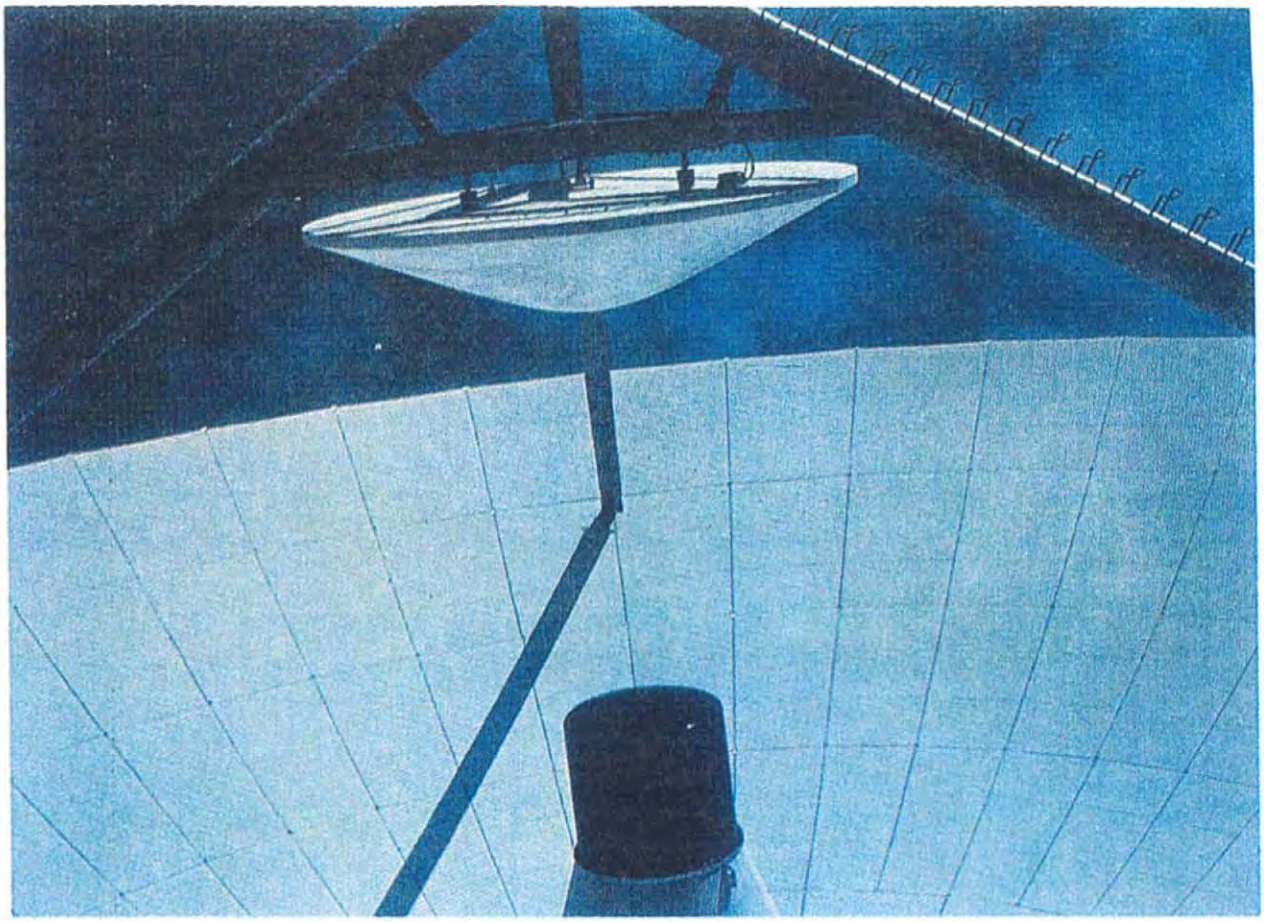

EISCAT

EUROPEAN INCOHERENT SCATTER SCIENTIFIC ASSOCIATION

ANNUAL REPORT 1983

S-98127 KIRUNA, SWEDEN, PHONE (0980) 18740

ADDRESSES

Headquarters
EISCAT Scientific Association
Box 705
S-981 27 KIRUNA, Sweden
Telephone (0980) 187 40
Telex 8778 EISSWE S

SITES

Tromsø station
EISCAT
Ramfjordmoen
N-9027 RAMFJORDBOTN, Norway
Telephone (083) 92 166
Telex 64455 EISNO N

Kiruna station
EISCAT
Kiruna Geophysical Institute
Box 704
S-981 27 KIRUNA, Sweden
Telephone (0980) 290 10
Telex 8754 GEOFYSK S

Sodankylä station
EISCAT
Geophysical Observatory
SF-99600 SODANKYLÄ, Finland
Telephone (993) 124 62
Telex 37254 GEFSO SF

EISCAT SCIENTIFIC ASSOCIATION

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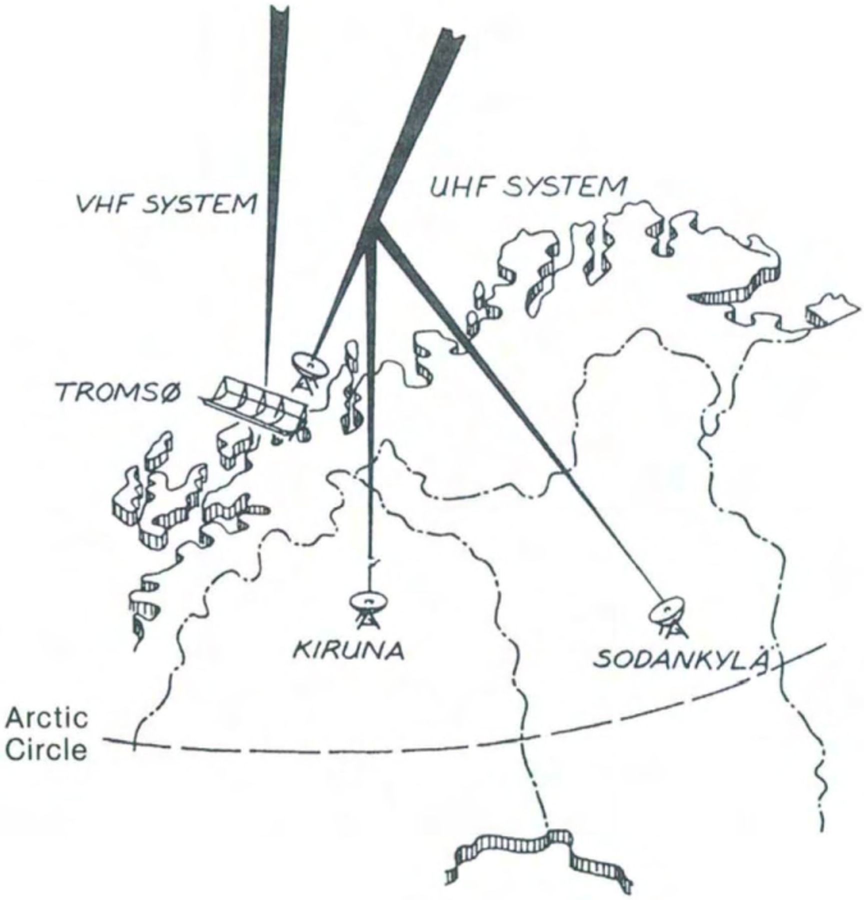

EISCAT, the **E**uropean **I**ncoherent **Scat**ter Scientific Association, is established to conduct research on the upper atmosphere, ionosphere and aurora using the incoherent scatter radar technique. The experimental facilities are located in Scandinavia, north of the arctic circle. They comprise two independent radar systems (UHF at 933 MHz and VHF at 224 MHz), both 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.

The EISCAT Scientific Advisory Committee meeting at Ramfjordmoen, 17 March, 1983.

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CHAIRMAN's PAGE

1983 has been a year of great progress for EISCAT. Continuous operation of the UHF system at the initially planned level was reached for the first time in October 1983 and has been maintained into spring 1984. My confidence, expressed in last year's report, that the previous problems would soon be overcome, was well founded. The Director and his staff can be proud of their achievements and of the great many scientific results that were obtained by the users even before EISCAT reached continuous operation. I want to express to all of them the most sincere thanks of the EISCAT council and the associates.

For me it was particularly satisfying that I happened to participate in a special program experiment at the beginning of this period of rich harvest, hunting auroral arcs both optically and with the UHF system. The easy steerability of the antennas allowed us to select within minutes the best location in the F-region to measure the three-dimensional plasma velocity vector adjacent to auroral arcs. EISCAT was designed for programs of this type and proved that it is able to fulfill our expectations.

The top of the EISCAT personnel is undergoing a significant change in 1984. The Associate Director Technical, Dr. Kristen Folkestad, has left the association in April 1984 and Dr. Jürgen Röttger, the Associate Director Science, will leave in September. Kristen has been with EISCAT from its very beginning in 1976 and even before that during its birth phase. His share in making EISCAT operational cannot be overestimated. EISCAT associates, staff members and users owe Kristen respect and deep thanks. It would be premature to honour Jürgen Röttger's contributions to EISCAT already now, but we wish him all the best and great satisfaction with his new task at Arecibo.

Gerhard Haerendel
Chairman

DIRECTOR's PAGE

It is with a great deal of pleasure that I report that 1983 was the year in which the EISCAT UHF system became fully operational. The EISCAT statutes projected an average weekly observing time goal of 48 hrs. This level of operations was achieved and often exceeded for the last three months of 1983, and indeed has continued into the third month of 1984.

The data quality is much improved over previous years. This is a result of a number of factors. The UHF transmitter now operates reliably at higher powers giving better signal-to-noise ratios for the measurements. Peak power levels during experiments are typically between 1.0 and 1.5 MW, and the incidence rate of crowbars is comparable to that experienced by other incoherent scatter radar facilities.

By the end of 1983, the reliability of other parts of the UHF system had been noticeably improved. The correlators, which in the past have been quite troublesome, are approaching an acceptable reliability level. In the receiving system, a new complement of post-detector filter/amplifiers, with much better stability and filter characteristics, has been installed at all sites. Modifications to the receiver layout have greatly reduced the 50 Hz hum levels previously present in the signal channels. The entire system is much better calibrated than before.

It would be misleading to give the impression that all technical problems with the UHF system have been solved. Several less serious ones remain and are being dealt with. However, whereas in previous years EISCAT produced a trickle of data, it is now producing a flood of high quality data.

This flood of data, driven by the pressure from associate scientists for observational campaigns, creates a new set of challenges for the EISCAT staff. Scheduling of time on the instrument involves resolving many conflicting requirements among associate scientists. Negotiations and compromises must be found in a diplomatic way. EISCAT's science director, Dr. Jürgen Röttger, has done an excellent job in this respect, aided greatly by the fine spirit of cooperation exhibited by most of the associate scientists.

Personnel at the EISCAT sites, particularly in Tromsö, have had to adjust their working hours so that the site is staffed during the very frequent night and weekend operations. The staff has needed to pay closer attention to inter-site communication and coordination in order to cope with the frequent and often unscheduled changes in operating mode during campaigns.

The data flood has greatly increased the pressures on the HQ computer staff. In the 3-month period from October through December 1983, 200 raw data tapes were recorded. Extrapolated over a full year, and considering copies made for archiving and distribution as well as tapes needed for analysis results, the HQ computer staff, Walter Schmidt and Kjell Persson, must handle about 2500 tapes per year. This is almost a full time job in itself. And it stresses the tape transport resources available on the HQ computer. Steps have already been taken to simplify the tape handling procedures, but further steps will be needed to enable the data analysis to keep up with the data flow.

