Name of research institute or organization:

Physikalisches Institut, Universität Bern

Title of project:

Neutron Monitors – Study of solar and galactic cosmic rays

Project leader and team

Prof. Erwin Flückiger, project leader
Dr. Rolf Bütikofer

Project description:

The Cosmic Ray Group of the Division for Space Research and Planetary Sciences of the Physikalisches Institut at the University of Bern, Switzerland, operates two standardized neutron monitors (NM) at Jungfraujoch: an 18-IGY NM (since 1958) and a 3-NM64 NM (since 1986). The NMs at Jungfraujoch are part of a worldwide network of standardized cosmic ray detectors. Ground-based measurements ideally complement space observations. NMs provide key information about the interactions of galactic cosmic radiation with the plasma and the magnetic fields in the heliosphere, about the production of energetic cosmic rays at the Sun, and about geomagnetic, atmospheric, and environmental effects of cosmic rays. By using the Earth's magnetic field as a giant spectrometer, the NM network determines the energy dependence of primary cosmic ray intensity variations in the GeV range. Furthermore, the high altitude of Jungfraujoch provides good response to solar protons with energies ≥ 4.6 GeV and to solar neutrons with energies as low as ~250 MeV.

In 2003 the operation of the two neutron monitors at Jungfraujoch was continued. The IGY neutron monitor was in operation during 100 % of the time, whereas the NM64 had some interruptions in operation mainly due to breaks in the power supply that lasted longer than the autonomy time of the uninterruptible power supply (UPS). Nevertheless, the operation reliability of the NM64 neutron monitor was 99.7 %.

The records of the two NMs at Jungfraujoch are published in data books, special reports, and on a webpage (http://cosray.unibe.ch/). The relative daily averaged counting rate of the IGY NM for 2003 is shown in Figure 1. As the sunspot activity cycle 23 is on its decreasing phase the variability of the NM data was less pronounced than during the preceding years. However, extreme solar-terrestrial events were recorded by many ground-based and space-borne instruments in October and November 2003, as illustrated in Figures 1, 2, and 3.

At the end of October and the beginning of November two active regions (NOAA regions 0486 and 0488) produced a series of highly energetic solar eruptions. The worldwide network of NMs recorded ground level enhancements (GLEs), i.e. short-time cosmic ray intensity increases due to the arrival of relativistic solar particles on October 28 (GLE#65), on October 29 (GLE#66), and on November 2 (GLE#67). Solar particles with energies above the Jungfraujoch geomagnetic cutoff rigidity of 4.63 GV were probably present only on October 28, causing an increase of ~3.5% in the 5-minute count rate of the IGY and NM64 NMs as shown in Figure 2 (see also our report in this volume on the SONTEL measurements at Gornergrat).

The giant Forbush decrease, i.e. the dramatic decrease of more than 20 % in the counting rate of IGY NM at end of October (Figure 3) was a consequence of the X17.2 flare on October 28, 2003, located almost at the center of the visible solar disk (16°S, 08°E). The coronal mass ejection initiated by this flare was emitted at a high speed directly towards the Earth. It passed the Earth after less than one day and was followed by a region which was depleted of galactic cosmic rays. The geomagnetic storm triggered by the head-on collision of the associated interplanetary shock with the Earth's magnetosphere caused intense northern lights (aurora) which were visible worldwide even at low geographic latitudes. Eye-witness reports in Switzerland include locations such as Jungfraujoch and the region of Lake Constance.

The solar-terrestrial effects caused by the events which occurred after October 28 were less pronounced, either because they were less energetic or because their position at the Sun was less favorable for such effects. On November 4, 2003, the most energetic solar eruption ever observed, an X28 flare, occurred just at the west limb of the Sun. Due to the limb position of this flare the ensuing disturbance propagating away from the Sun did not influence the region near Earth. Therefore, no disturbances of the geomagnetic field and no decrease of the galactic cosmic ray flux were observed near Earth. Moreover, due to the missing magnetic connection between the flare site and the Earth the solar cosmic rays possibly produced during this energetic event had practically no chance to reach the Earth.

The extreme solar events of October and November 2003 attracted the attention of scientists, engineers, and the public worldwide. Analysis of these events offers new insight into the high-energy processes at the Sun and into the coupling mechanisms of the solar-terrestrial system. They are also of special interest in the space weather domain because of their impacts on both technological and biological systems.

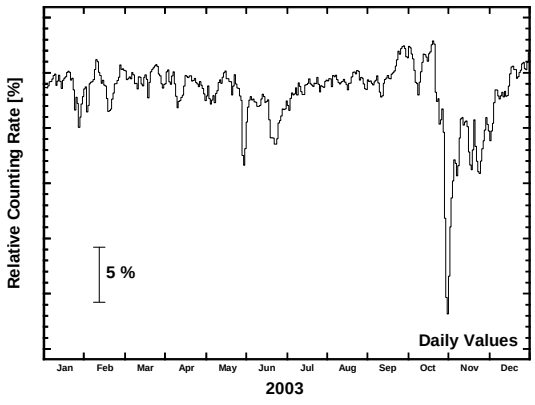

Figure 1: Pressure corrected relative daily counting rate of the IGY NM at Jungfraujoch for 2003.

