IONOSPHERIC NETWORK ADVISORY GROUP (INAG)*

IONOSPHERIC STATION INFORMATION BULLETIN NO. 39**

* Under the auspices of Commission G, Working Group of the International Union of Radio Science (URSI).

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1. INTRODUCTION

by W.R. Piggott, Chairman

This issue has largely been contributed by our colleagues and members in Australia and New Zealand and will, I hope, start a sequence of such regional or national efforts. I would like to express the thanks of INAG, myself, and our secretary, Alan Rodger, for these contributions. In my opinion, the network has become too reliant on the efforts of the Chairman in the past and it is essential for more people to contribute so that the organisation does not collapse when I am no longer available. Most workers in the field have been used to the system which has operated throughout their active working lives and do not realise that the service has been provided mainly by the efforts of a few individuals.

I have become interested in low latitudes particle phenomena in recent years and am astonished at how little is known about it. Even the satellite observations of particle precipitation from the Inner Van Allen belts have not stimulated any interest in the ionospheric phenomena which are readily observable with conventional or digital ionosondes. This is a particular example of a general problem. Most research people do not realise the value of studying existing data, particularly from a very powerful technique such as that provided by ionosondes. Thus most low latitude workers study phenomena reported from temperate latitudes but fail to study phenomena which are only seen at their latitudes. Another common misapprehension is that everything worth knowing was found by the pioneers 50 years ago. I have recently had cause to look at sporadic E over Western Europe and was surprised to find that the behaviour of the phenomena has changed considerably in the last 40 years. For example, the regular class of sporadic E, in which foEs-foE or fbEs - foE showed a large peak at 0.6MHz, is now much less evident. At some stations this dominated the Es behaviour averaged over the year, giving rise to explanations based on the magneto-ionic theory which are now known to be incorrect! No one has noticed this change in behaviour! Ever since the I.G.Y., the magnetic co-ordinates of most stations have shifted by between 100 and 300 km. Where conditions are changing rapidly with magnetic co-ordinates, this has caused large changes in local phenomena, which has not been reported. Possibly the current shortage of funds for research may encourage more interest in such phenomena which can be studied very cheaply. If so, rapid progress should be expected as the type of problem is complementary to those best studied by satellite, rocket or incoherent scatter.

Although the VI network is at present expanding rapidly, despite the loss of some old established stations, I feel that I ought to stress that not enough is being done locally or regionally to study the data obtained. It is also getting more and more difficult to maintain a skeleton network of ionosondes which have operated for many years to monitor long term changes, because the authorities believe that enough data have been obtained in the past. No one bothers to ask whether new phenomena are now present, so these go undetected.
So far most computer-controlled digital ionosondes have been used for particular research problems or in an exploratory mode. Little work has been done on identifying parameters, which have general significance and could really be used to widen the application of soundings techniques. This is largely because the amount of work needed to exploit a very flexible system properly is very large. One of the many reasons for the success of the VI network has been that physically interesting phenomena can be monitored and measured using very simple and quick techniques. As more workers become conversant with such equipment this will improve, but at present the rate of progress is disappointingly slow.
However, there are a number of problems raised by conventional sounding which could he solved with existing software by just taking sufficient samples. For example, the distortion of the F layer traces in the presence of tilt is a natural study. This could give statistical data to enable M(3000) to be corrected when such effects are present. Currently, this probably causes a systematic decrease in M(3000) medians of unknown magnitude - a point of considerable interest to operational users. Similarly, much controversy on the interpretation of Es traces could be resolved by adequate samples from such equipment. For example, is the systematic change in angle of incidence with frequency found by Dr. Wright for a case of strong sporadic E typical ? (The deviation angle is zero up to fbEs and then increases to foEs). What happens when weak sporadic E is present? If it is due to clouds, the point of reflection should show a random scatter. If it is due to a partial reflection, it should stay vertical.
If it is the same as the dense case studied, then it should change with frequency systematically for each ionogram. Some years ago, when such equipment was first developed, our Honorary Member, Mr. A.R. Shapley, made a list of such problems, none of which have been studied yet, as far as I know.

2. SOME COMMENTS ON PREVIOUS INAG ARTICLES

(a) COMMENTS ON "NEW PARAMETERS OF THE F1 LAYER"

by Professor K. Rawer, West Germany

The following comments have been received from Professor Karl Rawer on the note by Shchpepkin and Vinitsky on New parameters on the F1 layer published in INAG 37, pp. 5 - 6.

While foF1 is quite well defined whenever a maximum of h' occurs, readings under L-condition always suffer (a) from some personal judgements of the scaler, (b) from the particular frequency scale applied to the ionogram. The new procedure should be able to eliminate (a) at least. This is a remarkable improvement.

In view of a more satisfying physical interpretation of any F1-parameter, one should systematically study the method with different scaling laws of the ionogram (this could easily be done on a Computer) then compare the results with a high accuracy 'true height' profile computed from the same ionogram. I should like to stress the need to do such comparisons for many ionograms.

This is another indication that profile studies can not reasonably be undertaken with a few selected cases or with the 'median ionogram' method but need a statistically significant number of individual cases, taking account of systematic changes with hour, season, location and, possibly, lunar phase. Unfortunately, we do not have too many series of profile computations fulfilling this condition.

(b) A COMMENT ON INAG 38 SECTION 8

by R.W. Smith, World Data Centre - C1
for Solar Terrestrial Physics

In relation to our Chairman's welcome comments on my research note 'Deriving the M(3000) factor from the x-trace' I should like to ask him the following question: 'Why is the separation between the observed MUFs for the o- and x-modes not normally greater than fb/2, where fb is the gyro-frequency at the reflection point'. If the M(3000) factors are the same, one would expect this separation to be fb/2 x M(3000) or approximately 3fb/2 for a path of 3000 km.

Chairman's comments:- Experimentally, if $MUF(d)_O$ is the o- mode MUF and $MUF(d)_X$ is the corresponding x- mode MUF then $MUF(d)_X$ - $MUF(d)_O$ = fb/2. In most cases, it is equal to fb/2, but for certain special and rather rare cases, it can fall to zero. This is in accord with numerical ray-tracing calculations using the full magneto-ionic theory and can be deduced from the differences between the curves of Bookers complex variable q or q^2 for the two components. Physically the phase of the wave describes loops in both the vertical and horizontal planes during the refraction process. One component sets itself along the field, the others across the field in the physical zone of reflection. This theory then simplifies to the no field approximation for one mode (o) and one in which q involves fb/2 in the other. In energy terms, reflection occurs when the upward component of energy is fully used in exciting electrons. The horizontal component is not 'significant to the reflection process so the form of the reflection condition is unaltered as the angle of incidence changes. The number of electrons needed to reflect the wave in either mode decreases as the angle of incidence increases, giving the well-known MUF factor distance relation but the separation of the two components is unchanged.

(c) A COMMENT ON INAG 38 SECTION 10

by R.W. Smith, World Data Centre-C1
for Solar Terrestrial Physics

Scalers of high latitude ionograms will have found the article in INAG 38 'A daytime crossing of the auroral oval at Halley Bay' both interesting and informative. I agree with the interpretation and the values given in the table on page 12, except for foF2, fxI and h'F2 at 1430/1445 where I would have replaced G by Y. My reason is based on sequence and from 062 at 1345 to less than 044 at 1430/1445 and then increase to 052 at 1500.

