MADOCALIB ver.2.0 Manual

QZSS Strategy Office, Cabinet Office

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Contents

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1 Overview

This manual describes how to use the MADOCA-PPP (Multi-GNSS Advanced Orbit and Clock Augmentation - Precise Point Positioning) [1] test library called MADOCALIB. The purpose of distributing MADOCALIB is to facilitate the user algorithm implementation of MADOCA-PPP. MADOCALIB is constructed based on RTKLIB [2] and functions of PPP-AR and message conversion copyrighted by the third party and provides RNX2RTKP and CSSR2SSR.

RNX2RTKP is a utility for post-process positioning. It implements a processing mode called PPP (Precise Point Positioning) to make use of MADOCALIB. In this processing mode, the following functions are added to RTKLIB ver.2.4.3b34:

- To use the Galileo E1-E5a signal for PPP calculation
- To read the Compact SSR message of MADOCA-PPP
- To select GNSSs to be used for PPP calculation, and
- To select frequencies to be used for PPP calculation for each GNSS
- To process the ionospheric correction data of MADOCA-PPP
- To support triple/quad-frequency PPP

Users can refer to its output as a reference to achieve the performance criteria of MADOCA-PPP.
MADOCALIB also has a processing mode called PPP-AR (Precise Point Positioning-Ambiguity Resolution). Please note that the performance of MADOCA-PPP with the PPP-AR method is currently not defined in the specification documents.

CSSR2SSR is a utility for post-processing conversion of L6E message file containing MADOCA-PPP compact SSR data to RTCM3 SSR message file.

[1] IS-QZSS-MDC-004: https://qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html
[2] RTKLIB: https://github.com/tomojitakasu/RTKLIB.git

2 Getting Start

2.1 System Requirements

The executable binary CUI Aps included in the package require Microsoft Windows environment. On the other OS (Linux, etc.) or environment, you have to compile and build CUI Aps by yourself. The executable CUI Aps are built by mingw-w64 which can be obtained from the following and tested on Windows 11 (64bit).
URL: https://www.mingw-w64.org/

2.2 Installation

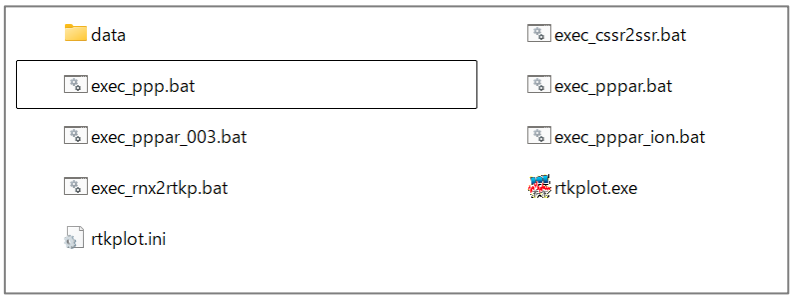
Extract the program package `madocalib` to appropriate directory <*installed_dir*>.on the local disk. The directory structure of the package is as below.

<*installed_dir*>		Directory where this software is installed
	¥app¥consapp	The application resources are stored.
	¥cssr2ssr	The source files and makefile of CSSR2SSR are stored.
	¥rnx2rtkp	The source files, makefile and sample configuration files of RNX2RTKP are stored.
	¥bin	Executable binary of APs for Windows
	¥doc	Document source files
	¥sample_data	Sample data and sample BAT files for APs.
	¥src	Source files of MADOCALIB library.

2.3 Quick Start with Sample Data

Here are quick start guide for RNX2RTKP and CSSR2SSR using the sample data included in this package.

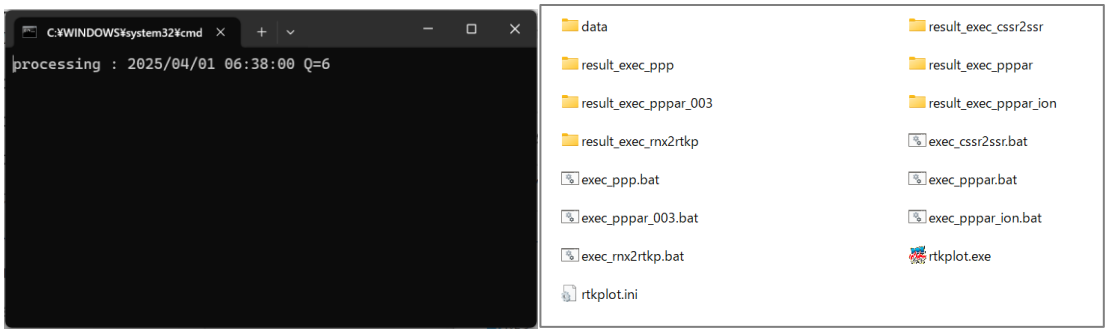
Open the following folder on “Windows Explorer”.
`<installed_dir>¥sample_data`



There are BAT files which execute PPP/PPP-AR from 00min00sec to 59min30sec every hour.

