19. STUDIES OF IONOSPHERIC IRREGULARITIES AROUND L=4 IN THE SOUTHERN HEMISPHERE USING SATELLITE BEACONS

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ABSTRACT

From 28 December 1983 to 10 March 1985 total electron content (TEC) data were gathered from Macquarie Island (54.5°S, 158.9°E geographic) in the southern auroral zone using the Faraday rotation technique. The beacons on the geostationary satellites ATS-1 and ETS-2 transmitting on 137.35 MHz and 136.112 MHz were used. Preliminary analysis of the data indicates that large scale fluctuations in the TEC occur which are associated with auroral activity. Some of these disturbances propagate towards the mid latitudes with speeds of from 200 to 1000 ms^{-1}. Large scale rapid decreases in TEC were observed during the evening hours on about one third of the September equinox days studied. These decreases occurred at a geomagnetic latitude assumed 60°S and could be associated with the main ionospheric trough travelling through the ray path from the satellite to the receiving station.

19.1 INTRODUCTION

Total electron content (TEC) studies of the auroral ionosphere using geostationary satellites have been limited by either the low elevation angle to the satellite or the lack of a land-based station, particularly in the Southern Hemisphere. Macquarie Island is the most favourable location in the Southern Hemisphere for TEC studies as it has geomagnetic and geographic latitudes of 65°S and 54.5°S respectively (see Figure 1).

From 28 December 1983 to 10 March 1985 TEC data were gathered from Macquarie Island (54.5°S, 158.9°E geographic) using the Faraday rotation technique.

TEC data were also available for Beveridge (37.3°S, 144.6°E geographic) for this period. Some preliminary results and conclusions are presented below.

19.2 EXPERIMENTAL DETAILS AND RESULTS

The 136.112 MHz beacon signal for the geostationary satellite ETS-2 located at 130°E was used in this study. During equinoxes when the ETS-2 was switched off, the beacon signal on 137.35 MHz from the geostationary satellite ATS-1 located at 166°E was used. Although ATS-1 had a higher elevation of 28° average from Macquarie Island when compared to the 20° for ETS-2, ATS-1 had a large inclination of 11°. In the preliminary analysis presented here, the correction for this large inclination has not been made. The correction, ranging from 0 to approximately ± 10% over a day, does not affect the interpretation of the gross features in the TEC variation.

The TEC baseline is obtained from the f_oF_2 data for the Macquarie Island and Hobart ionosondes (see Figure 1) (Smith 1971). A preliminary analysis indicates that, for fifty autumn equinox days, the average nighttime minima is of the order of 25×10^{15} em^{-2}.

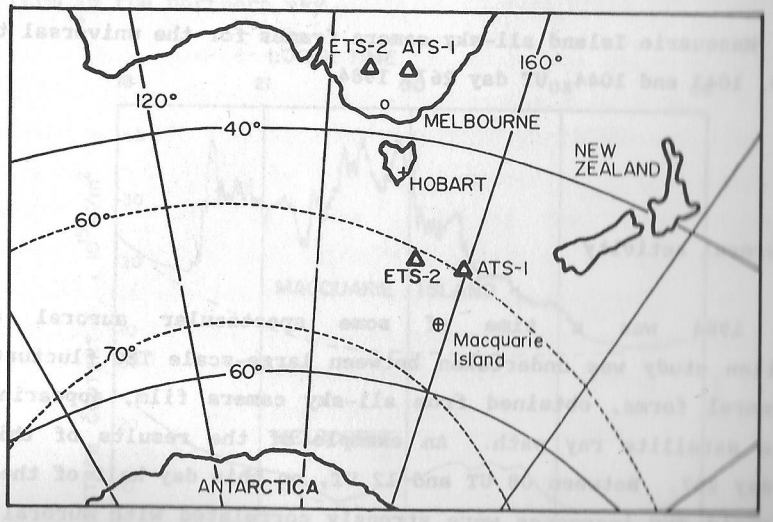

Figure 1. Location map showing Faraday rotation monitoring station (0), ionosondes (+), average satellite/station sub-ionospheric points (Δ) and geomagnetic latitudes (dashed lines).

