



On-line Precise Point Positioning 'How To Use' Document

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1. How to use PPP

1.1. Service Specifications

1.1.1. Description

The Canadian Spatial Reference System (CSRS) Precise Point Positioning (PPP) service provides post-processed position estimates over the Internet from GPS observation files submitted by the user. Precise position estimates are referred to the CSRS standard North American Datum of 1983 (NAD83) as well as the International Terrestrial Reference Frame (ITRF). Single station position estimates are computed for users operating in static or kinematic modes using precise GPS orbits and clocks. The online PPP positioning service is designed to minimize user interaction while providing the best possible solution for the given observation availability. Currently, users need only specify the mode of processing -- static or kinematic -- and the reference frame for position output -- NAD83(CSRS) or ITRF. The observations processed are selected from the submitted RINEX file in the following order:

1. **L1 and L2 pseudo-range and carrier phase observations**
2. **L1 pseudo-range observation**

An L1 pseudo-range only solution will be performed in case of failure of the L1 and L2 pseudo-range and carrier phase solution. Failure to detect one of the above two observation sets results in an unsuccessful job termination.

1.1.2. Availability of Precise Orbits and Clocks

The PPP application can only process GPS observations if precise GPS orbits and clocks products are available. It will use the best products available at the time the data is submitted. The Availability Table below lists the solutions that can be obtained. It is important to note that the quality of the GPS orbit and clock estimates, and consequently of the PPP derived positions, has improved from 10cm and several nanoseconds in 1994 to about 2cm and 0.1 nanoseconds in 2003.

PPP Availability Table

Period		IGS Product		Latency		Solution Interval
From	To	Orbits	Clocks / Format	From	Delay	
Jan 02, 1994	Oct 28, 2000	Final	Final / SP3	none		15 minute
Oct 29, 2000	21 GPS Days prior to Today	Final	Final / CLK	none		User sampling
21 GPS Days prior to Today	Today	Final	Final / CLK	End of Current GPS day	14 to 21 days	User sampling
Start of current GPS Day	End of current GPS Days	Rapid	Rapid / CLK	End of Current GPS day	17 hours	User sampling
Start of current GPS Day	End of current GPS Days	Ultra	Ultra / SP3	End of Current GPS day	3 hours	15 minutes
Start of current GPS Day	Noon of current GPS Day	Ultra	Ultra / SP3	Start of Current GPS day	15 hours	15 minutes

1.1.3. Applicability

Since PPP processing is based on precise GPS orbit and clocks products that are global in nature it may be used to process GPS observations made anywhere on or near Earth, at anytime of day. Observation session duration is subject to the following restrictions:

Minimum duration of GPS data set

There is no minimum length for a GPS observation session . However, the quality of a PPP computed positions will not be optimal until the carrier phase ambiguities have converged. For short data sets, positions will effectively be calculated using only the pseudo-range observations. Longer data sets make it possible to resolve the ambiguities required to recover positions using the more precise carrier phase observations.

Maximum duration of GPS data set

Data sets up to six days long can be processed with PPP providing the uncompressed RINEX observation file is less than 100Mb. Submission of a file exceeding 100Mb will result in an unsuccessful job termination.

1.1.4. User Support

PPP was designed to be, as much as possible, a self-serve application. Error messages for unsuccessful job termination are provided to help users resolve common problems. A more severe failure of the PPP application will automatically generate a notification to GSD personnel to initiate investigation of the problem leading to user follow-up. In case of recurring problems, GSD's Information Services Unit personnel can be contacted via e-mail or phone.

Email: information@geod.nrcan.gc.ca

Tel. (613) 995-4410 or 992-2061

Fax. (613) 995-3215

User feedbacks and suggestions for future PPP service improvements are always welcome and can be provided via either internet or e-mail.

http://www.geod.nrcan.gc.ca/index_e/contact_e/comment_e.html

or

Email: comments@geod.nrcan.gc.ca

1.2. Guidelines

1.2.1. Data Submission

Assuming you have created a valid RINEX observation file from your raw GPS observation data, five simple steps are all that is needed to use PPP.

- **Step 1**

Using the browse button, select the RINEX observation file you wish to process;

- **Step 2**

Select the mode of processing required: **static** for a "fixed" GPS receiver or **kinematic** for a "moving" GPS receiver;

- **Step 3**

Select the Reference Frame for output positions: **NAD83(CSRS)** or **ITRF**;

- **Step 4**

Press the submit button;

- **Step 5**

Once processing has successfully completed, select from the "Results Download" box the processing output files you wish to retrieve. PPP results should be verified to ensure their validity.

1.2.2. Data Format

The only valid formats for GPS pseudo-range and carrier phase observations are RINEX and its variation, Compact RINEX. Any other format will result in an unsuccessful job termination. To minimize upload time, file compression is recommended. The greatest file size reduction is achieved by compressing a Compact RINEX file.

