Readme: Cosmic Rays

Cosmic Rays

Cosmic rays are energetic particles that are found in space and filter through our atmosphere. Cosmic rays have interested scientists for many different reasons. They come from all directions in space, and the origination of many of these cosmic rays is unknown. Cosmic rays were originally discovered because of the ionization they produce in our atmosphere. Cosmic rays also have an extreme energy range of incident particles, which have allowed physicists to study aspects of their field that cannot be studied in any other way.

In the past, we have often referred to cosmic rays as "galactic cosmic rays" because we did not know where they originated. Now scientists have determined that the sun discharges a significant amount of these high-energy particles. "Solar cosmic rays" (cosmic rays from the sun) originate in the sun's *chromosphere*. Most solar cosmic ray events correlate relatively well with solar flares.

Scientists have postulated that cosmic rays can affect the earth by causing changes in weather. Cosmic rays can cause clouds to form in the upper atmosphere, after the particles collide with other atmospheric particles in our troposphere. The process of a cosmic ray particle colliding with particles in our atmosphere and disintegrating into smaller pions, muons, and the like, is called a *cosmic ray shower*. These particles can be measured on the Earth's surface by neutron monitors.

Cosmic rays affect satellite electronics and ground-based computer systems at high altitudes. The following text is taken the IBM Journal #40 by Zigler and Srinivasan (1996), "Modern electronic circuits are highly complex systems and, as such, are susceptible to occasional errors or failures. In addition to permanent hardware failures, electronic components are subject to random transient errors which originate from various electronic noise sources. In digital electronics, errors which are not caused by permanent damage to the circuits are referred to as *soft errors, soft fails,* or *single-event upsets*. This issue of the *IBM Journal of Research and Development* focuses on studies of soft errors in computer chips caused by cosmic rays at terrestrial altitudes. Soft errors caused by radioactive contaminants are also considered, but emphasis is placed on the experimental, theoretical, and modeling aspects of cosmic-ray-induced soft errors in computer chips." Engineers can find useful information about soft errors in electronics from cosmic rays at the Particle Interactions with Matter website. High energy particles affect airplane passengers – the Federal Aviation Administration (FAA) has an online calculator for determining galactic radiation received in flight. These effects are especially augmented during large solar particle events. During these times, polar flights are generally diverted to lower latitude flight paths.

AVAILABLE DATASETS

Dataset: Cosmic-Ray Neutron Data (1953-2012)

Description: Cosmic-ray neutron fluxes (pressure-corrected and level-adjusted) taken by a global network of neutron monitors. Data provided by the World Data Center for Cosmic Rays (WDCCR) at Nagoya University's Solar-Terrestrial Environment Laboratory as a part of the activities of the Climate and Weather of the Sun-Earth System-II (CAWSES-II) program under the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP), International Council for

Science (ICSU). The database includes corrected 1-hour values and plots of monthly averages. Some recent datasets are provisional and it is recommended that interested parties refer to the WDCCR website to obtain the most current datasets. Inquiries should be addressed to Dr. Takashi Watanabe (wdccr@stelab.nagoya-u.ac.jp). When these data are used in scientific publications please refer to this datasets as "Cosmic-ray Neutron Data in 1953-2012, CAWSESDB-J-OB0063" and acknowledge the World Data Center for Cosmic Rays, Solar-Terrestrial Environment Laboratory, Nagoya University.

Dataset: Interplanetary - Cosmic Ray Neutron Monitors (1957-data -- daily and monthly averages from a worldwide network 1953-present ---- Download Data COSMIC RAYS (from SGD Explanation of Data Reports)

Cosmic Ray Tabulated Observations -- The table presents the daily (UT) average counting rates per hour (scaled) for seven high counting rate neutron monitors: Thule, Deep River, Kiel, Climax, Beijing, Tokyo, and Haleakala. The characteristics of the stations are given below; the data are corrected applying the barometric coefficients to the listed standard station pressure.

