

The Influence of Gravity and Topographic Mass Density on Heights

Degree:	M.Sc (by research) or Ph.D
Key-words:	Physical geodesy, height systems, orthometric heights and corrections, gravity inside the topographic masses, topographic mass density, geoid
Entry:	Bachelors, preferably 1st class Honours, Postgraduate Diploma or Masters degree in geoscience, physics, mathematics, or any related science or engineering discipline
Supervisor:	Dr.-Ing. Michael Kuhn (kuhnm@vesta.curtin.edu.au)
Project Funding:	Various
Student Funding:	Student is required to win APA, IPRS or other scholarship (http://www.scholarships.curtin.edu.au/) At the beginning the student will be funded by the project.
Resources:	Australian gravity and terrain data, Australian Height Datum data, software routines to compute the gravitational effect of different shaped bodies, density model in the Perth region, geological maps of Australia
Collaboration:	Geoscience Australia, International Association of Geodesy
Starting Date:	Unrestricted

Project Description:

Heights must be rigorously defined in the Earth's gravity field, because it is gravity that drives the flow of water. However, the drawback of actual (practical) height systems in use is their often very crude approximation of the Earth's gravity field. This is mainly due to the approximation of real gravity values and neglecting the variation of topographic mass density, which holds also for the Australian Height Datum (AHD, Roelse et al. 1971).

The consequence is that practically defined height systems are in general not consistent with the Earth's gravity field (Heiskanen and Moritz 1967, chapter 4). A theoretical and practical study of the principal differences between these height systems mainly under the consideration of taking gravity and topographic mass density data into account should be performed by this project.

This will be achieved by the research in the following areas:

- A complete study of orthometric heights, which are rigorously defined in the Earth's gravity field (e.g. Heiskanen and Moritz 1967, p. 166). This involves mainly the determination of the gravity vector along the plumb line inside the topographic masses. To do this, different methods based on the computation of the gravitational effect caused by the regarded mass distribution are available from the geodetic literature (e.g. Heiskanen and Moritz 1967; p. 163, Sjöberg 1995). Applying these methods will show the differences in the resulting orthometric heights by using various topographic mass density models, which can give a better insight in the possible practical use of the orthometric height system.
- As mentioned before, practical defined height systems such as the AHD are very often not consistent with the classical definition of geodetic height systems such as orthometric or normal height systems (e.g. Featherstone 1998, Featherstone and Stewart 1998, Morgan 1992, Kearsley et al. 1988). Therefore another important part of this project will be the study of the relations between different actual height systems in use (e.g. AHD or the German height system DHHN) and the before mentioned geodetic height systems. The outcomes of this study can contribute to the redefinition of these and other height systems.

- The actual study involves mainly the use of height, gravity and topographic mass density data. The major part of these data will be provided practical studies over Australia. However, additional data where they are necessary will be collected during this project by different field campaigns. The most problematic data are the topographic mass densities, which are mainly provided indirectly over Australia by a set of geological maps showing the surface rock type. Therefore the possibility of constructing a three-dimensional Digital Density Model (DDM) from geological maps together with additional information from geology and geophysics. Additional methods exist to determine a mean density value from surface gravity data (e.g. Parasnis, 1962), which should be included in this study.

Recommended Reading:

- Allister, N.; Featherstone, W.E. (2001): Determination of Helmert orthometric heights using digital barcode levelling, observed gravity and topographic mass-density data over part of the Darling Scarp, Western Australia, *Geomatics Research Australasia*, **75**:25-52.
- Featherstone, W.E. (1998): IAGG SSG3.177 Synthetic modelling of the gravity field of the Earth, <http://www.cage.curtin.edu.au/~will/iagsg3177.html>
- Featherstone, W.E. (1998): Do we need a gravimetric geoid or a model of the base of the Australian Height Datum to transform GPS heights?, *The Australian Surveyor*, **43**(4):273-280.
- Featherstone, W.E.; Stewart, M.P. (1998): Possible evidence for distortions in the Australian Height Datum in Western Australia, *Geomatics Research Australasia*, **68**:1-12.
- Grafarend, E.W.; Syffus, R.; You, R.J. (1995): Projective heights in geometry and gravity space. *AVN 10/1995* pp. 382-402.
- Huang, J.; Vanicek, P.; Pagiatakis, S.D.; Brink, W. (2001): Effects of topographical density on geoid in the Canadian Rocky Mountains. *Journal of Geodesy*, **74**:805-815.
- Heiskanen, W.A.; Moritz, H. (1967): *Physical Geodesy*. W.H. Freeman and Company, San Francisco.
- Kearsley, A.H.W., Rush, G.J., O'Donnell, P.W. (1988): The Australian Height Datum – problems and proposals. *The Australian Surveyor*, **34**(4):363-380.
- Kuhn, M. (2000): Density Modelling for Geoid Determination. In M.G. Sideris (ed.): *Gravity, Geoid and Geodynamics 2000*, International Association of Geodesy Symposia, **123**:272-276.
- Kuhn, M. (2001): On the indirect effect of Helmert's condensation methods. *Int. Geoid Service Bulletin* (accepted)
- Morgan, P.J. (1992): An analysis of the Australian Height Datum: 1971. *The Australian Surveyor*, **37**(1):46-63.
- Nagy, D., Papp, G., Benedek, J. (2000): The gravitational potential and its derivatives for the prism. *Journal of Geodesy*, **74**: 522-560.
- Pagiatakis, S.D.; Fraser, D.; McEven, K.; Goodracer, A.K.; Véronneau, M. (1999): Topographic mass density and gravimetric geoid modeling. *Boll. Geof. Teor. Appl.*, **40**(3-4):189-194.
- Parasnis, D.S. (1962): *Principles of applied geophysics*. Methuen, London.
- Roelse, A.; Granger, H.W.; Graham, J.W. (1971): The adjustment of the Australian levelling survey – 1970-71. Technical Report 12, Division of National Mapping, Canberra.
- Sjöberg, L.E. (1995): On the quasigeoid to geoid separation. *Manuscripta geodaetica*, **20**(3):182-192.
- Strange, W.E. (1988): An Evaluation of Orthometric Height Accuracy Using Bore Hole Gravimetry. *Bulletin Géodésique*, **56**:300-311.
- Vanicek, P., Janak, J. (2001): Mean Vertical Gradient of Gravity. In M.G. Sideris (ed.): *Gravity, Geoid and Geodynamics 2000*, International Association of Geodesy Symposia, **123**:259-262.