Scientific Association and its facilities

EISCAT

Contents:

1) Introduction, setting the radar in the context
2) EISCAT as an association, organisation, operation
3) Overview of the EISCAT facilities

See:
Web pages: www.eiscat.se
www.eiscat3d.se

EISCAT_3D blog, twitter and facebook pages

Dr. Esa Turunen

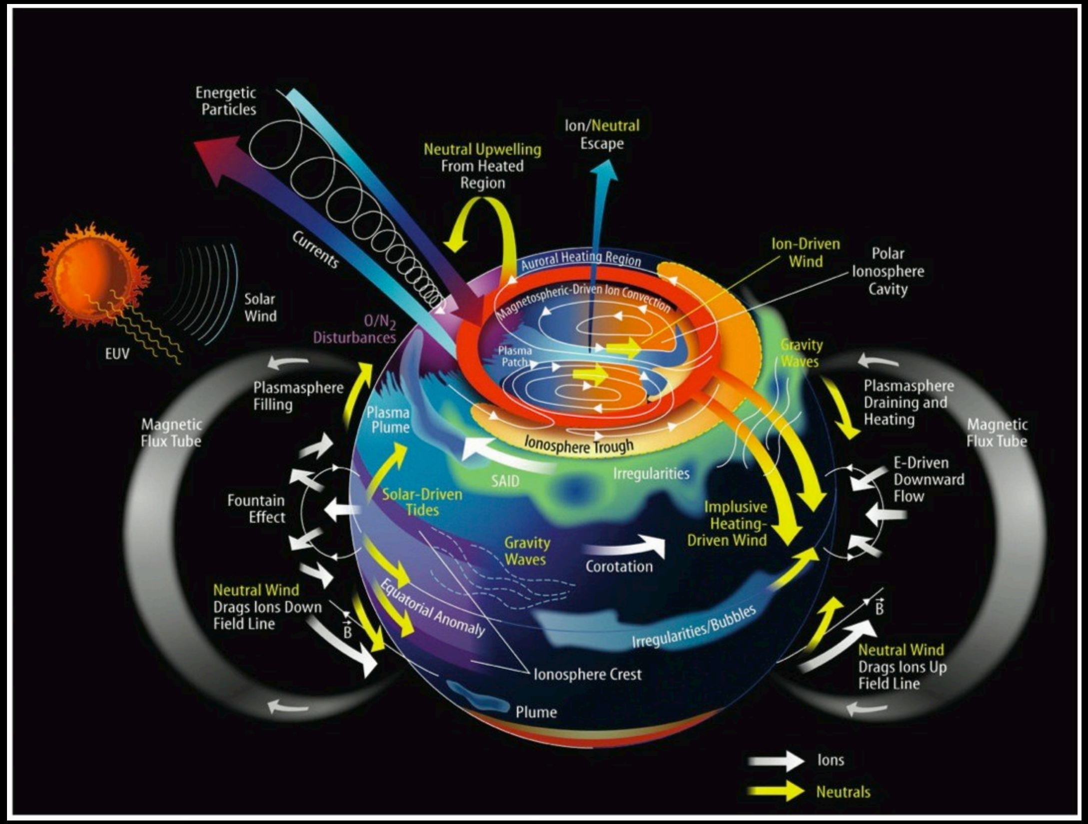
Director, EISCAT Scientific Association

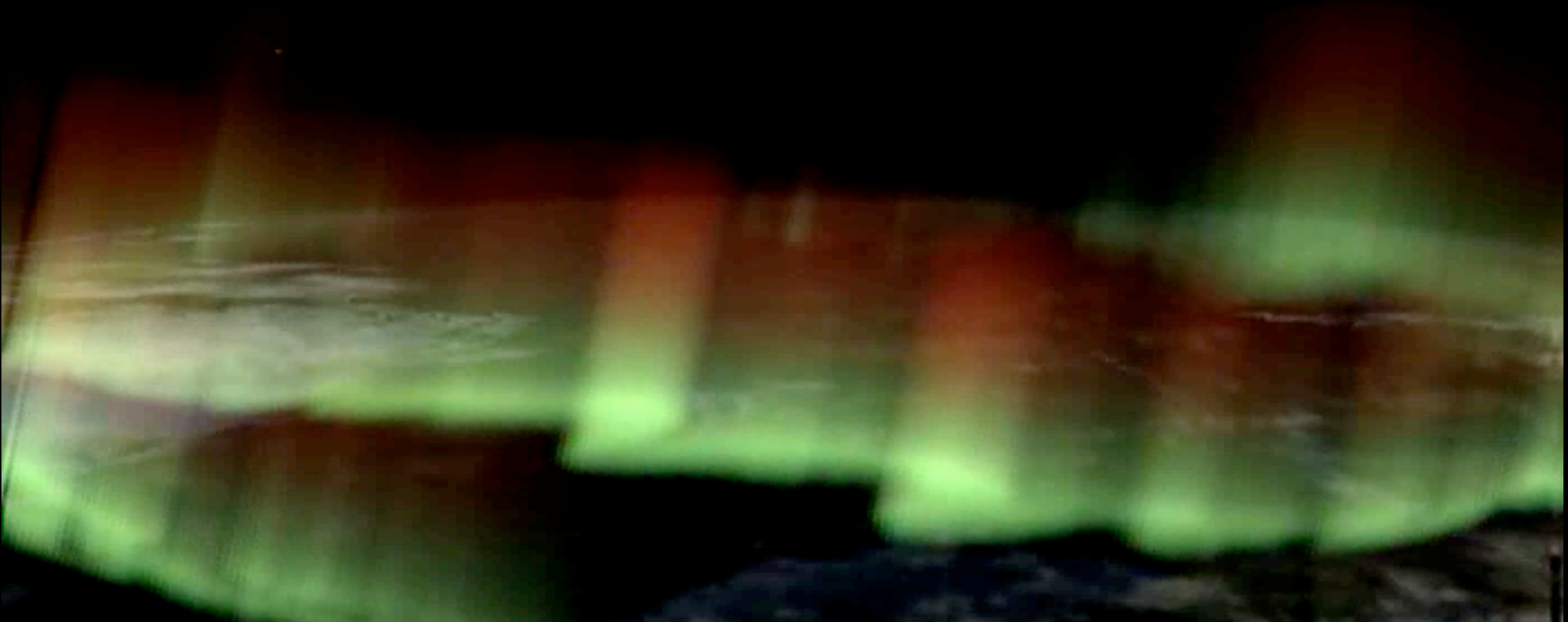
EISCAT Svalbard Radar

System approach to the Geospace Environment:

-Understand and predict responses of the Earth as a system

(NSF Geovision report, 2009)





International ISR Workshop, Kangerlussuaq, Greenland 18-23 July, 2011

Children of stardust

WE NEED DATA

Models:

- Statistical
- Assimilation
- Physical principles

- Empirical data
- Data as driver
- Key input data

What kind of tools do we need in order to understand what happens to the atmosphere here?

Geospace - a vital part of our environment

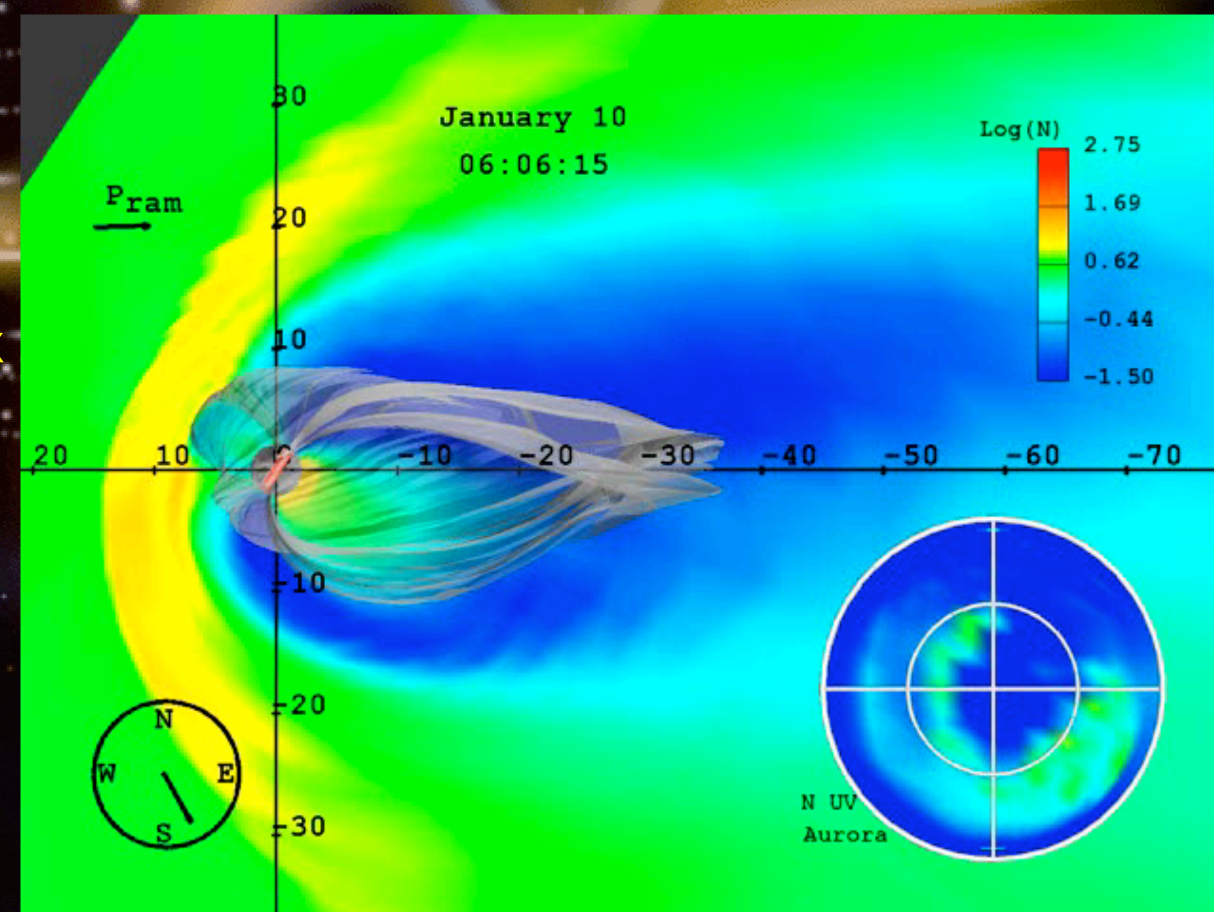
We live in the neighbourhood of a star, SUN

- Key questions:
  - How does Space Weather affect the climate?
  - How do the atmospheric layers couple to each other?

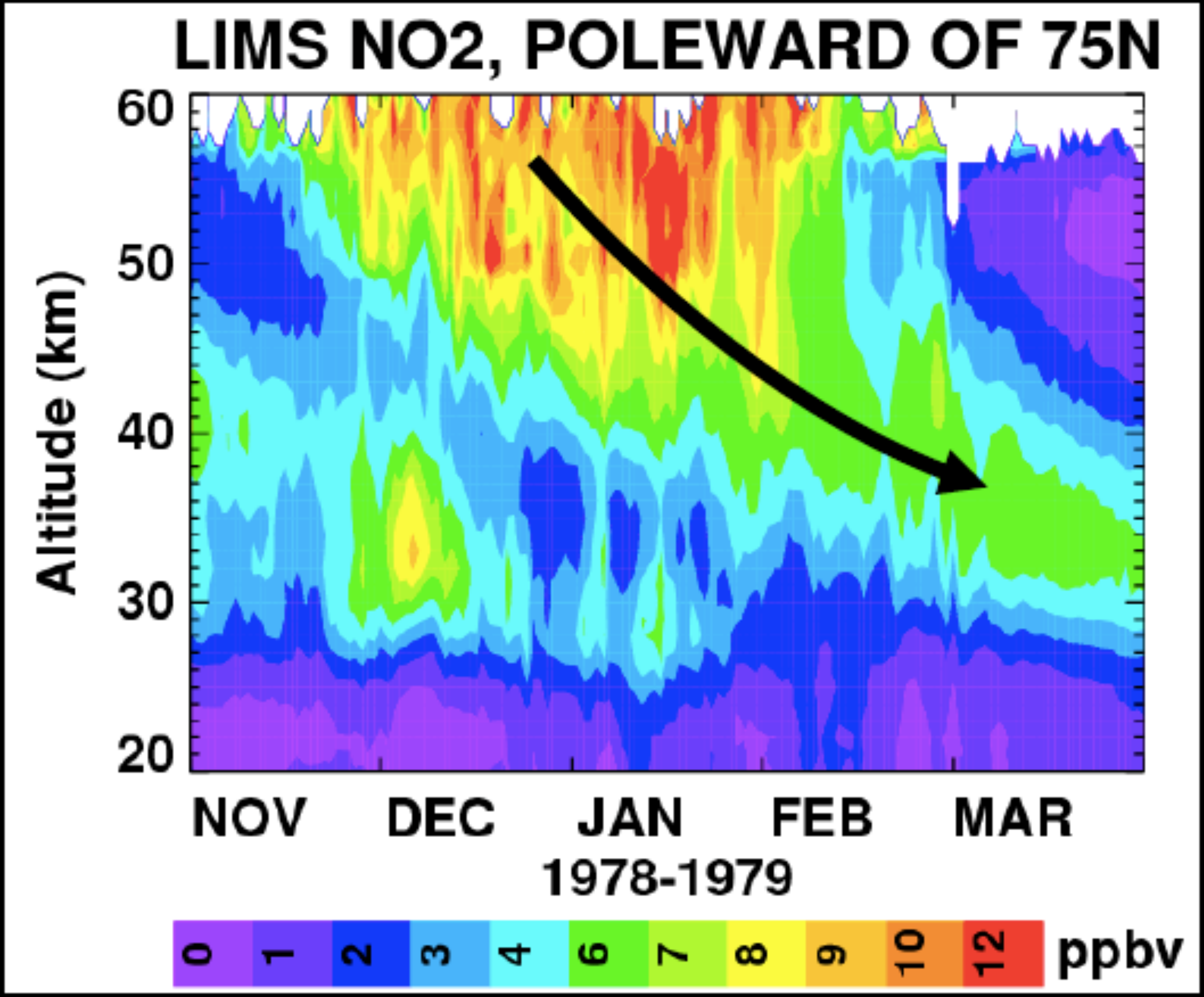
Energetic particle precipitation (EPP) creates NO_x and HO_x

O_3 is affected !

NO_x is long-lived in the absence of sunlight



First satellite observations of EPP Indirect Effect from LIMS in NH, 1978-1979



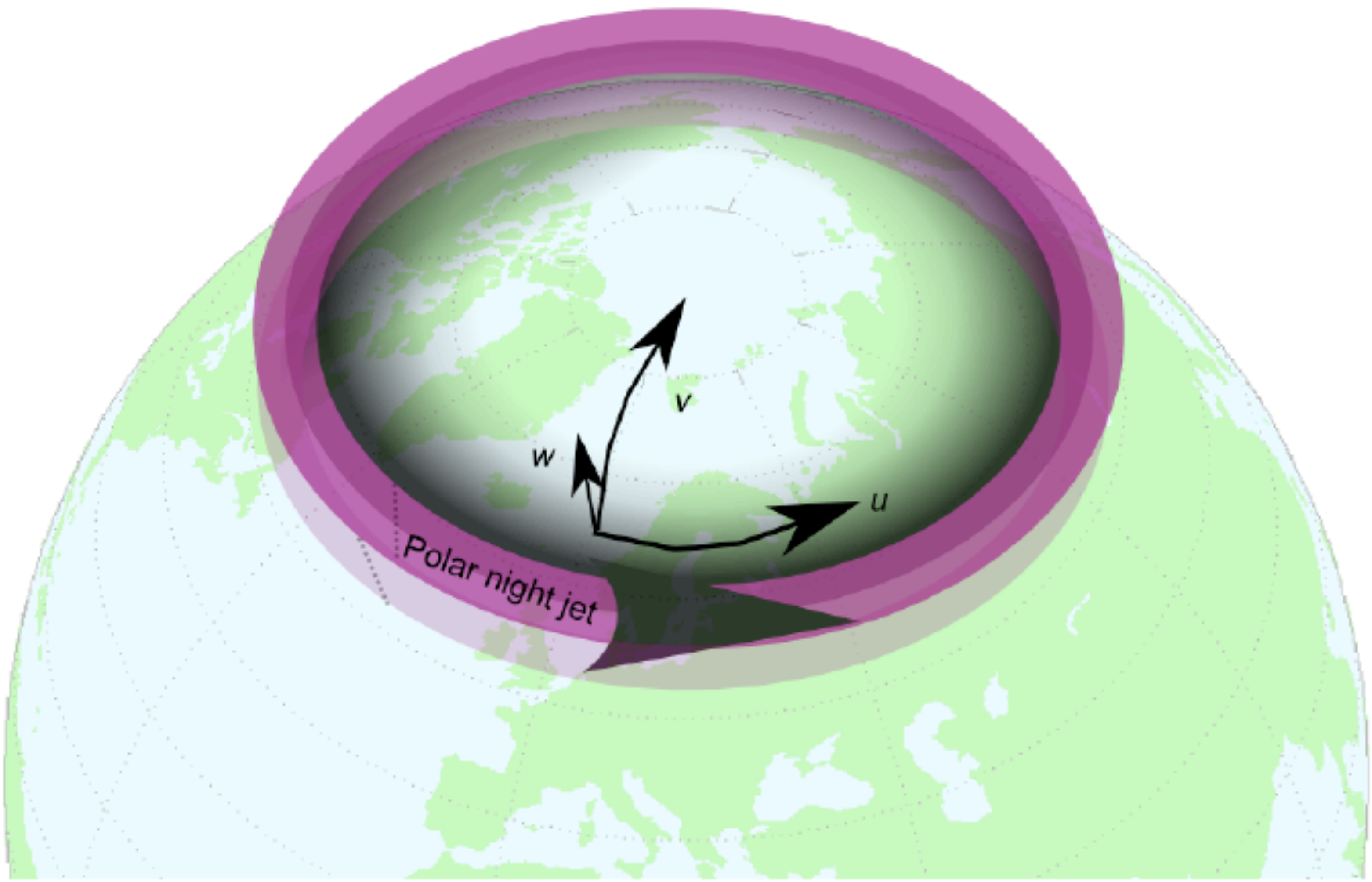
EPP is the **ONLY** source of mesospheric NO_x in the polar winter!

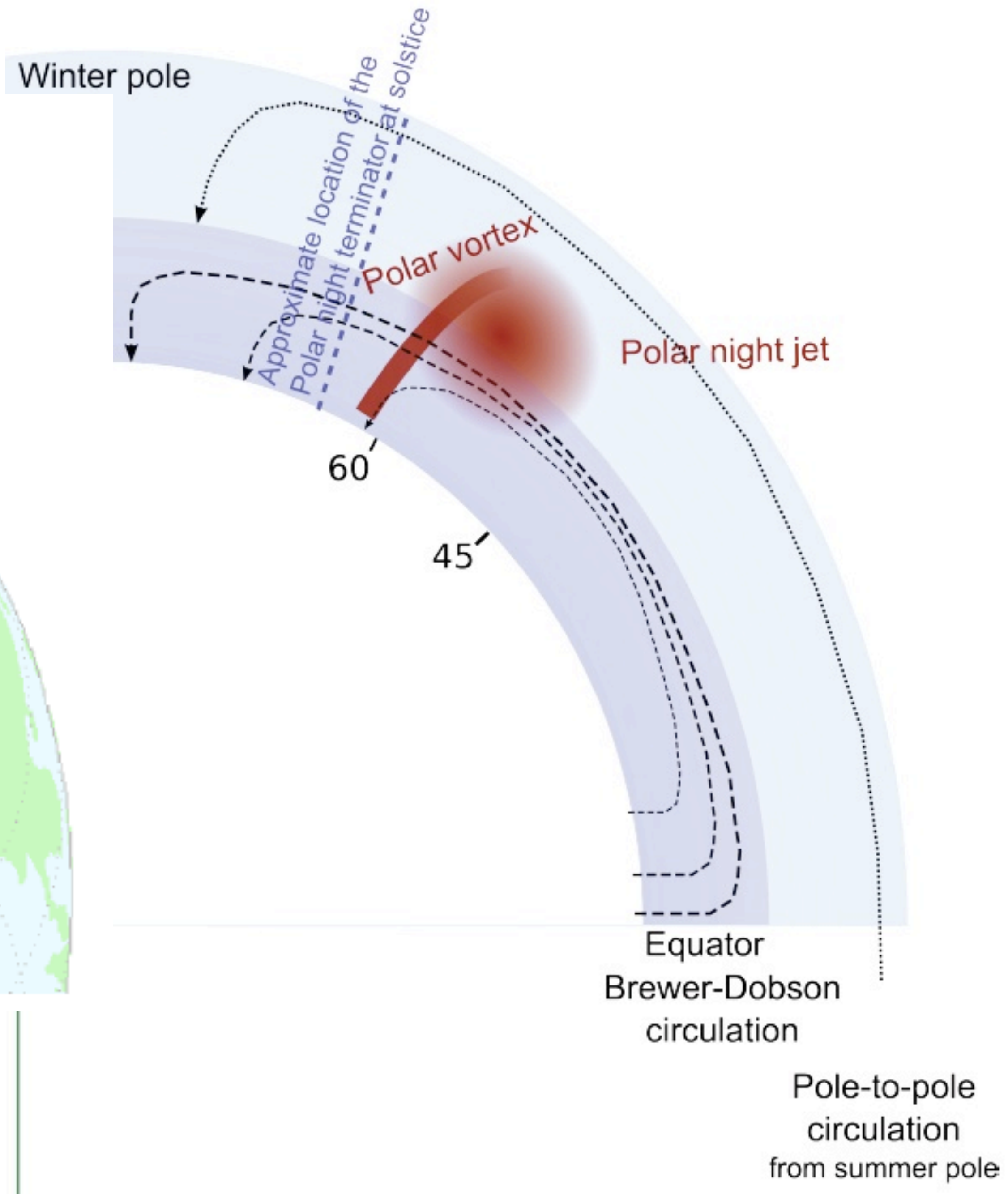
Based on Russell et al., 1984

By C. Randall

Polar vortex

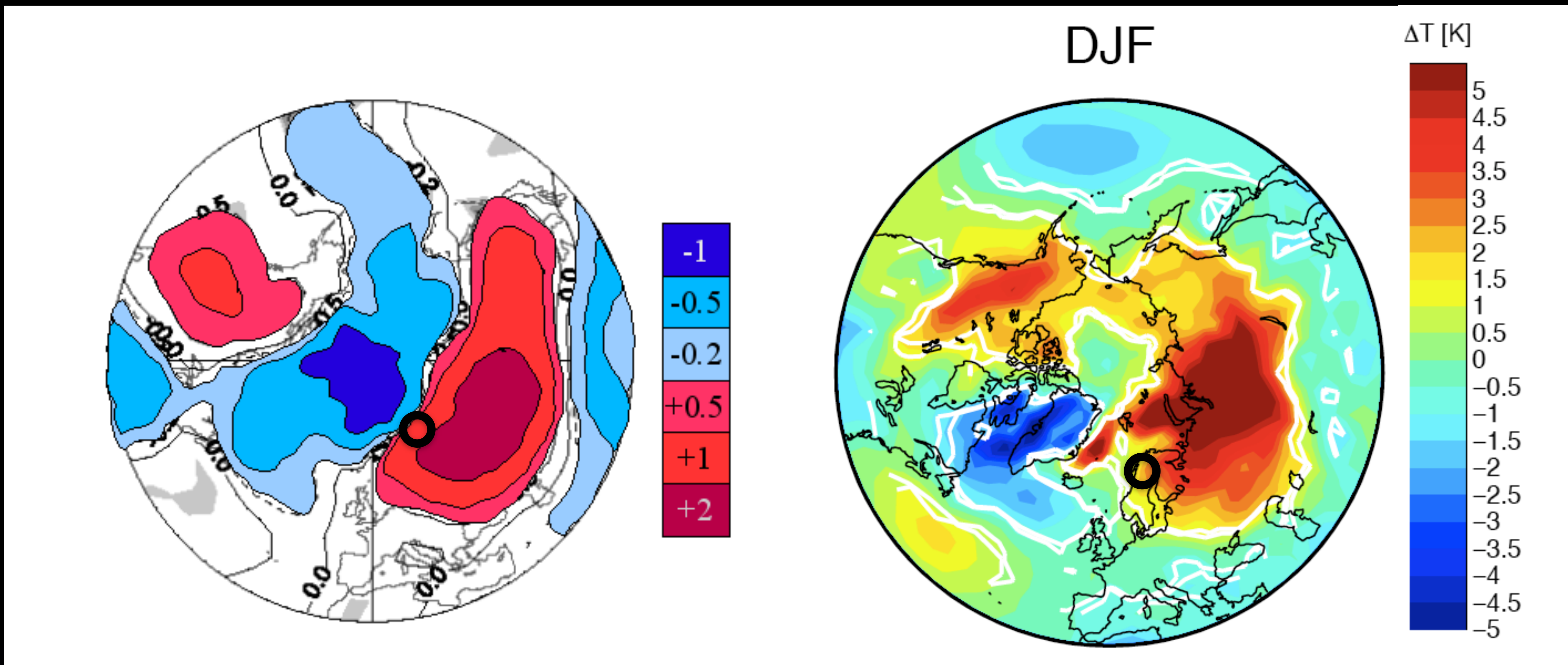
- Normally at 60° N
- Isolates the air in the polar area from rest of the atmosphere, 16km - mesosphere.





