

Relevance of long term time – series of atmospheric parameters at a mountain observatory to models for climate change

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A detailed analysis has been made of annual meteorological, and cosmic ray, data from the Lomnický štít mountain observatory (2634 masl), from the standpoint of looking for possible solar cycle (including cosmic ray) manifestations.

Apart from the Pressure, Sunspot number correlation, we find no significant Solar Cycle dependence (i.e. difference from one Cycle to the next) of the relationship between local temperature and pressure, cloud cover and pressure, cloud cover and Sunspot Number, and cloud cover and cosmic rays, corrected for atmospheric pressure, or not, in contrast with the results of others for the cloud cover, cosmic ray intensity correlation. The apparent rise in cloud cover with increasing cosmic ray intensity is smaller than found by others and is, in our view, due at least in part to atmospheric pressure effects.

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1.Introduction

The Earth's climate has always been changing. The reasons for these changes, however, have always been subject to discussions and in need of further analysis. The case of the contribution of cosmic rays (CR) to the magnitude of cloud cover (CC) is an example. Although the likelihood of its being very small is high, e.g. the IPCC report [1] it is not necessarily zero.

Authors in [2] find that the solar influence on cloud cover is not uniquely defined by one solar driver (cosmic rays and the UV irradiance), but both seem to play a role depending on the climatic conditions and altitude.

Paper [3] identified a significant correlation between CR and CC. At first sight the correlation appeared to have a natural explanation in terms of the role of CR ions forming cloud – condensation nuclei (CCN) upon which cloud droplets preferentially form. However, later work in some detail, e.g. [4, 5, 6], showed that the effect, if it existed at all, was much smaller than claimed. Nevertheless, there do appear effects to be explained and it is possible that CR have an indirect effect on CC, for example by way of the atmospheric electric circuit [7, 8, 9]. Thus further study is needed.

In this article we examine the atmospheric parameters from the Lomnický štít (LS) mountain observatory [10]. Because CR are dependent on the Solar Cycle (SC) we examine the two SC (SC22 and SC23) separately.

2.The basic data

The manner in which the data are collected is discussed elsewhere [11] and only a summary will be given here, of relevance to those parameters involved in the present analysis.

These are: Cloud cover - 'cloudiness' (CC) [12], Atmospheric pressure (P), Atmospheric temperature (T) [13], Cosmic ray intensity from neutron monitor data: CRCORR (corrected for atmospheric pressure) and CRUNCORR (uncorrected).

3.The analysis

3.1 Pressure, temperature and cloud cover

In Figure 1, we plot of the annual averages of the pressure cover against two different meteorological parameter; namely temperature for 30 years (1984 - 2013) and cloud cover for 32 complete years covered by the cloud data 1982 – 2013 and separately for SC22 (1986 - 1996) and SC23 (1996 - 2008). The relationship between atmospheric pressure and cloud cover has a well known meteorological origin. When a low-pressure area moves in, the air rises, cools and condenses out moisture, which forms clouds and precipitation. The correlation coefficient between these two parameters and pressure is shown in Table 1.

	1982 - 2013		SC22		SC23	
	T	LSCC	T	LSCC	T	LSCC
P	0.52	-0.63	0.90	-0.47	0.82	-0.42

Table 1 Linear correlation coefficient between pressure and temperature and cloud cover at Lomnický štít.

