Detection and Analysis of GNSS Multipath

KARTDAGARNA 2017

2A Analys av mätningars kvalitet

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Nordregio

For your info

- Master thesis project 2016, KTH
- Supervisor: Professor Anna Jensen
- Nordregio, established in 1997 by the Nordic Council of Ministers

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Outline

- Introduction – Background, Purpose statement
- Method – Trimble baseline analysis, RINEX analysis
- Experiment – station KTH
- Application – station Vidsel and station Botsmark
- Conclusion

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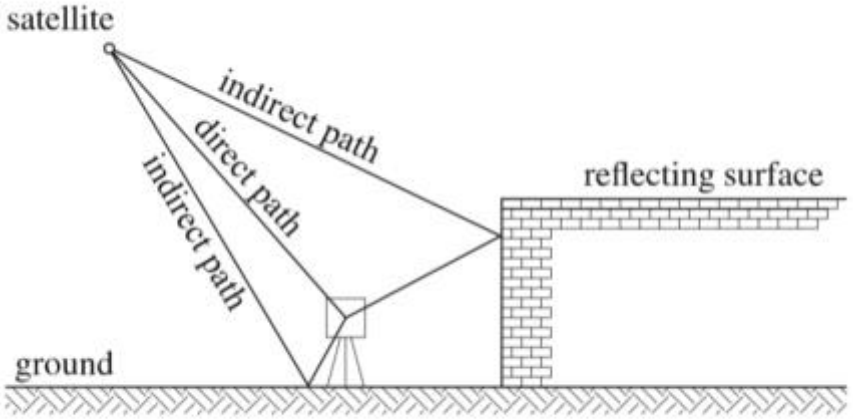
Introduction – Background

- Multipath describes the situation where the signals from the GNSS satellites travel over multiple paths before they arrive at the antenna front end.



Outdoor multipath effect (Hofmann-Wellenhof et al., 2008)

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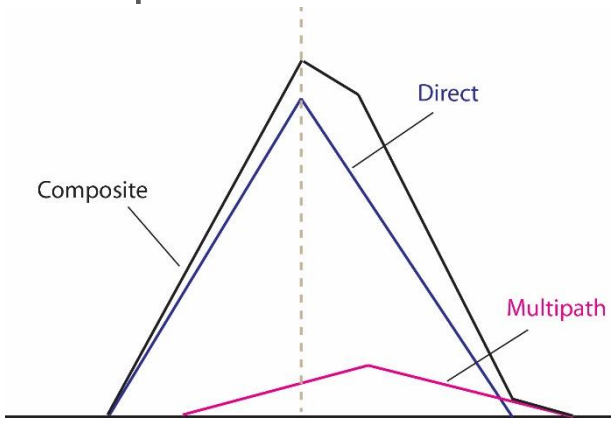
Introduction – Background

- The presence of multipath can be detected and analysed in several ways.



Effect of multipath on pseudorange code measurement(Axelrad et al., 2005)

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Introduction – Background

- Multipath's effect on pseudorange code and carrier phase measurements: 1-5m and1-5cm.
- Multipath mainly depends on: the surrounding environment of the GNSS antenna; the satellite geometry (satellites at low elevation angle more susceptible to multipath)
- Multipath's behavior: random short-term behavior; repeated after 23 hours 56 minutes and a day-to-day correlation.

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Introduction – Purpose statement

- Dominant error source for most fixed sites and stations.
- Cannot be ignored with the aim of precise positioning; an influence on other applications derived from GNSS observations.
- The thesis project aims at investigating the presence of multipath, examining the daily pattern, and differentiating its effect on pseudorange from carrier phase measurements.
- It is expected that users of GNSS signals become more aware of the presence of multipath and also its influence on the signal quality.

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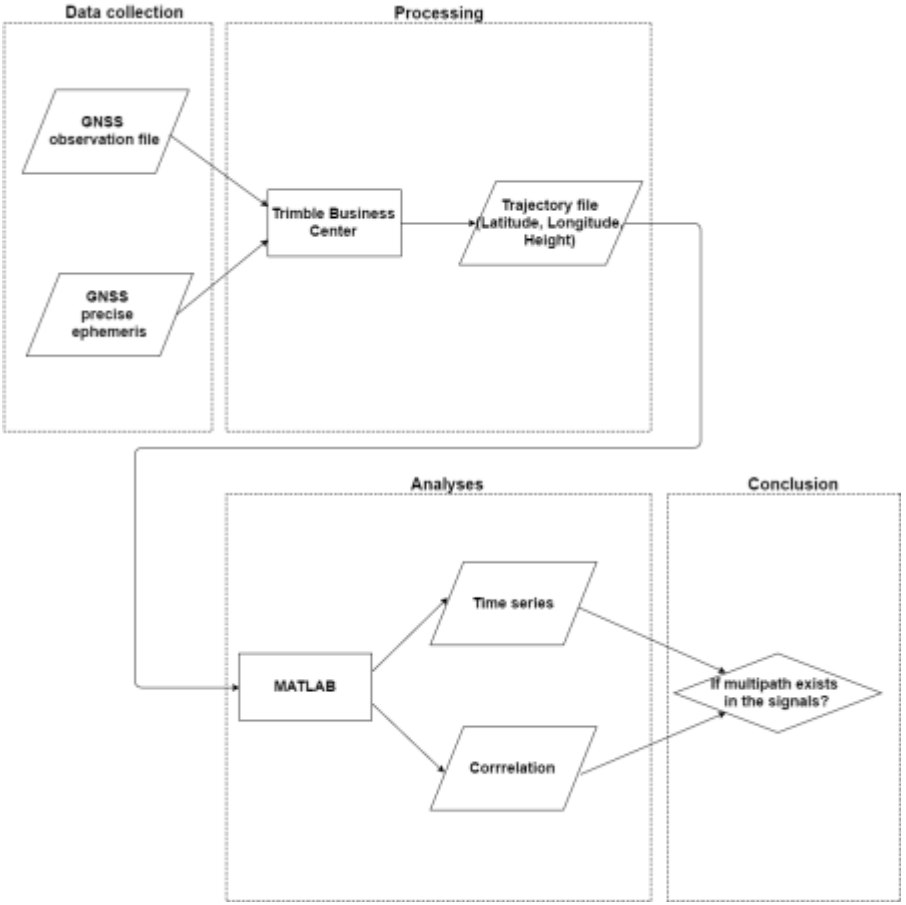
Method – Trimble baseline analysis

