MONITORING OF COSMIC RAYS IN REAL TIME AND INFORMATION SYSTEM OF THE MOSCOW COSMIC RAY STATION

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ABSTRACT

The Internet becomes one of mostly important tools for researchers working in Solar-Terrestrial physics. Cosmic ray (CR) variations, an important characteristic of the space weather, are presented on the Internet in real time since July 1997, when the new information system has been created at the Moscow cosmic ray station. The paper considers this system - its advantages and disadvantages, appeared problems and perspectives of development, the content of our web-site, the statistics of visits.

INTRODUCTION

Now the Internet becomes one of mostly important tools for researchers working in Solar-Terrestrial physics. Many of them use Internet resources practically every day and these resources are automatically and regular updated, i.e. they are real time resources. The real time Internet is, possibly, the most interesting and perspective part of the Net. We see tight relation and mutual penetration of the space weather and Internet. It is not accidentally that both terms have been adopted in our every day life practically simultaneously and simultaneously occupy new positions in the information space. Many people firstly know about problems of solar-terrestrial and space physics after have been interested by space weather in the Internet. Surely, this is a positive effect for the science and society. At present everyone can get in few minutes rich, diverse and mostly fresh information on space weather and heliospheric effects. This information is really rich – it includes not only words and figures, but also high-resolution pictures and even movies. This information is really fresh, it is updated every minute, or even frequently, on some space weather sites. This information is really diverse – it includes data obtained by many tens of instruments for studies of different solar, interplanetary, and geophysical effects. Parameters of the interplanetary medium can be obtained simultaneously from three spacecrafts: ACE, WIND and SOHO. A variety of solar, magnetospheric and ionospheric data is much wider.

However, one important detail was not presented in this complex and colorful picture till now –cosmic ray variations practically were not presented there. The picture of space weather is not complete without cosmic ray information. Cosmic rays, mostly the galactic cosmic rays, are a part of the interplanetary medium and the human environment, their variations reflect all large effects of the solar activity and solar wind disturbances. The GOES satellites provide us some information about cosmic ray behavior in real time now. This is very useful information, however, which only concerns the solar cosmic rays and several CR magnetospheric effects. The world network of ground based cosmic ray stations can provide reliable and rather complete information on galactic cosmic ray variations. We mean, at first, the neutron monitor network, where cosmic ray data are obtaining and accumulating during more than 40 years. The problem is that data of particular stations become available for public use about one year later the observations and about two years are necessary to collect all data and calculate CR characteristics as differential density and anisotropy. Therefore, it is impossible to use these data, in so delayed form, for the space weather monitoring.

We organized the information system at the Moscow cosmic ray station to start the solving of this problem. This system allows to collect and process data of the Moscow neutron monitor automatically and to present cosmic ray variations to the Internet in real time. We consider our work as a first step for including of galactic cosmic ray variations to the Internet as real time resource of the space weather.

This work considers the information system of the Moscow CR station, its advantages and demerits, appeared problems and perspectives of development.

THE MOSCOW STATION

The Moscow CR station (55.47N, 37.32E, 200 m above the sea level) situates in the Troitsk town, 20 km to south-west from Moscow, and is operated by the staff of IZMIRAN Cosmic Ray Department. Cosmic rays are continuously observed here since 1958 by the IGY neutron monitor till 1968 and later by the NM-64 neutron monitor up to now. The neutron monitor is eventually modernized. At present the neutron monitor is assembled using 24 standard counters associated within 4 sections. Earlier the ionization chamber and two muon telescopes were operated in our laboratory.

The chamber has been moved later to the Yakutsk CR station, where it is still working successfully. A new multi-directional scintillation telescope of large effective area replaced the old muon telescopes.