(from A. Seppälä)

Could these couplings change the surface temperatures?



Rozanov et al., 2005 | Seppälä et al., 2009

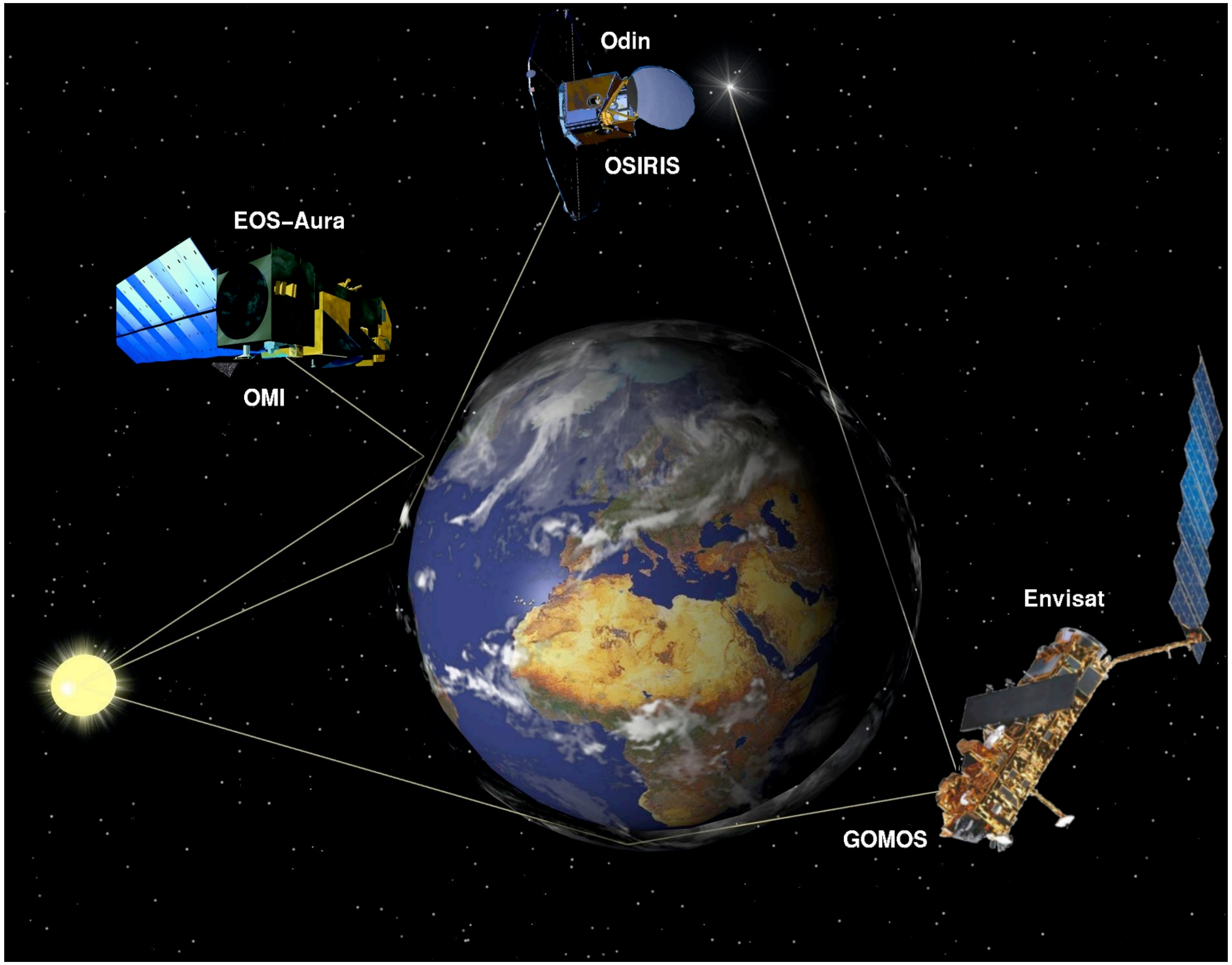
40 years of surface T data show consistent areas with +4 C warmer during magnetically active winter months (right).

General Circulation Model study with Energetic Particle Precipitation shows similar consistent structures as experimental data on Earth surface temperatures during high solar activity, in winter months

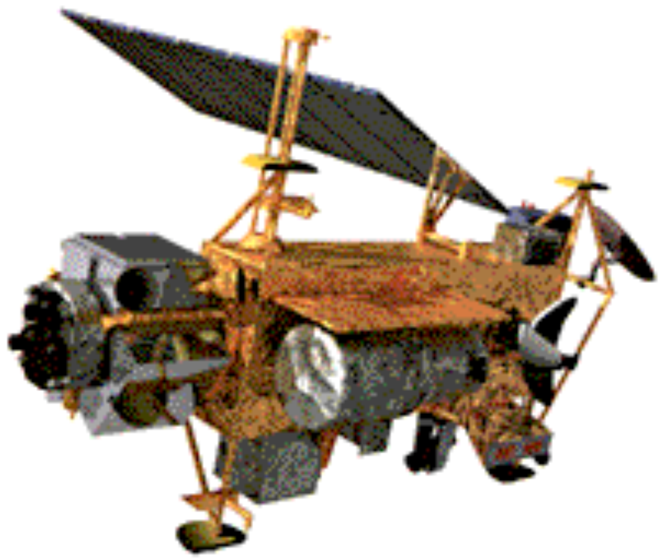
Seppälä, A., C. E. Randall, M. A. Clilverd, E. Rozanov, and C. J. Rodger (2009), Geomagnetic activity and polar surface air temperature variability. J. Geophys. Res., 114, A10312, doi:10.1029/2008JA014029

Satellite instruments

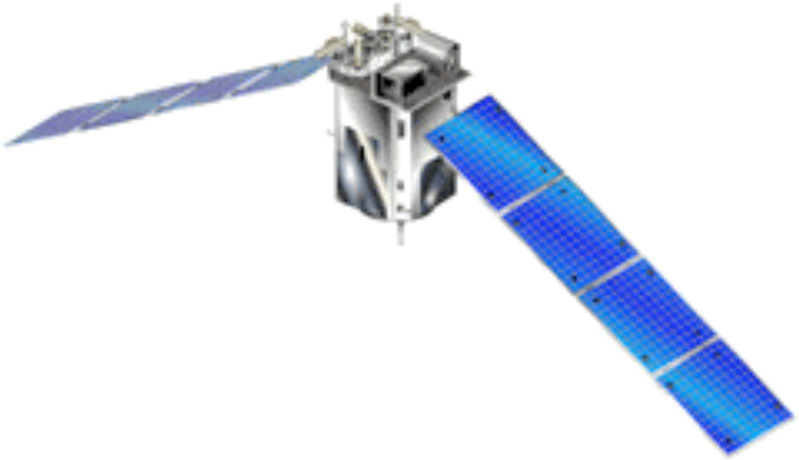
- ENVISAT
  - GOMOS
    - O_3
    - stratosphere-mesosphere
  - MIPAS,
    - O_3, No_y
    - stratosphere
  - SCIAMACHY
    - O_3,No_x
    - stratosphere-mesosphere
- Odin
  - OSIRIS
    - O_3
  - SMR,
    - O_3,NO,HO_2
- Aura
  - OMI
  - MLS
    - O_3, OH, HO_2,H_2O



Satellite instruments



- UARS
  - HALOE
    - O_3,NO_y
- SNOE
  - UVS
    - NO
- TIMED
  - SABER
    - O_3,NO,OH



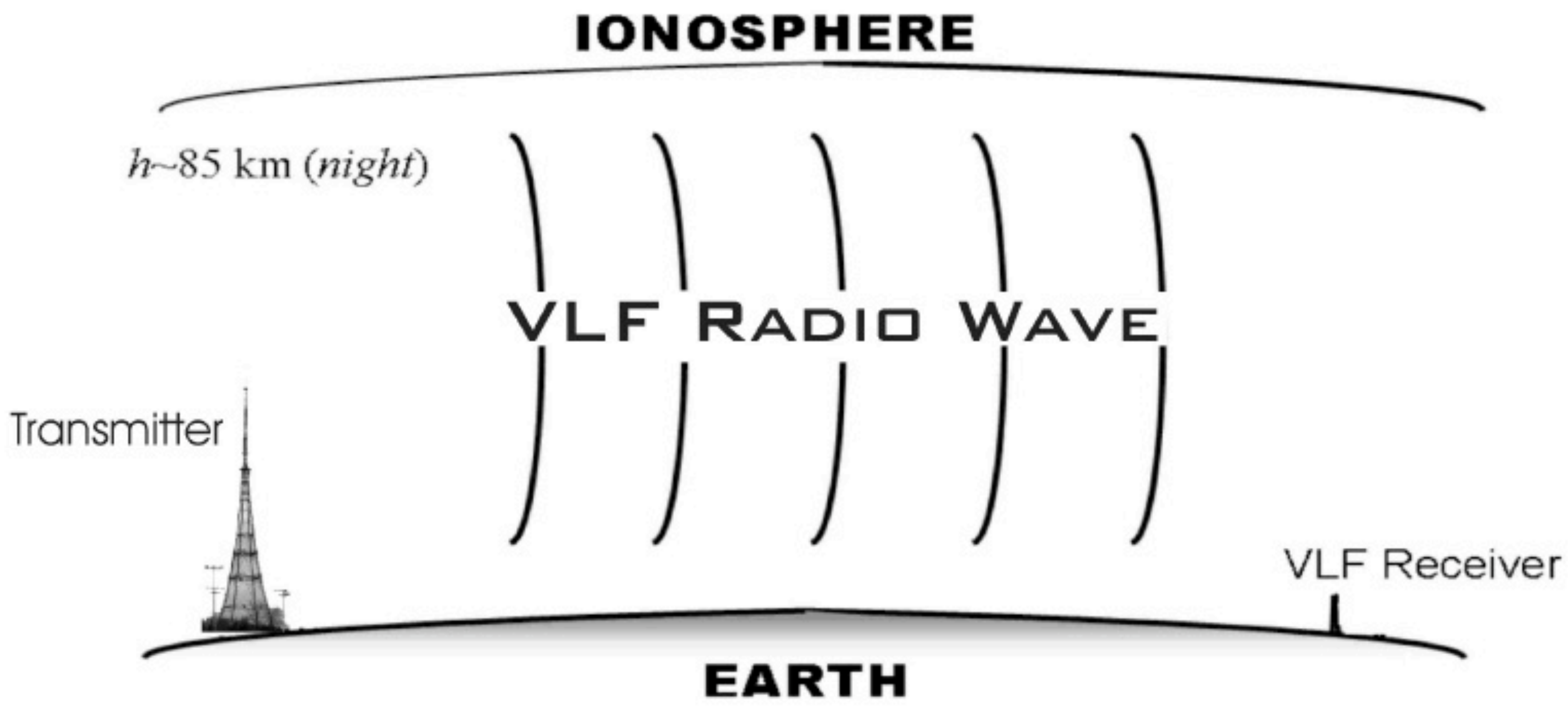
Ground based radio methods

- Ionospheric sounders
  - Real time digital sounder network
- Coherent radars
  - MF, HF, VHF, MLT, meteor, SUPERDARN
- Incoherent scatter radars
  - EISCAT, AMISR, Millstone Hill, Arecibo, Søndre Strømfjord, Jicamarca, Mu
- Satellite tomography
  - LEO satellites, GPS
- MF and HF radio propagation
- VLF radio propagation
- Riometers
  - Imaging riometers, GLORIA-proposal
- mm-band radiometers
  - continuous monitoring of minor constituent variations (e.g. H_2O, O_3)
  - often used for tracing atmospheric dynamics, but can be used to monitor in-situ production and loss processes, too

Optical measurements

- Imagers
  - Auroral all-sky, airglow
- Photometers
  - multichannel, scanning
- Spectrometers
  - imaging
- Interferometers
  - Fabry-Perot, Michelson
- Lidars
  - Rayleigh, Raman, Mie scattering, differential absorption

Propagation of VLF radio waves



Amplitude and phase of the received signal are sensitive to pertubations in the lower boundary of the ionosphere along the propagation path

EISCAT Scientific Association

EISCAT Mission

We want to understand the various forms of

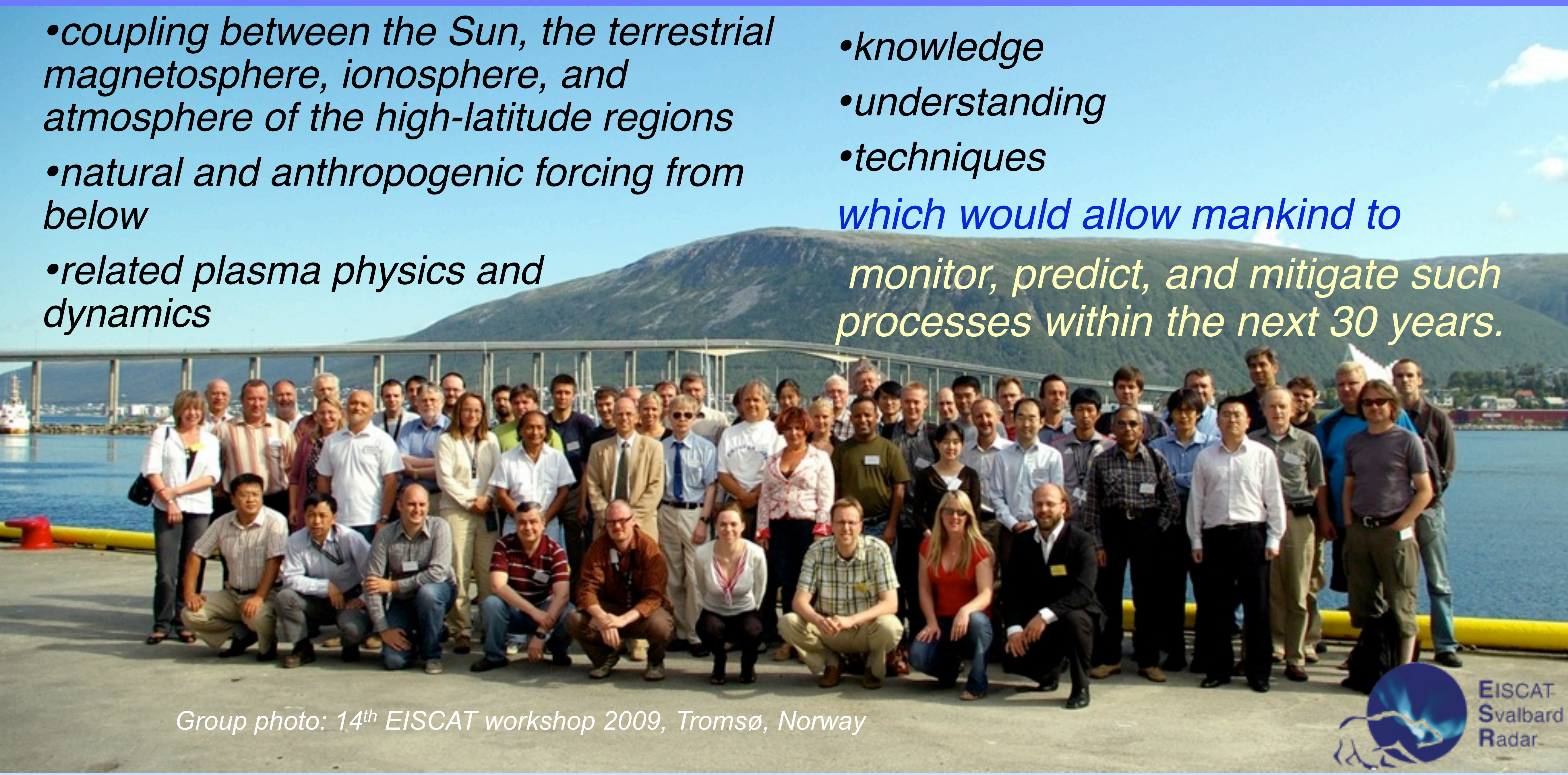
- *coupling between the Sun, the terrestrial magnetosphere, ionosphere, and atmosphere of the high-latitude regions*
- *natural and anthropogenic forcing from below*
- *related plasma physics and dynamics*

We aim to achieve the necessary

- *knowledge*
- *understanding*
- *techniques*

which would allow mankind to

monitor, predict, and mitigate such processes within the next 30 years.



Group photo: 14th EISCAT workshop 2009, Tromsø, Norway

EISCAT Svalbard Radar

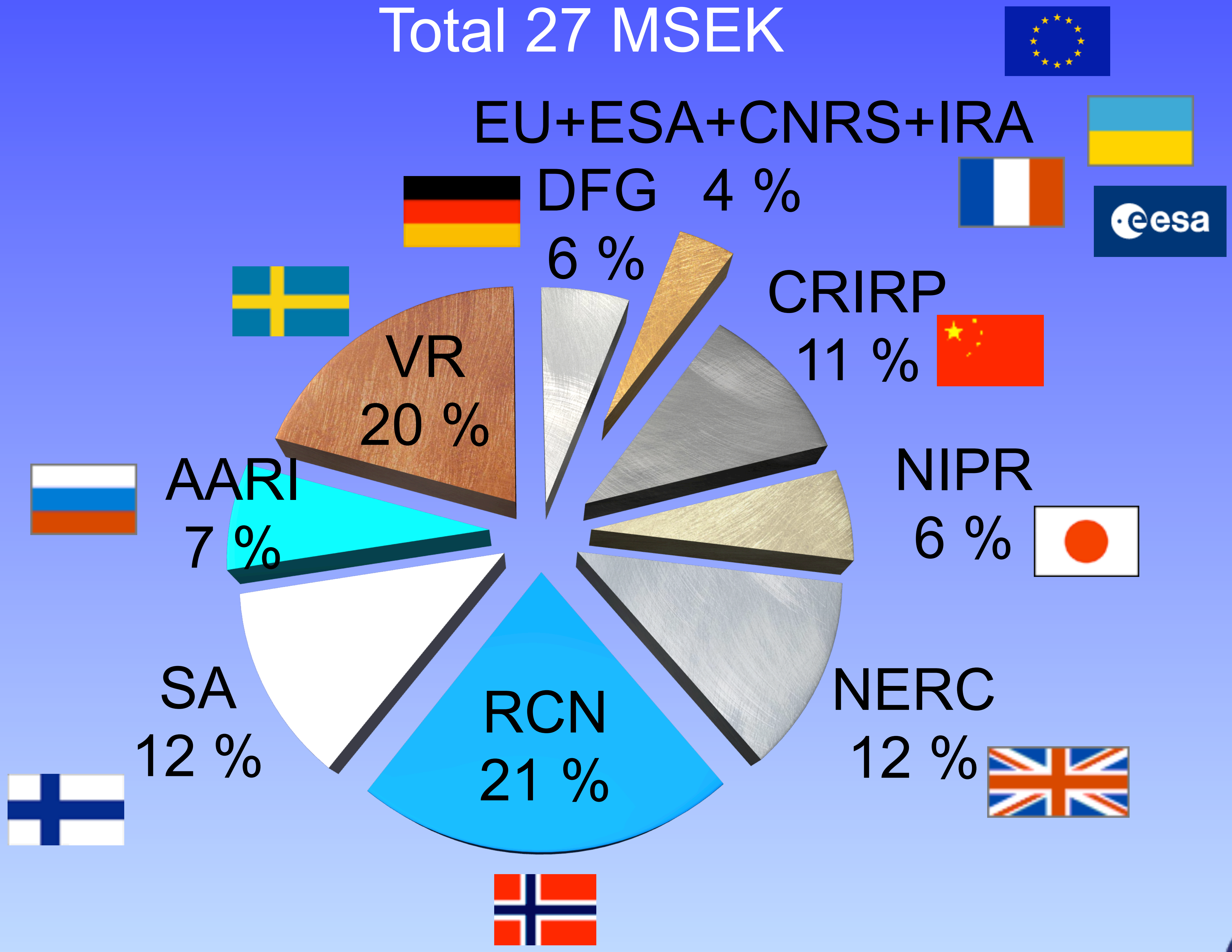
EISCAT associates and facilities

Associate countries and institutes

Contributing:

