High accuracy GNSS positioning – compatibility and the future mass market

Martin Håkansson

Lantmäteriet, KTH

KTH VETENSKAP OCH KONST

LANTMÄTERIET

Outline of this presentation

1. GNSS hardware biases
   a) Overview of biases in precise GNSS positioning
   b) Some results from my research

2. The future mass market of precise GNSS positioning
   a) Characterization of GNSS measurements from a Nexus 9 tablet

KTH VETENSKAP OCH KONST

LANTMÄTERIET

GNSS hardware biases

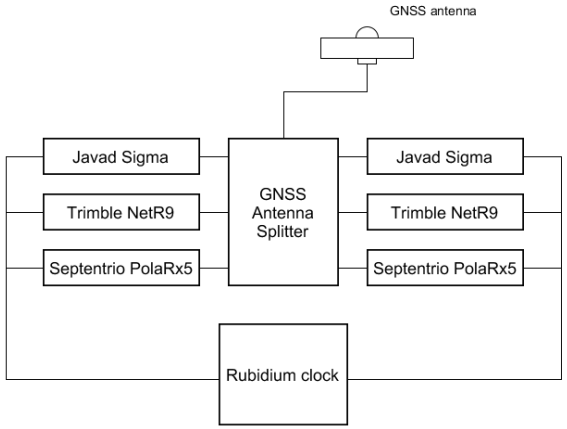
- Induced in the hardware of both receivers and satellites
- Appear in GNSS measurements as small constant offsets between GNSS system, signals, or receiver types
- Affects precise GNSS positioning in various ways

GNSS hardware biases

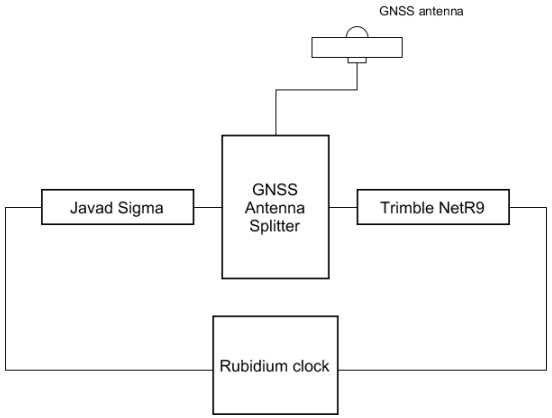
- Positioning with GLONASS:
  Code and phase inter-frequency biases (IFBs)
- Positioning with multiple GNSS systems:
  Code and phase inter-system biases (ISBs)
- PPP-AR
  Satellite phase biases
- Positioning not using the ionosphere-free LC
  Differential Code Biases (DCBs)

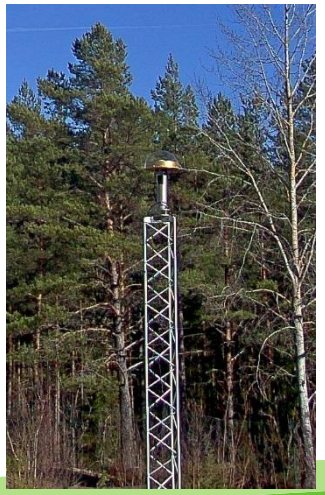
Experiment to determine GNSS phase biases