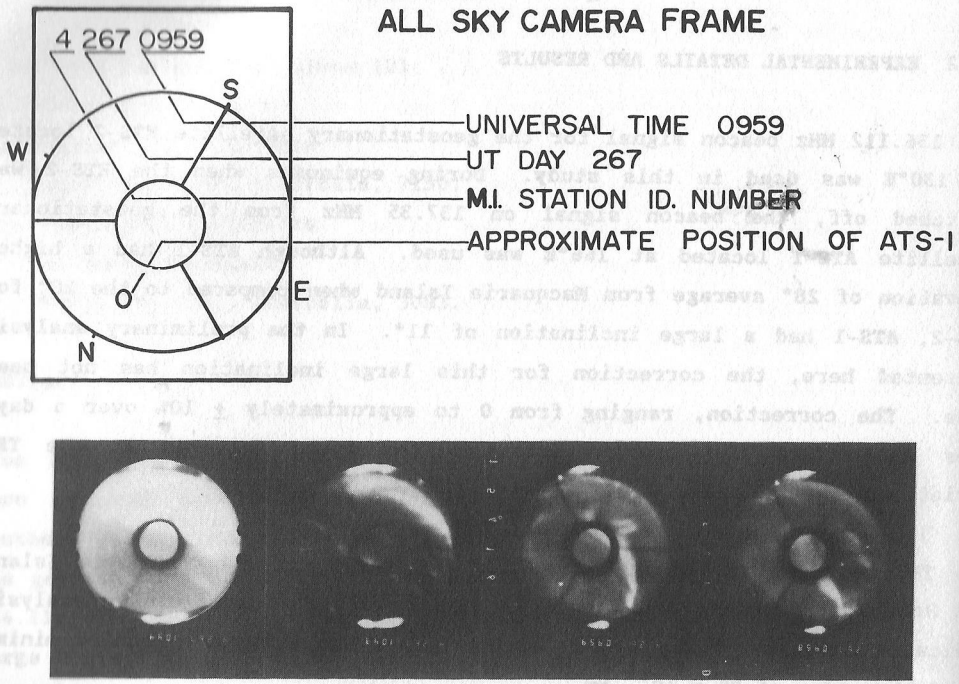

Figure 2. Macquarie Island all-sky camera frames for the universal times; 0958, 0959, 1043 and 1044, UT day 267, 1984.

19.2.1 Auroral activity

September 1984 was a time of some spectacular auroral displays. A correlation study was undertaken between large-scale TEC fluctuations and bright auroral forms, obtained from all-sky camera film, appearing in the station to satellite ray path. An example of the results of this day is that for day 267. Between 08 UT and 12 UT, on this day half of the fourteen observed rapid TEC increases were strongly correlated with auroral activity (Figures 2 and 3). Increases in the nighttime TEC of up to 60% in the space of a few minutes have been observed. Nights of continuing auroral activity show elevated nighttime TEC for several hours (Figure 4).

