GPS-tide calculation
on RV Heincke

Information about the processing and the created dataset

Contents

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Ref.: Heincke_GPS_Tide.pdf	Vers.: 1.1	Date: 2019/10/16	Status: final

1 Introduction

In February 2018, a system was installed to record raw GNSS data from the Trimble SPS461 GPS Receiver onboard RV Heincke. The system consists of an eBOX-PC (eBOX620-841-FL) with a Debian GNU/Linux 9 (shell only) operating system and a FTP service. The PC (IP: 192.168.110.52) is connected to the ships network and receives raw-data via FTP.

The raw data is further translated into Receiver Independant Exchange Format (RINEX) and post-processed using the open source program package RTKLIB to achieve higher position accuracies. Finally, the resulting position files are filtered / fitted to create tidal-correction files that can be used in the post-processing of bathymetric surveys.

2 Workflow

The following abbreviations are used:

```
%Y  =  yyyy  :  year (4 digits)  (2000-2099)
%y  =  yy    :  year (2 digits)  (00-99)
%m  =  mm    :  month            (01-12)
%d  =  dd    :  day of month     (01-31)
%h  =  hh    :  hours            (00-23)
%n  =  ddd   :  day of year      (001-366)
%W  =  wwww  :  gps week         (0001-9999)
%D  =  d     :  day of gps week  (0-6)
```

Storage of raw data
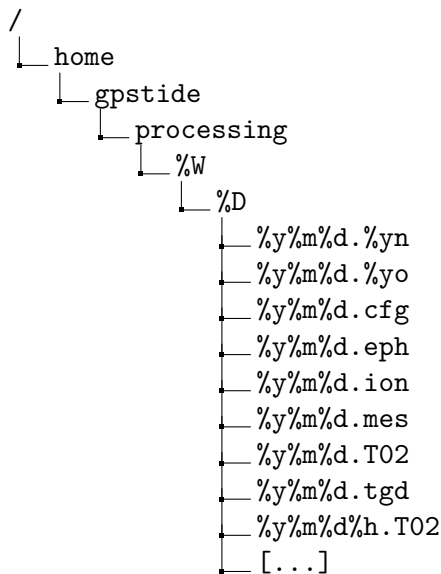
Every hour, a raw Trimble T02 file is pushed from the GPS unit to the PC and stored in the folder `trimbledata`.

```
/
└── home
    └── gpstide
        └── trimbledata
            ├── %y%m%d%h.T02
            └── [...]
```

Conversion to RINEX

The first part of the processing is to create a day file out of the 24 raw T02 files and to convert it into the RINEX Version 2.11 format. This is achieved by the Python-Scripts `1_merge_hourfiles_to_day.py` and `2_process_to_rinex.py` which are located in `/home/gpstide/Skripte`. The scripts are run daily at 00:05 UTC using a **cron** job scheduler.

The file `%y%m%d.T02` is first transformed into `%y%m%d.tgd` by the program **runpkr00** and then into the RINEX observation file `%y%m%d.%yo` and the RINEX navigation file `%y%m%d.%yn` by the program **teqc**. The following files are created:

```
/
└── home
    └── gpstide
        └── processing
            └── %W
                └── %D
                    ├── %y%m%d.%yn
                    ├── %y%m%d.%yo
                    ├── %y%m%d.cfg
                    ├── %y%m%d.eph
                    ├── %y%m%d.ion
                    ├── %y%m%d.mes
                    ├── %y%m%d.T02
                    ├── %y%m%d.tgd
                    ├── %y%m%d%h.T02
                    └── [...]
```
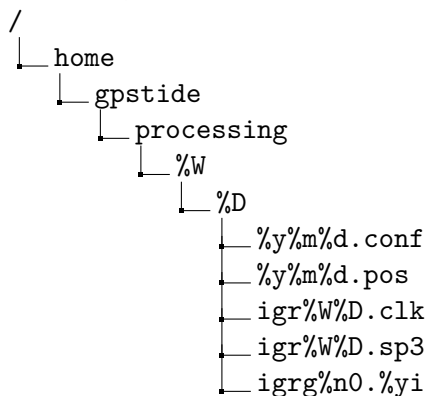
Post-Processing of GNSS data using PPP

The second part of the processing is to create a corrected day file from the RINEX file using the Python-Script `3_download_IGS_and_process.py` and to create GPS-Tide files using the script `4_smooth_tide_and_export_tid.py`, both scripts are located in `/home/gpstide/Skripte`. The scripts are run daily at 20:00 UTC using a **cron** job scheduler as IGS correction data are available around 19:00 UTC each day.

