



GEODESY 2026–2035

- WORK TOWARDS A NEW STRATEGIC PLAN FOR GEODESY AT
LANTMÄTERIET, SWEDEN

EUREF SYMPOSIUM COVILHÃ, PORTUGAL 2025-06-25—26

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OUTLOOK

- Looking back
- Current situation
- Looking forward
- Trends in surveying
- Reference frames
- Height and gravity
- Other things to consider



LOOKING BACK

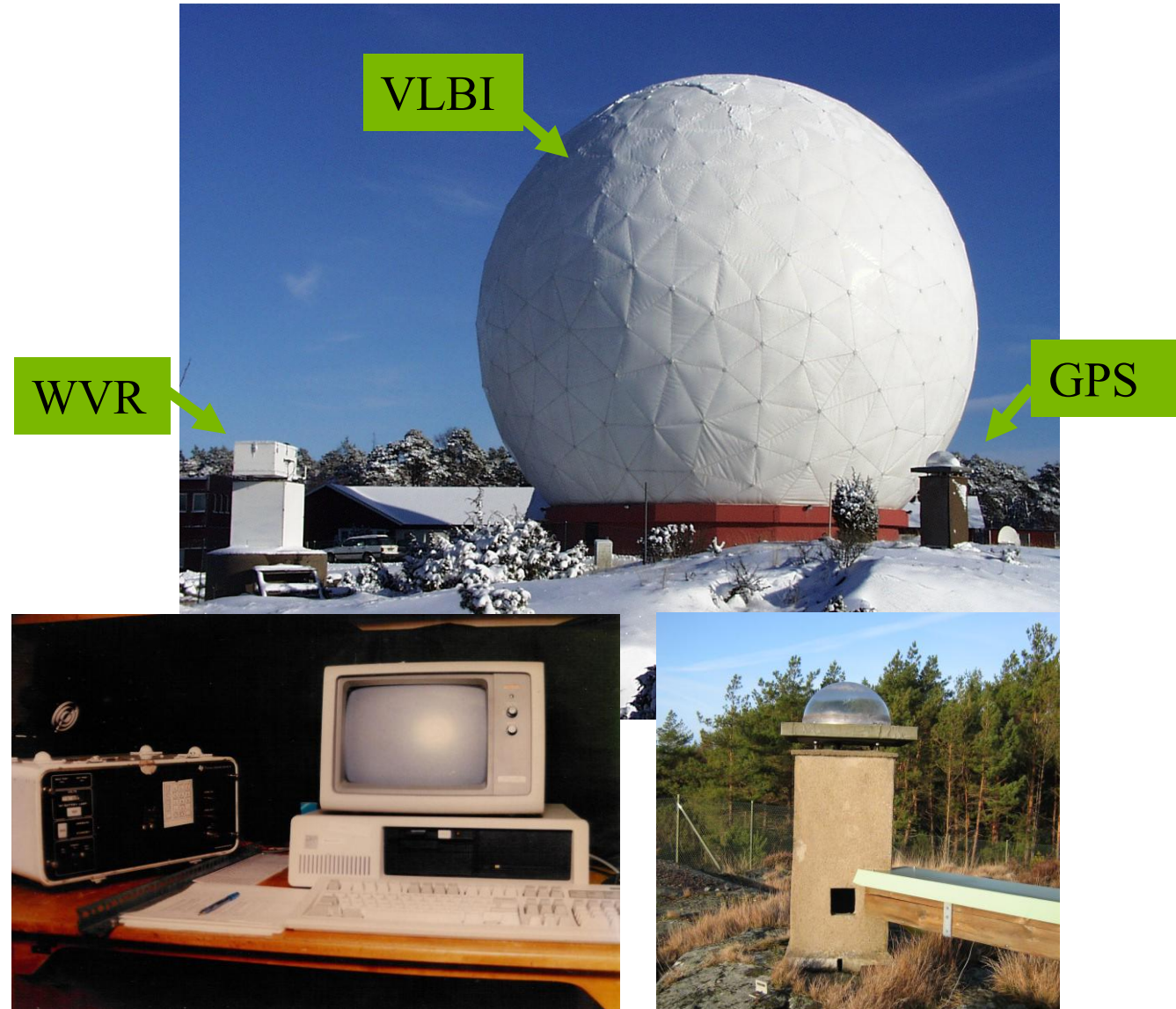
Some development steps in (space) geodesy (slight Swedish bias):

