

GFZ GERMAN RESEARCH CENTRE FOR GEOSCIENCES

GFZRNX - Users Guide

Version 2.1.10

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1. Overview

1.1 Welcome

Welcome to the online documentation of gfzrnx. The latest version of this documentation can be found via the following links.

1.1.1 Documentation (HTML)

The web based documentation is available via:

https://gnss.git-pages.gfz-potsdam.de/gfzrnx

1.1.2 Documentation (PDF)

The PDF version of this documentation is available via:

 $https://gnss.git-pages.gfz-potsdam.de/gfzrnx/pdf/GFZRNX_Users_Guide.pdf$

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1.2 Scope of Operation

The software gfzrnx is a toolbox for the check and manipulation of RINEX files for the major versions 2, 3, and 4.

The following RINEX data types are supported:

- · Observation data
- Navigation data
- Meteorological data

The following operations/tasks are supported:

- RINEX file check and repair
- RINEX file format conversion (versions 2, 3, 4 into each other)
- · RINEX file splice
- · RINEX file split
- RINEX file statistics generation
- RINEX file manipulations like:
- · data sampling
- · observation types selection
- · satellite systems selection
- elimination of overall empty or sparse observation types
- · PRN renaming
- · Automatic version dependent file naming on output file.
- RINEX file (re)naming support (version 2 to 3 or 4)
- RINEX header editing
- · RINEX file metadata extraction
- · RINEX file comparison
- RINEX file tabular representation
- Multi RINEX file operations with a single command

See also the Rinex Standard Extensions/NonConformity section for further information.

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1.3 End User License Agreement

 $@ \ Helmholtz\text{-}Centre\ Potsdam\ -\ \textbf{GFZ}\ German\ Research\ Centre\ for\ Geosciences, Section\ 1.1\ Space\ Geodetic\ Techniques$

The software gfzrnx - RINEX GNSS Data Conversion and Manipulation Toolbox can be used under the following licenses:

- License for Scientific Partners (free)
- License for Commercial Users (chargeable).

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1.4 Examples

You can always find examples in boxes with coloured background like the one below.

Example Box

All given examples are valid for UNIX-based systems like Linux, SunOS or OSX. In the example boxes you will find <code>gfzrnx</code> used as a synonym for the operating system-dependent executable (gfzrnx_lx64, gfzrnx_osx64, ...).

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1.5 Follow us

1.5.1 Documentation (HTML)

https://gnss.git-pages.gfz-potsdam.de/gfzrnx

1.5.2 Documentation (PDF)

https://gnss.git-pages.gfz-potsdam.de/gfzrnx/pdf/GFZRNX_Users_Guide.pdf

1.5.3 Join Mailing List

There is a mailing list gfzrnx@gfz-potsdam.de, that will be used for information transfer (new features, versions, etc.). It can also be used for questions not covered by the documentation.

One can join the mailing list by sending an empty email to:

gfzrnx-on@gfz-potsdam.de

After getting a Confirmation Request email, please don't forget to reply to it. This reply is mandatory to finish your list joining.

1.5.4 Drop Out of Mailing List

One can drop out of the mailing list sending an empty email to:

gfzrnx-off@gfz-potsdam.de

1.5.5 Twitter: @gfzrnx



1.5.6 Bug Reports and Comments

For bug reports or comments please use the mailing address: gfzrnx_bug@gfz-potsdam.de Please use the following procedure for bug reports:

- · Make sure that you are using the latest version.
- If you are using the latest version, please provide the complete command line you have used.
- attach your input file(s) to your e-mail or provide a link for the input data download. Shrink the input file(s) if possible.

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2. Basics

2.1 Download

One can download the software via

https://gnss.gfz-potsdam.de/services/gfzrnx

You will find an **official version** with a version number and a **development version** (DEVEL) with ongoing bug fixing and new features.

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2.2 Installation

The software consists of a **single executable** (operating system dependent) to be used at the command prompt of a Terminal window or in batch scripts.

| Operating Systen | Executable |
|---------------------|---------------------------|
| Linux (64) | gfzrnx_lx64-x.x.x |
| Linux (32) | gfzrnx_lx32-x.x.x |
| SunOS (Sparc) | gfzrnx_sun-x.x.x |
| SunOS (i86) | gfzsun_suni86-x.x.x |
| MS Windows 11 (64) | gfzrnx_win11_64-x.x.x.exe |
| MS Windows 10 (64) | gfzrnx_win10_64-x.x.x.exe |
| MS Windows 7,8 (64) | gfzrnx_win64-x.x.x.exe |
| MS Windows 7,8 (32) | gfzrnx_win32-x.x.x.exe |
| Mac OSX (64) | gfzrnx_osx64-x.x.x |
| Mac OSX (arm64, Mx) | gfzrnx_osxarm64-x.x.x |
| Linux-ARM (64) | gfzrnx_armlx64-x.x.x |
| Linux-ARM (32) | gfzrnx_armlx32-x.x.x |

2.2.1 UNIX

Put the executable to a directory of the search path **\$PATH**. Simply run the following command to show the elements of your search path **\$PATH**. This search path can differ depending on your overall setup.

```
> echo $PATH
/opt/local/bin:/opt/local/sbin:/usr/local/bin:/usr/bin:/usr/sbin:/sbin:/opt/X11/bin
```

Copy the executable into a directory covered by your system search **\$PATH** variable and create a symbolic link **gfzrnx** for the ease of use. Here is an example using e.g. /usr/local/bin and the downloaded executable gfzrnx_osxarm64-1.16-8154:

```
> sudo copy gfzrnx_osxarm64-1.16-8154 /usr/local/bin
> sudo chmod a+x gfzrnx_osxarm64-1.16-8154
> cd /usr/local/bin
> sudo ln -s gfzrnx_osxarm64-1.16-8154 gfzrnx
```

The which command should show up with the search fullpath of the gfzrnx-command.

```
> which gfzrnx
/usr/local/bin/gfzrnx
> gfzrnx -h
```

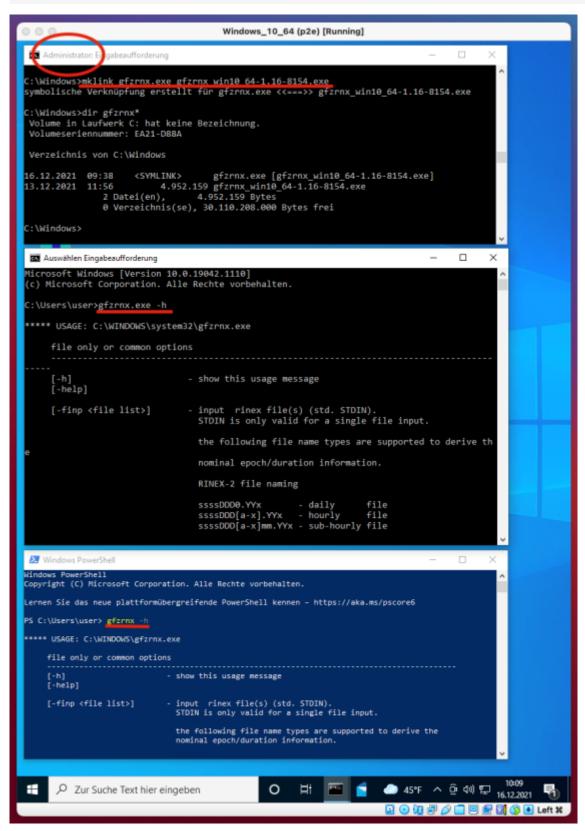
2.2.2 MS Windows

Create a symbolic link **gfzrnx.exe** in your **C:\Windows** to the real executable location (e.g. c:\Users\user\gfzrnx_1.16-8154_win10.exe). This allows you now to use the short command name <code>gfzrnx.exe</code> or simply <code>gfzrnx</code>.

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Open cmd.exe as Administrator (right mouse click on cmd.exe).

```
C:\Users\user > cd c:\Windows
C:\Windows > mklink /J gfzrnx.exe c:\Users\user\gfzrnx_1.16-8154_win10.exe
```



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2.2.3 Temporary Directory

The gfzrnx will store and execute libraries in a temporary directory.

| os | Default Temporary Directory |
|---------|-----------------------------|
| UNIX | /tmp |
| Windows | \$WINDIR (C:\Windows) |

If this is not an option for you, you can specify an alternative temporary directory via the environment variables **\$TEMP** or **\$TMP** on all platforms.

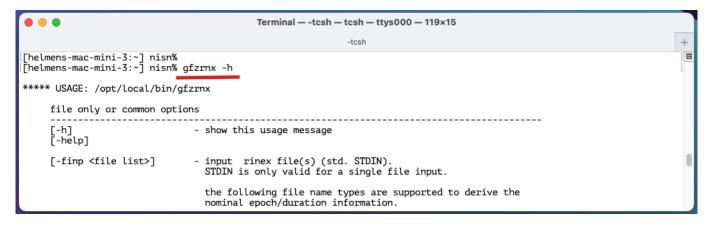
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2.3 Usage

gfzrnx is a command line executable. It can be used in a terminal window or batch scripts. It has NO graphical interface!

2.3.1 Unix

For Unix (Linux, MacOS, SunOS) users it can be run in any terminal application or used in shell scripts...



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2.3.2 Windows

```
×
 Auswählen Eingabeaufforderung
Microsoft Windows [Version 10.0.19042.1110]
(c) Microsoft Corporation. Alle Rechte vorbehalten.
C:\Users\user>gfzrnx.exe -h
***** USAGE: C:\WINDOWS\system32\gfzrnx.exe
     file only or common options
     [-h]
                                 - show this usage message
     [-help]
     [-finp <file list>]
                                 - input rinex file(s) (std. STDIN).
                                   STDIN is only valid for a single file input.
                                   the following file name types are supported to derive th
                                   nominal epoch/duration information.
                                   RINEX-2 file naming
                                                                      file
                                   ssssDDD0.YYx

    daily

                                   ssssDDD[a-x].YYx
                                                      - hourly
                                                                      file
                                   ssssDDD[a-x]mm.YYx - sub-hourly file
 ➢ Windows PowerShell
                                                                                         Windows PowerShell
Copyright (C) Microsoft Corporation. Alle Rechte vorbehalten.
Lernen Sie das neue plattformübergreifende PowerShell kennen - https://aka.ms/pscore6
PS C:\Users\user> gfzrnx -h
***** USAGE: C:\WINDOWS\gfzrnx.exe
    file only or common options
    [-h]
                             - show this usage message
    [-help]
    [-finp <file list>]
                            - input rinex file(s) (std. STDIN).
                               STDIN is only valid for a single file input.
                               the following file name types are supported to derive the
                               nominal epoch/duration information.
```

For MS Windows you can use e.g. cmd.exe, powershell.exe, or create and execute batch scripts (whatever.bat).

Here, a small batch file example.bat is shown. The input data are sampled at 30s time interval.

```
gfzrnx.exe -finp C:\data\XXXXX0010.15o -fout C:\data_30\XXXXX0010.15o -smp 30
gfzrnx.exe -finp C:\data\XXXXX0020.15o -fout C:\data_30\XXXXX0020.15o -smp 30
...
gfzrnx.exe -finp C:\data\XXXXX3650.15o -fout C:\data_30\XXXXX3650.15o -smp 30
```

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2.3.3 Fast Help

Simple usage information you can get via command line parameter -h or -help.

```
gfzrnx -h
***** USAGE: gfzrnx
     file only or common options
     [-h]
                             - show this usage message
     [-help]
     [-finp <file list>]
                            input rinex file(s) (std. STDIN).
                                STDIN is only valid for a single file input.
                                the following file name types are supported to derive the
                                nominal epoch/duration information.
                                RINEX-2 file naming
                                                  - daily
                                ssssDDD0.YYx
                                                               file
                                ssssDDD[a-x].YYx - hourly file
                                ssssDDD[a-x]mm.YYx - sub-hourly file
                                RINEX-3/4 file naming
                                SSSSMRCCC_S_YYYYDDDHHMM_NNN_FRQ_TT.FMT
                                SSSSMRCCC_S_YYYYDDDHHMM_NNN_TT.FMT
                                see Documentation for details
                                splice mode:
                                * list of input files
     [-fout <file>]
                              - output rinex or statistics file (std. STDOUT)
                               automatic output file name if filename given is "::RX2::", "::RX3::" or "::RX4::"
     [-4to9 <file>]
                            - renaming information for rinex-3 type (re)naming
                                ( NNNN -> NNNNMRCCC / POTS -> POTS00DEU )
     [-f]
                              - force overwrite of output file if it already exists
                                (std. no overwrite)
     [-sifl]
                              - perform an operation on a single file if a file list is
     [-single_file]
                               provided via "-finp"
     [-ant_rename]
                              - rename historical antenna names to be IGS conform
  [-nomren23 <[s,][mr,][iso]>] - fast nominal output file name for RINEX-2 to RINEX-3 file renaming.
                                RINEX-3 output file name is written to STDOUT.
                                   s - data source (S|R)
                                                                 (default R)
                                   mr - marker receiver number (default 00)
                                   iso - 3 char. iso country code (default XXX)
                                the input parameters can be given in any order.
                                supported \ input \ file \ names \ nnnnddde.yyt[.cmp] \ or \ nnnndddedd.yyt[.cmp]
                                if providing a compressed file all information which is usually taken
                                from file header (sat. system(s), data frequency) has to be given via the
                                command line parameter (see documion for details).
     [-vo <2|3|4>]
                              - output RINEX version (std. latest)
     [--version_out <2|3|4>]
                              - output RINEX version (fully standard conform)
     [-vosc <2|3|4>]
                              - change header VERSION number and set output RINEX version
     [-vnum m.nn]
                                (only the version number is changed / output RINEX version is the highest supported
```

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```
one)
     [-pr3rx2 <list>]
                               - komma separated list of list of signal priorities used for rinex 3 -> 2 conversion
                                 to overwrite the standard settings, see documentation for details.
                                 S:n[n...]:STRING
                                        - satellite System [CEGJRSI]
                                        - frequency number(s)
                                 STRING - prority STRING
                                 G:12:PWCSLXYN,G:5:QXI,R:12:CP
     [-errlog <file>]
                               - store (append) error logs to a file (std. print to STDERR)
     [-smp <num>]
                               - sampling rate in sec. (std. no sampling / resolution 1 ms)
     [-smp_nom <num>]
                               - sampling rate (num) in sec to be used for automatic file naming
     [-smp_lli_shift]
                               - perform LLI shifts via data sampling to sampling epoch
     [-nav_mixed]
                               - create a mixed nav. filename
     [-no_nav_stk]
                               - no nav. splice header statistic tables
                               - output data statistics information (std. STDOUT)
     [-stk_obs]
     [-stk_only]
     [-crux <file>]
                               - rinex header manipulations definitions for input files
     [-cx\_updins < string(s)>] - rinex header manipulation(s) definition for input files
                                given via command line
     [-cx addinthd]
                               - if using using a crux-file (-crux) internal/data headers are created
                                at crux-settings starting epochs.
     [-show_crux]
                               - show crux structure adopted and used by the program
     [-hded]
                               - perform the header edit ONLY mode (with -crux)
     [-stk_epo <n[:list]>]
                               - ASCII timeplot of data availability (std. STDOUT)
                                 n - time resolution in seconds
                                 list - comma separated list (prn,otp) (std. prn)
     [-ot <list>]
                               - obs. types list to be used (pattern matching). the list can be given
     [--obs_types <list>]
                                 globaly or sat. system dependent. the sat. system dependent record
                                 replaces fully a global one.
                                 list can be: [S:]OT1,OT2,...[+S:OT3,OT4,...][+...]
                                 S - satellite system [CEGJRSI]
                                 OT - observation type identifier
                                 I 1 I 2 C1 C2 P1 P2
                                 L1, L2, C1, C2, P1, P2+C:L1, L7, C1, C7+G:L1C, L2W, C1, C2
     [-ots <string>[:<attr>]] - obs. types output sorting
[--obs_types_sort <string>[:<attr>]]
                                 the "string" consists of the 1st obs. type id. characters ( e.g. \ensuremath{\mathsf{CPLDS}} ),
                                 the "attr" can be [frqasc|frqdsc|frqi,j,...] (frequ. numbers (i,j,...) = 1,...,n),
                                 which means a preferred sorting by frequency (ascending, descending or
                                 a list of distinct frequency numbers)
                               - komma separated list of PRNs to be used
     [-prn <prn-list>]
                                 range notations are possible G1-32,C01-5,R01-10,E14,E18
                              - komma separated list of PRNs to be skipped
     [-no_prn <prn-list>]
                                range notations are possible G1-32,C01-5,R01-10,E14,E18
     [-kaot]
                               - keep all obs. types (including fully empty ones)
     [-rsot <n>]
                       - remove sparse obs. types.
```

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```
[--remove\_sparse\_obs\_types < n>] n - defines the % limit of the median number of observations
                                    per observation type used to delete an observation type fully.
                               - satellite system(s) to be used (CEGIJRS) (std. CEGIJRS)
     [-satsys <letters>]
                                C - Beidou
                                E - Galileo
G - GPS
                                I - IRNSS
                                 J - OZSS
                                 R - Glonass
                                S - SBAS
                              - output order of navigation records. type = [time|prn] (std. prn)
     [-ns
             <type>]
     [--nav_sort <type>]
                                time - sort by time,prn
                                prn - sort by prn, time
              <type-list>] - '+' separated list of nav. selection records (version >= 4).
     [-nt
                                record = [<sat.system(s)>::]<nav.type(s)>:[<message.type(s)]</pre>
     [-nav_type <type-list>]
                                type(s) are separated via '.
     [-split n]
                               - split input file in <n seconds> pieces
                                 - valid only with -fout ::RX2:: or ::RX3::
                                 - valid if n is a multiple of 60 seconds.
                                 - only supported for single input file
                               - extended formal checks on input file (slower)
     [-chk]
     [-meta <type[:format]>] - extract file meta data. the type can be (basic|full).
                                 supported formats are json|xml|txt|dump
     [-fdiff]
                               - compare two rinex files of the same format (major version id.)
                                the two input files have to be given via -finp
     [-met nwm]
                               - edit a rinex meteo file(1) by the means of a reference NWM file(2).
                                 the two input files have to be given via -finp.
                                 the second file contains reference NWM data and check limits
                                 (can be used in conjunction with -obs_types, -ot)
     [-site <sitename>]
                              - use the 4- or 9-char sitename for output filename via automatic file naming
                                or for header editing settings extractions (crux)
                                or for "MARKER NAME" in case it is missing.
     [-kv]
                               - keep major output version number same as in input
     [-q]
                               - quiet mode
                               - file duration (seconds) (std. ignored on input
     [-d <sec>]
     [--duration <sec>]
                                                          std. 86400 on output )
     [-epo_beg <EPOCH>]
                              - first output epoch (<EPOCH> see below)
     [-sei <in|out>]
[--strict_epoch_interval <in|out>] - output epoch interval according to in/output file name
                                    (only valid in case of RINEX conform file names)
     [-enb <n>]
                              - extend the nav. epoch interval by +- n seconds
                                (when using strict epoch interval)
     [-nav_epo_filter]
                              - only standard epochs are passed to the output
                              - only nominal epochs are passed to the output
     [-nav epo strict]
     [-nav_latest]
                              - only latest nav. record per PRN are passed to the output
     [-splice_direct]
                              - use no RAM to store observations via splice operations
                                (no header data statistics)
                              - try append mode to fasten the splice process with
     [-try_append <sec>]
                                smallest nominal file duration (seconds) of part files
     [-direct]
                              - direct input/output of single rinex OBS. files (!!! no header statistics !!!)
     [-use_obs_map <file>]
                              - use modified obs. types mapping
     [-out_obs_map] - output std. obs. types mapping
```

