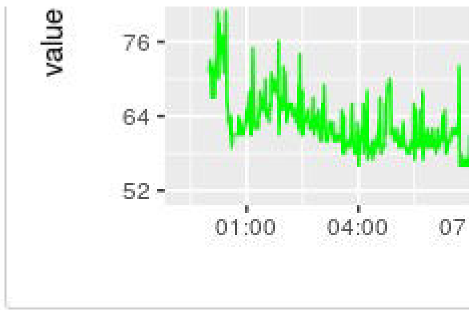
For the rest of this blog post I'll assume that the following variables are defined and that you intend to use the functions of the **fitbitViz** package from the R Console (or RStudio IDE):

```
#..................
# parameter setting
#..................

USER_ID = 'My user-id'                  # Specify here your 'user-id'
token = "My token"                      # Specify here your 'token'




WEEK = 11                              # for this use case pick the 11th
week of the year 2021

num_character_error = 135              # print that many character in case
of an error

weeks_2021 = fitbitViz:::split_year_in_weeks(year = 2021)         #
split a year in weeks

# Start the week at monday (see: https://github.com/tidyverse/lubridate/issues/509)
date_start = lubridate::floor_date(lubridate::ymd(weeks_2021[WEEK]),
unit = 'weeks') + 1

# Add 6 days to the 'date_start' variable to come to a 7-days plot
date_end = date_start + 6

sleep_time_begins = "00H 40M 0S"
sleep_time_ends = "08H 00M 0S"

VERBOSE = FALSE                             # disable verbosity
```

The previous code snippet uses one week of my personal *Fitbit* data (the *11th week of 2021*) to plot my

- **heart rate time series**
- **heart rate heatmap**
- **heart rate variability during sleep time**
- **sleep time series**
- **GPS data of outdoor activities**
- **3-dimensional map of activities**

The pre-processed data of all these functions are also available to download by clicking on the **CSV** buttons,



CSV

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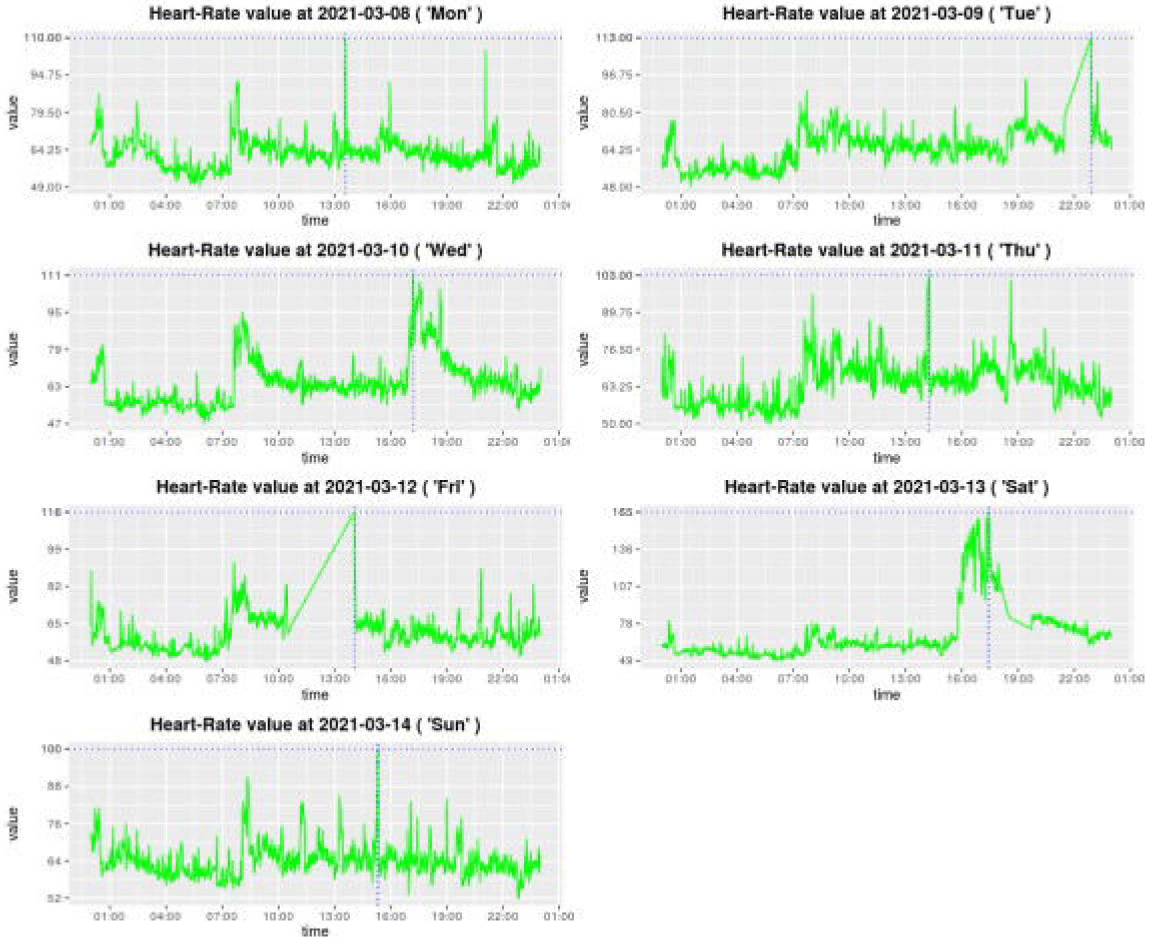
2021-03-08 00:00:00

