The 3rd generation SWEPOS™ network - towards a modern GNSS reference station infrastructure

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SWEPOS™

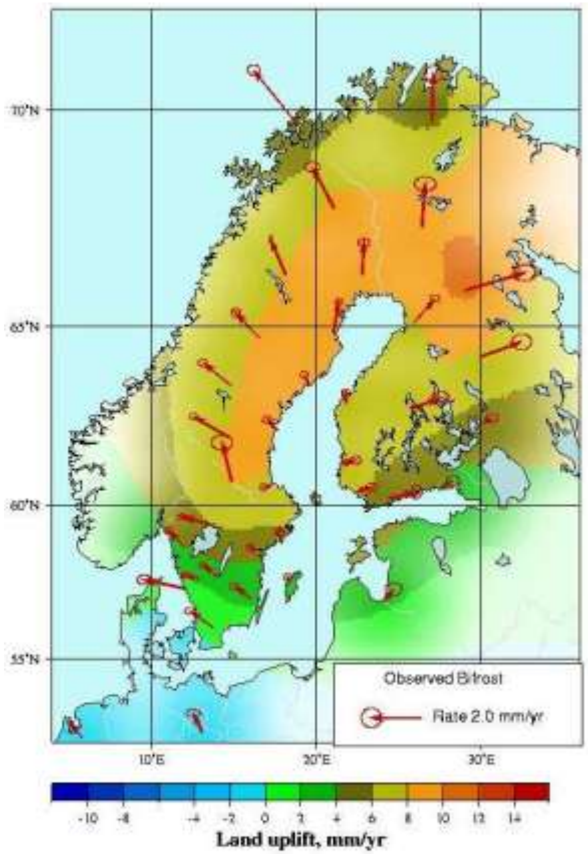
- National network of permanent reference stations and is a part of the national geodetic infrastructure
- Basic investments are made with government funding.
- Running costs and upgrades are covered by user fees.

SWEPOS™ - Purpose

Överkalix – class A station

- Supplying GNSS data for
  - Navigation
  - Positioning
  - Science and education
- Realization of the National reference system SWEREF 99
- Monitor the integrity of the GNSS systems

SWEPOS™ - Scientific applications



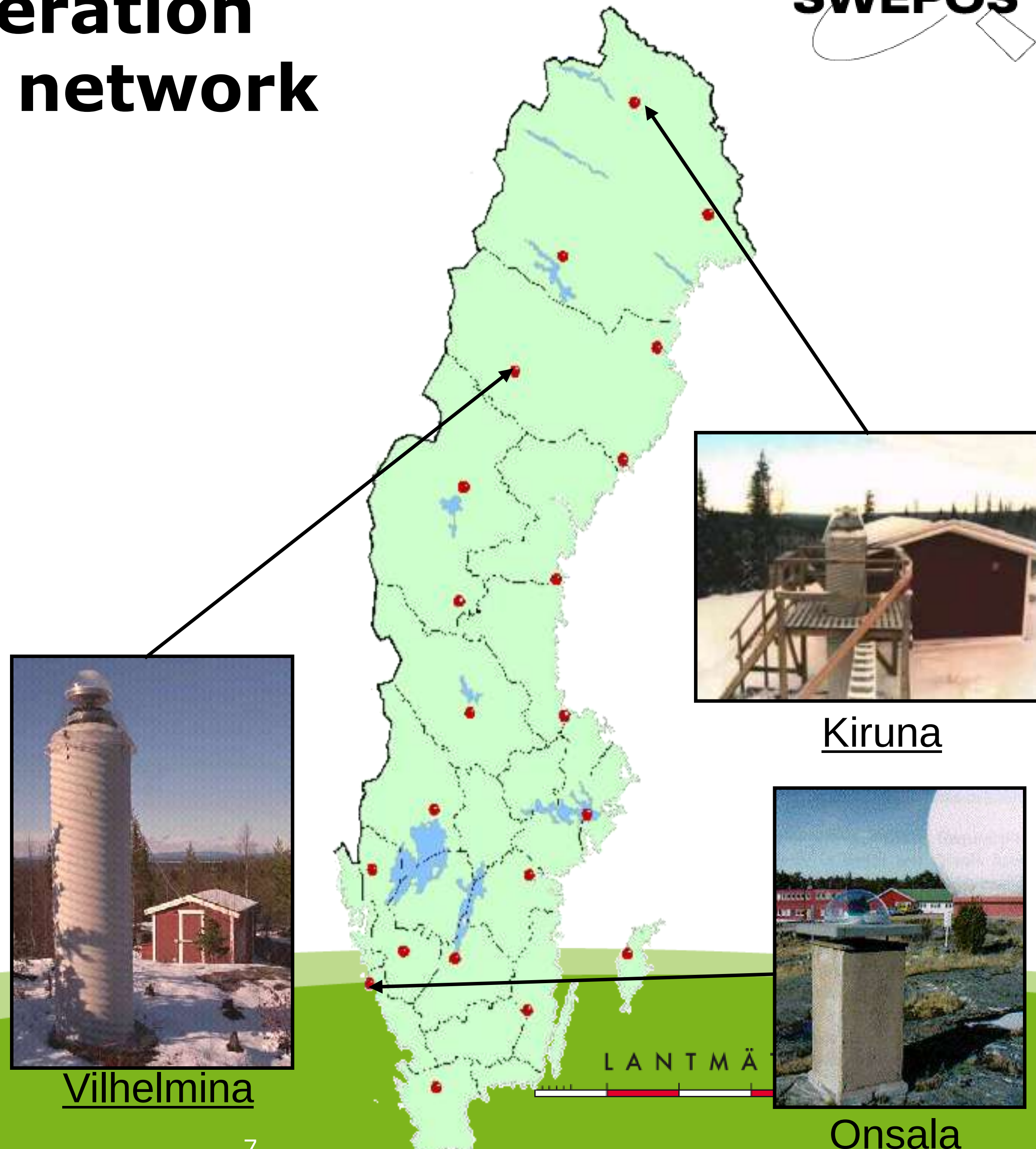
- …defines and monitors the national reference frame SWEREF 99
- …contributes with data to
  - IGS (International GNSS Service)
  - EPN (EUREF Permanent Network)
- …is used for
  - International reference frame (ITRF)
  - Geodynamic models (land-uplift)
  - Climate research and meteorology

