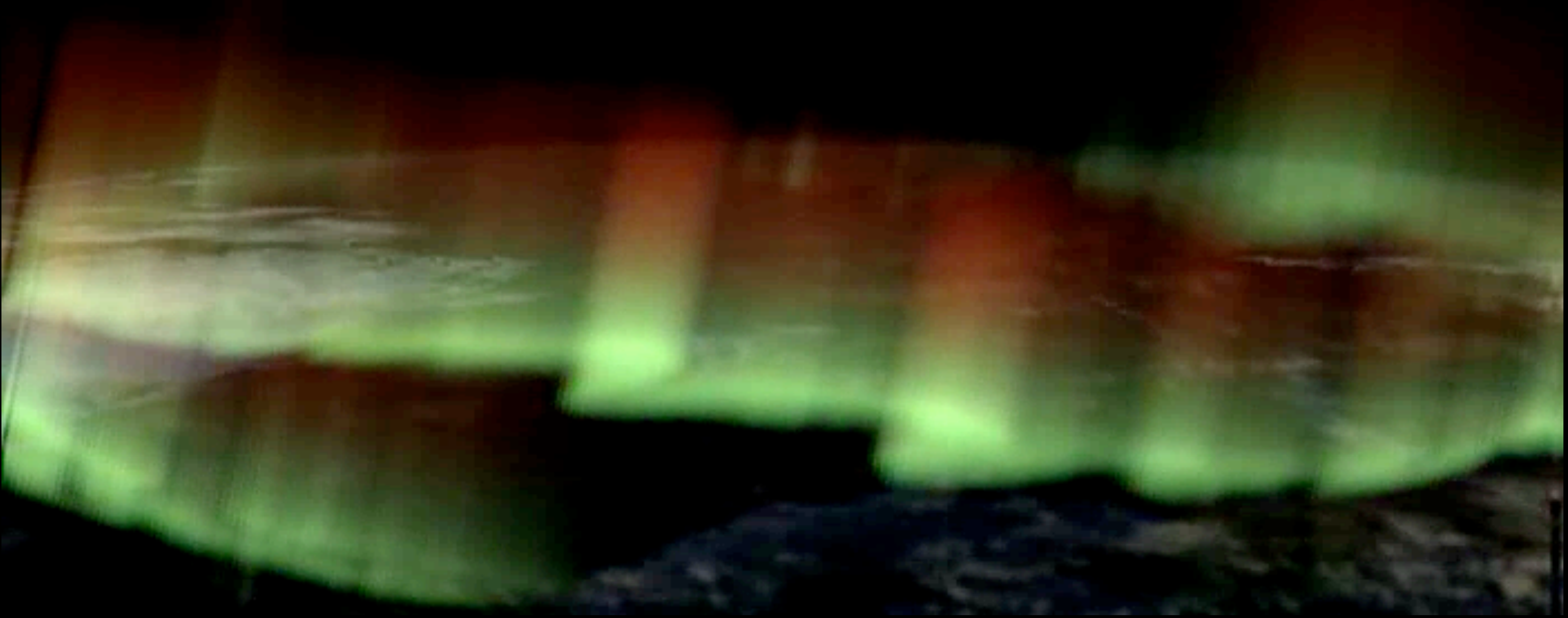
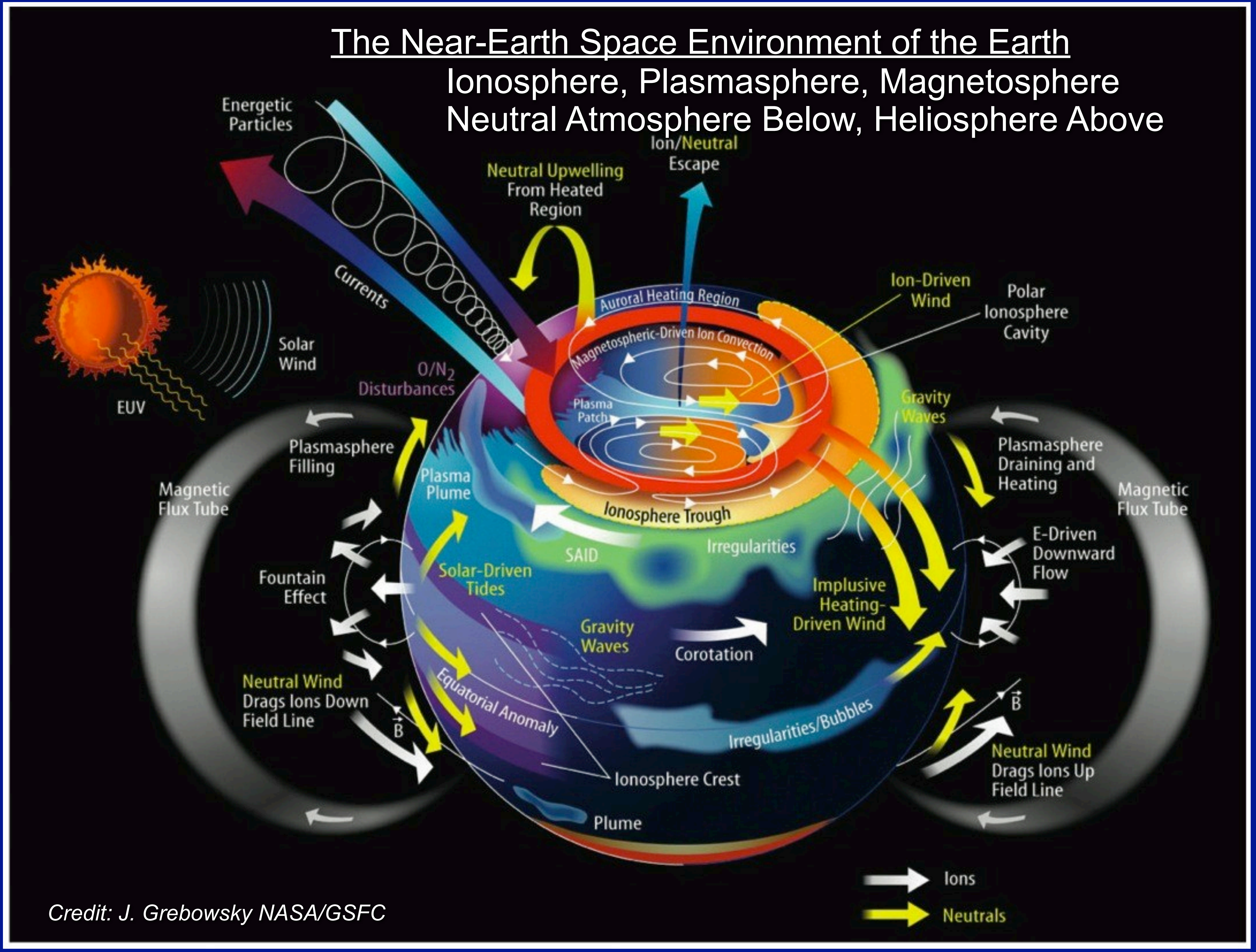
New environmental research tool:
EISCAT 3D

Our Window to Geospace Environment

Esa Turunen
EISCAT Scientific Association, Kiruna, Sweden



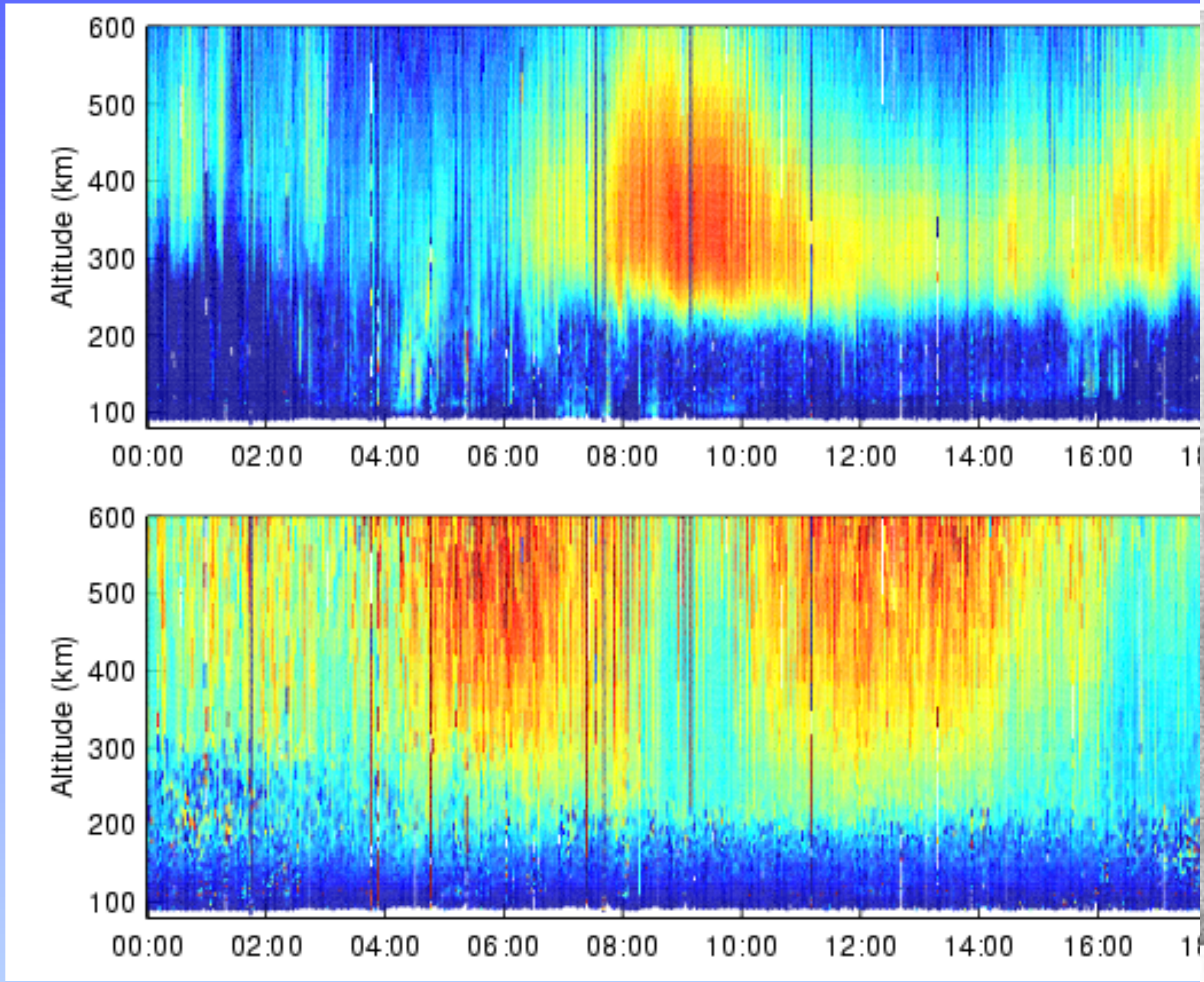
The Geospace Environment



Credit: J. Grebowsky NASA/GSFC

GEOVISION (report 2009): Understand and predict responses of the Earth as a system—from the space-atmosphere boundary to the core, including the influences of humans and ecosystems

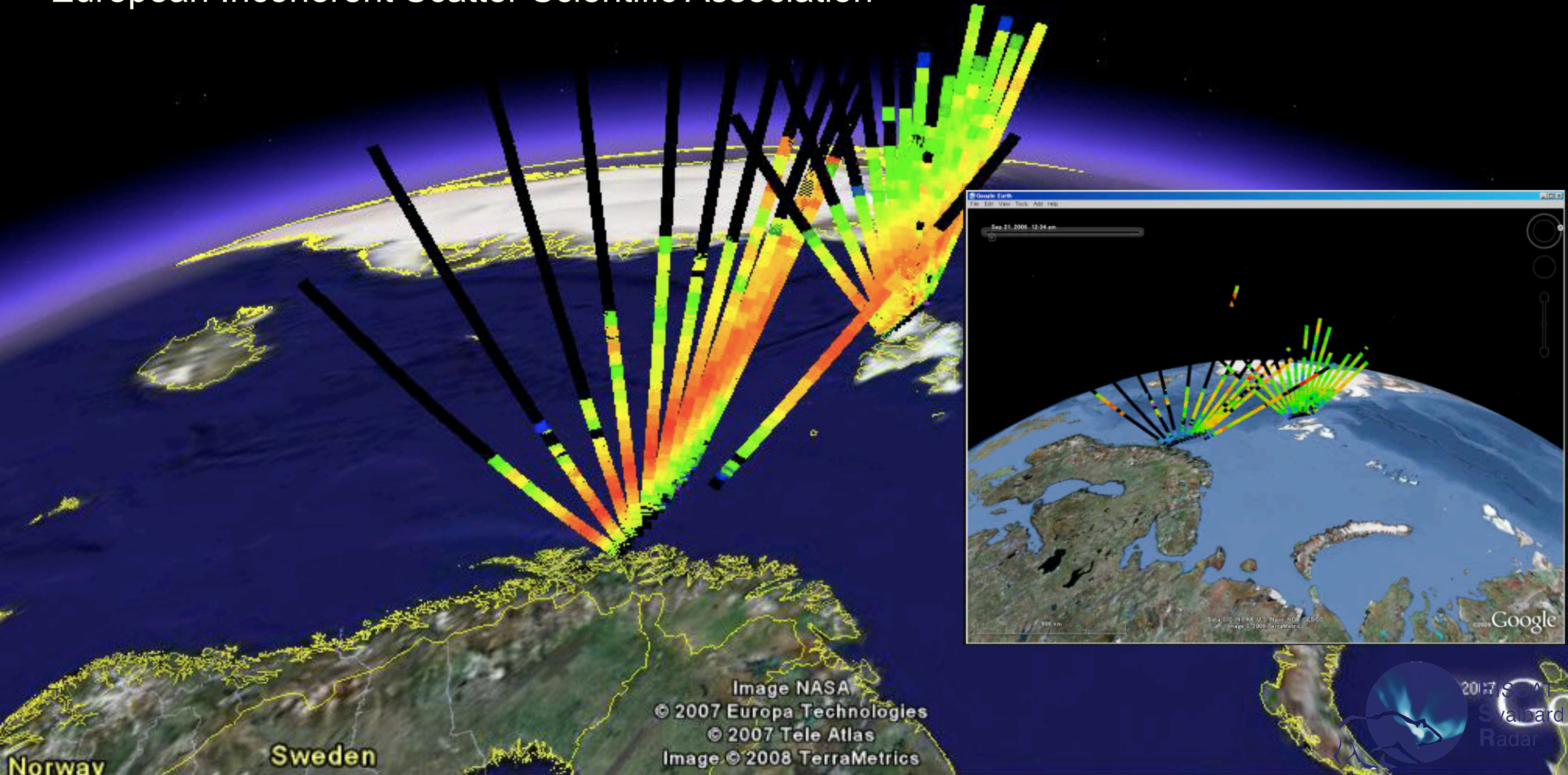
But interpretation of the radar data is not always straightforward

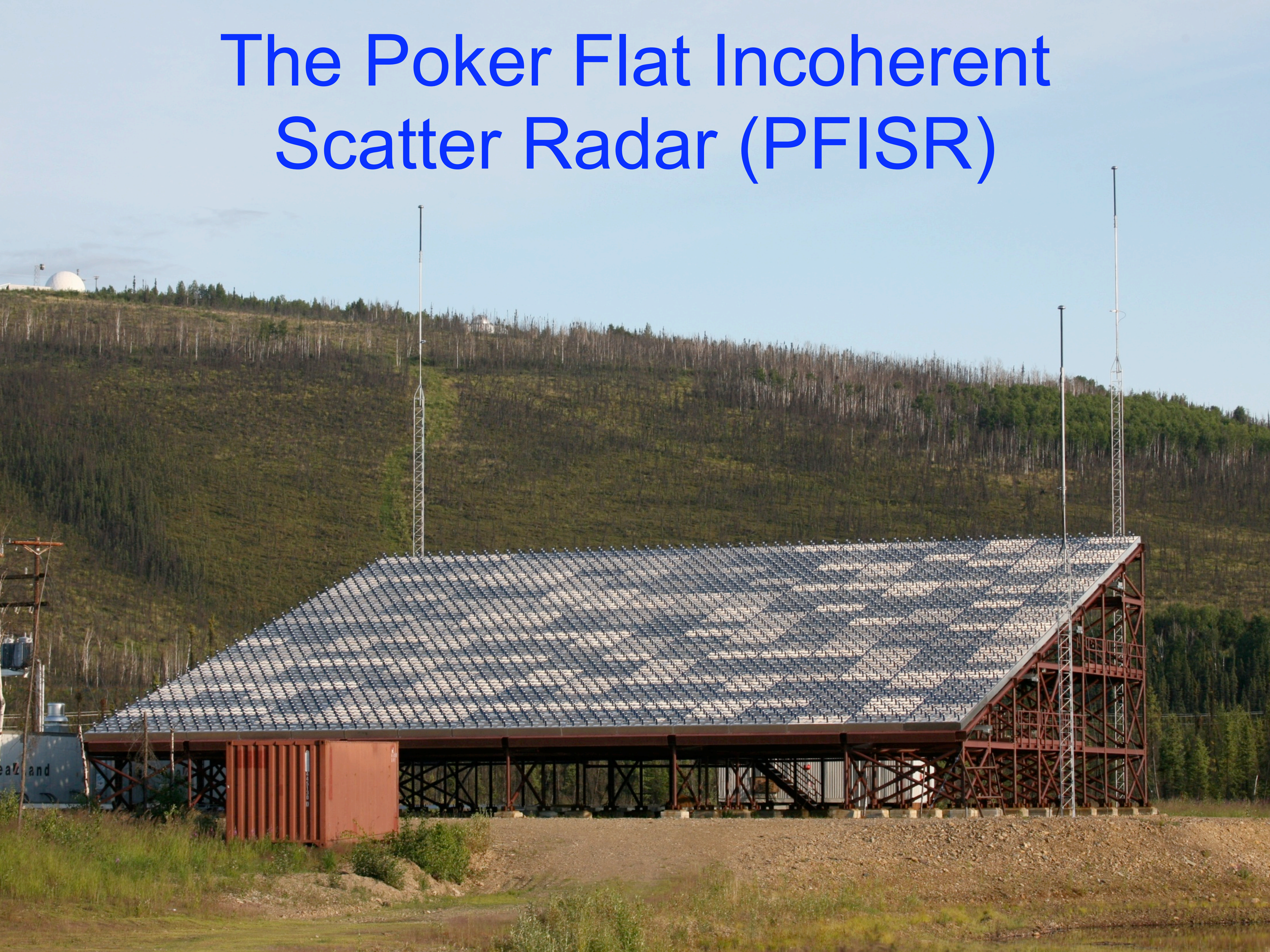


The current EISCAT radars can see in 2 dimensions
We will change the view to be 3 dimensional...

Courtesy of Y Ogawa and A Saito, Google Earth

European Incoherent Scatter Scientific Association

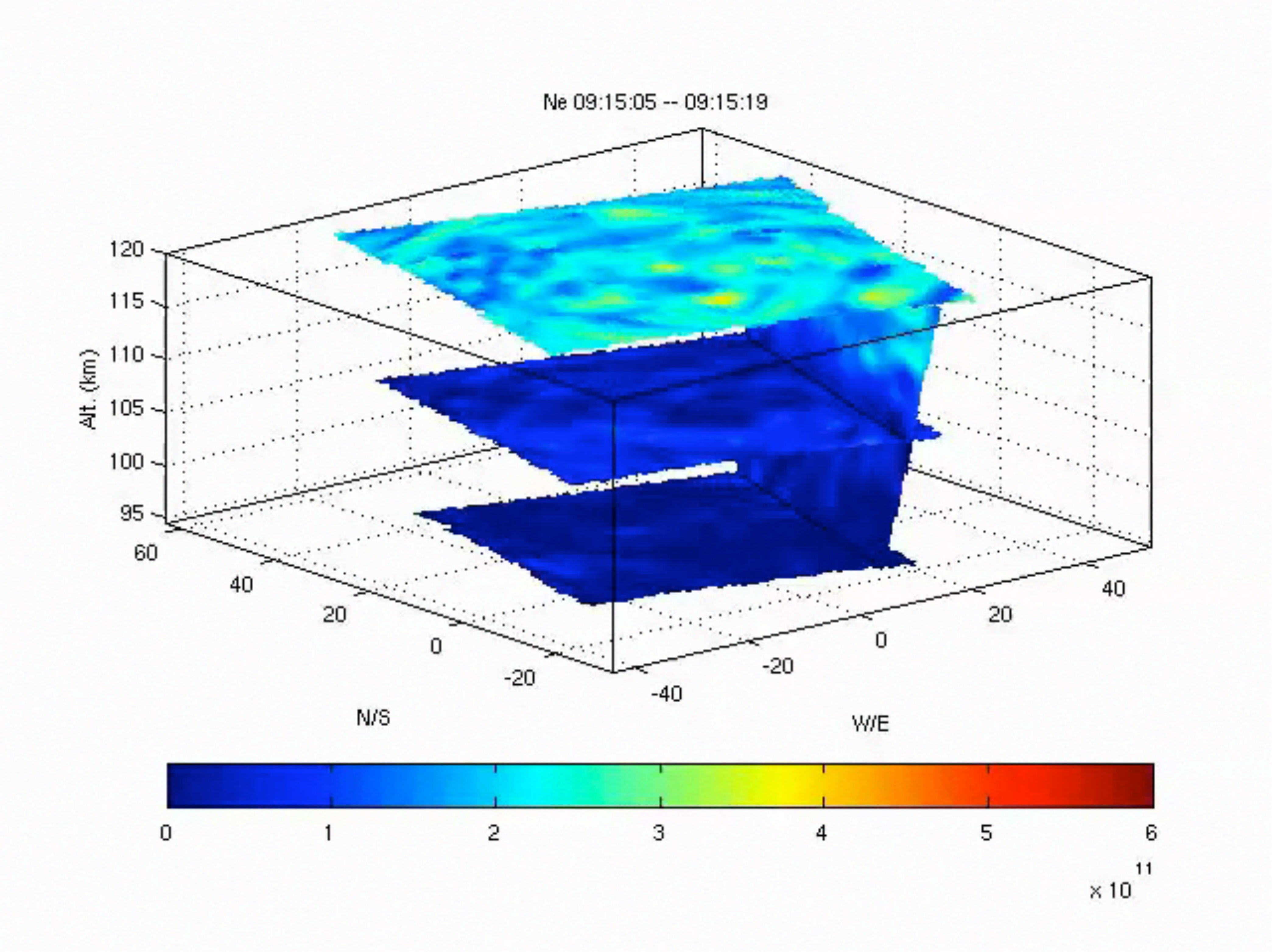



The Poker Flat Incoherent
Scatter Radar (PFISR)

The Resolute Bay Incoherent Scatter Radar (RISR)

Poker Flat Incoherent Scatter data by J. Semeter et al.

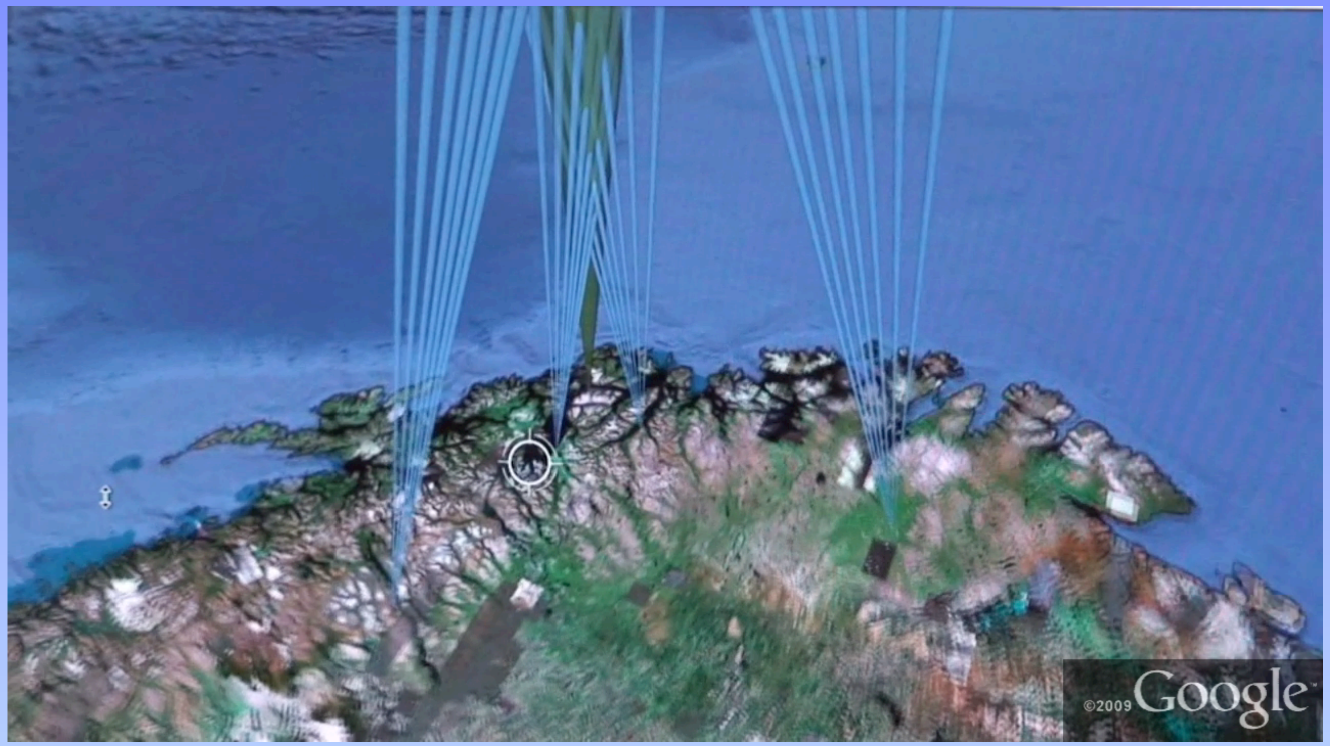
Example of a 3-dimensional radar: PFISR

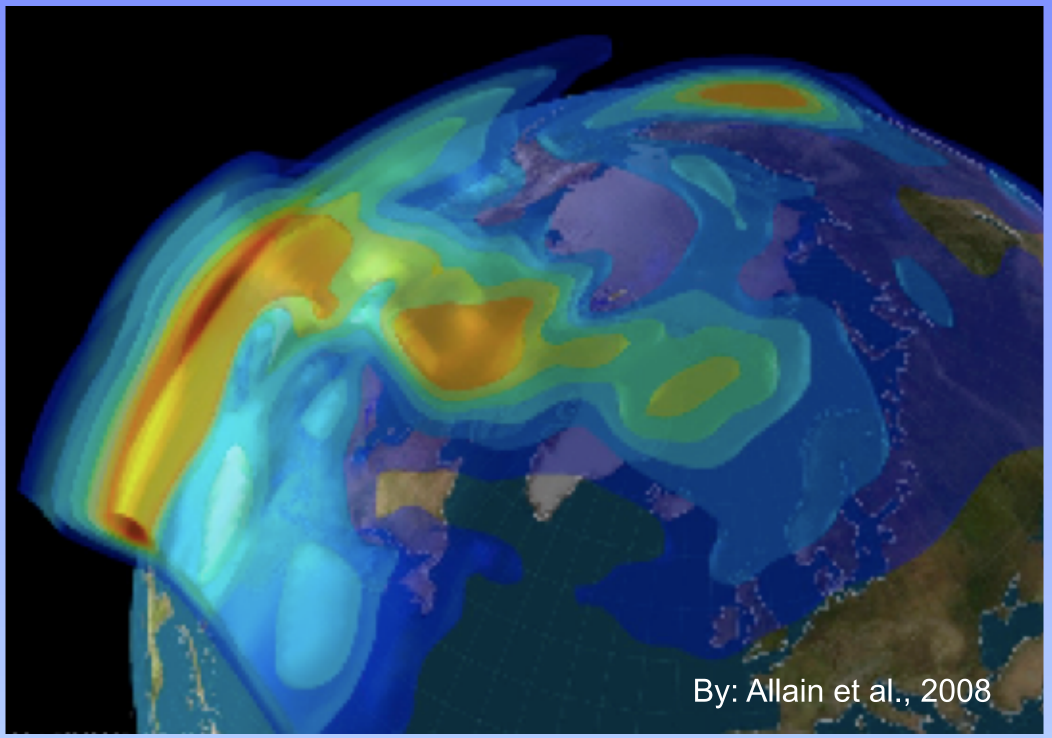


Semeter et al., JASTP., 2008

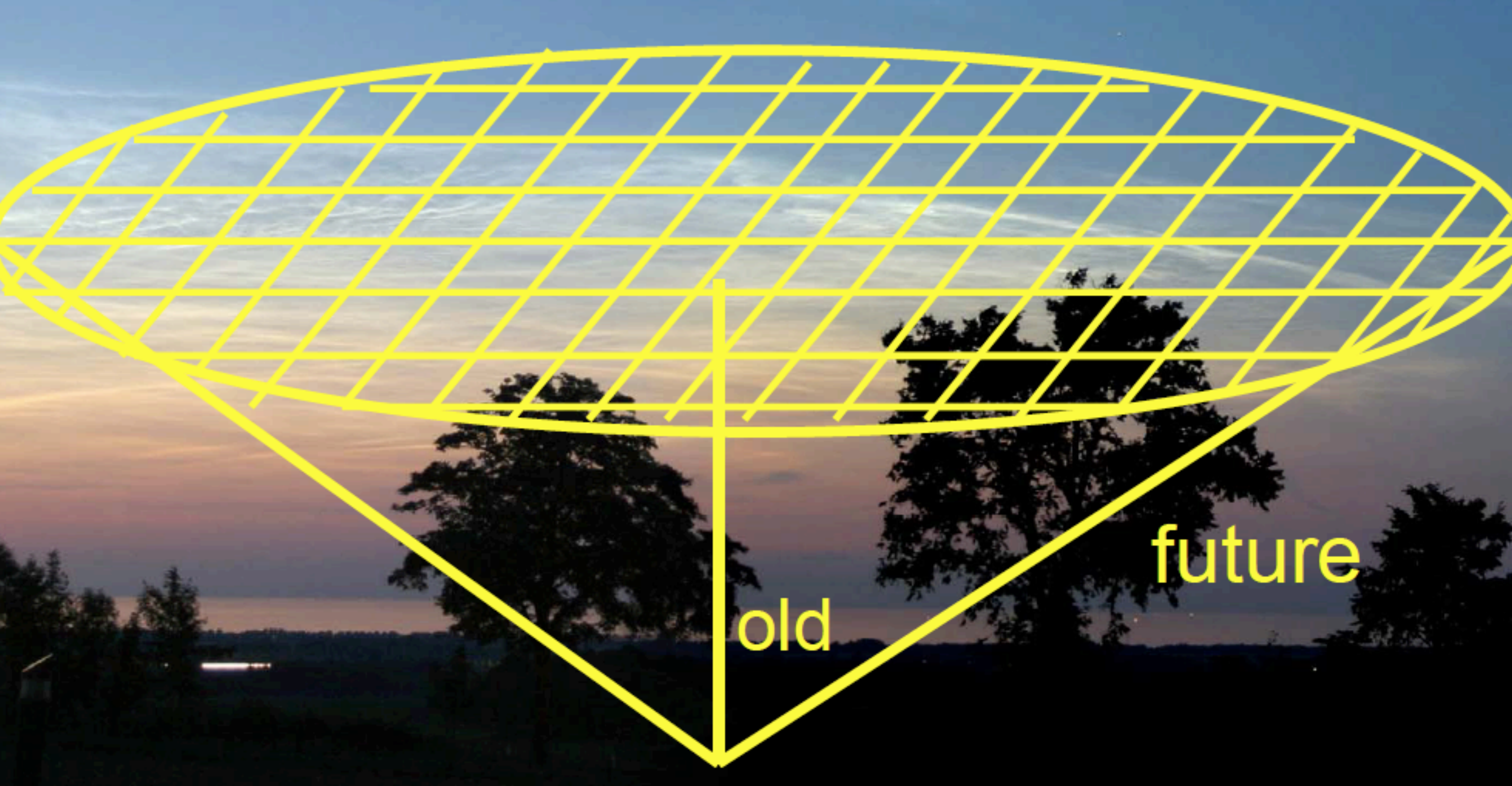
EISCAT_3D

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





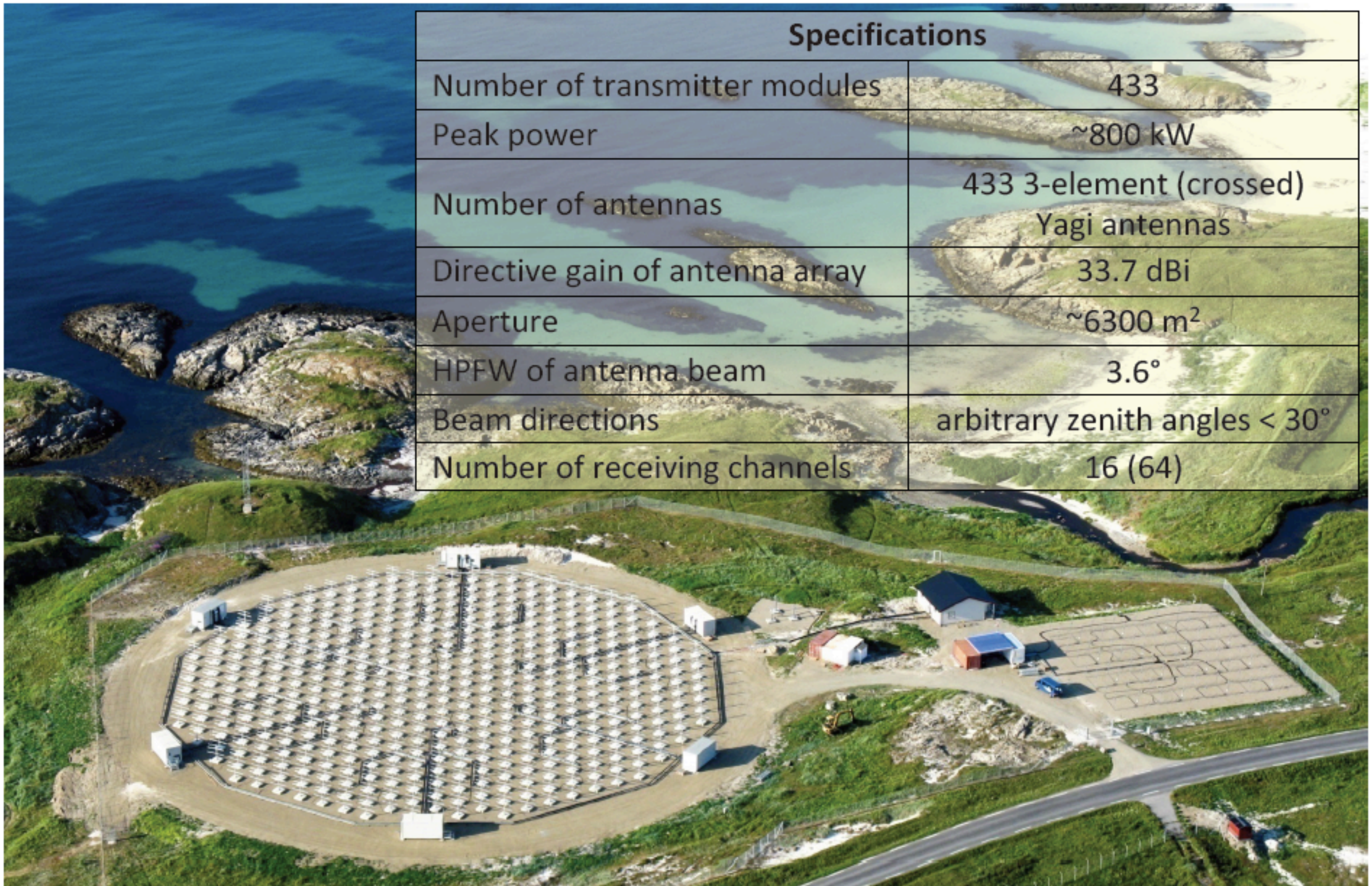
EISCAT Svalbard Radar



What is missing so far?