Chairman's Comments:- The distinction between cases when G and Y should be used when F2 lacuna and slant Es are likely to be present are always difficult and occasionally not uniquely determinable. They give most trouble at stations where these phenomena are infrequent and for this reason INAG simplified the problem by saying 'Use G unless there is clear evidence that Y (lacuna) is appropriate.' In most cases of G, severe tilts are also present so Y can theoretically be used. However, there is much scientific interest in the occurrence of lacuna associated with slant Es and it is therefore desirable to restrict the use of Y in these cases, to examples where there is little doubt that F2 lacuna was present. Experimentally, strong examples of Fl lacuna often proceed to total lacuna (no F traces seen) but otherwise F2 lacuna seems to be due to a different cause and shows a different morphology. Thus the interpretation adopted is in accord with INAG recommendations.

Examining the 1430 and 1500 ionograms in detail, they show severe tilts at foF1 as indicated by typical 14UF noses at 1430 and inverted noses at 1500. This is unusual and has not been reported with lacuna type phenomena. In general, large decreases in foF2 are accompanied by small decreases in foF1. The tilts at hmF1 must be considerable to give the patterns shown- Mr. Smith may be right and certainly cannot be proved to be wrong, though my guess would be that this is a G. A good check would be to look at the local magnetic traces. Short lived G conditions are normally associated with large deviations in the magnetic field.

3. SEMI-AUTOMATIC SCALING SYSTEMS

by P.J. Wilkinson, Ionospheric Production Service, Australia

Many organisations use semi-automatic methods to scale ionograms in a computer accessible form. Such methods normally involve projecting the ionogram image onto an active tablet from which the co-ordinates of ionospheric parameters can be retrieved and interpreted in a computer. Normally, the final output from the computer is the scaled data already checked for internal consistency. Because this approach can produce significant reduction in data handling costs and can be implemented quite cheaply, it will be used more frequently in the future. For instance, a commercially built system, the KEL-46 (INAG 38 p13) is now available. In view of the anticipated greater use of these methods, it is timely for INAG to open discussion on semi-automatic scaling and possibly offer guidelines for future development and use. Hopefully, the following comments will stimulate further discussion.

1. Accuracy

In manual scaling, the human eye can make reasonable allowances for non-orthogonal axes (eg, resulting from distorted images) and non-linear scales (eg, resulting from film movement irregularities). A semi-automatic method must be supplied with the position of the ionogram and sufficient information to correct for these effects when present. If the ionogram image is not held fixed with respect to the tablet to within, typically, a millimeter while scaling takes place, then the resultant scaled values will probably be in error by amounts greater than normal URSI accuracy limits. Clearly, new positional information must be entered each time the ionogram is moved.

Ideally, the positional observations should be repeated after scaling so that this can be verified before the scaled parameters are accepted by the computer.

2. Scaling restrictions

If a scaling system is to be successful, it must reduce the workload of the scaler while maintaining scaling accuracy. This includes both qualitative accuracy and, more importantly, accuracy of interpretation.

Semi-automatic systems, in almost any form, will reduce the overall cost of producing scaled data from ionograms. However, requiring the ionogram image to remain fixed during scaling of all hourly parameters can result in a loss of flexibility. Normally sequences of ionograms are used to resolve ambiguities in interpreting parameters.

A fixed image during scaling can also inhibit the use of overlays and scaling aids. This will he especially true if the projection system is not sufficiently rigid. Again, poor scaling habits can be reinforced with a rapid loss in overall accuracy.

These scaling restrictions are an unfortunate by-product of semi-automatic scaling and can only be overcome if it is possible to check and if necessary re-enter positional information at any time during the scaling of an ionogram with a minimum interruption to scaling.

3. Scaling Conventions

Checks on the scaling can be made to ensure that the scaling letter usage is consistent with URSI conventions and the scaled value falls in an expected range. Such checks, while not obligatory for a scaling system, can offer major advantages and can be especially useful for training new scalers on the job. If handled in an interactive mode, data corrections can often be detected and corrected while scaling the ionogram resulting in significant reductions in handling. INAG should, however, offer guidance on an acceptable set of checks and possibly even maintain a standard which is to be equivalent to normal scaling conventions.

While checks have many positive aspects, it is possible for scalers to encounter ionogram_that seem to defy scaling conventions. This may be because the initial interpretation is ambiguous or inaccurate, or because the checks in use are not correct or the ionogram is quite unusual. Scalers need to scale these but the ionogram involved should be logged for further consideration. Such ionograms may well be good examples for INAG to study.

There should also be some discussion on the negative aspects of consistency checks. On-line scaling checks will allow the scaler to always scale consistently irrespective of the ionogram. Inconsistency in a data set can be a valuable indicator of changes in data quality alerting the experimenter to potential problem areas.

4. Data Handling

Although data may be scaled using a semi-automatic system, it is quite possible that because no further computer facilities are available locally, the digitised data are then lost to the international community. This problem has already been raised by Mr. Kelly of KEL Aerospace (see INAG 38 p. 13) and INAG should consider it further. While it is unlikely that INAG will be able to recommend a standard format and media for data collection, it can certainly promote organisations with computing facilities who are able to convert between types of media.

5. Software Reliability

At the heart of all semi-automatic scaling systems is a computer program. Most programs will have been designed to handle specific hardware conditions and even, potentially, local ionospheric conditions. INAG should consider whether it is reasonable to set up tests for these program_to establish that they actually carry out the functions for which they were designed.

6. New parameters?

INAG may wish to promote new or alternative parameters which can be conveniently scaled using a semi-automatic system but which would be unreasonable n a manual system. For instance, a height and frequency pair are scaled for each ionogram parameter and very few extra points would be required to define the ordinary ray trace for most ionogram_. INAG should also be concerned with improving techniques for scaling old parameters so that the full computing power is utilised efficiently. M(3000)F2, for instance, can be scaled in different ways using a semi-automatic system.

<u>Chairman's Note</u>: This contribution comprises of two parts:-

(a) a section describing difficulties which arise when semi-automatic (or automatic) analysis is started. This should be considered by all starting such programmes as many difficulties can be avoided by initial training.

(b) Suggestions for improving and standardising; semi-automatic procedures and outputs. These are very valuable but need testing. INAG would like to hear views from others using such techniques.

4. PROJECT I S A A C

(International South Atlantic Anomaly Campaign)

Ever since the days of the first satellite observations of the fluxes of high-energy particles in the South Atlantic Anomaly, there has been interest in the possible atmospheric effects of the precipitating particles. Recently Gledhill and Hoffman (J. Geophys. Res., <u>86</u>, 6739-6744 (1981)) have published electron fluxes-observed near 300 km altitude by the satellite AE-C. From the observed fluxes it may be estimated that there should normally be observable extra ionization in the D and E regions, especially at night, giving about 1 R of emission at 391.4 nm.

Project I S A A C is designed to investigate these predictions. The research vessel S.A. Agulhas will pass through the region of greatest precipitating electron flux as observed by Gledhill and Hoffman, carrying an ionosonde, a riometer and photometers. Simultaneously observations will be made by groups in countries around the South Atlantic - Argentina, Chile, Brazil and South Africa - and the Antarctic stations run by the United Kingdom, United States of America and South Africa. Some of these involve the observation of electromagnetic waves passing through the Anomaly, others are concerned with the observation of upper atmospheric phenomena by the conventional methods, ionosondes, riometers, airglow photometers, etc.

Cooperation is sought with all groups having an interest in the South Atlantic Anomaly. In particular, the organiser would welcome agreements to turn on and record data from any relatively low-level satellites that will pass through the region during the campaign.

