

NATIONAL REPORT 2005, FINLAND, NORDIC GEODETIC COMMISSION, MEETING OF THE WORKING GROUP FOR GEODYNAMICS, ÅS, NORWAY MARCH 13-15, 2006.

Ruotsalainen H., J. Ahola, M. Bilker-Koivula, J. Jokela, H. Koivula, P. Lehmuskoski, J. Mäkinen, M. Ollikainen, J. Piironen, M. Poutanen, P. Rouhiainen, M. Tervo, H. Virtanen

ABSOLUTE GRAVIMETRY

In the frame of the Nordic absolute gravity project the FGI measured in 2005 at the Metsähovi AB, AC, Vaasa AA, AB, Joensuu, Sodankylä, Kevo and Kuusamo absolute gravity stations.

A comparison of absolute gravimeters of IfE (Institute für Erdmessung, University of Hannover, Germany) and FGI took place in May and August 2005 in Metsähovi, Finland.

Absolute gravity measurements financed by the European Commission continued at the Władysławowo tide gauge in Poland (23.-26.9.2005) in cooperation with the Polish Space Center.

The FGI participated in the large intercomparison of absolute gravimeters at BIPM, Sevres, France, 16-20.9.2005. A bilateral comparison between absolute gravimeters of FGI and of TsNIIGAiK, took place in Zvenigorod, Moscow, Russia, 14.-18.10.2005.

The FGI continued absolute gravity measurements at the Finnish Antarctic base Aboa (3-11.12.2005), at the South African Antarctic base SanaelV (28.-31.1.2006) and the Russian Antarctic Base Novolazarevskaya (5.-7.2.2006).

The FGI measured also at Paarl 16.-18.2.2006 and the Astronomical Observatory in Sutherland, South Africa (22.2.-3.3.2006). The measurement in Sutherland is a cooperation with GeoforschungZentrum (GFZ), Potsdam, Germany and it has taken place also in 2001 and 2004.

RELATIVE GRAVIMETRY

Relative gravity measurements at the Keurusselkä impact structure (discovered by amateur geologists in 2004) were carried out by the FGI in cooperation with the Department of Physical Sciences of the University of Helsinki in 2005 and revealed a more detailed Bouguer anomaly map of the impact structure.

A 1km x 1km detailed Bouguer anomaly field around the Metsähovi gravity laboratory was calculated from gravity survey data of 2004 and estimation of the underground bedrock surface topography, soil and turf structure were carried out in cooperation with the Department of Physical Sciences of the University of Helsinki.

Relative gravity data from the Fennoscandian land uplift gravity line campaigns have been put into EXCEL-data files for further calculations.

SUPERCONDUCTING GRAVIMETRY

The superconducting gravimeter GWR T020 at Metsähovi observes temporal variations in gravity. Depending on the frequency, it is capable of detecting gravity variations as small as 0.01 nm s^{-2} . For single events (e.g., steps) the detection limit is about 1 nm s^{-2} . The main goal is the maintenance of the equipment, continuous data acquisition and good quality. It participates in the GGP (Global geodynamics project) and the data has been transmitted to the common data bank GGP-ISDC (<http://ggp.gfz-potsdam.de>). Due to high precision, the data has been applied all-round to investigations at Metsähovi. Studies of gravity data comprise the gravity spectrum from microseismics to Chandlerian period. The main topics were Earth tides, local hydrological effects on gravity (rain, snow and groundwater) and loading effects due to regional and global water storage.

Investigation of the local hydrology in Metsähovi was continued in the project *Modelling and Monitoring Local Hydrological Effects in Gravity*, in co-operation with the Laboratory of Geoenvironmental Technology, Helsinki University of Technology, the Finnish Environment Institute and the Geological Survey of Finland. The detailed mapping of fractures in the bedrock was pursued further with ground penetrating radar (GPR) techniques. The gravity effect of groundwater in the fractures was modelled.

Hydrological loading effects were calculated using both the high accurate model for Finland (Watershed Simulation and forecasting System, WSFS) and the Climate Prediction Center global soil moisture data set (CPC). Results were compared and evaluated with SG and local permanent GPS observations.

The global model for total water storage (CPC water storage) correlates well with the highly accurate model for Finland (WSFS water storage). We have compared monthly gravity models of the GRACE satellite and time series of the superconducting gravimeter at Metsähovi with both water storage models. We found that gravity variations correspond well with the models. The local groundwater has a strong effect on gravity observed with the superconducting gravimeter at Metsähovi. It proved that local variation in the groundwater level is clearly connected to the whole water storage in Finland.

