On multipath characterization through software receivers and ray-tracing

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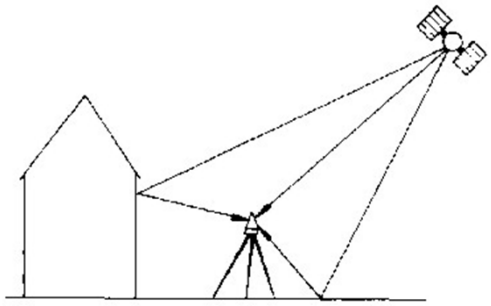
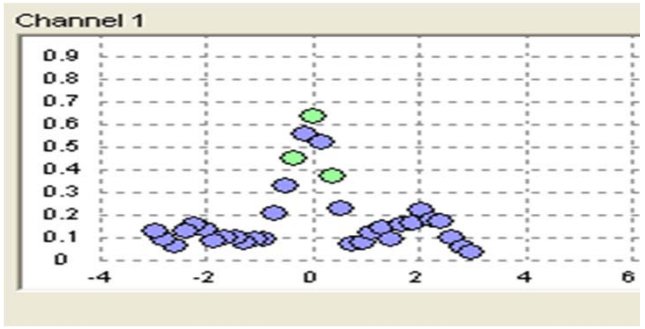
Motivation

- Multipath rays distort the correlation function during tracking
- Correlation output is fed into the code and carrier tracking loops
- Correlation output is used for C/N_0 calculation

Impact on C/N_0 observables is investigated and compared with the results from a ray-tracing approach





Carrier phase error
Code phase error
C/N_0 amplitude variations

Factors having an impact on C/N_0

C/N_0 and Multipath

- Prompt correlator is used for the estimation of the C/N_0
- Multipath rays distort the correlation output (composite signal)
- Multipath rays affect the C/N_0 values and create amplitude variations

Ray-tracing can describe the characteristics of reflected rays

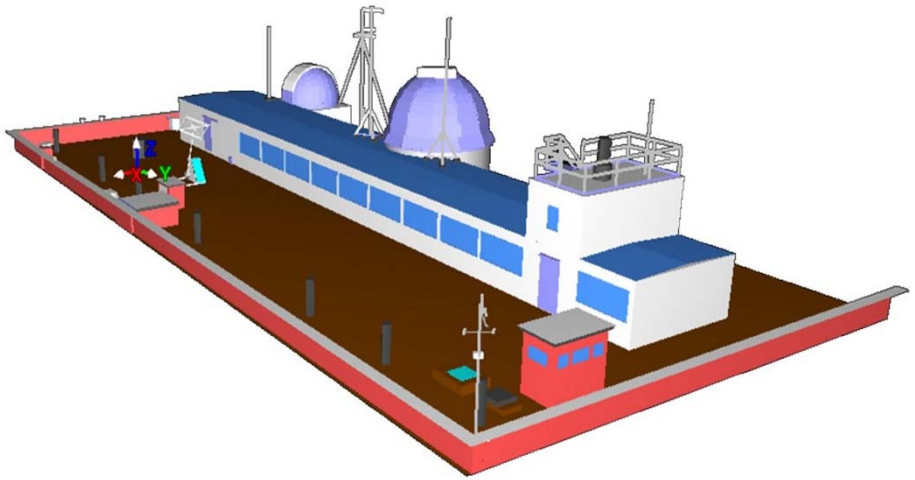
Other factors influencing C/N_0

- Antenna characteristics
- Coherent integration time
- Loop filter bandwidth
- C/N_0 estimation method

With software receivers the above factors can be investigated

Scenario

The more accurate the description of the physical environment of the receiver, the more accurate the channel estimation



GIH building rooftop (source: GIH)

Scenario:

- Measured by a terrestrial laser scanner (Z+F Imager 5006)
- Scenario formed by 783 rectangles, 35 box shapes and 99 cylinders
- Coordinates of all planes are known with mm accuracy
- Material properties of all planes are known

+

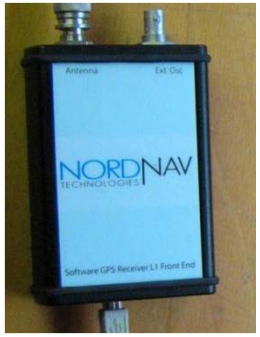
Weather information

Experiment

Date	Data	Antenna
03.03.2011	Raw observations + IF	Leica AX1202GG
04.03.2011	Raw observations + IF	Leica AX1202GG
07.03.2011	Raw observations + IF	Leica AX1202GG
08.03.2011	Raw observations + IF	Leica AR25
09.03.2011	Raw observations + IF	Leica AR25
10.03.2011	Raw observations + IF	Leica AR25

