MADOCALIB ver.1.2 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.

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

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.

II Usage of Utilities

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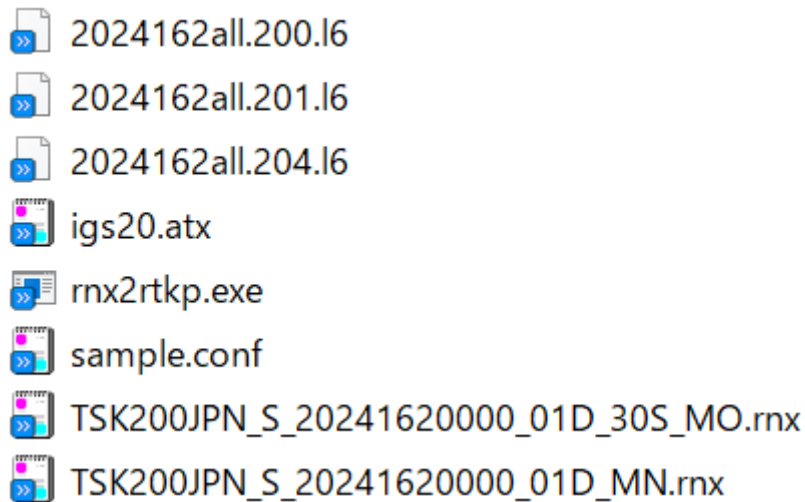
6．The following settings are required in the conf file to process for PPP/PPP-AR.

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

        Example: See lines 110 and 111 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 14: pos1-ionoopt=est-stec

        Line 26: 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 24 below.

Line 24: 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 4 below should be fixed for PPP using L1+L2 or L1+L5 signals.
Line 4: pos1-frequency=l1+2

Additionally, you should set the types of signals and frequencies of used GPS and QZSS with the options on lines 49-52 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 49: pos2-siggpsIIR-M=0
Line 50: pos2-siggpsIIF=0
Line 51: pos2-siggpsIIIA=0
Line 52: pos2-sigqzs1_2=0

6-5. Setting the ionospheric correction to ON

By setting the following,
Line 14: pos1-ionoopt=est-stec
Line 25: 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
*The first L6 file[.l6] is L6E archive data, the second L6 file[.l6] is L6D archive data

In MADOCALIB, when the contents of L6D are uncertain, you can use Trace (Level 4) to analyze which Area was selected during positioning. First, try using L6D in two ways: with PRN200 input and with 201 input. If you check the following with the

output Trace, 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

```
 1 #
 2 # sample.conf : configuration for ppp
 3 #
 4 # Rev.2024/06/13
 5 #
 6
 7 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)
 8 pos1-frequency      =l1+2        # (1:l1,2:l1+2,3:l1+2+3,4:l1+2+3+4,5:l1+2+3+4+5)
 9 pos1-soltype        =forward     # (0:forward,1:backward,2:combined)
10 pos1-elmask         =10          # (deg)
11 pos1-snrmask_r      =off         # (0:off,1:on)
12 pos1-snrmask_b      =off         # (0:off,1:on)
13 pos1-snrmask_L1     =0,0,0,0,0,0,0,0,0
14 pos1-snrmask_L2     =0,0,0,0,0,0,0,0,0
15 pos1-snrmask_L5     =0,0,0,0,0,0,0,0,0
16 pos1-dynamics       =off         # (0:off,1:on)
17 pos1-tidecorr       =on          # (0:off,1:on,2:otl)
18 pos1-ionoopt        =dual-freq   # (0:off,1:brdc,2:sbas,3:dual-freq,4:est-stec,5:ionex-tec,6:qzs-brdc)
19 pos1-tropopt        =est-ztd     # (0:off,1:saas,2:sbas,3:est-ztd,4:est-ztdgrad)
20 pos1-sateph         =brdc+ssrapc # (0:brdc,1:precise,2:brdc+sbas,3:brdc+ssrapc,4:brdc+ssrcom)
21 pos1-posopt1        =on          # (0:off,1:on)
22 pos1-posopt2        =on          # (0:off,1:on)
23 pos1-posopt3        =on          # (0:off,1:on,2:precise)
24 pos1-posopt4        =on          # (0:off,1:on)
25 pos1-posopt5        =off         # (0:off,1:on)
26 pos1-posopt6        =off         # (0:off,1:on)
27 pos1-exclsats       =           # (prn ...)
28 pos1-navsys         =29          # (1:gps+2:sbas+4:glo+8:gal+16:qzs+32:bds+64:navic)
29 pos2-ionocorr       =off         # (0:off,1:on)
30 pos2-armode         =off         # (0:off,1:continuous,2:instantaneous,3:fix-and-hold)
31 pos2-arsys          =25          # (1:gps+8:gal+16:qzs)
32 pos2-gloarmode      =on          # (0:off,1:on)
33 pos2-bdsarmode      =on          # (0:off,1:on)
34 pos2-arthres        =2.5
35 pos2-arelmask       =15          # (deg)
36 pos2-arminfix       =10
37 pos2-armaxiter      =99
38 pos2-aroutcnt       =5
39 pos2-slipthres      =0.15        # (m)
40 pos2-rejionno       =100         # (m)
41 pos2-rejgdop        =30
42 pos2-niter          =1
43 pos2-siggpsIIR-M    =0           # (0:L1C/A-L2P,1:L1C/A-L2C)
44 pos2-siggpsIIF      =0           # (0:L1C/A-L2P,1:L1C/A-L2C,2:L1C/A-L5)
45 pos2-siggpsIIIA     =0           # (0:L1C/A-L2P,1:L1C/A-L2C,2:L1C/A-L5)
46 pos2-sigqzs1_2      =0           # (0:L1C-L5,1:L1C/A-L2C)
47 out-solformat       =llh         # (0:llh,1:xyz,2:enu,3:nmea)
48 out-outhead         =on          # (0:off,1:on)
49 out-outopt          =on          # (0:off,1:on)
50 out-outvel          =off         # (0:off,1:on)
51 out-timesys         =gpst        # (0:gpst,1:utc,2:jst)
52 out-timeform        =hms         # (0:tow,1:hms)
53 out-timendec        =3
54 out-degform         =deg         # (0:deg,1:dms)
55 out-fieldsep        =
56 out-outsingle       =off         # (0:off,1:on)
57 out-maxsolstd       =0           # (m)
58 out-height          =ellipsoidal # (0:ellipsoidal,1:geodetic)
59 out-geoid           =internal    # (0:internal,1:egm96,2:egm08_2.5,3:egm08_1,4:gsi2000)
60 out-solstatic       =all         # (0:all,1:single)
61 out-nmeaintv1       =0           # (s)
62 out-nmeaintv2       =0           # (s)
63 out-outstat         =0           # (0:off,1:state,2:residual)
```