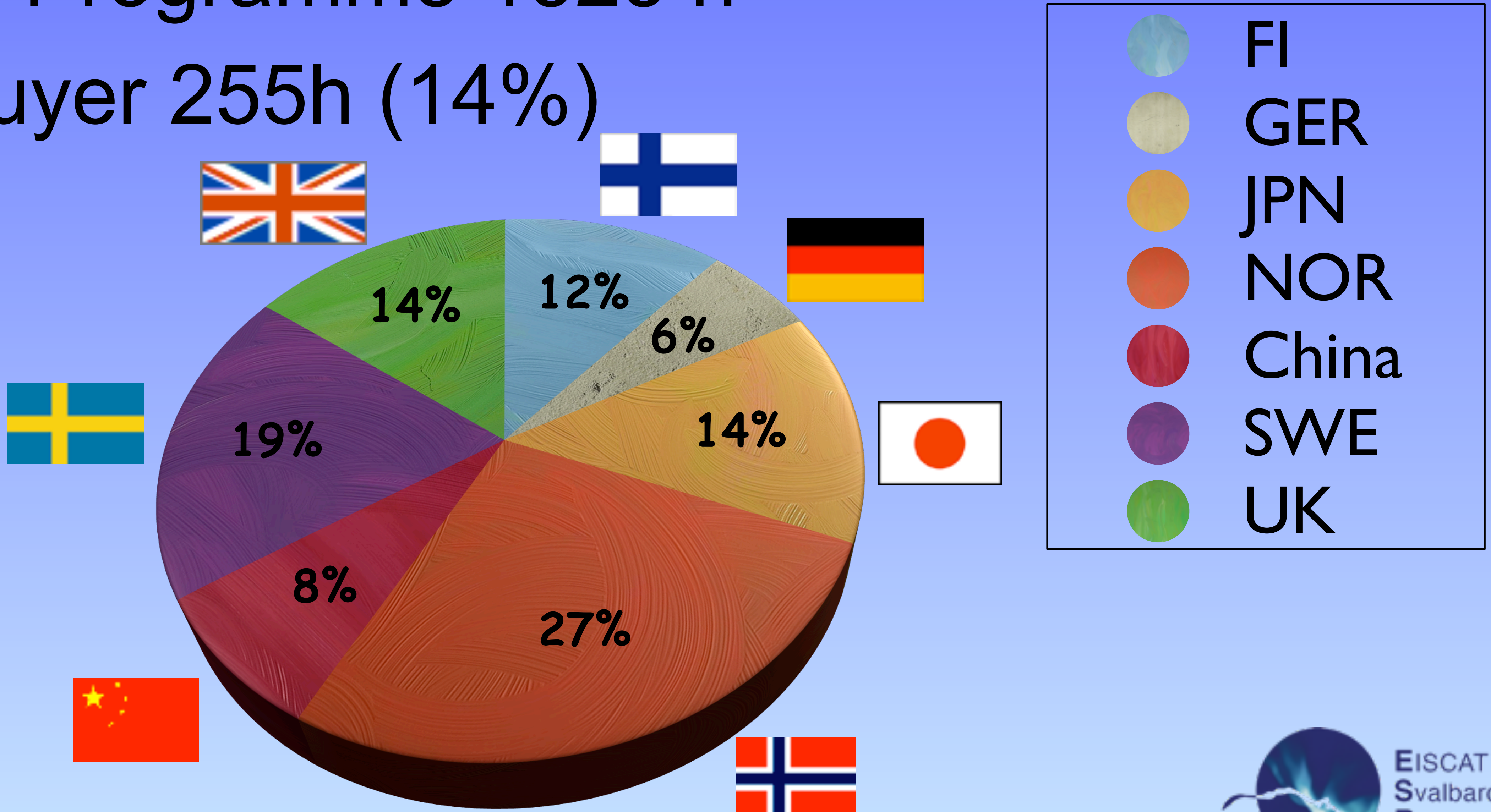
Contributions 2010

Total 27 MSEK



Operations 2010

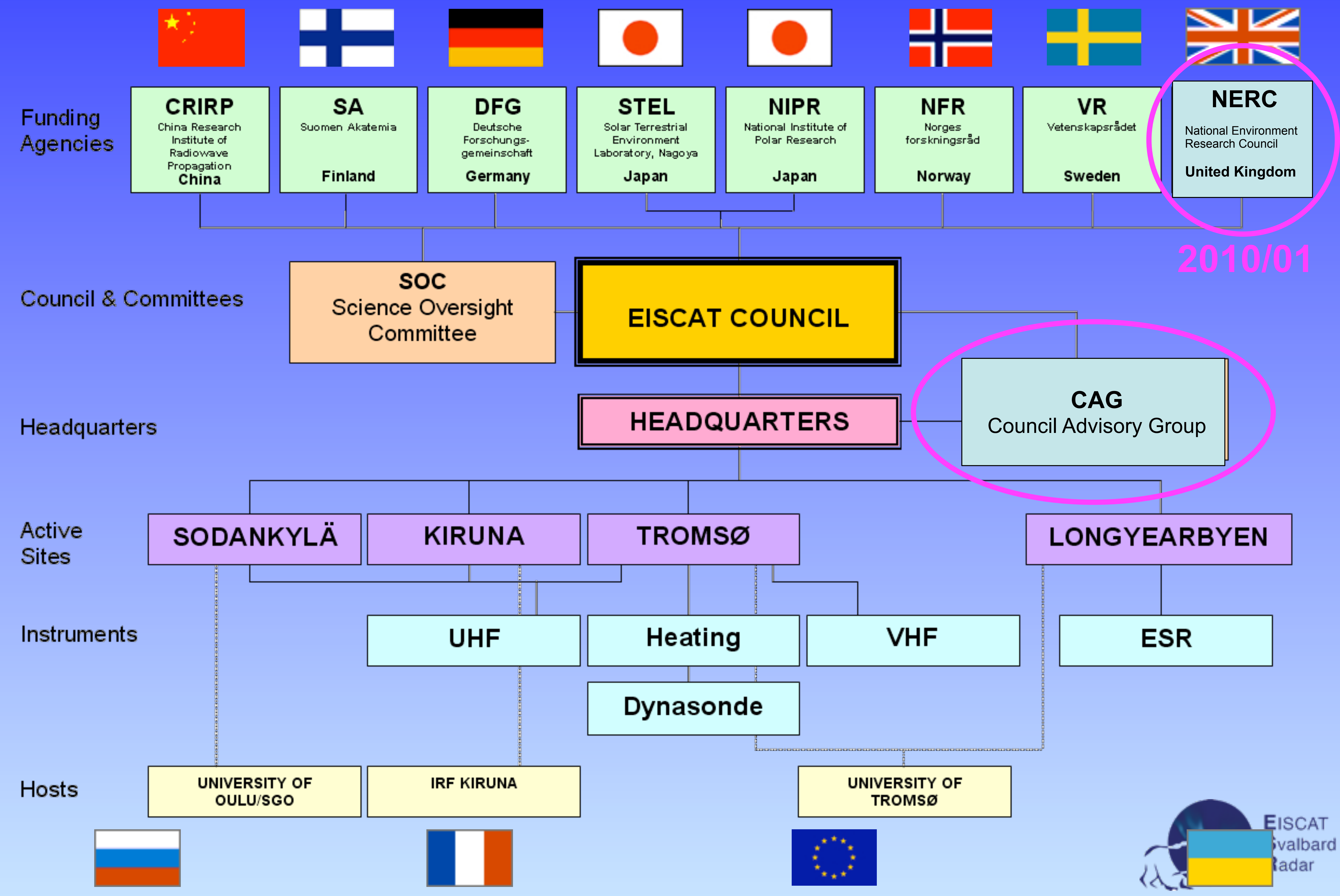
- Total operating hours, incl.passive, 3635 h
- Common Programme 1683 h
- Special Programme 1523 h
- Time-buyer 255h (14%)



EISCAT Svalbard Radar

EISCAT Scientific Association

EISCAT: Organisation



Affiliates

- Ukraine (Picture of Kharkov radar was missing in Anja's talk, here it is)

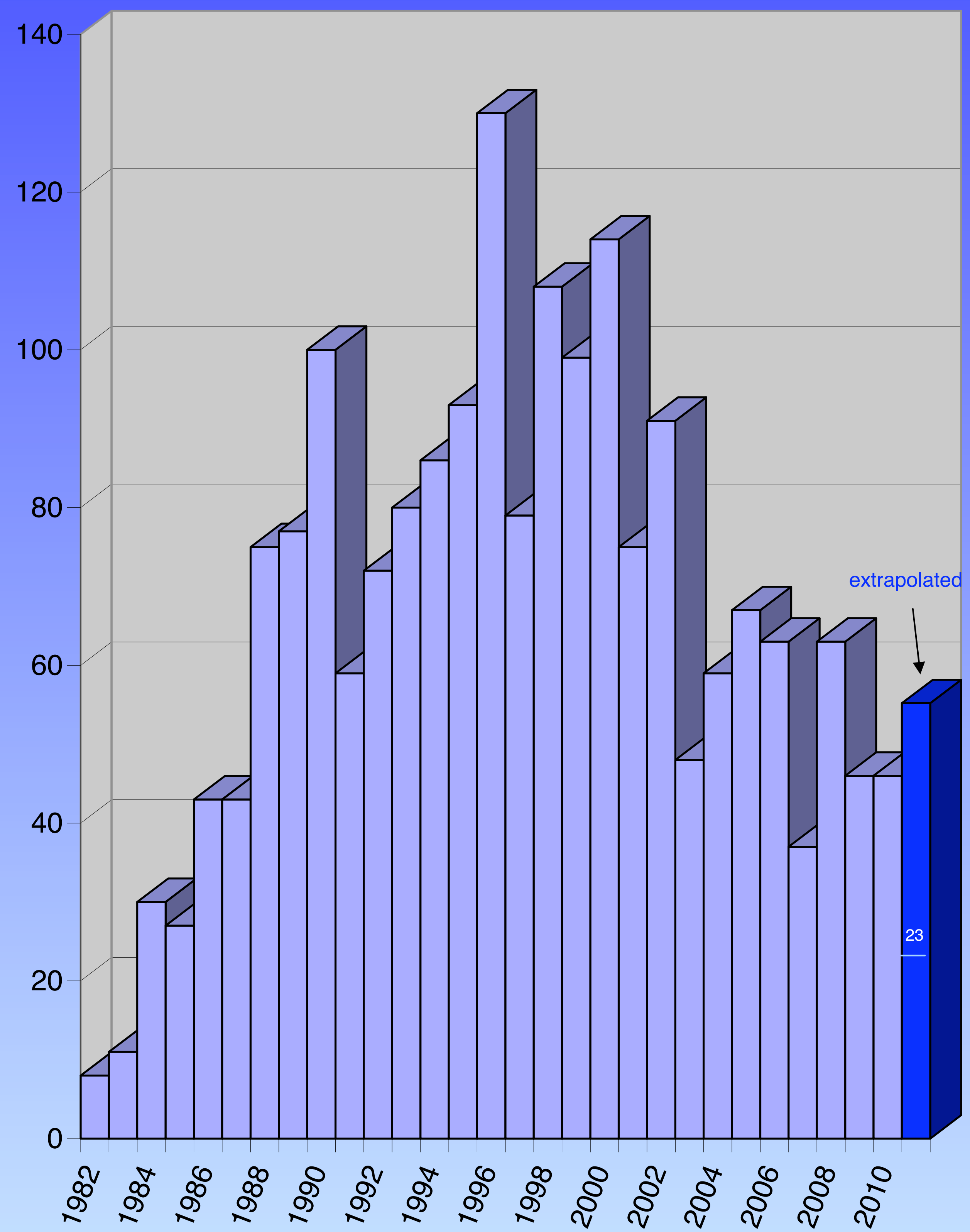
Antenna diameter in Kharkov 100 m

- Radar can be run 1-3 days per month
- Support?
  - –currently bilateral discussions with Norway

Publications 1982-2011

EISCAT publication history by year

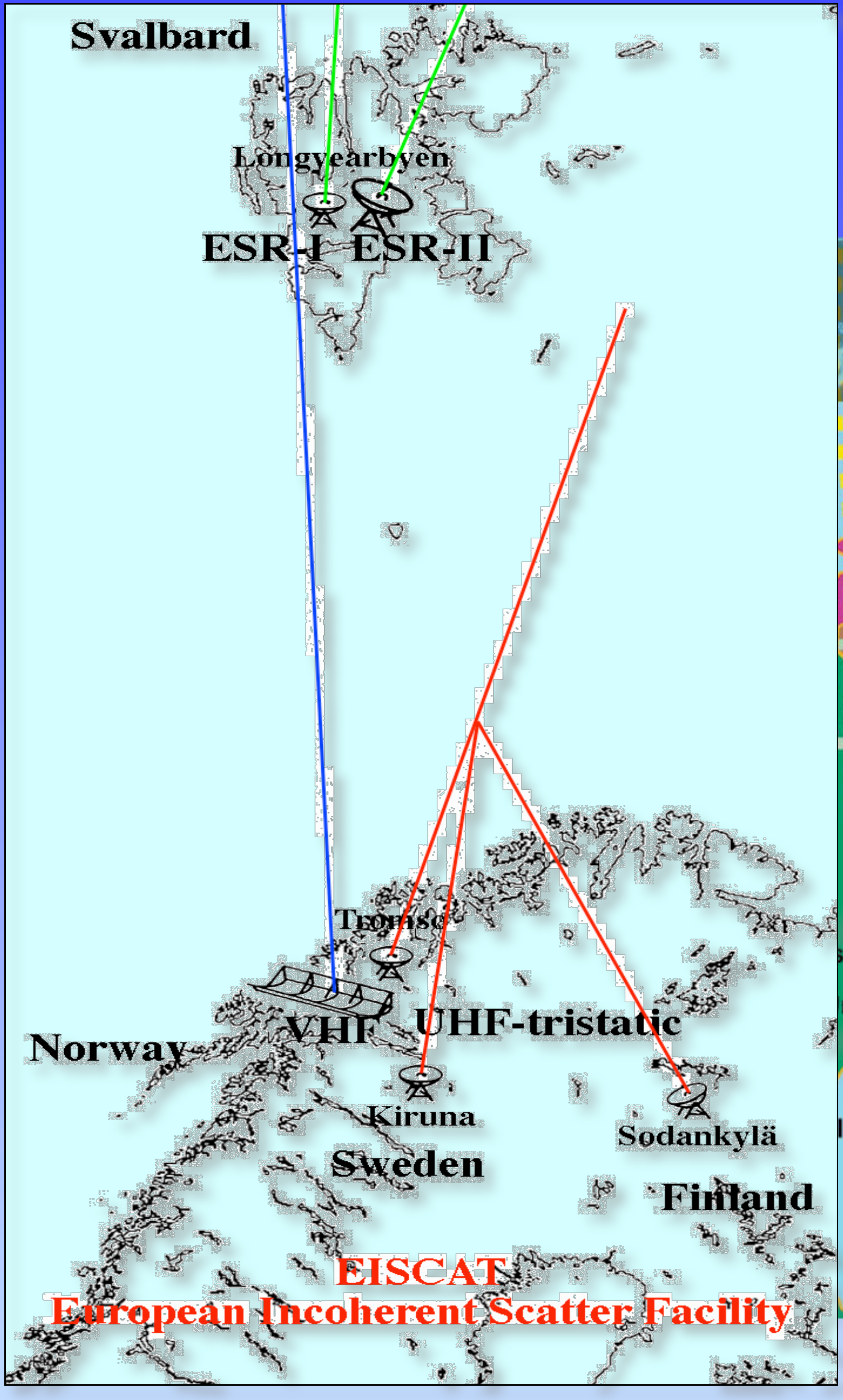
Total 1952 (27 May 2011)



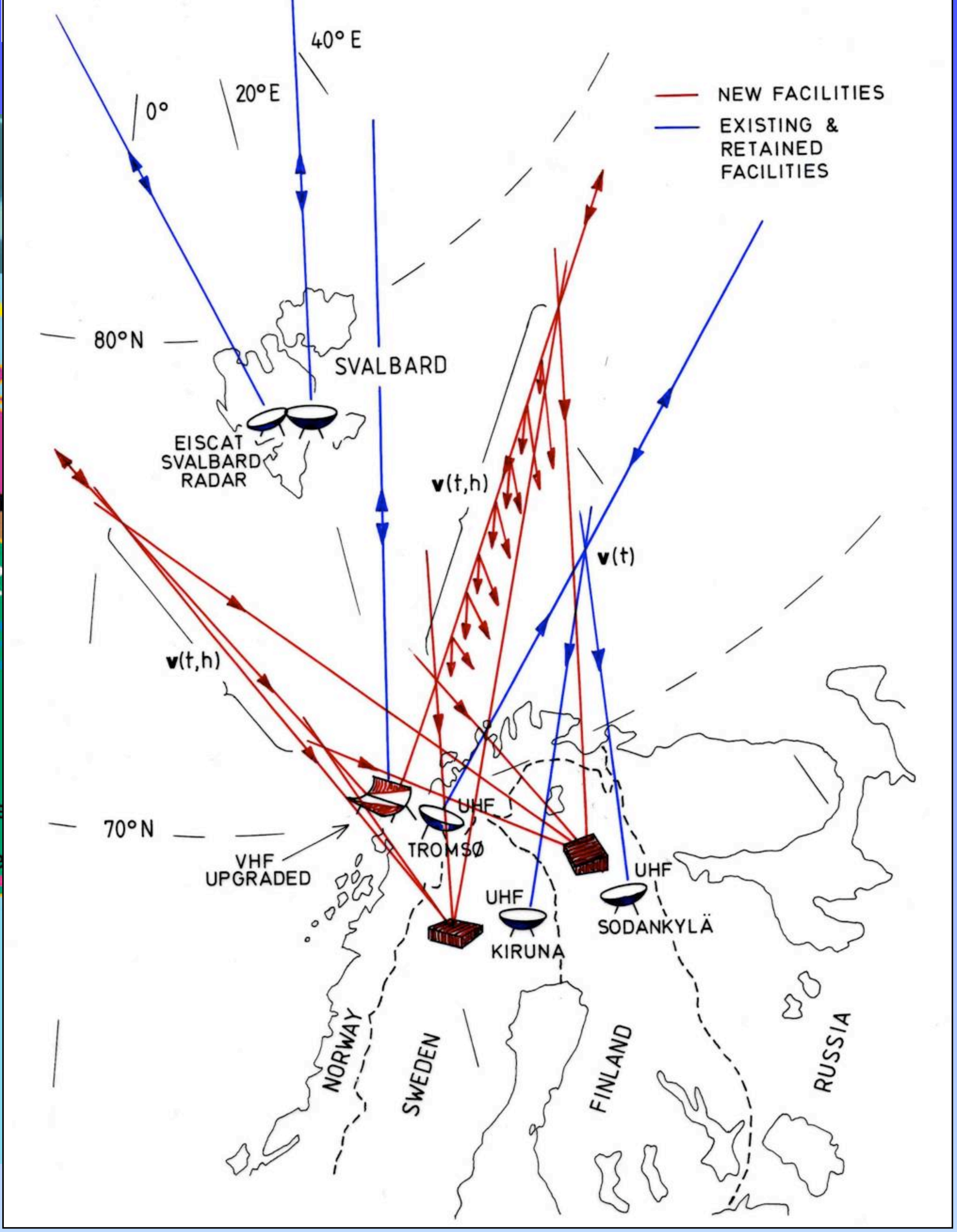
EISCAT Svalbard Radar

Where is EISCAT?

Across 3 countries in Northern Scandinavia and Svalbard



Old idea of the future - but shows some current development



EISCAT IS radars

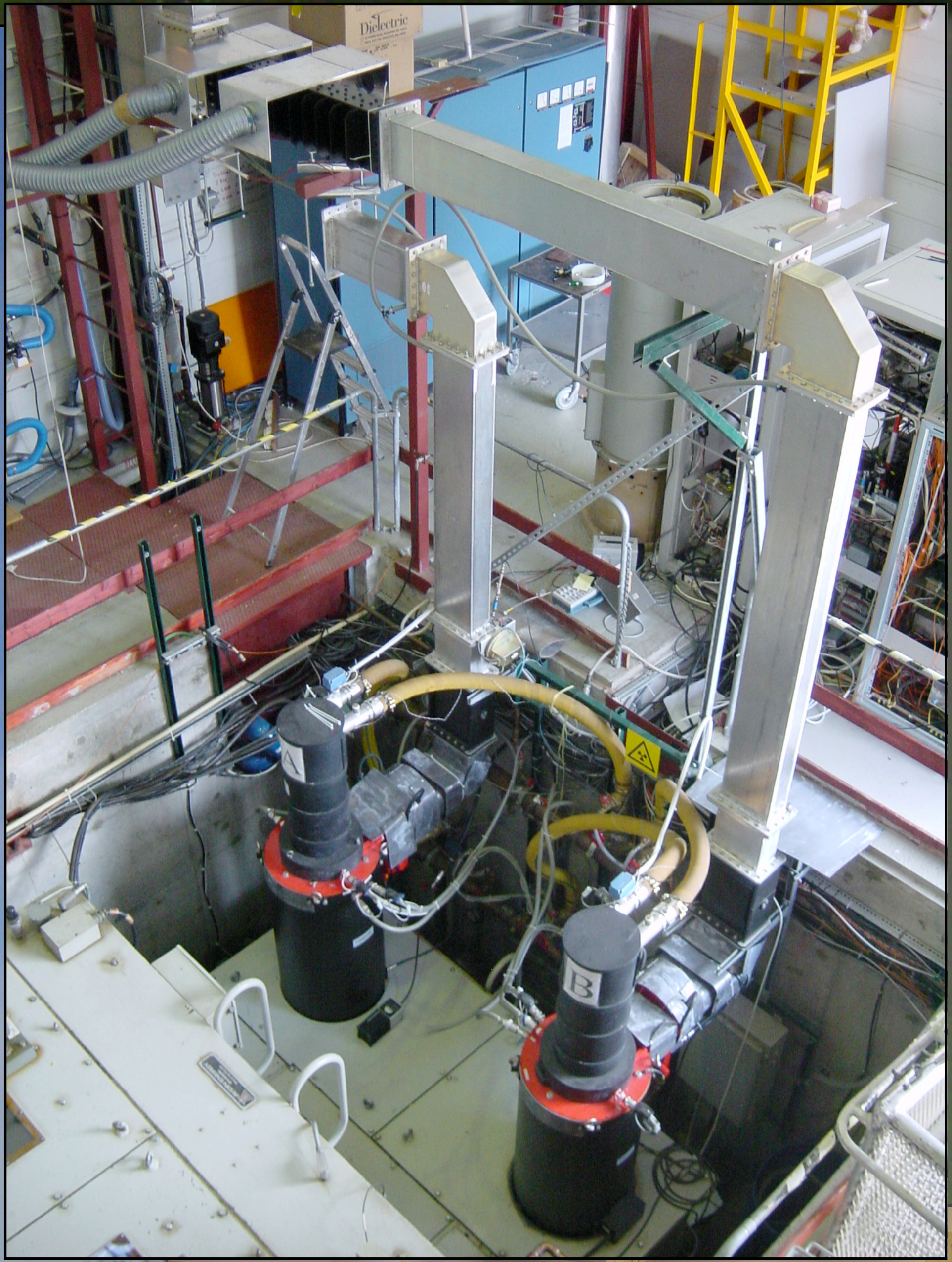
Location	***Tromsø***	***Kiruna***	***Sodankylä***		***Longyearbyen***	
Geograph. Coordinates	69°35´N 19°14´E		67°52´N 20°26´E	67°22´N 26°38´E	78°09´N 16°02´E	
Geomagn. Inclination	77°30´N		76°48´N	76°43´N	82°06´N	
Invariant Latitude	66°12´N		64°27´N	63°34´N	75°18´N	
Band	**VHF**	**UHF**	**UHF**	**UHF**	**UHF**	
Frequency (MHz)	224	929	929	929	500	
Max. TX bandwith (MHz)	3	4			10	
Transmitter	2 klystrons	2 klystrons	-	-	16 klystrons	
TX Channels8	8	8	8		Continuously tuneable	
Peak power (MW)	2x1.5	2X1.3	-	-	1.0	
Average power (MW)	2x0.19	0.3	-	-	0.25	
Pulse duration (msec)	.001-2.0	.001-2.0	-	-	<.001-2.0	
Phase coding	binary	binary	binary	binary	binary	
Min. interpulse (msec)	1.0	1.0	-	-	0.1	
Receiver	analog-digital	analog-digital	analog-digital	analog-digital	analog-digital	
System temp. (K)	250-350	70-80	30-35	30-35	55-65	
Digital processing	14 bit ADC, Lag profiles 32 bit complex				12 bit ADC, lag profiles 32 bit complex	
					Antenna 1	**Antenna 2**
Antenna	cylinder 120mx40m	dish 32m	dish 32m	dish 32m	dish 32m	dish 42m Fixed
Feed systemline feed	Cassegrain 128 crossed dipoles	Cassegrain	Cassegrain	Cassegrain	Cassegrain	
Gain (dBi)	46	48	48	48	42.5	45
Polarization	circular	circular	any	any	circular	circular

EISCAT Svalbard Radar

EISCAT history

- Originally designed primarily for auroral electrodynamics research; sited at the southern edge of the auroral oval
- Started with international collaboration/ownership by FI, FR, GE, NO, SE, UK
- Mainland stations built in late 70s, operation started 1981,
  - UHF (928 MHz) RX/TX in Tromsø, RX in Kiruna, Sodankylä
  - VHF (224 MHz) RX/TX in Tromsø
- In late 1980s, user focus beginning to shift towards
  - solar/terrestrial interactions (e.g. ESA CLUSTER),
  - middle atmosphere physics and dynamics (PMSE etc.)
- Additional radar on Spitsbergen (ESR) planned 1990-92,
- ESR constructed 1993 – 1998, operations started 1996,
- Mainland systems modernised to ESR standards 1999 – 2001
- Japan joined the Association in 1996
- China joined the Association in 2007
- France buys time after 2006
- Russia buys time from 2009, Russia signed a new 3-year contract in 2011
- Ukraine buys time from 2009
- ESA buys time from 2010

