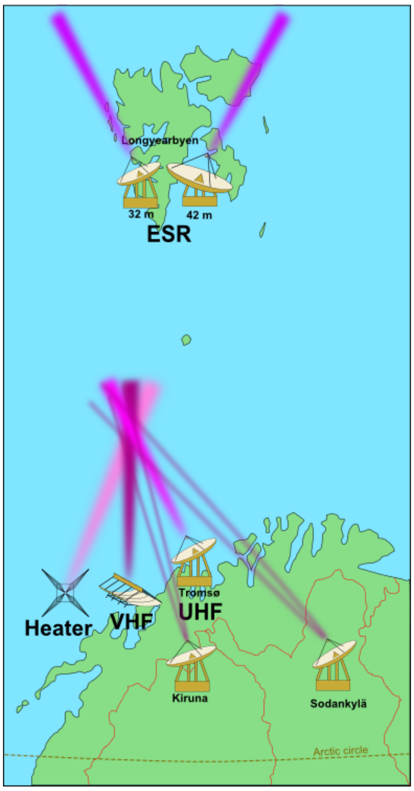
EISCAT

EUROPEAN INCOHERENT SCATTER
SCIENTIFIC ASSOCIATION

ANNUAL REPORT 2012



EISCAT Radar Systems

Location	**Tromsø**		**Kiruna**	**Sodankylä**	**Longyearbyen**	
Geographic coordinates	69°35′N 19°14′E		67°52′N 20°26′E	67°22′N 26°38′E	78°9′N 16°1′E	
Geomagnetic inclination	77°30′N		76°48′N	76°43′N	82°6′N	
Invariant latitude	66°12′N		64°27′N	63°34′N	75°18′N	
Band	UHF	VHF	VHF	VHF	UHF	
Frequency (MHz)	929	224	224	224	500	
Maximum bandwidth (MHz)	8	3	8	8	10	
Transmitter	2 klystrons	1 klystron	-	-	16 klystrons	
Channels	6	6	6	6	12	
Peak Power (MW)	2.0	1.6	-	-	1.0	
Average power (MW)	0.25	0.20	-	-	0.25	
Pulse duration (ms)	0.001–2.0	0.001–2.0	-	-	0.0005–2.0	
Phase coding	binary	binary	binary	binary	binary	
Minimum interpulse (ms)	1.0	1.0	-	-	0.1	
Digital processing	14 bit ADC on IF, 32 bit complex autocorrelation functions, parallel channels					
					Antenna 1	**Antenna 2**
Antenna	parabolic dish 32 m steerable	parabolic cylinder 120 m × 40 m steerable	parabolic dish 32 m steerable	parabolic dish 32 m steerable	parabolic dish 32 m steerable	parabolic dish 42 m fixed
Feed system	Cassegrain	line feed 128 crossed dipoles	crossed dipole	crossed dipole	Cassegrain	Cassegrain
System temperature (K)	90	250	100	100	80	65
Gain (dBi)	48.1	46	48.1	48.1	42.5	44.8
Polarisation	circular	circular	any	any	circular	circular

EISCAT Heating Facility (Tromsø)

Frequency range: 4.0 MHz to 8.0 MHz, Maximum transmitter power: 12×0.1 MW, Antennas: Array 1 (5.5 MHz to 8.0 MHz) 30 dBi, Array 2 (4.0 MHz to 5.5 MHz) 24 dBi, Array 3 (5.5 MHz to 8.0 MHz) 24 dBi.
Additionally, a Dynasonde is operated at the heating facility.

Cover picture:

The EISCAT receiver stations in Kiruna and Sodankylä were converted from UHF to VHF during 2012.
Photo: William Rideout

EISCAT Scientific Association
2012

EISCAT, the European Incoherent Scatter Scientific Association, is established to conduct research on the lower, middle and upper atmosphere and the ionosphere using the incoherent scatter radar technique. This technique is the most powerful ground-based tool for these research applications. EISCAT is also being used as a coherent scatter radar for studying instabilities in the ionosphere, investigating the structure and dynamics of the middle atmosphere, studying meteors and as a diagnostic instrument in ionospheric modification experiments with the heating facility.

There are fourteen incoherent scatter radars in the world, and EISCAT operates three of the highest-standard facilities. The EISCAT sites are located north of the Arctic Circle in Scandinavia. They consist of two independent radar systems on the mainland, together with a radar constructed on the island of Spitzbergen in the Svalbard archipelago — the EISCAT Svalbard Radar (see sketch and operating parameters on the inside of the front cover).

The EISCAT VHF radar operates in the 224 MHz band with a peak transmitter power of 1.6 MW, using a 120 m × 40 m parabolic cylinder antenna which is subdivided into four sectors. This antenna can be steered mechanically in the meridional plane from vertical to 60° north of the zenith; limited east-west steering is also possible using alternative phasing cables. Receiving sites are also located in Kiruna (Sweden) and Sodankylä (Finland), allowing for tri-static radar measurements.

The monostatic EISCAT UHF radar in Tromsø operates in the 931 MHz band with a peak transmitter power of 2.0 MW, and employs fully steerable 32 m parabolic dish antennas.

The EISCAT Svalbard radar (ESR), located near Longyearbyen, operates in the 500 MHz band with a peak transmitter power of 1.0 MW, and employs a fully steerable parabolic dish antenna of 32 m diameter and a fixed antenna, aligned with the local magnetic field, with a 42 m diameter. The high latitude location of this facility is particularly aimed at studies of the cusp and the polar cap region.

The basic data measured with the incoherent scatter radar technique are profiles of electron density, electron and ion temperatures and bulk ion velocity. Subsequent processing allows derivation of a wealth of further parameters, describing the ionosphere and neutral atmosphere. A selection of well-designed radar pulse schemes are available to adapt the data-taking routines to many particular phenomena, occurring at altitudes from about 50 km to above 2000 km. Depending on geophysical conditions, a best time resolution of less than one second and an altitude resolution of a few hundred meters can be achieved.

Operations of 3000 h to 4000 h each year are distributed between Common Programmes (CP) and Special Programmes (SP). At present, six well-defined Common Programmes are run regularly, for between one and three days, typically about once per month, to provide a data base for long term synoptic studies. A large number of Special Programmes, defined individually by Associate scientists, are run to support national and international studies of both local and global geophysical phenomena.

Further details of the EISCAT system and its operation can be found in various EISCAT reports, including illustrated brochures, which can be obtained from EISCAT Headquarters in Kiruna, Sweden.

The investments and operational costs of EISCAT are shared between:

China Research Institute of Radiowave Propagation, Peoples Republic of China
National Institute of Polar Research, Japan
Natural Environment Research Council, United Kingdom
Norges forskningsråd, Norway
Solar-Terrestrial Environment Laboratory, Nagoya University, Japan
Suomen Akatemia, Finland
Vetenskapsrådet, Sweden

Contents

Words from the EISCAT Chairman

As in the previous year, the main focus during 2012 was the realization of Eiscat_3D project and the third Svalbard antenna.

With regard to EISCAT_3D, an application for finance of part of the future system was sent in to the Norwegian Research Council. To design the application, a lot of coordinating discussions was needed in order to understand what would be a suitable Norwegian contribution and what could be a final design of the system that all associates would appraise. Whatever will be the final outcome of the application it should be seen as a milestone in realizing the EISCAT_3D system. In 2013, Swedish researchers will send in an application to the Swedish Research Council, essentially building on the same base as the Norwegian one and the other associates are planning for similar actions. Beside the actual application, the process also involves national gathering of all researchers (impressive amount) interested in a future EISCAT_3D-system and initiated scientific discussion, which gives input to the fine tune final design of the system. In short, the journey has begun.

Another major effort has been performed by the New Agreement group, who probably in 2013 will be able to present a first draft of an agreement for EISCAT Scientific Assosciation. Many important issuses have been analysed, as how the new member status will look (the role of associates, affiliates and the possibility for time buying) and how the data access should be designed and regulated in the new system. The first item is of course important when approaching possible new members, while the second issue needs careful consideration since the data from the new system will be different and with very high resolution and may in some cases be sensitive if used wrongly.

An important mechanism for introducing new users and possible associates to the system is the 200 hours of peer reviewed time announced yearly. During 2012 the program has seen applications for more than twice the time announced and granted, which is a good sign for the future.

The feasibility study regarding the Svalbard 3rd antenna has developed rapidly and in the beginning of 2013 Council will need to consider the overall picture of the results in order to decide the feasibility for Eiscat taking responsibility for the planned radar. This was also one of the reasons why the autumn meeting of Council was moved to February 2013.

Since the EISCAT Director Esa Turunen will become Director for Sodankylä Geophysical Observatory (SGO) in 2013, Council started a recruitment process for a new director. Among several excellent candidates the choice fell on Craig Henselman from SRI International, who was the technical director behind the construction of the American phased array radars.

Dr. Tomas Andersson
Chairperson, EISCAT Council

EISCAT_3D

This is a short text reporting the progress of the work in the EISCAT_3D Preparatory Phase project during 2012.

Background of the Preparatory Phase

The high-latitude atmosphere and ionosphere are critically important for the study of Solar-Terrestrial relationships as well as the physical processes and the coupling of the different altitude regions in the Earth's atmosphere. The Arctic areas of Northern Europe provide a unique opportunity to observe this region from the ground with instruments placed within a well-developed infrastructure of observational facilities and research institutions. EISCAT_3D will be a world-leading international Research Infrastructure, using the incoherent scatter technique to study the atmosphere in the Scandinavian Arctic and to investigate how the Earth's atmosphere is coupled to space. EISCAT_3D will provide an advanced tool for studying plasma physics phenomena in the atmosphere, a key atmospheric monitoring instrument for climate and space weather studies and an essential element in international global multi-instrument campaigns for studying the environment.

EISCAT_3D will consist of several phased-array antenna sites for transmission of high-power radio waves and reception of faint signals back-scattered by charged particles in the atmosphere. Measuring and analysing the radio signal accurately probes the composition and physical parameters of the upper atmosphere. Each antenna array will consist of a large number of single antennas whose individual signals are digitally manipulated and combined to provide a cutting-edge atmospheric radar system. This will enable new types of volumetric imaging observations, multi-static observations, detailed studies on small scales, and quasi-continuous observations of the upper atmosphere. In order to reach the measurement objectives the radar will be distributed over several sites in Northern Scandinavia. The flexibility of the new instrument requires new measurement strategies and opens the radar observations to an expanding user community.

EISCAT_3D will contribute to the growing field of research based on accumulating, handling and analysing large data volumes for Earth system studies. The fully working array will produce a data rate of several TB/s and the expected stored data volume in the initial phase of operation will be of the order of 1000 TB per year. Exploitation of its full potential requires collaboration with regional e-infrastructures and close connection to global e-infrastructures for the environment.

EISCAT Scientific Association is the Coordinator of the EISCAT_3D Preparatory Phase project. EISCAT is currently funded and operated by research councils of Norway, Sweden, Finland, Japan, China and the United Kingdom and has its headquarters in Kiruna, Sweden. It runs a radar system on Svalbard and a system on the Northern Scandinavian mainland consisting of a main transmitting and receiving radar site in Tromsø, Norway, and receiving sites in Sodankylä, Finland, and Kiruna, Sweden. The latter mainland system, that has successfully been producing incoherent scatter data for more than 30 years, will be replaced by the new EISCAT_3D system. The EISCAT host institutions actively participate in the project.

The current Preparatory Phase, that started in October 2010, aims to ensure that the project will reach a sufficient level of maturity so that the implementation of EISCAT_3D can begin immediately after its conclusion in September 2014.

