IONOSONDE NETWORK ADVISORY GROUP (INAG)*

Ionospheric Station Information Bulletin No. 56**

CONTENTS

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

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Issued on behalf of INAG by the World Data Center A for Solar-Terrestrial Physics, National Oceanic and Atmospheric Administration Boulder, Colorado 80303, USA. Others wishing to be on the mailing list should notify the INAG Secretary, Ray Conkright, WDC-A for STP or the INAG Chairman, Phil Wilkinson.

1. COMMENTS FROM THE CHAIR

Since the Prague meeting, I have spent most of my INAG time writing to people.

I wrote to the rest of the people on the mailing list telling them they were shortly to be removed and would no longer receive the Bulletin. There was a good response and roughly 30% of the people who had not previously replied did on this occasion. Prior to the Prague meeting there was an assumed membership of 328 people. Of these, 149 are now to be removed from the membership list either by their choice, or because they have failed to respond. The working membership list now has 185 active members from 40 countries. Although people are still writing in, I think the INAG membership is probably reasonably stable at this stage. The current official membership is attached to this Bulletin and if there are names missing from it, please let me know.

I have also commenced writing to all members requesting material for the Bulletin. Here, also, the response has been good. This Bulletin has been produced mainly from material I have received as a result of these letters. However, don't wait to be asked. If you think the INAG Bulletin is worth getting, and you are reading this now, you have something to contribute that will be of real interest to the readers. **Don't wait - write now!** I NEED MORE ARTICLES. Send me articles on your station, its history and what equipment you used then and now, what you do with ionosonde data, your views of the future of the field. All are valuable insights for others.

INAG will be sponsoring a symposium at the forthcoming URSI meeting in Kyoto, 1993, called "Ionosonde Networks and Stations" which will be concerned with the ionosonde technique, ionogram interpretation and the value of ionosonde data. A key aspect of this meeting will be to help people speak openly about the practical (usually financial) problems they are having operating their ionosonde stations. It is vital that we share our experiences in this area. There is little point advising a network that isn't there. If you have any thoughts about what you want to know, or say, let me know NOW.

In this regard - how many of you are aware of the moves to commercialise the International Geomagnetic Reference Field (IGRF)? Are you also aware of INTERMAGNET? Issues associated with these proposals were discussed at the recent IUGG meeting and will have highlighted problems encountered in running observatories that are common to both our communities. Are we close to constructing an international, global real-time satellite-based ionosonde network similar to INTERMAGNET? I don't think so; but we should be thinking about these issues. Closer to the present, we should also be seeking to effectively implement support between well-established organisations and those that are currently disadvantaged. Such activities may not be endorsed officially, but where ad hoc arrangements are achieved, there should be some level of reporting to entice others into the field of helping and being helped. I expect that these and many other topics will be presented at this symposium. To have a global picture of the ionosphere, we need global measurements and therefore we need a global ionosonde network. At the same time as we preserve our history of the ionosphere, we must also preserve as many of our station locations so we have a reliable future base to work from.

Several other issues were raised at the Prague meeting. In some cases there has been no progress to date. While I have followed up the general membership, I have not yet done anything about two other important groups - Honorary members and Network representatives. I hope to have more to report on these topics in the future. I have not yet considered ways in which INAG can be more closely associated with international programs, such as STEP. Nor have I had further thoughts on computer reduction of ionograms. However, Australia will move a step closer to distributing computer scaled data on January 1, 1992. On that date, all ionograms recorded by our 5A ionosonde will be validated and distributed in place of the current manually scaled 4B ionospheric data. At this stage, we will be using the computer scaling as a scaling aid; if it scales the ionogram correctly then the data is accepted, if not a person will correct it. In this respect, the new scaling letter, the slash, has yet to be described fully in the Bulletin. This will now appear in the next Bulletin.

Please send me your thoughts and comments and especially ARTICLES for future INAG Bulletins.

2. A NEW IONOSONDE: THE DIGITAL IONOSONDE - PARUS

contributed by Dr S. Feldstein, WDC B2, Moscow, USSR

TECHNICAL PARAMETERS

Sounding frequency range	0.5 - 20 MHz
Transmitter power	1 KW
Transmitter amplifier power	(15KW)*
Pulse width (optional)	20 - 400 microsec
Frequency increment (optional)	multiple of 5 KHz
Receiver sensitivity	2 microV
Receiver bandwidth	20 KHz
Sounded height resolution(optional)	multiple of 1.5 Km
Maximum sounded height programmed	
Microprocessor control unit RAM	up to 1 Mbyte
ROM-driven sounding signal modulator	
Dimensions	460x430x400 mm
Weight	30 Kg
Power consumption	150 W
Dimensions	(460x430x550 mm) *
Weight	(70 Kg) *
Power consumption	(600 W) *

* The asterisk applies to the ionosonde provided with a transmitter output vacuum-tube amplifier

It is planned to use a newly developed ionosonde to re-equip the ionospheric vertical sounding network of USSR. The ionosonde provides diagnostics of the ionosphere and is intended to operate as a part of a real-time HF-communication forecasting system that can also include onboard satellite sounding equipment.

The design of the ionosonde is entirely modular allowing versatility and easy reconfiguration.