The ship is due to leave Cape Town on 23 June 1983 and sail to Gough Island. From there she will cruise towards the Brazilian coast, turning southwards at about 30° S 50° W and returning to Cape Town along the 40° S parallel, arriving back about 2 August.

Enquiries for space aboard the vessel are welcome, as are all offers of collaboration. The address is:

Prof. J.A. Gledhill
Organizer, Project I S A A C,
Department of Physics and Electronics,
Rhodes University,
GRAHAMSTOWN,
6140,
South Africa

Chairman's Note:

This is a good opportunity to promote interest in low latitude particle phenomena at stations all round the world as well as in the South Atlantic zone. Practically nothing is known about the ionospheric effects of such precipitation. The Chairman has seen such effects in a wide range of longitudes at magnetic latitudes near 22° N and S. We badly need to know the morphology of both the world-wide low latitude precipitation zone and that associated with the South Atlantic Anomaly. Phenomena to look for include:

(i) sudden changes in F-layer structure or Spread-F at night, often associated with increased absorption.

(ii) large changes in the behaviour of foF2 and M(3000)F2 on some storm days

(iii) presence of storm types of Es, typically Es-a.

(iv) abnormal behaviour of Es on stormy days, e.g. sequences of normal Es becoming scattered (resembling Es-q) and sometimes associated with Es-s.

(v) Abnormally low Es-l especially at night.

5. STATION NOTES

Ilorin, Nigeria

A new ionospheric observatory began operating with an IPS-42 ionosmeter on 1 October approximately 250 km north of Lagos. Orthogonal wire delta aerials are used for transmitting and receiving with the ionograms recorded on 16 mm. black and white film. The data will be analysed using a KEL-46 Data Analyser (INAG 38 p. 13). For further information or discussions of possible collaborative work, write to:

Professor John Oyinloye,
Dean of Science,
University of Ilorin,
Ilorin,
Nigeria

Kochel

INAG has been informed that this station was operational between July 1938 and May 1946 with monthly median data produced from July 1940. At present, efforts are being made to procure tabulations or at least monthly medians for inclusion in the World Data Centre system.

Turin (Torino), Italy

Turin was not operational between 28 April and 15 September, 1982 due to equipment difficulties.

Argentine Islands, Antarctica

An IPS-42 ionosonde has been successfully deployed at Argentine Islands, and became the observatory instrument from 11 January, 1983.

6. THE NEW ZEALAND IONOSONDE NETWORK

by C.A. Roper, Geophysical Observatory, Christchurch,
New Zealand

Ionospheric soundings have been made by New Zealand workers since the early 1940's. In the time since then various types of sounder have been employed, from home-made hand-tuned units through J28's and C4's to the New Zealand designed and built P's which are now being replaced by KEL-made IPS-42 ionosondes.

There are three stations in the continuous recording chain. The station at Christchurch is currently located at Godley Head at the entrance to Lyttelton Harbour. The technical maintenance is carried out by staff from the Geophysical Observatory in Christchurch. The P2 ionosonde is operating concurrently with an IPS-42 at the new station at Eyrewell. Godley Head is to be replaced by Eyrewell, 40 km away. Operations at Godley Head are likely to cease in December, 1982 (See INAG 38 p. 4).

Campbell Island station has been operating since 1942. It is operated and maintained by technicians who are part of the Meteorological Services party stationed on the Island for a year. An IPS-42 was installed during August 1982 and operated alongside the C2/3 for some time. The latter equipment was returned to New Zealand in November 1982.

The ionosonde at Scott Base has been operating since 1957. Staff of the Antarctic Division of DSIR are employed on a yearly basis to operate and maintain the scientific equipment at the base. The present P2 equipment will be replaced by an IPS-42 in January 1983. The P2 will be returned to New Zealand later that year.

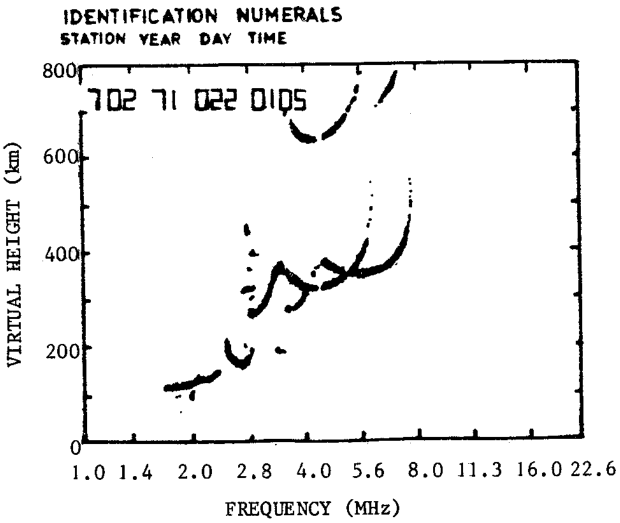
Records from all the ionosondes are returned to the Christchurch offices of the Observatory for detailed interpretation. Six-hourly values of foF2 are read at the stations and passed to Christchurch for transmission to the Ionospheric Prediction Service in Australia each week. Scaling of ionograms is in accordance with URSI standards. The use of a digitising table and a computer program which automatically creates data files and checks the data for consistence with and observance of the scaling rules has speeded up the publication of results, reduced the workload and improved the accuracy of the readings.

The future of the three stations is assured and expansion in research useage of the equipment is currently being discussed.

7. FORMAT OF THE AUSTRALIAN IONOGRAMS

A number of examples of ionograms recorded on the Australian ionosonde appear in this copy of INAG. All the ionograms have the same format as shown in the accompanying diagram.

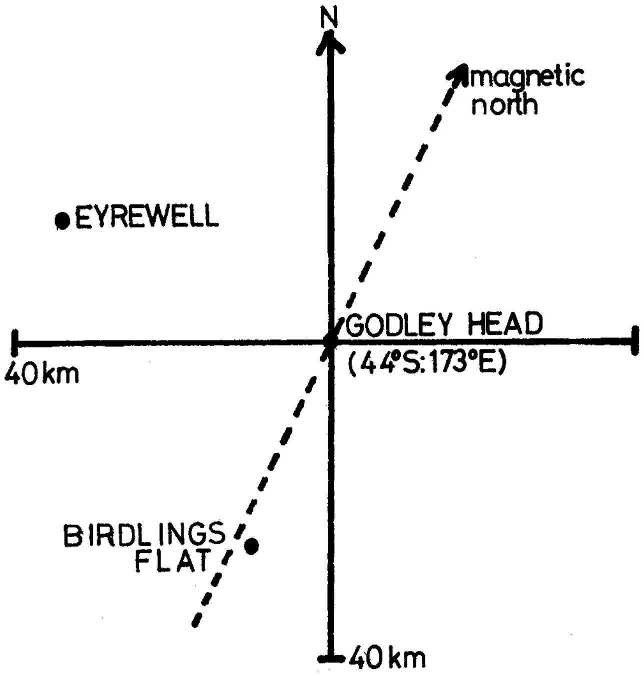
The level displayed on the ionogram between approximately 0 km and 80 km gives an indication of receiver gain. When the level is high the receiver is operating on low gain and the echo returned from the ionosphere will probably be too low in intensity to be recorded. A gap will then appear in the ionogram. trace. Normally, the receiver gain is reduced in response to interfering signals so the level can be used as an indication of interference effects on the ionogram.



