EISCAT

ANNUAL REPORT 2002

EUROPEAN INCOHERENT SCATTER
SCIENTIFIC ASSOCIATION

The front cover shows the Beynon Medal.

Professor Tor Hagfors (inset and above left, photographed with Professor W J G Beyon at Sodankylä, in 1979) was the first person to receive this prestigious award. He received the medal during a ceremony in connection with the special meeting of Council in Copenhagen. The medal is engraved with the following words: “Awarded to Professor Tor Hagfors on 4th February 2002 for his outstanding services to the EISCAT Scientific Association and to Ionospheric Physics”.

EISCAT Scientific Association
2002

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

There are ten incoherent scatter radars in the world, and EISCAT operates three of the highest-standard facilities. The experimental sites of EISCAT are located in the Scandinavian sector, north of the Arctic Circle. They consist of two independent radar systems on the mainland, together with a further radar constructed on the island of Spitzbergen in the Svalbard archipelago - the EISCAT Svalbard Radar.

The EISCAT UHF radar operates in the 931 MHz band with a peak transmitter power of more than 2.0 MW and 32 m, fully steerable parabolic dish antennas (see the table on page 45 for detailed operating parameters). The transmitter and one receiver are in Tromsø (Norway). Receiving sites are also located near Kiruna (Sweden) and Sodankylä (Finland), allowing continuous tri-static measurements to be made.

The monostatic VHF radar in Tromsø operates in the 224 MHz band with a peak transmitter power of 2 x 1.5 MW and a 120 m x 40 m parabolic cylinder antenna, which is subdivided into four sectors. It 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.

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

The basic data measured with the incoherent scatter radar technique are profiles of electron density, electron and ion temperature, and ion velocity. Subsequent processing allows a wealth of further parameters, describing the ionosphere and neutral atmosphere, to be derived. A selection of well-designed radar pulse schemes are available to adapt the data-taking routines to many particular phenomena, occurring at altitudes between about 50 km and more than 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 approximately 2500 hours each year are distributed equally 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 specific and global geophysical phenomena.

The Annual Reports present a summary of EISCAT's operations, developments, scientific results, publications, budget, and Council and committee structure for each year. Further details of the EISCAT system and 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:

Suomen Akatemia, Finland
Centre National de la Recherche Scientifique, France
Max-Planck-Gesellschaft, Federal Republic of Germany
National Institute of Polar Research, Japan
Norges forskningsråd, Norway
Vetenskapsrådet, Sweden
Particle Physics and Astronomy Research Council, United Kingdom

EISCAT Scientific Association 2002

Contents

Introduction

This short report reflects the EISCAT Scientific Association's return to Annual Reports, in contrast to the multi-year reports which have been generated in the recent past. The report concatenates material generated as part of other reporting requirements, including the year-end operations summary, the legal reporting requirement of the Association as a Swedish, not-for-profit organisation, the documentation of the senior staff and committee members, the annual publication list extracted from the full on-line bibliography, and the huge mass of scientific reporting generated by the various national communities of the Associates.

In contrast to previous Annual and Multi-Annual Reports, and in reflection of the increasing importance of internet based document distribution, this Report is primarily published as a web document, but is formatted for easy printing. As downloaded, the Report is intended to be printed double-sided at A4 or A5 sizes.

The overall community efforts, as well as the individual contributions of the principal authors of this report, are gratefully acknowledged.

This report was generated using contributions by Mike Lockwood, Tauno Turunen, Ingemar Häggström, Assar Westman, Brett Isham, Vikki Howells, Henrik Andersson, Tony van Eyken, and many others who contributed smaller, but still important, contributions, as well as the members of the EISCAT scientific community, elements of whose work appear in the scientific sections.

Council Chair's Page

It is my hope and my belief that 2002 will come to be seen as a key year in the history of EISCAT. It was a year in which we charted our way through some considerable financial difficulties, largely induced by changes in currency exchange rates. Our thanks go to the staff for their flexibility and patience and, through a combination of temporary changes and additional contributions from Associates, a solution was found which allowed us to turn our attention to the future.

Because the world of science has moved on considerably during the years covered by the present EISCAT agreement, all possibilities and suggestions for the future, no matter how radical, had to be considered and included or rejected according to their desirability and viability. The discussions on the goals for the Association after 2006, and how it can best pursue them, led to the "E-prime" proposal which addressed the philosophy, funding model and optimum facilities, in addition to the scientific goals. This was only a start, but did provide a basis for discussion and a forum which has since been developed to the point where it can be taken to the existing Associates and to the Research Councils in other countries interested in becoming partners of some kind. The project will need to be flexible enough for partnership to take a variety of forms, but we hope that there will be some new full members of the Association. In this regard, a workshop and special visit to China were an outstanding success; our thanks go to several individuals for working so hard to make this come about. At the close of the year, Dr Tony van Eyken was chosen to be the director to take EISCAT through the process of defining the new facilities, organisation and agreement. His task is a challenging one but progress has been promising and Council are confident that his unique knowledge, skills and dedication will get us to where we need to be in 2006.

Against the background of the financial difficulties, the last thing that we needed was a major technical failure. Although we had known for some time that the VHF klystron was a risk, the timing of its demise could not have been worse. The director and staff are to be congratulated on the deft manner in which they allowed the various possibilities to remain open and Council were delighted to be able to find a way to implement the excellent solution that eventually emerged. To have lost such a major element of our capability at this crucial stage would have been a serious blow, especially considering that the renovation of the systems means that EISCAT has never been in such sound shape technically. The quality of the new data is truly astonishing. One outstanding success, which broke new ground scientifically, technically and even logistically, was the unique 30-day run. This has provided a dataset which really tests coupled ionosphere-thermosphere models and can expose the degree to which the persistence of initial conditions may have been aiding the models to match shorter runs of observations.

Lastly, on behalf of all on Council, I give my warmest thanks to Dr Tauno Turunen, for whom 2002 was his last full year as director. It has been a pleasure to work with him and under his fine stewardship the radars have progressed in their resolution, capability and ease of use. His contributions to EISCAT have been tremendous and so Council were delighted to be able to thank him with the award of the second Beynon medal.

Mike Lockwood
Chair 2002

Director's Pages

The year 2002 in EISCAT

From the Director's point of view, the year 2002 started in quite unusual way. At the end of 2001, the EISCAT Council did not accept the budget proposal presented by the Headquarters. Council decided to have an extra Council meeting in February 2002 and requested that a preparation meeting also be arranged to go through the EISCAT financial background in detail before the Council meeting. Nothing similar had ever happened before in the history of the EISCAT Scientific Association.

The basic reason for this lay in a Council decision taken some years earlier, that the contributions from the Associates would be kept constant from year to year in terms of the Swedish Crown. This decision, and the careful way EISCAT used the available money, lead first to considerable savings, which maximized around the millennium change when the savings reached their largest value, roughly equivalent to about four months' operational expenses of the Association.

However it was already very clear by 2001 that the savings would be completely used sometime during, or at the end of, 2003, at the latest, because EISCAT latterly used more money than it received from the Associates. Exchange rate fluctuations made the situation quite unpredictable. During the year 2001, discussions on how to handle the demand to decrease the operational cost of EISCAT started at very serious level and the analysis contained some difficult matters, among which were the future of EISCAT operations and especially the future of the EISCAT personnel. This was necessarily also reflected in Council discussions and decisions.

Finally, the EISCAT budget was accepted by Council in its February meeting essentially unchanged. Later, in the summer meeting of EISCAT Council, the basic plans of how EISCAT should proceed, once the necessary decrease of cost levels has to be done, was discussed once again. Subsequently, EISCAT has, to large extent, essentially followed the outcome of these considerations, which took place especially in 2002 both in EISCAT Headquarters and in the Council and Committees. EISCAT had to go through this discussion period in good time before the later, very final, decisions had to be made.

In the beginning of 2002 there were also some other high level matters in progress. The candidates for the next director were selected and, in the February 2002 meeting, Council selected Dr Tony van Eyken to be the director of EISCAT from the beginning of the year 2003. The EISCAT Future Committee worked and discussed ideas for the next phase of the Association. A lot of ideas were presented of course, but in the end the E'-concept was presented; however it was by no means clear what kind of solution might finally become a reality. Nevertheless, the discussions in the Future Committee will certainly be reflected in the future decisions of EISCAT.

The KST system was fully operational, but the whole UHF transmitter power available could not be exploited. The reasons were understood but implementing a solution turned out to be time consuming and quite expensive. A detailed report analysing the remaining older parts in the whole KST system was also prepared in 2002.

Then, near the end of September 2002, one of the two VHF klystrons failed. This failure was not at all unexpected because it was inevitable that such a failure would happen sooner or later. The decision to try to repair the klystron was made in the last Council meeting of 2002. It was a good, but also risky, decision and one only can hope for success.

In 2002, EISCAT came to the end of the technically renovation period, which had lasted several years. The EISCAT Svalbard Radar (ESR) worked well. The signal processing was changed to essentially the same configuration as in KST system in early summer 2002, and this finalized the planned renovation works in the EISCAT radars. The ESR renovation also required new experiments to be developed. The capabilities to measure again were restored after the renovation with practically no gap while some new empirical modes were also developed.

The whole renovation, both in the KST and subsequently in the ESR systems, was done largely in house within EISCAT based on our own developments and, in many cases, even our own production using EISCAT personnel and the available laboratories and workshops. The installations were also often made by EISCAT's own staff. Testing of these new systems, and development of new measuring routines, also fell on the shoulders of the EISCAT personnel. At the same time, the site personnel successfully served the users as widely as possible during the renovation phase and resulting system changes.

The EISCAT radars became a good radar system in the renovation and the quality of the new data shows it immediately (see, for example, the data displayed on pages 12 and 13). I want both congratulate and give my warmest thanks to the EISCAT personnel, who made all this possible; it demanded exceptional professional competence and huge amounts of work.

My contract with EISCAT ended 31.12.2002. I want to use this opportunity present my sincere thanks to the EISCAT Council and other committees of the EISCAT Scientific Association for the co-operation during altogether five years when I worked as the Director of EISCAT. Finally I hope that the work and planning for the future of EISCAT finally ends with successful results and we continue to see incoherent scatter measurements and related science results after the time that the present EISCAT contract come to an end.

