
Preparation, Analysis and Processing of RINEX v3.x files

Analysis of RINEX observation file

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Contents

1	Overview of rnxproc	3
1.1	General directory structure for (semi-)permanent monitoring	3
1.2	Purpose	4
1.2.1	Converting (six-)hourly SBF files to (compressed) RINEX v3.x files	4
1.2.2	Combining (15 minutes) P3RS2 RINEX files into daily RINEX v3.x files	4
1.2.3	Converting and analysing RINEX files to observation tabular and statistics files	4
2	Python scripts	5
2.1	Converting (six-)hourly SBF files to (compressed) RINEX v3.x files	5
2.1.1	sbfdaily.py	5
2.1.2	sbfrinex.py	5
2.1.3	prepare_sbf2rnx.py	7
2.2	Combining (15 minutes) P3RS2 RINEX files into daily RINEX v3.x files	10
2.2.1	rnx15_combine.py	10
2.2.2	prepare_rnx15.py	12
2.3	Converting and analysing RINEX files to observation tabular and statistics files	15
2.3.1	rnxobs_tabular.py	15

1 Overview of rnxproc

1.1 General directory structure for (semi-)permanent monitoring

The repository is based on the following directory structure¹ 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 `rinx` 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/amu_ls/RxTURP/BEGPIoS/P3RS2/rinx`. 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:

¹I 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_202033000008_01D_01S_M0.crx.Z
-rw-rw-r-- 1 amuls amuls 165168 Jan 13 16:41 P3RS00BEL_R_202033000000_01D_MN.rnx.gz
```

1.2 Purpose

rxnproc 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_sbf2rxn.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
rxn15_combine.py	Combines 15 minutes RINEX files from P3RS2
prepare_rxn15.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
rxnobs_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/RX3proc] [RX3proc]$ sbf_daily.py --help
usage: sbf_daily.py [-h] [--dir DIR] [--overwrite] [--logging LOGGING LOGGING]
```

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

optional arguments:

<code>-h, --help</code>	show this help message and exit
<code>--dir DIR</code>	Directory of SBF file (defaults to .)
<code>--overwrite</code>	overwrite daily SBF file (default False)
<code>--logging LOGGING LOGGING</code>	specify logging level console/file (default INFO DEBUG)

Example run

```
[amuls:~/amPython/RX3proc] [RX3proc]$ sbf_daily.py --dir ~/RxTURP/BEGPIOS/ASTX/19134/
INFO: sbf_daily.py - main_combine_sbf: working directory is /home/amuls/RxTURP/BEGPIOS/ASTX/19134/
INFO: sbf_daily.py - main_combine_sbf: changed to directory /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - main_combine_sbf: combine SBF (six-)hourly files to daily SBF file
INFO: sbf_daily.py - main_combine_sbf: reusing daily SBF file SEPT1340.19_
```

```
[amuls:~/amPython/RX3proc] [RX3proc]$ sbf_daily.py --dir ~/RxTURP/BEGPIOS/ASTX/19134/ --overwrite
INFO: sbf_daily.py - main_combine_sbf: working directory is /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - main_combine_sbf: changed to directory /home/amuls/RxTURP/BEGPIOS/ASTX/19134
INFO: sbf_daily.py - main_combine_sbf: combine SBF (six-)hourly files to daily SBF file
INFO: sbf_daily.py - main_combine_sbf: creating 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. A time span can be specified.

Usage

```
[amuls:~/amPython/RX3proc] [RX3proc]$ sbf_rinex.py --help
usage: sbf_rinex.py [-h] --sbffile SBFFILE [--rxndir RXNDIR] [--startepoch STARTEPOCH] \
  [--endepoch ENDEPOCH] [--logging 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
--sbffile SBFFILE         Binary SBF file
--rnxdir RNXDIR           Directory for RINEX output (default .)
--startepoch STARTEPOCH   specify start epoch hh:mm:ss (default 00:00:00)
--endepoch ENDEPOCH       specify end epoch hh:mm:ss (default 23:59:59)
--logging LOGGING LOGGING specify logging level console/file (two of CRITICAL|ERROR|WARNING|INFO|DEBUG|NOTSET, c
```

Example run using all data in the SBF file