8. A THREE IONOSONDE EXPERIMENT

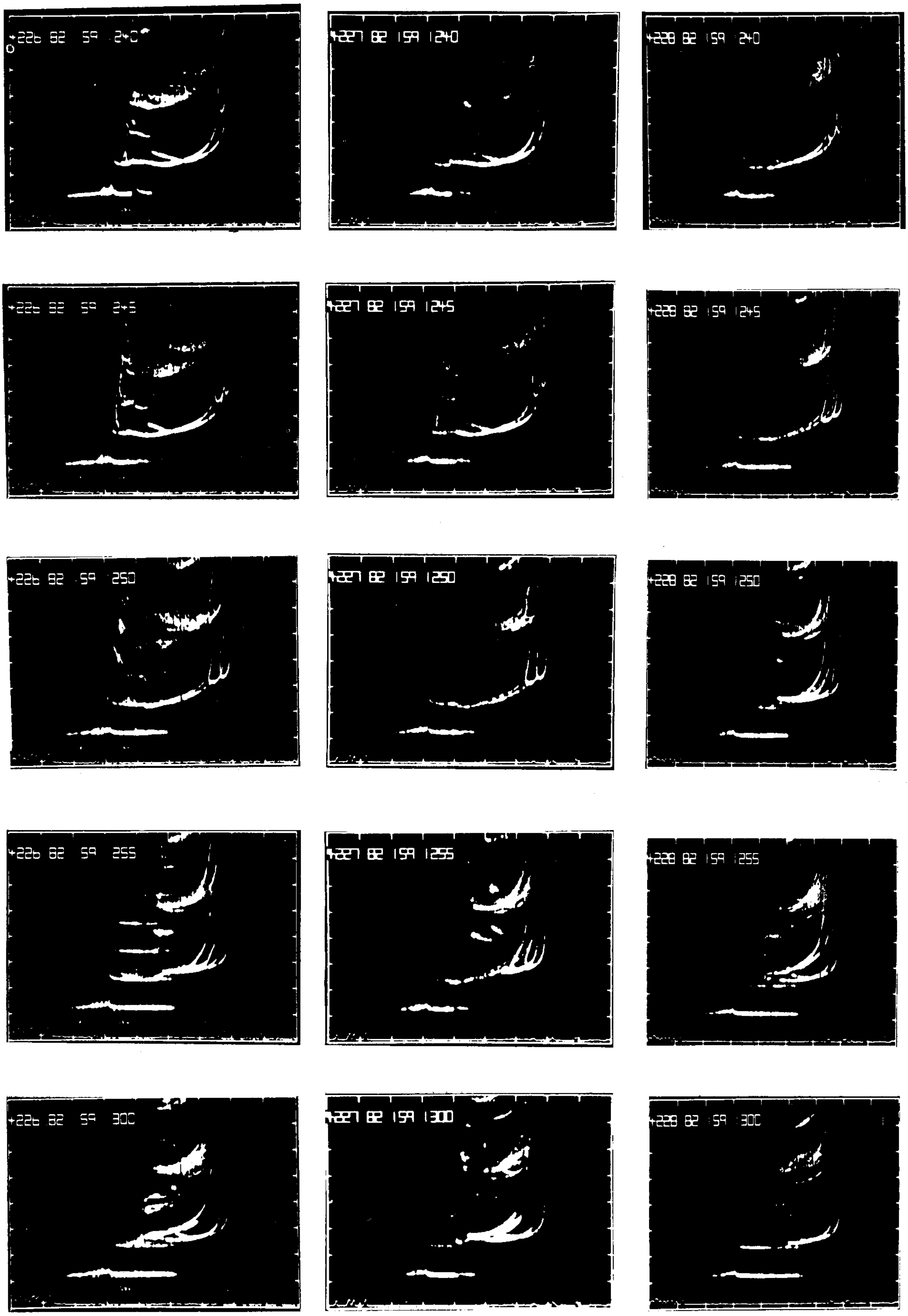
by J. Cooper, Geophysical Observatory, Christchurch

Two IPS-42 ionosondes were available for scientific use near Christchurch, New Zealand during their testing and shakedown period before deployment at Campbell Island and Scott Base (INAG 38, page 4). A triangular array was set up with ionosondes at Godley Head, Eyrewell Magnetic Station and the University of Canterbury Physics Field station at Birdlings Flat. These sites are separated by about 40 km and their positions show in the figure



The sequence of ionograms for the three stations recorded at five-minute intervals on 8 June, 1982 is shown on the next page. Station identification is as follows:

4226 - Godley Head
4227 - Eyrewell
4228 - Birdlings Flat


+227 82 159 1240
+227 82 159 1245
+227 82 159 1250
+227 82 159 1255
+227 82 159 1300

The ionosonde data for the 8th June have been analysed in several different ways.

The data for day 159 has been analysed in several different ways:

(1) The speed and direction of disturbances have been found from timelags obtained from direct visual comparison.

(2) The F1-transition analysis of King (1969) and Lawden (1969) has been used to determine ledge shape height profiles of electron concentration and the production rate of ionisation in the F1 region.

(3) The results of a correlation analysis of the virtual height changes between stations have been compared with those of (1).

(4) True-height reductions are to be performed in the near future.

Theoretical work in support of the experimental analysis includes ray-tracing studies of radio-waves propagation in a distorted ionosphere, which has largely successfully reproduced the ionogram traces observed in the F2 region, and a calculation of the wind and changes in production of ionisation near the Fl peak arising from this passage; consequently, the shape of the Fl layer internal gravity waves.

A paper on this work is in preparation.

References

King, C.A.M., J. Atmos. Terr. Phys., 31, 515, (1969).

Lawden, M.D., J. Atmos. Terrestrial Phys., 31, 47 (1969).

Some Comments by Alan Rodger

The sequence of ionograms presented by Dr. Cooper are an excellent illustration of some of the similarities and differences which can be observed in the ionosphere over a comparatively short distance. At a first glance the ionograms from Godley Head and Eyrewell show very similar first order F region traces through most of the sequence shown. The ionograms from Birdlings Flat show some differences to the ionograms from the other stations at the same time. However, closer comparison of the ionograms shows that the F region traces at Birdlings Flat are almost identically reproduced 5 minutes later at the other two stations, for example, compare 1250 at Birdlings Flat with 1255 at the other observatories.
This strongly suggests that the disturbance is travelling in a geographically north-east direction, i.e. in the magnetic meridian and assuming it has a plane wave front, then the speed is approximately 360 km/hour which is a typical speed for a medium scale travelling ionospheric disturbance.

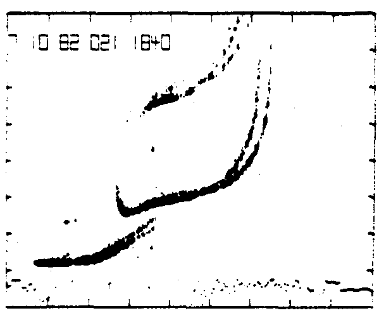
The number and frequency extent of the multiple order traces (see UAG-23A, pages 15 - 17) on the Godley Head ionograms is consistently greater than on the Eyrewell ionogram suggesting that the overall sensitivity of the equipment at Godley Head is higher than at Eyrewell. Also, fmin is consistently lower at Godley Head than at Eyrewell providing confirmation of the observation.

The receiver sensitivity at the two stations appears to be similar as indicated by the line in the 0-50 km height range. Thus, the difference in sensitivity of equipments at the two sites probably results from a difference in the antennae used. Overall system sensitivity may be responsible for the differences in foEs observed between Eyrewell and Godley Head, though additional information would be required to test this hypothesis.

