and visual observations. Visual observations during the night are limited; the huge gas and ash columns towering above the edifice during large Vulcanian explosions and the hazardous pyroclastic flows running from the summit along the flanks of the volcano are not visible to the human eye. Thus, infrasonic monitoring at SHV has proven its great value, especially during severe weather conditions when visual observations were precluded and alternative means for identifying the onset of an eruption were limited, as during the 29 July 2008 eruption.

The use of infrasound technology has positively influenced monitoring operations at MVO, allowing scientists to be able to make more informed decisions during eruptive crises. Thus far, flows have run in the direction of Plymouth, now a ghost town. But pyroclastic flows could run northeast toward inhabited villages—in such a case, quick detection and a precise monitoring system will allow MVO researchers to resolve some ambiguities in the assessment of the eruptive activity.

Local infrasound monitoring exhibits a great potential for integration with other geophysical measurements, particularly seismic, and may assist with their interpretation by yielding information on the mechanisms of eruptions and the propagation of density currents [*Moran et al.,* 2008]. Its continued use can yield important dividends in the assessment of volcano-related hazards and the management of civil protection operations on Montserrat, as well as at other volcanoes worldwide.

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A Global Ground-Based Magnetometer Initiative

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With the motto "Knowledge is the common wealth of humanity," the 2007–2008 Electronic Geophysical Year (eGY) advocated that scientists have the responsibility to create and implement strategies that utilize the full potential of digital capabilities in providing information for present and future generations.

Although eGY has officially ended, the geomagnetic research community continues to support the goals of eGY through a global ground-based magnetometer initiative. This initiative, called SuperMAG, helps scientists have easy access to measurements of the Earth's magnetic field.

What Is SuperMAG?

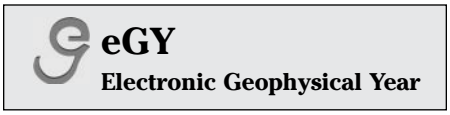
SuperMAG is a worldwide collaboration of organizations and national agencies that currently operate more than 200 ground-based magnetometers. It provides measurements of magnetic field perturbations from all available stations in the same coordinate system, with identical time resolution and a common baseline removal approach.

SuperMAG utilizes vector measurements of the magnetic field, which represent a variety of file formats, temporal resolutions, units, and coordinate systems, and are provided with or without baseline subtracted. SuperMAG resamples the raw data to 1-minute temporal resolution and converts all units into nanoteslas (nT). Artifacts and errors are removed by automated as well as manual correction routines. Data are then rotated into a local geomagnetic coordinate system, and finally the baseline is subtracted by an automated technique.

Why Is SuperMAG Needed?

Before SuperMAG, global or even local studies required painstaking and labor-intensive data handling, which effectively limited research. Analysts faced several inherent complications: confusing or even unknown coordinate systems, a multitude of data artifacts and errors, unknown baselines, and even difficulties obtaining data. These problems have resulted in a serious underutilization of data from magnetometers. Now the collected and processed high-quality ground-based magnetic field data provide an easier way to globally study magnetic data.

SuperMAG offers the unique opportunity to address the global spatiotemporal behavior of the large-scale ionospheric electric current system and its coupling to the magnetosphere. Studies of the variations caused by electric currents flowing in the ionosphere and magnetosphere require a subtraction of the dominant and slowly varying Earth main field. Hence, both absolute and variometer data (data with unknown baselines) are included in SuperMAG.



SuperMAG is intended to be a collaboration of all organizations operating ground-based magnetometer stations. Users must register with the SuperMAG site (http://supermag.jhuapl.edu/) to have access to a variety of data plots and products. As an added and much needed benefit, the registration system incorporates a logging system that allows the usage statistics of individual users to be tracked, providing principal investigators with the feedback needed to justify future funding from their respective supporting agencies.

Reaching Beyond Scientists

Beyond the research community, SuperMAG targets the general public, in particular, teachers and students. This puts additional requirements on the site because these groups cannot be assumed to have extensive knowledge of either the data set or the underlying physics. Consequently, the SuperMAG's Web service is based on an intuitive interface with easily accessible tools and products.

