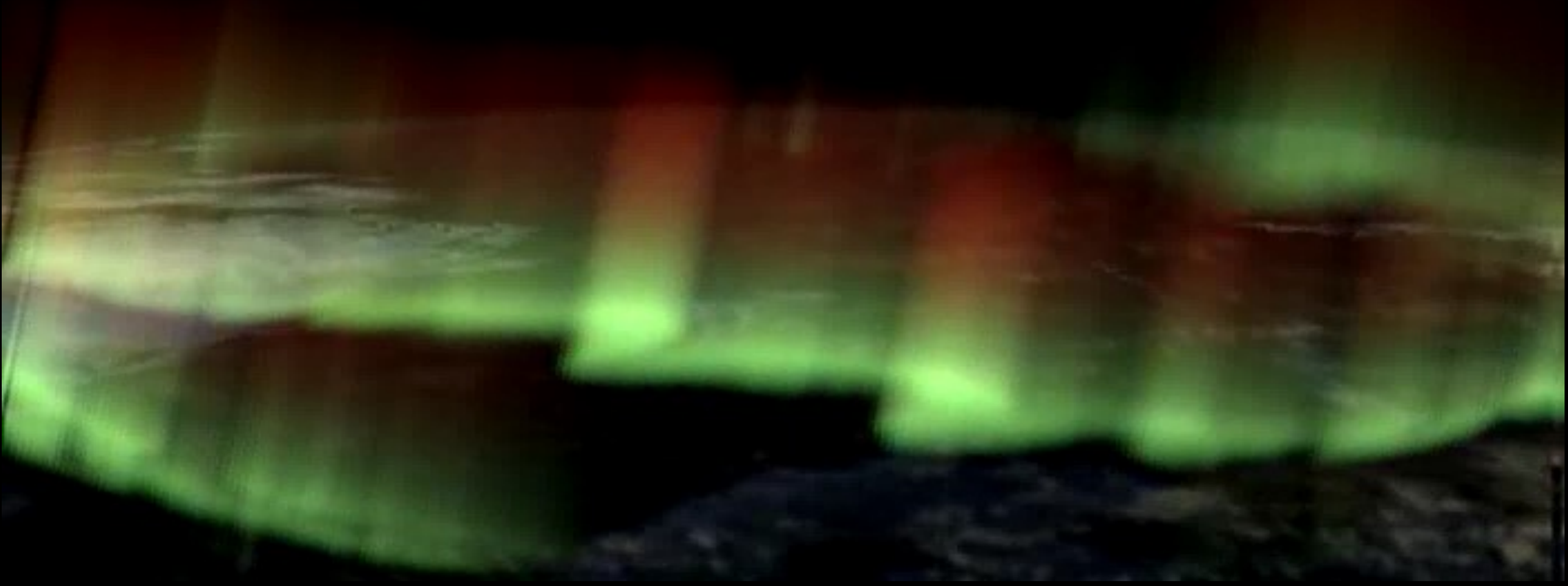
Space research and geophysics at Sodankylä over 100 years

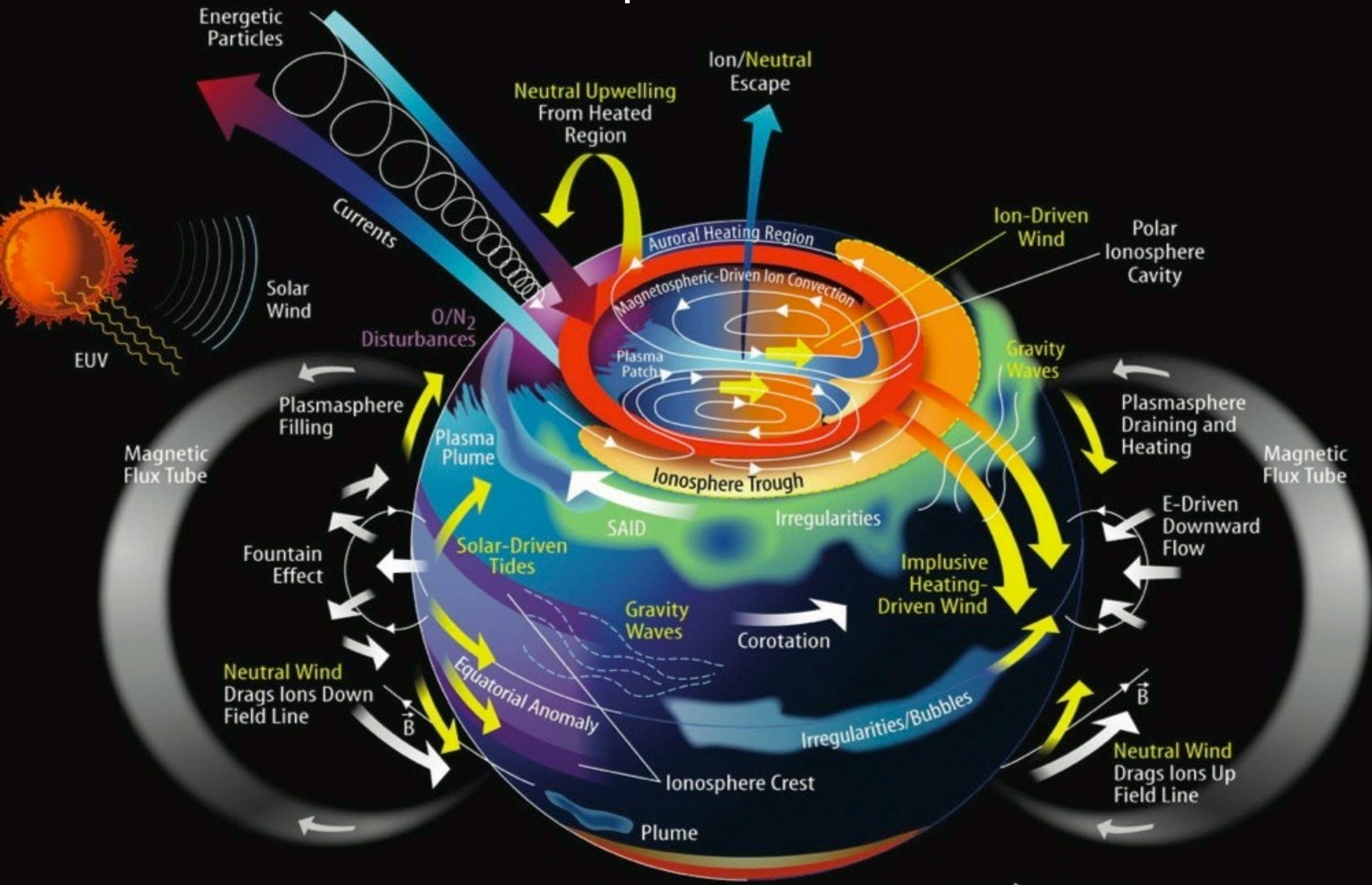
Jyrki Manninen, Adj.prof., PhD, Deputy Director
Sodankylä Geophysical Observatory, University of Oulu



Sodankylä Geophysical Observatory

- 1st International Polar Year 1882/83
- Established by Finnish Academy of Science and Letters in 1913
- Finland became independent in 1917
- Joined to University of Oulu in 1997
- The oldest research institute in Lapland

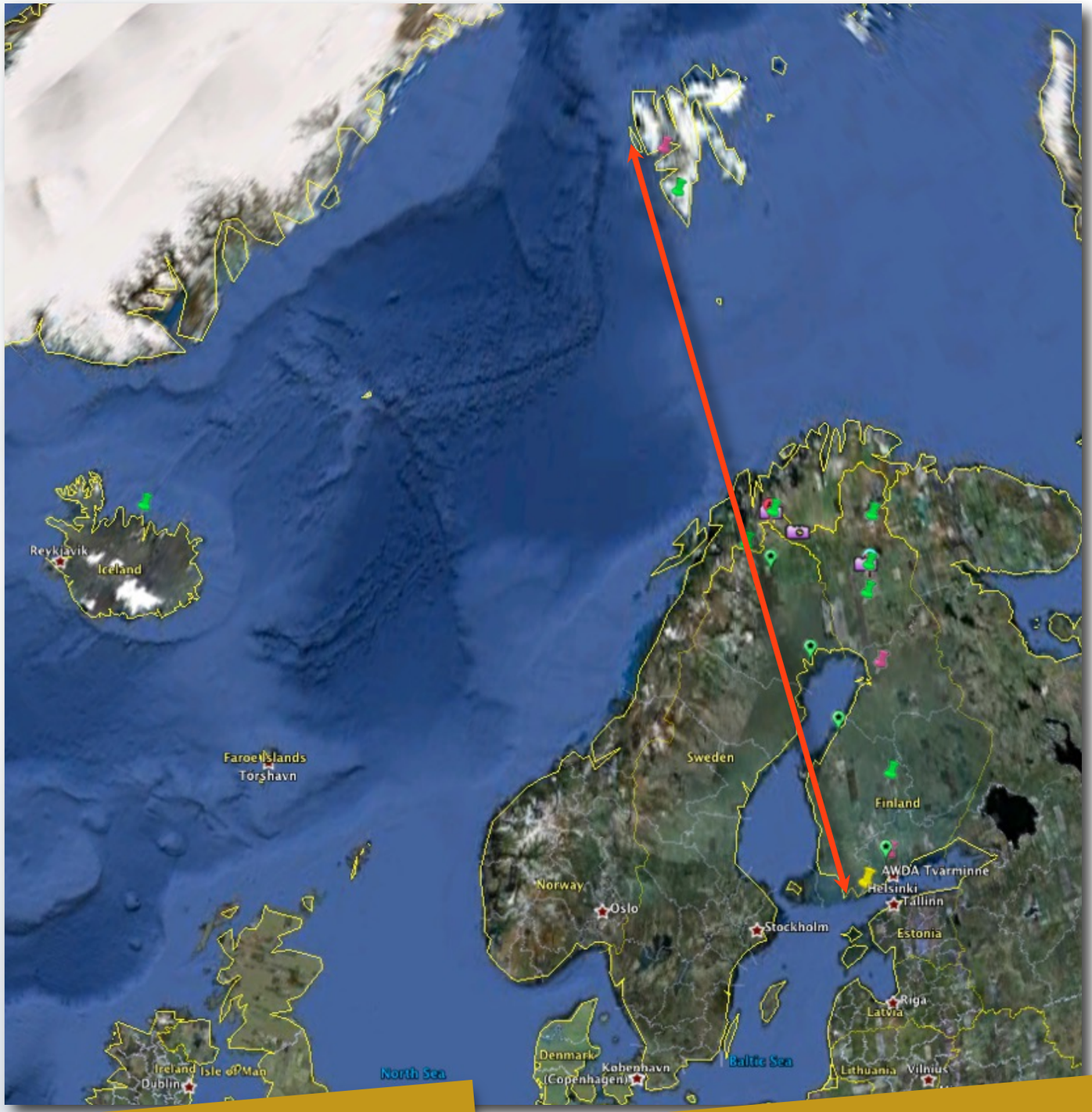
Geospace Environment



Operations extend over 2070 km meridional distance!

We operate:

- Magnetometers
- Pulsation Magnetometers
- Ionosonde
- Riometer Chain
- All-Sky Cameras
- Ionospheric Tomography Chain
- Neutron Monitor
- Various VLF receivers
- Network of Seismometers
- Imaging Riometer (U Lancaster)
- Meteor Radar (U Leicester)
- Fabry-Perot Interferometer (UCL)
- EISCAT Incoherent Scatter Radar
- KAIRA radio telescope, Kilpisjärvi

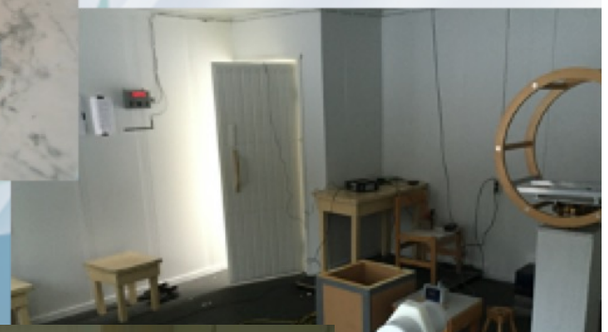


+Etiopia

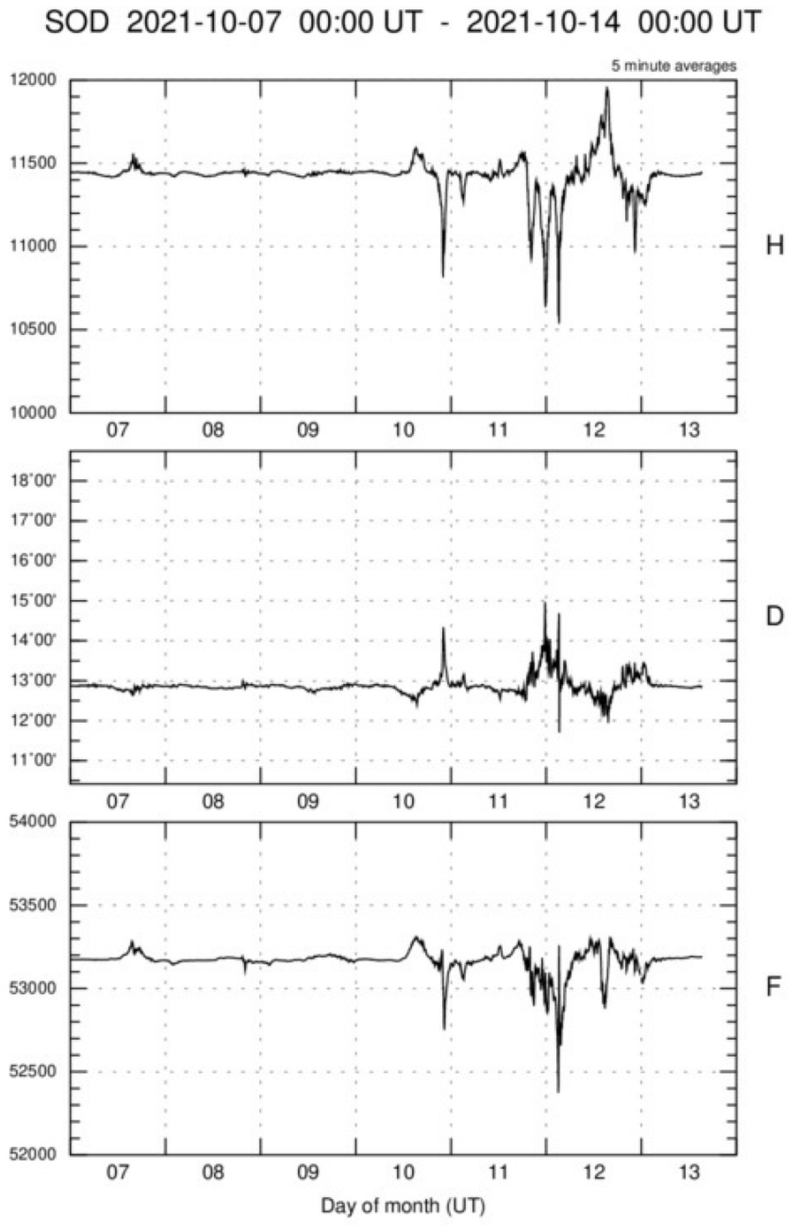
+Antarctica

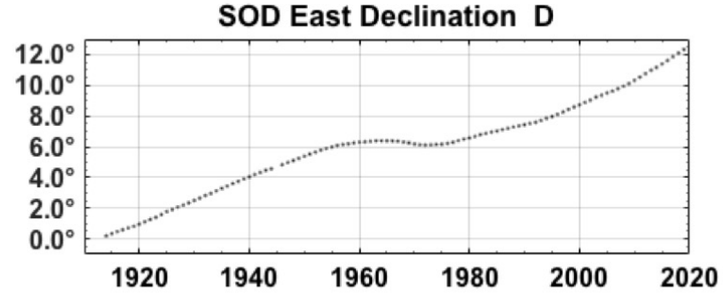
Earth’s magnetic field

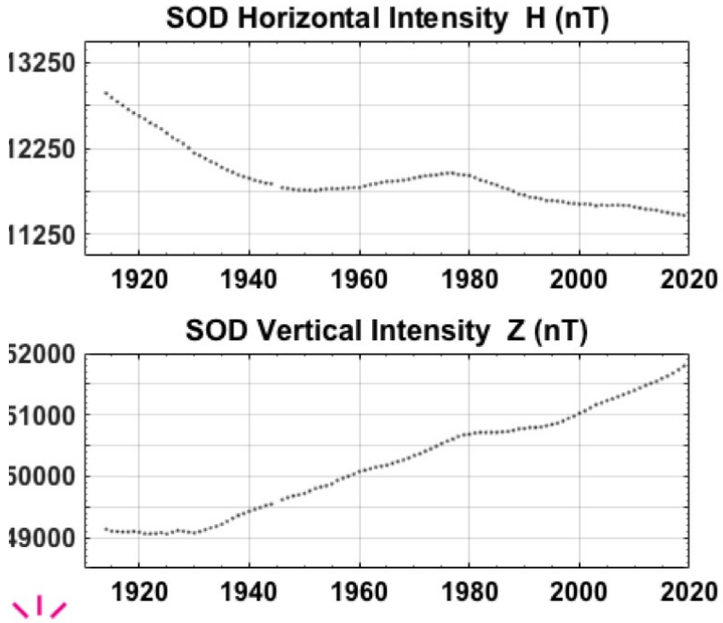
- Measured officially since 1 January 1914
- Varies in different time scales
- Basic parameter in space weather effects
- International network of observatories

