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Ionosonde observations at King George Island, Antarctica: 1986-1991

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Abstract: The structure of the thermosphere and ionosphere are particularly interesting along the longitude sector containing South America and the Antarctic Peninsula due to the unique geometry of the geomagnetic field. For these locations, solar associated effects are probably well separated from geomagnetic effects. Modeling of the Thermosphere-Ionosphere-Plasmasphere system has shown that the relation between thermospheric circulation, vertical motions, and composition changes has specific characteristics in this longitude sector. Moreover, the ionospheric phenomena related to tropospheric forcing such as atmospheric gravity waves, are also of significant interest, since the Antarctic Peninsula may be considered as an effective barrier to the prevailing and strong westerly winds, being almost perpendicular to the barrier. To better assess some of the above indicated characteristics and phenomena, a latitudinal extension of available ionospheric observations for many years at Argentine Islands (65°S, 64°W), Port Stanley (52°S, 58°W) and Halley Bay (76°S, 27°W) was needed. Thus an ionospheric station was installed and operated at King George Island (62°S, 59°W), and the present report makes the corresponding data base obtained, available to the scientific community at large. Detailed instructions are given to access the hourly (at 15 min intervals for a few cases) and monthly mean values for the 1986-1991 interval. Also, a routine is provided on request to plot diurnal variations of critical frequencies and virtual heights for the ionospheric E- and F-regions.

1. Background & Summary

It has long been recognized that the structure of the thermosphere and ionosphere may be unique along the longitude sector containing South America and the Antarctic Peninsula. For these locations, solar associated effects (which are better represented on geographic latitude) are probably well separated from geomagnetic effects (which depend on geomagnetic latitude). See for example, [1]. In particular, modeling using the Coupled Thermosphere-Ionosphere-Plasmasphere model [2] has shown that the relation between thermospheric circulation, vertical motions, and composition changes has specific characteristics in this longitude sector [3, 4, 5], a sector identified by [6] as "far-from-pole" (magnetic pole). Along these longitudes, the equatorial boundaries of the auroral zones, where energy is received in the thermosphere from electric fields and particle precipitation generated by magnetospheric processes, are farther away from the equator than elsewhere in the southern hemisphere. Furthermore, due to the offsets of the magnetic poles, the geographic latitudes of these boundaries change with longitude by about 15° in the southern hemisphere as compared with only 8° in the northern hemisphere [3]. Moreover, eastern South America and the Antarctic Peninsula are on the westward slope of the South Atlantic Geomagnetic Anomaly, making the longitude sector globally unique.

The ionospheric phenomena related to tropospheric forcing such as atmospheric gravity waves, are also of significant interest since the Antarctic Peninsula may be considered as a long (thousand km) and high (2 km mean height) barrier to the prevailing and strong westerly winds, being almost perpendicular to the barrier.

To better assess some of the above indicated characteristics and phenomena, a project was developed which would need the latitudinal extension of available ionospheric observations for many years at Argentine Islands (65°S, 64°W), Port Stanley (52°S, 58°W) and Halley Bay (76°S, 27°W). In particular, the scientific questions raised and partial results obtained from the data base presented here are thermospheric irregularities [7], thermospheric winds [8, 9, 10], and Sporadic Es.

2. Location

The observations were made at the then called Chilean Antarctic Base Tte. Marsh (now Base Presidente Eduardo Frei Montalva) located in King George Island (62°12'S, 58°54'W geographic; -51.0°, 8.2° geomagnetic), South Shetland Islands, north of the Antarctic Peninsula. An ionosonde and the associated antennae were installed on a roughly horizontal area near the isthmus leading to the Fildes Peninsula, some 800 m from the main base buildings, on the south east tip of King George Island (Fig. 1).

3. Methods

The ionosonde was installed and operated on the framework of the Chilean Antarctic Institute (INACH) Thermospheric Irregularities and Radio-wave Absorption (ITARA) project, by the University of Concepción[11]. The programed installation was announced at the Upper Atmosphere Physics group of the Scientific Committee of Antarctic Research (SCAR) at the 1984 meeting in San

Diego, USA[12]. The operation of the ionosonde was started on the 15 February 1986 at 16:15 LT (60° W) and the first results were published in 1987 [13].