- Trimble Business Center (TBC) and MATLAB



Workflow for Trimble baseline analysis

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Method – Trimble baseline analysis

- **Data collection and processing**
- SWEPOS – Lantmäteriet:

  The GNSS observation file in RINEX
- International GNSS Service (IGS):

  GNSS precise ephemeris
- TBC: the baseline processing

SWEPOS stations and other stations used in positioning services

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Method – RINEX analysis

- **Theory description**
- Multipath effect for pseudorange code observations:

$$R_{P2} - R_{P1} = (\rho_{P2} - \rho_{P1}) + (d\rho_{P2} - d\rho_{P1}) + [c(\delta_{rP2} - \delta_{P2}^{S}) - c(\delta_{rP1} - \delta_{P1}^{S})] + (I_{P2} - I_{P1}) + (T_{P2} - T_{P1}) + (v_{P2} - v_{P1})$$

- Multipath effect for carrier phase observations:

$$\varphi_{L1} - \varphi_{L2} = (\rho_{L1} - \rho_{L2}) + (d\rho_{L1} - d\rho_{L1}) + [c(\delta_{rL1} - \delta_{L1}^{S}) - c(\delta_{rL2} - \delta_{L2}^{S})] + (\lambda_{L1}N_{L1} - \lambda_{L2}N_{L2}) - (I_{L1} - I_{L2}) + (T_{L1} - T_{L2}) + (v_{L1} - v_{L2})$$

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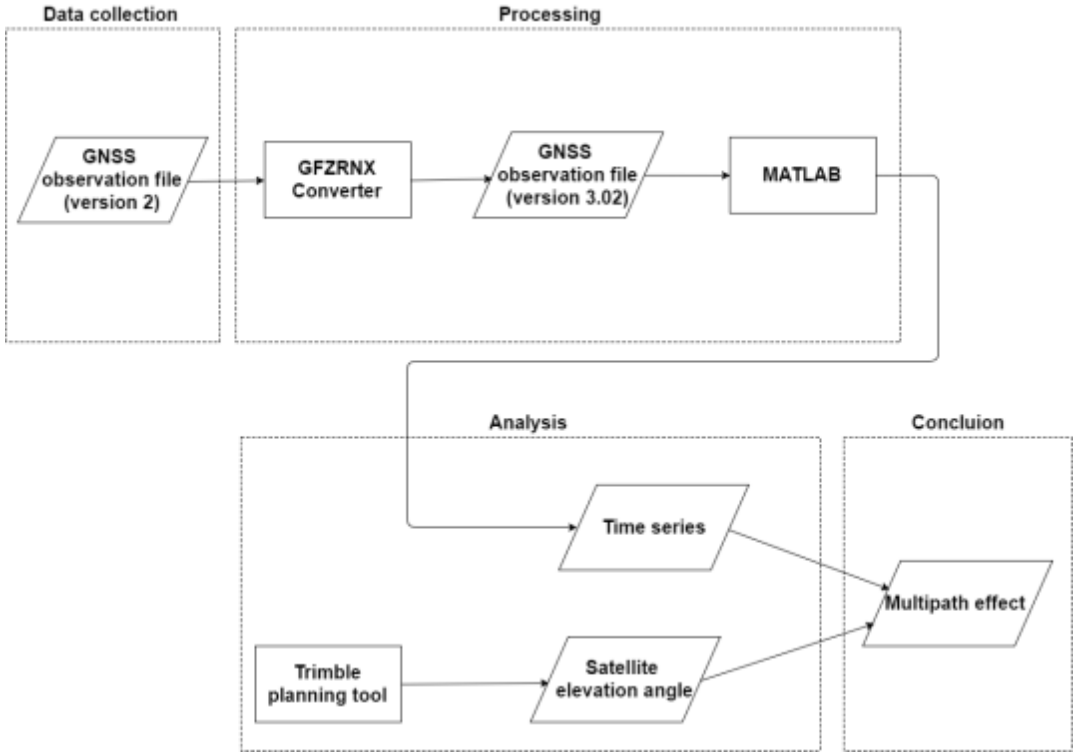
Method – RINEX analysis

