IONOSPHERIC NETW0RK ADVISORY GROUP (INAG)*

IONOSPHERIC STATION INFORMATION BULLETIN No. 37**

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* Under the auspices of Commission G, Working Group G1 of the International Union of Radio Science (URSI).

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1. INTRODUCTION

by W. R. Piggott, Chairman

The question of the value of continuing ionospheric sounders in the days when rockets, satellites, incoherent scatter equipments and other advanced tools are available has often been asked in the past and is still being asked. From time to time, the URSI Commission (now G) and individuals have collected the reasons which remain valid. Much confusion arises, in these days when there is both National and International planning on a large scale, because only relatively little of the network has been planned as a network so that the actual reasons why the stations exist are often unrelated or even incompatible. The VI network is a free association of independent groups who maintain ionosondes partly for their own use and partly as a contribution to world service. About a quarter of the stations which are active do not circulate data, except by special request. These stations may not appear in the World Data Centre station lists and do not form part of the network. This is unfortunate as their data would often be invaluable for special studies, e.g. of abnormally quiet or disturbed conditions.

Usually, stations are set up primarily to meet local needs. Originally, these were mainly the needs for controlling and understanding ionospheric communications, though now possibly the longest established groups are associated with meteorological organisations.

In general, remarkably little of the data obtained were studied effectively. The practical problems often demanded the use of only the simplest and most significant data. As a result, the potential value of the data is widely underestimated. Many users accept the literature as true and well established, but this is often not so. Usually, a valuable conclusion, true part of the time or in limited areas of the world, is accepted as true everywhere when even a superficial study would show that it did not apply locally. This gives many useful opportunities to do new work relatively easily and very inexpensively.

Another important point is that modern research tends to concentrate on the intense study of limited samples. This is very efficient, but tends to ignore world-wide phenomena which cannot be studied by such means. The ionospheric forces change with position and time so that particular zones have special advantages for testing the truth of particular hypotheses. For example, it is notorious that in many parts of the world (in contrast with Europe) consecutive quiet days can show very different phenomena - sometimes more different than that between quiet and disturbed periods. No one appears to be studying such problems and thus complementing and re-interpreting the data from advanced techniques. In my view, this is a gap which is rapidly increasing in importance and thus offers the chance for recognising new major problems. Much work of this type was done in the early days of the ionosphere, but was limited by lack of knowledge of the dynamics and composition of the ionosphere. With the much better tools now available and this know ledge, the time appears ripe for a reconsideration of the morphological problems. I have been surprised that the regional groups have not paid much attention to this type of problem. For example, some of the considerable differences in the behaviour of the equatorial ionosphere with longitude have been studied using ionosonde data, but little work has been done on the regions of intense turbulence, generating slant Es (Es-s) - diffuse Es similar to Es-q: and also auroral Es at latitudes around 25° from the magnetic equator. Few, if any stations have reported particle effects in the D, E and F regions at low latitudes, though these can often be found if looked for. The possibilities of doing good new research using the ionosphere are still very great, but are little exploited. I feel that this is now probably the most important point to be considered, in the use of our data, the training of our young men and our justification for the future.

2. REPORT OF THE INAG MEETING, FAIRBANKS ALASKA, U.S.A.

A short INAG meeting was held on 12 August 1982 during the URSI International Symposium on Radio Probing of the High Latitude Ionosphere and Atmosphere: New Techniques and New Results in Fairbanks, Alaska, U.S.A. The meeting was attended by 16 people representing 7 countries.

Participants:

R 0 Conkright	USA	Assistant Secretary and Chairman for the meeting
A S Rodger	UK	Secretary
J A Gledhill	South Africa	Member
R D Hunsucker	USA	Member
B Reinisch	USA	Member
T Turunen	USA	Member
P J Wilkinson	Australia	Member
P Argo	USA	
J Buchau	USA	
K Davis	USA	
K Folkestad	Norway	
A Hedberg	Sweden	
T Kelly	Australia	
J MacDougall	Canada	
D Varvel	Australia	
J W Wright	USA	

Chairman's Introduction

The Chairman welcomed the participants and thanked them for making the effort to attend the meeting at such an early hour in the morning. He also expressed INAG's thanks to Professor Hunsucker for the facilities and co-operation received in organising the meeting.

Network Status

USA The status of the ionosondes under the control of the Geophysical Research Institute of the University of Alaska remains unchanged from the report included in INAG 34, page 3, except that the NOAA SEL digital sounder, which was at the Cleary field site has been moved to Roberval and will eventually be deployed at Sonderstromfjord. The World Data Center A in Boulder continue to fully support the ionosondes at Boulder, Maui and Wallops Island and provide some limited support for other stations.

The ionosondes at Goose Bay, Fort Monmouth and Millstone Hill continue to operate, but only the former presently, submits data to WDC-A in Boulder. The NOAA digital sounder, which was at White Sands, is now at Los Alamos National Laboratory in New Mexico.

Australia It is intended to open a station at Darwin towards the end of this year.

Brazil A temporary station was established in Brazil for June to September by the AFGL of USA.

Finland The new ionosonde developed by Dr T Turunen has been operational at Sodankyla since April 1982.

South Africa Hermanus is to restart operation in a few weeks with an IPS-42 ionosonde.

Sweden No change of operational stations was reported, but all observatories are now administered by the Kiruna Geophysical Institute.

United Kingdom No change in station status was reported. Port Stanley is not yet operational.

KEL Aerospace About 52 ionosondes of the IPS-42, 4A and 4B types will be operational by the end of the year. New IPS-42 ionosondes are to be commissioned for Lannion, Dakar, Nigeria, Yugoslavia and Iraq in the next few months. It was estimated that about 40 of these equipments were replacements for existing stations and 12 were machines for new sites. It was pointed out that the IPS-42 type (or equivalent of ionosonde) will shortly become the most common equipment of all time as 55 C3/C4 and only 37 Union Radio ionosondes were made.

Master Station List

INAG is trying to compile an up-to-date master station list of all ionospheric observatories, together with the dates for which the stations were in operation. INAG requests the cooperation of all readers of the Bulletin to submit amendments to the list which is published in this Bulletin.

Equipment Status

The Lowell Digisonde 256 is now available. A more complete description of the equipment will be given in the next Bulletin.

A new digital ionosonde has been developed by the ionospheric group in Grahamstown and will be operational later this year, either at Grahamstown or at SANAE in Antarctica.

KEL Aerospace are now producing three products of interest to the ionospheric community, the IPS-42 ionosonde, the DBD-43 digital receiver and the KEL-46 semi-automatic ionogram digitising system. A more detailed description of the latter two items will appear in a future INAG Bulletin.

KEL Aerospace also announced they would be prepared to consider short term rental of this equipment at about 4% of the purchase price/day. All enquiries should be made direct to KEL Aerospace, 12 Brennan Close, Asquith, NSW 2078, Australia.

INAG Bulletin

There was a general consensus that the revised format of the Bulletin was preferred. However, the Chairman again stressed the need for those who could afford to pay for the Bulletin to do so as soon as possible. He also pointed out that the frequency at which the Bulletin was produced depended to a large extent upon the Secretary, Alan Rodger, receiving notes, articles, ionograms or any other contributions from readers of the Bulletin.

Data Exchange

Some questions were raised on the agreed international convention for ionospheric data exchange. Readers are referred to Chapter 9 of UAG-23 for a very complete discussion of this topic.