1.2.2.1. RINEX

The RINEX format (Receiver Independent Exchange Format) was designed to facilitate the exchange of GPS data produced by receivers of different manufacturers. Most GPS manufacturers offer software to transform their native output format to the RINEX standard. Third party software can also be used to translate receiver specific observation files into RINEX formatted files (for example: [UNAVCO's TEQC](#) for geodetic type receiver, [GRINGO](#) for **Garmin hand-held type receiver**).

[RINEX Format Description](#)

1.2.2.2. Compact RINEX

The Compact RINEX format, developed by Y. Hatanaka, Geographical Survey Institute, exploits features of the RINEX format to pack the

original GPS observations in a smaller ASCII file. Encoding and decoding software is required to transform RINEX files into Compact RINEX and vice versa.

[Compact RINEX Format Description](#)

[Compact RINEX Software README file](#)

[Compact RINEX Compression/Decompression Software](#)

1.2.2.3. File Compression

Since both the RINEX and Compact RINEX are in ASCII format, it is possible to use standard compression algorithms to further reduce the upload file size.

PPP Compatible Compression Modes

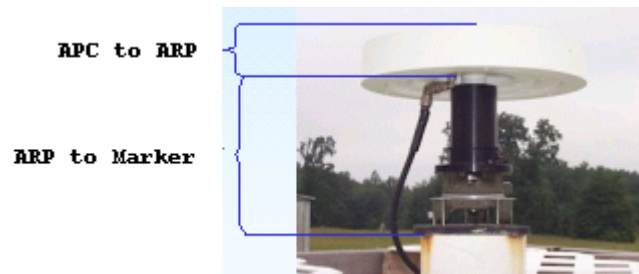
<u>Mode</u>	<u>File Extension</u>
gzip	.gz
zip	.z
unix compression	.Z

Note that although the zip mode supports file archiving, PPP currently expects a submitted zip file to contain only one RINEX or Compact RINEX observation file.

1.2.3. Antenna Information

Online PPP computes the height, as well as latitude and longitude, of the antenna phase centre realised by the processed observations. In order to obtain the position of the ground marker, the vertical distance between the ground marker and the antenna reference point (ARP) as well as the distance between

the ARP and the antenna phase centre (APC) must be known.



ARP to Marker

The vertical distance between the point to be positioned and the antenna reference point is a function of the antenna installation. If known, the ARP to marker distance in units of metre should be input as the H component of the "ANTENNA: DELTA H/E/N" RINEX header record (see section 1.2.2.1). Note that the E and N components, even if non-zero, are not considered in the PPP computations at this time.

ARP to ACP

The distance between the antenna reference point and its phase center is frequency dependent and a function of the electronic characteristics of the antenna. It is usually obtained from laboratory or field calibration and is expected to remain constant among all antennas of a given model and manufacturer. Online PPP uses the antenna phase centre calibration values published by the International GPS Service (IGS) and by the [U.S. National Geodetic Survey \(NGS\)](#). The IGS convention for [antenna model identification](#) is used to uniquely identify on the "ANT # / TYPE" RINEX header record the GPS antenna model used at data collection. The same model identification number is also used to retrieve from the antenna phase calibration table the appropriate ARP to ACP values.

The "marker to ARP" and "ARP to APC" distances used for PPP computations are included on the output summary report and should be verified to validate the computed position.

1.2.4. Reference Frame

Online PPP position estimates can be obtained in NAD83(CSRS), the standard Canadian national reference frame, or the global ITRF reference frame. Since coordinates in both reference frames are not output by default in the position file and are not directly compatible, users need to select whichever system is most appropriate for their purpose.

1.2.4.1. NAD83(CSRS)

The North American Datum of 1983 (NAD83) is the adopted reference coordinate system in both Canada (NAD83(CSRS)) and the United States (NAD83(NSRS)). It is a 3-dimensional representation of the NAD83 horizontal datum adopted in 1986. To comply with a resolution of the International Association of Geodesy (IAG), the North American plate fixed NAD83(CSRS) is rigorously related to the current International Terrestrial Reference Frame via a 6 parameter transformation (3 translations and three rotations). The ITRF scale was adopted for NAD83(CSRS) so that the two reference frames are very similar except for an approximate 2m difference in earth centre position.

[Definition of NAD83\(CSRS\) and transformation to ITRF](#)

1.2.4.2. ITRF

The models that define the geocentric reference system along with the station coordinates and velocities used to realise the International Terrestrial Reference Frame currently give the best representation of the solid Earth and its time variations on a global scale. The coordinates of the reference frame are based on combinations of several geodetic space techniques including VLBI, SLR, DORIS and GPS. The ITRF reference system is global and as such is not fixed to any specific tectonic plate. Therefore, coordinates defined in ITRF will change over time due to the displacement of the plates and possibly to some intra-plate motions. It is for that reason that the ITRF frame defined in terms of both coordinates and velocities is referenced to a specific epoch of time.