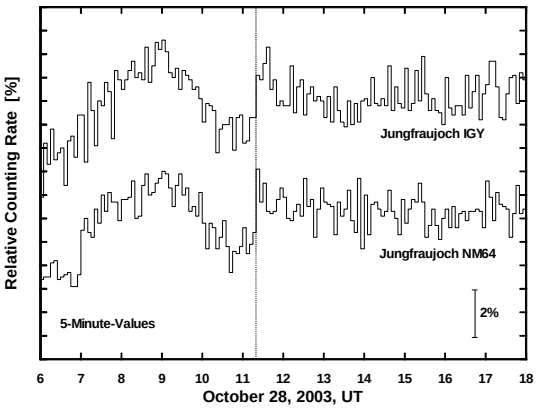

Figure 2: The relativistic solar particle event on October 28, 2003, as recorded by the NMs at Jungfraujoch (relative pressure corrected 5-minute counting rates).

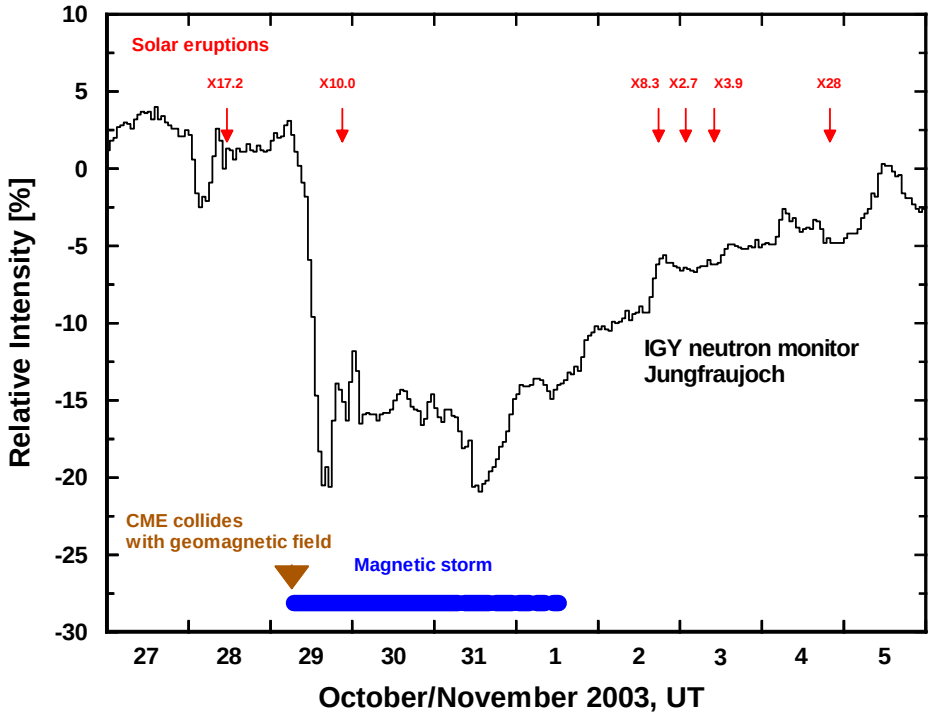

Figure 3: Pressure corrected relative hourly counting rate of the IGY NM at Jungfraujoch from October 27 to November 5, 2003. The red arrows and numbers indicate the time and the magnitudes of the large solar eruptions in this time period.

Key words:

Astrophysics, cosmic rays, neutron monitors; solar, heliospheric and magnetospheric phenomena

Internet data bases:

http://cosray.unibe.ch/

Collaborating partners/networks:

International Council of the Scientific Union's (ICSU) Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)

World Data Centers A (Boulder), B (Moscow), C (Japan), International GLE database

Scientific publications and public outreach 2003:

Conference papers

Flückiger, E.O., R. Bütikofer R., L. Desorgher, and M.R. Moser, Solar neutron observations at Jungfraujoch and Gornergrat, Workshop on "Cosmic Rays and Dark Matter", Solar-Terrestrial Environment Laboratory, Nagoya University, Nagoya, Japan, to be published, 2003.

Flückiger, E.O., Cosmic Ray Absolute Flux and Variation Measurements, Invited Presentation, HIMONTONET European Workshop, 28 June - 3 July 2003, Borovetz, Bulgaria.

Flückiger, E.O., ATPROMO and the High Altitude Research Station Jungfraujoch, 1st ATPROMO meeting (Atmosphere Parameters and Radiation On Mountain Observatories), 7-8 May 2003, Area di Ricerca Roma - Tor Vergata, Italia.

Data books and reports

Data Reports: Data of the 18IGY-Neutron Monitor Jungfraujoch, 01.01.-30.06.2003

Data of the 18IGY-Neutron Monitor Jungfraujoch, 01.07.-31.12.2003

Data of the 3NM64 Neutron Monitor Jungfraujoch, 01.01.-30.06.2003

Data of the 3NM64 Neutron Monitor Jungfraujoch, 01.07.-31.12.2003

Magazine and Newspapers articles

"Lässt neuer Sonnensturm Polarlichter leuchten?", Zeitung im Espace Mittelland, November 04, 2003.

"Auf der Sonne ist einiges los", Basler Zeitung, November 04, 2003.

"Aurores boréales visibles jusqu'à mardi", l'agefi, November 04, 2003.

"Was ist mit der Sonne los?", Blick, November 05, 2003.

"Berner Physiker schauen genau zur Sonne hinauf", Berner Zeitung / Bieler Tagblatt, November 06, 2003.

"Die unberechenbare Sonne / Flares, Massenauswürfe und ihr Einfluss auf die Erde", NZZ Neue Zürcher Zeitung, December 24, 2003.

Radio and television

Interviews with Rolf Bütikofer on local television TeleBärn and Radio Extra Bern about the solar eruptions end of October/beginning of November, November 4, 2003.

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