IONOSPHERIC NETWORK ADVISORY GROUP (INAG)*

Ionosphere Station Information Bulletin No. 24 **

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I. INTRODUCTION

by

J. Virginia Lincoln, Vice-Chairman, INAG

This issue of the INAG Bulletin is months overdue because of unforeseen complications. Much of the manuscript was actually prepared in July 1976 in anticipation that by early August the Chairman's report, the Minutes of the INAG meeting held in Boulder in June 1976, and the *ad hoc* meeting held in Cambridge, England in July 1976, would be completed. For good reasons, our Chairman has been unable to furnish these sections, and we have decided to publish the existing manuscript at this time in order to avoid delaying it further.

As soon as our Chairman's manuscript is available, we intend to issue another INAG Bulletin. We also anticipate issuing a separate edition of the INAG Bulletin to present clarifications to the Report UAG-23, *U.R.S.I. Handbook of Ionogram Interpretation and Reduction,* along with a collection of the various additions or corrections to UAG-23 that were presented in the INAG Bulletins during the past years.

II, The Ionospheric Alphabet
by W. R. Piggott

(Chapter 3, pages 51 and 53, Handbook)

It is widely known that the ionospheric alphabet, the letter symbols used to qualify and describe ionospheric measurements, has a long and interesting history. During this and the next issues of this Bulletin I will give short accounts of how the meanings of the letters were first chosen. While I believe that the accounts given below are in general true, there are a few cases where I am not certain and an alternative may be more accurate. If you have heard such alternatives, please let me know as I will probably be able to remember which was correct.

A - Measurement influenced by, or impossible because of, the presence of a lower thin layer, for example, Es.

The origin of the use of letter A to show effects due to a thin layer comes from Appleton's original name for sporadic E - abnormal E. It was, in fact, in use for absorption measurements before the first ionosonde was built and is thus one of the earliest ionospheric letter symbols. Qualifying letter A (p.6) is a modern extension of the use of A, originally a descriptive letter.

B - Measurement influenced by, or impossible because of, absorption in the vicinity of fmin.

B dates back to the Second International Polar Year, 1932-33, in which it was used at Tromso, Norway, to denote the absence of echoes due to black-out. Its original meaning was 'blackout' - no echoes because of excessive absorption. This was later extended to cases of non-total black-out and hence to the loss of parameters due to high absorption.

C - Measurement influenced by, or impossible because of, any non-ionospheric reason.

In the early days of ionospheric measurements, ionospheric equipments were usually deployed on farms and the usual cause for losing observations was that- cows rubbed themselves against the antenna masts and brought down the antennas. Thus in the very early 1930's, sequences of observations rather often contained the word 'cows!' This was shortened to C and later extended to its present loss or degradation of observations for non-ionospheric reasons.

D - Qualifying letter-greater than, later descriptive letter - Measurement influenced by, or impossible because of, the upper limit of the normal frequency range.

The origin of this letter is somewhat controversial, I believe that it came from the original meaning of Deutsch (German) — great people, though it was first introduced in the major organization of letter symbols made by the World Wide Soundings Committee in preparation for the IGY. Originally D meant only 'greater than' and was invented for two reasons, (a) to enable easy transmission of a greater than sign by telegraph, and (b) to remove confusion between badly drawn greater than signs (>) and numbers in tables. The use of letter D as a descriptive letter followed almost immediately.

E - Qualifying letter - less than. Later descriptive letter - Measurement influenced by, or impossible because of, the lower limit of the normal frequency range.

Again E was originally invented as-a qualifying letter to replace the 'less than' sign (<) and was rapidly extended to include the descriptive letter usage also. E was the next letter in the alphabet to D and so adopted for this purpose. It is one of the few letters without a specific direct link with the phenomena described.

F - Measurement influenced by, or impossible because of, the presence of spread echoes.

Letter F for spread originated from the fact that spread F was widely recognized as the most remarkable abnormality of the F layer. In the earliest days it was written Sp.F. but this was both inconvenient and could cause confusion with letter S so fairly rapidly the Sp. was omitted and F became the recognized letter symbol to show the presence of spread traces in any layer.

G - Measurement influenced or impossible because the ionization density of the reflecting layer is too small to enable it to be made accurately.

The origin of G comes from the reaction of Appleton to the first disturbed ionogram which was made (in those days manually, point by point) which showed no F2 layer. He said 'Good gracious, what has happened to the F2 layer?' and originally GG was written in the F2 parameter table for such conditions. Thus it was natural to shorten this to G when the alphabet was first used systematically.

H - Measurement influenced by, or impossible because of, the presence of stratification.

The history of H is very similar to that of G. Originally people said "what a horrible looking ionogram" (in the early days it was called "record" before the invention of the words ionosonde and ionogram). There was a period when entries for such records were described or qualified by an exclamation mark or question mark but these rapidly caused confusion with the numbers so that H for 'horrible' was used instead.

I - Value has been replaced by an interpolated value.

This qualifying letter was invented by the World Wide Soundings Committee in preparation for the IGY to show the presence of interpolated value.

J - Ordinary component characteristic deduced from the extraordinary component.

This again has a very long history dating back to the mid-1930's. In those days Mr. J. A. Ratcliffe, at Cambridge, in contrast with the other U.K. groups, used to prefer to build up the h'F pattern starting from the highest frequency and moving to lower frequencies. In the days before the interpretation and nomenclature of the layers had been widely accepted and adopted there was much stress on measuring the maximum critical frequency of the F layer and Mr. Ratcliffe felt that it was more reliable to identify this when moving down in frequency. He therefore used to measure the extraordinary component fxF2 and deduce the ordinary from it. This procedure became generally known as 'Jack's procedure', which was shortened to letter J and J has ever since represented the deduction of an o-mode parameter from an x-mode operation.

K - Presence of a night E layer.

In the earliest days letter K was used to denote the presence of storm perturbations on the ionogram and thus to identify disturbed from more normal conditions. Unfortunately there was little agreement amongst different groups about what was meant by disturbed conditions so the use of this letter was killed at the beginning of the IGY. After its original usage had been discontinued for sufficient years to prevent misunderstanding the modern usage to show the presence of a Particle E layer was introduced. At the time when this was first done, it was widely believed that Particle E was normally seen only under disturbed conditions so there was a natural link with the obsolete use of K. While this is still usually true, we now know that Particle E can occur in magnetically quiet conditions so that the historical origin of the letter usage is now slightly misleading.

L — Measurement influenced by, or impossible because the trace has no sufficiently definite cusp between layers.

Originally letter L was used when the F1 cusp was lost and denoted the loss of the distinct F1 layer. At the beginning of the IGY this usage was made systematic by the World Wide Soundings Committee who extended the original meaning L = F1 layer lost, to its present meaning.

M - Interpretation of measurement uncertain because ordinary and extraordinary components are not distinguishable.

Controversial history. I am told that M was largely picked for this situation because people hummed (made the sound mmmmm) when trying to make up their minds whether the trace was an o or x trace. This is possible, but it is also possible that the choice was made from the letters not in use when the W.W.S.C. was unifying the alphabet. I would like to receive a definite statement from whomever was present when this letter was originally adopted.

N - Conditions are such that measurements cannot be interpreted.

N had been in use amongst a few groups well before the IGY as an abbreviation for 'not understood' and this meaning was adopted in general use by the W.W.S.C.

III. <u>Beastie and Beastiemen</u>

by W. R. Piggott

The names 'Beastie' and 'Beastiemen' for ionosonde and the people who operate it, have been in use in Antarctica and some other countries, for nearly a quarter of a century. I am occasionally asked which of the anecdotes about the origin of these names is true.

I believe that the name ‘Beast’ for ionosonde was first used at Port Lockroy in 1952, when the first British automatic ionosonde was sent to Antarctica. This was the largest piece of scientific equipment to be installed at Port Lockroy and gave much trouble both in unloading and making it operate under Antarctic conditions. Thus it was universally known on the base as ‘the Beast’. The interference to gramophones and radio crystallized the use of the name. Later when the equipment was fully accepted the diminutive form, ‘Beastie’ which in English indicates some affection towards the beast, was adopted, and later still this was regarded as an acronym for Beamed Electronic Automatic Sounding the Ionosphere Equipment - probably at the mid—winter party at Halley Bay, who claim to have originated the term. Beastie and Beastiemen are thus historical names for ionosondes and ionospheric staff at U.K. observatories in Antarctica, from which they have spread to other bases operating ionosondes, mainly as a result of technical discussion by radio between stations. I believe that the above account is as close to the actual facts as is at present obtainable, but would like to hear any other stories which have reached you.