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```
[-tab]
                                      - create a tabular data representation output
      [-tab_date]
                                      - use other date (pattern) for tabular observation output
                                         (yyyy-mm-dd \mid yy-mm-dd \mid yyyy-ddd \mid wwww-d \mid yyyymmdd \mid yymmdd \mid yyyyddd \mid wwwwd \mid mjd \mid ddd)
      [-tab_time]
                                      - use other time pattern for tabular observation output
                                         (hh:mm:ss|hhmmss|sod|fod)
      [-tab_sep <string>]
                                      - column separator string (default: BLANK)
      epoch <EPOCH> parameter
     mjd 56753 or 56753_123000
wwwwd 17870 or 17870_12:30:00
yyyyddd 2014096 or 2014096_123000
yyyymmdd 20140406 or 2014046_12:30:00
yyyy-mm-dd 2014-04-06 or 2014-04-06_123000
      all these date types can be combined via '_' with a time string of type:
      hhmmss
      hh:mm:ss
\ensuremath{\text{@}} Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences
  Section 1.1 Space Geodetic Techniques
  see https://gnss.gfz-potsdam.de/services/gfzrnx
  for license details and manual
  Thomas Nischan, nisn@gfz-potsdam.de
  VERSION: gfzrnx-2.1.8
```

2.4 Data Input/Output

2.4.1 Supported Format Versions

gfzrnx supports all versions 2.x, 3.x, 4.x formats as input. The output format will be only the latest standard format of the major formats 2, 3 or 4.

Standard out put version for major RINEX version:

| Major | Standard Output |
|-------|-----------------|
| 2 | 2.11 |
| 3 | 3.05 |
| 4 | 4.01 |

2.4.2 Input

The input of a single file can be done via the -finp command line parameter or via **STDIN**.

2.4.3 Output

The standard output channel is **STDOUT**. The output to a dedicated file can also be done via the -fout command line parameter.

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2.4.4 Examples Input/Output

Input via -finp

```
gfzrnx -finp pots007a.15o ...
```

Input via STDIN

```
cat pots007a.15o | gfzrnx ...
crx2rnx pots007a.15d - | gfzrnx ...
```

Output via -fout

```
gfzrnx -finp pots007a.15o -fout pots007a.15o_rx3
```

Output via STDOUT

```
gfzrnx -finp pots007a.15o > pots007a.15o_rx3
gfzrnx -finp pots007a.15o | rnx2crx > pots007a.15d
gfzrnx -finp pots007a.15o | rnx2crx | gzip > pots007a.15d.gz
```

The program rnx2crx is here the Hatanaka RINEX compression and gzip a common file compression program.

2.4.5 Log Messages

By default, log messages (Notices, Errors, Warnings) are sent to **STDERR**. One can store the log messages into a file using the **-errlog** command line parameter.

```
DATE/TIME | C | EPOCH/FILE | SITE | T | MESSAGE | CONTINUE | C | EPOCH/FILE | SITE | T | MESSAGE | CONTINUE | C | EPOCH/FILE | SITE | T | MESSAGE | CONTINUE | C | EPOCH/FILE | SITE | T | MESSAGE | CONTINUE | C | EPOCH/FILE | SITE | T | MESSAGE | CONTINUE | C | EPOCH/FILE | SITE | T | MESSAGE | CONTINUE | C | EPOCH/FILE | SITE | T | MESSAGE | CONTINUE | C | EPOCH/FILE | SITE | T | MESSAGE | CONTINUE | C | EPOCH/FILE | SITE | T | MESSAGE | C | EPOCH/FILE | C | EP
```

The log table information consists of:

| Label | Description |
|--------------|------------------------------|
| DATE/TIME | processing epoch |
| C(ode) | N(otice), W(arning), E(rror) |
| EPOCH / FILE | affected epoch in input file |
| SITE | 4-char. station identifier |
| T(ype) | Data Type |
| MESSAGE | log message |

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Output of log information to a file via <code>-errlog</code> command line parameter.

```
gfzrnx -finp leid2000.13o -fout xxxx -errlog leid2000.13o_log
```

2.4.6 Direct Mode (-direct)

For a single **OBS.** rinex file it is possible to use a **direct** input/output mode. The I/O is done epoch by epoch and you miss information stored in the header like statistics and the automatic removal of empty obs. types. The advantage is the economic utilisation of RAM.

```
> gfzrnx -finp leid2000.13o -fout leid2000.13o_rx3 -direct
```

2.5 Supported File Names

The following input file names are supported and used to initialize the nominal data epoch interval.

2.5.1 RINEX-2 naming convention

| File Name | Description | Example |
|--------------------|-----------------|----------------|
| SSSSDDD0.YYT | daily file | pots0070.15o |
| SSSSDDD[a-x].YYT | hourly file | pots007a.15o |
| SSSSDDD[a-x]MM.YYT | sub-hourly file | pots007r45.15o |

| Var. | Description | Example |
|------|----------------------------|---------|
| SSSS | 4-char. station identifier | pots |
| DDD | day of year | 007 |
| YY | 2-digit year | 15 |
| MM | minute of data begin | 45 |
| Т | data type (o,d,m,n,) | 0 |

Examples

· daily file

pots0070.15o

hourly files

pots007a.15o pots007b.15o pots007c.15o ... pots007v.15o pots007w.15o pots007x.15o

• sub-hourly files (15 min)

pots007a00.15o pots007a15.15o pots007a30.15o pots007a45.15o

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2.5.2 RINEX-3 naming convention

| File Name | Example |
|--|--|
| SSSSMRCCC_S_YYYYDDDHHMM_NNN_FRQ_TT.FMT[.CMP] | POTS00DEU_R_20150070000_01H_30S M0.rnx.bz2 |
| SSSSMRCCC_S_YYYYDDDHHMM_NNN_TT.FMT[.CMP] | POTS00DEU_R_20150070000_01H_MN.rnx.gz |

| Var. | Description | Example |
|-------------|-------------------------------|-------------|
| SSSSMRCCC | station identifier | POTS00DEU |
| SSSS | 4-char. identifier | POTS |
| М | Monument number | 0 |
| R | Receiver number | 0 |
| CCC | ISO country code | DEU |
| S | data source | R |
| YYYYDDDHHMM | start epoch | 20150070000 |
| YYYY | year | 2015 |
| DDD | day of year | 007 |
| НН | hour | 00 |
| ММ | minute | 00 |
| NNN | nominal file period (nominal) | 01H |
| FRQ | data frequency | 30S |
| TT | data type | МО |
| FMT | format extension | rnx |
| CMP | compression method | gz, bz2, |

For more details, see RINEX-3 file format definitions.

2.5.3 Automatic Output File Naming

For an automatic output file naming, one can use the ::RX2::, ::RX3:: or RX4:: parameter for the -fout command line switch.

RINEX-2 Site Name

The 4 character site name is taken from the "MARKER NAME" header record. If the site name is not given in the file header, it is taken from the input file name (if standard file name). In all other cases, it has to be provided via the -site command line parameter.

RINEX-3 Site Name

```
gfzrnx -finp pots0070.15o -fout ::RX3::
gfzrnx -finp pots0070.15o -fout /tmp/::RX3::
```

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This works if the header **MARKER NAME** fully matches the RINEX-3 "SSSSMRCCC" naming style. For a 4-character **MARKER NAME** one has to provide at least the **marker-**, **receiver numbers**, and the **ISO country code** in the command line. If no station information is found, the full information has to be given on the command line.

```
gfzrnx -finp pots0070.15o -fout ::RX3::pots,00,DEU gfzrnx -finp pots0070.15o -fout /tmp/::RX3::pots,00,DEU
```

The following examples will give the same result for a 4-char header. MARKER NAME is set. The parameters order is not relevant.

```
gfzrnx -finp pots0070.15o -fout ::RX3::00,DEU gfzrnx -finp pots0070.15o -fout ::RX3::DEU,00
```

The output file name will be: POTS00DEU_R_20150070000_01H_30S_MO.rnx.

The default data source identifier is R (Receiver). If one needs the S (Streaming), simply add it to the ::RX3:: sub-information.

```
gfzrnx -finp pots0070.15o -fout ::RX3::00,DEU,S
gfzrnx -finp pots0070.15o -fout /tmp/::RX3::00,DEU,S
```

The output file name will be: POTS00DEU_S_20150070000_01H_30S_MO.rnx.

RINEX-3 Site Name (-4to9)

Besides the naming definitions on the command line (-fout ::RX3::00,DEU) multiple site identifier definitions can be provided via the -4to9 command line parameter providing a simple file with the naming information.

```
gfzrnx -finp pots0070.15o -fout ::RX3:: -4to9 four2nine.conf
```

The -4to9 input file (e.g.) must have the following structure:

```
# name mr iso
0001 pots 00 DEU
0002 brux 00 BEL
0003 tash 00 UZB
...
```

A correct numbering can be ignored if it is out of interest to you. In this case, you can use the same number for all stations.

```
# name mr iso
1 pots 00 DEU
1 brux 00 BEL
1 tash 00 UZB
...
```

An up-to-date 4to9 configuration file for diverse networks like IGS, MGEX, EUREF, TIGA and others can be derived from GFZ's

SEnsor Meta Information SYStem (SEMISYS) via a simple command line:

```
For more details see the SEMISYS api and download page http://semisys.gfz-potsdam.de/semisys/download.
```

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RINEX-2 Start Epoch/Duration

By default, the start epoch and file duration are used to create the epoch parts of the output name. To force the automatic file naming to a distinct type ::RX2:: can be extended by the letters L, S or D (Long, Short, Day) to ::RX2L::, ::RX2S:: or ::RX2D::.

The following examples illustrate the standard behavior for a station ABCD with start epoch 2015-123 03:05 and different durations.

| Duration | < 1 hour | 1 hour | > 1 hour |
|----------|----------------|----------------|----------------|
| ::RX2:: | abcd122d05.15o | abcd122d.15o | abcd1220.15o |
| ::RX2L:: | abcd122d05.15o | abcd122d05.15o | abcd122d05.15o |
| ::RX2S:: | abcd122d.15o | abcd122d.15o | abcd122d.15o |
| ::RX2D:: | abcd1220.15o | abcd1220.15o | abcd1220.15o |

The cases ::RX2L::, ::RX2S:: allow storing not only hourly or sub-hourly files. For durations larger than 1 hour, one can use it to store sub-daily files too. In this case, the file epoch indicates the start time (hour, minute) only. In the case of sub-hourly, file names with nominal begin epochs (-epo_beg / -sei in) and the nominal duration -d 900 are used by default. For other time intervals, the duration (-d) has to be given.

If the data start minute is 17 and the duration e.g. 300 s the following commands give different output file names:

```
gfzrnx -kv -finp pots125x15.13o -fout TMP/::RX2::
TMP/pots125x15.13o

gfzrnx -kv -finp pots125x15.13o -fout TMP/::RX2L::
TMP/pots125x15.13o

gfzrnx -kv -finp pots125x15.13o -fout TMP/::RX2L:: -d 120
TMP/pots125x16.13o

gfzrnx -kv -finp pots125x15.13o -fout TMP/::RX2L:: -sei in
TMP/pots125x15.13o

gfzrnx -kv -finp pots125x15.13o -fout TMP/::RX2L:: -epo_beg 2015125_230000 -d 1800
TMP/pots125x00.13o

gfzrnx -kv -finp pots125x15.13o -fout TMP/::RX2S::
TMP/pots125x.13o
```

RINEX-3 Start Epoch/Duration (real)

For the RINEX-3 file renaming, the following rules are valid for all observation types (**O/N/M**). The example observation files in the table below with the following characteristics are used to illustrate the (re)naming process.

| Characteristics | pots0070.15o | pots007c.15o | pots007c30.15o |
|----------------------------|--------------|--------------|----------------|
| Time Begin | 01:12:30 | 02:13:30 | 02:33:13 |
| Time End | 23:59:30 | 02:55:30 | 02:44:50 |
| Duration (implicit) | 1 day | 1 hour | unknown |
| Duration (nominal) | 1 day | 1 hour | 15 min |
| Duration (real hh: mm: ss) | 22:47:00 | 00:42:00 | 00:11:37 |
| Sampling Rate | 30s | 30s | 1s |

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Using the following basic command, you will get file names containing the real values derived from the file content.

```
gfzrnx -finp <RINEX-2 Name> -fout ::RX3::01,DEU
```

By default, the real beginning epoch and duration information based on the file content are used:

| RINEX-2 | RINEX-3 |
|----------------|--|
| pots0070.15o | POTS00DEU_R_20150070112_23H_30S_M0.rnx |
| pots007c.15o | POTS00DEU_R_20150070213_42M_30S_MO.rnx |
| pots007c30.15o | POTS00DEU_R_20150070233_12M_01S_M0.rnx |

RINEX-3 Start Epoch/Duration (nominal)

Similar to the RINEX-2 file naming, to get **nominal** beginning and duration information in the RINEX-3 file name, additional command line parameters are needed.

The general method is to give the beginning epoch and the duration information via the -epo_beg and -d command line parameters.

```
gfzrnx -finp file.rnx -fout ::RX3::ABCD,05,DEU -epo_beg 20150812_020000 -d 3600
gfzrnx -finp pots0070.15o -fout ::RX3::00,DEU -epo_beg 20150107_000000 -d 86400
```

Assuming 30 s sampling rate and GPS-only data, the output file names will be:

ABCD05DEU_R_20152240200_01H_30S_GO.rnx, POTS00DEU_R_20150070000_01D_30S_GO.rnx.

In the case of **nominal** standard RINEX input file names you can get nominal RINEX-3 output file names, providing the <code>-sei in</code> command line parameter (strict epoch interval), which uses the epoch and implicit duration information from the input file name. If no implicit duration information is given (RINEX-2 11.3 file names) it has to be provided in addition via the <code>-d</code> (duration) command line parameter (otherwise the real duration is used). This can be useful in renaming scenarios.

| RINEX-2 | command line parameters | RINEX-3 |
|----------------|-------------------------|--|
| pots0070.15o | -sei in | POTS00DEU_R_20150070000_01D_30S_MO.rnx |
| pots007c.15o | -sei in | POTS00DEU_R_20150070200_01H_30S_MO.rnx |
| pots007c30.15o | -sei in -d 900 | POTS00DEU_R_20150070230_15M_01S_MO.rnx |

RINEX-3 Mixed Broadcast Splice File Naming -nav_mixed

If generating a mixed broadcast navigation file with automatic file naming (::RX3::) in an ongoing accumulation mode one should use the nav_mixed command line parameter to ensure that a _MN file name is generated, nevertheless a single satellite system is found in the given
file(s).

Remark

In the file split mode, the duration information will be nominal (split interval).

The **nominal** mode has to be used with caution, especially in renaming operations.



Using the **NOMINAL** mode gfzrnx does not only (re)name the given output files. It ensures that the file content fits to the file name. This way, extra observations are removed!

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For navigation files, this nominal interval can be extended via the -enb command line parameter (extend navigation boundaries). See the Operation/Tasks - Rinex File Epoch Interval section.

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3. Tasks

3.1 Operation / Tasks

The following operations/tasks are supported:

- RINEX file check and repair
- RINEX file format conversion (versions 2, 3, 4 into each other)
- · RINEX file splice
- · RINEX file split
- · RINEX file statistics generation
- RINEX file manipulations like:
- · data sampling
- · observation types selection
- satellite systems selection
- elimination of empty or sparse observation types on a file level
- elimination of empty or sparse observation types on a PRN level
- PRN renaming
- · Automatic version dependent file naming on output file.
- RINEX file (re)naming support (version 2 to 3 or 4)
- RINEX header editing
- · RINEX file metadata extraction
- · RINEX file comparison
- RINEX file tabular representation
- Multi RINEX file operations with a single command



To get the full available checks via data input, one has to use the -chk option, to make sure that the output data are formally correct. If you are sure that your input files are correct, and you want to do some data manipulation only, you can omit this command line parameter to speed up the work.



Please keep in mind that compared to other tools, working on a single epoch level, **gfzrnx** stores the whole RINEX data set in the computer's memory before output. This leads to some performance degradation but offers complete data handling opportunities.

andard RINEX output version

The standard output format of gfzrnx is at the moment the latest supported version of major version RINEX-3 (e.g. 3.05).

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The major version RINEX-4 is supported. Use the _-vo_4 command line parameter to force the RINEX-4 file output.

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3.2 RINEX File Check and Repair

If one gets data of unknown quality, one should pass them at least once through a check procedure. If an output file is created it will be RINEX conform nevertheless the input was corrupt.

With gfzrnx this can be done via:

```
gfzrnx -finp pots0070.15o -fout pots0070.15o_chk -chk -kv
```

With -chk all formal checks are done on the input file.

The -kv (keep version) ensures the same output version as the input file (standard output format is the latest supported format).

The following modifications are done in the output file:

- Update of observation types to really existing ones, overall empty observation types are removed.
- SYS / # / OBS TYPES
- # / TYPES OF OBSERV
- · Statistical information is added or updated in the file header.
- PRN / # OF OBS
- # OF SATELLITES
- INTERVAL
- TIME OF FIRST OBS
- TIME OF LAST OBS

Here is an example of an updated RINEX header information:

