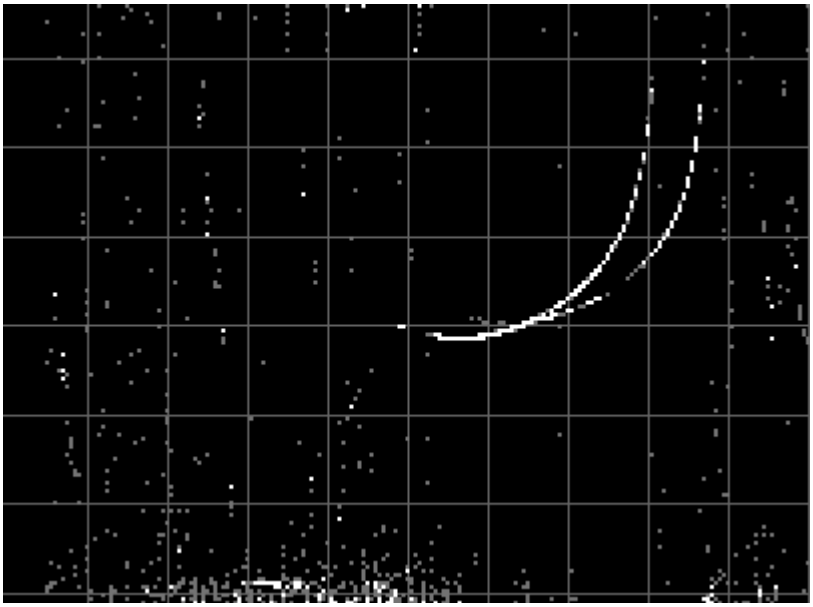
Interpre

Software for editing and scaling vertical ionograms recorded by the AIS ionosonde



Technical Manual

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1. Software Installation

The program is written in Visual Basic 6.0 and it runs on any Windows operating system. The monitor resolution has to be at least 1024 X 768 pixels.
In a directory chosen by the user the following files and directories have to be present:

- the file ***interpre_v2023.exe*** (that can be found in the directory "D:\software_AIS\Interpre\" of the XP virtual machine) that is the real interpretation program;

- the file ***setting.txt*** that keeps tracks of the parameters of the on-going interpretation;

- the directory ***ionograms*** inside which the ionogram files must be kept.

1.1 Content of the file setting.txt

The file "*setting.txt*" is an ASCII file and it is made of 5 records. The first, the second and the third record hold respectively the date, the hour and the minutes of the last interpreted ionogram; the fourth record contains the chosen difference in minutes that has to pass between two consecutive ionograms; the fifth record memorises the number of the line, of the output file, where the program writes the values obtained from the interpretation of the ionogram.

1.2 Ionogram File Format

All ionogram files have extension .RDF and are binary files. The name of the ionogram file is ML10L*_yyyygggghhmmss.rdf*, where *yyyy* are the four digits of the year, *ggg* are three digits to identify the day of the year, *hh* are the two digits identifying the hour, *mm* the two digits identifying the minutes (that can only take the following values: 00, 05, 10, 15, 20, 25, 30, 35, 40, 45, 50 and 55), and *ss* the two digits identifying the seconds (ex. ML10L*_2023151154500.rdf* where *2023* is the year, *151* is the day of the year, *15* is the hour, *45* the minutes and 00 the seconds).
Every file has a header of 197 bytes where the bytes between 1 and 6 represent the initial frequency of the sounding (that cannot be smaller than 1.0 MHz), the bytes between 8 and 13 represent the final frequency of the sounding (that cannot be bigger than 20.0 MHz) and the bytes between 15 and 19 represent the frequency step (whose size can be 0.050, 0.100, 0.200 or 0.500 MHz), while the remaining bytes are parameters concerning the receiver settings, the signal processing algorithm and geophysical constants depending on the specific installation site. Next to the header the RDF file is structured in a certain number (depending on the monitoring frequency band width) of records of 150 bytes, each record representing the sounding in height in correspondence of a determined value of the frequency; the value of the first byte represents the energy reflected back towards the ground from a height of 90.0 km, the byte 150 represents the energy reflected back towards the ground from a height of 760.5 km, therefore the passage between two successive bytes of the record is equal to a movement in height of 4.5 km.

1.3 Output File Format

The output file are ASCII files whose name is ML10L*_ddmmyyyy_DD.txt*, where *dd* is the day of the month, *mm* the month, *yyyy* the year, and *DD* the chosen difference in minutes between the ionograms under study (ex. ML10L*_31012023_60.txt* is the output file of January the 31st, 2023 with a difference of 60 minutes between the ionograms under study at Malindi). The output files are created in the directory "*ionograms*".

The standard line/record of the output file is made of 248 bytes. The first 5 bytes identify the hour of the ionogram, the byte number 6 is a blank byte, thereafter the record structure is 16(8A,"=",3I,2A,"blank") where 8A identifies the name of the ionospheric parameter, 3I the corresponding numeric value obtained from the interpretation, 2A the corresponding qualifying and descriptive letters potentially written during the interpretation phase; the last two bytes of the record are those of carriage and return.
Values of the different ionospheric parameters are stored according to the URSI (International Union of Radio Science) standard (for instance if *fo*F2 is equal to 8.2 MHz, this value will be stored in the output file as 82; if *fo*F1 is equal to 4.25 MHz, it will be archived in the output file as 425).
The number of lines/records of these files depends on the chosen difference in minutes in the initial graphic interface of the program (see Figure 1); choosing 60 minutes, the number of lines/records will be 24; choosing 30 minutes, the number of lines/records will be 48; choosing 15 minutes, the number of lines/records will be 96; choosing 5 minutes, the number of lines/records will be 288.

