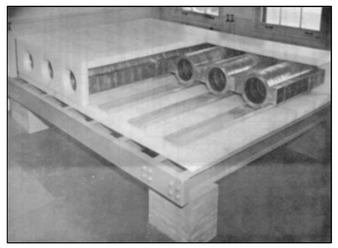
Integration of the UNH Neutron Monitors into the Neutron Monitor Database

Leslie Lamarche; Advisers: Dr. James Ryan and Dr. Marc Lessard

Abstract: Neutron monitors remain the state of the art method for ground-based measurements of the cosmic ray flux on Earth. Cosmic rays consist of high energy particles which travel through the interplanetary medium. In an effort to ease research on cosmic rays and monitor space weather, an international database has been created with the intention of maintaining a standardized record of all neutron monitor data. Here, we discuss efforts made to begin contributing the data from neutron monitors operated by the University of New Hampshire to the neutron monitor database, and the challenges associated with such.



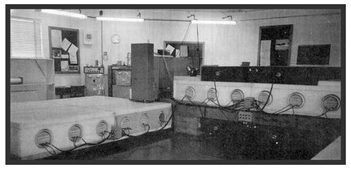


Figure 1: Two neutron monitors. The photo on the left show the interior construction and the heavy metal producers which contain a cavity for the gas detector tubes.
http://cr0.izmiran.rssi.ru/invk/main.htm
http://se-en.crd.yerphi.am/Neutron_Monitors

Neutron Monitors

Neutron Monitors are ground-based instruments used to detect cosmic rays on a global scale. Cosmic rays will interact with air molecules in the upper atmosphere and produce high energy secondary particles. These particles will then interact with other air molecules, creating a cascade of energetic particles through the atmosphere. Once this cascade reaches a surface neutron monitor, the particles will interact with the heavy metal producer in the neutron monitor to produce neutrons, which are then detected by the gas detector tube.

Neutron monitors were first used experimentally by John Simpson in 1947. Since then, they have been installed and operated by many institutions around the world. The University of New Hampshire currently operates two functional neutron monitors – one in Durham, NH, and one in Leadville, CO. In addition, the university is the custodian of historical data from three other neutron monitors – Mount Washington, NH (operational from 1955 to 2006), Climax, CO (operational from 1951 to 2006), and Haleakala, HI (operational from 1991 to 2006). Currently, none of the data from any of these monitors has been contributed to the neutron monitor database.

Cosmic Rays

Cosmic rays consist of high energy subatomic particles, primarily protons or α particles. They generally originate from stars, supernova, or are particles in the interplanetary medium that have been accelerated in some way (shocks or magnetic fields, for instance). Typically, these particles have energies that range from about 100 MeV to about 10 GeV. This wide range is measured from detectors on satellites above Earth's atmosphere. Due to attenuation in the atmosphere, only particles with a high enough incident energy (above 1 GeV) will ever reach the surface of the earth to be detected by neutron monitors. The magnetic field also plays a role in what the minimum energy a particle must have for it to be detected at ground level. At lower latitudes, the magnetic field impedes the motion of charged particles more, so particles must have more energy to create a cascade that will reach the ground.

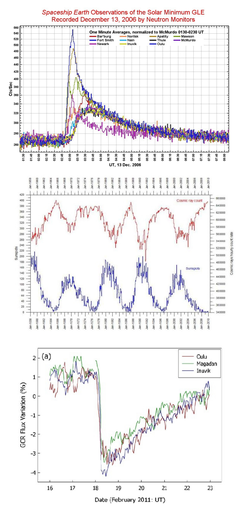


Figure 2: Three events typically studied with neutron monitors: ground level enhancements (GLE) (top), solar modulation (middle), Forbush decreases (bottom). (figure on right)
http://neutronm.bartol.udel.edu/
http://www.mailmagazine24.com/environment-and-climate/02-2012/part4b-dynamic-solar-system-the-actual-effects-of-climate-change.html
http://tallbloke.wordpress.com/2012/08/13/forbush-decreases-caused-by-cmes-are-globally-simultaneous/

