# MADOCALIB ver.1.3 Manual

QZSS Strategy Office, Cabinet Office

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## Contents

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# I Overview

This manual describes how to use the MADOCA-PPP (Multi-GNSS Advanced Orbit and Clock Augmentation - Precise Point Positioning) 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 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

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 but the PPP-AR mode will be continuously improved with the expectation of better performance than the PPP mode.

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

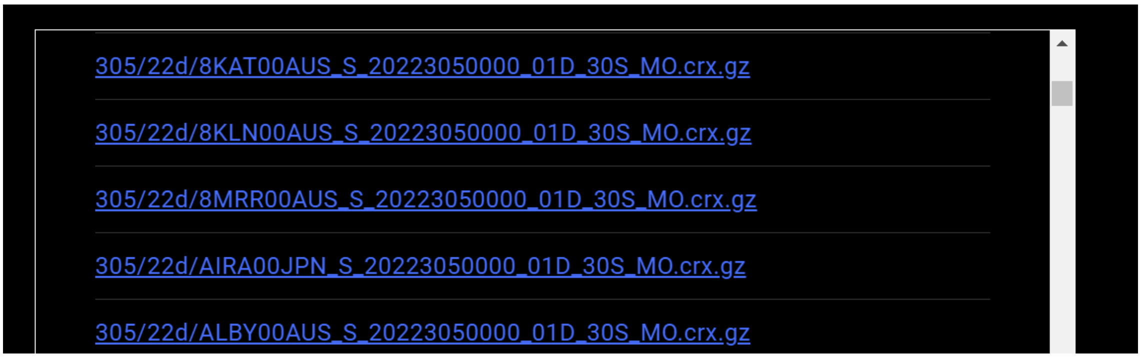
## II　Usage of Utilities

### II-1 RNX2RTKP

To run the RNX2RTKP the following files are required.

a) RINEX OBS and NAV
b) ATX file (.atx)
c) QZSS L6 correction data (.l6)
d) Configuration file (.conf)

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

URL：

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

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

２．The antenna phase information file (e.g. igs20.atx, igs14.atx) can be obtained from the below URL.

https://cddis.nasa.gov/Data_and_Derived_Products/GNSS/GNSS_product_holdings.html

*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.

３．The QZSS L6 correction data can be downloaded from the following QZSS Web URL. Since the files are separated for each hour, they need to be integrated according to the time to be evaluated. (For example, a file for one day on Jun.10, 2024 is generated by executing the command type "copy /b 2024162*.204.l6 2024162all.204.l6" at the Command Prompt.)

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

４．As for the configuration file, the following sample file included in the MADOCALIB package can be used.

- sample.conf

This sample configuration file is tuned specifically for PPP processing for observation data at 30-second intervals at MIRAI or IGS stations, using the MADOCA-PPP archive data as augmentation data. Therefore, it is recommended that the parameters be tuned accordingly for each case if augmentation data other than the MADOCA-PPP archive data is used, or where observation data conditions such as data intervals are different.

５．Place the following files in the Windows local environment.

・RINEX OBS, NAV files

・igs20.atx (or igs14.atx)

・L6 archive data (extension l6)

・conf file (sample.conf)

・rnx2rtkp.exe

2024162all.200.l6
2024162all.201.l6
2024162all.204.l6
igs20.atx
rnx2rtkp.exe
sample.conf
TSK200JPN_S_20241620000_01D_30S_MO.rnx
TSK200JPN_S_20241620000_01D_MN.rnx

6． The following settings are required in the conf file to process for PPP/PPP-AR.

6-1. Describe the path of the ANTEX file (igs20.atx) in the conf file.

Example: See lines 99 and 100 below.

file-satantfile= (specify the path where igs20.atx is saved)

file-rcvantfile= (Specify the path where igs20.atx is saved)

6-2. Setting the PPP-AR mode to ON

(Noted: 6-2 is skipped for PPP mode)

By setting the following,

Line 18: pos1-ionoopt=est-stec

Line 30: pos2-armode=continuous

If you want to select GNSS to use for the AR process, you can set the following,

| | |
|---|---|
| pos2-arsys=1 | # GPS only |
| pos2-arsys=8 | # Galileo only |
| pos2-arsys=9 | # GPS, Galileo |
| pos2-arsys=16 | # QZSS only |
| pos2-arsys=17 | # GPS, QZSS |
| pos2-arsys=24 | # Galileo, QZSS |
| pos2-arsys=25 | # GPS, Galileo, QZSS |

Note that you also need to configure the following section 6.3.

