Joint observations of solar radio bursts and cosmic ray events recorded by ARTEMIS IV radio spectrograph and the Athens Cosmic Ray Station (Super 6NM-64) of the University of Athens

Caroubalos C. [1], Hillaris A. [2], Bouratzis C. [2], Mavromichalaki H. [3], Souvatzoglou G. [3], Sarlanis C. [3], Tatsis S. [3], Maroulis D. [1], Patavalis N. [1], Polygiannakis J. [2], Moussas X. [2], Preka- Papadema P. [2], Alissandrakis C. [4], Bougeret J-L. [5], Dumas G. [5], Perche C. [5], Kontogeorgos A. [6], and Tsitsipis P. [6]

[1] *Dept. of Informatics, University of Athens, Panepistimiopolis Zografos, GR-15783, Athens, Greece*

[2] *Section of Astrophysics, Astronomy and Mechanics, Dept. of Physics, University of Athens, Panepistimiopolis Zografos, GR-15784, Athens, Greece*

[3] *Nuclear and Particle Physics Section, Dept. of Physics, University of Athens, Panepistimiopolis Zografos, GR-15783 , Athens, Greece*

[4] *Section of Astro-Geophysics, University of Ioannina, GR-45110, Ioannina, Greece*

[5] *Observatoire de Paris, Dept. De Recherche Spatial, CNRS UA 264, F-92195 Meudon Cedex, France*

[6] *Dept. of Electrical Engineering , Technonogical Education Institute of Lamia, Lamia, Greece*

Abstract

The transient activity at the Sun causes interplanetary and geomagnetic phenomena, cosmic ray storms and pertubed space weather, the study of which requires joint observations of different parameters. In this report we present observations of sequences of solar transients, consisting of strong flares, type II and IV radio bursts and CMEs, as well as subsequent Cosmic ray effects. (a) Solar radio bursts are recorded by ARTEMIS IV multichannel radio spectrograph of Athens University, operating at Thermopylae, Greece. (b) The hadronic component in atmospheric secondary radiation, related to primary cosmic rays, is continously recorded by the ground based Athens Neutron Monitor (NM) station (Athens University), being very interesting for the study of cosmic ray anisotropies, power spectra etc. It is the first latitudinal NM station of the Worldwide NM Network which provides corrected cosmic ray data of 1 and 5 min in real time. Such concurrent observations provide the ability of connecting transient solar activity with the corresponding space weather effects on the Earth magnetosphere.

1 Introduction

Type II bursts trace the passage of an MHD shock wave through the solar corona; their radio emission is due either to energetic electrons accelerated at the shock front or plasma turbulence excited by the shock; they originate either by a flare blast wave or by a CME forward shock (Maia 2000, Aurass 1997). The continua observed during periods of activity, on the other hand, represent the radiation of energetic electrons trapped within magnetic clouds, CMEs and plasmoids and they appear under the name type IV bursts. Some of them follow type II bursts and are possibly caused by energetic electrons produced in the wake of the type II shock.

CME's are plasma ejections from the solar atmosphere involving initially closed field regions which are expelled into the interplanetary medium. Such transients have pronounced effects on the local and even global cosmic ray (CR) intensity. When both the CME's and shock effects are present, the resulting CR event is