The ionosonde, an Australian IPS 42 [14] (Fig. 2(a)), was housed in a wooden hut placed some hundreds of meters from the transmitting and receiving antennas, and connected to them using RG8 and RG58 coaxial cables, respectively.

IPS-42 ionosonde specifications (IPS, 1983)

- Power output (peak pulse): 5 kW
- Frequency range: 1-22.6 MHz
- Frequency generation: digital synthesizer (576 frequencies)
- Frequency sweep configuration: logarithmic
- Frequency sweep time: 12 s
- Pulse width: 41.7 µs
- Pulse interval: 5.33 ms
- Height range: 90-800 km
- Frequency markers: 1.0, 1.4, 2.0, 2.8, 4.0, 5.6, 8.0, 11.3, 16.0 and 22.6 MHz
- Dimensions: height = 609 mm, depth = 457 mm, width = 520 mm
- Weight: 52 kg
- The ionograms were recorded on photographic 16 mm film.

Antennae

Two mutually perpendicular vertical delta antennas are used for transmitting and receiving, respectively (Fig. 2(b)). The vertical plane of the transmitting antenna is at 45° E from the magnetic north. Two 27 m long segments form each of the delta bases and are at about 1.6 m above the ground. All four delta sides are 38 m long. The antenna side wires are hanged from a 30 m height mast and pulled together with the delta base wires from four auxiliary poles. A central pole pulls all four base wires. Each delta antenna is ended by a 600 Ω radiation resistors and fed by unbalanced transmission/receiving 50 Ω coaxial cable using 16:1 impedance matching baluns (Figs. 2(c) and 2(d)).

To interpret and scale the ionograms, a KEL-46 Data Analyzer System was used. The ionograms were projected on to an Apple Graphics Tablet[15] connected to an Apple II computer using a data analyzer main program (Version 1.4 – K4607, 26 November 1984). A stylus was used to digitize, qualify and describe the values of standard 13 ionospheric characteristics and transferred to a digital data base on a main frame computer. For all purposes, agreed international rules were used[16].

4. Data Records

Files were prepared for hourly values (for 15-minute values in the case of March and June 1991) and monthly median values using the old "punched cards" format that not allowed more than 80 characters per card. The file names are j6kYYMMTT.dat and j6kYYMMTT.pch, for hourly values and monthly median values, respectively, where j6k is the station code, YY stands for year (e.g. 86 for 1986), MM for month (e.g. 03 for March) and TT for values at the hour (00), fifteen minutes past the hour (15), half past (30) and forty-five minutes past (45). The rows 1-14 and 930 (last), of 73 columns each, for a sample hourly values file (j6k860300.dat = values at the hour for March 1986, Marsh station) are:

File heading

	1 - 73
1	1,2
2	MARSH J6K 62.2S 58.9W 60W 010 200 86 03
3	1 5 10 5 1 1 1 5 5 5 5 5 1
4	4 1 5 5 5 1 1 1 5 5 5 5 5 1

File data

	1	2	3-5	6&7	8&9	10&11	12-13	14-16	17&18	19-21	22&23	..	69-71	72&73
5	1	1	j6k	86	03	01	42	014	EC	014	EC	..	018	
6	1	2	j6k	86	03	01	42	018		020		..	013	EC
7	1	1	j6k	86	03	01	32		C	016		..	032	
8	1	2	j6k	86	03	01	32	032		032		..	015	
9	1	1	j6k	86	03	01	30		C	018	JA	..	036	
10	1	2	j6k	86	03	01	30	033		032		..	017	JA
11	1	1	j6k	86	03	01	34		C	135		..	117	
12	1	2	j6k	86	03	01	34	122		117		..	120	
13	1	1	j6k	86	03	01	36			F4		..	H1	
14	1	2	j6k	86	03	01	36	H1		H1		..	F1	
..	.	.	…	…	…	…	…	...		…	…	..	…	…
930	1	2	j6k	86	03	31	04		C	220		..		