With regard to the VHF transmitter, delivery delays due to technical difficulties continued through 1983. Further contractual negotiations were necessary resulting in a major change in the VHF procurement process and, I believe a much better possibility for EISCAT to have an operating VHF system in 1985. These developments are described in more detail later in this report.

The foregoing part of my report has dealt with the technical health of the system and with operational matters. From these standpoints, EISCAT has never been in better shape and is, for practical purposes, operating as intended and invisaged by its founders. But the true standard by which EISCAT must ultimately be judged, is its long-term scientific productivity.

Scientific productivity, for a new facility, is somewhat difficult to measure. It is clear, from the one-week EISCAT workshop held in Aussois, France, in September 1983, that there is a generally young, enthusiastic and talented group of scientists working with EISCAT. Quite a number of papers were presented at meetings and submitted or published in journals during the year (a list appears later in this Annual Report). A special issue of the Journal of Atmospheric and Terrestrial Physics devoted to EISCAT research is in press. But the number of publications and the enthusiasm of the scientists only provides a hint to the quality and originality of the research.

Although a more complete overview of the scientific results is contained in the next section of this report, I would here point out three results that are truly new. They make use of unique EISCAT capabilities and enable measurement of ionospheric parameters not previously obtainable from incoherent scatter measurements. Scientists from every associate country and EISCAT staff contributed to at least one of these three new results.

The first made use of the tristatic nature of the system to measure and confirm theoretical expectations that the F-region ion temperature is anisotropic during periods of high velocity ion flow. The ion temperature perpendicular to the earth's magnetic field was found to be several hundred degrees higher than the parallel ion temperature.

The second involved the development of a method for deriving the zonal component of the F-region neutral wind from the radar measurements. Comparison of the radar measurements with simultaneous 6300Å optical observations confirmed that the method is viable and, after some further refinement, will enable monitoring of the high latitude thermospheric wind even during periods when conventional optical observations are not possible. This technique would then make important inputs to global thermospheric modelling.

The third made use of the unique modulation capabilities of the UHF transmitter and the flexibility of the correlators to obtain E-region measurements with 450 m height resolution. A very thin (~1 km), sporadic-E layer was unambiguously detected for the first time at auroral latitudes using radar. The layer was formed, not by particle precipitation, but by converging wind flow.

The three results mentioned above are illustrative of the exciting, high quality research that is beginning to emerge from EISCAT.

What can we look forward to in 1984? The scientific output can only increase as the mass of data collected in late 1983 and early 1984 is analyzed and studied. On the technical side, we can expect UHF transmitter power levels of 1.5 MW on a routine basis. We can expect the system's reliability to be better as the improvements currently being developed, are installed. We can expect a cleaner and faster responding system after the new real-time operating software is installed. We can expect delivery of a VHF transmitter; but we cannot expect it to perform to specifications until the new klystrons are delivered and tested in early 1985.

In 1984, we will also see the departure of Dr. Kristen Folkestad from EISCAT. Kristen is one of few who have been with EISCAT from its beginnings. He suffered through all the disappointments and delays. He has fought through an overwhelming mass of technical and administrative problems, maintaining his sense of humour throughout. I think it is fair to say that no one has put in longer hours of dedicated work over a period of many years than Kristen. In April he will take up a new position with the Norwegian Telecommunication Authority in Oslo where he can once again live with his family. I'm sure I speak for all the associates in saying "lykke til", we will miss you.

Murray Baron
Director

SCIENTIFIC RESULTS

Many interesting scientific results have emerged from EISCAT measurements in 1983. The results summarized in this section are only the beginning, a taste of what is to come. There is necessarily a delay between the collection of data in the field and the subsequent analysis and interpretation of the data. The intense data collection efforts of the last three months of 1983 and early 1984 are sure to result in continually increasing scientific output in the months ahead.

Scientists from all the associate countries are actively involved in EISCAT research. In some cases, several aspects of the research are being pursued independently in several countries. The summary which follows intentionally omits credits to individuals and associate countries. Our purpose here is simply to review the work performed using EISCAT.

Ionospheric Convection

Ionospheric convection was a topic of great interest. The term convection refers to large scale motions of the ionospheric plasma in the high latitude regions. This motion is illustrated in Fig. 1. The length and orientation of the vectors show the speed and direction of the plasma motion over the latitude range 60° - 72° N and throughout a 24 hr period. In the afternoon and evening sectors, there is high speed westward flow, often exceeding 1 km s^{-1}, towards noon; in the post-midnight sector, there is high speed eastward flow, also towards noon. The flow pattern visible in Figure 1 closes by flow over the polar cap from noon towards midnight. The cross-cap closure was poleward of EISCAT's view during this particular experiment. The entire convection pattern thus has a characteristic two-celled appearance, with a clockwise-rotating cell in the evening (dusk) sector and a counterclockwise cell in the morning (dawn) sector. The convection is driven by a dawn-to-dusk electric potential in the magnetosphere.

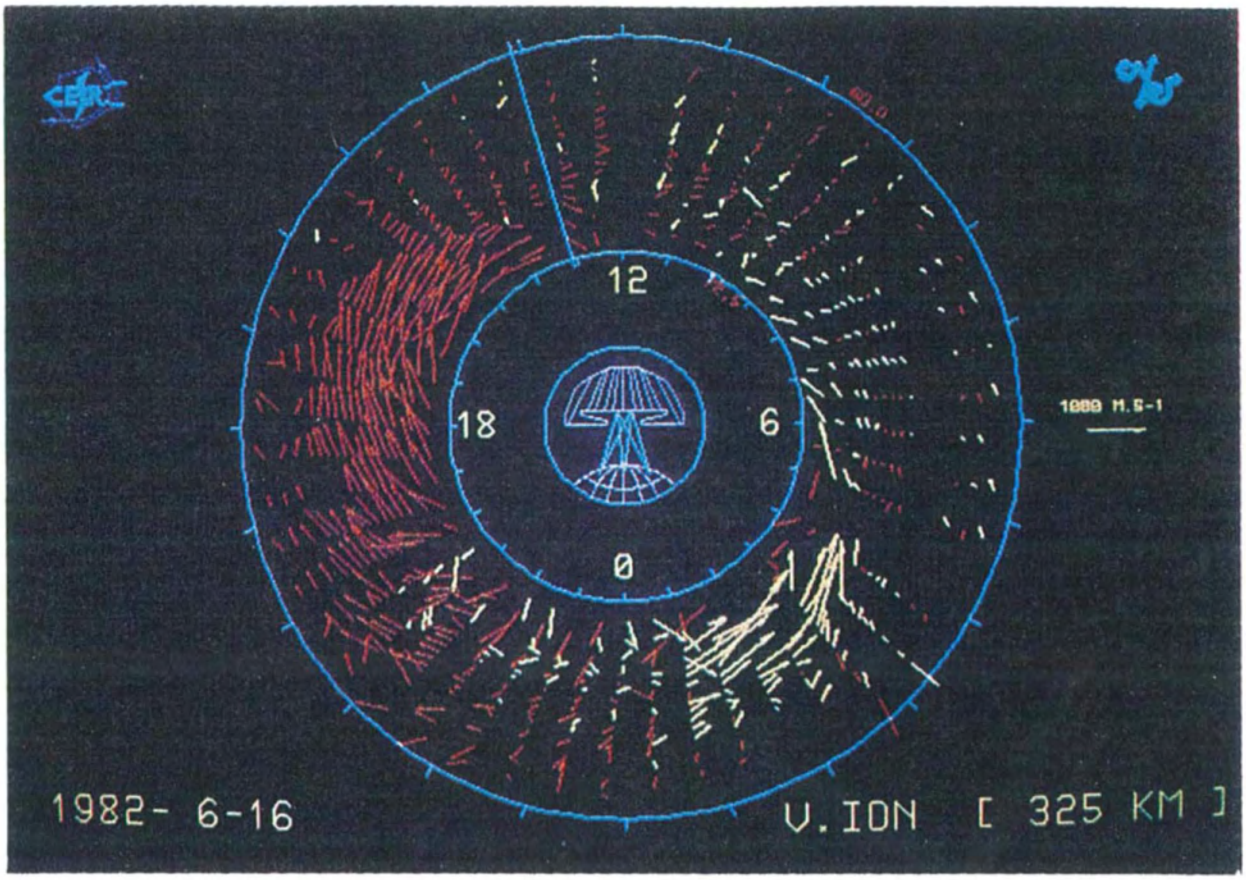


Fig. 1 Polar diagram of ion velocity in magnetic time/invariant latitude coordinates. Inner and outer circles correspond to 72.5° and 60° invariant latitude.

Many aspects of convection were studied, including:

— Its role in determining F-region morphology
— The effects of substorms in the dusk to midnight sector
— The influence of the interplanetary magnetic field
— Its relationship to the solar wind
— Its relationship to ground magnetic signatures
— Coupling with the neutral atmosphere
— Its role in creating ion temperature enhancements (Joule heating)
— Global convection patterns using data from several incoherent scatter radars
— Extension of measurements to very high (polar cap) latitudes
— Its role in the formation and maintenance of the trough
— Its role in creating non-Maxwellian ion populations.

The role of plasma convection in determining the morphology of the high-latitude F-region during winter was studied using supporting information on E-region currents from a cross of magnetometers, and on auroral particle precipitation from a chain of riometers and an all-sky camera. Data from the ISEE-3 satellite provided information on the interplanetary magnetic field (IMF) and the solar wind. It was found that if rapid westward flows and an equipotential polar cap boundary in the afternoon sector are extended towards noon, then the mid-latitude trough can extend into the sunlit hemisphere at dusk. In this case a steep termination to the trough is observed where depleted plasma in the dusk cell meets plasma convecting slowly eastward in the dawn cell. It was also found that a northward IMF allowed a trough to form and persist as it convected slowly towards dawn at a high, yet sub-auroral, latitude.

The effects of substorms were studied in the dusk and the near-midnight sector during southward and northward IMF orientations. The substorms caused enhanced convection speeds, a swing to equatorward flow, enhanced E-region densities and a depleted F-layer. The westward-travelling surge expansion of a substorm in the pre-midnight sector caused a swing to purely southward convection coincident with the surge front. F-region densities were high when plasma that had emerged from the cap, spent sufficient time in passing through the auroral oval to respond to soft-particle precipitation.

The effect of a prolonged period of strongly northward IMF was studied using EISCAT common program data. Both field-aligned and field-perpendicular plasma flows showed effects of the northward IMF: convection was slow and irregular and field-aligned flow profiles were characteristic of a steady-state polar wind outflow with a flux of order 10^{12} m^{-2} s^{-1}, leading to the possibility of O^+ escape into the magnetosphere. The apparent influence of the IMF over both field-perpendicular and field-aligned flows can be explained in terms of the cross-cap potential difference and the location of the auroral oval.