Future Meetings

It is hoped to hold an INAG meeting during the IAGA General Assembly in Hamburg in August 1983. INAG members are also encouraged to hold meetings when suitable occasions arise and send a report: of the proceedings for publication in INAG.

Other items could not be covered due to lack of time.

3. THE IONOSPHERIC STATION AT DOURBES, BELGIUM: 25TH ANNIVERSARY

The ionospheric station at Dourbes, in southern Belgium, was installed 25 years ago and, in order to mark the occasion, the Institut Royal Meteorologique and Professor Bossy organised a two-day symposium in Brussels and a visit to Dourbes, which was attended by 40 scientists belonging to 10 nations.

At the Opening Session on 13 May, the Director of the IRM, Professor R Sneyers, and Professor Bossy welcomed the participants. The Chairman of the morning session was Professor T B Jones, University of Leicester. UK, and the following papers were presented:

The role of the world network of vertical incidence stations in future research; W. R. Piggott, Chairman, Ionospheric Network Advisory Group (INAG).

On the continuing importance of soundings for ionospheric modelling; K. Rawer, Universitat Freiburg, FR Germany.

The use of ionosondes for a knowledge of the E layer; M. Nicolet, IRM, Brussels.

Geometric optics in absorbing media; K. Suchy, Institut fur Theoretische Physik der Universitat Dusseldorf, FR Germany.

URSI, Belgium and the Ionosphere: 1882-1922; C. M. Minnis, Secretary General Emeritus of URSI, Brussels.

Dr Piggott was Chairman for the afternoon session, during which the following papers were presented:

The role of the digital ionosonde in ionospheric physics; T. B. Jones, University of Leicester, UK.

Improved use of ionospheric vertical sounding stations for hf radio communications; P. Dominici, Instituto Nazionale di Geofisica, Rome, Italy.

Consideration of several reflection areas for spectrum analysed directional drift data; K. Bibl, University of Lowell, USA.

A method based on Es parameters for the determination of aeronomical parameters; P. Bencze, Hungarian Academy of Sciences (presented by T. B. Jones)

Lunar tidal oscillations in the mid-latitude ionosphere; G. Sethia, University of Lancaster, UK.

Long-term relationships between sunspots, solar faculae and the ionosphere; P. A. Smith, Rutherford and Appleton Laboratory, Chilton, UK.

On 14 May, the participants visited the Geophysics Centre of the Institut Royal Meteorologique at Dourbes. During the morning, there was a demonstration of the newly installed Digisonde 256, and the specially designed 7-element receiving antenna.

The afternoon was devoted to a continuation of the Symposium. The session was chaired by Professor K. Rawer, and the following papers were presented:

On features of the Digisonde 256; K. Bibl, B. Reinisch and D. Kitrosser, University of Lowell, USA.

Measurement of sea-state parameters; J. Delloue Laboratoire de Physique de I'Exosphere, universite de Paris VI, France.

The ionosonde at Kiruna; G. Gustafsson, Kiruna Geophysical Institute, Sweden.

Summing up the end of the Symposium, Professor Rawer referred to the new types of measurement that could be made using modern ionosondes of advanced design, such as Doppler shift and polarisation observations, and the possibility of distinguishing between vertical and oblique incidence echoes. These facilities opened up a large range of new applications in studies covering the broad field of the 'dynamics of the ionosphere', which includes the earlier, but more restricted, studies of 'irregularities and drifts'.

However, Professor Rawer emphasised that ionosondes of traditional design still had an important role to play within the world network of stations. These stations provided information that was needed for improving the mapping of ionospheric parameters, especially over oceans and in the Southern Hemisphere. The data acquired were essential also for scientific investigations, including those relating to conditions in the equatorial belt and at polar latitudes.

Finally, traditional ionosondes were needed for the production of good N-h profiles; these are required for the compilation of the International Reference Ionosphere, which is being sponsored by URSI and COSPAR, and also for aeronomic modelling. Where possible, special attention should be given to the characteristics of the valley between the E and F regions.

4. IONOGRAM INTERPRETATION MEETING AT WORLD DATA CENTRE - C1

A meeting was held in the new World Data Centre – C1 at the Rutherford and Appleton Laboratory near Chilton, UK (INAG 36, page 14) between R. W. Smith (WDC-C1), P. Morris (New Zealand), S. M. Broom and A. S. Rodger (both of British Antarctic Survey). Sequences of ionograms from Christchurch, Campbell Island and Scott Base, Antarctica were examined, together with detailed discussion of their interpretation. Many interesting points were raised. For example, the value of having quarter-hourly, five minute or even continuous sounding was well illustrated by some of the sequences: the ionograms from Christchurch (a magnetic mid-latitude observatory) for magnetically disturbed periods were found to be quite similar to those of Campbell Island (a sub-auroral station) under normal magnetic activity conditions. Some of the examples discussed will be reproduced in future INAG Bulletins. The meeting was most helpful to all the participants and others involved in ionogram analysis who may visit UK are strongly encouraged to arrange similar meetings at the Data Centre.

5. NATIONAL RADIO SCIENCE MEETING 1983

This open scientific meeting will be held from 5 to 7 January 1983 at the University of Colorado, Boulder, CO 80309, USA, sponsored by the US National Committee for the International Union of Radio Science. There will be an URSI Commission G (Ionospheric Radio and Propagation) section of interest to INAG.

Papers on any topic of interest are welcome, but in addition, certain subjects will be emphasized as indicated in the later Call for Papers. The dead line for the receipt of abstracts is 1 October 1982.

For further information, contact the Steering Committee Chairman:

Professor S. W. Maley
Department of Electrical Engineering
University of Colorado
Boulder
CO 80309
U S A

6. INTERNATIONAL RADIO CONSULTATIVE COMMITTEE (CCIR)

Following the closing of the XV Plenary Assembly of the CCIR (Geneva 1982), M. M. Thue, Chairman of the URSI-CCIR-CCITT Liaison Committee, has sent the terms of reference and names of Officers of CCIR Study Group 6 (Propagation in Ionised Media) which is of interest to INAG.

Terms of reference:

To study with the object of improving radio communications:

1. the propagation of radio waves through the ionosphere, and through ionized regions beyond the ionosphere;

2. the characteristics of related radio noise.

Chairman: L. W. Barclay (United Kingdom)
Vice-Chairman: Miss G. Pillet (France)

7. MIDDLE ATMOSPHERE PROGRAMME – UPPER ATMOSPHERE PROGRAMMES BULLETINS

Some INAG readers, particularly those in developing countries, may have difficulties in linking with the major atmospheric research projects planned and underway, such as the Middle Atmosphere Programme. Special issues of the Upper Atmosphere Programmes Bulletins (UAPB), 82-1 and 82-2, have been published this year summarising plans, discussions and results. Copies of these can be obtained from:

SCOSTEP Secretariat
University of Illinois
1406 W. Green Street
Urbana
Illinois 61801
U S A

or

World Data Center A
N 0 A A
D63
325 Broadway
Boulder
Colorado 80303
U S A

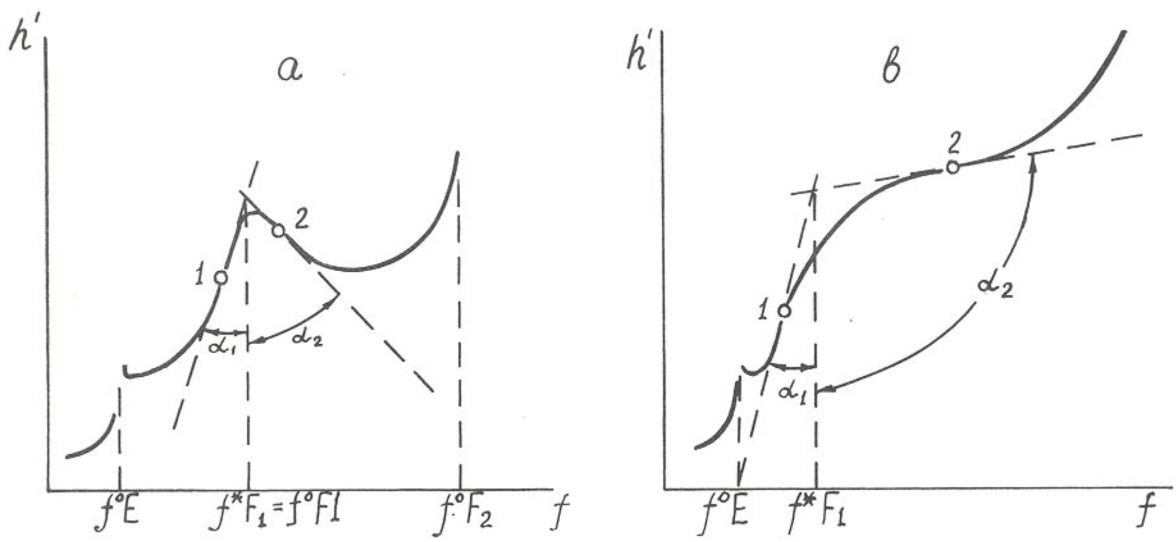
8. NEW PARAMETERS OF THE F1 LAYER

by L. A. Shchepkin and A. V. Vinitsky

Chairman's Note

In accord with INAG policy of publishing material found useful by its contributors or having bearing on INAG policy decisions, we publish the following paper. Readers of the INAG Bulletin will note that the philosophy of obtaining more numerical foF1 data differs from that at present adopted by INAG, where DL and EL values are ignored (INAG 32, page 6; see also the discussion of the F1 parameters on INAG 27, pp 26-27). INAG wishes to draw the attention of other workers to the problem of whether such values have physical meaning. The final test is whether scientifically usable data are obtained which add to our knowledge of the ionosphere. Papers showing new points obtained by new techniques are, of course, acceptable for publication in the general literature, but it would be helpful to the INAG community to have occasional references to such papers so as to provoke other groups to use them.

A method of evaluating the F1 layer maximum plasma frequency (henceforth referred to as f*F1) is proposed which permits numerical values to be obtained in those cases when foF1 is tabulated or f-plotted by the symbol L. For this purpose, on an o-mode trace of the ionogram (see Fig. a, b) points "1" and "2" are chosen where the h'-f relationship has the steepest slope. Tangents are drawn at these points. The value of f*F1 is measured on the frequency of their intersection.



The angle a between the tangents can also be determined. it is a measure of the degree of F1 layer development and contains information about the thermospheric gas composition (reference 1).

The model calculations (reference 2) showed that where the F1 layer is well developed and foF1 can be measured with confidence (foF1 as an unqualified value), then f*F1 = foF1. These values coincide with the plasma frequency of the height level at which the height derivative of electron density (N' = dN/dh) is zero or has a minimum in the height dependence of (f_F) (reference 3). With regard to 'foF1-L' cases, then f*F1 agrees with f_F to within ±0.05 MHz.

In the "foF1UL" cases, when most frequently $90° \le \alpha < 110$-$130°$ (depending on the scale factor of the ionogram determined by the ratio of scales on the height, h, and frequency, f, axes), the value of f*F1 agrees with f_F within an error not greater than ±0.1 MHz. N'(h) in these cases has a minimum, being either well defined or smeared and stretched in altitude. In the latter case f_F corresponds to the plasma frequency of the level, from which upwards a systematic increase in N' starts.

The "foF1DL" case usually displays a shape of the N'(h) profile, characterized by an approximate constancy of N' with height or by a slight growth and by a change towards a more rapid increase in N' upwards, as identified from the model curves to within ± 2km. f_F agrees also to within 0.1 MHz with the f*F1 measure and corresponds to the break level in N'(h).

At $\alpha > 140$-$160°$, when "L-conditions" are taking place, f_F agrees to within 0.15 MHz with the level of a break in the gradient of N'.

The procedure of derivation of the parameter, a, has one essential limitation due to the diversity of scales used with ionosondes. This requires the values to be corrected to a common datum. The method of evaluating the parameters of f*F1 and of the degree of F1 layer development has been verified and substantiated in the' process of experimental reduction at a number of ionospheric observatories of the USSR.

References:

1. A. V. Vinitsky, L. A. Shchepkin, Issledovaniya po Geomagn., Aeronomii i Fizike Solntsa, 41, Moscow, "Nauka", 1977, p. 46.

2. L. A. Shchepkin, A. V. Vinitsky, Geomagn. i Aeronomiya, 1981, 21, 359.

3. J. R. Dudeney, J. Atm. Terr. Phys., 1978, 40, 195.

9. APPLICATION OF Es PARAMETERS FOR THE INVESTIGATION OF AERONOMICAL PROCESSES

by P. Bencze

Chairman's Note

The following interesting article by Dr. P. Bencze of the Geodetical and Geophysical Research Institute of the Hungarian Academy of Sciences has been sent to INAG in response to the Chairman's Introduction in INAG 35. This is a good example of the way in which quantities derived from ionosonde measurements can be "Complementary to research done using expensive or elaborate equipment".

There are many advantages of ground-based methods of ionospheric investigation, for example, they enable the continuous observation of the upper atmosphere simultaneously from several points of the Earth's surface. Moreover, these measurements may be scaled and controlled with in situ measurements by rockets and satellites. Thus, the indications of ground-based observations, interpreted by means of in situ measurements, might be used to monitor phenomena not possible by rocket or satellite methods.

The parameters of the sporadic E layers, derived from the vertical sounding of the ionosphere in mid-latitudes, may directly be connected with the dynamical conditions of the upper atmosphere. As Reddy and Matsushita (1968) have shown, the effective vertical shear of the horizontal wind can be computed from the Es parameter, fbEs, using the wind-shear theory of mid-latitude sporadic E. If the height of the Es layer is also taken into consideration in this procedure and the background electron density is computed using an ionospheric model (e.g. the International Reference Ionosphere 1979), then the height variation of the vertical wind shear can also be determined (Bencze, 1980). In this method, h'Es is considered as the real height of the Es layer and foE is used for the determination of the background electron density from an ionospheric model. The measured parameters fbEs, h'Es and foE, are used to ensure that the computed values approximate the actual values as well as possible.

Further dynamical quantities may be computed, if we realize that the gradient of the Richardson's number, giving the criterion of turbulence, is the ratio of the vertical gradient of temperature to the square of the vertical shear of the horizontal wind. Although the basic equation of wind-shear theory supplemented by Chimonas (1974) includes turbulent diffusivity, this can not directly be determined because there is more than one unknown quantity in the equation - the wind-shear and the turbulent diffusivity. The vertical gradient of temperature can be computed using an atmospheric model (e.g. CIRA 1972), hence the gradient of Richardson's number may be determined. In studies on the structure of atmospheric turbulence, the relations between the intensity of turbulence, the gradient of Richardson's number and the horizontal wind have also been investigated. We compute the intensity of turbulence from the relation thus found (Lumley and Panofsky, 1964). The horizontal wind should be measured, or may be calculated using an atmospheric model. The turbulent diffusivity and the rate of turbulent dissipation are calculated from the turbulent intensity (Bencze, 1981).

