COSMIC RAYS AND AIR MASS EFFECTS AT MACQUARIE ISLAND*

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In a recent paper (Jacklyn 1954) it was shown that the barometer coefficient for cosmic rays at Macquarie Island varied consistently according to the type of air mass present over the station. This was found to be due to the different average values of $\delta H/\delta B$ (the rate of change of the height of the assumed production level for mesons with surface pressure) in the two air mass types considered. For temperate air $\delta H/\delta B$ was practically zero ($+0 \cdot 0002$ per cent./mb)

TABLE 1

REGRESSION OF HEIGHT ON SURFACE PRESSURE

Pressure level (mb)	800	600	400	200	100
Polar air $\delta H/\delta B$ (km/mb $\times 10^2$) . .	$+0\cdot 85$	$+0\cdot 975$	$+1\cdot 128$	$+1\cdot 189$	$+1\cdot 341$
r	$0\cdot 992$	$0\cdot 963$	$0\cdot 917$	$0\cdot 904$	$0\cdot 833$
Temperate air $\delta H/\delta B$ (km/mb $\times 10^2$)	$+0\cdot 762$	$+0\cdot 701$	$+0\cdot 640$	$+0\cdot 366$	0
r	$0\cdot 958$	$0\cdot 875$	$0\cdot 686$	$0\cdot 330$	$0\cdot 106$

* Manuscript received August 30, 1954.

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and for polar air had the value $+0 \cdot 1028$ per cent./mb. Since then, an analysis of these air mass types has shown why one should expect the ratio to vary in the way it does.

For each type of air mass the total regression of height H on surface pressure B was calculated for the following pressure levels: 100, 200, 400, 600, and 800 mb, using data obtained from the daily radiosonde flights at Macquarie Island. The regression and correlation coefficients are set out in Table 1.

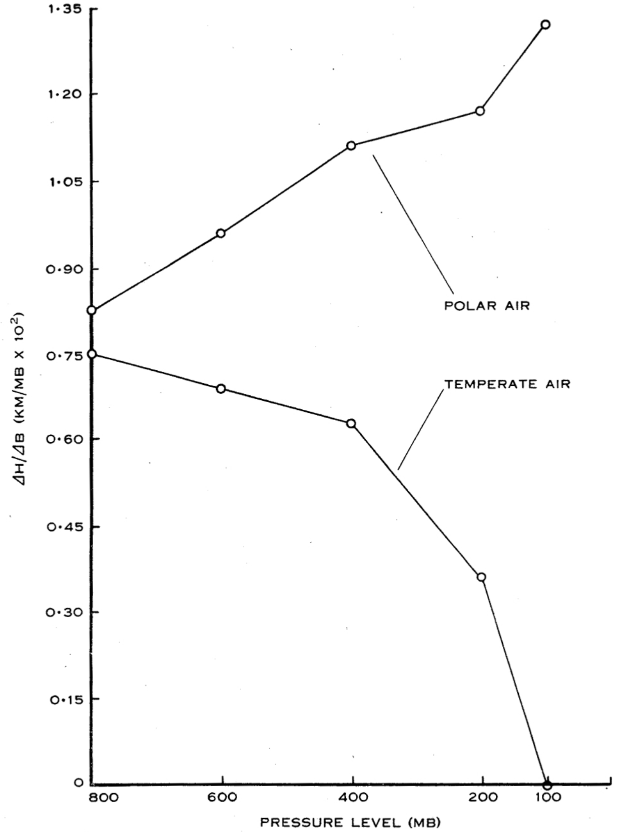

Fig. 1.—Variation of height H of pressure level per millibar increase of surface pressure B, for the series of pressure levels 800, 600, 400, 200, 100 mb, under polar and temperate air mass conditions.

From these, and from Figure 1, it can be seen that $\delta H/\delta B$ progressively increases as one proceeds upwards in polar air, and in temperate air it progressively decreases. In other words, there is a tendency for polar air to expand at all levels, and for temperate air to contract, as surface pressure increases.

If then, the height of production, H, of mesons, is considered as a function of the mean atmospheric temperature θ and the surface pressure B, and we have

$$\frac{\mathrm{d}H}{\mathrm{d}B}=\left(\frac{\partial H}{\partial \theta}\right)_B \frac{\mathrm{d}\,\theta}{\mathrm{d}B}+\left(\frac{\partial H}{\partial B}\right)_\theta,$$

it seems that $d\theta/dB$, the rate of expansion with surface pressure, would be positive in polar air and negative in temperate air. As a measure of the mean atmospheric temperature θ, the thickness of the atmosphere between 100 and 1000 mb was taken, and the regression coefficient $d\theta_P/dB$ and $d\theta_T/dB$ were found, the suffixes P and T referring to polar and temperate air respectively. The values were

$$\frac{d\theta_P}{dB} = +0\cdot521 \times 10^{-2} \text{ km/mb},$$

$$\frac{d\theta_T}{dB} = -0\cdot808 \times 10^{-2} \text{ km/mb}.$$

A check on the consistency of the figures can be made if it is assumed that $(\partial H/\partial\theta)_B$ and $(\partial H/\partial B)_\theta$ are constants ; then

$$\frac{\delta H_P}{\delta B} - \frac{\delta H_T}{\delta B} = \left(\frac{\partial H}{\partial \theta}\right)_B \left(\frac{d\theta_P}{dB} - \frac{d\theta_T}{dB}\right).$$

Knowing the values of $\delta H_P/\delta B$ (approximately $+1\cdot34 \times 10^{-2}$ km/mb) and $\delta H_T/\delta B$ (approximately 0 km/mb) arrived at from the radiosonde data independently of the temperature coefficients, $(\partial H/\partial\theta)_B$ is found to be $1\cdot01$, close to the expected value of unity (i.e. the method of measurement of θ implies that δH and $\delta\theta$ may each be considered as a measure of the variation of the depth of the atmosphere between 100 and 1000 mb at constant surface pressure).

It seems that these effects are characteristic of the pattern of weather associated with the passage of cold fronts at Macquarie Island during winter ; that is, general atmospheric warming of temperate air precedes the arrival of the low, and is followed again by atmospheric warming of polar air accompanied by increasing surface pressures, after the front has passed. Presumably, this is true of other places where marked increases of cosmic ray intensities, " corrected " for pressure, have followed the passage of cold fronts. Since the Macquarie Island measurements agree substantially with those found by Loughridge and Gast (1940), using a shielded ionization chamber at sea off the west coast of North America, a similar maritime weather pattern probably held there. But Nishina *et al.* (1940), using an ionization chamber at Tokyo, found no significant effect for cold fronts, and this may have been due to the modifying effect of the neighbouring land on the atmospheric temperature characteristics of the air masses.

The author would like to thank Professor A. L. McAulay, Dr. A. G. Fenton, and Mr. N. R. Parsons for several helpful discussions, and Mrs. P. James for her assistance with the computations. The data used were obtained from the records of the Australian National Antarctic Research Expedition.

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