Preparation, Analysis and Processing of RINEX v3.x files

Analysis of RINEX observation file

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Contents

1 Overview of `rnxproc`

1.1 General directory structure for (semi-)permanent monitoring

The repository is based on the following directory structure[1] for the binary receiver data:

```
${HOME}/RxTURP
    BEGPIOS
        ASTX
            ...
            19133
            19134
            19135
            ...
        BEGP
            ...
            19133
            19134
            19135
            ...
        P3RS2
            LOG
                pvt_ls
```

where YYDDD represents 2 digits for the year and 3 digits for the day of year.

During processing, in each receiver type directory (ASTX, BEGP, …) a `rinex` sub-directory is created with sub-directories with the same YYDDD as the original raw binary data sub-directories.

The P3RS2 outputs RINEX observation and navigation files each 15 minutes into a single directory `LOG/pvt_ls` and need to be treated differently. These files uses the following naming convention, loosely based on the official RINEX v3 naming convention:

- **P3RS-2_RX_R_YYYYDOYHHMM_15M_MN.rnx** for the RINEX navigation files,
- **P3RS-2_RX_R_YYYYDOYHHMM_15M_00U_MO.rnx** for the RINEX observation file

where:

- **YYYY** … 4 digit year number
- **DOY** … 3 digit day of year number
- **HHMM** … hour and minutes of file creation

The resulting ::RX3:: formatted daily files are stored under directory /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex. In this directory the daily created files are organised in sub-directories **YYDOY** similar to the structure followed for the other receivers. The ::RX3:: files are stored in Hatanaka compressed form for observation files, while **gzip** compresses the navigation files. As example:

---

[1]I never tested this repository using another directory structure.

```
[amuls:~/RxTURP/BEGPIOS/P3RS2/rinex/20311] $ ls -l
total 1740
-rw-rw-r-- 1 amuls amuls  12534623 Jan 13 16:43 P3RS00BEL_R_20203300008_01D_01S_MO.crx.Z
-rw-rw-r-- 1 amuls amuls    165168 Jan 13 16:41 P3RS00BEL_R_20203300000_01D_MN.rnx.gz
```

1.2 Purpose

rnxproc provides several python scripts which can be run in stand alone mode or be called from other python scripts. The purpose is to create scripts performing a specific task. Some tasks will be grouped in a more general (super-)script to perform several elementary steps in a row.

1.2.1 Converting (six-)hourly SBF files to (compressed) RINEX v3.x files

Script	Task
sbf_daily.py	Combine (six-)hourly SBF files to daily files
sbf_rinex.py	Convert SBF daily file to RINEX v3.X observation & navigation file
prepare_sbf2rnx.py	Combines above scripts and offers to get compressed RINEX v3.x files

1.2.2 Combining (15 minutes) P3RS2 RINEX files into daily RINEX v3.x files

Script	Task
rnx15_combine.py	Combines 15 minutes RINEX files frim P3RS2
prepare_rnx15.py	Uses above script and add possibility for compressed RINEX v3.x files

1.2.3 Converting and analysing RINEX files to observation tabular and statistics files

Script	Task
rnxobs_tabular.py	creates observation tabular/statistics file for selected GNSSs
obsstat_analyse.py	analyses observation statistics file for selected GNSSs

2 Python scripts

2.1 Converting (six-)hourly SBF files to (compressed) RINEX v3.x files

2.1.1 sbf_daily.py

`sbf_daily.py` creates a daily SBF file based on (six) hourly SBF files found in given directory

Usage

```
[amuls:~/amPython/rnxproc] [rnxproc]$ sbf_daily.py -h
usage: sbf_daily.py [-h] [-d DIR] [-o] [-l LOGGING LOGGING]

sbf_daily.py creates a daily SBF file based on (six) hourly SBF files found in given directory

optional arguments:
  -h, --help            show this help message and exit
  -d DIR, --dir DIR     Directory of SBF file (defaults to .)
  -o, --overwrite       overwrite daily SBF file (default False)
  -l LOGGING LOGGING, --logging LOGGING LOGGING
                        specify logging level console/file (default INFO DEBUG)
```

Example run

```
[amuls:~/amPython/rnxproc] [rnxproc]$ sbf_daily.py -d ~/RxTURP/BEGPIOS/ASTX/19134/
INFO: sbf_daily.py - main: working directory is /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - main: changed to directory /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - main: combine SBF (six-)hourly files to daily SBF file
INFO: sbf_daily.py - main: creating daily SBF file SEPT1340.19_

[amuls:~/amPython/rnxproc] [rnxproc]$ sbf_daily.py -d ~/RxTURP/BEGPIOS/ASTX/19134/
INFO: sbf_daily.py - main: working directory is /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - main: changed to directory /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - main: combine SBF (six-)hourly files to daily SBF file
INFO: sbf_daily.py - main: reusing daily SBF file SEPT1340.19_
```

2.1.2 sbf_rinex.py

`sbf_rinex.py` converts a SBF file into RINEX v3.x observation and navigation files.

