IONOSPHERIC NETWORK ADVISORY GROUP (INAG)*

Ionosphere Station Information Bulletin No. 7**

I. Introduction

It is with much pleasure that we are able to announce that the URSI Committee of Officers has agreed to make available URSI funds to support the reproduction and circulation of the INAG Bulletin. The earlier issues were financed with the aid of WDC-A to whom we are sure you would wish us to convey our thanks. This publication has only been made possible in the past through the good will of the authorities controlling WDC-A funds and the personal efforts of your contributors and Committee. The generosity of URSI removes the financial difficulties which have continually threatened the continuance of this Bulletin. It is now up to you to use the Bulletin so that the next General Assembly of URSI is convinced that the grant was justified and should be maintained while the Bulletin is useful to you.

The proposals for revisions in rules for Ionogram Interpretation and Reduction raised in previous issues of this Bulletin have generated considerable interest and some controversy which should be resolved before any International recommendations are agreed. It is, however, difficult to get those directly concerned together at one time and place. INAG therefore proposes to hold at least two meetings to discuss these problems, linking them with suitable International meetings and depending on INAG members to represent the views of those not present. Possible opportunities include:

(a) The URSI/STP Committee meeting at Brussels 27-28 July 1971

(b) The URSI General Assembly at Warsaw 1972.

In view of the short notice available before the URSI/STP meeting it will not be possible for all concerned to attend this meeting. However it is easier for some groups to attend this than attend the General Assembly and hence we propose to hold a Discussion Meeting on "Problems of Interpretation of Ionograms" during the period 26-29 July 1971 at Brussels. The exact duration and dates will be notified to those expressing an interest in attending and will depend on the amount of support from you. If you are unable to attend but have problems you wish discussed (preferably illustrated by ionograms) please send details to the Chairman or Secretary of INAG as soon as possible and not later than July 15, 1971.

The main discussions at Brussels will involve the Recommendations of the Leningrad Seminar (INAG-3, p. 1-2; INAG-4, p. 2-11, INAG-5, p. 4-9), FxI rules (INAG-l, p. 9-11), matters raised in the Bulletins or by individual groups (e.g. INAG-2, p. 9-10, INAG-3, p. 19-20, INAG-4, p. 15, INAG-6, p. 18). It has become clear that several of the high latitude problems are also common at low latitudes though the tilts are due to different causes and tend to give different problems on the ionograms.

The low F layer problem (INAG-2, p. 9) is now being studied using top side sounders. The results published so far confirm the interpretation of the ground based ionograms, hmF2 can fall as low as 120 km during quiet days in years of low solar activity. This phenomenon will become more common in the next few years and some collaborative research between ground based and satellite techniques could be valuable. INAG writes notes from stations reporting this phenomenon and suggests that those interested send their names to the Secretary so that they can be put in touch with each other.

As mentioned in INAG-5, p. 15-16, there have been a number of requests for more ionograms to be reproduced in the URSI Handbook 2nd Edition. It is not possible for the editors to collect such ionograms but they invite you to submit possible examples for consideration and reproduction. Please do not complain of lack of examples if you have not sent any.

INAG is aware that the value of the Bulletin is restricted by the difficulty that many of the operators who would like to read them do not understand English sufficiently well. The job of translating all or part of the Bulletins into other languages is quite large but it could be done if we could get a panel of people willing to translate particular articles into French, Russian or Spanish. Are you willing to volunteer? Even a rough translation would be much more valuable than no translation at all. At present, Mlle. Pillet has translated many articles into French, and Drs. Mednikova and Besprozvannaya have helped with Russian translations. We have no Spanish translations.

* Under the auspices of the Solar-Terrestrial Physics Committee of the International Union of Radio Science (URSI/STP Committee).

** Issued on behalf of INAG by World Data Center A, Upper Atmosphere Geophysics, National Oceanic and Atmospheric Administration, Boulder, Colorado 80302, U.S.A. The 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 distribution list should notify WDC-A.

INAG is very pleased with the reception that the Bulletins have received and the growing support from stations and individuals. Administratively we are always open to the criticism that we spend too much time preparing them and considering your problems, and it is helpful if you write to us -- spoken comments are not evidence.

Several groups interested in the measurement of ionospheric absorption have asked whether the Bulletins could be extended to cover their problems also. Rocket measurements of the electron density and collision frequency profiles with height and the availability of computers have transformed the problems of interpreting these data and the results obtained in the ICY and IQSY show that the morphology of the D region is almost as complex as that of the F region. Thus there is an equatorial anomaly in D-region absorption with low values on the magnetic equator and high about 300 dip, large anomalies in the winter hemisphere and near the auroral zone. The number of stations active is far too small to delineate this morphology and it is possible that some groups operating ionosondes might become interested in the D—region problem also. With modern technology the work involved in obtaining useful data is much less than it has been in the past. Your views are invited. We have previously given some hints on the use of ionogram data for absorption problems (INAG-l, p. 12-13) and a few groups are actually using such methods.

Roughly every three to four years, the C.C.I.R. considers problems which are important from the point of view of practical communications and requests the assistance of URSI in drawing attention to these problems and giving advice to C.C.I.R. on them. Full details can be found in the "Reports of the C.C.I.R. XIIth Plenary Session New Delhi 1970" which are now published by the International Telecommunication Union, Geneva, Switzerland. Three of these are particularly interesting to us:

(1) Reports of the C.C.I.R. XIIth Plenary Session, New Delhi 1970, Volume II, Part .2, "Ionospheric propagation" (This gives the work of Study Group 6), and the two specialized reports (in English, French and Spanish) on the C.C.I.R. interim methods of predicting MUFs and estimating sky wave field intensities,

(2) C.C.I.R. Report No. 340, Oslo 1966,

(3) C.C.I.R. Report No. 252-2, New Delhi 1970 respectively.

Three particular documents from Vol. II, Part 2, which may interest you are reproduced below.

W. R. Piggott
Chairman, INAG and URSI/STP VI Consultant

II. Excerpts from C.C.I.R. XIIth Plenary Assembly, New Delhi 1970. Volume II. Part 2, Ionospheric Propagation (Study Group 6)

QUESTION 2-1/6 (From p. 243)

GEOGRAPHIC DISTRIBUTION AND PROGRAMME OF REGULAR IONOSPHERIC OBSERVATIONS

(1966 - 1970)*

The C.C.I.R.,

CONSIDERING

(a) that the earth is imperfectly covered with ground-based ionosondes which, from the viewpoint of numerical mapping and short-term synoptic studies, are required for making better ionospheric propagation predictions;

(b) that specialized satellite observing programmes can be used to overcome some aspects of the present deficiencies;

(c) that the regular use of oblique incidence point-to-point and backscatter sounders is increasing,

UNANIMOUSLY DECIDES that the following question should be studied:

what are the best worldwide ionospheric observing programmes for:

- long-term predictions;
- short-term predictions (from a few hours to a few days in advance)?

Note.- The Director, C.C.I.R., is requested to transmit this text to U.R.S.I., and IUCSTP for comment.

* Dates of Plenaries acting on the subject.

STUDY PROGRAMME 2-lA-l/6 (From p. 244)

IMPROVEMENT IN THE WORLD-WIDE IONOSPHERIC OBSERVING

PROGRAMME FOR NUMERICAL MAPPING PURPOSES

(1965 - 1966 — 1970)

The C.C.I.R.,

CONSIDERING

(a) that the present world-wide network of ground-based ionosondes, operating regularly and participating in the world-wide interchange of data, is far from ideal from the viewpoint of ionospheric propagation predictions;

(b) that regular satellite observations could be used in ionospheric numerical mapping, but:

- at present, satellite soundings are not conducted often enough in certain regions to permit the deductions of hourly and monthly median values of foF2 and h_{max} with a sufficient degree of accuracy;
- at present the number of telemetry stations for satellites is seriously limited;

(c) that regular oblique-incidence ionospheric observations could be used in ionospheric numerical mapping, DECIDES that the following studies should be carried out

1. the identification of geographical areas within which, for both long- and short-term predictions
   - the installation of new fixed ionosondes would provide significant improvements;
   - the actual density of fixed ionosondes working on a routine basis appears to be satisfactory;
2. the practicability of incorporating in the work of numerical mapping ionospheric observations from satellites when made on a regular basis
   - by comparing soundings from above, within and below the ionosphere to determine whether systematic errors are caused by interference, horizontal electron-density gradients, non-vertical path, etc.;
   - by identifying regions where additional telemetry stations should be established;
3. the practicability of incorporating in the work of numerical mapping ionospheric observations from oblique-incidence sounders, including highly directional backscatter sounders, when made on a regular basis.

Note.- The Director, C.C.I.R., is requested to transmit this text to the U.R.S.I., and the IUCSTP for comment.