The neutron monitor itself was not changed dramatically since 1968, it was only displaced by ~50 m and enlarged. This allowed getting very long and homogeneous data set. However, the system of data accumulation and analysis was changed considerably several times, radio-lamps were replaced by transistors and transistors by micro-schemes. So, a level of data analysis automatics increased eventually. However, the totally automatic system based on PC technique appeared at the station only in the year of 1993. The system, including software (Belov et al., 1988) was designed in the CR department of IZMIRAN. The analogous systems installed by the IZMIRAN team now operate in Kiel (Germany) and Cape Shmidt (Russia). In near future this system should be installed in the Alma-Ata high-altitude station (Kazakhstan).

The IZMIRAN computer network joined the Internet in 1995 year (thanks to the NASA support) and we needed at that time only to adjust the working automatic system for new conditions. Unfortunately, the IZMIRAN connection with Internet was realised, at first, via slow telephone line. Moreover, this connection disappeared for a long period in 1997. At that time the web-server of IZMIRAN Division of Solar-Terrestrial Physics (helios.izmiran.rssi.ru) was created with only one webpage, the page of neutron monitor data, and we temporally used the network of Troitsk town for communication with Internet. Later the connection of IZMIRAN was re-established, hopefully, by using more rapid channels. Now our web-site and Division server (considerably increased) is a part of the Russian Space Network (rssi.ru).

We do not see reasons to discuss here technical features of our information system. We only mention, it has been created without any special financial support, so the cheapest and easiest ways were selected among possible solutions. However, this is not the best way to achieve the system reliability, that's why we update the information ones per hour and not frequently. In this way we try to decrease a probability of software errors during data transfer from the register system to the server by local network. So hourly data presented on our webpages are actually real time data, but this is not so for one and five minute data. This is a crucial defect only for rare moments of solar proton ground level events, nevertheless it should be correct in the near future.

CONTENT OF THE SITE

Our web-site (helios.izmiran.rssi.ru/cosray/main.htm) began operations on the Internet in July 1997 and several days after, its work was firstly presented to the international CR community during the 25th ICRC in Durban (South Africa). Since that time new pages with additional information has been added, so there are 17 pages on our site now. The main page presents variations of hourly NM count rate for the last 27 days (the solar rotation period) and references to other web-sites concerning CR variations and the space weather. Obviously, we could not show here all appropriate references, a field of the space Internet is very large, so many interesting places are possibly missed, but using our information everyone can easy find more complete lists of references (for instance, http://eu6.mpi-hd.mpg.de/CosmicRaySites– for cosmic rays and http://space.rice.edu/ISTP – for the space weather).

A special page shows one and five minute data for the last 11 hours. Besides, there are pages with daily data for the last 670 days and monthly data for the whole period of observation (40 years). These pages are designed in a similar way, but they are different in physics of presented phenomena and answered different questions. If you are interesting in solar cosmic rays or in short–periodic variations, then minute data are necessary. Forbush-effects and solar daily variations are better seen in hourly data, but recurrent variations, like the 27-day variation, in daily data. Monthly data show better the long period variations associated with solar cycles of 11- and 22 years. We have special pages for ground level proton events (GLE) of the current solar cycle. Several GLE's were registered in this cycle. There are pages for the events of November 6, 1997, May 2 and 6, 1998 and August 24, 1998. The first two events of November 6

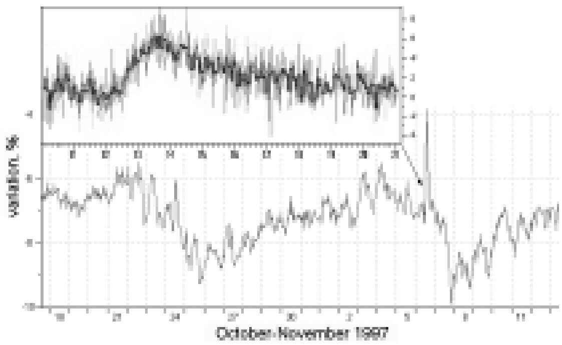

Figure 1 The largest GLE, observed in the current solar cycle (Moscow NM data - hourly means - lower panel, 5- and 1-minute means - upper panel)

and May 2 are confirmed as GLE by the worldwide NM network, but there are no data enough now to confirm the last two events. An enhancement was registered undoubtedly by the Moscow NM only on November 6 (Fig. 1). However, to our opinion, it is worthy to present data in all questionable cases, so everyone could compare our data with other data sets and do his own conclusions. We hope that the new solar cycle will cause us to create more GLE pages.

