KTH Architecture and
the Built Environment

Visualization of a SWEPOS Coordinate Analysis

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1. Abstract

Lantmäteriet, The Swedish Mapping, Cadastral and Land Registration Authority, is responsible for the operation and maintenance of SWEPOS and SWEREF99 (the Swedish official reference frame) and therefore also responsible for control and verification of the data provided by the reference stations.

Clas-Göran Persson at Lantmäteriet has created a new controlling procedure, including software, to analyze the position uncertainties of the SWEPOS stations using various statistical methods. The software evaluates the daily calculated coordinate data of the stations subsequently; it will not be installed directly on the actual stations. The primary goal is to study the stability of SWEPOS from a SWEREF 99 point of view, not to analyze SWEPOS real-time service. The controlling procedure is referred to as “the CGP Program”.

The CGP Program is a toolbox of statistical methods created in MATLAB, determining standard deviation, correlation, distribution (outliers) and more. Its main purpose is to determine if the SWEPOS data consists of uniform uncorrelated normal distributed deviations, known as white noise, or not.

The purpose of my Thesis is to; based on this new controlling procedure, create a graphical overview of the current status of the SWEPOS network for Lantmäteriet. Instead of making a thorough analysis of each station the maps created in this Thesis will visualize the outcome on an overall basis and identify the stations and areas of interest for further analysis.

Together with representatives from Lantmäteriet we decided that three different map types where of interest. All the maps were to be based on SWEPOS data from 2010, analyzed by the CGP program, and visualized on a nationwide basis. They differ in their cartographic appearance and they all describe different characteristics of the SWEPOS stations.

Conclusions from the maps and the numerical analyzes:

* There is a clear "winter effect", most obvious in the height coordinate. Removal of the snow-period results in lower standard deviations and fewer unwanted systematic effects.

* The Northing coordinate has a slightly higher standard deviation than the Easting coordinate. The standard deviation in Height is around 50% larger than the horizontal standard deviation.

* There is no evidence for physical movements, when comparing the official SWEREF 99 coordinates with the 2010 positions.

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B.Sc. Thesis: Visualization of a SWEPOS Coordinate Analysis

2. Background

SWEPOS is a Swedish national network of permanent reference stations for GNSS. Very simplified, SWEPOS consists of stations with GNSS receivers, constantly logging GNSS-data received by antennas placed on fixed markers with known coordinates. The purpose of SWEPOS is to provide data from the GNSS satellites, for example real-time positioning with centimeter accuracy and data collection for geographic databases. SWEPOS also forms the basis of the reference system SWEREF 99.

Lantmäteriet (the Swedish Mapping, Cadastral and Land Registration Authority) is responsible for the operation and maintenance of SWEPOS and therefore responsible for the control and verification of the data provided by the reference stations. Lantmäteriet is always seeking to improve the reliability of the SWEPOS and SWEREF 99 systems and this thesis is a small part of its continued development.

Clas-Göran Persson at Lantmäteriet has created a new controlling procedure, including software, to analyze the positioning uncertainties of the SWEPOS stations using various statistic methods. The software is meant to evaluate the daily calculated coordinate data of the stations subsequently; it will not be installed directly on the actual stations. For convenience, this software will be referred to as “the CGP Program” for the remainder of this thesis.

The CGP Program is part of an ongoing project to secure a high level of quality for the national reference system at Lantmäteriet and the research surrounding the CGP Program is not something that can be covered by this Thesis alone. It was with respect for the limited time available (10 weeks) distinct limits for the extent of this thesis was determined.

The focus is to visually describe the current overall status of the SWEPOS system, using GNSS data collected during 2010 and some of the statistic tools available in the CGP Program. It is not to make any deeper analysis or research. Further specifications will be mentioned in the introduction.

(See *Figure 1* for an example of a SWEPOS Class A station.)

Figure 1: Class A SWEPOS station Leksand

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2:1 SWEPOS and SWEREF 99

The SWEPOS national network of reference stations is divided into two classes, A and B. The main difference between these two classes is that class A antennas are attached to concrete pillars or steel frameworks founded on rock while the class B antennas are attached to permanent (normally municipality) buildings, but there are other differences as well. For example does the class A stations have more strict rules regarding the maintenance of the antennas than the class B stations. Also, the Class A stations equipment is redundant and it can, in case of power failure, be run on UPS for approximately 24 hours. [SWEPOS webpage-stations] (See *Figure 1* for an example of a SWEPOS Class B station.)

Together with a number of similar class A stations in Finland, Norway and Denmark, the original 21 Class A SWEPOS stations define the Swedish national coordinate system SWEREF 99. These stations have been given their coordinates in a GPS-campaign during the summer of 1999. Coordinates for the remaining SWEPOS stations has been determined continuously, at the time of their establishment or in relation to a replacement of the stations antenna, meaning that the time of the official coordinates determination vary between the SWEPOS stations. Every determination is based on a combined solution of 3-5 weeks daily calculations of SWEPOS, which has been reduced for land up-lift between the time of the stations individual establishment and the establishment of SWEREF 99. Finally, new stations are fitted into the surrounding, well defined, stations nearby. SWEREF 99 is the current Swedish realization of the European reference system ETRS89. [Jivall, 2011].

Figure 2: Class B SWEPOS station Sälen

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3. Introduction

The overall algorithm for this thesis is can be narrowed down to a few steps;

1. Collect logged SWEPOS data from 2010.
2. Use the CGP Program to evaluate the data for each SWEPOS Station.
3. Visualize the overall results on a series of maps.
4. Analyze the results briefly.

3:1 The CGP Program

As already mentioned; the CGP Program is a toolbox of statistic methods created in MATLAB, determining standard deviation, correlation, distribution (outliers) and more. All methods are mentioned in Appendix 2. Its main purpose is to determine if the SWEPOS data consists of uniform uncorrelated normal distributed deviations, known as white noise, or not. See *Appendix 2* for an example analysis of the data that was recorded by the SWEPOS-station Älvsbyn in 2010. Älvsbyn is known as a problematic station with obvious seasonal variations, as described in *Figure 3* below. The time serie in *Figure 3* is from an older analysis and not a plot from the CGP Program.

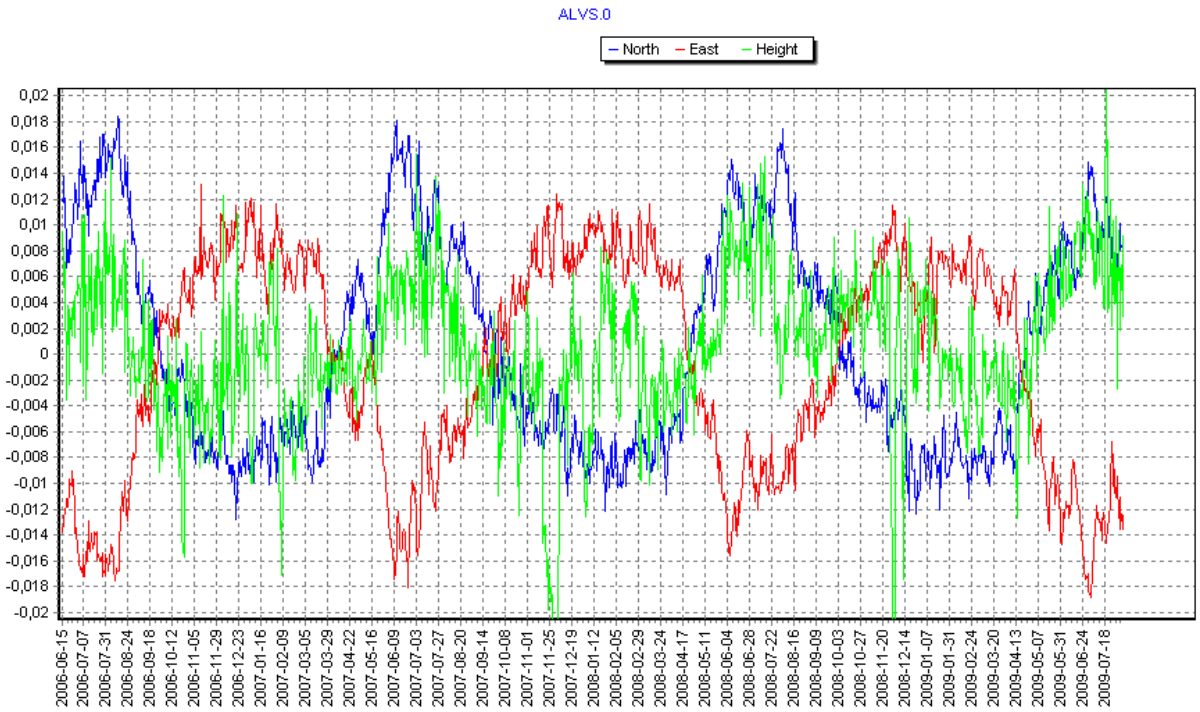

Figure 3: Example time serie analysis of Class B SWEPOS station Älvsbyn

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3:2 Warnings in the CGP Program

A station gets a warning in the CGP program when there is an indication that the hypothesis regarding ”white noise” is not true. The following variables are used in the description:

- sN = standard deviation, Northing (≈ 1.7 mm)
- sE = standard deviation, Easting (≈ 1.2 mm)
- sH = standard deviation, Height (≈ 3.2 mm)
- sNE = horizontal standard deviation; sNE = sqrt(sN^2+sE^2) (≈ 2.1 mm)

Warnings are generated in the following cases:

- If the standard deviations exceed the following values: sN > 2.0 mm; sE > 1.5 mm; sH > 4.0 mm; sNE > 2.5 mm. [1]
- If the difference between the max and min value over the entire year exceeds 8 sigma, that is if it is larger than 8*sN (≈ 14 mm), 8*sE (≈ 10 mm) or 8*sH (≈ 25 mm).
- If the standard deviations after the Fourier analysis is significantly smaller than the standard deviation before this analysis, using an F-test for each co-ordinate N, E and H. Two wave-lengths are estimated: whole and half year.
- If the reduction of V’V (the squared sum of least-squares residuals) after Fourier analysis is more than 30 %, for N, E and H.
- If the total annual amplitude of the two Fourier estimated sine-functions exceeds 2 sigma, that is if it is larger than 2*sN (≈ 3.4 mm), 2*sE (≈ 2.4 mm) or 2*sH (≈ 6.4 mm).
- If the total annual horizontal “movement” – measured with the use of the Fourier series for Northing and Easting – exceeds the standard error ellipse.
- If the annual amplitude of the Moving Averages exceeds 2 sigma (c.f. the corresponding Fourier analysis above.)
- If any of the internal correlation coefficients between the three co-ordinates of one station exceeds 0.4, that is if ρNE, ρNH or $\rho EH > 0.4$.
- If the correlation length (of correlation functions estimated over the entire year for each co-ordinate) exceeds 5 days. The correlation length is defined as the (time) distance where the correlation has decreased below the value $1/e \approx 0.3679$.