Usage

```
[amuls:~/amPython/rnxproc] [rnxproc]$ rinex.py --help
usage: sbf_rinex.py [-h] -f SBFF [-r RNXDIR] [-l LOGGING LOGGING]

sbf_rinex.py convert binary raw data from SBF to RINEX Obs & Nav files

optional arguments:
```

```
 -h, --help             show this help message and exit
 -f SBFF, --sbff SBFF  Binary SBF file
 -r RNXDIR, --rnxdir RNXDIR
                        Directory for RINEX output (default .)
 -l LOGGING LOGGING, --logging LOGGING LOGGING
                        specify logging level console/file (default INFO DEBUG)
```

Example run

```
[amuls:~/amPython/rnxproc] [rnxproc]$ sbf_rinex.py --sbff /home/amuls/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ --rnxdir /home/amuls/RxTURP/BEGPIOS/AS
INFO: sbf_rinex.py - sbf2rnx3: arguments processed: dRnx = {'dirs': {'sbf': '/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134', 'rnx': PosixPath('/me
INFO: sbf_rinex.py - checkValidityArgs: check existence of sbfDir /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_rinex.py - checkValidityArgs: check existence of binary file /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ to convert
INFO: sbf_rinex.py - checkValidityArgs: check existence of rnxdir /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134 and create if needed
INFO: location.py - locateProg: sbf2rin is /opt/Septentrio/RxTools/bin/sbf2rin
INFO: sbf_rinex.py - sbf2rnx3: convert binary file to rinex
INFO: sbf_rinex.py - sbf2rinex: RINEX conversion from SBF binary
INFO: sbf_rinex.py - sbf2rinex: creating RINEX observation file
INFO: amutils.py - run_subprocess_output: running
/opt/Septentrio/RxTools/bin/sbf2rin -f /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ -x RSCJI -s -D -v -R3 -l -O BEL
Creating RINEX file: done                                                   |  0%
INFO: sbf_rinex.py - sbf2rinex: creating RINEX navigation file
INFO: amutils.py - run_subprocess_output: running
/opt/Septentrio/RxTools/bin/sbf2rin -f /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ -x RSCJI -s -D -v -n P -R3 -l -O BEL
Creating RINEX file: done                                                   |  0%
INFO: sbf_rinex.py - sbf2rnx3: dRnx =
{
    "dirs": {
        "sbf": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134",
        "rnx": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134"
    },
    "sbff": "SEPT1340.19_",
    "bin": {
        "SBF2RIN": "/opt/Septentrio/RxTools/bin/sbf2rin"
    },
    "obs3f": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_01S_MO.rnx",
    "nav3f": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_MN.rnx"
}
```

2.1.3 prepare_sbf2rnx.py

This script combines the scripts sbf_daily.py and sbf-rinex.py and offers the possibility to
perform compression of these files:

- RINEX observation file undergoes a Hatanaka compression using the program rnx2crz,
- RINEX navigation file is gzip compressed.

Usage

```
[amuls:~/amPython/rnxproc] [rnxproc]$ prepare_sbf2rnx.py -h
usage: prepare_sbf2rnx.py [-h] [-r ROOT_DIR] -m MARKER -y YEAR -d DOY [-c] [-o] [-l LOGGING LOGGING]

prepare_sbf2rnx.py Combining and conversion of SBF files to RINEX v3.x Obs/Nav files

optional arguments:
  -h, --help             show this help message and exit
  -r ROOT_DIR, --root_dir ROOT_DIR
```

```
                              Root directory of SBF data collection (default /home/amuls/RxTURP/BEGPIOS/)
    -m MARKER, --marker MARKER
                              marker name (4 chars)
    -y YEAR, --year YEAR  Year (4 digits)
    -d DOY, --doy DOY     day-of-year [1..366]
    -c, --compress        compress obtained RINEX files
    -o, --overwrite       overwrite daily SBF file (default False)
    -l LOGGING LOGGING, --logging LOGGING LOGGING
                              specify logging level console/file (default INFO DEBUG)
```

