McGinnis, D. F., S. Bocaniov, C. Teodoru, G. Friedl, A. Lorke, and A. Wüest (2006), Silica retention in the Iron Gate I reservoir on the Danube River: The role of side bays as nutrient sinks, *River Res. Appl.*, *22*, 441–456.

Panin, N., D. C. Jipa, M. T. Gomoiu, and D. Secrieru (1999), Importance of sedimentary processes in environmental changes: Lower River Danube–Danube Delta–Western Black Sea system, in *Environmental Degradation of the Black Sea: Changes and Remedies*, edited by S. T. Besiktepe et al., pp. 23–42, NATO Sci. Ser., Springer, New York.

Teodoru, C., and B. Wehrli (2005), Retention of sediments and nutrients in the Iron Gate I reservoir on the Danube River, *Biogeochemistry, 76*, 539–565.

Teodoru, C., A. Dimopoulos, and B. Wehrli (2006), Biogenic silica accumulation in the sediments of the Iron Gate I reservoir on the Danube River, *Aquat. Sci.*, in press.

Zessner, M., and H. Kroiss (1998), Retention and losses of nutrients in the hydrosphere, paper presented at the 8th River Basin Conference: Management of Large River Basins, Int. Assoc. on Water Qual., Budapest, Hungary, 13–16 Sept.

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Data Acquisition for Volcano Monitoring

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In the past decade, systems and techniques for volcano monitoring activities have improved rapidly. The scientific community focused on the development of new methods and techniques, while the electronic systems for experimental activity and monitoring networks were developed mainly by commercial companies.

However, these commercial systems often do not fit simultaneously all the needs of geophysical research. A new project, led by the Italian Institute of Geophysics and Volcanology (INGV) 'Osservatorio Vesuviano' (OV) in Naples is trying to fill this niche with the development of data acquisition systems for multiparametric volcanic monitoring.

The INGV-OV is monitoring high-risk active volcanic areas such as Vesuvius, the Phlegrean Fields, and Stromboli through the acquisition of several geophysical parameters, including seismic, infrasonic, strain, and geochemical data. In such multiparametric data collection, each type of data requires a different acquisition system; some of these parameters require continuous data acquisition, whereas others may need particular actions to be made on the sensors or at the acquisition site. To perform many tasks and to be adaptable to the specific requirements of each type of data acquisition, instruments need to be modular and flexible.

Volcano monitoring often is characterized by the need for instrument installations in remote places, usually reachable only on foot. In such places, the only power source is energy provided by solar panels and stored in accumulators. For this reason, there is the need for low power consumption by field electronics instruments in order to minimize the number of solar panels and accumulators to be transported and installed.

Thus, such a complex acquisition model requires low power, modularity, and adaptability for several field applications. Currently, commercial solutions are task-oriented and do not simultaneously fit all of these needs.

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Moreover, these commercial instruments often are 'black boxes' for which the final user only has limited possibilities to adapt the hardware to his particular needs. For instance, placement of a data-logger in areas unreachable by global positioning system (GPS) signals requires a technical action (usually the separation of the GPS receiver) that is achievable only by the manufacturer.

In this context, the INGV-OV decided to start a new technological research project with the goal of studying, developing, and producing a data acquisition system specifically devoted to multiparametric volcanic monitoring. This project was named GILDA, for Geophysical Instrument for Low-Power Data Acquisition.

The first phase of the project involved the development of a basic electronic system to accomplish essential functions, such as analog to digital conversion of sensor signal, station status monitoring, time labeling of data, and data transmission, with the main goal of low power consumption. Other fundamental characteristics include a high resolution in analog to digital conversion, a high dynamic range as required by most of the signals produced in volcanic environments, a versatile usage configuration, and a low cost production. In a subsequent phase, a complete system with all features of modularity and flexibility will be realized.

