oiseaux de l'ile aux Cochons, Archipel Crozet (46°06'S, 50°14'E). *CNFRA*, **40,** 107-148, 1976.
Frost, P.G.H., Grindley, J.R., & Wooldridge, T.H. Report on South African participation in cruise MD08 of M.S. *Marion Dufresne*, March–April, 1976. *S. Afr. J. Antarct. Res.* (in press).
Gambell, R., Best, P.B., & Rice, D.W. Report on the international Indian Ocean Whale-marking cruise, 24 November 1973–3 February 1974. *International Whaling Commission Report*, **25,** 240-252, 1975.
Leatherwood, S., Evans, W.E., & Rice, D.W. The whales, dolphins and porpoises of the Eastern North Pacific. A guide to their identification in the water. *U.S. Naval Undersea Research and Development Centre Technical Report*, **282,** 1-175, 1972.
Masaki, Y. Japanese pelagic whaling and sighting in the Antarctic 1974/75. *Report of the Scientific Committee of the International Whaling Commission 1975*, 333-349, 1976.
Mitchell, E.D. Pigmentation pattern evolution in delphiniid cetaceans: an essay in adaptive coloration. *Can. J. Zool.*, **48,** 717-740, 1970.
Omura, H. A review of pelagic whaling operations in the Antarctic, based on the effort and catch data in 10° squares of latitude and longitude. *Scientific Report of the Whales Research Institute, Tokyo*, **25,** 105-203, 1973.
Schevill, W.E. Sight records of *Phocoena phocoena* and of cetaceans in general. *J. Mammal.*, **49,** 794-796, 1968.
Slijper, E.J., van Utrecht, W.L., & Naaktgeboren, C. Remarks on the distribution and migration of whales, based on observations from Netherlands ships. *Bijdragen tot de Dierkunde*, **34,** 3-93, 1964.
Townsend, C.H. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica, New York*, **19,** 1-50, 1935.

Observations of the ionosphere over the South Atlantic Ocean

R. Haggard and **J.A. Gledhill**

Department of Physics, Rhodes University, Grahamstown.

Observations from a shipborne ionosonde at Gough Island (40,4°S, 9,9°W) are presented for a 21-day period, extending from 13 October to 2 November, 1975. The maximum median foF2 value was found to be 9,2 MHz, while the minimum median foF2 value was 3,2 MHz. A comparison with four surrounding stations is made. Observations were also made during the voyages from Cape Town to Gough Island and back for October/November, 1975 and August/September, 1976. The observations show a marked increase in foF2 as recorded on board ship when compared to observations made at Grahamstown, with a maximum increase of 5 MHz.

Waarnemings soos gevind met 'n ionosonde aan boord skip te Gough Eiland (40,4°S, 9,9°W) word aangewys vir 'n tydperk van 21 dae, van 13 Oktober tot 2 November 1975. Die maksimum mediaanwaarde van foF2 was 9,2 MHz, die minimum mediaanwaarde van foF2 was 3,2 MHz. 'n Vergelyking met vier ander stasies in die omgewing is gemaak.

Waarnemings is ook gedurende die vaart van Kaapstad na Gough Eiland en terug gedurende Oktober/November 1975 en Augustus/September 1976 gedoen. Waarnemings aan boord skip toon 'n verhoging in foF2 teenoor die waarnemings te Grahamstad, met 'n maksimum verhoging van 5 MHz.

Introduction

There is considerable interest in the ionosphere over the South Atlantic Ocean. No observations made with an ionosonde in this remote area have been published in the literature, but the presence of the South Atlantic Anomaly (Gledhill, 1976) suggests that unusual phenomena may be expected there. Satellites have recorded relatively large particle fluxes in the area at low altitudes (Ginzburg *et al.*, 1962) and Greenspan and Stone (1964) recorded a pronounced airglow enhancement in the region about 35°S, 6°E, during a voyage to Gough and Bouvet Islands in 1962. This is summarised in Fig. 1.

