

IGS Workshop 2010

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



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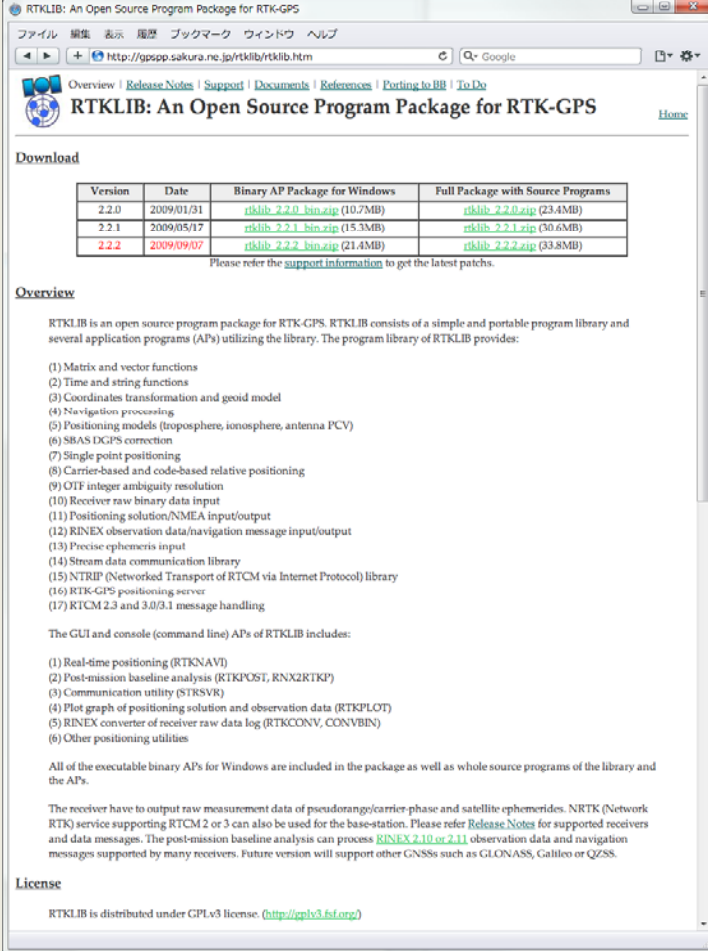
# Outline

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- 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



The screenshot shows the RTKLIB website with a navigation menu, a download table, and an overview section. The download table lists versions 2.2.0, 2.2.1, and 2.2.2 with their respective dates and file sizes. The overview section lists various functions and utilities provided by the library.

Version	Date	Binary AP Package for Windows	Full Package with Source Programs
2.2.0	2009/01/31	<a href="#">rtklib_2.2.0_bin.zip</a> (10.7MB)	<a href="#">rtklib_2.2.0.zip</a> (23.4MB)
2.2.1	2009/05/17	<a href="#">rtklib_2.2.1_bin.zip</a> (15.3MB)	<a href="#">rtklib_2.2.1.zip</a> (30.6MB)
2.2.2	2009/09/07	<a href="#">rtklib_2.2.2_bin.zip</a> (21.4MB)	<a href="#">rtklib_2.2.2.zip</a> (33.8MB)

**Overview**

RTKLIB is an open source program package for RTK-GPS. RTKLIB consists of a simple and portable program library and several application programs (APs) utilizing the library. The program library of RTKLIB provides:

- (1) Matrix and vector functions
- (2) Time and string functions
- (3) Coordinates transformation and geoid model
- (4) Navigation processing
- (5) Positioning models (troposphere, ionosphere, antenna PCV)
- (6) SBAS DGPS correction
- (7) Single point positioning
- (8) Carrier-based and code-based relative positioning
- (9) OTF integer ambiguity resolution
- (10) Receiver raw binary data input
- (11) Positioning solution/NMEA input/output
- (12) RINEX observation data/navigation message input/output
- (13) Precise ephemeris input
- (14) Stream data communication library
- (15) NTRIP (Networked Transport of RTCM via Internet Protocol) library
- (16) RTK-GPS positioning server
- (17) RTCM 2.3 and 3.0/3.1 message handling

