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u-blox社NEO-M8N受信機による マルチGNSS RTK性能の評価

Evaluation of Multi-GNSS RTK performance with u-blox NEO-M8N receivers

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Contents

- **Background**
- **u-blox NEO-M8N**
- **Performance Evaluation of RTK**
- **Receiver Biases between Satellites**

Background

Background

- **Low Cost RTK (real-time kinematic)**
 - Feasible with consumer-grade receivers
 - Poor AR performance by single-frequency RTK-GPS
- **Multiple-constellation GNSS**
 - GPS, GLONASS, QZSS, BDS, Galileo, IRNSS and SBAS
 - Over 100 satellites in 2017
 - Much improved RTK performance with many satellites
- **Technical Issues on Multi-GNSS-RTK**
 - Receiver bias: ISB, IFB, cycle-shift

Receivers Modules

Vender	Module	GNSS						Raw Output	Feature
		GPS	GLO	QZS	BDS	GAL	SBS		
u-blox	NEO-7P	Y*1	Y*1	Y	-	*3	Y	Y (GPS)	56 CH, 1-10Hz
	NEO-M8* MAX-M8*	Y	Y*1	Y	Y*1	*3	Y	*2	72 CH, 1-10Hz
NVS	NV08C- CSM	Y	Y	-	Y?	Y	Y	Y (GPS,GLO)	32 CH, 1-10Hz
SkyTraq	S1722F8- *-RAW	Y	Y*1	Y	Y*1	-	Y	Y	167 CH, 1-20Hz
Furuno	GN-87	Y	Y	Y	-	*3	Y	Y	26 CH, 1-10Hz

*1 exclusive use, *2 officially not supported, *3 planned

u-blox NEO-M8N

NEO-M8N Module

Receiver Type:

72-channel u-blox M8 engine

GPS/QZSS L1 C/A, GLONASS L10F

BeiDou B1

SBAS L1 C/A: WAAS, EGNOS, MSAS

Navigation Update Rate:

Single GNSS up to 18 Hz

Concurrent GNSS up to 10 Hz

Position accuracy: 2.0 m CEP

Acquisition:

Cold starts: 26 s

Aided starts: 2 s

Reacquisition: 1.5 s

Sensitivity:

Tracking & Nav: -167 dBm

Cold starts: -148 dBm

Hot starts: -156 dBm

Assistance :

AssistNow GNSS Online

AssistNow GNSS Offline (< 35 days)

AssistNow Autonomous (< 6 days)

OMA SUPL & 3GPP compliant

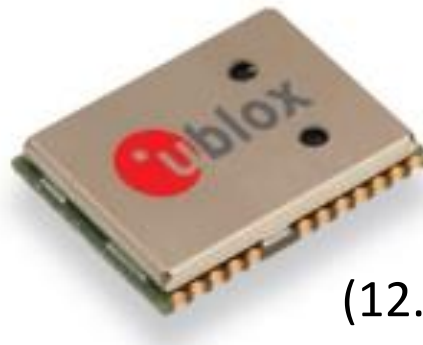
Oscillator : TCXO

RTC Crystal: built-In

Memory: Flash

Supported Antennas:

Active and passive



(12.2 x 16.0 x 2.4 mm)

<http://www.u-blox.com/>

Receiver with NEO-M8N



\$65.99@1pcs (w/o antenna, shipping)

<http://www.csgshop.com/>

UbloxRAW

Firmware	RXM-RAW (0210)	RXM-SFRB (0211)	RXM-SFRBX (0213)	RXM-RAWX (0215)	TRK-TRKD5 (030a)	TRK-MEAS (0310)	TRK-SFRB (0302)	TRK-SFRBX (030f)	TRK-TRKD2 (0306)
antaris4 ROM 5.00	R(L)	R(L)	-	-	-	-	X	-	X
antaris4 EXT	F(L)	F(L)	-	-	-	-	X	-	X
antaris4 premium	X	X	-	-	-	-	X	-	X
ublox5 ROM 5.00	-	-	-	-	X	-	X	-	-
ublox5 EXT 6.02	F	F	-	-	X	-	X	-	-
ublox5 premium (LEA-5T)	X	X	-	-	X	-	X	-	-
ublox6 ROM 6.02	R	R	-	-	X	-	X	-	-
ublox6 ROM 7.03	R	R	-	-	X	-	X	-	-
ublox6 EXT 7.03	F	F	-	-	X	-	X	-	-
ublox6 EXT 7.03 DR 6R C0 2.00	-	-	-	-	X	-	X	-	-
ublox6 premium (LEA-6T, NEO-6P)	X	X	-	-	X	-	X	-	-
ublox6 EXT 1.00	F	F	X	-	X	-	-	X	-
ublox7 ROM 1.00	-	-	-	-	X	-	-	X	-
ublox7 EXT 1.00	F	F	-	-	X	-	-	X	-
ublox7 EXT 1.01PPP	X	X	X	-	X	-	-	X	-
ubloxM8 EXT 2.00	-	-	-	-	-	X	-	X	-
ubloxM8 ROM 2.01	-	-	-	-	-	X	-	X	-
ubloxM8 premium (LEA-8T)	?	?	X	X	-	X?	-	X?	-

<http://wiki.openstreetmap.org/wiki/UbloxRAW>

TRK-MEAS (1)

Sync	Class	ID	Length (B)	Payload	Checksum
0xB5 0x62	0x03	0x10	2 bytes	see below	CK_A CK_B

Offset	Size	Format	Name	Description
0	2	-	?	?
2	2	U2	nch	number of channels (= n)
4	100	-	?	?
104	56	-	ch1 data	channel 1 meas. data (see next page)
160	56	-	ch2 data	channel 2 meas. data
216	56	-	ch3 data	channel 3 meas. data
272	56	-	ch4 data	channel 4 meas. data
...
	56	-	ch n data	channel n meas. data

(NEO-M8N, F/W ver. 2.01)

TRK-MEAS (2)