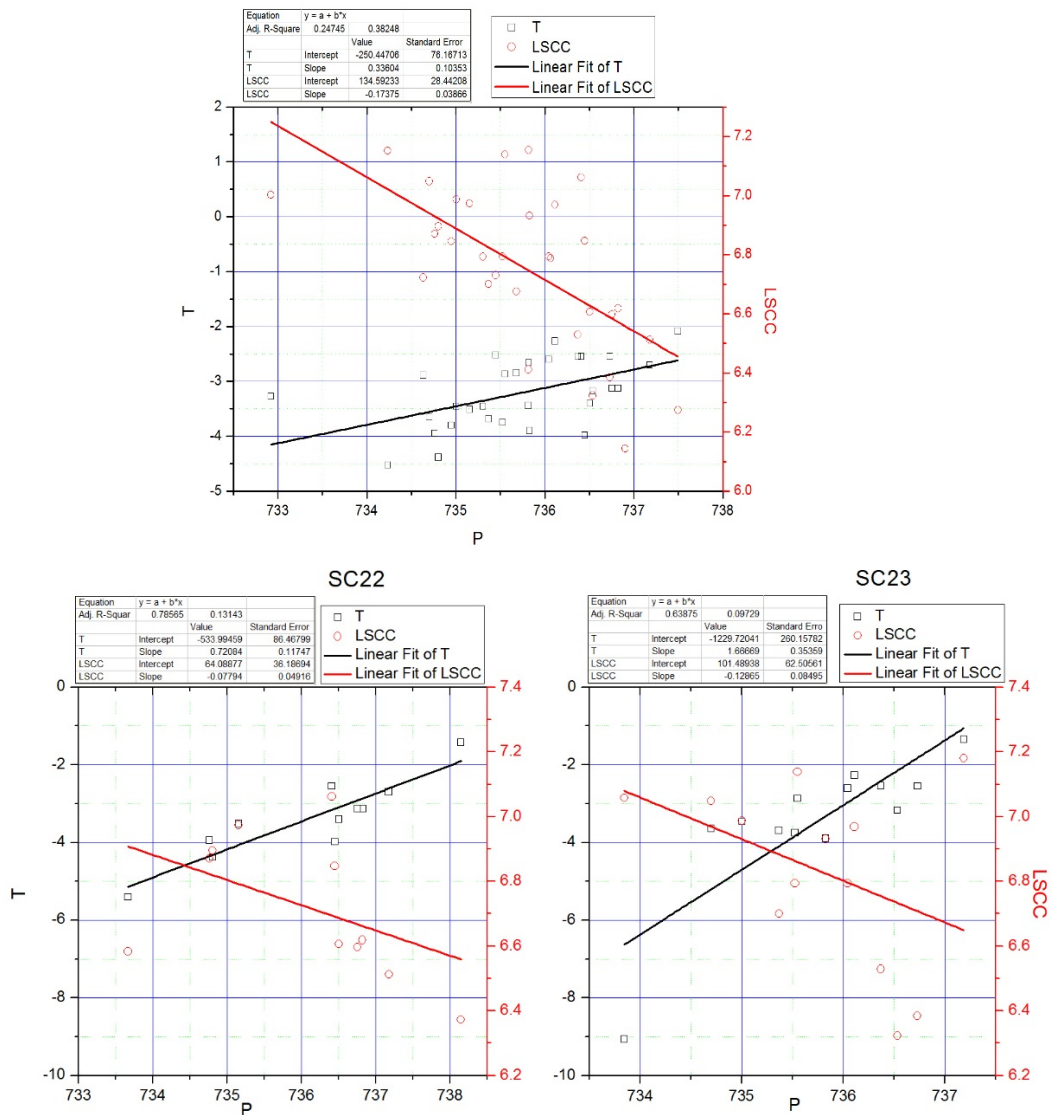


Figure 1 Temperature and cloud cover versus pressure (annual means) for the whole period (upper panel) and for separate cycles 22 and 23 (lower panels). The whole period (1982 – 2013) is somewhat longer than that of SC22 plus SC23.

3.2 Sunspot number (SSN), pressure and cloud cover

Figure 2 shows dependence between sunspot number and pressure and cloud cover at Lomnický stit. Table 2 shows the results. It is clear that there is a weak correlation.

	1982 - 2013		SC22		SC23	
	P	LSCC	P	LSCC	P	LSCC
SSN	0.47	-0.26	0.36	-0.15	0.04	-0.06

Table 2 Linear correlation coefficient between sunspot number and pressure and cloud cover at Lomnický stit.

The correlation may be related to that in the CR intensity, as discussed in the next section.

