EISCAT

EUROPEAN INCOHERENT SCATTER SCIENTIFIC
ASSOCIATION

ANNUAL REPORT 1984

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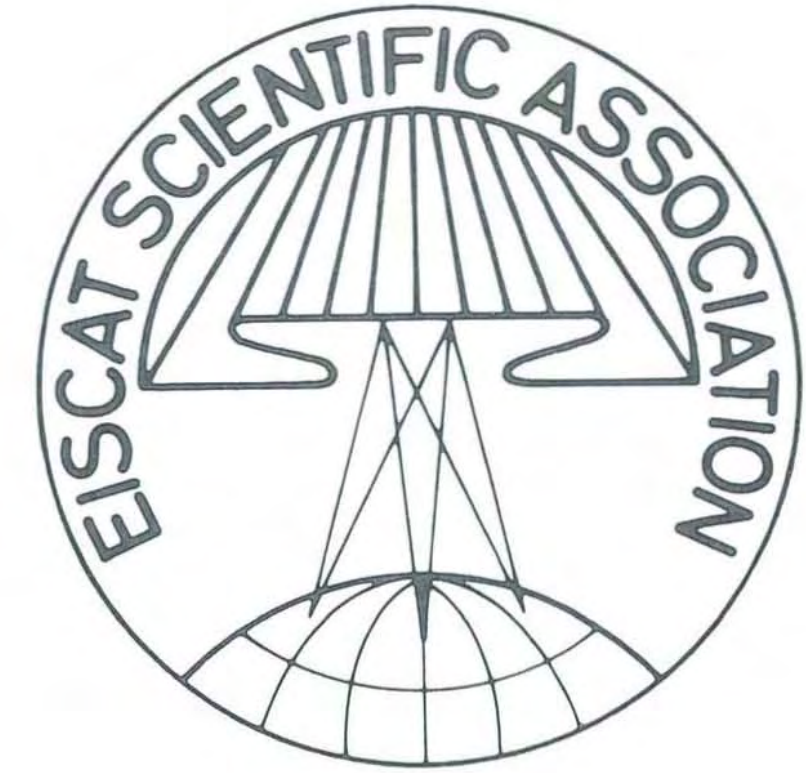

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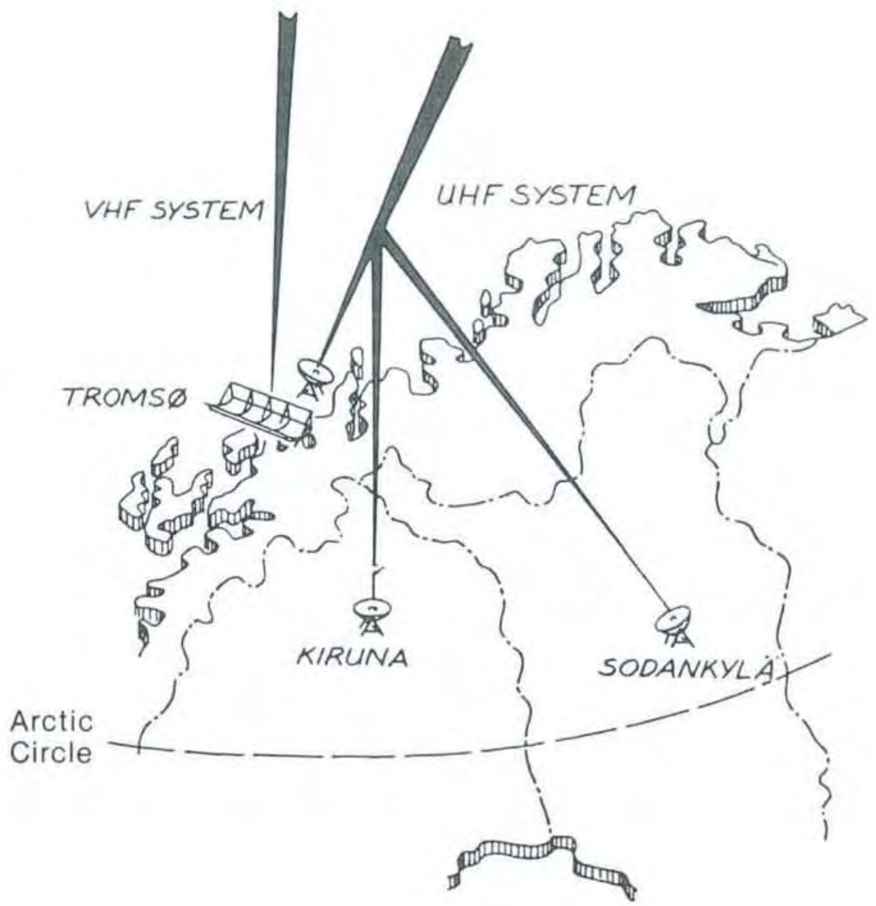

EISCAT, the European Incoherent Scatter Scientific Association, is established to conduct research on the upper atmosphere, ionosphere and aurora using the incoherent scatter radar technique. The experimental facilities are located in Scandinavia, north of the arctic circle. They consist of two independent radar systems (UHF at 933 MHz and VHF at 224 MHz) with transmitters and receivers in Tromsö. The UHF system also has receivers in Kiruna and Sodankylä.

Investments and operational costs are shared between:
Suomen Akatemia, Finland
Centre National de la Recherche Scientifique, France
Max-Planck-Gesellschaft, W. Germany
Norges Almenvitenskapelige Forskningsråd, Norway
Naturvetenskapliga Forskningsrådet, Sweden
Science and Engineering Research Council, United Kingdom.

EISCAT Council Meeting, Stockholm, May, 1984. Seated (from left): M. Petit, M. Baron, G. Haerendel, G. Beynon. Standing (from left): B. Thorwid, M. Blanc, J-C. Ribes, J. Röttger, O. Holt, O. Ranta, H. Kohl, H. Jantke, G. Preiss, A. Siivola, M. Rieperdinger, M.O. Ottosson, K. Folkestad, H. Atkinson, B. Hultqvist, M. Ravaut, A. Brekke, G. Rowe, J. Gustavsson.

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DIRECTOR's PAGE

As I look back over the accomplishments of the year 1984, it is with a feeling of pride in the work of the entire EISCAT staff. New records have been set for operational hours on the UHF system – almost twice the time achieved in 1983. This has been made possible by the increased overall system reliability, together with the site staffs' improved skills in overcoming problems that arise from time to time. Indicative of the operational smoothness of recent months is the log book notation made at one of the stations after completion of a 24-hr experiment, "Ain't perfection boring!"

The acquisition of high quality data is a necessary step toward fulfilling EISCAT's mission. However, it is the scientific results that are the final product. For these, EISCAT depends in large part on the scientists in the associate countries. It is noteworthy that the scientific output, as measured by number of publications in refereed journals, has also increased by a factor of two in 1984 compared to 1983.

Between data acquisition and scientific results is the time consuming task of data analysis. Until late in 1984, most of the analysis was being done at associates' home institutions. But recently, the EISCAT organization has taken two significant steps toward providing the associates with geophysical parameters instead of raw data. The first step was the addition to HQ staff of a research associate whose primary task is analysis of the Common Program (CP) data. This has enabled us, for the first time, to keep up to date with the analysis of the CP data, and even work slowly into the backlog.

The second step may be even more important in the long term. A prototype on-line analysis system is beeing implemented at Tromsö. As designed, it should be able to keep up with the data acquisition so that geophysical parameters are available within some tens of minutes after an experiment is finished instead of weeks or months. Preliminary comparisons of the on-line analysis results against those of the standard HQ analysis program are most encouraging.

In contrast to previous annual reports, there is little to say on the Director's page regarding the technical health of the UHF system. Seldom are experiments postponed or cancelled due to technical problems. The few remaining weak points in the equipment are being systematically corrected. Improvements that better the data quality, simplify the operation, and enable better use of the system's inherent capabilities are being continuously implemented.

With regard to the VHF system, progress is finally visible on-site. The VHF transmitter was physically installed in Tromsö during the summer of 1984, and testing began in the fall. By the end of the year, most (but not all) of the installation bugs had been found and fixed, the power supply had been run to full voltage, and the modulator pulsed to about 80 % of full voltage. Testing of the one remaining original klystron had begun. The first of two new-design klystrons was manufactured by the end of the year, and electrical tests had started. In the testing of both the transmitter and the new tube, no major problems had occured.

Overall, it is clear that 1984 was the most productive year in EISCAT's history. But 1985 should be even better. We can expect the VHF system to come on-line; perhaps not initially to its full design capability, but with sufficient sensitivity to perform useful new experiments looking very high and very low in altitude. 1985 will also be a year of extensive cooperative experiments with satellites. In the first half of the year, much time will be allocated to AMPTE spacecraft collaborations. In the last quarter, intensive campaigns associated with the exciting VIKING satellite are planned. And it is quite possible that by the end of the year, the on-line analysis system will be operational for most common programs.

EISCAT's progress during the past year and prospects for the coming year are a result of the dedicted work of the entire staff. The inclusion in this report of staff photographs is in recognition of their individual and collective contributions. In addition, I want to say a special word of thanks to Dr. Jürgen Röttger who left EISCAT in October 1984. Jürgen's scientific and technical skills are well known and well appreciated throughout the community. What may not be so well known are several other abilities that were particularly valuable to me, personally, and to EISCAT HQ. These include: his organizational/administrative work, his ability to mediate fair solutions to scheduling conflicts, and his well-thought-out suggestions and comments regarding various internal and external situations.

I am sure the EISCAT associates share my pride in the staff's 1984 accomplishments and my feeling of great optimism for the coming years.

Murray Baron
Director

Kiruna site staff: (from left) G. Wannberg, L.-G. Vanhainen, K. Koskenniemi, A. Björk, I. Wolf, K.-O. Johansson.

SCIENTIFIC RESULTS

As EISCAT matures it becomes increasingly difficult to summarize the scientific results. The topics under study are numerous and there are several tens of scientists spread throughout the associate countries actively engaged in EISCAT-related research.

The overview in this section contains contributions from all EISCAT associate countries and from the EISCAT scientific staff. No effort is made to credit individual scientists or groups of scientists. Specific contributions can be found in the list of publications given later in this annual report.

D- and E-region Phenomena

We begin our summary in the lower altitude regions accessible to the EISCAT radar. Below about 100 km altitude, collisions between electrons and neutral molecules become important. These collisions result in the absorption of radio waves traversing the 70–100 km altitude region. At auroral latitudes, absorption is sometimes sufficiently intense to cause a "black-out" (total loss of signal) on HF communication channels. Therefore, there is a practical interest in studying and understanding the physical phenomena relevant to radio wave absorption.