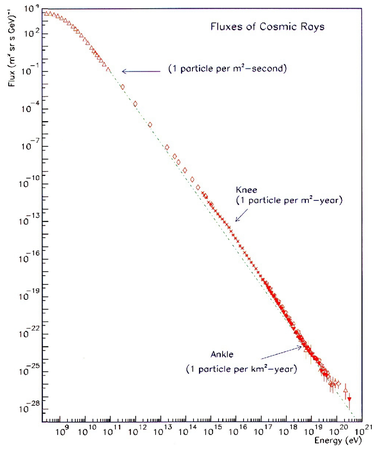


Figure 3: Energy spectrum of cosmic rays.
http://www.lanl.gov/milagro/cosmicrays.shtml

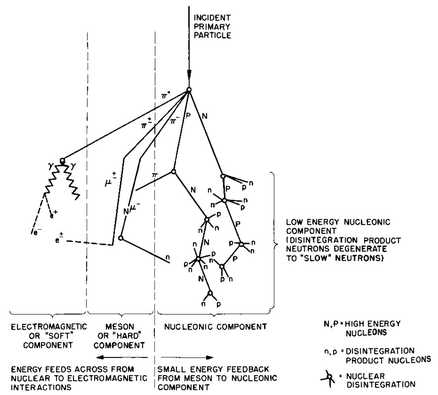


Figure 4: Cascade of particles in the atmosphere from an incident cosmic ray.
http://star.arm.ac.uk/climate/

Neutron Monitor Database

The Neutron Monitor Database is a project that aims to create a standardized network of data collected by neutron monitors world wide. Because cosmic ray events effect large portions of the globe, it is useful to be able to compare measurements from monitors over a wide area instead of from just one instrument. Historically, cosmic ray researchers have been open in sharing their neutron monitor data with the community. However, researchers had to request data individually from the monitors they were interested in and institutions each used their own data formatting protocols, making data processing difficult. The *Real-time database for high-resolution Neutron Monitor Measurements* (NMDB) is a project that is attempting to collect data from neutron monitors around the world into one common database. This eases both the acquisition and processing of data, as a standardized format is used. It is supported by the European Commission as an e-Infrastructures project in the Capacities section of the Seventh Framework Programme and can be accessed online at www.nmdb.eu. Figure 5 shows the location of all neutron monitors currently incorporated into the NMDB.

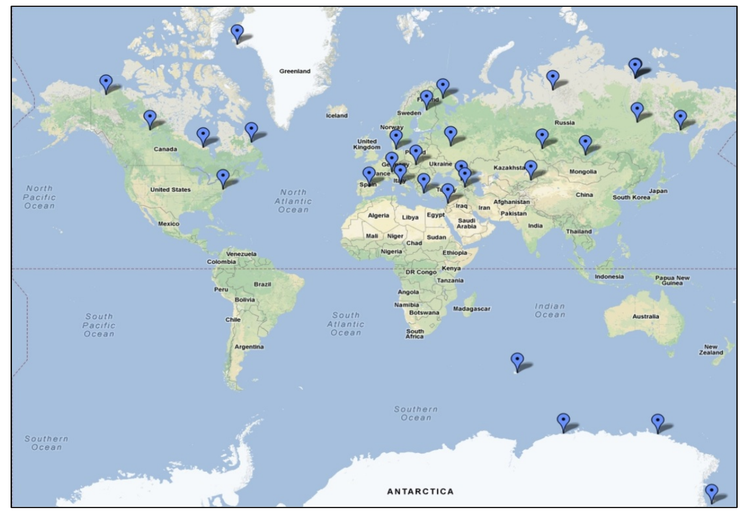
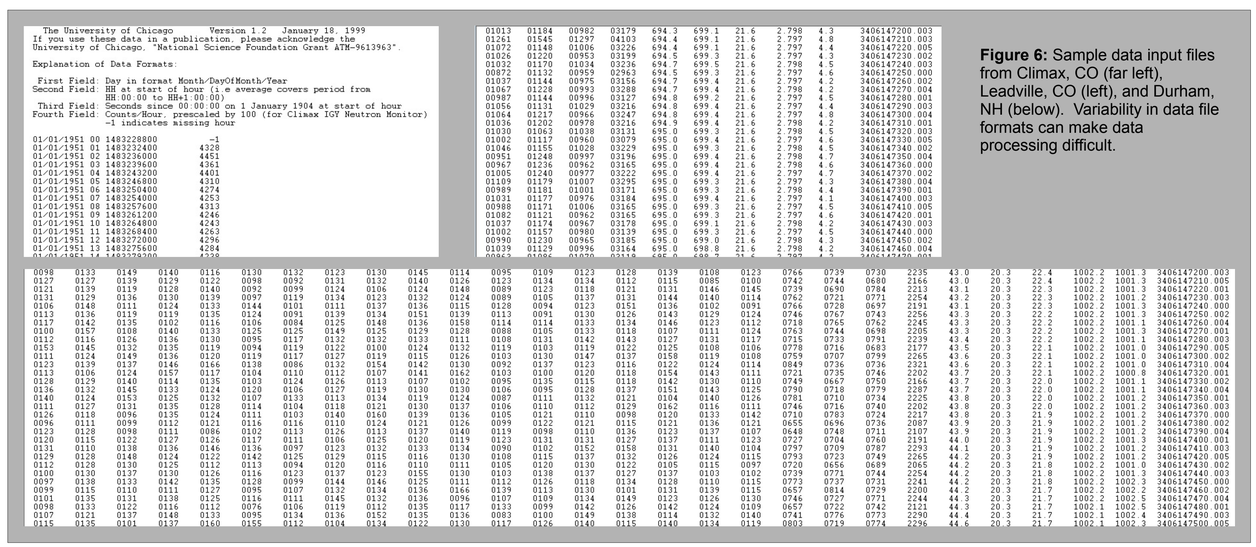