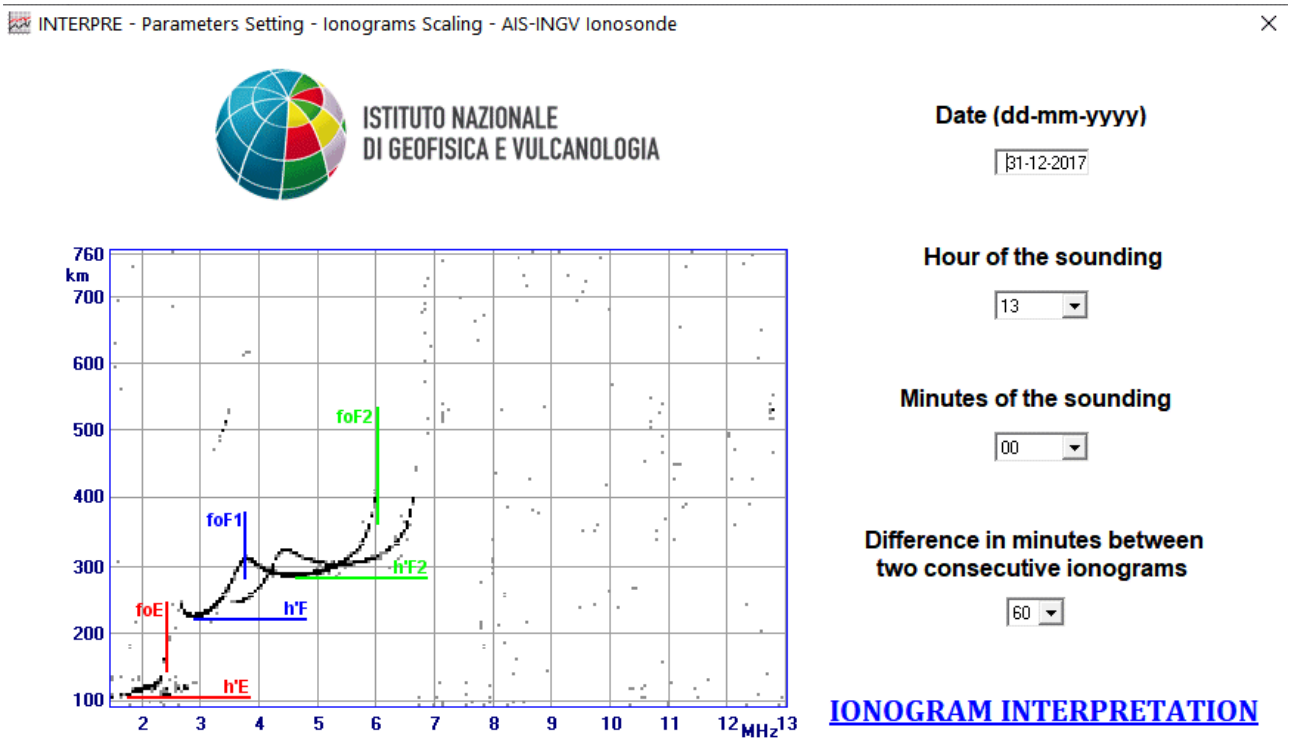

Figure 1. Initial graphical interface of program Interpre.

2. Start up and operation of *Interpre*

To start up the software you have to double-click the icon *interpre_v2023.exe*. Doing this the graphical interface of Figure 1 will appear and you will have the possibility to select the date of the day you want to scale the ionograms, and the difference in minutes between the ionograms that can be of 5, 15, 30 or 60 minutes; if you select 60 minutes the program will look for the ionogram files whose names start with 00 instead of *mm*; if you select 30 minutes the program will look for the ionogram files whose names start with 00 or 30 instead of *mm*; if you select 15 minutes the program will look for the ionogram files whose names start with 00, 15, 30 or 45 instead of *mm*; if you select 5 minutes the program will look for the ionogram files whose names start with 00, 05, 10, 15, 20, 25, 30, 35, 40, 45, 50 or 55 instead of *mm.*

Once these parameters are set, clicking on IONOGRAMS INTERPRETATION you will be introduced to the graphical interface that will be used for the real interpretation of the ionograms (Figure 2). Now, you will be able to notice that when the cursor is inside the ionogram it becomes a green cross and in the upper part of the graphical interface you will see the frequency and the height of the corresponding point of the ionogram.

To scale an ionospheric characteristic you need to click on the corresponding label; upon this operation the label becomes red and in this way it will be possible to write on the fields qualifying letter (q.l.) and descriptive letter (d.l.). As for the value field, it is necessary to move the cursor inside the ionogram and click the point which is more suitable to the characteristic you need to scale. This procedure is executed for the ionospheric characteristics *fmin*, *h*'E, *fo*E, *fo*Es, *h*'Es, *fb*Es, *h*'F, *fo*F1, h'F2, *fo*F2, and *fx*I.