The GUI and console (command line) APs of RTKLIB includes:

- (1) Real-time positioning (RTKNAVI)
- (2) Post-mission baseline analysis (RTKPOST, RNX2RTKP)
- (3) Communication utility (STRSVK)
- (4) Plot graph of positioning solution and observation data (RTKPLOT)
- (5) RINEX converter of receiver raw data log (RTKCONV, CONVBIN)
- (6) Other positioning utilities

All of the executable binary APs for Windows are included in the package as well as whole source programs of the library and the APs.

The receiver have to output raw measurement data of pseudorange/carrier phase and satellite ephemerides. NRTK (Network RTK) service supporting RTCM 2 or 3 can also be used for the base-station. Please refer [Release Notes](#) for supported receivers and data messages. The post-mission baseline analysis can process [RINEX 2.10 or 2.11](#) observation data and navigation messages supported by many receivers. Future version will support other GNSSs such as GLONASS, Galileo or QZSS.

**License**

RTKLIB is distributed under GPLv3 license. (<http://gpv3.fsf.org/>)

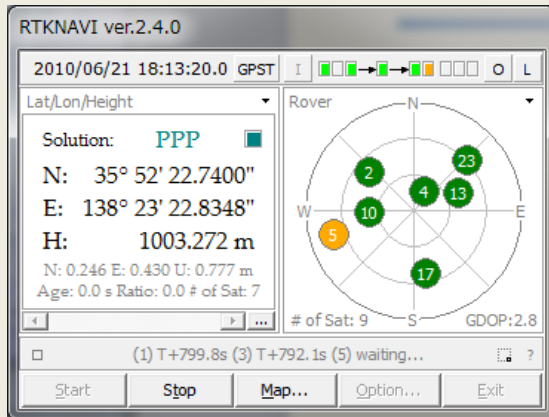
<http://gpspp.sakura.ne.jp/rtklib/rtklib.htm>

# Features

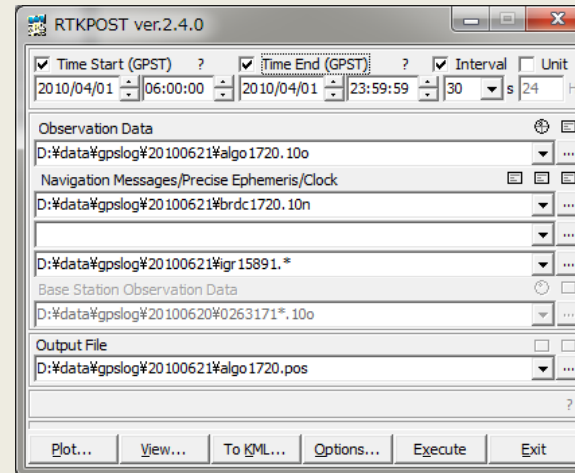
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- Standard and precise positioning algorithms with:
  - GPS, GLONASS, SBAS (and Galileo, QZSS)
- Various positioning modes:
  - Single, SBAS, DGPS, RTK, Static, Moving-base and PPP
- Supports many formats/protocols and receivers:
  - RINEX 2.1, RTCM 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