```
[amuls:~/amPython/RX3proc] [RX3proc]$ sbf_rinex.py --sbff /home/amuls/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ \
--rnxdir /home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134
INFO: sbf_rinex.py - sbf2rnx3: arguments processed: dRnx = {'dirs': {'sbff': '/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134', 'rnx': PosixPath('/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134')}, 'sbffile': '/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_', 'rnxdir': '/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134'}
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": {
    "sbff": "/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"
}
```

Example run using selected data in the SBF file

```
[amuls:~/amPython/RX3proc] [RX3proc]$ sbf_rinex.py --sbff /home/amuls/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_ \
--rnxdir /home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134 --startepoch="07:15:45" --endepoch="10:05:30"
INFO: sbf_rinex.py - main_sbf2rnx3: arguments processed: dRnx = {'dirs': {'sbff': '/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134', 'rnx': PosixPath('/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134')}, 'sbffile': '/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134/SEPT1340.19_', 'rnxdir': '/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134'}
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 - main_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 -b 07:15:45 -e 10:05:30
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 - sbf2rinex: sorted list (by modification time) of rnx files:
/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_01S_MO.rnx
```

```

/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340715_02H_01S_MO.rnx
/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_MN.rnx
INFO: sbf_rinex.py - main_sbf2rnx3: dRnx =
{
  "dirs": {
    "sbf": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/19134",
    "rnx": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134"
  },
  "sbff": "SEPT1340.19_",
  "time": {
    "startepoch": "07:15:45",
    "endepoch": "10:05:30"
  },
  "bin": {
    "SBF2RIN": "/opt/Septentrio/RxTools/bin/sbf2rin"
  },
  "obs3f": "/media/amuls/porsche/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340715_02H_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/RX3proc] [RX3proc]$ prepare_sbf2rnx.py --help
usage: prepare_sbf2rnx.py [-h] [--root_dir ROOT_DIR] --marker MARKER --year YEAR --doy DOY \
    [--startepoch STARTEPOCH] [--endepoch ENDEPOCH] [--rnxdir RNXDIR] [--compress] [--overwrite] \
    [--logging 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
--root_dir ROOT_DIR      Root directory of SBF data collection (default /home/amuls/RxTURP/BEGPIOS/)
--marker MARKER          marker name(4 chars)
--year YEAR              Year (4 digits)
--doy DOY                day-of-year [1..366]
--startepoch STARTEPOCH
                        specify start epoch hh:mm:ss (default 00:00:00)
--endepoch ENDEPOCH      specify end epoch hh:mm:ss (default 23:59:59)
--rnxdir RNXDIR          Directory for RINEX output (default YYDOY subdir)
--compress               compress obtained RINEX files
--overwrite              overwrite daily SBF file (default False)
--logging LOGGING LOGGING
                        specify logging level console/file (default INFO DEBUG)

```

Example run