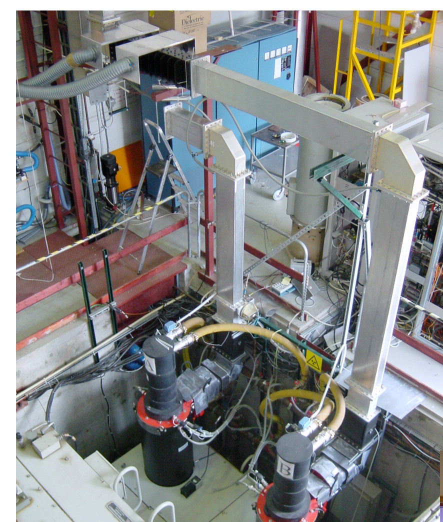
UHF 933MHz



UHF-receivers

UHF radar, 933 MHz

- 3 identical fully steerable 32 m paraboloids
- Passive reception also at 1.420 GHz
- Mobile phones operate at the current frequency
- Tromso UHF monostatic radar continued at least to end of 2013



VHF 224MHz

EISCAT VHF 224 MHz, Tromsø

- Worlds largest klystrons in transmitter
- Antenna cylindrical paraboloid 40 m x 120 m
- Plan to replace the transmitter with solid state units in the antenna

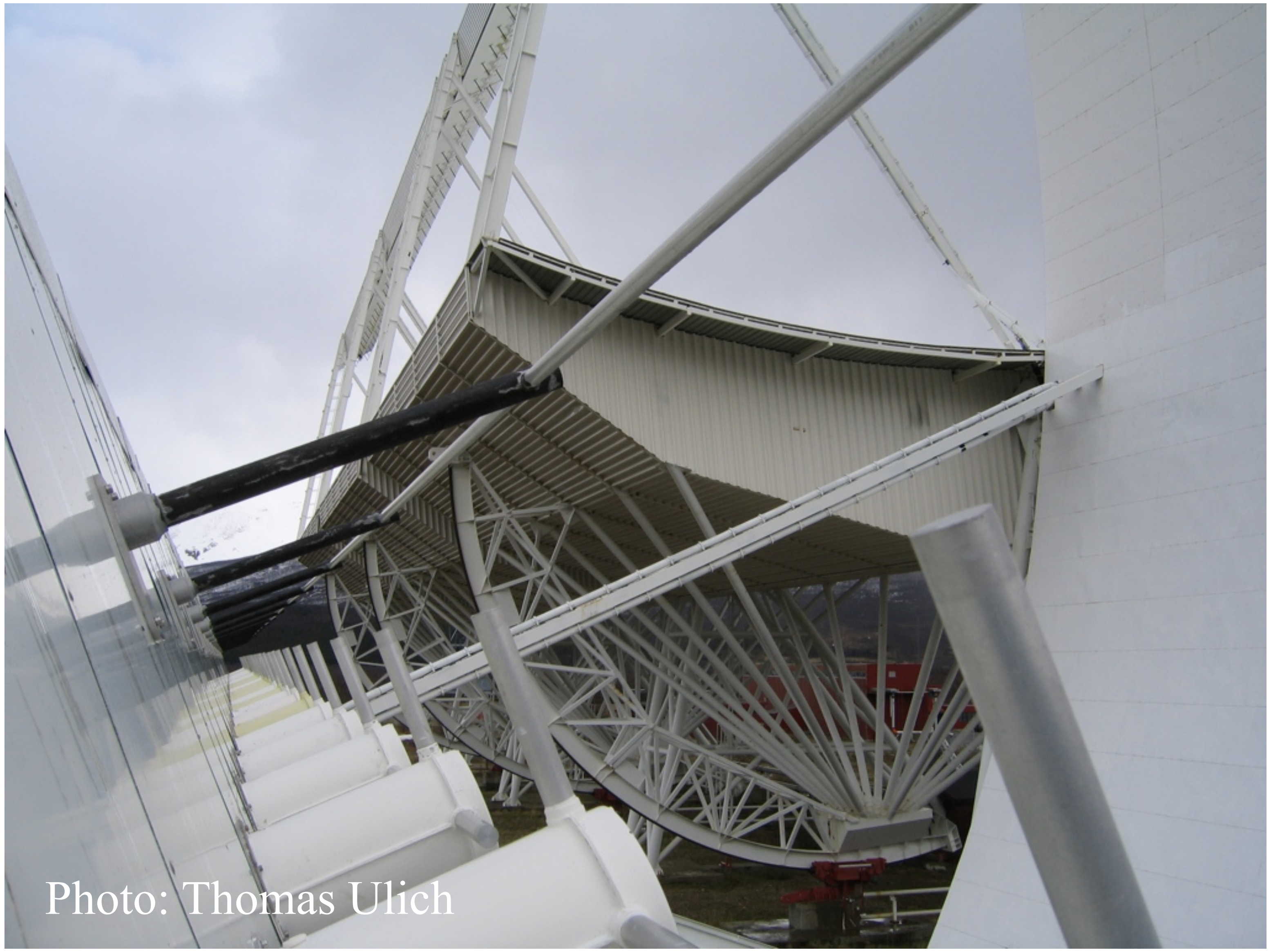
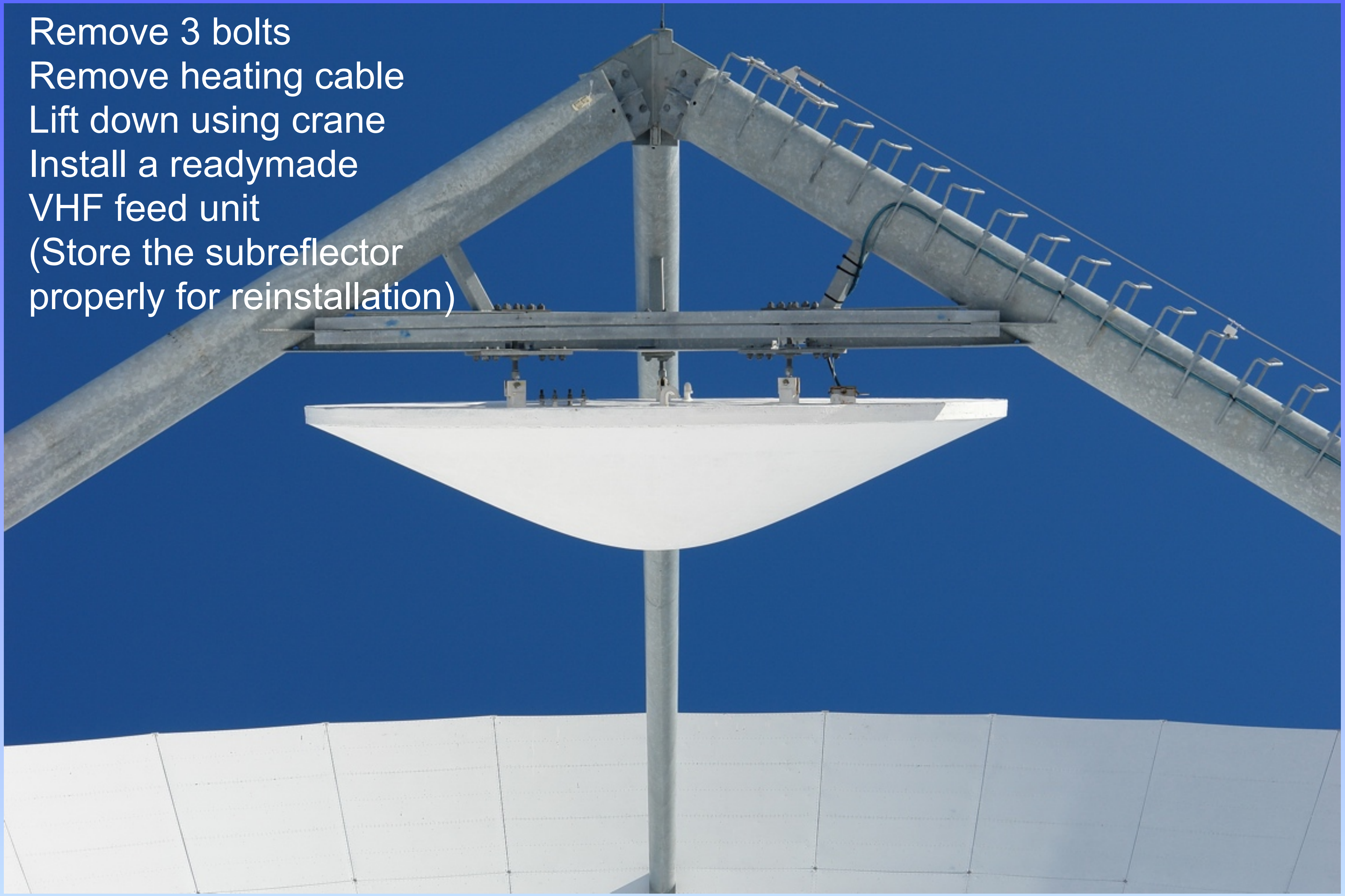


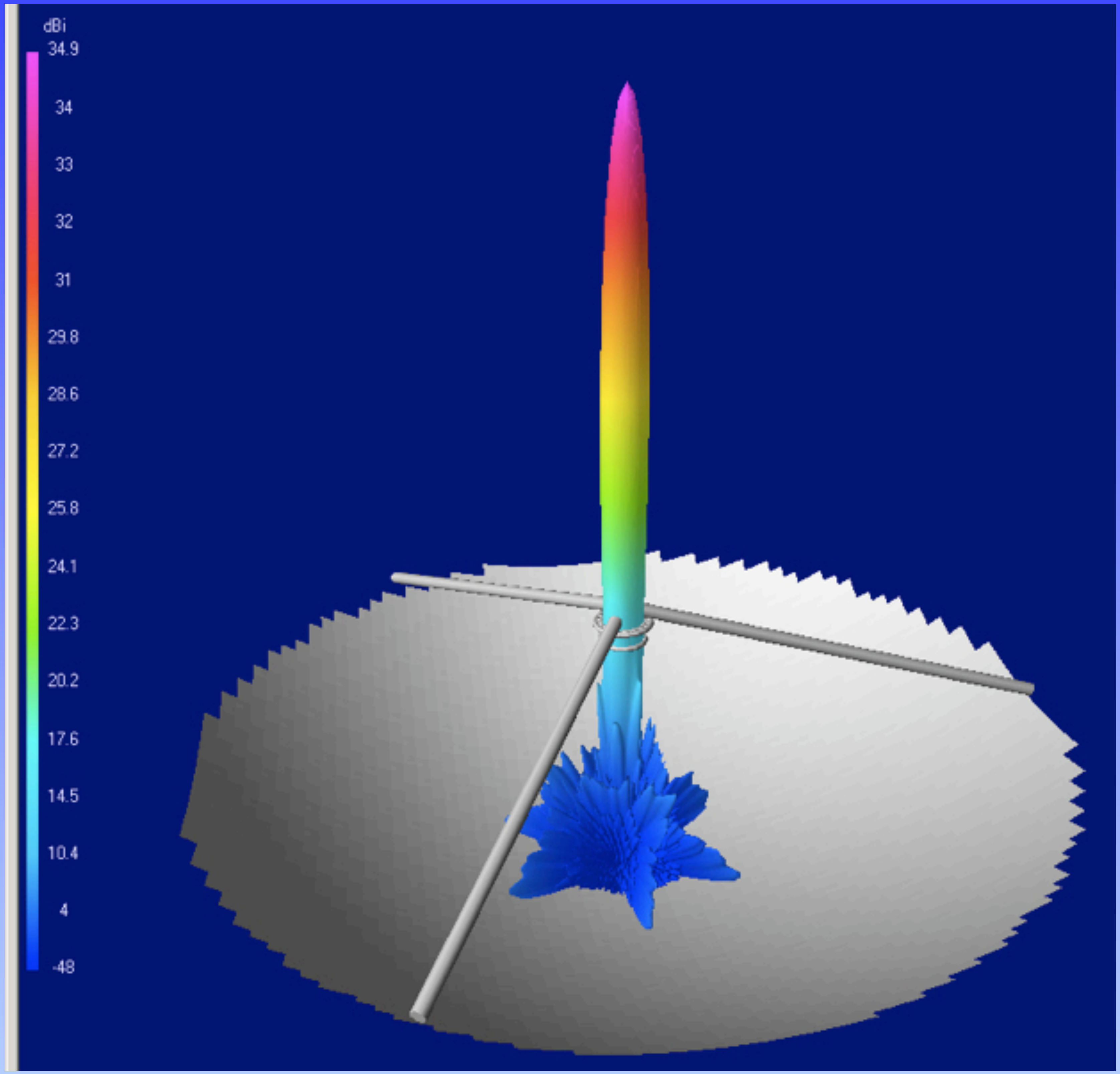
Photo: Thomas Ulich

Receiveing VHF Tx with UHF antennas?

VHF conversion of UHF antennas is straightforward and reversible

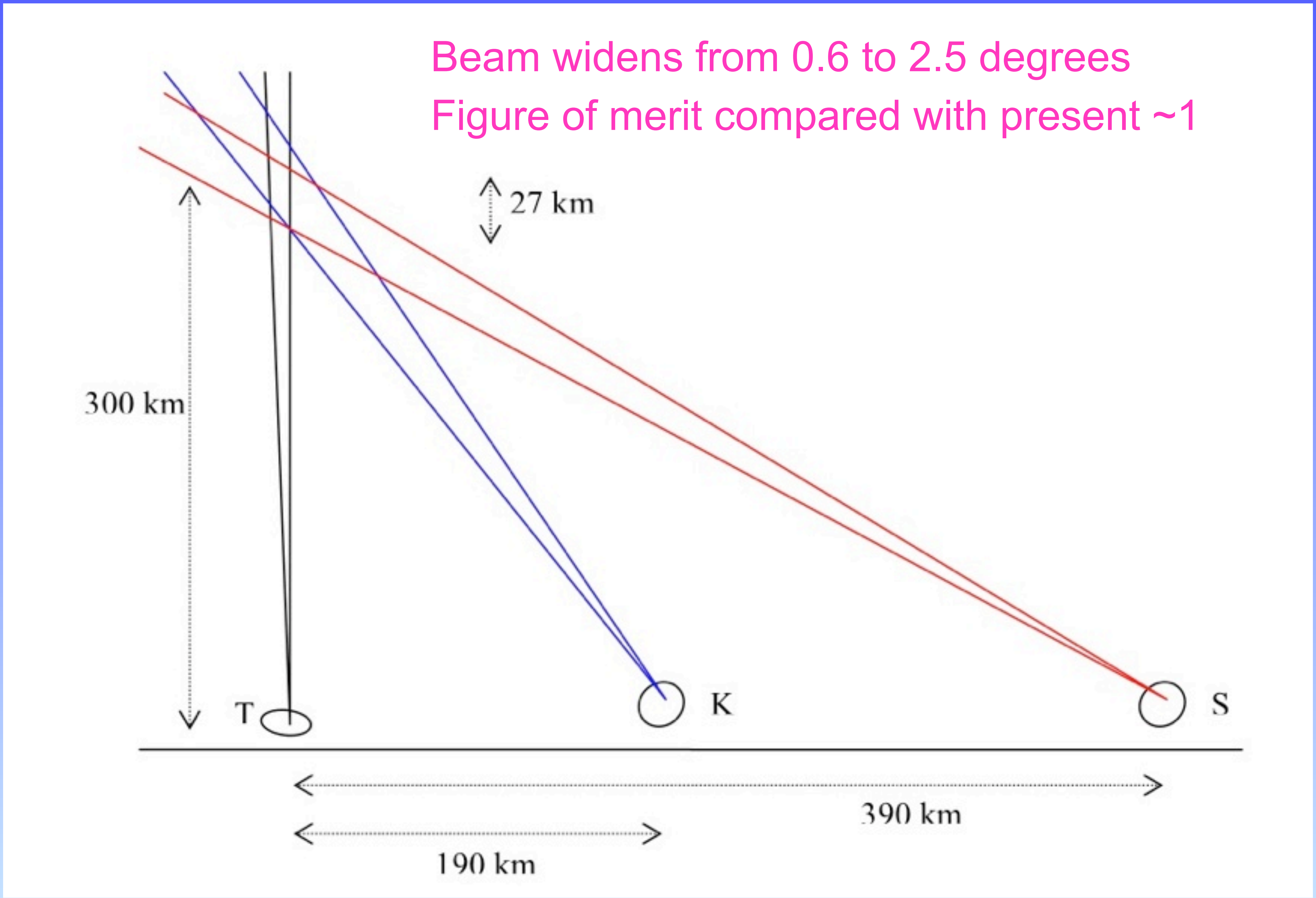
Remove 3 bolts
Remove heating cable
Lift down using crane
Install a readymade VHF feed unit
(Store the subreflector properly for reinstallation)





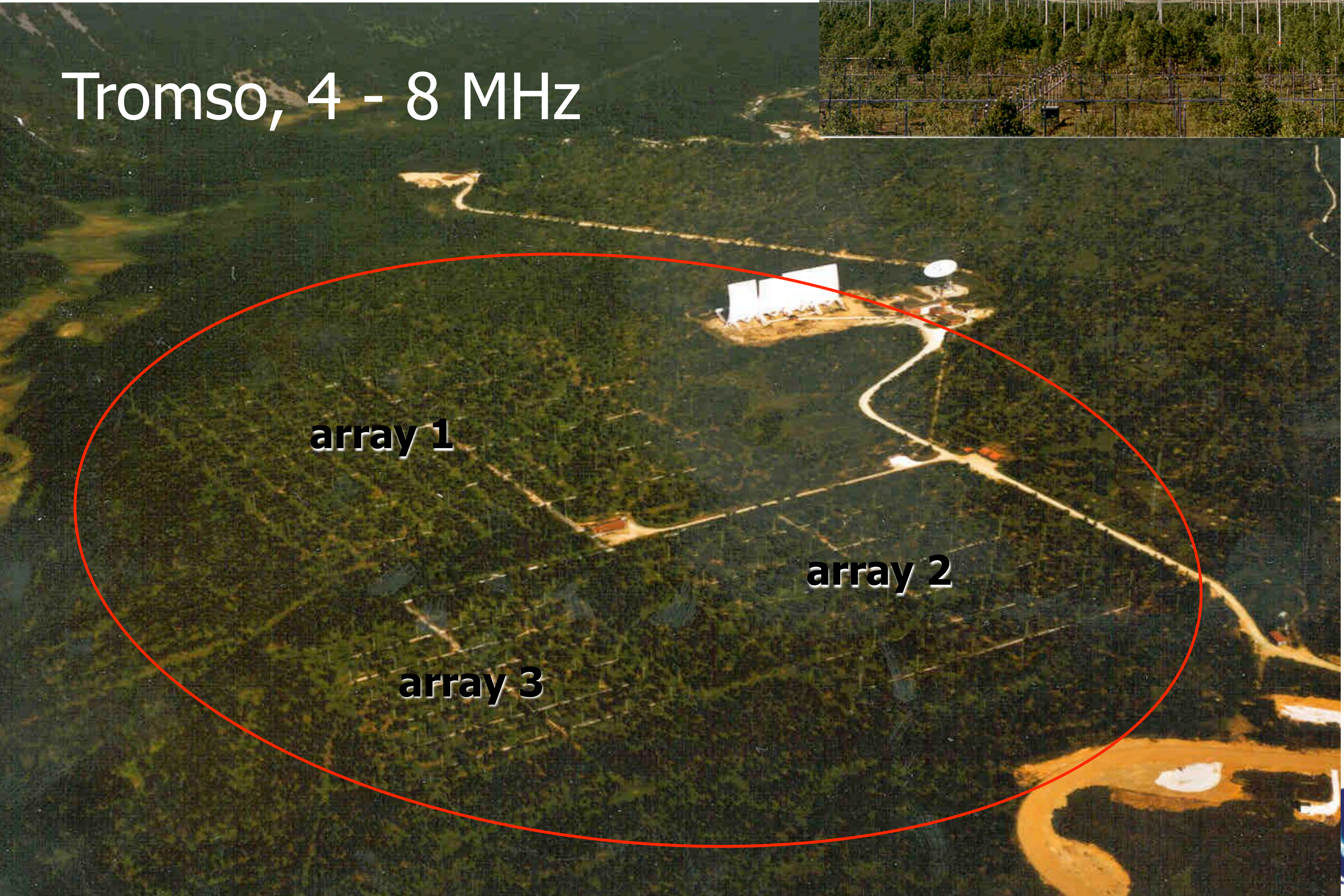
4nec2 wire frame full model of 32m EISCAT including feed supporting structure and dipole-ring-disk feed with super imposed radiation pattern (A.Westman)

Geometry for possible VHF reception at remote sites KIR and SOD



HF Heating Facility

Tromso, 4 - 8 MHz



EISCAT HF Heating Facility

- World-class opportunity
  - Hardware upgrade in 2009
  - Still novel physics waiting!!!
  - Supported by VHF
  - Monostatic UHF up to 2013 at least, then EISCAT_3D
  - Also a magnetospheric radar
  - Multiple uses simultaneously
  - Ionosonde support
  - User Optical Instruments

ESR 500MHz Svalbard

42m field-aligned antenna

EISCAT Svalbard Radar

EISCAT Scientific Association
Photo: Anja Strømme
EISCAT
Svalbard
Radar

One of world's most advanced radars:
The EISCAT Svalbard Radar

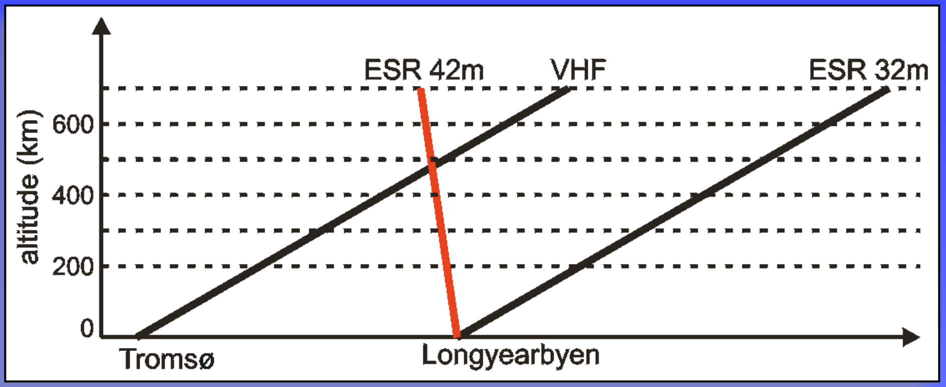
- upper atmospheric programme of the ESFRI SIOS project
- Proposal for a 3rd antenna by China
- Continued international ISR collaboration

