IGS Workshop 2010

Real-time PPP with RTKLIB and IGS real-time satellite orbit and clock

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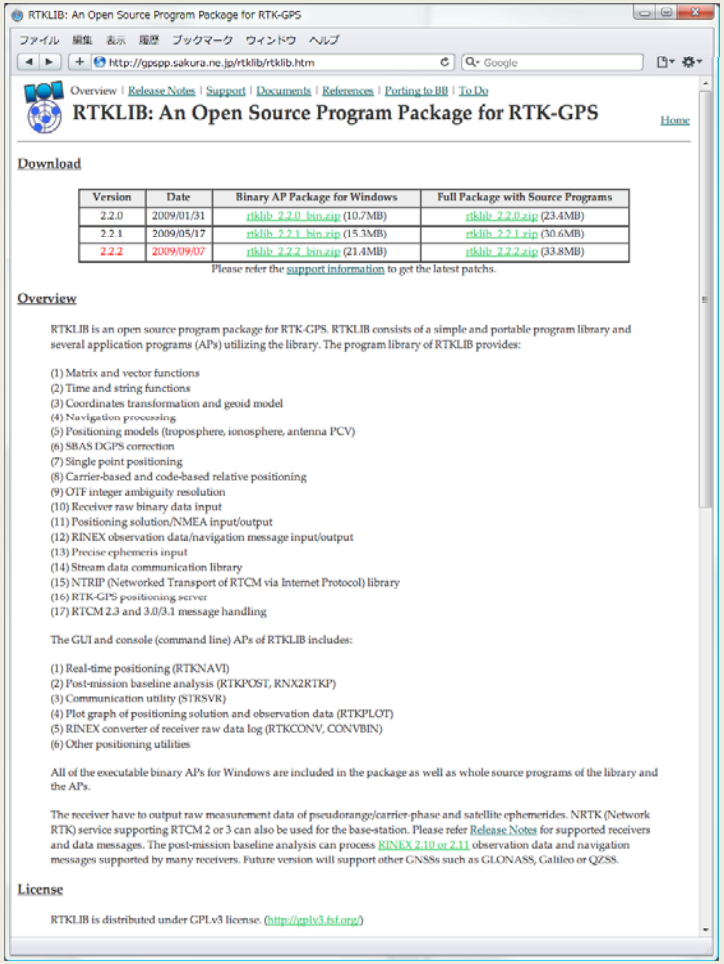
Outline

- Introduction of RTKLIB
- RTKLIB 2.4.0
- PPP implementation in RTKLIB 2.4.0
- Test results of real-time PPP with IGS RT orbits/clocks

Introduction of RTKLIB

- Open source program package for RTK-GPS/GNSS
  - Whole source codes are freely available
  - License: GPLv3
  - 5000+ downloads (2.3.0)
- Portable library + several APs
  - ANSI C + socket/pthread …
  - Portable command-line APs
  - GUI APs for Windows

