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 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 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 $\geq$ 3.6 GeV and to solar neutrons with energies as low as ~250 MeV.

In 2010, 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 database of NMDB (Neutron Monitor Database) and can be obtained from the webpage www.nmdb.eu. Figure 1 shows the daily pressure corrected relative counting rate of the IGY NM at Jungfraujoch for 2010. The average counting rate of the IGY NM decreased in the first three months in 2010 by about 1% per month and from April to December 2010 by about 0.1% per month. Figure 2 shows the measurements of the IGY NM at Jungfraujoch in the lower panel and the sunspot number for the years 2005-2010 in the upper panel. In the middle of 2009 the sunspot number started to rise significantly, which indicates increasing solar activity and thereby increasingly disturbed conditions in the interplanetary magnetic field. As a consequence, the flux of the GCRs in the inner heliosphere declines and the counting rates of the NMs are decreasing as can be seen in Figures 1 and 2.

Cosmic ray shower particles are the main source of ionization in the lower and middle atmosphere. Based on this fact, Ney (1959) pointed out that if the climate on Earth is sensitive to the amount of tropospheric and/or stratospheric ionization, then the climate should be sensitive to the CR flux. Ney's ideas were revived by Dickinson (1975), who discussed the ion-induced formation of sulphate aerosols by GCRs and a possible influence on the variation of cloudiness caused by the modulation of the GCR flux. Svensmark and Friis-Christensen (1997) reported a correlation between the CR intensity and the global cloud coverage during the 11-year solar cycle from an analysis of satellite and NM data for the time period 1980–1995. The idea that CR changes could influence the climate caused a controversial discussion in the past about a possible correlation between the ionization in the atmosphere caused by CRs and climate on Earth. In the last decennium many papers pro and contra this hypothesis have been published, see e.g. Scherer et al. (2006) and references therein. In this context, an increasing need for detailed information on the CR induced ionization in the Earth's atmosphere with high resolution in space and in time is apparent. Therefore an application was developed (essentially by the University of Bern) that computes the ionization rate at an altitude of about 3 km above sea level in near real-time based on the NM data from NMDB within the framework of the European Seventh Framework (FP7) project NMDB. The ionization rate in the region of Jungfraujoch (46.5°N, 8°E) at 700 g/cm$^2$ (about 3.2 km asl) is plotted for the year 2010 in Fig. 3. Similar to the count rate of the IGY NM at Jungfraujoch the ionization rate shows as expected a decrease (~0.7% per month) in the first three months at the beginning of 2010 and stays about constant during the rest of the year. The computations of the ionization rate are made automatically and the measurements of the NMs are transferred to the database without preceding quality checks. We therefore skipped the values with very large discrepancies in Fig. 3. Based on the predicted increase in solar activity for the next few years and on the disturbances in interplanetary space that will result from this solar activity, the variations in the ionization rate are also expected to increase.