Example run

```
[amuls:~/amPython/rnxproc] [rnxproc]$ prepare_sbf2rnx.py  -m ASTX -y 2019 -d 134  -c
INFO: === prepare_sbf2rnx.py - combine_sbffiles: passing control to sbf_daily.py (options: --dir /home/amuls/RxTURP/BEGPIOS/ASTX/19134) ===
INFO: sbf_daily.py - combine_sbf: working directory is /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - combine_sbf: changed to directory /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - combine_sbf: combine SBF (six-)hourly files to daily SBF file
INFO: sbf_daily.py - combine_sbf: reusing daily SBF file SEPT1340.19_
INFO: >>>>>> prepare_sbf2rnx.py - prepare_rnx_data: obtained daily SBF file = SEPT1340.19_
INFO: === prepare_sbf2rnx.py - sbf_rnx3: passing control to sbf_rinex.py  (options: --sbff /home/amuls/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ --rn
INFO: sbf_rinex.py - sbf2rnx3: arguments processed: dRnx = {'dirs': {'sbf': '/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134', 'rnx': PosixPath('/me
INFO: sbf_rinex.py - checkValidityArgs: check existence of sbfDir /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_rinex.py - checkValidityArgs: check existence of binary file /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ to convert
INFO: sbf_rinex.py - checkValidityArgs: check existence of rnxdir /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134 and create if needed
INFO: location.py - locateProg: sbf2rin is /opt/Septentrio/RxTools/bin/sbf2rin
INFO: sbf_rinex.py - sbf2rnx3: convert binary file to rinex
INFO: sbf_rinex.py - sbf2rinex: RINEX conversion from SBF binary
INFO: sbf_rinex.py - sbf2rinex: creating RINEX observation file
INFO: amutils.py - run_subprocess_output: running
/opt/Septentrio/RxTools/bin/sbf2rin -f /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ -x RSCJI -s -D -v -R3 -l -O BEL
Creating RINEX file: done                                                                              |  0%
INFO: sbf_rinex.py - sbf2rinex: creating RINEX navigation file
INFO: amutils.py - run_subprocess_output: running
/opt/Septentrio/RxTools/bin/sbf2rin -f /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ -x RSCJI -s -D -v -n P -R3 -l -O BEL
Creating RINEX file: done                                                                              |  0%
INFO: sbf_rinex.py - sbf2rnx3: dRnx =
{
    "dirs": {
        "sbf": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134",
        "rnx": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134"
    },
    "sbff": "SEPT1340.19_",
    "bin": {
        "SBF2RIN": "/opt/Septentrio/RxTools/bin/sbf2rin"
    },
    "obs3f": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_01S_MO.rnx",
    "nav3f": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_MN.rnx"
}
INFO: >>>>>> prepare_sbf2rnx.py - prepare_rnx_data: obtained RINEX observation file = /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BE
INFO: >>>>>> prepare_sbf2rnx.py - prepare_rnx_data: obtained RINEX navigation files = /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BE
INFO: location.py - locateProg: rnx2crz is /home/amuls/bin/rnx2crz
INFO: location.py - locateProg: gzip is /usr/bin/gzip
INFO: compress_utils.py - compress_rnx_obs: Compressing RINEX observation /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_2019134
INFO: amutils.py - run_subprocess: running
/home/amuls/bin/rnx2crz -f -d /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_01S_MO.rnx
INFO: >>>>>> prepare_sbf2rnx.py - prepare_rnx_data: compressed RINEX observation file = /home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20_
INFO: compress_utils.py - gzip_compress: Compressing RINEX navigation /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_
INFO: amutils.py - run_subprocess: running
/usr/bin/gzip -f /media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_MN.rnx
INFO: >>>>>> prepare_sbf2rnx.py - prepare_rnx_data: compressed RINEX navigation file = /home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_2019
INFO: prepare_sbf2rnx.py - prepare_rnx_data: SBF preparation information =
{
    "dirs": {
        "root": "/home/amuls/RxTURP/BEGPIOS/",
        "sbf": "/home/amuls/RxTURP/BEGPIOS/ASTX/19134",
        "yydoy": "/home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134"
    },
    "cli": {
```

```json
        "marker": "ASTX",
        "yyyy": 2019,
        "doy": 134,
        "compress": true,
        "overwrite": false
    },
    "rnx": {
        "obs3f": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_01S_MO.rnx",
        "nav3f": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_MN.rnx",
        "obs3fc": "/home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_01S_MO.crx.Z",
        "nav3fc": "/home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_MN.rnx.gz"
    },
    "sbffile": "SEPT1340.19_",
    "bin": {
        "rnx2crz": "/home/amuls/bin/rnx2crz",
        "gzip": "/usr/bin/gzip"
    }
}
```

Resulting directory structure

```
[amuls:~/amPython/rnxproc] [rnxproc]$ ls -lht ~/RxTURP/BEGPIOS/ASTX/rinex/19134
total 29M
-rw-rw-r-- 1 amuls amuls 3.1K Feb  4 15:16 prepare_sbf2rnx.log
-rw-rw-r-- 1 amuls amuls  28M Feb  4 15:16 SEPT00BEL_R_20191340000_01D_01S_MO.crx.Z
-rw-rw-r-- 1 amuls amuls  439 Feb  4 15:16 sbf_rinex.json
-rw-rw-r-- 1 amuls amuls 117K Feb  4 15:16 SEPT00BEL_R_20191340000_01D_MN.rnx.gz
```

2.2 Combining (15 minutes) P3RS2 RINEX files into daily RINEX v3.x files

2.2.1 rnx15_combine.py

`rnx15_combine.py` combines the 15 minutes RINEX files from P3RS2 Rx for a specific day to create observation and navigation files in correct RINEX v3.x format.

Usage

```
[amuls:~/amPython/rnxproc] [rnxproc]$ rnx15_combine.py -h
usage: rnx15_combine.py [-h] [-f FROM_DIR] [-r RNX_DIR] -m MARKER -y YEAR -d DOY \
         [-c CRUX] [-l LOGGING LOGGING]

rnx15_combine.py combines P3RS2 RINEX observation / navigation files

optional arguments:
  -h, --help            show this help message and exit
  -f FROM_DIR, --from_dir FROM_DIR
                        Directory of P3RS2 RINEX files (default .)
  -r RNX_DIR, --rnx_dir RNX_DIR
                        Root directory of P3RS2 RINEX files \
                            (default /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/)
  -m MARKER, --marker MARKER
                        marker name (4 chars)
  -y YEAR, --year YEAR  Year (4 digits)
  -d DOY, --doy DOY     day-of-year [1..366]
  -c CRUX, --crux CRUX  CRUX template file for updating RINEX headers \
                            (default ~/amPython/rnxproc/p3rs2-obs.crux)
  -l LOGGING LOGGING, --logging LOGGING LOGGING
                        specify logging level console/file (two of CRITICAL|ERROR|WARNING|INFO|DEBUG|NOTSET, \
                            default INFO DEBUG)
```