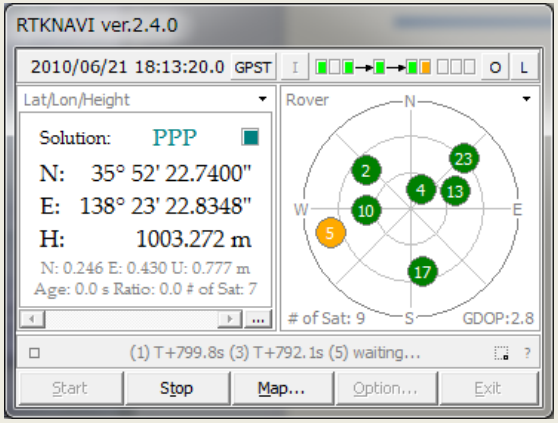


http://gpspp.sakura.ne.jp/rtklib/rtklib.htm

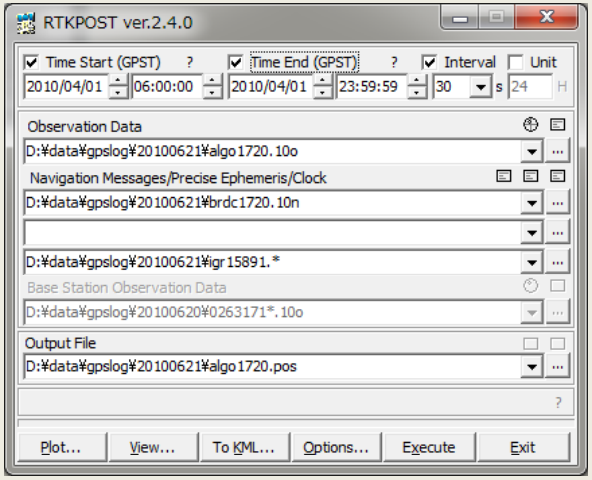
Features

- Standard and precise positioning algorithms with:
  - GPS, GLONASS, SBAS (and Galileo, QZSS)
- Various positioning modes:
  - Single, SBAS, DGPS, RTK, Static, Moving-base and PPP
- Supports many formats/protocols and receivers:
  - RINEX 2.1, RTCM v2/v3, NTRIP 1.0, NMEA183, SP3, RINEX CLK, ANTEX …
  - NovAtel, Hemisphere, u-blox, SkyTraq …
- External communication via:
  - Serial, TCP/IP, NTRIP and file streams