- **Data collection, processing and analysis**
- MATLAB and TBC



Workflow for RINEX analysis

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Experiment – station KTH

- Surrounding and the reference station

Photo for the mounted antenna of station KTH

Location of station KTH and its reference station Mosebacke

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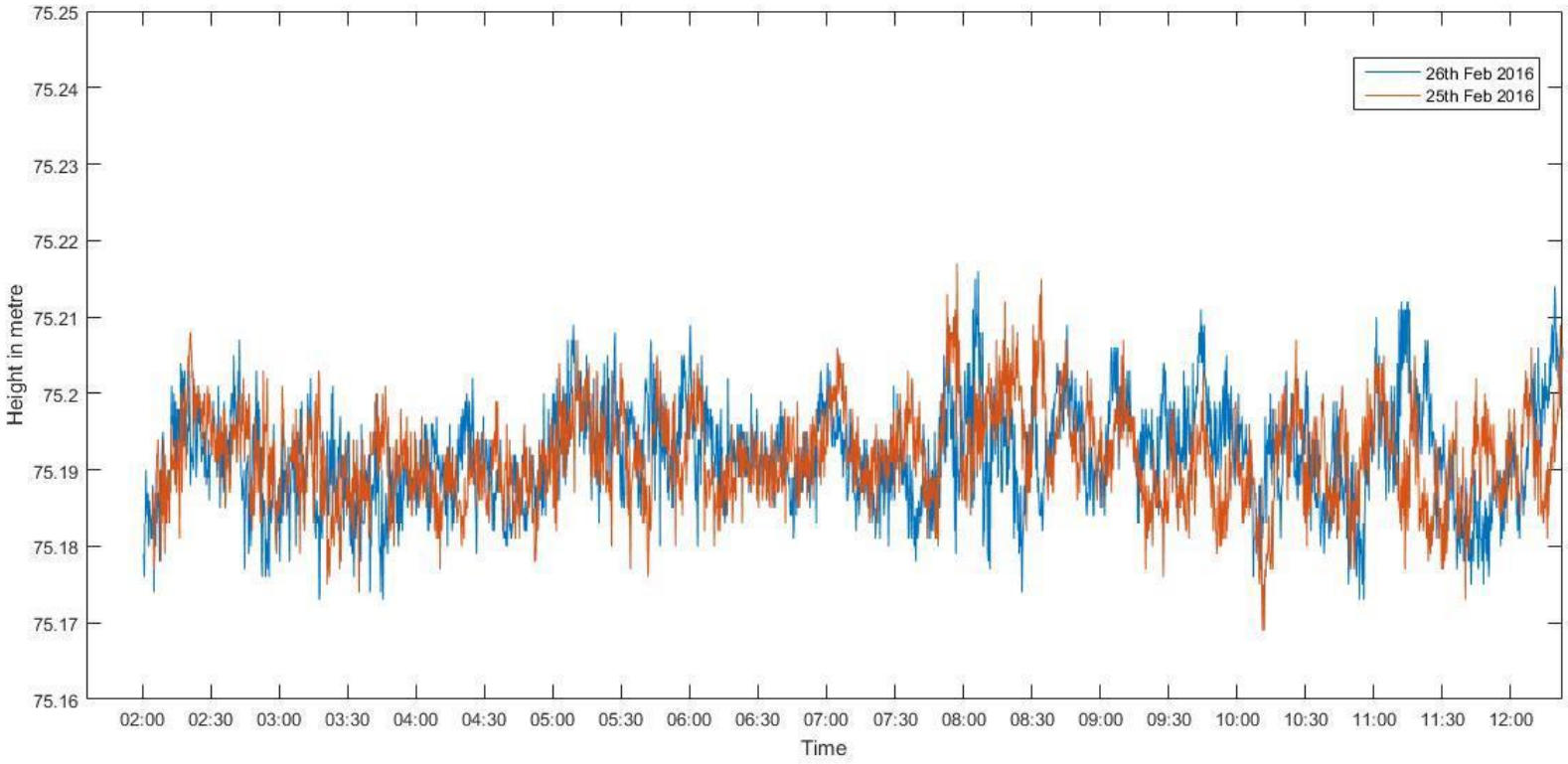
Experiment – station KTH