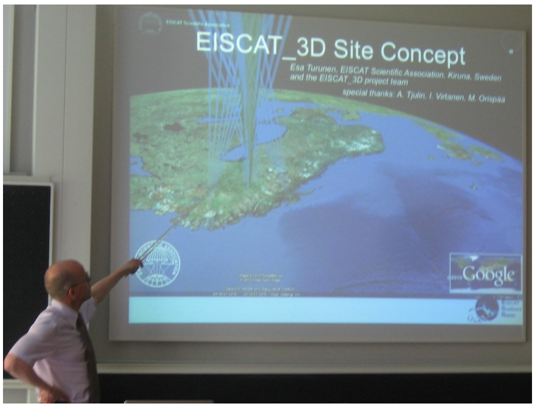
Progress during the year

The Preparatory Phase is concerned with forming a consortium, procuring the financing, selecting the sites, preparing for the data handling, considering the scientific requirements and planning construction and operation. For all these tasks researchers and other stakeholders are involved. The project actively involves the scientific user community and all relevant documents can be found on the project website[1], the major fraction being open to the public.

EISCAT Scientific Association will provide the basis for the future EISCAT_3D consortium. The current EISCAT Associates have stated their support for the new EISCAT_3D. EISCAT Council has formed a working group together with the project to negotiate a new consortium agreement for the EISCAT Association that should be more suitable for constructing and operating EISCAT_3D and for attracting new members. Procedures will also be implemented within the research infrastructure to safeguard good scientific practice and to ensure the commitment to excellent research.

To procure the finances, major investments will be needed from several countries. The current estimate of costs for EISCAT_3D that assumes a total budget of 120 M€ to be invested over five to eight years, needs to be confirmed based on detailed planning and site selection. Funding opportunities for research infrastructures for possible investment into EISCAT_3D in the coming years are identified in Norway, Sweden and Japan. The Finnish user community has submitted a proposal to include EISCAT_3D in the national roadmap for research infrastructures. Funding situations in China and the United Kingdom are currently explored. Several other countries are either actively pursuing research based on EISCAT measurements or planning to do so in the near future. These are Belgium, Germany, Ireland, Italy, Poland, Russia and Ukraine. Some of these countries currently consider possible future participation in the EISCAT_3D consortium. The outreach activities of the project, conference presentations by the project participants and the EISCAT_3D project meetings are particularly important in this context.

The site selection makes some progress, though the requirements for site location vary for the different measurement objectives and need to be balanced. The site surveys, that are carried out by the project, investigate the radio environment as



EISCAT Director Esa Turunen presents the EISCAT_3D site selection process during the annual EISCAT_3D User Meeting in Uppsala (photo: Thomas Ulich).

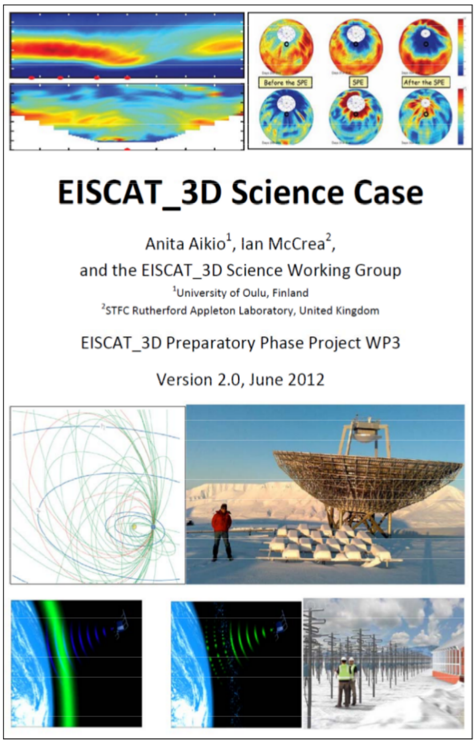
well as the local infrastructure conditions. These surveys can not be made during the Arctic winter which constrains the schedule to the summer. Allocations for the frequency range of the EISCAT_3D system have been obtained in Norway for the area around the present EISCAT systems, but not yet in any other areas of Norway or in Finland and Sweden. Progress in frequency allocation can be made as soon as the there are firm decisions on the site locations and the first construction funding for the project is granted.

Planning for the data handling covers issues ranging from the direct connection of radar sites to the internet to the maintenance of the data and its placement within the framework of international geospace observatories and environmental research infrastructures.

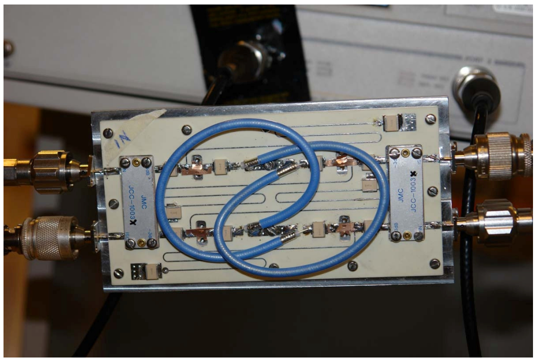
Preparatory work is also carried out in the frame of other projects. EISCAT, as Coordinator of the EISCAT_3D Preparatory Phase, participates in consortia funded by the European Union through Framework Programme 7: ENVRI is related to the common needs of ESFRI projects in terms of data handling, storage and management. ESPAS will facilitate user access to space weather data from ground-based and satellite experiments. COOPEUS that is currently under negotiation will facilitate collaboration with US environmental research institutions for common data policies and standards relevant to global research infrastructures in the environment field.

The scientific requirements have a major influence on the system design and for this a Science Case is continuously revised in collaboration with the present EISCAT user community and with prospective future users. Communication with the

[1] www.eiscat3d.se



Cover of the 2012 version of the EISCAT_3D Science Case.



Board used for testing of the T/R switch design for EISCAT_3D.

scientific user community is facilitated through outreach activities, conference presentations and a series of dedicated meetings organized by the project. The website for EISCAT_3D has been online since March 2009 and is regularly maintained and updated.

The project sets a high priority on expanding the user base into the space weather and middle atmosphere communities, which have not been major users of EISCAT in the past. Nonetheless, discussions also showed that in order to prepare competitive proposals to the national funding bodies it is important to clearly state the primary objectives of the project and to emphasise the key scientific issues that focus on those measurement capabilities of EISCAT_3D that are unique: the capability of continuous observations, of both small and large scale observations and the flexibility of changing the modes in order to directly respond to observed phenomena.

Planning the construction and operation of the EISCAT_3D requires a detailed instrument design. The design planning is based on a previous Design Study (funded within FP6) and on the long experience with the existing EISCAT radars. The project also aims to make use of innovative theoretical studies in signal processing, radar coding, data handling and data analysis. This recent progress is summarised in a handbook of measurement principles, whose initial version was prepared during the first months of the Preparatory Phase for consideration during the planning. The new instrument will carry out signal processing using Software-Defined Radio (SDR) receiver systems. The hardware needed for the field-testing of the planned signal processing development has been acquired. In order to produce designs of antennas, array layout, receiver front end and calibration systems suitable for manufacturing, antenna elements were identified and an antenna array layout was recommended. For designing and evaluating the EISCAT_3D radar transmitter subsystem, a prototype 3-channel exciter has during this year been successfully tested at the Jicamarca radar facility in Peru. While work on specific technical tasks makes good progress, the results still need to be combined within an instrument design.

The project faces a wide range of expectations from researchers and other stakeholders. User expectations are in some cases contradictory, ranging from the desire to have a new system workable as quickly as possible to the desire to design the system in a sophisticated way based on the results of mathematically rigorous considerations. Combined with some gaps in the technical work that was proposed in the original project plan and with a deficiency in available engineering workforce at the project Coordinator, this has severely delayed the preparation of the instrument performance specification. This delay of a Deliverable in the project has an impact on some of the technical Work Packages and imposes uncertainties on budget and experiment description needed for the consortium negotiations. The project Coordinator approached this problem with the recruitment of a technical manager for the EISCAT_3D project and through continued efforts to communicate with the user community. Other delays of Milestones and Deliverables have less impact on the work plan. Delayed starts of some of the Work Packages have also required minor changes in the project planning that will be compensated by an intensified activity later in the project.

The project benefits from its location within a network of well-developed observational facilities and research institutions that are very supportive of the project. At the same time they have different expectations that have to be met in a way so that all stakeholders are satisfied. To meet this challenge the project Coordinator benefits from exchange of experience, networking and training on managing international research infrastructures that is offered by projects within the Framework Programme 7. Swedish Research Council supports the development of the project with a 7 MSEK planning grant for 2012 and 2013 from its funding programme for research infrastructures. A major fraction of this funding is planned for negotiations and organisational preparation of the project.

Expectations

The goal of the Preparatory Phase is to bring the EISCAT Scientific Association in the position to begin implementing the new infrastructure in 2014. While not all of the Deliverables of the project have yet been delivered on time, the reasons for delays have been identified and measures have been taken to compensate for these delays so that there is confidence within the project that the EISCAT_3D Preparatory Phase will end successfully. Regional and national enterprises from a wide range of industrial sectors are expected to participate in building the new system. The project expects that the EISCAT_3D data will be managed in collaboration with the local e-infrastructure in the Nordic countries. The Research Infrastructure will be connected to universities and research institutions locally in Northern Scandinavia close to the sites, and globally through the members of the association and the international research community. EISCAT_3D will also provide young researchers and engineers the opportunity to gain experience in the maintenance and handling of huge data volumes and will introduce young scientists to environmental research on internationally competitive level.

Project partners

There are eight partners in the EISCAT_3D Preparatory Phase:

- EISCAT Scientific Association (EISCAT)
- University of Oulu (UOULU)
- Luleå University of Technology (LTU)
- Swedish Institute of Space Physics (IRF)
- University of Tromsø (UiT)
- Science & Technology Facilities Council (STFC)
- Swedish Research Council (VR)
- National Instruments Belgium NV (NI)

The host institutions for the present EISCAT systems are Sodankylä Geophysical Institute (independent department of University of Oulu), University of Tromsø and Swedish Institute of Space Physics.

Scientific highlights 2012

Studies using artificial ionospheric heating

Observations of pump-enhanced plasma temperature and optical emission excitation rate as a function of power flux

Optical emissions and EISCAT derived temperatures during high power heating were used to investigate the relationships between the pump wave power flux at the Upper Hybrid Resonance height, enhanced electron temperature and $O(^1D)$ excitation rate. It was demonstrated (Figure 1) that a quasi-linear relationship exists between the HF power flux and both the excitation rate and electron temperature with a threshold at around $37.5\,\mu W\,m^{-2}$. The HF flux loss due to self-absorption in the D-region (typically 3 dB to 11 dB) and refraction in the F-region was quantified to determine the flux which reaches the upper-hybrid resonance height. On average about 70 % of the HF flux at the upper-hybrid resonance height goes into heating the electrons for fluxes above the threshold compared to about 40 % for fluxes below the threshold. It was determined that for electrons with a Maxwellian energy distribution about 40 % of the pump energy goes into ohmic heating of the plasma and about 30 % is transferred to electrons via electrostatic UH waves. It was estimated that about 20 % of the pump wave energy is transferred to the suprathermal electrons, a third of which is lost to excitation of the $O(^1D)$ state where a total of about 1 % of the pump flux at the UHR altitude is converted into photons.

