PJW

IONOSONDE NETWORK ADVISORY GROUP (INAG)*

IONOSPHERIC STATION INFORMATION BULLETIN NO. 49**

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

** Prepared by R Haggard, Hermann Ohlthaver Institute for Aeronomy, Department of Physics and Electronics, Rhodes University, Grahamstown, 6140, South Africa.
Issued on behalf of INAG by World Data Center A for Solar Terrestrial Physics, National Oceanic and Atmospheric Administration, Boulder, Colorado 80303, USA. This Bulletin is distributed to stations by the same channels (but in the reverse direction) as their data ultimately flow to WDC-A. Others wishing to be on the distribuion list should notify WDC-A.

INAG 49 December 1986

1. From the Chairman

by J A Gledhill

The main topic of this note is to point out the importance of the world ionosonde network for the WITS (World Ionosphere/Thermosphere Study) programme, which was accepted by SCOSTEP at its recent meeting in Toulouse. The Co-chairmen are:

Prof K D Cole
Div. Theoretical and Space Physics
La Trobe University
Bundoora, Victoria
Australia 3083

and

Prof C H Liu
Dept. Electrical and Computer Engineering
University of Illinois
1406 W. Green St
Urbana, IL 61801
U S A

Details of the programme can be obtained from them. They have asked me, together with Prof S M Radicella, to investigate the question of the possible location in developing countries of a few ionosondes at key positions. The map shows the locations of stations that sent data during 1980-1984 to a WDC, and a few others known to be active at present. (Map modified from one provided by Dr H Rishbeth).

Clearly the greatest gaps are in the Atlantic, Pacific and Indian Oceans, in Africa, the interior of South America, North West America and China. It is also clear that the density of stations is much greater in the northern hemisphere than in the southern one.

Desirable locations for additional stations are:

Atlantic Ocean

Reykyavik
Azores Is.
Ascension I.
Tristan da Cunha or Gough I.*
Bouvet I.

Pacific Ocean

Easter I.
Pitcairn I.
Kermadec. I.
Kwajalein I.
Guam I.

Indian Ocean

Cocos Is.
Marion I.

Africa

Nairobi
Brazzaville or Libreville or Bangui
Kinshasa Binza
Lubumbashi
Tamanrasset
Khufra

South America

Brasilia
Manaos

North America

Meanook
Sachs Harbor

China

Somewhere in the interior, eg Ichang or Chungking.

* A proposal by the Hermann Ohlthaver Institute for Aeronomy, Rhodes University, Grahamstown, South Africa, to run an ionosonde and airglow photometers at Gough Island during 1988 and 1989 is at present under consideration.

Of course, the places mentioned above merely draw attention to the desirable locations of ionosondes and in many cases are places where ionsondes have been operated in the past. Other locations in neighbouring countries would be very acceptable. WITS starts officially on 1 July 1987, so there is not much time to plan. Prof Radicella or I would be very glad to hear of any plans to fill the gaps. His address is:

Prof S M Radicella
Secretario Ejecutivo
PRONARP
Arenales 1446-6 "C"
1061 Buenos Aires
Argentina.

The main problems are finding the funds to acquire the ionosondes and install them, and, equally importantly, the funds to pay the operators and train them adequately and to buy film and chemicals. Considering the financial difficulties in which developing countries find themselves at present, it would seem that the finance must come mainly from the developed countries, though a stake in it would be a very good way of maintaining local enthusiasm.

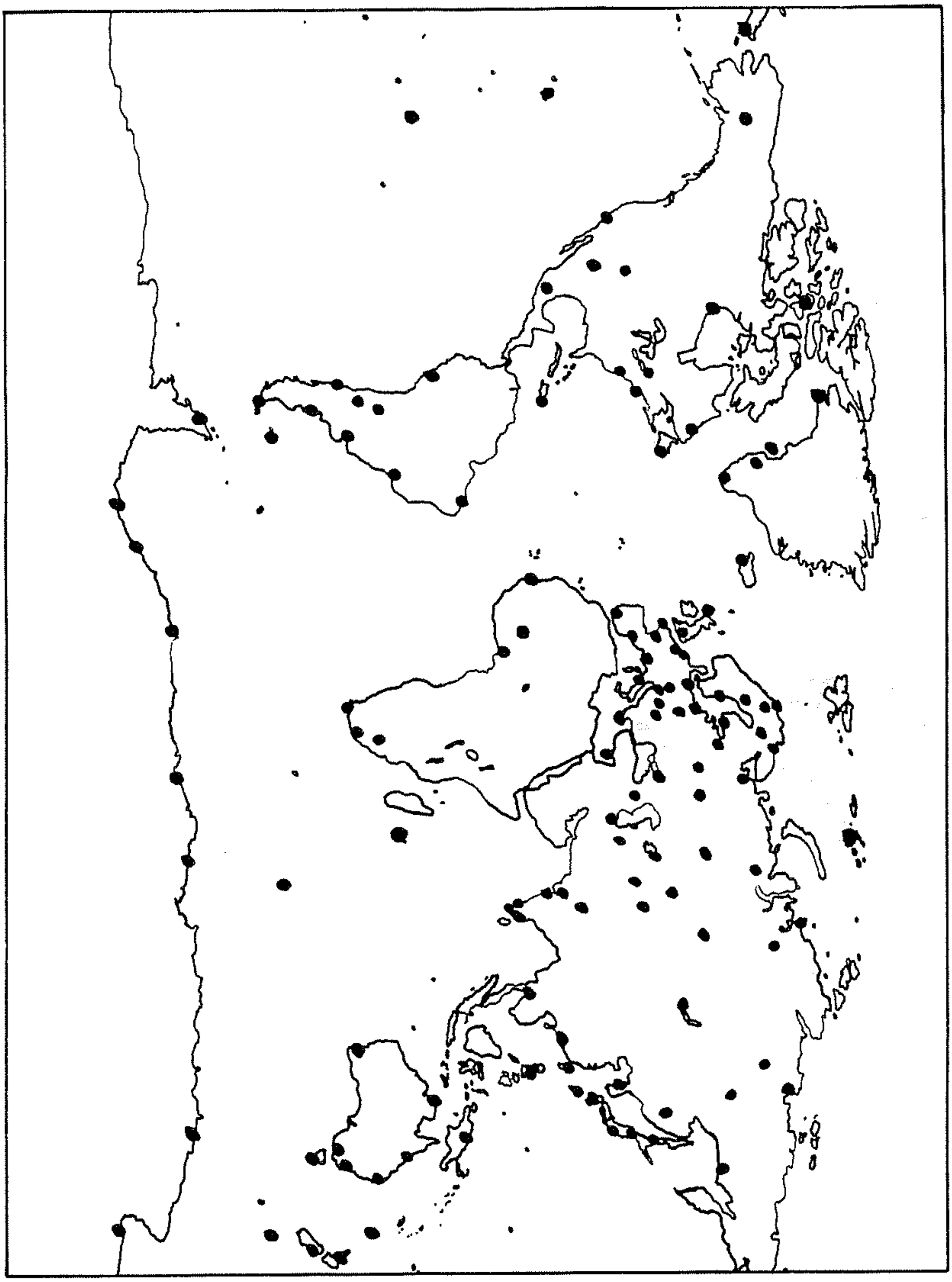
All members of INAG and recipients of the Bulletin are asked to give thought to this question and to discuss possibilities with their local Government Authorities, Universities and other organisations that may, even remotely, be able to help. The official adoption of the WITS programme by SCOSTEP shows conclusively how great is the interest in a world-wide study of the ionosphere.

2. Ionospheric Sounding: The Need For Real-time Remote Control

by T D Kelly and C G McCue
Kel Aerospace, Australia

Abstract

It is suggested that studies should be conducted to test the two proposals that H F communications technology has developed to a stage where it would be served better by real-time ionospheric forecasting than by traditional forecasting methods and that H F frequency allocations should be revised to allow the improved communications performance resulting from



Map of all ionosphere vertical sounding stations known to be active at present.

real-time forecasting. To accommodate such changes the vertical incidence ionospheric monitoring network must provide real-time data under remote control.

1. Introduction

Real-time ionospheric monitoring using remotely-controlled digital ionosonde systems is now possible, eg using the IPS-42/DBD-43 system. However, HF communications have not yet made proper use of this. This paper suggests that it is time for the appropriate studies to be made that could lead to improved HF communications performance through revised frequency allocations and the use of real-time ionospheric monitoring.

If such is possible

2. The New Technology of HF Frequency Management

2.1 The New Generation of HF Radio Systems

Real-time frequency management capability is now being built into HF communications systems. These automatic systems normally operate without requiring any information from external sources. They maintain synchronization between transmitter and receiver and simply 'seek-and-find' the best possible HF channel of the five or six allocated to the service. They stay on that channel until required to change by an unacceptable bit error rate. They are currently low speed, low priority systems which carry private and commercial data at 75 or 150 bits/second.

There is already a need, which will increase, for high speed, high priority systems to transmit large volumes of data. With high-speed digitally-controlled channel selection it might be possible to use the HF spectrum more efficiently. The system would select one channel automatically from an allocated range of tens or hundreds. For example, propagation possibilities controlled by solar activity cycle/season/hour of the day might reduce the likely channels to ten or so and then noise/interface/bit error rate would determine the best channel. Regular monitoring of conditions would maintain an order of merit on all likely channels.

