オーロラ現象の地上多点ネットワーク観測

Ground-based multi-point network observations of auroral phenomena

門倉　昭

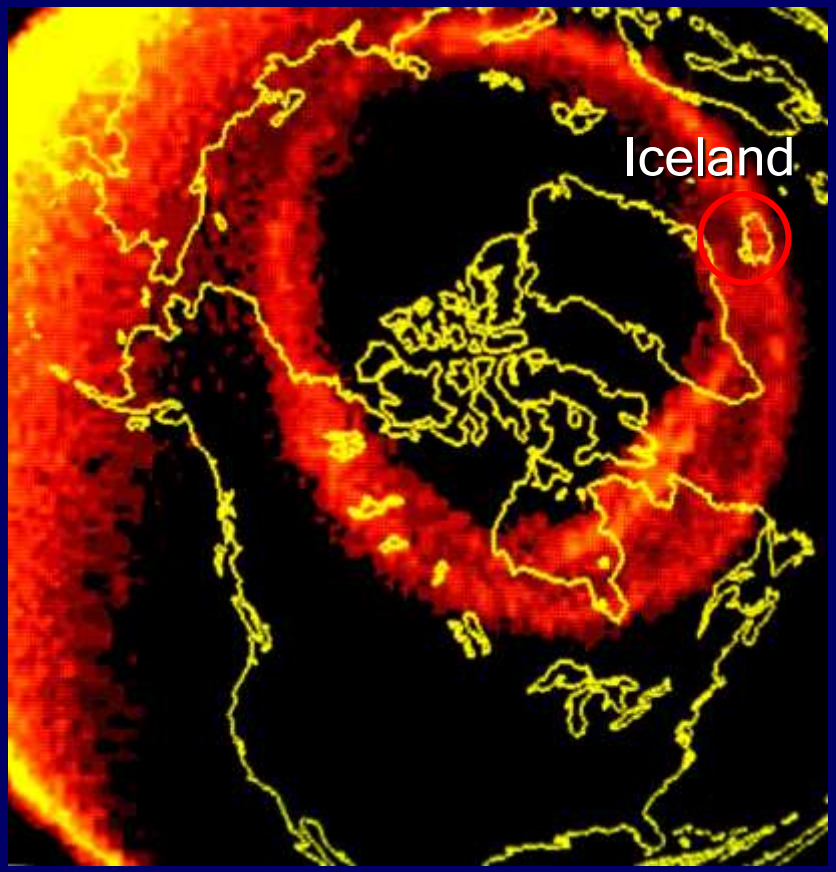
国立極地研究所・宙空圏研究グループ

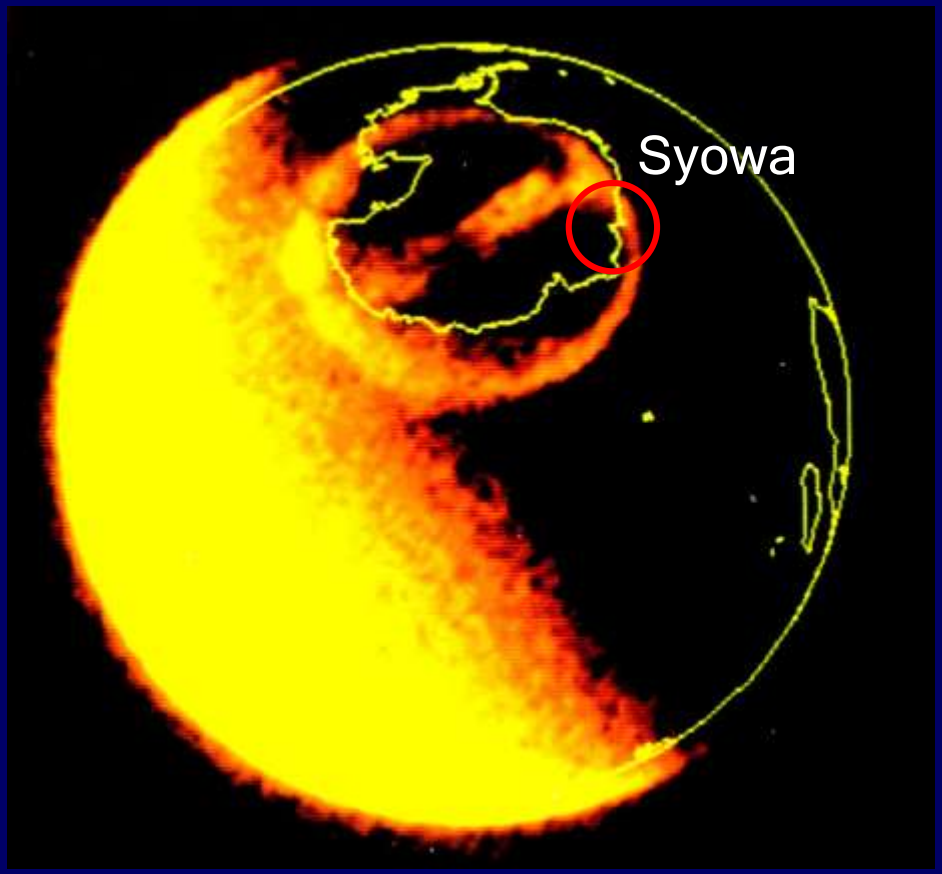
Akira Kadokura

National Institute of Polar Research,

ROIS-DS, Polar Environment Data Science Center

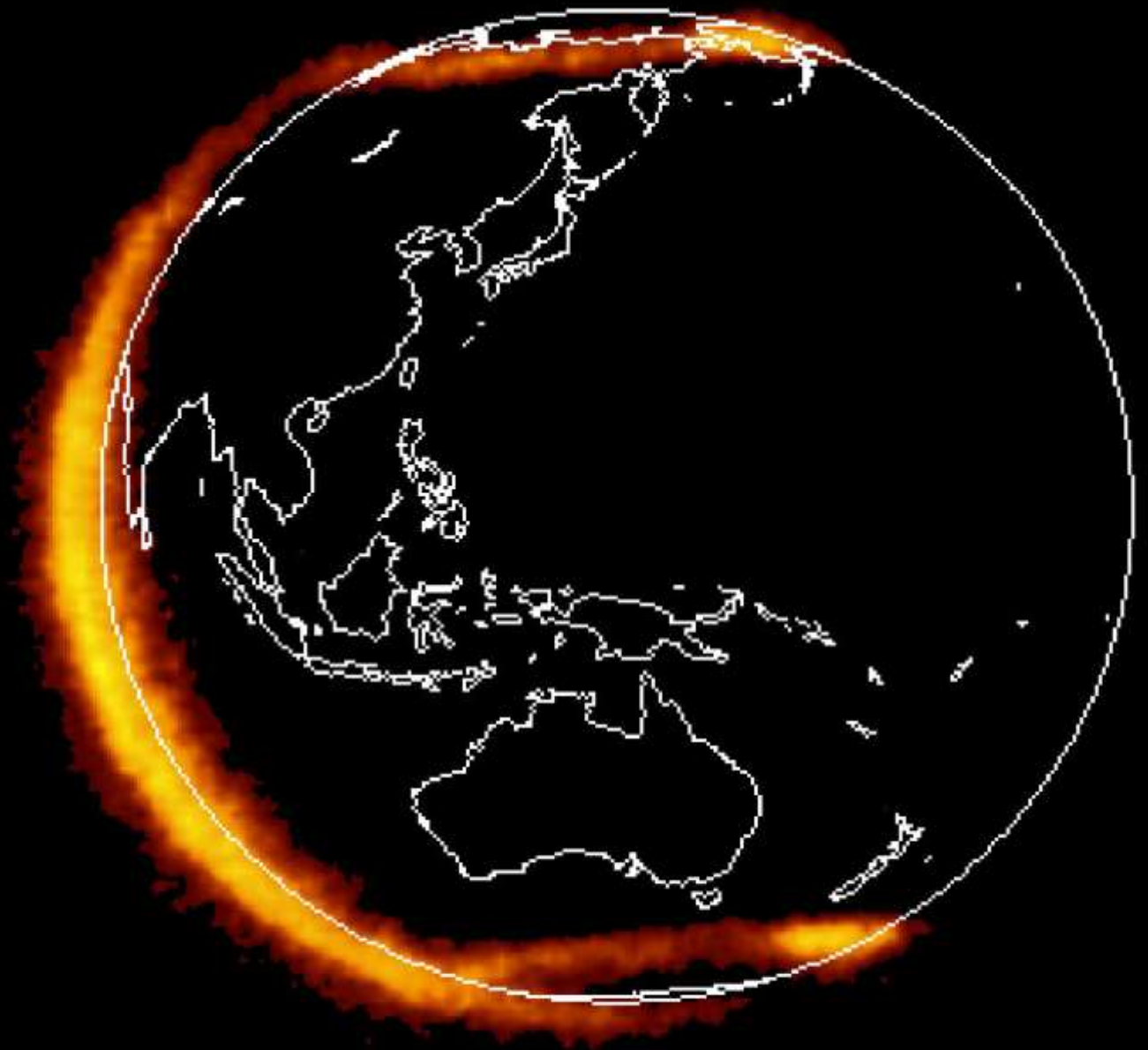
Aurora oval





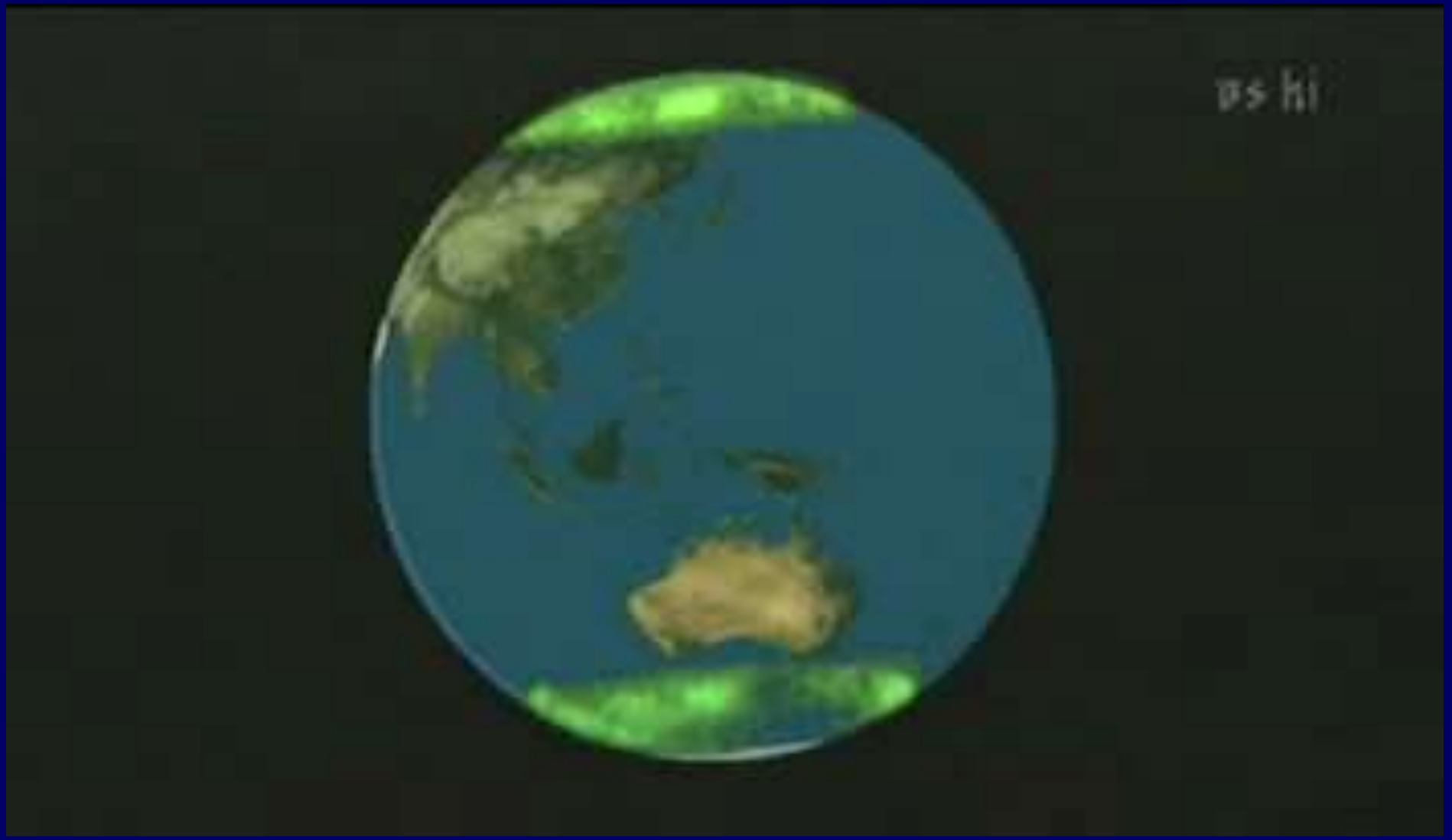
DE-1 (Dynamics Explorer) satellite UV imager (1981)

Aurora oval



POLAR Satellite (Frank et al, 2003, JGR)

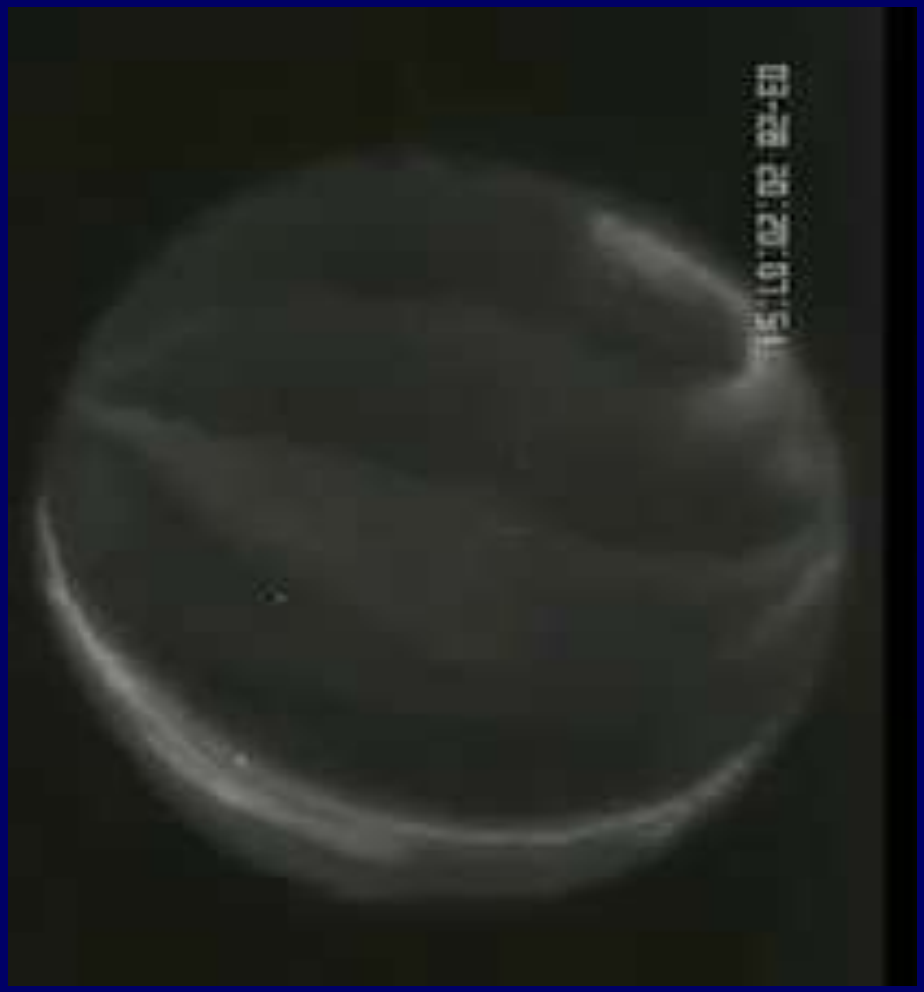
人工衛星による南北同時観測



POLAR 衛星

Auroral Substorm at ground

M.S



W

E

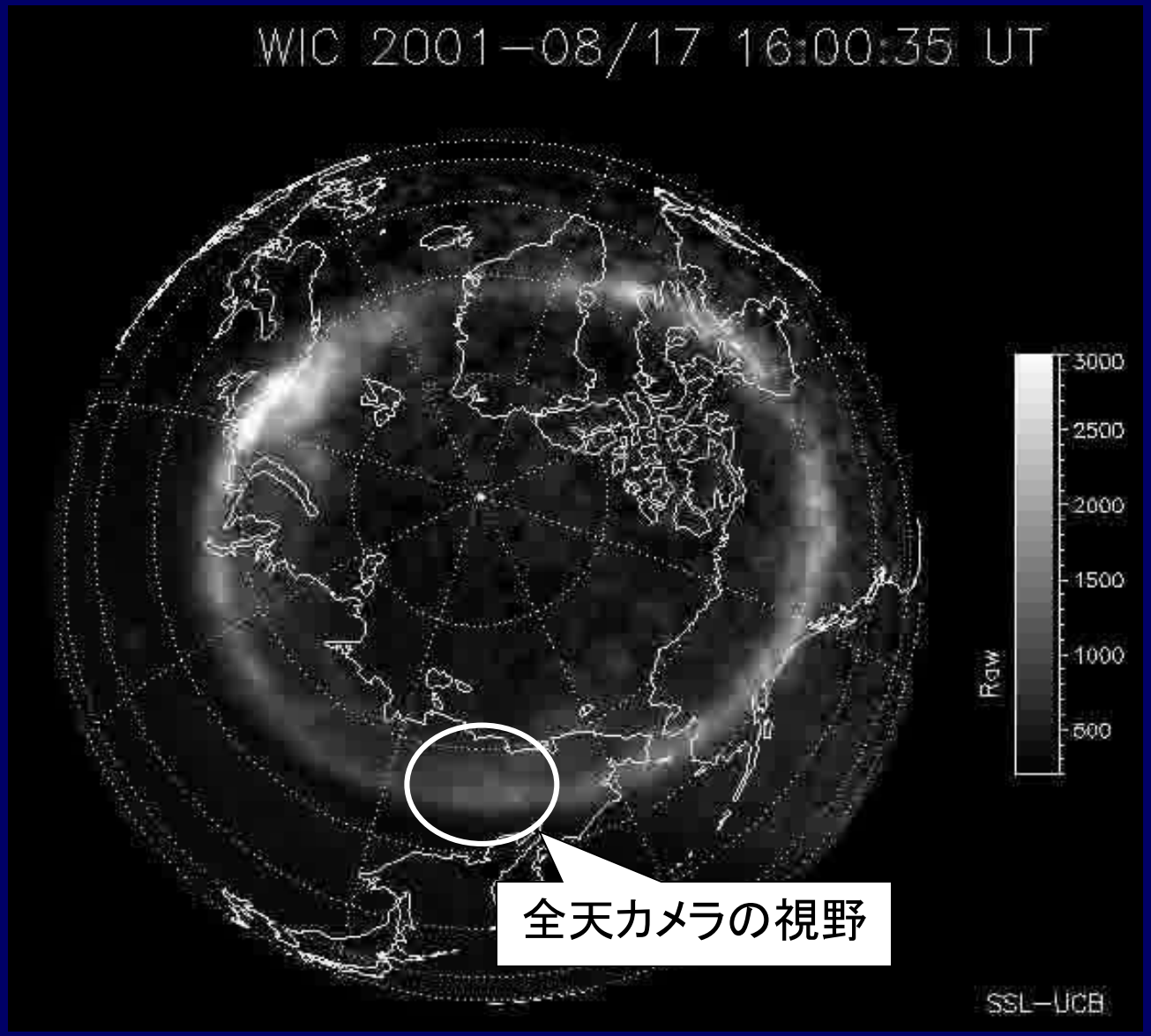
M.N.

