Relational Database of the Dourbes Ionosonde Measurements (1957 – 2011)

Authors:	Myriam Nemry	RMI	M.Nemry@meteo.be
	Stan Stankov	RMI	S.Stankov@meteo.be
Release:	0.2	02.08.2012	Unclassified

DISCLAIMER

DOCUMENT CHANGE RECORD

VERSION	DATE	CHANGE RECORD	AUTHOR
0.1	01.07.2012	First Draft	M. Nemry
0.2	02.08.2012	Draft, revised and updated	S. Stankov

SUMMARY

The Belgian ionosonde (URSI code: DB049) located at the RMI Geophysical Centre in Dourbes (4.6°E, 50.1°N) has been providing regular observations of the ionosphere since August 1957. Over the years, large datasets with ionosonde measurements was accumulated; however, the data was scattered on different carriers and in different archival formats. A new relational database was built comprising all the Dourbes ionosonde data in the period from August 1957 through to April 2011, with a particular focus on the manually-scaled data. First, all records has been automatically extracted from the original files (in three different formats) according to the year of acquisition and then saved on a new file system in the now commonly used CSV format. After that, the content of these new files was inserted into a new, relational database. The content of the database was checked for consistency and several plots were produced in the process.

ACKNOWLEDGEMENTS

The authors thank P. Marinov, T. Verhulst, D. Sapundjiev, and J.C. Jodogne for the helpful discussions. Thanks are also due to K. Stegen, G. Crabbe, E. Van Malderen, and L. Lejeune for the past and ongoing technical support. This work is funded by the Royal Meteorological Institute (RMI) via the Belgian Solar-Terrestrial Centre of Excellence (STCE).

TABLE OF CONTENTS

1. INTRODUCTION 4
2. EXISTING FORMATS OF DOURBES IONOSONDE DATA 5
3. COMMON CLASSIFICATION OF IONOSPHERIC VALUES 9
4. FORMAT AND ORGANISATION OF CSV FILES GENERATED BY PARSERS 18
5. STRUCTURE OF THE RELATIONAL DATABASE 19
6. PROGRAMMING 20
7. EXECUTION 21
8. RESULTS 24

REFERENCES 27

1. Introduction

The ionosonde was and still remains one of the most reliable instruments for observing the key ionospheric characteristics. This relatively inexpensive instrument was around since the dawn of the ionospheric research and went through several significant improvements, most important being the digitalisation and, consequently, the automatisation of scaling (autoscaling) the ionospheric charactiristcs from digital ionograms (*Wright*, 1969; *Reinisch*, 1996; *Pezzopane and Scotto*, 2005; *Reinisch* et al., 2009).

Nowadays, the real-time ionospheric data provision from digital ionosondes offers important input to address the needs of radio communication services and various ionosphere / space weather monitoring applications (*Stankov*, 2002; *Stamper* et al., 2004; *Stankov* et al., 2011a, 2011b; and the references therein). However, various studies have already pointed at some autoscaling deficiencies (cf. *Stankov* et al., 2012; and the references therein) which highlight the importance of manually-scaled ionograms. For research purposes therefore, the long-term series of (manually-scaled) ionosonde measurements are indispensable.

The Belgian ionosonde (URSI code: DB049) located at the RMI Geophysical Centre in Dourbes (4.6°E, 50.1°N) has been providing regular observations of the ionosphere since August 1957. The first (analogue) ionosonde (Sondeur Panoramique), installed at the site in early 1957, recorded the ionograms on photographic films. The digital sounding started in September 1970 with a Digisonde-128 (DGS-128) and continued, since 1984, with a Digisonde-256 (DGS-256), both developed and produced by the University of Massachusetts Lowell (UML). The Dourbes digisonde employs a ‘delta’ transmit antenna and 7 receive antennas.

Over the years large datasets with ionosonde measurements was accumulated (*Jodogne and Stankov*, 2002) that, unfortunately, were scattered on different carriers – from paper to DVDs. The problem was exacerbated by the existence of different archival formats and addition of new ionospheric characteristics, especially after the introduction of the digital ionosonde and the automatic scaling of ionograms. The efforts in the recent years (*Stankov* et al., 2010) went into the complete overhaul of this comprehensive ionosonde data collection and creating a database of hourly, manually-scaled (cf. Piggot and Rawer, 1972, 1978; Wakai et al., 1987) ionosonde measurements covering a period of more than 50 years, from 1957 to 2011.

The purpose of this report is to present the new relational database of the Dourbes ionosonde observations comprising all ionosonde data in the abovementioned period from August 1957 through to April 2011, with a particular focus on the manually-scaled data.

The report is organized as follows. First, a brief information on the available ionosonde data at Dourbes and the data formats used in the past is provided, followed by the definition of a common new classification and format of ionospheric values. Next, the structure of the new relational database is presented together with some programming and execution details. The report concludes with a few representative examples of data selection and plotting.

2. Existing manually-scaled ionosonde data and data formats at Dourbes

A (monthly) summary of the data available at Dourbes is provided in **Table 2-1**. Manual scaling has ceased with the installation of the new ionosonde (Digisonde-4D) in April 2011 and the utilisation of the ARTIST-5 autoscaling software.

DB049 Data Availability – Monthly Details — Note: Daily files may be incomplete

Year	1	2	3	4	5	6	7	8	9	10	11	12	Format
2011	31	28	31	24	-	-	-	-	-	-	-	-	SAO
2010	31	28	31	30	31	30	31	31	30	31	30	31	SAO
2009	31	28	31	30	31	30	31	31	30	31	30	31	SAO
2008	31	29	31	30	31	30	31	31	30	31	30	31	SAO
2007	31	28	31	30	31	30	31	31	30	31	30	31	SAO
2006	31	28	31	30	31	30	31	31	30	31	30	31	SAO
2005	31	28	31	30	31	7	31	31	30	31	30	31	SAO
2004	31	29	31	30	17	30	31	31	24	31	30	31	SAO
2003	31	28	31	30	31	29	2	0	9	28	30	31	SAO
2002	0	28	31	29	16	30	30	31	30	31	30	31	SAO
2001	31	28	31	30	31	30	31	31	30	31	30	0	URSI-I
2000	0	29	31	30	31	30	31	31	30	31	30	31	URSI-I
1999	31	28	31	28	31	30	31	31	30	31	30	22	URSI-I
1998	31	28	31	30	31	30	31	30	30	31	30	31	URSI-I
1997	31	28	31	30	31	30	31	31	30	31	30	31	URSI-I
1996	31	29	31	30	31	30	31	31	30	31	30	31	URSI-I
1995	31	28	31	30	31	30	31	31	30	31	30	31	URSI-I
1994	30	28	31	30	31	30	31	31	30	31	30	31	URSI-I
1993	31	28	30	30	31	30	31	30	30	31	29	31	URSI-I
1992	31	29	28	30	31	30	28	31	30	31	30	31	URSI-I
1991	31	28	31	30	31	30	30	31	30	31	30	31	URSI-I
1990	31	28	31	30	31	30	31	31	30	31	30	31	URSI-I
1989	31	28	31	30	31	30	31	31	30	31	30	31	URSI-A
1988	31	29	31	30	31	30	31	31	30	31	29	31	URSI-A
1987	31	28	31	30	31	30	31	31	30	31	30	31	URSI-A
1986	31	28	31	30	31	29	31	31	30	31	30	31	URSI-A
1985	31	28	31	30	31	30	31	31	30	30	30	31	URSI-A
1984	31	29	31	30	31	30	31	31	30	31	30	31	URSI-A
1983	31	28	31	30	31	30	31	31	30	31	30	31	URSI-A
1982	31	28	31	30	31	28	31	31	30	31	30	31	URSI-A
1981	30	28	31	26	31	30	31	31	30	31	30	31	URSI-A
1980	31	29	31	30	30	30	31	31	28	31	30	31	URSI-A
1979	31	28	31	30	31	30	30	31	30	31	30	31	URSI-A
1978	31	28	31	30	31	30	31	31	30	31	30	31	URSI-A
1977	31	28	31	30	31	30	31	31	30	31	30	31	URSI-A
1976	31	29	31	30	31	29	31	31	30	31	30	31	URSI-A
1975	31	28	31	30	31	30	31	31	30	31	30	31	URSI-A
1974	31	28	31	30	31	30	31	31	30	31	30	31	URSI-A
1973	31	28	31	30	31	18	31	31	30	31	30	31	URSI-A
1972	31	29	31	30	31	29	31	31	30	31	30	31	URSI-A
1971	30	28	31	30	30	30	31	31	30	29	30	31	URSI-A
1970	31	28	31	30	29	30	31	31	30	31	30	30	URSI-A
1969	30	28	31	29	31	30	22	31	28	30	30	31	URSI-A
1968	30	27	30	30	31	30	31	31	30	31	28	30	URSI-A
1967	31	28	31	29	28	28	31	21	29	31	28	31	URSI-A
1966	31	28	31	30	31	30	30	31	30	31	30	31	URSI-A
1965	31	27	29	30	31	30	31	29	30	30	30	31	URSI-A
1964	31	27	30	30	31	30	31	31	29	31	29	31	URSI-A
1963	31	28	30	28	31	28	31	31	30	31	30	31	URSI-A
1962	31	28	31	30	29	30	31	31	30	30	30	31	URSI-A
1961	31	27	31	29	30	30	31	30	30	31	30	31	URSI-A
1960	31	29	31	22	31	30	31	30	30	31	28	31	URSI-A
1959	31	27	31	27	28	28	27	31	30	31	30	30	URSI-A
1958	30	28	31	30	30	30	30	31	30	24	30	31	URSI-A
1957	-	-	-	-	-	-	-	29	29	25	30	30	URSI-A

SAO – Standard Archiving Output format, URSI-I the URSI IIWG format - Report UAG-23 WDC-A, URSI-A – URSI/AGI Brussels '56 and Lindau-Tokyo '57

Table 2-1. Dourbes ionosonde data catalogue of manually-scaled ionograms, 1957-2011 (cf. *Stankov et al.*, 2010).

