South African research in geodesy: 1999–2003

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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 International Association of Geodesy. This report is divided into the major sections of the IAG relevant to these activities; positioning, advanced space technology, and gravity field. We conclude with a selected number of publications to indicate active contributions from a South African perspective.

Positioning

Much effort has been placed on the establishment and extension of a network of permanent Global Positioning System (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 (Fig. 1). Only post-processing data are 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 begun at Hartebeesthoek Radio Astronomy Observatory (HartRAO), the University of Cape Town (UCT) and Hermanus Magnetic Observatory (HMO). Preliminary results of the water vapour studies conducted at HartRAO were displayed on the front cover of the January/February 2003 issue of the *South African Journal of Science.*

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Preliminary discussions and planning for the unification of the geodetic datums for southern Africa were held in Cape Town in March 2001 and in Windhoek in December 2002. Besides existing international GPS service (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 seven 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 (for African Reference Frame), is strongly supported by the IAG and IGS and in May 2003 was incorporated into the structures of the UN Economic Commission for Africa (UNECA) Committee on Development Information (CODI), a statutory organ of UNECA.

HartRAO has launched a project in collaboration with GFZ Potsdam (Geo Forschungs Zentrum) of Germany and several local institutes to establish a sub-network of AFREF, the SADC (Southern African Development Community, which consists of 14 countries) GPS network. This network will form part of the southern component of AFREF and the first phase of this project includes the installation of at least one GPS receiver in each SADC country.

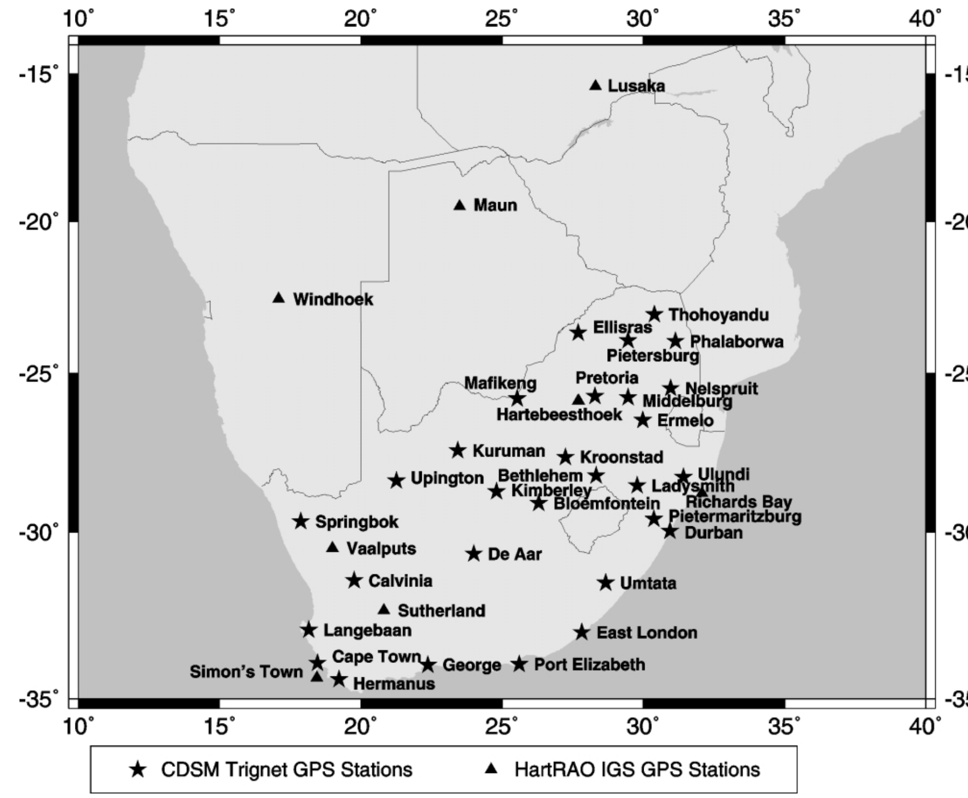

Fig. 1. Distribution of TrigNet and SADC GPS Network stations in September 2003.

Fig. 2. The antenna for the GPS equipment located at the laboratory of the Okavango Research Centre, Maun, Botswana. Installed by HartRAO in collaboration with Natural Resources Canada and the University of Botswana, this facility forms part of the SADC GPS network and will be instrumental in providing data for ionospheric studies, measuring water levels in the Okavango Delta, and land management.