For test of distribution the following criteria are used:

- If the difference between two consecutive days exceeds 3.3 sigma, horizontally (≈ 7 mm) or in height (≈ 12 mm) we have an indication of an out-lier. A warning is generated if the proportion of such indications exceeds what could be expected in a normal distribution.

[1] This and other numerical values are based upon experiences from the report Persson (2011):”Analys av 7 SWEPOS-stationer under 2010”.

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- If the difference between the last day and the mean of the week before exceeds 2.75 sigma, horizontally (≈ 6 mm) or in height (≈ 10 mm) we have also an indication of an out-lier. A warning is generated if the proportion of such indications exceeds what could be expected in a normal distribution.
- If the difference between the last day and the mean for the entire year exceeds 3 sigma, horizontally (≈ 6.5 mm) or in height (≈ 11 mm) we have a third indication of an out-lier. Also in this case, a warning is generated if the proportion of such indications exceeds what could be expected in a normal distribution.

In the first version of the CGP program the numbers of warnings were used as "bad quality indicators". However, in later program versions the warnings are classified in the categories "Systematic", "Uncertainty" and "Distribution" according the type of measure that has been applied. A separation is also made between the horizontal and height dimensions. Thereafter, the warnings are transformed to the rating scale 0-6 (0 is perfect, 6 is bad), with a maximum of 1 rating point for each aspect and dimension. This should make evaluation of the result easier.

3:3 Map Types

Together with representatives from Lantmäteriet we decided which map types that were of interest and the conclusion was originally three different types of maps. All the maps were to be based on SWEPOS data from 2010, analyzed by the CGP program, and visualized on a nationwide basis. They differ in their cartographic appearance and all of them show different characteristics of the SWEPOS stations. The three map types requested to describe SWEPOS were:

Stoplight: Six maps. The stoplight maps are based on the number of warnings registered by the CGP program. Every warning is an indication that the white noise hypothesis is not true. These maps detect stations and areas that generate a lot of warnings. These maps are named after its characteristic colors; red-yellow-green.

Vector: Four maps. The Vector maps are arrow maps. The arrows length and orientation are based on a comparison between the official SWEPOS coordinates stored by Lantmäteriet and the coordinates from 2010 calculated by the CGP program.

Ellipse: Two maps. The ellipse maps describe the uncertainty of every stations logged data in the plane over time.

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4. Overall Methodology

The SWEPOS data was run through the CGP Program in MATLAB and the analysis together with the data processing was done in MATLAB and in Microsoft Excel. The actual visualization, the different maps, was created in ArcGIS and the free software QGIS.

4:1 Data

For this thesis I have used coordinates in the SWEREF99 system, already calculated at Lantmäteriet. The SWEPOS network is processed on daily basis by Lantmäteriet with a delay of two days due to the delay in rapid satellite course calculations (17-41 hrs.). The processing, which is performed with the Bernese GPS Software, is based on 24 h sessions and IGS rapid products (orbits, clocks and earth orientation parameters). The daily solutions are originally in ITRF 2005, but the stations are also determined in SWEREF 99 by a seven parameter Helmert-transformation. All stations with SWEREF 99 coordinates are used as fitting points in this Helmert transformation, except stations that in a first run have residuals larger than 8 mm per horizontal component and 10 mm in height. Since the fitting is done on the entire network and not locally on every station, some systematic properties may occur. It should however be mentioned that the solution is reduced for deformations due to the land-up lift between the epoch of observation and the epoch of SWEREF 99 (1999.5) according to the model NKG_RF03vel before the Helmert fit. [Jivall, 2011].

The logged data has the following appearance:

Table 1:Example of logged SWEPOS data from 2010.

Year & day	N	E	H
100010	7315776.76656029	554809.895314086	462.119347985798
100020	7315776.76543046	554809.894022046	462.121812037399
100030	7315776.76786191	554809.891433363	462.120704884657
100040	7315776.76385963	554809.891999293	462.114611672142

The different columns in *Table 1* represent: Year and day (1-365 2010), North, East and ellipsoidal height coordinate in the SWEREF99 system. This logged data is stored in a unique text file for each SWEPOS station and therefore the in data for this thesis was originally 239 text files representing 239 stations containing the information mentioned above. (*Figure 4*).

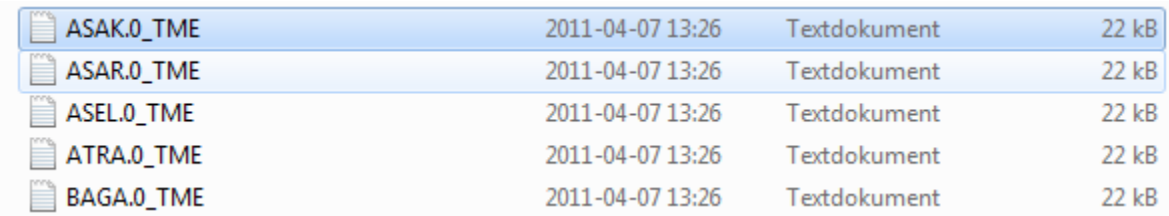

Figure 4: File examples from the original 239 text files of SWEPOS Station data

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Not all stations were operational during the entire period, 2010. The SWEPOS network is being densified continuously and many of these 239 stations are new ones set up sometime during 2010. These stations had to be sorted out of the analysis. A few days of missing data is not a problem but when the greater part of a year is missing these stations will make the results inaccurate. After cutting the stations that was missing data 187 stations remained for the ellipse and stoplight analyses, while 183 stations remained for the vector maps.

I have used data from two different time-frames. The figures marked "All Year Data" or "365" have been created from data collected over the entire year 2010, while the figures marked "No Winter" have been created from data collected day 66-314. These dates were chosen by Lantmäteriet, representing a non-snow-covered period of 2010.

4:2 The Software

The CGP program is originally designed for analyzing one station at a time and not for creating the maps for this thesis. The CGP program run the entire controlling procedure on one station at the time and print all the results in a new text file marked "Station_name_analysis". Since I did not want to run the program 187 times, open 187 analysis text files and copy-paste de parameters of interest 187 times, twice (one for each time-frame), I had to modify the program to do this for me. With some help from Lantmäteriet I managed to get all the parameters of interest into one text file for each map on a single run. The program was modified by implementing a for-loop over the original program, making it run all files in a data catalogue at once.

4:3 Background Maps

The background maps over Sweden used in this project are provided by Lantmäteriet. Lantmäteriet has a series of maps over Sweden available for free download on their homepage. These maps are normally for personal use only and therefore I always have to include the following permit on my figures: *© Lantmäteriet Gävle 2011. Approval 1 2011/0083.* I chose the background map SWEDEN 1:1 million, with rivers and county lines included, from the maps available.

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4:4 QGIS

On an early basis I developed my first maps using QGIS, a free GIS software available for download on http://www.qgis.org/. This was mostly because of curiosity; I wanted to find out how good this software is by comparison to the traditional GIS giant ArcGIS. My conclusions is that QGIS is a very user-friendly software capable of solving many GIS problems but that ArcGIS in the end is superior when it comes to solving more complex tasks. QGIS is a good alternative though, for users lacking ArcGIS licenses or for mac users since, unlike ArcGIS, QGIS runs on both platforms. QGIS is also an alternative for new GIS users, since it is very user-friendly and also available in Swedish. (See *Figure 5* for an example of a Stoplight map created in QGIS.)

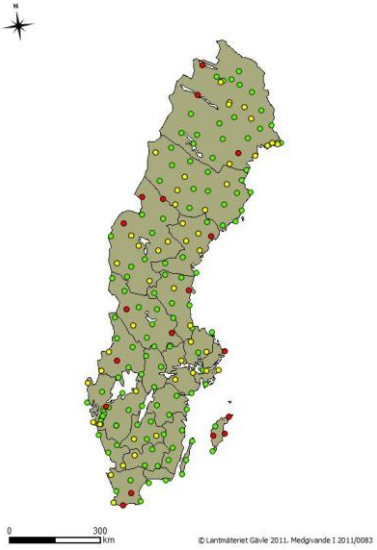

Figure 5: QGIS Stoplight map

4:5 Cartography

Since we haven't had any real cartography classes in school yet, most of my knowledge in this area has been developed during this thesis. I have learned a lot about colors and scales on learning by doing basis and working with cartography issues has been a big part of my work. I have learned during this thesis that over 350 000 people in Sweden are colorblind in one way or another and since one of these 350 000 was my supervisor at Lantmäteriet, Clas-Göran Persson, I needed to take this into serious consideration. This could have been a problem, especially since I chose a green-red scale for my stoplight maps, but after adjusting the color-scale a bit the resulting maps are easy to interpret for both colorblind people as well as everybody else. Since I did this thesis for Lantmäteriet, I also had to make some adjustments regarding scale to imitate a format as they are accustomed. (See *Figure 1* for an example of a classic color blind test.)

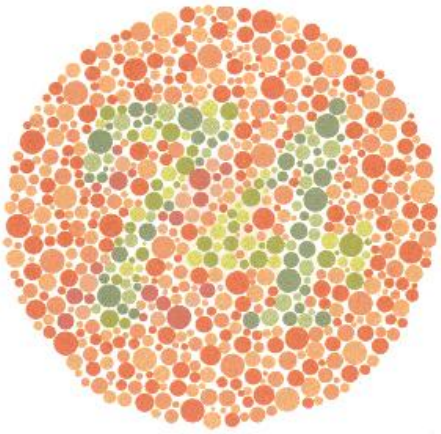

Figure 6: Classic color blind test

There are some areas with shorter distances between the SWEPOS stations than others. One example is the Trollhättan area in the south-west of Sweden, areas such as this had to be highlighted in an adjusted scale in order to make interpretation possible. (*Appendix 1).*

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5. Specific Methodology

5:1 Stoplight Maps

The first map created was a stoplight map visualizing the overall result of a number of algorithms run by the CGP Program. A SWEPOS station gets a warning for every deviation from the white noise hypothesis the CGP program recognizes (as described in the *Introduction*.) The rating for the overall result of these warnings goes from 0-6, in accordance to the following algorithm:

Table 2: The stoplight rating system simplified.

	Systematic	Uncertainty	Distribution
Height	0-1 pts.	0-1 pts.	0-1 pts.
Plane	0-1 pts.	0-1 pts.	0-1 pts.

Where:

- "Systematic" includes systematic/correlated effects detected with the use of Fourier analysis, Moving averages and covariance functions
- "Uncertainty" shows large standard deviations and error ellipses.
- "Distribution" indicates an unexpected amount of out-liers, compared to the normal distribution.

