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GPS Monitoring Data for Active Volcanos Available on Internet

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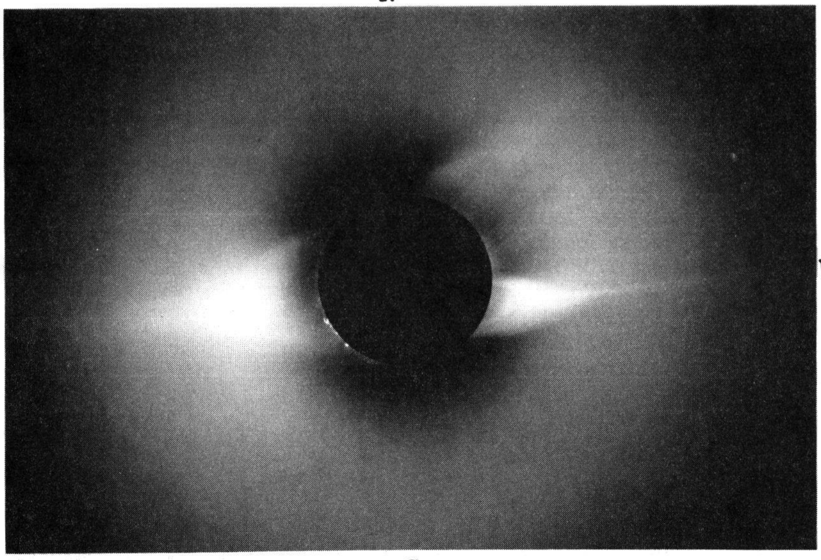

this image along with the simultaneous X ray image of the uneclipsed solar disk made by the SXT imager on the YOHKOH spacecraft. This comparison will link the coronal structures in the eclipse photograph to their underlying sources lower in the atmosphere.

The High Altitude Observatory's Newkirk camera uses a radially graded filter to compensate for the rapid coronal density gradient. It has recorded the corona at nine eclipses, the first in 1966. The photograph is a 28-s exposure on 2415 Kodak 70-mm film. The 1994 High Altitude Observatory eclipse team includes Alice Lecinski, Greg Card, David Elmore, Kim Streander, and Oran White.—*Oran White and Art Hundhausen, High Altitude Observatory, Boulder, Colo.*

SECTION NEWS

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Recent technological advances have now made it possible for volcanologists to continuously monitor active volcanoes with the Global Positioning System (GPS). These observations allow detection of large changes in surface strain near active volcanoes that may precede major volcanic eruptions by days, weeks or even months. They are therefore a critical component of programs designed to assess hazard and predict eruptions of active volcanoes.

Researchers who are unfamiliar with GPS technology or who do not have facilities to process large amounts of GPS data may have difficulty obtaining GPS results, however. To address this problem, we recently initiated a "proof of concept" system that provides, to anyone with access to Internet, analyzed results from two permanent GPS sites in Long Valley Caldera in California.

Scientists funded by NASA and the USGS have monitored activity in Long Valley caldera since January, 1993, from a permanent GPS station at the USGS two-color laser facility, CASA (named for nearby Casa Diablo hot springs) near the top of the resurgent dome. Following a 3-month period in early 1993 when the antenna was covered by snow, the system has provided a nearly continuous record of three-dimensional surface strain. *Webb et al.* [1994] summarized results from the first year of observations. A second GPS site, KRAKATAU, was installed about 8 km north of CASA at the end of September 1994. Monitoring projects at both sites were subject to the harsh conditions that are typical of many volcanoes. The temperature range at CASA has exceeded 55°C, and the antenna has been covered by up to 2 m of snow. While the CASA facility had a power supply, the remote KRAKATAU site required the use of solar panels and batteries. A dedicated telephone line was installed at CASA, and the KRAKATAU site was connected to it via high-speed radio link.

The data in our public archives begin April 1, 1994, for CASA and October 6, 1994, for KRAKATAU. Figure 1, a plot of processed data from one of the Internet files (GOLD-