Wave fields have a 3d-structure!

The IAP-approach: MAARSY



Specifications	
Number of transmitter modules	433
Peak power	~800 kW
Number of antennas	433 3-element (crossed) Yagi antennas
Directive gain of antenna array	33.7 dBi
Aperture	~6300 m^2
HPFW of antenna beam	3.6°
Beam directions	arbitrary zenith angles < 30°
Number of receiving channels	16 (64)

Key Capabilities

- The most sophisticated research radar ever!

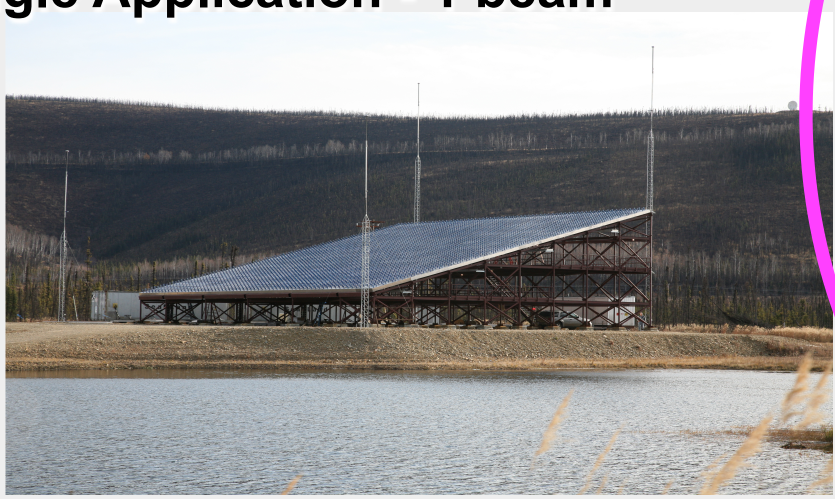
- Five key capabilities:
  - Volumetric imaging and tracking
  - Aperture Synthesis imaging
  - Multistatic configuration
  - Greatly improved sensitivity
  - Transmitter flexibility

- These abilities never before combined in a single radar

EISCAT 3D : The Next Step
Advanced Digital Geospace Radar Systems

Modern Geospace Array Radar

Narrowband Analog Array
Agile Beams from a Single Aperture
Single Application - 1 beam



Digital Aperture

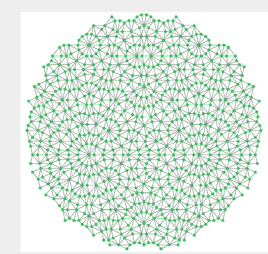
Scalable Architecture

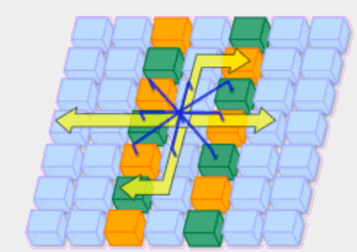
Software Radar

Geospace Supercomputing

Advanced Geospace Radar System

Broadband – Distributed
All Digital RF Elements
Adaptive beams : TX and RX
Simultaneous TX / RX - 1000 beams
Deep per element data buffers
Multiple Simultaneous Applications



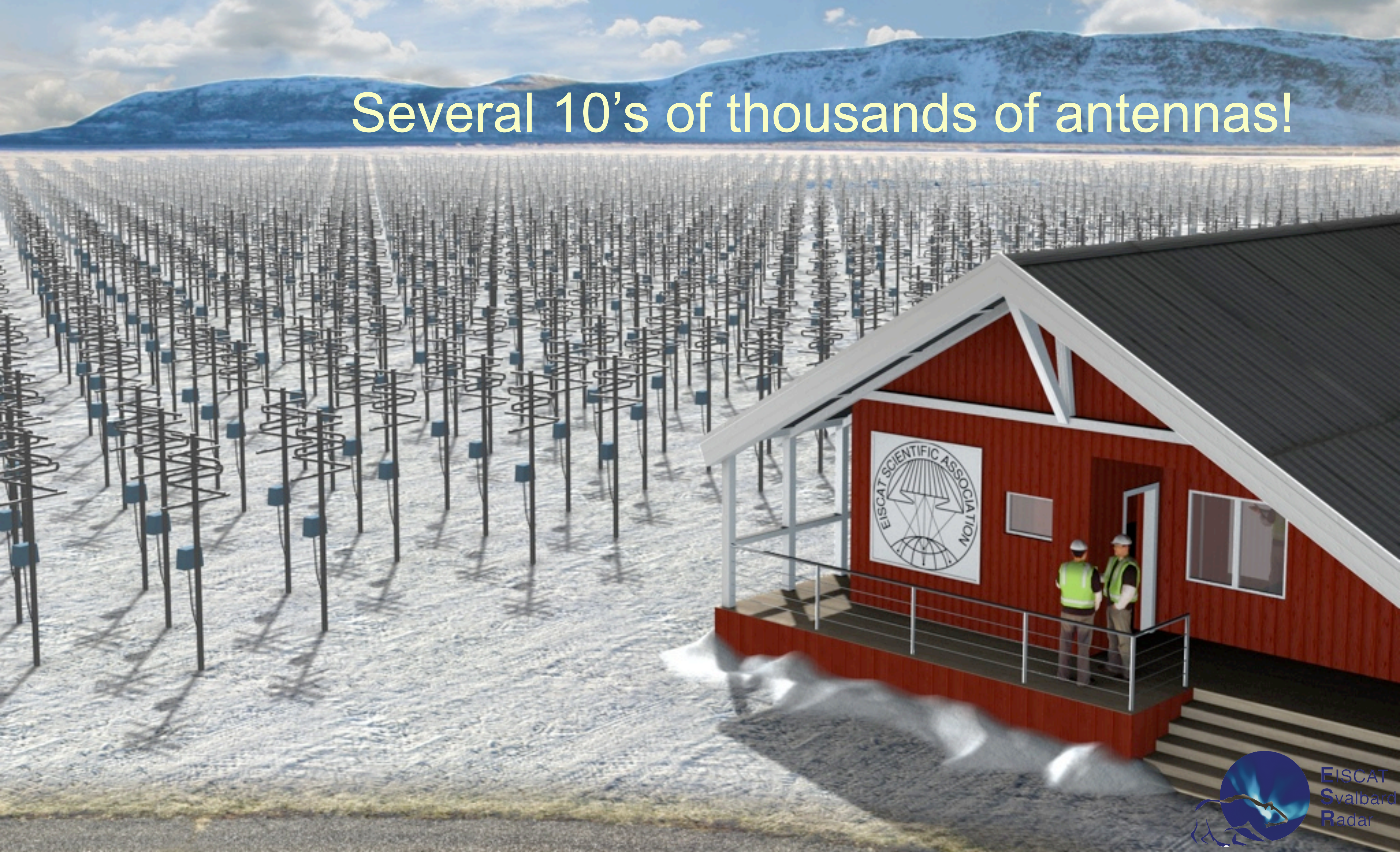


EISCAT 3D is the first of a New Class of Geospace Radars

Broadband, adaptable, all digital electromagnetic interface
Transform applications through applied computing power
Enable a wide range of applications and broader science basis

<u>Collaboration is Key to Successfully Develop This Instrument</u>

Artist's vision of EISCAT_3D

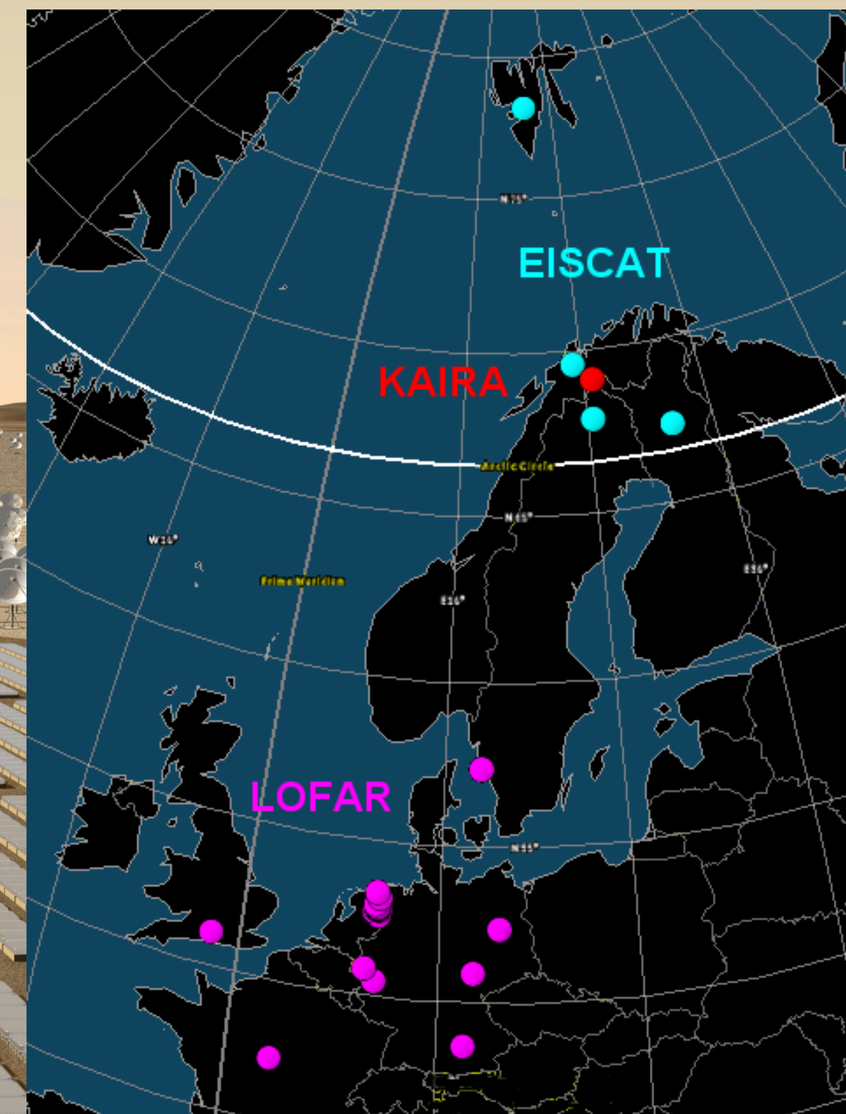


EISCAT Svalbard Radar

Artist's vision

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
  - Remote sensing : Coronal Mass Ejection magnetic field orientation



Detailed Ionospheric Measurements from Low Frequency Astronomy Arrays are Calibration Residuals

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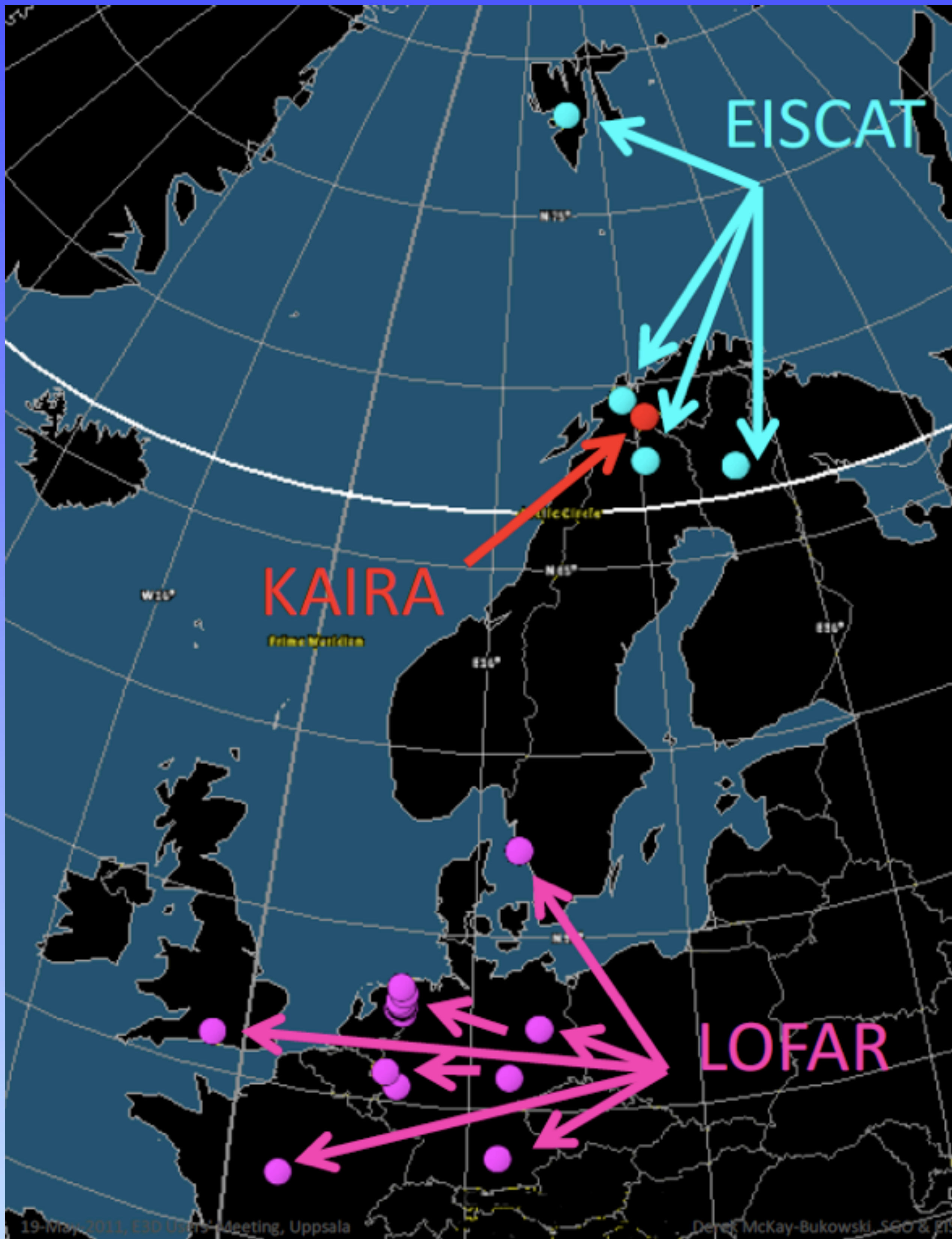
http://kaira.sgo.fi



KAIRA is a new VHF passive receiver system, which serves 3 main roles:

- Powerful expt. in its own right
- Test bed for EISCAT_3D
- Valuable extension of the LOFAR array

EISCAT Svalbard Radar

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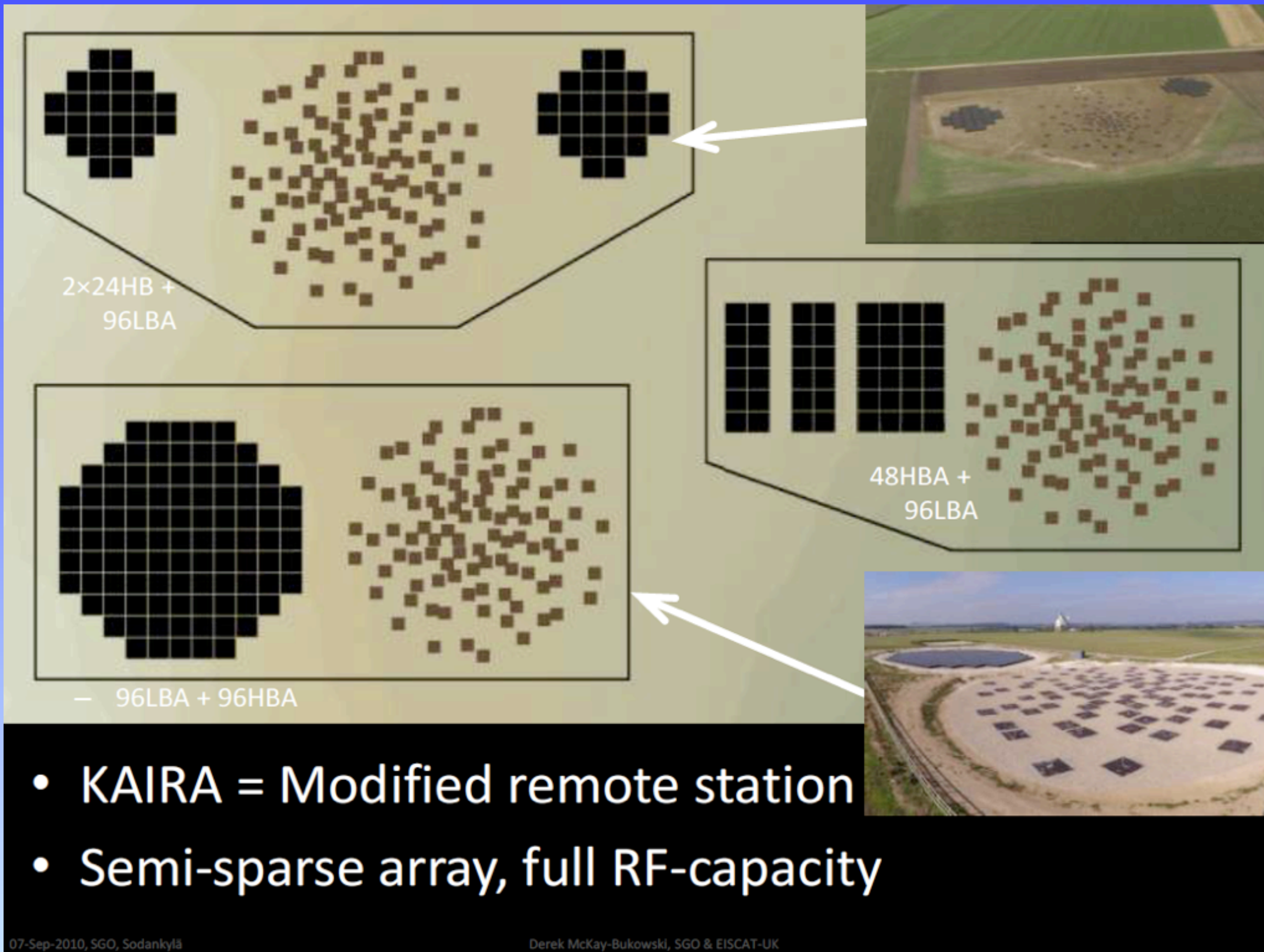
LOFAR antenna setups



EISCAT
Svalbard
Radar

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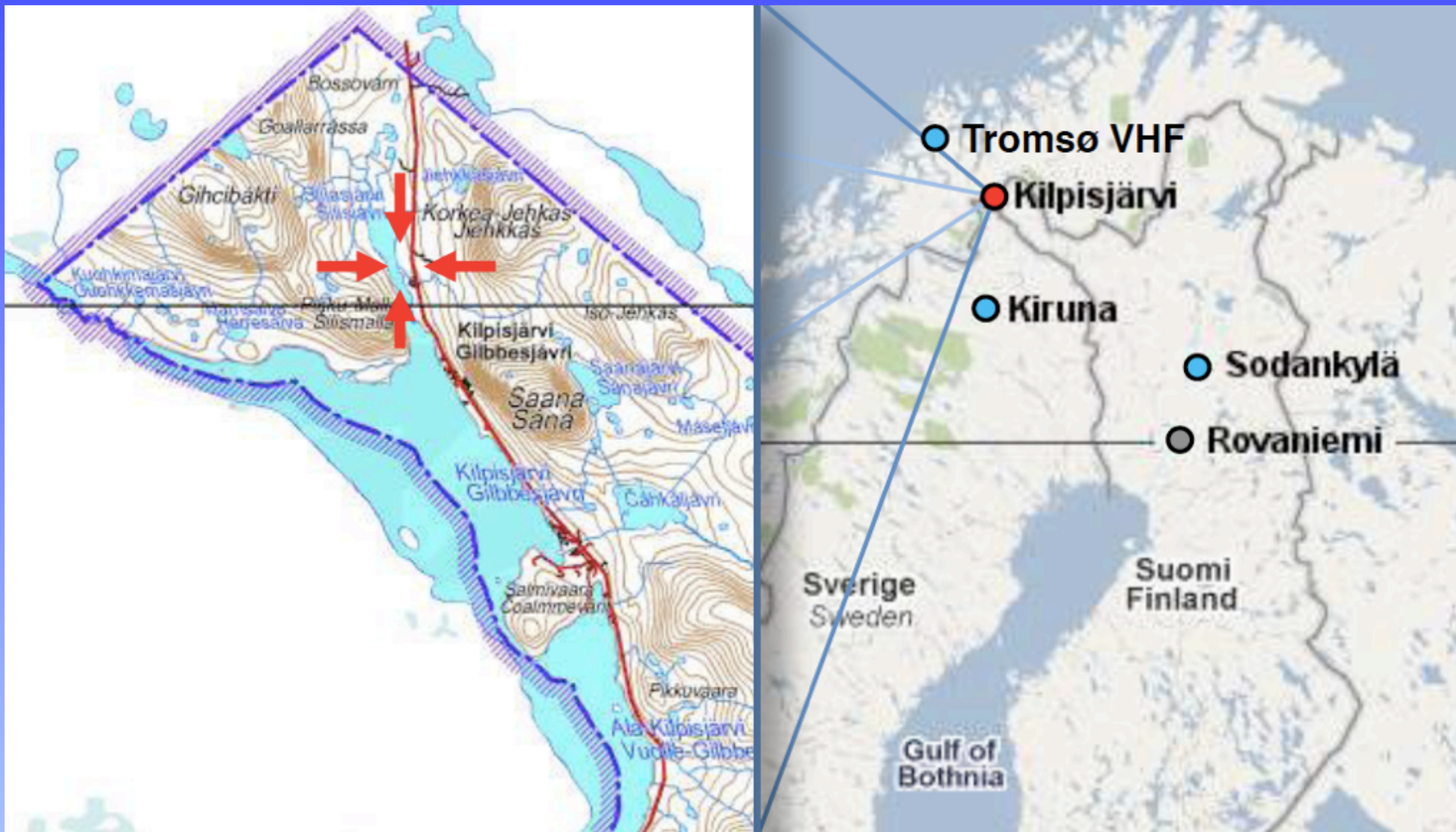
KAIRA location



- Located at Kilpisjärvi (not far from the Riometer)
  - Closest Finnish point to the Tromsø VHF transmitter

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Svalbard
Radar

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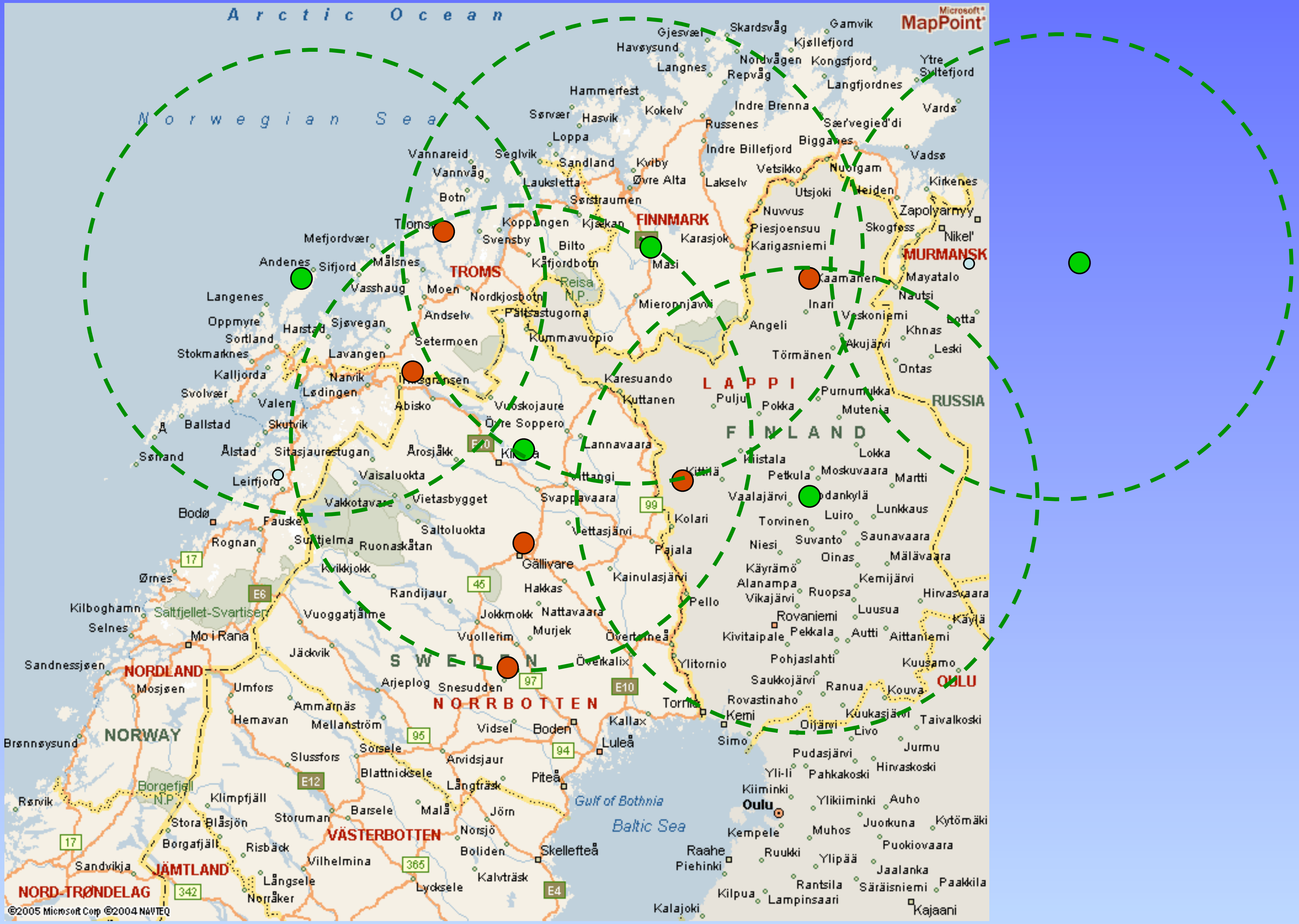
Svalbard
Radar

Modular construction:

- We can think a bit bigger here...

Many active and passive sites!



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Site selections (month 12)

- University of Oulu preparing evaluation tools for geometry

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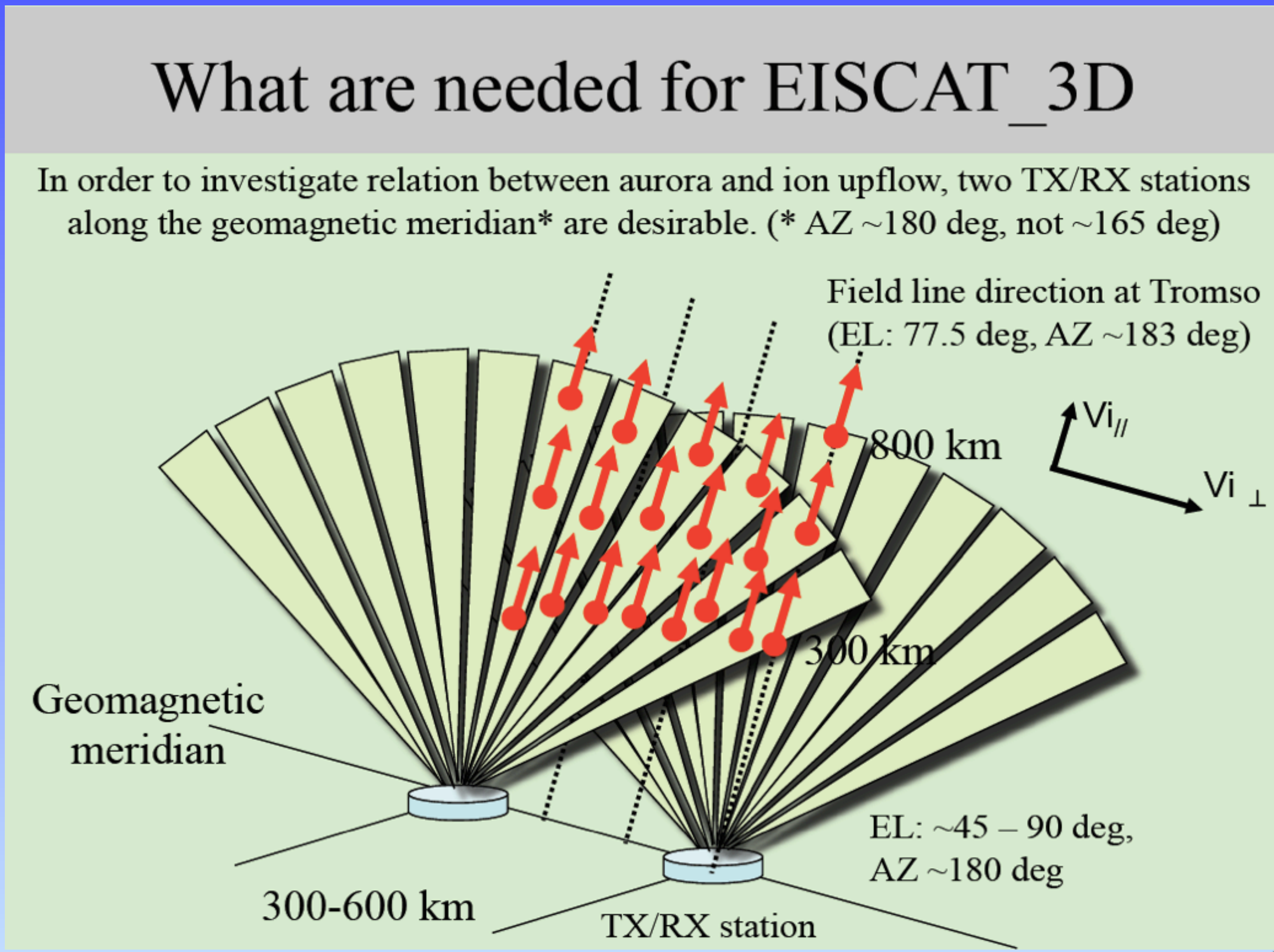
Sites are still open and discussed

e.g.: proposal by Y. Oqawa:



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Atmospheric Energy Budget

- Coupling processes
  - Particle input
  - Chemical coupling
  - Dynamical coupling
  - Ion-neutral coupling
  - Electrodynamics
  - Potential drops, acceleration
- Short-term variability
- Long-term change
  - Anthropogenic effects

Space Plasmas (1)

- Dusty plasmas
  - PMSE
  - Aerosols
- Turbulence
  - Neutral turbulence
  - Plasma turbulence
- Small-scale processes
  - Auroral fine structure
  - NEIALs
  - Thin layers
  - Small-scale dynamics

Space Plasmas (2)

- Large-scale processes
  - Auroral forms
  - Magnetospheric dynamics
  - (Convection, storms, substorms)
  - Reconnection
  - Ion outflow

Space Environment (2)

- Service applications
  - Navigation
  - Satellite tracking
  - Polar Flights

New Techniques (1)

- New experimental philosophies
  - Troposphere/Stratosphere measurements
  - Continuous measurements up to MLT
  - New Coding Strategies
  - Higher Time Resolution
  - Orbital Angular Momentum?
- Active experiments
  - Ionospheric Modulation
  - PMSE modulation
  - Electrojet Modulation
  - Ionospheric Alfven Resonator

Space Environment (1)

- Space Weather
- Space debris
- Meteors
  - Orbits
  - Meteoric input
- Planetary Radars
  - Near-Earth Objects
- Solar Wind measurements (and coronal radar)

New Techniques (2)

- Interferometry and imaging
  - ISR interferometry
  - Tristatic interferometry (meteors)
  - HF interferometry (stimulated emissions)
- Data processing
  - Removal of meteors and space debris
- Assimilation and modelling