2.2 The Need for Real-time Vertical Incidence Data

Whilst low speed, low priority systems do not require external real-time assistance, this will not be so for the high speed systems where real-time VI data will be necessary at times when problems arise on these HF circuits. Then, real-time VI data will be needed to identify the type and degree of disturbance, to forecast its duration and likely recurrence, and to plan immediate alternative communications action.

Forecasters and communicators will need to work closely together to establish new practices to help communicators make real-time decisions based on short-term forecasts and real-time VI ionograms which can be very complex during disturbed conditions.

2.3 The Need for Traditional VI Data

Traditional VI ionospheric data will still be required for many research purposes. These data will be needed also to discover the strategies and practices to be employed using real-time data during periods of communications difficulties.

3. The future of HF Radio

3.1 A More Important Role for HF

Modern HF communication systems will have an important role within integrated communications networks in the near future. The enhanced performance of adaptive digital HF systems will induce communicators to utilise the economy and mobility of HF systems in more circumstances than at present.

3.2 Data Transmission and Frequency Agility

The new digital HF systems will transmit voice or data. Data with error correction for noise and fading will be the more popular, with expected data rates up to 2400 bits/second. Channel frequency may be changed in milliseconds if noise, signal level or bit error rate becomes intolerable. These adaptive systems will re-synchronise automatically in a second or less, enormously faster than manual methods.

For proper efficiency adaptive systems must have tens or hundreds of available channels and this will require new international policies on frequency allocation. The feasibility of this change must be examined since frequency mobility would seem a better way to overcome poor signal/noise conditions than the use of increased power. This proposal may well lead to a quieter, more efficient use of the HF spectrum, enabling it to carry vastly increased quantities of data.

3.3 Solar Minimum

Unfortunately these studies must take place as sunspot activity is close to a minimum and the HF spectrum becomes more crowded due to lower MUF's.

4. Problems of Organisation, Co-operation and Engineering

4.1 International Co-ordination

The international ionospheric monitoring community involves many individual countries and organisations, each with its own priorities. Through URSI and CCIR it could be possible to co-ordinate all ionospheric monitoring stations into an international real-time network. Maybe INAG could take up this challenge? Would URSI and CCIR support this initiative?

Many difficulties confront this establishment of an internationally accessible real-time monitoring network, eg there must be special communications links and uniform digital communications protocols. Such co-ordination also needs funding.

4.2 Communicators Control Funding

Government organisations throughout the world are spending huge amounts on new communication systems. Such expenditure programmes, if properly approached could provide the necessary funds for the proposed monitoring network. The ionospheric monitoring community must recognise this and develop their services to better support the communicators, both civil and military. This applies in all countries, even in those which previously have not provided ionospheric monitoring services but depended on organisations in other countries doing so. Monitoring organisations must canvass the new needs of communicators and attempt to fulfill them in order to attract funding.

4.3 Real-Time Channel Evaluation (RTCE)

An RTCE algorithm for selecting an optimum HF communications channel must consider the following factors for each available channel:

- Noise and interference density;
- Signal strength; and
- Specific ionospheric propagation parameters, eg multipath and Doppler spread.

The new generation of digital HF systems can be expected to monitor the above factors and to select the optimum channel by resolving the RTCE algorithm. These systems will actually be 'sounding' the ionosphere along their oblique paths, evaluating propagation conditions for all available channels from those allocated and ranking them in order of merit.

If such systems were able to function in all situations, HF communicators would not need the existing ionospheric monitoring networks.

Nobody expects 100% performance from HF circuits, but communicators do strive for maximum realisation of potential HF communications capabilities, including maximum data transmission speeds and minimum disruption, even within integrated systems. Real-time VI ionospheric monitoring can contribute significantly towards achieving this.

4.4 Real-Time Ionospheric Modelling Using VI Data

Past VI data will enable a model to be made of the ionosphere and a small network of ionosondes could be used to update the model in real-time. The establishment of the model and the method of updating it, present an exciting challenge. The final technique should be incorporated into an automatic real-time HF management system, allowing the aims in 4.3 to be realised. This will be most important in suggesting alternative action during periods of ionospheric disturbance.

Implementation of this proposal will undoubtedly proceed in stages from initial modelling, selecting an adequate real-time network of ionosondes, to semi-automatic testing and to final full implementation.

It is the authors' opinion that oblique incidence ionospheric sounding will not be able to provide as valuable data for decision making as the VI sounders.

Oblique sounding applies only to fixed circuits whereas VI sounding applies directly to all oblique circuits. Secondly, pulsed sounding seems preferable to 'chirp' which would probably create undue radio interference.

Finally, the authors suggest that the data from satellite (top-side beacon) sounding will also be inadequate due to the different and transitory nature of topside sounding from orbiting satellites and the lack of ionospheric definition which is obtained by TEC monitoring of geostationary beacon satellites.

5. Where to from here?

5.1 The Need

The new generation of HF communications systems will require real-time VI data from a world-wide, co-ordinated network on a 24 hours/day basis. HF broadcasters are an exception for obvious reasons.

5.2 New HF Channel Allocations

Digital data communication with automatic channel selection will give greater opportunity to most communicators to use efficiently a large number of channels. Spectrum utilization will increase and channel selection will be used to overcome signal-to-noise problems rather than increased power. This approval of allocating tens or hundreds of channels to a service using this technology must be studied and debated urgently within CCIR.

5.3 Real-Time Ionospheric Modelling

Whilst the objective is the automatic translation of ionospheric parameters into communications management control factors, as a first step physicists should develop ionosphere models with real-time updating techniques, interpreting these in terms of communications decisions, eg frequencies and circuits to use. This should result in a semi-automatic system for selecting frequencies and circuits. This should be tested and, if possible, fully automated. It will also be necessary to establish a suitable digital communications network to service the real-time remotely-controlled ionospheric sounding network.

3. Universal Time - Local Time Considerations

INAG 47 included a proposal by R O Conkright, endorsed by our Chairman, that all ionosonde observatories should provide their published data and ionograms in Universal Time (UT) rather than Local Meridian Time (LMT) which has been used extensively in routine ionosonde work for over 50 years. In this note, we would like to present some of the advantages and disadvantages of such a change.

In general, the regular variations of the ionosphere are best described in LMT. For example, the diurnal variation of foE, foF1 and to a lesser extent foF2 are controlled by the solar zenith angle. Indeed historically, this was the principal reason for using LMT with ionosonde data. In contrast, the irregular behaviour and events are often better ordered in UT or sometimes Magnetic Local Time (MLT). An example of this type of ordering would be the effects of a Sudden Ionospheric Disturbance (SID). Therefore the choice of time depends greatly upon what is the primary interest of the individual; namely whether it is the regular or irregular behaviour of the ionosphere. The main problem with LMT occurs when events are being studied, and as geophysicists are normally more concerned with these than the regular variations of the ionosphere they prefer UT. Those interested in optimising frequency allocations are more concerned with the regular variations and hence usually choose LMT. There are data sets extending over 50 years from some stations and over 25 years from many more. These data series are now sufficiently long and coherent to be used to study long term effects such as those

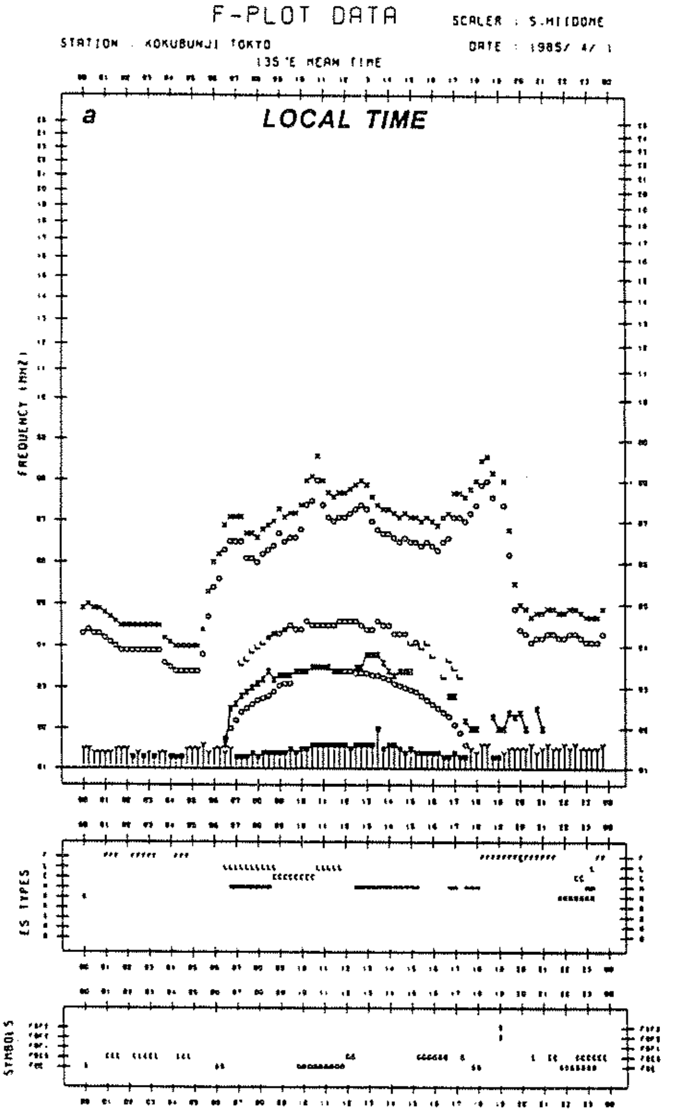


Fig. 1 a f-plot data from Kokubunji, Tokyo for 1 April 1985 in local meridian time (UT + 9h).

resulting from the gradual migration of the magnetic poles. These studies are only just beginning to become important. A change in definition of a month from a 'LMT month' to a 'UT month' will increase the difficulties for this work and may introduce a detectable discontinuity when an individual station changes from LMT to UT.