Offset	Size	Format	Name	Description
0	1	U1	chn	channel number
2	1	U1	mesQl	0:idle,1:search,2:aquired,4-7:lock
4	1	U1	system	0:GPS,1:SBS,2:GAL,3:BDS,5:QZS,6:GLO
5	1	U1	svid	satellite ID (PRN/slot number)
7	1	U1	fcn	GLO frequency channel number+7
8	1	U1	status	tracking/lock status (bit3: half-cycle)
16	1	U1	lock1	code lock count
17	1	U1	lock2	carrier lock count
20	2	U2	cno	C/N0 (2^{-8} dBHz)
24	8	I8	txTow	transmission time in gps week (2^{-32} ms)
32	8	I8	adr	accumulated Doppler range (2^{-32} cycle)
40	4	I4	dop	Doppler frequency ($2^{-32} \times 10$ Hz)

(NEO-M8N, F/W ver. 2.01)

TRK-SFRBX

Sync	Class	ID	Length (B)	Payload	Checksum
0xB5 0x62	0x03	0x0F	2 bytes	see below	CK_A CK_B

Offset	Size	Format	Name	Description
0	1	-	?	?
1	1	U1	system	0:GPS,1:SBS,2:GAL,3:BDS,5:QZS,6:GLO
2	1	U1	svid	satellite ID (PRN/slot number)
4	1	U1	fcn	GLO frequency channel number+7
13	40	X4[10]	GPS nav	GPS LNAV subframe (24 bits x 10)
	16	X4[4]	GLO nav	GLO nav string with hamming (85 bits)
	40	X4[10]	QZS nav	QZSS LNAV subframe (24 bits x 10)
	40	X4[10]	BDS nav	BDS D1/D2 subframe (26 bits x 10)
	32	X4[8]	SBS nav	SBAS message frame (226 bits)

(NEO-M8N, F/W ver. 2.01)

Enable TRK-MEAS, -SFRBX

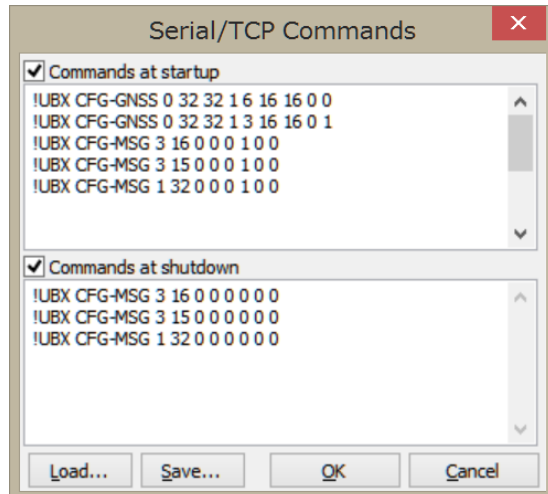
UBX-CFG-MSG (Set Message Rate)

Sync	Class	ID	Length (B)	Payload	Checksum
0xB5 0x62	0x06	0x01	0x08 0x00	0xFF 0xFF X X X X X X	CK_A CK_B

Message & Class ID

Send Rate on 6 I/O Ports

RTKNAVI-Input Streams-Cmd



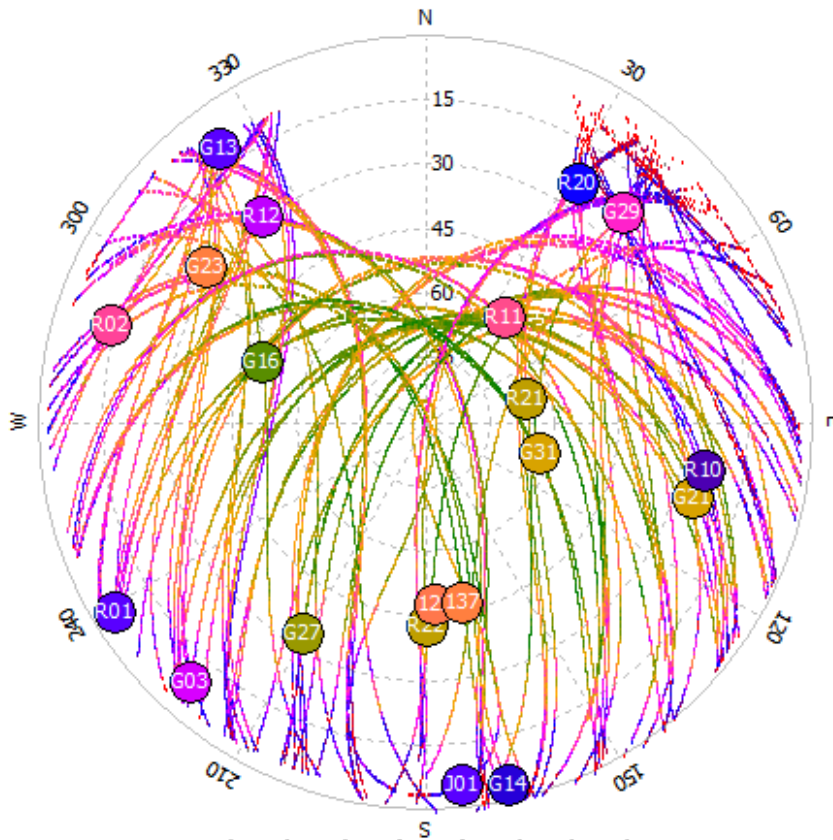
Serial Command File

RTKLIB¥data¥ubx_m8n_bds_raw_1hz.cmd
(for GPS/QZS/SBS/BDS)

RTKLIB¥data¥ubx_m8n_glo_raw_1hz.cmd
(for GPS/GLO/QZS/SBS)

(RTKLIB 2.4.2 p8 ~)

