Reduction of Pseudorange Multipath Error in Static Positioning

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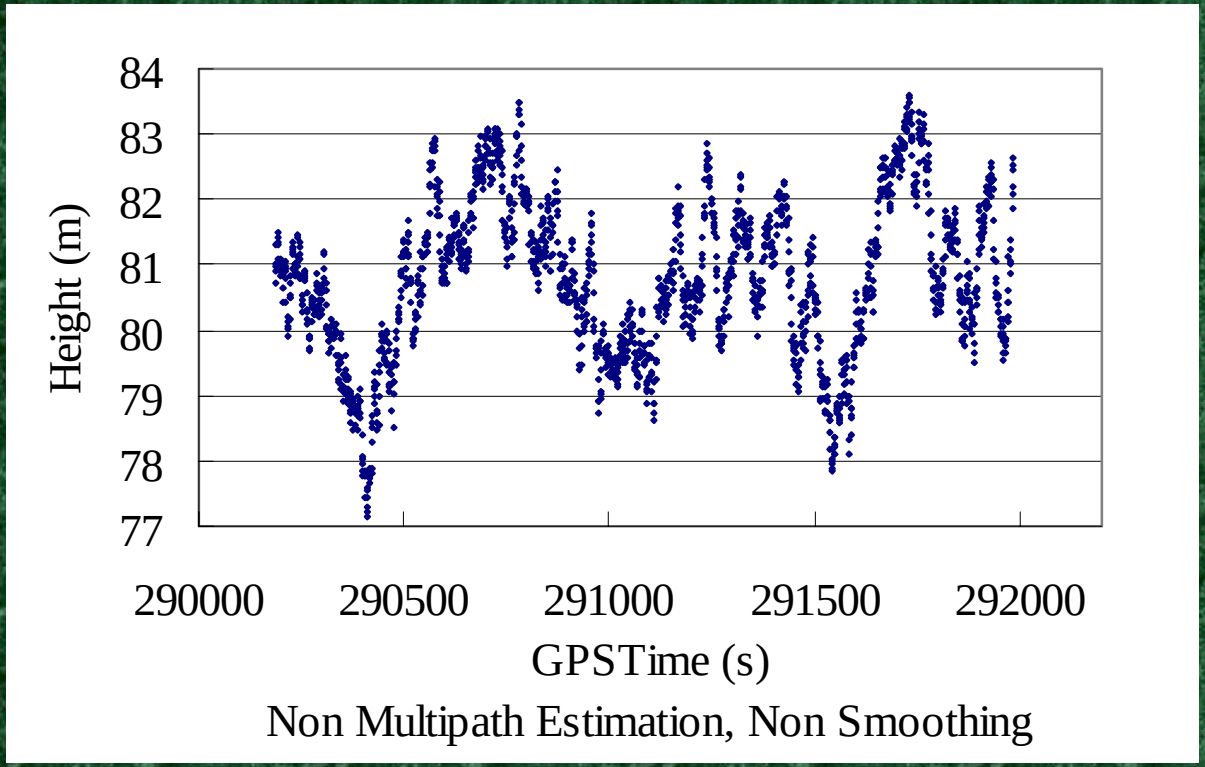
Brief

- Many researchers have tried to reduce the multipath effect from both hardware and software.
- Due to their efforts, long-delay code multipath is significantly reduced and carrier multipath also can be reduced recently.
- Short-delay code multiapth is still a problem.

