SHARE – An HF Radar System for SANAE

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Planning is currently under way for the installation of an HF radar system at SANAE to probe a large area of the ionosphere over Antarctica. Funding for the proposed system (of the order of R1 million) will be provided jointly by three institutions in South Africa, the UK and USA. The researchers taking part in this international collaborative experiment come from the University of Natal, Durban (UND), Potchefstroom University for Christian Higher Education (PUCHE), British Antarctic Survey (BAS) and the Applied Physics Laboratory (APL) of the Johns Hopkins University in the USA. APL and BAS currently operate HF radars at Goose Bay in Canada and Halley in Antarctica respectively (Greenwald *et al* 1985; Baker *et al* 1989). The proposed radar at SANAE will be similar to these two radars; the SANAE and Halley radars will together be known as SHARE – the Southern Hemisphere Auroral Radar Experiment. The fields of view of the two radars over Antarctica are shown in Figure 1. Also shown is the conjugate area (i e mapped along the geomagnetic field lines from the northern hemisphere) of the Goose Bay radar.

HF radars have proved to be very important instruments for investigating the high latitude ionosphere and magnetosphere (e g Greenwald *et al* 1990; Walker *et al* 1992). The basic geometry of such a radar is illustrated in Figure 2 (from Schlegel, 1984). A radar pulse in the HF radio band (8-20 MHz) is transmitted at a low angle of elevation. The frequency is just above the maximum plasma frequency in the ionosphere, so that the rays are refracted somewhat. These waves are scattered from magnetic-field aligned irregularities (regions with density slightly different from the surrounding plasma) in the ionosphere (Walker *et al* 1987). In order to obtain a significant back-scattered signal, the ray direction must be perpendicular to the magnetic field, as illustrated in Figure 2. Such a radar must thus be located at high latitudes and look polewards. The Halley radar has a transmitting and receiving array of 16 broadband (8-20 MHz) log periodic antennas, each of which has elements approximately 15 m long and is mounted on a tower at least 7 m high. The beam formed by this array can be directed into one of 16 well-defined directions. A pulse pattern is transmitted and analysis of the return signal allows the determination of the back-scattered power, the Doppler velocity and other spectral information for up to 75 ranges along the beam. A complete sweep of all the beams takes typically 90 s. The combination of beam directions and ranges produces a map of the measured properties of the irregularities over a very large spatial region (of the order of a million square kilometres) with a time resolution of 90 s.

One of the most important types of measurement is that of the Doppler velocity of the irregularities in the direction of the beam. If one has two radars with

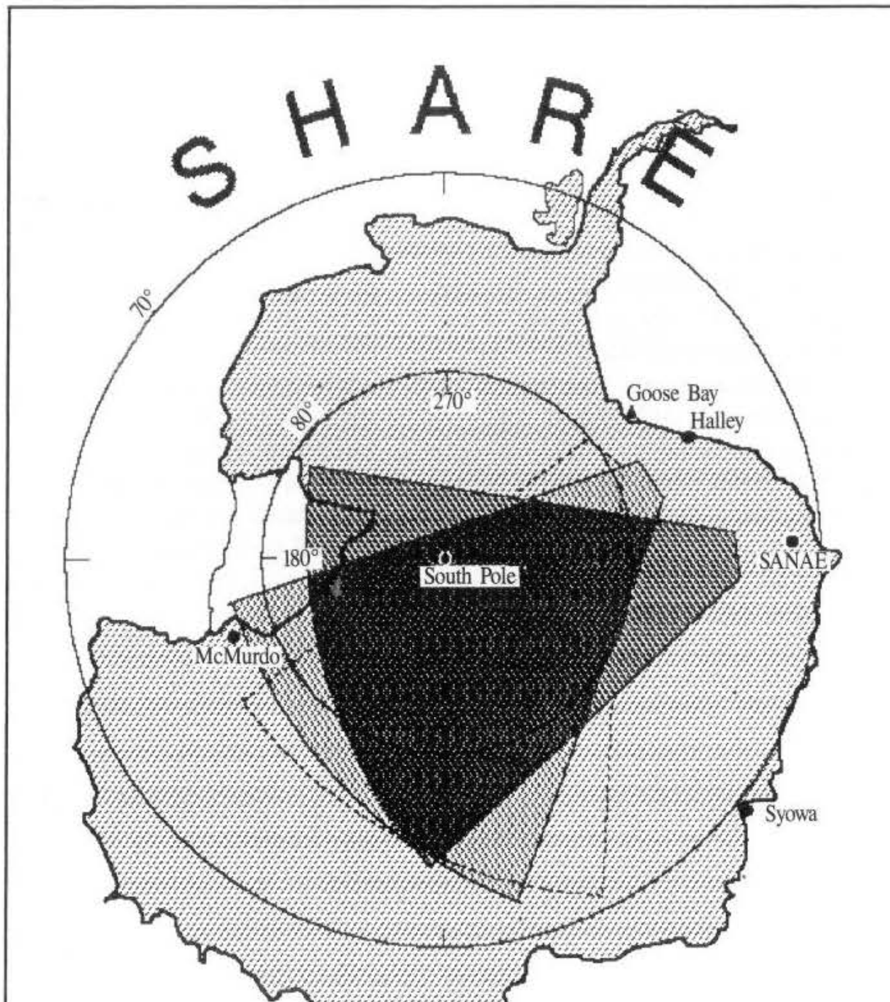

Fig 1 The field of view of the proposed HF radar at SANAE with the field of view of the existing radar at Halley and the conjugate position of the field of view of the Goose Bay radar