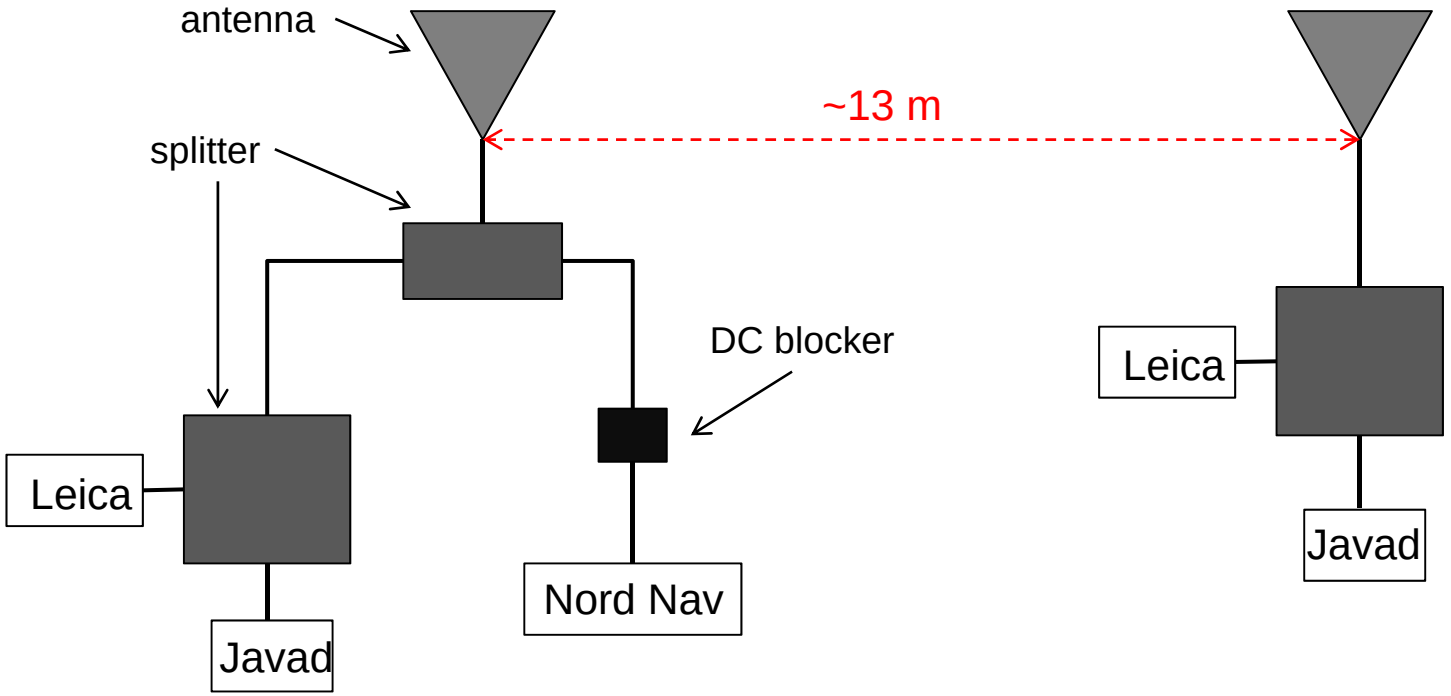
Javad G3T Delta

Leica GRX1200 +GNSS



Nord Nav R30

Experiment setup



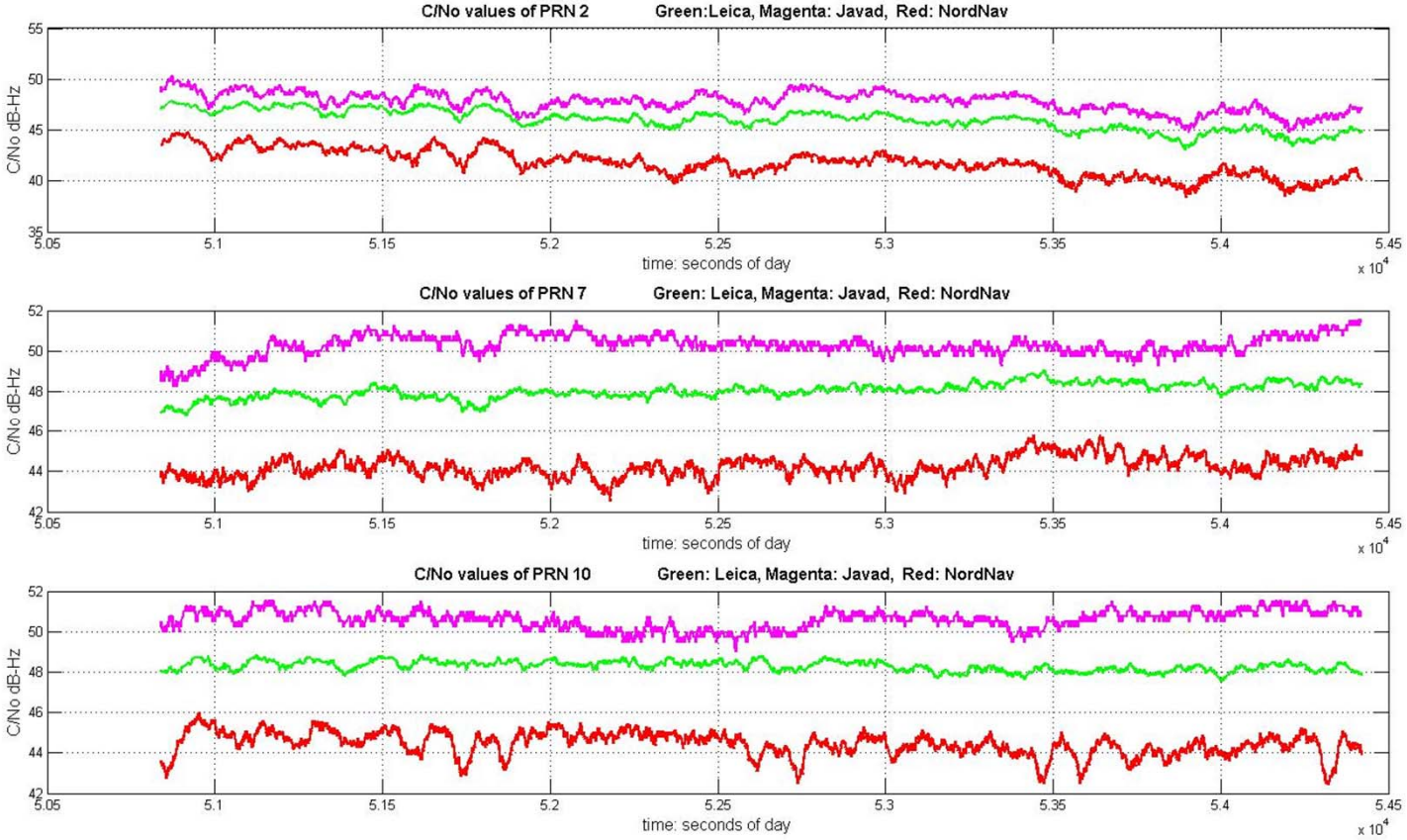
RINEX data processing:

- Matlab based modules developed at Institut für Erdmessung

IF data processing:

- Nord Nav firmware
