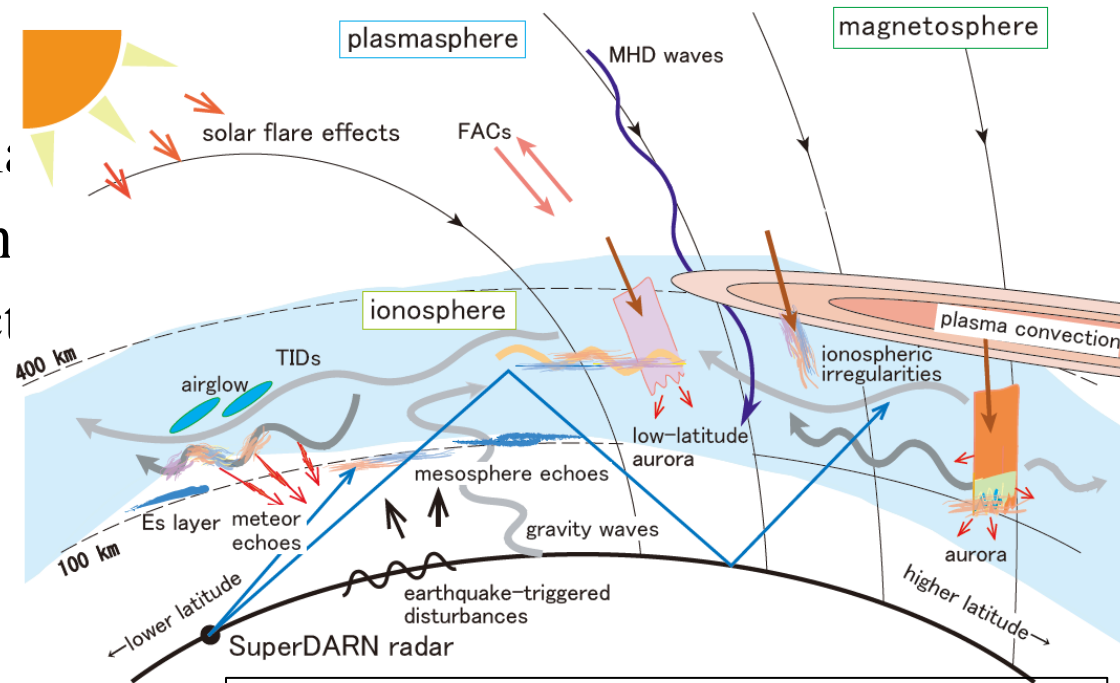
SuperDARN Hokkaido Pair of (HOP) radars (2006.11-)



Review of the accomplishments of mid-latitude SuperDARN

- 1. Introduction
- 2. Convection
- 3. Ionospheric Irregularities
- 4. HF Propagation Anisotropy
- 5. Ion-Neutral Interactions
- 6. MHD waves
- 7. Future directions

Published in PEPS:
18 March 2019



20 authors, 28,000 words (main text only), 37 figures, 225 references (+38 in the supplement)

Details by Nishitani's presentation

2007 SuperDARN Workshop in Hokkaido

SuperDARN Workshop 2007

Program and Abstracts



June 4–8, 2007
Abashiri, Hokkaido,
Japan



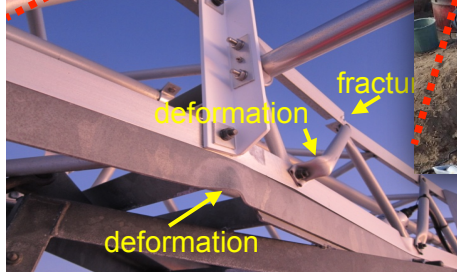
2007 SuperDARN Workshop in Hokkaido



Syowa ongoing project (1)



● Upgrade aged and damaged antenna



Current conventional LP antenna array (Syowa I)



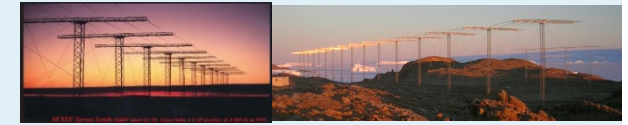
Upgrade work started in 2017 and going on...