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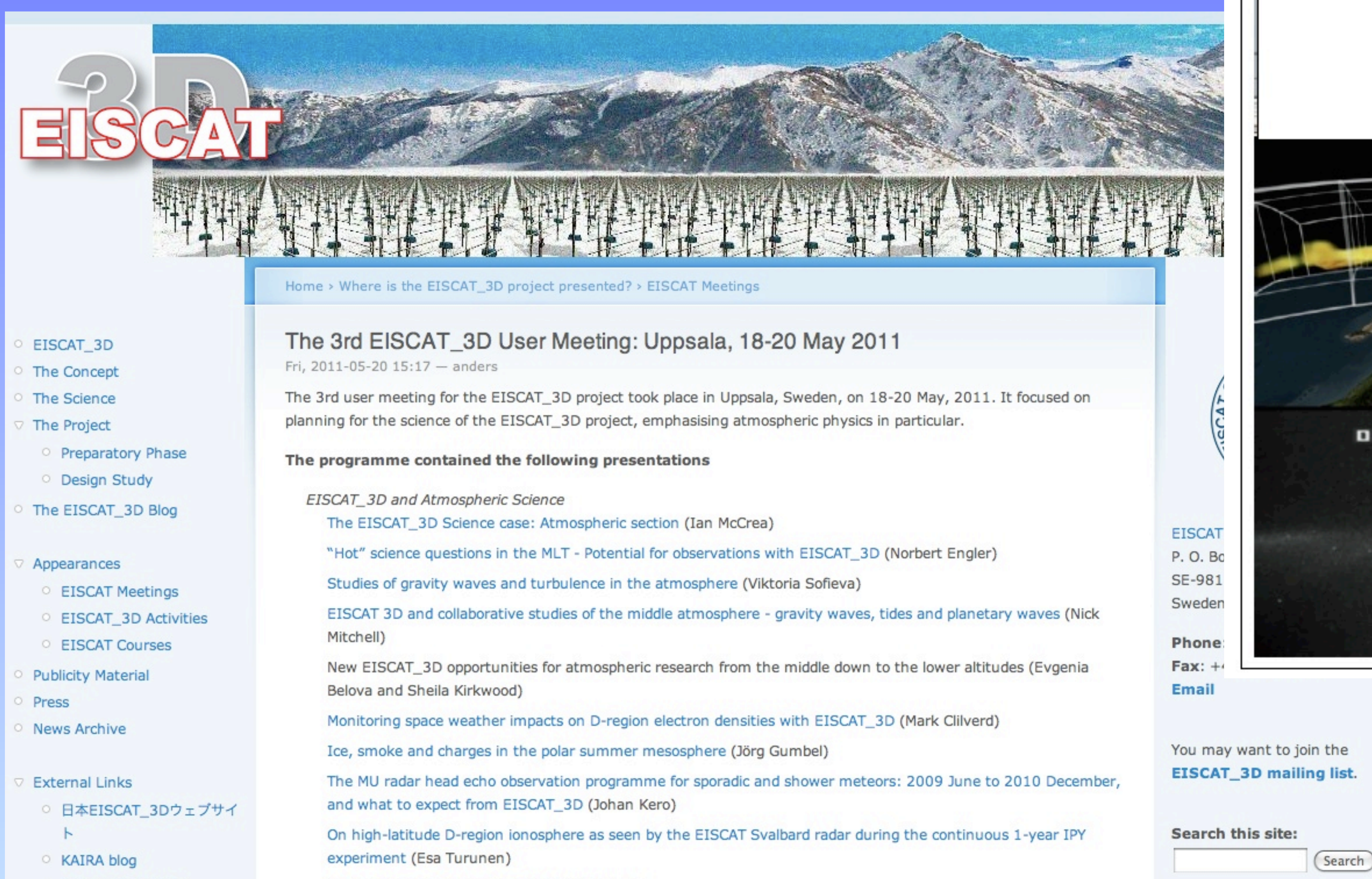
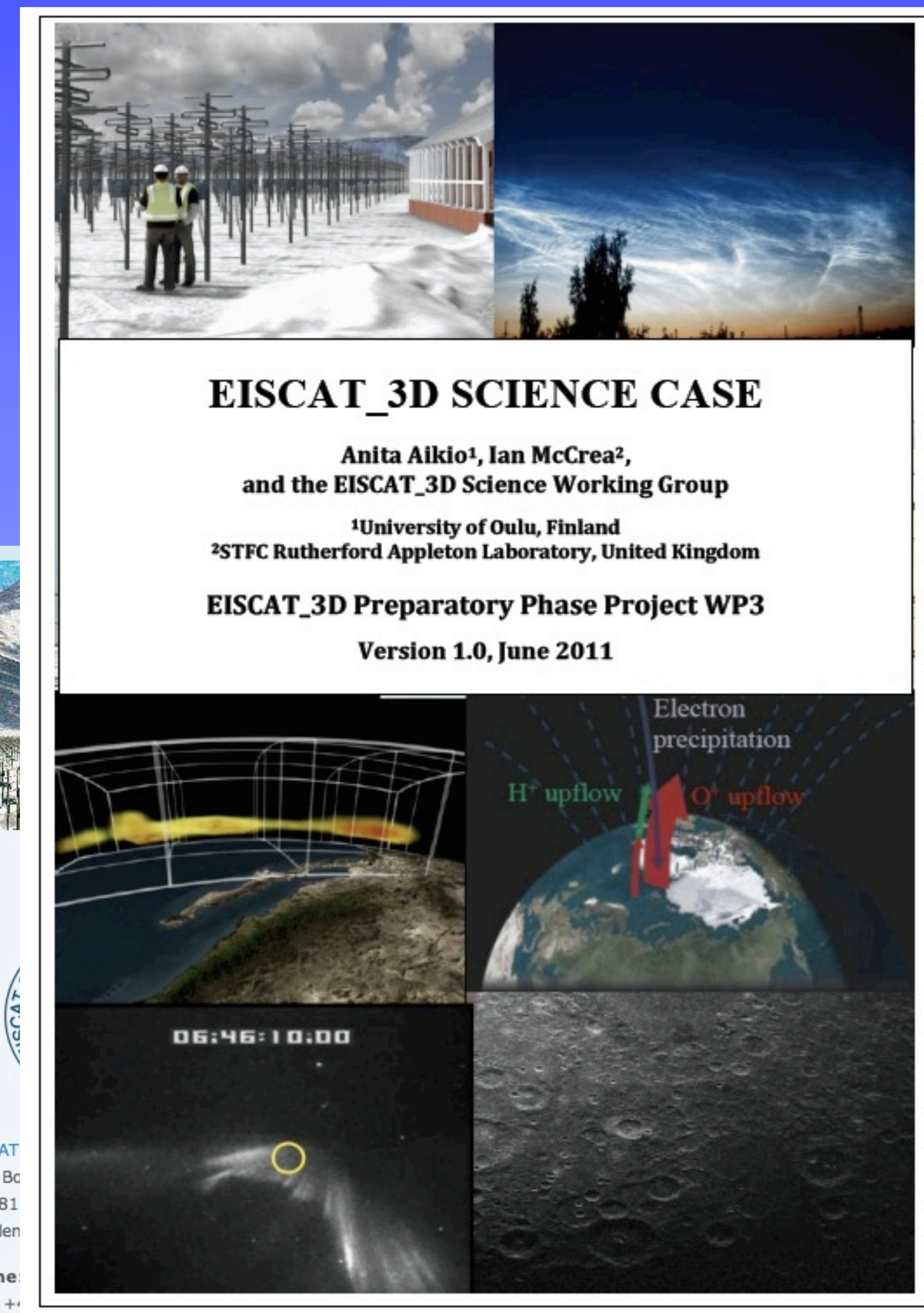
Science Case

- Document on www.eiscat3d.se
- See also talks in EISCAT_3D User Meetings





EISCAT Svalbard Radar

The Science Case Document:

A. Atmospheric physics and global change

B. Space and plasma physics

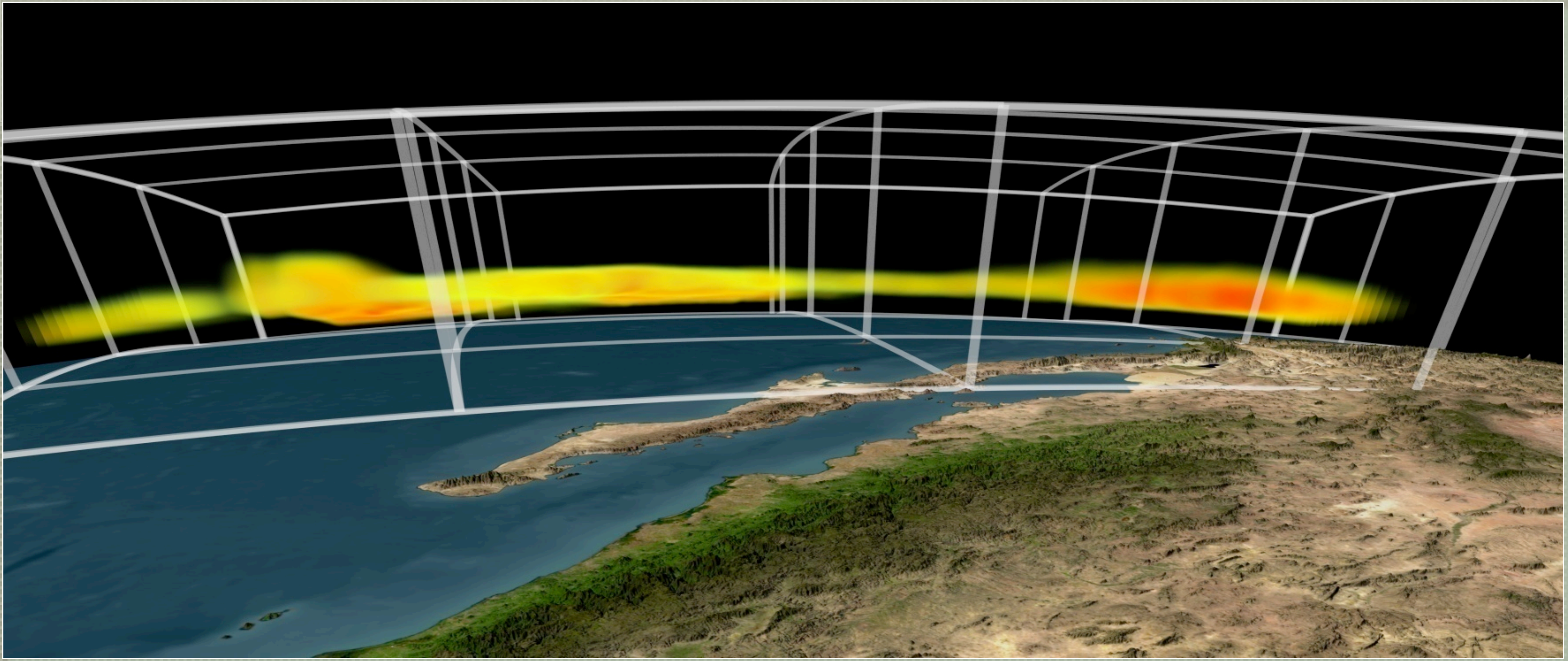
C. Solar system science

D. Space weather and service applications

E. Radar techniques, coding and analysis

Appendix A: Table of EISCAT_3D radar performance requirements by science topics

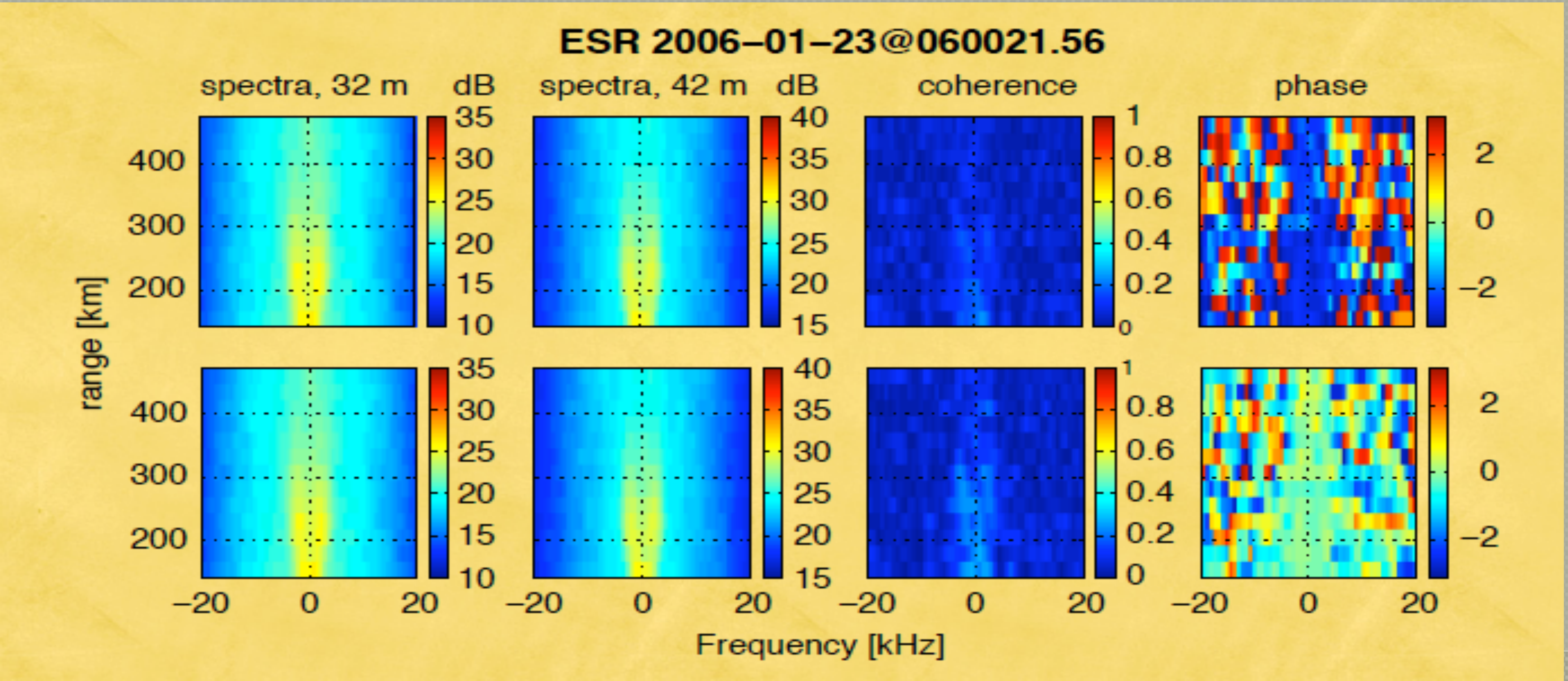
Volumetric Imaging



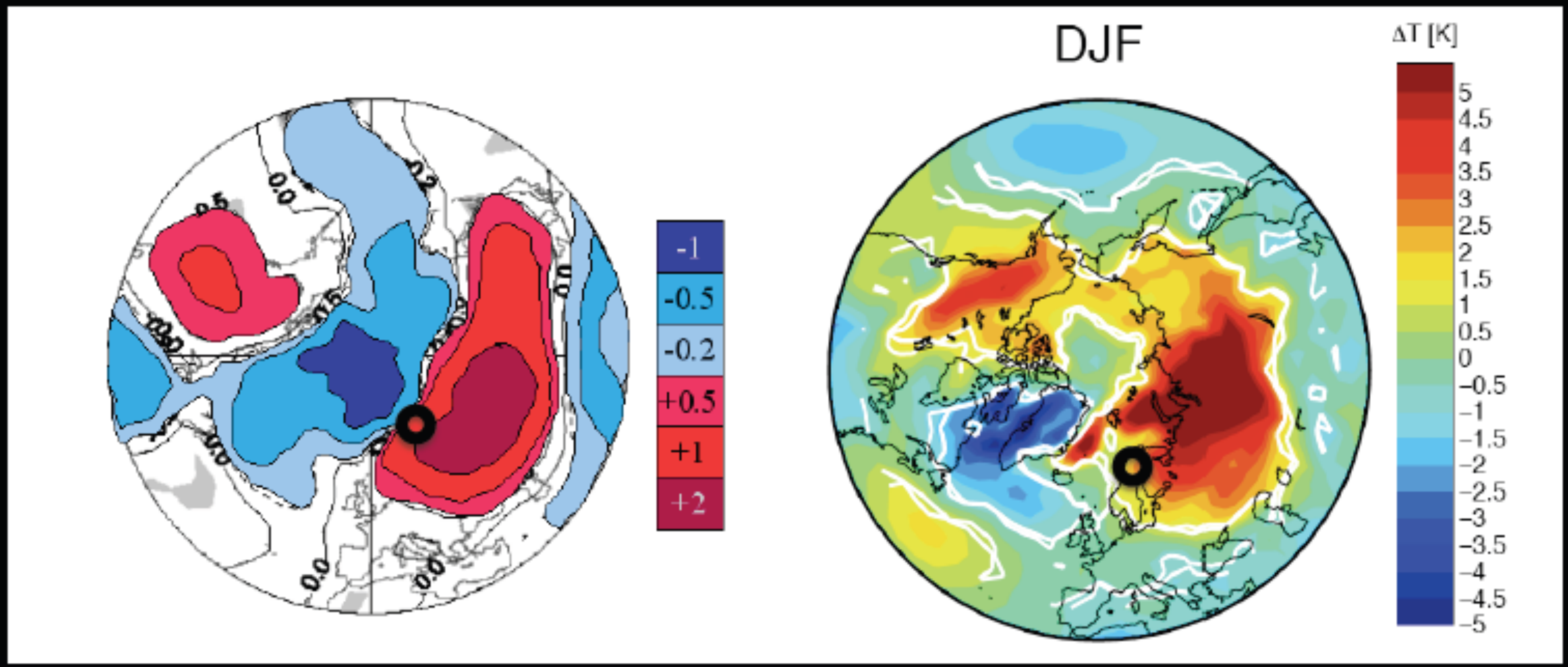
Aperture Synthesis Imaging

Imaging concept already developed by UiT on the ESR system

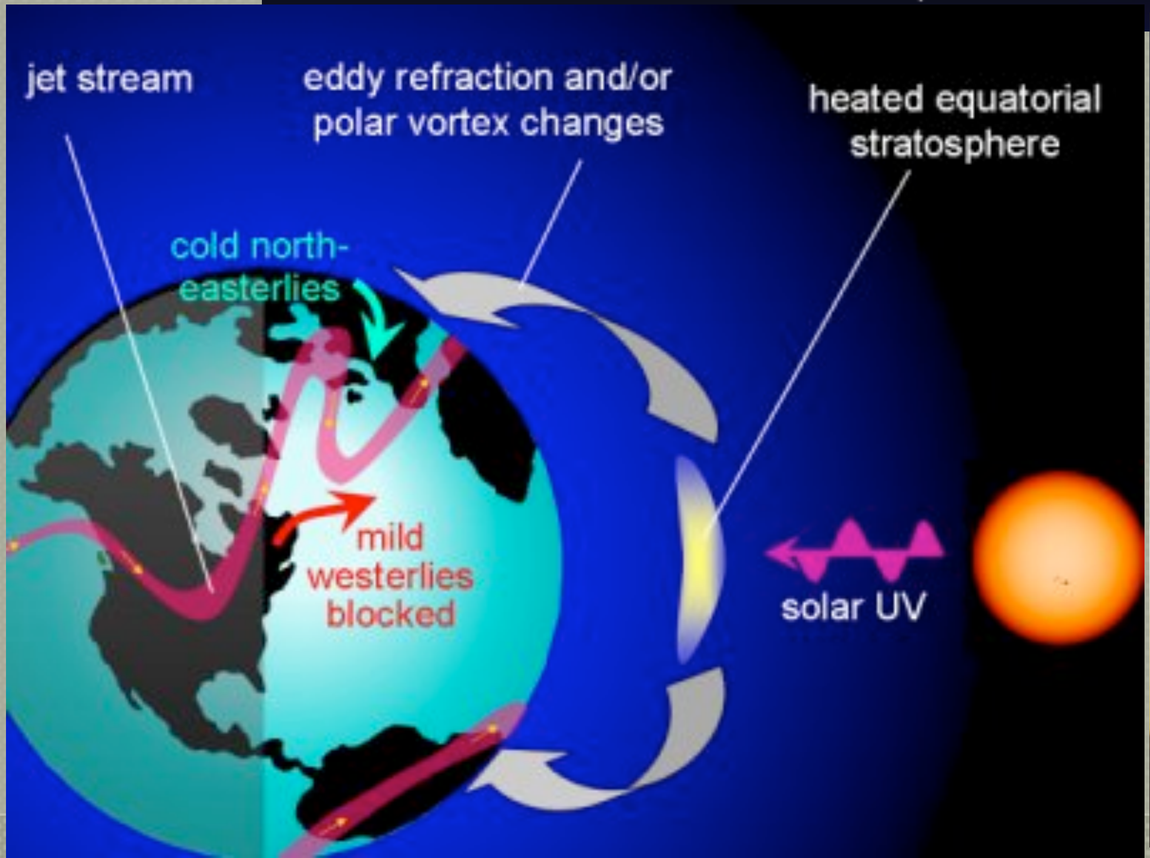
Extended to a modular array for EISCAT_3D type array and demonstrated at Jicamarca



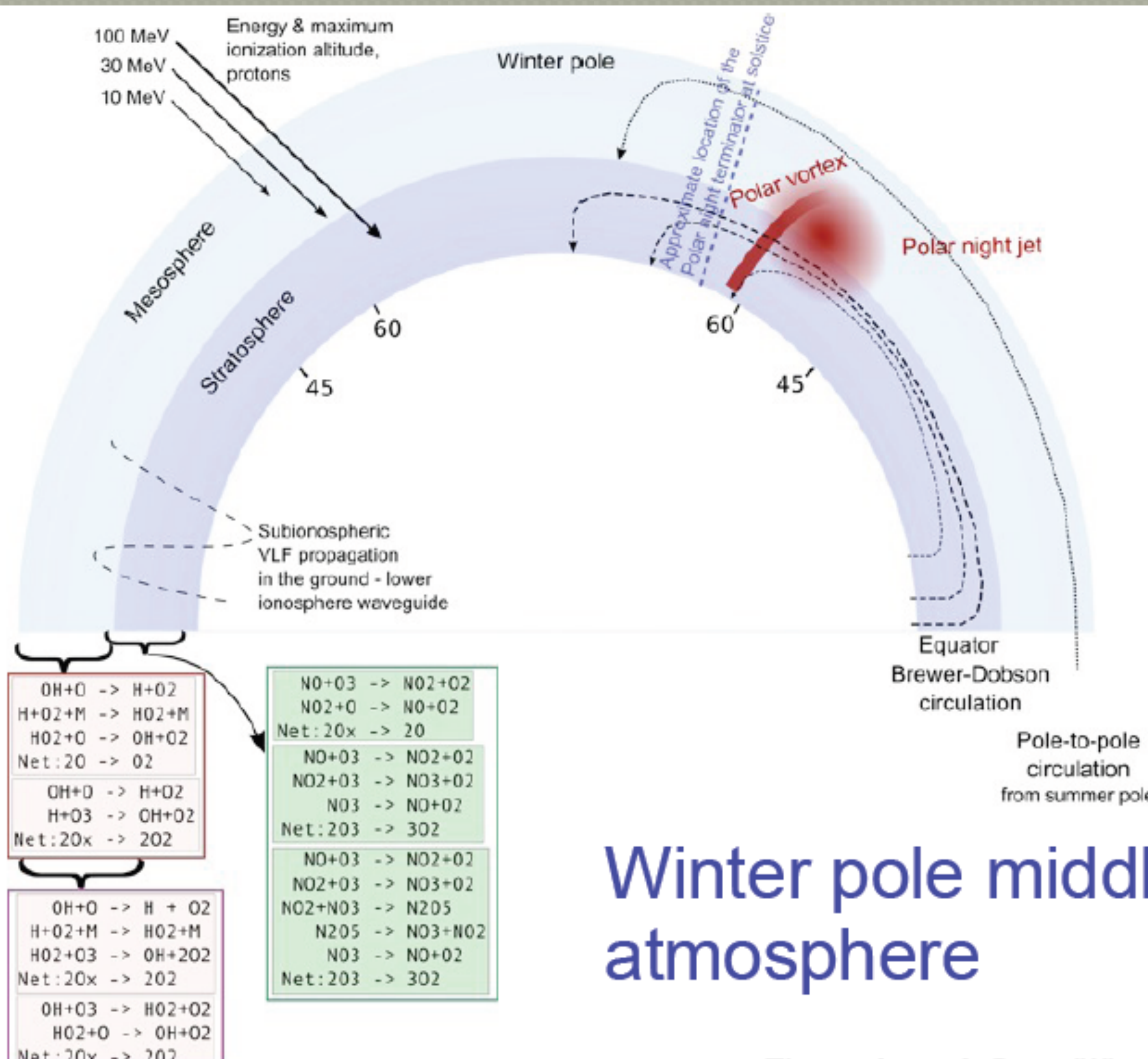
Upper atmosphere links to climate?



Rozanov et al., 2005 Seppälä et al., 2010

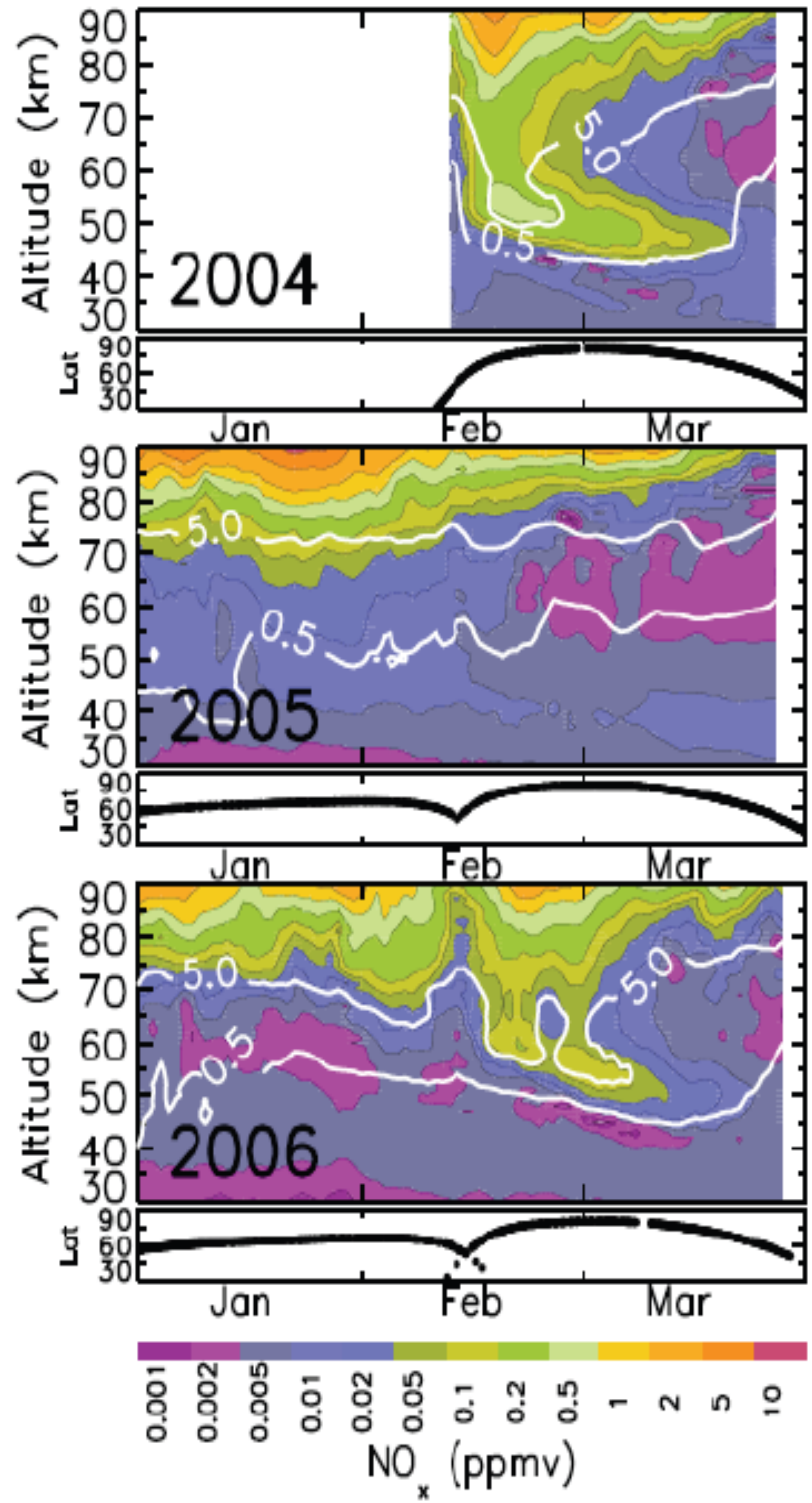


Atmospheric Coupling: The Polar Vortex

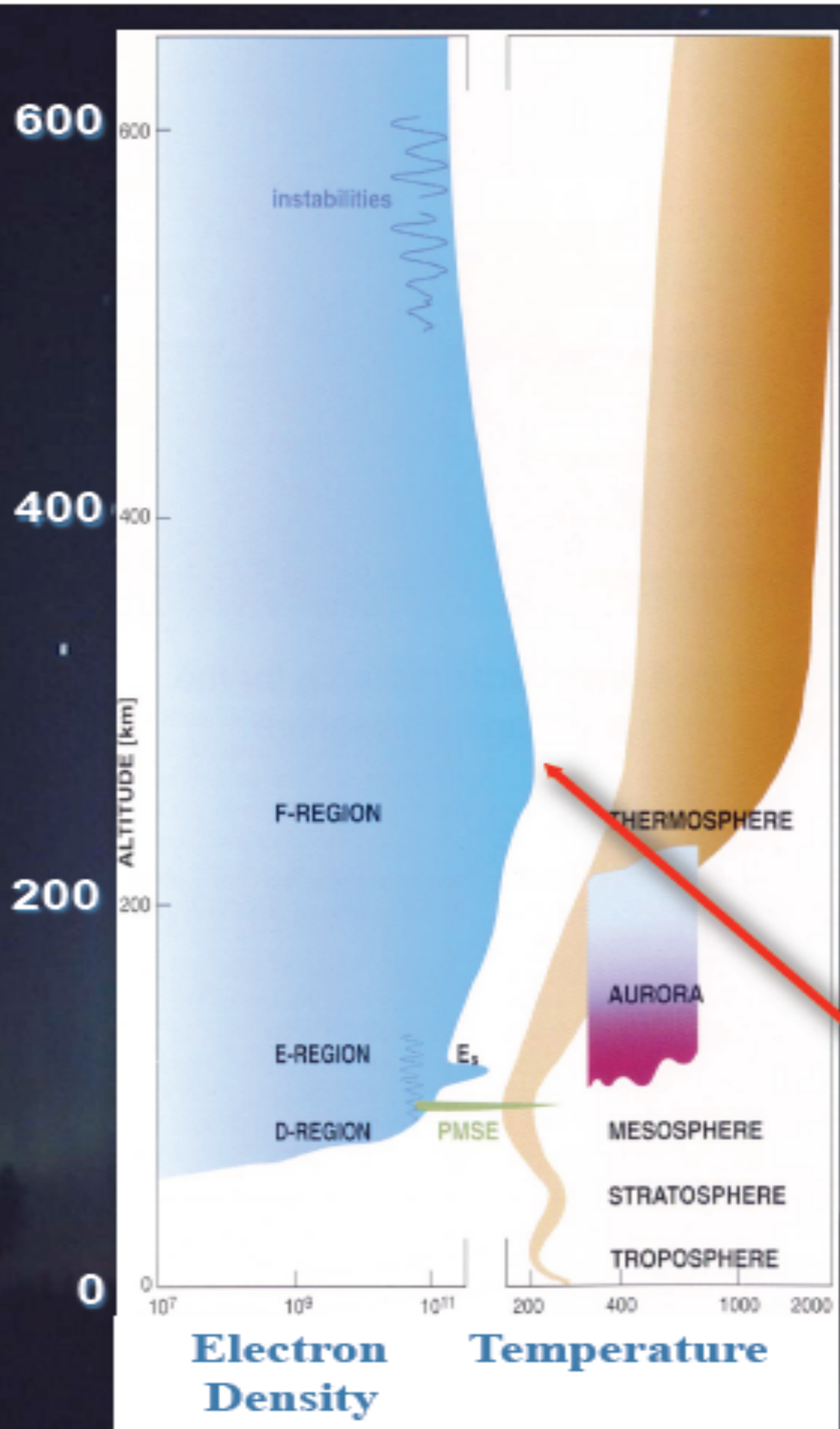


Winter pole middle atmosphere

Figure from A.Seppälä , 2007



Long-Term Trends in the Upper Atmosphere



Greenhouse Cooling

Doubling of [CO_2] and [CH_4]

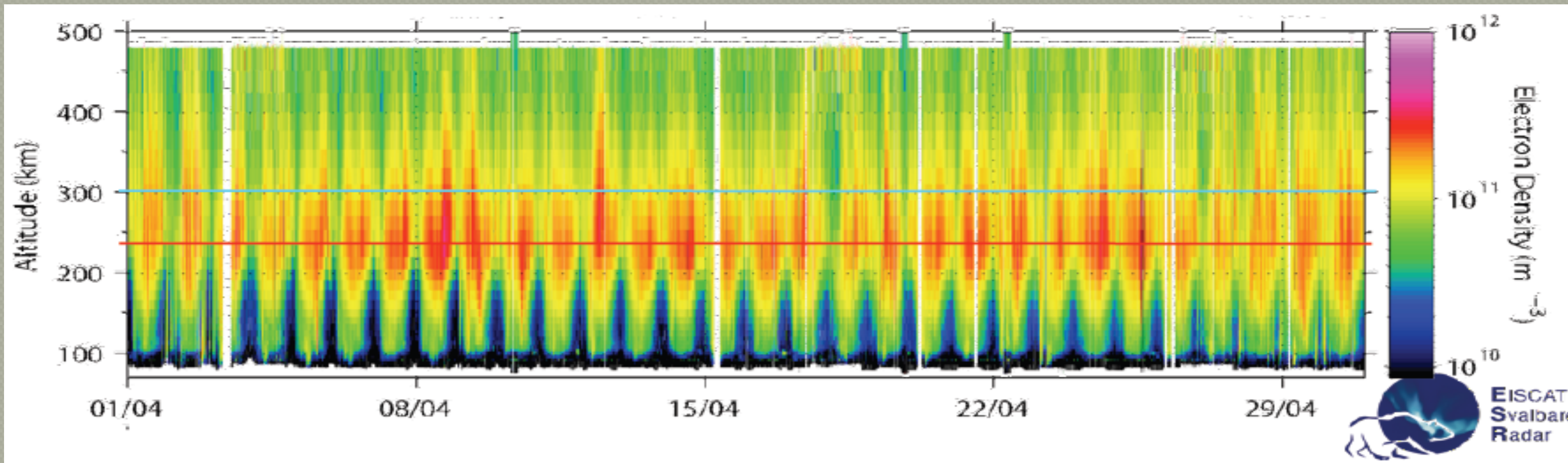
cools

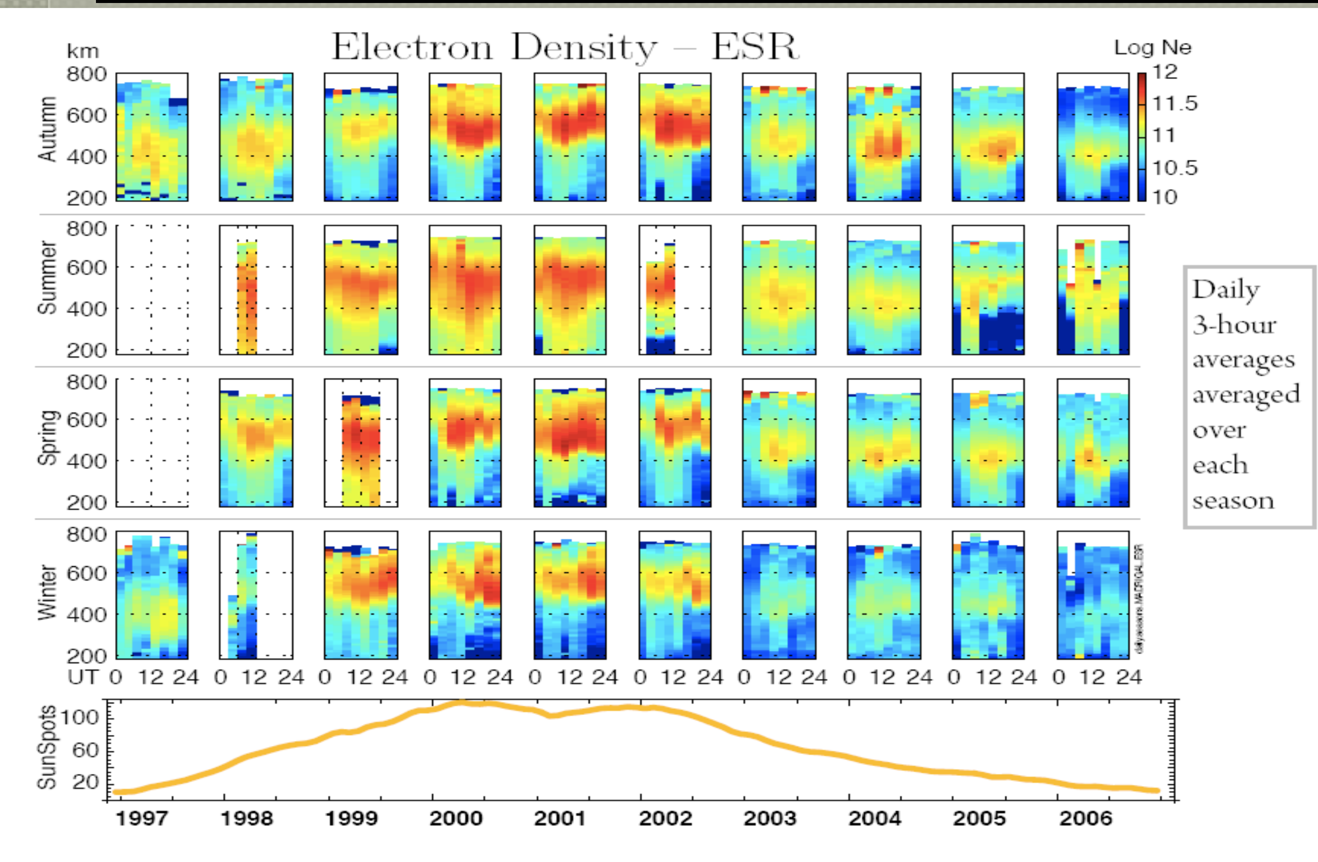
Mesosphere by **10 K** and Thermosphere by **50 K**.