As solar proton events the Forbush effects soon disappear from the current plots. Understanding that it is better to use data of the whole NM network for event selection, we, nevertheless, have decided to create and support a preliminary list of transient CR variations (possible Forbush-effects). We suppose that a large part of such events should be caused by coronal mass ejections (CME) and propagating disturbances of the solar wind. For data selection we use not only the data of Moscow NM, but also solar wind data obtained aboard the ACE, SOHO and WIND spacecrafts and observations of solar flares, disappearing filaments and CME's (SOHO/LASCO). Besides the date and onset time for selected events CR variations are presented. The list is regularly updated, new events are included to the list on the same day, and arbitrary even the same hour, when the solar wind disturbance arrives the Earth. There are about 160 events for the 1997 year and the first ten months of 1998 in the list divided into two groups – events of the 1997 year (events97.htm) and events of the current year (events.htm). In general the effect is small (<3%), but rather large Forbush-effects (see Fig. 2) have been registered on August 26, 1998 (6.5 %) and September 24-25, 1998 (9%).

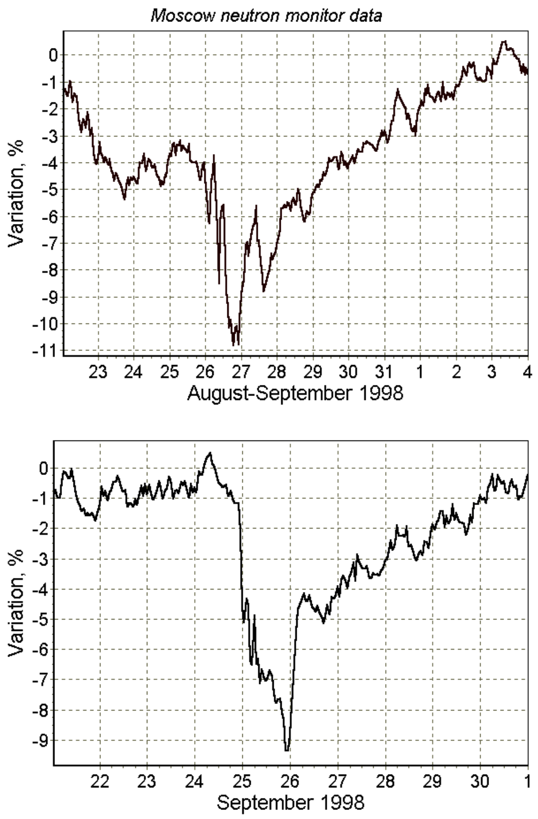

Figure 2. The largest Forbush-decreases observed in the current solar cycle up to November 1998 (Moscow NM data).

Recently, a new page appeared on our site. This page http://helios.izmiran.rssi.ru/cosray/indices.htm presents the experimental indices of cosmic ray activity (Belov et al., 1998).

STATISTICS OF VISITS

During first months of our work on the Internet we did not account the statistics of visits. We began to register our web pages in the main search systems and wrote a special software to arrange a list of the visitors only in the end of 1997. Besides our own information we used free services provided by the Russian site http://counter.rambler.ru and the site http://extreme-dm.com from Netherland. Here we acknowledge that with great attitude. Nevertheless, during some short periods information from these three sources has not been accessible, so figures presented below show the lower limit. We have registered in total nearly 12 thousands of visits and more than 2900 different visitors up to November 1998. These figures are not very large; however, they are reasonable for the pure scientific site. A frequency of visits is determined mainly by the quality of our communication with the Internet. In the best case we have about 40-50 visitors and about 60-100 visits per day. A number of visits decreases during week-ends, apparently, our visitors use their office computers but not home PC. We see also a correlation with the solar activity – a number of visits increases during large solar and cosmic ray events. The last happened, for instance, in May and August 1998. Many people return and some of them become our permanent clients and visit our site nearly every day or even several times per day. This permanent interest is a good sign, however, we understand that it is not our achievement. The Sun itself continuously provides us new information keeping the interest of visitors on a certain level, so all space weather sites are in a privileged situation. At present about 60% of our visitors have visited us previously. Different ways lead visitors to our site, in particular, some search systems will provide our address using keywords as cosmic rays, neutron monitor, space weather and solar wind. Tens of web pages, mainly scientific, already have links to our site. The first reference appeared in the Chicago University (http://odysseus.uchicago.edu/NeutronMonitor/neutron.html) just after the beginning of our work. Since, a lot of people have found us by this way.