Tauno Turunen
Director 2002

Figure 1 The Annual Review Meeting held in Äkäslompolo, northern Finland

Figure 2 UHF data output after the mainland renovation

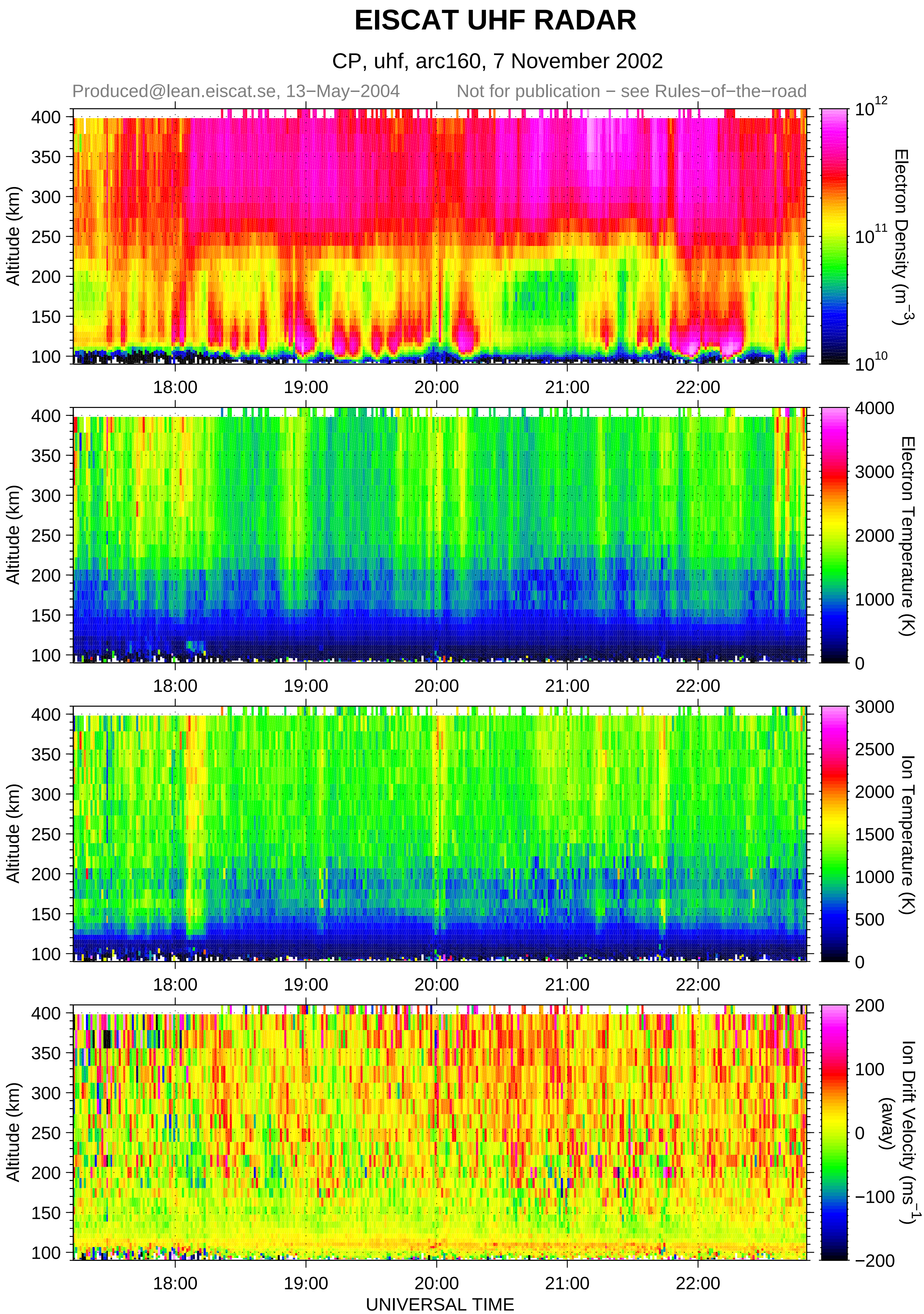
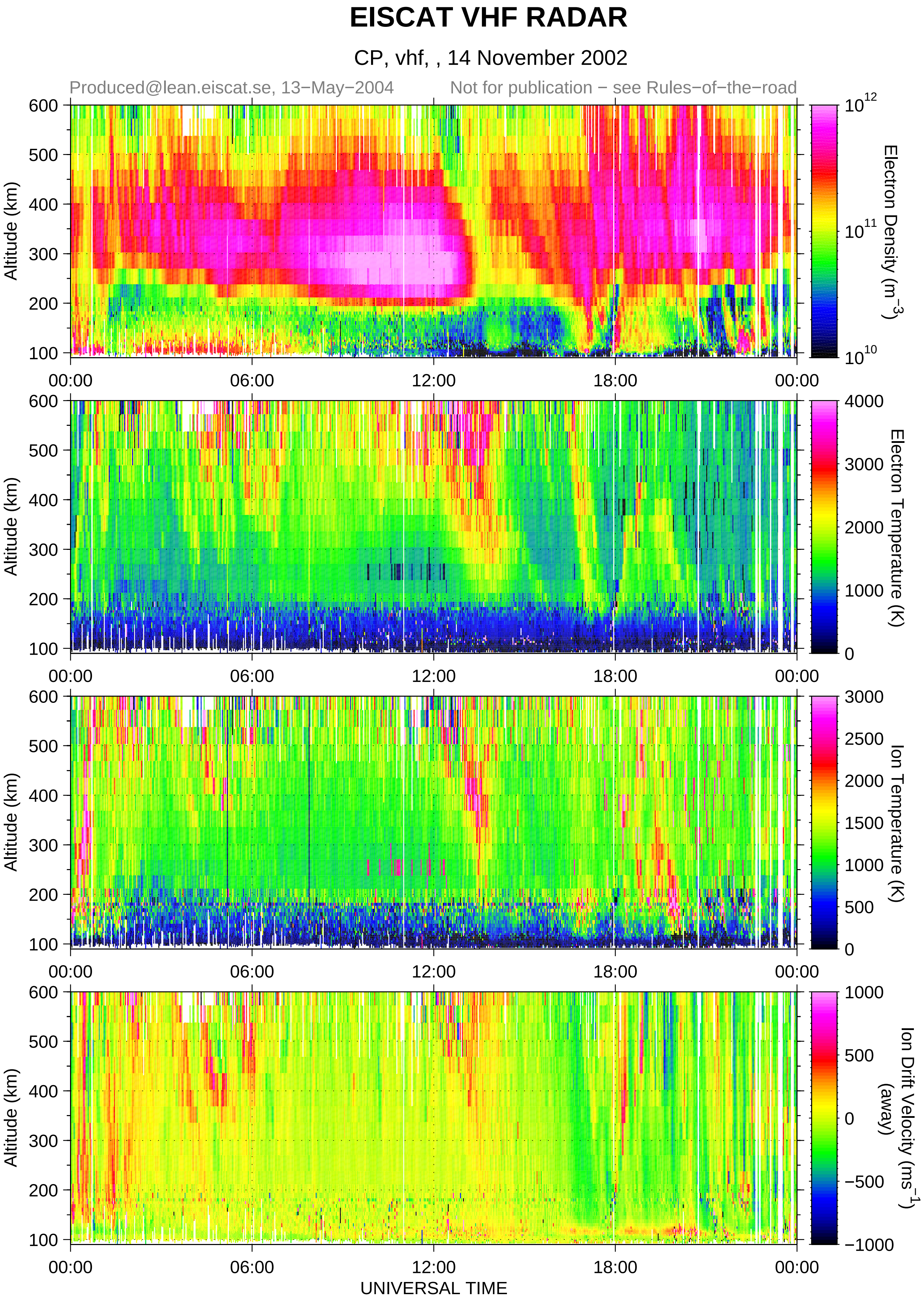


Figure 3   An example of VHF data after the renovation



EISCAT Operations

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 sec. 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 between 90 and 700 km altitude.

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 km 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.

Table 1 Modulation schemes currently in use

Experiment Name	Radar	Pulse Schemes Used	Time Resolution	Range Coverage	Comment
tau0	ESR	Alt. Code	3.2, 6.4, 12.8 s	90-1200 km	General purpose ESR experiment
tau1	VHF	Alt. Code	5 s	300-1900 km	Low elevation
tau2	UHF	Alt. Code	5 s	90-750 km	General purpose
tau3	UHF	Alt. Code	5 s	90-1400 km	Long range coverage, used for scanning
tau7	VHF	Alt. Code	5 s	150-2000 km	High altitude
tau8	VHF	Alt. Code	5 s	150-1400 km	General purpose dual beam VHF experiment
arc 1	UHF	Alt. Code	0.4 s	95-350 km	High time resolution for auroral studies
d layer	VHF	Coded pulse-to-pulse	5 s	60-120 km	High spatial resolution for D-layer and PMSE
cp1l	UHF	Alt. Code Long Pulse Power Profile	5 s	90-700 km	Cp1k converted for new system
cp4b	VHF	Long Pulse Power Profile	10 s	400-1800 km	Cp4b converted for new system

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 minute 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. Alternating codes for spectral measurements between 90 and 1300 km range are used. 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 were often operated simultaneously during the CP experiments in 2002. 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.

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 normally used.

Common Programme Seven, CP 7, probes high altitudes and is particularly aimed at polar wind studies. The present version uses both of the VHF klystrons and is designed to cover altitudes up to 2000 km vertically above Ramfjordmoen.

Equivalent Common Programme modes are available for the EISCAT Svalbard Radar. CP-1L is directed along the geomagnetic field (81.6° inclination). CP-2L uses a four position scan with spacing matching CP-2. CP-3L is a 30 position elevation scan with southerly beam swinging positions overlapping those of CP-3. CP-4L combines observations in the F-region viewing area of the two beams of CP-4 with field-aligned and vertical measurements. CP-1L, CP-2L, CP-3L, CP-4L, and CP-7L (same as CP-1L) have been operated in conjunction with the corresponding modes on the mainland. The pulse scheme used for all modes covers approximately 80 to 1200km using two alternating codes with integral clutter removal below 150 km.

Table 1 summarises the presently available modulation schemes on the three incoherent scatter radars.

Table 2 provides an overview of EISCAT Common Programme experiments in 2002. WD indicates a co-ordinated 'World Day' incoherent scatter experiment, * indicates multiple radar operation for some or all of the interval.

Table 3 gives the total number of operating hours per facility and Figure 4 shows the distribution over the year.

The remaining tables show the accounted hours on the various facilities for each month and for each Common Programme (CP) or Associate (SP), Special Programme mode.

UHF Common Programmes during 2002	
2002-03-25 10UT 03-28 12UT CP-2WD	*
2002-04-15 10UT 04-18 22UT CP-3WD	*
2002-06-11 10UT 06-12 16UT CP-1WD	*
2002-08-13 10UT 08-14 16UT CP-3WD	*
2002-10-05 10UT 10-12 14UT CP-1WD	*
2002-10-15 10UT 10-18 06UT CP-1 *	
2002-10-22 10UT 10-25 10UT CP-1 *	
2002-11-11 10UT 11-15 16UT CP-2WD	*
2002-12-03 13UT 12-05 21UT CP-1WD	*

VHF Common Programmes during 2002	
2002-06-11 10UT 06-12 16UT CP-4WD	*
2002-08-13 10UT 08-14 16UT CP-4WD	*
2002-10-05 10UT 10-08 16UT CP-7WD	*
2002-10-08 17UT 10-12 14UT CP-4WD	*
2002-11-11 10UT 11-15 16UT CP-4WD	*

ESR Common Programmes during 2002	
2002-03-25 10UT 03-28 16UT CP-2LWD	*
2002-04-15 10UT 04-18 22UT CP-3LWD	*
2002-06-11 10UT 06-12 16UT CP-4NWD	*
2002-08-13 10UT 08-14 16UT CP-3LWD	*
2002-10-02 16UT 11-03 18UT CP-2LWD	*
2002-11-11 10UT 11-15 16UT CP-2LWD	*
2002-12-03 13UT 12-05 21UT CP-1LWD	*