Example run

```
INFO: location.py - locateProg: gfzrnx is /home/amuls/bin/gfzrnx
INFO: location.py - locateProg: rnx2crz is /home/amuls/bin/rnx2crz
INFO: location.py - locateProg: gzip is /usr/bin/gzip
INFO: rnx15_combine.py - list_rinex_files: found 13 RINEX observation files
INFO: rnx15_combine.py - list_rinex_files: found 13 RINEX navigation files
INFO: rnx15_combine.py - create_crux_file: created crux file /tmp/tmpqei5s1w9
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203110910_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A      SYS / # / OBS TYPES\n', \
         'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203110925_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A      SYS / # / OBS TYPES\n', \
         'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111019_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A      SYS / # / OBS TYPES\n', \
         'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111034_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A      SYS / # / OBS TYPES\n', \
         'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111049_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A      SYS / # / OBS TYPES\n', \
         'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111104_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A      SYS / # / OBS TYPES\n', \
```

```
            'G    4 C1C L1C D1C S1C                                    SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111119_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A     SYS / # / OBS TYPES\n', \
        'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111134_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A     SYS / # / OBS TYPES\n', \
        'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111149_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A     SYS / # / OBS TYPES\n', \
        'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111207_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A     SYS / # / OBS TYPES\n', \
        'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111222_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A     SYS / # / OBS TYPES\n', \
        'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111309_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A     SYS / # / OBS TYPES\n', \
        'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203111324_15M_00U_MO.rnx: \
        ['E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A     SYS / # / OBS TYPES\n', \
        'G    4 C1C L1C D1C S1C                                     SYS / # / OBS TYPES\n']
DEBUG: rnx15_combine.py - check_obstypes_order: obs types found
                                                   E                                    G
0    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
1    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
2    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
3    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
4    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
5    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
6    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
7    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
8    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
9    E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
10   E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
11   E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
12   E   12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A... G    4 C1C L1C D1C S1C              ...
INFO: rnx15_combine.py - combine_rnx_obs: combined 13 RINEX files into /tmp/P3RS3110.20O
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnx -finp /tmp/P3RS3110.20O -nomren23 04,BEL
INFO: rnx15_combine.py - convert_obsrnx3: adjusting RINEX header for P3RS3110.20O
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnx -finp /tmp/P3RS3110.20O -crux /tmp/tmpqei5s1w9 -f \
      -fout /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/20311/P3RS04BEL_R_20203110000_01D_00U_MO.rnx
INFO:     process output = DATE/TIME          | C | EPOCH / FILE        | SITE | T | MESSAGE
--------------------+---+----------------------+-----+---+------------------------------------------------------------...
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | CRUX: (STRING) repair line >rnx_writer-1.0.0    P3RS-2 Receiver     20201106 091001
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | no MARKER NAME in header / taken from file name
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | mismatch between header MARKER NAME () and file/station name (P3RS) / using >P3RS<
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | CRUX: skip >G                                         SYS / PHASE
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | CRUX: skip >  0                                       GLONASS SLOT
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >ANT # / TYPE< idx. 0 -> >BEANT<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >ANT # / TYPE< idx. 1 -> >NAVXPERIENCE<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >APPROX POSITION XYZ< idx. 0 -> >4023741.3045<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >APPROX POSITION XYZ< idx. 1 -> >309110.4584<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >APPROX POSITION XYZ< idx. 2 -> >4922723.1945<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >COMMENT< idx. 0 -> >HEADER CHANGED BY RMA-CISS<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >MARKER NAME< idx. 0 -> >P3RS04BEL<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >MARKER NUMBER< idx. 0 -> >0004<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >MARKER TYPE< idx. 0 -> >P3RS04BEL<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >OBSERVER / AGENCY< idx. 0 -> >CISS<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >OBSERVER / AGENCY< idx. 1 -> >RMA-BEL<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >REC # / TYPE / VERS< idx. 0 -> >BEP3RS2<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >REC # / TYPE / VERS< idx. 1 -> >P3RS2<
2021-02-09 14:28:25 | N | 0000-00-00 00:00:00.000 | P3RS | O | update of head label >REC # / TYPE / VERS< idx. 2 -> >001<
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | header SYS / PHASE SHIFT: missing
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | header SYS / PHASE SHIFT: E -> L1A not found
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | header SYS / PHASE SHIFT: E -> L1B not found
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | header SYS / PHASE SHIFT: E -> L6A not found
2021-02-09 14:28:25 | W | 0000-00-00 00:00:00.000 | P3RS | O | header SYS / PHASE SHIFT: G -> L1C not found
INFO: rnx15_combine.py - combine_rnx_obs: combined 13 RINEX files into /tmp/P3RS3110.20M
INFO: rnx15_combine.py - convert_navrnx3: adjusting RINEX header for P3RS3110.20M
INFO: amutils.py - run_subprocess_output: running
```

```
/home/amuls/bin/gfzrnx -finp /tmp/P3RS3110.20M -crux /tmp/tmpqei5s1w9 -f -sei in -chk -fout ::RX3::04,BEL
INFO:    process output = DATE/TIME          | C | EPOCH / FILE         | SITE | T | MESSAGE
-------------------+---+-----------------------+------+---+---------------------------------------------------...
2021-02-09 14:28:30 | W | 0000-00-00 00:00:00.000 | P3RS | N | CRUX: (STRING) repair line >rnx_writer-1.0.0    P3RS-2 Receiver    20201106 091004
2021-02-09 14:28:30 | W | 0000-00-00 00:00:00.000 | P3RS | N | SKIP of EPOCH: not valid >2020 11 40 14 50 00.0000000<
2021-02-09 14:28:30 | W | 2020-11-06 09:00:00.000 | P3RS | N | wrong nav. value >4.756587184875e-234<
2021-02-09 14:28:30 | W | 2020-11-06 09:00:00.000 | P3RS | N | SKIP of EPOCH: not valid >2020 11 60 80 50 00.0000000<
2021-02-09 14:28:30 | W | 2020-11-06 08:50:00.000 | P3RS | N | wrong nav. value >1.375831935030e-233<
2021-02-09 14:28:30 | W | 2020-11-06 09:00:00.000 | P3RS | N | wrong nav. value >1.375831935030e-233<
2021-02-09 14:28:30 | W | 2020-11-06 08:50:00.000 | P3RS | N | wrong nav. value >1.375831935030e-233<
...
2021-02-09 14:28:35 | W | 2020-11-06 11:30:00.000 | P3RS | N | wrong nav. value >8.176072524854e-233<
2021-02-09 14:28:35 | W | 2020-11-06 11:30:00.000 | P3RS | N | SKIP of 202 records via input (EPOCH CHECK)
INFO: rnx15_combine.py - combine_rnx15: Project information =
{
    "cli": {
        "from_dir": "/home/amuls/RxTURP/BEGPIOS/P3RS2/LOG/pvt_ls/",
        "rnx_dir": "/home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/",
        "marker": "P3RS",
        "year": 2020,
        "doy": 311,
        "crux": "/home/amuls/amPython/rnxproc/p3rs2-obs.crux"
    },
    "dirs": {
        "rinex": "/home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/",
        "yydoy": "/home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/20311"
    },
    "bin": {
        "gfzrnx": "/home/amuls/bin/gfzrnx",
        "rnx2crz": "/home/amuls/bin/rnx2crz",
        "gzip": "/usr/bin/gzip"
    },
    "rnx": {
        "date": "2020-11-07",
        "obs3f": "P3RS04BEL_R_20203110000_01D_00U_MO.rnx",
        "nav3f": "P3RS04BEL_R_20203110000_01D_MN.rnx"
    },
    "p3rs2": {
        "obs": [
            "P3RS-2_RX_R_20203110910_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203110925_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111019_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111034_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111049_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111104_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111119_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111134_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111149_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111207_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111222_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111309_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203111324_15M_00U_MO.rnx"
        ],
        "nav": [
            "P3RS-2_RX_R_20203110910_15M_MN.rnx",
            "P3RS-2_RX_R_20203110925_15M_MN.rnx",
            "P3RS-2_RX_R_20203111019_15M_MN.rnx",
            "P3RS-2_RX_R_20203111034_15M_MN.rnx",
            "P3RS-2_RX_R_20203111049_15M_MN.rnx",
            "P3RS-2_RX_R_20203111104_15M_MN.rnx",
            "P3RS-2_RX_R_20203111119_15M_MN.rnx",
            "P3RS-2_RX_R_20203111134_15M_MN.rnx",
            "P3RS-2_RX_R_20203111149_15M_MN.rnx",
            "P3RS-2_RX_R_20203111207_15M_MN.rnx",
            "P3RS-2_RX_R_20203111222_15M_MN.rnx",
            "P3RS-2_RX_R_20203111309_15M_MN.rnx",
            "P3RS-2_RX_R_20203111324_15M_MN.rnx"
        ]
    }
}
```

