Review of recent research in geodesy in South Africa: 2003 - 2006

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Introduction

This paper gives a brief review of activities and research results of South African institutes with activities relating to the International Association of Geodesy (IAG) during the quadrennium 2003-2006. The report forms part of the South African National Report to the International Union of Geodesy and Geophysics (IUGG) for presentation at the IUGG General Assembly to be held in Perugia, Italy, during July 2007. South African institutions actively involved in IAG-related activities during the last four years included: Division of Geomatics, University of Cape Town; Hartebeesthoek Radio Astronomy Observatory (HartRAO), National Research Foundation (NRF), Hartebeesthoek; Chief Directorate: Surveys and Mapping, Department of Land Affairs, Cape Town.

The South African geodetic community

The South African geodetic community is relatively small and consists of about 10 geodesists, geophysicists and engineers who are involved in the activities of the IAG. Due to the size of the community, the IAG is not formally organized in South Africa. At a meeting of the South African National Committee for the IUGG in 30 March 2005 concern was expressed at the paucity and calibre of young researchers in the disciplines of geodesy and geophysics. Most of the researchers in these fields are of mature age and many will be retiring over the next five to ten years. The number of individuals beginning postgraduate studies is small, and a significant number of these, while being good MSc students, do not progress further to take up PhD studies. Although the committee has no formal figures to support this claim, we believe that the potential exists for a crisis in research in geodesy and geophysics within the next ten years.

Part of the problem is the small pool from which to draw potential researchers. The number of undergraduate students taking geomatics and geology (from which most researchers in these disciplines are drawn) is small and diminishing. Most graduates from this small pool are attracted into industry and very few move forward into research. Members of the committee and their colleagues are doing their best, via schools and public outreach programmes, to enlarge the pool and to encourage graduates to study further.

Commission 1: Reference Frames

From an African perspective, South Africa has a very strong and well-established geodetic infrastructure. There are five IGS stations located in South Africa operated by the Space Geodesy Programme of HartRAO. The geodetic infrastructure at HartRAO formed the backbone of the South African network of permanent GPS base stations (known as TrigNet).

TrigNet

A great deal of effort has been placed on the extension and modernisation of **TrigNet**. Currently 43 stations are operational, each of which is equipped with two GPS receivers connected to a common choke ring antenna (see figure 1). All stations provide dual frequency post processing data. A real time service (both DGPS and RTK) was established from all stations streaming data to the control centre in Cape Town via Networked Transport of RTCM via Internet Protocol (NTRIP) since 2005. Three virtual reference station clusters, in the Cape Peninsula, Gauteng and Durban Metropolitan areas will be established during 2007. Most users of TrigNet data and services are in the surveying, mapping, aerial photography and GIS environments.