The specific ITRF frame used by PPP is the one realised by IGS at the epoch for which the precise GPS orbits were computed. With the production of orbit estimates on a daily basis, the ITRF realisation epoch will always be within a day of the submitted GPS data.

[International Terrestrial Reference Frame \(ITRF\) Definition](#)

[ITRF2000 Definition](#)

1.3. Output Description

PPP generates two forms of output; summary reports (short and detailed) and graphical time series plots. All output can be downloaded using the link provided in the PPP service returned e-mail. The short summary includes session results and critical statistics giving the "vital signs" of the solution. It is useful to quickly validate the PPP results. The detailed summary is in two text files, the .sum file containing average session results and the .pos file with epoch-by-epoch parameter estimates. The graphical outputs included as part of the short summary (postscript file) depict time series of estimated parameters with corresponding standard deviations, observations residuals and phase ambiguities. The following sections provide a description of the PPP output.

1.3.1. The CSRS-PPP Summary File

The CSRS-PPP summary filename is created by changing the extension of the user submitted RINEX observation file to .sum. It contains a header record followed by 3 sections. Section 1 is a File Summary that specifies the INPUT, OUTPUT and INTERNAL filenames used during processing. Section 2 gives the processing parameters extracted from the INTERNAL files (maintained centrally at the CSRS-PPP site). It reports Cycle slip filter thresholds (2.1), Satellite antenna phase center (APC) offsets (2.2), User antenna phase center (APC) offsets (2.3), Reference frame transformation parameters between ITRF and NAD83-CSRS (2.4), ocean loading coefficients (2.5) and surface meteorological data (2.6). Section 3 is a Session Processing Summary that reports Processing Options (3.1), Observation Session (3.2), Coordinate estimates (3.3), Coordinate differences (3.4), Receiver clock estimates (3.5) and Observation residuals (3.6).

The Header Record

The header record contains the application name, the version of the executable, the date it was compiled and contact information.

```

-----
GPS Precise Point Positioning (CSRS-PPP      1.01/2003-11-12)
Natural Resources Canada, Geodetic Survey Division, Geomatics Canada
615 Booth Street, room 440, Ottawa, Ontario, Canada, K1A 0E9
Phone: (613) 995-4410, fax: (613) 995-3215
Email: information@geod.nrcan.gc.ca
-----

```

The File Summary (SECTION 1)

The File Summary (SECTION 1) specifies the INPUT, OUTPUT and INTERNAL filenames used during processing.

The **INPUT files** include the RINEX observations submitted by the user, the processing options selected on-line, the precise GPS satellite orbits and clocks and an ionospheric delay grid (for single frequency processing).

The **OUTPUT files**, named by changing the extension of the submitted RINEX file, provide a processing summary (.sum), estimated station parameters for each epoch observed (.pos), satellite residuals and ambiguity estimates (.res) and a short session summary (.ses).

The **INTERNAL files** are stored on the CSRS-PPP server and updated by its administrator. They contain filter thresholds for cycle slip detection, satellite antenna phase center offsets, GPS antenna phase center offsets, ocean loading coefficients for selected locations and transformation parameters between ITRF and NAD83-CSRS reference frames.

```

-----
SECTION 1. File Summary
-----
Content                INPUT Filenames
Observations           gs200090.04o
Processing options     gpSPACE.cmd
Satellite orbits      /vhe/macs/home/heroux/work/data/igr12525.sp3
Satellite clocks      /vhe/macs/home/heroux/work/data/igr12525.clk
Ionospheric model     /vhe/macs/home/heroux/work/data/brdc0090.04i
                       OUTPUT Filenames
Processing summary     gs200090.sum
Estimated parameters  gs200090.pos
Satellite residuals   gs200090.res
Session summary       gs200090.ses
                       INTERNAL Filenames
Filter thresholds     /nfs/kepler/home/heroux/work/pace/cfg/gpSPACE.flt
Satellite offsets     /nfs/kepler/home/heroux/work/pace/cfg/gpSPACE.svb
Antenna offsets       /nfs/kepler/home/heroux/work/pace/cfg/gpSPACE.pcv
Ocean loading          /nfs/kepler/home/heroux/work/pace/cfg/gpSPACE.olc
ITR->NAD transform    /nfs/kepler/home/heroux/work/pace/cfg/gpSPACE.trf
-----

```

The Summary Of Processing Parameters (SECTION 2)

The Summary of Processing Parameters (SECTION 2) reports the constants that were input from the selected internal files and set by the application prior to initiating the processing of the user observation session.

```
-----  
SECTION 2. Summary of processing parameters  
-----
```

Cycle slip filter thresholds (Section 2.1)

The tolerances for carrier narrowlane and code/carrier widelane variation over the observing interval are used by the application pre-processor to detect cycle slips. Cycle slips are detected in code/carrier processing and during dual-frequency code filtering.

```
2.1 Cycle slip filter thresholds - CM  
Narrowlane : 20.0      Widelane : 500.0
```