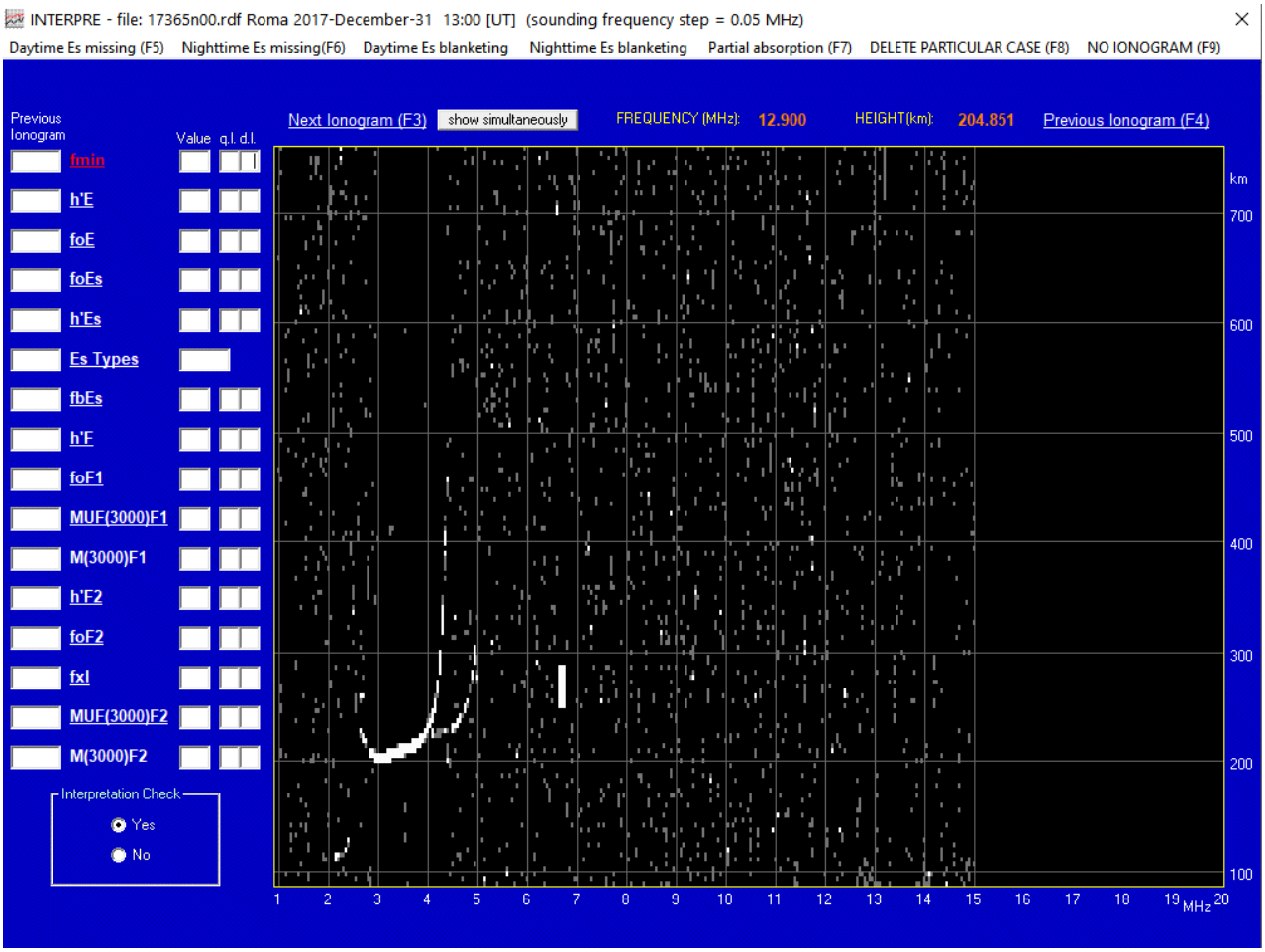

Figure 2. The graphical interface of *Interpre* used for the interpretation of the ionograms.

For the ionospheric parameter *fmin*, if the clicked value corresponds to the lowest limit of the sounding frequency range, an E as descriptive letter will be displayed.

If *fo*F2 is partially absent and identifiable with difficulty, but *fx*I is instead clearly identifiable without letters, in this case *fx*I is scaled normally, then to have a value for *fo*F2 the cursor (the green cross) has to be moved near *fx*I and once there, after clicking, the software automatically puts a X as descriptive letter for *fx*I and a J as qualificative letter for the value of *fo*F2 which will be calculated from the value of *fx*I taking into account the value of the girofrequency of the sounding site. On the contrary, if *fo*F2 is clearly identifiable without letters, while *fx*I is partially absent and identifiable with difficulty, in this case *fo*F2 is scaled normally and then to have a value for *fx*I the cursor (the green cross) has to be moved near *fo*F2 and once there, after clicking, the software automatically puts a O as descriptive letter for the value of *fx*I which will be calculated from the value of *fo*F2 taking into account tha value of the girofrequency of the sounding site.

For the ionospheric characteristics *MUF*(3000)F2, if a value for *fo*F2 has been already identified, after clicking on the corresponding label a transmission curve will appear on the ionogram close to the point where *fo*F2 has been taken; the slope of the transmission curve has to be modified until you find the tangential condition with the ordinary trace in the F2 region (see Figure 3).