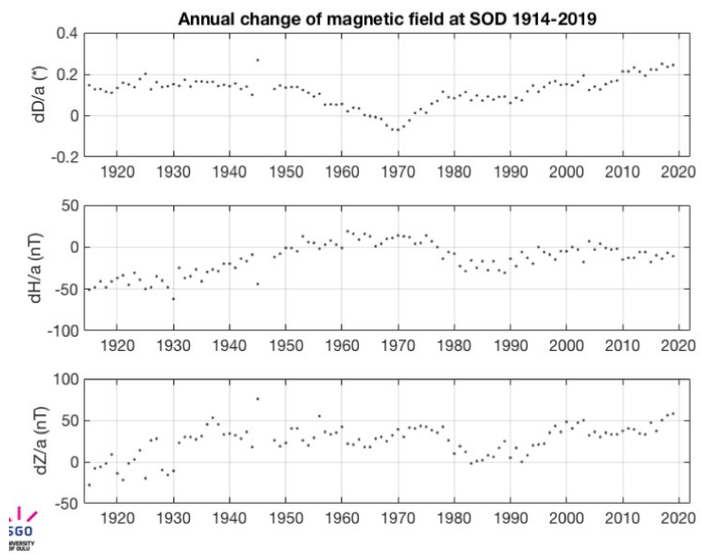


Sodankylä

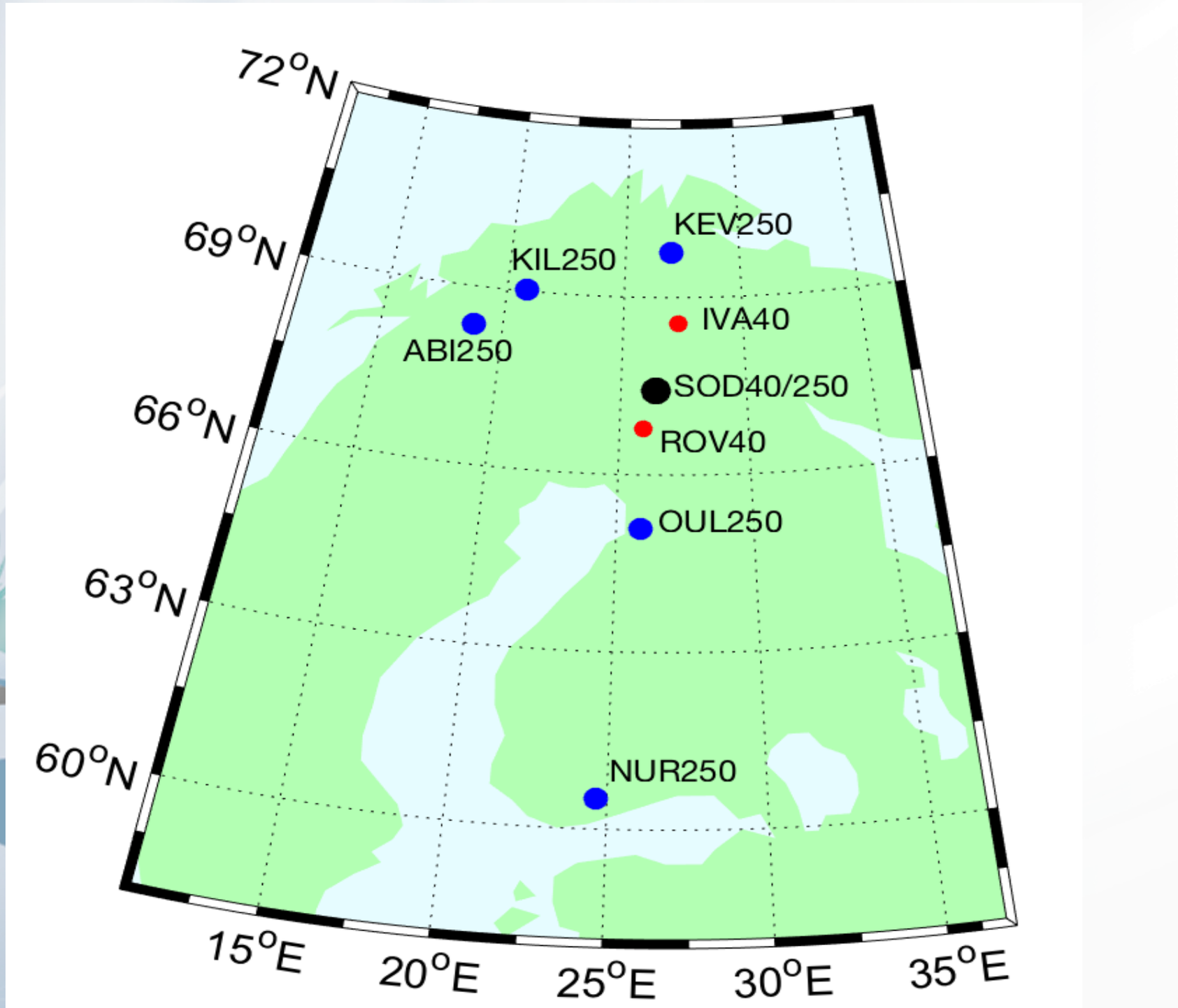




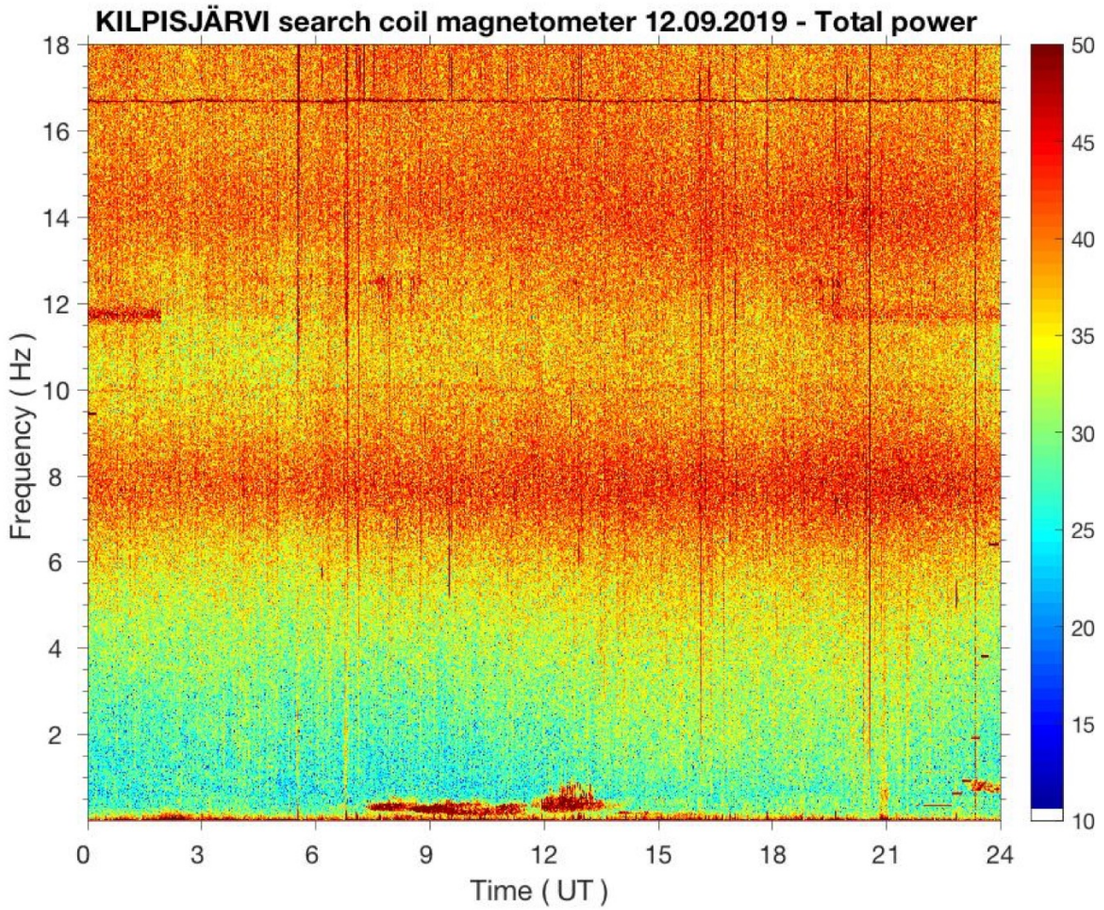


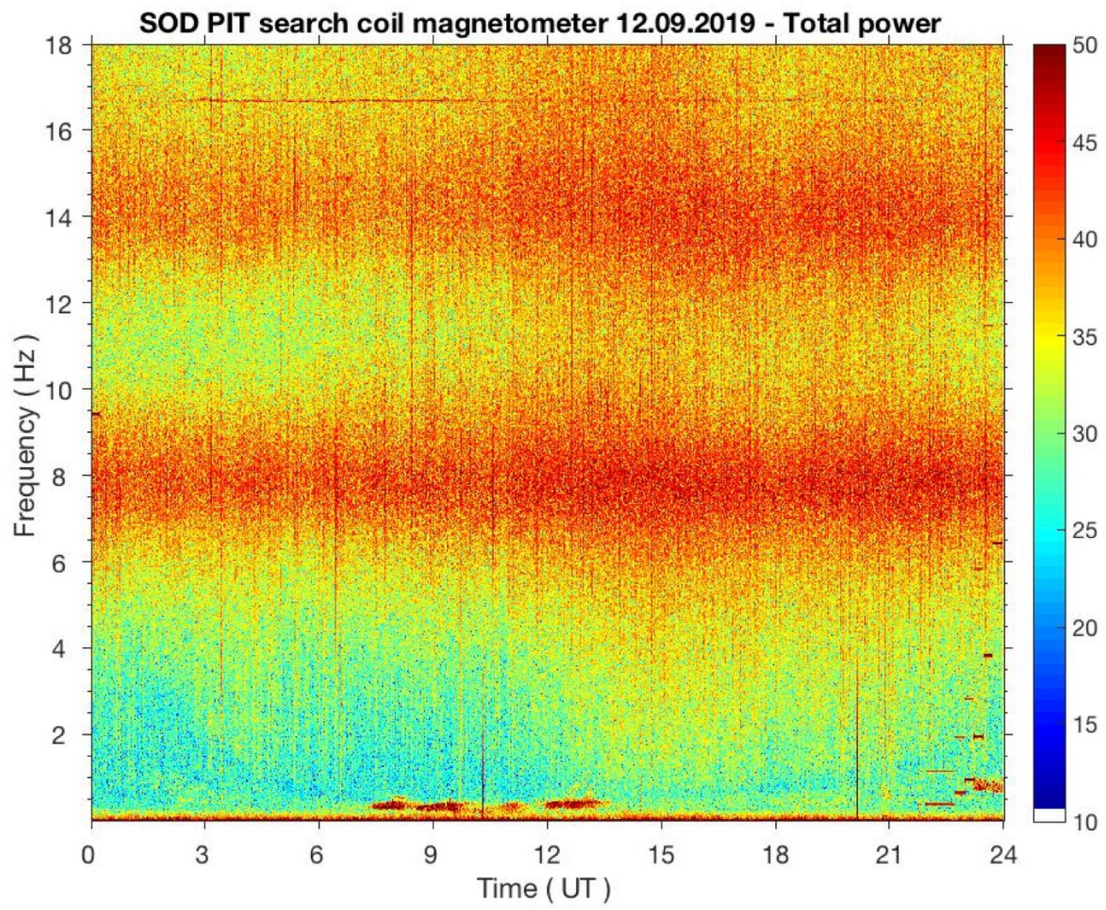


Pulsation magnetometers (induction coil magnetiometers, dB/dt)

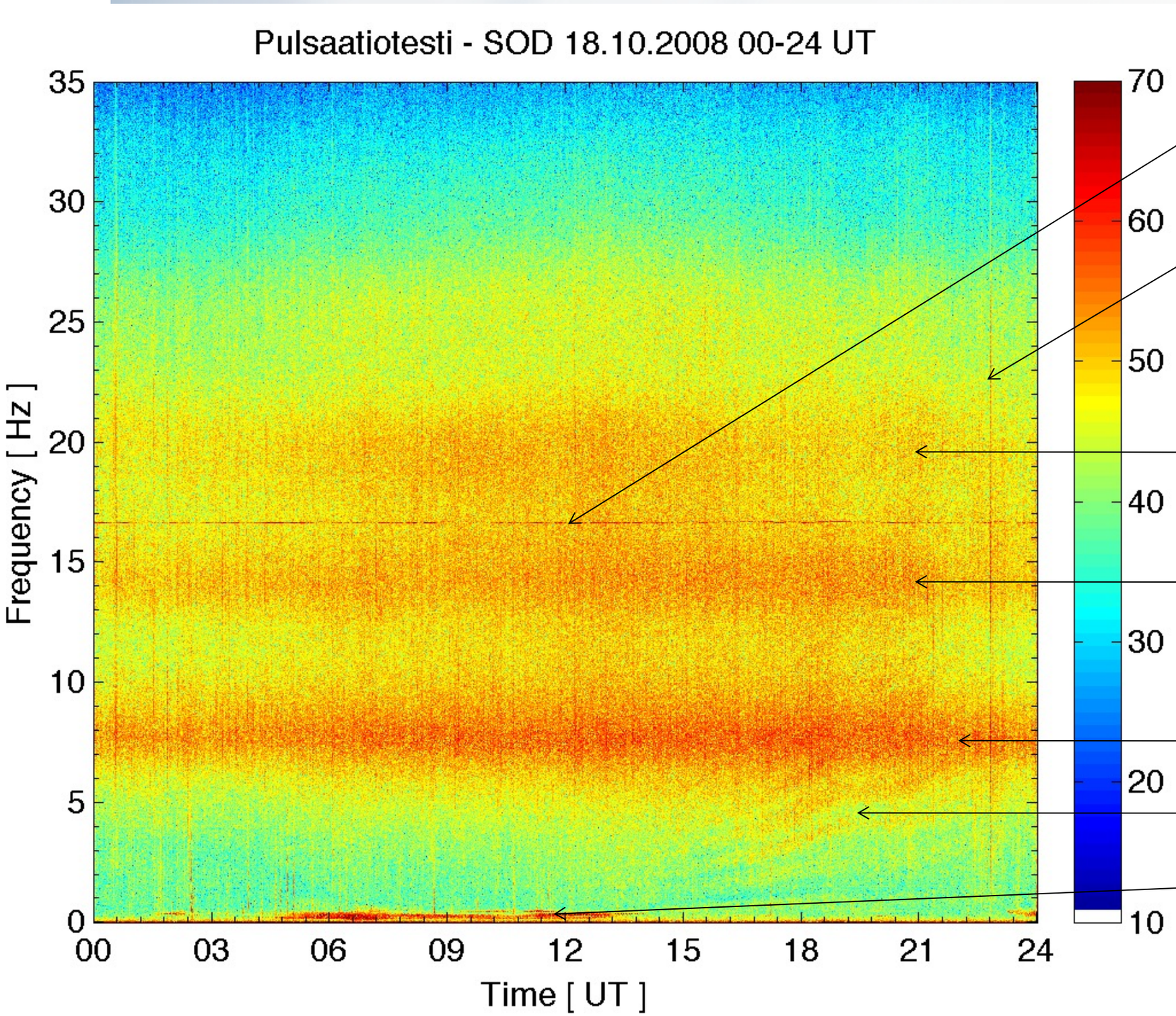


Instruments and two examples





Magnetic pulsations



16.67Hz Swedish railway system

Giant remote lightning

3rd Schumann resonance

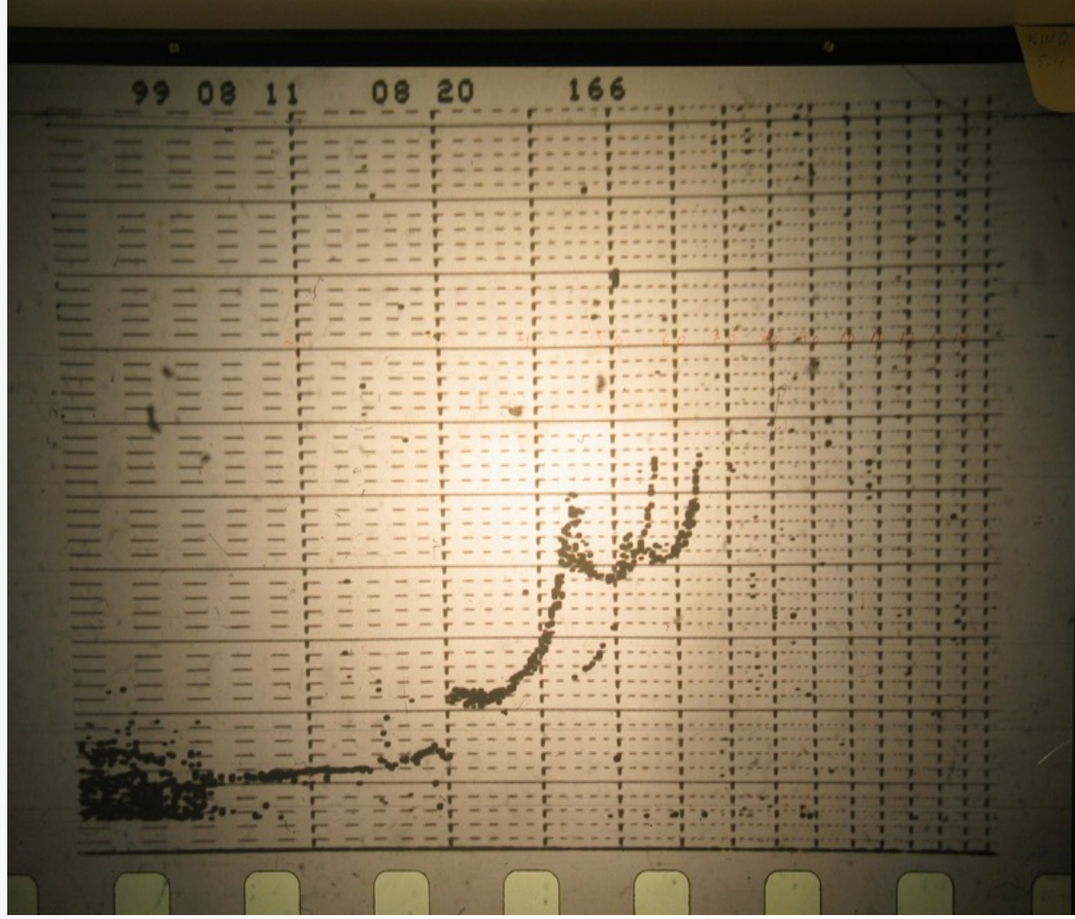
2nd Schumann resonance

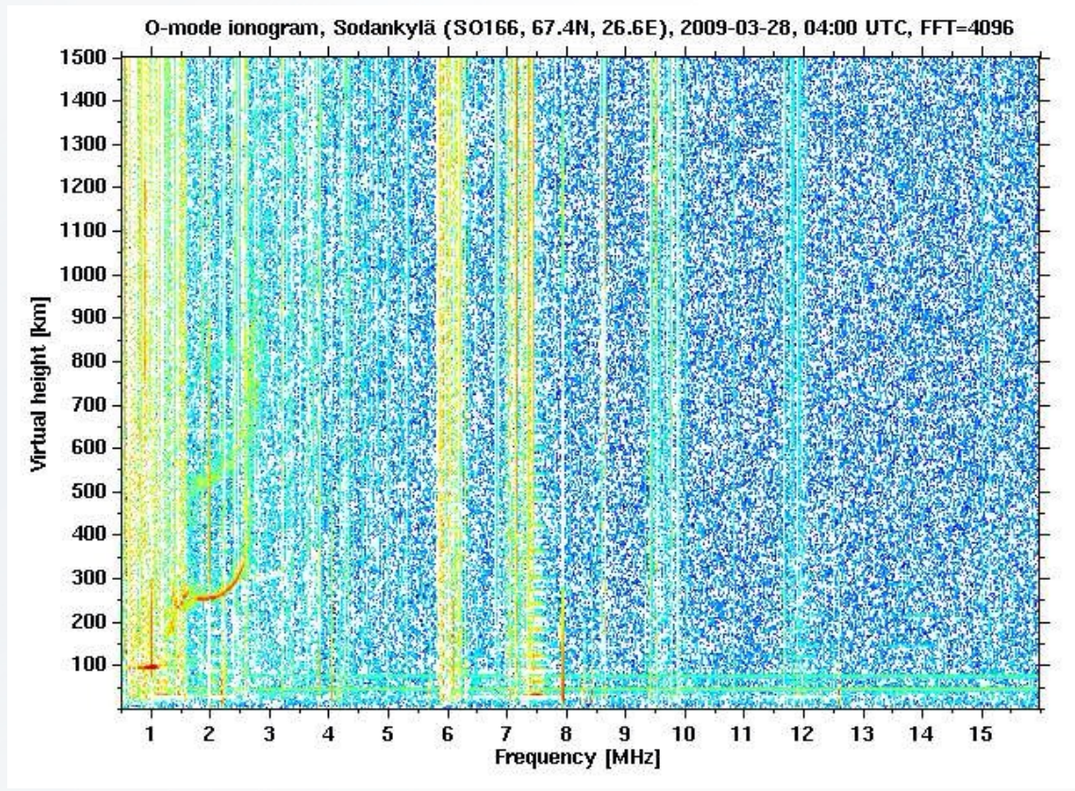
1st Schumann resonance

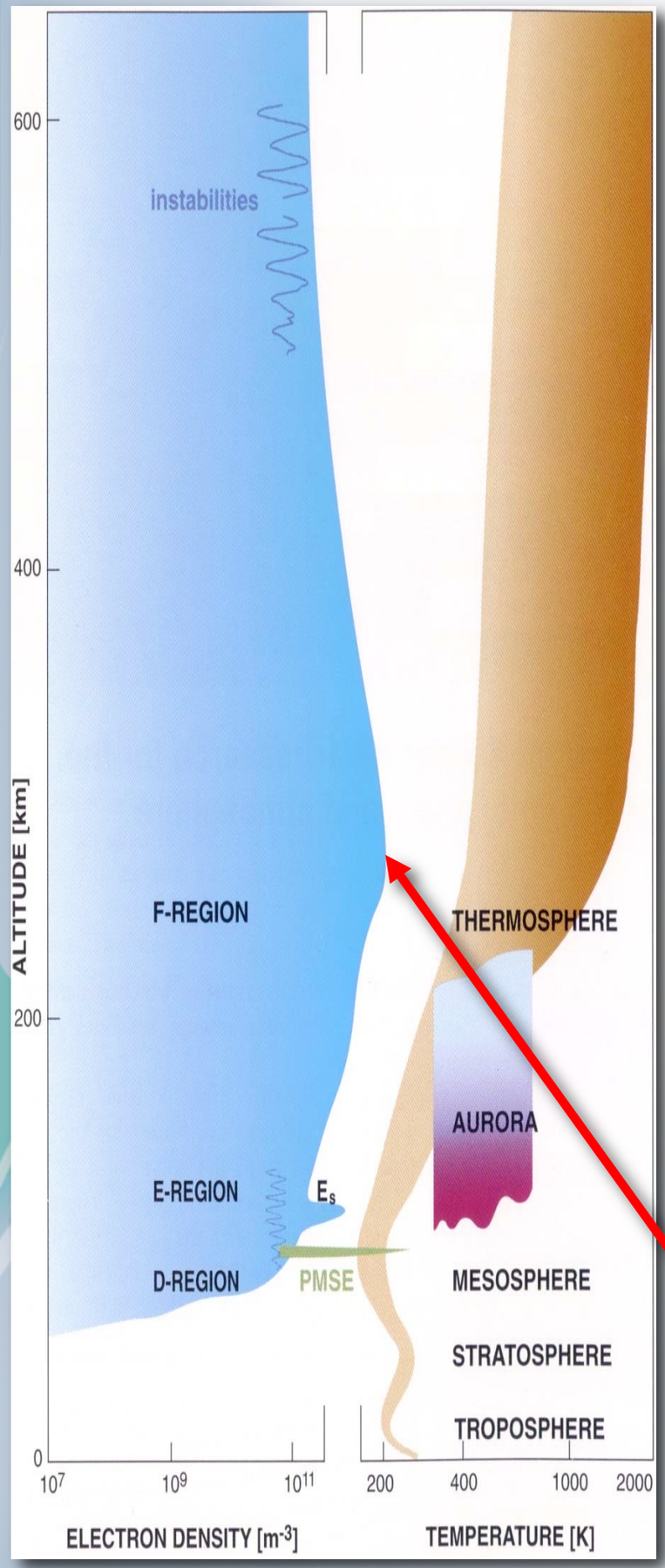
IAR

Pc1

Ionospheric sounding since 1957







Greenhouse Cooling

Doubling of [CO_2] ja [CH_4]