- 1968: first transatlantic geodetic VLBI
- 1984: plate tectonics can be measured using geodetic observations (VLBI)
- 1987: EUREF was founded
- CIGNET, GIG'91, Epoch 92
- 1990: the ETRS89 was agreed
- 1993: SWEPOS started (August)
- 1994: IGS operational in its first version
- 1996: EUREF Permanent GNSS Network, EPN, started
- 2000: GPS Selective availability (SA) turned off (May 2nd)
- 2004: SWEPOS Network-RTK started as a service

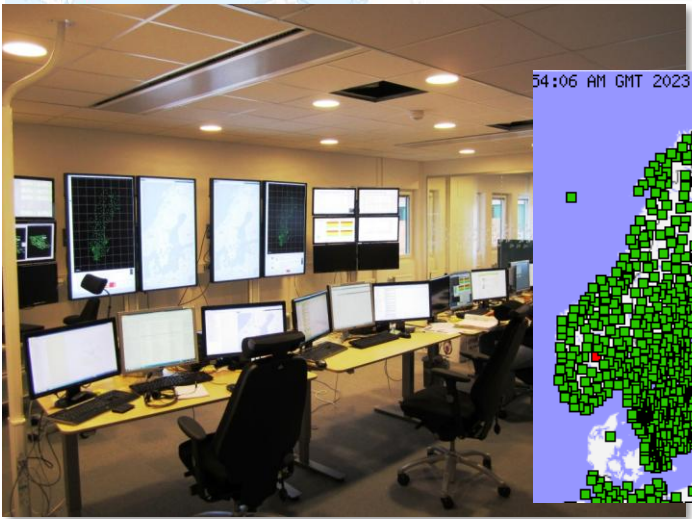
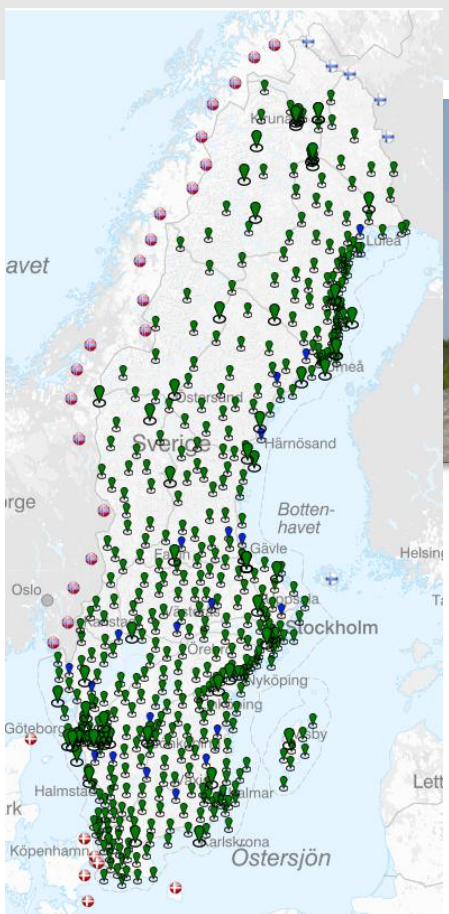


EXAMPLE – ONSALA SPACE OBSERVATORY 1986

- Geo-VLBI 1968, 1980-
- CIGNET/IGS station in Onsala 1986:
 - Onsala CIGNET station => ONSA IGS
 - CIGNET permanent network started in 1986 with 8 stations
 - Receiver TI4100 about USD 100 K
 - Could track 4 satellites
 - Only 4-6 satellites available during 4-6 hours per day
 - Data processing several weeks/months after data collection
 - Accuracy several cm to dm



SWEPOS[®] today



LOOKING BACK (part two)

Some development steps in satellite gravimetry:

- (Retro-reflectors placed on the Moon by the Apollo missions)
- 1976: LAGEOS I launched
- 2000: CHAMP satellite gravity mission launched
- 2002: launch of the GRACE satellite gravity mission
- 2009: launch of the GOCE satellite gravity mission
- 2015: IAG resolution on International Height Reference System (IHRF)
- 2018: launch of GRACE-FO mission
- 2019: IAG resolution on International Height Reference Frame (IHRF)