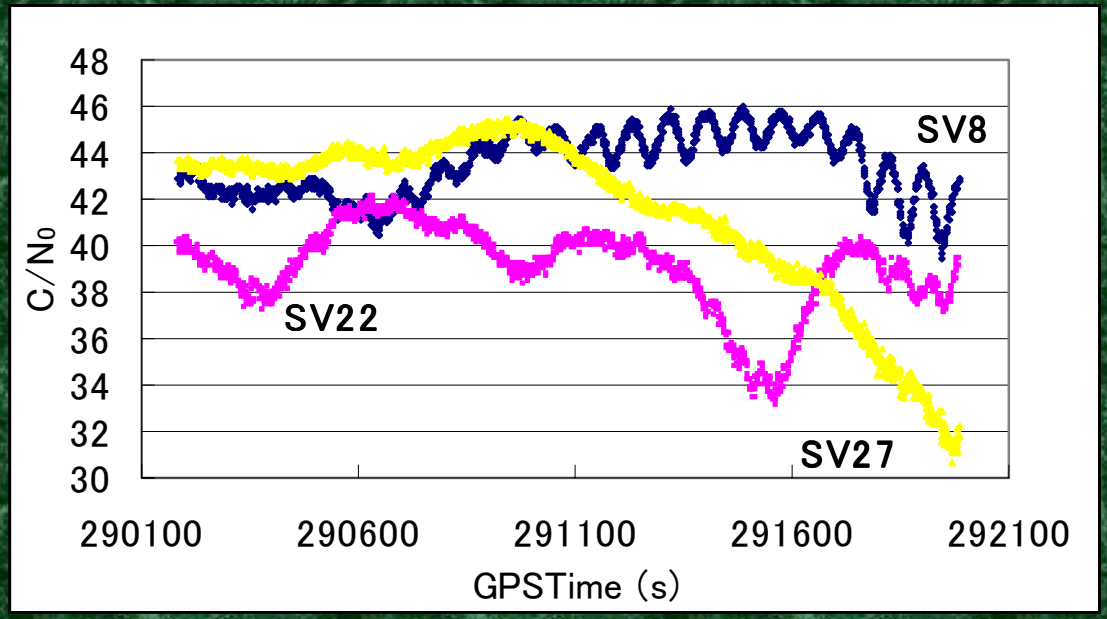
My purpose is to reduce short-delay code multipath in a static positioning.

DGPS under multiapth condition



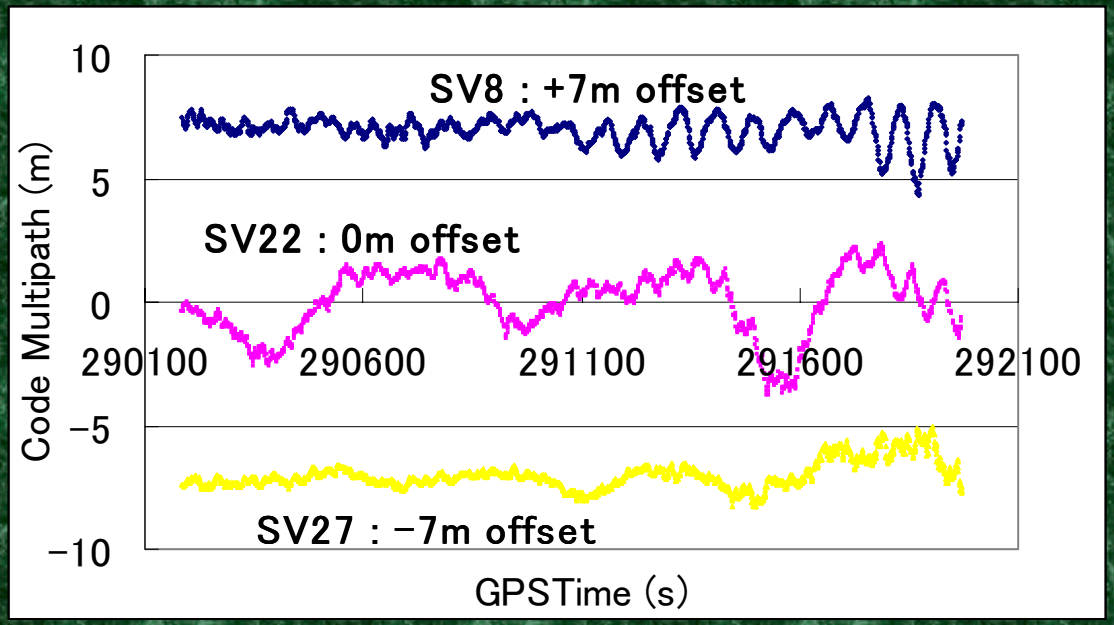
*Novatel RT-2
*Mask 5 degrees
*Csmooth 20s
*Model502 Ant. (choke-ring)

Reference station was installed under clear condition.
Rover station was installed under multipath condition.
Next picture shows the environment around rover station.