The first prototype of the basic system is currently undergoing testing. This first GILDA version (code-named Lilith) is a multiboard system composed of a high-resolution (24-bit) analog to digital converter (ADC) board with four channels, a central processing unit board, a timing board, and a GPS receiver unit. All of these boards and the power section are housed and interconnected on a main board. The main board also is equipped with an eight-channel 12-bit ADC, in order to obtain device status information (temperature, power consumption, battery voltage, solar panel power, and so forth). Expansion ports are available to connect a third medium-resolution 16-bit ADC for low-rate

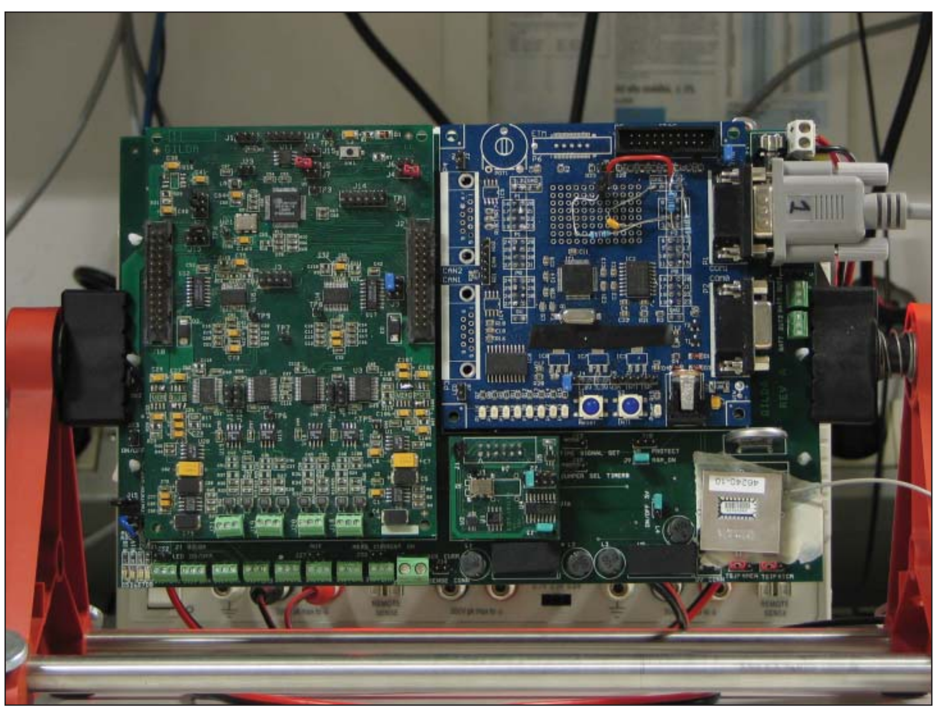

Fig. 1. The first prototype of the basic GILDA system. Visible at the left is the ADC board; the microcontroller board is on the top right, and the timing board as well as the GPS unit are on the bottom right.

data acquisition and some general purpose electronics cards.

The multimodule architecture of GILDA also provides an important feature: It is possible to rebuild and replace some modules to achieve future improvements. For instance, an additional interface board is being designed that will place the GPS unit far from the main system. This is important whenever the sensor and the system are to be installed in places not reached by GPS signals, such as wells and underground caves.

The full development of the GILDA project will proceed through the realization of the above-mentioned complete system. Such a system makes it easy to add modules to realize more complex configurations and functions. For instance, it will be possible to add a module if the user needs more input channels than those provided.

In the first laboratory tests, the GILDA prototype has reached the project targets, achieving an excellent compromise among performance, features, and power requirements. In fact, the prototype shows a power consumption (in a running configuration of four active channels at an acquisition rate of 100 samples per second) below 850 milliwatts. This level is significantly under the initial target of the project, which was about one watt. The prototype also has a low electronic intrinsic noise level, around 320 nanovolts (measuring in the same running configuration described above). This last value, with the 24-bit ADC, provides both a high dynamic range and a good conversion resolution, similar to the best performances provided by commercial instruments.

The software system allows a complete configuration of the parameters required by the user applications (i.e., number of operating channels, sampling rate, filter coefficients, and so forth). The current prototype is designed mainly to interface a seismic three-component signal plus a channel for an additional single signal sensor, as in the case of an infrasonic microphone. Also important, the GILDA digitizer is an inexpensive instrument: The production cost of the basic system is below US$2000.