The research ship *RSA* passes through this region on its way to and from Gough Island and Tristan da Cunha. By arrangement with the South African Department of Trans-

Table 1

Location	Observations	First voyage 1975	Second voyage 1976
Cape Town–Gough Island	Every 15 minutes	4–10 Oct.	14–19 Aug.
At Gough Island	Every 15 minutes when possible	13 Oct.–2 Nov.	——
Gough Island–Cape Town	Every 15 minutes	3–9 Nov.	30 Aug.–4 Sept.

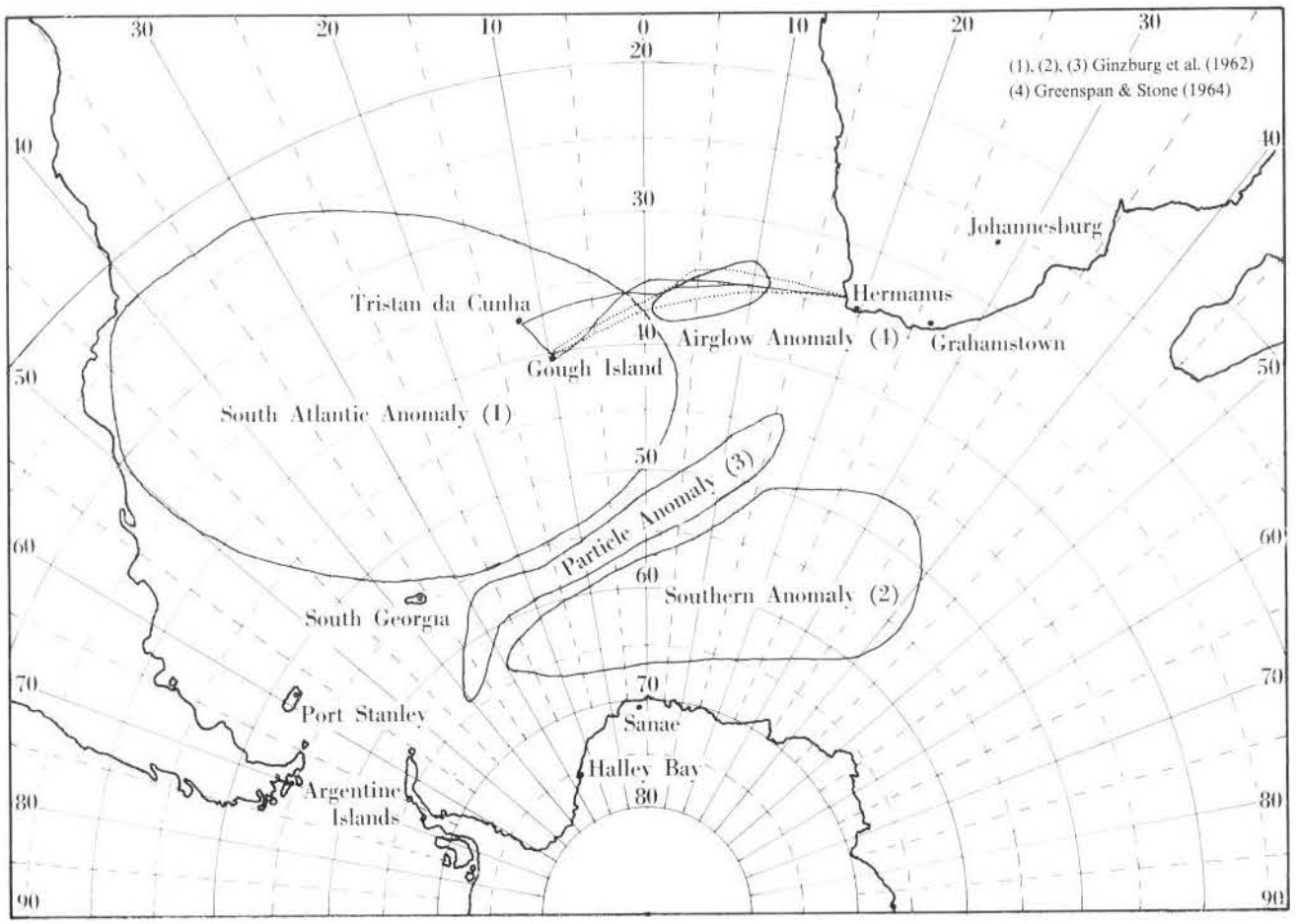

Fig. 1. The south Atlantic Ocean, showing anomalous areas previously reported and the routes taken by the *RSA* in 1975 (——) and 1976 (· · ·).