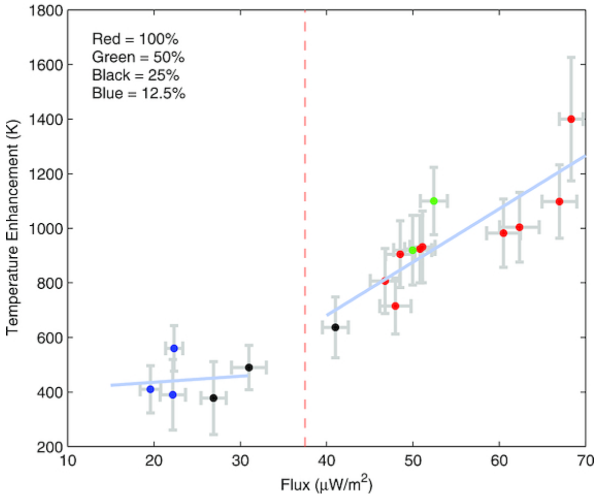


Figure 1: Electron temperature enhancement above background as a function of pump power flux at the UHR height. The data point colors correspond to the heater power level as shown by the figure legend, 100 %=565 MW ERP. Linear fits have been applied to points above and below the threshold. The dashed line at $37.5\,\mu W\,m^{-2}$ shows the approximate threshold flux.

C. J. Bryers, et al., "EISCAT observations of pump-enhanced plasma temperature and optical emission excitation rate as a function of power flux", Journal of Geophysical Research, 117, doi:10.1029/2012JA017897, 2012.

HF energy absorption in ionosphere

Based on energy and momentum equations and using the electron density, electron temperature obtained in the EISCAT heating campaign on August 16–19, 2009 in Tromsø, Norway, the energy absorption flux near the reflection height is calculated. It is shown by Figure 2 that the energy absorption is approximate to Gaussian distribution, but not symmetric along beam absorption centre. In addition, the dependence of absorption on the difference of HF and critical frequency shown in Figure 3 indicates that there is a break point at 0.6 MHz, which shows that the frequency of HF, f_H, with a difference 0.6 MHz from the critical frequency, f_0F, is optimum.

Xu Bin, et al., "Measurement of energy absorption rate by incoherent scatter radar in polar ionospheric heating experiment (in Chinese)", Chinese Journal of Radio Science, 2012(02), 2012.

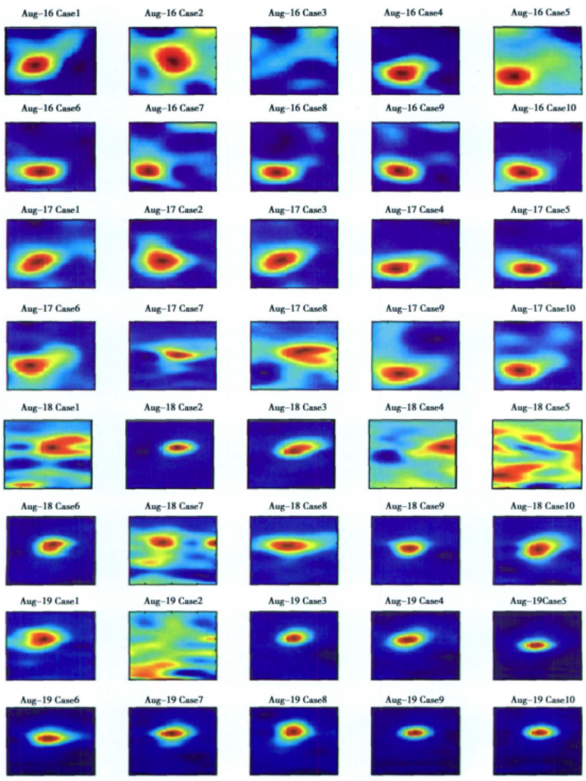


Figure 2: The spatial distribution of the energy absorption.

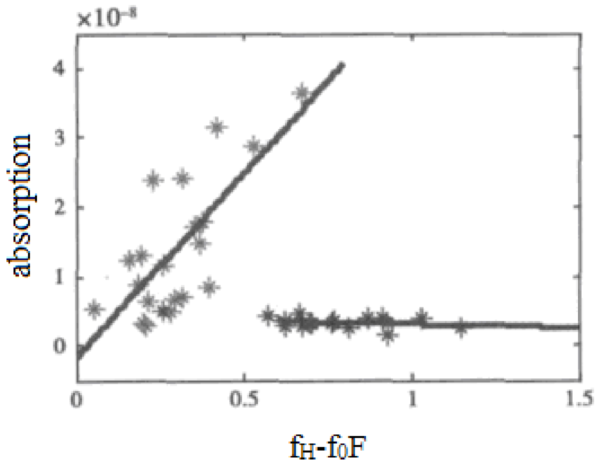


Figure 3: Dependence of absorption on the difference of HF and critical frequency.

Modelling of optical emissions enhanced by the HF pumping of the ionospheric F-region

Pumping HF radio waves at high power into the ionosphere can excite a plethora of optical emissions, as it has been earlier discovered with the EISCAT heater. Sergienko et al. (2012) have now

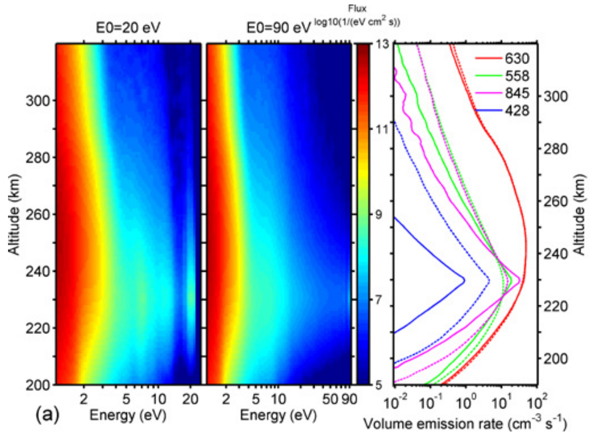


Figure 4: The electron differential flux and the volume emission rate for the heating pulse at 18:12 UT. Left: The altitude energy variation of the electron flux for the mono-energetic accelerated electrons with an initial energy of 20 eV. Centre: The same, but for an initial energy of 90 eV. Right: Profiles of volume emission rates of the 630.0 nm (red), 557.7 nm (green), 844.6 nm (magenta) and 427.8 nm (blue) optical emissions. The solid lines correspond to an accelerated electron energy of 20 eV, the dashed lines correspond to an energy of 90 eV.

modelled electron transport and optical emissions using the EISCAT UHF results to determine the ionospheric background conditions. The results are that the 630.0 nm emission with an excitation threshold of 1.96 eV is formed predominately by thermal electrons. But in order to explain the experimentally observed intensities for the emissions with a higher excitation threshold, namely the 557.7 nm and 427.8 nm emissions, accelerated electrons must have gained an energy of more than 60 eV, which corresponds to a thermal energy of 700 000 K, see also Figure 4.

T. Sergienko, et al., "Modelling of optical emissions enhanced by the HF pumping of the ionospheric F-region", Annales Geophysicae, 30, 885–895, doi:10.5194/angeo-30-885-2012, 2012.

The comparison of numerical simulation and measurements of ionospheric heating

As an aid to proving the ionospheric heating model considering transport processes, the comparison of the numerical simulation of ionospheric heating and experiment carried out on January 10 and 11, 2008 in Tromsø, Norway, was performed and shown in Figure 5, where the dots and

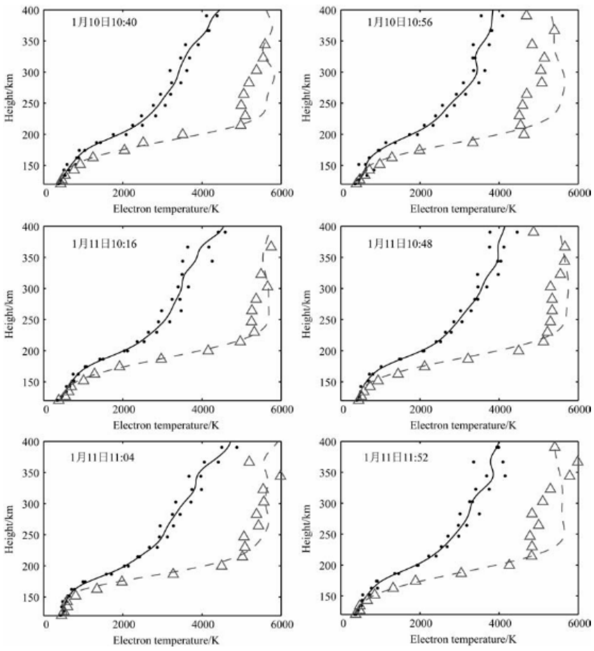


Figure 5: Comparison between the numerical simulation and observation of electron temperature.

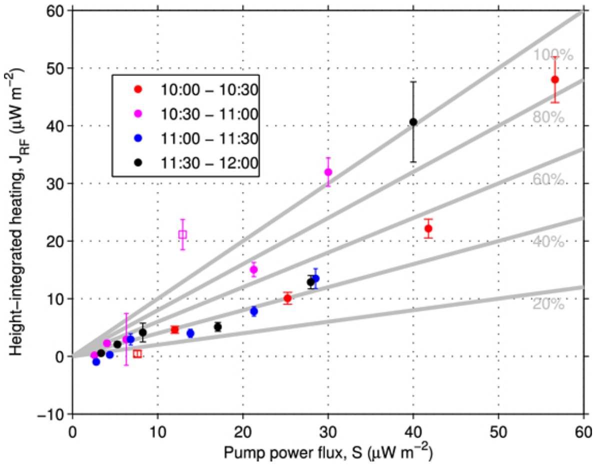


Figure 6: Height-integrated heating rate due to HF pumping versus the estimated pump power flux at 202 km altitude. The five gray lines of increasing slope indicate heating efficiencies $\eta = J_{\mathrm{RF}}/S$ of 20 %, 40 %, 60 %, 80 % and 100 % respectively. The points marked with open squares may be unreliable due to incomplete radar data coverage.

solid line denote the initial electron temperature observed by EISCAT UHF radar and its fitting respectively, and triangles and dashed line the heated electron temperature obtained from the EISCAT UHF observation and the numerical simulation by model respectively. The results are consistent with the observations very well, but there is a small error, which can be due to the inaccurate absorption rate at reflection height and model IRI and MSIS.

Wang Zhan-Ge, et al., "A comparison of numerical simulation and measurements during ionospheric heating (in Chinese)", Chinese Journal of Geophysics, 55, doi:10.6038/j.issn.0001-5733.2012.03.004, 2012.

The dependence of F-region electron heating on HF radio pump power

An analysis was performed of measurements of F-region electron temperature enhanced by the high-power HF radio wave from Heating, to obtain the electron heat source due to the radio wave as a function of transmitter power (Figure 6). It was determined that the absorption of the wave in the D-region has a significant influence on the F-region heating; small variations in the D-region electron density have a significant effect on the amount of pump power reaching the F-region. By correcting for this effect it was shown that the efficiency of the conversion of pump energy to electron thermal energy increases with pump power. At the highest power fluxes, the efficiency appears to be close to 100 %. It was determined that this behaviour seems to be consistent with the development of geomagnetic field-aligned plasma density irregularities associated with the conversion of the radio wave to electrostatic upper-hybrid waves.

A. Senior, et al., "The dependence of F-region electron heating on HF radio pump power: Measurements at EISCAT Tromsø", Journal of Geophysical Research, 117, doi:10.1029/2011JA017267, 2012.