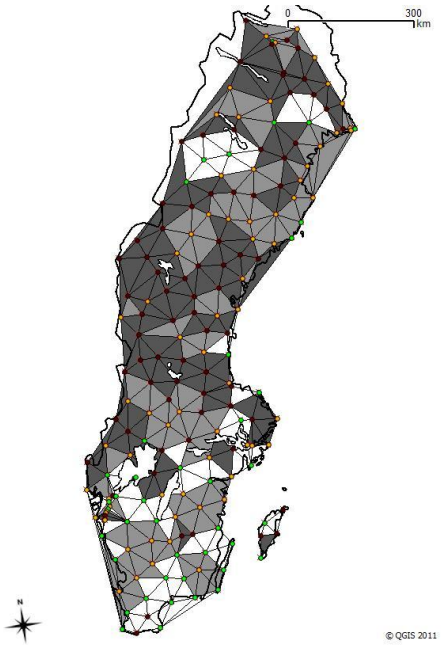

Figure 7: QGIS Interpolation Grid

After generating data tables for this for this task Microsoft Excel this data was used to create a total of six different maps; one for the two dimensions height and plane (rated 0-3) and one for the overall result of the warnings. Each of these three map types was then divided into one map visualizing the result over 365 days and one map visualizing the result with the winter period excluded, giving a total of 12 maps.

The idea of using a background interpolation was originally to help identify patterns and cluster areas on the stoplight maps but it also makes interpretation of the maps much easier and accurate. After trying an interpolation from MATLAB *(Figure 8)* and also imitating it using QGIS *(Figure 7),* the smoother *IDW interpolation* in ArcGIS gave the most satisfying result for this particular analysis. This method interpolates a raster surface from points using an inverse distance weighted (IDW) technique.

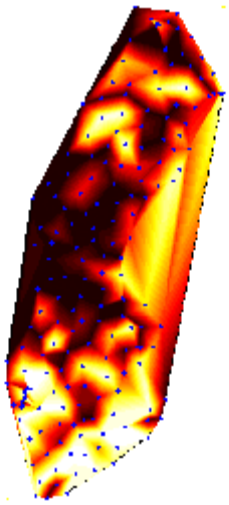

Figure 8: MATLAB Interpolation

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5:2 Vector Maps

The vector maps are based on a comparison between the coordinates calculated by the CGP Program and the official SWEREF 99- coordinates for every SWEPOS station. The height vector maps is the difference between these two coordinates: [CGP Calculated coordinates] minus [Official coordinates], while the plane vector maps needed some two-dimensional calculations:

1. Difference (d)= [CGP Calculated] –[Official Coordinates].
2. Vector length = $\sqrt{dN^2 + dE^2}$ (Pythagoras)
3. Vector orientation = $Arctan2\left({dN}/{dE}\right) + n360$ or in excel: =DEGREE(ARCTAN2(dE;dN))

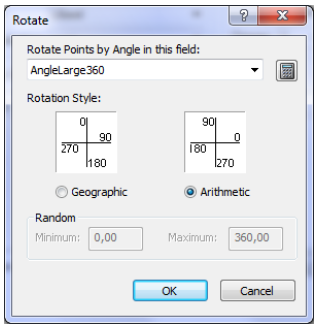

Figure 9: Rotation style Arc GIS

After some confusion with the orientation it was looked into a little extra: Arctan2 returns orientations in 0-180 and 0-(-180) degrees. By adding 360 degrees to all negative values angles from 0-360 degrees are created. The orientations originate from the x-axis on the unit circle or, as described in ArcGIS, have an "arithmetic rotation style". (*Figure 9).*

All calculations were made in Microsoft Excel before imported into ArcGIS.

5:3 Ellipse Maps

All parameters to create the ellipses describing the deviation in the plane over time where given in the CGP Program: Major- and minor- axis in meters as well as orientation of the ellipses in gons. There is a function "Table to ellipse" for this in the ArcGIS Toolbox in newer versions of ArcGIS. The data had only to be adjusted to fit the function:

The gon orientation values were changed into degrees by multiplying all orientations with 0.9.

All axis values was magnified 10^7 times to make the results visible on a nation-scale maps.

All settings are described in *Figure 10.*

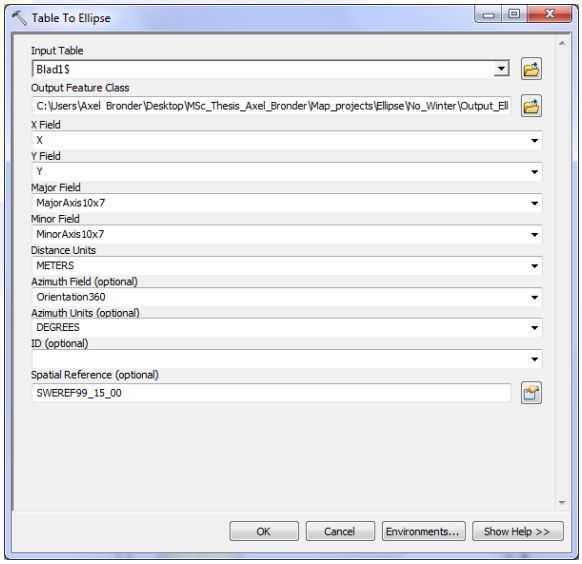

Figure 10: Settings Table to Ellipse

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6. Results, Analysis and Discussion

6:1 Overall Results

See Appendix.1 for the 12 resulting maps.

6:2 Conclusions: Winter Issues

We knew from the beginning that the snow would affect the outcome of this analysis. The figures show that the data provided by the SWEPOS system is less accurate during the snow-covered months than during the summer

143 stations have better (lower) ratings for the non-winter period, 30 of them have equal rating and only 14, out of 187, have a worse (higher) rating. The median rating goes from 2.4 (yellow) down to 0.4 (green).

Figure 11: Class A SWEPOS station Leksand , winter

(See *Figure 11* for an example of how the winter changes the conditions for the SWEPOS stations.)

6:3 Conclusions: Vector Maps

The magnitude of the differences between the official SWEREF 99 coordinates and the 2010 positions is less than ±5 mm for the majority of stations, both horizontally and in height. Appendix 1, map 3-6. The small systematic effects ("whirls") that can be observed are probably due to the least squares calculations and transformations involved in the data processing. There is no clear evidence for real, physical movements.

6:4 Conclusions: Ellipse Maps

We can see a quite uniform pattern, where the uncertainty seems to be somewhat larger in the North/South direction. However, some obvious out-lier stations can also be detected. There is almost no difference between "All Year Data" and the "No Winter" data. (Appendix 1, map 1-2).

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6:5 Problematic Stations

The following 19 stations generated a value of 3 or more on the warnings-scale, when the snow-period was excluded. Three of these stations are situated on the island of Gotland, so there might be a "Gotland effect" as well. Only one class A station generated a value higher than 3.0: Stora Sjöfallet in Lappland. (See *Table 3* for the entire list.)

Table 3: An example of 19 "problematic" stations with a value (based on warnings) of 3 or more.

Station Names				365		"No Winter"	
	ID4+1	ID3	Class	Warnings	Value	Warnings	Value
Örnsköldsvik	ORNS.0	0ORN		24	5	24	5,4
Älvsbyn	ALVS.0	0ALB		26	5,4	23	4
Sälen	SALE.0	0SAL		15	4,9	10	4
Trollhättan	TROL.0	0TRO		18	3,8	16	3,8
Smygehamn	SMYG.0	0SMY		20	3,5	20	3,5
Stora Sjöfallet.1	SSJO.1	1SSJ	A	11	4,1	10	3,5
Arholma	ARHO.1	1ARH		8	1,8	9	3,5
Norråker	NRRA.0	0NRA		19	4,5	18	3,4
Malmberget	MALB.0	0MLM		25	5,8	17	3,4
Fårö	FARO.0	0FAR		15	3,1	15	3,4
Gäddede	GADD.0	0GAD		16	4,9	12	3,4
Kallsedet	KASE.0	0KAS		15	5	12	3,3
Edane	EDAN.0	0EDA		20	3,6	19	3,1
Klintehamn	KLIN.0	0KLI		17	3	18	3,1
Abisko	ABIS.0	0ABI		11	4	8	3,1
Hudiksvall	HUDI.0	0HUD		18	3	18	3
Långshyttan	LANG.0	0LAN		22	5,3	17	3
Vollsjö	VOLL.0	0VOL		18	3	16	3
Katthammarsvik	KATT.0	0KAT		15	3,1	14	3

"Warnings" means the actual amount of warnings generated by the CGP Program. "Value" means the weighted value used on the stoplight maps. We used the weighted value in this report due to the fact that the warnings generated by the CGP Program sometimes are generated from the same anomalies. The weighted value is a more accurate evaluation of the analysis.

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6:6 Continued Development

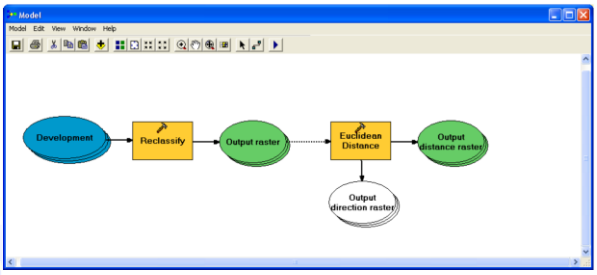

Figure 12: ArcGIS Model Builder

The next step in the future work of the CGP Program is yet to be determined. The program still needs to be properly tested and made operationally reliable before the implementation can be made on a more regular basis. Hopefully this thesis has proven the value of creating a graphical overview of the results and thereby contributed to the continued development at Lantmäteriet surrounding SWEPOS, SWEREF 99 and the CGP Program.

Regarding the continued development in the area of visualization, here are some suggestions:

1. A thesis in the cartographic area surrounding the CGP Program could just as likely have been on the masters level, in other words: twice as big as this thesis. For example; using the ArcGIS function *Model Builder*, the maps created in this thesis could have been standardized and made faster to produce in the future. With *Arc GIS Model Builder* one can create new Tools for Arc GIS by putting together a series of other standard functions. For example, the new Tool "Create Stoplight Map" could have been created from all the Arc GIS functions used for the stoplight maps in this thesis. That would be time-saving in the future and it would also make mapping the data from the CGP Program much more accessible. *Figure 12.*
2. A more long-term development could be to have a GIS-software designed specifically for the continued graphical analysis of the SWEPOS and the SWEREF99 systems. This would probably exceed the limits of any student thesis work, but maybe it is an idea to keep in mind for the future. GIS Software such as this could be designed as a real-time environment where the user can swich between the three different map types, adjust the time scale analysed, zoom in and out, print the areas of interest and more. *Metria* is an example of a combany capable of developing such a service, and *Figure 13* is an example of a similar Webb-based GIS Tool available on their homepage.

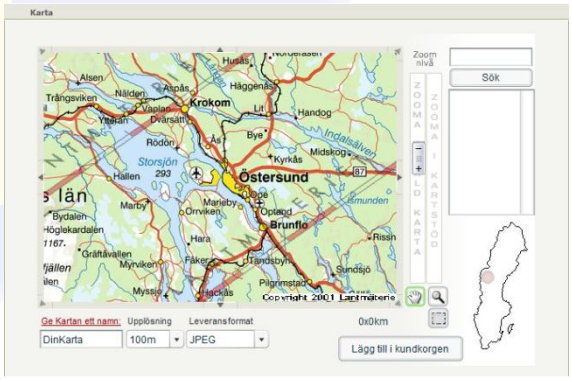

Figure 13: Web-based GIS Tool example from the Metria homepage http://www.metria.se/.

