Name of research institute or organization:

Physikalisches Institut, Universität Bern

Title of project:

Study of solar and galactic cosmic rays

Part of this programme:

NMDB

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 also an important role in the space weather domain.

In 2014, operation of the two NMs at Jungfraujoch was pursued without major problems. No significant technical modifications were necessary. It is planned that in 2015 the data registration of both NMs will be replaced by a new system that is developed by our Spanish colleagues from the University of Alcala. 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 relative monthly count rates of the IGY neutron monitor at Jungfraujoch (lower panel) since it was put into operation in 1958. 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.

The dosimetric measurements with a GammaTracer and a Liulin device inside the detector housing of the NM64 neutron monitor were continued. Figure 2 presents the measurements of the three devices, i.e. NM64 neutron monitor (count rate is not corrected for atmospheric pressure), GammaTracer, and Liulin device. The plot shows daily values for the time interval 2008-2014. Continous measurements with the Liulin device at Jungfraujoch are available since June 2008. The reason for the large gap in the data of the GammaTracer in 2013 was caused by an interruption of operation for the modification of the device by the manufacturer Saphymo GmbH, Frankfurt, Germany (see our report in the Activity Report 2013 of the International Foundation HFSJG). As the GammaTracer was first operated in Bern after the recommissioning, the radiation dose rate is only ~100 nSv/h, i.e. about a factor of two smaller than at Jungfraujoch. From these measurements it is clear that the contribution of cosmic rays to the radiation dose rate at the altitude of Jungfraujoch is essential. This can also be seen from the comparison of the measured radiation dose rates with the atmospheric pressure measurements at Jungfraujoch, see Figure 3. The measured radiation dose rates are in anti-correlation with the atmospheric pressure measurements. A higher atmospheric pressure means a larger mass of air above the measuring instrument which attenuates the flux of secondary cosmic rays at ground.

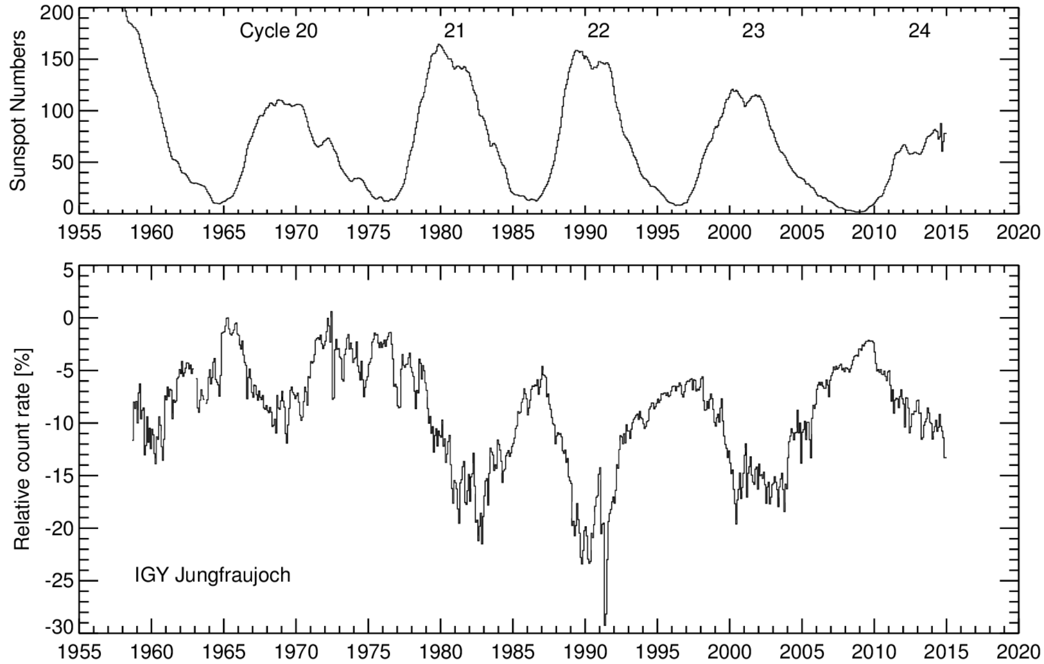

Figure 1. Smoothed sunspot numbers (from www.sidc.be/silso/datafiles, top panel), pressure corrected monthly average counting rates of IGY neutron monitor at Jungfraujoch (bottom panel) for the years 1958-2014. The neutron monitor count rate is expressed in relative units with respect to May 1965.