The satellite gravity missions, and new Earth Gravity Models (EGMs) provide fundamental improvements to local and regional geoid modelling

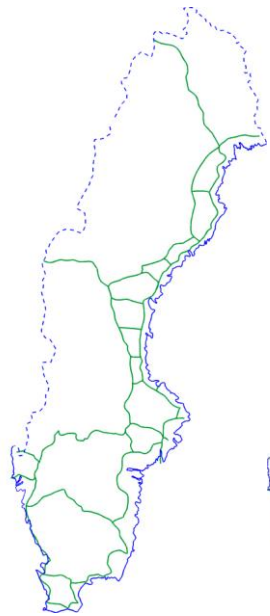
And the IHRF makes it possible to connect height frames between continents!

LAGEOS I,
Courtesy NASA

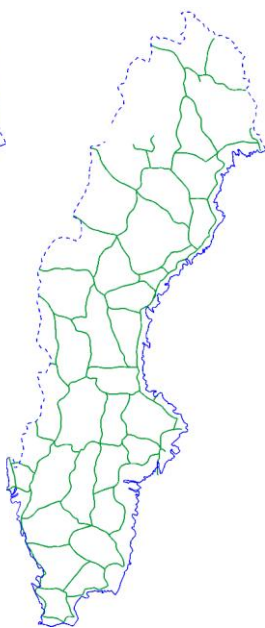


"Our mission is to provide society needs with a uniform, sustainable geodetic infrastructure and ensure its availability usability."

Building infrastructure takes time!



RH 1900



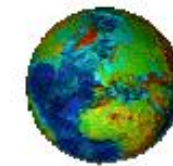
RH 1970



RH 2000



SVEPOS



Geodesi 2000

– svensk geodesiverksamhet
under kommande tioårsperiod



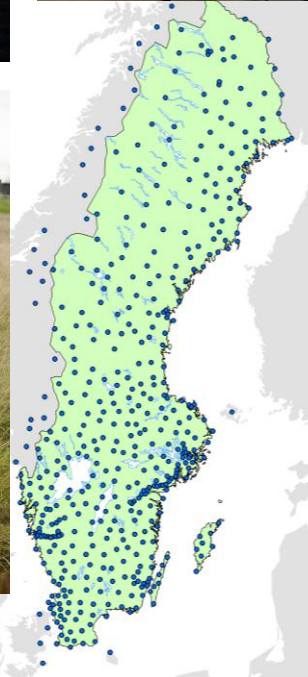
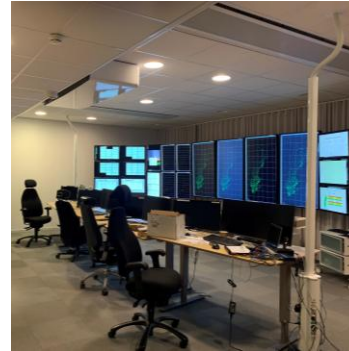
LANTMÄTERIET – DEPARTMENT OF GEODETIC INFRASTRUCTURE