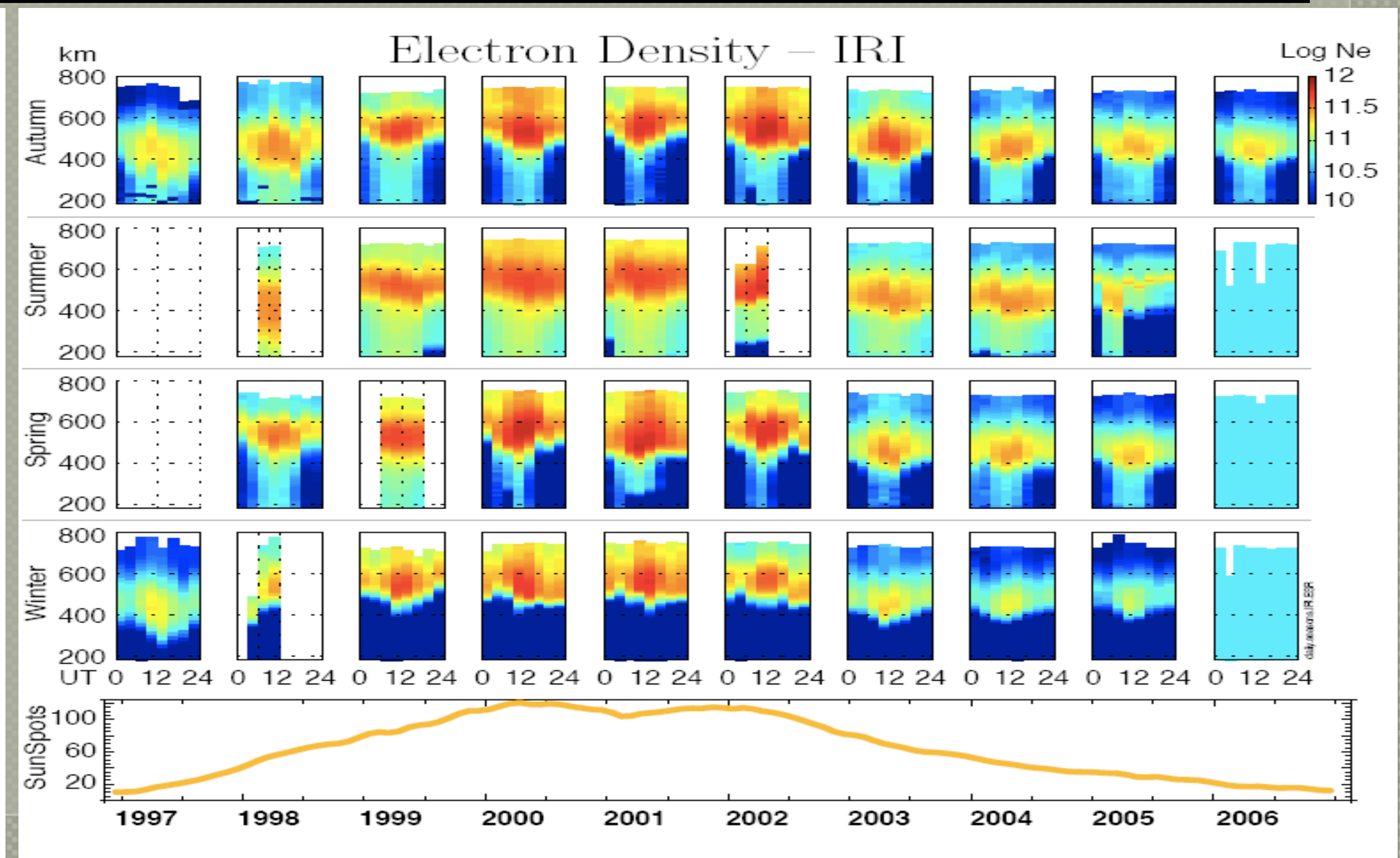
Atmosphere shrinks.

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

Continuous, long-period data

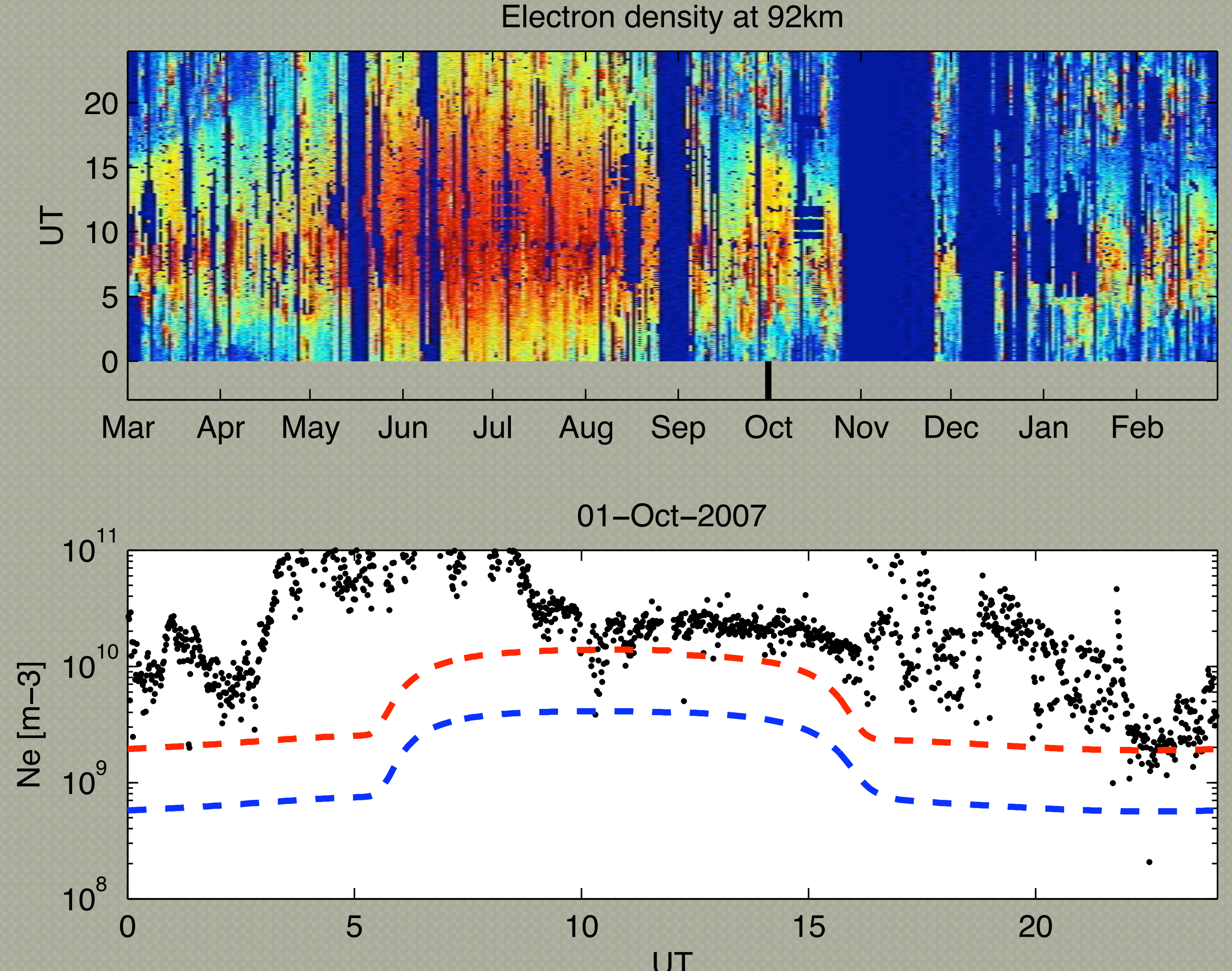






International Polar Year at ESR

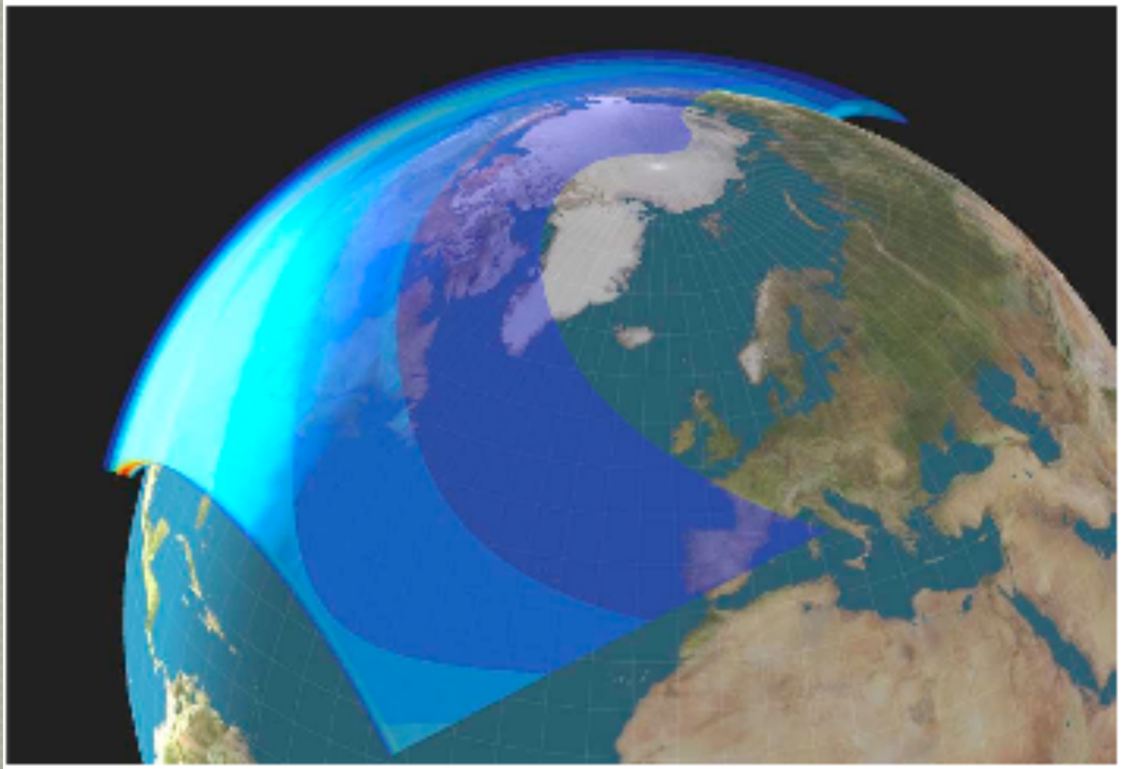
- D-layer data shows enhanced NO in autumn (ionised by Solar Lyman-alpha)
- Model calculation with 10 x [NO] (red) corresponds better the time variation of Ne at sunset, than standard [NO] (blue).

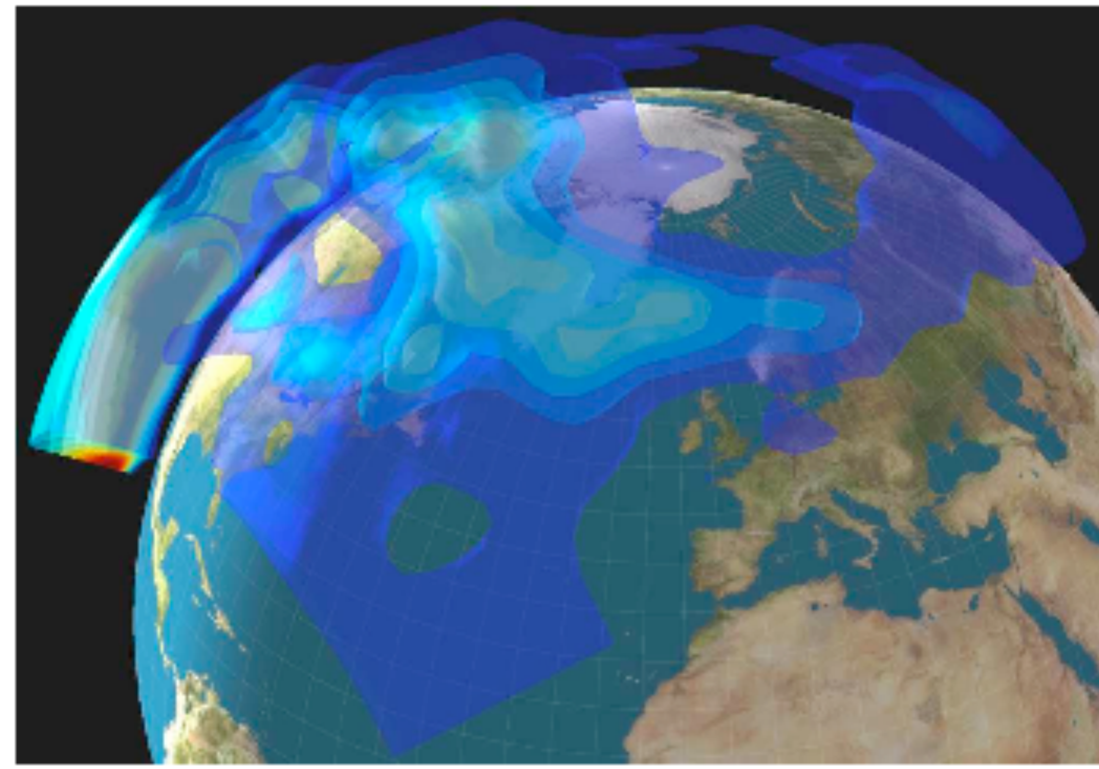


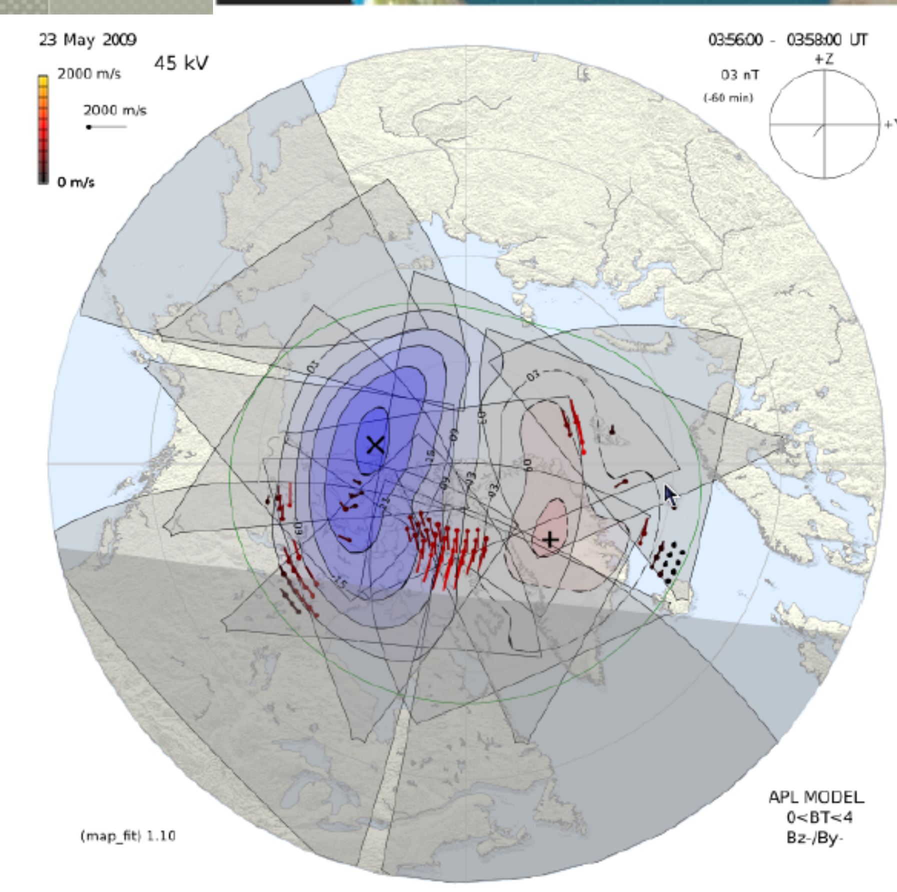
Electron density at 92 km follows sunset in the autumn, but model fits the baseline of Ne (due to ionisation by Lyman-alpha) only with enhanced NO, caused by precipitation earlier. Sudden variations in Ne data are due to electron precipitation events.

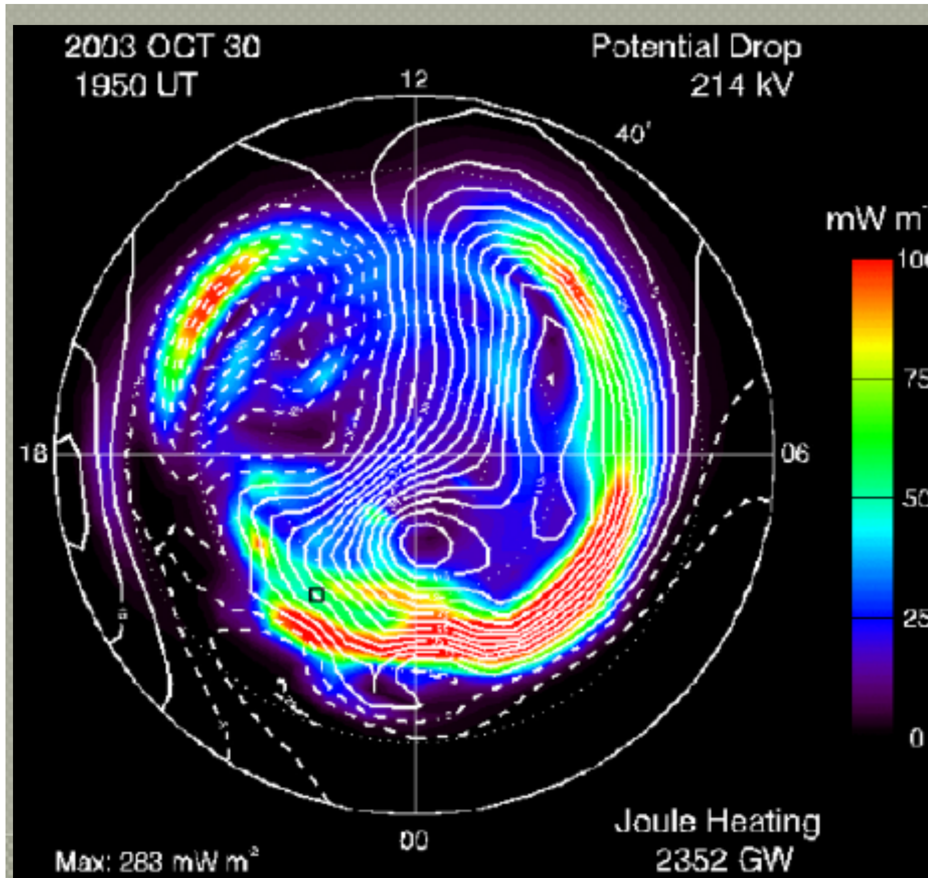
[see talk by A.Kero et al., EGU 2011, Vienna, Austria]

