IONOSONDE NETWORK ADVISORY GROUP (INAG)*

Ionospheric Station Information Bulletin No. 58**

CONTENTS

*Under the auspices of Commission G, Working Group G 1 of the International Union of Radio Science (URSI)

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People wishing to be placed on a mailing list to receive this Bulletin should notify the INAG Chair, Phil Wilkinson, or the INAG Secretary, Ray Conkright, WDC-A for STP, NOAA, Boulder, Colorado 80303, USA.

1. Comments from the Chair.

1.1. Opening comments

My special thanks to Jens Olesen who has contributed two articles to this Bulletin. Jens has been one of our most active members over the last three years which, I gather, he attributes to his retirement. I appreciate all his articles and the good will and informed comment that comes with them.

1.2. Nomination of INAG Officers

At the last URSI General Assembly we decided to elect officers for INAG by popular vote among the members. The first step in this process is to obtain nominations for the positions of Chair and Secretary. I am the current Chair and Ray Conkright is the current Secretary. Both of us are willing to stand again for these positions.

I intend following the same procedure that I did at the last election for Officers. First there is a call for nominations, then I make up a list of nominees and send out ballot papers to all members, you then fill them out and return them to a Returning Officer. The first stage starts with this Bulletin. The nomination form appears as the last page of the Bulletin. I have included two copies of this form with the Bulletin, for your convenience. Please remove this page, **fill out the nomination form as directed, and return it to me as soon as possible.** People nominated by two or more members will be asked if they are willing to hold the office for which they have been nominated. If they agree, their name will be placed on the Ballot paper. The Ballot papers will be distributed with the next INAG Bulletin, which I expect to be producing in March, next year. My task is made easier if I receive your nominations by February as it will take me some time to contact people.

Please note; it is important that you confirm your membership, by filling in the address details on the nomination form, even if you do not wish to make any nominations.

1.3. Questionnaire on INAG

I have decided to take advantage of the call for nominations and distribute a short questionnaire to members. Please take the time to fill this in also. The information gathered in the questionnaire will help make the INAG Bulletin more effective. If you think of other comments about the Bulletin as you fill out the questionnaire, please jot a comment of two on a piece of paper and send it to me.

1.4. URSI meeting, Kyoto 1993, and the INAG Workshop

I hope everyone has already given some thought to this Workshop. I have included a short note in this Bulletin on the expectations I hold for the Workshop, together with a list of relevant articles and comments that have appeared in the Bulletin over the last three years. Remember; submit your abstracts **now**.

1.5. Real time data exchange

For many years data, including ionospheric data, have been circulated on a daily basis using telex messages. IUWDS, the organisation that supervises this activity, offers a model for data exchange. I have summarised the ionospheric data codes that have been used in the past, but you are encouraged to speculate on what codes could be used if direct computer to computer data exchange is used. It seems likely to me that the future ionosonde will record digital data, scale it using computer methods and then be ready to share the data in near real time. We should all be considering the prospects we will have as members of a global data bank.

1.6. GPS and Ionospheric models

I have received requests recently for information on the global ionosonde network and the availability of foF2 and M(3000)F2 for supporting TEC models used in correcting GPS observations. While this application of ionospheric data is not new, there appears to be more interest now than in the past. This may be another area where real time ionosonde data has a part to play in the future. Anyone who is working on this problem, or has comments on it, please contact me.

1.7. Global Campaign 20 - 30 January, 1993

All ionosonde operators are reminded that there is a major incoherent scatter radar campaign taking place in late January, next year. This was in the World Days Calendar, in the last Bulletin. Where possible, all ionosonde stations should make additional soundings during the campaign periods mentioned in the Calendar. Because this particular campaign covers a long period of time, 11 days, it is of special importance to the scientific community. Data collected during campaign periods are more likely to generate interest. Even if you are not going to make a special study of your data, it may be possible to create additional interest in your local research community because your data were recorded during a special campaign period.

1.8. Krieger's address

A summary of reviews of Leo McNamara's book

The Ionosphere :
Communications, Surveillance, and Direction Finding

appeared in the last INAG Bulletin. However, I neglected to add the essential information about where to order the book. I was reminded of this within two weeks of posting out the Bulletin by someone asking me where they could buy it. My apologies to people who were inconvenienced by this omission. You can order the book, cost US$60, from

ORBIT SERIES
Krieger Publishing Company
P O Box 9542
Melbourne, Florida 32950 - 9542
USA.
Telephone : +1 407 724 9542
Direct Order Line : +1 407 727 7270
Facsimile : +1 407 951 3671

2. URSI General Assembly Meeting G6 Ionosonde Networks and Stations

All members of INAG are invited to contribute to this Workshop to be held during the URSI General Assembly in Kyoto, 25 August to 2 September, 1993. Please send in your abstract **immediately**.

If you have a point of view you wish presented at the Workshop, but you are unlikely to be able to attend, please offer your thoughts to me **as soon as possible**. All inputs will be aired on any topic of interest to the ionosonde network.

As indicated in INAG - 55, when the workshop was first mentioned, the prime discussion point will be how ionosonde stations can continue to operate in the years to come. Administrations worldwide are seeking ways to lower costs and minimise exposure in long term activities. The economics of ionosonde stations is an essential component of their survival profile. What activities make an ionosonde station important for the parent body funding the station and for the country in which the station is situated? What is the **relevance** of an ionosonde station? For many people operating stations, these questions have never been thought about seriously. Similarly, people who use the data, even profit from it, take it for granted that somebody else will preserve the stations and ensure sustained operation of the network.

This Workshop will go some way towards addressing these questions if **you**, the members of INAG, participate with enthusiasm. To help, I have compiled a list of some of the articles and notes that have appeared in INAG over the last three years. These address some of the problems we need to face, and identify some of the areas where ionosondes can be useful.

- Applications
  - INAG 55; Hedburg's comments on the response to a questionnaire on data distribution
  - INAG 56; Fox's article on evaluating models of total electron content
  - INAG 57; McNamara's article on ionosonde data for single site location systems
  - INAG 57; my comments on the ionosonde community
- Economic Station Operation
  - INAG 53; Fox's article on autoscaling ionograms
  - INAG 54; Rodger's comments on polar lacuna and scaling rules
  - INAG 56; my article on the IPS 5A ionosonde network
  - INAG 57; Rodger's comments on computer scaling of ionograms
- Environmental monitoring
  - INAG 54; Rishbeth's article on Why Keep Ionosondes
  - INAG 54; my article on Baseline stations
  - INAG 56; my comments on supporting other groups

- INAG 57; Danilkin's paper on a global real time satellite based ionosonde system

- Science

  - INAG 55; Besprozvannaya's comment on a role for ionosondes in science
  - INAG 57; Pulinets note on the Russian ionospheric monitoring workshop
  - INAG 57; Somayajulu and Cherian's article on the equatorial electrojets

- National prestige

  There have been no articles on this topic. Nobody has suggested it is relevant to the ongoing existence of an ionosonde station. Yet, by observing the ionosphere, a country is participating in the monitoring of their near space environment.

Give this Workshop careful thought. You are interested in ionosonde data. If you weren't, you wouldn't have gone to the trouble of requesting that you remain a member on INAG. Now think how ionospheric data is useful to you. Consider how you use it. Think how you last defended your budget to operate your ionosonde stations. The answers to these issues, when shared with others, will assist in strengthening the Worldwide Ionosonde Community.

Ideas, shared now, will help preserve our network.

This Workshop is your opportunity to share your information with others. To help in planning the Workshop, abstracts should be submitted in the usual way. I am looking forward to seeing many of you in Kyoto. Phil Wilkinson, Convenor G6, Chair INAG.

Please send your abstract in now.

3. A New Scaling Letter — the Slash (/).

3.1. Background

Scaling letters are used to indicate levels of confidence that can be placed in values scaled from ionograms. A scaler usually spends a significant amount of time deciding whether a scaling letter is appropriate or not and sometimes rather large efforts are spent deciding between different options.

Researchers, faced with these scaling letters, react in different ways. Regrettably, because of the volume of data now available from the worldwide ionosonde network, some feel they can safely ignore any value with an attached scaling letter, or worse, ignore all scaling letters. Others admit to ignoring any value with the qualifying letters E or D. This casual attitude to a good amount of effort by the scaler is a disincentive. But many researchers, while not fully appreciating the effort involved in producing the final scaled values, understand the significance given to the scaled data by the attached scaling letters. In some cases, for instance spread F studies, the scaling letter may be the most important piece of data collected.

Computer scaling programs, for automatically scaling ionograms, currently do not add any scaling letters to the scaled values. However, there is now a large body of computer scaled data available and it should be merged into data archives. At the Lowell Ionospheric Informatics Workshop in 1989, a new scaling letter was proposed to make it possible to readily identify data from an automatic scaling system that had not been manually checked.

3.2. Definition of /

1. Tabulated URSI characteristics from computer scaling programs will have a slash / in both the qualifying and descriptive letter positions.

   Note :

   - If a computer scaling system also produces scaling letters, these will be entered in the appropriate positions, overwriting the slash.

- However, computer scaling software **must not** enter a blank in **either** of the scaling letter positions.

2. In the process of manually checking and editing the computer scaling records, the appropriate qualifying and descriptive letters are inserted in place of the slash. In most cases, the new scaling letter will be a blank.

Note :

- This is an essential quality control step that validates the computer scaled data. The absence of a slash will confirm the data has been manually checked.

- When a few days in the month are manually checked, it will be up to the researcher to note that there is a mix of checked and unchecked data present in the data set. The presence of slashes in the data suggests quality control on the data is patchy.

3. Occasionally, computer scaled data will be manually checked, but no effort will be made to enter qualifying or descriptive letters. Only the gross errors in the scaled values will be corrected. In these cases, the descriptive letter will be changed from a slash to a blank, leaving the qualifying letter as a slash.

These rules are summarised in the following table.

Q — D	Qualifying, Q, and descriptive, D, letters used according to UAG 23A
/ — /	Computer scaled data; and no manual check has been made of it.
/ — ...	Computer scaled data; only values have been manually checked
... — ...	Qualifying and descriptive letters are used in the normal fashion.
... — /	No current meaning

3.3. Comments

For this scaling letter to be useful, **all computer scaling systems <u>must</u> place the slash into the qualifying and descriptive letter positions as part of the ionogram scaling process.**

Some thought should go into deciding how to treat medians calculated from a mixture of manually checked data and unchecked data. A simple rule could be, if 50% of the data had a descriptive or qualifying letter that was a slash, then the median would also have this letter.

Where data are key entered and the qualifying and descriptive letters are not entered, a / can be automatically placed in the qualifying letter position to signify the value is good.

For the present, the slash is an indicator of the extent to which a computer scaled data set has been subject to quality control checks.

4. Ionospheric Data Exchange by Telex.

by P J Wilkinson, IPS, Australia

4.1. Introduction

A network of ionosondes reporting data in near real time is a powerful input for global ionospheric models whose output should optimise the operation of systems affected by the ionosphere. There are two problems. First, we need a method for describing ionospheric conditions so that a small regional data set gives a maximum amount of information about the global ionosphere. Second, a method for transmitting the data widely needs to be available. After brief comments on the first problem, the current methods for solving the second are outlined.

The ionosphere is variable and the different variations may be indicators of complex global events. However, the interpretation involves a measure of qualitative judgement; at least partly because of an incomplete understanding of the processes involved, but also because of the sparseness of stations and the real difficulty of developing uniform scaling rules. Piggott reported, in INAG - 03, the results of one such method and admitted later that it was difficult to specify regional conditions in this way without a great deal of experience. Since a qualitative approach may be difficult to implement in a physical model, the additional information on an ionogram, which is not easily scaled from it, is likely to be ignored in modelling developments. A compromise solution has been to scale a selection of ionospheric parameters and use these to describe ionospheric conditions. While this places limits on our knowledge of ionospheric behaviour, it appears to be an acceptable solution.

The International Ursigram and World Days Service, or IUWDS, supports codes, originally for the telex transmission of geophysical data, that are used for data exchange between Regional Warning Centres, or RWCs. There are RWCs in Australia, Canada, China, Czechoslovakia, France, Germany, India, Japan, Poland, Russia and USA. The codes are most suitable for reporting isolated events, such as solar flares and their effects, but can also be used for routine observations. Ionosonde measurements fall into this last category.

One code, now almost obsolete, was the UFOFS code that used four foF2 values per day (the 00, 06, 12 and 18 UT foF2 values) to describe the ionosphere. Other codes in common use are the UFOFH and IONFM codes. The UFOFH code is similar to the UFOFS code except that it reports hourly instead of six hourly values. The IONFM code cannot handle foF2 > 9.9 MHz and descriptive letters are used only to explain a missing value, although it does allow foF2, M(3000)F2, foEs and fmin to be distributed in one code.

The main strength of the codes is that they have been in use and some people are familiar with them. While, as will become apparent, they limit the amount of ionospheric information that can be distributed, they have established formats that have proven acceptable. The clear identification of each record, coupled with the ease with which the UFOFH and IONFM codes can be applied to any hour of the day are also strengths.

This note gives an overview of these codes and some suggestions for future changes.

