THE EFFECT OF SOLAR PERTURBATIONS ON IONOSPHERIC ABSORPTION OVER ANTARCTICA

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ABSTRACT

Solar events and strong magnetic storms during november 2001 are selected and their effects on the Antarctic upper atmosphere are investigated by using riometer data. The results are presented and discussed as depending on strong solar protons emission and as function of the magnetic index PC (Polar Cap).

INTRODUCTION

The electron density in the ionospheric D layer is greatly dependent on the chemistry of this region that is strongly controlled by solar radiation. In fact, under disturbed conditions, one of the principal causes of ionisation is due to the influx of the solar energetic particles penetrating into the atmosphere increasing the electron density and then the ionospheric absorption. The so-called Polar Cap Absorption (PCA) is an increasing of the ionospheric absorption in the D region at high latitude, determined by the emission of energetic protons coming from the Sun in connection with major solar flares (see [1], [2], [3]). The absorption effects of a solar proton event (SPE) reach a maximum hours after the flare and can last for several days or more. Hence, the consequences for radio communications and radio operations, expecially in polar regions, can be extreme with regard to both magnitude and duration [4].
Since 1950 the riometer technique was introduced for monitoring the radio absorption (see [5]) and modern instruments carried on geostationary satellites are now able to provide continuous measurements of the solar proton flux.
Also the analysis of the Polar Cap (PC) index should be useful to examine the solar wind-magnetosphere interaction on the high latitude Ionosphere. The PC index has been introduced by Troshichev in [6] for monitoring the geomagnetic activity over the poles due to changes in the Interplanetary Magnetic Field (IMF) and solar wind.

DATA USED

In this paper the events of strong solar protons events (protons event with maximum flux well above 1000 pfu) occurred in November 2001 are investigated by analysing both ionospheric and magnetospheric parameters.
For this scope the following data are taken into account:

- The ionospheric absorption data (A2 method) derived from 30 sec. cosmic noise measurements acquired at the Italian Antarctic Station of Terra Nova Bay (geographic coordinates: 74.69S, 164.12E) by a 30 MHz Riometer station. With the A2 method the ionospheric absorption is calculated by the ratio between the cosmic noise P0, i.e. the cosmic noise that would be observed in the absence of ionosphere, and P, i.e. the cosmic noise measured at the time t. The best estimation of P0, the so-called Quiet Day Curve (QDC), is calculated on the base of a Fourier analysis of the cosmic noise levels distribution on a given sideral time interval (sideral day equal to 23h, 56') on several days periods (see [7] and [8]);
- The North Polar Cap index (PCN) 1 min. data recorded at Thule (geographic coordinates: 77.50N, 290.80E) ([9]). This choice is due to the fact that, unfortunately, the South Polar Cap index (PCS) 1 min. data from Vostok (geographic coordinates: 78.27 S, 106.52 E) are not available for the period here considered. Generally PCN values greater than 2.5 nT indicate disturbed magnetospheric conditions ([9]).
- The 5 min solar protons flux with energy > 10 MeV derived by the NOAA GOES-8 satellite in geo-synchronous orbit.

OBSERVATIONS

In the following figures the 5min solar proton flux with energy > 10 MeV, the PC North index and ionospheric absorption are plotted for each strong solar protons events period in November 2001. An inspection of these figures leads to the following main considerations:
The period November 4-10 (Figure 1) shows:
the solar proton event on 04 November 2001 was associated with the solar flare on 04 November 2001 at 16:03, importance X1/3b. The solar proton flux with E>10 MeV exceeds the threshold at 17;05 UT as ionospheric absorption. The solar proton flux has his maximum on 06 November 2001 at 02:15 and then it declines.. The solar event finish on 10 November 2001 at 07:05 while at the end of the day the ionospheric absorption is still around 0.9 dB. PCN exceeds 2.5 for a considerable time between 5 November at 20:46 and 6 November at 6:01 and from 6 November at 17:15 to 7 November at 1:56.
From November 19 to 20 (Figure 2):
the solar proton event on 19 November 2001 is associated with the solar flare on 17 November 2001 at 04:49, importance M2.8/1N. The solar proton flux with E>10 MeV exceeds the threshold at 12:30 UT while at the same time the ionospheric absorption is next to 1.0 dB. The solar proton flux has his maximum on 20 November 2001 at 00:10 and then it declines. The absorption maximum is 3.4 dB on 20 November at 3:09 has. The solar event finish on 20 November 2001 at 14:20 while the ionospheric absorption at the end of the day is still 0.9 dB. PCN exceeds 2.5 for a considerable time between 19 November at 19:10 and 20 November at 21:05 and on 20 November from 0:03 to 9:12.
The period November 22 – 28 (Figure 3) shows:
the solar proton event on 22 November 2001 is associated with the solar flare on 22 November 2001 at 17:00, importance M1.2/1f. The solar proton flux with E>10 MeV is higher than the threshold at 23:20 UT while at the same time the ionospheric absorption is 0.1 dB. The solar proton flux has his maximum on 24 November 2001 at 05:55 and then it declines. Unfortunately the ionospheric data are not available. The solar event finish on 28November 2001 at 01:00 while the ionospheric absorption at the end of the day is still ~1:00 dB. PCN exceeds remarkably 2.5 from 23 November at 20:40 to 24 November at 8:39 and on 24 November between 11:00 and 17:58.
After some encouraging preliminary results obtained by analysing Terra Nova Bay Riometer measurements recorded during some PCA and magnetic storm events along 1998 ([10]), the interesting results obtained from this new analysis confirm promising Space Weather applications.

