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Versatile GPS System for Monitoring Deformation of Active Landslides and Volcanoes

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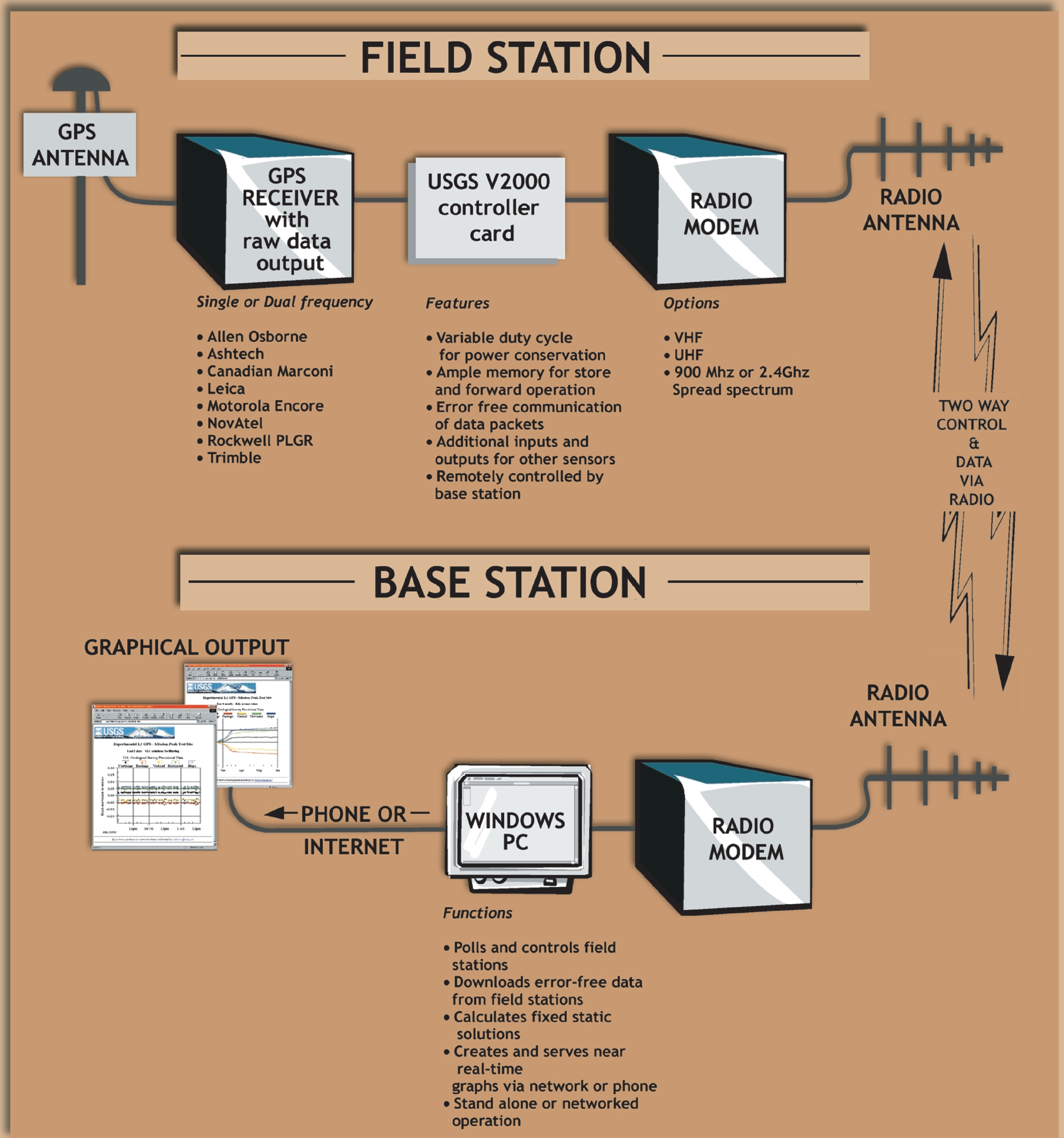
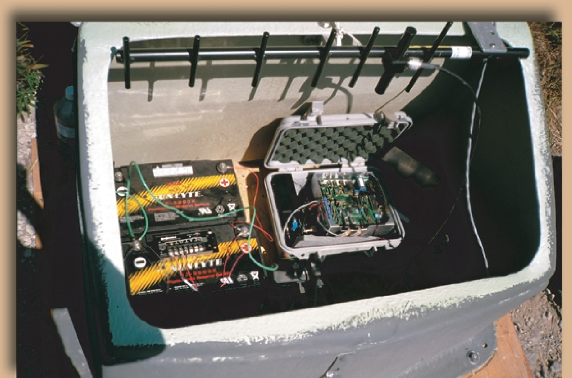
System Design