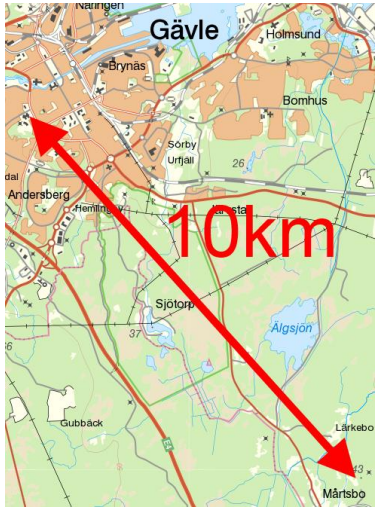
Gävle



Mårtsbo

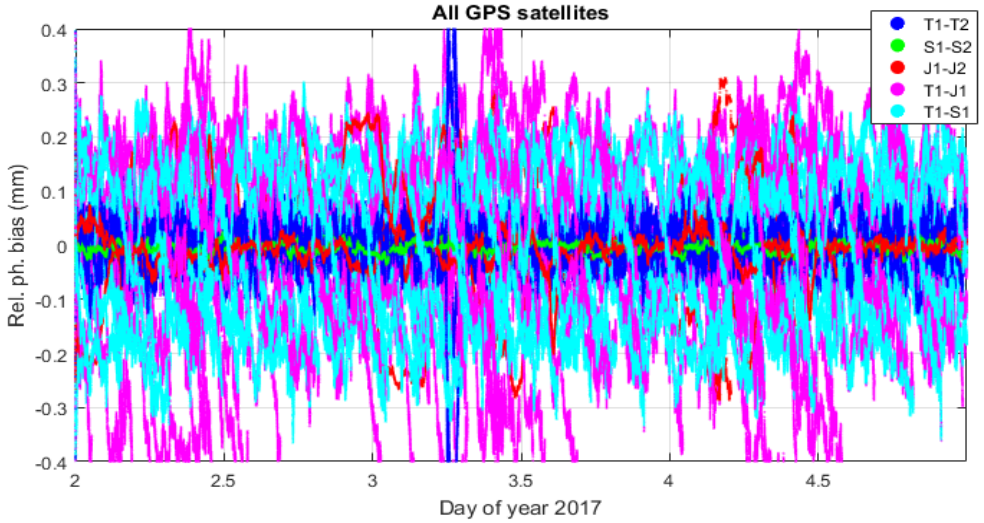






Some results

Between receivers phase biases:



The relative biases between receivers of different types shows significant variations over time in relation to same receiver type combinations.