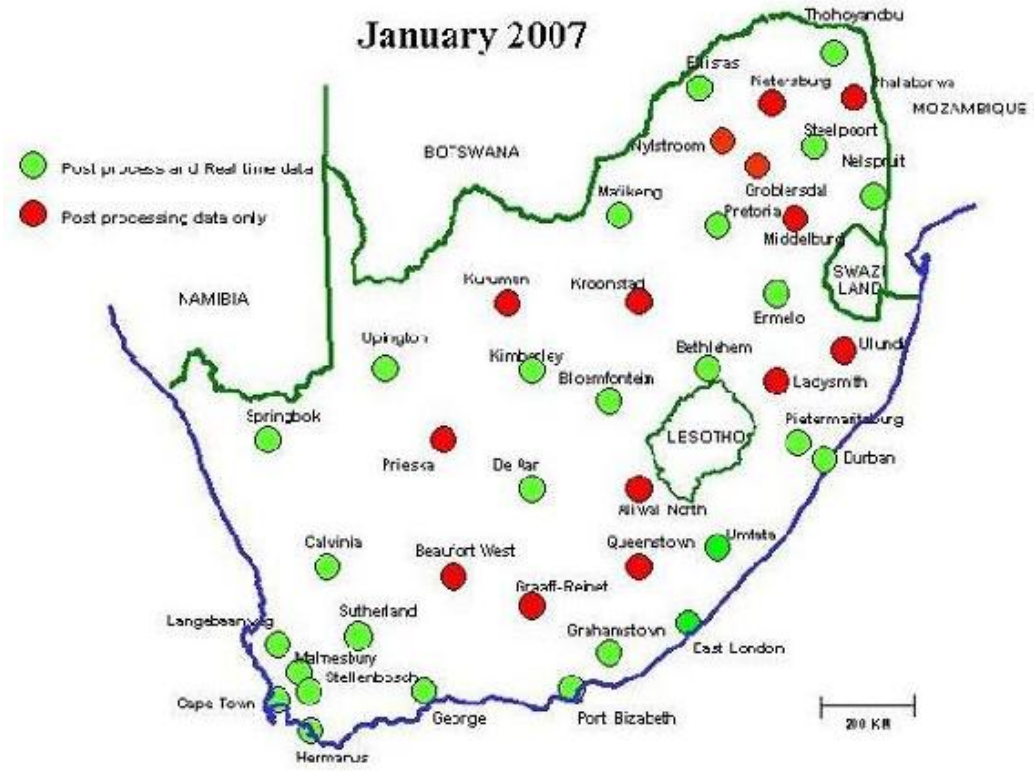

Figure 1: Distribution of TrigNet stations as at January 2007

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 Research and development of the operational application of GNNS data derived from TrigNet for meteorological applications to be carried out between CDSM and SA Weather Service while applications in space weather is progressing well and will be included in IHY and IPY activities.

AFREF

The African Reference Frame (AFREF) is aimed at unifying the co-ordinate reference systems and frames of Africa to create an environment in which all activities requiring sound geo-spatial information such as surveying, mapping, geographical information systems, navigation, engineering projects, atmospheric and geophysics research and applications and disaster monitoring and mitigation are based on a uniform modern international co-ordinate system. The project has been initiated from within Africa and is being implemented, managed and executed by African geodesists, surveyors and scientists with assistance from the international community.

In March 2006, a dedicated AFREF workshop was organized by FIG Commission 5 at the FIG Regional Conference, Accra. Five papers presented followed by general discussion session. A great deal of interest was generated interest within West Africa as indicated by number of countries from that region present at this workshop and currently installing permanent GNSS receivers.

Although the ideals and concepts of AFREF have been debated for a number of years, the scientific and technical aspects of the project had never been highlighted in a dedicated workshop. The possibility of South Africa hosting such a technical workshop was raised at a United Nations Office for Outer Space Affairs (UNOOSA) meeting in Vienna in December 2004. A small Local Organising Committee was constituted and the University of Cape Town was selected as the most appropriate venue. The workshop was initially planned for January / February 2006 but, because of insufficient funding at the time, was postponed to July 2006. The University of Cape Town and the Chief Directorate: Surveying and Mapping jointly organised the first AFREF Technical Workshop in July 2006, relating to the establishment of the African Geodetic Reference Frame. Delegates from 24 countries attended. 38 representatives from 17 countries with a good geographical distribution throughout Africa were represented at the workshop. 4 representatives from 2 of the 3 regional centres for mapping in Africa also participated in the workshop viz. the Regional Centre for Mapping of Resources for Development (RCMRD) based in Kenya and the Regional Centre for Training in Aerospace Surveys (RECTAS) based in Nigeria. In addition to the above representatives from Africa, 15 speakers from a number of organisations outside of Africa gave presentations.

Figure 2: AFREF logo launched at the technical workshop held in July 2006

Commission 2: Gravity Field

Research at the Division of Geomatics at the University of Cape Town 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, the contribution of the Molodensky G_1 term and the influence of changing the geopotential reference model. Research has also been carried out in investigating the impact of errors in digital elevation models on height anomalies.

A revised geoid model has recently been computed for the continent of Africa, and tested using GPS/levelling data from South Africa and Algeria. For the 62 points in South Africa a RMS agreement of 18cm was achieved, while for the 14 points in Algeria the RMS agreement was 27cm. The best results were obtained using the low-order (less than 120) CG03C geopotential reference model. The high-order version of this model and the high-order EGM96 model produced less accurate results.