EISCAT has measured the electron density in the D- and E-region with an altitude resolution of 750m and a time resolution of 15s. From the EISCAT measurements, the expected absorption can be calculated and compared with conventional riometer measurements. Such a comparison is shown in Figure 1 (bottom portion). For this data set, the two techniques give very similar results. The upper portion of Figure 1 shows the altitude dependence of the absorption, a quantity that cannot be obtained from the riometer.

The excellent agreement shown in Figure 1 does not occur in all data sets, and herein lies the interesting physics. When the EISCAT results exhibit the same mean value as the riometer measurements but are more variable in time, significant spatial variability of the absorbing layer is indicated. This follows because the EISCAT radar is probing a region less than 1 km^2 in horizontal extent while the riometer is measuring an average over more than 1000 km^2. On other occasions there is a persistent difference between the two measurements. The exact reason for this has not been conclusively determined, but it may relate to uncertainties in the radar scattering cross section under certain conditions, e.g. when significant concentrations of negative ions are present.

At altitudes below 120 km or so, collisions between ions and neutral molecules become increasingly important. So much so that, at these altitudes, the ion motions are largely determined by the motions of the neutral atmosphere. This phenomena was utilized to study the upper mesosphere/lower thermosphere during the intensive MAP/WINE (Middle Atmosphere Program/Winter in Northern Europe) campaign held early in 1984. About a hundred hours of EISCAT data were obtained to study the winds, tides, density and temperature profiles. One significant finding was the detection of a strong semidiurnal tide, about equal in amplitude to he prevailing wind, at 70° latitude. This is shown in Figure 2, a set of three EISCAT meridional wind profiles taken at 6-hr intervals.

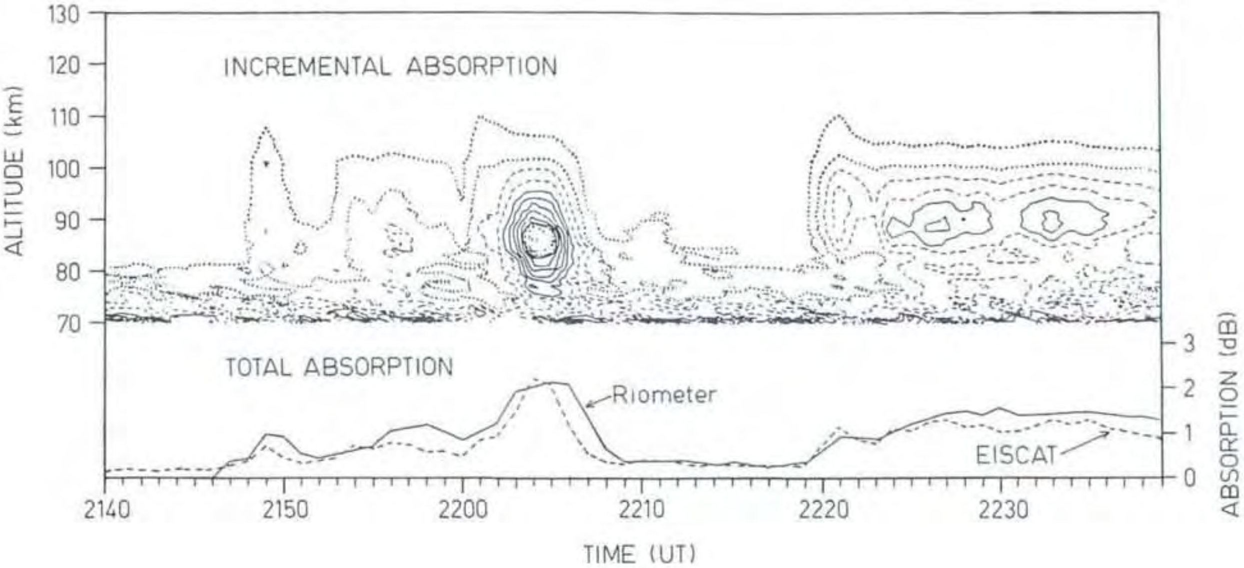


Figure 1: Contours of incremental absorption (dB/km) derived from EISCAT together with comparison of total absorption measured by riometer and calculated from EISCAT data.

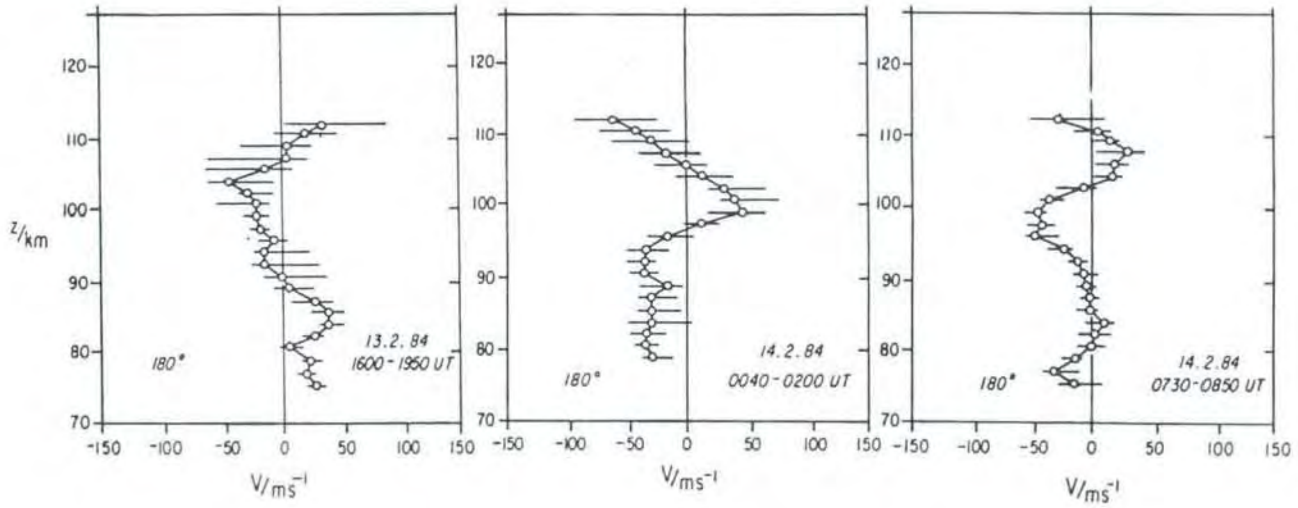


Figure 2: Plasma meridional velocity (nearly equal to neutral air velocity) between 75 and 115 km at 6 hour intervals. Note the phase of the pattern reverses each 6 hrs indicating a semidiurnal tide in the neutral atmosphere.

For the determination of neutral atmospheric motions described above, exact knowledge of the ion neutral collision frequency (v_{in}) is not required; provided that it is large compared to the ion gyro frequency. However, the v_{in} profile can be measured with EISCAT over the altitude region 90–105 km. The purpose of this research is 1) to determine whether standard atmospheric models properly describe the v_{in} profile, and 2) to determine the effects of auroral energy inputs on v_{in}. Since the collision frequency depends on the atmospheric density and temperature, insight into the dependence of these two parameters on auroral phenomena can also be obtained. Preliminary results of this work indicate that, for much of the time, the CIRA72 model compares well with the EISCAT results. But during periods of time of enhanced energy input to the atmosphere due to joule heating, particle precipitation, or large amplitude waves, the collision frequency at a given altitude can change by 50 % or more. This implies a corresponding change in the neutral atmospheric density. Simultaneously, the ion temperature which is closely related to the neutral temperature, was seen to increase by more than 10 %.

E-region electron density enhancements due to auroral particle precipitation are a common and easily detectable feature in the EISCAT data. These auroral E-layers have typical vertical thicknesses of a few tens of kilometers. Another type of E-region feature, termed sporadic-E, has a characteristic thickness of order 1 km and is thus much more difficult to detect. By making use of EISCAT 's advanced capabilites, namely Barkercoding of multipulse waveforms, the density and velocity structure associated with sporadic-E can be studied with excellent height (600 m) and time (15s) resolution. An example is shown in Figure 3 in which a very thin sporadic-E layer is seen to be slowly descending amid the intermittent bursts of energetic particle enhancements. The auroral layer is composed of molecular (NO^+, $0^+{}_2$) ions with short lifetimes of some seconds to tens of seconds. The sporadic-E layer must be composed of metallic ions which have very much longer chemical lifetimes. Using the ion velocity data analyzed from an event similar to that shown in Fig. 3 together with simultaneous STARE radar data, it was determined that the thin sporadic-E layer formed in a region of (vertically) convergent ion flow. However, the convergent flow is believed to be driven, not by a neutral wind shear as is the case at mid-latitudes, but by a 'corkscrew' effect, induced by electric fields and resulting from the upward decrease of col-