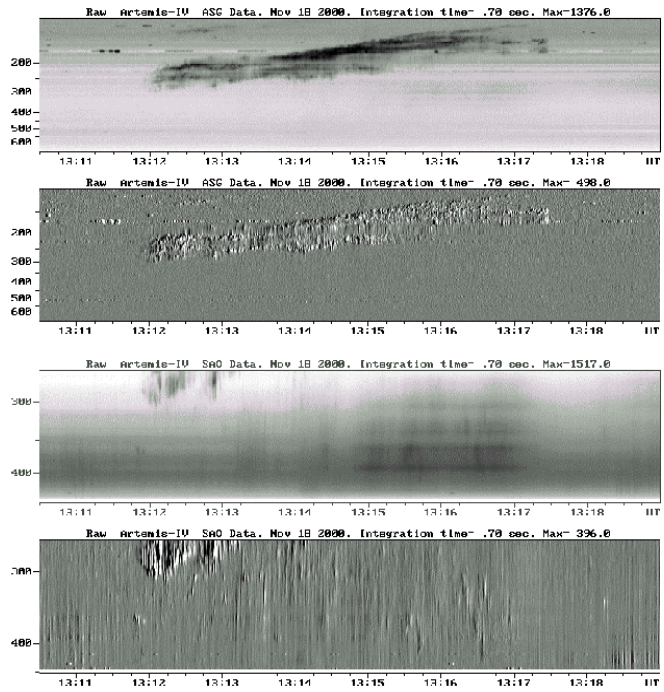

Figure 1: Intensity and differential dynamic spectra of the November 18, 2000 event (type II) obtained by the ARTEMIS IV solar radiospectrograph (13:10-13:19 UT), ASG (110-688MHz), SAO (265-465MHz).

called Forbush decrease (FD). These effects are recorded by NM stations of the Worldwide Network. The necessity to compare a number of high rigidity stations in a good quality data is required for a detailed study of some kind cosmic ray variations and space weather conditions.

In this paper we present combined observations of sequences of solar energetic events, consisting of strong flares, type II radio bursts and CMEs, and subsequent CR decreases for the time period of 18-26/11/2000.

2 Combined observations

Radio burst observations were obtained with the ARTEMIS-IV solar radiospectrograph, (Caroubalos et al, 2001). This instrument covers the frequency range of 110 to 687 MHz, using two receivers operating in parallel (Global Spectral Analyser - ASG, and Acousto-Optical Spectrograph - SAO) from sunrise to sunset on a daily basis.

The Athens NM (Super 6NM-64), thanks to joint efforts of Cosmic Ray groups of Athens University (Greece) and IZMIRAN (Russia), connected with the family of the Worldwide Network of NMs since November 10, 2000. It meets all modern requirements for data presentation (*http://cosray.phys.uoa.gr*), useful to space weather studies (Mavromichalaki et al., 2001). This station is unique in the Balkan area and the east part of the Mediterranean Sea at an altitude of 260m above sea level and vertical cut-off rigidity of 8.53 GV The system consists of six BF_3 gas proportional counters with the enriched isotope B^{10} type BP28 Chalk River Canada (Simpson, 2000).

The dynamic spectrum of a type II radio burst, recorded by the Artemis IV (ASG and SAO) on 18/11/2001 between 13:11-13:18 UT is shown in fig. 1. Concurrently, a flare initiating from AR 9235 (N11E37, at 13:02-13:50 UT as recorded by GOES) and a large ragged loop front CME from NE (13:54 UT), were recorded. This CME with velocity 532 km/sec (*http://cdaw.gsfc.nasa.gov/CME_list/* , compiled by Seiji Yashiro and Grzegorz Michalek under the guidance of Nat Gopal-

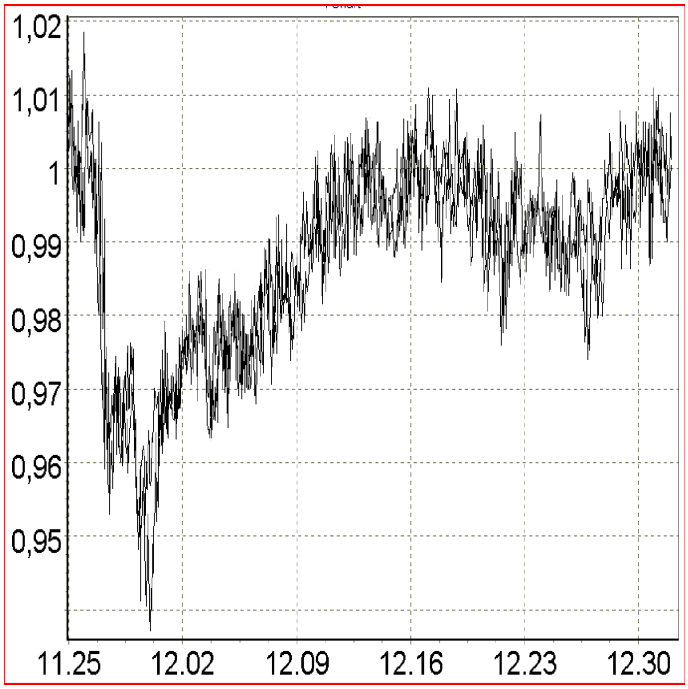

Figure 2: Cosmic ray data corrected for pressure from the Athens station, for the large Forbush event of November 26, 2000. It was the first event recorded after station renewal.