Ionospheric studies

Polar cap thermosphere and ionosphere during the solar minimum period: EISCAT Svalbard radar observations and GCM simulations

The IPY long-run data were obtained from the European Incoherent Scatter Svalbard radar (ESR) observations during March 2007 and February 2008. Since the solar and geomagnetic activities were quite low during the period, this data set is extremely helpful for describing the basic states (ground states) of the thermosphere and ionosphere in the polar cap region. The monthly-averaged ion temperatures for 12 months show similar local time (or UT) variations to each other

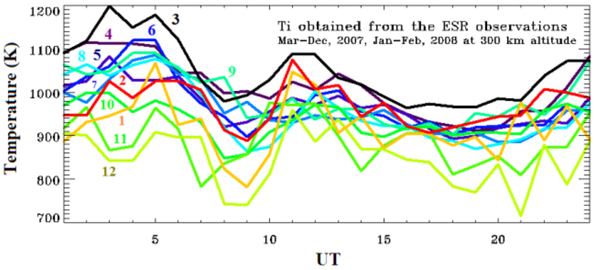


Figure 7: Monthly-averaged values of the ion temperature obtained from the ESR observations at about 300 km altitude in the field-aligned direction. The numbers labeled in the figure indicate the month.

(Figure 7). The ion temperatures also show significant seasonal variations. The amplitudes of the local time and seasonal variations observed are much larger than the ones predicted by the IRI-2007 model. In addition, numerical simulations were performed with a general circulation model (GCM), which covers all the atmospheric regions, to investigate variations of the neutrals in the polar thermosphere. The GCM simulations show significant variations of the neutral temperature in the polar region in comparison with the NRLMSISE-00 empirical model. These results indicate that both the ions and neutrals would show larger variations than those described by the empirical models, suggesting significant heat sources in the polar cap region even under solar minimum and geomagnetically quiet conditions.

Hitoshi Fujiwara, et al., "Polar cap ionosphere and thermosphere during the solar minimum period: EISCAT Svalbard radar observations and GCM simulations", Earth Planets Space, 64, doi:10.5047/eps.2011.05.023, 2012.

Statistical distribution of height-integrated energy exchange rates in the ionosphere

The EISCAT radar in Tromsø has been used to estimate statistics of electromagnetic (EM) energy transfer rates by utilising calculated electric fields, conductivities and E-region neutral winds (Figure 8). It was found that the magnetospheric EM energy input is slightly larger in the evening than morning sector, but due to winds, the Joule heating rate has the largest values in the morning sector. The duskside subauroral region contains large northward electric fields and is a site of significant magnetospheric EM energy input and Joule heating. For quiet conditions ($K_{\rm p}$: 0−2+), the neutral wind is the major source for Joule heating at all MLT except at the evening maximum of magnetospheric EM input. For medium ($K_{\rm p}$: 3−4+) and high ($K_{\rm p} \leq 5$) activity levels, winds increase Joule heating rates in the morning, but decrease them in the evening. The positive contribution of winds during the morning maximum is 30 % and 20 % for medium and high activity levels, respectively. The region where winds are a net load for the magnetospheric EM energy input is 17–20 MLT for medium and 13–18 MLT for high activity conditions. The median EM energy transfer to mechanical work made on winds is 20 % at maximum. An event with a long-lasting high electric field showed that the ion drag acting on neutrals can decrease the Joule (ion-neutral collisional) heating by more than 50 %.

A. T. Aikio, L. Cai, and T. Nygrén, "Statistical distribution of height-integrated energy exchange rates in the ionosphere", Journal of Geophysical Research A, 117, A10325, 2012.

Temporal variations of the ion-neutral collision frequency from EISCAT observations in the polar lower ionosphere during periods of geomagnetic disturbances

The ion-neutral collision frequency in the lower ionosphere (106 km to 135 km) was estimated using data from the European Incoherent Scatter (EISCAT) radar at Tromsø, Norway during the Dynamics and Energetics of the Lower Thermosphere in Aurora 2 (DELTA-2) campaign in 2009. Vertical component of the ion velocity was used with the ion momentum equation for the calculations. The ion-neutral collision frequency was found to be approximately equivalent to that predicted using modeled density data (Figure 9). However, notable increases were found above 126.8 km during natural ionospheric heating events. A depression in calculated values was also found between 114.6 km and 126.8 km just after cessation of a heating event. Contributions of the vertical thermospheric motion to variations of the ion-neutral collision frequency are discussed.

S. Oyama, et al., "Temporal variations of the ion-neutral collision frequency from EISCAT observations in the polar lower ionosphere during periods of geomagnetic disturbances", Journal of Geophysical Research, 117, doi:10.1029/2011JA017159, 2012.

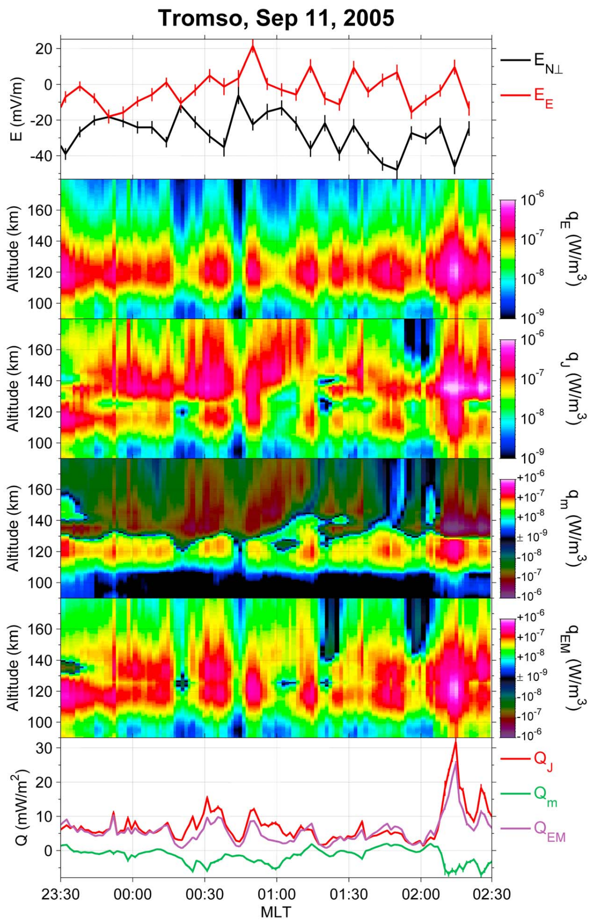


Figure 8: Two electric field components and their standard deviations (first panel), height-dependent EM energy transfer rates (second through fifth panels) and height-integrated EM energy transfer rates and their standard deviations for 11 September 2005 (sixth panel).

Auroral studies

Monoenergetic high-energy electron precipitation in thin auroral filaments

The visible aurora can sometimes be found in structures of very thin filaments of a few tens of metres width, as images and videos from high-resolution cameras have shown. Dahlgren et al. (2012) investigated the properties of such narrow filaments, particularly the energy spectrum of precipitating electrons causing the auroral emissions. The authors found that the energy distribution of the electron precipitation responsible for about 70 m wide and dynamic auroral filaments are sharply peaked at around 8 keV. The events were captured with high resolution low-light optical imagers located near Tromsø, Norway. The

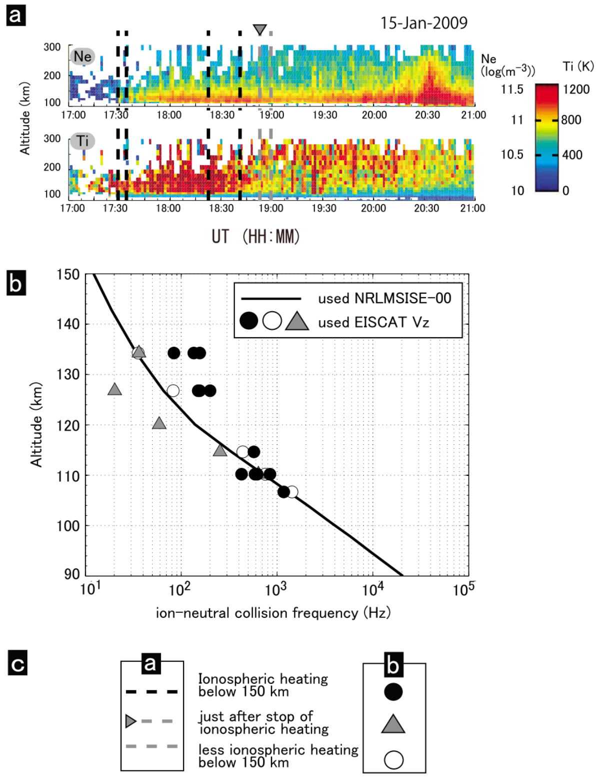


Figure 9: Results from 15 January 2009. (a) Height-time profile of the EISCAT radar data of the electron density and the ion temperature. (b) Calculated height profile of the ion-neutral collision frequency (circles and triangles) and the NRLMSISE-00 model (solid line). (c) Line and marker styles used in Figures a and b.

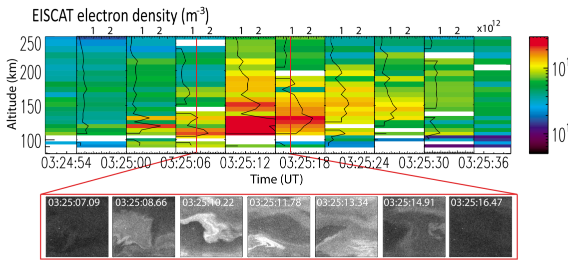


Figure 10: (top) Electron density measurements as spectra and line plot from the EISCAT radar. The enhancements up to $5.0 \times 10^{-12}\,\mathrm{m}^{-3}$ are coincident with structured auroral emissions seen by the ASK imagers. (bottom) $I(\mathrm{O}_2^+)$ snapshots from the time interval.

EISCAT mainland UHF radar was providing estimates of the electron density in the ionospheric E and F region at 1.8 km to 5.4 km range and 5 s temporal resolutions. The radar was pointing field-aligned.

The method uses imaging in two emissions which have different energy dependent responses to auroral electron precipitation. The key feature of the events was that no difference in the altitude of the two emissions was detected, nor any time-of-flight dispersion, thus leading to the conclusion that the filaments were caused by monoenergetic precipitation. Comparisons with an electron transport and ion chemistry model show that the high energy filaments were embedded in a region of lower energy precipitation of about 4 keV, see also Figure 10.

H. Dahlgren, N. Ivchenko, and B. S. Lanchester, "Monoenergetic high-energy electron precipitation in thin auroral filaments", Geophysical Research Letters, 39, L20101, doi:10.1029/2012GL053466, 2012.

An application of the finite length Cowling channel model to auroral arcs with longitudinal variations

A physical process for the latitudinal motion of an auroral arc based on the four-side bound Cowling channel model is proposed. Assuming that an upward field-aligned current (FAC) is associated with the auroral arc that forms a Cowling channel with finite lengths not only latitudinally but also longitudinally and that the upward FAC region is primarily embedded in a purely northward electric field, the primary Hall current driven by the northward electric field accumulates positive excess charges at the eastern edge of the channel and negative charges at the western edge for a perfect or partial Cowling channel with a nonzero Cowling efficiency. The charges produce a westward secondary electric field (Figure 11), indicating that a westward electric field can thus be produced by a purely northward primary electric field. This secondary electric field moves the arc with its magnetospheric source drifting together with the magnetospheric plasmas equatorward and simultaneously produces the electric field outside the channel that moves the downward FAC equatorward of the upward FAC region equatorward together with the upward FAC. Thus, the whole three-dimensional current system is expected to move equatorward as often observed in the afternoon auroral zone.

R. Fujii, et al., "An application of the finite length Cowling channel model to auroral arcs with longitudinal variations", Journal of Geophysical Research, 117, doi:10.1029/2012JA017953, 2012.