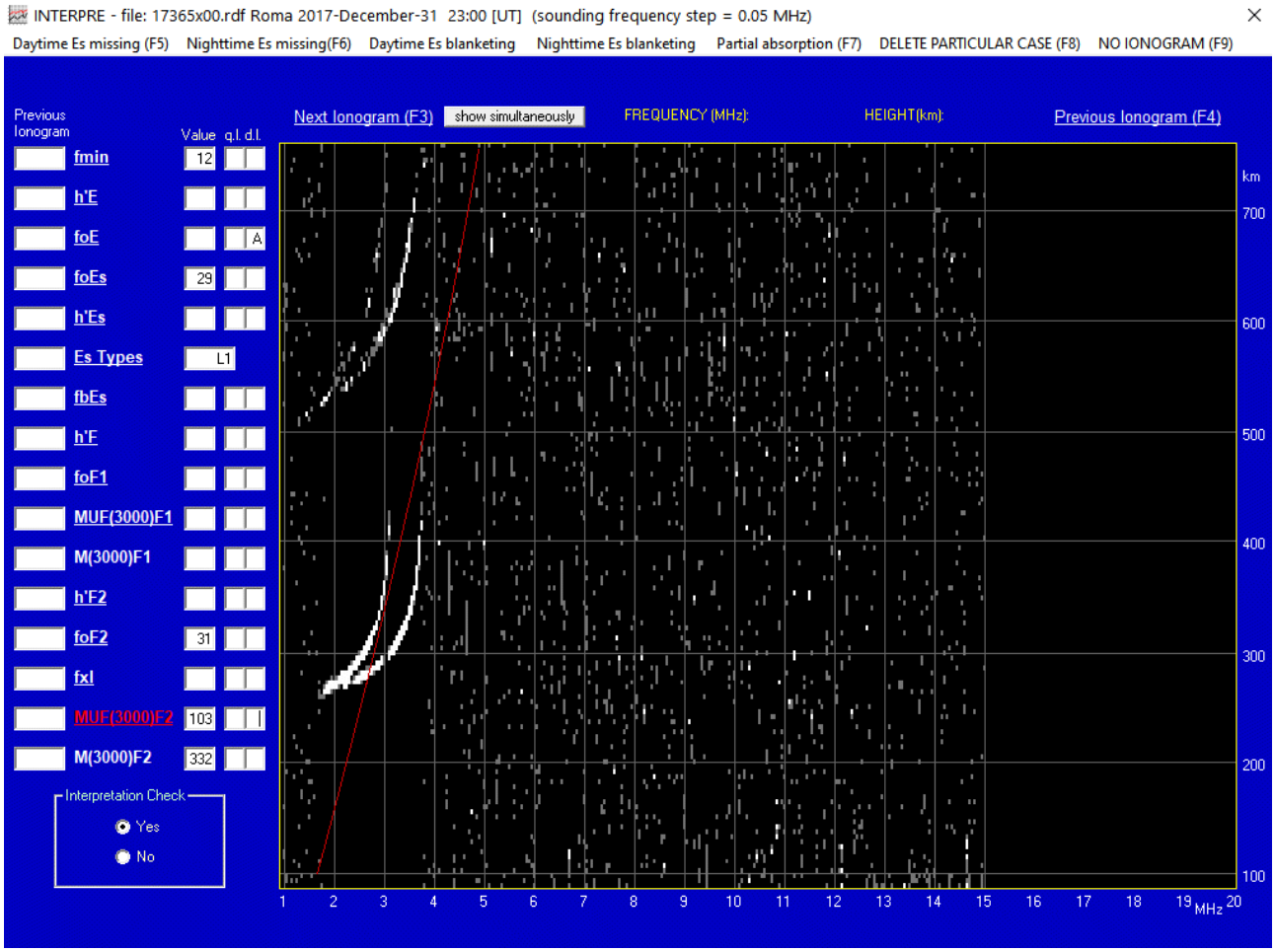

Figure 3. The transmission curve used to find the value of *MUF*(3000)F2, tangential to the ordinary trace of the F2 region.

The slope of the transmission curve can be modified using either the arrows up/down, which correspond to movements of 0.1 MHz, or the combinations CTRL + arrow up/CTRL + arrow down, which correspond to movements of 2.0 MHz.

Analogously, for the ionospheric characteristics *MUF*(3000)F1, if a value *fo*F1 has been already identified, after clicking on the corresponding label a transmission curve will appear on the ionogram close to the point where *fo*F1 has been taken; the slope of the transmission curve has to be modified until you find the tangential condition with the ordinary trace in the F1 region. The slope of the transmission curve can be modified using either the arrows up/down, which correspond to movements of 0.1 MHz, or the combinations CTRL + arrow up/CTRL + arrow down, which correspond to movements of 2.0 MHz.

Concerning the characteristics *M*(3000)F2 and *M*(3000)F1 of the layer F1 and F2, it is not possible to click on the corresponding labels because these characteristics in terms of value, qualifying and descriptive letters, are automatically calculated once values, qualifying and descriptive letters for the critical frequency and MUF of the corresponding layer have been identified.

For the field “Es Types” by clicking on the corresponding label it is possible write the sporadic E type in the value field considering that it will not be possible to input from the keyboard the number zero and letters which are different from A, C, D, F, H, K, L, Q, R and S. As for the qualifying and descriptive letters of all characteristics, the corresponding fields will not accept from the keyboard letters that are not valid; in case the user tries for example to enter a U as descriptive letter the message “This is not a descriptive letter” will be displayed.
Concerning the “Es Types”:
-if the value field of *fo*E is empty and the corresponding descriptive letter is equal to A, once clicking on *h*’Es, or clicking directly on the label “Es Types”, the “Es Types” field will be filled with L1;
-if the value field of *fo*Es (and/or the corresponding qualifying or descriptive letters) is not empty, while the value fields of *fo*E and *h*’E are instead empty, once clicking on *h*’Es, or clicking directly on the label “Es Types”, the “Es Types” field will be filled with F1;
-if the value field of *fo*Es (and/or the corresponding qualifying or descriptive letters) is not empty, and the value fields of *fo*E and *h*’E are not empty too, once clicking on *h*’Es, or clicking directly on the label “Es Types”, the “Es Types” field will be filled with C1;
-if *h*’Es ≥ 160 km then the “Es Types” field will be filled with H1.

Moreover, when clicking on the “Es Types” label to little buttons “u” (up) and “d” (down) will appear close to the “Es Types” field (see Figure 4); if the Es type is characterized by more than one reflection, you can click the button “u” to increase the number of the Es type, for example to pass from L1 to L2. The user can increase the number of reflections until five, this meaning that in the “Es Types” field it is possible to write maximum L5, F5, C5. The button “d” allows the user to decrease the number of the Es type, for instance from C4 to C3.

