PPPLib User Manual

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1 Introduction

PPPLib adopts post-processing mode for PPP processing to integrate multi-frequency and multi- GNSS data (GPS, BDS, Galileo and GLONASS as well as QZSS). PPPLib was developed in C/C++ environment. It can compile and run on the popular operating systems, such as Windows, Linux. It is recommended that one debugs PPPLib under JetBrains CLion and then compiles, runs it in Linux for batch processing. The main features include:

- GNSS common functions
- Support GPS/BDS/GAL/GLO/QZS
- Support any single system or combined
- Standard single point positioning (SPP)
- Precise point positioning (PPP)
- single- to triple frequency with multi-constellation PPP using ionosphere-free observations
- single- to triple frequency with multi-constellation PPP using uncombined observations
- inospheric constranit PPP
- Support BDS-3 satellites and new signals(B2a)
- Ample output
- Ample debug information
- data download and result analysis

Future features of PPPLib will be:

- loosely/tightly coupled PPP/INS (on the way)
- PPP-AR
- PPPLib-GUI

Note triple-frequency PPP beyond the author's research. In current version, PPPLib can process triple-frequency data, but some bugs may still exist. If you want to develop triple-frequency mode, you should to solve the inter-frequency clock bias (IFCB) for third frequency carrier phase.

2 How to use

PPPLib uses Cmake for project management. Currently the software supports compile and run in Linux and Windows. The test system includes the virtual machine Ubantu 16.0, Ubantu 16.0 and Win10. The author uses JetBrains CLion2019.3 software platform for developing and debug. No test for other platforms.

2.1 Linux User

If you use Linux, you can run PPPLib by:

1 Clone

```
cd [Your Path]
git clone https://github.com/heiwa0519/PPPLib_v1.0.git
```

2 Compile

```
cd [Your Path]/PPPLib
mkdir build
cd build
cmake ..
make
```

3 Run

```
cd [Your Path]/PPPLib/bin
e.g. SF-UC simulate Kinematic GBERJ-PPP
./PPPMain -pd 2019/12/01 -do 0 -cf ../conf/PPPLib.ini -level 128 -
    sys GBERJ -md PPP-KINE_SIM -ion 4 -frq 1
e.g. DF-IF Static B-PPP
./PPPMain -pd 2019/12/01 -do 0 -cf ../conf/PPPLib.ini -level 128 -
    sys B -md PPP-STATIC -ion 3 -frq 2
e.g. TF-IF simulate Kinematic GB-PPP
./PPPMain -pd 2019/12/01 -do 0 -cf ../conf/PPPLib.ini -level 128 -
    sys GB -md PPP-KINE_SIM -ion 3 -frq 3
```

-do 1 whether used default options(int 0:no 1:use, default use). Recommended to set 0. If set 1, you should download data first using python scripts, then change DEFPRC_DIR in '//include//Core//CmnFunc//CmnFunc.h' to your local data store dir.

-cf customize configuration file path(if [-do]==0, this parameter is required)

-pd process data date(yyyy/mm/dd e.g. 2019/12/01)

-sys use GNSS option(G/B/E/R/J, default use GPS)

-md PPPLib processing mode(string SPP-KINE, PPP-STATIC, PPP-KINE, ...)

-frq number frequency(3 triple-frq 2 dual-frq 1 single-frq)

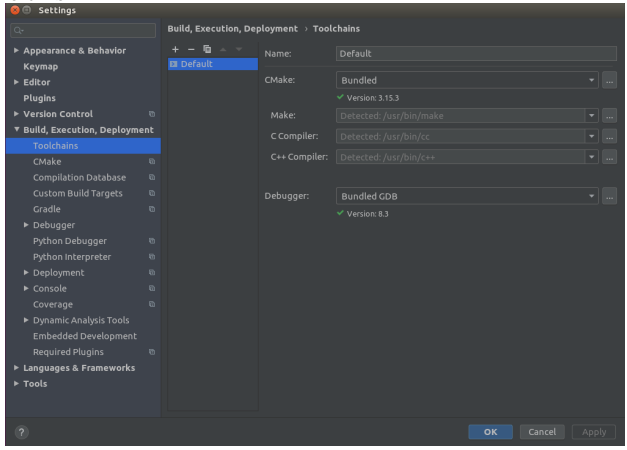
-ion ionospheric options(4 UC 3 IF)

-level output debug information level (128 Info 32 Warning 1 Debug)

- More specific configuration, please refer to "Configure file" section.