9. SLANT TYPE SPORADIC E OBSERVED IN AUSTRALIA

by P.J. Wilkinson, IPS, Australia

Slant type sporadic E has been seen at Townsville (19° S Geographic (GG), 28° S Geomagnetic (GM) and 48° S dip(D)), Canberra (35° S GG, 44° S GM, 66° S D), Sydney (34° S GG) and Hobart (43° S GG, 52° S GM and 73° S D). An example is enclosed here for Hobart. On this particular day slant types Es was observed between 1745 and 1900. During this period examples similar to those presented in INAG 35, P8 were observed and in addition splitting of the slant into two traces was observed as shown in the 1840 ionogram.



During the summer of 1981-82 slant Es when present was most frequently seen in the late afternoon and legs often in the morning around 07-08LT. This is typical for the Hobart station.

On the occasions when slant Es was observed at Sydney, a similar event was not seen at Canberra (about 180 miles away) suggesting this could be quite a localised phenomenon although, the transitory nature of the event reduces the significance of this result. To date, no obvious lacuna event has been observed in association with slant Es.

A more careful study will be made of the occurrence of slant Es at Australian stations in the future.

Some Comments on Es-s by Alan Rodger

The work of Oleson and colleagues in the northern hemisphere and Sylvain and others in the south (see INAG 35, page 5 for references) have provided us with a good description of the conditions under which Es-s is observed in the auroral ozone and polar cap. However, since the publication of the Es-s example from Wuhang in INAG 35 page 8, a considerable interest in the phenomena at lower latitudes has been aroused. Dr. Wilkinson's example above further illustrates that Es-s is not uniquely a polar feature. There is a very real need for further observations of Es-s and this provides an ideal opportunity for ionogram scalers at all latitudes to make a major contribution to our understanding of the ionosphere by noting with particular care occasions when Es-s is observed. Present theory for the formation of Es-s at high latitude requires a very large electric field (15 mVm^{-1}) to be present. Fields of this magnitude are thought to be very rare outside polar regions.

I have not seen many examples from stations equator ward of the auroral zone, but the nature of the Es-s observed at these lower latitudes does appear to be different in a number of respects. For example, Es-s at lower latitudes does not appear to be such a weak and intermittent trace as is normally observed at higher latitudes. The occurrence of Es-s at lower latitudes does not appear to be associated with increased absorption in the frequency range of the Es-s or with increases in fmin as is frequently seen at higher latitudes. Lacuna with lower latitude events is rare or absent. To date I have not seen an example of an Es-s layer from lower latitudes which extends significantly above fxE in frequency; this contrasts strongly with high latitudes, e.g. UAG-23A, page 57. Many more observations of Es-s are necessary especially from magnetic mid and low latitudes before these impressions can be confirmed.

The types of question which an ionogram scaler could answer are:-

a) When does Es-s occur?
i) time of day
ii) season
iii) solar cycle

b) What phenomena seem to be related to the occurrence of Es-s? At high latitudes lacuna is very strongly associated, but at other latitudes large changes in foF2 or virtual height of the layer might be seen or even local thunderstorms might be present (as these can be a source of electric fields in the ionosphere).

c) Is there any relationship between the occurrence of Es-s and magnetic storms?

d) Is the appearance of the Es-s traces always strong, always weak or variable? Under what conditions does the appearance of the layer change?

e) Is the rise in virtual height of the Es-s layer with increasing frequency always the same? If not, how does it vary?

f) If ionogram scalers can combine data from more than one observatory, what is the spatial extent of individual cases? Dr. Wilkinson notes an occasion when Es-s is not observed at a station 180 km away. Is this normal?

I would encourage ionogram scalers to send further examples to INAG and the results of any analysis which they can carry out.

10. AN EXAMPLE OF BLANKETING?

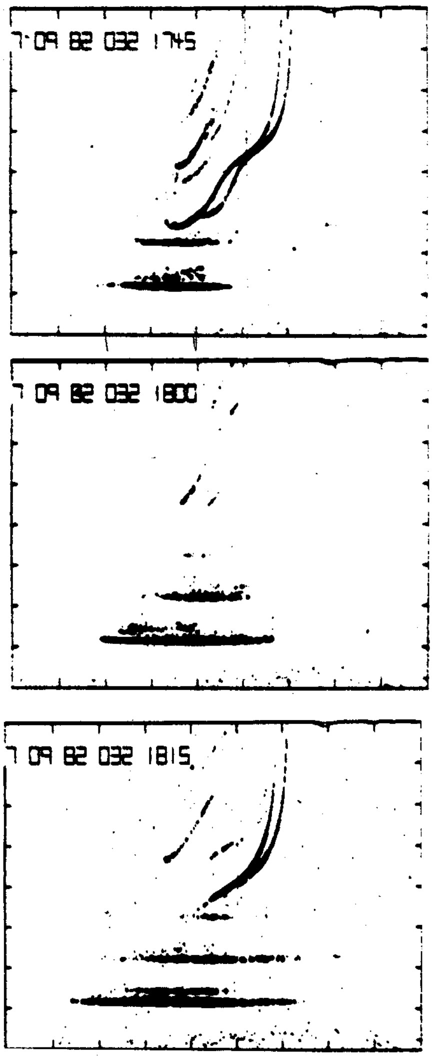
by P.J. Wilkinson, Ionospheric Prediction Service, Australia

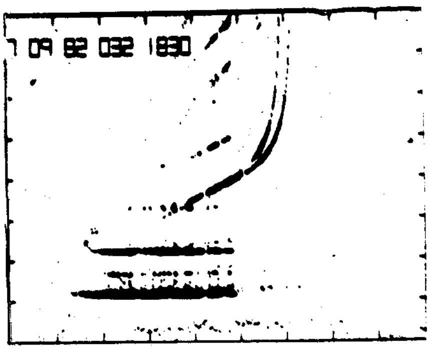
Date 1 February, 1982

Place Townsville (19° S - 147° E)

Question How should foF2 and fbEs be scaled at 1800?

Summary A sporadic E layer appears to be blanketing the F region. However, from the sequence, foF2 > ftEs suggesting blanketing is not the entire explanation. Two other possible contributing factors are interference and tilts in the F region. (The ionograms are otherwise quite normal for this time of the day).





1 . Tilts

Arguments for a tilted F2 region.

- 2F, although weak and possibly defocused, is present.
- the lower F1 region shows significant changes on each 15 minute ionogram.

Arguments against tilted F2 region.

- foF2 and most of the trace above 6MHz is unchanged between 1730 and 1830.

Conclusion: The stability of the F2 region is strong evidence against the presence of tilts. A tilt large enough to cause F2 lacuna would normally show some precursor. The tilts in the F1 region are not unusual for this time of day and at most would only affect returns below 5.6MHz. A tilt is possible only as a subsidiary effect.

2. Interference

Arguments for interference

- There is some evidence for a change in interference between 1745 and 1800. On a 4B ionosonde, interference results in a reduction of receiver gain, the change in gain being displayed between 0 and 50 km on the ionogram. There is a slight AGC gain change apparent between ftEs and 8MHz.

Arguments against interference

- Similar AGC gain changes are evident at 1815 which have little effect on the ionogram.

Conclusion: There is some evidence for interference effects and if foF2 were already a weak trace, the drop in gain might be sufficient to eliminate it. However, this would not eliminate fxF2 also. Interference could contribute, but it is probably a subsidiary effect.

