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). NMs provide key information about the interactions of galactic cosmic radiation with the plasma and the magnetic fields in the heliosphere and about the production of energetic cosmic rays 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 cosmic ray detectors. By using the Earth's magnetic field as a giant spectrometer, this 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 ≥ 3.6 GeV and to solar neutrons with energies as low as ~250 MeV.

In 2007, 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 (http://cosray.unibe.ch). In 2007 a proposal for a European Seventh Framework Program project (FP7) for building up a neutron monitor database in real-time was successfully submitted together with 10 European operators of neutron monitor stations. The new neutron monitor database will provide high time resolution neutron monitor data in real-time as well as deduced information from the neutron monitor measurements such as alert of solar cosmic ray events, galactic and solar cosmic ray flux near Earth (energy spectrum, information about anisotropy) and ionization and radiation dose rates in the Earth's atmosphere.

Figure 1 shows the daily counting rates of the IGY NM for 2007. The counting rate increased slightly during the first months in 2007 and fluctuated about a more or less constant level afterwards. The yearly average count rate of 2007 is about 2% higher than in 2006. It is probable that the solar activity reached its minimum in 2007, and that the new solar activity cycle number 24 has started at the end of 2007 or will start at the beginning of 2008. In Figure 2 the measurements of the IGY neutron monitor at Jungfraujoch (lower panel) since the begin of measurements in 1958 are shown. This unique dataset reflects the variations of the primary cosmic radiation over four solar sunspot cycles. The galactic cosmic ray intensity shows an 11-year variation in anti-correlation with the solar activity characterized by the sunspot number plotted in the upper panel of Figure 2.

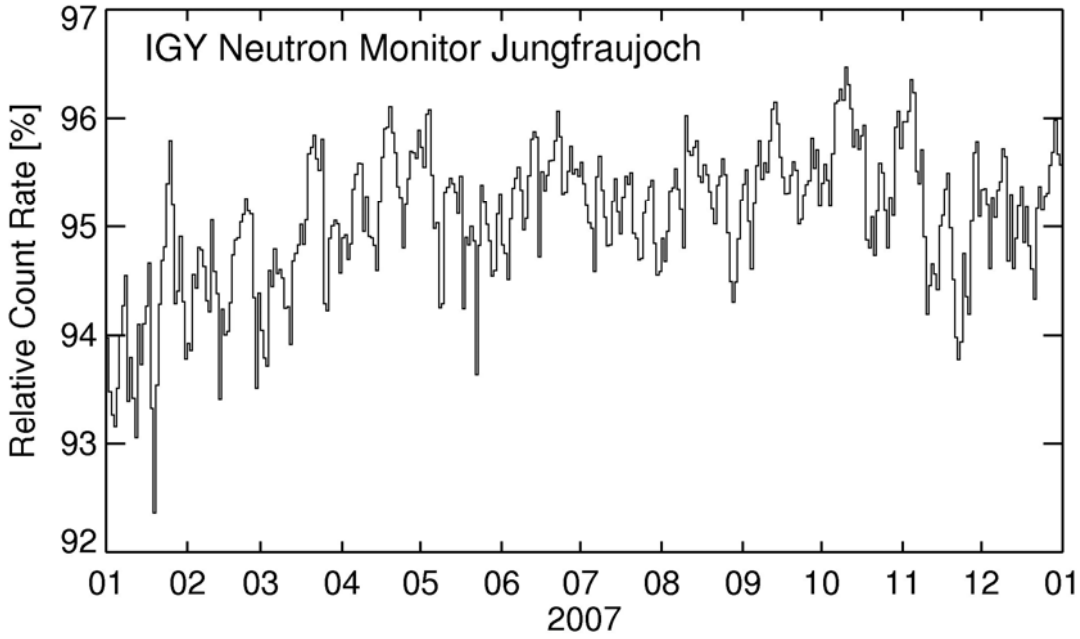

Figure 1: Relative pressure corrected daily counting rates of the IGY neutron monitor at Jungfraujoch for 2007.

