SONTEL-Measurements at Gornergrat and Environmental Radioactivity

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Abstract

The solar neutron telescope (SONTEL) at Gornergrat, Switzerland, has been in operation since 1998 as the European cornerstone of a worldwide network for the study of high-energy neutrons produced in energetic processes at the Sun. During the GLE on April 15, 2001, the proportional counters of SONTEL showed a large count rate increase that started several hours before the GLE onset and that had a much longer duration compared to the GLE response as recorded by the other detector channels. Simultaneously, an increased level of environmental radioactivity was measured in the detector housing. Since April 2001 further events of enhanced environmental radioactivity have been observed which were not associated with a GLE. For the investigation of these enigmatic increases we additionally made measurements of the radon concentration in the detector housing. In this paper we compare the different measurements and discuss possible causes for the unusual increases in the count rates of the SONTEL proportional counters.

1. Introduction

During the last decade a global network of solar neutron detectors was initiated by the Solar-Terrestrial Environment Laboratory of the Nagoya University [7,6]. Today a network of six detectors around the world enables the possibility to observe solar neutrons 24 hours a day [3]. The station at Gornergrat, Switzerland (7.78° E, 45.98° N, 3135 m asl) has been in operation since 1998 [2,1].

The proper interpretation of the measurements requires detailed knowledge of the detection properties [5]. In addition it is equally important to know the environmental effects on the counting rates. In this paper a possible contribution of enhanced radon concentration in air to the count rates of the Gornergrat detector is discussed.

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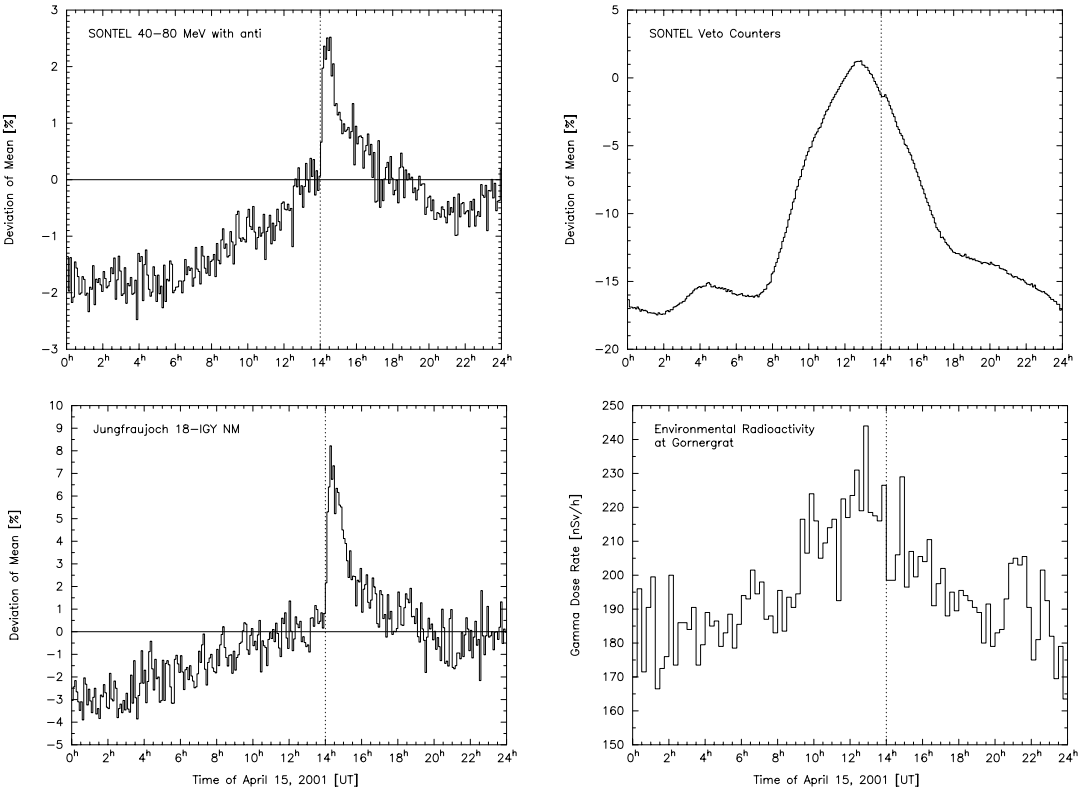

Fig. 1. The GLE on April 15, 2001. Relative 5-minute counting rates of the lowest neutron channel (40–80 MeV) and of the proportional counters of SONTEL (top left and right), and of the 18-IGY neutron monitor at Jungfraujoch (bottom left). The environmental radioactivity at Gornergrat (bottom right) is plotted in 15-minute average values.

2. Measurements

During the GLE on April 15, 2001, a significant increase was observed in the SONTEL counting rates due to relativistic solar particles, similar to the increase in the count rates of the neutron monitors at Jungfraujoch, as illustrated in Fig. 1. At the time of the event Gornergrat was in a favorable local-time position for the detection of solar neutrons. However, no evidence was found for the presence of high-energy solar neutrons near Earth.