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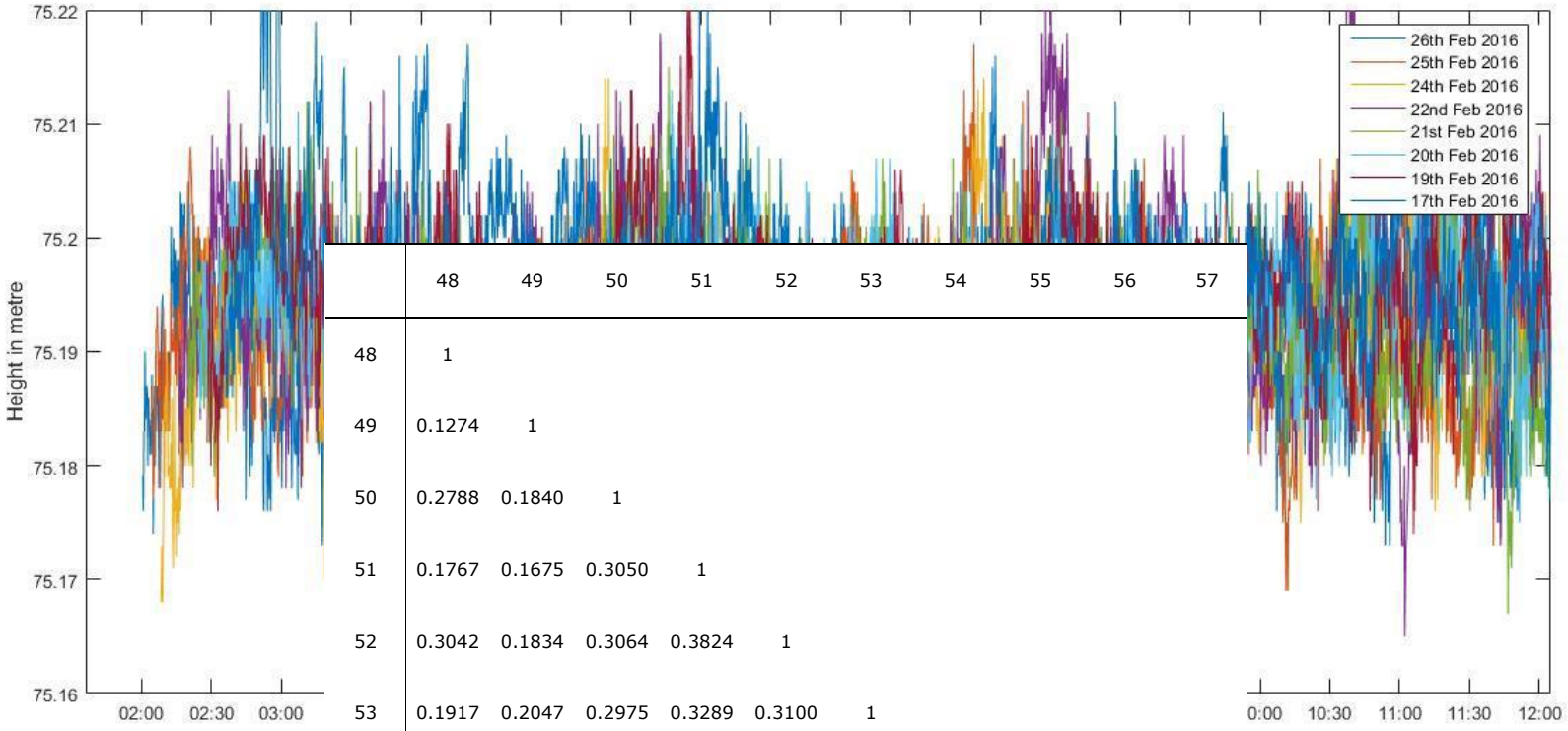
Experiment – station KTH



	48	49	50	51	52	53	54	55	56	57
48	1									
49	0.1274	1								
50	0.2788	0.1840	1							
51	0.1767	0.1675	0.3050	1						
52	0.3042	0.1834	0.3064	0.3824	1					
53	0.1917	0.2047	0.2975	0.3289	0.3100	1				
54	0.1285	0.0779	0.2138	0.2274	0.0861	0.1738	1			
55	0.1245	0.1652	0.2453	0.2982	0.2903	0.3224	0.0646	1		
56	0.1253	0.1162	0.2321	0.2798	0.3223	0.3527	0.1362	0.3824	1	
57	0.2013	0.1780	0.2879	0.2521	0.3271	0.2659	0.0583	0.3530	0.3491	1

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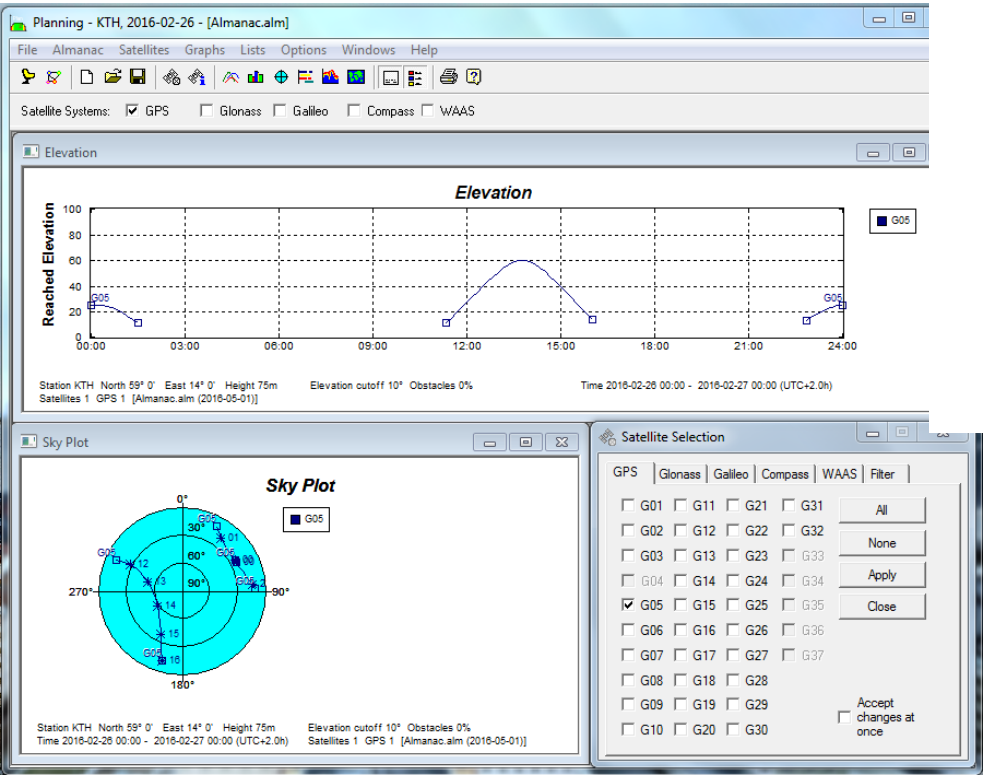
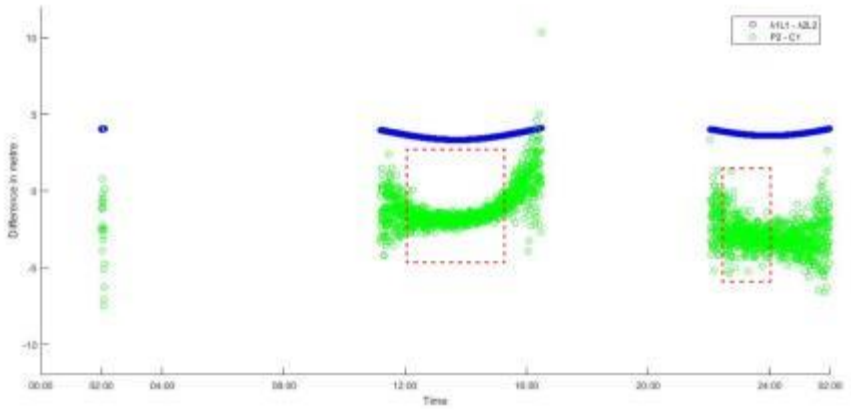
Experiment – station KTH