OPINION 22-1 (From p. 284-285)

ROUTINE IONOSPHERIC SOUNDING

(1966 - 1970)

The C.C.I.R.,

CONSIDERING

(a) that the routine hourly observations from the existing ground-based network of vertical incidence ionospheric sounding stations make possible continuous improvements in the basic data for long-term ionospheric predictions;

(b) that the efficiency of this network has been considerably improved by the guidance given by international scientific committees since 1956;

(c) that routine observations from satellite programmes can also be expected to contribute to the improvement of long-term ionospheric predictions;

(d) that the existing ground-based network of ionospheric sounding stations represents a very important international effort and, together with satellite and oblique sounding programmes, provides synoptic information that will be indispensable in the ultimate development of techniques for producing short-term predictions;

(e) that the increasing importance of space research and Earth-space communications will require con-tinued collection of the information derived as a matter of routine, together with possible increases and changes;

IS UNANIMOUSLY OF THE OPINION that Administrations should make every effort

1. to continue the operation of the existing ionosonde network, and interchange of basic data through the World Data Centres;
2. to establish new ionosondes at places recommended by the C.C.I.R. in fulfilment of Question 2-1/6;
3. to support any suitable arrangement which may be made by the Inter-Union Commission on Solar-Terrestrial Physics (I.U.C.S.T.P.) for providing scientific guidance needed anywhere in the network;
4. to explore the use of ionospheric data from satellite programmes now available at the World Data Centres for ionospheric predictions.

Note 1.- This Opinion will be brought to the attention of the U.R.S.I., the I.U.G.G., the I.U.C.S.T.P. and the COSPAR.

Note 2.- The Inter-Union Commission on Solar-Terrestrial Physics (I.U.C.S.T.P.) provides a common meeting ground for the four International Unions with interests in some aspect of solar-terrestrial physics : Astronomy (I.A.U.), Geodesy and Geophysics (I.U.G.G.), Radio Science (U.R.S.I.), and Pure and Applied Physics (I.U.P.A.P.).

III. The IF2 INDEX OF SOLAR ACTIVITY

by

W. R. Piggott

The oldest index of solar activity is the Zurich or Wolf Mean Sunspot Number, R. This is a standardized measure of the average number of sunspot groups and spots which would be expected to be visible using a standard telescope in average seeing conditions. The actual number seen by a particular instrument depends on local conditions and the size of the instrument - a large instrument in good seeing conditions can observe an order of magnitude more spots than given by the index.

While statistics are available for this index going back several centuries, we are now in the twentieth cycle in this series - the index itself is a rather indirect measure of solar activity and is loosely linked with both ionizing photon emission from the sun and with solar wind and particle activity. One difficulty is that quite important visible sunspot groups can be quiet and not associated with any change in other types of solar activity. Thus on different occasions a given level of solar activity can be associated with different sunspot numbers ranging over about $\pm$ 10 units from the mean even in years of low solar activity and this can be larger in maximum years. For this reason other indices are preferred when higher correlation is required. These are matched with the sunspot number in order to estimate likely future behaviour so that data from the large statistical group can be used.

In the case of the F2 layer the response of foF2 to changes in solar activity varies with position on the earth, season, time of day and epoch in the solar cycle. Changes in solar output change both the rate of ion production in the region, the circulation in the earth's atmosphere, the electric forces acting on the ionization and probably the chemistry of the atmosphere.

The practical man is more interested in the net effect of all of these variables than in each separately so it is natural to try to use the F-layer data as a measure of the combined influences of changes in solar output. Such an index is also much more closely allied to the actual solar cycle changes in the F2 layer than purely solar indices and gives higher correlation with observations at individual stations. The scatter or noise is about one fifth of that found using a sunspot number.

The IF2 index was prepared originally by Minnis and Bazzard (J. Atmos. Terr. Phys. 18, 297, 1960). Starting in January 1971, the CCIR has added extra stations to those used in preparing the index so as to give a better balance between changes in the Southern and Northern hemispheres - like Kp the original index was slightly biased by more stations in the North than South though the method of analysis minimized effects due to this.

The IF2 index is based on noon observations originally at nine stations but now at thirteen stations. It is thus a measure of the daytime variation of the F2 layer with solar activity. The index was standardized against the sunspot number and is expressed using the same scale. Thus an IF2 number of 100 is equivalent to a sunspot number of 100. Owing to the variations in solar output at constant sunspot number the index can go negative in months of low activity. This means that the actual solar output was less than in the years used for standardization. There is also a discrepancy between the two indices due to the fact that solar output does not vary linearly with sunspot number. The main effect of fitting a linear law is to cause systematic shifts between sunspot number and solar output indices at the extremes of the range.

Inherently IF2 can be used for shorter time intervals than one month. In practice the minimum average period is likely to be about one week without losing accuracy. For even shorter periods the index is much more reliable than sunspot numbers but can be subject to error due to storm effects. With thirteen stations this should be small but the error increases rapidly as the number of usable stations decreases when storms are present.

The four new stations included in the index with effect from 1 January 1971 are:Johannesburg

Moscow

Mundaring

Port Stanley

For IF2 purposes Mundaring is equivalent to Watheroo, a station used in the early investigations.

Current measured and predicted values of IF2 are published by the CCIR monthly, in the URSI Information Bulletin or can be obtained from R.S.R.S., Slough, Bucks., England.

IV. Ionospheric Storm Project

The data resulting from the ISP (see INAG-4, p. 11; INAG-5, p. 16; and INAG-6, p. 9) is steadily flowing to regional coordinators. The ISP comprised two periods: 28 October - 2 November 1970 and 6-12 November 1970.

For the Euro-African meridian, Taieb (Paris) has reported that about two-thirds of what is expected has been received. His preliminary information cites data from Tromso, Sodankyla, Kiruna, Kevo, Nurmijarvi, De Bilt, Garchy, Poitiers, Schwarzenburg (Sottens), Roma, Tortosa, Athens, Haifa, Dakar, Ouagadougou, Djibouti, Ft. Archambault, Ibadan and Tananarive.

The International Satellites for Ionospheric Studies (ISIS) Working Group has agreed to make all Alouette II and ISIS I data acquired during the special ISP days readily available to the scientific community. At the present time, therefore, priority is being given to processing and depositing the relevant topside ionograms in the appropriate data centres; later, it is hoped that data acquired simultaneously by the other experiments on board the satellites (measurements of Te, Ti and energetic particles for example) will also become available. Full details of the ISIS satellites can be obtained from a special issue of the Proceedings of the IEEE (June, 1969).

Between 20 and 30 satellite passes per day were recorded by telemetry acquisition stations. Detailed lists are available from the Radio and Space Research Station, Slough (Attention: Miss P. Dadds) giving (a) Acquisition station, (b) U.T. Latitude and longitude of start of pass, (c) U.T. Latitude and longitude of end of pass, (d) L.M.T. and height of satellite at midpoint of pass. Other World Data Centers have similar information.

Table 1
THE IONOSPHERIC INDEX I_{F2} 1938-1961

Month	1938	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
Jan.	110	138	71	65	49*	16	7	26	38	135	126	125	122	55	40	16	2	5	76	154	172	159	142	67
Feb.	122	98	73	51	46*	15	2	22	76	148	114	142	110	49	38	8	-2	10	89	150	162	162	135	61
Mar.	134	94	84	49	54*	27	18	25	99	142	122	144	112	50	30	2	-2	2	119	151	161	151	111	66
Apr.	130	101	90	37	56*	26	2	35	107	160	154	158	120	68	21	13	2	8	135	154	176	154	121	61
May	125	130	80	33	55**	18*	-6	37*	109	178	158	158	125	84	12	6	-6	19	138	168	184	167	126	58
June	130	128	84	46	28*	18*	2	58	103	150	174	140	124	74	27	2	-14	27	122	166	168	166	124	64
July	146	119	93	56	25*	16	4	48	108	173	157	137	94	72	30	7	-8	41	124	168	151	145	113	60
Aug.	150	113	100	65	21	26	20	48	130	166	154	140	80	66	34	2	0	34	157	166	191	161	117	84
Sept.	137	150	104	66	29	5	14	49	121	179	156	174	66	72	30	6	-10	48	184	182	208	166	155	60
Oct.	117	133	95	58	23	-4	20	74	126	174	147	162	67	65	10	-1	-10	64	183	195	206	143	118	54
Nov.	129	113	84	51	21	-2	4	61	137	175	142	157	56	57	14	-4	-7	68	175	184	189	133	109	36
Dec.	126	86	59	50	22	4	11	46	142	156	144	156	56	56	14	-13	-15	85	182	178	182	151	96	24

Notes: 1. Except for the years 1938-1941, the index values are based on the stations listed by Minnis and Bazzard (J. Atmos. Terr. Phys., Vol. 18, p.297, 1960) but excluding San Francisco.

2. From 1942 onwards, index values based on data from less than nine stations are indicated thus:
* 8 stations ** 7 stations

Table 2
THE IONOSPHERIC INDEX I_{F2} 1962-1970

Month	1962	1963	1964	1965	1966	1967	1968	1969	1970
January	24	14	0*	6	15	79	121	95	109*
February	32	14	6*	5	21	95	109	104	114*
March	58	18	20*	20	33	113	109	127	126*
April	46	16	13*	18	37	114	109	122	130
May	54	23	2*	10	46	115	113	118	144
June	44	10	-3	16	55	92	111	119	(125) GDH
July	32	14	0	15	55	89	96	114	(122) GDH
August	22	18*	-4	11	53	108	104	122*	(119) GDH
September	28	16*	4	9	42	124	121	115*	133
October	30*	8*	3	6	47	125	133	110*	119
November	22*	15*	-2	5	64	106	106	106*	(131) CHU
December	10	2*	-4	-1	66	115	112	108*	(108) CHU

* 8 stations

Where data from some stations are still awaited, provisional I_{F2} values are given in parenthesis and the missing stations are identified as follows:-

CNB: Canberra
GDH: Christchurch
CHU: Churchill
DEL: Delhi
FAI: Fairbanks (College)
HUA: Huancayo
SLO: Slough
TOK: Tokyo
WAL: Wallops Island

V. Topside Sounding

ISIS-2 was successfully launched on 1 April 1971. The orbit is circular at 1400 km, and inclination is essentially polar, as planned. Experiment checkout has been completed and routine operation has commenced.