6-3. Setting the used navigation satellite systems

Example: See line 28 below.

Line 28: pos1-navsys=29 (GPS+GLO+GAL+QZS)

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".

6-4. Setting the used signals

The setting in line 8 below should be fixed for PPP using L1+L2 or L1+L5 signals.
Line 8: pos1-frequency=l1+2

Additionally, you should set the types of signals and frequencies of used GPS and QZSS with the options on lines 43-46 below.
In the example below, L1C/A and L2P of GPS IIR-M, L1C/A and L2P of GPS IIF, L1C/A and L2P of GPS IIIA, and L1C and L5 of QZSS are used.

Line 43: pos2-siggpsIIR-M=0
Line 44: pos2-siggpsIIF=0
Line 45: pos2-siggpsIIIA=0
Line 46: pos2-sigqzs1_2=0

6-5. Setting the ionospheric correction to ON

By setting the following,
Line 18: pos1-ionoopt=est-stec
Line 29: pos2-ionocorr=on

In addition to the above settings, to apply ionospheric correction using L6D, you can specify the L6D archive file using the following command line argument -mdciono [.l6]

Example:
rnx2rtkp.exe -k conf file OBS file NAV file L6 file[.l6] -mdciono L6 file[.l6] -o pos file -x 2
*The first L6 file[.l6] is L6E archive data, the second L6 file[.l6] is L6D archive data
**The command line arguments "-x 2" indicate output the trace log file at level 2

In MADOCALIB, when the contents of L6D are uncertain, you can use the trace log file (Level 2) to analyze which Area was selected during positioning with the command line arguments “-x 2”. First, try using L6D in two ways: with PRN200 input and with 201 input. If you check the following with the output the trace log, you can see which L6D archive should be used for correction.

mdciono.c

------------------------------------------------ ---------------------

■ L:483

trace(2,"miono_sel_area: lat=%.2f,lon=%.2f%¥n", ll[0],ll[1]); ⇒ You can find out the user position used for selection in the corresponding epoch.

------------------------------------------------ ---------------------

■ L:510

trace(2,"miono_sel_area: closest RegionID=%d,AreaNo=%d,dist=%.3f¥n", i, j, dist);
⇒ You can see Region ID and Area Number correspond to the receiver position.
If this Trace does not appear to be output, this means that it did not contain the L6D used in any valid Areas. RegionID indicates the Region ID, AreaNo indicates the Area Number, and dist indicates the distance to the center of the Area.

You can also set ionospheric correction using stat file[.stat] including $ION line. Note that the input stat file[.stat] is limited to the one defined by the ionospheric delay in the slant direction.