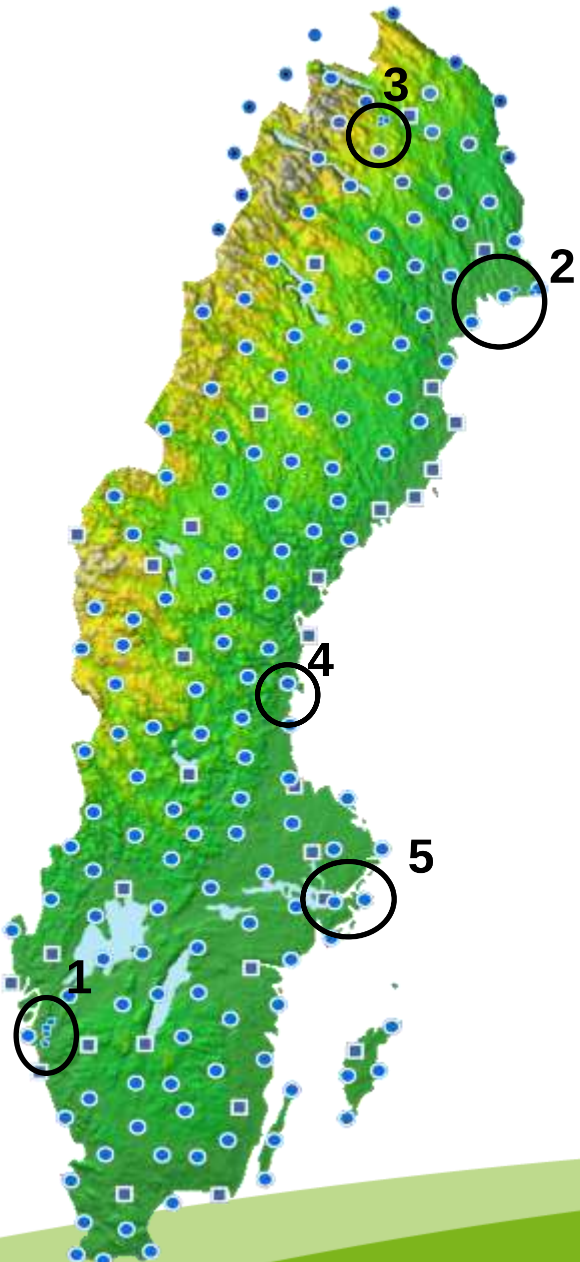
Introduction

- SWEPOS Network-RTK Service
  - Based on the Virtual Reference Station concept
  - 195 (GPS/GLONASS) reference stations (September 2010), plus a number of Norwegian, Danish and Finnish stations in the border regions (total 218 stations)
  - Average distances between stations ~ 70 km
  - 1500+ users
- Expected rover position uncertainty (68%)
  - Horizontal ~ 15 mm
  - Vertical (ellipsoidal height) ~ 25 mm

1st generation SWEPOS network

- The **1st generation** network consist of 21 pillar stations established during the mid- 1990s
- The 21 complete SWEPOS-stations are mounted on bedrock and have redundant equipment for GNSS-observations, communications, power supply etc.