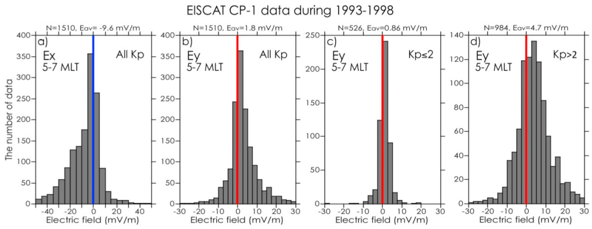


Figure 11: Histograms of (a) E_x, (b) E_y for all K_P, (c) E_y for $K_\mathrm{p} \leq 2$, and (d) E_y for $K_\mathrm{p} > 2$ during 5–7 MLT observed with EISCAT. All CP-1 data during 1993 and 1998 are used.

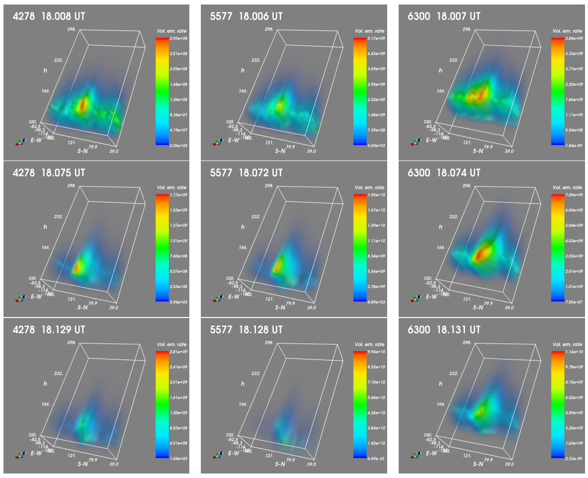


Figure 12: Volume rendering of volume emission rate estimates $\varepsilon_{427.8}$, $\varepsilon_{557.7}$ and $\varepsilon_{630.0}$ for arbitrarily selected times.

Tomography-like retrieval of auroral volume emission ratios for the 31 January 2008 Hotel Payload 2 event

Quantitative tomography-like volume estimates of the $\mathrm{N}_2^+(^1N)$ emission at 427.8 nm, the $\mathrm{O}(^1S)$ emission at 557.7 nm and the $\mathrm{O}(^1D)$ emission at 630.0 nm can be retrieved from data from the Auroral Large Imaging System (ALIS) spectral imagers operated at field stations in northern Sweden and Norway. Enell et al. (2012) is a case study of a quiet auroral arc passing over the imagers in the evening of 31 January 2008 (Figure 12), before the launch of the Hotel Payload 2 (HotPay 2) rocket from Andøya Rocket Range.

The reconstructed spectroscopic ratios at the lower altitudes close to the mesopause region can be used as indicators of the NO and O profiles, as the atomic oxygen $\mathrm{O}(^1S)$ and $\mathrm{O}(^1D)$ states are excited partly through chemical reactions. The profiles of the ratios of the volume emission rates $\varepsilon_{557.7}$ and $\varepsilon_{427.8}$ observed by ALIS over northern Norway show nothing unambiguously unusual within the accuracy of the calibration and retrieval, whereas HotPay 2 indicated subsidence of lower thermospheric air, with higher NO concentrations. This is consistent with observations of NO and CO by satellite instruments, which indicate subsidence in vortex filaments only in the NW as seen from the Scandinavian mainland.

C.-F. Enell, et al., "Tomography-like retrieval of auroral volume emission ratios for the 20080131 Hotel Payload 2 event", Geoscientific Instrumentation, Methods and Data Systems Discussions, 2(1):1-21, 2012.

Other studies

High-precision measurement of satellite velocity using the EISCAT radar

Nygrén et al. (2012) present a method of measuring the velocity of a hard target using radar pulses reflected from the target flying through the radar beam. The method has two stages. First, the Doppler shifts of the echo pulses are calculated at a high accuracy with an algorithm which largely improves the accuracy given by the Fourier transform. The algorithm also calculates the standard deviations of the Doppler frequencies with Monte Carlo simulation. The second step is to fit the results from a sequence of radar pulses to a velocity model allowing linear variation of the second time derivative of target range. The achieved accuracies are demonstrated using radio pulses reflected by a satellite passing through the beam of the EISCAT UHF radar working at 930 MHz frequency (Figure 13). At high SNR levels, the standard deviations of the frequency from a single pulse reach typically down to 0.2 Hz. The best standard deviations of velocity fit are below 5 mm/s while those of the second time derivative of range are below 1 cm/s^2.

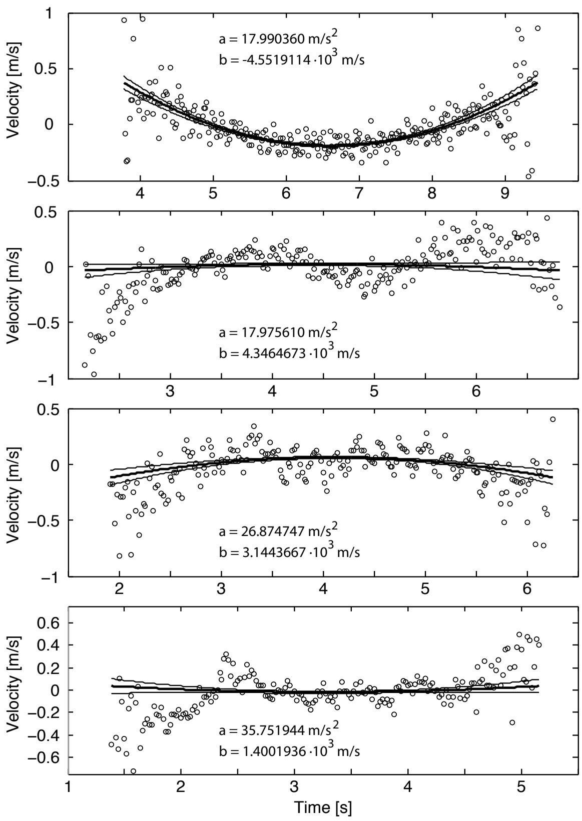


Figure 13: Detrended velocities calculated from the Doppler frequencies (open circles), together with velocities fitted to the model (heavy line). The 3σ limits of the fitted velocity are shown by the thin lines. The subtracted trend is $v_{\mathrm{L}} = a \cdot t + b$ with the numbers given in each panel.

T. Nygrén, et al., "High-precision measurement of satellite velocity using the EISCAT radar", Annales Geophysicae, 30, 1555–1565, 2012.

Soliton-induced spectrally uniform ion line power enhancements at the ionospheric F region peak

Enhancements of the ion line have been found with EISCAT, first with an increased shoulder or more double-humped spectra. Other types of natural enhancements exist as well. Ekeberg et al. (2012) present European Incoherent Scatter (EISCAT) observations of spectrally uniform ion line power enhancements (SUIPE), where the up- and downshifted shoulder and the spectral valley between them are enhanced simultaneously and equally. In data from the EISCAT Svalbard radar taken during the International Polar Year 48 cases of this type of ion line were identified. The SUIPEs are observed at altitudes 210 km to 280 km with a standard deviation of 9 % of the average occurrence height 230 km. The power enhancements are one order of magnitude above the thermal level. The SUIPEs occur at the ionospheric F region density peak with 85 % of the cases located within 10 km of the peak, see also Figure 14. These characteristics are in good agreement with the predictions of a model for soliton-induced ion-line enhancements at the F region peak. The SUIPE occurrence shows a clear preference for magnetically disturbed conditions, with the likelihood of occurrence increasing with increasing K index. A ma-

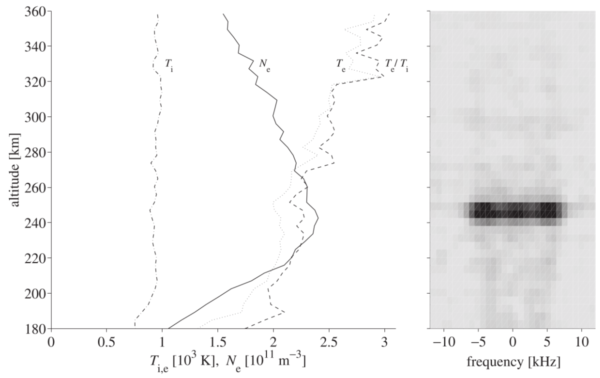


Figure 14: ESR data from 5 April 2007. (Left) Profiles of ion and electron temperature $T_{\mathrm{i,e}}$, electron density N_{e} and electron to ion temperature ratio averaged over 17:04:30 UT – 17:14:30 UT. (Right) 6 s average range corrected power spectral density at 17:14:30 UT coded with a grey scale.

jority of the events occur in the magnetic evening to pre-midnight sector.

J. Ekeberg, et al., "Soliton-induced spectrally uniform ion line power enhancements at the ionospheric F region peak", Earth Planets Space, 64, 605-611, doi:10.5047/eps.2012.02.005, 2012.

Equatorwards expansion of unperturbed, high-latitude fast solar wind

EISCAT was used with other radio telescopes to perform measurements of interplanetary scintillation (IPS) with extremely long baselines (ELB) to examine meridional flow characteristics of the ambient fast solar wind at plane-of-sky heliocentric distances of 24 to 85 solar radii. An equatorwards deviation of 3° to 4° was identified in the bulk fast solar wind flow direction over both northern and southern solar hemispheres during different times in the declining phase of Solar Cycle 23.

G. D. Dorrian, et al., "Equatorwards expansion of unperturbed, high-latitude fast solar wind", Solar Physics, 285, doi:10.1007/s11207-012-0081-y, 2013.

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EISCAT Operations 2012

The EISCAT radars operate in two basic modes, using approximately half the available observing time for each. In the Special Programme mode, users conduct individual experiments dedicated to specific experiments and objectives. The resulting data are reserved for the exclusive use of the experimenters for one year from the date of collection. Special programmes often make use of the well developed pulse schemes and observing modes of the Common Programme. EISCAT Common Programmes are conducted for the benefit of the entire user community and the resulting data are immediately available to all. The Common Programme modes are developed and maintained by EISCAT staff, and the overall programme is monitored by the Scientific Oversight Committee (SOC). Common Programme operations are often conducted as part of the coordinated World Day programme organised by the International Union of Radio Scientists (URSI) Incoherent Scatter Working Group (ISWG).

Common Programme One, CP-1, uses a fixed transmitting antenna, pointing along the geomagnetic field direction. The three-dimensional velocity and anisotropy in other parameters are measured by means of the receiving stations at Kiruna and Sodankylä (see map, inside front cover). CP-1 is capable of providing results with very good time resolution and is suitable for the study of substorm phenomena, particularly auroral processes where conditions might change rapidly. The basic time resolution is 5 s. Continuous electric field measurements are derived from the tri-static F-region data. On longer time scales, CP-1 measurements support studies of diurnal changes, such as atmospheric tides, as well as seasonal and solar-cycle variations. The observation scheme uses alternating codes for spectral measurements.

Common Programme Two, CP-2, is designed to make measurements from a small, rapid transmitter antenna scan. One aim is to identify wave-like phenomena with length and time scales comparable with, or larger than, the scan (a few tens of kilometers and about ten minutes). The present version consists of a four-position scan which is completed in six minutes. The first three positions form a triangle with vertical, south, and south-east positions, while the fourth is aligned with the geomagnetic field. The remote site antennas provide three-dimensional velocity measurements in the F-region. The pulse scheme is identical with that of CP-1.