port, a vertical incidence ionosonde was operated on board the vessel during the voyages in October/November, 1975 and August/September, 1976. The courses followed on these two voyages are also shown in Fig. 1.

In this paper we report the observations made during those trips, including the results of 21 days of recordings while the ship was at Gough Island. (Table 1).

The ionosphere at Gough Island

We consider first the results of the 21 days of observations at Gough Island (40,4 °S, 9,9 °W).

Figure 2 shows medians of the ordinary ray critical frequencies of the E, F1 and F2 layers, together with the minimum frequency on which an echo could be detected, f_{min}. The number of values represented by each point is also indicated on the diagram. Of the magnetic three-hour range *K*-indices scaled at Hermanus during this period, 156 were 3 or less and only 9 exceeded 3, the maximum value being 5. In Fig. 3 the upper and lower quartiles of foF2 are shown together with the medians, to illustrate the consistency of the behaviour of the F2 layer under these conditions. These are, to our knowledge, the first observations of the ionosphere in this part of the world to be published.

Figure 4 compares the median values of foF2 at Gough Island with those for the surrounding permanent ionosphere observatories at Grahamstown (33,3 °S, 26,5 °E), Port Stanley (51,7 °S, 57,9 °W), South Georgia (54,4 °S, 36,5 °W) and Sanae (70,5 °S, 2,5 °W).

It is noticeable that foF2 at Gough Island exceeds those at all the other stations during the daylight hours, but during the night it is comparable with those at Grahamstown and Sanae. Night time values at South Georgia tend to be higher and those at Port Stanley higher still.

Figure 5 shows the maximum median values of foF2, foF1 and foE plotted against the geographic latitude for Johannesburg (26,1 °S), Grahamstown (33,3 °S), Hermanus (34,4 °S), Gough Island (40,4 °S), Port Stanley (51,7 °S), South Georgia

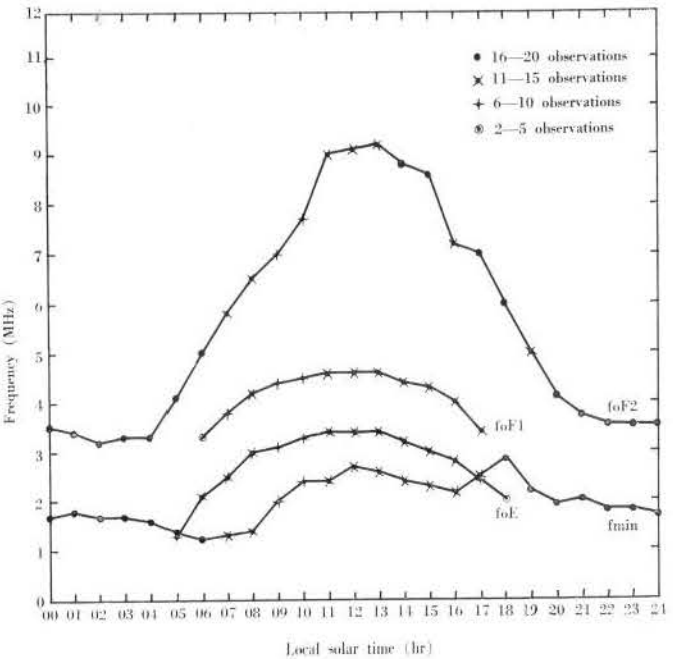

Fig. 2. Median values of ionospheric parameters observed at Gough Island between 13 October and 2 November, 1975.