Example:
rnx2rtkp.exe -k conf file OBS file NAV file L6 file stat file[.stat] -o pos file

```
#
# sample.conf : configuration for ppp
#
# Rev.2024/06/13
#

pos1-posmode       =ppp-kine    # (0:single,1:dgps,2:kinematic,3:static,4:movingbase,5:fixed,6:ppp-kine,7:ppp-static,8:ppp-fixed)
pos1-frequency     =l1+2        # (1:l1,2:l1+2,3:l1+2+3,4:l1+2+3+4,5:l1+2+3+4+5)
pos1-soltype       =forward     # (0:forward,1:backward,2:combined)
pos1-elmask        =10          # (deg)
pos1-snrmask_r     =off         # (0:off,1:on)
pos1-snrmask_b     =off         # (0:off,1:on)
pos1-snrmask_L1    =0,0,0,0,0,0,0,0,0
pos1-snrmask_L2    =0,0,0,0,0,0,0,0,0
pos1-snrmask_L5    =0,0,0,0,0,0,0,0,0
pos1-dynamics      =off         # (0:off,1:on)
pos1-tidecorr      =on          # (0:off,1:on,2:otl)
pos1-ionoopt       =dual-freq   # (0:off,1:brdc,2:sbas,3:dual-freq,4:est-stec,5:ionex-tec,6:qzs-brdc)
pos1-tropopt       =est-ztd     # (0:off,1:saas,2:sbas,3:est-ztd,4:est-ztdgrad)
pos1-sateph        =brdc+ssrapc # (0:brdc,1:precise,2:brdc+sbas,3:brdc+ssrapc,4:brdc+ssrcom)
pos1-posopt1       =on          # (0:off,1:on)
pos1-posopt2       =on          # (0:off,1:on)
pos1-posopt3       =on          # (0:off,1:on,2:precise)
pos1-posopt4       =on          # (0:off,1:on)
pos1-posopt5       =off         # (0:off,1:on)
pos1-posopt6       =off         # (0:off,1:on)
pos1-exclsats      =            # (prn ...)
pos1-navsys        =29          # (1:gps+2:sbas+4:glo+8:gal+16:qzs+32:bds+64:navic)
pos2-ionocorr      =off         # (0:off,1:on)
pos2-armode        =off         # (0:off,1:continuous,2:instantaneous,3:fix-and-hold)
pos2-arsys         =25          # (1:gps+8:gal+16:qzs)
pos2-gloarmode     =on          # (0:off,1:on)
pos2-bdsarmode     =on          # (0:off,1:on)
pos2-arthres       =2.5
pos2-arelmask      =15          # (deg)
pos2-arminfix      =10
pos2-armaxiter     =99
pos2-aroutcnt      =5
pos2-slipthres     =0.15        # (m)
pos2-rejionno      =100         # (m)
pos2-rejgdop       =30
pos2-niter         =1
pos2-siggpsIIR-M   =0           # (0:L1C/A-L2P,1:L1C/A-L2C)
pos2-siggpsIIF     =0           # (0:L1C/A-L2P,1:L1C/A-L2C,2:L1C/A-L5)
pos2-siggpsIIIA    =0           # (0:L1C/A-L2P,1:L1C/A-L2C,2:L1C/A-L5)
pos2-sigqzs1_2     =0           # (0:L1C-L5,1:L1C/A-L2C)
out-solformat      =llh         # (0:llh,1:xyz,2:enu,3:nmea)
out-outhead        =on          # (0:off,1:on)
out-outopt         =on          # (0:off,1:on)
out-outvel         =off         # (0:off,1:on)
out-timesys        =gpst        # (0:gpst,1:utc,2:jst)
out-timeform       =hms         # (0:tow,1:hms)
out-timendec       =3
out-degform        =deg         # (0:deg,1:dms)
out-fieldsep       =
out-outsingle      =off         # (0:off,1:on)
out-maxsolstd      =0           # (m)
out-height         =ellipsoidal # (0:ellipsoidal,1:geodetic)
out-geoid          =internal    # (0:internal,1:egm96,2:egm08_2.5,3:egm08_1,4:gsi2000)
out-solstatic      =all         # (0:all,1:single)
out-nmeaintv1      =0           # (s)
out-nmeaintv2      =0           # (s)
out-outstat        =0           # (0:off,1:state,2:residual)
```

```
stats-eratio1      =300
stats-eratio2      =300
stats-uraratio     =0.1
stats-errphase     =0.003      # (m)
stats-errphaseel   =0.003      # (m)
stats-prnbias      =0.0001     # (m)
stats-prniono      =0.01       # (m)
stats-prntrop      =0.0001     # (m)
stats-prnpos       =0          # (m)
ant1-postype       =llh        # (0:llh,1:xyz,2:single,3:posfile,4:rinexhead,5:rtcm,6:raw)
ant1-pos1          =90         # (deg|m)
ant1-pos2          =0          # (deg|m)
ant1-pos3          =-6335367.6285 # (m|m)
ant1-anttype       =*
ant1-antdele       =0          # (m)
ant1-antdeln       =0          # (m)
ant1-antdelu       =0          # (m)
ant2-postype       =llh        # (0:llh,1:xyz,2:single,3:posfile,4:rinexhead,5:rtcm,6:raw)
ant2-pos1          =90         # (deg|m)
ant2-pos2          =0          # (deg|m)
ant2-pos3          =-6335367.6285 # (m|m)
ant2-anttype       =
ant2-antdele       =0          # (m)
ant2-antdeln       =0          # (m)
ant2-antdelu       =0          # (m)
ant2-maxaveep      =0
ant2-initrst       =off        # (0:off,1:on)
misc-timeinterp    =off        # (0:off,1:on)
misc-sbasatsel     =0          # (0:all)
misc-rnxopt1       =
misc-rnxopt2       =
misc-pppopt        =
misc-rtcmopt       =
#file-satantfile    =..¥sample_data¥igs20.atx
#file-rcvantfile    =..¥sample_data¥igs20.atx
file-satantfile    =igs20.atx
file-rcvantfile    =igs20.atx
file-staposfile    =
file-geoidfile     =
file-ionofile      =
file-dcbfile       =
file-eopfile       =
file-blqfile       =
file-tempdir       =
file-geexefile     =
file-solstatfile   =
file-tracefile     =
```