```
10 C1I C6I C7I D1I L1I L6I L7I S1I S6I S7I
                                                     SYS / # / OBS TYPES
13 C1X C5X C7X C8X D1X L1X L5X L7X L8X S1X S5X S7X S8X SYS / # / OBS TYPES
20 C1C C2W C2X C5X D1C D1P D1W D2W L1C L1P L1W L2W L2X SYS / # / OBS TYPES
   L5X S1C S1W S2C S2W S2X S5X
                                                     SYS / # / OBS TYPES
 19 C1C C1X C1Z C2X C5X C6L D1C L1C L1X L1Z L2X L5X L6L SYS / # / OBS TYPES
   S1C S1X S1Z S2X S5X S6L
                                                     SYS / # / OBS TYPES
 13 C1C C1P C2C C2P D1C L1C L1P L2C L2P S1C S1P S2C S2P SYS / # / OBS TYPES
 4 C1C D1C L1C S1C
                                                     SYS / # / OBS TYPES
 76
                                                     # OF SATELLITES
    C01
    2863
                                                     PRN / # OF OBS
C14
    1365 1363 1363 1365 1365 1363 1363 1365 1363PRN / # OF OBS
                                                     PRN / # OF OBS
     1363
E11
     900
           895
                 893
                      899
                            900
                                  900
                                       895
                                             893
                                                   899PRN / # OF OBS
           895
                                                     PRN / # OF OBS
     900
                893
                      899
E19
    1605
          1601
               1601
                     1603
                           1605 1605 1601 1601 1603PRN / # OF OBS
    1605
          1601
                1601
                     1603
                                                     PRN / # OF OBS
                                                  1189PRN / # OF OBS
GØ1
    1189
          1148
               1181
                     1181
                           1189
                1148 1181 1181 1189
                                            1181 1148PRN / # OF OBS
    1181 1181
                                                     PRN / # OF OBS
                                                  1247PRN / # OF OBS
G32
    1247 1241
                           1247
                1241
                                 1247
                                                  1241PRN / # OF OBS
                                                     PRN / # OF OBS
J01
    2863
          2863
                2863
                     2863
                           2863 2863
                                      2863
                                            2863
                                                2863PRN / # OF OBS
                                            2863 2863PRN / # OF OBS
    2863
          2863
                2863
                     2863
                           2863
                                2863
                                      2863
    2863
                                                     PRN / # OF OBS
R01
     713
           713
                 709
                      706
                            713
                                 713
                                       713
                                             709
                                                  706PRN / # OF OBS
     713
           713
                 709
                      706
                                                    PRN / # OF OBS
                                           695 695PRN / # OF OBS
R24
     695
          695
                695
                      695
                            695 695
                                      695
```

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| S26 | 695 1973 | 695 1973 | 695 1973 | 695 1973 | | | PRN / # OF OBS PRN / # OF OBS |
|------|-------------|-------------|-------------|-------------|------------|-----|----------------------------------|
| | | | | | | | |
| S37 | 2863 | 2863 | 2863 | 2863 | | | PRN / # OF OBS |
| 30. | 000 | | | | | | INTERVAL |
| 2014 | 8 | 17 | 0 | 0 | 0.0000000 | GPS | TIME OF FIRST OBS |
| 2014 | 8 | 17 | 23 | 59 | 30.0000000 | GPS | TIME OF LAST OBS |
| | | | | | | | |

The repair of a file is different concerning RINEX-2 and RINEX-3(4,...). Data values are not corrected! Via the repair operation, formally corrupt observation parts are omitted only.

- RINEX-2
- A complete epoch block is removed in case of corrupted data detection.
- · RINEX-3 and higher
- A complete satellite block (line) is removed in case of corrupted data detection.

3.2.1 Navigation Data Epoch Filter

Use the <code>-nav_epo_filter</code> command line parameter to filter the navigation data input via epoch record checks. In this case, only **nominal** epochs are passed to the output file. Excluded records are given in the log table. Only epoch minutes and hours are checked at the moment. The following table shows valid hours and minutes per satellite system:

| Sat. System | Minutes | Hours (modulo) |
|-------------|------------------|----------------|
| С | 0 | 1 |
| E | 0,10,20,30,40,50 | 1 |
| G | 0 | 2 |
| R | 15,45 | 1 |
| J | 0 | 1 |

3.2.2 Meteo Data check/edit against NWM-Data

RINEX-meteo site data can be checked against a reference RINEX-file created from e.g. Numerical Weather Model (**NWM**) data (predicted or reprocessed). Two input files have to be given via the <code>-finp</code> command line parameter. The first file is the one to be checked, the second file is the reference file to be checked against.

The check limits for the different observation types are taken from the reference file "SENSOR MOD/TYPE/ACC" header records. Here is an example:

| DNSXGFZ ERA5/ECMWF 10.0 PR SENSOR MOD/TYPE/ACC DNSXGFZ ERA5/ECMWF 10.0 TD SENSOR MOD/TYPE/ACC DNSXGFZ ERA5/ECMWF 100.0 HR SENSOR MOD/TYPE/ACC | BN01/057 | ED 1 E 1 E 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 10.0 | | WAR (T)/RE (100 |
|---|----------|--|-------|-----------|-----------------|
| | DNSXGFZ | ERA5/ECMWF | 10.0 | | |
| DNSXGFZ ERA5/ECMWF 100.0 HR SENSOR MOD/TYPE/ACC | DNSXGFZ | ERA5/ECMWF | 10.0 | TD SENSOF | MOD/TYPE/ACC |
| | DNSXGFZ | ERA5/ECMWF | 100.0 | HR SENSOF | MOD/TYPE/ACC |

Observations that exceed the difference limits are eliminated and don't go to the output file.

```
gfzrnx -met_nwm -finp POTS00DEU_R_20200010000_01D_05M_MM.rnx POTS00DEU_R_20200010000_01D_05M_MM.rnx_nwm -fout
POTS00DEU_R_20200010000_01D_05M_MM.rnx_chk
```

By default, all observation types found in the reference file are used for the differences checks. To limit the tests to single observation types, they can be given via the <code>-obs_types</code> or <code>-ot</code> command line parameters.

```
gfzrnx -met_nwm -finp ... -fout POTS00DEU_R_20200010000_01D_05M_MM.rnx_chk -ot TD,HR
```

The removed observations are documented in the log.

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3.3 RINEX File Statistics / Information

3.3.1 Observations Statistics

The -stk_only or -stk_obs outputs observations statistics information to STDOUT. Only the nonzero (nonempty) data values are counted.

```
gfzrnx -finp pots0070.15o -stk_obs
```

You can store it into a file using the -fout command line parameter.

```
gfzrnx -finp pots0070.15o -stk_obs -fout pots0070.15o_stk
```

Here is an example for the observations file sin12290.14o:

```
gfzrnx -finp sin12290.14o -stk_obs
 STP sin1 C TYP
                 C1I
                        C6I
                              C7I
                                    D1I
                                          L1I
                                                L6I
                                                       L7I
                                                             S1I
                                                                   S6I
 STO sin1 C C01 2863
                       2863 2863
                                   2863
                                         2863
                                               2863
                                                      2863
                                                            2863
                                                                  2863
                                                                        2863
 STO sin1 C C02 2863
                       2863
                            2863
                                   2863
                                         2863
                                               2863
                                                      2863
                                                            2863
                                                                  2863
 STO sin1 C C14 1365
                       1363
                             1363
                                   1365
                                          1365
                                                1363
                                                      1363
                                                            1365
                                                                  1363
 STP sin1 F TYP
                              C7X
                                                                                S5X
                                                                                     S7X
                                                                                            S8X
                 C1X
                        C5X
                                    C8X
                                          D1X
                                                I 1 X
                                                      1.5X
                                                             17X
                                                                   1 8 X
                                                                         S1X
 STO sin1 E E11
                  900
                        895
                              893
                                     899
                                          900
                                                 900
                                                       895
                                                             893
                                                                   899
                                                                         900
                                                                                895
                                                                                     893
                                                                                            899
 STO sin1 E E12
                1230
                       1230
                             1230
                                   1230
                                         1230
                                               1230
                                                      1230
                                                            1230
                                                                  1230
                                                                              1230
                                                                                    1230
                                                                        1230
                                                                                           1230
 STO sin1 E E19
                 1605
                       1601
                             1601
                                   1603
                                          1605
                                                1605
                                                      1601
                                                            1601
                                                                  1603
                                                                        1605
                                                                               1601
                                                                                    1601
 STP sin1 G TYP
                 C1C
                        C2W
                              C2X
                                    C5X
                                          D1C
                                                       L1C
                                                             L1P
                                                                   L1W
                                                                         L2W
                                                                               L2X
                                                                                     L5X
                                                                                           S1C ...
 STO sin1 G G01 1189
                             1181
                                   1181
                                                               0
                                                                                    1181
                       1148
                                         1189
                                                      1189
                                                                     0
                                                                        1148
                                                                              1181
                                                                                          1189 ...
 STO sin1 G G10
                  886
                        881
                                          886
                                                       886
                                                                         881
                                                                                       0
                                                                                            886 ...
 STO sin1 G G32
                 1247
                       1241
                                0
                                          1247
                                                      1247
                                                               0
                                                                     0
                                                                        1241
                                                                                 0
                                                                                        0
                                                                                           1247 ...
 STP sin1 J TYP
                              C17
                 C1C
                        C1X
                                    C2X
                                          C5X
                                                 C6I
                                                       D1C
                                                             11C
                                                                   I 1 X
                                                                               12X
                                                                                     1.5X
                                                                                           L6L ...
                                                                         117
 STO sin1 J J01 2863
                       2863
                             2863
                                   2863
                                         2863
                                                2863
                                                      2863
                                                            2863
                                                                  2863
                                                                              2863
                                                                                    2863
                                                                                           2863 ...
                                                                        2863
 STP sin1 R TYP
                  C1C
                        C1P
                              C2C
                                     C2P
                                          D1C
                                                 L1C
                                                       L1P
                                                             L2C
                                                                   L2P
                                                                         S1C
                                                                                S1P
                                                                                     S2C
                                                                                            S2P
                 713
                        713
                              709
                                                       713
                                                             709
                                                                         713
                                                                               713
                                                                                     709
 STO sin1 R R01
                                    706
                                          713
                                                713
                                                                   706
                                                                                            706
 STO sin1 R R02 1143
                       1143
                             1141
                                   1141 1143 1143
                                                     1143
                                                            1141
                                                                        1143
                                                                              1143
                                                                                    1141
                                                                                           1141
                                                                  1141
 STO sin1 R R24
                  695
                        695
                              695
                                     695
                                          695
                                                 695
                                                       695
                                                             695
                                                                   695
                                                                         695
                                                                                695
                                                                                     695
                                                                                            695
 STO sin1 S TYP
                 C1C
                        D1C
                              1.1C
                                    S1C
 STO sin1 S S26
                1973
                       1973
                             1973
                                   1973
 STO sin1 S S27 2863
                       2863
                             2863
                                   2863
 STO sin1 S S37 2863
                       2863 2863
                                   2863
```

3.3.2 ASCII Time plot of Observables

The <code>-stk_epo</code> command line parameter can be used to create an ASCII time plot to show the availability of observations per **PRN** (std.) and/ or **observation type**.

In the simplest mode, one has to provide the time bin to be used in seconds (here 1800).

Timeplot per PRN

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```
gfzrnx -finp stas0400.15o -stk_epo 1800
gfzrnx -finp stas0400.15o -stk_epo 1800:prn
```

```
STT 20150209 00:00 04:00 08:00 12:00 16:00 20:00 00:00
           +---+---+
STE stas C C05 ****************************** C05
STE stas C C06 ******* | | | | | | | **** | C06
STE stas C C07 | | ********* | | | | | C07
                    STE stas C C08 |
STE stas C C09 ***********
STE stas C C10 | | | *********** | |
STE stas C C11 **** | | | | ****** | | | | ****** | C11
STE stas C C12 | | | | | ******* | | | ******** | C12
STE stas C C14 ********* | | | | | ******** | | | C14
        |---|---|---|---|---|---|---|---|---|
STS
STE stas E E11 ****** | | | | ****** | | | | E11
STE stas E E12 *** | | | | ******* | | | | *** | E12
STE stas E E19 **** | | | | ********** | | | | E19
STE stas E E20 ** | | | | ********* | | | E20
          |---|---|---|---|---|---|---|---|---|
STS
STE stas G G03 | | | ********** | | | | ***** | | G03
STE stas G G30 | ***** | | | ******* | | | | G30
STE stas G G31 *** | | | ******* | | | |
STE stas G G32 | | ********* | | | | | ***** | | G32
STS
STE stas J J01 ** | | | | | | | | *** *| J01
STS |---|---|---|---|---|---|---|
| **| R02
STE stas R R03 | ******* | | | | ******** | | | R03
STE stas R R22 | |
STE stas R R23 |
STH
STT 20150209 00:00 04:00 08:00 12:00 16:00 20:00 00:00
```

TIMEPLOT PER PRN AND/OR OBSERVATION TYPE

A timeplot per observation type is available, providing the **[:[prn/otp]]** parameter list. This can be combined with other parameters like **-smp**, **-satsys**, **--obs_types**, **-prn**, **-no_prn** etc.

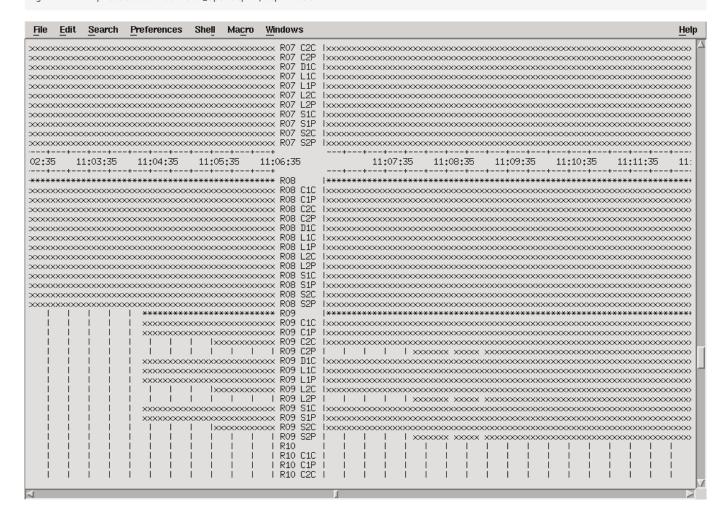
gfzrnx -finp stas0400.15o -stk_epo 1800:prn,otp -satsys E -ot C,L

| OTIL | 0:00 04 | | | 00 | 12:00 16 | | | 00: | • • | |
|--------------------|---------|---|-----|----|----------|-------|-----|-----|-------|-----|
| STH | ++ | + | ++ | + | + | ++- | + | -++ | | |
| STE stas E E11 | ***** | | | | ***** | 1 | | | | E11 |
| SOT stas E E11 C1X | XXXXXXX | | | | xxxxxx | | | 1 1 | C1X | E11 |
| SOT stas E E11 C7X | XXXXXXX | | | | xxxxxx | | | 1 1 | C7X | E11 |
| SOT stas E E11 C8X | XXXXXXX | | | | xxxxxx | | | 1 1 | C8X | E11 |
| SOT stas E E11 L1X | XXXXXXX | | | | xxxxxx | | | 1 1 | L1X | E11 |
| SOT stas E E11 L7X | xxxxxxx | | | | xxxxxx | 1 1 | | 1 1 | L7X | E11 |
| SOT stas E E11 L8X | XXXXXXX | | | | xxxxxx | | | 1 1 | L8X | E11 |
| STE stas E E12 | *** | | | | ***** | | | *** | | E12 |
| SOT stas E E12 C1X | xxx | | | | xxxxxx | | | xxx | C1X | E12 |
| SOT stas E E12 C7X | xxx | | | | xxxxxx | | | xxx | C7X | E12 |
| SOT stas E E12 C8X | xxx | | | | xxxxxx | | | xxx | C8X | E12 |
| SOT stas E E12 L1X | xxx | | | | xxxxxx | | | xxx | L1X | E12 |
| SOT stas E E12 L7X | xxx | | | | xxxxxx | | | xxx | L7X | E12 |
| SOT stas E E12 L8X | xxx | | | | xxxxxx | | | xxx | L8X | E12 |
| STE stas E E19 | **** | | | | ***** | ***** | * | | | E19 |
| SOT stas E E19 C1X | XXXXX | | | | xxxxxx | xxxxx | x | | C1X | E19 |
| SOT stas E E19 C7X | XXXXX | | | | xxxxxx | xxxxx | x | | C7X | E19 |
| SOT stas E E19 C8X | XXXX | | | | xxxxx | xxxxx | | 1 1 | C8X | E19 |
| SOT stas E E19 L1X | YYYYY | 1 | 1 1 | 1 | xxxxxx | VVVVV | v I | 1 1 | 1 1 X | E19 |

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Using an editor that is able to scroll horizontally through a text file (**nedit** for Unix, or **Notepad++** for MS Windows)one can visually check data availability details down to a single observation in case of problems. Here is an example of an input file with 5 s sampling rate:

gfzrnx -finp stas0010.15o -stk_epo 5:prn,otp -fout xxxx



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3.4 RINEX File Format Conversion

3.4.1 RINEX OBS File Format Conversion (4, 3, 2 to 2, 3, 4)

Observation Types Mapping

The used observation types mapping is hard-coded in**gfzrnx**. It can be shown up via the following command:

```
gfzrnx -out_obs_map
gfzrnx -out_obs_map -fout obs_types_map.txt
```

The information in columns 2, 3 and 4 is treated as a comment only and is not used.



During the conversion process, the data values - observation, loss of lock indicator (LLI), signal strength indicator (SSI) - are left as they are. The LLI meaning differs between versions 2 and 3 or 4 and the Interpretation of bits 1 and 2 has to be used with caution!

RINEX-2 to RINEX-3 or 4

Please use this conversion only if you are sure that the output files are usable in the environment the data are supplied to! The output format for this conversion/transition is RINEX-3.01 to be standard-compliant. The 2-characters observation types are kept as they are except the code observations for GPS and GLONASS (see below).

As RINEX-3 is the standard output format of gfzrnx, simply run:

```
gfzrnx -finp pots0070.15o -fout pots0070.15o_rx3
```

or

```
gfzrnx -finp pots0070.15o -fout ::RX3::00,DEU gfzrnx -finp pots0070.15o -fout ::RX3::DEU,00
```

or

```
gfzrnx -finp pots0070.15o -fout ::RX3::00,DEU -sei in gfzrnx -finp pots0070.15o -fout ::RX3::DEU,00 -sei in
```

to create a RINEX-3 compliant output file name POTS00DEU_R_201500700_01D_30S_MO.rnx .

For naming details, see the Automatic Output File Naming section.

A hard-coded observation types mapping for the GPS and GLONASS code observations is implemented:

| System | RINEX-2 | RINEX-3/4 |
|--------|---------|-----------|
| G | P1 | C1W |
| G | C1 | C1C |
| G | P2 | C2W |
| G | C2 | C2C |

| System | RINEX-2 | RINEX-3/4 |
|--------|---------|-----------|
| R | P1 | C1P |
| R | C1 | C1C |
| R | P2 | C2P |
| R | C2 | C2C |

This is used because both Px and Cx code types are mapped to the single Cx? RINEX-3 or 4 code type.