Any change instigated by INAG will lead to a period of confusion. As previous experience has shown, this could last upwards of five years. Also a special difficulty arises in the interchange of ionogram data which do not normally show the time zone used. Very careful documentation will be needed when changing the time used with the data. Most stations currently obey the rule calling for all published data to show the LMT in use but this is not universally adopted even after 30 years.

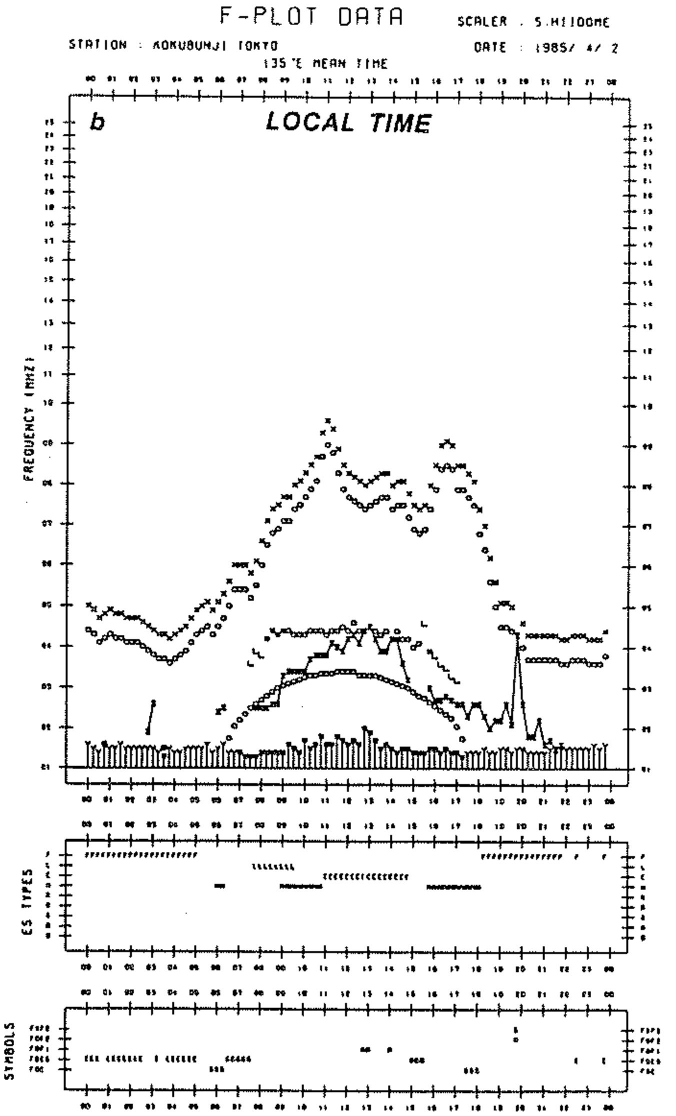


Fig. 1 b f-plot data from Kokubunji, Tokyo for 2 April 1985 in local meridian time (UT + 9h).

Frequency plots from stations which are well displaced from the Greenwich meridian will look peculiar with the solar controlled parameters spread over two days as in Fig. 1. Figs. 1a and b show f-plots for 1 and 2 April 1985 in LMT whilst Fig. 1c is the f-plot for the 1 April in UT. It is most unusual to see a significant minimum in foF2 and no foE values in the centre of the plot. Suggestions have been made that f-plots should still be in LT. Surely we would not ask a station to adopt two separate time standards which is likely to result in further confusion.

What will be gained by a change to UT? The rest of the geophysics community normally use UT but we should remember that the majority of the people funding ionosondes are more interested in radio communications and normally prefer their data in LMT. We should be aware that most people actively involved with INAG are

radio communicators using LMT?

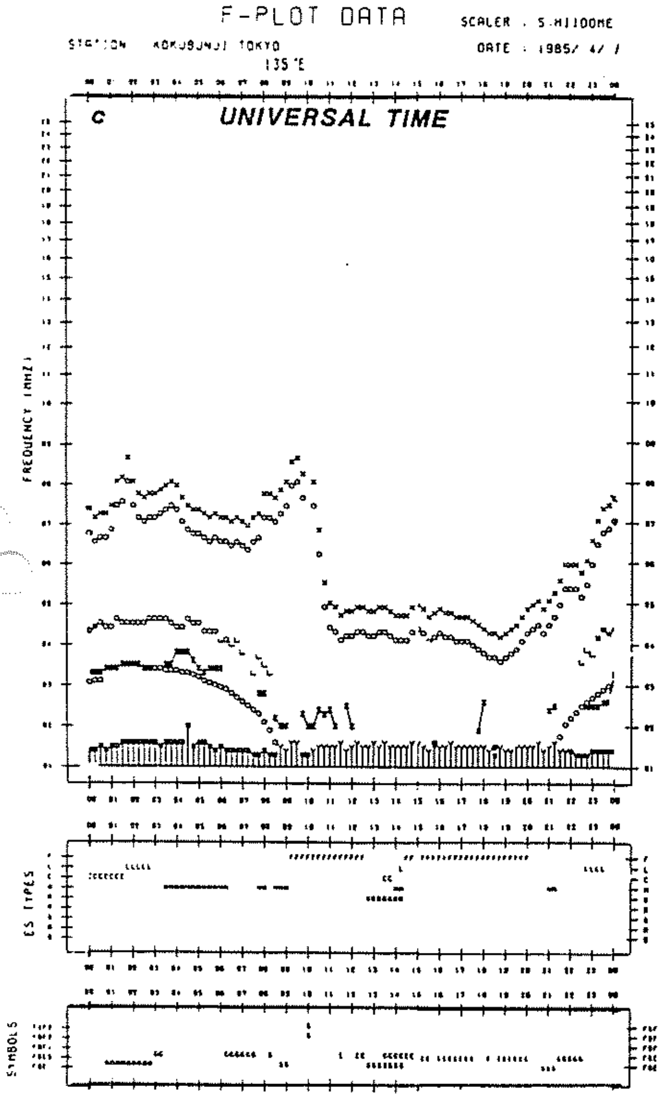


Fig. 1 c f-plot data from Kokubunji, Tokyo for "Universal Time" day of 1 April 1985.

heavily biassed towards geophysics. Thus radio communicators are not fairly represented here but we need to bear in mind their requirements when discussing this problem.

Problems concerning data requests not being fulfilled accurately will remain, whether or not INAG adopts a recommendation to use UT. INAG is a free association of individuals and groups who will do what they consider is most convenient. With today's computer technology it should be relatively easy to change from UT to LT and vice versa, but it remains the responsibility of the data user, and not the data provider, to put the data into whatever time-scale that the user prefers.

We do not feel that the case for a change from LMT to UT is sufficiently strong to justify the many disadvantages involved. We appreciate the need to have a very clear statement with each data set of what time is used and what is the relationship between UT and LMT. Therefore we would suggest that the proposal in INAG 47 should read: - "Ionospheric data sent to the World Data Centres and other requesting institutions should be reported in whatever time is most convenient for the station providing the data.

However it is essential that the data should be accompanied by a very clear statement of the time used on the data and of the relationship between the Local Meridian Time and Universal Time".

A S Rodger (former Secretary of INAG)

W R Piggott (former Chairman of INAG)

R W Smith (ionogram consultant to Rutherford Appleton Laboratory and British Antarctic Survey)

H Rishbeth (Member of ICSU panel for World Data Centres)

M A Hapgood (World Data Centre-C1 for Solar Terrestrial Physics)

4. Disclaimer: Chirp vs Pulse

by A W V Poole, Rhodes University, South Africa

From time to time one encounters claims as to the superiority of pulse over chirp radar. These claims appear to be founded on commonly held misconceptions about the chirp technique, probably originating from the performance and specifications of a vertical/oblique incidence ionosonde that was commercially available in the early 1970's. However, chirp radar, for the purpose of scientific applications in the ionosphere, has advanced since these early days and many of these claims are no longer true. It is now possible to measure group range, Doppler velocity, angle of arrival, O/X mode and amplitude by means of the chirp technique. Furthermore, because of microprocessor control, the latest chirp ionosonde is just as agile in terms of frequency hopping as any other device. In fact, there are some areas in which the chirp technique can claim superiority. These are firstly, the use of low peak powers, which means no dangerous voltages in the transmitter section (which is good news for the maintenance personnel). The second advantage concerns noise discrimination. Much noise that is troublesome to ionosondes is spiky in the time domain and thus difficult to distinguish from pulsed echoes. Such noise has a flat spectrum in the frequency domain. A chirp "echo" appears as a spike in the frequency domain and is thus there readily distinguishable from noise, of any sort, by means of a simple amplitude criterion.