`exec_ppp.bat` : for PPP (no integer ambiguity resolution) by RNX2RTKP
`exec_pppar.bat` : for PPP-AR (with integer ambiguity resolution) by RNX2RTKP
`exec_pppar_ion.bat`: for PPP-AR with ionospheric correction by RNX2RTKP
`exec_cssr2ssr.bat` : for converting cssr to ssr by CSSR2SSR

Double-click on the above BAT file for each scenarios. You can see the command prompt window and get output solution files in the result folder of `result_<BAT filename>`.

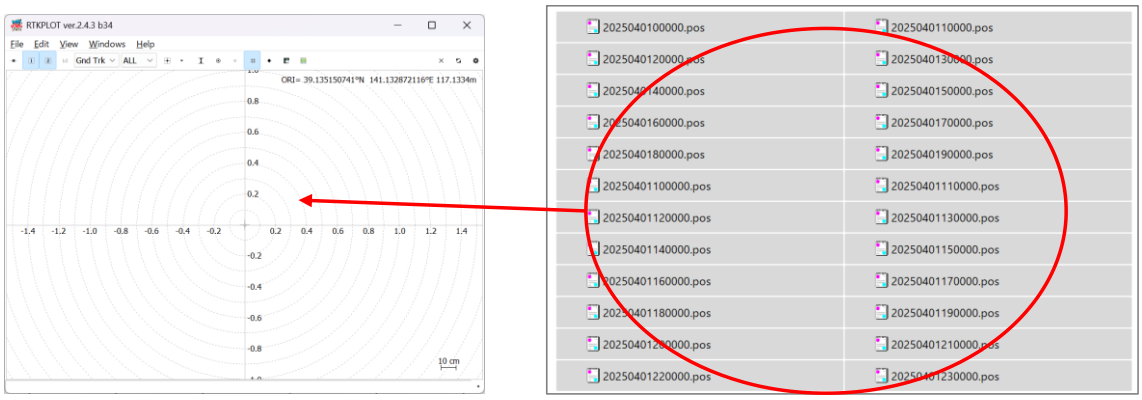


The file output by RNX2RTKP contains the receiver positions calculated by PPP, which can be visualized by RTKPLOT included in RTKLIB package.
The RTKPLOT is included in the folder of `sample_data`, you can use it to visualize the following steps.

- Double-click `rtkplot.exe` to start it.
- Click to select the RNX2RTKP output `*.pos` files in the result folder of `result_<BAT`

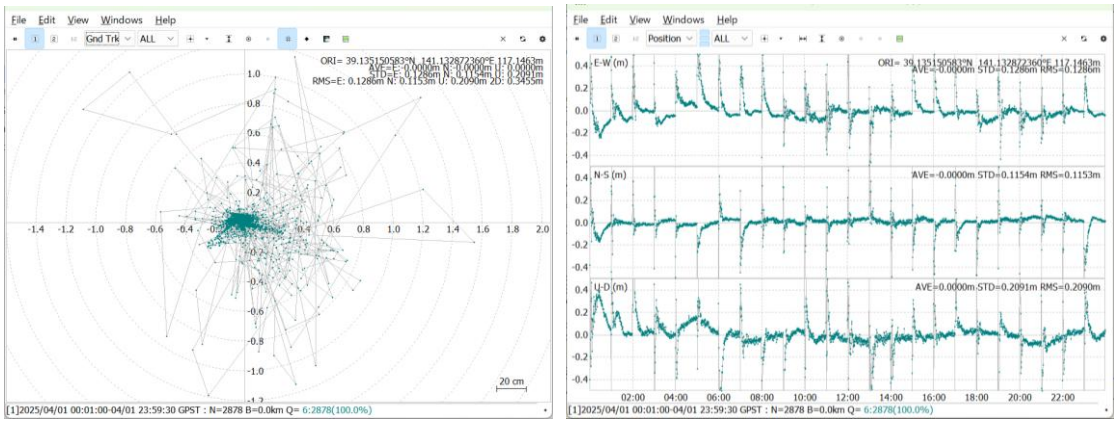
filename> to visualize.

- Drag and drop selected `*.pos` files into the RTKPLOT



A time series plot can be viewed by selecting “Position” from the pull-down menu in the upper left corner of the RTKPLOT. For the detail of RTKPLOT, see RTKLIB manual [4].

