Upgraded gravity anomaly base of the United States

G. Randy Keller, University of Texas at El Paso, U.S.
Thomas G. Hildenbrand, U.S. Geological Survey, Menlo Park, California, U.S.
Robert Kucks, U.S. Geological Survey, Denver, Colorado, U.S.
Dan Roman, National Oceanic and Atmospheric Administration, Silver Spring, Maryland, U.S.
Allen M. Hittelman, National Oceanic and Atmospheric Administration, Boulder, Colorado, U.S.

A concerted effort to compile an upgraded digital gravity anomaly database, grid, and map for the United States by the end of 2002 is under way. This joint effort by the geophysics groups at the University of Texas at El Paso (UTEP), U.S. Geological Survey (USGS), and National Oceanic and Atmospheric Administration (NOAA) (with support from the National Imagery and Mapping Agency [NIMA]), is an outgrowth of the new geoscientific community initiative called Geoinformatics (*www.geoinformaticsnetwork.org*). This dominantly geospatial initiative reflects the realization by Earth scientists that existing information systems and techniques are inadequate to address the complex scientific and societal issues that we must confront. Currently, the lack of standardization and chaotic distribution of available geoscience data, a lack of documentation about them, and the lack of easy-to-use access tools and computer codes for their analysis are major obstacles for scientists, government agencies, and educators alike. A good example of the type of activities envisioned within the context of Geoinformatics is the construction, maintenance, and growth of a public domain gravity database and development of the software tools needed to access, use, and expand it. A product such as this is far more than a high-quality database; it is a data system for a specific type of geophysical measurement. The effort