Field and base station components





System components

Trial Applications

Mission Peak Landslide

Fremont, CA

An ideal first site for trial application is found at Mission Peak Landslide in Fremont, California. A massive rock block at the head of the landslide has intermittently moved several decimeters during the last several years. We installed the system and started its operation the end of January 2000, before seasonal movement began.

SYSTEM CONFIGURATION

Antenna: Micropulse 1372
Receiver: Canadian Marconi Allstar OEM single frequency
Transceiver: Microwave Data Systems MDS 9810 900 MHz spread spectrum
Data processing engine: Waypoint Precise DLL
Baseline length: 70 meters
Operating schedule: Store, forward and process 20 minutes of 10 second L1 data every 30 minute intervals

Photo above shows the massive sandstone block with prominent tension cracks. The complete GPS master station (MS) is on stable ground near the ridgetop. The remote instrument station (RS) is located downslope but just off the block for survivability. The remote GPS antenna (RA) is on the block and cabled to the remote station.

The lower station is located on the moving block. Both GPS and radio antennas are on the mast near the electronics package inside a box with a 20 watt solar panel.

Mount St. Helens, WA

SYSTEM CONFIGURATION
Equipment : same as above Baseline lengths : 2 to 6 Km

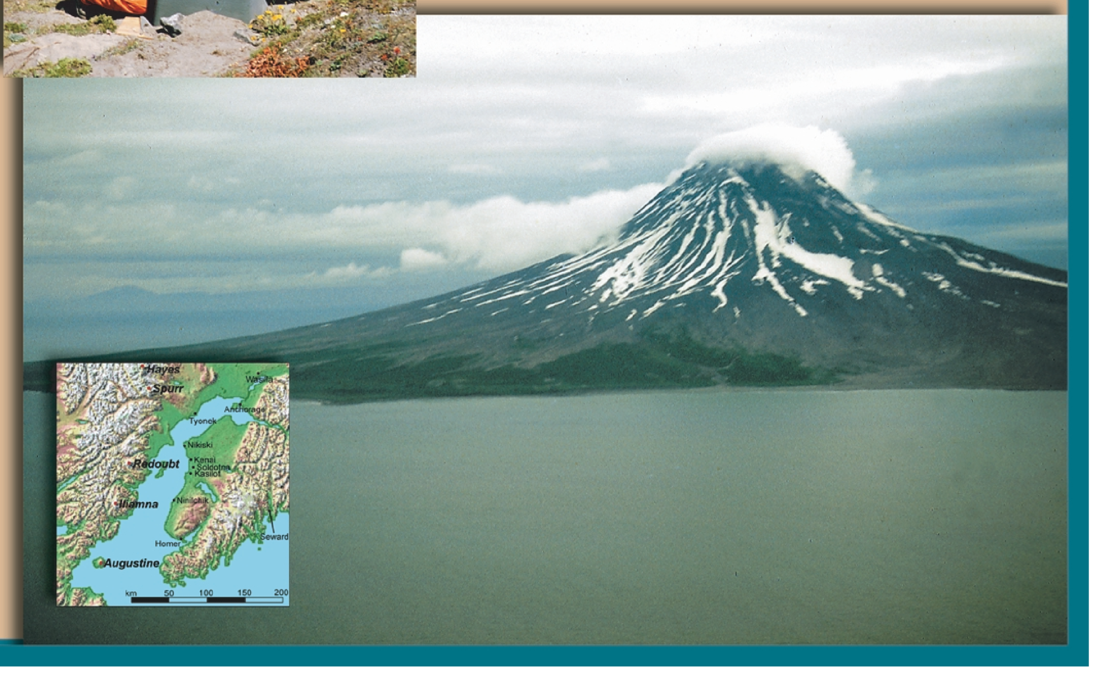
One of three stations at Mount St. Helens volcano is located on the dome in the crater. Access to all three remote sites is by helicopter. In the foreground, the GPS antenna is shown mounted on a steel pipe. In the background, an instrument shelter houses the remaining field station components as well as a seismic station and a tiltmeter. Only one of the 20 watt solar panels provides power to the GPS system.

