IONOSONDE NETWORK ADVISORY GROUP (INAG)*

Ionospheric Station Information Bulletin No. 60**

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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.

JURGEN BUCHAU 1933 - 1993

Jurgen Buchau unexpectedly died on 9 August 1993 as a result of a heart attack. He was born in the Free City of Danzig on 1 July 1933. He attended the University of Freiburg in Southern Germany majoring in physics and graduating with the diploma in 1963. His thesis research on the inverse Seddon technique to measure ionospheric electron density profiles on board a rocket was done under Prof. Karl Rawer at the Ionospheric Institute in Breisach. From there on his professional life was dedicated to ionospheric research. He continued working on ionospheric rocket experiments at the Fraunhofer Institute for Space Research in Freiburg until 1965, when he emigrated with his family to the United States where he joined the ionospheric physics group of Dr. Klaus Bibl at the Lowell Technological Institute in Massachusetts. He began developing innovative sounding techniques for the Airborne Ionospheric Observatory (AIO) of the Air Force Cambridge Research Laboratory (AFCRL) which he joined in 1967 working in Dr. Georg Gassmann's research branch. For more than 25 years Jurgen influenced and stimulated national and international ionospheric research from his position as an Air Force scientist while the laboratory changed its name from AFCRL to AFGL (Geophysics Laboratory) to PL (Phillips Laboratory, Geophysics Directorate). In this time he remained the technical and scientific leader of the AIO research. It was a sad moment in Jurgen's life, and for all of us associated with the KC 135 No. 55-3131, when the Air Force retired the plane from research duty in 1992.

In his early AIO research, together with his colleagues Jurgen was able to measure the extent and the dynamics of the equatorial bubbles. After years of studying the equatorial ionosphere, he directed an extensive airborne and ground-based investigation of the high latitude ionosphere. This work verified for the first time the existence of the complete auroral oval including the daytime aurora, thus confirming Ya. Feldstein's oval concept.

As part of the auroral research program, Jurgen established the Goose Bay Ionospheric Observatory in 1970 with a Digisonde, magnetometers, satellite beacon receivers, riometers and optical sensors. Recognising the need for high quality automatic data, he sponsored the development of advanced digital sounders and in the eighties, in cooperation with the Air Weather Service, initiated the installation of additional Digisonde stations at Argentia, Narsarssuaq, Sondre Stromfjord and Qaanaaq. This cooperation with the Air Weather Service led to the procurement and deployment of the Digital Ionospheric Sounding System (DISS), the world's only globally operating fully automated ionospheric sounding system that provides ionospheric characteristics in real time to the USAF Space Forecasting Center (AFSFC).

Jurgen's exhaustive studies of the polar cap ionosphere were conducted with his "optical" colleagues, led by his friend Ed Weber, and with members of the academic community in the Boston area and led to the discovery of the F layer polar cap auroral arcs and large scale ionisation patches drifting across the polar cap in anti-sunward direction. Jurgen initiated an international program to measure the convection pattern as a function of the interplanetary magnetic field conditions using the high latitude Digisonde chain, in order to establish the specifications of the high latitude ionosphere required for AFSFC's modelling effort.

Because of Jurgen's extensive knowledge of ionospheric processes and radiowave propagation, he became the Laboratory's representative scientist during the development and operation of the Over-The-Horizon (OTH) backscatter radar system. He recognised the effects of ionospheric variability and dynamics on the radar system performance and advised on the design of mitigation techniques.

As a long time member of URSI, Jurgen has contributed to the success of scientific meetings for many years and has published over 40 scientific papers. One year after his death, I still cannot believe that we no longer have his scientific advice and the excitement he always created with his enthusiasm for solving the mysteries of the ionosphere. I grieve having lost my friend, and I know many share this grief with me. We all extend our sympathy to his family, his wife Christel and the children Susanne, Thomas, Katrina and George.

Contributed by:
Bodo Reinisch
University of Massachusetts

1. COMMENTS FROM THE CHAIR

Our meeting was quieter in Kyoto with the absence of Jurgen Buchau who died, suddenly, on August 9, 1993. His enthusiasm will be missed by all of us. I can remember the first and last times I met Jurgen and I wish there were many more occasions between than time allowed.

The preparation of this Bulletin has been delayed somewhat by the production of the UAG Report on *Ionosonde Networks and Stations*. This report will be sent to all INAG Members in 6 to 8 weeks. The introductory comments are included here to give you a taste of what was covered in the oral and poster sessions and also what will be appearing in the UAG report.

This collection of papers forms the bulk of the papers that were presented, either orally or as Poster papers, at the 1993 Kyoto URSI General Assembly session sponsored by the URSI Commission G Working Group INAG (Ionosonde Network Advisory Group).

> The ionosonde has been used to measure ionospheric information for over fifty years. During much of this time it has been a routine instrument, data often being processed months after recording. For long term measurements of the climate of the ionosphere this is adequate. However, it is now inescapable that if ionosonde stations cannot offer a more timely service, so that the data can be used in near real time, they will cease to be funded. This situation has been developing over the last decade and has both positive and negative aspects to it. On the negative side, many ionosonde stations are now threatened with closure because upgrading of equipment to deliver real time data is economically unrealistic. Some indication of these problems are presented in the papers by Baker and Shirochkov.
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> On the other hand, more modern ionosondes, coupled with automatic scaling methods and a greater appreciation of the value of real time ionospheric data show this challenge can be met. The potential that can be realised with modern ionosondes is demonstrated in papers by Reinisch and Buchau et. al. New ionosondes are discussed in MacDougall et. al. and Akchyurin et. al. while Titheridge outlines a low cost method for upgrading a film based IPS-42 ionosonde to record digital records. Several papers (Pulinets, Igi et. al., Poole et. al., Vugmeister et. al. and Bakhitzhqan et. al.) discuss automatic processing of ionosonde records in varying degrees of detail accompanied by comments on applications for the data. Applications of ionosonde data for frequency management (Lynn) forecasting (Minullin et. al.), climate monitoring (Eliseyev) and as a new ionosonde site (Shaptev) are discussed. These papers offer views regarding the future deployment and use of ionosonde data in a range of applications.
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> Allied with these papers are papers on techniques, eg. Nozaki, and new analysis methods for the data recorded (Tsai et. al., Denisenko et. al. and Weixing Wan et. al.). Several papers report on the results of analysing ionosonde data to improve forecasting methods (Gulyaeva, Bowman and Igarashi et. al.) and for improving models (Chong et. al., Shun-rong Zhang et. al. and Bradley et. al.). Finally, two papers develop oblique propagation (Blagoveshchensky et. al.) and transionospheric propagation (Danilkin) ideas.
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> The ionosonde has already made a valuable contribution to our knowledge of the ionosphere and it is hoped it will continue to make an equally valuable and enlarged contribution in the years to come. This collection of papers offers an insight into the wide range of ways ionosonde collection and data use is changing in response to changing economic times.

I felt this session went well at URSI and look forward to the session INAG will be responsible for in 1996. Please note the topic and consider now what you will be submitting. I hope we can have a good overview of the methods people are using to scale ionograms using the computer. These techniques are now used widely although, as far as I am aware, few data are being archived directly from computer scaling programs.

I am sorry that another ionosonde station has had to close. Maui ionosonde station is a long established station, having run for over 50 years, sited in an equatorial region and remote from other ionosonde stations. The loss of sites such as this is particularly important and we will all hope that it is only a temporary situation and that some replacement station can be reopened in the region, preferably before the next solar cycle has commenced. Maui satisfied most, if not all, the criteria for a key station and demonstrates how fragile these concepts are. Last year I was asked to offer comments on the closure of the South African ionosonde network. I have reproduced my comments in this Bulletin. Many of us are asked, from time to time, to offer comments of a similar nature on the future of ionosonde stations and networks. It would be most helpful if everyone could share their comments with us in the Bulletin. I feel we can all gain some insights and, most likely, some useful phrases and arguments we can adapt to our needs when we are next called on to offer support. If we cannot support each other in these ways, we will have little chance of convincing better organised groups we are serious.

Another interesting exercise arose from the questionnaire I circulated last year. I was asked to prepare a literature search on ionosonde papers. The results of a moderately comprehensive search appears later in the Bulletin. By the time you read this the American Geophysical Union will have confirmed its key words for the next publishing year. In setting up this list they have removed all reference to types of recording equipment. The AGU key word list is now science oriented, but of no value to groups such as INAG who would like to keep track of publications whose contents depend on particular equipment. While I have indicated my feelings to the AGU Working Group I am not optimistic that a change will be made at this stage. I feel the key word listing should definitely contain a reference to equipment and all authors should be encouraged to indicate at least one key word noting where any data they used came from. ***Before I claim this is an INAG viewpoint, I would appreciate hearing other opinions on this topic.***

This bulletin features a four articles on ionosondes and ionosonde suppliers. The latter is a table I have prepared and I am unsure that it is complete. I will reprint this table in the next Bulletin if there are any changes to it.

There are three papers on two new ionosondes and an upgrade for the IPS-42 ionosonde. IPS has installed several of John Titheridge's digion boards in our 4B ionosondes and we are very happy with the results. We have now eliminated our reliance on film records at all our sites. This raised an interesting issue we had not previously considered. The costs of running an ionosonde station are not small, yet often the final step of recording the data is the most risky aspect of the exercise. Retrospectively, it is hard to understand why ionosondes were not equipped with two cameras, for instance. I have worked out that around 80% of all the data IPS has lost over the last 20 years can be directly attributed to a failure of the recording medium (poor representation on the oscilloscope, poor film handling). Any digital system can minimise this risk first by eliminating the film stage completely, and then, more importantly, by producing multiple copies of the original ionogram at the recording stage. At IPS we are now copying the raw ionogram to a DAT tape, storing it on the hard disk of the computer and copying it to a floppy disk. Shortly we will add down loading to a central computer as well. While this appears unnecessary duplication, it costs very little to do and it limits the risk of not getting a useful record due to a failure of one of the modes of record delivery. We also collect a film record, because the digion allows it, but this would only be used if the computer failed. I would strongly recommend everyone consider how secure their systems are in delivering a raw ionogram to an archive.

Thank you to the contributors for this issue of the INAG Bulletin. Five of the submissions were prepared from text supplied to me either on disks or by email. If you are preparing an article, I would much prefer to receive it by email, or on a disk, as this greatly eases the handling problems at my end.

INAG email Directory

Finally, I would like to make up an email address list for INAG members. If you use email, could you send me a message so I can confirm your address. I will include an INAG email directory in the next Bulletin.

Phil Wilkinson, Chair, INAG.

2. INAG MEETING, 26 AUGUST 1993, URSI GENERAL ASSEMBLY KYOTO, Japan

2.1. Attendance:

Duncan Baker (South Africa)
L.W. Barclay (UK)
Klaus Bibl (USA)
G. Bowman (AUS)
P.A. Bradley (UK) Meeting Secretary
Tamara Gulyaeva (Russia)
Rudi Hanbaba (France)
R. Hunsucker (USA);
Terry Kelly (AUS)
Ken Lynn (AUS)
K. Marubashi (Japan)
Horacio C. Neto (Portugal)
Allan Poole (South Africa)
Sergei Pulinets (Russia)
Bodo Reinisch (USA)
Werner Singer (Germany)
A.J. Smith (UK)
John Titheridge (NZ)
N. Wakai (Japan)
Bruce Ward (AUS)
A.W. Wernick (Comm. G. Chair)
Matthew Wild (UK) WDC-C1
P. Wilkinson (AUS) Chair

The meeting commenced at 1400 by remembering departed members: Natiliya Benkova, Clarrie McCue, Sergei Chavadarov and Jurgen Buchau.

The meeting endorsed Phil Wilkinson as Chair and Ray Conkright as Secretary for a further three years. This was recommended and accepted by Commission G.

2.2. Terms of Reference:

Two topics raised by members: oblique ionograms and topside sounding. To incorporate either of these topics into INAG would involve changing the terms of reference slightly. Before doing this, broad interest in them must be established.

2.2.1. Oblique incidence ionograms.

This topic has been raised by several members over the last three years. A task group will report back on possible action INAG should take. Klaus Bibl, Ken Lynn, Peter Bradley and Bruce Ward form the nucleus of this group and any *INAG members who are interested in offering comments should contact the Chair of INAG (PJW).* Peter Bradley later pointed out there was a similar group in IIWG headed by himself. In view of this, Peter will lead this group and it will either remain in IIWG or become incorporated into INAG depending on outputs.

2.2.2. Topside Sounding

Sergei Pulinets presented Professor Danilkin's proposal to establish a topside sounding community. The original proposal was to form a new working group within the Commission to promote a topside sounding project based on a new Russian topside sounder. However, the proposal was judged likely to have more success if it was first developed within either working group (INAG) or (IIWG). In his presentation, Pulinets proposed that interested groups could build topside ground stations, using a design supplied by Izmiran for ~$1,000. The station could interrogate the proposed Russian topside sounders. The first two topside sounders could not have optimum orbits, but it would establish the principle and, presumably, prepare the way for a larger effort.

Wernik pointed out that the Canadians have a substantial number of tapes (hundreds) of Isis data that have never been processed. He wondered if somebody would like to process this data and how a new sounding program would overcome the substantial cost problems that were encountered in earlier topside programs. Bibl pointed out that a new program would enhance co-operative experiments more effectively than retrospective studies could.