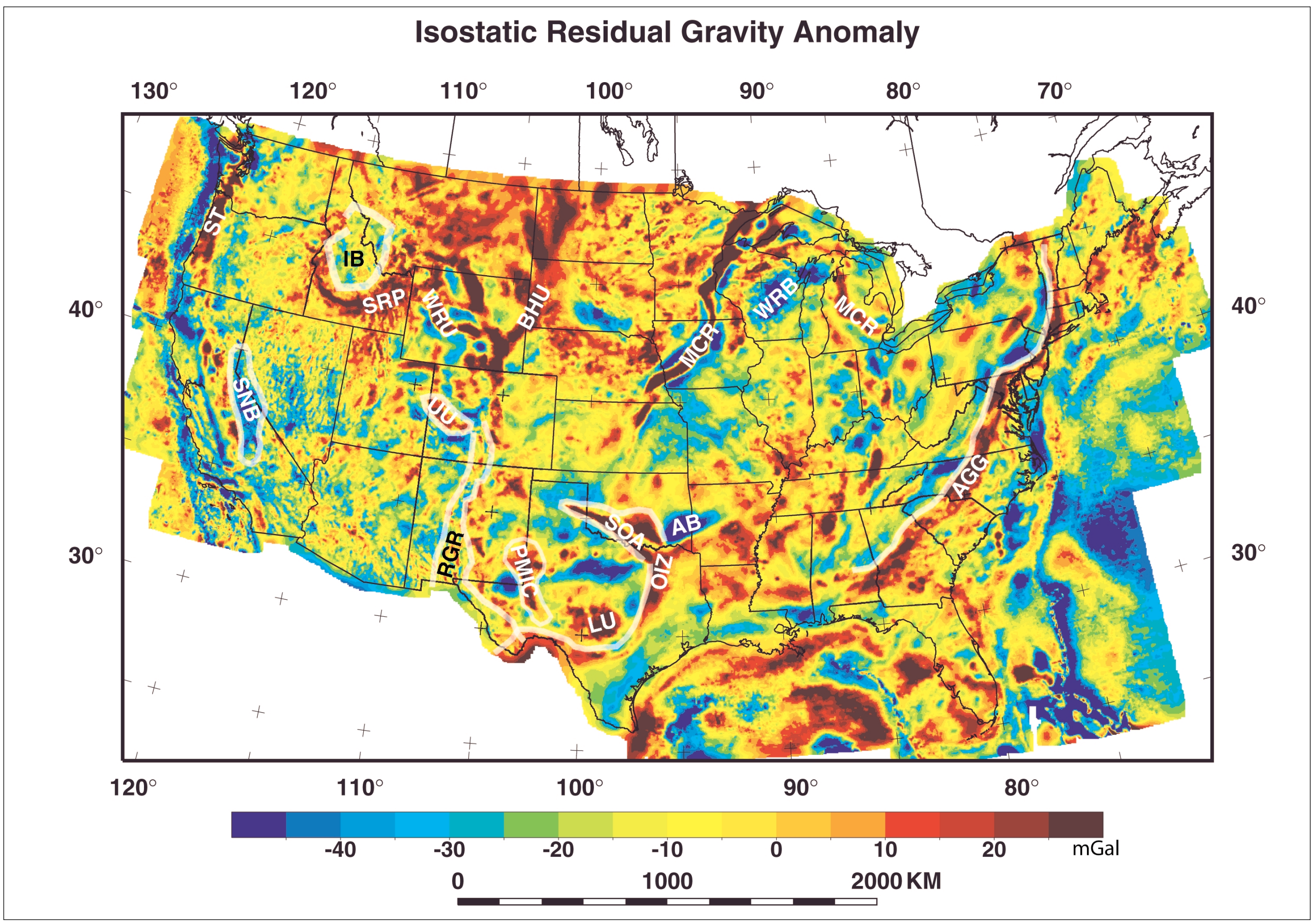

Figure 1. Isostatic residual gravity anomaly map of the conterminous United States (after Simpson et al., 1986). A few major gravity features are highlighted, such as the highs related to the Snake River plain (SRP), Siletz terrane (ST), Midcontinent rift system (MCR), Uncomphagre uplift (UU), Pecos mafic igneous complex (PMIC), Southern Oklahoma aulacogen (SOA), Llano uplift (LU), Black Hills uplift (BHU), Wind River uplift (WRU), and Ouachita interior zone (OIZ) and the lows associated with the Sierra Nevada batholith (SNB), Idaho batholith (IB), Rio Grande rift (RGR), Arkoma basin (AB), and Wolf River batholith (WRB). The Appalachian gravity gradient (AGG) that marks the ancient margin of North America is also labeled.

we are launching can thus be thought of as the first step in building a data system for gravity measurements, and it builds on existing collaborative efforts. This compilation effort will result in the additions to and refinement of the benchmark national database that is released publicly via NOAA's National Geophysical Data Center.

The primary goal of upgrading the U.S. gravity database and ultimately creating a robust data system is to provide more reliable data that support societal and scientific investigations of national importance. An additional reason is the international intent to compile an enhanced North American gravity database, which will be critical in understanding regional geologic features, the tectonic evolution of the continent, and other issues that cross national boundaries. This article outlines the strategy for assembling the individual map and digital products related to the United States gravity database.

Gravity data. Studies of the Earth's gravity field find broad applications in geodesy, geophysics, and geology including determining the detailed shape of the Earth (geodesy), predicting the orbits of satellites and the trajectories of missiles, determining the Earth's mass and moment of inertia, and conducting geophysical mapping and interpretation of lithospheric structure and geodynamic processes. In studies of the upper crust, gravity data such as those shown in Figure 1 can help address a broad range of basic geologic questions, delineate geologic features related to natural hazards (faults, volcanoes, landslides), and aid in the search for natural resources (water, oil, gas, minerals, geothermal energy). Such studies provide elegantly straightforward demonstrations of the applicability of classical physics and digital processing to the solution of a variety of geologic problems.

Because of their utility and the relative ease of data collection, compilation of large gravity databases has been under way for many years, and NOAA and NIMA have been leaders in these efforts. Thus, a specific goal of our cooperative effort is to begin development of a Web-based system designed to significantly increase the quantity and quality of contributions to this benchmark gravity database. This would be accomplished by carrying out an extensive search for existing data that have not been sent to NIMA or NOAA's National Geophysical Data Center and by providing software tools needed to acquire additional high-quality data for inclusion into this database. Standardization and quality control will be critical in this effort. For example, a single and clear approach to calculate terrain corrections for data from high relief areas will be incorporated.