- Breakup
- Poleward expansion
- Westward Traveling Surge
- Drifting Patches

All-sky TV camera
at Syowa Station

x 60 speed

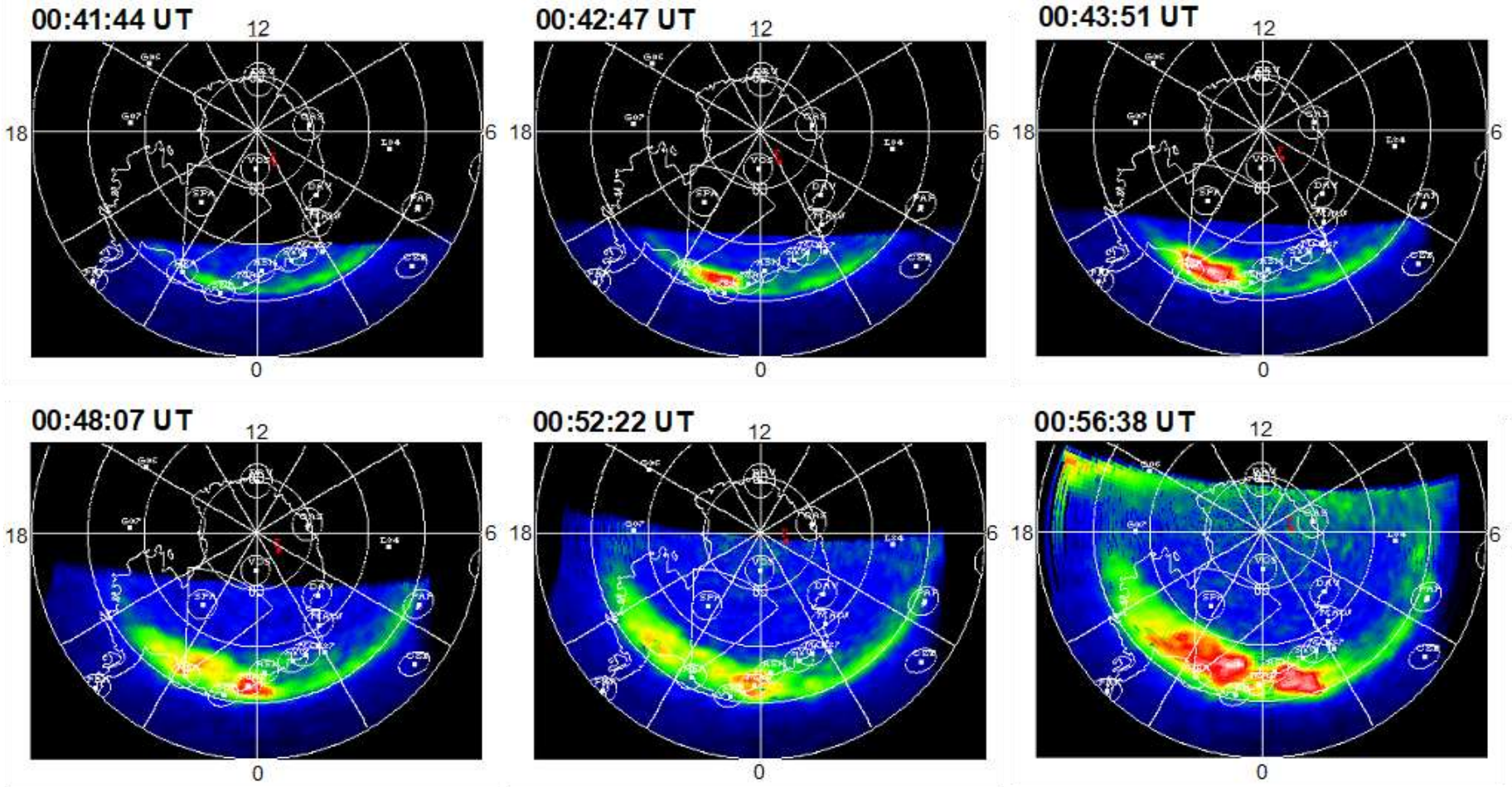
人工衛星から見たオーロラ嵐



IMAGE衛星

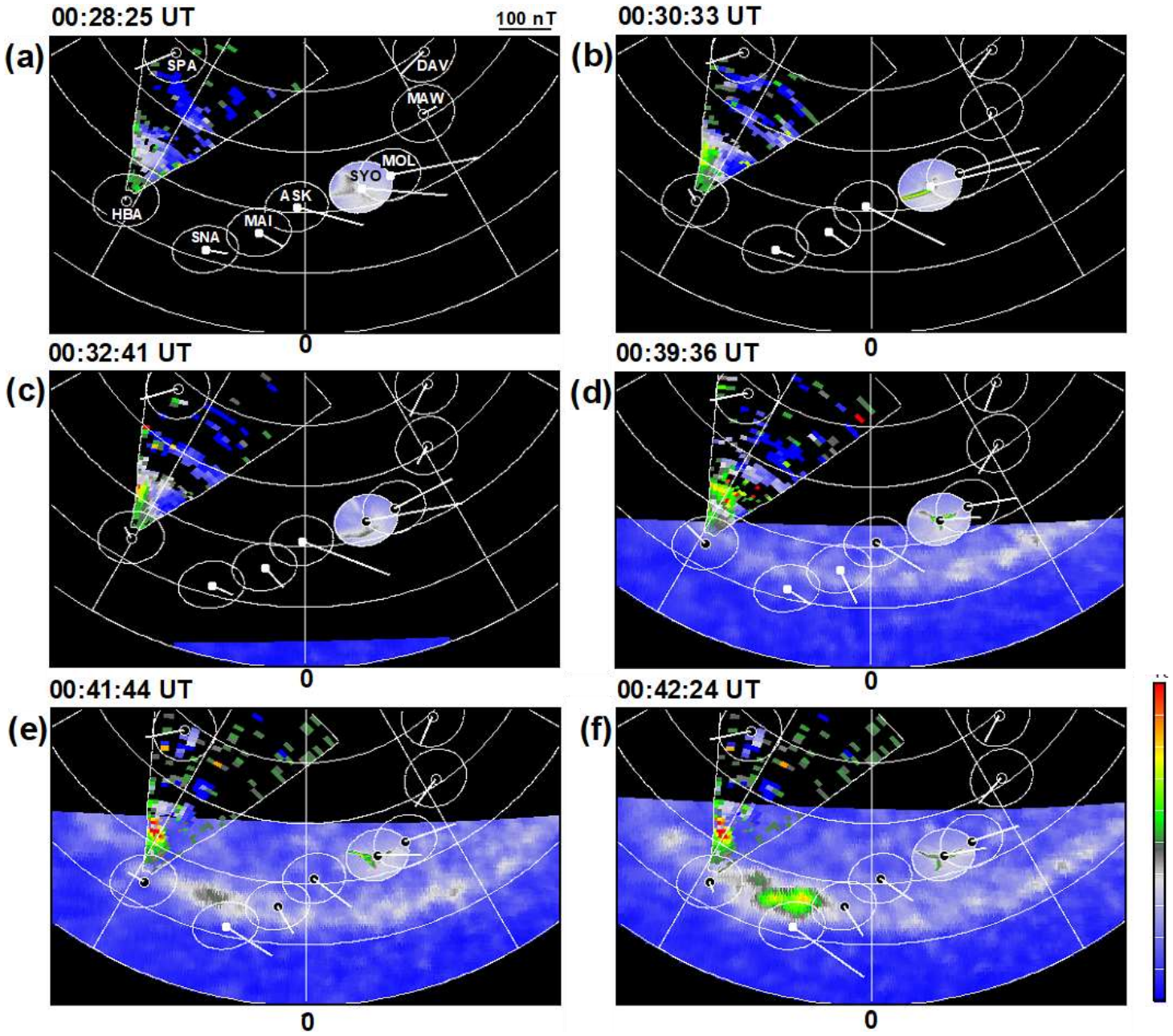
Auroral Substorm observed by Akebono satellite

using the data received at Syowa Station



Kadokura et al. (2002)

AKEBONO ATV-UV data on June 7, 1989

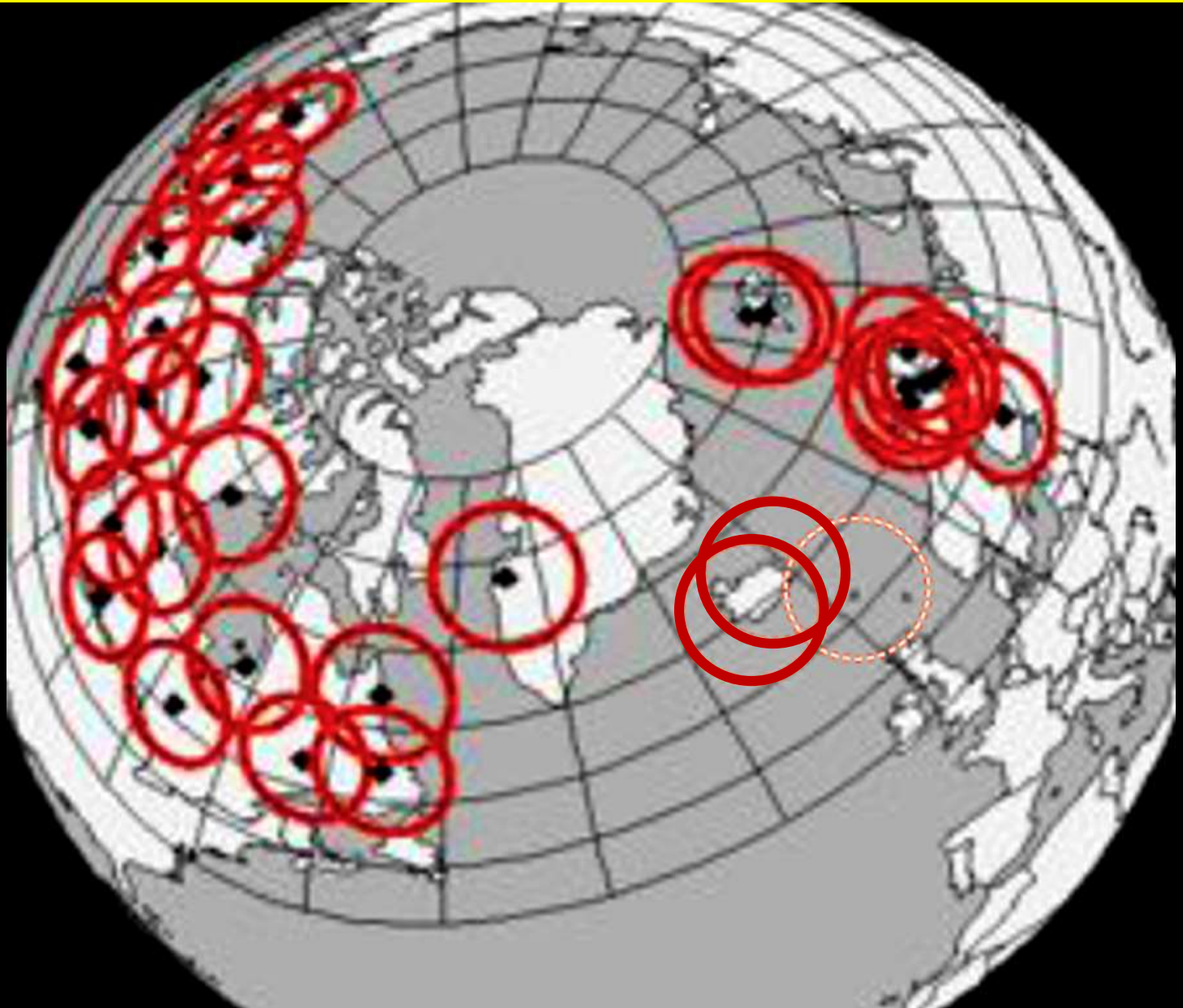


Equivalent current variation during auroral substorm

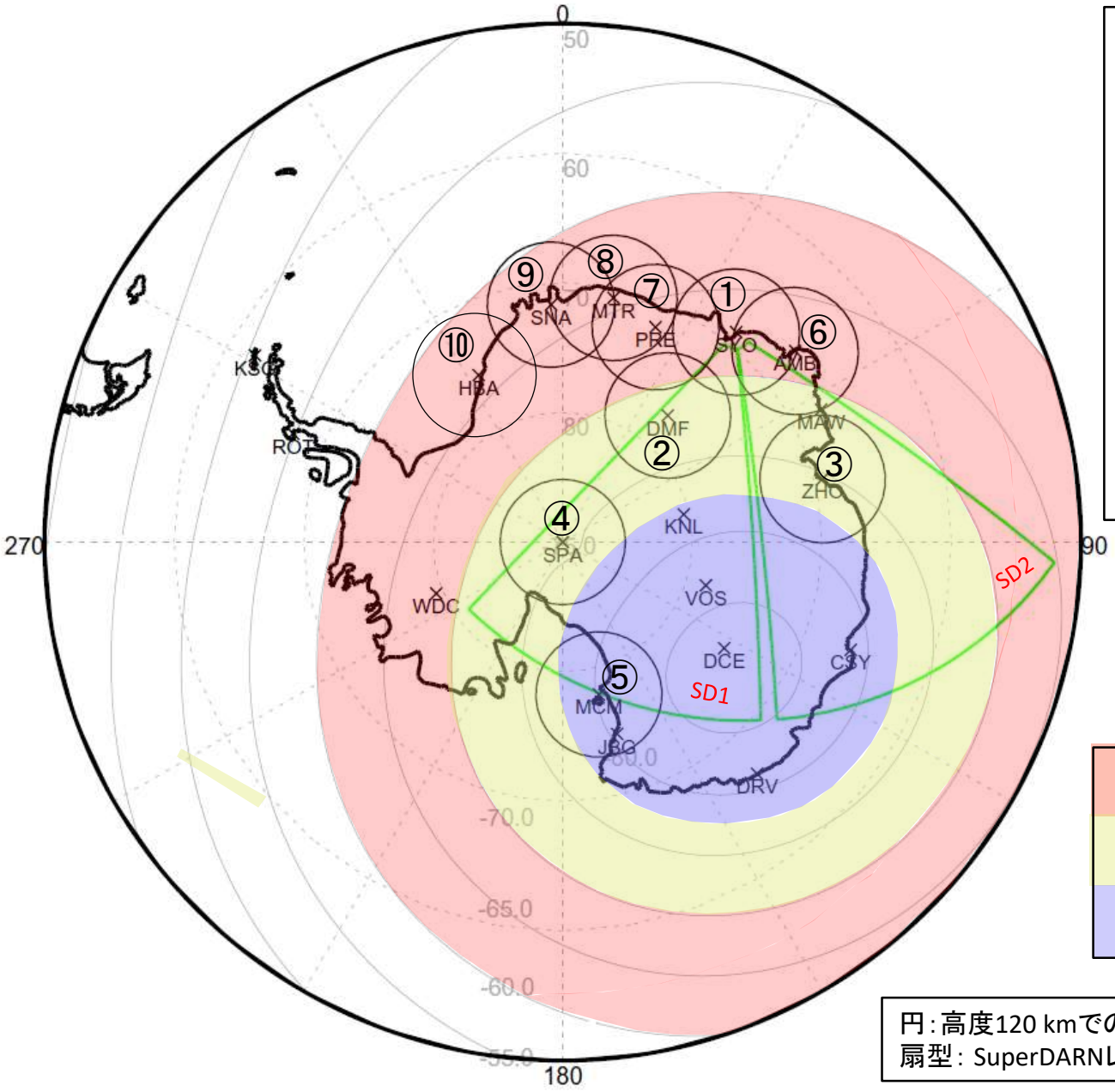
Growth phase to onset

Kadokura et al. (2002)