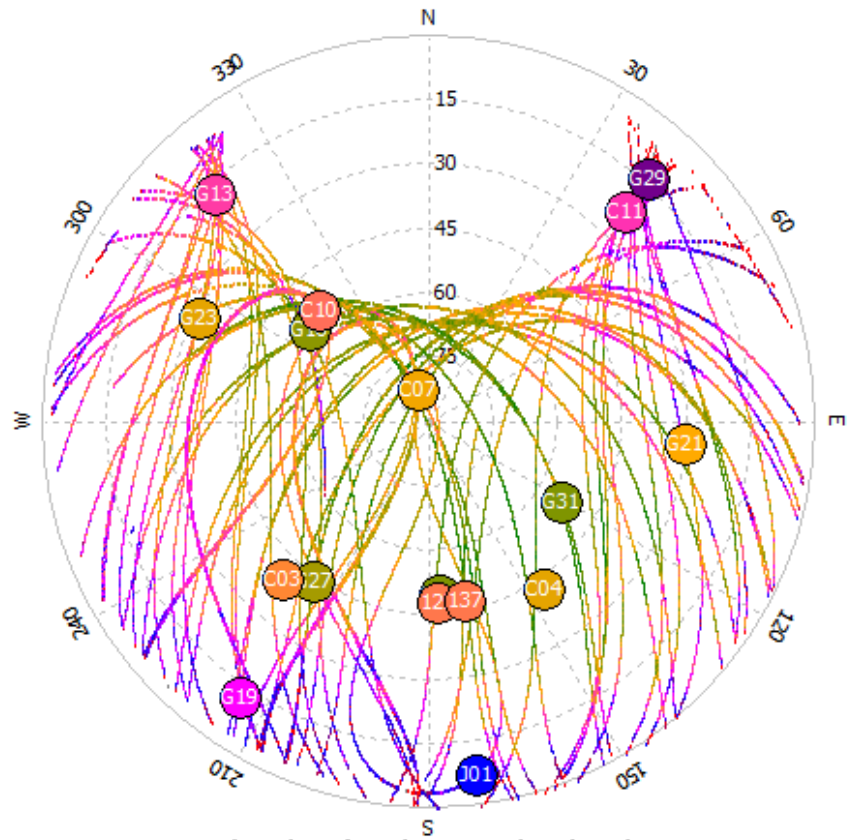
Tracking Satellites



GPS+GLO+QZS+SBS

2014/8/13 0:00-23:59 GPST

SAT=12-22, Ave GDOP=1.7



GPS+QZS+BDS+SBS

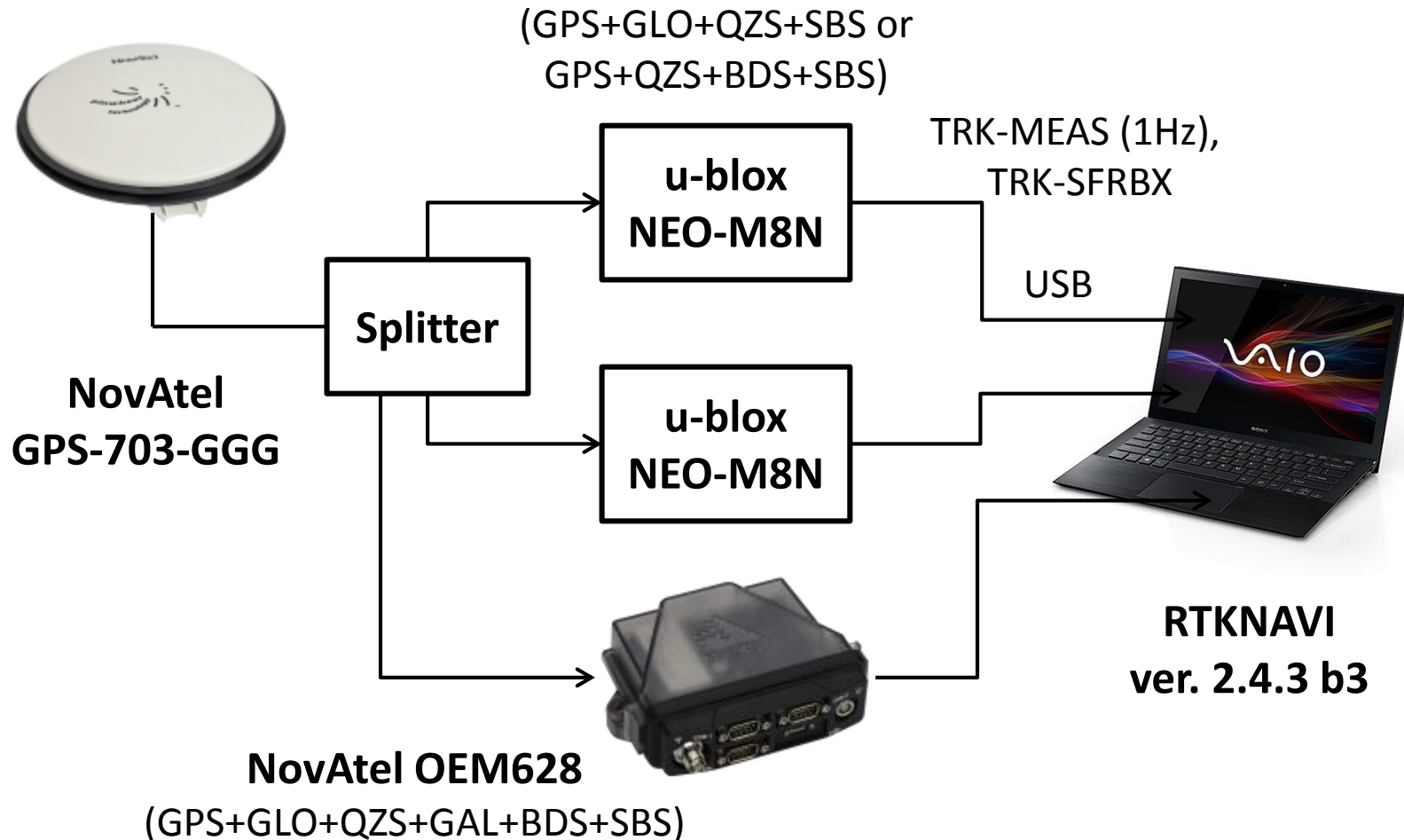
2014/8/19 0:00-23:59 GPST

SAT=14-23, Ave GDOP=1.9

(At Yamanashi, El mask = 15 deg)