The first four rows give the heading of the file. The first row values (1, 2) indicate the beginning of the file. The second row lists station name (Marsh) and code (j6k), station latitude and longitude, and Local Time zone (60° W) plus two numbers (010 200), and abbreviations for year (86) and month (03). The third and fourth rows give parameters for the program that creates the file.

On the other hand, rows 5 to 930 give hourly values of the 13 ionospheric characteristics (see Table 1) . The meaning of numbers and letters in columns 1 to 73 of each row are given in Table 2. It should be noted that columns 12-13 show ionospheric characteristics given in Table 1. Column 2 shows local time range, i.e., "1" indicates 00 to 11 LT, and "2" indicates 12 to 23 LT. Therefore, two rows give one-day data for an ionospheric characteristic, and 26 rows give full one-day data (24 hourly data for 13 ionospheric characteristics).

Files for the monthly median values are similarly constructed. However, in this case, no heading rows are given. The meaning of numbers and letters in columns 1 to 73 are given in Table 3. Again, columns 12-13 show ionospheric characteristics, and column 2 local time range. Columns 10-11 show that monthly data consist of three values, i.e., median, count, and interquartile range. These three values use three rows for an ionospheric characteristic. Therefore, 36 rows are necessary to give three monthly values for 12 ionospheric characteristics. Note that there is no median values, count and interquartile range for Type of Es. Thus, there are only 12 ionospheric parameters to be included. Moreover, note that column 2 is always "1" for rows 1 to 36 and "2" for rows 37 to 72. That is, rows 1 to 36 give monthly data in 00 to 11 LT, and rows 37 to 72 in 12 to 23 LT.

Rows 1 to 12, 36 to 49 and 72 (last) of a sample file (j6k860300.pch = monthly median values at the hour for March 1986, Marsh station) are:

	1	2	3-5	6&7	8&9	10&11	12&13	14-16	17&18	19-21	22&23		69-71	72&73
1	2	1	j6k	86	03	40	00	044		040	UF	..	059	
2	2	1	j6k	86	03	50	00	26		27		..	27	
3	2	1	j6k	86	03	80	00	015		015		..	007	
4	2	1	j6k	86	03	40	03	285		280		..	340	
5	2	1	j6k	86	03	50	03	20		23		..	27	
6	2	1	j6k	86	03	80	03	020		010		..	020	
7	2	1	j6k	86	03	40	10					..	390	
8	2	1	j6k	86	03	50	10					..	5	
9	2	1	j6k	86	03	80	10					..	040	
10	2	1	j6k	86	03	40	20					..	270	
11	2	1	j6k	86	03	50	20					..	24	
12	2	1	j6k	86	03	80	20					..	025	
..	.	.	…	…	…	…	…	…	…	…	…	..	…	…
36	2	1	j6k	86	03	80	34	018		027		..	011	

37	2	2	3-5	6&7	8&9	10&11	12&13	14-16	17&18	19-21	22&23	..	69-71	72&73
38	2	2	j6k	86	03	40	00	060		061		..	045	
39	2	2	j6k	86	03	50	00	27		27		..	27	

40	2	2	j6k	86	03	80	00	005		005		..	016	
41	2	2	j6k	86	03	40	03	350		340		..	290	
42	2	2	j6k	86	03	50	03	27		27		..	25	
43	2	2	j6k	86	03	80	03	020		020		..	030	
44	2	2	j6k	86	03	40	10	401		410		..		
45	2	2	j6k	86	03	50	10	3		4		..		
46	2	2	j6k	86	03	80	10	045		025		..		
47	2	2	j6k	86	03	40	20	280		270		..		
48	2	2	j6k	86	03	50	20	24		26		..		
49	2	2	j6k	86	03	80	20	015		020		..		
..	.	.	…	…	…	…	…	…	…	…	…	..	…	…
72	2	2	j6k	86	03	80	34	010		099		..	010	

The meaning of numbers and letters of the file rows is explained in Tables 1 and 3.