北半球のオーロラ観測点



南極域のオーロラ観測点



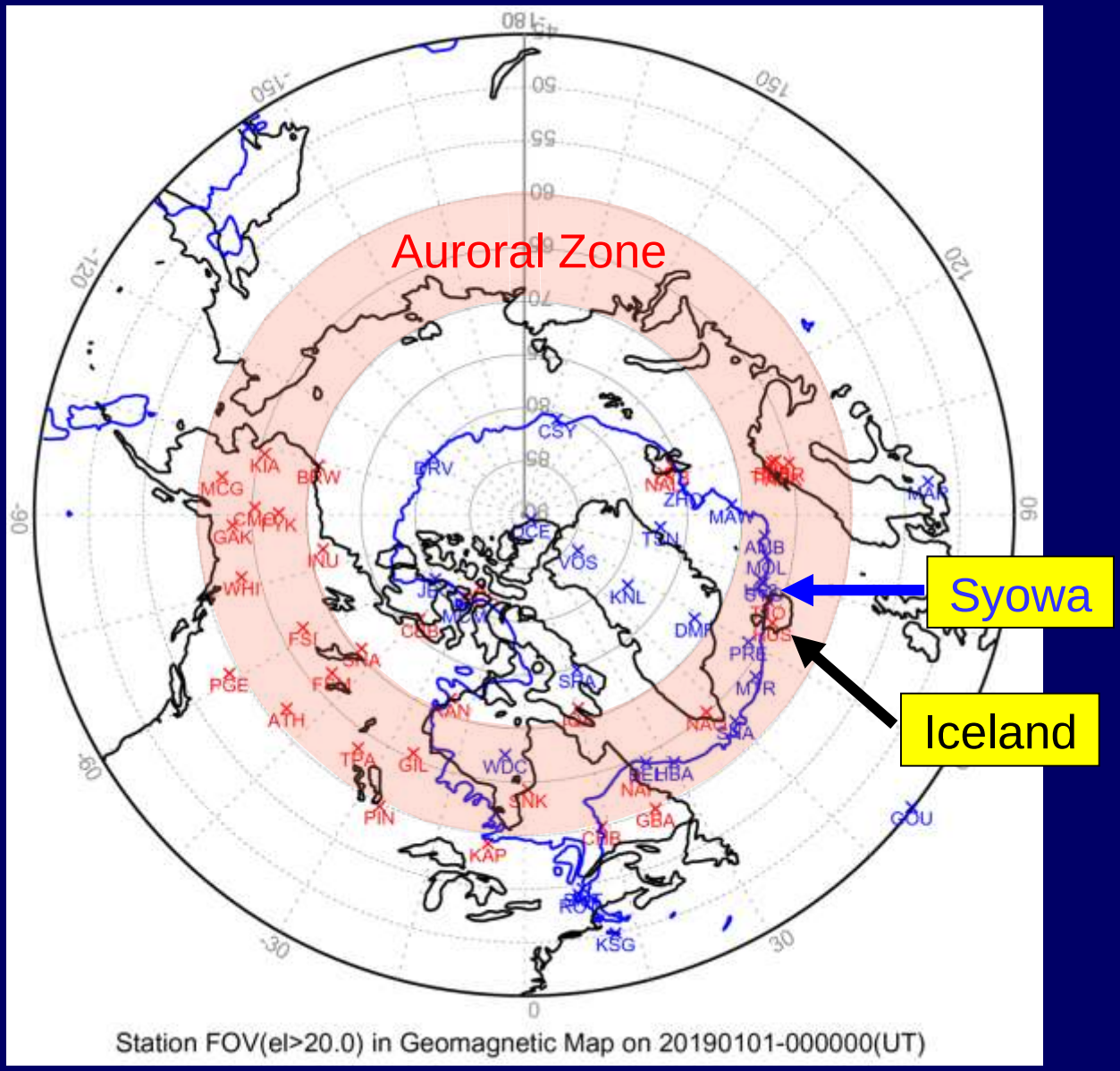
①昭和基地（日本）
②ドームふじ（日本）
③中山基地（中国）
④南極点基地（米国）
⑤マクマード基地（米国）
⑥アムンゼン湾（無人）
⑦プリンセスエリザベス基地（ベルギー）
⑧マイトリ基地（インド）
⑨サナエ基地（南ア）
⑩ハレー基地（英国）

オーロラ帯
境界領域
極冠域

円：高度120 kmでの全天カメラの視野（仰角10度以上）
扇型：SuperDARNレーダーの視野

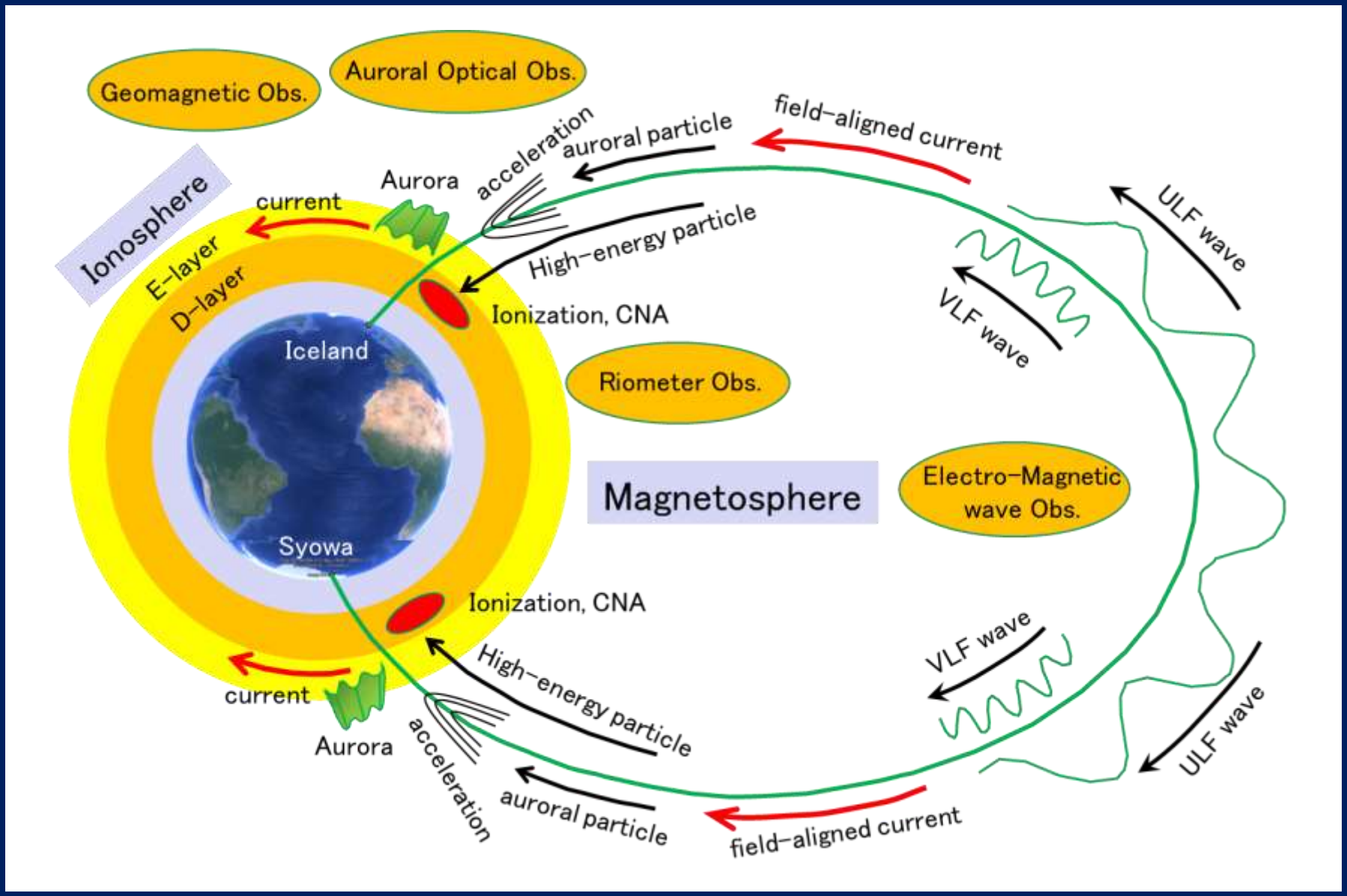
Syowa – Iceland Conjugate Observation for Auroral phenomena

Mapping on Geomagnetic coordinates

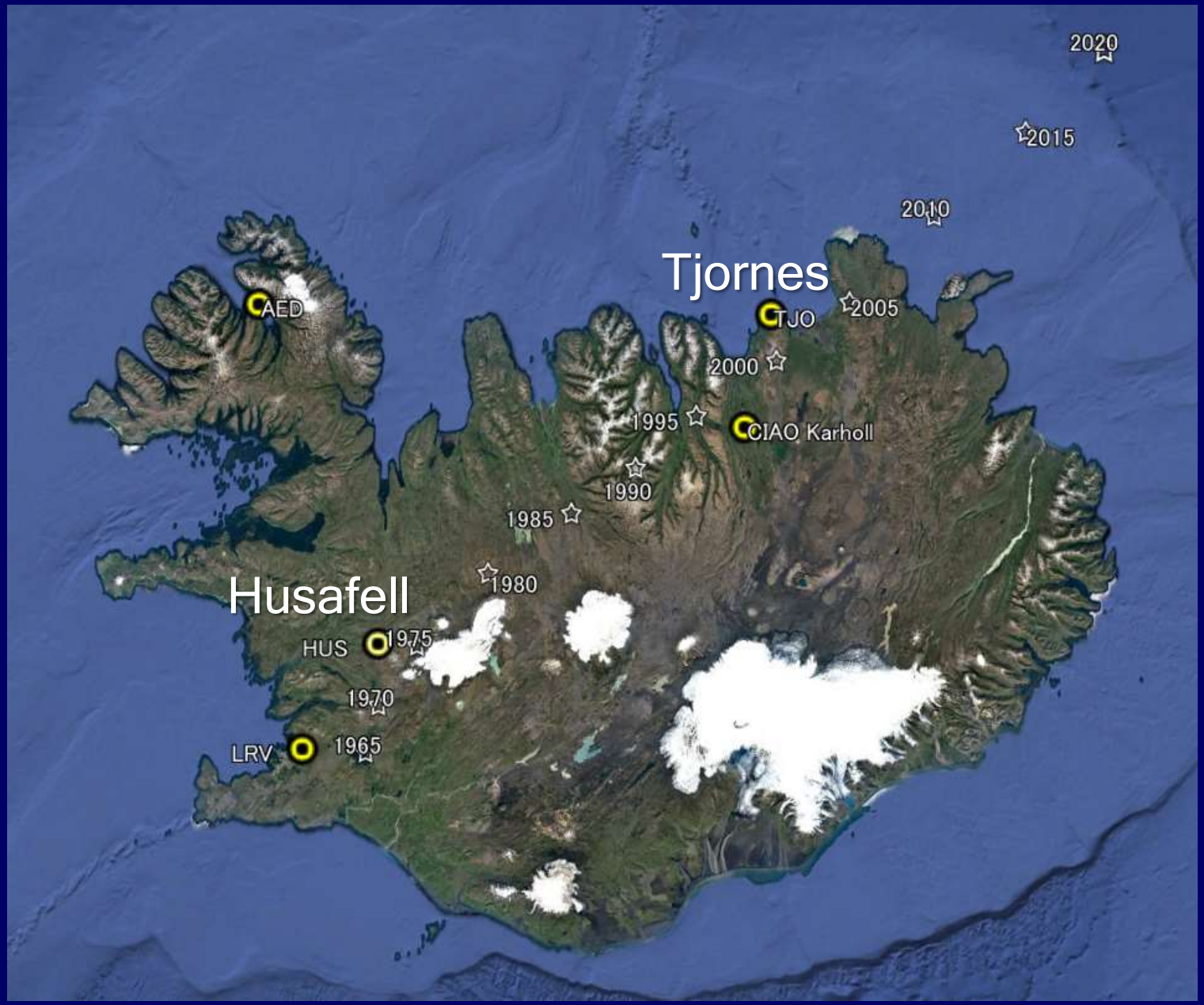


Iceland - Syowa Conjugate Observation for Auroral phenomena

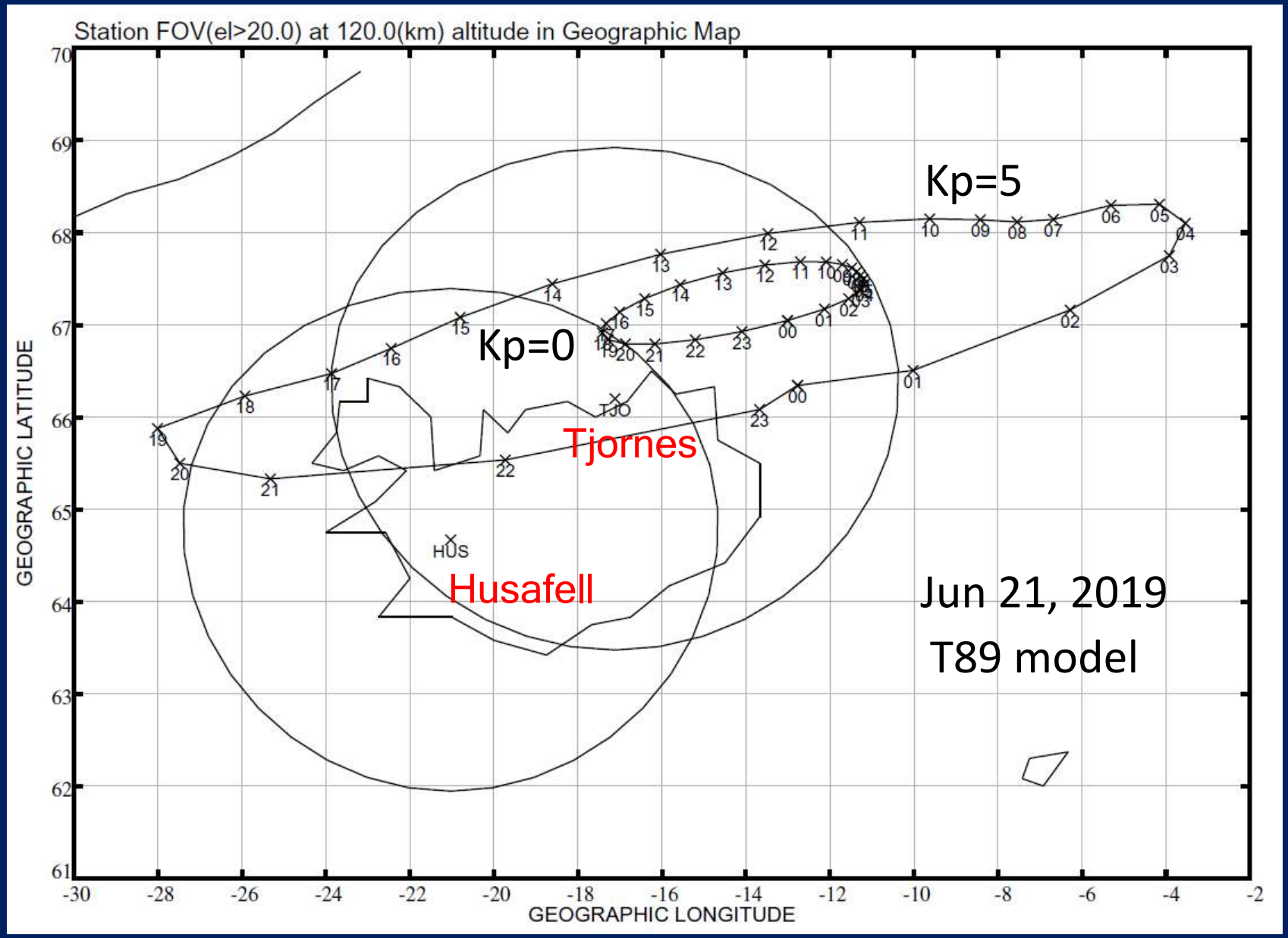
Long-term monitoring observation since 1983



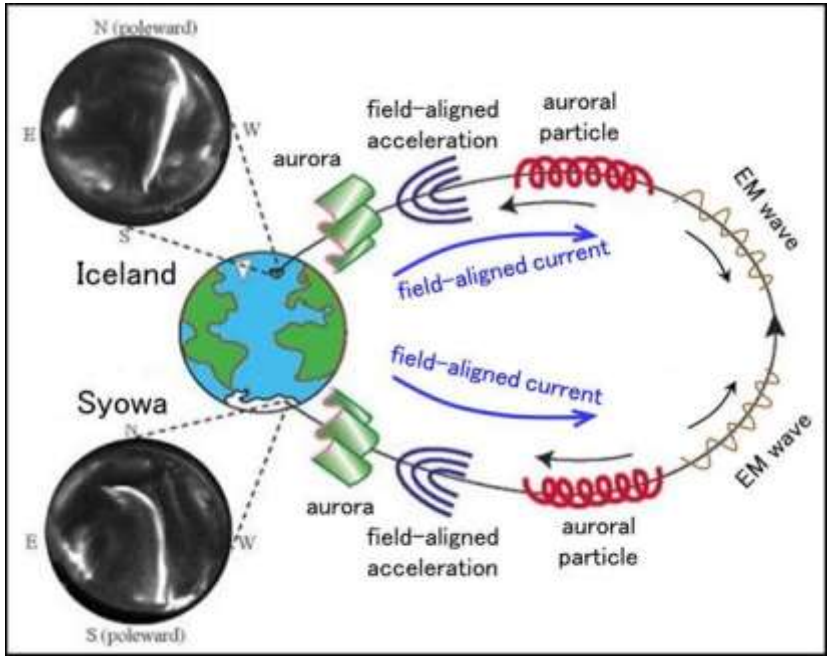
Conjugate point of Syowa Station in Iceland (IGRF)



