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:

Dr. Rolf Bütikofer

Project description:

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). NMs provide key information about the interactions of galactic cosmic radiation (GCR) with the plasma and the magnetic fields in the heliosphere and about the production of energetic CRs at or near the Sun (solar cosmic rays, SCR), as well as about geomagnetic, atmospheric, and environmental effects. They ideally complement space observations. The NMs at Jungfraujoch are part of a worldwide network of standardized CR detectors. By using the Earth's magnetic field as a giant spectrometer, this network determines the energy dependence of primary CR intensity variations in the GeV range. Furthermore, the high altitude of Jungfraujoch provides good response to solar protons ≥ 3.6 GeV and to solar neutrons with energies as low as ~250 MeV. Neutron monitors play increasingly an important role in the space weather domain.

In 2012, operation of the two NMs at Jungfraujoch was pursued without major problems. No significant technical modifications were necessary. The recordings of the NM measurements are published in near-real time in the neutron monitor database NMDB (www.nmdb.eu). Figure 1 shows the measurements of the IGY neutron monitor at Jungfraujoch (lower panel) since it was put into operation in 1958. This unique dataset reflects the variations of the CR intensity in the near Earth space over four full solar sunspot cycles. The GCR are always present, and their intensity shows an 11-year variation in anti-correlation with the solar activity characterized by the smoothed sunspot number plotted in the upper panel of Figure 1. SCR events having an effect at Earth, so-called Ground Level Enhancements (GLE), are rare, they occur sporadically, and are generally of a duration of up to a few hours.

On 17 May 2012, 01:25 UT, the active region NOAA 11476 produced a moderate (GOES class M5.1) flare. The active region was located at N07 W88 at the Sun, i.e. at or close to the foot points of the interplanetary magnetic field lines that connect the Sun with the Earth. As the solar cosmic ray protons propagate along the interplanetary magnetic field lines, the SCR protons during the event on 17 May 2012 reached the near Earth space. As the solar protons had energies larger than the atmospheric cutoff energy for sea level NMs (~2 GeV), some high latitude NMs of the worldwide network detected an enhancement in the counting rate at around 02 UT. The last GLE was observed on 13 December 2006. Figure 2 shows the time profile of the data from selected neutron monitor stations provided by the NMDB network. The maximum increase of the 1-minute data of the NM stations Apatity and Oulu was about 17 % and ~5 % at Kiel NM station. The NM stations at mid-latitudes, as e.g. Jungfraujoch and Rome, did not show an increase in the counting rate. The different signatures of the records of the neutron monitors of the worldwide network give information on the energy spectrum of the solar protons and on the anisotropy of the solar particle flux. The fact that the NM stations Jungfraujoch and Rome did not see the event gives information on the maximum energies of the solar protons during this GLE. The combination of the data of all NM stations of the network and of satellite measurements in space is needed to understand the characteristics of the energetic particles and to understand the acceleration processes at or near the Sun. In addition, the characteristics of the SCR particle flux near Earth deduced from NM measurements play an important role in the radiation dose rates at flight altitudes. The

dose rate can increase by orders of magnitude for a short time during energetic SCR events at high latitudes. Therefore, the working group WG11 “High energy radiation fields” of EURADOS (association for promoting research and development and European cooperation in the field of the dosimetry of ionising radiation) investigates the radiation dose rates at flight altitudes during GLEs in detail. Prof. Erwin Flückiger and Rolf Bütikofer are members of this EURADOS working group. During the GLE on 17 May 2012 the additional contribution of SCR to the radiation dose caused by cosmic rays at flight altitudes is negligible.