Excerpts from the NASA Operations Plan which describe the mission and experiments follow:

The International Satellites for Ionospheric Studies (ISIS) program is a joint undertaking of the Canadian and the United States governments for the scientific study of the upper atmosphere. The overall objective of the program is to develop a better understanding of the physics of the ionosphere through a series of spacecraft measurements taken over a large part of the solar cycle. ISIS-2 is the third spacecraft in the ISIS series, The first consisted of Alouette II and Explorer XXXI. The second was ISIS-l.

The primary objective of ISIS-2 is to acquire information on the rates of ion formation in the various production processes, on ionization losses, and on the means of ion transport within the ionosphere, such as diffusion, large-scale wave motions, electric and magnetic fields, and ionospheric winds. ISIS-2 carries instrumentation to fulfill the primary objective by acquiring information on:

- The distribution of free electrons and the various species of ions as a function of time and position. Measurements will be made with sufficient rapidity and over a time interval sufficient to permit investigation of diurnal, seasonal, solar cycle, and disturbance time variations. Measurements will aim at acquiring sufficient spatial resolution to cover as much of the ionosphere as is necessary to permit studies of irregularities, such as spread F and field-aligned ionization,

- The composition and fluxes of energetic particles that interact with the ionosphere,

- The velocity distribution of thermal electrons and ions.

Instruments that obtain information for the primary objective also frequently provide valuable information for other scientific investigations which represent secondary objectives. Secondary objectives are:

- Study solar radio-noise emission,

- Determine cosmic-noise intensity as a function of frequency, and its distribution over the celestial sphere,

- Investigate radio-wave propagation in an ionized medium, including such subjects as whistler mode propagation, radio-wave reflection and absorption, and propagation in an irregular medium,

- Study impedance and radiation patterns of an antenna imbedded in an anisotropic plasma,

- Study the relation between very low-frequency (VLF) emissions and other ionospheric data,

- Study the spacecraft to medium interaction,

- Investigate ion cyclotron resonance,

- Investigate auroral zones.

To supplement and advance the existing scientific study of the ionosphere, the ISIS-2 has the following complement of experiments:

- Swept-frequency sounder
- Fixed-frequency sounder
- VLF receiver
- Cosmic noise
- 136/137-MHz beacon
- Energetic particle detector
- Soft particle spectrometer
- Ion mass spectrometer
- Cylindrical electrostatic probe
- Ion temperature
- Auroral redline photometer
- Auroral scanning photometer

VI. Numerical Maps of Spread-F Occurrence

by

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The worldwide morphology of spread-F occurrence can be investigated by the analysis of the F-notations entered in tabulations of foF2 at stations comprising the ionosonde network. This method of studying ionospheric irregularities has been used by a number of authors (Wright, Koster, and Skinner, 1956; Penndorf, 1962a, 1962b; Tao, 1965; Singleton, 1968).

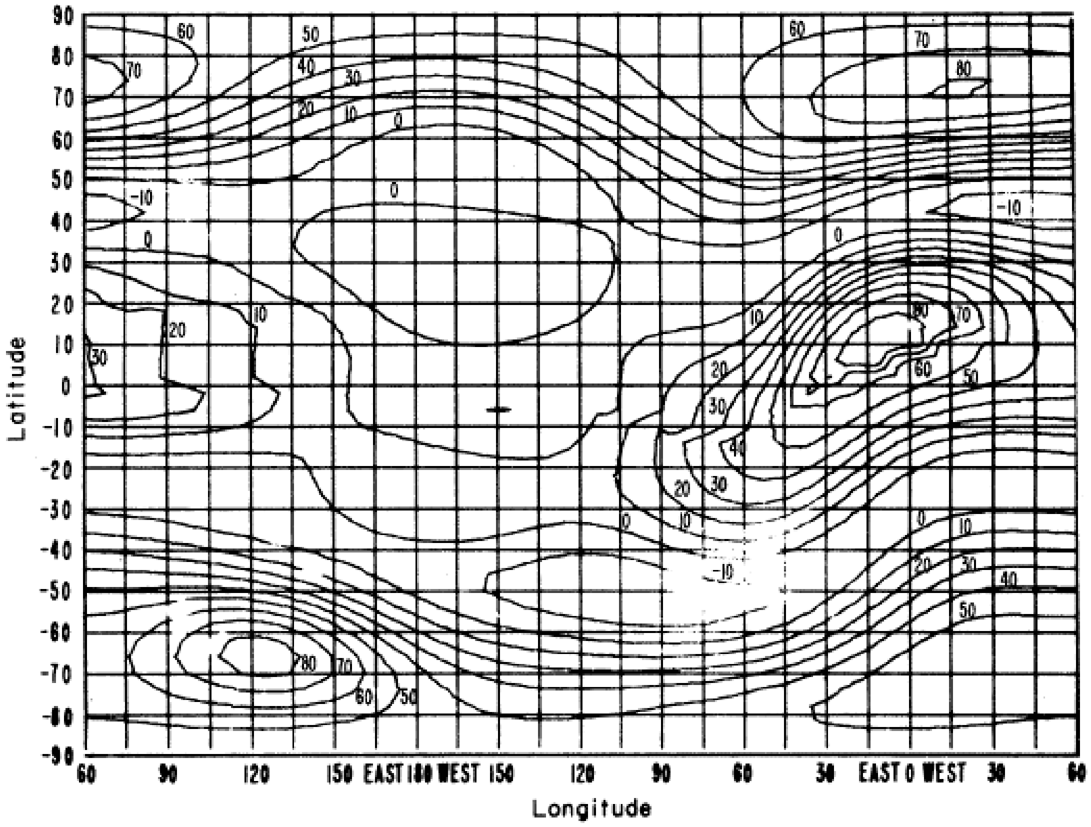
The percentage probability of occurrence of spread F during a month derived for individual stations has been mapped numerically at the Institute of Telecommunication Sciences at Boulder, Colorado. The method used is that developed by Jones and Gallet (1962, 1965) and extended by Jones, Graham, and Leftin (1969).

A numerical map is actually a mathematical function that defines the time and space variations of the variable of interest, in this case the percentage of days (Ø) during a month that spread F occurs at a given universal time hour at a given location, In the figure two examples of the maps are represented by world contour charts. The charts apply to October 1958 and 1964 and to 0000 hours UT**.** Similar maps have been developed for all months of 1958 and 1964; from them (Ø) can be estimated for any location at any time.

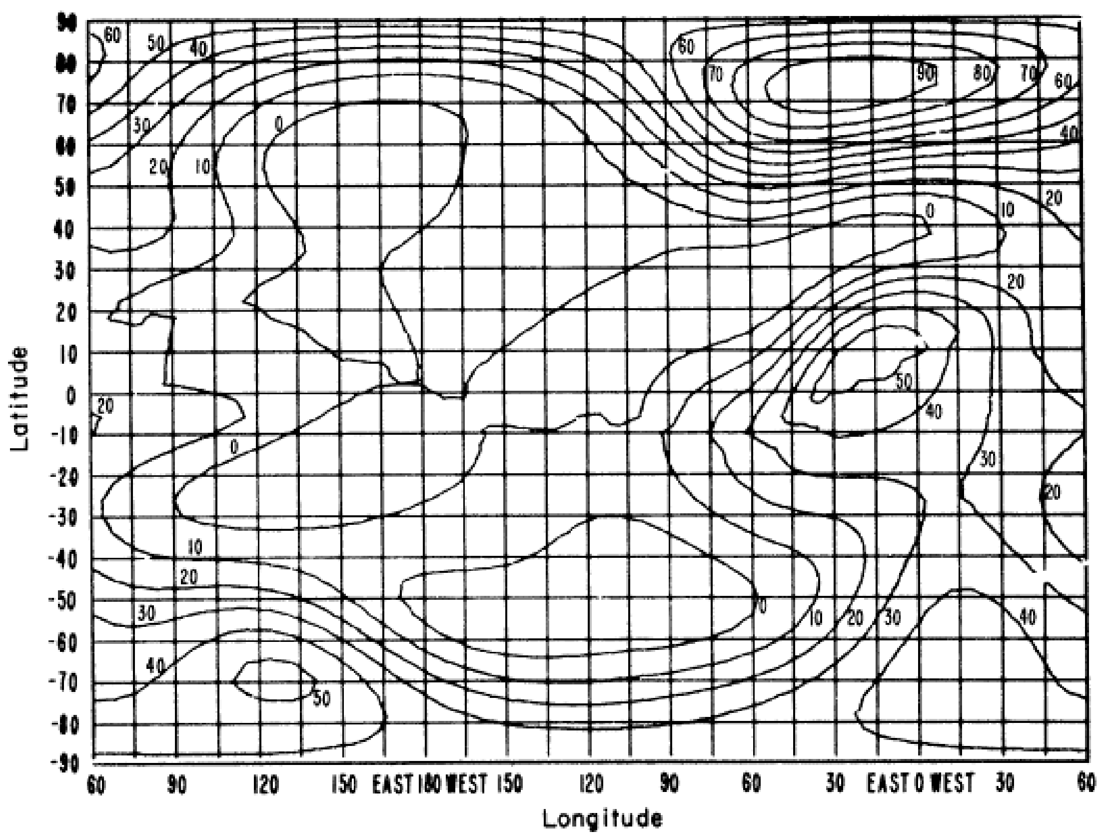
An examination of spread F in the ionosonde records of Anchorage, Washington, and Huancayo for selected months of 1958 and 1964 was made by a single observer. Rules for treating the vertical-incidence notations were then devised so as to result in levels of Ø reasonably close to those found in the direct study. The count of F's during a month was made by giving the symbol F alone a weight of 1, and the combinations UF, DE, and EF were also given a weight of 1. A numerical value of foF2 accompanied by the descriptive symbol F was given a weight of 1/2. The denominator of the percentage spread-F ratio was found by omitting from the count days when the sole notation was A, B, C, S, N or R, In addition, days showing scaled values of foF2 with one of these descriptive symbols were omitted, if the qualifying symbol U or I was added.