- Matlab based software receiver modules for C/N_0 estimation developed at Institut für Erdmessung

C/N_0 output of the receivers



Javad G3T Delta

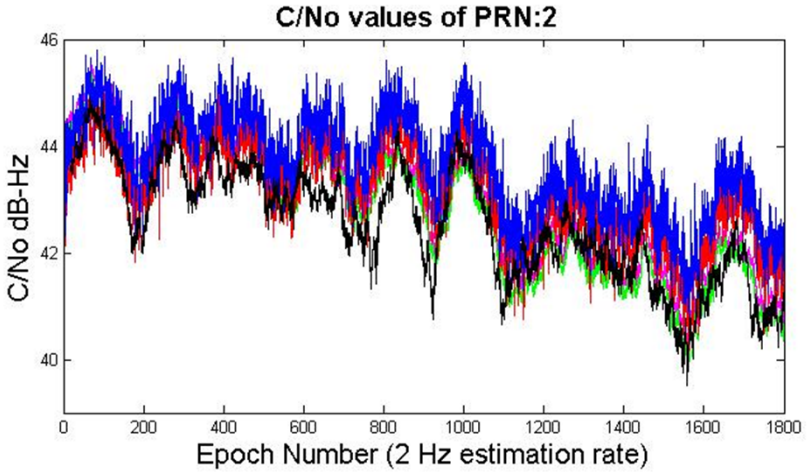
Leica GRX1200 +GNSS

Nord Nav R30

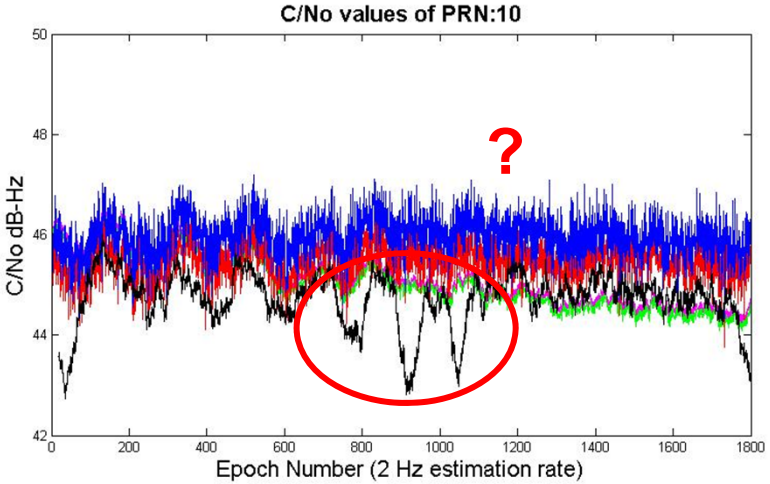
Data captured on 07.03.2011 at 14:06:00
Duration 1 hour