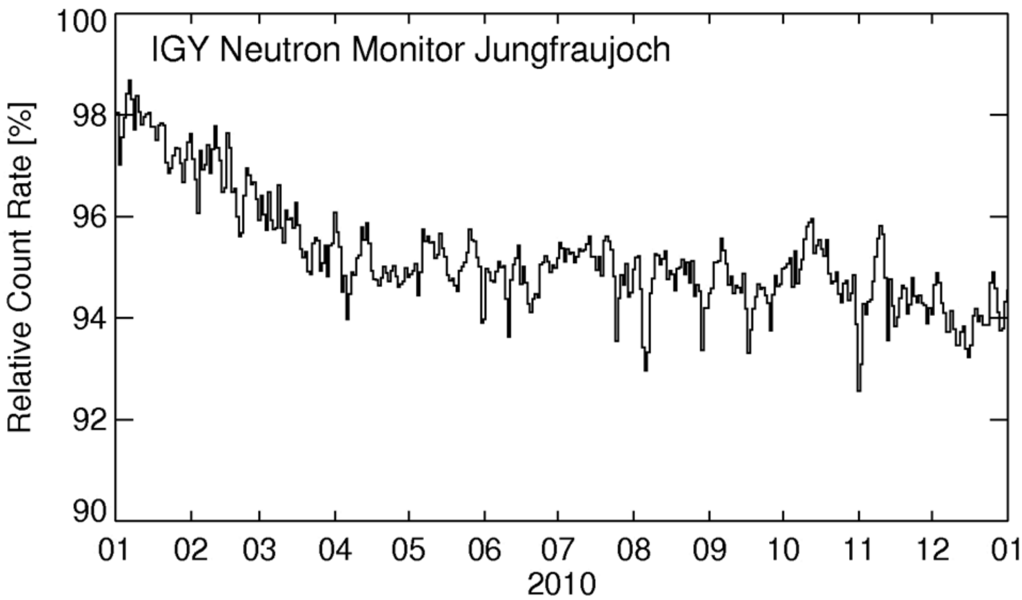


Figure 1: Relative pressure corrected daily counting rate of the IGY neutron monitor at Jungfraujoch for 2010.

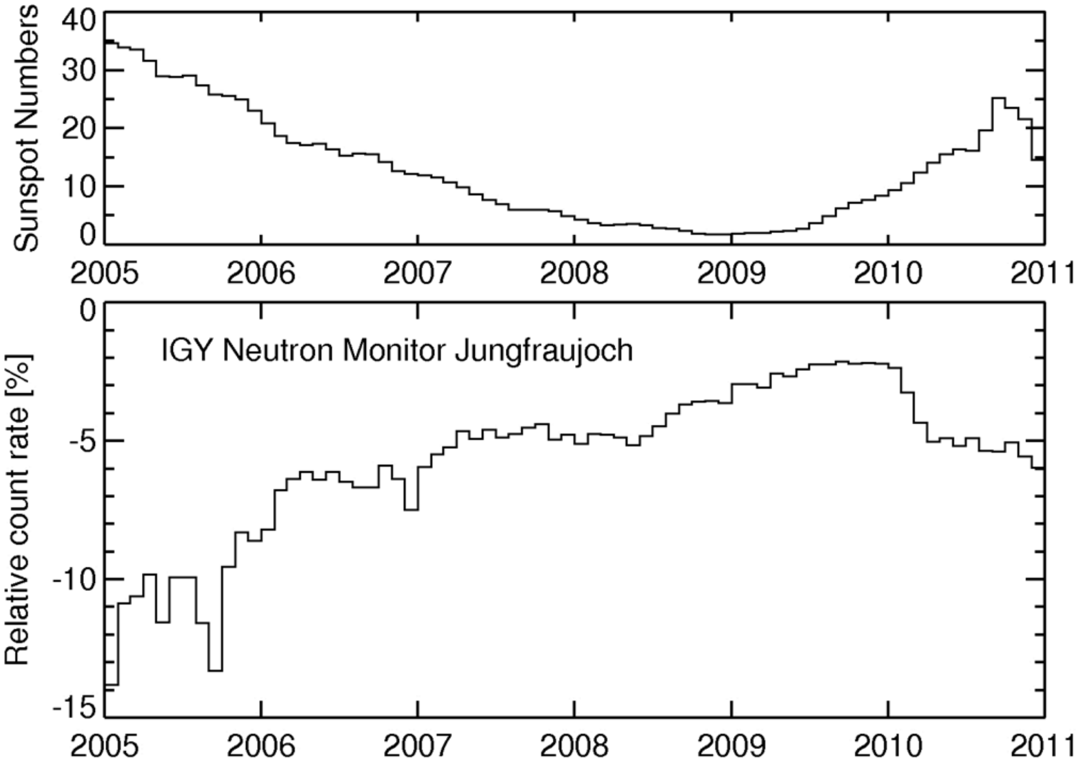


Figure 2: Smoothed monthly sunspot numbers (January 2005-June 2010) and monthly sunspot numbers (July 2010-December 2010) (top pannel), pressure corrected monthly average counting rate of IGY neutron monitor at Jungfraujoch (bottom pannel) for the years 2005-2010. The neutron monitor count rate is expressed in relative units with respect to May 1965.

