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Ground-Level Solar Cosmic Ray Data from Solar Cycle 19

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Abstract

We have recently begun a two-year project to compile ground-based cosmic ray detector data for the major ground-level proton events of Solar Cycle 19. Many of these unique datasets have been published, but much small-time-resolution data exist in uncatalogued notebooks, etc.

The largest events (2/23/56, 5/4/60, and 11/12&15/60), will be catalogued, verified and deposited in the data center. Many of these records are in primitive form, (strip charts, film, graphs); much of the data was used for specific analyses at the time. The major 1961 events will be catalogued, but further verification will be postponed, pending future funding.

It is important to compile these data since they have not been adequately modeled using modern techniques, because of a lack of a reliable database. Our primary goal is to compile such a comprehensive database, allowing new analyses of these events. This project is funded by grants from NASA's Data Restoration Program.

1 Introduction:

We have recently started a two-year project to compile neutron monitor data for the major ground-level proton events (GLEs) of Solar Cycle 19. While a few of these unique datasets have been published, most of the data, particularly data for small time intervals, exist in uncataloged notebooks and private data collections. Although much of the data was used for specific analysis at the time of the events, many of these records have been stored in relative primitive form such as strip charts, film, graphs, etc.

The relativistic solar proton events of the 19th solar cycle were not only the first GLEs recorded by neutron monitors but also some of the largest GLEs since 1955. These events have not been adequately modeled using modern techniques and theories because of the unavailability of a reliable and easily accessible database. The goal of this project is to compile the data for some of the major GLEs of the 19th solar cycle, allowing new analyses of these events. This paper presents an overview and status report of this project.

2 Identification of Events:

Ten ground-level events were identified by neutron monitors during the 19th solar cycle. The GLE of 23 February 1956, with an increase of over 4000% recorded at Leeds, UK, remains the largest GLE since the advent of neutron monitors. In addition to being some of the largest events since 1955, the events exhibited a variety of time-intensity profiles from classic "fast rising-rapid decay" to extremely complex particle behavior. These events also occurred during both quiet and extremely disturbed interplanetary and geomagnetic conditions. Table 1 lists the 10 GLEs and the approximate increases recorded by high latitude neutron monitors.

3 Cataloging Procedures:

Neutron monitor data records are being obtained and examined to determine what data exist for the events of 23 February 1956, 4 May 1960, and the three events in November 1960. We are particularly interested in small time interval data which can be utilized to identify the times of onset and maximum inten-

sity as well as unusual flux variations. Table 2 lists the data we have already located for the five major events. Very few neutron monitors were operating during the 23 February 1956 event, and the data are relatively limited. Many more neutron monitors were in operation during 1960 although, at the present time, we do not have small time-interval data for many of these stations. In several cases bi-hourly data are the only records we have located. Small-time intervals, for the purposes of this table, include intervals from 1 minute to 30 minutes. Much of the earlier recording devices acquired data in 15-minute intervals although, in some cases, strip charts were available for smaller intervals.

Our plans are to codify as much as these data as possible into the standard GLE format (Gentile, 1993). The data records will not be as complete as those acquired during the events of the 22nd solar cycle since some parameters such as barometric pressure and uncorrected data have been lost. Nevertheless, this effort is expected to produce a useful and more easily accessible database for studies of these unusual events. Throughout this process we also expect to acquire information on data availability for the remaining five GLEs during solar cycle 19 in addition to information on muon and ionization data for the 23 February 1956 event. Only two events since 1955 (23 February 1956 and 29 September 1989) have significant increases recorded by muon monitors and ionization detectors. Unfortunately, funding resources do not permit the cataloging of these data at this time.

4 Specific Request to the Cosmic Ray Community:

We have not yet been able to acquire data from all neutron monitors in operation during the time periods of interest. Cosmic ray scientists are requested to search their laboratory notebooks and personal archives to aid us in this project. In addition to the small time-interval data we need for this project, there are some stations (e.g. Tbilisi) for which we have no data at all, even though it was in operation in 1960. Copies of data records can be sent to any of the above authors.

5 Summary:

Neutron monitor data are being acquired for the major ground-level events that occurred in the 19th solar cycle. Our primary goal is to compile a comprehensive database for new analyses of these unique solar proton events. The database will be deposited in the World Data Centers at which time they will be available to the scientific community.

6 Acknowledgements:

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References

Gentile, L.C., 1993, J. Geophys. Res., 98, 21,107.