```
[amuls:~/amPython/RX3proc] [RX3proc]$ prepare_sbf2rnx.py --root_dir /media/amuls/porsche/RxTURP/CMT/ \
--marker TURP --year 2021 --doy 89 --compress --rnxdir /media/amuls/porsche/RxTURP/CMT/rnx/
INFO: === prepare_sbf2rnx.py - combine_sbf_files: passing control to sbf_daily.py (options: --dir /media/amuls/porsche/RxTURP/CMT/TURP/21089) ===
INFO: sbf_daily.py - main_combine_sbf: working directory is /media/amuls/porsche/RxTURP/CMT/TURP/21089
INFO: sbf_daily.py - main_combine_sbf: changed to directory /media/amuls/porsche/RxTURP/CMT/TURP/21089
INFO: sbf_daily.py - main_combine_sbf: combine SBF (six-)hourly files to daily SBF file
INFO: sbf_daily.py - main_combine_sbf: reusing daily SBF file TURX0890.21_
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: obtained daily SBF file = TURX0890.21_
INFO: === prepare_sbf2rnx.py - sbf_rnx3: passing control to sbf_rinex.py (options: --sbff /media/amuls/porsche/RxTURP/CMT/TURP/21089/TURX0890.21_
INFO: sbf_rinex.py - main_sbf2rnx3: arguments processed: dRnx = {'dirs': {'sbf': '/media/amuls/porsche/RxTURP/CMT/TURP/21089', 'rnx': PosixPath('/media/amuls/porsche/RxTURP/CMT/TURP/21089')}, 'sbff': '/media/amuls/porsche/RxTURP/CMT/TURP/21089/TURX0890.21_', 'rnxdir': '/media/amuls/porsche/RxTURP/CMT/rnx'}
INFO: sbf_rinex.py - checkValidityArgs: check existence of binary file /media/amuls/porsche/RxTURP/CMT/TURP/21089/TURX0890.21_ to convert
INFO: sbf_rinex.py - checkValidityArgs: check existence of rnxdir /media/amuls/porsche/RxTURP/CMT/rnx and create if needed
INFO: location.py - locateProg: sbf2rin is /opt/Septentrio/RxTools/bin/sbf2rin
INFO: sbf_rinex.py - main_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/CMT/TURP/21089/TURX0890.21_ -x RSCJI -s -D -v -R3 -l -O BEL
Creating RINEX file: done
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/CMT/TURP/21089/TURX0890.21_ -x RSCJI -s -D -v -n P -R3 -l -O BEL
Creating RINEX file: done
INFO: sbf_rinex.py - sbf2rinex: sorted list (by modification time) of rnx files:
/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210881014_13H_01S_MO.rnx
/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210881014_13H_MN.rnx
/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx
/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx
INFO: sbf_rinex.py - main_sbf2rnx3: dRnx =
{
  "dirs": {
    "sbf": "/media/amuls/porsche/RxTURP/CMT/TURP/21089",
    "rnx": "/media/amuls/porsche/RxTURP/CMT/rnx"
  },
  "sbff": "TURX0890.21_",
  "time": {
    "startepoch": "00:00:00",
    "endepoch": "23:59:59"
  },
  "bin": {
    "Sbf2rin": "/opt/Septentrio/RxTools/bin/sbf2rin"
  },
  "obs3f": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx",
  "nav3f": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx"
}
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: obtained RINEX observation file = /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: obtained RINEX navigation files = /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_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 /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx
INFO: amutils.py - run_subprocess: running
/home/amuls/bin/rnx2crz -f -d /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: compressed RINEX observation file = /media/amuls/porsche/RxTURP/CMT/rnx/ASTX02BEL_R_20210890000_13H_01S_MO.rnx
INFO: compress_utils.py - gzip_compress: Compressing RINEX navigation /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx
INFO: amutils.py - run_subprocess: running
/usr/bin/gzip -f /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: compressed RINEX navigation file = /media/amuls/porsche/RxTURP/CMT/rnx/ASTX02BEL_R_20210890000_13H_MN.rnx
INFO: prepare_sbf2rnx.py - main_prepare_rnx_data: SBF preparation information =
{
  "dirs": {
    "root": "/media/amuls/porsche/RxTURP/CMT/",
    "sbf": "/media/amuls/porsche/RxTURP/CMT/TURP/21089",
    "rnxdir": "/media/amuls/porsche/RxTURP/CMT/rnx/"
  },
  "cli": {
    "marker": "TURP",
    "yyyy": 2021,
    "doy": 89,
    "startepoch": "00:00:00",
    "endepoch": "23:59:59",
    "compress": true,
    "overwrite": false
  }
}
```



```

    },
    "rnx": {
        "obs3f": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_M0.rnx",
        "nav3f": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx",
        "obs3fc": "/media/amuls/porsche/RxTURP/CMT/rnx/ASTX02BEL_R_20210890600_09H_01S_M0.crx.Z",
        "nav3fc": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx.gz"
    },
    "sbffile": "TURX0890.21_",
    "bin": {
        "rnx2crz": "/home/amuls/bin/rnx2crz",
        "gzip": "/usr/bin/gzip"
    }
}

```

Resulting directory structure

```

[amuls:~/amPython/RX3proc] [RX3proc]$ 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_M0.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

