Detection method of anomalous crustal deformation from tilt data, and its application to the earthquake swarms in the Izu Pen..

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1.Introduction

Crustal deformation associated with subsurface magma movement is occasionally observed several hours or days before a volcanic eruption. It is crucial for mitigation of volcanic disaster to quickly obtain information of magma movement from crustal deformation data before an eruption.

NIED conducts observation of crustal deformation by borehole tiltmeters in Mt. Fuji, Miyakejima, and Izu Oshima, and collects data in real time. Tiltmeter is useful for observation of volcanic crustal deformation because it excels in accuracy and time resolution. We are developing a system that quickly estimates a source of volcanic crustal deformation just after the beginning of it. As a part of the system, we developed a detection method of anomalous crustal deformation from the tilt data, and tested it by applying to crustal deformation associated with the earthquake swarm activities in the eastern Izu Peninsula.

2.Method

We define a time when a sample of tilt data significantly differs from a value that predicted by the data obtained until t hours before the time as an occurrence time of anomalous crustal deformation. We calculate statistically the prediction by a Kalman Filter (e.g. Brockwell and Davis, 2000).

Power spectrum of tilt data shows that we can approximate the data by sum of a random work component, tidal components, and a white noise component. The characteristic of spectrum is common to tiltmeters in Mt. Fuji, Miyakejima, Izu Oshima, and the eastern Izu Peninsula. We express each component by status variables, and calculate prediction of tilt change by the Kalman filter. The variance of each component is obtained from the data by the maximum likelihood method. We used 6, 12, 24, 48, 72 hours prediction for detection of anomalous crustal deformation.

3.An application to crustal deformation associated with the earthquake swarm activities in the eastern Izu Peninsula

In the eastern Izu Peninsula, earthquake swarm activities frequently occurred, and they are usually accompanied by tilt changes. The crustal deformation is interpreted by dike intrusion into the crust (e.g., Okada and Yamamoto, 1991). In this study, we tested the detection method whether it can detect the crustal deformation. We use hourly sampled tilt record that obtained at ITO and YOS in the eastern Izu Peninsula during the period from 2001 to 2003. In this period, two small-scale activities occurred in May 2002 and June 2003, and both of them ceased in about 5 days. At the stations, tilt changes of about 2micro radian were observed in the activities.

We found that the method can detect almost only both crustal deformations within one day after the beginning of the earthquake swarm when we choose 5*sigma as the threshold of anomalous tilt change, where sigma is standard deviation of predicted tilt data (0.04-0.1 micro radian for 6 hours prediction).

4.Summary and Future work

We developed a detection method of anomalous crustal deformation from tilt data, and applied to tilt data obtained in the eastern Izu Peninsula during the period 2001 to 2003. Using the method, we could detect almost only both crustal deformations within one day after the beginning of the earthquake swarm activities.

Since tilt data of other stations have a common characteristic of spectrum, the method can be applied to the stations. Lengthening the prediction period, we can apply the method to crustal deformation with various time constants. We did not correct disturbance of tilt data by rainfall because observation of precipitation does not conducted at ITO and YOS. However, we need to correct it for the other station to improve the accuracy of our method.