Reference frames

- SWEREF 99
- RH 2000
- RG 2000
- Geoidmodell



SWEPOS



Råd & stöd

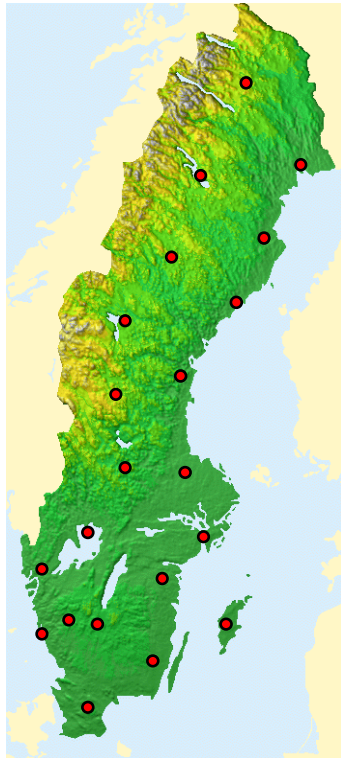


THE GEODETIC REFERENCE NETWORKS

Gravity

Geoid models

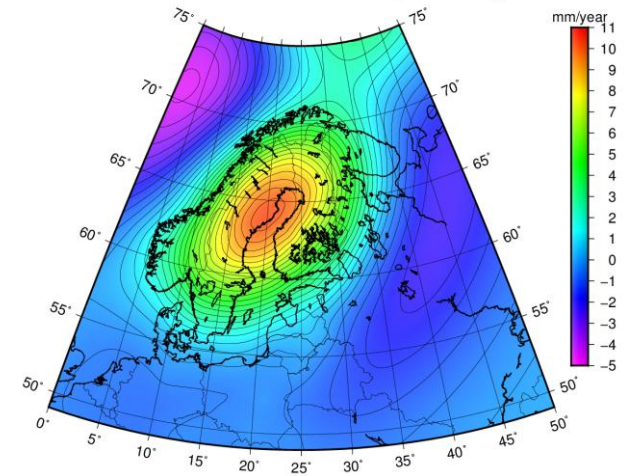
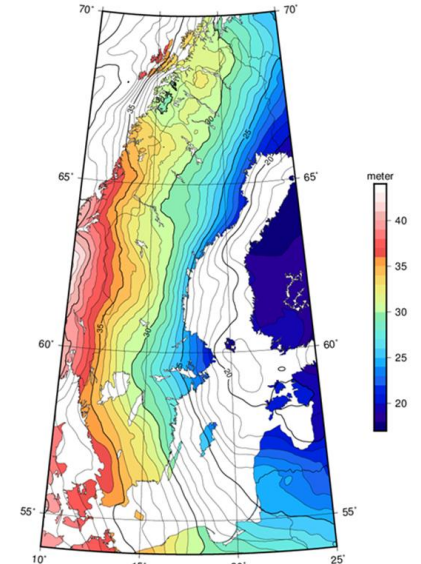
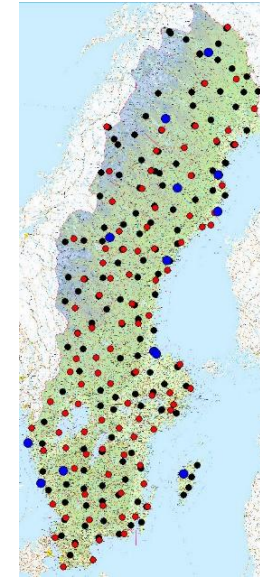
Materializes the Reference Frames



horizontal
SWEREF 99



vertical
RH 2000



“Land uplift”

PURPOSE OF A NEW STRATEGY FOR GEODESY?

- The instruction for Lantmäteriet is on a “high level” regarding geodesy, but more detailed instructions are missing (*and that is actually good!*)
- So, the strategy on geodesy is a way to describe how we will fulfil the instruction and serve societal needs
- *It is also an opportunity for “us” to present “geodesy” to the board of Lantmäteriet*
- The strategic plan on geodesy assist:
 - Our selves within Lantmäteriet (so we have a plan for what to do and why)
 - Decision makers and funders (so they know what will be achieved)
 - Stake holders (so they can plan for a future improved situation)

LOOKING FORWARD

- Effective equipment for surveying and data capture
- Surveying and data capture tend to merge to one profession
- Decrease in number of educated persons with a solid competence in geodesy
- Cadastral borders determined by coordinates?
- Mass market for cm-level GNSS (for drones, autonomous cars, robotic lawn mowers)
- Global players on the positioning market
- Navigation in the Global Reference Frame (ITRF)
- The Society more dependent on the global geodetic infrastructure (without being aware of it!)
- More focus on security aspects (redundant, reliable methods, competens)
- AI!



ISSUES

- How much is included in our mission?
- What is the role of a Geodetic authority in relation to a Mass market for precise positioning?
- What is the lifetime of our Reference Frames?
- What about global height frames (IHRF/IHRF)?
- Connecting reference frames for land and sea?
- How to contribute to the “Global Geodesy Supply Chain”?
- What are the needs for geodetic infrastructure in a crisis situation, and how do we meet those needs?
- InSAR (ground motion services)?



