STU SvF SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA FACULTY OF CIVIL ENGINEERING

Multipath Detection with Three-frequency SNR Combination Example from Urban Environment

EUREF Symposium in Wroclav, May 17 – 19, 2017

P. Špánik, J. Hefty, Ľ. Gerhátová, J. Papčo

Slovak University of Technology, Faculty of Civil Engineering, Department of Theoretical Geodesy, Slovakia

email: peter.spanik@stuba.sk

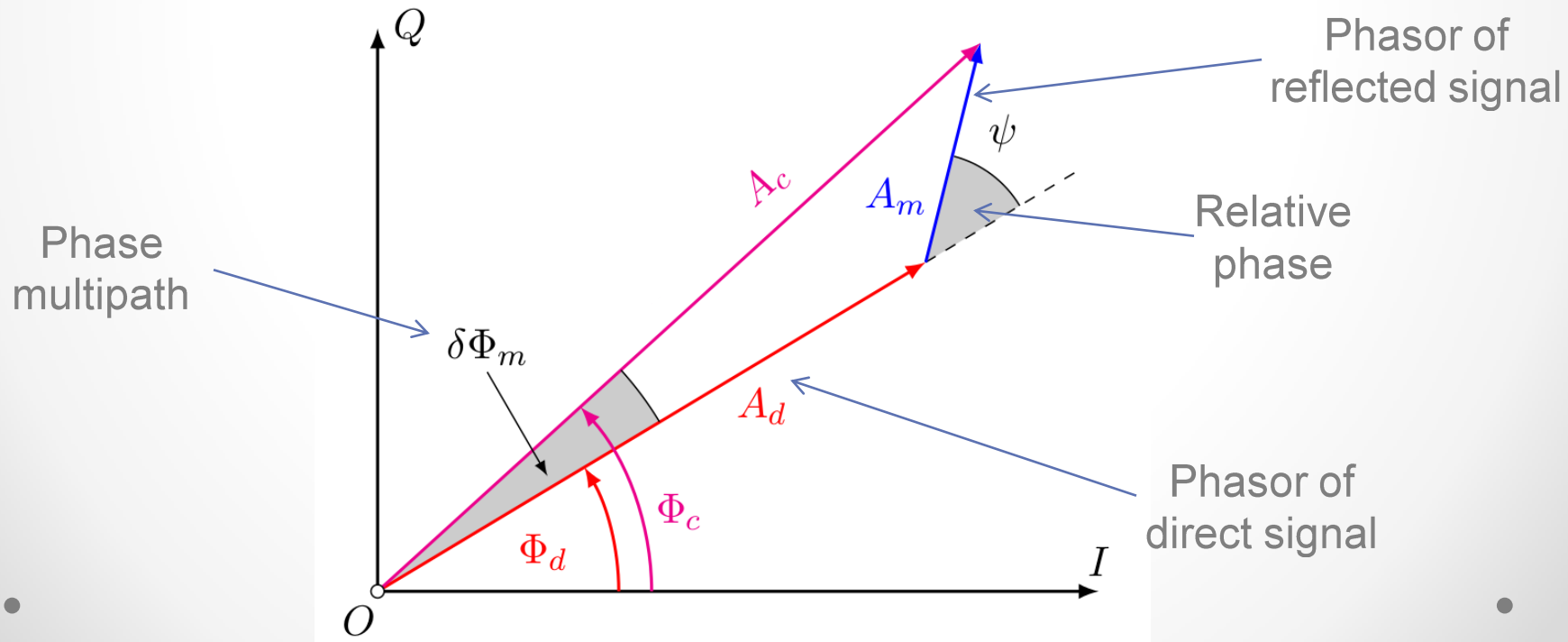
Presentation overview

- Introduction of multipath detection method using three-frequency Signal-to-Noise measurements (Strode and Groves, 2016)
- Description of calibration measurement, definition of detection criterion for measurement rejection
- Multipath detection in urban environment
- Conclusion, future work plans