From Figures 2 and 3 a clear yearly periodicity can be seen, i.e. the variations in the NM64 count rate and in the radiation dose measurements (GammaTracer and Liulin) are mainly caused by different amounts of air mass in the atmosphere above the detectors. To eliminate the effect of the atmospheric pressure variation on the radiation dose measurements and on the NM64 count rate, the measurements can be corrected for atmospheric pressure. Figure 4 shows the pressure corrected NM64 count rates and radiation dose measurements by the GammaTracer and Liulin devices at Jungfraujoch. The NM64 count rates show a significant long term decrease from 2008 to 2014 as a cause of the 11-year solar activity cycle, see also the measurements of the IGY neutron monitor in Figure 1. This tendency of decreasing cosmic ray flux near Earth is also present in the radiation dose measurements by the GammaTracer and the Liulin device at Jungfraujoch. The most pronounced variations in the NM64 data can also be observed in the GammaTracer and the Liulin measurements. However, the shape of the variations is much weaker in the radiation dose detectors, e.g. the Forbush decrease in March 2012 shows only a small reduction of the radiation dose rate measured by the GammaTracer and could not be seen in the data of the Liulin device. The clear negative signal in the NM64 count rate in the early summer 2013 was probably caused by large accumulations of snow on the roof and around the detector housing as this trend was not observed in the data of the IGY neutron monitor at Jungfraujoch. Due to the much smaller sensitive volumes of the GammaTracer and the Liulin device compared to the NM64, the statistics of the two radiation dose meters are considerably lower than of the NM64 detector. The radiation dose detectors are therefore not reasonable instruments to investigate short time cosmic ray flux variations, as solar cosmic ray events, so-called ground level enhancements (GLEs), or Forbush decreases.

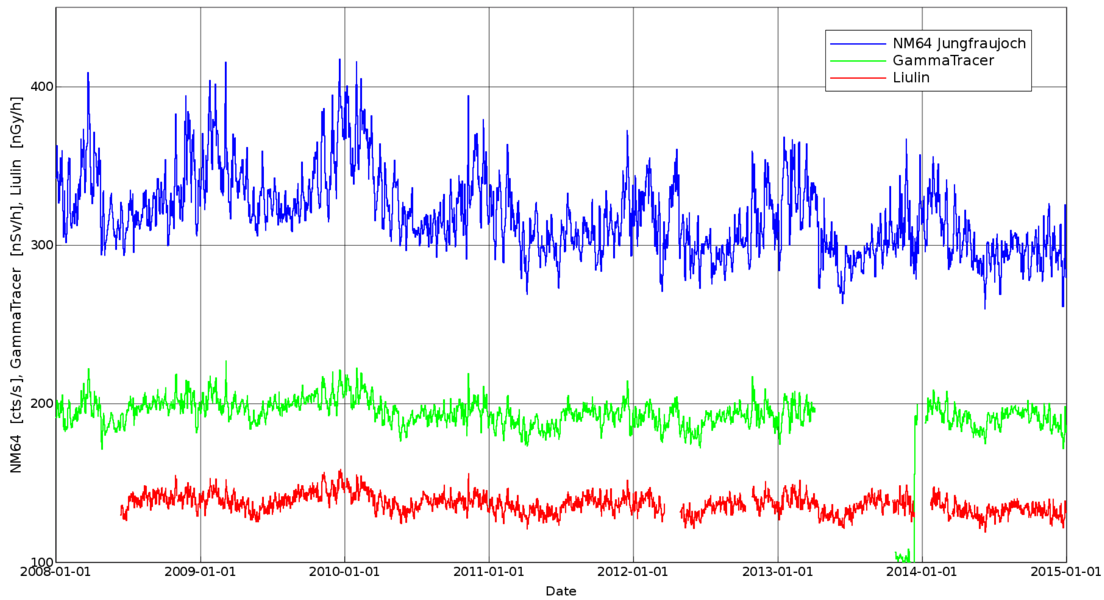

Figure 2. Daily values of NM64 neutron monitor data (not corrected for atmospheric pressure), radiation dose rates measured by GammaTracer and by Liulin device for the time interval 2008-2014.