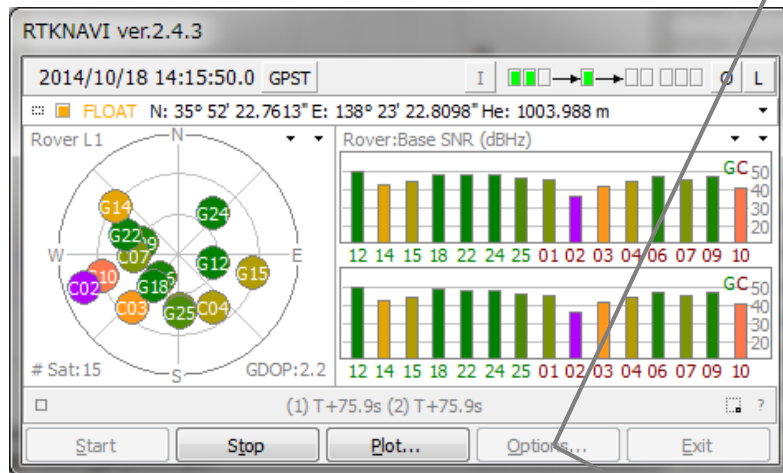
Performance Evaluation of RTK

RTK-Experiment Setup



RTKNAVI AR Option

RTKNAVI ver. 2.4.3 b3



Options

Options

Tabs: Setting1, Setting2, Output, Statistics, Positions, Files, Misc

Integer Ambiguity Res (GPS/GLO/BDS) Cont OFF OFF

Min Ratio to Fix Ambiguity 3.0

Min Confidence / Max FCB to Fix Amb 0.9999 0.20

Min Lock / Elevation (°) to Fix Amb 0 0

Min Fix / Elevation (°) to Hold Amb 10 0

Outage to Reset Amb / Slip Thres (m) 5 0.050

Max Age of Diff (s) / Sync Solution 30.0 OFF

Reject Threshold of GDOP/Innov (m) 30.0 30.0

Number of Filter Iteration 1

☐ Baseline Length Constraint (m) 0.000 0.000

Buttons: Load, Save, OK, Cancel

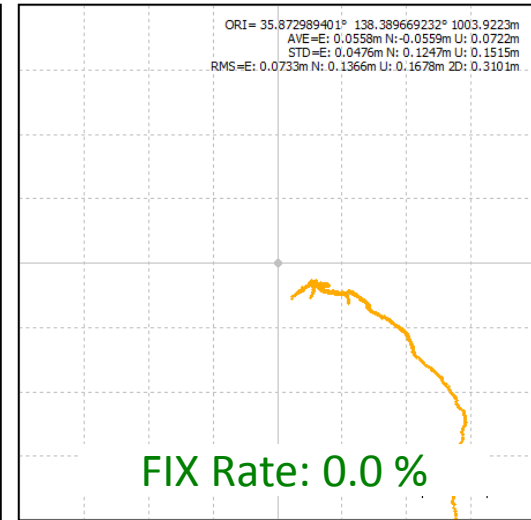
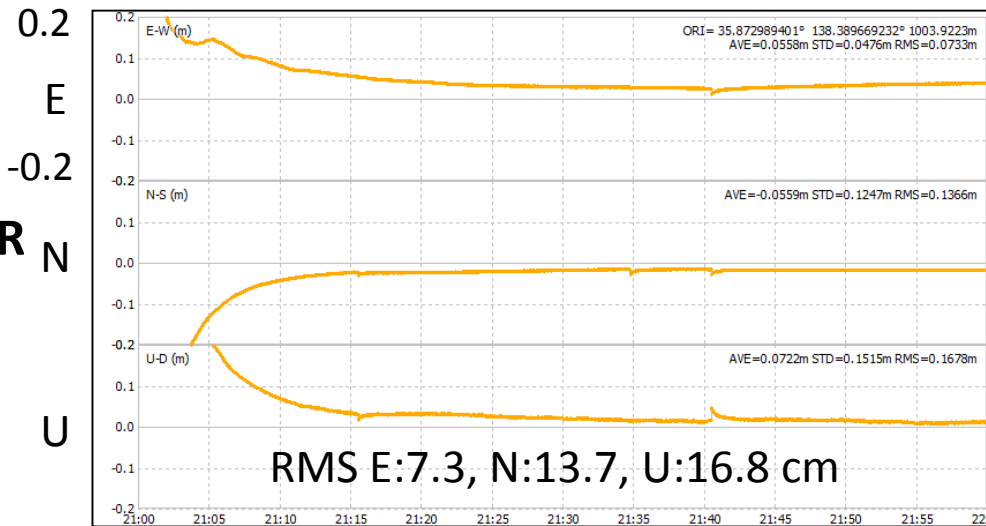
GLO AR
Option