Three data formats have been in use over the years - URSI-A, URSI-I, and the SAO. Detailed description of each format is available in the RMI technical report by *Stankov et al.* (2010); here we provide just a few sample data printouts.

The oldest, URSI-A format, was used from August 1957 to January 1990.

```
1104977010100020DC020DC025JC023JC020      A015  022  040  056  065DC058
1204977010100057  053  050  048  048  033  020  021  025  027  029  029
1104977010200027  028  027  026 F024  019  015 H022  052  053  061  062
1204977010200059  056  052  048 H040  029  023  022  024  025 F027 F026
1104977010300026  027  029  027  023  023  024  027  051  060  059  063
1204977010300060  053 H053 H048 C042  037       A020  022  024  028  031
1104977010400031  028  026  024  023  023  023  026       R059  057  054
1204977010400056  056  056  060  043  031  019  022  024  026  027  028
1104977010500030  032  033 F038 F024  018       A023  043  060  058  065
1204977010500065  059  053  048  050  033  021  023  028  031 F033  033
1104977010600031  030  029  028  021       A019  024  049  055  052  057
1204977010600066  072  061  053  043  034  033  030UA032  033  037  035
1104977010700032 F033  040  035UF028 F023  019  026  052  059  063  069
1204977010700072  065  053  048 H041  030  022UA024  029  033  031  035
1104977010800033  031  032  031  029  030  023  025  053  055  055  055
...
```

```
12 4977 11203357  367  367  387  352  300  308  312  335       A324  333
11 4977 11303319  318  311  323  348 N317  333  327  370       C382 C366
12 4977 11303364  386  343  350  368  357  355  324  315  334  314  316
11 4977 11403306  322  313  321  331  377  370  340  372  381  348  368
12 4977 11403366  371  373  352  357  353  357  315  304  307  306  306
11 4977 11503314  309  303  309  344  348  305 A304  380 R373 R386  375
12 4977 11503351  354  357  358  349  357UA    A321  306  315  312  303
11 4977 11603331  322 F316  319       F325  324  352  370       C368  371
12 4977 11603366  370  378  378  366  329  333  350  354  329  330  308
11 4977 11703312  318  296       F305UF316UF328UF318  375  385  353UH382
12 4977 11703385  360  370  347  335  324  357  358  315UF315  322  341
11 4977 11803304  317  315  304  308  321  333  341  365  366  380  362
12 4977 11803365  349  382  364  360  339  344  353  340  300UN317  317
11 4977 11903306  316  311  303 F325UF321UF345  367  370  359  371  357
...
21 4977 17003304  303  303  310  312  324  325  327  356  358  352  362
22 4977 17003357  354  349  353  350  333  320  312  304  306  306  306
21 4977 18003015  015  013  011  032  026  027  026  017  022  021  016
22 4977 18003014  020  021  020  016  024  027  035  036  021  018  014
11 4977 10104                                                           L
12 4977 10104    L
11 4977 10204                                                      L    L
12 4977 10204    L    L
11 4977 10304                                                       233
12 4977 10304    L    L    L
11 4977 10404
12 4977 10404         L
11 4977 10504
12 4977 10504                   A
11 4977 10604                                                      L    L
12 4977 10604    L    L    L
11 4977 10704                                                           L
12 4977 10704    L215      L
11 4977 10804
12 4977 10804         L
11 4977 10904                                                           L
12 4977 10904    L
...
21 4977 16020                                        145  210  235  245
22 4977 16020252  245  225  190  145
21 4977 17020                                        135  185  220  230
22 4977 17020235  232  210  182  130
21 4977 18020                                        010  025  015  015
22 4977 18020017  013  015  008  015
1104977010124                                            A112      A125EA
1204977010124112  112       A    B    A
1104977010224                                            A    A115  120EA
1204977010224115  112  120  119       A
1104977010324                                            A    A    A    C
1204977010324    A    C    A    A    A
1104977010424                                            A117  112  112
1204977010424    A111  115  117       A
1104977010524                                            A    A    A    A
1204977010524    A112  120EA    A    A
...
```

The URSI-I format was used from January 1990 to April 2002.

DGS 256 foF2 in units of 0.1 MHz

DOURBES Belgium Latitude: 50.1 Longitude: 4.6 October, 1998

foF2

Time in UT

Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	39/	37/	34/	38/	39/	33/	49/	63/	70/	76/	93/	109/	100/	101/	85/	81/	80/	84/	81/	74/	58/	50/	39/	42/
2	42/	40/	38/	37/	33/	30/	45/	57/	61/	69/	88/	93/	93/	99/	96/	90/	88/	85/	82/	75/	63/	57/		
3								45/	52/	64/	78/	71/	78/	79/	77/	80/	84/	85/	71/	59/	51/	45/	42/	41/
4	39/	38/	37/	37/	34/	27/	50/	61/	71/	77/	87/	88/	92/	87/	89/	91/	90/	85/	63/	60/	50/	46/	45/	44/
5	43/	40/	41/	41/	36/	29/	49/	66/	78/	79/	89/	92/	91/	86/	87/	83/	84/	80/	69/	63/	63/	50/	41/	41/
6	41/	42/	41/	39/	37/	32/	54/	68/	80/	85/	90/	93/	93/	89/	86/	87/	87/	80/	73/	64/	59/	54/	51/	50/
7	49/	45/	45/	45/	45/	41/	58/	72/	83/	89/	106/	100/	100/	97/	102/	110/	104/	93/	77/	61/	56/	61/	56/	53/
8	55/	41/	36/	36/	33/	30/	40/	51/	52/	55/	59/	69/	78/	79/	83/	82/	76/	70/	62/	58/	45/	44/	40/	39/
9	37/	36/	35/	34/	32/	25/	39/	50/	54/	54/	68/	76/	71/	77/	76/	70/	66/	62/	59/	49/	35/	31/		30/
10	27/	30/	31/	32/	27/	26/	40/	55/	72/	75/	78/	78/	74/	80/	76/	78/	80/	78/	75/	63/	40/	32/	33/	35/
11	35/	34/	32/	33/	30/	30/	49/	59/	70/	76/	84/	93/	86/	80/	84/	89/	87/	82/	69/	60/	45/	32/	31/	32/
12	35/	35/	34/	35/	35/	30/	54/	66/	76/	83/	90/	99/	83/	92/	93/	84/	90/	83/	73/	66/	57/	42/	39/	39/
13	39/	41/	41/	42/	39/	36/	52/	77/	83/	89/	97/	101/	94/	93/	86/	88/	90/	79/	67/	63/	56/	40/	38/	37/
14	38/	37/	37/	38/	36/	32/	52/	75/	91/	88/	99/	106/	93/	86/	86/	89/	81/	80/	67/	61/	51/	45/	42/	39/
15	38/	38/	38/	37/	34/	32/	50/	72/	82/	100/	102/	111/	103/	100/	93/	97/	101/	87/	72/	73/	63/	52/	50/	48/
16	46/	45/	45/	44/	43/	40/	51/	75/	88/	95/	101/	104/	91/	93/	102/	102/	94/	80/	66/	59/	53/	46/	47/	46/
17	45/	46/	44/	43/	41/	33/		72/	88/	96/	106/	119/	116/	113/	98/	100/	97/	85/	77/		59/	48/	45/	47/
18	48/	48/	46/	45/	44/	38/	48/	67/	78/	89/	93/	98/	100/	104/	107/	100/	89/	70/	68/	59/	55/	51/	47/	47/
19	49/	48/	47/	42/	37/	27/	39/	51/	61/	58/	80/	83/	84/	87/	85/	88/	68/	50/	41/	39/	29/	31/	31/	39/
20	41/	37/	32/	29/	25/	24/	35/	45/	50/	54/	57/	66/	68/	69/	77/	76/	77/	59/	50/	41/	34/	34/	36/	32/
21	34/	30/	31/	32/	25/	22/	36/	51/	56/	69/	79/	87/	91/	84/	87/	76/	77/		66/	50/		45/	46/	29/
22	30/	29/	30/	30/			41/	67/	78/	84/	94/	100/	108/	98/	102/	97/	89/	70/	63/	56/		39/	38/	39/
23	37/	37/	39/	37/	35/	29/	41/	66/	74/	93/	100/		94/	88/	87/	96/	91/	71/	70/	62/	58/	45/	47/	45/
24	41/	39/	35/	31/	25/	20/	31/	44/	49/	55/	60/	64/	57/	61/	59/	63/	58/	47/	39/	35/	28/	26/	27/	27/
25			25/				30/	45/	55/	61/	68/	78/	83/	77/	69/	71/	67/	54/	49/	41/	29/	25/	25/	24/
26	24/	22/	21/	20/	19/	20/	34/	55/	66/	79/	78/	84/	91/	84/	83/		80/	65/	51/	39/	31/	27/	26/	27/
27	27/	29/	29/	31/	31/	31/	35/	63/	71/	75/	86/	91/	93/	89/	87/	84/	76/	61/	53/	52/	46/	36/	34/	33/
28	33/	35/	35/	34/	35/	26/	35/	67/	80/	84/	104/	107/	110/	93/	85/	90/	78/	60/	61/	54/	53/	44/	44/	41/
29	40/	39/	40/	39/	38/	35/	38/	56/	71/	89/	87/	103/	109/	94/	89/	90/	77/	57/	55/	58/	39/	35/	36/	34/
30	34/	34/	35/	34/	30/	28/	34/	61/	82/	89/	95/	101/	96/	93/	93/	90/	83/	66/	52/	45/	33/	31/	33/	34/
31	35/	35/	35/	36/	37/	31/	38/	60/	75/	82/	91/	94/	93/	89/	96/	101/	82/	68/		45/	37/	38/	39/	40/
Med	39/	37/	35/	37/	35/	30/	41/	61/	72/	79/	89/	93/	93/	89/	87/	88/	83/	74/	66/	59/	51/	44/	39/	39/
NO	29	29	30	29	28	28	29	31	31	31	31	30	31	31	31	30	31	30	30	30	29	31	29	30
UQ	42/	41/	41/	40/	37/	32/	50/	67/	80/	89/	97/	101/	100/	94/	93/	96/	90/	83/	72/	63/	57/	48/	45/	44/
LQ	34/	34/	32/	32/	30/	26/	35/	51/	61/	69/	78/	83/	83/	80/	83/	81/	77/	62/	55/	49/	36/	32/	33/	33/
QR	8	7	9	8	7	6	15	16	19	20	19	18	17	14	10	15	13	21	17	14	21	16	12	11
UD	49/	48/	45/	45/	44/	40/	54/	75/	88/	95/	104/	109/	109/	101/	102/	101/	97/	85/	77/	73/	63/	54/	51/	48/
LD	27/	29/	29/	29/	25/	20/	31/	45/	52/	55/	60/	69/	71/	77/	76/	71/	67/	54/	49/	39/	29/	27/	26/	27/