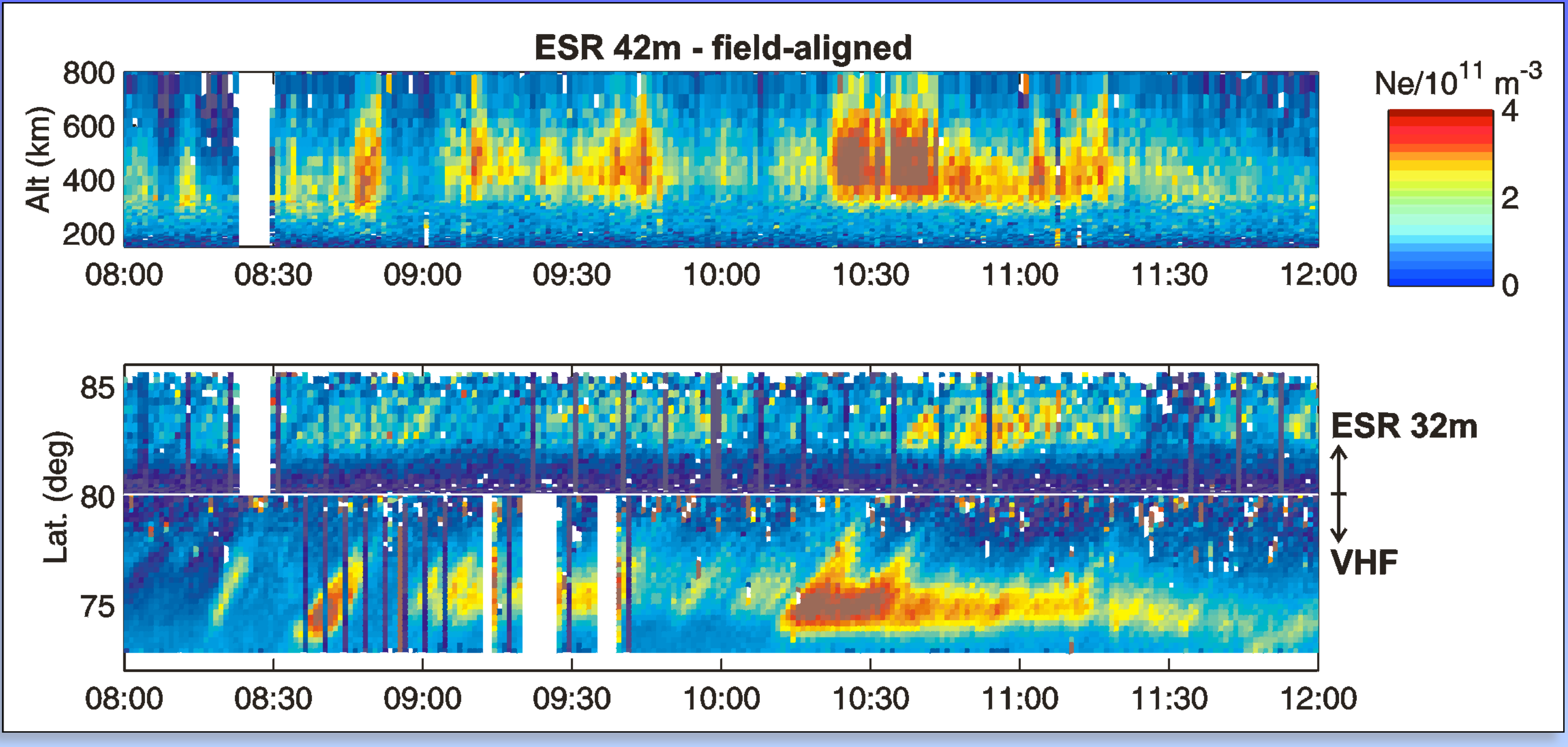
EISCAT Scientific Association

Multi-radar data

Poleward Moving Forms

4 October 2002

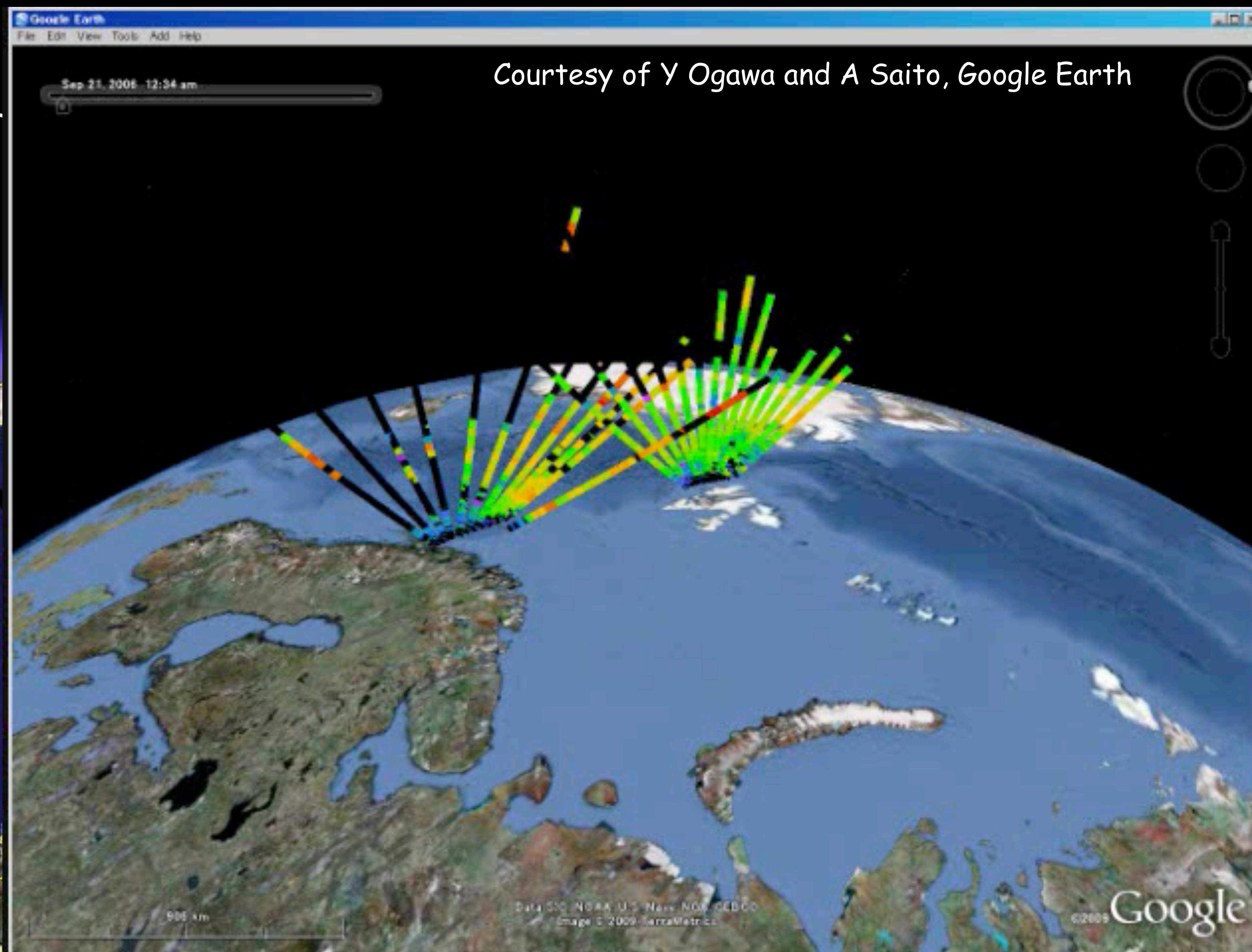




K.A. McWilliams, University of Saskatchewan

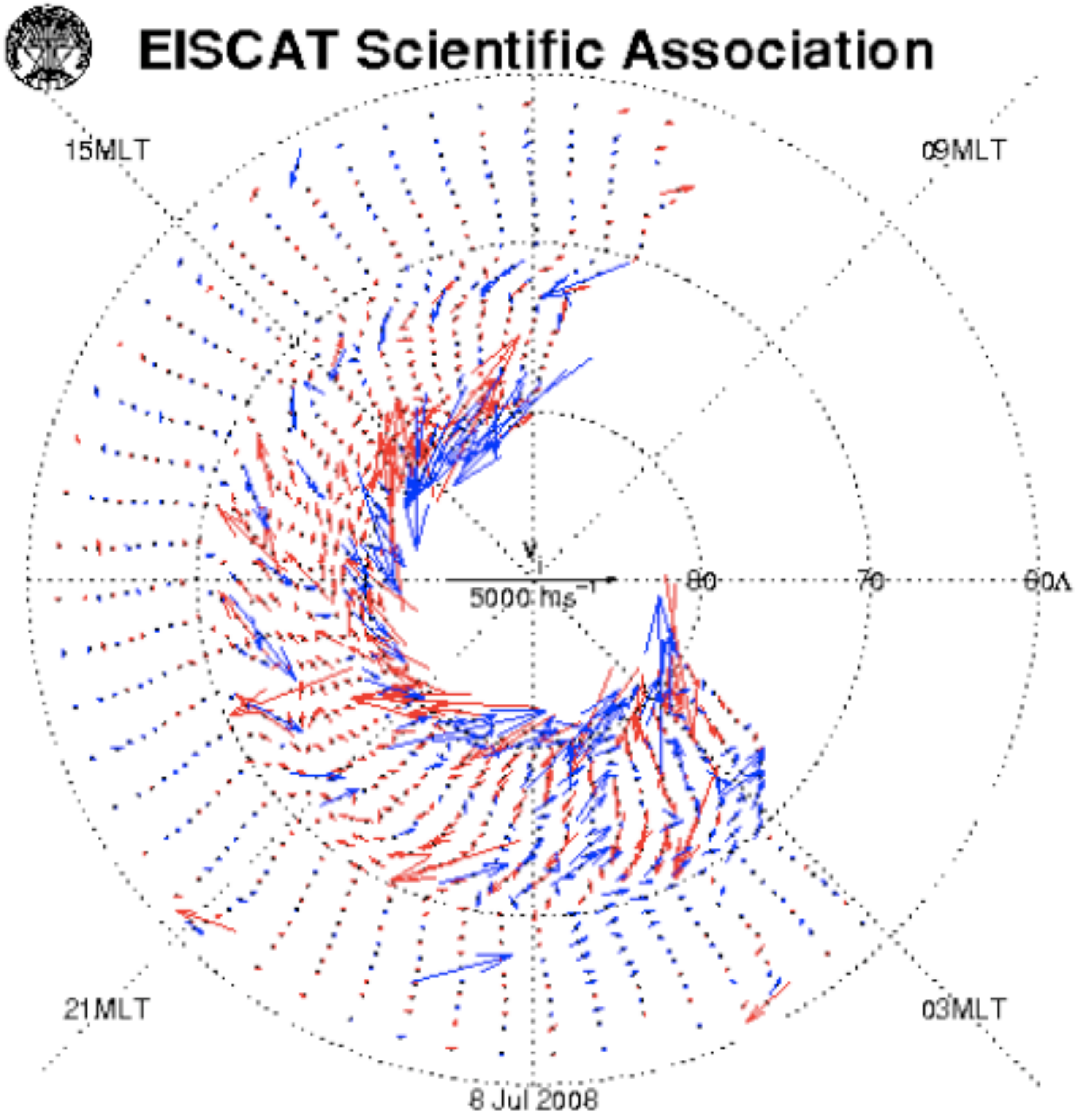
Combined use of several radars

European Incoher



Multisite vectors

- CP3
  - ESR
  - UHF
  - KIR
  - SOD



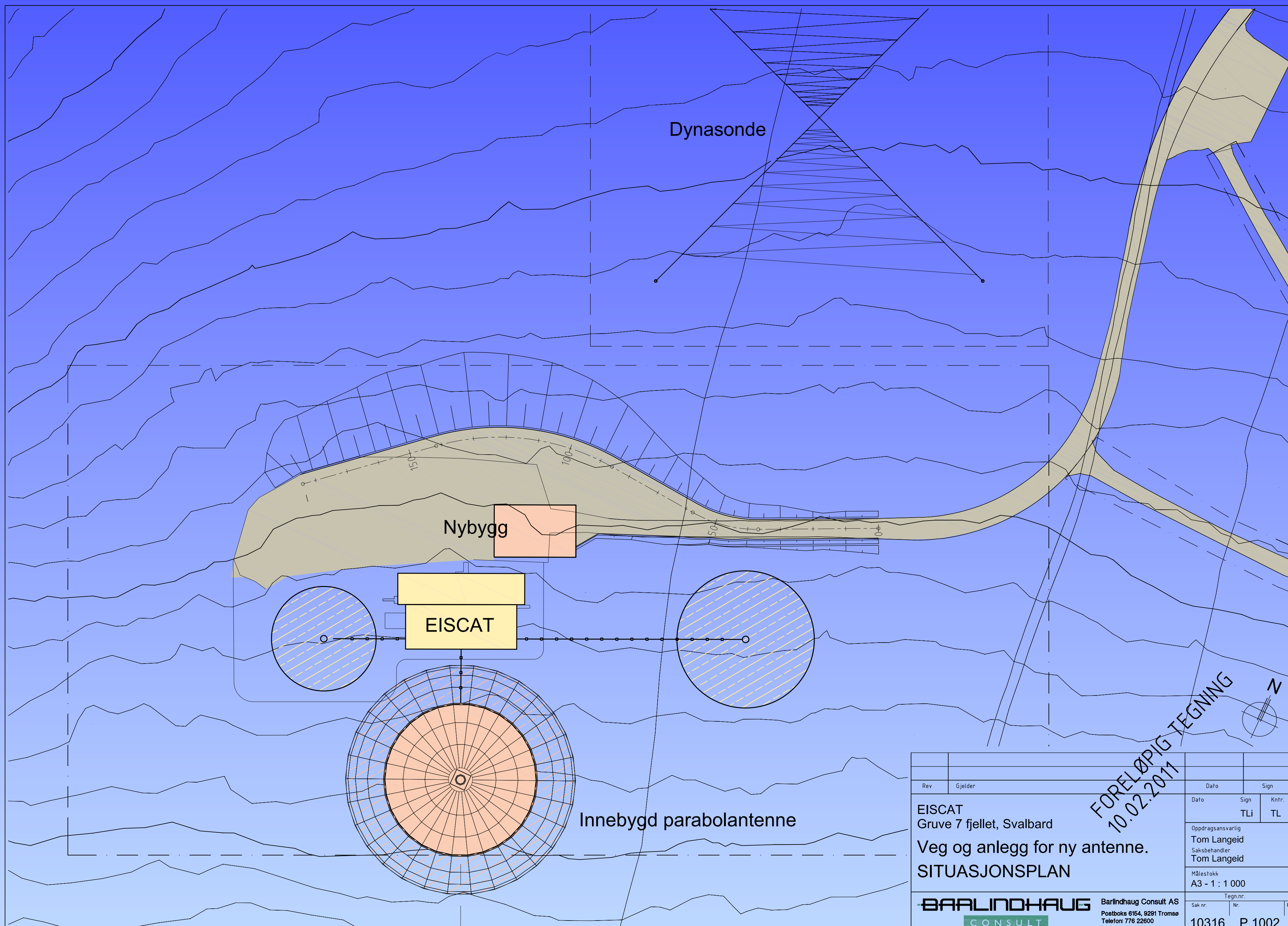
Chinese investment: 3rd antenna

50 m høy antenne

70m høy radom

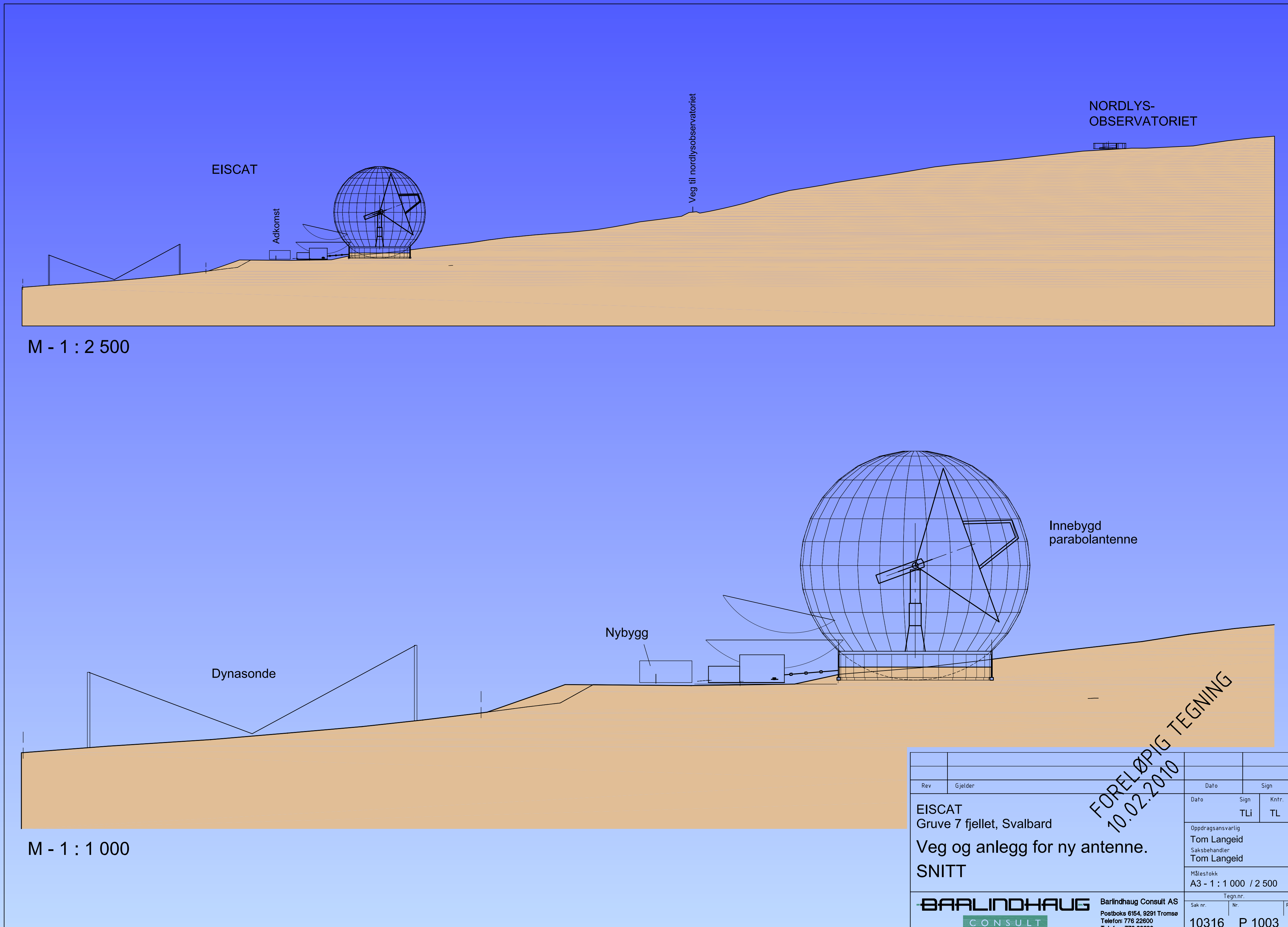
Estimated cost: 300 MRMB

Concept Plan ESR 3rd Antenna



EISCAT Svalbard Radar

Concept Plan ESR 3rd Antenna



EISCAT Svalbard Radar

Dynasonde on Svalbard

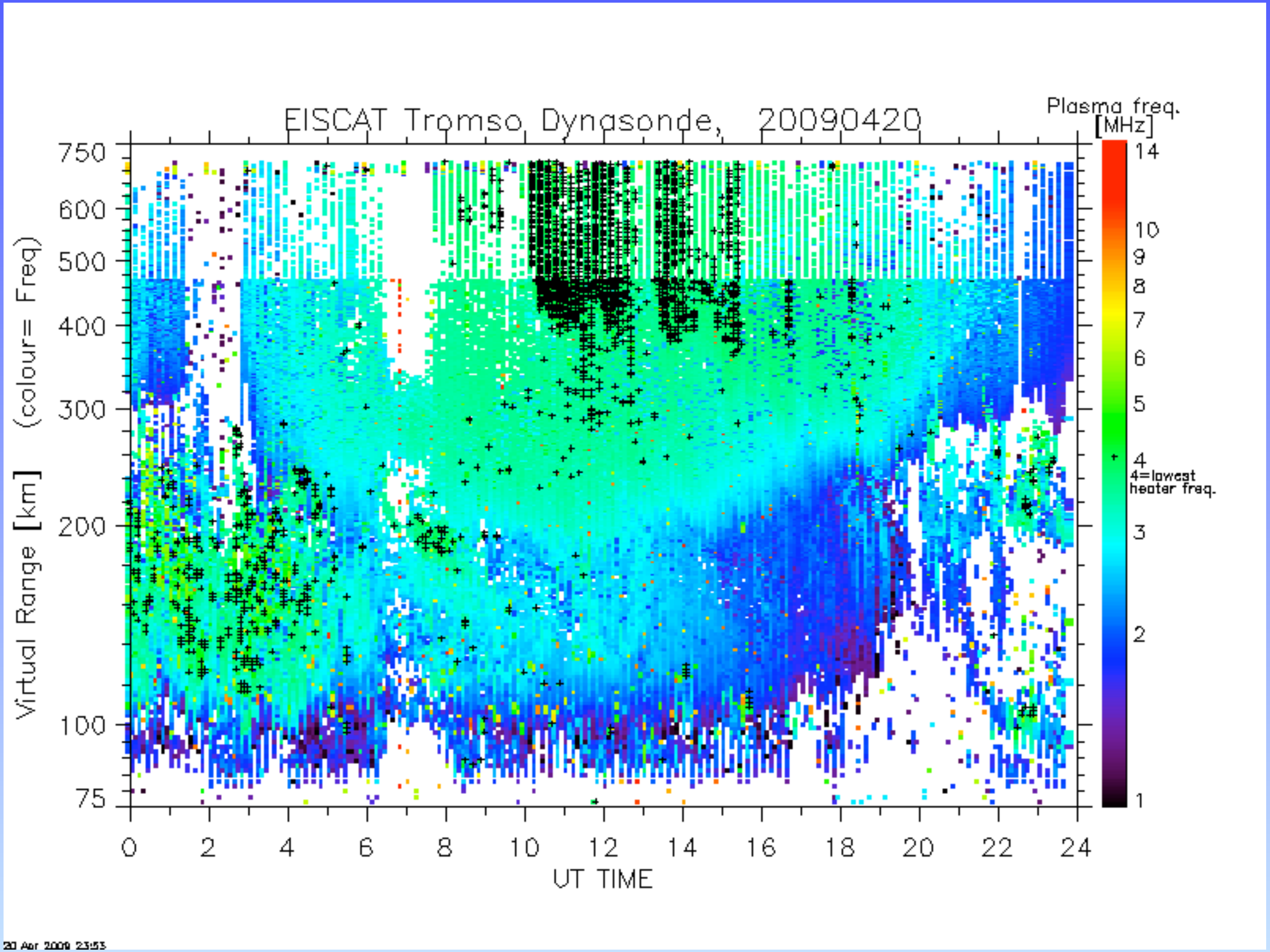
A receiving dipole antenna, with ESR in background

Inside and outside the container

EISCAT Scientific Association

Example data

(*everyone can access the CONTINUOUS data*)



European Strategy Forum on Research Infrastructures

ESFRI

The EUROPEAN Next-Generation Incoherent Scatter Radar proposal EISCAT_3D was accepted on the ESFRI Roadmap of Large-Scale European Research Infrastructures for the next 20-30 years.