Table 2 Common Programme overview

Table 3 Total Operations Summary

2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
UHF	40	96	165	72	13	66	13	32	7	373	208	71	1156
VHF	66	101	89	10	6	19	142	57	0	180	155	65	890
Heating	6	12	25	0	0	0	24	0	16	54	29	0	166
ESR	104	141	150	75	6	57	72	109	34	664	266	129	1807
Dual	30	64	62	0	0	12	13	24	0	165	151	12	533
Passive	0	0	0	1	66	0	0	0	0	0	55	0	122

Figure 4 Operating hours per month

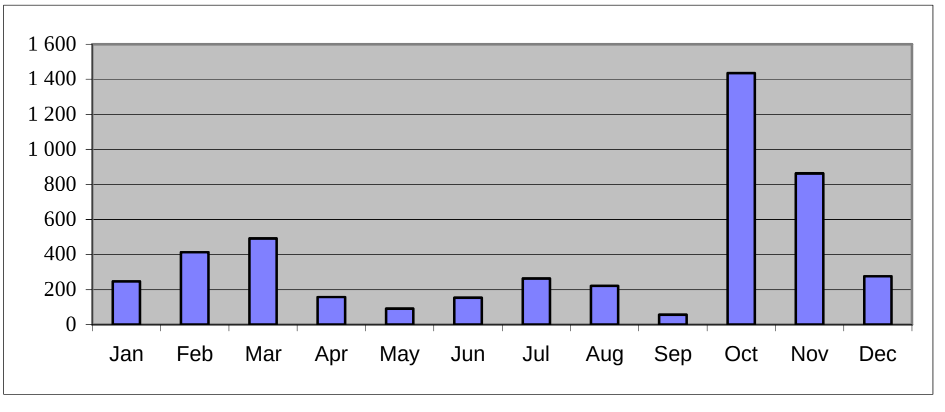


Table 4 Mainland Common Programme

2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot	%
CP1										311		57	368	35
CP2			70								101		171	16
CP3				72				44					116	11
CP4						37				59			96	9
CP6													0	0
CP7										75	51		126	12
UP1	5	9		10	6			5		24	12	14	85	8
UP2	34	30	27										91	9
UP3													0	0
Total	39	39	97	82	6	37	0	49	0	469	164	71	**1053**	100

Table 5 Mainland Special Programmes

2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot	%
3rdP		20	12			9					5	13	59	7
EI											8		8	1
FI			8								53		61	7
FR	12										35	8	55	6
GE		25	18		13	32	76			28	19	11	222	25
NI	18	30	8					10			13		79	9
NO	5	41					54			24		17	141	16
SW	12		42				14	18			9		95	11
UK	11	26	55		11		16		12	29	4	16	180	20
Total	58	142	143	0	24	41	160	28	12	81	146	65	**900**	100

Table 6 ESR Common Programmes

2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot	%
CP1L											164		164	12
CP2L			55							648			703	50
CP3L				65				30					95	7
CP4L						29	23						52	4
CP6													0	0
CP7L												57	57	4
UP1	5	9		10	6		11	9		8	14	13	85	6
UP2	13	37	31				38	29	34				182	13
UP3	7	27	24										58	4
Total	25	73	110	75	6	29	72	68	34	656	178	70	**1396**	100

Table 7 ESR Special Programmes

2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot	%
3rdP												10	10	2
EI						14					23		37	9
FI											37		37	9
FR	10										26	6	42	10
GE		18										9	27	7
NI	10	3						10			2		25	6
NO	42	27	4			14		13				14	114	28
SW	10							18					28	7
UK	7	20	36							8		20	91	22
Total	79	68	40	0	0	28	0	41	0	8	88	59	**411**	100

Electric fields and currents of stable drifting auroral arcs in the evening sector

In this study, the spatial distribution of electric fields, conductances and currents were determined from steadily-drifting medium-scale (15-50 km) auroral arcs by EISCAT UHF radar measurements at Tromsø in the evening sector (20-23 MLT). Optical measurements of the arcs were used to confirm that there were no major changes in the arc appearance as it drifted equatorward through the EISCAT beam. Optical observations also allowed the determination of the changing distance of EISCAT observations from the edge of the arc.

The arcs residing in the northward convection electric field region were in most cases associated with an enhanced northward directed electric field region on the equatorward side of the arc. The width of the region of the enhanced electric field was 1 to 4 times the width of the arc and in some cases the electron density reduction was so pronounced that the region could be described as an auroral ionospheric density cavity. From the divergence of the horizontal current, the field-aligned current (FAC) was calculated and it turned out that the FAC was downward within the region of the enhanced electric field and upward from the arc region with enhanced conductances. It has been argued that a downward FAC is efficient in producing density cavities in the E and F regions. See Figure 5.

In addition, it was shown that the widths (L) of these medium-scale arcs and their Pedersen conductances (ΣP) obeyed the prediction of the electrostatic magnetosphere-ionosphere coupling model, i.e. $L = \sqrt{\Sigma P/K}$, where K is the field-aligned conductance.

A new incoherent scatter technique implemented at the EISCAT Svalbard radar

Unlike often assumed, range ambiguities do not necessarily destroy an incoherent scatter measurement. This is demonstrated in an observation carried out at the EISCAT Svalbard radar in November 1999. The measurement consists of phase coded modulations at two frequencies; one of them containing 22 bits and the other 5 bits. Both transmissions are further sub-modulated by a 5-bit Barker code. The data were collected by means of an additional receiving system connected after the 70 MHz mixer in parallel with the standard ESR receiver. With this equipment the data were sampled at an effective rate of 1 MHz and stored on hard disk for later processing. Hence no ACF estimates were produced during the measurements.

The range ambiguity functions of both modulations are composed of a set of positive and negative spikes of equal height thus creating range ambiguities which look serious at first sight. In spite of this, unambiguous range profiles for different lags of the data can be obtained by means of stochastic inversion. An example is shown in

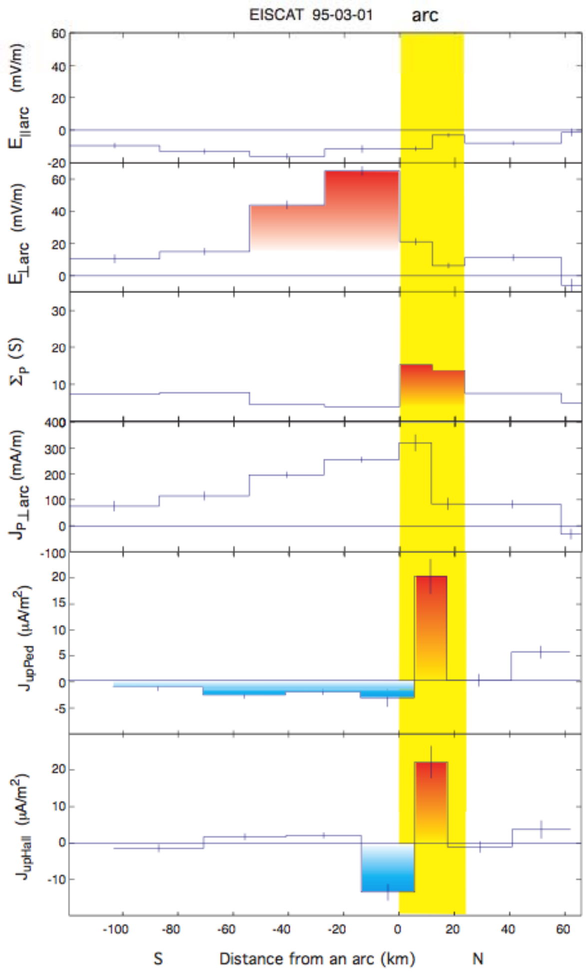


Figure 5. Panels from top to bottom are: electric field parallel (positive eastward) to the arc; electric field perpendicular (positive northward) to the arc; Pedersen conductance; horizontal Pedersen current; FAC calculated from the Pedersen and Hall currents; Hall curent. The yellow vertical bar shows the location of the auroral arc.

Figure 6, portraying a height profile of the real part of the 30 µs lag. The top panel shows the lag profiles for the 22 bit and 5 bit transmissions separately. The data are selected from a time period when an intense sporadic-E layer was present. Due to the range ambiguities, the layer appears as a sequence of spikes at both frequencies. The bottom panel shows the lag profile calculated from these two profiles by means of stochastic inversion. The results indicate that inversion completely removes the range ambiguities.

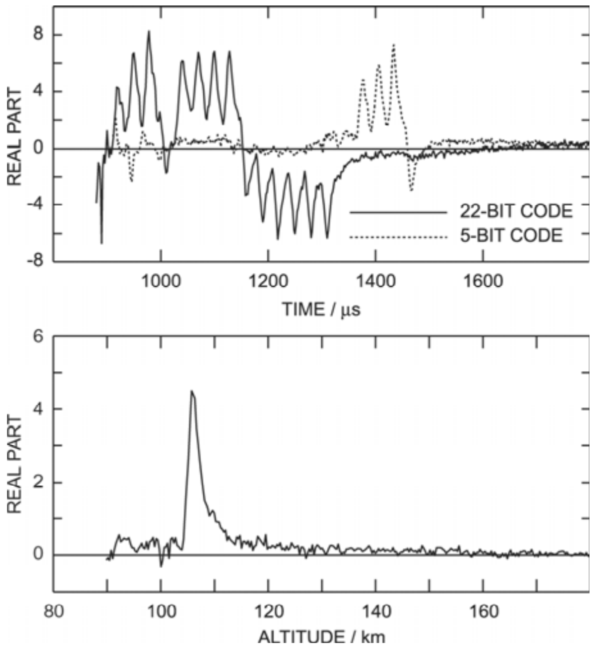


Figure 6. Top: Height profiles of the real part of the 30-s lag for the applied 22-bit and 5-bit codes. Bottom: The corresponding lag profile obtained means of the inversion method.

Thermospheric curls (tourbillons)

EISCAT measurements have been used to monitor the meridional neutral wind and have been compared to interferometer measurements. The intercomparison study led to the proposal of a new interpretation of the neutral wind, and to the suggestion of the existence of thermospheric curls (called "tourbillons") at altitudes up to 400 km.

Space weather

Two uses of EISCAT for space weather studies have been examined and seem quite promising. The first one is to use the ionosphere as tracer of the thermosphere when using T/I models. It allows the determination of the atomic oxygen correction factor in thermospheric models used in orbitography. The second one is the use of EISCAT to correct GPS TEC measurements and to calibrate ionosonde.