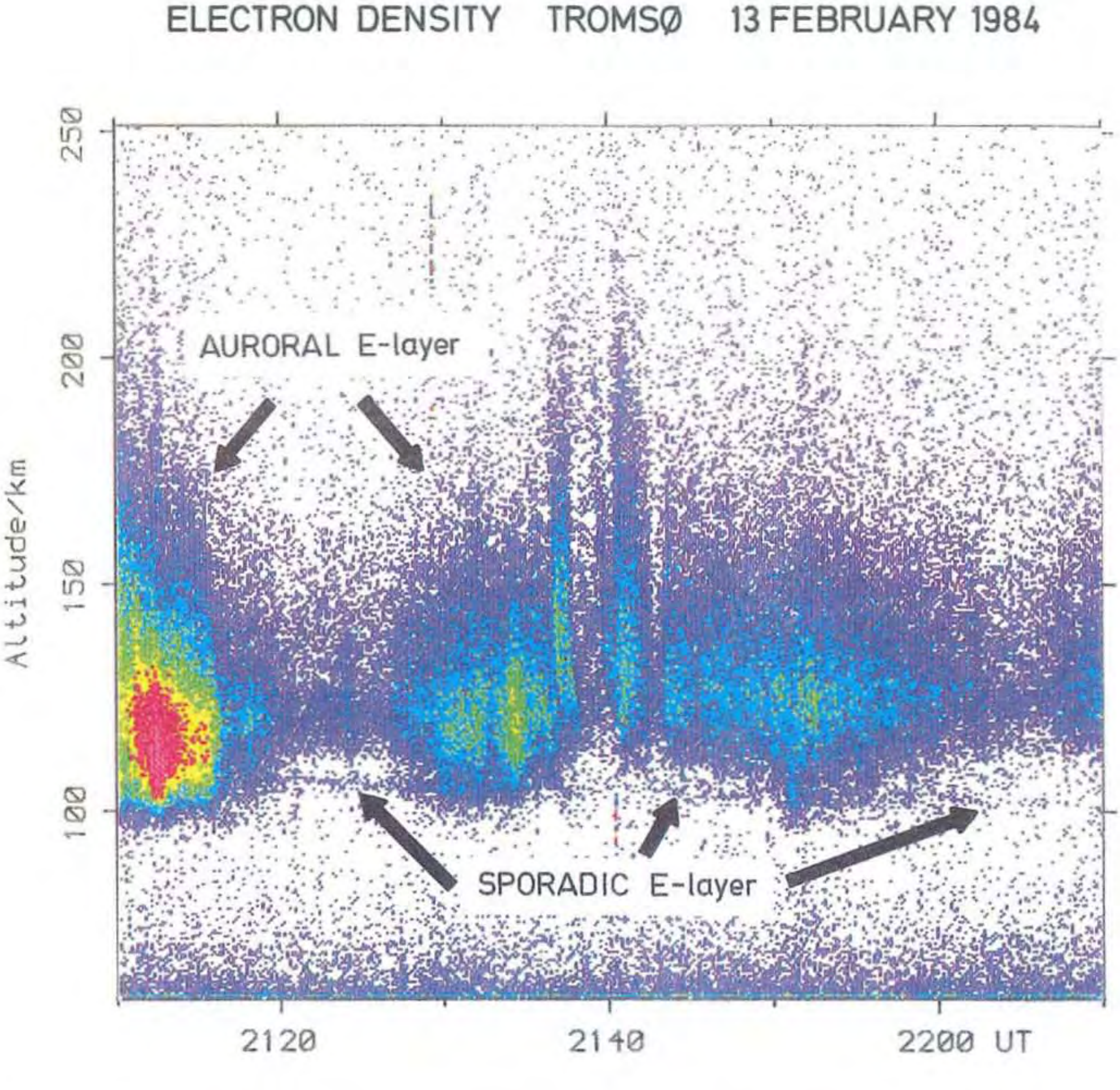


Figure 3: Simultaneous occurance of sporadic-E and auroral-E layers. The altitude and time resolution are 600 m and 15 s, respectively.

lision frequency. This mechanism can only apply at auroral latitudes where strong electric fields are present and at times when the field is directed in the north-west quadrant.

Transition Region

The transition region refers to the altitude region of about 130 to 250 km, in which the ion composition changes from molecular ions at the lower altitudes to atomic oxygen ions at the higher altitudes. The composition profile and its variations have been measured and studied. It was found that, on average, the transition altitude varies with solar zenith angle in a similar manner to that found at mid-latitudes. The summer-winter seasonal variation determined at EISCAT was also in agreement with previous work at mid-latitudes as well as at auroral latitudes. The variations with zenith angle and season are as would be expected from a photochemical equilibirum model. However, several unusual events were found that deviate from the equilibrium model. The discrepancies have been related to variations in other simultaneously measured ionospheric parameters, such as electric fields, particle precipitation, and plasma temperature. A new result concerns the effects of particle precipitation which can either reduce or increase the percentage of 0^+ ions, depending on the penetration altitude of the energetic electrons.

Another new result is that apparently the transition region is thinner than previous thought. Up to now, only data with 45–50 km altitude resolution has been analyzed for composition studies. Careful analysis based on comparisons with plasma line results and ionosonde data indicates the transition region may be considerably thinner than the height resolution of the measurements. Future work on this topic must employ pulse codes to obtain adequate altitude resolution.

Magnetosphere – Ionosphere Coupling

The interaction of the solar wind and the earth's magnetosphere imposes a dawn-dusk electric field on the high latitude ionosphere. Several consequences of this interaction are being studied with EISCAT, including the distributions of electric potential and field, and of the electrojet and field-aligned currents. EISCAT's capability for measuring the F-region plasma flow (convection) as a function of latitude and local time is by now well known, cf. Fig. 1 of EISCAT 1983 Annual report. The plasma convection pattern seen in such diagrams

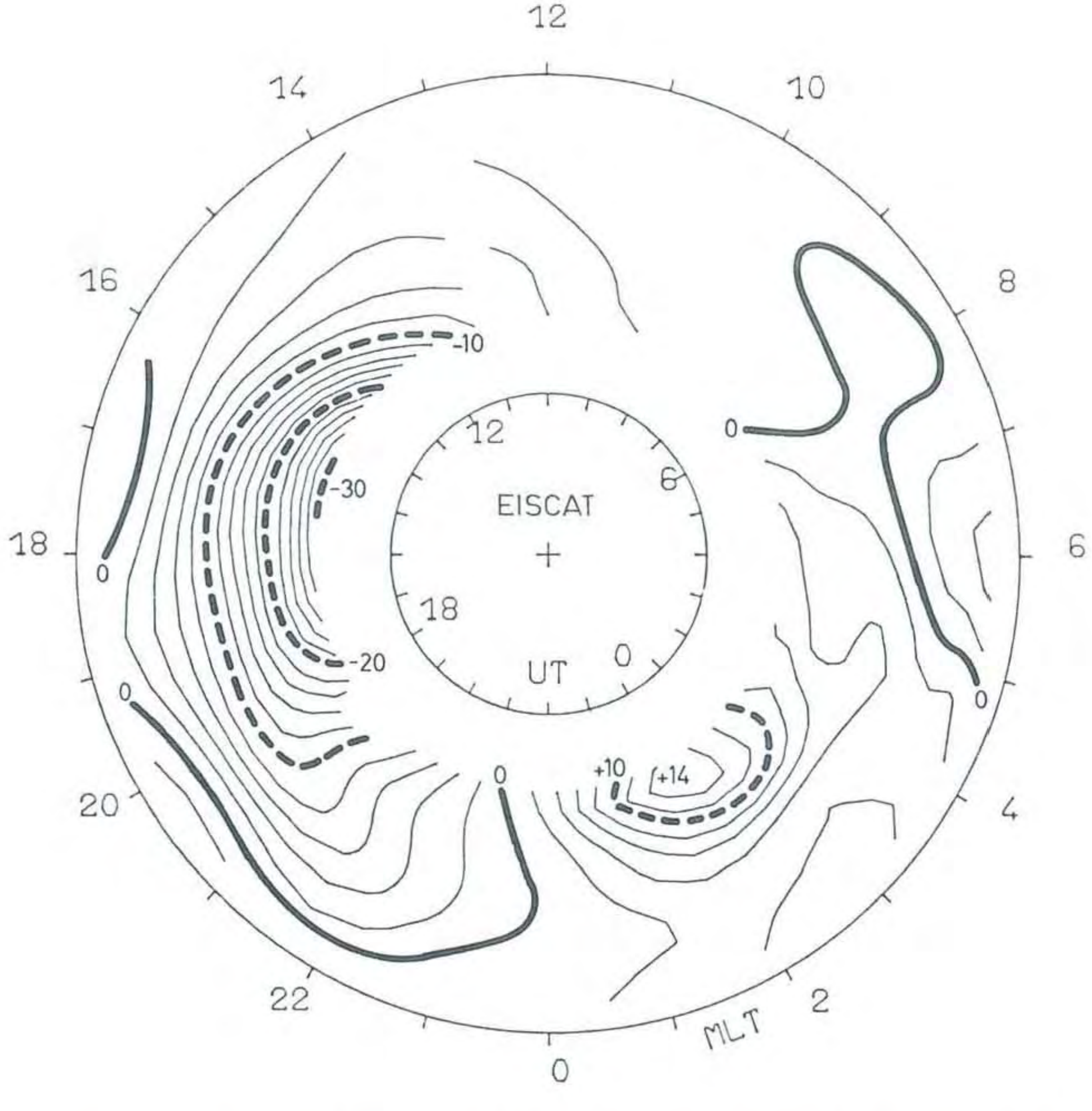


Figure 4: Electrostatic Potential for 16 June 1982 with 6-term harmonic fit in time and 9 term polynomial expansion in latitude. Contour intervals are 2 kV.

is a consequence of the magnetosphere crosstail potential. At other incoherent scatter radars, techniques have been developed to derive the potential pattern from the measurements of plasma velocity as a function of space and time. In general, the previous techniques have one or both of the following limitations: (1) the potential is assumed to be zero for all local times at the lowest latitude probed by the radar, (2) the convection pattern is tacitly assumed to be constant over a 24-hr period. A new approach has been made with EISCAT data in which the first assumption is not necessary, and which gives information regarding the applicability of the second assumption. An example is shown in Figure 4 in which contours of constant electrostatic potential are shown as a function of invariant latitude and magnetic local time. The plasma flows along the contours; the electric field is inversely proportional to the line spacing. On this rather quiet day, the cross-tail potential was in excess of 44 kV. Further work is in progress relating the potential pattern to auroral activity and solar wind parameters.

By combining electric field measurements with the Hall and Pedersen conductivities obtained from E-region electron densities, the horizontal electrical currents flowing in the auroral regions can be derived. Taking this one step further, it is possible to estimate the parallel (Birkeland) currents from the divergence of the horizontal currents. This has been done with EISCAT data giving the results of Figure 5. Such results can be compared with satellite measurements of the region 1 and 2 current systems and also used to locate the position of the radar relative to the global pattern of field-aligned currents.

The results shown above have a time resolution of one hour or longer. But the electrodynamical parameters, e.g. horizontal currents, often exhibit significant variations on time scales of minutes. Such short-period oscillations in the electrojet current are commonly detected as pulsations on ground-based magnetometers. Recently, EISCAT experiments have detected variations in the F-region ion velocity and temperature that are closely correlated with ground-based magnetometer signatures of ULF pulsations of the type Pc3, Pc4, and Pc5. The pulsation-related temperature perturbations are a new result made possible by the sensitivity of the EISCAT system.

