IONOSPHERIC OBSERVATORY DEVELOPMENT AT MARIO ZUCCHELLI STATION

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Abstract

Since 1995 Italian Ionospheric Antarctic Observatory at Terra Nova Bay, now "MARIO ZUCCHELLI", station (geographic coordinates: 74.70°S, 164.11°E) performs continuous and systematic ionospheric vertical soundings. Long time series of continuous and accurate ionospheric observations (more than one solar cycle) are necessary for a deeper understanding of the complex phenomena occurring in the upper atmosphere at high latitude; furthermore high rate soundings (at least four soundings per hour or more) contribute to the short-time prediction of the radiopropagation conditions and to the Space Weather.
During 2003–2004 Antarctic campaign a new digital ionosonde, recently developed at the Istituto Nazionale di Geofisica e Vulcanologia (INGV) in Rome, (Italy), has been installed the Ionospheric Observatory and preliminary tests have been carried out. This new Advanced Ionospheric Sounder-INGV, briefly AIS, is integrated in a stand alone system during winter time: the sounding, device settings and data sending to Rome are completely automatic and remote programmable. Ionograms are available on line at the INGV web and ftp server.
The new features of the Ionospheric Observatory are presented and preliminary statistics on the reliability and validation of the experimental observation are shown and discussed.

The AIS-INGV ionosonde

The advanced HF-radar techniques employed permit to reduce the transmitted power (less than 200 W), weight, size, power consumption, hardware complexity and to have an excellent reliability (Zuccheretti et al., 2003). AIS uses a 16 bit complementary phase code together with the most advanced HF-radar techniques such as the pulse compression and phase coherent integration. These features give the new system the possibility of better distinguish highly coherent ionospheric layers giving, when possible, more accurate values for layers' critical frequencies useful for communication purposes; on the other hand layers with poor coherence or changing very quickly are barely visible or completely ignored.
This ionosonde has been installed at "Mario Zucchelli" station. In spite of the hard environmental conditions the station is capable of working without human intervention: a windows 2000 server has been developed in Rome at the INGV for AIS management.
In details the ionosonde can be switched on and off, soundings parameters can be changed and data are visible real time through a satellite link. For Space Weather applications the new ionosonde will continue to contribute to ionospheric data base at high latitude with great improvement with respect to past as for the on-line data availability, remote control and sounding reliability. Further an automatic scaling software for high latitude regions is under development so that Space Weather services will be improved.
After the installation lots of efforts have been spent to find the best parameters for the new ionosonde related to the Antarctic particular environment. From November 2003 to March 2004 we produced lots of ionograms to evaluate the behaviour of such a system with highly variable ionospheric conditions. Even though this was only a test session results are so good to be collected in a partial bulletin soon available through ftp link to our server under request.