The created RINEX file is now used to enhance the position accuracy using the method of Precise Point Positioning (PPP). Therefore, the software package **RTKLIB** is used together with auxiliary data of the satellite clocks (`igr%W%D.clk`), the satellite ephemerides (`igr%W%D.sp3`) and the ionosphere (`igrg%n0.%yi`).

The following files are created:

```
/
└── home
    └── gpstide
        └── processing
            └── %W
                └── %D
                    ├── %y%m%d.conf
                    ├── %y%m%d.pos
                    ├── igr%W%D.clk
                    ├── igr%W%D.sp3
                    └── igrg%n0.%yi
```

The configuration file (`%y%m%d.conf`) includes all settings necessary for the processing within the program **rnx2rtkp**. The POS file (`%y%m%d.pos`) is the result in 1-second-resolution including standard deviations and number of visible satellites.

Tide correction files

From the created POS file (`%y%m%d.pos`), two CARIS TID files are created in 1-minute resolution named `%y%m%d_medfilt.tid` and `%y%m%d_fitted.tid`. For the file `%y%m%d_medfilt.tid`, a median-filter is applied for a timespan of 10 minutes (i.e. 601 datapoints, since an odd number is needed for the function). For the file `%y%m%d_fitted.tid`, a Least-Squares minimization (Trust Region Reflective method) is performed using the following tidal constituents:

Tidal Constituent	Phase (rad)	Amplitude (m)	Period (hr)
M_2 (Principal lunar semidiurnal)	$0 - 2\pi$	$0 - 3$	12.42
K_1 (Lunar diurnal)	$0 - 2\pi$	$0 - 3$	23.93
S_2 (Principal solar semidiurnal)	$0 - 2\pi$	$0 - 3$	12.0
O_1 (Lunar diurnal)	$0 - 2\pi$	$0 - 3$	25.82

The following figure shows the resulting tide solutions for Sunday (2018-04-15). The black line displays the fitted tide, the red line the result on the 10-minute median filtering.
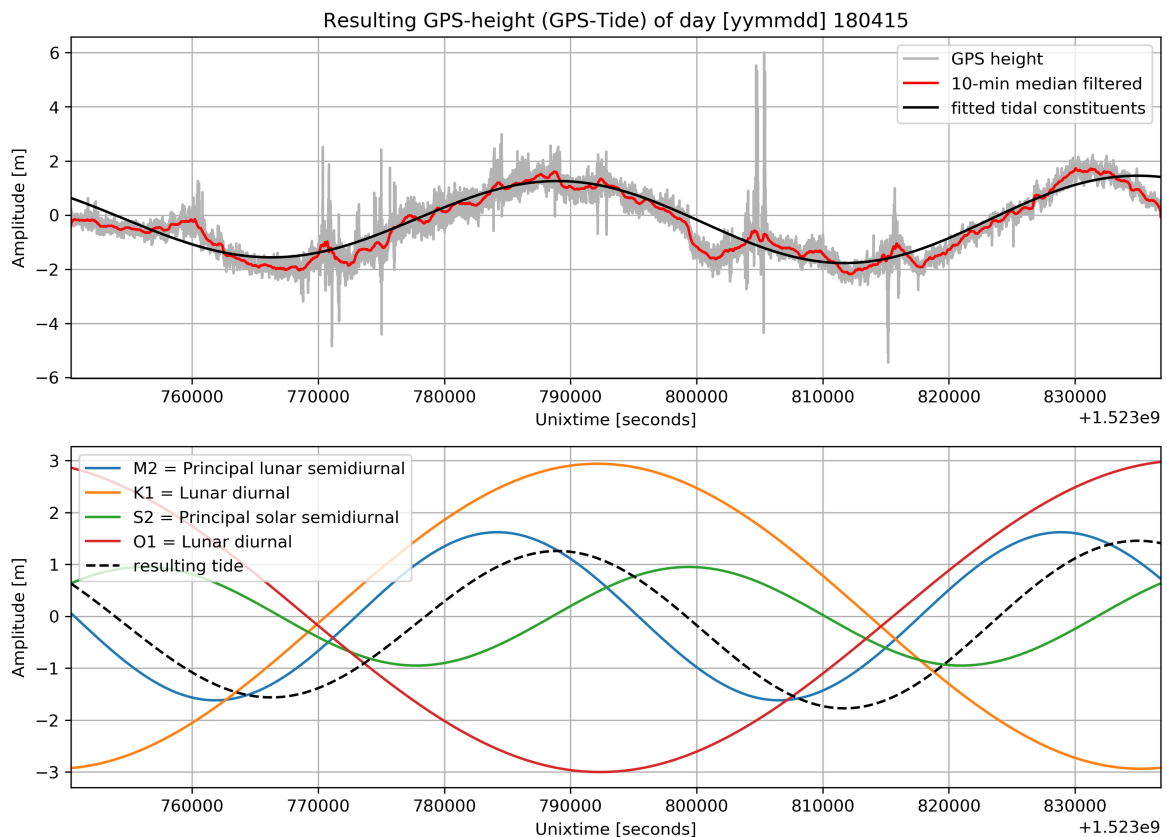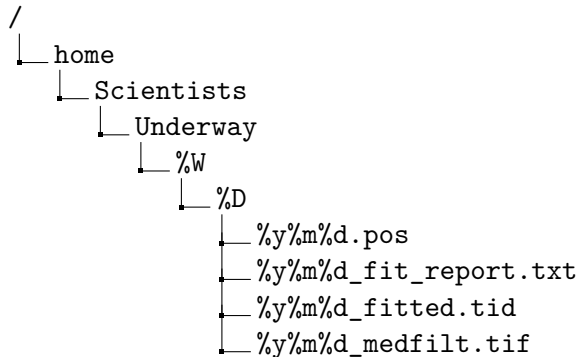