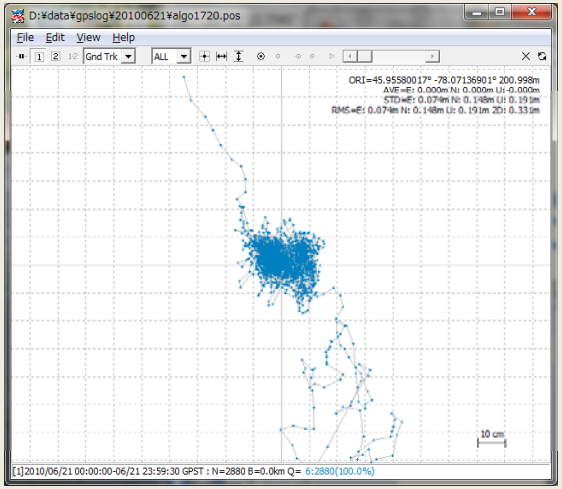
RTKLIB APs on Windows



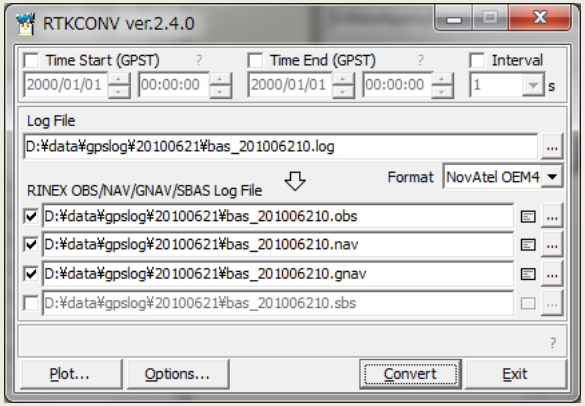
RTKNAVI: Real-time AP



RTKPOST: Post-Processing

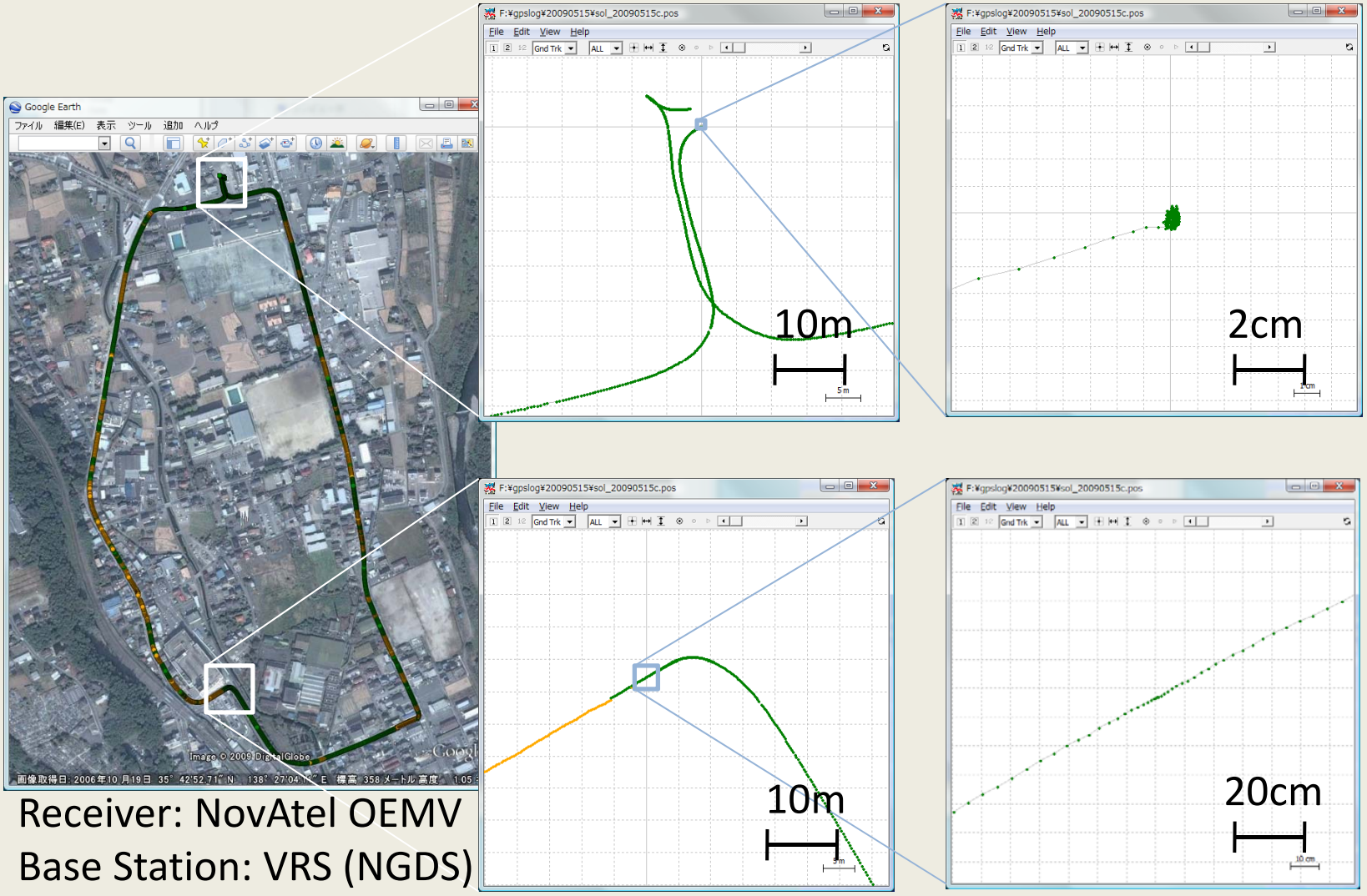


RTKPLOT: Plotting solutions



RTKCONV: RINEX converter

RTK Example by RTKNAVI

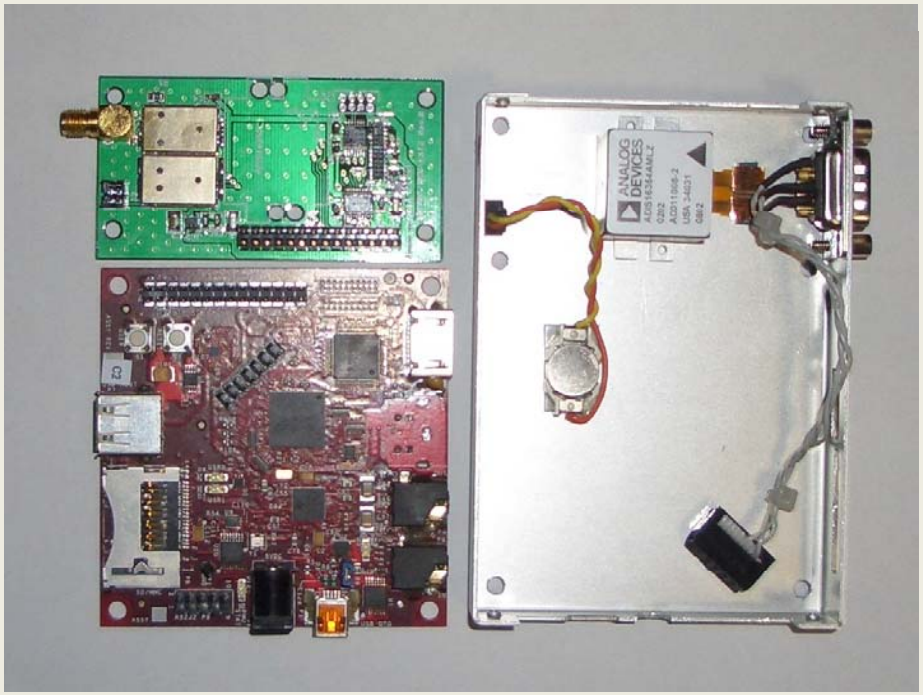


Receiver: NovAtel OEMV

Base Station: VRS (NGDS)

Low-Cost RTK Receiver with RTKLIB

- Implementation
  - CPU: Beagle Board
  - u-blox LEA-4T