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7. Acknowledgements

This thesis was written with the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

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Milan Horemuz, KTH.

Takeshi Shirabe, KTH.

Lotti Jivall, Lantmäteriet.

Christina Lilje, Lantmäteriet.

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Jivall L. 2001: “SWEREF 99 - New ETRS 89 Coordinates in Sweden”. LMV-report 2001:6.

Jivall L. 2011: Personal communication.

www.lantmateriet.se

SWEPOS webpage-stations. Available online 2011-05-27: http://swepos.lmv.lm.se/stationer/stationer.htm

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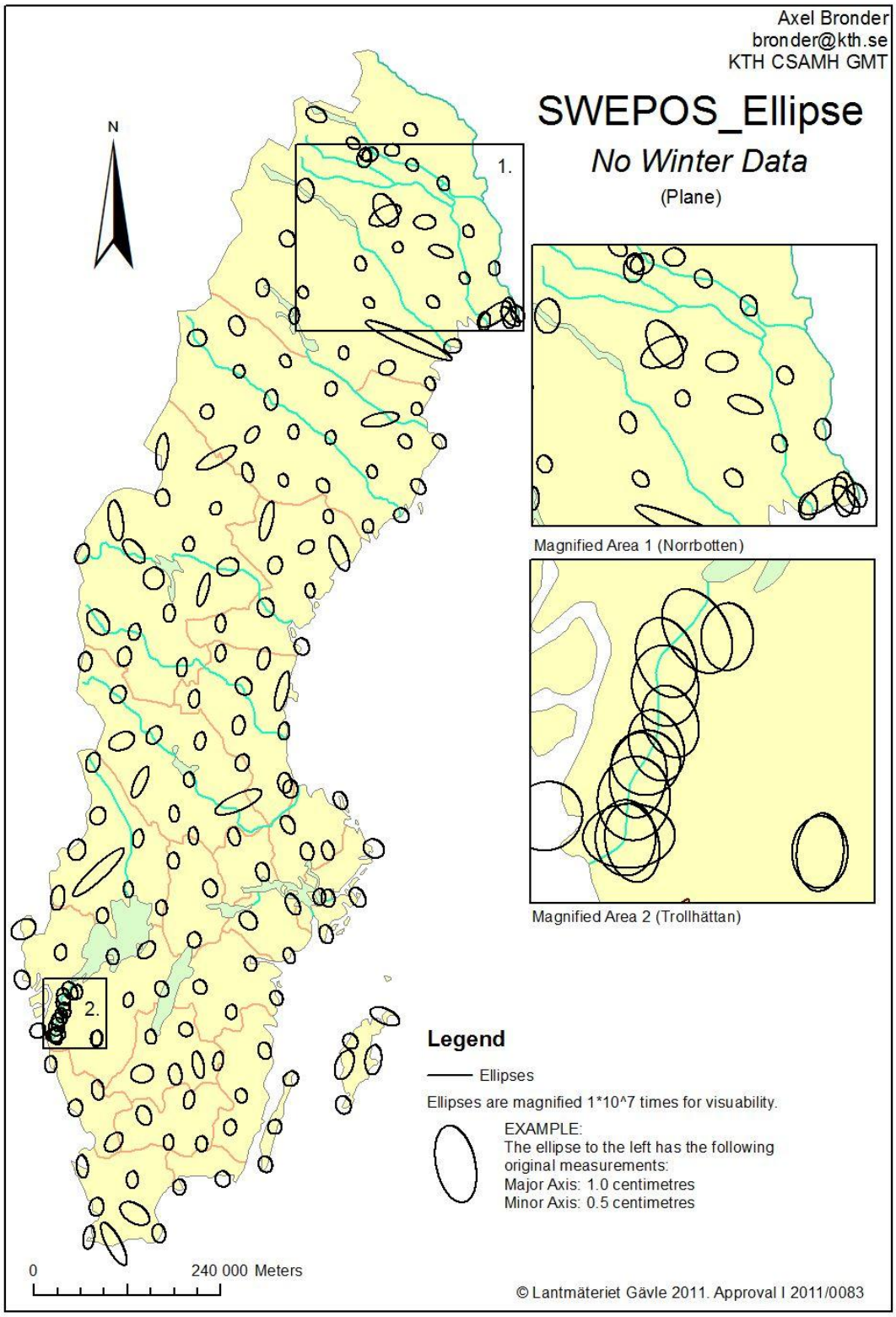
9. Appendix.1: Maps.

Map 1: Ellipse| Plane | No Winter Data



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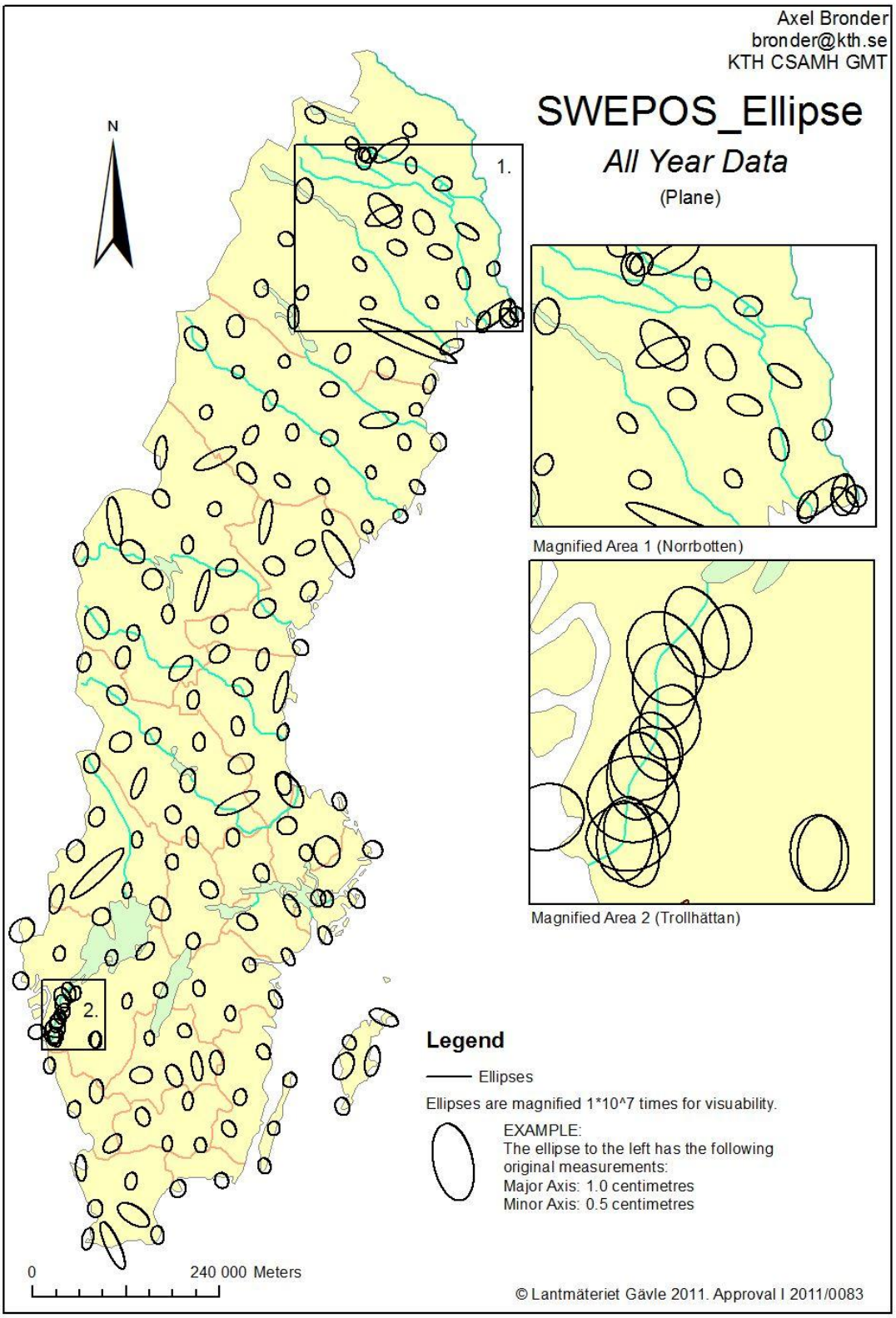
Map 2: Ellipse | Plane | All Year Data



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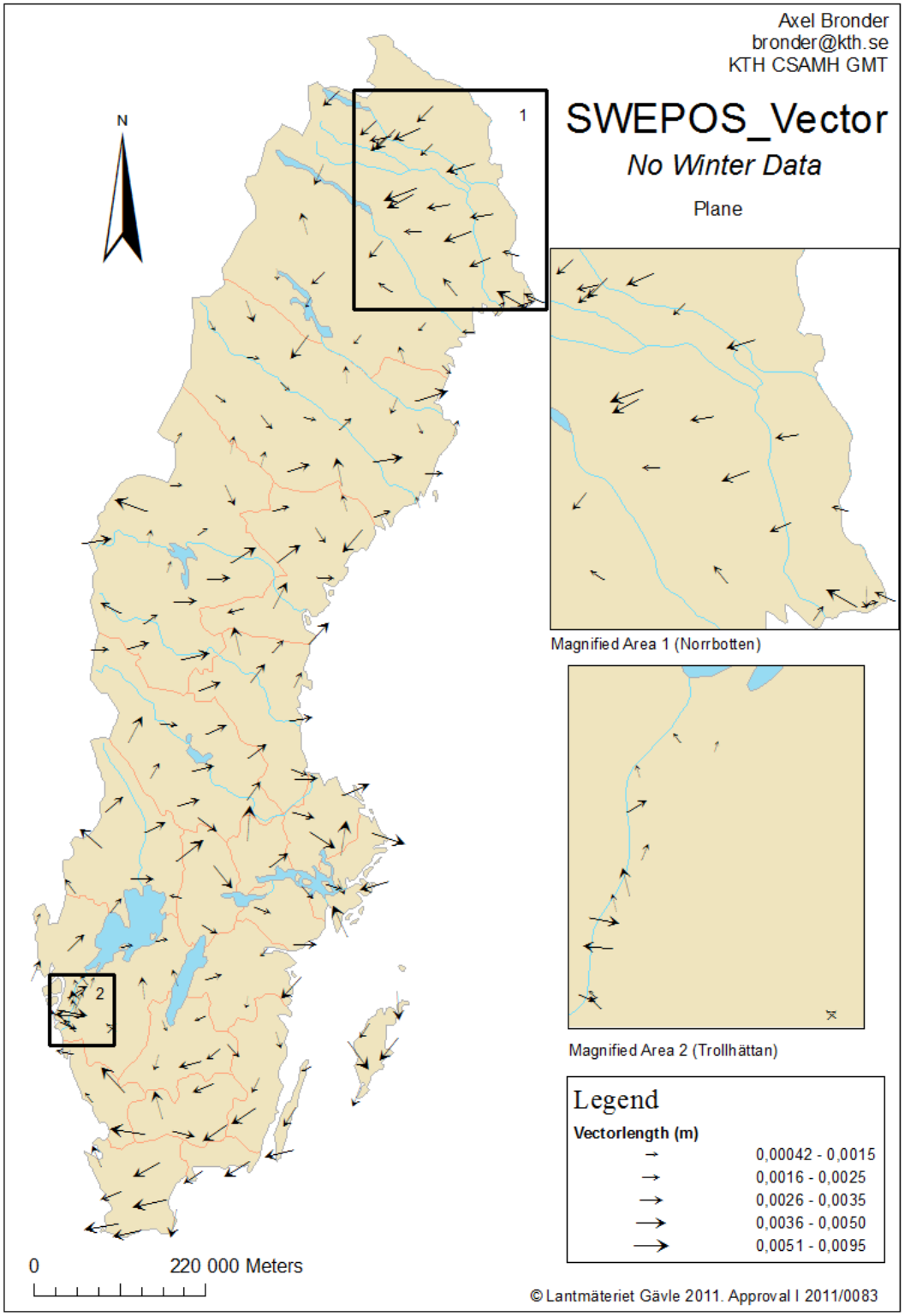
Map 3: Vector| Plane | No Winter Data