This picture shows $\underline{C/N_0}$ in rover station.

Main reason
SV8: Reflection by Wall
SV22: Reflection by BWO
SV27: Diffraction



This picture shows **Code Multipath** in rover station.

BWO: **B**ox for Weather Observation

Purpose

- Observing effects of code multipath due to near obstruction.

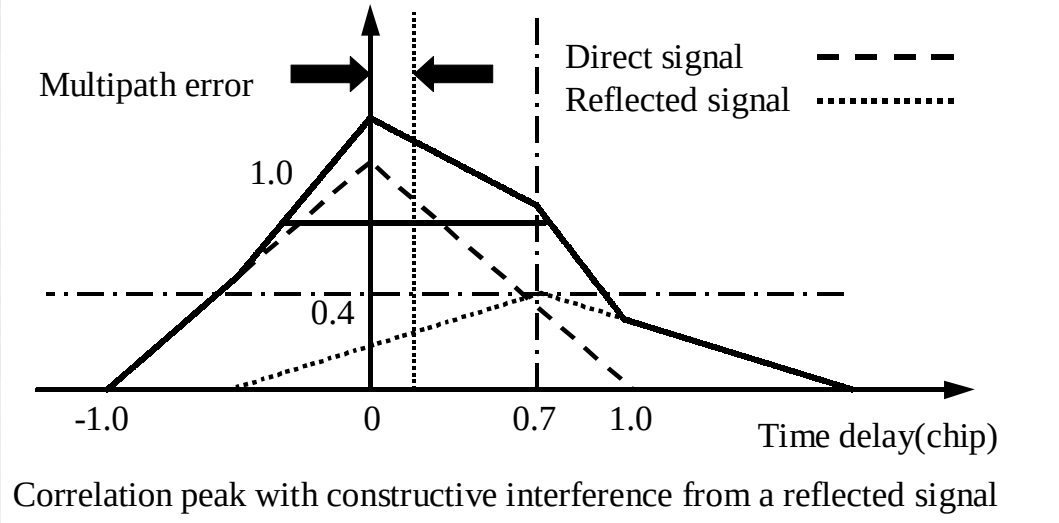
- Estimating code multipath due to near obstruction as correctly as we can.

- Improving accuracy in case of short-delay code multipath. (Short period and long period test)

Multipath effect on pseudorange (1)

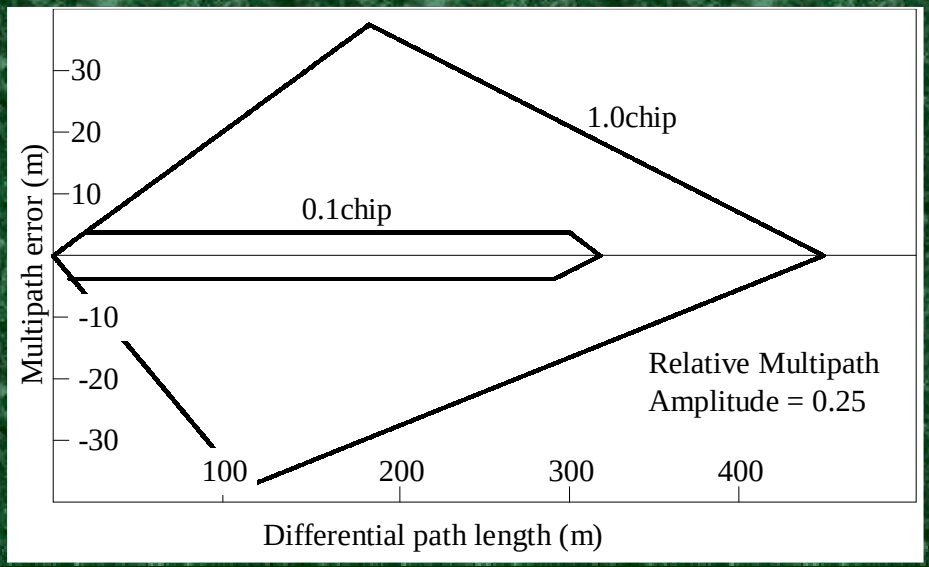
- In principal, code multipath can be estimated if we can parameterize signal **amplitude**, **time delay**, and **phase** of multipath.
- When GPS rover antenna moves, it is very difficult to estimate them. Because multipath parameters vary according to the environments. But in case of stationary antenna, we can almost estimate multipath parameters.