Mean elevation: PRN2 35° PRN7 63° PRN10 75°

C/N_0 estimators vs Nord Nav C/No values



Elevation angle between 40° and 35°



Elevation angle between 70° and 75°

Nord Nav R30

vs

Power Ratio estimator

vs

Variance Summing estimator

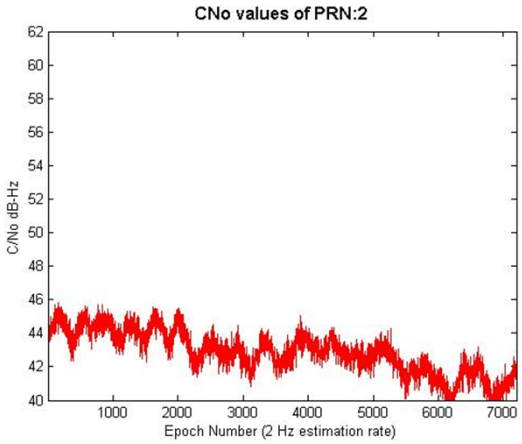
vs

Squaring estimator

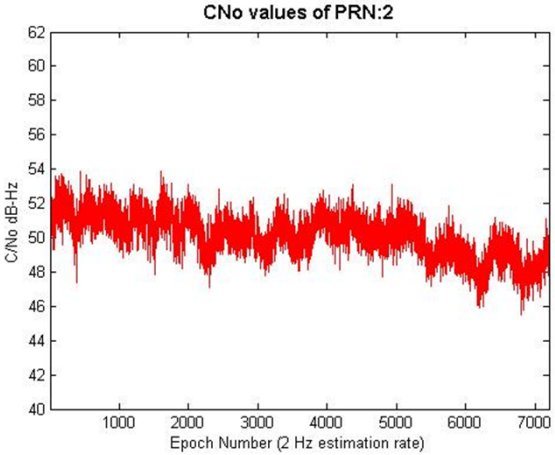
vs

Differential estimator

Different integration times and averaging periods



T=1msec, rate=0,5 sec



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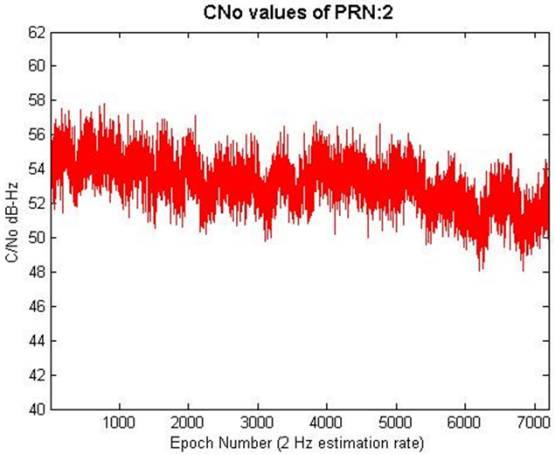
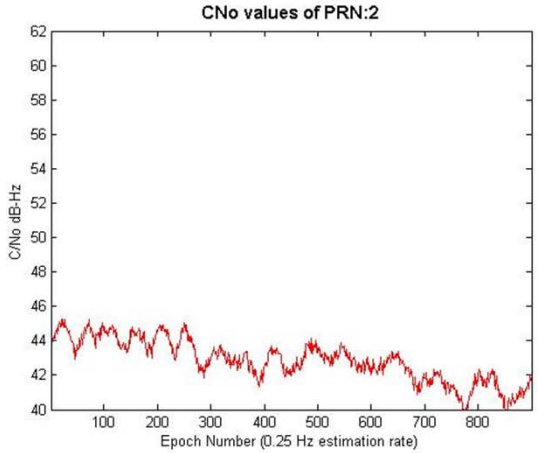
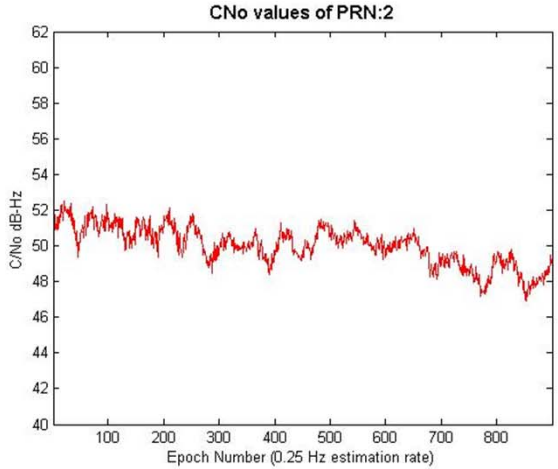