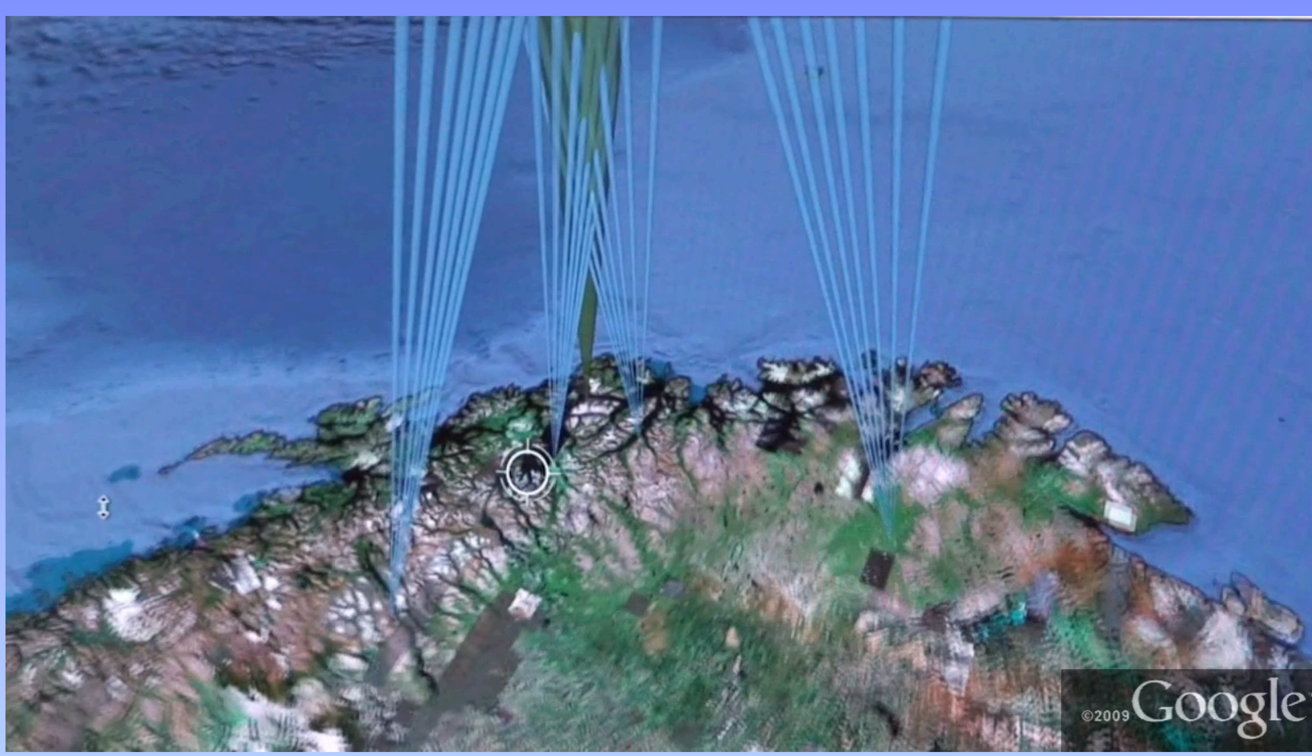
The Svalbard Integrated Arctic Earth-Observation System SIOS was also accepted to the ESFRI Roadmap. ESR is an essential part of SIOS.

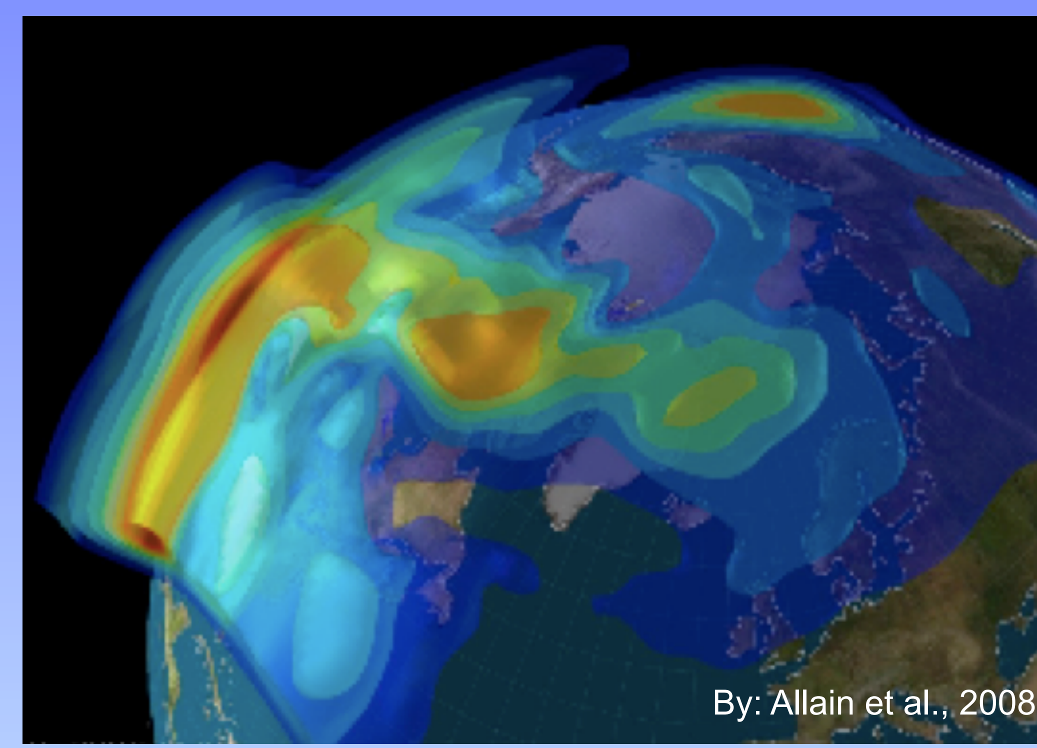
EUROPEAN ROADMAP FOR RESEARCH INFRASTRUCTURES

Roadmap 2008

EISCAT_3D

- EISCAT_3D is a 3-dimensionally imaging radar
- *Continuous measurements of the space environment - atmosphere coupling at the statistical southern edges of the polar vortex and the auroral oval.*



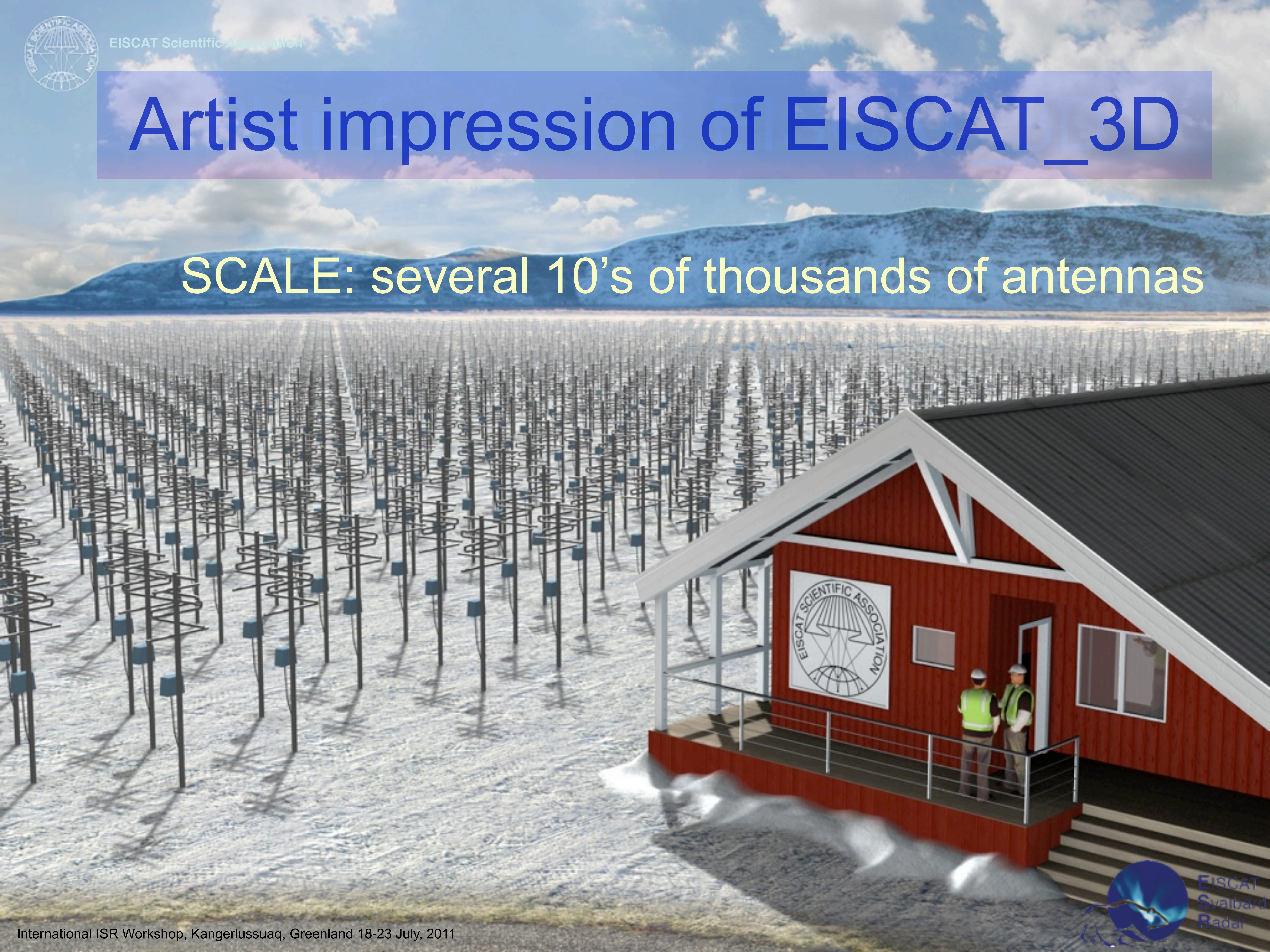


By: Allain et al., 2008

EISCAT Svalbard Radar

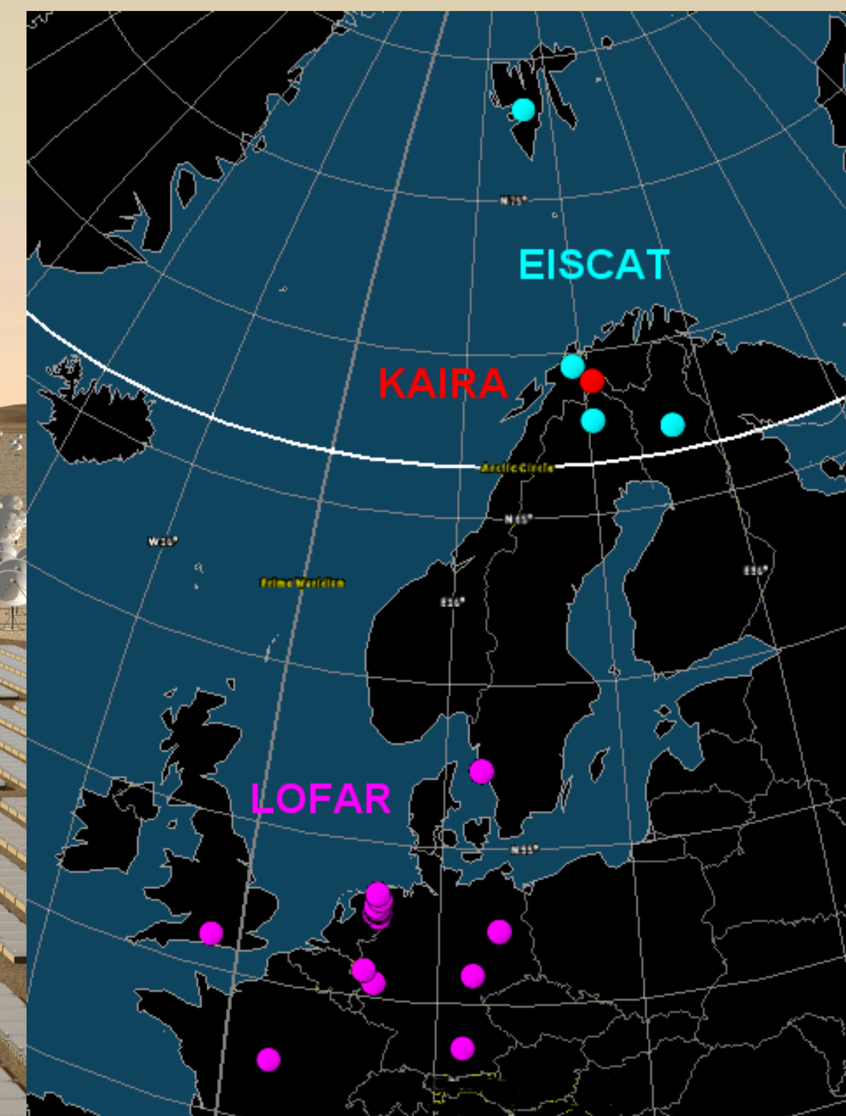
Artist impression of EISCAT_3D

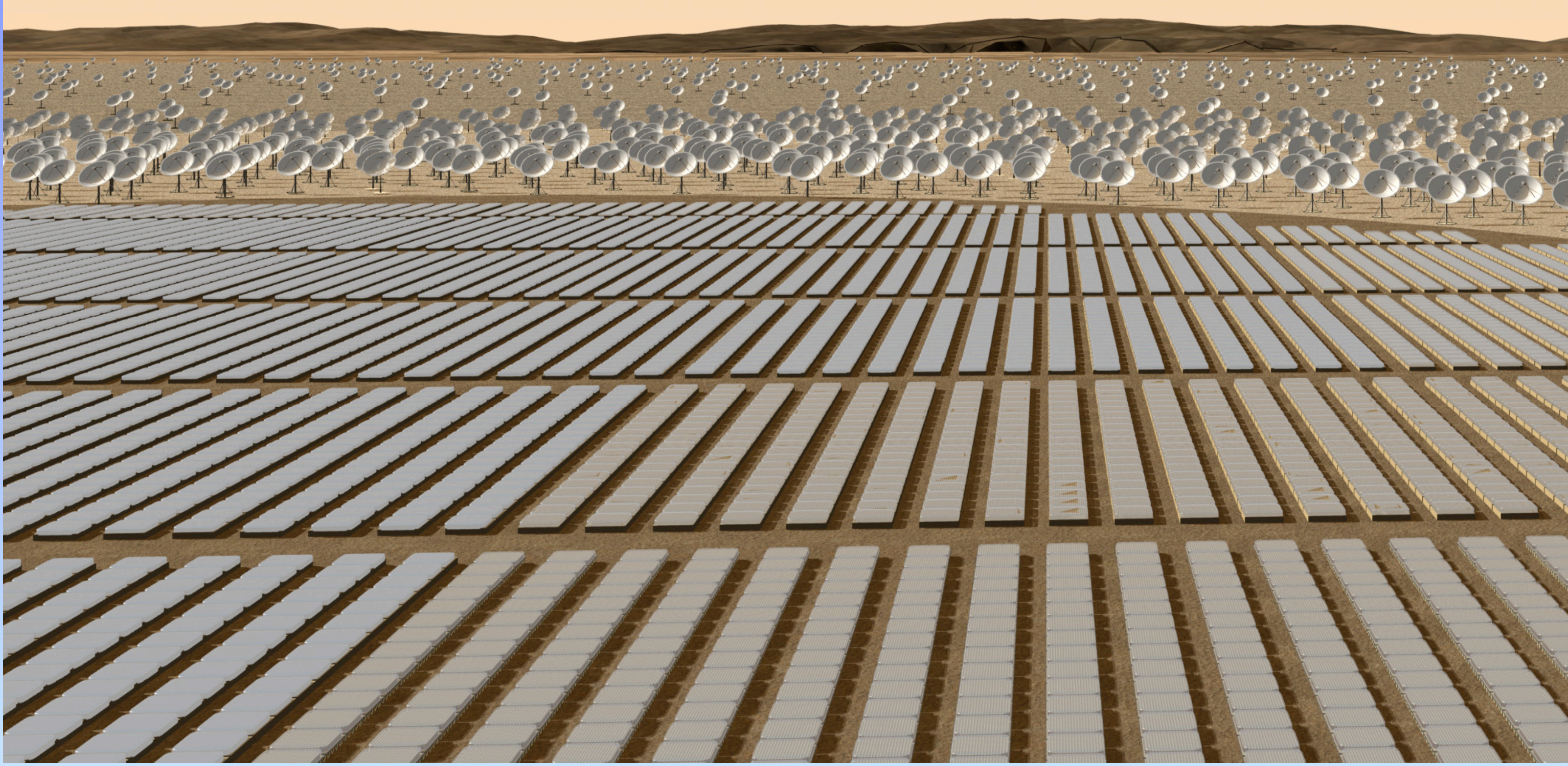
SCALE: several 10's of thousands of antennas



Similarity to modern radio astronomy

- SKA project
  - artist image below
- LOFAR (Low Frequency Array)
  - One LOFAR international site was ordered to Finland, to be installed as a test and technology prototyping receiver site for EISCAT_3D in Northern Finland
  - test instrument is called KAIRA
  - see http://kaira.sgo.fi/’
- MWA (Murchison Wide Field Array)
  - Explicit Solar, Heliosphere, and Ionospheric Science part
  - US/AU/India



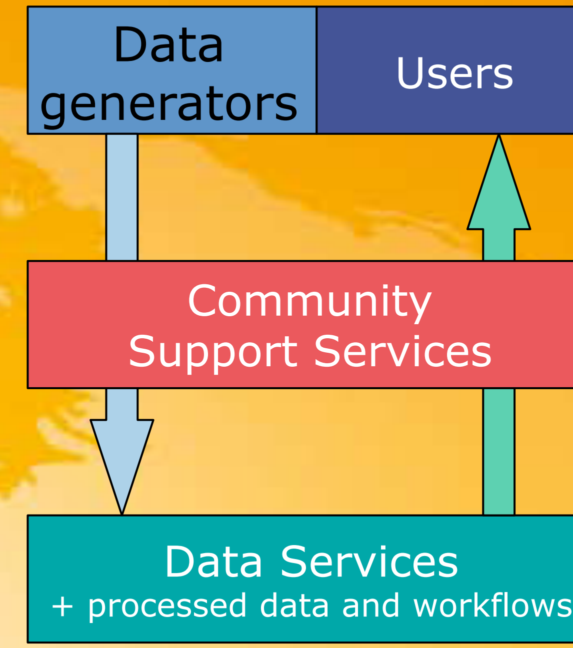


EISCAT_3D: A European three-dimensional imaging radar for atmospheric and geospace research

- For details, see separate lecture on Friday

- Preparatory Phase project 2010-2014
- EU funds by 4.5 MEUR

ENVRI, joint EU FP7 e-infrastructure proposal by the environmental ESFRI projects

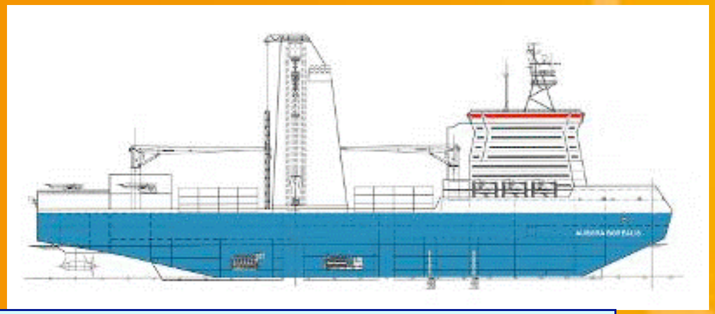


EURO-ARGO

SIOS

IAGOS-ERI

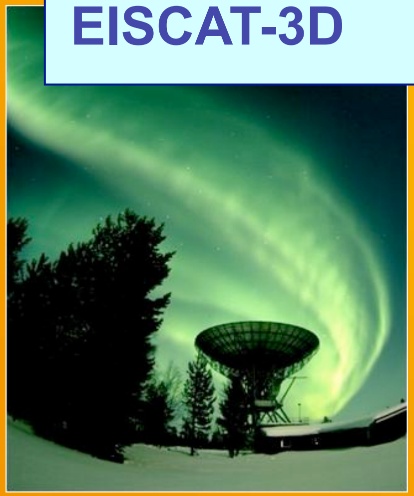
EUFAR-COPAL



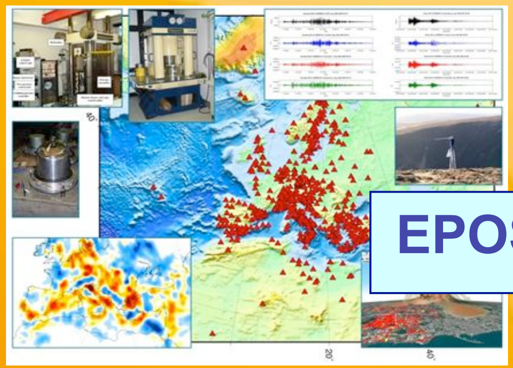
AURORA BOREALIS

LIFEWATCH

EISCAT-3D



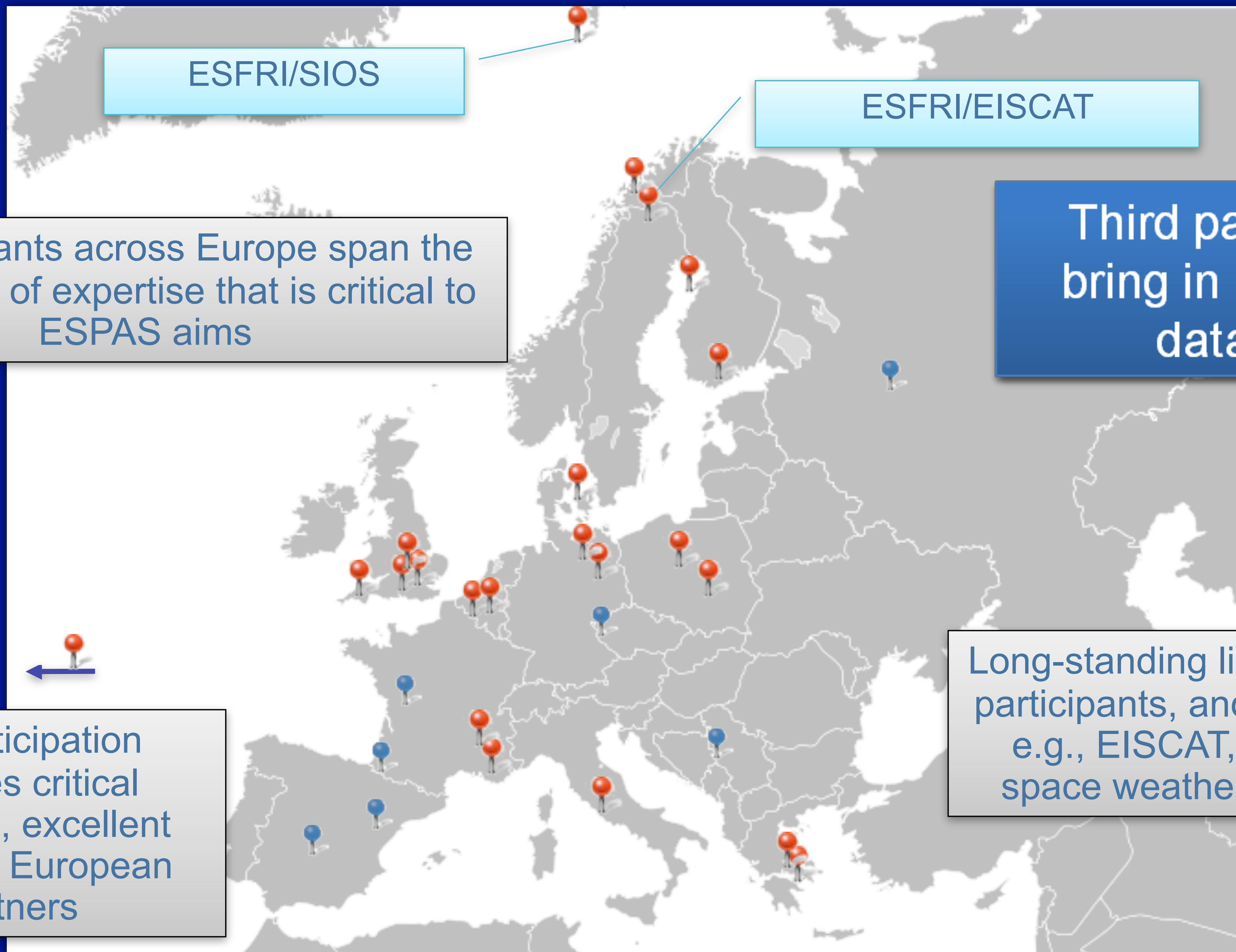
EMSO



EPOS

ICOS

ESPAS: Near-Earth Space Data Infrastructure for e-Science *(proposal to EU FP7)*



21 participants across Europe span the wide range of expertise that is critical to ESPAS aims