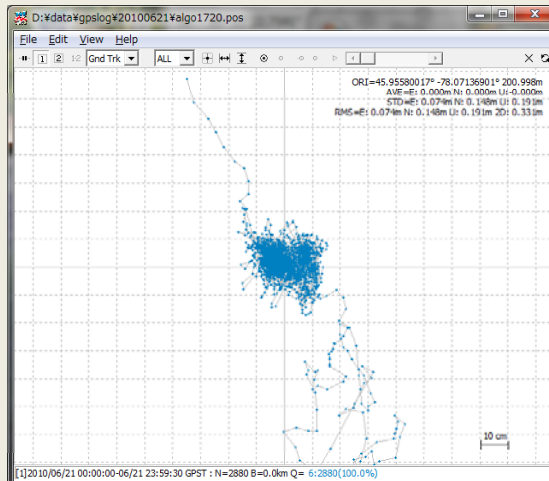
# RTKLIB APs on Windows



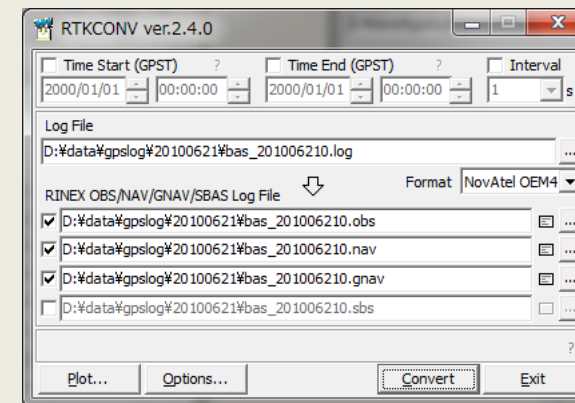
RTKNAVI: Real-time AP



RTKPOST: Post-Processing

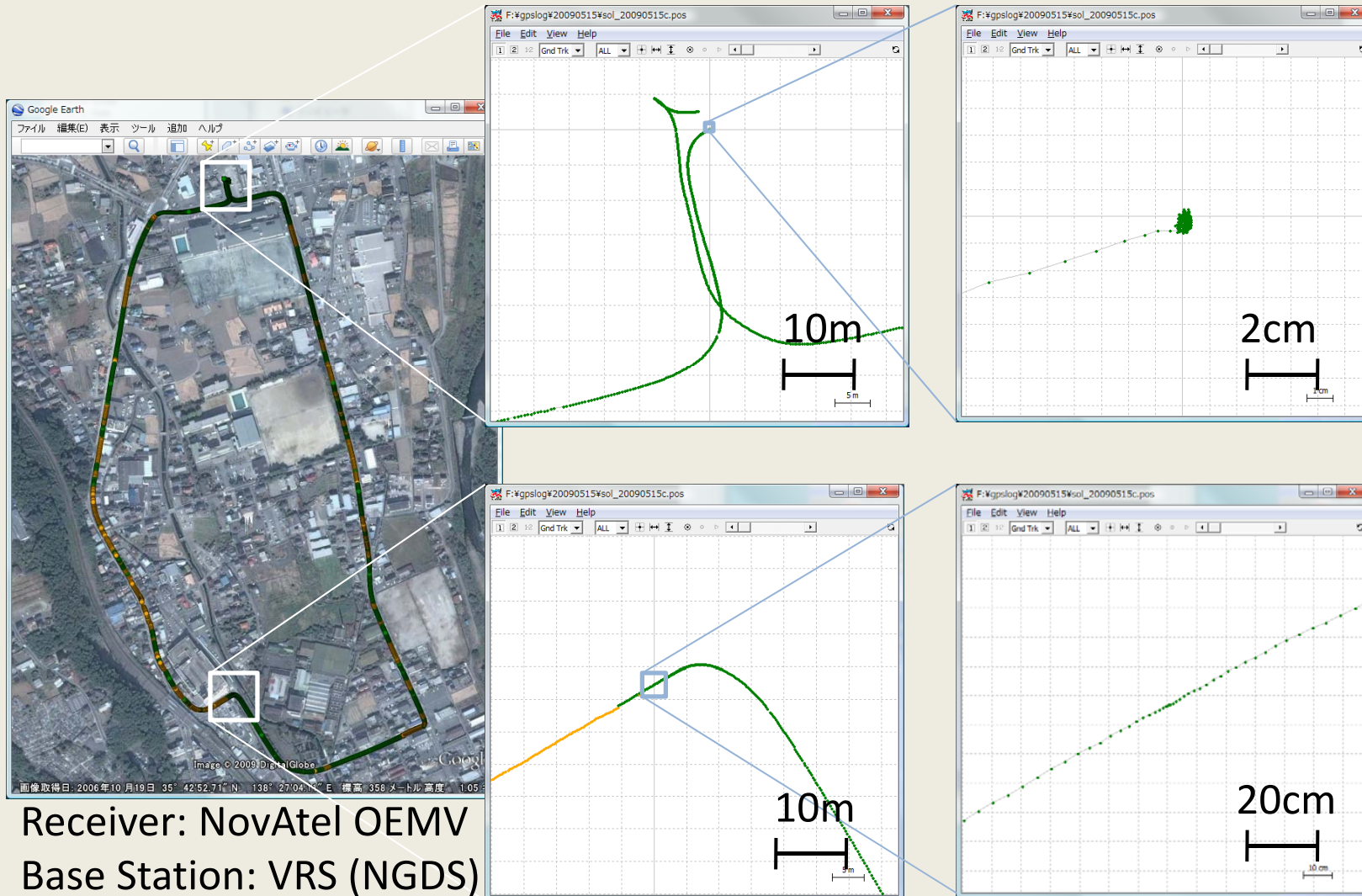


RTKPLOT: Plotting solutions



RTKCONV: RINEX converter

# RTK Example by RTKNAVI



# 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

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- 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