While those present agreed the proposal had merit, no individual support was proposed.

2.3. Membership and email

A complete membership list was circulated to check current names and addresses. Members were asked to add email addresses and also were encouraged to become familiar with email if it was available locally to them. While email cannot be the sole means for communication, it would make the Chair's task easier if those who are able to use it, do so.

2.4. State of Network

2.4.1. Australia

IPS, with the assistance of University of Papua-New Guinea, is working towards re-opening Port Moresby by the end of 1993. (Note added

October 1993: severe security problems at Pt. Moresby has now delayed the reopening of the ionosonde station there. Currently, we are investigating alternative sites and considering the costs that would be involved to reach a sufficiently high level of security at the current site to make the operation there viable.)

The 4B ionosonde at Casey has been replaced by a Portable Digisonder (DPS) operated by ANARE.

2.4.2. United Kingdom

Andrew Smith reiterated the earlier announcement in INAG that Argentine Islands would close although, if it is feasible, a low power system operating on long storage batteries and / or solar power would replace the current sounder. Matthew Wild announced that a new sounder would be opened at RAL, 40km from Slough, to replace the current station at Slough. Matthew also pointed out that Slough has all the original records for Slough in archives at WDC-C1.

2.4.3. Poland

Poland will be setting up an ionosonde in Spitzenbergen. It will be used during the summer and will record Doppler on 32 frequencies.

2.4.4. South Africa.

Allon Poole reported that, due to a lack of funds, the ionosonde was not placed at Gough Island. Duncan Baker later reminded people that Johannesburg had stopped producing data, as there were now no funds to continue operation of the stations.

2.4.5. KEL Aerospace

Terry Kelly announced that KEL will discontinue production of the IPS-42 ionosonde in favour of the IPS-71 described in INAG-59. They will continue to support IPS-42 Ionosondes already in operation. Kelly emphasised the significant advantages of real time data availability that the IPS-71 offers.

The Chair, while agreeing that modern digital ionosondes are a valuable step forward, reminded the meeting that the prime objective of INAG is to support the collection and archiving of a consistent and homogeneous data set from ionosondes. While real time data may help in maintaining future ionosonde networks, it is subordinate to the main interest of INAG.

2.5. INAG Session G6

The meeting was reminded of this meeting and that papers could be published in a UAG report to appear after the meeting. A comment on this meeting appeared on p3 of this Bulletin.

2.5.1. Proposed INAG Session for 1996 URSI General Assembly.

The Chair proposed that INAG should be responsible for a session titled "Computer Aided Processing of Ionograms and Ionosonde Records" at the URSI General Assembly, in Lille in 1996. The proposed objective of the session would be to obtain papers on the various automatic scaling systems now available for processing ionograms and to attract papers describing the systems, discuss errors encountered in automatic scaling as well as consider the value of the data. Those present were interested in the proposal and suggested it should also include oblique sounding. This proposed session will be put forward for consideration by URSI. *This was accepted by URSI and a notice for the meeting appears elsewhere in the Bulletin.*

2.6. Baseline Stations

The Chair reminded the meeting about Baseline Stations and pointed out that there had been few comments on this topic. Oleson had suggested all stations had some special value and the Chair suggested people should identify the special value of their stations.

2.7. Other Business

Matthew Wild requested that any groups whose stations are contributing to the IF2 and the IG ionospheric indices, and who are now not able to supply regular data, could they advise him of their status so he can seek alternates.

Matthew also requested that any group that is currently sending paper print outs of scaled data to WDCs also send a disk copy, as digital data is significantly more valuable to the data center.

The meeting closed at 1530.

3. INAG SESSION FOR URSI 1996, LILLE, FRANCE

COMPUTER AIDED PROCESSING OF IONOGRAMS AND IONOSONDE RECORDS

This session has been proposed by INAG and confirmed by URSI for the next General Assembly: It will address the following broad issue: computer scaling of ionograms. Papers on the methods currently available for computer scaling ionograms will be sought for presentation both orally and as posters. Emphasis will be placed on the limitations of the methods and the level of errors encountered compared with manual scaling. The value and applications of the data from computer scaling will also be discussed. This topic includes handling vertical incidence and oblique incidence ionograms and will range from fully automatic to semi-automatic manual scaling methods.

There is a growing body of opinion that the majority of ionosonde records collected will soon be processed, almost entirely, by automatic methods. It is therefore important to discuss widely the current methods used and the potential to improve them. As before, I expect to collect all the papers offered in a single publication.

4. INAG MEETING: CHRISTCHURCH, NEW ZEALAND, 31 DECEMBER 1993

4.1. Attendance:

Prof. Jack Baggaley
Dr Bob Bennett
Dr Harvey Cummack
Christer Juren
Dr John Titheridge
Lester Tomlinson
Dr Phil Wilkinson

Since Christer was visiting New Zealand and wanted to meet with some of the people in New Zealand and Australia who were concerned with ionospheric monitoring, a short meeting was held at the University of Canterbury. There was no agenda and people expressed views and outlined their expectations for their respective networks and stations. The meeting started at 0900 and ended at 1300.

4.2. Comments from Christer

Christer opened the meeting by briefly describing the Swedish Institute of Space Physics before giving a more detailed explanation of their present ionosonde network (see INAG-59 for more details). Computerising the network started roughly three years ago, when there were suggestions that the network may have to close. The system is based around several transputers. Currently the three ionosondes of the Swedish network (Kiruna in the north, Lycksele and Uppsala) can be accessed from the Internet, provided the codes are known. A later demonstration of this was frustrated by a couple of unhelpful computers placed in the network line somewhere. At each station the sampling speed is 1MHz and is achieved using five transputers. A further two transputers are used for GPS measurements so that there is absolute time synchronisation between the three sites. Phase and amplitude are measured at each site but ordinary and extraordinary separation has not yet been implemented, making automatic computer scaling difficult.

The upper level data access system is programmed in Smalltalk. Currently, it is set up in a PC environment and can also be accessed in an X-windows environment on UNIX. Manual scaling, using the computer, is also written in Smalltalk. Several other languages are used at different stages in the network: C and pascal for passing information to the transputers, occam for control in the transputers.

Data from the Kiruna station is accessed in real time to support the nearby rocket station at Esrange. These data, together with other sources, are used to select periods when rockets are fired. Data are also used to support HF systems as well as other scientific groups such as EISCAT. One interesting scientific purpose for collecting the data is to track gravity waves formed at high latitudes. It has been suggested that these processes may be important in global warming. Finally, the ionograms (images) and scaled data form the basis for a moderate sized database. This is a good prototype system capable of being expanded to include the collection of other solar terrestrial data sets.

4.3. Phil's Comments

IPS Radio and Space Services is a service based organisation within a service oriented Government Department. The main theme of IPS operations is to collect ionospheric data and return it, in one form or another, to customers. Although there are no definite customers for real time ionospheric data, near real time data is of interest and the IPS network will be able to supply both types of data on request in the near future. The 5A ionosonde development, described in an earlier INAG Bulletin has not been wholly successful. While the software development has succeeded and the system can be managed from a central location, scaled and raw data being stored in separate directory files, the hardware has been disappointing. This phase of the development is now under review. In the interim period, the DIGION board, developed by John Titheridge, at the University of Auckland, is being installed at all the IPS stations. When fully implemented, the system will include a DAT tape system to record five minute raw ionograms together with autoscaled data. These scaled data, together with raw hourly ionograms will be sent by telephone to the central computer.

4.4. John's comments

John gave a brief review of the growth of his department. He built up a chain of total electron content stations which has now been reduced to two stations at Auckland and Invercargill. He pointed out that TEC is the most accurate measurement available of the ionosphere being, potentially, capable of 0.1% error with good calibrations. This accuracy can be maintained objectively for periods as short as minutes to several decades.

The Auckland ionosonde station supports these TEC measurements as well as offering bottomside information directly. In 1987 a student started developing ways of recording data digitally from the IPS-42. The present DIGION board has been developed from this work. The IPS-42 stores data with 0.8km resolution in virtual height for 576 frequency channels. Three soundings are made per frequency channel and for an echo to be judged real it must appear in all three soundings. This information is passed back to the analogue display and is the information intercepted by the DIGION. While 0.8km resolution could be stored, in fact this is divided by two-thirds giving a final resolution of 1.6km which is adequate for inverting ionograms using polan. More details on the DIGION are given in an accompanying article in this issue of INAG.

Accompanying the DIGION is display software for scaling the ionograms. For research purposes, John pointed out there is not much value in a scaling system that is right 80% of the time and can be completely wrong the rest of the time. To improve scaling, there is considerable value in using digital ionograms with a scaling system designed to ease manual labour. He stressed how easy it is to compare ionograms digitally. In scaling foF2 for gravity wave studies, it is very easy to scale large numbers of ionograms quickly. His scaling system has several features to aid scaling. When heights are displayed, the primary height is accompanied by a series of height markers at 2*height and 3*height so multiples can be lined up and quickly recognised. For mid latitudes, by far the majority of returns come from overhead, as can be shown using the multiples. Frequencies are shown with an accompanying pair of ordinary and extraordinary cursors scaled mathematically correctly. This makes scaling easier as sometimes one or other trace is indistinct and using the pair of traces makes feature identification simpler. Currently, John is working on an improved manual input to polan based on the present DIGION. There is obviously much work yet to be done in developing user friendly, and effective, computer aided scaling systems for manually processing ionogram data.

John pointed out that there are some errors in the display of the IPS-42. The frequency marker display around the border of the ionogram is incremented one frequency channel high and the heights are in error by a constant 9km. This last point was discussed as the Christchurch ionosonde did not appear to have this error. All people using any data must be constantly aware of the possible errors inherent in their data due to the methods used to record it.

4.5. Comments from Jack

When New Zealand ceased to support an ionosonde network the Campbell Island (and many years earlier, the Rarotonga) ionosonde was closed and the Scott Base and Christchurch ionosondes were passed over to the University of Canterbury. Operation of the ionosondes has been patchy over the last few years and some of the data is still to be processed by IPS. However, the Scott Base ionosonde will now be converted, using a DIGION, to collect digital ionograms early in 1994. The hardware for this has been funded by the US Navy. Later this year, the Christchurch ionosonde will also be converted.

4.6. Summary

After discussions, the DIGION was demonstrated and an attempt was made to contact the Swedish network through Internet. Unfortunately, this was unsuccessful. However, aside from that minor setback, this was a useful and interesting half day meeting. It demonstrated very clearly the wide range of computer based techniques that are now being used with, in some cases, moderately old equipment. Provided funding is available, there is likely to be more progress in this area over the years to come.

5. CLOSURE OF MAUI IONOSONDE STATION

The Solar-Terrestrial Physics Division of the National Geophysical Data Center (NGDC) wishes to announce the permanent closure of the Maui, Hawaii, ionosonde site on June 1, 1994. The site has run for more than 50 years with an amazing record of reliability thanks, in the last 16 years, to Stephen S. Barnes' mindful efforts to keep the vintage C2 film-based ionosonde running smoothly. The historical archive of ionograms held at NGDC for Maui will remain an invaluable resource. Its closure will leave a large hole in Pacific Ocean and in global coverage of ionospheric vertical incidence data.

6. CLOSING A NETWORK

Last year I was asked what effect the closure of the South African ionosonde network would have on IPS. This is a general issue affecting many groups and I feel the ideas I presented may have wider interest. For instance, it is often hard to think what to put in such a letter. It is also hard to see that it is really any of your business, even when the request for support is clearly personal. I am offering this letter as a sample letter I sent supporting a particular ionosonde network. If you have written a similar letter of support recently, please consider having a copy published in INAG. The ideas in these letters may be helpful for others seeking to express their support, but uncomfortable with the style and content that will most effectively in stating their beliefs.

Here is what I wrote.

You pose a difficult question - what can I say to persuade you to continue to operate your ionosonde network? It is an expensive activity and if you are not getting value from the network yourself then why should you be making the effort on behalf of people elsewhere? There is no simple answer to this but it is a question that is being posed by many other people.

First, it is as well to establish some important issues regarding the operation of an ionosonde network. The longer, and more reliably a network has been operated, the more important and the more easily replaced it becomes. A paradox? We *(at IPS)* find that because the South African network has been reliable in the past, the monthly maps *of the F2 region that* we have prepared for the globe are well defined in the region of South Africa. For simple, but important work of this type, the past contribution from your stations will always be preserved for general purpose use. This is true for many other good ionosonde stations around the world. Many could have closed ten years ago and we would still benefit today from their past existence. However, we can make that observation only with hindsight. To make it with any certainty, we need reliable stations to continue to operate for as long as their institutes can afford to support them. Reliable station networks are fundamentally important to the global ionosonde network as a whole because their reliability acts as a standard against which apparent secular changes can be measured. In other words, the longer a network has collected data, the more desirable it is for it to continue to collect data. I have written in the INAG Bulletin on the topic of baseline stations. I believe this is a valuable function and an excellent reason for maintaining long term ionosonde networks.

With this background, I will answer your questions.

