Third International School on
"Least Squares Approach to Modelling the Geoid"

After the successful experiences in the determinations and evaluations of precise local geoid models in different countries as well as the very well met 1st and 2nd International Geoid Schools at Yildiz Technical University, Istanbul, in September 2010 and Universiti Teknologi Malaysia, Johor Bahru, in February-March 2012, we plan to arrange the 3rd International Geoid School based on the KTH Approach. (KTH is a Swedish abbreviation for Royal Institute of Technology, Stockholm, Sweden). The school will be arranged at KTH from 18 to 22 of August, 2014.

The KTH approach to geoid determination is unique in the sense that it uses least squares technique in the spectral domain to combine the data in an optimum way by considering the errors of the EGM, the gravity data and the truncation of Stokes’ integral to a cap around the computation point. Another feature that distinguishes the KTH method from others is the way corrections for topography, atmosphere and ellipsoidal shape of the earth are applied: all corrections are added as separate additive corrections. This method was successfully applied in the determination of several regional geoid models: over Sweden, the Baltic countries, Greece, Iran, Sudan, Zambia, Ethiopia, Tanzania, Serbia, Moldova, part of Turkey and, finally, in the 2009 test project for the comparison of up-to-date methods of geoid modelling in Auvergne, France. See also the reference Yildiz et al. (2012) below. The official geoid models of Sweden and Estonia are based on the LSMSA technique.

The school will be organized with theoretical lectures in the mornings followed by computer exercises in the afternoons, where the software available at KTH will be used. Computers will be simultaneously available for the exercises. Since the Geoid School has a full-week intensive program, it can be counted as an external full graduate course.

The school is primarily offered only for university students and personnel from public organizations, and the software package is made available only for training of students and scientific works.

Why KTH approach?

Many different methods have been proposed through the years for regional geoid determination by gravimetric data, each based on its own technique and philosophy. Today, all such methods combine long-wavelength Earth Gravity Models (EGMs) with local gravity data, and they mainly differ in the way they combine these data sets. The KTH approach is unique in the sense that it uses least squares technique in the spectral domain to combine the data in an optimum way by considering the errors of the EGM, the gravity data and the truncation of Stokes’ integral to a cap around the computation
point. Another feature that distinguishes the KTH method from others is the way corrections for topography, atmosphere and ellipsoidal shape of the earth are applied: in contrast to other methods, which all apply these corrections both to the gravity anomaly (direct effects) and to the preliminary computed geoid heights (indirect effects), it only corrects the preliminary geoid heights by so-called additive corrections. Any of the additive corrections can be added afterward at any time when better data are available for its improvement (without the need to repeat all the computations). The method, called Least Squares Modification of Stokes Formula with Additive corrections (LSMSA), is the result of 30 years of research and several M.Sc. and Ph.D. theses at KTH. The LSMSA is an accurate, simple and practical method of determining the geoid. The theoretical and practical aspects of this method have been developed since 1984 to present mainly by and under the supervision of Prof. Lars E. Sjöberg. (See numerous papers, e.g. in J. of Geodesy.) The method has been successfully applied in the determination of several high-resolution regional geoid models in different areas. Through the LSMSA approach, various data, such as a Global Geopotential Model, gravity anomalies and a high-resolution photogrammetric/SRTM Digital Elevation Model are combined to a gravimetric geoid model, and the method can be (and usually is) designed to match with GPS/levelling data by using the least-squares principle. Several of the successful applications are reported in M.Sc. and Ph.D. theses at www.infra.kth.se/geo. Notable among these studies are the applications in rough topographic areas and in several developing countries with only limited gravity anomaly data. The results of comparisons clearly show that the LSMSA is advantageous to other methods.

Finally, in the recent test project for the comparison of up-to-date methods of geoid modelling with data from Auvergne area in France, no method provided better results than the LSMSA. A comparison of remove-compute-restore and LSMS techniques on this data set is also reported in Yildiz et al. (2012; see open access reference below).

The lecture notes will be prepared on a CD, which contains also exercises, data sets and software. Each student will receive a copy of the CD, and it will also be sent electronically to students well ahead of the school.

All lectures are followed by computer exercises, where the software available at KTH will be used. The participants should bring their own laptop for the exercises.

This training course provides a good opportunity for the student to familiarize himself with the latest developments in geoid determination, as well as to enhance the international collaboration in gravity field modelling by building contacts to the professionals dealing with geoid determination in various countries.

Reference
## Preliminary Program

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<tr>
<th>Days</th>
<th>Lecture (Morning)</th>
<th>Lecture (Afternoon)</th>
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<td>1</td>
<td>- Opening of the school.</td>
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<td>- Lecture 1</td>
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<td>- Basic Physical Geodesy</td>
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<td>- Modification of Stokes’ formula (Part 1)</td>
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<td><em>Lecturer: Prof. Lars Sjöberg</em></td>
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<td>- Lecture 2</td>
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<td></td>
<td>- Modification of Stokes’ formula (Part 2)</td>
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<td>- Additive corrections (Part 1)</td>
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<td><em>Lecturer: Prof. Lars Sjöberg</em></td>
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<td>- Lecture 3</td>
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<td>- Additive corrections (Part 2)</td>
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<td>- Lecture 4</td>
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<td>- LSMSA vs. the RCR-Technique</td>
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<td>- Some practical experiences (e.g., from recent Ph.D. theses at KTH)</td>
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<td>- Lecture 5</td>
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<td>- KTH GEOLAB Software Sample Full Project Workshop (Part 1)</td>
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<td>- KTH GEOLAB Software Sample Full Project Workshop (Part 2)</td>
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<td><em>Dr. Ramin Kiamehr</em></td>
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<td>3</td>
<td>- Lecture 5</td>
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<td></td>
<td>- KTH GEOLAB Software Sample Full Project Workshop (Part 3)</td>
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<td>- Summary of the course and Final Discussion</td>
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<td>- Closing the school</td>
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<td>- Fitting the Gravimetric Geoid to GPS on Benchmarks. (Including Exercises) <em>Dr. Ramin Kiamehr</em></td>
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<td><em>Lars Sjöberg &amp; Ramin Kiamehr</em></td>
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1) Morning lectures 9-12 am 2) Afternoon lectures 1-4 pm

## The Venue

The school will be held at Royal Institute of Technology, Division of Geodesy and Geoinformatics, Drottning Kristinas väg 30, Stockholm (see the attached map over Stockholm). The workshop dinner is planned for Thursday evening August 21, and the sight-seeing tour in Stockholm after the closing of the school on Friday afternoon.
Registration

The registration fee is 5000 SEK to be paid due 15 June, 2014. Late registration fees of 6000 SEK are accepted after that date. The fee includes lecture notes, preliminary software manual, a CD with the LSMSA software package, lunches, coffee/tea at breaks, a social dinner and a city sight-seeing tour.

Details for payment are provided by the contact persons given below.

Notification of your interest to participate in the school

Please send an email to Mr. M. Bagherbandi (mohbag@kth.se) as soon as you know that you are likely to participate.

Accommodation

There are many hostels and numerous hotels in Stockholm (search the web), but unfortunately not many with low prices. For example, STF hostel /hotel (www.fridhemsplan.se/) (newly renovated) has single rooms from 550 SEK, double rooms from 650 SEK and triple from 900 SEK. The participants must book their accommodation by themselves. If anyone needs a room-mate among participants, the organizers may help to find one.

More information

Contact the organizer (see below) or Mohammad Bagherbandi (mohbag@kth.se) for additional questions.

Organizer

The geoid school is led by:

Lars E. Sjöberg
Head of Geoid School

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