4 Debug

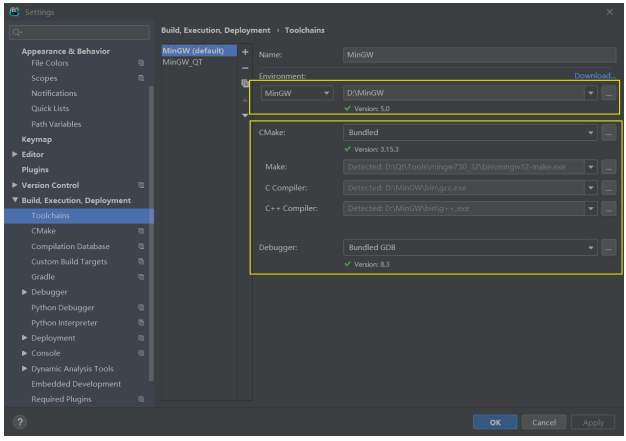
For PPPLib Debug in linux, it is recommended to use CLion. In Ubantu 16, my CLion toolchains like this



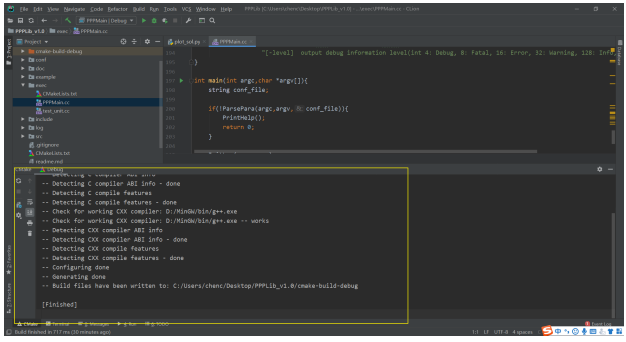
Other configuration steps please see Windows user guild.

2.2 Windows User

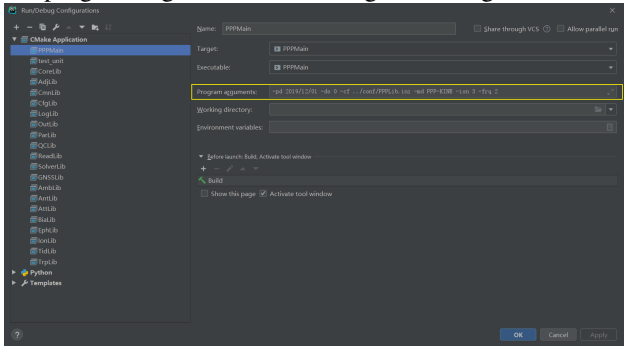
If you use Windows, it is recommended to use CLion for running and debug. My CLion configuration like this



After load PPPLib project, CLion can cmake automatically. If configured ok, the cmake window will output like this

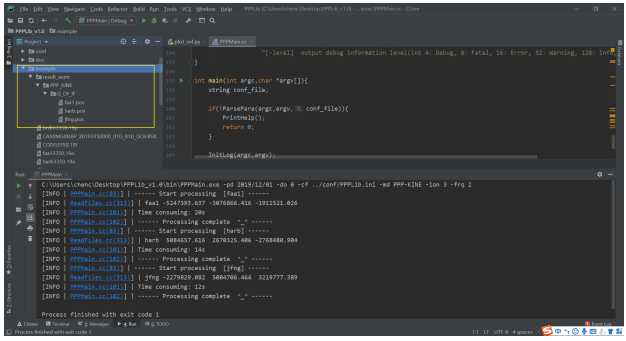


Then, you can set program arguments for running and debug



About [-do], whether used default options(int 0:no 1:use, default use). Recommended to set 0. If set 1, you should download data first using python scripts, then change DEFPRC_DIR in '//include//Core//CmnFunc//CmnFunc.h' to your local data store dir.

After running, The solution file will be generated according to the positioning mode in corresponding folder.