DGS 256 foF1 in units of 0.01 MHz

DOURBES Belgium Latitude: 50.1 Longitude: 4.6 October, 1998

foF1

Time in UT

Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1										520/	500/		500/											
2																								
3										440/	450/		450/											
4													490/											
5											490/													
6												480/												
7																								
8									390/	410/	450/	450/	450/											
9									380/		450/	450/	460/	440/										
10												460/	440/	420/										
11																								
12												490/		490/										
13																								
14																								
15																								
16																								
17																								
18																								
19									410/		440/	450/	430/	410/										
20										385/	400/		410/											
26																								
27																								
28																								
29																								
30																								
31																								
Med	0/	0/	0/	0/	0/	0/	0/	0/	390/	415/	450/	450/	450/	420/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/
NO	0	0	0	0	0	0	0	0	3	6	9	8	9	5	0	0	0	0	0	0	0	0	0	0
UQ	0/	0/	0/	0/	0/	0/	0/	0/	400/	440/	470/	470/	475/	465/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/
LQ	0/	0/	0/	0/	0/	0/	0/	0/	385/	390/	417/	445/	432/	407/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/
QR	0	0	0	0	0	0	0	0	15	50	53	25	43	58	0	0	0	0	0	0	0	0	0	0
UD	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/
LD	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/	0/

The most recent data, from to April 2002 to April 2011, were stored in the Standard Archiving Output (SAO) format (first published in the INAG Bulletin #62 in 1998).

.


```
  5  1 77 49  0  8 56  0 56 56 56  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 10  0  7  0
 49  2  0  0  0  0  0  0  0  0 74 74 74 49 49120  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  5
  1.182 65.459 50.100  4.600 -1.000
DGS-256 049/DB049, NAME Dourbes, NH 4.31, VIEWER SAO Explorer v 3.4.08
FE201009003310000051009000000052142000001000010D410001209C2004941D1425003122B0
   4.3009999.000   2.921  12.561   1.5509999.000   1.5509999.0009999.000   4.961 267.912 267.9129999.0009999.0009999.000
9999.0009999.0009999.000   1.5009999.0009999.000    .0709999.0009999.000   3.950 377.500    .000    .354   1.550   1.550
9999.000 326.8689999.000 273.254   2.4399999.000  76.3679999.000   3.852  40.467  68.400   3.0909999.0009999.0009999.000
9999.0009999.0009999.0009999.000
 -5.469 -3.906 -2.344  -.781   .781  2.344  3.906  5.469
 267.912 267.912 267.912 270.549 271.429 272.308 272.308 274.066 274.945 277.582 279.341 281.978 282.500 282.500 282.500
 282.500 287.500 287.253 295.165 295.165 295.165 295.165 297.802 298.681 300.440 301.319 301.319 303.956 308.352 311.868
 314.505 314.505 318.022 318.022 317.500 322.500 322.500 327.500 332.500 332.500 337.500 342.500 342.500 347.500 352.500
 357.500 367.500 372.500 377.500 387.500 398.729 411.585 426.446 443.823 485.055 547.473
 96 92 96 92 96 96 96 92100 96 96100104100104100104104104102106104110108110102110106110110 84108 88110110108106110 84110
110110106106 80110110106106106106106106  0  0
333333433343333433343333433334334333344443444433333443388
   1.550   1.600   1.650   1.700   1.750   1.800   1.850   1.900   1.950   2.000   2.050   2.100   2.150   2.200   2.250
   2.300   2.350   2.400   2.450   2.500   2.550   2.600   2.650   2.700   2.750   2.800   2.850   2.900   2.950   3.000
   3.050   3.100   3.150   3.200   3.250   3.300   3.350   3.400   3.450   3.500   3.550   3.600   3.650   3.700   3.750
   3.800   3.850   3.900   3.950   4.000   4.050   4.100   4.150   4.200   4.250   4.300
 .354000E+0 .430000E+1 .326868E+3 .000000E+0-.127539E+3 .232860E+2-.889000E+1 .112200E+1-.100000E+0 .273254E+3
 .200000E+0 .354000E+0 .110000E+3 .000000E+0-.187910E+2 .243500E+1-.142000E+0
545555544555454444000542555255524444244444444454444
 .104747E+3 .154000E+0
.....
```

3. Common classification of ionospheric values

A common classification has been defined in the Extensible Markup Language (XML) (*Fawcett* et al., 2012) format (both human-readable and machine-readable) taking into account the different classifications provided over time by URSI and UML. Here is the definition of this new format expressed in XML Schema Definition (XSD) (**Ref**.3).

```
<?xml version="1.0" encoding="UTF-8"?>
  <xs:schema elementFormDefault="qualified"
              targetNamespace="http://oma.be/iono/characters"
              xmlns:characters="http://oma.be/iono/characters"
              xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="IonoCharacteristics">
     <xs:complexType>
          <xs:sequence>
               <xs:element maxOccurs="unbounded" ref="characters:Group"/>
          </xs:sequence>
     </xs:complexType>
  </xs:element>
  <xs:element name="Group">
     <xs:complexType>
          <xs:sequence>
               <xs:element ref="characters:Name"/>
               <xs:element ref="characters:CharacteristicList"/>
          </xs:sequence>
               <xs:attribute name="gid" type="xs:NCName" use="required"/>
     </xs:complexType>
  </xs:element>
  <xs:element name="CharacteristicList">
     <xs:complexType mixed="true">
          <xs:sequence>
               <xs:element maxOccurs="unbounded"
                          minOccurs="0"
                               ref="characters:Characteristic"/>
          </xs:sequence>
     </xs:complexType>
  </xs:element>
  <xs:element name="Characteristic">
     <xs:complexType>
          <xs:sequence>
               <xs:element ref="characters:Name"/>
               <xs:element minOccurs="0" ref="characters:ArtistName"/>
               <xs:element ref="characters:Dimension"/>
               <xs:element ref="characters:Desc"/>
          </xs:sequence>
          <xs:attribute name="code" type="xs:NMTOKEN" use="required"/>
          <xs:attribute name="sao_pos" type="xs:integer"/>
          <xs:attribute name="type" type="xs:NCName" use="required"/>
     </xs:complexType>
```

```
  </xs:element>
  <xs:element name="ArtistName" type="xs:string"/>
  <xs:element name="Dimension">
     <xs:complexType>
          <xs:sequence>
               <xs:element minOccurs="0" ref="characters:UrsiFactor"/>
               <xs:element ref="characters:Unit"/>
          </xs:sequence>
     </xs:complexType>
  </xs:element>
  <xs:element name="UrsiFactor" type="xs:double"/>
  <xs:element name="Unit" type="xs:string"/>
  <xs:element name="Desc" type="xs:string"/>
  <xs:element name="Name" type="xs:string"/>
</xs:schema>
```