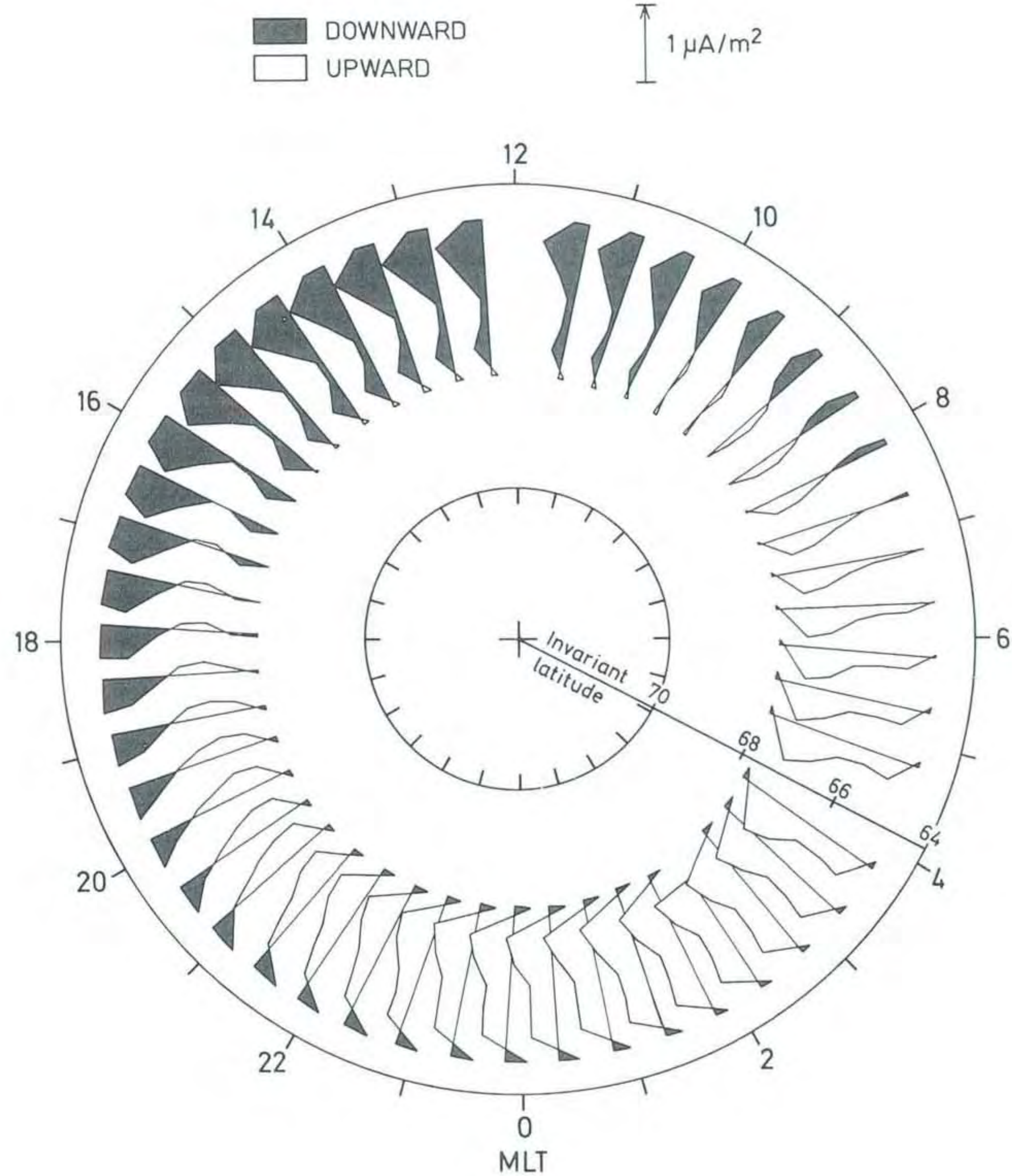


Figure 5: Field aligned current pattern derived from the EISCAT experiment of 16 June 1982. The amplitude and direction of the currents are shown as a function of invariant latitude (radially) and magnetic local time (circumstantially).

F-region Phenomena

F-region structure has been studied at a number of spatial and temporal scale regimes. In the longer period and larger size region, wavelike periodic structure has been detected. An example is presented in Figure 6a. Here, the F-layer electron density is fully developed between 12 and 14UT. Note the wavelike structure at the bottom of the layer. After 14UT, the observed region of the ionosphere enters the trough where the F-region densities decrease by almost an order of magnitude. This periodic structure is also present in the field-aligned velocity (Figure 6b) and in the temperature data and is probably the effect of a gravity wave with a time period 33 minutes and vertical wavelength of 750 km.

The trough has been seen on a number of occasions and found to exhibit a regular pattern of behavior. The decrease in electron density is commonly accompanied by an increase in ion temperature and ion velocity. When sufficient statistics have been collected, it should be possible to us the EISCAT results to distinguish among several mechanisms that have been proposed for the trough formation.

Beam scanning experiments have been used to study irregularities of scale sizes from a few to a few tens of kilometres. Irregularities in the F-region were observed only during periods of geomagnetic disturbance ($Kp < 3$). The irregularities become more intense, relative to the mean density, with increasing altitude and have been detected up to 750 km. Some of the irregularities appear to have a wavelike structure, with a periodicity of near 1 minute occuring rather frequently.

The presence of smaller scale structure imbedded within larger (100 km) scale enhancements has been previously detected at other radars. But the mechanism for the evolution of the structure from the larger to the smaller scales has been in question. The EISCAT tristatic system can make an unique contribution to this topic because of its ability to resolve the vector electric field at a single point in space. A specific experiment was performed with EISCAT to investigate the hypothesis that the magnetic-flux-tube intercharge process is active in the structuring of auroral F-region plasma. The results obtained show that the plasma density structure was indeed accompanied by similar scale variations in the ionospheric electric field, and that the sense of relative motion between high- and low-density plasma was consistent with the production of smaller scale structures. However,

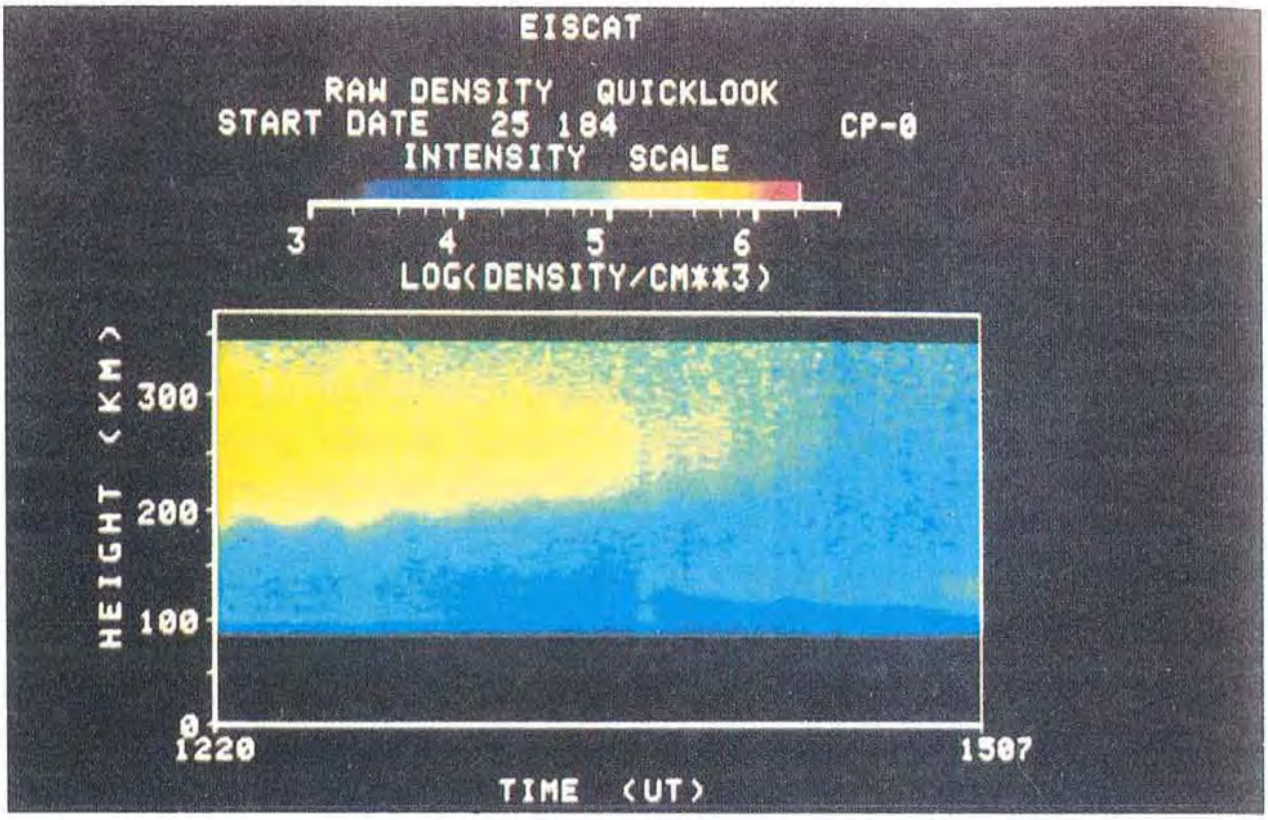


Figure 6a: Electron density as a function of height and time showing clear indication of gravity waves with 33 minute period from 1220 to 1400 UT.