cools

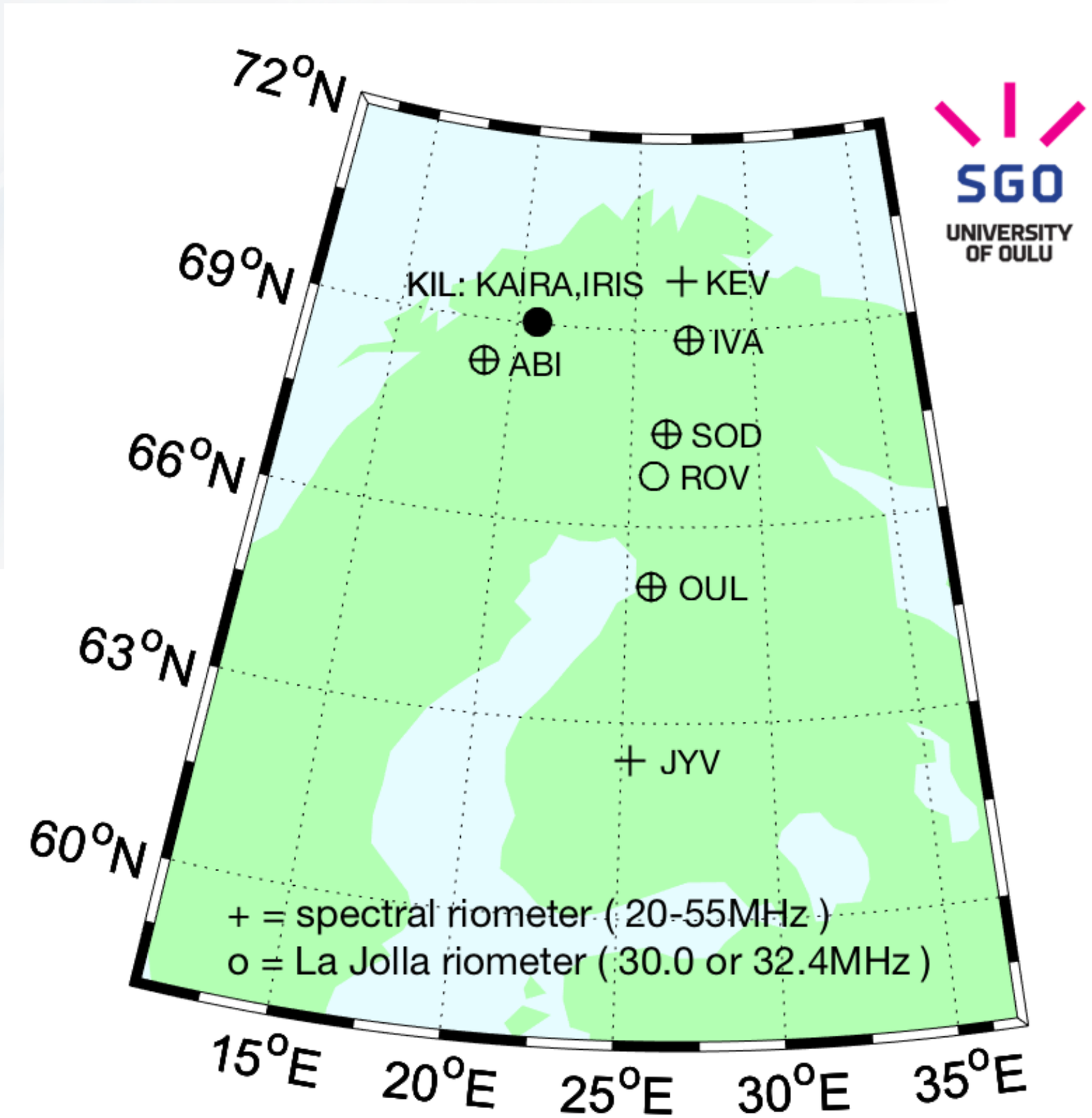
Mesosphere by **10 K** and
Termosphere by **50 K**.

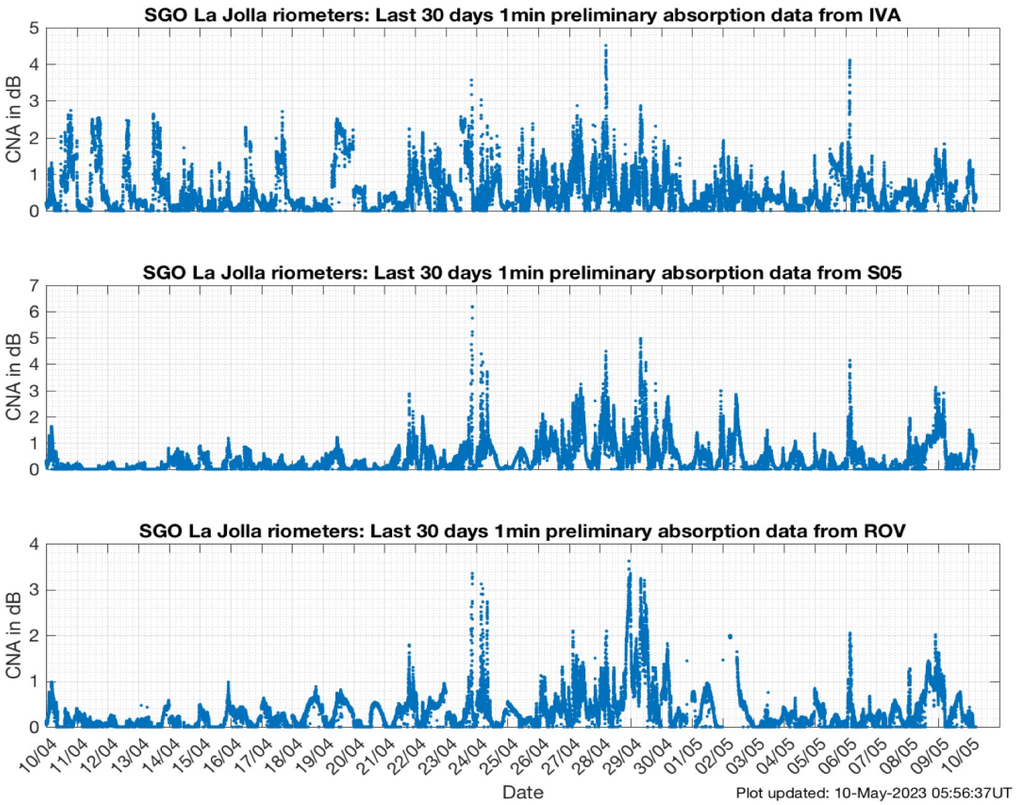
Atmosphere shrinks

Layer of maximum electron density *lowers* by 15-20 km.

Riometer chain

- **R**elative **I**onospheric **O**pacity **meter**
- Measure cosmic radio noise intensity on the ground
- Gives ionospheric absorption in dB at ~70 km altitude
- Simple instrument for e.g. auroral studies

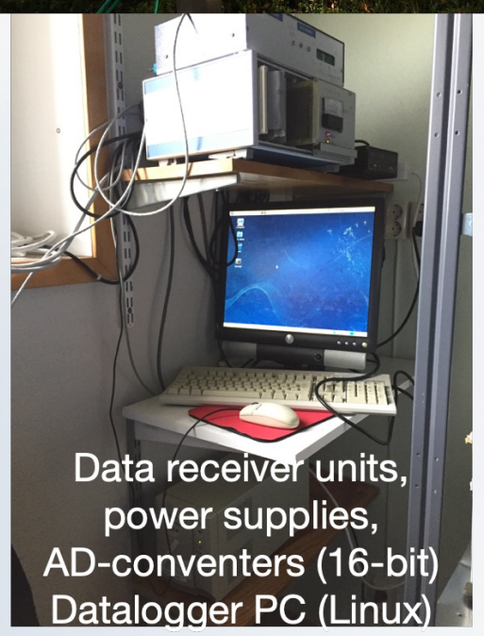


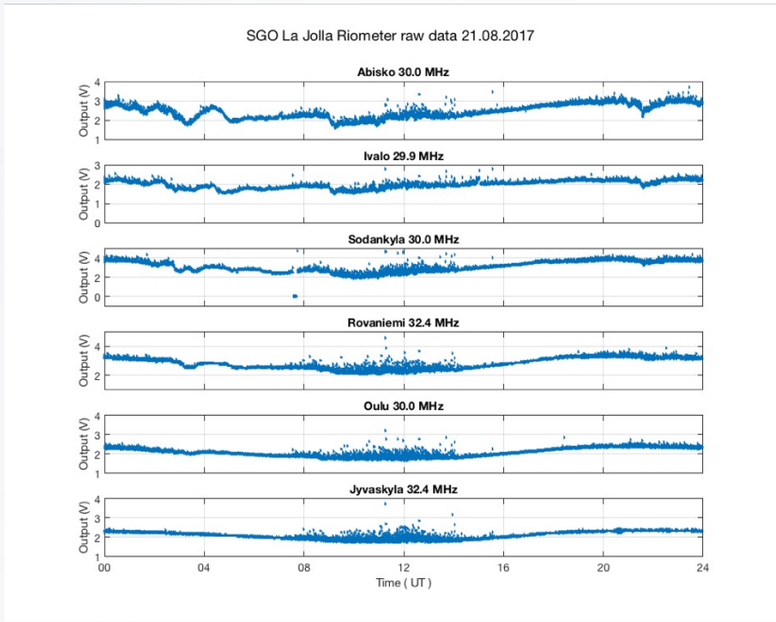


Narrow band wide angle La Jolla riometers (30.0 MHz and 32.4 MHz)

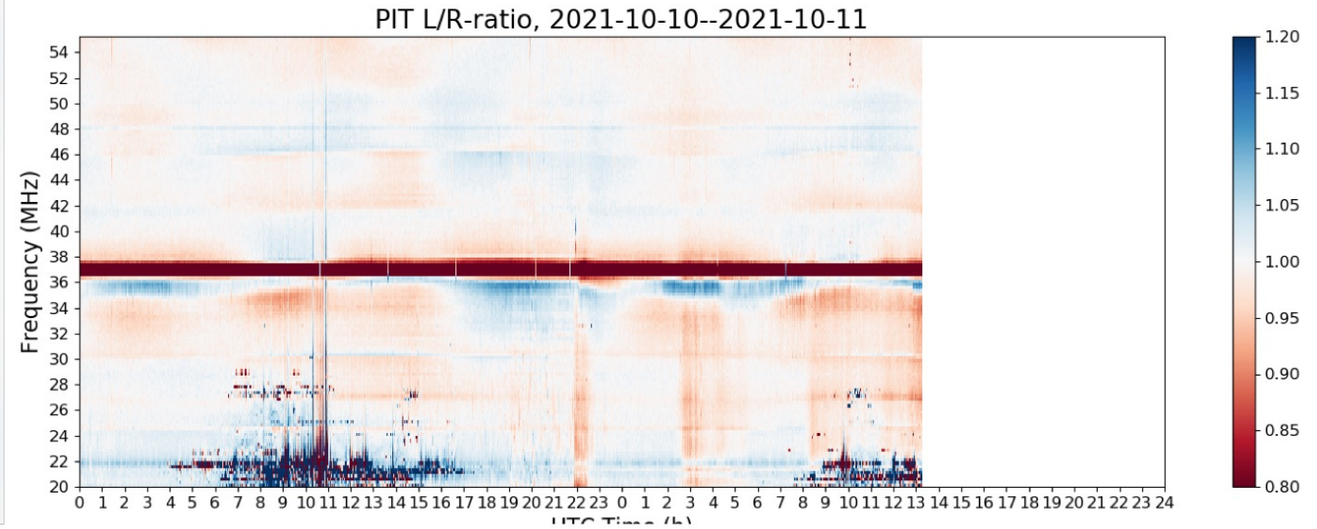

Abisko 30.0MHz riometer antenna. Photo: Tero Raita

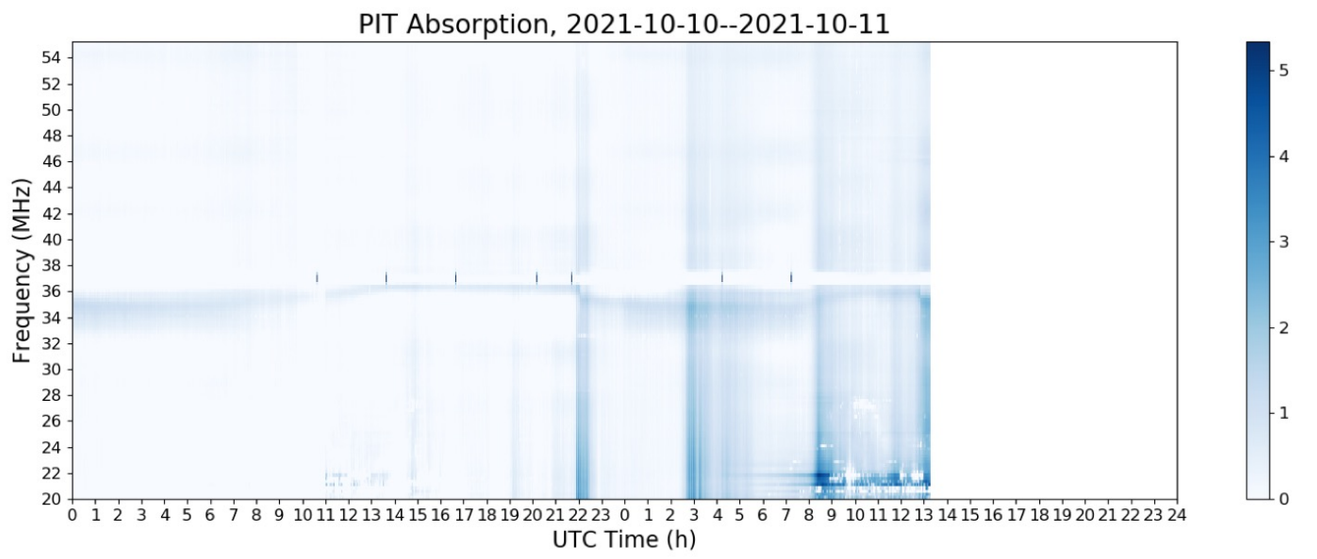

30.0MHz riometer receiver. Photo: Tero Raita

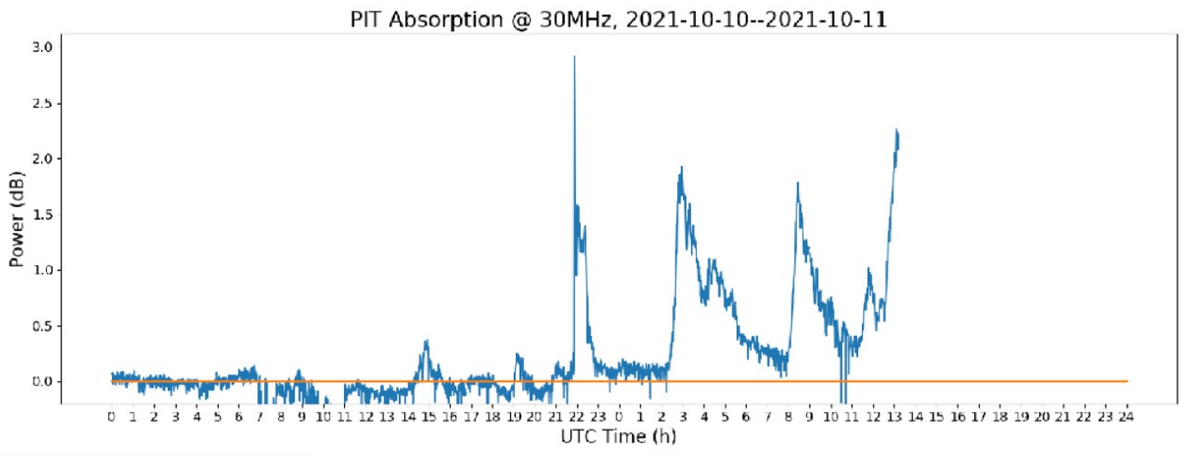

Data receiver units,
power supplies,
AD-conventers (16-bit)
Datalogger PC (Linux)



Wide-band (20-55 MHz) spectriometer







Sodankylä Geophysical Observatory 1913–2013

All-Sky Camera – www.sgo.fi

Photo: Thomas Ulich.

Sodankylä Geophysical Observatory 1913–2013

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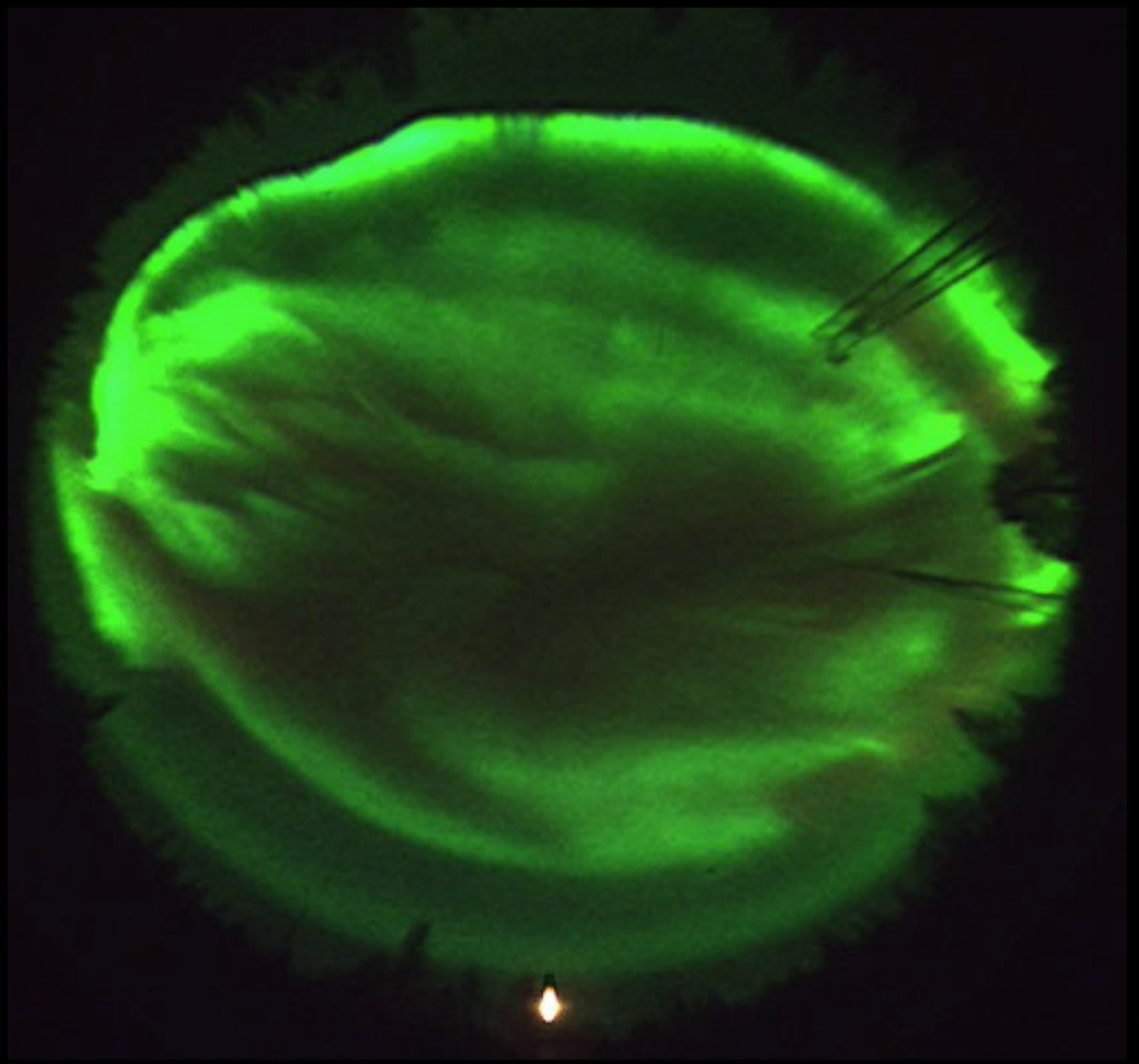
600 km