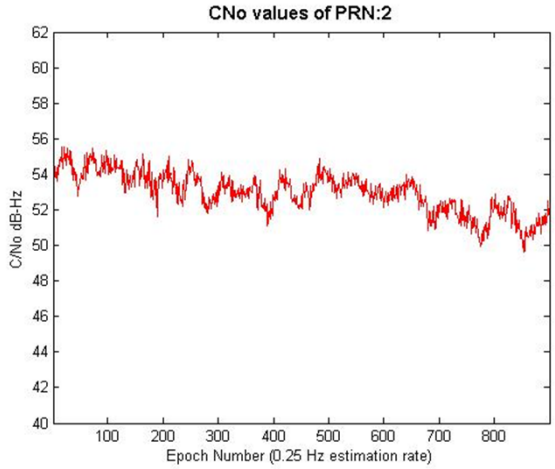
T=10msec, rate=0,5 sec



T=1msec, rate=4 sec



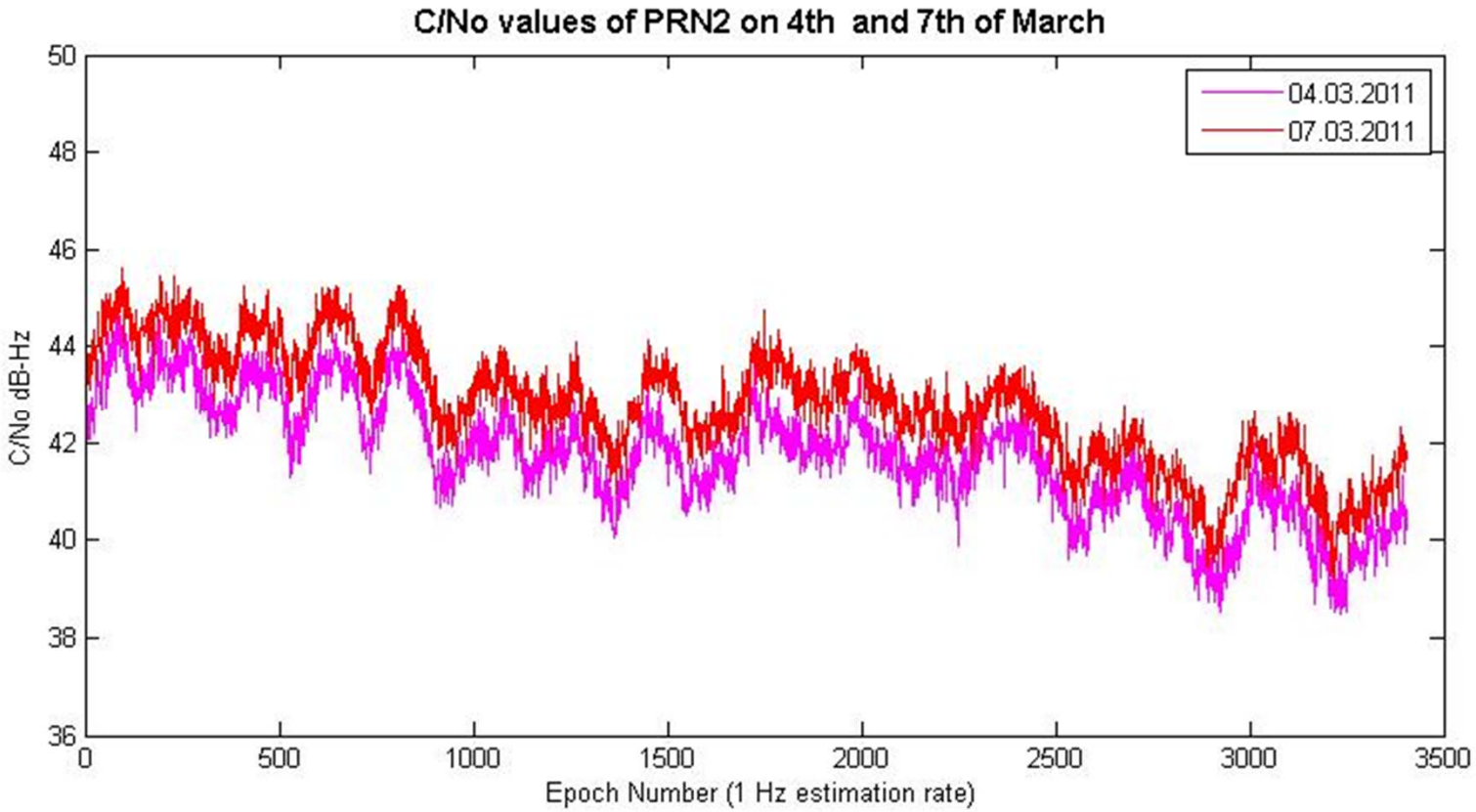
T=5msec, rate=4 sec



T=10msec, rate=4sec

Variance Summing estimator (1 hour IF data set)