BDS AR
Option

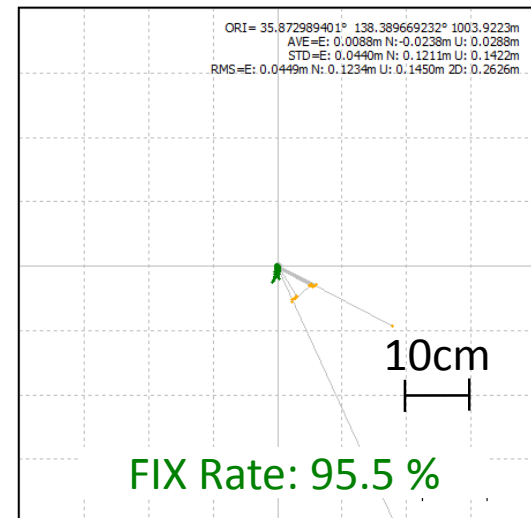
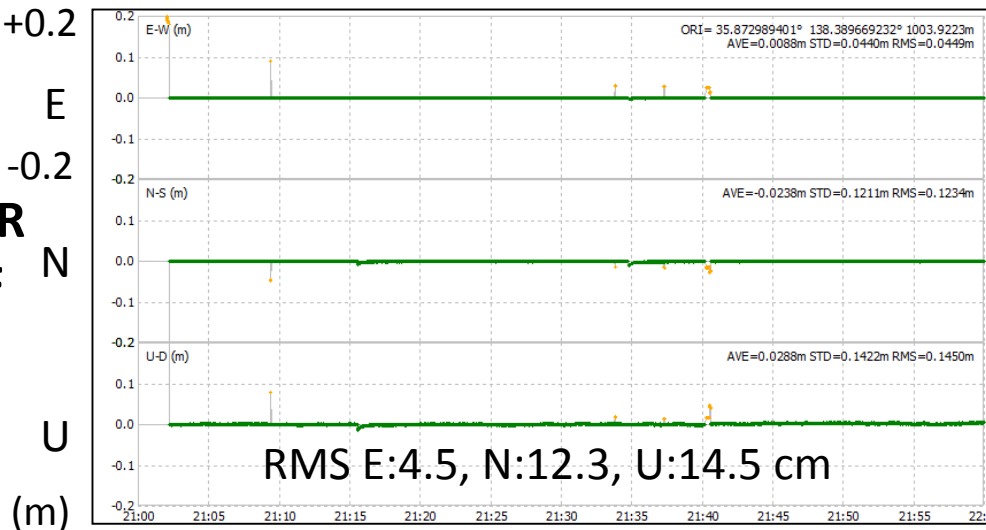
https://github.com/tomojitakasu/RTKLIB/tree/rtklib_2.4.3

RTK Results (GPS+GLO+QZS)

**GLO AR
= ON**



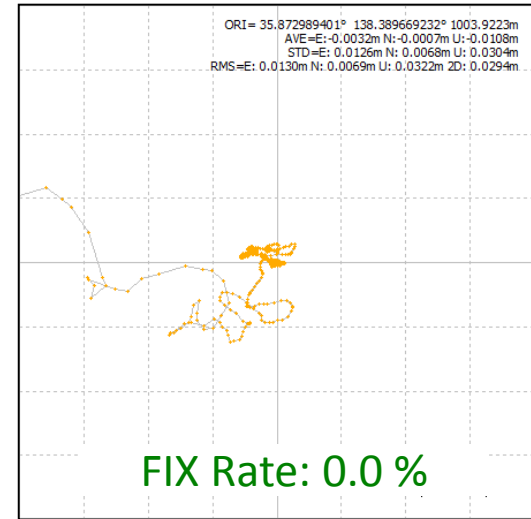
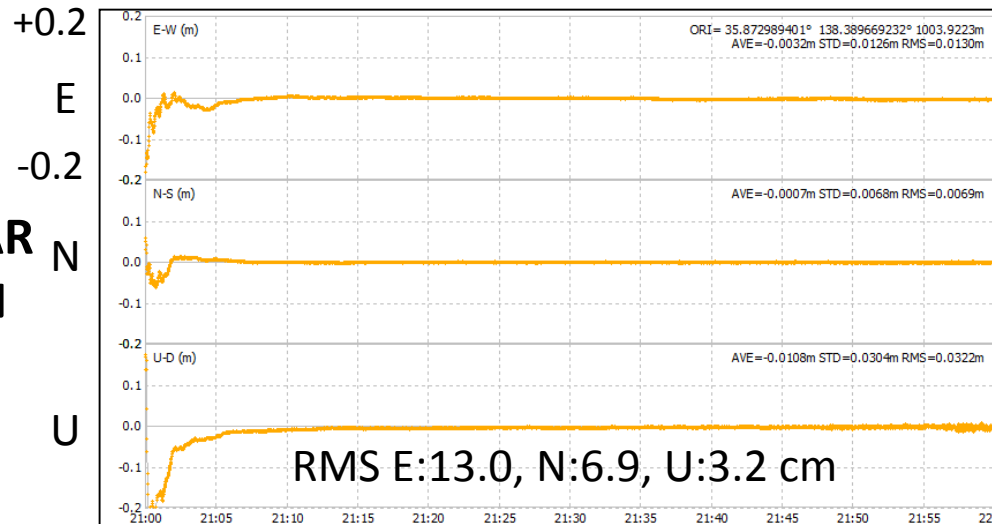
**GLO AR
= OFF**



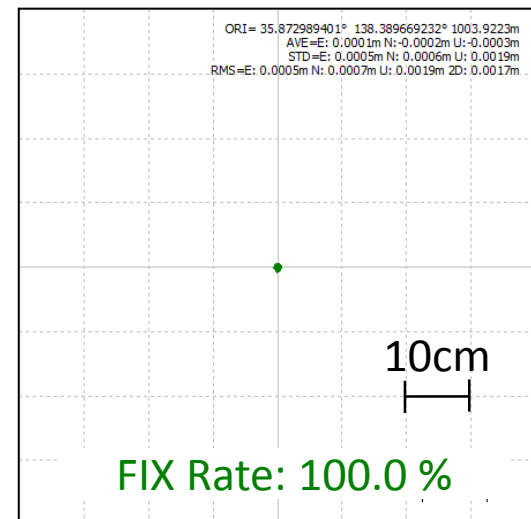
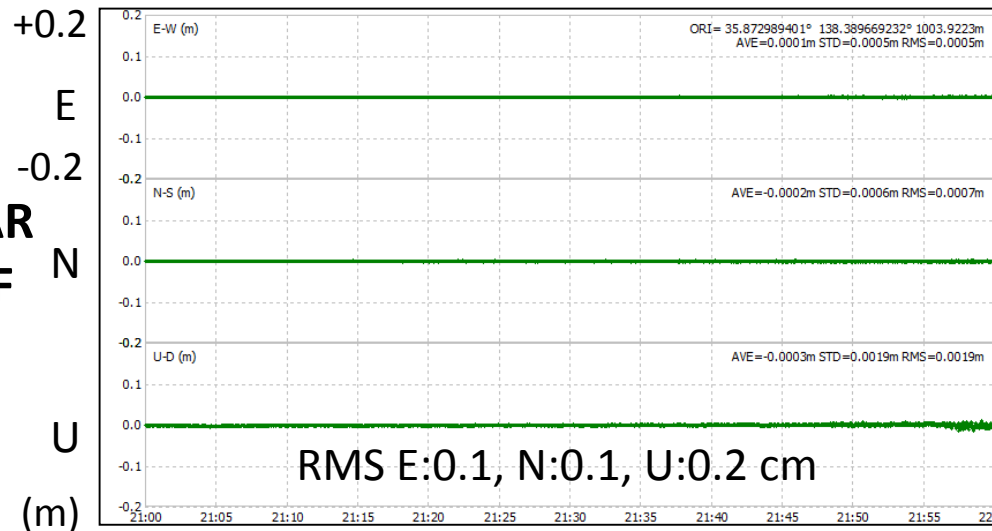
2014/10/20 21:00 - 22:00 GPST, El mask=15 deg, # SAT=12-17