For all of these reasons, the GILDA instrument is a valid choice for geophysical projects, even those that are low-budget, which involve the deployment of many monitoring stations in remote environments.

The INGV GILDA project's custom and valuable instrument was created by researchers without commissioning private companies to develop any artifact, product, or study needed for the project.

Thus, by means of this project, the INGV also follows the strategic long-term target to autonomously develop the technology necessary for future instrumental applications. This instrument soon will be used in several INGV projects and in research projects where the INGV is involved in collaborative activities. All scientists cooperating with the INGV will be able to use GILDA and access all its features.

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Internet Mapping Tools Make Scientific Applications Easy

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Organizing complex information in the form of a map is a powerful and effective way of communication. This is especially true when linking spatially distributed scientific information to 'real-world' applications. However, creating an intuitive and easy-to-use interface between the user and the data requires a large amount of development time for user feedback and programming.

To reduce this development time, it is now possible to couple spatial data with the increasingly popular Google Earth software (http://earth.google.com) package (Figure 1). (The products mentioned in this work do not indicate an endorsement by the authors. Additionally, the authors have no affiliation with the Google™ company.) This free-to-use package allows users to avoid the costs associated with other high-end geographical information systems (GIS). While other free Internet GIS packages exist, including NASA's World Wind (http://worldwind.arc.nasa.gov) and Microsoft's Virtual Earth (http://local.live.com), one significant advantage of Google Earth is the use of Keyhole Markup Language (KML) for managing three-dimensional geospatial data. KML is an XML-based markup language that can be used to import and overlay user-defined data (vector or image form) and control views and zooming.

Tools are available to translate existing GIS data directly into Google Earth (see http://www.manifold.net/googleset.html). For image overlays, any image format simply needs to be geospatially referenced (currently, Google Earth only supports WGS84 datum projections) and mapped into Google Earth. The KML program and the associated spatial data then are bundled together (as a KMZ file) and distributed to end users. A KMZ file is a compressed file that can easily be transferred over the Internet.

Packaging the data in a single application file allows end users with no previous knowledge of GIS environments to view and interact with the application data using a freely downloaded copy of Google Earth. A commercial version of Google Earth exists for adding and editing various shape elements, but is not needed for viewing the KMZ file. The end user then simply clicks on the KMZ file and may begin interacting with the data. During the initial startup of the application, the Google Earth viewer zooms from an overview of the entire globe to the specific location being considered. Users then can navigate to the specific locations on the map that interests them, using standard zoom and pan functions, or search for specific coordinates. Additionally, users can explore three-dimensional oblique angles within the viewing software.

To demonstrate the effectiveness of coupling spatial data and Google Earth, a tool was created that maps 'runoff contributing areas' [e.g., *Betson*, 1964] in a watershed. These areas are prone to runoff after they become saturated [e.g., *Dunne and Black*, 1970], i.e., hydrologically active areas (HAAs) [*Walter et al.,* 2000]. This 'Town Brook' demo and movie fly-through are available for download (see http://www.bee.cornell.edu/swlab/SoilWaterWeb/research/VSA).

As runoff-producing areas, HAAs play central roles in controlling pollutant and nutrient loading to surface water. Modeling of the spatial extent of these HAAs used the Soil Conservation Service (SCS) curve number method reformulated in a manner consistent with saturation excess overland flow theory [*Lyon et al.,* 2004]; the curve number was calibrated using 30 years of discharge and rain data, and water was distributed as a function of topographic index [*Beven and Kirkby*, 1979].

By displaying the spatial data from the HAA model within the Google Earth application, it is easy to visualize where HAAs are located relative to pollutant application and/or population clusters. Future features could include definition of agricultural field boundaries (Figure 1a) and point-and-click data acquisitioning (Figure 1b), both of which can be programmed in the KML language used by Google Earth. Also, Google Earth provides the facilities to include network tools from other locations, allowing automatic update of weather data to provide real-time information for planners. Planners could use this type of information, for example, to model areas that may potentially flood during large storms. It is easy to envision other spatial tools that could be developed using Google Earth or other similar packages.

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