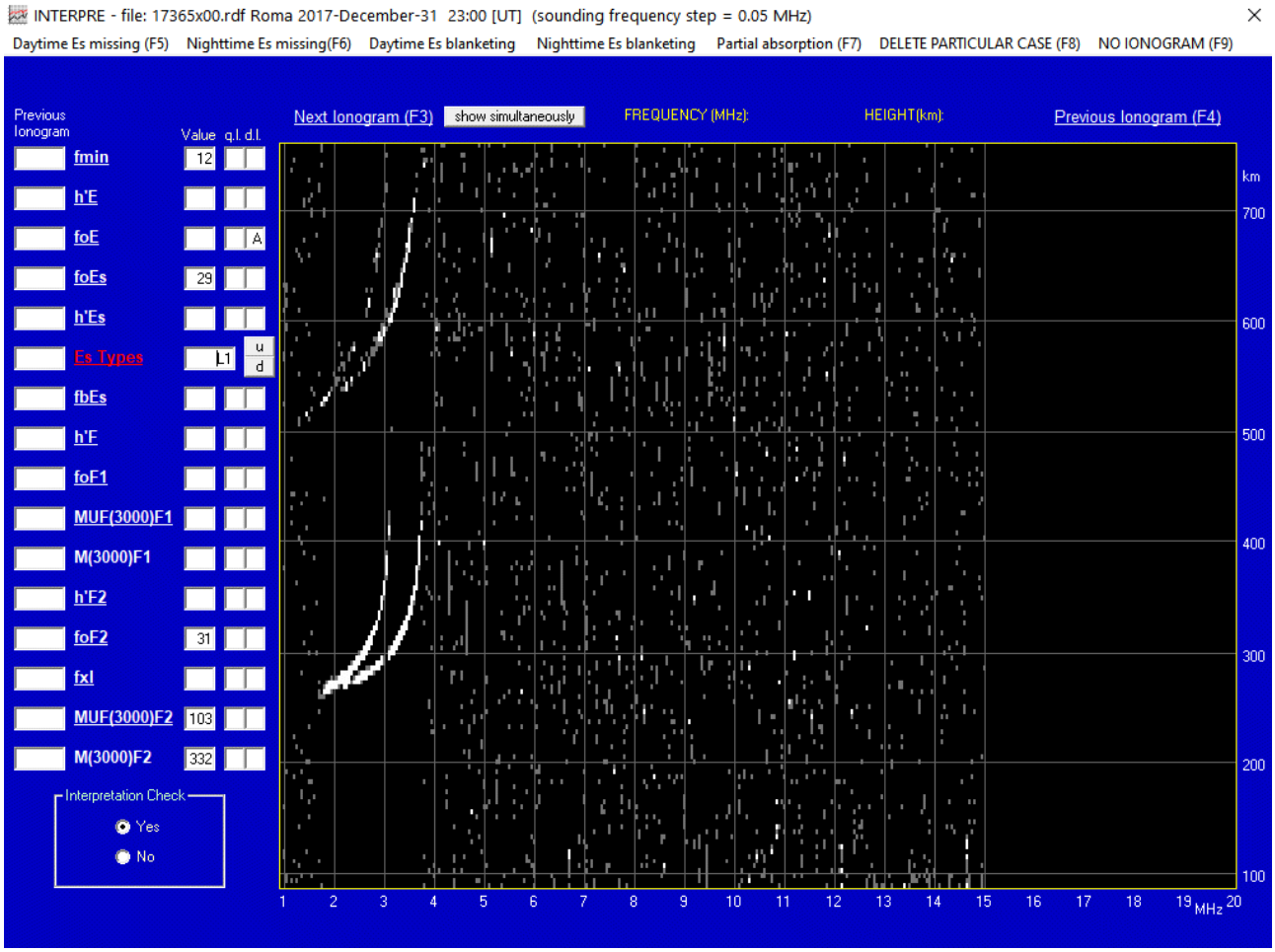

Figure 4. Graphical interface used for the interpretation of the ionograms where the buttons “u” and “d” are visible close to the “Es Types” field.

Once the interpretation of all characteristics is done you can move on to the next or previous ionogram of the same day by clicking the corresponding labels “Next Ionogram” or “Previous Ionogram” (or using the corresponding keys F3 and F4). In the passage between ionograms, if the property “Interpretation Check” in the bottom left corner of the frame is set to YES, the ionogram the user is leaving will be subjected to some control rules, otherwise the control on the interpretation will not be performed. When moving to the next ionogram, the ionospheric characteristics (along with the corresponding descriptive and qualifying letters) potentially scaled in the ionogram the user is leaving will be visible in the fields column named “Previous ionogram” (see Figure 5).

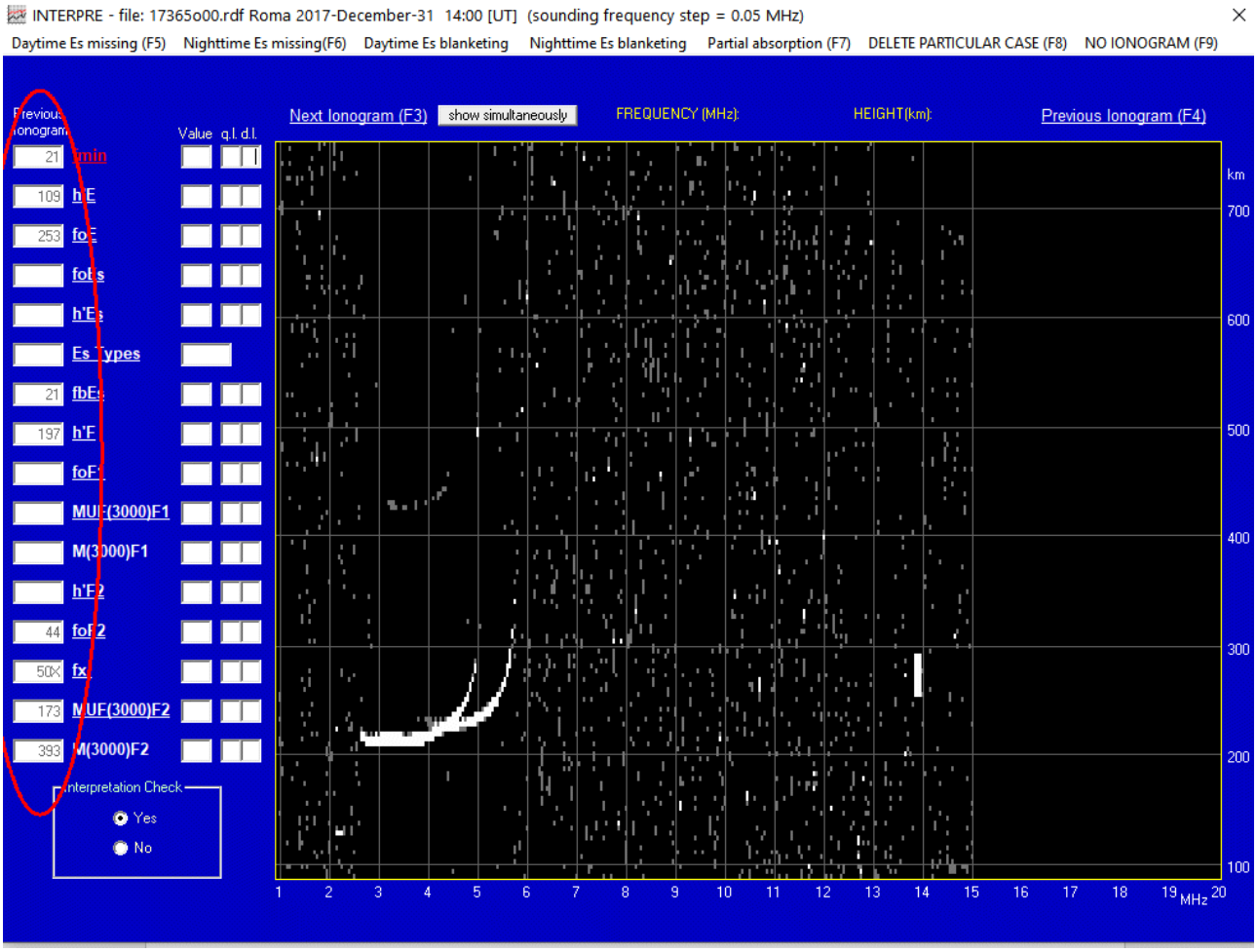

Figure 5. Graphical interface used for the interpretation of the ionograms where the column of fields “Previous ionogram” is highlighted by a red ellipse.