IV. Future of Canadian Stations

At the Ionospheric Network Advisory Group of URSI, Commission G, at Boulder, Colorado, June 11, 1976, which was attended by 18 members and observers, the following resolution was passed unanimously:

INAG views with great concern the possible closure of the Canadian chain of ionosonde stations. These stations occupy a key location for studying the Magnetosphere and links between the Ionosphere and Magnetosphere. Data from these stations have been and continue to be widely used by the international scientific community. It is particularly important during the major international study of the magnetosphere (IMS) currently in progress, that these stations remain in operation.

H.F. techniques will continue to play a major role in world communications and it is necessary to continue ionospheric sounding at key sites around the glob-e both to improve our understanding of the medium and to monitor long term changes due to movements of the magnetic poles. The Canadian stations are particularly important for these purposes.

INAG urges the Canadian authorities to maintain their network in operation, at least to the end of IMS (1979).”

B. Currie, Canadian IMS Coordinator, has sent the news in October 1976 that the regular Canadian ionospheric stations will continue to operate for at least another year. Operation will be subject to annual review. A letter of December 6, 1976 from T. R. Hartz of CRC, Canada, confirms this with the exception of the closing of the station at Kenora as of December 31, 1976.

V. Uncle Roy’s Column

JANUARY 1977

Missing Traces

The following sequence has been contributed by Richard Smith, Appleton Laboratory, Slough, for discussion by INAG.

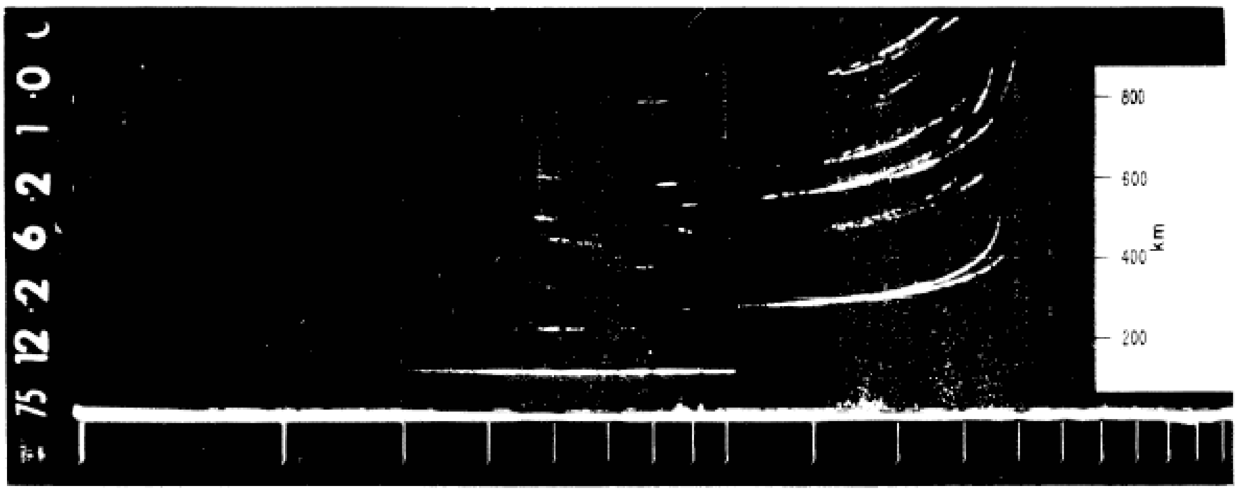
“At Port Stanley we have had some problems due to missing traces. This effect is illustrated in the sequence of three ionograms. We would like an explanation of what is happening and advice on the numerical reduction and use of letter symbols in these examples.”

While quarter-hourly records would have been much more informative, a reasonable estimate of what is happening can be obtained from the sequence shown.

0.5 1.5 2 3 4 6

Figure 1. Port Stanley, December 26, 1975 (2100-summer night).

Figure 1. 2100



foF2 is 057, h’ for the F trace at 3 MHz is 285, h’F would be either 270-A or 270UA depending on the height accuracy in use. The true value is likely to be about 5 km below that seen. A strong Es trace is visible with 3 multiples having h’Es = 115, 220, 325. This suggests that the Es layer is not horizontal (Figure 2.5, Handbook, page 36). Strong (2F — E) = (N), and (2F + E) traces are visible at frequencies about 3 MHz, i.e. well above foEs. These imply a rapid variation of foEs and distance and some tilt either of the Es or F layer. The heights of the F multiple traces are consistent so the ionogram shows that the tilt is in Es layer. Note the (2F + E) trace is only about 70 km above the 2F trace. We conclude that at 2100 we have near horizontal F layer with a tilted flat type Es below it. Figure 2 shows the mechanism of reflection of the (2F - E) trace.

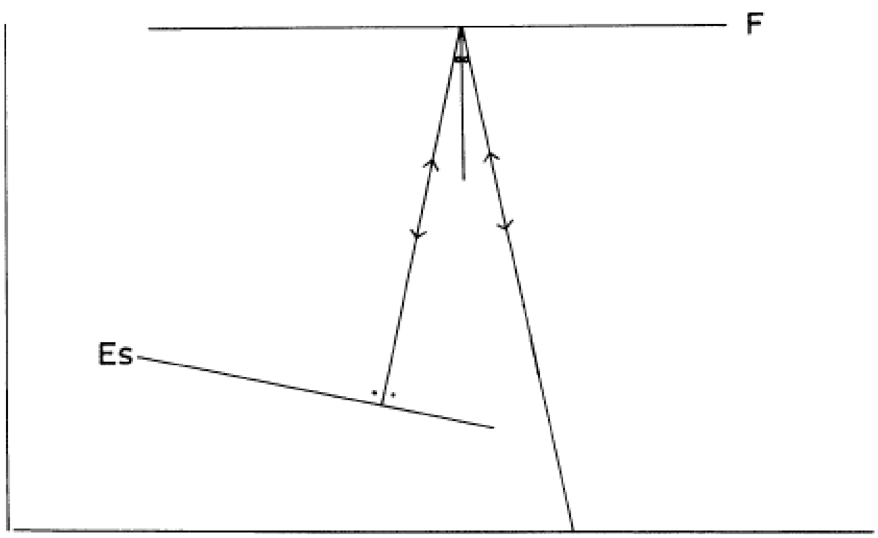
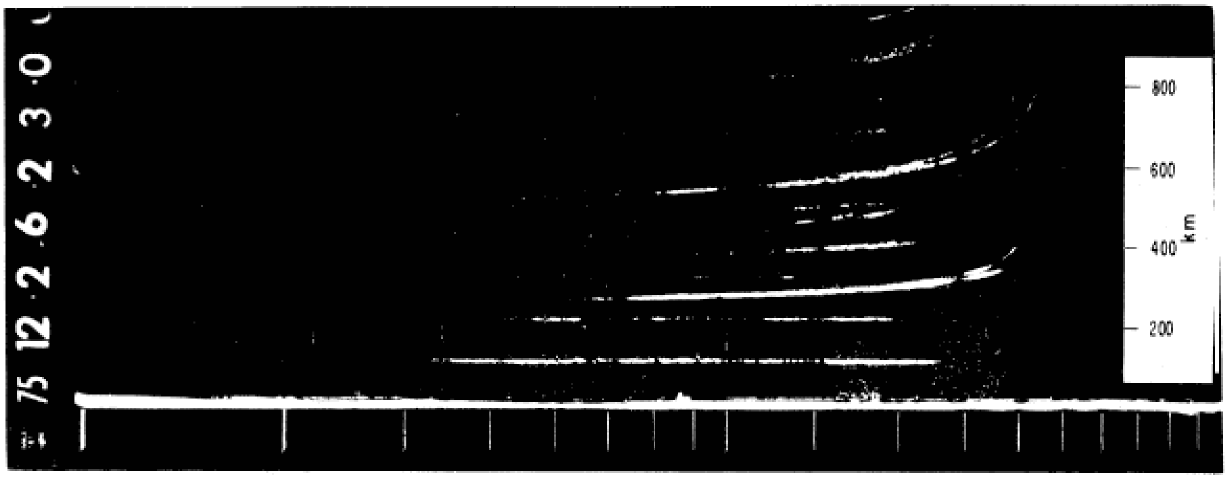


Figure 2. Mode of reflection from a horizontal F layer and tilted Es or E layer (oblique M reflection).