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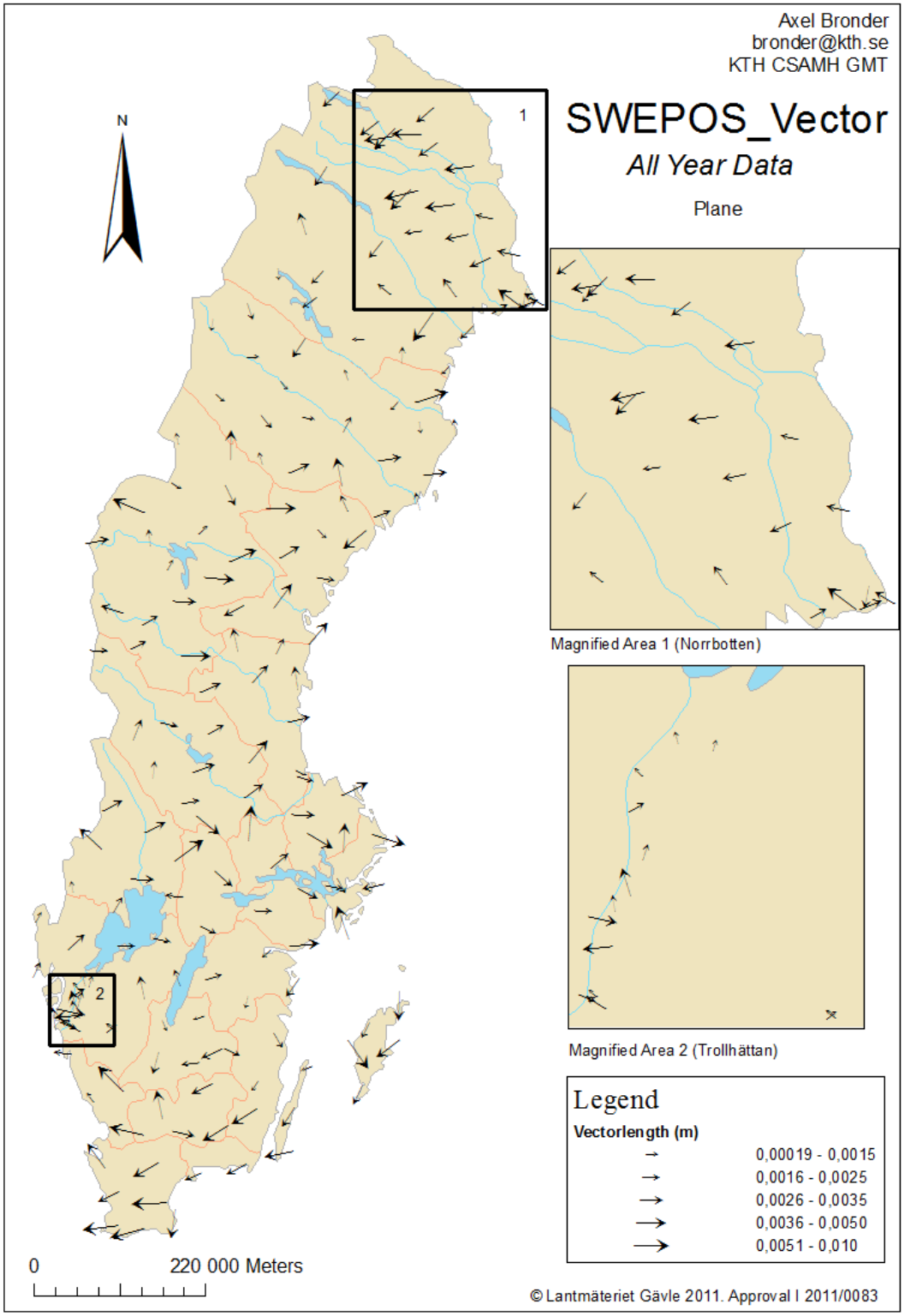
Map 4: Vector| Plane | All Year Data



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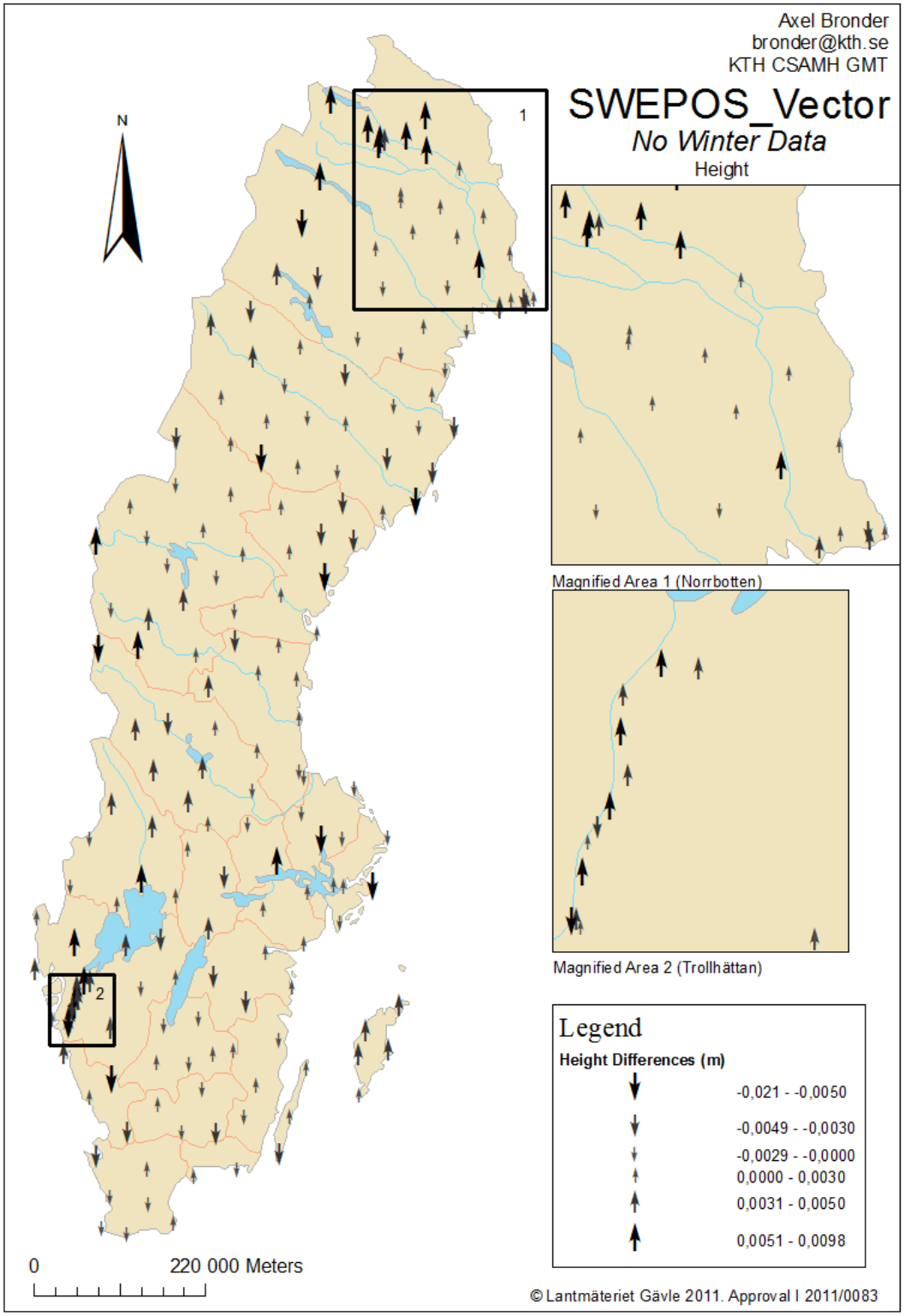
Map 5: Vector| Height | No Winter Data



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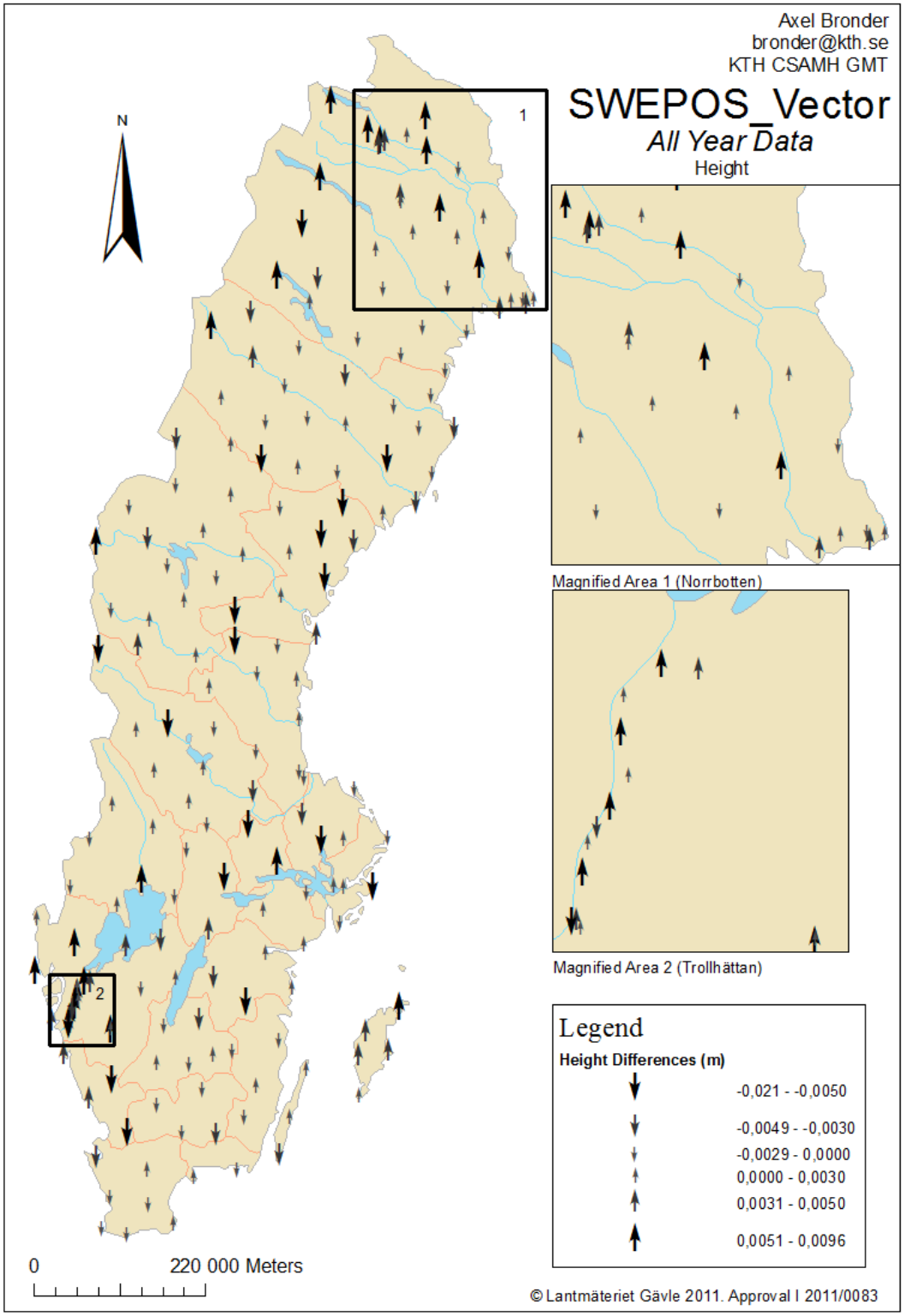
Map 6: Vector| Height | All Year Data