4.2. UFOFS Code

At IPS, until the mid 1980s, UFOFS data arrived daily from a number of northern hemisphere stations and weekly from Australian stations. Daily indices of ionospheric conditions were made using the four foF2 values from different locations. These indices, although crude, could be used both for forecasting future ionospheric conditions and for assessing the extent of a current disturbance. While more data from each station improved the indices, adding more stations improved the indices most. Wilkinson, 1986 (IPS Technical Report IPS TR-86-02) describes this in more detail. Now, UFOFH and IONFM codes are more common. The additional data make it possible to consider using more complete modelling methods than those implied by ionospheric indices.

The UFOFS code is a typical telex code. The code consists of a five letter alphabetic keyword followed by coded blocks of five digits. Data, together with identification information, are summarised as briefly as possible. The code has the following form.

UFOFS IIIII YMMDD /HHmm fgggh fgggh .....

where :

IIIII = IUWDS station indicator number

YMMDD = UT date for first record

Y = last digit of year, e.g., Y = 2 for 1982

MM = month

DD = day

/HHmm UT hour and minute of first record

/ = (slash) filler. Always used.

HH = UT hour

mm = UT minutes

fgggh ionospheric data - a repeated group

f = hour indicator

hour (UT)	00	06	12	18
f	0	3	6	9

ggg = value of foF2 in 0.1 MHz units

000 if no value can be scaled.

h = descriptive letter (sec. 4.5)

Data are coded using repeated "fgggh" groups, e.g. for 7 days' data, the date and time would refer to the first "fgggh" group and 28 groups would be coded altogether in the single UFOFS message. An example follows.

```
UFOFS 12345 20221 /0000 0103/
30450 60606 9074/
```

This reports the four values of foF2 for the station with the IUWDS number 12345 for the second year of the decade (1992 in this case) for the 21st day of the second month of the year and the data start at 0000 UT. Following the date information is the foF2 data for one UT day starting at 0000 UT. (Please contact me if you want more information on these codes. The information here is for explanatory purposes).

4.3. UFOFH Code

The UFOFH code has the same form as the UFOFS code. However, to accommodate hourly scaled data, the coding of the first position in the data grouping, fgggh, is changed. The coding for f is given below.

f	UT
0	**00**
1	01
2	02
3	03
4	04
5	05
6	**06**
7	07
8	08
9	09
0	10
1	11
2	**12**
3	13
4	14
5	15
6	16
7	17
8	**18**
9	19
0	20
1	21
2	22
3	23

Thus the position of the data block with respect to the start time code /HHmm gives f its meaning. The bold hours are the hours of data that would appear in the equivalent UFOFS code starting at the same hour. An example code for a day of data is shown next.

```
UFOFH 12345 20221 /0000 0103/
1085/ 2085/ 3075/ 4052/ 5051/
60450 7047/ 8046/ 9049/ 0055/
10616 20606 30366 4045/ 5067/
6074/ 7071/ 8074/ 9074/ 0085/
1047/ 2090/ 3112/
```

The code refers to the same day as the earlier UFOFS code and the UFOFS values are bold here so they can be picked out easily.

4.4. IONFM Code

The form of the code is

IONFM IIIII YMMDD /HHmm KFFMM EEENN

where IIIII YMMDD /HHmm have the same meaning as in UFOFS.

Each hour of ionospheric information is coded in the remaining nine locations.

FF = foF2 in 0.1 MHz units
MM = M(3000)F2 in 10 * units
EEE = foEs in 0.1 MHz units
NN = fmin in 0.1 MHz units

When a value is reported, no scaling letters are added to it. When no value is reported, the first character (and second for EEE) is replaced by a slash and the last character is a letter explaining why the data entry is missing.

K is given in the table below and is a double hour (UT) indicator.

K	UT
0	**00**
0	01
1	02
1	03
2	04
2	05
3	**06**
3	07
4	08
4	09
5	10
5	11
6	**12**
6	13
7	14
7	15
8	16
8	17
9	**18**
9	19
0	20
0	21
1	22
1	23

This code carries more ionospheric data than the UFOFH code, but achieves it at the expense of the descriptive information. It is unsuitable for general use as foF2 is limited to 9.9 MHz and the IUWDS rules for using the code have no recommendation about how to handle the entry if it occurs. A convenient fix is to enter /4 for FF (see sec. 4.5.5) - value not entered because it exceeds the available space. This option is exercised in the example below. Where foF2 is not expected to exceed 9.9 MHz, for instance at high latitudes, this code would be adequate.

```
IONFM 12345 20221 /0000 0/4//
///// 085// ///// 185// /////
175// ///// 252// ///// 251//
///// 345// ///// 347// /////
446// ///// 449// ///// 555//
///// 561// ///// 660// /////
636// ///// 745// ///// 767//
///// 874// ///// 871// /////
974// ///// 974// ///// 085//
///// 047// ///// 190// /////
112// /////
```

The large number of / entries emphasises that IONFM was not developed for exchanging only foF2.

4.5. Scaling letters usage

These codes only use a limited selection of the scaling letters described in the URSI Handbook of Ionogram Interpretation and Reduction (UAG 23 and 23A) because the IUWDS codes are numerical rather than letter based codes. Only ten numbers, plus a slash, summarise the full texture of complete scaling. The UAG-23A rules are used where possible, with only occasional relaxation if more ionospheric information is likely to be collected.

The scaling letters identify conditions where foF2 is unscaleable (for all codes), or possibly in error (only for UFOFS and UFOFH). In other words, they identify conditions, which affect the accuracy of the scaled value, and which scalers with limited training can easily recognise on ionograms.

4.5.1. No scaling letter required = /

When no scaling letter is required, a slash (/) or an X is used.

4.5.2. Blanketing, (A) = 1

Blanketing sporadic E can prevent foF2 from being scaled. In addition, other layers may make the scaling of foF2 suspect and an A may offer a suitable error indicator. While an admission of confusion, an untrained scaler faced with a complex ionogram may find confidence in doing this. The scaling letter is useful.

4.5.3. Absorption, (B) = 2

Major absorption events may be severe enough to make foF2 unobservable. This could be due to a fadeout or, at high latitudes, to particle ionisation (such as polar cap absorption and auroral absorption). This letter has most meaning for high latitude data.

4.5.4. Equipment failure, (C) = 3

This has its usual meaning and is a useful descriptive letter.

4.5.5. Above upper limit, (D) = 4

During low latitude nights, foF2 can be unresolved and the associated range spread may exceed the ionosonde upper frequency limit. However, this is an unlikely letter to use with a modern ionosonde. Note, this is not an estimate of accuracy and therefore has limited value. The letter probably has most value for replacing IONFM foF2 values greater than 9.9 MHz.

4.5.6. Below lower limit, (E) = 5.

Normally, in modern ionosondes, radio interference fixes the lower frequency limit making the letter S more appropriate. However, in radio quiet locations, foF2 may drop below the lower limit of the ionosonde. It would be useful to use this number for either E or S. Note; again, this is not an estimate of accuracy.

4.5.7. Spread F, (F) = 6

The descriptive letter F is scaled whenever spread F is present near foF2. This should be a priority scaling as the letter offers significant information on the state of the ionosphere.

4.5.8. A "G" condition, (G) = 7

When foF2 is less than foF1, a typical response to an ionospheric storm, the foF1 value replaces foF2 and the descriptive letter G is used. This is an important limiting case of foF2. It is unclear how this can be handled using the IONFM code.

4.5.9. Interpolation, (I) = 8

Interpolation is rarely used in scaling ionospheric parameters, yet it is one of the descriptive letters with the IUWDS codes. At IPS we have encouraged the use of I for IUWDS codes whenever there is a chance to get a measurement. This is particularly true for UFOFS data where a chance blanketing layer or equipment failure could prevent ionospheric conditions being recorded for 12 hours. There are occasions when interpolation is not appropriate, but with care foF2 can be scaled when it might not be measured. IPS offers advice to scalers intending to use I. For instance, we suggest they never interpolate if the process that has prevented foF2 being measured is related to foF2 in some way, e.g., a G condition, D, E or F conditions, or absorption is possible. If foF2 is changing rapidly, or is irregular, interpolation may have no meaning. Generally, we prefer to restrict interpolation to the 3 hours either side of the hour for which foF2 is being measured. Using I correctly takes skill and practice, so when interpolation is used it should always be noted by adding the I. In this way, I is potentially valuable.

4.5.10. Retardation, (R) = 9

The radio wave slows near a critical frequency, resulting in increased virtual height and increased absorption. R shows increased (deviative) absorption has affected the value scaled.

Normally, retardation should not cause major problems for a confident scaler, but less well trained people will scale the data discussed here. Consequently, at IPS we decided to describe all "reflection process errors" by R when using the telex codes. This means that defocussing and some travelling ionospheric disturbance effects are described by R. With these qualifications, R is useful.

4.5.11. Any other letter = 0

This is used when the appropriate scaling letter is not one of the 9 allowed letters. In many cases this is satisfactory, although times will occur when the loss of a descriptive letter allows a potentially misleading value to be used. At least the recipient of the data has been warned.

4.6. Comments

IUWDS operates a real time network for international data exchange. This network operates through eleven locations around the world and is the logical starting point for coordinating real time ionospheric data exchange.

IUWDS has already developed codes for exchanging many types of data, including ionospheric data. The general format of these codes has proven useful in the past and is therefore a good starting point if more codes need developing. The root format, described in the codes presented in this note, is worth preserving.

However, these codes originated many years ago. It appears compromises were required and they have persisted into the present day. Brevity was a key issue in the early codes because both coding and decoding were done manually and some information was sacrificed because of this. In many cases, the telex messages are now handled by computers, so clarity and redundancy are more important issues than brevity.

Three codes were described in this note. The UFOFS and IONFM codes have the advantage that they are short, but they limit the information being transmitted, and in some cases errors may be made because of the shortened format. Where manual coding is still used, or transmission costs are very high, these codes are probably still useful. I would recommend altering the IONFM code by interchanging the positions where foF2 and foEs are recorded, thereby allowing foF2 to exceed 9.9 MHz. I would also suggest recording foEs in units of 1.0 MHz. If this change was adopted, a new keyword would be needed, say IONFN, so there would be no confusion about which code is being used.

The UFOFH code is more useful than the previous two as it conveys more information. However, I would prefer a code that allowed both qualifying and descriptive letters to be transmitted. I feel this should be discussed more widely than it has been to date. It appears that the codes discussed here were set up to exchange data, but the data were not being used by many people. Consequently, only a limited amount of thought has gone into ensuring the codes offer complete information. I don't think the next generation of codes should be limited either by the transmission medium or by the amount of use that can be made of the data now. Rather, the codes should be used to transmit as much unambiguous ionogram information as possible. At the very least, the codes should allow for all the qualifying and descriptive letters. Remember the wealth of additional information that can be obtained from ionograms in the form of "flags" (e.g., Wilkinson, 1984, INAG 43/44, p11).

IUWDS has now largely moved to computer based data exchange and this will expand further in the future. When direct computer exchange of data becomes common, codes can safely be made longer as transmission costs will be minimal. I would suggest developing a code similar to UFOFH with two basic changes. The keyword, UFOFH would be replaced by a name UFOXX where XX is the URSI two digit code for the different ionospheric characteristics (see article 8 for full list). Second, I would replace the five figure fgggh block with fgggkh where f and ggg have the same meaning as before, while kh is alphabetic where k is the qualifying letter and h is the descriptive letter. The telex codes could then conform with the full URSI scaling methods described in UAG - 23A. However, in a computer oriented data exchange system, there is no good reason to preserve telex codes at all. More radical solutions will probably be appropriate.

Different options may also be possible using digital ionosondes scaling the ionograms automatically. However, until the alternatives have been experimented with widely, there seems no good reason to abandon the current well tested methods. The main objective is to avoid limiting future options by narrow choices based on old technologies.

Finally, hourly data are a compromise and more work is needed to establish better ways of describing the disturbed ionosphere. Real time data exchange is limited if this issue is not treated seriously.

5. HF Atmospheric Echoes : Atmosphere - Ionosphere Coupling

by J K Olesen, Copenhagen, Denmark.

5.1. Introduction

I should like to ask for comments from INAG on the possibilities for reflections at HF from structures in the atmosphere - troposphere or stratosphere - and on the **POSSIBLE** interplay with the ionosphere / ionospheric echoes. My question is especially directed towards mechanisms related to electrified cloud systems such as thunder clouds and tropospheric jet wind streams. The reason for my question is that during our ionospheric experiments in Greenland - at Sondre Stromfjord, 74° Invariant Latitude - we have, during recent years, obtained HF-echoes which seem to originate in the atmosphere.

We had at the station a C3/4 ionosonde, a 12.3 MHz pulse backscatter set-up with horizontally rotating 3-element Yagi antenna and in addition a 12.3 MHz CW spectral doppler backscatter installation using the same Yagi for receiving.