Three-frequency SNR multipath detection

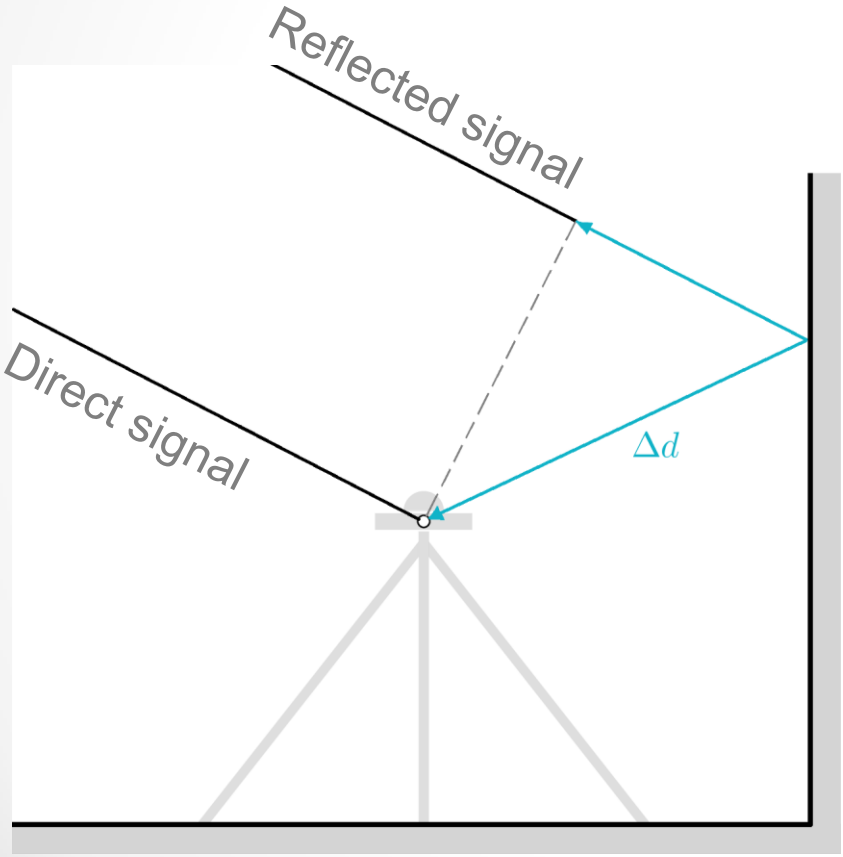
- Method proposed by Strode and Groves in 2016
- Utilize close relation of SNR values with phase observation and thus also with phase multipath

$$SNR \approx A_d^2 + A_m^2 + 2A_d A_m \cos\psi$$



One path delay = different relative phases

- Reflected signal is always delayed



Path delay for single reflection is constant while relative phases on different carriers change:

$$\psi_1 = \frac{\Delta d}{\lambda_1} \sim SNR_1$$

$$\psi_2 = \frac{\Delta d}{\lambda_2} \sim SNR_2$$

$$\psi_5 = \frac{\Delta d}{\lambda_5} \sim SNR_5$$

Multipath detection statistics S_a^s

1. As proposed in original article of Strode and Groves

$$S_a^s = \sqrt{(SNR_1 - SNR_2 - \Delta C_{12}(\theta_a^s))^2 + (SNR_1 - SNR_5 - \Delta C_{15}(\theta_a^s))^2}$$

Measured SNR on L1 and L2 carrier

Estimated value of SNR difference between SNR on L1 and L2 (L5) carriers (subject of calibration measurement)

SNR on L5

$$S_a^s = |SNR_1 - SNR_2 - \Delta C_{12}(\theta_a^s)|$$

2. Simplified formula for only two frequencies (older GPS satellites, GLONASS satellites)

Calibration measurement

- Have to be performed in low multipath environment, (environment without significant reflectors)
- Estimation of regression parameters for SNR differences at two carriers which will serve as reference