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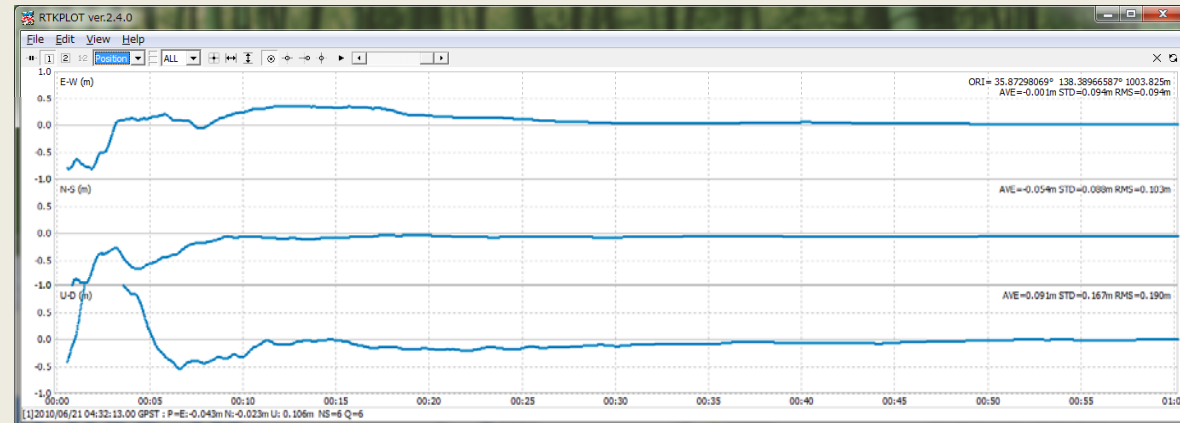
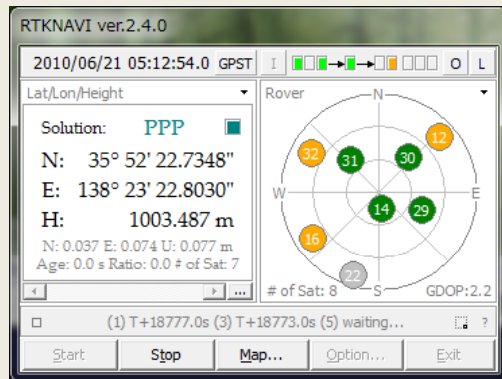
- Kalman-Filter based parameter estimator
  - PPP-Kinematic or PPP-Static mode
- Atmosphere corrections:
  - Only L3-LC with dual-freq for Ionosphere
  - ZTD estimation with NMF for troposphere
- Solid earth tides by IERS 2003 (subset)
- Satellite and receiver antenna phase center models
  - ANTEX (IGS05.ATX)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

