Name of research institute or organization:

Physikalisches Institut, Universität Bern

Title of project:

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 also an important role in the space weather domain.

In 2015, operation of the two NMs at Jungfraujoch was pursued without major problems. No significant technical modifications were necessary. The planned replacement of the data registration of both NMs from the late nineties of the last century by a new system that is developed by our Spanish colleagues from the University of Alcala could not yet be realized. 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. Since July 2015, the original Sunspot number data are replaced by a new entirely revised data series. The most prominent change in the new Sunspot Number with the version number 2.0 is the choice of a new reference observer, A. Wolfer (pilot observer from 1876 to 1928) instead of R. Wolf. This means dropping the conventional 0.6 Zürich scale factor, thus raising the scale of the entire Sunspot Number time series to the level of modern sunspot counts. For more details see e.g. http://www.sidc.be/silso/datafiles.

The dosimetric measurements with a GammaTracer and a Liulin device inside the detector housing of the NM64 neutron monitor were continued in 2015.

When high-energy neutrons of the secondary cosmic rays in the Earth's atmosphere reach the ground and interact with nuclei, e.g. by exciting the nuclei of the ground material, the excited nuclei return to their ground state by emitting fast neutrons, so-called evaporation neutrons, with energies in the order of 1 MeV. The evaporation neutrons lose their energy in head-on collisions with atomic nuclei. The energy loss in these collisions is maximal when the masses of the two bodies are identical, i.e. hydrogen atoms. This effect has been used in recent years to develop a new method to determine the soil moisture. In this method a neutron detector measures the neutrons that are generated in the air, the soil and other materials and are moderated afterwards mainly by hydrogen nuclei that are present primarily in soil water. When the water concentration in the soil is high, the flux of albedo neutrons is low and vice versa. This method seems to be promising as it led to major investments in the research fields of environmental and hydrological science. More than 100 sensors, so-called Cosmic-Ray

Neutron Sensors, are in operation worldwide since 2008, see http://cosmos.hwr.arizona.edu. The small neutron detectors contain a tube with ^3He or BF_3 gas and are either bare or shielded with a thin polyethylene layer. For more information about the sensors see http://hydroinnova.com. Of course the measured neutron intensity by these devices is not only dependent on soil moisture but also on temporal variations of the atmosphere and of the primary cosmic ray flux at the top of the Earth's atmosphere. Much to the surprise of the author of this report the correction for variations in the primary cosmic ray flux near Earth is made by using the data of the Jungfraujoch IGY neutron monitor. It seems that a first group decided to use the Jungfraujoch neutron monitor data (Zreda et al., 2012, COSMOS: The COsmic-ray Soil Moisture Observing System) and that other groups followed to use also the Jungfraujoch IGY neutron monitor data (Baatz et al., 2014 and 2015; Han et al., 2014; Hawdon et al., 2014; McJannet et al., 2014; Zhu et al., 2015). As the measured count rates of the neutron monitors at Jungfraujoch are often influenced by snow accumulations on and around of the detector housing we think that the use of the Jungfraujoch neutron monitor data for this application is not suitable. We informed Marek Zreda, the author that first used Jungfraujoch neutron monitor data, about our assessment. He answered that the reasons for the selection of the IGY neutron monitor at Jungfraujoch are as follow: "Because at the time when we developed the COSMOS system there was no neutron monitor in the USA with real-time data. … COSMOS computes soil moisture every hour and we needed real-time data source. I looked at all stations in NMDB and Jungfraujoch IGY neutron monitor seemed to be best in terms of data continuity (few gaps) and quality (I cross-checked all stations for consistency)."

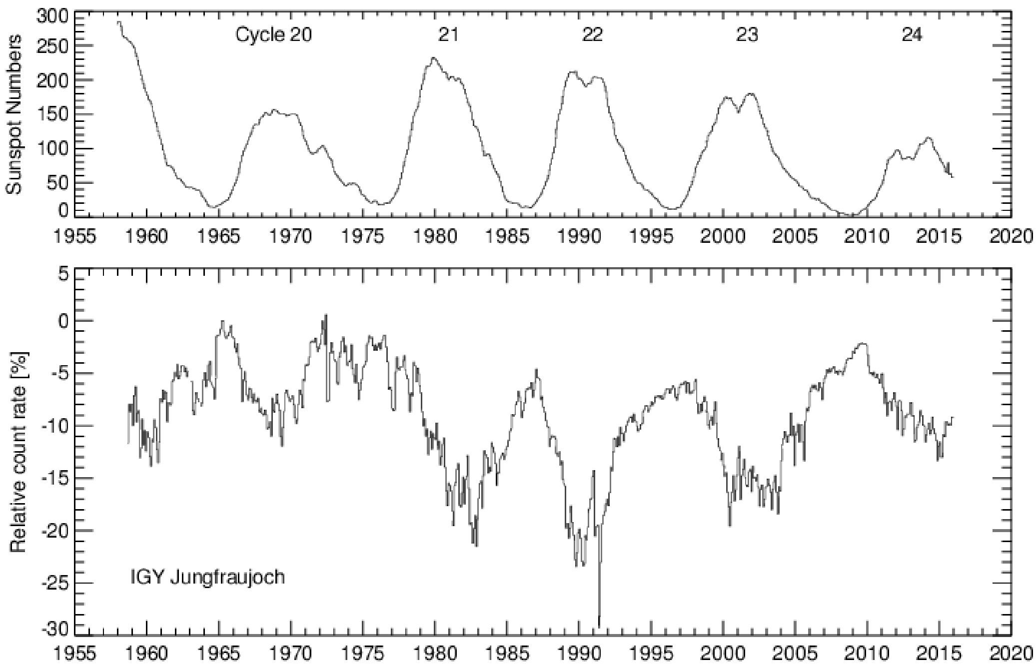

Figure 1. Smoothed sunspot numbers (Source: WDC-SILSO, Royal Observatory of Belgium, Brussels (www.sidc.be/silso/datafiles), top panel), pressure corrected monthly average counting rates of the IGY neutron monitor at Jungfraujoch (bottom panel) for the years 1958-2015. The neutron monitor count rate is expressed in relative units with respect to May 1965.

Key words:

Astrophysics, cosmic rays, solar neutrons

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

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