7． Finally, start the Command Prompt and move to the folder containing rnx2rtkp.exe specified in step 5.

8． Execute the following command.

Command format：

rnx2rtkp.exe -k conf file OBS file NAV file L6 file -o output file

Example：

```
rnx2rtkp.exe  -k  sample.conf  TSK200JPN_S_20241620000_01D_30S_MO.rnx
TSK200JPN_S_20241620000_01D_MN.rnx 2024162all.204.l6 -o test.pos
```

A file (test.pos) containing time series positioning results of PPP is obtained.

Contents of test.pos (below, excerpt)

```
% program    : MADOCALIB ver.1.2
% inp file   : TSK200JPN_S_20241620000_01D_30S_MO.rnx
% inp file   : TSK200JPN_S_20241620000_01D_MN.rnx
% inp file   : 2024162all.204.l6
% obs start  : 2024/06/10 00:00:00.0 GPST (week2318  86400.0s)
% obs end    : 2024/06/10 23:59:30.0 GPST (week2318 172770.0s)
% pos mode   : PPP Kinematic
% freqs      : L1+2
% solution   : Forward
% elev mask  : 10.0 deg
% dynamics   : off
% tidecorr   : on
% ionos opt  : Iono-Free LC
% tropo opt  : Estimate ZTD
% ephemeris  : Broadcast+SSR APC
% navi sys   : GPS GLONASS Galileo QZSS
% ar sys     : GPS Galileo QZSS
% amb res    : OFF
% val thres  : 2.5
% antenna1   : TRM159900.00    NONE  ( 0.0000  0.0000  0.0000)
%
% (lat/lon/height=WGS84/ellipsoidal,Q=1:fix,2:float,3:sbas,4:dgps,5:single,6:ppp,ns=# of satellites)
%  GPST                  latitude(deg) longitude(deg)  height(m)   Q  ns   sdn(m)   sde(m)   sdu(m)  sdne(m)  sdeu(m)  sdun(m) age(s)  ratio
2024/06/10 00:00:30.000   36.105576250  140.087121541    70.2987   6  11   5.6860   4.0337   8.8617  -1.9501   0.7962  -4.4922   0.00    0.0
2024/06/10 00:01:00.000   36.105577531  140.087119601    71.0876   6  11   3.8524   2.8466   5.6844  -1.2728   0.5909  -2.9644   0.00    0.0
2024/06/10 00:01:30.000   36.105574574  140.087121277    70.8690   6  11   2.9403   2.3071   4.0859  -0.9017   0.5150  -2.2025   0.00    0.0
2024/06/10 00:02:00.000   36.105576816  140.087121023    71.0848   6  16   2.1873   1.9056   3.0110  -0.2156  -0.4508  -1.5768   0.00    0.0
2024/06/10 00:02:30.000   36.105578729  140.087122111    70.4542   6  17   1.7477   1.6425   2.3593   0.3592  -0.4642  -1.2660   0.00    0.0
2024/06/10 00:03:00.000   36.105580235  140.087123076    70.2562   6  17   1.4201   1.4590   1.9088   0.3816  -0.3944  -1.0404   0.00    0.0
2024/06/10 00:03:30.000   36.105579786  140.087124771    70.2004   6  18   1.1605   1.3027   1.5797   0.3599  -0.2766  -0.8614   0.00    0.0
2024/06/10 00:04:00.000   36.105578957  140.087124362    70.4188   6  18   0.9590   1.1794   1.3311   0.3024  -0.1454  -0.7121   0.00    0.0
2024/06/10 00:04:30.000   36.105576913  140.087126342    70.1096   6  18   0.8023   1.0774   1.1378   0.2371   0.1293  -0.5907   0.00    0.0
2024/06/10 00:05:00.000   36.105577131  140.087125893    70.1026   6  18   0.6802   0.9907   0.9843   0.1715   0.2027  -0.4938   0.00    0.0