RINEX-3 or 4 to RINEX-2

The RINEX-2 output version is 2.11.

Use the --version_out or -vo command line parameter to define the RINEX format version of the output file.

```
gfzrnx -finp pots0070.150 -fout pots0070.15o_rx2 -vo 2 gfzrnx -finp POTS00DEU_R_201500700_01D_30S_MO.rnx -fout pots0070.15o --version_out 2
```

SPECIFIC OBSERVATION TYPE SELECTION

In the RINEX-3 or 4 format, one can have multiple observation types per data type and frequency (tracking mode or channel attribute). For a specific observation type selection for the format conversion, you can use the observation types selection feature in addition. Add the -ot command line parameter to the upper command like in the example below to select the RINEX-3 or 4 observation types to be converted and to get a distinct conversion.

```
-ot G:C1W,L1W,D1W,S1W+C2W,L2W,D2W,S2W+R:C1P,L1P,S1P,D1P,C2P,L2P,S2P,D2P
```

OBSERVATION TYPE SELECTION VIA SIGNAL PRIORITIES

By default, the following signal priorities per frequency and satellite system are used for the RINEX-3 or 4 to RINEX-2 conversion:

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| Sat. System | Freq. Num. | RINEX-3 Signal Priority |
|-------------|------------|-------------------------|
| G - GPS | 1 | PRWCSLXYMN |
| G - GPS | 2 | PRWCDSLXYMN |
| G - GPS | 5 | IQX |
| | | |
| R - GLO | 1 | PC |
| R - GLO | 2 | PC |
| R - GLO | 3 | IQX |
| R - GLO | 4 | ABX |
| R - GLO | 6 | ABX |
| | | |
| E - GAL | 1 | BCX |
| E - GAL | 5 | IQX |
| E - GAL | 6 | BCX |
| E - GAL | 7 | IQX |
| E - GAL | 8 | IQX |
| | | |
| J - QZS | 1 | SLXCZ |
| J - QZS | 2 | SLX |
| J - QZS | 5 | IQX |
| J - QZS | 6 | SLX |
| | | |
| C - BDS | 1 | IQX |
| C - BDS | 2 | IQX |
| C - BDS | 5 | DPX |
| C - BDS | 6 | IQX |
| C - BDS | 7 | IQX |
| C - BDS | 8 | DPX |
| | | |
| I - IRN | 5 | ABCX |
| I - IRN | 9 | ABCX |
| | | |
| S - SBS | 1 | С |
| S - SBS | 5 | IQX |
| | | |

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The observation code's priority is **LCDS**: phase, code, doppler and signal strength. It defines the basis for the selection of the other observation types of that frequency, if existing. You can update the internal signal priority list by providing update records via the -pr3rx2 command line parameter. According to the upper table, it should consist of a comma-separated list of a satellite system identifier, colon, frequency number, colon, and the signal priority string. Observation types not covered by the priority string are simply ignored via conversion. See the following example:

```
-pr3rx2 G:5:QXI,I:59:CXAB
```

The same priority string per satellite system for different frequencies can be given combined.

USED OBSERVATION TYPES

The observation types per satellite system used for the format conversion can be found as COMMENTs in the RINEX file header.

```
************ COMMENT
                                                   * COMMENT
               WARNING - FORMAT CONVERSION
            ----- * COMMENT
* The data values: observation, loss of lock (LLI) and * COMMENT
* signal strength (SSI) indicators are left as they are. * COMMENT
    The LLI meaning differs between versions 2 and 3
                                                   * COMMENT
    and the Interpretation of bit 1 and 2 has to be
                                                   * COMMENT
                                                   * COMMENT
                 used with caution !!!
********** COMMENT
                                                      COMMENT
RINEX 3 -> 2 TYPE CONVERSION DETAILS:
                                                      COMMENT
                                                      COMMENT
   C C1I -> C1
                                                      COMMENT
   C C6I -> C6
                                                      COMMENT
   C C7I -> C7
                                                      COMMENT
   C D1I -> D1
                                                      COMMENT
   C L1I -> L1
                                                      COMMENT
   C L6I -> L6
                                                      COMMENT
   C L7I -> L7
                                                      COMMENT
   C S1I -> S1
                                                      COMMENT
                                                      COMMENT
   C S6I -> S6
   C S7I -> S7
                                                      COMMENT
                                                      COMMENT
   E C1X -> C1
                                                      COMMENT
   E C5X -> C5
                                                      COMMENT
   F C7X -> C7
                                                      COMMENT
   E C8X -> C8
                                                      COMMENT
   E D1X -> D1
                                                      COMMENT
   E L1X -> L1
                                                      COMMENT
   F I 5X -> I 5
                                                      COMMENT
   E L7X -> L7
                                                      COMMENT
   F I 8X -> I 8
                                                      COMMENT
   E S1X -> S1
                                                      COMMENT
   E S5X -> S5
                                                      COMMENT
   E S7X -> S7
                                                      COMMENT
   E S8X -> S8
                                                      COMMENT
                                                      COMMENT
   G C1C -> C1
                                                      COMMENT
   G C2X -> C2
                                                      COMMENT
   G C5X -> C5
                                                      COMMENT
   G D1C -> D1
                                                      COMMENT
   G L1C -> L1
                                                      COMMENT
   G L2W -> L2
                                                      COMMENT
   G L5X -> L5
                                                      COMMENT
   G C2W -> P2
                                                      COMMENT
   G S1C -> S1
                                                      COMMENT
   G S2W -> S2
                                                      COMMENT
   G S5X -> S5
                                                      COMMENT
```

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REMARK

To avoid the selection of an observation type with sparse observations using **Signal Priorities** mode, it can be useful to add the **-rsot** command line parameter (remove sparse observations types) in addition.

```
gfzrnx -finp pots0070.150 -fout pots0070.15o_rx2 -vo 2 -rsot 40 gfzrnx -finp POTS00DEU_R_201500700_01D_30S_M0.rnx -fout pots0070.150 -vo 2 -rsot 40
```

3.4.2 RINEX NAV File Format Conversion (3.04/3.05)

There is a significant change in the GLONASS broadcast records in the RINEX version 3.05 (one additional record).

The GFZRNX output version is always the highest supported one. For the RINEX-3 standard output, a "dummy" record is added to be 3.05 standard compliant.

If you can't use this latest 3.05 version because e.g. your software does not support this, you can create a 3.04-formatted file via the _-vo , _-version_out command line parameters.

```
gfzrnx -finp enao080a00.21G -fout enao080a00.21G -vo 3.04
```

This works for splice operations too.

```
gfzrnx -finp enao080a00.21* -fout ENAO00XXX_R_20210800015_15M_MN.rnx -vo 3.04
```

3.5 Rinex File Nominal Renaming Support

3.5.1 RINEX File Nominal Renaming Support (2, 3 or 4)

A fast file name conversion of RINEX-3 or 4 files with RINEX-2 style file names to RINEX-3 or 4 style file names is supported. It can be used without reading the input files, using all necessary information from the RINEX-2 style file name and from information provided via command line parameters (useful for compressed files).

For uncompressed observation files, including hatanaka compressed files, some required information can also be derived from the file header.

The supported RINEX-2 style file names are:

| Name | Example | Description |
|--------------------|----------------|---------------------------------------|
| nnnnddd0.yyt | pots1230.15o | daily obs. file |
| | pots1230.15d | daily obs. file (hatanaka compressed) |
| nnnnddd[a-z].yyt. | pots123a.15n | hourly nav. file |
| nnnnddd[a-z]mm.yyt | pots123x15.15m | sub-hourly met. file |

The renaming support can be invoked via the **-nomren23** (nominal rename) command line parameter. The output is the RINEX-3 file name (printed to STDOUT) which can be used for renaming operations. The input can be a full path, the output is the file name only.

Using -nomren23 command line parameter the following additional information **s,mr,iso** has to be provided via command line because they are not available from the RINEX-2 style file name or RINEX file header.

| | Information | Values | Default |
|-----|------------------------|--------|---------|
| s | data source | R or S | R |
| mr | marker/receiver number | mr | 00 |
| iso | iso country code | ISO | XXX |

```
gfzrnx -finp pots1230.15n -nomren23 DEU,12
POTS12DEU_R_20151230000_01D_GN.rnx

gfzrnx -finp pots1230.15g -nomren23 S,DEU,12
POTS12DEU_S_20151230000_01D_RN.rnx

gfzrnx -finp pots1230.15m -nomren23 DEU
POTS00DEU_R_20151230000_01D_00U_MM.rnx
```

Via the -4to9 command line parameter, one can provide multiple site identifier information from a provided configuration file. See the **Automatic Output File Naming** section for details on -4to9.

```
gfzrnx -finp pots1230.15o -nomren23 -4to9 four2nine.conf
gfzrnx -finp tash1230.15o -nomren23 -4to9 four2nine.conf
```

There are default mappings from the extension letter to the RINEX-3 data type identifier:

| Extension | Data Type |
|-----------|-----------|
| o | _MO.rnx |
| d | _MO.crx |
| n | _GN.rnx |
| g | _RN.rnx |
| I | _EN.rnx |
| С | _CN.rnx |
| q | _JN.rnx |
| j | _JN.rnx |
| h | _SN.rnx |
| р | _MN.rnx |
| m | _MM.rnx |

All other extension letters end up with $\tt _XX.rnx$.

```
gfzrnx -finp pots1230.15b -nomren23 DEU,12
POTS12DEU_R_20151230000_01D_XX.rnx
```

To support additional extensions, these default mappings can be overwritten or extended via the -extsysdt23 command line parameter, providing a comma-separated list of extension letter-colon-data type pairs.

```
gfzrnx -finp pots1230.15b -nomren23 DEU,12 -extsysdt23 b:SA,j:JN POTS12DEU_R_20151230000_01D_SA.rnx
```

Meteo- and Navigation files don't have additional information which can be derived from the file header.

For observation files, the data frequency and satellite system can be derived from the "INTERVAL" and

"SYS / # / OBS TYPES" RINEX header records. For compressed files, this information can be provided via the command line parameters -smp and -satsys.

Here are some examples, including hatanaka compressed files:

```
      gfzrnx -finp pots1230.15o.gz -nomren23 DEU -smp 30 -satsys G

      POTS00DEU_R_20151230000_01D_30S_GO.rnx.gz

      gfzrnx -finp pots1230.15o.gz -nomren23 DEU -smp 30 -satsys GR

      POTS00DEU_R_20151230000_01D_30S_MO.rnx.gz

      gfzrnx -finp pots1230.15d.gz -nomren23 DEU -smp 30 -satsys GR

      POTS00DEU_R_20151230000_01D_30S_MO.crx.gz

      gfzrnx -finp pots1230.15d.gz -nomren23 DEU

      POTS00DEU_R_20151230000_01D_00U_MO.crx.gz
```

Using the following RINEX-3 or 4 header information:

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```
E 6 C1X C5X L1X L5X S1X S5X SYS / # / OBS TYPES
G 8 C1C C1P C2C C2P L1P L2P S1P S2P SYS / # / OBS TYPES
```

| R | 8 C1C C1P C2C C2P L1P L2P S1P S2P | SYS / # / OBS TYPES |
|---|-----------------------------------|---------------------|
| | 10.000 | INTERVAL |

results in the following file names:

```
gfzrnx -finp pots1230.15o -nomren23 DEU
POTS00DEU_R_20151230000_01D_10S_MO.rnx

gfzrnx -finp pots1230.15d -nomren23 DEU
POTS00DEU_R_20151230000_01D_10S_MO.crx
```

A single satellite system file with the following information:

| Е | 6 C1X C5X L1X L5X S1X S5X | SYS / # / OBS TYPES |
|---|---------------------------|---------------------|
| | 5.000 | INTERVAL |

leads to the file names:

```
gfzrnx -finp pots1230.15o -nomren23 DEU
POTS00DEU_R_20151230000_01D_05S_EO.rnx
gfzrnx -finp pots1230.15d -nomren23 DEU
POTS00DEU_R_20151230000_01D_05S_EO.crx
```

Sub-daily files need the additional duration information if it is not 15 minutes (std.). It can be given via the -d, -duration command line parameter.

```
gfzrnx -finp pots123b30.15o -nomren23 DEU
POTS00DEU_R_20151230130_15m_01S_MO.rnx

gfzrnx -finp pots1230c35.15o.gz -nomren23 DEU -d 300 -smp 5
POTS00DEU_R_20151230235_05M_05S_MO.rnx.gz
```



Information provided via the command line has priority.

3.6 RINEX File Splice

For the RINEX file splicing, one can give an unsorted list of input files of a single station. The observation types order can also differ from input file to input file, and an observation type order change inside of a single file is also taken into account.

Simply provide a list of input files and the output file:

```
gfzrnx -finp pots007b.14o pots007a.14o ... pots007x.14o -fout pots0070.14o -kv
```

For bash command shell, it can be shortened using filename expansion options.

```
gfzrnx -finp pots007{a..x}.14o -fout pots0070.14o -kv
gfzrnx -finp /tmp/pots007{a..x}.14o -fout /tmp/pots0070.14o -kv
```

For csh command shell it is:

```
gfzrnx -finp pots007[a-x].14o -fout pots0070.14o -kv gfzrnx -finp /tmp/pots007[a-x].14o -fout /tmp/pots0070.14o -kv
```

For windows-users in cmd.exe or powershell.exe it is:

```
gfzrnx -finp pots007[a-x].14o -fout pots0070.14o -kv gfzrnx -finp c:\tmp\pots007[a-x].14o -fout c:\tmp\pots0070.14o -kv
```

This works similarly for navigation and meteo files.

```
gfzrnx -finp pots007[a-x].14m -fout /tmp/pots0070.14m --version_out 2 gfzrnx -finp /tmp/pots007[a-x].14? -fout /tmp/brds0070.14n --version_out 3
```

3.6.1 Observation Data Splice Specials

There are two different splice modes available

Standard Mode (default)

The input file order is derived automatically. In case of overlapping input files, the file with fewer epochs is preferred. This will allow the splice of resubmitted files into an existing "big" file. All output data records are stored in RAM to allow a full data statistics output in the header while reading any input file only once. The output data types are derived from input statistics. This allows omitting "empty" observation types.

Fast / RAM save Mode (-splice_memsave)

Via the <code>-splice_memsave</code> just the pure line-by-line output data block is stored in RAM for a fast output after the RINEX output header is written. Empty observation types are left in the output files because the observation types from the input header information are used to derive the output observation types.

```
gfzrnx -finp pots007[a-x].14o -fout pots0070.14o -kv -splice_memsave
```

Direct Mode (-splice_direct)

Via the -splice_direct command line parameter, an epoch by epoch output of the observations data can be reached, which leads to a small RAM utilization. Using this mode, a full data statistics header output is impossible.

```
gfzrnx -finp pots007[a-x].14o -fout pots0070.14o -kv -splice_direct
```

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Try Append (-try_append)

The -try_append n command line parameter initiates an initial check over all input files if append to the first file is possible. This can be useful in environments where e.g. a daily file is accumulating e.g. hourly files with time. In case of the append mode, the process will be significantly faster. The parameter of -try_append is the shortest nominal file duration (s) of the part files to be appended (e.g. 3600 for hourly files or 900 for 15-min files).

```
gfzrnx -finp pots007[a-x].14o -fout pots0070.14o -kv -try_append 3600
gfzrnx -finp pots007[a-x].14o -fout pots0070.14o -kv -try_append 3600 -splice_direct
```

3.6.2 Navigation Data Splice Specials

The navigation data splice is based on a majority filter for redundant navigation data records. There is a statistics table in the file header giving information about how many files contributed to the outputs per PRN. This can be useful in the case of creating navigation summary files for e.g. one day.

The header statistics table can be avoided via the <code>-no_nav_stk</code> command line parameter.

Here is shown an example header statistics table for BDS only:

| B_T0P | | | | | | | | | | | | COMMENT |
|--------|------|------|------|-------|--------|------|------|------|------|-------|------|-----------|
| B_TOP | | | | | | | | | | | | COMMENT |
| B_TOP | 7 | # of | NAV. | EP0CH | S base | d on | # of | FILE | CONT | RIB. | | COMMENT |
| B_TOP | | | | | | | | | | | | COMMENT |
| B_TOP | | | | | | | | | | | | COMMENT |
| B_BEG | С | | | | | | | | | | | COMMENT |
| B_HD | BTP | С | MTP | =1 | `<5 | <10 | <15 | <25 | <50 | >`=50 | #E | PO COMMEI |
| B_LN | | C - | | | | | | | | | | COMMENT |
| B_STK | EOP | C19 | CNVX | | | 1 | | | | | 94 | COMMENT |
| B_STK | EOP | C20 | CNVX | | | 1 | | | | | 72 | COMMENT |
| B_STK | FOP | C45 | CNVX | | 1 | | | | | | 75 | COMMENT |
| B_STK | | | | | | | | | | : | | COMMENT |
| B_STK | | | | 1 | 13 | 11 | | | | | | COMMENT |
| B_STK | | | | 1 | | 12 | | | | | | COMMENT |
| | LFII | COZ | DZ | ' | • | 12 | 12 | • | • | • | 23 | COMPLNI |
| B_STK | EPH | C56 | D1 | | 1 | | | | | | 1 | COMMENT |
| B_STK | EPH | C59 | D2 | 13 | 12 | | | | | | 25 | COMMENT |
| B_STK | EPH | C60 | D2 | 1 | 24 | | | | | | 25 | COMMENT |
| B_STK | ION | C01 | D1D2 | 1 | | | | | | | 2 | COMMENT |
| B_STK | ION | C02 | D1D2 | 7 | 8 | | | | | | 16 | COMMENT |
| | | | | | | | | | | | | |
| B_STK | | | | 8 | | | | | | | | COMMENT |
| B_STK | | | | 4 | | | | | | | | COMMENT |
| B_STK | | | | 1 | | | | | | | 2 | COMMENT |
| B_STK | ST0 | C02 | D1D2 | 1 | | | • | • | • | • | 16 | COMMENT |
| B_STK | ST0 | C46 | D1D2 | 1 | 2 | | | | | | 15 | COMMENT |
| B STK | | | | 2 | | | | | | | | COMMENT |
| _ | | | | | | | | | | | | COMMENT |
| B_SUM | EOP | С | CNVX | | | | | | | | 2174 | COMMENT |
| | | | | | | | | | | | | COMMENT |
| B SUM | | | | | | | | | | | | COMMENT |
| B LN | | C | | | | | | | | | | COMMENT |
| B_SUM | | | CNV1 | | | | | | | | | COMMENT |
| B_SUM | | | CNV2 | | | | | | | | | COMMENT |
| B_SUM | | | CNV3 | | | | | | | | | COMMENT |
| B_SUM | | | D1 | | | | | | | | | COMMENT |
| B_SUM | | | D2 | | | | | | | | | COMMENT |
| | | | | | | | | | | | | COMMENT |
| B_SUM | | | | | | | | | | | | COMMENT |
| | | | | | | | | | | | | COMMENT |
| B_SUM | | | CNVX | | | | | | | | | COMMENT |
| B_SUM | | | D1D2 | | | | | | | | | COMMENT |
| | | | | | | | | | | | | COMMENT |
| B_SUM | | | | | | | | | | | | COMMENT |
| D_00/1 | 1014 | 9 | | | | | | | | | 2710 | COMMENT |

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```
B_LN --- C ------ COMMENT
B_SUM STO C CNVX
                                          2174 COMMENT
B_SUM STO C D1D2
B_LN --- C -----
                                   ----- COMMENT
B_SUM STO C
                                         2656 COMMENT
B_LN --- C ------
                                   ----- COMMENT
B_ALL EOP -
                                          3414 COMMENT
                                         17109 COMMENT
B ALL EPH -
                                          5455 COMMENT
B_ALL ION -
                                          5207 COMMENT
B_ALL STO -
                                              COMMENT
      33
                                              MERGED FILE
```

Navigation Data Epoch Filter

Use the -nav_epo_filter command line parameter to filter the navigation records. Only records with **standard** epochs are left in the output file

Use the -nav_epo_strict command line parameter to filter the navigation records. Only records with **nominal** epochs are left in the output file.