This article does not set out to establish the superiority of chirp over pulse sounding, and least of all is it directed against the equipment described in INAG 48. There are advantages and disadvantages to both techniques. This article has rather set out to redress some measure of balance, that is perhaps long overdue.

5. Guide to International Data Exchange through World Data Centres

Ionospheric Phenomena

edited by M A Hapgood and H Rishbeth

The following text replaces Section B on pages 23 - 28 of the 1979 Edition of the Guide.

1. World Data Centres

A World Data Center A for STP
NOAA, E/GC3
325 Broadway
BOULDER
Colorado 80303
USA
Telex: 592811 NOAA MASC BDR

B World Data Center B2
Molodezhnaya 3
MOSCOW 117296
USSR
Telex: 411478 SGC SU

C1 World Data Centre C1 for STP
Rutherford Appleton Laboratory
Chilton
DIDCOT
Oxfordshire OX11 0QX
United Kingdom
Telex: 83159 RUTHLAB G

C2 World Data Center C2 for Ionosphere
Radio Research Laboratories
2-1, Nukui-Kitamachi 4-chome
Koganei-shi
184 TOKYO
Japan
Telex: 2832611 DEMPA J

2. Ionosphere Vertical Soundings

2.1 Programme of Observations

The normal programme for vertical incidence sounding is to record an ionogram every 15 minutes, with more frequent soundings during periods of special interest. These are listed in the International Geophysical Calendar, copies of which can be obtained from WDCs in the September of the preceding year. See also section 9 of the URSI Handbook of Ionogram Interpretation and Reduction (UAG-23).

2.2 Data Analysis

Data analysis should be carried out in accordance with UAG-23, as revised by UAG-23A. Additional notes on the interpretation of high-latitude ionograms are provided in UAG-50. Further guidelines are published in the Ionosonde Network Advisory Group (INAG) Bulletins, which can be obtained through World Data Center A for STP.

Monthly tables of hourly values of the following parameters:

foF2, M(3000)F2 (or MUF(3000)F2), foEs, foE, fbEs, foF1, fxI, fmin, h'F, h'E, h'Es, h'F2, M(3000)F1 (or MUF(3000)F1), types of Es

should be sent to the World Data Centres. A subset of these parameters is acceptable. Monthly summaries (medians, quartiles, etc.) should be supplied with the monthly table for each parameter (Except types of Es).

Frequency plots (f-plots) should be made for Regular World Days and nominated special periods in the International Geophysical Calendar.

2.3 Information To Accompany The Data

The following information is required with all data submitted to the data centres:

* Station name

* Geographic co-ordinates

* Time zone applicable to the data

* Type of ionosonde used

* Normal sounding schedule

* Any deviations from URSI scaling conventions (see UAG-23 and UAG-23A)

* Media on which the ionograms are available

* Media on which scaled data are available

* Contact name and address, telephone and telex numbers

2.4 Stations Which Do Not Record Data On A Regular Basis

Stations which do not have a regular schedule should notify the WDCs of the nature of the programme and the availability of the ionograms and scaled data, giving a contact name and address, telephone and telex number.

2.5 Methods For Data Exchange

(a) The recommended method for exchanging hourly values and monthly summaries of scaled parameters is on 9 track, 0.5 inch magnetic tape. A recording density of 1600 bpi is preferred. The data should be written in EBCDIC characters (ASCII characters are also acceptable) and the format given in appendix A should be adopted.

General guidelines for the exchange of data in digital form, eg the documentation required to be sent with the magnetic tape, are available on request from WDCs.

In the past, scaled parameters have been written on magnetic tape in the form of card images. Although this method is not the preferred mode of data exchange, it is still acceptable and is described in UAG-23.

(b) Tables of data and f-plots, on microfiche or paper, are acceptable. To ensure good reproduction, microfiche should be prepared with white characters on a dark background. Data submitted on paper should be on white paper with characters printed in black. The paper submitted to the WDCs should not exceed A4 paper size (297 x 210 mm, 11.7 x 8.3 inches). Each page of tables should clearly indicate the station name, the month and year in which the data were recorded, and the name of the tabulated parameter.

(c) Special arrangements should be made with the WDCs if data are to be supplied by other methods, such as magnetic cassettes or floppy disks, or telecommunications links.

(d) The use of microfilm for tabulations is discouraged.

(e) A few selected ionograms to illustrate the height and frequency scale of the ionosonde, and to illustrate typical quiet and disturbed days for each season, should be sent to WDCs when practical.

(f) Some stations produce electron density profiles from ionograms for periods of special interest. These data should be exchanged on magnetic tape as described above, but using the format given in INAG 46 pages 6 and 8.

2.6 Data From Digital Ionosondes

It is recommended that the nomenclature shown in INAG 40/41 page 9 is used in conjunction with data from digital ionosondes which measure echo phase and amplitude.

3. Other Active Ionospheric Datasets Held By WDCs

For all types of data the following information is required from each station, if possible annually:

* Station name

* Geographic co-ordinates

* Media on which data are available

* Contact name and address, telex and telephone number for obtaining these data

It would be helpful if reprints or reports describing the experimental techniques and data analysis could be deposited in WDCs.

3.1 Ionospheric Absorption

Ionospheric absorption is measured by three methods (A1, Pulse Echo; A2, Riometer; A3, CW Field Strength). These methods are described in UAG-57. Data from riometers at high latitudes are particularly in demand by scientists. WDCs should be notified annually of the availability of data from these three methods. In particular, experimenters should indicate whether data are scaled and, if so, the type of scaling used (events, hourly values, etc.).

3.2 Oblique Incidence Sounding

This technique is described in a note by Dieminger, IQSY Notes, No. 4, 25 - 33 (1963). Experimenters are asked to notify WDCs of their general programme of observation and analysis, in particular the names and location of transmitter and receiver, path length, midpoint and parameters scaled, such as maximum observed frequency (MOF) and lowest observed frequency (LOF). Tables of scaled data should be supplied if possible.

3.3 Total Electron Content and Scintillations From Satellite Beacons

Experimenters are asked to notify WDCs of their general plan of observations, including the satellites and radio frequencies, and the parameters measured.

4. Ionospheric Datasets Held By Experimenters

Many ionospheric datasets will normally be retained by the experimenters and will not be archived in WDCs. Experimenters holding datasets of general interest are encouraged to provide WDCs with information about these datasets, so that WDCs may refer requests to the group holding the data. Future WDC Catalogues will contain details of such datasets. The following information should be supplied to the WDCs:

* Time periods, geographic regions and altitudes for which reduced data (eg electron density, temperatures, composition, ...) are available

* Time periods, geographic regions and altitudes for which raw data are available

* The availability of facilities for processing raw data

* Restrictions on the use of data

* Media on which data are available

* Contact name and address, telephone and telex number for obtaining data

Experimenters are encouraged to send reduced data of wide interest to WDCs, but raw data should be retained by the experimental group. This referral process will become increasingly important with the development of distributed databases.

The table overleaf gives examples of datasets covered by these guidelines, and, where appropriate, the name of an internationally recognised advisory body which may draw up detailed guidelines for experiments and data exchange.

* Rocket measurements (consult WDC for Rockets & Satellites)

* Satellite measurements (consult WDC for Rockets & Satellites)

* Incoherent Scatter (consult National Centre for Atmospheric Research, P O Box 3000, Boulder, Colorado, 80307, USA)

* Coherent Scatter (eg STARE, SABRE)

* Whistlers, VLF and ELF Emissions

* Partial Reflections - electron densities and drifts

* HF Doppler measurements

* Meteor Winds

- * MST Radars

Information on the stations at which such measurements are made may be obtained from the WDCs. See also the "Directory of Solar-Terrestrial Physics Monitoring Stations" prepared by the MONSEE Committee of SCOSTEP.

5. Other Ionospheric Data Sets

There exist many other ionospheric datasets, of types listed in earlier editions of the Guide, to which little or no new data are now added, but which comprise a valuable archive to be held permanently in the WDCs. Thus it seems unnecessary to retain the guidelines previously issued for data collection, but WDCs should continue to list these datasets in their catalogues. These categories are as follows:

* Topside Soundings

* Solar flare effects

* Ionospheric Drifts

* Ionospheric Back- and Forward-scatter

* Atmospheric Radio Noise

6. Solar-Terrestrial Indices

Several solar-terrestrial indices, not necessarily ionospheric in origin, are frequently used in ionospheric research. Values of these indices should be sent to the WDCs, preferably in machine-readable form. Examples include:

* Geomagnetic activity indices: Kp, Ap, Dst, the Auroral Electrojet indices

* Solar activity indices: Sunspot Number, Solar 10.7 cm Radio Flux

* Ionospheric indices: IF2, IG12

* Interplanetary Medium Data

7. Models

Empirical models are frequently used in ionospheric research; examples include:

* International Reference Ionosphere (IRI); see UAG-82 and UAG-90

* International Geomagnetic Reference Field (IGRF); see Barraclough, D. R., Nature, 294, 14 - 15 (1981)

* Mass Spectrometer - Incoherent Scatter Thermospheric Model (MSIS); see Hedin, A. E., J. Geophys. Res. 88, 10170 - 10188 (1983)

Groups which develop models for free use by the scientific community are encouraged to send details to the WDCs. Copies of computer programs may be sent, but only if the code is properly documented and all machine-dependent routines are clearly indicated.