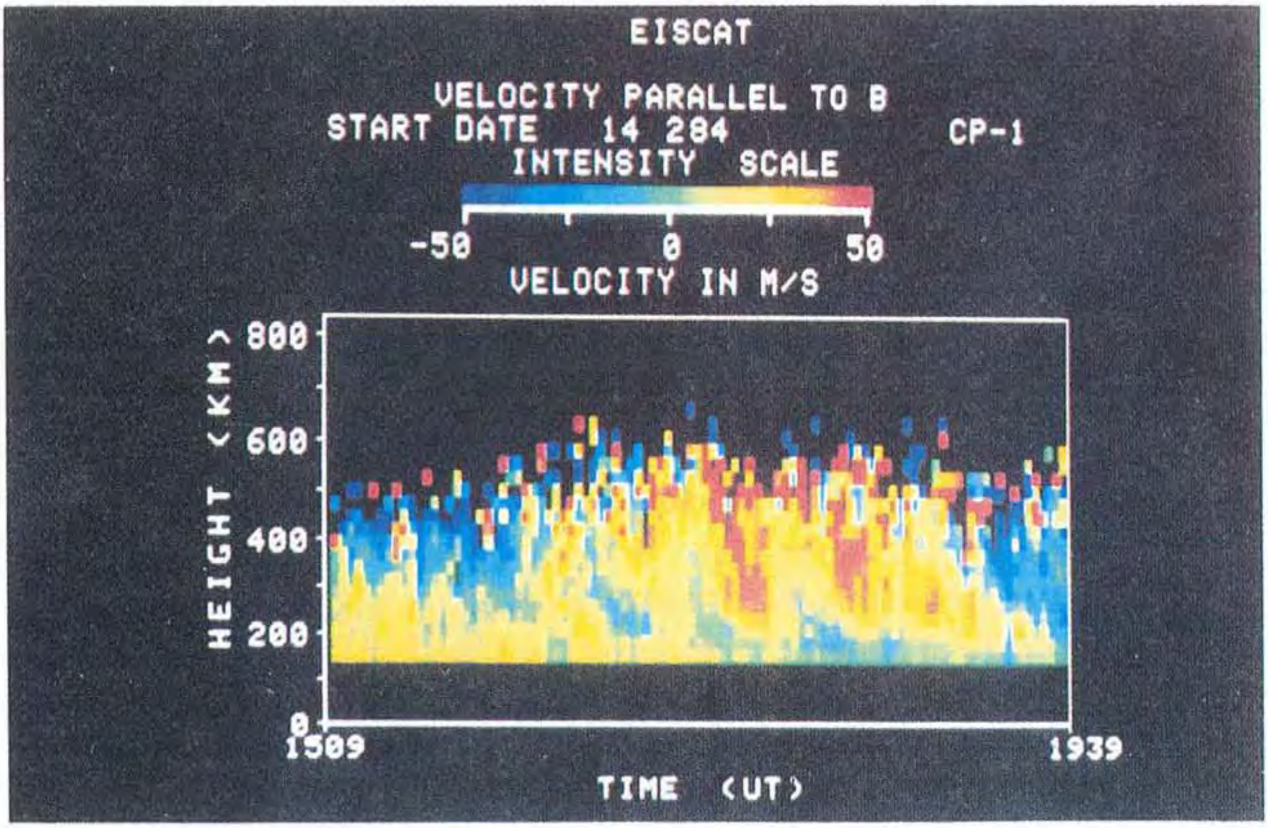


Figure 6b: Parallel ion velocity as a function of height and time showing clear indication of gravity waves.

the driver for the fluxtube interchange process responsible for the observed structure was not clear. For this case study, neither the gradient-drift nor the current-corrective instability appeared to be the primary source.

Plasma Line Studies

Enhanced plasma lines are regularly observed in the E- and lower F-regions during the entire daytime summer season. The plasma lines are enhanced above the thermal (background) level when there is a suprathermal tail to the electron distribution function which increases the excitation rate by a greater factor than it increases the damping rate of the plasma waves. For these observations, the suprathermal tail was due to locally produced photoelectrons, not particle precipitation or ionospheric modification (heating) effects. The plasma lines were observed at frequencies between 2.9 Mhz and 5 Mhz which correspond to photoelectrons of very low energies, 0.6 to about 2 eV. Thus these measurements give information about the low-energy electrons in this poorly known part of the electron spectrum.

Plasma lines and ion lines were measured on a pulse-to-pulse (10 ms) basis during heating experiments to study the time development of the parametric decay instability. It was found that immediately after heater switch on, enhanced ion lines appear. After about 60 ms, strong upshifted (downward travelling) plasma lines appear but at an altitude several kilometers below that of the enhanced ion line. Enhanced downshifted waves were not observed. The observations were interpreted in terms of excitation of Langmuir waves of longer wavelength, which suffer less Landau damping, that propagate downwards and become shorter in wavelength until they match the radar wavelength. The upward travelling waves become longer in wavelength and cannot be observed.

Cooperative Experiments

EISCAT participated in many cooperative experiments and programs during 1984. Experiments coordinated with other radars, rockets, satellites, balloons, and optical equipment were performed, either under the direction of associate scientists or by EISCAT staff as part of world-wide measurements programs.

Together with the other incoherent scatter radars, EISCAT participated in the following URSI-sponsored programs:

* MITHRAS – Magnetospheric, Ionospheric, Thermospheric Radar Studies. This program involved the Chatanika and Millstone Hill radars and had as a primary goal the separation of globally-simultaneous (UT) effects from local time effects in auroral phenomena.

* GISMOS – Global Incoherent Scatter Measurements and Observations of Substorms. This program involved primarily the Sondrestrom, Millstone, and St. Santin radars and is a continuation of the work of MITHRAS with extension to higher and lower latitudes.

* GTMS – Global Thermospheric Measurement Study. This program involved all the incoherent scatter radars plus Fabry-Perot interferometers and satellites and was directed at providing a global view of thermospheric dynamics.

An important aspect of all three of the above programs is the close involvement of theoreticians and modellers so that the experimental results can be applied to and compared against global models.

Other studies, on a more local basis, were performed together with the following HF/VHF radar systems:

* STARE – Scandinavian Twin Auroral Radar Experiment
* SABRE – Sweden And Britain Radar Experiment
* SAFARI – Scandinavian And French Auroral Radar Investigation
* EDIA – Etude Doppler des Irregularities Alignees
* HF Doppler radar in Norway – Univ. of Leicester

Most of the cooperative work with the above radars focused on convection flow, electric fields, and E-region irregularities.

Cooperative work continues with EISCATs close neighbors at Ramfjordmoen, the MPI Heating facility and the Univ. of Tromsö PRE (Partial Reflection Experiment) facility.

More than 100 hours of 1984 operations were devoted to participation in the MAP/WINE campaign, a part of the international middle atmosphere program. This program included collaboration with PRE and with meteorological rockets among other instruments.

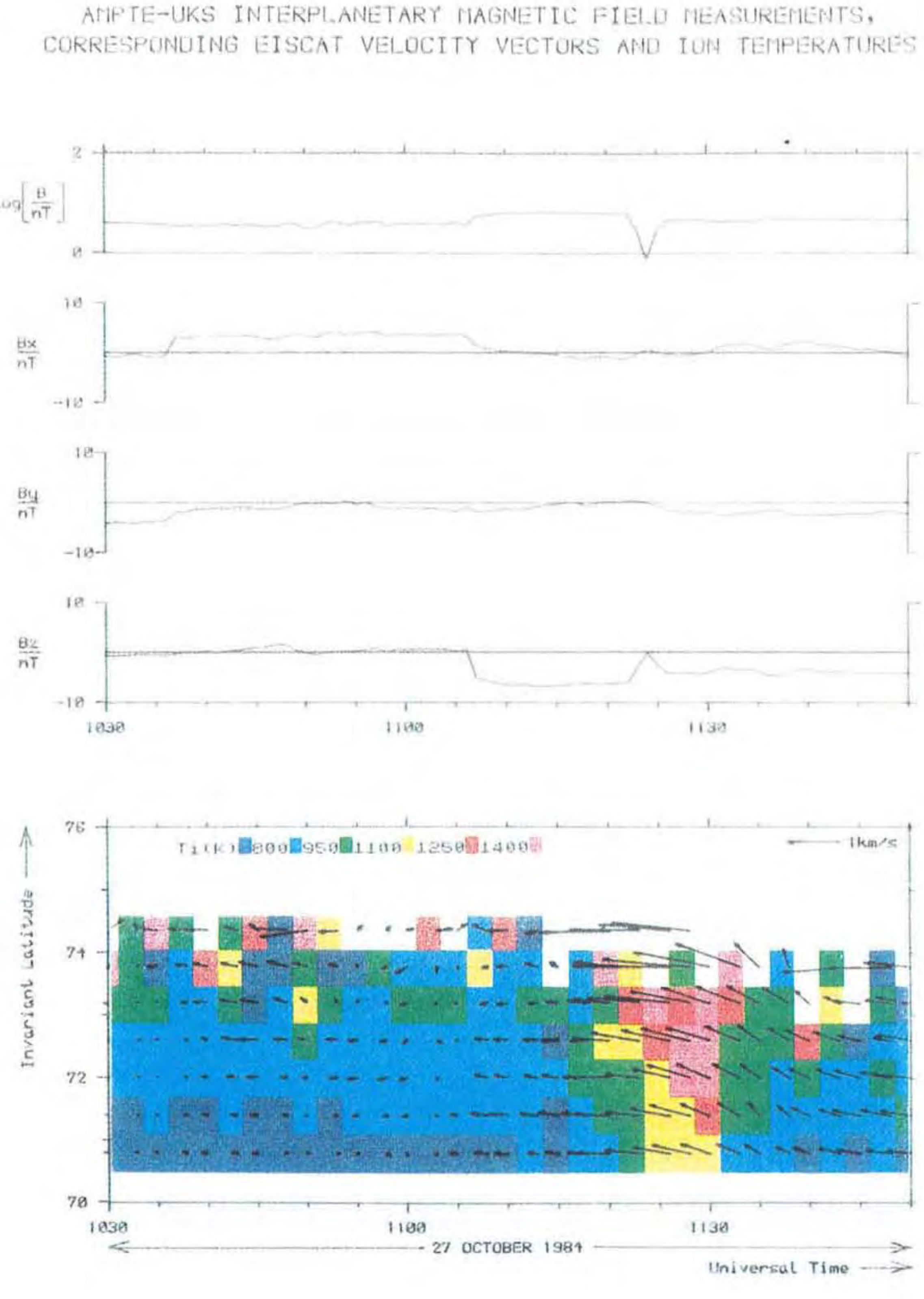
The CEBO (Coordinated EISCAT-Balloon Observations) campaign was successfully completed in 1984. The balloon carried x-ray flux and electric field sensors. EISCAT measured electron density, temperatures and electric fields above the balloon for many hours. The combined data set should provide information on the mapping of ionospheric electric fields into the lower atmosphere and the relationship between x-rays and the auroral particle precipitation.

Experiments were also carried out together with optical equipment at Spitzbergen and in Northern Scandinavia to study thermospheric dynamics, including coupling between the ionized and neutral constituents.

Finally, coordinated experiments with the following satellites are producing interesting new results in the topic areas indicated:

* ARCAD3 – energetic particle spectra, field line tracing
* GEOS-2 – stagnation region, plasmapause variations
* NNSS – F-region irregularities, scintillations
* HILAT – F-region irregularities, scintillations
* AMPTE – Solar wind-ionosphere coupling
* DE – Electric fields

An example of EISCAT-AMPTE collaboration is shown in Figure 7. The AMPTE measurements show an abrupt southward-turning ($B_z < 0$) of the interplanetary magnetic field (IMF) after an extended period in which B_z was close to zero. The IMF is carried by the solar wind and the B_z perturbation is followed, with a few minutes delay, by a large increase in the ion velocity as measured by EISCAT. The ion velocity enhancement, in turn, results in frictional heating of the ion gas.



AMPTE-UKS INTERPLANETARY MAGNETIC FIELD MEASUREMENTS, CORRESPONDING EISCAT VELOCITY VECTORS AND ION TEMPERATURES

Figure 7: Relationship between interplanetary magnetic field as measured by the AMPTE space craft and ionospheric velocities and temperatures as measured by EISCAT. The southward turning of B_z at 1107UT is followed by enhanced convection velocities and joule heating of the ion gas.