The time-constants in normal ionosondes - and also in our pulse backscatter set-up - prevents the observation of very short distance echoes due to the blocking of the receiver for some time after the transmitter pulse, eg. up to maybe 50 km range. However, when, in 1980, we introduced in our CW system a 150 Hz amplitude modulation in order to use a phase comparison method to obtain range information on the CW data, we apparently obtained several cases of reflections from very short ranges, e.g., 10-30 km. We investigated these cases more closely and found, in all cases up to now, weather conditions which favoured atmospheric Jet Wind Streams (JET) with related Clear Air Turbulence (CAT). Various investigations have revealed possible relationships of JET-CAT to several peculiar phenomena as follows:

1. Major damage to expensive aeroplane acryl windows - probably due to electrical discharges.
2. Increased ozone content, demanding special filtering in aeroplanes.
3. Patches of abnormally high electric fields as measured by balloons and on the ground and an apparent relationship between jet wind velocity and E-field strength.
4. Possibly low frequency noise and light emissions related to JET-CAT.
5. Possibly some interplay between thunder clouds and jet winds.
6. Loss of HF contact between the aeroplane and the ground station.

In addition to the above peculiarities connected to events of short range CW-echoes and JET-CAT, we find our 12 MHz pulse backscatter and ionosonde-echoes somewhat special in these cases, as the following examples demonstrate.

5.2. Event : August 19 1980

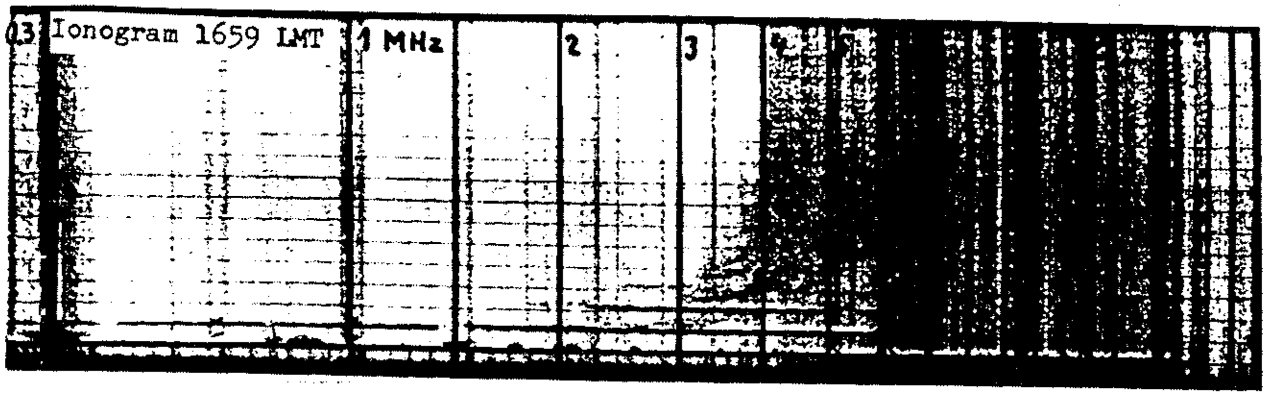
Figure 1a is an ionogram recorded at 1659 LMT which has an Es layer showing three multiples. Notice the sudden stop of first and second multiples simultaneously (screening of the atmosphere?) and also the "ghost" echoes above these two multiples at an additional range of 10-30 km.

Figure 1b is a 12 MHz pulse backscatter record made with a low elevation rotating Yagi at 1655 LMT; 4 minutes before the above ionogram. Notice the peculiar appearance around East with strong interference streaks and low range signal dots.

Figure 1c is a backscatter record made at 1555 LMT, one hour before the above record. Notice the double trace at 300 km and the third trace at 400 km, all towards North.

Figure 1d are 12 MHz CW doppler and range 3-D plots for the period 1702-2016 LSOT = 1902-2016 UT = 1602-1916 LMT. Notice the return at a range starting at about 200 km and decreasing to low values - and the associated broad doppler spectra.

Figure 1e is a 10 second registration of the CW backscatter signal amplitude 2031:19 to 2031:29 UT. Notice the fading frequency of about. 3-5 Hz and the amplitude of considerable strength and the



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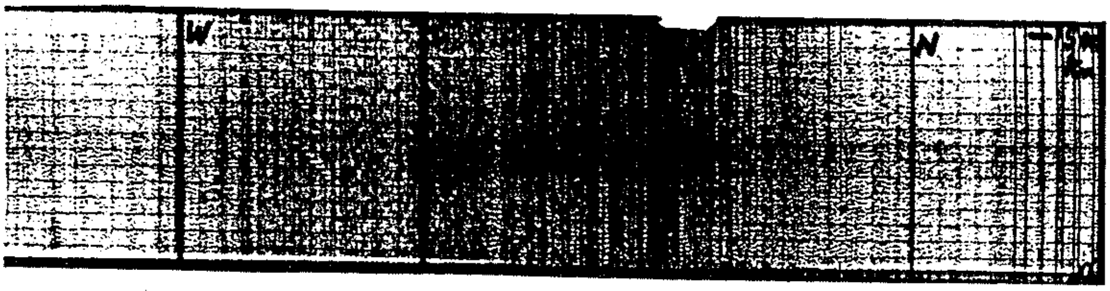
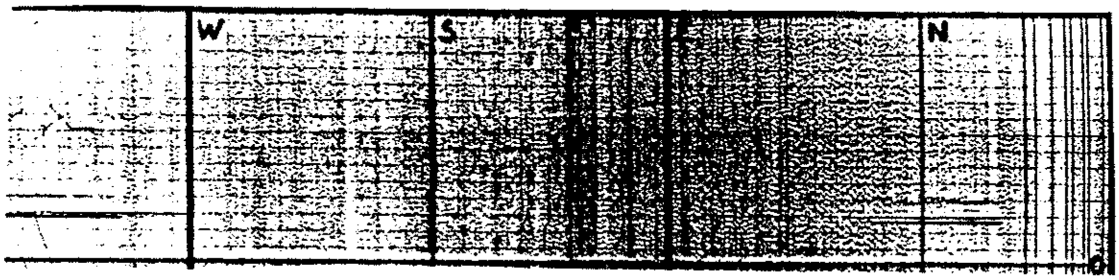


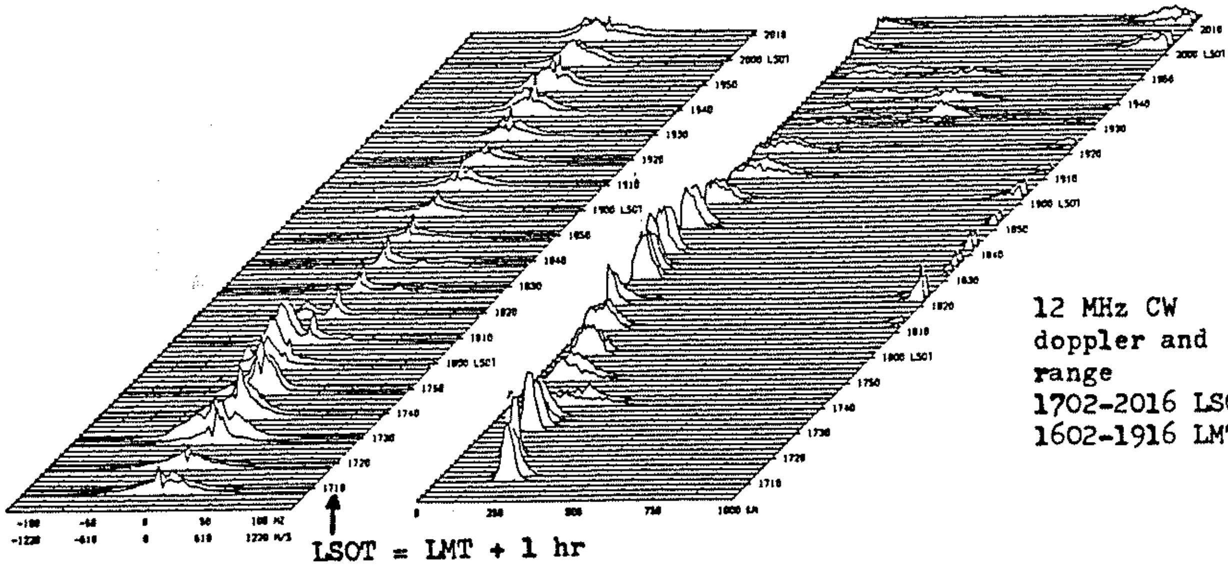
12 MHz Back-
scatter
1655 LMT

b



12 MHz Back-
scatter
1555 LMT

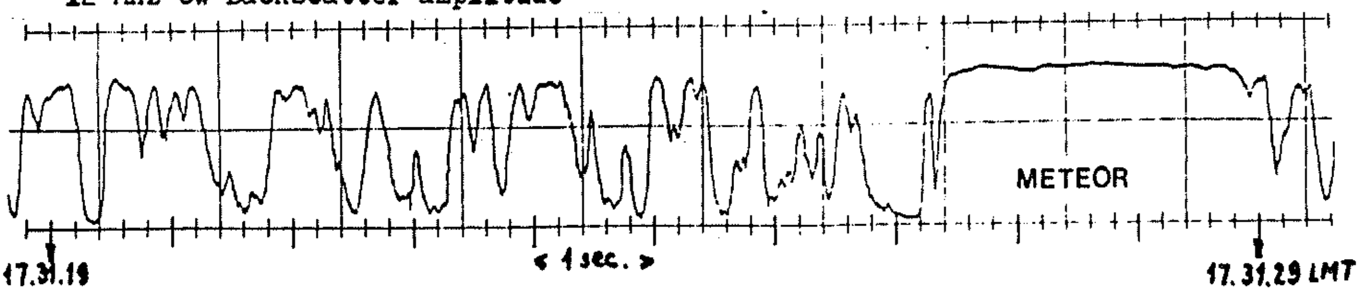
c



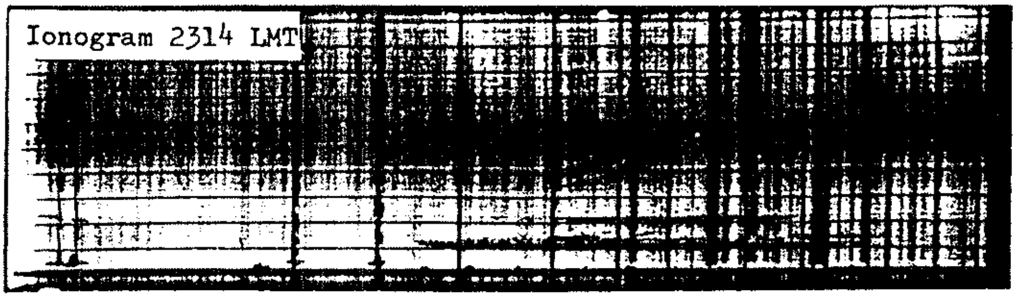
12 MHz CW
doppler and
range
1702-2016 LSOT =
1602-1916 LMT