- Result for RINEX analysis
- Satellite G05 for 26th Feb 2016



Elevation angle and azimuth



Multipath effect on pseudorange and carrier phase observations

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Application – station Vidsel

- Surrounding and the reference station

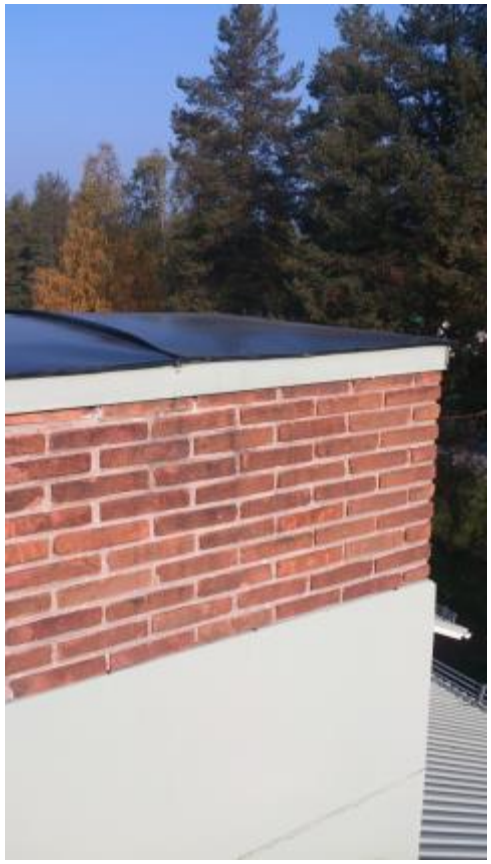
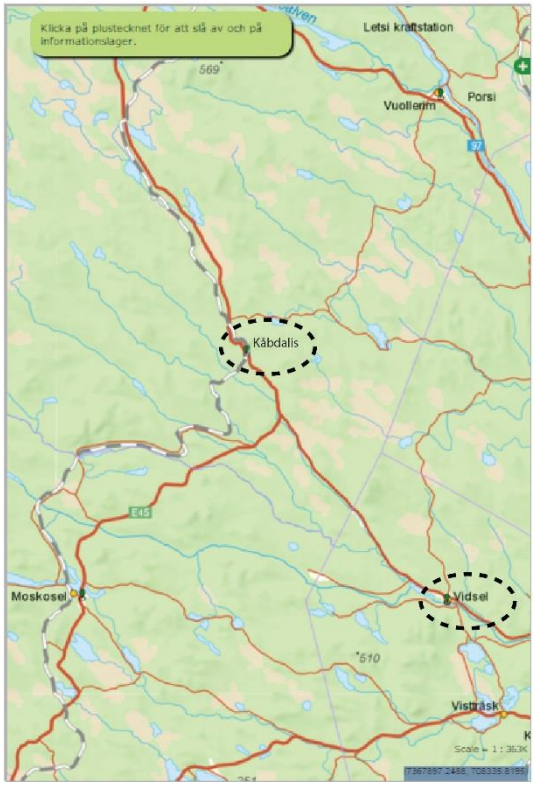


Photo for the surrounding environment of station Vidsel, and the antenna is mounted on the side of the chimney



