Magnetospheric electrons precipitating into the atmosphere

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INTRODUCTION

Polar lights, called aurorae, are due to electrons, precipitating into the upper atmosphere from the magnetosphere. They ionize the ionospheric F region down to an altitude of ~ 105 km. Occasionally more energetic electrons are entering the atmosphere and ionizing the D region of the ionosphere down to altitudes below 90 km. It is these more energetic electrons that produce odd hydrogen and odd nitrogen compounds in the upper atmosphere. HO_X and odd nitrogen can reduce the ozone concentration in the atmosphere. Odd nitrogen can remain for several days to months, depending on its altitude of formation and transport after formation.

THE RIOMETER

Cosmic radio noise is recorded by a radio receiver, the Relative Ionospheric Opaque METER, the so-called riometer. When cosmic radio noise propagates through the ionosphere, the wave intensity is reduced by a fraction which depends on the integral electron density in the ionosphere; most effectively by the electron density in the D layer below ~ 90 km. This absorption of (i e reduction in) cosmic radio noise signal strength is then a measure of the energy, spatial extent and intensity of energetic precipitating electrons (Stoker 1987).

A wide beam double dipole 30 MHz riometer has been in operation at SANAE since 1964. G J Kühn (1971) analysed riometer observations of 1964 and 1965, and was able to distinguish between auroral type of energetic electron precipitation and electron precipitation from the magnetospheric trapping- (closed field line) region. The trapping-region precipitation events seem to correlate with the auroral type of events and these associated events increase linearly with increasing magnetic activity.

Minnaar *et al* (1975) reported on an electron precipitation event recorded at SANAE during 14 November 1974. Enhanced count rates were observed in the stratosphere by Geiger-Müller detectors carried aloft from SANAE by balloons. The geomagnetic field was disturbed (K_p = 5-) during this balloon flight. The results showed that the Geiger-Müller detectors have recorded X-ray bremsstrahlung from energetic precipitating electrons. The energy spectrum of these precipitating electrons was determined from these results. The 30 MHz riometer recorded simultaneous to the flight an absorption due to D layer ionization caused by the precipitating electrons. Hence the integral flux of precipitating electrons could be determined.

A detailed theoretical study was made (Stoker 1987) on the interpretation of absorption events seen by the wide beam riometers of 20, 30 and 51,4 MHz at SANAE. It appeared that the depth of atmospheric ionization by precipitating electrons and hence the energy of these electrons cannot be determined by multifrequency riometry. It turned out that spatial inhomogeneities in ionization contribute much stronger to changes in the relative absorptions recorded at different radio noise frequencies than the depth of ionization. In order to see spatial inhomogeneity in precipitation rather than to conclude that the precipitation was inhomogeneous, an image riometer was set up at SANAE during January 1991, using a 16-element crossed dipole antenna. The first results will be analyzed when the data are received early 1992.

THE SOUTH ATLANTIC RADIATION ANOMALY

Experimental observations of large fluxes of high-energy electrons at ionospheric F region heights in the region of the South Atlantic Magnetic Anomaly were first reported by Ginzburg and his group in the USSR (Gledhill 1971). Particles such as electrons and protons, trapped in the magnetosphere, approach the earth's surface much more closely in region of the South Atlantic than elsewhere. Consequently these particles precipitate in an area at and north-west, south and south-west of Gough Island. This so-called South Atlantic Radiation Anomaly is a result of the non-uniform strength of the earth's surface magnetic field. There is a large area in the vicinity of Rio de Janeiro, where the total intensity at the surface shows very low values compared to those at other places, the so-called Brazilian Magnetic Anomaly. Furthermore, the horisontal component of the surface magnetic field shows south of South Africa a minimum value. Consequently the inclination of the geomagnetic field is about the same at Cape Town and at SANAE. This so-called Cape Town Magnetic Anomaly coupled with the Brazilian Magnetic Anomaly, results in the South Atlantic Radiation Anomaly.

On one of the first voyages of the new Antarctic research vessel the *SA Agulhas* had to put buoys *en route* to Gough Island and to the south of Gough Island. During this voyage in October/November 1978, about 15 balloons were launched with a standard Geiger counter telescope. A detector launched 0610 Local Time (LT) on 5 November 1978 reached ceiling altitude at 7,5 mb two hours later. At 0907 LT another detector was launched. Whereas the first detector detected convincingly an enhanced count rate, the count rate of the second detector was normal. The enhanced count rate of the first detector can only be ascribed to X-rays from precipitating radiation belt electrons. Geomagnetic activity was very low during both flights (K_p = 1). These electrons may precipitate due to increasing post-dawn exospheric density caused by solar microwave heating. The results require an additional heating, presumably due to electron precipitation from the South Atlantic Radiation Anomaly. A clear electron precipitation event with peaks of 0,3 to 0,75 dB was also seen by a 30 MHz riometer on Gough Island from about 0830 to 1730 UT on 21 January 1985. Both these are isolated observations which have to be confirmed in the future by a permanent imaging riometer to be set up on Gough Island.

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