Tromsö site staff: seated from left: J. Wright, S. Kirkwood, A. Knutsen. Standing from left: F. Pettersen, T. Flå, K. Ringstad, M. Halvorsen, J.-B. Henriksen, H. Boholm, K. Helvig, H. Berglund, R. Jacobsen, Å. Fredriksen.

OPERATIONS

For 1984 as a whole, operations of the UHF system were nearly at the originally intended level of approximately 2000 hrs per year. This is a remarkable achievement considering that from May through December the work priority at the Tromsö station was almost equally shared between UHF operations and VHF installation. Figure 8 summarizes the operating hours by month and shows the division of time between common programmes and special programmes. The total in 1984 was 85 % higher than the total for 1983.

The distribution of operations according to time of day is shown in Figure 9. Note that common program time is fairly uniformly spread over the day, while the special program time of day distribution has a very marked peak in the evening hours. This evening peak necessitates a great deal of shift work and this will ultimately limit the total operating hours that can be achieved with the present staff size. During 1984, each Tromsö staff member worked about 400 hrs outside normal working hours.

The level of operations achieved in 1984 resulted in the use of 2274 digital magnetic tapes. The handling, copying, cataloging, archiving of these tapes has become a significant load on EISCATs financial, computer and personnel resources.

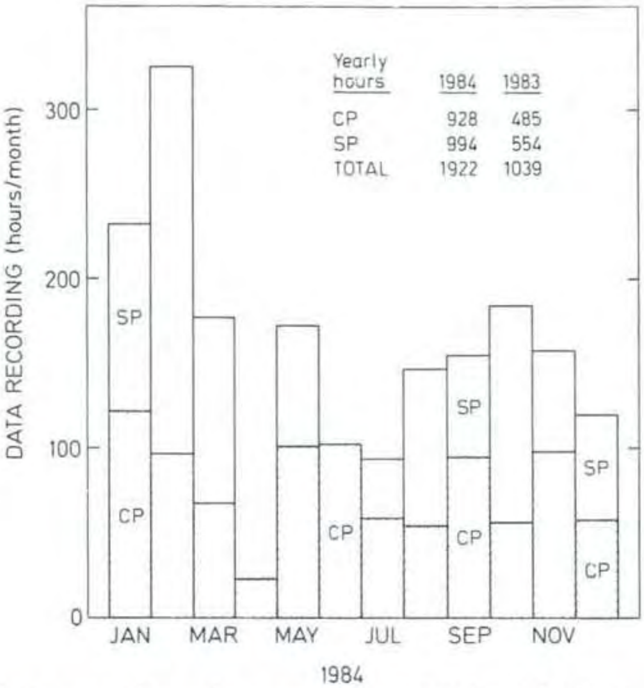


Figure 8: EISCAT data recordings by month for 1984 with Common programme (CP) and Special programme (SP) shown separately.

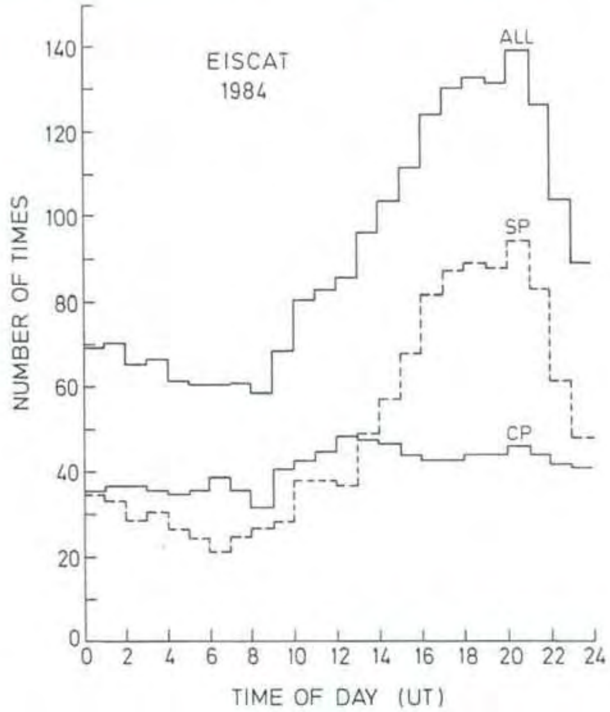


Figure 9: Distribution of operations according to time of day.

As a long term goal, EISCAT operating hours are to be equally shared between the common and special programmes. Further, the available special programme time is to be subdivided amongst the Associates in prescribed ratios. The cumulative distribution of accounted time on the instrument as partitioned between the various categories is shown in Figure 10. It can be seen that the cumulative percentages are generally within 5 % of the stated goals.

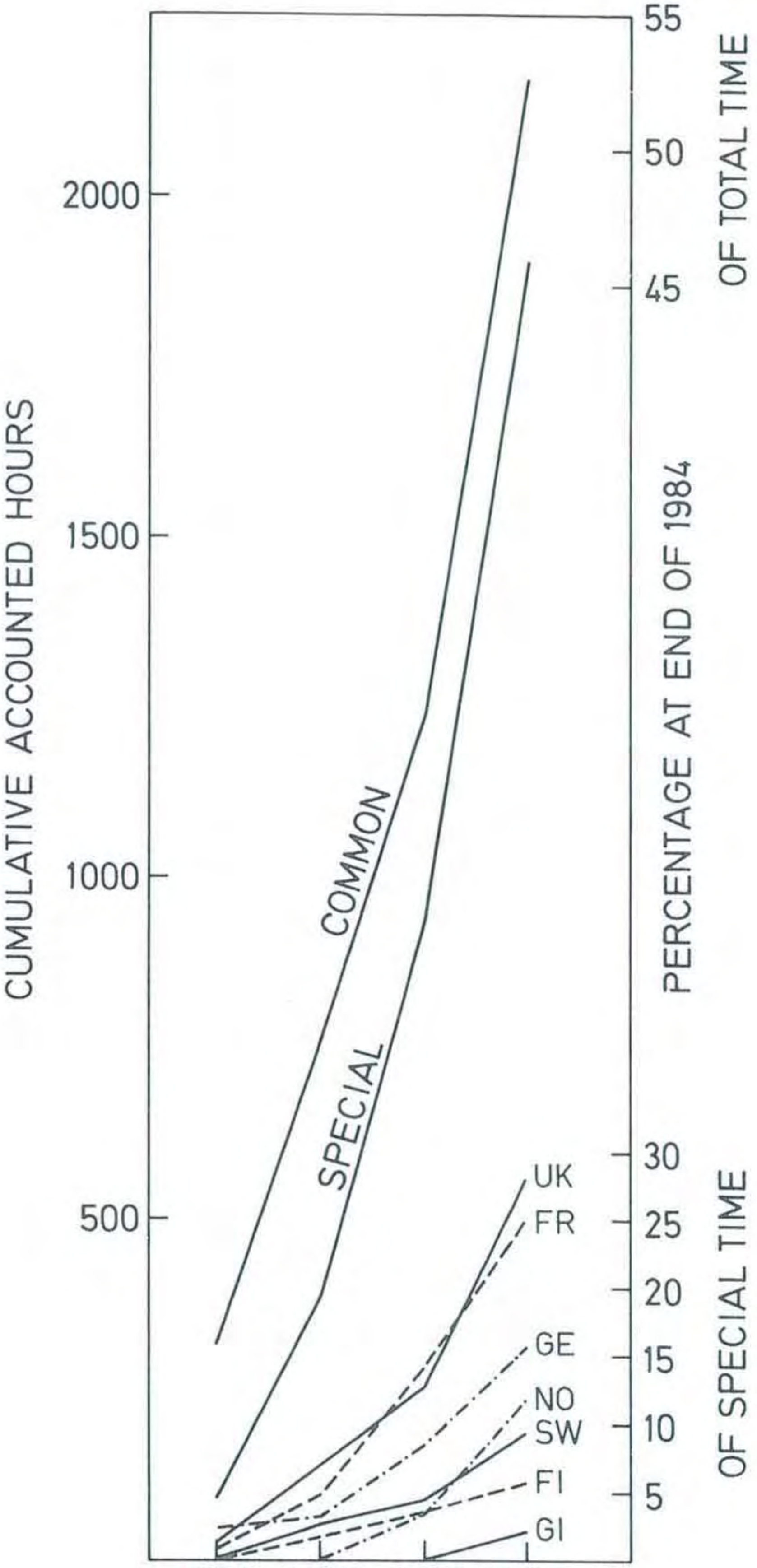


Figure 10: Cumulative distribution of accounted time among the EISCAT associates and between the common and special programmes for the period 1981 through 1984.

Sodankylä station staff: left to right – J. Silén, M. Postila, T. Laakso, A-L. Turunen, T. Mustonen.

TECHNICAL REVIEW

UHF Facility

Most of the technical developments in 1984 were aimed at increasing the systems reliability and flexibility, and improving the quality of the data. In contrast to previous years, there were no major problems that prevented operations for extended periods of time. The ability of the staff to deal rapidly with technical difficulties made a major contribution to reliability.

A completely rewritten version of the experiment control operating system (EROS-II) was installed in March. Its main advantages compared to the previous version are: higher execution speed, more consistency checks within the compiler, special test features, improved inter-site communications, greater flexibility, and simplified operator interaction.

Two channels of fast (10 MHz) analog-to-digital converters were installed at all sites. A side benefit of these fast converters is that each contains its own 2048 sample buffer memory, effectively increasing the available buffer memory size. The integral buffer memories also allow the simultaneous use of Barker-coded and non-Barker-coded pulses within the same radar controller program.

Sixty new postdetection filter cards were completed and allocated amongst the stations. Included were 16 wideband filters, 16 Butterworth filters, and 12 linear phase filters. These filled out the filter complement at the sites. In addition, 16 linear filters with bandwidths shifted by half-octaves from the original widths were built. These permit better experiment optimization because the receiver bandwidth can be more closely matched to the signal bandwidth.

The reliability of the correlators is being improved in two ways: the construction of new high-quality circuit boards and the redesign of the logic chassis. The former eliminates problems due to intermittent connections and oxidized socket contacts; the latter eliminates problems due to signal cross-talk, poor grounding, noisy power supply buses, and poor thermal design. The two developments together result in about a two order of magnitude reliability improvement. By the end of 1984, two chassis had been rebuilt and two new sets of cards completed. The rest of the cards should be completed and tested by mid-1985 with the remaining chasses to follow by the end of the summer. As part of this effort, the feasibility of doubling the result memory size has been demonstrated.

