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ABOUT THE CORRELATION BETWEEN THE COUNTING RATES OF THE MESONTELESCOPE AND THE NEUTRON MONITOR

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Abstract

The registrations of the megamesontelescope and the neutron monitor have been compared in three different ways. The regression coefficient between them has been calculated, the maximum amplitudes of enhanced (the first harmonic) daily variations as seen by the mentioned intruments have been compared as well as some simultaneous decreases of the pressure corrected intensities. It was observed that the overall regression coefficient was about 0.29. The averaged ratio of the maximum amplitudes in harmonic daily variations was 0.64. The amplitude ratio of the anharmonic decreases varied in the range 0.2—1.2 and was found to be approximately inversely proportional to the decrease.

Introduction

The neutron monitor [5] and the megamesontelescope [4] of the Department of Physics, University of Oulu, have been employed in this work.

The neutron monitor registers primarily the nucleonic component of cosmic rays. This component consists of the low energy particles, mostly secondary nucleons. The megamesontelescope registers the meson component of the so called hard cosmic rays, so that the lower limit of the energy of the secondary particles to be detected by it is about 200 Mev. Normally sea level neutron monitors record secondaries from primaries of rigidities 3—30 GeV and mesontelescopes respond mostly to primaries of rigidities >6 GeV. The energy ranges overlap partially. Thus it is clear that a variation of the primaries introduces different variations in the high and low energy secondaries. If a variation occurs in the low or high energy part of the primary spectrum then it mainly responds in the neutron component or the meson component, respectively.

Methods of analysis

A multiple regression and correlation analysis according to the Duperier model was used in analysing the meson data. The intensity was explained by the sea level barometric pressure (B), the height (H) of the averaged meson producing layer, the temperature (T) of that layer, and the pressure corrected neutron intensity (N). The most probable producing layer was according to this work the height of 100 mb pressure level. Three first mentioned variables take into account the atmospheric conditions. Assuming that no atmospheric variations exist in the last variable it corrected the meson component according to the primary radiation and its variations. The variation of the meson intensity can accordingly be put into the form:

$$\Delta I = a\Delta B + b\Delta H + c\Delta T + d\Delta N$$

where a, b, and c are the partial pressure, height, and temperature coefficients. The coefficient d can be called the overall neutron monitor coefficient and it illustrates the general relation between the variations of different components. All changes can be expressed in percents or as absolute values. The analysis was also made without the neutron data (normal Duperier model).

In the cosmic ray intensity a harmonic daily variation can be shown to exist. It can be seen very clearly during such quiet periods when there are no other disturbances in the primary intensity and after great Forbush-decreases during so called enhanced variations. It is seen as well in soft as hard component after the atmospheric corrections have been made. The maximum amplitude of the first harmonic was obtained for some periods of enhanced daily variations. This was examined for both components. During quiet periods the correlation between the meson intensity and the neutron intensity can be compared by calculating the ratio of the maximum amplitudes of these harmonic variations.

During disturbed periods the correlation can be examined by comparing the percentage values of the simultaneous anharmonic decreases of the corrected meson and neutron intensities.

Results and conclusions

In order to calculate the total neutron monitor coefficient periods of one month were used between August and December of 1968. The coefficients were calculated separately for the wide angle, cubical and directional telescopes. According to the residual deviations and t-numbers obtained by the regression and correlation analyses it was observed that the best reference level was the height of 100 mb pressure level. The available aerological data were from the meteorological station of Sodankylä.

Following values of the overall neutron monitor coefficients d were obtained:

the wide angle telescope	0.293 ± 0.034
the cubical telescopes	0.327 ± 0.020
the directional telescopes	0.289 ± 0.017

It was observed that during the studied period of five months the coefficients increased a little. This fact is supposed to be caused by the sunspot maximum, which was approaching. The activity of the sun affects most the variations of the low energy particles and thus (due to the lower energy range of the neutron monitor) the energy ranges of the particles registered by the meson telescope and neutron monitor overlap more than during low-activity periods. That is why the neutron monitor becomes more significant in explaining the meson intensity and the overall regression coefficient reaches a maximum value.

CARMICHAEL [2] *et al.* have done some studies on the meteorological corrections to the meson intensity. The overall neutron monitor coefficient for the wide angle telescope layed in the range from 0.20 to 0.40 depending on the reference level and the regression model.

For the meteorological corrections when using absolute variations of pressure, the height and the temperature of 100 mb pressure level the following regression coefficients were obtained for the wide angle telescope:

the barometric coefficient	$\alpha = -0.120 \pm 0.015\,\%/\text{mb}$
the height coefficient	$\beta = -4.4 \pm 1.0\,\%/\text{km}$
the temperature coefficient	$\gamma = +0.04 \pm 0.02\,\%/{}^\circ\text{C}$

The pressure coefficient of the used pressure corrected neutron monitor data was −0.74 %/mb.