Satellite antenna phase center offsets (Section 2.2)

Adopted by IGS for their GPS orbit and clock products, they are the conventional components of the vector between the satellite center of mass and the phase center of the antenna L1/L2 ionospheric-free combination, in the satellite reference frame (along, across and radial). The PRNs active during the user observation session are listed under the satellite block headers (IIR, IIA, II) followed by the list of inactive PRNs.

```
2.2 Satellite antenna phase center (APC) offsets - MM  
Center of mass -> APC [Along, Across, Radial]  
IIR [ 0, 0, 0]  
PRN 11 13 14 16 18 20 21 28  
IIA [ 279, 0,1023]  
PRN 01 03 04 05 06 07 08 09 10 23 24 25 26 27 29 30 31  
II [ 279, 0,1023]  
PRN 02 15 17  
INACTIVE  
PRN 12 19 22 32
```

Antenna phase center offsets (Section 2.3)

The antenna phase center offsets are stored in calibration files maintained at the IGS Central Bureau and give the components of the vector between the L1 and L2 antenna phase center (APC) and the antenna reference point

(ARP) in the antenna local reference frame (North, East and Up). Elevation dependent antenna offsets at 5 degree increments from horizon to zenith are also provided.

```

2.3 Antenna phase center (APC) offsets - MM
Antenna Model      LEIAT501
APC [North, East, Up]      L1 [ 0, 0, 0], L2 [ 0, 0,171]
Offset variation with respect to elevation angle
ELV 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
L1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
L2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
    
```

Reference frame transformation parameters (Section 2.4)

These transformation parameters are selected to relate a realization of ITRF at the observation epoch to the NAD83 reference frame. The 3 translations, 3 rotations and scale factor along with their yearly rates are stored in an internal file and selected according to the ITRF realization specified in the GPS orbit file header. The transformation parameters are in agreement with values adopted for unification of the NAD83 reference frame in North-America.

```

2.4 Reference frame transformation parameters          ITRF00->NAD83
Translations (Tx,y,z), Rotations (Rx,y,z), Scale (S)

Tx      Ty      Tz      S      Rx      Ry      Rz
(cm)    (cm)    (cm)    (ppb)  (mas)   (mas)   (mas)
99.560 -190.130 -52.150  .630  -25.915  -9.426  -11.599

dTx     dTy     dTz     dS     dRx     dRy     dRz
(cm/y)  (cm/y)  (cm/y)  (ppb/y) (mas/y) (mas/y) (mas/y)
.070   -.070   .050   -.200  -.067   .757   .051
    
```

Ocean loading coefficients (Section 2.5)

The coefficients computed for selected locations are stored in internal file on the CSRS-PPP server. At this time, ocean loading corrections are applied during processing only if the user's initial position is within 100 km of a location for which coefficients have been computed and stored. Neglecting to apply ocean loading coefficients at coastal stations introduce systematic errors at the cm level in the parameters.

```

2.5 Ocean loading coefficients          FOUND
Radial      North-South      East-West
Amplitude   Phase   Amplitude   Phase   Amplitude   Phase
(mm)        (deg)  (mm)        (deg)  (mm)        (deg)
M2          5.0    138.370    .5     184.740    .9     336.890
S2          1.7    170.710    .2     246.870    .3     296.090
    
```

K1	3.0	356.730	.3	287.170	.6	116.200
O1	1.6	353.660	.1	333.570	.2	91.740
N2	.9	125.040	.1	176.850	.3	326.400
P1	1.1	348.120	.1	298.500	.2	112.030
K2	.4	168.720	.0	227.370	.1	291.470
Q1	.3	358.580	.1	314.780	.0	91.350
MF	.0	.000	.0	.000	.0	.000

Surface meteorological data (Section 2.6)

The default meteorological data is stored in an internal file and the surface pressure is adjusted taking into account the a-priori station ellipsoidal height. The meteorological data is used for tropospheric delay modeling unless the tropospheric zenith delay is estimated, in which case it is used only at the initial epoch as a-priori estimate.

2.6 Surface meteorological data	
Temperature (deg C):	20.00
Pressure (Mb):	978.90
Relative humidity(%):	50.00

The Session Processing Summary (SECTION 3)

The Session Processing Summary (SECTION 3) reports the selected **Processing options** for this run (3.1), user **Observation session** information/statistics (3.2), user **Coordinate estimates** and precision (3.3), **Coordinate differences** and RMS with respect to a-priori value (3.4), **Receiver clock estimates**(3.5) and detailed (per satellite) **Observation residuals** (3.6).

----- SECTION 3. Session Processing Summary -----

Processing Options (Section 3.1)

A summary of the options set by PPP on-line prior to processing the session observations. The processing options are either **USER SELECTED**, initialized from specific records in the RINEX FILE HEADER or **PRESET** by the on-line application. Using preset values simplifies user interaction and should provide optimal parameter estimates.