[amuls:~/amPython/RX3proc] [RX3proc]$ ls -lht /media/amuls/porsche/RxTURP/CMT/rnx/
total 111M
-rw-rw-r-- 1 amuls amuls 3.2K Apr  2 16:11 prepare_sbf2rnx.log
-rw-rw-r-- 1 amuls amuls 4.1M Apr  2 16:11 TURX00BEL_R_20210890000_13H_01S_M0.crx.Z
-rw-rw-r-- 1 amuls amuls 506 Apr  2 16:11 sbf_rinex.json
-rw-rw-r-- 1 amuls amuls 2.5K Apr  2 16:11 sbf_rinex_py.log
-rw-rw-r-- 1 amuls amuls 79K Apr  2 16:11 TURX00BEL_R_20210890000_13H_MN.rnx.gz
-rw-rw-r-- 1 amuls amuls 355K Apr  2 11:46 TURX00BEL_R_20210881014_13H_MN.rnx
-rw-rw-r-- 1 amuls amuls 53M Apr  2 11:46 TURX00BEL_R_20210881014_13H_01S_M0.rnx
-rw-rw-r-- 1 amuls amuls 4.2M Mar 31 17:04 TURX00BEL_R_20210881014_13H_01S_M0.crx.Z
-rw-rw-r-- 1 amuls amuls 79K Mar 31 17:04 TURX00BEL_R_20210881014_13H_MN.rnx.gz
-rw-rw-r-- 1 amuls amuls 12M Mar 31 16:36 ASTX02BEL_R_20210890600_09H_01S_M0.crx.Z
-rw-rw-r-- 1 amuls amuls 21M Mar 31 16:36 ASTX02BEL_R_20210890000_14H_01S_M0.crx.Z
-rw-rw-r-- 1 amuls amuls 17M Mar 31 16:35 ASTX02BEL_R_20210881200_12H_01S_M0.crx.Z
-rw-rw-r-- 1 amuls amuls 103K Mar 31 16:33 ASTX02BEL_R_20210890000_15H_MP.rnx.gz
-rw-rw-r-- 1 amuls amuls 87K Mar 31 16:33 ASTX02BEL_R_20210881200_12H_MP.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/RX3proc] [RX3proc]$ rnx15_combine.py --help
usage: rnx15_combine.py [-h] [--from_dir FROM_DIR] [--rnx_dir RNX_DIR] --marker MARKER --year YEAR \
                        --doy DOY [--startepoch STARTEPOCH] [--endepoch ENDEPOCH] [--crux CRUX] [--logging LOGGING LOGGING]
```

rnx15_combine.py combines P3RS2 RINEX observation / navigation files

optional arguments:

```
-h, --help                show this help message and exit
--from_dir FROM_DIR      Directory of P3RS2 RINEX files (default .)
--rnx_dir RNX_DIR        Root directory of P3RS2 RINEX files (default /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/)
--marker MARKER          marker name (4 chars)
--year YEAR              Year (4 digits)
--doy DOY                day-of-year [1..366]
--startepoch STARTEPOCH specify start epoch hh:mm:ss (default 00:00:00)
--endepoch ENDEPOCH      specify end epoch hh:mm:ss (default 23:59:59)
--crux CRUX              CRUX template file for updating RINEX headers (default /home/amuls/amPython/RX3proc/gfzrnx)
--logging LOGGING LOGGING specify logging level console/file (two of CRITICAL|ERROR|WARNING|INFO|DEBUG|NOTSET, or
```

Example run

```
[amuls:~/amPython/RX3proc] [RX3proc]$ rnx15_combine.py --from_dir ~/RxTURP/CHIRPSAWT00TH/P3RS2/ORIGS/ \
--rnx_dir ~/RxTURP/CHIRPSAWT00TH/rnx/ --year 2020 --doy 349 --marker P3RS \
--startepoch='14:06:45' --endepoch='14:55:30'
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 5 RINEX observation files
INFO: rnx15_combine.py - list_rinex_files: found 5 RINEX navigation files
INFO: rnx15_combine.py - create_crux_file: created crux file /tmp/tmpdpx548q3
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203491354_15M_00U_MO.rnx: ['E 12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203491409_15M_00U_MO.rnx: ['E 12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203491424_15M_00U_MO.rnx: ['E 12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203491439_15M_00U_MO.rnx: ['E 12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A
DEBUG: rnx15_combine.py - check_obstypes_order: P3RS-2_RX_R_20203491454_15M_00U_MO.rnx: ['E 12 C1B L1B D1B S1B C1A L1A D1A S1A C6A L6A D6A S6A
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 ...
INFO: rnx15_combine.py - combine_rnx_obs: combined 5 RINEX files into /tmp/P3RS3490.200
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnx -finp /tmp/P3RS3490.200 -nomren23 04,BEL
INFO: rnx15_combine.py - convert_obsrnx3: adjusting RINEX header for P3RS3490.200
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnx -finp /tmp/P3RS3490.200 -crux /tmp/tmpdpx548q3 -f -fout /home/amuls/RxTURP/CHIRPSAWT00TH/rnx/20349/P3RS04BEL_R_20203490000_
```

11 of 19