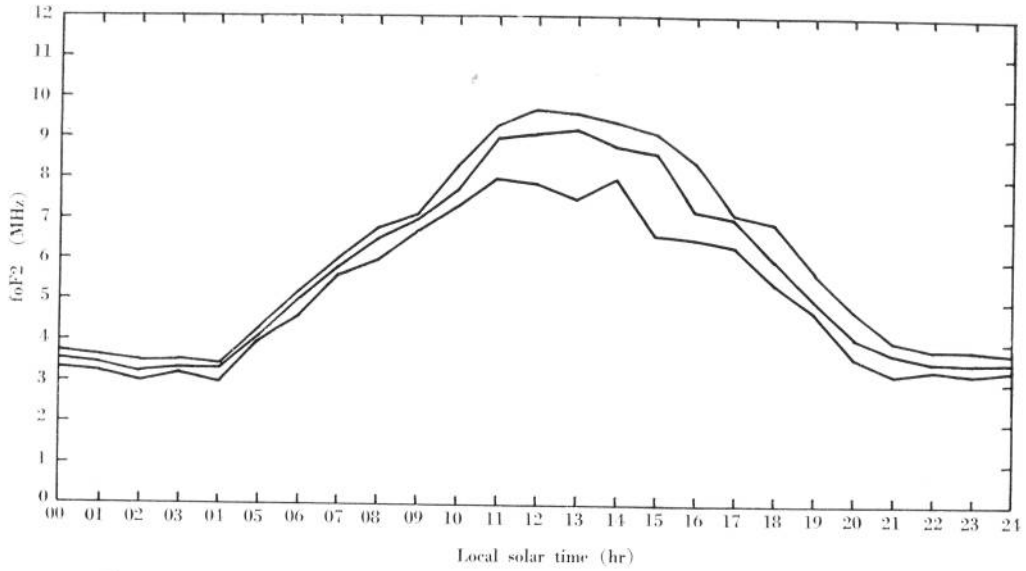

Fig. 3. Median and upper and lower quartiles of foF2 values at Gough Island.

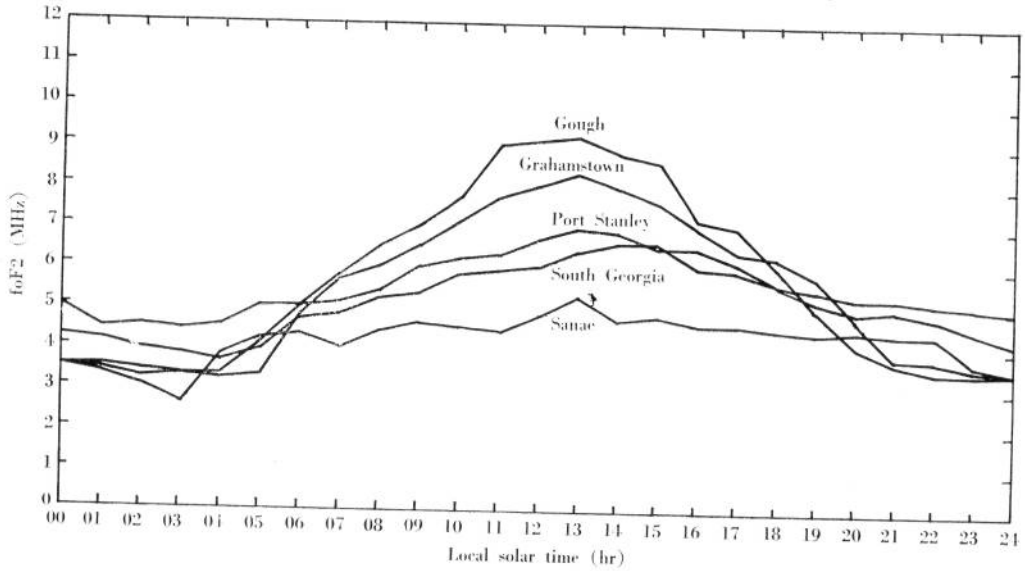

Fig. 4. Comparison of median foF2 values at five selected stations.

