Cosmic ray and cloudiness: do the local connections exist?

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Abstract: We examined daily means of cosmic ray (CR) neutron monitor data at Lomnicky stit (2634 m a.s.l) and the cloudiness measured by Slovak Hydrometeorological Institute at the same site for periods 1982 - 2010. The scatterplot of the two values indicate there is correlation coefficient consistent with being zero. Checking the power spectrum density of the two time series, there is a clear difference at periodicity near 1 year (present for cloudiness, insignificant in CR). The averaging over 10 and 100 days slightly changes the linear correlation coefficient to positive values. Averaging by 1 year leads to the linear correlation coefficient being slightly different from zero. Analysis is done for few selected FDs and solar flare events with particles accelerated to high energies. Only marginal mutual dependence in the two data sets is found, if long time averaging is used.

Keywords: Cosmic ray, cloudiness

1 Introduction

Paper [1] identified a positive correlation between the total cloud coverage over oceans and the cosmic ray (CR) flux during the years 1983-1991. The discussion about the connection between CR flux and the cloud coverage is continuing for two decades. Recently that connection is discussed e.g. in papers ([2-4,8,14] and references therein). Paper [5] reports that correlation between the production of clouds and ionisation due to CR is not a global effect, but it is observed only in certain regions. Calogovic et al [6] indicated that sudden CR decreases are not accompanied by any change of the cloud cover over the globe. Authors in [12] in study of clouds versus GCR Forbush decreases shows that decreases of total cloud cover are most distinctly seen in belt of latitudes 60 -64° and disappear at lower latitudes. Analysing of data from ISCCP D2 satellite records in the period 1989 - 1991, the authors of [7] found small evidence on connection between CR flux and cloudiness with some possible exceptions at specific sites and for specific clouds. In [9] the authors found the correlation between low cloud cover and CR weaker than that for solar irradiance and clouds. Probably the spatial correlation patterns are more important than correlations using globally averaged characteristics.

Assuming that, we check the relations between the cloud coverage (CL) and CR measured at the same site, specifically at Lomnicky stit over the period 1982 - 2010 using daily means of the two time series. Preliminary results indicate there is only marginal relation between CL and CR at that site for longer time averages of the data and no clear changes during the “extreme” events observed in CR.

2 Data

Two data sets have been used for the analysis, namely CR (from http://neutronmonitor.ta3.sk/ ) and daily averages of the CL (Cloudiness - the amount of sky covered by clouds, obtained from Slovak Hydrometeorological Institute). CL is determined visually. The extent of cloud formation is measured on a 10-point scale, with a value of 0 correspond-
Figure 1: Daily data on clouds Lomnicky stit (CL) with smoothing window 180 days (upper panel left, red) and of CR in per cents (100% corresponds to September 1986 and represented 1,745,200 counts per hour). Right panel is Lomb-Scargle periodogram of the two time series. Power spectrum density (PSD) is in arbitrary units.

Figure 2: Values of linear correlation coefficient ($r$) between the CR and CL at various averagings: up to 100 days of averaging $r$ is consistent with being zero at probability 0.3. Using yearly averages, the probability that the sample is taken from population with zero correlation, is 0.05, and for two years averages it is 0.13 (non-directional). The slopes ($s$) of the linear fits with their errors in brackets are shown. At yearly averages (in the scale plotted) $s = 0.0173 \pm 0.0086$. 
Figure 3: The profiles of daily means of CR and CL around the time of one of the deepest FD (left) and of the ”strongest” GLE observed at LS (right panel).

Figure 4: Comparison of the 2 - year averages of daily means of CL and CR (upper panel) and CL and sunspot numbers (SSN averaged from daily data downloaded from NASA OMNIWEB) in lower panel. Points on x axis are the centers of intervals with averaging. The correlation is (at number of points 15) only slightly different from being zero. Large deviations from “simultaneous” profiles for both cases is after 2006 and during the deep solar activity minimum with high CR flux.

Acknowledgment: The authors acknowledge VEGA grant agency project 2/0040/13 for support and Slovak Hydrometeorological Institute for providing data.

References
[13] Cloud data obtained from Slovak Hydrometeorological Institute, A. Vinceova, personal communication.