GEODESY 2026-2035, short summary

- We plan for keeping our current geodetic reference frames for a long time (*during the planning period and beyond*)
- SWEPOS is our main tool for providing the reference frame to users and to promote efficiency in surveying in Sweden
- Users asks for better accuracy in height. Therefore better geoid models are needed, and we need to measure gravity!
- The GNSS technology will develop
- Surveying equipment, technology and methodology will develop, but may not have major impact on the needs for the basic geodetic infrastructure
- Increased need for knowledge and competence due to the change in political/security situation



REFERENCE FRAMES

- **SWEREF 99 and RH 2000** will be the national reference frames for a long time
- This requires **continuous maintenance, management and development work** – *the alternative would be very costly!*
- Digitalization in society including cadastral markers determined through coordinates require that SWEREF 99 is stable over time
- Models of the crustal deformations (Post Glacial Rebound) and geoid models needs further developments

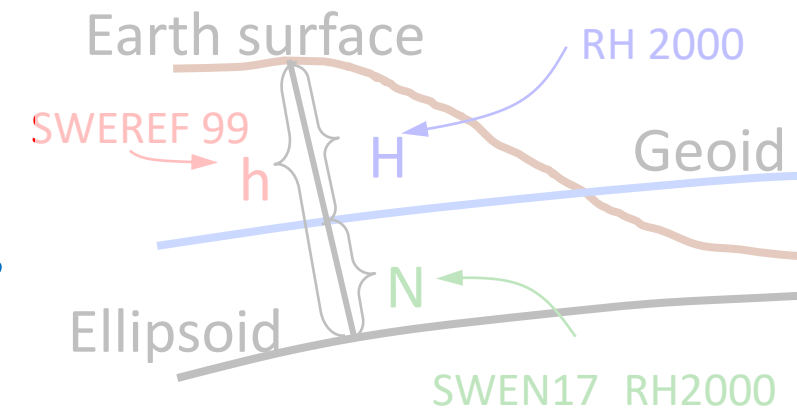


SWEREF 99

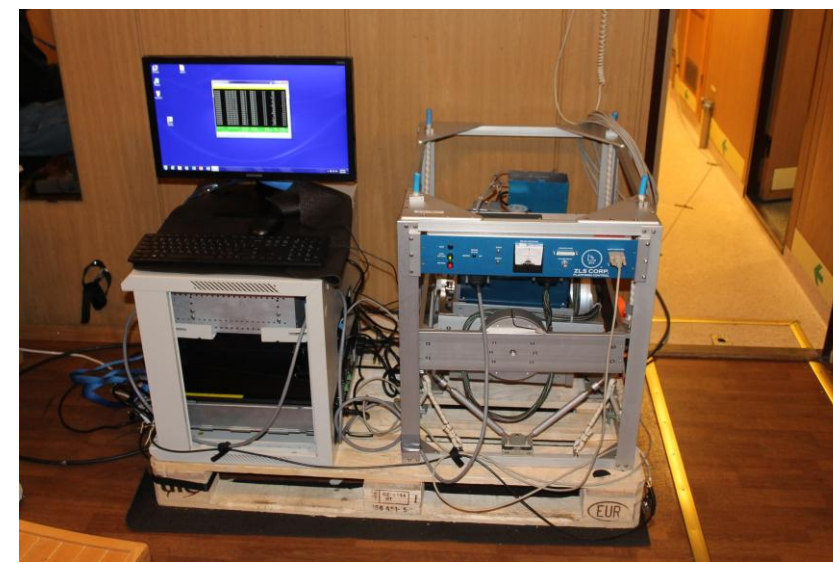
- SWEREF 99 will be our national geodetic reference frame for long time
- But:
- There will be needs for using the “Global Geodetic Reference Frame” in parallel (ITRF)
- So called ”Two Frame Approach”
- We have today good transformation relations between SWEREF 99 and ITRF
- However, we need to make the use more simple by e.g. standardization
- And owe time better models of crustal deformations (horizontally and vertically)