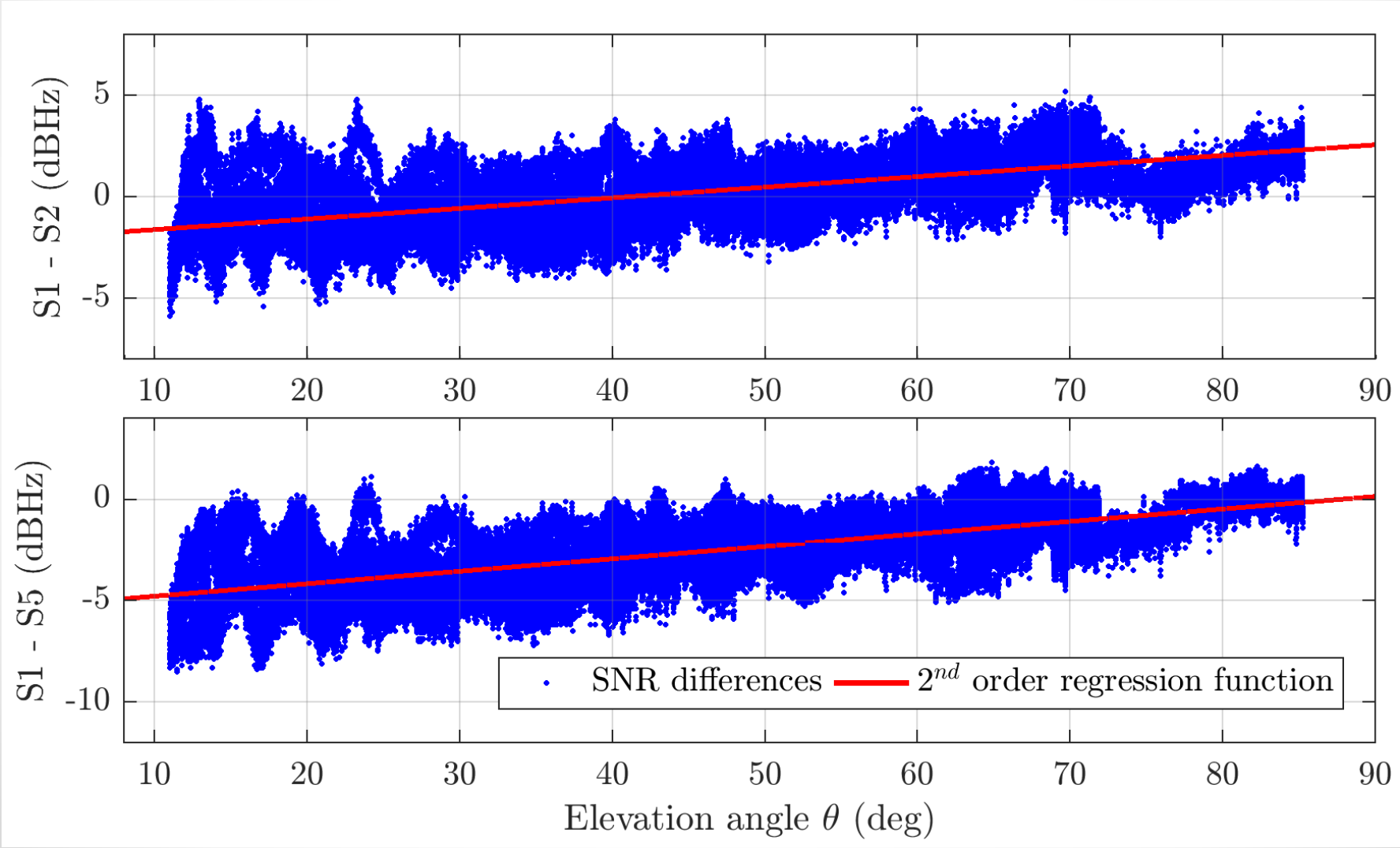
Trimble R8 Model 3 multi-GNSS receiver supporting three-frequency GPS and Galileo signal acquisition.