Daily variation of Conjugate point of Syowa



Iceland-Syowa Auroral Conjugate Observation



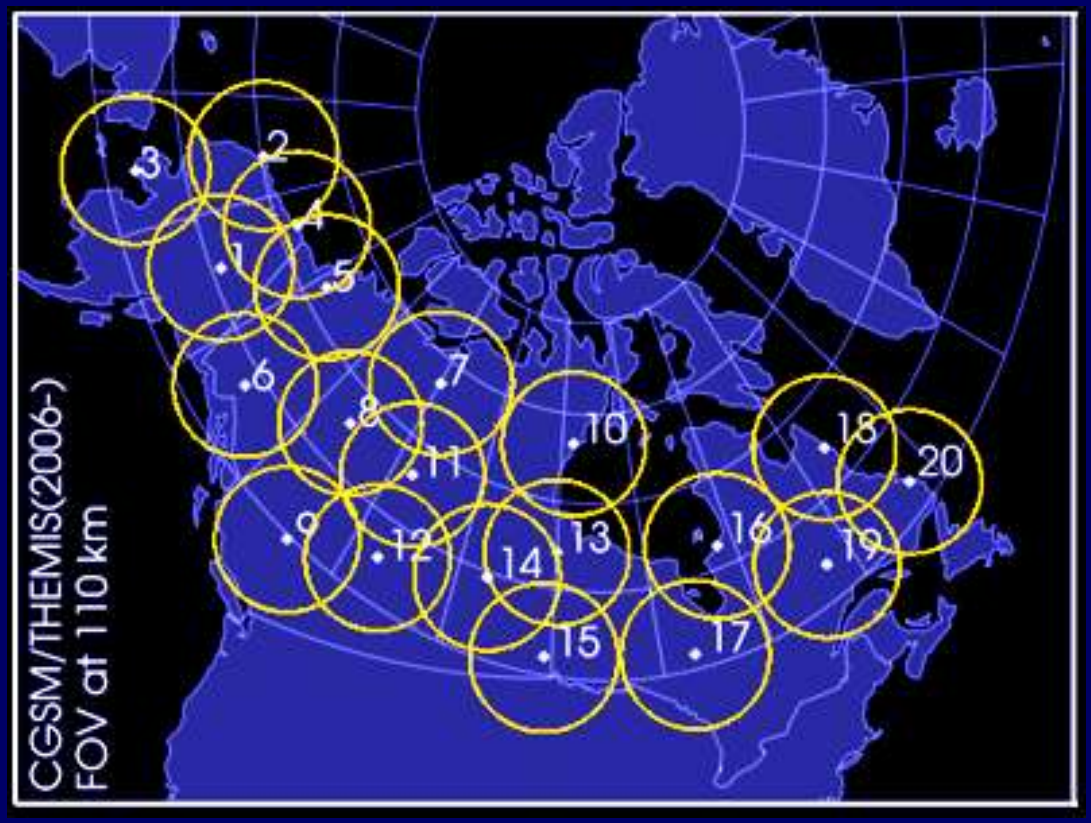
Husafell (HUS)

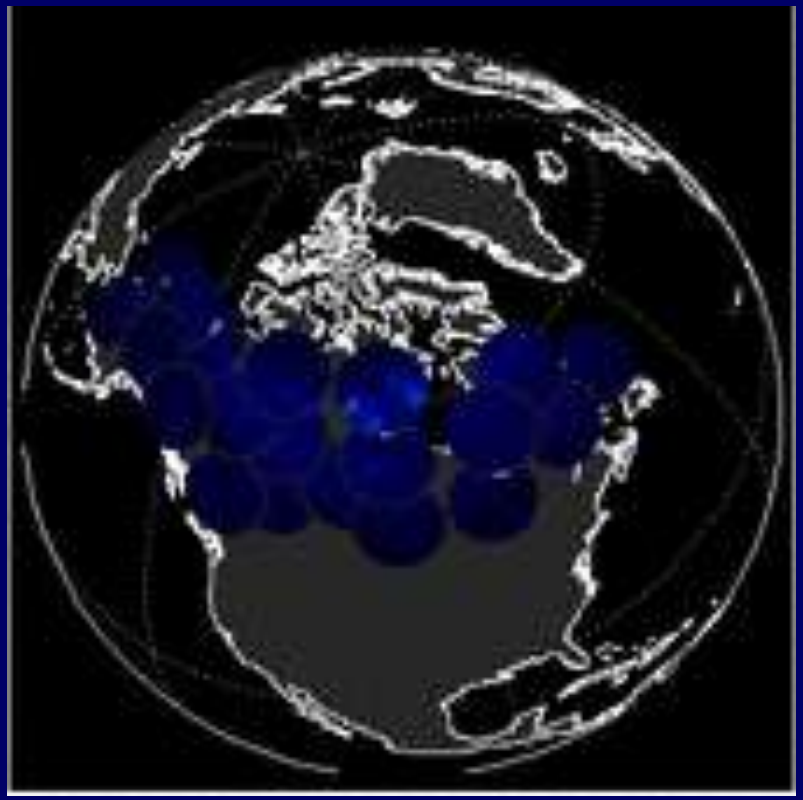
Tjornes (TJO)

Syowa Station (SYO) in Antarctica

- Collaboration between University of Iceland and NIPR, Japan Since 1983.
- Observations of Auroral Phenomena have been carried out at two sites in Iceland, Husafell (Augastadir) and Tjornes (Manarbakki)

THEMIS　地上観測ネットワーク
GBO (Ground Based Observatory)

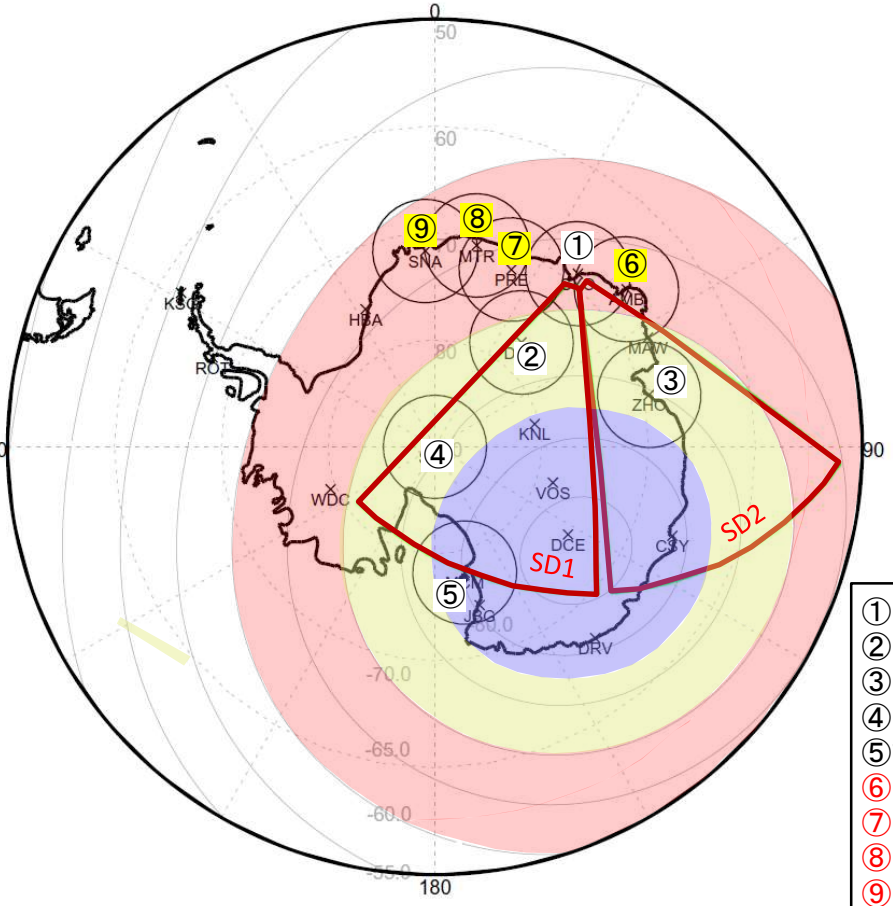




第Ｘ期重点研究観測　AJ1007
極冠域から探る宇宙環境変動と地球大気への影響

＜無人システムを利用したオーロラ現象の広域ネットワーク観測＞

オーロラ観測ネットワーク

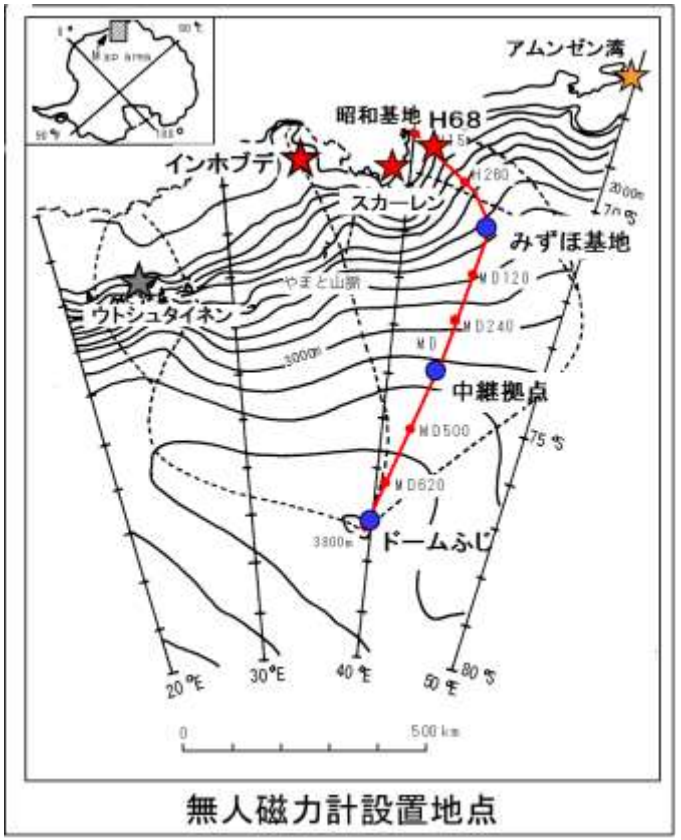


円や扇型：
高度120 kmでの全天カメラとSuperDARNレーダーの視野

オーロラ帯
境界領域
極冠域

① 昭和基地（日本）
② ドームふじ（日本）
③ 中山基地（中国）
④ 南極点基地（米国）
⑤マクマード基地（米国）
⑥ アムンゼン湾（無人）
⑦ ベルギー基地（無人）
⑧ マイトリ基地（インド）
⑨ サナエ基地（南ア）

無人磁力計ネットワーク

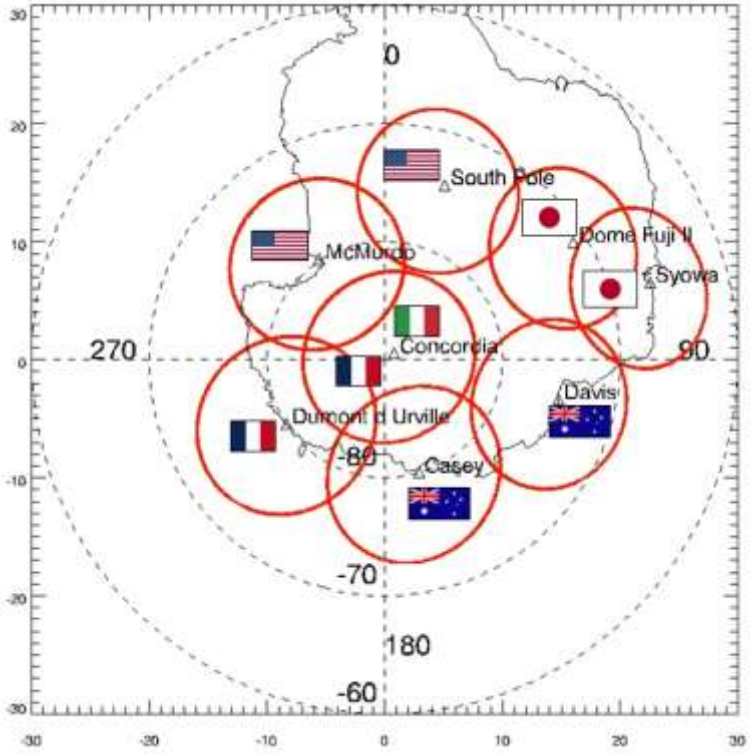


無人磁力計設置地点

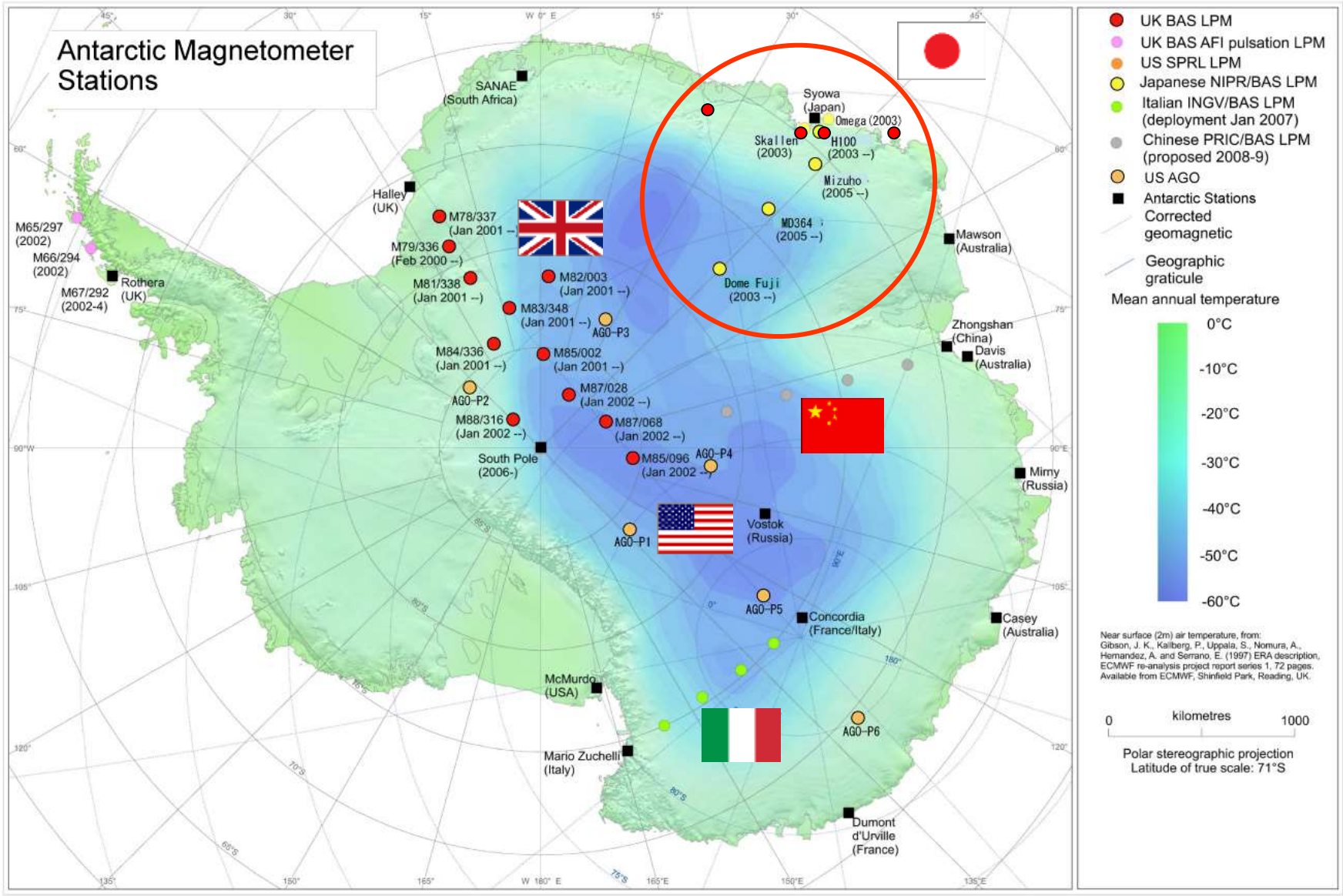
第Ｘ期重点研究観測　AJ1007
極冠域から探る宇宙環境変動と地球大気への影響

代表者：片岡龍峰（極地研）

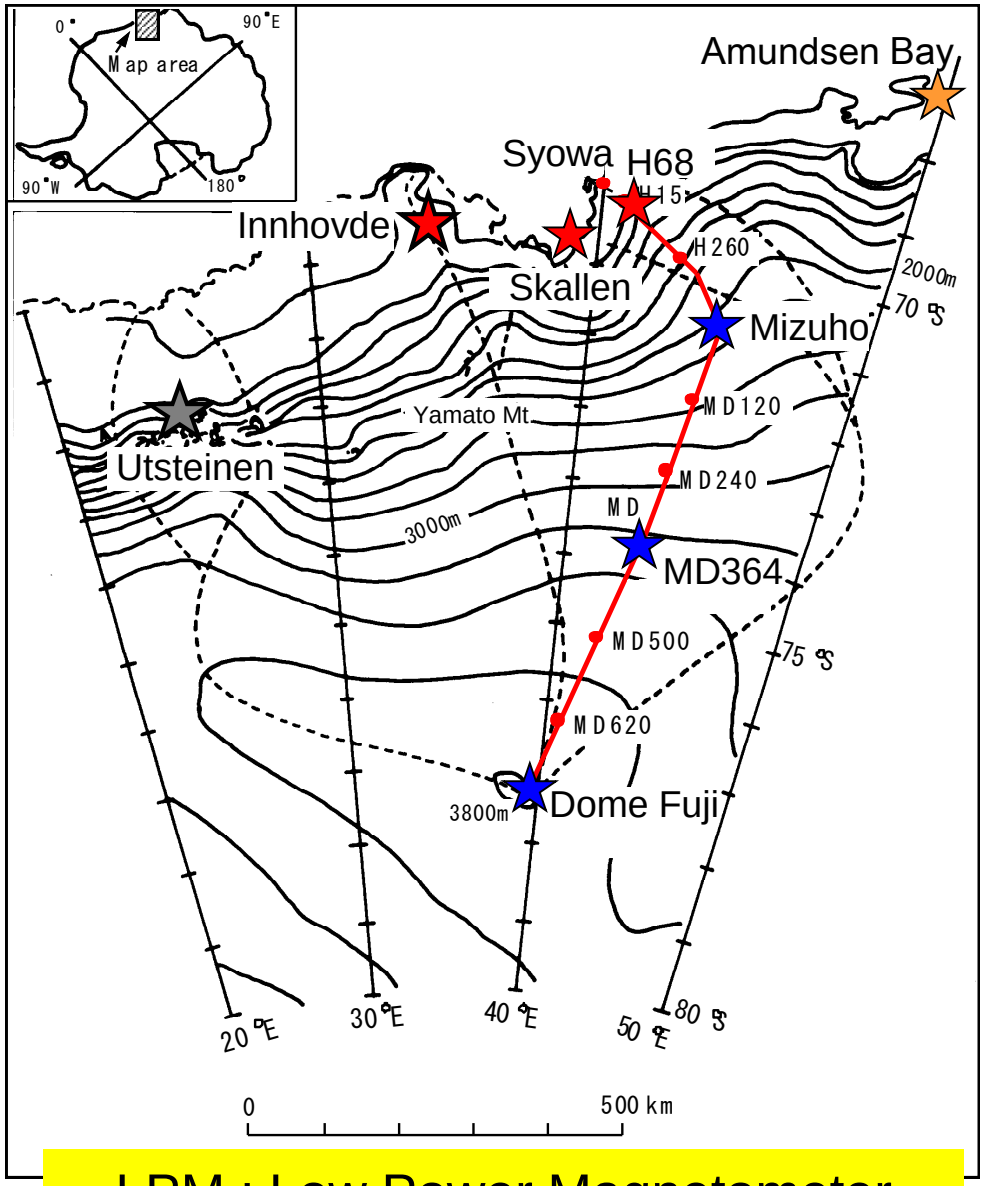
https://polaris.nipr.ac.jp/~aurorax/index.html