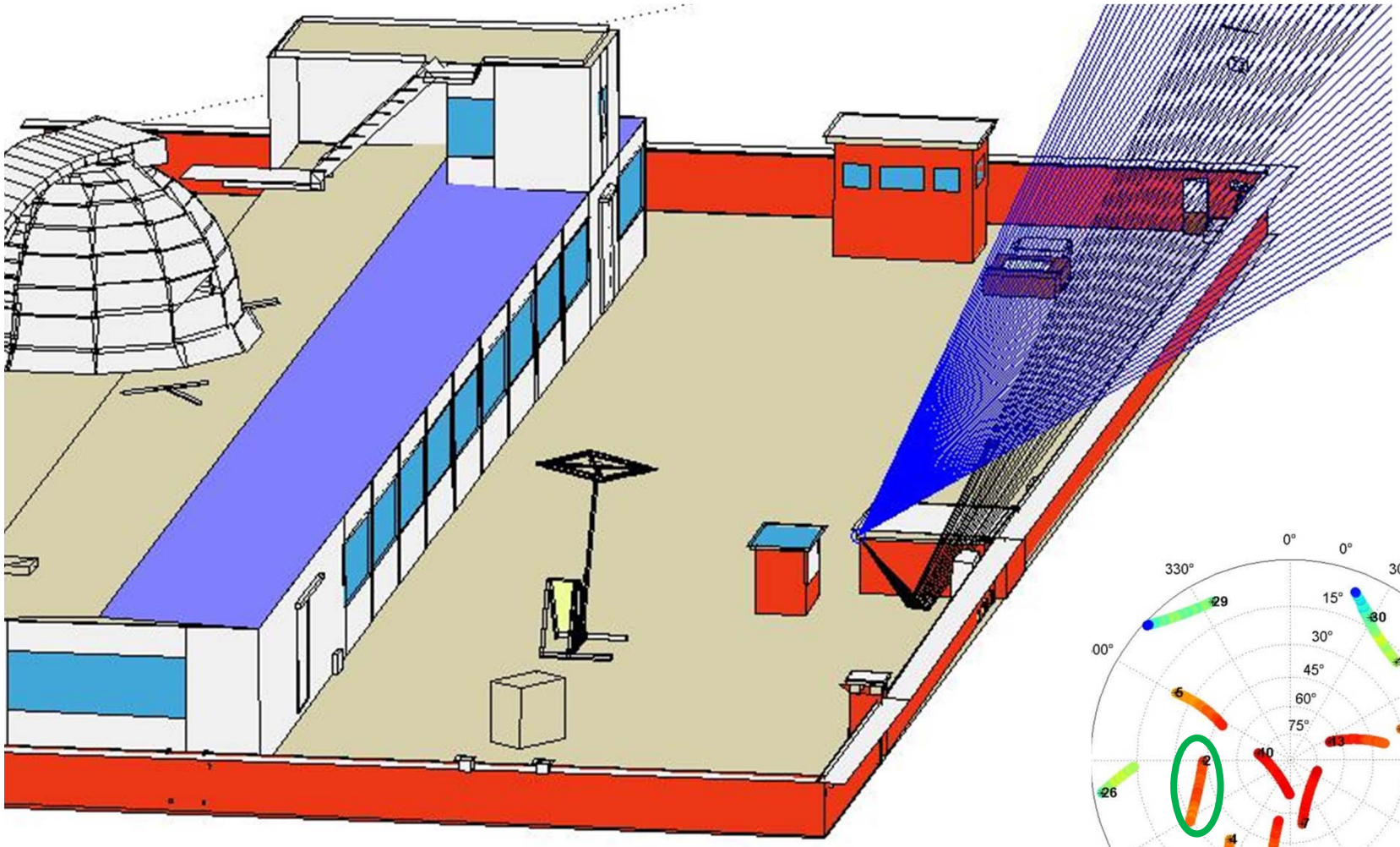
Sidereal repeatability

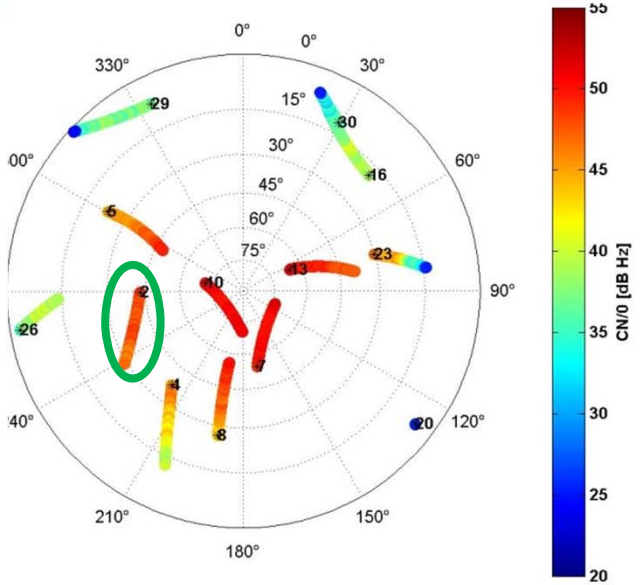


Mean offset value: 1.038 dB-Hz and σ=0.443 dB-Hz