Planned Web site access to gravity information. The scientific community working with gravity data has been traditionally small and well networked with a history of open cooperation and sharing of data. However, technical developments such as GPS and the rising recognition of the utility of gravity data are creating a demand for gravity data by nonspecialists, as well as an expanding ability to collect new gravity data. Thus, it is highly desirable to establish one consistent database that includes all of the public domain data possible. Therefore, the database that we are compiling for the United States will be made accessible from a Web site. In addition, we will provide a mechanism for ensuring quality control, capturing corrections when bad data points are identified, and making additions. This latter effort is important because researchers often begin their investigations of a specific area with the public domain gravity data available in the national database. They then identify areas with sparse coverage in their region of interest and conduct a field campaign to fill in these areas and/or attempt to find data from other sources. However, a lack of infrastructure, standardization, and documentation guidelines (metadata) often results in the new data resulting from these efforts never appearing in existing national databases. A result is that groups build overlapping and duplicative data sets in which the identity of truly new data is lost.

Another consideration is the relative ease of accessing various existing gravity databases and of acquiring new gravity data can lead to newcomers overlooking important details that are not widely known except by specialists. For example, NIMA is the curator of an international network of base stations for gravity surveys that must be used if workers are to add data that can be merged into the existing databases. However, it is difficult for a newcomer to the field to access information about the stations in this network, because its existence is not widely known. A Web site will be an ideal way to help newcomers access this information.

A system will be devised to ensure data integrity of the upgraded national database. For example, an on-going UTEP effort is focused on advanced techniques of identifying and eliminating erroneous data points and duplicates in a gravity database, because their inclusion can degrade the quality of the resulting data processing and analysis. We believe that this effort is particularly important because the same problems will emerge in other geospatial databases in which measurement results made by different groups are combined.

The ultimate goal of this project is a fully integrated data system populated with high quality, freely available data, as well as a robust set of software for data reduction and analysis. This system will feature the database, software tools, and convenient access and will enhance the quality and quantity of data being contributed to the gravity database that will be a shared community resource. For example, the U.S. Geological Survey and UTEP are cooperating to develop a Web-based toolkit that will permit access to gravity data and manipulation of the data using tools that support, for example, modeling, mapping, filtering, and construction of profiles. The goal is to produce a Web-based data system that will facilitate the efforts of researchers and students who wish to collect data from regions currently not represented adequately in the database.

Long-term goals of the data system. The data system that we build will be designed to meet general criteria that would make easily adaptable to other geospatial data. Our ultimate goal is to facilitate the creation of an open and flexible data system populated and maintained by user-members of the earth science community. Community involvement is central to the vitality and longevity of the data system. Simplicity and flexibility are also crucial in developing a system that can respond to changing technologies and user needs. The data system must be flexible and have minimal infrastructure requirements (i.e., minimization of operating system dependencies, various data management protocols, and peripheral hardware requirements) and a minimum of mandated data format requirements. In order to make the transition from raw data sets to database to data system, the development of a toolbox is a vital task. This software element of the system requires development and maintenance of a well designed front-end for a variety of programs needed to extract, map, process, and model the data and ready access to these programs as public domain, user-friendly, and platform independent tools.

(Continued on p. 387)

(Keller, from p. 367)

Schedule of milestones. The first milestone will be to gather existing gravity data presently not in the national database available from NOAA/NGDC by the summer of 2002. We strongly encourage those working with gravity to send *any* gravity data that they suspect are not in existing national files and as much documentation as possible to Robert Kucks (*rkucks@usgs.gov*). The second milestone is to conduct quality control analysis of and calculate terrain corrections for the upgraded U.S. database and have available a 4 km grid of these data on the Web by summer of 2002. The third milestone is to publish a new U.S. complete Bouguer anomaly map by winter of 2002. A Web site with substantial capabilities will be ready by summer of 2002, but this site will, of course, evolve, and its ultimate capabilities will be determined by input and contributions from the scientific community.

Suggested reading. "A new isostatic residual gravity map of the conterminous United States with a discussion of the significance of the isostatic residual anomalies," by Simpson et al. (*Journal of Geophysical Research*, 1986). TLE

Corresponding author: tom@usgs.gov