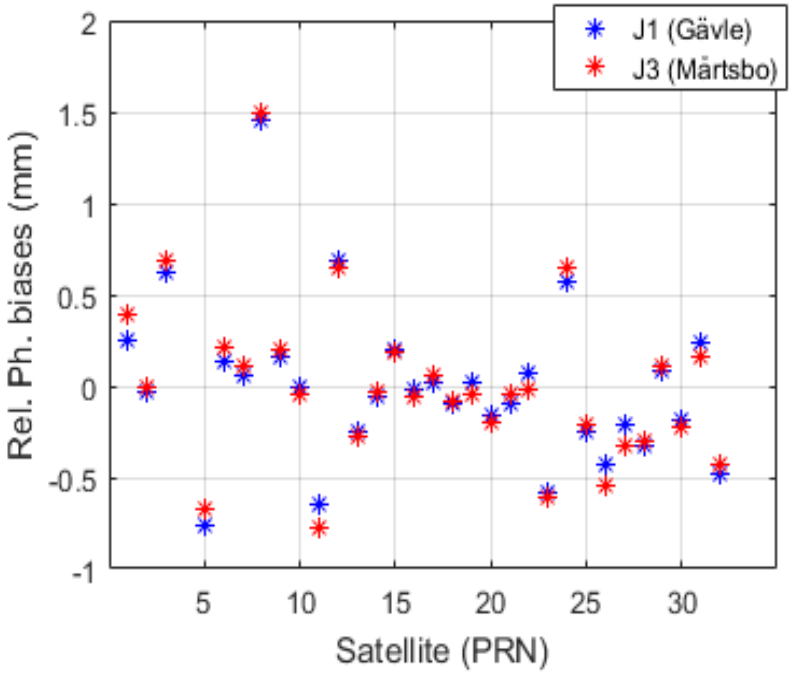
KTH VETENSKAP OCH KONST

LANTMÄTERIET

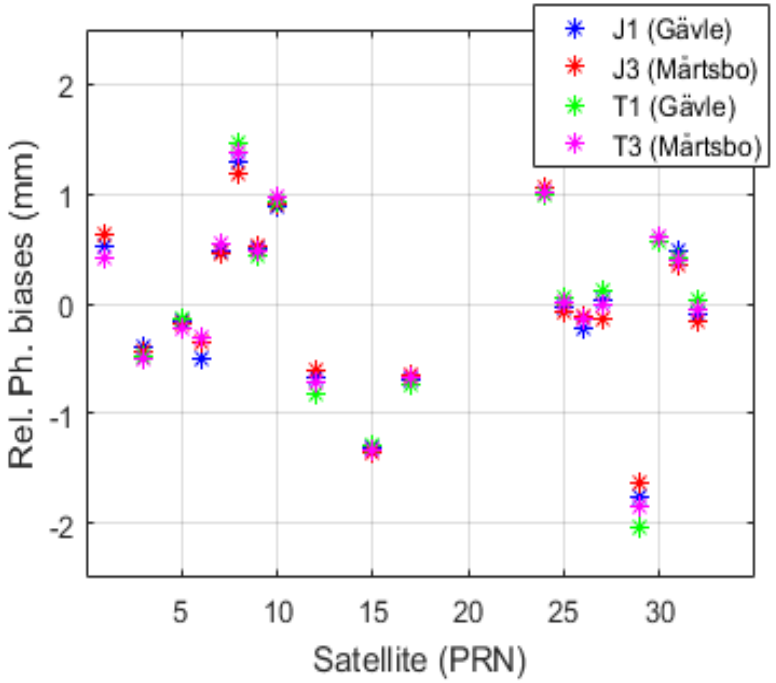
Some results

Between signals phase biases:

L1



L2



KTH VETENSKAP OCH KONST

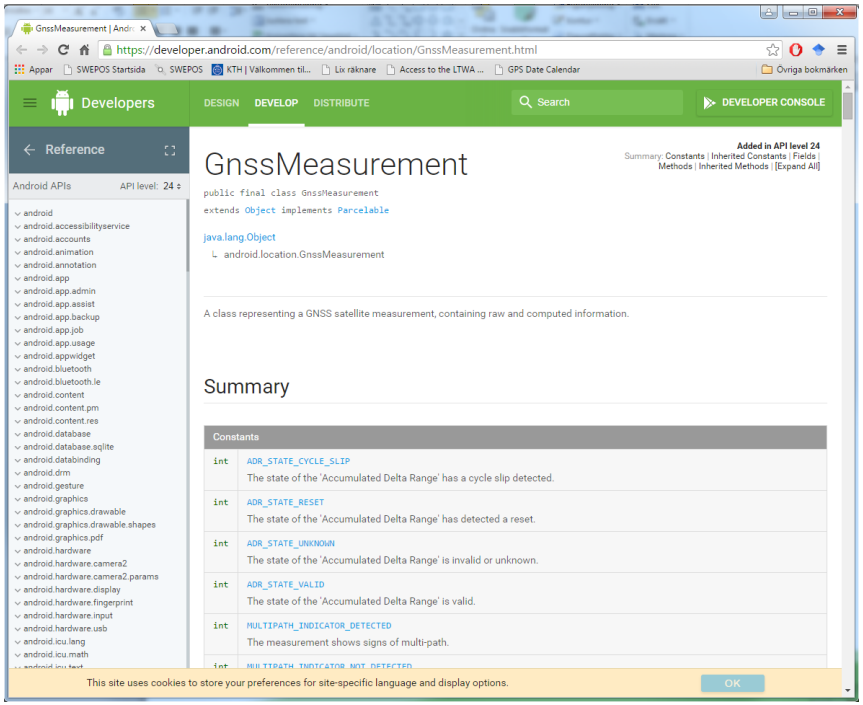
LANTMÄTERIET

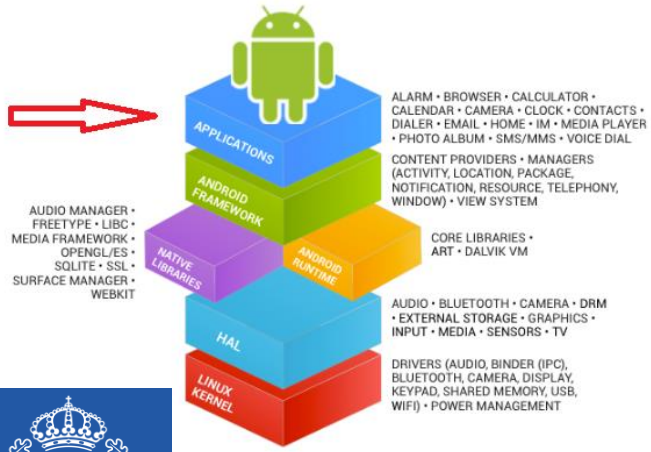
Future mass market

- GNSS chips with capabilities required for precise positioning get more affordable and easy to acquire for both professional and non-professional applications
- Precise GNSS positioning might be an essential component for autonomous driving, especially for the higher levels of autonomy.
- Support for GNSS correction data is include in the standard 3GPP for future cellular telecommunication
- The Android API now supports GNSS raw data

Precise GNSS positioning with Android devices

- Raw GNSS measurements are available in the Android API from version 7.0 of the Android OS.
- This enables new types of applications for GNSS positioning, including precise positioning

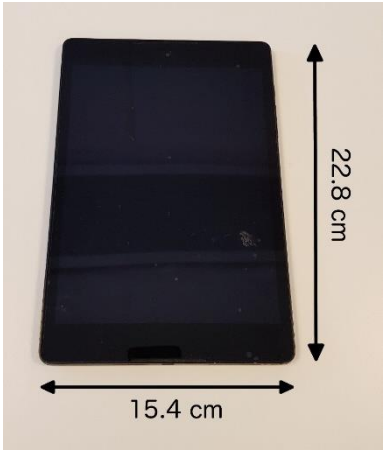




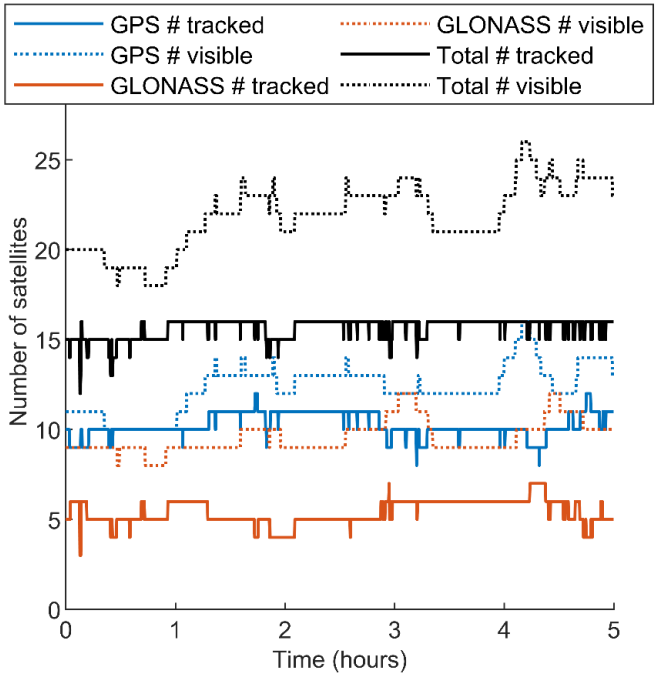
KTH VETENSKAP OCH KONST

LANTMÄTERIET

Characterization of Nexus 9 GNSS observations



- Maximum number of tracked satellites is 16
- GPS seems to be prioritized before GLONASS
- Code noise levels of several meters, both for GPS and GLONASS. (Decimeter level for high-end geodetic receivers)
- Very simple antenna sensitive to multipath

