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An Overview of the ground level enhancement of cosmic rays on May 17, 2012

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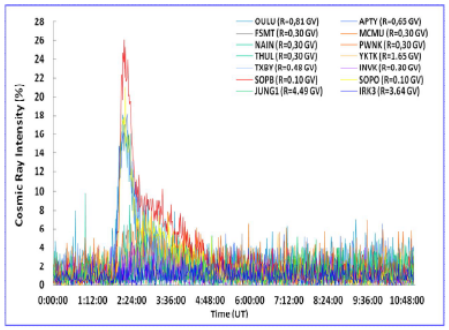
Abstract: Ground level enhancement (GLE) events represent the GeV energy component of solar energetic particle (SEP) events, emanating from the solar activity. In this work, we present a review and examine some aspects of the event of May 17, 2012, known as GLE71, which is the first one of solar cycle 24. In order to study the variation of the cosmic ray flux at this time period, as a function of some parameters e.g. rigidity, we consider data from 30 ground-level neutron monitor stations from Neutron Monitor Database (NMDB) worldwide. In addition, taking advantage of data for the X-ray, radio and proton flux from GOES just before the event, coupled with data for solar flares and coronal mass ejections (CMEs), we determine if the previously mentioned event can be attributed to any of these solar eruptive phenomena.

1 Introduction

Ground level enhancements are considered as sudden increases in the cosmic ray intensity recorded by ground-level monitors, due to high-energy solar particles approaching Earth. They are usually correlated with SEP events of energies greater than 433 MeV/nucleon. There are two particle acceleration mechanisms, usually combined: a) acceleration in type-X topologies in the solar flare reconnection region and b) stochastic acceleration in fast MHD shocks driven by CMEs. The presence of GLEs is conspicuous at all solar cycles from 19^{th} to 24^{th}, as total 71 GLE events have occurred to date [1]. It is noted that in descending phase of the cycles, the number of sunspots is a bit greater than in the ascending phase and it is interesting that the GLEs occurrence rate follows the same behavior.

2 Solar activity and recordings on Earth

On May 17, 2012, the active region AR11476 situated at N11W76 on Sun produced a medium strength M5.1 solar flare started on 1 : 25 UT and peaked on 1 : 47 UT. Electrons were accelerated first on 1 : 29 UT, in the reconnection region of the flare, accompanied with type III radio bursts and hard X-ray emission (see fig. 2). A halo CME of 1582 km/s linear speed followed the flare and was recorded on 1 : 48 UT together with type II radio burst. The majority of the eject directed off the west limb [2],[3],[4]. Protons accelerated by the shock wave caused a SEP gradual event on Earth, starting on 2 : 10 UT, which recorded as a GLE event by ground-based NM ($E > 500$MeV). During this solar activity, no intense geomagnetic activity appeared while it was prevailing a stable magnetic field. GLE events are characterized by anisotropy, thus their onset time and the time profile differ from one NM to another. Time profiles of normalized CR intensity for NM (fig. 1), show that SOPO, APTY and OULU stations registered the most intensive fluxes during GLE71 and APTY was the first one to record this event. The most important parameters of the recordings coupled with the maximum percentage increase of the CR flux recorded by the NM, as a function of their cut-off rigidity are given in Fig. 1. It is concluded that stations with rigidities, below 1GV had the most intensive enhancements, beyond



Station	Lognitude (degrees)	Latitude (degrees)	Rigidity (GV)	ΔN / N̄ (%)	T_{onset} (UT)	T_{max} (UT)	T_{max}-T_{onset}
SOPO	0	-90	0,1	17,89	1:58	2:12	14
OULU	25,47	65,05	0,81	18,14	1:54	2:08	14
APTY	33,3	67,55	0,65	18,22	1:50	2:15	25
FSMT	-112	37,68	0,3	5,76	2:00	2:15	15
MCMU	166,6	-77,95	0,3	5,23	2:03	3:05	63
NAIN	-61,7	56,55	0,3	4,41	1:53	3:33	100
PWNK	85,44	54,98	0,3	6,51	1:59	3:00	61
THUL	-68,8	76,5	0,3	7,59	1:58	2:20	22
SOPB	0	-90	0,1	26,07	1:58	2:10	12

Figure 1: Left panel: CR intensity enhancement during GLE71 as recorded in NM stations with the corresponding rigidities. Right panel: Main characteristics of GLE71 as recorded by nine NM.

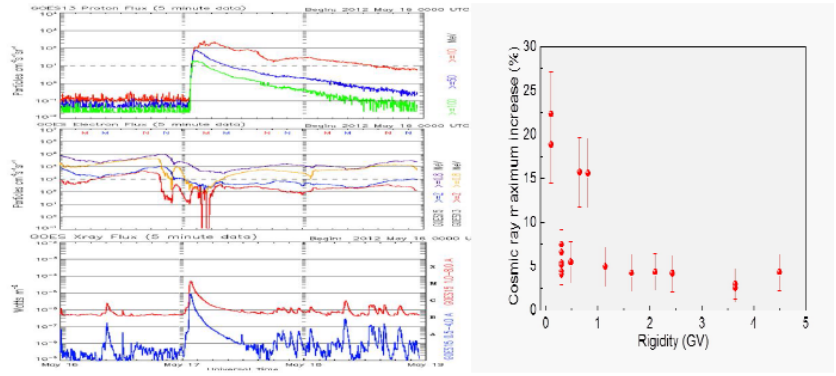


Figure 2: Left panel: From up to bottom panel: proton, electron and X-ray flux measured from GOES during GLE71. Right panel: Maximum increase of CR flux at different stations during GLE71 event, versus their cut-off rigidity.

2GV present a slight increase and greater than 4GV did not register any variation, thus the maximum energy of the solar cosmic rays was about 4GeV.

Conclusions:GLE71 event occurred on May 17, 2012 at 1.55 UT and was the first of solar cycle 24. It was a medium strength event and was registered by APTY, OULU, SOPO, FSMT stations in real time by the GLE Alert system of the Athens University 39 minutes before the Alert given by GOES [4] , in conjunction with the support of NMDB. Relativistic protons driven by a medium strength M5.1 flare and a correspondent CME produced from the AR11476 active region, caused a SEP event consistent with GLE71. It is also confirmed the nearly exponentially decreasing spectrum of CR as a function of rigidities.

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