If moving from an ionogram to another, the ionogram should be unavailable, then the space where normally the ionogram is visualised will be totally black; in this case, the menu “NO IONOGRAM” is activated and, when clicking on it (or alternately pushing the F9 key), in correspondence to the ionospheric characteristics *fmin*, *fo*F2, *MUF*(3000)F2, *M*(3000)F2, *h*’F and *fx*I, the descriptive letter C is automatically displayed.

The button “show simultaneously” highlighted by a green ellipse in Figure 6 gives the user the possibility to view simultaneously the next and previous ionograms respect to that the user is working on.

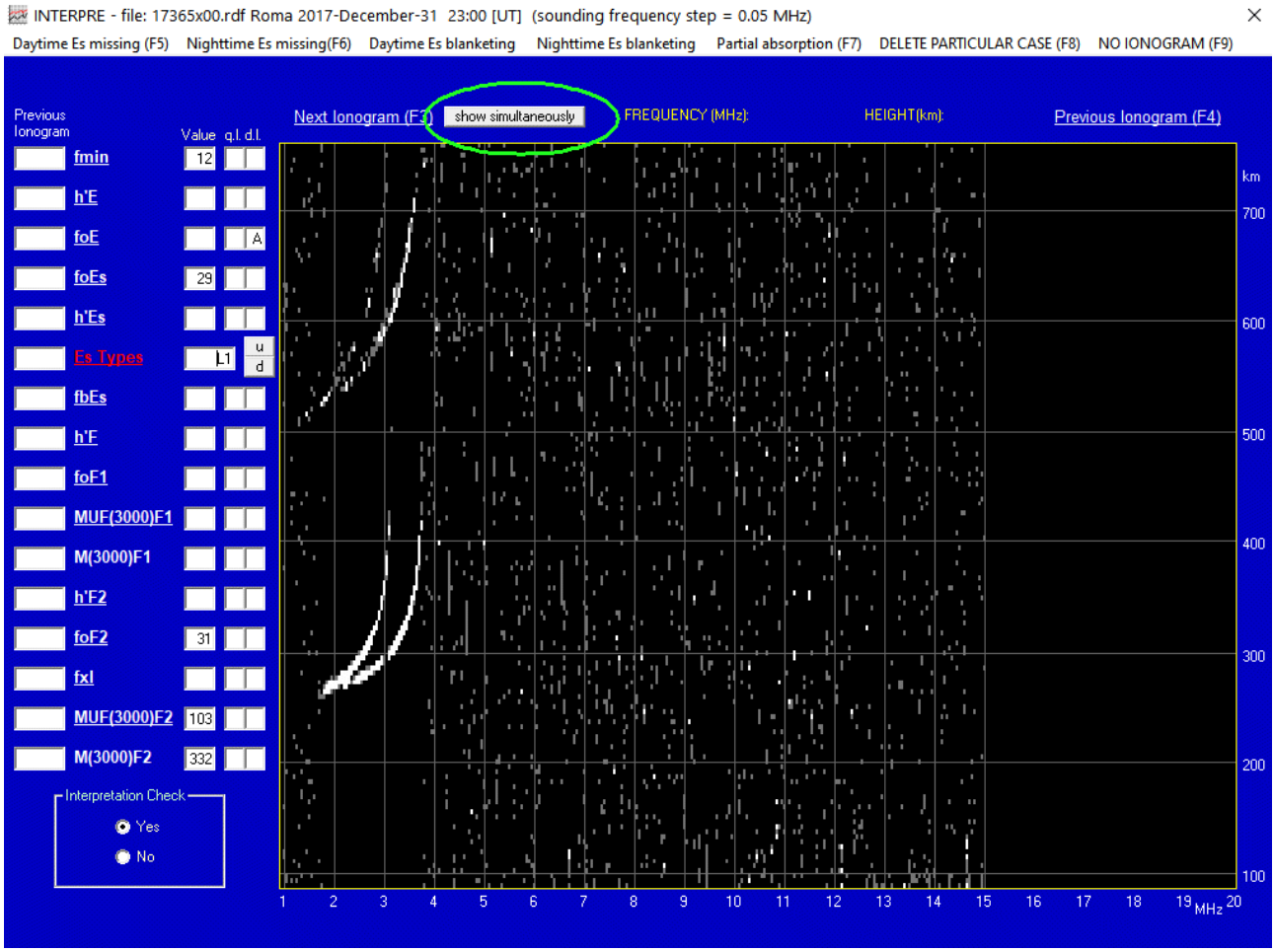

Figure 6. Graphical interface used for the interpretation of the ionograms where the button “show simultaneously” is highlighted by a green ellipse.

When the user needs to scale the ionograms belonging to a different day he has to go back to the graphical interface of Figure 1 (by pushing on the ESC key) and insert the corresponding date.

3. Available commands from the keyboard

- **ESC**: from the graphical interface of Figure 2 returns to the graphical interface of Figure 1.
- **F1**: this key is used to move down along the ionospheric characteristics to be scaled.
- **F2**: this key is used to move up along the ionospheric characteristics to be scaled.
- **F3**: this key is used to move to the next ionogram.
- **F4**: this key is used to move to the previous ionogram.
- **F12**: this key is used to delete the value, the qualifying and descriptive letters of the selected characteristic.

When interpreting *MUF*(3000)F1 and *MUF*(3000)F2 the following commands are available from the keyboard:

- **DOWN ARROW**: increases by 0.1 MHz the value of *MUF*(3000)F1 or *MUF*(3000)F2 referred to the displayed transmission curve;
- **UP ARROW**: decreases by 0.1 MHz the value of *MUF*(3000)F1 or *MUF*(3000)F2 referred to the displayed transmission curve;
- **CTRL + DOWN ARROW**: increases by 2.0 MHz the value of *MUF*(3000)F1 or *MUF*(3000)F2 referred to the displayed transmission curve;
- **CTRL + UP ARROW**: decreases by 2.0 MHz the value of *MUF*(3000)F1 or *MUF*(3000)F2 referred to the displayed transmission curve.