How is the data that we receive used? Some years ago, all data received at IPS were promptly entered into the computer and compared against our global ionospheric maps. This is still a relevant exercise, but we have limited people available, and far more for them all to do, so it is not done as regularly as was once the case. However, over a period of two to three years, all the monthly median data we receive are still entered in the computer and used as a check on our global ionospheric maps. In addition, they are also used to calculate an ionospheric index. The sooner we receive the data, the more impact these data have on our regular operations. On occasions, we are involved in studies of the ionosphere where hourly data becomes important. The recent series of Sundial campaigns is an example. During these periods, we entered hourly data and studied stations in comparison with each other to build a global picture of ionospheric storms and disturbances. South African data is most important in these studies as there is almost no other comparable information in the world. This is partly because of the Atlantic anomaly, partly the paucity of data in the southern hemisphere. These type of studies are carried out irregularly, but I always use the South African data when I do this type of work. There have been occasions when an ionospheric storm is seen in Australia, but not in South Africa, and on another occasion, there was a storm in Europe, but nowhere else. The South African data established that nothing was seen in comparable southern locations. Unfortunately, this work was not published. It was part of a larger study that has, recently, suffered funding setbacks.

What would be the impact if the data were discontinued? It would produce an important global gap in our knowledge of the ionosphere. When event analyses are carried out, the southern hemisphere will be poorly represented. In your time sector there is only one station reporting data outside South Africa - that is the French station at La Reunion. It is far enough north of your stations to leave your geographical and geomagnetic region unmeasured. The significance of this can be measured against the general comments I have made above. In the longer term, as we move towards global ionospheric mapping, as I feel we will, your region will not be covered. There is no other reliable mid latitude ionospheric information available.

At IPS, and also through INAG, we are exploring ways to make the data recorded at ionosonde stations useful in real time. There appear to be a growing number of potential applications for real time data. I feel that where possible, these options should be harnessed first as support for established stations and second as a basis for establishing new stations. To some extent this will depend on how significant HF is in your region. I can quote examples, for instance, Pakistan has invested in three ionosondes to cover all of their country. Other groups are moving in similar directions. Single site direction finding systems require ionosonde data for real time updates. IPS is exploring ways that such systems can use our ionosonde stations in real time. While there appears to be an interest, there is also, still, a major problem getting the data from a station to the person who can use them in a timely fashion. While this could be solved now, it appears a difficult task that will be easily managed in the near future rather than now. We feel that this approach is necessary if large numbers of ionosonde stations are to be supported in the future. IPS also feel that networks will need to become digital based and use computer scaling software for real time data. This is a reasonable financial investment for a network that is having problems, but it should be a small investment compared to the capital outlay over past years.

I hope these comments are some help. I recognise that eventually funding becomes an important problem and it is not possible to continue to support a network. We are aware that our own future is by no means guaranteed even though ionospheric sounding has a reasonable profile in

Australia. If people do not see an immediate need it is very difficult to sustain their interest. I will be publishing an INAG Bulletin in May and if you wish to put in a note outlining your situation and ask for further input, I will be happy to include the note. I should add, however, that it is difficult to get people to commit any thoughts to paper in regard to station closures. Please don't interpret a lack of response as a lack of interest. I agree the silence is no help to you, but people don't always recognise their responsibilities in these matters. They may think, as happened in IPS once, that by saying the data are useful they are placing you under an obligation to supply them.

That is what I said. It is longer than necessary and did not result in the continued routine collection of ionosonde data in South Africa, as is apparent from the URSI INAG Meeting report.

It is very important that we work together, share our ideas on these matters and become a more effective voice supporting our ionosonde networks, both in our own country and in others. I would be very pleased, as I have said, to publish similar letters of support for ionosondes and for groups involved in ionospheric research. I feel we can all benefit from an exchange of ideas in this area.

7. LITERATURE SEARCH ON IONOSONDE AND IONOGRAM

In the survey last year one person suggested I should make a survey of publications on ionosondes. This seemed a good idea so our librarian, Vivian To, had several on line data bases searched using the key words ***ionogram*** and ***ionosonde***. The following list of papers were what we obtained. I should have spent the extra effort in putting the search results into alphabetic order, but for various reasons, I didn't. The search looks at the titles of papers and also at any key words if these have been specified and was made for the years 1991 and 1992.

Did you write a paper and now you fail to see it in the list? What went wrong? Possibly our search did not include the publication outlet you used, although our search was reasonably comprehensive, as a quick check of the journals represented shows. More likely, you did not mention ionosondes or ionograms either in the title or in the key words of your paper. Failure to do this could lead to the impression that ionosondes are not being used for published research. That would be most unfortunate as some groups use research as a supporting reason for continuing to operate an ionosonde.

I would like to encourage **everyone** who is using ionosonde data to remember to mention this in either their title, or in the key words they supply to editors to describe the paper content. This will help keep ionosondes visible in the literature. Furthermore, if journals have citation lists for describing articles, and the words *ionosonde* or *ionogram* are unavailable, draw this omission to the Editor's attention.

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8. OCCURRENCE OF A PECULIAR SEQUENTIAL Es AT KARACHI

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8.1. Abstract

This study reveals the frequent occurrence, maximising in Winter, of a peculiar sequential Es recorded by the Digisonde DGS-256 at Karachi during 1992-93. The sequential Es is peculiar in the sense that it is formed by a clear detachment of the bottom side of the F1-layer. The detached part of the F1-layer is converted, directly or through E2-layer, into a sequential Es; which descends from around 200km to about 130km at a velocity of about 6m/sec. A study of this sequential Es may enable us to deduce the neutral meridional wind pattern in the middle ionosphere at Karachi.

8.2. Introduction

Sequential Es (Sporadic E) is frequently the last part of a much longer sequence starting high up in the F-region (Robinson, 1960). Sequential Es appears preferentially at low latitudes and quite often it descends at a velocity of about 1m/sec, increasing in electron density and becoming thinner (Whitehead, 1970). Rawer (1962b, 1963) pointed out that the sequential Es did not occur often over the European zone. Bibl (1960) found both decreases and increases in h'Es with foEs varying in anti phase to it. Lanchester et al. (1991) reported that descending Sporadic-E Layers above Tromso are generated by a wind shear associated with the semi-diurnal solar tide. They, using the data of the EISCAT (European Incoherent SCATter) UHF radar, reported that on 3 and 4 August 1988, Sporadic-E Layers, associated with the afternoon wave of the semi-diurnal tide, were formed and descended from the bottom of the F1-layer at Tromso (I=76°N).

The main aim of this short paper is to present examples of a peculiar sequential Es, recorded by Digisonde DGS-256 during 1992-93 and a preliminary study thereof; which occurs frequently at Karachi (24.95°N, 67.14°E,I=36° N). This sequential Es is peculiar in the sense that it is formed by a clear detachment of the bottom side of the F1-layer, which is often converted directly into sequential Es of h-type and goes on descending to join E-layer at foE; thereby forming a c-type sequential Es. At times, the detached part of F1-layer is first converted partly into E2-layer and Es, which soon merge with each other forming a single sequential Es of h-type.

8.3. Examples of peculiar sequential Es at Karachi

Two clear examples of conversion of the bottom side of the F1-layer into 'h' type (high type) sequential Es at Karachi on 26-02-1993 and 01-07-1993 are shown in Figs. 1(a-g) and 2(a-h), respectively. *Both sets of ionograms have the same format. The frequency scale starts at 1 MHz and there is a vertical dotted line marking each 1MHz increase in frequency. The frequency scale is linear. The vertical virtual height scale is also linear and starts at 50km with a horizontal line for each step of 50km. Virtual heights of 100km, 200km and 400km are marked on the ionograms, but may not be easily read.*

Fig 1(a) shows the normal F1-layer at 1014 hours LT on 26-02-1993, while Fig, 1(b-c) shows the detachment of the bottom side of the F1-layer from the parent layer. In Fig. 1(b) the bottom side (3.6-4.2 MHz) of the F1-layer tends to get detached from the parent layer (indicating the onset of the sequential Es) at 1029 hours LT, while Fig. 1(c) shows the process of detachment is complete at 1044 hours LT. Later, this part of F1-layer is fully converted into h-type sequential Es at 1059 hours LT as is seen in Fig. 1(d). This sequential Es then continues to descend (Fig. 1(e-g)) until it joins E-layer at foE and is converted into a c-type sequential Es at 1144 hours LT.

Another example of conversion of the bottom side of the F1-layer into sequential Es, observed on 01-07-1993, is shown in Fig. 2(a-h). in this example, unlike the previous one, the bottom side (3.9-4.5 MHz) of the F1-layer is first converted partly into E2-layer and Es at 1344 hours LT, which persist up to 1359 hours LT (Fig. 2(b-c)). Later, E2-layer and Es merge together to form a single h-type sequential Es at 1429 hours LT (Fig. 2(e)); which continues to descend until it is ultimately converted into a c-type sequential Es at 1559 hours LT (Fig. 2(g)).

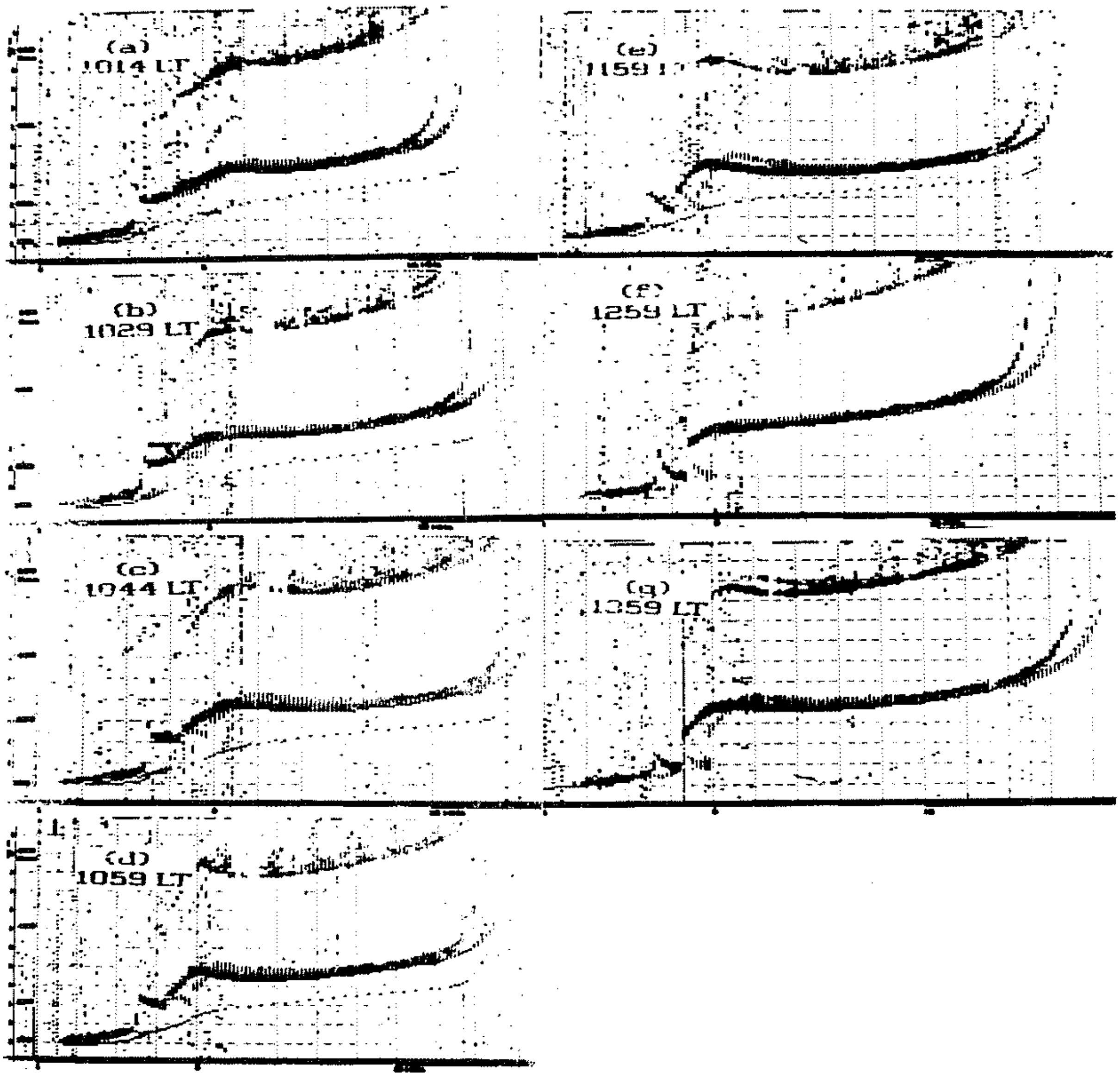

Fig. 1(a-g): Conversion of bottom side of F1-layer into sequential Es-layer at Karachi on 26-02-93. Fig. 1(a) shows the normal ionogram.