Under these weighting rules, percentage spread F was computed by digital computer at each hour of the day, in each month, at the set of stations where the data were deemed to be acceptable. The number of stations ranged from 108 in January 1964 to 120 in July 1958.

The numerical analysis of Ø was carried out by first performing a "screen" analysis to control instability in areas of the world where no data existed. The original station data augmented by values of Ø at about 38 screen points were then subjected to a second analysis (Jones, Graham, and Leftin, 1969) to obtain the final numerical map.



Percentage Spread F, October 1958, 0000 UT



Percentage Spread F, October 1964, 0000 UT

In the second analysis the geographic variation of Ø at each UT hour is represented by least-squares fitting of a set of trigonometric functions to the data. The functions are chosen from the list in table 7 of Jones, Graham, and Leftin (1969). At each order of longitude additional terms are added until the standard deviation of residuals ceases to be decreased by the additional term. For the present analysis 8 terms were adopted for the zeroth order longitude variation (simple latitude variation), 20 terms for the first order longitude, 12 terms for the second order longitude, and 4 terms for the third order longitude variation. Finally, the Fourier analysis was made to represent the diurnal variation of each of the coefficients of the geographic terms. It was found that this could be done satisfactorily with the use of only two harmonics. In selecting the number of screen points, the number of geographic functions, and the number of harmonics, it was necessary to reach a compromise among the numbers that would be optimum for the various months.

The geographic functions involve a variable X, which represented modified magnetic dip in the Jones, Graham, and Leftin report. Tests were made to determine whether this or some other coordinate would best serve in the analysis of spread-F occurrence. It was concluded that invariant latitude resulted in the smallest residuals. Therefore the entire analysis of Ø has been carried out in terms of invariant latitude.

The standard deviation of residuals has varied between 10.9 percent and 14.2 percent in the months analyzed, (except for a high value of 17.2 percent in November 1958).

The worldwide contour charts of Ø developed here are similar in many gross features to those of Tao (1965). However, substantial differences in the values of Ø are found. In this work, Ø is analyzed by individual month rather than season, and values for any UT hour are available from the numerical mapping technique.

There have been suggestions in the literature that the local time, seasonal, and solar activity dependence of spread F are different in the cases of frequency and range spreading (Huang, 1970). It would be very useful to future investigations of spread F if a differentiation between the two types could be made in the tabulations of foF2.

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VII URSI Working Group on Digital Data Pre—Processing and Display

This working group of URSI Commission III has held discussion meetings at Ottawa (1969) and Leningrad (1970). The minutes of the latter appear in URSI Information Bulletin No. 178, March 1971, pp 51—62, which we summarize here.

The WG derives from Recommendation 111.6 of the XVI General Assembly. Its purpose is to give guidance to users of new recording techniques and to help in making possible the exchange and the joint utilization of digital data. The present membership is Bibl (USA), chairman; Belrose (Canada), Bossy (Benelux, SW and SE Europe), Bourne (Australia and Far East), Chesalin (USSR), Harnischmacher (Mid and S. Europe), Kasuya (Japan), Monet (France and French—speaking Africa), Piggott (UK, Asia and English—speaking Africa), Radicella (S. America), Taubenheim (E. Europe).

At Leningrad, several participants reported on real—time data. Belrose reported on a real—time output from his partial reflection experience which monitors D—layer ionization by digital comparison of the two circularly polarized echo components. Slutz (USA) described the real—time data compiling system for short—term forecasts and warnings of space environment conditions, using outputs from various local sensors and telegraphic data. Several European ionospheric sounding stations participate in a network for real—time collection of hourly data on foF2, MUF(3000), fbEs and fmin. Digital iono— sondes are in use in USA at Boulder, Florida, Maynard (Mass), and a jet aircraft, mainly in support of related experiments and sample monitoring of remote, unmanned sites. Bossy (Dourbes) is using a small on—line computer to further compress the digital data to form ionospheric characteristics as time— functions, and for flexible programming of the ionosonde operations. Boulder and Brisbane are also using this approach.

Digital data formatting: In contrast to many other fields of geophysical research, ionospheric data gathered by radio sounding exhibit a multitude of parameters which must be measured simultaneously to permit correct interpretation: magnitude and phase of echo amplitude, measured over large frequency and height ranges and in quite different scales of time, disclose the local and temporal dynamic structure of the ionosphere only if the parameters are brought into right perspective. Multiple and oblique echoes must be eliminated and the two magneto—ionic components separately considered. For this reason, proper formatting of the records is of paramount importance. Digital data gathering can overcome the technical handicap of the limited standardization in optically recording equipment: cameras, oscilloscopes and film developing.

In the past, it was found impossible to standardize height and frequency range, not to talk about accuracy, identification, resolution and reproducibility of the height and frequency scanning function. With digital data, this can be done in a joint effort, even on an international basis. But it must be done soon to match the fast growing intention to generate digital data. In Appendix I, a set of proposed formats is presented for discussion. The formats are mainly meant for digital ionogram recording (Fig. 1) but can be applied for compressed time functions of ionospheric parameters (for example, Fig. 2) and other data as well, for example, a digital spectrogram.

Computer features: The key to success in digital data recording is some understanding of computer properties. Neither big nor small computers should be used for data storage or data printout.

Complete ionograms, i.e., amplitude record for the whole frequency and height range, must be printed out directly and/or recorded on magnetic tape, since the millions of data bits can not be stored on punch cards or punched tapes. Optical storage of digital data on film or plastic ribbons will become possible in the future.

Compression of data, even after integration, with the help of on—line special purpose computers can reduce the data flow (T. Gautier, ESSA, USA) and permit the use of teletype and paper punch equipment for display and storage. This route is, however, limited. Temporary storage on magnetic tape is preferable if a computer is accessible for printer data compression and reformatting. Scanning devices forming special fonts for the selected numbers are available, permitting use of reliable facsimile printers even on remote locations.

Not only small computers with limited memory, but also computers with fast data intake require strict limitation in the size of individual records. It is, therefore, almost always impossible to have a complete ionogram on a single record. Records of about 400 IBM words of six characters appear very economical; they require almost 4 in. (10 cm) (five times the gap length) on a tape with a density of 556 bits/inch. For limited data flow, a 200 bits/inch tape recorder might be usable. Then the formatting of echo amplitudes from about 100 height ranges to independent records can become feasible, making the record length about as long as the record gap. Single line records have the important advantage that neither additional storage nor an incremental reading capability is required for subsequent printout of the records on inexpensive synchronous facsimile printers. Even if about ten frequency lines are combined to a record, it is advisable to start each line within the record with a new preface, This makes the format of the data more periodic and therefore easier to program for identification of selected frequency data and for suppression and correction of errors, The record gap can be used to select the first preface for identification and for frequency or time marks in the printouts.

Related Fields: Similar data preprocessing and display techniques can be applied in the following fields: (a) incoherent scatter and radio—astronomical measurements; (b) optical scanning; (c) acoustical sounding.

Appendix I: Data must be broken into records consisting of 120 to 2,400 characters of 6 or 8 bits organized in 20 to 400 words of 6 characters or 12 to 240 words of 10 characters.

Each word may contain 6, 4, 3, or 2 numbers each consisting of 1, 1½, 2, or 3 characters.

If four numbers per word are used on 6 bit tracks, then three octals are available for each number so that the upper octal of the second character belongs to the first number and the lower octal of the second character belongs to the second number: a scheme which repeats with a multiple of three charact as module. Those nine bits may mean nine bits of a scalar amplitude or six bits of magnitude and three bits of phase for a complex amplitude. If this accuracy seems insufficient, two or more characters can be combined to a more precise number. Linear or piecewise linear height and frequency scan is proposed Virtual height should be sampled in 1½, 3, 4½, or 6 km increments. Frequency should be increased in 25 50, or 100 kHz increments.

One record shall contain: 1, 2, 4, 5, 8, 10 or 16 frequencies. The preface can consist of 2 to 4 words of 6 characters. Additional information can be stored in subsequent prefaces. Ionogram data recorded in such a format can be played back at any location and would require only simple instruction for the printout, while the variable parameters may be contained specially keyed in the preface.

For scaling, the smallest frequency and the lowest height range must be known in addition.

Comments on the above are invited by the WG Chairman, Dr. K. Bibl, Lowell Technological Institute Research Foundation, 450 Aiken Street, Lowell, Massachusetts, 01854, USA.