2nd generation SWEPOS network

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- The **2nd generation** network consist of a regional densification (baselines ~70 km), established between the years 2002-2009
- A recent trend is a further densification of the 2nd generation network (15-30 km), aimed towards large-scale constructions projects

1. BanaVäg i Väst 2007
2. Haparanda railway 2008
3. Kiruna 2009
4. The Sundsvall bypass 2010
5. Stockholm 2010

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Assessing the quality of network-RTK

- A number of field studies with network-RTK have been conducted since 2001 as part of SWEPOS establishment projects and diploma works
- The focus of these studies have primarily been to:
  - Verify various aspect of the network-RTK technique (e.g. network-RTK software and rover functionality)
  - Quantify position uncertainty levels for the user community

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Previous studies

- The rover positioning uncertainty with network-RTK seem to decrease over these years:
  - Horizontal: 15-20mm → 10-15mm (68%)
  - Vertical: 25-30mm → 20-25mm (68%)
- This can be explained by a combination of different factors
  - Modernization of GNSS-equipment (e.g. GNSS antennas with more effective multipath reduction)
  - Better modeling of atmospheric errors in network-RTK software
  - New satellite signals, etc

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CLOSE-RTK project

- CLOSE-RTK was initiated by Lantmäteriet, SP Technical Research Institute of Sweden and Chalmers University of Technology

- Main objectives for this project were to:
  - **Current:** Investigate the achievable uncertainty for network-RTK based on a detailed study of contributing error sources
  - **Future:** Evaluate the expected quality of network-RTK positioning, given possible changes in the infrastructure of space and ground segments

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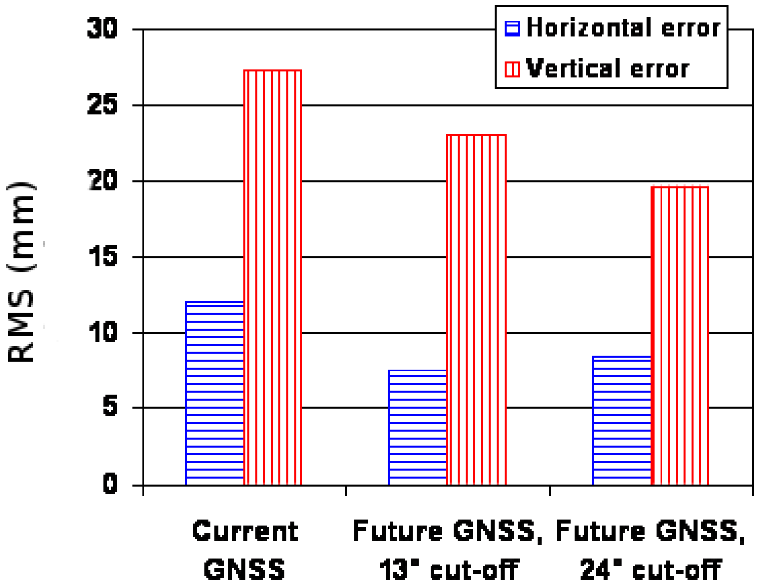
CLOSE – Future situation
New GNSS constellation

- **Future GNSS constellation + higher elevation cut-off angle =** lower position uncertainty
- **Future GNSS constellation =** reduction in the error contribution from ionosphere and local effects
- **The availability of future GNSS =** reduces the vertical uncertainty from 27 mm to 20 mm (68%)