Unmanned Magnetometer Network in Antarctica



Unmanned Magnetometer Network in JARE



LPM : Low Power Magnetometer

NIPR-LPM sites

H68 [69˚11' 32.2”S, 41˚03’ 1.3"E]

Skallen [69˚40' 21“S, 39˚24’ 07”E]

Amundsen Bay [66˚47’44.2”S, 50˚34’ 37.9”E]

Innhovde [69˚51’21.3”S, 37˚06‘31" E]

Utsteinen [71˚55' 51"S, 23˚19’52"E]
（terminated：Feb. 2, 2018）

BAS-LPM sites

Mizuho [70˚42’5.6“S, 44˚16’47.2"E]

MD364 [74˚00’37.0"S, 42˚59’30.4"E]

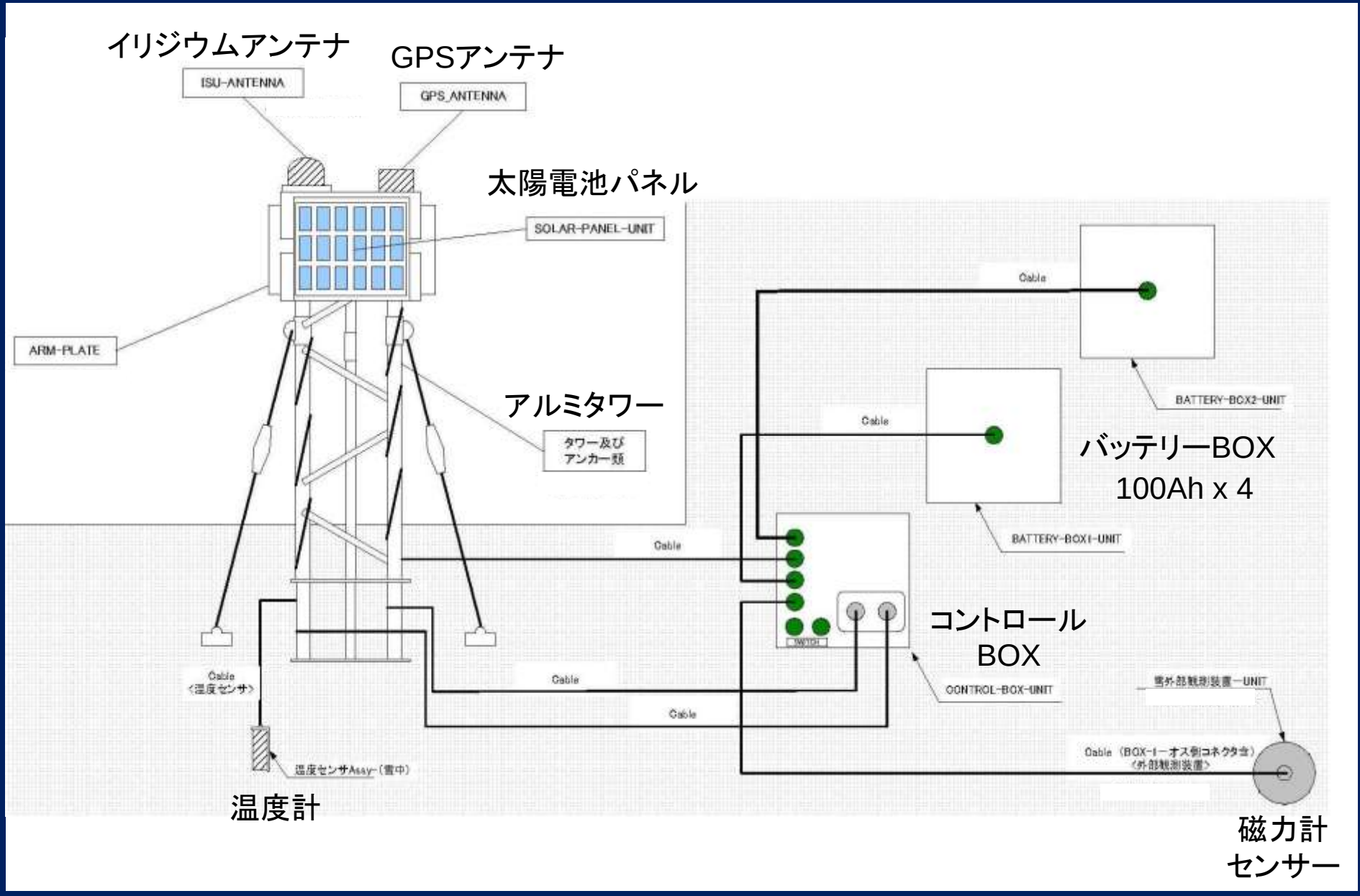
Dome Fuji [77˚19'01.6"S, 39˚42’31.7"E]

Site Name	Latitude	Longitude	Altitude (m)	Start day	Type
Amundsen Bay	-66˚ 47' 44"	50˚ 34' 38"	37	2008.02.25	NIPR
H68	-69˚ 11' 32"	41˚ 03' 01"	1,175	2010.02.09	NIPR
Skallen	-69˚ 40' 21"	39˚ 24' 07"	11	2007.01.03	NIPR
Innhovde	-69˚ 51' 21"	37˚ 06' 31"	57	2010.02.05	NIPR
Mizuho	-70˚ 42' 06"	44˚ 16' 47"	2,250	2004.10.18	BAS
MD364	-74˚ 00' 37"	42˚ 59' 30"	3,353	2004.10.29	BAS
Dome Fuji	-77˚ 19' 02"	39˚ 42' 32"	3,783	2003.02.06	BAS

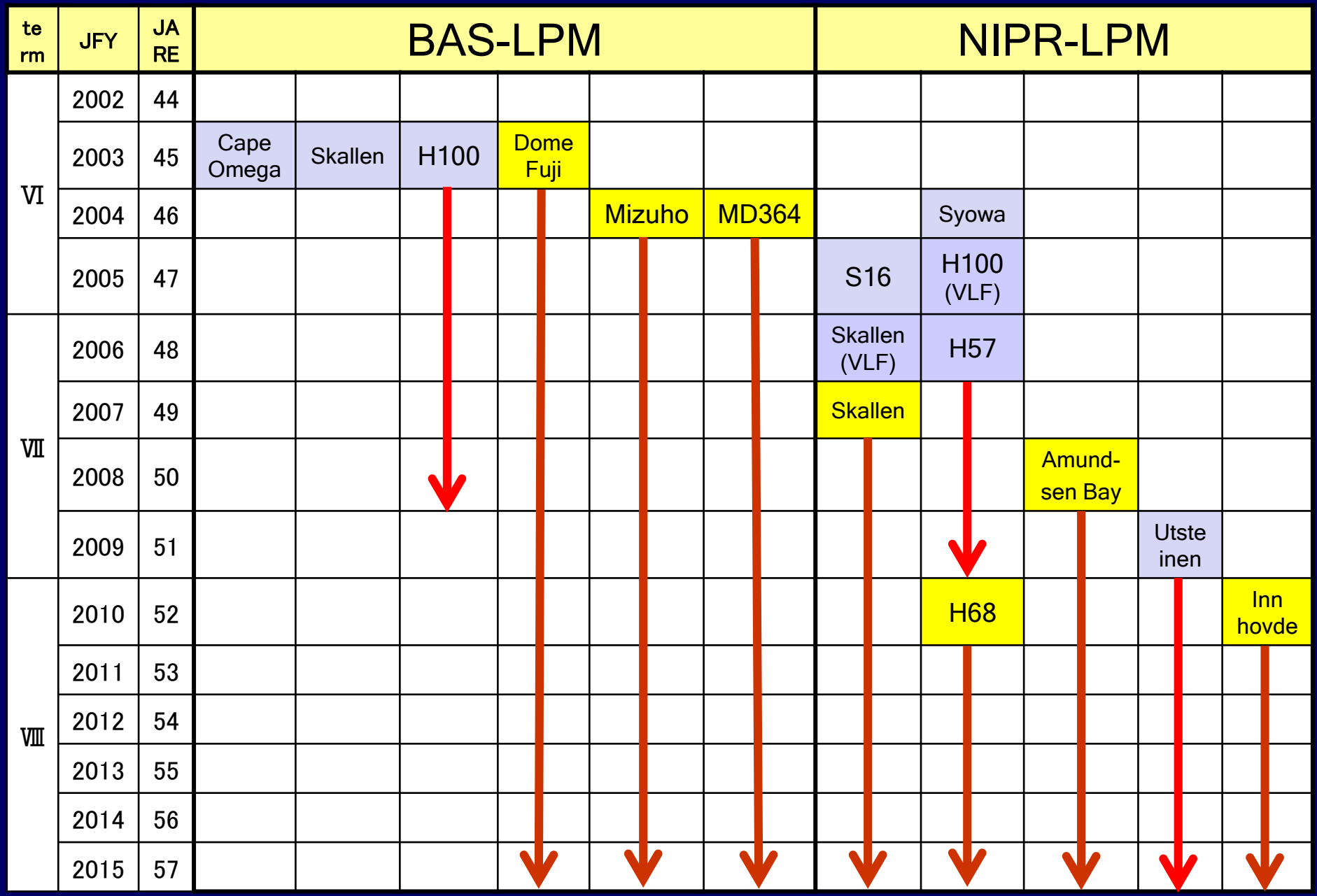
BAS type and NIPR type

	BAS-LPM	NIPR-LPM
Magnetometer	MAG-03MC	MAG-03MC
Resolution	16 bit	16 bit
Noise level	1 nT	0.2 nT
Low Pass Filter	100 Hz	15 Hz
Power consumption (1 sec sampling)	0.42 W	0.16 W
Data acquisition	Flash memory card	Iridium satellite Flash memory card
Command sending	×	○

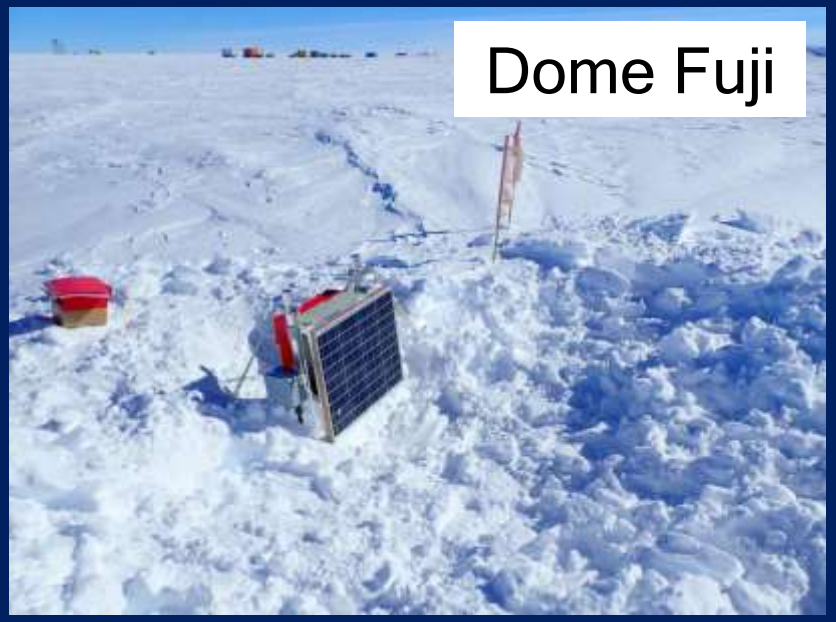
極地研型無人磁力計の構成



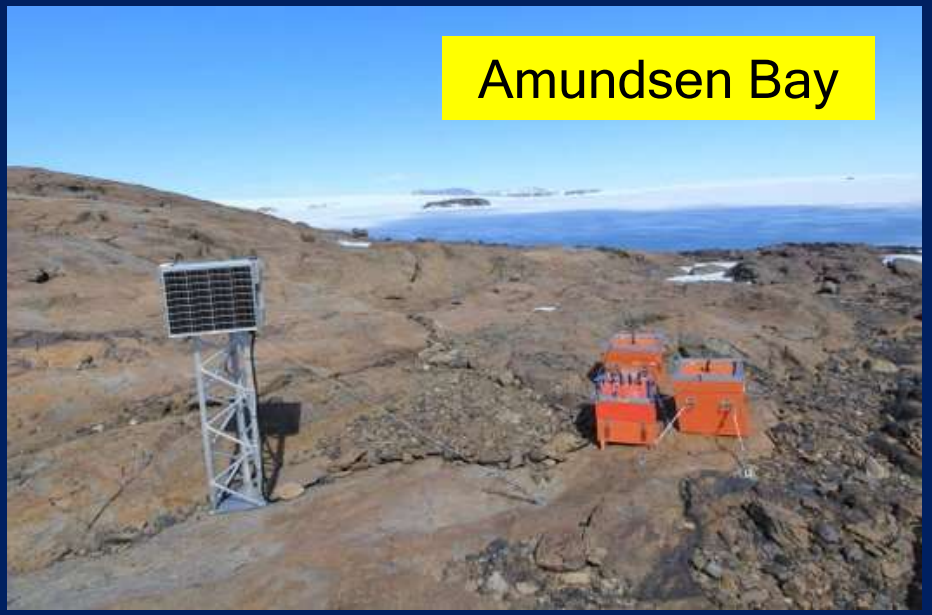
Unmanned magnetometer network observation in JARE