At Tromsö, the troublesome 2nd local oscillators were replaced by high quality synthesizers. A system for computer control of the synthesizers was designed.

Also at Tromsö, an expanded audible alarm system has been installed. Originally an audible alarm to alert the staff was activated only if the transmitter ceased to function properly. Now, the operation of other key subsystems is monitored by the computer and the alarm activated if any of a number of error conditions are found. This results in minimizing the time between the onset of a problem and the initiation of corrective action.

At all sites, the ND-10 computer memory size has been doubled using new EISCAT-designed memory boards. At Kiruna and Sodankylä, where the ND-10 is used as the experiment control computer, the increased memory results in less disc swapping and faster execution of program commands.

VHF Facility

There has been a great deal of visible progress on the VHF transmitter during 1984. The transmitter was shipped from California and physically installed at Ramfjordmoen during the period May–August. Figure 11 is a photograph of the VHF modulator/klystron tank after installation at Ramfjordmoen. In addition to the transmitter itself, a platform over the transmitter area was constructed to hold the waveguide, dummy load and duplexor.

After physical installation, electrical testing began. This was done in two week periods alternating with two week periods of UHF operation. Normal amounts of installation bugs were found and had to be corrected before high voltage testing could begin. By the end of the year, testing had begun but progress was slow due to a variety of minor problems that were encountered and had to be solved. The transmitter testing has been done by engineers from SRI International under a subcontract from AYDIN.

At the end of 1983, a contract was placed with VALVO in Hamburg, Germany for two new-design VHF klystrons. The first of the two was mechanically assembled by late October 1984 and is seen in the photograph of Fig. 12. It was vacuum-pumped and baked in November and should have started testing in December. Unfortunately, a failure in the Valvo test set-up prevented further testing of the klystron in 1984.

In the early months of 1985, there were further delays in testing, both with the transmitter in Tromsö and the new Valvo tube in Hamburg. Assuming no further major problems arise, the following timetable can be estimated for VHF system completion:

Jan–April: Completion of testing with the one Varian tube.
May–June: Delivery and testing on-site of first Valvo klystron*.
July: Testing of two-tube transmitter.
August: Delivery of second Valvo klystron.
Aug–Dec: Preliminary VHF operations.
Jan 1986: Full operation of VHF system.

During the summer, thorough tests were made on the VHF antenna to ascertain that its (low-power) electrical performance was unchanged from the time of its acceptance tests. Within measurement accuracy, no deterioration in performance was detected. However, a physical inspection of the antenna revealed that an elevation bearing on one of the four antenna sections had broken loose and moved 24 millimeters. The bearing was repositioned by the Tromsö staff using a 60 ton jack and properly secured in place. All other bearings were checked and reinforced.

* Press time note: Technical problems arose in April that will result in a delay of approximately three months.

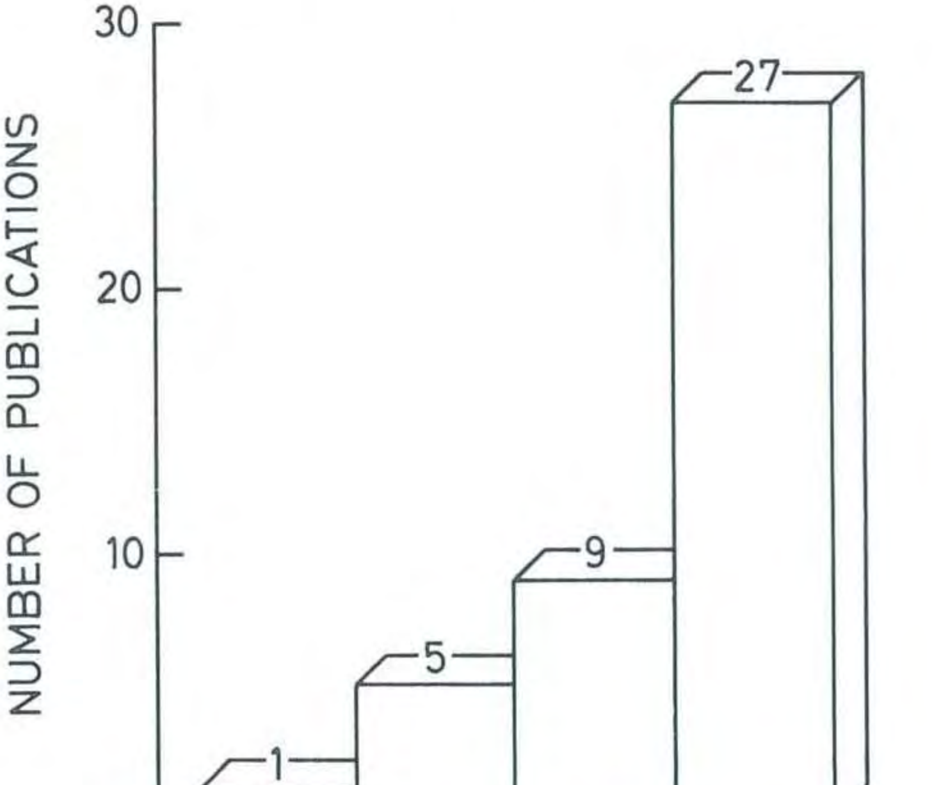
Figure 11: VHF transmitter installed in transmitter hall at Ramfjordmoen. The two large cylinders are the focus magnet assemblies which encase the klystrons. The waveguide is connected only to the klystron on the right.

Figure 12: VALVO VHF Klystron on hoist before positioning in bake-out station. The tube is more than 5 metres long and is designed to produce 3 Mw of peak pulse power.

PUBLICATIONS

EISCAT-related articles have been published in refereed journals, proceedings of meetings and symposia, internal research memoranda and reports, newsletters, handbooks, theses and as chapters of books. Oral presentations or poster papers have been given at many meetings and symposia. To list all the 1984 publications and presentations in this annual report would consume too much space. Instead, we list only the refereed journal publications and show the development of these publications over the life of EISCAT.

REFEREED JOURNALS



Refereed Journal Publications

G. Crowley, T.B. Jones, T.R. Robinson, N.M. Wade, O. Holt, "Determination of the vertical neutral temperature and wind profiles using EISCAT and HF Doppler radar", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 501–507, 1984.

E. Mjölhus, T. Flå, "Direct access to plasma resonance in ionospheric radio experiments", *J. Geophys. Res.*, Vol. 89, pp. 3921–3928, 1984.

B. N. Maehlum, T. Hansen, A. Brekke, O. Holt, K. Folkestad, "Preliminary results from a study of the F-region heating during an intense aurora observed by EISCAT". *J. Atmos. Terr. Phys.* Vol. 46, pp. 619–623, 1984.

S. Perraut, N. Björnå, A. Brekke, M. Baron, W. Kofman, C. Lathuillere, G. Lejeune, "Experimental evidence of non-isotropic temperature distributions of ions observed by EISCAT in the auroral F-region", *Geophys. Res. Lett.*, Vol. 11, pp. 519–522, 1984.

S. Perraut, A. Brekke, M. Baron, D. Hubert, "EISCAT measurements of ion temperatures which indicate nonisotropic ion velocity distributions", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 531–543, 1984.

K. Schlegel, G. Kremser, A. Korth, "Data comparison of EISCAT and the energetic particle instrument on GEOS 2", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 509–515, 1984.

K. Schlegel, "A case study of a high latitude ionospheric electron density depletion", *J. Atmos. Terr. Phys.*, Vol. .46, pp. 517–520, 1984.

T. Turunen, J. Silén, "Modulation patterns for the EISCAT incoherent scatter radar", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 593–599, 1984.

D. Alcayde, P. Bauer, J. Fontanari, "Dynamical coupling of the auroral F-region ionosphere and thermosphere: case studies", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 625–633, 1984.

G. Caudal, O. de la Baujardière, D. Alcayde, J. Holt, G. Lejeune. "Simultaneous measurements of the electrodynamic parameters of the auroral ionosphere by the EISCAT, Chatanika and Millstone Hill radars", *Ann. Gèophys.*, Vol. 2, pp. 369-, 1984.

O. de la Beaujardière, V.B. Wickwar, M. J. Baron, J. Holt, R. M. Wand, W. L. Oliver, P. Bauer, M. Blanc, C. Senior, D. Alcayde, G. Caudal, J. Foster, E. Nielsen, R. Heelis, "MITHRAS: A brief description", *Radio Science*, Vol. 19, No. 2, pp. 665–673, 1984.

D. Hubert, "Non-Maxwellian velocity distribution functions and incoherent scattering of radar waves in the auroral ionosphere", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 601–611, 1984.

W. Kofman, F. Bertin, J. Röttger, A. Cremieux, P. J. S. Williams, "The EISCAT mesospheric measurements during the CAMP campaign", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 565–575, 1984.

C. Senior, M. Blanc, "On the control of magnetospheric convection by the spatial distribution of Ionospheric conductivities", *J. Geophys. Res.*, Vol. 89, pp. 261–, 1984.

A. D. Farmer, M. Lockwood, R. B. Horne, B. J. I. Bromage and K. S. C. Freeman, "Field-perpendicular and field-aligned plasma flows observed by EISCAT during a prolonged period of northward IMF", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 473–488, 1984.

M. Lockwood, A. D. Farmer, H. J. Opgenoorth and S. R. Crothers, "EISCAT observations of plasma convection and the high-latitude, winter F-region during substorm activity", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 489–500, 1984.

Å. Steen, C. H. Chen, J. Murdin and G. Wannberg, "A nonlinear maximum entropy method for spectral estimation applied to incoherent scatter radar measurements: application to synthetic incoherent scatter data", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 613–618, 1984.

A. P. van Eyken, H. Rishbeth, D. M. Willis and S. W. H. Cowley, "Initial EISCAT observations of plasma convection at invariant latitudes 70°–77°", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 635–641, 1984.

M. Baron, "The EISCAT facility", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 469–472, 1984.

D. Rees, N. Lloyd, P. J. Charleton, M. Carlson, J. Murdin, I. Häggström. "Comparison of plasma flow and thermospheric circulation over northern Scandinavia using EISCAT and a Fabry-Perot interferometer", *J. Atmos. Terr, Phys.*, Vol. 46, pp. 545–564,; 1984.

B. J. I. Bromage, "Errors in velocities determined from EISCAT data", *J. Atmos. Terr. Phys.*. Vol. 46, pp. 577–591, 1984.

R. B. Horne, "The effects of differential ion flows on EISCAT observations in the auroral ionosphere", *J. Atmos. Terr. Phys.*, Vol. 46, pp. 1159–1168, 1984.