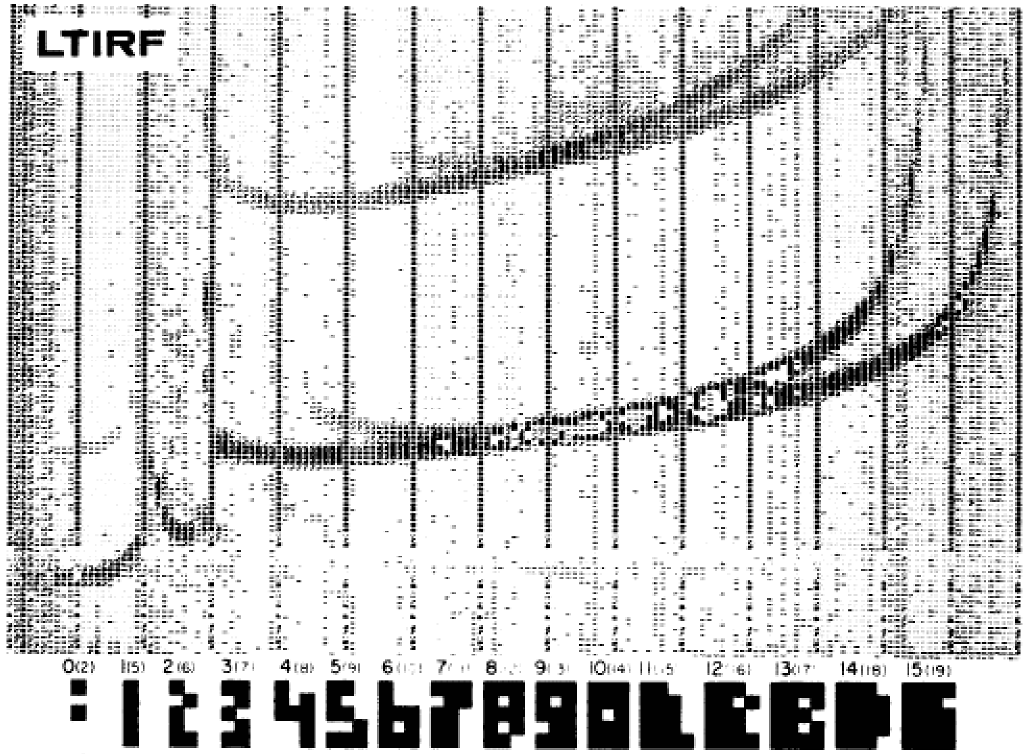

Fig. 1. A Digionogram produced in real time with Digisonde 128. The magnitude of the complex amplitude is shown as a function of frequency and range (printed with an on-line printer).

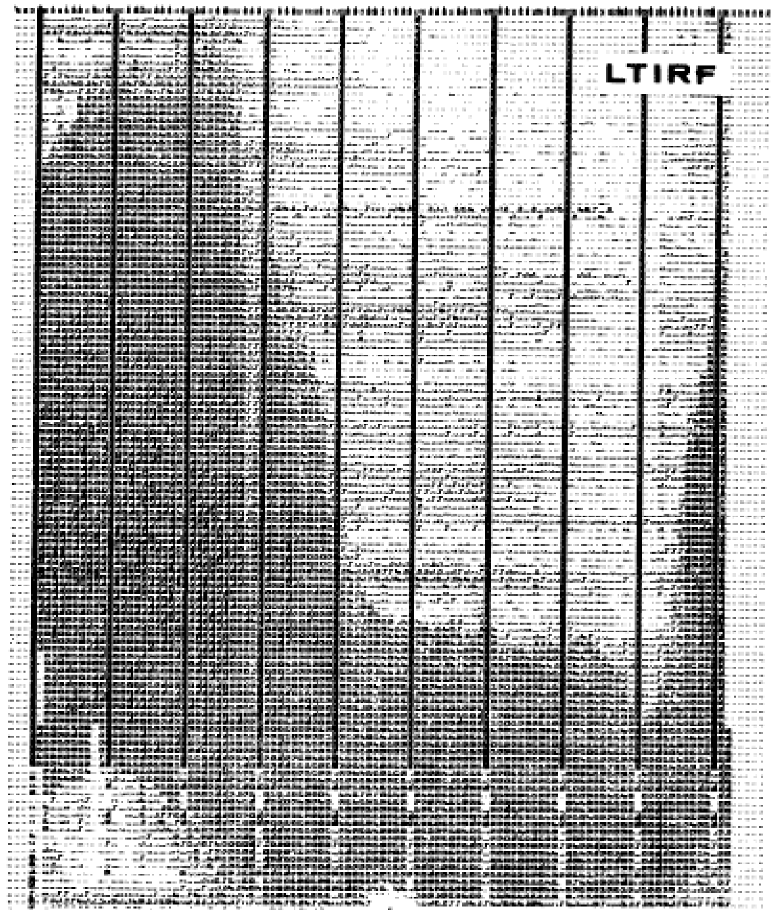

Fig. 2. F-region top frequency ftF(t) shown as a function of time.

VIII. Special Announcements

1. Future Application of Satellite Beacon Measurements* Proposed Symposium at Graz, May 1972

Dear Colleague,

1. Thanks to the efforts of Dr. Hartmann and his colleagues of the Max-Planck-Institut fur Aeronomie a very successful Symposium on the Application of Satellite Beacon Experiments was held at Lindau/Harz in June 1970. As agreed on this occasion the next Symposium on related topics will be held at Graz (Austria). Under the title "Johannes Kepler Symposium' it will be one of the contributions of the University at Graz to the so-called "Kepler Year". The Institut fur Meteorologie und Geophysik will distribute information about the meeting to colleagues interested in this field of research, by means of circulars continuing the series started by Dr. Hartmann.

2. We understand from NOAA (K. Davies) that the launch of ATS-F has been postponed for about half a year and is now expected in spring 1973. In agreement with Dr. Davies and Dr. Hartmann we have therefore postponed the next Symposium until May 1972. The exact date cannot yet be given, since it depends on the date and the place of the 1972 COSPAR Plenary Meeting. If this is held in Europe -- as is expected -- we will arrange our Symposium to follow the COSPAR meeting. In case COSPAR does not meet in Europe (or nearby, e.g. North Africa) it would be bad policy to hold our Symposium immediately after or before the COSPAR meeting. In this case we will try to fix the date so that it follows some other European meeting on a topic related to ionospheric research or wave propagation. If you have information on any such conferences please let us know. In any case, the Symposium will be arranged for the first half of 1972.

3. The efforts to get approval by an International Scientific Union as Interim Working Group on Satellite Beacon Experiments (see Report in URSI Information Bulletin, No. 176, September 1970) will be continued by Dr. Hartmann. Decisions on this question are to be expected from the meeting of GOSPAR Panel lB at Seattle in June 1971.

* Reprinted from URSI Information Bulletin, No. 178, p. 63-64, March 1971.

4. Please feel free to make comments and suggestions on the proposed Symposium, as a means to further cooperation in the use of beacon satellites for research and application.

Yours sincerely,

Dr. R. Leitinger
Institut für Meteorologie und Geophysik
Universität
A -- 8010 Graz (Austria)

14 January 1971

2. Fourth International Symposium on Equatorial Aeronomy 1972

Professor Raymond Wright, Department of Physics at the University of the West Indies, Kingston 7, Jamaica, is exploring the need and possibility of holding a Fourth International Symposium on Equatorial Aeronomy in Nigeria in November 1972. Further details can be obtained from him. The following abstracts come from his first exploratory circular:

"On my return to Jamaica I have found many letters raising the question of the 'Fourth International Symposium on Equatorial Aeronomy'. Very tentative plans were set at the last meeting for this to be held in 1972. Various locations have been suggested, but we now have accepted a formal offer from Nigeria to act as the host country.

The meetings are held to give the active workers in the field a chance to meet and discuss their common problems and to get up-to-date with developments in other areas with similar interests. The need for meetings separate from the large, universal-scope general assembly meetings of the International Aeronomical Unions, International Association of Geomagnetism and Aeronomy and the International Scientific Radio Union, was felt to be due to the highly isolated situations that most workers in equatorial work have to live in. Also, a need for a meeting with a rather restricted area of discussion. Indeed, much of the work in equatorial aeronomy still has to be done in the so-called developing countries. The scientists working in their isolated sites are normally not in the international swim of the major meetings. Indeed, one major feeling was that the meetings should, if possible, take place at an equatorial site where active work in the field is being conducted. This would have the advantage of giving the benefit of a major meeting of scientists with the consequent fillip to the scientific community in the young country. The visiting international scientists carry prestige to their colleagues, who are usually working under difficulties.

I should stress that the main participants should be active workers in the field, and that in addition it was hoped to obtain the participation of a group of outstanding scientists with more general interests who could provide a sense of balance to the proceedings with an integration of the work into the general scientific work in other fields."

3. Solar Eclipses*

Two years ago, in URSI Information Bulletin No. 170, we complimented the National Science Foundation on the appearance of Solar Eclipse 1970 Bulletin A and on the evidence it provided on the progress made in the central coordination of the scientific programmes proposed for the total solar eclipse of 1970 March 7.

With the recent issue of Bulletin F, the last in the series, it seems appropriate again to congratulate the NSF on the successful completion of its task and, in particular, the U.S. Coordinator, Dr. A. E. Belon, who has collected together, in Bulletin F, the descriptions of the numerous observational programmes of all kinds and, in many cases, preliminary reports on the results obtained, including numerical and graphical data and photographs.

Dr. Belon points out, however, that Bulletin F is not intended to be a scientific treatise, but rather a source of information on the observations planned and in many cases carried out according to plan. There seems little doubt that it will serve as a means of enabling those who made measurements during the eclipse to make contact with others who obtained data which may complement or supplement their own observations.