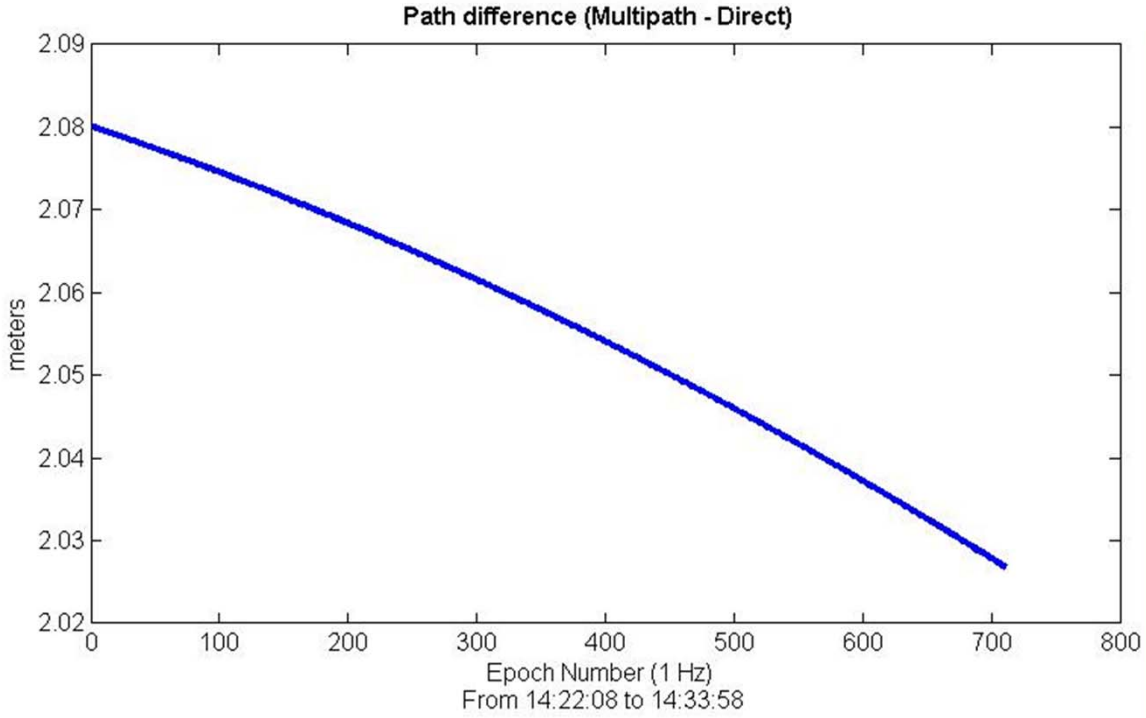
Date	Start time	End time
04.03.2011	14:22:08	15:18:53
07.03.2011	14:09:56	15:06:41