# Satellite Orbits and Clocks for PPP

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- 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	<b>10.6 cm</b>
N-S	15.4 cm	8.9 cm	<b>7.5 cm</b>
U-D	35.2 cm	16.7 cm	<b>12.1 cm</b>

2010/06/21, every 1H x 1Hz, 24 cases, NovAtel OEMV-3G  
[www.igs-ip.net:2101/CLK11](http://www.igs-ip.net:2101/CLK11) by BKG RTNet, GPS only

# Example of Orbit/Clock Correction

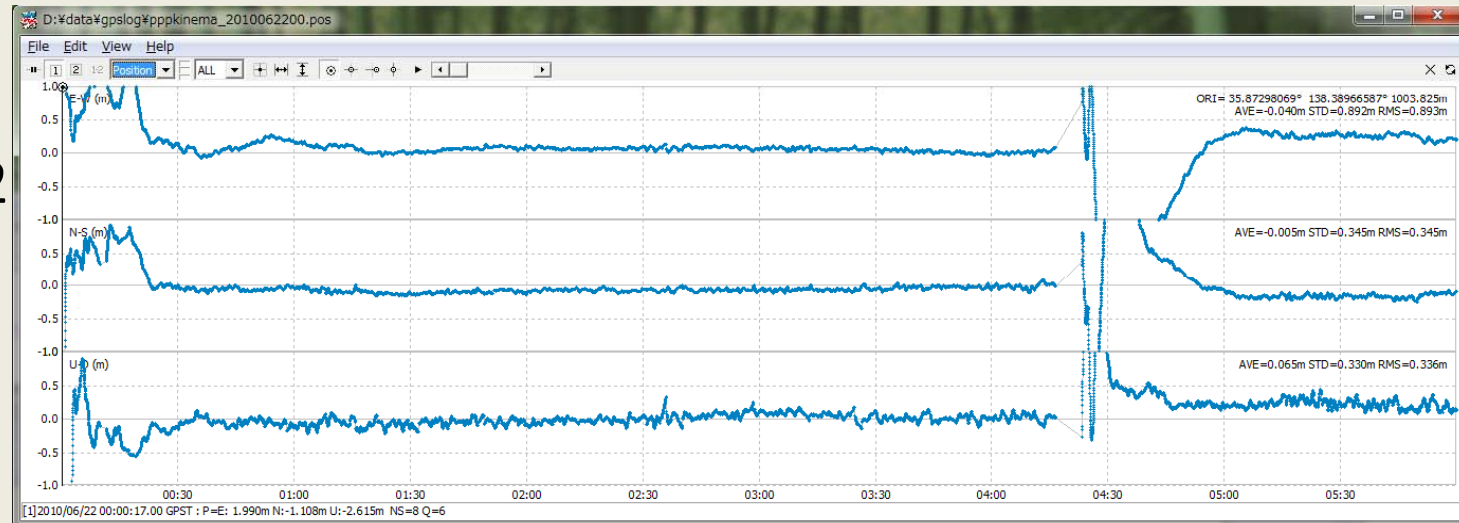
SAT	Status	Intv(s)	IOD	URA	Da	TO	D0-A(m)	D0-C(m)	D0-R(m)	D1-A(mm)	D1-C(mm)	D1-R(mm)	C0(m)	C1(mm/s)	C2(mm/s <sup>2</sup> )	C+R(m)	B+L1C	B+L1P(m)	B+L1CP	B+L1CD	B+L2C(m)	B+L2P(m)	B+L5I(m)	B+L5Q(m)	B+L6(m)	B10(m)	B11(m)	B12(m)	B13(m)	B14(m)	B15(m)	B16(m)		
1	-	1	77	0	0	2010/06/21 03:34:55	0.492	1.364	-1.107	-0.003	0.112	-0.324	0.389	0.000	0.0000	0.000	1.50	0.97	0.00	0.00	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
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	0.0000	0.000	2.38	2.48	0.00	0.00	0.00	4.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
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	0.0000	0.000	-1.65	-1.38	0.00	0.00	0.00	-2.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
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	0.0000	0.000	-0.53	0.78	0.00	0.00	0.00	-1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