d

12 MHz CW Backscatter amplitude



e



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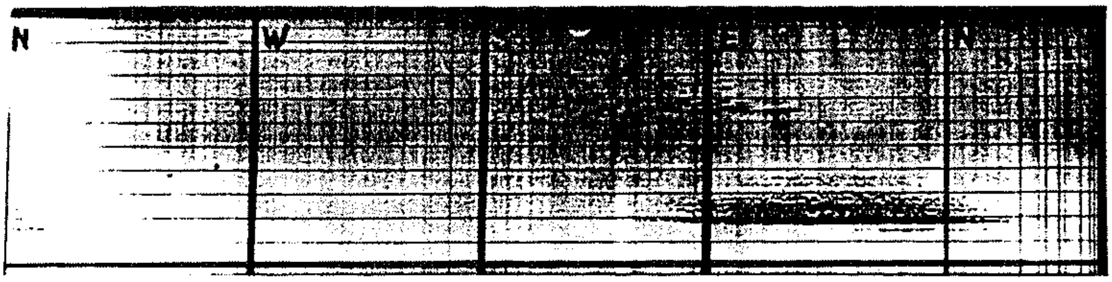
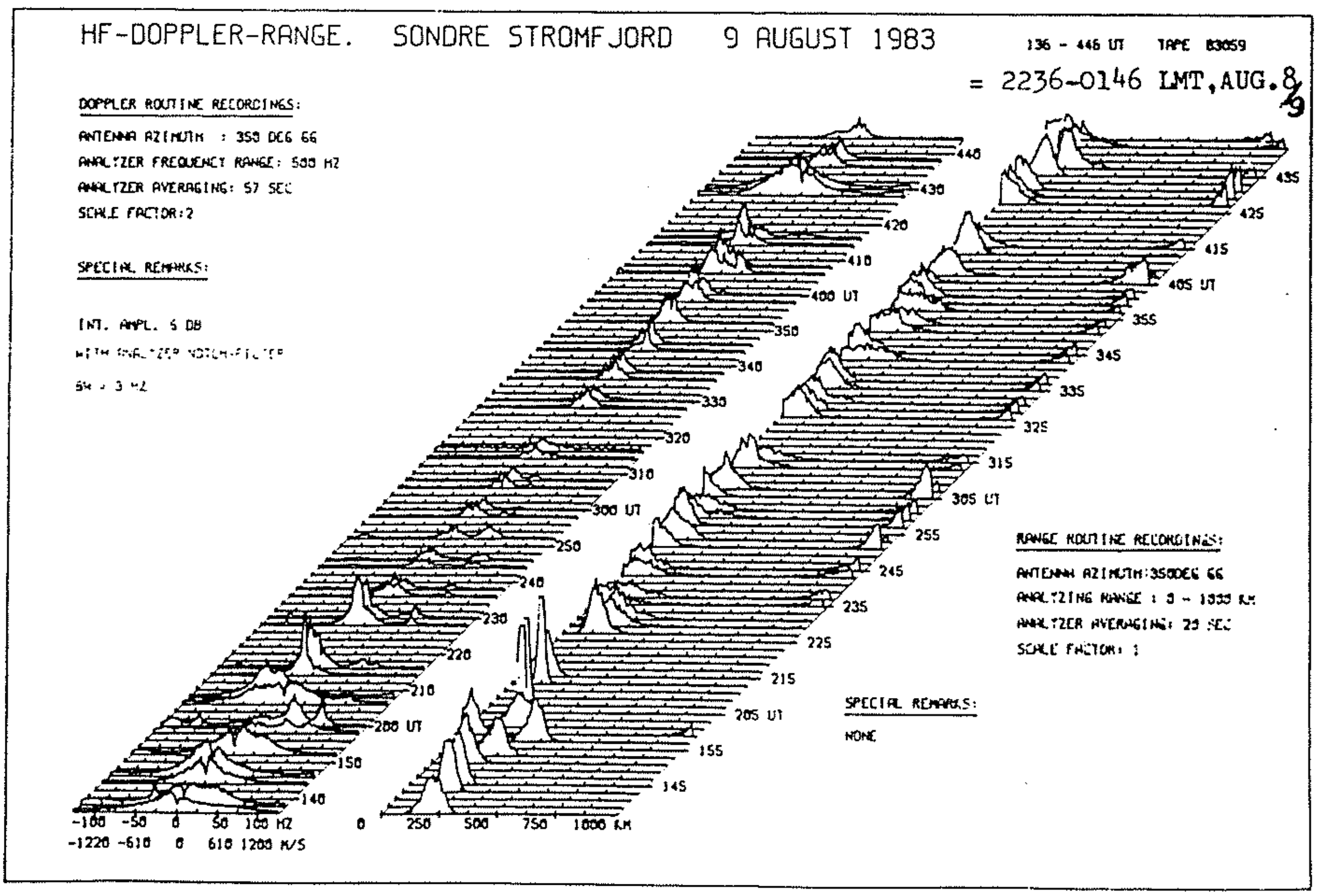


12 MHz Back-scatter 2314 LMT

b



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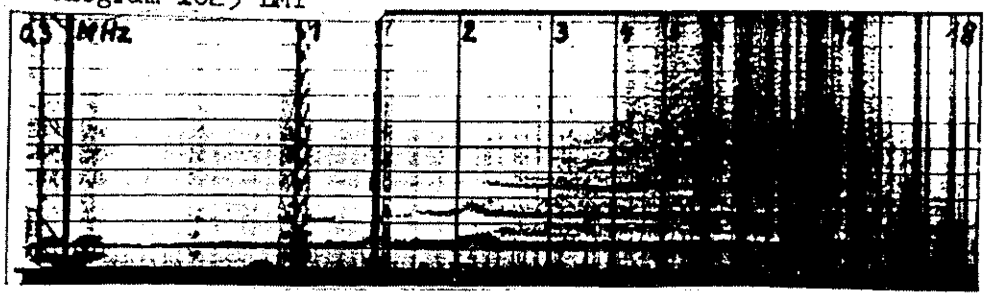

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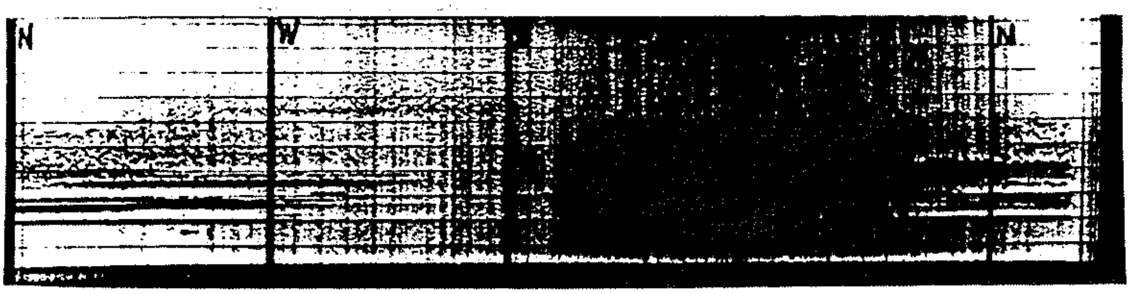
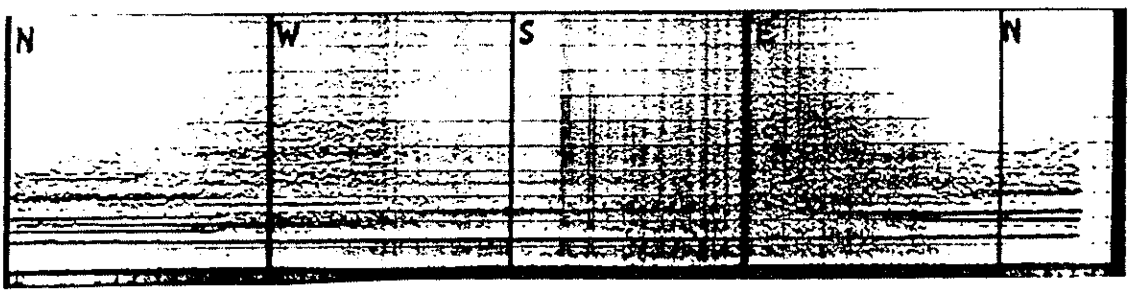


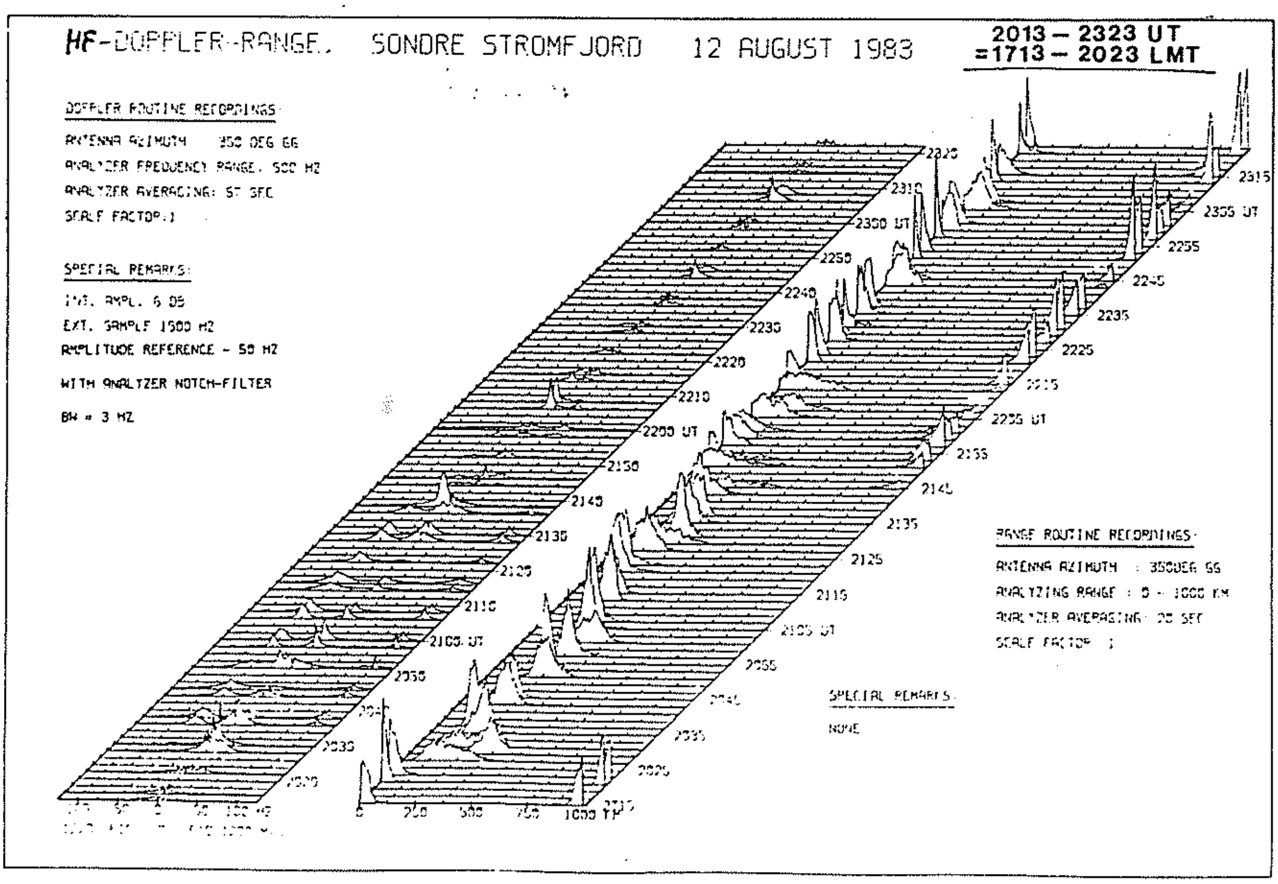
12 MHz Back-scatter 1755 LMT.

b



12 MHz Back-scatter 1825 LMT

c



d

same order of magnitude as that of a very strong meteor reflection.

5.3. Event : August 8 1983

Figure 2a is an ionogram recorded at 0214 UT=2314 LMT and showing Esf (or Esc?) with three multiples. Notice again the "ghost" echoes above the second multiple at an distance of about. 20-30 km. There are also oblique returns associated with the F-region echoes.

Figure 2b is the backscatter record at 2314 LMT. Notice the crowded echo pattern towards the north east, at 190-360 km range. (The characteristic intermittent echo pattern towards east south east is a recurrent phenomenon, whose source has not yet been identified).

Figure 2c is the 12 MHz CW doppler and range 3-D plots for the period 0136-0446=2236-0146 LMT. Notice the range recordings at about 200 km decreasing to very low values and the broad doppler spectra.

5.4. Event : August 12 1983

Figure 3a is an ionogram recorded at 1829 LMT showing Esc at 110 km with four multiples. Notice again the "ghost" echoes above the first three multiples, at about 30 km, and more above the third multiple.

Figures 3b and 3c are the two corresponding 12 MHz pulse backscatter records made at 1755 and 1825 LMT, respectively. Notice the peculiar echoes at 120-400 km range and the double-traced echoes separated by 10 to 30 km.

Figure 3d is the corresponding 12 MHz CW doppler and range plots with characteristics similar to the previous two events.

5.5. Summary

Everyone would agree on the importance of atmospheric reflections (if they are real!) in the interpretation of ionogram traces, especially if these could be created by oblique paths, including a combination of atmospheric and ionospheric sources. Although the type of event is not rare at Sondre Stromfjord, I wonder why they happened to show up in several JET-CAT events. There was no big magnetic activity, so probably no strong particle precipitation.

Summing up briefly, we have made a brief literature review of reports on similar observations. A list of subjects and the corresponding literature is given below.

1. HF-reflections from troposphere and stratosphere. (5,6,7,8,14,18)

2. Trimpy effects, i.e., electron precipitation generated by whistlers. (11,12,13)

3. Electron precipitation, E-region ionisation, and wave propagation effects generated by lightning or other cloud electrification mechanisms. (1,2,4,7,10,11,12,14,17)

4. The possible interplay between thunder and jet streams. (15,19)

5. Possible interplay between E-region ionisation and barometric pressure. (1,2,3,7,9,16).

It seems that in many reports of particle precipitation, or E-region ionisation, the experiments lacked ionograms, and in cases where ionograms were obtained, the unreliability introduced in ionograms by various equipment problems, e.g., low sensitivity, antenna characteristics, etc, is the limiting factor.

There seems to be a need for renewed tests of the above phenomena with high quality equipment by qualified ionosonde and ionospheric experts — these remarks also apply to our own data!

5.6. References

1. Appleton and Naismith, Proc. Phys. Soc., London, 45, 389, 1933

2. Appleton, Naismith and Ingram, Phil. Trans. A, 236, 191, 1937

3. Colwell, Proc. IRE, 21, 5, 21, 1933

4. Colwell, Nature, 133, 948, 1934

5. Colwell and Friend, Phys.Rev., 50 632, 1936

6. Friend and Colwell, Proc. IRE, 25, 1531, 1937

7. Friend and Colwell, Proc. IRE, 27, 626, 1939

8. Friend, Proc. IRE, 116-138, 1949

9. Gherzi, Bull.Amer.Met.Soc., 27, 114, 1946

10. Goldberg, Barcus, Hale and Curtis, JATP, 48, 3, 293, 1986

11. Helliwell, Katsufrakis and Trimpi, JGR, 78, 22, 4679, 1973

12. Inan, Wolf and Carpenter, JGR, 93, A9, 9841, 1988

13. Inan, Shafer, Yip and Orville, JGR, 93, A10, 11455, 1988

14. Isted, Marcony Review, XVII, 113, 37, 1954

15. Orville, Henderson and Bosart, GRL, 15, 2, 129, 1988

16. Ranzi, Nature, 130, 3279, 368, 1932

17. Smith Jr., Rep.3575, NBS, CRPL, US Dep.Comm., p232, 1955

18. Wattson Watt, Wilkins, Bowen; Proc.Roy.Soc., A, 161, 181, 1936

19. Olesen and Jacobsen; Techn.Rep. 90-6, Danish Met. Inst., 1990

6. Sequential Sporadic E

by P J Wilkinson

ABSTRACT

Sporadic E layers are frequently observed to descend from a height around 150km down to the E region. This descent can take several hours. This type of sporadic E is called sequential sporadic E, among other names, and its gross features can be determined using scaled data from a conventional ionosonde. In this note, some of the features of sequential sporadic E are discussed, together with potential areas where useful research is possible. This phenomenon may provide new insights into the processes producing some mid-latitude sporadic E.