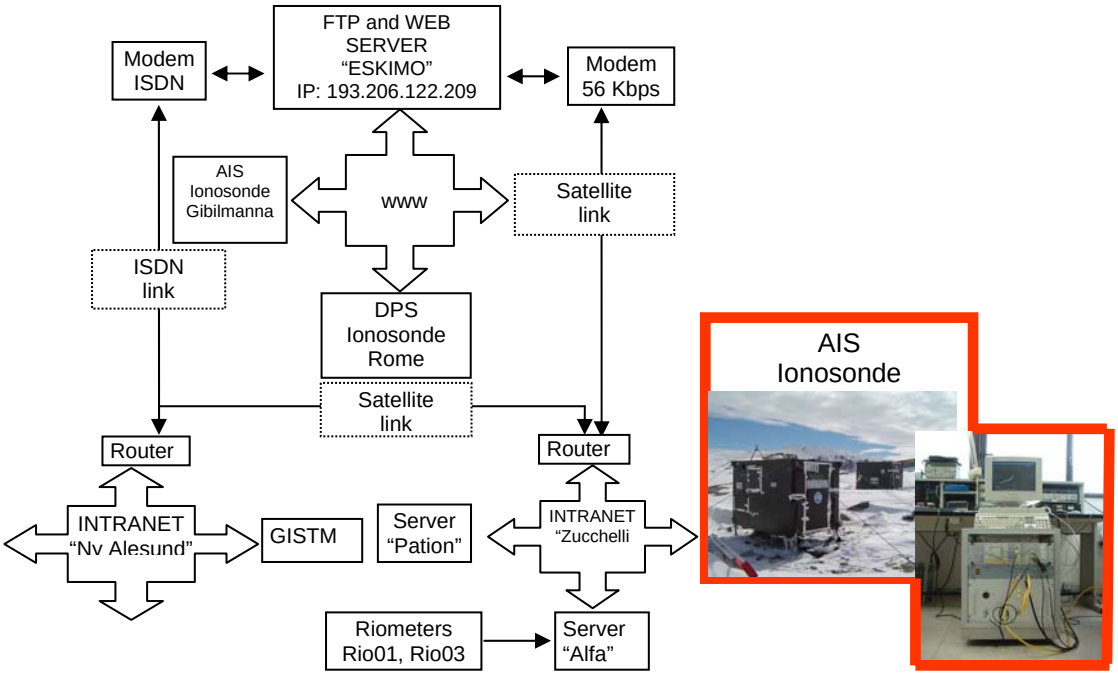

Figure 1: Blocks Diagram of ESKIMO server and remote links: http://eskimo.ingv.it. In Rome and Gibilmanna (Sicily, Italy) are located the INGV ionospheric observatories at mid latitude. The AIS ionosonde at Antarctic "Mario Zucchelli" Station is connected to ESKIMO via satellite link.

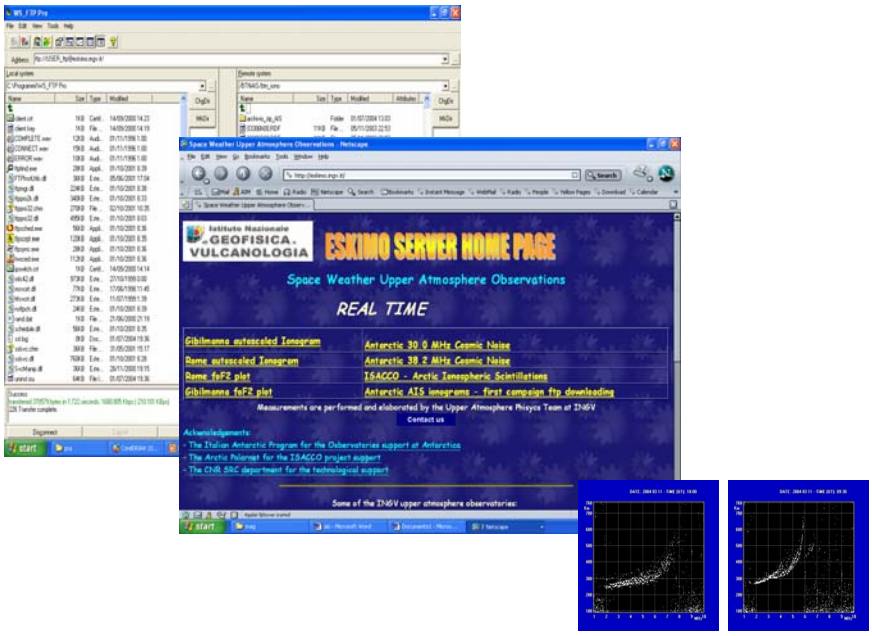

Figure 2: Eskimo home page: **http://eskimo.ingv.it**. From eskimo is possible to download the latest and historical ionograms.

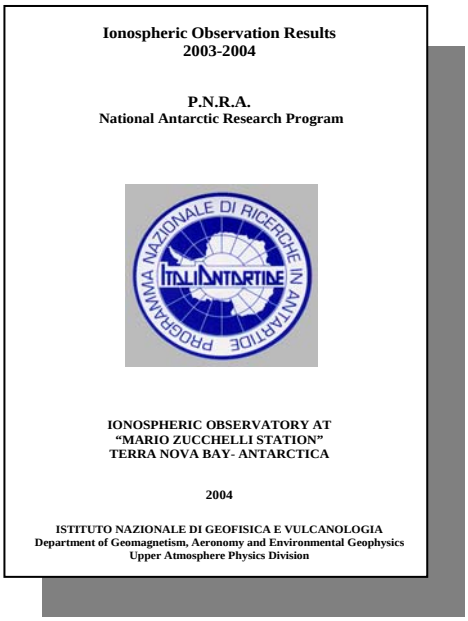

Figure 3: Bulletin cover of 2003-2004 ionospheric observation results: available on demand.