HF-pump-induced electron temperature enhancements and ion outflows at magnetic zenith

An increasing range of phenomena excited by powerful HF pump waves exhibit a clear dependence on the angle between the HF ray and the magnetic field. In this example, from 7 October 1999, the UHF radar antenna scanned through

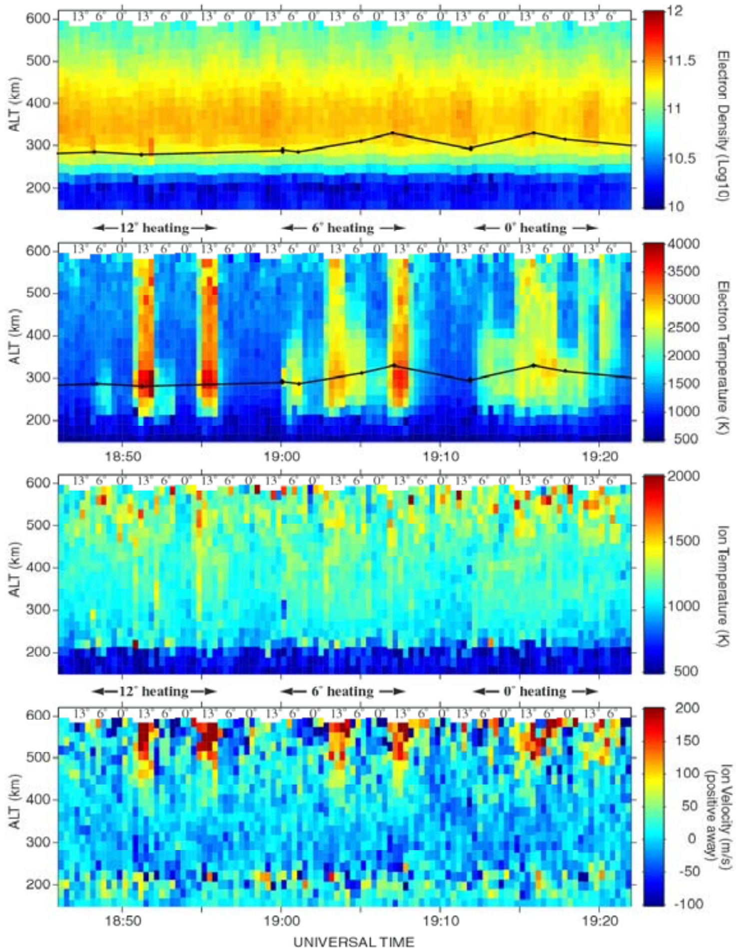


Figure 7. Data from the EISCAT UHF radar at Tromsø on 7 October 1999, analysed with 20s integration time, showing the effects of HF pumping. The HF was cycled 8 min on, 4 min off, with the beam directed at southward zenith angles shown below the upper and above the lowest panels. The UHF antenna was continually scanned in a 4-min cycle between almost the same positions, 6º, 0º, 12.8º zenith angles, which are shown inside each panel at the top. The solid line in the upper two panels connects points where the HF-enhanced ion line occurred, which should be close to but below the HF reflection height.

three positions between vertical and geomagnetic field-aligned in a 4-minute cycle, while the powerful O-mode HF wave at 4.544 MHz from the heating facility was switched 8 minutes on and 4 minutes off. The HF beam was also tilted between the same three zenith angles as the UHF radar but in a 12 minute cycle. Surprisingly, the electron temperature enhancements were almost always stronger in the field-aligned direction, irrespective of the direction of the HF beam, as is shown in Figure 7. At the same time artificial airglow in the 630 nm red oxygen line was produced, also staying in the field-aligned position in spite of the HF beam scanning. There were also strong indications from coherent HF radars that decameter scale irregularities (striations) were strongest at this HF beam position.

Figure 7 also shows one of the first observations of HF-induced ion outflows, with velocities increasing above about 450 km to several hundreds of m/s. The increased plasma pressure caused by the heating is the likely mechanism but this needs verification by modelling which may contribute to understanding the mechanism of natural ion outflows.

Upper hybrid wave turbulence, which is thought to be responsible for energising the electrons producing the increased temperatures and the airglow, is excited by the perpendicular component of the pump electric field to the magnetic field. It is still unclear why these and other phenomena show a strong dependence on the direction of the HF ray to the magnetic field, but self-focusing on field-aligned striations is a candidate mechanism.

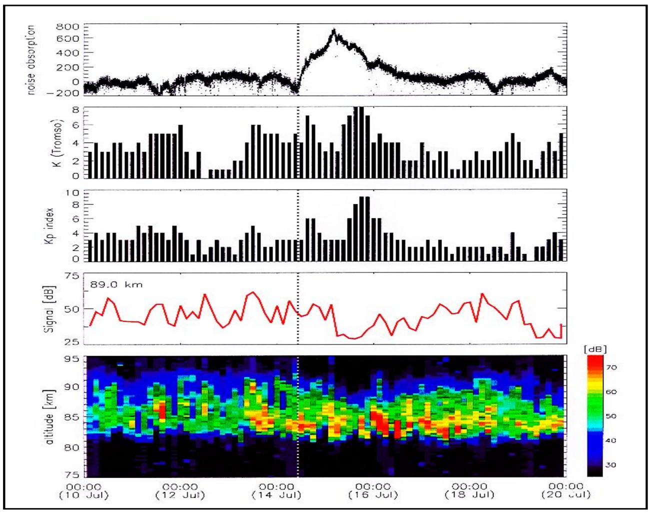


Figure 8. Five days of observations covering the Bastille II event. In the upper panel the cosmic noise absorption at 53.5 MHz is shown. The two centre panels show the K index of Tromsø in northern Norway and the planetary index K_p, respectively. The fourth panel from the top shows the signal strength of PMSE at 89 km, and the lower panel shows the height-time-intensity plot of PMSE over the full height range and period. The PMSE were observed with the SSR at 53.5 MHz.

Upper mesosphere temperature changes observed in PMSE and incoherent scatter during a strong polar cap absorption event

In mid-July 2000 an extremely strong solar proton event occurred (named Bastille II), which caused major polar cap absorption (PCA) due to the strong increase of D-region electron density by high energy particle precipitation. The concurrent ionospheric disturbances led to enhanced electric fields, which caused an increase of the ion drift and the neutral wind in the lower thermosphere and possibly the upper mesosphere as well. The enhanced ion drag usually results in increases of ion and neutral temperature, which is known as Joule heating. Evidence of this was sought in coherent scatter observations of PMSE with the SOUSY Svalbard Radar (SSR at 53.5 MHz) and in observations of incoherent scatter with the EISCAT Svalbard Radar (ESR at 500 MHz). Two independent observations were found which indicate a potential temperature increase of the upper mesopause region due to ion heating.

It is assumed that the surprising decrease in PMSE strength above 85 km in Figure 8 on the 14 July is caused by a warming of the mesopause. Figure 9 shows the calculated Joule heating rate using the electron density profile and electric field measured by the ESR, and neutral densities, temperatures and collision frequencies from models. Figure 10 shows the resultant accumulated neutral heating

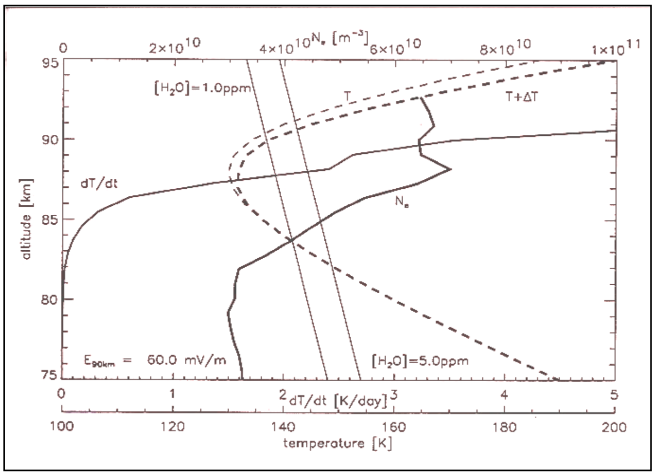


Figure 9 Height profiles of measured electron density Ne, heating rate dT/dt, neutral temperature T before and after the Joule heating (dashed lines), and the limiting water vapour mixing ratio.

rate neglecting heat transport and radiation. The temperature increase from this model is not sufficient to cause melting of the ice particles and thereby explain the decrease of PMSE echo strength. Perhaps the natural heating causes a reduction in the scatter cross section, similar to the effect of artificial electron heating.

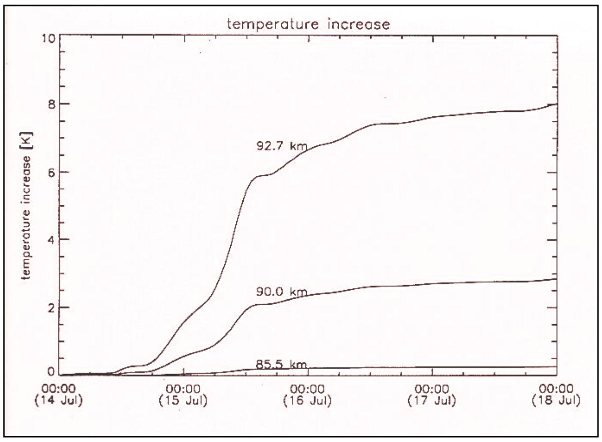


Figure 10. Cumulative heating rate (temperature increase as function of time) at different altitudes around the mesopause.

CHAMP-EISCAT Electron Density Profile Comparisons

On board the German CHAMP satellite, dual frequency GPS measurements in the limb sounding mode, also called radio occultations, have been used to deduce vertical electron density profiles. At Leipzig University, 3D-tomographic reconstructions of the ionosphere are performed using GPS (ground-based and satellite-borne) data and additional information such as that from ionosondes or incoherent scatter radars. EISCAT electron density profiles have been used for validation of the CHAMP GPS satellite electron density profiles. An example is given in Figure 11. Including EISCAT profiles into the reconstruction algorithm has been tested, and is planned in future work.

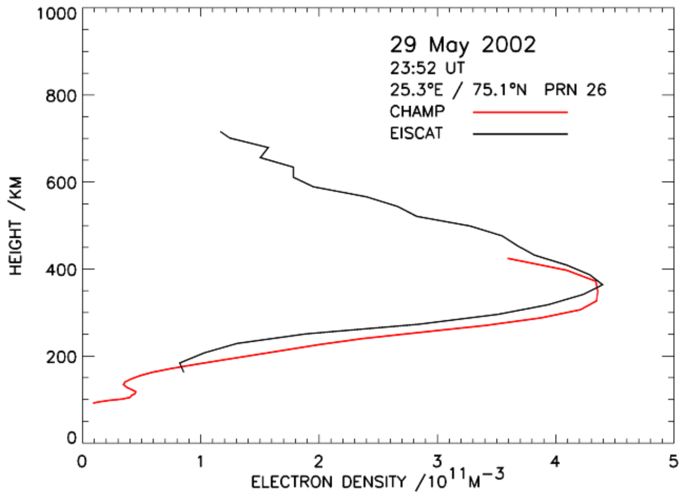


Figure 11. Electron density profiles from CHAMP-GPS reconstruction (red) and the EISCAT UHF radar (black) where the long pulse data from the cp1lt modulation was used.