600 km



Utsjoki

Sodankylä

Oulu

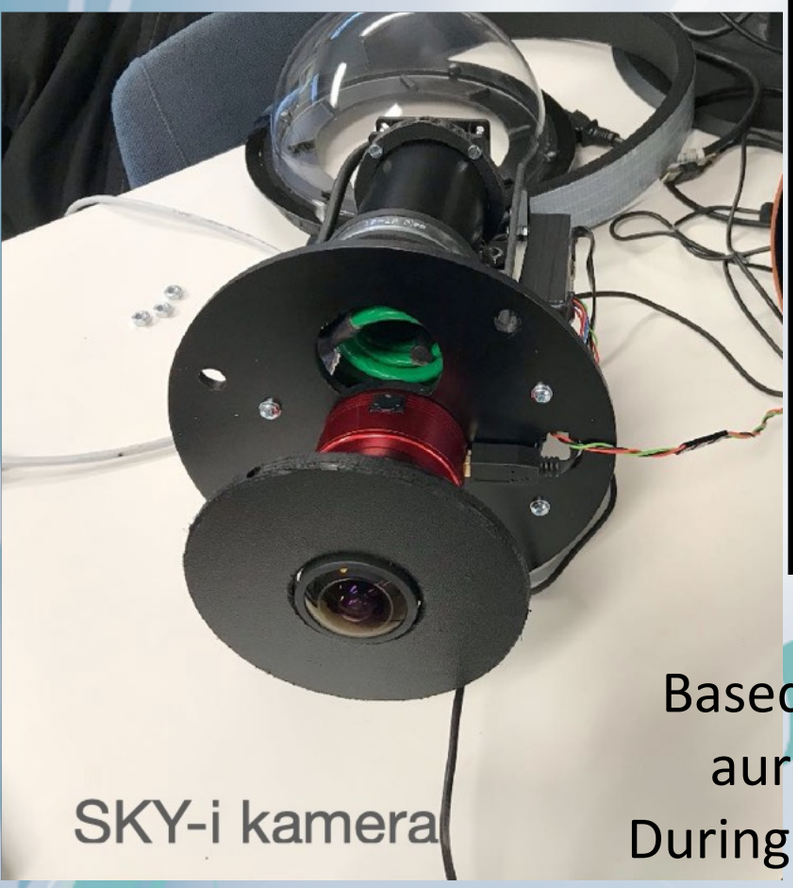
www.sgo.fi

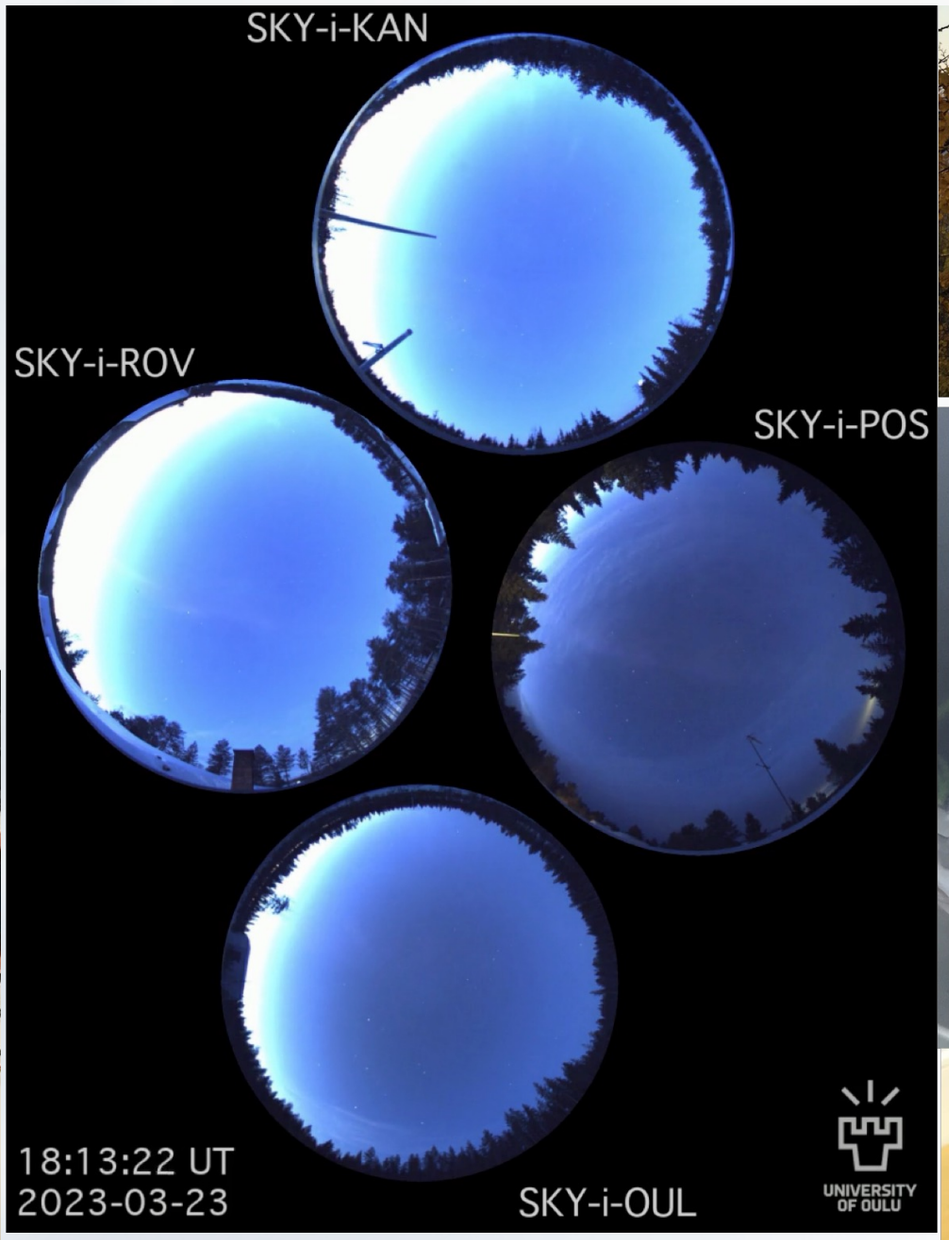
Kiruna

Sodankylä

Apatity

All-sky cameras



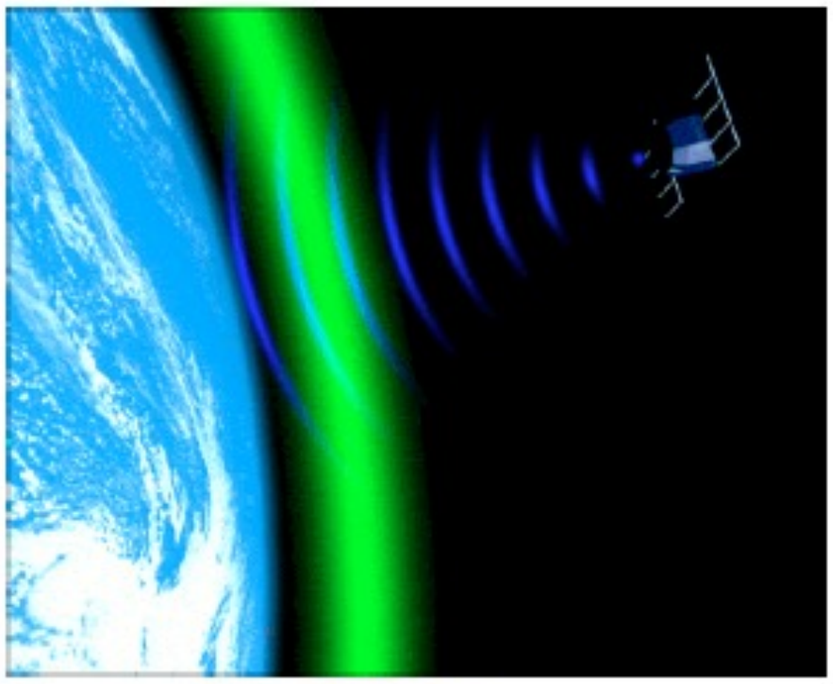


SKY-i cameras

Based on ZWO-ASI 294 camera. Compact auroral camera. First bought in 2020. During winter 2022-2023 already 6 cameras in operation. More coming.

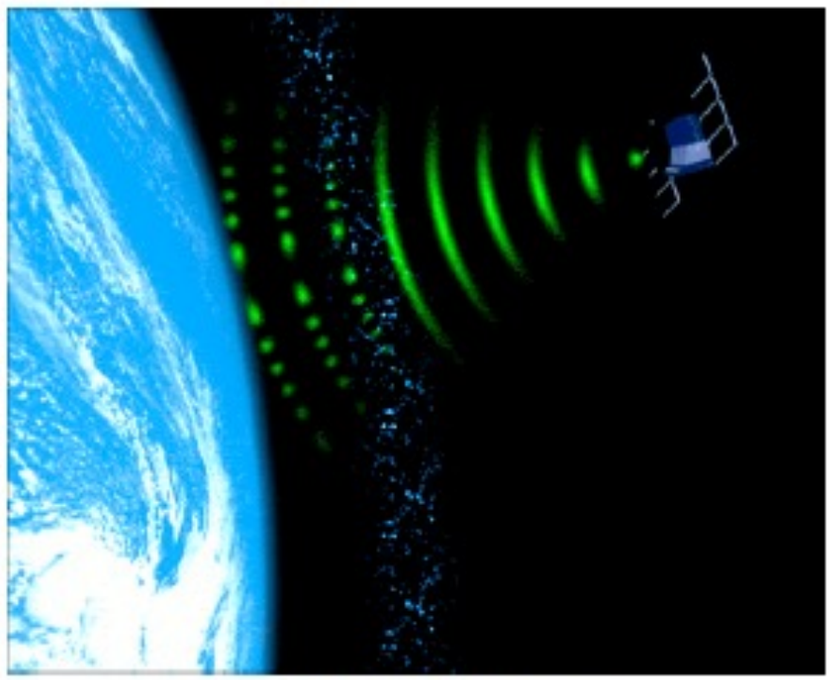
Ionosphere impacts on navigation

Ionosphere and GPS



Delay

Perturbs the signal propagation speed proportional to total electron content tens of metres error at solar maximum

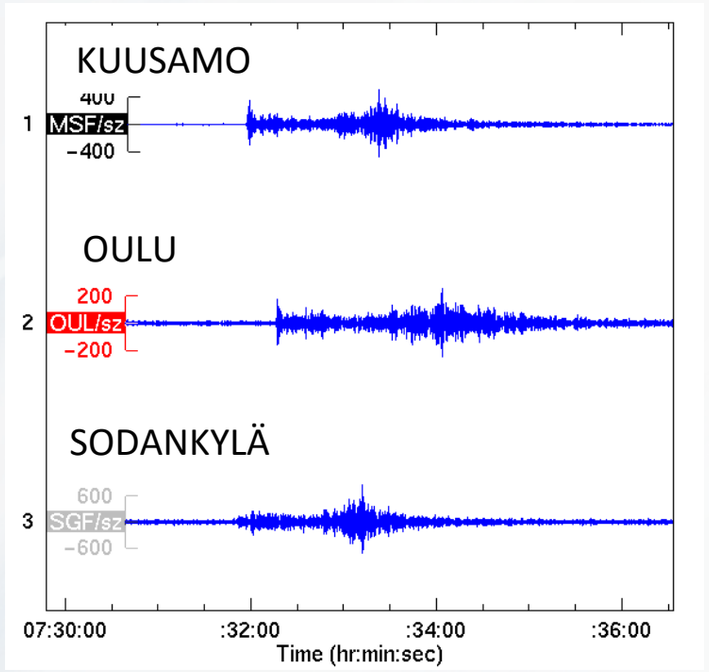


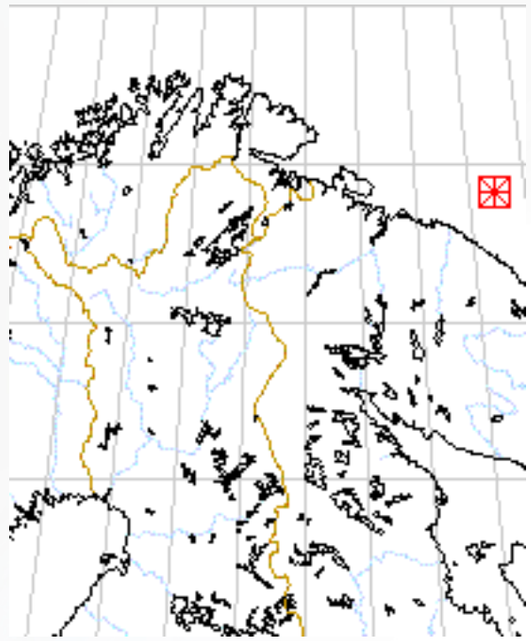
Scintillation

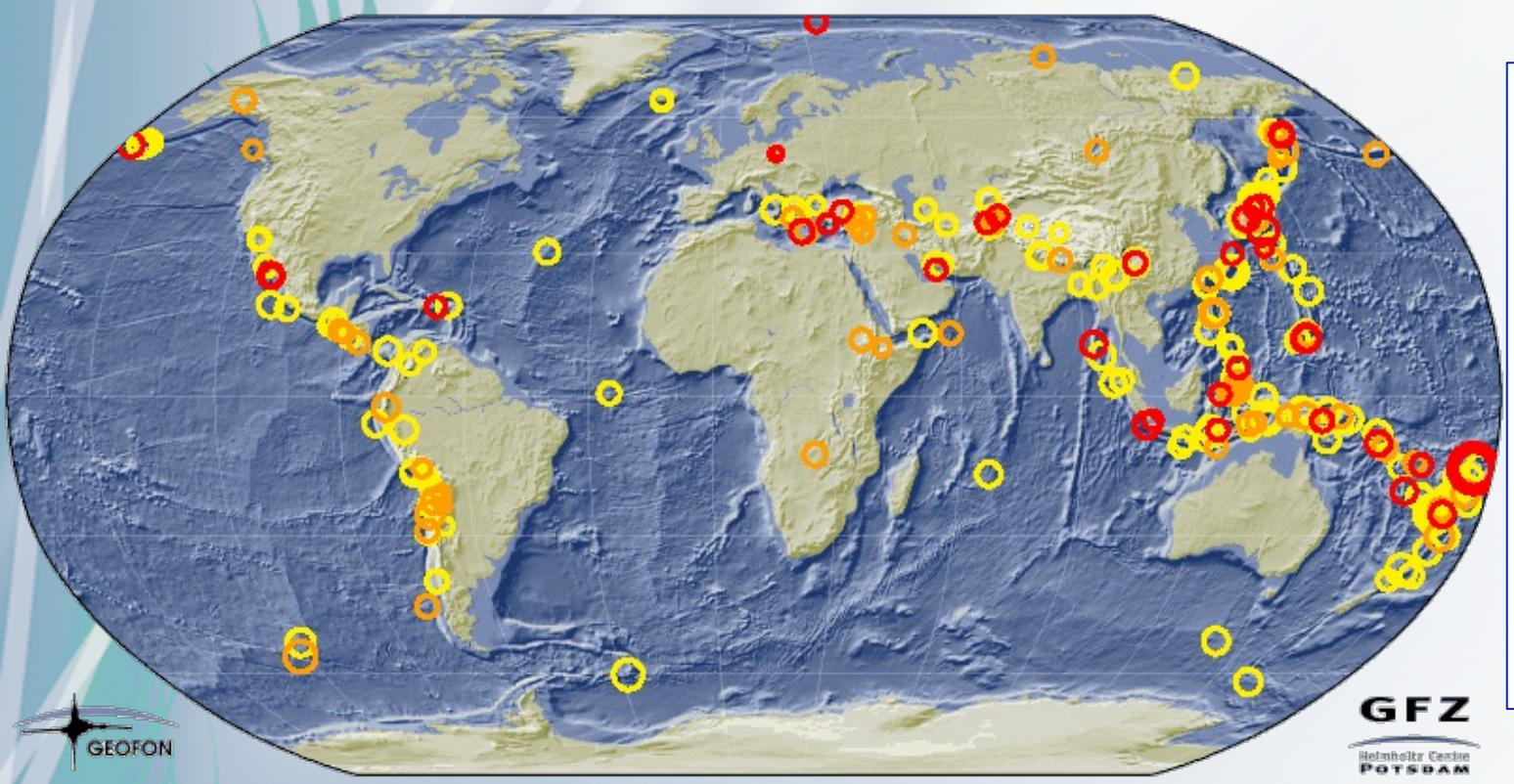
Causes rapid changes in signal phase and signal strength – most severe in auroral/equatorial regions and storms

Seismic recordings:

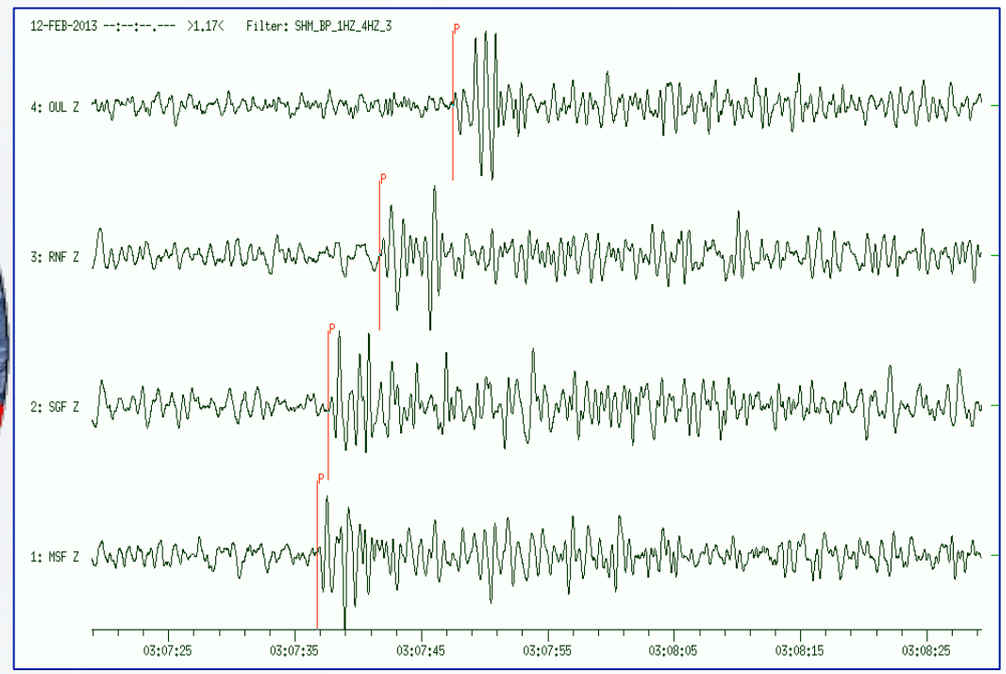
Kursk sank on 12 Aug 2000







Nuclear explosion in North Korea on 12 Feb 2013
recorded by SGO's seismometers



EISCAT

Photo: Anja Strømme

ISRs, Heater, Dynasondes

ESR, 500 MHz

UHF, 930 MHz

VHF, 224 MHz

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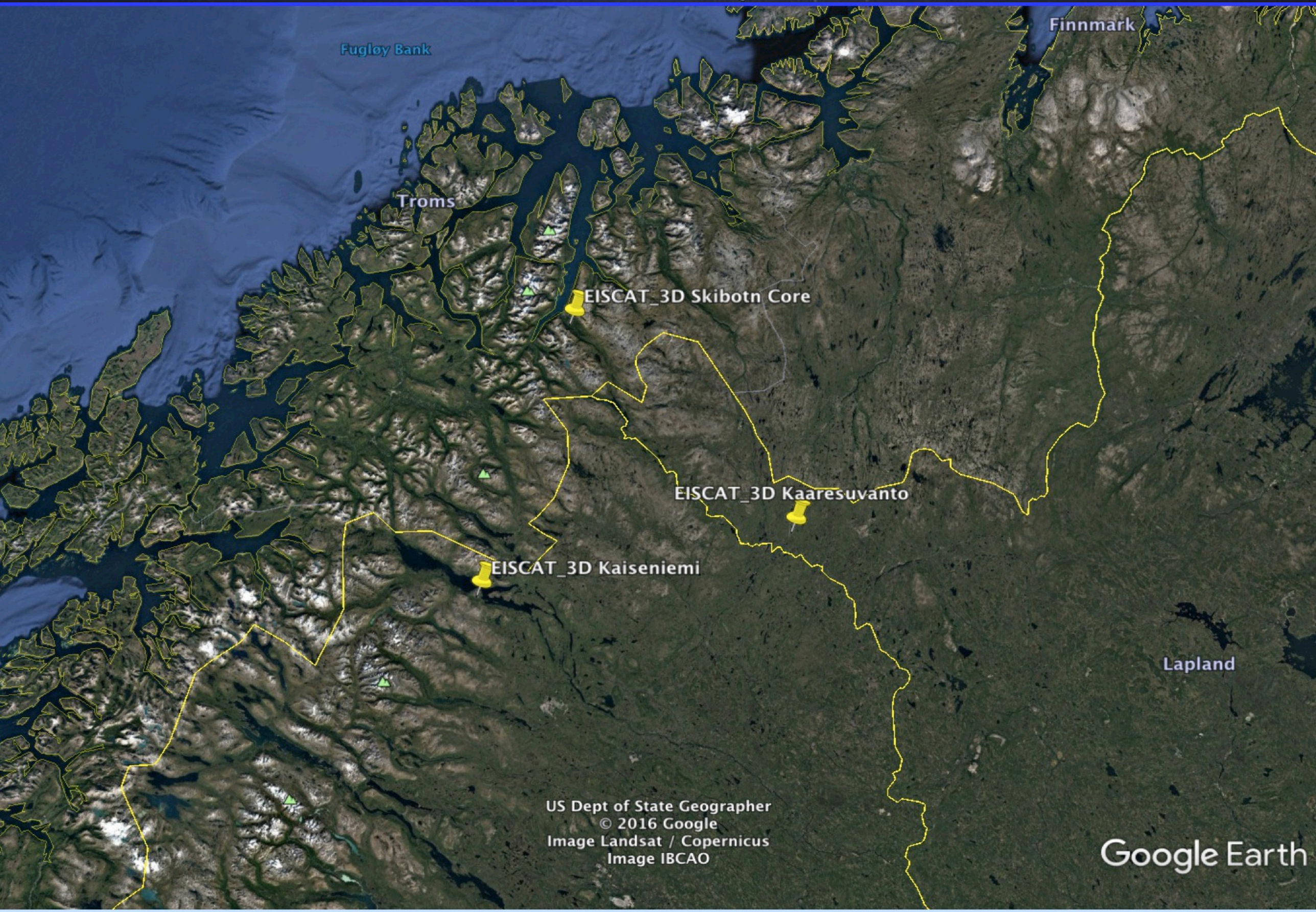
EISCAT_3D

KARESUVANTO, FINLAND



Thomas Ulich, Tero Raita & Jyrki Manninen, Sodankylän geofysiikan observatorio, 2015.

www.sgo.fi

Thomas Ulich, Tero Raita & Jyrki Manninen, Sodankylän geofysiikan observatorio, 2015.