RTK Results (GPS+QZS+BDS)

**BDS AR
= ON**



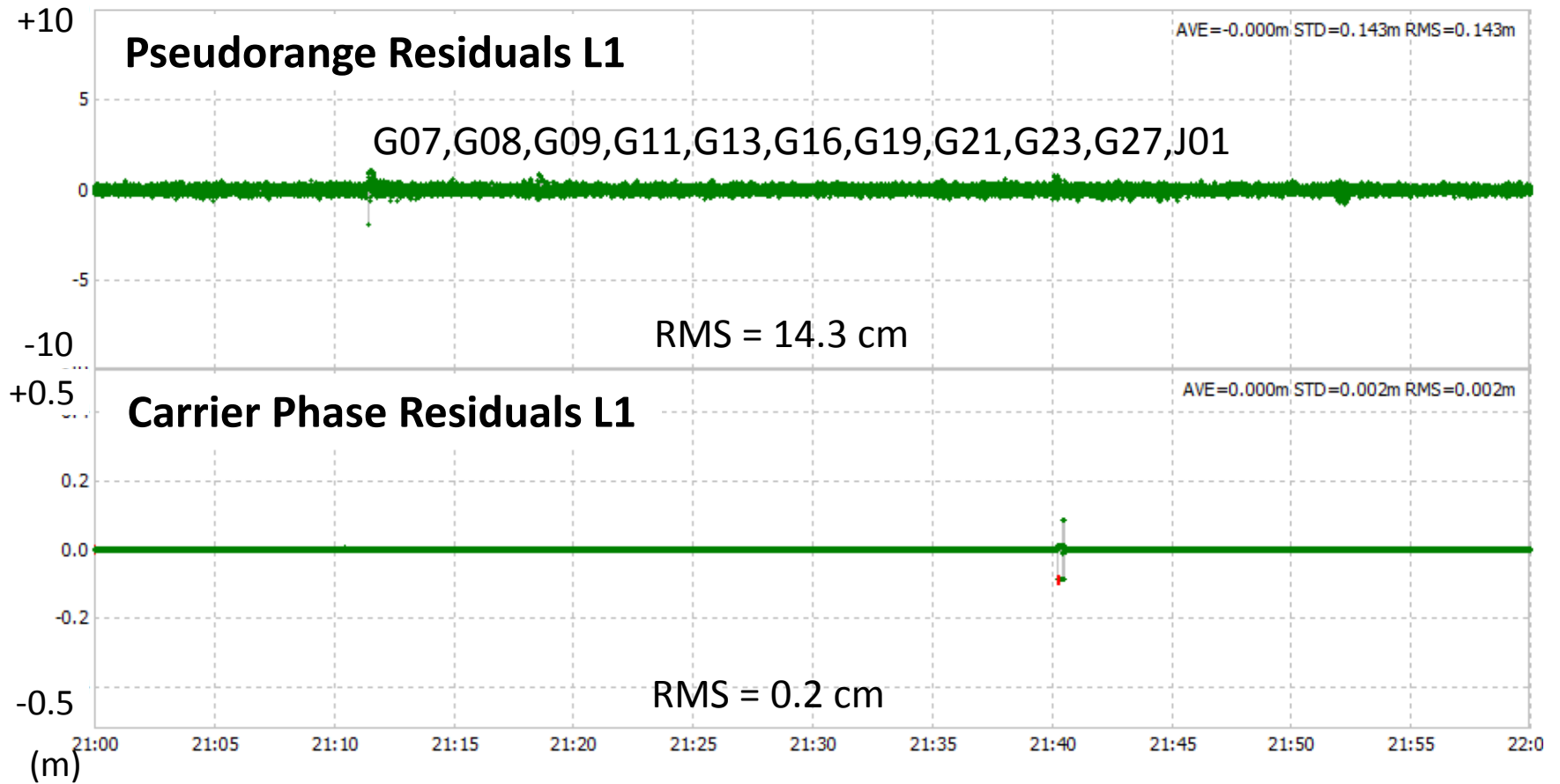
**BDS AR
= OFF**



2014/10/20 21:00 - 22:00 GPST, El mask=15 deg, #SAT=11-15

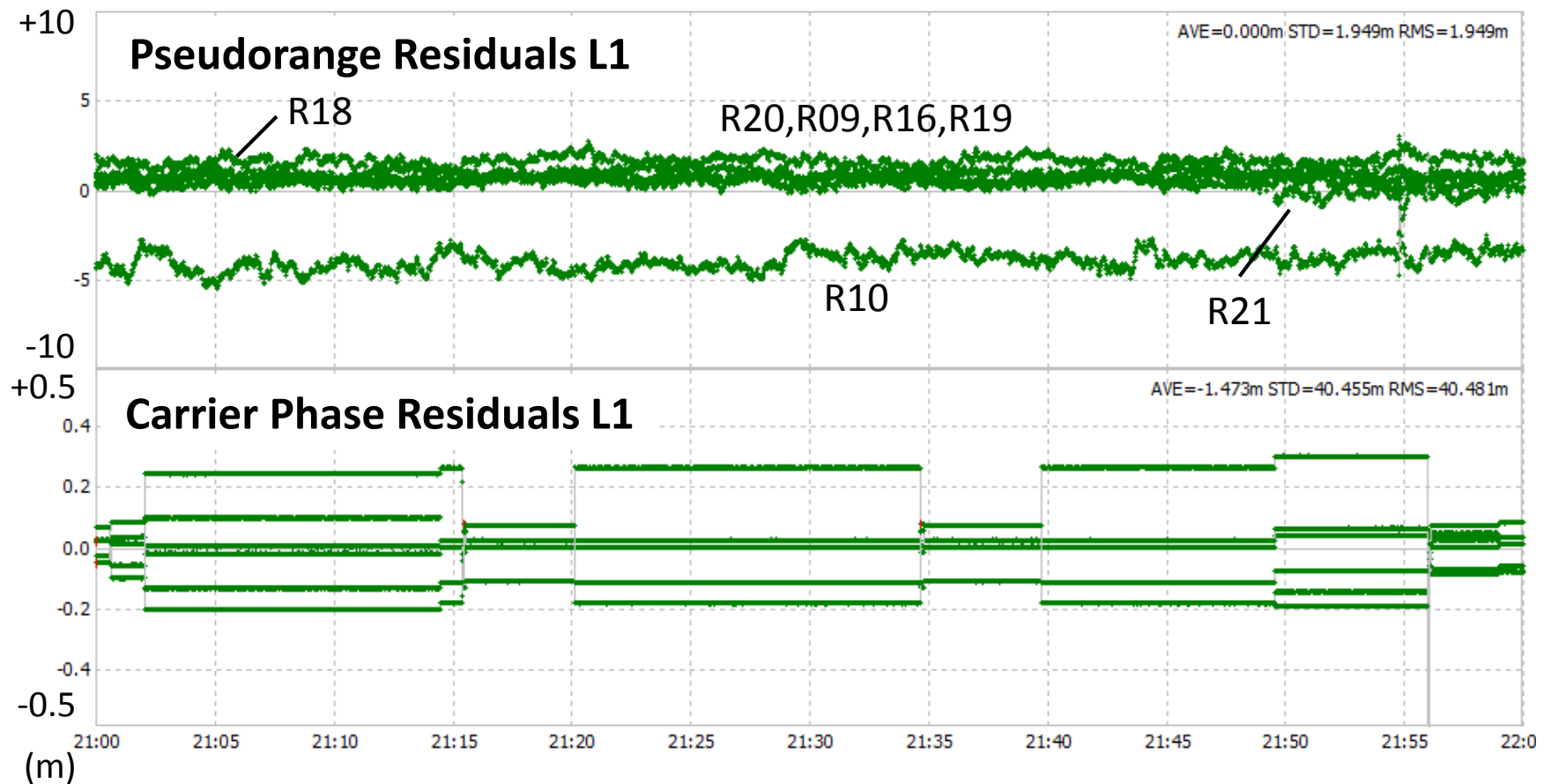