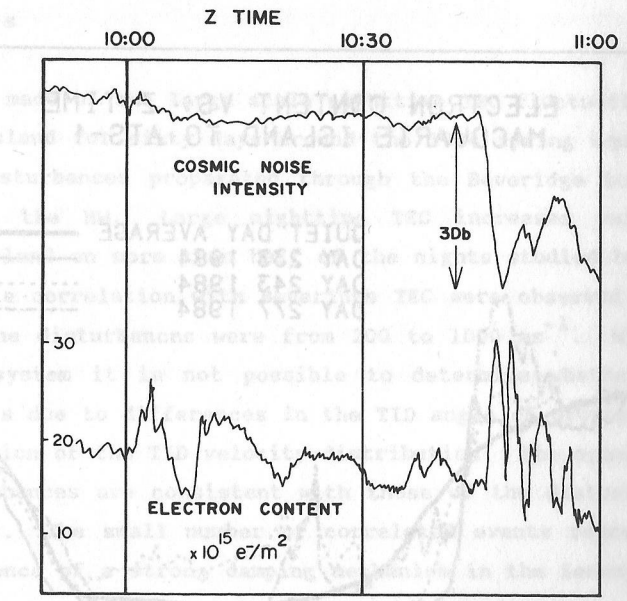

Figure 3. Cosmic noise intensity from a standard riometer at Macquarie Island and the TEC fluctuations from Macquarie Island to ATS-1 for the UT day 267, 1984. TEC fluctuations around 1000 UT correspond to northward travelling auroral forms. The cosmic noise absorption event and TEC fluctuations around 1045 UT correspond to the sudden appearance of a bright auroral form in the northern sky.

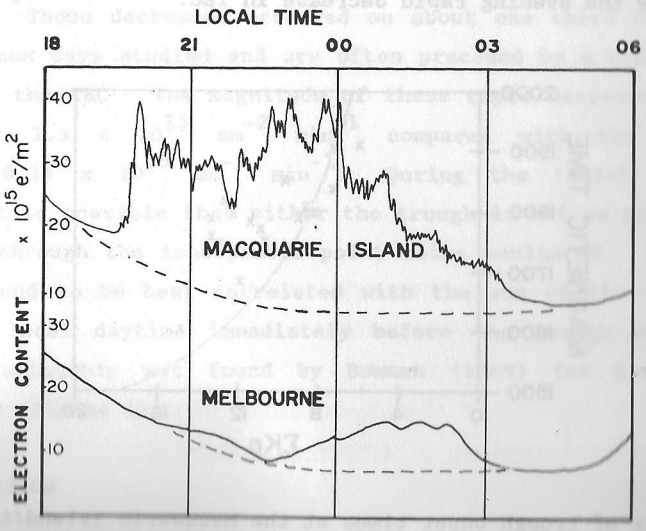

Figure 4. Large-scale ionospheric TEC fluctuations as seen from Macquarie Island and Beveridge to ATS-1 during the days 263 and 264, 1984.

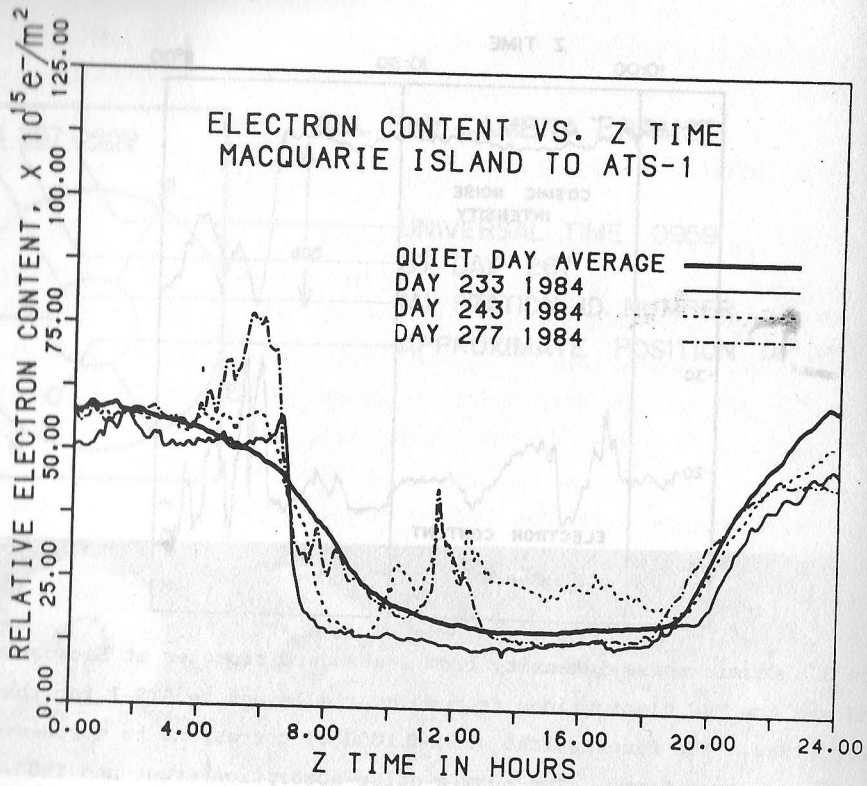

Figure 5. Daily TEC plots showing an average of eight quiet days plus three days which show the evening rapid decrease in TEC.