Using the method outlined above, the vertical shear of the horizontal wind has been studied during stratospheric warmings (Bencze, 1980). It has been found that the wind-shear decreases during circulation disturbances in the lower thermosphere connected with stratospheric warmings. Since the wind-shear is proportional to the intensity of turbulence, this means that the turbulent intensity and turbulent diffusivity also decrease in such periods.

Further studies using this method were aimed at the determination of turbulent parameters during and after geomagnetic disturbances. It has been found that during 12 selected geomagnetic disturbances of the year 1973, turbulent diffusivity decreases. Since most of the data refer to altitudes above 120 km, this is in agreement with the conclusions of other investigations. Also, the height of the turbopause has been determined as that height, where molecular diffusivity, which increases with rising altitude, is equal to the turbulent diffusivity. The height of the turbopause is an important factor controlling the composition of the neutral upper atmosphere. For a given height in the ionosphere, a rise of the turbopause results in increased concentration of molecular gases (O_2, NO) and decreased concentration of atomic oxygen, conversely a fall of the turbopause produces increased concentration of atomic oxygen and decreased concentration of molecular gases at a given height.

Thus, adopting our method, the parameters fbEs, h'Es and foE read from ionograms can be used for synoptic investigations of such quantities, as turbulent parameters and composition changes in the lower thermosphere.

References

Bencze, P., 1980. Acta Geodaet Geophys. et Montanist. Acad. Sci. Hung., 15, 247.

Bencze, P., 1981. Manuscript.

Chimonas, G., 1974. J. Atmos. Terr. Phys., 36, 235.

Lumley, J. L. and Panofsky, H. A., 1964. The St Structure of Atmospheric Turbulence. Interscience Publishers, New York.

Reddy, C. A. and Matsushita, S., 1968. J. Atmos. Terr. Phys., 30, 747.

Zimmerman, S. P. and Murphy, E. A., 1977. In Dynamical and Chemical Coupling Between the Neutral and Ionized Atmosphere. Eds. B. Grandal and J. A. Holtet, D. Reidel Publ. Co., Dordrecht, Holland.

10. MASTER LIST OF VERTICAL IONOSPHERIC STATIONS

INAG is trying to compile a list of all ionospheric stations which are currently operating, together with those which have operated in the past. The list of stations reproduced on the following pages is incomplete. For example, the geographic co-ordinates, the opening and closing dates of many stations, are not known; even stations may not be included in the list. Every reader of the INAG Bulletin is requested to check the entries of the stations about which they have some information and send any corrections and additions to either R 0 Conkright at WDC-A or A S Rodger at BAS.

Both addresses are on page 1 of the Bulletin. INAG is most grateful to R W Smith and C Doidge of WDC-C1 in UK and to R 0 Conkright and his colleagues at WDC-A in USA for their work in preparing this list.

MASTER LIST OF IONOSPHERIC VERTICAL SOUNDING STATIONS

STATION	LAT	LONG	CODE		OPEN	CLOSE	ALTERNATIVE NAME
ABERYSTWYTH	52.43	355.93	AB		12/61	12/61	
ACCRA	5.63	359.83	AG		8/61	7/63	LEGON
ADAK	51.90	183.40	AD	651	10/45	12/65	
ADELAIDE	-34.60	138.40					
AHMEDABAD	23.02	72.60	AH	223	2/53	CLOSED	
AKITA	39.70	140.10	AK	539	12/49		
ALERT	82.60	297.40	AL	J82	8/57	12/58	
ALMA-ATA	43.25	76.92	AA	343	1/43		
AMDERMA	69.46	61.41					
ANCHORAGE	61.20	210.10	AN	761	4/49	12/65	
ARCTICA 1	82.00		XA	483			
ARCTICA 2	86.00		XC	687			
ARCTICA (NP- 6)	82.40	9.50	XG		7/57	9/59	
ARCTICA (NP- 7)	86.40	296.60	XH		7/57	3/59	
ARCTICA (NP- 8)	80.00	165.00	XI		6/60	11/61	
ARCTICA (NP-10)	78.00	165.00	XJ		12/62	4/64	
ARCTICA (NP-11)	79.00	165.00	XK		7/62	10/62	
ARCTICA (NP-12)	79.00	187.00			5/63	4/64	
ARCTICA (NP-13)	81.00	165.00	XL		7/64	9/66	
ARCTICA (NP-16)	78.08	176.48	XM	676	6/68	3/70	
ARCTICA (NP-19)	78.00	150.00	XP		7/70	10/72	
ARECIBO	18.50	293.17	AR	J19	6/63		
ARGENTINE IS	-65.20	295.70	AI	J6M	5/48		PORT LOCKROY
ARKHANGELSK	64.60	40.50	AZ	163	NK		
ASHKHABAD	37.90	58.30	AS	237	/56		
ATHENS	38.00	23.60	AT	138	12/43		SCARAMANGA
AUCKLAND	-37.00	175.00	AU	63P	1/67		
BADDOW	51.70	0.50	01	061	11/40	4/46	
BAGNEUX	48.80	02.30	55	039	3/47	12/49	
BAGUIO	16.40	120.60	BF	416	3/52	1/64	
BAIE ST PAUL	47.38	289.45	PL	J48	11/61	2/62	QUEBEC
BAKER LAKE	64.30	264.00	BL	964	2/49	2/59	
BANDOENG	- 6.90	107.60	02	400	5/43	9/45	
BANGKOK	13.70	100.60	BK	314	8/63		
BANGUI	4.60	18.60	BI	104	2/58	9/66	
BARBADOS	13.12	300.40	BS	J13	1/57	6/67	
BARROW	71.30	203.20	BW	771	12/49	11/65	POINT BARROW
BARTER ISLAND	70.00	216.00					
BATAVIA	39.40	275.90	03	939	9/51	10/52	
BATON ROUGE	30.50	268.80	04	930	7/43	9/53	
BAUDOUIN	-70.40	23.30	BB	171	4/58	2/67	
BEDFORD	42.00	289.00					
BEIJING							