3. Blanketing

Arguments for blanketing

- the sporadic E layer is blanketing at 1745, and foEs is significantly higher at 1815.
- fbEs is dropping between 1815 and 1830 suggesting blanketing could have been higher still at 1800.
- 2ftEs >1ftEs (just) at 1815 suggesting the Es layer contains blobs of more intense ionization. The satellite first-order Es trace suggests similar structure.

Arguments against blanketing

- 2ftEs >1ftEs by over 2MHz so probably fbEs is less than foF2 by 2MHz.
- 2F, although weak, appears to be present.
- ftEs will be the x-component and there is some evidence for foEs being less than ftEs. Even if the Es layer is blanketing to ftEs, then F layer O-Mode trace should be present.

Conclusion: Although there is strong evidence for blanketing there does not appear to be evidence for the sporadic E layer to be totally blanketing up to ftEs.

Summary

- Although some blanketing is certainly present, there does not appear to be good evidence for total blanketing above 2ftEs.
- Interference could possibly prevent the F2 region being seen above ftEs.
- Tilts in the lower F1 region may result in blanketing of this layer while still allowing 2F, N and M echoes to be observed below 5.6 MHz. However, there appears to be no good evidence for tilts in the F2 region.
- Allowing this, there is still a gap between 2ftEs and 1ftEs where some F2 return would be expected.

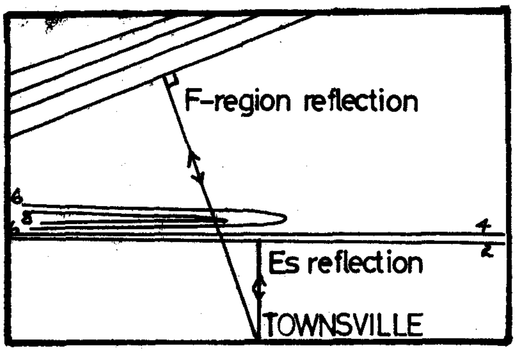
Suggested scaling:

fbEs = 2ftEs = 056
foF2 = 076IA

<u>Some additional comments on this blanketing example</u>

<u>by Alan Rodger</u>

Dr. Wilkinson has provided a very good summary of the arguments which can be used for interpreting this interesting sequence. However, it should be noted that there is a strong indication of a small tilt in the F2 region on the 1745LT ionogram: The height of this second-order trace at 4.0 MHz is slightly less than twice that of the first order. See section 2.72 of UAG-23A for a discussion of small tilts. This combined with the observations made by Dr. Wilkinson that foEs and fbEs are both changing relatively quickly with time, and that 2ftEs >1ftEs at 1815 strongly suggests that blanketing is responsible for the missing F layer at 1800. The sketch shows a possible configuration of the iso-ionic contour for 1800 and illustrates how the F-layer can be blanketed, yet the ionogram shows a lower value of foEs than necessary to cause the loss of the F region traces.



The small numbers in the Es layer indicate contours of equal plasma frequency (MHz).
The tilt of the F-region is exaggerated for clarity but could be just a few degrees.

The often under-used qualifying letter I, indicating an interpolated value for foF2,is correctly used.
It should also be possible to determine an interpolated value for M(3000)F2.

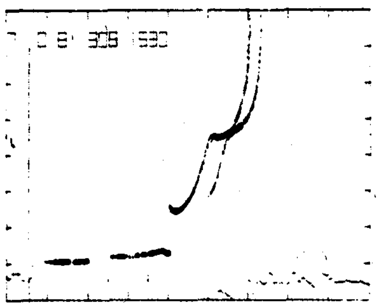
Chairman's note.- When N-,(E + F), M-,(2F + E) or higher multiple reflections are present (UAG-23A, pp 15 - 17), these can give additional information on both the variation of fbEs with position and the tilt. In general, consistency between the top frequencies at Es, 2Es, 3Es...., M's and N's or both, implies that the critical frequency of the Es cloud is either not changing with position or that all echoes are coming from the same direction; usually the latter. When this is not true, M and N reflections are usually further from the station than the Es multiples. A large difference between fbEs, as shown by the F-trace (fminF) and as shown by the multiples of Es or M and N traces means that one or both reflecting structures must be tilted. In cases I have been able to check, the Es has been most often the tilted layer. However, it is easy to cause tilts in the lower part of the F-layer. When this occurs the F-layer trace is usually weak, becoming stronger at the true overhead fbEs. We badly need echo location studies (skymap) to confirm my interpretation. Unfortunately most height measurements are only accurate to 5 km, thus quite significant tilts in the Es layers cannot be distinguished.

11. SOME COMMENTS ON SCALING IN THE PRESENCE OF LOW TYPE ES

by G.T. Goldstone and P.J. Wilkinson.
Ionospheric Prediction Service, Australia.

1. Scaling h'E

The INAG recommendation "that low type sporadic E traces with foEs and fbEs less than foE should be ignored" has been adopted by IPS. The adoption of this rule removes an anomaly that had previously occurred when scaling WE in the presence of a low sporadic layer. A local convention which arose in IPS has now been eliminated. The convention is demonstrated by the three scalings for the Hobart ionogram 1530.



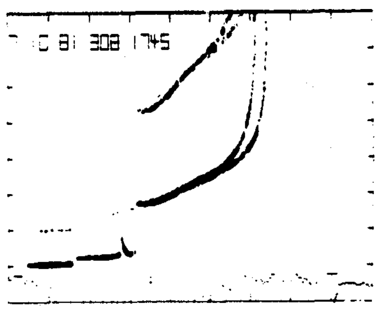
	Type of Es	foEs	fbEs	h'E	Comment
1.	1	020-G	Y	110UY	Incorrect use of Y
2.	1	020-G	G	110UB	Acceptable
3.	1	020-G		110UB	Normal

Scaling 1 demonstrates the convention once adopted by IPS but disputed for some time by Mr. Goldstone. A descriptor Y was used to denote a gap in the trace. Scaling 2 would be an acceptable scaling if foEs and fbEs are to be scaled for the low type Es layer. However, case 3 is the normal convention adopted by IPS now. (Note: there is in fact a second layer with foEs > foE present so foEs and fbEs would be scaled for this layer but for the purposes of this discussion the cusp Es is ignored).

The descriptive letter B is used to indicate why WE cannot be accurately measured. This makes the very reasonable assumption that the absorption is occurring to the normal E region trace between the visible normal E trace and the low sporadic E layer.

2. Is low type Es due to partial reflections?

If the low type Es layer (see 1530 ionogram) is a partial reflection, then it is also probably only a weak return made to look strong by the echo processing and display characteristics of the Australian Ionospheric Prediction Service 4B ionosonde, (the 4B ionosonde is virtually identical to the commercially produced IPS-42 ionosonde). If the 4B is accentuating a weak return so that it can be mistaken for a strong return then this would obviously cause concern. However, this does not appear to be the case for low type Es reflections observed at Australian stations above the gyro-frequency. Such a belief is supported by the multiple of the low Es layer seen on the 1745 Hobart ionogram. Also, low Es layer seen on the Sydney ionosonde, which is co-sited with an A1 vertical absorption experiment, appear quite dramatically on the Al as total reflections, the normal E region being blanketed. Not all low type Es can be dismissed as partial (and therefore weak) echoes.



Consistent with comments made in the Australian Operator's Conference report (INAG 36, P10), IPS would scale fmin from the low type Es layer and always include low type as the second Es type. If no other sporadic E layer is present the type only is recorded. No value is given for foEs or fbEs unless foEs is greater than foE.