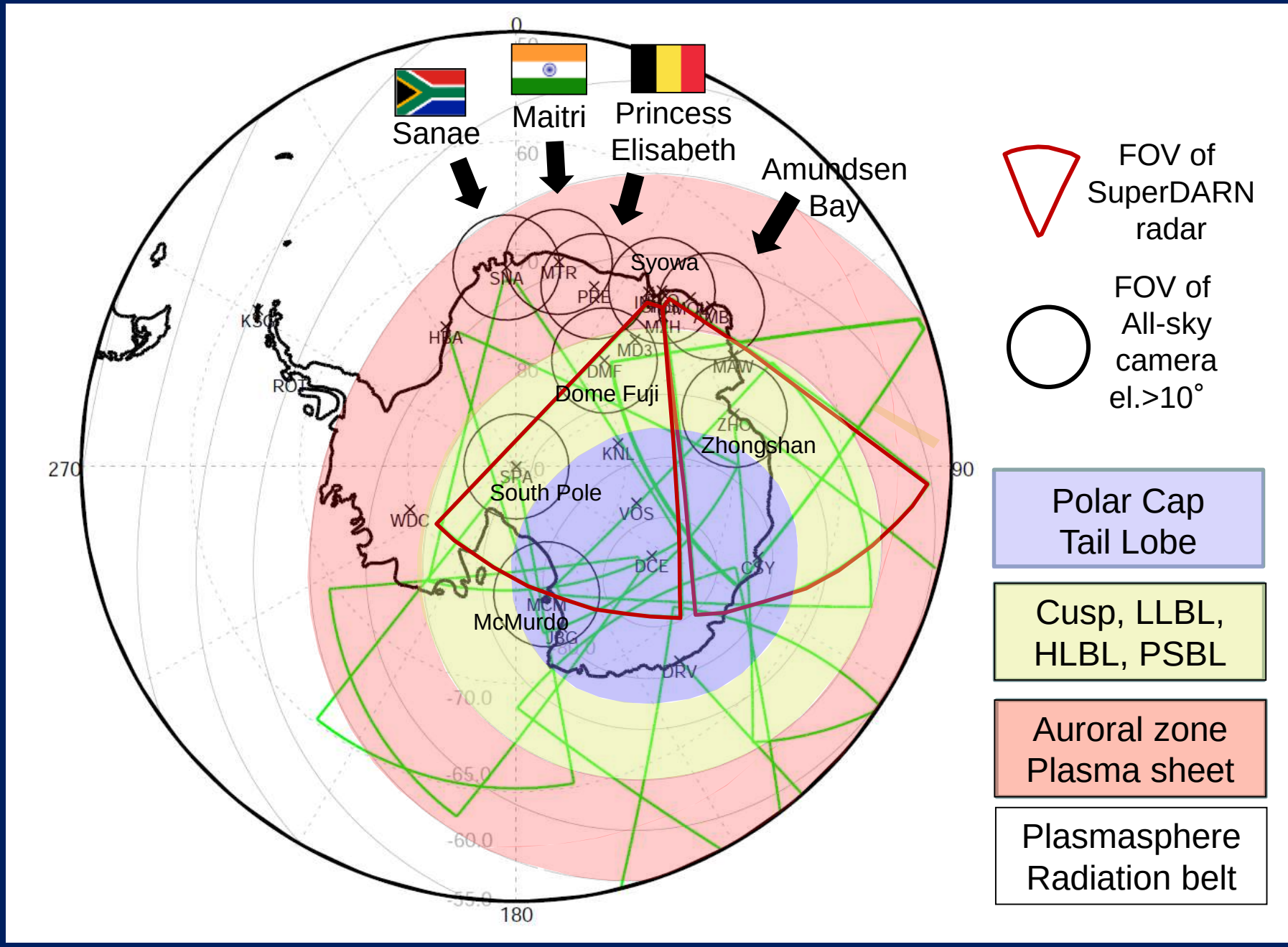
BAS type Low Power Magnetometer in JARE



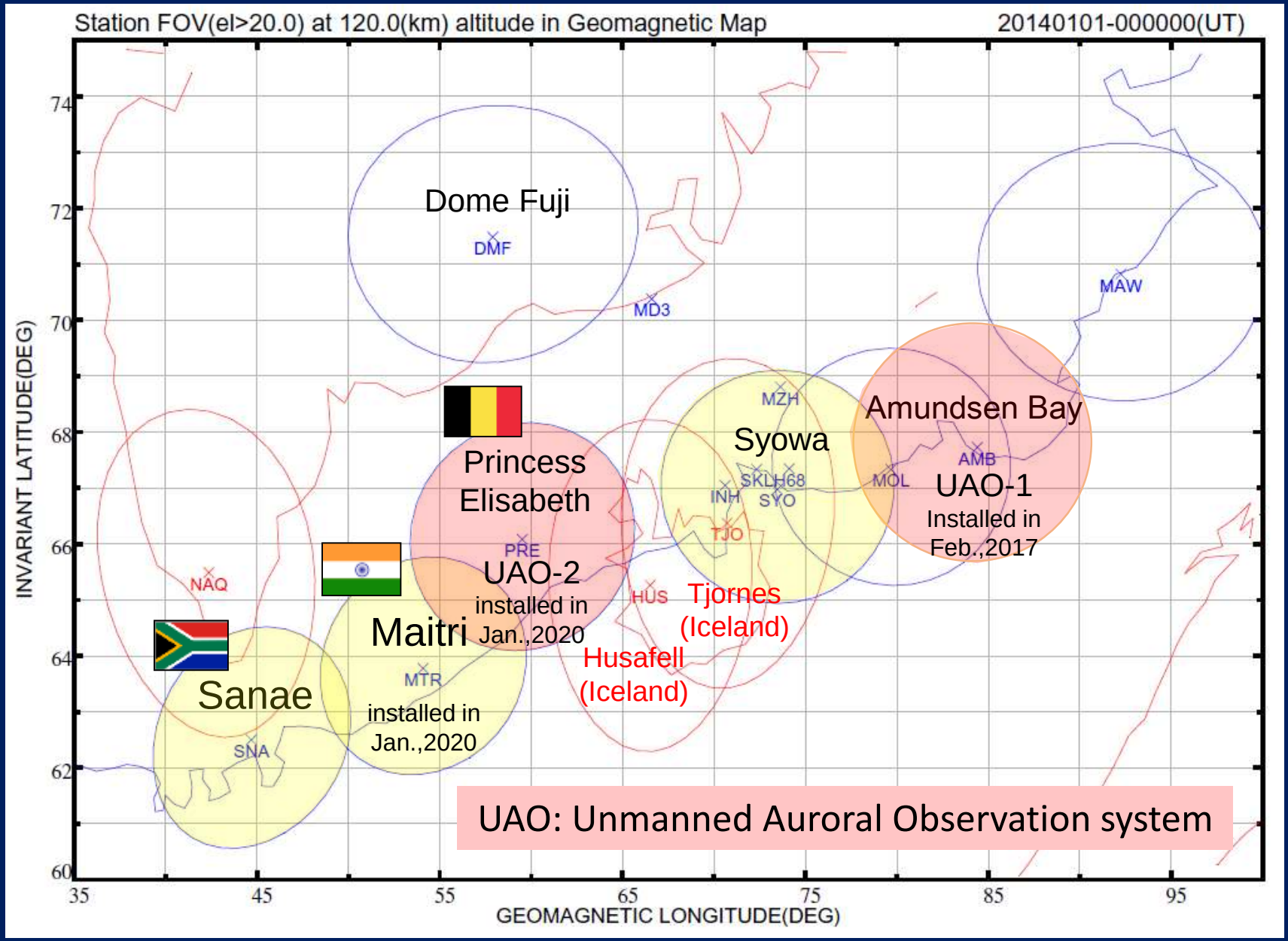
NIPR type Low Power Magnetometer



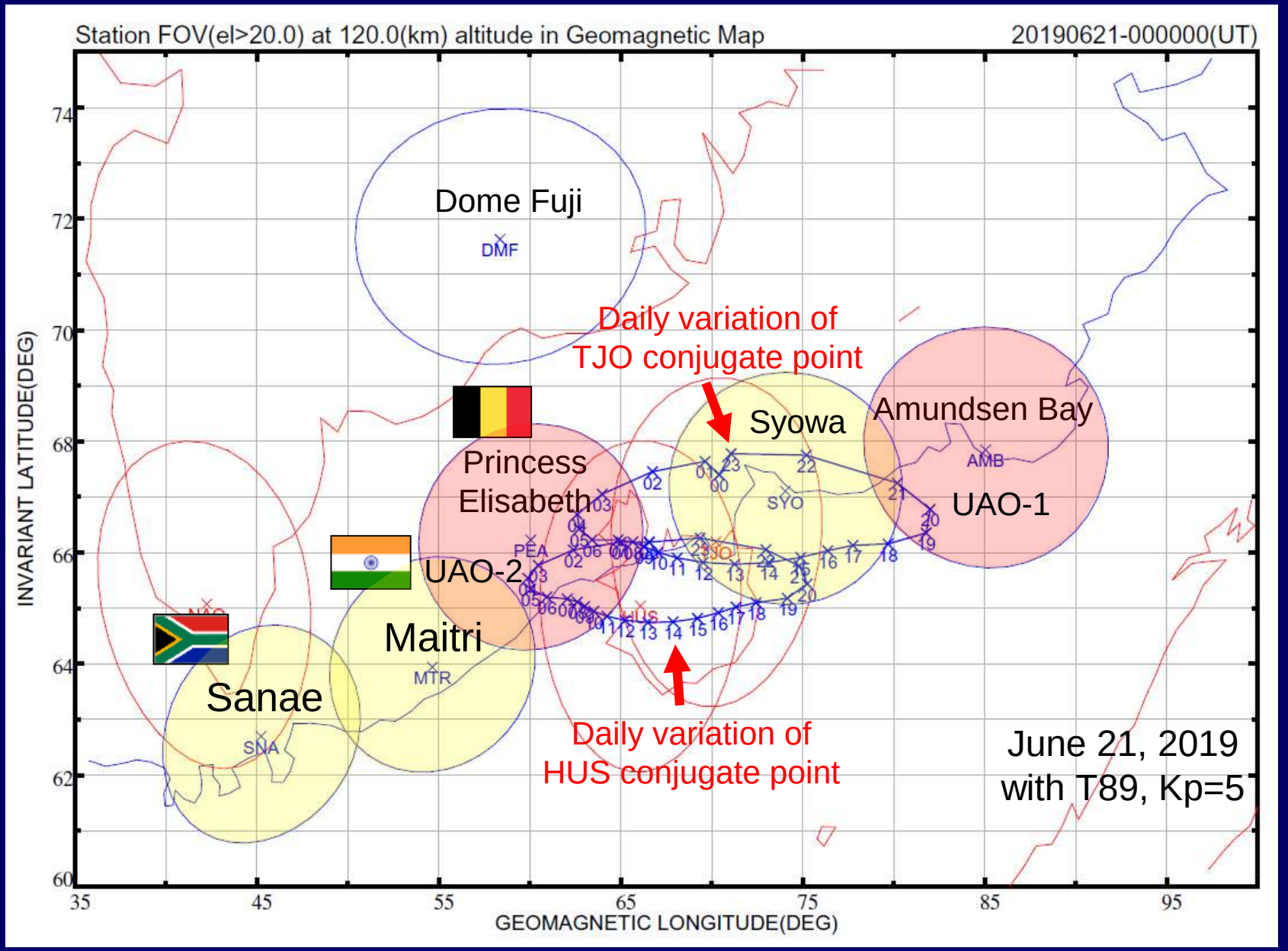
Antarctic Auroral Observation network using unmanned system



Auroral conjugate observation network using unmanned system



Auroral conjugate observation network using unmanned system



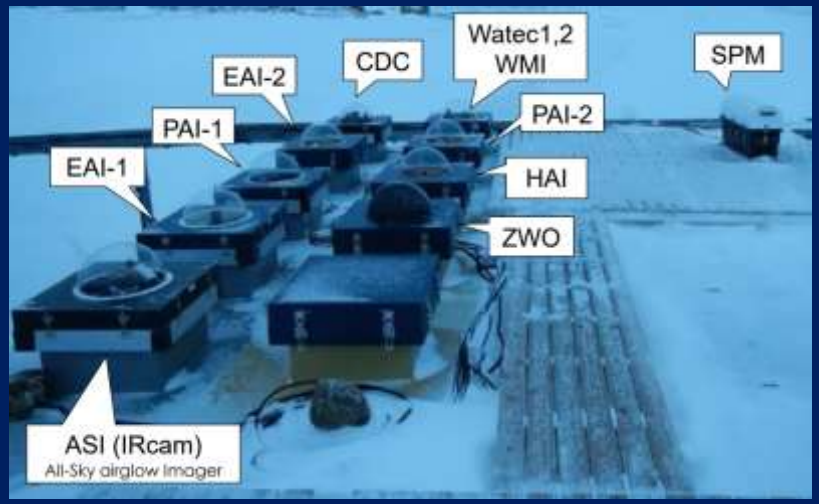
Station & Instrument List (Geomagnetic parameter Epoch: 2022/01/01 00 UT)

Station name	Code	Glat (deg)	Glon (deg)	Alt (km)	Inv.lat (deg)	Mlon (deg)	MLT at 0UT (hr)	Instrument	Responsible organization
Amundsen Bay	AMB	-66.80	50.58	0.037	67.42	84.30	0.45	UAO-1: Watec(B&W), GNSS/TEC, FMAG	NIPR
Syowa	SYO	-69.00	39.58	0.029	66.66	73.49	23.73	WMI(42,55,48, B&W), PAI(39,55,63,67), FMAG, IMAG, RIO, IRIO, VLF, GNSS/TEC	NIPR
Princess Elisabeth Antarctica	PEA	-71.95	23.35	1.300	65.81	59.73	22.81	UAO-2: Watec(B&W), GNSS/TEC, FMAG	International Polar Foundation
Maitri	MTR	-70.77	11.74	0.130	63.54	54.40	22.46	WMI(color, B/W, 55, 63), FMAG, IMAG, IRIO, VLF, GPS/TEC	Indian Institute of Geomagnetism
Sanae	SNA	-71.67	-2.84	0.850	62.34	45.05	21.83	FMAG, RIO, IRIO, VLF, GPS/TEC	South African National Space Agency
Unmanned magnetometer 4 sites	Skallen H68 Innhovde AMB	-69.67 -69.18 -69.86 -66.80	39.40 41.05 37.11 50.58	0.011 1.175 0.057 0.037	67.028 67.037 66.742 67.422	72.367 74.152 70.677 84.296	23.654 23.773 23.541 0.449	FMAG	NIPR
Tjornes	TJO	66.20	-17.12	0.011	65.94	69.06	23.43	ASI(B&W), FMAG, IMAG, RIO	NIPR University of Iceland
Husafell	HUS	64.67	-21.03	0.150	64.74	64.96	23.16	ASI(B&W), FMAG, IMAG, RIO, IRIO, VLF	NIPR University of Iceland

Deployment History

JARE term	Year	JARE winter	UAO-1 at Amundsen Bay	UAO-2 at PEA Station	Maitri	Sanae
Ⅷ	2013	54	Development in Japan			
	2014	55	Development in Japan			
	2015	56	Development in Japan			
Ⅸ	2016	57	Test operation at Syowa	Development in Japan		
	2017	58	Installation at AMB in Feb.	Development in Japan		
	2018	59	Operation continue Maintenance at AMB in Feb.	Development in Japan		
	2019	60	Operation continue Maintenance at AMB in Feb.	Development in Japan		
	2020	61	Operation continue	Install at PEA in Jan.	Install at MAI in Jan.	
	2021	62	Operation continue	Stop on Feb.14 (system trouble)	Continue	
Ⅹ	2022	63	Operation continue Maintenance at AMB in Feb.	Jan.22 - Feb.21 (system trouble) Restart from Nov.26	Continue	Preparation
	2023	64	Operation continue	Stop on Apr.26 (system trouble) Restart on Nov.19	Continue	Preparation
	2024	65	Operation continue Maintenance at AMB in Feb.	Continue	Continue	Install during Dec. – Jan.
	2025	66	Continue	Continue	Continue	Continue
	2026	67	Continue	Continue	Continue	Continue

Auroral instruments at Syowa Station

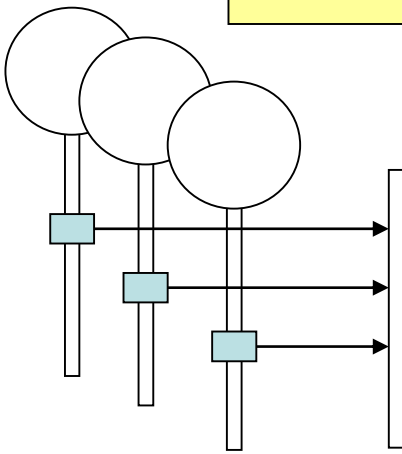


UAO-1 at Amundsen Bay

AIS (Auroral Imager System) at Maitri Station

UAO-2 at Princess Elisabeth Antarctica Station

UAO-1 at Amundsen Bay



Wind Generators
FM910: 192W x 3

Solar Panels
62W x 8, 17.4V,40A

Charge Control

Battery Box

12V,100Ah x 10

WAT-910HX

Aurora camera

Explorer 500

Inmarsat BGAN

Zephyr Rover Ⅱ

GNSS Antenna

Video Encoder

AXIS Q7411
320x240
1Hz

- HK data
- Aurora: Keogram 5min, 160x120
- Mag:1sec
- GNSS:30sec

GNSS Board

Trimble BD982
TEC 30sec

Fluxgate Magnetometer

Tierra Tecnica
SCM-3ADN & Mag-03TB
3-axis, ±70000nT, 0.01nT
1Hz sampling

Intrerface unit

Power Control Unit

Central Control Unit
(RCL: Remote Control Logger)

House Keeping data logger

Temperature

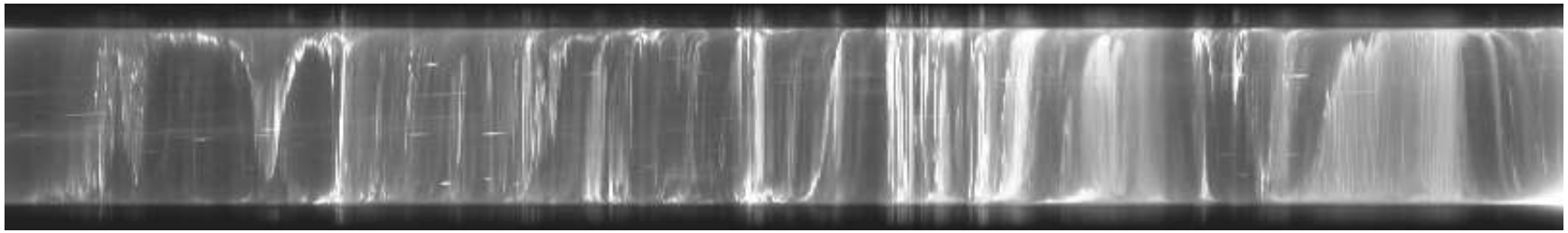
Generator and battery status

Total Power Consumption:
Camera ON: 18W
Camera OFF: 14W

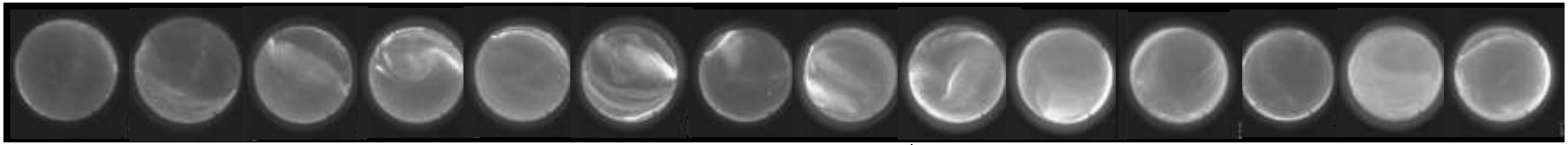
UAO-1 test operation at Syowa Station
in 2016 by JARE-57