Sampling interval: 1s

Duration: 8 hours

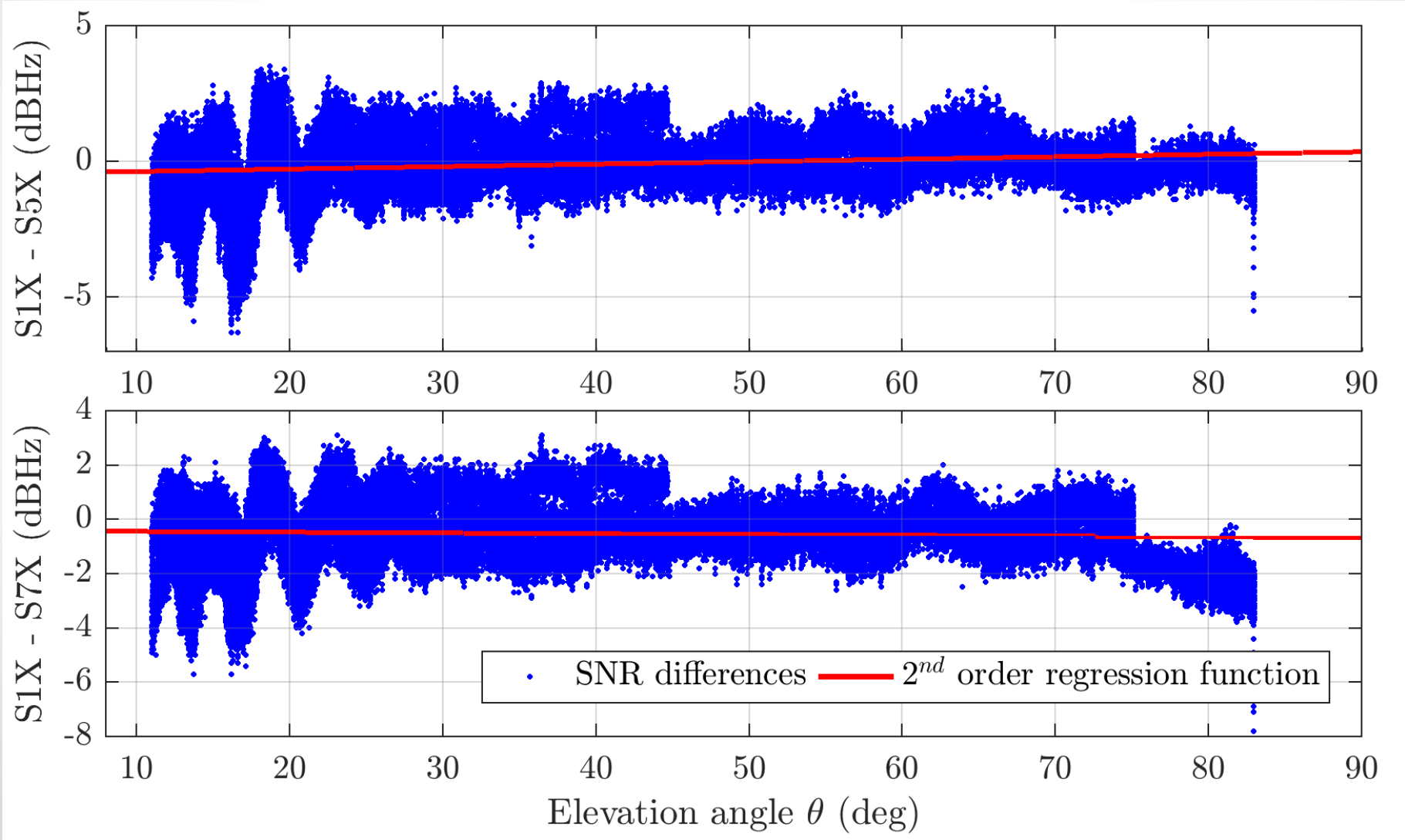
Calibration measurement results

GPS Block II-F (in time of observation 8 satellites visible)