The data of T020 together with 7 worldwide SGs have been compared with variation in regional gravity observed with the GRACE satellites, and with the variation in regional gravity predicted from global models of terrestrial water storage. On the whole, a good correlation was found.

Modelling of the Influence of Atmospheric Masses and Baltic Sea Level on Gravity in cooperation with the Finnish Meteorological Institute and the Finnish Institute of Marine Research continued.

The gravimeter has been used as a long-periodic seismometer to study free oscillations of the Earth after major earthquakes.

WATERTUBE TILT METER

An interferometrically recording Michelson-Gale (MG) type water tube tilt meter has been developed since 1965 at the FGI.

In 1977 - 1998 crustal tilt recordings were carried out with EW (177m) and NS (62m) water tube tilt meters with a film based recording system and the results were promising for studying the crustal dynamics and studies on the Earth's internal structure.

A modern version of the water tube tilt meter with automated interferometrical recording has been developed and built since 2000. A prototype of the instrument has been recording periods since august 2005 at the laboratory of FGI.

METSÄHOVI GEODETIC OBSERVATORY

The observatory was founded in 1978 and it became an essential part of the activities of the FGI and is globally one of the most versatile space geodetic observatories. The instrumentation covers geodetic VLBI, permanent GPS & Glonass receivers, Doris beacon (CNES, France), superconducting gravimeter, seismometer, a fundamental absolute gravity point and a satellite laser ranging system (SLR). The SLR has been under renovation since spring 2005 and has not been operational.

LOCAL CRUSTAL DEFORMATION STUDIES USING HIGH PRECISION GPS MEASUREMENTS

Since 1994 the investigations of local crustal movements have been regularly carried out at Olkiluoto, Kivetty and Romuvaara in cooperation with Posiva Oy. The investigation areas are candidates for the final disposal of spent nuclear fuel used in Finland. The local GPS network at Olkiluoto has been measured twice per year and the GPS pillars at Kivetty and Romuvaara has been observed annually. The network at Olkiluoto has been precise levelled in 2003 and 2005 for vertical deformations studies too. The network at Olkiluoto has been precise levelled in 2003 and 2005 for vertical deformation studies.

The GeoSatakunta project has been established in 2002 for the studies of geology and geodynamics at the province Satakunta in Western Finland. The network of ten GPS pillars is located near Olkiluoto investigation area, and it has been measured three times per year since 2003.

POSTGLACIAL REBOUND STUDIES WITH FINNREF-GPS NETWORK

Studies on temporal variations of the time series of the Finnish permanent GPS network FinnRef are continued. The variations are studied in connection with the work made for the rebound studies with GPS and repeated precise levellings together with atmospheric and ocean loading modelling. The goal is to study crustal deformations like PGR but also atmospheric effects on GPS signals.

The international cooperation in the BIFROST (Baseline Inferences for Fennoscandian Rebound Observations, Sea Level and Tectonics) project was continued.

GPS observations together with observations obtained from the superconducting gravimeter were used for modelling the atmospheric loading effect. The work was a part of a joint project with the Finnish Meteorological Institute.

ANTARCTIC PROJECT

The FGI has participated in geophysical research at Antarctic since 1989. In the field expeditions the FGI has measured the geodetic reference net for the mapping of the surroundings of the Finnish Antarctic Station Aboa and a regional gravity network around it.

One research topic is the repeated absolute gravity measurements at the Aboa absolute gravity station. During the 2005-2006 expedition the absolute gravity was measured for the fourth time at the Aboa station.

A permanent GPS station of the FGI was put into operation at Aboa in the beginning of the year 2003. The Javad Legacy GPS receiver has been operating three years now without any major interrupts.

PUBLICATIONS

ARTICLES IN INTERNATIONAL JOURNALS

Francis, O., T. van Dam, M. Amalvict, M. Adrade de Sousa, M. Bilker, R. Billson, G.D'Agostino, S. Desogus, R. Falk, A. Germak, O. Gitlein, D. Johnson, F. Klopping, J. Kostelecky, B. Luck, J. Mäkinen, D. McLaughlin, E.

nunez, C. Origlia, V. Palinkas, P. Richard, E. Roderiguez, D. Ruess, D. Schmerge, S. Thies, L. Timmen, M. van Camp, D. van Westrum, H. Wilmes, 2005: 'Results of the International Comparison of Absolute Gravimeters in Walferdange (Luxembourg) of November 2003.' In: C. Jekeli, L. Bastos, J. Fernandes (Eds.) *Gravity, Geoid and Space Missions, GGSM 2004*, IAG International Symposium, August 30 - September 3, 2004, Porto, Portugal. Springer-Verlag, 2005. pp. 272-275.