The operational parameters of the ionosonde are software controlled, to meet the requirements of a specified sounding facility. According to the selected configuration, the ionosonde allows identification of ordinary and extraordinary polarization of the echoes, provides the signal amplitude, spectrum, waveform and phase processing with the output to serial interface.

The ionosonde can operate in a vertical or oblique incidence regimes, or as a backscatter sounder. Another capability is the transionospheric sounding by means of satellite-based sounder with appropriate synchronisation system.

In the accompanying figures there are two sample ionograms: a raw ionogram and a processed ionogram which shows a higher noise rejection threshold. The two ionograms are taken at, roughly, 16:53 and 16:56 LT. and can be used to compare small differences in the ionosphere, recorded by the ionosonde. The virtual height range runs from 0 Km to over 700 Km and the frequency range is form 1 Mhz through to 10 Mhz, the scale markers being placed every 1 Mhz.

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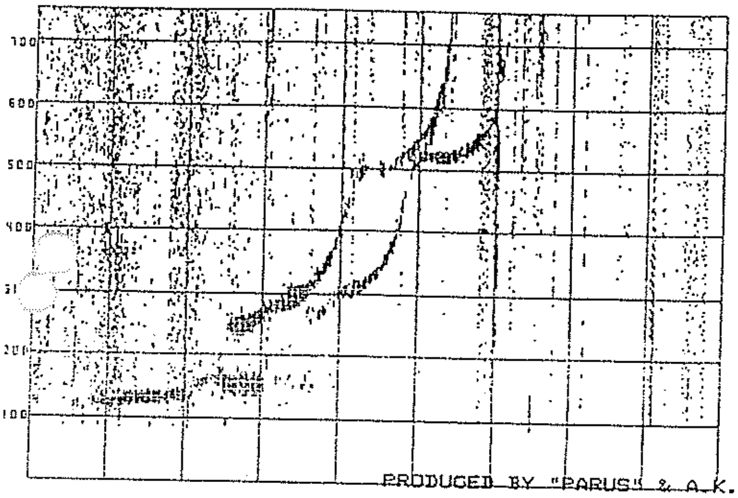
Moscow Region 142092
USSR

Telephone 334-09-08 Fax (095)930-55-09
Telex 412623 SCSTP SU

MOSCOW, IZMIRAN : 55.47 N, 37.32 E
DATA:08-JUL-91 16:53:30
FREQUENCY RANGE : 1000 <=> 10000 Kc.



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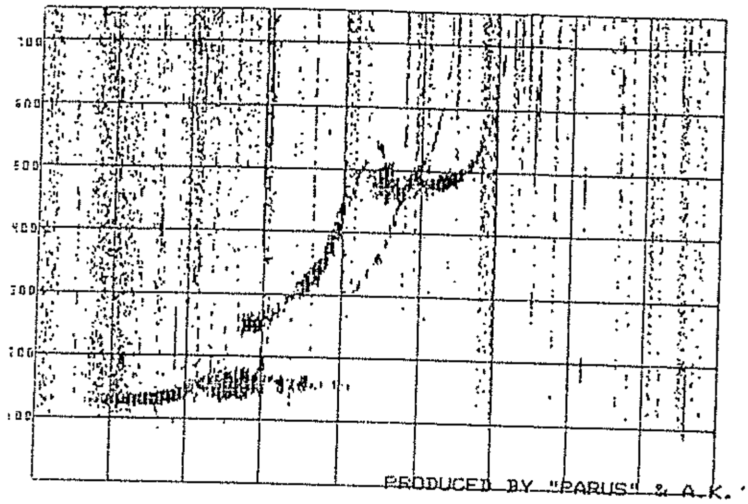

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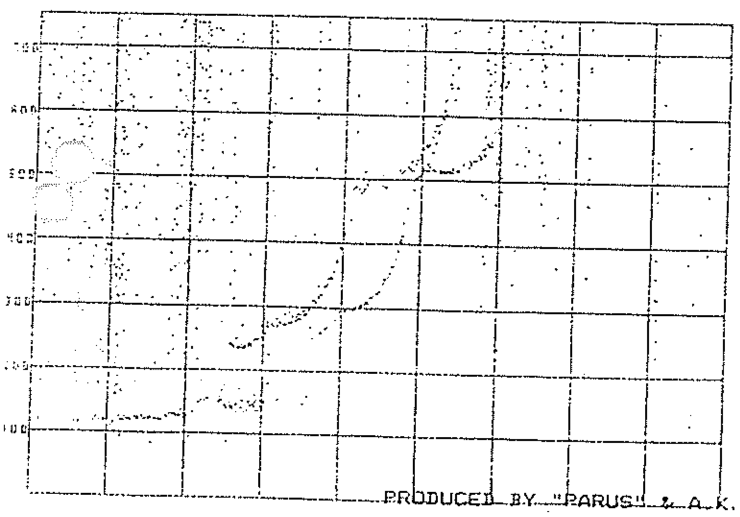