2.2.2 prepare_rnx15.py

`prepare_rnx15.py` calls script `rnx15_combine.py` and offers possibility to compress the obtained RINEX v3.x observation and navigation files.

Usage

```
[amuls:~/amPython/rnxproc] [rnxproc]$ prepare_rnx15.py -h
usage: prepare_rnx15.py [-h] [-f FROM_DIR] [-r RNX_DIR] -m MARKER -y YEAR -d DOY [-c] [-l LOGGING LOGGING]

prepare_rnx15.py Combining partial (15 minutes) RINEX v3.x Obs/Nav files

optional arguments:
  -h, --help            show this help message and exit
  -f FROM_DIR, --from_dir FROM_DIR
                        Directory of 15 min P3RS2 data collection (default /home/amuls/RxTURP/BEGPIOS/P3RS2/LOG/pvt_ls/)
  -r RNX_DIR, --rnx_dir RNX_DIR
                        Root directory of P3RS2 RINEX files (default /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/)
  -m MARKER, --marker MARKER
                        marker name (4 chars)
  -y YEAR, --year YEAR  Year (4 digits)
  -d DOY, --doy DOY     day-of-year [1..366]
  -c, --compress        compress obtained RINEX files
  -l LOGGING LOGGING, --logging LOGGING LOGGING
                        specify logging level console/file (default INFO DEBUG)
```

Example run

```
OUTPUT FROM RNX15_COMBINE.PY COMES HERE

INFO: >>>>>> prepare_rnx15.py - prepare_P3RS2_data: RINEX directory = /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/20311
INFO: >>>>>> prepare_rnx15.py - prepare_P3RS2_data: obtained RINEX observation file = P3RS04BEL_R_20203110000_01D_00U_MO.rnx
INFO: >>>>>> prepare_rnx15.py - prepare_P3RS2_data: obtained RINEX navigation files = P3RS04BEL_R_20203110000_01D_MN.rnx
INFO: location.py - locateProg: rnx2crz is /home/amuls/bin/rnx2crz
INFO: location.py - locateProg: gzip is /usr/bin/gzip
INFO: compress_utils.py - compress_rnx_obs: Compressing RINEX observation P3RS04BEL_R_20203110000_01D_00U_MO.rnx
INFO: amutils.py - run_subprocess: running
/home/amuls/bin/rnx2crz -f -d /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/20311/P3RS04BEL_R_20203110000_01D_00U_MO.rnx
INFO: >>>>>> prepare_rnx15.py - prepare_P3RS2_data: compressed RINEX observation file = P3RS04BEL_R_20203110000_01D_00U_MO.crx.Z
INFO: compress_utils.py - gzip_compress: Compressing RINEX navigation P3RS04BEL_R_20203110000_01D_MN.rnx
INFO: amutils.py - run_subprocess: running
/usr/bin/gzip -f /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/20311/P3RS04BEL_R_20203110000_01D_MN.rnx
INFO: >>>>>> prepare_rnx15.py - prepare_P3RS2_data: compressed RINEX navigation file = P3RS04BEL_R_20203110000_01D_MN.rnx.gz
INFO: prepare_rnx15.py - prepare_P3RS2_data: SBF preparation information =
{
    "dirs": {
        "pvt": "/home/amuls/RxTURP/BEGPIOS/P3RS2/LOG/pvt_ls/",
        "rnx_root": "/home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/",
        "yydoy": "/home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/20311"
    },
    "cli": {
        "marker": "P3RS",
        "yyyy": 2020,
        "doy": 311,
        "compress": true
    },
    "rnx": {
        "obs3f": "P3RS04BEL_R_20203110000_01D_00U_MO.rnx",
        "nav3f": "P3RS04BEL_R_20203110000_01D_MN.rnx",
        "obs3fc": "P3RS04BEL_R_20203110000_01D_00U_MO.crx.Z",
        "nav3fc": "P3RS04BEL_R_20203110000_01D_MN.rnx.gz"
    },
    "bin": {
        "rnx2crz": "/home/amuls/bin/rnx2crz",
        "gzip": "/usr/bin/gzip"
    }
}
```