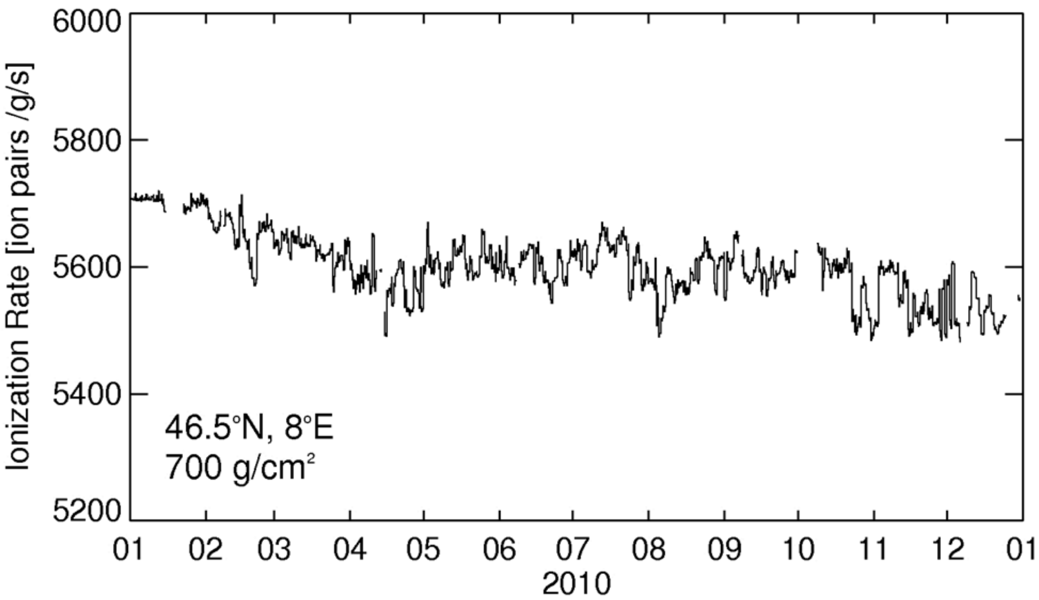


Figure 3: Ionization rate in the region of Jungfraujoch (46.5°N, 8°E) at 700 g/cm$^2$ (about 3.2 km asl) for 2010 as determined by the application "Ionization and radiation dose rates in the Earth's atmosphere" under www.nmdb.eu.

References

Dickinson, R.E., Solar variability and the lower atmosphere, Bull. Am. Meteorol. Soc., 56, 1240-1248, 1975.

Ney, E.P., Cosmic radiation and the weather, Nature 183, 451, 1959.

Scherer, K., et al., Interstellar-terrestrial relations: Variable cosmic environments, the dynamic heliosphere, and their imprints on terrestrial archives and climate. Space Sci. Rev., 127, 327-465, 2006.

Svensmark, H., and Friis-Christensen, E., Variations of cosmic ray flux and global cloud coverage – A missing link in solar climate relationships. J. Atm. Terrest. Phys. 59, 1225, 1997.

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 2010:

**Refereed journal articles**

Bütikofer, R., E.O. Flückiger, Radiation doses along selected flight profiles during two extreme solar cosmic ray events, accepted for publication in Astrophys. Space Sci. Trans., 2010.

**Conference papers**

Flückiger, E.O., Terrestrial effect of cosmic rays, 22$^{nd}$ European Cosmic Ray Symposium, Turku, Finland, 3-6 August 2010, abstract, 2010.

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