Figure 1: example of GPS heights and derived tidal components

Data Availability

The generated data can be downloaded from the on-board server (`//xdc1/home/Scientists/Underway`) and used to correct recorded bathymetric data:

```
/
└── home
     └── Scientists
          └── Underway
               └── %W
                    └── %D
                         ├── %y%m%d.pos
                         ├── %y%m%d_fit_report.txt
                         ├── %y%m%d_fitted.tid
                         └── %y%m%d_medfilt.tif
```

3 Additional Information

Log files

Each Python script throws INFO, WARNING or ERROR messages, that are stored in the folder `/home/gpstide/Skripte/logs`. Each day, an individual file named `readings.log.%Y-%m%d` is created and contains the information thrown by the scripts that are called by the cron job.

example: readings.log.2018-04-29

```
2018-04-29 00:05:02,020 - gpstide - INFO - day file 180428.T02 created
2018-04-29 00:05:14,058 - gpstide - INFO - 180428.tgd created
2018-04-29 00:05:29,115 - gpstide - INFO - 180428.18o & 180428.18n created
2018-04-29 00:05:29,122 - gpstide - INFO - ToDo file for 180428 created
2018-04-29 20:00:17,523 - gpstide - INFO - igr19986.sp3.Z downloaded and extracted
2018-04-29 20:00:17,524 - gpstide - INFO - igr19986.sp3 valid
2018-04-29 20:00:43,163 - gpstide - INFO - igr19986.clk.Z downloaded and extracted
2018-04-29 20:00:43,163 - gpstide - INFO - igr19986.clk valid
2018-04-29 20:01:00,743 - gpstide - INFO - igrg1180.18i.Z downloaded and extracted
2018-04-29 20:01:00,743 - gpstide - INFO - igrg1180.18i valid
2018-04-29 20:01:00,744 - gpstide - INFO - 180428.conf created
2018-04-29 20:01:00,744 - gpstide - INFO - Executing rnx2rtkp:  /usr/local/bin/rnx2rtkp
-k /home/gpstide/processing/1998/6/180428.conf -o /home/gpstide/processing/1998/6/180428.pos
/home/gpstide/processing/1998/6/180428.18o /home/gpstide/processing/1998/6/180428.18n
/home/gpstide/processing/1998/6/igr19986.sp3 /home/gpstide/processing/1998/6/igr19986.clk
2018-04-29 20:11:28,107 - gpstide - INFO - 180428.txt RTK Post-Processing successful
2018-04-29 20:13:07,532 - gpstide - INFO - 180428_fitted.tid & 180428_medfilt.tid created
```

```
2018-04-29 20:13:07,536 - gpstide - INFO - 180428_fit_report.txt created
2018-04-29 20:13:23,682 - gpstide - INFO - Daily Status mail sended succesful
```

Fitting reports

For each day, an individual report file of the fitted tide is created named `%y%m%d_fit_report.txt` that contains all information on the initially chosen parameters and the resulting parameters after the Least-Squares minimization.