3. Inconsistency in figures showing the z-mode.

There is an inconsistency between figures 1.4a, 1.5 and 1.6 in describing the z-mode in UAG-23A.

Figures 1.4a to c correctly portray the relative positions of the x- o- and z- modes for a single reflecting layer. However, in figure 1.5 and 1.6 there is a distinct turnup in the o-component near fzE. This is accentuated in UAG 23 for the same diagrams. In figure 1.6 the end of the o- component clearly stops at fzE. Both these diagrams are in conflict with figure 1.4a where the o- component passes continuously through fzEas expected.

While these diagram are probably good generalisations of real ionogram, it seems unreasonable to show any turnup or to terminate the o-component in the special position it occupies in figure 1.6; at fzE.

These diagrams were used by Rodger (INAG 34, P14) as partial justification for identifying traces on ionogram below the gyro-frequency as z-mode echoes. Unfortunately, the inconsistency between the figures has resulted in some doubts at IPS about Rodger's identifications.

In the absence of absorption, both o- and z- modes could be present in all the examples discussed by Rodger. However, all these examples show only one obvious mode. Either the o-mode is not present, absorption being greater for the o-mode than the z-mode, or the coupling process for the z-mode is not effective. It is not obvious that the two modes can be simply resolved on the basis of a single ionogram.

In fact, all the examples quoted look like low type Es. In particular, the example from UAG 50, P79 carried the additional comment that the h'E would normally be expected to be 130 km whereas the trace at 0.5 MHz, identified as a z-trace, appears closer to 90 km.

4. Scaling fmin.

At IPS we always scale fmin as the lowest frequency at which echoes are observed on an ionogram thereby treating fmin primarily as an equipment parameter.

As the 4B ionosonde has a low frequency limit of l.0MHz, and echoes would not normally be seen below l.6MHz due to broadcast interference, the question of which magnetoionic mode is being scaled for fmin rarely arises. However, if the z-mode echo is obviously lowest frequency observed, fmin would be scaled from it and described by z.

When fmin is scaled from a low Es layer, the presence of a low type Es is always recorded. This means fmin can later be used for absorption studies, all values measured from low type sporadic E being treated separately.

By regarding fmin first as an equipment parameter and second as an absorption parameter the problem of dealing with weak traces and different magneto-ionic components is eased. Any echo presence indicates the ionosonde is operating and should be used for scaling fmin. By appropriate use of Es types and use of descriptors for fmin (i.e. z) some of the integrity of fmin as an absorption index can also be retained for statistical studies.

If fmin is to be used first as an absorption parameter then the points raised by Rodger in INAG 34 are most important. It would possibly be preferable, in this case, for INAG to consider introducing a further parameter as an optional alternative to fmin.

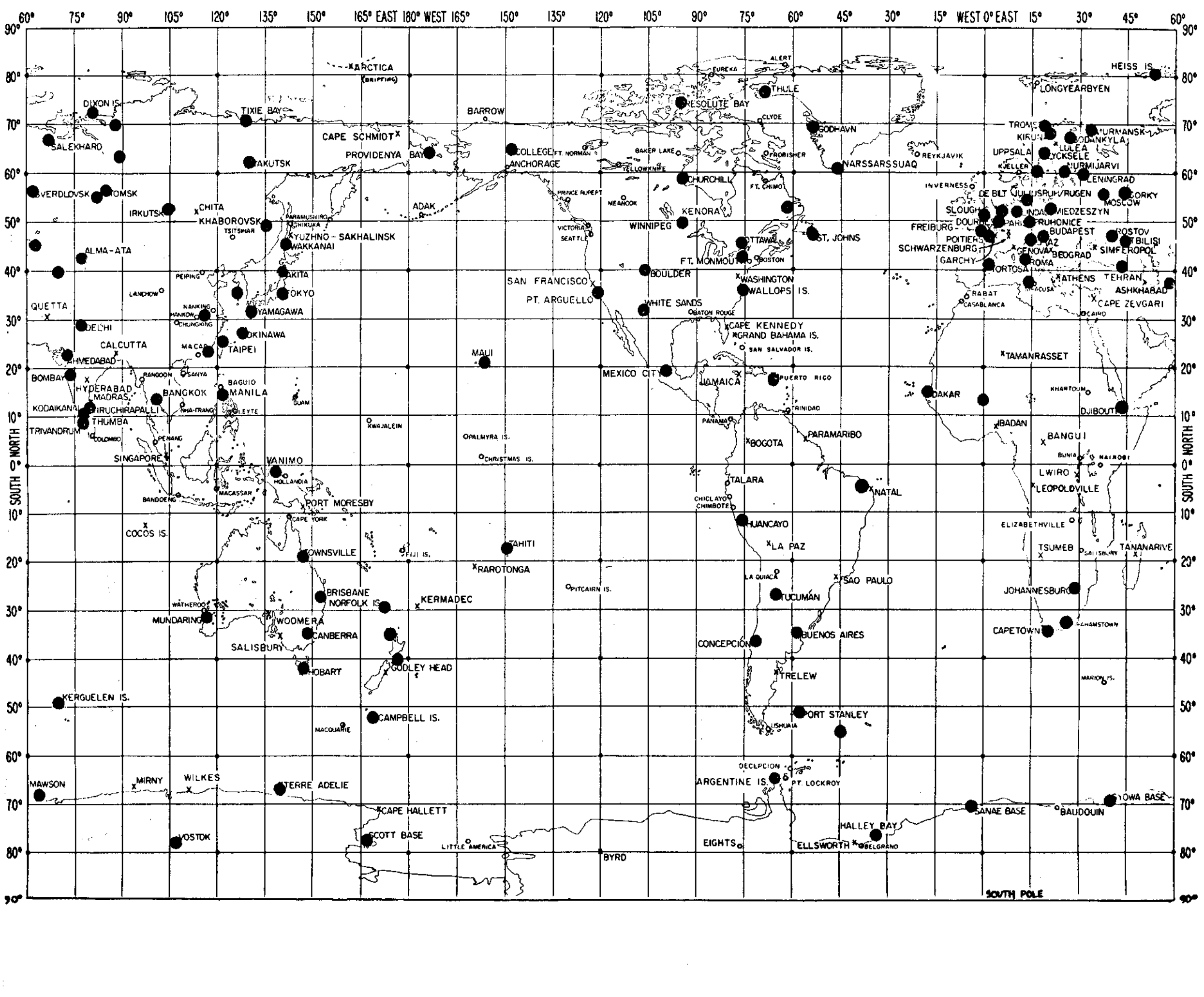
Chairman's comment on section 3, z-, o-, x- traces below the gyro-frequency:- This problem has been described more fully in the I.Q.S.Y. Guide to V.I. sounding. Actually the inconsistency is apparent rather than real. It is due to the different behaviour for thick and thin layers, and to the height at which critical coupling occurs. Unfortunately, magneto-ionic theory as applied below the gyro-frequency has not had attention in recent years and the main points are now forgotten. Perhaps the easiest way of seeing what is happening is to remember that below the critical collision frequency both modes behave as if they were z-mode. Near this level a full wave analysis is essential and shows that the o-mode retardation is imposed on the z-mode. Coupling occurs over a range of frequencies giving rise to partial reflection phenomena. This was first noticed experimentally on F-layer reflections in the presence of a thick E-layer (foE at night is usually near 0.5 - 0.6 MHz). For a thin layer there is no retardation, so no anomaly in o-mode at fzEs. For a simple layer the retardation is not seen as the o mode on the frequencies near fzEs is reflected below the levels where group retardation is found.
Ray-tracing (preferably full wave) studies show that the coupling depends upon the electron density and its gradient near the level of critical coupling. The deviative absorption is always greater for the o-mode than for the z-mode; non-deviative absorption shows the same type of difference at levels above the critical coupling level. The clean z-mode trace often seen when weak Spread-F is present, is due to an entirely different mechanism - the energy of the o-mode signal is scattered so that some travels along the field line and is reflected at fzF2.