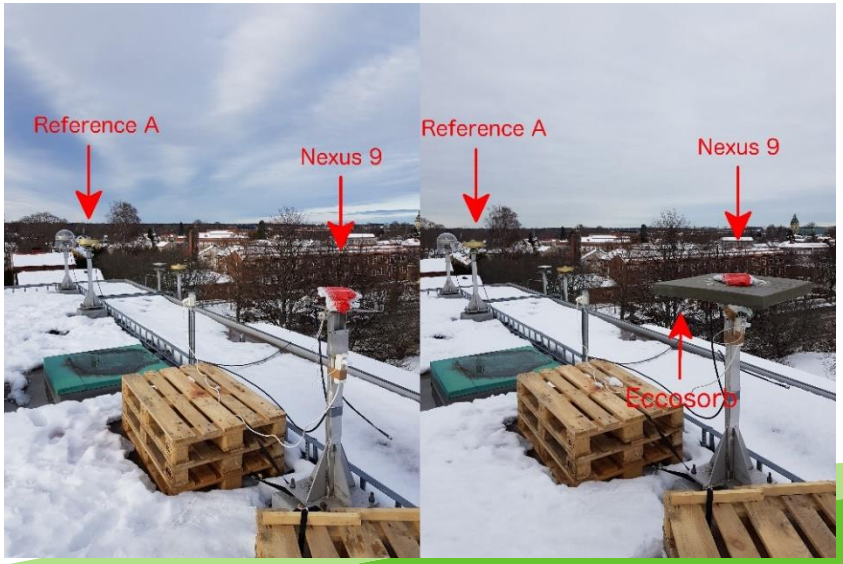


LANTMÄTERIET

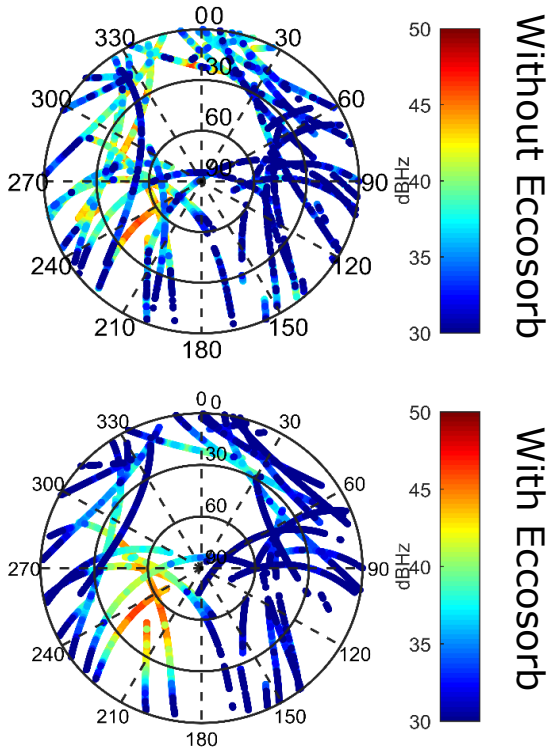
Experimental setup

- GNSS observations were collected on the roof of the Lantmäteriet headquarter building

- Two setups were employed:
  -without Eccosorb (left)
  -with Eccosorb (right)