All data for 41 months out of a total of 72 are scaled values available at http://www2.dgeo.udec.cl/IONO/IPS42/islareyjorge/. Furthermore, selected photographic copies of individual ionograms from the full March 1986 – December 1991 interval can be requested at nominal production cost. Preliminary displays of the data can be obtained using a simple MATLAB routine that can also be requested free of charge. Sample displays of f- and h'-plots thus produced are given in Figs. 3 and 4.

5. Technical Validation

The recorded values were then used as an input to the IOND program that validated the recorded data. This identified scaling errors, making it sure that there were no inconsistencies between the values, qualifying and descriptive associated letters for the different characteristics and that numerical values were within the ionograms limits (frequencies and heights). Finally, hard copies of the program output listings were visually checked and digital files prepared.

6. Competing interests

The author declares no competing interests.

7. Figures

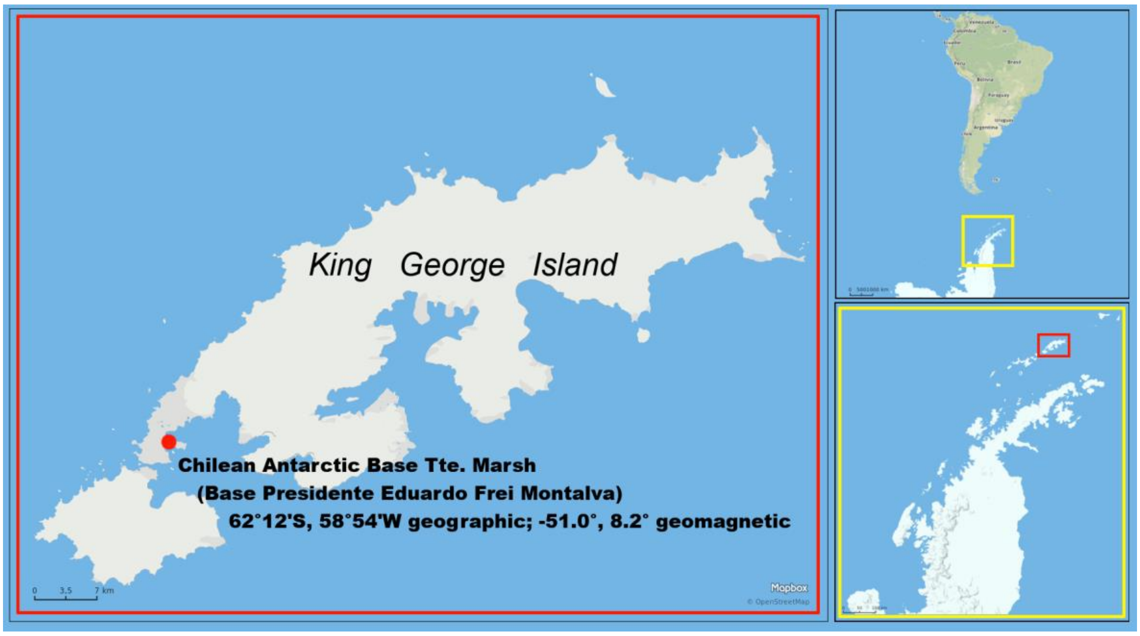

Fig. 1. Location of observations. South west tip of King George Island (62°12’S, 58°54’W geographic; -51.0°, 8.2° geomagnetic), the South Shetland Islands, northwest of the Antarctic Peninsula, South America longitude sector.