Multi-point observations of the low-altitude cusp

SIRCUS (Satellite and Incoherent scatter Radar CUsp Studies) is a research program built upon a sequence of observational campaigns each of which lasts for a few days. They are coordinated efforts to get the best data return from the CHAMP and Ørsted satellites and to benefit from temporal and spatial coincidence with the EISCAT and Sondreström incoherent scatter radars. The object of investigation is the dynamics of the low-altitude magnetospheric cusp and its foot-point in the ionosphere. One winter and one summer campaign have been conducted so far. The first SIRCUS campaign covered 16-22 February, 2002. The primary data set was supplemented by DMSP F13 and F14 particle flux and ACE solar wind measurements. On February 21 all instruments were operated in campaign mode and delivered usable data. The low-altitude cusp was identified based on signatures in the multi-instrument data set and a consistent time-dependent mapping of the cusp in terms of magnetic local time and latitude was derived. It was demonstrated that small-scale variations of the magnetic field i.e. field-aligned currents (spatial scales of several hundred meters) can be used to identify the cusp. However, their

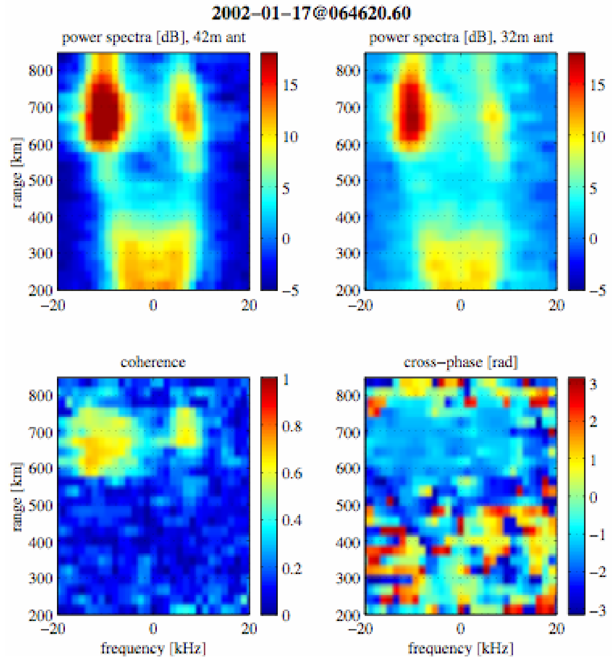


Figure 12. Data from January 17th, 2002. 0.2 seconds of data were integrated, starting at 06:46:20.60 UT. The top two panels show power spectra from the two antennas, on a logarithmic scale. Background subtraction and correction for range square attenuation has not been made. The lower left panel shows coherence (normalized cross-correlation) where high coherence indicates a narrow scattering region. The lower right panel shows the cross-spectrum phase, which is random except where coherence is high.

general ability as cusp signature has not yet been proven. An extended analysis of several SIRCUS campaigns is expected to give a qualified answer.

Multi-instrument observations of neutral atmospheric dynamics

A study of neutral winds in the polar upper mesosphere/lower thermosphere has been conducted using two collocated radars, the EISCAT UHF radar (931 MHz) and the Tromsø MF radar (2.8 MHz). On the basis of simultaneous observations by the two radars, comparisons of winds over a height range from ~90 to ~100 km are made for about 20 days between February and October 1999. In the study, we directly compare temporal wind variations and also mean, diurnal and semidiurnal wind components. No significant departures between instantaneous winds from the two radars are identified. In general, both statistical altitude profiles are well connected, but significant disagreements exist for the mean and tidal wind components for summer. From these comparisons, we raise strong concerns regarding the use of summer wind data above 91 km obtained by high latitude MF radars under high solar activity conditions. The wind values in the winter and equinox observed by the two radars are complementary. As case studies, we utilize altitude profiles of electron density obtained by the EISCAT radar at and above 62 km height to determine the total reflection height as well as to estimate the effect of group retardation of 2.8-MHz radio wave. It can be seen that the effect of particle precipitation sometimes penetrates into the *D* region (down to ~84 km).

Hall conductivies and the nightside electrojet

Based on 10 years of EISCAT radar data, we have investigated the variation of ionospheric conductivities, electric fields, and currents over magnetic local time (MLT). Pedersen and Hall currents are generally enhanced especially on the nightside, and the MLT dependencies of these two types of ionospheric currents are similar. We readdress the question to what extent the conductivity or the electric field contributes to the ionospheric current in different periods of MLT.

On average, higher Pedersen conductivities are seen at 2000–0800 MLT in comparison with other MLT intervals, and these conductivities crucially contribute to Pedersen currents over two MLT sectors, around midnight and in the late morning. However, when the Pedersen current is stronger, not only the Pedersen conductivity but also the electric field becomes higher statistically on the nightside.

Hall conductivities are also higher at about 2000–0800 MLT, showing two maxima, around midnight and in the late morning, and they increase more strongly than Pedersen conductivities on a statistical basis. Thus the nightside electrojets are mainly due to high Hall conductivities.

Interferometry at the ESR

Whenever currents are carried by a plasma, there seems to be a tendency for the current to form channels, or filaments, of current densities far higher than those in the plasma as a whole. Therefore it has been suggested that such current filamentation is likely to occur also in the auroral ionosphere, a suggestion which is supported by optical observations of auroral fine structure.

The phenomenon of naturally enhanced ion-acoustic echoes [Rietveld et al., 1991] was suggested to be caused by a relative drift between the thermal populations of electrons and ions, an explanation which required current densities orders of magnitude above those observed e.g. by satellites. The difference in current densities can be explained if the current is carried in narrow channels.

To obtain observational evidence for such fine structure, resolution within the illuminated volume must be obtained. The Jicamarca observatory has performed a number of observations of the equatorial ionosphere over the last two decades where such sub-beam resolution is achieved using radar interferometry. During the winters of 2000/2001 and 2001/2002, a number of attempts were made at using the two antennas of the EISCAT Svalbard Radar as an interferometer to establish the existence of such narrow scattering regions. One antenna is used to transmit, and both are used to receive the scattered signal.

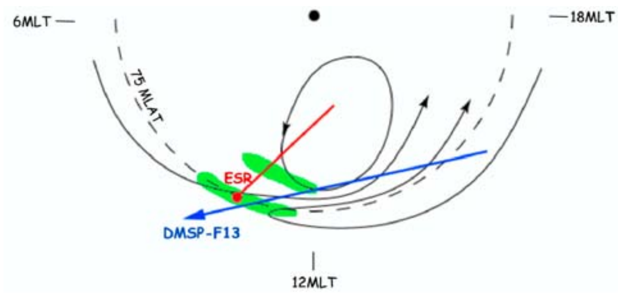


Figure 13: Schematic of the dayside polar ionosphere around 07:25 UT on 26 November 2000 showing the plasma flow in black, the EISCAT Svalbard Radars in red, the DMSP-F13 projected orbit in blue as well as the two cusp regions in green.

In January 2002, the first observations showing evidence of narrow scattering regions were made. Using a long-pulse measurement and a separate data acquistion system where voltage-level data was recorded from both antennas, observations were made during a period of naturally enhanced ion-acoustic echoes, which were shown to evolve on a typical time scale of 0.1 second. Figure 12 shows an example of such an observation The coherence levels indicate scattering regions as narrow as 300 metres horizontally, while they extend more than 100 km in the direction along the magnetic field. The phase of the cross-spectrum between the two signals is an indication of position in the horizontal direction parallel to the baseline, and this phase clearly indicates that when both ion-acoustic shoulders are enhanced and spatially localised, they are localised in the same volume, a result which cannot be explained through the streaming instability mentioned above.

ESR and DSMP observations of a double cusp

Magnetic merging is relatively widely accepted as a process forming the cusp regions where solar wind plasma can get into contact with the ionosphere. Reconnection also transfers momentum and is considered a main driver of plasma convection in and near the cusp. Its location and ionospheric footprint depends on the orientation of the interplanetary magnetic field (IMF). Typically the cusp is equatorward of the ESR for southward IMF or poleward for northward IMF, and the convection is tailward or sunward, respectively. What happens in the time when the IMF changes direction? Using ESR and DMSP data in a period when the z component of the IMF changed sign several time we interpret the observations so that a cusp formed quasi-simultaneously at two locations, see the schematic drawing in Figure 13.

HF stimulated optical emissions

A high frequency (HF) electromagnetic pump wave transmitted into the ionosphere from the ground may stimulate optical emission (enhanced airglow or enhanced luminescence), which can be detected on the ground. The emissions result from excitation of electron states in atmospheric atoms and molecules, due to electron acceleration in the electromagnetically driven plasma turbulence. With its dependence both on plasma turbulence energizing electrons and the interaction of the electrons with the ambient thermospheric neutral gas, the optical emissions are useful for studies both of fundamental aspects of the dissipation of plasma turbulence as well as to determine thermospheric parameter values that are not easily accessible by other means.

Experiments performed with the EISCAT HF facility in 2002 have produced the first nearly-simultaneous images of enhanced optical emissions at 6300 Å and 5577 Å. The emissions were imaged with the Auroral Large Imaging System (ALIS) alternatively at 5577 Å and 6300 Å during the same HF pump pulse. The rather high intensity ratio of the 5577 to 6300 Å emissions of 0.3-0.4 implies that the excitation is caused by a nonthermal electron population. The experiments have given the first images of emissions at 4278 Å, which implies that molecular nitrogen is ionized by the HF pumping. Previously, enhancements at 4278 Å have been observed with a photometer (M. Kosch et al.).

Detection of this emission shows that electrons are accelerated to a few tens of eV in the experiments. A most interesting result is that the emission was strongest for pump frequencies slightly above an harmonic of the electron gyro frequency. The dependence of the 4278 Å emission intensity on the pump frequency around the gyro harmonic gives important input for the theoretical modeling of electron acceleration.

HF modification of polar mesospheric summer echoes (PMSE)

PMSE are closely connected to charged aerosol particles existing near the mesopause in summer. The action of powerful HF (high frequency) pumping on PMSE can shed some light on the microphysics of the scattering mechanism for these echoes.

The first HF/PMSE experiment was conducted in 1999 using the EISCAT VHF radar and the EISCAT HF facility. It showed clear modulation of PMSE power by HF pumping. PMSE decreased when the HF pump was switched on with a response time less than 30 ms. Unfortunately, the next attempt to repeat PMSE modification by HF pumping, undertaken in 2001, was not successful.

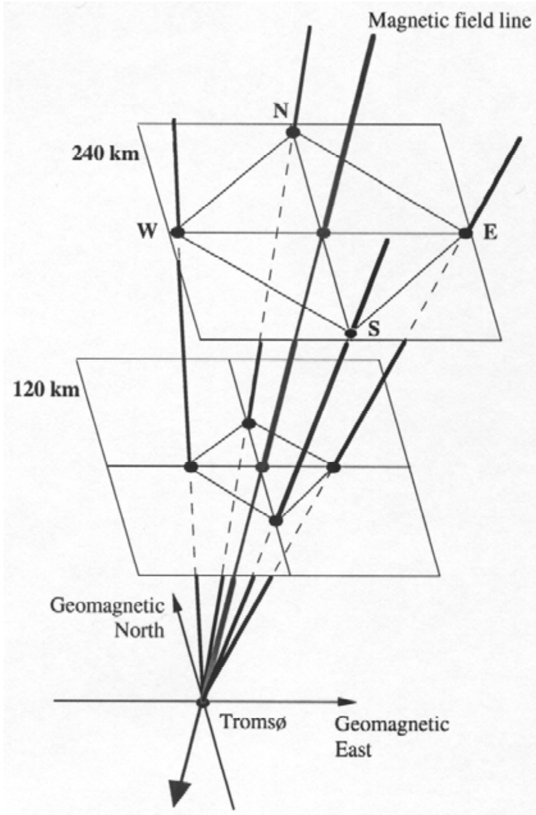


Figure14. The scanning arrangement, with squares of 50 and 100 km on a side in the F-layer. Each scan takes 10 minutes throughout which a steady state ionosphere is assumed.

The HF/PMSE experiment conducted in July 2002 was aimed firstly to confirm the pump effect on PMSE then to get a more accurate estimate of the time constant for the effect by making use of a higher time resolution of 7 ms. This is important for physical interpretation of the observations.