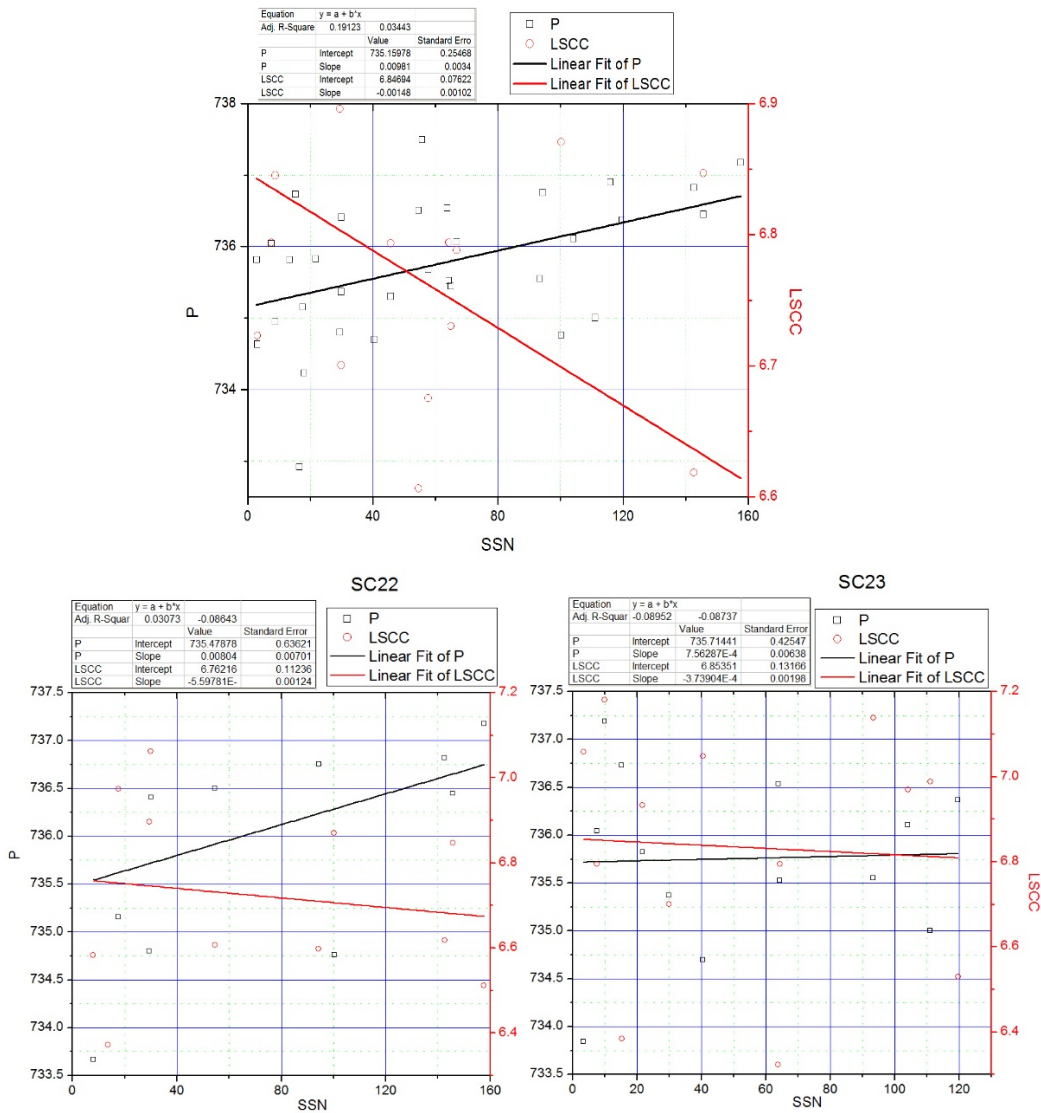


Figure 2 Cloud coverage and pressure versus sunspot number (annual means) for the whole period studied (upper panel) and for solar cycles 22 and 23 (lower panels). The whole period is somewhat longer than that of SC22 plus SC23 and the total number (32) is correspondingly greater than 11+13.

3.3 Cosmic ray intensity and cloud cover

Figure 3 shows the straight forward correlation of LSCC and CR (corrected and uncorrected).

	1982 - 2013		SC22		SC23	
	CRCORR	CRUNCORR	CRCORR	CRUNCORR	CRCORR	CRUNCORR
LSCC	0.27	0.32	0.10	0.13	0.42	0.47

Table 3 Linear correlation coefficient between cosmic ray intensity (corrected and uncorrected) and cloud cover at Lomnický štít.

It will be noted that the values for the correlation are at the 1.93 and 2.3 standard deviations levels, i.e. bordering on significant.