BEKESCSABA	46.40	21.20	BF	147			BUDAPEST
BELGRANO	-77.90	321.40	GE	A70	7/58	CLOSED	
BEOGRAD	44.80	20.50	BE	145	3/58		BELGRADE
BEVERIDGE	-37.29	144.59					
BILLERICA	-04.00	15.00	LZ				
BLUMENAU							
BOGOTA	4.50	285.80	BG	J05	8/45	6/67	
BOMBAY	19.00	72.80	BM	219	8/45	CLOSED	
BOSTON	42.40	288.70	56	J43	3/45	7/51	MAYNARD BILLERICA
BOULDER	40.00	254.70	BC	840	7/58		
BRAZZAVILLE	-04.00	15.00	LZ				
BRETIGNY	49.00	358.00	GN				
BRIBIE IS	-27.50	152.90					
BRISBANE	-27/50	152.90	BR	52P	6/43		
BUDAPEST	46.77	21.10	BU	147	1/56		BEKESCSABA
BUENOS AIRES	-34.50	301.50	BA	J3M	2/50	CLOSED	
BUNIA	01.50	30.20	BN	102	10/57	11/60	
BURGHEAD	57.70	356.30	06	063	1/41	1/47	
BYRD STATION	-80.00	240.00	BI)	88!	7/57	12/70	
CAIRO	30.00	31.19	05	130	11/45	9/46	
CALCUTTA	23.00	88.60	CU	322	7/44	NK	HARINGHATA
CAMBRIDGE	52.00	00.00					
CAMDEN	-34.00	150.67	CD				
CAMPBELL IS	-52.50	169.20	CI	65K	4/44		
CANBERRA	-35.30	149.00	CB	53N	3/37		
CAPE HALLETT	-72.30	170.20	HT	67K	1/57	2/64	
CAPE JONES	55.00	280.00					
CAPE KENNEDY	28.00	279.40	CC	929	3/58	6/66	CAPE CANAVERAL
CAPE PARRY	70.17	179.50	CE	870	OPEN FOR CAMPAIGNS		
CAPE SCHMIDT	68.90	179.50	CE	669	1/60		
CAPETOWN	-34.10	18.30	CT	13M	9/44	5/71	HERMANUS
CAPE YORK	-11.00	142.40	07	51J	12/44	5/46	
CAPE ZEVGARI	34.60	32.90	CV	135	1/64		CYPRUS, AKROTIRI
CASABLANCA	33.60	352.40	CA	033	10/51	2/58	
CASEY	-66.28	110.33	CW	460	2/69	12/75	WILKES
CENTRO GEOFISICO	23.00	277.80					CUBA
CHANGCHUN							
CHICLAYO	-06.80	280.20	CY	90P	7/57	5/59	
CHIMBOTE	-09.10	281.40	CM	90R	7/57	5/59	
CHITA	52.00	113.50	CX	452	1/46	5/63	
CHRISTCHURCH	-43.60	172.80	GH	64L	9/42		GODLEY HEAD
CHRISTMAS IS	1.90	202.70	08	701	12/44	7/46	
CRUNKING	29.40	106.30	09	429	8/45	10/49	
CHUNG-LI	25.00	121.00	CL				TAIPEI
CHURCHILL	58.80	265.80	CH	958	7/43		
CLYDE RIVER	70.50	291.40	CR	J70	10/43	10/58	BAFFIN
COCOA	28.20	279.40	10	928	1/52	6/52	
COCOS IS	-12.20	96.80	C5	31K	11/61	10/74	
COLLEGE	64.90	212.20	GO	764	7/41		FAIRBANKS
COLLM	51.00	13.00					

COLOGNE	51.00	07.00					KOLN
COLOMBO	6.90	79.87	11	306	4/45	7/46	
CONCEPTION	-36.60	287.00	CP	J30	10/57		
CORAL HARBOUR	64.00	277.00					
CUBA	23.00	278.00	CD	923	8/64		CENTRO GEOFISICO
DAIRAN	39.00	121.60	12	439	12/44	2/45	
DAKAR	14.70	342.58	DK	A14	5/49		
DAPANGO	10.80	000.10	DA	011			TOGO
DECEPCION	-63.00	299.30	DE	J6L	1/51	11/67	
DELHI	28.60	77.16	DH	328	1/42	CLOSED	
DE BILT	52.10	5.20	DT	053	11/49		
DIXON	73.50	80.40	DI	373	7/57		
DJIBOUTI	11.50	42.80	DJ	111	10/51	8/81	
DOMONT	49.00	2.30	12	062	3/50	4/51	
DOURBES	50.10	4.60	DB	049	6/57		
DURBAN	-29.80	31.00					
DUSHANBE	38.57	68.78	DS	238	7/57		
EAST GRANDFORKS	49.00	263.00	GF				
EBRO	40.80	00.30	EB	040			TORTOSA
EDINBURGH	56.00	357.00	ED				
EGLIN AFB	30.38	273.30	EG	930	3/64	1/69	
EIGHTS	-75.23	282.84	EI	97N	12/61	9/65	SKY HI
EKALI	38.00	23.00					
ELIZABETHVILLE	-11.60	27.50	EZ	11J	4/52	6/60	KARAVIA
ELLSWORTH	-77.72	318.90	EL	A7P	7/57	11/72	WEDDELL SEA
EL ARENOSILLO	37.10	353.27			12/69		
ERIE	40/01	254.70	ER	842	6/69		
ERROL	44.79	288.87			11/68	4/74	
EUREKA	80.00	274.10	EU	980	7/57	1/59	
FAREWELL	62.00	206.00					
FIJI	-18.00	178.20	14	61Q	4/46	4/48	
FLETCHER'S ICE	75.90	235.70	XC	982	6/57	1/59	
FORTALEZA	- 3.70	321.20	FZ	AOM	/74		
FORT ARCHAMBAULT	9.20	18.35	FA	109	1/69	2/74	
FORT CHIMO	58.10	291.60	FC	J58	4/49	12/58	
FORT MONMOUTH	40.40	285.90	FM	J40	3/55		
FORT MYERS	27.00	278.00	FØ				
FORT NORMAN	64.90	234.50	FN	864	7/57	10/58	
FORT YUKON	67.00	215.00					
FRASERBURGH	57.60	357.90	15	065	3/48	9/51	
FREIBURG	48.10	07.60	FR	048	7/46	12/76	BREISACH
FROBISHER BAY	63.80	291.40	FB	J63	9/57	1/59	
FUJI SHIP	00.00	000.00			11/65	4/67	
FUKAURA	40.60	139.90	16	541	3/47	12/49	
GARCHY	47.30	03.10	GY	042	10/59		
GENOVA	44.60	09.00	GV	044	5/56	12/73	
GIBILMANNA	37.59	14.01	GM	037	4/76		
GODHAVN	69.30	306.50	GO	J69	11/51		
GOOSE BAY	54.30	299.67	GS	J53	2/72		
GORKY	56.15	44.28	GK	156	3/58		