Advanced space technology

Apart from the 32 TrigNet and four IGS permanent GPS stations established in South Africa, a further three IGS stations have been installed in southern Africa by HartRAO, one each in Botswana (in collaboration with Canada) (Fig. 2), Namibia (in collaboration with Germany) and Zambia (in collaboration with the U.S.A.). 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 along the southern African coastline, and studies of the 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 a 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 (very-long-baseline interferometry), SLR (satellite laser ranging) and GPS, are supported. A Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS) system is also collocated with these three systems:

- VLBI: 17% of the 26-m radio telescope's time has been allocated to geodetic VLBI and has led to an average of 56 twenty-four-hour experiments per year. The thin-tape data recording equipment will be replaced 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 in terms of performance. 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 GPS at Tide Gauge (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 started to promote the study of crustal dynamics. The analysis of data and development of reduction techniques are showing great promise for determining vertical crustal motion due to earth tide effects as determined by GPS. This will allow calibration of gravity changes due to tidal effects at installations such as superconducting gravimeters. The longer-term component could be used to calibrate satellite orbits, such as those of CHAMP (for CHAllenging Minisatellite Payload). This is a German, small-satellite mission for geoscientific and atmospheric research and applications. With its multifunctional and complementary payload elements (magnetometer, accelerometer, star sensor, GPS receiver, laser retro-reflector, ion drift meter) and its orbit characteristics (near polar, low altitude, long duration) CHAMP will produce precise gravity and magnetic field measurements over a 5-year period.

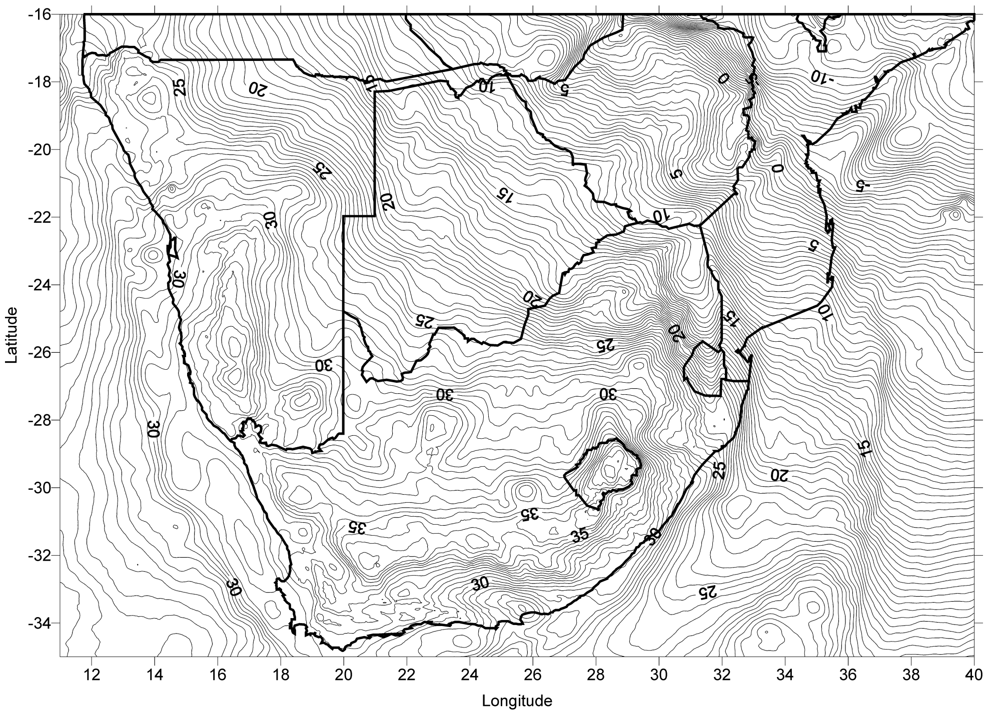

Fig. 3. Quasi-geoid for southern Africa (contour interval: 0.5 m).

Determination of the gravity field

Research in 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 two-dimensional spherical convolution and the contribution of the Molodensky G_1 term (G_1 is the first term in the Molodensky expansions, and can be used in corrections for the gravity field as experimental observations are made on non-level surfaces, due to varying topography). Research has also been carried out on the effect 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 (Fig. 3), as has a provisional geoid model for the continent of Africa. This has implications for the broader AFREF project, which not only concentrates on unifying the horizontal but also the vertical geodetic systems of Africa.

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