6.1. Introduction

The term ''sporadic E'' is used for a wide range of ionospheric E-region perturbations seen on ionograms and encompasses particle precipitation, plasma instability and dynamic processes extending from the pole to the equator. While different physical processes are recognised, empirically based statistical models (e.g., Smith 1957, Leighton et al. 1962) have rarely been able to discriminate between them, thereby confusing the macro and micro scale structures. This deficiency arises, in part, because the global data set comes solely from ionogram analysis where it is difficult to devise unambiguous rules for discriminating between different physical processes. In this note, one particular type of sporadic E, sequential sporadic E, is described.

There is a long history of sporadic E being described as a descending layer and explained in terms of atmospheric tides. Descending sporadic E layers are frequently observed on ionograms from some mid latitude locations. One of the earliest reported observations (McNichol and Gipps, 1951) recognised the semidiurnal nature of sequential Es and suggested this explained the two maxima seen in sporadic E occurrence. They described sequential Es as a layer that formed above the E region, sometimes higher than 150km, and descended into the E region where it dissipated. They called this type of sporadic E, sequential Es, or Ess. They propose that sporadic E is divided into two classes, one of which was sequential Es, or Ess. The McNichol and Gipps paper outlines all the important properties of sequential sporadic E. Their general points are outlined here.

- The layer starts in the F1 region and descends first as E2,
- normally it appears after sunrise, with a second less prominent appearance after noon,
- it is a strong blanketing layer (the morning layer may blanket the E/F region preventing the afternoon layer from being seen).
- As the layer descends, foEs increases and there is evidence of the layer thinning (the high frequency retardation part of E2 disappears),
- as it reaches 110-100km the layer becomes patchy and breaks up.
- Often two descending sequences of Es are seen, one in the morning and the second in the afternoon. These descending sequences may explain the double peaked sporadic E occurrence statistics.
- The layer lifetime depends on season, being most important in summer, although it is still present in winter when Ess is seen one day in four,
- when two sequences occur in a day, the second sequence has a lower reflection coefficient (fbEs-foEs is smaller) and when the morning

sequence has an especially high blanketing frequency, the afternoon sequence will also be high blanketing.

- Ess is seen over a wide area (Brisbane to Canberra), as the long lifetime suggests.

These are good observations, as data on sequential sporadic E layers at Australian stations verifies.

It is unclear why these results have not been effective in changing people's ideas about sporadic E. Evidently, from the early work, sporadic E at high altitudes was linked to the peaks in occurrence of sporadic E at lower altitudes.

Observations have been reported many times in the literature (e.g., see Thomas, 1956 for pre-1950 references). Thomas (1956) appears to have been the first person to suggest atmospheric tides could be responsible for sequential sporadic E. Evidently sequential Es is less prevalent at European stations than at Australian stations (Whitehead, 1970). Notwithstanding, MacDougall (1974, 1978) used sporadic E data from the global ionosonde network to explore the possible associations with atmospheric tides. More recently, Wilkinson et al. (1992) demonstrated that the formation of a long lived sequential sporadic E layer was consistent with wind fields predicted by the NCAR Thermospheric and Ionospheric Global Circulation Model, or TIGCM. The modelling successfully showed that windshears in the neutral atmosphere, due to atmospheric tides, together with the local electric field offer a satisfactory explanation for the appearance of a long lived descending sporadic E layer. This result showed the potential for the TIGCM to model sequential sporadic E and offers the prospect that a plausible cause - effect relationship can be deduced for some sporadic E formation. How important these processes are remains to be seen.

In this note, the sporadic E sequence modelled by Wilkinson et al is presented, together with hourly ionosonde data, demonstrating both the appearance of sequential Es on ionograms and also in scaled data. Following this is a discussion of the results, the problems and comments on possible future work.

6.2. View of the layer descent

During the September 1989 SUNDIAL campaign, descending sporadic E layers at Townsville were observed on several days and the best example was selected for study.

The sequence of hourly ionograms shows the development of a sequential sporadic E layer at Townsville, 18 September 1989 (figure 1). The local time of recording is displayed in the upper left hand frame of each ionogram. The vertical axis is virtual height with vertical markers every 100km in virtual height. The horizontal axis is logarithmic in frequency, measured in megahertz. The sporadic E layer is identified with an arrow, foEs and fbEs are identified by a vertical line and h'Es by an horizontal line.

Initially, a layer is seen with an electron density only slightly greater than the normal E layer but with a large virtual height that is difficult to measure accurately due to retardation. McNicol and Gipps (1951) state the Ess sequence starts with a thicker layer breaking away from the F region. This is not always the case, as shown in figure 1. Possibly this is a matter of the extent of ionisation affected or maybe it is a matter of qualitative interpretation. Because of the low sporadic ionisation, the underlying normal E region retardation effects are significant. These increase the virtual height making it a biased estimator of the real height. While allowance for retardation effects is possible, it is likely that the real heights are biased too high if the electron density of the sporadic layer is not 30% to 40% greater than the electron density in the underlying normal E layer.

As the layer descends, the electron density increases and is probably accompanied by layer thinning (McNichol and Gipps, 1951 and Thomas, 1956), and the virtual height becomes a better estimator of the real layer height. Often, during the layer descent before noon, as in the example, the normal E layer and the sporadic layer increase in peak electron density at a similar rate, with the sporadic layer being just greater than the normal E layer. As foE increases, the layer remains visible, but is only slightly higher in electron density than the normal E region. By local noon, the layer is below 130 km. The normal E layer electron density, which is solar controlled, then begins decreasing but the sporadic layer electron density either stays constant or increases while the layer continues to descend. Clearly, in the example, much of the time the sporadic layer virtual height overestimates the real height. However, by 1400 LT the sporadic layer critical frequency is large enough for the errors in reading heights off analogue film to be larger than the retardation effects from the underlying normal E region. The sporadic E layer remains detached from the normal

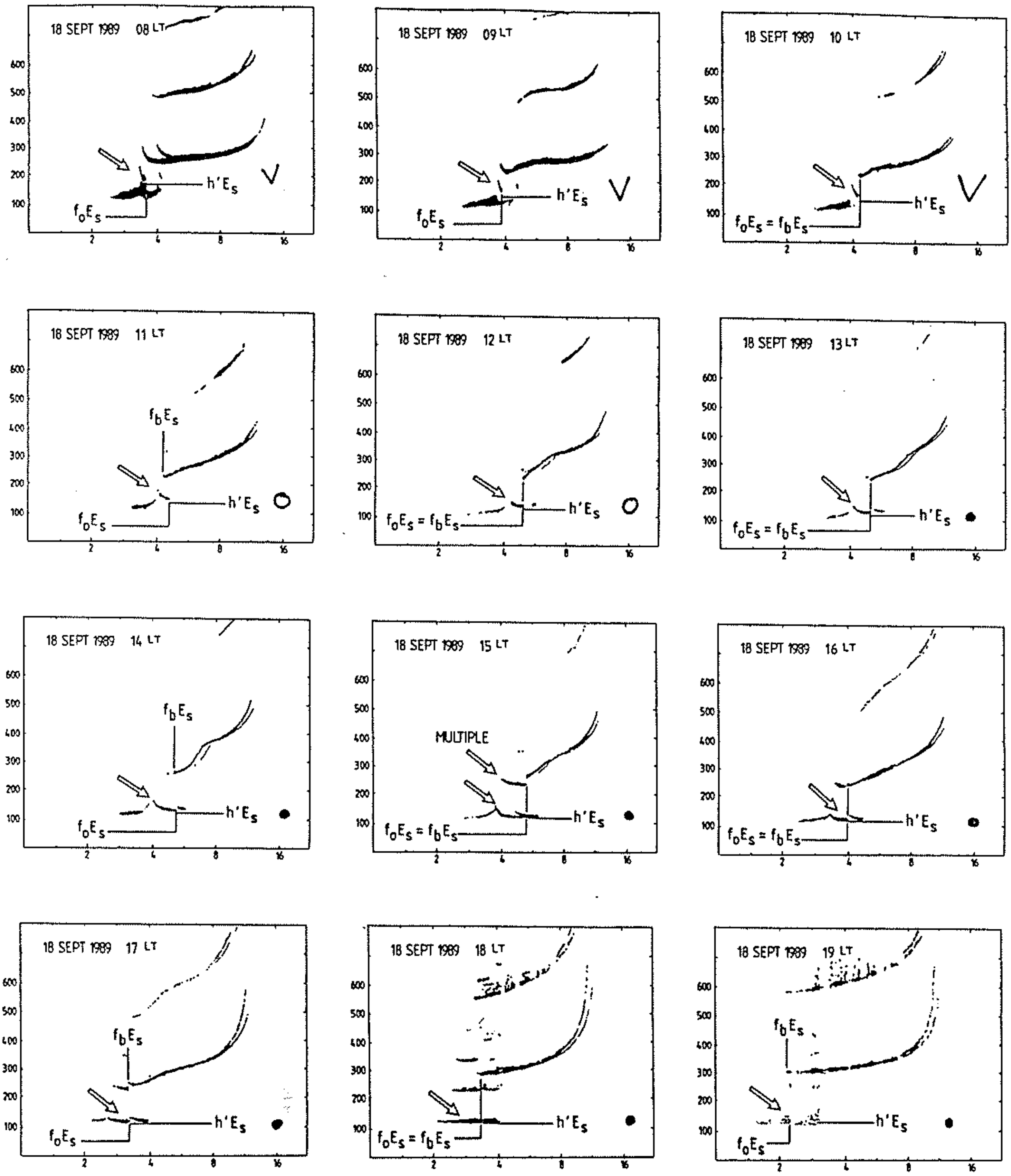


Figure 1.
A sequence of hourly ionograms recorded with the IPS-4B ionosonde at Townsville. The unfilled arrow indicates where the sequential sporadic E layer is, the horizontal line indicates where h'Es was scaled and vertical lines are used to indicate foEs and fbEs. The symbols used to code the level of confidence in the h'Es ploted in figure 2 are shown to the right of the h'Es label.

E region until 1500 LT when it appears attached on the ionogram. Prior to 1500 LT it is called a high-type sporadic E layer and afterwards it is cusp-type sporadic E. Near sunset the layer breaks up, although in this sequence sporadic E continued to be present well into the night. It is unclear whether this ionisation is maintained by the same processes thought responsible for the daytime descending layer.

In figure 2, the corrected values for the sporadic E virtual heights, both good values from below 130 km and with probable bias above this level, link together well. The layer is descending and for the later stages there is a rate of descent of roughly 5 km per hour which falls in the range of previously estimated descent rates (Whitehead, 1970). The rate of descent decreases as the layer approaches 100 km, as has been observed by other workers. After reaching this level, the layer dissipates. The region of interest is the mid height range between where the bias is small and where the layer approaches a "saturation region". It seems likely that the layer descent is controlled by a major wind shear influence, resulting in the long lived nature of the layer as it descends.

People unfamiliar with ionograms thought, on seeing these examples, that the layer may not be above the station. There are, however, a number of features that confirm the layer is overhead. A notable feature of this sequence is that, for much of the time, the blanketing frequency for the layer is almost equal to the layer critical frequency. This strong evidence that the layer is overhead has been cited by other authors. It assumes that the F region is overhead; a good assumption at these latitudes during the daytime. By 1500 LT, a multiple for the layer corroborates this fact. Finally, in the example shown, the layer is present for roughly 12 hours, making it likely that it was overhead.