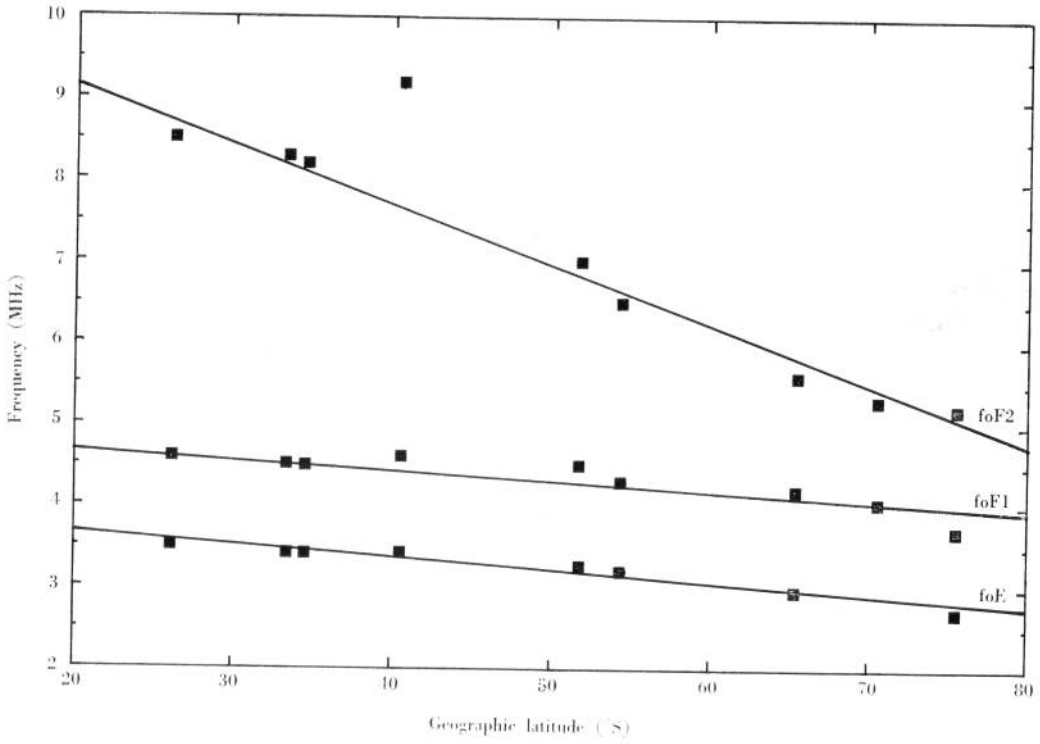

Fig. 5. Maximum median foF2, foF1 and foE values versus geographic latitude.