heart rate time series

The **heart_rate_time_series()** function takes the **user-id**, **token**, the **start-** and **end-dates**, the **start-** and **end-time**, the **detail level** (1 minute) and returns the **heart rate time series**. Each output plot (of the *multiplot*) includes in the **x-axis** the **time** and in the **y-axis** the **heart rate value**. The highest heart rate value (peak) of the day is highlighted using a vertical and horizontal **blue** line,

```
#......................
# heart rate time series
#......................

heart_dat = fitbitViz::heart_rate_time_series(user_id = USER_ID,
                                              token = token,
                                              date_start =
as.character(date_start),
                                              date_end =
as.character(date_end),
                                              time_start = '00:00',
                                              time_end = '23:59',
                                              detail_level = '1min',
                                              ggplot_intraday = TRUE,
                                              ggplot_ncol = 2,
                                              ggplot_nrow = 4,
                                              verbose = VERBOSE,
                                              show_nchar_case_error =
num_character_error)
heart_dat$plt
```



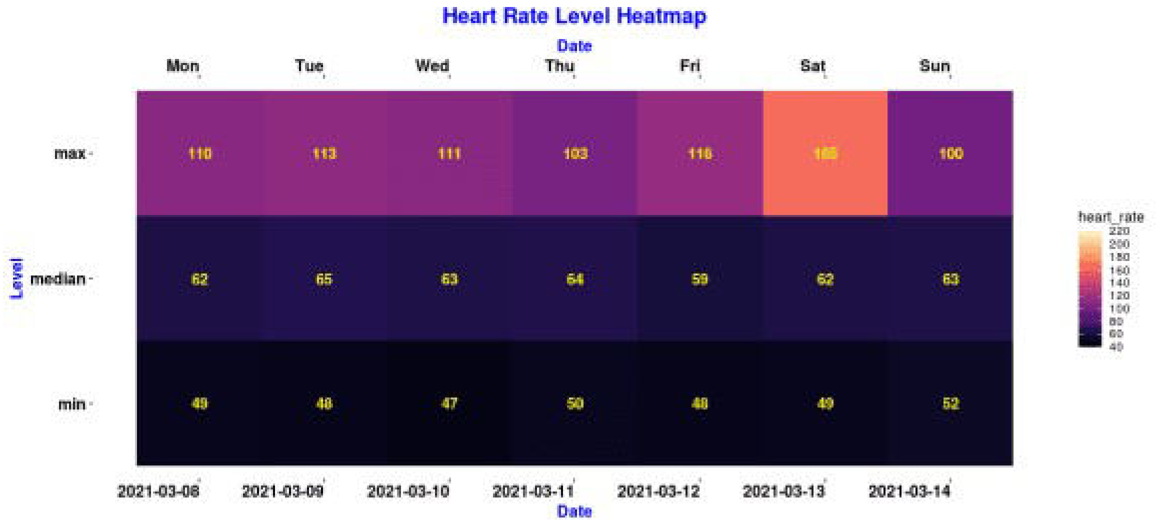
heart rate heatmap

The **heart rate heatmap** shows the **min**, **median** and **max** heart rate Levels in the **y-axis** for each day of the specified week (**x-axis**). As the legend shows, the displayed values range from 40 to 220 and higher values appear in *purple* or *orange* color,

```
#...........................
# heart rate intraday heatmap [ plot options: https://yihui.org/knitr/options/#plots ]
#...........................

heart_intra = heart_dat$heart_rate_intraday

hrt_heat = fitbitViz::heart_rate_heatmap(heart_rate_intraday_data = heart_intra,
                                         angle_x_axis = 0)
hrt_heat
```