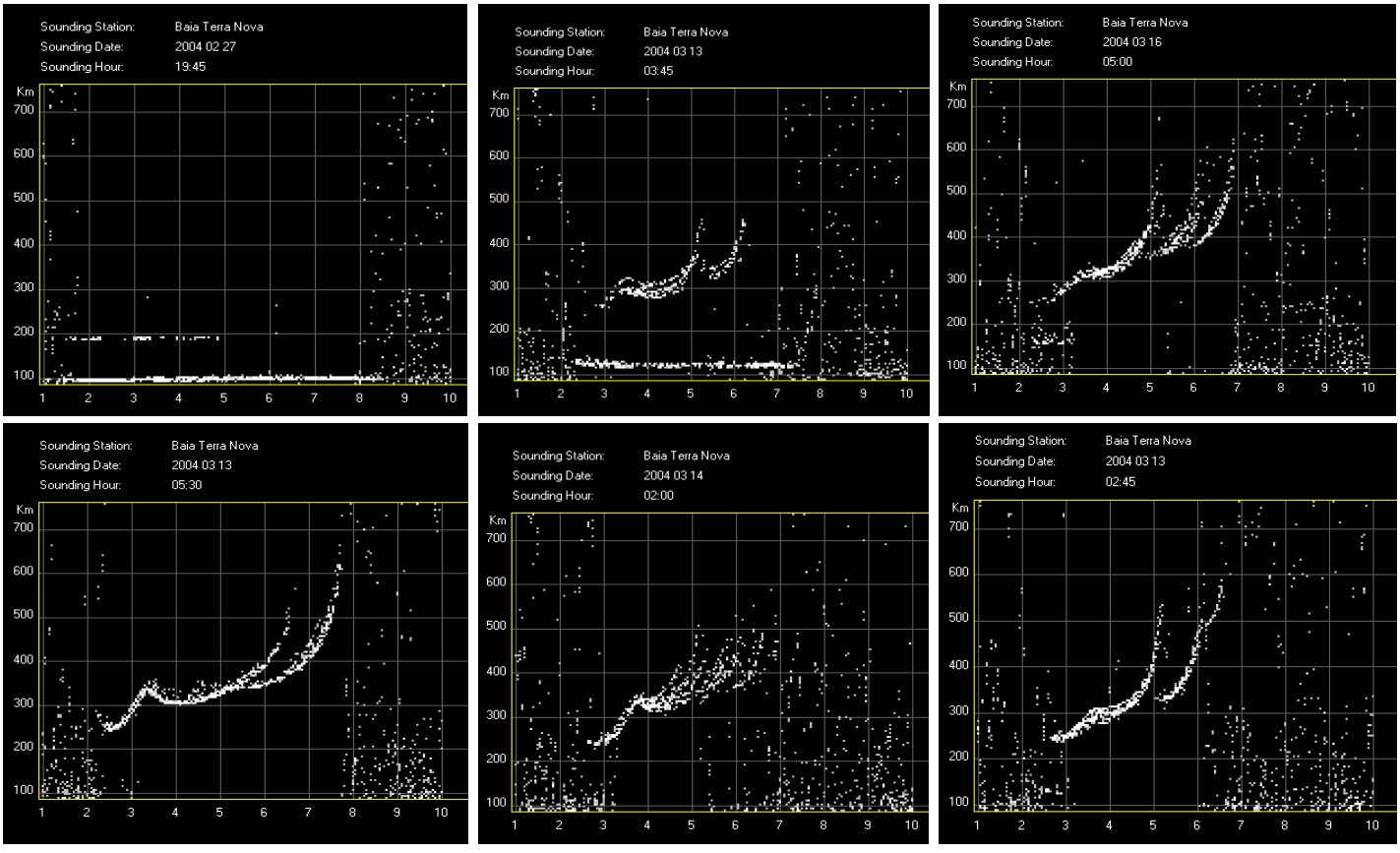

Figure 4. Some ionogram samples showing different ionospheric conditions. Fine tuning of parameters such as integration number and noise filtering can enhance signal to noise ratio and ionogram's quality.