Common Programme Three, CP-3, covers a 10° latitudinal range in the F-region with a 17-position scan up to 74°N in a 30 min cycle. The observations are made in a plane defined by the magnetic meridian through Tromsø, with the remote site antennas making continuous measurements at 275 km altitude. The coding scheme uses alternating codes. The principle aim of CP-3 is the mapping of ionospheric and electrodynamic parameters over a broad latitude range.

Common Programmes One, Two, and Three are run on the UHF radar. Three further programmes are designed for use with the VHF system. The UHF and VHF radars are often operated simultaneously during the CP experiments. Such observations offer comprehensive data sets for atmospheric, ionospheric, and magnetospheric studies.

Common Programme Four, CP-4, covers geographic latitudes up to almost 80°N (77°N invariant latitude) using a low elevation, split-beam configuration. CP-4 is particularly suitable for studies of high latitude plasma convection and polar cap phenomena. However, with the present one-beam configuration of the VHF radar, CP-4 is run with either both UHF and VHF radars or with UHF only in a two position scan.

Common Programme Six, CP-6, is designed for low altitude studies, providing spectral measurements at mesospheric heights. Velocity and electron density are derived from the measurements and the spectra contain information on the aeronomy of the mesosphere. Vertical antenna pointing is used.

Common Programme Seven, CP-7, probes high altitudes and is particularly aimed at polar wind studies. The present version, with only one of the VHF klystrons running, is designed to cover

The EISCAT receiver stations in Kiruna and Sodankylä went through a conversion from UHF to VHF during the year. This necessitated some changes of the antenna hardware. (Photo: William Rideout)

altitudes up to 1500 km vertically above Ramfjordmoen.

Equivalent Common Programme modes are available for the EISCAT Svalbard Radar. CP-1 is directed along the geomagnetic field (81.6° inclination). CP-2 uses a four position scan. CP-3 is a 15 position elevation scan with southerly beam swinging positions. CP-4 combines observations in the F-region viewing area with field-aligned and vertical measurements. Alternating code pulse schemes have been used extensively for each mode to cover ranges of approximately 80 km to 1200 km with integral clutter removal below 150 km. CP-6 is similar to the mainland radar CP-6.

The tables on the next pages summarise the accounted hours on the various facilities for each month and for each Common Programme mode (CP) or Associate (SP).

Dr. Ingemar Häggström
Senior Scientist, EISCAT Scientific Association

2012

KST COMMON PROGRAMMES

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	%	Target%
CP1			3.5	1.5	2.5	2.5		2	1	1	5		19	3	16
CP2	255.5		1.5					2					259	40	16
CP3										3.5			3.5	1	12
CP4								2.5				130	132.5	21	10
CP6						86.5			85.5				172	27	20
CP7													0	0	18
UP	27.5		27.5										55	9	
Total	283	0	32.5	1.5	2.5	89	0	6.5	86.5	4.5	5	130	**641**	100	
%	44	0	5	0	0	14	0	1	13	1	1	20	100		

KST SPECIAL PROGRAMMES

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Incl AA	Target
CN												19.5	19.5	20	67
FI								12				96.5	108.5	109	92
GE													0	0	0
NI			27.5							7	47	29.5	111	111	108
NO	19	6.5	9.5		14		93.5			10.5	39.5	18	210.5	211	207
SW										53	43	72	168	168	156
UK		27			9		18		5	33.5			92.5	93	95
AA													0		
Total	19	33.5	37	0	23	0	111.5	12	5	104	129.5	235.5	**710**	**710**	**724**
%	3	5	5	0	3	0	16	2	1	15	18	33	100		

	EI	CN	FI	GE	NI	NO	SW	UK	
Target		9.27	12.73	0	14.88	28.55	21.49	13.08	%

KST OTHER PROGRAMMES

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Target
PP						10.5	58.5				6.5		75.5	108
EI		5					0.5						5.5	30
RU		101								80.5			181.5	170
TB	12		12										24	24
Total	12	106	12	0	0	10.5	59	0	0	80.5	6.5	0	**286.5**	**332**

KST TOTALS

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Target
CP	283	0	32.5	1.5	2.5	89	0	6.5	86.5	4.5	5	130	641	600
SP	19	33.5	37	0	23	0	111.5	12	5	104	129.5	235.5	710	724
OP	12	106	12	0	0	10.5	59	0	0	80.5	6.5	0	286.5	332
Total	314	139.5	81.5	1.5	25.5	99.5	170.5	18.5	91.5	189	141	365.5	**1637.5**	**1656**

USAGE BREAKDOWN

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Target
UHF	261.5	64	42	1.5	6	11	60.5	8	1	121.5	75.5	160	812.5	745
VHF	38.5	2.5	36.5		6.5	86.5	44.5	10	85.5		46	132	488.5	671
Heating	14	73.5	2.5		4.5	2	60			63	18	25	262.5	240
Passive KST					35.5				21	15	4	190	265.5	0
Bolt array	27		6		4	87	38.5		39				201.5	
ESR	288.5	68	161.5	0	5	93.5	29.5	1	65.5	25	67	151.5	956	1273
Passive ESR									4	4			8	

2012

ESR COMMON PROGRAMMES

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	%	Target%
CP1	45.5					7.5		1	62				116	25	54
CP2	147												147	32	16
CP3													0	0	12
CP4												83.5	83.5	18	10
CP6					3	86							89	19	
CP7													0	0	
UP	15		11.5										26.5	6	
Total	207.5	0	11.5	0	3	93.5	0	1	62	0	0	83.5	**462**	100	
%	45	0	2	0	1	20	0	0	13	0	0	18	100		

ESR SPECIAL PROGRAMMES

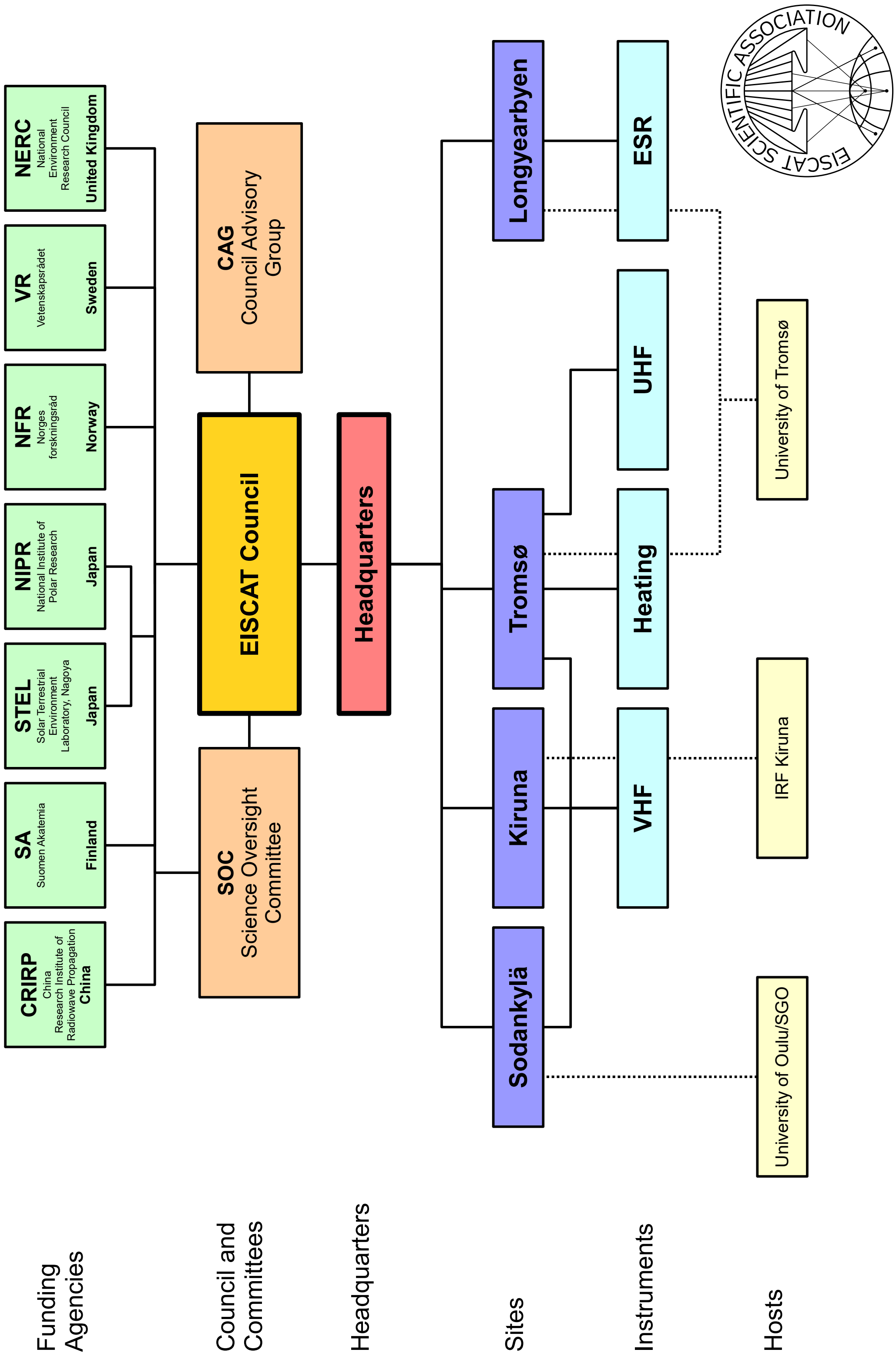
2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Incl AA	Target
CN													0	0	47
FI												39.5	39.5	40	65
GE													0	0	0
NI			27.5								28	12	67.5	68	76
NO	34.5		61.5				29.5		3.5	25	8.5	9	171.5	172	146
SW	23.5		26.5									2	52	52	110
UK	17		22.5						1	1		5.5	47	47	67
AA													0		
Total	75	0	138	0	0	0	29.5	0	4.5	26	36.5	68	**377.5**	**378**	**510**
%	20	0	37	0	0	0	8	0	1	7	10	18	100		

ESR OTHER PROGRAMMES

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Target
PP		8									16		24	43
EI													0	20
RU											14.5		14.5	20
TB	6	60	12		2								80	80
Total	6	68	12	0	2	0	0	0	0	0	30.5	0	**118.5**	**163**

ESR TOTALS

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Target
CP	207.5	0	11.5	0	3	93.5	0	1	62	0	0	83.5	462	600
SP	75	0	138	0	0	0	29.5	0	4.5	26	36.5	68	377.5	510
OP	6	68	12	0	2	0	0	0	0	0	30.5	0	118.5	163
Total	288.5	68	161.5	0	5	93.5	29.5	1	66.5	26	67	151.5	**958**	**1273**



EISCAT organisational diagram, December 2012.

EISCAT Scientific Association

December 2012

Council

The Council consists of a Delegation with a maximum of three persons from each Associate. Esa Turunen leaves the position as Director of EISCAT at the end of 2012.

P. R. of China	
Prof. Q. Dong	
Prof. J. Wu	*Vice-Chairperson*, Delegate
Finland	
Dr. A. Aikio	
Dr. K. Kauristie	
Dr. K. Sulonen	Delegate
Japan	
Dr. H. Miyaoka	Delegate
Dr. S. Nozawa	
Norway	
Prof. A. Brekke	
Dr. B. Jacobsen	Delegate
Dr. L. Lønnum	
Sweden	
Dr. T. Andersson	*Chairperson*, Delegate
Prof. J. Gumbel	
Prof. D. Murtagh	
United Kingdom	
Dr. I. McCrea	
Dr. M. Schultz	Delegate

Scientific Oversight Committee

The EISCAT scientific community organises the Scientific Oversight Committee (SOC), under the guidance of the Council.

