Volcanic Ash Can Pose Hazards to Air Traffic

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When volcanoes erupt, lava flows are what concern many people. But as air traffic increases, some scientists at agencies in the U.S. and abroad—including the National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), and NASA—also are focusing on how to avoid costly and potentially deadly problems that can arise from volcanic ash clouds.

The clouds can rise into the cruise altitude of aircraft and can affect traffic thousands of kilometers away from a volcano, as wind carries the ash. The ash can ruin planes, and cause loss of thrust and even flameouts. It also can slicken runways and damage planes on the ground.

While awareness of the problem is growing, scientists soon will lose some key satellite instrumentation for tracking ash (see above).

A global network of nine Volcanic Ash Advisory Centers (VAACs)—organized through the World Meteorological Organization and International Civil Aviation Organization—works with local meteorological watch offices and others to quickly identify and track plumes. The VAACs, which some scientists say vary in technical ability, also aim to communicate information rapidly so that pilots receive sufficient warning of ash clouds.

The network relies on data from pilots, government agencies, onsite seismic stations, and remote sensing devices. Polar orbiting satellites provide coverage of polar regions, including Alaska, several times a day. GOES geostationary orbiting satellites can be used to pick out silicate particles by subtracting data on one channel from that on another, and can track plumes every 15 minutes.

That time resolution is vital to protect aircraft, said Terry Keith, scientist in charge at the Alaska Volcano Observatory (AVO) in Anchorage, which is managed by the USGS and works closely with the VAACs.

But the next series of three GOES satellites—to be launched around the year 2002—will not have that split-channel capability.

The Air Line Pilots Association (ALPA) and others are pushing to restore the capability on subsequent GOES satellites, though it would still mean a 3-5 year data gap.

That lack of satellite data "could cause an ash plume to go for a potentially dangerous distance in the air before anybody catches it," Keith said. "It will increase the risk of flying into a volcanic ash cloud."

That gap in data also could mean more false alarms issued, as ash monitors react conservatively to volcanic events.

Ash is "something that can be avoided" if it can be seen on imagery, said Grace Swanson, supervisory meteorologist with the Satellite Analysis Branch of NOAA's National Environmental Satellite, Data, and Information Service, who works at the Washington, D.C. VAAC. "Why walk through a known hazard," she said, "when you could go around something?"

Some scientists are investigating stop gap measures to provide satellite detection of ash clouds. A team led by NASA Senior Research Scientist Arlin Krueger has proposed building a volcanic ash monitor, or Volcam. Two cameras, one infrared and one ultraviolet, could detect ash clouds and sulfur dioxide clouds, provide other science data, and ride piggyback on satellites that have available space. Three or four orbiting Volcams could monitor the entire disk of the Earth continuously at 15-minute intervals, he said.

Of the world's 550 or so active volcanoes, about 60 erupt each year, and about 10 raise ash clouds that can affect air traffic locally and possibly in distant regions.

Volcanic ash is composed of microscopic silicate minerals and shards of glass. When a plane flies through ash, engines—particularly those on two-engine jets that are larger and more fuel-efficient than older engines, but that take in enormous amounts of air and operate at higher temperatures—ingest the ash. It then can melt and solidify, clog air flow, erode parts, and lead to engine flameout. It also can abrade leading edges of aircraft.

Several close calls with ash clouds have occurred. In 1989, for instance, a KLM 747 flew into ash from Alaska's Mount Redoubt and lost engine power. The plane made an emergency landing, but suffered $80 million in damages. "For the first time, it made the problem real to us here in the United States," said USGS Acting Director Thomas Casadevall, an expert on volcanic ash hazards.

The ash problem is compounded with more planes in the air, often traveling at night when clouds are less visible, and flying more flexible routes. More planes also are flying above potential volcanic hot spots, such as the Pacific "ring of fire" that includes active volcanoes in the Philippines, Indonesia, Japan, Russia, Central and South America, the Pacific Northwest, and Alaska.

The Anchorage airport, for instance, is near about 70 active volcanoes in the Aleutian Arc and Kamchatka, Russia. This air traffic hub, through which 93% of all cargo flights from Asia to the United States are funneled, is "an amazing juxtaposition of volcanoes and airplanes," said volcanologist Tom Miller, scientist in charge at AVO from 1988-1993.