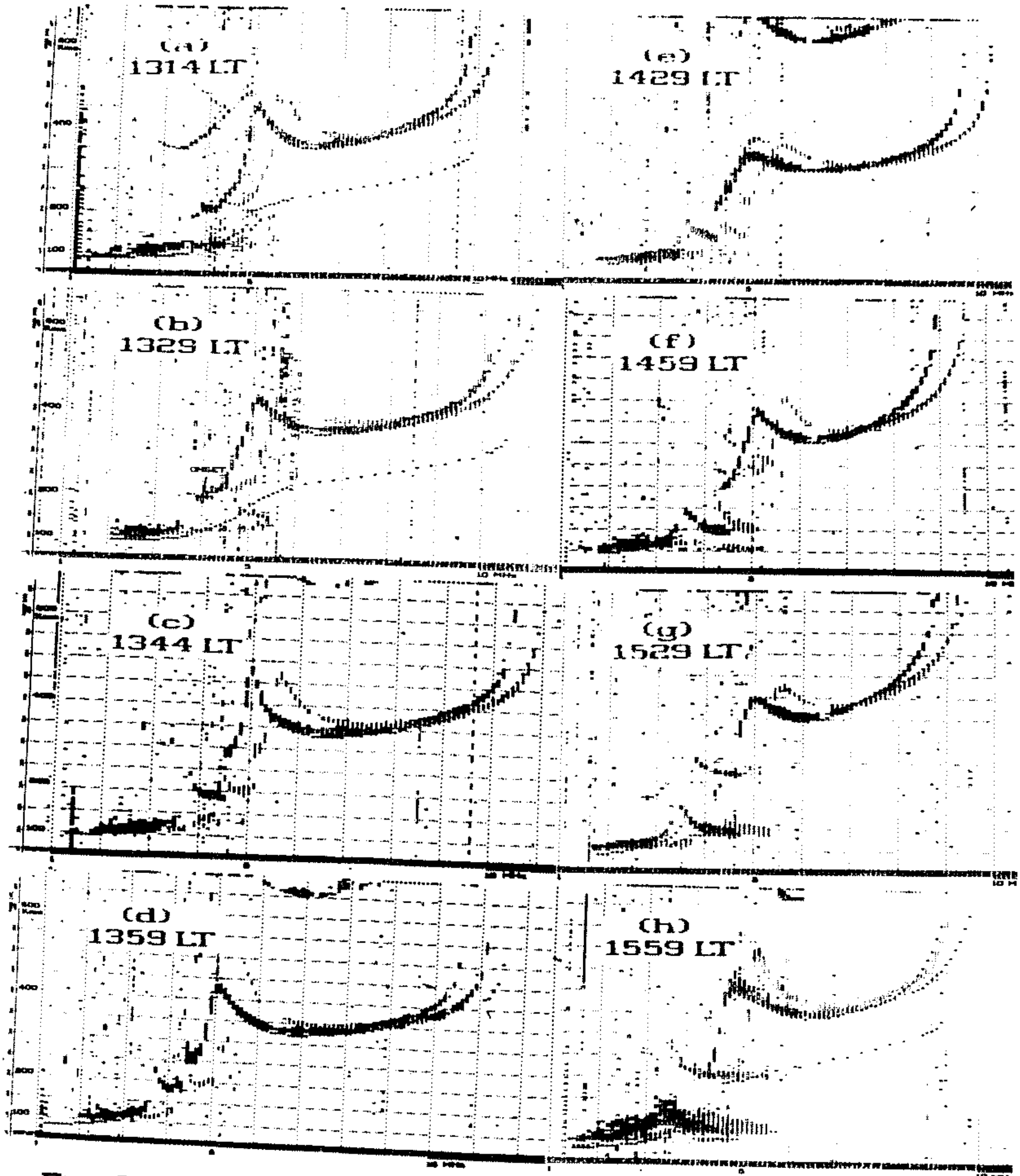

Fig. 2(a-h): Conversion of bottom side of F1-layer into E2 and Es -layers which merge together to form a sequential Es-layer at Karachi on 01-07-93. Fig. 2(a) shows the normal ionogram.

8.4. Results

A preliminary study of the peculiar sequential Es occurring at Karachi during 1992-93 has shown that:

(i) This is a daytime phenomenon which (irrespective of the season) starts at Karachi around noon and continues up to 1800 hours LT at the most. This phenomenon when started before noon is usually found to be stronger and prolonged.

(ii) The occurrence of sequential Es is more frequent in Winter (35%) than in Equinoxes (18%) and Summer (13%). In Winter (1992-93), its occurrence is found to be maximum in the month of November (53%)

(iii) The virtual height of the sequential Es is found to be around 200Kms at the time of its onset.

(iv) As the sequential Es descends, foEs often remains constant or shows a nominal increase. At times, foEs may increase abruptly when sequential Es is converted into a 'c' type Es.

(v) The downward speed, d(h'Es)/dt, of sequential Es is on average about 6m/sec.

(vi) The sequential Es is blanketing in nature.

8.5. Conclusions and Discussion

A study of the Karachi ionograms for the year 1992-93 reveals conversion of the bottom side of the F1-layer, directly or through E2-layer, into sequential Es. This peculiar sequential Es, with its onset around noon, descends from a virtual height of around 200Km to about 130Km at a velocity of about 6m/sec. A study of sequential Es, which normally descends from 200Km to 130Km, may help us to deduce the neutral meridional wind patterns in the middle ionosphere at Karachi. This is because the wind shear theory predicts that, below about 130Km, Es layers are controlled more by the zonal wind that by the meridional wind (Chen and Harris, 1971).

8.6. Acknowledgments

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9. COMPUTER CONTROL OF AN IPS-42 IONOSONDE

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9.1. The Hardware

Our IPS-42 ionosonde, purchased from KEL Aerospace in 1983, continues to give yeoman service. On average we lose 0.1% of possible recording time through ionosonde failures and servicing, and 1.2% through camera, film and processing problems. Six years ago we began work on a computer-controlled system to collect the ionograms in digital form, and to store, display and scale these as required. This project was initially quite ambitious, with facilities for specifying the frequencies to be sounded and the number of pulses transmitted. We have now settled on a simplified version for routine operation, as outlined below.

The IPS-42 sounds 3 times on each frequency. Echoes are detected by a voltage comparator, and clocked into a 1024--bit shift register which stores data from the first 800 km of effective height. The data is re-circulated during the 2nd and 3rd soundings, on the same frequency, to zero any bits which do not correspond to a consistent return. The result is then passed out to the video display -- at which point we grab it along with the associated clock signal, as indicated at the top left of Fig. 1. We also extract Scan-on, transmitter-on (Xmr) and display-on (Yb) signals from inside the IPS-42. All these, plus a Min signal, are accessed by clipping leads on to existing edge connectors. One further wire is soldered to the "Monitor Sweep" button, so that the computer can `push' this as required.

The signals are processed on a small printed-circuit board installed at the rear of the ionosonde. The three control and timing signals are combined into a single control line (Y), which is sent to the computer in true and inverted form. At the computer, which can be 1--20 metres away, differential processing reconstitutes the Y signal free of interference. Incoming clock and control signals are also processed to remove any rapid fluctuations. The serial data stream is converted to parallel form and fed to the computer as 64 8-bit bytes at each frequency (the top right of Fig. 1). The software also carries out numerous error checks, and disables the receiving system (using the "inhibit" line) during transmission periods. As a result we get perfect records at all times, except during power failures; and recording resumes automatically as soon as power is restored.

9.2. The Software

When the computer is switched on it connects to the ionosonde, and waits for a one-minute time signal. This is used to readjust the computer's clock, over a range of ñ30 sec, to agree with the ionosonde. (Synchronisation is also carried out every hour throughout the recording interval, to maintain accurate timing.) The main recording routine is then entered to obtain ionograms at specified intervals. These appear on the monitor display and on the computer screen. Any film program can proceed independently; e.g. you could collect digital ionograms every 5 minutes, and film ionograms every half hour. The last ionogram is always displayed on the computer, and is available in a separate file for remote retrieval and viewing if required.

Each ionogram is stored with header, date and time information. The height resolution of 1.6 km is about twice that available on film, or from KEL's DBD-43 unit, and requires 37 kB to store each ionogram in its raw state. This is reduced by a factor of about 5 by compacting the data with a type of run-length encoding, designed to match the data. A further factor of 2 is obtained if the ionograms are first "cleaned" by deleting the date-time numerals, all information below 70 km, all of the graticules (apart from 4 reference marks), and most isolated dots. The graticules and date-time information are readily restored from the ionogram header when required, as shown in Fig. 2.

Hourly ionograms are left uncleaned to provide a full check on ionosonde operation. For 5 minute ionograms this processing reduces the average size to typically about 3.5 kB, so that the 288 ionograms for one day occupy about 1.0 MB. Every five days a standard data-compression program reduces the files by a further factor of about 1.8, and copies them to tape. Thus the final storage requirements for high-resolution ionograms, recorded every 5 mins, is about 15 to 20 MB per month.

9.3. Results

A separate software package is used for display and scaling of the stored data. Arrow keys give a fast forward or backward scan of successive ionograms, at rates of 2 or 3 per second. Other keys scan the data in steps of 30 minute or two hours; jump to the first or last ionogram of this day (or adjacent days); or jump immediately to the ionogram at the same time on preceding or following days. This last facility is invaluable for examining strange effects near sunrise or sunset.

Scaling of data is carried out using a computer aided approach, giving fast, accurate and fully checked results. The computer displays, as coloured lines, the critical frequencies and minimum heights scaled from the previous ionogram. These are adjusted as required using the cursor keys. Tapping `return' then saves these values and displays the next ionogram.

A `site' number is included in the header information for each file. This is used to identify the station, and to select the correct value of gyrofrequency (for each layer) so that fo and fx are both displayed with the correct separation. This greatly increases the ease and accuracy with which critical frequencies can be determined, as in Fig. 2 where foF2 is defined best by fx (broken line). Height lines are shown at h, 2h and 3h, for checking against multiple echoes. Further

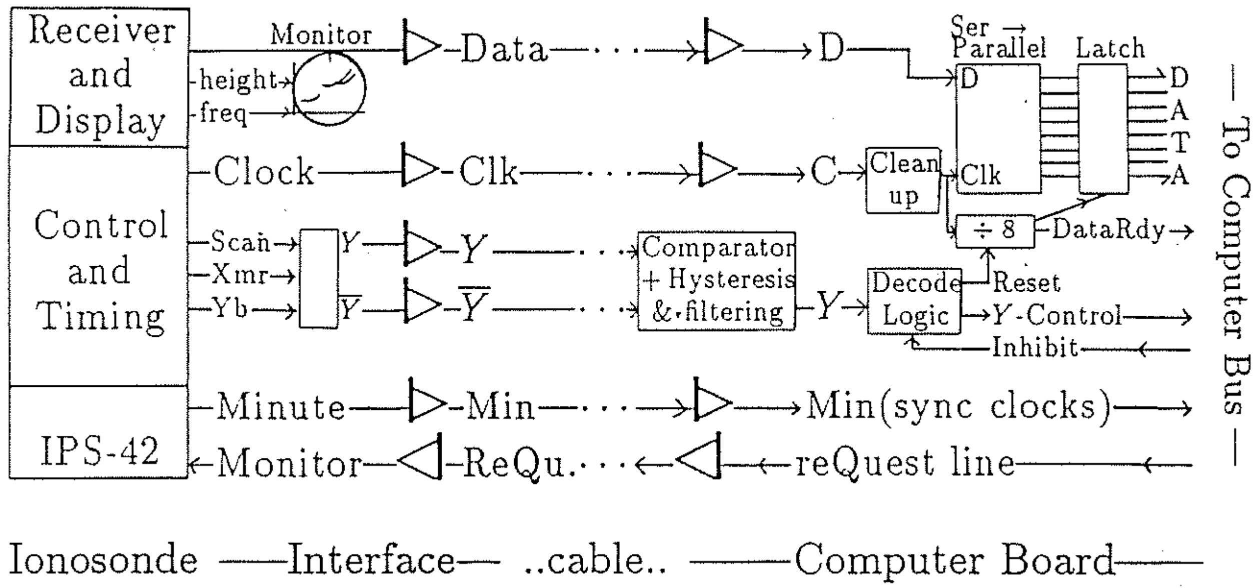


Figure 1. Block diagram showing the signals extracted from the IPS-42, the general processing, and the signals fed to the computer. The triangles are RS232 drivers and receivers.

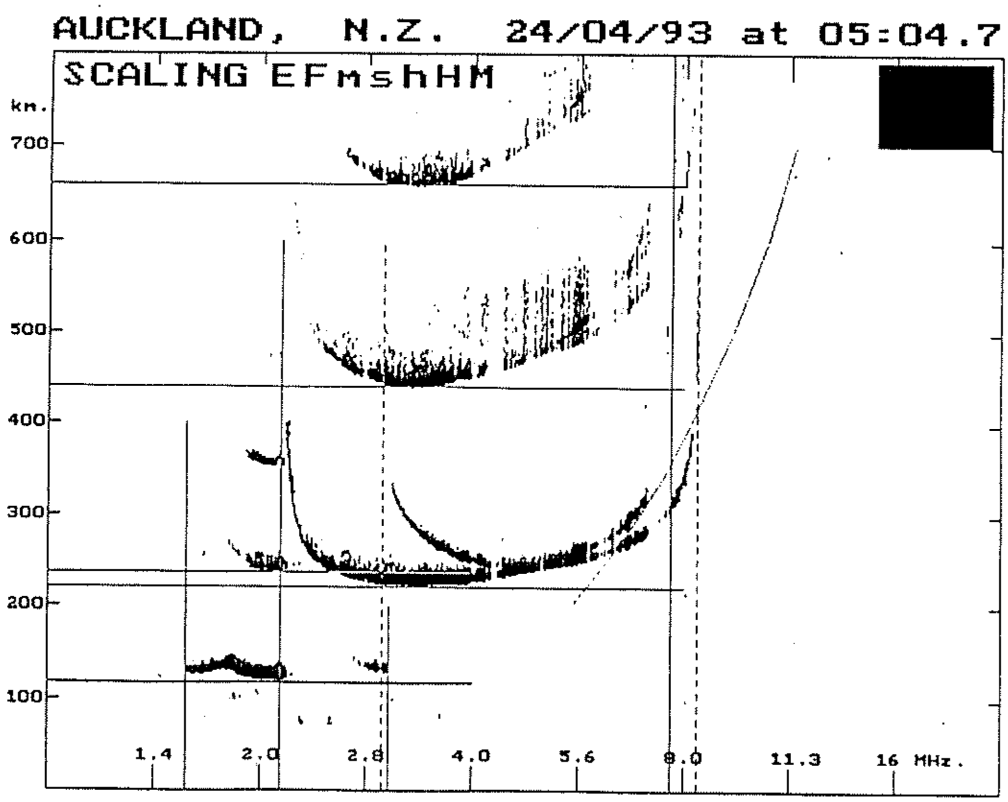


Figure 2. A typical digital ionogram as displayed on a VGA monitor. Straight lines are added by the computer for scaling heights and frequencies; the curved line is for M(3000).