Receiver Biases between Satellites

Receiver Biases GPS/QZSS



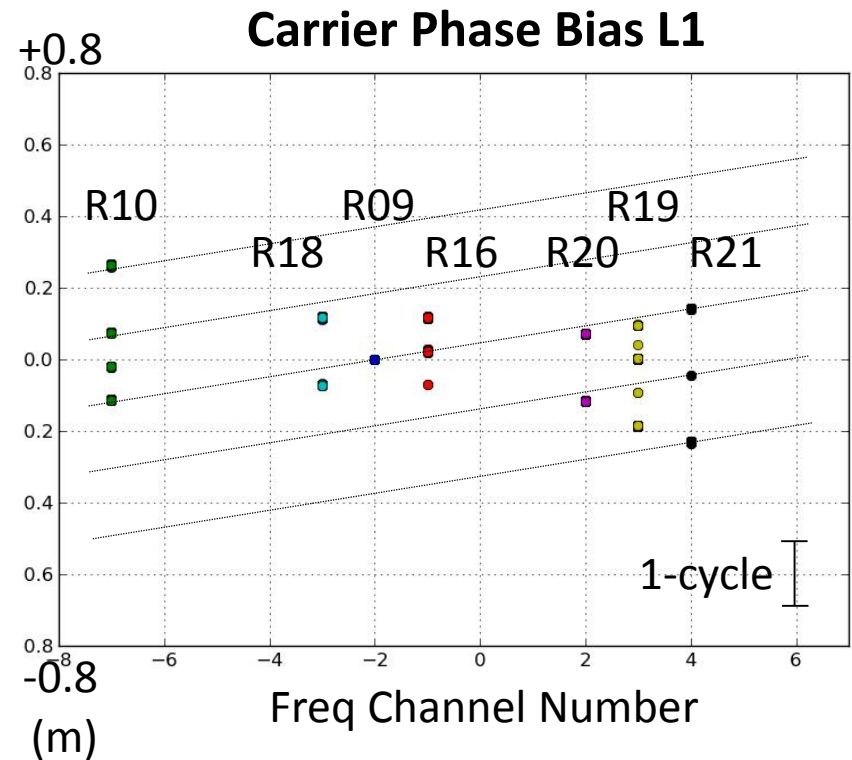
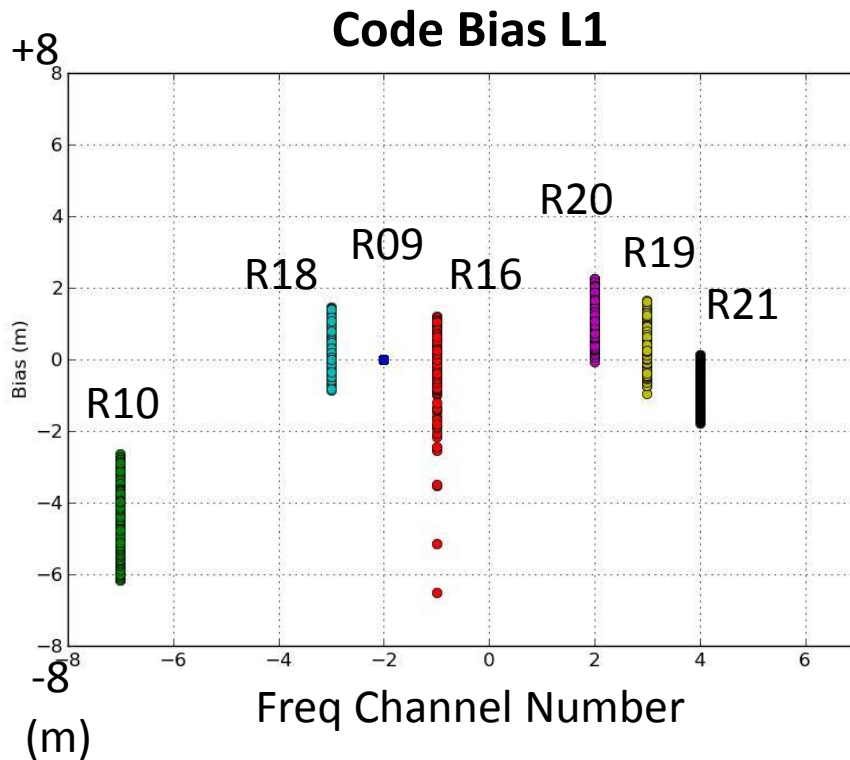
2014/10/20 21:00 - 22:00 GPST, Mode=Fixed, Min Ratio=1