Appendix A - Draft Format For Representing Tabulations of Vertical Incidence Ionosonde Data In Digital Form On Magnetic Tape

Data for each parameter during one month form a physical block of fixed length 4800 bytes, which comprises 40 records each of length 120 bytes. The first record identifies the station, month of observation and the parameter recorded. Subsequent records contain the actual data in the form of 24 groups of 5 characters representing values for the 24 hours of the day. Each 5 character group is coded using the rules laid down in UAG-23A. Data for a year form a file of 12N blocks where N is the number of parameters scaled.

The format of each physical block is as follows:

Record	Positions	Format	Description
1	1 - 20	A20	Station name
1	21 - 25	A5	Station code
1	26 - 29	A4	Standard time meridian of the station (eg 150W, 090E, etc)
1	30 - 33	I4	Geographic co-latitude in tenths of a degree
1	34 - 37	I4	Geographic east longitude in tenths of a degree
1	38 - 41	I4	Year
1	42 - 43	I2	Month
1	44 - 45	A2	Parameter code (see UAG-23)
1	46 - 120	75X	Spare
2		A120	Hourly data for the first day of the month
.			..
.			..
32		A120	Hourly data for the thirty-first day of the month (fill with blanks if there are less than 31 days in the month)
33		A120	Medians
34		A120	Count
35		A120	Upper Quartile (UQ)
36		A120	Lower Quartile (LQ)
37		A120	Upper Decile
38		A120	Range (UQ-LQ)
39		A120	Lower decile
40		A120	Spare

If part of a month's data is missing, the full block must be created but with blanks in the appropriate positions. The arrangement of blocks in each file should ensure that the data for each month form a consecutive set of N blocks. For example, if the standard 14 parameters are scaled the blocks should be arranged as follows:

Block	Month	Parameter
1	January	foF2
2	January	M(3000)F2
.	..	..
.	..	..
14	January	fxI
15	February	foF2
.	..	..
.	..	..
168	December	fxI

6. The scaling of fxI from M, N and higher order traces

by R W Smith (Rutherford Appleton Laboratory, UK)
and
A S Rodger (British Antarctic Survey, UK)

During a recent ionogram interpretation and scaling course, one problem concerning the scaling of fxI occurred for which the rules given in UAG-23A are inadequate. In this note we describe the problem ionogram, then illustrate another related example and conclude with a recommendation to amend slightly the definition of fxI.

Normally we find that multiple order traces (M, N and higher order traces) give much the same critical frequency as the first order, but in the example illustrated in Fig. 1 the top frequency of a multiple order trace is 0.5 MHz above fxF2. Fifteen minutes later the multiple critical frequency exceeds fxF2 by 1 MHz. The sequence of ionograms shows that the critical frequencies of the multiple order traces agree until ftEs exceeds fxF2, when the unusual oblique trace begins to appear. It is evidently related to the Es both in amplitude and frequency. A possible explanation, for which the measured heights

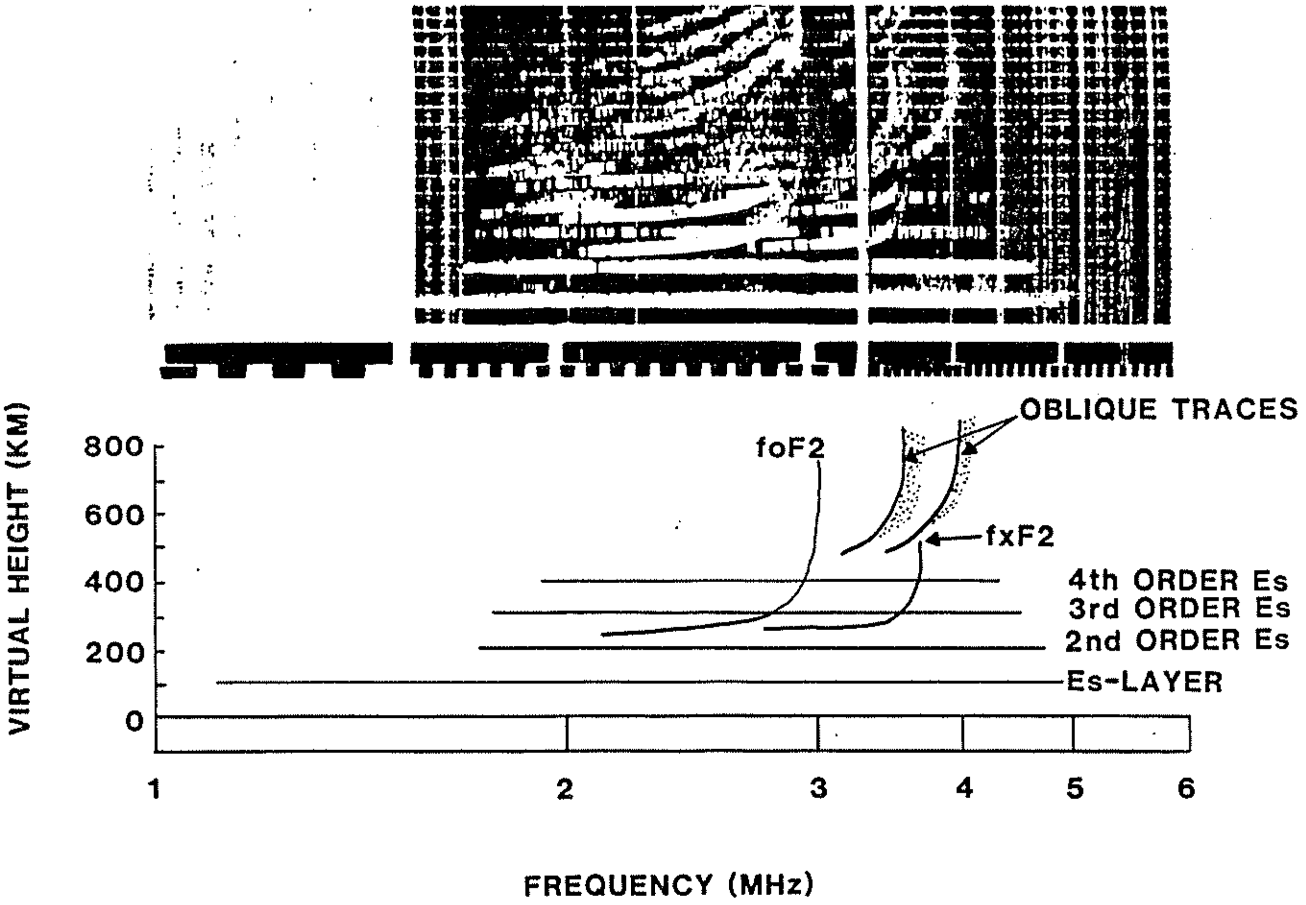


Fig. 1 (a) Argentine Islands ionogram recorded at 1845 LMT on 27 July 1968.
(b) Schematic diagram of the ionogram in (a) showing only the important traces.

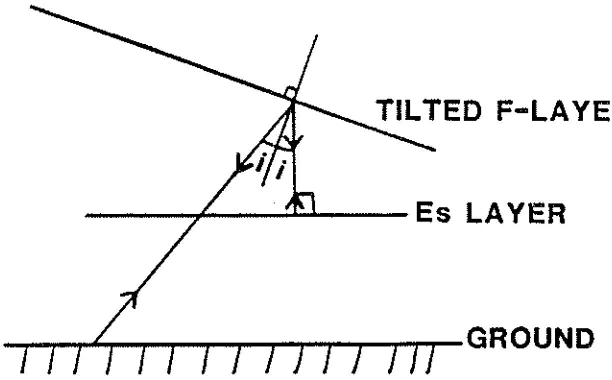


Fig. 2 Suggested path of the radio waves necessary to cause the oblique traces shown in Fig. 1.

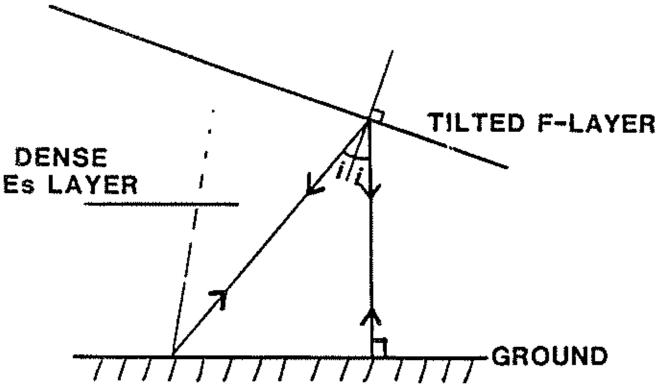


Fig. 3 Schematic illustration showing another method under which the first order traces from the F-layer are missing but a second order type trace is seen.

agree reasonably well, is illustrated in Fig. 2. The radio waves forming this oblique trace reflect from the F-layer to the top of the Es layer, back to the F-layer then finally to the ionosonde. The F-layer at this time is quite severely tilted. There are many multiple order reflections present and a low value of fmin showing that D-region absorption is small, but there is little or no evidence of a second order F-trace. The apparent increase in the critical frequency of the oblique trace is the result of the non-vertical propagation of the radio wave which effectively multiplies the critical frequency of the overhead F-layer by a factor sec(i) where the angle i is shown in Fig. 2. Assuming that there is no horizontal gradient in electron concentration, the angle i is ≈ 30° for this case.