2024/06/10 00:05:30.000   36.105576049  140.087125373    70.3568   6  18   0.5843   0.9159   0.8605   0.1028   0.2357  -0.4169   0.00    0.0
2024/06/10 00:06:00.000   36.105576393  140.087125185    70.3733   6  18   0.5081   0.8505   0.7595  -0.0458   0.2511  -0.3561   0.00    0.0
2024/06/10 00:06:30.000   36.105575989  140.087125154    70.3052   6  18   0.4468   0.7926   0.6760  -0.1017   0.2569  -0.3078   0.00    0.0
2024/06/10 00:07:00.000   36.105574920  140.087125072    70.2931   6  18   0.3969   0.7409   0.6063  -0.1246   0.2568  -0.2693   0.00    0.0
2024/06/10 00:07:30.000   36.105575254  140.087125375    70.2630   6  18   0.3570   0.6962   0.5480  -0.1421   0.2512  -0.2369   0.00    0.0
2024/06/10 00:08:00.000   36.105575220  140.087125605    70.2053   6  18   0.3234   0.6562   0.4991  -0.1516   0.2422  -0.2097   0.00    0.0
2024/06/10 00:08:30.000   36.105574788  140.087125721    70.2265   6  18   0.2951   0.6197   0.4572  -0.1565   0.2328  -0.1874   0.00    0.0
2024/06/10 00:09:00.000   36.105575335  140.087126166    70.2132   6  18   0.2708   0.5863   0.4209  -0.1584   0.2233  -0.1689   0.00    0.0
2024/06/10 00:09:30.000   36.105574896  140.087126721    70.2129   6  18   0.2499   0.5553   0.3891  -0.1581   0.2143  -0.1536   0.00    0.0
```

II-2 CSSR2SSR

To run the CSSR2SSR the following files are required.

a) QZSS L6E correction data (.l6)

Specify the L6E message file as a file in command line argument. The results are output as a file specified with -o options.

Supported Compact SSR messages (cssr) 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
  ---------------------:-----------------------------------------------
  SSR Orbit Correction :  1057       1063        1240(*1)    1246(*1)
      Clock Correction :  1058       1064        1241(*1)    1247(*1)
      URA              :  1061       1067        1244(*1)    1250(*1)
      Code Bias        :  1059(*2)   1065(*2)    1242(*1*2)  1248(*1)
      Phase Bias       :  1265(*2)   1266(*2)    1267(*1*2)  1268(*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
```

Of the signals stored in MADOCA-PPP, those not defined in RTCM SSR use the following signal and tracking mode identifier.

```
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
```

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 2024/06/10 -o 2024162all.204.rtcm3 2024162all.204.l6
```

# III Sample BAT file

## III-1 RNX2RTKP

Batch files and configuration files showing an example of executes PPP-AR and PPP-AR with ionospheric correction are included in the package.

Move to the folder of “sample_data” and execute `exec_pppar.bat` for PPP-AR or `exec_pppar_ion.bat` for PPP-AR with ionospheric correction. These BAT files execute PPP-AR from 00min00sec to 59min30sec every hour.

## III-2 CSSR2SSR

Move to the folder of “sample_data” and execute `exec_cssr2ssr.bat` for conversion of L6E message file containing MADOCA-PPP compact SSR data to RTCM3 SSR message file.