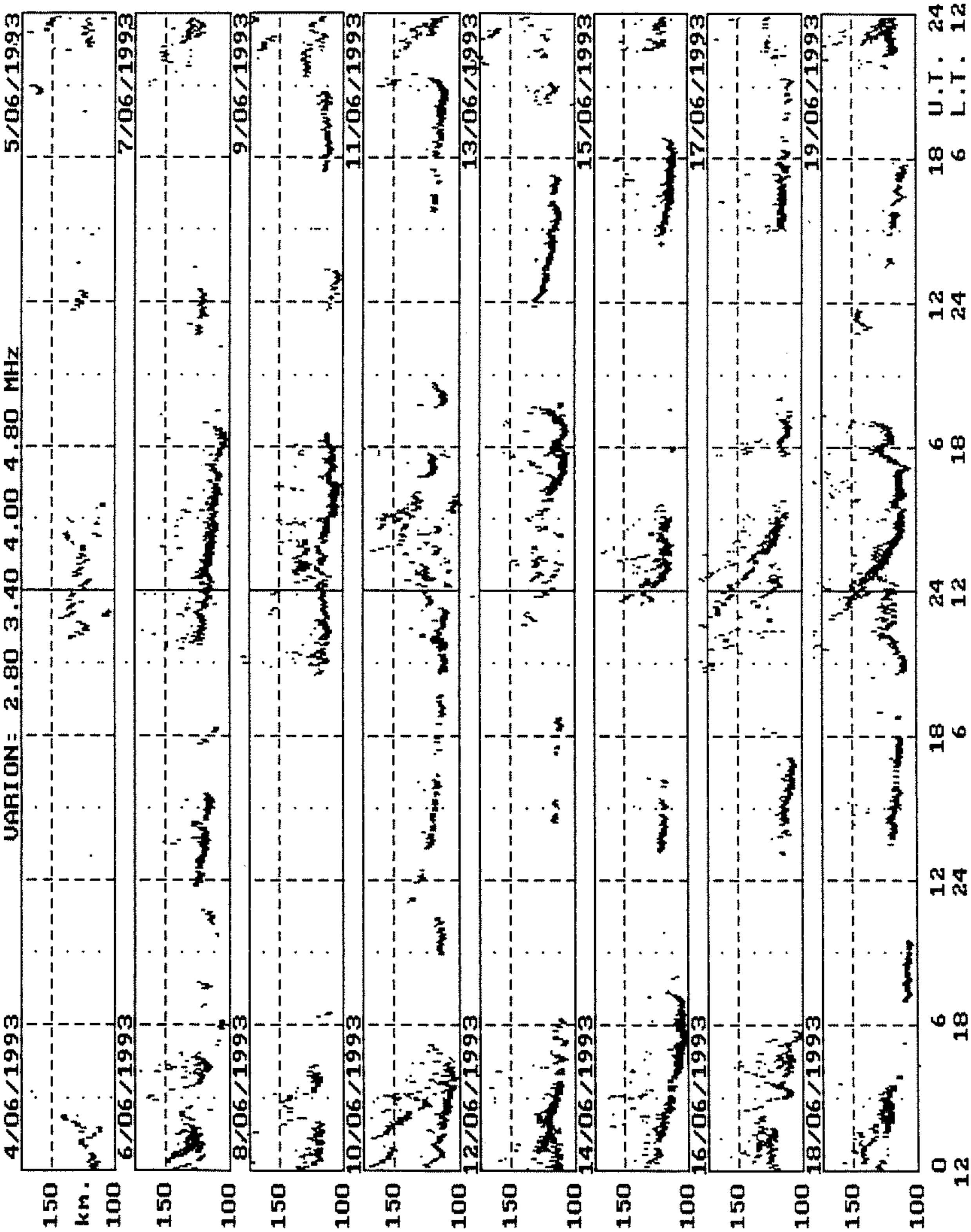


Figure 3. Echo heights plotted from 5-min ionograms for 16 successive days in winter. The 4 frequencies used are listed at the top, coloured to match the corresponding echoes. This synthesis of data from 4,600 ionograms (16 MB of compacted data) is produced in 38 sec.

developments will involve interactive real-height calculations using POLAN, to display the ionogram, the scaled data, the calculated profile and the corresponding (calculated) virtual heights.

Virtual--height variations at a fixed frequency can also be readily extracted from digital ionograms. A program VARION plots echo height against time for any required frequencies, for periods of 1 to 20 days. Echoes are displayed only when there is a return on at least 2 of the 3 channels closest to each given frequency, to reduce noise and avoid problems caused by blanking of individual channels. For greater clarity a leading-edge detection algorithm can be invoked. An example of this, for echoes in the height range 100 to 180 km over a period of 16 days, is shown in Fig. 3. Two of these plots cover one month, giving an excellent summary of the occurrence and characteristics of sporadic E.

9.4. Summary

An obsolete XT computer with a 40 MB hard disk is ideal for running the Auckland `Digion' system; this will allow storage of all programs plus 5-min ionograms for about six weeks. Such computers can be obtained for less than US$250, or $500 with a new streaming tape drive for long-term storage. We can supply copies of our system (with plug-in printed circuit boards for the computer and the ionosonde, plus the cable and all programs) for about US$1,600. Data is stored in a simple but efficient format, and source code is provided for all programs so that a user can get whatever he wants from the data. The advantages of changing to computer control have proved compelling, and may be summarised as:

⇒ Recording-- No film to buy, expose, process and store. Make copies in your computer.

⇒ Viewing-- Scan data rapidly at your desk. Check quickly against adjacent ionograms, or at the same time on other days.

⇒ Scaling-- More detail and resolution than with film ionograms, and the position of each dot is known exactly (with no calibration). The display of fx calculated from fo, and lines at h, 2h and 3h, allows the use of all information.

⇒ Savings-- To store 5 minute ionograms costs about $50 per year. Two minute ionograms would cost another $1 per week.

⇒ New Uses-- Plot h'(t) at any number of frequencies for a clear display of ionospheric changes, TID's and gravity waves. Do interactive real-height calculations.

10. CANADIAN ADVANCED DIGITAL IONOSONDE (CADI)

The Canadian Advanced Digital Ionosonde (CADI) is a state of the art, low cost, full featured ionosonde ideal for both routine ionospheric monitoring and scientific research.

CADI provides sounding capability using high power radio frequency pulses at vertical incidence. The system integrates phase coding techniques, solid state electronics and PC technology to make CADI a significantly smaller and less expensive ionosonde. The system may be operated with single or multiple receivers. Observables include: echo delay (height) versus frequency; the phase and amplitude of the echo; angle of arrival; and polarisation of the echo. Drifts can also be measured using the spaced-antenna method. This information is used in radio propagation forecasts of the most effective operating frequency for point to point radio communication. The data is also used in scientific research relating to the ionosphere.

10.1. Features:

Height range up to 512 km (to be increased to 1000 km) with 6 km resolution.

- The digital control system provides high flexibility. Multiple operating modes are available.
- Frequency range from 1 to 20 MHz. Three standard sweeps are provided: low resolution (100 frequencies), medium resolution (200 frequencies), high resolution (400 frequencies). The step size may be selected to be linear or logarithmic.
- System is PC-based with the major units of the ionosonde mounted on plug-in boards. A basic one-receiver system uses two plug-in boards.

Transmitter - The transmitter power required is only 600W. Amplifier units are all solid state and include monitors for forward and reverse power. The use of pulse coding techniques gives an 11 dB signal to noise (S/N) ratio improvement, equivalent to having about thirteen times the transmitter power.

Receiver - The system can incorporate four or more receivers for spaced antenna measurements. The receiver outputs are sampled simultaneously using two microprocessors per channel. The increased data rate over a time-shared antenna system allows further improvements to the S/N ratio using post-detection processing.

Frequency Synthesiser - Frequency generation is provided by a frequency synthesiser based on direct digital synthesis (DDS). The synthesiser has two channels and can produce two output frequencies that can be changed almost instantaneously in frequency or phase. The DDS synthesiser provides the transmitter frequency and the receiver local oscillator frequency.

Noise Suppression - Coherent pulse averaging is used to further improve the S/N. In practice, four pulse averages (at medium resolution) are used, giving a 6 dB S/N improvement. Longer averages tend to obscure real changes in the ionosphere. If the data is processed in a *spectral* mode, longer averages are possible. This is usually done only for selected data.

Post processing using Fast Fourier Transforms (FFTs) is being evaluated as an alternative. The sample length would no longer be limited; cancellation is avoided as the phase difference between pulses becomes a frequency shift. For a 64 pulse sample FFT, the S/N improvement is 18 dB over a single pulse sample. The use of FFTs on a modern PC offers tremendous benefits without a large delay (a few minutes per ionogram) or expensive special processors.

Operation - The operating software provides a menu of operating modes from which the operator makes a selection.

A complete ionogram requires from a few seconds (at low frequency resolution and averaging two pulses) to several minutes (at high resolution averaging 16 pulses). A medium resolution ionogram with four pulse averaging requires about 45 seconds.

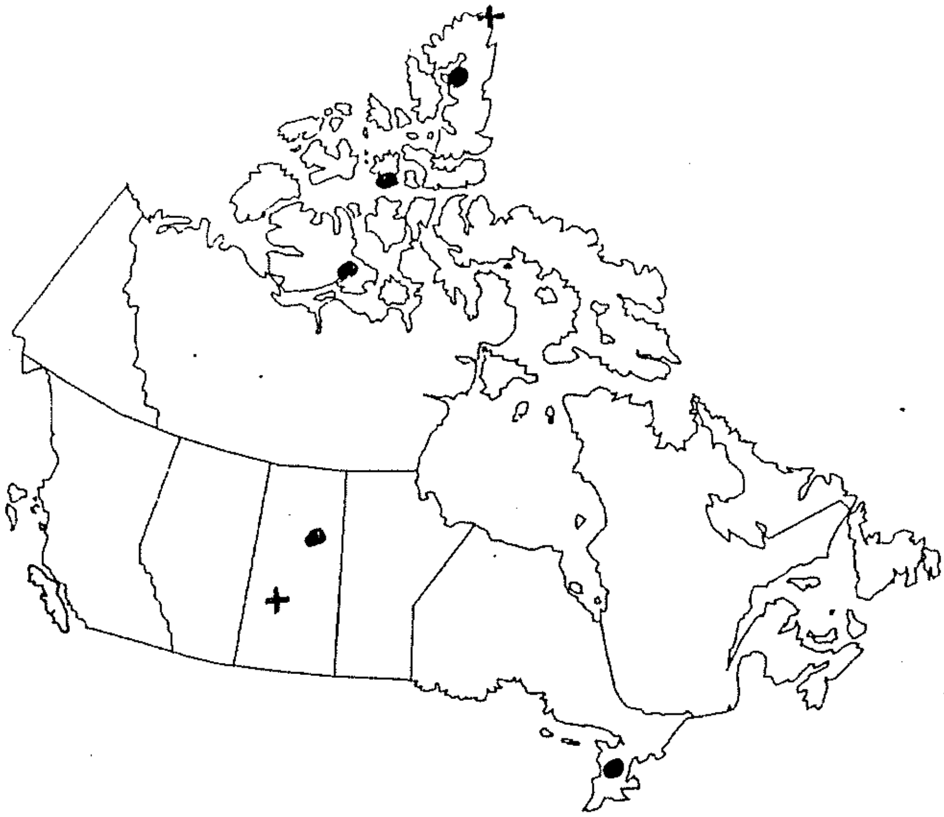
Data is stored to the computer's hard disk. The data is periodically backed up to 120 MB tape cartridges using a standard Colorado Memory Systems backup unit. Remote control and communication is possible using standard PC communication packages.

