THE NEW AIS-INGV IONOSONDE AT ITALIAN ANTARCTIC OBSERVATORY

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Abstract. The Italian Ionospheric Antarctic Observatory of Terra Nova Bay (74.70S, 164.11E) was recently equipped with the AIS-INGV ionosonde developed at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, (Italy). This paper aims to describe briefly which are the main characteristics of the instrument and show the good quality and reliability of the recorded ionograms.

Key words: ionosonde, antarctic ionospheric observatory, ionospheric data, vertical soundings.

1. Introduction

AIS-INGV (Advanced Ionospheric Sounder) is the digital low-power pulse-compressed ionosonde recently developed at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, (Italy). The advanced HF-radar techniques employed permit the reduction of the transmitted power, weight, size, power consumption, hardware complexity and to have an excellent reliability.

Fig.1. Geographical location of the Italian Antarctic Base

This ionosonde was installed at the Italian Ionospheric Antarctic Observatory of Terra Nova Bay (74.70°S, 164.11°E) (Fig. 1).

In spite of the hard environmental conditions the ionosonde is capable of working without human intervention: sounding scheduling, device settings and data management are controlled remotely. For Space Weather applications the new ionosonde will continue to contribute to ionospheric data bases at high latitudes, with great improvement with respect to the past as for the on-line data availability, remote control and sounding reliability. In this work the new features of the Ionospheric Observatory are presented and the first results (ionograms and characteristics) are briefly discussed.

2. Main characteristics of the AIS-INGV

The aim of this new digital ionosonde (AIS-INGV) is to fulfill the request to have a simple and easy system to sound the ionosphere. To do this we designed a system in which the most advanced HF radar techniques have been employed (Skolnik, 1981; Skolnik,1990).

The result is the reduction of the transmitted power and, consequently, weight, size, power consumption and hardware complexity. These aims are appreciable in a harsh environment where a large amount of energy is not available at low cost. Nevertheless using low power techniques implies a large number of integrations which might be affected by quickly varying ionospheric conditions typical at high latitudes.

To compensate the power reduction a 16 bit complementary phase code is employed (Golay, 1961) together with pulse-compression and a phase coherent integration, giving the possibility to investigate the ionosphere with a power of 200W only. The ionosonde is completely programmable and the data acquisition, control, storage and on-line processing are supported by a PC (Zuccheretti et al., 2003; Bianchi et al., 2003; Arokiasamy et al., 2002).

3. Installation and configuration

Since 1991, the Italian Antarctic Observatory at Mario Zucchelli Station (MZS) has run hourly soundings during the austral summer. In 1995 observations were extended to the whole year, even though it is always difficult to obtain long and complete data series in such hard environmental conditions.

At the end of 2003 the analog IPS42 ionosonde was substituted by the new AIS-INGV digital ionosonde.

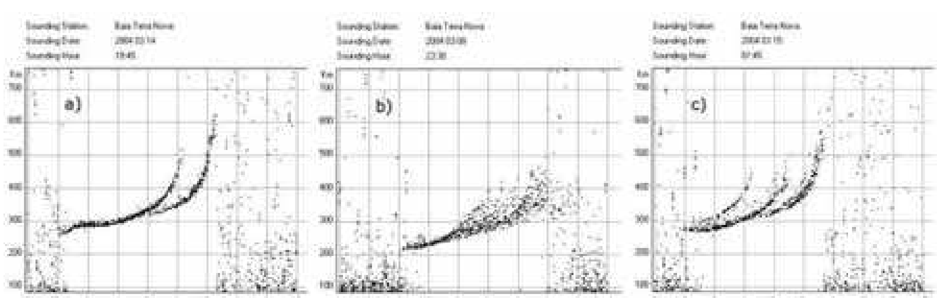

Fig.2. Three examples of soundings with a good quality of the trace. a) Ionogram in which the ordinary and the extraordinary rays are clearly visible. b) Ionogram characterized by spread-F echoes. c) Triple splitting of the trace (Z ray, ordinary and extraordinary rays) which can often distinguish ionograms recorded at high latitudes.)

In Fig. 2 three examples of good quality ionogram recorded by AIS-INGV are shown.