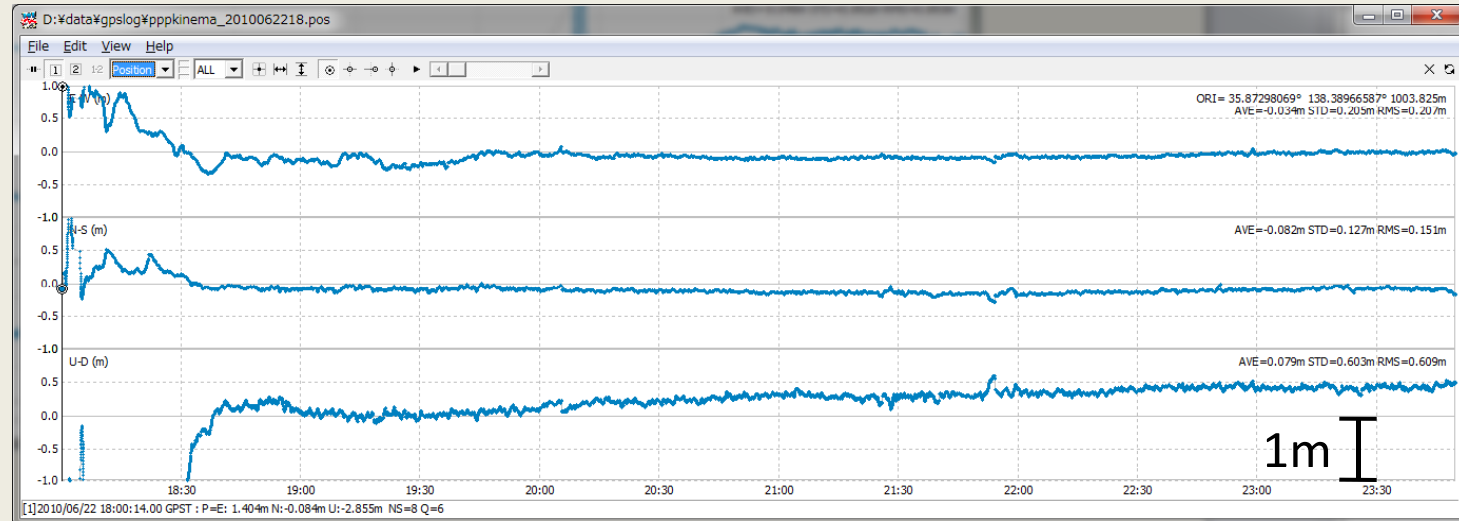
SAT	Status	Intv(s)	IOD	URA	Da	TO	D0-A(m)	D0-C(m)	D0-R(m)	D1-A(mm)	D1-C(mm)	D1-R(mm)	C0(m)	C1(mm/s)	C2(mm/s <sup>2</sup> )	C+R(m)
1	-	1	77	0	0	2010/06/21 03:34:55	0.492	1.364	-1.107	-0.003	0.112	-0.324	0.389	0.000	0.0000	0.000
2	OK	1	3	0	0	2010/06/21 05:58:25	0.572	0.011	0.691	0.224	-0.060	-0.020	-0.345	0.000	0.0000	0.000
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	0.0000	0.000
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	0.0000	0.000

# 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](http://www.igs-ip.net:2101/CLK11) by BKG RTNet, GPS only

# Current Concerns about IGS-IP

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- 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

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- 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

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- 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