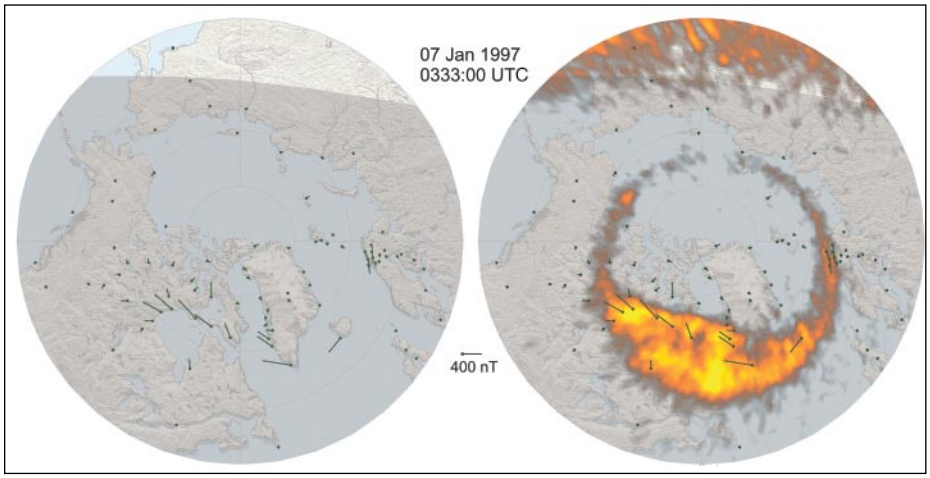


Fig. 1. Ground magnetometers operated by SuperMAG collaborators during the peak of an auroral event known as a classical bulge-type substorm. Time is expressed in coordinated universal time (UTC). The vectors (lines with starting points at dots) are in units of nanoteslas (nT) and are rotated 90° clockwise to indicate the ionospheric equivalent current direction [e.g., Kamide and Kokubun, *1994]. Left panel data are currently available at the Web site, while the right side includes an image from the Polar Visible Imaging System's Earth Camera (courtesy L. A. Frank, J. B. Sigwarth, and R. Barnes), showing the auroral oval and the equivalent ionospheric currents. The ability to compare magnetometer data with images allows scientists to investigate the spatiotemporal behavior of the aurora and ionospheric currents as well as their coupling to the magnetosphere.*

This is in line with the eGY declaration that states, "providing ready and open access to the vast and growing collections of cross-disciplinary digital information is the key to understanding and responding to complex Earth system phenomena that influence human survival" [see *Baker et al.*, 2008]. Although humankind is likely to survive without magnetic field data, the philosophy behind the SuperMAG initiative certainly is in line with eGY's focus on data availability, access, and utilization.

SuperMAG and Data Collection in the Virtual Observatory Era

A central feature of eGY is the promotion of virtual observatories (VOs) and similar cyber-based systems for providing scientists and the general public with ready access to data, information, and services. Virtual observatories already provide access to a wide variety of data acquired in the solar wind, in the magnetosphere, and on the ground.

However, one of the fundamental assumptions of virtual observatories is that data and data descriptions are available online. Most often this is not the case for ground-based magnetometer data. The SuperMAG collaborators are typically funded by their individual national agencies to install and operate the stations, and it cannot be taken for granted that they have resources to provide any service other than their station data.

Unfortunately, these matter-of-fact conditions effectively invalidate the standard VO approach for accessing ground-based magnetometer data. Instead, SuperMAG must operate as a data repository, through obtaining raw data from all collaborators, performing all required data-handling procedures (data resampling, error detection and correction, rotations, and baseline determination and subtraction), and making the observations and various data products available online.

Future Directions

SuperMAG is funded to expand its capabilities in four key areas:

- Increase the holdings of ground magnetometer data (stations and time);
- Develop additional user-friendly tools for the Web site;
- Link to existing VOs, thereby expanding the capabilities of both SuperMAG and the VOs;
- Include auroral images from a list of imaging sources.

The last point has proved critical to analysis of ionospheric dynamics. Figure 1 shows two polar plots of the ground perturbation vectors. The left plot (currently available on the Web Site) is the set of perturbation magnetic field vectors, and the right plot shows a Polar Visible Imaging System (VIS) Earth Camera image of the ultraviolet aurora with vectors superimposed. Combining these two data sets, as first suggested by *Frank et al.* [1981] and later quantified by *Fujii et al.* [1994] and *Gjerloev and Hoffman* [2000], reveals that ground perturbations are related to the overhead emissions rather than to any fixed coordinate system. Combining these different data sets provides a powerful tool for scientists to help unlock the secrets of dynamic large-scale auroral disturbances.

A Recommendation for Other Groups Who Seek to Fulfill the Goals of eGY

SuperMAG was fortunate to reach a milestone of 100 registered users within just 3 months of its public release, underscoring the need for this service. It is recommended that similar data services in other research areas be driven by the needs of the users, aiming first at the requirements of the typical user and later expanding by responding to user requests. The validity of SuperMAG or any VO type of service is defined not by the funding agencies or the Web site developers themselves but by the users.

More information on SuperMAG, as well as access to the data repository, can be found at http://supermag.jhuapl.edu/.

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