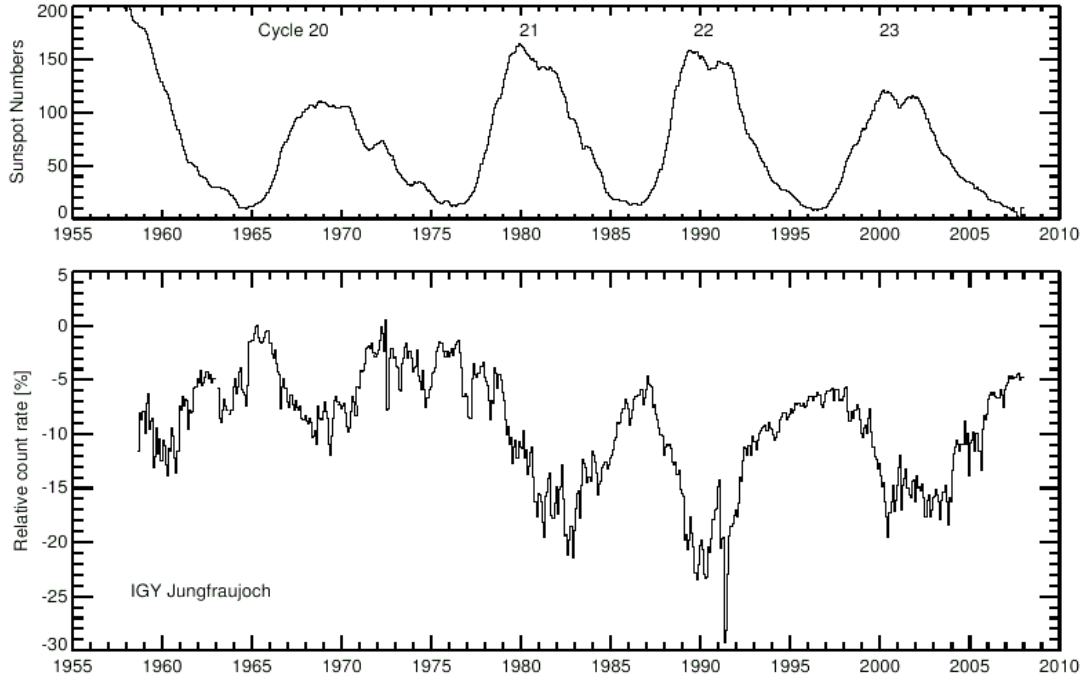

Figure 2: Smoothed sunspot numbers (top panel), pressure corrected monthly average counting rates of IGY neutron monitor at Jungfraujoch (bottom panel) for the years 1958-2007. The neutron monitor count rate is expressed in relative units with respect to May 1965.

In addition to the NMs, a device to measure environmental radioactivity has been in operation since 2002 in the housing of the NM64 by the Bern Cosmic Ray Group. In Figure 3 the monthly average radioactivity measurements with the radiation-monitoring unit GammaTRACER manufactured by Genitron Instruments GmbH,

Frankfurt am Main, Germany, are plotted together with the relative count rates of the Jungfraujoch neutron monitors for the time interval 2002-2007. All three measurements exhibit a similar intensity vs. time trend. In addition the NM64 neutron monitor and the dose rate measurements show seasonal variations. This can be explained by snow accumulations on and around the detector housing. At the location of the IGY on the roof terrace of the Sphinx building, which is exposed to strong winds, the wind blows the snow away from the roof and the surrounding of the detector housing. In addition the custodians at Jungfraujoch remove the snow from the roof of the IGY neutron monitor housing at least once per day. The NM64 detector housing, in contrast, is less exposed to winds, and therefore snow accumulation often occurs on the roof as well as around the detector housing. During springtime when the temperature increases, the falling snow is wet, and it is removed from the roof by wind to a lesser extent. Therefore the snow accumulation and the snow effect are most dominant during the spring season. In summer the temperature at Jungfraujoch during the daytime is mostly above the freezing point, and therefore the snow melts away again shortly after periods with snow fall. Therefore, the counting rates of the NM64 neutron monitor and the GammaTRACER often increase with the increasing temperatures (~ after the month of May). The dose rate and the count rate of the NM64 neutron monitor are strongly affected by the snow effect, although the detectors are sensitive to different radiations (GammaTRACER mainly measure photons and muons; neutron monitor measure almost exclusively neutrons).