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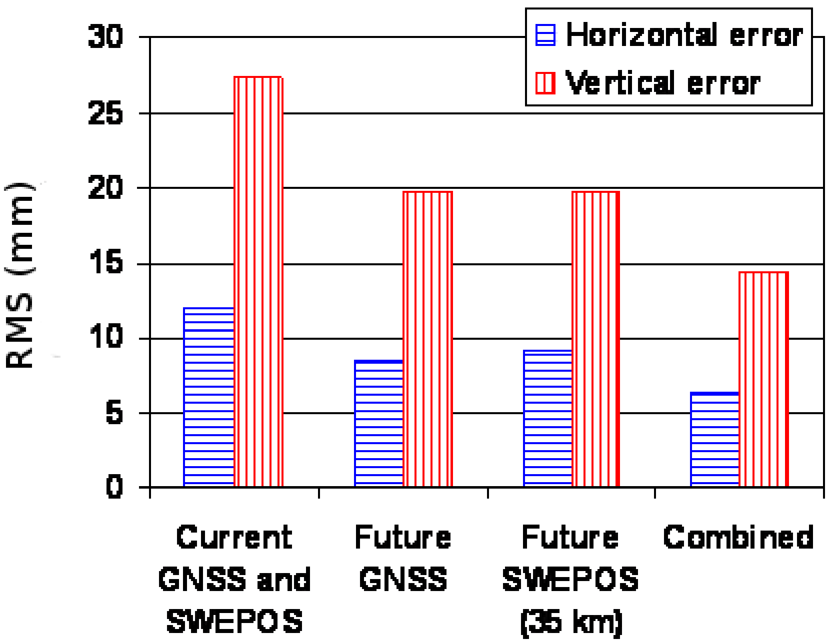
CLOSE – Future situation
Densified reference network

- **Densified network (35 km) + current GNSS constellation** = reduces the vertical position uncertainty from 27 mm to 20 mm (68%)
- **Densified (35 km) + future GNSS constellation** = vertical position uncertainty of 14 mm (68%)
- **Further densified network (10 km) + future GNSS constellation** = vertical position uncertainty of 8 mm (68%)

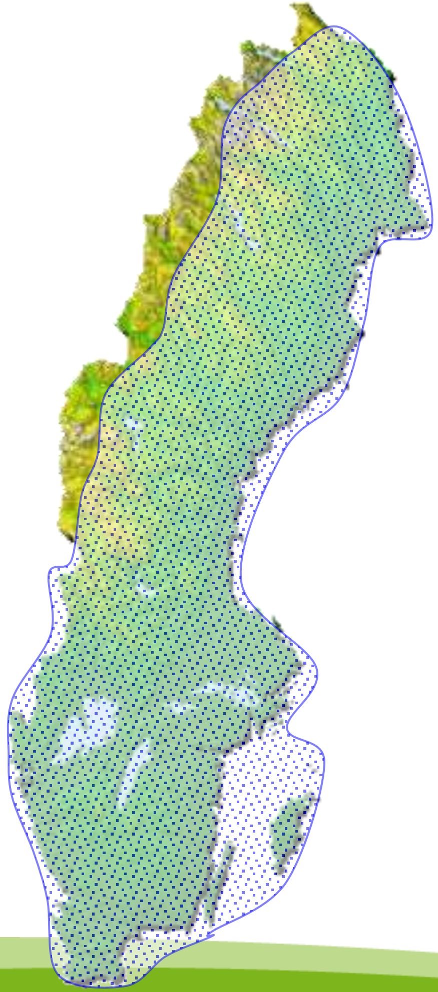


The 3rd generation SWEPOS network

- During recent years many users have requested improvements especially in the vertical position uncertainty

- Results and experiences from previous studies (e.g. CLOSE) have inspired the development for a 3rd generation network

- The **3rd generation** SWEPOS network will be a nation-wide densification of the 2nd generation network, with in-between distances of **~35 km**