```

        "nav3f": "SEPT00BEL_R_20203491041_03H_MN.rnx"
    },
    "p3rs2": {
        "obs": [
            "P3RS-2_RX_R_20203491354_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203491409_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203491424_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203491439_15M_00U_MO.rnx",
            "P3RS-2_RX_R_20203491454_15M_00U_MO.rnx"
        ],
        "nav": [
            "P3RS-2_RX_R_20203491340_15M_MN.rnx",
            "P3RS-2_RX_R_20203491355_15M_MN.rnx",
            "P3RS-2_RX_R_20203491410_15M_MN.rnx",
            "P3RS-2_RX_R_20203491425_15M_MN.rnx",
            "P3RS-2_RX_R_20203491440_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/RX3proc] [RX3proc]$ prepare_rnx15.py --help
```

```
usage: prepare_rnx15.py [-h] [--root_dir ROOT_DIR] [--rnx_dir RNX_DIR] --marker MARKER --year YEAR --doy DOY [--startepoch STARTEPOCH] [--endepoch ENDEPOCH]
```

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

optional arguments:

```

-h, --help            show this help message and exit
--root_dir ROOT_DIR  Directory of 15 min P3RS2 data collection (default /home/amuls/RxTURP/BEGPIOS/P3RS2/LOG/pvt_ls/)
--rnx_dir RNX_DIR    Root directory of P3RS2 RINEX files (default /home/amuls/RxTURP/BEGPIOS/P3RS2/rinex/)
--marker MARKER      marker name (4 chars)
--year YEAR          Year (4 digits)
--doy DOY            day-of-year [1..366]
--startepoch STARTEPOCH
                    specify start epoch hh:mm:ss (default 00:00:00)
--endepoch ENDEPOCH  specify end epoch hh:mm:ss (default 23:59:59)
--obs_crux OBS_CRUX  CRUX template file for updating RINEX headers (default /home/amuls/amPython/RX3proc/gfzrnx/P3RS2-obs.crux)
--compress           compress obtained RINEX files
--logging LOGGING LOGGING
                    specify logging level console/file (default INFO DEBUG)

```

Example run