He said ash clouds are a concern in Alaska 4 days per year on average, with the 15,000-20,000 people flying in airplanes above Alaska on a typical day potentially at risk.

With more people flying and more cargo being shipped by air, the chance of encountering ash clouds could increase, without accurate warning systems. With uncertainty about what cloud density planes can safely fly through, scientists seem in agreement that the best strategy is to accurately track volcanic ash and quickly communicate that data so that airplanes avoid ash clouds.

Rerouting or cancelling flights to avoid ash may be costly, due to using extra fuel and delays in delivering goods, but it is cheaper than losing planes and people. "If traffickers need to spend a little money to reroute traffic," said William Phaneuf, ALPA staff engineer, "that's the cost of doing business."—*Randy Showstack*

New Program Maps Geoscience Data Sets Interactively

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During the last decade many new and improved global geoscience data sets have been evaluated by researchers around the world. While new techniques such as satellite altimetry were developed to compute the geoid and marine gravity field to high resolution, existing data sets such as earthquake catalogs and hotspot location lists were enhanced.

These data sets contain invaluable information for every Earth scientist whether the focus is global or regional. With the advent of high-speed Internet connections, global access to these immense resources is now easy, but actual processing still poses some obstacles.

Interactive Generic Mapping Tools (iGMT) is intended to help remove some of the hurdles. This software, now being released, allows interactive mapping of geoscience data sets. The software is based on Tcl/Tk computer language [*Ousterhout*, 1993] and is a graphical interface for the Generic Mapping Tools (GMT) package [*Wessel and Smith*, 1995].

In its current version, iGMT runs on any UNIX computer and is distributed as free software under the GNU public license [*Free Software Foundation*, 1991]. While iGMT lacks the database query functions of Geographical Information Systems, it is capable of displaying various raster data sets (such as topography) and superimposing multiple polygon data sets (such as hypocenters). It also allows the user to customize most parameters such as symbol size and color.

In addition to providing a graphical user interface to the already widely used GMT mapping tools, iGMT has built-in support for