GRAHAMSTOWN	-33/30	26/50	GR	13L	3/58		
GRAND BAHAMA	26.60	281.80	GB	926	6/57	6/71	
GRAZ	47.10	15.50	GZ	146	8/47		
GREAT WHALE	55.00	282.00					
GUAM	13.50	144.87	17	513	12/44	5/56	
GUANGZHOV							
HAIFA	32.82	34.98	HA	132	1/60		
HAINAN IS	18.30	109.30	18	419	6/42	7/43	
HALLEY BAY	-75.50	333.40	HB	A7N	6/57		
HANKOW	30.70	114.30	19	432	9.41	1/45	
HANOVER	43.70	287.80	HN	J44	11/68	4/74	
HEISS IS	80.60	58.00	BT	280	1/38		TIKHAYA BAY
HERMANUS	-34.42	19.23	HE	13N	5/71		CAPE TOWN
HIGHGATE SPGS	45.01	286.91					
HIRAISO	36.40	140.60	20	536	7/36	8/45	
HIRATSUKA	35.30	139.30	21	533	12/40	5/45	
HOBART	-42.90	147.30	HO	54K	12/45		
HOLLANDIA	- 2.50	140.80	HL	50K	12/57	2/59	
HONG KONG	22.33	114.20	HK	423	1/69		
HUANCAYO	-12.00	284.70	HU	91K	11/37		
HUNTSVILLE	34.44	273.65	HV	934			
HYDERABAD	17.35	78.47	HY	317	5/63		
IBADAN	07.40	03.90	IB	007	12/51		
ILO	-17.40	288.80	IL	J1P	2/59	5/59	LA PAZ, JULIACIA
INVERNESS	57,40	355.80	IN	056	10/51	6/63	
IRKUTSK	52.50	104.00	IR	352	/56		
ISTANBUL	41.00	29.00	IS				
IVALO	69.00	28.00					
JAMAICA	18.00	283.20	JA	918	4/62	/74	
JICAMARCA	-11.95	283.14	JI	91J	4/62		
JODRELL BANK	53.00	358.00					
JOHANNESBURG	-26.10	28.10	JO	120	5/46		
JULIACA	-15.50	289.80	JU	J1N	3/59	5/59	ILO, LA PAZ
JULIUSRUH/RUGEN	54.60	13.40	JR	055	4/57		
JYVASKYLA	62.00	26.00					
KALININGRAD	54.70	20.62	KL	154	2/64		
KAMINOGE	35.60	139.60	22	532	1/45	8/45	
KANO	12.00	09.00	KN				
KARAGANDA	49.82	73.08	KR	250	8/64		
KASHIMA	36.00	141.00	KX				
KAUAI	22.00	200.00	KW				
KENORA	9.80	265.60	KE	948			WINNIPEG
KERGUELEN	-49.35	70.24	KG	24R	2/53		
KERMADEC	-29.20	182.10	KC	62R	6/43	9/72	RAOUL IS
KEVO	70.00	26.00					
KHABAROVSK	48.50	135.10	KB	548	9/59		
KHARKOV	49.00	37.00					
KHARTOUM	15.55	32.58	23	115	3/52	3/54	
KIEV	50.72	30.30	KV	151	1/64		
KINGSTON	08.00	283.20					

KING SALMON	58.00	203.00					
KINSHASHA BINZA	- 4.50	15.20	LB	10M	2/52		LEOPOLDVILLE
KIRUNA	67.84	20.42	KI	167	3/49		
KJELLER/OSLO	60.00	11.10	OS	059	4/42	1/59	
KNOB LAKE	55.00	293.00					
KOCHEL	47.70	11.40	24	064	1/41	/46	
KODIAKANAL	10.20	77.50	KO	310	7/52		
KODIAK	57.78	207.60	RD	758	1/79		
KOKOBUNJI	35.70	139.50	25	535	8/43	12/44	TOKYO
KOLBERG BERLIN	52.00	14.00					
KOOTWIJK	55.00	06.00					
KOUROU	22.00	13.00	KF				
KUHLUNGSBORN	54.10	11.80					
KWAJALEIN	09.05	167.20	26	609	1/45		
KYOTO	35.10	135.50					
LANCASTER	53.00	358.00					
LANCHOW	36.10	103.80	27	336	12/46	7/49	
LANNION	48.45	356.73	LN	047	1/71		
LAUDER	-45.00	170.00	LR				
LA PAZ	-16.50	291.90	LP	J10	10/57	CLOSED	ILO JULIACA
LA QUIACA	-22.10	294.40	LQ	J2K	6/58	1/59	
LA REUNION	-21.10	55.90	LR	22J	10/81		
LEGON	06.00	00.00					ACCRA
LEICESTER	52.00	359.00					
LENINGRAD	59.95	30.70	LD	160	1/39		
LEOPOLDVILLE	- 4.38	15.25					KINSHASA BINZA
LEYTE	11.00	125.00	28	411	6.45	9.48	
LIMA	-12.00	283.00	LM				
LINCOLN	40.82	262.32					
LINDAU	51.65	10.10	LI	050	11/47	7/79	
LITTLE AMERICA	-78.20	197.80	LA	770	7/57	12/58	
LONGYEARBYEN	78.20	15.70	LG	178	6/56	8/59	
LOPARSKAYA	68.00	33.00	LS	168			MURMANSK
LOSHAN	29.50	103.70	29	329	1/46	5/46	
LULEA	65.60	22.10	LU	165	9/47	/69	
LWIRO	-02.30	28.80	LW	10K	2/52	8/67	
LYCKSELE	64.62	18.76	LY	164	1/57		
MACAU	22.20	113.60	MC	422	5/58		
MACQUARIE IS	-54.50	159.00	MW	55M	6/50	11/58	
MADRAS	13.10	80.30	MD	313	7/44	/70	
MAGADAN	60.00	151.00	NN				
MAKASSAR	- 5.20	119.50	30	40N	1/44	11/44	
MANIB	14.39	120.59					
MANILA	14.60	121.00	MN	414	3/44		
MANZHOULI							
MARION IS	-46.87	37.85	MR	140	7/57	5/80	
MAUI	20.80	203.50	MA	720	3/44		
MAWSON	-67.60	62.90	MW	26P	2/58		
MAYNARD	42.43	288.55	MY	J43	10/70	6/75	BOSTON, BILLERICA
MEANOOK	54.60	246.70	ME	855	7/57	1/59	

MEGURO	35.60	139.70	31	534	6/34	12/40	
MEXICO C1TY	19.40	260.30	MX	919	4/58		EL CERRILLO
MICHURIN							
MIEDZESZYN	52.20	21.20	MZ	152	7/58		WARSAW
MILLSTONE HILL	42.60	288.50	MH	J45	4/63		
MINNEAPOLIS	45.00	267.00					
MIRNY	-66.50	93.00	MI	360	4/56	1/73	
MOLODEZHAYA							
MOOSONEE	51.00	279.00					
MOSCOW	55.50	37.30	MO	155	3/44		KRASNAYA PAKHRA
MUNDARING	31.99	116.31	MU	43K	4/59		WATHEROO
MURMANSK	69.00	33.00	MM	168	3/56		LOPANSKAYA
NAIROBI	-0.128	36.83	NR	10J	3/52		
NANKING	32.10	119.00	32	432	9/47	1/49	
NARSSARSSUAQ	61.20	314.55	NQ	J61	9/50		
NATAL	-05.70	324.80	NL	AON	8/57	CLOSED	
NEUSTRELITZ	53.00	13.00					
NHA TRANG	12.25	109.20	33	412	7/51	4/56	
NORFOLK IS	-29.00	168.00	NI	63!	2/64		
NORILSK	69.40	88.10	NO	369	1/68		
NOVOKAZALINSK	45.77	62.12	NK	246	3/64		
NOVOSIBIRSK	54.60	83.20	NS	355	1/69		
NURMIJARVI	60.50	24.60	NU	159	1/57		
OKINAWA	26.30	127.80	OK	426	4/46		
ORRORAL	-36.00	149.00	OL				
OSLO	60.00	11.10	OS	059			
OTTAWA	45.40	284.10	OT	945	1/42		
OUAGADOUGOU	12.37	358.47	OU	012	5/66		
OULU	65.00	26.00					
PALAU IS	7.30	134.50	34	407	7/39	6/44	
PALMYRA	5.38	197.82	35	705			
PANAMA	9.40	280.10	PN	909	6/51	12/58	BALBOA HEIGHTS
PARAMARIBO	5.80	304.80	PH	J06	7.57		
PARAMUSHIRO	50.10	155.30	36	550	11/43	10/44	
PARIS SACLAY	48.10	2.30	SC	047	6/60	12/70	
PATRICK	28.20	279.40					
PAULISTA							
PAXSON	63.00	214.00					
PEIPING	39.90	116.40	37	440	4/46	12/48	
PENANG	5.50	100.40	38	305	3/44	8/45	
PENN STATE UNIVERSITY	41.00	282.00					
PESHAWAR	34.00	71.50	234	8/45	5/47		
PETROPAVLOVSK	53.02	158.65					
PITCAIRN IS	-25.00	230.00	40	82N	10/44	12/45	
PLATTEVILLE	40.01	254.80	PV	842	10/70	8/71	
PODKAMENNA							
POINT ARGUELLO	35.60	239.40	PA	836	7/63		
POITIERS	46.57	0.35	PY	046	7/48		
POPAYAN	2.45	283.38	PP	902	5/70		
PORTAGE LA PRAIRIE	49.90	261.70	41	950	9/46	4/51	