Analysis revealed that the pump effect on PMSE is repeatable. PMSE power again dropped markedly and recovered in phase with the HF pulses with a delay of only 7 to14 ms. Additionally, we found that the dependence of the HF/PMSE effect on pump power is very close to linear, i.e. the higher the power the stronger the reduction of PMSE amplitude which was observed. Contrary to the results of a previous experiment, no dependence of the pump effect on the initial level of PMSE was found. These results may be an indication that HF affects PMSE by altering the electron diffusivity in plasma containing charged dust. We found also that pumping does not influence the Doppler shifts and widths of the coherent spectra of the radar backscattered power. That is in agreement with our understanding that electron heating cannot modify the motion of the neutrals.

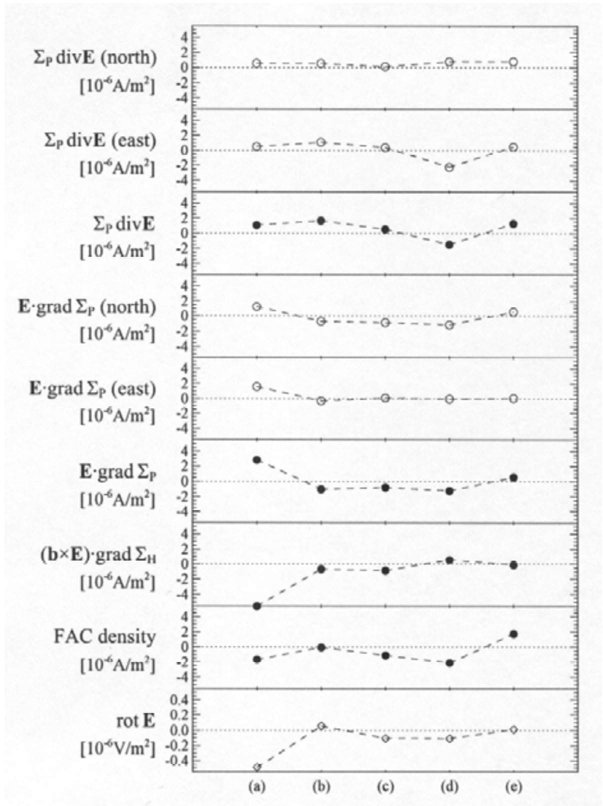


Figure 15. The various components of the terms associated with inferring the field-aligned current. In addition, the rot E term is shown, which ideally should be zero.

Magnetic field-aligned currents

Field-aligned currents are the primary coupling mechanism between the ionosphere and magnetosphere. They may be inferred from ground-based measurements using $J_{||} = \Sigma P \text{ div } E + \nabla \Sigma P \bullet E + \nabla \Sigma H \bullet (\hat{z} \times E)$, where J|| is the field-aligned current, E is the ionospheric horizontal electric field, ΣP is the Pedersen conductance, and ΣH is the Hall conductance. EISCAT is able to measure all these terms, although estimating the divergence of E and the gradients of ΣP and ΣH requires scanning. In a collaboration with STELAB, Nagoya University, Japan, a scanning experiment was undertaken on 9 October 1999 (see Figure 14).

The field-aligned current was successfully estimated for the majority of scans, however, in one case rot E is clearly large (see Figure 15). All-sky optical images show that this was due to an aurora passing over EISCAT. Hence, the steady-state assumption required throughout the scan was not fulfilled and demonstrates the need for more rapid scanning.

Dayside ion outflow

To better understand the locations, occurrences and characteristics of dayside field-aligned (FA) ion upflows, 170 events simultaneously observed with ESR and the DMSP satellites are examined. It was found that ion upflows occur not only in the cusp and cleft (the low-altitude portion of the low-latitude boundary layer), which have been traditionally regarded as the regions of ion upflow, but also in the region connected to the mantle. Ion upflows are less frequently seen in the boundary plasma sheet (BPS) and very rarely in the central plasma s at high latitude on the dayside. Almost all of the events in which the average FA ion velocity is more than 100 ms^{-1} are associated with relatively high soft electron precipitation with differential electron energy flux of > 10^7 eV cm^{-2} s^{-1} sr^{-1} eV^{-1} at 100 eV, although soft electron precipitation with such a high flux exists also in the BPS, where the ion velocities are mostly less than 100 m s^{-1}. These results indicate that soft particle precipitation is the predominant energy source to drive ion upflow in the topside ionosphere, and it triggers ion upflow effectively not in the BPS but only in the other high latitude regions on the dayside.

Short-lived ion outflow

Characteristics of field-aligned (FA) ion motions in the *E* and *F* region (below *F* peak) ionosphere have been determined based on an analysis of ESR and KST EISCAT data. Sporadic/burst upward FA ion motions are observed in southward electric field enhancement regions or in the post-midnight region, while relatively stable downward FA ion motions are seen in northward electric field enhancement regions or in other regions. Long-term (diurnal) variations of these upward and downward FA ions are likely driven by the large-scale day-to-night thermospheric wind. However, each short-lived upward FA flow has neither one-to-one correspondence to an enhancement (or depletion) of the electric field nor that of electron density. The driving mechanism of the short-lived upward flow cannot thus be understood yet, although atmospheric gravity waves can be one of the possible mechanisms to create the short-term upward FA ion motions in the southward electric field region or in the postmidnight region.

Validation of GPS tomography

An inversion algorithm called MIDAS (Multi Instrument Data Analysis Software) has been used to generate images of the ionisation distribution in the ionosphere using code and phase data from a European network of dual-frequency GPS receivers. The algorithm can produce maps of vertical TEC in latitude or longitude, or vertical slices showing electron concentration as a function of height and latitude (Figure 16). It was desirable to compare MIDAS images with independent data, so in January 2002 and again in September 2002 the UHF radar was run using the tau3t_limb_UK@uhf data-taking program.

This observation consists of a geographical meridional scan starting at a low northward elevation of 21°. The scan continues southward in 50 latitude steps of 0.152° defined at 262.5 km, with a dwell time of 30 s. Allowing 150 sec for the radar to return to its starting position, this gives a total scan time of 30 minutes. The transmitted signal was a tau3t alternating code, providing information about the electron concentration, ion and electron temperatures, and plasma velocity from 90-1400 km in range. The range resolution is 5.4 km, and a 5 second pre-integration period was used with the data being post-integrated at 1 minute to improve the data quality by adding two adjacent scanning positions.

Contemporaneous data from the Tromsø dynasonde was used to calibrate the radar.

Fan plots were generated from the radar data (Figure 17), which were compared with electron density plots produced by MIDAS. Both sets of data clearly show a mid latitude trough moving southward in the early afternoon period.

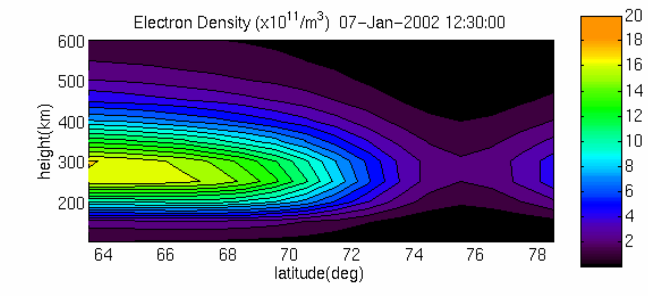


Figure 16. Electron density plot using MIDAS data.

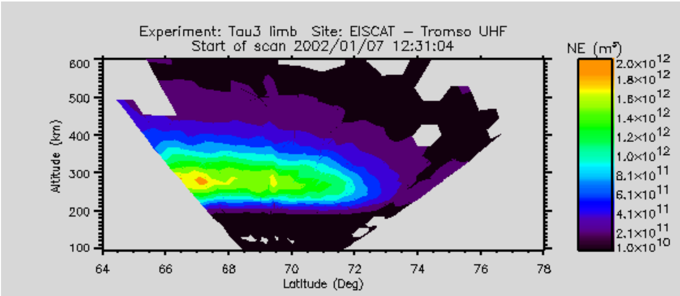


Figure 17. Fan plot of electron density using EISCAT data.

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Meetings 2002

COUNCIL	Extra-ordinary meeting 5 February	Copenhagen, Denmark
	58th meeting, 4-5 June	Grenoble, France
	59th meeting, 6-7 November	Abingdon, United Kingdom
AFC	58th meeting, 2-3 May	Stockholm, Sweden
	59th meeting, 10 October	Copenhagen, Denmark
SAC	62nd meeting, 18-19 April	Paris, France
	63rd meeting, 3-4 October	Oulu, Finland
ARM	Annual Review Meeting 17–19 September	Äkäslompolo, Finland
Future Committee	Meeting, 6 February	Copenhagen, Denmark

Annual Report of the Accounts 2002

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

Annual report for the financial year 2002-01-01 – 2002-12-31

The EISCAT Council and the Director for the Association herewith submits the annual report for 2002.

ADMINISTRATION REPORT

Ownership, organisation and objective

The EISCAT Scientific Association was established in 1975 through an agreement between the Centre National de la Recherche Scientifique (France), the Max Planck Gesellschaft (Germany), Vetenskapsrådet (Sweden), Norges forskningsråd (Norway), the Particle Physics and Astronomy Research Council (United Kingdom) and Suomen Akatemia (Finland). In 1996, the National Institute of Polar Research (Japan) joined the Association. These organisations are called EISCAT Associates. 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, which may be carried out as part of wider international project. 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. Depending on the available funding, scientific priorities and operational targets are adjusted on an annual basis.

The Association is governed by the EISCAT Agreement, Statutes, Financial Rules, and the Rules for the Management of Scientific Programmes.

The EISCAT Council is charged with the overall administration and supervision of the Association's activities. The Council consists of a Delegation of each Associate with a maximum of three members from each Associate. The Council appoints a Director, who is responsible for the daily management and operation of the facilities of the Association, for signing negotiable instruments, cheques and contracts entered into in the Association's name, and executing the Council's decisions, subject to such rules as may be laid down by the Council. The Director selects the senior management team.

Two committees support the EISCAT Council, one handle scientific issues, and the other covers administrative and financial matters. An additional, temporary, Future Committee completed its work during the year and was replaced by a small committee charged with preparing the ground for the negotiations necessary to achieve a new Agreement to cover the timescales beyond the term of the present Association.

Dr. Tauno Turunen completed his period as Director of the Association at the end of 2002. Professor Anthony P. van Eyken assumed the role of Director from January 1, 2003, for an initial term of two years.

Operation and scientific development

Following several years of extensive modernisation and upgrading, the Association’s facilities were in excellent condition throughout 2002 and achieved hitherto impossible levels of availability and reliability. The various elements of the facilities again operated for a total of more than 4 000 hours, with extensive use of each of the three incoherent scatter radars and the heater. In comparison to earlier years, the demand for operation of the VHF radar increased dramatically, reflecting the technical advances, particularly in radar coding techniques, now applied to that instrument.

52% of the operations were accounted to the Common Programme, while the remaining 48% were accounted to the Special Programme, experiments conducted by scientists from the countries of the Association.

During the current year, the EISCAT Svalbard Radar programme included a single continuous operation exceeding 31 days, the longest operation ever achieved by such a radar and of incomparable value for the study of tides and waves in the atmosphere and for the development of atmospheric and ionospheric models.