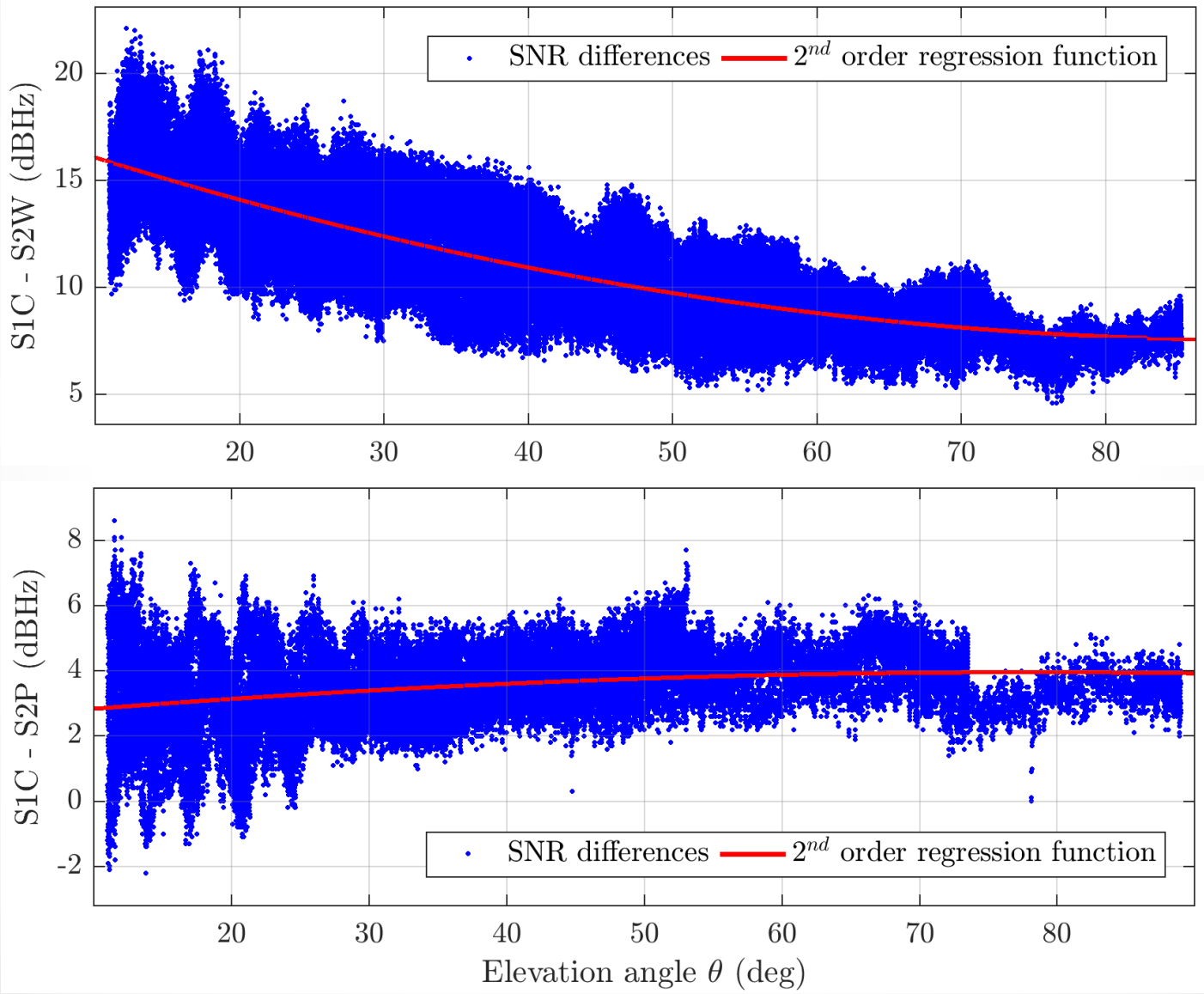


Calibration measurement results

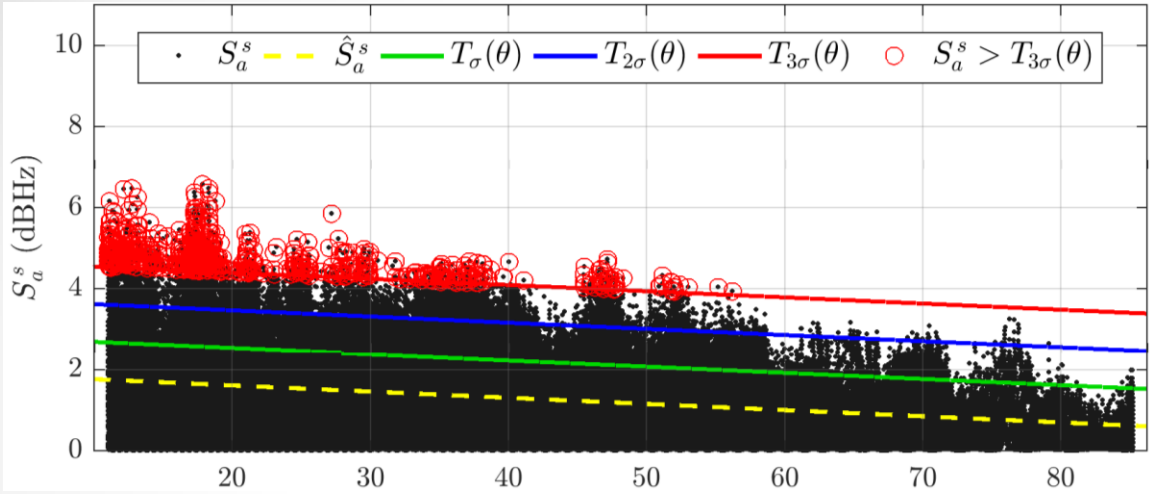
Galileo satellites (in time of observation 8 satellites available)



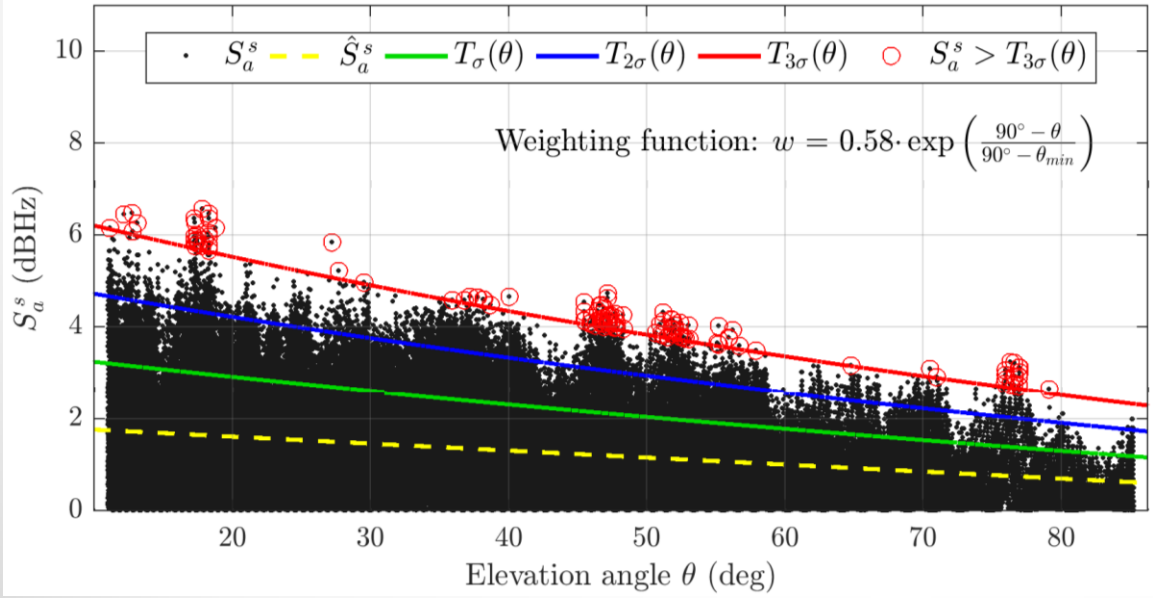
Calibration measurement results (two frequencies)



Calibration measurement – detection statistics



Criterion based on 3-sigma rule is proposed by authors of the method. Many observation under 40 degrees would be consider as multipath.