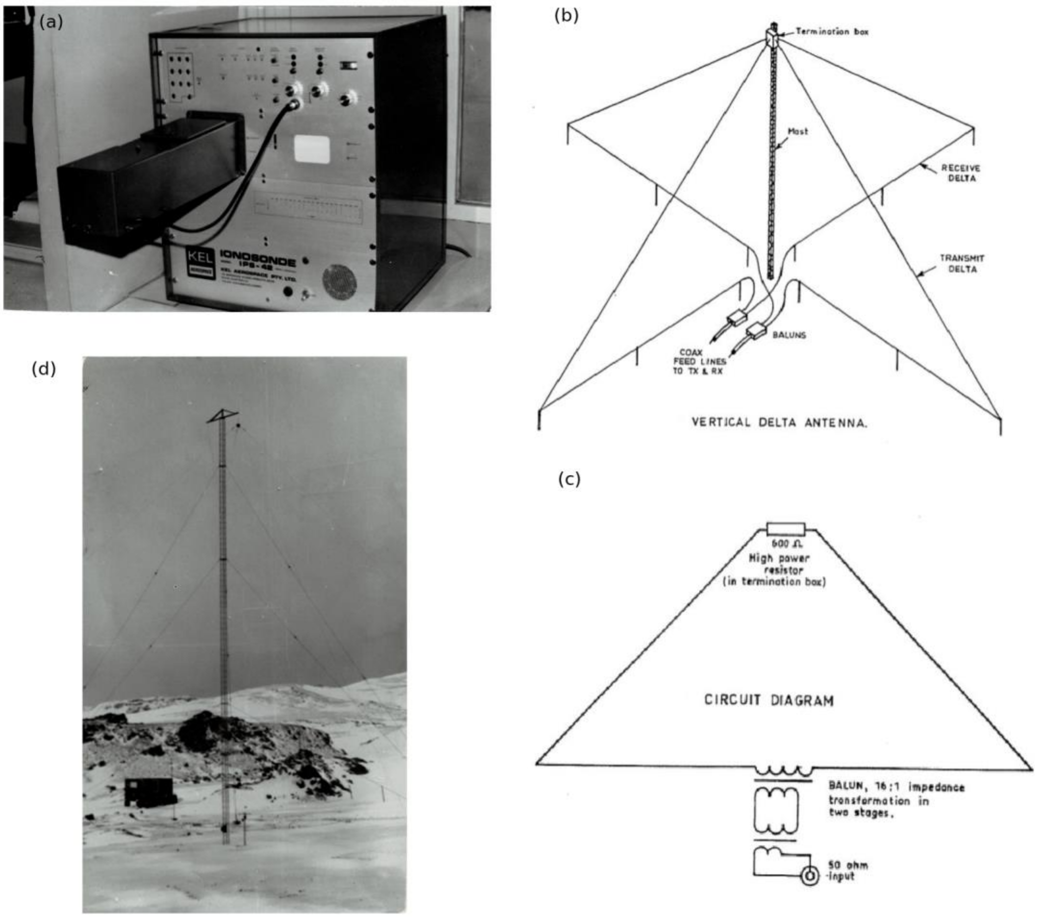

Fig. 2. (a) Australian IPS 42 photo showing control panel and recording 16 mm movie camera (protruding black box) and CRT display. (b) Vertical delta antennae diagram. (c) Antennae circuit diagram. (d) Antennae and ionospheric station hut photo.

