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ON THE VARIATIONS OF COSMIC RAY μ-MESON INTENSITY DURING RAPID PRESSURE VARIATIONS AND ABOUT THE APPLICABILITY OF DUPERIER'S MODEL

by

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Abstract

P. TANSKANEN has found out that in the μ-meson intensity there is a »hysteresis» phenomenon during rapid pressure variations. This paper includes an effort to explain the observed loop-like variations by the changes in the structure of the atmosphere. In this connection the good applicability of Duperier's model has been confirmed. There has also been some success in using neutron monitor data to describe primary variations.

Secondary cosmic μ-mesons registered on the ground are produced everywhere in the atmosphere but the average production level is about 150 mb. The μ-mesons lose their energy through ionization and so the thickness of the atmosphere has an effect on their absorption. Further μ-mesons have a finite life-time, and so the height of the production level will also influence the μ-meson ground level intensity. As the temperature controls the free path of μ-mesons, the atmospheric effects on the meson intensity I registered on the ground can be presented according to DUPERIER [1] approximately by the formula

$$\frac{\Delta I}{I} = \alpha \Delta B + \beta \Delta H + \gamma \Delta T \,, \tag{1}$$

where H and T are the height and temperature of the pressure level of 150 mb and B is the barometric pressure on ground level. The partial correlation coefficients α , β and γ are according to our calculations [2] at Oulu

$$\alpha = -\ 0{,}13\ \%/\text{mb},$$
$$\beta = -\ 3{,}69\ \%/\text{km and}$$
$$\gamma = +\ 0{,}05\ \%/°\text{C}.$$

In general only $\alpha \Delta B$ is a significant term because ΔH and ΔT are usually small. On the other hand because of the scarcity of aerological data it is not possible to take these terms into consideration. Thus it is usual to neglect the terms $\beta \Delta H$ and $\gamma \Delta T$ in correcting the meson intensity *e.g.* when studying long period variations. But then we neglect the variations due to periodic variations in the atmosphere. For instance, ΔH can be between summer and winter 0,5—1 km, and so the observed seasonal variation of the μ-meson intensity is perhaps mainly due to that [3].

We have continued TANSKANEN's studies [4] about μ-meson intensity variations during rapid pressure variations. Comparing experimental values with the theoretical values calculated by the equation 1 and taking into consideration other factors effecting on the μ-meson intensity the applicability of Duperier's model can also be studied. We have studied only the periods when our meson telescope has operated well.

We can think that in the idealized atmosphere all the layers follow each other's movements. If there are no changes in barometric pressure the average production height of μ-mesons should be constant. Then the intensity should also be constant, if there are no changes in primary radiation.

When we plot 3-hourly means of the μ-meson intensity as a function of mean pressure, we obtain graphs examples of which are shown in Figures 1—3. In the same figures also the graphs of mean pressure and H as a function of time are given.

Usually the intensity does not follow the same path during decreasing and increasing pressure. Consider an actual case shown in Figure 1. In figures also the graphs calculated using equation 1 and aerological data from Sodankylä are drawn.

When we examine the corresponding aerological data we can see that after a rapid pressure decrease the pressure level of 150 mb is still lowering in spite of the pressure increase. The phase shift can be from some hours to one day. Now we can understand that during the pressure increase the intensity is greater. The experimental and theoretical

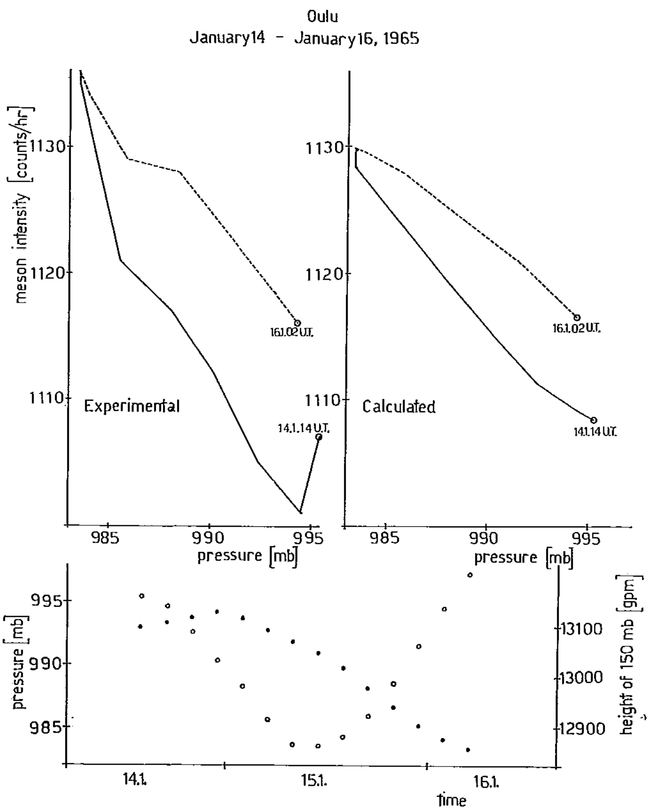

Fig. 1. Experimental and calculated graphs of μ-meson variations as a function of mean pressure and mean pressure and height of 150 mb as a function of time from the 14th to the 16th of January

——— pressure decrease
- - - - pressure increase
○ mean pressure
● height of 150 mb

graphs are similar. The difference in the areas of loops can be explained by primary cosmic ray variations. From the 14th to the 16th of January the neutron intensity at Oulu had decreased 0,4% and so the smaller area of the experimental loop can be understood.