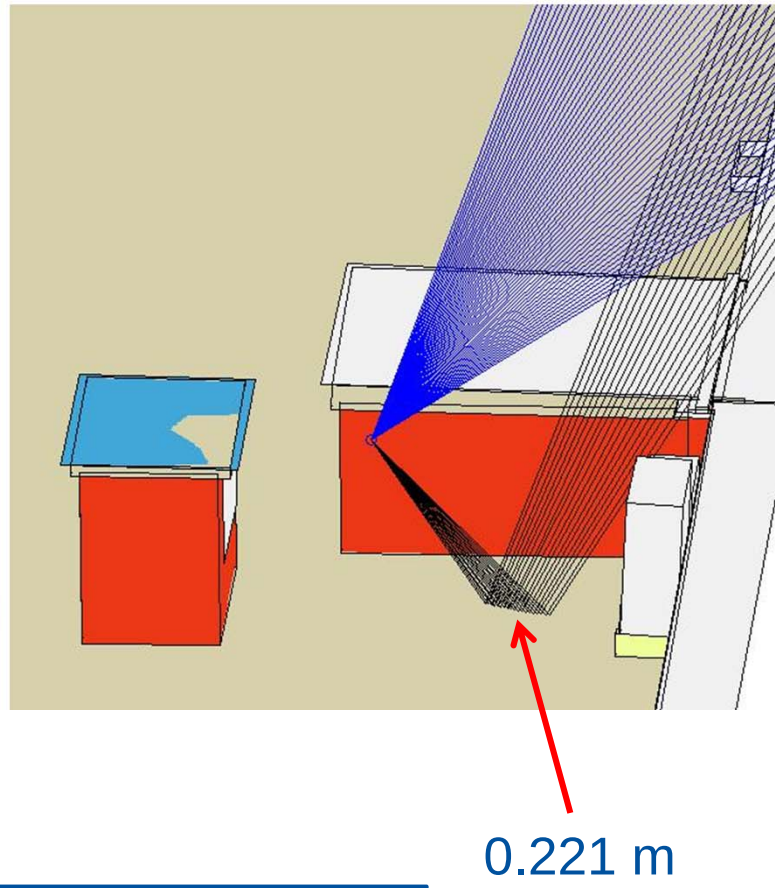
Ray-tracing results for PRN 2





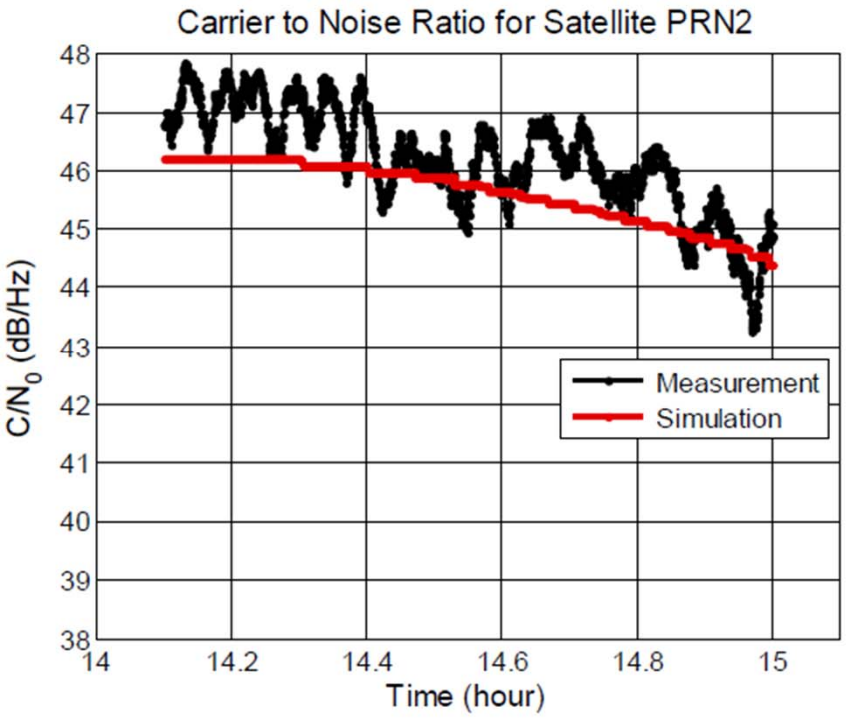
Ray-tracing results (04.03.2011)
PRN 2 ground multipath





- **Ground multipath identified for 11 min 50 sec**

C/N_0 observed vs simulated



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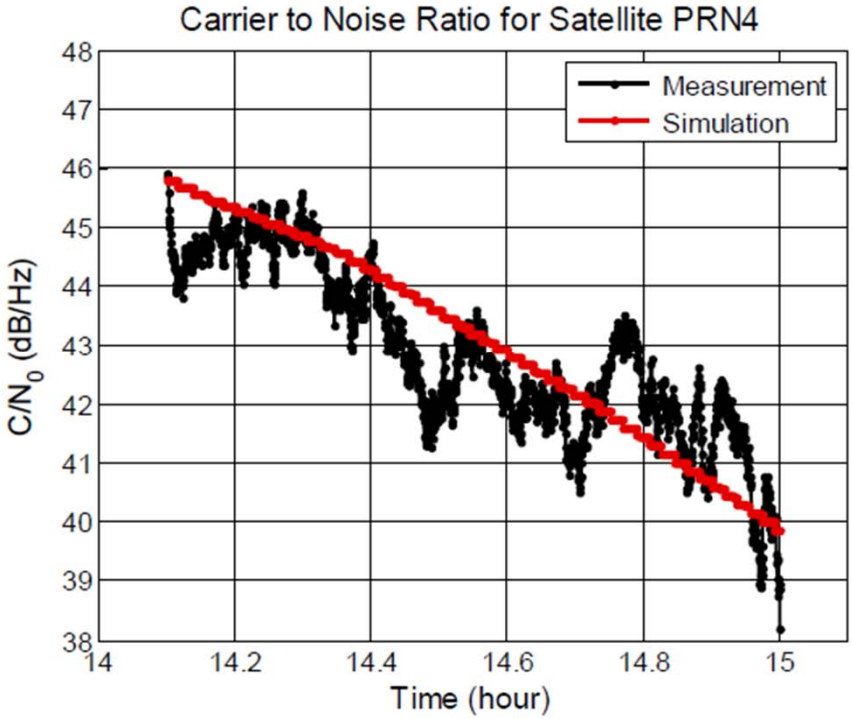

M. Liso et al. 2011*

- Simulation ‘’follows’’ the measurements but not the power oscillations
- Direct signal dominates and multipath signals are very weak

* M. Liso Nicolas, M. Jacob, M. Smyrnaios, S. Schön, T. Kürner, ‘’ Basic Concepts for the Modeling and Correction of GNSS Multipath Effects using Ray Tracing and Software Receivers’’, 2011

Conclusion-Future work

- Different receivers C/N_0 output time series
- Different coherent integration intervals and different averaging periods
- Comparison with first results from a Ray-Tracing approach

- Diffraction will be taken into account, as well as second order reflections
- Characteristic cases are to be investigated e.g. maximum error in signal amplitude results in minimum phase multipath
- Impact on phase observations

Acknowledgements:

We'd like to acknowledge GFZ Potsdam and DLR-GSOC for providing their Nord Nav receivers for the measurement campaigns.

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