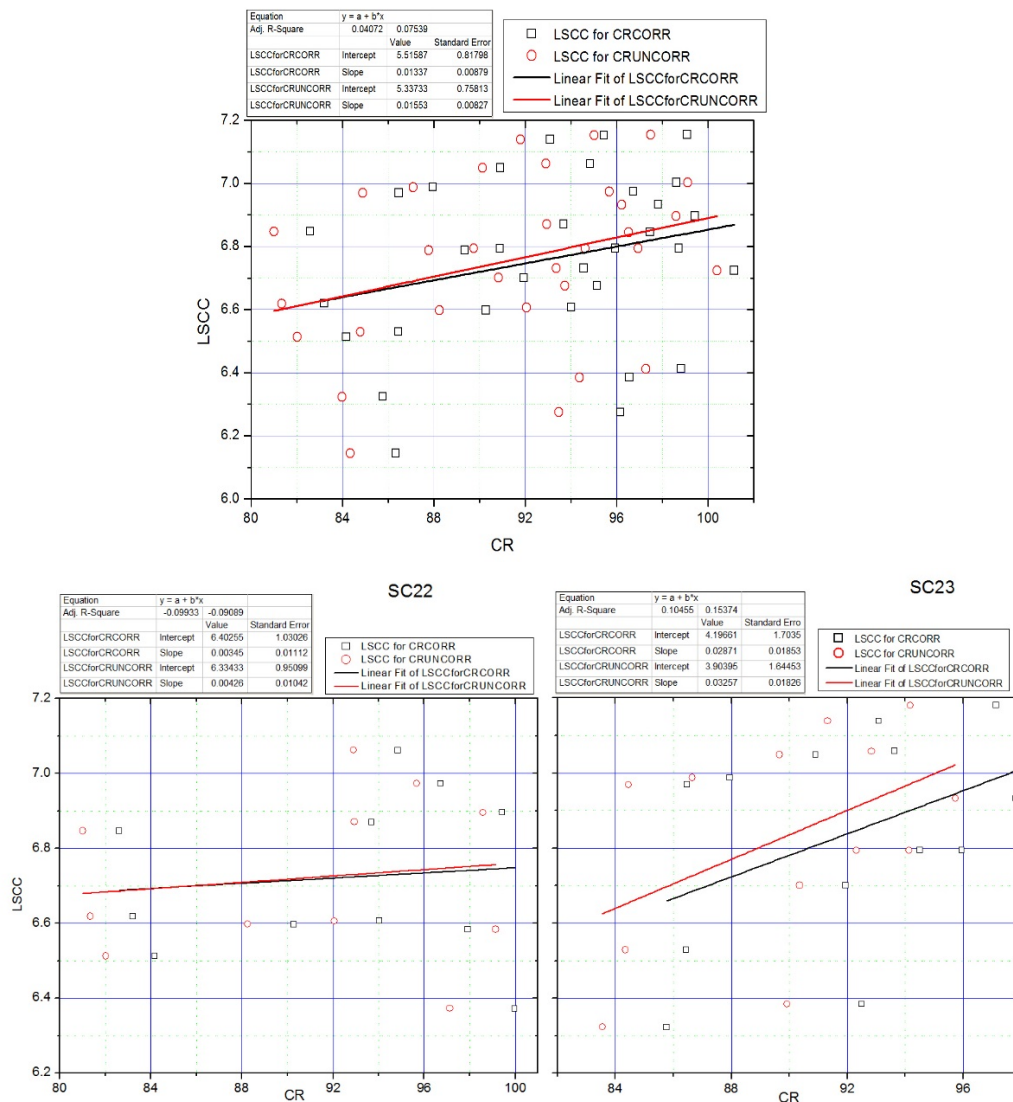


Figure 3 Cloud cover versus corrected and uncorrected CR intensity at LS (annual means) for the whole period (upper panel) and for separate cycles 22 and 23 (lower panels). The whole period is somewhat longer than that of SC22 plus SC23 and the total number (32) is correspondingly greater than 11+13.

4. Summary

Concerning the CR correlations, the lack of a difference between the correlations for corrected and uncorrected CR intensities (annual means) points against the hypothesis that CR ionization is responsible for significant CC changes.

As remarked already (Introduction) a correlation need not be causal and we consider this to be the cause for the CC, CR (SSN) correlations.

The results are thus in favour of those reported in introduction which disfavour the ionization hypothesis.

Previous work using subsets of the present mountain data [14] found 'slightly different' correlation coefficients for averaging periods ranging from 1 day via 10 days to 100 days and longer periods, but an overall value is only marginally different from zero.

Acknowledgments

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