HEIGHT FRAME, GEOID MODELS AND GRAVITY

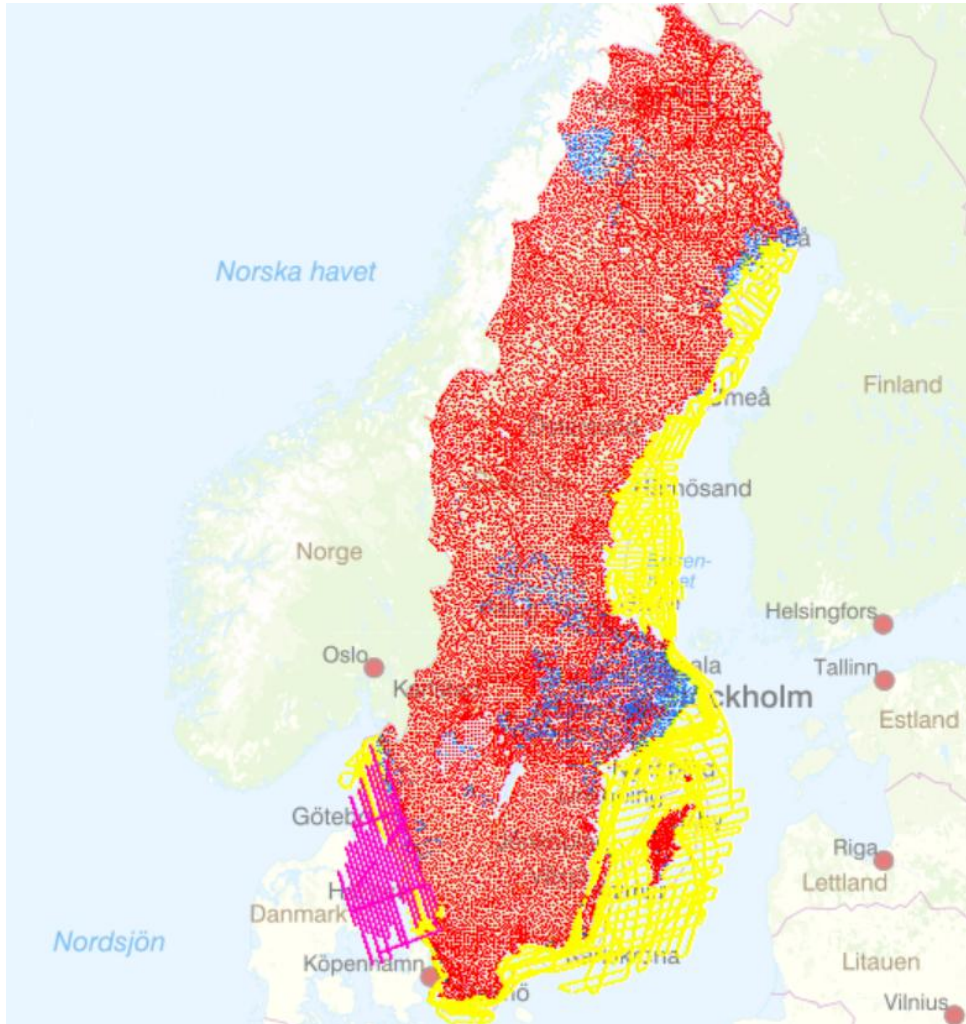
- RH 2000 will be used for a long time ($> \sim 20$ yr)
- Thus continue maintenance by inventory of Bench Marks
- Most users access RH 2000 through SWEPOS Network RTK service – thus, the geoid model is crucial
- We therefore need to improve the gravity observations and improve the geoid models
- This will pave the way for the possibility to turn to a geoid based height frame maybe 20 year from now
- To consider:
 - RH 2000 is good but,
 - Global Height Frames is on the way (IHRF)
 - Relativistic geodesy, determine geopotential differences using clocks, independent technology able to connect continents – considered to develop the next 10 years



Example of gravity surveys



Gravity data!