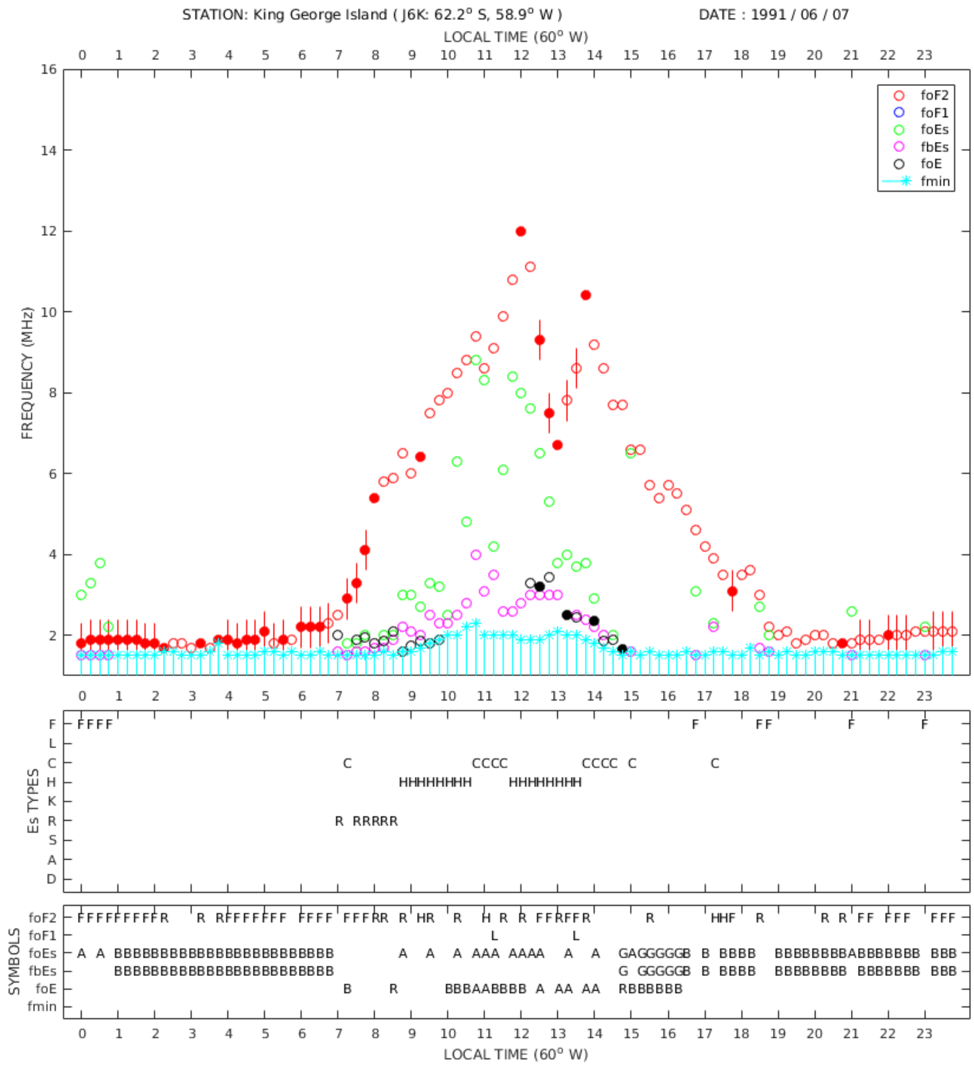

Fig. 3. Diurnal variations of ionospheric critical frequencies (top panel, f-plot) and observed types of Sporadic-E (middle panel) layers at King George Island (62°12'S; 58°54'W) on 7 of June 1991. Diagram produced using a MATLAB routine. (open circles) Unqualified values, (filled circles) values qualified as doubtful (associated descriptive letters in the bottom panel) and (filled circles crossed by vertical lines) Spread-F. Other symbols that may be used for different days are (filled triangles) values lower than (downward) and higher than (upward) indicated value. Rules to qualify and to describe values are those given by the WDC. U.R.S.I. Handbook of ionogram interpretation and reduction, Second Edition, World Data Center A for Solar-Terrestrial Physics report UAG 23, November 1972.