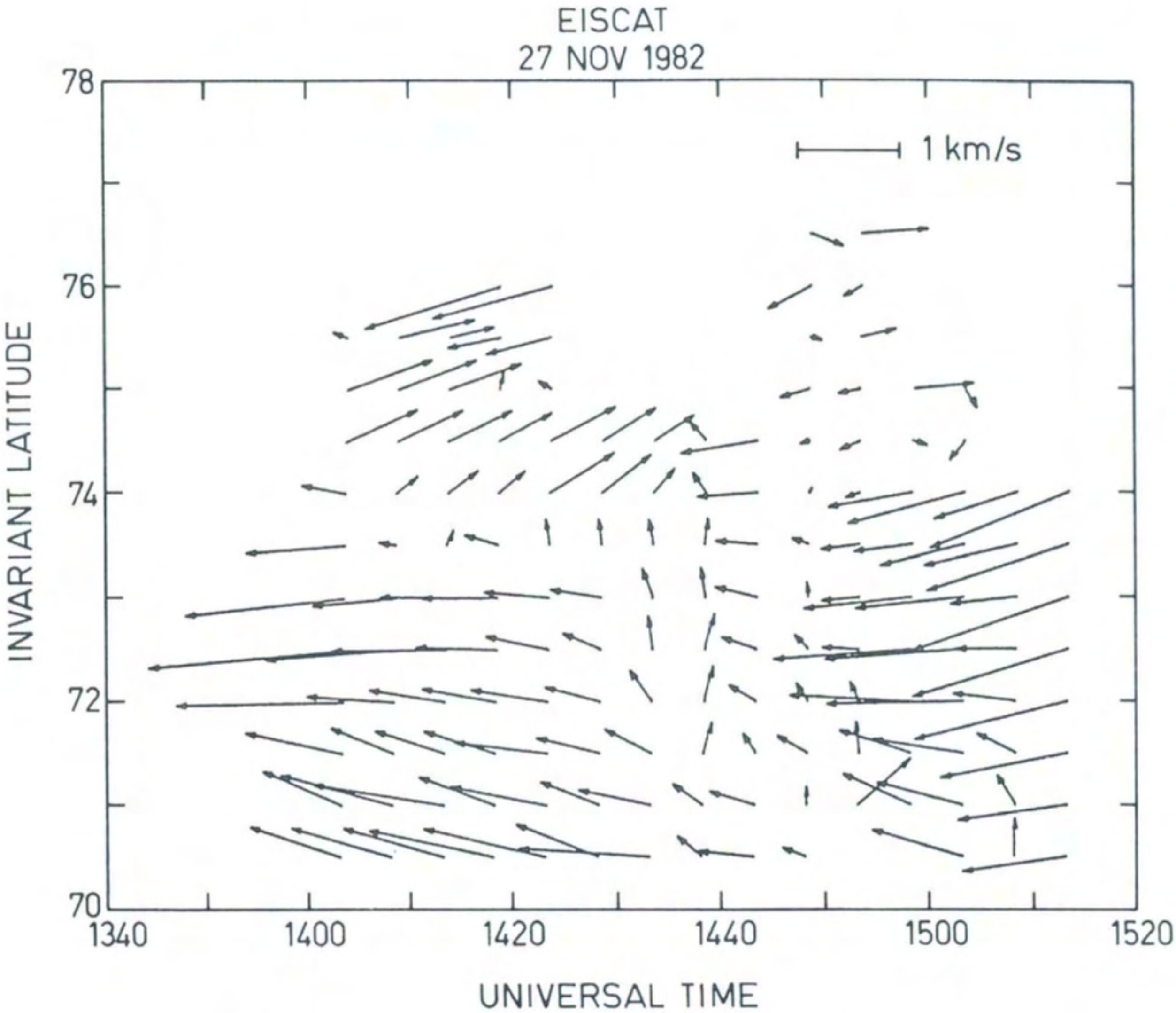


Fig. 2 Horizontal plasma velocity vectors measured as a function of invariant latitude between 70°N and 77°N.

The capability of the EISCAT radar system for observing plasma convection patterns at very high latitudes was explored in several experiments. Using a beam swinging technique, plasma velocity was measured at slant ranges out to more than 1000 km, enabling velocity vectors to be derived for invariant latitudes up to 77°. An example of convection measurements at these very high latitudes can be seen in Figure 2. Typical afternoon westward flows of about 1000 m s^{-1} were recorded and important temporal and spatial variations were seen as a result of the good time and space resolutions of 5 minutes and 75 km, respectively. An interruption of the westward flow by a 10 minute surge of poleward flow (see Fig. 2) was interpreted as related to dynamic coupling occurring at the dayside magnetopause, such as by a flux transfer event.

The F-region nighttime ionization over the Chatanika, EISCAT and Millstone Hill radars was compared. In the midnight sector the F-region densities were largest over EISCAT and were lowest over Millstone Hill. This systematic behaviour was interpreted as being a consequence of the displacement between the earth's geographic and magnetic poles. The production of F-region ionization is related to the geographic latitude while its transport is related to magnetic latitude. The F-region ionization observed at midnight often originates in daylight regions and is transported across the polar cap by convection. At EISCAT, the ionization observed at midnight would travel a shorter path after its production and thus decay less than would the ionization observed at Millstone Hill.

Ionosphere - Thermosphere Coupling

The ionosphere and (neutral) thermosphere are coupled in their motions, thermal balance, and chemistry. Ion and neutral particles interact through collisions between the species. These collisions also result in heating of the two gases (Joule heating) and, under certain conditions, in altering the particle energy distribution functions from their normal Maxwellian shapes. Thermal energy is exchanged amongst the ions, electrons, and neutrals. Studies of ionospheric - thermospheric coupling are very important to the understanding and modelling of global thermospheric phenomena.

As discussed earlier, EISCAT can easily monitor the motions of the ionized gas. It is also well-established that F-region neutral winds in the meridional direction can be inferred from incoherent scatter data. Recent developments indicate that it may also be possible to infer the zonal neutral wind with an incoherent scatter radar. However, the standard well-proven instrument used for monitoring neutral winds is the Fabry-Perot interferometer (FPI). Observations of thermospheric winds were made at Kiruna with a ground-based FPI and compared to simultaneous EISCAT radar observations. A comparison of the neutral wind derived from the two techniques is shown in Fig. 3. Note the excellent agreement in the north - south wind and

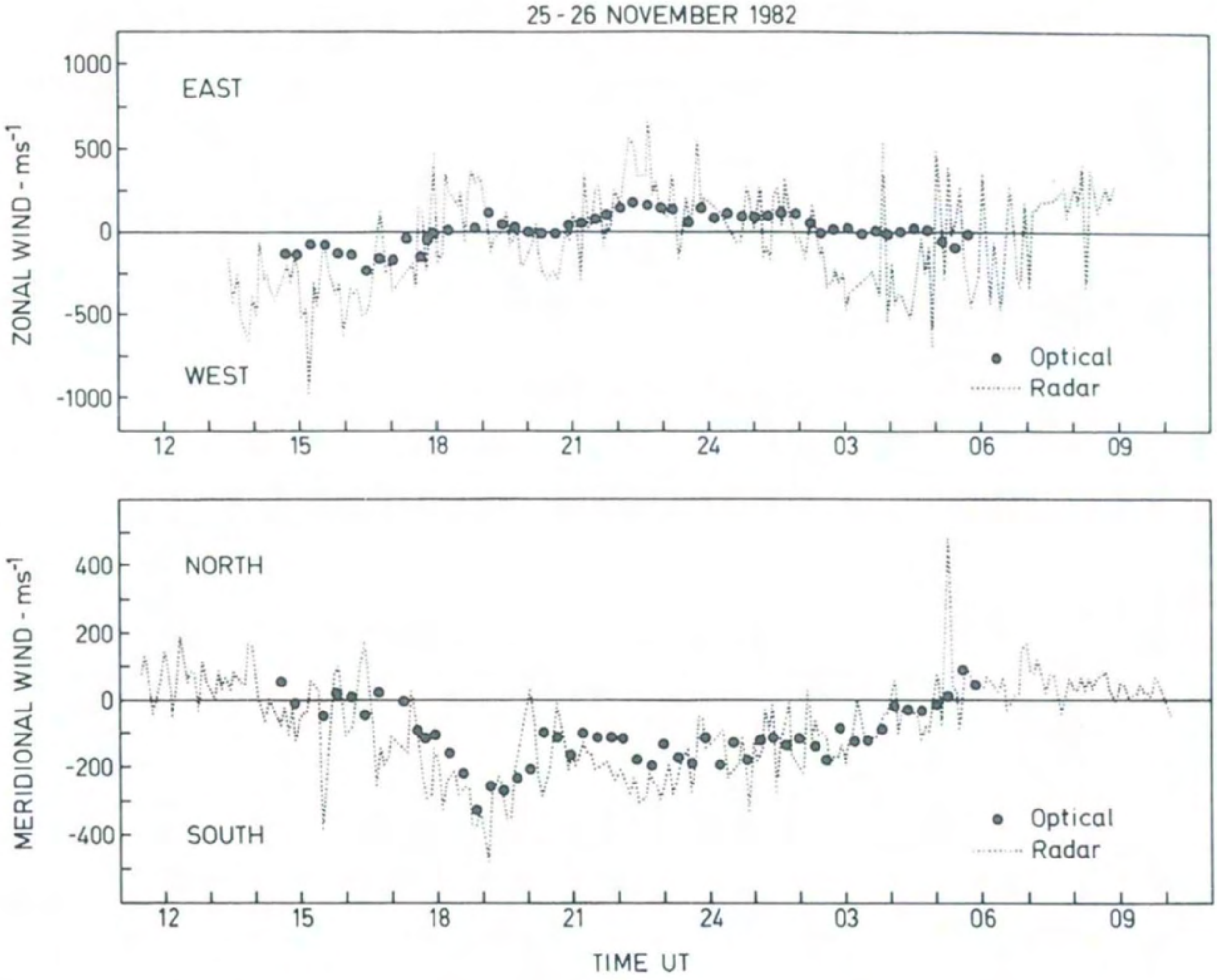


Fig. 3 Meridional and zonal thermospheric neutral wind as measured by EISCAT (lines) and the optical Fabry-Perot interferometer (dots) at Kiruna.

the qualitative agreement in the east - west (zonal) wind through most of the measurement period.

Furthermore, the EISCAT ion velocity observations during this period showed clearly the ebbing and flowing of regions of strong convective flow associated with the auroral oval. As individual geomagnetic disturbances occurred, the overall ion flow pattern intensified and moved equatorward. The zonal thermospheric wind responded rapidly to surges of the local ionospheric convection, while the meridional wind responded more slowly, apparently to much larger-scale phenomena of the high latitude thermosphere. Periods of strong heating of the ionospheric ions and of the thermospheric gas could be identified. These were compared with Joule and particle heating rates deduced from the observations of ionospheric drifts, neutral winds, electron densities and auroral emission rates. A three-dimensional, time-dependent global thermospheric model was used to distinguish between local and global features of the thermospheric wind field.

Simultaneous observations were also made of the ion velocity measured by EISCAT looking north - west at low elevation, and the ion velocity measured from Spitzbergen using Fabry-Perot interferometers. For the first series of observations two objectives were established, namely to compare ion velocity components measured by the two instruments, and to study ion-neutral coupling. In pursuing the first objective the geometry of the two systems allowed only two of the three components of ion velocity to be measured. Combining the two sets of observations resulted in the surprising conclusion that there was a downward field-aligned component of O^+ velocity in addition to a northward field-perpendicular drift. In pursuing the second objective, these early investigations compared the temperatures of the ion and neutral populations during a quiet evening period followed by a period of moderate activity. During the quiet period, the ion temperature was stable and close to the neutral temperature. As the active period developed, the ion velocity changed rapidly and the ion temperature rose until it exceeded the neutral temperature by over 300 K.