SETTING	OPTION	ON-LINE PPP	
		L1	L1&L2
USER SELECTED			
User dynamics	STATIC/KINEMATIC	STATIC/KINEMATIC	STATIC/KINEMATIC
Reference frame	ITRF/NAD83 (CSRS)	ITRF/NAD83 (CSRS)	ITRF/NAD83 (CSRS)
FROM RINEX HEADER			
Frequency observed	L1/L1&L2	RECORD '# / TYPES OF OBSERV'	
Marker->ARP distance		RECORD 'ANTENNA: DELTA H/E/N'	
Type of Antenna		RECORD 'ANT # / TYPE'	
PRESET BY APPLICATION			
Observation processed	CODE/CODE&PHASE	CODE	CODE&PHASE
Satellite orbits	BROADCAST/PRECISE	PRECISE	PRECISE
Satellite clocks	15-MINUTE/5-MINUTE ^(*)	5-MINUTE ^(*)	5-MINUTE ^(*)
Ionospheric model	BROADCAST/IONEX/L1&L2	IONEX	L1&L2
Marker coordinates	FIXED/ESTIMATED	ESTIMATED	ESTIMATED
Tropospheric delay	MODELED/ESTIMATED	MODELED	ESTIMATED
Clock interpolation	YES/NO	YES	YES
Parameter smoothing	YES/NO	NO	YES
Coordinate system	CARTESIAN/ELLIPSOIDAL	ELLIPSOIDAL	ELLIPSOIDAL
Pseudorange sigma	A-PRIORI ESTIMATE	2.000 m	2.000 m
Carrier phase sigma	A-PRIORI ESTIMATE	0.100 m	0.010 m
Cutoff elevation	0->90 DEGREES	10.000 deg	10.000 deg

^(*)for data after October 28, 2000; 15 minutes otherwise

User Selected Options

The **User dynamics** option determines whether the user coordinates will be independently estimated for each observation epoch (KINEMATIC) or averaged over time (STATIC). Knowing that the dataset was collected in static mode provides the benefit of increased precision by allowing time averaging (summation of normals) over the full session length for optimal parameter estimation. While data sets observed with fixed or moving GPS receivers could both be processed using the KINEMATIC option, datasets collected with a moving receiver CANNOT be processed with the STATIC option. Attempt to do so will result in the program rejecting the majority of the observed epochs. On the other hand, processing data collected with a fixed receiver using the KINEMATIC option can be useful to evaluate the scatter of independent position estimates over time.

The **Reference frame and Coordinate system** settings affect only the coordinates output to the .pos file. The main purpose for this is to minimize the size of the .pos file, since it reports parameter estimates for each processed epoch. As you will see below, the coordinates output to the summary file are in both reference frames and coordinate systems.

Options Set From Rinex Header

The **Frequency observed**, **Marker to Antenna Reference Point (ARP)** and **Type of Antenna** are not really options, but more precisely variables that are set when reading the user RINEX file header. The observable identified in the RINEX file header record with label '# / TYPES OF OBSERV' will determine if the dataset is single or dual frequency and affect a number of PRESET OPTIONS that are frequency dependent. The marker to ARP offsets found in the RINEX header record with label 'ANTENNA: DELTA H/E/N' will be used, along with the Antenna Phase Center (APC) offsets (found in 2.3) to transfer the coordinates from the observation point at the APC to the Marker. The Antenna Phase Center (APC) offsets (in 2.3) are obtained from the antenna calibration file using the antenna type identifier recorded on the RINEX header record with label 'ANT # / TYPE'.

Options Preset By Application

The **Satellite orbit** option is always set to PRECISE. The **Satellite clock** is always set to 5-MINUTE and **Clock interpolation** is enabled unless the user's observation session is prior to 28/10/2000, the epoch at which precise clock files at 5-MINUTE interval became available. In this instance, 15-MINUTE precise clocks are used and **Clock interpolation** is disabled, yielding position estimates at 15-MINUTE epochs ONLY, in contrast to the usual updates provided at user observed epochs. **Marker coordinates** are always ESTIMATED and the **Coordinate system** for output to the position file is ELLIPSOIDAL.

Currently, the type of **Observation processed** depends on the **Frequency observed** by the GPS user equipment and stored in the submitted RINEX file. Ideally, the ionospheric-free CODE&PHASE combination would be used for both L1 and L1&L2 processing. Due to robustness issues with the L1 CODE&PHASE implementation this solution is not yet supported and L1 processing is CODE based only.

Since the ionosphere delays L1 CODE observations, an **Ionospheric model** is required for correction. The source of ionospheric corrections selected for the L1 processing by the on-line application are the combined global ionospheric maps produced at 2-hour intervals in IONEX format by IGS. The L1&L2 processing uses the L1&L2 ionospheric-free combination of the CODE&PHASE observations and does not require input of an external source of ionospheric information.

