1999 – 2003

South African National Report

To The

International Association of Geodesy

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Introduction

The South African geodetic community is relatively small and consists of 10 to 15 geodesists and engineers who are involved in the activities of the IAG. This report is divided into the major sections of the IAG relevant to these activities.

Section I: Positioning

A great deal of effort has been placed on the establishment and extension of a network of permanent GPS base stations known as TrigNet. Currently 32 stations are operational each of which is equipped with two GPS receivers connected to a common choke ring antenna (see Appendix figure 1). Only post processing data is available at present but testing is under way to provide a real time correction service. Most users of the data are in the surveying, mapping and GIS environments with perhaps the largest user group being aerial photography companies. Very recently, non-geometric research on the precipitable water vapour and ionospheric mapping of the atmosphere using data from the network was commenced at Hartebeesthoek Radio Astronomy Observatory (HartRAO), the University of Cape Town (UCT) and Hermanus Magnetic Observatory (HMO).

Preliminary discussions and planning for the unification of the geodetic datums for Southern Africa were held in Cape Town in March 2001 and Windhoek in December 2002. Besides existing IGS stations and the 32 operational stations in South Africa, a further 18 potential sites have been identified for the installation of permanent GPS base stations in 7 Southern and East African countries. These will form the basis of a fiducial network from which densification and eventual recomputation and unification of the national geodetic networks in the region can be carried out. The project, which is known as AFREF, is supported very strongly by the IAG and IGS and in May 2003 was incorporated into the structures of the United Nations Economic

Commission for Africa (UNECA) Committee on Development Information (CODI), a statutory organ of UNECA.

Section II: Advanced Space Technology

Apart from the 32 TrigNet and 4 IGS permanent GPS stations established in South Africa, a further 3 IGS stations have been installed in Southern Africa by HartRAO – one each in Botswana, Namibia and Zambia. These, together with others to be installed, will provide valuable information not only for the AFREF project but also for other projects such as the expansion of the network of tide gauges on the Southern African coastline and studies of East African Rift system and the Nubian and Somalian plates of the African plate.

A preliminary determination of the relative positions of tide gauges on the South African coastline was carried by the Department of Geomatics at UCT, using GPS measurements.

HartRAO has in the past four years developed its Space Geodesy Programme to the extent that it has become one of five fiducial geodetic installations in the world. The three major space geodetic techniques, VLBI, SLR and GPS, are supported. A DORIS system is also collocated with these three systems.

- VLBI: 17 % of the 26 m radio telescope time has been allocated to geodetic VLBI and has led to an average of 56 twenty four hour experiments per year. A budget allocation has been made to replace the thin tape system with the MKV disk cartridge system during 2003 to keep abreast of latest developments.
- SLR: MOBLAS6 achieved operational status in mid 2001 and achieved superior performance levels in mid 2002. This system is constantly in the top ten SLR tracking sites as far as performance is concerned. Future plans include the conversion of MOBLAS6 to provide a Lunar Laser Ranging capability and the replacement of MOBLAS6 with an SLR2000 system.
- GPS: HartRAO joined the TIGA pilot project of the IGS as a regional data and associate analysis centre, in addition to being an IGS regional data centre. Two GPS systems have been collocated with tide gauges and a further similar system is in the process of being installed.

Several projects have been initiated to further the study of crustal dynamics. The analysis of data and development of reduction techniques is showing great promise to determine vertical crustal motion due to earth tide effects as determined by GPS. This will allow calibration of gravity changes due to earth tide effects at installations such as superconducting gravimeters. The longer term component could be used to calibrate satellite (e.g. CHAMP) orbits.

Section III: Determination of the Gravity Field

Research at the Department of Geomatics at UCT has concentrated on developing software for geoid determination, and then applying this software to the computation of regional and continental geoids. Special attention has been paid to the refinement of 2D spherical convolution and the contribution of the Molodensky G_1 term. Research has also been carried out in investigating the impact of errors in digital elevation models on height anomalies.