A special issue of Nature (20 June 1970) contained preliminary results on over 40 experiments relating to the 1970 eclipse and isolated papers have been published in Sky and Telescope and elsewhere, but the principal conclusions will not appear in print until 1971. A Symposium on the eclipse, sponsored jointly by URSI, IAU, IAGA and COSPAR, is to be held in Seattle in June 1971 during the COSPAR Meeting, and will provide the first occasion for discussion of some of the latest information and conclusions on the solar atmosphere and its radiation, the bottom- and top-side ionosphere, etc.

Eclipse observers are never satisfied with the results they have obtained and it is not surprising that Bulletin F contains a 43 page Chapter on future partial, annular and total eclipses. This includes not only numerical data, based on information provided by the Nautical Almanac Offices in the U.S.A. and the U.K., but also reports of surveys of sites in West, Central and East Africa made by Drs. Meazel and Pasachoff, of the total eclipse of 1973 June 30 which will have a maximum duration of more than 7 minutes. The track of the total eclipse of 1972 July 10 will be more easily accessible than that of the 1973 eclipse; unfortunately totality will last for only 2 1/2 minutes and, for those making optical observations, the prospects will be less favourable in Eastern Siberia, Northern Alaska and Canada than in Africa. However, this need not deter radio scientists from planning new observations for 1972 and perhaps for improving on the techniques used in 1970.

* Reprinted from URSI Information Bulletin, No. 178, p. 65-66, March 1971.

Note: World Data Center A, Upper Atmosphere Geophysics Report UAG-12, "Solar-Geophysical Activity Associated with the Major Geomagnetic Storm of March 8, 1970" contains twelve contributions on the March 7, 1970 solar eclipse. Among these, six are concerned with ionospheric effects

4. The Sun and the Earth - A Film Series

The National Academy of Sciences, Washington, D. C., is currently producing a series of motion pictures exploring the complex range of relationships between the Sun and the Earth. A record of findings made during the International Years of the Quiet Sun (1964-1965), as well as a survey of the subject, the series carries forward a film documentation program that began during a previous worldwide program, the International Geophysical Year (1957-1958). At that time, the National Academy of Sciences produced a series of thirteen films covering IGY activities and findings in the geophysical and related sciences, from glaciology and seismology to meteorology and geomagnetism That series, entitled "Planet Earth," has had wide distribution and acceptance throughout the world, and the titles continue to be used.

Four films have been completed in the "Sun and Earth" series:

The Quiet Sun
The Active Sun
Interplanetary Space
The Magnetosphere

Three more are planned:

The Upper Atmosphere
The Lower Atmosphere
The Sun on Earth

The films are intended to present an up-to-date and authoritative picture of the Sun, its influence in interplanetary space and solar control of our own planet and its environment, as well as on many new techniques of scientific investigation. To this end, the cooperation of distinguished scientists in astronomy, physics and geophysics, and of their laboratories, in many parts of the world has been obtained.

For information concerning these films, write to:

McGraw Hill Films
Division of McGraw Hill Book Company
330 W. 42nd Street
New York, N. Y. 10036 U.S.A.

5 S.C.A.R. Symposium on Technical and Scientific Problems Affecting Antarctic Telecommunications

The meeting will be at the Park Hotel, Sandefiord, Norway, May 10-16, 1972. (See INAG-6, p. 3, for other information concerning this Symposium.)

Tentative First Program

1. Formal Introduction and Opening

2. Review of Communication requirements and Statement of main practical difficulties

2.1 Fixed services
(i) within Antarctica
(ii) between Antarctica and external communication centres

2.2 Mobile services
(i) Land mobile)
(ii) Aeronautical and maritime) National and
(iii) Radio determination of position) International

2.3 Operational technical problems
(i) The operator at base and mobile stations
(ii) Operational coordination
(iii) Equipment maintenance; construction and maintenance of antennas in Antarctic terrain (iv) Man-made noise and snow static

3. Review of advantages and disadvantages of various transmission media, Review papers, followed by discussion and summary

3.1 (i) Ionosphere; LF, MF, HF
(ii) Troposphere; VHF (iii) Ionospheric forward scatter
(iv) Tropospheric forward scatter

3.2 Methods of using Communication satellites

4. Scientific results and developments which might improve Antarctic communications. Special stress on the following topics:

(i) HF prediction and forecasting
(ii) Forward scatter techniques
(iii) Propagation over snow and ice and the effect of poor earth
(iv) Antenna performance in the Antarctic environment including elevated and buried antennas (in snow)

(v) Satellites in elliptical polar and equatorial orbits, and developments in unmanned earth stations
(vi) Methods of reducing effects of snow static and man-made noise
(vii) Modulation and data systems

5. Policy and cost discussions

(i) priorities of various objectives
(ii) relative advantages of various techniques; satellites, forward scatter, conventional systems and combinations of these
(iii) use of automatic stations and electronic developments

6. Recommendations

(i) practical improvement of existing systems
(ii) future systems

6. XIVth Meeting of COSPAR. Seattle, Washington, June 17-July 2. 1971

In connection with this meeting there will be several symposia of interest to ionosphere workers.

(a) Symposium on the Total Solar Eclipse of 7 March 1970 at Seattle, June 18-27, sponsored by COSPAR, IAU, IUGG/IAGA and (JRSI

(b) Symposium on Dynamics of the Thermosphere and Ionosphere above 120 km at Seattle, June 24-26, sponsored by URSI/COSPAR

(c) Symposium on November 1969 Solar Particle Event at Boston, Massachusetts, June 16-18, sponsored by COSPAR

(d) Symposium on D- and E-Region Ion Chemistry, Urbana, Illinois, July 6-8, sponsored by COS- PAR

In addition, open meetings of COSPAR working groups will present the following Panel discussions:

Panel 3B Flare Forecasting Methods used in the U.S.A. and Flare Observations

4A Properties of the Upper Atmosphere - - Stratosphere and Mesosphere --Thermosphere and Exosphere

4B International Reference Ionosphere

4C Daytime High Latitude Phenomena, Night-time High Latitude Phenomena, Polar Cap Phenomena

Results of four following geophysical events especially requested: 2-5 February,

23-25 March, 8 June and 27-30 September 1969.

7. International School of Atmospheric Physics

This school will be held at Erice, Trapani, Sicily, June 13-27, 1971 sponsored by National Research Council, Regional Sicilian Government and Italian Ministry of Public Education. The subject is "Structure and Dynamics of the Upper Atmosphere" presented through lectures and seminars by world authorities in their fields. Some of the topics will be Chemistry in the Ionosphere, Structure of the D and E Regions, Structure of the F-Region, Ionospheric Irregularities, Sporadic E Layers, and Corpuscular Effects in the Ionosphere. The Director of the school is F. Verniani.

IX. Finnish Ionosonde

The Helsinki University of Technology is building a prototype low cost ionospheric sounder in cooperation with the Post and Telegraph Administration in Finland and the Sodankyl~ Geophysical Observatory. The sounder specifications are:

Frequency range	: 1 - 16 MHz, 4 octaves
Frequencies/octave	: 200 nominal
Frequency markers	: one per octave
Sweep rate	: logarithmic, 40 s/octave nominal
Programming	automatic, approximate 100 different programs selectable, discrete frequency sounding is possible
Output power	: 1 kW (equivalent to 20 kW in conventional sounders)
Pulse width	: 448 μs (7 x 64 μs), pulse phase modulation, 7 bit Barker code (gives 5 **...** 8 dB improvements or S/N ratio)
Time resolution	64 μs below 340 km, 80 μs above 340 km
Pulse frequency	: 50 Hz
Pulses/output frequency	10
Virtual height range	: 70 - 1000 km
Height markers	at 50 km intervals below 400 km. 100 km intervals above 400 km

Signal correlator	100 channel analog signal (bandwidth 1 kHz), sweep voltage for recorders (length 200 ms), this equipment can be used with telephone lines and facsimile recorders.
Power consumption	: about 500 VA, 220 V AC or 24 V DC
Approximate cost	: 25 000 US $

Prof. Kalevi Kalliomäki, Helsinki University of Technology, Finland would like to hear from you if you are interested in such a sounder. Any comments you might have concerning the above specifications would be welcome.

X. Notes from Stations Japanese Stations

I. Kasuya stated that the ionospheric vertical incidence observations (VI) at the five Japanese Ionospheric stations, at Wakkanai, Akita, Tokyo and Yamagawa in Japan as well as at Syowa in Antarctica have been conducted without any trouble since the last report.

San Miguel de Tucuman

Dr. Manzano reports that they have available ionograms for:

Year	1957:	starting in July
"	1958:	complete
"	1959:	complete
."	1960:	except October and November (failures)
."	1961:	except October, November and December because of burning of equipment
."	1962:	except January to August because of burning of equipment
"	1963:	complete
"	1964:	except February and March (failures)
."	1965:	except January to April (failures)
"	1966:	except April and half of May (failures)
."	1967:	except half of August and half of September (failures)
."	1968:	complete
."	1969:	complete

At present, they are working on the correlation between scintillation signals and spread—F. Several years of reliable reception of satellite signals are covered which will permit the study, besides the daily and seasonal variations, of the behavior during the increase of the solar activity.

Singapore

After a run of nearly 25 years, the station will finally close at the end of July 1971. It has been a particularly interesting station as the satellite telemetry facility has permitted correlation between ground—based and T.S.S. measurements of the equatorial anomaly, but after July all R.S.R.S. activity in Singapore will cease.