The Climax, CO, USA, and Huancayo, Peru, (replaced by Haleakala, Hawaii) Neutron Monitor data are communicated by J.A. Simpson and G. Lentz of the Enrico Fermi Institute for Nuclear Studies, University of Chicago. The instruments are standard Chicago type neutron monitors, utilizing 12 BF3, counter tubes, divided into two identical and independent sections. For a more detailed description of the neutron intensity monitors see J.A. Simpson, Annals of the IGY, Vol. IV, Part VII, 351-373, 1957. The publication of these data in this monthly series began September 1960 for Climax and in January 1979 for Huancayo. Hourly averages, both corrected and uncorrected and local pressure data are available in both tabular and digital form for these stations from the WDC-A for Solar-Terrestrial Physics, Boulder, CO.

The Deep River, Ontario, Canada, neutron monitor, follows the IQSY design [IQSY Instruction Manual No. 7 which is published in the Annals of the IQSY, Vol 1, Chapter 13]. Publication of the daily rates in SGD began in January 1966 but a chart of hourly values from Deep River, described below, has been published in SGD since January 1959. Until December 31, 1972, the station was operated and maintained by Atomic Energy of Canada Ltd., but on January 1, 1973, the National Research Council of Canada took over the responsibility for maintenance of the station.

The 18-NM-64 neutron monitor located at Alert, Northwest Territories, Canada, was unique because its asymptotic cone of acceptance in space is less than 10 degrees wide and is aligned within 7 degrees of the spin axis of the Earth. Hence, unlike the stations whose cones of acceptance rotate with the Earth approximately in the plane of the ecliptic, Alert always "looks" into a fixed cone directed northward. It experiences negligible periodic diurnal intensity variation. The monitor at Alert was provided by Atomic Energy of Canada, Ltd., and housed in a building provided by National Research Council of Canada. It is the responsibility of the National Research Council; the day-to-day operation is by courtesy of the Canadian Meteorological Service. The data for Deep River and Alert are now provided by Margaret D. Wilson and M. Bercovitch of the National Research Council of Canada. The original data can be obtained from National Research Council of Canada, Ontario, Canada K1A OR6, or from any of the World Data Centers.

The Thule nucleonic intensity detector, of standard IQSY design, was originally located at the Geopole Station Greenland: latitude 76 degrees 36'N, longitude 68 degrees 48'W, altitude 260m, geomagnetic threshold rigidity essentially zero. At the end of 1976, it was moved to a new site on Thule Air Base. The coordinates are essentially unchanged except that the altitude is now close to sea level. Data acquired after station relocation have been renormalized to be compatible with the earlier data. Thule data are communicated by John W. Bieber, Bartol Research Institute, University of Delaware, Newark, DE 19716 U.S.A. Thule data published in Solar Geophysical Data are preliminary. Final data are released to the World Data Centers and to the scientific community following an annual comprehensive review of instrument status and stability.

The Beijing super-neutron monitor data are available from Prof. Du Heng, WDC-D Space Sciences, Center for Space and Applied Research, Beijing, China. The monitor was set up in 1983 and operated since early 1984. Its counting rate is 20 times as large as that of an IGY neutron monitor. Its statistical accuracy is 4.5 times as large as that of an IGY monitor. Data are exchanged routinely among the WDCs.

Two other monitors, at Kiel (18-NM-64) and Tokyo (36-NM-64), have asymptotic cones of acceptance much different from those given above. Therefore, they can be used to distinguish between UT-dependent and LT-dependent time variations. Higher cutoff rigidities also aid further estimation of rigidity dependence.

The publication in SGD of the Kiel and Tokyo data began with the December 1973 data. The data from both neutron monitors are routinely submitted to the World Data Centers A, B, and C2 for Cosmic Rays as well as to listed researchers. Kiel data have been available since September 1964 and Tokyo (or Tokyo-Itabashi) data since January 1970. Since there were changes in the number of counters, a revision of pressure reduction, and so on, the level of Tokyo data has changed several times. The Kiel data are communicated to Solar-Geophysical Data by K. Takahashi after receiving the Kiel data from K. Rohrs.

Charts -- Variations of cosmic ray intensity are depicted in chart form in SGD for the above stations. The vertical scale lines mark the days of the month in Universal Time. The horizontal scale lines are in intervals of 5% deviation from the arbitrarily chosen 100% reference level for each station. The 100% reference levels are based upon (after barometric correction) 0.6740x106 counts per hour for Deep River, and 0.7132x106 for Alert. For Thule, Kiel, Climax, and Tokyo, the plots represent percentage deviation from the mean intensity of the corresponding 27 days which is taken to be the 100% level.