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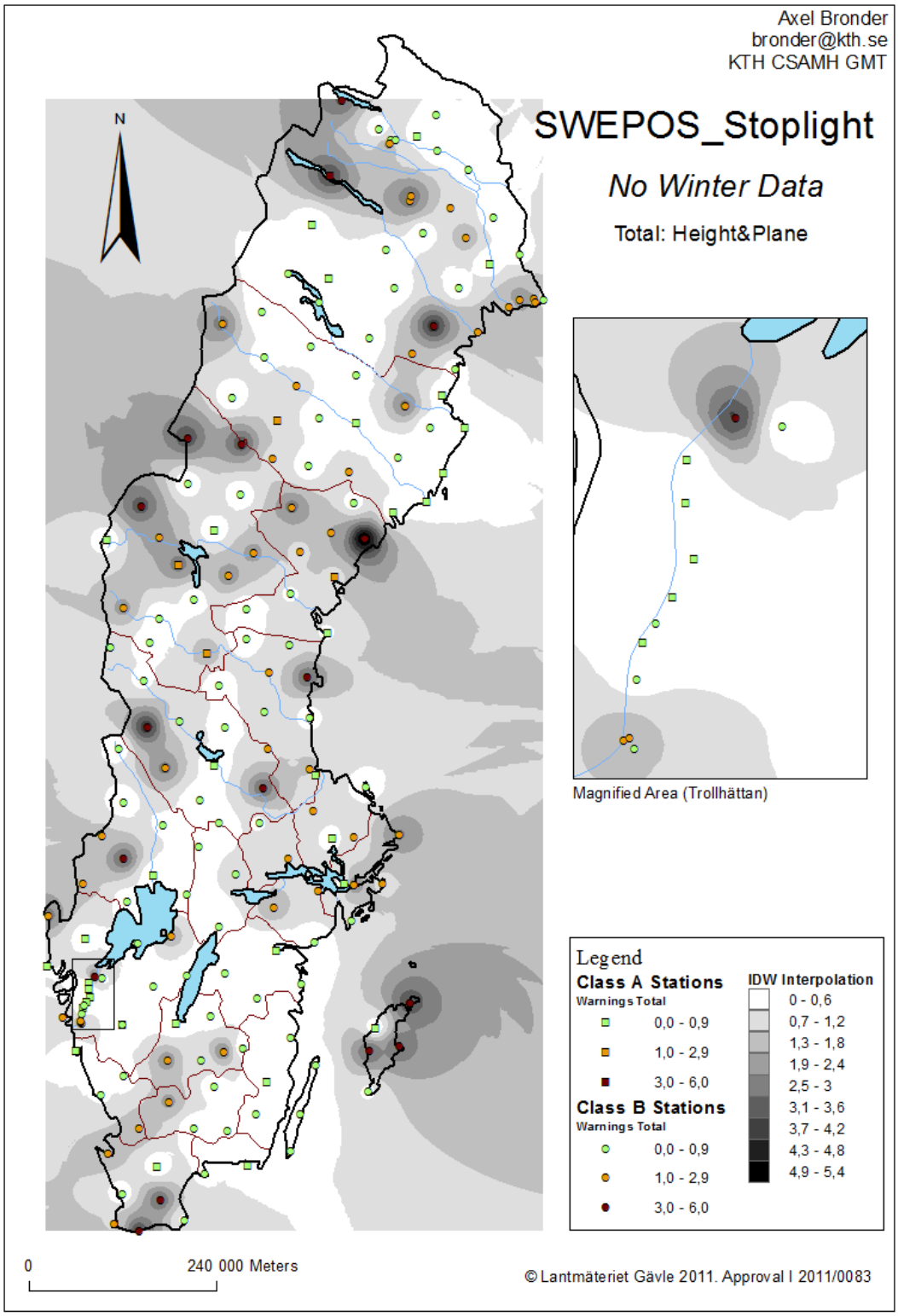
Map 7: Stoplight | Height & Plane | No Winter Data



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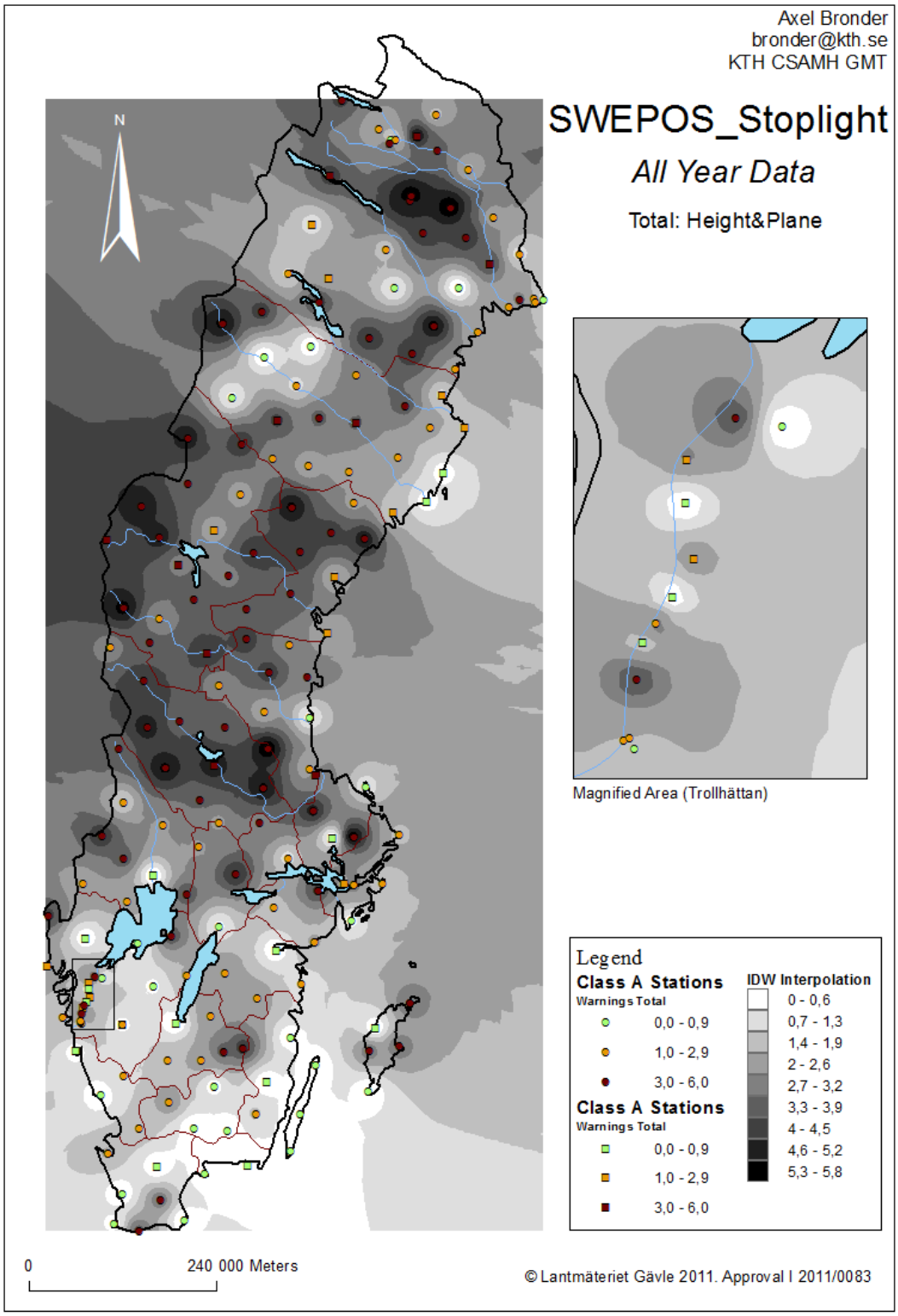
Map 8: Stoplight | Height & Plane | All Year Data



