Status report from the ongoing work with the new Swedish Gravity System RG2000

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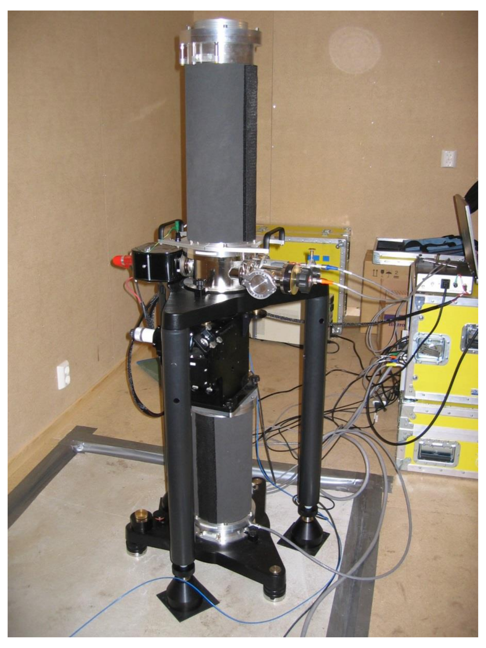
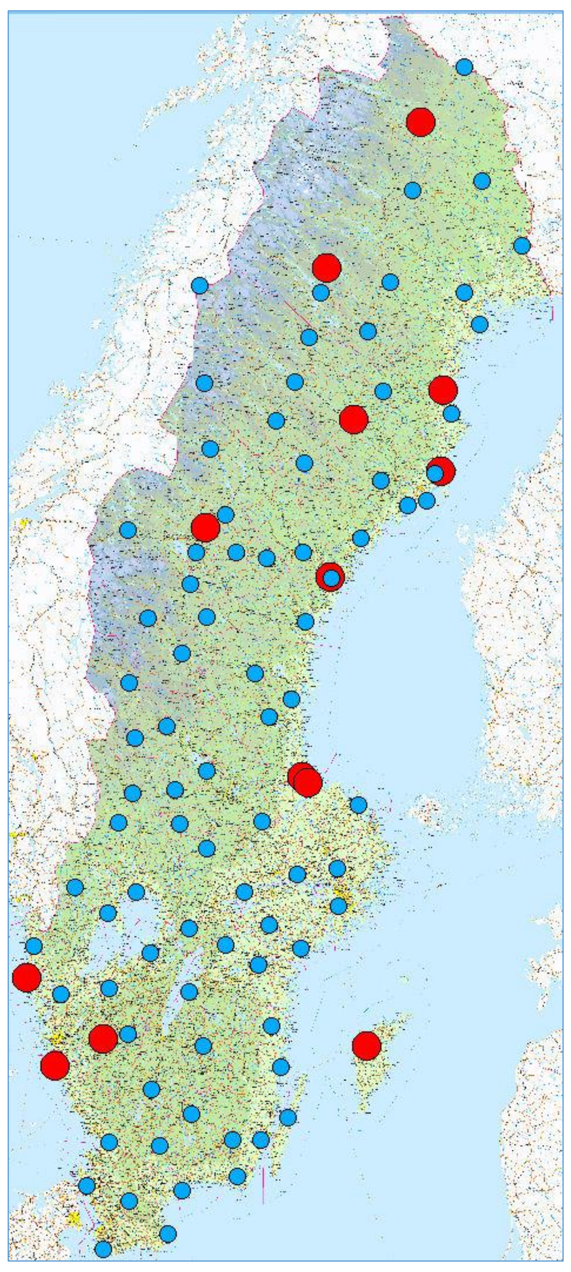
ABSTRACT: The present gravity system in Sweden, RG82, is based on four absolute gravity measurements from 1976 by an old Italian instrument. The zero order network consists of 25 sites spread all over Sweden and was measured relatively with two LaCoste & Romberg gravimeters in 1981-82. Today, almost 40 years after these absolute gravity measurements, the absolute gravimeters are at a totally different standard and accuracy. Since autumn 2006, Lantmäteriet has owned a FG5 absolute gravimeter (FG5-233) and measured regularly at 13 different places all over Sweden with a very high accuracy. When correcting for the gravity changes due to the Scandinavian phenomenon postglacial rebound, the whole RG82 is about 15 microGal wrong. This is less than expected, when considering how long ago the Italian instrument set the level of the network, but still it is significantly too much considering the accuracy of the present technique. So now it is high time to make a new gravity system.