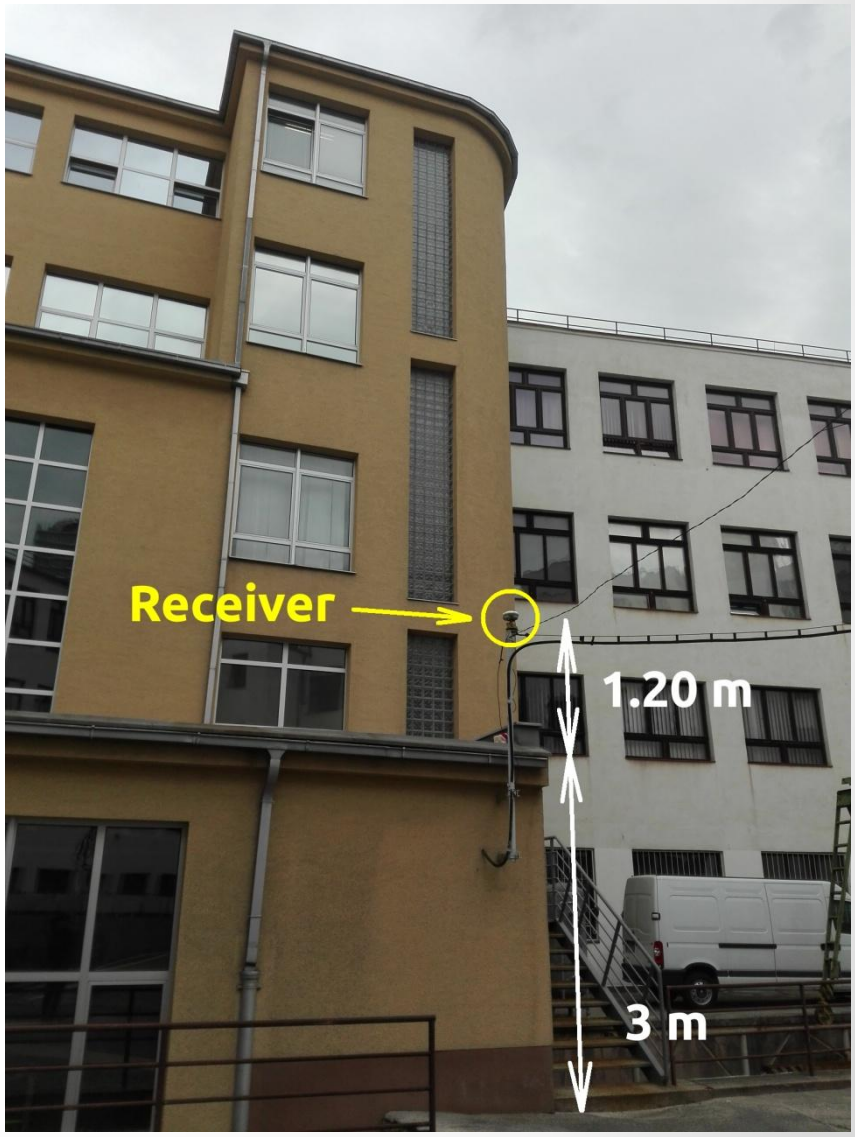
We proposed criterion based on weighted 3-sigma, where weight depends exponentially on the value of satellite elevation angle. Parameter of weighting function is chosen empirically. Only 0.1% of observation is greater than 3-weigth-sigma.

Multipath detection in urban environment

Selected area at SUT principal residence. Closest wall was 5 m from receiver. Height about ground was about 4.2 m. Surrounding buildings should cause severe multipath.