The present definition of fxI (UAG-23A, p99) precludes the use of ground scatter and Es backscatter traces but makes no reference to multiple order traces of the type illustrated in Fig. 1. Therefore it would seem reasonable to scale fxI from this unusual oblique trace. However, as the increased frequency results from the sec(i) factor, it is logical to ignore this trace and scale fxF2 as fxI. With our recommended scaling, we are trying to assess the maximum plasma frequency of the F-layer in the vicinity of the station, which is an essential principle for fxI measurement (see INAG Bulletin 22, p8 - 9).

A similar problem occurs when, because of the presence of a tilted F-layer and an oblique dense Es layer, the first order F-trace is missing but an apparent second order is produced by the process shown in Fig. 3. For this example we would scale foF2 and fxI with the replacement letter Y, although the replacement letter A could also be acceptable. As we have illustrated with Fig. 1, the scaling of F-layer parameters from multiple order traces could lead to serious error. However, if quarter-hourly ionograms are available, interpolation may be possible provided that there is no large change in foF2 over half an hour period.

Given the examples discussed here, we suggest that the definition of fxI might be slightly modified to read "The parameter fxI is defined as the highest frequency on which first-order reflections from the F region are recorded, independent of whether they are reflected overhead or at oblique incidence. Thus fxI is the top frequency of spread-F traces including polar or equatorial spurs, but not including ground backscatter, Es backscatter, M, N or higher order traces". Comments on this proposal are invited in the near future, so that a decision on this recommendation may be possible at the next URSI General Assembly to be held in August 1987.

7. Manual of Ionogram Scaling - Revised Edition

It has been noted (INAG 46, p4-6) that the Manual of Ionogram Scaling was published in March 1985 by the authors, N Wakai, H Ohyama and T Koizumi of the Radio Research Laboratory (RRL), Japan. About 100 copies of the manual were distributed to users at ionospheric sounding stations throughout the world, members of INAG and other individuals on request.

A large number of valuable comments and suggestions concerning the manual was sent to the authors. This resulted in a revision of the manual which was published in July 1986 and it will be distributed to all the users who received the first edition.

The authors have invited users to comment and provide suggestions concerning the revised manual for further improvement and they have also invited requests from new users for distribution of the revised manual.

The contact address is:

Ionospheric Observation Section
Technical Information Division
Radio Research Laboratory
Nukui-Kitamachi 4-2-1
Koganei-shi
Tokyo 184
Japan

Telephone: 0423-21-1211
Telex: 2832611 DEMPA J
Facsimile: 0423-24-9061

8. Forthcoming conferences and INAG meetings

The XIX th General Assembly of the International Union of Geodesy and Geophysics (IUGG) will be held in Vancouver, Canada from 9 to 22 August 1987.

Further information may be obtained from:

Conference Secretariat
c/o Venue West
801-750 Jervis Street
Vancouver, B C
Canada V6E 2A9

Telephone: (604) 681-5226
Telex: 04-352848 VCR

An INAG meeting has been scheduled for Monday evening 17 August 1987 in Room Chem 126.

The XXII nd General Assembly of the International Union of Radio Science (URSI) will be held in Tel Aviv, Israel from Tuesday, 25 August to Wednesday, 2 September, 1987.

Further information may be obtained from:

The Secretariat
XXII nd General Assembly of URSI
P O Box 50006
Tel Aviv 61500
Israel

Telephone: (03) 654571
Telex: 341171 KENS IL
Facsimile: 972 3 655674

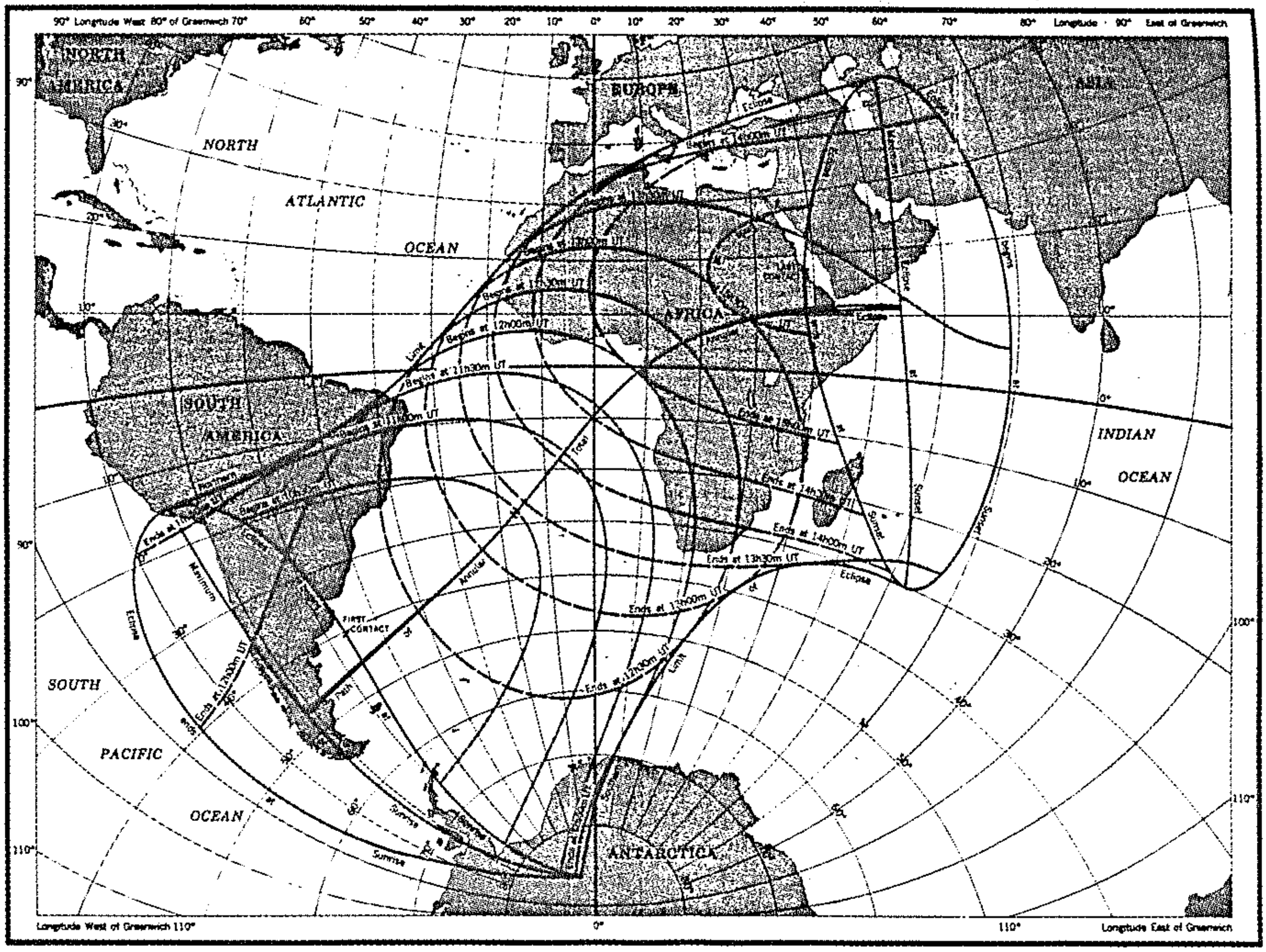
A business meeting of INAG, which is Working Group G. 1 of Commission G of URSI, will be held before the Business Meeting of Commission G, so that INAG can report to Commission G.

Anyone wishing to submit items for the agenda of the above two INAG Meetings is requested to forward them to the Executive Secretary, R Haggard, (address page 1) as soon as possible so that the agendas can be published in the next INAG Bulletin.