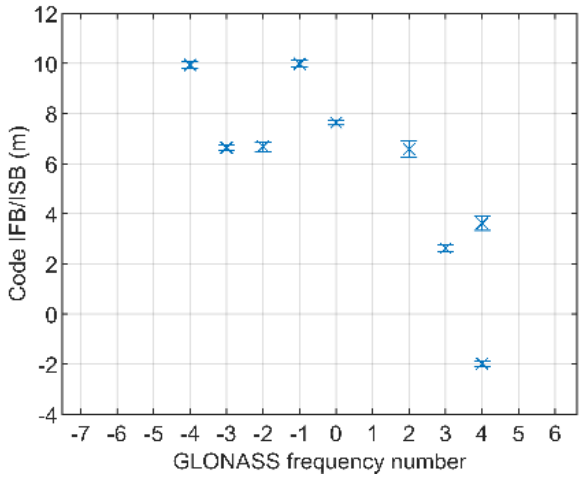


Utan Eccosorb Med Eccosorb

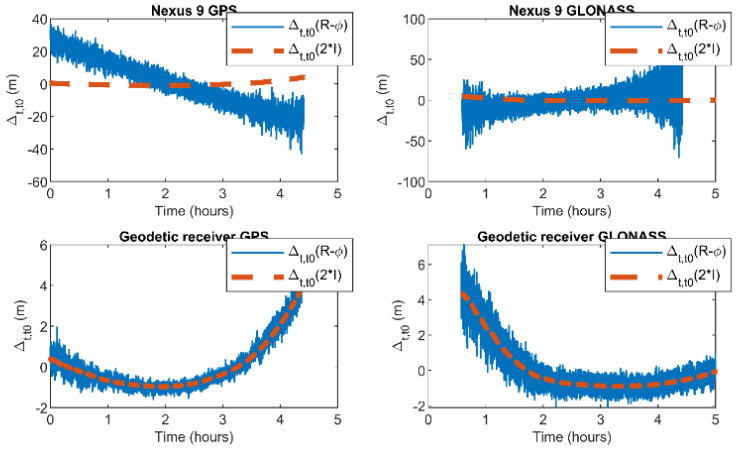


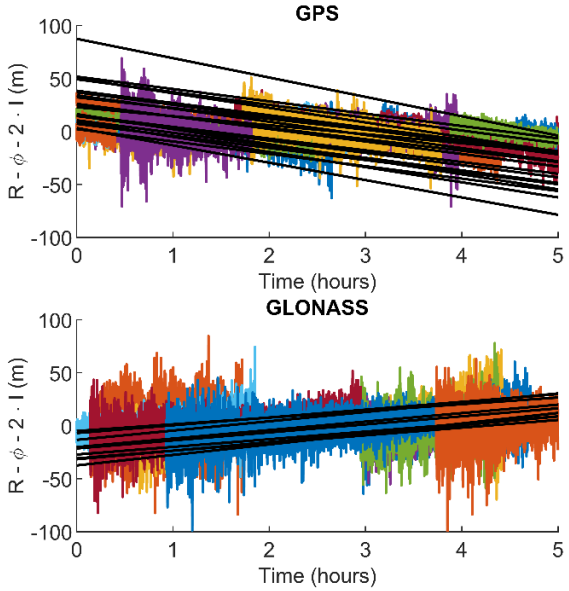
Hardware biases in the Nexus 9 observations

- Kännedom om ”inter-system biases” (ISBs) och ”inter-frequency biases” (IFB) kan ha betydelse vid kombinerad GPS-Glonass-positionering.



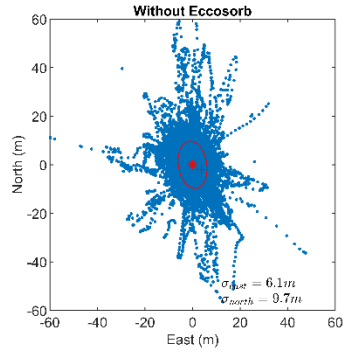
- Drift mellan kod och bärvåg upptäckt för Nexus 9.