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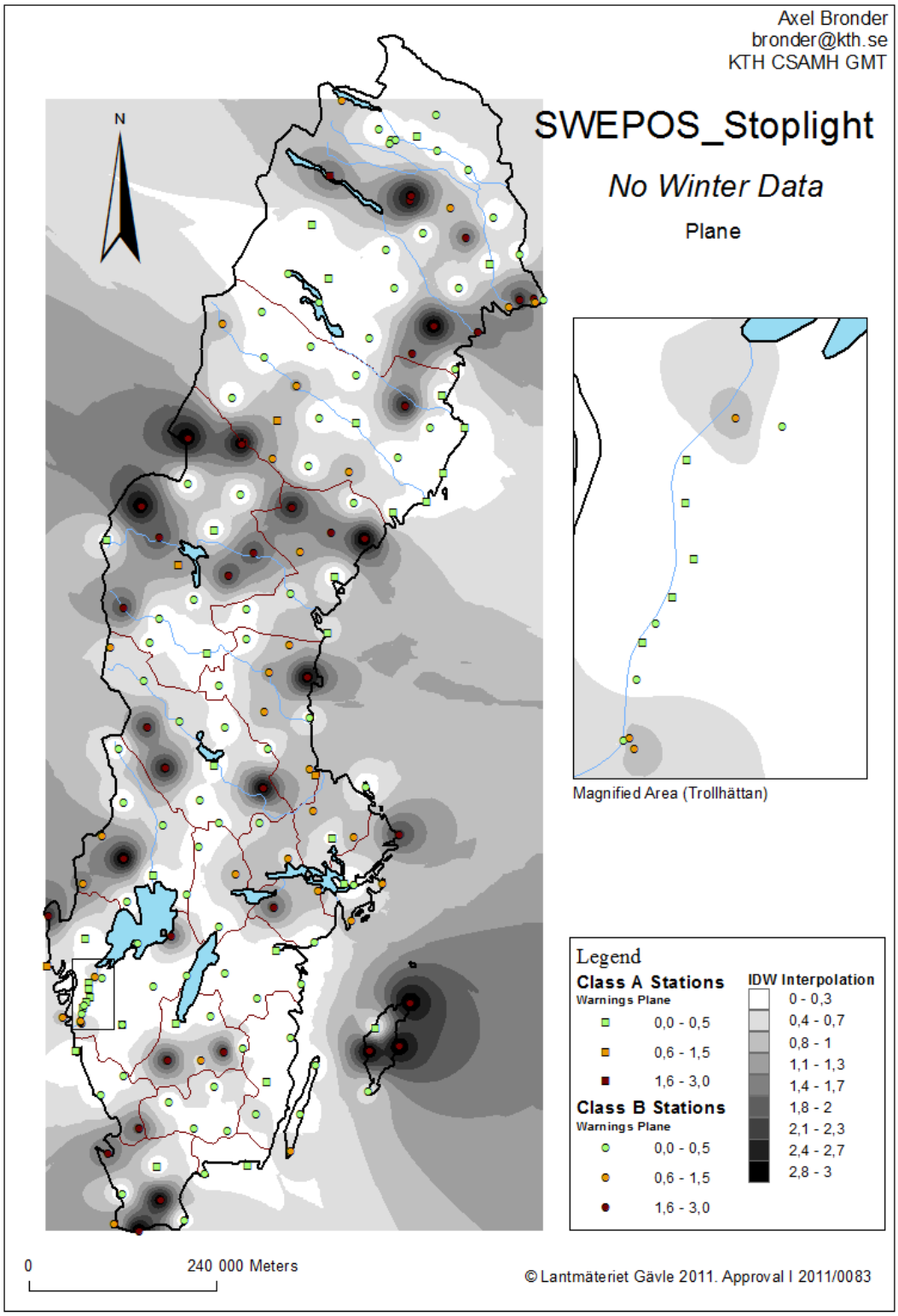
Map 9: Stoplight | Plane | No Winter Data



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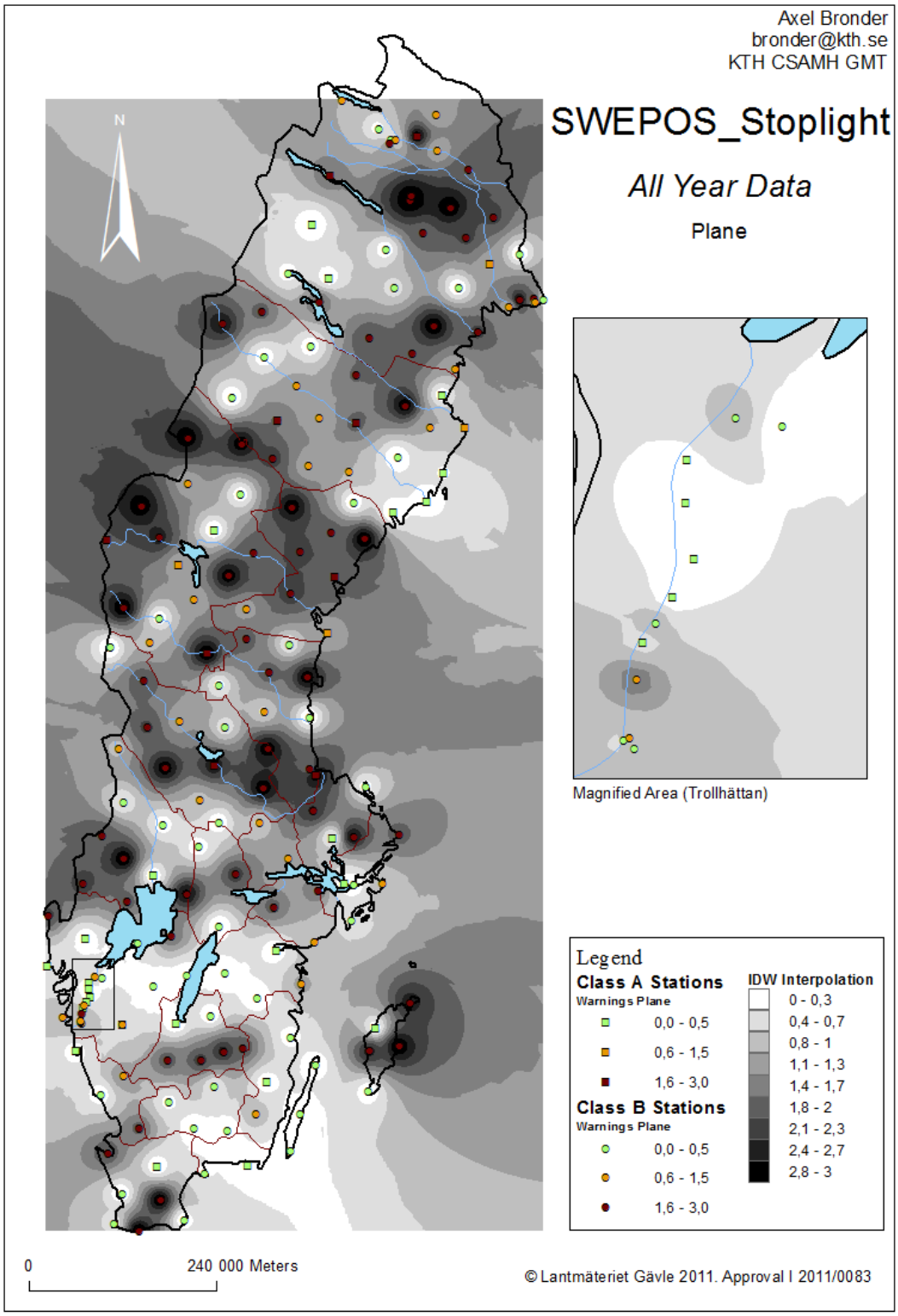
Map 10: Stoplight | Plane | All Year Data



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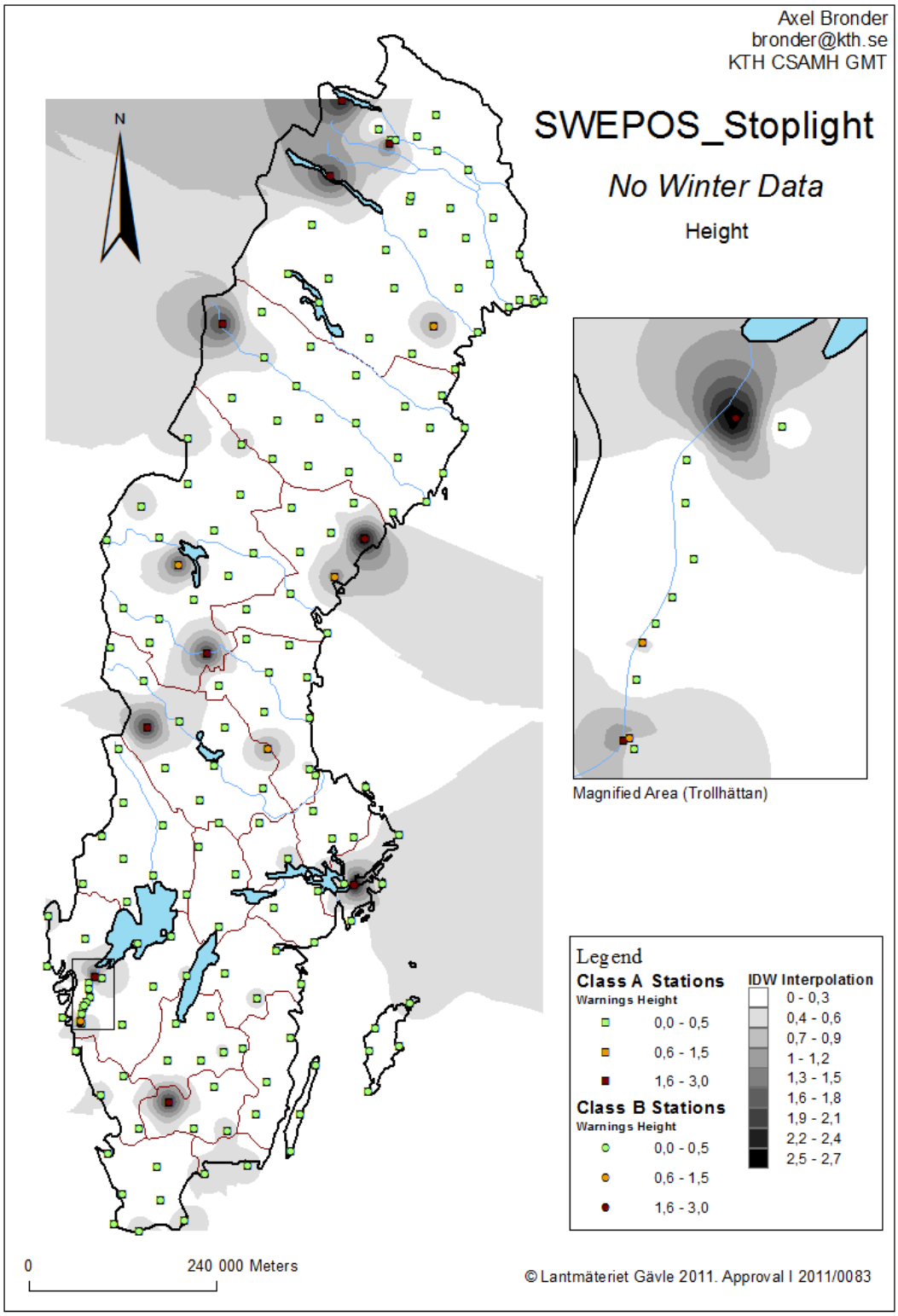
Map 11: Stoplight | Height | No Winter Data