The **Tropospheric delay** affecting the observations also needs to be removed. The approach used to do so will depend on the **Frequency observed**. This is due to the significant difference in precision that exists between the L1 CODE and L1&L2 CODE&PHASE combination of the observations. While the L1&L2 CODE&PHASE combination has millimeter precision, the L1 CODE observation is precise to only a few decimeters for

higher-end single frequency GPS receivers, which is insufficient for tropospheric delay estimation. Therefore, L1 CODE processing uses a tropospheric model along with default surface meteorological data and an elevation mapping function to correct the along path tropospheric delay. The L1&L2 CODE&PHASE solution estimates the total zenith delay.

3.1 Processing Options	
User dynamics	: STATIC
Observation processed	: CODE
Frequency observed	: L1
Satellite orbits	: PRECISE
Satellite clocks	: 5-MINUTE
Ionospheric model	: IONEX
Station coordinates	: ESTIMATED
Tropospheric delay	: MODELED
Clock interpolation	: YES
Parameter smoothing	: NO
Reference frame	: NAD83
Coordinate system	: ELLIPSOIDAL
Pseudorange sigma	: 2.000
Carrier phase sigma	: .100
Marker->ARP distance	: 2.000
Cutoff elevation	: 10.000

Observation Session (Section 3.2)

The **Observation Session** section gives a general understanding of the quantity and quality of observations processed.

The first item reports the **Marker name** read from the RINEX file header record followed by the session **Start** and **End** times in YYYY/MM/DD hh:mm:ss.ss. The **Observation interval** is derived by 'majority voting' the intervals computed between each one of the first 10 observation epochs. The **Estimation interval** refers to the time interval at which parameter estimates are updated and should correspond to the **Observation interval** for observation files containing data collected after 28/10/2000. The following 4 items are counters of the total number of satellites and epochs processed followed by the number of observations processed and rejected. Finally the Code and Phase residuals are reported giving the user an appreciation of the quality of the GPS equipment used to collect the data submitted.

3.2 Observation Session	
Marker name	: POINT00001
Start	: 2004/01/09 19:30:00.00
End	: 2004/01/09 21:25:00.00
Observation interval (sec)	: 1.00
Estimation interval (sec)	: 300
Number of epochs processed	: 24
Number of satellites processed	: 10
Number of observations processed	: 141
Number of observations rejected	: 0
Pseudorange residuals (m)	: .34
Carrier phase residuals (cm)	: 5.65

Coordinate estimates (Section 3.3)

The session marker **Coordinate estimates** are given in 2 tables containing CARTESIAN and ELLIPSOIDAL coordinates and precision estimates in the NAD83(CSRS) and ITRF reference frames, plus the NAD83-ITRF coordinate difference. These tables are meaningful mainly for observations made in **STATIC** mode. For data collected in **KINEMATIC** mode, the estimated coordinates are the mean position of the session trajectory and the Sigma represents the average distance from the mean position.

3.3 Coordinate estimates				
CARTESIAN	NAD83	ITR00	Sigma(m)	NAD-ITR(m)
X (m)	535731.7122	535731.0698	.2682	.6424
Y (m)	-5268114.0204	-5268112.5425	.6002	-1.4780
Z (m)	3543955.2623	3543955.0984	.2185	.1638
ELLIPSOIDAL				
Latitude (dms)	33 58 16.2070	33 58 16.2305	.2432	-.7220
Longitude (dms)	-84 11 36.1201	-84 11 36.1392	.2864	.4896
Elevation (m)	287.1296	285.7647	.5819	1.3649

Coordinate differences (Section 3.4)

The marker **Coordinate differences** resulting from session processing are given in 2 tables containing CARTESIAN and ELLIPSOIDAL estimated and a-priori coordinates with the Delta and RMS of the differences.

These tables are once again meaningful mainly for **observations collected in STATIC mode**. **In PPP processing using the STATIC option**, the Delta is the difference between the FINAL estimated coordinates and the a-priori values found in the user RINEX file header or estimated at first epoch using code observations. This comparison can be useful for PPP validation using GPS data observed at control monument. With the known coordinates stored in the RINEX file header, the Delta gives the difference between the PPP estimated and published coordinates of a control point. It represents the error in either PPP processing or control point coordinates. The RMS of the differences is not very meaningful in static processing since its computation includes position differences obtained prior to solution convergence. **In processing of static data using the KINEMATIC PPP option**, the Delta is the mean of the differences between epoch coordinate estimates and the a-priori values. When known coordinates are input through the RINEX file

header, the RMS gives an estimate of the scatter of the estimated coordinates during a session, which indicates the accuracy of kinematic PPP positioning.