Table 1

Date	Increase (%)	Station
23 Feb 1956	4554	Leeds, UK
31 Aug 1956	3	Chicago, USA
17 Jul 1959	10	Resolute, Canada
4 May 1960	290	Churchill, Canada
3 Sep 1960	4	Murmansk, Russia
12 Nov 1960	135	Thule, Greenland
15 Nov 1960	160	Mawson, Antarctica
20 Nov 1960	8	McMurdo, Antarctica
18 Jul 1961	24	Thule, Greenland
20 Jul 1961	7	Ottawa, Canada

Table 2. Data Received for Five Major GLE's in Solar Cycle 19

Station	**23 Feb 1956**	**4 May 1960**	**12 Nov 1960**	**15 Nov 1960**	**20 Nov 1960**
Ahmedabad	---	BH	H	H	BH
Albuquerque	H, ST	---	---	---	---
Alma Ata-A	---	---	BH	BH	BH
Bergen	---	H	H	H	H
Berkeley	---	ST*	BH	BH	BH
Buenos Aires	---		H, ST	H, ST	H
Chacaltaya	---	---	H, ST	H, ST	H
Chicago	H, ST	BH	BH, ST	BH, ST	BH
Churchill	---	H, ST	H	H	H
Climax	H, ST	H	H, ST	H, ST	H
College	---	H, ST	BH, ST	BH, ST	BH, ST
Deep River	---	H, ST	H, ST	BH	BH
Durham			BH, H	BH	
Ellsworth	---	ST*	H, ST	BH, ST	H, ST
Halle	---	BH	BH	BH	BH
Heiss Island	---	BH	BH	BH	BH
Hermanus	---	BH, ST	BH, ST	BH, ST	BH
Herstmonceux	---	BH, ST	---	---	---
Hobart	---	---	H	H	
Huancayo	H, ST	H	H, ST	H, ST	H
Irkutsk	---	BH	BH	BH	BH
Jungfraujoch	---	H	H, ST	H, ST	H
Kerguelen Is.	---	BH	BH, ST	BH, ST	BH
Kiel	---	BH	BH	BH	BH
Kodaikanal	---	BH	BH	BH	BH
Lae	---	H	H	H	H
Leeds	H, ST	BH, ST	BH, ST	BH, ST	BH
Limeil	---	**	**, ST	**, ST	**
Lincoln	---	BH	BH	BH, ST	BH
Lindau	---	BH, ST	BH, ST	BH, ST	BH
Lomnicky Stit	---	BH	---	---	---

London	---	---	BH, ST	BH, ST	BH
Makapuu	---		BH	BH	BH
Makerere	---	BH			
Mawson	---	H, ST	H, ST	H, ST	H, ST
McMurdo	---	H	H, ST	H, ST	H
Mexico City	ST*		ST	H, ST	
Mina Aguilar	---	H	H, ST	H, ST	H
Mirny	---		H	H	BH
Moscow	---	BH	BH	BH	BH
Mt. Washington		H, ST	H, ST	H	H
Mt. Wellington	---	H, ST	H, ST	H, ST	H
Munich	---	BH	BH, ST	BH, ST	BH
Murmansk	---	BH	BH	BH	BH
Nera	---	BH	H, ST	H, ST	H
Nt. Norikura	BH	BH	BH	BH	BH
Ottawa-1	H, ST	H, ST	H	H	H
Ottawa-2	H, ST				
Pic du Midi	---	BH	BH, ST	BH, ST	BH
Prague	---	BH	BH, ST	BH, ST	BH
Resolute	---	H, ST	H	H	H
Rio de Janeiro	---	BH	H	H	H
Rome	---	BH, ST	BH	BH	BH
Sacramento Peak	ST*	H	H, ST	H	H
Schauinsland	---	H	H	H	H
Sulphur Mt.	---	BH, ST	BH	BH	BH
Syowa	---	BH, ST	BH	BH	BH
Thule	---	BH, ST	H, ST	BH, ST	BH
Uppsala	---	H	H, ST	H, ST	H
Ushuaia	---		H, ST	H, ST	H
USS Arneb	ST	---	---	---	---
Yakutsk	---	BH	BH	BH	BH
Zugspitze	---	BH, ST	BH	BH	BH

Codes:

BH = Bihourly data
H = Hourly data
ST = Small-time interval data
* = Extremely limited data
** = 4-hourly data.

Notes: The dashed line indicates that the station was not in operation.
Small time-interval data are from 1-minute to 1800 minute intervals.