Photos from Craig Heinselman's post

in Timeline Photos

Like Comment Options Send in Messenger

Untitled Map

tion for your map.

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Site seen from satellite

Legend

EISCAT_3D KAR

EISCAT_3D KAR

Google Earth

Image © 2020 CNES / Airbus

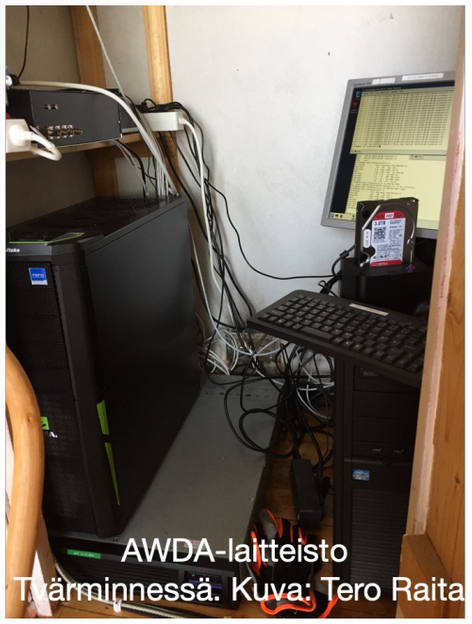
N

100 m

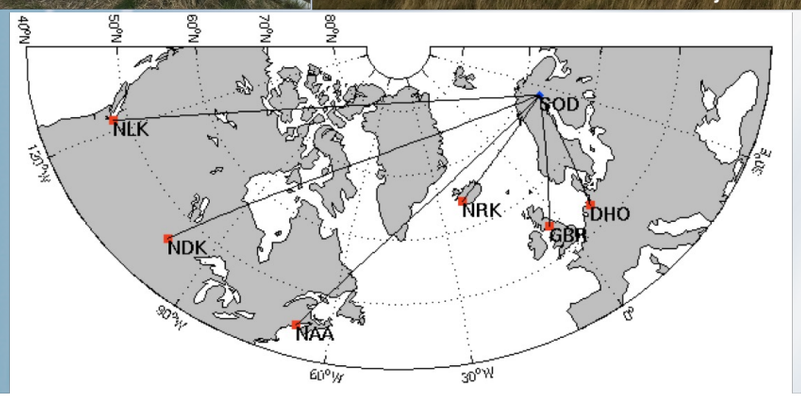
VLF receivers at SGO (0.2 – 40 kHz)

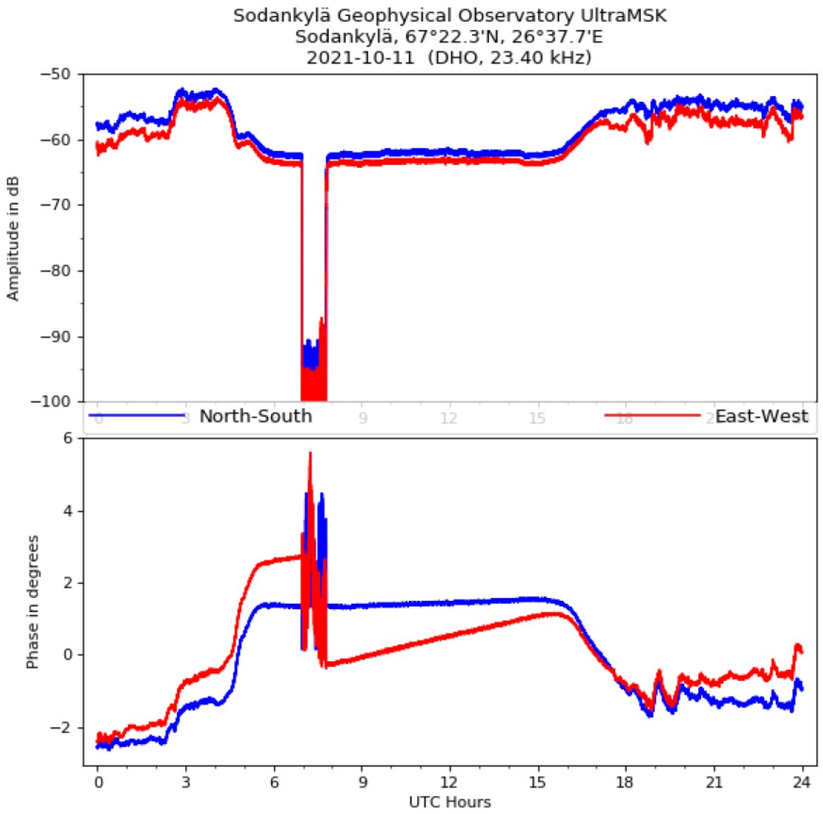
AARDDVARK UltraMSK antennit ja IRIS-antennikenttä Kilpisjärvellä. Kuva: Tero Raita

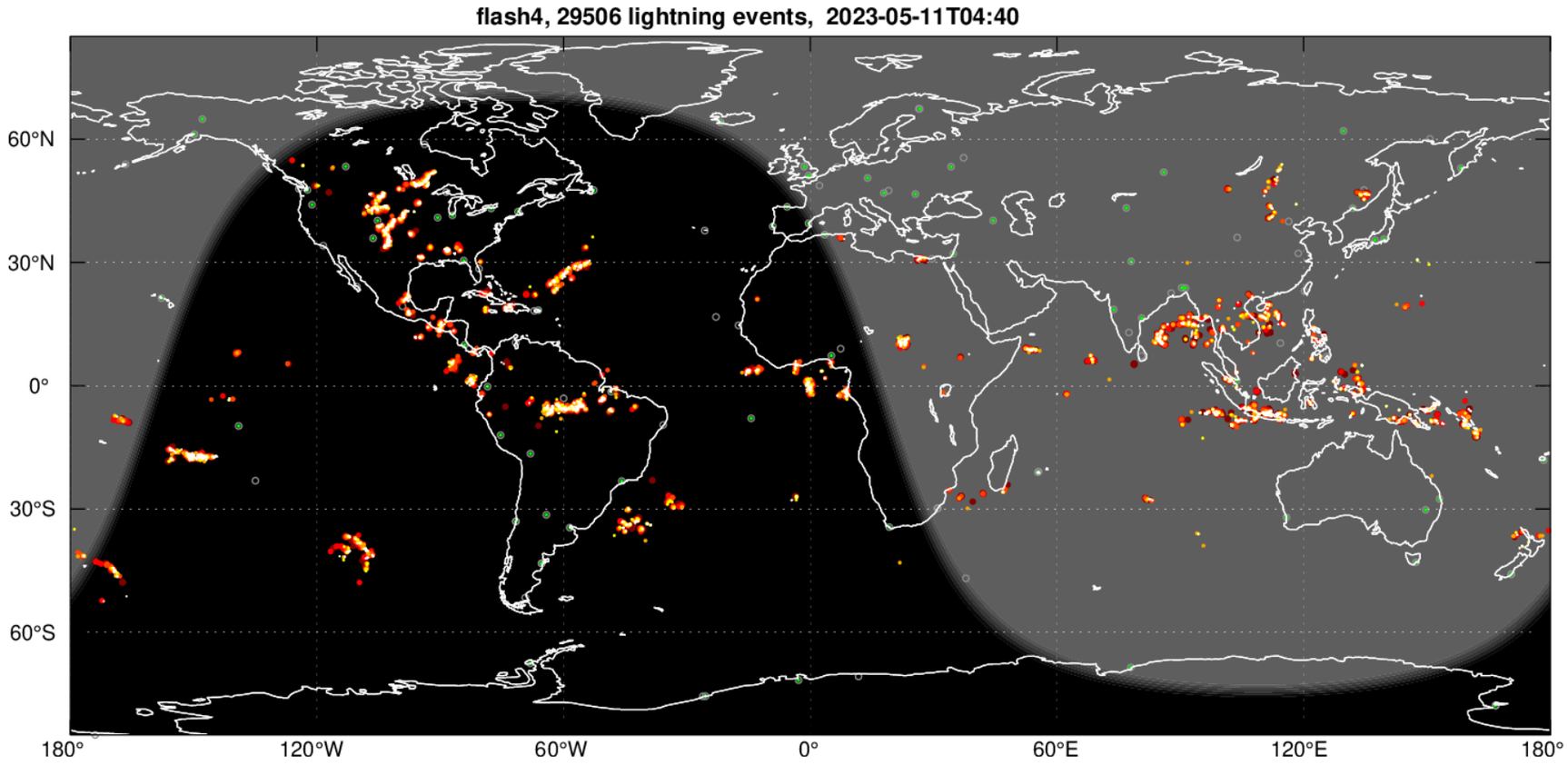
AWDA-antennit Tvärminnessä. Kuva: Tero Raita



AWDA-laitteisto
Tvärminnessä. Kuva: Tero Raita







Location in the Arctic region (PWING network)

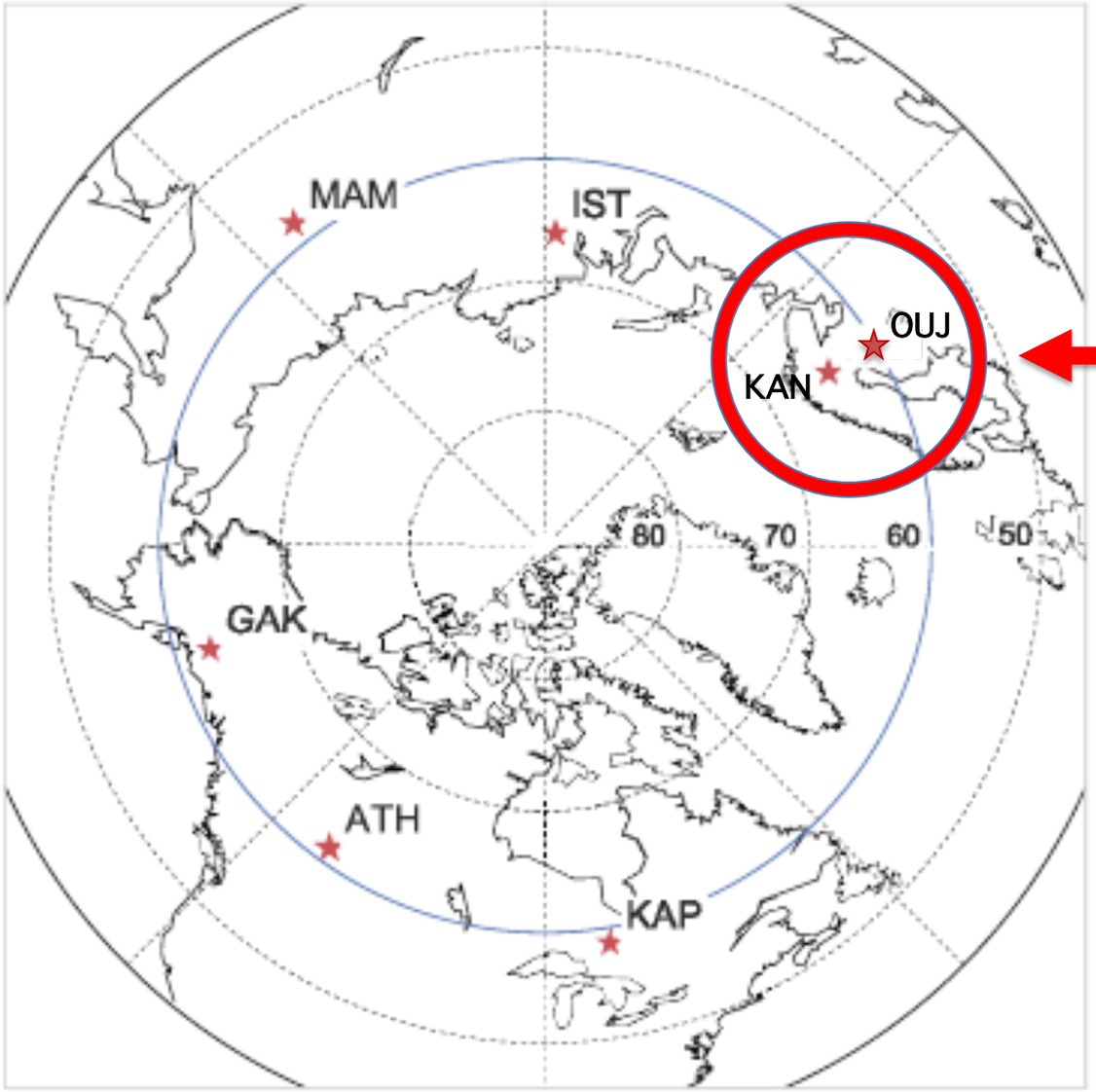
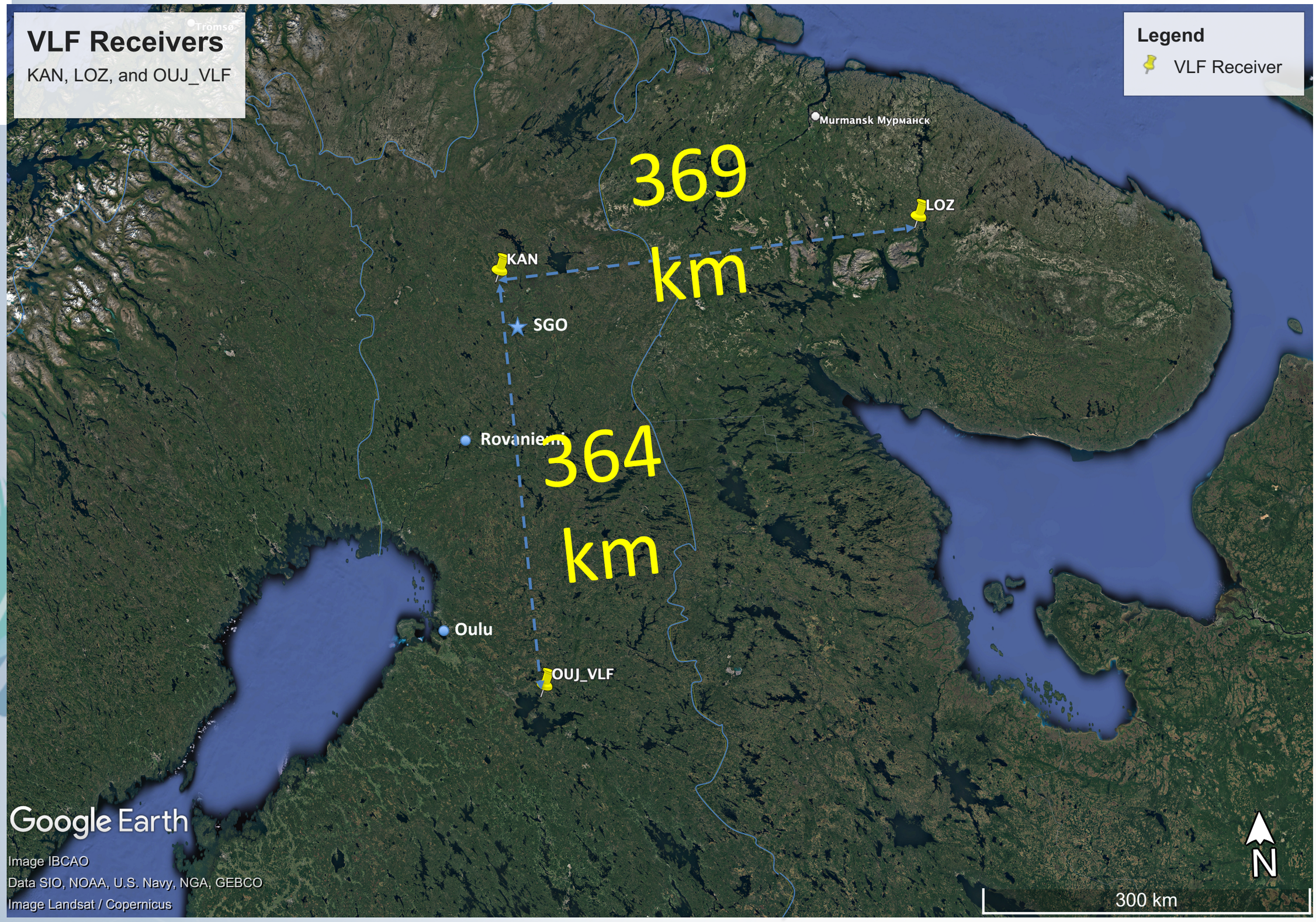


Figure 1. MLAT (magnetic latitude)-MLT (magnetic local time) map of the PWING stations. All stations are located at subauroral latitudes (~ 60° magnetic latitude). ATH, Athabasca; GAK, Gakona; IST, Istok; KAN, Kannuslehto; KAP, Kapuskasing; MAM, Maimaga.

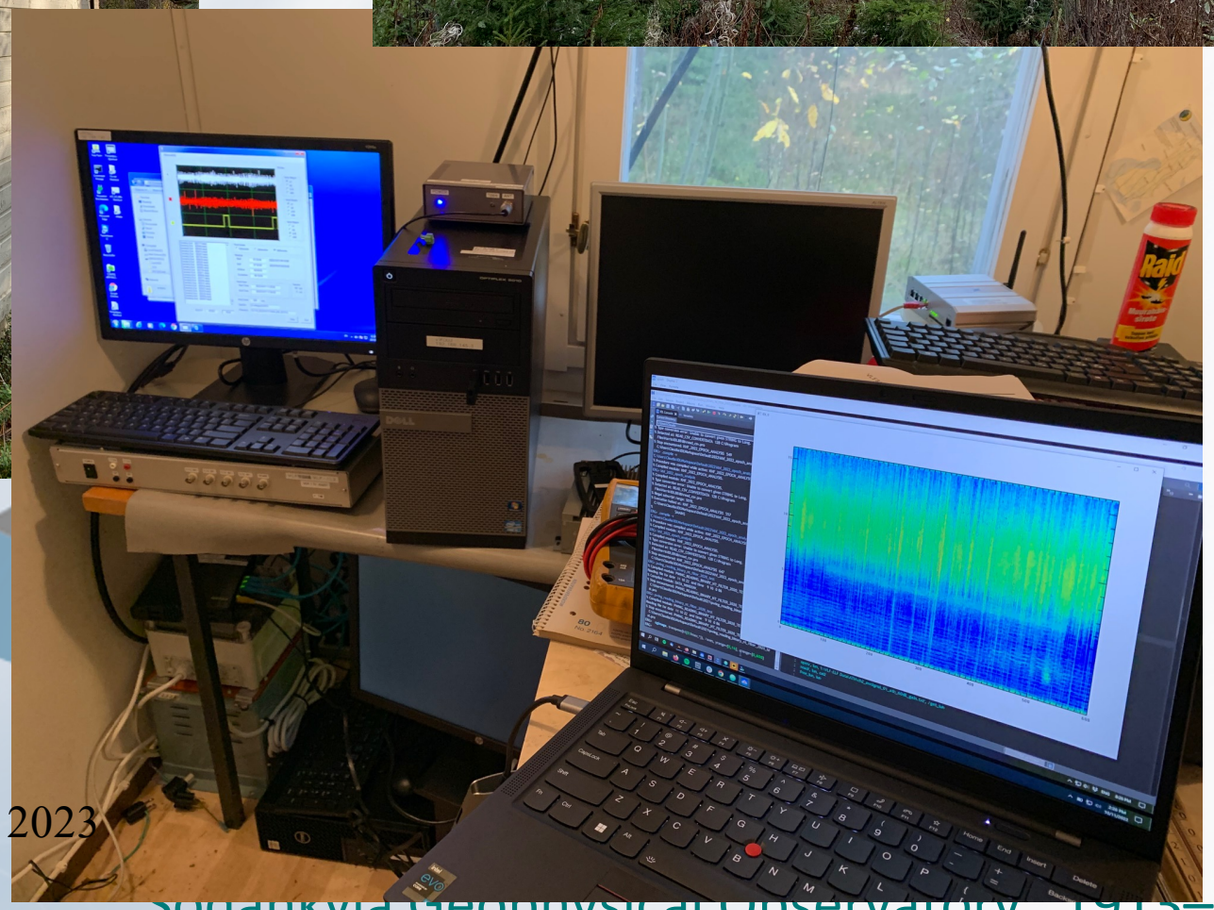
New locatio n at OUJ

(From Takeshita et al., 2019)

New VLF receiver at OUJ in Finland



New VLF receiver at OUJ in Finland



11 Jan 2023

Sodankylä Geophysical Observatory 1913–2013

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10 m

10 m

Nick name:VLF100aT

Frequency range:0.2 – 39.1 kHz

Noise level: 10^{-14} nT^2/Hz

Some facts from Kannuslehto

- Kannuslehto CGM: +64.31°; 119.66°; L = 5.5
  - ➢ electron gyrofrequency at the equator $f_{ce} \approx 5.2$ kHz -> $f_{ce}/2 \approx 2.6$ kHz