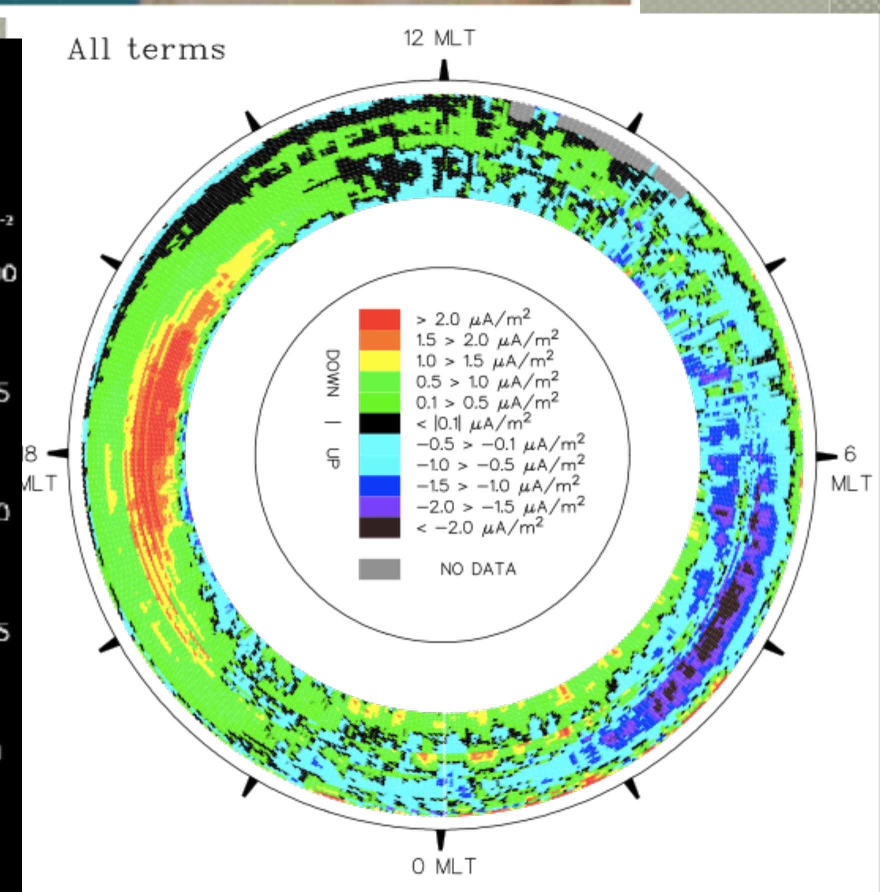
Large-scale monitoring



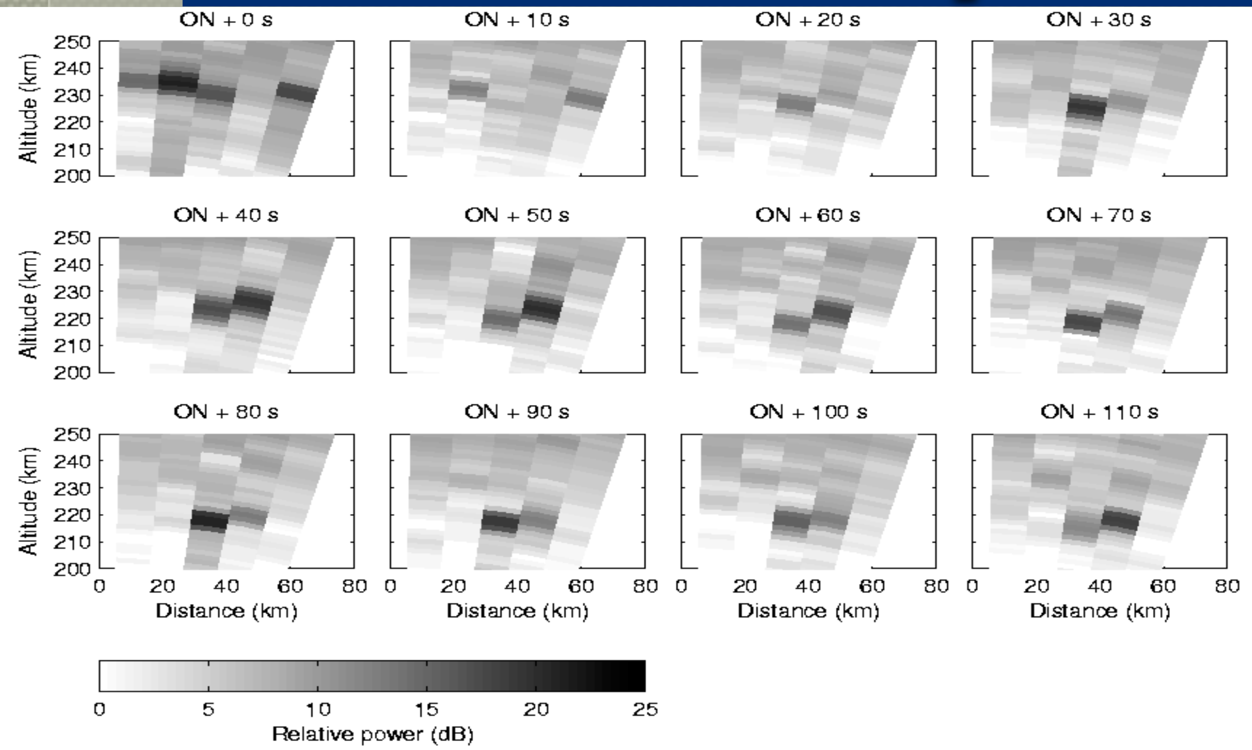


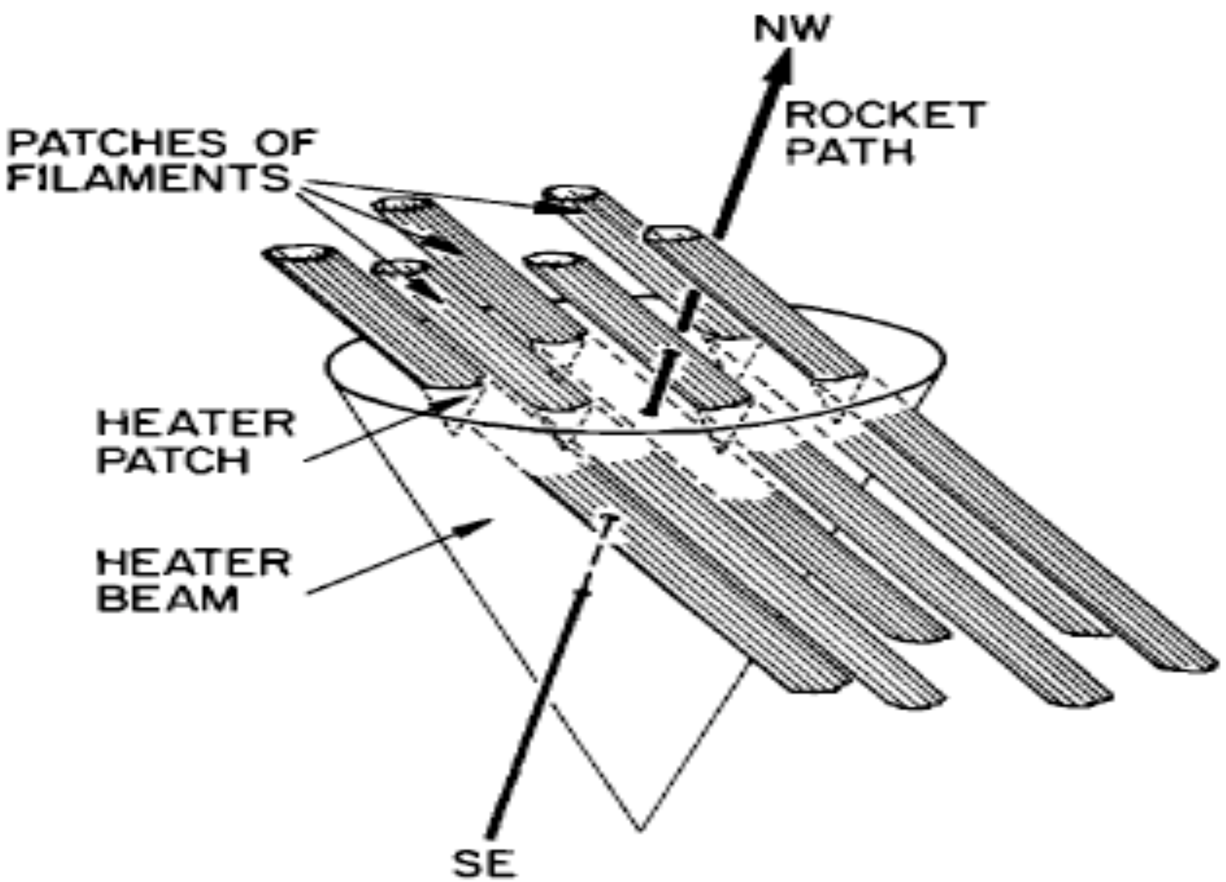


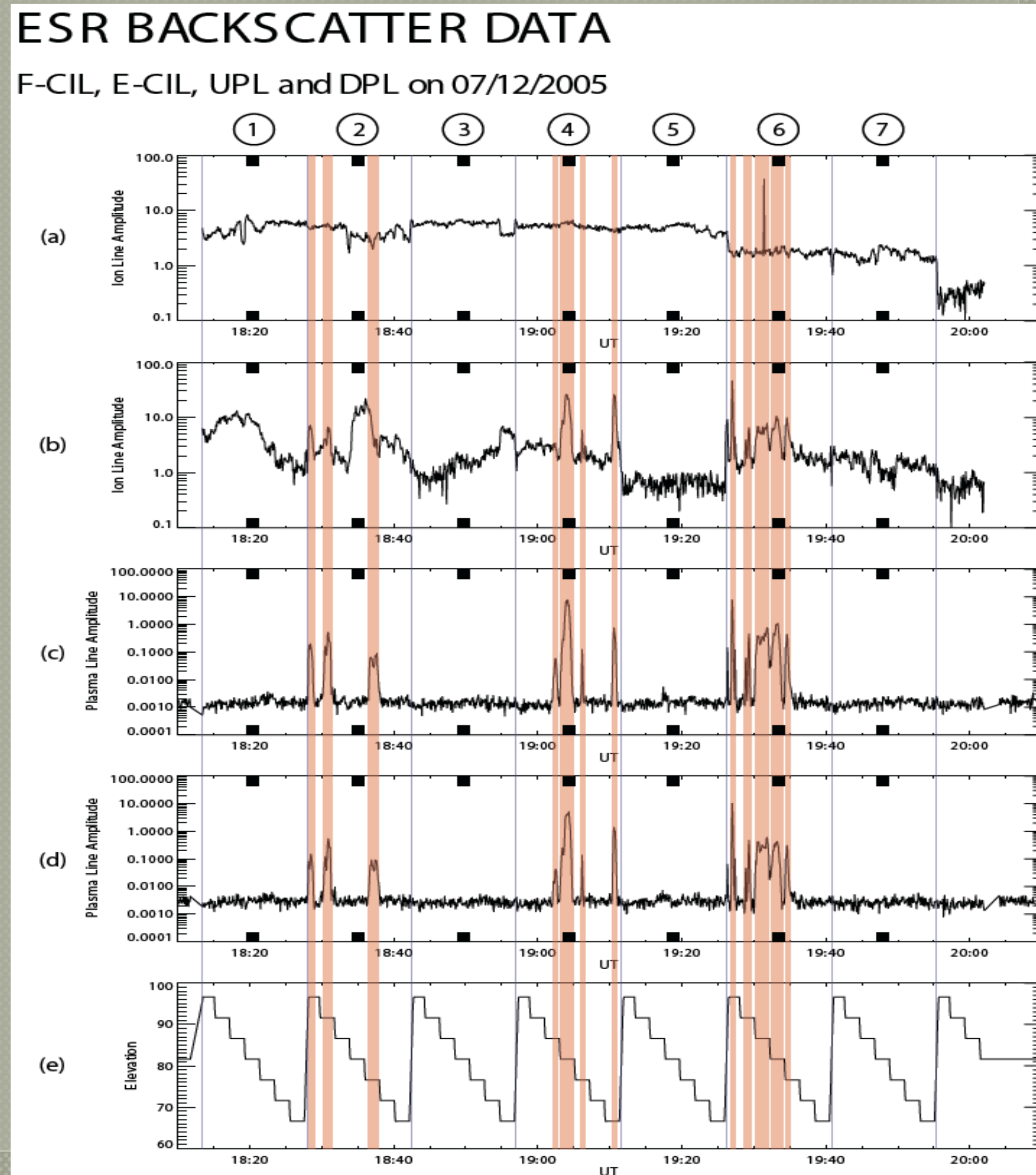




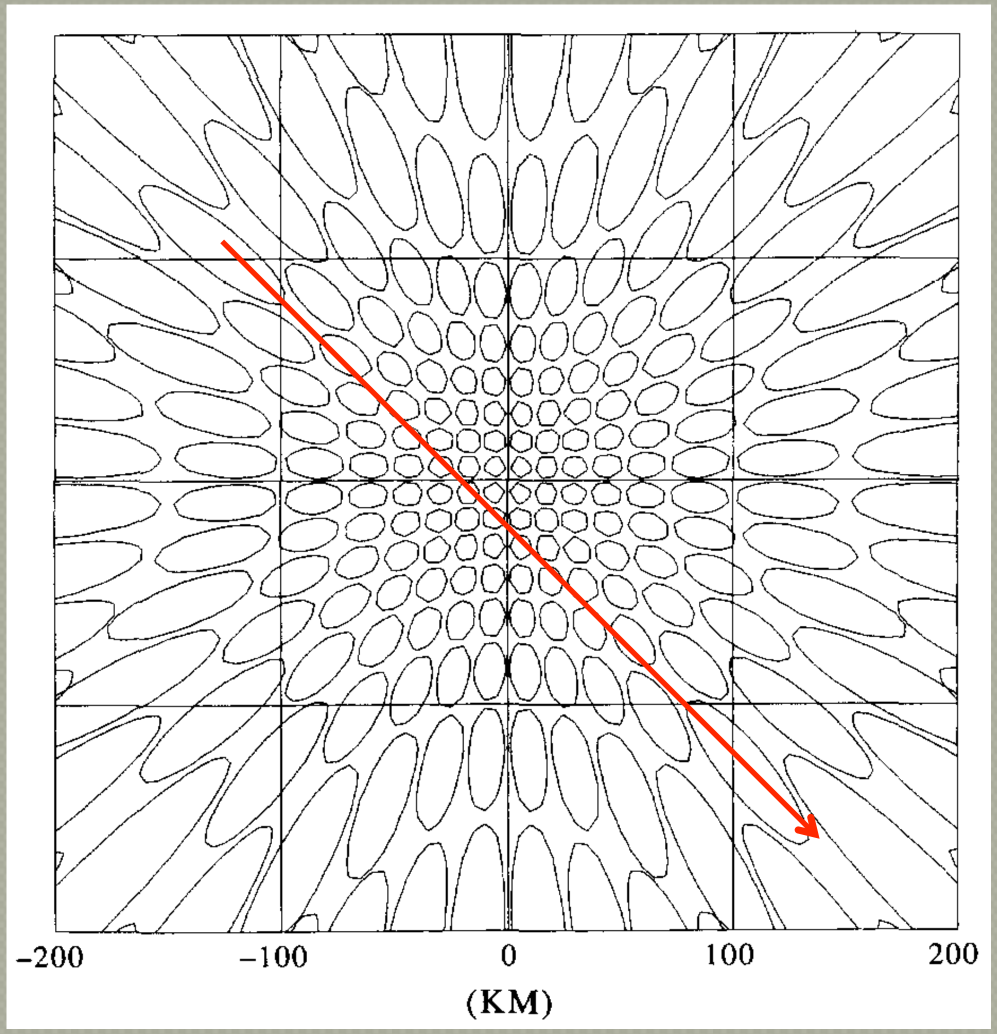
Plasma Physics: Waves and turbulence

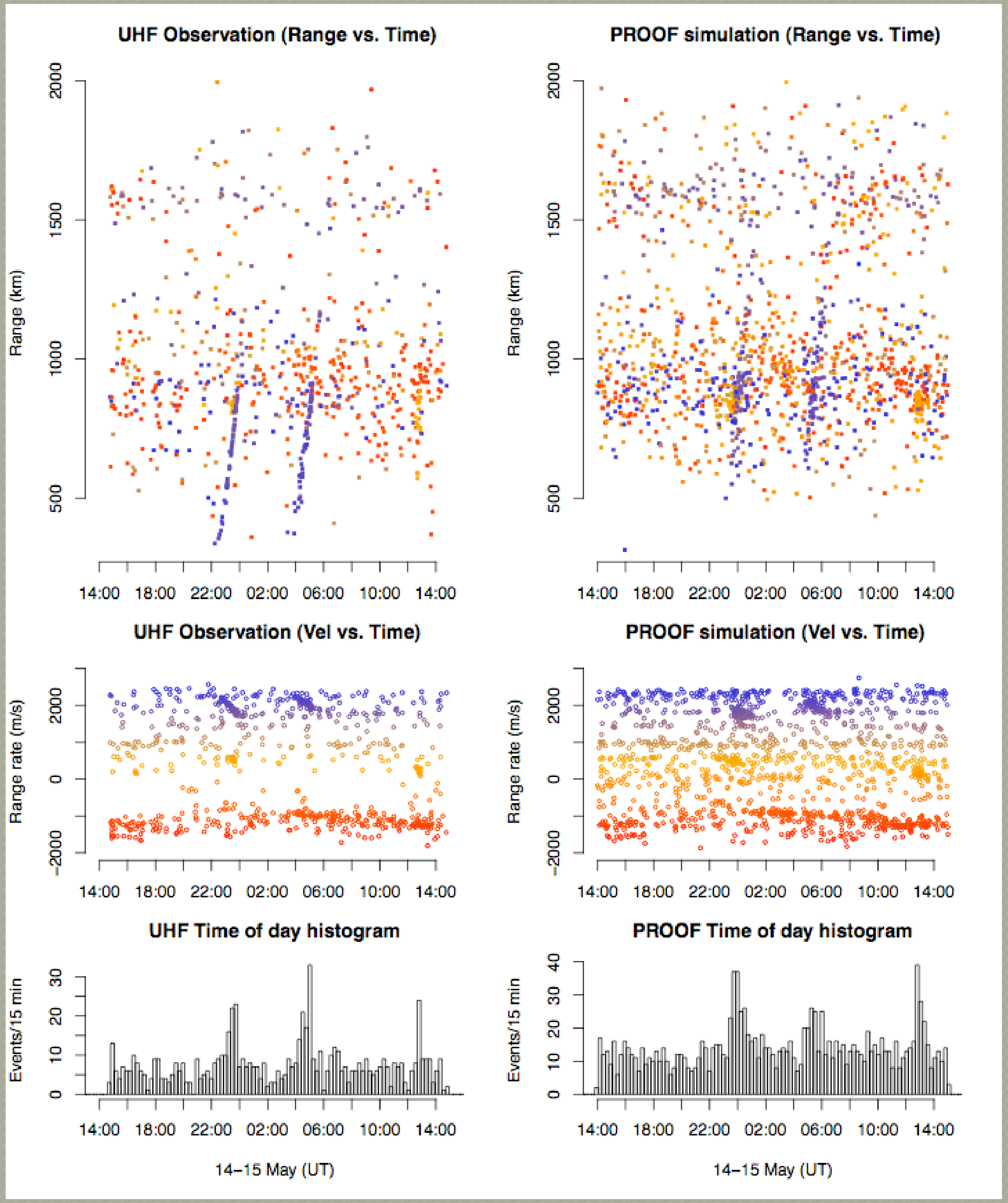


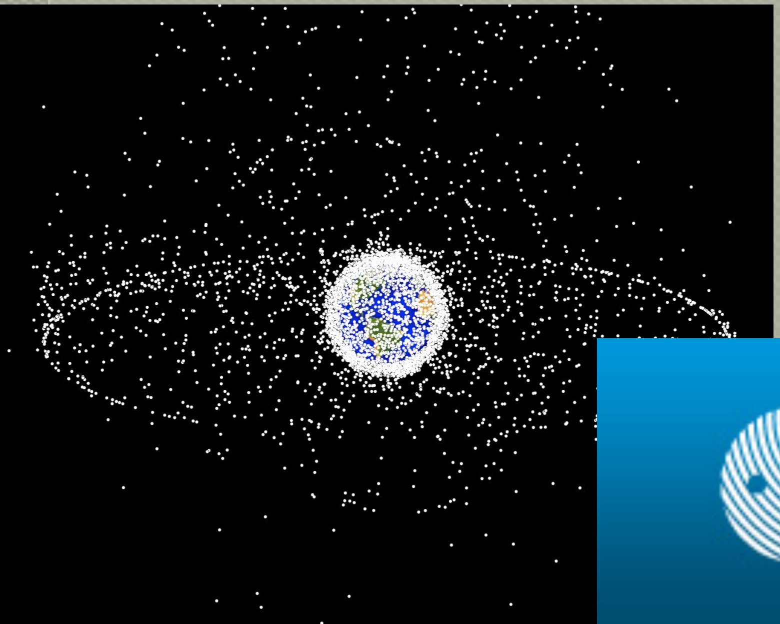




Space Situational Awareness



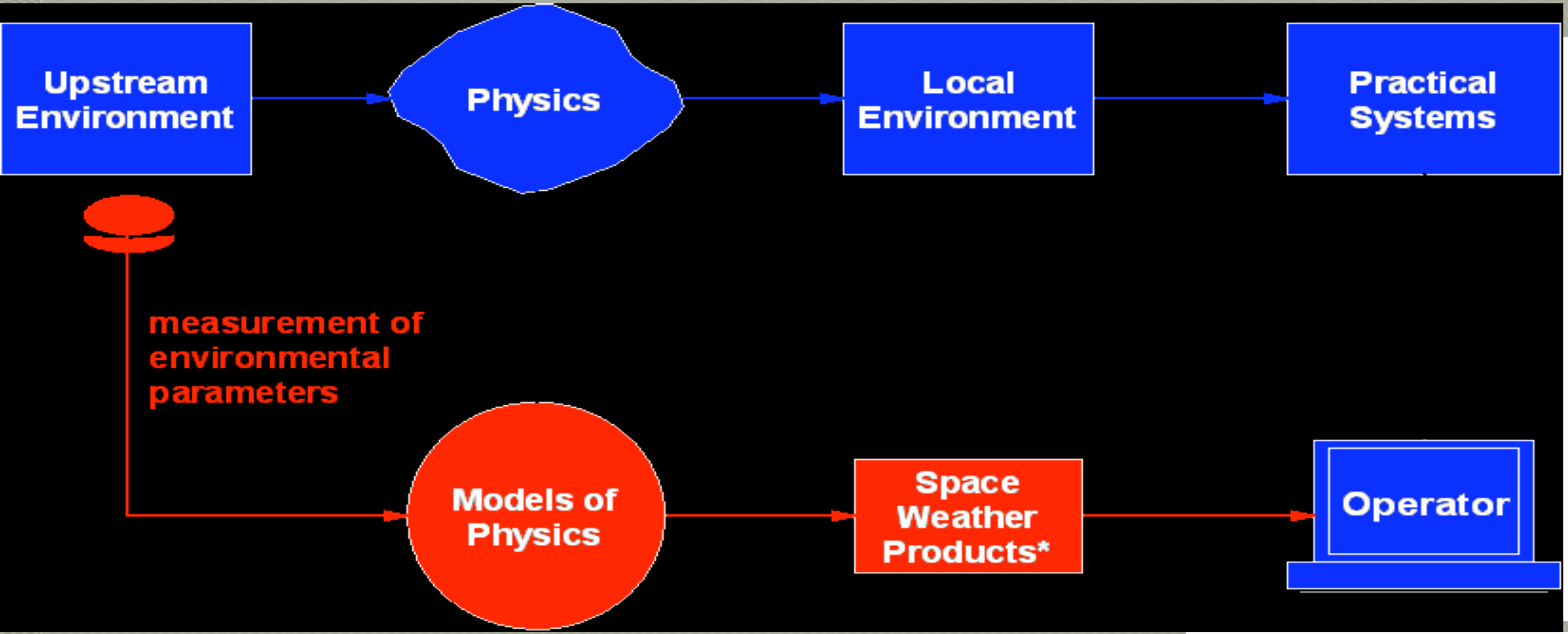


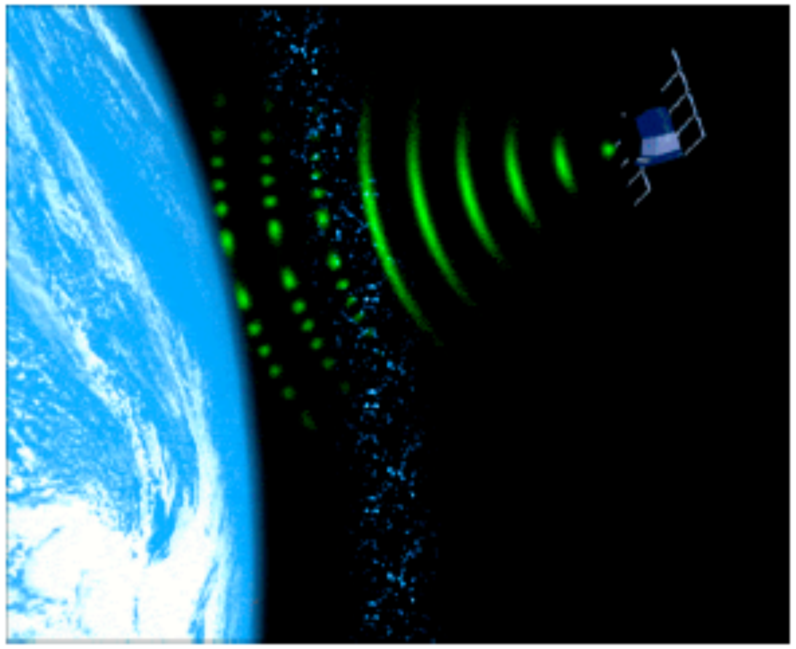


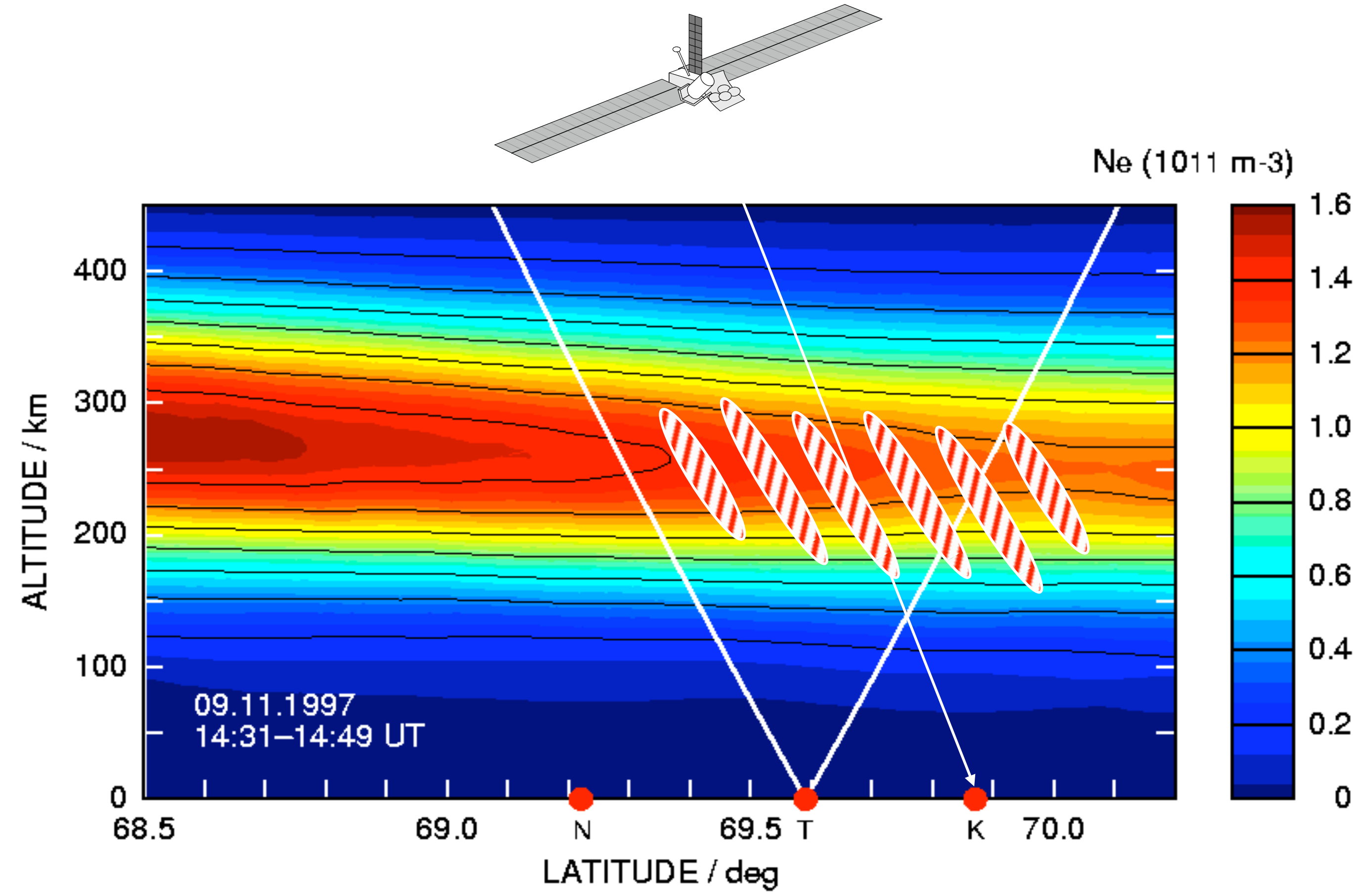
esa space situational awareness

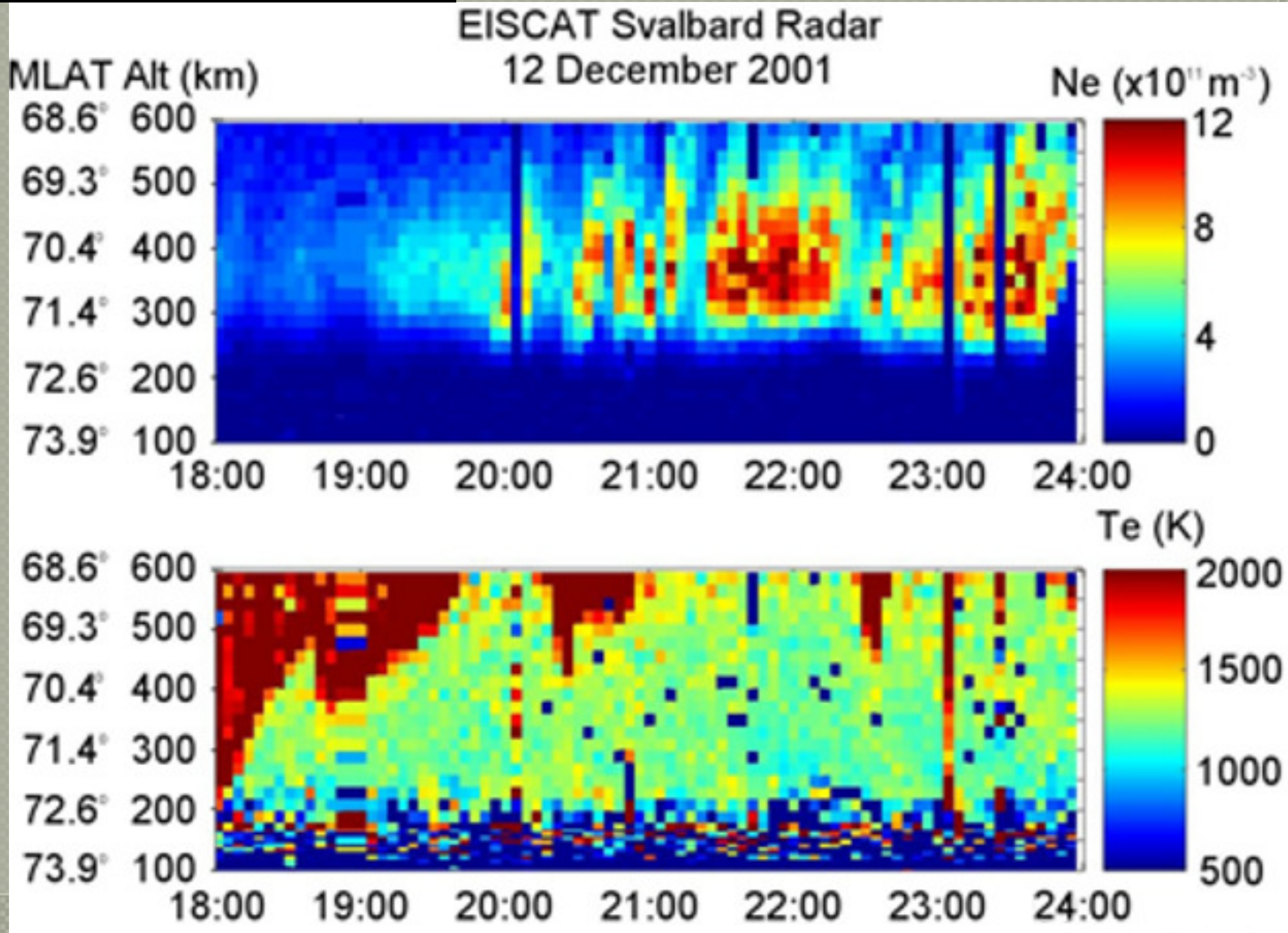
European Space Agency

Space Weather Services



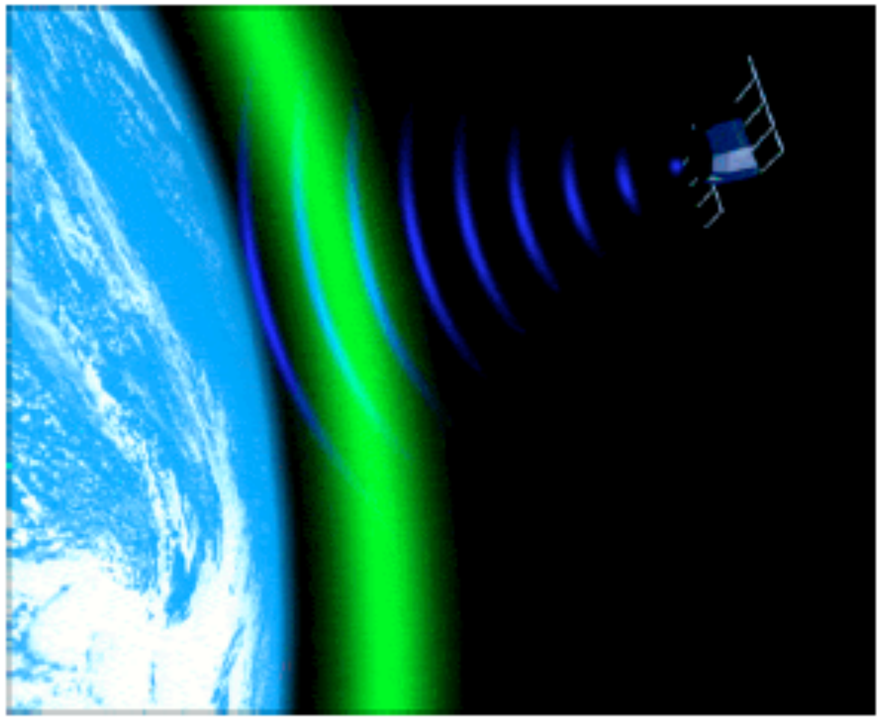




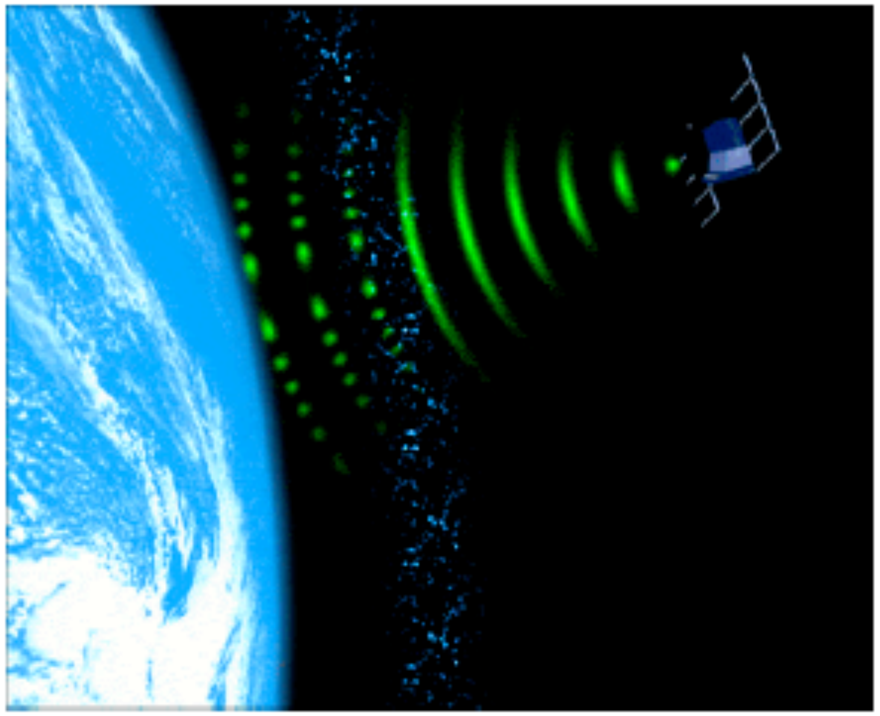


Ionosphere affects navigation applications

Ionosphere and GPS



Delay

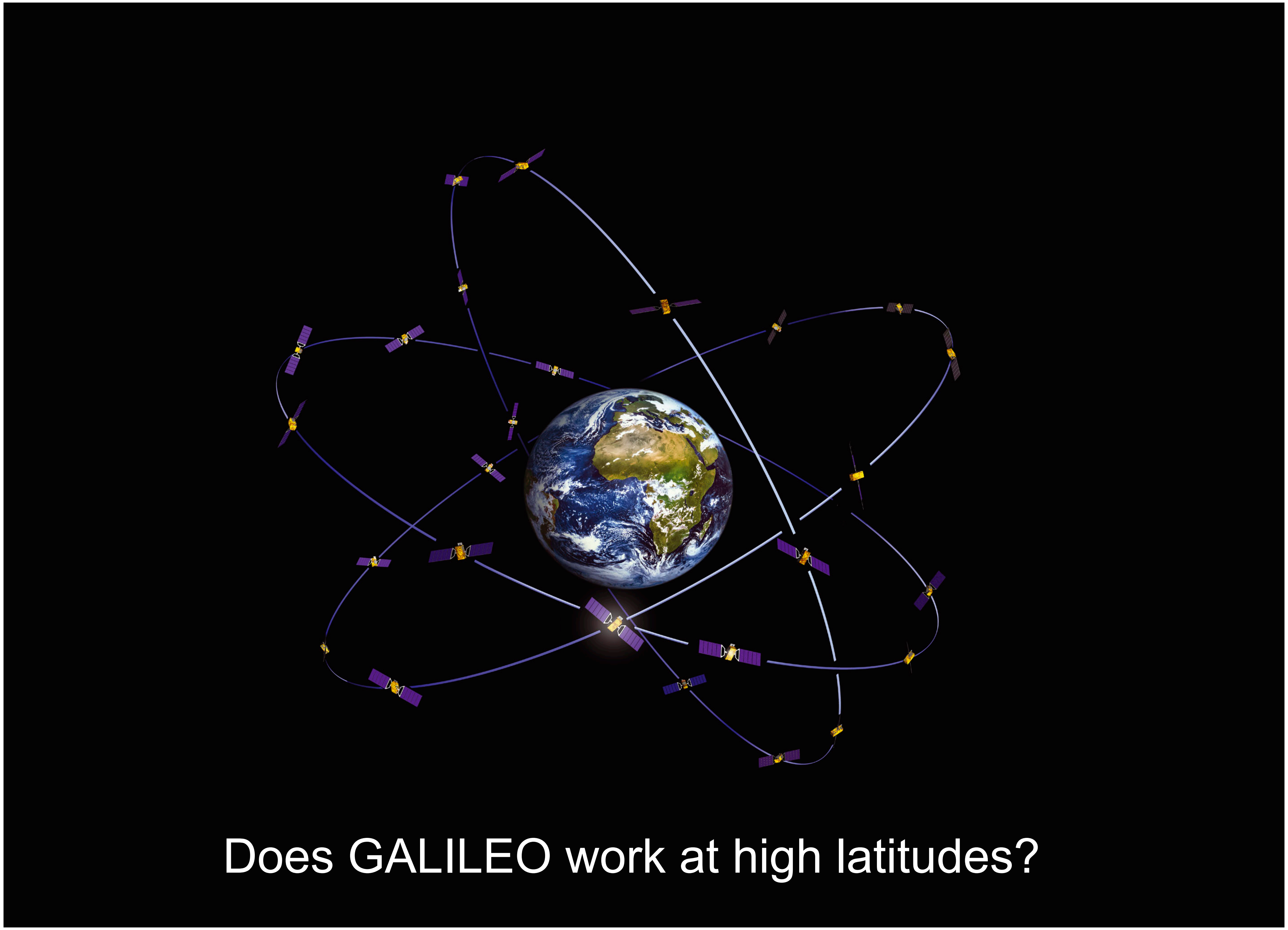


Scintillation

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

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

Space Weather: Navigation application



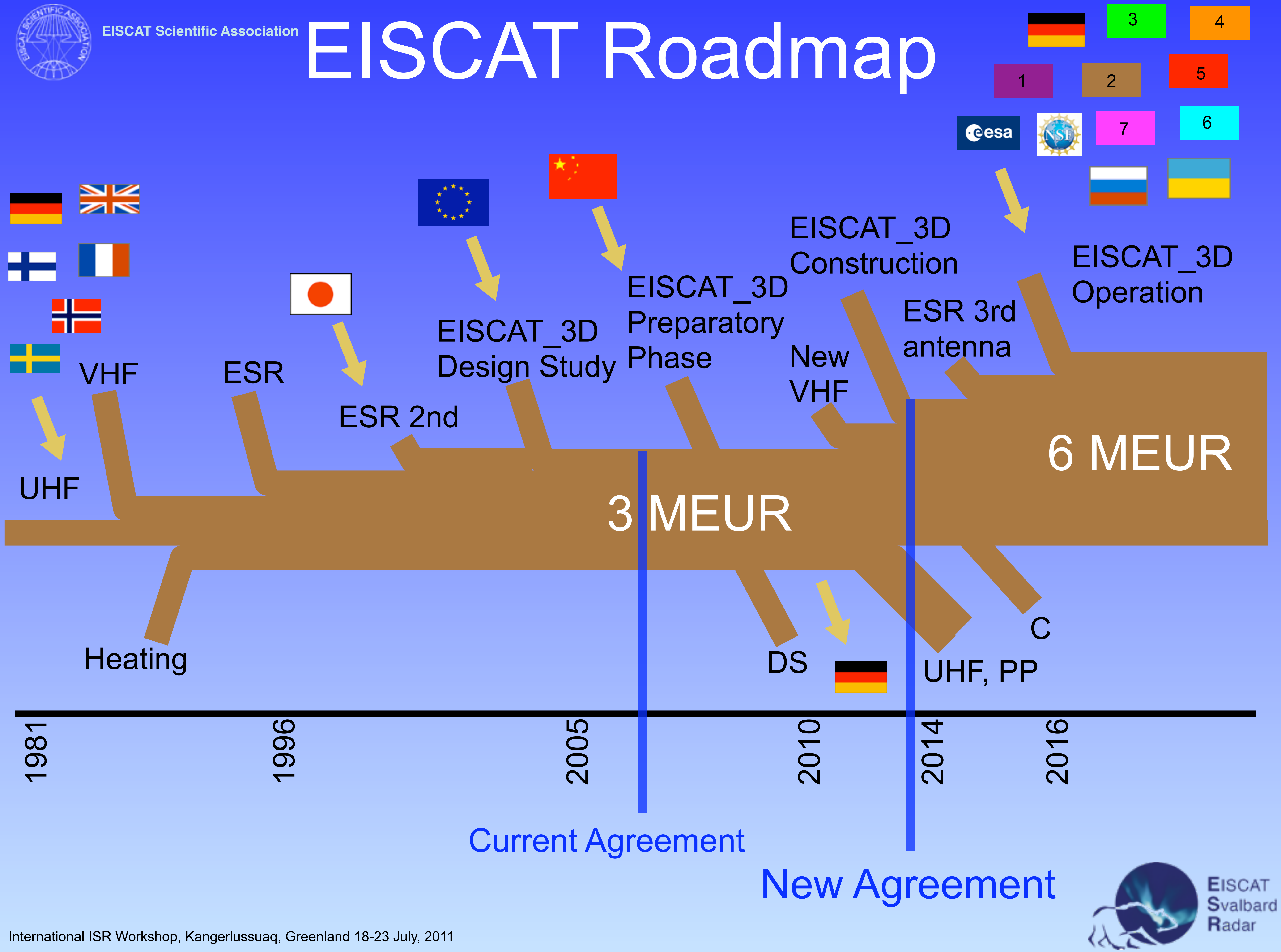
Space Weather variations:
Radiation belts

- complex behavior during magnetic storms
- loss process in the radiation belts: precipitation into the atmosphere


European Strategy Forum
on Research Infrastructures
ESFRI
Strategy Report
on Research Infrastructures
Roadmap 2010

EISCAT Roadmap

EISCAT Scientific Association



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EISCAT_3D Design Study finished 30.4.2009

- 5 partners, 30 man years
  - EISCAT, University of Tromsø, Luleå University of Technology, Rutherford Appleton Laboratory, Swedish Institute of Space Physics
- TI budgeted volume 2.8 MEUR
- EU FP6 support 2 ME

WP1: Project Management
WP2: Evaluation of design performance goals
WP3: Evaluation of options for the active element
WP4: Phased array receivers
WP5: Interferometric receivers
WP6: Active element
WP7: Distributed control and monitoring and Observation scheme
WP8: Data Archiving and Distribution
WP9: Signal Processing
WP10: New uses
WP11: Implementation Blueprint
WP12: Time and frequency distribution
WP13: Enabling procedures

EISCAT Svalbard Radar

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Design Study target (from 2005)

EISCAT 3D Design Specification Document
FP6-2003-Infrastructures-4: EISCAT 3D Proposal #011920

Appendix 1
Tentative EISCAT 3D System Layout

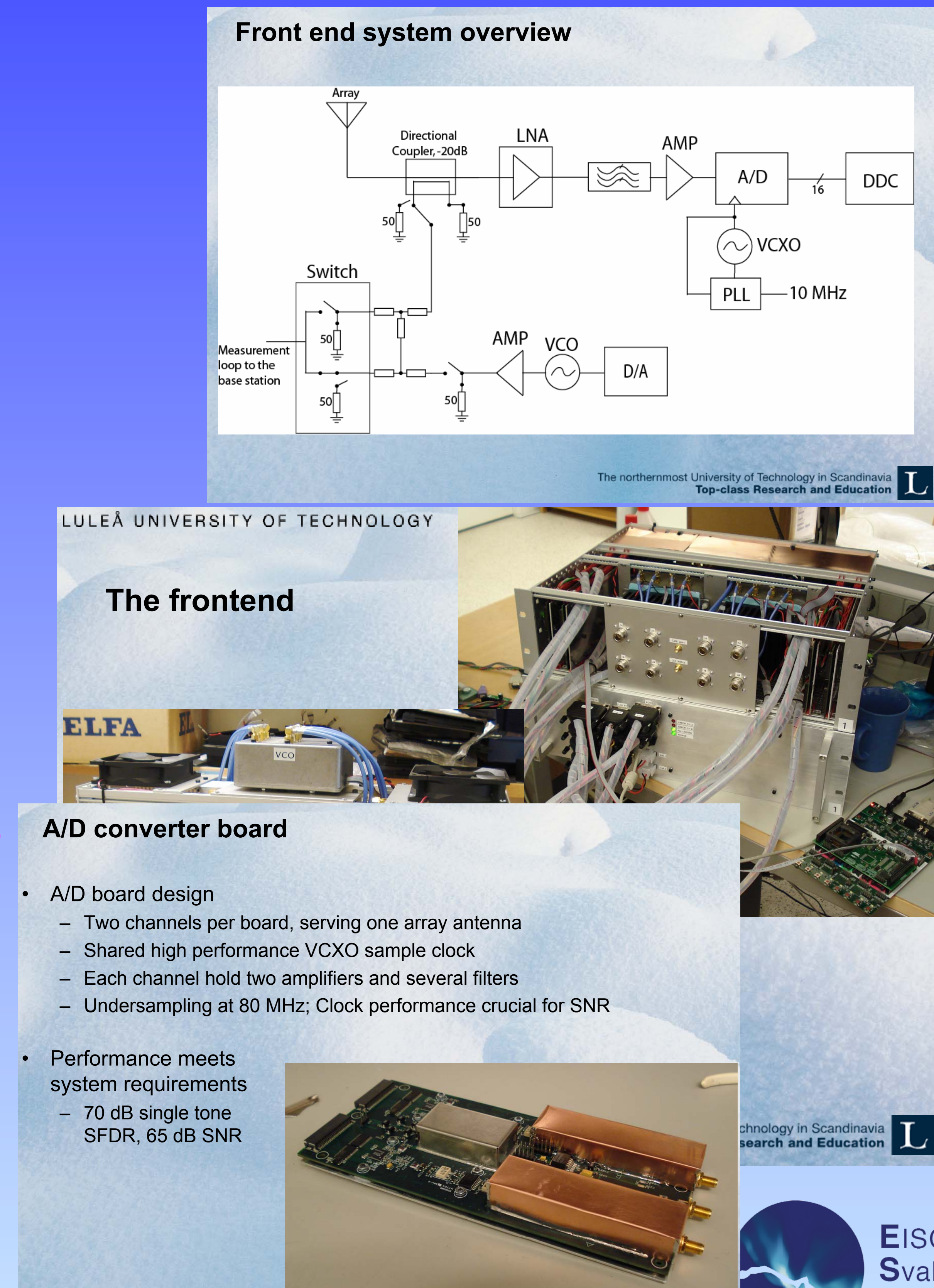
The figure shows one possible layout of the EISCAT 3D system. In this configuration, the central core (denoted by a green filled circle) is assumed to be located near the present Norwegian EISCAT site at Ramfjordmoen. The dashed circle with a radius of approximately 250 km indicates the approximate extent of the field-of-view of the central core at 300 km altitude. Phased-array receiving sites located near Porjus (Sweden) and Kaamanen (Finland) provide 3D coverage over the (250-800) km height range, while two additional receiving sites near Abisko (Sweden) and Masi (Norway) cover the (70-300) km height range.