PORT LOCKROY	-64.80	296.50	J	J6M	5/48	12/61	ARGENTINE IS
PORT MORESBY	- 9.40	147.10	PY	50R			
PORT STANLEY	-51.70	302.20	PS	J5J	12/45		
PRETORIA	-26.00	28.00	PE				
PRINCE ALBERT	53.00	254.00	PB				
PRINCE RUPERT	54.30	229.70	42	854	6/45	6/54	
PROVIDENYA	64.40	186.60	PD	664	3/57		
PRUHONICE	50.00	14.56	PQ	052	4/58		PRAGUE, PANSKA-VES
PUERTO RICO	18.50	292.80	PR	J18	2/41	6/63	RAMEY AFB
PULLMAN	47.00	243.00					
QUETTA	30.20	67.00	QT	230	10/57	12/64	
QUITO	- 1.00	281.00	QO				
RABAT	33.90	353.90	RT	034	2/58		
RAMAY	05.00	292.80					
RANGOON	16.80	96.50	43	316	6/4?	2/45	
RAOUL IS	-29.20	182.10					KERMADEC
RAROTONGA	-21.20	200.20	RA	72J	1/45	3/80	
RESOLUTE BAY	74.70	265.10	RB	974	2/49		
REYKJAVIK	64.10	338.20	RK	A64	4/44	12/64	
RIVER SWAN	52.10	258.80					
ROME	41.90	12.52	RO	041	1/51		
ROSMAN	35.00	277.00	RM				
ROSTOV	47.20	39.68	RV	149	1/57		
ROVANIEMI	66.00	26.00					
SACHS HARBOR	72.00	234.85	SH	872	OPEN FOR CAMPAIGNS		
SALEKHARD	66.50	66.70	SD	266	7/57		
SALISBURY (AUST)	-34.70	138.60	SR	53M	10/62	10/73	
SALISBURY (RHOD)	-17.80	31.00	SY	11P	1/58	12/58	
SANAE	-70.30	357.60	QM	07!	6/62		
SANTIAGO	-33.00	289.00	NT				
SAN JOSE	-22.70	324.80	BZ	J2L			SAO JOSE DOS CAMPOS
SAN JUAN (ARG)	-31.55	291.50	SN	J3J	6/80	CLOSED	
SAN SALVADOR	24.10	285.50	SS	J24	11/58	2/65	
SANYA	-18.30	109.30					
SAO PAULO	-23.50	313.50	SP	J2L	8/53	5/65	
SARDINIA	39.00	09.00	ES				
SASKATOON	52.10	253.40					
SCHWARZENBURG	46.60	6.70	SZ	045	12/50	11/75	SOTTENS
SCOTT BASE	-77.90	166.80	SB	670	3/57		
SEATTLE	47/75	237.58	SE	847	1/58	10/60	
SEOUL	37.39	126.39	SU	437	10/66		
SHEEP MOUNTAIN	62.00	212.00					
SHEFFIELD	53.00	359.00					
SHIBATA	37.90	139.30	44	537	11/45	10/49	
SHIKUKA	49.30	143.00	45	549	10/40	12/41	
SIMEIS	45.00	34.00					
SIMFEROPOL	44.80	34.10	SF	144	1/57	12/59	
SINGAPORE	1.40	103.70	SI	301	2/43	7/71	
SLOUGH	51.50	359.43	SL	051	1/30		
SLUTSK	59.70	30.50	46	151			

SNAINTON	54.20	00.00	46	050	8/44	9/44	
SODANKYLA	67.40	26.60	SO	166	8/57		
SOFIA	42.70	23.40	SQ	143	/60		
SOTTENS	46.70	6.70					SCHWARZENBURG
SOUTH ATLANTIC	-52.00	302.00	FS				
SOUTH GEORGIA	-54.27	323.50	SG	A5M	7/70		
SOUTH POLE	-90.00	00.00	PO	09!	7/57	3/68	POLE STATION
SOUTH UIST	57.20	352.86	US				
SOYA SHIP	-60.00	00.00	XD		1/56	5/62	
STANFORD	37.40	237.80	ST	837	2/42	3/75	SAN FRANCISCO
ST JOHNS	47.60	307.30	SJ	J47	5/44	9/81	
ST KILDA	-38.00	139.00	KA				
SVERDLOVSK	56.70	61.10	SV	256	5/44		
SWANSEA	52.00	356.00					
SWAN RIVER	52.10	258.80	48	952	4/46	8/46	
SYDNEY							
SYOWA BASE	-69.00	39.60	SW	16R	2/59		SHOWA
TAHITI	-17.70	210.70	TT	71P	12/57		TARAVAO
TAIPEI	25.00	121.20	TP	424	3/50		CHUNG LI
TALARA	-04.60	278.70	TA	90M	10/54	12/65	
TAMANRASSET	22.80	5.53	TN	022	2/56	/70	
TANANARIVE	-18.80	47.50	IV	21Q	11/51	5/72	
TANGERANG	- 6.17	106.63	OP				
TASHKENT	41.33	69.62	TO	241	9/61		
TIBLISI	41.70	44.80	TB	142	6/63		
TEHRAN	35.70	51.40	TE	236	4/63		
TERRE ADELIE	-66.66	140.02	DU	560	12.49		DUMONT D'URVILLE
THE PAS	54.00	259.00	49	954	5/46	12/53	
THULE (TUTO)	76.40	291.30	TH	J76	7/55	6/66	
THULE (QANAQ)	77.50	290.80	TH	J77	9/68		
THUMBA	8.60	76.90	TC	309	10/64		TRIVANDRUM
TIRUCHIRAPALLI	10.80	78.70	TI	311	2/49	CLOSED	
TIXIE BAY	71.60	129.80	TX	471	7/57		BUKHTA TIKSY
TOGO	10.80	0.40	TG	011	7/65	2/67	DAPANGO
TOKYO	35.70	139.50	TO	535	6/34		KOKOBUNGI
TOMSK	56.50	84.90	TK	356	3/37		
TORRECHIARUCCIA.	42.00	12.00					
TORTOSA	40.80	0.30	EB	040	5/57		EBRO
TOWNSVILLE	-19.63	146.65	TV	51R	6/46		
TOYOHARA	46.90	142.80	50	546	9/42	8/44	
TRELEW	-43.20	294.70	TW	J4L	4/58		
TRINIDAD	10.75	298.43	51	J10	2/44	6/51	
TRIVANDRUM	8.50	77.00	TM	308	1/57	10/64	THUMBA
TROMSO	69.70	19.00	TR	169	8/32		
TSITSIHAR	47.30	123.90	52	447	4/40	8/45	
TSUMEB	-19.20	17.70	TS	11R	7/57	12/75	
TUCUMAN	-26.90	294.60	TU	J20	7/57		
TUNGUSKA	61.60	90.00	TZ	362	1/68		
ULASKA	65.00	212.00	UL				
UNALASKA	54.00	193.00					