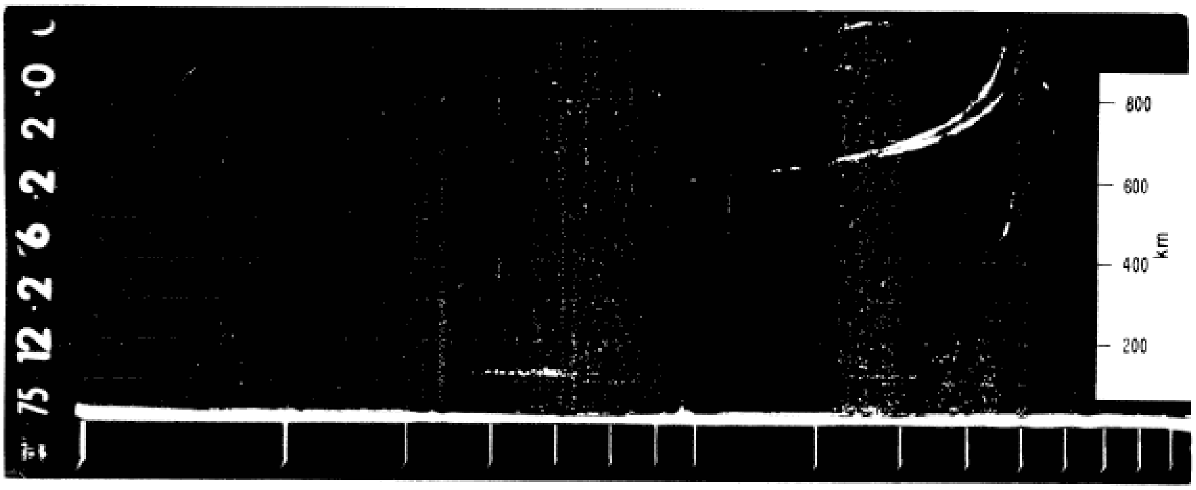


0.5 1.5 2 3 4 6

Figure 3. Port Stanley, December 26, 1975 (2300)

Figure 3, 2300

foF2 is 061, h' for the F trace at 3 MHz is 280, consistent with that seen at 2100. h'F is given 265-A or 265UA (note the second order trace which is seen to a lower frequency would suggest h'F = 260). Three strong



multiple Es are present at heights near 118, 218 and 320 kin, again consistent with a tilted Es layer. foEs is O4lJA and the value of fbEs given by the F trace, about 012, is much lower than would be expected from the strength of the multiple Es traces. These would suggest fbEs = 039AA. The presence of (F + E), and (2F - E) and (2F + E) traces again suggest a tilted Es layer and again the height differences confirm this. The F layer multiples are again consistent with a near horizontal F layer. Thus both before and after the difficult ionogram we have blanketing by a tilted Es layer.

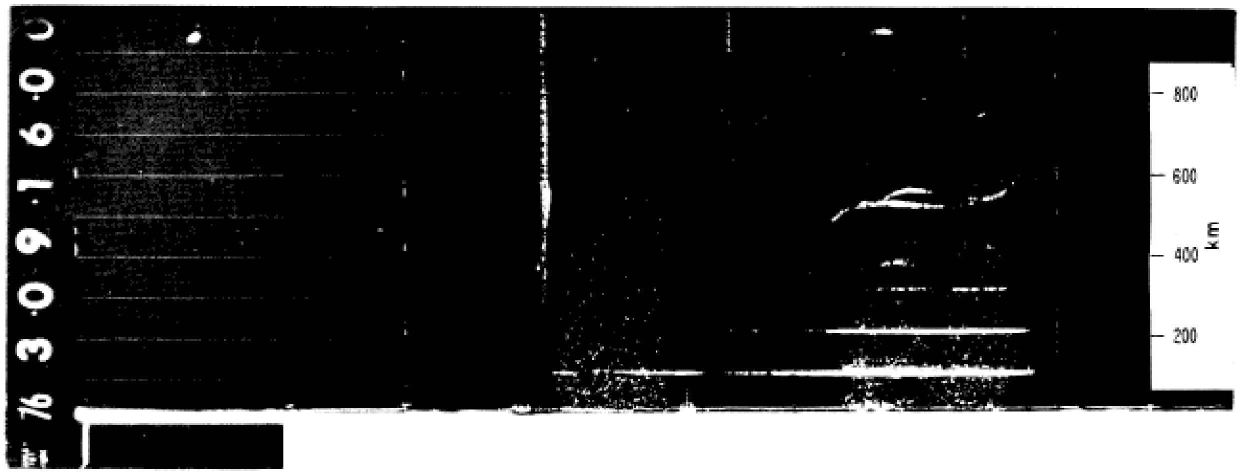
0.5 1.5 2 3 4 6

Figure 4. Port Stanley, December 26, 1975 (2200).

Figure 4, 2200, the abnormal ionogram.

Comparing the virtual heights at 3 MHz for all three ionograms it is clear that the main F-type pattern at 640 km is due to a (2F + E) reflection. The corresponding second order F traces at 3 MHz at 2100 and 2300 were 570 and 560 km respectively so that the observed trace is 80 km above the expected height for a 2F trace at 3 MHz. This is consistent with the (2F + E) trace seen at 2100. The expected height for a (2F + E) mode with little tilt in either layer would be at least 675 km at 3 MHz.

The weak trace with a critical frequency of 058 MHz could be either a first order o-mode trace similar to that found at 2100 but is also consistent with an CE + F) mode trace when compared with the 2300 ionogram. In my view no certain interpretation is possible. The sequence makes it fairly certain that the normal F traces are missing because of the effect of a tilted blanketing Es so that physically the best description of the ionogram would be foF2 = 057UA, all other F parameters replaced by A. fbEs = OSSAY. The Es traces on this ionogram are very remarkable. This is the first time in which I have seen an apparently strong blanketing tilted Es layer without seeing strong multiples at abnormal heights. The two reference ionograms give the usual pattern for a



tilted Es layer. Note that the values of fmin in the three ionograms are consistent, suggesting that the absorption was normal. This is an occasion on which the availability of quarter hourly ionograms, even if not usually analyzed, would have given enough information to make an interesting short article.

This is clearly not a lacuna in the normal sense, but I feel that the average operator would be justified in using lacuna rules for it, replacement letter Y. It is of course essential to recognize that the trace is not a 2F trace.

I would like to throw the interpretation of the ionogram open to fuller discussion so that a consensus of how to reduce examples of this type can be decided. Please send your comments to the Chairman.

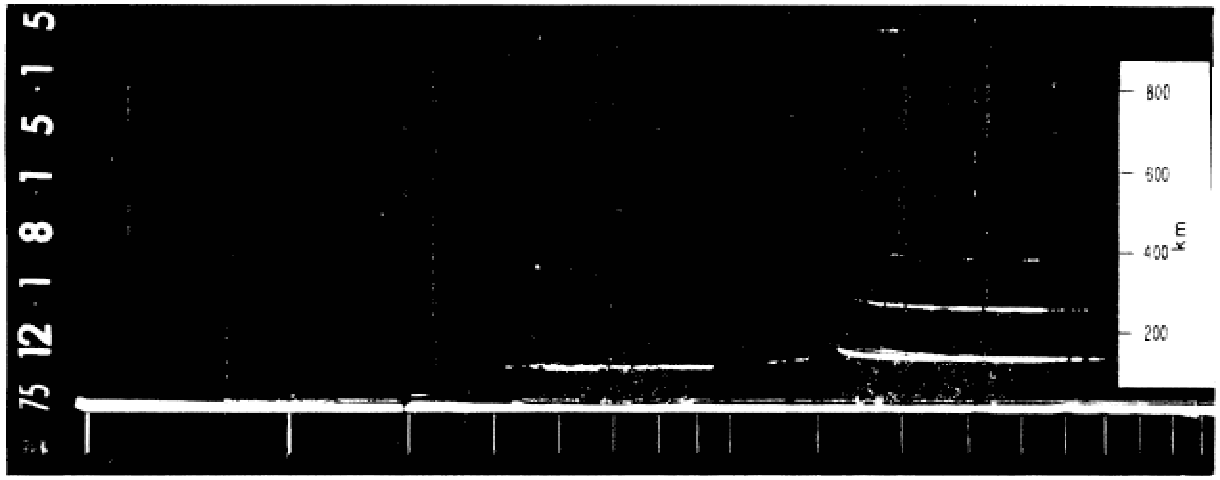
The following two ionograms have also been submitted by Mr. Richard Smith:

0.5 1.0 1.5 2 3 4 6

Figure 5. Port Stanley, 9th March. 1975. 1600

The adjacent ionograms, not reproduced, show that at 1500 h'F = 240EA, and at 1700 h'F = 250. Hence 2h'F at 1600 would be expected to be near 500 km. This is higher than the F1 trace seen, so this trace must be (2F - E), CM) mode seen at oblique incidence. The heights of the multiple Es traces are consistent with an effectively horizontal Es layer overhead, when foEs = 058JA, fbEs = 058AA, h'Es = 105, foE = A, h'E = A.

The apparent value of h’E, 115 kin, is greater than that of h’Es, suggesting that the low Es moved in while



the ionogram was being made. If the ionogram had been taken a few seconds later, and the interpretation is correct, h’E would not have been seen. I prefer the simple interpretation, as given above. The alternative is, of course, that the normal E was seen at oblique incidence where the low Es was transparent. This is very unlikely.