Multipath effect on pseudorange (2)



Correlation peak with constructive interference from a reflected signal

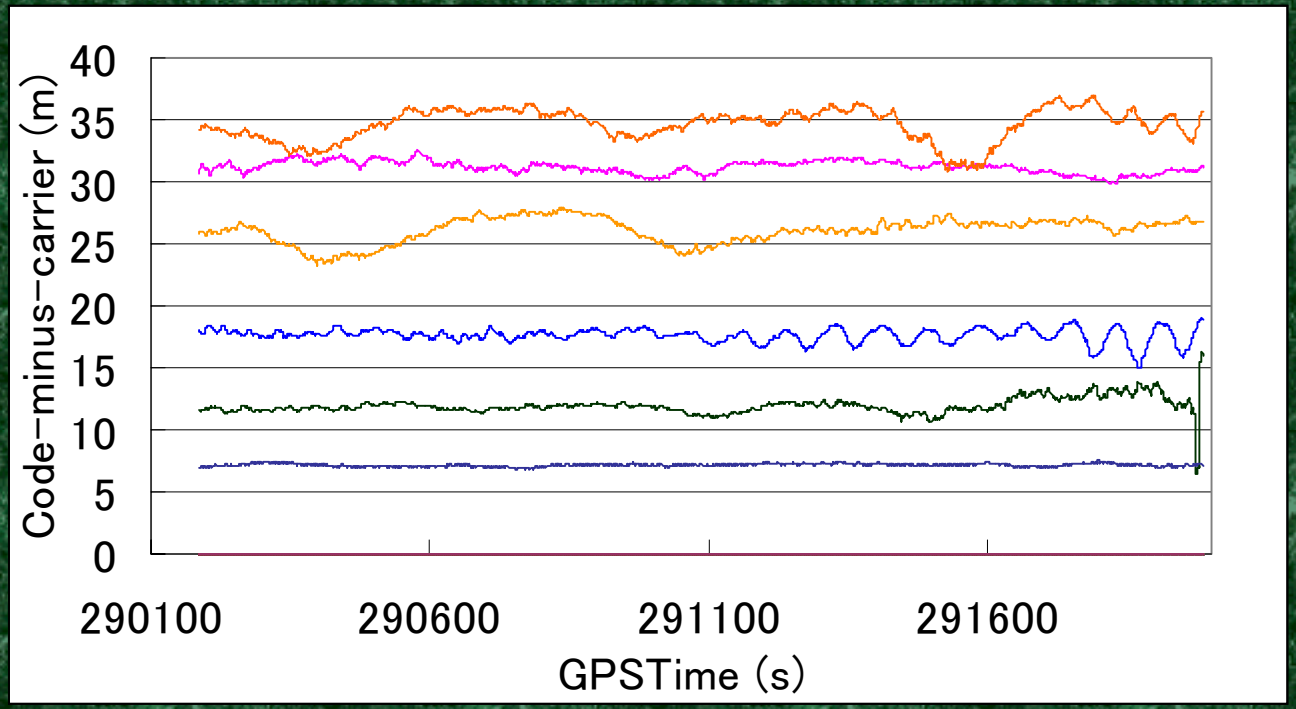
This picture shows correlatio
peak contaminated by a
reflected signal.
Most GPS receivers use a
DLL (early-late correlator)
to track the signal.