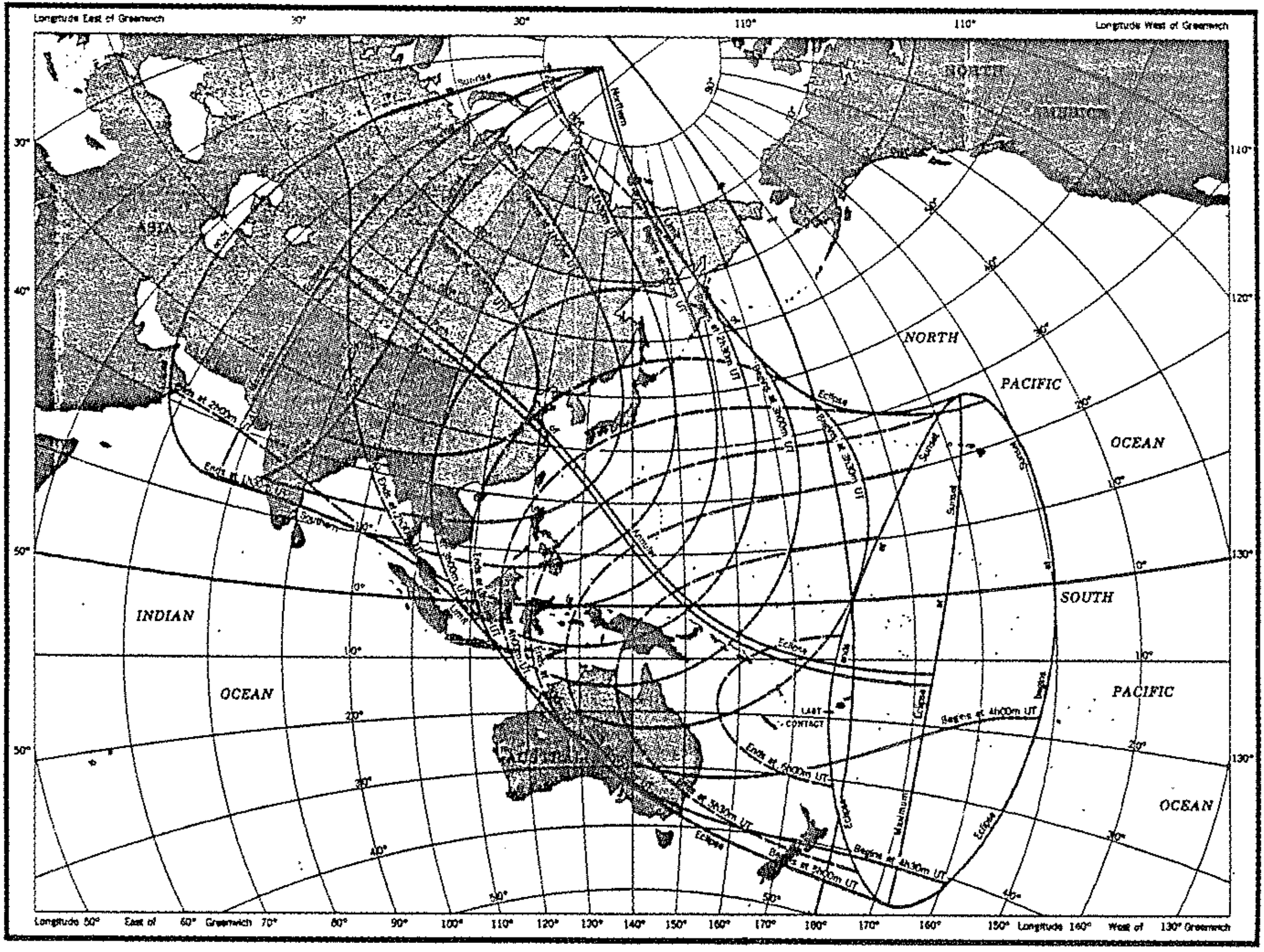
9. Solar Eclipses in 1987

There will be an annular-total solar eclipse on 29 March 1987 and an annular solar eclipse on 23 September 1987. Further details are available in the Astronomical Almanac.

ANNULAR-TOTAL SOLAR ECLIPSE OF 1987 MARCH 29



ANNULAR SOLAR ECLIPSE OF 1987 SEPTEMBER 23



The eclipse diagrams reproduced from the Astronomical Almanac with kind permission from the US Government Printing Office.

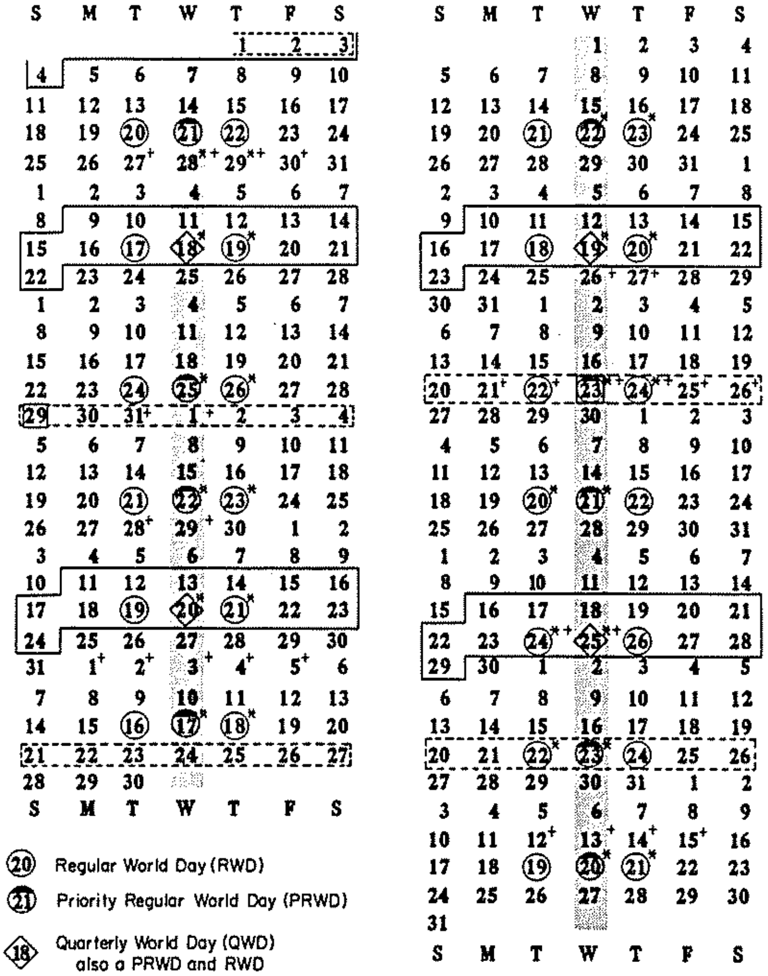
10. INAG Bulletin

A gentle reminder to all recipients of INAG Bulletin please to submit articles of general interest, forthcoming events, station news, equipment problems and solutions, scaling aids and general comments and ionograms for interpretation and discussion for inclusion in future bulletins.

Since the INAG mailing list questionnaire only solicited 25 responses, which amounts to 8% only, it has again been included on page 17 in the hope that the other 92% will now respond.

11. International Geophysical Calendar 1987

(See other side for information on use of this Calendar)



	S	M	T	W	T	F	S
					1	2	3
	4	5	6	7	8	9	10
JANUARY	11	12	13	14	15	16	17
	18	19	⑳	㉑	㉒	23	24
	25	26	27+	28*+	29*+	30+	31
	1	2	3	4	5	6	7
FEBRUARY	8	9	10	11	12	13	14
	15	16	⑰	◇18*	⑲*	20	21
	22	23	24	25	26	27	28
	1	2	3	4	5	6	7
MARCH	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	㉔	㉕*	㉖*	27	28
	29	30	31+	1+	2	3	4
	5	6	7	8	9	10	11
APRIL	12	13	14	15	16	17	18
	19	20	㉑	㉒*	㉓*	24	25
	26	27	28+	29+	30	1	2
	3	4	5	6	7	8	9
MAY	10	11	12	13	14	15	16
	17	18	⑲	◇20*	㉑*	22	23
	24	25	26	27	28	29	30
	31	1+	2+	3+	4+	5+	6
JUNE	7	8	9	10	11	12	13
	14	15	⑯	⑰*	⑱*	19	20
	21	22	23	24	25	26	27
	28	29	30				
	S	M	T	W	T	F	S

S	M	T	W	T	F	S	
			1	2	3	4	
5	6	7	8	9	10	11	
12	13	14	15	16	17	18	JULY
19	20	㉑	㉒*	㉓*	24	25	
26	27	28	29	30	31	1	
2	3	4	5	6	7	8	
9	10	11	12	13	14	15	AUGUST
16	17	⑱	◇19*	⑳*	21	22	
23	24	25	26+	27+	28	29	
30	31	1	2	3	4	5	
6	7	8	9	10	11	12	
13	14	15	16	17	18	19	SEPTEMBER
20	21+	㉒+	㉓*+	㉔*+	25+	26+	
27	28	29	30	1	2	3	
4	5	6	7	8	9	10	
11	12	13	14	15	16	17	OCTOBER
18	19	⑳*	㉑*	㉒	23	24	
25	26	27	28	29	30	31	
1	2	3	4	5	6	7	
8	9	10	11	12	13	14	NOVEMBER
15	16	17	18	19	20	21	
22	23	㉔*+	◇25*+	㉖	27	28	
29	30	1	2	3	4	5	
6	7	8	9	10	11	12	
13	14	15	16	17	18	19	DECEMBER
20	21	㉒*	㉓*	㉔	25	26	
27	28	29	30	31	1	2	
3	4	5	6	7	8	9	
10	11	12+	13+	14+	15+	16	1988 JANUARY
17	18	⑲	⑳*	㉑*	22	23	
24	25	26	27	28	29	30	
31							
S	M	T	W	T	F	S	

⑳ Regular World Day (RWD)

㉑ Priority Regular World Day (PRWD)

◇18 Quarterly World Day (QWD)
also a PRWD and RWD

7 Regular Geophysical Day (RGD)

12 World Geophysical Interval (WGI)

19+ Incoherent Scatter Coordinated
Observation Day and Coordinated
Tidal Observation Day

2 Day of Solar Eclipse

29 30 Airglow and Aurora Period

28* Dark Moon Geophysical Day (DMGD)

NOTES:

1. Days with unusual meteor shower activity are: Northern Hemisphere Jan 3,4; Apr 21-23; May 4-5; Jun 8-12; Jul 28-29; Aug 11-14; Oct 20-23; Nov 2-4, 17-18; Dec 13-16, 22-23, 1987; Jan 3,4, 1988. Southern Hemisphere May 4-5; Jun 8-12; Jul 27-30; Oct 20-23; Nov 2-4, 17-18; Dec 5-7, 13-16, 1987.