King Salmon wire L-P. antenna

Courtesy of West Japan Electronics co.(wje.jp)

Alaska観測用アンテナ

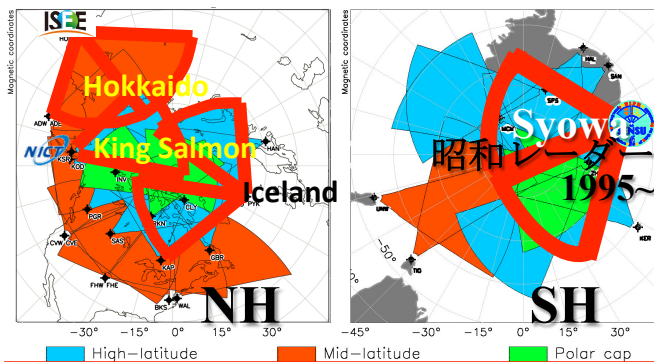
Syowa ongoing project (2)



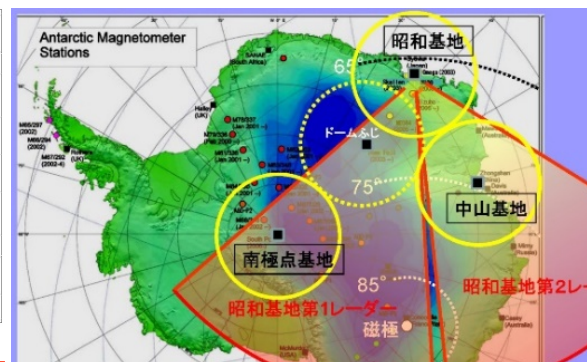
9th phase 6-year JARE project (2017-2022/JARE58-63)

Scientific targets of Syowa SENSU SuperDARN radars observation with ground based optical observing network and with relevant satellite missions,

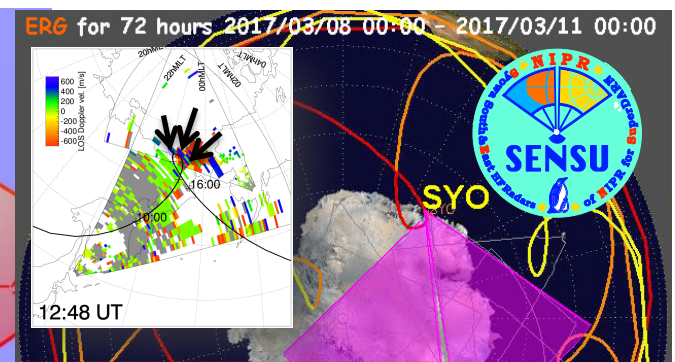
- ① **Influence of possible grand minimum or very low solar activity**
on geospace, polar upper atmosphere, and global climate change quantitatively
- ② Contribute to understanding **inner magnetospheric dynamics**
in conjunction with satellites like ERG/Arase, VAP and G.B. optical network etc.
- ③ Continuous contribution to **Space Weather research as a part of SuperDARN**



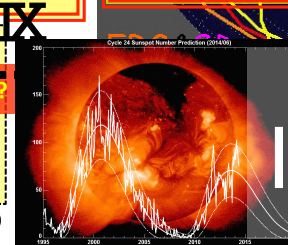
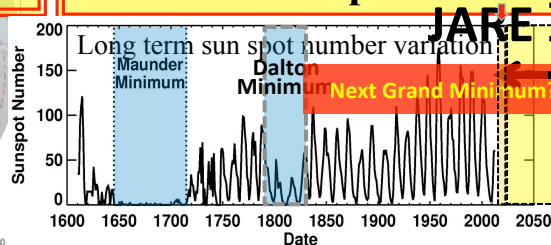
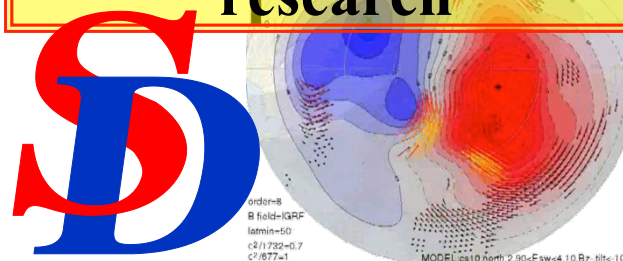
Continuous contribution to
space weather
research



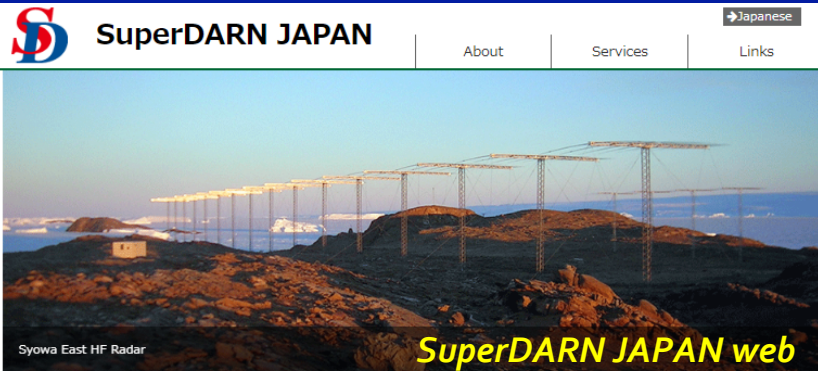
Influence of possible grand
minimum or very low solar
activity on polar upper
atmosphere



Inner magnetospheric
dynamics in joint obs.
with satellites etc.