A failure of one of the two main transmitter amplifier tubes in the VHF radar during the autumn necessitated a reduction in power on that radar but EISCAT nevertheless continues to provide experimental facilities of the highest standard ensuring that the Association continues to enjoy access to the World's best incoherent scatter radars.

Future operation and scientific development

The repair of the failed VHF transmitter tube will be completed and the system is expected to return to full power operation in the summer. Redesigned high-power components of the UHF radar antenna feed system will also be delivered and installed during the year, allowing further increases in the output power, and consequently enhanced sensitivity, of that system.

Further planned enhancements to the signal processing will also be completed both on Svalbard and at the mainland sites together with the installation of hardware improvements to further support the use of the UHF antenna and receiver systems for studies of the solar wind close to the solar surface using interplanetary scintillation techniques.

A second-stage pilot project to demonstrate the utility of the UHF radar for the real-time detection and monitoring of space debris will be started at the beginning of 2003 and will run for two years under a contract from the European Space Agency.

The Association's radars will play a full part in the World-wide programme of co-ordinated incoherent scatter observations as well as supporting further Common and Special Programme operations at levels comparable, or exceeding earlier years. A full program of ionospheric heating is also planned in a series of concentrated campaigns throughout the year.

Following reviews of the tasks conducted with the Association, and the skill-sets required to achieve the Associations goals with the modernised facilities at its disposal, the budgetary and staffing constraints will be re-evaluated in order to develop strategies to maintain the Association's output while developing the foundations necessary for a new Agreement.

A necessary and prudent continuing development programme will be targeted on issues identified by the Future Committee's work while the Association's highest priority remains the efficient support of its scientific users through full operation of all of its various facilities at nominal, or, where possible, enhanced, operational levels.

The work of the Council and its committees

The Council held three meetings during 2002, one of which was a special meeting to select a new Director to follow Dr. Turunen at the end of his term. Professor Ryoichi Fujii was elected as the next Chairman of the EISCAT Council at the November meeting and will serve for two years from January 1, 2003. Both the Administrative and Finance Committee and the Scientific Advisory Committee held two meetings while a single meeting of the Future Committee was held in conjunction with the special meeting of the Council.

Financial constraints, partially caused by disadvantageous currency exchange rates but fundamentally rooted in the Associates' inability to compensate for inflation, dominated the work of both the Council and the AFC. Whilst options were being pursued to increase the income of the Association, a fall back plan was developed to deal with the financial shortfall if these were not successful. Although some improvement of the income was achieved it was necessary to include 4 448 kSEK of own reserves to reach a balanced budget and to start to implement staff reductions in the coming years. The first priority remains maintaining the highest level of operations. The actions now taken have put the Association on a sound basis for the future.

Budget development during the year

The year developed somewhat unpredicted. Early in the year, it became clear that the exchange rate levels of NOK (for the Norwegian operation) and EURO (for the Finnish operation) meant that the budget would not hold. Some mechanical issues were discovered on the mainland UHF antennas, located in Tromsö, Kiruna and Sodankylä. In addition, difficulties with lightning and roof leaks created unbudgeted cost increases. Finally, the staff costs in Norway went up because of a new way the pension payments were handled. The regularly calculated forecasts resulted in predicted deficits between 62 and 1 418 kSEK, where the last one indicated a 626 kSEK deficit. Towards the end of the year, there were modest improvements in the financial situation. The income side improved because the Norwegian Associate paid for the cost increase caused by the costlier pension scheme in Norway. In addition, some other income improved. On the expenditure side, the Council decision not to take over the SOUSY radar facility on Svalbard and better exchange rates throughout the final months of the year, coupled with carefully planned operations during the last quarter resulted in further improvements. The outcome actually meant that we made a zero result (+1 kSEK).

The financial five years plan

The financial plan incorporates a cost reduction strategy and additional income from some of the Associates. The budget basis for 2004 and following years includes increased operational efficiency resulting in reduce operation cost, which makes room for higher number of operating hours.

The result for 2002 and the surplus handling

The year was balanced. The small surplus of 1 kSEK has been transferred to the surplus fund.

PROFIT AND LOSS ACCOUNTS

in thousands of Swedish Crowns

	Note	2002	2001
	Note 1	***2002***	***2001***
Associate contributions	Note 2	29 765	29 489
Other operating income		435	203
		30 200	29 692
Operation costs		-6 869	-7 475
Administration costs		-6 240	-6 084
Personnel costs	Note 3	-20 670	-19 142
Depreciation of fixed assets		-22 685	-22 458
		-56 465	-55 159
Operating profit/loss		*-26 265*	*-25 467*
Interest income		689	722
Other financial income and cost		-134	-6
Own reserves and funds	Note 4	3 026	238
		3 581	954
Profit/loss after financial items		*-22 684*	*-24 514*
Appropriations	Note 5	-1	2 055
Transfer from funds invested	Note 6	22 685	22 458
		22 684	24 514
Net profit/loss for the year		*0*	*0*

BALANCE SHEET
in thousands of Swedish Crowns

		2002	2001
ASSETS			
<u>Fixed assets</u>			
Tangible fixed assets	Note 7		
Buildings		16 717	19 943
Radar systems		67 880	84 047
Equipment and tools		6 741	8 905
		91 338	112 895
<u>Current assets</u>			
Receivables		263	1 397
Prepayments and accrued income	Note 8	546	715
Cash at bank and in hand	Note 9	14 217	19 278
		15 026	21 390
Total assets		*106 364*	*134 285*
CAPITAL AND LIABILITIES			
<u>Capital</u>			
Funds invested	Note 10	91 338	112 895
Funds held on reserve	Note 11	7 729	12 121
		99 067	125 016
<u>Liabilities</u>			
Liabilities, trade		6 410	7 836
Provisions	Note 12	476	1 017
Other liabilities		411	416
		7 297	9 270
Total capital and liabilities		*106 364*	*134 285*
Pledged assets		*none*	*none*
Contingent liabilities		*none*	*none*

STATEMENT OF CASH FLOWS

in thousands of Swedish Crowns

	2002	***2001***
<u>Operating activities</u>		
Operating result before financial items	-26 265	-25 467
Transfer from funds invested	22 685	22 458
Interest received	689	945
Currency exchange rate changes	-177	-55
Extra ordinary income and cost	43	49
Increase/decrease of receivables	1 134	1 566
Increase/decrease of prepayments and accrued income	169	-125
Increase/decrease of creditors and liabilities	-1 973	2
Cash flow from operations	*-3 694*	*-627*
<u>Investment activities</u>		
Investments in tangible assets	-1 367	-4 771
Cash flow from investment activities	*-1 367*	*-4 771*
Cash flow for the year	*-5 061*	*-5 398*
Liquid assets at the beginning of the year	*19 278*	*24 676*
Liquid assets at the end of the year	*14 217*	*19 278*

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 and intangible 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 10 - 50 years, Radar systems 3 - 20 years and Equipment and tools 3 - 5 years.

Note 2 *Associate contributions*
The Associates contributed to the operation during the year according to a fixed percentage.

		2002
CNRS (France)	23.25%	6 856
MPG (Germany	23.25%	6 856
NIPR (Japan)	7.00%	2 064
PPARC (United Kingdom)	23.25%	6 856
RCN (Norway)	9.30%	2 742
SA (Finland)	4.65%	1 371
SRC (Sweden)	9.30%	2 742
	100.00%	29 489

Two Associates made additional contributions during the year

RCN (Norway)	249
SA (Finland)	28
	276
Total contribution	29 765

Accumulated contributions status as of 2002-12-31

	1976 - 2002
CNRS (France)	162 650
MPG (Germany	155 980
NIPR (Japan), 1996 -	54 306
PPARC (United Kingdom)	173 928
RCN (Norway)	105 604
SA (Finland)	42 694
SRC (Sweden)	80 457
	775 619

Note 3 *Personnel costs and average number of employees*
The Association employs directly the Headquarters staff, which includes the Director and deputies. 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.

	2002	***2001***
Personnel costs in total		
Salaries and emoluments paid to the Deputy Directors and the Director	2 536	2 346
Other personnel, employed and provided via site contracts	12 627	12 098
Social security contributions amounted to	4 533	3 700
of which for pension costs	2 129	1 319

Of the pension costs, 880 kSEK (620 kSEK) relates to the Deputy Directors and the Director. The Deputy Directors, the Director and all other directly employed staff are included in ITP based occupational pension plans. For the personnel provided via site contracts, the pension plans are handled by their respective employer. The large pension cost increase is related to a reorganised pension payment scheme in Norway.

The members of the board (EISCAT Council) and members of committees do not receive remunerations from the Association. Travel expenses in connection with Council and committee meetings are paid by the different Associates and then reimbursed from the Association, excluding the Japanese Associate who pay the travel cost for their own members.

Salaries and emoluments and average number of staff per country

	2002	2001
Finland		
Salaries and emoluments	1 777	1 682
Average number of staff - men and women	4 + 1	4 + 1
Norway (including Svalbard)		
Salaries and emoluments	8 808	8 319
Average number of staff - men and women	16 + 2	17 + 2
Sweden		
Salaries and emoluments	4 577	4 442
Average number of staff - men and women	8 + 2	8 + 2

Note 4 *Own reserves and funds*
The following is the financing use of our own reserves and funds

	2002	2001
Capital Operating reserve		
Budgeted transfer to the reserve for capital operating use	-1 421	-1 441
Evolutionary Development fund		
Transfer from the fund to cover recurrent expenses relating to the evolutionary projects	0	323
Spare parts reserve		
Budgeted transfer to the reserve	-60	-126
Spare parts purchased	59	282
Budgeted use of our own funds/reserves		
Surplus fund transfer	3 502	1 199
Capital operating reserve transfer	946	0
Sum own reserves and funds	*3 026*	*238*

Note 5 *Appropriations*

The outcome for this year became a surplus amounting to 1 kSEK. The amount has been transferred to the surplus fund. The 2001 outcome was negative (-2 055 kSEK) and it was covered using funds from our own reserves.

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 2002

	2002	***2001***
Buildings		
Opening acquisition value	41 367	41 367
Acquisitions during the year	0	0
Disposals during the year	0	0
Closing acquisition value	41 367	41 367
Opening accumulated depreciation	-21 424	-18 198
Depreciations during the year	-3 226	-3 226
Closing accumulated depreciation	-24 649	-21 424
Closing residual value	16 717	19 943
Radar systems		
Opening acquisition value	242 622	242 084
Acquisitions during the year	464	538
Disposals during the year	0	0
Closing acquisition value	243 086	242 622
Opening accumulated depreciation	-158 574	-142 071
Depreciations during the year	-16 631	-16 503
Closing accumulated depreciation	-175 206	-158 574
Closing residual value	67 880	84 047
Equipment and tools		
Opening acquisition value	28 360	24 303
Acquisitions during the year	903	4 233
Disposals during the year	-238	-176
Closing acquisition value	29 025	28 360
Opening accumulated depreciation	-19 455	-16 725
Depreciations during the year	-2 829	-2 730
Closing accumulated depreciation	-22 284	-19 455
Closing residual value	6 741	8 905
Sum tangible fixed assets	*91 338*	*112 895*

Note 8 *Prepayments and accrued income*

	2002	***2001***
Prepaid rents	73	68
Other items	473	647
	546	715

Note 9 *Bank balances status*

The Sparebanken NOR account was closed during the year.