Resulting directory structure Output shown when compress option has been chosen.

```
[amuls:~/amPython/rnxproc] [rnxproc]$ ls -l 20311/
total 1392
-rw-rw-r-- 1 amuls amuls 1218353 Feb  9 14:38 P3RS04BEL_R_20203110000_01D_00U_MO.crx.Z
-rw-rw-r-- 1 amuls amuls   20838 Feb  9 14:38 P3RS04BEL_R_20203110000_01D_MN.rnx.gz
-rw-rw-r-- 1 amuls amuls    2598 Feb  9 14:38 prepare_rnx15.log
-rw-rw-r-- 1 amuls amuls  173172 Feb  9 14:38 rnx15_combine.log
```

2.3 Converting and analysing RINEX files to observation tabular and statistics files

The following scripts convert the RINEX obtained files to a tabular observation file (`*.obstab`) and an overview of general observation statistics file (`obsstat`). An analysis based on these files is performed and LaTeX sections are generated.

2.3.1 rnxobs_tabular.py

`rnxobs_tabular.py` converts the RINEX file to the tabular and statistics files and creates a summary LaTeXsection for the report.

Usage

```
[amuls:~/amPython/rnxproc] [rnxproc]$ rnxobs_tabular.py --help
usage: rnxobs_tabular.py [-h] -r RNXOBSF [-g GNSSS [GNSSS ...]] [-l LOGGING LOGGING]

rnxobs_tabular.py creates observation tabular/statistics file for selected GNSSs

optional arguments:
  -h, --help            show this help message and exit
  -r RNXOBSF, --rnxobsf RNXOBSF
                        RINEX observation file
  -g GNSSS [GNSSS ...], --gnsss GNSSS [GNSSS ...]
                        select (1 or more) GNSS(s) to use (out of E|G, default E)
  -l LOGGING LOGGING, --logging LOGGING LOGGING
                        specify logging level console/file (two of CRITICAL|ERROR|WARNING|INFO|DEBUG|NOTSET, c
```