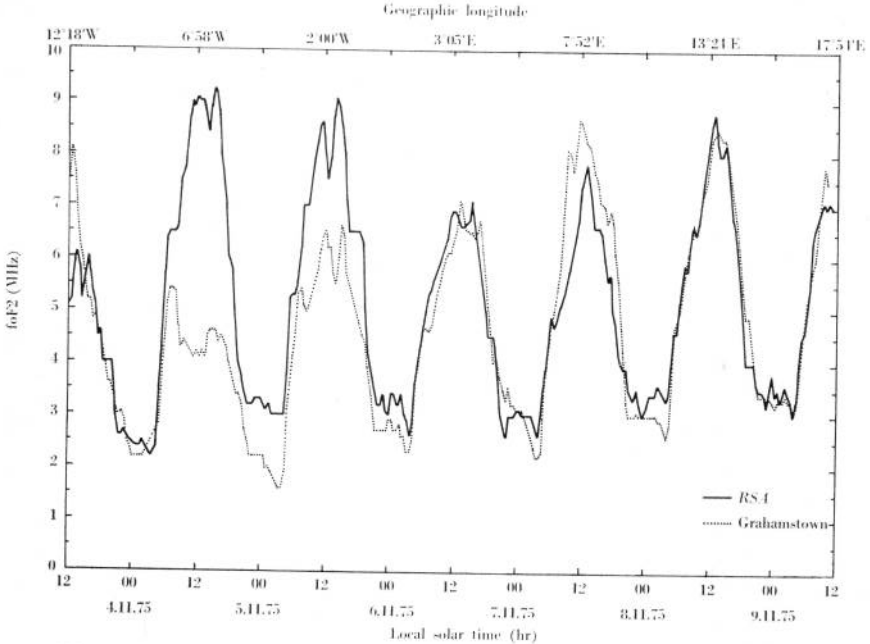

Fig. 6. Values of foF2 observed on the *RSA* and at Grahamstown during the return voyage, 1975.

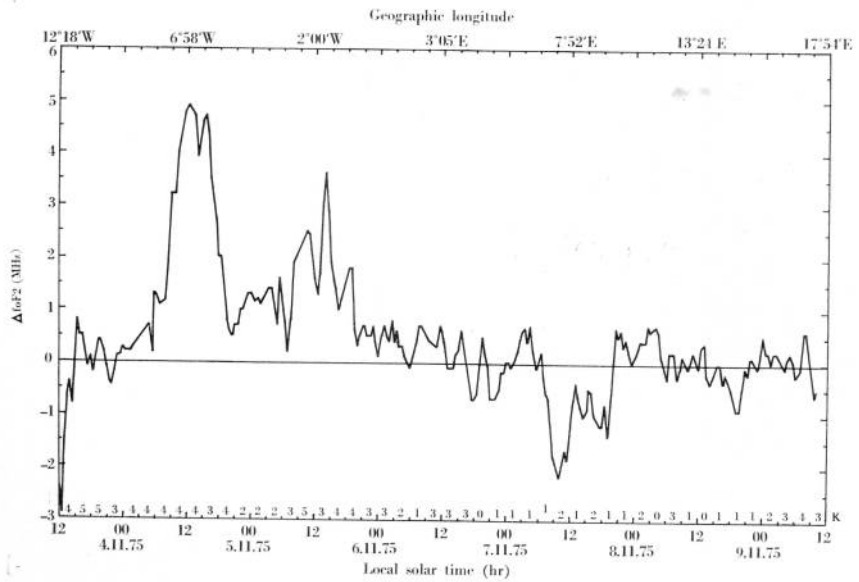

Fig. 8. ΔfoF2 values between the *RSA* and Grahamstown, return voyage, 1975. Hermanus *K*-indices above abscissa axis.

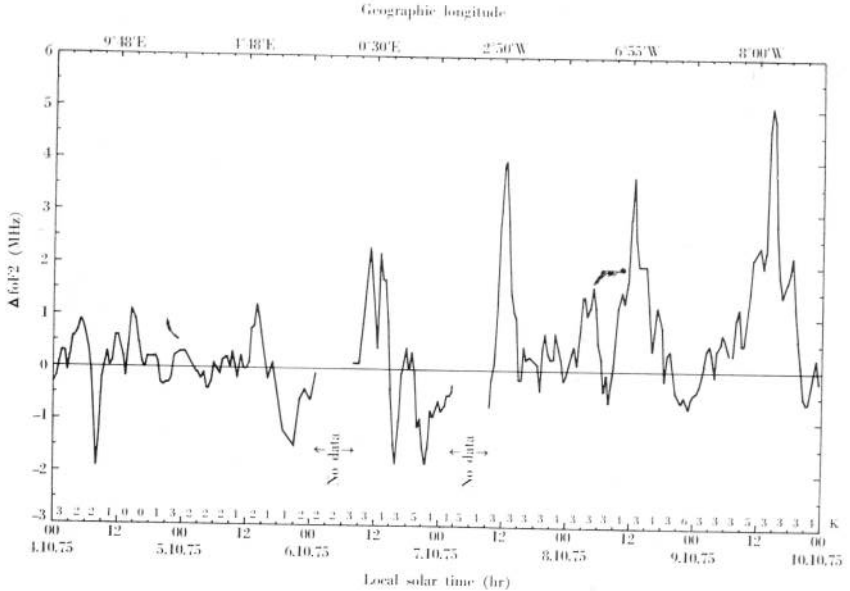

Fig. 7. ΔfoF2 values between the *RSA* and Grahamstown, outward voyage, 1975. Hermanus *K*-indices above abscissa axis.