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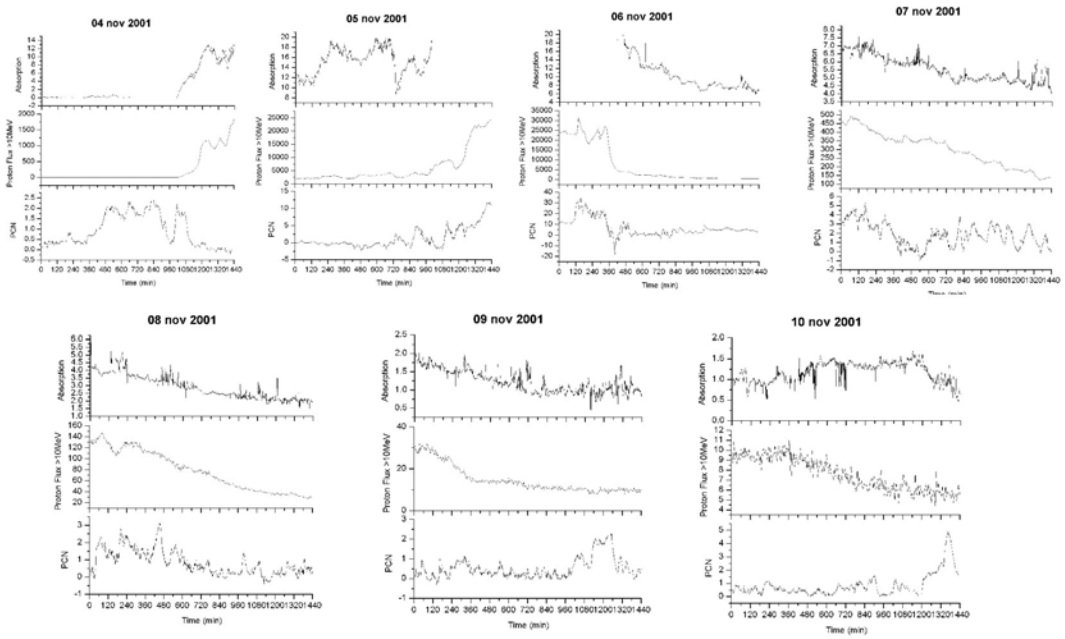

Figure 1. Daily behaviour of Ionospheric absorption (dB), Proton Flux >10 MeV (counts cm^{-2} s^{-1} sr^{-1}) and PCN vs minutes in the period 4-10 November 2001

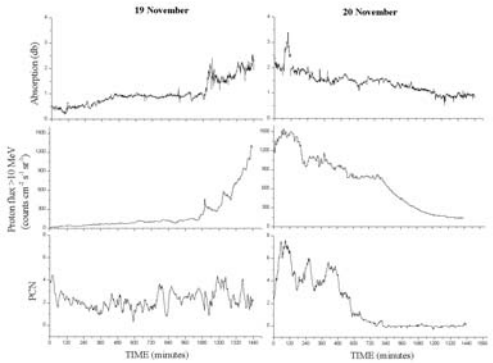

Figure 2. Daily behaviour of Ionospheric Absorption (dB), Proton Flux >10 MeV (counts cm^{-2} s^{-1} sr^{-1}) and PCN vs minutes in the period 19-20 November 2001.

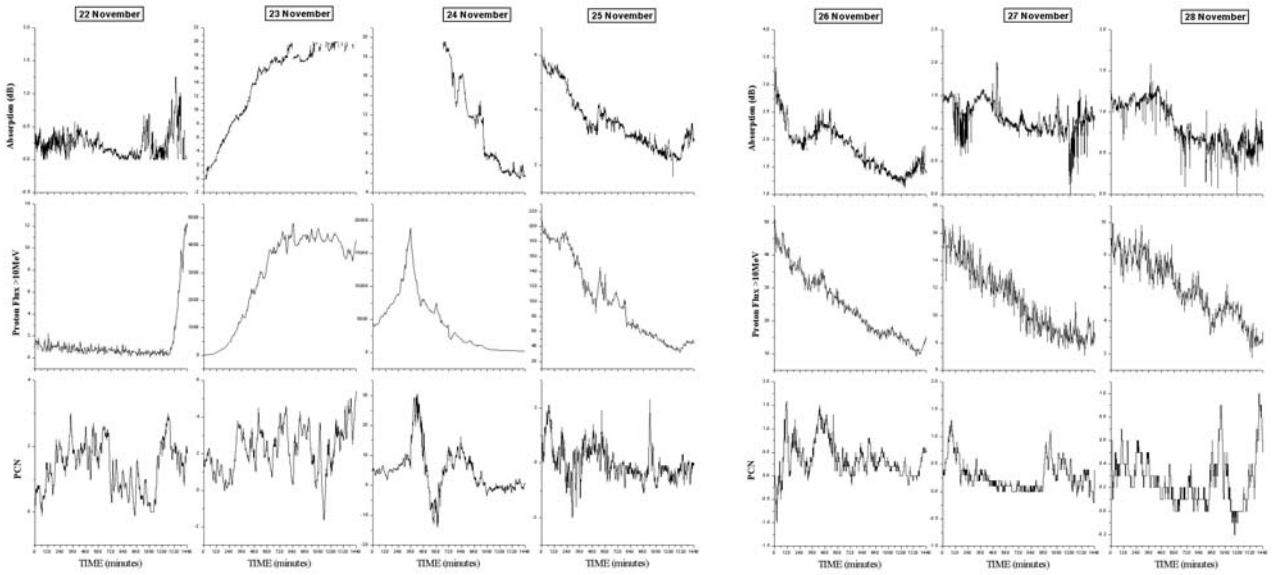

Figure 3. Daily behaviour of Ionospheric Absorption (dB), Proton Flux >10 MeV (counts cm^{-2} s^{-1} sr^{-1}) and PCN vs minutes in the period 22-28 November 2001.