[3] RTKLIB manual: https://github.com/tomojitakasu/RTKLIB/blob/master/doc/manual_2.4.2.pdf

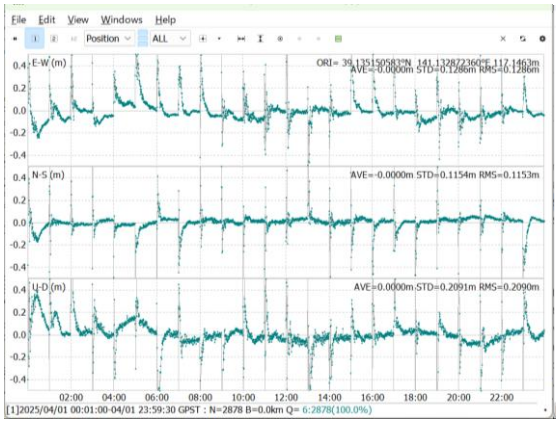


By open each batch file in a text editor, you can see the input data, output data, location of the configuration file, and how to specify the commands used in each.

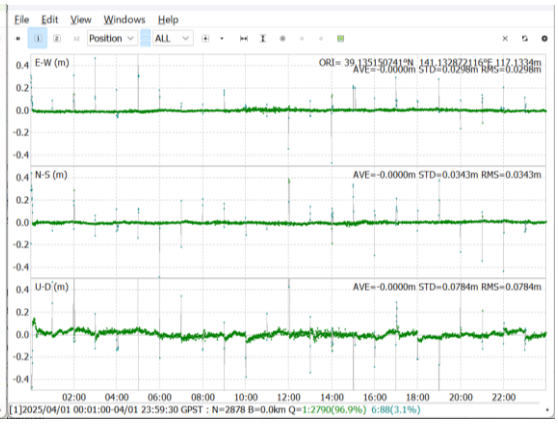
In MADOCALIB version 2.0, sample data corresponding to IS-QZSS-MDC-004 is stored and PPP scenarios are prepared. In addition, sample data corresponding to IS-QZSS-MDC-003 is also stored, and scenarios using these data are prepared in the following batch files. If you want to evaluate data corresponding to editions prior to the IS-QZSS-MDC-004, please utilize this scenario.

`exec_pppar_003.bat`: for PPP-AR (with integer ambiguity resolution) by RNX2RTKP

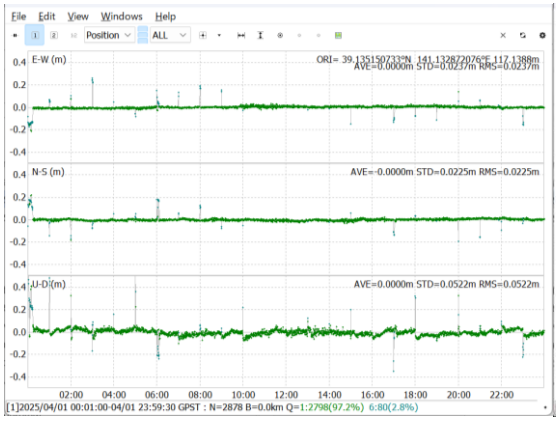
Sample output results for each scenario are shown below.



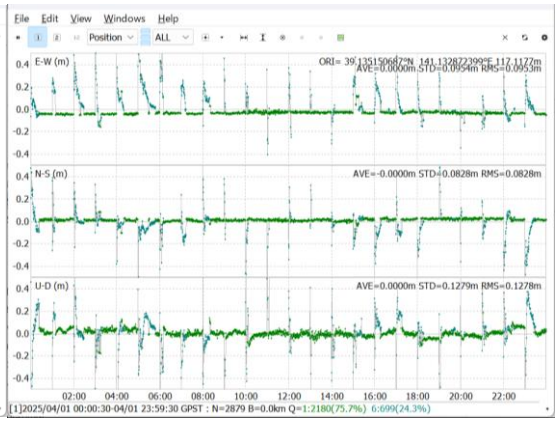
exec_ppp.bat



exec_pppar.bat



exec_pppar_ion.bat



exec_pppar_003.bat

2.4 **Quick Start with Downloaded Data**

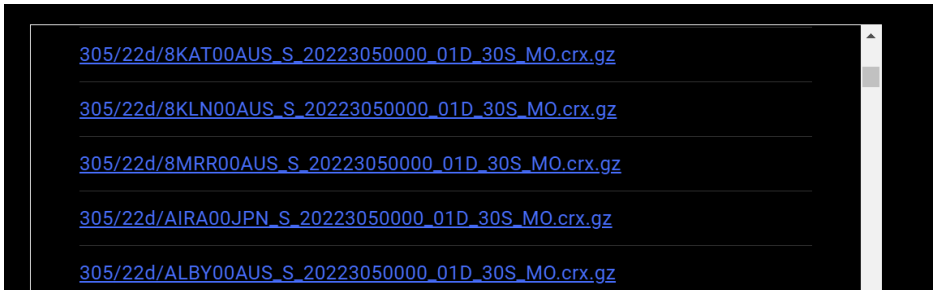
Here is a quick start guide for RNX2RTKP using the downloaded data.

(1) Getting RINEX OBS and NAV files

The RINEX OBS and NAV data can be downloaded from the following IGS's and MIRAI's URL.