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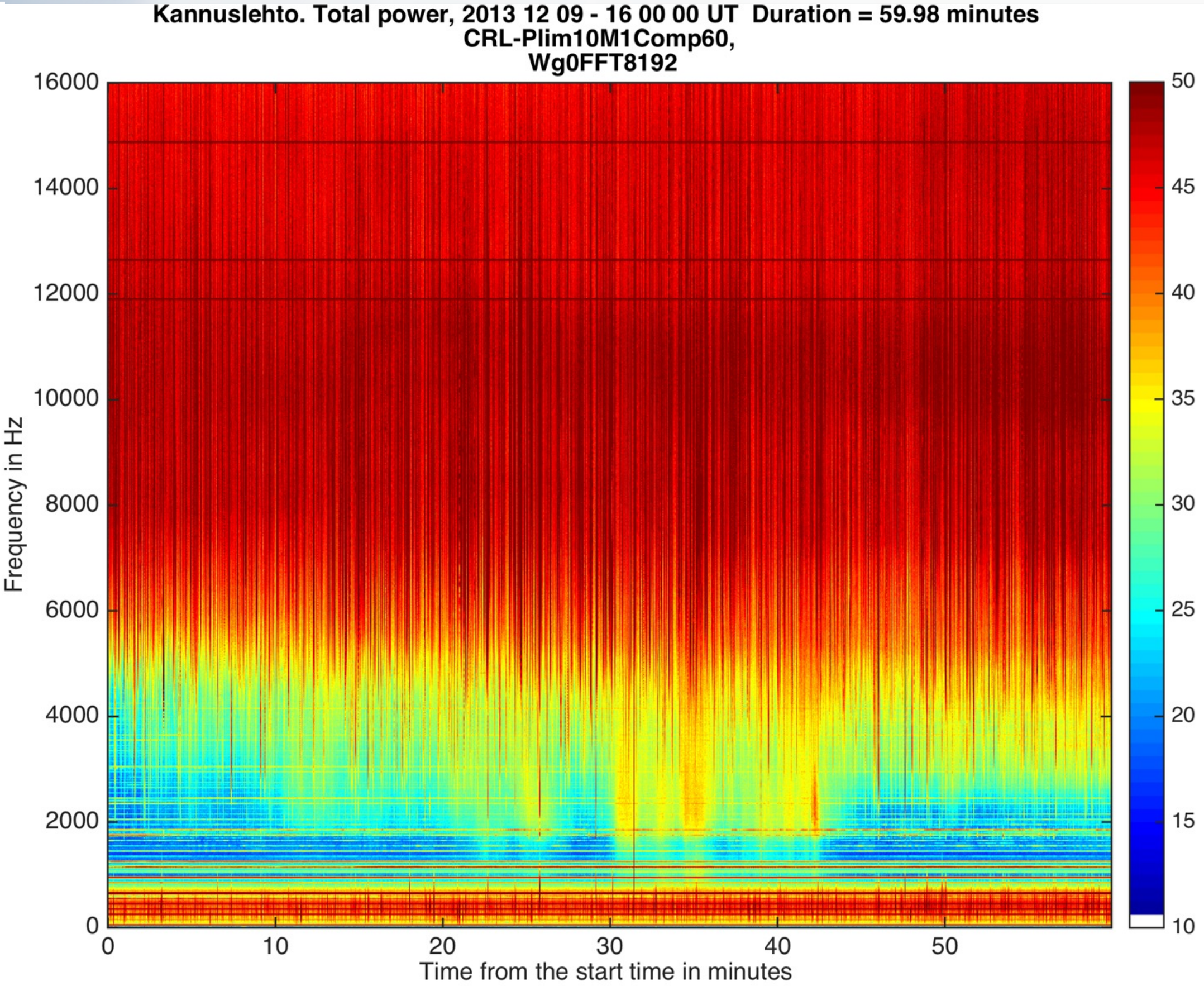

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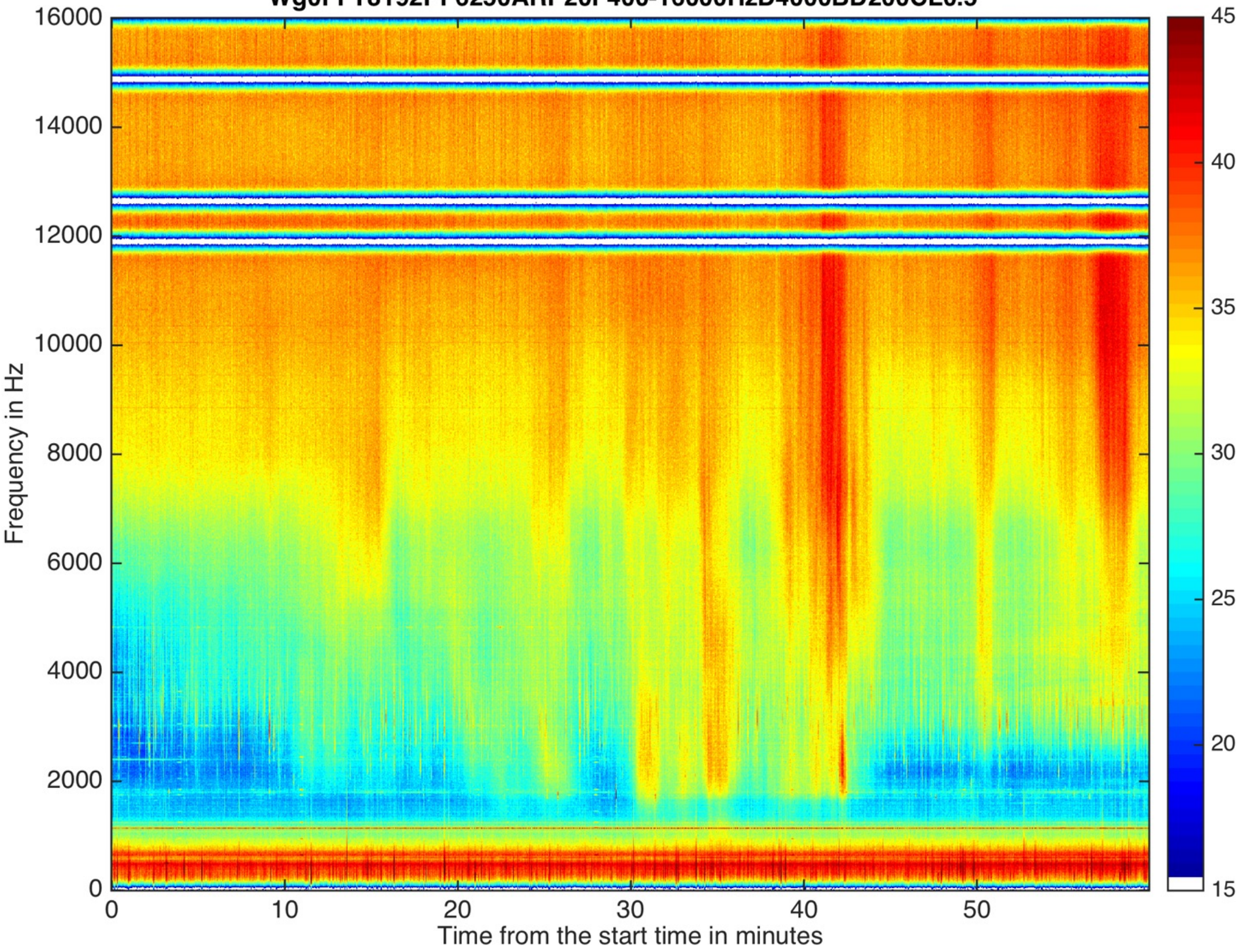
Kannuslehto. Total power, 2013 12 09 - 16 00 00 UT Duration = 59.98 minutes
CRL-Plim10M1Comp60,
Wg0FFT8192PF6250ARP20F400-16000HzD4000BD200CL0.5



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Sodankylä Geophysical Observatory

Kannuslehto. Total power, 2013 12 10 - 12 00 00 UT Duration = 59.98 minutes
CRL-Plim10M1Comp60,
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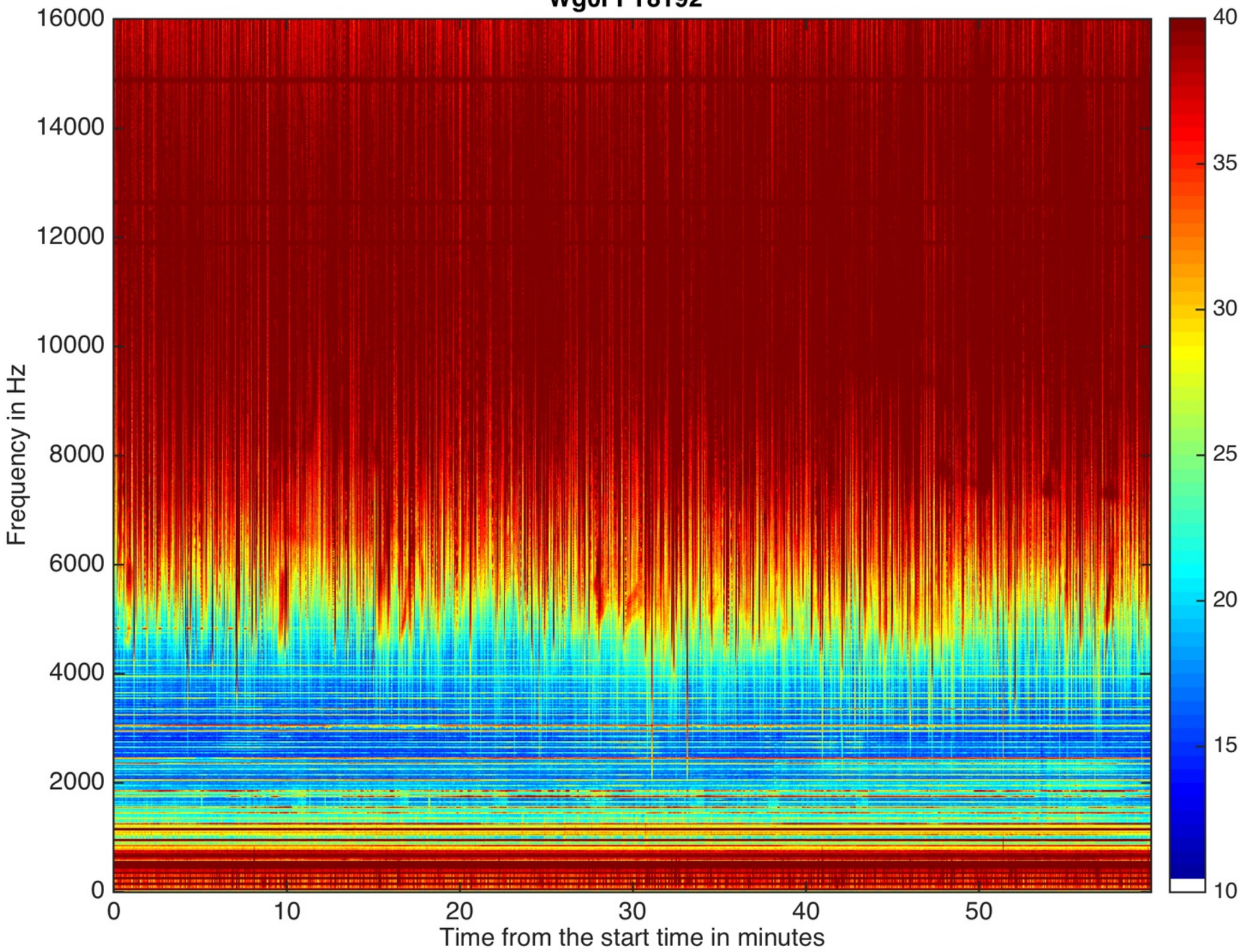

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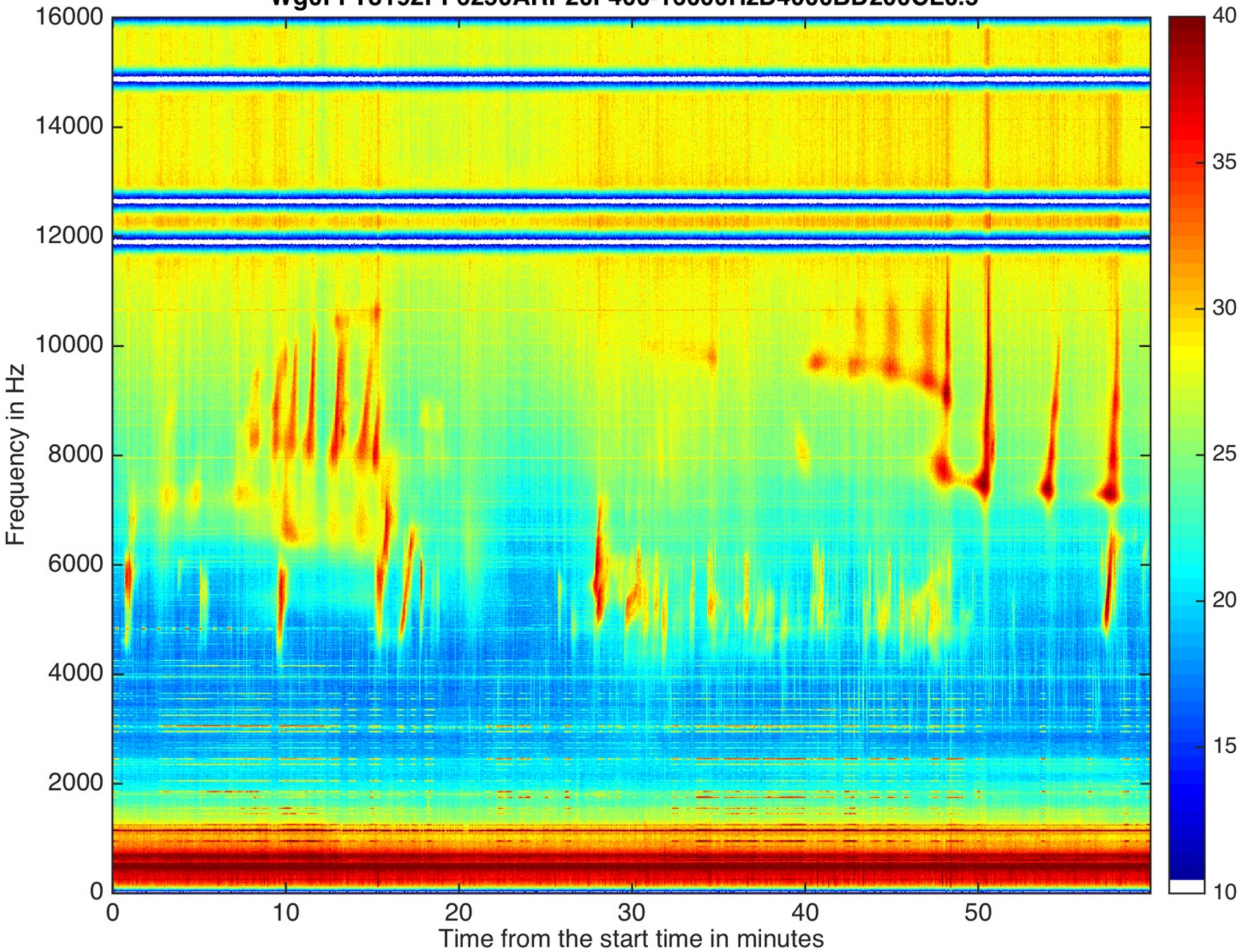
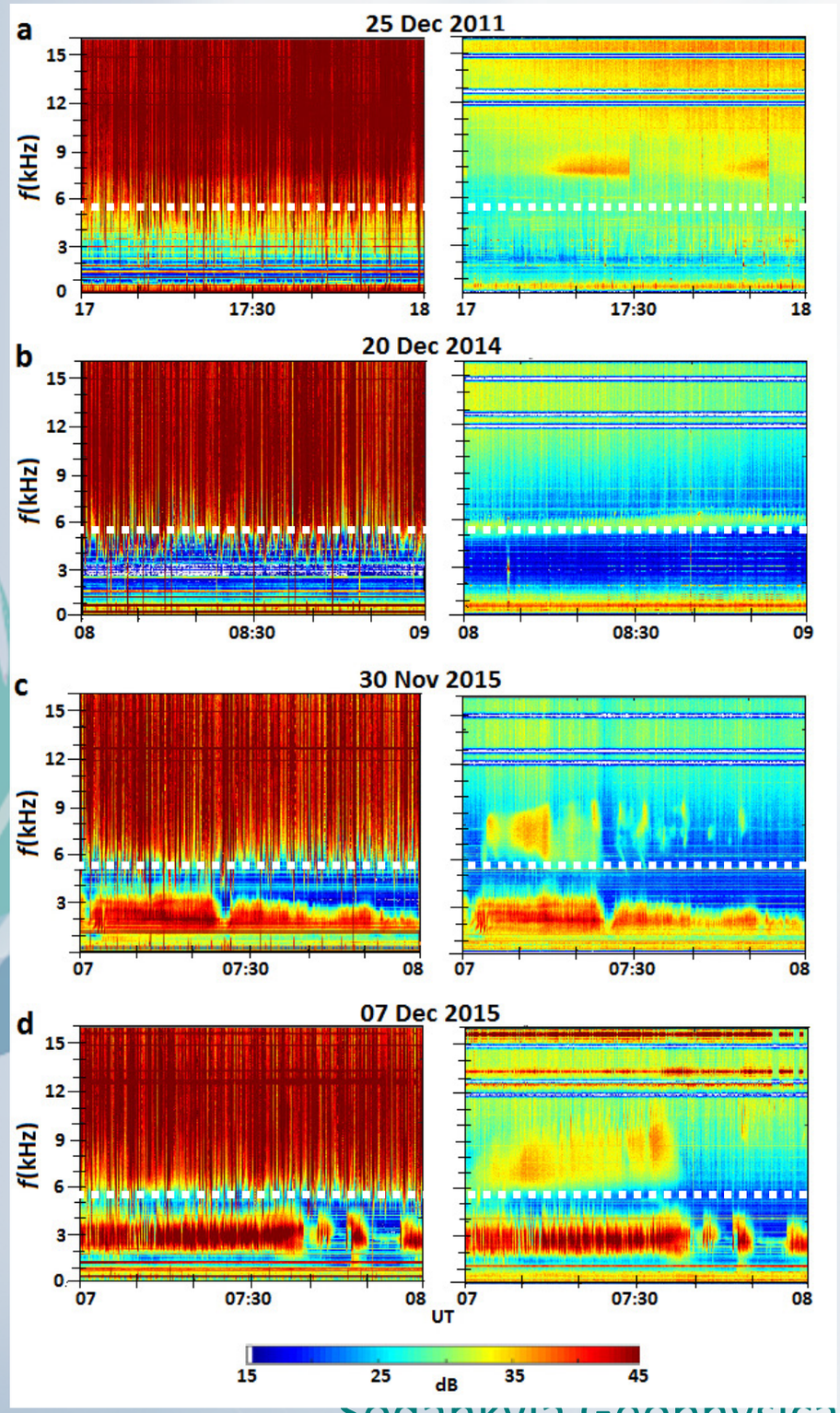
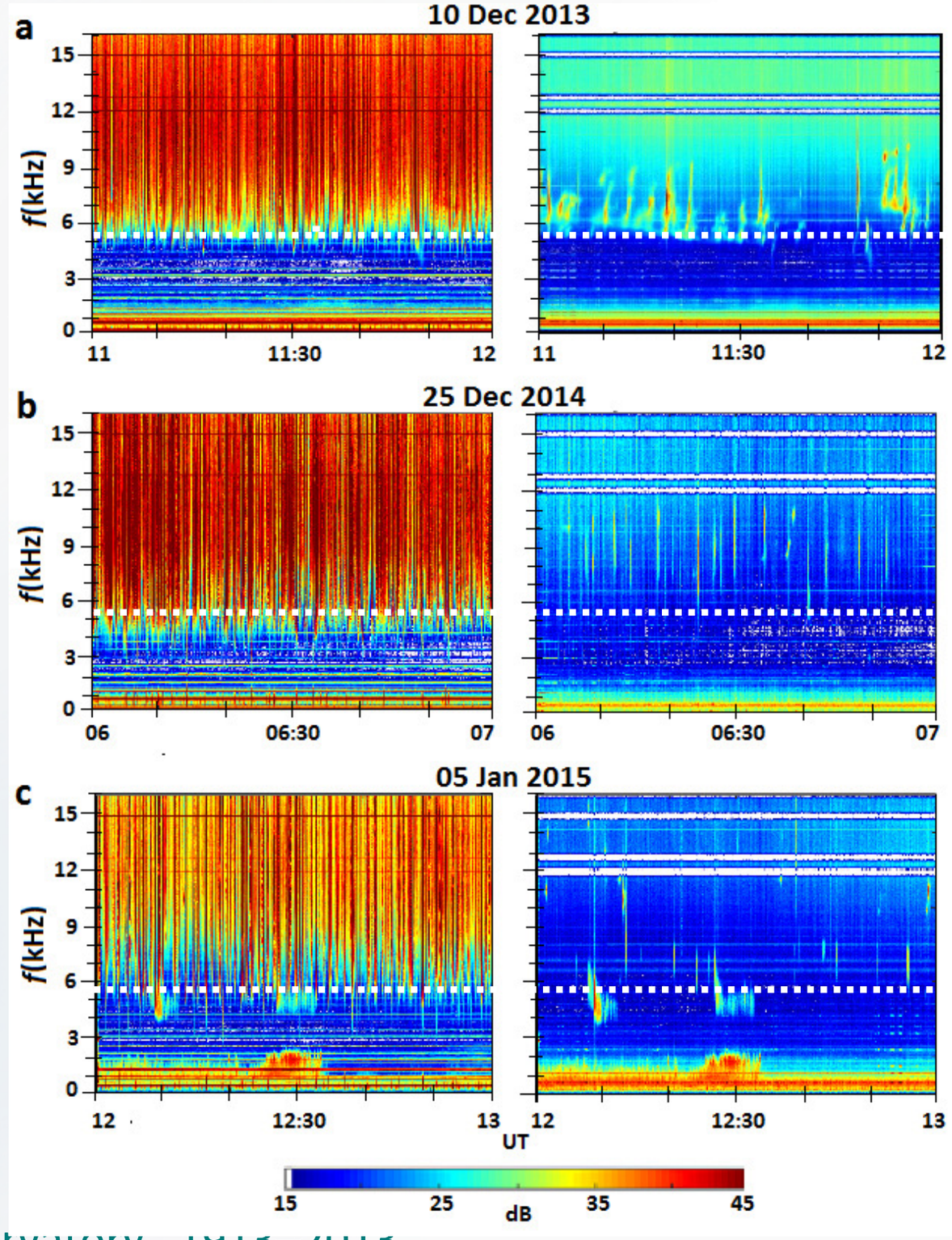
Sodankylä Geophysical Observatory

