Presented at the FIG Working Week 2016,
May 2-6, 2016 in Christchurch, New Zealand

On the Management of Reference Frames in Sweden

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FIG Working Week 2016

CHRISTCHURCH, NEW ZEALAND 2–6 MAY 2016

Recovery from disaster

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Outline

- The national reference frames SWEREF 99 and RH 2000
- Sweden is affected by post-glacial land uplift → reference frames are deformed
- Handling of deformations in SWEPOS Positioning Services
- SWEREF 99 consolidation points
- Maintenance of RH 2000
- Future work

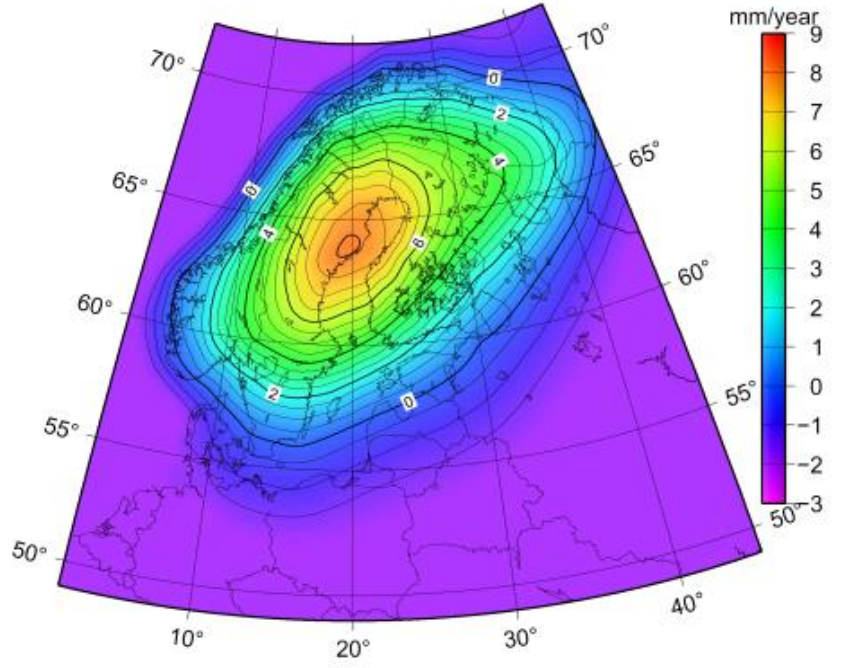
National reference frames

- SWEREF 99: Official ETRS89 realization
  - Defined through the CORS network, SWEPOS™
  - Coordinates are in principle fixed to the original realization, at the epoch 1999.5, i.e. coordinates are static
  - Update of coordinates to be consistent with absolute antenna models (2011)
- RH 2000: The Swedish EVRS realization
  - Defined by the benchmarks from the third precise levelling
  - Treatment of post-glacial land uplift was not stated in the EVRS definition, and thus had to be handled at the Nordic level

Third precise levelling network

Land uplift models

- Present land uplift model NKG2005LU is a combination:
  - Lambeck's geophysical model outside the Nordic area
  - Vestøl's mathematical model within the Nordic area
- Velocity model NKG_RF03vel is a combination:
  - Milne's GIA model transformed to GPS-derived velocity field → horizontal displacements relative to stable Eurasia
  - NKG2005LU for the vertical component