Here is an example of the F2 layer definitions in an XML file:

```
<?xml version="1.0" encoding="UTF-8"?>
<IonoCharacteristics xmlns="http://oma.be/iono/characters">
<!-- =========================================================    -->
<!-- mapping between ursi and artist code according to reference -->
<!-- http://ulcar.uml.edu/~iag/CHARS.htm                          -->
<!-- NOTE:                                                        -->
<!-- ursi_codes 1957:                                             -->
<!-- MUF F2: 02 becomes 07                                        -->
<!-- MUF F2: 12 becomes 17                                        -->
<!-- =========================================================    -->
<Group gid="F2">
     <Name>F2 Layer Parameters</Name>
     <CharacteristicList>
          <Characteristic type="ursi" code="00" sao_pos="01">
               <Name>foF2</Name>
               <Dimension>
                    <UrsiFactor>.1</UrsiFactor>
                    <Unit>MHz</Unit>
               </Dimension>
               <Desc>F2 layer o-mode (ordinary) critical frequency</Desc>
          </Characteristic>
          <Characteristic type="ursi" code="01">
               <Name>fxF2</Name>
               <Dimension><UrsiFactor>.1</UrsiFactor>
                         <Unit>MHz</Unit></Dimension>
                         <Desc>F2 layer x-mode (extraordinary)
                                   critical frequency</Desc>
          </Characteristic>
          <Characteristic type="ursi" code="02">
               <Name>fzF2</Name>
               <Dimension><UrsiFactor>.1</UrsiFactor>
                         <Unit>MHz</Unit></Dimension>
               <Desc>F2 layer z-mode critical frequency</Desc>
          </Characteristic>
          <Characteristic type="ursi" code="03" sao_pos="03">
               <Name>M3000F2</Name>
               <Dimension><UrsiFactor>.01</UrsiFactor>
                         <Unit>NA</Unit></Dimension>
               <Desc>F2 layer M UrsiFactor (the ratio of the maximum usable
                         frequency divided by the critical frequency)</Desc>
          </Characteristic>
          <Characteristic type="ursi" code="04" sao_pos="12">
               <Name>h'F2</Name>
               <Dimension><UrsiFactor>1</UrsiFactor>
                         <Unit>km</Unit></Dimension>
               <Desc>F2 layer o-mode minimum virtual height</Desc>
```

```
          </Characteristic>
          <Characteristic type="ursi" code="05">
               <Name>hpF2</Name>
               <Dimension><UrsiFactor>1</UrsiFactor>
                         <Unit>km</Unit></Dimension>
               <Desc>An estimate of the true height of the F2 layer
                    (measurement of the ordinary mode virtual height
                    at a frequency of 83.4% of the foF2)</Desc>
          </Characteristic>
          <Characteristic type="ursi" code="06">
               <Name>h’Ox</Name>
               <Dimension><UrsiFactor>1</UrsiFactor>
                         <Unit>km</Unit></Dimension>
               <Desc>F layer minmum virual height of the x-mode trace
                    at a frequency equal tothe foF2</Desc>
          </Characteristic>
          <Characteristic type="ursi" code="07" sao_pos="04">
               <Name>MUF3000F2</Name>
               <ArtistName>MUF(D)</ArtistName>
               <Dimension><UrsiFactor>.1</UrsiFactor>
                         <Unit>MHz</Unit></Dimension>
               <Desc>F2 layer maximum usable frequency for 3000km path</Desc>
          </Characteristic>
          <Characteristic type="ursi" code="08">
               <Name>hc</Name>
               <Dimension><UrsiFactor>1</UrsiFactor>
                         <Unit>km</Unit></Dimension>
               <Desc>The height of the maximum obtained by
                    fitting a theoretical h’F curve for the parabola
                    of best fit to the observed ordinary mode trace near foF2
                    and correcting for under-lying ionizaton</Desc>
               </Characteristic>
               <Characteristic type="ursi" code="09" sao_pos="40">
                    <Name>qc</Name>
                    <ArtistName>ScaleF2</ArtistName>
                    <Dimension><UrsiFactor>1</UrsiFactor>
                              <Unit>km</Unit></Dimension>
                    <Desc>EF layer scale height</Desc>
               </Characteristic>
               </CharacteristicList>
</Group>
<Group gid="F1">
  ...
</Group>
</IonoCharacteristics>
```

Note: It has been noticed that two of the ionospheric characteristics have different code values in URSI-A and in the subsequent classifications. In order to rectify the mismatch, the following substitution was performed in `URSIArecord.cpp`:

```
if (ursiCode == "02")
        ursiCode = "07";
if (ursiCode == "12")
        ursiCode = "17";
```

The XML file can be read by a dedicated program that feeds two tables in the relational database with its contents: `iono_goups` and `iono_defs`.

gid	code	name	sao pos.	ursi factor	unit	description
Custom	art_19	DownF	19	1	km	Lowering of F-trace to the leading edge
Custom	art_20	DownE	20	1	km	Lowering of E-trace to the leading edge
Custom	art_21	DownEs	21	1	km	Lowering of Es-trace to the leading edge
Custom	art_27	dlt foF2	27	1	MHz	Ajustment to the scaled foF2 during profile inversion
Custom	art_36	fminEs	36	1	km	Minimum frequency of Es-layer
E	ursi_20	foE	9	0.01	MHz	E layer o-mode critical frequency
E	ursi_22	foE2		0.01	MHz	E2 layer o-mode critical frequency
E	ursi_24	h'E	13	1	km	E layer o-mode minmum virual height
E	ursi_26	h'E2		1	km	E2 layer o-mode minimum virtual height
Es	ursi_30	foEs	6	0.1	MHz	Es layer hightest o-mode frequency
Es	ursi_31	fxE		0.1	MHz	Es layer highest x-mode frequency
Es	ursi_32	fbEs	48	0.1	MHz	The blanketing frequency of layer used to derive foEs
Es	ursi_33	ftEs		0.1	MHz	Top frequency of the Es trace (any mode)
Es	ursi_34	h'Es	14	1	km	The minimim virtual height of the layer used to derive foEs
Es	ursi_36	Type Es	49	1	NA	A characterization of the shape of Es trace
F1	ursi_10	foF1	2	0.01	MHz	F1 layer o-mode critical frequency
F1	ursi_11	fxF1		0.01	MHz	F1 layer x-mode critical frequency
F1	ursi_13	M3000F1		0.01	MHz	F1 layer M UrsiFactor (see code 03)
F1	ursi_14	h'F1		1	km	F1 layer o-mode minimum virtual height
F1	ursi_16	h'F	11	1	km	F layer o-mode minimum virual height
F1	ursi_17	MUF3000F1		0.1	MHz	F1 layer maximum usable frequency(see code 07)
F2	ursi_00	foF2	1	0.1	MHz	F2 layer o-mode (ordinary) critical frequency
F2	ursi_01	fxF2		0.1	MHz	F2 layer x-mode (extraordinary) critical frequency
F2	ursi_02	fzF2		0.1	MHz	F2 layer z-mode critical frequency
F2	ursi_03	M3000F2	3	0.01	NA	F2 layer M UrsiFactor
F2	ursi_04	h'F2	12	1	km	F2 layer o-mode minimum virtual height
F2	ursi_05	hpF2		1	km	An estimate of the true height of the F2 layer
F2	ursi_06	h'Ox		1	km	F layer minmum virual height of the x-mode trace
F2	ursi_07	MUF3000F2	4	0.1	MHz	F2 layer maximum usable frequency for 3000km path
F2	ursi_08	hc		1	km	The height of the maximum obtained by fitting a theorectical h'F
F2	ursi_09	qc	40	1	km	EF layer scale height
Modeled	art_28	foEp	28	1	MHz	Predicted value of foE (Model CCIR-79)
Modeled	art_29	f(h'F)	29	1	MHz	Frequency at which h'F occurs
Modeled	art_30	f(h'F2)	30	1	MHz	Frequency at which h'F2 occurs
Modeled	art_31	foF1p	31	1	MHz	Predicted value of foF1 (Model IRI-90)
Modeled	art_35	foF2p	35	1	MHz	Predicted value of foF2 (Model URSI-88)
Nh	ursi_90	hmE (zmE)	15	1	km	True height of E-layer, ??? method
Nh	ursi_91	hmF1 (zmF1)	33	1	km	True height of F1 peak, ??? method
Nh	ursi_92	hmF2 (zmF2)	32	1	km	True height of F2 peak, ??? method
Nh	ursi_93	zhalfNm	34	1	km	True height at half peak electron density
Nh	ursi_94	yF2	37	1	km	Parabolic F2 layer semi-thickness
Nh	ursi_95	yF1	38	1	km	Parabolic F1 layer semi-thickness