  - Ubuntu 9.04
  - Wi-Fi, Bluetooth or HSDPA
- RTKRCV in RTKLIB
- GPS single-freq
- $400 w/o option



RTKLIB 2.4.0

- Almost finished but still in work for tests
- Release in July or August
- New Features:
  - Real-time and Post-processing PPP
  - Supports long-baseline RTK up to 1,000 km
  - Supports additional formats and models: RINEX clock ext., ANTEX, earth tides, satellite antenna PCV, phase windup …
  - Real-time plot by RTKPLOT

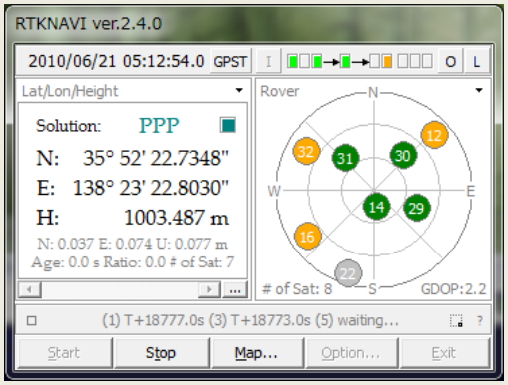
PPP Features in RTKLIB 2.4.0

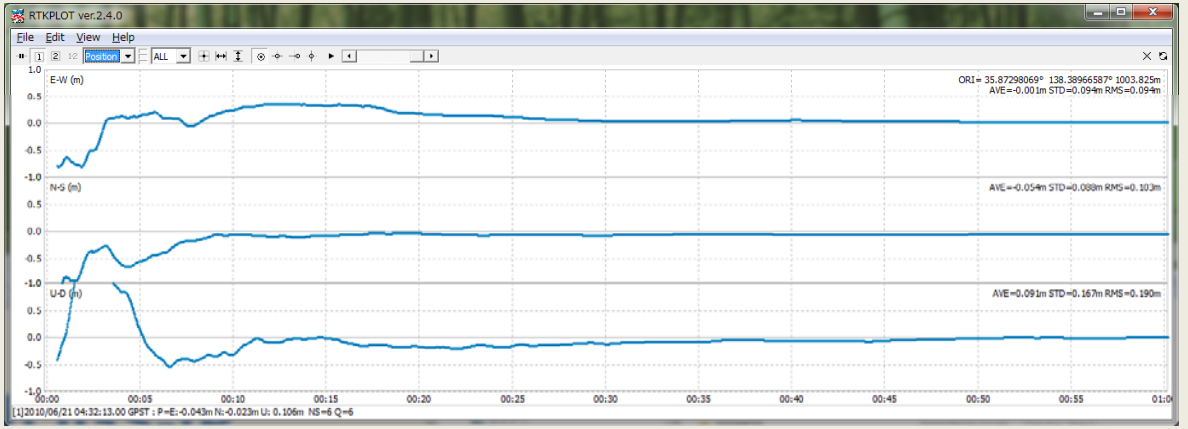
- Kalman-Filter based parameter estimator
  - PPP-Kinematic or PPP-Static mode
- Atmosphere corrections:
  - Only L3-LC with dual-freq for Ionosphere
  - ZTD estimation with NMF for troposphere
- Sold earth tides by IERS 2003 (subset)
- Satellite and receiver antenna phase center models
  - ANTEX (IGS05.ATX) or NGS
- Antenna rotation effect for phase