Dr. N. Blagoveshchenskaya	External member
Dr. S. Buchert	Sweden
Prof. W. Jun	P. R. of China
Dr. M. Kosch	United Kingdom
Dr. E. Kudeki	External member
Prof. C. La Hoz	*Chairperson*, Norway
Dr. Y. Ogawa	Japan
Dr. M. Rapp	External member
Dr. T. Ulich	Finland

Director

Dr. E. Turunen

Council Advisory Group

The Council Advisory Group (CAG) prepares matters to be brought to the Council.

Dr. A. Aikio	Council Member
Mr. H. Andersson	Head of Administration
Dr. T. Andersson	Council Chairperson
Prof. A. Brekke	Council Member
Dr. I. McCrea	Council Member
Dr. H. Miyaoka	Council Member
Dr. E. Turunen	Director

Executives

Senior Management

Mr. H. Andersson	Head of Adm., Deputy Dir.
Dr. E. Turunen	Director

Site Leaders

Station Managers

Mr. H. Boholm	EISCAT Svalbard Radar
Mr. R. Jacobsen	Tromsø Radar
Mr. J. Markkanen	Sodankylä Site
Dr. M. Rietveld	Tromsø Heating
Mr. L.-G. Vanhainen	Kiruna Site

Photo from the Annual Review Meeting, 19–21 November 2012, at Hotel Levi Panorama in Finland. From left: Craig Heinselman (incoming Director), Roger Jacobsen, Lars-Göran Vanhainen, Arild Stenberg, Erlend Danielsen, Stian Grande, Michael Rietveld, Peter Bergqvist, Guttorm Mikalsen, Ingemar Häggström, Halvard Boholm, Henrik Andersson, Björn Gustavsson, Jussi Markkanen, Anders Tjulin, Espen Helgesen, Ingrid Mann, Elisabet Goth, Assar Westman, Esa Turunen (Director).

EISCAT Scientific Association
Registered as a Swedish non-profit organisation
Organisation number: 897300-2549

Annual report for the financial year 2012-01-01 – 2012-12-31

The EISCAT Council and the Director for the Association submits herewith the annual report for 2012.

ADMINISTRATION REPORT

Ownership, organisation and objective
The EISCAT Scientific Association was established in 1975 through an agreement between six European organisations. Japan joined in 1996 and the Peoples Republic of China in 2007.

The EISCAT Associates at 2012-12-31 are: China Research Institute of Radiowave Propagation (Peoples Republic of China), National Institute of Polar Research (Japan), Natural Environment Research Council (United Kingdom of Great Britain and Northern Ireland), Norges forskningsråd (Norway), Solar-Terrestrial Environment Laboratory, Nagoya University (Japan), Suomen Akatemia (Finland), and Vetenskapsrådet (Sweden).

The now running EISCAT Agreement came into force 2007-01-01, with all Associates making long term funding commitments to the Association. The Association has its formal seat in Kiruna, Sweden, and is registered as a non-profit organisation.

The aim of the Association is to make significant progress in the understanding of physical processes in the high latitude atmosphere by means of experimental programmes generally conducted using the incoherent scatter radar technique, which may be carried out as part of wider international projects. For this purpose, the Association has developed, constructed, and now operates, a number of radar facilities at high latitudes. At present, these comprise a system of stations at Tromsö (Norway), Kiruna (Sweden), Sodankylä (Finland), and Longyearbyen (Svalbard).

The Association is fully funded by the Associates but additional operations may also be funded by short term additional contributions from both Associate and non-Associate bodies. Depending on the available funding, scientific priorities and operational targets are adjusted on an annual basis.

The EISCAT Council is charged with the overall administration and supervision of the Association's activities. The Council appoints a Director, who is responsible for the daily management and operation of the facilities of the Association.

Operation and scientific development
The EISCAT Radars delivered a full programme of operations for the user community and operated reliably throughout the year with only some interruptions due to equipment or operational problems.

The various EISCAT radars operated for a total of 2 596 accounted hours (2 846 hours in 2011).

Tristatic modes of operation were reinstated after a frequency conversion of the two remote sites at Kiruna (Sweden) and Sodankylä (Finland). The remote sites are now receiving the transmitted VHF signal.

Common Programmes amounted to 42% (43%) of the operations. Special Programmes amounted to 42% (39%) and other operations amounted to 16% (18%) of the total hours.

Scientists from France, Ukraine and Russia paid for the use of the facilities. Totally 300 hours (391.5 hours) were accounted on behalf of these countries. Both Ukraine and Russia have Affiliate agreements. The introduced Peer-Review Programme attracted several applications and user groups from Belgium, Germany, Russia, USA and United Kingdom were granted time, at no cost, on the systems. Peer-Review time amounted to 99.5 accounted hours (117.5 hours).

Four EU Framework Programme 7 projects were ongoing at the end of the year: EISCAT_3D_2 “EISCAT_3D: A European three-dimensional imaging radar for atmospheric and geospace research (Preparatory Phase)”, ENVRI “Common Operations of Environmental Research Infrastructures”, ESPAS “Near-Earth Space Data Infrastructure for e-Science” and the latest, COOPEUS “Strengthening the cooperation between the US and the EC in the field of environmental research infrastructures”. EISCAT Headquarters is the coordinator of EISCAT_3D_2 and partner in the other projects. COOPEUS started 2012-09-01 and will run until 2015-08-31. The IMPRES bid submitted in 2011 did not get funding. In autumn, EISCAT joined a new EU FP7 bid; MISW: “Mitigation of space weather threats to GNSS services”.

The “third antenna system on Svalbard with dual mode capabilities” development continued also during 2012. Most needed permits are now in place and the design work has mostly been completed. The final “delplan” decision is expected in June 2013. The investment and operating costs aspects are now well understood.

At the beginning of 2012, a further project was started which relates to the continued planning of EISCAT_3D. This project, “planering av EISCAT_3D” is a two plus one year project funded by Vetenskapsrådet (Sweden).

Future operation and scientific development

During 2013, EISCAT will continue to support the wide range of existing and new programmes proposed by the various Associates’ scientific communities, including the hosting of user-supplied equipment.

All systems are ready for users. These comprise of the EISCAT Svalbard Radar, UHF and VHF radars with the possibility to run the VHF in tristatic mode. For the VHF, and small receive-only array in Kiruna is also available. This array will be equipped with, as part of the EISCAT_3D preparatory phase field-test work, multi-beam capabilities during summer 2013. The Heating system continues also to be available.

The work of the Council and its committees

The Council had one ordinary meeting, in Stockholm, Sweden, 29 – 30 May, 2012, under the leadership of the Chairperson, Dr. Tomas Andersson. The second ordinary meeting was, due to logistics reasons, postponed into 2013. The Council Advisory Group had two meetings under the leadership of the Chairperson, Dr. Tomas Andersson. The spring meeting was held in Copenhagen, Denmark, and the autumn meeting was held at Vetenskapsrådet, Stockholm, Sweden. The Scientific Oversight Committee had two meetings during the year.

The spring meeting was held in Tromsö, Norway and the autumn one was held at the Sodankylä Geophysical Observatory, Finland. Prof. Cesar La Hoz chaired both meetings.

The work at Council and its committees were much related to regular activities, including financial aspects. The development of the EISCAT_3D preparatory phase and the continued planning draw particular attention. A large undertaking by Council this year was the search and recruitment of a new Director for the Association.

Council decided in the spring meeting to offer the Director position to Dr. Craig Heinselman, USA. The Council Chairperson, supported by the Head of Administration and Dr. Heinselman met in Stockholm, 2012-07-03 - -04, to agree on the employment terms and a three year employment contract was signed. Dr. Heinselman took over the Directorship from Dr. Esa Turunen at the end of the year.

Budget development during the year

The 2012 operations ended below the operating target set for the year. One reason for that was a fault in the Svalbard 32 meter antenna which meant that sweeping experiments could not be done.

The overall spend followed well the forecast for the year. A budgetary principle change was introduced during the year relating to when to account income from EU projects. It was earlier agreed to make use of such income after the end of a project but this was changed to rather take this annually. This principle change meant that the budget for 2013 could be balanced but will cause much more constraint on the budget for 2014-. Since the project income is now taken annually, it resulted in a positive effect on the overall outcome for 2012 as well.

The long-term budget plan

The long-term budget plan continues to be challenging. The positive result for this year will be used to assist the budget balancing for 2014 - 2015. The budget for 2013 is already balanced.

The result for 2012 and the surplus handling

The year was balanced by transferring 2 356 kSEK to the Surplus fund.

PROFIT AND LOSS ACCOUNTS

in thousands of Swedish Crowns

	Note 1	***2012***	***2011***
Associate contributions	Note 2	22 325	23 164
Other operating income		10 572	5 061
		32 897	28 225
Operation costs		-7 998	-6 914
Administration costs		-4 716	-4 448
Personnel costs	Note 3	-17 170	-16 967
Depreciation of fixed assets		-1 061	-1 203
		-30 946	-29 533
Operating profit/loss		*1 952*	*-1 308*
Interest income		195	230
Other financial income and cost		1 337	740
Own reserves and funds	Note 4	-2 188	1 033
		-656	2 002
Profit/loss after financial items		*1 295*	*694*
Appropriations	Note 5	-2 356	-1 898
Transfer from funds invested	Note 6	1 061	1 203
		-1 295	-694
Net profit/loss for the year		*0*	*0*

BALANCE SHEET

in thousands of Swedish Crowns

		2012	2011
ASSETS			
Fixed assets			
Tangible fixed assets	Note 7		
Buildings		2 895	3 194
Radar systems		742	832
Equipment and tools		1 759	1 622
		5 396	5 648
Current assets			
Receivables		3 392	2 435
Prepayments and accrued income	Note 8	5 578	2 202
Cash at bank and in hand	Note 9	33 148	24 166
		42 117	28 803
Total assets		*47 513*	*34 450*
CAPITAL AND LIABILITIES			
Capital			
Funds invested	Note 10	5 396	5 648
Funds held on reserve	Note 11	21 024	17 289
		26 420	22 937
Current liabilities			
Liabilities, trade	Note 12	20 326	11 320
Provisions	Note 13	429	0
Other liabilities		339	193
		21 093	11 513
Total capital and liabilities		*47 513*	*34 450*
Pledged assets		*none*	*none*
Contingent liabilities		*none*	*none*

STATEMENT OF CASH FLOWS

in thousands of Swedish Crowns

	2012	***2011***
Operating activities		
Operating result before financial items	1 952	-1 308
Transfer from funds invested	1 061	1 203
Interest received	195	230
Currency exchange rate changes	1 283	695
Extra ordinary income and cost	54	45
Increase/decrease of receivables	-957	615
Increase/decrease of prepayments and accrued income	-3 376	-1 073
Increase/decrease of creditors and liabilities	9 580	-64
Cash flow from operations	*9 791*	*343*
Investment activities		
Investments in tangible assets	-810	-888
Cash flow from investment activities	*-810*	*-888*
Cash flow for the year	*8 982*	*-545*
Liquid assets at the beginning of the year	*24 166*	*24 711*
Liquid assets at the end of the year	*33 148*	*24 166*

NOTES

Note 1 *Accounting principles*

The accounting and valuation principles applied are consistent with the provisions of the Swedish Annual Accounts Act and generally accepted accounting principles (bokföringsnämnden allmänna råd och vägledningar).

All amounts are in thousands of Swedish kronor (SEK) unless otherwise stated.

Receivables
Receivables are stated at the amounts estimated to be received, based on individual assessment.