Ionogram statistics

A simple statistical analysis on 3401 ionograms from 7th November 2003 to 29th March 2004 has been performed to have a confirmation of instrumentation proper working. As shown in figure 5:

- 72% are good quality ionograms (readily scaled ionograms)
- 14% is formed by poor quality ionograms (auxiliary letters are needed)
- 14% ionograms are without trace, including absorption cases confirmed by other close ionospheric observatories (Scott Base and Casey).

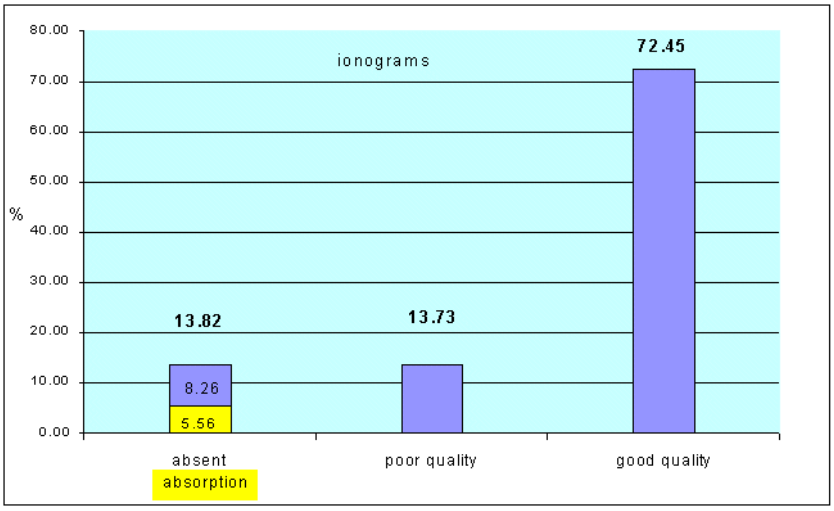

Figure 5. Ionograms statistics.

A Case study

A case study related to the disturbed period between 17th and 23rd November 2003 is here presented as a first attempt to invesigate AIS capabilities. Along this time interval ten M-class flares occurred, in particular a M9 flare on 20 November at 07:47 UTC was associated with a Halo CME. This high activity has produced major to severe geomagnetic storming on 20 November and on early 21 November, with estimated Kp reaching 9 and 6 on 20 and 21 November, respectively (for further details, please visit: http://www.sel.noaa.gov/weekly/pdf2003/prf1473.pdf).
In figure 6 the foF2 monthly medians, foF2_m, and hourly values, foF2_h, are plotted vs time: from 20 November the severe ionospheric conditions have caused the blanketing of the AIS ionograms because of scarce quality of the trace or because of the absorption of the radio signal transmitted. A deeper investigation (in preparation) should allow to study the foF2 enhancement in comparison with the median behaviour recorded just before and after the magnetic storm.

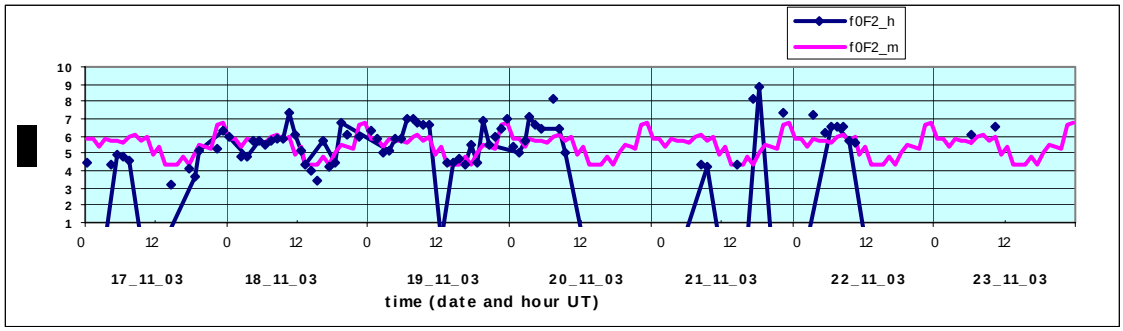

Figure 6: foF2 monthly medians, foF2_m, and hourly values, foF2_h, from 17 November to 23 November 2003 plotted vs time.