Use the -nav_latest command line parameter to filter the navigation records. Only the latest record per PRN is left in the output file. In this case, the header statistics tables are omitted and the default **prn** output sorting is used.

Navigation Data output for GLONASS

With Rinex version 3.05 an additional record was introduced to the GLONASS navigation data block.

Use the -vo 3.04 command line parameter to output version 3.04 omitting the additional GLONASS record to be compatible with your existing navigation data environment.

Remark - Splice/Split

It is possible to combine the splice and split operation of observation data via a single command line call.

Here is an example of splicing e.g. 15 min input files and splitting to hourly files keeping the version in output.

```
gfzrnx -finp pots007[a-x]??.14o -fout /tmp/::RX2:: -kv -split 3600
```

This can be additionally combined with data sampling, satellite system- and observation type selection etc..

Remark - Filename Expansion - UNIX

On UNIX systems, the file name expansion is usually done by the calling command shell. Please adopt the filename expansion options like ?, *, [], etc. to your used command shell. The [a-x] or $\{a...x\}$ can be used too, depending on the used command shell.

Remark - Filename Expansion - Microsoft Windows

MS Windows does not support the file name expansion in its command line interfaces. Therefore, this is done within **gfzrnx**. Only ?, *, [] are supported here.

3.7 RINEX File Split

The RINEX file split can be initiated by providing a split interval in seconds via the -split command line parameter. For the output file, the automatic file naming ::RX2/3:: is mandatory.

The following command:

```
gfzrnx -finp pots0070.15o -fout /tmp/::RX2:: -split 3600 -kv
```

will split a daily file into hourly files, keeping the input file RINEX version and using the RINEX-2 file naming.

```
pots007a.15o pots007b.15o pots007c.15o pots007d.15o pots007e.15o pots007f.15o pots007f.15o pots007h.15o pots007h.15o pots007h.15o pots007h.15o pots007n.15o pots007n.15o pots007n.15o pots007n.15o pots007n.15o pots007r.15o pots007r.15o pots007t.15o pots007t.15o pots007t.15o pots007t.15o pots007t.15o pots007t.15o pots007t.15o pots007t.15o pots007t.15o
```

The following command:

```
gfzrnx -finp pots0070.15o -fout /tmp/::RX3::00,DEU -split 3600
```

will split a daily file into RINEX-3 hourly files using the RINEX-3 file naming.

```
/tmp/POTS00DEU_R_20150070000_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150070100_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150070200_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150070300_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150070400_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150070500_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150070600_01H_30S_MO.rnx /tmp/POTS00DEU_R_2015007000_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150070800_01H_30S_MO.rnx /tmp/POTS00DEU_R_2015007000_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150071000_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150071100_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150071200_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150071300_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150071400_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150071500_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150071600_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150071700_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150071800_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150071900_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150072000_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150072100_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150072200_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150072100_01H_30S_MO.rnx
/tmp/POTS00DEU_R_20150072200_01H_30S_MO.rnx /tmp/POTS00DEU_R_20150072300_01H_30S_MO.rnx
```



It is possible to combine the split with a splice operation of observation data. See splice section for details.

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3.8 RINEX File Output Epoch Interval

3.8.1 Supported Date/Time/Epoch Formats

Date

| Date Type | Abbreviation | Example |
|----------------|--------------|------------|
| MJD | MJD | 56753 |
| GPSweekWeekday | WWWWD | 17870 |
| YearDayofyear | YYYYDDD | 2014096 |
| YearMonthDay | YYYYMMDD | 20140406 |
| Year-Month-Day | YYYY-MM-DD | 2014-04-06 |

Time

| Time Type | Abbreviation | Example |
|--------------------|--------------|----------|
| HourMinuteSecond | HHMMSS | 123000 |
| Hour:Minute:Second | HH:MM:SS | 12:30:00 |

Epoch

An Epoch string can be formed, connecting any Date-string via _ with a Time-string.

| Date Type | Example |
|----------------|-------------------|
| MJD | 56753_123000 |
| GPSweekWeekday | 17870_12:30:00 |
| YearDayofyear | 2014096_123000 |
| YearMonthDay | 20140406_12:30:00 |
| Year-Month-Day | 2014-04-06_123000 |

3.8.2 Dedicated Output Epoch Interval

To extract a dedicated epoch interval from a RINEX-file you have to provide a Start-Epoch via <code>-epo_beg</code> and the duration <code>-d</code> or <code>-duration</code> in seconds.

Here is an example to extract the first hour of a daily input file.

```
gfzrnx -finp pots0070.15o -fout pots007a.15o -epo_beg 2015-01-07_000000 -d 3600 gfzrnx -finp pots0070.15o -fout pots007a.15o -epo_beg 2015007_00:00:00 -d 3600 gfzrnx -finp pots0070.15o -fout pots007a.15o -epo_beg 20150107_000000 -d 3600
```

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3.8.3 Strict Epoch interval (-sei)

If you want that your output epoch interval strictly follows a RINEX file naming, you can give the <code>-sei</code> command line parameter to omit all data that do not fit the implicitly given epoch interval of your input or output file name. You have to use the parameters in, out to the <code>-sei</code> switch to indicate if either the input- or the output filename has to be used for the strict epoch interval handling.

```
gfzrnx -finp pots0070.15o -fout pots007a.15o_chk -chk -sei in gfzrnx -finp pots0070.15o -fout pots007a.15o_smp -smp 30 -sei out
```

The last example extracts the first hour from the daily input file, including a data sampling operation.

3.8.4 Extend Navigation File Boundaries (-enb)

Navigation information files often contain records that don't correspond to the nominal time interval given via the in/out file names. To avoid the elimination of data extending the nominal time interval one can extend the interval to be checked via the -enb command line parameter. The check time interval will be extended at both boundaries by the number of seconds given. Choose a reasonable value to ensure the quality of the output file.

```
gfzrnx -finp grac182n.15f -fout ::RX3::FRA -f -sei in -enb 86400
```

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3.9 RINEX File Manipulation

The following manipulations are useful mainly to shrink an input file to size and content really needed for the analysis purpose. All these manipulations can be combined with the other described operations.

3.9.1 Data Sampling (-smp)

Provide the sampling rate [sec] and the optional tolerance range [sec] to link an observation epoch to its nominal epoch via -smp command line parameter. This parameter can be given for any **gfzrnx** operation.

```
-smp num[:eps]
```

For observation data, the default tolerance range (eps) is 0.5 times of the input sampling rate taken from the INTERVAL header element.

In case the INTERVAL header element is not available or not mandatory (e.g. meteorological data) the default tolerance range (eps) is 0.5 times of the via -smp specified sampling rate (num).

```
gfzrnx -finp pots0070.15o -fout pots0070.15o_rx3_5min -smp 300 gfzrnx -finp pots0070.15o -fout pots0070.15o_rx3_5min -smp 300:0.5
```

LLI shift

The LLIs (Loss of Lock Indicator) of the unused data epochs between two sample epochs are shifted to the sample epoch if you provide the -smp_lli_shift command line parameter. Otherwise, the LLIs of the sample epoch data are left as they are, and the information is lost. The use of this option slows down the sampling operation.

```
gfzrnx -finp pots0070.15o -fout pots0070.15o_rx3_5min -smp 300:0.5 -smp_lli_shift
```



If more than one observation epoch is found in the tolerance range, only the nearest to the nominal epoch is used. Having several observation epochs within a tolerance range slows down the sampling process, especially for observation files. You can fasten the sampling process providing a reasonable tolerance range (eps) on the command line.

The default tolerance ranges are:

| Sampling Rate | Default eps |
|---------------|-------------|
| >= 1 s | 0.5 s |
| <1s | 5 ms |

3.9.2 Satellite System Selection (-satsys)

If you are interested in a subset of satellite systems only, you can use the -satsys command line parameter to provide your desired satellite system. All other satellite systems are omitted in the output file.

```
-satsys <string>
```

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The satellite systems string (string) consists of Satellite system letters (G-GPS, R-Glonass, E-Galileo, C-Beidou ...).

```
gfzrnx -finp pots0070.15o -fout pots0070.15o_rx3_GR -satsys GR
gfzrnx -finp pots0070.15o -fout pots0070.15o_rx3_GRE -satsys GRE
gfzrnx -finp pots0070.15o -fout pots0070.15o_rx2_G -satsys G --version_out 2
```

3.9.3 PRN Selection (-prn, -no_prn)

For RINEX Observation files one can use a PRN selection/deselection via -prn and -no_prn command line parameters to include/exclude specific PRNs in the RINEX or statistics output. Both parameters can be mixed (-no_prn is prioritized). Simply provide a comma-separated list of PRNs or PRN-ranges.

```
gfzrnx -finp pots0070.15o -fout pots0070.15o_rx3_small -prn G01,G05-20,R01-24,C05,C06 \
-no_prn G10,R05-7,R10
```

3.9.4 Observation Types Selection (-obs_types)

If you are interested in a subset of observation types only, you can use the <code>-obs_types</code> command line parameter to provide your desired observation types via a comma-separated list of patterns.

The observation types selection works via a pattern matching mode. The pattern matching is done left aligned (e.g. L,L2,L2C or 1,1C).

Here are some examples:

RINEX-2

The input file contains the following observation types.

```
8 C1 D1 L1 L2 P2 D2 S2 S1 P1# / TYPES OF OBSERV
```

Select code and phase observations only.

```
gfzrnx -finp pots0070.15o -fout pots0070.15o -obs_types P,C,L
```

The result will be a file containing the following observation types only.

```
5 C1 L1 L2 P1 P2 # / TYPES OF OBSERV
```

The following command line

```
gfzrnx -finp pots0070.15o -fout pots0070.15o --obs_types P2,C,L
```

will result in a file containing the following observation types, omitting the P1 observable too.

```
4 C1 L1 L2 P2 # / TYPES OF OBSERV
```

RINEX-3\/4

In a simple case, it works the same way as for RINEX-2. For RINEX-3 it is possible to do the selection down to the satellite systems. One has to concatenate the global and the satellite system-dependent definitions via the + character. For satellite system-dependent selections, you have to start with the satellite system character and colon.

```
list can be: [S:]OT1,OT2,...[+S:OT3,OT4,...][+...]
```

```
S - satellite system [CEGJRS]
OT - observation type identifier
```

A satellite system-dependent record fully replaces a global one.

Here is a global selection overall satellite systems (simple mode) selecting phase and code observations only:

```
gfzrnx ... -obs_types L1,L2,C1,C2
```

Here is a selection of frequencies only:

```
gfzrnx ... -obs_types 1,2
```

Here is a global selection with special selections for C (Beidou) and G (GPS).

```
gfzrnx ... -obs_types L1,L2,C1,C2+C:L1,L7,C1,C7+G:L1C,L2W,C1,C2
```

3.9.5 Remove of Sparse Observation Types (-remove_sparse_obs_types)

This option works on a satellite system or file level. One can give a limit in % which can be used to eliminate sparse observation types. The basis is the median of the number of observations per single observation type of a satellite system

```
gfzrnx -finp pots0070.15o -fout pots0070.15o_ok --remove_sparse_obs_types 5 gfzrnx -finp pots0070.15o -fout pots0070.15o_ok -rsot 5
```

3.9.6 Remove of Sparse Observation Types per PRN (-rsot_prn)

This option works on the PRN level. One can give a limit in % which can be used to eliminate sparse observation types on the PRN level. The basis is the median of the number of observations per single observation type of a satellite system.

```
gfzrnx -f -finp SVTL00RUS_R_20240840000_01D_30S_MO.rnx -fout SVTL00RUS_R_20240840000_01D_30S_MO.rnx_filtered -rsot_prn 20
```

The data statistics show here the sparse obs. types.

```
853PRN / # OF OBS
G12
      854
            854
                   854
                               837
                                      837
                                            837
                                                  837
                         854
      853
            853
                                                          1PRN / # OF OBS
                                                            PRN / # OF OBS
        1
              1
R10
      945
            945
                                                          12PRN / # OF OBS
                   945
                         945
                               945
                                      945
                                            945
                                                  945
       27
             27
                   12
                           0
                                 0
                                        A
                                              0
                                                    A
                                                           0PRN / # OF OBS
                                                            PRN / # OF OBS
```

After using the option -rsot_prn sparse data are eliminated and your statistics should look like the following:

```
G12
      854
            854
                   854
                         854
                                837
                                      837
                                             837
                                                   837
                                                          853PRN / # OF OBS
                                                            PRN / # OF OBS
      853
            853
                   853
                         837
                                837
                                      837
                                            837
                                                             PRN / # OF OBS
R10
      945
            945
                  945
                         945
                               945
                                      945
                                            945
                                                   945
                                                             PRN / # OF OBS
                                                             PRN / # OF OBS
                                                             PRN / # OF OBS
```

3.9.7 Keep all Observation Types (-kaot)

For GNSS observation files, complete empty observation types are removed by default. Complete empty PRN data records are removed too. To keep all this data, use the -kaot command line parameter.

3.9.8 Observation Types Sorting (-ots)

```
-ots <CPLSD>[:<attribute>]
```

The default observation types output sorting order is alphanumeric. To control the observation types output order (GNSS observation files only) a string of the first observation types letters should be given. To order by frequency first, the following attributes are possible:

| attribute | order by |
|--------------------------------------|--|
| frqasc | frequency & observation type (ascending) |
| frqdsc | frequency & observation type (descending) |
| <pre>frq <frq-list></frq-list></pre> | comma-separated list of frequencies given in a certain order |
| froasc | observation type & frequency (ascending) |
| frodsc | observation type & frequency (descending) |
| <pre>fro <frq-list></frq-list></pre> | comma-separated list of frequencies given in a certain order |

Some examples:

```
-ots PCLDS
-ots CL
-ots PCLDS:frqasc
-ots PCLSD:frq1,5,7
-ots PCLDS:frodsc
-ots PCLDS:frodsc
```

The following obs type order on input:

```
G 21 C1C L1C D1C S1C L1P D1P L1W D1W S1W D2C S2C C2W L2W SYS / # / OBS TYPES
D2W S2W C2X L2X S2X C5X L5X S5X
```

creates the following output order using different -ots parameters:

-ots CPLDS

```
G 21 C1C C2W C2X C5X L1C L1P L1W L2W L2X L5X D1C D2C D1P SYS / # / OBS TYPES D1W D2W S1C S2C S1W S2W S2X S5X SYS / # / OBS TYPES
```

-ots CPLDS:frqasc

```
G 21 C1C L1C L1P L1W D1C D1P D1W S1C S1W C2W C2X L2W L2X SYS / # / OBS TYPES D2C D2W S2C S2W S2X C5X L5X S5X SYS / # / OBS TYPES
```

-ots CPLDS:froasc

```
G 21 C1C C2W C2X C5X L1C L1P L1W L2W L2X L5X D1C D1P D1W SYS / # / OBS TYPES
D2C D2W S1C S1W S2C S2W S2X S5X SYS / # / OBS TYPES
```

3.9.9 Navigation File Sorting (-nav_sort)

The output order of the navigation records can be controlled via -nav_sort or -ns command line parameter. Two options **prn**, **time**, **prnmtype** are possible.

- In the time mode, the sorting order is by time and prn.
- In the **prn** mode, the sorting order is by prn and time.
- In the **prnmtype** mode, the sorting order is by prn message_type time.

The standard mode is prn.

```
gfzrnx -finp pots0070.15n -fout pots0070.15o_srt -ns time
```

This can be used for any operation on navigation files (check, splice, split, ...).

```
gfzrnx -finp ????0070.15n -fout brds0070.15n -ns time
gfzrnx -finp ????0070.15n -fout ::RX3:: -split 3600 --nav_sort time

gfzrnx -finp *.rnx -fout splice.rnx -vo 4 -ns prnmtype
```

3.9.10 Navigation Types Selection (-nav_types)

With RINEX version 4 navigation record types (EPH, STO, EOP, ION) have been introduced.

| Туре | Description |
|------|------------------------------|
| EPH | Satellite Orbit Ephemmeries |
| STO | System Time Offset |
| EOP | Earth Orientation Parameters |
| ION | Ionospheric Model Parameters |

For every navigation record type message types (e.g. CNAV, LNAV, CNV3, ...) have been introduced additionally. If you are interested in a subset of navigation record types and selected message types only, you can use the --nav_types or -nt command line parameter to provide your desired selection.

The selection definition consists of a concatenation via '+' of global or satellite-dependent settings. One complete selection element consists of:

```
<satellite_system(s)>::<list_of_nav_types>:<list_of_message_types>
```

It is possible to omit the **satellite_system(s)** or the **list_of_message_types**. In this case, all valid supported elements are used. Lists are built via **dot**. Here are some examples:

```
--nav_types GC::EPH
--nav_types C::ION.STO
--nav_types C::ION.STO:CNVX
--nav_types EPH+C::ION.STO:CNAV
--nav_types C::ION.STO:CNVX+C::EPH:D1.D2.CNV1+E::EPH:INAV
--nav_types EPH.STO
```

Countless selection variations are possible to extract needed information only.

```
gfzrnx -finp *N.rnx -fout BRDC00GFZ_S_20210760000_01D_MN.rnx_EPH_STO -nav_types EPH,STO
gfzrnx -finp *N.rnx -fout BRDC00GFZ_S_20210760000_01D_MN.rnx_ION -nav_types ION
gfzrnx -finp *N.rnx -fout BRDC00GFZ_S_20210760000_01D_MN.rnx_BDS -nav_types C::EPH:D1D2+E::EPH:INAV
```



Additional command line selection options like <code>-satsys</code> , <code>-prn</code> can be used too.