gid	code	name	sao pos.	ursi factor	unit	description
Other1	ursi_40	foF1.5		0.01	MHz	The o-mode critical frequency of the F1.5 intermediate :
Other1	ursi_42	fmin	5	0.1	MHz	The lowest frequency at whcih an o-mode echo is observed
Other1	ursi_43	M3000F1.5		0.01	MHz	F1.5 layer M UrsiFactor (see code 03)
Other1	ursi_44	h'F1.5		1	km	F1.5 layer o-mode minimum virtual height
Other1	ursi_47	fm2		0.1	MHz	The fmin for the second order o-mode trace
Other1	ursi_48	hm		1	km	The height of the maximum electron density of the F2 later
Other1	ursi_49	fm3		0.1	MHz	The fmin for the third order o-mode trace
Other2	ursi_80	fminF	7	0.1	MHz	Minimum frequency of F-layer echoes
Other2	ursi_81	fminE	8	0.1	MHz	Minimum frequency of E-layer echoes
Other2	ursi_82	HOM		1	km	Parabolic E layer peak height
Other2	ursi_83	yE	16	1	km	Parabolic E layer semi-thickness
Other2	ursi_84	QF	17	1	km	Average range spread of F trace
Other2	ursi_85	QE	18	1	km	Average range spread of E trace
Other2	ursi_86	FF	22	0.01	MHz	Frequency spread between fxF2 and fxI
Other2	ursi_87	FE	23	0.01	MHz	As FF but considered beyond foE
Other2	ursi_88	fMUF3000	25	0.01	MHz	MUF (D) /obliquity UrsiFactor
Other2	ursi_89	h'MUF3000	26	1	km	Virtual height at MUF (D) /obliquity UrsiFactor
ProfE	ursi_C0	[A0E]		1	km	Coefficient A0, truncated to integer km
ProfE	ursi_C1	<A0E>		1	m	A0 - [A0], truncation reminder
ProfE	ursi_C2	[A1E]		1	km	Coefficient A1
ProfE	ursi_C3	<A1E>		1	m	A1 - [A1 .]
ProfE	ursi_C4	[A2E]		1	km	Coefficient A2
ProfE	ursi_C5	<A2E>		1	m	A2 - [A2]
ProfE	ursi_C6	[W]		1	km	Valley width [W], truncated
ProfE	ursi_C7	<W>		1	m	W - [W]
ProfE	ursi_C8	[D]		1	km	Valley depth [D], truncated
ProfE	ursi_C9	<D>		1	m	D - [D]
ProfE	ursi_CA	[fsE]		1	MHz	starting frequency
ProfE	ursi_CB	<fsE>		1	kHz	fs - [fs]
ProfE	ursi_CC	[fmE]		1	MHz	ending frequency
ProfE	ursi_CD	<fmE>		1	kHz	fm - [fm]
ProfE	ursi_CE	[hmE]		1	km	peak height, truncated
ProfE	ursi_CF	<hmE>		1	m	hm - [hm]
ProfE	ursi_CG	EppE		0.1	km	error per point an average mismatch of original h'(f) trace :
ProfE	ursi_CH	ValleyID		1	NA	Valley Model ID
ProfE	ursi_D0	B0		1	km	IRI Thickness parameter
ProfE	ursi_D1	B1	43	0.1	NA	IRI Profile Shape parameter
ProfE	ursi_D2	D1		0.1	NA	IRI Profile Shape parameter, F1 layer

gid	code	name	sao pos.	ursi factor	unit	description
ProfF1	ursi_B0	[A0F1]	41	1	km	Coefficient A0, truncated to integer km
ProfF1	ursi_B1	<A0F1>	42	1	m	A0 - [A0], truncation reminder
ProfF1	ursi_B2	[A1F1]		1	km	Coefficient A1
ProfF1	ursi_B3	<A1F1>		1	m	A1 - [A1]
ProfF1	ursi_B4	[A2F1]		1	km	Coefficient A2
ProfF1	ursi_B5	<A2F1>		1	m	A2 - [A2]
ProfF1	ursi_B6	[A3F1]		1	km	Coefficient A3
ProfF1	ursi_B7	<A3F1>		1	m	A3 -[A3]
ProfF1	ursi_B8	[A4F1]		1	km	Coefficient A4
ProfF1	ursi_B9	<A4F1>		1	m	A4 - [A4]
ProfF1	ursi_BA	[fsF1]		1	MHz	starting frequency of the layer, truncate
ProfF1	ursi_BB	<fsF1>		1	kHz	fs - [fs]
ProfF1	ursi_BC	[fmF1]		1	MHz	ending frequency fm
ProfF1	ursi_BD	<fmF1>		1	kHz	fm - [fm]
ProfF1	ursi_BE	[hmF1]		1	km	peak height, truncated
ProfF1	ursi_BF	<hmF1>		1	m	hm - [hm]
ProfF1	ursi_BG	EppF1		0.1	km	error per point an average mismatch of original h'(f) trace
ProfF2	ursi_A0	[A0F2]		1	km	Coefficient A0, truncated to integer km
ProfF2	ursi_A1	<A0F2>		1	m	A0 - [A0], truncation reminder
ProfF2	ursi_A2	[A1F2]		1	km	Coefficient A1
ProfF2	ursi_A3	<A1F2>		1	m	A1 - [A1]
ProfF2	ursi_A4	[A2F2]		1	km	Coefficient A2
ProfF2	ursi_A5	<A2F2>		1	m	A2 - [A2]
ProfF2	ursi_A6	[A3F2]		1	km	Coefficient A3
ProfF2	ursi_A7	<A3F2>		1	m	A3 -[A3.]
ProfF2	ursi_A8	[A4F2]		1	km	Coefficient A4
ProfF2	ursi_A9	<A4F2>		1	m	A4 - [A4]
ProfF2	ursi_AA	[fsF2]		1	MHz	starting frequency of the layer, truncate
ProfF2	ursi_AB	<fsF2>		1	kHz	fs - [fs]
ProfF2	ursi_AC	[fmF2]		1	MHz	ending frequency fm
ProfF2	ursi_AD	<fmF2>		1	kHz	fm - [fm]
ProfF2	ursi_AE	[hmF2]		1	km	peak height, truncated
ProfF2	ursi_AF	<hmF2>		1	m	hm - [hm]
ProfF2	ursi_AG	EppF2		0.1	km	error per point an average mismatch of original h'(f) trace
SpreadF	ursi_50	foI		0.1	MHz	The highest o-mode frequency of spread F
SpreadF	ursi_51	fxI	10	0.1	MHz	The highest frequency of spread F traces (any mode)
SpreadF	ursi_52	fmI		0.1	MHz	The lowest o-mode frequency at which spread traces are observed
SpreadF	ursi_53	M3000I		0.01	MHz	M UrsiFactor deduces from upper frequency edge of spread traces
SpreadF	ursi_54	h'I		1	km	Minimum slant range of the spread F trace
SpreadF	ursi_55	foP	46	0.1	MHz	Highest ordinary wave critical frequency of F region patch trace
SpreadF	ursi_56	h'P	47	1	km	Minimum virtual height of the trace used to determine foP
SpreadF	ursi_57	dfs		0.1	MHz	The frequency spread of the scatter pattern

gid	code	name	sao pos.	ursi factor	unit	description
TEC	ursi_70	I2000		1e+17	1/m2	Ionospheric electron content Faraday technique
TEC	ursi_71	I	39	1e+17	1/m2	Total electron content to geostationary satellite
TEC	ursi_72	I1000		1e+17	1/m2	Ionospheric electron content to height 100 km using Digisonde
TEC	ursi_79	T		1e+17	1/m2	Total sub-peak content Titheridge method
Tith	ursi_60	h'F2		0.1	MHz	The frequency at which h'F2 is measured
Tith	ursi_61	h'F		0.1	MHz	The frequency at which h'F is measured
Tith	ursi_63	h'mF1		1	km	The maximum virula height in the o-mode F1 cusp
Tith	ursi_64	h1		1	km	True height at f1 Titheridge method
Tith	ursi_65	h2		1	km	True height at f2 Titheridge method
Tith	ursi_66	h3		0.01	MHz	True height at f3 Titheridge method
Tith	ursi_67	h4		0.01	MHz	True height at f4 Titheridge method
Tith	ursi_68	h5		1	km	True height at f5 Titheridge method
Tith	ursi_69	H		1	km	Effective scale height at hmF2 Titheridge method

4. Format and organisation of CSV files generated by parsers

```
CSV
 |-- 1957
        |--01
             |--DB049-<YYYY>-<DOY>.csv
        |--02
        ...
        |--11
        |--12
 ...
|-- 2011
        |--01
        |--02
        ...
        |--11
        |--12
```

<YYYY> is four digits for the year
<DOY> is three digits for the day of the year.

In total, 689 directories and 19223 files were generated.

The format of one CSV file is as follows:

- Column 1: Date time with time zone UTC <YYYY-MM-DD HH:mm:ss>
- Column 2: Code <type>_<code> where type and code are the attributes defined in the XML scheme above.
- Column 3: Read value for the ionospheric characteristic. 9999 means unread value
- Column 4: Qualifying letter
- Column 5: Descriptive letter

The qualifying and descriptive letters are only available in files with URSI_A format. In the subsequent formats, a character "/" means that they are no longer provided. Here is an example:

```
#DATETIME;CODE;VALUE;QL;DL
1957-07-01 00:00:00 UTC;ursi_00;9999;;C
1957-07-01 01:00:00 UTC;ursi_00;9999;;C
1957-07-01 02:00:00 UTC;ursi_00;9999;;C
1957-07-01 03:00:00 UTC;ursi_00;9999;;C
1957-07-01 04:00:00 UTC;ursi_00;9999;;C
1957-07-01 05:00:00 UTC;ursi_00;9999;;C
1957-07-01 06:00:00 UTC;ursi_00;9999;;C
1957-07-01 07:00:00 UTC;ursi_00;9999;;C
1957-07-01 08:00:00 UTC;ursi_00;9999;;C
1957-07-01 09:00:00 UTC;ursi_00;9999;;C
1957-07-01 10:00:00 UTC;ursi_00;9999;;A
1957-07-01 11:00:00 UTC;ursi_00;5.5;U;A
1957-07-01 12:00:00 UTC;ursi_00;9999;;A
1957-07-01 13:00:00 UTC;ursi_00;9999;;A
...
```

5. Structure of the relational database

PostgreSQL is used as a relational database management system. One table per year is created in the relational database to avoid tables with too big size that could decrease the performances of queries.