IGS<https://igs.org/data/#daily_data>

MIRAI<https://go.gnss.go.jp/mirai/miraiarchive/>



RINEX OBS files are saved in Compact RINEX format, so converting them to RINEX v3 is required. The RNXCMP (a tool that converts the Hatanaka compact RINEX format (extension crx) is used to convert to the commonly used RINEX format (extension rnx)) and can be obtained from the following

https://terras.gsi.go.jp/ja/crx2rnx.html

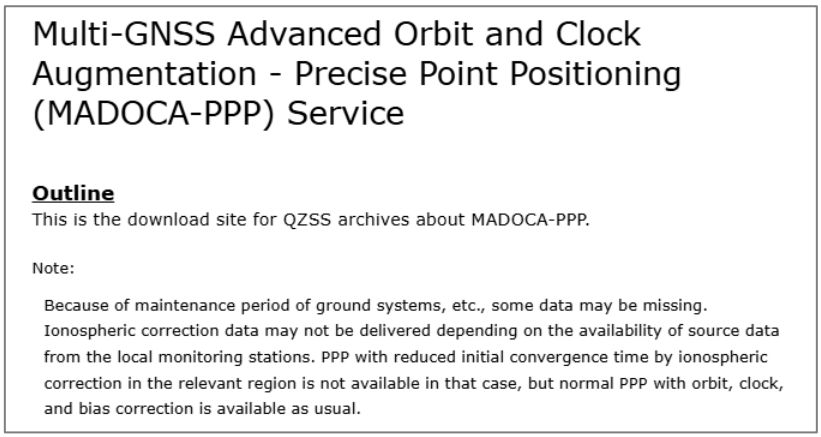
For Windows 64-bit environment, download RNXCMP_4.1.0_Windows_mingw_64bit.

(2) Getting QZSS L6 message files

L6E and L6D archive data file can be downloaded from the following QZSS URL.

https://sys.qzss.go.jp/dod/en/archives.html

Hourly files can be obtained for each PRN number. To perform PPP/PPP-AR in the Asia Oceania region, download the PRN204 and PRN206 files. For further ionospheric correction, please download the PRN200 and PRN201 files.



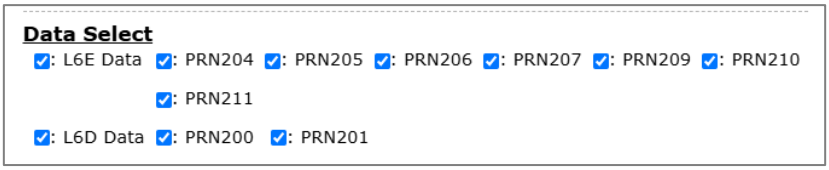
Multi-GNSS Advanced Orbit and Clock Augmentation - Precise Point Positioning (MADOCA-PPP) Service

Outline

This is the download site for QZSS archives about MADOCA-PPP.

Note:

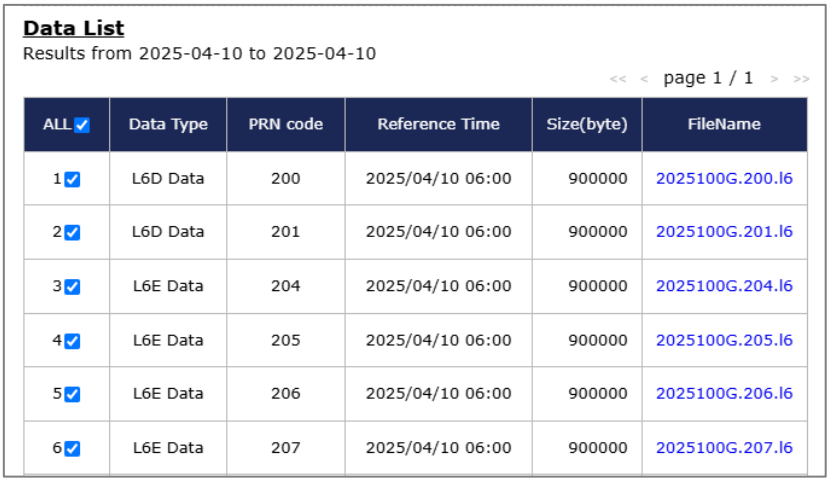
Because of maintenance period of ground systems, etc., some data may be missing. Ionospheric correction data may not be delivered depending on the availability of source data from the local monitoring stations. PPP with reduced initial convergence time by ionospheric correction in the relevant region is not available in that case, but normal PPP with orbit, clock, and bias correction is available as usual.