Land uplift model NKG2005LU

Handling of reference frames in SWEPOS Positioning Services

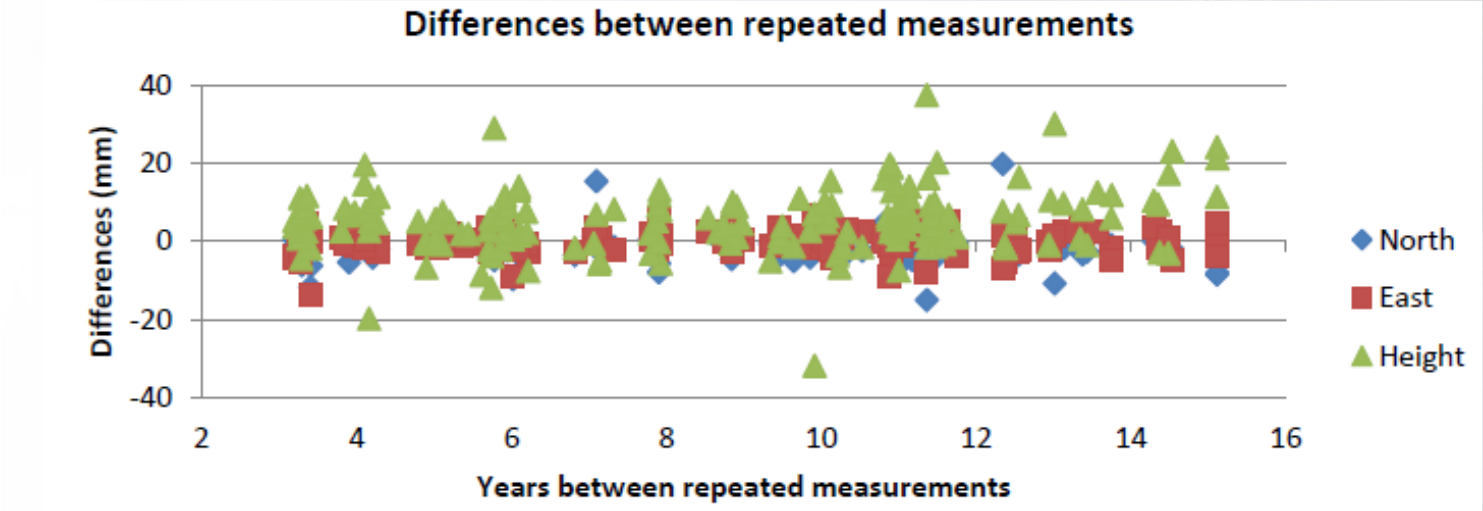
- Network RTK Service
  - SWEREF 99 coordinates are transformed to present ITRF and constrained in modelling of error sources
  - EUREF standard transformation in combination with NKG_RF03vel velocities → constrained coordinates agrees with present situation; will not introduce systematics in error modelling
- Post-processing Services
  - Calculations are performed in present ITRF
  - Solution is reduced to epoch 1999.5, using NKG_RF03vel velocities, and finally fitted to SWEREF 99 on the SWEPOS stations, using a 3D similarity transformation

SWEREF 99 consolidation points

- SWEREF 99 is realized by the CORS → dependent on the CORS and possible alterations
- Approx. 300 consolidation points have been introduced to have control of these changes
  - 50 points are re-measured every year → every point is re-measured every six years
- Measurements between 1996 and 2011 have been processed using a similar strategy

SWEREF 99 consolidation points

- During this time period no degradation of the repeatability is seen
  → we are, after 15 years, able to determine coordinates in SWEREF 99 with approximately the same uncertainty
- We have lately noted that alignment to SWEREF 99 has degraded, especially in the north, indicating that updated velocity models will soon be needed



Maintenance of RH 2000

- Deformations caused by land uplift can be neglected when measuring to close-by points → important that a rather dense network remains
- All benchmarks are invented, but only a selection of them can be replaced, implying that some benchmarks are more important than others, e.g.
  - In municipalitites where the local authority has not done their transition to RH 2000
  - Bedrock demarcations are of higher value than other demarcations
  - Network nodal points

Future work

- Velocity models are seen as subjects of development – new models are developed to make the national reference frames useful and sustainable over time
- Demands on velocity models will increase with time, but in course of time, more observations will be also available and increase the possibilities to develop better models
  - New empirical land uplift model, based on longer GNSS time series and refined GIA model
  - New geoid model(s)

Thanks for your attention!