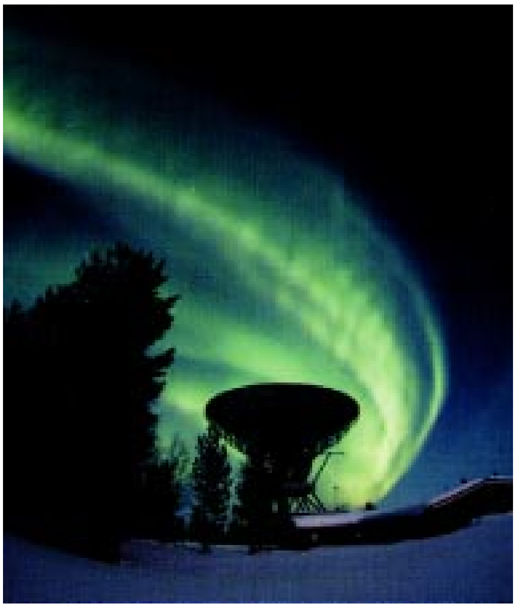
EISCAT Svalbard

Contributes to the understanc

After decades of research much of the interaction between thee arth and the sun, the sun's effect on our surroundings and the mechanisms that control the effects are not so well known. Before the satellites and sounding rockets were introduced, ground based instruments were the only tools used to investigate the phenomena, and several facilities, with today's technology, were built. But, in spite of the possibilities the satellite techniques provide, ground based instruments are still the most cost effective way to gain new knowledge, with satellites and rockets as important supplements. This is one of the reasons for the steady development of the EISCAT antenna system. EISCAT, short for European Incoherent SCATter, has several types of antennas at the high latitudes in the Nordic countries and the latest on the market is the EISCAT Svalbard Radar.



Northern Lights over the Kiruna antenna.
Photo: EISCAT

ding of the sun's effect

The main antenna and the station building. Photo: Nordic Space Activities

Why Svalbard?

In spite of increasingly improved means of communication, Svalbard is still an outpost of the world, so why place the large facilities in Svalbard? The solar wind deforms the earth's magnetic field, which primarily affects the ionosphere at high magnetic latitudes. The sunward side of the auroral oval at the cusp region is usually at magnetic latitudes around 70 to 80 degrees. Svalbard is the maximum location for ground-based instrument studies of the magnetosphere - ionosphere interactions in this region. The high geographic latitude also allows combined radar and optical observations during the whole day, even in the darkest periods of winter.

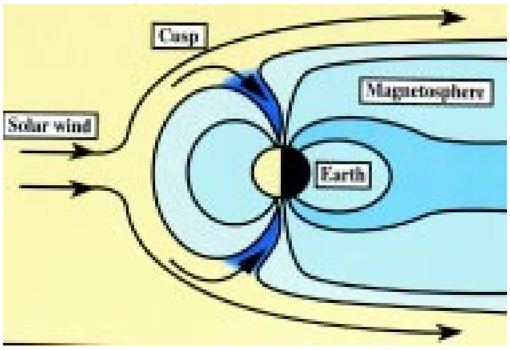
The EISCAT Svalbard Radar is a third-generation research instrument of the highest standard. Contractors constructed components such as antennas, transmitters, and buildings, whereas EISCAT staff designed and constructed special radar instruments, such as the sophisticated modulation, receiver, controller, and signal generator, as well as the digital signal- processing instrument. EISCAT staff also designed system software.

The main antenna has a main reflector at 32 metres, is movable above 360 degrees in azimuth, and from 0 to 180 degrees in elevation. The angular speed of up to 3 degrees per second is exceptional. In addition, the facilities are completed with a fixed antenna at 24 metres, and always pointed in the same direction.

Observations of geophysical phenomena in the high latitude middle and upper atmosphere apply optical techniques, in-situ sensing by balloons, rockets and satellites, as well as radio and radar methods. Computer simulations and models increase these. The radar technique is one of the major ground-based observational tools for the investigations of the related phenomena, and their effects on the earth's space environment. The incoherent scatter technique, applied by EISCAT, relies on the scattering of radio waves from the incoherent motions of the electrons in the ionosphere.

Besides studies of geophysical phenomena in the middle, upper atmosphere, and ionosphere, plasma physics, as well as meteorological phenomena can be studied with the applied radar methods. To use these methods the EISCAT Scientific Association was founded in 1975 by research councils and academies in six European countries: Finland, France, Germany, Norway, Sweden and the United Kingdom. Japan has later become the seventh member. EISCAT studies the interaction between the sun and the earth as revealed by disturbances in the magnetosphere and the ionised parts of the atmosphere. This phenomenon is visibly demonstrated through the spectacular Aurora Borealis or Northern Lights.

The EISCAT Radar System consists of a VHF antenna near Tromsø, Norway, and Parabolic UHF antennas in Tromsø, in Kiruna, Sweden, Sodankylä, Finland and near Longyearbyen, Svalbard. Close by Tromsø, a heating facility is established to support various active plasma physics experiments in the high latitude ionosphere. Headquarter for the organisation is established in Kiruna.