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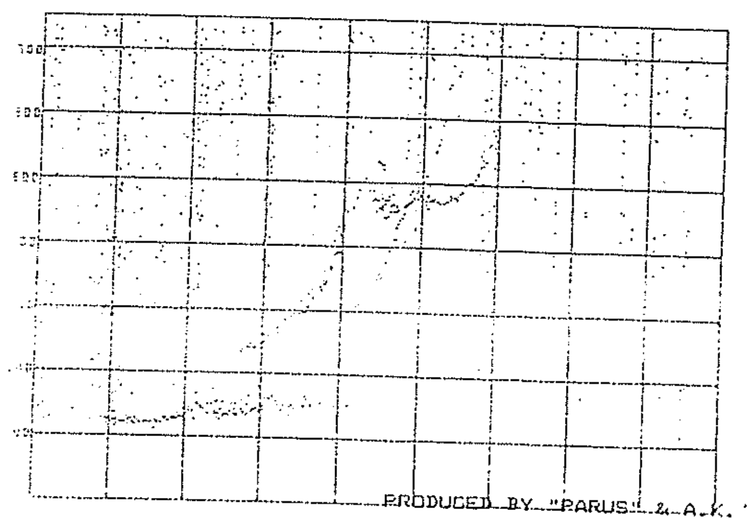

3. CHINESE IONOSPHERIC SOUNDING NETWORK - GLANCE OF AN OUTSIDER

by Dr A. Feldstein, WDC B2, Moscow, USSR

In the second half of July 1991 a WDC B (Moscow, USSR) delegation visited WDC D in China. In the course of the visit I obtained more or less exhaustive information about the Chinese ionospheric sounding network. I think it is expedient to share this information with INAG Bulletin readers.

The China Research Institute of Radiowave Propagation (CRIRP) is the only institute in China specially concentrating on propagation research of all radiowaves from EHF to VLF ranges. Its address is: P.O. Box 138 Xinxiang, Henan 453003, P.R.China. Unfortunately they have no contemporary communication links at present, but hope to install a facsimile soon. The town of Xinxiang is situated 600 km to the south of Beijing. Prof. Wu Mingyi is CRIRP director, Prof. Jiao Peinan is Deputy Director in charge of Observatory Administration Section, Dr. Tu Shicong is Deputy Director in charge of Scientific Planning Section. The Institute belongs to Ministry of Machinery and Electronics Industries.

CRIRP is responsible for collecting, processing and exchanging of ionospheric data, and provides ionospheric disturbances predictions. All CRIRP network VS sites are equipped by the Chinese made automatic ionosondes, mostly TD 4. The network consists of 8 stations in China:

1. Manzhouli (117° 27' E; 49° 35' N)
2. Changchun (125° 16' E; 43° 50' N)
3. Wulumuchi (87° 36' E; 43° 45' N)
4. Beijing (116° 18' E; 40° 00' N)
5. Lanzhou (103° 52' E; 36° 04' N)
6. Chongqing (106° 25' E; 29° 30' N)
7. Guangzhou (113° 21' E; 23° 09' N)
8. Haikou (110° 20' E; 20° 00' N)
9. Great Wall - Antarctica (58° 58' W; 62° 13' S)
10. Zhong Shan - Antarctica (76° 23' E; 69° 22' S)

Stations 1, 3 and 8 are also equipped with satellite Doppler facilities, and stations 6 and 7 with ionospheric polarization sounding. All stations probe ionosphere twice per hour and data from the first 8 stations are sent in real time to the Beijing Research Center Ionospheric Disturbance Warning section; (Address: Ionospheric Prediction Center of CRIRP, P.O. Box 134-70, 100039 Beijing, P.R.China where Prof. Xiong Hao is the Center Director). The Ionospheric Prediction Center supplies all Chinese users with ionospheric information and regularly exchanges ionospheric data with Australia, Japan and USSR. Antarctic stations data are sent to CRIRP twice per year. All the Chinese network ionosonde data are in analogue form (ionograms, standard monthly tabulations of hourly data) and are stored in special archives in CRIRP.

CRIRP has also one "Digisonde 256". It is used in scientific experiments and is installed in Xinxiang (113d 49' E; 35d 18' N) at present. They plan to transfer it to Beijing in order to replace an obsolete network ionosonde there.

Two other "Digisonde 256" ionosondes belong to the Wuchang Institute of Physics and Center for Space Science and Applied Research; both groups also belonging to The Chinese Academy of Sciences. One is working in Wuchang (114° 24' E; 30° 30' N), and the second is in Hainan (109° 06' E; 19 (de 30' N). Contact addresses are the following: Prof. Li Jun, Wuchang Institute of Physics, The Chinese Academy of Sciences, P.O.Box 72003, Wuchang, Hubei 430072 P.R.China; and Mr. Guo Jian-shan, Center for Space Science and Applied Research, The Chinese Academy of Sciences, P.O.Box 8701, Beijing 100080 P.R.China.

In China, they also have a few KEL ionosondes.

4. HISTORY OF THE YUGOSLAVIAN IONOSONDE NETWORK

by Dr Davorka Grubor,
Geomagnetic Institute,
Belgrade, Yugoslavia.