Data Select

☑: L6E Data ☑: PRN204 ☑: PRN205 ☑: PRN206 ☑: PRN207 ☑: PRN209 ☑: PRN210 ☑: PRN211

☑: L6D Data ☑: PRN200 ☑: PRN201



Data List

Results from 2025-04-10 to 2025-04-10

<< < page 1 / 1 > >>

ALL ☑	Data Type	PRN code	Reference Time	Size(byte)	FileName
1 ☑	L6D Data	200	2025/04/10 06:00	900000	2025100G.200.l6
2 ☑	L6D Data	201	2025/04/10 06:00	900000	2025100G.201.l6
3 ☑	L6E Data	204	2025/04/10 06:00	900000	2025100G.204.l6
4 ☑	L6E Data	205	2025/04/10 06:00	900000	2025100G.205.l6
5 ☑	L6E Data	206	2025/04/10 06:00	900000	2025100G.206.l6
6 ☑	L6E Data	207	2025/04/10 06:00	900000	2025100G.207.l6

(3) Set up execution commands

Store the downloaded RINEX and L6 files in the following folders respectively.

`<installed_dir>¥sample_data¥data¥rinex`

`<installed_dir>¥sample_data¥data¥l6¥<4digit year>¥<3digit day of year>`

Open the batch file in the following folder with a text editor.

`<installed_dir>¥sample_data¥exec_rnx2rtkp.bat`

Rewrite the followings to specify the downloaded RINEX OBS, RINEX NAV, L6E message and

L6D message.

```
OBS=data/rinex/MIZU00JPN_R_%Y%n0000_01D_30S_MO.rnx
NAV=data/rinex/BRDM00DLR_S_%Y%n0000_01D_MN.rnx
L6E1=data/l6/%Y/%n/%Y%n%HU.204.l6
L6E2=data/l6/%Y/%n/%Y%n%HU.206.l6
L6D1=data/l6/%Y/%n/%Y%n%HU.200.l6
L6D2=data/l6/%Y/%n/%Y%n%HU.201.l6
```

It is recommended that file paths be specified using keywords that are replaced to date/time. See 3.1.2.

Rewrite the following start date/time and end date/time according to the date and time of the analysis

```
TS_DATE=2025/04/01
TS_TIME=00:00:00
TE_DATE=2025/04/01
TE_TIME=23:59:30
```

Double-click the batch file to run it. And you can get output files in the following directory.

<*installed_dir*>¥sample_data¥data¥result_exec_rnx2rtkp

Note. In the batch file, `%` is replaced with `%%` to escape the special character `%` in Windows.

3 Usage of Utilities

3.1 RNX2RTKP

3.1.1 Overview

RNX2RTKP is a utility for post-process positioning. It implements a processing mode called PPP (Precise Point Positioning) to make use of MADOCALIB.

3.1.2 Inputs and Outputs

The input and output files for the RNX2RTKP are as follows.

Inputs

No.	Item	Description
1	RINEX OBS files	RINEX v3.x Observation files (*.rnx)(*1).
2	RINEX NAV files	RINEX v3.x Navigation files (*.rnx) (*1).
3	QZSS L6E files	L6E archive data file which can be downloaded from the following QZSS website (*.*PRN*.l6) (*1). PRN=204~211 https://sys.qzss.go.jp/dod/en/archives.html
4	QZSS L6D files	L6D archive data file which can be downloaded from the following QZSS website (*.*PRN*.l6) (*1). PRN=200,201 https://sys.qzss.go.jp/dod/en/archives.html
5	ANTEX file	The antenna phase information file (e.g. igs20.atx, igs14.atx) which can be obtained from the following IGS website.(*For monitoring stations that do not use the same combination of antenna and radome used for IGS stations, a dedicated antenna phase information file needs to be used instead of the above file.) https://cddis.nasa.gov/Data_and_Derived_Products/GNSS/GNSS_product_holdings.html This file is only used for receive antenna correction.
6	Configuration file	Configuration file of RNX2RTKP. See 3.1.3.

Outputs

No.	Item	Description
1	Position Solution file	File containing the receiver's position as calculated by the PPP process (*1). The file is a simple text file, and its format is defined in the RTKLIB manual “B.1 Positioning Solution File” at the following URL. https://github.com/tomojitakasu/RTKLIB/blob/master/doc/manual_2.4.2.pdf

(*1)
These file path can be specified with the keywords replaced as below

```
%Y -> yyyy year (4 digits) (2000-2099)
%y -> yy year (2 digits) (00-99)
%m -> mm month (01-12)
%d -> dd day of month (01-31)
%h -> hh hours (00-23)
%H -> a hour code (a-x)
%M -> mm minutes (00-59)
%n -> ddd day of year (001-366)
%W -> wwww gps week (0001-9999)
%D -> d day of gps week (0-6)
%HU-> h hour code (A=0,B=1,C=2,...,X=23)
```

3.1.3 **Configuration file**

The keywords which can be included in the configuration file for RNX2RTKP are shown in the following tables.