UAO-1 data in 2016 obtained by the Inmarsat satellite link system

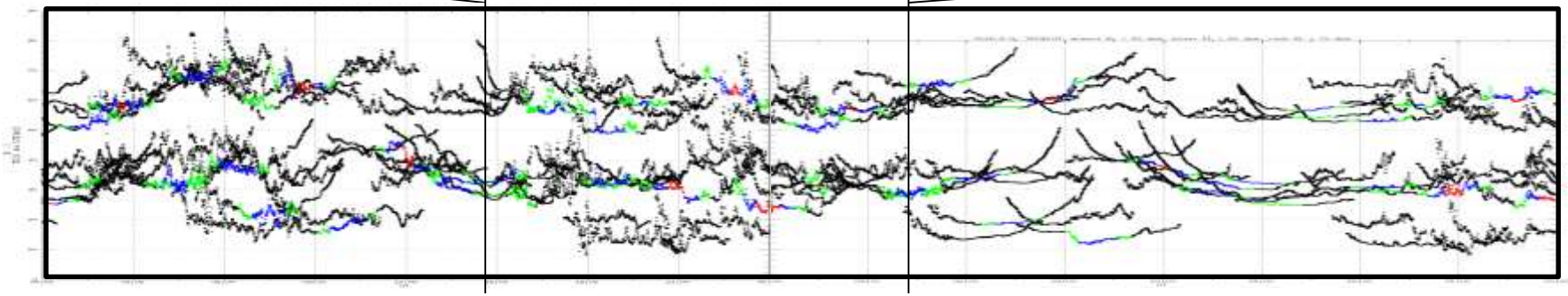
8-9 May, 2016 Watec all-sky imager data



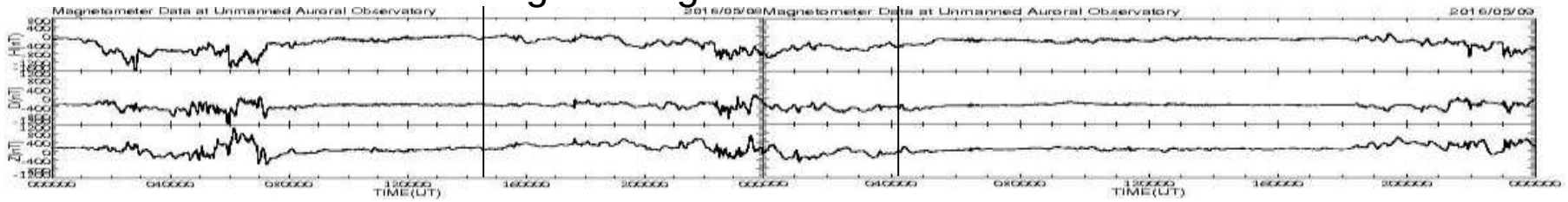
14:45 TIME (UT) 04:15



GNSS TEC data

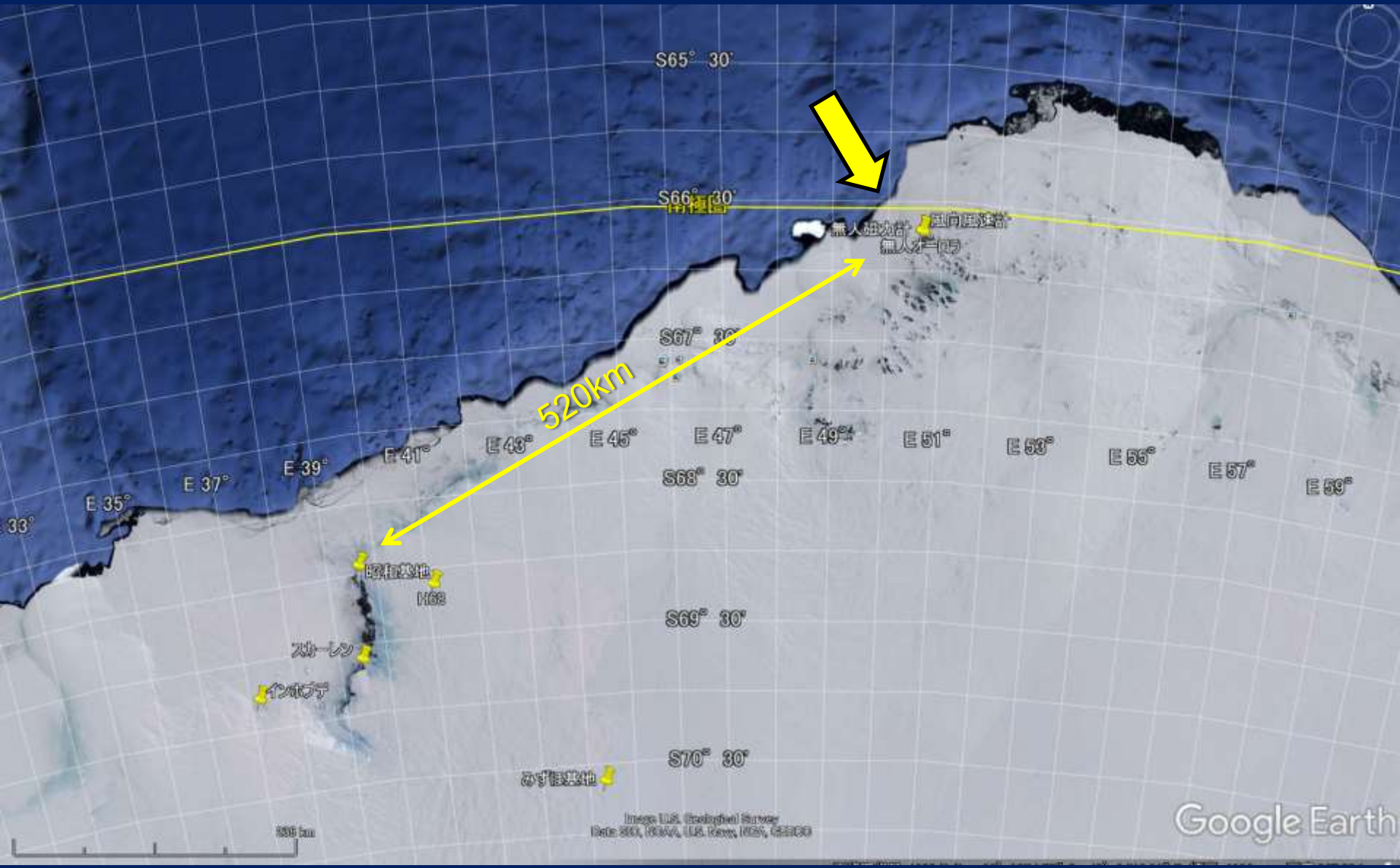


Fluxgate magnetometer data



00:00 8 May 00:00 9 May 00:00

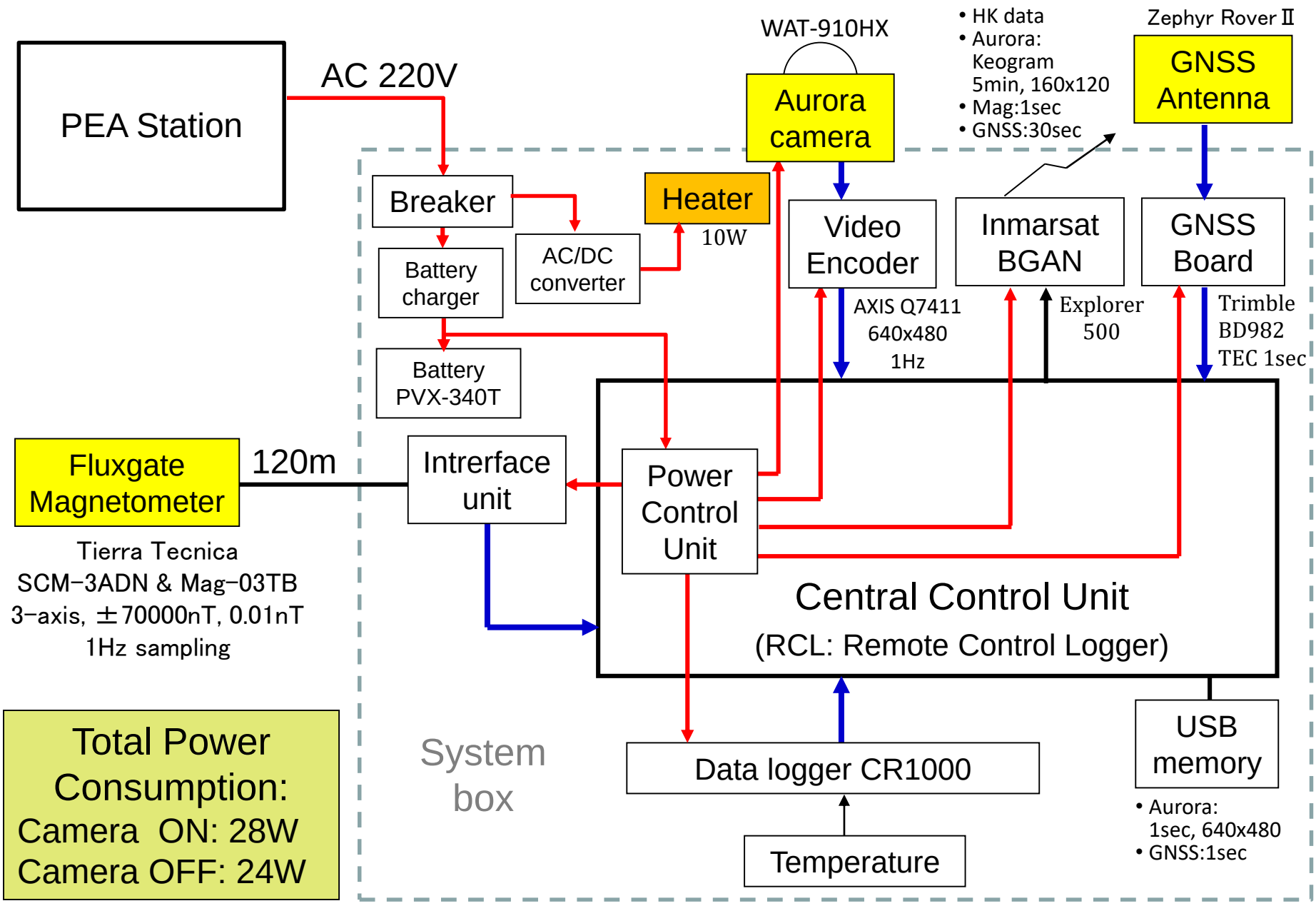
アムンゼン湾　宙空無人サイト



UAO-1 installation at Amundsen Bay

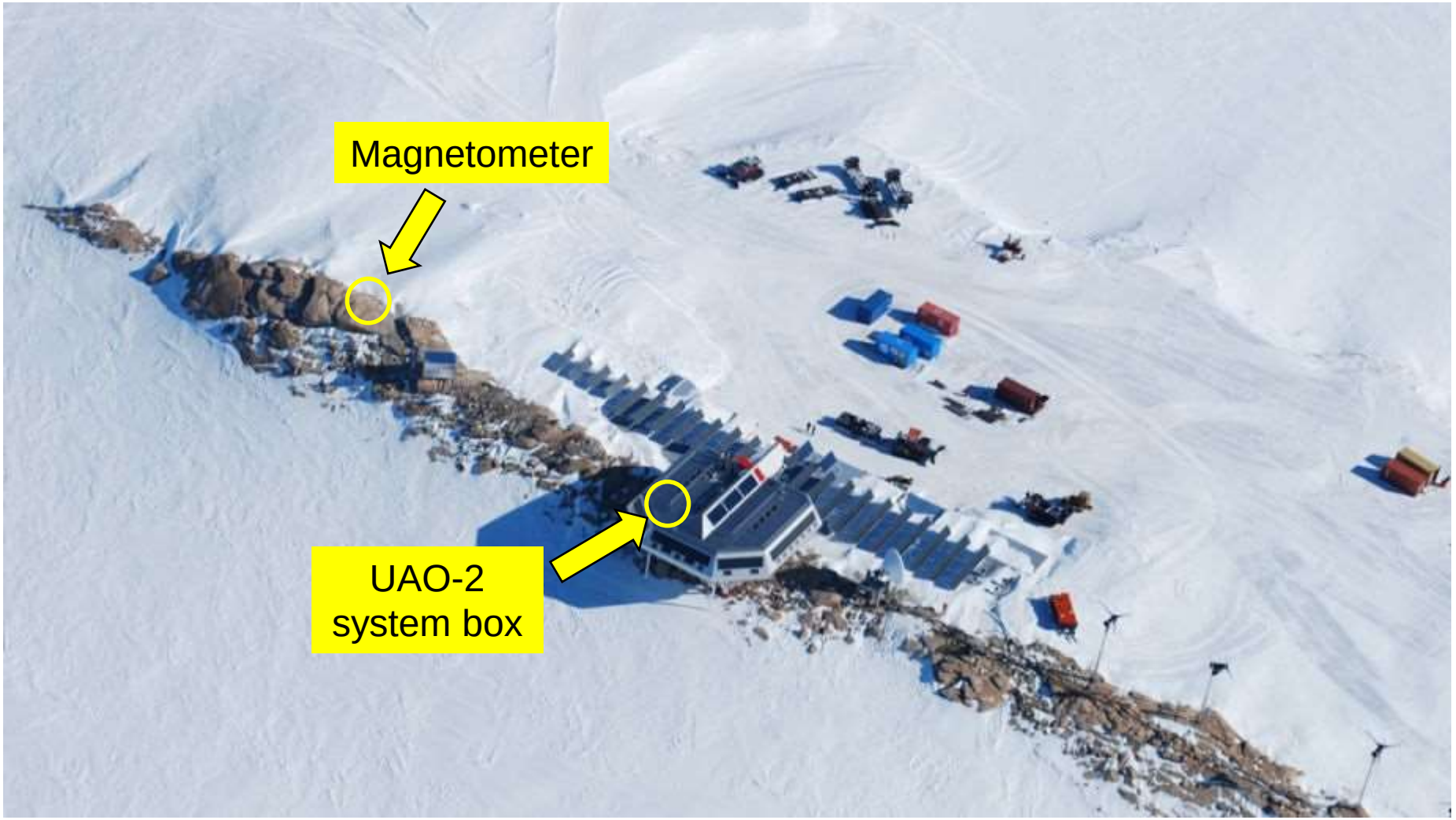
in Feb. 19,23,24, 2017 by JARE-58 & 57

UAO-2 at Princess Elisabeth Antarctica Station

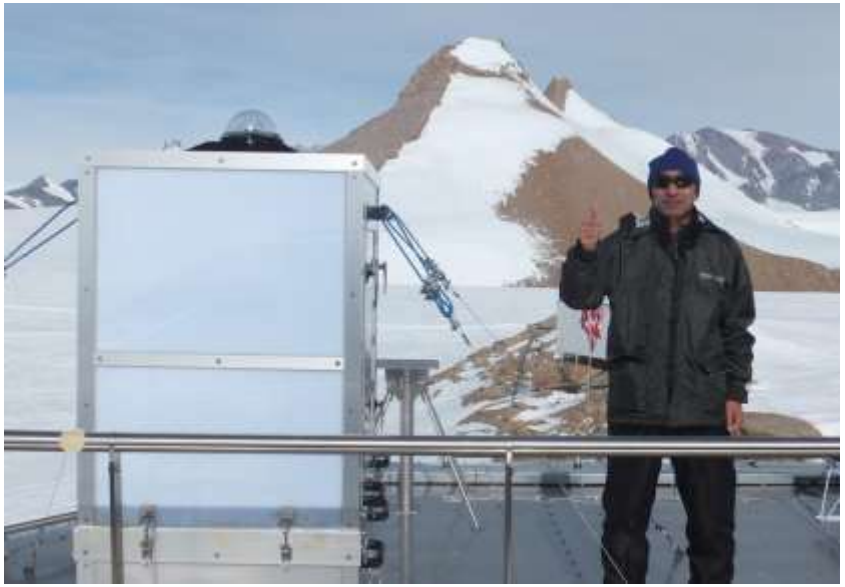


Unmanned Auroral Observation system (UAO-2)

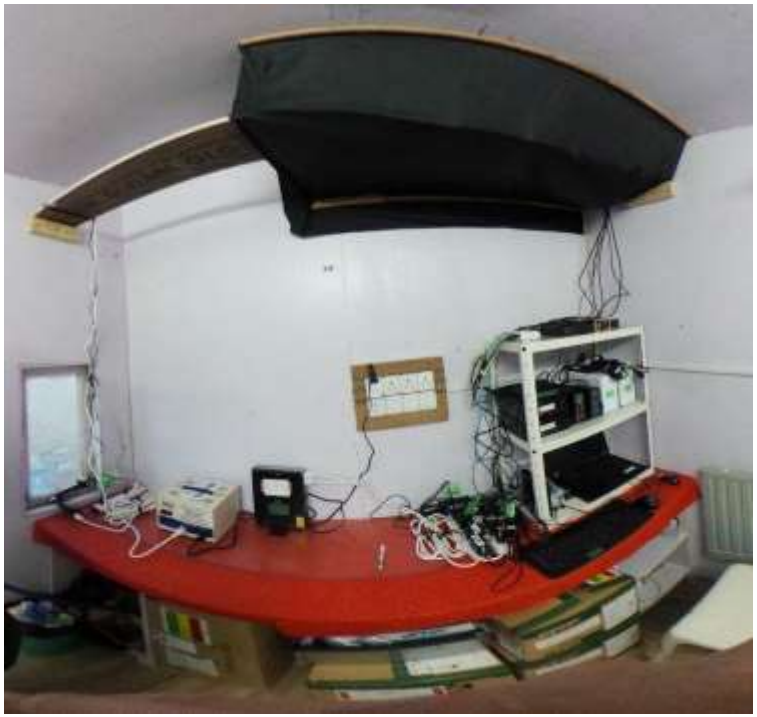
Installation at PEA (Princess Elisabeth Antarctica) station



Installation of UAO-2 at PEA station during 15-24 January, 2020



Installation of Auroral Imager System (AIS) at Maitri Station during 24 January – 2 February, 2020