Ionospheric sounding actually started at the Geomagnetic Institute with a domestically produced ionosonde developed in the Institute for Electronics and Radio Techniques, "Mihajlo Pupin", in Belgrade. It began to work regularly in 1958, under the control of the ionospheric observatory situated at this institute and lead by Dr M Vukicevic-Karabin. In 1973 the ionosonde, with all documentation and data, was moved 36 km east from Belgrade, to the Geomagnetic Institute in Grocka where a new ionospheric group was founded. It could be said that this ionosonde was continuously in operation from 1958 until 1982, at practically the same location. It was switched off in December 1982. The characteristics of this ionosonde were:

frequency range	1.5 - 17 MHz
the time of taking the ionogram	45 s
approximate power in peak	10 kW
frequency of pulse repetition	80 - 120 Hz
pulse width	50 - 100 us
antenna type	vertical delta
height range	800 km
height step	50 km intervals
height scale	linear
frequency scale	logarithmic

The data scaled regularly were: fmin, foE, fbEs, foEs, foF1, foF2, fxF2, h'E, h,Es, h'F, h'F2 and Es type. The ionograms are only stored on micro- film.

This was the first ionosonde working in Yugoslavia

From 1982, a new ionosonde, the KEL AEROSPACE IPS-42, commenced operation. In the period 1983-1985, the geophysical terminal DBD-43, KEL-46 and KEL-47 were linked to the IPS-42. After ten years of gathering data from the IPS-42, we can say that this ionosonde gives us a comparable picture of local ionospheric conditions to the old one. That results from the fact that from 1973 until now, the same well trained people have scaled the ionograms, and the data are supervised and interpreted strictly according to the URSI rules. Besides this, the data from both ionosondes, for the whole 1958-1991 period, were used in a number of scientific works and satisfactory consistency between them was proved.

The additional parameters scaled since 1983 are M(3000)F1 and M(3000)F2. However, currently malfunctions in the IPS-42 and associated equipment are appearing more frequently. Also, the capacity for data storage on the KEL-47 hard disc is limited to 11 years of data, and we are approaching the end of that period. Last year, software for storage and processing the vertical sounding data, using a PC-computer, was developed in our observatory.

Vertical sounding is the only experimental technique for investigation of the lower and upper ionosphere that we have, so there is a need for some of the other data beside echo range; for instance, we could use amplitude, phase, angle of arrival, polarization, Doppler. We are now thinking about the possibilities of getting a new ionosonde. That was one of the reasons why we am interested in INAG bulletin, as it contains information about various ionosondes that can be found. The realisation of our plans depends a lot on the support coming from the users of our data, but mainly it depends on the federal government institutions.

5. HISTORICAL BACKGROUND OF THE SWEDISH IONOSONDE NETWORK

by Dr Harold Derblom,
Lycksele Ionospheric Observatory,
Sweden.

The following material was written by Dr Derblom as part of the manual for the new Swedish Ionosonde Network, or SIN. My thanks to Ove Klang for forwarding the material to me.

In 1901 Marconi succeeded sending radio signals from Cornwall in England to Newfoundland in America. This theoretically unpostulated but experimentally verified possibility for long distance communications gave rise to considerable discussion in the scientific community which tried to explain the propagation mode of the radio waves around the curved surface of the Atlantic Ocean. Since radio waves are nothing but electromagnetic waves similar to radiant heat and light, it was natural to suppose that the propagation was due to diffraction. Calculations showed, however, that the diffraction effect was inadequate to explain the bending of the waves so far beyond the horizon.

A year later, Kennely in America and Heaviside in England, postulated the existence of a conducting layer in the upper atmosphere having the ability to deflect the radio waves and force them to follow the curvature of the earth. Further, Heaviside suggested that the reflecting layer most probably consisted of positive and negative ions, produced by the action of solar radiation. The conducting and radio wave reflecting layer in the upper atmosphere lacked the support of direct evidence until 1925 when Appleton and Barnett, by comparing the radio signals received simultaneously on a loop and on a vertical whip antenna, proved the existence of sky waves coming down after reflection in the Kennely-Heaviside layer. Shortly afterwards Smith-Rose and Barfield confirmed the presence of reflected sky waves by means of direction-finding radio equipment.

However, the most striking experimental evidence for the existence of a reflecting layer was furnished by Breit and Tuve in 1926. These scientists showed that short-duration radio pulses sent out by a transmitter produced not only one impulse in the receiver but two or more impulses delayed in time. Obviously, the first impulse was caused by the direct wave travelling along the ground between the transmitter and receiver and those arriving later were due to reflections in the Kennely-Heaviside layer, later named the ionosphere by the Scottish physicist R A Watson-Watt. This so called echo or group-retardation method was subsequently developed and improved by various workers into the modern ionosonde. Experience of ionospheric sounding in England led Watson Watt, in 1935, to suggest that the same methods could be used to detect and follow aeroplanes. Radar was born and in 1939 the famous Chain Home network became operational using HF waves in the range 22 to 28 MHz. The Chain Home played an important role in the defence of England during World War II.

Ionosondes are still one of the most powerful methods for investigating the Earth's ionosphere and its variation. At present the network consists of about 140 ionospheric sounding stations spread around the world. Experimental data are collected in the form of so called ionograms and evaluated according to internationally adopted rules. All data are available on request for the scientific community. A direct, regular data exchange is going on between some of the stations but data is also stored, for interested users, at the World Data Centers (WDC).

5.1 Sounding activity in Sweden

To our knowledge the first more or less regular ionospheric sounding in Sweden began back in 1948 at Kiruna under the leadership of O Rydbeck from the Chalmers Technical University (CTH), Gothenberg. Prior to that, W Stoffregen, at the High Tension Research Institute of Uppsala University in 1942, developed an ionosonde and published critical frequency data of the ionosphere above Uppsala for the period July 1942 to June 1943. Later during this same decade sporadic work in the field was undertaken by this worker (Dr Derblom); for instance, a solar eclipse campaign, July 1945, in northern Sweden.