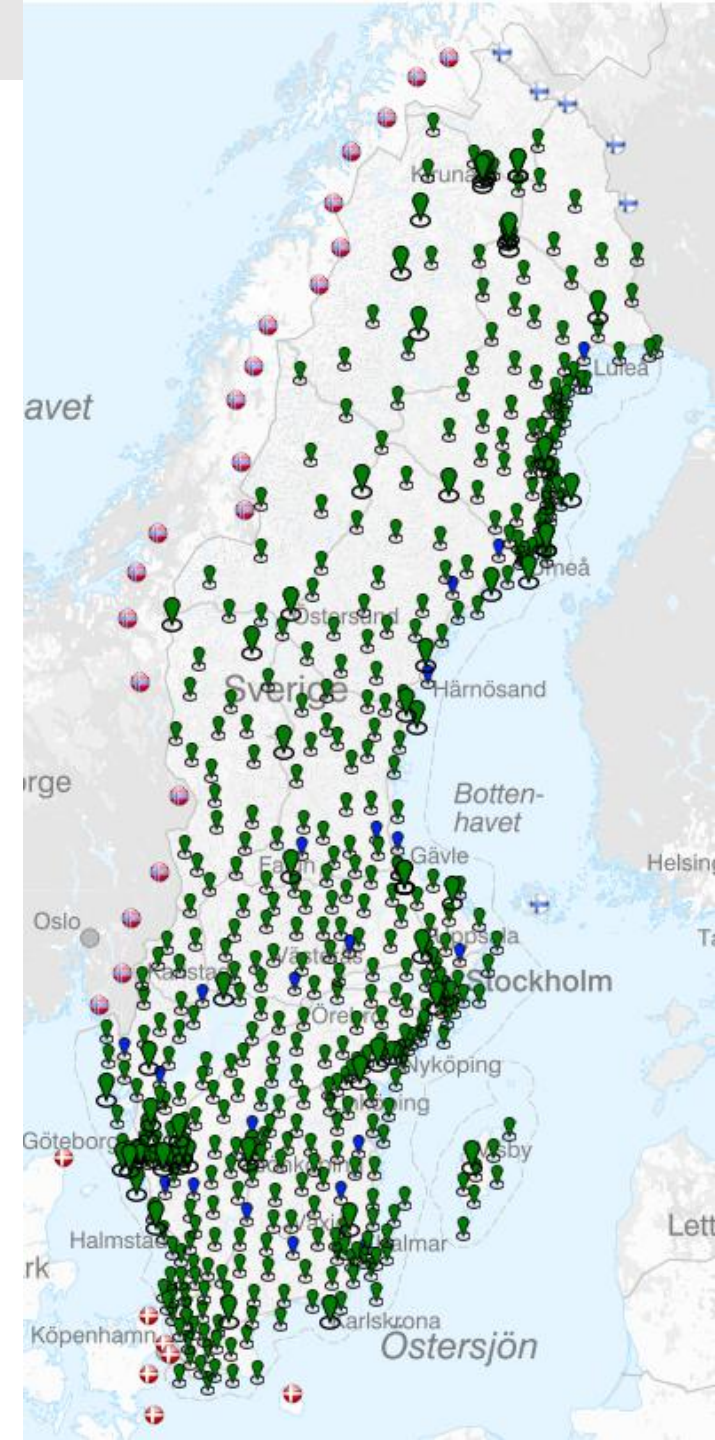
- We have a “reasonable” gravity data set
- On land about 5 km spacing
- Marine gravity data
- But much of the land gravity data are “old”, 1970’s and 1980’s
 - Gravity value usually fine
 - But height of the observation and horizontal position unreliable
- We should densify to ~3 km spacing
- And at the same time check quality of the existing gravity data
- Some 40 000 new gravity observations (realistic time frame ~ 20 years)

TRENDS IN FUTURE SURVEYING TECHNOLOGY

- Combination and integration of technology and methodology
- GNSS (SWEPOS Network RTK), total station, scanner
- "Drones", airborne, on water, and on land as platform for surveying equipment (ex, a "robot dog" walking around a construction area and scan (slam) every night!?)
- Integrated processing of point clouds – partly in the instruments, but also as post processing to identified and survey individual objects in cloud based AI/ML solutions
- The profession as "information collector" will be more "problem solver" than Survey engineer
- Continuous demand to our "Handbooks in Surveying and Mapping"
- But so far no findings that change the basic needs of the national geodetic infrastructure

SWEPOS

- Professional users in surveying, building, construction, cadastral, etc. will also in the future ask for “best performance” which today is the Network RTK service from SWEPOS (and other providers)
- But we need to continuously work for better quality and reliability in operation of the service
- We need to improve the “knowledge base” for precise GNSS real time services (current CLOSURE reports from 2008)
- The station network is the backbone for the services from Lantmäteriet
- But real time raw data will be provided (by fee) for others so they can provide their services based on the infrastructure in SWEPOS