Joule heating resulting from differential ion and neutral velocities was studied using Common Programme 3 observations performed during a period of relatively quiet magnetic activity. Two enhancements of the convection, in the afternoon and in the early morning hours, with ion velocities reaching 1000 m s^{-1} were observed. (Fig. 1). The second enhancement was accompanied by a significant localized increase in the ion temperature at 325 km, while no temperature increase was evident during the first enhancement. Such behaviour was previously observed at Chatanika for equinox conditions, and was explained as a consequence of variations in the ion-neutral coupling resulting from large differences in the electron densities during the afternoon and early morning periods. However, the same explanation cannot fully account for the effect observed with EISCAT

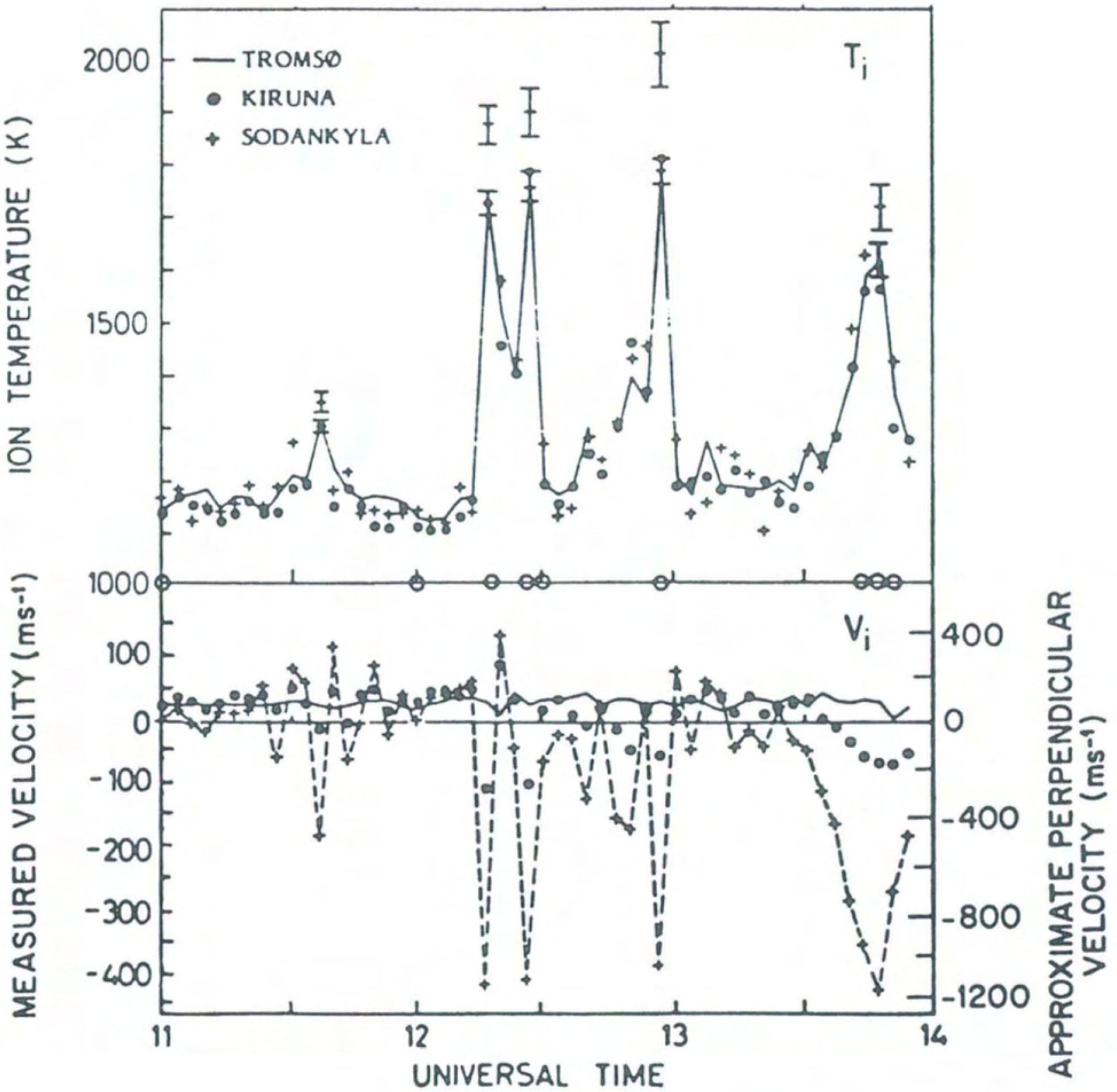


Fig. 4 Ion temperatures and ion velocities as measured at the three EISCAT sites. Note the temperature enhancements coincident with the velocity spikes. During these events the temperature measured at Sodankylä is higher than those measured at the other stations.

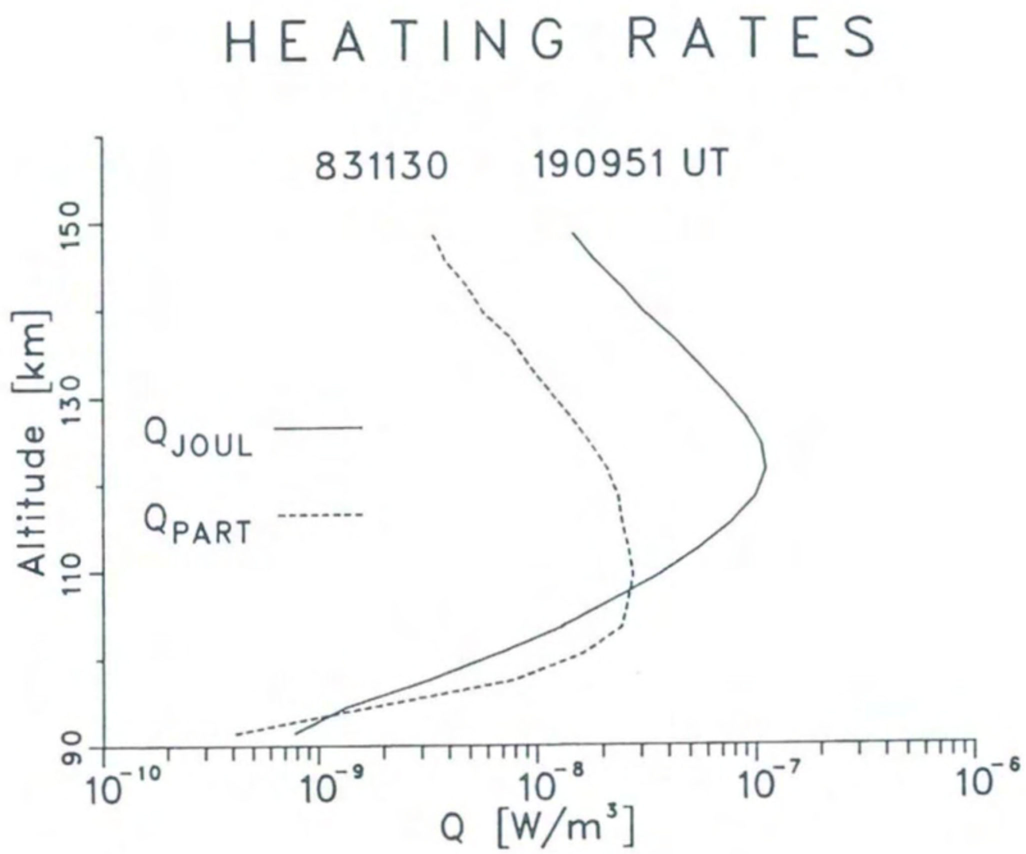
in summer since, due to continuous solar illumination, the diurnal variation in electron concentration is much smaller. It appears, in fact, that the Coriolis forces associated with the global equatorward motion of the thermosphere are largely responsible for the relative motions between the ionosphere and the thermosphere in the early morning hours.

A substantial increase on the ion temperature is often observed at high latitudes as a consequence of strong convection electric fields. With EISCAT, it was possible to measure the three independent components of the ion velocity vector and the temperature in the same scattering volume. During periods of strong variations in the ion velocity (consequently of the electric field) the ion temperatures derived at the three sites were different. This difference, which appears to be systematic, has been interpreted in terms of different ion temperature perpendicular and parallel to the magnetic field (Fig. 4). The Sodankylä temperature measurement is sensitive to the perpendicular temperature while the Tromsö and Kiruna measurements are sensitive almost entirely to the parallel temperature. The temperature anisotropy is a consequence of a non-Maxwellian ion distribution function caused by intense electric fields.

D- and E-Region Phenomena

The altitude region from 70 to 200 km is an important one to study. It is in this region that energetic particles deposit their energy, creating the visual aurora. It is in this region that the electrojet currents flow and Joule heating rates are highest. In the lower part of this region, radio wave absorption occurs and, because of the close coupling between the ions and neutral atmosphere, EISCAT measurements can be used to probe the (neutral) mesosphere. Instabilities resulting in coherent radar aurora echoes, such as those monitored by STARE and SABRE, also occur in this altitude region at around 110 km.

Simultaneous electron differential energy spectra were obtained during coordinated measurements between the EISCAT incoherent scatter radar and the Aureol-3 satellite. Although the satellite and radar observations were separated by a few degrees in latitude, the radar-derived and satellite-measured electron precipitation fluxes and energy distribution functions were in excellent agreement in the 1—10 keV energy range.



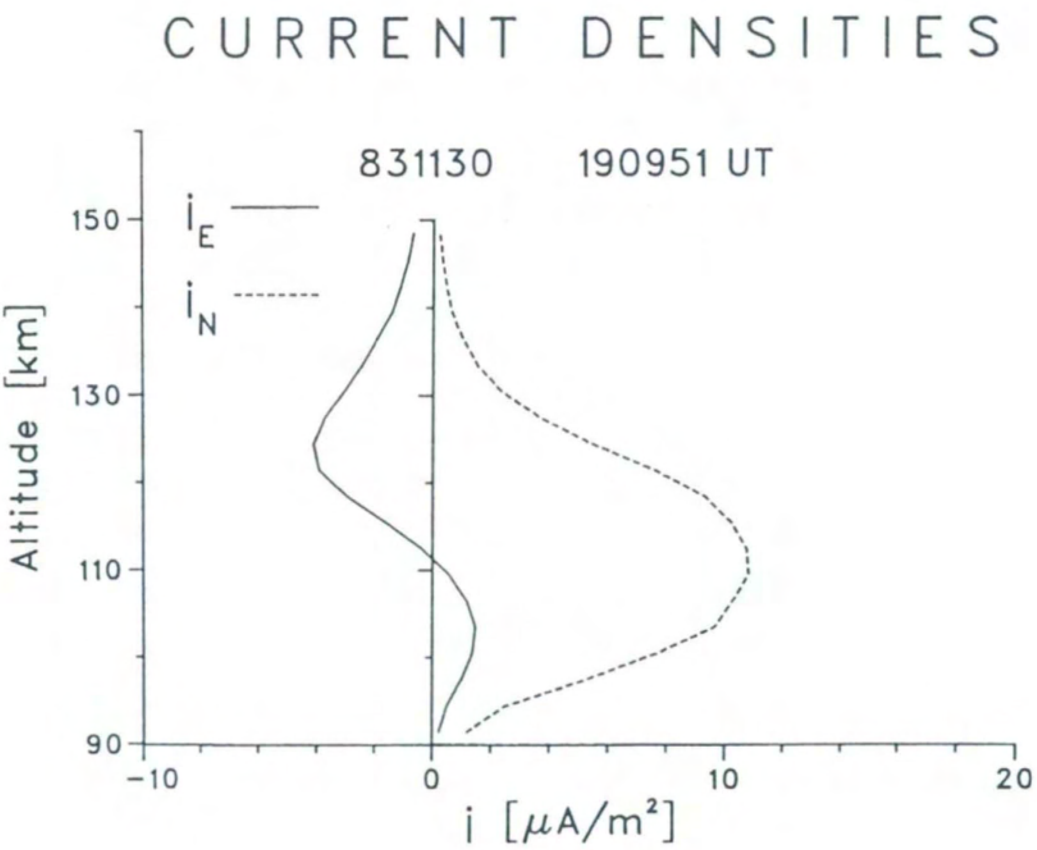


Fig. 5 Northward (i_N) and eastward (i_E) current densities and Joule and particle heating rates (Q) as function of altitude with 3 km resolution.