The naming convention for a table containing data for one year <YYYY> of hourly (1-hour) measurements is: `iono_scaled_value_1h_<YYYY>`. The relations between those tables and the tables of definitions based on codes are used. In addition to those tables, a table `iono_sonde_stats_1h` contains the monthly statistical values calculated from the contents of the previous tables. An open question remains concerning the benefits, if any, in storing the missing entries of a time series.

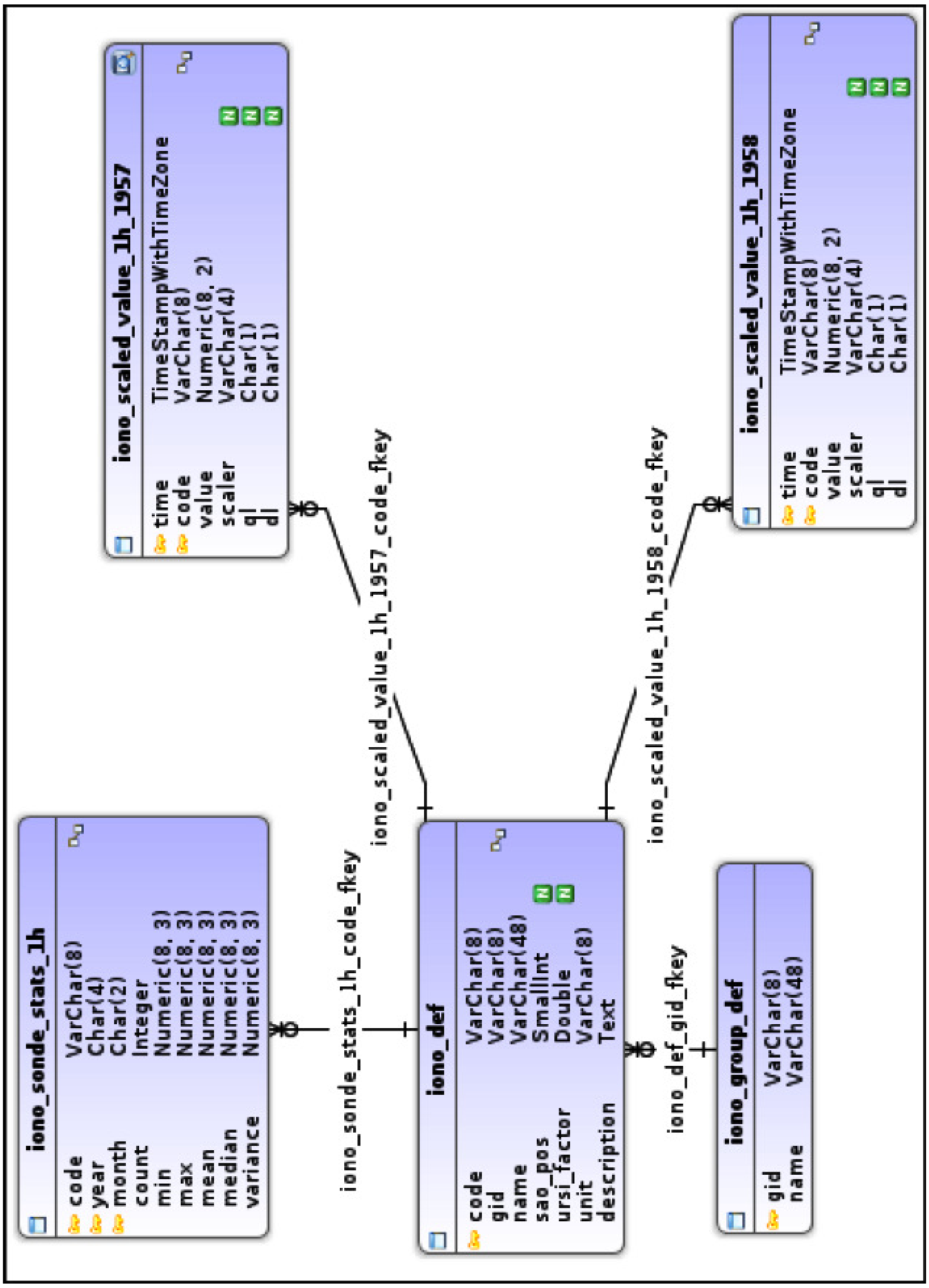


Fig.4.1. Structure of the relational database of the Dourbes ionosonde measurements.

6. Programming

The programming was performed in the C++ language utilising the scientific computing libraries Boost and SOCI.

6.1 Boost

- The package `boost::xpressive` was used to recognize the regular patterns that are unaligned and without a common delimiter.
- The package `boost::filesystem` was used to manipulate easily paths on files system.
- The package `boost::posix` was used to manipulate easily times fields with different formats.
- The package `boost::accu::statistics` was used to calculate, in a few lines of code (3), the basic statistical quantities that are saved in the database (count, mean, std_dev, median)

6.2 SOCI

SOCI was used as relational database access library.

6.3 DISLIN

DISLIN (*Michels*, 2010) was used as scientific data plotting software.

The general organization of the developed framework `IonoDrbs` will be the subject of another (internal) report.

7. Execution

In a UNIX environment, the suite of following commands was executed:

7.1 Environment settings

Set the environment variable IONODRBS to identify the installation directory of the framework IonoDrbs and update the environment variable PATH to be able to access the different binaries executable files and the scripts provided by that framework. The framework IonoDrbs will be described in a follow-on report.

```
$ export IONODRBS=<INSTAL DIR>/IonoDrbs/dist
$ export PATH=${PATH}:${IONODRBS}/bin/digisonde:${IONODRBS}/etc/digisonde
```

7.2 Create the relational database ionodrbs, load definitions into it

On a machine running the Postgresql database system, the following scripts are executed to create the database ionodrbs with the structure described above:

```
$ ${IONODRBS}/sql/newIonoDrbs.sh
```

7.3 Generate CSV files

The raw files are contained in the input directory <RAW_DIR> that were read recursively by the parsers to generate CSV files in the output directory <CSV_DIR> by running the following commands.

```
$ ionoRaw2Csv -I <RAW_DIR> -O <CSV_DIR> -f URSI_A DB049
$ ionoRaw2Csv -I <RAW_DIR> -O <CSV_DIR> -f URSI_I DB049
$ ionoRaw2Csv -I <RAW_DIR> -O <CSV_DIR> -f SOA DB049
```

This can also be performed by running the script $IONODRBS/etc/convertRawFiles.sh

Note: the last argument that identified the station cannot be effectively used in case of URSI_A because it was found that the Dourbes station was identified by "125" or "049" or " 49" in URSI_A files.

7.4 Load CSV files into the database

```
>>> ${IONODRBS}/etc/digisonde/loadCsvFiles.sh
```

7.5 Calculate statistical quantities and save them in database

```
>>> ${IONODRBS}/etc/digisonde/saveIonoStats.sh
```

7.6 Save information about Scaler

Execute the following script with psql interpreter:

```
>>> cat ${IONODRBS}/dist/sql/saveScalerInfo.sql

update iono_scaled_value_1h_2002 set scaler='EvM';
update iono_scaled_value_1h_2003 set scaler='EvM';
update iono_scaled_value_1h_2004 set scaler='EvM';
update iono_scaled_value_1h_2005 set scaler='EvM'
                                 where time < '2005-09-01 00:00:00';
update iono_scaled_value_1h_2005 set scaler='LL'
                                 where time >= '2005-09-01 00:00:00';
update iono_scaled_value_1h_2006 set scaler='LL';
update iono_scaled_value_1h_2007 set scaler='LL';
update iono_scaled_value_1h_2008 set scaler='LL';
update iono_scaled_value_1h_2009 set scaler='LL';
update iono_scaled_value_1h_2010 set scaler='LL';
update iono_scaled_value_1h_2006 set scaler='LL';

psql (9.1.4)

Type "help" for help.

ionodrbs=# \i setScalerInfo.sql

UPDATE 285446
UPDATE 397486
UPDATE 401994
UPDATE 234508
UPDATE 115460
UPDATE 312110
UPDATE 368920
UPDATE 354890
UPDATE 399188
UPDATE 247388
UPDATE 312110
```

7.7 Plot generation

The following command will generate 2D plots for every ionospheric quantity in the given directory. These plots show the global evolution of the monthly medians from 1957 to 2010.

```
>>> ${IONODRBS}/bin/digisonde/ionoStats2DPlot -O <IMG_DIR> -f pdf
```

After that, a more detailed view can be generated, giving daily variations along the same time period. The shell script `plot2D.sh` invokes that function for the restricted set of quantities that are listed in the "Bulletin mensuel of the Institut Royal Météorologique de Belgique".