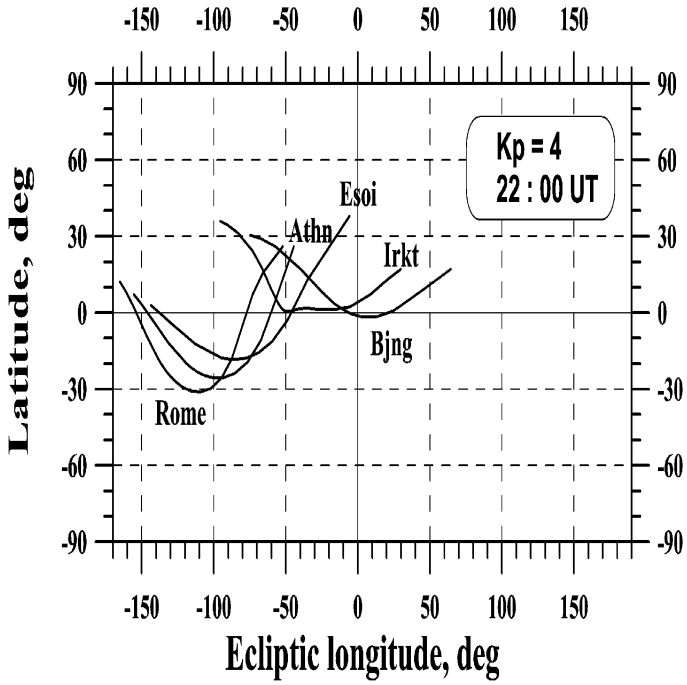

Figure 3: Asymptotic directions of the Athens NM and some other stations of high rigidity calculated for the start of the event (22:00 UT). The similar asymptotic directions for stations of different cutoff rigidity (Rc) (Rome, Athens, Esoi) give an oportunity to study really anisotropic effects in CR at this time.

swamy) apparently reached the Earth, causing the FD on 22/11/2001, as recorded by the World Wide Network. Furthermore there was no other type II or IV radio burst recorded in the time period from 18-22/11/2001.

The first significant FD, recorded by Athens NM on 26/11/2001 (22:00 UT) is shown in fig. 2. The CR intensity decrease was 7% relative to the 25th November level. The asymptotic directions of Athens NM station along with some other stations of high rigidity, for the time period of the considered event are given in fig. 3. The sequence of the most important solar events, consisting of a strong flare, a type II radio burst and a CME (Solar Geophysical Data), for the time period preceding the FD, and probably causing it, are given in Table I. The flare eruption time is given by GOES data. We note that there was only one type II burst followed by a type IV burst (25/11/2000 01:17-01:31 UT).

Table 1. Major solar events preceding FD of 26/11/2001

Date	Active region	Position	Flares	Importance	Type II bursts	CME
23/11	9236	N22W03	23:18-23:37	1N	23:24-23:36	23:54
24/11	9236	N20W05	04:55-05:08	3B	05:02-05:28	05:30
24/11	9236	N22W07	14:51-15:21	2B	15:07-15:14	15:30
24/11	9236	N21W14	21:13-21:18	2N	21:52-21:57	22:06
25/11	9240	N07E50	00:59-02:01	2N	01:07-01:16	01:31
25/11	9236	N20W23	18:33-18:55	2B	18:39-18:49	19:31

3 Conclusions

A preliminary analysis of a sequence of strong solar events such as flares, type II and IV radio bursts and CME's, as well as Forbush effects recorded within the NM energy range, related to geomagnetic storms in the time period from 18 to 30 November, 2000, has been carried out. The observed time sequence of events of this time period indicates that the initiation of CME's is closely related to type II radio bursts and strong solar flares, thus promising the ability of space weather prediction, as soon as precursory effects are recorded by solar observatories.

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