Item	Description	Configuration File	Notes
Positioning Mode	Set the positioning mode. MADOCALIB supports following options. - `ppp-kine` : PPP with kinematic mode - `ppp-static` : PPP with static mode	`pos1-posmode`	
Number of Frequencies	Set the used number of frequencies - `l1` : Single frequency. N/A for `ppp-*` modes. - `l1+2` : Dual-frequency - `l1+2+3` : Triple-frequency - `l1+2+3+4` : Quad-frequency	`pos1-frequency`	
Ionosphere Correction	Set the ionospheric correction option. - `off` : Not apply ionospheric correction - `brdc` : Apply broadcast ionospheric correction. - `dual-freq` : Ionosphere-free linear combination with dual-frequency. This should be selected if PPP is performed. - `est-stec` : Estimate ionospheric delay for each	`pos1-ionoopt`	

	satellite. This should be selected if PPP-AR is performed.		
Navigation System	Set the used number of navigation satellite systems. - `1` : GPS - `4` : GLONASS - `8` : Galileo - `16` : QZSS - `32` : BeiDou If you want to use PPP with GPS+GAL+QZS, you should set the sum of these numbers to "`25`" because GPS is "`1`", GAL is "`8`", and QZS is "`16`".	`pos1-navsys`	
Ionospheric Correction	Set apply for ionospheric correction by L6D. - `off` : Not apply ionospheric correction - `on` : apply ionospheric correction	`pos2-ionocorr`	L6D file must be specified as input file when applying the ionosphere correction.
Integer Ambiguity Resolution	Set the strategy of integer ambiguity resolution. - `off` : No ambiguity resolution - `continuous` : Continuously integer ambiguities are estimated and resolved - `fix-and-hold` : Continuously integer ambiguities are estimated and resolved. If the validation OK, the ambiguities are tightly constrained to the resolved values.	`pos2-armode`	
Validation Ratio to Fix Ambiguity	Set the integer ambiguity validation threshold for "ratio-test", which uses the ratio of squared residuals of the best integer vector to the second-best vector.	`pos2-arthres`	
Std-Dev for Ambiguity Search	Set the maximum standard deviation threshold of the 3D position to start narrow-lane integer ambiguity search (m).	`pos2-arthres1`	
Signal Option for GPS	Set the priority of used signals for GPS. - `L1/L2` - `L1/L5` - `L1/L2/L5`	`pos2-siggps`	The actual number of frequencies to be used shall be set by "`pos1-frequency`". If L1/L2/L5 are set and "`pos1-frequency`" is set to "`l1+2`", dual frequencies of L1/L2 are used. (*1)
Signal Option for	Set the priority of used signals for QZSS. - `L1/L5`	`pos2-sigqzs`	Same as above.

QZSS	- L1/L2 - L1/L5/L2		
Signal Option for Galileo	Set the priority of used signals for Galileo. - E1/E5a - E1/E5b - E1/E5a/E5b/E6 - E1/E5a/E6/E5b	pos2-siggal	Same as above.
Signal Option for BeiDou-2	Set the priority of used signals for BeiDou-2. - B1I/B3I - B1I/B2I - B1I/B3I/B2I	pos2-sigbds2	Same as above.
Signal Option for BeiDou-3	Set the priority of used signals for BeiDou-3. - B1I/B3I - B1I/B2a - B1I/B3I/B2a	pos2-sigbds3	Same as above.

(*1)

The signal option settings mean from left to right: 1st frequency, 2nd frequency, 3rd frequency, 4th frequency. Observation data for the 1st and 2nd frequencies must be required to perform PPP, while observation data for the 3rd and 4th frequencies are optional. Therefore, if the observed data for the frequencies set in 1st freq. and 2nd freq. are not present in one of them, PPP will not be performed properly.

For example, if the following options are set for a receiver outputting observation data of the L1 and L2 frequencies, PPP will be performed in dual-frequency mode internally.

```
pos1-frequency     =l1+2+3
pos2-siggps           =L1/L2/L5
```

However, with the same settings, PPP cannot be performed for observation data of L1 and L5 frequencies. In this case, it should be set up as follows.

```
pos2-siggps           =L1/L5
```

The following sample files are included on the directory as below.

<*installed_dir*>¥app¥consapp¥rnx2rtkp¥gcc_mingw

sample.conf

Configuration for PPP (no integer ambiguity resolution) whose performance is specified in PS-QZSS. This configuration performs PPP by ionosphere-free linear combination with dual-frequency with GPS, GLONASS, QZSS and Galileo by setting as below.

```
pos1-navsys        =29
pos1-frequency     =l1+2
pos1-ionoopt       =dual-freq
```

```
pos2-armode       =off
```

`sample_pppar.conf`

Configuration for PPP-AR (with integer ambiguity resolution). This configuration performs PPP-AR with quad-frequency with GPS, GLONASS, QZSS, Galileo and BeiDou by setting as below.

```
pos1-navsys       =61
pos1-frequency    =l1+2+3+4
pos2-armode       =continuous
```

`sample_pppar_iono.conf`

Configuration for PPP-AR with ionospheric correction on L6D message. This configuration performs PPP-AR with ionospheric correction by setting as below.

```
pos2-ionocorr     =on
```

These sample configuration files are tuned specifically for PPP processing for observation data at 30-second intervals at MIRAI or IGS stations, using the MADOCA-PPP L6 message archive data as augmentation data. Therefore, it is recommended that the parameters especially `pos2-arthres` and `pos2-arthres1` be tuned accordingly for each case where observation data conditions such as data intervals are different.