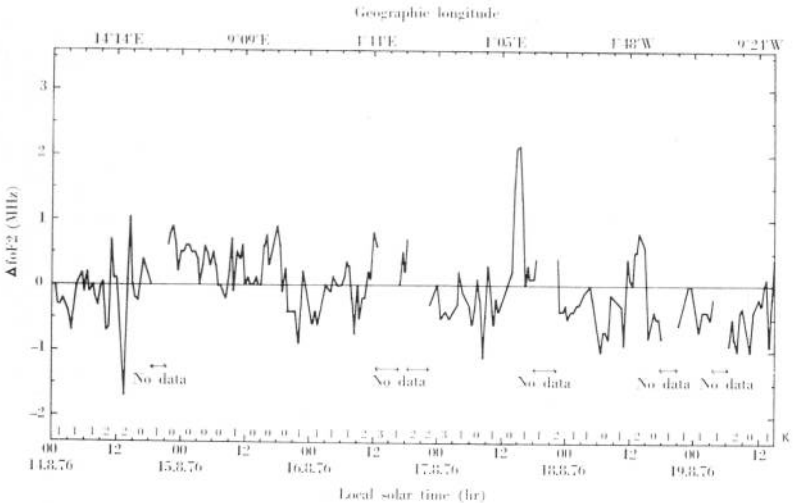

Fig. 9. ΔfoF2 values between the *RSA* and Grahamstown, outward voyage, 1976. Hermanus *K*-indices above abscissa axis.

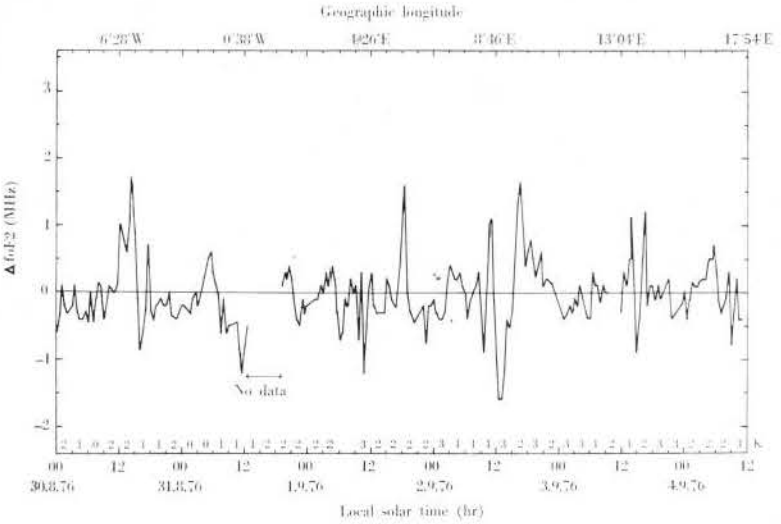

Fig. 10. ΔfoF2 values between the *RSA* and Grahamstown, return voyage, 1976. Hermanus *K*-indices above abscissa axis.

(54,4 °S), Argentine Islands (65,3 °S), Sanae (70,5 °S) and Halley Bay (75,5 °S). The variation is surprisingly regular, with the exception of foF2 at Gough Island, which deviates from the straight line shown by about 1,5 MHz. It may not be a coincidence that Gough Island is also the only station which lies inside the zone marked 'South Atlantic Anomaly' in Fig. 1. Most workers who have made satellite-borne observations over the South Atlantic have reported *increases* in the electron density there (Gledhill, 1976), in agreement with this hypothesis.

Results during voyages

The courses followed by the *RSA* during the voyages to and from Gough Island and Tristan da Cunha hardly deviate from the geomagnetic latitude 34 °S, which corresponds to a value of 1,75 of McIlwain's (1961) parameter *L*. Thus the observations might be expected to show up the longitudinal dependence of phenomena due to precipitated particles, if such existed.