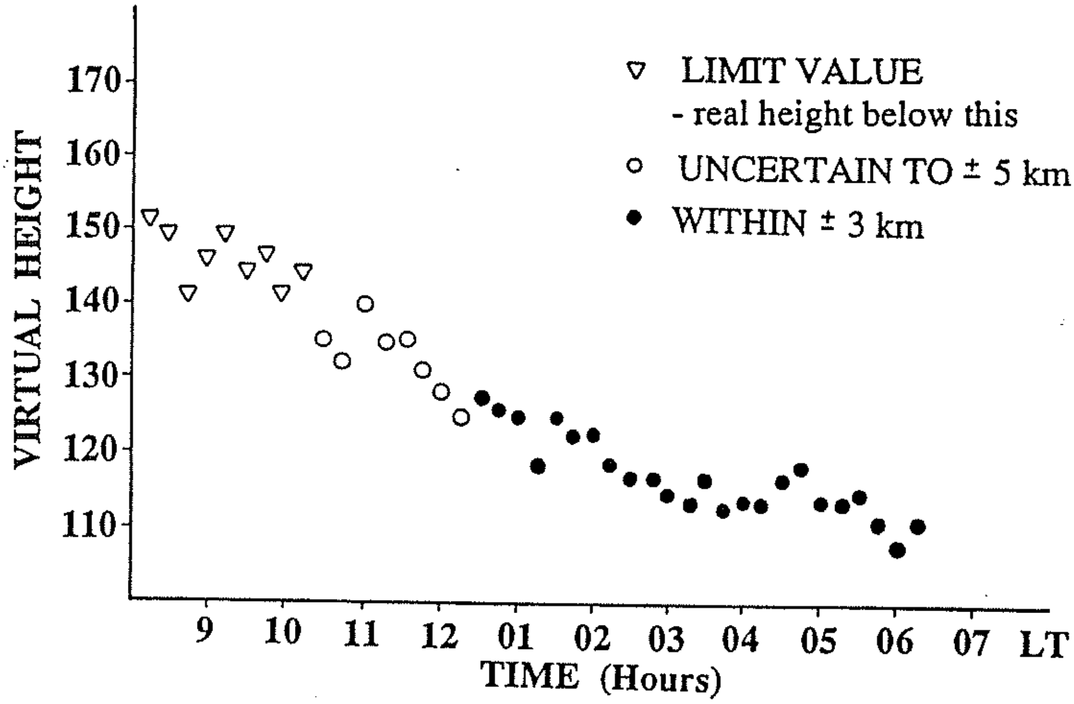


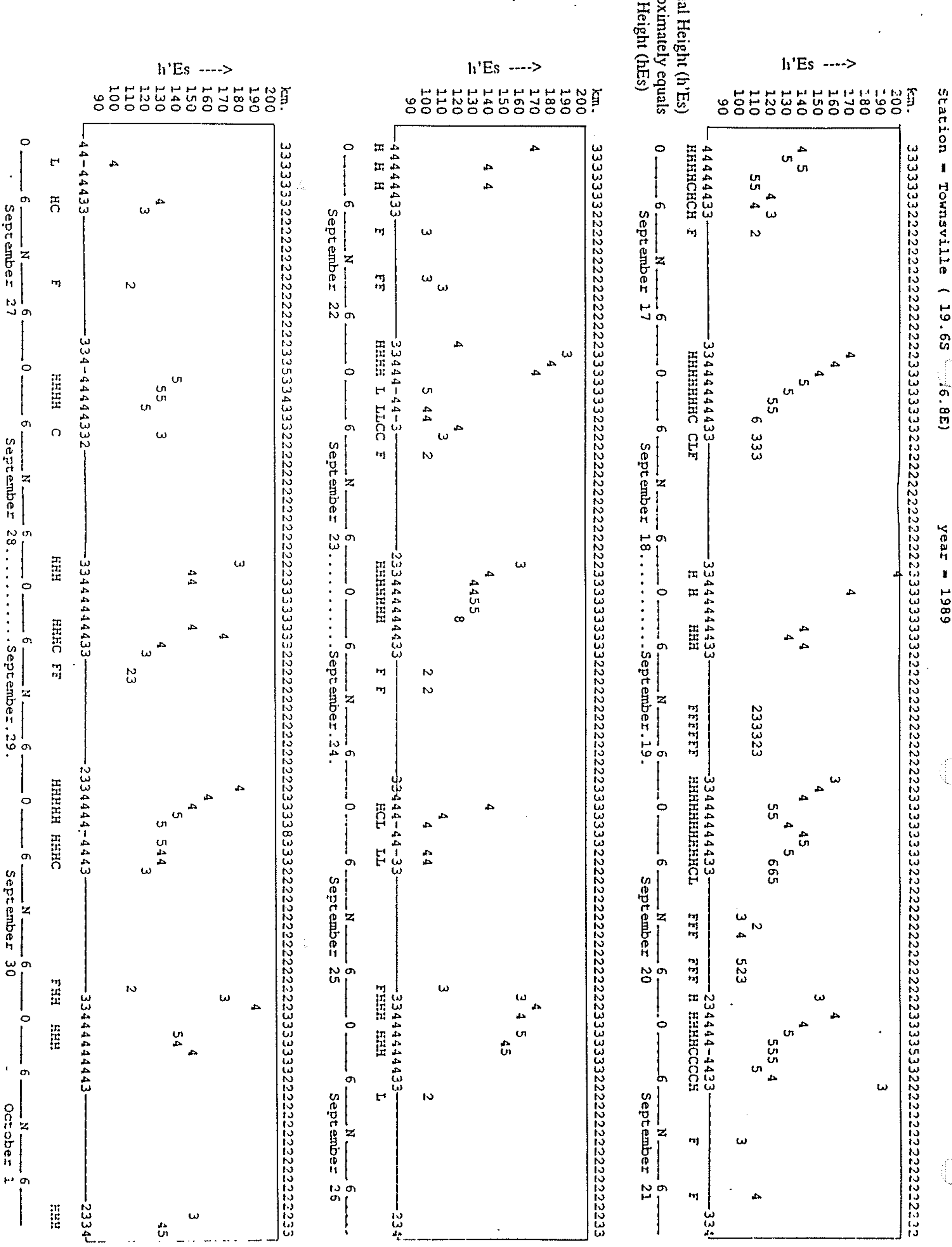
Figure 2.
The corrected h'Es virtual heights for the ionogram sequence in figure 1 are displayed for the 15 minute ionograms.

6.3. Presentation of hourly data

Slowly descending sporadic E layers can be identified using sporadic E virtual height data scaled regularly from ionograms, together with other scaled data from the sporadic E layer and the normal E region.

These features are shown in figure 3. In the figure, the highest observed ordinary wave reflection from the sporadic E layer (foEs), rounded to the nearest megahertz, is displayed on the diagram at the virtual height of the sporadic layer. This value is bracketed by fmin (top line) and foE (bottom line), defining a lower frequency threshold below which sporadic E ionisation cannot seen. The type of

Figure 3.
Hourly data for the period 17 September to 1 October, 1989.



sporadic E is plotted beneath the time series. There is no allowance for possible bias in the virtual heights recorded, but the frequent intrusions of sporadic E starting from apparently great altitudes and then descending, near local noon, are clear on several days. Because of the small differences between the sporadic layer maximum and the normal E layer electron density, it is not surprising that several sequences are broken, or start at low altitudes. The predominant feature of the figure are the clear descending sequential sporadic E layers, characterised by falling virtual heights as the day progresses. Inspection of the ionograms recorded for this period shows this even more convincingly.

6.4. Discussion of the results

Summarising these observations, descending sporadic E layers have been observed at many sites around the world and attempts have appeared in the literature to associate them with a source of wind shear, such as atmospheric tides. The reasons for making such an association are clear here; the layer descent is slow, occurring over an appreciable length of time and is roughly repetitive at the same time each day.

In this section, some possible areas for future work are indicated.

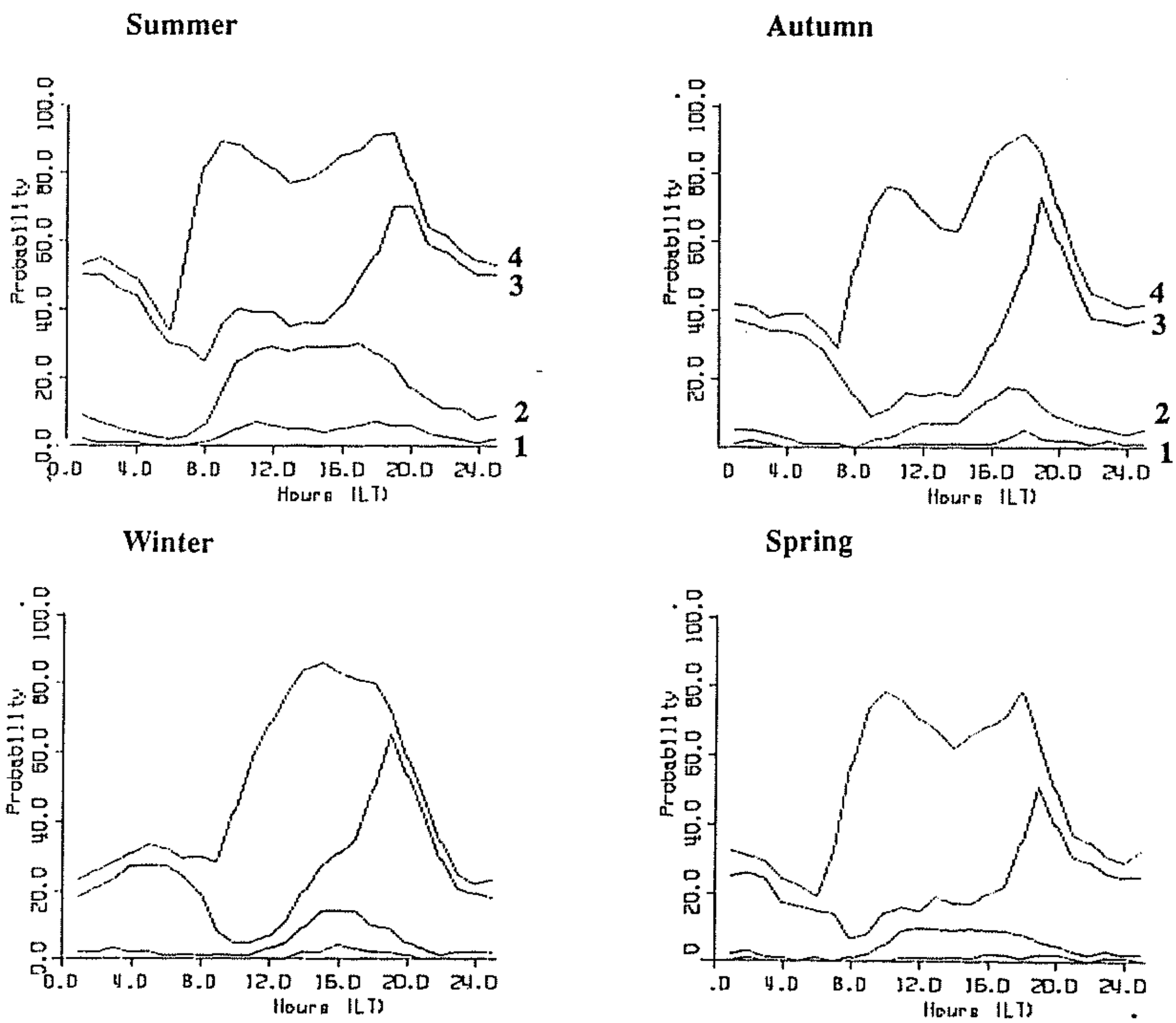


Figure 4. Occurrence of Sporadic E at Townsville (19° S).

Four probability levels for sporadic E occurrence are shown:

1. Probability foEs > 7.5 MHz.
2. Probability foEs > 5 MHz.
3. Probability foEs > foE + 1 MHz.
4. Probability that Sporadic E is present.

6.4.1. Some sporadic E statistics

As an example, some sporadic E statistics for Townsville are presented in figures 4 and 5.

In figure 4, all sporadic E observations recorded at Townsville between 1983 and 1990 are displayed using four different probability thresholds of sporadic E activity that have appeared in the literature.

Curve 1 is for intense sporadic E, defined as the probability that foEs will exceed 7.5 MHz. Curve 2 is a more familiar threshold; the probability that foEs exceeds 5MHz. This threshold has been used to construct world wide maps of sporadic E occurrence and is introduced in Smith (1957). Curve 3 uses a threshold similar to one introduced by Piggott and also, earlier, by J W Wright. I have included it here to illustrate another option for dealing with sporadic E. This threshold takes the position that if foEs is sufficiently larger than foE, then it is important. This is a way of eliminating solar dependence of sporadic E occurrence so that the general behaviour can be studied. At night the threshold was set at 2MHz and during the day, when foE is measured, a threshold of (foE + 1 MHz) was chosen.

All three of these statistical thresholds eliminate the type of sequential layer shown in figures 1 and 2 for much of their development. Therefore, a fourth probability option was introduced. Curve 4 is the probability that sporadic E is present and is calculated as the probability that h'Es is non-zero. This is valid because h'Es is always recorded at Australian stations if any sporadic E, other than slant type sporadic E, is present.

All these measures of probability have problems associated with them and need to be interpreted with care. However, they are useful here for illustrating sporadic E behaviour. Curve 4 shows clear double peaked behaviour for all seasons but winter. The curve also illustrates something most Townsville scalers know well — sporadic E is almost always present sometime during the day. While foEs may not be large, the layer is nevertheless present in all seasons. Curve 2 shows the more familiar seasonal behaviour reported in the literature for sporadic E. Daytime, summer occurrences are significantly higher than for other seasons. There is no double peaked probability distribution, as mentioned by McNichol and Gipps, but instead there is a broad maximum.