Third parties bring in more data

US participation provides critical expertise, excellent links with European partners

Long-standing links between participants, and 3rd parties, e.g., EISCAT, EGU and space weather initiatives

ESPAS : technology (interoperability, efficiency) AND policies (quality, access)

EU-US collaboration on large-scale research infrastructures

- funding call to be opened in July 2011 *(announced at EGU 2011)*

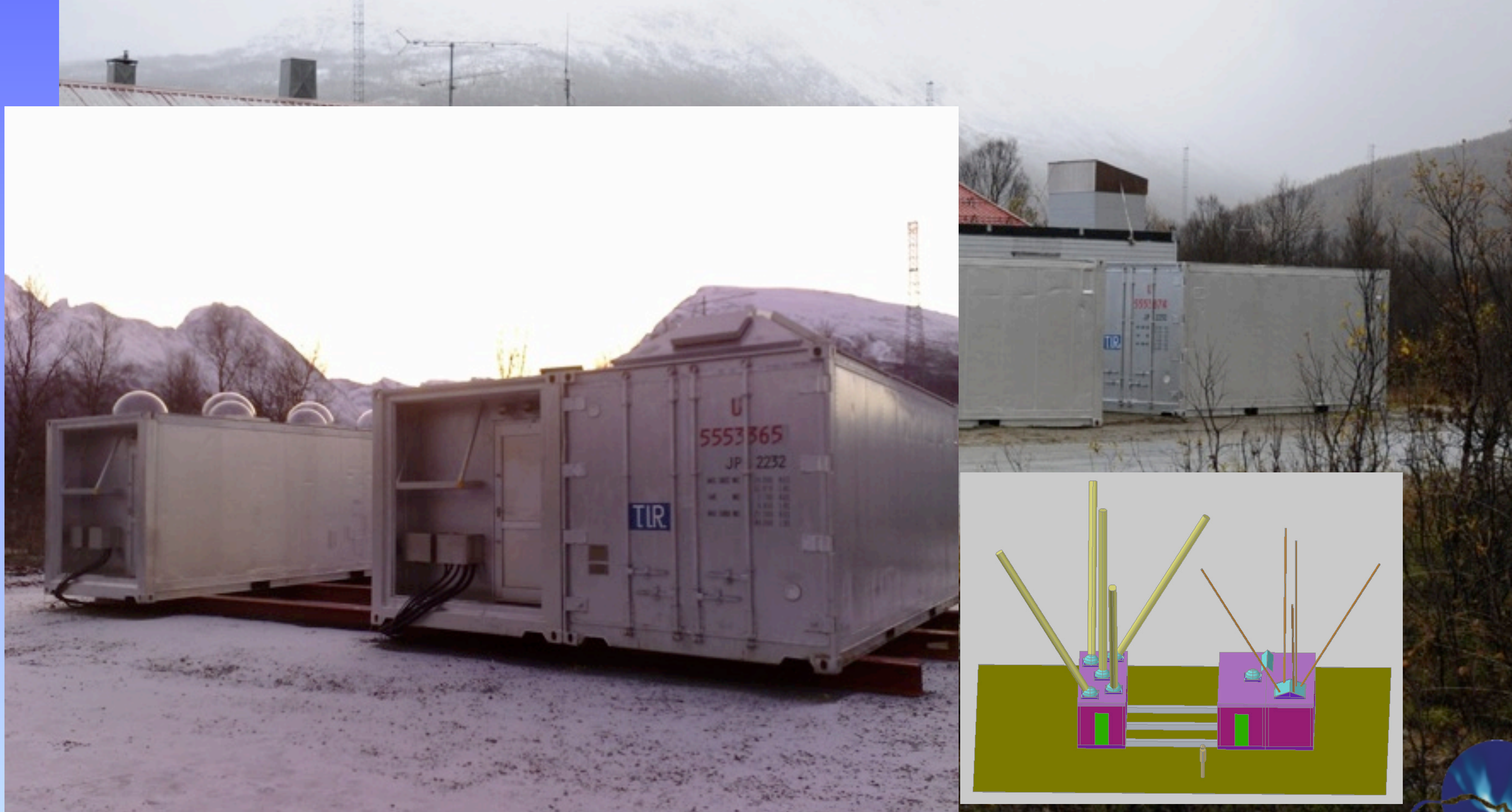
ISR collaboration:

- Coordinate operations
  - InFO (coordination office) action funded in the USA;
  - EISCAT to join -> bulk of the radars and radar data
  - URSI ISWG and other working groups
  - World Day program
- enable data sharing, including models
  - Maintain knowledge base, promote education and mobility at all levels
- develop hardware in collaborative projects
  - EISCAT_3D and AMISR II
- consider also new locations for the new radars in future

EISCAT Scientific Association

New user operations at EISCAT

- The Japanese lidar installation at the Tromsø site includes 3 container houses
- A major optical instrument to be used with EISCAT radars for the next 10 years

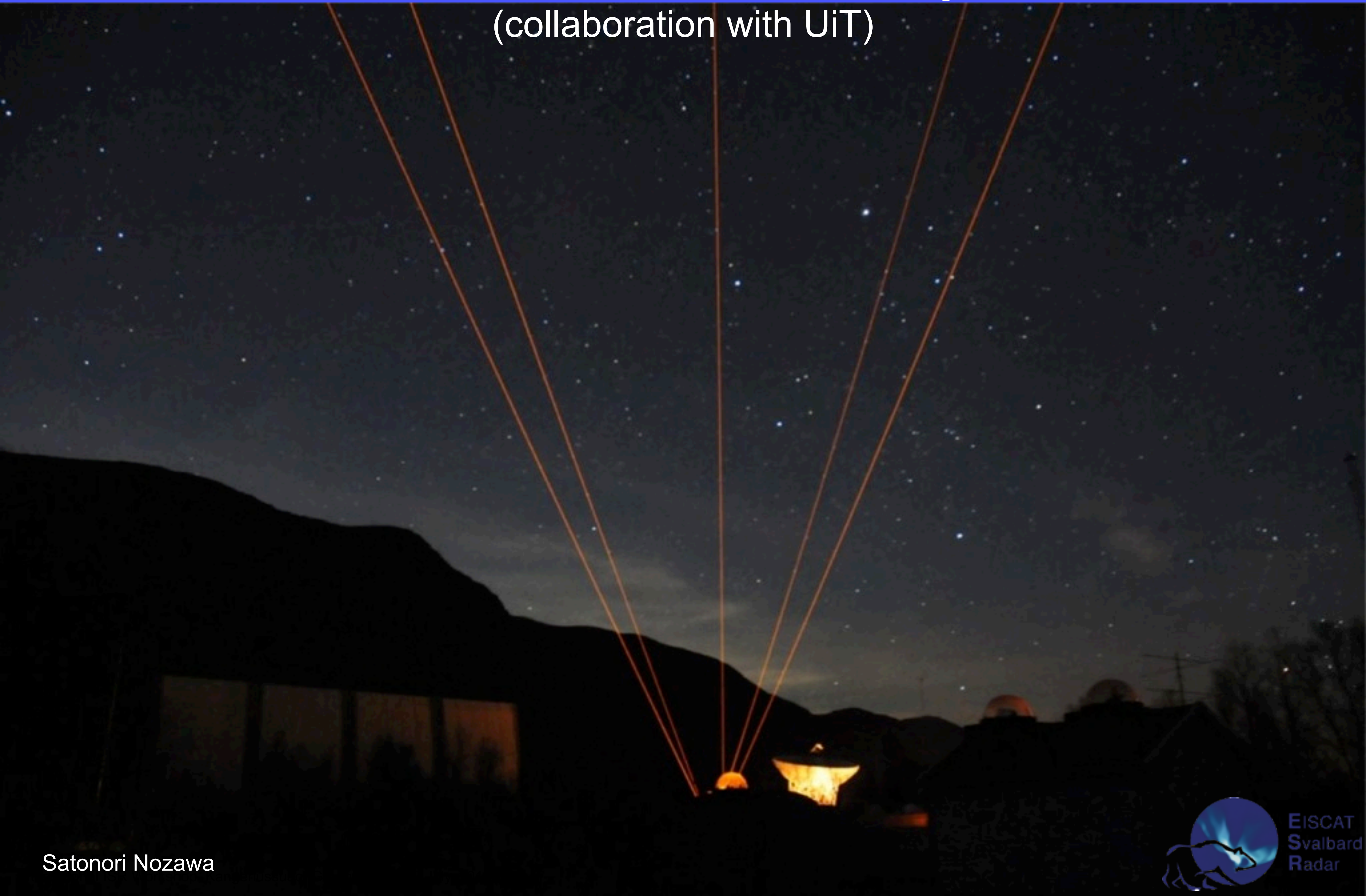


EISCAT Svalbard Radar

EISCAT Scientific Association

Japanese lidar laboratory Tromsø

(collaboration with UiT)



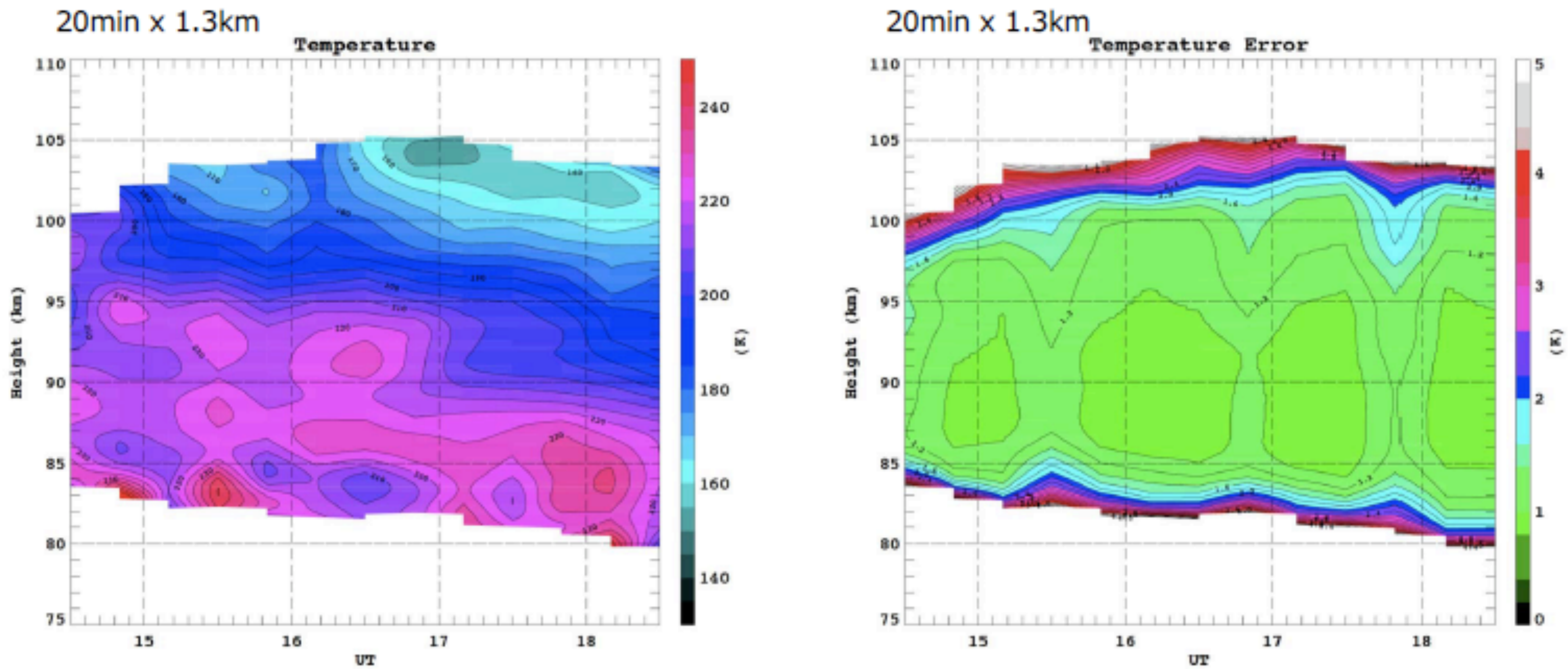
Satonori Nozawa

EISCAT Svalbard Radar

First lidar data Oct/Nov 2011

TEST OBSERVATION: Observed temperature

Credit: Figure by T. Tsuda et al. in AGU Fall meeting 16.12.2010



We succeeded detections of backscatter signals from the sodium layers at 85-110 km height. We found that precision of obtained temperature data is less than 5 K in a case of 20-min time-resolution and 1.3-km height-resolution.

EISCAT Svalbard Radar

Radar interferometer at Svalbard

First successful data recorded in spring 2010
Further campaigns planned
Supports work for EISCAT_3D by UiT

EISCAT Reaching for The Moon

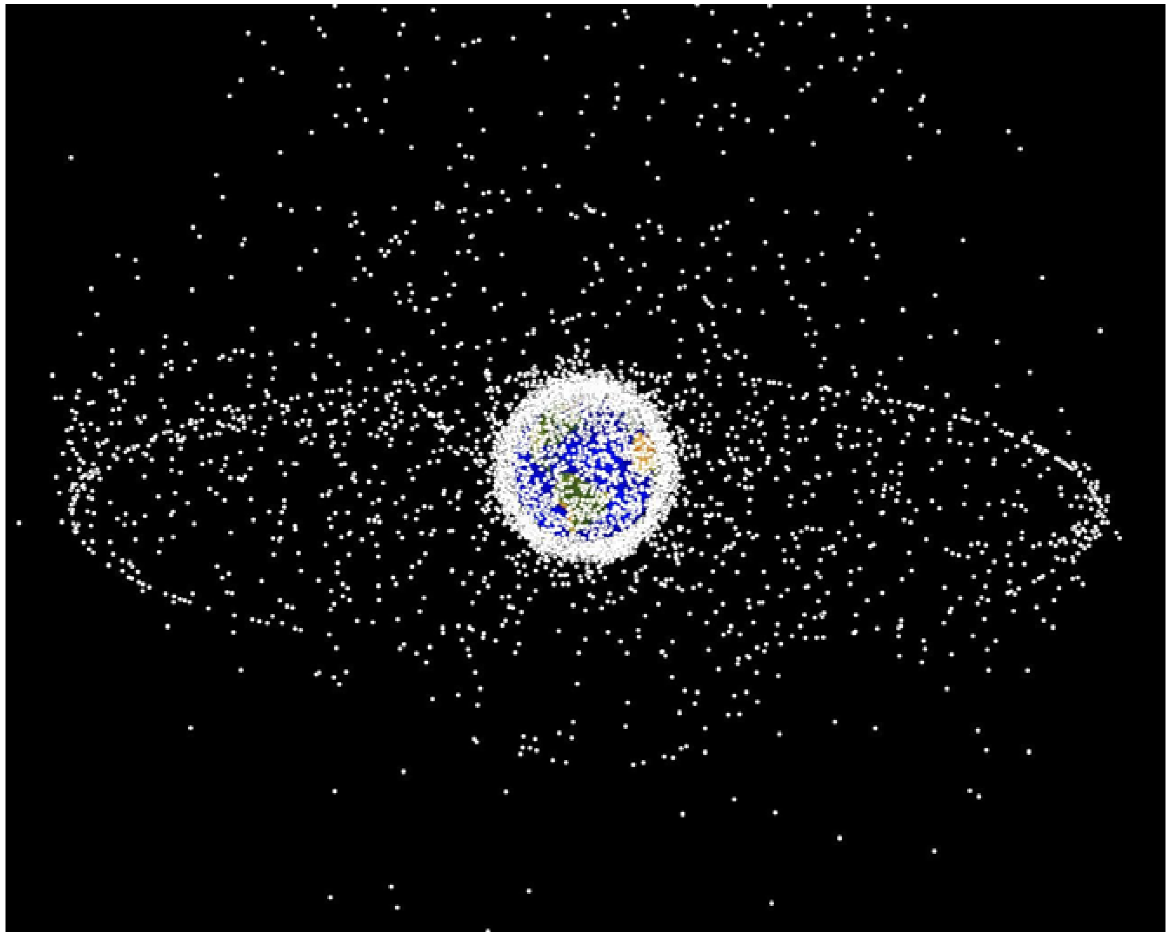
Credits: Juha Vierinen and Markku Lehtinen, Sodankyla Geophysical Observatory, Finland

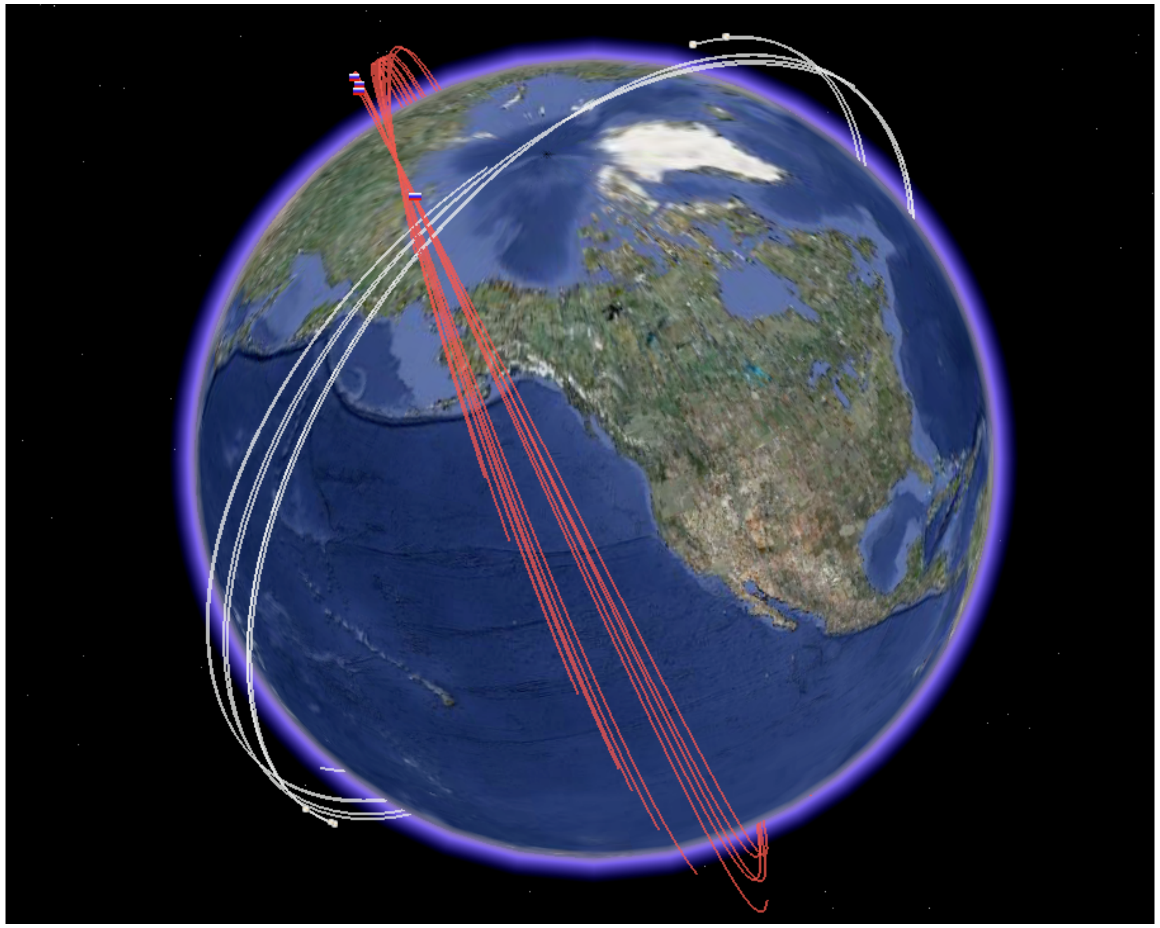
EISCAT
Svalbard
Radar

Reach down to 600 m resolution

- the Finnish user group has improved their inital analysis during 2009

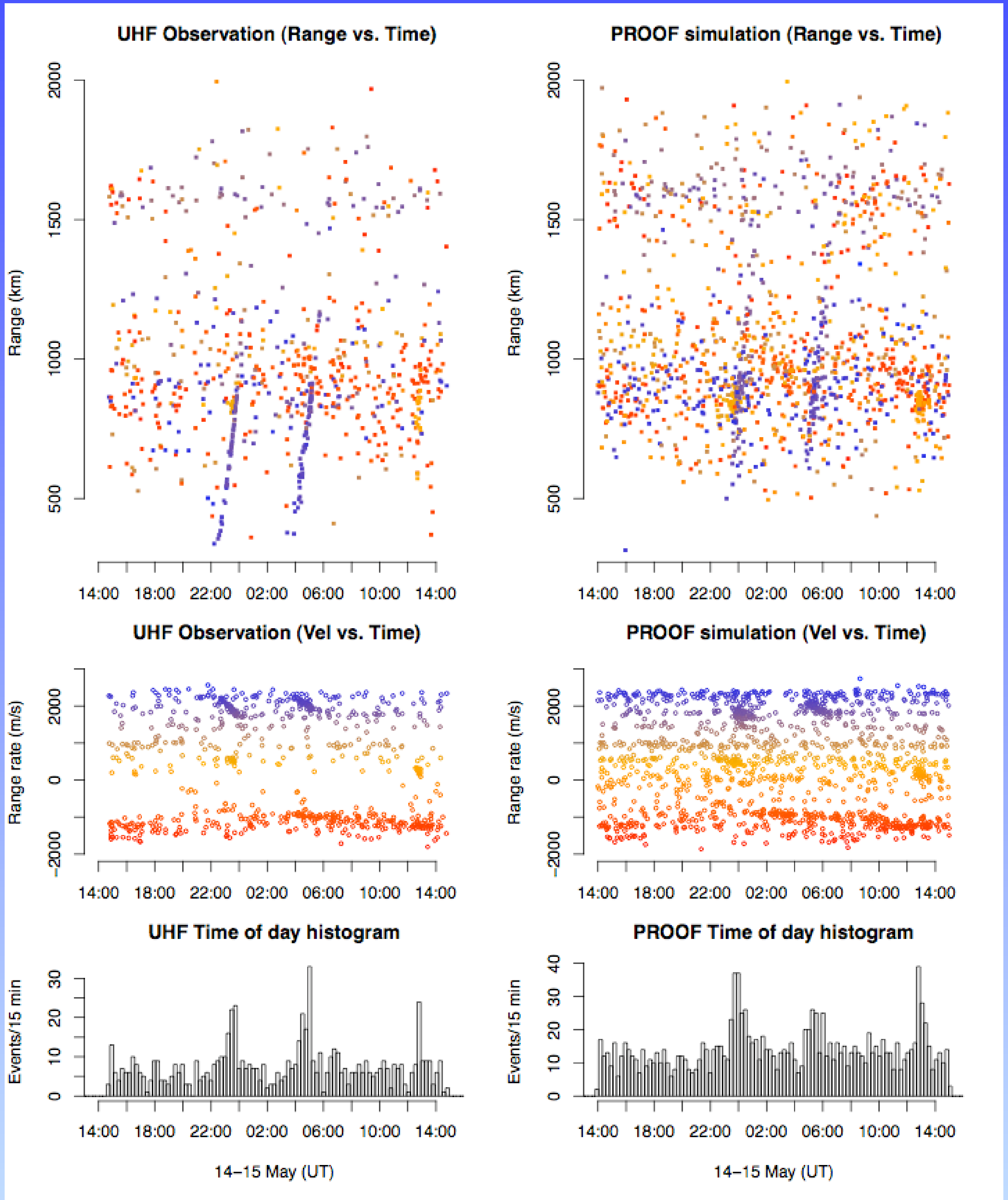
Track space debris





EISCAT Scientific Association

Recent highlights



Space debris detected using the EISCAT UHF system on May 14-15th 2009, a few months after the Iridium-Cosmos satellite collision.

