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A SUGGESTED STANDARDIZED FORMAT FOR COSMIC RAY GROUND-LEVEL EVENT DATA

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ABSTRACT

A standardized format is suggested for the archival and exchange of neutron monitor data obtained during solar-flare-initiated ground-level cosmic ray events. Using the data for the 7 May 1978 ground-level event, we have developed a format that incorporates hourly data preceding and following the event and small-time interval data immediately before and during the event. Provision has been made for the inclusion of uncorrected and corrected data as well as the atmospheric pressure. The cosmic ray intensity data are then reduced to a standard counting rate of counts per second facilitating the graphing and comparison of these data for various analyses.

1. Introduction. Thirty-four relativistic solar proton events have been detected by ground-based neutron monitors since 1955. These events are intensely studied not only for the physics of the flare process, but also for information on relativistic solar particle propagation in the interplanetary medium and entry into the magnetosphere. The first ground-level cosmic ray event detected by neutron monitors on February 23, 1956, was so unexpected and unique that many scientific papers were written on the measurements at just one station. However, the events of May and November 1960 illustrated the necessity of utilizing data from the world-wide neutron monitor network to study interplanetary and magnetospheric propagation characteristics.

Unfortunately one of the most time-consuming tasks in the analysis of multi-station ground-level event data is the collection and assembly of these data into a common useable format since most cosmic ray stations use their own unique data collection system regarding time intervals, scaling factors, and normalization factors. Since the rapid and efficient exchange of data relating to solar-flare-initiated ground-level events would be practical and beneficial to the community, we have developed a format that includes the parameters that cosmic ray scientists use in the analysis of these relatively unusual events, and suggest that this format be adopted as a standard for the archival and exchange of these data.

2. Method. To develop a useful format we first identified the data we felt were essential for the analysis of any ground-level cosmic ray event that utilizes the data from the world-wide neutron monitor network. These included sufficient data to establish a pre-event level, small time increments during the rising and maximum portion of the event, and both uncorrected and corrected data to permit use of the two-attenuation

method of correcting the solar flare particle spectrum for atmospheric effects (McCracken, 1962). Using neutron monitor data from 32 stations for the ground-level cosmic ray event of 7 May 1978, we proceeded to identify the data we felt should be included as follows:

6 May 1978: 0000-2400 UT 7 May 1978: 0000-0200 UT	}	Hourly data (uncorrected data) (corrected data) (barometric pressures)
7 May 1978: 0200-0700 UT	}	Small time interval data (uncorrected data) (corrected data) (barometric pressures)
7 May 1978: 0700-2400 UT	}	Hourly data (same as above)

The hourly data for the day preceding the event would permit consideration of any unusual daily variations that might be present for some stations. The small time interval data, which are station specific, would give information on the rate of rise and maximum intensity, as well as a portion of the decay of the event. The hourly data for the remainder of 7 May would cover the complete decay of the event for all stations. In order to be able to compare cosmic ray intensities both throughout the event and between stations, we adopted a standard counting rate in units of counts per second. This necessitated utilizing multiplication factors and/or normalization factors for each individual station. However, the advantange of this procedure is that odd time intervals, such as changes from hourly to five-minute or one-minute data, can be easily compared. The following format was adopted:

Columns 1 - 10:	Station identification (alphanumeric)
Columns 11 - 19:	Year, month and day (3I3)
Columns 20 - 23:	Number of minutes in this time interval (I4)
Columns 24 - 33:	Time interval included (I5, 1H-, I4)
Columns 34 - 50:	Uncorrected counting rate; counts per second (6X,F11.2)
Columns 51 - 57:	Barometric pressure (F7.1)
Columns 58 - 68:	Corrected counting rate; counts per second (F11.2)
Columns 69 - 75:	Percentage increase (F7.1) normalized to some pre-event level.

Table 1 illustrates a portion of the data for Leeds, UK. The intensity for the hour immediately preceding the increase (i.e., 0200-0300 UT) was selected as the pre-event level. Figure 1 illustrates the cosmic ray intensity increase for this same station. Notice that this method allows inclusion of "odd" time intervals such as the 3-minute value obtained prior to the activation of the flare alarm rapid time recorder.