During the past four years local geoid models have been computed and tested (against GPS/levelling data) in the Western Cape and Gauteng provinces. On a broader scale a quasi-geoid model for southern Africa has been produced (see Appendix figure 2), as has a provisional geoid model for the continent of Africa. This also has implications for the broader AFREF project which not only concentrates on unifying the horizontal geodetic systems of Africa but also the vertical systems.

Appendix

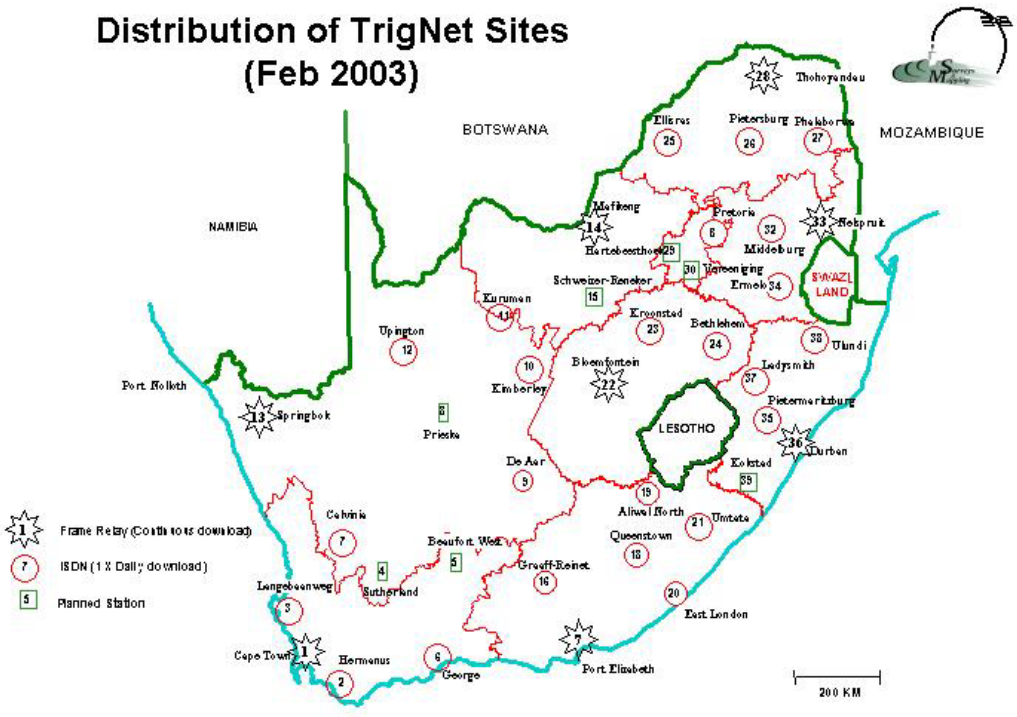

Figure 1: Distribution of TrigNet stations as at February 2003

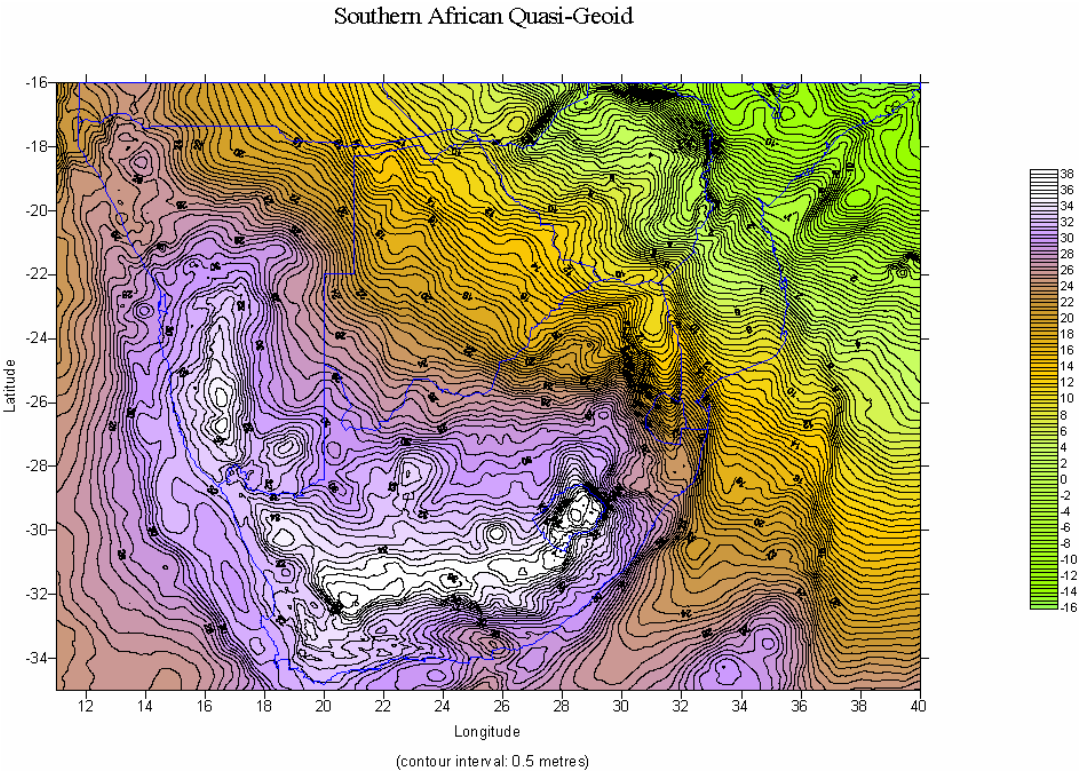

Figure 2: Quasi-Geoid - Southern Africa

Publications by Section

Section I

Combrinck, L and Nsombo, P (2002): The IGS station and its Role in Land Delivery in Zambia. Presented, Fourth United Nations/United States of America Regional Workshop on the Use and Applications of Global Navigation Satellite Systems, Lusaka, Zambia, July 2002.

Cilliers P. J., Gouws D., Opperman B., Wonnacott R.T. and Combrinck, L. (2003). The South African network of dual-frequency global positioning system satellite receiver base stations: a national asset with many applications and research opportunities. *SA. J. Science*. **99**, 12: 51-55.