The above mentioned corrections were carried on the data of the wide angle telescope, after which the earlier mentioned harmonic analysis was applied to the corrected data of both the telescope and the neutron monitor. Some examples of the harmonic variations can be seen in Fig. 1. The results are as follows:

Period	Instrument	Max. amplitude	The ratio of the amplitudes
1.—5. 8. 68	Z	0.21±0.04%	0.70
	NM	0.30±0.10%	
18.—22. 9. 68	Z	0.33±0.04%	0.97
	NM	0.34±0.10%	
10.—14. 10. 68	Z	0.19±0.04%	0.33
	NM	0.57±0.10%	
9.—13. 11. 68	Z	0.37±0.04%	0.62
(Fig. 1)	NM	0.60±0.10%	
20.—24. 12. 68	Z	0.15±0.04%	1.50
	NM	0.10±0.10%	
The sums of the former	Z	0.23±0.02%	0.64
periods (Fig. 1)	NM	0.36±0.04%	
1.—31. 8. 68	Z	0.19±0.02%	0.61
	NM	0.31±0.04%	

Some comments can be made. The variations of the nucleon component, except in one case, are larger than the ones of the meson component. A significant ratio is 0.64 from the sums, because it represents all periods and it has a better statistics than the other ratios. The value of the December is not significant, because then the variations were small and thus the statistics very poor. All ratios are markedly larger than the overall neutron monitor coefficient obtained by the regression and correlation analyses. The difference in the values is caused by the fact that in the former method there were all possible disturbances and that in the latter one there were only enhanced periods with clear daily variations. Furthermore the daily variation appears in the whole cosmic ray spectrum and on the other hand the disturbances as Forbush-decreases appear mostly on the low energy region. Bercovitch [1] has obtained the ratio 0.47. According to Hashim *et al.* [3] the value is normally about 0.50. The values are a little lower than the value obtained in this work but however greater than the overall neutron monitor

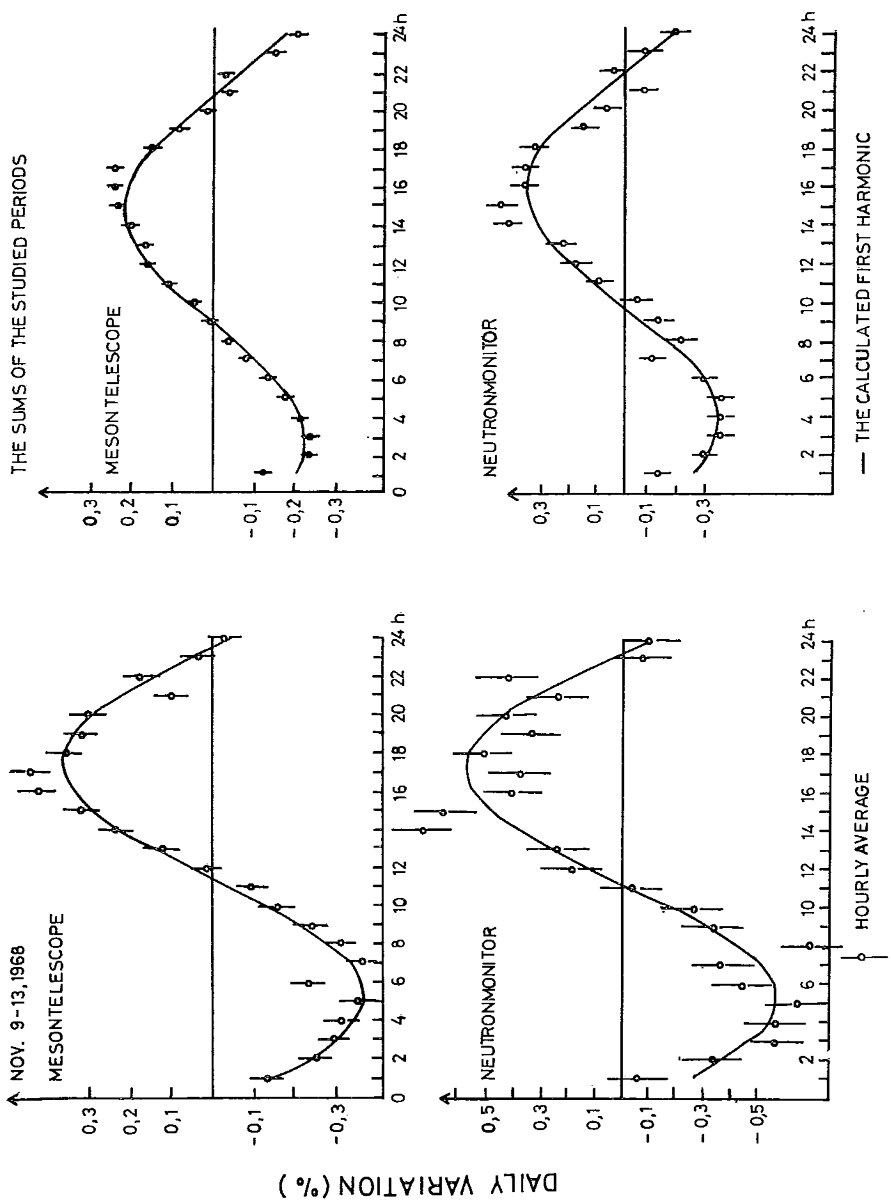

Fig. 1. Harmonic daily variations as seen by the mesontelescope and the neutron monitor during Nov. 9—13, 1968 and the sums of periods Aug. 1—5, Sept. 18—22, Oct. 10—14, Nov. 9—13 and Dec. 20—24, 1968.