From the 3rd to the 5th of April (Fig. 2) the pressure level of 150 mb has rapidly gone up during the pressure increase after the pressure decrease. Now it has been, on the average, higher than during the pres-

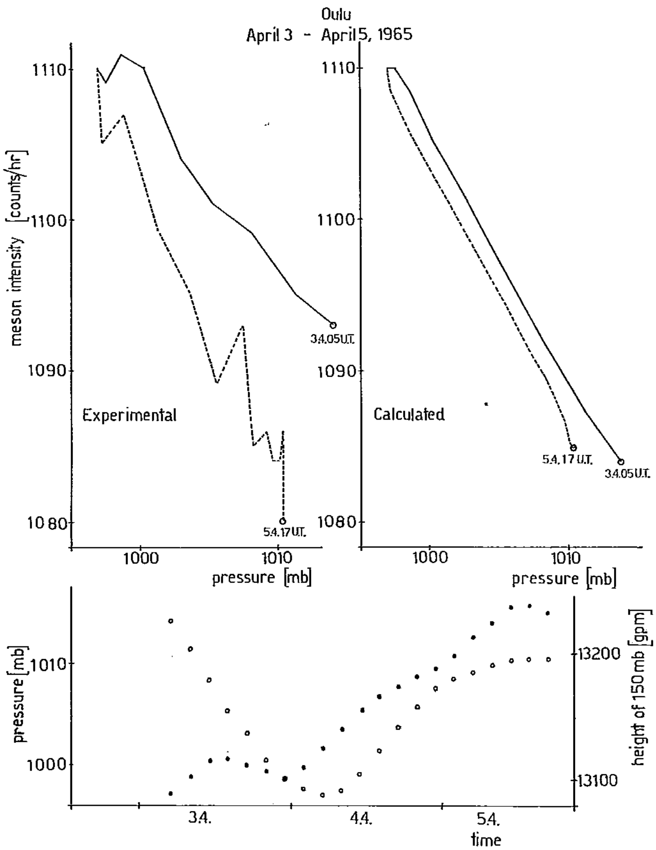

Fig. 2. Experimental and calculated graphs of μ-meson variations as a function of mean pressure and mean pressure and height of 150 mb as a function of time from the 3rd to the 5th of April

———	pressure decrease
- - - -	pressure increase
o	mean pressure
●	height of 150 mb

sure decrease. Because the neutron intensity has decreased 1%, the μ-meson intensity has been much smaller during the pressure increase. Accordingly we can explain the difference in the areas of the experimental and theoretical loops.

From the 3rd to the 6th of December (Fig. 3) we observed a case when the experimental and theoretical graphs differ very much from each others. Although the pressure level of 150 mb has been high during

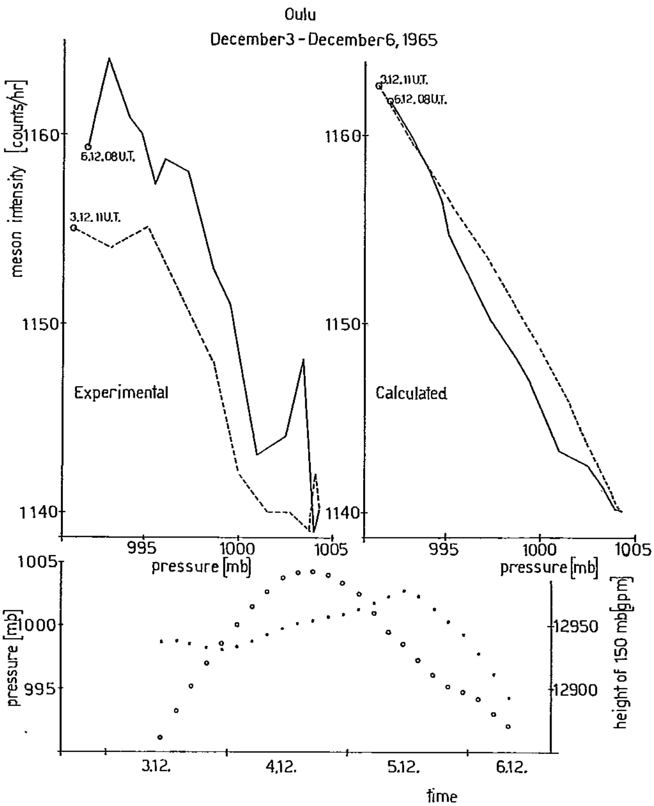

Fig. 3. Experimental and calculated graphs of μ-meson variations as a function of mean pressure and mean pressure and height of 150 mb as a function of time from the 3rd to the 6th of December

—— pressure decrease
- - - - pressure increase
o mean pressure
● height of 150 mb

the pressure decrease the intensity has increased. At the same time the neutron intensity has increased 0,5%, but it can hardly explain the difference between the loops.

The foregoing three examples illustrate how the number of μ-mesons varies during rapid pressure variations. In general the character of the phenomena is as in Figure 1. The examples show that in studying variations of short duration one should take into consideration the changes in the whole atmosphere. Also it is desirable to have data from more than two meteorological soundings every day.

When comparing Duperier's model to other models it has been proved that its results are comparable with these calculated using more exact but more complicated methods [5]. The examples presented here show also that Duperier's simple linear model is accurate enough.

In this work it was supposed that the variations of the pressure-corrected neutron data describe variations in primary cosmic radiation. It has been observed that the energy regions of μ-meson and neutron components do not coincide in small energy values [6]. The results of this work show that neutron monitor data can be used to some extent to explain primary cosmic ray variations in connection with the meson telescope.

When long period cosmic ray variations are studied, short periods with geomagnetic disturbances are often neglected. In accordance with the results of this work the periods with very rapid pressure variations should also be disregarded, if the data have been corrected only for barometric pressure.

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