4. The menu bar

The menu bar includes some particular cases clicking on which the user can speed up the interpretation of the ionogram. The considered particular cases, with the corresponding conditions to activate them and the corresponding effected actions, are the following:

1-*Daytime Es missing*

Conditions to activate the particular case:

*fo*E	=	read
*fo*Es	=	empty
Es Types	=	empty

Actions:

*fo*Es	=	*fo*E EG
*fb*Es	=	*fo*E EG
h'Es	=	G

****

2-*Nighttime Es missing*

Conditions to apply the particular case:

fmin	=	read
h'E	=	empty
*fo*E	=	empty
*fo*Es	=	empty
h'Es	=	empty
Es Types	=	empty

Actions:

fmin	=	*fmin* ES
*fo*Es	=	*fmin* ES
*fb*Es	=	*fmin* ES
h'Es	=	S

****

3-*Daytime Es blanketing – single reflection*

Conditions to apply the particular case:

h'E	=	read
*fo*E	=	read
*fo*Es	=	read
h'Es	=	read
Es Types	=	read

Actions:

*fb*Es	=	A
h'F	=	A
*fo*F2	=	A
*fx*I	=	A
M(3000)F2	=	A
MUF(3000)F2	=	A

4-*Daytime Es blanketing – multiple reflections - second reflection ≥ foEs*

Conditions to apply the particular case:

h'E	=	read
*fo*E	=	read
*fo*Es	=	read
h'Es	=	read
Es Types	=	read

Actions:

*fb*Es	=	*fo*Es AA
h'F	=	A
*fo*F2	=	A
*fx*I	=	A
M(3000)F2	=	A
MUF(3000)F2	=	A

5-*Daytime Es blanketing – multiple reflections - second reflection < foEs*

Conditions to aplly the particular case:

h'E	=	read
*fo*E	=	read
*fo*Es	=	read
h'Es	=	read
Es Types	=	read
*fb*Es	=	read

Actions:

*fb*Es	=	*fb*Es AA
h'F	=	A
*fo*F2	=	A
*fx*I	=	A
M(3000)F2	=	A
MUF(3000)F2	=	A

****

6-Nighttime Es blanketing – single reflection

Conditions to apply the particular case:

*h'*E	=	empty
*fo*E	=	empty
*fo*Es	=	read
*h'*Es	=	read
Es Types	=	read

Actions:

*fb*Es	=	A
*h'*F	=	A
*fo*F2	=	A
*fx*I	=	A
M(3000)F2	=	A
MUF(3000)F2	=	A

7-Nighttime Es blanketing – multiple reflections - second reflection ≥ foEs

Conditions to apply the particular case:

*h'*E	=	empty
*fo*E	=	empty
*fo*Es	=	read
*h'*Es	=	read
Es Types	=	read

Actions:

*fb*Es	=	*fo*Es AA
*h'*F	=	A
*fo*F2	=	A
*fx*I	=	A
M(3000)F2	=	A
MUF(3000)F2	=	A

8-Nighttime Es blanketing – multiple reflections - second reflection < foEs

Conditions to apply the particular case:

*h'*E	=	empty
*fo*E	=	empty
*fo*Es	=	read
*h'*Es	=	read
Es Types	=	read
*fb*Es	=	read

Actions:

*fb*Es	=	*fb*Es AA
*h'*F	=	A
*fo*F2	=	A
*fx*I	=	A
M(3000)F2	=	A

MUF(3000)F2 = A

****

9-*Partial absorption*

Conditions to apply the particular case:

fmin = read

Actions:

*h'*E = B
*fo*E = B
*fo*Es = *fmin* EB
*h'*Es = B
Es Types = empty
*fb*Es = *fmin* EB

Particular cases 1, 2 and 9 can be applied also by pushing respectively the keys F5, F6 and F7.
If the user tries to apply a particular case but there aren't the right conditions to do it, the message "There aren't the right conditions to apply this particular case" will be displayed; on the contrary, if there are the right conditions to apply the particular case, in the upper left corner of the frame the particular case chosen by the user will be displayed (Figure 7).