Figure 6 compares the values of foF2 recorded on the *RSA* with those recorded at Grahamstown for the corresponding local time during the return voyage from Tristan da Cunha in 1975. The geographic longitude of the ship at noon each day is shown at the top of the figure. It is very striking that the values over the South Atlantic exceed those at Grahamstown by as much as 5 MHz at 7 °W, far in excess of the normal difference between the medians at Gough Island and Grahamstown near local noon, as shown in Fig. 4.

Similar graphs were prepared for the other three voyages, but the results are more clearly displayed by plotting ΔfoF2, that is, foF2 observed on the *RSA* minus foF2 observed at Grahamstown at the same local time. These values are shown in Figs 7–10 for the four passages through the region between Cape Town and the islands. In all four cases the values are shown as functions of local solar time, so that the longitudes at the top run in opposite directions for the outward and return trips.

Figures 7 and 8 show that foF2 over the ship was abnormally high compared with that at Grahamstown during both the outward and return trips in 1975, especially during the daylight hours. The region concerned lies between 0 ° and 9 °W on both trips so that it lies to the west of the 'Airglow Anomaly' found by Greenspan and Stone (1964). Unfortunately, the highest values of the magnetic *K*-index coincide with the passage of the ship through the same region in both directions, so that it is not possible to draw any definite conclusions from the abnormal behaviour. During the 1976 voyage, high values were observed between 14 °E and 7 °W during daylight hours on most days on both the outward and return trips; the differences are much less, however, and the *K*-indices are also lower than during the previous year.

Greenspan and Stone (1964) observed enhancement of both 557,7 nm (OI) and 427,8 nm (N_2^+) emission in the region shown in Fig. 1, in the vicinity of 35 °S, 6 °E. Van der Walt *et al.* (1966), making observations from an aircraft following the route taken by Greenspan and Stone, also observed an enhanced emission of the 557,7 nm line at about 38 °S, 1 °W in both flight directions. This region lies close to that in which maximum intensity of electron precipitation has been predicted by Torr *et al.* (1975). No particle E was observed on any of the voyages reported here. We conclude that, although it is possible that an anomaly of some kind does exist in the region between Gough Island and Cape Town, many more observations will be necessary to confirm this.

Acknowledgements

We thank the Department of Transport, which financed the voyages and the research programme of which they formed a part; also Captain E. Funk, the officers and crew of the *RSA* for their co-operation during the voyages and at Gough Island. We also thank Mr J. Lichtenberg, who was responsible for most of the design and construction of the portable ionosonde, for operating it during the 1976 voyage.

References

Ginzburg, V.L., Kurnosova, L.V., Logachev, V.I., Razorenov, L.A., Sirotkin, I.A. and Fradkin, M.I. Investigation of charged particle intensity during the flights of the second and third space ships. *Planet. Space Sci.*, **9,** 845-854, 1962.

Gledhill, J.A. Aeronomic effects of the South Atlantic Anomaly. *Rev. Geophys. Space Phys.*, **14,** 173-187, 1976.

Greenspan, J.A., and Stone, C.A. The longitudinal variation of night airglow intensity in the region of the South Atlantic magnetic anomaly. *J. geophys. Res.*, **69,** 465-469, 1964.

McIlwain, C.E. Co-ordinates for mapping the distribution of magnetically trapped particles. *J. geophys. Res.*, **66,** 3681-3691, 1961.

Torr, D.G., Torr, M.R., Walker, J.C.G., and Hoffman, R.A. Particle precipitation in the South Atlantic geomagnetic anomaly. *Planet. Space Sci.*, **23,** 15-26, 1975.

Van der Walt, A.J., Stoker, P.H., Maree, J.P., Zeeman, P.B., and Hamm, F.M. Airglow and enhanced penetrating electromagnetic radiation in the southern radiation anomaly. *Space Res.*, **6,** 189-202, 1966.