3. Discussion. In compiling these data into a standard format it became evident that much of the data we wanted to include was not available from the data that had been exchanged among various investigators. The following data were most commonly found to be missing: all data for the day prior to the event, uncorrected data throughout the event, and data multiplication and/or normalization factors. Data given for different time intervals without any notation as to changes in multiplication and/or normalization factors were extremely difficult to include. In the case of Hermanus, hourly data were given for four sections of the

Table 1. An example of the ground-level event data, in the proposed standard format, for 0000-0500 UT for the event on 7 May 1978. Only a portion of the complete data set for the Leeds neutron monitor is shown. The time interval of 0200-0300 UT was selected as the pre-event level.

STATION	YY	MM	DD	MIN	TIME SPAN	UNCOR.	PRES.	COR.	% INC.
LEEDS	78	05	07	60	0000-0100	167.97	751.7	170.42	-.1
LEEDS	78	05	07	60	0100-0200	178.19	751.6	170.50	-.1
LEEDS	78	05	07	5	0200-0205	178.67	751.5	170.67	.0
LEEDS	78	05	07	5	0205-0210	175.67	751.5	168.00	-1.5
LEEDS	78	05	07	5	0210-0215	178.33	751.6	170.67	.0
LEEDS	78	05	07	5	0215-0220	178.00	751.6	170.33	-.2
LEEDS	78	05	07	5	0220-0225	178.67	751.6	171.00	.2
LEEDS	78	05	07	5	0225-0230	180.33	751.6	172.67	1.2
LEEDS	78	05	07	5	0230-0235	178.67	751.6	171.00	.2
LEEDS	78	05	07	5	0235-0240	177.67	751.5	170.00	-.4
LEEDS	78	05	07	5	0240-0245	180.00	751.5	172.00	.8
LEEDS	78	05	07	5	0245-0250	179.33	751.5	171.33	.4
LEEDS	78	05	07	5	0250-0255	177.33	751.5	169.67	-.6
LEEDS	78	05	07	5	0255-0300	178.00	751.5	170.33	-.2
LEEDS	78	05	07	5	0300-0305	178.67	751.5	170.67	.0
LEEDS	78	05	07	5	0305-0310	177.67	751.5	170.00	-.4
LEEDS	78	05	07	5	0310-0315	179.67	751.6	172.00	.8
LEEDS	78	05	07	5	0315-0320	176.00	751.6	168.33	-1.4
LEEDS	78	05	07	5	0320-0325	179.00	751.6	171.33	.4
LEEDS	78	05	07	5	0325-0330	179.67	751.6	172.00	.8
LEEDS	78	05	07	5	0330-0335	179.00	751.6	171.33	.4
LEEDS	78	05	07	3	0335-0338	217.22	751.6	207.78	21.8
LEEDS	78	05	07	1	0338-0339	301.67	751.6	288.33	69.0
LEEDS	78	05	07	1	0339-0340	316.67	751.6	303.33	77.8
LEEDS	78	05	07	1	0340-0341	331.67	751.6	316.67	85.6
LEEDS	78	05	07	1	0341-0342	328.33	751.6	315.00	84.6
LEEDS	78	05	07	1	0342-0343	315.00	751.6	301.67	76.8
LEEDS	78	05	07	1	0343-0344	308.33	751.6	295.00	72.9
LEEDS	78	05	07	1	0344-0345	300.00	751.6	286.67	68.0
LEEDS	78	05	07	1	0345-0346	293.33	751.6	280.00	64.1
LEEDS	78	05	07	1	0346-0347	288.33	751.6	276.67	62.1
LEEDS	78	05	07	1	0347-0348	280.00	751.6	268.33	57.2
LEEDS	78	05	07	1	0348-0349	266.67	751.6	255.00	49.4
LEEDS	78	05	07	1	0349-0350	271.67	751.5	260.00	52.4
LEEDS	78	05	07	1	0350-0351	260.00	751.5	248.33	45.5
LEEDS	78	05	07	1	0351-0352	258.33	751.5	246.67	44.6
LEEDS	78	05	07	1	0352-0353	240.00	751.5	230.00	34.8
LEEDS	78	05	07	1	0353-0354	245.00	751.5	235.00	37.7
LEEDS	78	05	07	1	0354-0355	240.00	751.5	230.00	34.8
LEEDS	78	05	07	1	0355-0356	238.33	751.5	228.33	33.8
LEEDS	78	05	07	1	0356-0357	235.00	751.5	225.00	31.9
LEEDS	78	05	07	1	0357-0358	228.33	751.5	218.33	27.9
LEEDS	78	05	07	1	0358-0359	220.00	751.5	210.00	23.1
LEEDS	78	05	07	1	0359-0400	226.67	751.5	216.67	27.0
LEEDS	78	05	07	1	0400-0401	220.00	751.5	210.00	23.1
LEEDS	78	05	07	1	0401-0402	211.67	751.5	201.67	18.2
LEEDS	78	05	07	1	0402-0403	211.67	751.5	201.67	18.2
LEEDS	78	05	07	1	0403-0404	215.00	751.5	205.00	20.1
LEEDS	78	05	07	1	0404-0405	213.33	751.5	203.33	19.2
LEEDS	78	05	07	5	0405-0410	205.67	751.5	196.67	15.3
LEEDS	78	05	07	5	0410-0415	199.00	751.5	190.33	11.5
LEEDS	78	05	07	5	0415-0420	194.33	751.5	186.00	9.0
LEEDS	78	05	07	5	0420-0425	192.67	751.6	184.33	8.0
LEEDS	78	05	07	5	0425-0430	189.00	751.6	181.00	6.1
LEEDS	78	05	07	5	0430-0435	186.33	751.6	178.33	4.5
LEEDS	78	05	07	5	0435-0440	184.00	751.6	176.00	3.1
LEEDS	78	05	07	5	0440-0445	186.00	751.6	178.00	4.3
LEEDS	78	05	07	5	0445-0450	184.33	751.6	176.33	3.3
LEEDS	78	05	07	5	0450-0455	185.33	751.6	177.33	3.9
LEEDS	78	05	07	5	0455-0500	183.00	751.6	175.00	2.6