Location of station Vidsel and its reference station Kåbdalis

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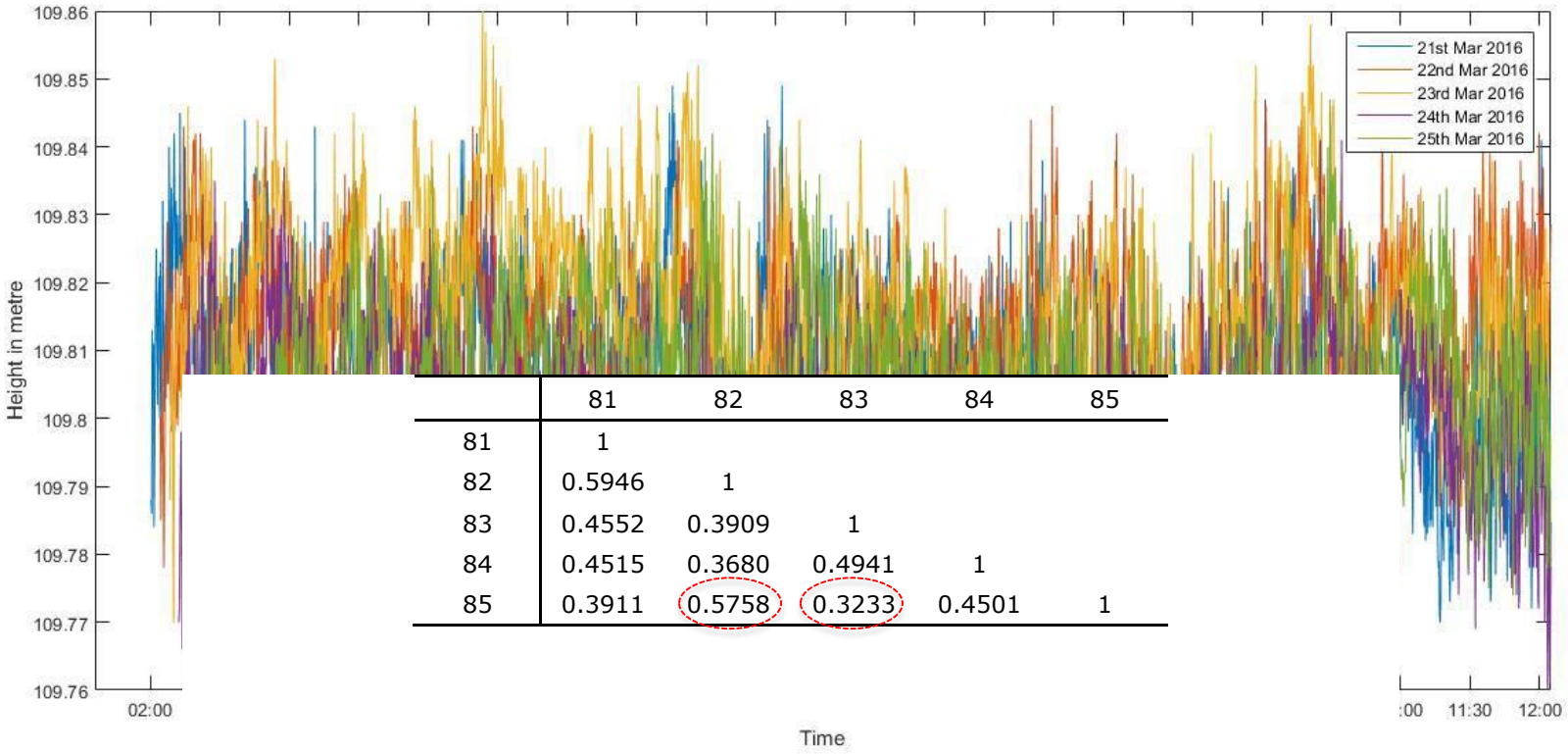
Application – station Vidsel



	81	82	83	84	85
81	1				
82	0.5946	1			
83	0.4552	0.3909	1		
84	0.4515	0.3680	0.4941	1	
85	0.3911	0.5758	0.3233	0.4501	1

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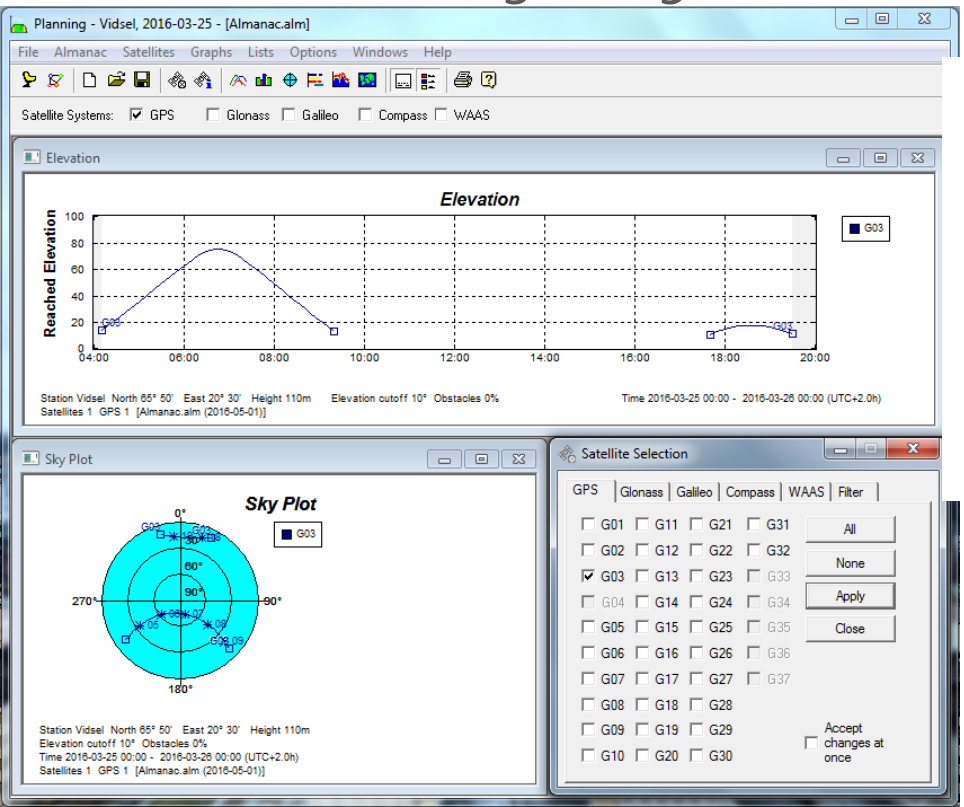
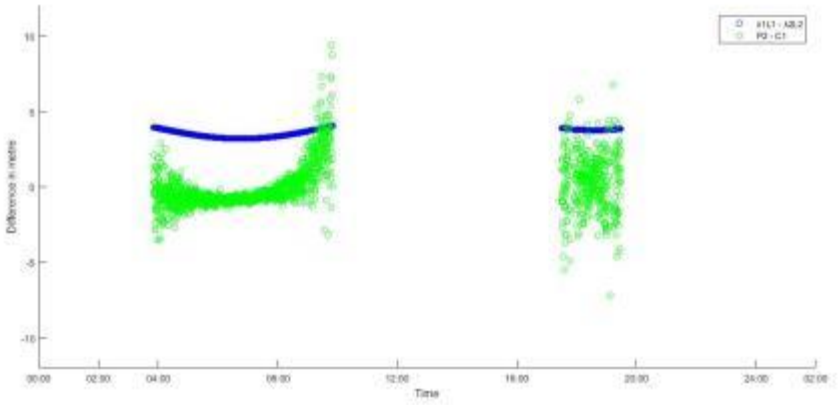
Application – station Vidsel