Figure 5: Locations of all the neutron monitors currently incorporated into the NMDB.
http://www.nmdb.eu/?q=node/8



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   The University of Chicago      Version 1.2   January 18, 1999
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University of Chicago, "National Science Foundation Grant ATM-9613963".

Explanation of Data Formats:

 First Field: Day in format Month/DayOfMonth/Year
Second Field: HH at start of hour (i.e average covers period from
              HH:00:00 to HH+1:00:00)
 Third Field: Seconds since 00:00:00 on 1 January 1904 at start of hour
Fourth Field: Counts/Hour, prescaled by 100 (for Climax IGY Neutron Monitor)
              -1 indicates missing hour

01/01/1951 00 1483228800       -1
01/01/1951 01 1483232400     4328
01/01/1951 02 1483236000     4451
01/01/1951 03 1483239600     4361
01/01/1951 04 1483243200     4401
01/01/1951 05 1483246800     4310
01/01/1951 06 1483250400     4274
01/01/1951 07 1483254000     4253
01/01/1951 08 1483257600     4313
01/01/1951 09 1483261200     4246
01/01/1951 10 1483264800     4243
01/01/1951 11 1483268400     4263
01/01/1951 12 1483272000     4296
01/01/1951 13 1483275600     4284
01/01/1951 14 1483279200     4238
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```

Figure 6: Sample data input files from Climax, CO (far left), Leadville, CO (left), and Durham, NH (below). Variability in data file formats can make data processing difficult.

Current Work

To include the UNH operated neutron monitors in the NMDB, the original data had to be reformatted to match the required format. This included:

- finding the total count rate of the whole monitor and correcting it for any tubes that did not report a value
- correcting the total count rate for the pressure conditions and the detector's efficiency
- changing the time stamp to YYYY-MM-DD HH:MM:SS format
- finding the hour average of the count rates

The NMDB has three tables for each set of maximum resolution data submitted: STATION_ori, which lists the original and pressure and efficiency corrected measurements, STATION_rev, which has the same categories as STATION_ori, but is only used if a revision has to be made to the data at a later date, and STATION_env, which lists the environmental conditions for each measurement. In addition, there are three additional tables: STATION_1h, which is a one hour average of the measurements; STATION_meta, which is a human generated record of the station; and station_information, which contains information about the monitor and station.

Figure 6 shows sample input data from Climax, CO, Leadville, CO, and Durham, NH.

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