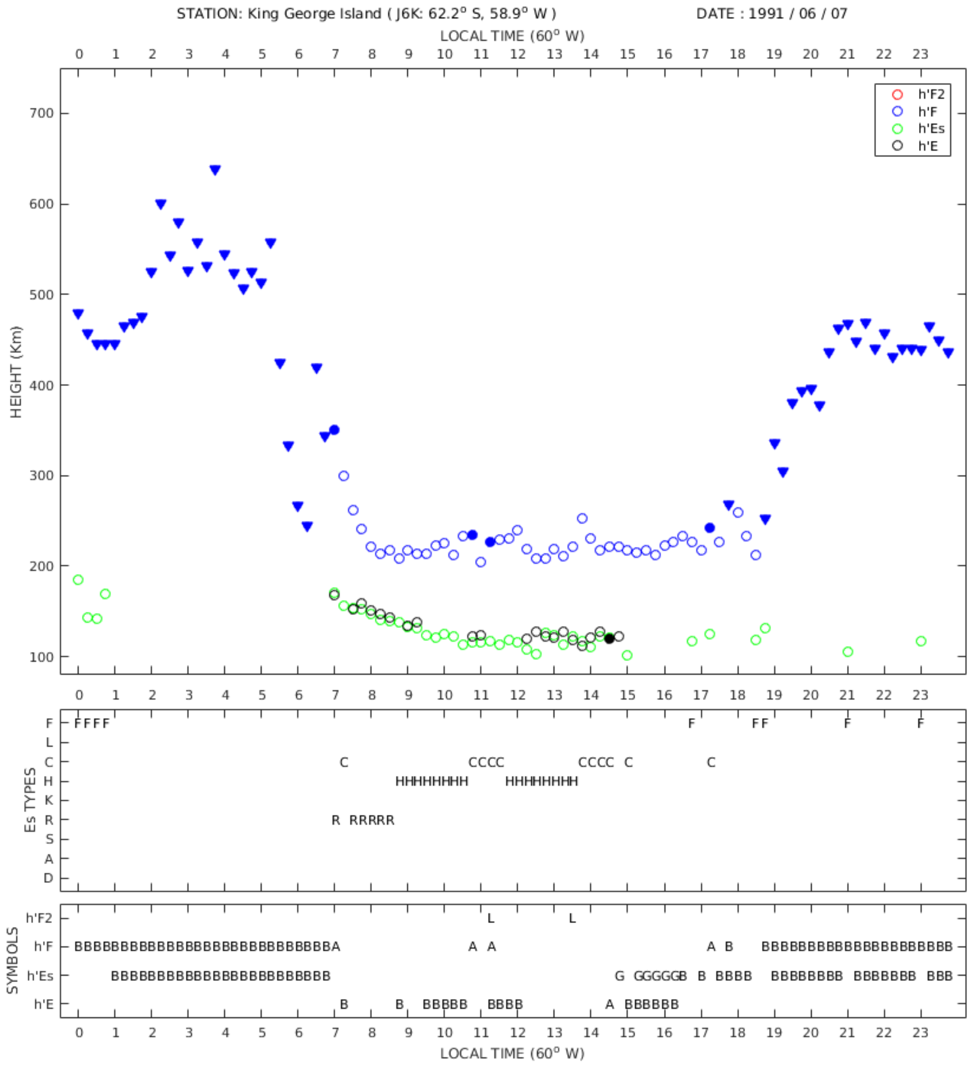

Fig. 4. Diurnal variations of ionospheric layers virtual heights (top panel, h'-plot) and observed types of Sporadic-E (middle panel) layers at King George Island (62°12'S; 58°54'W) on 7 of June, 1991. Diagram produced using a MATLAB routine. (open circles) Unqualified values, (filled circles) values qualified as doubtful (associated descriptive letters in the bottom panel) and (filled triangles) values lower than (downward). For other days the higher than symbol (upward) may be used. Rules to qualify and to describe values are those given by the WDC. U.R.S.I. Handbook of ionogram interpretation and reduction, Second Edition, World Data Center A for Solar-Terrestrial Physics report UAG 23, November 1972.