- Result for RINEX analysis
- Satellite G03 for 25th Mar 2016



Elevation angle and azimuth



Multipath effect on pseudorange and carrier phase observations

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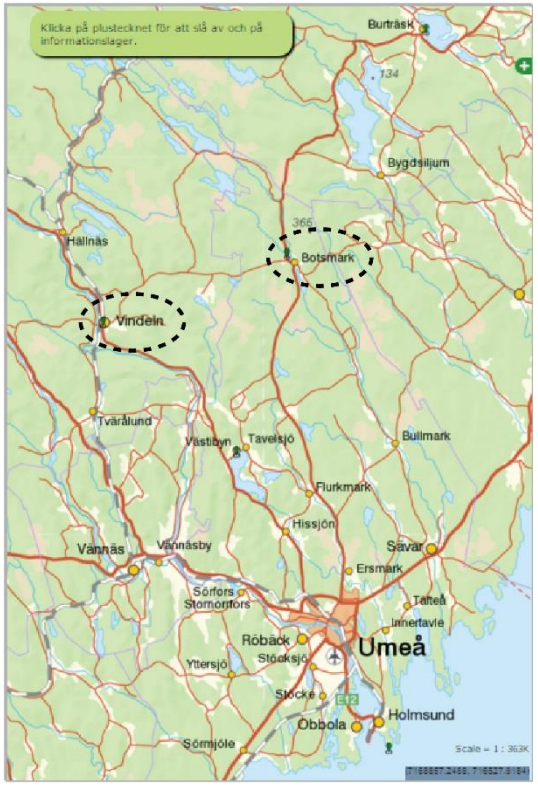
Application – station Botsmark

- Surrounding and the reference station

Photo for the mounted antenna of station Botsmark



Location of station Botsmark and its reference station Vindeln

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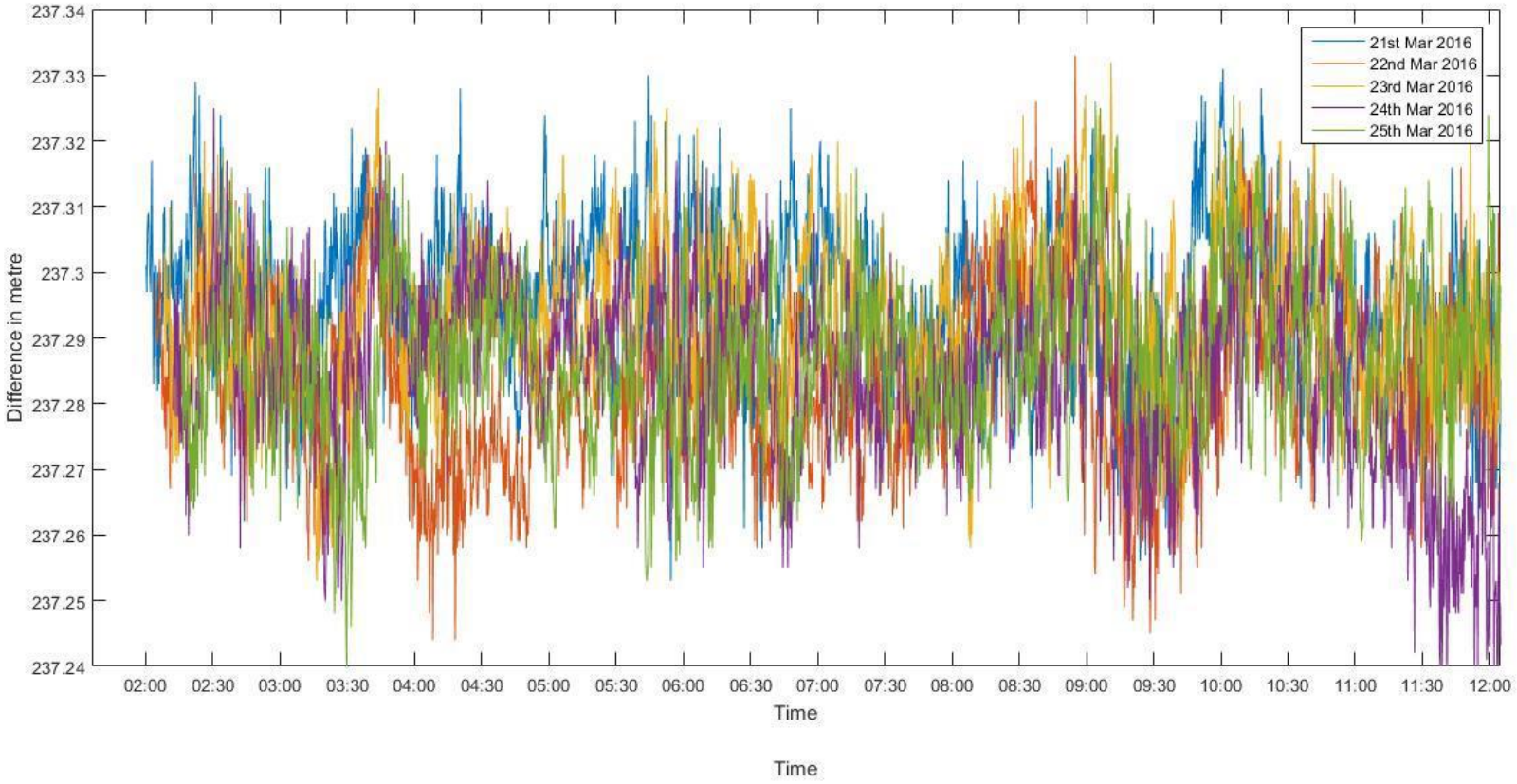
Application – station Botsmark