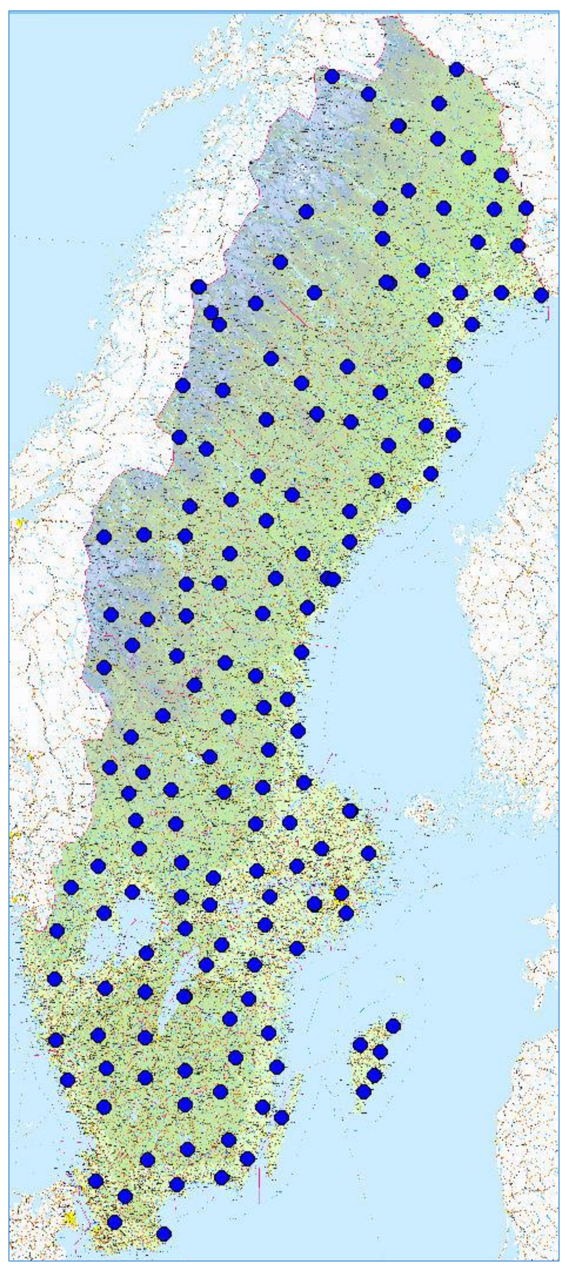
The FG5-site Östersund AA from outside, with co-located GNSS.



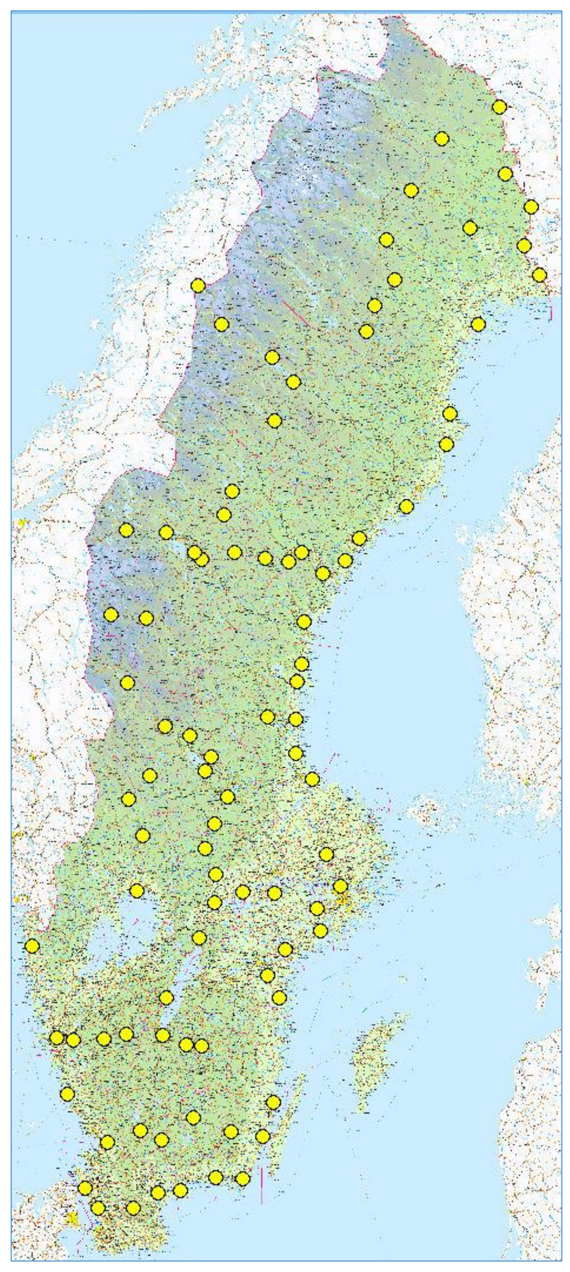
FG5-233 measuring at the FG5-site Ratan AA.