Mäkinen J., Engfeldt A., Harsson B. G., Ruotsalainen H., Strykowski G., Oja T. and Wolf D. (2005): The Fennoscandian Land Uplift Gravity Lines 1966 - 2003, in C. Jekeli, L. Bastos, J. Fernandes (Eds.), *Gravity, Geoid and Space Missions, GGSM2004*, International Symposium Porto, Portugal, August 20 - September 3, 2004, International Association of Geodesy Symposia, Vol. 129, Springer

Poutanen M., J. Jokela, M. Ollikainen, H. Koivula, M. Bilker, H. Virtanen, (2005): Scale variation of GPS time series. In F. Sansò (Ed.) *A Window on the Future of Geodesy*. IAG General Assembly in Sapporo, Japan 2003. pp. 15-20. IAG Symposia 128, Springer Verlag.

ARTICLES IN NATIONAL AND INTERNATIONAL CONFERENCE PROCEEDINGS

Ahola, J. (2005): Tarkkoihin GPS-mittauksiin perustuva kallioperän deformaatiotutkimus Olkiluodossa. Maanmittaustieteiden päivät Epävarma maailma 17.-18.11.2005, Maanmittaustieteiden Seuran julkaisu n:o 42. s. 66-73.

Ahola, J., M. Ollikainen, H. Koivula and J. Jokela (2005): GPS operations at Olkiluoto, Kivetty and Romuvaara in 2004. Working Report 2005-41, Posiva Oy. Olkiluoto. 286 pp.

Bilker, M., 2005: 'Evaluation of the new global gravity field models from CHAMP and GRACE with GPS-levelling data in Fennoscandia.' In: A. Viljanen, P. Mäntyniemi (Eds.) *XXII Geofysiikan Päivät*, Helsingissä 19.-20.5.2005. Geofysiikan Seura, Helsinki, 2005. pp. 21-26.

P. Heikkinen, L. J. Pesonen, A. Korja, H. Virtanen ja A. Beckmann (2005): Sumatran luonnonkatastrofin geofysiikkaa. XII Geofysiikan päivät Helsingissä 19.-20.5. 2005, s 45-49. (in finnish)

Koivula H., J. Mäkinen ja J. Ahola (2005). Maankuoren nykyliikkeet ja painovoiman muutokset Kuningatar Maudin maalla Etelämatereella. XXII Geofysiikan päivät. (Toim. A. Viljanen ja P. Mäntyniemi). p. 83-88. (in finnish)

Lehmuskoski, P., Rouhiainen, P., Saaranen, V., Takalo, M. ja Virtanen, H.: Liikkuvatko kalliopisteet - tapaus Metsähovi. XXII Geofysiikan Päivät Helsingissä 19.-20.5.2005. Geofysiikan Seura. (Kokoomajulkaisu, toim. A. Viljanen ja P. Mäntyniemi). (in finnish)

Pesonen L.J., S. Hietala, M. Poutanen, J. Moilanen, M. Lehtinen and H.E. Ruotsalainen (2005): The Keuruselkä meteorite impact structure, Central Finland: geophysical data. XXII Geofysiikan päivät. (Toim. A. Viljanen ja P. Mäntyniemi). p. 165-170.

Pesonen L.J., S. Hietala, M. Poutanen, J. Moilanen, M. Lehtinen and H.E. Ruotsalainen (2005): Keuruselkä - The eleventh meteorite impact structure in Finland, in Siili Tero, Huttunen Emilia, Koskinen Hannu (toim.): *Kymmenes Suomen avaruustutkijoiden kokous, (FinCospar) kokousjulkaisu 57, Raportti 2005:3, Ilmatieteen laitos*

Piironen J., M. Poutanen (2005): Geodeettinen VLBI Metsähovissa. XXII Geofysiikan päivät. (Toim. A. Viljanen ja P. Mäntyniemi). p. 171-174. (in finnish)

Poutanen M., P. Knudsen, M. Lilje, T. Nørbech, H.- P. Plag, H.-G. Scherneck, (2005). NGOS. Report of the Nordic Geodetic Commission Task Force. <http://www.nkg.fi/nggos.html>. 30 pages.