```

prepare_sbf2rnx.py --root_dir /media/amuls/porsche/RxTURP/CMT/ --marker TURP --year 2021 --doy 89 --compress --rnx_dir /media/amuls/porsche/RxTURP/
INFO: === prepare_sbf2rnx.py - combine_sbf_files: passing control to sbf_daily.py (options: --dir /media/amuls/porsche/RxTURP/CMT/TURP/21089) ===
INFO: sbf_daily.py - main_combine_sbf: working directory is /media/amuls/porsche/RxTURP/CMT/TURP/21089
INFO: sbf_daily.py - main_combine_sbf: changed to directory /media/amuls/porsche/RxTURP/CMT/TURP/21089
INFO: sbf_daily.py - main_combine_sbf: combine SBF (six-)hourly files to daily SBF file
INFO: sbf_daily.py - main_combine_sbf: reusing daily SBF file TURX0890.21_
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: obtained daily SBF file = TURX0890.21_
INFO: === prepare_sbf2rnx.py - sbf_rnx3: passing control to sbf_rinex.py (options: --sbf /media/amuls/porsche/RxTURP/CMT/TURP/21089/TURX0890.21_
INFO: sbf_rinex.py - main_sbf2rnx3: arguments processed: dRnx = {'dirs': {'sbf': '/media/amuls/porsche/RxTURP/CMT/TURP/21089', 'rnx': PosixPath('/
INFO: sbf_rinex.py - checkValidityArgs: check existence of sbfDir /media/amuls/porsche/RxTURP/CMT/TURP/21089
INFO: sbf_rinex.py - checkValidityArgs: check existence of binary file /media/amuls/porsche/RxTURP/CMT/TURP/21089/TURX0890.21_ to convert
INFO: sbf_rinex.py - checkValidityArgs: check existence of rnx_dir /media/amuls/porsche/RxTURP/CMT/rnx and create if needed
INFO: location.py - locateProg: sbf2rin is /opt/Septentrio/RxTools/bin/sbf2rin
INFO: sbf_rinex.py - main_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/CMT/TURP/21089/TURX0890.21_ -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/CMT/TURP/21089/TURX0890.21_ -x RSCJI -s -D -v -n P -R3 -l -O BEL
Creating RINEX file: done | 0%
INFO: sbf_rinex.py - sbf2rinex: sorted list (by modification time) of rnx files:
/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210881014_13H_01S_MO.rnx
/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210881014_13H_MN.rnx
/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx
/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx
INFO: sbf_rinex.py - main_sbf2rnx3: dRnx =
{
  "dirs": {
    "sbf": "/media/amuls/porsche/RxTURP/CMT/TURP/21089",
    "rnx": "/media/amuls/porsche/RxTURP/CMT/rnx"
  },
  "sbff": "TURX0890.21_",
  "time": {
    "startepoch": "00:00:00",
    "endepoch": "23:59:59"
  },
  "bin": {
    "SBF2RIN": "/opt/Septentrio/RxTools/bin/sbf2rin"
  },
  "obs3f": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx",
  "nav3f": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx"
}
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: obtained RINEX observation file = /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: obtained RINEX navigation files = /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_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 /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx
INFO: amutils.py - run_subprocess: running
/home/amuls/bin/rnx2crz -f -d /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: compressed RINEX observation file = /media/amuls/porsche/RxTURP/CMT/rnx/ASTX02BEL_R_20210890000_13H_01S_MO.rnx.gz
INFO: compress_utils.py - gzip_compress: Compressing RINEX navigation /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx
INFO: amutils.py - run_subprocess: running
/usr/bin/gzip -f /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx
INFO: >>>>> prepare_sbf2rnx.py - main_prepare_rnx_data: compressed RINEX navigation file = /media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx.gz
INFO: prepare_sbf2rnx.py - main_prepare_rnx_data: SBF preparation information =
{
  "dirs": {
    "root": "/media/amuls/porsche/RxTURP/CMT/",
    "sbf": "/media/amuls/porsche/RxTURP/CMT/TURP/21089",
    "rnxdir": "/media/amuls/porsche/RxTURP/CMT/rnx/"
  },
  "cli": {
    "marker": "TURP",
    "yyyy": 2021,
    "doy": 89,
    "startepoch": "00:00:00",
    "endepoch": "23:59:59",
    "compress": true,
    "overwrite": false
  },
  "rnx": {
    "obs3f": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_01S_MO.rnx",
    "nav3f": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx",
    "obs3fc": "/media/amuls/porsche/RxTURP/CMT/rnx/ASTX02BEL_R_20210890000_09H_01S_MO.crx.Z",
    "nav3fc": "/media/amuls/porsche/RxTURP/CMT/rnx/TURX00BEL_R_20210890000_13H_MN.rnx.gz"
  },
  "sbffile": "TURX0890.21_",
  "bin": {
    "rnx2crz": "/home/amuls/bin/rnx2crz",
    "gzip": "/usr/bin/gzip"
  }
}
```

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

```
[amuls:~/amPython/RX3proc] [RX3proc]$ ls -l 20311/
total 1392
-rw-rw-r-- 1 amuls amuls 1218353 Feb  9 14:38 P3RS04BEL_R_20203110000_01D_00U_M0.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 (obssstat). 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 LaTeX section for the report.