This picture shows bounds
on C/A code error due to
multipath.

Target

- Specular code multipath
- L1-L2 GPS receiver (carrier phase output)
- Static DGPS



GPS Antenna was installed near the wall (3.5m)

30minutes data

SV with many cycle-slips are removed

Steps for estimating code multipath

- Detect cycle-slips. Determine cycle-slip free interval each SV. (Max 30 minutes)
- Calculation of zero-mean code multipath from code-carrier technique. (A)
- Estimation of multipath parameters from Satellite-GPS Antenna geometry. Determine mean code multipath. (B)
- New code multipath is estimated from both A and B.

Method to estimate code multipath

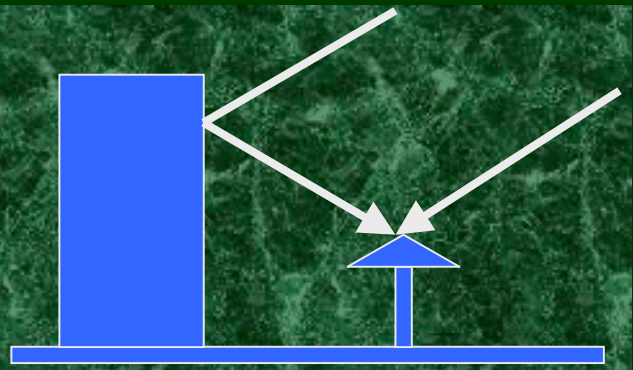
Variation is almost correct, but mean can't be estimated.

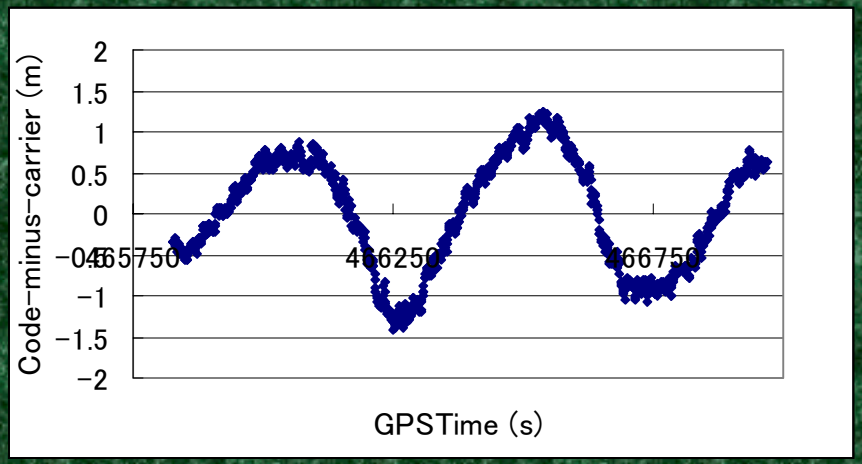
Estimation of multipath parameters

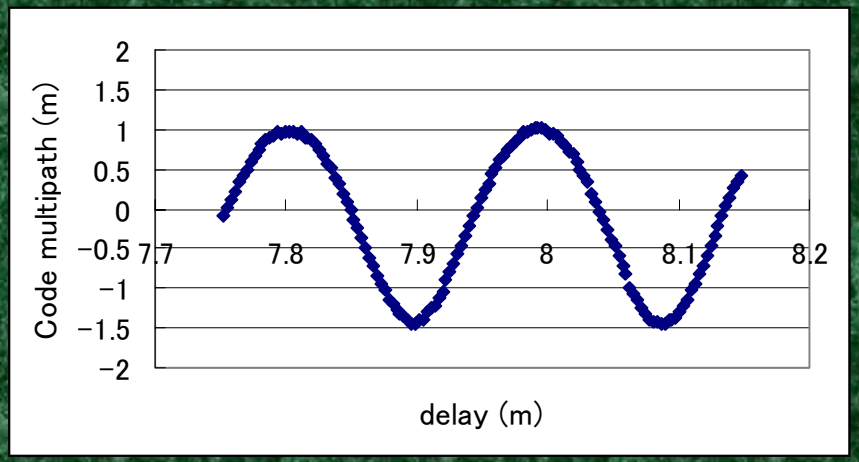
Code-minus-carrier technique + Mean code multipath