Like other recent ionospheric sounders, the AIS-INGV ionosonde is built around a Personal Compuetr (PC), which comprises the most important part. This allows the system to send ionograms through the Internet and makes remote control possible.

To better understand the problems and solutions for a such remote station it is important to review the organization of the observatory. The

Fig.3. The Italian Antarctic ionospheric observatory.

ionosonde and its PC are stored in a small container close to the antennas and distant from the populated base, MZS (Fig. 3).

In particular the ionosonde PC is connected through an HDSL (High bit rate Digital Subscriber Line) to the MZS local network, which is linked to the world via satellite link (Fig. 4). As a consequence data can be automatically sent to a server that makes ionograms available on demand by INGV where data are scaled and results are spread worldwide.

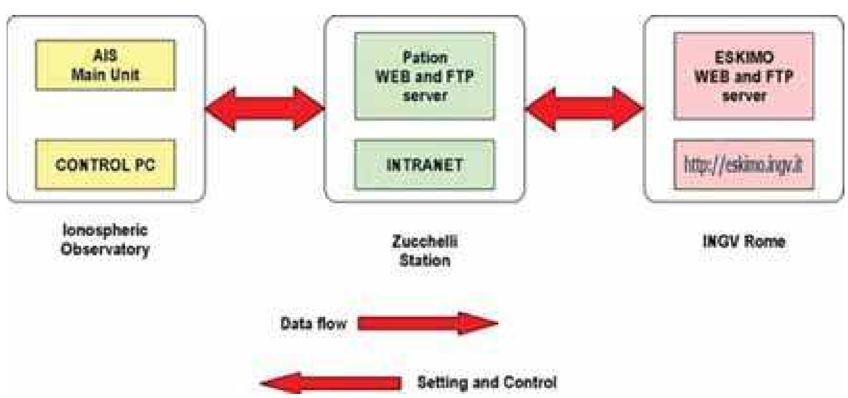

Fig.4. Diagram showing the AIS-INGV ionosonde data flow.

4. **First statistical analysis**

After installing the system a lot of work was spent determining the optimum operational parameters for the system. Particularly sensitivity; the number of integrations and the noise rejection filters were adjusted according to the local Antarctic environment. Good settings are confirmed by the quality of observed ionograms. We have considered 3401 ionograms acquired in about 130 days from 7th November 2003 to 29th March 2004. A simple statistical analysis was performed to confirm the correct operation of the instrument. In particular we divided the total number of ionograms into three categories: good quality ionograms in which exact parameters can be derived; poor quality ionograms in which it is necessary to add auxiliary letters to the scaled value and soundings without any kind of trace. In this last category blank ionograms are due to ionospheric absorption, as was confirmed by reference to other nearby ionospheric observatories (Scott Base and Casey).

The results are shown in Fig. 5 in which more than 70% of total number of ionograms collected were good quality ionograms and only 8% of cases are due to poor system sensitivity.

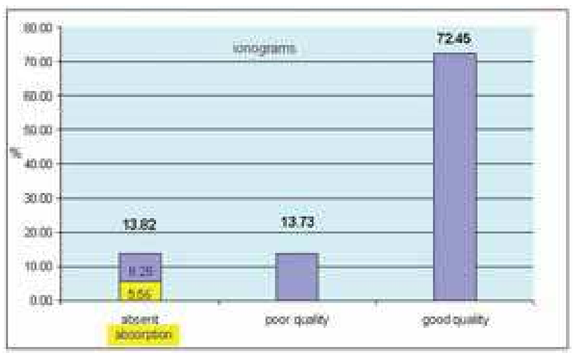

Fig.5. Simple statistical analysis of the ionogram quality.

5. A good agreement between different instruments

The presence of different instruments dealing with the ionosphere at the Antarctic observatory offers the possibility of validating results from one instrument with data coming from another.

One such case is the absence of ionograms due either to ionospheric absorption or to an improper working of the ionosonde. Variation from a normal behaviour can be due to the ionospheric absorption (Hunsucker, 1991). Two riometers have been installed at MZS since 1993. The riometer is a well-known instrument able to measure the relative opacity of the ionosphere (Romano et al., 2002).

In Fig. 6 the complete sequence of ionograms for 26th February 2004 is shown for two ionospheric absorption events.