Where are our visitors from? The geography of visits is wide and includes about 70 countries, but Russia and USA are leaders undoubtedly. Who they are? We know several names, we have ideas about some others, but mostly they are unknown. Among our permanent visitors we can distinguish several groups. The internal circle includes specialists working with cosmic rays, which can compare now their own data with ours. Specialists in close related problems as solar wind, solar physics and geophysics compose a wider circle. Specialist in medicine, biology and techniques also visit our site. A large part of visitors are from different educational institutions. Practically a full list of Russian universities can be extracted from our statistics

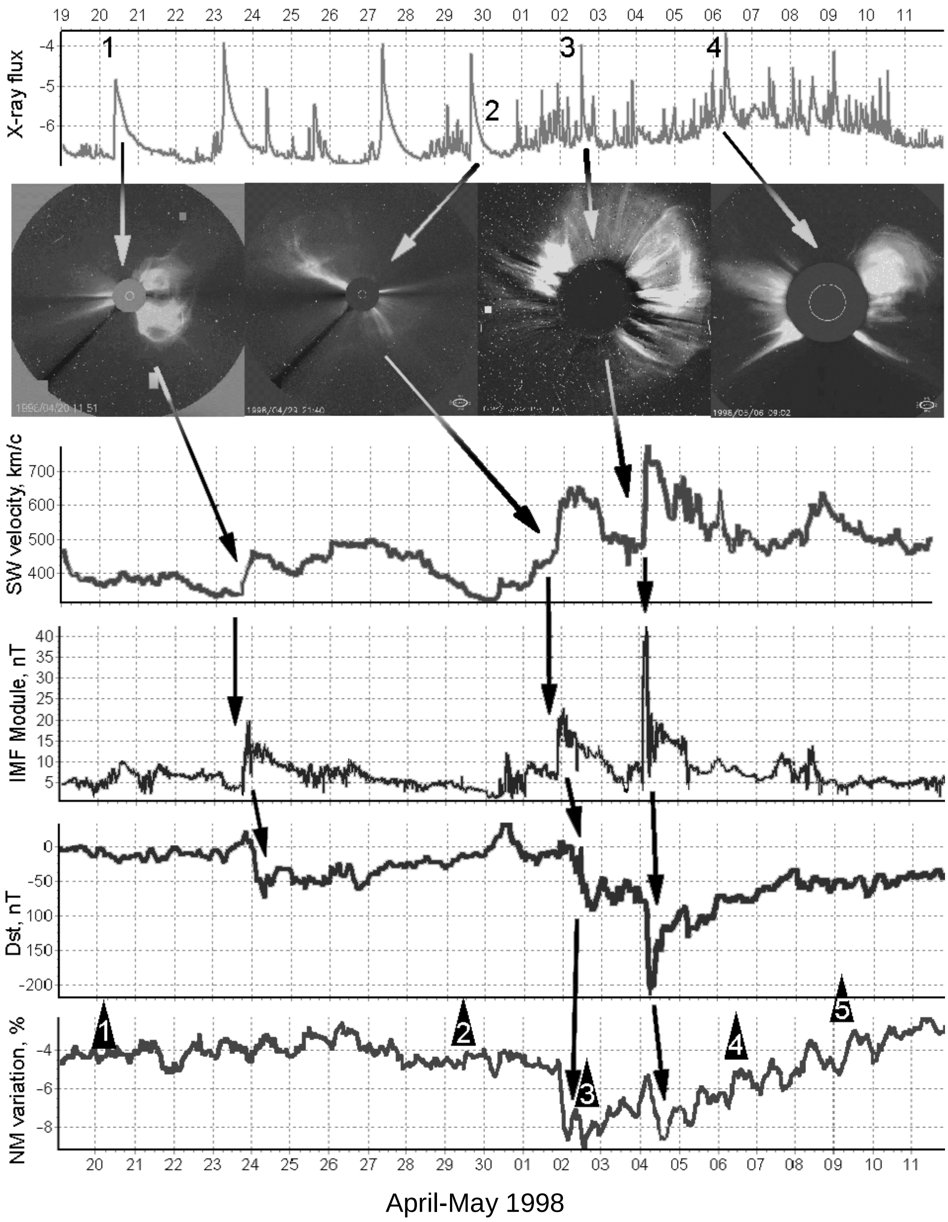

Figure 3. Active solar-period (April-May 1998) in different data, accessible in real time Internet: X-ray Flux -from GOES-8 (GOES data); CME -as seen by SOHO/LASCO C2,C3 (SOHO/LASCO data); solar wind velocity - from SOHO/MTOF proton monitor (SOHO/MTOF-PM data); module of interplanetary magnetic field (ACE data and WIND data); Dst-variation of geomagnetic field (Dst data); cosmic ray variation - from Moscow neutron monitor; the triangles in the low panel - the onsets of solar proton enhancements near Earth (GOES data).

as well as of some famous foreign universities. It was a great surprise for us that our web pages were used as educational material for students of American Air Force Academy. And, the last and mostly wide circle is ordinary people interesting in science, natural phenomena and the Russian Internet. In any case, it is not matter why they are interesting in our web-site, they are welcome.

BENEFITS AND PROBLEMS

It is a difficult task demanding time and permanent attention to create and support an open information system on the Internet. We have no special personal in our department for maintaining of the computer network, programming and web-design, so the scientific staff does this sometimes instead their main scientific work. It is impossible to introduce automatics everywhere. Unexpected obstacles appear often and a human interference is necessary. The quality and stability of the communications is a serious problem. Sometimes