The Iridium cloud orbital plane passes are visible at about 00:00 and 13:00 UT; and the Cosmos cloud pass at about 00:00 and 06:00 UT. The figure also compares the measurement with a statistical debris model called PROOF.

Differences show that the model could be improved by using the EISCAT measurements.

(from J. Vierinen et al., 2009)

EISCAT Svalbard Radar


Education

Educate a new generation of engineers and scientists!

Radar course:

General radar principles

Transmitter-antenna-scattering-antenna-receiver

Radar equation

Incoherent scatter

Scattering process

Nyquist theorem

Scatter spectrum

Ion + plasma lines

Plasma parameters

Aurora, Aeronomy, Interactions, Dynamics

EISCAT organizes annually since 2010 a radar course for the international Space Masters students in Kiruna

Second course run successfully in spring 2011 - 45 students!

EISCAT Svalbard Radar

Photo: Martin Langteigen

Coordinator

- Luleå University of Technology
- Students from all over the world

Visiting lecturer

- Dr. Phil Erickson (PI of MIT Haystack ISR)
- Visiting EISCAT HQ
- Introduction to radar and radar methods
- To be continued in 2012

Laboratory work

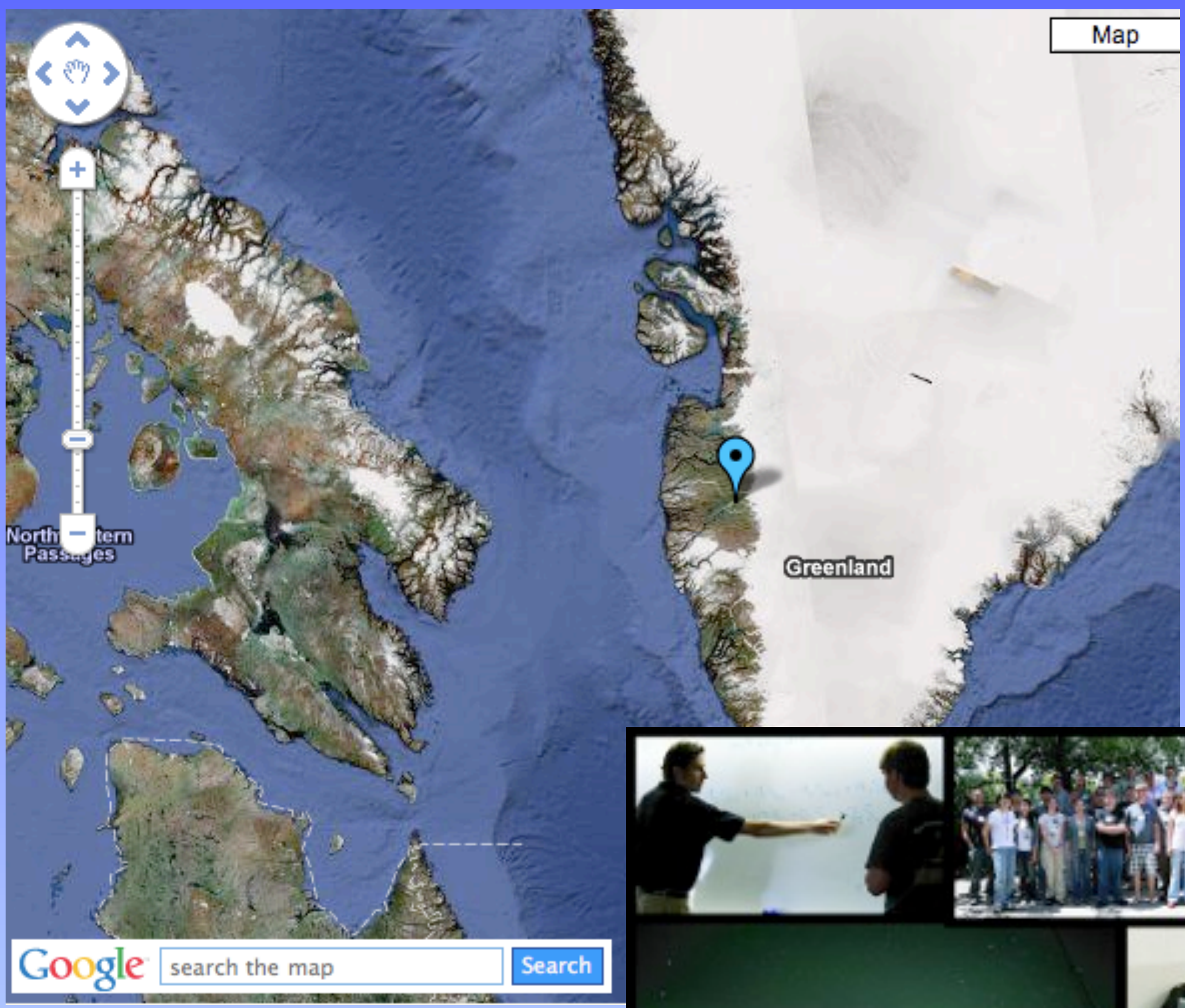
- Use the EISCAT Svalbard radar
  - Study a geophysical process
  - Active run of the experiment
  - the students use 2 MW of radio power!
  - Analyse the data
    - Get ionospheric parameters
    - GUISDAP analysis software
    - Present the results

ISCAT
valbard
adar

Mobility

- EISCAT can offer master thesis projects
  - Within EISCAT_3D
  - Using present systems
  - Hardware/software projects
- Examples of previous projects
  - Space debris detection
  - Antenna design
  - Meteor detection and analysis
- MARIE CURIE PROGRAMME “TRANSMIT” starts in fall 2011
  - Coordination by University of Nottingham, UK
  - Mobility programme: students at partner institutes
  - EU funds all the costs of students
  - EISCAT is an official Associate Partner
  - 2 studentships at EISCAT offered annually, max 6 months

Joint US-EISCAT Radar School 2011 in Greenland, at Sondre Stromfjord radar

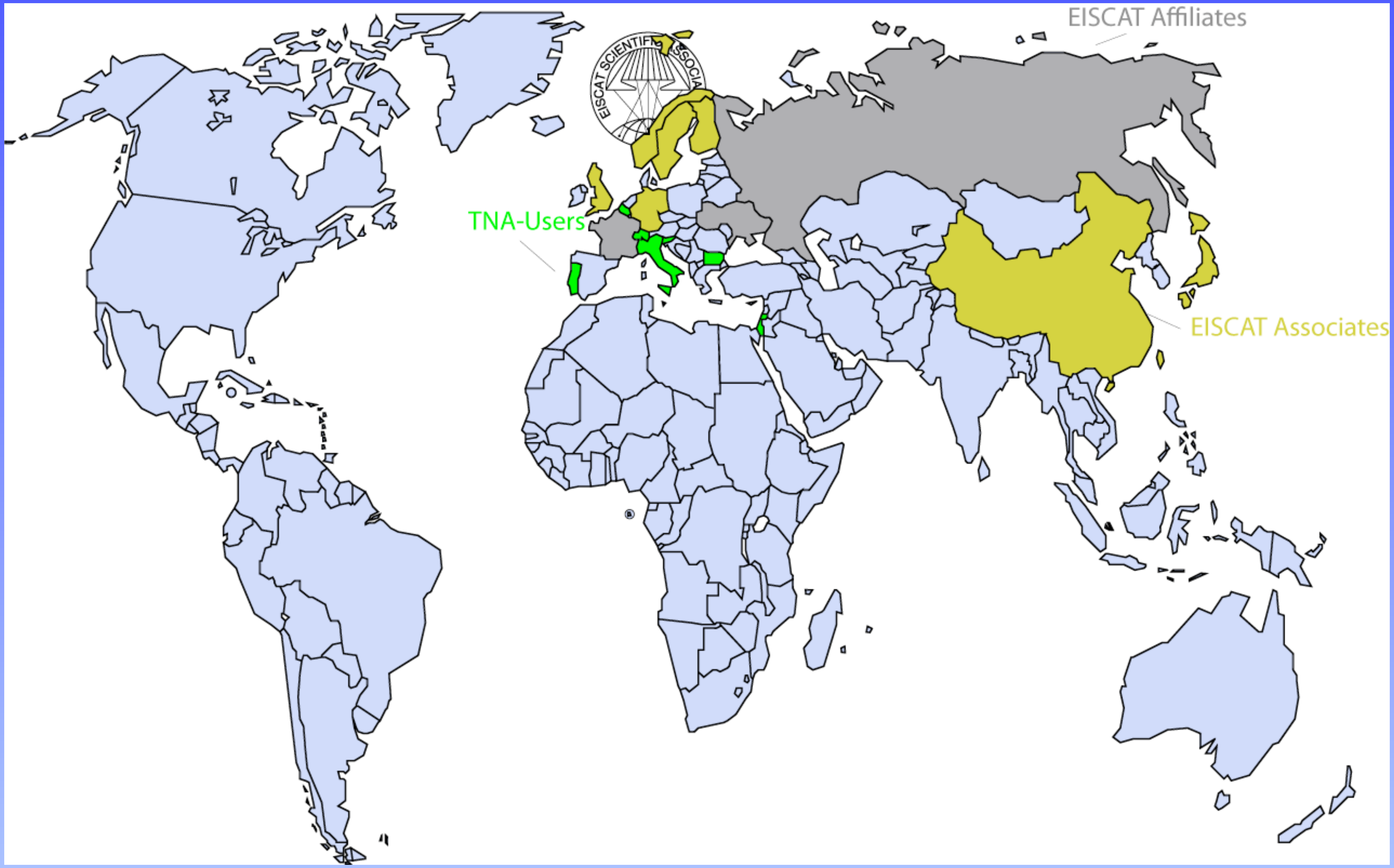


- Organisers:
  - Dr. Anja Strømme, SRI
  - Dr. Thomas Ulich, SGO
- School time:
  - 18-23 July 2011

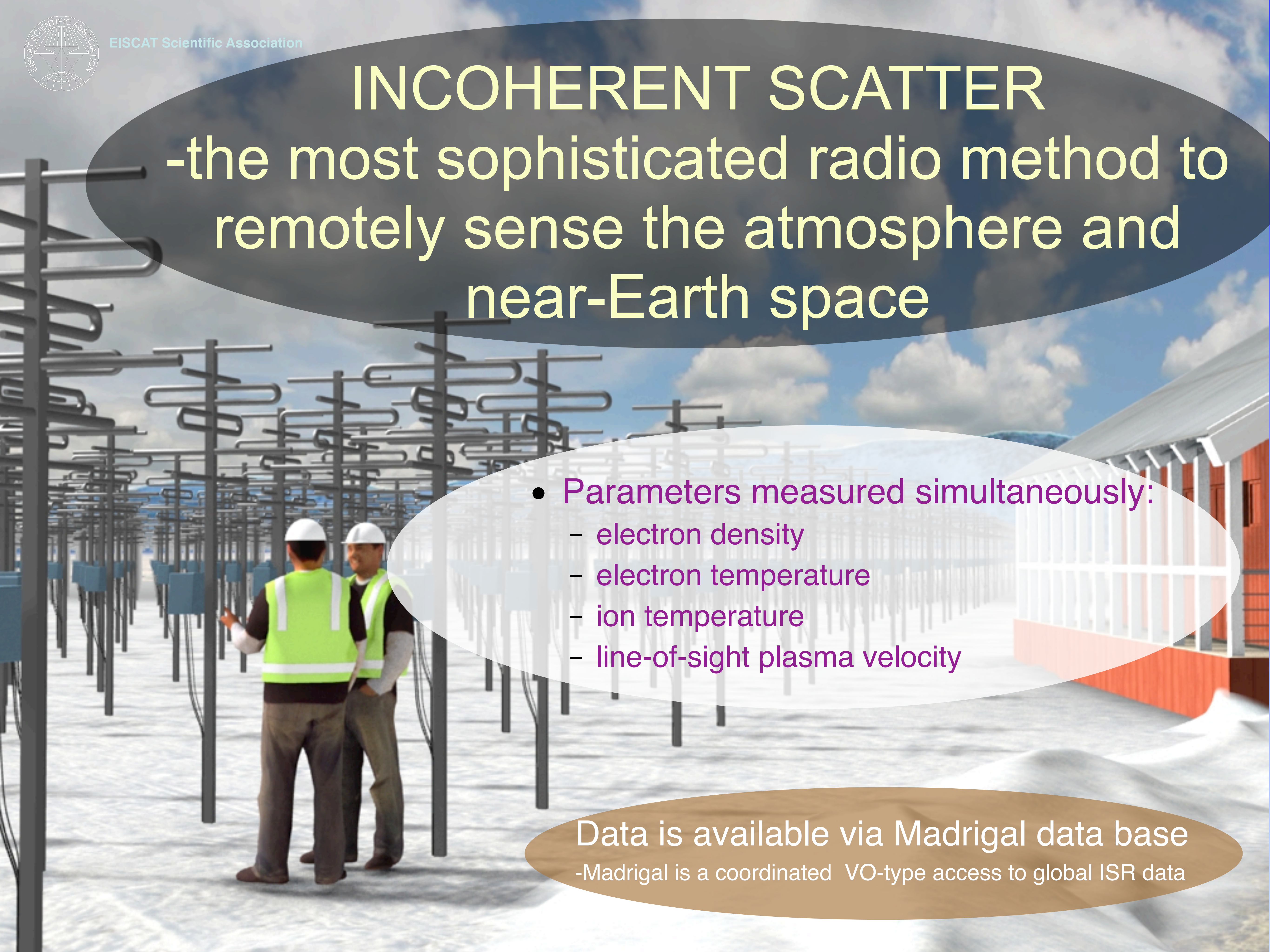
Address the Space Weather community

- 8th European Space Weather Week Namur, Belgium, 28th Nov - 2nd Dec 2011.
- EISCAT plays an active role as one of the sponsors
  - support inviting experts
- Note: EISCAT is proposed as one of the Expert Service Centers (ESC) in ESA's Space Weather Preparatory Programme

Development towards open access



- First step: 200 h peer-reviewed exp allocation 2011
  - First deadline 1 Dec 2010 received 7 applications
  - 5 proposals accepted
  - 2nd application deadline 1 May 2011, 7 proposals evaluated



INCOHERENT SCATTER -the most sophisticated radio method to remotely sense the atmosphere and near-Earth space

- Parameters measured simultaneously:
  - electron density
  - electron temperature
  - ion temperature
  - line-of-sight plasma velocity

Data is available via Madrigal data base

-Madrigal is a coordinated VO-type access to global ISR data

ISR is a unique science opportunity in order to answer important fundamental questions:

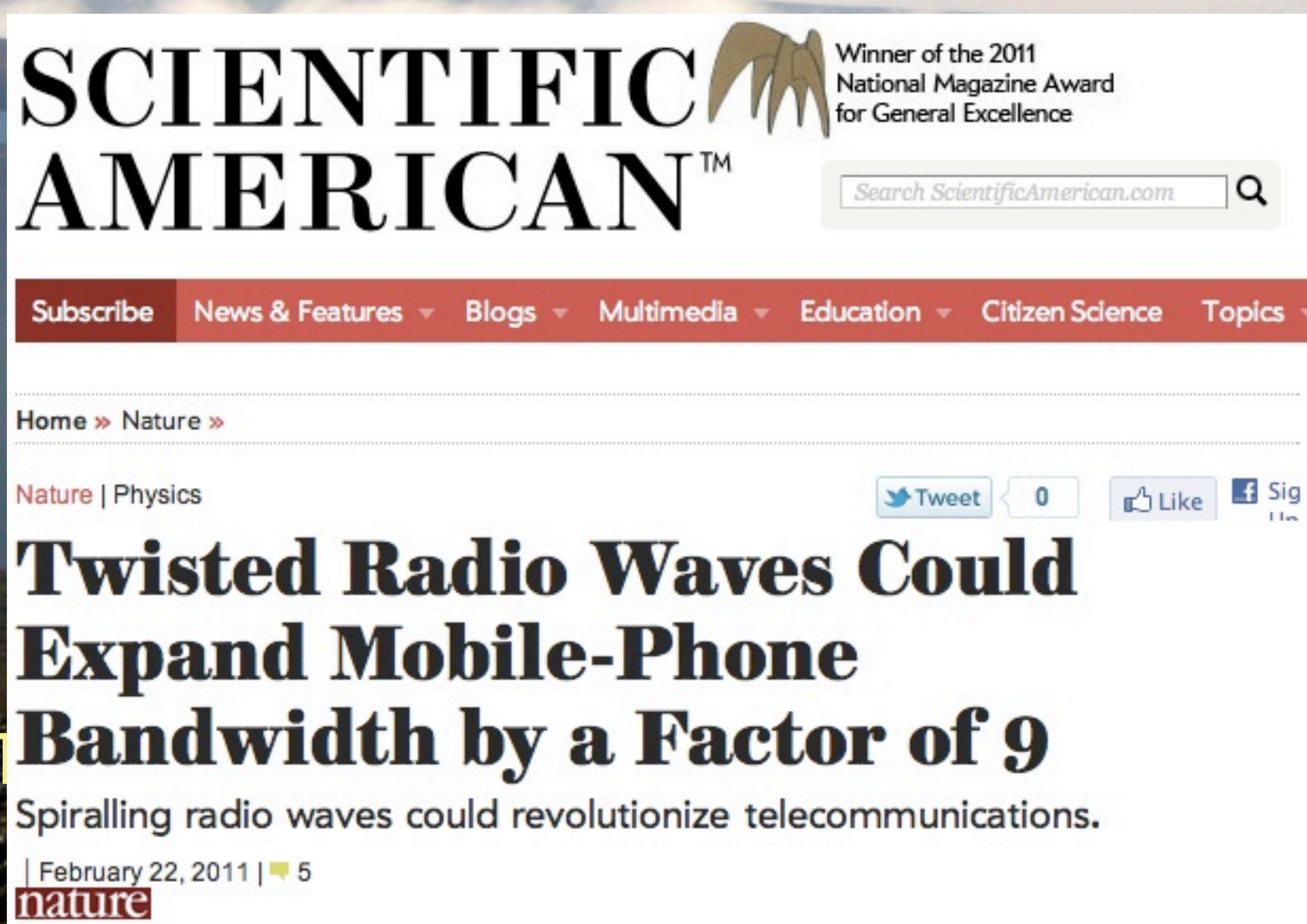
- Solar variability -> atmospheric effects -> coupling of atmospheric layers
- Solar wind-magnetosphere-ionosphere interaction, magnetic reconnection
- Turbulence in the neutral atmosphere and space plasmas
- Dust and aerosols, heterogenic chemistry, dusty plasma, meteoric input
- Ion outflow, evolution of planetary atmospheres

Apply EISCAT peer-review time for your experiment!

The Global ISR network is our tool to understand the Geospace Environment

ISR is a unique science opportunity in order to answer important fundamental questions:

- Solar variability -> atmospheric effects -> coupling of atmospheric layers
- Solar wind-magnetosphere-ionosphere interaction, magnetic reconnection
- Turbulence in the neutral atmosphere and space plasmas
- Dust and aerosols, heterogenic chemistry, dusty plasma, meteoric input
- Ion outflow, evolution of planetary atmospheres


SCIENTIFIC AMERICAN™

Winner of the 2011 National Magazine Award for General Excellence

Search ScientificAmerican.com

Subscribe | News & Features | Blogs | Multimedia | Education | Citizen Science | Topics

Home » Nature »

Nature | Physics

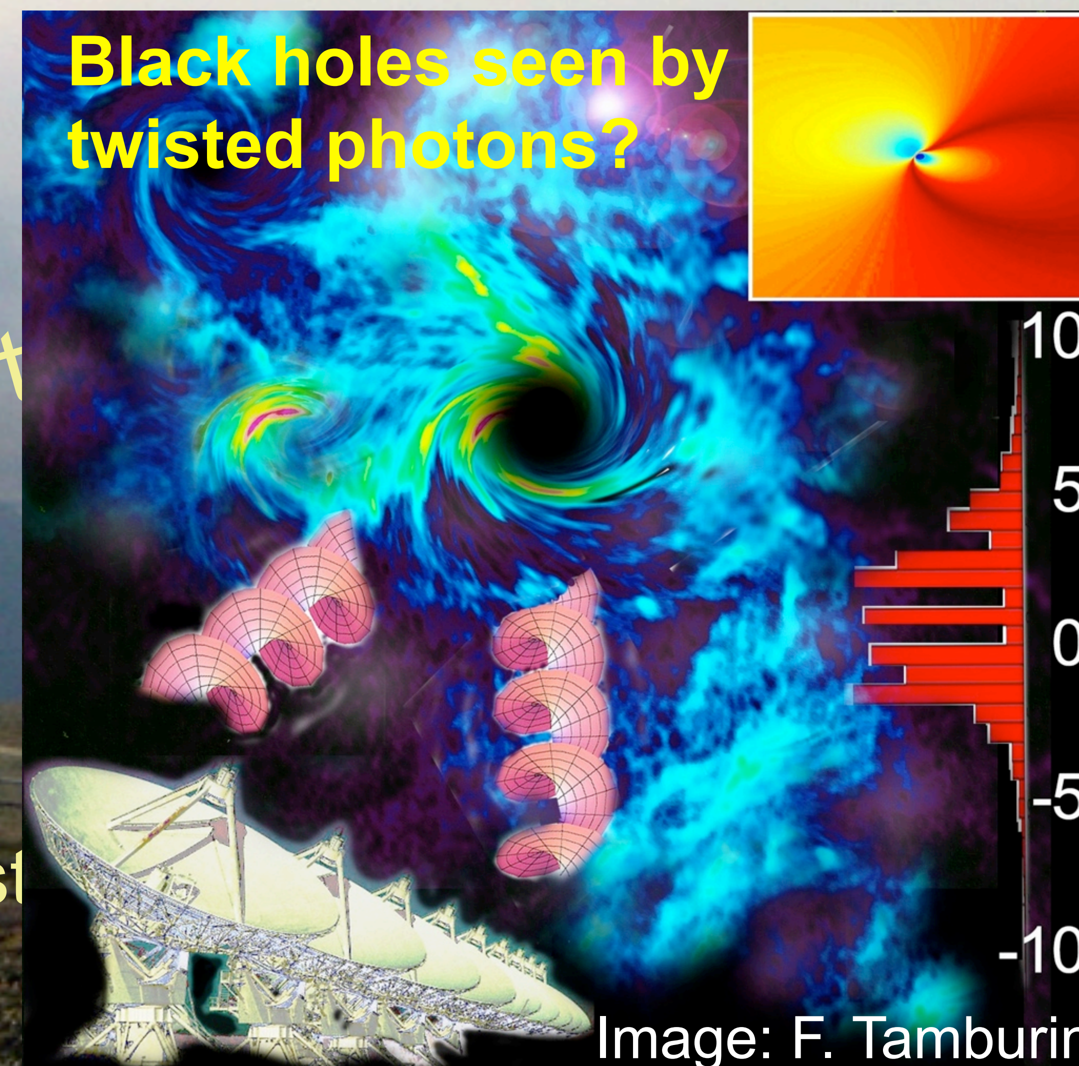
Tweet 0 Like

Twisted Radio Waves Could Expand Mobile-Phone Bandwidth by a Factor of 9

Spiralling radio waves could revolutionize telecommunications.

| February 22, 2011 | 5

nature



ISR is a unique science opportunity in order to answer important fundamental questions:

- Solar variability -> atmospheric effects -> coupling of atmospheric layers
- Solar wind-magnetosphere-ionosphere interaction, magnetic reconnection
- Turbulence in the neutral atmosphere and space plasmas
- Dust and aerosols, heterogenic chemistry, dusty plasma, meteoric input
- Ion outflow, evolution of planetary atmospheres

Thanks!

And remember to send in your application for EISCAT Peer-Reviewed time, wherever you come from!