Receivables and payables in foreign currencies
Receivables and payables in foreign currencies are valued at the closing day rate. Where hedging measures have been used, such as forwarding contracts, the agreed exchange rate is applied. Gains and losses relating to operations are accounted for under other financial income and cost.

Bank accounts in foreign currencies
Bank balances in foreign currencies are valued at the closing day rate.

Fixed assets
Tangible fixed assets are stated at their original acquisition values after deduction of depreciation according to plan. Assets are depreciated systematically over their estimated useful lives. The following periods of depreciation are applied: Buildings 5 - 50 years, Radar systems 3 - 20 years and Equipment and tools 1 - 5 years.

Note 2 *Associate contributions*

The Associates contributed to the operation during the year in accordance with the agreement. The commitments are in local currencies. The received contributions have been accounted in SEK. DFG (Germany) left the Association at the end of 2011.

	2012
CRIRP (P. R. of China)	3 107
NIPR (Japan)	1 842
RCN (Norway)	5 633
SA (Finland)	3 130
NERC (United Kingdom)	3 214
VR (Sweden)	5 400
	22 325

Accumulated contributions status as of 2011-12-31

	1976 - 2012
Previous Associates	382 168
CRIRP (P. R. of China)	19 321
NIPR (Japan)	72 152
RCN (Norway)	151 119
SA (Finland)	68 444
NERC (United Kingdom)	224 253
VR (Sweden)	124 229
	1 041 685

Note 3 *Personnel costs and average number of employees*

The Association employs directly the Headquarters staff, currently about eight positions, including the Director. The Headquarters is located in Kiruna, Sweden. The personnel working at the Kiruna (Sweden), Sodankylä (Finland), Svalbard and Tromsö (Norway) sites are not employed by the Association. Instead, the personnel are provided via site contracts by the Swedish Institute of Space Physics (Kiruna site staff), Oulu University (Sodankylä staff) and Tromsö University (Tromsö and Svalbard staff). The Association refunds all expenses related to the provided staff, as well as an additional overhead.

	2012	*2011*
Personnel costs in total		
Salaries and emoluments paid to the Director	1 385	1 335
Other personnel, employed and provided via site contracts	11 067	10 835
Social security contributions amounted to	4 192	3 888
of which for pension costs	2 026	1 923

The Director in 2012, Dr. Esa Turunen, started his time-limited employment 2009-01-01 and left 2012-12-31. Dr. Craig Heinselman was recruited as new Director and joined the Association 2013-01-01.

Of the pension costs, 354 kSEK (344 kSEK) relates to the Director. He and all other directly employed staff are included in ITP like occupational pension plans. For the personnel provided via site contracts, the pension plans are handled by their respective employer.

The members of the board (EISCAT Council) and members of committees, who represents Associates, do not receive remunerations from the Association. Travel expenses in connection with Council and committee meetings are normally covered by the Associates. For the Council Advisory Group, the Association cover meeting and travel costs.

Salaries and emoluments and average number of staff per country

	2012	2011
Finland		
Salaries and emoluments	592	1 001
Average number of staff - men and women	1 + 0	2 + 0
Norway (including Svalbard)		
Salaries and emoluments	5 971	5 996
Average number of staff - men and women	9 + 0	10 + 0
Sweden		
Salaries and emoluments	5 890	5 173
Average number of staff - men and women	7 + 2	6 + 2

Members of the board and Directors at year-end - men and women
The board consist of delegations from every Associate country each having a Delegate (formal member) and up to two Representatives.

	2012	2011
Board members (EISCAT Council)	11 + 3	12 + 4
Directors	1 + 0	1 + 0

Note 4 *Own reserves and funds*
Transactions involving own reserves and funds.

	2012	2011
Capital Operating reserve		
Transfer to the reserve	-941	-1 105
Transfer from the reserve	790	888
Investments made	-810	-888
Spare parts reserve		
Transfer to the reserve	-19	-18
Transfer from the reserve	29	159
Surplus fund		
Transfer from the fund	0	2 362
Transfer to the fund	-1 237	-365
Sum own reserves and funds	*-2 188*	*1 033*

	2012	2011

Note 5 *Appropriations*

The outcome for this year became a surplus relative to the budget amounting to 2 356 kSEK. The amount has been transferred to the surplus fund. The 2011 outcome resulted in surplus (1 898 kSEK), which was transferred to the surplus fund.

Note 6 *Transfer from funds invested*

The depreciation cost is covered by funds from Capital - funds invested

Note 7 *Tangible fixed assets*

Changes in tangible fixed assets during 2012.

	2012	2011
Buildings		
Opening acquisition value	42 428	42 382
Acquisitions during the year	0	46
Disposals during the year	0	0
Closing acquisition value	42 428	42 428
Opening accumulated depreciation	-39 234	-38 825
Depreciations during the year	-299	-409
Disposals during the year	0	0
Closing accumulated depreciation	-39 533	-39 234
Closing residual value	2 895	3 194
Radar systems		
Opening acquisition value	244 693	244 542
Acquisitions during the year	0	151
Disposals during the year	0	0
Closing acquisition value	244 693	244 693
Opening accumulated depreciation	-243 861	-243 795
Depreciations during the year	-90	-67
Disposals during the year	0	0
Closing accumulated depreciation	-243 952	-243 861
Closing residual value	742	832
Equipment and tools		
Opening acquisition value	33 459	33 011
Acquisitions during the year	810	691
Disposals during the year	2 915	237
Closing acquisition value	31 354	33 459
Opening accumulated depreciation	-31 838	-31 347
Depreciations during the year	-672	-728
Disposals during the year	2 915	237
Closing accumulated depreciation	-29 595	-31 838
Closing residual value	1 759	1 622
Sum tangible fixed assets	*5 396*	*5 648*

Note 8 *Prepayments and accrued income*

The main buildings and systems insurance for 2013 was paid in December. All costs relating to the Antenna III feasibility work were invoiced in January 2013 (1 548 kSEK in other items). Resources in staff and direct costs spent in the now four plus one (EU and VR funded) ongoing projects are covered by accrued income until settled by periodic report claims. Periodic reports are due at various times. EISCAT_3D_2's first period ended 2012-03-31 and ESPAS had its first period end 2012-10-31.

	2012	2011
Prepaid rents	104	100
Prepaid insurances	533	507
Accrued income, COOPEUS project	63	0
Accrued income, EISCAT_3D_2 project	2 777	1 221
Accrued income, ENVRI project	58	14
Accrued income, ESPAS project	215	19
Accrued income, VR-PG project	110	0
Other items	1 717	342
	5 578	2 202

Note 9 *Bank balances status*

	2012	2011
Nordea	33 147	24 164
Cash in hand	1	1
	33 148	24 166

Note 10 *Funds invested status*

	2012	2011
Buildings	2 895	3 603
Radar Systems	742	832
Equipment and Tools	1 759	1 213
	5 396	5 648

Note 11 *Funds held on reserve*

Less investments were made but more spare parts than budgeted were bought. Both actions were budget neutral since the differences were covered by reserve transfers. The surplus for this year (2 356 kSEK) was added to the surplus fund.

	2012	2011
Capital operating reserve	2 203	2 051
Equipment repair fund	754	754
Investment fund	7 971	7 971
Restructuring reserve	4 101	4 101
Spare parts reserve	139	149
Surplus fund	5 856	2 262
	21 024	17 289

Note 12 *Liabilities, trade*

Four projects financed by EU's European Commission through the Framework Programme 7 scheme and one project financed through Vetenskapsrådet are ongoing. All projects work with prefinancing. The prefinancing is kept as liability until the project has ended and been financially concluded. The guarantee fund is kept as contingency by the Commission for the EISCAT_3D_2 project, which EISCAT is the Co-ordinator of. The guarantee fund will be released at the end of the project, 2014-09-30. AARI (Russia) prepaid their contribution for 2013-2014 (2 134 kSEK in other prefinancing).

	2012	2011
COOPEUS prefinancing	1 581	0
EISCAT_3D_2 guarantee fund, whole project	1 929	2 003
EISCAT_3D_2 prefinancing	4 881	5 069
ENVRI prefinancing	519	539
ESPAS prefinancing	2 408	0
VR-PG prefinancing	3 500	0
Other prefinancing	2 134	0
Liabilities, trade	3 374	3 709
	20 326	11 320

Note 13 *Provisions*

Thales Electron Devices SAS, France, performed pre-study for potential VHF transmitter replacement. Invoiced only in 2013.

	2012	2011
Pre-study work	429	0
	429	0

Oslo 2013-05-27

Dr. Tomas Andersson

Dr. Bjørn Jacobsen

Dr. Hiroshi Miyaoka

Dr. Michael Schultz

Dr. Kati Sulonen

Prof. Jian Wu

Dr. Craig Heinselman
Director

Our audit report was issued on 2013-06-14.

Mrs. Annika Wedin
Authorised Public Accountant

Audit report

To the council of EISCAT Scientific Association, Corporate Identity Number 897300-2549

Report on the annual accounts

I have audited the annual accounts of EISCAT Scientific Association for the year 2012.

Responsibilities of the council and the director for the annual accounts

The council and the director are responsible for the preparation and fair presentation of the annual accounts in accordance with the Annual Accounts Act, and for such internal control as the council and the director determine is necessary to enable the preparation of annual accounts that are free from material misstatement, whether due to fraud or error.

Auditor's responsibility

My responsibility is to express an opinion on the annual accounts based on my audit. I conducted my audit in accordance with International Standards on Auditing and generally accepted auditing standards in Sweden. Those standards require that I comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the annual accounts are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the annual accounts. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the annual accounts, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the association's preparation and fair presentation of the annual accounts, in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the association's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by the council and the director, as well as evaluating the overall presentation of the annual accounts.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my audit opinion.

Opinion

In my opinion, the annual accounts have been prepared in accordance with the Annual Accounts Act and present fairly, in all material respects, the financial position of the association as of 31 December 2012 and its financial performance and its cash flows for the year then ended in accordance with the Annual Accounts Act. The statutory administration report is consistent with the other parts of the annual accounts.

Report on other legal and regulatory requirements

In addition to my audit of the annual accounts, I have also audited the administration of the council and the director of EISCAT Scientific Association for the year 2012.

Responsibilities of the council and the director

The council and the director are responsible for the administration.

Auditor's responsibility

My responsibility is to express an opinion with reasonable assurance on the administration based on my audit. I conducted the audit in accordance with generally accepted auditing standards in Sweden.

As a basis for my opinion on the council and the director´s administration, in addition to my audit of the annual accounts, I examined significant decisions, actions taken and circumstances of the association in order to determine whether any member of the council or the director have undertaken any action or is guilty of negligence which may entail a liability for damages. I also examined whether any council member or the director has, in any other way, acted in contravention of the Annual Accounts Act or the statutes.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my opinion.

Opinion

The council and the director have not acted in contravention of the statutes.

Gävle, 14 June 2013

Annika Wedin
Authorized Public Accountant

Report 2012 of the EISCAT Scientific Association

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Scientific contributions: EISCAT Associates and staff

The EISCAT Associates

December 2012

CRIRP

China Research Institute of Radiowave Propagation
China
www.crirp.ac.cn

NERC

Natural Environment Research Council
United Kingdom
www.nerc.ac.uk

NFR

Norges forskningsråd
Norway
www.forskningsradet.no

NIPR

National Institute of Polar Research
Japan
www.nipr.ac.jp

SA

Suomen Akatemia
Finland
www.aka.fi

STEL

Solar Terrestrial Environment Laboratory, Nagoya
Japan
www.stelab.nagoya-u.ac.jp

VR

Vetenskapsrådet
Sweden
www.vr.se

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