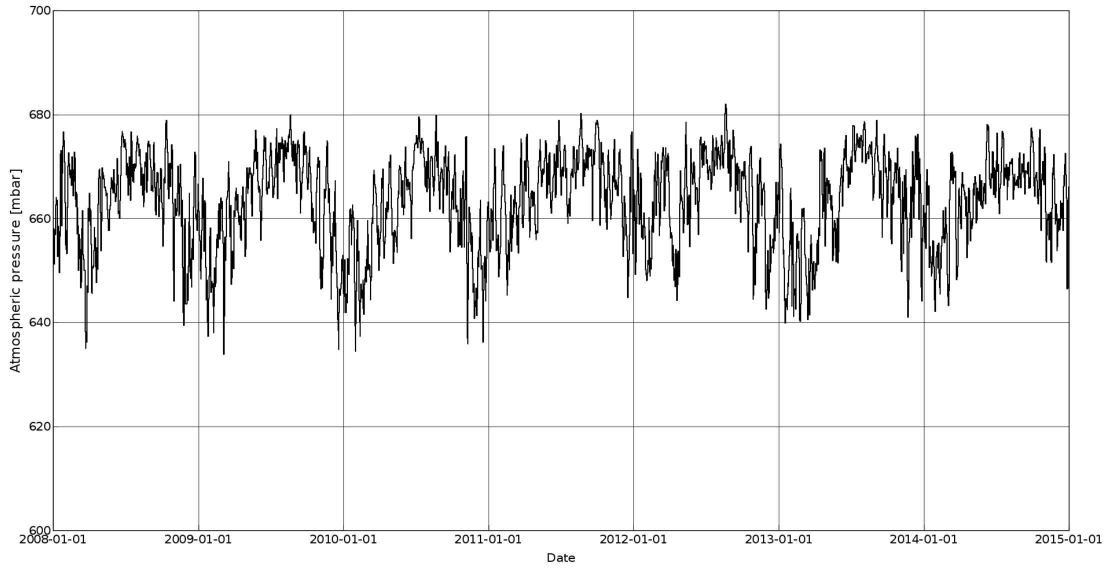

Figure 3. Daily averaged atmospheric pressure measurements at the NM64 neutron monitor Jungfraujoch for the time interval 2008-2014.

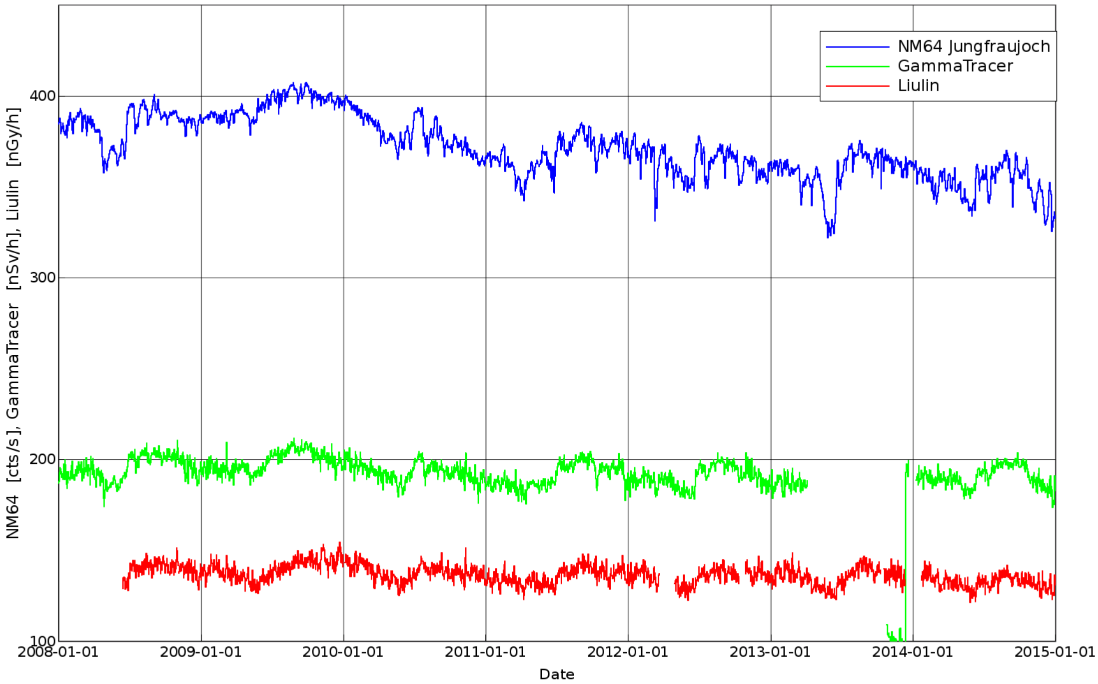

Figure 4. Daily atmospheric pressure corrected values of NM64 neutron monitor data and of radiation dose rates measured by GammaTracer and by Liulin device for the time interval 2008-2014.

Key words:

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

Internet data bases:

http://cosray.unibe.ch

Collaborating partners/networks:

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

Scientific publications and public outreach 2014:

Refereed journal articles and their internet access

Kubančák, J., I. Ambrožová, R. Bütikofer, K. Kudela, R. Langer, M. Davídková, O. Ploc, A. Malušek, Liulin silicon semiconductor spectrometers as cosmic ray monitors at the high mountain observatories Jungfraujoch and Lomnický štít, Journal of Instrumentation, **9**, 7018-7032, doi: 10.1088/1748-0221/9/07/P07018, 2014. http://iopscience.iop.org/1748-0221/9/07/P07018/pdf/1748-0221_9_07_P07018.pdf

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