Another GPS site at Mount St. Helens is housed in a fiberglass shelter with a small solar panel on the roof. Inside the fiberglass shelter is a yagi antenna, 2 batteries, and an environmental case containing a CMC Allstar L1 receiver, the USGS V2000 controller, and a 900 MHz spread spectrum transceiver.

Augustine Island Volcano, AK

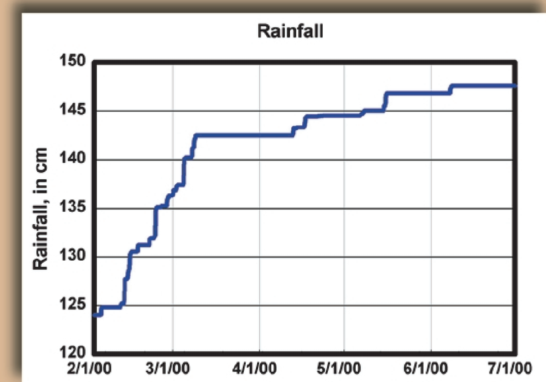
SYSTEM CONFIGURATION
Equipment same as above
Baseline lengths: 2-4 Km
Transmission distance: >100 Km

Three field stations were installed on Augustine Island Volcano in the Fall of 2000 and data are telemetered to Homer, Alaska. This site is particularly challenging because of difficult access, severe snow and ice accumulations, limited solar influx in Winter and presence of corrosive aerosols.