Supported output versions (-vo) for NAV-files are 2, 3.04, 3.05 and 4.

3.9.11 GPSweek Rollover Correction (-shift_gpsw)

Due to firmware or Rinex converter problems, we have seen files that show up with data epochs affected by 1024-week rollovers, which leads to data epoch shifts by a multiple of 1024. The week shift to be added must be provided via the <code>-shift_gpsw</code> command line parameter. The file name epoch needs to be corrected first before using the <code>-shift_gpsw</code> command line parameter. **gfzrnx** checks if the gpsweek difference between the first data epoch and the filename epoch is a multiple of 1024. Only in this case, the epoch shift will be applied.

Here is one example for the file MAR100DEU_R_20190440015_15M_01S_GO.rnx, where the gpsweek for 20190440015 (2019 02 13) is 2040.

```
OBSERVATION DATA
                                                           RINEX VERSION / TYPE
    3.03
                                       T (TRNSS)
                                       20190214 093312 UTC PGM / RUN BY / DATE
Convert 2.4
MAR100DFU
                                                           MARKER NAME
MAR1
                                                           MARKER NUMBER
gnss@gfz-potsdam.de GFZ
                                                           OBSERVER / AGENCY
DCH09470100
                   NOV OEMV1
                                       3.01-TT
                                                           REC # / TYPE / VERS
DCH09470100
                   NOVSMART-V1
                                   NONE
                                                           ANT # / TYPE
    4 C1C D1C L1C S1C
                                                           SYS / # / OBS TYPES
    1.000
                                                           INTERVAL
 1999
          6
               30
                      0
                           15
                                 0.0000000
                                               GPS
                                                           TIME OF FIRST OBS
                                                           TIME OF LAST ORS
 1999
          6
               30
                      0
                           29
                                59.0000000
                                               GPS
                                                           END OF HEADER
> 1999 06 30 00 15 0.0000000 0 12
                                        -0.000000000000
G01 24177867.102 6
                      3413.676
                                  127055545.211 6
                                                          41.000
                                  108235118.641 8
                                                          49.000
G08 20596455.180 8
                        791.348
> 1999 06 30 00 15 1.0000000 0 13
                                        -0.000000000000
G01 24177217.656 7
                    3412.410 127052132.391 7
                                                          42.000
G08 20596304.750 8
                         789.719
                                  108234328.086 8
                                                          49.000
```

The gps-week of 1999 06 30 is 1016 (2040-1016=1024). The shift by 1024 weeks results in the correct data epochs.

 $\tt gfzrnx - shift_gpsw \ 1024 - finp \ MAR100DEU_R_20190440015_15M_01S_GO.rnx - fout \ MAR100DEU_R_20190440015_15M_01S_GO.rnx_0K - fout \ Mar100DEU_R_20190440$

```
3.04
                    OBSERVATION DATA
                                                            RINEX VERSION / TYPE
Convert 2.4
                    GFZ ODC
                                        20190214 093312 UTC PGM / RUN BY / DATE
gfzrnx-1.12-2370
                   FILE CONVERSION
                                        20190214 142041 UTC COMMENT
MAR100DEU
                                                            MARKER NAME
MAR1
                                                            MARKER NUMBER
gnss@gfz-potsdam.de GFZ
                                                            OBSERVER / AGENCY
DCH09470100 NOV 0EMV1
                                        3.01-TT
                                                            REC # / TYPE / VERS
DCH09470100
                    NOVSMART-V1
                                   NONE
                                                            ANT # / TYPE
    4 C1C D1C L1C S1C
                                                            SYS / # / OBS TYPES
     1.000
                                                            INTERVAL
                                                            TIME OF FIRST OBS
 2019
          2
               13
                       A
                            15
                                  9.999999
                                                GPS
 2019
               13
                      0
                           29
                                 59.0000000
                                               GPS
                                                            TIME OF LAST OBS
                                                            END OF HEADER
> 2019 02 13 00 15 00.0000000 0 12
                                         -0.000000000000
G01 24177867.102 6
                        3413.676 127055545.211 6
                                                           41.000
```

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```
G08 20596455.180 8 791.348 108235118.641 8 49.000
...
> 2019 02 13 00 15 01.0000000 0 13 -0.000000000000
G01 24177217.656 7 3412.410 127052132.391 7 42.000
G08 20596304.750 8 789.719 108234328.086 8 49.000
...
```

3.9.12 Antenna Rename (-ant_rename)

Historical files, especially GPS observation files before the year 2000, use outdated non-IGS-conform antenna names.

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With the -ant_rename command line parameter, the antenna names can be updated using the fix implemented table below to have IGS-standard conform antenna names in the header. The renaming is documented in the RINEX header via a COMMENT record which is added.

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| FROM | то |
|----------------------|-----------------|
| DORNE MARGOLIN ASH | ASH700936A_M |
| GEODETIC III L1/L2 | ASH700718A |
| GEODETIC L1/L2 L | ASH700228A |
| GEODETIC L1/L2 P | ASH700228D |
| MARINE/RANGE | ASHMAR/RANGE |
| A-C L1 | ASHAC_L1 |
| A-C L1/L2 | ASHAC_L1/L2 |
| ASH701945.02B | ASH701945B_M |
| ASH701946.012 | ASH701946.2 |
| ASH701946.022 | ASH701946.2 |
| ASH701975.01Agp | ASH701975.01AGP |
| TR GEOD L1/L2 GP | TRM22020.00+GP |
| TR GEOD L1/L2 W/O GP | TRM22020.00-GP |
| TRM10877.10+RGP | TRM12333.00+RGP |
| JPSMARANT_GGD | JNSMARANT_GGD |
| TRM10877.10+SGP | TRM11877.10+SGP |
| DORNE MARGOLIN LEICA | LEIAT504 |
| LEICA AT201 | LEIAT201 |
| LEICA AT202 | LEIAT202-GP |
| LEICA AT302 | LEIAT302-GP |
| LEICA AT202 GP | LEIAT202+GP |
| LEICA AT302 GP | LEIAT302+GP |
| LEICA AT303 | LEIAT303 |
| LEICA AT501 | LEIAT501 |
| LEICA AT502 | LEIAT502 |
| LEICA AT503 | LEIAT503 |
| MAGELLAN PM-500 | MAGPM-500 |
| M-PULSE L1/L2 SURVEY | MPLL1/L2_SURV |
| MACROMETER X-DIPOLE | MAC4647942 |
| MINIMAC PATCH | MACPATCH |
| DORNE MARGOLIN B | AOAD/M_B |
| DORNE MARGOLIN R | JPLD/M_R |
| DORNE MARGOLIN T | AOAD/M_T |
| | |

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| FROM | то |
|---------------------|-----------------|
| TOPCR3_GGD | TPSCR3_GGD |
| 4000SE INTERNAL | TRM17200.00 |
| 4000SL MICRO | TRM12333.00+RGP |
| 4000SLD L1/L2 | TRM12562.00+SGP |
| 4000ST INTERNAL | TRM4000ST_INT |
| 4000ST KINEMATIC | TRM14156.00-GP |
| 4000ST L1 GEODETIC | TRM14177.00 |
| 4000ST L1/L2 GEOD | TRM14532.00 |
| 4000SX MICRO | TRM11877.10+SGP |
| DORNE MARGOLIN TRIM | TRM29659.00 |
| STXS9+X001A | STXS9PX001A |

3.9.13 Antenna Rename Table output (-ant_rename_out)

The table for the antenna renaming can be extended or corrected. Via the command line parameter <code>-ant_rename_out</code> one can get the currently used table for extension or correction. The output file is in <code>json</code> format.

```
gfzrnx -ant_rename_out
{
    "4000ST L1 GEODETIC" : "TRM14177.00",
    "MINIMAC PATCH" : "MACPATCH",
    ....
    "MAGELLAN PM-500" : "MAGPM-500",
    "TR GEOD L1/L2 W/O GP" : "TRM22020.00-GP"
}
```

For a direct file output use:

```
gfzrnx -ant_rename_out -fout ant_rename.json
```

3.9.14 Antenna Rename Table input (-ant_rename_inp)

If you want to use an own or extended renaming table, you can provide it via the <code>-ant_rename_inp</code> command line parameter. It overwrites completely the internal table. The input file must be in <code>json</code> format.

```
gfzrnx -kv -finp pots0030.95o -fout pots0030.95o_new -ant_rename_inp ant_rename.json
```

3.10 Handling a Group of Files with a Single Command (-single_file)

Usually a list of input files via "-finp" leads to a splice operation, where the output is a single file. To initiate a file by file operation for a group of input files with a single command, the command line parameter "-single_file" or "-sifi" has to be used.

For the output file naming, the automatic file naming must be used (::RX2::, ::RX3::, ::RX4::) or the ::INP:: variable. The ::INP:: means, that the output file name is the same as the input file name.

Here is an example for a data sampling operation on a group of input files:

```
gfzrnx.exe -finp c:\Rinex10sec\????3050.16o -fout e:\Rinex30sec\::INP:: -smp 30 --single_file
gfzrnx.exe -finp c:\Rinex10sec\????3050.16o -fout e:\Rinex30sec\::RX3:: -smp 30 -sifl

gfzrnx -finp ????3050.16o -fout ./Rinex30sec/::INP:: -smp 30 --single_file
gfzrnx -finp ????3050.16o -fout ./Rinex30sec/::RX2:: -smp 30 -sifl
```

3.11 RINEX File Header/Data Editing

RINEX file header editing can be invoked by providing a configuration file for the header manipulations to be done. It has to be specified via the **-crux** command line parameter providing the configuration file name.

There are two modes available: * Header editing as part of other operations on the input RINEX file. * Header editing only. Only the header input, editing and check are performed, but the data part is simply copied as it is.

In the following examples, the configuration file header_crux.txt is used.

3.11.1 Header Editing (Standard)

```
gfzrnx -finp mizt1600.15o -fout mizt1600.15o_new -crux header_crux.txt
```

3.11.2 Header Editing (Only)

For the editing only mode one has to use the -hded option in addition.

```
gfzrnx -finp mizt1600.15o -fout mizt1600.15o_hded -crux header_crux.txt -hded
```

An additional epoch and station identifier have to be given if no standard RINEX file names are used. If no additional information provided, the **MARKER NAME** and the first data epoch is used if it exists. This information is needed to extract the right header editing information from the overall configuration information.

3.11.3 Editing Operations

The following operations are supported: * Update single elements of an existing header line (label) * Insert single elements of a non-existing header line (label) * Update (insert) a complete header line or multiple header lines per label * Common string replacement in a string- or regular expression mode * Renaming of PRN in the header and data part * Renaming of OBS types in the header par * Station-, data type- and epoch interval-dependent settings in a single configuration file are possible

3.11.4 Show Config. File Interpretation (-show_crux)

Due to the variety of input options, one can check how the configuration is interpreted in the program. It can be used as a kind of check via the -show_crux option before the real use.

```
gfzrnx -crux header_crux.txt -show_crux
gfzrnx -crux header_crux.txt -show_crux -fout crux.log -f
```

The default header edit settings are shown via:

```
gfzrnx -show_crux
```

3.11.5 Configuration file

Formally there are 3 major modes: update_insert, replace or rename delimited by colon.

In case of **rename** a type (prn|obs) has to be given additionally. The mode definition line has to be followed by an optional data type identifier string (OMN Obs., Met., Nav.) delimited with a hyphen, an optional epoch interval delimited by a hyphen, and a valid station identifier (4- or 9-char.) or dot-separated list of station identifiers delimited by a colon. Now the editing definitions can follow.

```
Update_insert :
#------

[OMN-][YYYYMMDD:HHMMSS YYYYMMDD:HHMMSS-] ALL:
...

[OMN-][YYYYDDD:SSSSS YYYYDDD:SSSSS-] STA1[.STA2[.STA3...]:
    [OMN-][YYYYDDD:SSSSS YYYYDDD:SSSSS-] STA1MRCCC[.STA2MRCCC[.STA3MRCCC...]:
...

Replace :
#------
    [OMN-][YYYYMMDD:HHMMSS YYYYMMDD:HHMMSS-] ALL:
...

[OMN-][YYYYDDD:SSSSS YYYYDDD:SSSSS-] STA1[.STA2[.STA3...]:
...
```

Every **rename** setting has to be done completely on a single line using the following syntax:

```
Rename : prn

#------

[ON-][YYYYMMDD:HHMMSS YYYYMMDD:HHMMSS-] - <prn-from> - <prn-to> : ALL

[ON-][YYYYDDD:SSSSS YYYYDDD:SSSSS-] - <prn-from> - <prn-to> : STA1[.STA2[.STA3...]

[ON-][YYYYDDD:SSSSS YYYYDDD:SSSSS-] - <prn-from> - <prn-to> : STA1MRCCC[.STA2MRCCC[.STA3MRCCC...]

Rename : obs

#------

[OM][YYYYMMDD:HHMMSS YYYYMMDD:HHMMSS-] <obs-from> - <obs-to> - <sat.sys> : ALL

[OM][YYYYDDD:SSSSS YYYYDDD:SSSSS-] <obs-from> - <obs-to> - <sat.sys> : STA1[.STA2[.STA3...]

[OM][YYYYDDD:SSSSS YYYYDDD:SSSSS-] <obs-from> - <obs-to> - <sat.sys> : STA1MRCCC[.STA2MRCCC[.STA3MRCCC...]
```

The following rules have to be taken into account:

- · Comment lines have to begin with #
- The file name station identifier has to be used for the station name. Currently, only the 4 characters station identifier is supported (RINEX-2 file naming)
- \bullet For non-specific station definitions, the ALL station identifier can be used
- Omitting the data types identifier extends the validity to all supported data types (OMN)
- · Omitting the epoch interval leads to an overall validity
- · Station-dependent settings overwrite non-specific ALL settings
- · Overlapping epoch intervals for the same header label and station lead to an error
- The date of the epoch interval can be given either as YYYYDDD (year, day of year) or YYYYMMDD (year, month, day of month)
- \cdot The **time** of the epoch interval can be given as **SSSSS** (second of day 0-86399) or **HHMMSS** (hour, minute, second)
- Unlimited begin or end of an epoch interval can be given using zeros in the date and time values (e.g. 0000000:000000)

See also the examples below.

Update - Single Header Element

Single header element update/insert can be done by providing the label in double quotes, "+" an optional time interval, ":" and the list of index-value pairs enclosed in curly brackets. Every definition should cover only one line!

```
"<label>" [+ YYYYMMDD:HHMMSS YYYYMMDD:HHMMSS ] : { k: "<value>", [ [ 1: "<value>" ], ... ] }
"<label>" [+ YYYYDDD:HHMMSS YYYYDDDD:HHMMSS ] : { k: "<value>", [ [ 1: "<value>" ], ... ] }
...
```

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```
indexes k,1,\ldots = 0,1,...
```

See some examples below:

```
update_insert :
#------
0 - POTS.OUST.WINT:
    "REC # / TYPE / VERS" : { 1 : "TRIMBLE NETR9" }

0 - 2015209:00000 0000000:00000 - MIZT00JPN:
    "APPROX POSITION XYZ" : { 0: "-3857167.6484", 1: "3108694.9138", 2: "4004041.6876" }
    "ANTENNA: DELTA H/E/N" : { 0: "0.1209", 1: "0.0008", 2: "0.0007" }

0 - POTS00DEU:
    "OBSERVER / AGENCY" + 0000000:00000 2013126:86399 : { 0:"automatic", 1:"GFZ" }
    "OBSERVER / AGENCY" + 2013127:00000 0000000:000000 : { 0:"gfz", 1:"GFZ/IHL" }
```

- Multi-string elements in the index-value pairs have to be enclosed with double quotes. Please make sure that the given values don't exceed the element's format length!
- The first header element is at index 0
- The **site** name used to **search** for site-dependent settings in the loaded **crux** information is extracted from the standard RINEX-2 or 3 input file name. In case of wrong or non-standard input file names or in pipe environments, the site name has to be provided via the -site command line parameter. The -site parameter overwrites any otherwise derived site name in general.

Supported String Substitutes

The following variable string substitutes are supported to be used via **crux** single header elements updates and **added** COMMENT lines. To be more independent of OS-derived values, the following environment variables are used with a higher preference if existing.

| Substitute String | Substitute/Example | Description | Environment variables |
|-------------------|-----------------------|---|-----------------------|
| uSeR | nisn | user name provided by os | USERNAME, USER |
| pRoGrAm | gfzrnx-1.08-8003 | gfzrnx-version-revision | |
| hOsTnAmE | serv01 | simple hostname provided by os | HOSTNAME |
| hOsTdOmAiNnAmE | serv01.gfz-potsdam.de | fully qualified hostname provided by os | HOSTFQDN |
| dOmAiNnAmE | gfz-potsdam.de | domain name provided by os | USERDOMAIN |
| tlmEsTaMp | 20170712 113126 UTC | time stamp of current time | |



Please check in advance if you get the expected results for your operating system!

```
update_insert :
#---
MNO - ALL:
```

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```
"COMMENT" : "PG tImEsTaMp pRoGrAm uSeR@dOmAiNnAmE"
"PGM / RUN BY / DATE" : { 0: "pRoGrAm" , 1: "uSeR@dOmAiNnAmE", 2: "tImEsTaMp" }
```

For the upper configuration, the "PGM / RUN BY / DATE" record will be updated and the "COMMENT" record below will be added:

```
PG 20170712 120203 UTC gfzrnx-1.08-7179 nisn@gfz-potsdam.de COMMENT gfzrnx-1.08-7179 nisn@gfz-potsdam.de 20170713 065255 UTC PGM / RUN BY / DATE
```

If the "COMMENT" string gets longer than 60 characters, it will be cut to 60!

Update - Multi Header

Multiple header elements like the "SENSOR MOD/TYPE/ACC" or "SENSOR POS XYZ/H" for meteo data need an additional condition (here the sensor identifiers TD, PR, HR,...). An additional "+ column_number:value" pair has to be added to the label and optional epoch interval information. The column counter starts with 0. Here is a **crux** example block.

Here is a crux example block.