2.3 Configuration file

If in command line, [-do] sets 1, then [-cf] should be set, which is customize configuration file path. The configuration file including:

```
prc_data_dir: primary directory for data storage,please set this to you
    local path when use python scripts to download data. If you want to
    this commond takes effect, your should set [-do]=0 and [customize_file
    ]=0. If you set [-do]=1, change DEFPRC\_DIR in '//include//Core//
    CmnFunc//CmnFunc.h' to your local data store dir for batch processing
    using default options.
prc_date: process data date- yyyy/mm/dd
prc_mode: position mode 0-SPP 1-PPP
prc_mode_opt: position mode options 0-STATIC 1-KINE 2-KINE_SIM

obs_sample: GNSS observation sample- s
prod_ac: product AC 0-brd 1-cod 2-wum 3-gfz 4-gbm
num_use_frqs: GNSS used frequency number 1-single_frq 2-dual_frq 3-third_
    frq
use_GPS_frq: set GPS used frequency 0-L1  1-L2  2-L5  16-L1&L2  32-L1&L5
      33-L2&L5  528-L1&L2&L5
```

```
use_BD2_frq: set BD2 used frequency0-B1I 1-B2I 2-B3I 16-B1I&B2I 32-B1I&B3I
     33-B2I&B3I 528-B1I&B2I&B3I
use_BD3_frq: set BD3 used frequency0-B1I 1-B2a 2-B3I 3-B1C      16-B1I&B2a
     32-B1I&B3I 48-B1I&B1C 528-B1I&B2a&B3I
use_GAL_frq: set GAL used frequencyset GAL used frequency 0-E1  1-E5a 2-E5
    b 16-E1&E5a  32-E1&E5b  33-E5a&E5b 528-E1&E5a&E5b
use_GLO_frq: set GLO used frequency0-G1  1-G2  3-G3  16-G1&G2   32-G1&G3
      33-G2&G3   528-G1&G2&G3
use_QZS_frq: set QZS used frequency0-L1  1-L2  2-L5  16-L1&L2   32-L1&L5
      33-L2&L5   528-L1&L2&L5
p_h_err_ratio: pseudorange/phase/dopplor error ratio
meas_err_ratio: measurement error ratio
ele_min:min elevation- deg
sat_eph: satellite ephemeris type 0-brd 1-precise
cbias_prd_type: code bias product type   0-OFF 1-TGD 2-DCB 3-OSB
cbias_prd_ac: code bias product ac     0-COD 1-CAS
if3_opt: triple frequency if opt  0-single 1-dual(have bug)
trp_opt: troposphere option       0-off 1-saas 2-est_wet
trp_map_opt: troposphere map function 0-el  1-GMF 2-VMF1 3-NEIL
tid_opt: tide correction option   0-off 1-solid + 2-ocean + 4-pole
rec_pcv: receiver pco and pcv     0-off 1-on
sat_pcv: satellite pco and pcv    0-off 1-on

phw_corr: phase windup correction 0-off 1-on
bd2_multipath_corr: BD2 code multipath correction 0-off 1-on

exclude_sat: manual culling satellite(sat no.) 1,45,101

customize_file: 1if set 1, please prepare data like example dir
customize_dir: if customize_file == 1, please set data dir
```

2.4 Python scripts

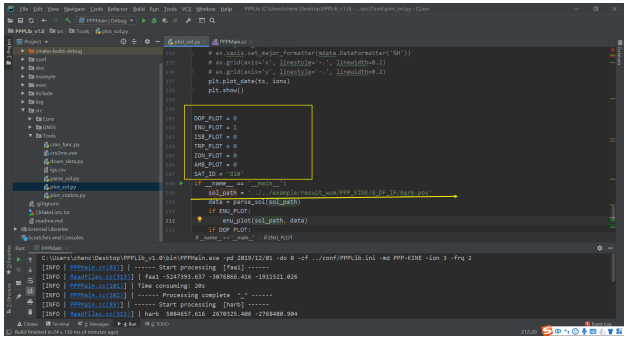
PPPLib provides python scripts to parse solutions and download data. Your can found these scripts in "/PPPLib/src/Tools" folder. To use scripts, some requirements should be installed before it launched.

- Matplotlib

- Numpy
- Pandas
- unlzw
- gzip

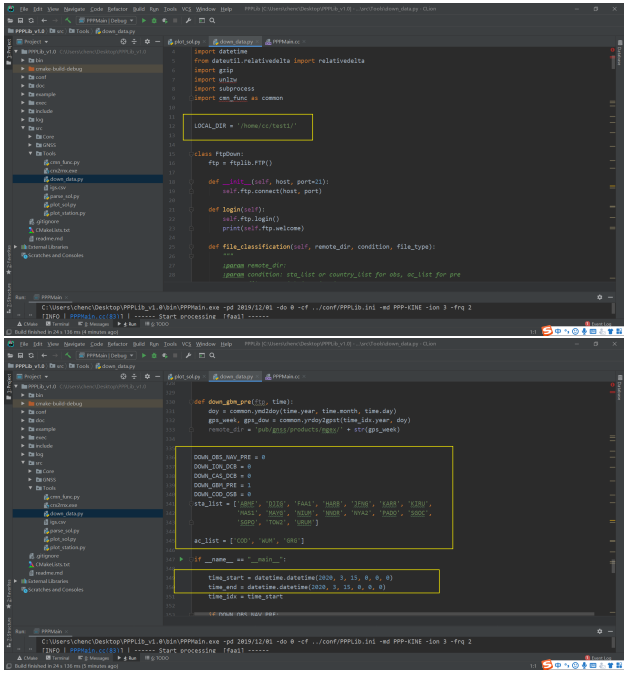
For solution visualization, plot_sol.py will be use. In this script, some parameter can be for different output.

- DOP_PLOT: plot pdop and satellite number
- ENU_PLOT: plot positioning error in east, north and up direction
- TRP_PLOT: plot dry and wet tropospheric delay
- SAT_PLOT: plot satellite related, e.g. residual,ambiguity.
- sol_dir: solution file dir



For data download, down_data.py will be use.