Usage

```
[amuls:~/amPython/RX3proc] [RX3proc]$ 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 ...], --gnssss 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, or
```

Example run

```
[amuls:~/amPython/RX3proc] [RX3proc]$ rnxobs_tabular.py --rnxobsf ~/RxTURP/BEGPIOS/ASTX/rinex/19134/SEPT00BEL_R_20191340000_01D_01S_MO.rnx \
-g G E
INFO: location.py - locateProg: gfzrn is /home/amuls/bin/gfzrn
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/gfzrn -finp SEPT00BEL_R_20191340000_01D_01S_MO.rnx -fout SEPT00BEL_R_20191340000_01D_01S_MO-obs.json -meta basic.json -f
...
ltx_gfzrn_report.py - report_information: report creation information {'title': NoEscape(Analysis of observations
14 May 2019), 'subtitle': NoEscape(Receiver SEPT00BEL @ 2019/134), 'author': ['A. Mu\ls'], '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/gfzrn -finp SEPT00BEL_R_20191340000_01D_01S_MO.rnx -tab_obs -fout SEPT00BEL_R_20191340000_01D_01S_MO_G.obstab -f -tab_sep , -satsys
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 | 0 | 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 | 0 | mismatch of number of satellites(20) and records got(11) 2019 05 14 23 59 59.00000000
2021-03-02 14:42:13 | N | 2019-05-14 23:59:59.000 | SEPT | 0 | 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.obssstat
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrn -finp SEPT00BEL_R_20191340000_01D_01S_MO.rnx -stk_obs -fout SEPT00BEL_R_20191340000_01D_01S_MO_G.obssstat -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 | 0 | 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 | 0 | mismatch of number of satellites(20) and records got(11) 2019 05 14 23 59 59.00000000
2021-03-02 14:43:20 | N | 2019-05-14 23:59:59.000 | SEPT | 0 | 734601 records skipped via input (SEPT00BEL_R_20191340000_01D_01S_M0.rnx)
INFO: rxnobs_tabular.py - create_tabular_observations creating observation tabular file SEPT00BEL_R_20191340000_01D_01S_M0_E.obstab
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnrx -finp SEPT00BEL_R_20191340000_01D_01S_M0.rnx -tab_obs -fout SEPT00BEL_R_20191340000_01D_01S_M0_E.obstab -f -tab_sep , -satsys E
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 | 0 | 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 | 0 | mismatch of number of satellites(20) and records got(9) 2019 05 14 23 59 59.00000000
2021-03-02 14:43:51 | N | 2019-05-14 23:59:59.000 | SEPT | 0 | 957276 records skipped via input (SEPT00BEL_R_20191340000_01D_01S_M0.rnx)
INFO: rxnobs_tabular.py - create_tabular_observations creating observation statistics file SEPT00BEL_R_20191340000_01D_01S_M0_E.obsstat
INFO: amutils.py - run_subprocess_output: running
/home/amuls/bin/gfzrnrx -finp SEPT00BEL_R_20191340000_01D_01S_M0.rnx -stk_obs -fout SEPT00BEL_R_20191340000_01D_01S_M0_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 | 0 | 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 | 0 | mismatch of number of satellites(20) and records got(9) 2019 05 14 23 59 59.00000000
2021-03-02 14:44:31 | N | 2019-05-14 23:59:59.000 | SEPT | 0 | 957276 records skipped via input (SEPT00BEL_R_20191340000_01D_01S_M0.rnx)
INFO: rxnobs_tabular.py - rxn_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_M0.rnx",
    "path": "/home/amuls/RxTURP/BEGPIOS/ASTX/rinex/19134"
  },
  "bin": {
    "gfzrnrx": "/home/amuls/bin/gfzrnrx"
  },
  "hdr": {
    "data": {
      "epoch": {
        "first": "2019 05 14 00 00 00.00000000",
        "last": "2019 05 14 23 59 59.00000000"
      }
    },
    "file": {
      "duration": "86400",
      "epo_first": "2019 05 14 00 00 00.00000000",
      "epo_first_name": "2019 05 14 00 00 00.00000000",
      "interval": "1.000",
      "md5": "325bd5f1cbfae170bd4dd49d8a2f8cb4",
      "name": "SEPT00BEL_R_20191340000_01D_01S_M0.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/RX3proc] [RX3proc]$ 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
-rw-rw-r-- 1 amuls amuls     97118 Mar  2 16:57 obsstat_analyse_py.log
-rw-rw-r-- 1 amuls amuls       834 Mar  2 16:57 obsstat_analyse.json

./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]{rc}
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]{rc}
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}
```