our server is not accessible at all or is accessibly only for mostly patient clients, so all our efforts are fruitless. However, we never mind that have started this work and plan to continue and even enlarge it. Because, we are not only sure that this work is useful for others, but also feel its usefulness. Firstly, the data quality increases. Any problem appeared should be solved immediately and do it by “hot steps”, as a rule, is much easier. Secondly, our data are open for public discussion and their usefulness increases. Thirdly, exchanging by scientific information and establishing of scientific contacts become easier. Fourthly, the main thing, we have a possibility to study CR variations in real time comparing our data with other Internet resources of real time and clearing up correlation between different phenomena. Figure 3 illustrates this possibility. We present here some information concerning the large increase of the solar activity in April-May, 1998. This information could be presented on the desk (precisely, the monitor screen) of researcher during these events. The correlation between events on the Sun, in the solar corona, the cosmic rays and the Earth magnetosphere is seen rather clear and marked by arrows. We think that a work with real time data is considerably different from the analogous work with archive data and should be much more effective.

CONCLUSIONS

Data of the Moscow NM are presented in real time on the Internet more than 15 months. They are a part of the Internet space weather resources now. It has become clear that data in this form are necessary and interesting for multi-disciplinary scientific community. Creating our web-site, we hoped that successors would appear after several months, but one year appeared to be necessary. Recently, in September 1998 another Russian cosmic ray station – Apatity http://pgi.kolasc.net.ru/monitor.htm joined the real time Internet. As we know, other CR stations will join the Internet in perspective. We still hope that a number of CR stations on the Net will be large enough soon for real time estimates of cosmic ray variation characteristics.

ACKNOWLEDGEMENTS

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WIND data, http://www.sel.noaa.gov/wind/