```
update_insert :
#----

M - 2015209:00000 0000000:00000 - ALL :

"SENSOR MOD/TYPE/ACC" + 3:"TD" : { 0:"Vaisala", 1:"PTU 303/5.14", 2:"0.10" }

"SENSOR MOD/TYPE/ACC" + 3:"PR" : { 0:"Vaisala", 1:"PTU 303/5.14", 2:"0.05" }

"SENSOR MOD/TYPE/ACC" + 3:"HR" : { 0:"Vaisala", 1:"PTU 303/5.14", 2:"1.7" }

"SENSOR MOD/TYPE/ACC" + 3:"XX" : { 0:"XXXXXXXX", 1:"XXX 125", 2:"1.0" }

M - POTS00DEU :

"SENSOR POS XYZ/H" + 4:"TD" : { 0:"3275753.9120", 1:"321110.8651", 2:"5445041.8829", 3:"5" }

"SENSOR POS XYZ/H" + 4:"HR" : { 0:"3275753.9120", 1:"321110.8651", 2:"5445041.8829", 3:"5" }

"SENSOR POS XYZ/H" + 4:"HR" : { 0:"3275753.9120", 1:"321110.8651", 2:"5445041.8829", 3:"5" }

"SENSOR POS XYZ/H" + 4:"HR" : { 0:"3275753.9120", 1:"321110.8651", 2:"5445041.8829", 3:"5" }

"SENSOR POS XYZ/H" + 4:"XX" : { 0:"3275753.9120", 1:"321110.8651", 2:"5445041.8829", 3:"5" }
```

If an element is not found, it will be added (see the "XX" sensor).

See below a small example of a header manipulation with the initial header and the manipulation result.

```
gfzrnx -finp pots3410.15m -f -fout pots3410.15m_new -crux crux.txt
```

pots3410.15m

```
2.11
                    METEOROLOGICAL DATA
                                                             RINEX VERSION / TYPE
TPP 3.1
                                        2015-12-07 00:01:03 PGM / RUN BY / DATE
                                                             MARKER NAME
    3
         TD
               HR
                     PR
                                                             # / TYPES OF OBSERV
                    Model 760
Paroscientific
                                                   0.1
                                                         TD SENSOR MOD/TYPE/ACC
Paroscientific
                    Model 760
                                                  2.0
                                                       HR SENSOR MOD/TYPE/ACC
Paroscientific Model 760
3275756.3423 321111.4422 5445046.8829
                                                  0.1
                                                        PR SENSOR MOD/TYPE/ACC
                                                  0.0000 TD SENSOR POS XYZ/H
  3275756.3423 321111.4422 5445046.8829
                                                  0.0000 HR SENSOR POS XYZ/H
```

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```
3275756.3423 321111.4422 5445046.8829 0.0000 PR SENSOR POS XYZ/H
END OF HEADER
```

pots3410.15m_new

```
3.03
                  METEOROLOGICAL DATA
                                                          RINEX VERSION / TYPE
TPP 3.1
                                      2015-12-07 00:01:03 COMMENT
                  GFZ FILE CONVERSION 20150807 14:32:19UTCPGM / RUN BY / DATE
RINEX DB.pm
                                                         MARKER NAME
                   PTU 303/5.14
                                               0.1
                                                      TD SENSOR MOD/TYPE/ACC
Vaisala
Vaisala
                  PTU 303/5.14
                                                1 7
                                                      HR SENSOR MOD/TYPE/ACC
Vaisala
                 PTU 303/5.14
                                                0.1
                                                    PR SENSOR MOD/TYPE/ACC
 3275753.9120 321110.8651 5445041.8829
                                                5.0000 TD SENSOR POS XYZ/H
  3275753.9120
               321110.8651
                            5445041.8829
                                                5.0000 HR SENSOR POS XYZ/H
 3275753.9120 321110.8651 5445041.8829
                                                5.0000 PR SENSOR POS XYZ/H
                  XXX 125
                                                     XX SENSOR MOD/TYPE/ACC
   3275753.9120 321110.8651 5445041.8829
                                                5.0000 XX SENSOR POS XYZ/H
                                                          # / TYPES OF OBSERV
       3 HR
                 PR
                      TD
                                                          END OF HEADER
```

Proposed Use

There are several possibilities to organize the header editing configuration file. The clearest form would be to organize it per station. Below you can find a configuration example for the single station POTS covering the whole station history information for Observation and Meteo file header entries.

```
update insert:
OM - POTS:
"APPROX POSITION XYZ" : { 0:"3800689.6341", 1:"882077.3857", 2:"5028791.3179" }
                       : { 0:"POTS" }
"MARKER NAME"
"MARKER NUMBER"
                       : { 0:"14106M003" }
"OBSERVER / AGENCY"
                       : { 0:"GFZ", 1:"GFZ" }
"REC # / TYPE / VERS" + 1994274:00000 1996015:86340 : { 0:"289", 1:"ROGUE SNR-8000",
                                                                                                   ...}
"REC # / TYPE / VERS" + 1996016:49680 1996151:28380 : { 0:"279", 1:"ROGUE SNR-8000", "REC # / TYPE / VERS" + 1996151:28860 1999231:00000 : { 0:"289", 1:"ROGUE SNR-8000",
"REC # / TYPE / VERS" + 1999232:00000 2000232:00000 : { 0:"281", 1:"AOA SNR-8000 ACT",
"REC # / TYPE / VERS" + 2000233:00000 2009089:00000 : { 0:"281-U",1:"AOA SNR-8000 ACT",
"REC # / TYPE / VERS" + 2009089:00000 2011046:61200 : { 0:"1358", 1:"SEPT POLARX2",
"REC # / TYPE / VERS" + 2011046:61200 2011307:52200 : { 0:"205", 1:"JAVAD TRE_G3TH DELTA",...}
"REC # / TYPE / VERS" + 2011307:52200 2011354:38280 : { 0:"205", 1:"JAVAD TRE_G3TH DELTA",...}
"REC # / TYPE / VERS" + 2011354:38280 2012164:32400 : { 0:"205", 1:"JAVAD TRE_G3TH DELTA",...}
"REC # / TYPE / VERS" + 2012164:32400 2013009:36720 : { 0:"205", 1:"JAVAD TRE_G3TH DELTA",...}
"REC # / TYPE / VERS" + 2013009:36780 2015258:50280 : { 0:"205", 1:"JAVAD TRE_G3TH DELTA",...}
"REC # / TYPE / VERS" + 2015258:50280 0000000:00000 : { 0:"205", 1:"JAVAD TRE_G3TH DELTA",...}
"ANT # / TYPF"
                       + 1994301:00000 1995276:28800 : { 0:"261", 1:"AOAD/M_T"
                                                                                            2:"NONF" }
                       + 1995276:28800 2009105:47700 : { 0:"235", 1:"AOAD/M_T",
"ANT # / TYPE"
                       + 2009105:47700 2011046:61200 : { 0:"354-U",1:"AOAD/M_T"
"ANT # / TYPF"
                                                                                            2:"NONF" }
                       + 2011046:61200 0000000:00000 : { 0:"316", 1:"JAV_RINGANT_G3T",2:"NONE"
"ANT # / TYPE"
"ANTENNA: DELTA H/E/N"+ 1994301:00000 1995276:28800 : { 0:"0.046", 1:"0", 2:"0" }
"ANTENNA: DELTA H/E/N"+ 1995276:28800 2009105:47700 : { 0:"0.046", 1:"0", 2:"0"
"ANTENNA: DELTA H/E/N"+ 2009105:47700 2011046:61200 : { 0:"0.046", 1:"0", 2:"0"
"ANTENNA: DELTA H/E/N"+ 2011046:61200 0000000:00000 : { 0:"0.121", 1:"0", 2:"0" }
"SENSOR MOD/TYPE/ACC" + 1996254:00000 2006011:00000 + 3:"PR" : { 0:"Vaisala", 1:"PTB100B",... }
"SENSOR MOD/TYPE/ACC" + 2006011:00000 0000000:00000 + 3:"PR" : { 0:"Vaisala", 1:"PTU200", ... }
"SENSOR MOD/TYPE/ACC" + 1996254:00000 2006011:00000 + 3:"HR" : { 0:"Timetech",1:"HC 500", ... }
"SENSOR MOD/TYPE/ACC" + 2006011:00000 0000000:00000 + 3:"HR" : { 0:"Vaisala", 1:"HMP45A-P",.. }
"SENSOR MOD/TYPE/ACC" + 1996254:00000 2006011:00000 + 3:"TD" : { 0:"Timetech",1:"PT100",
"SENSOR MOD/TYPE/ACC" + 2006011:00000 0000000:00000 + 3:"TD" : { 0:"Vaisala", 1:"HMP45A-P",.. }
```

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Depending on the first data epoch the appropriate header entry is updated.



There is one exception concerning the RINEX header fields manipulation. According to IGS antenna definition (number, antenna + radome) the "ANT # / TYPE" record consists of 3 columns, which is a deviation from the RINEX standard.

This means the standard (A20,A20) RINEX definition is in gfzrnx handled as (A20,A16,A4). A correction record should be of the following form:

```
update_insert :
# ------
POTS:
    "ANT # / TYPE" : { 0:"30336561", 1:"TRM55971.00", 2:"NONE" }
```

Complete Header Line(s) Update

For a single line definition, one has to give the label name in double quotes followed by an "+" optional epoch interval string followed by a colon and the 60 char. string to be updated or inserted. The multi-line definition has to be enclosed in square brackets as a comma-separated list of 60 char. strings with one string per line. The square brackets have to be given on the first ([) and last (]) 60 char. string definition line.

```
"<label>" [+ YYYYMMDD:HHMMSS YYYYMMDD:HHMMSS ] : [ "<60-char. string>",
                                                  "<60-char. string>",
                                                  "<60-char. string>" ]
update_insert :
0 - 2015010:00000 00000000:00000 - POTS00DEU:
    "OBSERVER / AGENCY" : "Automatic
                                                   Deutsches GeoForschungsZentrum (GFZ)
    "SYS / PHASE SHIFT"
                          : [ "G L1C 0.00000
                              "J L1C 0.00000
                              "J L1X 0.25000
                              "E L1X 0.00000
                              "C L7I 0.00000
                              "R L1P 0.25000
                              "R L2C 0.00000
                              "R L2P 0.25000
                              "G L2X -0.25000
                              "G L5X 0.00000
```

Please keep in mind that an already existing header label content is completely removed. Only COMMENT header lines are appended.



COMMENT lines are inserted only

Header Label Independent String Replacement

For the string replacement, the major mode **replace** has to be used. One has to define the station identifier as before. Afterward, you can define from/to pairs of type **regexp** or **string**. The **regular expression** syntax follows **Perl** syntax. Each pair element (from/to) should be given on a separate line. The example below shows how to correct an erroneous label name.

```
replace :
#-----
ALL:
    regexp_from : "^(.{60})PGM\s*/\s*RUN\s*BY\s*/\s*DATE\s*$"
```

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```
regexp_to : "$1PGM / RUN BY / DATE"

ALL:

string_from : "PGM/RUN BY/DATE"

string_to : "PGM / RUN BY / DATE"
```

To remove single header label lines on input use an empty regexp_to (""). To remove all COMMENT lines use:

```
replace :
#-----
ALL:
    regexp_from : "^.{60}COMMENT\s*$"
    regexp_to : ""
```

To remove lines containing the string "ABC DEF" use:

```
replace :
#-----
ALL:
    regexp_from : "^.*ABC DEF.*$"
    regexp_to : ""
```

Rename - PRNs

If raw data conversion programs don't assign the right PRN, this can be changed via the "rename: PRN" mode. Here is the crux configuration syntax:

Here are some examples:

```
rename: prn
#------
ON - 20140105:000000 20150101:000000 - E51 - E01: ALL
ON - 20140105:000000 00000000:000000 - E52 - E02 : ABC1.ABC2.ABC3
E51 - E01 : ALL
E52 - E02 : ALL
```

Rename - OBS types

```
rename: obs
#------

20140105:000000 20150101:000000 - L2X - L2L - G : ABCD
20140105:000000 20150101:000000 - L2L - L2X - G : ABCD

20140105:000000 20150101:000000 - *2* - *1* - C : ALL
20140105:000000 20150101:000000 - *2 - *1 - C : ALL

20140105:000000 20150101:000000 - *XX - **L - C : ALL
20140105:000000 20150101:000000 - *2 - *1 - C : ALL

20140105:000000 20150101:000000 - *2 - *1 - C : ALL

20140105:000000 20150101:000000 - *XX - **L - G04.G08 : ALL
20140105:000000 20150101:000000 - *2 - *1 - G04.G08 : ALL

20140105:000000 20150101:000000 - *2 - *1 - G04.G08 : ALL

20140105:000000 20150101:000000 - *2 - *1 - G04.G08 : ALL
```



You can use 9-char. station names in crux-config-file for the handling of 4-char. station names too! The **replace** mode is done directly on input, the **update_insert** and **rename** modes are done after the whole header has been read.

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3.11.6 Header edit via command line (-cx_updins)

Single **update_insert** header edit options can also be provided via command line using the **-cx_updins** command line parameter, providing a list of edit options. The site definition has to be given before the header label change option.

See an example below Unix:

See an example below Windows (swapped single and double quotes):



Please pay attention to the different single/double quote usage on Windows- and Unix-based operating systems. Please check in advance with - show_crux the acceptance of your header edit options due to the mixture of different quotation marks after -cx_updins.

```
gfzrnx -show_crux -cx_updins \
'O - VALD: "APPROX POSITION XYZ" : { 0:"3800689.6341", 1:"882077.3857", 2:"5028791.3179" }' \
'O - VALD: "REC # / TYPE / VERS" : { 0 : "", 1 : "JAVAD TRE_G3TH DELTA", 2 : "3.6.3 Jul,01,2017" }'
```



COMMENT lines are inserted only

3.11.7 Internal/Data Headers via crux-file (-cx_addinthd)

Metadata changes following e.g. hardware changes can be introduced at the event epochs into the data part of a RINEX file if information is found in the crux-file. This mechanism can be activated additionally to the normal header edit operations via the -cx_addinthd command line parameter for update_insert crux-settings.

Here is an example:

```
gfzrnx -cx_addinthd -crux obwt_crux.txt -finp obwt107g.18o -fout obwt107g.18o_crx
```

The following crux-configuration

```
update_insert:
0 - 20141105:071700 20180417:060500 - OBWT:
    "REC # / TYPE / VERS" : { 0: "4831K57521", 1: "TRIMBLE NETR5", 2: "Nav 4.87 / Boot 4.18"}
    "ANT # / TYPE" : { 0: "30767802", 1: "TRM55971.00", 2: "TZGD"}
0 - 20180417:061500 00000000:000000 - OBWT:
    "REC # / TYPE / VERS" : { 0: "1705310", 1: "LEICA GR30", 2: "4.20.232"}
    "ANT # / TYPE" : { 0: "09440002", 1: "LEIAR25.R3", 2: "LEIT" }
```

will lead to file header records of e.g.:

```
4831K57521 TRIMBLE NETR5 Nav 4.87 / Boot 4.18REC # / TYPE / VERS 30767802 TRM55971.00 TZGD ANT # / TYPE
```

and a header block in the data part of a RINEX-2 file of:

```
127921488.413 6 99494529.138 8 23913582.523
    23913577.070
                                                                        42.100
       33.300
                                                                        38.700
   23773818.648
                  127129528.196 4
    18 04 17 06 15 00.0000000 4 2
                        LEICA GR30
                                           4.20.232
                                                                REC # / TYPE / VERS
09440002
                        LEIAR25.R3
                                       LEIT
                                                                ANT # / TYPE
    18 04 17 06 15 00.0000000 0 16G02G05G07G09G13G27G28G30R06R07R08R09
                               R10R16R23R24
   24247477.484 127421298.588 6 99289349.307 6 24247479.359
                                                                        42.200
       25.500
    21028794.141
                 110507030.196 7 86109402.765 9 21028797.266
                                                                        49.300
```



Windows users should swap single and double quotes using -cx_addinthd similar to -cx_updins command line options.

3.11.8 Manipulate Header Version Number (-vnum)

By default, the latest supported version number is used for the "RINEX VERSION / TYPE" header element, and there are made manipulations to fit this version. If a special version number is needed (for whatever reason) one can use the -vnum command line parameter to manipulate the version number to a certain value.

| | 3.04 | OBSERVATION DATA | М | RINEX VERSION / TYPE |
|----|------------|------------------|---|----------------------|
| gf | zrnx -finp | -vnum 3.03 | | |
| | 3.03 | OBSERVATION DATA | М | RINEX VERSION / TYPE |

This will change the default output header value e.g. 3.04 to the wished value of 3.03.



The -vnum version number change is only a formal exchange of the version number to meet any conditions of external software. The file content will be still conform to the highest supported version number!

3.12 RINEX File Metadata Extraction (-meta)

RINEX file meta information can be extracted from the header and data in different output formats.