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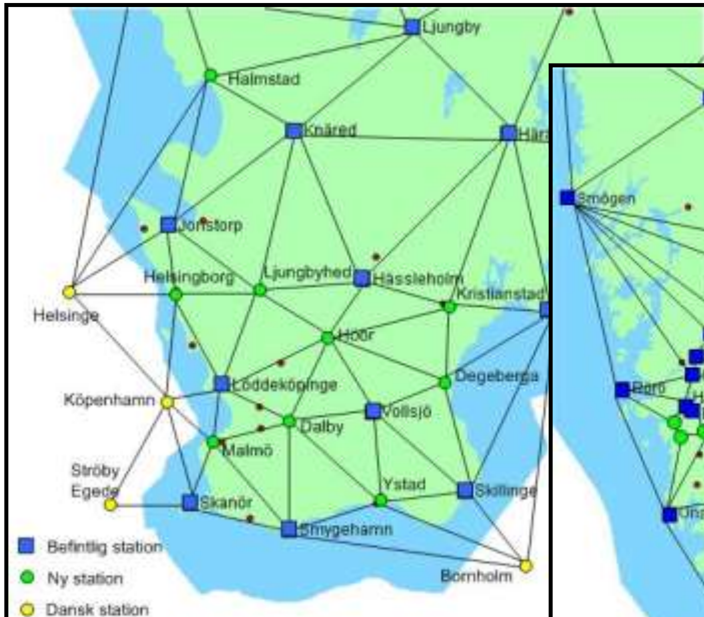
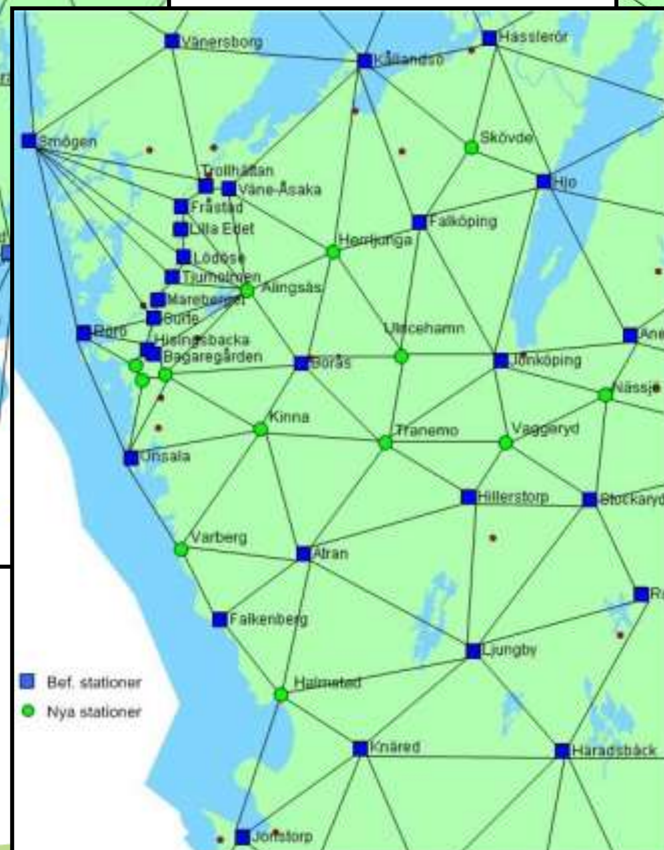
The 3rd generation SWEPOS network

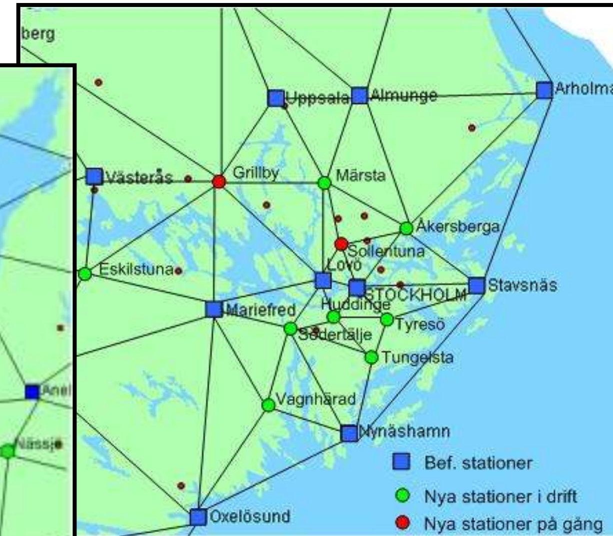
Densification 2010



Skåne
(8 new stations)



West Sweden
(13 new stations)



Stockholm - Mälardalen (10 new stations)

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Future and challenges

- The upcoming Solar-cycle maximum, CLOSE II - Ionospheric monitoring through web
- Establishment of monitor stations of the real-time network-RTK-services
- Dealing with incompatibilities between the CORS software and different brand of receivers/rovers
- Evaluation of different network-RTK software
- Providing network-RTK-services for the maritime industry - Precision navigation around the major ports
- Machine guidance and agriculture applications

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Conclusions

- The theoretical simulation in the CLOSE project confirmed the empirical values (from previous studies) for the vertical uncertainty
- Results from the CLOSE project and similar projects will continue to guide the development of SWEPOS to meet the demands of the user community
- This include a densification of the current reference station network, but also development of tools for real-time users, such as ionosphere monitoring via the SWEPOS web page
- The ongoing quality assessment of the SWEPOS Network-RTK services provides valuable information about the error sources and how they affect positioning

Thanks for listening

Questions?

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