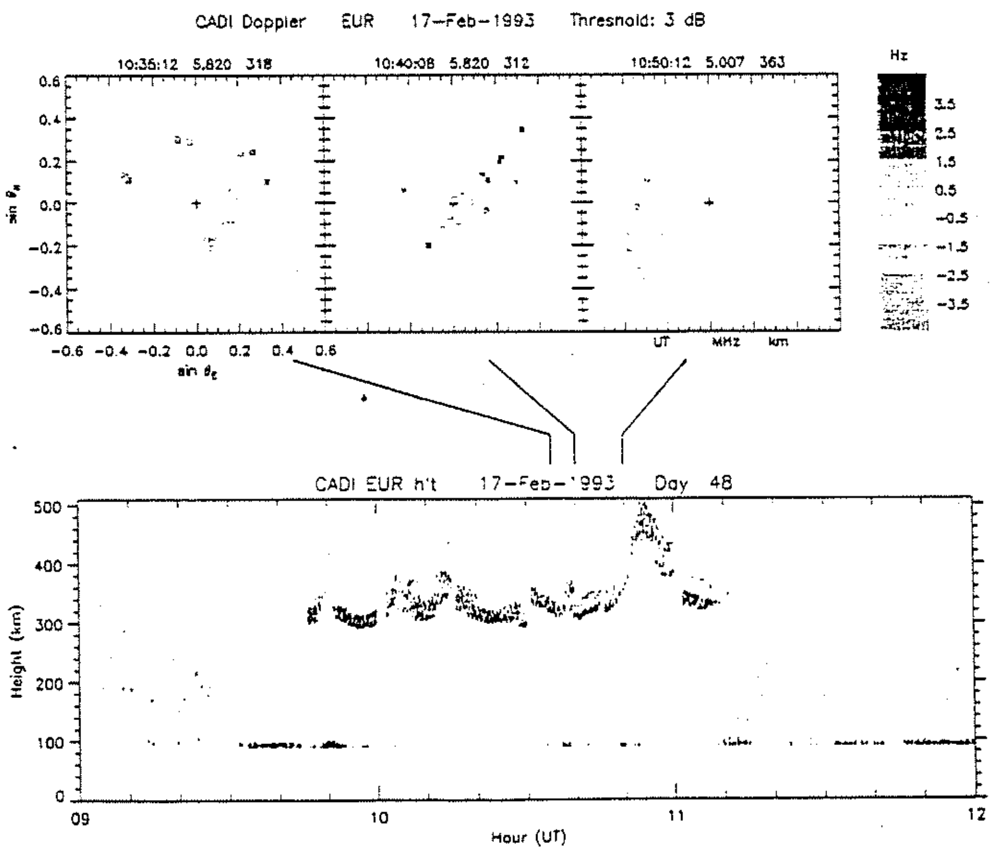
10.2. Applications

10.2.1. General Information

CADI is operated as a vertical incidence sounder (VIS) providing information on the state of the local ionosphere. CADI provides direct information on: the echo delay (virtual height) as a function of frequency; the phase and amplitude of the reflected signal; and the doppler shift due to motion of the reflector, at one or a series of

SPECIFICATIONS	
Pulse Power	00W
Frequency Range	1 to 20 MHz
Frequency Sweeps	100, 200, 400 linear or logarithmic steps
Frequency Generation	DDS-based synthesiser
Height Range	90 to 512 km
Height Resolution	6 km
Pulse Coding	13 bit Barker or single pulse
Storage	Standard 120 MB tape backups
Power Requirements	PC plug-in boards run off standard bus power. Power amplifier units require 110/220V, 50/60Hz, 100VA
Dimensions	Power amplifier cabinet 10 x 12 x 8 inches
Compute	IBM compatible PC with at least two free 8 bit slots (5 slots fora four-receiver system)
Graphics	CGA for single receiver EGA/VGA for multiple receivers




CADI Doppler EUR 17-Feb-1993 Threshold: 3 dB
10:36:12 5.820 318
10:40:08 5.820 312
10:50:12 5.007 363
Hz
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
UT MHz km
sin θ_E
sin θ_N
CADI EUR h't 17-Feb-1993 Day 48
Height (km)
Hour (UT)

frequencies. With multiple receivers the angle of arrival may also be determined from the phase delay at different receivers. From this information the electron density profile and the drift field may be derived.

Software: Data collection and analysis software was developed in close collaboration with researchers at the University of Western Ontario. Scaling software is provided to allow manual scaling of the standard URSI parameters. Advanced analysis software may be obtained on agreement between SIL and UWO. This package utilises Interactive Data Language (IDL) routines and has not yet been integrated in the commercial package.

The CADI Network: The CADI system has already become an integral part of the Canadian Network for Space Research program, one of Canada's Networks of Centres of Excellence. Extensive collaboration among the space and atmospheric research community is providing in depth and effective use of data from the sounders now operating.

Links have also been established with the Canadian military and the Department of Communications.

Locations: The following sites are presently operating -

Rabbit Lake, Sask	(58°N, 106°W)
Resolute Bay, NWT.	(75°N, 95°W)
Eureka, NWT	(80°N, 84°W)
Cambridge Bay, NWT	(69°N, 105°W)
London, Ontario	(test site)

Planned locations include -

Saskatoon, Sask	(52°N, 107°W)
Alert, NWT	(82°N, 63°W)
HIPAS, Alaska	

10.3. Usage

CADI is a full-featured digital ionosonde with a broad range of applications.

Atmospheric research: The combination of portability, low cost and ease of installation make CADI ideal for both permanent installations and campaign-type research programs of shorter duration.

The potential applications of the CADI sounder to atmospheric research is quite large. A short list of current applications includes:

- polar cap studies, including morphology and behaviour of patches and arcs;
- auroral zone studies, stand-alone and in conjunction with optical and VHF/HF radars:
- studies relating ionospheric effects to wind, wave and tidal measurements in the mesosphere;
- equatorial and high latitude electrojet studies.

CADI is a flexible, robust system which can be configured to suit a variety of user applications.

Ionospheric monitoring: CADI provides the full complement of basic information on the state of the ionosphere required for routine monitoring.

- scaling of standard URSI parameters;
- data storage format suitable for World Data Centre archives.

Communications: For communications applications, CADI provides the following capabilities:

- frequency management based on state of local ionosphere;
- diagnostic sounding, suitable for interpreting the known statistical behaviour of various ionospheric parameters;
- cooperative check target for an HFDF system;

10.4. Future Development

The development of the CADI system is an ongoing process. SIL and researchers at the UWO are involved in the joint development of additional features which will enhance the capabilities of the sounder. Our commitment is to the further development of CADI as an accessible, low cost, flexible full-featured instrument with a broad range of uses in scientific and communications research and monitoring of the ionosphere.

10.5. Publications

S. Gao & J. MacDougall. A dynamic ionosonde design using pulse coding. Can. J. Phys. 68, 1184 (1991)

10.6. For further information:

Scientific Instrumentation Ltd.
2233 Hanselman Avenue
Saskatoon, Saskatchewan S7L 6A7
Telephone: (306) 244-0881
Facsimile: (306) 665-6263
email: cansas::sil (SPAN)
sil@skisas.usask.ca (INTERNET)

11. THE NEW RUSSIAN ADVANCED DIGITAL IONOSONDE - *BIZON*.

A. M. Mirochin*, N. F. Blagoveshchenskaya**, A. V. Shirochkov**, O. A. Troshichev**
* - Technical Center "Jupiter" (9 Krestovsky Av., St-Petersburg, 197042, Russia).
**- Arctic and Antarctic Research Institute (38 Bering Str., St-Petersburg, 199397, Russia).

11.1. Introduction.

The catastrophic situation with the technological level of ground-based vertical ionospheric sounders in Russia became evident in the late 80's. The basic type of Russian vertical ionosonde with analogue recordings - the AIS (Automatic Ionospheric Station), which has been in operation since the International Geophysical Year (1957 - 59), needed to be replaced by a new type of ionosonde due to its having completely worn out. The necessity for a new modern type of ionosonde became urgent in this country, where the vertical ionosonde is the main tool for obtaining ionospheric data. Therefore many scientific institutes created their own ionosondes since they were unable to pay the big money required to order the complex commercial devices. Several types of such ionosondes ("Cyclon", "Parus" etc.) have been described in different issues of the INAG Bulletins. Basically all these ionosondes were semi-professional devices built in the laboratories of scientific institutes. None of them was properly tested in the field. Unfortunately there is no coordinated program in Russia for establishing a national ionospheric network with proper financial sponsorship from the state. Therefore the search for an optimum type of ionosonde is continuing.

11.2. The *BIZON* ionosonde. General description.

Several years ago a technical center for research of scientific equipment, Jupiter, in Saint-Petersburg, in close collaboration with the scientists of the Arctic and Antarctic Research Institute produced a new type of advanced digital multi-functional ionosonde called *BIZON* with the primary intention of using it as a basic tool for ionospheric prediction purposes as well as for ionospheric research. The *BIZON* is a low cost, two-channel version of the modern digital ionosonde that can operate in three modes: vertical sounding, bistatic and monostatic oblique soundings. The *BIZON* includes the following separate industrially-made units :

(a) a two-channelled ionospheric receiver Liliya;
(b) a two-channelled digital signal processing system Minipreweck;
(c) a synchroniser;
(d) transmitter *BIZON - R*.

The ionosonde is controlled by a standard IBM PC AT-286 with a good software library designed for preliminary signal processing as well as for scaling ionograms, Ne-profile calculations and data storing. The ionosonde is made using standard transmitting and receiving antennas and for specific research projects it can operate with a complex antenna array. The existing software provides possibilities to communicate the ionospheric data by means of standard modem on dial-up or other communication lines. The *BIZON* is housed in the special functional table-like cabinet with the dimensions of height 0.85 m and width 1.35 m.

11.3. Possible outputs of the *BIZON:*

(a) The standard vertical ionograms (and the possibility of displaying any part of it with an enlarged scale).
(b) The amplitude and Doppler characteristics at any chosen frequency for a defined time interval.
(c) Doppler ionograms.
(d) Phase Soundings.
(e) Oblique monostatic Soundings (backscatter mode).
(f) Polarisation ionograms.
(g) Vertical absorption measurement at any chosen frequency (A1 mode of absorption measurements).

It is also possible to perform oblique, bistatic soundings between two *Bizon's* located at different geographical points. Two features of *BIZON* are worthy of special mentioning:

FIG. 1

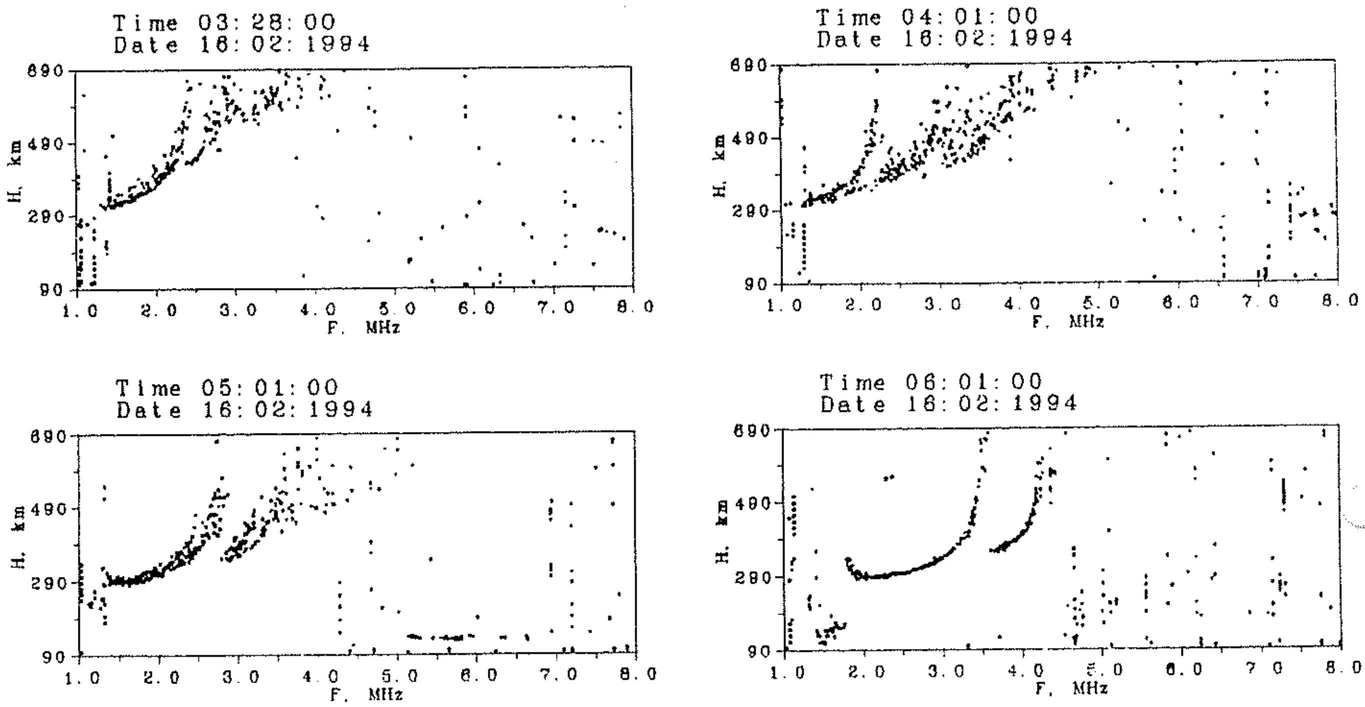

Time 03:28:00
Date 16:02:1994
H, km
F, MHz
Time 04:01:00
Date 16:02:1994
H, km
F, MHz
Time 05:01:00
Date 16:02:1994
H, km
F, MHz
Time 06:01:00
Date 16:02:1994
H, km
F, MHz