8. Tables

Table 1. Ionospheric characteristics scaled from ionograms

Ionospheric characteristic	**Abbreviation**	**Code**	**Accuracy**
Critical frequency F2-layer	foF2	00	0.1 MHz
Transmission factor F2-layer	M3000F2	03	0.01
Virtual height F2-layer	h’F2	04	1 km
Critical frequency F1-layer	foF1	10	0.01 MHz
Transmission factor F1-layer	M3000F1	13	0.01
Virtual height F-layer	h’F	16	1 km
Critical frequency E-layer	foE	20	0.01 MHz
Virtual height E-layer	h’E	24	1 km
Critical frequency Es-layer	foEs	30	0.1 MHz
Virtual height Es-layer	h’Es	34	1 km
Es blanketing frequency	fbEs	32	01.MHz
Type of Es	Es Type	36	-
Minimum frequency	fmin	42	0.1 MHz

Table 2. Hourly values files format concerning file for March 1986 at the hour (j6k860300.dat)

Column number	Symbol	Explanation
1	1	Ionospheric measurement
2	1 2	Values of ionospheric characteristic for 00 to 11 LT (60°W) Values of ionospheric characteristic for 12 to 23 LT (60°W)
3, 4 & 5	J6K	Station code (Chilean ionospheric station at King George Island)
6 & 7	86	Year (1986)
8 & 9	03	Month (March)
10 & 11	01	Day (1 March)
12 & 13	42	Ionospheric characteristic code (fmin)
14, 15 & 16	014 018	Numerical values of ionospheric characteristic for 00 LT (fmin = 1.4 MHz) Numerical values of ionospheric characteristic for 12 LT (fmin = 1.8 MHz)
17 & 18	EC none	Qualifying and descriptive letters for numerical value at 00 LT Qualifying and descriptive letters for numerical value at 12 LT
19, 20 & 21	014 020	Numerical values of ionospheric characteristic for 01 LT (fmin = 1.4 MHz) Numerical values of ionospheric characteristic for 13 LT (fmin = 2.0 MHz)
22 & 23	EC none	Qualifying and descriptive letters for numerical value at 01 LT Qualifying and descriptive letters for numerical value at 13 LT
…	…	…
69, 70 & 71	018 013	Numerical values of ionospheric characteristic for 11 LT (fmin = 1.8 MHz) Numerical values of ionospheric characteristic for 23 LT (fmin = 1.3 MHz)
72 & 73	none EC	Qualifying and descriptive letters for numerical value at 11 LT Qualifying and descriptive letters for numerical value at 23 LT

Table 3. Monthly-median values files format concerning file for March 1986 at the hour (j6k860300.pch)

Column number	Symbol	Explanation
1	2	Ionospheric monthly median values
2	1 2	Values of ionospheric characteristic for 00 to 11 LT (60°W) Values of ionospheric characteristic for 12 to 23 LT (60°W)
3, 4 & 5	J6K	Station code (Chilean ionospheric station at King George Island)
6 & 7	86	Year (1986)
8 & 9	03	Month (March)
10 & 11	40	Monthly median values
	50	Count (number of values used to compute the median)
	80	Interquartile range
12 & 13	00	Ionospheric characteristic code (foF2)
14,15 &16	044 060	Monthly median value of ionospheric characteristic for 00 LT (foF2 = 4.4 MHz) Monthly median value of ionospheric characteristic for 12 LT (foF2 = 6.0 MHz)
17 & 18	none none	Qualifying and descriptive letters for numerical value at 00 LT Qualifying and descriptive letters for numerical value at 12 LT
19, 20 & 21	040 061	Monthly median value of ionospheric characteristic for 01 LT (foF2 = 4.0 MHz) Monthly median value of ionospheric characteristic for 13 LT (foF2 = 6.1 MHz)
22 & 23	UF none	Qualifying and descriptive letters for numerical value at 01 LT Qualifying and descriptive letters for numerical value at 13 LT
…	…	…
69, 70 & 71	059 045	Numerical values of ionospheric characteristic for 11 LT (foF2 = 5.9 MHz) Numerical values of ionospheric characteristic for 23 LT (foF2 = 4.5 MHz)
72 & 73	none none	Qualifying and descriptive letters for numerical value at 11 LT Qualifying and descriptive letters for numerical value at 23 LT

Author contributions

AJF is the principal investigator, worked on the installation and operation of ionosonde, and did most of the writing. MAB processed the files and produced the display routine program. CUV and GC thoroughly revised all the diurnal variations of ionospheric characteristics.

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