This is a case where it is permissable to use replacement letter A for all F—layer parameters but foF2 = O6OUA, foF1 = 360UA would be slightly more informative. The (2F — E) trace is seen at oblique incidence and it is dangerous to try and deduce an F layer from it since it is not likely to be exactly 105 km above the F trace. The Es type is λ3. This pattern differs from that for 26th December, 1975, in that the Es trace overhead is horizontal. The isolated N trace could be due either to a tilted F layer or a tilted Es layer seen obliquely or both. Again the critical point in the interpretation is to recognize that the apparent F layer trace is not a 2F mode.

0.5 1.5 2 3 4 6

Figure 6. Port Stanley, 18th December 1975, 1515. fmin given by an Es type 9. trace

“The normal E trace is exceptionally weak compared with the Es trace and if the low trace had not been present fmin would have been near 021 instead of 010. What is the correct interpretation for such cases?”

The low Es trace is not a gradient reflection but due to a blanketing Es layer with foEs = fbEs = 023. The dip at Port Stanley is too small for z-mode interpretation to be likely though this is just possible. The presence of three multiples of the high Es trace also present would suggest relatively low absorption so there is little doubt that fmin should be nearer 010 than 021. The value of h’E is abnormally large for the time of day suggesting either an abnormally thick E layer or an E layer seen at oblique incidence. Either interpretation is usually associated with abnormally weak traces from the E layer. When the E layer is thick the deviative absorption, which depends mainly on the slope of the N(h) distribution, is also abnormally large. The normal E layer seen at oblique incidence usually presents a convex surface which weakens the signal by defocussing.

I conclude that this is a dense low Es trace and that fmin is correctly given by it. The interpretation is therefore, F parameters, A; foEs = 074JA, fbEs = 074AA, foE = 300-R, fmin = 010, Es types h3,λ1.

While fmin is particularly sensitive to changes in the 0-layer ionization and absorption, its actual value is determined by a mixture of nondeviative losses in the D and lower E layer, plus deviative losses during the process of reflection. A departure from the normal gradient in the tail of the E layer, as in this case, changes the deviative term. The steep gradient associated with the dense low Es in practice gives negligible deviative losses making fmin smaller than it would otherwise have been. In the absence of any information about how large the error is, and bearing in mind that fmin is sensitive to instrumental and noise factors, it would be adequate to describe fmin to give fmin = 010-A. By matching the ionogram to other examples where high or cusp Es is seen, but no low Es, for an expected similar absorption (same season and time of day, similar multiple traces) it is possible to see whether fmin was perturbed by more than that allowed by the accuracy rules, demanding the use of UA or DA. Studies of absorption using the pulse absorption technique (method Al) show that the shape of the absorption pattern when plotted against f/foE is normally linear when f/foE is small compared with unity. [George, P.L., 1971, J.A.T.P., *33,* 1893; Samuel, J.C. and Bradley, P.A., 1975, J.A.T.P., *37,* 1311.

In practice the absorption coefficient at large refractive index (high frequency) shows a maximum in the lower part of the E layer so that changes in the gradient here can have a significant effect on the observed absorption. It would be interesting to hear whether other groups see abnormal values of fmin when blanketing low Es is present.

<u>Gyro splitting in the ionosphere</u>

The theory of traces similar to those shown in Uncle Roy's column, INAG 23, pages 26, 27, will be found in most standard text books on magneto-ionic theory. For those interested, a detailed computation for a particular case has been published by A. Bourne, C.S.G.K. Setty, and R.A. Smith, in J.A.T.P., 1963, *25,* 687—697.

VI. <u>Selected Ionograms From Colleges Alaska, with Interpretive Comments</u>

by Robert D. Hunsucker, Geophysical Institute, University Alaska, College, Alaska 997O1.

<u>Introduction</u>

Vertical incidence ionosondes have been operated in the vicinity of College, Alaska since 1941. The present Model C3/C4 sounder [Buhmann *et al..,* 1974], is located at the Geophysical Institute Sheep Creek Field site, 5 miles (9.6 km) north-northwest of College, co-ordinates:

Geographic latitude = 64.90^0N
Geographic longitude = 212.20^0E
Geomagnetic latitude = 64.76^0N
L = 5.5
Geocentric Magnetic dip = 75.91°

A large number of geophysical sensors are also deployed, giving much associated data. These include:

<u>University of Alaska — Geophysical Institute Instrumentation</u>

Poker Flat Rocket Range
30 MHz Riometer - Chatanika and Ballaine Lake Field Site
All-sky cameras and various photometers - Poker Flat, Chatanika and Ester Dome

<u>Stanford Research Institute Instrumentation</u>

Chatanika incoherent scatter radar
Wide—band satellite receiving site — Poker Flat

Lockheed Palo Alto Research Labs
Various spectro—photometers — Chatanika site.

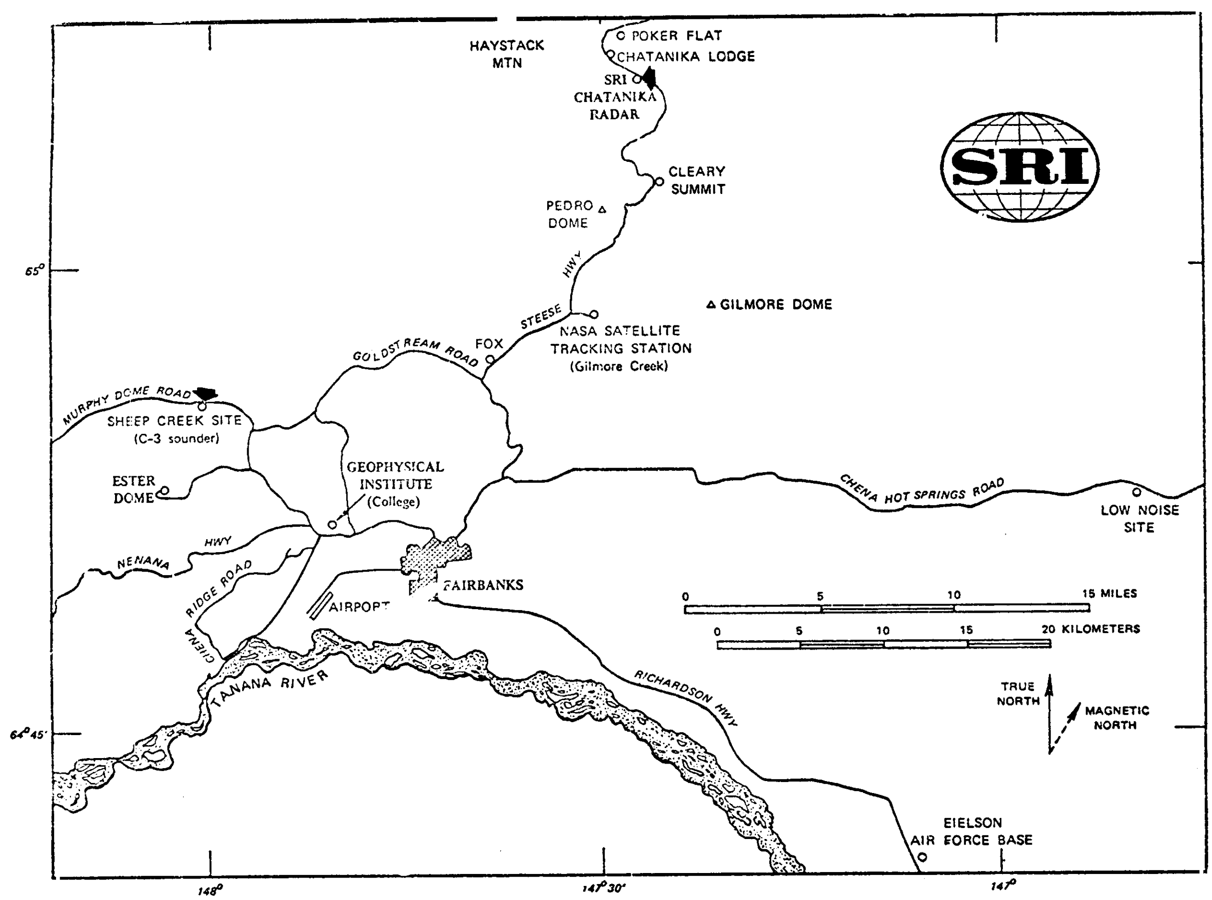
Figure 1. Map showing geophysical sensor instrumentation in the Fairbanks, College, Chatanika area.

The map of Figure 1 (courtesy of SRI) shows the location of these field sites with arrows denoting the College ionosonde and Chatanika radar locations.