RG2000, current situation. Red circles are FG5-sites. Blue circles are A-10-sites.



RG82 (1981-2002), the 177 sites out of 203 found in 2011 which still were usable.



RG62 (1962-1968), the 91 sites out of 198 found in 2011 which still were usable.

CURRENT SITUATION: Some work has already been done for the new system. There is a seven year time span of FG5 measurements with the Swedish instrument at 13 sites. In addition, e.g. many of these sites were measured in most years between 2004 and 2006 with another FG5 instrument, owned and operated by IfE from Hannover. Between 2011 and 2013, 84 old and new gravity sites evenly spread over Sweden were measured with the portable outdoor absolute gravimeter A-10, owned and operated by IGIK from Warsaw. In 2012, in connection to a NKG-project, 2 sites were also measured by the Danish A-10, owned and operated by DTU Space.

Typical RG82-site, Kåbdalis (zero order), also measured with A-10. The steel bolt is the point.

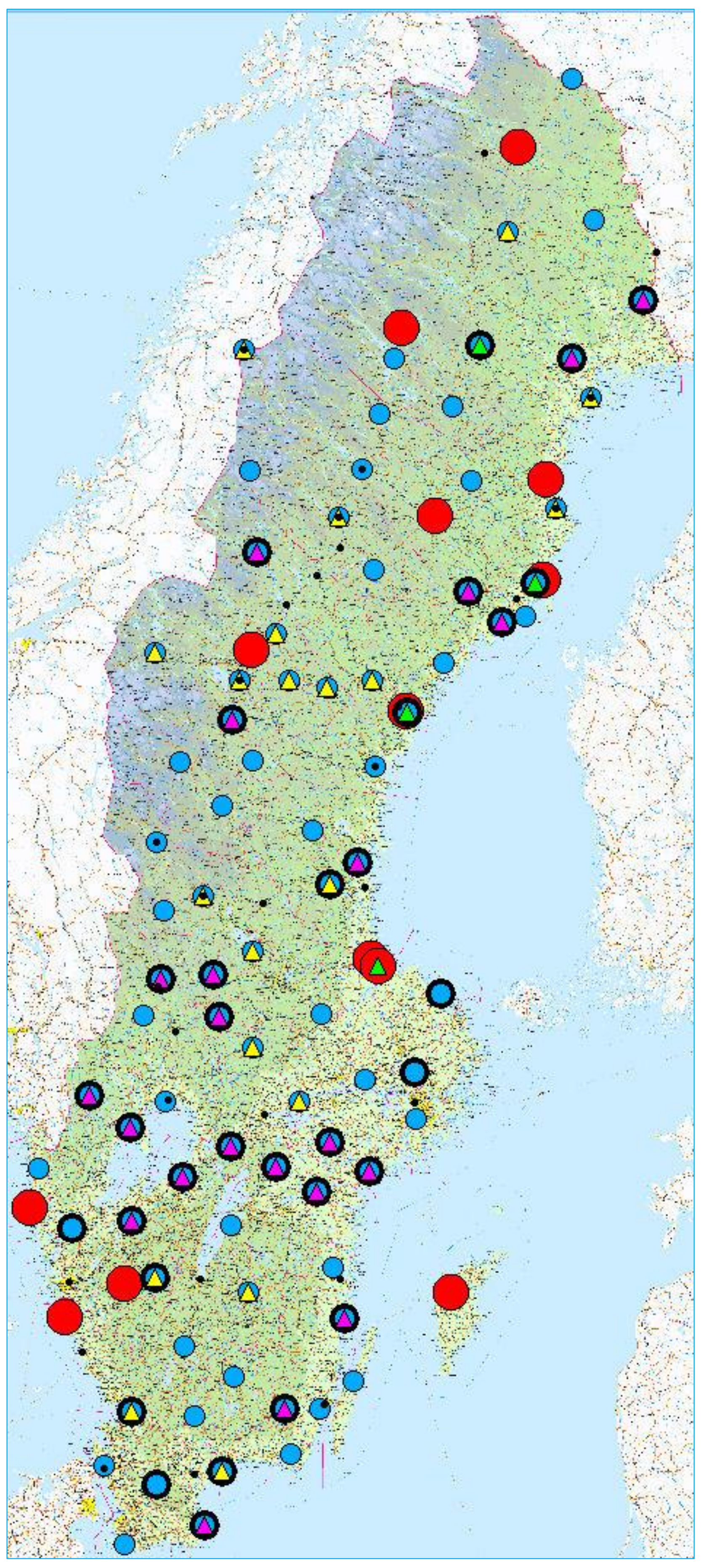
Typical RG62-site, Nässjö, on the church step. The site is not marked and on the photo a golf – peg is used to mark where the point is situated.