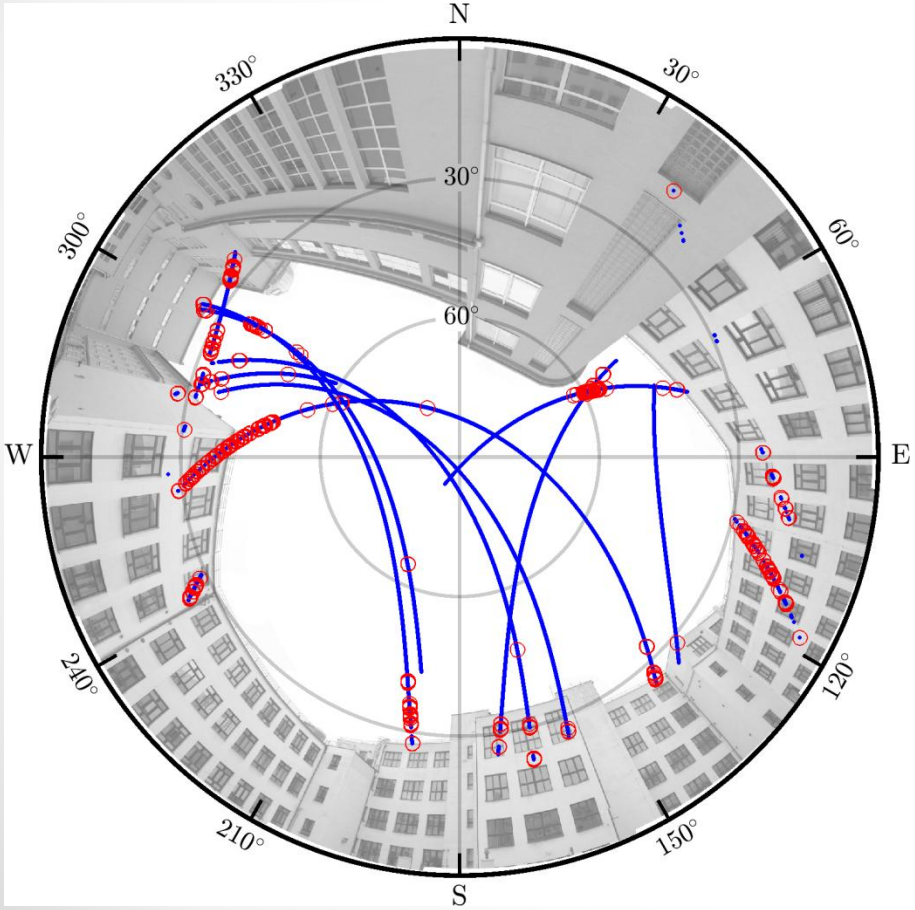
Sampling interval: 1s

Duration: 16 hours

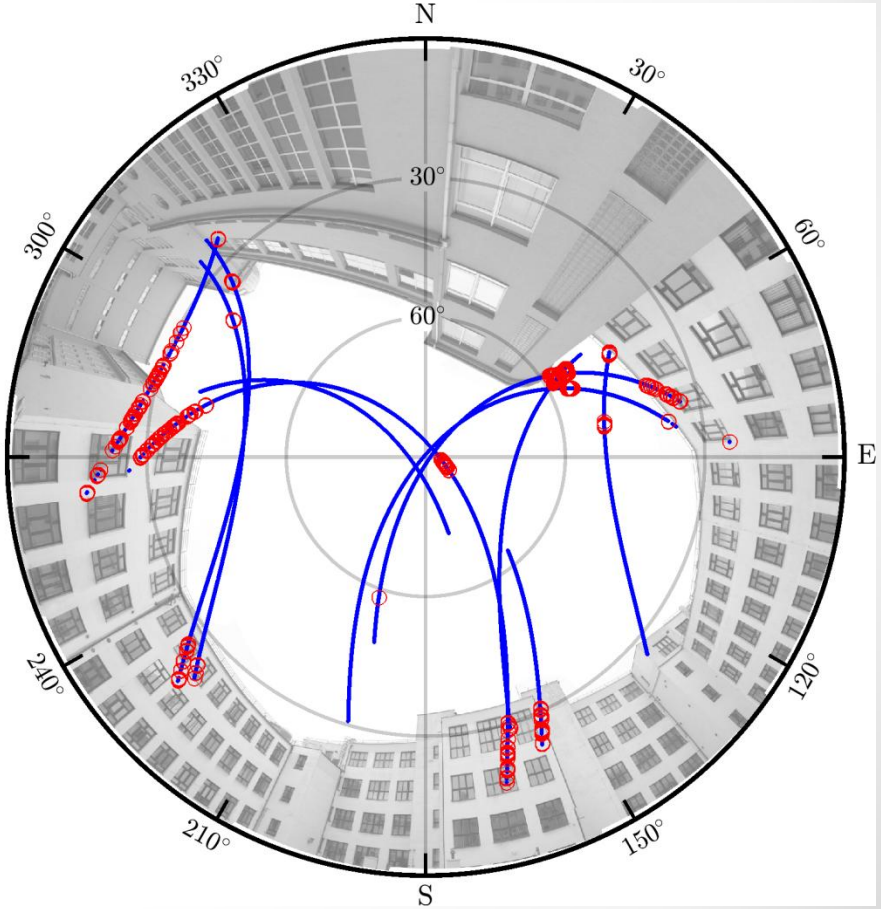


Detected multipath – first results (three freq.)