The purpose of this report is to present various “signatures” (patterns on high-latitude ionograms) obtained by the College sounder and to use the simultaneous data from various geophysical sensors to suggest the actual ionospheric structure associated with the signature. A similar approach was used by Hunsucker [1971A and B] in the interpretation of HF oblique backscatter signatures.

Some Early Interpretations

One of the first successful attempts to relate ionogram signatures (Es traces, in particular) to specific auroral features was reported by Heppner, *et al*'., [1952]. Their main conclusions were:



1. “Es ionization increased at successively greater heights as aurora approaches the College zenith from the north”.

2. “In the presence of different non—pulsating auroral forms, the Es ionization varies with changes in auroral form in a manner similar to the change in luminosity.., variations in the height of maximum ionization parallel variations in auroral heights.” They also related complete absorption with certain auroral types.

It is interesting that these qualitative relations discovered some 23 years ago have been quantitatively verified in the last few years. Hunsucker and Owren [1962] presented nineteen representative All—sky Camera (ASC)/ionosonde (C—3) comparisons for various ionospheric signatures collected in the IGY winter, 1957—58 and concluded that there was a striking increase in foEs whenever a discrete auroral form was present over the ionosonde.

Hunsucker [1965] estimated that the E—region electron densities in the auroral forms have values of N≈1 to 2 x 10^6 el/cm^3. These have since been verified using simultaneous ASC, ionosonde and incoherent scatter radar data.

Ionogram Comparison with Chatanika Radar and ASC Results

A significant advance in our knowledge of the high—latitude ionosphere started in 1971 when the Chatanika incoherent scatter radar system became operational. This system is described in considerable detail by Leadabrand *et al.,* [1972]. It is a monostatic radar system-using a 27 meter diameter parabolic reflector fully steerable antenna. Some other salient parameters are:

Antenna gain	= 42 dB
Frequency	= 1290 MHz
Transmitter power output (pulse)	= 4 megawatts
System noise temperature	= 1500 K
Pulse length	= 10 to 5OOμ sec
I.F. bandwidth	= 50 kHz

Approximately thirty papers have been published using data from this facility on high—latitude ionospheric and magnetospheric phenomena — some of these results are described in a recent review paper by Banks and Doupnik [1975]. One such study was an investigation of the effects of the total solar eclipse of July 10, 1972, on the high-latitude ionosphere [Baron and Hunsucker, 1973].
The F—region electron temperature decreased by more than 1200^0K and the ion temperature decreased by about 100^0K near eclipse totality, seriously altering the shape of the F layer. Electron concentrations in the E and F regions decreased by 50%. The behavior of the E, F and F2-layer critical frequencies and virtual heights as determined from the College ionograms was in general agreement with the simultaneous incoherent scatter radar observations.

The Quiet Ionosphere

Simultaneous ionograms and incoherent—scatter electron density profiles of the high—latitude ionosphere for a wide range of geophysical activity have been presented by Bates and Hunsucker [1974]. The following figures show simultaneous College ionogram tracings (top), and Chatanika radar electron density (N) and ion and electron temperature (Ti and Te) profiles (bottom) for relatively magnetically quiet summer days. The shape of the auroral zone ionosphere during magnetically quiet times is usually not appreciably different from that of the midlatitude ionosphere, except that the F1 layer on summer days is more pronounced. As discussed by Bates and Hunsucker [1974] the few electron density profiles available during these quiet conditions often show a distinct valley between the F1 and F2 layers.

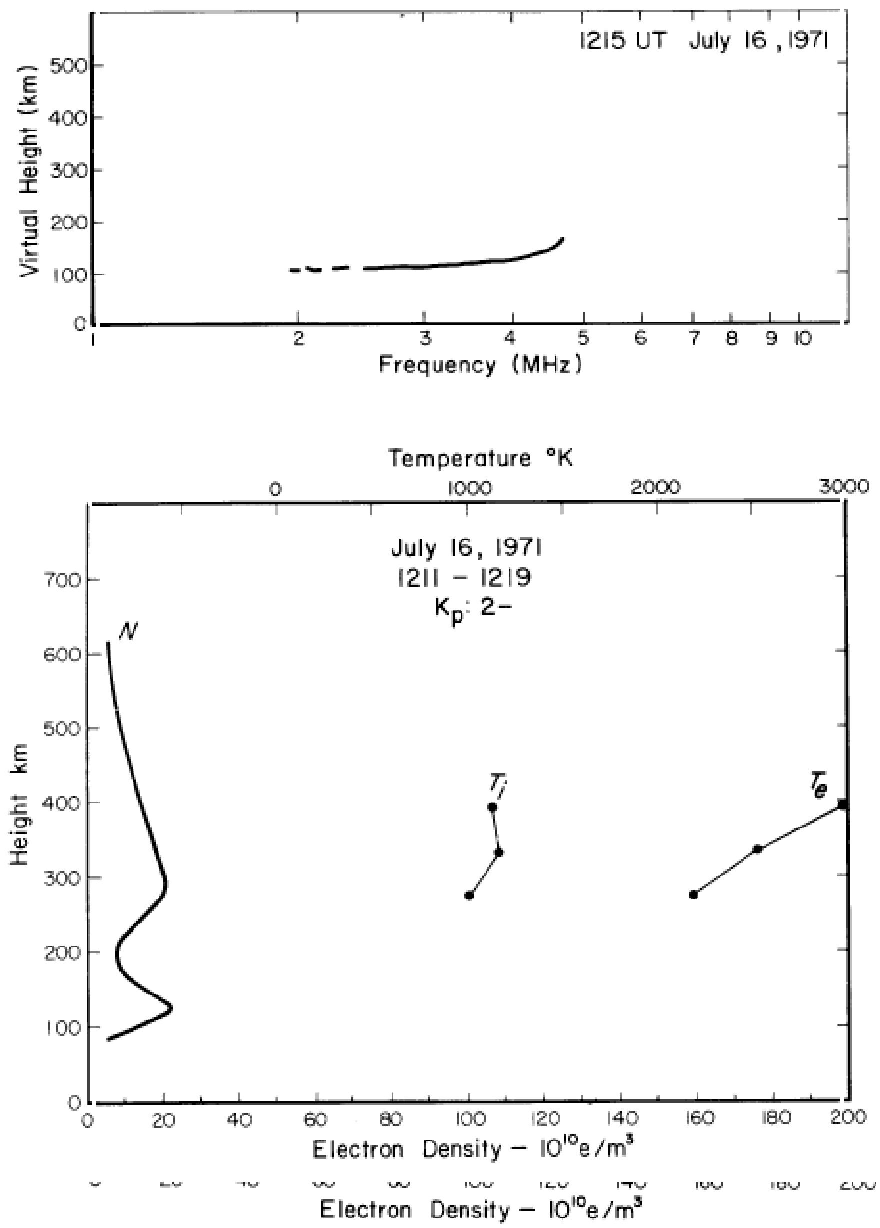


Figure 2. Simultaneous College ionogram and Chatanika radar N(h) for August 2, 1971, 2230 UT, 1030 LMT.

Note the presence of a true cusp at foF1 in Figure 2. The E and Fl layers appear as one layer on the N profile, but the ionogram clearly shows that there is a true maximum below the F1 layers.

Figure 3. Simultaneous College ionogram and Chatanika radar N(h) for July 16, 1971, 1215 UT, 0215 LMT.

Figure 3 shows an interesting case of a quiet day particle E layer screening the F layer. Note the deep valley between the two layers - the normal situation when the particle E is dense. (Chairman s note. The line drawing does not clearly show whether the trace was a true particle E, totally reflecting to foEs, or a retardation type Es. The critical frequency given by the N(h) pattern is 4.2 MHz, appreciably lower than foEs, 4.65 MHz, suggesting that the trace was really a retardation Es blanketing to 4.2 MHz the critical frequency of the particle E. It would be interesting to see the original ionogram).

Figure 4 is rather typical of quiet equinoctial conditions. The F1 layer appears as a small inflection of the Chatanika radar profile and on the College ionogram, while the F2 layer is well defined and the maximum density has increased from that in summer. The density at the peak of the quiet-day F region over College reaches its maximum for the year near the winter solstice.