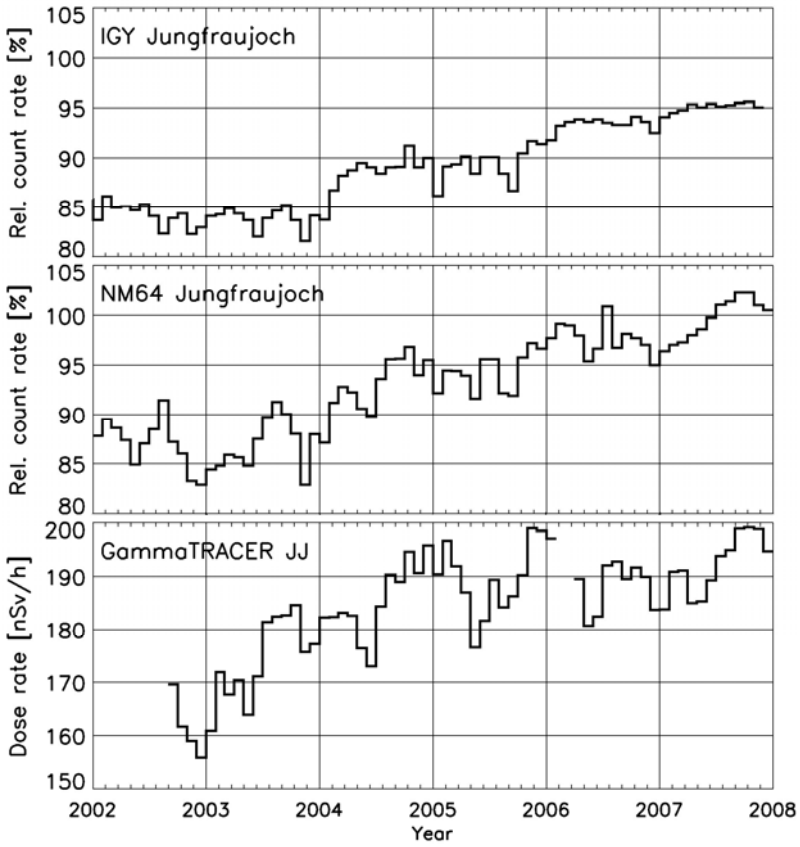

Figure 3: Monthly average relative count rates of IGY and NM64 neutron monitor at Jungfraujoch (top panels) and monthly average dose rates measured by the GammaTRACER unit in the detector housing of the NM64 neutron monitor for the time interval 2002-2007.

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 2006:

Refereed journal articles

Bütikofer, R., E.O. Flückiger, L. Desorgher, M.R. Moser, The Extreme Solar Cosmic Ray Particle Event on 20 January 2005 and its Influence on the Radiation Dose Rate at Aircraft Altitude, The Science of the Total Environment **391**, 177-183, 2007

Conference papers

Bütikofer, R., E.O. Flückiger, and L. Desorgher, Characteristics of Near Real-Time Cutoff Calculations on a Local and Global Scale, Paper 1032, 30th International Cosmic Ray Conference, ICRC-07, 3 - 11 July 2007, Merida, Yucatan, Mexico, 2007.

Flueckiger, E.O., M.R. Moser, R. Buetikofer, L. Desorgher, and B. Pirard, A Parameterized Neutron Monitor Yield Function for Space Weather Applications, Paper 1182, 30th International Cosmic Ray Conference, ICRC-07, 3 - 11 July 2007, Merida, Yucatan, Mexico, 2007.

Bütikofer, R., E.O. Flückiger, M.R. Moser, and L. Desorgher, Environmental Effects on the Neutron Monitor Measurements at High Altitudes as Observed at Jungfraujoch, BEOBAL conference, 21-25 March 2007, Gyulechitsa, Bulgaria, in Stamenov, J., Vachev, B. (eds.), Observatoire de Montagne de Moussala, 12, 64-71, 2007.

Flückiger, E.O., R. Bütikofer, M.R. Moser, and L. Desorgher, The Cosmic Ray Ground Level Enhancements on January 20, 2005, and December 13, 2006, European Geosciences Union EGU General Assembly, 16-20 April 2007, Vienna, Austria, 2007.

Bütikofer, R., E.O. Flückiger, L. Desorgher, M.R. Moser, and B. Pirard, The Cosmic Ray Ground Level Enhancement on 13 December 2006, Solar Extreme Events 2007 (SEE 2007) International Symposium, Athens, Greece, September 2007.

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