The Uppsala Ionospheric Observatory (UIO), was founded by W Stoffregen in 1952 and has been in regular service since then. The activity was financed by the National Defence Research Establishment (Swedish acronym FOA) until 1976 when the responsibility was taken over by the Kiruna Geophysical Institute, later named Swedish Institute of Space Physics (Swedish acronym IRF).

In 1956 the UIO located an additional ionospheric observatory to Lycksele, halfway between the existing stations at Kiruna and Uppsala. The aim was to complete a meridional chain of ionospheric stations in Sweden as part of the international effort planned for the International Geophysical Year, IGY, beginning at 1958. This station merged into IRF in 1970.

Also, at Kiruna, the organisational affiliation for the ionospheric sounding has been an object for changes. In 1957 the responsibility was taken over from CTH by FOA and from 1980 by IRF. Thus, IRF is running all three ionospheric stations in Sweden; Kiruna in the auroral zone, Lycksele in the subauroral area and Uppsala in the temperate latitude. Due to their location in a north-south chain and because of other major experimental research activities going on in the Kiruna area, for instance EISCAT and ESRANGE; both interested in support of ionogram data, the Swedish ionosonde chain is considered to be of significant importance for the scientific community now and in the future. There are also other users, such as for radio communication, navigation and geodetical workers, who are interested in having this chain kept operational and in preserving the ionospheric knowledge and experience which the staff involved in the ionospheric sounding activity represents.

5.2 Need of technical renewal

The three Swedish ionosondes were of different origin and, hence, showed up moderately diverging technical data. For different reasons they had also been developed independently from each other during the years passed.

The Kiruna ionosonde originates from the old CTH instrument, though much of the technique has been exchanged inside the casing. A major improvement was made in connection with the change of principal responsible agency from FOA to IRF. A modern frequency synthesizer was included for synchronous tuning of the transmitter and receiver and a new receiver was constructed according to a development by T Turenen in Finland.

The Lycksele equipment was originally constructed at UIO around 1956. No major changes or improvements had been made during the years, but a lot of effort had been spent on maintenance.

The Uppsala station is equipped with a commercial ionosonde. It is a co-operative Finnish-Swedish product delivered in 1976. It was only one of three based completely on solid-state components except for the power stages in the transmitter.

Due to the high cost of transmitter tubes and the long delivery times, the original transmitter was exchanged with a commercial solid state 1kW marine transmitter from Standard Radio (SRT) in Sweden a few years back. This transmitter has performed well in producing ionograms. These are recorded at Kiruna on 16 mm film, Lycksele on 60 mm wide photosensitive paper and Uppsala on 35 mm film. Uppsala differs in another way in that about 8 years back the digital storing and data handling of the ionograms was incorporated into the system (DAS). Data were presented on a remote, large colour screen and could be scaled semi-automatically. The final storage of the ionograms and the scaled data was made on standard magnetic tape via the Nord-100 minicomputer.

It may be obvious from the above brief description that the existing systems were old, worn, out of fashion and of messy configuration. The situation was discussed within IRF and it was decided to carry through a radical renewal and improvement of all three ionosondes based on micro-components. This renewal was possible mainly thanks to enthusiastic working with this special software and hardware at IRF-Kiruna. The goal was:

- similar equipment on all three stations
- make the ionosondes flexible for non routine experiments such as Doppler shift or angle of arrival measurements
- connect all stations by computer links to make the data and ionograms available for other users on telephone lines
- data scaling on a computer screen
- make use of the experience gained at Uppsala of the digital ionograms: their presentation, scaling and data checking procedures
- avoid photographic ionograms and store the ionograms and scaled data on optical disks
- make use of some parts in the old system such as transmitters, receivers, synthesizers etc.

The renewal, in spring 1991, is completed according to the lines above and the new system is ready for use.

Ove mentions briefly in his letter that the ionosondes are tied by computer links and that we can expect to hear more about the system later. I will be looking forward to receiving more details on how this system works.

6. THE HUNGARIAN IONOSPHERIC STATION AT BEKESCSABA

by Dr P Bencze,
Department of Aeronomy,
Geodetical and Geophysical Research Institute
of the Hungarian Academy of Sciences,
Sopron, Hungary.

The ionospheric station Bekescsaba, Hungary (43.3°N, 15°E) ceased to work in July 1990. The ionosonde was operated by the Meteorological Service at one of its meteorological stations. However, in the course of reorganising the Meteorological Service it was decided to close the station. The equipment was taken over by the Geodetic and Geophysical Institute of the Hungarian Academy of Sciences in Sopron, Hungary, where ionospheric research is carried out in the Department for Aeronomy. It is planned that the ionosonde will be operated at the Geophysical Observatory Nagycenk (47° 138'N, 16° 43'E) of the Institute.

The installation of the equipment is in progress. Though, the former place of the ionospheric station was more favourable from the point of view of the country, being nearer to its center, the new site is perhaps more advantageous considering the international network, since the new site is nearer to the ionospheric stations in Western Europe (France, Belgium). This is all the more important, since the closing of the ionospheric stations in Germany (Breisach, Lindau) has left a large area without ionosonde stations.