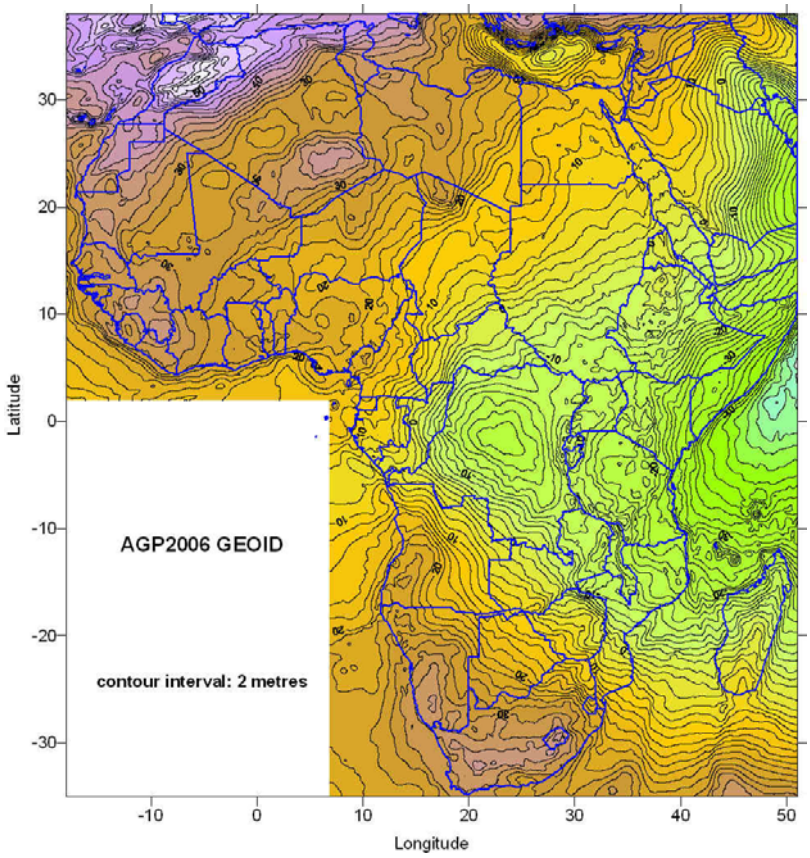

Figure 3: AGP2006 Geoid model for Africa

A more detailed (2' grid) quasi-geoid model for southern Africa was also developed and compared to GPS/levelling in the south-western part of South Africa. The RMS agreement was 15cm, after allowing for a 34cm bias. If the geoid model is tilted, to allow for datum biases between the geoid, GPS and levelling data, the RMS fit reduces to 4cm.

Commission 3: Earth Rotation and Geodynamics

HartRAO continued to participate in the global geodetic VLBI (IVS) and SLR (ILRS) networks, which provide data for Earth Orientation Parameters and global crustal dynamics studies. Approximately 54 geodetic VLBI experiments are performed per year. The VLBI system was upgraded with the Mark 5 disk pack to replace the high-density tape drive. A new Hydrogen MASER frequency standard was installed and the surface of the 26 metre radio telescope was upgraded to higher tolerance which improved the surface accuracy and the radio telescope efficiency.

Support was given by HartRAO (August 2006) to a consortium of universities (USA, UK, Tanzania) and the Surveyor General of Tanzania to study the dynamics of the East African Rift. This is a 5 year project and includes the establishment of a permanent GPS station in Dar es Salaam and the installation and GPS occupation of approximately 30 self-centring antenna mounting plates.

Data from the GFZ superconducting gravimeter at Sutherland were analysed at HartRAO along with GPS data from the collocated receiver. The relationship between mismodelled Earth tides and GPS-derived precipitable water vapour estimates was studied and a technique was presented to estimate the amplitude of Earth tides based on GPS measurements of vertical displacements.

Commission 4: Positioning and Applications

Total Electron Content (TEC) Mapping

The South African network of GPS receivers, as shown in Figure 2, is expanding and it is the long term plan to utilise the data from these receivers to derive ionospheric information over the areas that are not covered by the current ionosondes. This will allow using an existing network to supplement the ionospheric network, thereby providing a more comprehensive map of ionospheric behaviour over South Africa.

Fiducial site ties

During the period July to August 2003 report a comprehensive site tie was done at Hartebeesthoek and processed by a team consisting of members from CDSM (South Africa), HartRAO (South Africa), IGN (France) and GSFC (NASA). The eccentricities between the VLBI antenna, GPS, DORIS and SLR are now known at the millimetre level. This is an important constraint in the combination of techniques for the maintenance of the ITRF.

Defence applications

The Division of Geomatics at the University of Cape Town investigated the use of differential GPS for the calibration of weapons radar systems on board warships of the South African Navy.

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