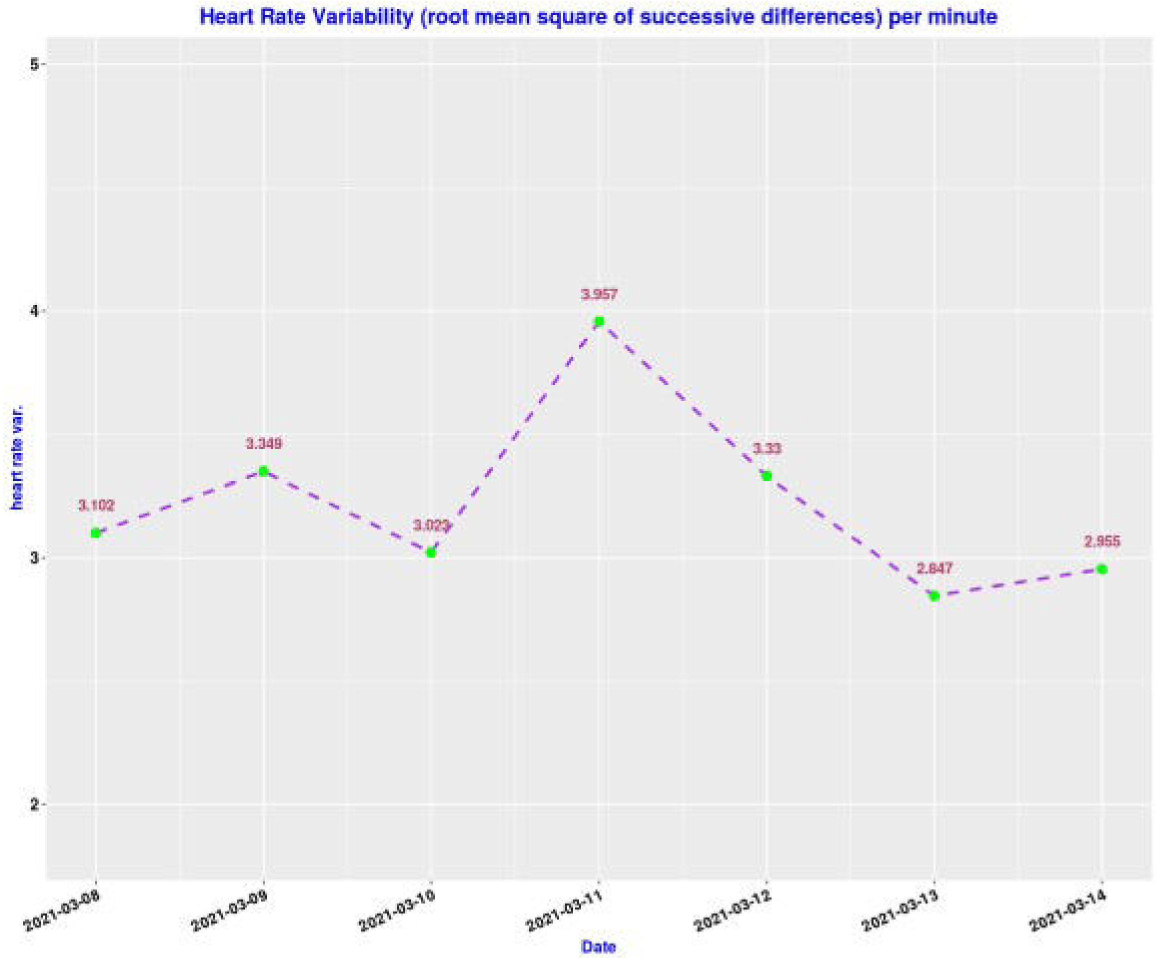
heart rate variability during sleep time

This function computes the **root mean square of successive differences (RMSSD)** and a *higher heart rate variability is linked with better health*. Based on the Fitbit application information and the Wikipedia article the heart rate variability is computed normally in ms (milliseconds), however I use the *'1min'* rather than the *'1sec'* interval because I observed that it is more consistent,

```
#.......................
# heart rate variability
#.......................

hrt_rt_var = fitbitViz::heart_rate_variability_sleep_time(heart_
rate_data = heart_dat,
                                                          sleep_begin =
sleep_time_begins,
                                                          sleep_end =
sleep_time_ends,
                                                          ggplot_hr_var
= TRUE,
                                                          angle_x_axis
```

```
= 25)
hrt_rt_var$hr_var_plot
```