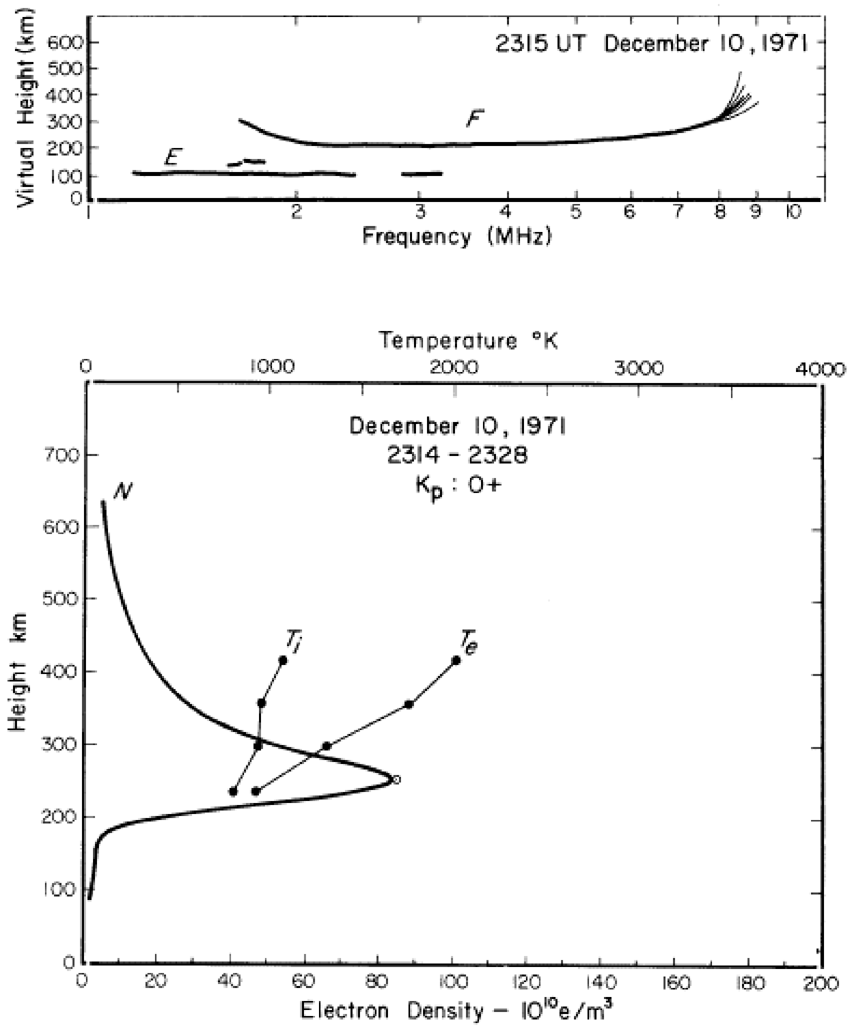


Figure 4. Simultaneous College Ionogram and Chatanika radar NCh) for September 23, 1971, 1245 UT, 0245 LMT.

Figure 5 gives a comparison for very quiet magnetic conditions. The dot at the maximum of the Chatanika radar profile in Figure 5 (bottom) is the electron density calculated from the F region critical frequency scaled from the inner edge of the spread trace on the College ionogram (top). This agrees with the practice in scaling spread traces as presented by Piggott and Rawer [1972].

Figure 5. Simultaneous College ionogram and Chatanika radar N(h) for December 10, 1971, 2315 UT, 1315 LMT.

The Disturbed Dayside Ionosphere

Figure 6 presents Chatanika radar ionospheric profiles made during two relatively strong magnetic storms, July 21st and August 10th, and during the solar proton event in August 1972. No ionospheric traces were observed at the times the profiles were obtained because of very high D region absorption. This illustrates how powerful the incoherent scatter radar technique is for investigating the high latitude ionosphere under very disturbed conditions. Striking features of these profiles are the small variation in electron density with altitude between 150 and 300 km height and, on August 4th, the large electron density in the E and D region associated with the proton event.

The Disturbed Nightside Ionosphere

The ionosphere over College, Alaska, is usually very disturbed at night during the period mid— September through mid-March. Many hours of ionosonde records during this part of the year show complete absorption or only Es traces. Recently Hunsucker [1975] has utilized simultaneous Chatanika incoherent scatter radar, auroral all—sky camera (ASC), ionosonde and photometric data to delineate the structure and dynamics of the auroral E layer for various types of ionospheric disturbances.

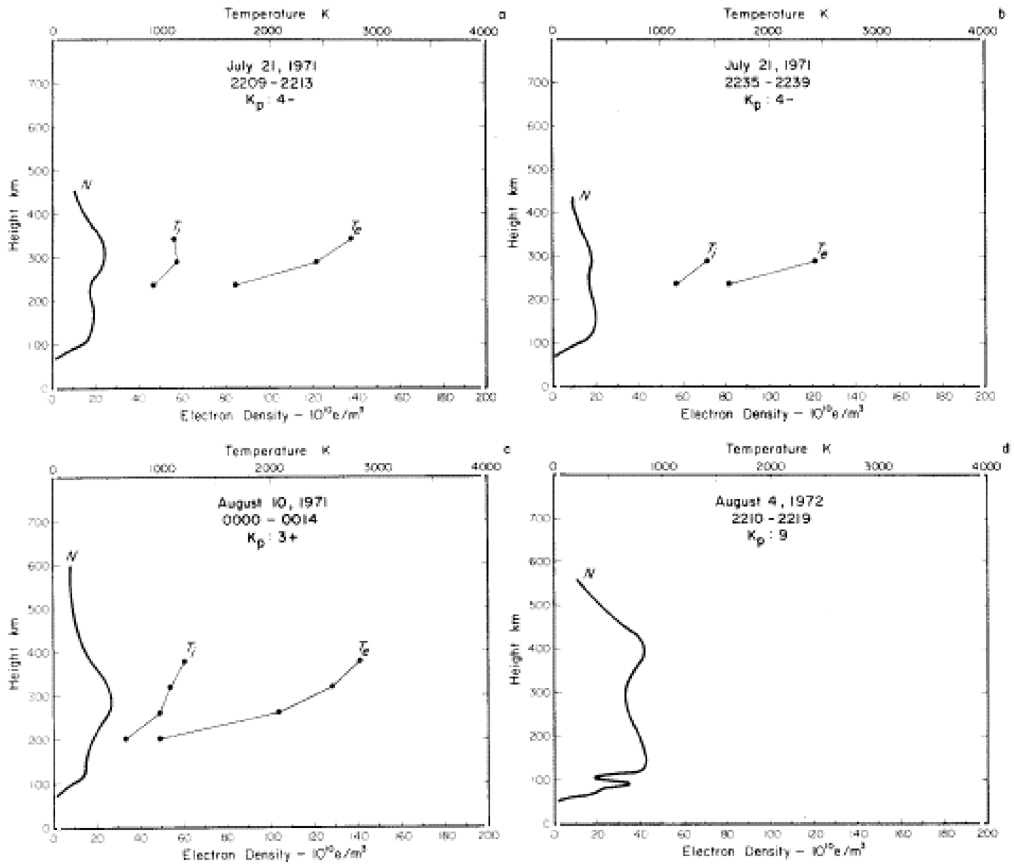


Figure 6. Chatanika radar N(h) profiles for disturbed dayside ionosphere conditions; a, b, c and d.