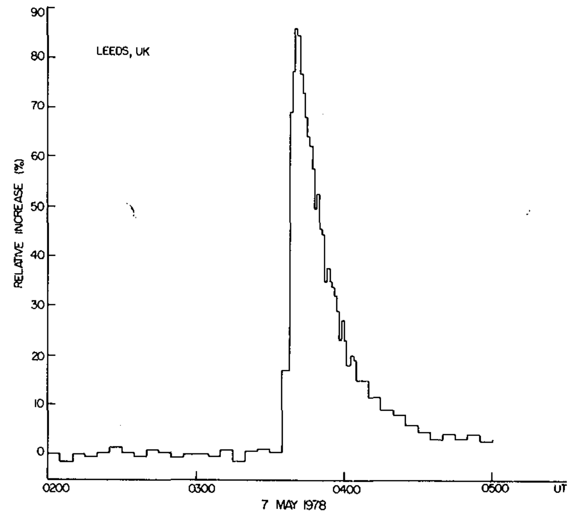

Figure 1. Relative increase recorded by the Leeds, UK neutron monitor for the 7 May 1978 ground-level event.

monitor, but the flare data only included three sections. When the proper normalization factors are obtained, we will be able to include these data in the standard format. Another problem was encountered with small-time interval data corrected for small-time increments, which, when summed over the hour, were not in agreement with the listed hourly data. The use of local time instead of Universal Time without any notation as to the difference between these times also caused some difficulty. Some stations in the Soviet Union listed hourly data in Universal Time and small-time interval data in local time; some also listed hourly time for the hour ending with the indicated time, but small-time interval data were listed at the start of the interval. Consequently we utilized information available from the World Data Center records and from previously published tables to complete, as much as possible, a uniform set of tables for the 32 neutron monitors.

4. Future Plans. We plan to complete and publish the uniform set of tables for the 7 May 1978 ground-level event, at the same time work is progressing on similar tables for the following events: 21 August 1979, 12 October 1981, 8 December 1982, and 16 February 1984. To complete some of these tables it will be necessary to contact the principal investigator; we would appreciate cooperation in supplying the data requested. We also anticipate compiling similar records for as many of the 34 ground-level events as time (and patience) permits. We are afraid that many of the records for the earlier events, particularly those prior to this solar cycle, may be difficult to obtain. Therefore, we request all cosmic ray physicists who have ground-level event data for either their own or other cosmic ray stations to send the data to any of the authors of this paper and to the World Data Centers for archival in an effort to preserve this historical data set.

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References

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