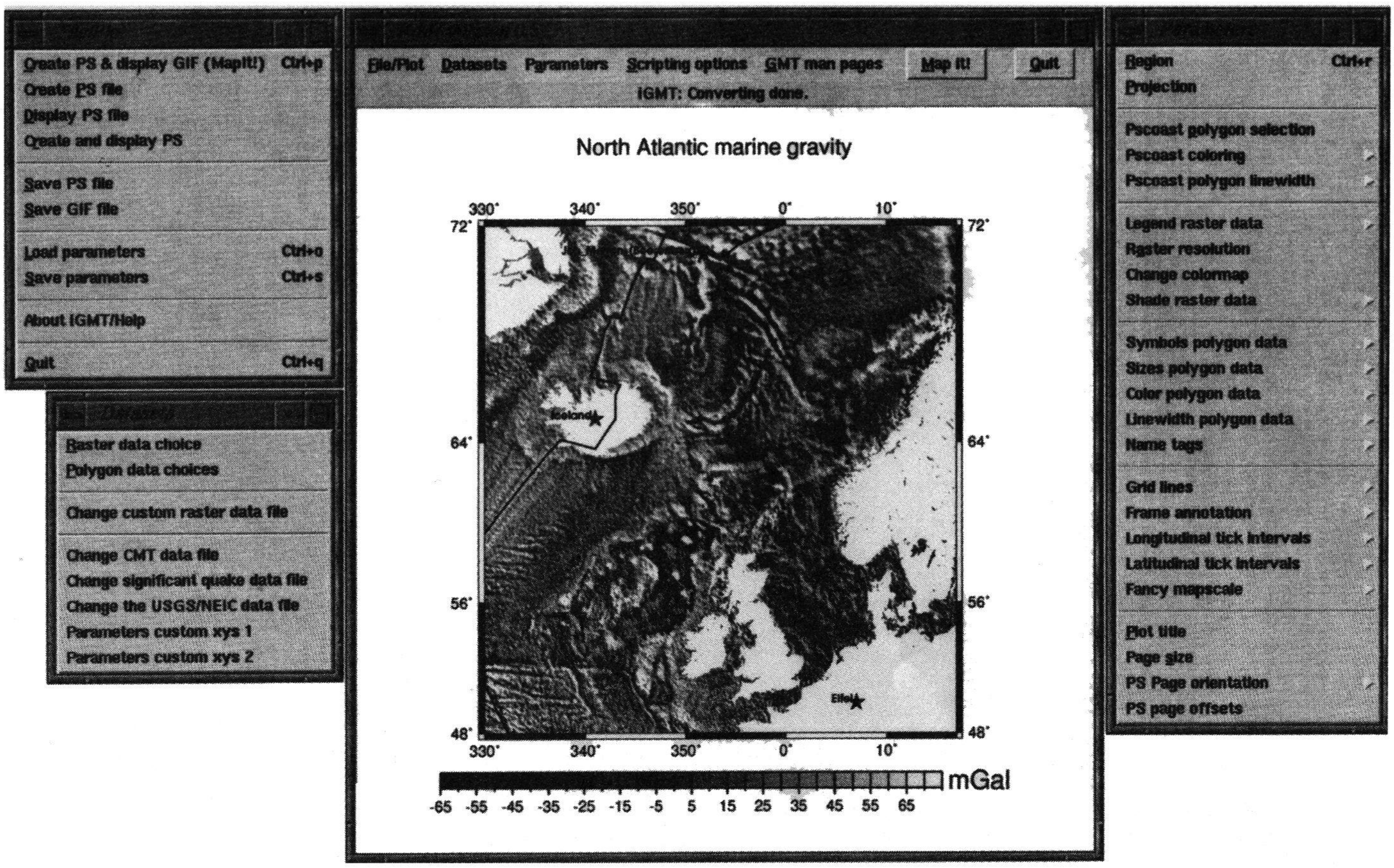

*Fig. 1. Screenshot of iGMT running on the IRIX6.3 operating system; pull-down menus have been detached for demonstration purposes. The map shows plate boundaries [*DeMets et al., *1990] and hotspot locations (*B. Steinberger, *unpublished manuscript, 1998) superimposed on the gravity anomalies in the Northern Atlantic [*Sandwell and Smith, *1997].*

standard and custom geophysical data set manipulation. Since it is programmed in a modular way, script-based, and documented, it should be fairly easy to include new data sets and extend the plotting abilities of iGMT. The program allows the user to make most efficient use of all information sources and tools that are available on the World Wide Web while reducing the burden of low-level data processing as much as possible.

Many raster and polygon data sets are currently supported by iGMT (Web locations can be found in Tables 1 and 2), and some polygon data have been included in the iGMT distribution. However, many more geophysical and geological data sets are available on the Web and the capabilities of iGMT can be extended to many other useful tasks. The latest iGMT version is available at either of two Web sites (www.seismology.harvard.edu/~becker/igmt/ or www.rz.uni-frankfurt.de/~braun/igmt/).

The program comes with a manual that describes technical details of installation and how iGMT works. Besides the GMT 3.0 software package and Tcl/Tk 8.0, iGMT needs a postscript viewer (for example, "ghostscript") and an image-converting tool (for example, "convert") for full functionality. Such programs are installed at most institutions running UNIX systems, so we predict a relatively painless installation and promise fast results.

After starting iGMT, the user is presented with menus for choosing the data sets, the geographic region to plot, and other parameters (Figure 1). When activating the map creation command, iGMT produces a "script"' for GMT whose automatic execution leads to a postscript file. This file is then converted and displayed on the screen, allowing for easy adjustments. After completing the session, the user is left with an executable GMT script that can be reused and modified for more complicated tasks. In setting it up this way, we have attempted to facilitate use of GMT without restricting its functionality or sacrificing performance. Furthermore, all files are processed on the fly using standard tools such as "awk" to allow for maximum compatibility when data sets are updated or replaced. The parameters that result from a

Table 1. Supported Raster Datasets.