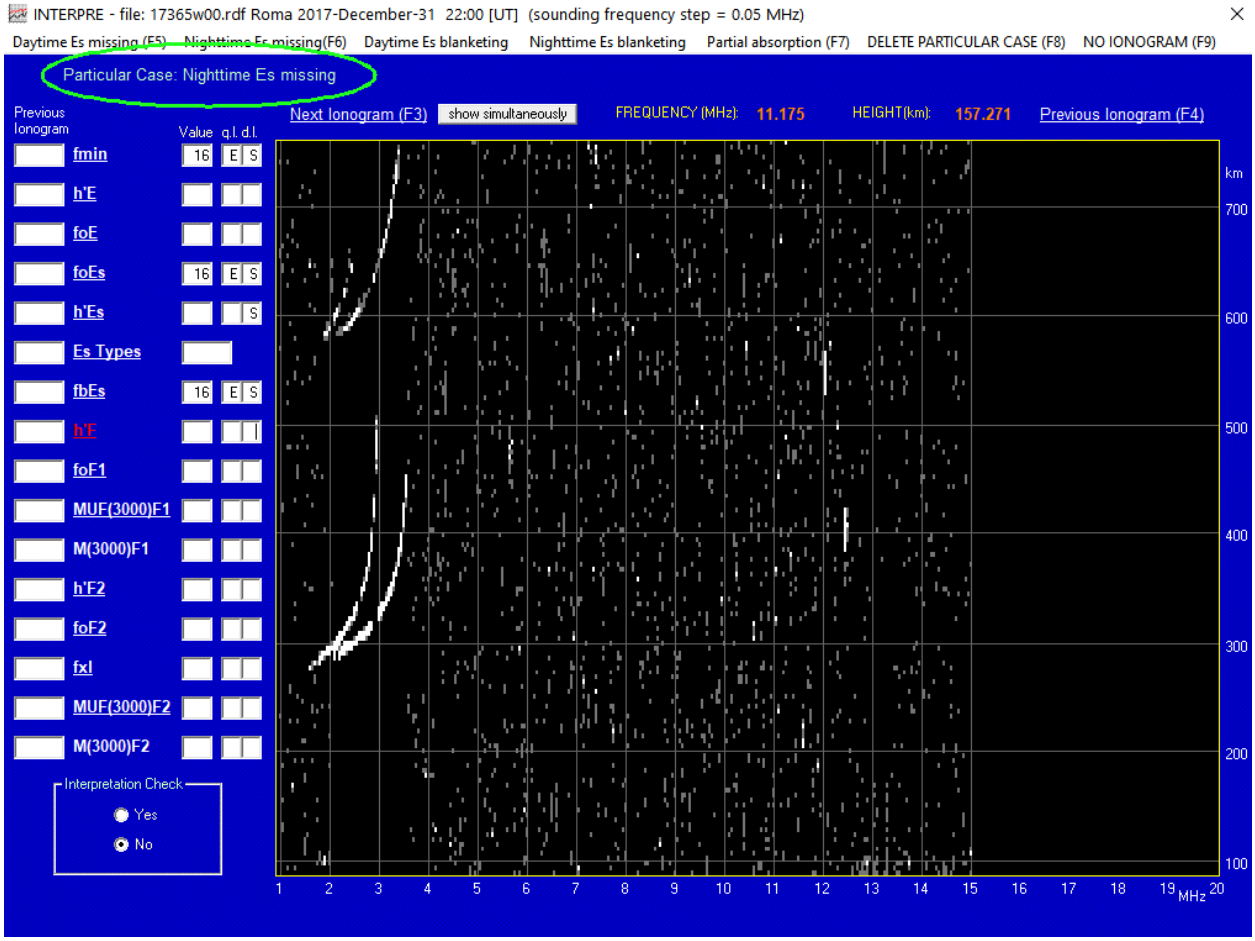

Figure 7. Graphical interface used for the interpretation of the ionograms where the particular case chosen by the user is highlighted by a green ellipse.

If the user wants to cancel the chosen particular case he has to click DELETE PARTICULAR CASE on the menu bar or alternately push the key F8; after doing this all the fields of the ionospheric parameters involved in the particular case will be emptied.

5. Checks during the interpretation phase

Normally the limits of some characteristics are highlighted; if during the interpretation phase the scaled values exceed these limits a message like "Impossible value for this characteristic. Continue?" will appear, if the user will answer YES the value will be written in the value field, on the contrary no action will be performed. The limits for the characteristics are the following:

- ***h'*E**: must be between 80 and 150 km;
- ***fo*E**: must be higher than *fmin*;
- ***h'*Es**: must be between 70 and 195 km and cannot be lower than (*h'*E-10);
- ***h'*F**: must be between 180 and 400 km; if *h'*Es has been read then it cannot be *h'*F<*h'*Es;
- ***h'*F2**: if *h'*F has been read it must be between 200 and 600 km.

In addition, a warning message will be displayed and a storage of the data will not be allowed for the following cases:

- in the interpretation of *fo*E or *fo*F1, if the user inside the ionogram clicks points corresponding to values in frequency that are greater than or equal to 10.0 MHz (displayed message: "Impossible value for this characteristic");
- in the interpretation of *fo*F2 or *MUF*(3000)F2, if the user identifies a value for *fo*F2 greater than *MUF*(3000)F2 (displayed message: "*fo*F2 cannot be greater than *MUF*(3000)F2");
- in the interpretation of *fo*F1 or *MUF*(3000)F1, if the user identifies a value for *fo*F1 greater than *MUF*(3000)F1 (displayed message: "*fo*F1 cannot be greater than *MUF*(3000)F1");
- in the interpretation of *fo*F2 or *MUF*(3000)F2, if the user identifies a *MUF*(3000)F2 value 10 times greater than *fo*F2 (displayed message: "*MUF*(3000)F2 cannot be 10 times greater than *fo*F2");
- in the interpretation of *fo*F1 or *MUF*(3000)F1, if the user identifies a *MUF*(3000)F1 value 10 times greater than *fo*F1 (displayed message: "*MUF*(3000)F1 cannot be 10 times greater than *fo*F1").

6. Interpretation Check

When passing from an ionogram to another, if the property "Interpretation Check" is set to YES, the ionogram the user is leaving will be subjected to some control rules and the user will be prevented from leaving the ionogram in the following cases:

- if there are ionospheric parameters which have only the qualifying letter (that is to say that the value field and the descriptive letter field are empty);
- if, for the ionospheric parameters *fmin*, *h*'F, *fo*F2, *MUF*(3000)F2 and *fx*I, the value field and the descriptive letter field are empty;
- if the ionospheric parameter *fo*E has the value field or the descriptive letter field (or both) not empty while the ionospheric parameter *h*'E has both the value field and the descriptive letter field empty;
- if the ionospheric parameter *h*'E has the value field or the descriptive letter field (or both) not empty while the ionospheric parameter *fo*E has both the value field and the descriptive letter field empty.

Moreover, in accordance with the possible chosen particular case the ionogram will be subjected to the following control rules:

Nighttime Es missing

an error message will be displayed and the user will be prevented from leaving the ionogram if:

h'E	≠	empty
Es Types	≠	empty
h'F2	≠	empty
*fo*E	≠	empty
*fo*F1	≠	empty
MUF(3000)F1	≠	empty
fmin	=	empty
h'F	=	empty
*fo*F2	=	empty
*fx*I	=	empty
MUF(3000)F2	=	empty

Daytime Es missing

an error message will be displayed and the user will be prevented from leaving the ionogram if:

h'E	=	empty
Es Types	≠	empty
*fo*E	=	empty
fmin	=	empty
h'F	=	empty
*fo*F2	=	empty
*fx*I	=	empty
MUF(3000)F2	=	empty

Daytime Es blanketing – single reflection
Daytime Es blanketing – multiple reflections - second reflection ≥ foEs
Daytime Es blanketing – multiple reflections - second reflection < foEs

an error message will be displayed and the user will be prevented from leaving the ionogram if:

1°character EsTypes	≠	C, H, L
2°character EsTypes	=	0
*fo*E	=	empty
*h'*E	=	empty
fmin	=	empty
*h'*F	=	empty
*fo*F2	=	empty
*fx*I	=	empty
MUF(3000)F2	=	empty

Nighttime Es blanketing – single reflection
Nighttime Es blanketing – multiple reflections - second reflection ≥ foEs
Nighttime Es blanketing – multiple reflections - second reflection < foEs

an error message will be displayed and the user will be prevented from leaving the ionogram if:

1°character EsTypes	≠	F
2°character EsTypes	=	0
*fo*E	≠	empty
*h'*E	≠	empty
*fo*F1	≠	empty
MUF(3000)F1	≠	empty
fmin	=	empty
*h'*F	=	empty
*fo*F2	=	empty
*fx*I	=	empty
MUF(3000)F2	=	empty