Kannuslehto. Total power, 2013 12 10 - 12 00 00 UT Duration = 59.98 minutes
CRL-Plim10M1Comp60,
Wg0FFT8192PF6250ARP20F400-16000HzD4000BD200CL0.5

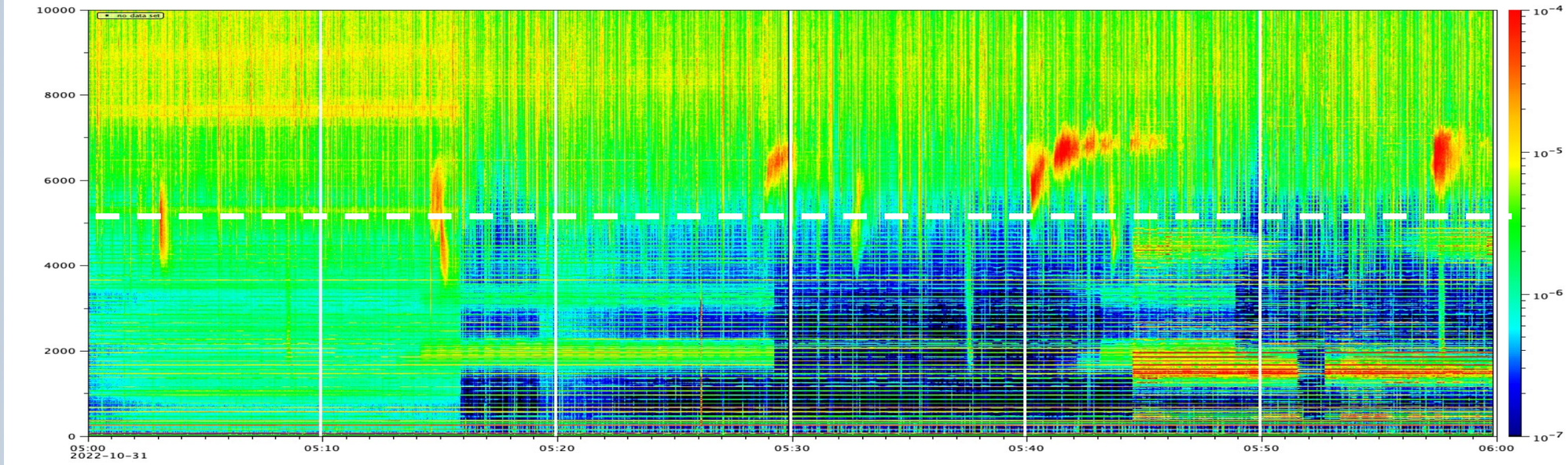


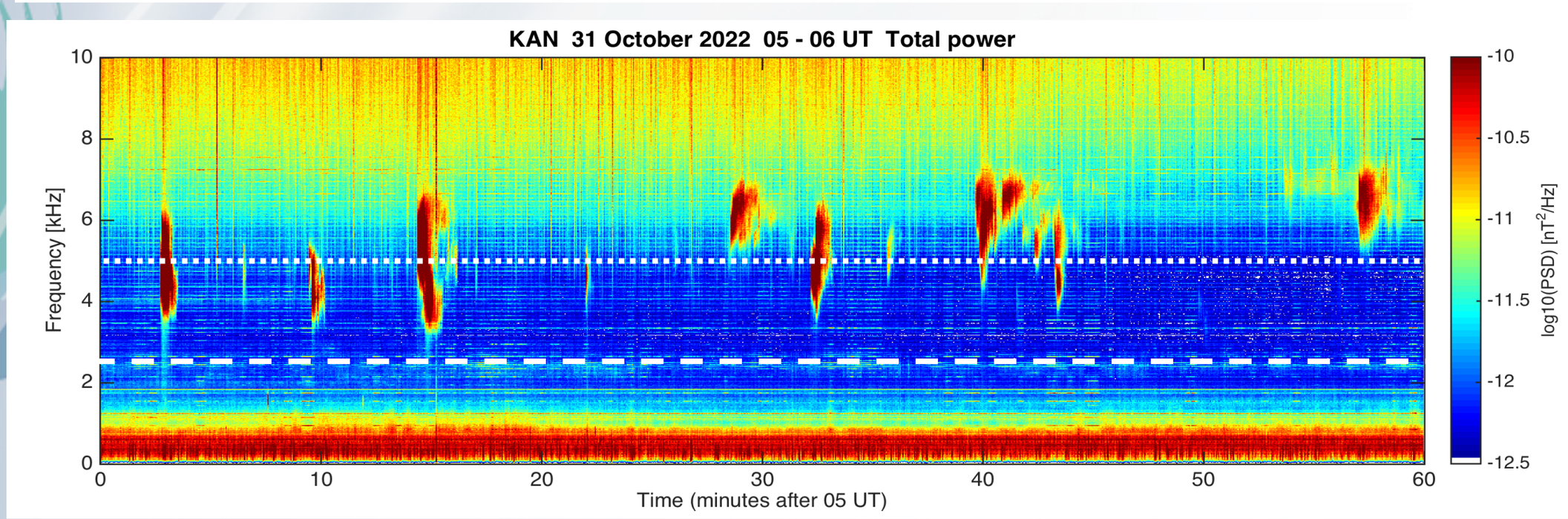
Recently revealed emissions at KAN (Manninen et al., 2016)



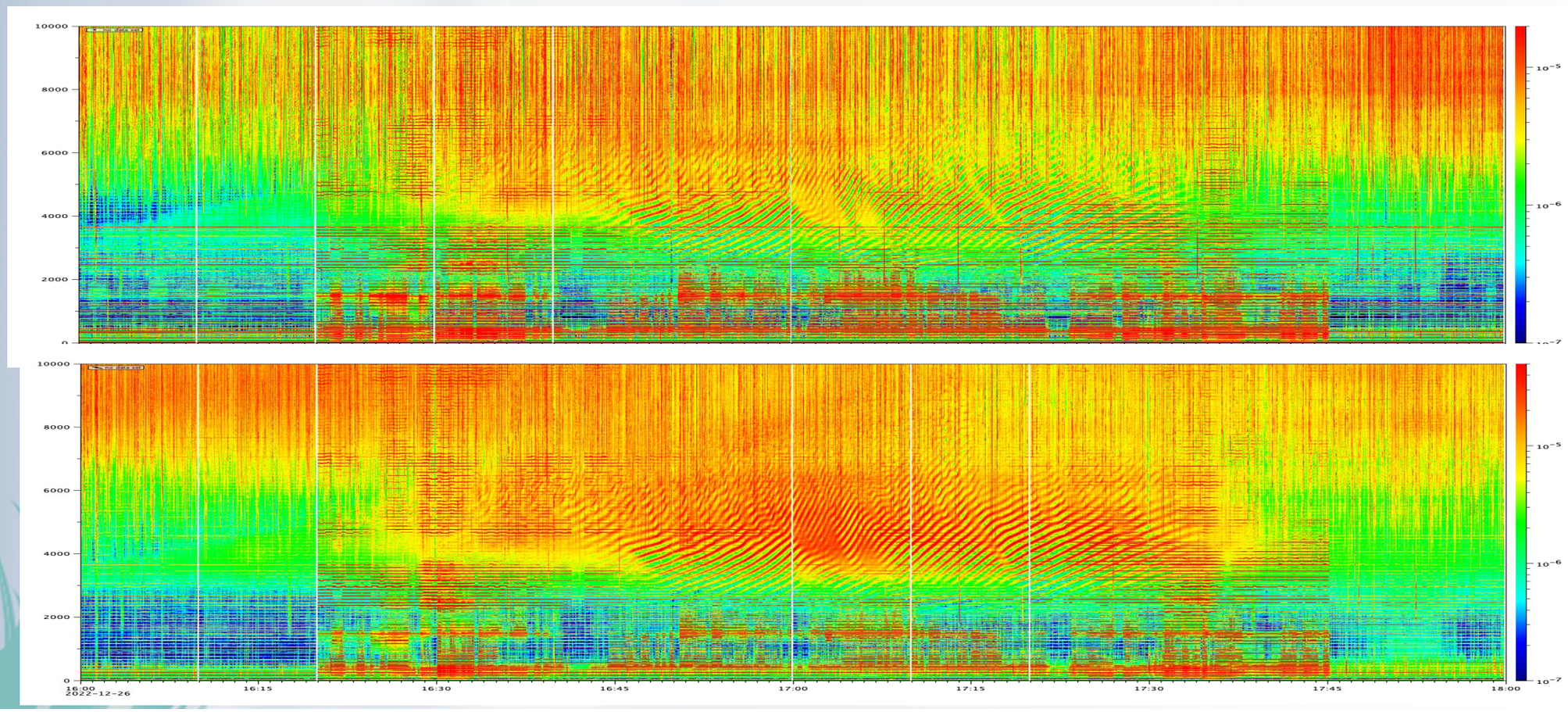


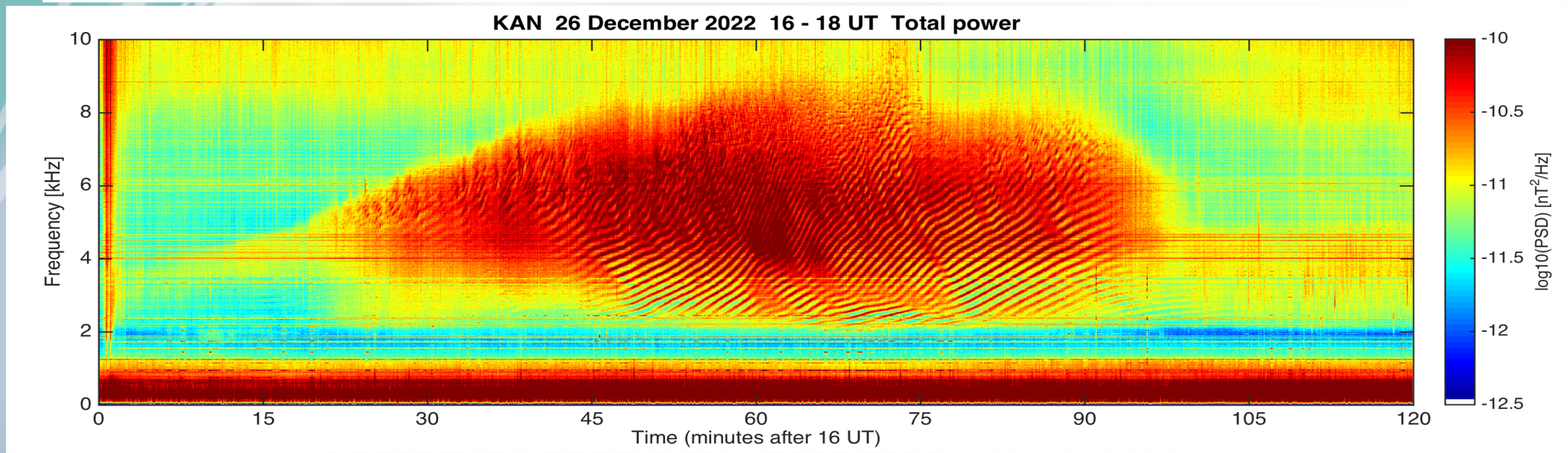
OUJ and KAN on 31 Oct 2022 05-06 UT



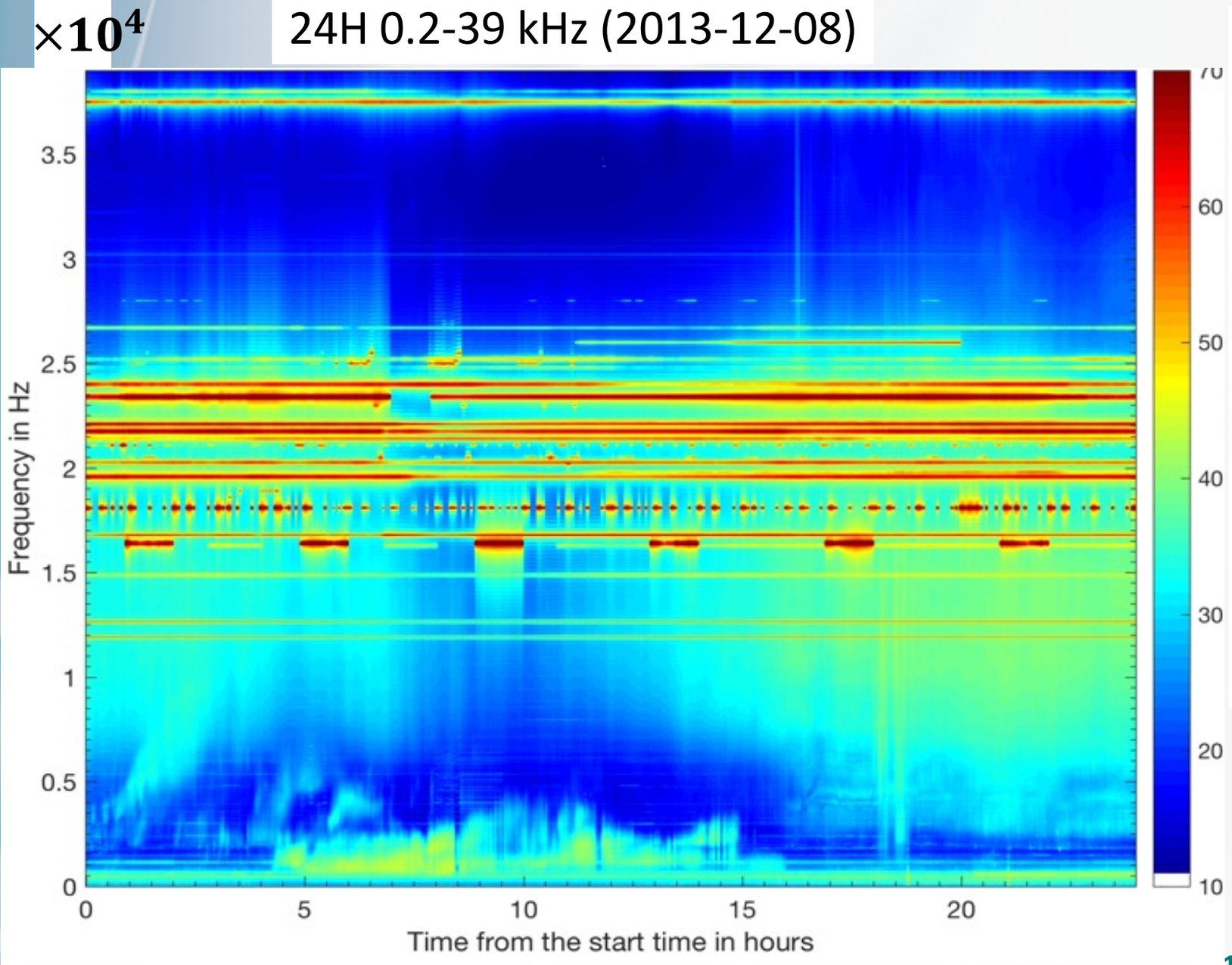


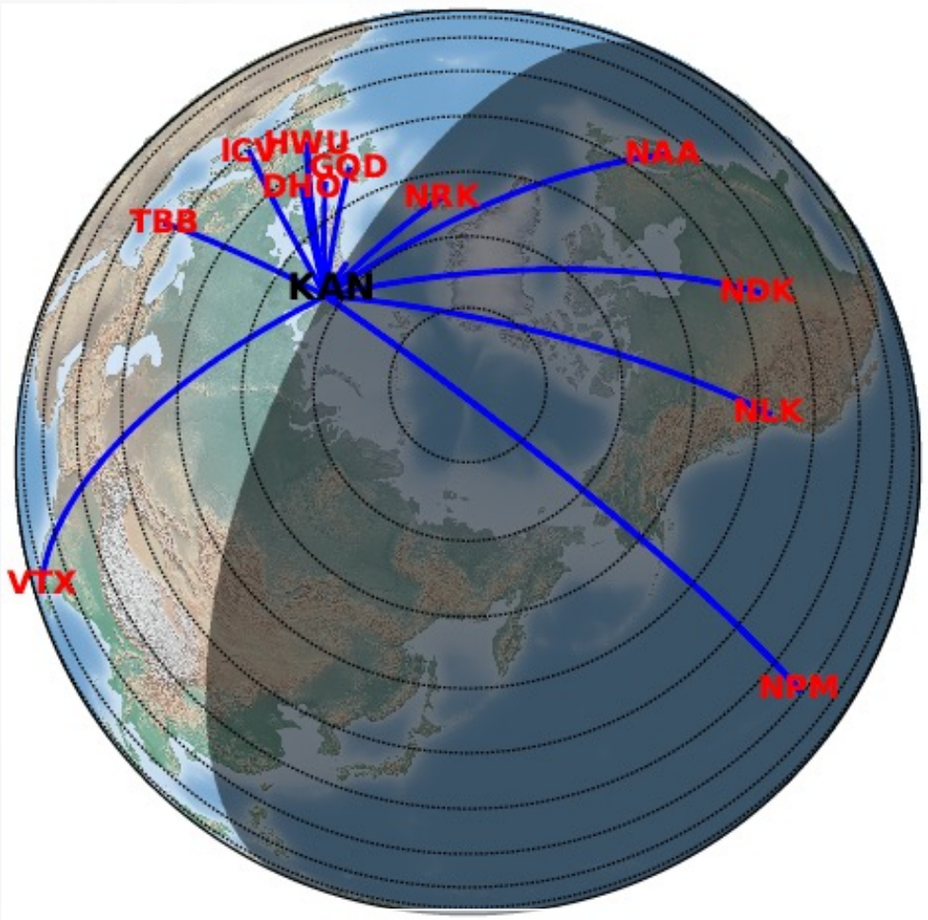
OUJ and KAN on 26 Dec 2022 16-18 UT





Kannuslehto





Propagation paths
of transmitter signals

VLF transmitters recorded at KAN			
N	ID	Freq Hz	Location
1	ZEVS	82	Kola Peninsula
2	Novosibirsk	11905	Novosibirsk
3	Khobarousk	12649	Khobarousk
4	VTX1	16300	India
5	JXN	16400	Norway
6	FTA	16800	France
7	SAQ	17200	Sweden
8	RDL	18100	Russia
9	VTX3	18200	India
10	HWU	18300	France
11	GBZ	19580	UK
12	NWC	19800	Australia
13	ICV	20270	Italy
14		20500	
15	FTA	20900	France
16		21100	
17	NPM	21400	Hawaii