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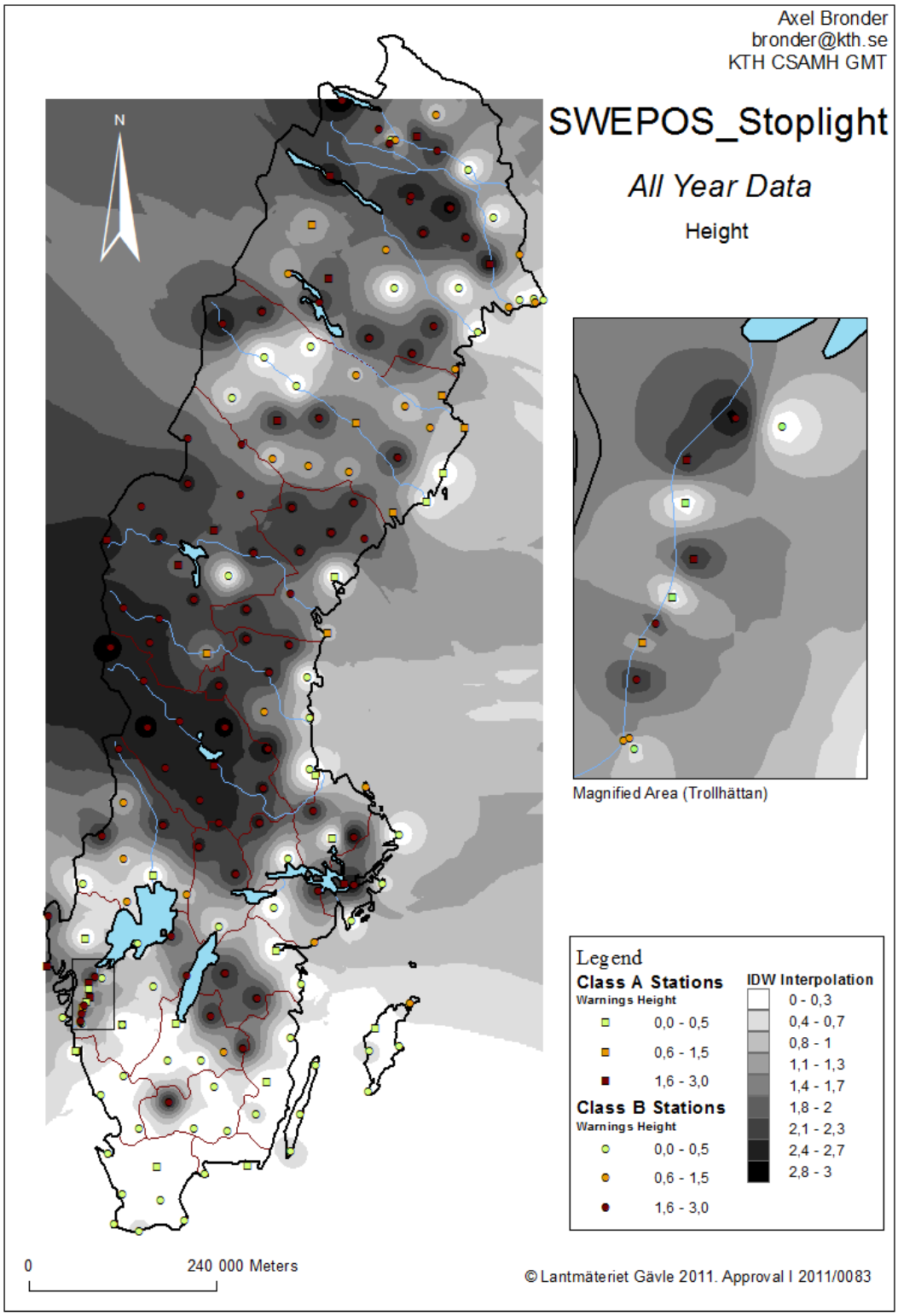
Map 12: Stoplight | Height | All Year Data



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10. Appendix 2: Analysis Example Älvsbyn

This is an example of an analysis file created by the CGP Program.

```
Infil: ALVS.0_TME.txt
Ny datafil: n.txt
Analysfil: a.txt

Antal dygn i ursprungsfilen:     364
Antal dygn i nya filen:          365
Antal "filled dates":              1
Största sammanhängande antal "filled dates":       1

                                  N              E              H
Ursprungsfilen, medeltal    7296773.0114     775764.7604         78.0296
Ursprungsfilen, medelfel          0.00568         0.00788          0.00531
Nya datafilen, medeltal     7296773.0114     775764.7603         78.0296
Nya datafilen, medelfel           0.00568         0.00789          0.00530
                                     Plan            3D
Ursprungsfilen, medelfel           0.00972         0.01107
Nya datafilen, medelfel            0.00972         0.01107
*****VARNING: Stort medelfel i Northing
*****VARNING: Stort medelfel i Easting
*****VARNING: Stort medelfel i Plan
*****VARNING: Stort medelfel i Höjd

                                  N              E              H
Diff=Max-Min                      0.0210         0.0270         0.0287
Antal sigma = 8.18

Sqrt(2)*Felellips                 a              b        sqrt((a^2+b^2)/2)
Stor- och lillaxeln             0.01363          0.00181          0.00972
Axelriktningar(gon)               140              40

Fourier                           N              E              H
Amplituder:                       0.0154         0.0211         0.0117
*****VARNING: Stor amplitud i Northing
*****VARNING: Stor amplitud i Easting
*****VARNING: Stor amplitud i Höjd
StdAvv före Fourier:              0.00568        0.00789        0.00530
StdAvv efter Fourier:             0.00170        0.00208        0.00372
Testkvoter:                     925.70         1223.84          94.65
*****VARNING: Stor testkvot i Northing
*****VARNING: Stor testkvot i Easting
*****VARNING: Stor testkvot i Höjd

Minskning av VV (procent):       91.1            93.1            51.3
*****VARNING: Stor procent i Northing
*****VARNING: Stor procent i Easting
*****VARNING: Stor procent i Höjd
*****VARNING: Årlig rörelse i plan utanför 1-sigma ellipsen

Glidande 31-medeltal              N              E              H
Diff max-min                      0.01535        0.02302        0.01695
*****VARNING: Stor amplitud i Northing
```


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```
*****VARNING: Stor amplitud i Easting
*****VARNING: Stor amplitud i Höjd

Korrelationsmatris                N              E              H
                                  1.00          -0.96           0.65
                                 -0.96           1.00          -0.71
                                  0.65          -0.71           1.00
*****VARNING: Hög korrelation

Korrelationsfunktioner:
                  Distans         N              E              H
                  0              1.00           1.00           1.00
                  1              0.96           0.98           0.79
                  2              0.95           0.97           0.76
                  3              0.95           0.97           0.74
                  4              0.94           0.96           0.69
                  5              0.93           0.96           0.69
                  6              0.93           0.95           0.64
                  7              0.92           0.94           0.62
                  8              0.91           0.94           0.63
                  9              0.91           0.94           0.59
                  10             0.91           0.93           0.57

Korrelationslängd (dagar)         58             58             35
*****VARNING: Stor korrelation i Northing
*****VARNING: Stor korrelation i Easting
*****VARNING: Stor korrelation i Höjd

Andel positioner över gränsvärdet
                          N              E              H             Plan
Mot föregående dygn, dynamiskt (procent)                0.00           0.00
Mot föregående dygn, fast  (procent)                    0.28           0.28
Medelfel                                              0.00338        0.00203

Andel positioner över gränsvärdet
                          N              E              H             Plan
Mot föregående vecka, dynamiskt (procent)               0.00           0.00
Mot föregående vecka, fast (procent)                    1.68          76.75
Medelfel                                              0.00305        0.00237
*****VARNING: Stor andel i Plan

Mot årsmedeltalet, dynamiskt (procent)
                          N              E              H             Plan
                          0.00           0.00           0.27          0.00

Mot årsmedeltalet, fast (procent)
                          N              E              H             Plan
                          48.63          80.77           5.22         72.80
*****VARNING: Stor andel i Northing
*****VARNING: Stor andel i Easting
*****VARNING: Stor andel i Höjd
*****VARNING: Stor andel i Plan
```


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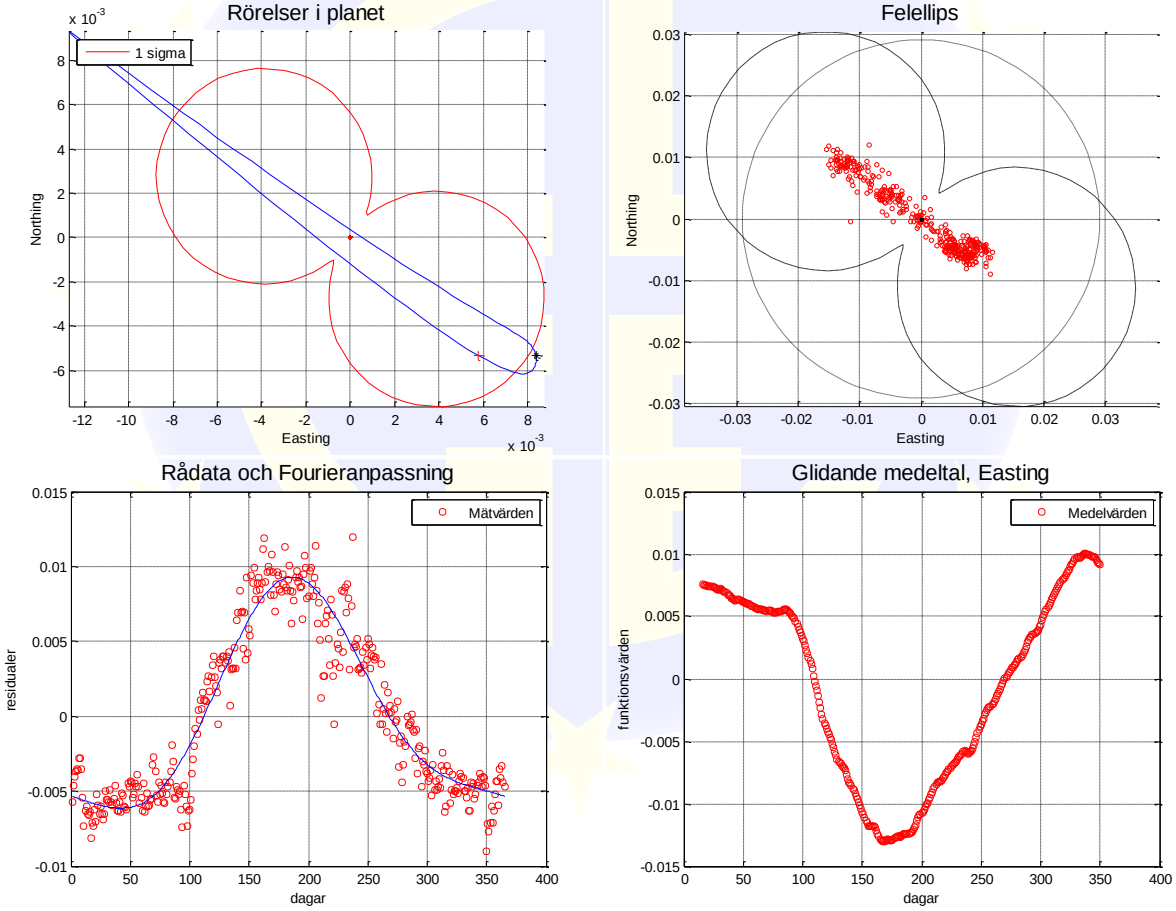
```
*****************************   SAMMANSTÄLLNING   ******************************

     Antal varningar i filen:      26
Belastningspoäng:    Osäkerhet        Systematik       Fördelning          Summa
Plan:                    1.0              1.0              1.0              3.0
Höjd:                    1.0              1.0              0.4              2.4
Summa:                   2.0              2.0              1.4              5.4

Total belastningspoäng:       5.4
```

Some plotting examples: (4 out of 14 in my version of the CGP Program.)



Northing