However, curve 1 does show two peaks in sporadic E occurrence. There is a clear tendency, in curves 1 and 2, for sporadic E to be more likely in the afternoon, prior to sunset, for all seasons other than summer.

Figure 5 is a more unfamiliar presentation of sporadic E. From 1983, Australian scalers were asked to scale all heights of ionospheric layers to 1 km. While the heights recorded this way were not thought to be this accurate, scalers had already shown they were able to scale common ionograms to this level of repeatability. These data have been sorted into bins 1km by 1 hour producing an array of counts that was contoured for counts of 5, 15, and then in steps of 15 up to 105, with a final contour for a count of 145. The selection of contours was a little arbitrary as the display of data was intended to visually present the height variability of sporadic E at Townsville rather than explore it statistically. A count of 5, for summer, means that sporadic E was seen in a bin on 5 occasions out of roughly 900 possible occasions. While these are small probabilities, there is consistency in the counts that is particularly clear for winter in Townsville - my best example, I admit. This figure shows the tendency for sporadic E to organise into height - time regimes. Patterns seen at high altitudes tend to be linked to lower altitudes; not surprising, considering figure 2. These type of data have been explored by MacDougall (1974, 1978).

Comparing figures 4 and 5, it is evident that the peaks in sporadic E occurrence in figure 4 match the structure sporadic E shows in figure 5. Summer, for instance, has two periods, in figure 5, when descending sporadic E is likely to occur and two peaks in sporadic E occurrence are seen in curve 1 of figure 4. In winter, figure 5 shows only one period when descending sporadic layers are likely, consistent with the late afternoon peak in sporadic E occurrence for curves 1 and 2 in figure 4.

These two figures offer a visual impression of the processes that appear important in the production of Townsville sporadic E.

6.4.2. E_2 relationship

The E_2 layer has been associated with descending sporadic E. The issue here is that E_2 has an identity in some locations as a normal solar produced layer, while when associated with descending sporadic E, as suggested here, it is a dynamic layer. At Uppsala, Derblom (1981) showed that E_2 descended through the E/F1 region to merge with the normal E. Earlier we had noted that E_2 could become Es. Here, E_2 has its own identity - a feature of the higher latitude maybe. The layer appears to descend at a rate of around 7 m/s in the height range 200-150 km, compared with 5.5m/s for sporadic E in the region 150-120km. Derblom rules out any clear association between E_2 and Es, but does not preclude a possible association.

offers a problem for detecting layers, but also a possibility for making indirect observations of the E/F1 valley. Observations of sporadic E during a solar eclipse have shown that the sporadic E layer can exist within the valley and be unseen for much of its descent.

6.4.4. Solar activity effects

Much of the literature on sporadic E emphasises

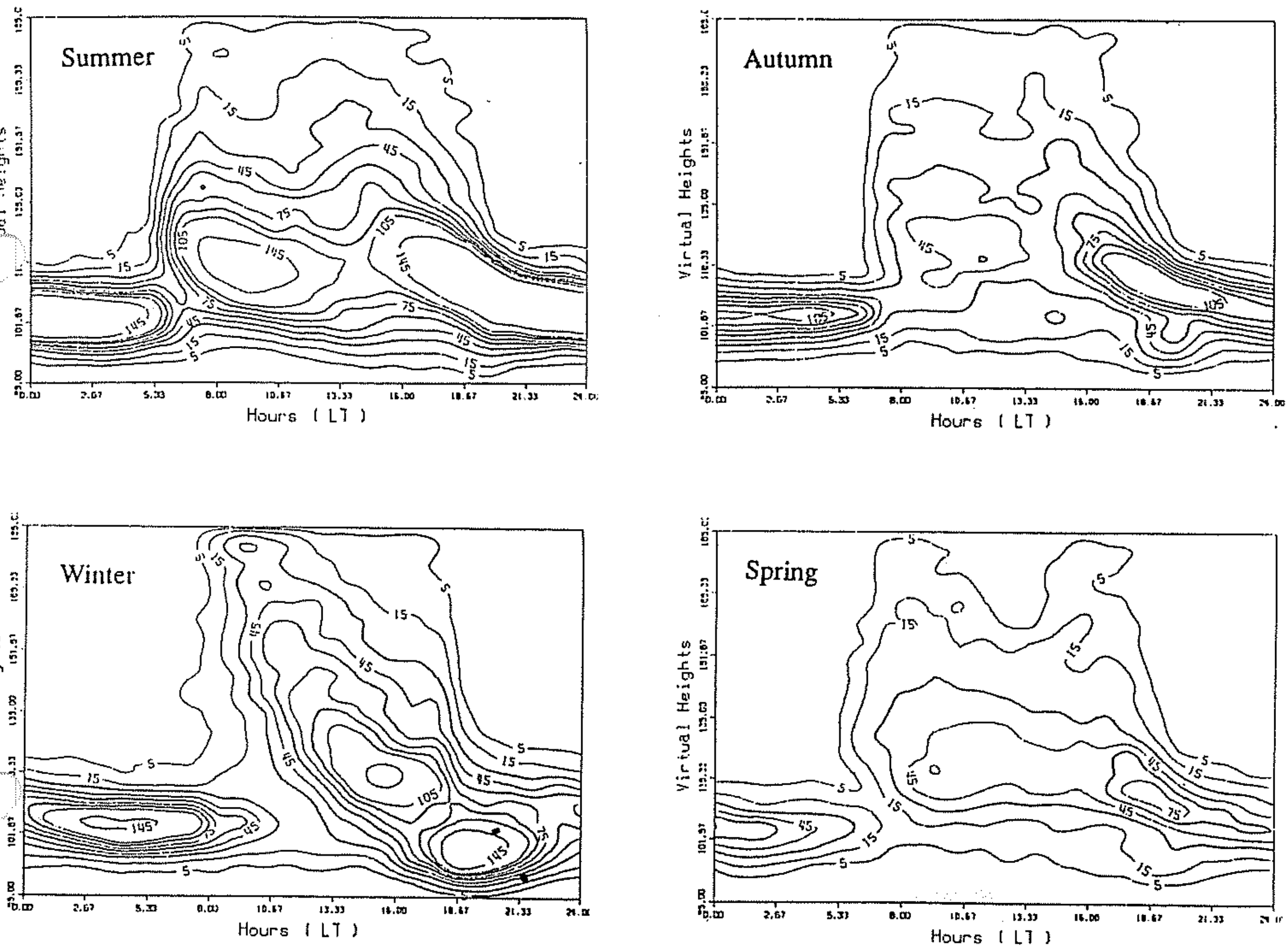


Figure 5. Height Behaviour of Sporadic E at Townsville (19° S).

The number of occasions sporadic E formed in a time (1 hour) height (1 km) cell was counted and selected counts (5, 15, 30, 45, 60, 75, 90, 105, 145) were contoured to give a visual impression of the behaviour of sporadic E.

6.4.3. Valley effects

An important possibility, not yet explored, is the effect of a valley between the E and F1 regions. Clearly, foEs is not much larger than foE above 130 km so that, if the valley is moderately deep and wide, no descending layer will be seen. This

that the layer must contain large numbers of metallic ions. The reason for molecular ions being thought less important is that a molecular layer could never reach the observed peak electron densities due to the more rapid chemistry in the layers. But do molecular ions play a part?

Figure 6.
All hourly foEs data is plotted against foE for the period 1983 to 1990 for Townsville. The data is partitioned into seven groupings of the data according to the uncorrected h'Es recorded. The scales used are in 0.1 MHz units, the vertical scale having been adjusted to make best use of the available space.

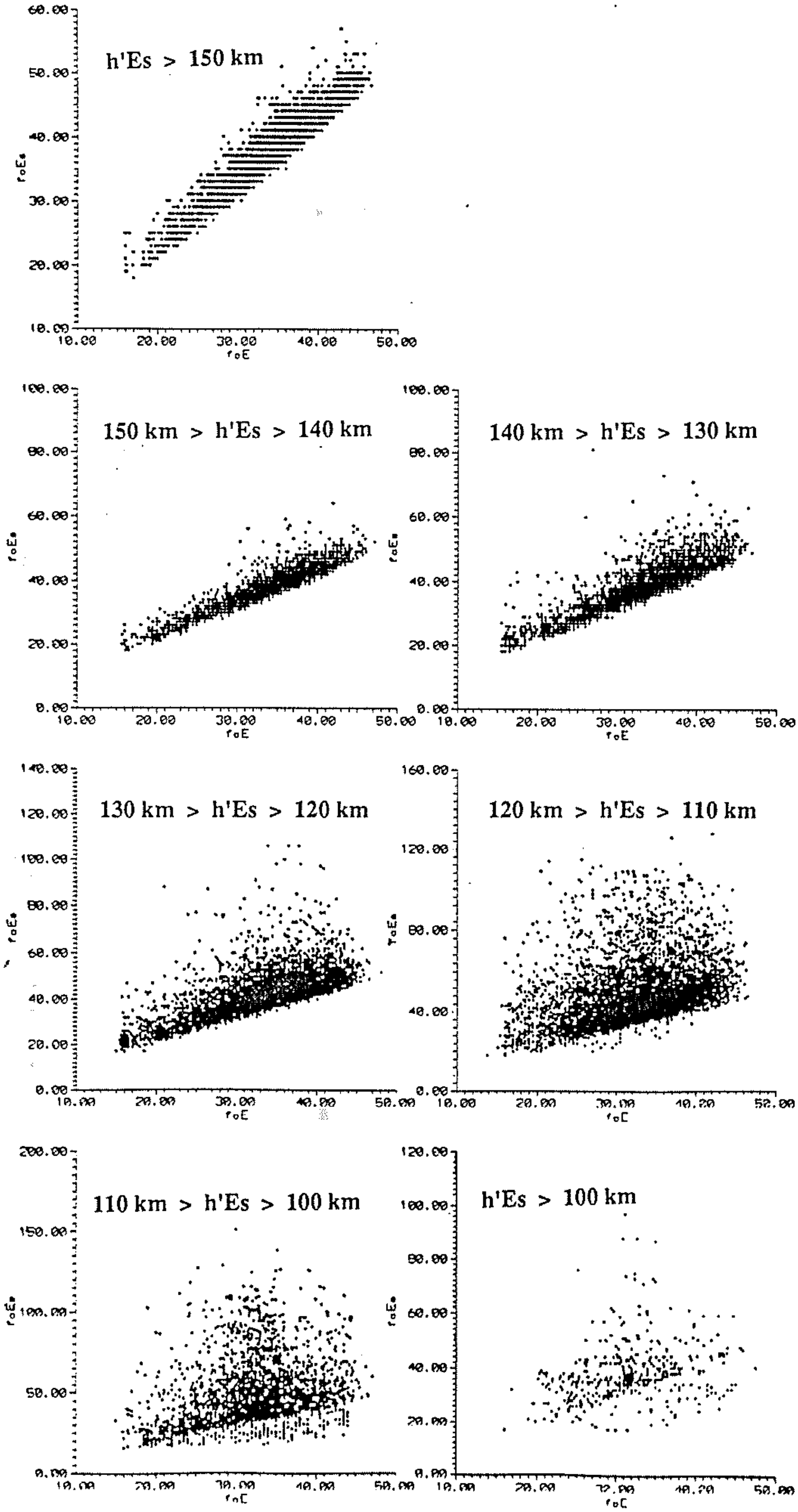


Figure 6, showing foEs plotted against foE, is a convenient display relating foEs to solar zenith angle. At greater virtual heights, above roughly 130km, foEs follows foE closely — the layer, when present, is solar controlled. This is obvious because high (Ess) sporadic E layer electron densities are never much different from the normal E region electron density. For virtual heights above 140km, foEs is never more than 1.0 MHz greater than foE at Australian stations — I searched over 20 years of data for five stations, and over a solar cycle for another five. It is a fundamental property.

Sporadic E layers are a mixture of ions. At greater altitudes, molecular ions may be more important - I deduce this from the solar control aspect. As the layer descends, metallic ions become the predominant feature of the layer. This seems to me to be moderately complex and, other than Derblom's report, I don't think it has been considered, since people appear to have concentrated mainly on sporadic E layers below 120 km.

6.5. Conclusion

These results have demonstrated that h'Es has value as a sporadic E parameter and may bring new insight to the sporadic E statistics.

The results show there is a number of interesting and potentially fruitful areas for further research to increase our understanding of this complex, but common, phenomenon in our atmosphere. There still seems to be much that can be learned from sporadic E using conventional hourly ionogram data.

6.6. References

Derblom H., "Non sporadic E Properties of Sporadic E" an internal report of the Uppsala Ionospheric Observatory UIO-SR-81-03, 1981.

Leighton H. I., A. H. Shapley and E. K. Smith, "The occurrence of sporadic -E during the IGY", Ionospheric Sporadic E, E. K. Smith and S. Matsushita (Eds.), MacMillan Co., New York, 1962.

MacDougall, J. W., "110 km neutral zonal wind patterns", Planet. Space Science, 22, p545-558, 1974.

MacDougall J. W., "Seasonal variation of semidiurnal winds in the dynamo region", Planet. Space Science, 26, p705-714, 1978.

McNichol, R.W.E. and G. deV. Gipps, "Characteristics of the Es region at Brisbane", J. Geophys. Res. 56, p 17-31, 1951.