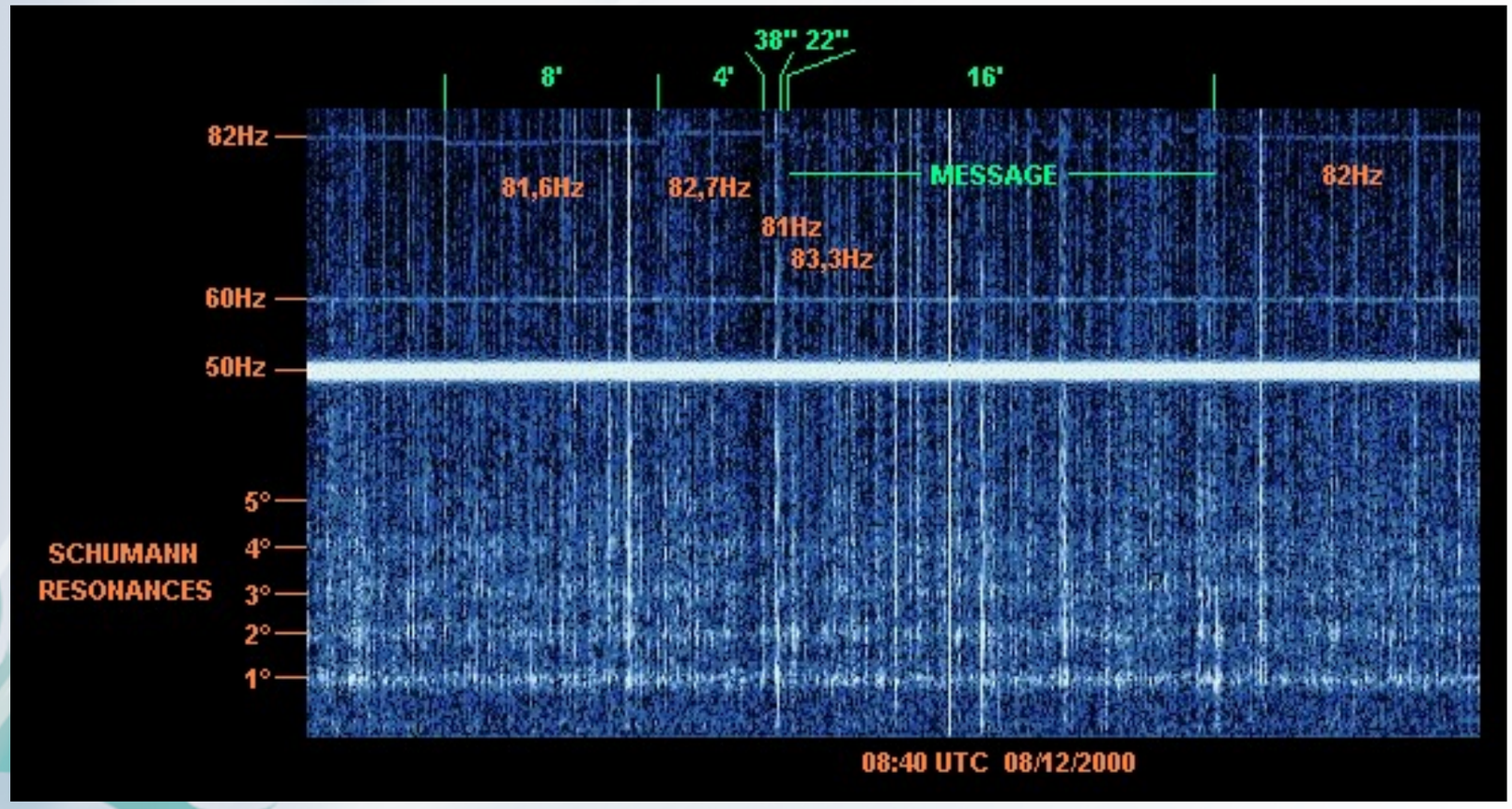
VLF transmitters recorded at KAN			
N	ID	Freq Hz	Location
18	HWU	21750	France
19	GQD	22100	UK
20		23000	
21	DHO	23400	Germany
22	NAA	24000	Cluter
23	NLK	24800	Washigton
24	unid25	25000	South Korea
25	NDK/NML	25200	Noth Dakota
26		25500	
27		26000	
28	TBB	26700	Turkey
29		28000	
30		30100	
31		30200	
32		35620	
33	NRK/TFK	37500	Iceland
34	SRC/NRJ	38000	Sweden

82 Hz ZEVS transmitter Kola Peninsula

- Transmitted power 10-14 MW (estimate)
- Wavelenght 3658,5 km
  - Can penetrate hundreds of meters deepness in the sea and ice
  - Antenna lenght > 60 km
- Very low transmission capacity: only few characters per minute
- Transmitting only – no receiving

82 Hz ZEVS transmitter Kola Peninsula

- MSK transmission in frequency range of 81,0 - 83,3 Hz



- Are used also for seismic sounding with frequencies of 31-166 Hz

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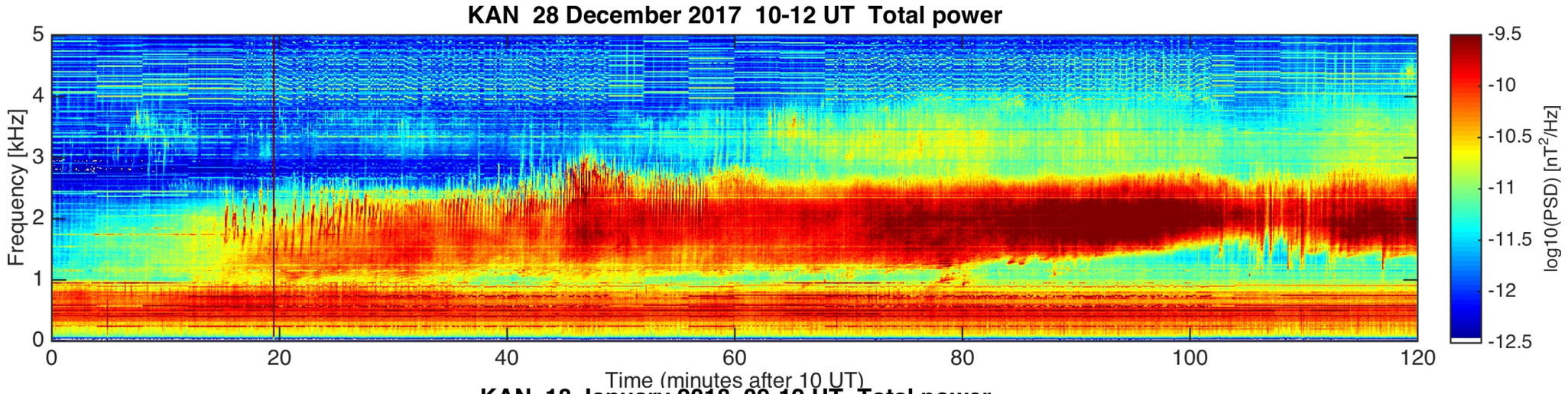
ZEVS observations at Kannuslehto



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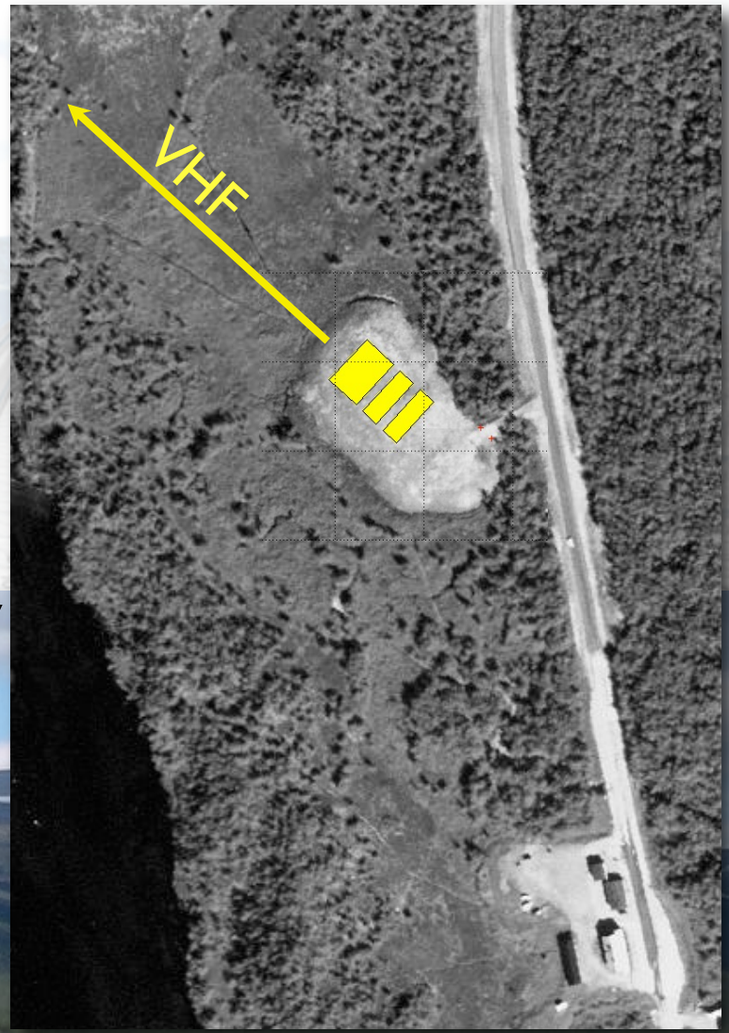
KAIRA

Kilpisjärvi Atmospheric Imaging Receiver Array



LOFAR receiver at Kilpisjärvi, 20-85 MHz and 110-250 MHz; operational since August 2012.

Leverage from the EU 2007–2013

European Union
European Regional Development Fund
European Social Fund

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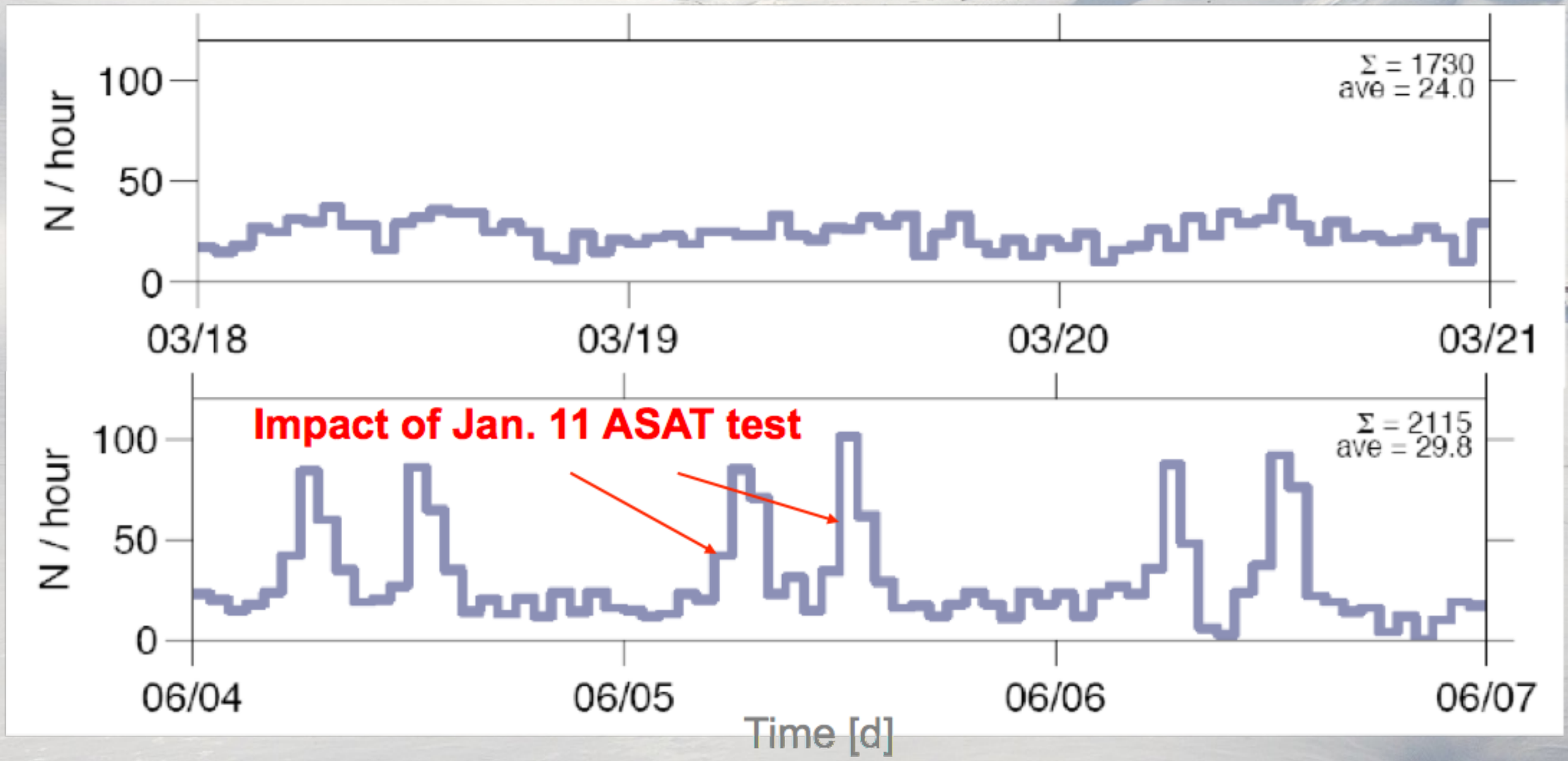
OULUN YLIOPISTO

EISCAT & Space Debris



11 Jan 2007 Chinese anti-satellite missile test taking down Fengyun weather satellite

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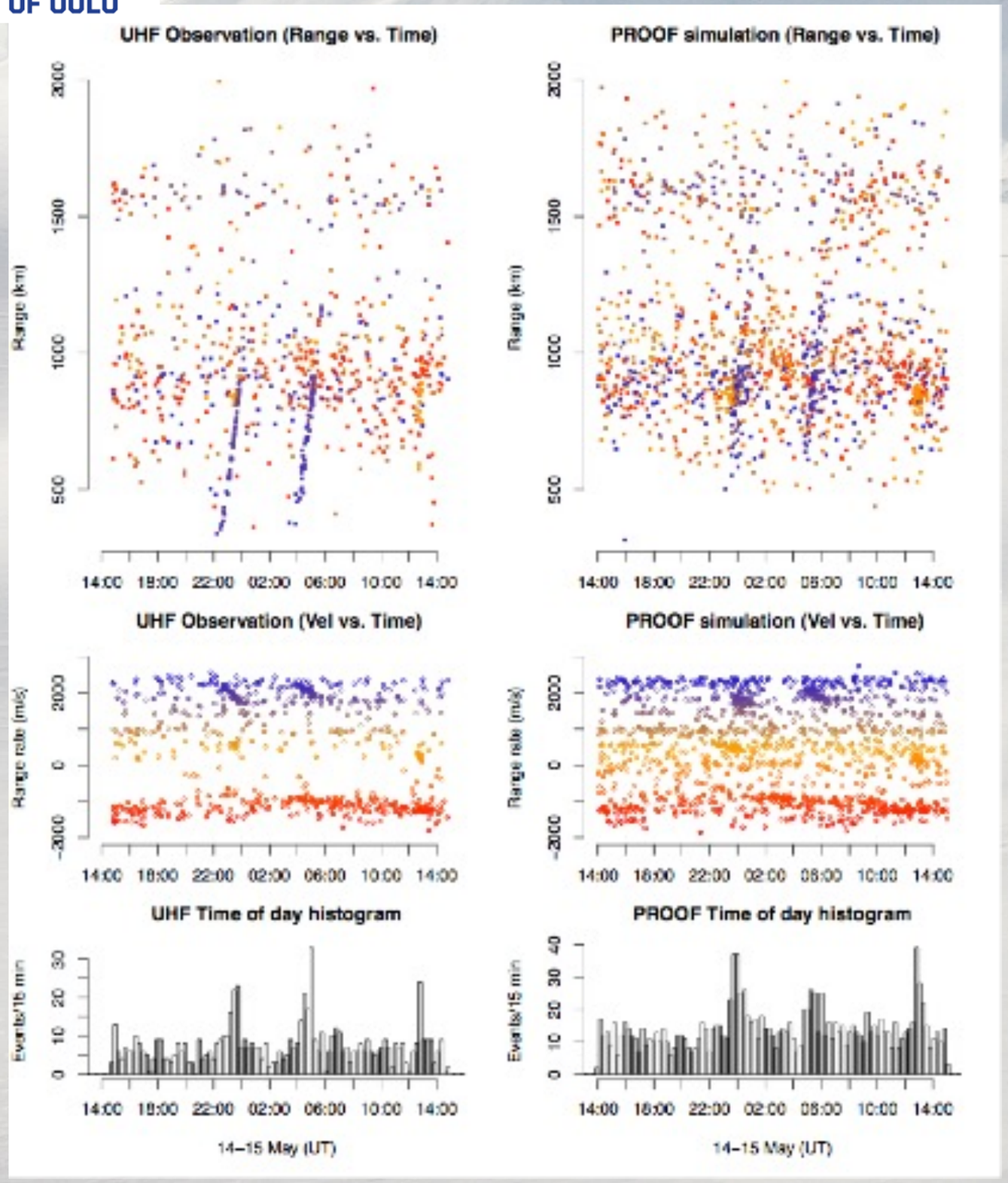
Iridium-Cosmos Collision seen by EISCAT UHF radar

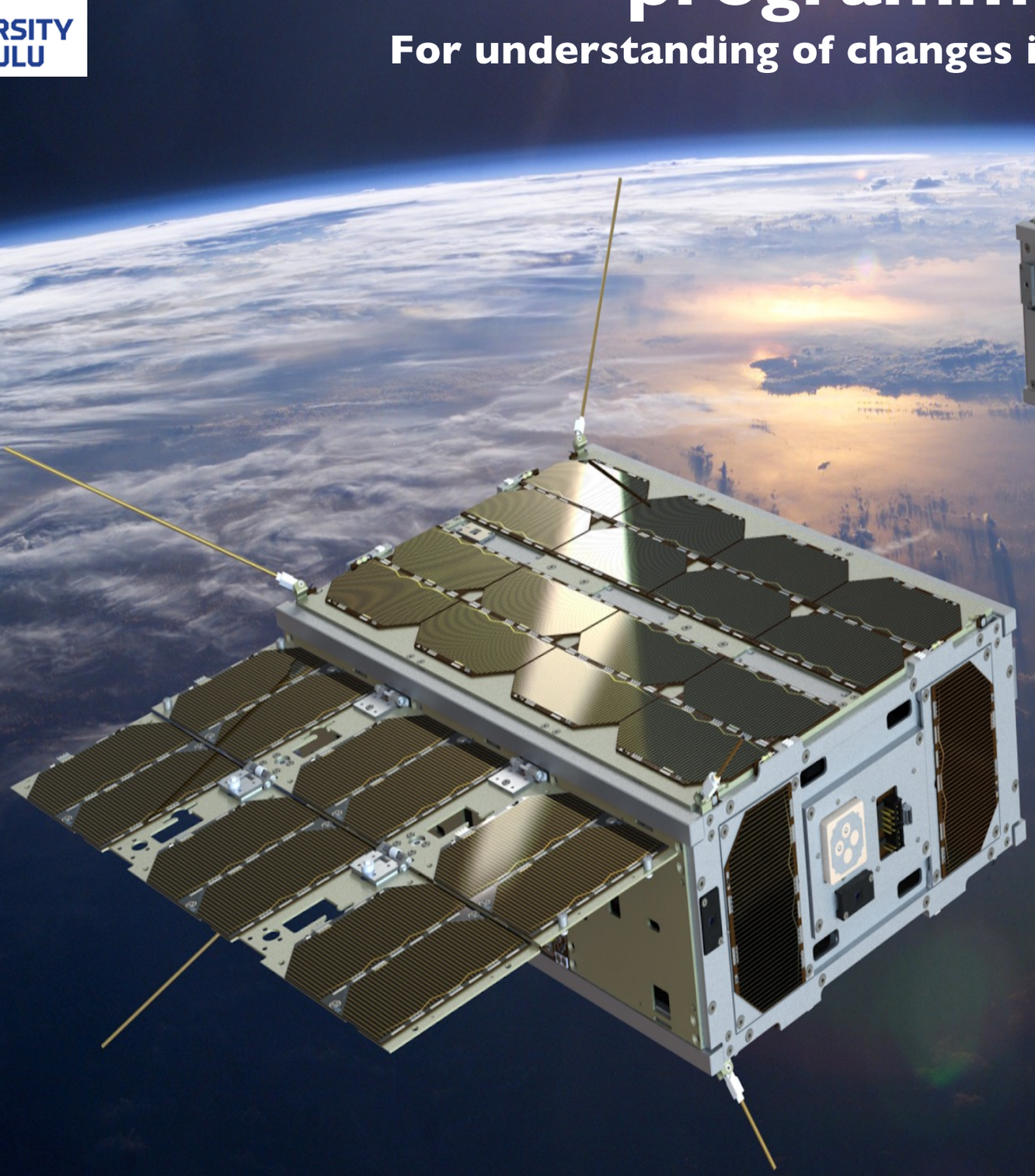


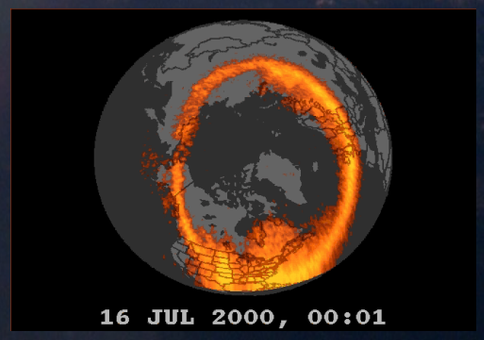
(J. Vierinen et al., 2009)

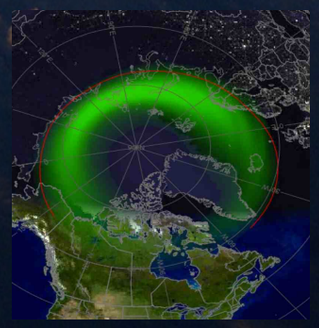
What happens, when an unstoppable object hits an indestructible barrier?
Here:1.7 g alumiinium sphere, Ø 1.2 cm at 6.8 km/s.

LappiSat-1 aurora satellite & satellite programme

For understanding of changes in Arctic area







Real-time information from environment by cameras, magnetometers, and photometers

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THANK YOU!