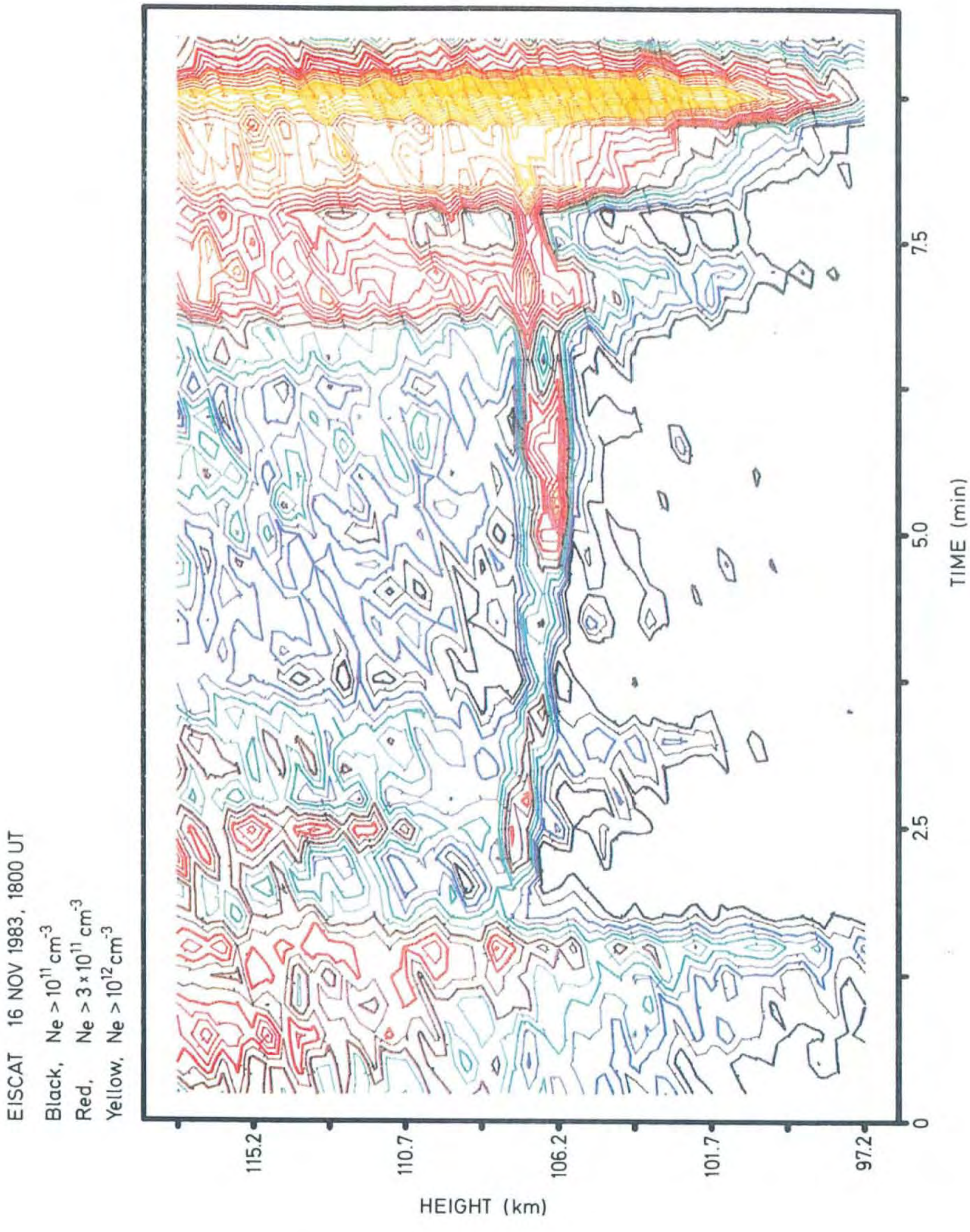


Fig. 6 Contour plot of the electron density measured with an altitude resolution of 450 m and a time resolution of 15 s during particle precipitation and sporadic-E layer events.

Using multipulse measurements with a height resolution of 3 km, the current densities and the particle and Joule heating rates were calculated from the basic ionospheric parameters N_e, T_e, T_i and V_i (Fig. 5). Such good E-region altitude resolution had never been obtained previously with any radar. These results will be used in comparison with STARE results to establish a relation between the STARE backscatter amplitude and the E-region currents.

Another experiment used Barker-coded pulses to obtain 450 m height resolution of the electron density in the D- and E-regions. A very thin, approximately 1 km, sporadic-E layer was detected (Fig. 6). The normal, particle-produced, thick auroral E-layer can be seen before and after the sporadic-E. These observations indicate that the sporadic-E layer formed at an altitude where convergence of the vertical ion velocity occurred, and that the layer consisted of heavy metallic ions rather than the usual NO^+ or $O_2{}^+$ ions, consistent with theory.

Mesosphere observations with EISCAT were continued during the international Middle Atmosphere Program campaign "Winter in Northern Europe" (MAP/WINE). The operations proved that during conditions of high energy particle precipitation, reliable electron density and wind profiles in the mesosphere down to 80 km can be measured.

Miscellaneous

F-region electron density depletions were observed which are probably caused by an enhancement of the NO^+ ion population and subsequent dissociative recombination. The NO^+ ions increase relative to O^+ ions because the strong electric fields speed up the reaction $O^+ + N_2 \rightarrow NO^+ + N$. Both the electron and the ion temperature within the density depletion were strongly enhanced.

Simultaneous observations by EISCAT and an HF Doppler system gave both the vertical and horizontal components of an atmospheric gravity wave. By applying cross-spectral analysis to the data, it proved possible to derive the vertical variation of the neutral wind and the Brunt-Väisälä period, which in turn gave the vertical profile of the neutral temperature.

Observations of large temporal variations in the ionospheric F-region temperature were compared with simultaneous observation of the E- and F-region plasma densities. The observations suggest that the F-region may be heated by current driven instabilities generated during intense precipitation of auroral electrons.

Plasma physics experiments with the Heating facility were made to further investigate the time development of artificially induced plasma waves. It was found that within 10 ms after the beginning of heating, the ion spectrum signal strength increased by about an order of magnitude. At the same time the plasma lines showed strong excitation with a rather broad spectrum. The reasons for these unexpected results are not yet known.

Passive experiments were also performed. The Kiruna and Sodankylä antennas were used to record signals from a number of quasi-stellar radio sources. By measuring the interplanetary scintillation, it was possible to derive the mean velocity of the solar wind and to estimate the dispersion of velocity both parallel and perpendicular to the ecliptic plane. Also, very-long-baseline-interferometer (VLBI) observations of the red-shifted 21 cm line of extragalactic radio sources were carried out at the Kiruna site.

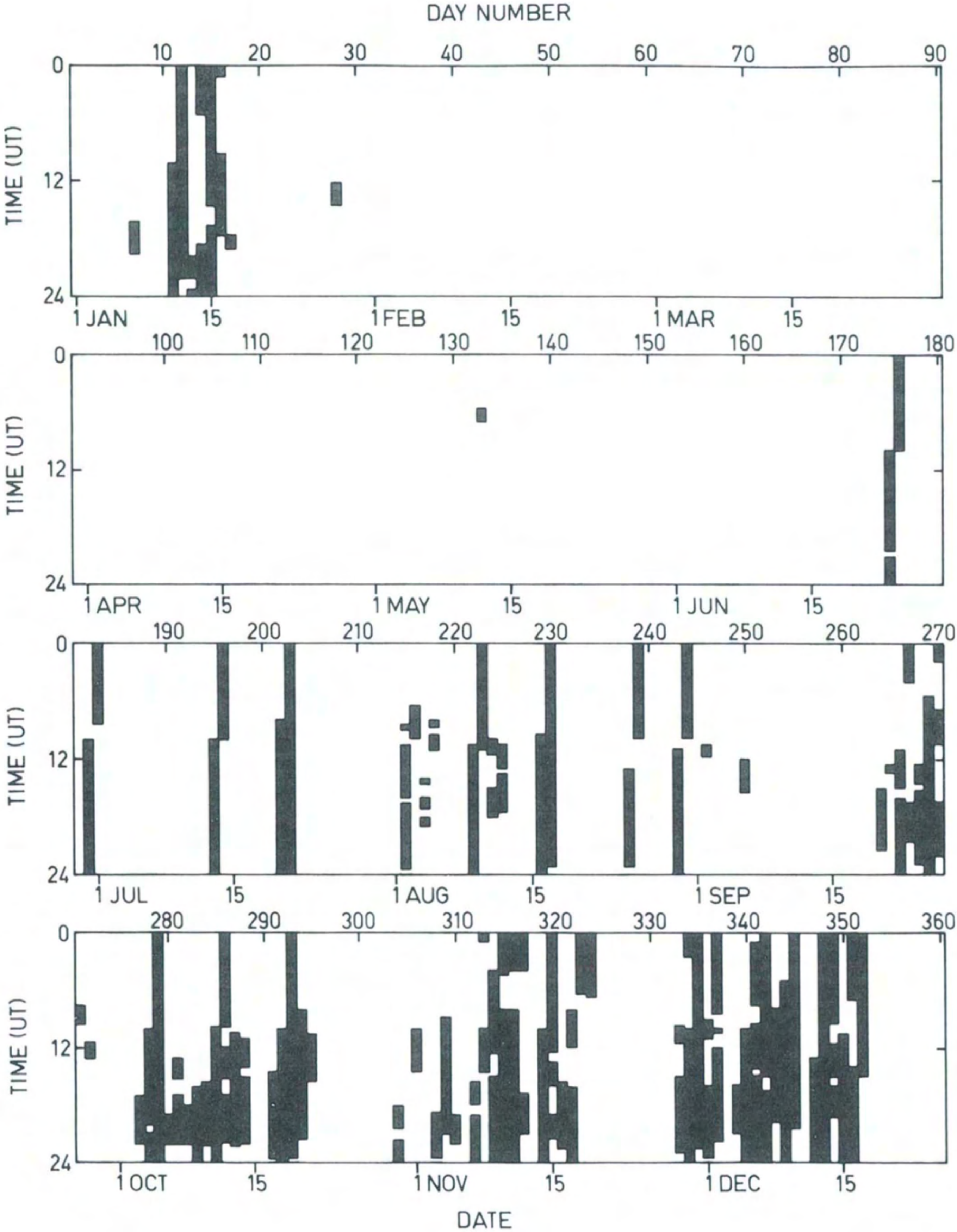


Fig. 7 EISCAT operating periods in 1983. For each day of the year (abscissa), the dark bars indicate the times (ordinate) during which data was recorded.