EPOCH: The epoch 2000 is chosen to connect this network to the most recent network in height, RH2000, and the most recent network in 3D, SWEREF99. To get the level of the measurements to the correct epoch, the gravity values need to be corrected for the land uplift. For RH2000 the model developed by Ågren & Svensson (2007) was used. Right now is an updated model on its way, which will be applied for all FG5-measurements and all A-10-measurements before the adjustment starts. Concerning the definition of RG2000, it is also decided that RG2000 will be a zero tide system.

A-10 measurements, at Säffle (first order RG82-site) in rain. The tent shall protect the A-10 from sun, wind and rain. This tent was though broken at the top, thus an umbrella was needed.

VERIFYING THE SITES MEASURED BY A-10: The accuracy of a FG5-measured site and an A-10-measured site are specified to 2 microGal and 10 microGal, respectively. However, like for all kind of measurement there is a risk of gross errors in all gravity measurements, no matter of what the specification says. The FG5-measurements in Sweden are verified by repeated measurements at the same site during several years. But the A-10-measurements have only been measured at one time. During all the (so far) four tours with the A-10 in Sweden, 1-2 FG5-sites have been measured during the tour, which has proven that the instrument works and that the measured gravity value is not so far away from the "known" value. Relative measurements between the A-10-sites and either a FG5-site or a RG82 site, give a good indication if there is a gross error in the measurement or not. Right now the plan is to make relative measurements between each one of the 50 still not connected A-10-sites and the closest FG5- or RG82-site. Another way to verify an A-10-site is to re-measure it, but this is a more expensive option.

The map below shows how the different sites are connected to FG5-sites or RG82-sites.



Red circle: FG5-site
Blue circle: A-10-site
Black circle: Connected either to a FG5-site of a RG82-site
Black dot: Value in both RG82 and RG62
Green triangle: Identical to a zero order RG82-site
Purple triange: Identical to a first order RG82-site
Yellow triangle: Identical to a RG62-site

SOMETHING TO THINK ABOUT – THE ZERO LEVEL OF THE NEW NETWORK: During the service of Lantmäteriet's FG5 instrument between the field seasons 2009 and 2010, all of a sudden the level of the gravity value of the instrument changed by about 4 microGal. This is proven in several comparisons with other instruments, but what caused this change is still unknown. This means that the epochs for the instrument must be treated differently between 2006 and 2009 than between 2010 and 2014. Normally, the zero level of the FG5 should have been the zero level for the new network after calculating it back to the year 2000 (with land uplift corrections). The present proposal to be discussed is to use the present level as the zero level of the network. Another discussion is how to use the data from other instruments in order to get a longer time series, like the FG5 measurements from Hannover. For using the old data of Hannover, the proposal is to add or subtract a mean value from the comparisons in Mårtsbo 2007, Walferdange 2007 and Paris 2009, to their results and to use the same land uplift corrections as for our instrument.

Gradient measurements for an A10-site, Östersund RG62. The instrument used is a Scintrex CG5. The idea is that the height difference between the set-ups should be as close as possible to the sensor height of A-10, which is 70 cm.

WHAT IS THE NEED OF MORE SITES IN RG2000?: In order to get more transformation connections between the systems, it would have been preferred to measure more old (RG82 and RG62) sites with A-10, but no more are suitable. Why would we otherwise need more A-10-sites? A few more are needed to densify the network and to make the coverage better. For Lantmäteriet purposes, we need a more densified network in the remaining areas for accurate geoid determination. However, in most areas with gaps either additional geoid measurements are not needed in the near future or there are no roads. Another reason to densify the network is to have a good starting point for gravity measurements closer to anywhere, something which will be useful for other users, like the Swedish Geological Survey.

All sites in the RG62 and RG82 networks, as well as all old geoid points where we have considered the accuracy good enough, will be transformed from their original system to RG2000 for our new gravity database. The transformation between RG62 and RG2000 will be a two-step transformation, where the first step is to transform all data to RG82 and the second step is to transform all data to RG2000. The less connections we have between the different systems, the less good the quality will be of the transformed data. Six of the RG62-sites measured with A-10 also have values in RG82. Excluding those and what has been derived through the A-10-measurements, we have 25 more sites spread over the country which are measured in both RG62 and RG82. It is also likely that a few more connections are needed, which will be measured with relative instruments.

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