```
-meta [mode:format] mode=[basic|medium|full], format=[txt|json|jsonp|xml|dump]
```

- The basic mode extracts only the header information, the first and last epoch from the RINEX file without reading the whole file (fast).
- The medium extends the basic information by real data interval, first/last epochs, and number of epochs.
- The **full** mode extends/updates the basic information with information derived from the complete data file like data statistics, the real data interval, and so on.
- The following output formats are supported: **txt**(default), **json**, **jsonp**(pretty json), **xml**, **dump**. They can be used for fast view or further applications.

The **file-**, **site-**, **receiver-**, **antenna-** sections information is derived from the RINEX header part only. The data-section holds information derived from the RINEX data part.

Here are some simple examples:

```
gfzrnx -finp pots0070.15o -meta basic
gfzrnx -finp pots0070.15o -meta basic:txt
gfzrnx -finp pots0070.15o -meta basic:json -fout pots0070.15o.json
gfzrnx -finp pots0070.15o -meta full:xml -fout pots0070.15o.xml
gfzrnx -finp POTS00DEU_00001024_FR0_RX3_M0_20180305_000000_01D_30S_GFZ.rnx -meta basic:txt
antenna:
        height:
            e = 0.0000
            h = 0.1206
            n = 0.0000
        name = JAV_RINGANT_G3T
       number = 316
        radome = NONE
data:
        epoch:
            first = 2018 03 05 00 00 00.0000000
            interval = 30.000
            last = 2018 03 05 23 59 30.0000000
exec:
        date = 2018-03-06 15:35:05 UTC
       meta = basic
        name = gfzrnx
        version = 1.10-7323
file:
        epo_first = 2018 03 05 00 00 00.0000000
        interval = 30.000
        md5 = 9a49ad078b4bcfbe1d1a2fe4de440de1
        name = POTS00DEU_00001024_FRO_RX3_MO_20180305_000000_01D_30S_GFZ.rnx
        pgm = JPS2RIN v.2.0.134
        pgm_date = 20180305 011547 UTC
        pgm_runby = GFZ ODC
        satsys = EGR
        site = POTS00DEU
        source = R
        sysfrq:
           E = 1.5
            G = 125
            R = 1 2
        sysobs:
            E = C1X C5X D1X D5X L1X L5X S1X S5X
            G = C1C C1W C2W C2X C5X D1C D1W D2W D2X D5X L1C L1W L2W L2X L5X S1C S1W S2W S2X S5X
```

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R = C1C C1P C2C C2P D1C D1P D2C D2P L1C L1P L2C L2P S1C S1P S2C S2P

```
system = M
        systyp:
            E = C D L S
           G = C D L S
           R = C D L S
        tvpe = 0
        version = 3.03
receiver:
        firmware = 3.6.7
        name = JAVAD TRE_G3TH DELTA
        number = 205
site:
       agency = GFZ
        name = POTS
        number = 14106M003
        observer = GFZ
        position:
           x = 3800689.6341
           y = 882077.3857
            z = 5028791.3179
```

```
gfzrnx -finp pots0070.15o -meta basic:jsonp

{"antenna":{"height":{"e":"0.0000", "h":"0.1206", "n":"0.0000"}, "name":"JAV_RINGANT_G3T",
    "number":"316", "radome":"NONE"}, "data":{"epoch":{"first":"2018 03 05 00 00 00.0000000",
    "interval":"30.000", "last":"2018 03 05 23 59 30.0000000"}}, "exec":{"date":"2018-03-06 16:56:40 UTC",
    "meta":"basic", "name":"gfzrnx", "version":"1.10-7323"}, "file":{"epo_first":
    "2018 03 05 00 00 00.0000000, "interval":30.000", "md5":"9a49ad078b4bcfbe1d1a2fe4de44dde1",
    "name":"POTS00DEU_00001024_FRO_RX3_MO_20180305_000000_01D_30S_GFZ.rnx", "pgm":"JPS2RIN v.2.0.134",
    "pgm_date":"20180305 011547 UTC", "pgm_runby":"GFZ ODC", "satsys":"EGR", "site":"POTS00DEU",
    "source":R", "sysfrq":{"E":["1","5"], "G":["1","2","5"], "R":["1","2"]},
    "sysobs":{"E":["C1X", "C5X", "D1X", "D5X", "L1X", "L5X", "S1X", "S5X"], "G":["C1C", "C1W", "C2X",
    "C5X", "D1C", "D1W", "D2W", "D2X", "D5X", "L1C", "L1W", "L2W", "L2X", "L5X", "S1C", "S1W", "S2W", "S2X",
    "S5X"], "R":["C1C, "C1P", "C2C", "C2P", "D1C", "D1P", "D2C", "D2P", "L1C",
    "L1P", "L2C", "L2P", "S1C", "S1P", "S2C", "S2P"]}, "system":"M", "systyp":{"E":["C", "D1, "L", "S"],
    "G":["C", "D1, "L", "S"], "R":["C", "D1, "L", "S"], "type":"0", "version":"3.03"},
    "receiver":{"firmware":"3.6.7", "name":"JAVAD TRE_G3TH DELTA", "number":"205"},
    "site":{"agency":"GFZ", "name":"POTS", "number":"14106M0003", "observer":"GFZ",
    "position":{"x":"3800689.6341", "y":"882077.3857", "z":"5028791.3179"}}}}
```

```
gfzrnx -finp pots0070.15o -meta basic:jsonp
    "antenna" : {
        "height" : {
            "e" : "0.0000",
            "h" : "0.1206",
            "n" : "0.0000"
        "name" : "JAV_RINGANT_G3T",
        "number" : "316",
"radome" : "NONE"
    }.
    "data" : {
        "epoch" : {
            "first" : "2018 03 05 00 00 00.0000000",
            "interval" : "30.000",
            "last" : "2018 03 05 23 59 30.0000000"
    "exec" : {
        "date" : "2018-03-06 16:55:57 UTC",
        "meta" : "basic",
        "name" : "gfzrnx"
        "version" : "1.10-7323"
    },
    "file" : {
        "epo_first" : "2018 03 05 00 00 00.0000000".
        "interval" : "30.000",
        "md5" : "9a49ad078b4bcfbe1d1a2fe4de440de1".
```

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```
"name" : "POTS00DEU_00001024_FRO_RX3_MO_20180305_000000_01D_30S_GFZ.rnx",
"pgm" : "JPS2RIN v.2.0.134",
"pgm" : "JPS2RIN v.2.0.134",
"pgm_date" : "20180305 011547 UTC",
"pgm_runby" : "GFZ ODC",
"satsys" : "EGR",
"site" : "POTS00DEU",
"source" : "R",
"sysfrq" : {
    "E" : [
    "1",
    "5"
    "
      ],
      "G" : [
     "1",
"2",
      "5"
      ],
"R" : [
     "1",
"2"
      ]
"sysobs" : {
     "E" : [
      "C1X",
      "C5X",
      "D1X",
      "D5X",
      "L1X",
      "L5X",
      "S1X",
      "S5X"
      "G" : [
     "C1C",
      "C1W",
      "C2W",
      "C2X",
      "C5X",
      "D1C",
      "D1W",
      "D2W",
      "D2X",
      "D5X",
      "L1C",
      "L1W",
      "L2W",
      "L2X",
      "L5X",
      "S1C",
      "S1W",
      "S2W",
      "S2X",
      "S5X"
      ],
"R" : [
     "C1C",
      "C1P",
      "C2P",
      "D1C",
      "D1P",
      "D2C",
      "D2P",
      "L1C",
      "L1P",
      "L2C",
      "L2P",
      "S1C",
      "S1P",
      "S2C",
```

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```
]
           },
          "system" : "M",
"systyp" : {
                 systyp" : {
    "E" : [
    "C",
    "D",
    "L",
    "S"
                     ],
"G" : [
"C",
"D",
"L",
"S"
                     ],
"R" : [
"C",
"D",
"L",
                       "S"
                      ]
           "type" : "0",
"version" : "3.03"
},
 "receiver" : {
          "firmware" : "3.6.7",
"name" : "JAVAD TRE_G3TH DELTA",
"number" : "205"
},
"site" : {
         "te" : {
    "agency" : "GFZ",
    "name" : "POTS",
    "number" : "14106M003",
    "observer" : "GFZ",
    "position" : {
        "x" : "3800689.6341",
        "y" : "882077.3857",
        "z" : "5028791.3179"
       }
```

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3.13 RINEX File Comparison (-fdiff)

The comparison of single-site RINEX files of the same time interval and files from different sources (e.g. real-time data, data from different rinex-converters, ...) are often not possible easily. **gfzrnx** offers a possibility to compare two input files of the same format (major version id.) via the **-fdiff** command line parameter. NOTE, different observation types orders in the input files are allowed!

```
gfzrnx -fdiff -finp <rinex_file_1> <rinex_file_2>
```

The output is RINEX-3-like, contains only the data epochs and data records, where both files differ in the data records. Internal or data headers are ignored.

- If per epoch, an observation type exists in both files. Its numerical difference (file1-file2) is shown.
- If per epoch an observation type is missing in one of the input files, the original data value of the corresponding input file is shown (merged).
- For the LLI and SSI values, absolute differences are always reported.

```
gfzrnx -fdiff -finp pots0140.16o_1 pots0140.16o_2 -fout pots0140.16o_diff
```

In the header, you can find the observation types order and the PRN-statistics of detected differences.

```
DATA COMPARISON
                                                  RINEX VERSION / TYPE
    3.00
                                     -----COMMENT
pots0140.16o_1
                                                  FILE_1
pots0140.16o_2
                                                  FTIF 2
                                   -----COMMENT
   4 C1C L1 L2 C2W
                                                  SYS / # / OBS TYPES
   4 C1C L1 L2 C2P
                                                 SYS / # / OBS TYPES
   20
                                                  # OF SATELLITES
       2 1
                                                 PRN / # OF OBS
  G02
  G03 2 1 1 1
                                                  PRN / # OF OBS
  G06
                                                  PRN / # OF OBS
             1 1
```

The data or differences part will look like the following example:

```
> 2016 01 14 11 00 00.0000000 0 2
G02
       1
G03
              1
> 2016 01 14 11 00 01.0000000 0 2
         0.052
                                                     0.012
G02
                       0.098
G19 19699748.072 105380370.084
                                81962499.868
                                             19699744.832
> 2016 01 14 11 00 02.0000000 0 19
G03 22232325.432 116831670.250
                                 91037637.373
                                               22232315.592
G06 23394480.604 122938818.380
                                95796470.667
                                               23394477.044
G31 23924131.742 125722160.848
                                 97965321.818
                                               23924126.722
> 2016 01 14 11 00 02.0000000 0 19
```

- In the first epoch, the data of two PRNs differ by 1 in the LLI (loss of lock indicator) value for the C1C observation type.
- In the second epoch, the PRN G02 differs (file1-file2) by the given values for the observation types C1C, L1, C2W. The PRN G19 seems to be fully missing in one of the files, or you see a merged record, where an observation type is missing either in the first or the second file.
- The third epoch seems to be fully missing in one of the files, or you see a merged record, where a full PRN or an observation type is missing either in the first or the second file.

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3.14 RINEX Hatanaka Compressed Files

Hatanaka RINEX compressed files are **not** directly supported, but the Hatanaka RINEX compression or decompression can be combined with **gfzrnx** using the standard in/output (via pipes).

The Hatanaka RINEX compression/decompression utilities **RNXCMP** are free software and can be downloaded from http://terras.gsi.go.jp/ja/crx2rnx.html.

On the following page, you can find some examples of the **RNXCMP** decompression/compression in combination with **gfzrnx** and **gzip** compression.

```
Decompression:
gunzip -c pots0700.17d.Z | crx2rnx - | gfzrnx -kv
                                                         -fout pots0700.17o
gunzip -c pots0700.17d.Z | crx2rnx - | gfzrnx -kv -smp 30 -fout pots0700.17o
gunzip -c POTS01DEU_R_20170700000_01D_30S_MO.crx.gz | crx2rnx - | gfzrnx -kv
                                                                                   -fout
POTS01DEU_R_20170700000_01D_30S_MO.rnx
gunzip -c POTS01DEU_R_20170700000_01D_01S_MO.crx.gz | crx2rnx - | gfzrnx -kv -smp 30 -fout
POTS01DEU_R_20170700000_01D_30S_MO.rnx
Compression:
gfzrnx -finp pots0700.17o
                            -kv | rnx2crx - | gzip -c > pots0700.17d.gz
gfzrnx -finp pots0700.17o -smp 30 -kv | rnx2crx - | gzip -c > pots0700.17d.gz
gfzrnx -finp POTS01DEU_R_20170700000_01D_30S_MO.rnx | rnx2crx - > POTS01DEU_R_20170700000_01D_30S_MO.crx
gfzrnx -finp POTS01DEU_R_20170700000_01D_30S_MO.rnx | rnx2crx - | gzip -c > POTS01DEU_R_20170700000_01D_30S_MO.crx.gz
cat POTS01DEU_R_20170700000_01D_30S_MO.rnx | gfzrnx
                                                          | rnx2crx -
POTS01DEU_R_20170700000_01D_30S_MO.crx
cat POTS01DEU_R_20170700000_01D_30S_MO.rnx | gfzrnx
                                                           | rnx2crx - | gzip -c >
POTS01DEU_R_20170700000_01D_30S_MO.crx.gz
cat POTS01DEU_R_20170700000_01D_01S_MO.rnx | gfzrnx -smp 30 | rnx2crx -
POTS01DEU_R_20170700000_01D_30S_MO.crx
cat POTS01DEU_R_20170700000_01D_01S_MO.rnx | gfzrnx -smp 30 | rnx2crx - | gzip -c >
POTS01DEU_R_20170700000_01D_30S_MO.crx.gz
```

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3.15 RINEX to Tabular Output

3.15.1 Standard Output

The tabular observations output allows to output a RINEX observations input file into a data table that can be used for simple visualization or for an easier introduction into third-party applications like EXCEL, Matlab, etc... All main options like satellite system selection (-satsys) and/or satellites selection (-prn) and/or observation types selection (-obs_types) and others are supported. It can be used for all RINEX data types (OBS, MET, NAV).

The tabular observation output can be initiated via the -tab command line parameter. Here is an example for a single satellite and selected observation types:

Tabular OBS data

```
gfzrnx -finp POTS00DEU_R_20150070000_01D_30S_MO.rnx -tab -fout POTS00DEU_2015007_G03.tab gfzrnx -finp POTS00DEU_R_20150070000_01D_30S_MO.rnx -tab -fout POTS00DEU_2015007_G03.tab -prn G03 -obs_types L1,L2
```

The last command leads to the following default tabular output, extracting phase observations for the PRN G03:

```
#HD G DATE TIME PRN L1C L1W L2W L2X

OBS G 2015-01-07 07:25:00.0000000 G03 134798128.476 134798125.823 105037501.328 105037506.181

OBS G 2015-01-07 07:25:30.0000000 G03 134629777.213 134629774.487 104906318.473 104906323.263

OBS G 2015-01-07 07:26:00.0000000 G03 134461452.299 134461449.545 104775156.193 104775160.914

OBS G 2015-01-07 07:26:30.0000000 G03 134293160.630 134293157.877 104644019.757 104644024.465
```

Every line begins with a line descriptor (#HD,OBS):

| Line type | Description |
|-----------|-------------------------------------|
| #HD | header line with column description |
| OBS | observation line |
| NAV | navigation line |
| MET | meteo line |

The first columns are fixed, showing the: + Line Type, + Satellite System, + Date, + Time, + PRN.

This is followed by the list of wished or given observation types as provided in the satellite system-specific header line order.

Tabular NAV Data

```
gfzrnx -finp *.rnx -fout RNX_C_CNV1.tab -f -vo 4 -tab -nt C::EPH:CNV1
```

The last command leads to the following tabular output, extracting only BDS EPH-records of message type CNV1

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Here the same with a different column separator ';'.

```
gfzrnx -finp *.rnx -fout RNX_C_CNV1.tab -f -vo 4 -tab -tab_sep \; -nt C::EPH:CNV1

#HD;S;DATE;TIME;NAV;PRN;MTYP;DATA ------
NAV;C;2021-03-17;00:00:00;EPH;C19;CNV1;
7.642341079190e-04;1.389732773305e-11;0.0000000000000e+00;2.871513366699e-03; ...
NAV;C;2021-03-17;01:00:00;EPH;C19;CNV1;
7.642844575457e-04;1.394262483245e-11;0.000000000000e+00;2.720832824707e-03; ...
NAV;C;2021-03-17;02:00:00;EPH;C19;CNV1;
7.643348653801e-04;1.396838200662e-11;0.0000000000000e+00;2.270221710205e-03; ...
```

Tabular MET Data

This works similarly to OBS data.

3.15.2 Date/Time Formats

The Date/Time format can be controlled via the <code>-tab_date</code> , <code>-tab_time</code> command line parameters. The following pattern describes selected <code>Date/Time</code> formats:

| Date Pattern | Example | Description |
|--------------|------------|-----------------------------------|
| mjd | 57029 | Modified Julian Date (MJD) |
| ddd | 007 | day of year |
| wwwwd | 18263 | gps-week,weekday |
| www-d | 1826-3 | gps-week,weekday |
| yyyyddd | 2015007 | year, day of year |
| yyyy-ddd | 2015-007 | year, day of year |
| yyyymmdd | 20150107 | year, month, day of month |
| yyyy-mm-dd | 2015-01-07 | year, month, day of month |
| yymmdd | 150107 | 2-digit year, month, day of month |
| yy-mm-dd | 15-01-07 | 2-digit year, month, day of month |

| Time Pattern | Example | Description |
|--------------|-------------------|------------------------|
| hhmmss | 013516.0000000 | hour, minutes, seconds |
| hh:mm:ss | 01:35:16.0000000 | hour, minutes, seconds |
| sod | 5716.0000000 | seconds of day |
| fod | 0.066157407407407 | fractions of day |

```
gfzrnx ... -tab_out -tab_date ddd -tab_time sod
```

The Date/Time patterns **ddd** and **sod** used above, result in the output below.

```
#HD G DATE TIME PRN L1C L1W L2W L2X
OBS G 007 26700.0000000 G03 134798128.476 134798125.823 105037501.328 9999999999.999
```

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```
OBS G 007 26730.0000000 G03 134629777.213 134629774.487 104906318.473 104906323.263
OBS G 007 26760.0000000 G03 134461452.299 134461449.545 104775156.193 104775160.914
OBS G 007 26790.0000000 G03 134293160.630 134293157.877 104644019.757 104644024.465
...
```

3.15.3 Column Separator

```
gfzrnx ... -tab_out -tab_date ddd -tab_time sod -tab_sep ','
```

The above command gives you a simple CSV output:

```
#HD,G,DATE,TIME,PRN,L1C,L1W,L2W,L2X
OBS,G,007,26700.0000000,G03,134798128.476,134798125.823,105037501.328,105037506.181
OBS,G,007,26730.0000000,G03,134629777.213,134629774.487,104906318.473,104906323.263
OBS,G,007,26760.0000000,G03,134461452.299,134461449.545,104775156.193,104775160.914
OBS,G,007,26790.0000000,G03,134293160.630,134293157.877,1046444019.757,104644024.465
OBS,G,007,26820.0000000,G03,134124902.769,134124900.043,104512909.644,104512914.387
```

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3.16 RINEX-2 BDS, QZSS, IRNSS support

As an extension to the RINEX-2.11 standard, the BEIDOU-, QZSS-, IRNSS- satellite systems are formally supported.

3.16.1 Navigation file extensions

In the RINEX-2 standard, there are no extension letters defined for single system BEIDOU-, QZSS-, IRNSS- single system navigation files. The following characters are used by gfzrnx:

| System | Letter | Example |
|--------|--------|--------------|
| BDS | С | pots0750.17c |
| QZSS | j | pots0750.17j |
| IRNSS | i | pots0750.17i |

3.16.2 RINEX-2 to RINEX-3 or 4 conversion

The RINEX-3.03 standard (and higher) does not allow an empty attribute identifier (tracking mode or channel) in observation type naming (tna - observation type|band/frequency|attribute). Converting files from RINEX-2 to RINEX-3 shows the problem of safely map 2-characters to 3-characters observation type names (e.g. L2 to L2?). As it is not foreseen to have an "unknown" or "converted" attribute identifier, the output version used is 3.01 to stay format conform.

3.16.3 Handling of unsupported observation types

gfzrnx s driven by hard-coded observation types, and the mapping table is compliant with RINEX standards. Running the program for unsupported or non-standard observation types results in the omitting of these data. To avoid this behavior, one has to extend the standard. This can be done with the following procedure:

• Extract the hardcoded table from the **gfzrnx** executable.

```
gfzrnx -out_obs_map
gfzrnx -out_obs_map -fout obs_types_map.txt
```

- Add new observation types records to the map. The information in the columns 2,3 and 4 is treated as a comment only and is not used.
- Run any gfzrnx command call with the modified table.

```
gfzrnx -use_obs_map obs_types_map.txt -finp ...
```



Be aware that this undermines the given RINEX standard and can be an error source if not used properly. The generated files are **for internal use only**!

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