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

By

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A thesis submitted to The University of New South Wales
in partial fulfilment of the requirements for the degree of
Doctor of Philosophy

School of Surveying and Spatial Information Systems
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July 2003

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 mid-latitude 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.

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ACKNOWLEDGEMENTS

As I complete this thesis, I would like to express my sincere gratitude to those who have contributed to my study and helped to make it all possible.

First and foremost, I would like to especially thank my supervisor Prof. Chris Rizos for his encouragement, support, valuable suggestions, and patient guidance throughout my study. Much gratitude also goes to my co-supervisor Dr. Bruce Harvey. Many thanks to A/Prof. Peter Morgan for his enthusiastic advice and support.

I wish to thank all the current and former members of the Satellite Navigation and Positioning (SNAP) group at the School of Surveying and Spatial Information Systems for their support during the period this research has been conducted. Special thanks to Dr. Craig Roberts – I have truly enjoyed our very educational and productive field trips to Gunung Papandayan in Indonesia. Also many thanks to the fantastic support staff of the School for their help during my study.

I would like to gratefully acknowledge the support given to me in form of an International Postgraduate Research Scholarship (IPRS) awarded by The University of New South Wales and funding from the Australian Research Council (ARC).

My gratitude goes out to my friends and colleagues at the ITB: Dr. Hasanuddin Abidin, Prof. Joenil Kahar, Mipi Kusuma, Dudy Darmawan, Dina Sarsito, Irwan Meilano, Gamal, and the ever cheerful driver Ohan. Thanks also to the many students who volunteered their help in the field: Deni, Heri, Asep, Susilo, Irawan, Deni, Marlon and Iing.

I would also like to express my appreciation to the Director of the Volcanological Survey of Indonesia, Dr. A.D. Wirakusumah and several staff members, especially Ony Suganda, for their expert advice. Many thanks to the VSI observers Momon, Achmad and Kresno at the Papandayan volcano observatory.

The invaluable help of several local farmers during the fieldwork on the volcano is gratefully acknowledged. An extra special thanks to Sarip for his initiative, skill, responsibility and reliability during the course of this project.

Many thanks to the staff at the VSI observatory at Gunung Guntur, the staff at the LAPAN observatory in Pameungpeuk, and Astri Pusana and her husband Ferry Augusta in Pangalengan for hosting the 'fiducial' GPS sites.

Finally I would like to express my deepest gratitude to my parents for their love, encouragement and support during all these years.