3.1.4 **CUI Command Reference**

```
synopsis:
  rnx2rtkp.exe [option]... obsfile navfile l6efile l6dfile [...]

options:
 -k file   input options from configuration file [off]
 -o file   set output file [stdout]
 -ts ds ts start day/time (ds=y/m/d ts=h:m:s) [obs start time]
 -te de te end day/time   (de=y/m/d te=h:m:s) [obs end time]
 -ti tint  time interval (sec) [all]
 -x level  debug trace level (0:off) [0]
 -ant file rcvantfile [specified by conf file]

example:
  rnx2rtkp.exe -ts 2025/04/01 00:00:00 -te 2025/04/01 23:59:30 -ti 30
               -k sample_pppar_iono.conf -o test.%Y%m%d%h%M%S.pos
                MIZU00JPN_R_%Y%n0000_01D_30S_MO.rnx
                BRDM00DLR_S_%Y%n0000_01D_MN.rnx
                %Y%n%HU.209.l6 %Y%n%HU.200.l6 %Y%n%HU.201.l6
```

3.2 **CSSR2SSR**

3.2.1 **Overview**

CSSR2SSR is a utility for post-processing conversion of L6E message file containing MADOCA-PPP compact SSR data to RTCM3 SSR message file.
Convert cssr message file to ssr message file. Supported Compact SSR messages (cssr) and SSR messages (ssr) are as bellow.

```
[Vendor ID]
  "010b" : MADOCA-PPP

[Message Type, Sub Type]
  MT4073,1 : mask
  MT4073,2 : orbit
  MT4073,3 : clock
  MT4073,4 : code bias
  MT4073,5 : phase bias
  MT4073,7 : ura
```

Supported SSR messages (ssr) are as bellow.

```
[Message Type]
  SSR Message          : GPS      GLONASS   Galieo      QZSS       BeiDou
  --------------------:-----------------------------------------------------
  SSR Orbit Correction: 1057     1063      1240(*1)    1246(*1)   1258(*1)
      Clock Correction: 1058     1064      1241(*1)    1247(*1)   1259(*1)
      URA             : 1061     1067      1244(*1)    1250(*1)   1262(*1)
      Code Bias       : 1059(*2) 1065(*2)  1242(*1*2)  1248(*1)   1260(*1)
      Phase Bias      : 1265(*2) 1266(*2)  1267(*1*2)  1268(*1*2) 1270(*1*2)

[format]
  nothing * :RTCM 10403.3
  (*1)      :Proposal of new RTCM SSR Messages
             SSR Stage 1:Galileo,QZSS,SBAS,BDS 2014-04-17 v05
  (*2)      :Proposal of new RTCM SSR Messages
             SSR Stage 2:Satellite Phase Biases 2014-04-17 v05
```

The signals stored in MADOCA-PPP that are not defined in RTCM SSR utilize the following signal and tracking mode identifiers.

```
GNSS    :Signal and Tracking Mode Identifier
  --------:----------------------------------
  GPS     :16- L5 I+Q
          :17- L1 L1C(D+P)
  Galileo : 3- E1 B+C
          : 7- E5a I+Q
          :10- E5b I+Q
  BeiDou  :13- B2a Q
          :14- B2a I+Q
```

3.2.2 **Inputs and Outputs**

The input and output files for the CSSR2SSR are as follows.

Inputs

No.	Item	Notes
1	QZSS L6E file	L6E message file containing MADOCA-PPP compact SSR (CSSR) data.

Outputs

No.	Item	Notes
1	RTCM3 SSR message file	RTCM3 SSR message file.

3.2.3 **Configuration file**

There is no configuration file for the CSSR2SSR.

3.2.4 **CUI Command Reference**

```
synopsis:
  cssr2ssr.exe [options] file

options:
  -td y/m/d      date for message time (y=year,m=month,d=day)
  -o file        output ssr file
  -d             dump debug log on decoding cssr [default : no dump]
  file           input l6E message file

example:
  cssr2ssr.exe -td 2025/04/01 -o 202509100.204.rtcm3 202509100.204.l6
```

Appendix. Specific Processing for MADOCA-PPP

This section outlines the specific processing of MADOCA-PPP within the MADOCALIB source files. In the source files located in the folder of `<installed_dir>¥src`, the following files are relevant to MADOCA-PPP processing.