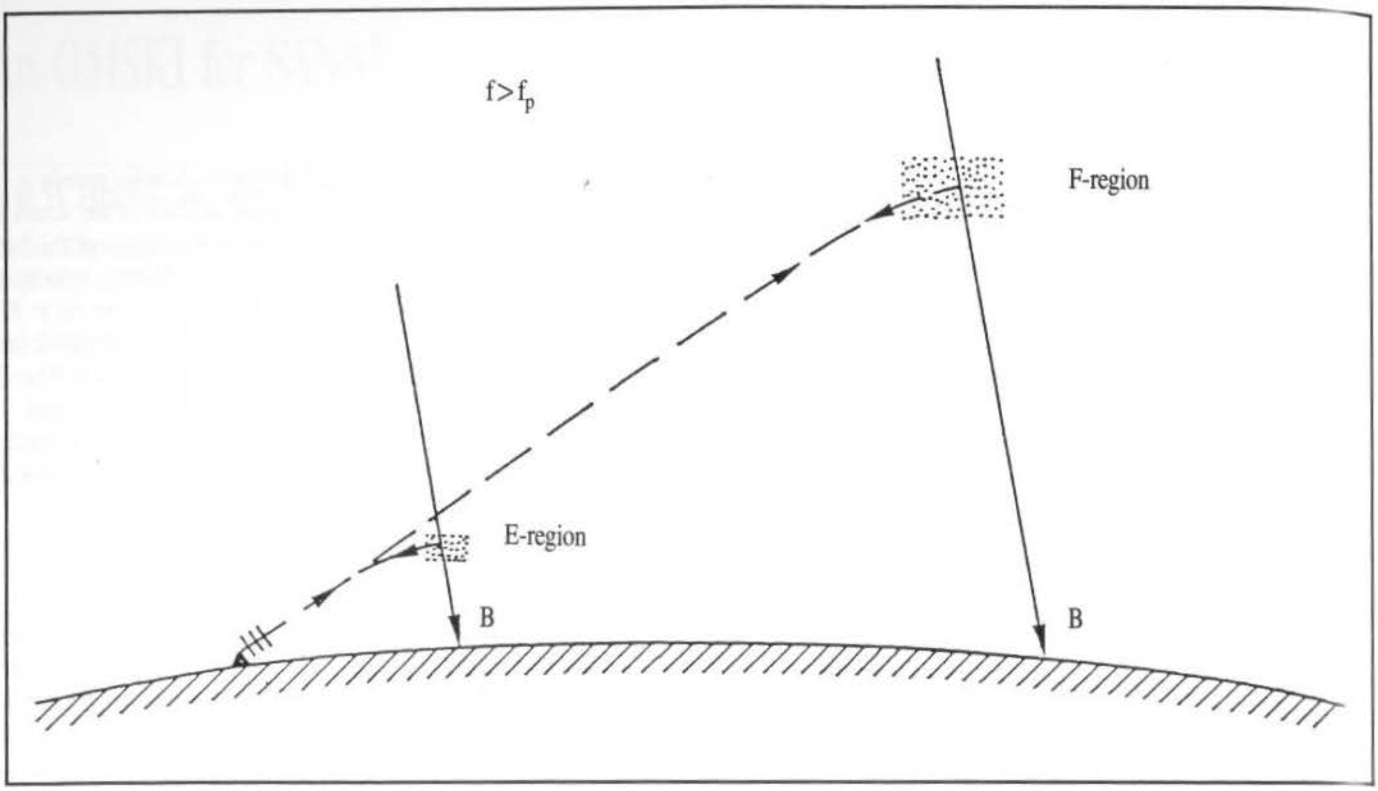

Fig 2 Geometry of the echo return process for an HF radar

crossed beams, then one can use the two components of velocity to get the vector velocity of the irregularities. These are diagnostic of the convection along the whole length of the geomagnetic field line linking this radar cell. A limitation of the existing radars is the lack of such two-dimensional information. The major reason for the SHARE proposal is to achieve such measurements with multiple crossed beams. These will produce maps of the velocity vectors over the large region of the ionosphere formed by the overlapping of the two fields of view shown in Figure 1. This will be of crucial importance in advancing one's understanding of the dynamics of the magnetosphere.

The study of the magnetosphere has now reached a stage where major progress can only come from taking a global view. Because many processes occurring far out in the magnetosphere map along geomagnetic field lines, the study of ionospheric convection at the foot of a field line allows an understanding of these processes. The field lines that penetrate deep into the magnetosphere where the key processes occur reach the ground at high geomagnetic latitudes in the polar regions. One also needs to understand both spatial and temporal changes. A radar such as SHARE permits the simultaneous observation of a large area of the ionosphere, which maps out to a large volume of the magnetosphere; this is something that cannot be done by satellites. The scientific goal of the SHARE programme is to increase one's understanding of the dynamics of the high latitude ionosphere and magnetosphere; magnetosphere-ionosphere coupling, the interaction of the magnetosphere with the solar wind, and the energy transfer mechanisms between the solar wind, the magnetosphere, the ionosphere and the upper atmosphere. Many of the studies proposed with the radar will be in conjunction with other existing observations at SANAE (e g auroral light, ionospheric absorption and magnetic field observations) and South Pole Station.

The installation of this radar at SANAE will be a considerable logistical task. However, it is believed both this and the necessary funding are realistically attainable, and the SHARE experiment represents an outstanding opportunity for international collaborative science.

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