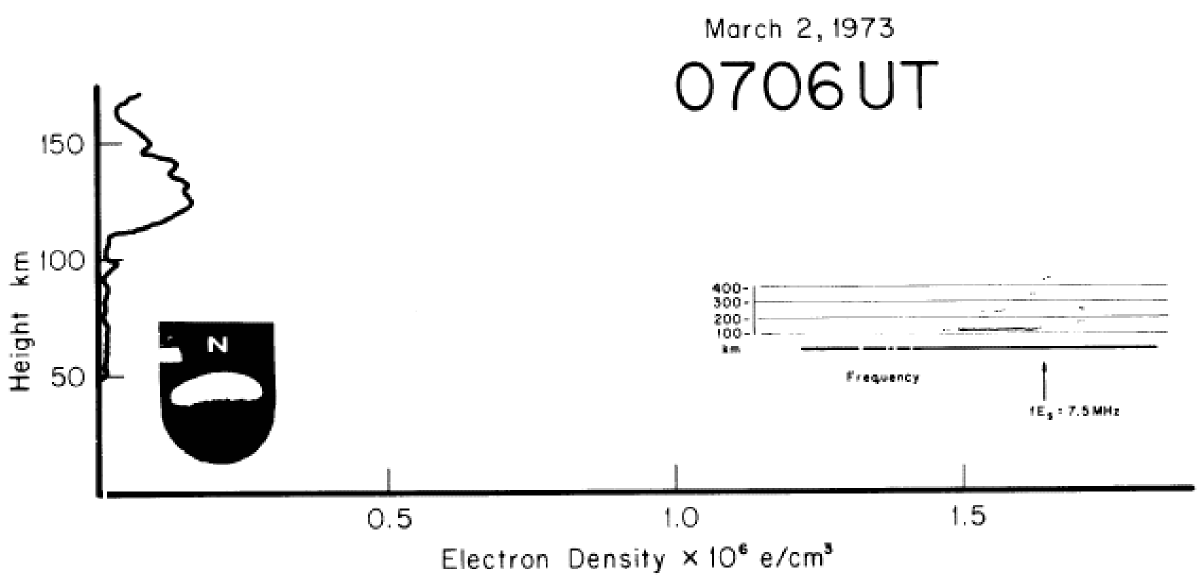
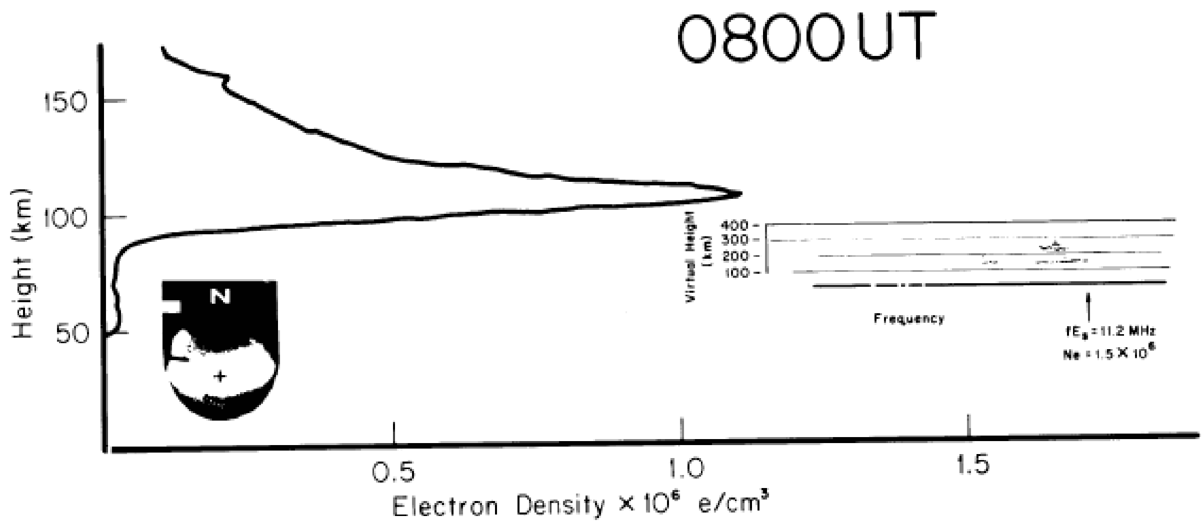


Figure 7. Simultaneous College ionogram, ASC photo and Chatanika radar N(h) aurorally-disturbed E-region, March 2, 1973, 0706 UT, 2106 LMT.

Figures 7 and 8 show the changes in the electron density in the E region as a discrete auroral form moves through the “field—of-view” of the observing stations. Simultaneous College ionograms, Chatanika radar electron density profiles, and Chatanika ASC photos are shown for 0706 and 0800 UT (2106 and 2200 local time). The position of the Chatanika radar beam at 100 km height is indicated by the (+) in the ASC photos in Figures 7 and 8. At 0706 the auroral arc was north of the latitudinal region being probed by the ionosonde. The College ionosonde shows an foEs value of 7.5 MHz and the Chatanika radar E—region electron density 33 km away was about 1.3 x 10^6 el/cm^3 corresponding to foE = 3.6 MHz at this time. When the auroral arc moved south into the



Chatanika radar beam at 0800 UT (Fig. 8) the electron density and foEs value dramatically increased.

Figure 8. Simultaneous College ionogram, ASC photo and Chatanika radar N(h) for aurorally disturbed E region, March 2, 1973, 0800 UT, 2200 LMT.

The E-region electron density calculated from, foEs on the ionogram was N = 1.5 x 10^6 el/cm^3, foE = 11.2 MHz, while that measured by the Chatanika radar was 1.2 x 10^6 el/cm^3, foE = 9.8 MHz. We have observed many instances when the value of N deduced from the College ionogram foEs value was very close to the N value determined from the Chatanika radar data always when a discrete auroral form was present in the region over the Chatanika radar and ionosonde. Electron density as high as 2.8 x 10^6 el/cm^3 have been observed during these conditions [Wilson, Hunsucker, and Romick 1976].

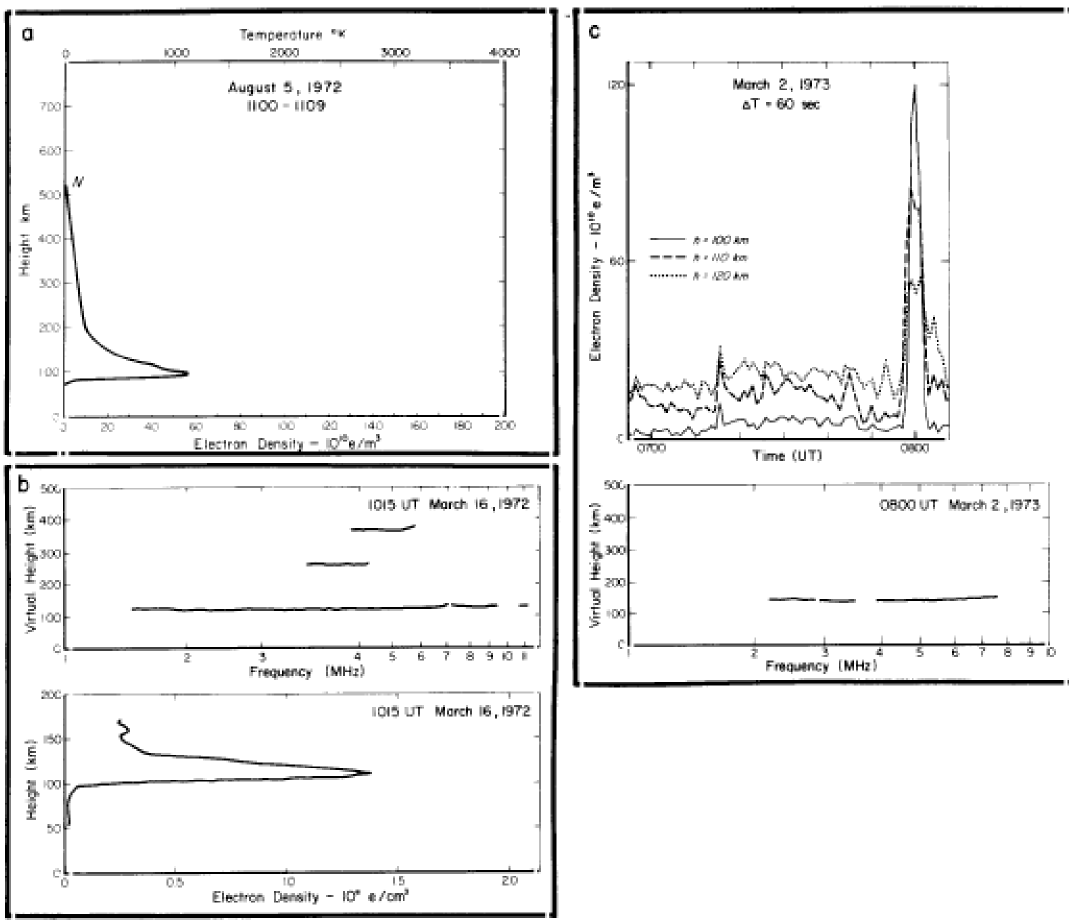


Figure 9.(a). Chatanika radar N(h) obtained during great geomagnetic storm of August 5th, 1972. 1105 UT, 0105 LMT.

(b). Simultaneous College ionogram and Chatanika radar N(h) for auroral conditions. March 16, 1972, 1015 UT, 0015 LMT.

(c). Chatanika radar electron density versus time plot, March 2, 1973, and College ionogram at maximum.

Other examples of nightside disturbed ionospheric conditions are shown in Figure 9a, b and c. Figure 9a shows a particle E layer with N max = 6×10^6 el/cm^3 obtained by the Chatanika radar at 0105 LMT during the great August 1972 magnetic storm. This type of profile is typical for a large storm. There was considerable ionization below 100 km, so the College ionogram for this period showed complete absorption. Figure 9b shows a simultaneous College ionogram (foEs = 9.6 MHz) and Chatanika radar N = 1.4×10^6 el/cm^3 profile which is equivalent to foE = 10.4 MHz for an aurorally active period. Figure 9c shows a plot of chatanika radar E-layer electron density at three different heights versus time along with a College ionogram obtained during the period when the E layer reached maximum density. The 'impulsive' nature of the E layer additional ionization is shown by Figure 9c. Due to hazy conditions it was not possible to precisely locate discrete auroral forms for Figure 9b and c, but visual observations indicated that there was considerable auroral luminosity present overhead on both occasions. The differences between values of foE deduced from the ionogram and radar can be ascribed to rapid changes in electron density with position (Fig. 1).

Figure 10. Simultaneous College ionogram showing spread F and Chatanika N(h) for November 19, 1971, 0345 UT, 1745 LMT.