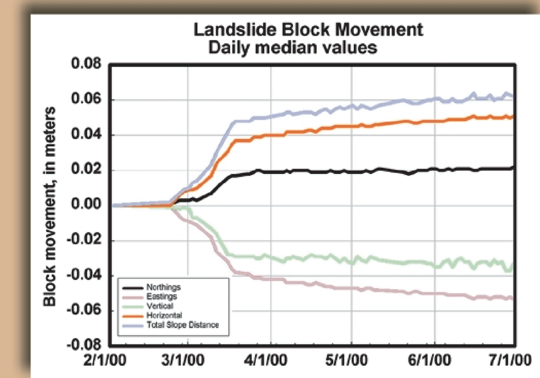


Results

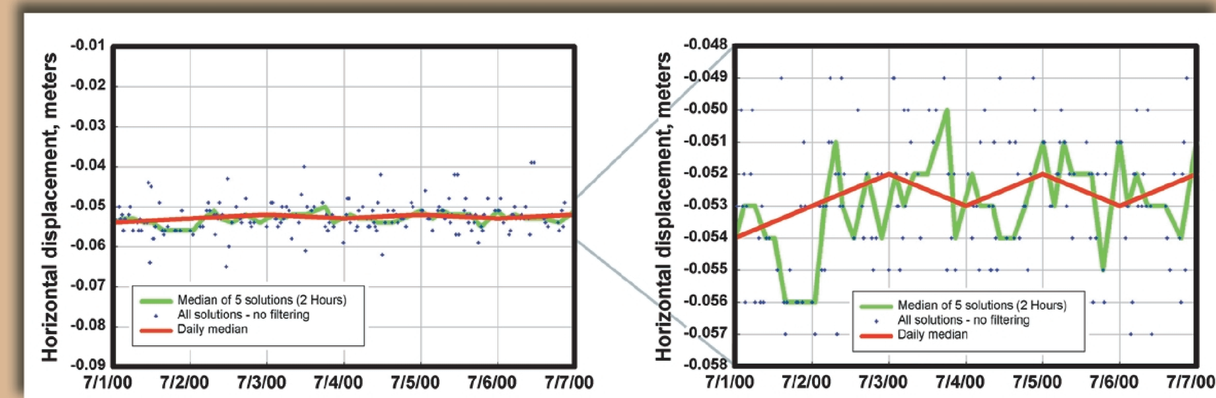
The massive block started moving in late February, initially moving at less than 1 cm/week then accelerated to twice that velocity apparently in response to periods of rainfall. The block decelerated at the cessation of seasonal rains at the end of March, but remained moving at a rate of 1 mm/week until late July. About 5 cm of cumulative displacement were detected over the 4 month period from February 1, 2000 to June 1, 2000.



Graphs showing rainfall and movement



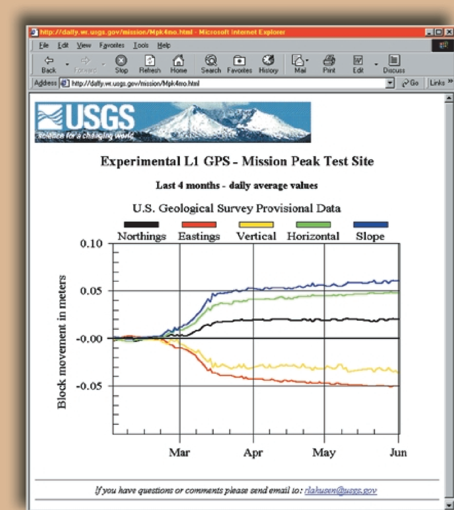
Comparison of filtered and unfiltered data

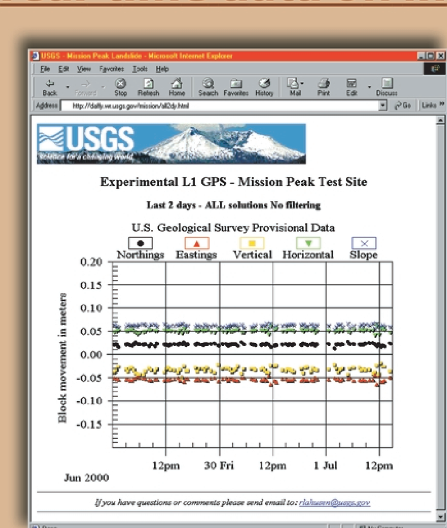


The inherent noise in GPS measurements can be seen in this graph showing all of the individual fixed static solutions. These typically showed repeatability +/- 1 cm horizontally and +/- 2cm vertically.

In order to better discern and visualize trends in the time-series, the median values for of a variable number of individual static solutions were found. This simple approach was found to be very effective in removing noise from the data and discriminating subtle movements.

Near real-time data on internet





Graphs of filtered and unfiltered solutions are automatically updated every thirty minutes and served via phone or network connections.

Conclusions

An automated GPS system for near real-time monitoring of remote geohazards was successfully developed and applied. The modular design uses a new low-power controller (USGS V2000) to store and forward raw data from a variety of GPS receivers to a Windows-based PC that controls the remote stations and intermittently calculates fixed static solutions. Initial short baseline (<10 Km) applications were configured using L1-only Marconi Allstar receivers and Waypoint Precise DLL for processing. Individual solutions obtained twice per hour from 5-20 minutes of 10-second data showed repeatability of 1 cm horizontal and 2 cm vertical. Simple filtering by finding median of 5 (2 hours) and 48 (24 hour) solutions allowed clear discrimination of sub-centimeter movements .