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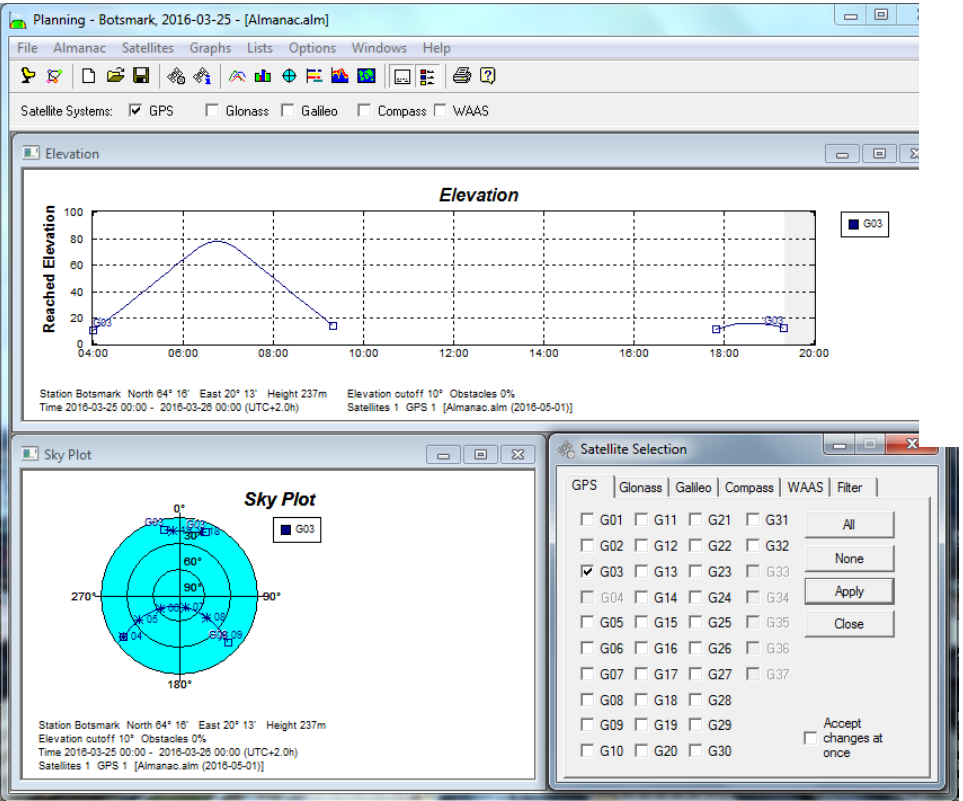
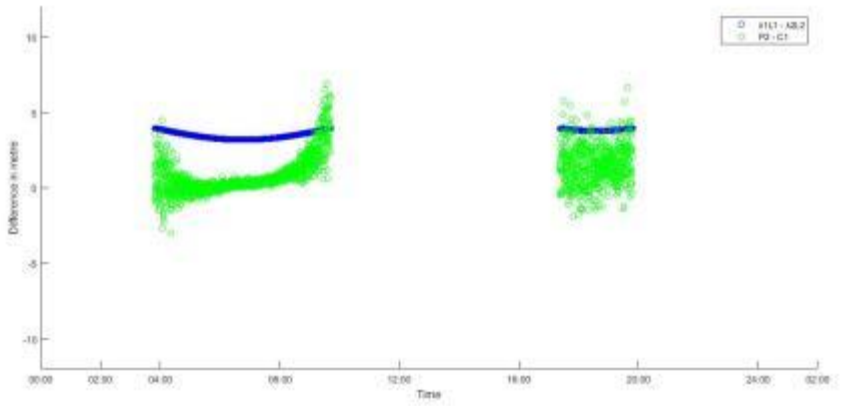
Application – station Botsmark

- Result for RINEX analysis
- Satellite G03 for 25th Mar 2016



Elevation angle and azimuth



Multipath effect on pseudorange and carrier phase observations

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Conclusion

- The presence of multipath in the GPS satellite signals has been investigated thoroughly;
- Both the overall daily pattern and the detailed selection of certain time period of multipath effect have been examined;
- The effect of multipath on pseudorange code and carrier phase measurements has been differentiated and analysed independently.

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Thank you!

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