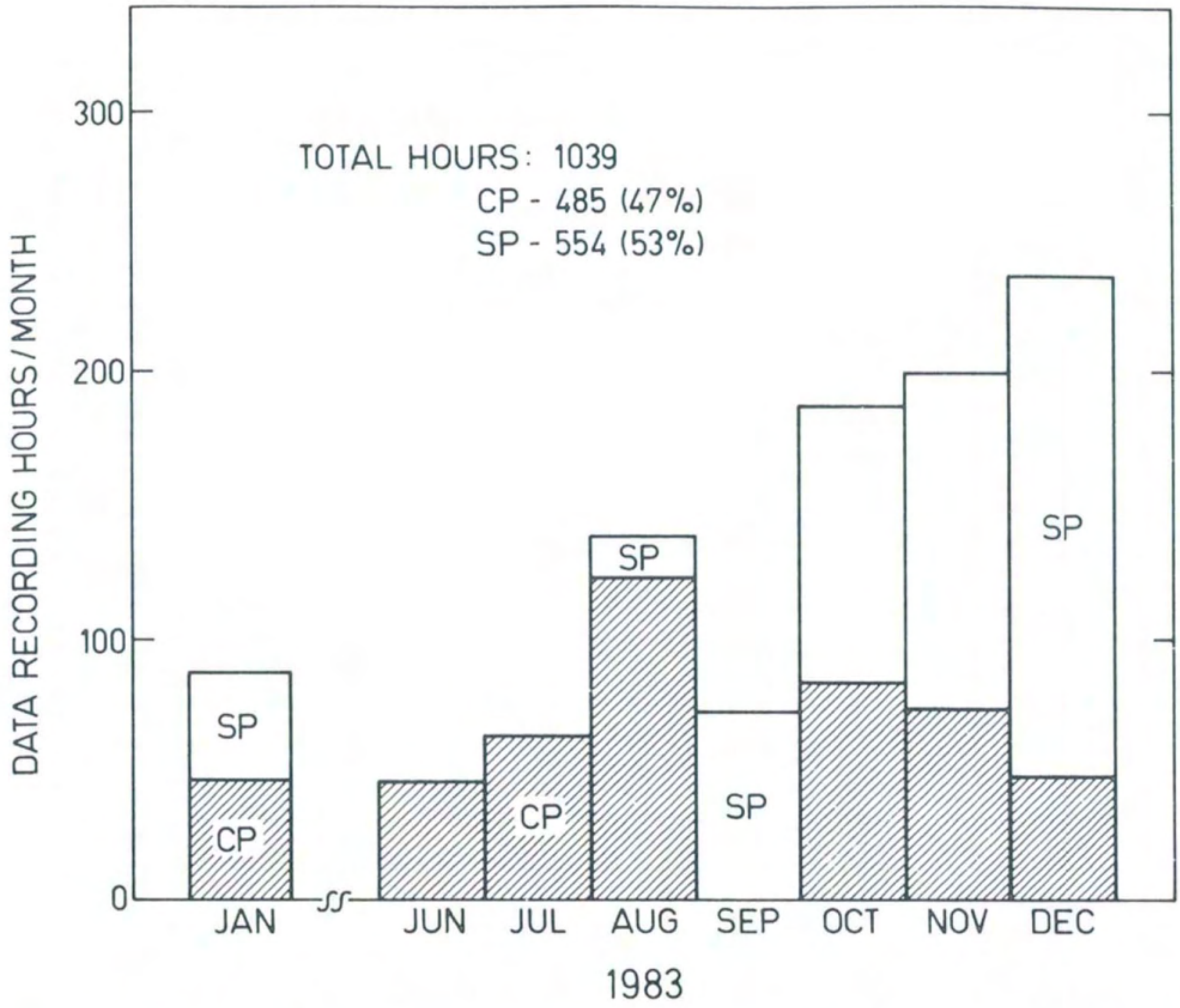


Fig. 8 EISCAT data recordings by month, with common programme (CP) and special programme (SP) operations shown separately.

OPERATIONS

For the last three months of 1983, EISCAT operations reached the originally intended level of about 200 hours per month. Figure 7 shows the distribution of operations throughout the year. The period from February to late June was one in which extensive repairs to the UHF transmitter were carried out. Through the summer months, only common programmes were run to test the system. Special programme campaigns began in September and continued for the rest of the year. The one week gaps in operation that occur approximately monthly are the periods set aside for system maintenance.

Figure 8 summarizes the operating hours by month and shows the division of time between common programmes (data available to all associates) and special programmes (data available only to the associate(s) responsible for the experiment). The total hours in 1983 were 24 % higher than the total in 1982. Slightly more time was allocated for special programme than for common programme experiments to compensate for the long period prior to September when special programme operations were quite limited.

The distribution of accounted special programme time among the six associates in 1983 is shown in Figure 9. The percentages are shown for 1983 alone, as well as cumulatively for 1982 and 1983. Although some deviations from the goal of 25, 25, 25, 10, 10, 5 percent are evident, this goal was intended as a long term average. Time allocations during 1984 will take the cumulative figures into account in an attempt to approach the desired ratios.

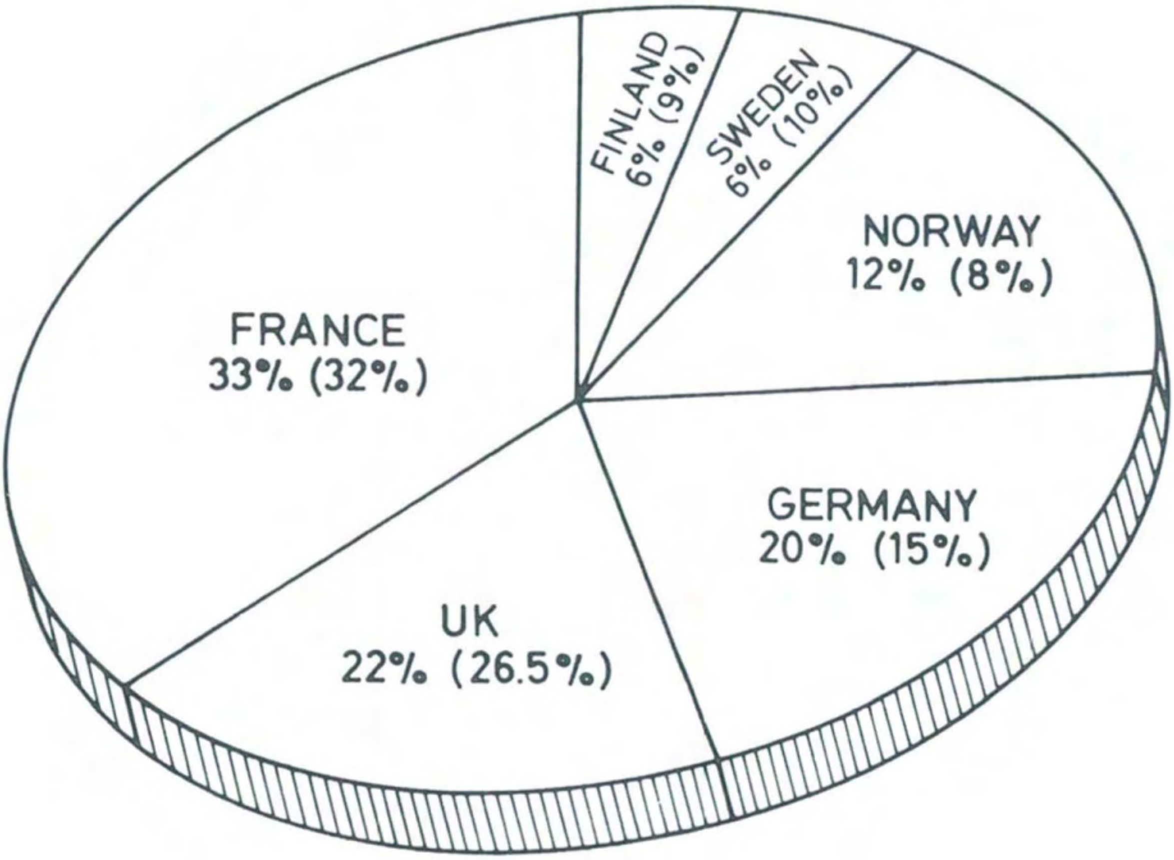


Fig. 9 Distribution of accounted operating time amongst the EISCAT associates in 1983, and cumulative for 1982 and 1983 (shown in parenthesis).

TECHNICAL REVIEW

UHF Facility

This was the year in which EISCAT UHF facility became fully operational. By the last three months of 1983, peak transmitted power levels of 1.0—1.5 MW were regularly achieved with good reliability.

In order to achieve the fully operational status, it was necessary to cease operations for almost a five month period early in 1983 to correct a number of serious system deficiencies. Some of the corrective actions will be reviewed here to give the reader an idea of the seriousness of the problems and the developed competence of the staff in overcoming them. Our fault-finding efforts disclosed that most of the transmitter crowbars (unplanned trip-offs) were occurring in the interval between transmitted pulses. This led Mr. Tallmadge of SRI-International to suggest a modification to the modulator. The proposed modification was built and installed, resulting in greatly increased operational reliability.

For the first part of 1983, pollution of the transmitter coolant was a growing concern, rapidly clogging the filters and threatening to clog the cooling channels in the klystron collector potentially leading to premature klystron failure. The principal pollutant was found to be rust in the glycol (anti-freeze) additive which developed while the glycol was in steel barrels during storage and transport to the site. A secondary source of pollutant was the deterioration of rubber hoses connecting the cooling manifold to the transmitter units. An extra, continuously pumped, purification loop was installed to remove the pollutants and the rubber hoses were all replaced by copper pipes. A dramatic improvement in coolant purity resulted from these actions.

Substantial leaks in the cooling system pump have been a permanent worry ever since the pump was installed in 1981. Finally in the spring of 1983, the pump lost most of its pumping capacity. A new pump was produced and installed in June. Thereafter there were no problems with coolant circulation or leakage.

Of the more serious transmitter incidents experienced for the first time in 1983 were: failures (twice) in the high voltage rectifiers, a broken shaft in the motor driven high-voltage variable transformer, and a damaged crowbar-trigger transformer. The staff, assisted on occasion by visiting engineers, was able to repair these damages within a few days without seriously affecting operations.

For some time, it had been noted that transmitter crowbars frequently destroyed the GaAsFET preamplifiers at Tromsö. This destruction was found to be caused by the crowbar transients disturbing the logic in the transmitter exciter and allowing RF energy to be fed into the klystron before the klystron beam current had decayed. The RF was amplified in the klystron and fed into the waveguide and thus to the receiver during the interpulse period when the receiver protector is not activated. The preamplifier destruction was eliminated by installing an appropriately controlled PIN-diode switch between the exciter and klystron input port.

Apart from the transmitter, the correlators continued to be a significant source of trouble. On several occasions, malfunctions were found to be due to faulty wire-wrap connections resulting in intermittently loose wires, shorted wires, or mechanical stresses due to use of underlength wires. On other occasions, oxidation within the (poor quality) IC sockets resulted in intermittent operation. Also, insufficient provision for cooling led to component failures. The staff at all sites became much more proficient at finding and fixing these faults. Reinforcement of the air-blowing systems led to improved reliability.