Cosmic Ray Tabulated Observations -- The tables present the daily (UT) average counting rates per hour (scaled) for about seven high counting rate neutron monitors: Thule, Deep River, Kiel, Climax, Beijing, Tokyo, and Haleakala. The characteristics of the stations are given below; the data are corrected applying the barometric coefficients to the listed standard station pressure.

Cosmic Ray Neutron Monitors

Geographic								
Station	**Lat. North**	**Long. East**	**Cutoff GV***	**Alt. m**	**Scaling Type**	**Scaling Factor**	**Baro. coeff. %/mm Hg**	**Standard press. mm**

								Hg
Thule	76.50	291.30	0.00	44	NM 64	100	0.99	754
Deep River	46.10	282.50	1.07	145	NM 64	300	0.987	747
Calgary	51.08	245.87	1.09	1128	NM 64	300	1.0155	671.1
Kiel	54.34	10.12	2.32	54	NM 64	100	0.961	755
Climax	39.37	253.82	2.97	3400	IGY	100	0.962	504
Beijing	40.08	116.26	9.56	47	NM 64	256	0.75%/mb	624.8
Tokyo	35.75	139.72	11.50	20	NM 64	256	0.888	760.5
Haleakala	20.71	203.07	13.30	3052	NM 64	1000	0.962	518

Calculated by DGRF75 (COSMIC RAY TABLE No.1, ed. WDC-C2 Japan, March 1983).

Hourly data for many stations are available in the Space Physics Interactive Data Resource (SPIDR) database management system -- an inventory of the data is available.

2. Cosmic Ray Forbush Decreases (FDs) from Mt. Washington Observatory 1955-1995 data -- (N44.30 E288.70; Cut-off Rigidity = 1.24 GV; Altitude 1900 m) -- Forbush decreases are abrupt decreases of the background galactic cosmic ray intensity as observed by neutron monitors. They are associated with major plasma and magnetic field enhancements in the solar wind at or beyond the earth. These magnetic field enhancements deflect the background cosmic ray particles. The phenomenon is named after Scott Forbush who studied them extensively.

- Table of YYMMDD and percent decrease of daily averages (text) -- dn/n% less than 3% are not included
    - Plottable x-y file of YYMMDD and percent decrease (text)
    - Supplemental List -- Mt. Washington Forbush decreases -- Remarks are included.

3. Cosmic Ray Ground Level Enhancements (GLEs) 1942-2001 -- M.A. Shea and D.F. Smart -- GLEs are sharp increases in the ground-level cosmic ray count to at least 10 percent above background, associated with solar protons of energies greater than 500 MeV. GLEs are relatively rare, occurring only a few times each solar cycle. When they occur, GLEs begin a few minutes after flare maximum and last for a few tens of minutes to hours. Intense particle fluxes at lower energies can be expected to follow this initial burst of relativistic particles. GLEs are detected by neutron monitors, e.g., the monitor at Thule, Greenland.

- List of GLEs -- includes the event number (1 to 65), event date, and some information about the baseline data used to determine the magnitude of the event.

4. Annals of the IGY Data -- Annals of the International Geophysical Year (IGY) Volumes XXVI (26), XXVII (27) and XXVIII (28), Editor J.A. Simpson, Special Committee for the IGY (CSAGI) Reporter for Cosmic Rays

- Explanation of the IGY Data Tables

- Tables of IGY Cosmic Ray Date, Part I
- Tables of IGY Cosmic Ray Date, Part II
- Tables of IGY Cosmic Ray Date, Part III

NOTE: These cosmic ray data were published in three volumes of the Annals of the IGY. Data were originally stored on 5 1/4 inch floppy diskettes and converted in 2005 to more recent storage media. Originally they were stored on punched cards. Not all station data published in the Annals have been found.

These bihourly cosmic ray databases include Neutron Monitor (46 stations), Cubical Telescope (38 stations), Vertical Telescope (2 stations), Ion Chamber (16 stations), Underground Telescope and Shower Apparatus (1 station) data monitored during the July 1957-December 1959 IGY and International Geophysical Cooperation (IGC) time period.

References

Ziegler, J.F. and G.R. Srinivasan (1996), Terrestrial cosmic rays and soft errors, *IBM Journal of Research and Development*, *40*, p. 133.