Figure 10 shows another example of “disturbed” ionospheric conditions — in this case, spread F as shown on the College ionogram (bottom). As in Figure 5, the foF2 value was obtained by scaling the inner edge of the spread trace, and the N value obtained thereby is shown as a dot near the Nmax value on the Chatanika radar electron density profile (top plot).

Concluding Remarks

It is hoped that the technique of interpreting the college ionogram 'signatures' using simultaneous Chatanika incoherent scatter radar and other geophysical sensor data will be useful in ascertaining more explicitly which ionospheric structures produce the various traces on a high latitude ionogram. A more complete Atlas of these simultaneous data is at present in the planning stage.

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VIII. Resolutions

COSPAR Decision No 7/76 proposed by the Executive Council on a proposal from Working Groups 4 and 1.
COSPAR

noting that ionosonde records complement spacecraft electron density data by providing detailed profiles with high time and altitude resolution at fixed locations for long periods of time,

draws the attention of URSI and CCIR to the need for an adequate network of ionosondes at key locations supplemented by special purpose temporary stations, and

requests URSI to define these requirements more precisely.,

5th Equatorial Aeronomy Symposium (ISEA) wishes to encourage future observational programs in equatorial aeronomy, particularly those that would provide simultaneous measurements over a wide range of longitudes. For example, the ISEA recommends that ionosonde stations be established near Davao, Philippines; Colombo, Sri Lanka; and some unspecified location in Papua New Guinea.

IX. Reports from World Data Centers

World Data Center-A for Solar-Terrestrial Physics, Boulder, CO

During the course of the year July 1975-June 1976, data were requested from 86% of all the vertical incidence stations currently operating (146) and from 58% of all stations which have ever operated and for which data are archived (320). These requests resulted in 9636 station months of data being transmitted to users, which is 5.5 times the current annual accumulation of data. An additional 1519 station months of data were requested but were not available. This was usually either because of late arrival of data or because of station closures. Data were requested from 59 stations which are no longer in operation.

Data are requested from stations located in all regions of the earth. This is evidenced by the following table which shows the number of requests during the year for data from twelve natural geographic regions plus the South Pole.

Longitude Range	Latitude Range	Number of Requests	Number of Stations Involved
40° -13O°E (Asia)	> 40^0N	86	18
	40^0N - 40^0S	95	23
	> 40^0S	15	6
130^0 -220^0E (Pacific)	> 40°N	45	10
	40°N - 40°S	98	15
	> 40^0S	25	7
220^0 -310^0E (Americas)	> 40^0N	193	21
	40^0N - 40^0S	178	29
	>40^0S	12	3
310^0 - 40^0E (Europe/Africa)	> 40°N	202	35
	40^0N - 40^0S	41	12
	> 40^0S	21	6

South Pole	90°S	6	1

Ionospheric data continue to be requested for past years as well as for recent years. Of the ionograms disseminated during the past year, 27% were from the IGY period 1957-1959, 16% from the IQSY period 1960-1965, and 44% from the years 1970-1976.

Catalog

In April 1976 Report UAG-54 *Catalog of Ionosphere Vertical Soundings Data* was issued by World Data Center A for Solar-Terrestrial Physics. This Catalog is the second in the series planned by World Data Center A (WDC-A) for Solar-Terrestrial Physics to cover in considerable detail the data disciplines in Solar—Terrestrial Physics singly or in groups. It intends to cover all the data known to exist for

ionospheric vertical soundings, the discipline listed as B.1 in the ICSU *Guide to International Data Exchange through the World Data Centres.* In contrast to earlier catalogs which have always begun with data for the International Geophysical Year, 1957—58, the present catalog includes all known data since the beginning of systematic multifrequency ionospheric soundings; the earliest data set is 1930. This includes all the relevant data held at the data center and direct or indirect information on data held elsewhere.

The Catalog is designed for the user rather than for the archivist. However it does give the data holdings in more detail than heretofore, both the types of data and data reports, and the time units of the data sets. Earlier catalogs indicated the completeness of data holdings by rough proportions of calendar years; the present catalog is in units of months, with corresponding indications of completeness.

World data Center C2 for Ionosphere, Radio Research Laboratories, Japan

Activities for the period April 1975 - March 1976

1.data received from WDCs A, B2, and C1 and Ionospheric Stations:

Booklets and Sheets:	1750	
Microfilms:	27	rolls of 1000 feet each
	31	rolls of 100 feet each
Microfiche:	14	leaves

2. Data sent and lent to users:

To	Other Centers	Domestic Researchers	Foreign Researches	Total
Booklets and Sheets	469	859	14	1342
Microfilm (roll)	104	1208	1	1313

3. Adjustment and compilation of microfilm data in office:

Microfilm from WDC-A	Ionograms	(21)	reels	(1000 feet each)
	Others	(1)	“	(100 “
Microfilm from WDC-B2	Ionograms	(37)	“	(1000 “
	Others	(20)	“	(100 “
Microfilm from WDC-C1	Ionograms	(27)	“	(100 “
	Others	(1)	“	(100 “

Microfilm from WDC-C2	Ionograms	(1616) “	(100 “
	Others	(3) “	(100 “

4. WDC-C2 Catalogue of Data for Ionosphere:

Cumulative catalogue of ionosphere data for the period 1 July 1957 - 31 March 1976 will be available in August 1976.

5. Daily hourly values of Japanese ionospheric data are stored on magnetic tape from June 1968 onwards.

X. Station Notes

Boulder, Pt. Arguello, Wallops Is. and White Sands

Robert Olsen at the White Sands Missile Range asked WDC-A for Solar-Terrestrial Physics to assist in asking ionosonde stations to run their equipment at an increased rate during an explosion experiment to be conducted at White Sands, October 6, 1976. WOC-A arranged for the Boulder, Wallops and Pt. Arguello ionosondes as well as the White Sands ionosondes, together with the Boulder and College infrasonic recorders, to run at their highest sweep rates during the period when the acoustic wave was anticipated to arrive at each of the recording stations. These recordings were continued for one hour to monitor the recovery phase of the shock wave. Control runs were made on October 7 and 8, 1976. Much of these ionosonde data are expected to be reduced to N(h) profiles in the near future.

Okinawa Station (Japan)

The vertical incidence ionospheric station at Okinawa closed on March 16, 1976, in order to move the station.

The ionospheric observations will resume at the beginning of 1977 after the new facility is completed.

The new station is located in Nakagusuku, Okinawa, 4 kilometers to the south-south-east of the old site. The accurate geographical and geomagnetic coordinates of the new site will be given later.

Pt. Arguello

The responsibility for ionospheric observations and data reduction at Pt. Arguello has been taken over by Mr. G. MacNeil. Mr. Raymond 0. Conkright visited the station in early December 1976 to discuss operation of the ionosonde and data reduction. Although the ionosonde is an old conventional Granger sounder, good quality quarter-hourly ionograms are being routinely produced. The hourly ionograms are scaled. The scalings and the quarter-hourly ionograms are in the archives of World Data Center A for Solar-Terrestrial Physics at Boulder, Colorado.

XI. Special Note

Ing. Alvaro Madal, Santo Domingo, Dominican Republic, obtained an M.S.E.E. degree at the University of Puerto Rico in 1972 in ionospheric propagation. He is now interested, as are others in his country, in the possibility of developing an observatory for ionospheric phenomena in the Dominican Republic. He asks if there are any International Organizations or institutions which could assist nim in such a project. If any one could provide such assistance please correspond directly with Ing. Alvaro Nadal, Santo Domingo, Dominican Republic.

XII. Training

PAIGH Sponsored Ionogram Interpretation and Reduction Trip to Argentina November 15-26, 1976

The objective of this trip was to unify the South American ionosphere vertical sounding data reduction efforts. A two-week class in data interpretation and reduction was given at LIARA in Buenos Aires by Raymond 0. Conkright of World Data Center A for Solar-Terrestrial Physics, Boulder, CO.
There were twenty-four participants. They came from eight organizations in four different countries (Argentina, Chile, Peru and Bolivia).

By far the greatest difficulty the South Americans are having is understanding the exact meaning of the words in Report UAG-23 plus keeping up with the changes and corrections to it. They feel the need is urgent to simplify and clarify the scaling rules.

At the end of the training class, the participants decided to write up a simple and clear set of local rules for the scaling procedures which gave them the most difficulty. Mr. Conkright was asked to help with this write-up so that their local rules would conform with the international rules as nearly as possible. This set of local rules will be sent to INAG when finalized.

The activity in ionospheric research is flourishing in South America, but is very dependent upon the generosity of other countries for station supplies, education and training. INAG should encourage a continuing effort to support the ionospheric activities in South America.

XIII. Index to INAG Bulletins