The increase in the SONTEL and neutron monitor count rates due to solar particles occurred after 1400 UT (marked in Fig. 1 by vertical dotted lines). The increase was ∼2.5 % in the 40–80 MeV scintillator channel with veto (neutrons) and ∼8 % in the count rate of the IGY neutron monitor at Jungfraujoch. However, as can also be seen in Fig. 1 the count rate of the proportional counters as well as the level of the environmental radioactivity (measured inside the detector housing by a *GammaTRACER* probe unit manufactured by Genitron

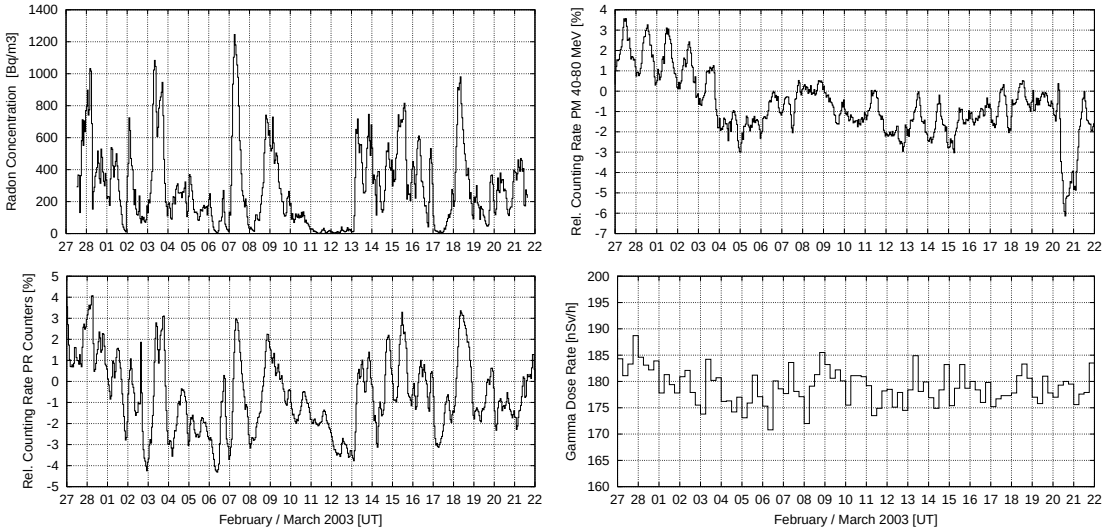

Fig. 2. Hourly values of radon concentration in the lab container (top left), relative counting rate of the SONTEL proportional counters (bottom left), relative counting rate of the 40–80 MeV SONTEL neutron channel (top right), and 6-hour averages of environmental radioactivity (bottom right) during the time interval February 27 – March 21, 2003. The SONTEL and the radioactivity data are corrected for atmospheric pressure variations. Radon concentration and environmental radioactivity are measured inside the SONTEL detector housing.

Instruments, Frankfurt, Germany) show with almost 20 % much greater increases that started about six hours before the onset of the GLE and that lasted almost half a day. Since the different energy channels of the scintillator counters do not show such an effect, the energy of the ionizing radiation causing the increase in the counting rate of the proportional counters must have been lower than 40 MeV.

Since April 2001 we identified further similar events (which were not accompanied with a GLE). We investigated a possible association with enhanced radon concentration. From February 27 to March 21, 2003 we made additional measurements of the radon concentration inside the SONTEL detector housing with a Genitron *AlphaGUARD* radon monitor. These measurements together with the SONTEL count rates of the proportional counters and the lowest scintillator energy channel as well as the environmental radioactivity are shown in Fig. 2.

3. Discussion

As can be seen from Fig. 2 the radon concentration is highly variable. The counting rate of the proportional counters shows a similar variability. The variations in the order of a few percent are highly correlated with the radon

concentration. On the other hand the changes in the count rate of the 40–80 MeV scintillator channel reflect mainly the variations of the primary cosmic ray intensity. Although the data of the *GammaTRACER* has a reduced statistics, the large increases in the radon concentration are also clearly visible in the 6-hour recordings of the environmental radioactivity.

On March 2, 2003, around 1500 UT, the count rate of the proportional counters of SONTEL shows a short increase of ∼3 %. This increase is also present, although with smaller amplitude, in the 10-minute count rates of the different scintillator channels (not shown here). However, the increase was not observed in the radon concentration. The cause of these increases is not clear. However, it is interesting to note that they occurred in close time coincidence with lightning in the region of Gornergrat [4].

The SONTEL laboratory container stands on an open foundation, about 1 m above the ground. It is assumed that radon outgassing from the rocky ground material can enter into the lab container through a small inlet for cables, especially during times when extensive snow accumulation surrounds and seals the foundation. For the time interval when the additional radon measurements were made, the space under the lab container was not completely sealed by snow. On March 11–12, and March 17 the wind speed at Gornergrat was with 5–10 m/s significantly higher than on the other days, and from Fig. 2 it can be seen that during these periods the radon concentration in the lab container was very low. However, correlation studies show that the variations in the radon concentration can not be associated with meteorological data in a simple manner.

It appears that many increases in the count rate of the SONTEL proportional counters can be explained by the effect of radon. However, it must be pointed out that the large increase during the GLE of April 15, 2001, is still unique in the entire operation-time of SONTEL at Gornergrat, and its cause is still a matter of investigation.

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References

1. Bütikofer R. et al. 2001, Proc. 27th ICRC, 8, 3053
2. Flückiger E.O. et al. 1998, Proc. 16th ECRS, 219
3. http://stelab.nagoya-u.ac.jp/ste-www1/div3/CR/Neutron/index.html
4. http://www.wetterzentrale.de/topkarten/tkbeoblar.htm
5. Moser M.R. et al. 2003, These proceedings
6. Muraki Y. et al. 1993, Proc. 23rd ICRC, 3, 171
7. Shibata S. et al. 1991, Proc. 22nd ICRC, 3, 788