P. J. S. Williams, G. O. L. Jones, A. R. Jain, "Methods of measuring plasma velocity with EISCAT", *J. Atmos. Terr, Phys.*, Vol. .46, pp. 521–530, 1984.

P-S. Kildal, "Radiation Characteristics of the EISCAT VHF Parabolic Cylindrical Reflector Antenna", *IEEE Transactions on Antennas and Propagation*, Vol. AP-32, No.p 6, pp. 541–5523, 1984.

P-S. Kildal, "Aperture Efficiency and Line Feed Phase Center of Parabolic Cylindrical Reflector Antenna", *IEEE Transactions on Antennas and Propagation*, Vol. AP-32, . No. 6, pp. 553–561, 1984.

P-S. Kildal, "A Formula for Efficient Computation of Radiation from a Current Source in Proximity to Cylindrical Scatterers", *IEEE Transactions on Antennas and Propagation*. Vol. AP-32, No. 7, pp. 754–757, 1984.

P-S. Kildal, "Diffraction Corrections to the Cylindrical Wave Radiated by a Linear Array Feed of a Cylindrical Reflector Antenna", *IEEE Transactions on Antennas and Propagation*, Vol. AP-32, No. 10, pp. 1111–1116, 1984.

EISCAT Reports – 1984

M. Baron and HQ staff:
EISCAT Incoherent Scatter Facility
Catalogue of Observations 1981–1983
EISCAT Technical Note 84/40.

K-O. Johanson, K. Persson, W. Schmidt and A-L. Turunen:
EISCAT Experiment Preparation Manual
EISCAT Technical Note 84/41.

T. Flå (Editor):
Proceedings of the EISCAT Annual Review Meeting, Kautokeino, Norway,
26–29 March, 1984.
EISCAT Meetings 84/9.

EISCAT Meetings

Council
23rd meeting, Stockholm,
2–3 May, 1984
24th meeting, Paris,
8–9 November, 1984

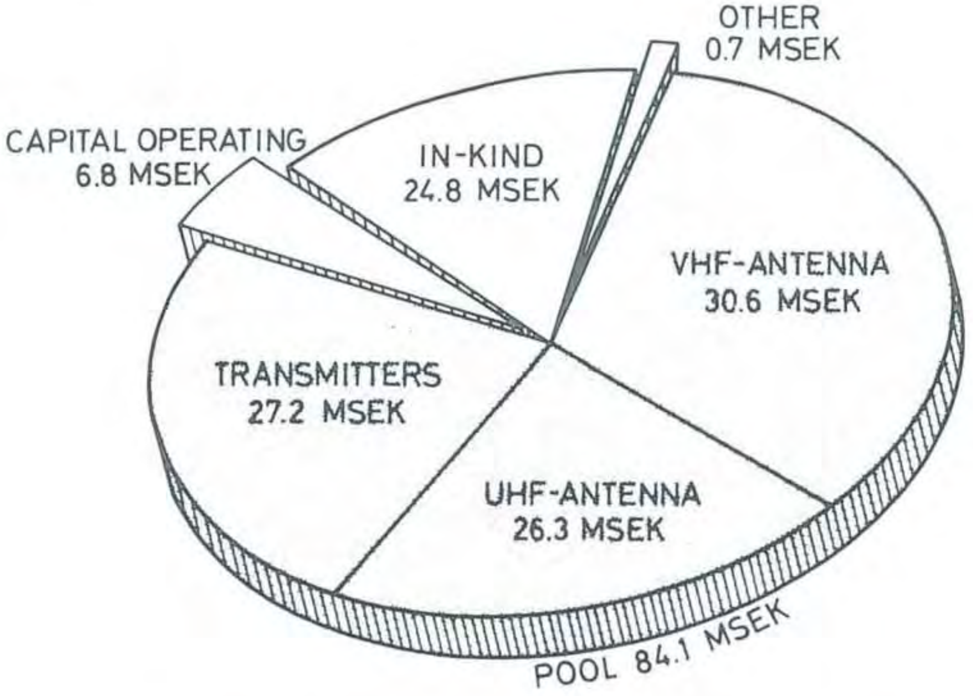
Scientific Advisory Committee (SAC)
26th meeting, Tromsö,
14–15 March, 1984
27th meeting, Sodankylä,
18–19 September, 1984

Administrative and Finance Committee (AFC)
22nd meeting, Hamburg,
22 March, 1984
23rd meeting, Tromsö,
26–27 September, 1984

EISCAT Annual Review Meeting
9th meeting, Kautokeino,
26–29 March, 1984.

CAPITAL INVESTMENTS

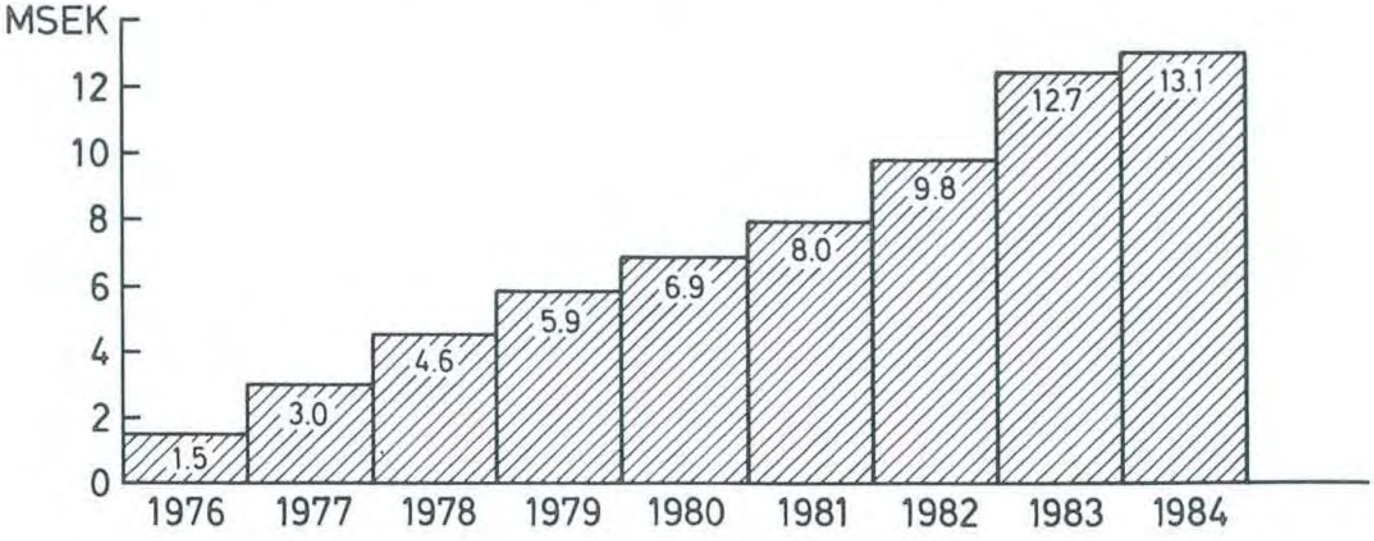
The cumulative capital investments (sum of costs at time of expenditure) to the end of 1984 are shown below:



TOTAL = 116.4 MSEK (1983 = 112.9 MSEK)

OPERATING COSTS

The operating costs increased to 13.1 MSEK in 1984 and are nearly up to the level for full operations. The annual cost history follows:



BALANCE SHEET

MSEK

Assets	At Dec. 31, 1983	Pool	Additions		Depreciation	At Dec. 31, 1984
			Cap.Op	Other		
FIXED ASSETS						
Buildings	8.3			0.7	0.2	8.8
Transmitters	26.1	1.2			0.7	26.6
UHF-antenna	20.0				1.3	18.7
VHF-antenna	24.2	0.4			1.5	23.2
Receivers	3.8				0.8	3.0
Computers etc.	4.2		0.2		1.5	2.9
Other	1.5		1.2		0.4	2.2
Total	88.2	1.6	1.4	0.7	6.3	85.4
CURRENT ASSETS						
Debtors	1.4					1.7
Prepayments and accrued income	0.2					0.1
Cash and Ordinary Bank Accounts	11.2					12.9
Special Accounts	0.2					0.1
Total Current Assets	13.0					14.8
GRAND TOTAL	101.2					100.2

Totals may not match because of rounding.

AT 31 DECEMBER 1984

MSEK

Liabilities	At Dec 31, 1983	At Dec. 31, 1984
CAPITAL		
Contributions		
Pool	82.6	84.1
Capital Operating	5.6	6.8
In Kind	24.8	24.8
Other		0.7
	112.9	116.4
Depreciations	24.7	31.0
Total Capital	88.2	85.4
RESERVES		
Pool	8.9	8.0
Capital Operating	1.1	0.2
Other	0.7	2.3
Total Reserves	10.7	10.5
Special Accounts	0.2	0.1
LIABILITIES		
Provisions	1.1	1.6
Other Liabilities	1.0	2.6
Total Liabilities	2.1	4.2
GRAND TOTAL		100.2

MEMBERSHIP OF COUNCIL AND COMMITTEES

	France	Finland	Federal Republic of Germany	Norway	Sweden	United Kingdom
COUNCIL	M. Petit M. Blanc/P. Bauer J-C. Ribes	O. Ranta A. Siivola	G. Haerendel[x] H. Kohl G. Preiss	A. Omholt O. Holt/A. Brekke	B. Hultqvist M. O. Ottosson	H. H. Atkinson W. J. G. Beynon H. Rishbeth
SAC	D. Alcayde P. Bauer/ W. Kofman	T. Turunen/ J. Kangas	P. Christiansen K. Schlegel	A. Brekke[x]	H. Opgenoorth	T. B. Jones H. Rishbeth
AFC	M. Ravaut	O. Ranta	M. Meinecke	L. Westgaard	M. O. Ottosson[x]	G. Rowe

SAC = Scientific Advisory Committee, AFC = Administrative and Finance Committee
[x] = chairman

Headquarters senior staff in 1984:

Director – M. Baron
Associate Director – K. Folkestad (until April) vacant thereafter
Associate Director – J. Röttger[x] (until Oct) T. Turunen thereafter
Business Manager – B. Thorwid

[x] on secondment from MPG

THE EISCAT ASSOCIATES

Centre National de la Recherche Scientifique,
France
(CNRS)

Suomen Akatemia,
Finland
(SA)

Max-Planck-Gesellschaft,
West Germany
(MPG)

Norges Almenvitenskapelige Forskningsråd,
Norway
(NAVF)

Naturvetenskapliga Forskningsrådet,
Sweden
(NFR)

Science and Engineering Research Council,
The United Kingdom
(SERC)