- System configuration:
- multiple phased-array ISR
  - **A central transmitting/receiving core facility**, located at, or close to, the EISCAT Tromsø radar.
  - **At least two receiving facilities** for the ionospheric **F1, F2 and topside regions**, located at distances of ~220-280 km south and east.
  - **At least two receiving facilities** for the ionospheric **D and E regions**, at distances of ~90-120 km south and east
  - Data storage and communication systems located at, or close to, each facility.
  - Essentially unattended **continuous operation**.
  - System control, monitoring, data access via Internet.
  - Relative time between sites better than 100 ns, absolute time maintained to GPS/Galileo standards.
  - At central core beam-steering systems for transmission and reception and several (4–10) outlier, receive-only phased-array antennas for in-beam **interferometry.**
  - At **receiving** facilities at least **5 beam formers**

EISCAT Svalbard Radar

Design Study target

- Spatial resolution:
  - Along the transmitted beam better than 100 m.
  - Horizontally (–3 dB) at 100 km better than 150 m.
- Radar field-of-view (FOV):
  - Central core steerable out to a maximum zenith angle of ≈40° in all azimuth directions. At 300 km altitude, radius of FOV is approximately 250 km.
  - Receiving facilities permit tristatic observations to be made at all altitudes up to 800 km.

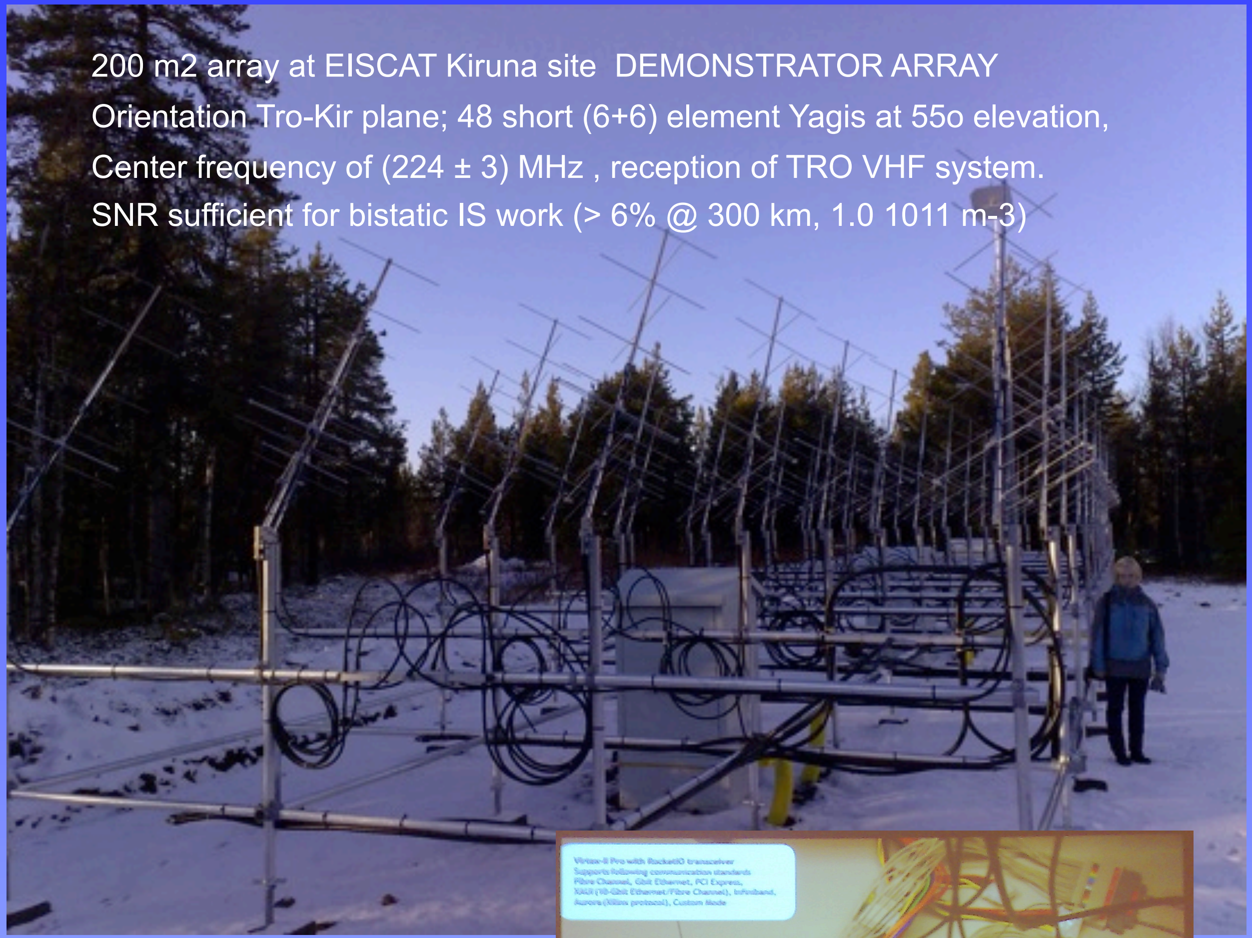


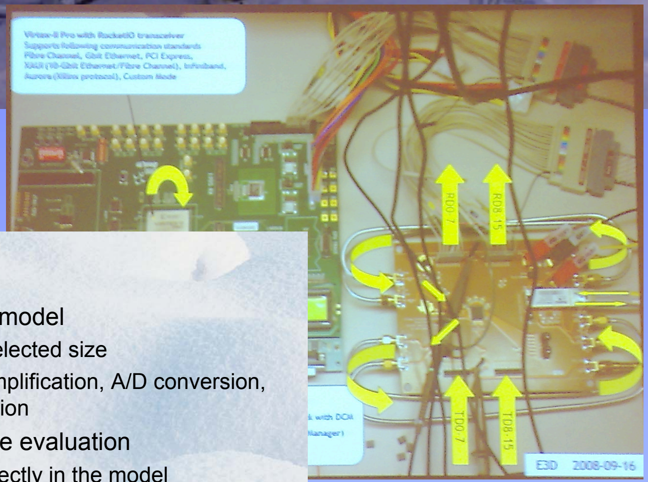
EISCAT Svalbard Radar

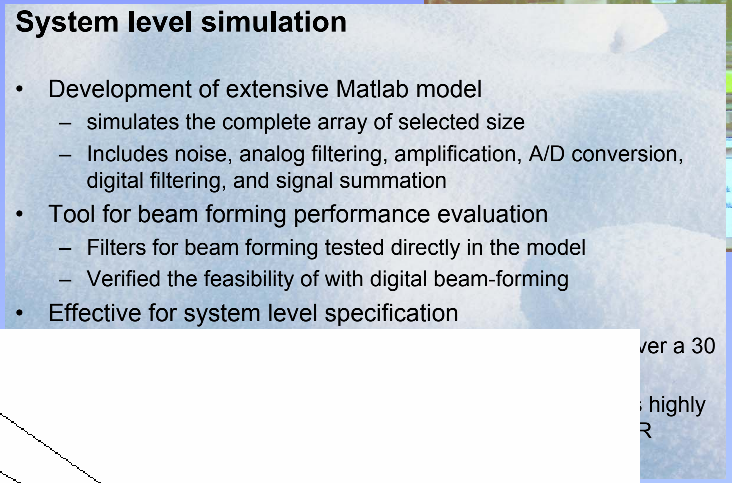
EISCAT Scientific Association

Design Study target

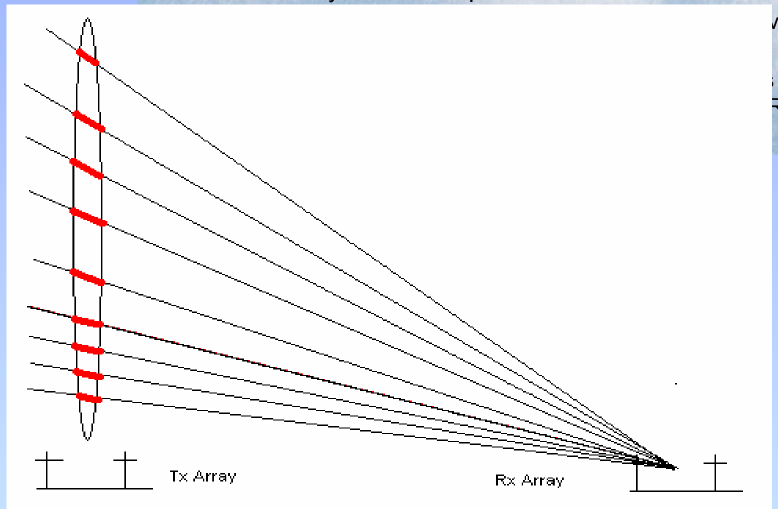
- Beam steering:
  - Central core beam steerable into any of ≥12000 discrete pointing directions, separated by on average 0.625° in each of two orthogonal planes.
  - System will operate on a <500 μs timescale.
  - receive-only sites synchronized with the central core, simultaneous generation of independently steerable beams intersecting the central core beam at different altitudes.
  - The D/E region receiving sites will provide 3D coverage from the mesosphere out to 250–300 km.
  - The F/topside region receiving sites will provide 3D coverage over the range 200-800 km
  - The transmit site will also provide continuing coverage into the topside to ~2000 km
-






System level simulation

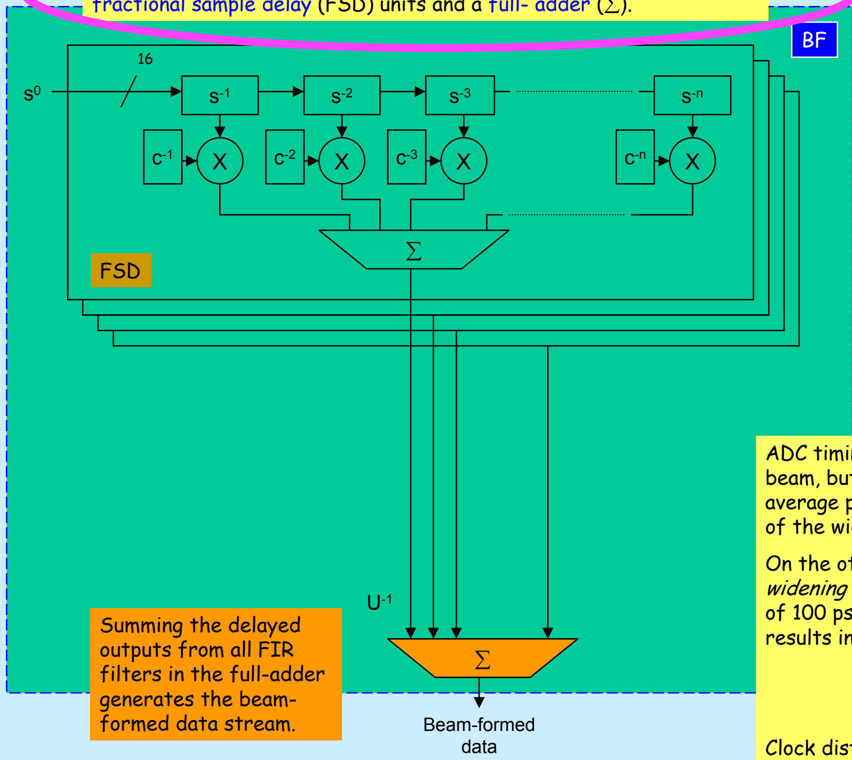
- Development of extensive Matlab model
  - simulates the complete array of selected size
  - Includes noise, analog filtering, amplification, A/D conversion, digital filtering, and signal summation
- Tool for beam forming performance evaluation
  - Filters for beam forming tested directly in the model
  - Verified the feasibility of with digital beam-forming
- Effective for system level specification



EISCAT Svalbard Radar

Digital beam-forming, multi-beaming and beam errors

A digital beam-former (BF) consists of two main parts, viz. a set of fractional sample delay (FSD) units and a full- adder (Σ).



One FSD unit is required per element antenna and beam. It can be realised as a generic FIR filter structure in FPGA logic.

The coefficients c^{-m}, m= 1…n, determine the filter group delay and must be computed for each element antenna and beam direction.

Summing the delayed outputs from all FIR filters in the full-adder generates the beam-formed data stream.

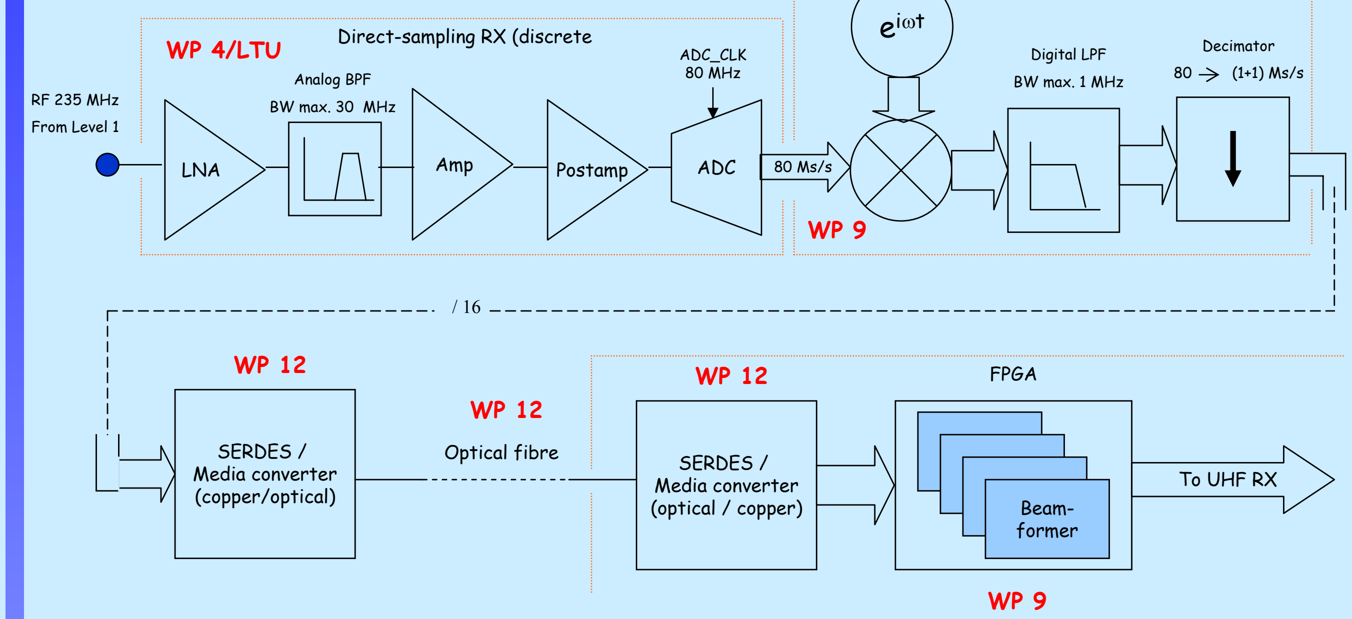
Multiple beams can be generated from the same data by simply adding more beam-formers, one per beam!

ADC timing jitter and other timing errors affect the beam, but when the error distribution is Gaussian, the average pointing direction stays the same regardless of the width of the distribution.

On the other hand, *Gaussian timing jitter causes a widening of the beam and a loss of gain.* A 3-σ jitter of 100 ps results in a 0.1 dB gain loss; 500 ps jitter results in almost 2 dB gain loss !

Clock distribution and ADC sampling stabilisation now become important issues; in order not to lose performance, the system must be designed for a 3-σ jitter of less than 100 ps, array-wide.

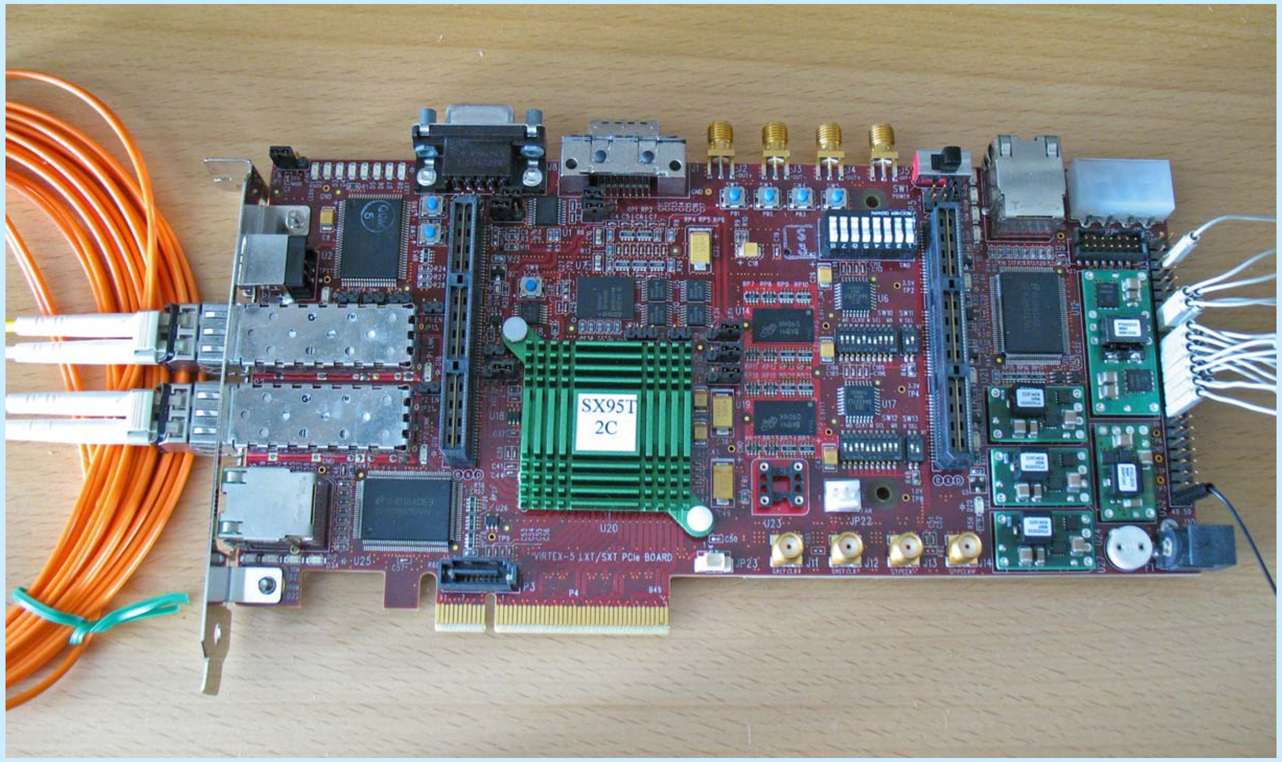
Block diagram of fully instrumented Demonstrator RX front end / beam-former

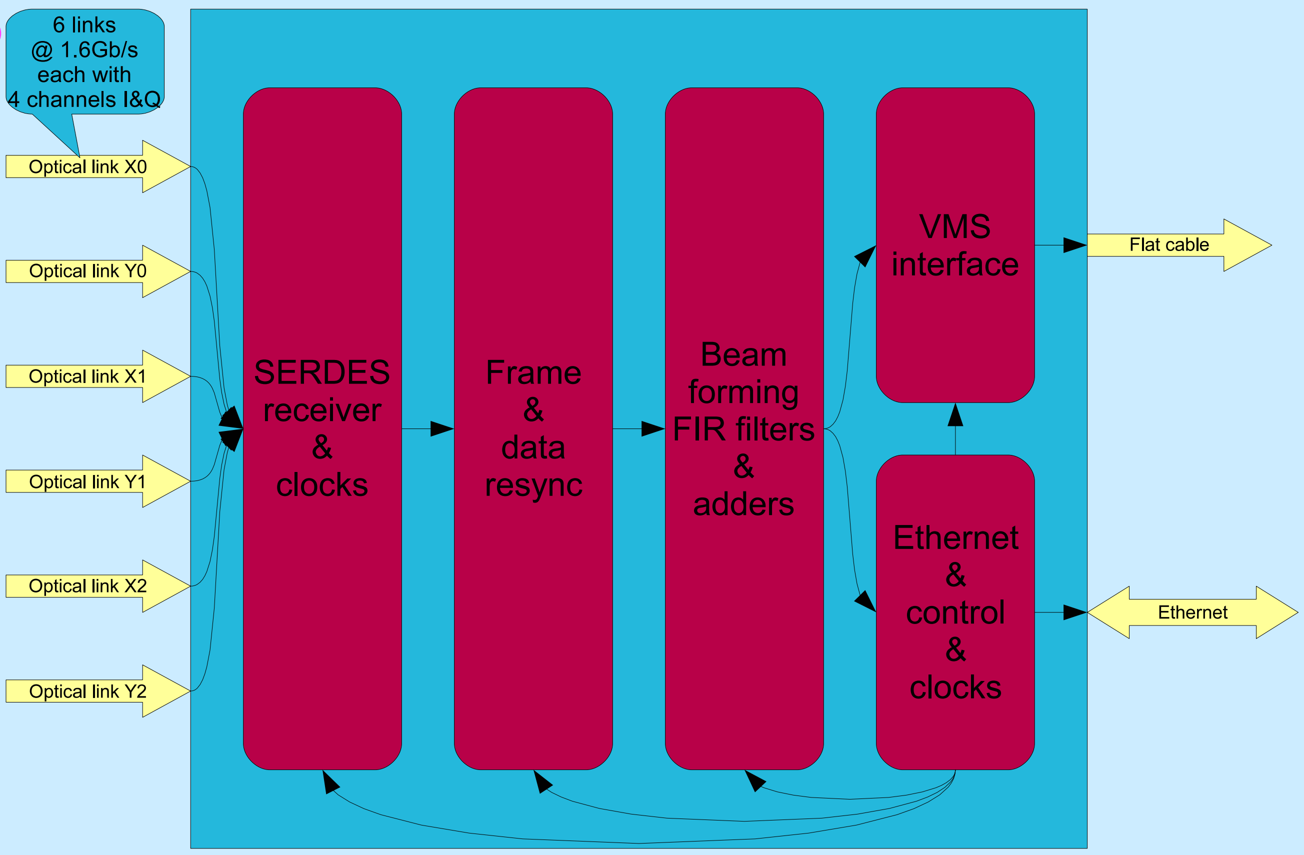


This architecture was adopted to get the Demonstrator array operational as quickly as possible:

- The digital down-converter unit band-limits the 30 MHz front end signal to 1 MHz, enough for ion line work,
- Decimated data from all rows is serialised, media-converted and transferred on optical fibre to the site control room,
- Multiple beam-former processes running in an FPGA combine signals from all rows into beam-formed data streams,
- These are fed into the existing UHF receiver channel boards and processed normally by lag_wrap under eros.

How the FIR filters are realised in practice: FPGA technology



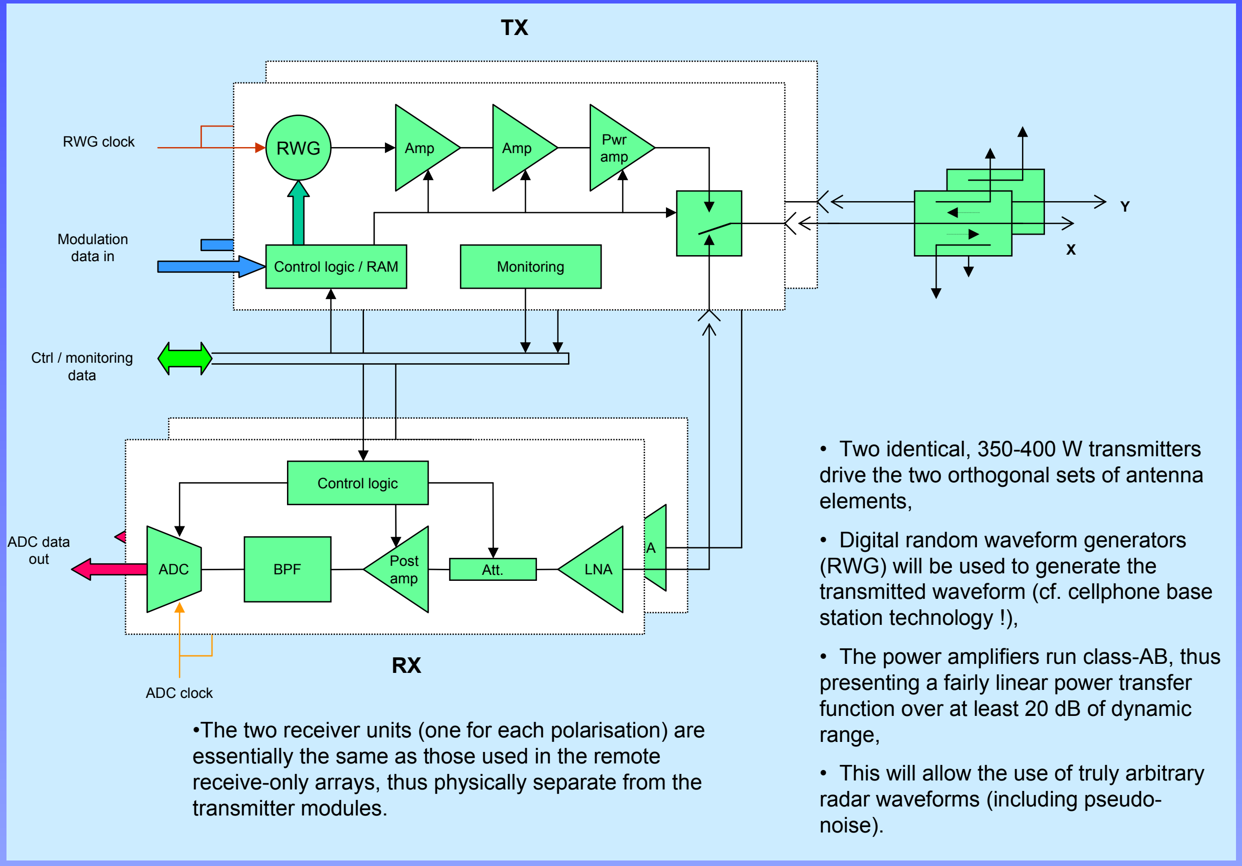


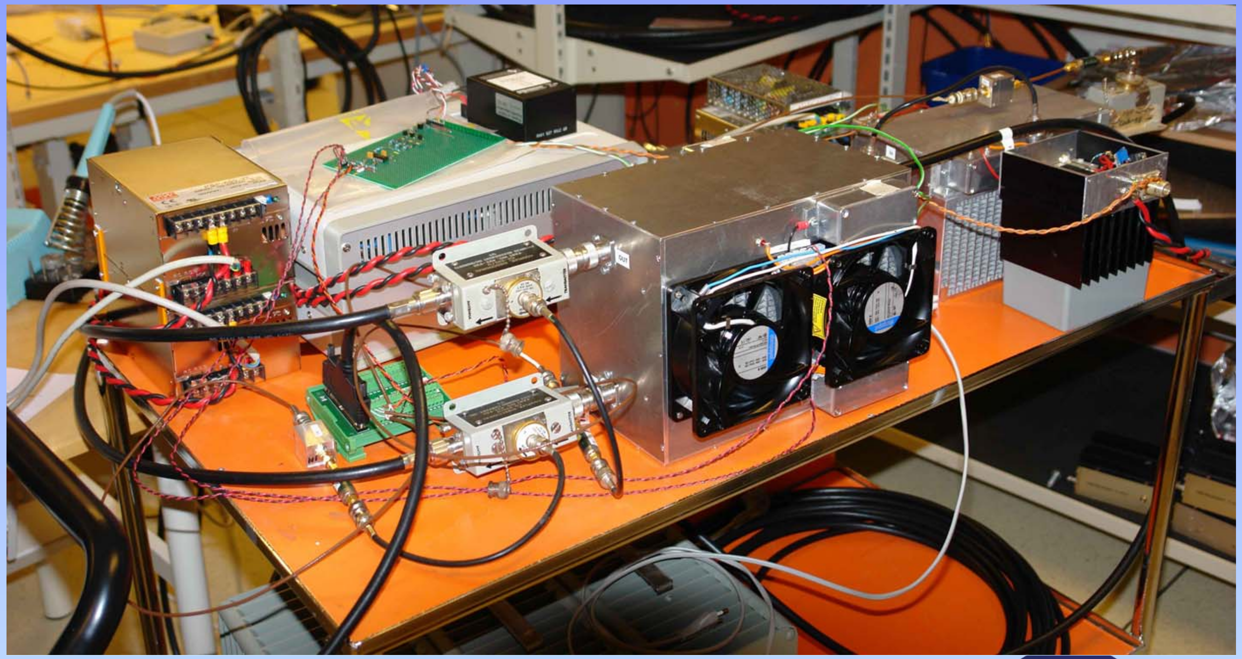
from: G. Wannberg: Uppsala, Sweden 28.5.2009

Radar

Design Study target

- Transmitter parameters:
  - Centre frequency: between 220 – 250 MHz, subject to allocation
  - Peak output power: ≥2 MW
  - Instantaneous –1 dB power bandwidth: ≥5 MHz
  - Pulse length: 0.5–2000 µs
  - Pulse repetition frequency: 0–3000 Hz
  - Modulation: Arbitrary waveforms, limited only by power bandwidth





Design Study target

- Receiver parameters:
  - Centre frequency: matching the transmitter cf.
  - Instantaneous bandwidth: ±15 MHz
  - Overall noise temperature: ≤50 K referenced to input terminals
  - Spurious-free dynamic range ≥70 dB

2.12 Sensor performance in incoherent scatter mode

The parameters of the different subsystems will be chosen such that, for each of the measurement scenarios tabulated below, the radar will generate estimates of incoherently scattered signal power (or equivalently, uncorrected electron density) with statistical accuracies of better than 10 % in the specified integration times:

Altitude [km]	Electron density [m^{-3}]	T_e/T_i	Ion composition	Height resolution [m]	Integration time [seconds]
80	1×10^8	1.0		≤100	30
100	3×10^9	1.0		100	1
150	1×10^{10}	1.0	50% NO^+, 50% O^+	100	1
300	3×10^{10}	2.0	100% O^+	300	1
800	3×10^{10}	3.0	5% H^+, 95% O^+	1000	10
1500	1×10^{10}	4.0	10% H^+, 90% O^+		60