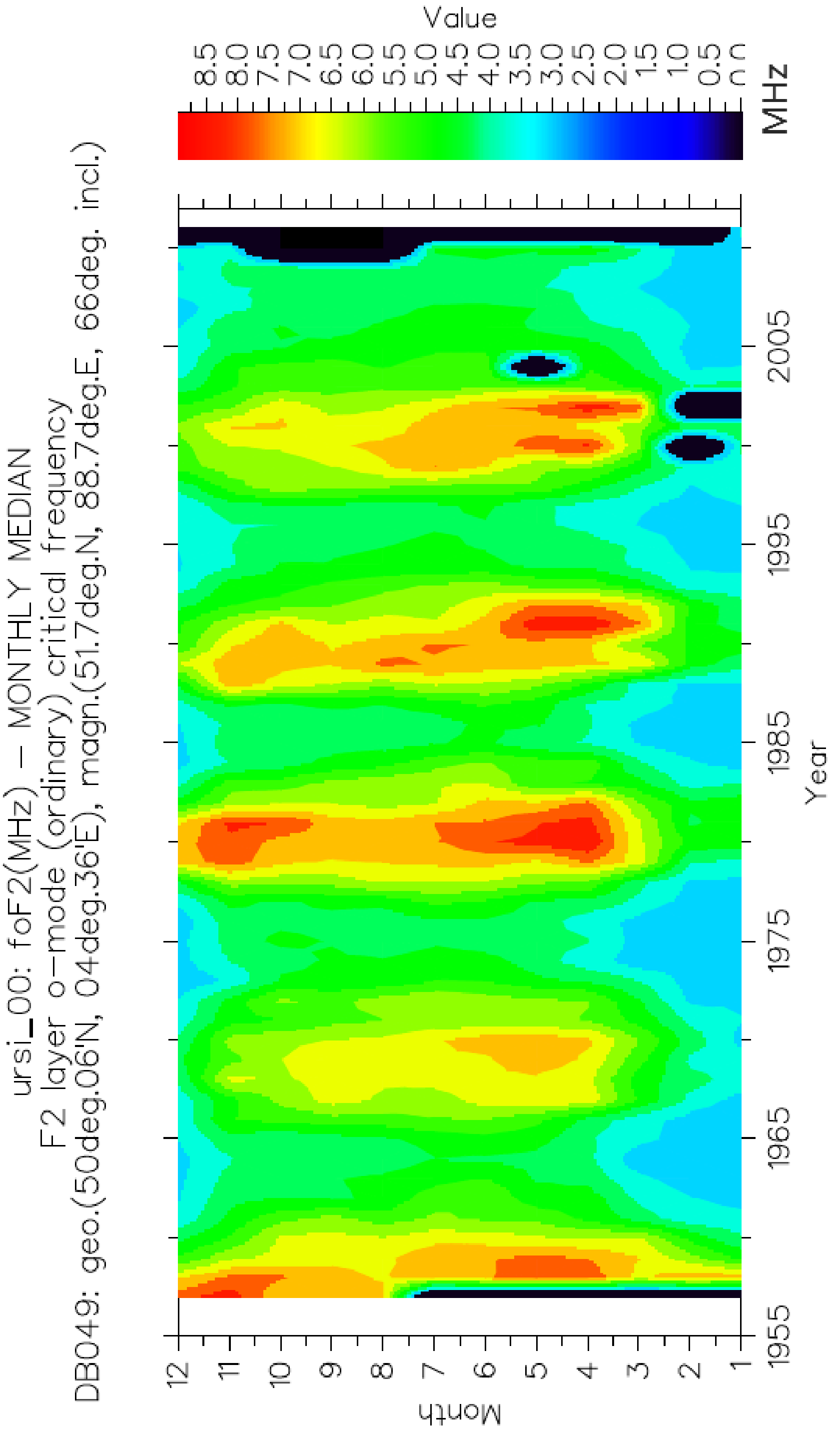
```
>>> ${IONODRBS}/etc/digisonde/plot2D.sh


>>> cat ${IONODRBS}/etc/digisonde/plot2D.sh
IMG_DIR=/opt/data/Ionosonde_1957-2010/Plots

BIN=${IONODRBS}/bin/digisonde

if [ -e ${BIN}/ionoScaledValues1hPlot ]; then

      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_20
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_10
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 3 -f pdf ursi_00
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_30
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_42
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_80
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_81
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_51
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_24
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_04
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_16
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_34
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_07
      ${BIN}/ionoScaledValues1hPlot -O ${IMG_DIR} -z 1 -f pdf ursi_03

Else

      echo "Please, set environment variable IONODRBS"

fi
```

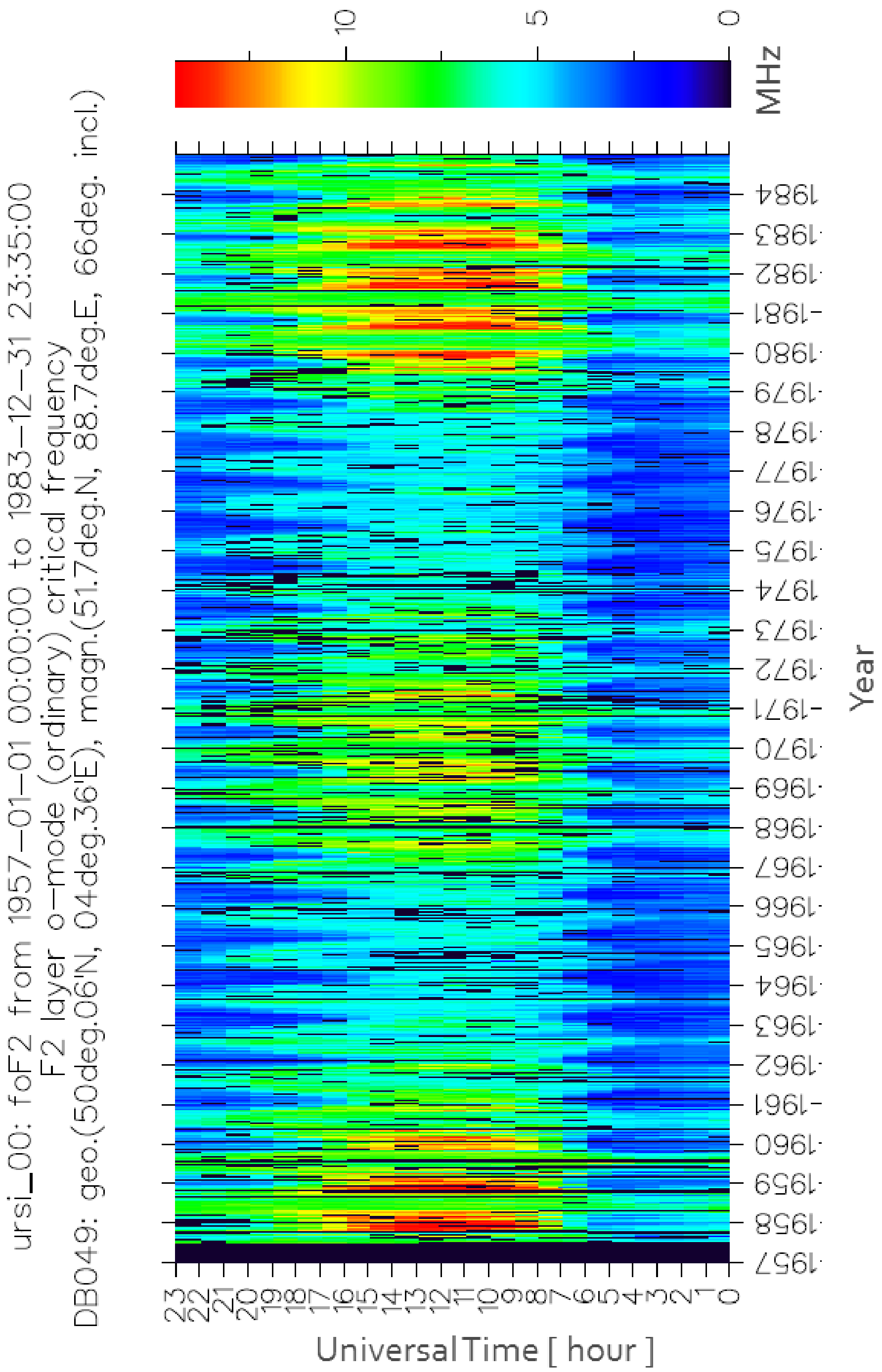
At this time, in addition to the output directory and the output format, parameters can be adjusted:

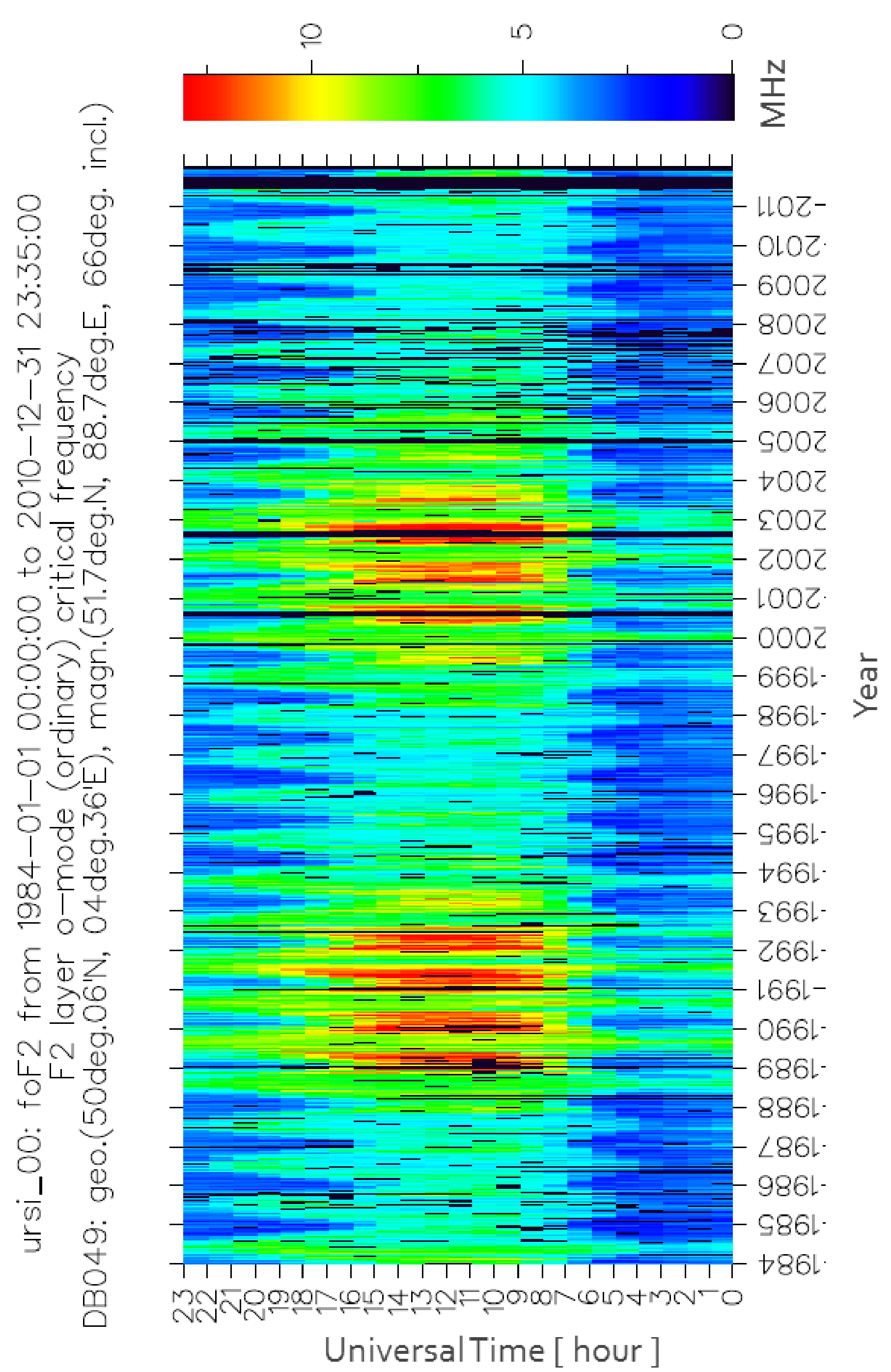
```
>>> ${IONODRBS}/bin/digisonde/ionoScaledValues1hPlot

ionoScaledValues1hPlot options arg

options: (-h | -O <ouput directory path> [-w winSize -f format -z
zScaledFactor]
           default value for format: png
           default value for winSize: 27
           default value for zScaledFactor: 3
arg: <ionospheric code>
```

8. Results

Included here are some plotsms generated for the code `ursi_00 (foF2)`. Others can be found on the accompanying DVD.




ursi_00: foF2 from 1957–01–01 00:00:00 to 1983–12–31 23:35:00
F2 layer o–mode (ordinary) critical frequency
DB049: geo.(50deg.06'N, 04deg.36'E), magn.(51.7deg.N, 88.7deg.E, 66deg. incl.)
MHz
Year
Universal Time [hour]



ursi_00: foF2 from 1984–01–01 00:00:00 to 2010–12–31 23:35:00
F2 layer o–mode (ordinary) critical frequency
DB049: geo.(50deg.06'N, 04deg.36'E), magn.(51.7deg.N, 88.7deg.E, 66deg. incl.)
MHz
10
5
0
Year
Universal Time [hour]

References

Fawcett, J., D. Ayers, L.R.E. Quin (2012): Beginning XML, Fifth Edition, John Wiley & Sons Inc., Indianopolis, IN, USA, 864 pages.

Jodogne, J.C., S. M. Stankov (2002): Ionosphere-plasmasphere response to geomagnetic storms studied with the RMI-Dourbes comprehensive database. Annals of Geophysics, Vol.45, No.5, pp.629-647.

Michels, H. (2010): The Data Plotting Software DISLIN, Version 10 , Shaker Media GmbH, Germany, 320 pages.

Pezzopane, M., C. Scotto (2005): The INGV software for the automatic scaling of foF2 and MUF (3000)F2 from ionograms: A performance comparison with ARTIST 4.01 from Rome data, J. Atmos. Sol.-Terr. Phys. 67(12), 1063-1073.

Piggott, W.R., K. Rawer (1972): Manuel URSI pour le dépouillement et l'interprétation des ionnogrammes. 2-nd edition, Report UAG-23A, WDC-A, NOAA, Boulder, Colorado, USA, 190 pages.

Piggott, W.R., K. Rawer (1978): URSI Handbook of Ionogram Interpretation and Reduction. 2-nd edition, Report UAG-23A, WDC-A, NOAA, Boulder, Colorado, USA, 136 pages.

Reinisch, B.W. Modern ionosondes. in: Kohl, H., Rüster, R., Schlegel, K. (eds.), Modern Ionospheric Science, European Geophysical Society, Katlenburg-Lindau, 440-458, 1996.

Reinisch, B.W., I.A. Galkin, G.M. Khmyrov, et al. (2009): New Digisonde for research and monitoring applications. Radio Sci., 44, RS0A24, doi:10.1029/2008RS004115.

Stamper, R., Belehaki, A., Buresova, D., Cander, L., Kutiev, I., Pietrella, M., Stanislawska, I., Stankov, S., Tsagouri, I., Tulunay, Y., Zolesi, B. Nowcasting, forecasting and warning for ionospheric propagation: tools and methods. Annals of Geophysics 47(2/3), 957–984, 2004.

Stankov, S. M. (2002): Ionosphere-plasmasphere system behaviour at disturbed and extreme magnetic conditions. OSTC Final Scientific Report, March 2002, Royal Meteorological Institute (RMI), Brussels, Belgium.

Stankov, S. M., R. Warnant, J.C. Jodogne (2003): Real-time reconstruction of the vertical electron density distribution from GPS-TEC measurements. Acta Geodaetica et Geophysica Hun., Vol.38, No.4 , pp.377-388.

Stankov, S. M., R. Warnant (2009): Ionospheric slab thickness - Analysis, modelling and monitoring. Advances in Space Research, Vol.44, No.11, pp.1295-1303.

Stankov, S., K. Stegen, R. Warnant (2010): RMI-Dourbes ionosonde database – Status 2010. Technical Report No. RMI-STR-2010-02, Version 1.0, 75 pages, Royal Meteorological Institute (RMI), Brussels, Belgium.

Stankov, S., K. Stegen, P. Muhtarov, I. Kutiev, G. Crabbe, R. Warnant (2011a): Operational system for local ionospheric electron density profile reconstruction (LIEDR). Technical Report No. RMI-STR-2011-01, Version 1.0, 13 pages, Royal Meteorological Institute (RMI), Brussels, Belgium.

Stankov, S. M., K. Stegen, P. Muhtarov, R. Warnant (2011b): Local ionospheric electron density profile reconstruction in real time from simultaneous ground-based GNSS and ionosonde measurements. Advances in Space Research, Vol.47, No.7, pp. 1172-1180, (doi:10.1016/j.asr.2010.11.039).

Stankov, S. M., J.C. Jodogne, I. Kutiev, K. Stegen, R. Warnant (2012): Evaluation of automatic ionogram scaling for use in real-time ionospheric density profile specification: Dourbes DGS-256/ARTIST-4 performance. Annals of Geophysics, Vol.55, No.2, pp.283-291, (doi:10.4401/ag-4976).

Wakai, N., H. Ohyama, T. Koizumi (1987): Manual of ionogram scaling. Radio Research Laboratory, Ministry of Posts and Telecommunications, Japan, 3-rd version, October 1987, 119 pages.

Wright, J.W. (1969), Some current developments in radio systems for sounding ionospheric structure and motions, Proc. IEEE, 57(4), 481-486.

Online References:

XML (http://www.w3.org/XML/)

XML Schema (http://www.w3.org/XML/Schema)

PostgreSQL (http://www.postgresql.org)

Boost C++ Libraries (http://www.boost.org)

SOCI C++ Database Access Libraries (http://soci.sourceforge.net)

DISLIN (http://www.dislin.de)

END OF DOCUMENT