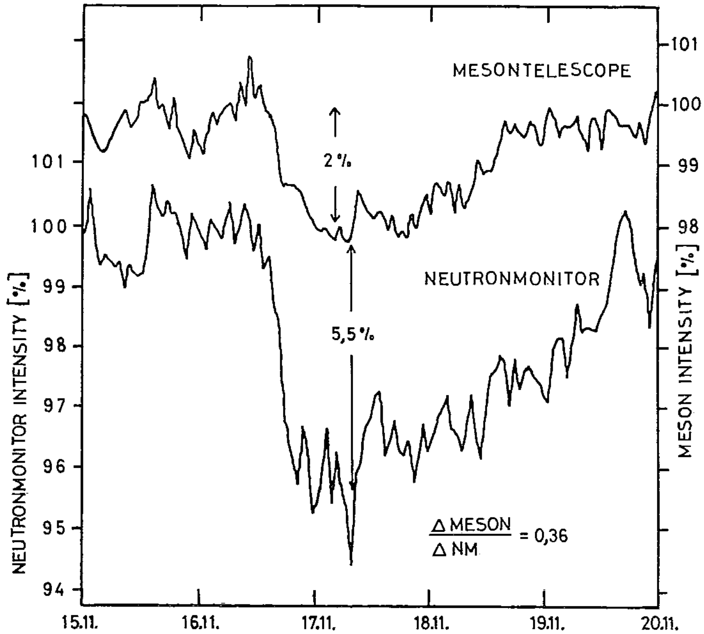

Fig. 2. The Forbush decrease, Nov. 16—19, 1968, as seen by the mesontelescope and neutron monitor.

coefficients in this work. The difference is caused as mentioned by the selected periods with maximum daily variations.

During periods with occasional decreases the comparison was made graphically. The ratio of the percentage decreases (see Fig. 2) of the components were plotted as a function of the decrease of neutron monitor intensity (see Fig. 3). It can be seen that the dependence of the counting rate of the meson telescope on the counting rate of the neutron monitor increases when the disturbance of the neutron component is decreasing. This effect can be explained as being caused by the difference in the average energy responses of the instruments. The larger decreases (Forbush-decreases) lie in the lower energy part of the spectrum which proportionally has the least effect on the meson component. On the average the ratio is smaller than the one obtained by the harmonic analysis. It, however, varies in the range 0.2—1.2.

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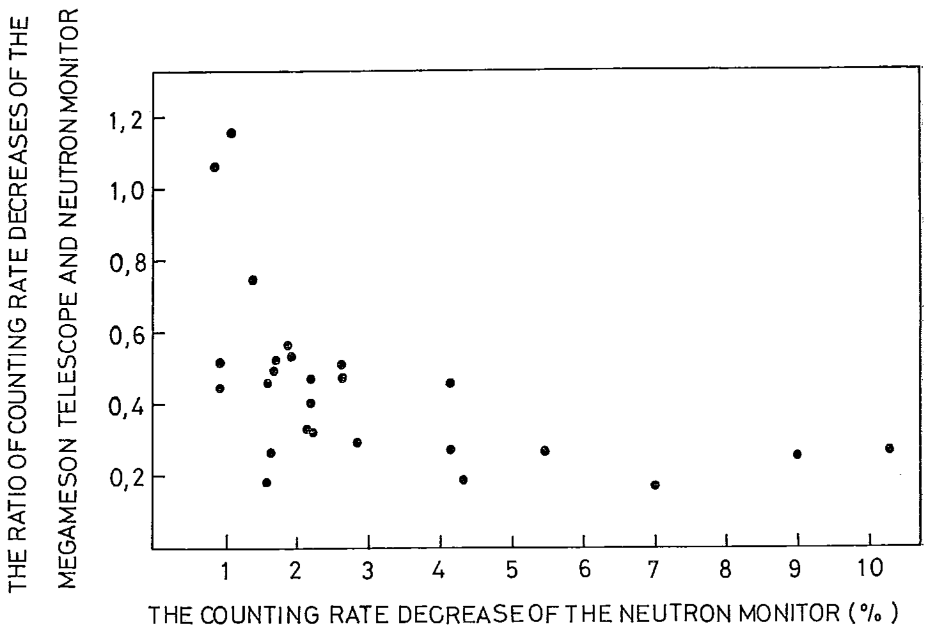

Fig. 3. The dependence of the ratio of the counting rate decreases of the meson telescope and neutron monitor on the counting rate decrease of the neutron monitor.

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