FIG. 2

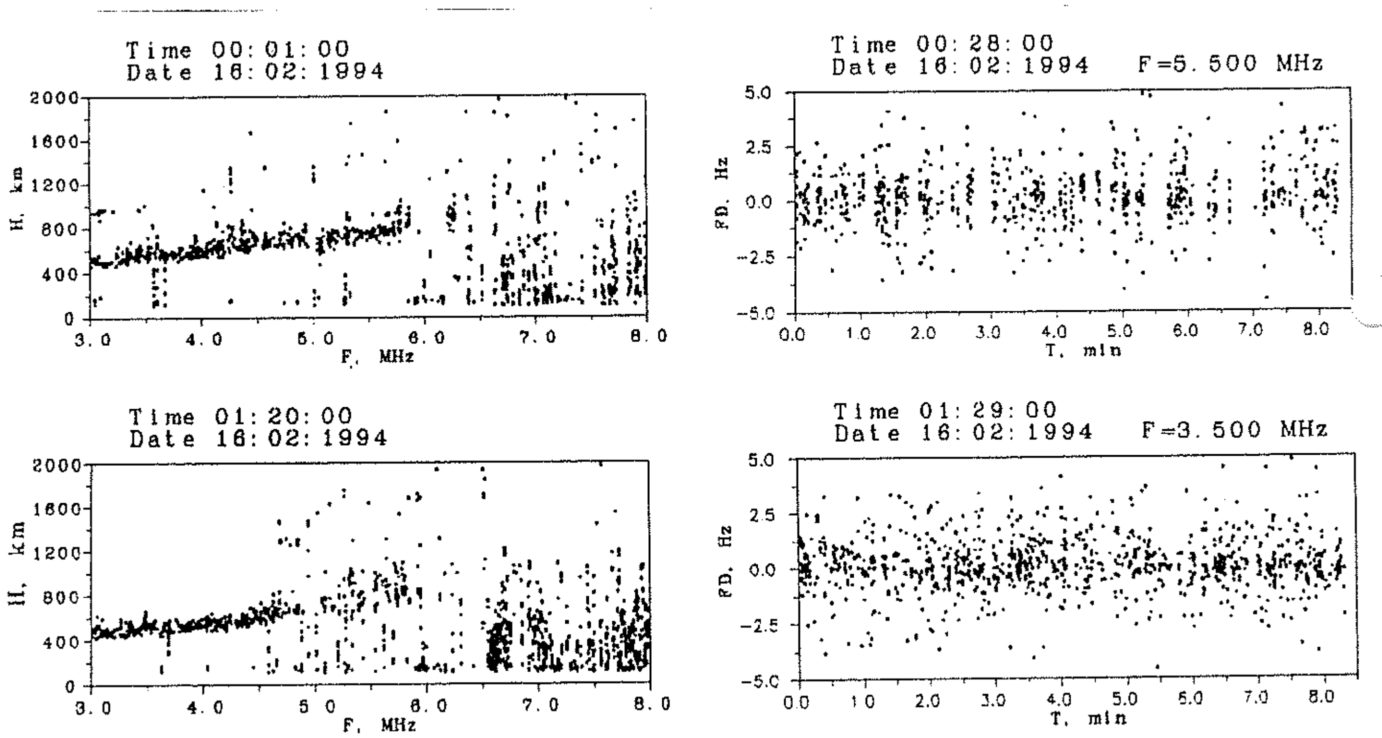

Time 00:01:00
Date 16:02:1994
H, km
F, MHz
Time 00:28:00
Date 16:02:1994 F=5.500 MHz
FD, Hz
T, min
Time 01:20:00
Date 16:02:1994
H, km
F, MHz
Time 01:29:00
Date 16:02:1994 F=3.500 MHz
FD, Hz
T, min

FIG. 3

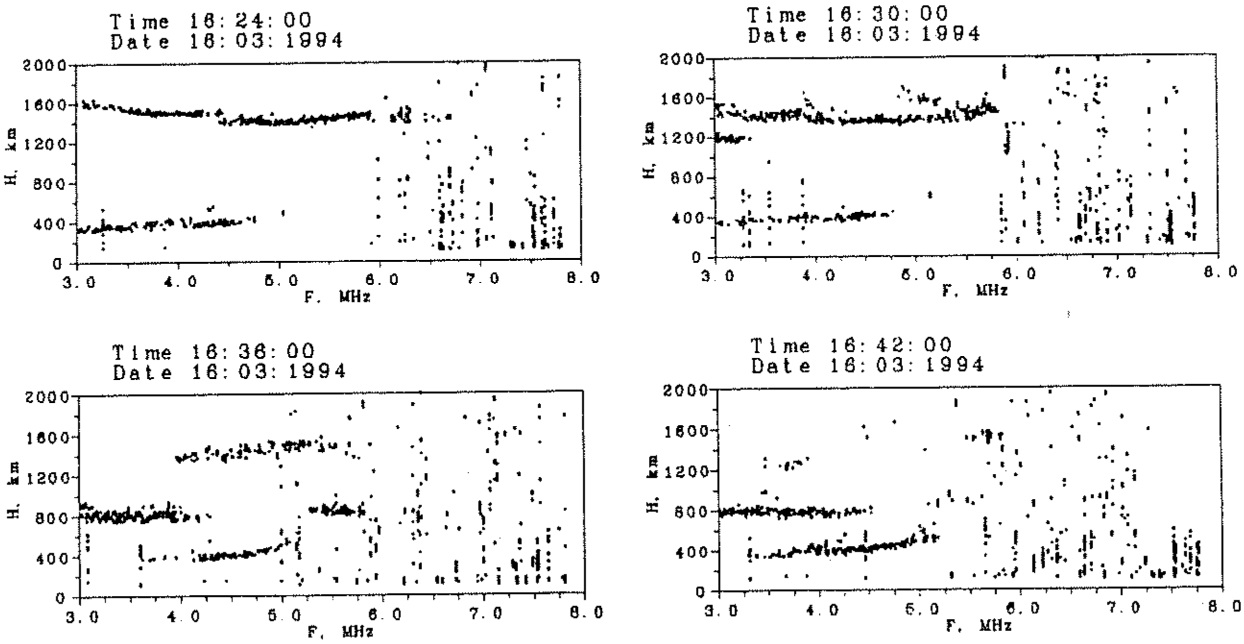
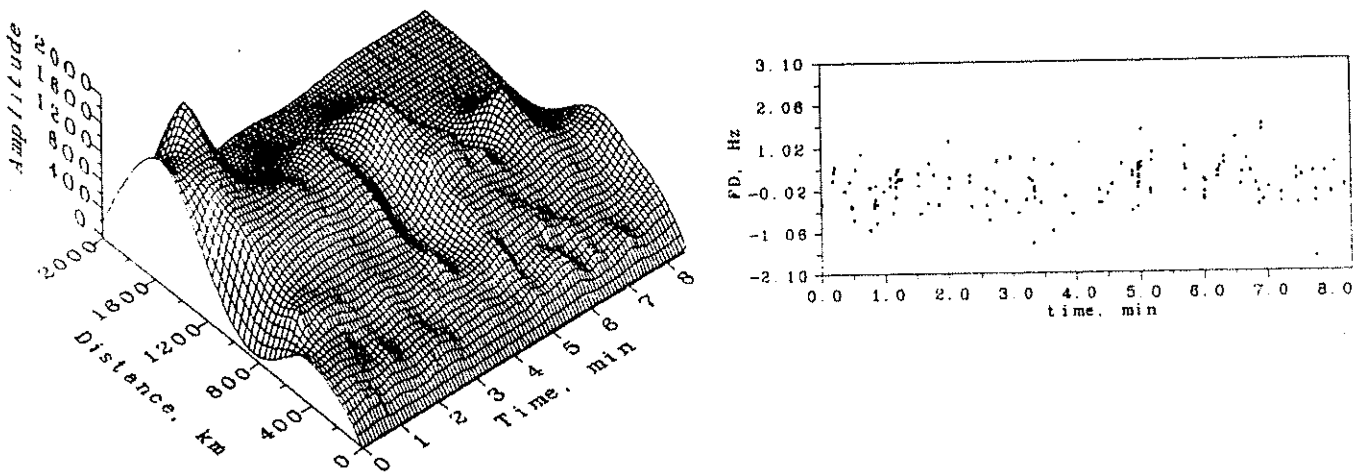


FIG. 4 January, 12, 1994, T=21.20 UT, F=4 MHz



(a) the two-channel receiver means precise phase measurements can be made;

(b) a wide dynamic range receiver, which could provide more reliable performance at high-latitudes where increased abnormal absorption in the lower ionosphere creates a "black - out" situation on many occasions.

11.4. *BIZON* field testing results.

One of the first *BIZON* units made underwent testing in different modes of sounding at the observatory of Arctic and Antarctic Research Institute located at 50 miles from Saint-Petersburg (latitude 59.95°N; longitude 30.70°E; invariant latitude 56.06°N). The tests are being made over several months in conditions of severe electromagnetic interference using a poor supply of power. The purpose of the testing was twofold: to check the technical and software parameters of ionosonde against their original design parameters as well as to be sure the *BIZON* can operate properly for a long time in a permanent sounding mode. The results of these tests were very successful and the *BIZON* proved a reliable performer. The next ionosonde units are under preparation for installation in observatories in the Arctic as well as in Antarctica. More detailed descriptions of the *BIZON* tests, in different modes of operation, are given below.

11.4.1. Vertical sounding.

A wide range of measurements can be made by the *BIZON* in the vertical sounding mode. First of all, a conventional ionogram with O/X separation is made. This mode of sounding is used for real-time operational information for different kinds of customers. Operator cannot alter the sounding program in this case. An output of each sounding is distributed as a message in the international URSI approved code. Besides that, it is possible to get an Amplitude Ionogram, a Doppler Ionogram as well as the angular and Direction of Arrival characteristics of the received signal (if the corresponding antennas are available). Ionospheric absorption using the A1 method is also possible. The ionograms are stored by using DBase code under the MS-DOS system. Data files are compressed (4:1) to save storage space. The ionogram can be processed immediately after recording and an

Technical details

Frequency range	0.5 - 30 MHz
Receiver bandwidths	1.2; 7.8; 15.0; 30.0 kHz
Receiver dynamic range	65 dB (for each channel)
Gain control	automatically selected fixed gain settings
Transmitting power	10 kW
Pulse widths	62.5 ; 125 ; 187.5 microseconds
Pulse repetition frequency	1 - 50 Hz
Number of range bins	500 (selectable range start)
Range resolution	1 km
Amplitude resolution	1 %
Phase resolution	0.1°
Doppler resolution	Discrete Fourier transform has a resolution of 1/T, where T is selectable from 0.1 to 100 secs.
User Interface	friendly software interface.
Power input	220 V, 50 - 60 Hz
Power consumption	≈3 kWA

operator can control this process. The software can filter the signal, remove certain frequencies, enlarge any part of the ionogram, present the ionogram in different coordinate systems etc. There is a special program for calculating Ne(h) profiles from the ionogram. Several periods of severe geomagnetic disturbances were recorded during the *BIZON* testing campaigns in January, February and March of 1994. Figure 1 shows the data from vertical sounding on February 16, 1994 for period 03.28 UT to 06.01 UT in a suburb of Saint-Petersburg. Noteworthy is the presence of the main ionospheric trough (03.28 UT) at this comparatively low invariant latitude. It is an indication of significant equatorward displacement of the auroral oval during the geomagnetic storm.

11.4.2. Monostatic oblique sounding (backscatter mode).

This mode of sounding was made by scanning the frequency range of the *BIZON* and was performed from January 1994. The observations take place during the Regular World Days (RWD) of each month in the period from 15 UT till 03 UT. This mode of sounding from Saint-Petersburg allows monitoring of the position (in space and time) of the poleward wall of the main ionospheric trough as well as to explore the ionospheric features of magnetospheric substorms which usually take place far northward from Saint-Petersburg.

Two different kinds of sounding were used in these experiments:

(a) backscattering in the scanning frequency range with time interval from 3 to 30 minutes between each sounding;

(b) continuously backscattering at fixed frequencies during the period from 8 to 25 minutes when the amplitudes and Doppler frequency shifts were registered.

Some examples of these data are given. Figure 2 presents several backscatter ionograms taken in the frequency scan mode using signals from the F region. The simultaneous time variations of Doppler frequency shifts (in Hz) taken at the fixed frequencies 3.5 MHz and 5.5 MHz on February 16, 1994 are also shown. Figure 3 shows a sequence of backscatter ionograms, with reflections from auroral forms, taken during the storm on February 16, 1994. The frequency scan mode is used here. An interesting feature of these ionograms is the lowest trace which probably belongs to a slant F-layer. Figure 4 shows the three-dimensional impression of amplitudes and the time variations of Doppler frequency shifts taken at a fixed frequency of 4 MHz during a geomagnetic storm on January 12, 1994. The time interval is from 21.20 UT until 21.28 UT. The data in Fig.4 shows wave-like variations of both amplitudes and Doppler shifts with periods of 2-3 minutes. Most probably these wave-like variations of the ionospheric parameters are connected with the infrasonic waves produced by the movements of auroral arcs. The data in Fig. 4 clearly demonstrate equatorward shift of the region of wave-like variations of amplitude from a distance of 1800 km to a distance of 800 km in 8 minutes. The corresponding velocity of such movement is of the order of 2 km second^{-1} which is in reasonable agreement with other available estimations of velocity of the auroral forms.

The examples in Figures 1, 2, 3 and 4 show the capabilities of the *BIZON* to perform as a reliable ionosonde in an ionospheric network as well as a modern research ionosonde. Another conclusion which can be derived from the *BIZON* testing is that its technical reliability is rather high. This is a very important quality of an ionosonde proposed for performance in severe and uncomfortable conditions at polar observatories.