DEVELOPMENTS IN GNSS

- "Mass market" for precise GNSS. (consumer products like GPS controlled robotic lawn movers, autonomous flying drones, autonomous cars have been foreseen for a long time now...)
- Galileo HAS – position at the "few dm" direct from the satellites (not yet but will come)
- LEO-PNT (satellites in low orbits, but many, to be used for positioning and navigation – possibly also other frequencies? Impact on antennas for LEO-PNT GNSS ??)
- Still, good performance need a ground infrastructure, and the ambition is that the station network of SWEPOS can contribute also for mass markets.

FINALLY

Lantmäteriet work on a strategic plan for how to meet the future needs for a national geodetic infrastructure



So thoughts, ideas and suggestions is very welcomed...!!



TACK! VI FINNS PÅ...

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EXEMPEL PÅ WEBBTILLGÄNGLIG LAYOUT

OBS! DEN HÄR SIDAN SKA TAS BORT NÄR DU LÄST KLART

Läsriktningen ska alltid vara i den här ordningen:

1. Rubriken
2. Texten
3. Bilden

Skriv alternativtext för dina bilder genom att högerklicka på bilden och välja *Redigera alternativtext*.

Skriv namn på dina avsnitt för att sidorna ska kunna läsas i rätt ordning. Högerklicka på sidor i vänsterfältet. Välj *Lägg till avsnitt*, skriv önskat namn.

[Länk till handledning steg för steg på intranätet.](#)



INFORMATIONSSIDA OM FÄRGER

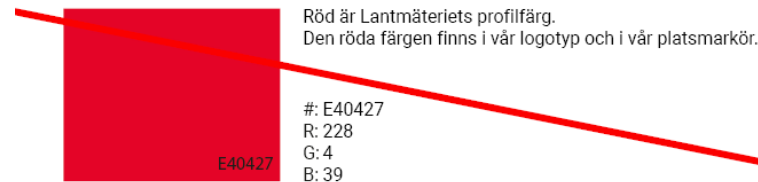
OBS! DEN HÄR SIDAN SKA TAS BORT NÄR DU LÄST KLART

Tänk på att du måste följa webbtillgänglighetsdirektivet när det gäller användning av färger och ha **rätt textfärg på rätt färgbakgrund**. Det gäller även symboler, skisser, diagram m.m. Här har du en färgskala som ska användas samt vilken textfärg som blir läsbar med respektive färg.

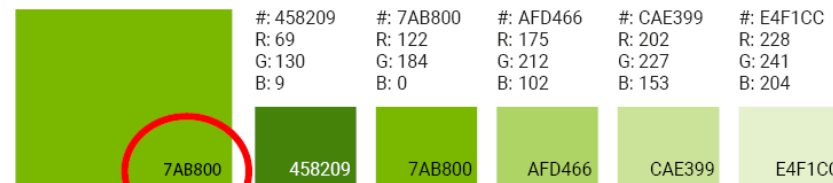
Den röda färgen är endast avsedd för våra varumärke (logotyp och platsmarkör) och ska inte användas i något annat sammanhang.

[Länk till intranätet för att se färger i större skala](#)

PROFILFÄRG



PRIMÄRFÄRG



ACCENTFÄRGER



INFORMATIONSSIDA OM ÖVRIGA GRAFISKA ELEMENT

OBS! DEN HÄR SIDAN SKA TAS BORT NÄR DU LÄST KLART

Skisser, diagram, illustration med mera ska sparas som separata powerpointbilder. Då kan du ta fram originalbilden igen, uppdatera och göra ändringar och spara som en ny powerpointbild.

När du är klar med din grafik klipper du ut den del du vill använda med hjälp av skärmklippverktyget, finns i programkatalogen, och sparar som en bild. Sedan kan du behandla grafiken som en bild i ditt bildspel, det vill säga infoga den och *Redigera alternativtext*.

*Exempel till höger är en skiss som är sparad som en bild.
Högerklicka på den för att läsa Alternativtext.*