3.4 Coordinate differences [NAD83]				
Cartesian	ESTIMATED	A-PRIORI	Delta (m)	RMS (m)
X (m)	535731.7122	535731.1893	.5229	.5127
Y (m)	-5268114.0204	-5268112.1812	-1.8392	2.0730
Z (m)	3543955.2623	3543955.4717	-.2094	.3318
Ellipsoidal				
Latitude (dms)	33 58 16.2070	33 58 16.2468	-1.2256	1.2748
Longitude (dms)	-84 11 36.1201	-84 11 36.1331	.3341	.3535
Elevation (m)	287.1296	285.6853	1.4443	1.7088

Receiver clock estimates (Section 3.5)

This section gives **Receiver clock estimates**, in particular the GPS receiver **Clock phase and drift** relative to the reference clock of the precise satellite clock product. Precision estimates obtained from a linear fit to the epoch clock estimates are also given along with the RMS of the clock residuals from the regression. The clock estimates are of interest mainly to GPS receivers slaved to external atomic clocks.

3.5 Receiver clock estimates				
Reference Epoch		:	2004/01/09 00:00:00.00	
Clock Phase	(ns)		-1086.23	57.78
Clock Drift	(ns/day)		1597.99	1167.42
RMS of residuals	(ns)		106.59	

Satellite residuals (Section 3.6)

This section is a more detailed report on the quantity and quality of the observations reported at a higher level in Section 3.2. It offers counters and statistics listed on a per satellite basis. Each row starts with the satellite PRN number followed by the number of satellite arcs and observation epochs processed. The columns reporting rejections due to cycle slip (SLP), missing satellite clock (CLK), missing satellite orbit (EPH), missing ionospheric grid point (IGP), residual check failure (RES) and outliers (OUT) follow. Finally, the last 4 columns give the average (AVG) and RMS of the CODE and PHASE residuals.

3.6 Satellite residuals

SV	#ARC	#OBS	#REJ						AVG (m)	CODE RMS (m)	PHASE	
			SLP	CLK	EPH	IGP	RES	OUT			AVG (cm)	RMS (cm)
4	1	24	0	0	0	0	0	0	.03	.37	1.47	3.68
5	1	3	0	0	0	0	0	0	-6.29	.18	1.73	4.35
7	1	24	0	0	0	0	0	0	-.20	.29	-1.47	5.28
8	1	4	0	0	0	0	0	0	-.75	.30	1.52	2.40
9	1	22	0	0	0	0	0	0	-.17	.28	-2.85	3.75
11	1	4	0	0	0	0	0	0	-.27	.36	-1.21	2.13
17	1	1	0	0	0	0	0	0	-.61	.00	.00	.00
20	1	22	0	0	0	0	0	0	-.47	.28	.74	7.49
24	1	13	0	0	0	0	0	0	-.97	.17	1.52	5.49
28	1	24	0	0	0	0	0	0	-.06	.41	1.43	6.55

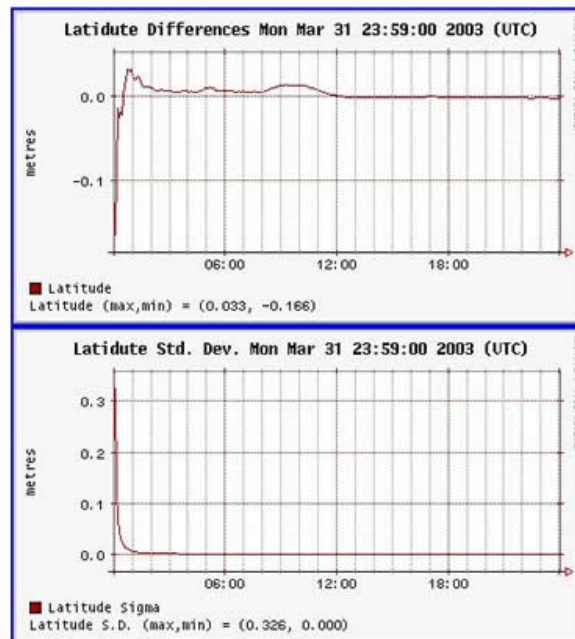
1.3.2. Estimated Parameter Plots Description

The observation residuals and phase ambiguities graphical output consists in a series of plots of observations (pseudo-ranges and/or carrier phase) and carrier-phase ambiguities versus time. Similarly to the estimated parameters plots, the resolution may only allow for averaged values to be plotted. Clicking on the plots does, however, display the plots with a one-to-one plot resolution.

PPP Estimated Parameters

(Horizontal Resolution: 1 PIXEL = Average of 9 Position Estimates)

Latitude



The graphical outputs show the variation of the estimated parameters and their respective standard deviations with respect to time. Plots are produced for latitude, longitude ellipsoidal height, tropospheric zenith delay and receiver clock offset.