Example run

```
[amuls:~/amPython/rnxproc] [rnxproc]$ rnxobs_tabular.py --rnxobsf ~/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_01S_MO.rnx \
        -g G E
INFO: location.py - locateProg: gfzrnx is /home/amuls/bin/gfzrnx
INFO: rnxobs_analysis.py - RX3obs_header_info extracting observation header info from SEPT00BEL_R_20191340000_01D_01S_MO.rnx
INFO: amutils.py - run_subprocess: running
/home/amuls/bin/gfzrnx -finp SEPT00BEL_R_20191340000_01D_01S_MO.rnx -fout SEPT00BEL_R_20191340000_01D_01S_MO-obs.json -meta basic:json -f

. . .

ltx_gfzrnx_report.py - report_information: report creation information {'title': NoEscape(Analysis of observations

14 May 2019), 'subtitle': NoEscape(Receiver SEPT00BEL @ 2019/134), 'author': ['A. Muls'], 'company': ['Royal Military Academy'], 'classification':

. . .

INFO: rnxobs_tabular.py - create_tabular_observations creating observation tabular file SEPT00BEL_R_20191340000_01D_01S_MO_G.obstab
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnx -finp SEPT00BEL_R_20191340000_01D_01S_MO.rnx -tab_obs -fout SEPT00BEL_R_20191340000_01D_01S_MO_G.obstab -f -tab_sep , -satsy
proc_out =
DATE/TIME           | C | EPOCH / FILE           | SITE | T | MESSAGE
--------------------+---+------------------------+------+---+--------------------------------------------------------------...
2021-03-02 14:41:35 | W | 0000-00-00 00:00:00.000 | SEPT | O | mismatch between header MARKER NAME (SEPT) and file/station name (SEPT00BEL) / using
2021-03-02 14:42:09 | W | 2019-05-14 23:59:59.000 | SEPT | O | mismatch of number of satellites(20) and records got(11) 2019 05 14 23 59 59.0000000
2021-03-02 14:42:13 | N | 2019-05-14 23:59:59.000 | SEPT | O | 734601 records skipped via input (SEPT00BEL_R_20191340000_01D_01S_MO.rnx)
INFO: rnxobs_tabular.py - create_tabular_observations creating observation statistics file SEPT00BEL_R_20191340000_01D_01S_MO_G.obsstat
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnx -finp SEPT00BEL_R_20191340000_01D_01S_MO.rnx -stk_obs -fout SEPT00BEL_R_20191340000_01D_01S_MO_G.obsstat -f -satsys G
```

```
proc_out =
DATE/TIME            | C | EPOCH / FILE            | SITE | T | MESSAGE
--------------------+---+------------------------+------+---+------------------------------------------------------------...
2021-03-02 14:42:42 | W | 0000-00-00 00:00:00.000 | SEPT | O | mismatch between header MARKER NAME (SEPT) and file/station name (SEPT00BEL) / using
2021-03-02 14:43:16 | W | 2019-05-14 23:59:59.000 | SEPT | O | mismatch of number of satellites(20) and records got(11) 2019 05 14 23 59 59.0000000
2021-03-02 14:43:20 | N | 2019-05-14 23:59:59.000 | SEPT | O | 734601 records skipped via input (SEPT00BEL_R_20191340000_01D_01S_MO.rnx)
INFO: rnxobs_tabular.py - create_tabular_observations creating observation tabular file SEPT00BEL_R_20191340000_01D_01S_MO_E.obstab
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnx -finp SEPT00BEL_R_20191340000_01D_01S_MO.rnx -tab_obs -fout SEPT00BEL_R_20191340000_01D_01S_MO_E.obstab -f -tab_sep , -satsy
proc_out =
DATE/TIME            | C | EPOCH / FILE            | SITE | T | MESSAGE
--------------------+---+------------------------+------+---+------------------------------------------------------------...
2021-03-02 14:43:23 | W | 0000-00-00 00:00:00.000 | SEPT | O | mismatch between header MARKER NAME (SEPT) and file/station name (SEPT00BEL) / using
2021-03-02 14:43:48 | W | 2019-05-14 23:59:59.000 | SEPT | O | mismatch of number of satellites(20) and records got(9) 2019 05 14 23 59 59.0000000
2021-03-02 14:43:51 | N | 2019-05-14 23:59:59.000 | SEPT | O | 957276 records skipped via input (SEPT00BEL_R_20191340000_01D_01S_MO.rnx)
INFO: rnxobs_tabular.py - create_tabular_observations creating observation statistics file SEPT00BEL_R_20191340000_01D_01S_MO_E.obsstat
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnx -finp SEPT00BEL_R_20191340000_01D_01S_MO.rnx -stk_obs -fout SEPT00BEL_R_20191340000_01D_01S_MO_E.obsstat -f -satsys E
proc_out =
DATE/TIME            | C | EPOCH / FILE            | SITE | T | MESSAGE
--------------------+---+------------------------+------+---+------------------------------------------------------------...
2021-03-02 14:44:04 | W | 0000-00-00 00:00:00.000 | SEPT | O | mismatch between header MARKER NAME (SEPT) and file/station name (SEPT00BEL) / using
2021-03-02 14:44:29 | W | 2019-05-14 23:59:59.000 | SEPT | O | mismatch of number of satellites(20) and records got(9) 2019 05 14 23 59 59.0000000
2021-03-02 14:44:31 | N | 2019-05-14 23:59:59.000 | SEPT | O | 957276 records skipped via input (SEPT00BEL_R_20191340000_01D_01S_MO.rnx)
INFO: rnxobs_tabular.py - rnx_tabular: Project information =
```
```
{
    "info": {
        "obs_date": "14 May 2019",
        "marker": "SEPT00BEL",
        "yyyy": 2019,
        "doy": 134
    },
    "cli": {
        "GNSSs": [
            "G",
            "E"
        ],
        "obsf": "SEPT00BEL_R_20191340000_01D_01S_MO.rnx",
        "path": "/home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134"
    },
    "bin": {
        "gfzrnx": "/home/amuls/bin/gfzrnx"
    },
    "hdr": {
        "data": {
            "epoch": {
                "first": "2019 05 14 00 00 00.0000000",
                "last": "2019 05 14 23 59 59.0000000"
            }
        },
        "file": {
            "duration": "86400",
            "epo_first": "2019 05 14 00 00 00.0000000",
            "epo_first_name": "2019 05 14 00 00 00.0000000",
            "interval": "1.000",
            "md5": "325bd5f1cbfae170bd4dd49d8a2f8cb4",
            "name": "SEPT00BEL_R_20191340000_01D_01S_MO.rnx",
            "pgm": "sbf2rin-13.4.5",
            "pgm_date": "20210302 130957 UTC",
            "pgm_runby": "",
            "satsys": "EG",
            "site": "SEPT00BEL",
            "source": "R",
            "sysfrq": {
                "E": [
                    "1",
                    "5"
                ],
                "G": [
                    "1",
                    "2",
                    "5"
                ]
```

```
                },
                "sysobs": {
                    "E": [
                        "C1C",
                        "C5Q",
                        "D1C",
                        "D5Q",
                        "L1C",
                        "L5Q",
                        "S1C",
                        "S5Q"
                    ],
                    "G": [
                        "C1C",
                        "C1W",
                        "C2L",
                        "C2W",
                        "C5Q",
                        "D1C",
                        "D2L",
                        "D2W",
                        "D5Q",
                        "L1C",
                        "L2L",
                        "L2W",
                        "L5Q",
                        "S1C",
                        "S1W",
                        "S2L",
                        "S2W",
                        "S5Q"
                    ]
                },
                "system": "M",
                "systyp": {
                    "E": [
                        "C",
                        "D",
                        "L",
                        "S"
                    ],
                    "G": [
                        "C",
                        "D",
                        "L",
                        "S"
                    ]
                },
                "type": "O",
                "version": "3.04"
            }
        },
        "ltx": {
            "path": "/home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134/ltx",
            "script": "/home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134/ltx/01_script_info"
        },
        "obstab": {
            "G": {
                "obs_G_tabf": "SEPT00BEL_R_20191340000_01D_01S_MO_G.obstab",
                "obs_G_statf": "SEPT00BEL_R_20191340000_01D_01S_MO_G.obsstat"
            },
            "E": {
                "obs_E_tabf": "SEPT00BEL_R_20191340000_01D_01S_MO_E.obstab",
                "obs_E_statf": "SEPT00BEL_R_20191340000_01D_01S_MO_E.obsstat"
            }
        }
}
dObstabs = {'G': {'obs_G_tabf': 'SEPT00BEL_R_20191340000_01D_01S_MO_G.obstab', \
                  'obs_G_statf': 'SEPT00BEL_R_20191340000_01D_01S_MO_G.obsstat'}, \
           'E': {'obs_E_tabf': 'SEPT00BEL_R_20191340000_01D_01S_MO_E.obstab', \
                  'obs_E_statf': 'SEPT00BEL_R_20191340000_01D_01S_MO_E.obsstat'}}
```