- DOWN_OBS_NAV_PRE: download observations, broadcast ephemeris, precise orbit, clock, SNX, ERP from ftp igs.gnsswhu.cn
- DOWN_ION_DCB: download GIM,DCB file from ftp.aiub.unibe.ch
- DOWN_CAS_DCB: download MGEX DCB from ftp.gipp.org.cn
- DOWN_GBM_PRE: download GBM precise products from ftp.gfz-potsdam.de
- sta_list: station lists for download observations
- ac_list: AC lists for download precise products
- time_start: batch download start time
- time_end: batch download end time
- LOCAL_DIR: the file storage path in your computer

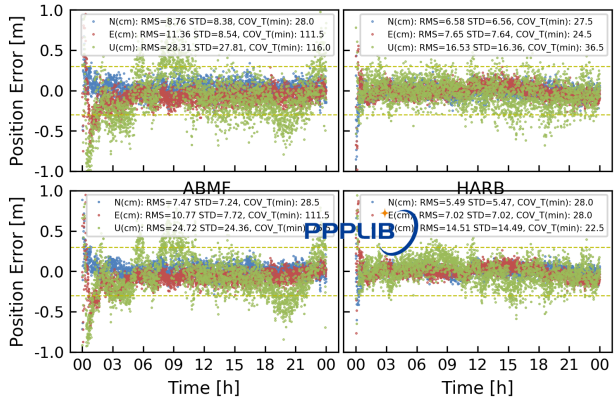


For batch process, recommended to use batch_process.py in Linux.

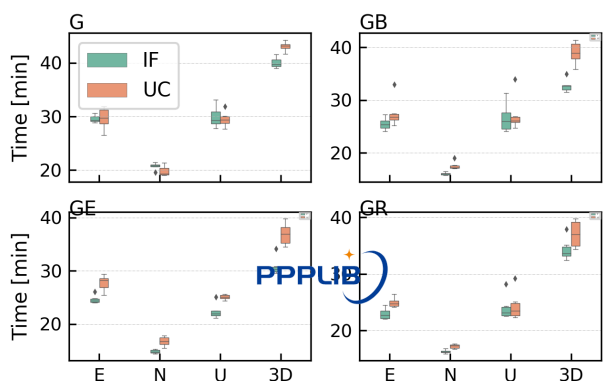
3 Result

Evaluate performance of PPPLib use a one-week period of data from 17 MGEX observation stations. Some example results also can be found in example folder.

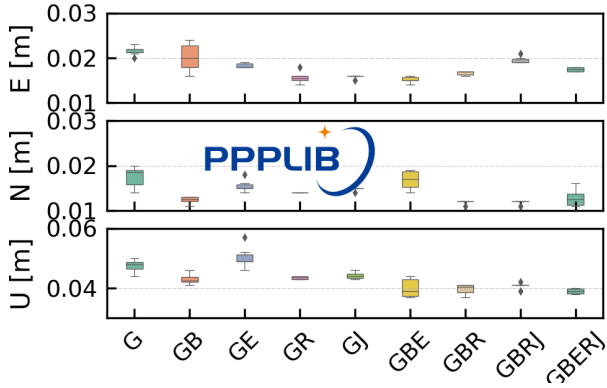
3.1 Single frequency



3.2 UC and IF

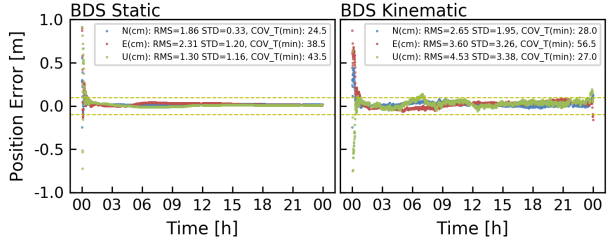


3.3 Multi-GNSS



3.4 BDS-TF

Chose a better result, some bugs exits in TF-PPP model



4 Acknowledgement

First of all, I pay tribute to Mr. Tomoji Tkasu, the author of RTKLIB software. I admire him for his selfless open source spirit and elegant programming. The developing of PPPLib also refers to HPRTK of Mowen Li from Shandong University, the GAMP software of Feng Zhou from Shandong University of Science and Technology, the MGAPP of Gongwei Xiao from Institute of Geodesy and GeophysicsChinese Academy of Sciences, and the PINS software of Gongmin Yan from Northwestern Polytechnic University. The log system of PPPLib uses easyloggingpp. Thanks to the authors of the above software. It is not easy to develop, please indicate the source

if you have any references.

5 Contact Author

Any suggestions, corrections, and comments about PPPLib are sincerely welcomed and could be sent to:

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