Satellite Orbits and Clocks for PPP

- Post Processing:
  - SP3 for orbits and clocks
  - RINEX Clock extension for clocks (CODE-5s OK)
- Real-time:
  - Broadcast + RTCM v3 SSR draft (MT 1057, 1058, 1060, 1062, 1063, 1064, 1066, 1068)
  - Broadcast + SBAS long-term/fast corrections
  - QZSS LEX MT 10, 11 (in v.2.4.x)

PPP-Static with IGS RT Orbit/Clock



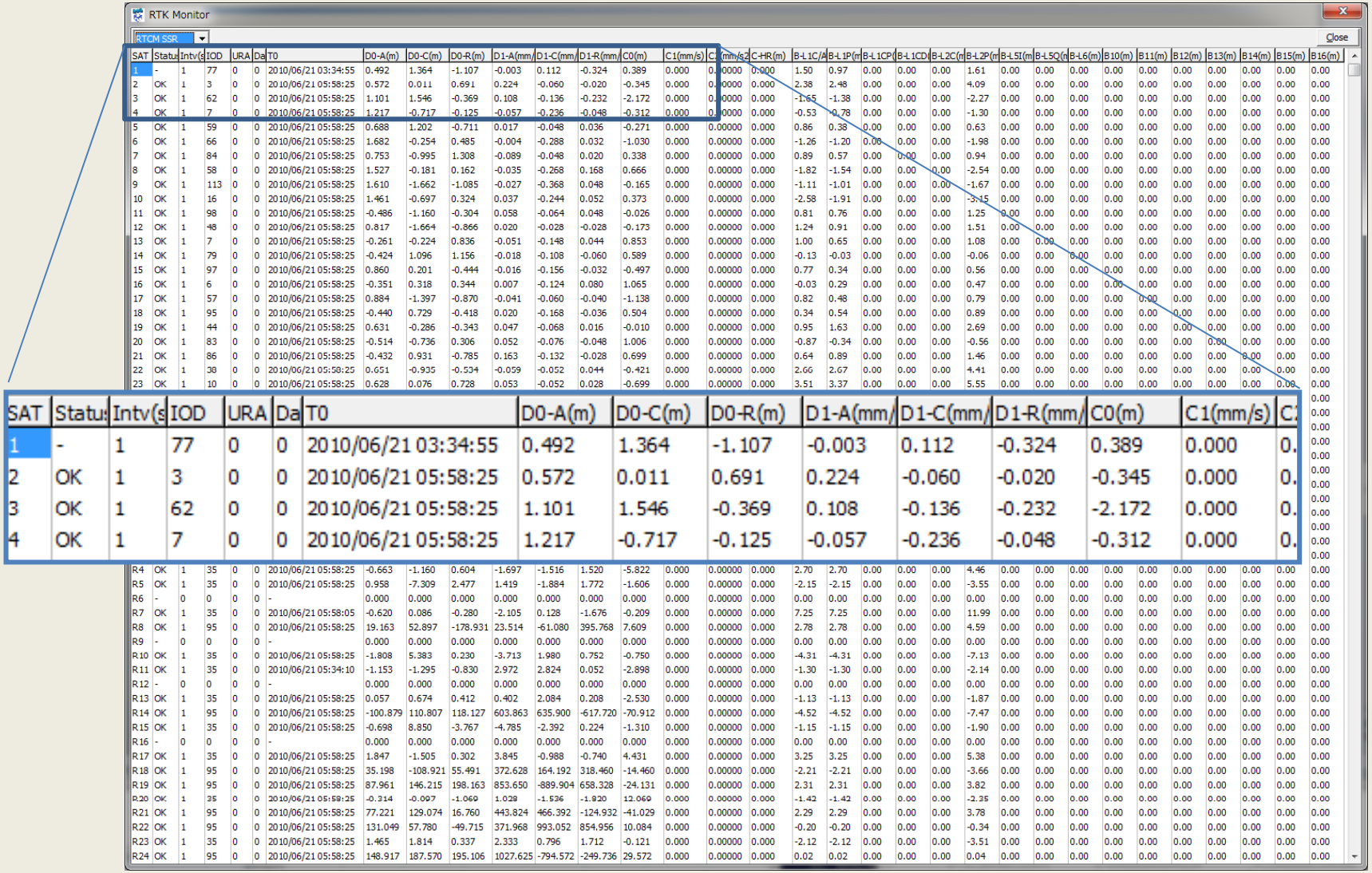


Solution RMS Error	After Convergence for		
	15 min	30 min	60 min
E-W	26.5 cm	15.4 cm	**10.6 cm**
N-S	15.4 cm	8.9 cm	**7.5 cm**
U-D	35.2 cm	16.7 cm	**12.1 cm**

