Leica Geosystems TruStory
GNSS Observation of Volcanic Activities in Sakurajima

Sakurajima is a volcano on the island of Kyushu. It is located on the southern edge of the Aira Caldera and erupts from the summit of Sakurajima. This summit is split into three peaks known as the Kita-dake (the northern peak), the Naka-dake (the central peak) and the Minami-dake (the southern peak). The volcano is located in close proximity to the densely populated Kagoshima city area. It is very active and is known to be the largest active volcano in Japan. The crater at Sakurajima's Minami-dake summit erupted in October 1955 (Showa 30). Since then, the volcano has been spewing volcanic products (volcanic gas, ashes, lapillus and cinders), and creating earth and rock avalanches, which continues to cause damage in every direction. Because of this, no person is allowed, without permission, within a 2 km range of the Minami-dake crater.

The volcanic explosion in October 1955 (Showa 30) was the starting point for volcanic eruption predictions at the Disaster Prevention Research Institute, and transitive volcanic activities have been monitored attentively ever since. In June 1956 (Showa 31), observation of volcanic activity in the mountain summits was on a full-scale level and it was determined that the duration would be of a long-term continual nature. This prompted the necessity to consider the construction of a permanent observation facility. The Sakurajima Volcanological Observatory was inaugurated in December 1960 (Showa 35) and originally constructed as an auxiliary facility to the Disaster Prevention Research Institute and was endorsed by the Ministry of Education, Science, Sports and Culture.

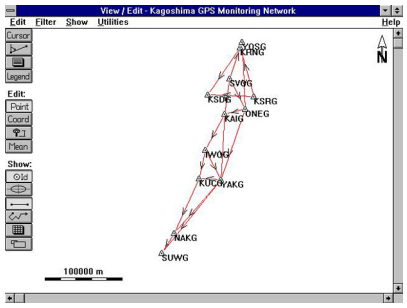
GEOSURF

- **Objective**
  Volcano monitoring to predict volcanic eruptions
- **Customer/Institution**
  Geosurf Corporation
  Disaster Prevention Research Institute Kyoto University, Sakurajima Volcanological Observatory
- **Date**
  Start August 1994
- **Location**
  Kagoshima Prefecture, Japan

- **Project Summary**
  Instruments
  Leica GMX902GG Receiver
  Leica GRX1200 Receiver
  Leica AX antenna
  Leica AT502 antenna
  Software
  Leica GNSS Spider
  Geosurf RIP (developed by Geosurf Corporation)
  Communication
  Internet
- **Challenge**
  Monitoring volcanic eruptions and predicting volcanic eruptions by utilizing the GNSS system

Emphasis is placed on seismic observation and ground deformation observation, both of which are conducted at the Sakurajima Volcanological Observatory. In order to capture a versatile picture and reach a comprehensive understanding, additional observation content is made sequentially observation to attain diversified observation. In Spring 1994 (Heisei 6), a total of 18 dual frequency GPS Leica SR299E receivers were installed, with 9 receivers at Kirishima Volcano Station and 9 at the Sakurajima Volcano Station. GPS Network Monitoring started in August of the same year.

Network System Coverage

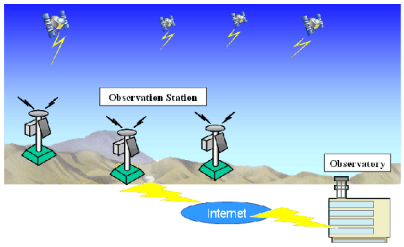


Network range is 70km x 300km

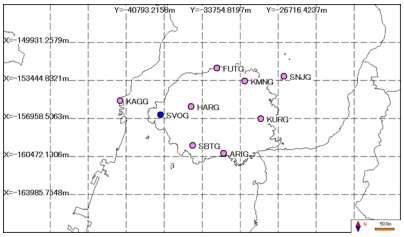
Network System Configuration

An upgrade of the GPS Network System began in 2005 (Heisei 17) and consisted of the latest in receiver and analysis software. The GPS network revision resulted in improvements in the positional system, system reliability and system efficiency.

- The implementation of the latest GNSS receiver resulted in the GNSS Network System enabling GPS + GLONASS reception
- The latest version of Leica GNSS Spider was installed on the analysis software
- The implementation of GEOSURF RIP enabled confirmation of positional data
- The enablement of GNSS receiver operation from remote areas (by Leica GNSS Spider) was accomplished
- Back-up of observed data through the implementation of CF cards on the newest receivers (Leica GRX1200) was performed in the event of problems with transmission.



Monitoring system setup



Locations of 9 observation stations in the Sakurajima network

Establishment of Observation Stations

The Leica GMX902 GG GNSS receivers were newly implemented and installed in 2 brand new observation stations and the Leica GRX1200 was updated in the existing observation station.

GPS antenna at "Kurogami" site

Characteristics of the new GNSS receiver model

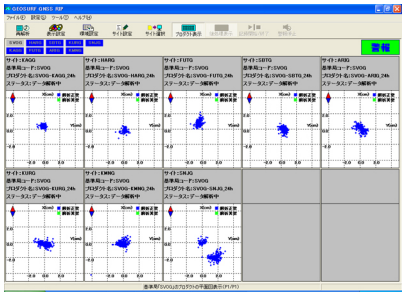
	Leica GRX1200	Leica GMX902 GG
GPS	✓	✓
GLONASS	✓	✓
Dual frequency	✓	✓
Electricity consumption	4W	2W
Leica SmartTrack	✓	✓
Web interface	✓	✓
CF card	✓	✓
Leica GNSS Spider connection	✓	o

Improvements were made in longterm reliability and static observation, by implementing Leica Geosystems "SmartTrack" function. Also, the web interface makes it possible to remotely control multiple receivers by using one computer terminal, eliminating the necessity to go to the observation station to modify the receiver configuration. Additionally, a CompactFlash card is used as a backup function for the observation data. This is particularly beneficial in volcano monitoring and observation, where circumstances do not necessarily guarantee the stability of transmitted data. With 1 GB, the CF card can

hold up to7 weeks' worth of data. The GMX902GG design is compact and solid and is a GNSS receiver that was exclusively developed for monitoring purposes.

Observation Data and Analysis

"Leica GNSS Spider" and "GEOSURF RIP" are both installed on the same computer terminal for analysis of observation data, which is then sent to the Volcanological Observatory. The main function of "Leica GNSS Spider" is positional analysis.

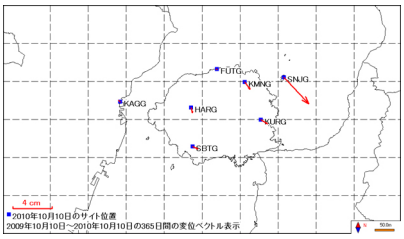


Main GUI of "Geosurf RIP"

"GEOSURF RIP" is a system equipped with a coordinate transformation function and converts coordinated measurements taken by "Leica GNSS Spider" using WGS84/ITRF into the local frame of reference and it simultaneously performs noise elimination.
Additionally, "GEOSURF RIP" utilizes the interface which displays a simple and graphic image of the horizontal position, height, and directional position on the monitor screen.

Horizontal Variation

Variation of the horizontal vector is a key element in the analysis of volcanic observation.
The following diagram displays horizontal direction movements, from the past year. The displayed movements originate from the respective observation stations. It is possible to attain the estimated pressure source positioning and magma output volume from such data, as well as other observations, which in turn lead to and enable volcanic eruption prediction.



Horizontal displacement vector from Oct 2009 to Oct 2010 when reference station is SVOG

Conclusion

The recent update in the observing system resulted in an improvement of positional accuracy.

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