11.5. Availability

Everybody who is interested in obtaining this type of ionosonde is encouraged to contact the manufactures of the *BIZON*.

Mr. A. M. Mirochin
Technical Center "Jupiter"
P. O. Box 93
Krestovsky avenue, 9
Saint-Petersburg, 197042, RUSSIA

12. IRI WORKSHOP: ANNOUNCEMENT AND CALL FOR PAPERS

Workshop: Low and Equatorial Latitudes in the International Reference Ionosphere (IRI)

Date: January 9 to 13, 1995

Location: National Physical Laboratory, New Dehli, India

Sponsors (expected): COSPAR, URSI, IAGA, COSTED, CSC, ISF, INSA

Objectives: This meeting continues the series of annual workshops coordinated by the URSI/COSPAR Working Group on the International Reference Ionosphere (IRI). IRI is the international standard representation of ionospheric densities, temperatures and drifts. The prime objective of the 1995 meeting are potential improvements and extensions of the IRI model at low and equatorial latitudes. Empirical and theoretical contributions are welcome. Of particular interest are:

(a) comparative studies of IRI with data, simulations and other models;
(b) investigations that could lead to better representation of ionospheric parameters in IRI;
(c) regional mapping of E and F peak parameters;
(d) occurrence statistics for Spread-F and other ionospheric irregularities;
(e) applications of IRI in science, engineering, and education.

One workshop day will be dedicated to the Verification of Ionospheric Models (VIM) effort of the URSI Working Group on Ionospheric Informatics (WGII). The Workshop will be part of the Diamond Jubilee celebration of the Indian National Science Academy (INSA) established in 1935. Dr. A. P. Mitra will be the Local Workshop Convener for INSA.

Program Committee:
Anderson, M. A. Abdu, D. Bilitza, A. Danilov, T. L. Gulyaeva. K. Mahajan, A. P. Mitra, K. Oyama, K. Rawer

Local Organising Committee:
P. Mitra (Chair), K. K. Mahajan (Secretary), E. S. R. Gopal, R. R. Daniel, S. C. Chakravarty, O. P. Nagpal, S. Aggerwal, M. K. Goel, V.K. Pandey, J. Kar, N. K. Sethi, R. Kohli, A. Singh, R. K. Bhasin, M. M. Sharma, H. R. Metha, C. S. P. Kumar, F. C. Khullar.

Abstracts: Please send Abstract to:
D. Bilitza, HSTX, NSSDC
7701 Greenbelt Road
Greenbelt, MD 20770, U. S. A.
FAX: (301) 441-9486, phone: (301) 441-4193
E-mail: BILITZA@NSSDCA.GSFC.NASA.GOV, NCF::BILITZA
DEADLINE: AUGUST 31.

Accommodation: Lodging will be provided in the NPL Guest House (single and double bedrooms; cost is about 5 US dollar per bed).

For reservations please contact:
K. K. Mahajan
National Physical Laboratory
Dr. K. S. Krishnan Road
New Dehli-110012, India,
FAX: 91-11-5752678, phone: 91-11-5788220
DEADLINE: OCTOBER 15

Travel Support: Limited travel support is expected for participants from post-communist countries and for young scientists. Please send an application detailing cost requirements with your Abstract to D. Bilitza.

13. IONOSONDE SUPPLIERS

Periodically I am asked to supply the names of groups that manufacture ionosondes. I am aware of several suppliers (listed alphabetically according to the country of origin) but I don't know for certain that this list is either complete or accurate. If you know of other suppliers, or prefer some other address and contact numbers, or if you have an email contact address that you are confident will be useful, please let me know.

Address	telephone	facsimile	Contact person	Selling
KEL Aerospace 231 High Street Ashburton Victoria 3147 AUSTRALIA	+61 3 889 0022	+61 3 889 0006	T D Kelly	IPS-71 IPS-42
Scientific Instrumentation Limited 2233 Hanselman Avenue Saskatoon CANADA S7L 6A7	+1 306 244 0881	+1 306 665 6263	Kirk McDuffie	CADI
POLSAT Co Ltd Kasprzaka 96 0.- 234 Warsaw POLAND	+48 39 12 12 73	+48 22 40 37	Dr. M. Suchanshi	KOS 98/2
IZMIRAN Troitsk Moscow Region 142092 RUSSIA	+7 095 334 0908	+7 095 930 5509	Prof A Reznikov	PARUS
Technical Center "Jupiter" P.O. Box 93 Krestovsky avenue, 9 Saint-Petersburg, 197042, RUSSIA			Mr. A.M.Mirochin	Bizon
University of Lowell Center for Atmospheric Research 450 Aiken Street Lowell MA 01854 USA	+1 508 458 2504	+1 508 453 6586	Prof. B. W. Reinisch	DGS-256 DPS

14. IONOSPHERIC DIGITAL DATABASE

WORLDWIDE VERTICAL INCIDENCE PARAMETERS

CD-ROM DATA SET

The National Geophysical Data Center (NGDC) wishes to announce the July 1994 release of the **Ionospheric Digital Database of Worldwide Vertical Incidence Parameters** on two compact discs (CDs) with custom-designed access and display software.

The CDs contain 40,000 station months (1350 megabytes) of digitised vertical incidence parameters from 130 sites around the world. These data have been contributed through a major effort among the World Data Centers and many ionosonde network organizations.

The User Documentation Manual included with the CD dataset package details instructions for equipment set up and installation of the software as well as information about the ionosphere and ionograms, vertical incidence parameters, data collection, quality control, format descriptions, and user instructions for the software. Instructions and navigation commands are also provided "on-line" as context-sensitive "help" windows inside the IDD display software.

With the Ionospheric Digital Database software, the user may browse and display any data on the CD database. In the individual mode a graph of the diurnal distribution for up to one month is displayed along with the monthly median values. Comparative or composite modes display up to six datasets of any combination of station, date, and ionospheric parameter data available. The browse mode allows the user to search through the numerical values in any one of the selected datasets.

The graphs that you create can be saved as PCX files for display at a later time or for creating your own series of computerised images for visual reproduction.

A world map with both Geographic Longitudes and Latitudes as well as corrected Geomagnetic Latitudes displays the catalogue of all ionosonde stations and stations with digital data contained on the CD database. The catalogue of digital stations may be searched by any geographic area, date, or ionospheric parameter ascertain availability of data. The map and a list of the stations containing digital data for the selection can be saved.

All the data contributed come from 1957 through 1990. They have been digitised, reformatted, converted to universal time (the software also can display the data in local meridian time), and passed through quality control filters. In November 1993, the Ionospheric Informatics Working Group (IIWG) format was adopted. Corrections, data to fill existing gaps, and data from before and after the 1957 through 1990 period of this release will be added to this continuing database. These data can be obtained from NGDC and will be issued on CDs in the future.

Corrections, data to fill existing gaps, and data from before and after the 1957 through 1990 period of this release will be added to this continuing database. These data can be obtained from NGDC and will be issued on CDs in the future.

The cost for the CD dataset package with 40,000 station months of hourly worldwide vertical incidence data including the IDD access and display software and the printed User Documentation Manual is $200. To order, please contact :

Raymond O. Conkright or
roc@ngdc.noaa.gov
Phone: 303-497-6414
FAX: 303-497-6513

Karen Fay O'Loughlin
kfo@ngdc.noaa.gov
Phone: 303-497-6468
FAX: 303-497-6513

15. CODE OF IONOSPHERIC CHARACTERISTICS

It is essential that all groups use the same characteristic code for entering ionospheric data. The standard characteristic code assignments of Table 1 was adopted internationally in January 1970. **There are now new parameters that need to be added to this table.**

Codes of Characteristics Table
Characteristics normally interchanged are marked with an asterisk (*)

CHARACTERISTIC CODES USED FOR IONOSPHERIC MEASUREMENTS **Jan 1970**											
FREQUENCIES						HEIGHTS					
		0	1	2	3	4	5	6	7	8	9
LAYER F2	**0**	00 foF2*	01 fxF2	02 fxF2	03 M(3000)F2*	04 h'f2*	05 hpF2	06 h'0x	07 MUF(3000)F2	08 hc	09 qc
F1	**1**	10 foF1*	11 fxF1		13 M(3000)F1*	14 h'F1		16 h'F*	17 MUF(3000)F1		
E	**2**	20 foE*		22 foE2		24 h'E*		26 h'E2			
Es	**3**	30 foEs*	31 fxEs	32 fbEs*	33 fEs	34 h'Es*		36 Type Es*			
Other	**4**	40 foF1.5		42 fmin*	43 M(3000)F1.5	44 h'F1.5			47 fm2	48 hm	49 fm3
Spread F and Oblique	**5**	50 fol	51 fx1*	52 fm1	53 M(3000)I	54 h'I			57 dfS		
N(h)	**6**	60 fh'F2	61 fh'F		63 h'mf1	64 h1	65 h2	66 h3	67 h4	68 h5	69 H
T.E.C.	**7**	70 I(2000)	71 I	72 I(xxxx)							79 T

15.1. TABULATION OF HOURLY VALUES

The table lists characteristics that should be exchanged internationally by all stations, with the addition of some characteristics regularly measured at some stations for voluntary interchange by special arrangement. In a few cases, an arbitrary code assignment was adopted but, in general, the WWSC system has been followed.

This table differs slightly from that given in the first edition. The following changes and additions have been adopted: Tens unit (Layer identification), index 5 was originally reserved for solar indices, but has not been used for this purpose since an independent solar code has been developed. Therefore, index 5 in tens unit was adopted for parameters associated with spread F and oblique reflections. Index 6 is adopted for electron density profile parameters and index 7 for total electron content parameters.

02	fzF2 (new)
07	MUF(3000)F2 (change of code number)
17	MUF(3000)F1` (change of code number)
26	h'E2 (new)
44	h'F1.5 (new)
47	fm2 (minimum frequency of second order trace) (new)
49	fm3 (minimum frequency of third order trace if required) (new)
50	reserved for foI if required
51	fxI (new standard parameters)
52	fmI, lowest frequency of spread (in use at some stations only) (new)
53	M(3000)I, factor deduced from upper frequency edge of spread traces and fxI (in use at some stations on experimental basis only) (new)
54	h'I, minimum slant range of spread (in use at some stations only) (new)
70	I_{2000} or I(2000) Definition: Ionospheric electron content up to 2000 km (for a geo-stationary satellite measured by Faraday technique).
71	I Definition: Total electron content up to a geostationary satellite.
72	I_{xxxx} or I(xxxx) Definition: Ionospheric electron content up to satellite height xxxx for non geostationary satellites.

The following allocations have been requested to facilitate interchange of electron density profile data. They will be reviewed in the future to see whether they have been used in practice, and may be changed.

Additional parameters needed to enable profiles to be calculated using conventional parameters (e.g., foF2, M(3000)F2, h'F2, foF1, M(3000)F1, foE, h'E, fmin).

60	fh'F2	Definition:	The frequency at which h'F2 is measured.
61	fh'F	Definition:	The frequency at which h'F is measured.
63	h'mF1	Definition:	The maximum virtual height in the o-mode F1 cusp. (i.e., the value of h' at foF1).

Profile characteristics calculated using Titheridge's method (Chapter 10).

48	hm	Definition:	The height of maximum density of the F2 layer calculated by Titheridge's method.
79	T	Definition:	The total sub-peak content calculated by Titheridge's method.
69	H	Definition:	The effective scale height at hmF2 calculated by Titheridge's method (H is similar to qc physically but liable to greater experimental errors).

64 65 66 67 68	h1 h2 h3 h4 h5	Definition:	True heights calculated by Titheridge's method at the sampling frequencies f1, f2, f3, f4, f5 Note: At night h1 represents f1.

More recently, the Ionospheric Informatics Working Group have addedfour characteristics to list true height parameters. Their choices were:

90	*hmE*	*from true height analysis*
91	*hmF1*	*from true height analysis*
92	*hmF2*	*from true height analysis (note: not just Titheridge - see 48)*
93	*h(half)Nm*	*from true height analysis*

Among the recent additions only fx1 (51) is now recommended for general use, but data available for other additions should conform to the recommended code when entered.

The following definitions are generally accepted but have not been standardised internationally. It should be noted that such local conventions may change with development and research.

x- and z-mode characteristics	For extraordinary-wave modes or z-wave mode (columns 1 and 3 Table 7.2), follow the corresponding definitions for o-wave mode characteristics.
44 h'F1.5	This is defined to be analogous to h'F2.
05 hpF2	This code may also be used for parameters analogous to hpF2 where this parameter is not measured at the station, e.g. hmF2 deduced by curve fitting without correction for underlying ionisation, but a note showing the exact parameter used must be included with the cards.
06 h'0x	Height of extraordinary-wave trace at frequency equal to foF2.
57 dfS	Frequency range of spread. This is normally equivalent to fx1-foF2, but can denote total frequency range of spread when foF2 or fxF2 cannot be identified, e.g., for equatorial scatter, when dfS = fx1 - fm1 may be used.
Note:	The URSI/STP Vertical Incidence consultant or members of the INAG should be consulted when preparing local conventions for regional use to ensure that scaling and reduction personnel receive instructions consistent in form with those of standard characteristics included in the current international exchange program.

These tables were copied from UAG-23. Please advise me of the additions and subtractions so I can publish a current table.

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