Chairman's comment on section 4, fmin:- I concur. INAG has already introduced fm2 as an optional parameter to measure absorption when fmin is not usable. It has had some limited use by the Chairman and his colleagues, particularly for eclipse studies where fmin and fm2 variations are out of phase. Otherwise there has been no interest from most of the community. This is regrettable. One area of possible use would be in studies of the absorption peaks near 25 0 magnetic latitude; these can show regular anomalies in the decimal variation of absorption.

12. VERTICAL INCIDENCE IONOSPHERIC OBSERVATIONS DURING THE INTERNATIONAL MAGNETOSPHERIC STUDY, 1976 - 1979

The map reproduced below shows the locations of the vertical incidence ionospheric observations which were operating during the International Magnetospheric Study 1976 - 1979 and have submitted data to the World Data Center A in Boulder. The map has been prepared by Raymond Conkright and colleagues. Not all the operating observatories identified by a large closed circle have had tMI-s-name reproduced but for those interested, it should be possible to determine the station from its geographic co-ordinates in conjunction with the master tests (INAG 37, p.7, UAG - 38 or UAG-54).

IONOSPHERE VERTICAL SOUNDING DATA, 1976-1979

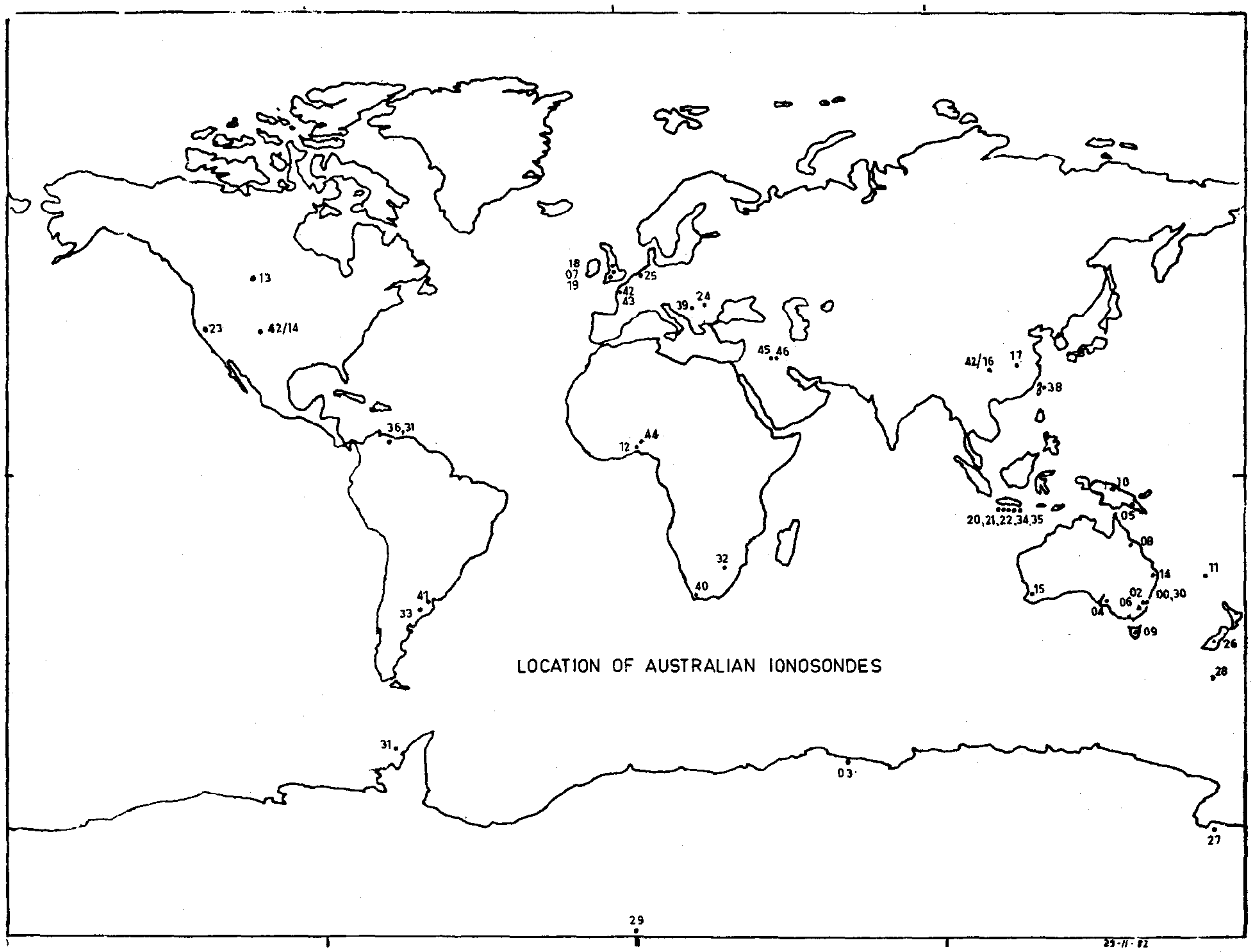


13. AUSTRALIAN IONOSONDE SITES

The map produced by Mr. David Varvel of KEL Aerospace, Australia shows the locations of IPS-42, 4A and 4B ionosondes as of November, 1982. The commercially built IPS-42 ionosondes carry a four figure station identifier number, the first two numbers of which are always 42. For convenience, only the last two numbers are displayed on the map. The earlier 4A and 4B ionosondes, built at the Ionospheric Prediction Service carry only a two figure station identification number (running currently from 1 to 16). Where this causes duplication on the map, the full IPS-42 number has been used. Geographic co-ordinates of stations not included in the list of stations (INAG 37, pp. 7-13) are given in brackets.

00	SYDNEY	08	TOWNSVILLE
01		09	HOBART
02	SYDNEY	10	VANIMO
03	MAWSON		
04	SALISBURY	11	NORFOLK ISLAND
05	PORT MORESBY	12	IBADAN
06	CANBERRA	13	SASKATOON
07	CAMBRIDGE	14	BRISBANE

42/14	BOULDER	33	BUENOS AIRES
15	MUNDARING	34	BANDOENG
16	WUHAN	35	BANDOENG
17	PEIPING	36	CARACAS (10.3N 293.0E)
18	LEICESTER		
19	SLOUGH	37	CARACAS
20	TANGERANG	38	CHUNGE-LI
		39	BEOGRAD
		40	HERMANUS
21	PAMEUNGPEUK (7.40S107.4E)		
22	PAMEUNGPEUK	41	BUENOS AIRES
23	MENLO PARK (Alternative now STANFORD)	42	LANNION
		43	DAKAR
		44	ILORIN (8.3N 4.4E)
24	BEKESCSABA		
25	DE BILT	45	BAGHDAD (33.2N 44.2E)
26	CAMPBELL ISLAND		
27	SCOTT BASE	46	BAGHDAD
28	CHITA		
29	SOUTH POLE		
30	SYDNEY		
31	ARGENTINE ISLANDS		
32	JOHANNESBURG		


LOCATION OF AUSTRALIAN IONOSONDES
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