At that time two ionosonde soundings per hour were performed, at minute 0 and minute 30, having a total number of 48 ionograms for each day.

The correspondence between the ionograms showing missing echoes and the absorption events is clear.

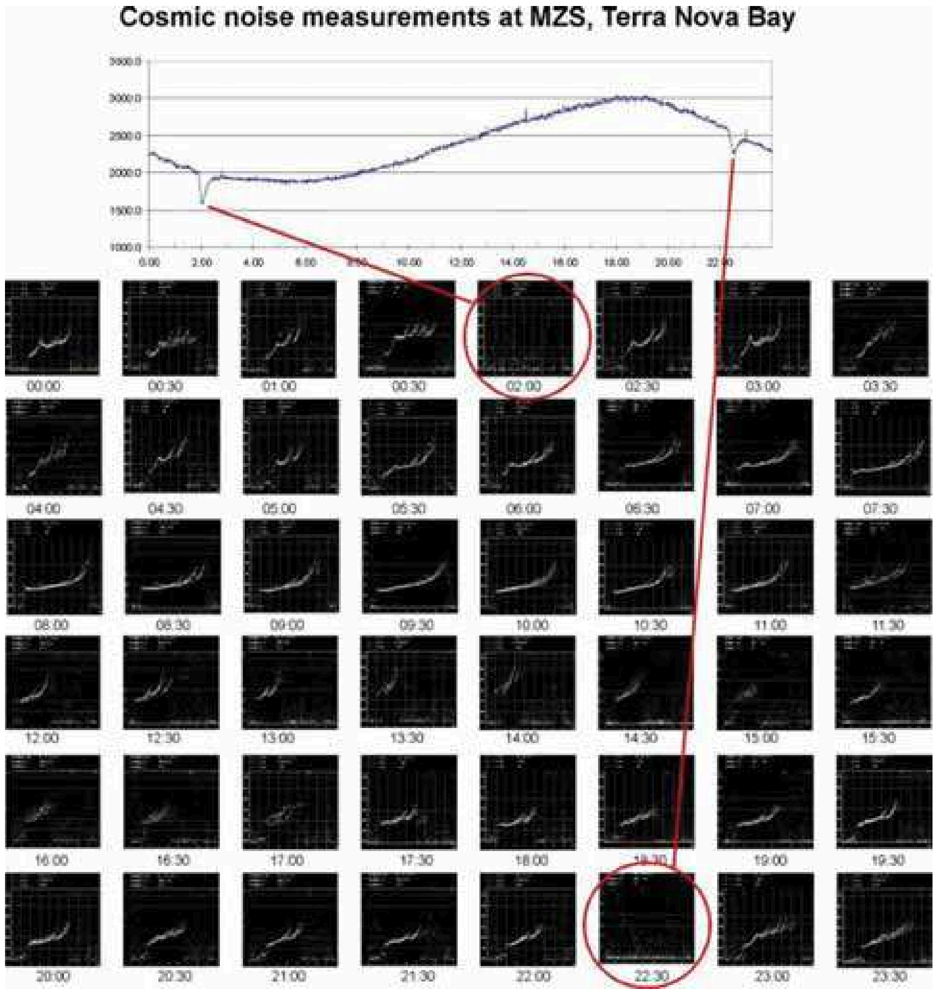

Fig.6. Qualitative comparison between the cosmic noise curve and ionograms recorded respectively by a 30 MHz riometer and by AIS-INGV ionosonde on 26th February 2004.

6. Conclusions and future developments

Results obtained during these first months operation demonstrate that a low-power pulse-compressed ionosonde based on modern radar techniques is suitable for polar ionospheric observations.

In fact the large number of ionograms acquired exhibits well-separated traces from which most of conventional ionospheric parameters can be scaled.

Nevertheless several improvements are necessary for a remote, unmanned observatory like MZS.

First of all, future efforts will be devoted to make the system more robust and reliable. Particularly system redundancy is required as well as automatic recording of system state parameters such as: temperature, main signals amplitude, matching between the transmitting antenna and the power amplifier.

Another important future aim is to increase the contribution to Space Weather by making scaled parameters from ionograms available in real time. The development of an appropriate automatic scaling program for high latitudes, derived from Autoscala software (Scotto and Pezzopane, 2003), is planned for the future.

7. References

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