South Uist

The Magnetic 1005 W ionosonde has now been installed but there are no plans to extend the previous usage and it will be operated only in support of rocket campaigns. These data will be lodged in WDC—Cl.

XI. Notes from WDCs

World Data Center-A, Upper Atmosphere Geophysics, Boulder, Colorado, U.S.A.

World Data Center-A, Upper Atmosphere Geophysics Report UAG-12, "Solar-Geophysical Activity Associated with the Major Geomagnetic Storm of March 8, 1970", was issued April 1971. It consists of 103 contributions, 29 of them directly concerned with ionospheric phenomena.

A special statistical study of our data center activities was made for the month of April 1971. We received 389 station months of ionospheric data (216 on paper, 16 on punched cards, 16 on 35 mm microfilm and 141 as ionograms). Fifty requests for ionospheric phenomena were initiated. For 51 orders completed during the month, 2298 station months of ionospheric data were distributed.

World Data Center-Cl, Radio and Space Research Station, Ditton Park, Slough, Bucks, England

The new ionospheric data catalogue being produced by computer printout has still not been completed, because of a shortage of effort, but it is hoped the next issue will be in the middle of the year.

Daily-hourly values for Slough, Singapore and Port Stanley are now available on tape from January 1967 onwards. Data are sorted according to year and month, within months according to characteristic, within characteristic according to day and within days according to half days. The card images are in the format published by Piggott and Rawer and the tapes are in two categories, Standard ICL unformatted Fortran tapes and IBM type tapes. Further details are available from WDC-Cl.

World Data Center-C2 for Ionosphere, Radio Research Laboratories, Japan

Activities for the period April 1970-March 1971:

1. Data received from WOCs A, B and Cl and stations in the WDC-C2 region:

Booklets:	3000	
Microfilms:	90	rolls of 1000 feet each
	57	rolls of 100 feet each

2. Data sent and lent to users:

to	Other centers	Domestic researchers	Foreigners researchers	Total

Booklets				
Microfilms (roll)	108	32	41	181

3. Adjustment and compilation of microfilm data in the WDC-C2 office:

Microfilm from WDC-A Ionograms (1963-1967): each)	315 rolls (1000 feet each) Others (1957-1969): 129 rolls (100 feet
Microfilm from WDC-B Ionograms (1965-1970): each)	69 rolls (1000 feet each) Others (1961-1970): 43 rolls (100 feet
Microfilm from WDC-Cl Ionograms(1969-1970):	27 rolls (100 feet each)

4. WDC-C2 catalogue of Data for Ionosphere:

Cumulative catalogue of ionospheric data for the period 1 July 1957 - 31 December

1970 will be issued in July 1971.

5. New publications on ionosphere received are:

"Ionospheric Data in Korea", January 1970

"Ionospheric Bulletin", Hong Kong University, January and February 1970

XII. Progress in Radio Science l966~l969*

Published by the International Union of Radio Science (URSI), 7, place Emile Danco, 1180 Brussels, Belgium.

Vol. 1: Ionosphere, Magnetosphere, Radio Noise, Ed. G. M. Brown, N. D. Clarence, and M. J. Rycroft (Published January 1971).
Vol. 2: Radio Propagation in Non—Ionized Media, Radioastronomy, Radio Measurements and Standards, Ed. J. A. Lane, J. W. Findlay, and C. E. White (To be published in April 1971).
Vol. 3: Radio Waves and Circuits, Radio Electronics, Ed. W. V. Tilaton, and M. Sauzade (To be published in June 1971).

***** Reprinted from URSI Information Bulletin No. 178, p. 66, March 1971.

These volumes contain most of the papers presented during the scientific sessions of the XVI General Assembly of URSI in August 1969. The programmes were arranged by the Chairmen of the respective URSI Commissions during the period 1966—1969 namely:

Vol. 1: C. 0. Hines, H. G. Booker, F. Homer.
Vol. 2: J. A. Saxton, E. J. Blum, L. Essen.
Vol. 3: F. L. Stumpers, P. Grivet.

The volumes are available at $5.00 (250 Belgian francs) per copy, surface postage included. If all three volumes are ordered together, the price is US $12.00 (600 Belgian francs). If required copies can be sent by air mail, by arrangement, for an additional charge.

Orders should be sent to URSI, 7, place Emile Danco, 1180 Brussels, Belgium.

A complimentary copy of Vol. 1 has already been posted to each Member Committee of URSI.

XIII. Literature Citations

A partial list of research papers utilizing ionosonde data is presented. After the references are given an abstract plus the stations whose data were used and, in some cases, the time period covered:

SUKHORUKOVA, E. V. and T. A. KHVIYUZOVA	1970	Meridional Cross Section of the Ionosphere Between Lenin grad and Murmanak, Komplekanyve Issledovaniva Polyarnoy lonosfery. Izd-vo "Nauka", 84-94.

A detailed study was made of the relationship between ionization for stations situated approximately on the same meridian. Murmansk is situated on the southern boundary of the auroral zone and Ken' is situated 500 km to the south. The ratio between maximum ionization at Murmanak and Ken' was studied separately for each night and each day in the winter of 1966/1967. The probability of the appearance of nighttime increased ionization at Murmansk was twice as great as at Kem'. However, the probability of increased nighttime ionization at Ken' is quite high. A stream of soft corpuscles most frequently penetrates into the auroral zone but almost one-third of the nights the stream penetrates farther to the south. There are two anomalies in the high-latitude ionosphere along this profile: winter daytime and winter nighttime, spaced in latitude. These anomalies are expressed most strongly during high solar activity but they also persist during low activity. Neither the daytime nor the nighttime anomaly always exists. Appearance of increased ionization has a sporadic nature; the frequency of appearance of an anomalous ionization increase during the daytime and nighttime increases with an increase in solar activity.

(Murmansk, Ken')

MIZUN, YU. G. 1970 Distribution of Electron Concentration in the Ionospheric F Region During a World Magnetic Storm, Komplekanyve Issledovaniya Polyarnoy lonosfery, Izd-vo "Nauka", 116-132.

The behavior of the ionospheric F region during a magnetic storm cannot be considered uniform for the entire low-latitude zone. One must discriminate an equatorial zone (near the geomagnetic equator) and a sub-tropical zone (to the north and the south of the equatorial zone). During the evening hours local time (1900-2300) the decisive role in the change in low-latitude electron concentration is played by ionization transfer from the equator to the subtropics. This is possible due to the great altitudes of the region in the equatorial zone in evening. The low-latitude distribution of electron concentration during a magnetic storm is determined by the phase of the storm. Investigation of the behavior of the disturbed low-latitude ionosphere exclusively in dependence on the Kp index leads to contradictory conclusions. During the initial phase of a magnetic storm ionization in the equatorial zone rises to greater altitudes than when conditions are quiet. Later electrons diffuse along the magnetic lines of force toward the subtropics. As a result, the electron concentration in the equatorial zone decreases, but in the subtropical zones it increases in comparison with a quiet state. The foF2 change attains ±4 Mc/sec. During the main phase of a magnetic storm during the evening hours (1900-2300 LT) the altitude of the lower boundary of the F2 layer decreases by 100-150 km.

SHARADZE, Z. 5. 1970 Moving Disturbances in the Ionospheric F Region and the Sporadic E Layer, Izvestiya Vysshikh Uchebnykh Zavedeniy, Radiofizika, Vol. XIII, No. 7, 1001-1011.

Some results of studies of moving disturbances in the F region and the Es layer over Tbilisi are given on the basis of ionospheric observations made from January 1964 through December 1967. Moving disturbances may be associated with the propagation of internal gravitational waves in the ionosphere. Since vertically moving disturbances at altitudes 350-430 kilometers are observed for the most part only in cases of small foF2, it can be postulated that when there is a low concentration in the F region the effect of moving disturbances is also propagated above $N_{max}F2$ (the penetration of moving disturbances to 500 kilometers has been demonstrated by Dyson). The inverse dependence of the number of well-developed moving disturbances on solar activity (on foF2) can be attributed to an increase in the absorption of gravitational waves in the ionosphere with an increase in concentrations. Moving disturbances cause appreciable changes in Es-layer parameters. The quasi-periodic changes in foEs and fbEs with a period of 10-60 minutes support the Hines hypothesis that the appearance of wind shears may be associated with internal gravitational waves.

(Thilisi January 1964 through December 1967)

LIKHACHEV, A. I. 1970 Cyclic Characteristics of the State of Ionization at the Level of the F2 Layer and the Limitation Phenomenon, Tomsk, Trudy Sib. Fiz.-Tekhn. In-ta pri Tomskom Un-te, No 53, 1970, 16—22.

The author gives the dependence of the monthly medians and mean annual foF2 values for the midday hours on solar activity on the basis of observational data for Tomsk. The nonlinearity of the dependence of foF2 on W cannot be attributed solely to a change in the state of atmospheric conditions. It is postulated that the attenuation of ionization can be caused by the absorption of UV radiation by the atmosphere above the maximum of the F2 layer.

(Tomsk)

POZIGUN, V. L. 1970 Es Formation, Geomagnetizm i Aeronomiya, Vol X, No 5, 907-909.