2010/06/21, every 1H x 1Hz, 24 cases, NovAtel OEMV-3G

www.igs-ip.net:2101/CLK11 by BKG RTNet, GPS only

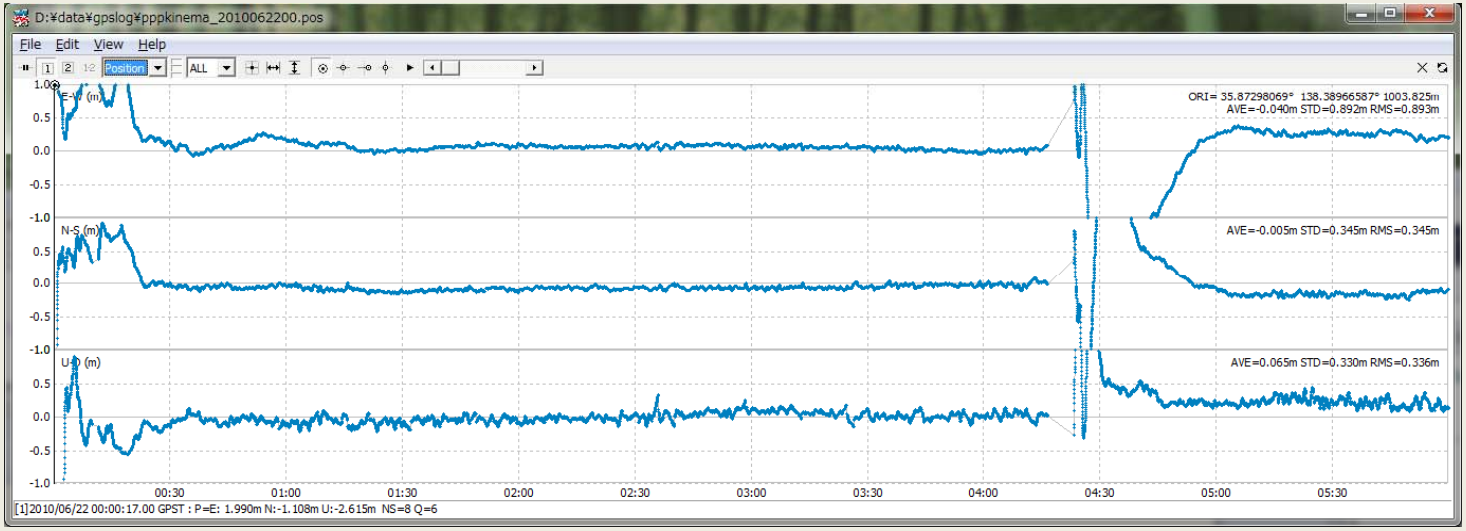
Example of Orbit/Clock Correction



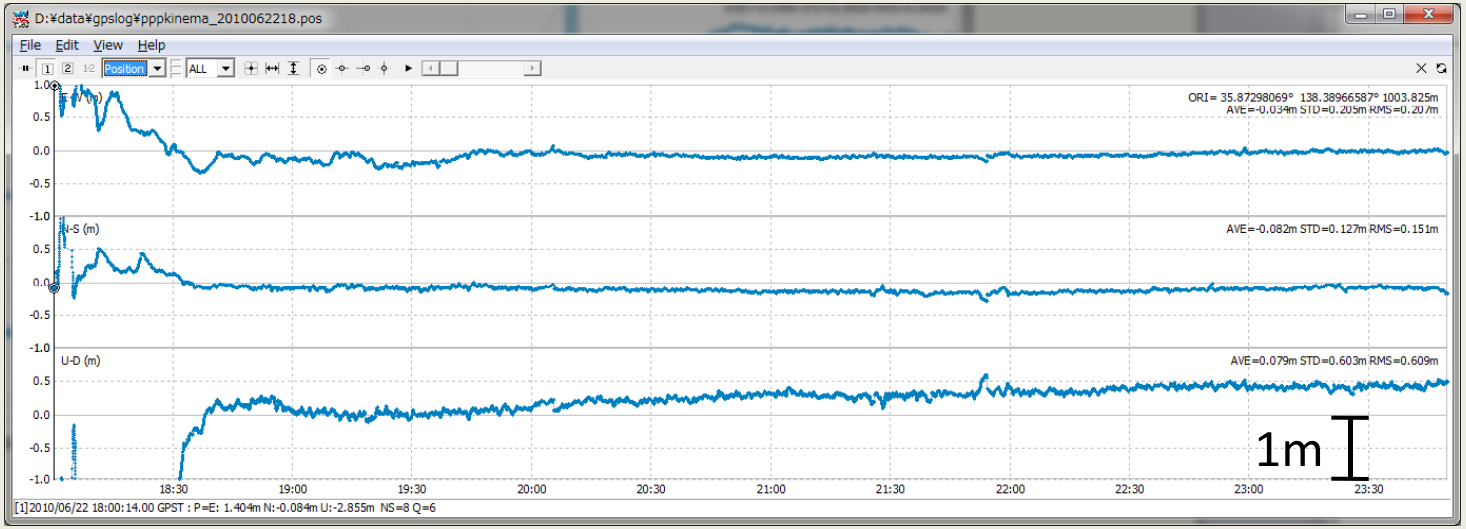
SAT	Status	Intv(s	IOD	URA	Da	T0	D0-A(m)	D0-C(m)	D0-R(m)	D1-A(mm/	D1-C(mm/	D1-R(mm/	C0(m)	C1(mm/s)	C
1	-	1	77	0	0	2010/06/21 03:34:55	0.492	1.364	-1.107	-0.003	0.112	-0.324	0.389	0.000	0.
2	OK	1	3	0	0	2010/06/21 05:58:25	0.572	0.011	0.691	0.224	-0.060	-0.020	-0.345	0.000	0.
3	OK	1	62	0	0	2010/06/21 05:58:25	1.101	1.546	-0.369	0.108	-0.136	-0.232	-2.172	0.000	0.
4	OK	1	7	0	0	2010/06/21 05:58:25	1.217	-0.717	-0.125	-0.057	-0.236	-0.048	-0.312	0.000	0.

PPP-Kinematic with IGS RT-O/C

2010/6/22 0:00:00-5:59:59



2010/6/22 18:00:00-23:59:59



www.igs-ip.net:2101/CLK11 by BKG RTNet, GPS only

Current Concerns about IGS-IP

- Minor bug (?) in implementation of RTCM SSR formats
- Needs clear definitions for coordinates of orbit corrections and polarity of delta-clocks to avoid user confusion
- Lack of user algorithms for GLONASS broadcast ephemeris
- Not good quality of GLONASS orbits and clocks (outage or out-of-date corrections)

To Do List for Future Versions

- Supports RINEX 3.0
- Supports NTRIP 2.0
- Supports SOC format
- Supports other receivers' raw formats
- Supports download tool for online GNSS data
- Supports IONEX Ionosphere corrections
- Supports INS/GNSS integration
- Supports RAIM
- ….

Summary

- Introduction of RTKLIB
- PPP implementation in RTKLIB 2.4.0
- Preliminary test results of real-time PPP with IGS RT orbits/clocks

http://gpspp.sakura.ne.jp/rtklib/rtklib.htm

or

Search “**RTKLIB**” by Google