Description	Web Location or Reference
ETOPO5 topography/bathymetry	www.ngdc.noaa.gov
GTOPO30/Smith & Sandwell topography/bathymetry	topex.ucsd.edu/marine_topo/mar_topo.html
Seafloor age	Omphacite.es.su.oz.au/StaffProfiles/dietmar/Agegrid/agegrid.html
Free-air gravity	topex.ucsd.edu/marine_grav/mar_grav.html
Geoid	cddisa.gsfc.nasa.gov/926/egm96/egm96.html
Custom user data	supported as GMT grid file

Table 2. Supported Polygon Datasets.

Description	Web Location or Reference
Plate boundaries	[DeMets et al., 1990], included
Hotspot locations	(B. Steinberger, unpublished manuscript, 1998), included
Volcano locations	www.volcano.si.edu/gvp/volcdata/index.htm, included
Centroid moment tensor fault plane solutions	www.seismology.harvard.edu/CMTsearch.html
Significant earthquakes	www.ngdc.noaa.gov/seg/hazard/sigintro.html
Preliminary determination of epicenters earthquakes	wwwneic.cr.usgs.gov/neis/epic/epic_global.html
Custom "xys" files	can be provided by user

session can be saved for future reference and the resulting postscript files can be postprocessed or printed with standard equipment.

The new program provides a powerful tool for mapping Earth science data sets on common UNIX platforms and could be ported to PCS and Macs. It can be expected to help geoscientists profit from available data and enhance their research without wasting time reading manuals or reformatting data. In addition, iGMT greatly reduces start-up time for researchers unfamiliar with GMT who ultimately wish to access its capabilities directly.—*Thorsten W. Becker, Department of Earth and Planetary Sciences, Harvard University, Cambridge, Mass., USA, and Alexander Braun, Institut für Meteorologie und Geophysik, J. W. Goethe-Universität Frankfurt am Main, Germany*

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SECTION NEWS

GEODESY

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Outstanding Student Paper Awards

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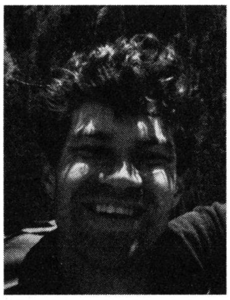
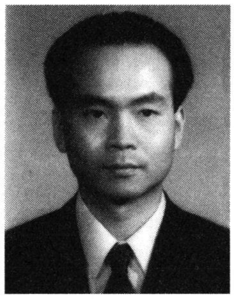
The Geodesy Section presented the following outstanding student paper awards at the 1998 Western Pacific Geophysics Meeting in Taipei, Taiwan, in July 1998.

Craig Roberts presented a paper titled "Antenna Phase Centre Variation: Cause for Concern for Precise GPS Deformation Monitoring Applications." Craig is a Ph.D. student at the School of Geomatic Engineering, University of New South Wales. He graduated from the University of South Australia with a bachelor of surveying in 1988. He began his career as a private surveyor in Adelaide.



Craig has worked as a geodetic engineer at UNAVCO in Colorado, where he was involved with GPS for geodynamic studies in Nepal, Ethiopia, Argentina, and Indonesia. Later, he was employed by the GeoForschungsZentrum in Germany where his main focus was orbit determination and prediction for a number of geodetic research satellites. Craig's doctoral studies concentrate on the development of a low-cost continuous GPS monitoring system for volcano monitoring. The work is supported by a scholarship from Trimble Navigation.

Yanlai Zhao presented a paper titled "Simulating Crustal Movement Around the Collision Boundary." Yanlai studied in the Geophysical Department of Beijing University from 1982 to 1986. He obtained a M.S. degree from the Chinese Seismological Bureau in 1992. At present, he is a doctoral student in the Department of Earth and Planetary Physics of the Graduate School of Science, University of Tokyo.



After graduating from Beijing University, he was a member of a group monitoring seismicity near Beijing using portable seismographic stations and did some work on rupture processes of large earthquakes. He subsequently worked at the Chinese Seismological Bureau investigating seismogenesis in north China by seismic tomography. Since then, Yanlai has worked with Professor Kunihiko Shimazaki in Tokyo studying dislocation models for aseismic deformation.