A Mixed-Mode GPS Network Processing Approach for Volcano Deformation Monitoring

By

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Thesis/Project Report Sheet

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Ground deformation due to volcanic magma intrusion is recognised as an important precursor of eruptive activity at a volcano. The Global Positioning System (GPS) is ideally suited for this application by being able to measure three-dimensional coordinate changes of the monitoring points over time. Due to the highly disturbed ionosphere in equatorial regions, particularly during times of maximum solar activity, a deformation monitoring network consisting entirely of single-frequency GPS receivers cannot deliver baseline solutions at the desired accuracy level. In this thesis, a mixed-mode GPS network approach is proposed in order to optimise the existing continuous single-frequency deformation monitoring system on the Papandayan volcano in West Java, Indonesia. A sparse network of dual-frequency GPS receivers surrounding the deformation zone is used to generate empirical 'correction terms' in order to model the regional ionosphere. These corrections are then applied to the single-frequency data of the inner network to improve the accuracy of the results by modelling the residual atmospheric biases that would otherwise be neglected.

This thesis reviews the characteristics of existing continuously operating GPS deformation monitoring networks. The UNSW-designed mixed-mode GPS-based volcano deformation monitoring system and the adopted data processing strategy are described, and details of the system's deployment in an inhospitable volcanic environment are given. A method to optimise the number of observations for deformation monitoring networks where the deforming body itself blocks out part of the sky, and thereby significantly reduces the number of GPS satellites being tracked, is presented. The ionosphere and its effects on GPS signals, with special consideration for the situation in equatorial regions, are characterised. The nature of the empirically-derived 'correction terms' is investigated by using several data sets collected over different baseline lengths, at various geographical locations, and under different ionospheric conditions. Data from a range of GPS networks of various sizes, located at different geomagnetic latitudes, including data collected on Gunung Papandayan, were processed to test the feasibility of the proposed mixed-mode deformation monitoring network approach. It was found that GPS baseline results can be improved by up to 50% in the midlatitude region when the 'correction terms' are applied, although the performance of the system degrades in close proximity to the geomagnetic equator during a solar maximum.

Declaration relating to disposition of project report/thesis

ABSTRACT

Ground deformation due to volcanic magma intrusion is recognised as an important precursor of eruptive activity at a volcano. The Global Positioning System (GPS) is ideally suited for this application by being able to measure three-dimensional coordinate changes of the monitoring points over time. Due to the highly disturbed ionosphere in equatorial regions, particularly during times of maximum solar activity, a deformation monitoring network consisting entirely of single-frequency GPS receivers cannot deliver baseline solutions at the desired accuracy level. In this thesis, a mixed-mode GPS network approach is proposed in order to optimise the existing continuous single-frequency deformation monitoring system on the Papandayan volcano in West Java, Indonesia. A sparse network of dual-frequency GPS receivers surrounding the deformation zone is used to generate empirical 'correction terms' in order to model the regional ionosphere. These corrections are then applied to the single-frequency data of the inner network to improve the accuracy of the results by modelling the residual atmospheric biases that would otherwise be neglected.

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