The proposed Yagi antenna

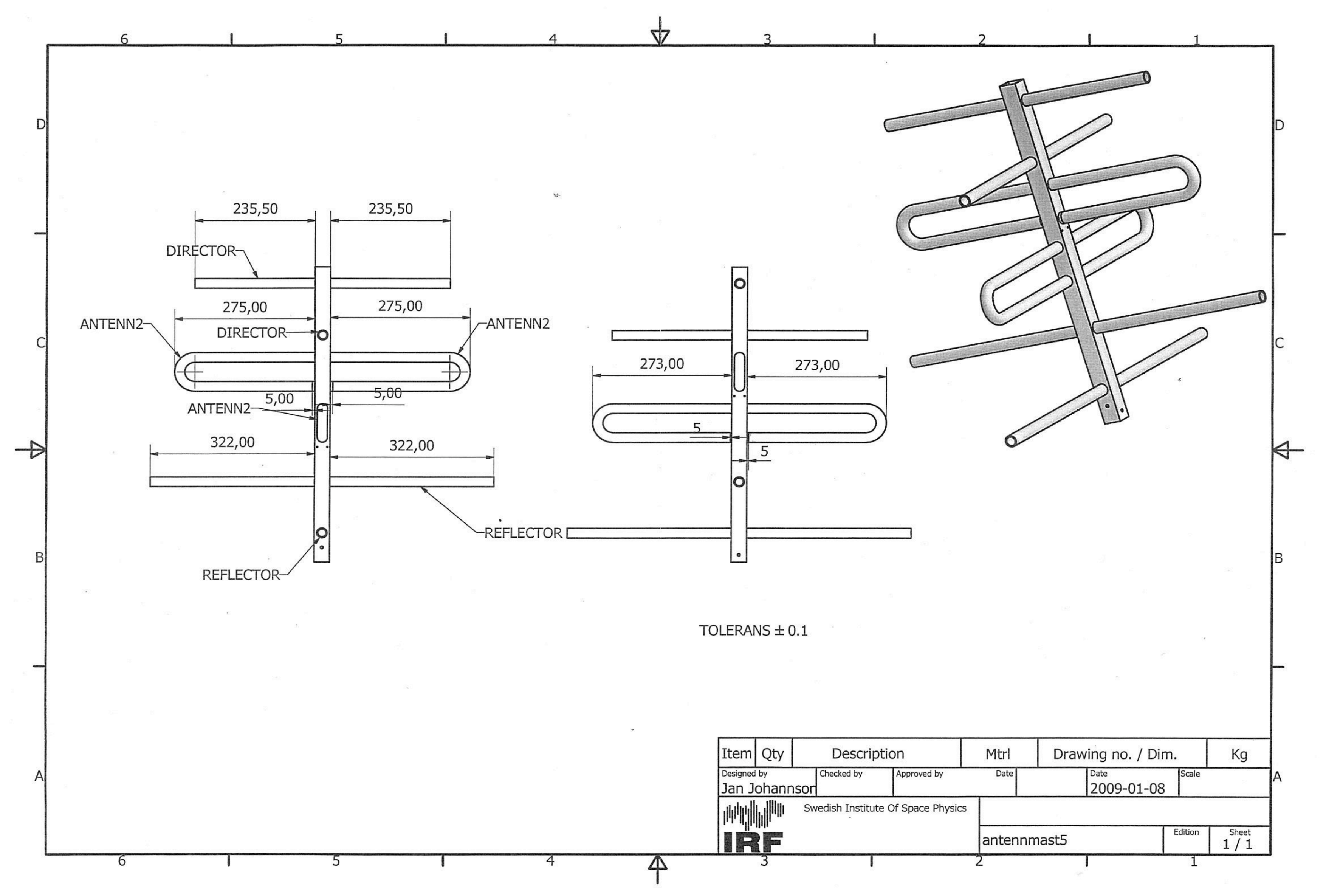
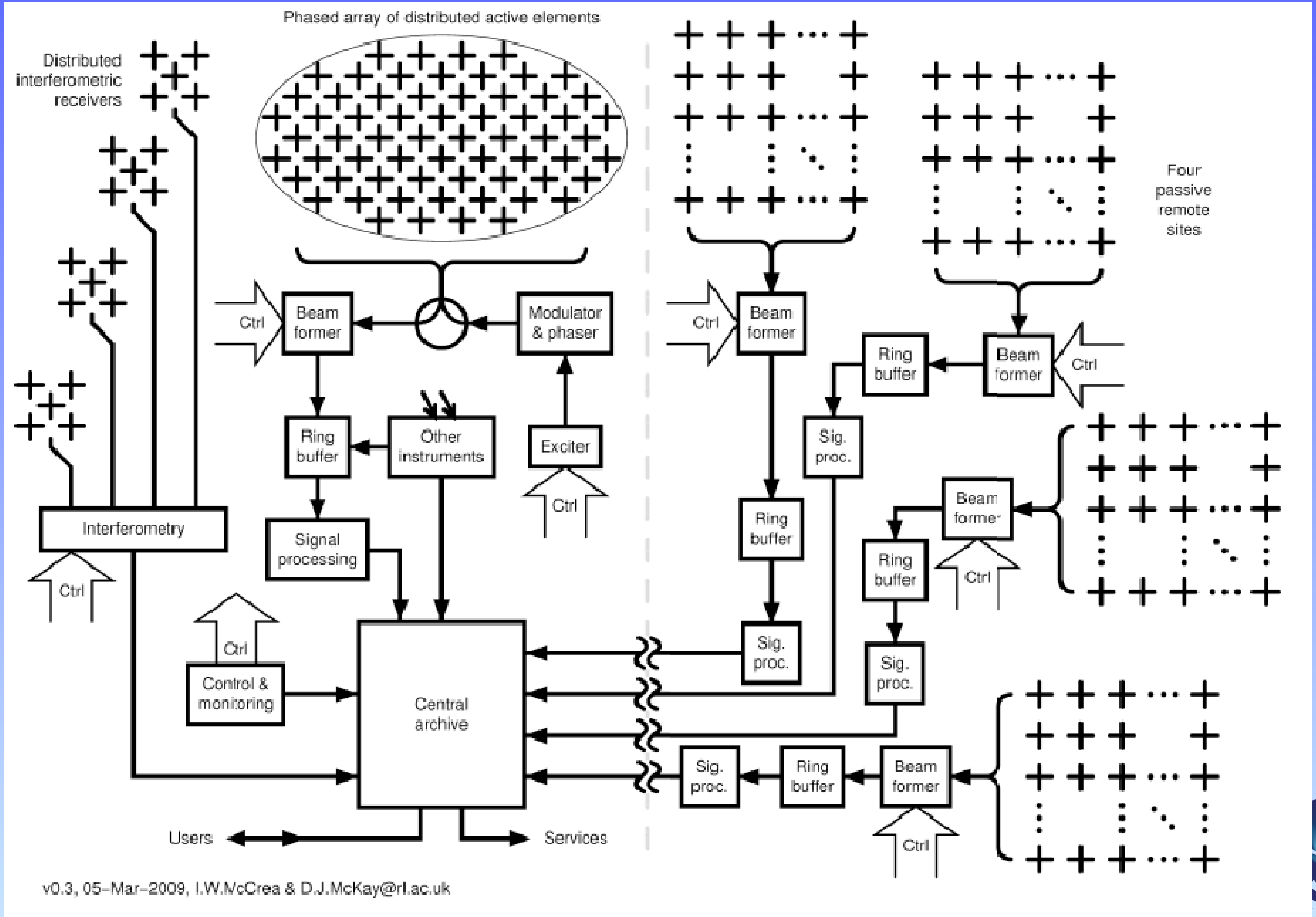


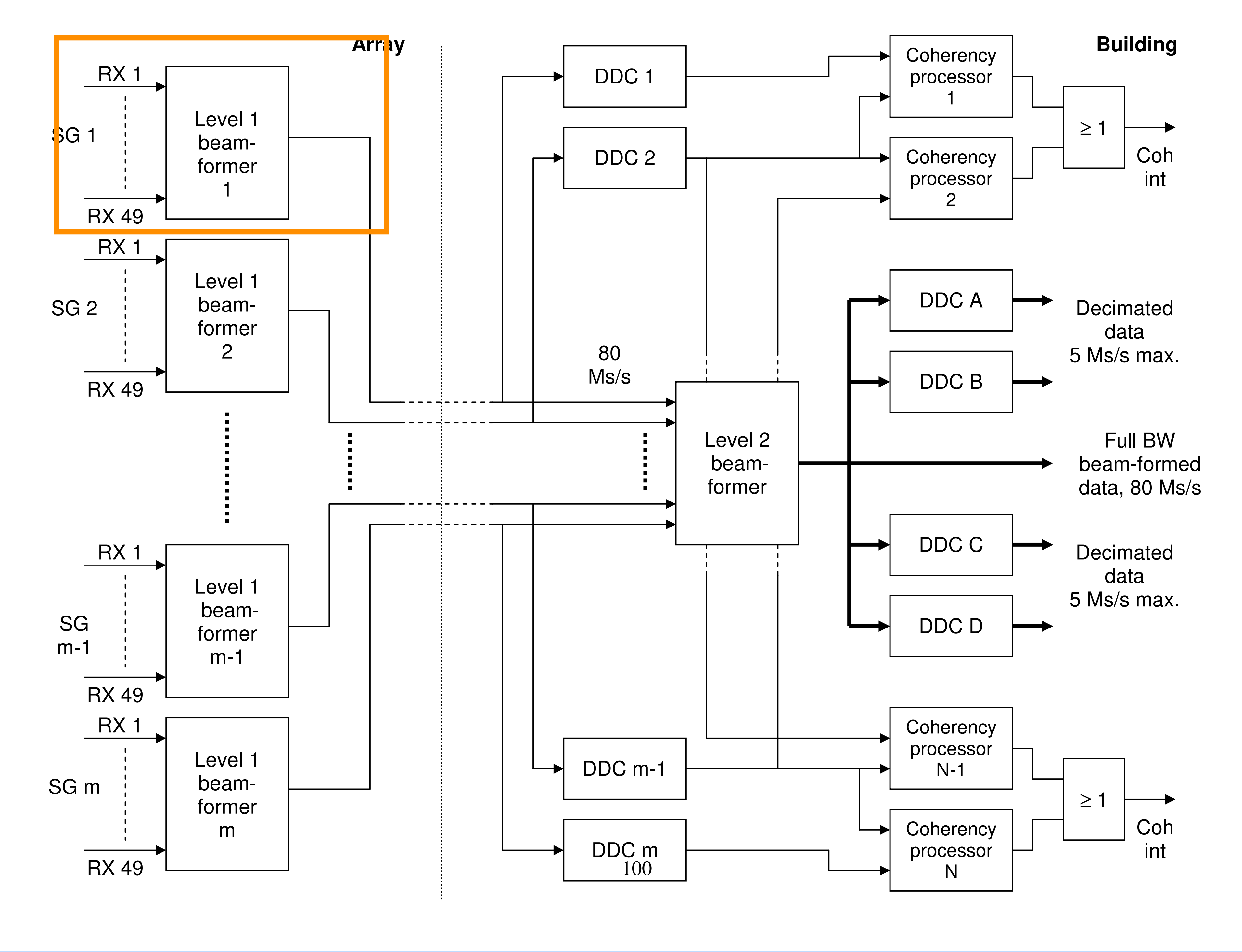
Figure 1. *Mechanical drawing of the "Renkwitz Yagi" recommended for use as the element antenna in the EISCAT_3D Core array.*

EISCAT Svalbard Radar

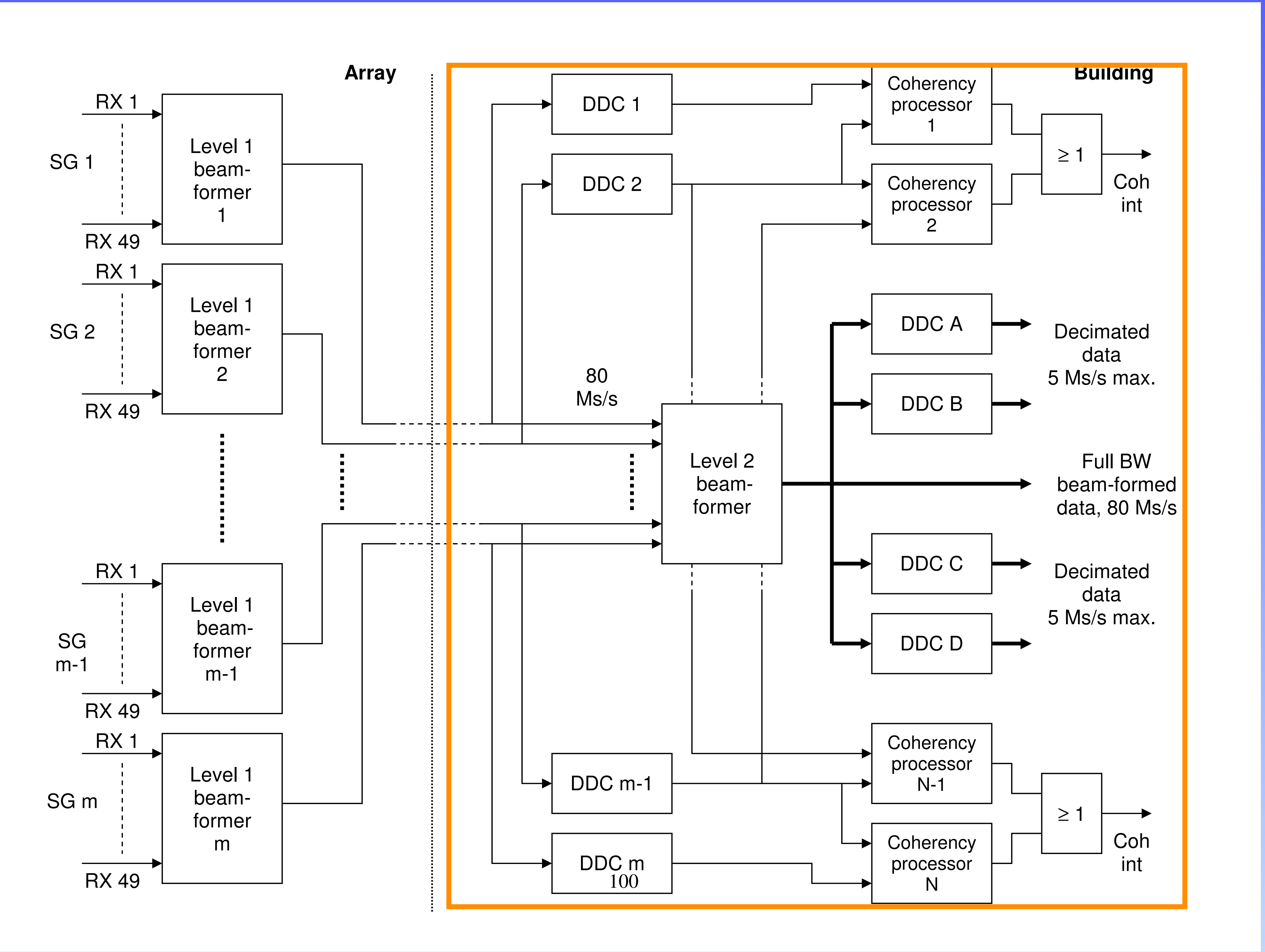
Design Study: system diagram



Possible architecture for EISCAT_3D



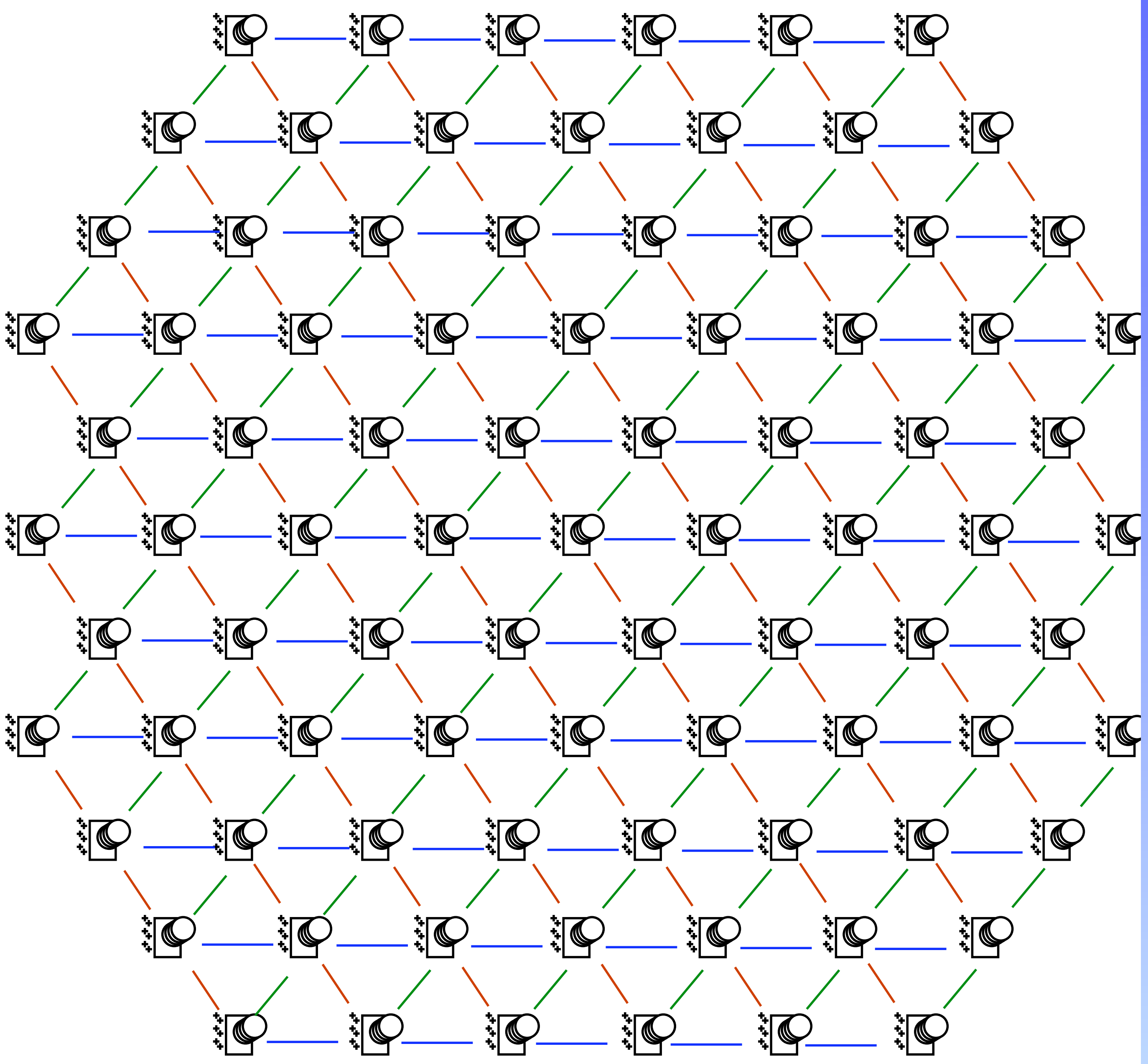
What about the level 2 beamforming?



Level 2 beamforming can be done in a computer cluster - more flexibility, more performance

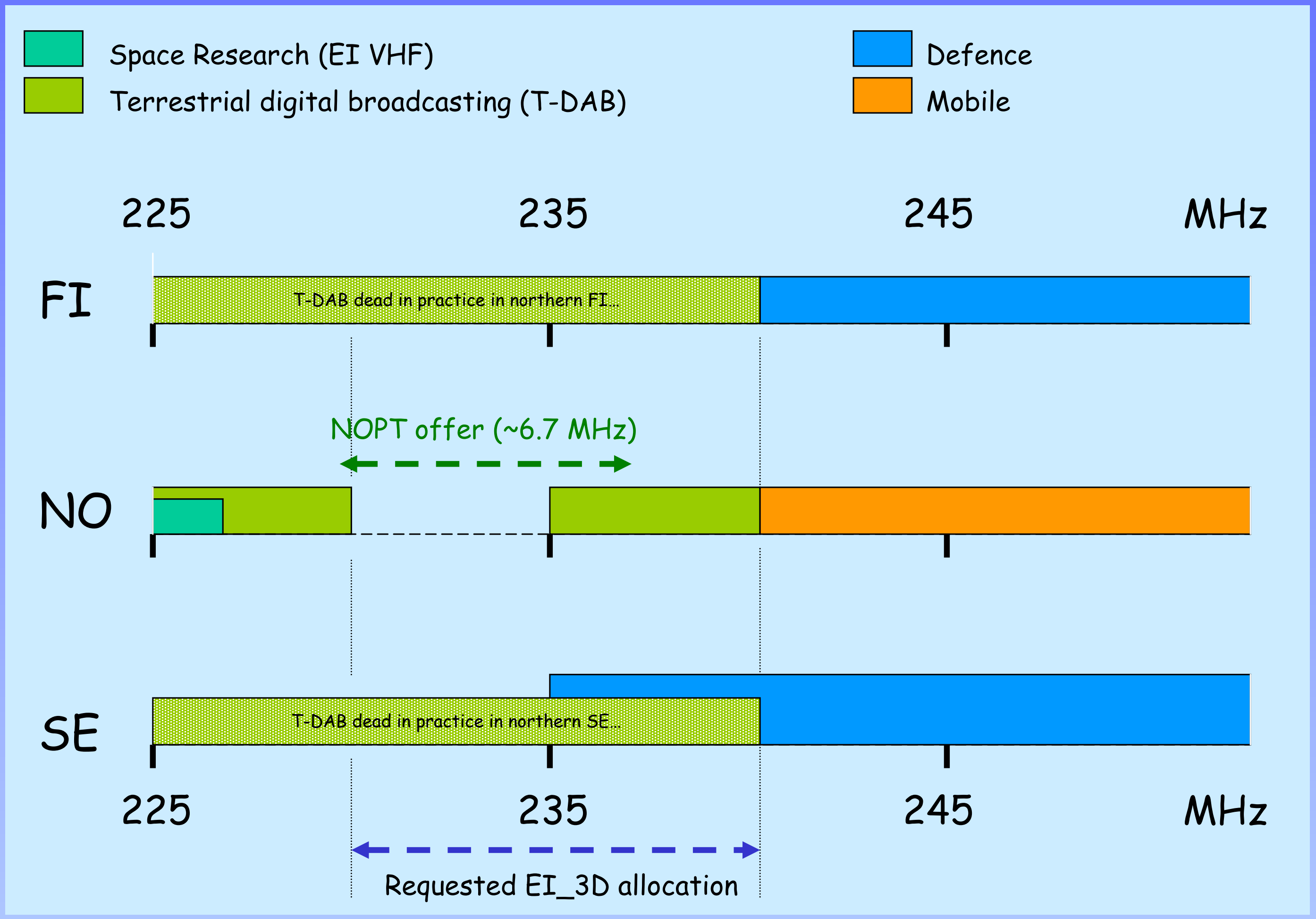
notes

- Each Level 1 unit is connected to 6 neighbors by 10G ethernet lines.
- 3 independent streams of $10G/80M/16 \approx 7.8$ full speed data can be routed for beamforming sums.
- totalling 23 beams.
- with band-limited data, much more, eg. for 5 MHz, 8*23=184 simultaneous beams



Frequency allocation

- Discussions with telecommunication authorities, spring 2009
  - Norway offers 229.9-236.6 MHz to EISCAT
  - Finland shows support to protect the band in Northern Finland for EISCAT
  - Sweden has future allocation to DAB development, but several authorities involved. Swedish Research Council offers to coordinate discussions. Apply for active license?



EISCAT Svalbard Radar

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

- For details, see http://www.eiscat3d.se

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

EISCAT Scientific Association

EISCAT_3D Preparatory Phase 2010-2014

- **Project start 1.10.2010**
  - 1st General Assembly held 6.10.2010
    - Elected the Executive Board
  - Kick-Off meeting 21-22.10.2010
    - project published
    - 42 participants
- Project manager position being filled
  - 11 applications, last interviews were held during week 11
  - First-ranked candidate withdraw the application, second-ranked expected to start working 1st of August
- EU application ENVRI, in order to fund development of data procedures (in negotiation)
  - Jointly with other Environmental ESFRI projects
    - » 9 months resource to be added on top of the PP project
    - » EISCAT participation coordinated by Dr. Ian McCrea
- EU application ESPAS, Near-Earth Space Data Infrastructure for e-Science (in negotiation)
  - EISCAT resource 53 months, mostly programmers work

EISCAT Svalbard Radar

FP7 Preparatory Phase

14 work packages:

WP1: Management and reporting
WP2: Legal and logistical issues
WP3: Science planning
WP4: Outreach activities
WP5: Consortium building
WP6: Performance specification
WP7: Signal processing
WP8: Antenna, front end and timing
WP9: Transmitter development
WP10: Aperture synthesis imaging
WP11: Software theory & implementation
WP12: System control
WP13: Data handling & distribution
WP14: Mass-production & reliability

EISCAT_3D

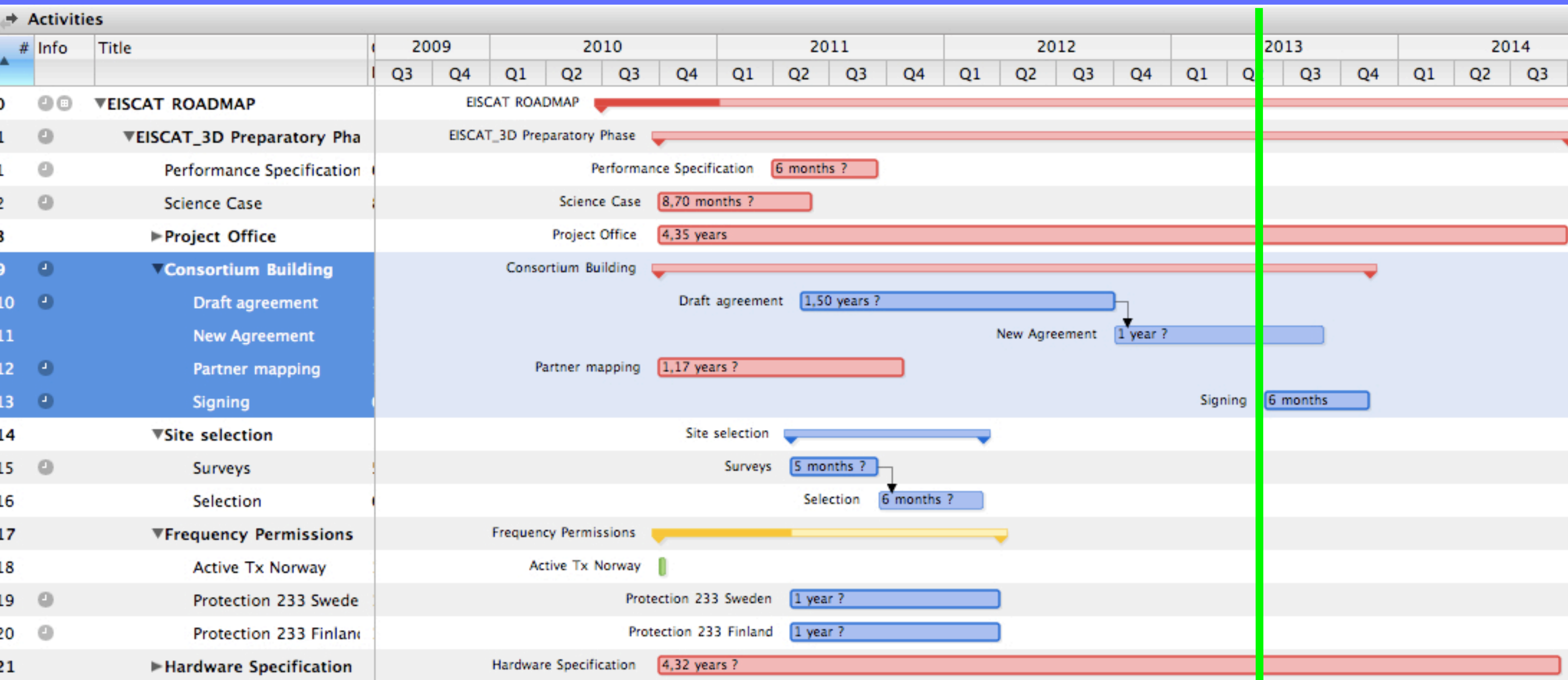
A European Three-Dimensional Imaging Radar for Atmospheric and Geospace Research

ESFRI Roadmap Project

EISCAT Scientific Association

WP 5, Consortium Building

- Swedish Research Council active
- Goal: New agreement, new partners



EISCAT Svalbard Radar

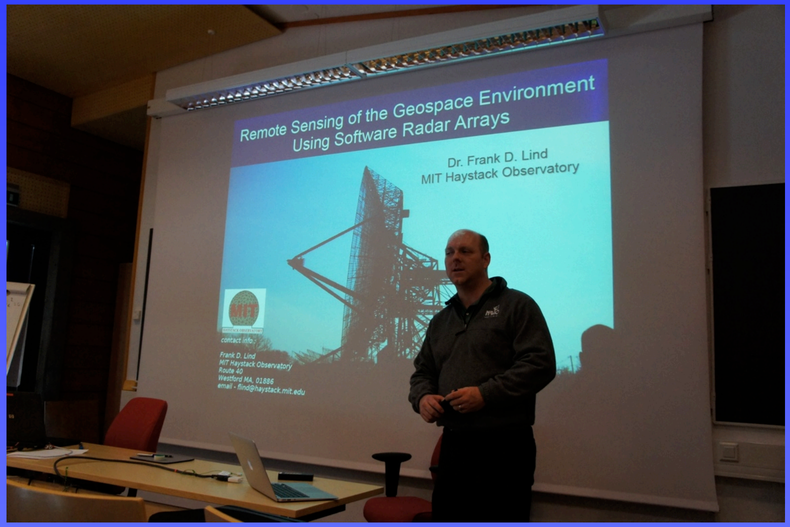
PP Project Partners

- EISCAT: Project management and reporting, site selection, consortium building, performance specification, system control, mass production issues, outreach activities
- University of Oulu: Signal processing, software development, theory, science planning
- University of Luleå: Antenna, front end and timing synchronisation, mass production
- IRF Kiruna: Transmitter development
- University of Tromsø: Radar imaging, site selection
- STFC RAL: Science planning, performance specification, project management
- National Instruments: Signal processing and timing, mass production issues
- VR-SNIC: Data handling and distribution
- VR (Swedish Research Council): Consortium building

EISCAT_3D_2
General Assembly

- Esa Turunen (EISCAT Scientific Association)
- Henrik Andersson (EISCAT Scientific Association)
- Cesar La Hoz (Universitetet i Tromsø)
- Jerker Delsing (Luleå Tekniska Universitet)
- Lars Eliasson (Institutet för Rymdfysik)
- Anita Aikio (Oulun Yliopisto)
- Tomas Andersson (Vetenskapsrådet)
- Leif Johansson (National Instruments)
- Richard Harrison (Science and Technology Facilities Council/ Rutherford Appleton Laboratory)

EISCAT_3D_2 TAC



- Technical Advisory Committee
  - Chair Frank Lind (Haystack Observatory, MIT)
  - Tom Grydeland (Norut, Tromsø)
  - Werner Singer (IAP Kühlungsborn)
  - Jan Geralt bin de Vaate (ASTRON, Netherlands)
  - Other experts to be invited according to needs
- Frank Lind and Phil Erickson/ MIT Haystack visited Scandinavia 7.-19.3.2011
  - Software radar seminar was held at Sodankylä on 17.3.2011

EISCAT_3D_2 Executive Board

- Esa Turunen (EISCAT Scientific Association)
- Henrik Andersson (EISCAT Scientific Association)
- Jonny Johansson (Luleå Tekniska Universitet)
- Thomas Ulich (Oulun Yliopisto/Sodankylän Geofysiikan Observatorio)
- Ian McCrea (Science and Technology Facilities Council/ Rutherford Appleton Laboratory)

- Anders Tjulin (EISCAT) participates meetings

EISCAT_3D_2 Executive Board

- Weekly teleconferences on Fridays at 11:00 UT
  - Written notes on all teleconferences
- Quarterly physical meetings
  - Quarterly financial reports by partners
  - Written notes on all meetings
- Monthly short activity reports by WP leaders sent to Executive Board

Events

3rd EISCAT 3D users meeting

- Uppsala, May 18-20, 2011

  -organized by Sweden (Dr. S. Buchert)

  -meeting focus on planning for the Science of the EISCAT_3D project, emphasizing particularly Atmospheric Physics (theme of the first day presentations)

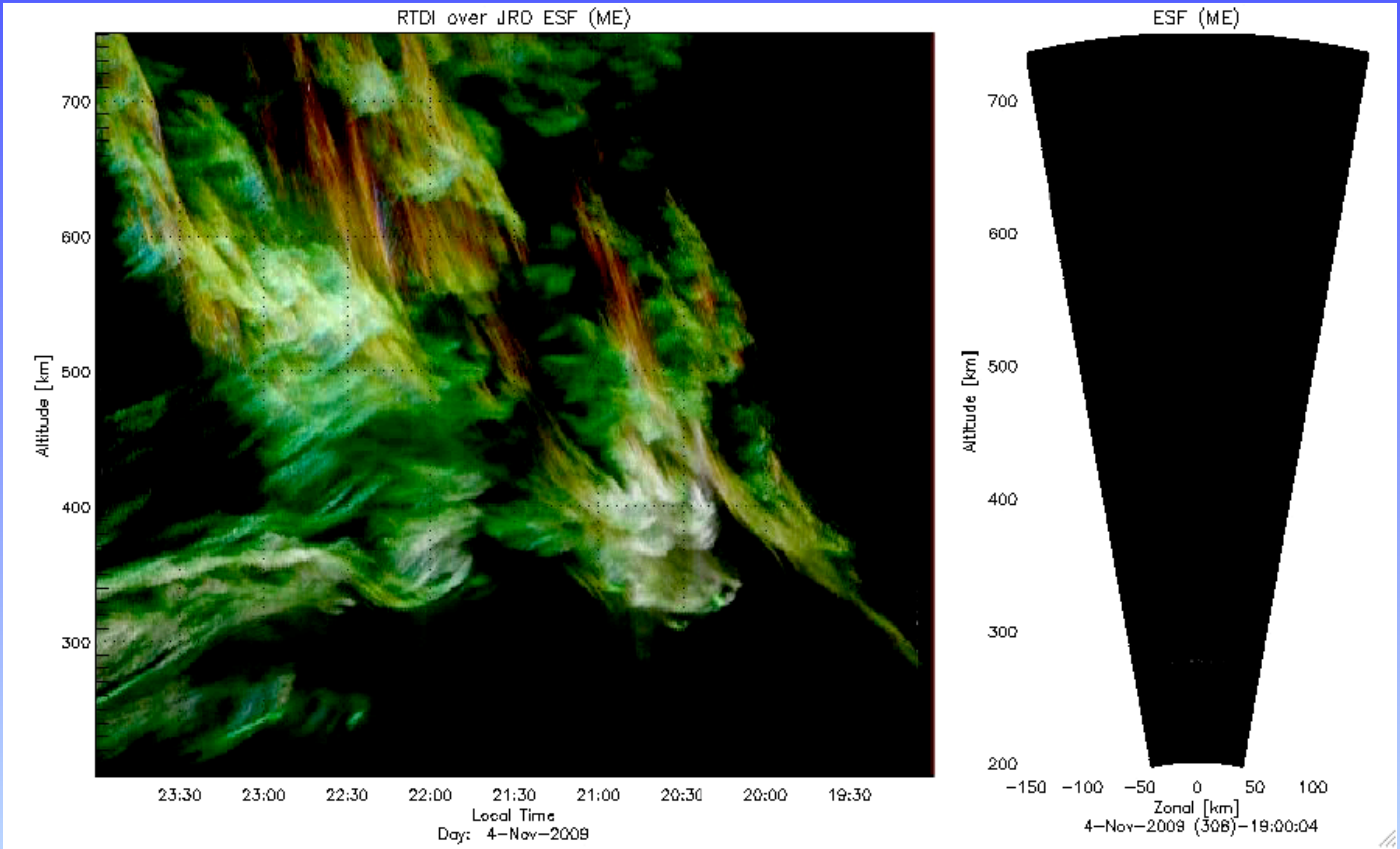
  -http://www.eiscat3d.se/

EISCAT Svalbard Radar

EISCAT: 5-10 years from now

Jicamarca - TODAY!

