each other. The subjects then climbed into the shielded room, where the strength of the magnetization of their chest area was measured. During the year of observations the amount of dust declined steadily to about 10% of the original level. (For smokers, however, their lungs cleaned themselves much more slowly, and after one year, about 50% of the dust still remained.)

Cytology:

When Peter Valberg and later Jim Butler, both accomplished physicists, arrived at the Harvard School of Public Health, they invented Magnetic Twisting Cytometry to study the mechanical properties and movement of macrophages - organisms that eat viruses. They fed iron-rich food to a small number of macrophages, and by using a fluxgate magnetometer, they could study how these organisms behaved in lung tissues.

VI: The THEMIS Magnetometer

6.1 Design and block diagram

The THEMIS mission studies substorm signatures on the ground and in space with time resolutions less than 30 seconds. Existing and new ground-based magnetometers built by the University of California at Los Angeles (UCLA) determine the signatures of the ionospheric currents induced by substorm auroras with nominal resolution of 1 second.

The University of California at Berkeley (UCB) team is responsible for the deployment, maintenance and data retrieval from the Alaskan sites. Existing (non-THEMIS) sites already provide a capable magnetometer network, which THEMIS enhances to meet its spatial and temporal resolution goals. The THEMIS ground based magnetometers were developed after the heritage of dozens of such sensors already deployed by the same UCLA team which has installed similar units at various sites internationally.

There are 20 magnetometer stations installed at sub-auroral-latitudes in North America. The GMAGs form a network of detection sites, ancillary to existing US mid-latitude stations already in place. The magnetometer data from the schools goes to UCB, where it is plotted and made available via the World Wide Web.

6.2 Hardware Setup

The magnetometer consists of a sensor for detecting the geomagnetic field, an electronics box for operating the sensor—including calculating the magnetic field—and a computer that logs the data and transmits it to the central collection site at UCB. For more details about the setup and installation, see the THEMIS GEONS slideshow at

http://ds9.ssl.berkeley.edu/themis/schools/installations/carson_city01.html

The sensor is designed to be installed in a post hole about 1 meter (three feet) below ground surface to minimize temperature effects. Typically the post hole is 30-meters (~100 feet) away from the building where the PC is housed, to avoid magnetic noise from the operator/cars. It includes internal heaters, which can be used to further stabilize the temperature. A protected cable connects the PC to the sensor assembly.

The cable inside the hose is routed into the building where the computer has been set up. Because no in-line amplifiers are used on the cable, the maximum length of the cable to the sensor can be no more than 100 meters (300 feet) to the back of the PC being used.

The magnetometer uses a GPS link to determine the correct latitude and longitude of the GMAG station, but more importantly, it uses GPS time signals to obtain a universal time (UT) base for comparing the measurements by the entire network of stations in the GEONS program.

Installation and calibration takes 2-8 hours depending on soil conditions, after logistics (hole digging, power connection, cable access from building to site) have been dealt with. The entire operation takes 2-4 days, depending on availability of local support. In most instances, you will be assisted by a scientist from the THEMIS team who will travel to your location and help with the installation.

Figure 31 - Magnetometer sensor located in the black tube, with the sensor cable located inside a garden hose for protection against chewing little creatures.

Figure 32 - White GPS antenna being attached to a pipe at the Carson City, Nevada site. Usually it is better to have the GPS away from fences, but this one had a big enough field-of-view in the other direction to get data from the GPS satellites.
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Figure 33 - Magnetometer electronics box (black box) sitting on a blue magnetic shield test can. Three wires come into this box: one is attached to the magnetometer sensor, one to the GPS, and the third is attached to the computer.

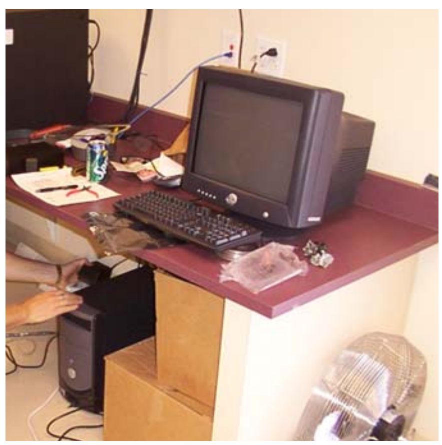

Figure 34 - The computer monitor and computer sitting in the classroom at the Western Nevada Community College in Carson City, Nevada. The electronics box is attached to the computer

6.3 Computer and Software Installation

The magnetometer board fits a standard desktop PC slot and has the following major sections:

1. GPS receiver
2. DC/DC converter, regulators
3. A single chip controller
4. ADC & low pass filters
5. Drive/sense circuits

6.4 Calibration and Data Collection

The calibration and qualification procedures entail sensor temperature drift, alignment and offset measurements. This is performed in a laboratory environment prior to shipping from UCB to the appropriate school.

GMAG data rate and volume:

- Digitization 16 bits
- Quantities 1+3 (time, Bx, By, Bz)
- Rep. rate 1 sample/sec
- Data rate 68 bits/s w/H/K & overhead
- Tx data per day 5.8 Mbits
- Tx Baud rate 30 kbps
- Tx time (only stream 1) 193 sec
- Data volume 0.265 Gbytes/year

Each site returns about 63 Gbytes of data per season via :

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- Hard disk swapping
- Mail distribution
- Direct Internet FTP or upload

These amount to about 4 terrabytes for the lifetime of the mission, including full data retrieval from the two winters before the THEMIS launch. Most of this is imaging data. EPO magnetometer data can be analyzed with standard Windows software packages such as Excel, by simply importing the ASCII data generated in the Science Files. THEMIS ground data, accessible to the public and to schools that host the magnetometers, are equipped with ASCII conversion routines, and web-based download functions.

VII Related Web Resources

7.1 THEMIS-Related resources

The main THEMIS education and outreach web page supports this guide and the other teacher guides in this series. The data from the magnetometers in the classroom are available on the site, and also information on the schools and teachers involved in the program. Additional information about the THEMIS mission can be found there, as well as images from the building of the instruments and spacecraft, scientist and engineer interviews, launch videos, and information about the education team.

http://ds9.ssl.berkeley.edu/themis

7.2 THEMIS Satellite Information

- ✓ THEMIS Mission Science
  http://ds9.ssl.berkeley.edu/themis/mission_mystery.html

- ✓ News and Events
  http://ds9.ssl.berkeley.edu/themis/news.html

7.3 Magnetic observatories

Professional research observatories often have web pages displaying real-time magnetometer data similar to the type of data that you will be recording on your own station. Visit the NASA Student Observation Network web page for a complete introduction and links to sample sites.

http://son.gsfc.nasa.gov/magnetosphere/from_obs.html