Ruotsalainen H. E. (2005): A Fizeau type thin film interferometer for precise fluid level sensing in the long water tube tilt meter, Proceedings of the Annual Meeting of the Finnish Optical Society 12.-13.4.2005 Jyväskylä Finland

Ruotsalainen H. E. (2005): Interferometrisesti rekisteröivän pitkän vesivaa'an kehitystyöstä ja sillä suoritetuista kallioperän liikkeiden tutkimuksesta In: A. Viljanen, P. Mäntyniemi (Eds.) *XXII Geofysiikan Päivät*, Helsingissä 19.-20.5.2005. (in finnish)

Tervo M., M. Poutanen ja H. Koivula (2005). GPS:n käyttömahdollisuudet mareografitutkimuksessa. XXII Geofysiikan päivät. (Toim. A. Viljanen ja P. Mäntyniemi). p. 229-233. (in finnish)

H. Virtanen (2005): Suprajohtavan gravimetrimin käytöstä geofysiikassa. XXII Geofysiikan päivät Helsingissä 19.-20.5. 2005, s. 263-267. (in finnish)

Heikki Virtanen (2005): Suprajohtava gravimetri ja painovoiman ajalliset muutokset. Maanmittaustieteiden Seuran julkaisu n:o 42, s. 17-22. (in finnish)

ABSTRACTS, POSTERS, ORAL PRESENTATIONS, LECTURES

- Ahola, J. (2005): Tarkkoihin GPS-mittauksiin perustuva kallioperän deformaatiotutkimus Olkiluodossa. Maanmittaustieteiden päivät 17.-18.11.2005. TKK, Espoo. (in finnish)
- Ahola, J. ja M. Poutanen (2005): GPS-mittaukset Satakunnassa. GeoSatakunta -symposio 25.10.2005, Pori. (Kutsuesitelmä), (in finnish)
- Hokkanen, T. & Virtanen, H. 2005. Hydrogeological Effects on Superconducting Gravimeter Data. Proceedings of the 67th EAGE Conference & Exhibition, June 13 - 16, Madrid, Paper H002, 4 pp. Abstract and oral presentation.
- Häkli, P. (2005): Verkko-RTK ja sen hyödyntämismahdollisuudet deformaatiomittauksissa. Esitys. Tutkijakoulu, Muodonmuutosmittaukset, seminaari. TKK, Espoo, 3.3.2005. (in finnish)
- Häkli, P. (2005): VRS:n merkitys - tutkimuksellinen näkökulma. Esitys. VRS-tukiasemaverkon rakentamishankkeen päätöstilaisuus. Saariselkä, Ivalo, 15.-16.6.2005. (in finnish)
- Häkli P. and H. Koivula (2005): Network RTK in Finland - Current status and test results. Oral presentation at the meeting of the Nordic Geodetic Commission (NKG) Working Group for Positioning and Reference Frames, November 16-17, 2005, Masala, Finland.
- Koivula H., J. Mäkinen ja J. Ahola (2005a). Geodetic monitoring of crustal deformation in Dronning Maud Land, Antarctica. Poster and oral presentation at the meeting of the Nordic Geodetic Commission NKG Working Group for Geodynamics, May 3-4, 2005, Masala, Finland.
- Koivula H., J. Mäkinen ja J. Ahola (2005b). Maankuoren nykyliikkeet ja painovoiman muutokset Kuningatar Maudin maalla Etelämatereella. Suullinen esitys. XXII Geofysiikan päivät. (in finnish)
- Koivula H., J. Mäkinen ja J. Ahola (2005c). Geodetic monitoring of crustal deformation in Dronning Maud Land, Antarctica. Poster presentation. European Geosciences Union General Assembly 2005 Vienna, Austria, 24 - 29 April, 2005.
- Koivula, H., J. Mäkinen, J. Ahola, M. Bilker, M. Poutanen, 2005: 'Estimating gravity change and crustal motion in Dronning Maud Land, Antarctica.' Abstract and oral presentation at IAPSO, 2005 IAG/IAPSO/IABO Joint Assembly, Cairns, Australia.
- Lehmuskoski, P., Rouhiainen, P., Saaranen, V., Takalo, M. ja Virtanen, H.: Liikkuvatko kalliopisteet - tapaus Metsähovi. Esitelmä, XXII Geofysiikan päivät 19.-20.5.2005 Helsingissä. (in finnish)
- Mäkinen J., J. Ahola, M. Bilker, J. Hyypä, H. Hyypä, M. Karjalainen, H. Koivula, and M. Poutanen (2005). Estimating glacial isostatic adjustment and present-day ice mass balance in Dronning Maud Land. Poster presentation. The first CryoSat User Workshop, ESRIN (Italy), 8-10 March 2005.
- Mäkinen, J, M. Bilker, L. Timmen, O. Gitlein, J. Muller, H. Denker, H. Wilmes, R. Falk, A. Reinhold, W. Hoppe, B.R. Pettersen, O.C.D. Omang, J.G. Svendsen, F. Klopping, H.-G. Scherneck, B. Engen, B.G. Harsson, A. Engfeldt, M. Lilje, G. Strykowski, R Forsberg, 2005: 'Observing Fennoscandian gravity and geoid change with absolute gravimetry and GRACE'. Abstract and oral presentation at IAPSO, 2005 IAG/IAPSO/IABO Joint Assembly, Cairns, Australia.
- Ollikainen M., J. Ahola (2005): Monitoring Local Crustal Movements Using High Precision GPS Network. Dynamic Planet 2005, Cairns, Australia, August 22-26, 2005. A joint meeting of the IAG, IAPSO and IABO. Program & Abstract Book. p. 249, PT0054.
- Pettersen, B.R., L. Timmen, O. Gitlein, J. Muller, H. Denker, J. Mäkinen, M. Bilker, D.I. Lysaker, O.C. Omang, J.G. Svendsen, H. Wilmes, R. Falk, A. Reinhold, W. Hoppe, H. Scherneck, M. Lidberg, B. Engen, O. Kristiansen, A. Engfeldt, G. Strykowski, R. Forsberg, F. Klopping, G. Sasagawa, 2005: 'Absolute Gravimetry in Fennoscandia - A Contribution to Understanding Postglacial Uplift.' Abstract and invited talk at AGU Fall Meeting, 5-9 december, 2005, San Francisco, USA.
- Ruotsalainen H. E.(2005): Interferometrisesti rekisteröivän pitkän vesivaa'an kehitystyöstä ja sillä suoritetuista kallioperän liikkeiden tutkimuksesta. XXII Geofysiikan Päivät, Helsingissä 19.-20.5.2005. (poster) (in finnish)
- Ruotsalainen H. E.(2005): A Fizeau type thin film interferometer for precise fluid level sensing in the long water tube tilt meter, Annual Meeting of the Finnish Optical Society 12.-13.4.2005 Jyväskylä, Finland (poster)