(1) mdccssr.c

There are decode functions for MADOCA-PPP Compact SSR messages in QZSS L6E signal defined in chapter 4 of IS-QZSS-MDC. The main functions are as follows.

function	Description
`input_qzssl6e()`	Stack QZSS L6E message and synchronize frame with L6 preamble.
`decode_qzss_l6emsg()`	Decode QZSS L6E message and convert to RTCM SSR. Decode L6 message header, frame recognition, call decode functions of each subtypes.
`decode_mcssr_mask()`	Decode Sub Type 1 Mask.
`decode_mcssr_oc()`	Decode Sub Type 2 GNSS Orbit Corrections.
`decode_mcssr_cc()`	Decode Sub Type 3 GNSS Clock Corrections.
`decode_mcssr_cb()`	Decode Sub Type 4 GNSS Satellite Code Bias.
`decode_mcssr_pb()`	Decode Sub Type 5 GNSS Satellite Phase Bias.
`decode_mcssr_ura()`	Decode Sub Type 7 GNSS URA.
`mcssr_sel_biascode()`	Select MADOCA-PPP code bias, phase bias code from observation code. IS-QZSS-MDC section 5.5.3.1 Applicable Signals of Code/Phase Bias

(2) mdciono.c

There are decode functions for MADOCA-PPP ionospheric correction messages in QZSS L6D signal defined in section 6.3 of IS-QZSS-MDC. The main functions are as follows.

function	Description
`input_qzssl6d()`	Stack QZSS L6D message and synchronize frame with L6 preamble.
`decode_qzss_l6dmsg()`	Decode QZSS L6D message and store ionospheric corrections. Decode L6 message header, frame recognition, call decode functions of each message types.
`decode_miono_coverage()`	Decode Message Type 1 STEC coverage message.
`decode_miono_correction()`	Decode Message Type 2 STEC correction message.
`miono_get_corr()`	Get MADOCA-PPP ionospheric correction data using the user position.

(3) ppp.c

There are functions for PPP processing performed by EKF (extended Kalman filter) based on the observation equations defined in section 5.5 of IS-QZSS-MDC. The main functions are as follows.

function	Description
pppos()	PPP processing for observation data of an epoch. Execute time propagation (called "temporal update" in the source file) of EKF states, generate residuals of pseudorange and carrier phase, measurement update of EKF, and ambiguity resolution.
udstate_ppp()	Execute time propagation (temporal update) of EKF states such as receiver position, clocks, tropospheric parameters, ionospheric parameters, inter-frequency bias for 3rd/4th and phase bias.
corr_meas()	Pseudorange and carrier phase correction by SSR code/phase correction, antenna correction and phase wind-up correction.
ppp_res()	Generate residuals of pseudorange and carrier phase based on observation equations defined in section 5.5.5 of IS-QZSS-MDC.

(4) ppp_ar.c

There are functions for integer ambiguity resolution (AR). The MADOCALIB employs cascading ambiguity resolution (CAR) method of fixing extra-wide-lane (EWL), wide-lane (WL) and narrow-lane (NL) ambiguities sequentially for multi-frequency AR instead of fixing full set of ambiguities simultaneously employed up to version 1.4.

The EWL ambiguities are derived by combining the ambiguities of the 2nd and 3rd frequencies, as well as those of the 2nd and 4th frequencies. The WL ambiguities are derived by combining the ambiguities of the 1st and 2nd frequencies. The NL ambiguities are ambiguities of 1st frequency such as L1, E1 and B1I. Integer ambiguity searches of EWL and WL are performed by simple rounding, while that for NL is performed by LAMBDA method.

The main functions are as follows.

function	Description
ppp_amb_ILS()	Ambiguity resolution by ILS (integer-least-square). Generate single-difference between satellites, search and fix extra-wide-lane, wide-lane and narrow-lane ambiguities and update EKF states.
gen_sat_sd()	Generate single-difference (SD) between satellites.
search_amb_ewl()	Search extra-wide-lane integer ambiguity.
search_amb_wl()	Search wide-lane integer ambiguity.
gen_sd_matrix_n1()	Generate SD-matrix of narrow-lane ambiguity.
search_amb_lambda()	Search integer ambiguity by LAMBDA.
update_states()	Update EKF states with integer ambiguity constraints.

(5) ppp_iono.c

There are functions for MADOCA-PPP ionospheric correction. In the MADOCALIB, the ionospheric corrections are added as a pseudo-observation to the EKF, thus constraining the states of ionospheric estimate to the ionospheric correction value. Also, before constrain by the ionospheric correction, the system bias between the delay by the STEC correction message and the delay by the estimated are removed described in section 6.5.2.2 of IS-QZSS-MDC.

The main functions are as follows.

function	Description
`const_iono_corr()`	Constraint to ionospheric correction. Estimate and removed system biases and constraint to external ionosphere correction.

Concluded