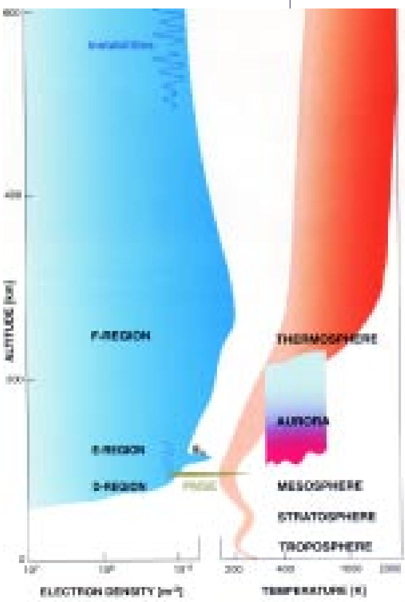


The figure shows why Svalbard is a so ideal for research of the solar effects at the earth. Figure: EISCAT

Why this profound interest in the ionosphere and the upper atmosphere?

As part of the solar system we are familiar with the sun, and its mostly positive influence on our lives. However, in spite of research throughout generations, there are many side effects that are not so well known, and every now and again increasingly new approaches turn up as to the effect of the sun, something that requires answers. Some of these answers can be provided through better knowledge about the processes in these parts of the earth's surroundings.

The sun emits a wide spectrum of electromagnetic waves into space, together with a stream of particles called the solar wind. Some of this electromagnetic radiation ionizes the earth's upper atmosphere. This radiation is absorbed there and does not the reach the lower atmosphere. The ionized part of the atmosphere is called the ionosphere. Without the absorption of these high-energy parts of the solar-electromagnetic spectrum in



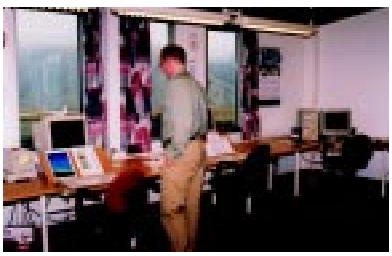
the atmosphere our life on earth would be impossible or seriously impaired.

The interaction of this solar radiation and the solar wind essentially takes place in the middle and upper atmosphere and the magnosphere - regions of the earth's space environment from some 10 km and many thousand of km above the planet's surface. Although the effects of these phenomena on earth's environment are well understood in principle, many details remain barely known or even mysterious. Observations of geophysical phenomena in the high latitude, middle, and upper atmosphere apply optical techniques, in-situ sensing by balloons, rockets and satellites, as well as radio and radar methods.

The earth's atmosphere

The atmosphere that encircles us is divided into the troposphere, stratosphere, mesosphere, and thermosphere. Biosphere is the term applied to the region near the earth's surface where life exists. The region above the lower mesosphere is particularly ionised by ultra-violet radiation from the sun. This region, where free electrons and ions exist, is called the ionosphere. It is subdivided in D-, E-, and F-regions.

At high latitudes the ionosphere is strongly influenced by particles and electric fields controlled by magnetospheric and solar wind processes. This causes for instance, the visible aurora, motions of the ionospheric plasma in the polar cap with velocities as high as a few kilometres per second, as well as dramatic temperature variations. Changes of the chemical composition occur, and plasma irregularities are created.



From the operators room in the station bulding.
Photo: Nordic Space Activities

The radar principle

The radar technique is one of the major ground-based observational tools for investigations of the related phenomena and their effects on the earth's space environment. The basic principle of radar uses the transmission of a series of pulsed electromagnetic waves. For incoherent scatter radar, electromagnetic waves in the frequency range 40 MHz to 1300 MHz are radiated from the transmitter through the antenna and into the ionosphere. The electrons of the ionospheric plasma scatter a very small fraction of this wave, some of which travel back towards the radar antenna and receiver. Measuring the time delay between the transmitted pulse and the returned signal determines the range of the scattering volume, science the electromagnetic waves travel with the speed of light.

The received signals are sampled at a sequence of ranges such that a full profile along the radar beam is obtained. The signals are analyzed thereafter in terms of the autocorrelation functions or the Fourier transforms - the power spectrum.

The research programmes

EISCAT radar operations are divided equally between Common Programmes (CP), Unusual Programmes (UP) and Special Programmes (SP). The three types of programmes include detailed observations over a wide range of altitudes and over a large geographic area.

- Common Programmes are run by EISCAT staff according to a pre-arranged programme, and the data is available to any scientist from the associate countries.
- Experiments in the Unusual Programme are similar to the Common Programmes, but are experiments of opportunity. Approval must be sought from the Director of EISCAT.
- For the Special Programmes the available time is apportioned to each Associate Country (AC) according to the size of their financial contribution to EISCAT.

The Auroral Phenomena.

Late in the autumn and in the winter season on clear evenings we can se very beautiful Northern Lights criss-cross the sky, phenomena that have fascinated the people at all times, but what really happens?

Energetic charged particles are deposited in the atmosphere, mainly at the E-regions highs, causing optical emissions and excess ionisation there. This phenomenon appears both at the Northern and the Southern Hemisphere and is named respectively Aurora Borealis or Aurora Australis. The zone where the light can be seen is around 5 degrees, lying normally 12 degrees from the magnetic pole at dayside and around 22 degrees from the pole at the night side. This depends on the magnetic activities, and sometimes the light can be seen in areas in the northern part of the European mainland.

With the use of the EISCAT antennas, this phenomenon can be «spotted» even in cloudy nights. The figure at the top is an example of very impulsive, short precipitation bursts separated by intervals of gradual decay as the electrons recombine with ions. Plasma irregularities can be created during such events, and temperature increases in the E-region are observed by EISCAT. The lower part of the figure showed the E-region electron density, auroral brightness, and ionospheric electric field for a period of three minutes when an auroral arc was very close to the radar beam. The joint observations indicated that the initial increase in electron density was the formation of an arc element in the radar beam, which then drifted in and out of the beam.