New code multipath

Estimation example







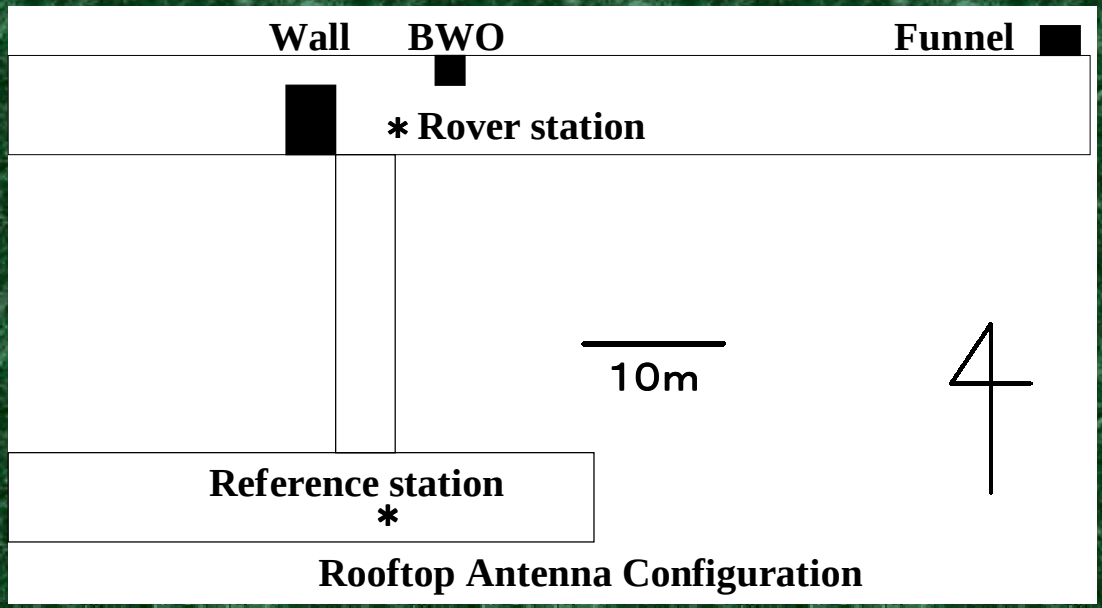
0-mean code multipath variation from code-carrier technique

Code multipath from multipath parameters. Amplitude=0.15

New code multipath = Variation of code multipath + Mean code multipath

DGPS TEST

- Rover station is 3.5m from the wall. Reference station is installed under clear condition. Applying new code multipath to pseudoranges in rover station. Short and long period.
- RT-2 GPS Receiver and Model 502 Antenna (choke-ring)