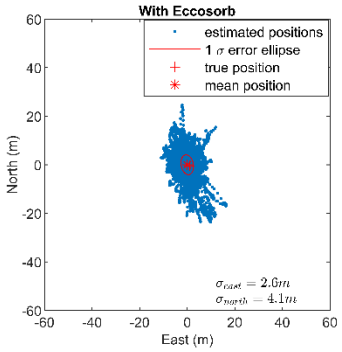


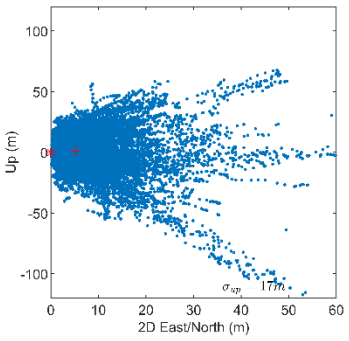


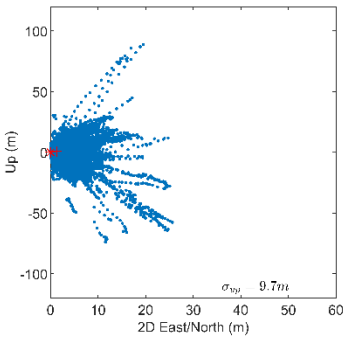
DGNSS-positioning

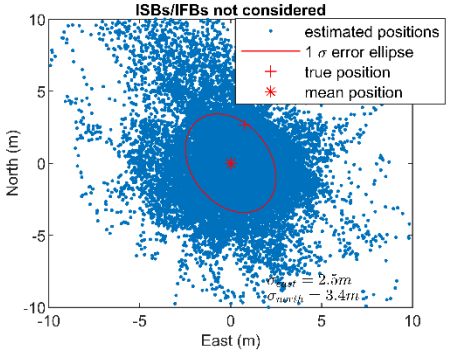
- The Eccosorb is effective but the benefit of DGNSS is still limited due to the high code noise levels
- Combined GPS-GLONASS-positioning only gives a marginal improvement of positioning accuracies

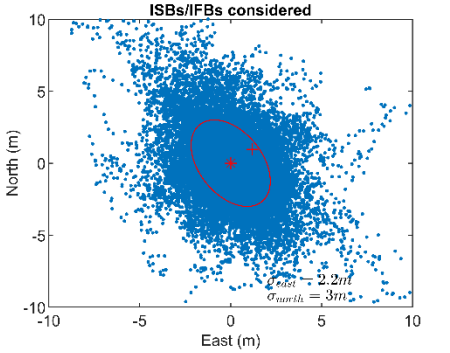










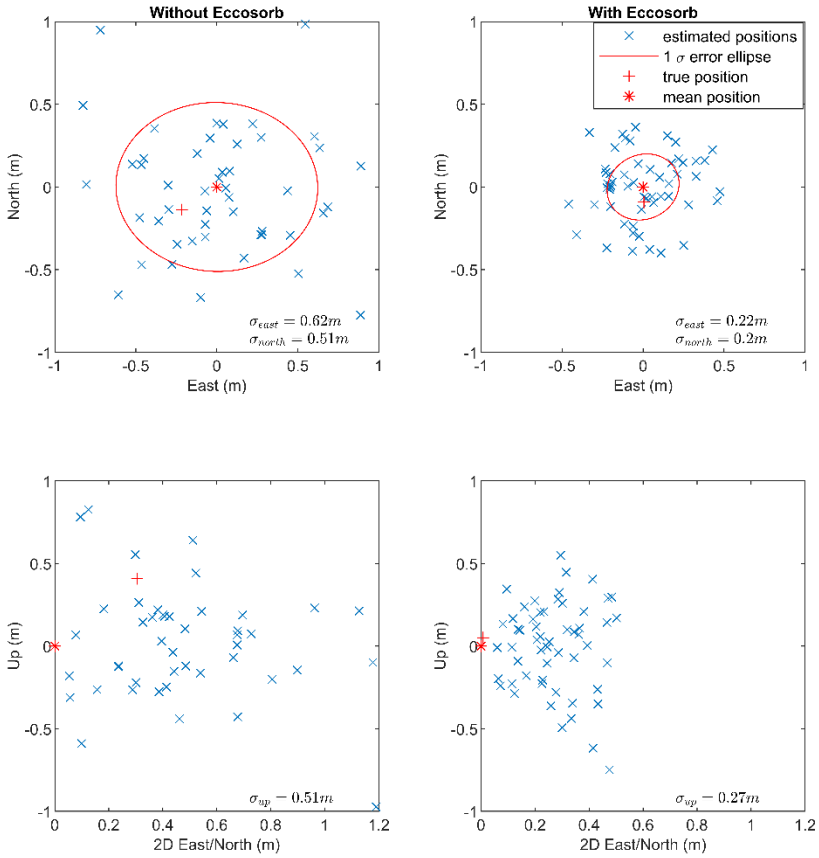


KTH VETENSKAP OCH KONST

LANTMÄTERIET

Relativ positioning from carrier phase observations

- Static 5-minute (phase only) solutions were calculated.
- Only float-solutions can be estimated from Nexus 9 measurements.
- Accuracies
  without Eccosorb: below meter-level
  with Eccosorb: decimeter-level



KTH VETENSKAP OCH KONST

LANTMÄTERIET

Thank you for your attention!

Questions?