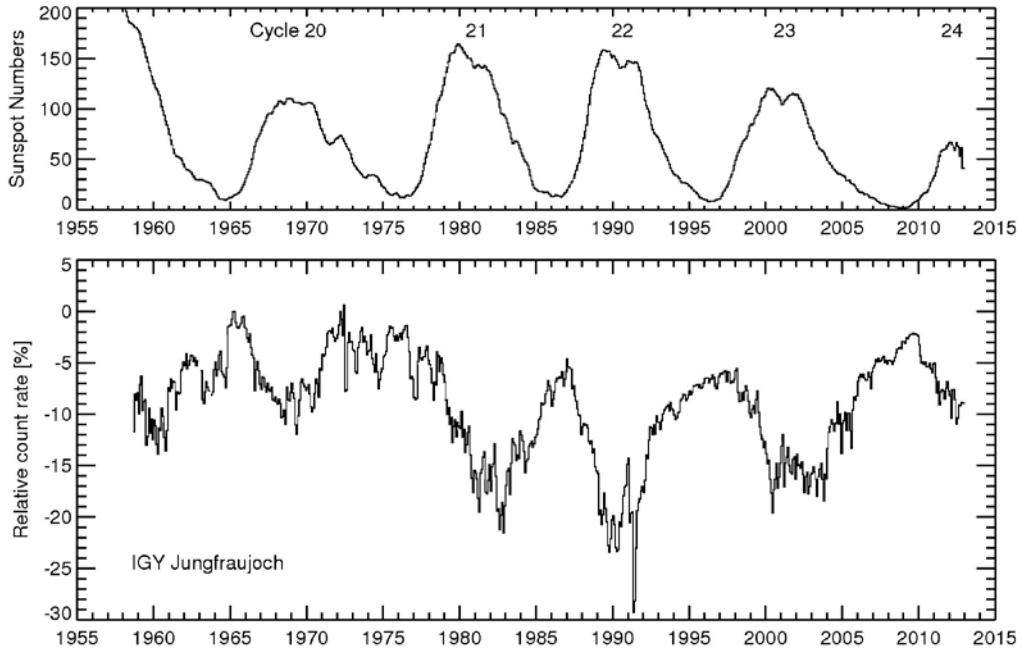

Figure 1: Smoothed sunspot numbers (top panel), pressure corrected monthly average counting rates of IGY neutron monitor at Jungfraujoch (bottom panel) for the years 1958-2012. The neutron monitor count rate is expressed in relative units with respect to May 1965.

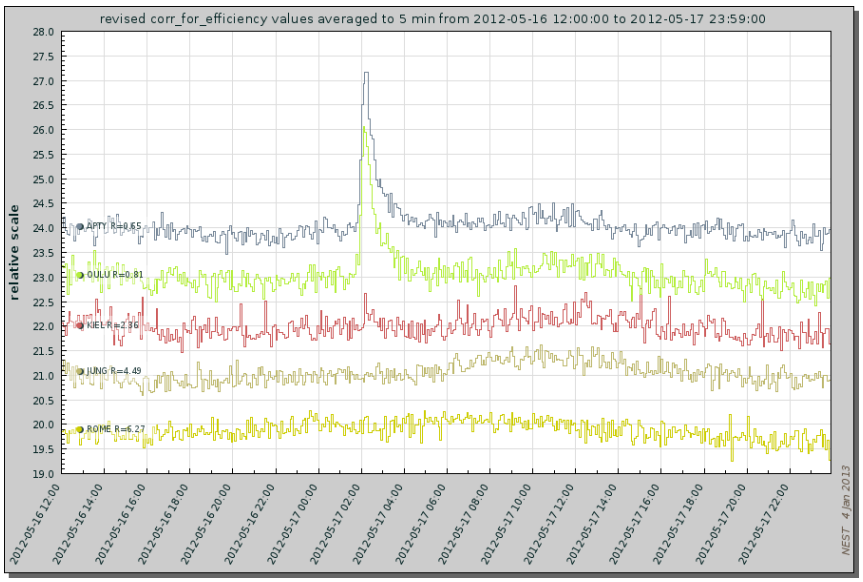

Figure 2: Relative pressure corrected 5-minute values of the European neutron monitor stations Apatity, Oulu, Kiel, Jungfraujoch, and Rome during the solar cosmic ray event on 17 May 2012 for the time interval 2012-05-16, 1200 UT until 2012-05-17, 2400 UT. Plotted with NEST (www.nmdb.eu).

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
European FP7 Project Real-Time Database for High Resolution Neutron Monitor Measurements (NMDB): http://www.nmbd.eu

Scientific publications and public outreach 2012:

Conference papers

Bütikofer, R. and Flückiger, E.O., Differences in published characteristics of GLE60 and their consequences on computed radiation dose rates along selected flight paths, 23rd European Cosmic Ray Symposium, Moscow, Russia, Conference Proceedings, 2012.

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