Fifth International School on
“Least Squares Approach to Modelling the Geoid”
- In memorial of Arne Bjerhammer

After the successful experiences in the determinations and evaluations of precise local
geoid models in different countries, as well as the very well met previous International
Geoid Schools in September 2010, February-March 2012, August 2014 and September
2016, we will arrange the Fifth International Geoid School based on the KTH Approach.
(KTH is a Swedish abbreviation for Royal Institute of Technology, Stockholm, Sweden).
The school will take place at KTH from 21 to 25 of August, 2017, honouring the
centennial anniversary of deceased Professor Arne Bjerhammer, who was born on 15
September, 1917. He was the first geodesist to apply analytical continuation in physical
geodesy, a method practised in the software package KTH-GEOLAB.

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, for
example over Sweden, the Baltic countries, Greece, Iran, Sudan, Zambia, Ethiopia,
Tanzania, Serbia, Moldova, part of Turkey, and also tested and compared to other
methods, e.g., for instance in the 2009 for the comparison of several up-to-date methods
of geoid modelling in Auvergne, France. See also Yildiz et al. (2012). The official geoid
models of Sweden and Estonia as well as the NKG2015 geoid model for Scandinavia,
Finland and Baltic states (Ågren et al. 2016) are all based on the LSMSA technique.

Several participants of previous schools have successfully completed their Ph.D. projects
using this technique. A description of the method and several examples can be found in
Sjöberg and Bagherbandi (2017).

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 https://www.kth.se/en/abe/inst/som/avdelningar/geo/geodesi/om-oss-1.78114, but also elsewhere. Notable among these studies are the applications in rough topographic areas and in some 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 the reference below).

Practical information

The lecture notes will be prepared on a USB stick, which contains also exercises, data sets and software. Each student will receive a copy of the stick.

All lectures are followed by daily computer exercises. The participants should bring their own laptop for the exercises/labs.

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 professionals dealing with geoid determination in various countries.
References


Sjöberg L E (2017) Lecture notes. [Updated from 2016. Will be distributed (only) to registered participants.] (Approx. 75 pages.)


Preliminary Program

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<th>Lecture (Morning)¹</th>
<th>Lecture (Afternoon)²</th>
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<td>1</td>
<td>- Opening of the school. Lecture 1</td>
<td>- Gravity data snooping and gridding</td>
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<td>- Basic Physical Geodesy</td>
<td>- Gravity field determination by global geopotential models. Prof. Ramin Kiamehr</td>
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<td>- Modification of Stokes’ formula (Part 1) Lecturer: Prof. Lars Sjöberg</td>
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<td>Lecture 2</td>
<td>Digital Elevation Models and Geoid Prof. Ramin Kiamehr</td>
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<td>- Modification of Stokes’ formula (Part 2)</td>
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<td>- Additive corrections (Part 1) Lecturer: Prof. Lars Sjöberg</td>
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<td>3</td>
<td>Lecture 3</td>
<td>KTH GEOLAB Software Sample Full Project Workshop (Part1) Prof. Ramin Kiamehr</td>
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<td>- Additive corrections (Part 2). Lecturer: Prof. Lars Sjöberg</td>
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<td>- LSMSA vs. the RCR-Technique</td>
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Lecture 5

KTH GEOLAB Software Sample Full Project Workshop (Part3)
- Fitting the Gravimetric Geoid to GPS on Benchmarks. (Including Exercises)  
  Prof. Ramin Kiamehr

Summary of the course and Final Discussion
- Closing the school
  Prof. Lars Sjöberg & Ramin Kiamehr

1) Morning lectures 9-12 am  2) Afternoon lectures 1-4 pm

If there is a general interest among participants there will also be an evening lecture on estimating Moho parameters by gravity led by Professor M. Bagharbandi.

The Venue

The school will be held at Royal Institute of Technology, Division of Geodesy and Geoinformatics, Drottning Kristinas väg 30, Stockholm (https://goo.gl/maps/EHBMuQBd6JC2). The workshop dinner is planned for Thursday evening August 24.

Registration

The registration fee is 5000 SEK to be paid due 15 June, 2017. Late registration fees of 6000 SEK are accepted after that date. The fee includes lecture notes, preliminary software manual, a USB stick with the LSMSA software package, lunches, coffee/tea at breaks and a social dinner.

Notification of your interest to participate in the school:

Please inform one of the contact persons as soon as you know that you are likely to participate.

Details for payment
Within Sweden: pay to bankgiro no. 895-9223

From outside Sweden: Pay to Den Danske Bank,
IBAN: SE15 1200 0000 0128 1011 8744, Swift code: DABASESX

In both cases, specify ORG AGC and name of participant. Send also emails to the contact persons.

A map of KTH and the L-building/DKV30 is given below.

More information

Contact one of the organizers below for additional questions.

Organizers

The geoid school is led by:

Lars E. Sjöberg Mohammad Bagherbandi
Head of Geoid School Contact person
Emeritus Professor Associate Professor
E-mail: lsjo@kth.se mohbag@kth.se
Phone: +46 8 7907330 +46 9 790 7369

Address:
Division of Geodesy and Satellite Positioning
Royal Institute of Technology
Drottning Kristinas väg 30
SE- 100 44 Stockholm
SWEDEN