# Development of Dam Displacement Monitoring Technology Using Satellite SAR

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## 1. Introduction

In dam safety management, measurement of displacement of dam or foundation rock is one of the important monitoring items, and such measurement is conducted using plumb line (pendulum) for concrete dams and electro-optical survey or GPS for embankment dams. Because conventional geodetic survey for embankment dams is relatively time-consuming, it is difficult to conduct quick geodetic survey after large earthquakes. Further, if displacement distribution with high spatial resolution is needed, the cost will increase accordingly by conventional geodetic survey. Therefore, NILIM has focused on satellite SAR (Synthetic Aperture Radar), which data has been increasingly used in the disaster prevention field and has been developing technology to use for displacement monitoring of large structures including dams. [1)]

## 2. Findings obtained and ongoing study

Displacement measurement using satellite SAR data has been conducted for 19 rockfill dams across the country which are operated by the MLIT and Japan Water Agency. [2)] As an example, Figure 1 shows displacement of the dam by the earthquake. The dam is located relatively near the epicenter of the Kumamoto Earthquake (Apr. 2016). For this dam, slight settlement was found by the electro-optical survey conducted after the earthquake by the dam management office, and the satellite SAR data provides spatial distribution of settlement of the dam. Note that the results of comparison of existing measurement data (including GPS measurement results) with displacement data of the satellite SAR in 19 rockfill dams show that the average difference was 5 mm in more than half of the dams and 10 mm in more than 80% of the dams, which suggests good accuracy of satellite SAR data displacement monitoring. For the cases of relatively large difference between SAR and existing survey, some error factors have been found, including relationship between the incident direction of radio waves from the satellite and the direction of slope gradient of the dam body surface, condition of the dam body surface that affects the scattering of radio waves, and vegetation of dam body surface. Based on the error factors we have found, we have been conducting technical development to improve the accuracy of displacement using satellite SAR data.

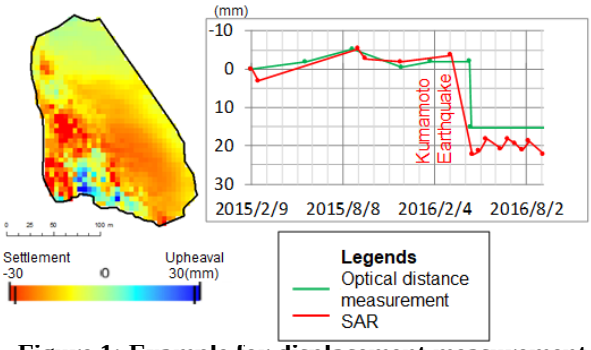


**Figure 1: Example for displacement measurement in a rockfill dam by satellite SAR (Left: Displacement distribution on the dam; Right: time series data on displacement at representative points (comparison of satellite SAR and electro-optical survey))**

## 3. Future activity

It has been found that the SAR-based displacement monitoring is highly expected to be applicable particularly to rockfill dams. For this reason, we plan to develop a manual that can be widely used by dam engineers as a manual in order to promote the utilization for monitoring displacement in rockfill dams. We also intend to conduct displacement monitoring of slopes around reservoirs, which is relatively difficult to monitor by other method, and establish a system for supporting utilization of satellite SAR data by dam administrators.

**☞See the following for details.**

1) Cross-ministerial Strategic Innovation Promotion Program ("SIP") infrastructure maintenance / renewal / management technology: "Development of a displacement monitoring methodology that detects deterioration in the ground and structures widely at an early stage using satellite SAR," http://www.jst.go.jp/sip/k07_kadai_dl.html

2) SATO Hiroyuki, KONDO Masafumi, KOBORI Toshihide, ONODERA Aoi: "External Deformation Monitoring of Nineteen Rockfill Dams Using Satellite SAR Data," Civil Engineering Journal, Sep. 2017, pp. 36-41