7. UNIVERSITY OF NAIROBI TROPICAL SCHOOL

by Prof. Robert Jallang'o Akello,
Department of Electrical Engineering,
University of Nairobi, Kenya.

There has been a wish here to start a Tropical School for Atmospheric and Space Sciences at the Equator. The activities of the school will include:

- Astronomy
- Telecommunications
    - Propagation of Radiowaves
    - Ionospheric Studies
- Lightning Studies
- Environmental Studies
- Advanced Meteorology
- Energy Studies

This should be an international research school set up by international organisations involved in the above studies elsewhere. It is thought that the advantage it would have would be that the studies would be made directly at the Equator.

A group of scholars are registering a National Committee for URSI under the Kenya National Academy and we are currently writing up the proposal for the project. This will also revive the early discussions and the proposal for a Great Equatorial Radio Telescope (GERT) for Astronomy.

8. COMMENTS FROM DR SHIROCHKOV, USSR

Dr Shirochkov is the Chief of the Ionospheric Research Laboratory in the Arctic and Antarctic Research institute at Leningrad, USSR.

For the time being, the situation with ionospheric research in my country is such that a vertical ionosonde will remain the principal ground-based tool for research for the near future. Another point is that we have a unique, extensive archive of vertical ionosonde data for both the Arctic and Antarctic regions accumulated over many years. Therefore, it is necessary to have some device for automatic scaling of these archives data.

We have managed to make such a device with our own efforts in both hardware and software. We are sure that such archives of data can help us clarify existing problems of the polar ionosphere physics such as the origin of the various forms of its fine structure, the nature of the Es-layers in the polar cap ionosphere etc.

Presumably, it would be useful to compare different technical methods for processing the vertical sounding data archives.

Generally speaking the polar cap ionosphere continues to be a kind of mystery for investigators. We try to make detailed classification of all the existing types of ionospheric reflections on polar cap ionograms, to connect them to different auroral forms in the polar caps and finally to develop an empirical model of the polar cap ionosphere for the different IMF orientations.

Another thing; we have used oblique sounding techniques for high latitude ionospheric research for approximately 20 years. This method has both advantages and disadvantages compared with the standard vertical sounding method. As far as we know, only a few other countries (for example, South Africa) use the same method for ionospheric research. Unfortunately, exchange of experiences in this ionospheric sounding technique is at zero level. Maybe INAG could initiate such an exchange of existing experience accumulated in different countries in this field. We are ready to make our own contribution in this direction. I even have a practical suggestion: organise a special symposium devoted to the explorations of ionosphere by means of the oblique sounding at the next URSI General

Assembly (Kyoto, Japan 1993). We are ready to contribute profoundly to such a symposium.

Dr. Shirochkov has raised some important issues here. How many groups have developed their own semi automatic scaling systems? How many other groups are using oblique sounding for ionospheric research? It will not be possible to organise a separate symposium for the Kyoto URSI meeting on this topic, but it is possible for it to be dealt with in one of the present symposia. For instance, the "High Latitude Ionosphere" has been proposed and there is also the "Ionospheric Prediction and Modelling" symposium that could include oblique incidence results.

9. THE IPS 5A IONOSONDE PROJECT

by Phil Wilkinson,
IPS Radio and Space Services, Sydney,
Australia.

9.1 Introduction

The following article is a summary of the new form the Australian ionosonde network will take in years to come. In many respects, we at IPS are still working hard to achieve all the goals outlined in this note. However, when fully functional, this is what IPS feels the Australian network will look like.

The overall plan for the 5A ionosonde project is to collect ionospheric data, process and archive it and maintain all hardware with a minimum of manual intervention. There are three major parts to the project and these are discussed starting first with the hardware, then the software which is treated in two sections, functions and automatic scaling, and finally there is the central office function for the complete system.

The hardware for the project involves a new ionosonde capable of being controlled remotely by computer interrogation. All normal functions of the ionosonde will be computer controlled - from the sounding frequencies used to the housekeeping data collected to ensure the ionosonde is functioning correctly. To achieve this IPS had to build a new ionosonde, but the design is not critical and although there are innovative aspects to the new ionosonde, any ionosonde capable of being connected to a computer would be satisfactory.

9.2 The Ionosonde

Some aspects of the ionosonde of interest here are that the synthesiser is more frequency-agile than the current 4B ionosonde, the transmitter pulse may be coded and shaped using software commands and the ionosonde sounding sequence will be fully computer controlled. Where possible, the design is modular, so that as new ideas or designs are adopted, conversion will be easy. For instance, we had intended using a solid state transmitter which IPS had produced but were advised that a valve transmitter would be more robust in thunderstorm areas like Darwin. A valve transmitter was designed and has been made part of any 5A ionosonde fielded in such places. However, the flexibility in the overall design has meant we can put a different transmitter in and still have a functioning ionosonde. We will record the ordinary and extraordinary ionograms separately and have developed a method of doing this. An early, and adequate, method was reported in INAG a few years ago. The new system we have developed is similar, but is considered more reliable.