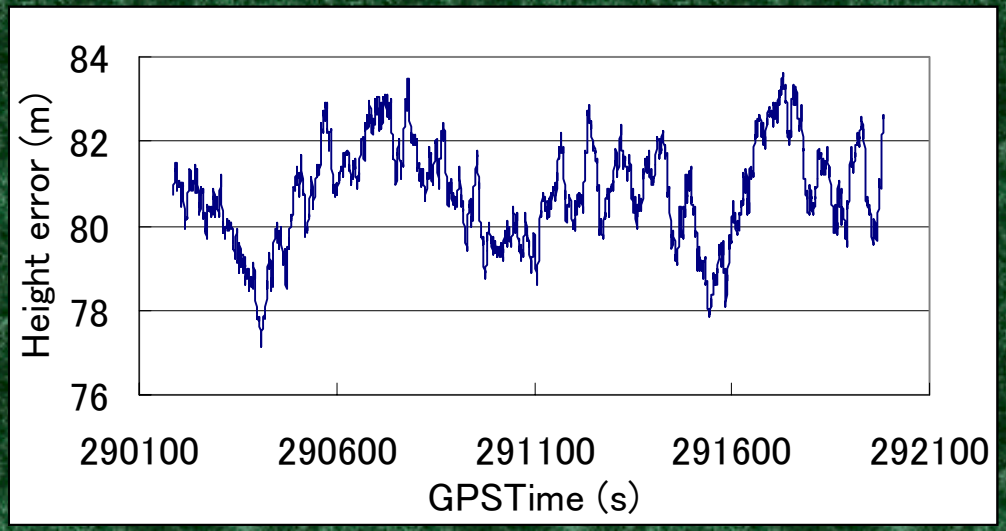


Rooftop Antenna Configuration

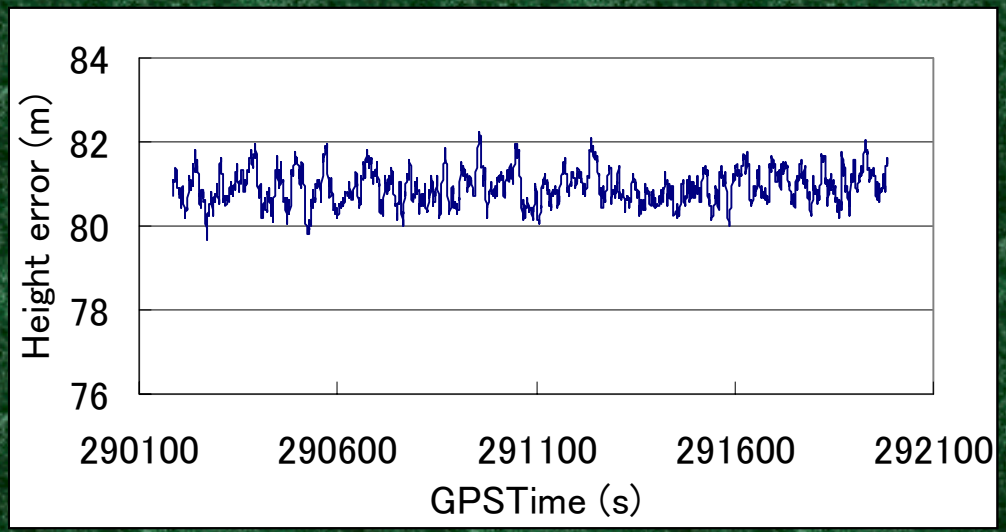
Steps for DGPS

- Produce correction data from measurements of reference station
- Produce new code multipath in rover station
- Produce new pseudorange in rover station. (raw pseudorange + new code multipath + correction)
- Calculate the rover position by least square method

Short period test (1)



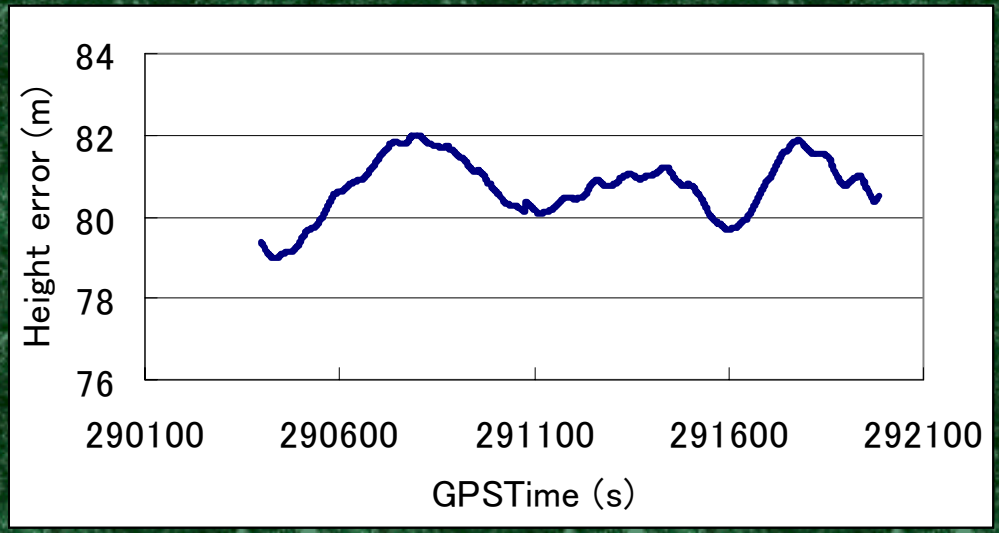
No multipath estimation
No carrier smoothing
6m (max variation)
1.19m (height 1 σ)