3-dimensional radar: Jicamarca 50 MHz



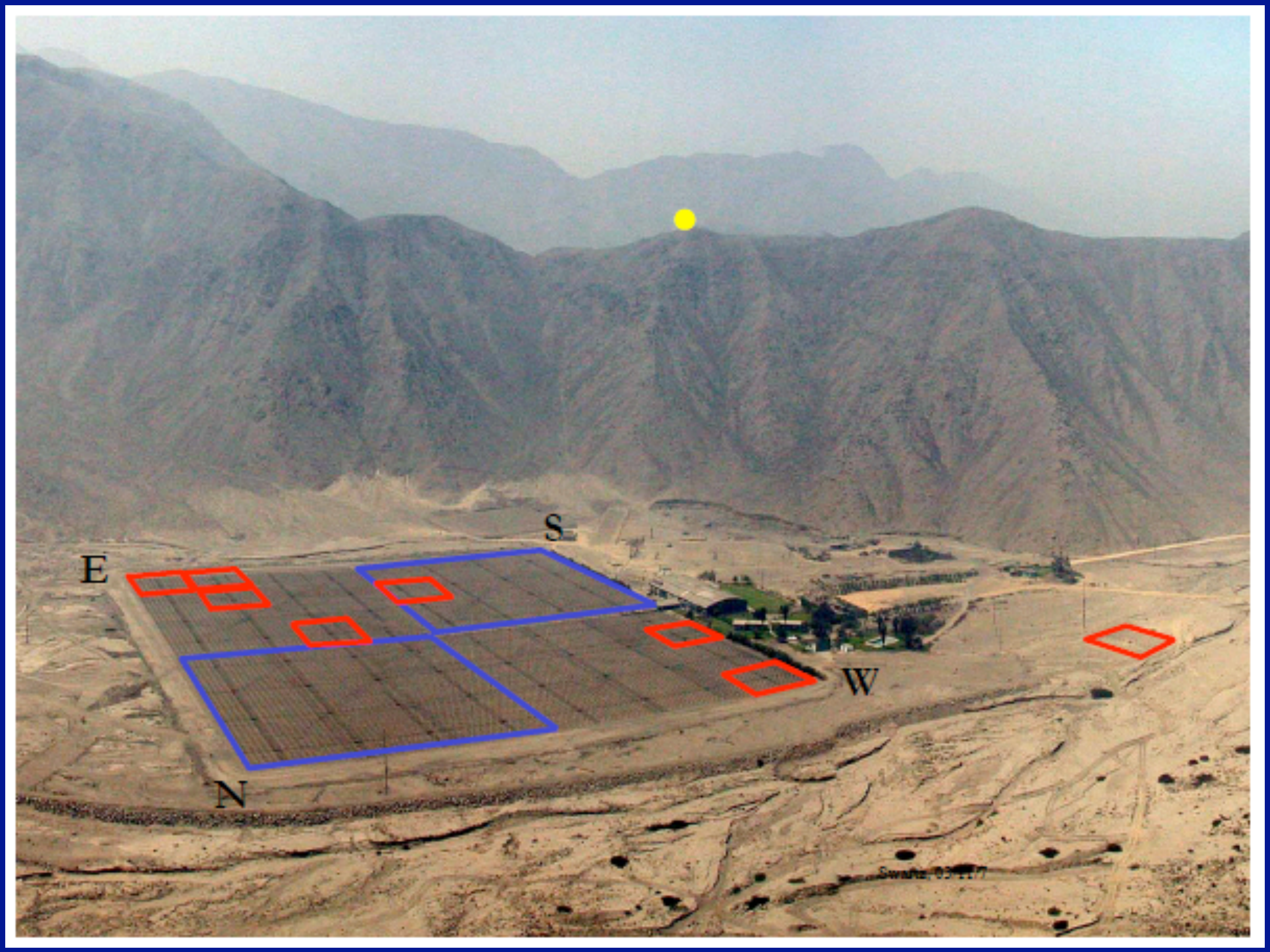
EU-US collaboration on large-scale research infrastructures

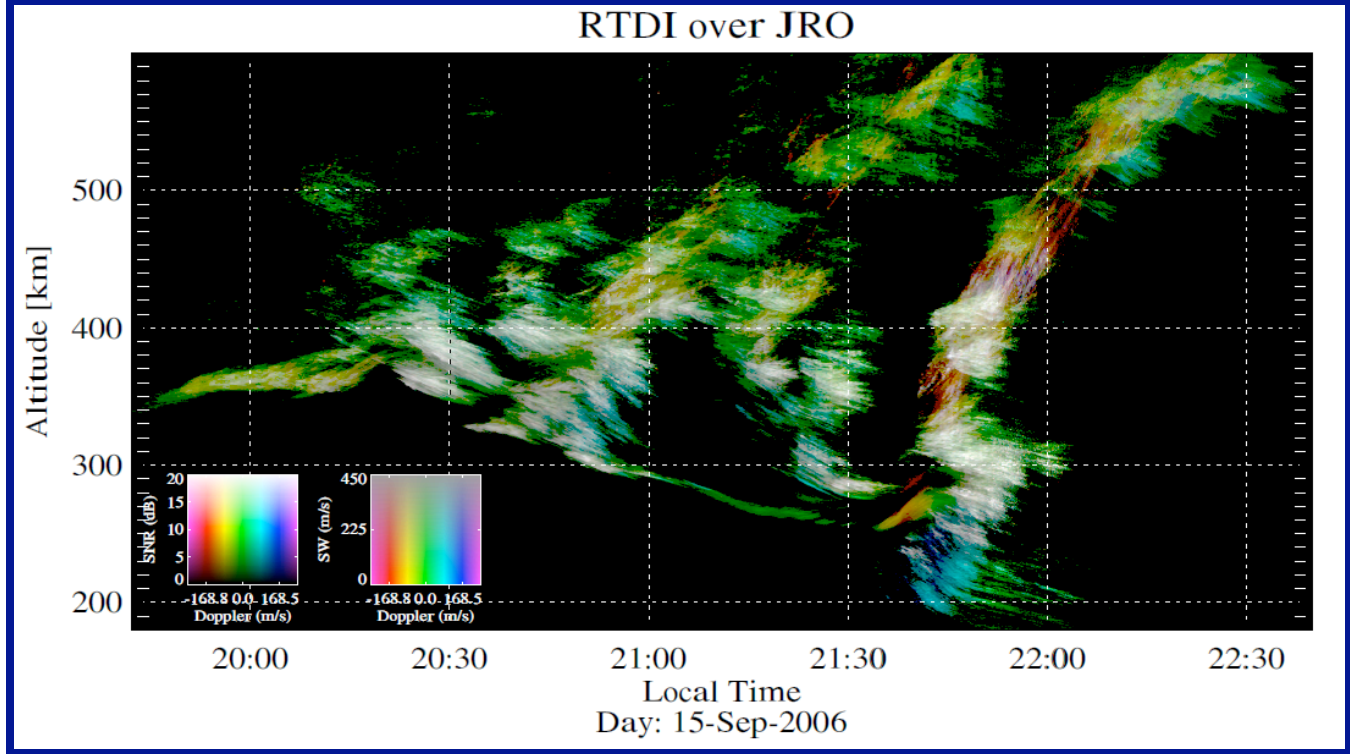
- funding call to be opened in July 2011 *(announced at EGU 2011)*

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

Joint Demonstrator Effort ?
EISCAT 3D Software Radar at Jicamarca





[Chau, et al., 2008]

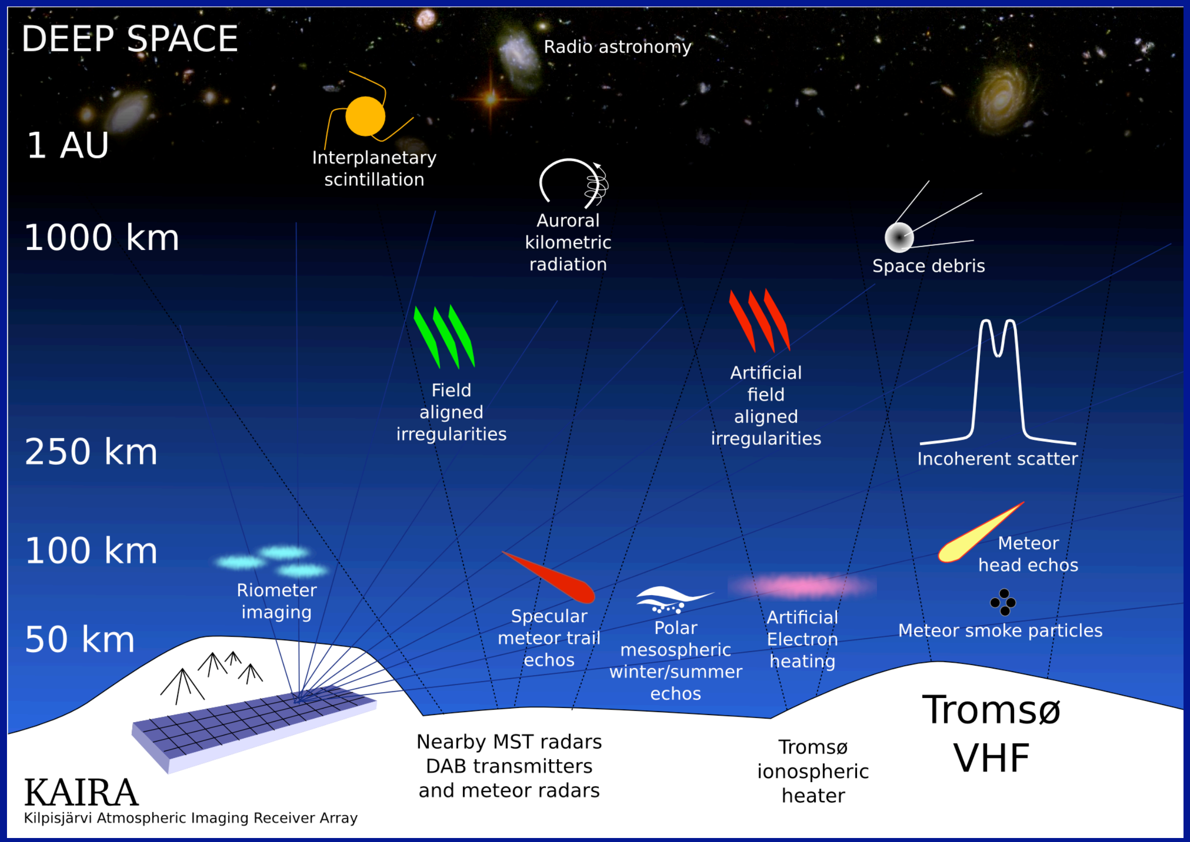
JRO as a Digital Array Radar Stepping Stone (done in Design Study)

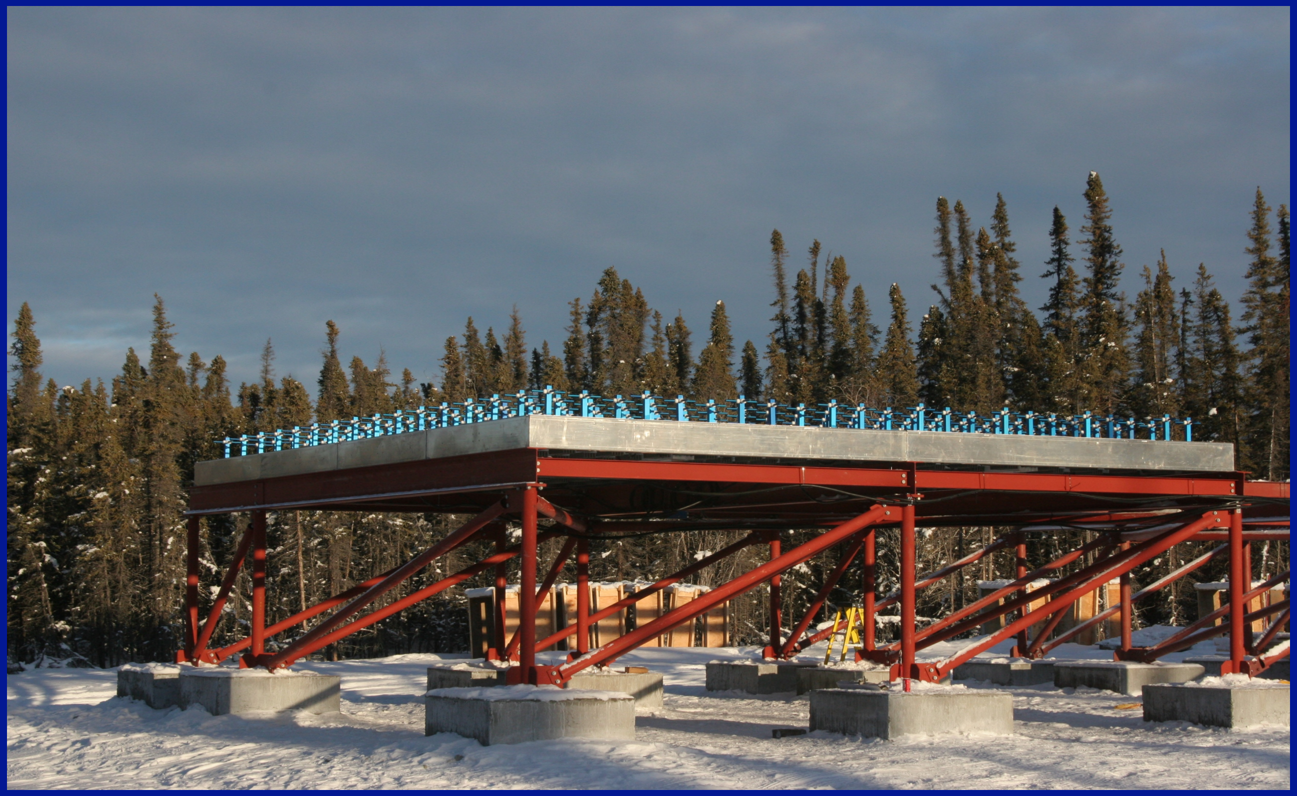
Deploy an Advanced Digital Receiver Network and Software Radar System at JRO

- Demonstrate 3D Radar Imaging and New Science Capabilities
- Manageable Complexity, Focus on Automation and Scalability

Target Science Focus : 3D Imaging of Equatorial Plasma Irregularities

Kilpisjärvi receiver “KAIRA”:
EISCAT 3D AMISR Based Transmitter





Build on the Engineering Investment in AMISR Antenna Element Unit

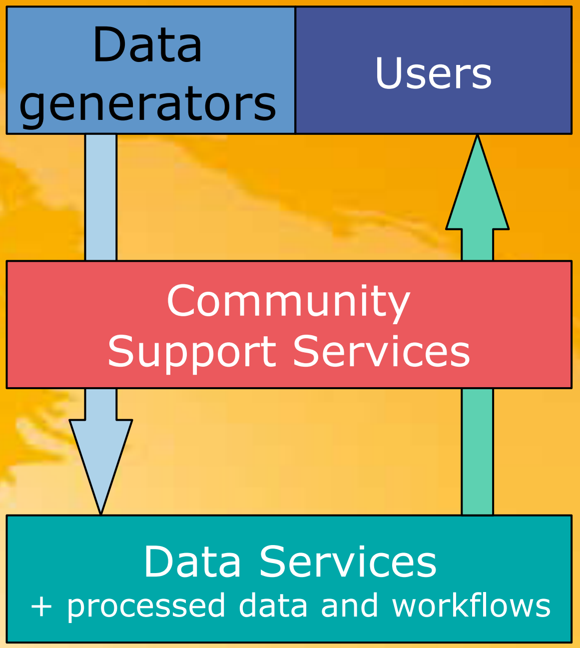
- Modernize and Retune for produce a Mk 2 unit suitable for EISCAT_3D
- Digital Waveform Generation, Polarization Control, Greater Efficiency

Deploy a Demonstrator Transmit Array in Tromsø Norway

Receive Signals with KAIRA in Finland

Target Science Focus : 3D Imaging of Polar Mesospheric Summer Echoes

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



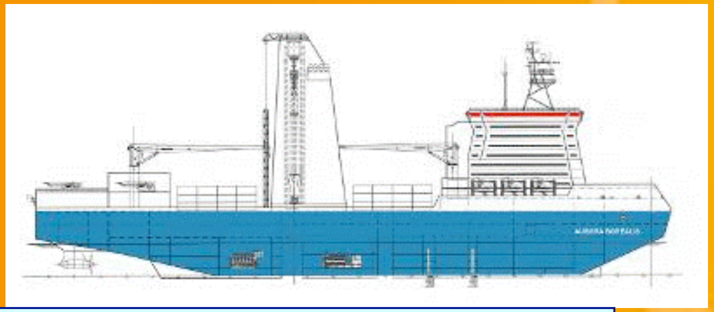
EURO-ARGO

SIOS

IAGOS-ERI

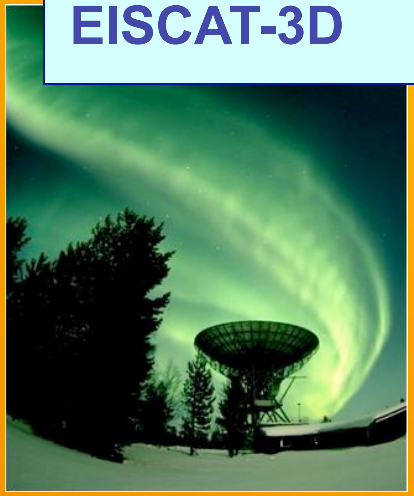
EUFAR-COPAL

AURORA BOREALIS



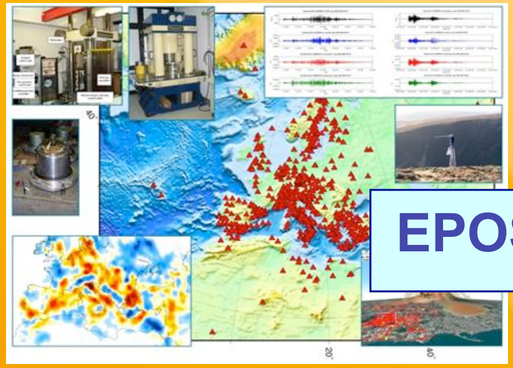
LIFEWATCH

EISCAT-3D



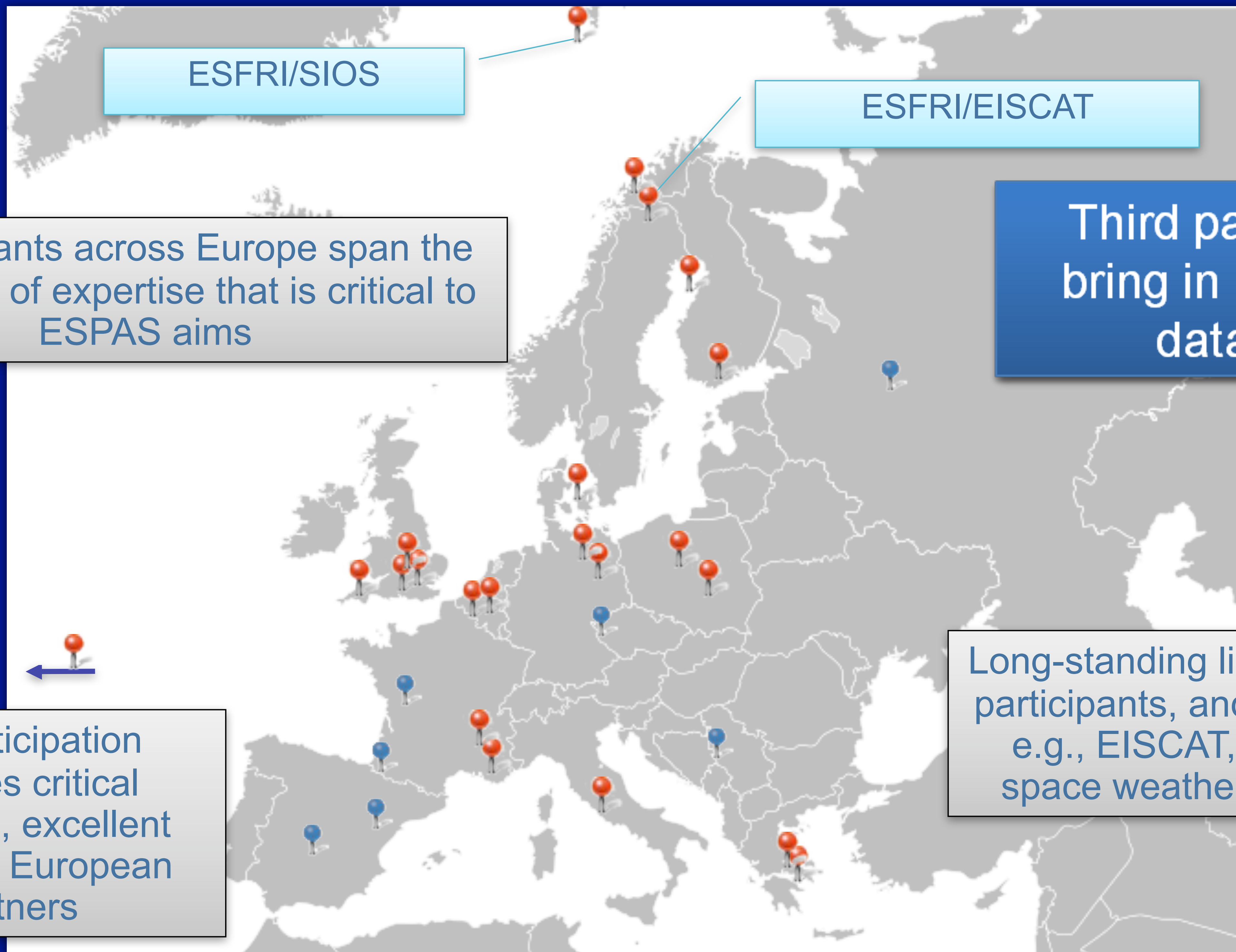
EMSO

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)

Coming EISCAT events

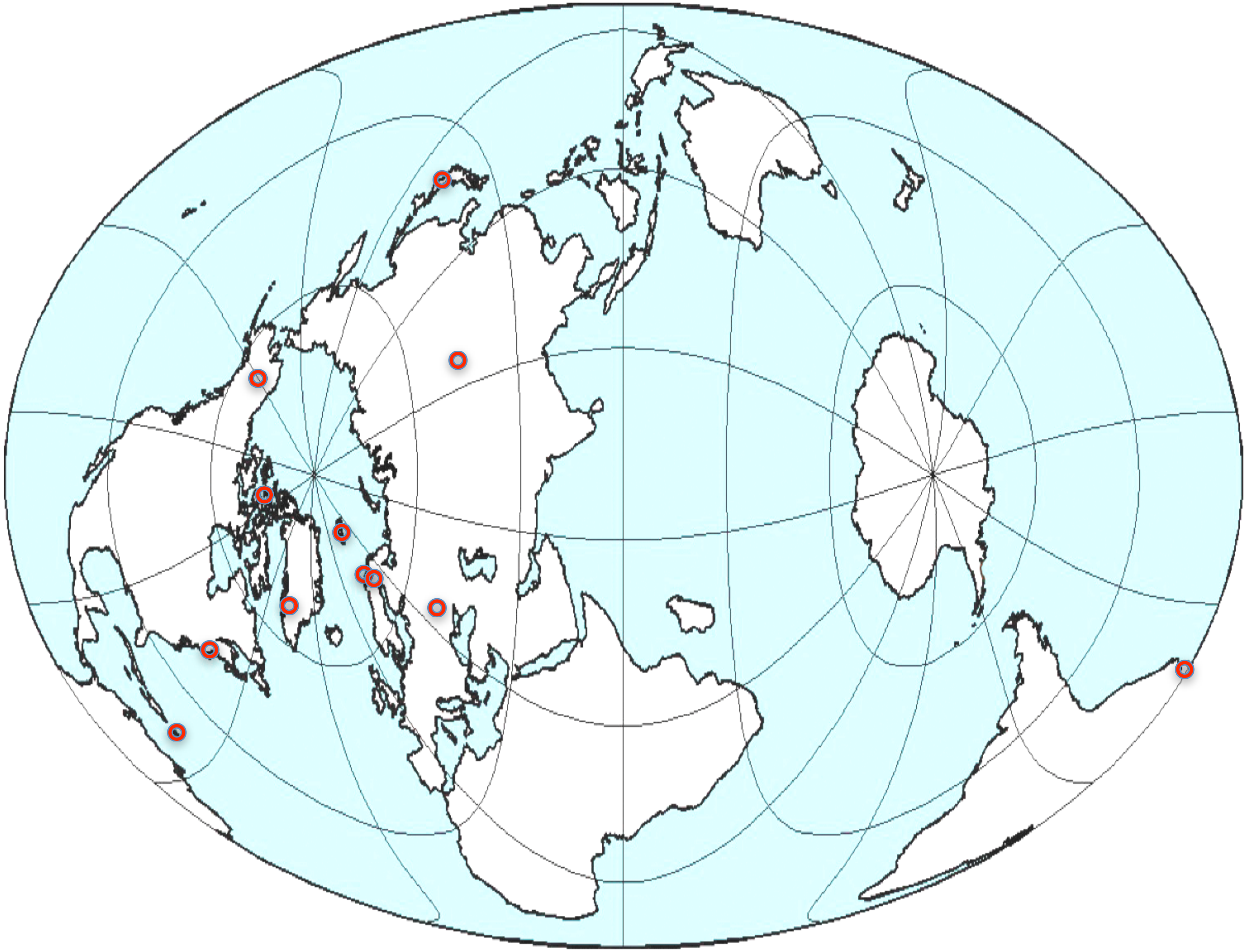
- 03-08.04.2011, EGU General Assembly, Vienna, Austria
  - Session ST3.4 "Advance in ionospheric research by incoherent scatter radars, related radio methods and novel large observational systems"
- 18-20.05.2011, 3rd EISCAT_3D Users meeting, Uppsala, Sweden
  - 1st day: Middle atmospheric science applications of EISCAT_D
  - 2nd and 3rd day: User applications of EISCAT_3D, status and actions in the Preparatory Phase Project
- 18-23.07.2011 International ISR workshop for students and new radar users in Greenland 18-23 July, 2011
  - An international incoherent scatter radar workshop aimed at providing participants with hands-on experience in designing and running incoherent scatter radar (ISR) experiments
  - At Sondrestrom Research Facility in Kangerlussuaq, Greenland
  - This workshop is a collaboration between the annual AMISR summer school and the EISCAT radar school.
- 13-20.08.2011 XXX URSI General Assembly and Scientific Symposium, Istanbul Turkey
  - Sessions G05 and G06: "Coordinated Studies with Multiple Incoherent Scatter Radars" and "Recent Developments in Incoherent Scatter Radar", respectively
- 5-9.09.2011, 15th EISCAT International Workshop, Qingdao, China
  - Session and ceremony "EISCAT 30 years"
  - Session "The EISCAT_3D and the future"
- 14-22-07.2012 39th COSPAR Scientific Assembly, Mysore, India
  - Session C04: New Generation Middle and Upper Atmosphere Radars: Application and Development

The Global Geospace Radar Array

Measure the Physical Properties of the Space Environment
Global Coverage Is Key for the Science and its Value to Society
Science As A Service : Connect Science to Society at All Levels

Current global coverage is uneven

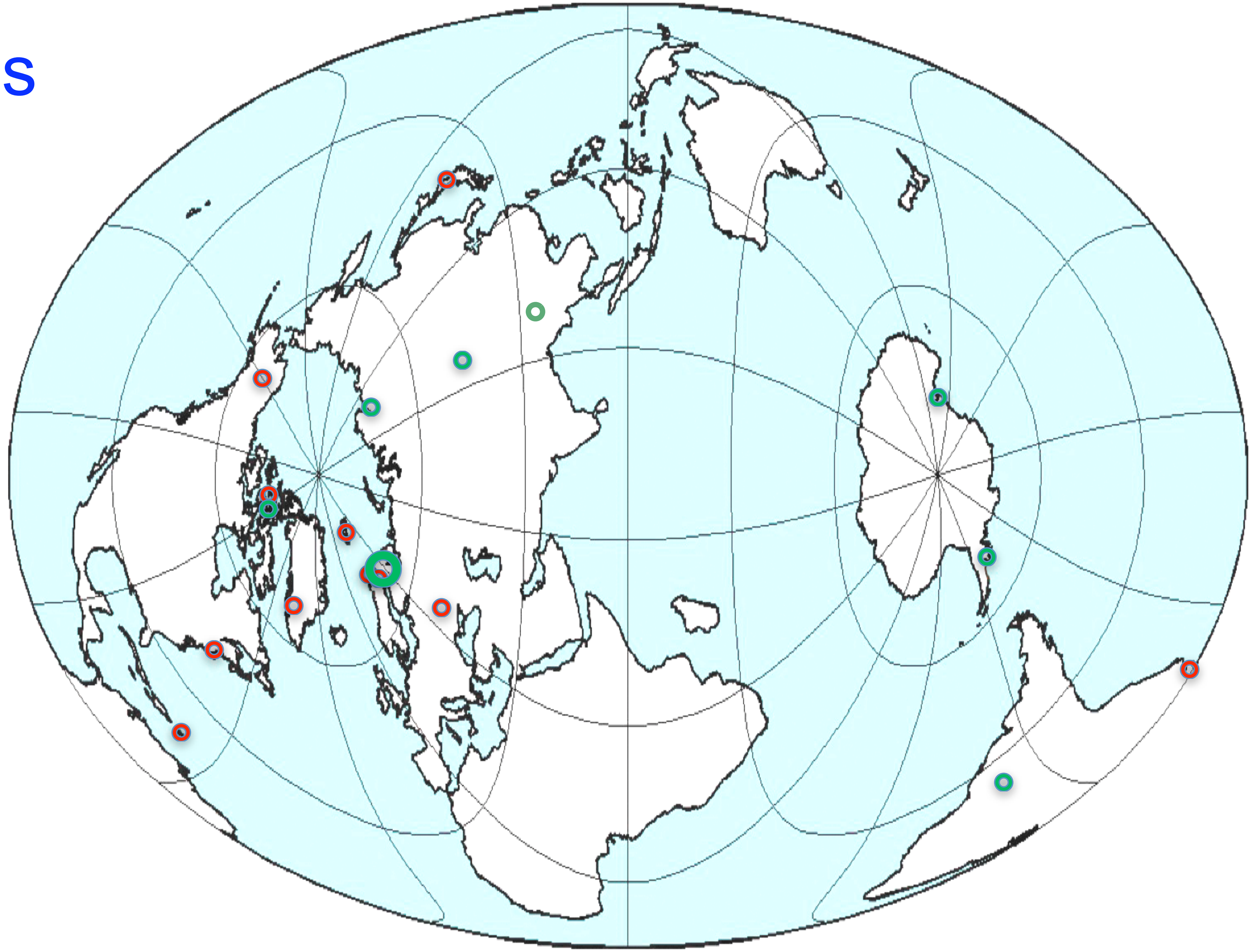
- Poker Flat
- Resolute Bay N
- Sondrestrom
- Millstone Hill
- Arecibo
- Jicamarca
- EISCAT ESR
- EISCAT UHF
- EISCAT VHF
- Kharkov
- Irkutsk
- MU



Future coverage foreseen

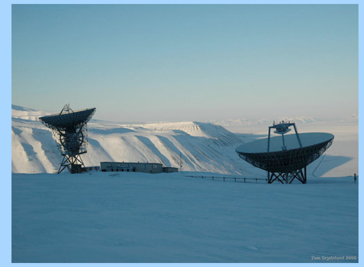
Additional sites

- AMISR
  - Resolute Bay
  - *Argentina*
  - *Antarctica (2)*
    - *Mc Murdo*
    - *MAISR-2*
- Europe
  - *EISCAT_3D*
- China
  - *Qujing*



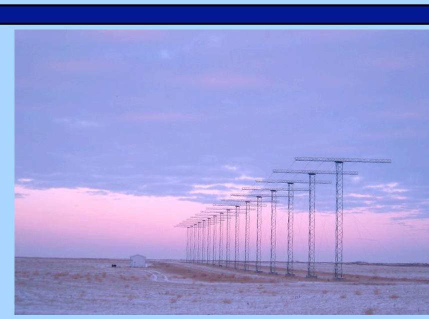
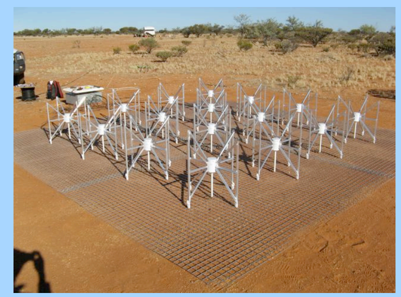
2020 The Geospace Instrument Array

Facility Scale Instruments

Major Geospace Facilities
Large Radio Telescopes

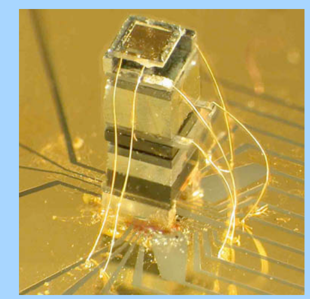
Medium Scale Instruments


SuperDARN Network
Low Cost IS Radars
Optics Arrays
(moderate numbers)

Small Scale Instruments



Software Radio Arrays
GPS Arrays
All Sky Camera Arrays
Magnetometer Arrays
(large numbers)

World Wide Web

Supercomputing Geospace Assimilation Grid

Geospace Search Engines	Virtual Observatories	Space Weather Models

Scientists Educators Public

2020

"If you are going to dream, dream big"

Bill Gordon
Creator of the Arecibo Observatory

Outreach

- Website
  - http://www.eiscat3d.se
- Video on Youtube
  - can also be downloaded at the eiscat3d web
- blog
  - http://blog.eiscat3d.org
- facebook page
  - http://www.facebook.com/EISCAT3D
- twitter feed
  - http://twitter.com/EISCAT_3D

Preparatory Phase 2010-2014

EISCAT 3D

our window to geospace

EISCAT_3D is a 3-dimensionally imaging incoherent scatter radar

Continuous measurements of the space environment - atmosphere coupling in the auroral oval and at the southern edge of the polar vortex.

- Influence of natural solar-terrestrial variability on atmosphere and climate.
- Long-term change due to human activity.
- Coupling between atmospheric layers.
- Space plasma physics.
- Measurements of solar wind and corona.
- Effects of meteors and energetic particles.
- Monitoring of space weather.
- Support for future space missions.
- Orbit determination of space debris and meteors.
- Radar mapping of near-Earth objects.

Distributed sites (at least 5)
Core site 5oom / 30 000 antennas