GPS

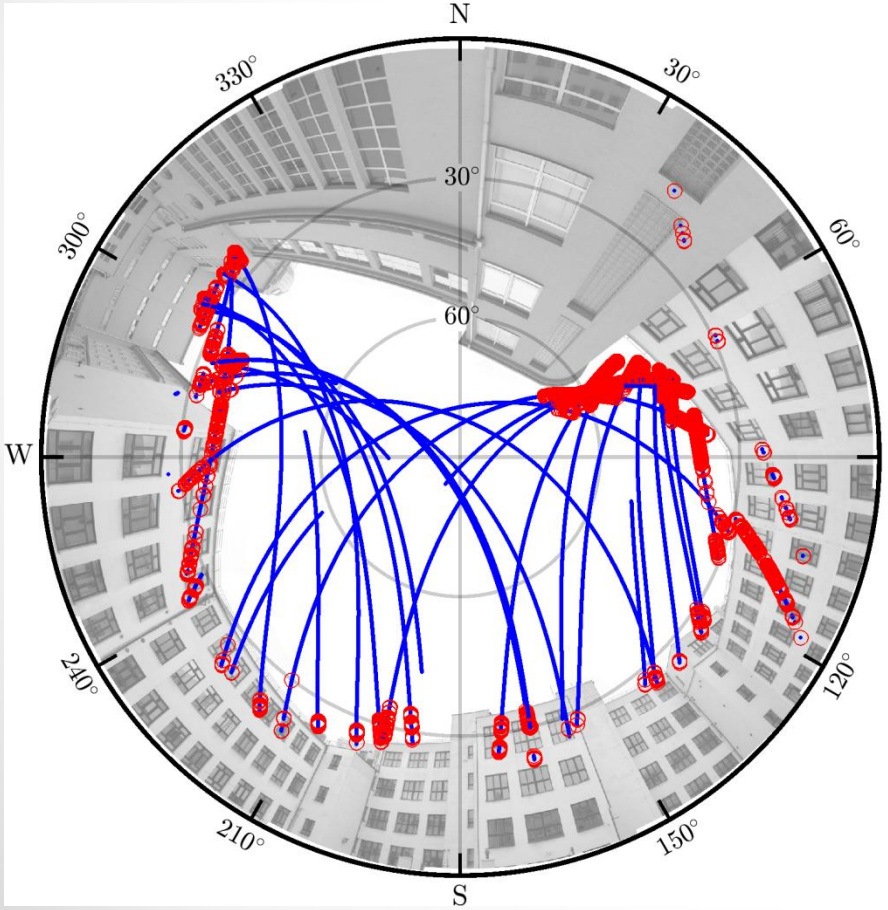


GALILEO

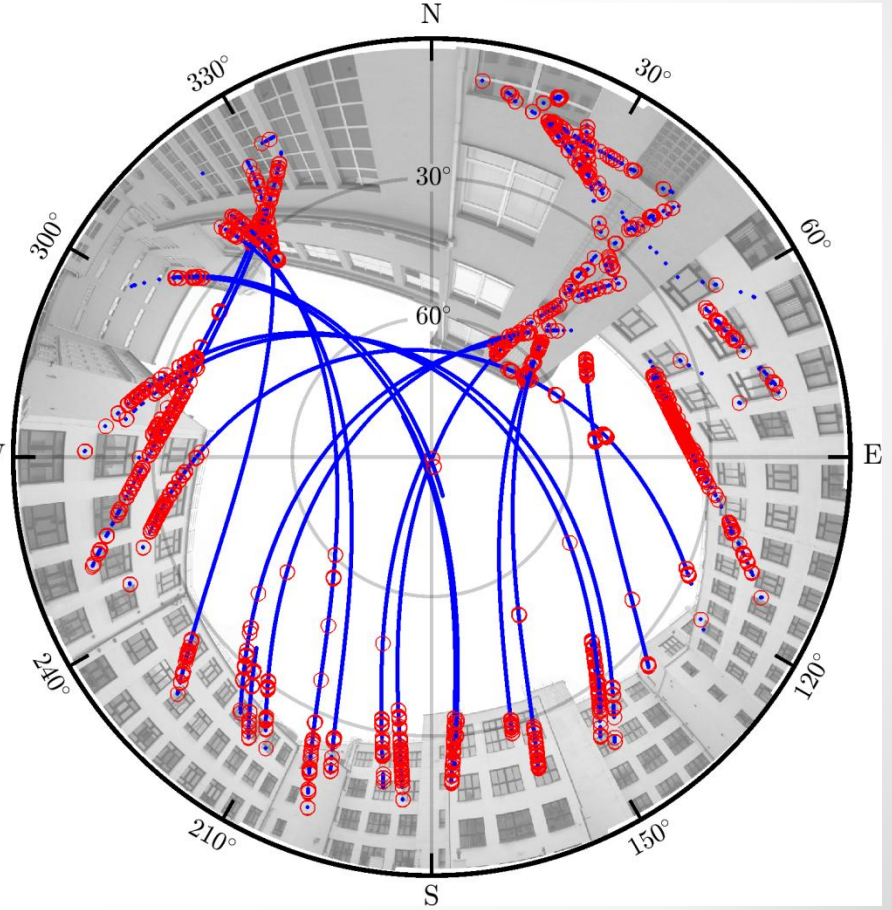


Detected multipath – first results (two freq.)

GPS



GLONASS



Future plans

- Compute position using original measurements and edited RINEX file with infected satellites excluded. Use simplified method for multipath detection on GLONASS satellites.
- Make calibration in different conditions, more similar to condition in urban areas (concrete or asphalt surface will be considered).
- During calibration put antenna approximately at the same height as it is during ordinary RTK surveys – 2 m (to get the same oscillation pattern of SNR values during calibration and real measurements).

Acknowledgement

This work was supported by the grant of Slovak University of Technology in Bratislava as part of programme to encourage young researchers.

References

Strode, P. R. R – Groves, P. D.: GNSS multipath detection using three-frequency signal-to-noise measurements, GPS Solutions 2016, Vol. 20, Issue 3, pp. 399 – 412.