9.3 The Ionosonde Computer Operating System

Moving on to the software aspect we come to the areas where the design is innovative. The software creates several files in association with the operation of the ionosonde. These include files of ionograms, scaled data, error messages on the data and housekeeping on the hardware. The software will manage all these files, compact them, and "send" them to a coordinating centre. For Australia, this will be in Sydney. The file transfers will take place over commercial telephone lines and provided the ionosonde can access a telephone, communications will be straight forward. In principle, it would be possible to handle ionosondes all over the world at one central location.

The sounding program would normally entail

- scanning all the predefined frequencies, excluding flagged frequencies,
- collecting the information into a file, called a raw ionogram, which would be cleaned and noise would be removed before storing
- start the automatic scaling of the ionogram and store the results in a file

and store any diagnostics from this step in a separate file

- do house keeping checks on the hardware - both ionosonde and computer - and store the results in a file
- store all files and check the time for sending results to the coordinating centre
- start the process again.

We expect the cycle to be quick enough for us to be able to record and scale ionograms every five minutes. At this stage, we have not made a final costing of the telecommunication costs, but we expect that it will be possible to save and transmit all cleaned ionograms recorded on the hour and all scaled data for the 5 minute ionograms. We expect that as we gain experience with the system we will learn how reliable the computer scaling is and this will tend to cause us to adjust the operational program.

At present, no 'raw' ionogram is written to a file if processing is to be done. The raw ionogram resides in memory and is processed in memory. A cleaned ionogram is all that is written to disk and it fills about 6kb. Compressed, these files are about 4kb in size and it takes about 9 minutes to transfer 24 ionograms to Sydney. A sound and clean takes less than 2 minutes.

The cleaned ionogram is similar to the ionograms from the present 4B ionosonde with the addition of echo amplitude. Ideally, the raw ionogram should be stored for later, more complex analysis. However, while an option, at present it would be too expensive to transmit raw ionograms on telephone lines for storage, so these are not kept.

9.4 Autoscaling Software

The computer scaling stage is an important part of this project and the automatic scaling software that has been written and enhanced here at IPS seems reliable. We are able to scale all the layers, including E2, F0.5 and F1.5. Sporadic E types have been added and the errors are tolerable. The problems associated with sporadic E multiples are not handled too badly, although this is the area where manual intervention is likely to be required most. A paper was in Radio Science and several IPS TR series have appeared discussing the method.

The software has been developed to work in a UNIX operating environment and is written in C. It has been run on a VAX 750, where it was initially developed; on a PC-AT which was the original target machine for running the ionosondes; a 386 computer, the current target machine, and a SUN workstation. All these machines used the UNIX operating system. We have handled ionograms from the prototype 5A, a digisonde and the BAS AIS ionosonde. The main change required in all these cases are minor adjustments to some variables that recognise the trace type from an ionosonde and location. Once done, the program operates well. This section of the process is called "training".

We expect to add scaling letter identification and have improved the trace recognition and trace following algorithms. I am convinced, having seen our own automatic scaling system working, that automatic scaling is improved to the point where manual intervention can be almost eliminated. I also expect that the programs can be trained to judge which ionograms are likely to be in error, further speeding the process of manual checking. A form of this approach has already been developed by the Lowell group who have a good data inspection program called ADEP.

9.5 Central Office System

At the coordinating centre, all files generated at all the ionosondes will be brought together into a master directory.

Scaling will be cross-checked and the hourly data will be archived, as will any other data recorded. However, only the hourly data can be validated. We expect to process all the data on a daily cycle so that, in principle, hourly data will be archived within a day of being recorded. Note that archived means it has been manually verified as correct and changes made if required. This is important for the long term integrity of the data series. We feel that without this step, the data is suspect.

We also plan to make statistical filters to flag data that are inconsistent with other data collected. We expect that the five minute data can be cleaned in this way and made more useful. This stage is experimental, but from scanning autoscaled outputs, it seems realistic. Even without these measures, the five minute computer scaled values from poor ionograms can give good estimates of hourly conditions. Little additional work should be needed to give reasonable confidence in the data. For instance, the 5 minute computer scaled data may be cleaned up by using a 30 minute trimmed mean of the data, or if this isn't severe enough, a median could be used.

If the hardware checks show possible problems, we will begin repairs from the central location. We have yet to finalise this aspect of the operation. At present, we operate some of our stations on a contract basis and we expect we will continue to do this. However, if the equipment is robust enough, it may prove more economic to fly people out from the head office to repair the equipment when problems arise.

9.6 The Present Status

At present, four 5A ionosondes have been installed at Hobart, Canberra, Townsville and Vanimo. Of these, Townsville was the first installed (September 1990) and to date it has been the most reliable. We have experienced unexpected problems at our older ionosonde stations (Canberra and Hobart) and these are not yet resolved. The problems seem unrelated to the 5A, but affect its operation at the sites.

At all stations the 4B ionosondes are running and we intend keeping them operating until we are completely satisfied with the 5A performance. However, from January 1, 1992, we will use the 5A ionosondes as the primary data source at those stations where it is operating. The 4B will then become a backup and while the ionograms on film will be kept, they will only be scaled if there is a 5A failure.

Data from all the sites are recalled to Sydney each night, confirming the data transfer system works as designed. At this stage, the full operational program has not been implemented, but we are confident it will be functional shortly. During one month, ionograms were recorded and scaled every five minutes and both the cleaned ionograms and scaled data were successfully returned to Sydney.

