SHORT COMMUNICATIONS

SUDDEN INCREASES IN COSMIC RAY INTENSITY*†

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At different times during a period of continuous recording of cosmic rays large increases in the intensity of cosmic radiation have been observed. Most of these are associated with formations on the visible side of the Sun. However, there are two exceptions: Carmichael *et al.* (1961) believe that the November 20, 1960 increase in intensity was due to a solar flare on the reverse side of the Sun, and Sud (1968) has shown that the intensity increase of January 28, 1967 also may not be connected with chromospheric eruptions on the visible side of the Sun.

Dorman, Koridze, and Shatashvili (1965) looked at data from Sulphur Mountain and Climax stations for sudden increases in cosmic ray intensity that were not associated with visible formations. The period covered in their study was the IGY and they looked at the data of five geomagnetically most disturbed days in a month. They selected those events for which the difference in intensity I in successive 2-hr intervals was 1% or more at Climax, that is, $I_{i+1} - I_i \geqslant 1\%$, where $i = 1, 2, 3, \ldots, 12$. They found 36 cases of almost simultaneous increase at Climax and Sulphur Mountain during the IGY period. Alania *et al.* (1965*b*) showed that these increases occur more frequently near local noon, while Alania *et al.* (1965*a*), using the data of Climax and Mt. Norikura from 1957 to 1964, found that the phase of the frequency distribution maximum remains unchanged around 12 hr local time.

TABLE 1

COSMIC RAY INTENSITY INCREASES REGISTERED DURING 1966

Station	Geographic Latitude (°)	Geographic Longitude (°)	Height above Sea Level (m)	Vertical Cutoff Rigidity (GV)	Poisson Error per Hour (±%)	Number of Increases > 1%
Deep River	46·1	282·5	145	1·02	0·07	9
Churchill	58·8	265·9	39	0·21	0·12	23
Kerguelen	−49·4	70·2	0	1·19	0·11	200
Mt. Norikura*	36·1	137·6	2270	11·39	0·25	30
Mt. Washington	−42·6	147·1	725	1·89	0·41	>1000
Ottawa	45·4	284·4	101	1·08	0·70	>2000
Pic du Midi	42·9	0·3	2860	5·36	0·06	17

* Data are bihourly and $\Delta I \geqslant 0\cdot6\%$.

In the present work, we subjected the pressure-corrected hourly neutron data of 1966 from widely distributed stations to a similar analysis, i.e. we looked for

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increases of the type $I_{i+1}-I_i \geqslant 1\%$, where $i = 1, 2, 3, \ldots, 24$. We did not select any particular days, but subjected all the data to this analysis. The data from Mt. Norikura are bihourly and as we did not find any increase $\geqslant 1\%$ in these data we changed our criterion for this station to $I_{i+1}-I_i \geqslant 0 \cdot 6\%$, $i = 1, 2, 3, \ldots, 12$. Statistical considerations show that an hourly increment of 1% will be found with more probability in a bihourly increment of 0·6%.

Table 1 gives particulars about the stations whose data were analyzed and also the number of increases of this type observed. When counting the number of increases we neglected those that took place on July 7, 1966, as Ahluwalia, Sud, and Schreier (1968) reported an intensity increase associated with a solar flare on that day. It is obvious that, with the exception of Kerguelen, the number of increases observed is larger for stations whose data have larger Poisson errors.

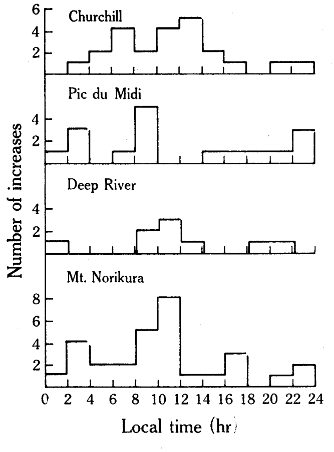

Fig. 1.—Frequency distribution of sudden cosmic ray intensity increases with $\Delta I_i \geqslant 1\%$ for Churchill (0 L.T. = 6 U.T.), Pic du Midi (0 L.T. = 0 U.T.), Deep River (0 L.T. = 7 U.T.), and with $\Delta I_i \geqslant 0 \cdot 6\%$ for Mt. Norikura (0 L.T. = 15 U.T.).

Figure 1 shows the frequency distribution of sudden increases of cosmic ray intensity for Deep River, Mt. Norikura, Churchill, and Pic du Midi stations. It is apparent that the maximum of the frequency distribution is between 9 and 13 hr local time. This is in agreement with the findings of Alania *et al.* (1965*a*). Although for Pic du Midi and Deep River there are few events, it seems that the maximum frequency distribution is still between 9 and 13 hr local time, which is in agreement with the interval of most probable error. With this error the maximum of the frequency distribution is found to be 11±03 hr 40 min for all the data of the four stations.

To check further on these increases, we also looked at the data from Sulphur Mountain (51·2° N., 115·5° W.) and Calgary (51·08° N., 114·09° W.). The reasons for choosing these stations were that both operate super-neutron monitors (Poisson error ~0·1%) and both have similar threshhold rigidity and almost identical asymptotic cones of acceptance. Their altitudes are 2283 and 1128 m respectively. The data of five geomagnetically most disturbed days in a month were considered. In addition we took into account the data of those days on which Deep River has registered an increase of this type. Table 2 gives the days and hours of the observed increases for Sulphur Mountain, Calgary, and Deep River. The results from Deep River are without any type of day selection.

Looking at the plots of the data from Alert, Deep River, Goose Bay, and Inuvik (Steljes 1967), we find that, with the exception of increases on days 3 and 120, all other increases reported in Table 2 occur during Forbush decreases, and it

TABLE 2

TIME AT WHICH LARGE INCREASES WERE RECORDED DURING 1966 AT SULPHUR MT., CALGARY, AND DEEP RIVER

Sulphur Mountain		Calgary		Deep River	
Day	Hour (U.T.)	Day	Hour (U.T.)	Day	Hour (U.T.)
				3	18
				120	17
20	20			20	19
		21	16		
		22	3		
		23	9		
				82	21
85	19	85	19		
87	22	87	22		
91	18			91	18
		92	7		
245	16				
246	9	246	13	246	8
246	16				
246	19				
250	20	250	20		
251	16				
266	18	266	19	266	16
347	16	347	16		
348	6	348	6	348	3
348	7	348	7	348	4

appears that these increases could be a usual feature of the Forbush phenomenon. Probably the effect is wide spread if either the accompanying storm is of high intensity or a few smaller storms follow each other in quick succession.

In conclusion we may say that it would be worth while looking for sudden increases that are not associated with solar flares and also do not form a part of the recovery phase of Forbush decreases in the data from high counting rate instruments.

We would like to thank all the investigators whose data have been used for this analysis.

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