Hedling, G, Parker, A and Wonnacott, R (2000): TrigNet - The Network of Active GPS Base Stations for South Africa. *Proceedings of Institute of Navigation ION GPS 2000, Salt Lake City,* September 2000.

Wonnacott, R (1999): The Implementation of the Hartebeesthoek94 Co-ordinate System in South Africa. *Survey Review* **35** (274): 243- 250.

Wonnacott, R (2002): The Southern African Reference Frame (SAFREF) – Progress and the Way Forward. Presented, Fourth United Nations/United States of America Regional Workshop on the Use and Applications of Global Navigation Satellite Systems, Lusaka, Zambia, July 2002.

Section II

Combrinck, L (1999): Space Geodesy at HartRAO. Conference proceedings, *Federation Internationale des Geometres Working Week*, 1999, Sun City, South Africa.

Combrinck, L (1999): Hartebeesthoek Radio Astronomy Observatory, in *International VLBI Service for Geodesy and Astrometry 1999 Annual Report*, edited by NR Vandenberg and KD Baver, NASA/TP-1999-209243, 1999.

Combrinck, L (2000): Local Surveys of VLBI Telescopes, in *International VLBI Service for Geodesy and Astrometry 2000 General Meeting Proceedings,* edited by NR Vandenberg and KD Baver, NASA/CP-2000-209893.

Combrinck, L (2001): HartRAO. IGS Regional/Operational Center Report, *International GPS Service 2000 Technical Report*, edited by K Gowey, R Neilan, A Moore, 2001.