2. Middle Atmosphere Cooperation (MAC) began 1 Jan 1986 and runs through 1988.

3. Day intervals that IMP 8 satellite is in the solar wind (begin and end days are generally partial days): 1986 Dec 31-1987 Jan 5; Jan 12-18; Jan 24-30; Feb 6-12; Feb 18-25; Mar 3-10; Mar 16-22; Mar 28-Apr 4; Apr 10-17; Apr 23-30; May 5-12; May 17-25; May 29-Jun 6; Jun 10-19; Jun 23-Jul 2; Jul 6-14; Jul 19-27; Jul 31-Aug 9; Aug 13-21, Aug 25-Sep 2; Sep 6-14; Sep 19-27; Oct 2-9; Oct 15-22; Oct 27-Nov 4; Nov 9-16; Nov 22-29; Dec 4-11; Dec 17-24; Dec 30-1988 Jan 6. There will not be total IMP 8 data monitoring coverage during these intervals. (Information kindly provided by the WDC-A for Rockets and Satellites, NASA/GSFC, Greenbelt, MD 20771 U.S.A.).

4. + Incoherent Scatter programs start at 1600 UT on the first day of the intervals indicated, and end at 1600 UT on the last day of the intervals.

OPERATIONAL EDITION, September 1986

EXPLANATIONS

This Calendar continues the series begun for the IGY years 1957-58, and is issued annually to recommend dates for solar and geophysical observations which cannot be carried out continuously. Thus, the amount of observational data in existence tends to be larger on Calendar days. The recommendations on data reduction and especially the flow of data to **World Data Centers (WDCs)** in many instances emphasize Calendar days. The Calendar is prepared by the **International Ursigram and World Days Service (IUWDS)** with the advice of spokesmen for the various scientific disciplines.

The **Solar Eclipses** are:

a.) *March 29 (annular-total)* beginning in the southern part of South America and part of Antarctica, moving across the S. Atlantic Ocean, across Africa except the northwest part, across the extreme southeast section of Europe and the southwest of Asia -- totality lasts only 8 seconds in a path 5 km wide over the S. Atlantic, off the coast of West Africa.

b.) *September 23 (annular-partial)* beginning in Asia (except the northeast and southwest sections) crossing China, moving across Japan, across the Pacific Ocean, the Philippine Islands, Indonesia (except the southwest section), New Guinea, Northeast Australia and New Zealand (except the extreme south), and ends near Samoa.

Meteor Showers (selected by P.M. Millman, Ottawa) include important visual showers and also unusual showers observable mainly by radio and radar techniques. The dates are given in Footnote 1 on the reverse side. Note that the meteor showers that come in the first week of May and the third week in October are of particular interest (fragments of Halley's comet).

Definitions:

Time = Universal Time **(UT)**;

Regular Geophysical Days **(RGD)** = each Wednesday;

Regular World Days **(RWD)** = Tuesday, Wednesday and Thursday near the middle of the month (see calendar);

Priority Regular World Days **(PRWD)** = the Wednesday **RWD**;

Quarterly World Days **(QWD)** = **PRWD** in the **WGI**;

World Geophysical Intervals **(WGI)** = 14 consecutive days each season (see calendar);

ALERTS = occurrence of unusual solar or geophysical conditions, broadcast once daily soon after 0400 UT;

STRATWARM = stratospheric warmings;
Retrospective World Intervals **(RWI)** = intervals selected by MONSEE for study.

For more detailed explanations, please see one of the following or contact H. Coffey (address below): *Solar-Geophysical Data,* November issue; *URSI Information Bulletin; COSPAR Information Bulletin; IAGA News; IUGG Chronicle; WMO Bulletin; IAU Information Bulletin; Solar-Terrestrial Environmental Research in Japan; Journal of the Radio Research Laboratories* (Japan); *Geomagnetism and Aeronomy* (USSR); *Journal of Atmospheric and Terrestrial Physics* (UK); *EOS Magazine* (AGU/USA).

Priority recommended programs for measurements not made continuously -- (in addition to unusual **ALERT** periods):

Aurora and Airglow -- Observation periods are New Moon periods, especially the 7 day intervals on the calendar;

Atmospheric Electricity -- Observation periods are the **RGD** each Wednesday, beginning on 7 January 1987 at 0000 UT, 14 January at 0600 UT, 21 January at 1200 UT, 28 January at 1800 UT, etc. Minimum program are **PRWDs.**

Geomagnetic Phenomena -- Observation periods on **RWDs.**

Ionospheric Phenomena -- Quarter-hourly ionograms; more frequently on **RWDs,** particularly at high latitude sites; f-plots on **RWDs;** hourly ionograms to WDCs on **QWDs;** continuous observations for solar eclipse in the eclipse zone. See Airglow and Aurora.

Incoherent Scatter – Observations on Incoherent Scatter Coordinated Days; also intensive series on **WGIs** or Airglow and Aurora periods. **Special programs:** Dr. V. Wickwar, SRI International, 333 Ravenswood Ave., Menlo Park, CA 94025 U.S.A., URSI Working Group G.5.

Ionospheric Drifts – During weeks with **RWDs.**

Traveling Ionosphere Disturbances – special periods, probably **PRWD** or **RWDs.**

Ionospheric Absorption – Half-hourly on **RWDs;** continuous on solar eclipse days for stations in eclipse zone and conjugate area. Daily measurements during Absorption Winter Anomaly at temperate latitude stations (Oct-Mar Northern Hemisphere; Apr-Sep Southern Hemisphere).

Backscatter and Forward Scatter – **RWDs** at least.

Mesospheric D region electron densities -- **RGD** around noon.

ELF Noise Measurements of earth-ionosphere cavity resonances – **WGIs.**

ALL PROGRAMS – Intensive observations during unusual meteor activity.

Meteorology -- Especially on **RGDs.** On **WGIs** and **STRATWARM** Alert Intervals, please monitor on Mondays and Fridays as well as Wednesdays.

Middle Atmosphere Cooperation (MAC) -- **RGDs, PRWDs** and **QWDs.** For planetary waves and tides monitor at least 10 days centered on **PRWDs** and **QWDs.** (Dr. T. VanZandt, NOAA R/E/AL3, 325 Broadway, Boulder, CO 80303 U.S.A.)

Solar Phenomena – Solar eclipse days, **RWDs,** and during **PROTON/FLARE ALERTS.**

Study of Traveling Interplanetary Phenomena (STIP) – XV = 12-21 Feb 1984 solar GLE; XVI = 20 Apr-4 May 1984 Forbush decrease; XVII = 24 Apr-30 Jun 1985 alignment of Venus magnetotail with satellites VEGA 1, VEGA 2, MS-T5, PVO, and ICE; XVIII = Sep 1985 Giacobini-Zinner Comet fly-by by ICE; XIX = March 1986 International Halley Watch.

Space Research, Interplanetary Phenomena, Cosmic Rays, Aeronomy – **QWDs, RWD,** and Airglow and Aurora periods.

URSI/IAGA Coordinated Tidal Observations Program (CTOP) -- Dr. R. G. Roper, School of Geophysical Sci., Geophysical Sci., Georgia Inst. of Tech., Atlanta, GA 30332 U.S.A. has the 1987 CTOP calendar.

The International Ursigram and World Days Service (IUWDS) is a permanent scientific service of the International Union of Radio Science **(URSI),** with the participation of the International Astronomical Union and the International Union Geodesy and Geophysics. IUWDS adheres to the Federation of Astronomical and Geophysical Services (FAGS) of the International Council of Scientific Unions (ICSU). The IUWDS coordinates the international aspects of the world days program and rapid data interchange.

This Calendar for 1987 has been drawn up by H.E. Coffey, of the IUWDS Steering Committee, in association with spokesmen for the various scientific disciplines in SCOSTEP, IAGA and URSI. Similar Calendars have been issued annually beginning with the IGY, 1957-58, and have been published in various widely available scientific publications.

Published for the International Council of Scientific Unions and with financial assistance of UNESCO.

Additional copies are available upon request to IUWDS Chairman, Dr. R. Thompson, IPS Radio and Space Services, 162-166 Goulburn St., Darlinghurst, NSW 2010 Australia, or IUWDS Secretary for World Days, Miss H.E. Coffey, WDC-A for Solar-Terrestrial Physics, NOAA E/GC2, 325 Broadway, Boulder, Colorado 80303 U.S.A.

12. INAG Mailing List Questionnaire

Please complete the following and return to the address given below as soon as possible.

Name: ____________________

Title: ____________________

Institution: ____________________

Street and/or box number: ____________________

City: ____________________

State: ____________________

Mail (ZIP) code: ____________________

Country: ____________________

Number of Bulletins required: ____________________

Comments: ____________________

____

____

____

____

____

Return address:

R Haggard
INAG Secretary
Hermann Ohlthaver Institute for Aeronomy
Department of Physics and Electronics
Rhodes University
P O Box 94
Grahamstown
6140
South Africa