Resulting directory structure

```
[amuls:~/amPython/rnxproc] [rnxproc]$ ll -R
.:
total 569628
drwxrwxr-x 2 amuls amuls      4096 Mar  2 14:37 ltx
-rw-rw-r-- 1 amuls amuls      1631 Mar  2 14:10 prepare_sbf2rnx.log
-rw-rw-r-- 1 amuls amuls      9873 Mar  2 14:44 rnxobs_tabular_py.log
-rw-rw-r-- 1 amuls amuls       475 Mar  2 14:10 sbf_rinex.json
-rw-rw-r-- 1 amuls amuls      2075 Mar  2 14:10 sbf_rinex_py.log
-rw-rw-r-- 1 amuls amuls      1537 Mar  2 14:44 SEPT00BEL_R_20191340000_01D_01S_MO_E.obsstat
-rw-rw-r-- 1 amuls amuls  89775895 Mar  2 14:44 SEPT00BEL_R_20191340000_01D_01S_MO_E.obstab
-rw-rw-r-- 1 amuls amuls      3969 Mar  2 14:43 SEPT00BEL_R_20191340000_01D_01S_MO_G.obsstat
-rw-rw-r-- 1 amuls amuls 179788882 Mar  2 14:42 SEPT00BEL_R_20191340000_01D_01S_MO_G.obstab
-rw-rw-r-- 1 amuls amuls      1172 Mar  2 14:41 SEPT00BEL_R_20191340000_01D_01S_MO-obs.json
-rw-rw-r-- 1 amuls amuls 312972740 Mar  2 14:10 SEPT00BEL_R_20191340000_01D_01S_MO.rnx
-rw-rw-r-- 1 amuls amuls    711736 Mar  2 14:10 SEPT00BEL_R_20191340000_01D_MN.rnx

./ltx:
total 4
-rw-rw-r-- 1 amuls amuls 1464 Mar  2 14:41 01_script_info.tex
```

The `*.obstab` and `*.obsstat` files are Comma Separated Values (CVS) files.

Latex section created `01_script_info.tex`

```
\subsection{Script details}%
\label{subsec:Scriptdetails}%
\subsubsection{Program information}%
\label{ssubsec:Programinformation}%
\setlength{\tabcolsep}{2pt}%
\begin{longtabu}[l]{rcl}%
Script&:&rnxobs\_tabular.py\\%
Run at&:&02/03/2021 14:41\\%
Run by&:&A. Muls\\%
&&Royal Military Academy\\%
\end{longtabu}

%
\subsubsection{Parameters}%
\label{ssubsec:Parameters}%
\setlength{\tabcolsep}{2pt}%
\begin{longtabu}[l]{rcl}%
RINEX root directory&:&/home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134\\%
RINEX observation file&:&SEPT00BEL\_R\_20191340000\_01D\_01S\_MO.rnx\\%
RINEX version&:&3.04\\%
Marker&:&SEPT00BEL\\%
Year/day{-}of{-}year&:&2019/134\\%
&&\\%
\end{longtabu}

%
\subsubsection{Observation header information}%
```

```
\label{ssubsec:Observationheaderinformation}%
\setlength{\tabcolsep}{2pt}%
\begin{longtabu}[l]{rcl}%
First epoch&:&2019/05/14 00:00:00\\%
Last epoch&:&2019/05/14 23:59:59\\%
Interval&:&1.0\\%
&&\\%
GNSS&:&G (GPS NavSTAR) \\%
&:&E (Galileo) \\%
Frequencies E&:&1, 5\\%
Frequencies G&:&1, 2, 5\\%
&&\\%
Observable types&:&C (Pseudorange) \\%
&:&S (SNR) \\%
&:&D (Doppler) \\%
&:&L (Carrier) \\%
&&\\%
\end{longtabu}

%
\subsubsection{Logged observables}%
\label{ssubsec:Loggedobservables}%
\setlength{\tabcolsep}{2pt}%
\begin{longtabu}[l]{rcl}%
Observable types E&:&C1C, C5Q, D1C, D5Q, L1C, L5Q, S1C, S5Q\\%
Observable types G&:&C1C, C1W, C2L, C2W, C5Q, D1C, D2L, D2W, D5Q, L1C\\%
&&L2L, L2W, L5Q, S1C, S1W, S2L, S2W, S5Q\\%
&&\\%
\end{longtabu}
```