

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
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Project description:

The Physikalisches Institut of 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 cosmic rays (CR) at the Sun, 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.

In 2009, 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 on the webpage www.nmdb.eu. Figure 1 shows in the lower panel the measurements of the IGY neutron monitor at Jungfraujoch since the start of operation in 1958. This unique dataset reflects the variations of the primary CR over four solar sunspot cycles. The GCR 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. The sunspot number was very low during the last few years. The yearly averaged smoothed sunspot number for 2009 was 3.1 (provisional value), which is only slightly higher than in 2008 (2.9). The GCR flux near Earth continued to increase during 2009 as can be seen from the bottom panel of Figure 1, which shows the IGY NM monthly averaged relative counting rate at Jungfraujoch.

The European Seventh Framework (FP7) project Neutron Monitor Database (NMDB, www.nmdb.eu) was completed at the end of 2009. At present about 20 NM stations, including Jungfraujoch, send data to the NMDB server. Figure 2 shows the relative pressure corrected hourly counting rates of the two NMs at Jungfraujoch for 2009, plotted with the NMDB data access tool NEST (www.nmdb.eu/nect/). In addition to the database, the NMDB project provides different data products such as the GCR flux near Earth but outside the geomagnetosphere, the solar cosmic ray (SCR) flux during SCR events measured at ground (so-called GLEs), different CR key parameters for space weather applications, and GLE alert systems. Another application is the near real-time determination of the ionization and radiation dose rates induced by CR in the Earth's atmosphere with software developed at the University of Bern. The determination of ionization rates at altitudes relevant for

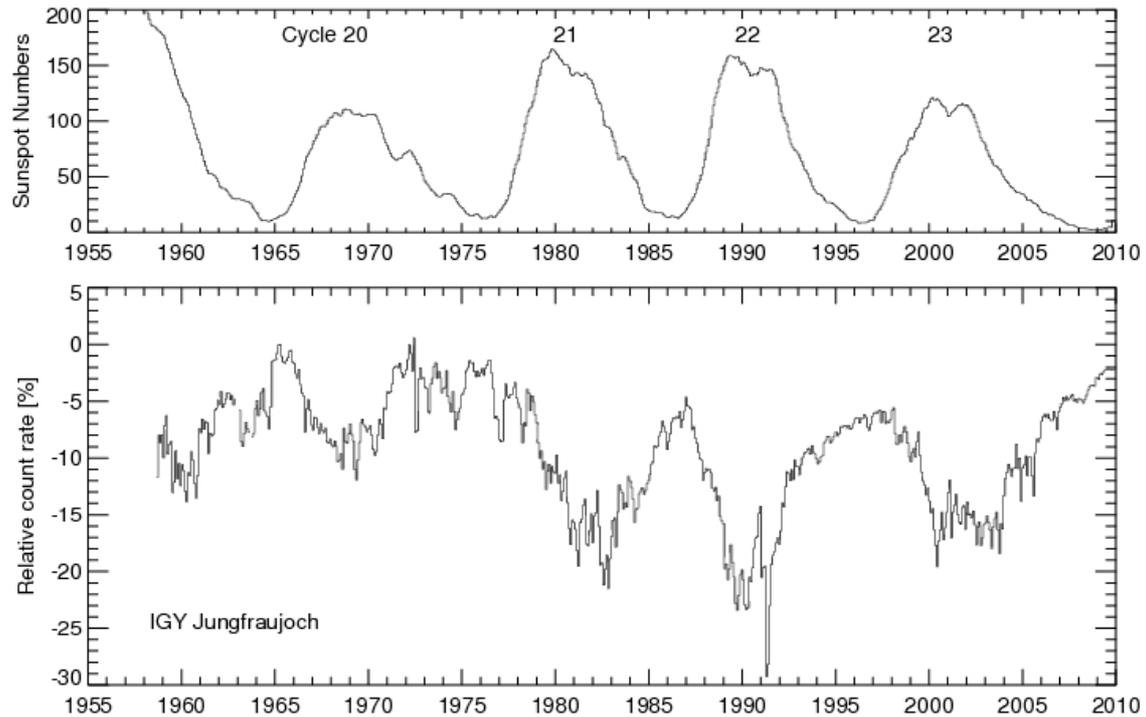


Figure 1: Smoothed sunspot numbers (top) and pressure corrected monthly average counting rates of IGY neutron monitor at Jungfrauoch (bottom) for the years 1958-2009. The NM count rate is expressed in relative units with respect to May 1965.