Combrinck, L (2001): Hartebeesthoek Radio Astronomy Observatory (HartRAO), in *International VLBI Service for Geodesy and Astrometry 2000 Annual Report*, edited by NR Vandenberg and K D Baver, NASA/TP-2000-209979, 2001.

Combrinck, WL and Chin, M (2001): IGS Stations: Station and Regional Issues*, Phys. Chem. Earth (A), Vol. 26, No. 6-8, pp.539-544.* Proceedings of the first COST Action 716 Workshop "Towards operational GPS meteorology" and the second Network workshop of the International GPS Service (IGS), Oslo, Norway, July 2000, guest editors H-P Plag, S Barlag, M Caissey, L Combrinck, G Elgered, A Moore, H van der Marel.

Combrinck, L (2002): The IGS Network in Africa; an update and real-time issues. Conference paper presented at the *IGS Network, Data and Analysis Center Workshop 2002*, 'Towards real-time', Ottawa, Canada, April 2002.

Combrinck, L (2002): Network, Instrumental Improvements and Future Plans of the HartRAO Fiducial Station, in *Proceedings of The Eleventh General Assembly of the Wegener Project, WEGENER 2002*, Athens, Greece, June 2002.

Combrinck L, and Haupt W (2002): HartRAO MOBLAS-6 station report, in *International Laser Ranging Service* 2001 Annual Report., 2002.

Combrinck, L (2002): Hartebeesthoek Radio Astronomy Observatory, in *International VLBI Service for Geodesy and Astrometry 2001 Annual Report*, edited by NR Vandenberg and KD Baver, NASA/TP-2002-21001, 2002.

Fernandes, R, Ambrosius, B, Noomen, R, Combrinck, L, Bastos, L, Spakman, W and Sucure, J (2003): Geodynamics of Africa from Continuous GPS Data: Analyses and Implications. EGS-AGU-EUG Annual Conference, Nice, France April 2003.

Zimba, R and Merry, CL (2001): First results for the GPS survey of South African tide gauges. *GPS Solutions*, **55**(1): 78-88.

Section III

Amod, A and Merry, CL (2002): The use of the two-dimensional spherical FFT for quasi-geoid modelling in South Africa. *Survey Review*, **36**(285): 508-520.

Amod, A and Merry, CL (2002): A note on the Molodensky G_1 term. *Bulletin of the International Geoid Service*, **12**: 52-80.

Merry, CL and Amod, A (2001): Proposals for a new South African quasi-geoid model. Proceedings, CONSAS 2001, Cape Town. CD-ROM.

Merry, CL and Blitzkow, D (2001): The African geoid project. Proceedings, IAG 2001 Scientific Assembly, Budapest. CD-ROM.

Merry, CL (2002): The gravity connection - the role of the geoid. Presented, Fourth United Nations/United States of America Regional Workshop on the Use and Applications of Global Navigation Satellite Systems, Lusaka, Zambia, July 2002.

Merry, CL (2003): DEM-induced errors in quasi-geoid modelling. Submitted, Journal of Geodesy.

Merry, CL (2003): A quasi-geoid model for Southern Africa: UCT2003. University of Cape Town, Department of Geomatics, Internal Report G-24, February 2003.

Merry, CL, Blitzkow, D, Abd-Elmotaal, H, Fashir, HH, John, S, Podmore, F and Fairhead, JD (2003): A preliminary geoid model for Africa. Submitted for presentation at the XXIII General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan, July 2003.

Neumeyer, J., Barthelmes, F., Combrinck, L., Dierks, O. and Fourie, P. (2002): Analysis Results from the SG registration with the Dual Sphere Superconducting Gravimeter at SAGOS (South Africa), published in International Center for Earth Tides' *Bulletin d' Informations Marées Terrestres (BIM) 135, 10607-10616, 2002,* and presented at the Third Workshop of the Global Geodynamics Project (GGP) on Superconducting Gravimetry.