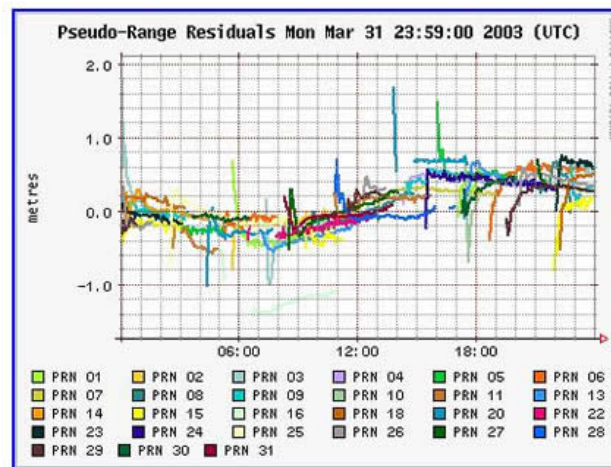
Depending on the number of processed epochs and duration of the data arcs, the plots may represent averages of estimates over a given interval. The exact number of estimates per average is given as the 'Horizontal Resolution' found below the plot header. Note that the series of plot is also a hyperlink to a one-to-one resolution series of the same plots.

Observation Residuals and Phase Ambiguities Plots Description

PPP Residuals/Phase Ambiguities

(Horizontal Resolution: 1 PIXEL = Average of 4 Values)

Pseudo-Range Observations Residuals



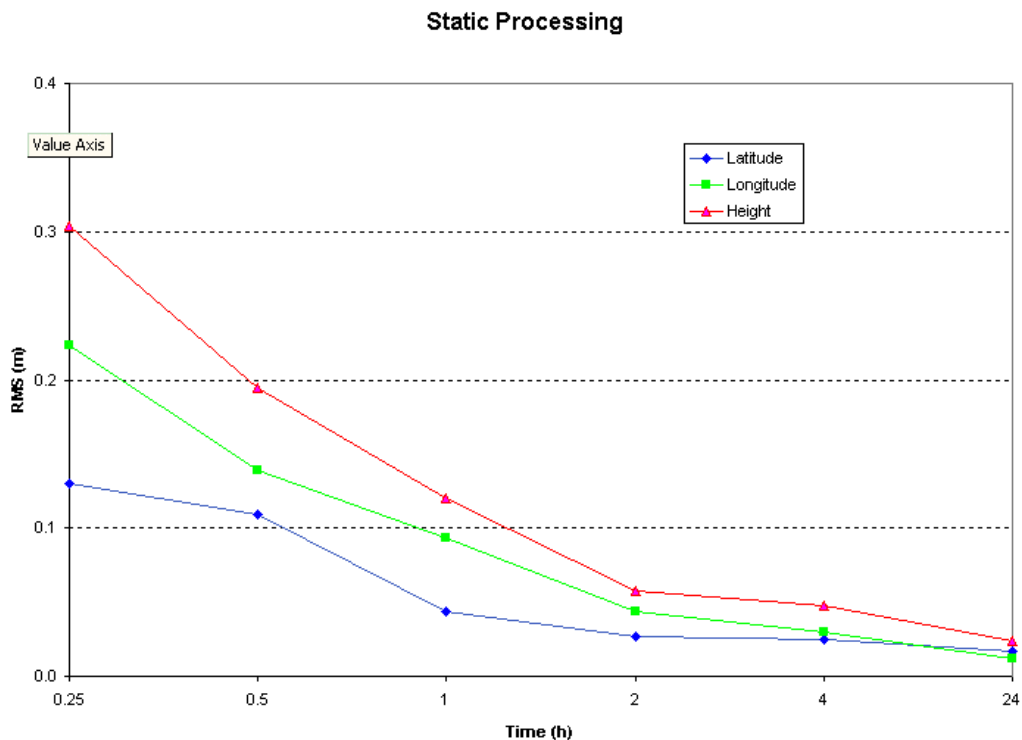
The observation residuals and phase ambiguities graphical output consists in a series of plots of observations (pseudoranges and/or carrier phase) and carrier-phase ambiguities versus time. Similarly to the estimated parameters plots, the resolution may only allow for averaged values to be plotted. Clicking on the plots does, however, display the plots with a one-to-one plot resolution.

1.4. Result Validation and Expected Accuracy

One proven validation method is to use your equipment, field procedures and processing software to obtain positions of points with known coordinates such as those of calibration baselines and basenets. The degree of care in doing such calibration is, of course, dependent on the required accuracy and intended use of the estimated positions.

Plots depicting expected positioning accuracy as a function of time for dual-frequency GPS observations are available below ([static](#) / [kinematic](#)). Carrier phase ambiguity estimation is the main factor affecting the convergence seen in the accuracy plots. Resolved ambiguities are key in benefiting from the full positioning accuracy provided by the carrier phase measurements.

The kinematic processing plot was obtained by processing in kinematic mode (position estimated independently at each observation epochs) data that was collected in static mode. As such it represents a best-case scenario by neglecting some of the real-word effects of observations collected from a moving receiver.



Kinematic Processing