- Saaranen V (2005): Tarkkavaaituksilla määritetty vuosittainen maannousu Suomen alueella. XXII Geofysiikan päivät Helsingissä 19.-20.5.2005. (in finnish)
- Tervo M., M. Bilker, H. Koivula, J. Makinen, M. Poutanen and H. Virtanen, 2005: 'Surface Loading Correlation With GPS Vertical Data.' Oral and poster presentation at COMET - Advances in GPS Data Processing and Modelling for Geodynamics meeting at the University College London (UCL), London 9-11 November, 2005.
- Timmen, L., O. Gitlein, J. Mäkinen, M. Bilker, R. Falk, A. Reinhold, H. Wilmes, B.R. Pettersen, O.C.D. Omang, J.G.G. Svendsen, 2005: 'Accuracy of absolute gravity control in Fennoscandia - groundtruth for GRACE'. Abstract and poster presentation at IAPSO, 2005 IAG/IAPSO/IABO Joint Assembly, Cairns, Australia.
- Virtanen, H., M. Bilker, J. Mäkinen, M. Poutanen, M. Tervo, B. Vehviläinen, M. Huttunen, R. Mäkinen, 2005: 'Comparison of modelled variation in water storage in Finland with GRACE and superconducting gravimeter observations'. Abstract and poster presented at EGU General Assembly, 24.-29.4.2005, Vienna, Austria. Geophysical Research Abstract, Vol 7. 06248
- Virtanen, H., M. Bilker, J. Mäkinen, M. Tervo, B. Vehviläinen, M. Huttunen, R. Mäkinen, M. Peltoniemi, T. Hokkanen, M. Pirttivaara, 2005. 'Comparison of modelled variation in water storage in Finland with superconducting gravimeter observations and with GRACE'. Abstract and poster presentation at IAPSO, 2005 IAG/IAPSO/IABO Joint Assembly, Cairns, Australia.