Receiver Biases GLONASS (1)



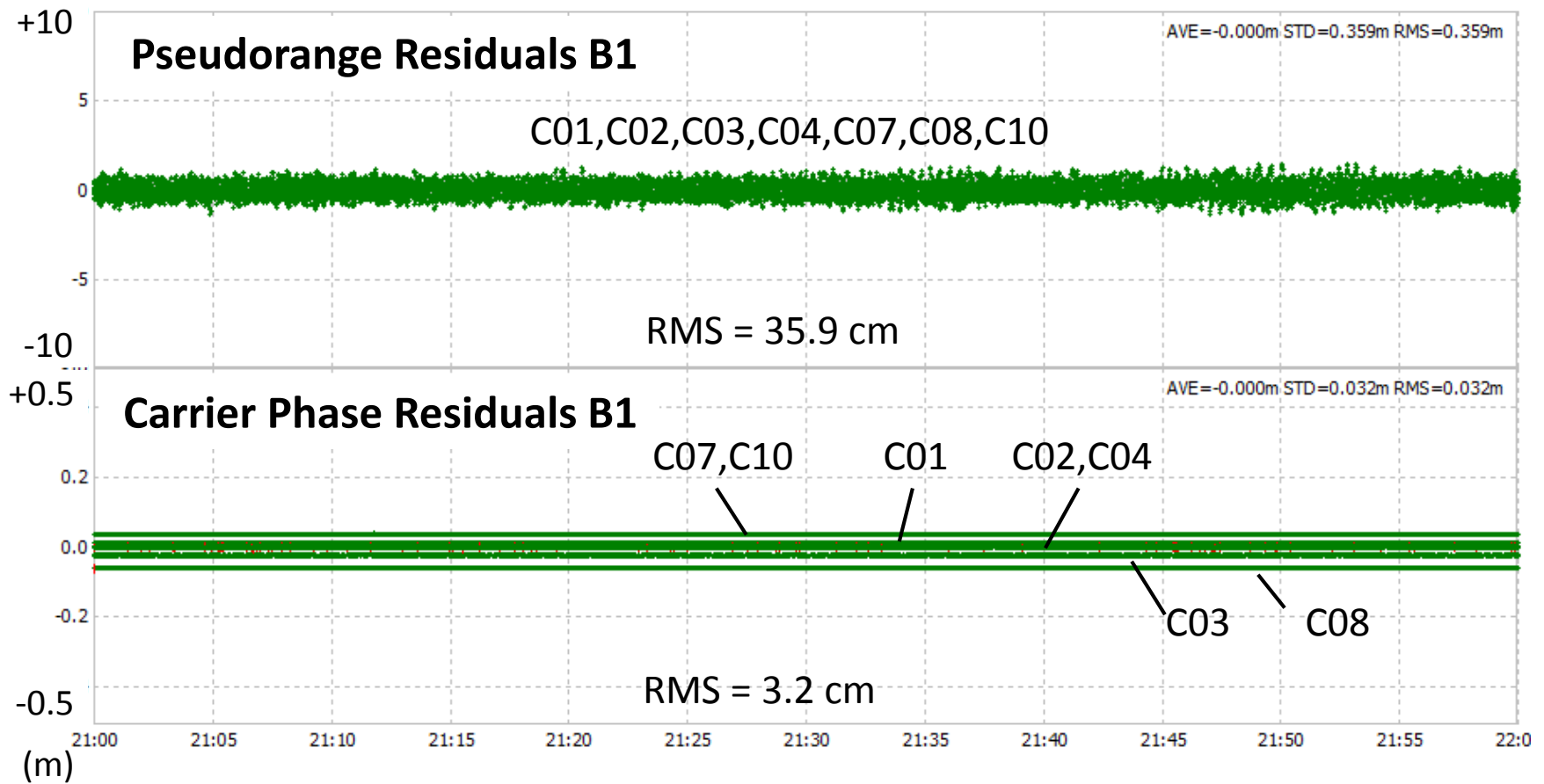
2014/10/20 21:00 - 22:00 GPST, Mode=Fixed, Min Ratio=1

Receiver Biases GLO (2)



2014/10/20 21:00 - 22:00 GPST, referenced to R09

Receiver Biases BDS



2014/10/19 21:00 - 22:00 GPST, Mode=Fixed, Min Ratio=1

Future Work

- **Low-Cost/Compact Multi-GNSS-RTK/INS Receiver**
 - Price Range: \$200 - \$500
 - Float RTK with many satellites integrated to MEMS-IMU
 - 10 cm-class accuracy expected in severe environment



NAVIO: Autopilot Shield for Raspberry Pi
(\$195 + \$40)
<http://www.emlid.com/>



(35.5 x
25.0 x
3.9 mm)

Intel Edison
(\$50)
<http://www.intel.com/>