UPPSALA	59.80	17.60	UP	158	11/51		
USHUAIA	-54.80	291.70	UA	J15M	11/57		
VAL D'OR	48.00	282.00					
VANIMO	- 2.70	141.30	VA	50L	7/64		
VICTORIA BEACH	50.80	263.92	53	951	7/45	9/45	
VICTORIA	48.40	236.60	VI	848	7/57	1/59	
VOLGOGRAD							
VOSTOK	-78.40	106.90	VO	47P	3/58		
WAKKANAI	45.40	141.70	WK	545	3/47		MOSHIRI
WALLOPS IS	37.90	284.50	WP	937	7/63		
WALTAIR	18.00	83.00					
WASHINGTON	38.70	282.90	WA	938	12/29	9/58	BELVOIR
WATHEROO	-30.30	115.90	WT	43!	4/35	3/59	MUNDARING
WELLINGTON	-41.00	175.00					LOWER HUT
WHITE SANDS	32.30	253.50	WS	832	6/46	3/82	
WILDWOOD	61.00	309.00					
WILKES	-66.90	110.50	WL	460	7/57	1/69	CASEY
WINKFIELD	51.00	359.00	WK				
WINNIPEG	49.80	265.60	WI	949	4/51	12/76	KENORA
WOOMERA	-31.00	138.60	WO	53J	5/61	12/69	
WUCHANG	30.60	114.40	54	430	8/46	5/49	
WUHAN	30.50	114.35	WU	430			
YAKUTSK	62.00	129.60	YA	462	2/57		
YAMAKAWA	31.20	130.60	YG	431	12/46		
YELLOW KNIFE	62.40	245.60	YE	862	11/57	1/59	
YUZHNO SAKHALINSK	47.00	143.00	SA	547	/56	8/70	
ZARYA SHIP			XF		8/59	11/66	

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11. THE IONOSPHERIC ALPHABET

by W. R. Piggott

As a considerable number of stations have opened since INAG 24 was published, and also as several groups have asked for the full alphabet to be in one place I have decided to reprint the original article, covering letters A-N, together with the second part of the history of the ionospheric alphabet in this Bulletin.

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

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

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

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

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

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

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

The origin of this letter is somewhat controversial, I believe that it came from the original meaning of Deutsch (German) - great people, though it was first introduced in the major organisation of letter symbols made by the World Wide Soundings Committee in preparation for the IGY. Originally, D meant only 'greater than' and was invented for two reasons,

(a) to enable easy transmission of a greater than sign.

(b) to remove confusion between badly drawn greater than signs (>) and numbers in tables. The use of letter D as a descriptive letter followed almost immediately.

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

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

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

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

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

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

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

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

I - Value has been replaced by an interpolated value.

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

J - Ordinary component characteristic deduced from the extraordinary component.

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

K - Presence of a night E layer.

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

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

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

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

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

N - Conditions are such that measurements cannot be interpreted.

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

O - Extraordinary component characteristic deduced from the ordinary component.

It was originally used as an abbreviation for o-mode and hence became used as a qualifying letter to show an x-mode characteristic deduced from an o-mode observation, e.g. fxI and fxEs in the old days when scaled by some stations instead of foEs.

P - Spur type spread F present.

This was first used in 1932-33 when spurs were first observed at Tromso during the second International Polar Year.

Q - Range spread present.

When Huancayo was just opened in 1937 one of its striking peculiarities was the evening spread-F which showed as a range spread trace. This was called equatorial type of spread-F and shortened to Q. The meaning was then broadened to include range spread types seen at other latitudes.

R - Measurement influenced by, or impossible because of, attenuation in the vicinity of critical frequency.

The attenuation due to either absorption, defocussing or a combination of the two, is associated with retardation near the critical frequency. Therefore, it was called retardation attenuation and denoted by R.

S - Measurement influenced by, or impossible because of, interference or atmospherics.

In the early days of ionospheric research, the most important source of interference was atmospherics. These were usually referred to as 'spherics' and this was shortened to S. When interference was important the same symbol was used. Now, of course, S usually refers to interference caused by radio stations.

T - Values determined by a sequence of observations.

When less was known about the interpretation of difficult ionograms and there was much stress on making hourly values representative of the hour, the sequence of ionograms was often used to determine the most representative value, e.g. by using an f-plot. Thus, the time-sequence was employed to get the value - hence the letter T.

U - Uncertain or doubtful value.

Doubtful values have been marked U for uncertain since the earliest days, even before ionosondes were developed.

V - Forked trace which may influence the measurement.

This was originally a sketch of the forked trace, but it rapidly became clear that the presence of a fork was more important than its actual shape. Hence the fork was noted as the letter V.

W - Measurement influenced or impossible because the echo lies outside the height range recorded.

When a trace was seen to move above the top level of recording, particularly on constant frequency records, the limit sign V was used until the trace came back. Thus it was common to see VV which was indicated later as W, the current letter symbol.

X - Measurement refers to the extraordinary component.

Originally, the X letter was used to indicate x-mode values, e.g. when the o-mode critical frequency decreased below fmin. Logically, X should be both a qualifying or a descriptive letter, but as explained for J, J became widely used before the logic was recognised.

Y - Originally intermittent trace, but now lacuna or severe F layer tilt.

The distinction between gradient reflection traces, meteoric traces or diffuse traces and normal traces were recognised many years ago, but the reasons for their appearance were not understood. It was because a convention to identify non-standard traces of these types by Why? or ?, but this notation was inconvenient, so the symbol was shortened to Y. The modern use for Y is to indicate the presence of abnormal traces, when large tilts or lacuna are present, is in accord with the original meaning - showing something special is occurring and worthy of further study.

Z-mode present or measurement deduced from the third magneto-electronic component.

Z was first used to denote the very rarely seen x-mode of reflection below the electron gyrofrequency. The o-mode reflection along the magnetic field line had separately been called z-mode when at the magnetic pole. Propagation in this mode should always be possible whenever there is enough ionization at the critical collision frequency level for the mode to be excited. As a result, this mode is seen over a range of latitudes, particularly for E-layer reflections. When it was realised that scatter and tilts in the ionosphere could enable the mode to be effective for F region reflections over a considerable range of latitude, the use of the letter Z was further extended to include all traces with the characteristic condition of reflection. The z-mode trace in the F layer is clear, even when spread-F is present as there is only one direction from which it can return to the station. For this direction, normally overhead fx - fz = fe. Therefore, it is usually possible to see which parts of the x-mode pattern are oblique.

12. THE NEXT INAG BULLETIN

With the publication of the master station list, it has not been possible to include an article in the Uncle Roy's Column series as there are restrictions on the number of pages in each Bulletin. However, INAG 38 will include several articles on ionogram interpretation and reduction. Also, INAG now has technical descriptions of the University of Lowell Digisonde 256 and of the Stanford Research Institute 610 M1 digital ionosondes. Summaries of these will also be included in INAG 38.

To maintain the regular publication of the INAG Bulletin there is a continuing need for articles, notes and ionograms for interpretation and discussion. Please send your contributions to Alan Rodger (address on page 1).