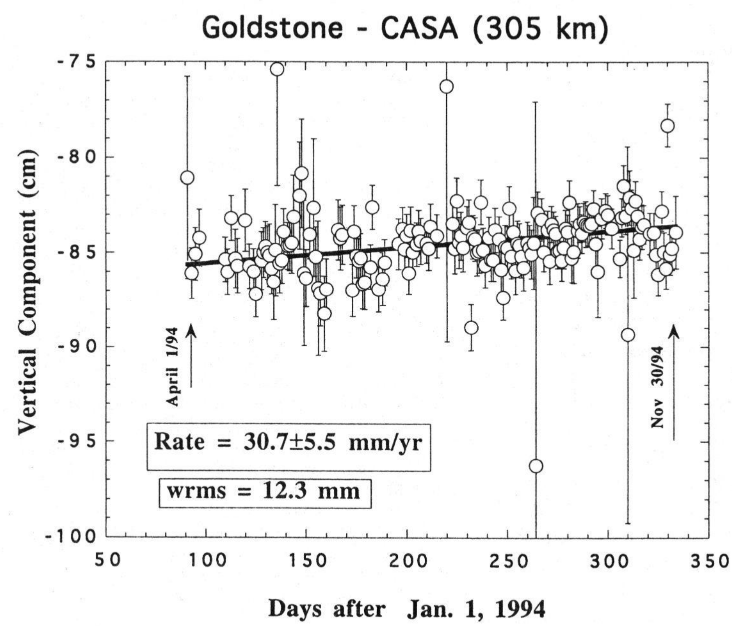

Fig. 1. Time evolution of the vertical component of the baseline vector between CASA (Long Valley) and Goldstone (Mojave Desert). Error bars represent one standard error. Weighted root mean square scatter (wrms) of the daily position estimates about the best fit line (12.3 mm) is a measure of data precision.

CASA.NEV), shows the vertical component of the baseline vector between CASA and GOLDSTONE, a station in the Mojave Desert about 300 km south-southwest of CASA. Over this 8-month period, average uplift of CASA relative to GOLDSTONE, presumably reflecting motion at CASA, occurred at a rate of 30.7 5.5 mm/yr. For comparison, uplift in 1979–1980 reached ~100–200 mm/yr [*Hill et al.*, 1985], while average uplift at CASA for 1989–1992 recorded by three GPS experiments was 27.5 4.7 mm/yr [*Dixon et al.*, 1993]. Thus we succeeded in detecting an uplift signal with a precision comparable to that achieved by the earlier intermittent GPS experiments, but over a much shorter time.

The first 2 months of data from the remote KRAKATAU site are available, and preliminary results indicate that this station is performing well. For example, on the 7.7 km CASA-KRAKATAU baseline, the wrms scatter of the north, east and vertical components is 1.5, 3, and 6 mm, respectively. We observed north-south lengthening of this baseline (25 6) mm/yr), reflecting the fact that these two sites span the deforming, expanding resurgent dome [*Langbein et al.*, 1993].

This rate agrees with the 2-color laser rate within uncertainties (J. O. Langbein, personal communication, 1994).

Raw data from CASA are sent automatically every 24 hours via high speed modem and telephone line to the International GPS Service for Geodynamics (IGS) Central Bureau at the Jet Propulsion Laboratory (JPL), much like other permanent GPS tracking sites around the world [*Zumberge et al.*, 1994]. Data from the remote KRAKATAU site are transmitted via radio link to CASA for incorporation into the data stream. Additional data from the southern California Permanent GPS Geodetic Array (PGGA) [*Bock*, 1991] and from the northern California Bay Area Regional Deformation network (BARD) [*Romanowicz et al.*, 1994] are also available. The raw data from Long Valley and the other global and regional sites are then transmitted from the IGS Central Bureau, PGGA or BARD to the University of Miami via Internet; they are analyzed within 24 hours with automated routines. Raw data are archived at JPL, Scripps Institution of Oceanography, Goddard Space Flight Center, the University of Miami and at other institutions.

In principle, any volcano could be monitored in this way as long as data are available for transmission via Internet. Data transmission within 24 hours of collection is preferable because these data can be included in our near-real time analysis and the results have direct relevance to hazard assessment. However, a second data stream that lags behind real time by several weeks or more can also be compiled in order to incorporate remote stations lacking automated communications.

We think this is an exciting development in the history of volcano studies, and we look forward to expanding and further testing the system on additional targets. Hazardous volcanoes in Mexico, Costa Rica, Columbia and Peru may be added to this monitoring system within the next one to two years, depending on receiver availability.

Analyzed data for CASA, KRAKATAU and selected other sites, residing on the public access directory of the University of Miami's Geodesy Lab computer, are available on Internet via anonymous ftp (ftp corsica.rsmas.miami.edu or use our IP address, ftp 129.171.100.35). The "README" file in the public directory (pub) gives a brief summary of the analytical techniques and available files—*Timothy H. Dixon, Frederic Farina and Ailin Mao, University of Miami; Frank Webb, Jet Propulsion Laboratory; Marcus Bursik, State University of New York, Buffalo; and Ross Stein and Grant Marshall, U.S. Geological Survey*

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