

Technical description of the method to obtain the ionospheric characteristics of ionograms measured by digisondes (supplementary material)

The DPS4D ionograms' records simultaneously provide measurements of seven observable parameters of reflected radio signals received from the ionosphere: frequency, range (or height for vertical incidence measurements), amplitude, phase, doppler shift and spread, angle of arrival and wave polarization. This is explained in the Technical Manual of the DPS4D (herein after, the DPS4D manual) available at https://digisonde.com/pdf/Digisonde4DManual_LDI-web.pdf (latest downloaded Document version 1.2.11 of 16 March 2022). See section 1 page 1-14 of the DPS4D manual.

The ionogram data is available at the GIRO portal (<https://giro.uml.edu/>, last accessed 2023.01.12) and it is provided a software tool for working with GIRO ionograms. This Data Visualization/Editing Tool is commonly known as SAO Explorer (SAO-X) and make possible to visualize and edit the ionospheric characteristics. We refer the reader to the URSI handbook of ionogram interpretation and reduction, Report UAG-23 (1972) by Piggott and Rawer for the meaning and measuring of the ionospheric characteristic from ionograms (https://www.ngdc.noaa.gov/stp/space-weather/online-publications/stp_uag/uag-023.pdf, last accessed 2023.01.12). SAO-X can be accessed to download at the website of the Center for Atmospheric Research (<https://ulcar.uml.edu/SAO-X/SAO-X.html>, last accessed 2022.03.16) and it has a user-guide (<https://ulcar.uml.edu/SAO-X/UsersGuide.html>, last accessed 2022.03.16). Users of SAO-X can connect to the Digital Ionogram DataBase (DIDB, <https://giro.uml.edu/didbase/>) which is an internet-accessible archive of digisonde ionograms for many locations and periods of time. Users should follow the Instructions to configure SAO Explorer to connect to DIDB (<https://ulcar.uml.edu/SAO-X/DIDB-connect.html>).

SAO-X allows in an easy way to visualize, measure and extract the ionospheric characteristics from the ionograms. This way, the following data corresponds to the hourly measurements of the plasma frequency of the F2-layer peak for both the ordinary and the extraordinary wave, foF2 and fxF2 respectively. The data was measured by the ionosonde of the Ebro Observatory, located at 40.8° N, 0.5° E for the 11 and 12 of February of 2016 and are expressed in MHz.

Data are arranged by colons with comma separated values with information of the date, time and measurement value of the characteristics, where **yyyy**, **MM**, **dd**, **(DoY)**, **HH**, **mm**, and **ss** mean year, month, day, (Day of Year), hour, minute, and second of the measurement respectively. foF2 and fxF2 mean the values of the plasma frequency of the F2-layer peak for both the ordinary and the extraordinary wave, respectively, expressed in MHz.

yyyy,MM,dd,(DoY),HH,mm,ss, foF2, fxF2 (MHz)

2016,02,11,(042),00,00,02, 3.300, 3.95

2016,02,11,(042),01,00,02, 3.450, 4.10

2016,02,11,(042),02,00,02, 3.550, 4.10

2016,02,11,(042),03,00,02, 3.550, 4.25

2016,02,11,(042),04,00,02, 3.600, 4.30

2016,02,11,(042),05,00,02, 3.650, 4.35
2016,02,11,(042),06,00,02, 3.150, 3.80
2016,02,11,(042),07,00,02, 4.950, 5.55
2016,02,11,(042),08,00,02, 7.450, 8.10
2016,02,11,(042),09,00,02, 8.425, 9.05
2016,02,11,(042),10,00,02, 9.025, 9.60
2016,02,11,(042),11,00,02, 9.125, 9.80
2016,02,11,(042),12,00,02, 9.125, 9.85
2016,02,11,(042),13,00,02, 8.575, 9.20
2016,02,11,(042),14,00,02, 9.225, 9.85
2016,02,11,(042),15,00,02, 8.825, 9.35
2016,02,11,(042),16,00,02, 7.450, 8.15
2016,02,11,(042),17,00,02, 7.725, 8.35
2016,02,11,(042),18,00,02, 5.850, 6.50
2016,02,11,(042),19,00,02, 5.100, 5.75
2016,02,11,(042),20,00,02, 4.150, 4.85
2016,02,11,(042),21,00,02, 3.550, 4.20
2016,02,11,(042),22,00,02, 3.550, 4.55
2016,02,11,(042),23,00,02, 3.600, 4.25
2016,02,12,(043),00,00,02, 3.700, 4.35
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2016,02,12,(043),02,00,02, 3.850, 4.55
2016,02,12,(043),03,00,02, 3.950, 4.55
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2016,02,12,(043),06,00,02, 2.350, 3.15
2016,02,12,(043),07,00,02, 5.350, 5.90
2016,02,12,(043),08,00,02, 7.225, 7.70
2016,02,12,(043),09,00,02, 8.475, 9.00
2016,02,12,(043),10,00,02, 9.975, 10.45
2016,02,12,(043),11,00,02, 9.700, 10.50
2016,02,12,(043),12,00,02, 9.050, 9.70
2016,02,12,(043),13,00,02, 9.525, 10.30
2016,02,12,(043),14,00,02, 10.600, 11.30
2016,02,12,(043),15,00,02, 10.975, 11.60

2016,02,12,(043),16,00,02, 7.900, 8.65
2016,02,12,(043),17,00,02, 6.350, 7.00
2016,02,12,(043),18,00,02, 5.500, 6.45
2016,02,12,(043),19,00,02, 4.850, 5.60
2016,02,12,(043),20,00,02, 5.150, 5.75
2016,02,12,(043),21,00,02, 5.000, 5.65
2016,02,12,(043),22,00,02, 4.350, 4.95
2016,02,12,(043),23,00,02, 4.550, 5.20