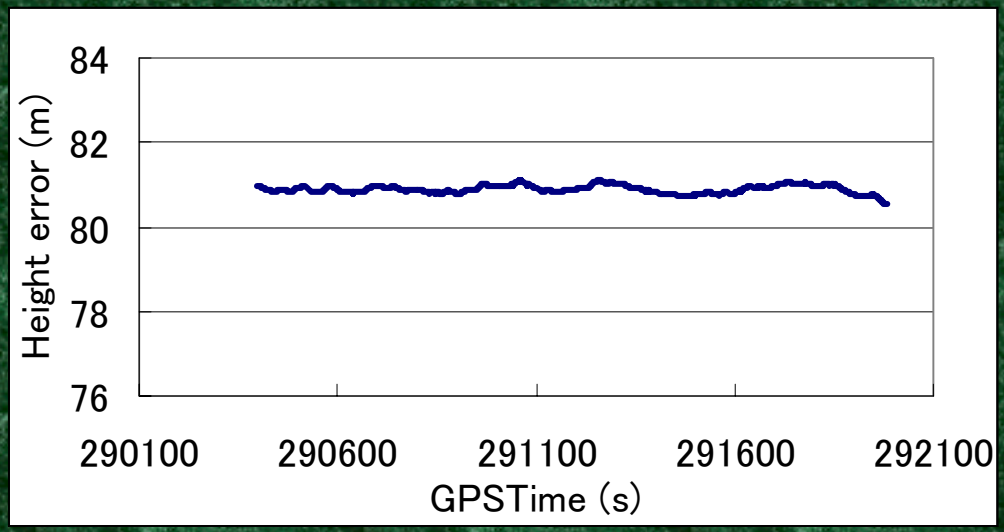
Multipath estimation
No carrier smoothing
2m (max variation)
0.40m (height 1 σ)

Precise height : 81.00m

Short period test (2)



No multipath estimation
Carrier smoothing (100s)
3m (max variation)
0.74m (height 1 σ)



Multipath estimation
Carrier smoothing (100s)
0.5m (max variation)
0.10m (height 1 σ)

Precise height : 81.00m

Long period test

MPE: Multipath Estimation

1) Antenna-Wall (3m, 15hours)			
Pattern	Height	Horizontal	Average
No MPE	**1.12m**	**0.76m**	**81.22m**
MPE(zero-mean)	**0.57m**	**0.25m**	**81.21m**
MPE(+mean)	**0.40m**	**0.22m**	**81.18m**
2) Antenna-Wall (7m, 15hours)			
No MPE	**0.70m**	**0.55m**	**81.09m**
MPE(zero-mean)	**0.27m**	**0.23m**	**81.19m**
MPE(+mean)	**0.19m**	**0.17m**	**81.05m**

DGPS accuracy (1σ) on MP estimation methods

Conclusion

- Code minus carrier technique can approximately estimate code multipath.
- Mean code multipath can be calculated by estimating multipath parameters and accuracy is a little better than only code multipath.
- We will apply this new technique to correction generating in reference station.
- The future object is to build technique to estimate code multiapth in real-time and to enhance robustness of this technique.