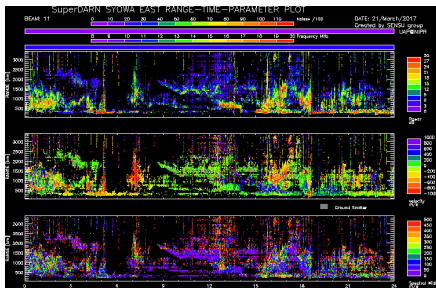
Research Collaboration in Japan & SuperDARN JAPAN



What's SuperDARN?

SuperDARN (Super Dual Auroral Radar Network) is an international collaboration project by eleven countries in the world. As of 01 January 2015, SuperDARN consists of twenty-two sites in the northern hemisphere and twelve sites in the southern hemisphere, covering over the northern and southern high- and mid-latitude regions. Among them, five radars have been operated by Japanese groups (2 in Syowa Station by National Institute of Polar Research, 1 in King Salmon, Alaska by National Institute of Information and Communications Technology and 2 in Hokkaido, Japan by Institute for Space-Earth Environmental Research, Nagoya University).

During common-time mode operation, the SuperDARN network monitors global-scale ionospheric plasma convection of the high- and mid-latitude regions with time resolution of 1-2 min. The radars can also monitor ionospheric plasma density perturbations, meteor and mesosphere echoes. Using these capabilities, the SuperDARN network is used not only for the ionospheric research but also for the thermospheric and mesospheric research.



What's New

March, 2019

[Mid-latitude SuperDARN review paper has been published in PEPS Journal. The paper can be accessed here.](#)

January, 2019

The SuperDARN Workshop 2019 will be held at the foot of Mt. Fuji, Highland Resort Hotel & Spa in Fujiyoshida, Japan from 2 to 7 June, 2019. The website is <http://superdarn2019.nict.go.jp/>.

October, 2018

[Domestic SuperDARN science meeting organised by 3 institutes was held at Nagoya University on October 16-17, 2018.](#)

September, 2017

[Domestic SuperDARN science meeting organised by 3 institutes was held at NICT.](#)

April, 2017

[QLplot](#) page and [Mapplot](#) page are available.

January, 2017

[2nd ISEE/CICR International Workshop on "Review of the accomplishments of the mid-latitude SuperDARN network"](#) was held at Nagoya University.

November, 2016

["About SuperDARN"](#) pages are available.

- ◆ 5 Japanese SuperDARN core research groups – NIPR, NICT, ISEE/Nagoya-U., UEC, ICSWSE/Kyushu-U. made a collaborative research contract in 2016 for future development
- ◆ Regular meetings by core members to share research activity and discuss future collaboration
- ◆ Domestic SD science research meeting is held every year.
- ◆ SuperDARN JAPAN web <http://polaris.nipr.ac.jp/~SD/sd japan/> where SD database is maintained behind to provide SD information and data products in order to promote collaborative activities.
- ◆ See! Yuka Kadowaki's poster presentation for more details.



Summary: “History of Japanese SuperDARN project”

1988: Syowa radar was proposed by Dr. Ogawa

1990: Plan to join DARN project, started budget request.

~1992 : Funded for building prototype HF radar developed an 8 antenna system ,
installed at Moshiri observatory in Hokkaido and tested

1993-1995: Funded for Syowa radar full system

1995: Syowa South radar operated

1997: Syowa East operated

1998: Tokyo SuperDARN Workshop

1999: Syowa South main antenna array replaced by Creative Design

2001: King Salmon radar operated

2006: Hokkaido East operated

2007: Hokkaido SuperDARN Workshop

2014: Hokkaido West radar operated

2019: Fuji SuperDARN Workshop

2020(?): The manuscript of “**History and progress of Japanese SuperDARN**”
will be submitted to “Polar Science” (in English) and “Antarctic Record” (in Japanese)

Thanks for Your Attention