The article examines the probability of the appearance of Es in relation to wind shifts. The directions of drift in the regular E layer, determined from measurements at Rostov-on-Don at three points, and the presence of Es at this time were compared. Comparisons were made for Es of types c and λ*.* When there is a vertical wind profile with a "wavelength" of the order of the thickness of the E layer the east-west movement of the atmosphere will cause movement of ionization to the maximum of the layer or to its base. The results were grouped by seasons. All cases of the simultaneous presence of measured drift directions and the existence of Es of a definite type during the years 1958-1968 were taken into account. During spring and summer in the overwhelming majority of cases drift was directed eastward. At this same time there was a maximum probability of the appearance of Es of type c. For Es of type λ the maximum probability of appearance is observed in autumn and winter; during these same seasons the predominant directions of drift is westward. The seasonal dependence of appearance of Es of types c and *A* agrees satisfactorily with the theory of wind shifts. However, it is stressed that the presence of a corresponding drift direction does not automatically lead to the appearance of Es. An appropriate wind profile is an extremely important factor, but alone is inadequate for Es formation. Another important condition is the value of the effective recomination coefficient, which changes with temperature (having a dependence on altitude and season), In addition, turbulence evidently plays an important role in the formation of Es type λ**.**

(Rostov-on-Don)

YEVLASHIN, L. S. and Z. I. NEKLYUDOVA 1970 Correlations Between Auroras and Ionospheric Disturbances During the Solar Activity Cycle, Leningrad, Kompleksnyye Issledovaniva Polyarnoy Ionosfery, Izd-vo "Nauka," 1970, pp 28-35).

This paper presents the results of investigations at Murmansk station during the years 1957-1966. The authors computed the correlation coefficients between the numbers of cases of appearance of total absorption, as well as the sporadic Es layer and auroras for all observation seasons. The values of the correlation coefficients are related to solar activity. It is concluded that there is a change in the energy spectrum of the flux of particles responsible for auroras during the cycle. The patterns of correlation between different types of auroras and the parameters of the disturbed ionosphere are examined. It was established that there is no change in the nature of this correlation from the years of maximum to the years of minimum solar activity.

(Murmansk)

NOVIKOVA, U. A. 1970 Determination of the Correlation Between Some Ionospheric and Tropospheric Parameters During the Solar Activity

Cycle, Tomsk. Trudy Sibirakogo Fiz.-Tekhn. Instituta pri Tomskom Universitete, No.53, 1970, pp 169-174.

Changes in the mean monthly $N_{max}F2$ values are compared for the years 1952-1954 on the basis of data for a number of middle-latitude ionospheric stations and tropospheric temperature and pressure at altitudes 200-300 mb. During the spring months there is an increase in the electron concentration at the maximum of the F2 layer and a decrease in tropospheric pressure. Tropospheric pressure at Siberian stations increases with transition from the maximum to the minimum of solar activity.

(Middle-latitude ionospheric stations 1952-1954)

PARK, C. G. 1970 Whistler Observations of the Interchange of Ionization between the Ionosphere and the Protonosphere, J. Geophys. Res. 75, No. 22, 4249-4260.

Whistlers recorded at Eights, Antarctica, in June 1965 were used to measure the electron content in magnetospheric tubes of force in the range $3.5 \leq L < 5$. Under quiet geomagnetic conditions, the observed rate of increase in daytime tube content gives an upward flux of $\sim 3 \times 10^8$ electrons/cm^2 sec across the 1000-km level, which is larger than the downward flux necessary to maintain the nocturnal ionosphere. The observed upward flux is primarily due to diffusion of protons through the diffusive barrier, rather than to an increase in the height of the barrier. The downward flux at night under quiet conditions is $\sim 1.5 \times 10^8$ electrons/cm^2sec, an amount that is considered sufficient to maintain the nocturnal ionosphere. The protonosphere is depleted in less than a day during a magnetic storm or polar substorm activities, and subsequent recovery of tube content takes place at a rate of $3\text{-}5 \times 10^{12}$ electrons/cm^2 per day. At this rate, an "empty" tube requires about 5 days to reach the monthly median value, and even after 8 days of quiet conditions it continues to fill. The average spacing of geomagnetic disturbances is such that we expect that the protonosphere almost never reaches the saturation level it would attain if it were in equilibrium with the ionosphere.

(Ottawa, Argentine Is.)

ROBLE, R. C.,
P. B. HAYS and
A. F. NAGY

1970 Comparison of Calculated and Observed Features of a Stable Midlatitude Red Arc, J. Geophys. Res., 75, No. 22, 4261-4265.

The Alouette 2 satellite passed over a stable midlatitude red arc on September 28-29, 1967. The electron temperature was measured at the satellite, and a topside sounder determined the electron density structure to the F2 peak. The data are used to calculate the intensity and extent of the red arc; heat flow into the ionosphere via thermal conduction is considered as the only energy source. The calculated 6300-A emission, photometric structure, height of the peak emission, and position of the arc are in general agreement with the observational data of the Fritz Peak airglow observatory.

(Boulder)

UTLAUT, W. F.,
E. J. VIOLETTE and
A. K. PAUL

1970 Some Ionosonde Observations of Ionosphere Modification by Very High Power, High Frequency Ground-Based Transmission, J. Geophys. Res., 75, No. 31, 6429-6435.

Some early observations of significant ionospheric modification resulting from F-region heating by a very high power, high frequency transmitter located near Boulder, Colorado, are presented., A single-plane inverted log periodic antenna, which has a half-power beam-width of the order of 90°, was used for transmitting. The ionosonde transmitter, which has a peak power of about 25 kw, was operated by using a 200-Hz pulse repetition rate with a pulse duration of 64μsec. Ionograms were recorded in 4-sec periods at 30-sec intervals. At other times in the 30-sec interval the computer-controlled ionosonde was programmed to record on digital tape the amplitude and phase of selected frequencies for subsequent analysis. Salient effects observed in the ionosonde records following the turn on of the high-power transmitter are: (1) a prompt ionospheric response appearing within 30 sec is a deformation in both 0 and X traces at the virtual height at which the extraordinary component of the frequency used for heating was reflected; (2) a development and growth of spread F, starting within tens of seconds, frequently followed by distinct structure in both magnetoionic echo traces; (3) a time-varying broad-band oblique incidence echo which, at times, develops after 10 min or more of heating and which also changes in range with time; and (4) variation in the strength of signals returned from the ionosphere.

(Erie)

BONKE, HANS A.,
HENRY A. BLAKE,
ARTHUR K. HARRIS and
DUANE J. SHEPPARD

1970 An Eclipse Study of Soft-X-Ray Distribution over the Sun and of the Relative Contributions of X Rays and LIV to E-Layer Formation, J. Geophys. Res., 75, No. 34, 6980-6990.

A simplified model for X-ray distribution over the sun (based on photographs provided by J. H. Underwood of NASA) was fitted to the changes in electron production rate during the November 12, 1966, eclipse to determine the relative contributions made by diverse solar regions to the formation of the E layer. The production rates were obtained by using Huancayo ionograms and our previously determined E-layer recombination coefficient (5.5×10^{-8} cm^3 sec^{-1}). It was found that two active regions covering only 6% of the solar disk accounted for 32% of the electron production. Moreover, by combining the results so obtained with Underwood's analysis of the X-ray photographs, we were able to determine the relative contributions of soft X rays and of extreme ultraviolet to ion production at the E-layer peak. At this intermediate epoch of the solar cycle, 68% of the production rate 'was found to be due to soft X rays and 32% to ultraviolet. Reduced to solar-minimum conditions, the X-ray contribution would be 54%, a value about midway between the values predicted by the major theories of E-layer formation. In addition, comparison of our results with computations made by Widing for coronal sources of X rays enabled us to infer that the temperature in the two active regions was about 3×10^6 °K.

(Huancayo)

FARLEY, D. T.,
B. B. BALSLEY,
R. F. WOODMAN and
J. P. MC CLURE

1970 Equatorial Spread F: Implications of VHF Radar Observations, J. Geophys. Res., 75, No. 34, 7199-7216.

Scatter from field-aligned irregularities associated with equatorial spread F has been studied using the powerful 50 MHz radar at Jicamarca. We find that these irregularities, which have a wavelength of 3 meters, first, at times can be generated anywhere in the F region, no matter with what vertical velocity the region is moving, second, have growth times of a few seconds or less, third, move at velocities comparable to that of the F layer, and fourth, may attain strengths of perhaps 10^7-10^8 times the background thermal level. There are also indications that there may be two types of irregularities, classified roughly as strong and weak, and that there may be a minimum threshold altitude that the bottom of the F layer must be above before the irregularities are first generated. These and other observed characteristics of the irregularities seem to rule out currently popular theories of their origin (the vertical drift instability suggested first by Martyn, mechanisms based on coupling between the E and F regions, gravitational instabilities, generation by hydromagnetic waves, and others) and several other well known types of plasma instability. Gradients of density and drift velocity remain as possible sources of instability, but at the moment we can only speculate as to what may ultimately prove to be the correct explanation.

(Huancayo)

CRAWFORD, F. W., D. M. SEARS and R, L. BRUCE — 1970 — Possible Observations and Mechanism of Very Long Delayed Radio Echoes, J. Geophys. Res., 75, No. 34, 7326-7332.

Observations have been made under controlled conditions of what are believed to be very long delayed radio echoes returning from the ionosphere about 10 sec after transmission. Ionosonde records have suggested a new mechanism for the phenomenon. It is proposed that the signals travel through the ionosphere at very low group velocity under conditions in which collisional attenuation is offset by weak beam-plasma instability.

(Stanford)

ALPHABETICAL INDEX