8

```
 64 stats-eratio1       =300↵
 65 stats-eratio2       =300↵
 66 stats-uraratio      =0.1↵
 67 stats-errphase      =0.003       # (m)↵
 68 stats-errphasel     =0.003       # (m)↵
 69 stats-prnbias       =0.0001      # (m)↵
 70 stats-prniono       =0.01        # (m)↵
 71 stats-prntrop       =0.0001      # (m)↵
 72 stats-prnpos        =0           # (m)↵
 73 ant1-postype        =llh         # (0:llh,1:xyz,2:single,3:posfile,4:rinexhead,5:rtcm,6:raw)↵
 74 ant1-pos1           =90          # (deg|m)↵
 75 ant1-pos2           =0           # (deg|m)↵
 76 ant1-pos3           =-6335367.6285 # (m|m)↵
 77 ant1-anttype        =*↵
 78 ant1-antdele        =0           # (m)↵
 79 ant1-antdeln        =0           # (m)↵
 80 ant1-antdelu        =0           # (m)↵
 81 ant2-postype        =llh         # (0:llh,1:xyz,2:single,3:posfile,4:rinexhead,5:rtcm,6:raw)↵
 82 ant2-pos1           =90          # (deg|m)↵
 83 ant2-pos2           =0           # (deg|m)↵
 84 ant2-pos3           =-6335367.6285 # (m|m)↵
 85 ant2-anttype        =↵
 86 ant2-antdele        =0           # (m)↵
 87 ant2-antdeln        =0           # (m)↵
 88 ant2-antdelu        =0           # (m)↵
 89 ant2-maxaveep       =0↵
 90 ant2-initrst        =off         # (0:off,1:on)↵
 91 misc-timeinterp     =off         # (0:off,1:on)↵
 92 misc-sbasatsel      =0           # (0:all)↵
 93 misc-rnxopt1        =↵
 94 misc-rnxopt2        =↵
 95 misc-pppopt         =↵
 96 misc-rtcmopt        =↵
 97 #file-satantfile    =..¥sample_data¥igs20.atx↵
 98 #file-rcvantfile    =..¥sample_data¥igs20.atx↵
 99 file-satantfile     =igs20.atx↵
100 file-rcvantfile     =igs20.atx↵
101 file-staposfile     =↵
102 file-geoidfile      =↵
103 file-ionofile       =↵
104 file-dcbfile        =↵
105 file-eopfile        =↵
106 file-blqfile        =↵
107 file-tempdir        =↵
108 file-geexefile      =↵
109 file-solstatfile    =↵
110 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)

```
  1 % program    : MADOCALIB ver.1.2↓
  2 % inp file  : TSK200JPN_S_20241620000_01D_30S_MO.rnx↓
  3 % inp file  : TSK200JPN_S_20241620000_01D_MN.rnx↓
  4 % inp file  : 2024162all.204.l6↓
  5 % obs start : 2024/06/10 00:00:00.0 GPST (week2318  86400.0s)↓
  6 % obs end   : 2024/06/10 23:59:30.0 GPST (week2318 172770.0s)↓
  7 % pos mode  : PPP Kinematic↓
  8 % freqs     : L1+2↓
  9 % solution  : Forward↓
 10 % elev mask : 10.0 deg↓
 11 % dynamics  : off↓
 12 % tidecorr  : on↓
 13 % ionos opt : Iono-Free LC↓
 14 % tropo opt : Estimate ZTD↓
 15 % ephemeris : Broadcast+SSR APC↓
 16 % navi sys  : GPS GLONASS Galileo QZSS↓
 17 % ar sys    : GPS Galileo QZSS↓
 18 % amb res   : OFF↓
 19 % val thres : 2.5↓
 20 % antenna1  : TRM159900.00    NONE  ( 0.0000  0.0000  0.0000)↓
 21 %↓
 22 % (lat/lon/height=WGS84/ellipsoidal,Q=1:fix,2:float,3:sbas,4:dgps,5:single,6:ppp,ns=# of satellites)↓
 23 %  GPST             latitude(deg) longitude(deg)  height(m)  Q  ns   sdn(m)  sde(m)  sdu(m)  sdne(m)  sdeu(m)  sdun(m) age(s)  ratio↓
 24 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↓
 25 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↓
 26 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↓
 27 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↓
 28 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↓
 29 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↓
 30 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↓
 31 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↓
 32 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↓
 33 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↓
 34 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↓
 35 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↓
 36 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↓
 37 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↓
 38 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↓
 39 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↓
 40 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↓
 41 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↓
 42 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↓
```

III   Sample BAT file

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.