Further work is required so both ordinary and extra-ordinary ionograms can be recorded separately. At present only the ordinary wave ionogram is recorded. Some further hardware development will be needed to clean up parts of the receiver and computer interface and the computer scaling software requires further development to make it more robust in the presence of strong interfering sources that cause substantial breaks in the ionogram trace. While this all implies a reasonable effort, we are now confident the 5A will realise all the goals set for it.

9.7 Summary

There are two principal reasons for moving towards this type of ionospheric sounding program.

Most important, we cannot continue to operate ionosondes as we have done over the last 30 years. It just isn't possible to recruit people and train them to handle the tedium of the work involved. The costs rapidly become prohibitive. The move to contract-run stations was an experiment to establish the potential for this approach and it has proven most satisfactory. Manual scaling, also, is expensive, requiring greater skills than we can afford. It is unreasonable to operate a network on goodwill. Our present hardware is becoming progressively harder to maintain. This is the final cost problem the new network instrument must solve. The modular design and reliance on software control is primarily a maintenance feature that also has major spinoff potential.

A closely related aspect of this development is the greater use that can then be made of both the data and the skills currently involved in scaling. If the data can be ready for use in close to real time, and we expect that a scaled ionogram can be delivered within five minutes of being recorded, then it is possible to use that data in ways that we have not seriously exploited previously. That is the reason for integrating the ionosonde system into a data transfer system, currently based on the local telephone system, but extendible to any communication system. This is a feature of the UNIX networking software and was part of our early design requirement for the ionosonde network. We were also keen to free skilled staff from the present repetitive tasks to handle more challenging work. These skills, developed, will be of much greater benefit to Australia.

We feel the 5A ionosonde project will allow ionospheric monitoring to continue in Australia into the 21st century when the data series could well have much greater significance than now.

10. EVALUATING IONOSPHERIC MODELS AS PREDICTORS OF TOTAL CONTENT

by Dr M . Fox, Boston University
Department of Astronomy
Boston, USA.

There are a variety of electron density profile models currently in use, each providing a useful numerical summary of data from different sources. One possible method of evaluating the predictive capabilities of these models is to compare the predictions provided by such models against data sets not used in the development of any of the models.

For this study, Total Electron Content (or TEC) data has been derived from polarimeter measurements made at eight mid and low latitude locations, have been compared to the predictions from the following models: Bent, FAIM, ICED, IRI, Penn. State and Damon-Hartranft/URSI.

Overall, none of the models provided a very good description of even the monthly mean observed TEC data, using the natural variability of the data as a standard. At least part of the inaccuracy in TEC estimates stems from the predictions of foF2 being inaccurate, so that the appropriateness of a particular model can depend on how well the local mean ionosphere (foF2) is described by the relevant coefficient set. The other source of difference is in the actual profile shapes, and this was where the IRI and FAIM models largely failed. The Bent model yielded marginally the best results on average, and ICED and Damon-Hartranft models were also generally reliable. If a global model of ionospheric slab thickness (TEC/Nmax) were availiable, this would be an additional tool in evaluating profile shapes; however slab thickness data is sparse.

11. BRIEF COMMENTS FROM LETTERS

From Dr. V. M. Somsikov, USSR :

Dr. Somsikov is coordinating a program to investigate the solar terminator. The major part of the project is concerned with creating an ionospheric model for the sunrise and sunset hours, a transition period in the ionosphere. The simulation relies on teamwork and ionospheric data from the ionospheric stations. If readers are interested in learning more of this interesting problem, please write to:

Dr. V M Somsikov
Institute of the Ionosphere
The Academy of Sciences
Alma-Ata 480068
USSR

From Lic. Pablo O. Canziani, Argentina :

Lic. Pablo O. Canziani is the Executive Secretary for the Local organising Committee for the 7th IAGA Scientific Assembly to be held in the city of Cordoba, Argentina. If you have enquiries, requests and suggestions please contact him at:

Lic P O Canziani
LIARA
Av del Liberador 327
163B Vte Lopez
Buenos Aires, 1638
Argentina

From Professor K C Yeh, USA :

Professor Yeh has been collecting data together from the March 1989 storm. He is most pleased with the number of groups who have forwarded their data to the World Data Centers and writes;
"The several world data centers have been extremely cooperative with my requests. I have nothing but praises for their cooperative attitude."

It is excellent to hear that so many in the network have forwarded their data to world data centers, because a key element in maintaining our global network is the free and prompt distribution of the data we collect. To also know that our efforts are easily appreciated, because of the excellent service of the World Data Centers, is a great affirmation of the system to which we belong. It is good to know we are all working together so well.

12. THE INAG MEMBERSHIP LIST - August 1991

Below is the current INAG membership list. These people can expect to receive a copy of the INAG Bulletin. Additional copies are not sent to individuals, or organisations. I assume that copying facilities are now widely available. Please contact me if you have problems in this respect.

Please read through this list. These are all people with whom you share a common interest. All of them want to receive INAG Bulletins and many of them will have contributions for the Bulletin in the years ahead.

When you find that names you expect to be see are missing, please notify me of the person and their address. I will contact them and ask them if they wish to become members of INAG. You don't need to know the person, just know of them. I have had these approaches in the past and am happy to handle them. In some cases people, or groups, are not interested - but in most cases they are.

My address:

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

Below is the present INAG membership list.

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