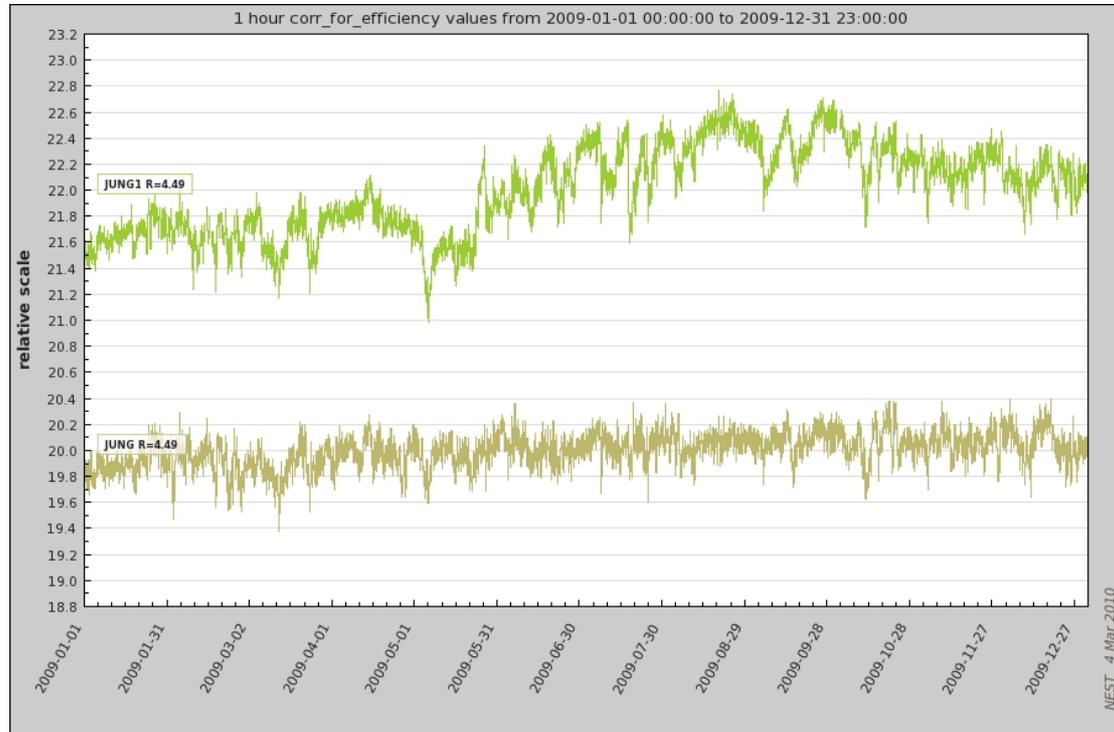


Figure 2: Relative pressure corrected hourly counting rates of the NM64 neutron monitor (JUNG1, top curve) and of the IGY neutron monitor (JUNG, bottom curve) at Jungfrauoch for 2009, plotted with the NMDB user tool NEST (www.nmdb.eu/nest/).

atmospheric physics and chemistry, as well as the radiation dose rates at typical flight altitudes with high resolution in space and in time, has become of increasing interest in recent years. The Bern group therefore developed an application that determines in near real-time the ionization rate and the radiation dose rate induced by CR in the Earth's atmosphere based on the measurements of the NM network stored in NMDB. The computed ionization and radiation dose rates can be accessed via the NMDB website as a global contour plot for a user defined time. Figure 3 shows as an example the global contour plot of the ionization rate due to the galactic cosmic rays on 1 August 2009, 1200 UT. It is also possible to generate a time-profile plot of the ionization and radiation dose rate for a selected time interval at a user-defined geographic location. NMDB as a neutron monitor database and its applications provide a comprehensive resource not only for cosmic ray scientists, but also for scientists who investigate terrestrial effects of cosmic rays, as well as for interested citizens. The published effective radiation dose rates are of interest to airline companies and airline passengers who want to get an idea about the radiation exposure.

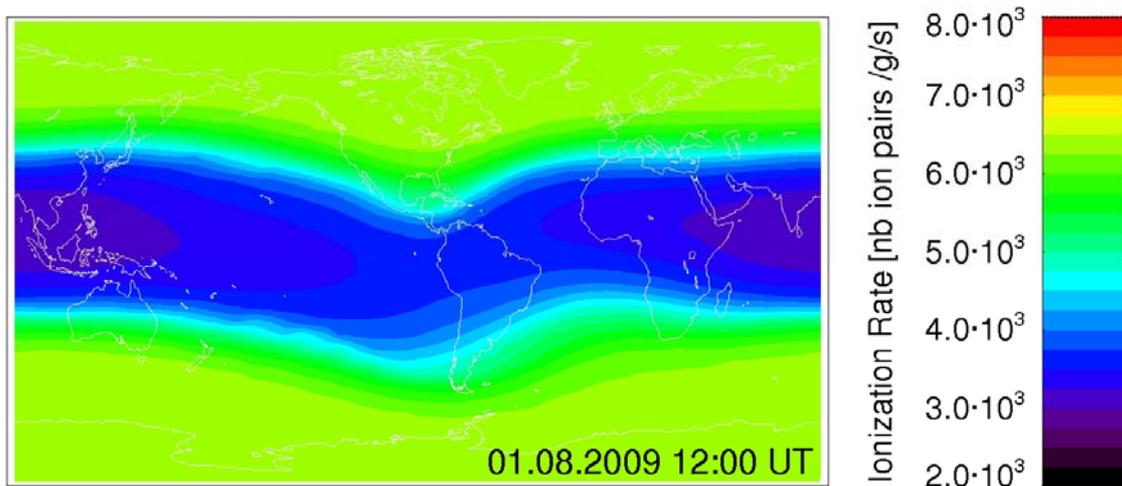


Figure 3: Global contours of computed ionization rates at an atmospheric depth of 700 g/cm^2 ($\sim 3.2 \text{ km asl}$) caused by GCR on 1 August 2009, 1200 UT.

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 2009:

Conference papers

Bütikofer, R., E.O. Flückiger, for the NMDB team, Near real-time determination of ionization and radiation dose rates induced by cosmic rays in the Earth's atmosphere – a NMDB application, 31st International Cosmic Ray Conference, Lodz, Poland, 7-15 July 2009, In Conference Proceedings, 2009.

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