	2002	2001
Nordea	14 215	18 892
Sparebanken NOR	0	384
Cash in hand	2	2
	14 217	19 278

Note 10 *Funds invested status*

The funds invested structure was changed during the year.

	2002	2001
Buildings	16 717	0
Radar Systems	67 880	0
Equipment and Tools	6 741	0
Pool	0	6 337
UHF Spare Klystron	0	125
Capital Operating	0	17 702
In Kind	0	4 189
Other	0	131
Heating	0	717
ESR	0	83 694
	91 338	112 895

Note 11 *Funds held on reserve*

322 kSEK was drawn from the evolutionary development fund for the UHF rotary joint replacement contract.

	2002	2001
Spare parts reserve	467	466
Capital operating reserve	1 514	2 085
Surplus fund	2 007	5 507
Equipment repair fund	1 979	1 979
Evolutionary development fund	1 762	2 084
	7 729	12 121

Note 12 *Provisions*

	2002	2001
Associate travel	366	360
Evolution contracts and services	111	657
	476	1 017

Oslo, 2003-06-04

Dr. Denis Alcaydé

Prof. Asgeir Brekke

Mrs. Fabienne Casoli

Prof. Ryoichi Fujii

Dr. Finn Karlsson

Dr. Wlodek Kofman

Prof. Mike Lockwood

Dr. Asta Pellinen-Wannberg

Dr. Tone Vislie

Prof. Anthony P. van Eyken
Director

Prof. Takehiko Aso

Mr. C. Graham Brooks

Mr. Atle Engebretsen

Prof. Shoichiro Fukao

Mr. Wieland Keinath

Prof. Hannu Koskinen

Prof. Tuomo Nygrén

Dr. Jürgen Röttger

Our audit report was issued on 2003-07-10

Mrs. Annika Wedin
Authorised Public Accountant

Mr. Robert Barnden
Authorised Public Accountant

Öhrlings

PRICEWATERHOUSECOOPERS

Audit report

To the council of EISCAT Scientific Association

Corporate identity number 897300-2549

We have audited the annual accounts, the accounting records and the administration of the council and the director of EISCAT Scientific Association for the year 2002. These accounts and the administration of the association are the responsibility of the council and the director. Our responsibility is to express an opinion on the annual accounts and the administration based on our audit.

We conducted our audit in accordance with generally accepted auditing standards in Sweden. Those standards require that we plan and perform the audit to obtain reasonable assurance that the annual accounts are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the accounts. An audit also includes assessing the accounting principles used and their application by the council and the director, as well as evaluating the overall presentation of information in the annual accounts. We examined significant decisions, actions taken and circumstances of the association in order to be able to determine whether any council member or the director has acted in contravention of the statutes.

The annual accounts have been prepared in accordance with the Annual Accounts Act and, thereby, give a true and fair view of the association´s financial position and results of operations in accordance with generally accepted accounting principles in Sweden.

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

Stockholm 2003-07-10

Annika Wedin
Authorized Public Accountant

Robert Barnden
Authorized Public Accountant

EISCAT Scientific Association

December 2002

	Finland	France	Germany	Japan	Norway	Sweden	United Kingdom
Council	Prof. H. Koskinen Prof. T. Nygrén	Dr. D. Alcaydé Dr. W. Kofman Mrs. F. Casoli	Dr. J. Röttger Mr. W. Keinath	Prof. R. Fujii* Prof. S. Fukao Prof. T. Aso	Dr. T. Vislie Mr. A. Engebretsen Prof. A. Brekke	Dr. A. Pellinen-Wannberg Dr. F. Karlsson	Mr. C. G. Brooks Prof. M. Lockwood
Administrative and Finance Committee	Ph.D. P. Pulkkinen	Dr. P.-L. Blelly	Mr. M. Schleier	Mr. S. Kuwata	Dr. T. Vislie	Dr. T. Andersson*	Mrs. S. Horne
Scientific Advisory Committee	Dr. A. Aikio	Dr. F. Forme	Dr. M. Förster	Prof. T. Ogawa	Prof. C. La Hoz	Dr. S. Buchert	Dr. I. McCrea*

* = Chairperson

EISCAT Executives

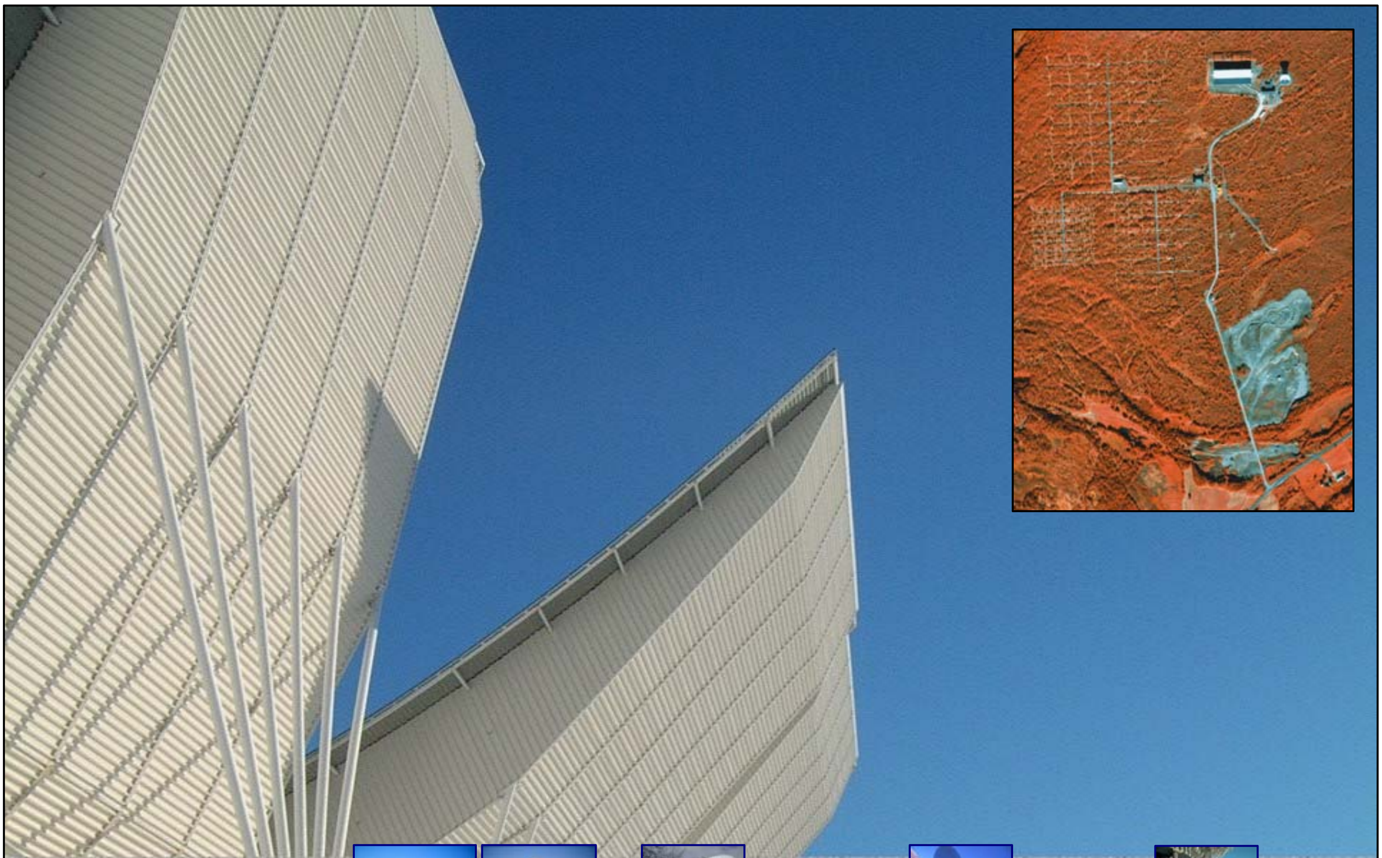
Director: Prof. T. Turunen
Deputy Director Technical: Dr. U. G. Wannberg
Deputy Director Science: Prof. A. P. van Eyken
Head of Administration: Mr. H. Andersson

EISCAT Site Leaders

EISCAT Svalbard Radar: Mr. H. Boholm
Kiruna: Mr. L.-G. Vanhainen
Sodankylä: Mr. M. J. Postila
Tromsö Radar: Mr. R. Jacobsen
Tromsö Heating: Dr. M. Rietveld

Non-Associates members of the Scientific Advisory Committee were Prof. J. Forbes (USA) and Dr. M. Ruohoniemi (USA).

EISCAT Technical Data



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°09´N 16°02´E	
Geomagnetic Inclination	77°30´N		76°48´N	76°43´N	82°06´N	
Invariant Latitude	66°12´N		64°27´N	63°34´N	75°18´N	
Band	VHF	UHF	UHF	UHF	UHF	
Frequency (MHz)	224	931	931	931	500	
Maximum bandwidth (MHz)	3	8	8	8	10	
Transmitter	2 klystrons	2 klystrons	-	-	16 klystrons	
Channels	8	8	8	8	6	
Peak power (MW)	2x1.5	2x1.3	-	-	1.0	
Average power (MW)	2x0.19	2x0.16	-	-	0.25	
Pulse duration (ms)	0.001-2.0	0.001-2.0	-	-	<.001-2.0	
Phase coding	binary	binary	binary	binary	binary	
Minimum interpulse (ms)	1.0	1.0	-	-	0.1	
Receiver	analog	analog	analog	analog	anal.-digital	
System temperature (K)	250-350	90-110	30-35	30-35	55-65	
Digital processing	14 bit ADC, 32 bit complex, autocorrelation functions, parallel channels				12 bit ADC, lag profiles 32 bit complex	
					Antenna 1	Antenna 2
Antenna	parabolic cylinder 120m x 40m Steerable	parabolic dish 32m Steerable	parabolic dish 32m Steerable	parabolic dish 32m Steerable	parabolic dish 32m Steerable	parabolic dish 42m Fixed
Feed system	line feed 128 crossed dipoles	Cassegrain	Cassegrain	Cassegrain	Cassegrain	Cassegrain
Gain (dBi)	46	48	48	48	42.5	45
Polarization	circular	circular	any	any	circular	circular

EISCAT Heating Facility in Tromsø

Frequency range: 4-8 MHz, Maximum transmitter power: 12 x 0.1 MW, Antennas: two arrays (4-8 MHz): 24 dBi, one array (5.4-8 MHz): 30 dBi. Additionally, a Dynasonde is operated at the Heating facility.

Annual Report 2002 of the EISCAT Scientific Association

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Scientific contributions: EISCAT Associates and staff

ISSN 0349-2710, June 2004

The EISCAT Associates

December 2002

SA

Suomen Akatemia
Finland

CNRS

Centre National de la Recherche Scientifique
France

MPG

Max-Planck-Gesellschaft
Germany

NIPR

National Institute of Polar Research
Japan

RCN

Research Council of Norway
(Norges forskningsråd)
Norway

VR

Vetenskapsrådet
Sweden

PPARC

Particle Physics and Astronomy Research Council
United Kingdom

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