Smith E. K., "Worldwide occurrence of Sporadic E",N.B.S. Circular 582, US Government Printing Office, 1957.

Thomas J. A., "Sporadic E at Brisbane", Aust. J. Phys.,9, 228-246, 1956.

Wilkinson P. J., E. P. Szuszczewicz, R. G. Roble, "Measurements and modelling of intermediate, descending, and sporadic layers in the lower ionosphere: results and implications for global-scale ionospheric-thermospheric studies", Geophys. Res. Lett., 19, 95-98, 1992.

Whitehead J. D., "Production and prediction of sporadic E", Reviews of Geophysics and Space Physics, 8, 65-144, 1970.

7. Comments from J. K. Olesen

7.1. Baseline stations and data — why keep them?

I guess people are hesitating somewhat in designating baseline (or key, master, class one etc.) stations due to the risk that remaining stations then might be degraded or even closed by too economical minded administrations. It seems to me to be necessary - if baseline stations are selected and designated - to simultaneously make recommendations for the continuation of the remaining stations by defining one or more "classes" of stations, such as, to offer some examples, ''scientific purpose station'', ''regional coverage station'', ''environmental anomaly station'', or some other more appropriate ''raison d'etre'' terms. By assigning existing ionosonde stations with a specified main objective without a specific grading as to importance, we maybe might secure the positive aims on baseline stations and avoid any negative consequences.
Chair comment : I think this is an excellent suggestion. I would be delighted to have people suggest similar categories for their stations.

As to the general problem of preserving the network, I wonder whether we ought to be more clever as to obtaining support through recommendations and even economically from users of forecasts and data, e.g., ITU, CCIG, ICAO ,etc. and related national bodies within communication and navigation, etc. Or does our scientifically oriented involvement make us forget about the economical value of our products and about the utilisation of that value. Although I have no complete knowledge on the matter, I have a feeling that we could learn something from meteorologists and their ability to obtain support for their activities from various bodies.

Chair comment : This is a very important issue. Any thoughts people have, please send them to me. I hope issues such as this are discussed at the URSI Commission G6 Symposium.

7.2. INAG Bulletin and members

I find the membership classification outlined in INAG Bulletin 55 is a good solution - and I take it that Dr. Piggott is already in the Honorary Membership List, so that the loss of the "ionospheric trinity" that the Chairman mentioned will not be fatal - Roy will still be with us!

Concerning the constant shortage of contributions to the Bulletin from members, I wonder whether there is a way of making articles in the Bulletin more formally ''referable'', since that might be a way of encouraging people to spend the necessary time on a contribution. But maybe that would require a more formal reviewing than we would like for our Bulletin?

I notice that the previously adopted plan with designated topic ''Reporters'' has failed. Looking in the rear-view-mirror, I find the plan was good ''on the paper'', but maybe the organising of it was not good enough. I would have proposed compulsory delivery of topic reports from ''Reporters'' at predetermined deadlines, e.g., 3, for 3 Bulletins a year. Even without ''Reporters'', I believe that the introduction of pre-determined deadlines and issue dates for the Bulletin (e.g., 1 January, 1 May, 1 September - with what little content there might be!) would be an improvement in contrast to present irregular issue dates, which might hinder a necessary activating effect on busy members.

Comment from the Chair : The reporter idea did fail. I seem to remember some discussion about compulsory preparation of papers for the Bulletin, but it had no effect. Possibly more formal refereeing would help. I would be interested to hear from others on this. Although the INAG Bulletin is not refereed, it did not prevent Goodman from referencing it in several places in his recent book ''HF Communications''. A deadline for Bulletins would be difficult for me, but if it would also help people produce articles, I would be more enthusiastic.

7.3. INAG Terms of reference

I wonder whether it might be desirable to make an addition to INAG objective No. 6 which now reads: ''To encourage the staff at ionosonde stations by informing them on the use of their data and allied matters''. The suggested addition: ''and by arranging expert visits and interchange of station personnel''. The proposal has some relation to the remarks on Dr. Piggott's previous visits on which the present Chairman states that ''this is no longer a realistic prospect for the Chairman of INAG'', which is understandable. However, it might be a realistic prospect for retired INAG people.

Comment from the Chair : I would be happy to mention names of such people in the Bulletin from time to time.

8. URSI Characteristic Codes

The following two pages are a table of URSI characteristic codes together with additional codes used in autoscaled data. The table was taken from the report :"Ionospheric Characteristics Data Format for Archiving at the World Data Centers" by R. R. Gamache and B. W. Reinisch (1990), a scientific report from the University of Lowell Center for Atmospheric Research, (ULRF - 467 / CAR).

9. Questionnaire for Readers of the INAG Bulletin

Please number the items in each question in order of importance to you. 1 is most important.

A. Articles and notes in the Bulletin are:

_ about the right level of interest.

_ more complex than I usually read.

_ generally of limited interest to me.

_ I file the Bulletin as a reference.

B. I would like to see more articles on

_ how other networks operate.

_ the history of ionosondes and ionosonde networks.

_ how to use ionosondes in applications.

_ training aids for manual scaling.

_ interpretation of difficult and interesting ionograms.

C. Articles I have read in INAG have

_ never affected me or my work.

_ have changed some of my ideas.

_ have been a source of encouragement.

_ have occasionally been very useful.

_ generally been interesting and helpful.

D. More articles would be written for INAG

_ if people were told what type of article they should write.

_ if the articles were refereed.

_ if the subject area were broadened.

_ if people felt the Bulletin was read widely.

_ if people felt the articles influence opinions.

E. I don't write articles for INAG because

_ I have never been asked to.

_ I don't think I can write anything that would interest readers of the Bulletin.

_ I'm always too busy.

_ I don't think it is important enough compared with my other responsibilities.

_ My English is poor.

_ I don't like writing.

F. I don't ask other people working for me to write articles for INAG because

_ it never occurred to me to do so.

_ there is nobody I could ask to write an article.

_ I have, but they refused.

_ I have and they never got around to it.

_ I have and they did.

G. What were the two most useful articles or notes published in the Bulletin during the last three years?

H. What were the least useful articles or notes?

I. Name one person who you feel would write a good article for the Bulletin.

10. Nomination form for INAG Officers

Please fill out this form and return it to the me by 26 February 1993.

I do not wish to make a nomination

My nomination for the Chair is:

Name :

Contact Address :

My nomination for Secretary is :

Name :

Contact Address :

My name :

My Address :

Please mail this form to :

Dr P J Wilkinson
IPS Radio and Space Services
P O Box 5606
West Chatswood NSW 2057
AUSTRALIA

or send it by facsimile to one of the following IPS facsimile numbers :
+61 2 414 8340
+61 2 414 8331

or send a telex message, marked Attention P J Wilkinson, to the Australian telex number :
AA 20663

or send an email message to my internet email address :
phil@ips.oz.au

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Table 2. List of Characteristics, URSI codes, and Dimensions

GROUP	CHARACTERISTIC ARTIST Name	ARTIST #	URSI Name	URSI #	DIMENSION	REFERENCE UAG23	DEFINITION
F2							
		1	foF2	00	.1 MHz	1.11	The ordinary wave critical frequency of the highest stratification in the F region
			fxF2	01	.1 MHz	1.11	The extraordinary wave critical frequency
			fzF2	02	.1 MHz	1.11	The z-mode wave critical frequency
	M(D)	3	M3000F2	03	.01 MHz	1.50	The maximum usable frequency at a defined distance divided by the critical frequency of that layer
	hpF2	12	h'F2	04	km	1.33	The minimum virtual height of the ordinary wave trace for the highest stable stratification in the F region
			hpF2	05	km	1.41	The virtual height of the ordinary wave mode at the frequency given by 0.834 of foF2 (or other 7.34)
			h'Ox	06	km	1.39	The virtual height of the x trace at foF2
	MUF(D)	4	MUF3000F2	07	.1 MHz	1.5C	The standard transmission curve for 3000 km
			hc	08	km	1.42	The height of the maximum obtained by fitting a theoretical h'F curve for the parabola of best fit to the observed ordinary wave trace near foF2 and correcting for underlying ionization
			qc	09	km	7.34	Scale height
F1							
		2	foF1	10	.01 MHz	1.13	The ordinary wave F1 critical frequency
			fxF1	11	.01 MHz	1.13	The extraordinary wave F1 critical frequency
				12			not used
			M3000F1	13	.01 MHz	1.50	See Code 03
			h'F1	14	km	1.30	The minimum virtual height of reflection at a point where the trace is horizontal
				15			not used
	hpF	11	h'F	16	km	1.32	The minimum virtual height of the ordinary wave trace taken as a whole
			MUF3000F1	17	.1 MHz	1.5C	See Code 07
				18			not used
				19			not used
E							
		9	foE	20	.01 MHz	1.14	The ordinary wave critical frequency of the lowest thick layer which causes a discontinuity
				21			not used
			foE2	22	.01 MHz	1.16	The critical frequency of an occulting thick layer which sometimes appears between the normal E and F1 layers
				23			not used
	hpE	13	h'E	24	km	1.34	The minimum virtual height of the normal E layer
				25			not used
			h'E2	26	km	1.36	The minimum virtual height of the E2 layer trace
				27			not used
				28			not used
				29			not used
Es							
		6	foEs	30	.1 MHz	1.17	The highest ordinary wave frequency at which a mainly continuous Es trace is observed
			fxEs	31	.1 MHz	1.17	The highest extraordinary wave frequency at which a mainly continuous Es trace is observed
			fbEs	32	.1 MHz	1.18	The blanketing frequency of the Es layer
			ftEs	33	.1 MHz		Top frequency Es any mode.
	hpEs	14	h'Es	34	km	1.35	The minimum height of the trace used to give foEs
				35			not used
			Type Es	36		7.26	A characterization of the shape of the Es trace
				37			not used
				38			not used
				39			not used

GROUP	CHARACTERISTIC ARTIST Name	#	URSI Name	#	DIMENSION	REFERENCE UAG23	DEFINITION
Other							
			foF1.5	40	.01 MHz	1.12	The ordinary wave critical frequency of the intermediate stratification between F1 and F2
				41			not used
		5	fmin	42	.1 MHz	1.19	The lowest frequency at which echo traces are observed on the ionogram
			M3000F1.5	43	.01 MHz	1.50	See Code O3
			h'F1.5	44	km	1.38	The minimum virtual height of the ordinary wave trace between foF1 and foF1.5 (equals h'F2 7.34)
				45			not used
				46			not used
			fm2	47	.1 MHz	1.14	The minimum frequency of the second order trace
			hm	48	km	7.34	The height of the maximum density of the F2 layer calculated by the Titheridge method
			fm3	49	.1 MHz	1.25	The minimum frequency of the third order trace
Spread F/Oblique							
			foI	50	.1 MHz	1.26	The top ordinary wave frequency of spread F traces
		10	fxI	51	.1 MHz	1.21	The top frequency of spread F traces
			fmI	52	.1 MHz	1.23	The lowest frequency of spread F traces
			M3000I	53	.01 MHz	1.50	See Code 03
			h'I	54	km	1.37	The minimum slant range of the spread F traces
				55			not used
				56			not used
			dfs	57	.1 MHz	1.22	The frequency spread of the scatter pattern
						7.34	Frequency range of spread fxI-foF2
				58			not used
				59			not used
N(h)							
		30	fh'F2	60	.1 MHz	7.34	The frequency at which h'F2 is measured
		29	fh'F	61	.1 MHz	7.34	The frequency at which h'F is measured
				62			not used
			h'mF1	63	km	7.34	The maximum virtual height in the o-mode F1 cusp
			h1	64	km	7.34	True height at f1 Titheridge method
			h2	65	km	7.34	True height at f2 Titheridge method
			h3	66	km	7.34	True height at f3 Titheridge method
			h4	67	km	7.34	True height at f4 Titheridge method
			h5	68	km	7.34	True height at f5 Titheridge method
			H	69	km	7.34	Effective scale height at hmF2 Titheridge method
T.E.C.							
			I2000	70	e/cm^3	7.34	Ionospheric electron content Faraday technique
			I	71	e/cm^3	7.34	Total electron content to geostationary satellite
			Ixxxx	72	e/cm^3	7.34	Ionospheric electron content to height xxxx
				73			not used
				74			not used
				75			not used
				76			not used
				77			not used
				78			not used
			T	79	e/cm^3	7.34	Total sub-peak content Titheridge method
AUTOMATIC							
		7	FMINF	80	.01 MHz		Minimum frequency of F trace (50 kHz increments) Equals fbEs when E present
		8	FMINE	81	.01 MHz		Minimum frequency of E trace (50 kHz increments).
		15	HOM	82	km		Parabolic E region peak height
		16	YM	83	km		Parabolic E region semi-thickness
		17	QF	84	km		Average range spread of F trace
		18	QE	85	km		Average range spread of E trace
		22	FF	86	.01 MHz		Frequency spread between fxF2 and fxI
		23	FE	87	.01 MHz		As FF but considered beyond foE
		25	fMUF3000	88	.01 MHz		MUF(D)/obliquity factor
		26	h'MUF3000	89	km		Virtual height at fMUF