In January, a fire originating in the Kiruna site correlator destroyed that unit. The VHF correlator was shipped from Tromsö and used at Kiruna for the rest of the year. Meanwhile, a new crate was built, paying proper attention to cooling and power distribution. And two completely new sets of professionally built high-quality cards have been ordered and are under construction.

The rest of the system, receivers and computers, performed well in general. Minor faults were quickly repaired by the site staffs. New post-detection filters are now in use at all sites providing increased stability and more optimized filter characteristics. A modification was made in the receiver chassis to significantly reduce the 50 Hz hum levels. Doppler sign calibrators were installed at all sites. The most serious remaining deficiency involves the 2nd local oscillators. Those originally supplied with the system have insufficient phase noise characteristics to be used in many applications, and must be replaced.

By the last quarter of 1983, all of the more serious problems had been cured and the system operated quite well. Attention then turned to evolutionary improvements to make the system perform even more reliably and flexibly in the future.

Work is in progress on:

— expanding the memories in the ND-10 site computers

— expanding the result memory in the correlators

— developing a lower noise GaAsFET preamplifier for Tromsö

— developing cooled GaAsFETs for use as remote site spares

— studying possible second generation correlator designs

— testing of the fast (10 MHz) ADCs

— reducing the effects of crowbars on the other equipment at Tromsö

— improving the experiment monitoring possibilities

— developing a new EROS-2 operating system to provide faster, more flexible experiment control.

It is expected that most of these improvements will be completed in 1984.

VHF Transmitter

Progress in completing the VHF transmitter at the contractor's plant has been discouragingly slow. Two out of the three VHF klystrons originally supplied have completely failed. These tube failures together with continuing problems with the transmitter itself resulted in a long and difficult period of contractual negotiations with the vendor.

Because of the experienced unreliability of the original VHF klystron and the high cost quoted by the original vendor for replacement klystrons, a search was initiated to find an alternate supplier for the klystrons. The search was successful. After studying the technical and financial aspects of the alternate supplier's proposal and comparing them with those of the original tube vendor, the decision was made to procure two new VHF klystrons from Valvo in Hamburg, Germany. The first of the new tubes is scheduled for delivery to Tromsö in December 1984, with the second to follow within three months.

The decision to procure future VHF tubes from Valvo influenced the negotiations with the transmitter vendor. Agreement was reached, and formalized in a contract amendment, to the effect that the extra costs incurred due to the failure of the two original klystrons would be almost equally divided between the two parties. Such extra costs include both the cost of the new tubes and the costs incurred by the vendor during extended attempts to repair the original tubes.

The current time schedule for the completion of the VHF transmitter is as follows:

January - February 1984	testing of the transmitter with the one remaining original tube
March	packing of system
April - May	shipment to Norway
June - July	physical installation
August - September	electrical testing with one tube
December	delivery of new Valvo tube
1st quarter, 1985	final testing of complete transmitter.

PUBLICATIONS

A good indicator of the productivity of a facility is the list of publications and presentations resulting from work done at the facility. Following are lists of the 1983 publications and oral presentations describing EISCAT-related work.

Journal Publications

Alcaydé, D., J. Fontanari, P. Bauer, O. de la Beaujardière:
Some properties of the auroral thermosphere inferred from initial EISCAT observations.
Radio Sci., Vol. 18, No. 6, pp. 881—886, 1983.

EISCAT Scientific Association:
EISCAT - the European incoherent scatter facility at auroral latitudes.
Eos, Vol. 64, No. 1, Jan. 4, 1983.

Folkestad, K., T. Hagfors, S. Westerlund:
EISCAT: An updated description of technical characteristics and operational capabilities.
Radio Sci., Vol. 18, pp. 867—879, 1983.

Greenwald, R.A., R.D. Hunsucker:
Current and future programs for high-latitude radio wave research.
Radio Sci., Vol. 18, pp. 1189—1194, 1983.

Hagfors, T.:
The EISCAT Facility,
High - Latitude Space Plasma Physics. Edited by Bengt Hultqvist and Tor Hagfors, Plenum Publ. Corp., 1983.

Hagfors, T., W. Kofman, H. Kopka, P. Stubbe, T. Äijänen:
Observations of enhanced plasma lines by EISCAT during heating experiments.
Radio Sci., Vol. 18, pp. 861—866, 1983.

Lathuillere, C., G. Lejeune, W. Kofman:
Direct measurements of ion composition with EISCAT in the high-latitude F_1-region.
Radio Sci., Vol. 18, pp. 887—893, 1983.

Murdin, J.:
Measurement of autocorrelation functions in a bi-static incoherent scatter radar.
J. Atmos. Terr. Phys., Vol. 45, pp. 67—72, 1983.

Nielsen, E., K. Schlegel:
A first comparison of STARE and EISCAT electron drift velocity measurements.
J. Geophys. Res., Vol. 88, pp. 5745—5750, 1983.

Stenflo, L.:
Stimulated scattering by collisional modes in the ionosphere.
Radio Sci., Vol. 18, pp. 1379—1382, 1983.

Proceedings and Reports

Baron, M.J., K. Folkestad:
EISCAT - the facility, the technique, and representative early results.
Third International Conference on Antennas and Propagation,
ICAP 83, Conf. Publ. Number 219, Part 2, pp. 169—175, 1983.

Baron, M., J. Röttger:
The potential use of the EISCAT and Sondrestromfjord radars in support of rocket and balloon measurements.
Proceedings Sixth ESA Symposium on European Rocket and Balloon Programmes and Related Research, ESA Sp-183, European Space Agency, ESTEC, Nordwijk, Netherlands, pp. 299—306, 1983.

Hultqvist, B.:
Growing electrostatic electron waves in the ionosphere related to the EISCAT VHF radar.
Preprint No. 061, Kiruna Geophysical Institute, 1983.

Kildal, P.- S.:
Characteristics of parabolic cylinder antennas.
Third International Conference on Antennas and Propagation, ICAP 83, Conf. Publ. Number 219, Part 1, pp. 313—321, 1983.

Latombe, C., F. Glangeaud, C. Lathuillere:
Traitement matriciel de signaux à n composantes et étude par couples.
Neuvième colloque sur le traitement du signal et ses applications; Nice, 16—20 Mai, 1983.

Röttger, J.:
Some capabilities of the EISCAT UHF radar for investigations of the stratosphere.
Preprint Vol. 21st Conference on Radar Meteorology, 1983, Am. Met. Soc., Boston, USA.

Röttger, J.:
EISCAT - Das europäische Incoherent-Scatter-Radar zur Erforschung der polaren Atmosphäre.
Mitt. Astron. Gesellschaft, Vol. 58, pp. 67—79, 1983.

Röttger, J.:
Middle atmosphere observations with EISCAT.
University of Bonn Report: Bonn-EP-83-1 (Campaign Handbook on The Project Winter in Northern Europe of the Middle Atmosphere Program (MAP/WINE), prep. by U. von Zahn, University of Bonn, May, 1983), pp. 43—46.

Röttger, J.:
The use of the EISCAT radar facility for middle atmosphere research.
Proceedings Sixth ESA Symposium on European Rocket and Balloon Programmes and Related Research, European Space Agency, ESTEC, Nordwijk, Netherlands, pp. 287—294, 1983.

Schlegel, K.:
Erste Ergebnisse mit EISCAT.
URSI, Kleinheubacher Berichte, Vol. 26, 1983.

Papers Presented at Meetings

Oral presentations that were also published as papers in meeting proceedings are not repeated here.

At Frühjahrstagung der Arbeitsgemeinschaft für Extraterrestrische Physik und der Astronomischen Gesellschaft. Konstanz, Germany, 22—25 March, 1983:

Kohl, H., K. Folkestad, T. Hansen, C. LaHoz, H. Kopka, G. Rose, P. Stubbe:
EISCAT-Beobachtungen von künstlich angeregten Plasma-Instabilitäten.

Kohl, H., K. Rinnert:
Vergleichende Messungen mit EISCAT und Dynamics-Explorer in der polaren Hochatmosphäre.

Luhr, H., N. Klöcker, S. Thurey:
Interpretation eines starken Pi2-events, registriert mit dem EISCAT-Magnetometerkreuz.

Nielsen, E., K. Schlegel:
Koordinierte Beobachtungen mit EISCAT und STARE.

Röttger, J.:
EISCAT - das Europäische Incoherent-Scatter-Radar zur Erforschung der polaren Atmosphäre. Plenary Paper.

Schlegel, K., G. Kremser:
Teilchenausfällungen in der polaren Ionosphäre beobachtet mit EISCAT und GEOS.

At the SCOSTEP/URSI/MAP Workshop on Technical Aspects of MST Radar, Univ. of Illinois, Urbana, Ill., USA, 23—27 May 1983:

Röttger, J.:
Techniques for measurement of horizontal and vertical velocities.

Röttger, J., M. Baron, K. Folkestad:
Capabilities and limitations of EISCAT as an MST radar.

At IAGA/IUGG, Hamburg, Germany, 15—27 August, 1983:

Alcaydé, D., J. Fontanari, C. Lathuillere:
Ion composition changes and thermospheric structure inferred from incoherent scatter observations at the EISCAT observatory.

Alcaydé, D., P. Bauer, O. de la Beaujardière, J. Fontanari, V. Wickwar:
High-latitude observations of thermospheric temperature and atomic oxygen concentration during MITHRAS operations.

Alcaydé, D., G. Caudal, M.L. Duboin, C. Mazaudier, C. Senior:
Determination of electrodynamical parameters from EISCAT incoherent scatter measurements.

Caudal, G., M. Blanc, C. Senior:
Large scale patterns of high-latitude plasma convection from the EISCAT incoherent scatter radar.

de la Beaujardière, O., V.B. Wickwar, D. Alcaydé, P. Bauer, W. Oliver, T. Killeen, G. Carignan, P. Hays:
Thermospheric parameters measured on 18 November 1981 using Chatanika, EISCAT, Millstone Hill, and DE-B.

Duboin, M.L.:
First results of heating rate determination from EISCAT measurements.

Fontaine, D., L. Barouch, G. Caudal, L. Girard:
Electrodynamic properties of auroral arcs as seen by EISCAT.

Fontaine, D., M. Blanc, L. Reinhard, R. Glowinski:
Modelling of the effects of electron precipitation on large-scale magnetospheric convection.

Hanuise, C.H., J.P. Villain:
Radar study of 5—10 m wavelength irregularities in the auroral electrojet.

Hanuise, C., G. Caudal, J.P. Villain:
High-latitude electric fields: A preliminary comparison between the Doppler motion of F-region small-scale irregularities and incoherent scatter measurements.

Häggström, I., J. Murdin, D. Rees:
Determination of the thermospheric neutral wind from incoherent scatter radar measurements.

Kofman, W., F. Bertin, A. Cremieu, J. Röttger, P.J.S. Williams:
The EISCAT mesospheric measurements during the CAMP campaign.

Kohl. H., H. Kopka, P. Stubbe:
Parametric instabilities induced in the ionosphere by strong RF-waves.

Lathuillere, C., W. Kofman, G. Lejeune:
Ion composition variation in the auroral ionosphere.

Oksman, J.:
Electric fields in the trough region.