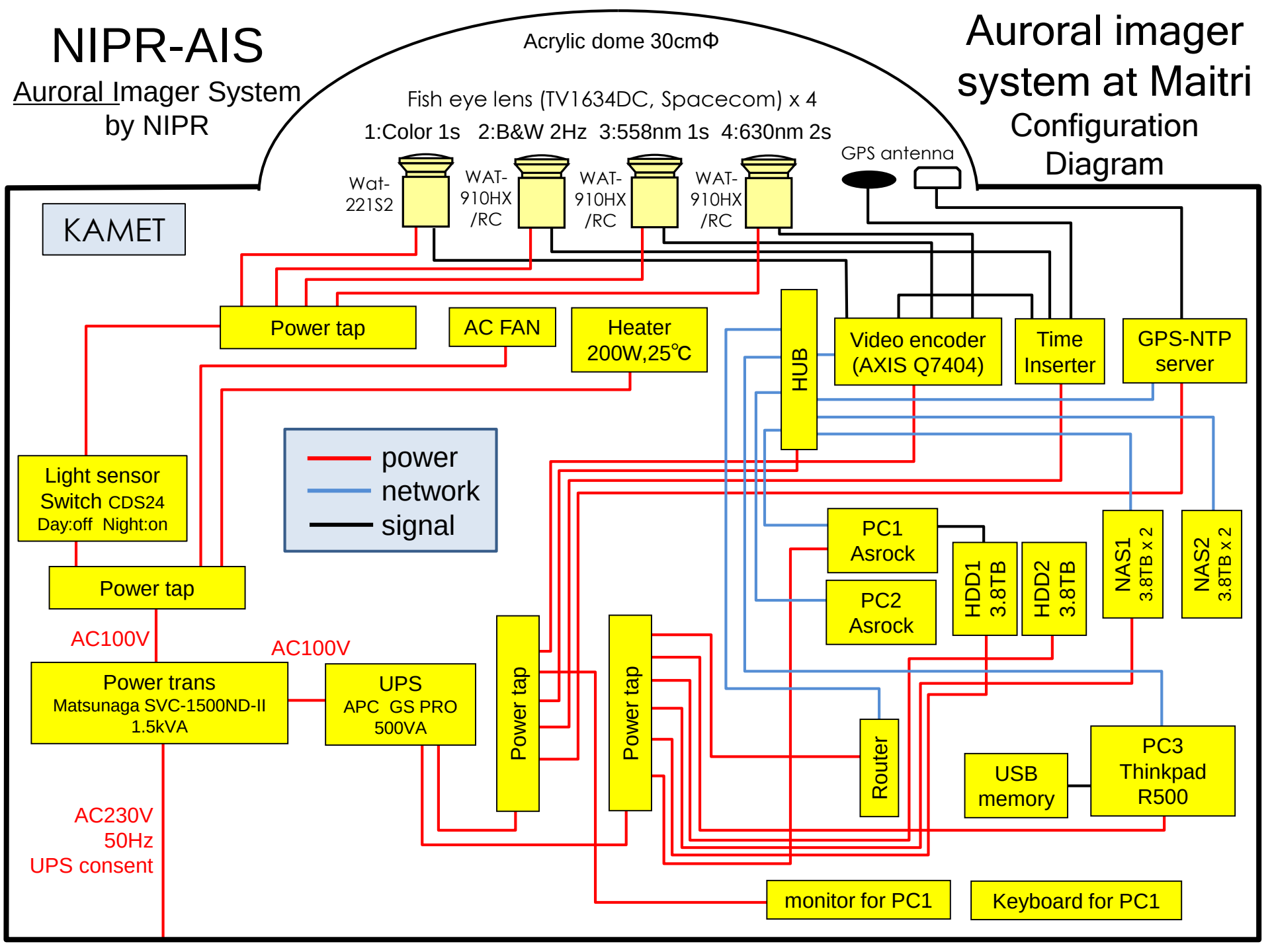


NIPR-AIS

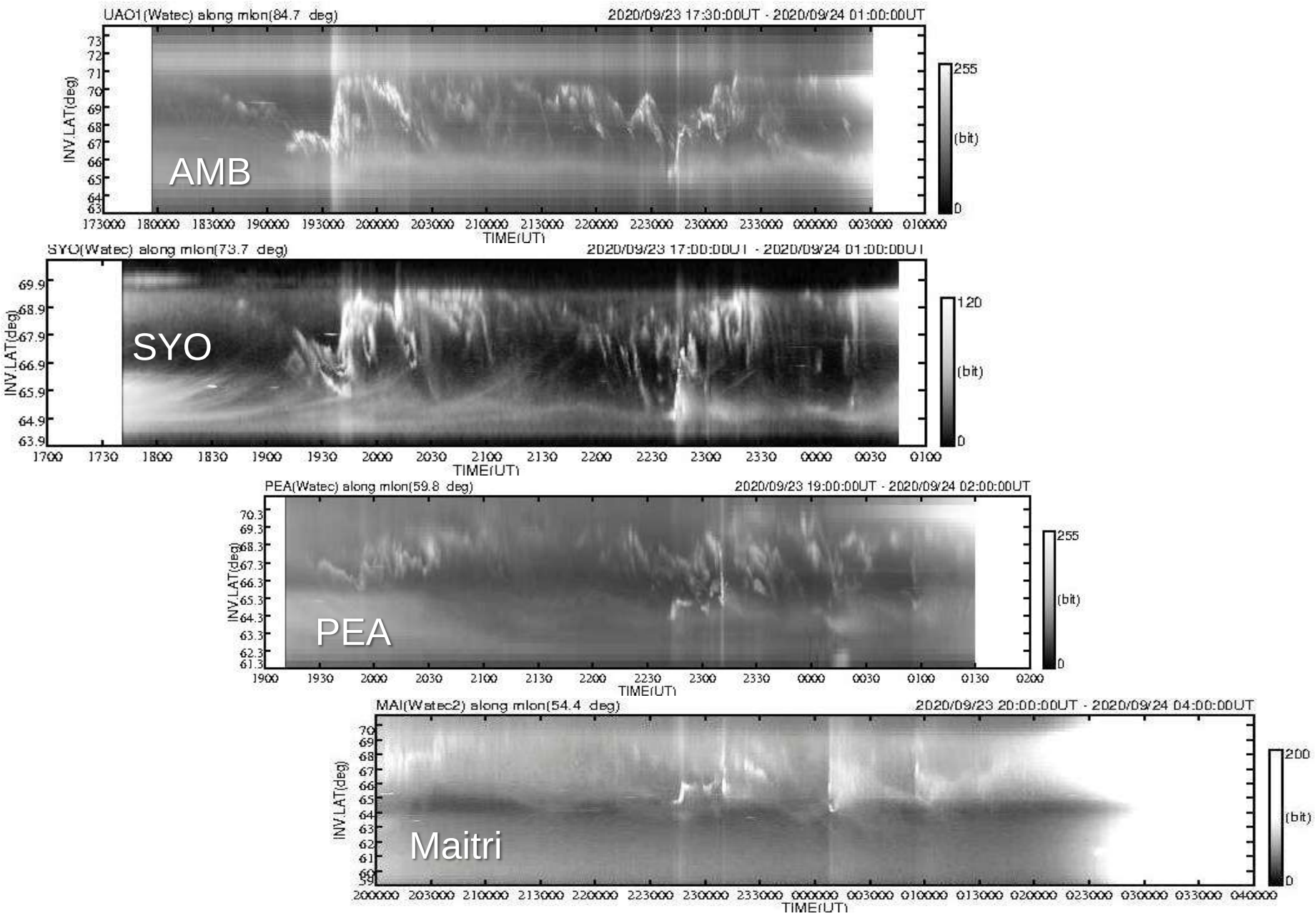
Auroral Imager System
by NIPR

Auroral imager system at Maitri

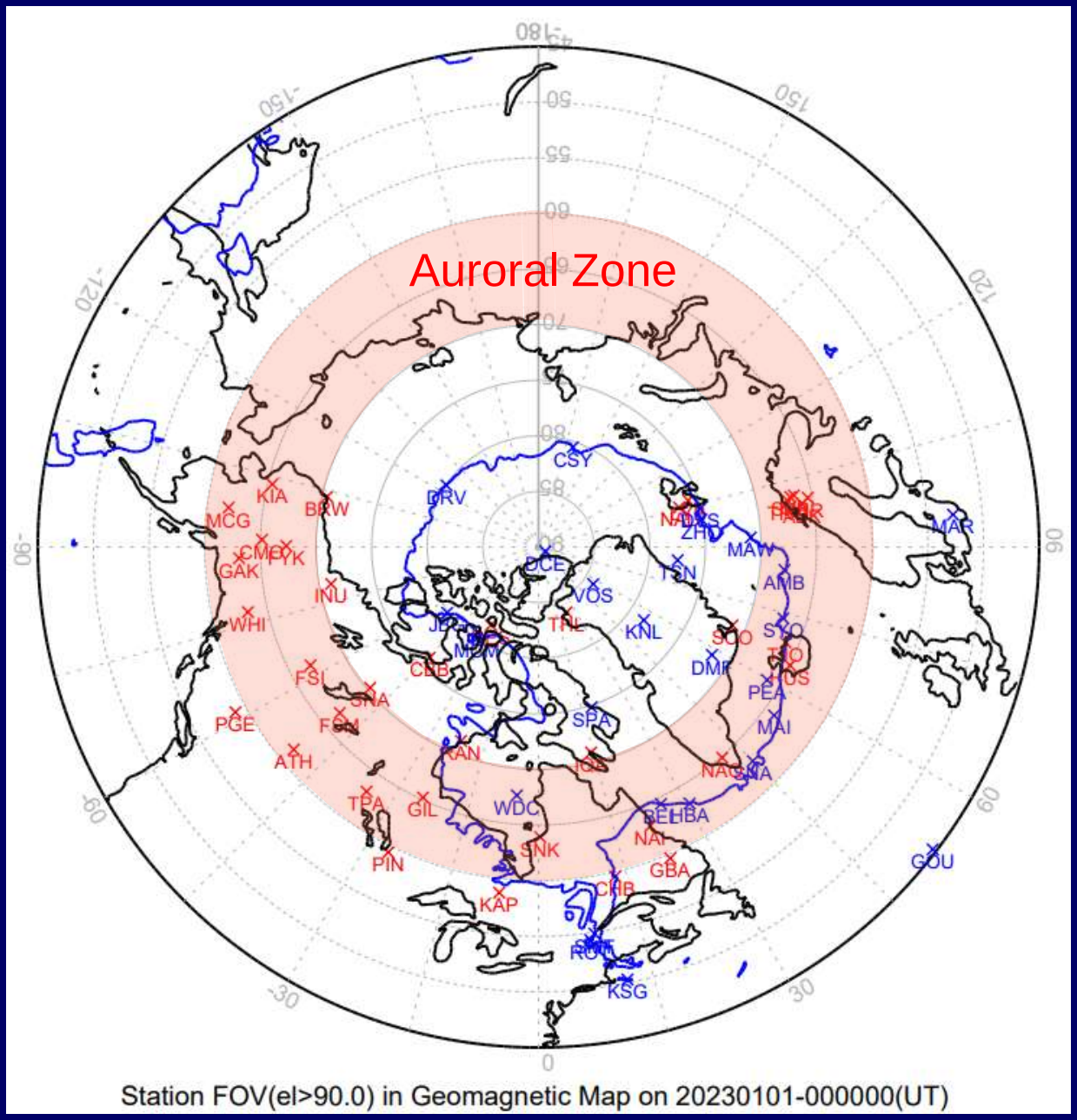
Configuration Diagram



Example of simultaneous observation: 23-24 Sep., 2020

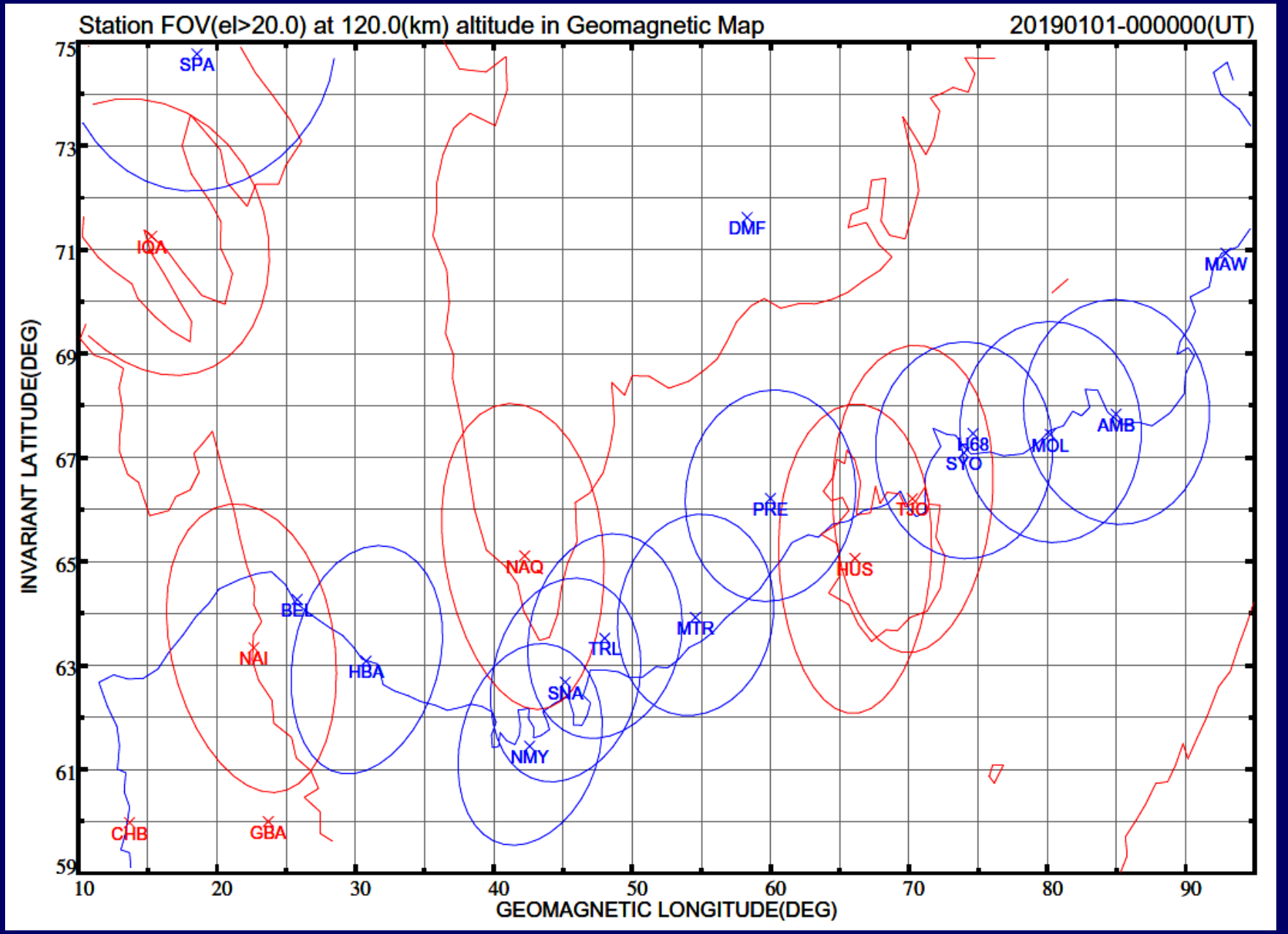


Auroral conjugate observation network



Station FOV(el>90.0) in Geomagnetic Map on 20230101-000000(UT)

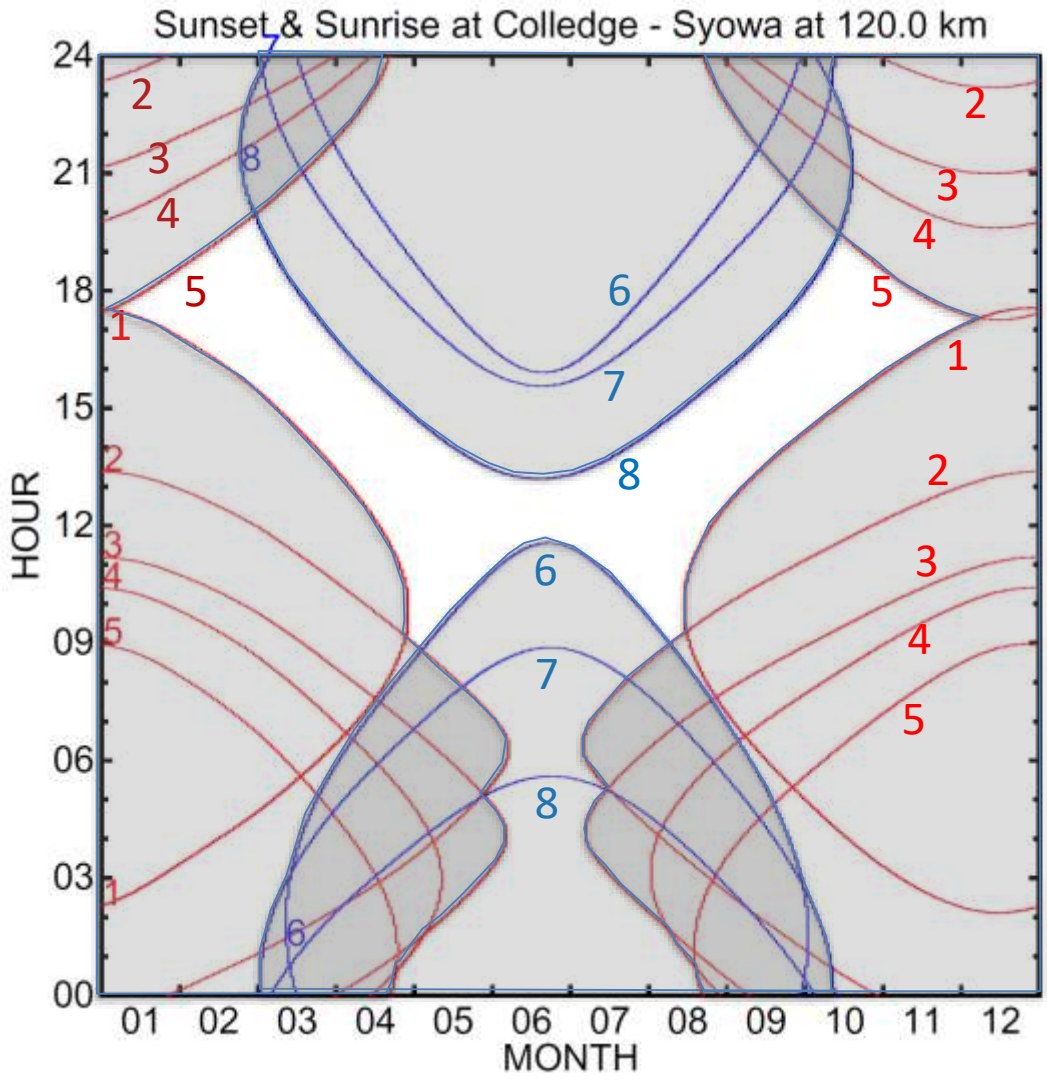
Auroral conjugate observation network using unmanned system



Station name	code	glat (deg)	glon (deg)	alt (km)	Resp. Org.	Instrument
Mawson	MAW	-67.60	62.87	0.005	AAD	
Amundsen Bay	AMB	-66.80	50.58	0.037	NIPR	B&W, GNSS/TEC, magne
Molodezhnaya	MOL	-67.67	45.85	0.036	AARI	
Syowa	SYO	-69.00	39.58	0.029	NIPR	WMI(42,55,48), PAI(39,55,63,67), CDC B&W Watec,B&W 100Hz EMCCD
Princess Elisabeth	PEA	-71.95	23.35	1.300	IPF	B&W, GNSS/TEC, magne
Maitri	MTR	-70.77	11.74	0.130	IIG	Watec(B/W, color, 55, 63) magne, ULF, VLF, IRIO, GPS/TEC,
Troll	TRL	-72.01	2.53	1.275	Univ. of Oslo	All-sky imager:427.8/577.7/630.0 CDC: every 10 min, GNSS/TEC
Sanae	SNA	-71.67	-2.84	0.850	SANSA	
Neumayer III	NMY	-70.68	-8.27	0.040	AWI	
Halley6	HBA	-75.57	-25.51	0.037	BAS	B&W all-sky imager
Belgrano2	BEL	-77.87	-34.63	0.250	Programa Antártico Argentino	
Tjornes	TJO	66.20	-17.12	0.000	NIPR	B&W Watec, B&W 100Hz EMCCD
Husafell	HUS	64.67	-21.03	0.000	NIPR	B&W Watec, OMTI
Narsarsuaq	NAQ	61.16	-45.44	0.004		
Nain	NAI	56.50	298.30	0.000	ISEE	PWING imager

Simultaneous observation in March～May, July～October

Sunset time at 120 km altitude in a year



1. Colledge
2. Gillam
3. Nain
4. Narsarsuaq
5. Tjornes
6. Halley Bay
7. Sanae
8. Syowa