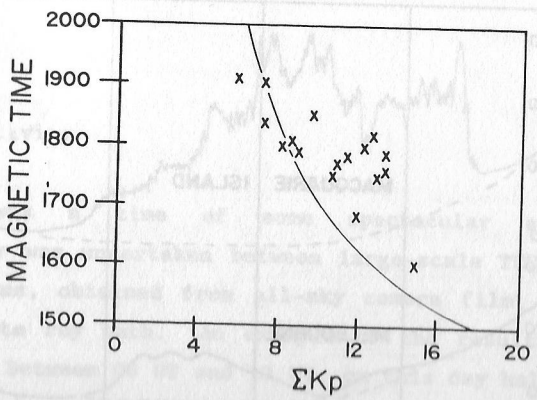

Figure 6. Plot of trough onset times at the Macquarie Island/ATS-1 ionospheric point against the sum of three Kp indices. Also shown is the curve fitted by Bowman (1969) to similar data from Ellsworth.

19.2.2 TID's

A study was made of the large scale nighttime TEC fluctuations observed from Macquarie Island for sixty days around the 1984 spring equinox to determine if these disturbances propagated through the Beveridge ionospheric points, 2000 km to the NW. Large nighttime TEC increases were observed from Macquarie Island on more than half of the nights studied but only ten cases of reasonable correlation with Beveridge TEC were observed (Figure 4). The speeds of the disturbances were from 200 to 1000 ms^{-1}. With a two-station monitoring system it is not possible to determine whether this spread in velocities is due to differences in the TID angle of propagation or due to a true reflection of the TID velocity distribution. The speeds and origins of these disturbances are consistent with those of the disturbances studied by Thome (1968). The small number of correlated events reported in our study may be evidence of a strong damping mechanism in the ionosphere or that the TID's tend to travel in directions other than NW.

19.2.3 Trough features

Sharp depletions in TEC during the evening have been observed and are thought to be evidence of the equatorial edge of the main ionospheric trough which can occur between the geomagnetic latitudes of 55°S and 70°S (Bowman) (Figure 5). These decreases occurred on about one third of the fifty-five spring equinox days studied and are often preceded by a ridge or a relative increase in the TEC. The magnitude of these rapid decreases in TEC can be as high as 1.3 x 10^{15} em^{-2} min^{-1} compared with the normal evening decays of 0.14 x 10^{15} em^{-2} min^{-1}. During the 'quiet' days shown in Figure 5, it is possible that either the trough is not as pronounced or does not travel through the ionospheric point being monitored. The trough onset time was found to be best correlated with the sum of the three Kp indices during the local daytime immediately before the trough was detected. A similar relationship was found by Bowman (1969) for Ellsworth (62.6°S, geomagnetic) (Figure 6).

19.3 DISCUSSION

Initial analysis of the TEC data gathered from Macquarie Island has shown some interesting effects due to auroras, TID's and the main ionospheric

trough. It is suggested that in future studies, a narrow angle photometer and directional riometer, both directed at the satellite being monitored, be deployed at Macquarie Island. These would provide more information on the electron-ion production and recombination rates and mechanisms. Also, a two station network around the auroral zone should be deployed to determine whether the large-scale TEC enhancements travel westward, as indicated by the observations of Weber et al. (1985) in the northern auroral zone. It would appear from the observations presented here, that large-scale TEC disturbances in the southern auroral region do not always produce TID's which travel large distances toward the equator.

Further work to be undertaken on the TEC data base for Macquarie Island include the study of medium scale TID's and their cut-off period from which the scale height may be calculated (Titheridge 1971), comparison of the seasonal and solar cycle variation with the ionospheric model for the region, and a comparison with Northern Hemisphere data from around L=4.

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