Perraut, S., N. Bjørnå, A. Brekke, M. Baron:
Experimental evidence of non-Maxwellian ion distributions in the auroral ionosphere observed by EISCAT.

Röttger, J.:
EISCAT: A research tool to investigate the high-latitude middle atmosphere (review paper).

Stamnes, K., M.H. Rees, B.A. Emery, R.G. Roble:
Calculations of high-latitude ionospheric parameters and spectroscopic emissions susceptible to incoherent scatter radar probing and optical measurements.

Villain, J.P., C.H. Hanuise:
Radar study of 10 m wavelength irregularities in the auroral and polar ionospheric F-region.

At the EISCAT Workshop, Aussois, France, 5—9 September, 1983:

Over 40 EISCAT-related papers were presented. A selection of these papers will be published in a special issue of the Journal of Atmospheric and Terrestrial Physics in July 1984.

At the AGU Fall Meeting, San Francisco, USA, 5—9 December, 1983:

de la Beaujardière, O., G. Caudal, J. Holt:
MITHRAS observations of the nighttime F-region ionization.

Fontaine, D., C. Senior, O. de la Beaujardière:
MITHRAS comparison of convection and precipitation at EISCAT and Chatanika.

Hanuise, C., J.P. Villain:
Radar study of 10 m wavelength irregularities in the auroral and polar ionospheric F-region.

Kofman. W., V.B. Wickwar:
The electron energy budget and elevated electron temperatures in the high-latitude F-region.

Wickwar, V.B., O. de la Beaujardière, W. Kofman:
Meridional winds at Chatanika and EISCAT during project MITHRAS.

At other meetings:

Bauer, P.:
Overview of some of its recent scientific achievements by the EISCAT scientific community.
National Radio Science Meeting, 11—13 Jan., 1984, Boulder; presented by W. Kofman.

de la Beaujardière, O., V. Wickwar. D. Alcaydé, P. Bauer:
Measurements of the exospheric temperature at Chatanika and EISCAT on 18 November 1981.
AGU Spring Meeting, 30 May — 3 June, 1983.

Schlegel, K.:
Some first results from the European incoherent scatter facility EISCAT.
Meeting of the Kyoto-Radar Group, 28.6.83, Dept. of Electrical Engineering, Kyoto University, Japan.

Schlegel, K.:
The incoherent scatter method and some first results from EISCAT. Meeting of the EXOS-C satellite working group, 25.5.83, Institute for Space and Astronautical Sciences, Tokyo, Japan.

EISCAT Reports — 1983

T. Ho, T. Turunen, J. Silén, M. Lehtinen:
The Lag Profile Routine and the Universal Program for the EISCAT Digital Correlators.
EISCAT Technical Note 83/37.

K. Folkestad:
EISCATs VHF antenna and Receiving System.
EISCAT Technical Note 83/38.

T. Äijänen:
Spectrum Analyzer.
EISCAT Technical Note 83/39.

J. Röttger (Editor):
Proceedings EISCAT Annual Review Meeting, Sirkka, Finland, 28 Feb. — 4 March 1983.
EISCAT Meetings 83/8.

EISCAT MEETINGS

COUNCIL

21st meeting, Sodankylä, 12 and 13 May, 1983
22nd meeting, Leicester, 3 and 4 November, 1983

SCIENTIFIC ADVISORY COMMITTEE (SAC)

24th meeting, Tromsö, 16 and 17 March, 1983
25th meeting, Aussois, 9 September, 1983

ADMINISTRATIVE AND FINANCE COMMITTEE (AFC)

20th meeting, Kiruna, 24 March, 1983
21st meeting, Hamburg, 20 September, 1983

EISCAT Annual Review Meeting

8th meeting, Sirkka, 28 February — 4 March, 1983

EISCAT Programmers Meeting

Kiruna, 21—24 November, 1983

BALANCE SHEET

MSEK

Assets

	At Dec. 31, 1982	Additions[2] Pool	Additions[2] Cap.Op	Depre-ciation	At Dec. 31, 1983
FIXED ASSETS					
Buildings	8.5			0.2	8.3
Transmitters[1]	25.2	0.8		—	26.1
UHF-antenna	21.3			1.3	20.0
VHF-antenna	25.9			1.5	24.4
Receivers	4.6			0.8	3.8
Computers etc.	5.5		0.2	1.4	4.2
Other	1.4		0.6	0.4	1.5
Total	92.4	0.8	0.8	5.6	88.2
CURRENT ASSETS					
Debtors	0.4				1.4
Prepayments and accrued income	0.3				0.2
Cash and Ordinary Bank Accounts	9.6				11.2
Special Accounts	—				0.2
Total Current Assets	10.3				13.0
GRAND TOTAL	102.7				101.2

Totals may not match because of rounding.

NOTES ON THE BALANCE SHEET:

1) Remaining commitments: MSEK 4.3.

2) In Kind contributions have been completed.

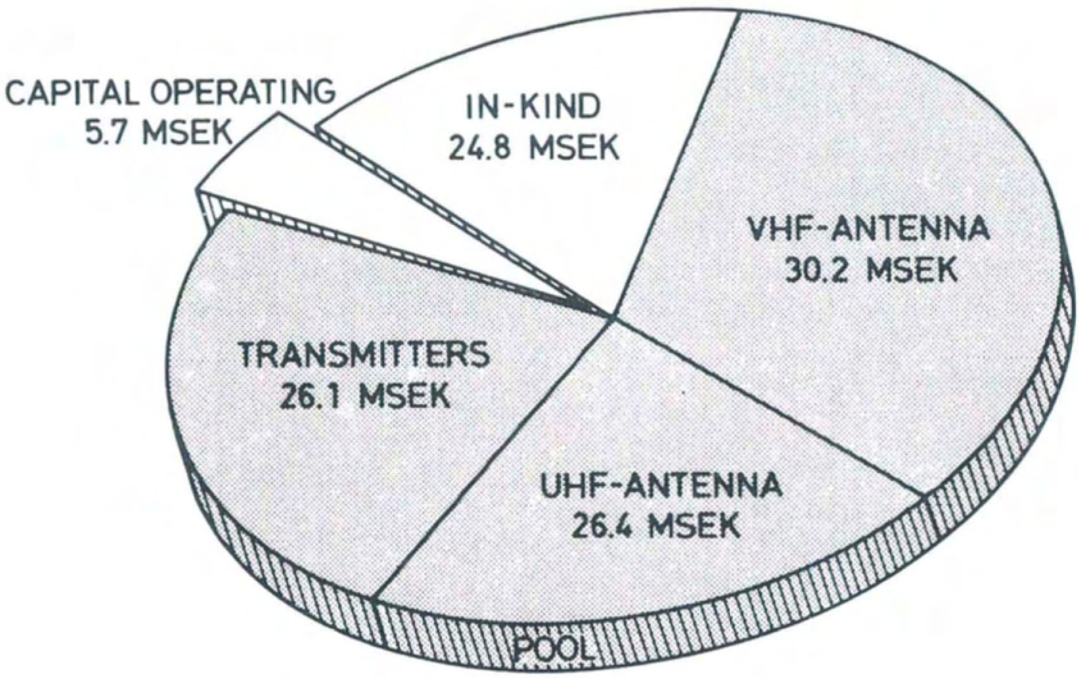
AT 31 DECEMBER 1983

Liabilities

	At Dec. 31, 1982	At Dec. 31, 1983
	MSEK	MSEK
CAPITAL		
Contributions		
Pool	81.8	82.6
Capital Operating	4.9	5.6
In Kind	24.8	24.8
	111.5	112.9
Depreciations	19.1	24.7
Total Capital	92.4	88.2
RESERVES		
Pool	7.1	8.9
Capital Operating	0.9	1.1
Other	—	0.7
Total Reserves	8.0	10.7
Special Accounts	—	0.2
LIABILITIES		
Provisions	1.6	1.1
Other Liabilities	0.7	1.0
Total Liabilities	2.3	2.1
GRAND TOTAL	102.7	101.2

CAPITAL INVESTMENTS

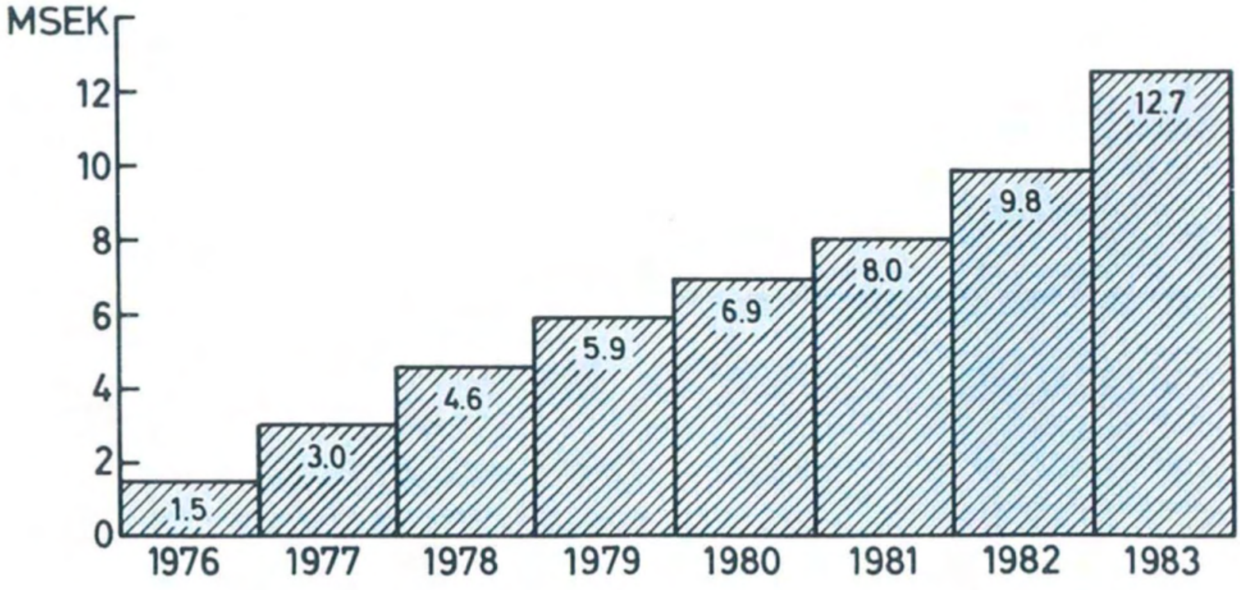
The cumulative capital investments (sum of costs at time of expenditure) to the end of 1983 are shown below:



TOTAL = 112.9 MSEK (1982 = 111.5 MSEK)

OPERATING COSTS

The operating costs increased to 12.7 MSEK in 1983 and are nearly up to the level for full operations. The annual cost history follows:



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SAC	D. Alcaydé P. Bauer	T. Turunen	P. Christiansen K. Schlegel	A. Brekke	R. Boström	T.B. Jones H. Rishbeth
AFC	M. Ravaut	O. Ranta	M. Meinecke	L. Westgaard	M.O. Ottosson	G. Rowe

SAC = Scientific Advisory Committee, AFC = Administrative and Finance Committee

HEADQUARTERS SENIOR STAFF AT 31 DECEMBER 1983:

Director	— M. Baron
Associate Director	— K. Folkestad
Associate Director	— J. Röttger*
Business Manager	— B. Thorwid

*on secondment from MPG

THE EISCAT ASSOCIATES

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