AIS future development in Antarctica

After the encouraging results obtained on mid-latitude ionograms (Scotto and Pezzopane, 2002) we are studying the possibility to equip the ionosonde with a software able to give as output the values of the ionospheric parameters foF2 and MUF(3000)F2 automatically scaled. In figure 7 it is reported an example of Antarctic AIS ionogram (13 December 2003) with the ionospheric parameters foF2 and MUF(3000)F2 automatically scaled by a preliminary release of the software. The green and the red curves represent respectively the ordinary and the extraordinary traces identified by the software. The critical frequency foF2 is calculated in correspondence of the vertical asymptote of the green curve while the parameter MUF(3000)F2 is numerically established finding the transmission curve tangent to the green curve. The application of the software needs to be carefully tested on a significant number of Antarctic ionograms for verifying its reliability under disturbed ionospheric conditions typical of high latitudes.

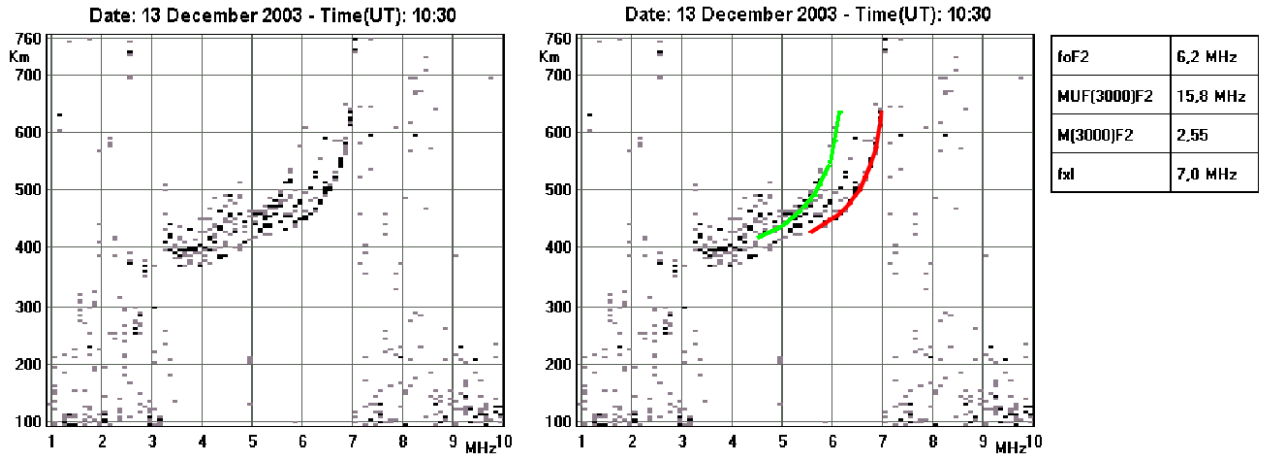

Figure 7. An example of Antarctic AIS ionogram (13 December 2003) with the ionospheric parameters foF2 and MUF(3000)F2 automatically scaled by a preliminary release of the software.

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References

Arokiasamy B. J., C. Bianchi, M. Pezzopane, V. Romano, U. Sciacca, C. Scotto, G. Tutone and E. Zuccheretti, "New Low Power Pulse Compressed Ionosonde at Gibilmanna Ionospheric Observatory" presented at EGS-AGU-EUG Nice 2003, submitted to Annals of Geophysics.

Bianchi C., U. Sciacca, A. Zirizzotti, E. Zuccheretti and B. J. Arokiasamy "Signal processing technique for phase-coded HF-VHF radars", Annals of Geophysics vol. 46, N. 4, pp. 697-705, 2003

Romano V., M. Cerrone, L. Perrone, M. Pietrella, "Magnetic And Solar Effects On Ionospheric Absorption At High Latitude", Annals of Geophysics, 45/1, 163-168, 2002.

Scotto C., M. Pezzopane, "A software for automatic scaling of foF2 and Muf(3000)F2 from Ionograms", Proceedings of URSI 2002, Maastricht 2002.

Zuccheretti E., G. Tutone, U. Sciacca, C. Bianchi and B. J. Arokiasamy "The new AIS-INGV digital ionosonde", Annals of Geophysics vol. 46, N. 4, pp. 647-659, 2003