sleep time series

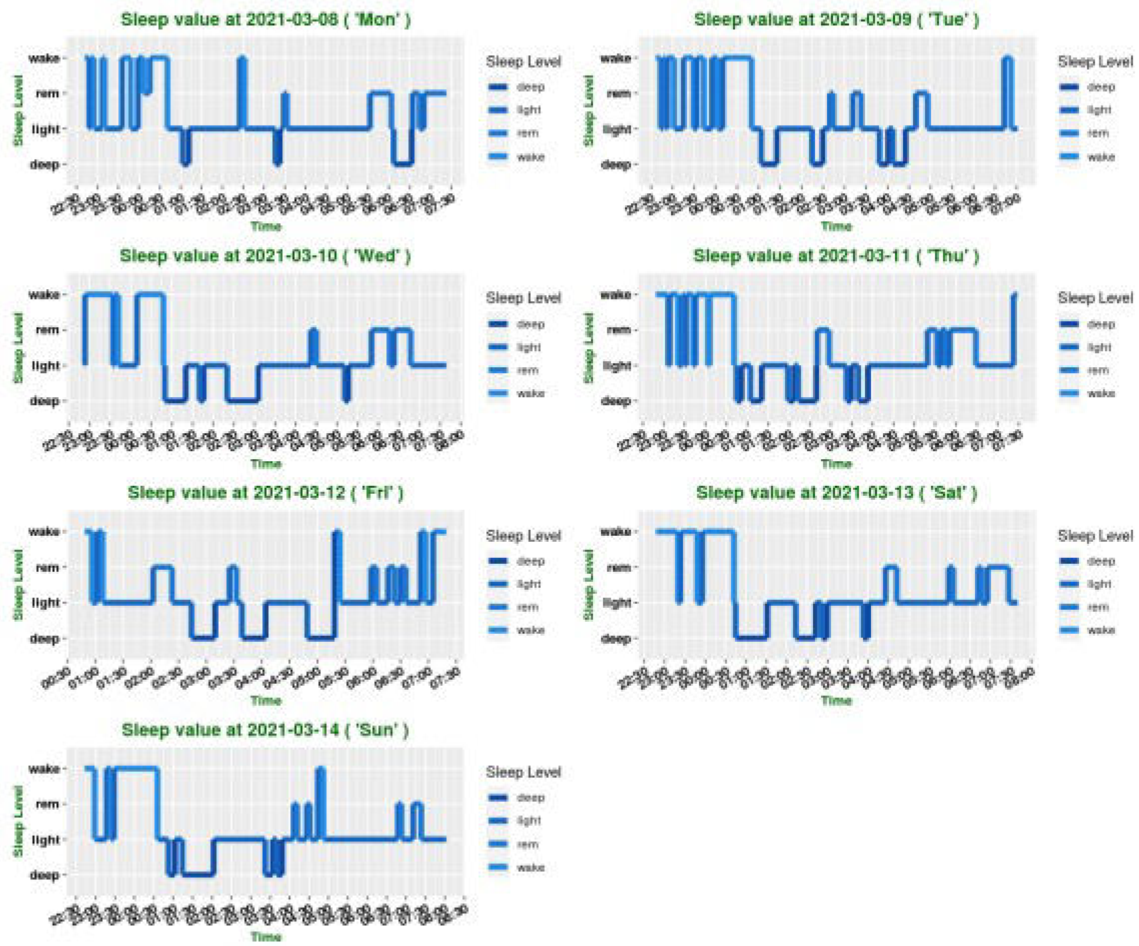
The **sleep time series** visualization is similar to the *Fitbit Mobile* Visualization and in the **x-axis** shows the specified by the user **sleep time interval** whereas in the **y-axis** shows the **sleep Levels** (*wake*, *rem*, *light*, *deep*). Lower levels like *deep sleep* appear in dark blue whereas higher levels like *wake* appear in light blue,

```
#......................
# sleep data time series
#......................

sleep_ts = fitbitViz::sleep_time_series(user_id = USER_ID,
                                        token = token,
                                        date_start =
as.character(date_start),
                                        date_end =
```

```
                                   as.character(date_end),
                                                                          ggplot_color_palette =
                                   'ggsci::blue_material',
                                                                          ggplot_ncol = 2,
                                                                          ggplot_nrow = 4,
                                                                          show_nchar_case_error =
                                   num_character_error,
                                                                          verbose = VERBOSE)

sleep_ts$plt_lev_segments
```



GPS data of outdoor activities

To make use of the *GPS data* from the Fitbit Application we have first to extract the **log-id** for a time interval after a specified *Date*,

```
#...................
# extract the log-id (required for the GPS data)
#...................
```

```
log_id = fitbitViz::extract_LOG_ID(user_id = USER_ID,
                                   token = token,
                                   after_Date =
as.character(date_start),
                                   limit = 10,
                                   sort = 'asc',
                                   verbose = VERBOSE)
# log_id
```

Once we have the *log-id* we can define the *time zone* of the route to receive all GPS data,

```
#......................................................
# return the gps-ctx data.table for the output log-id
#......................................................

res_tcx = fitbitViz::GPS_TCX_data(log_id = log_id,
                                  user_id = USER_ID,
                                  token = token,
                                  time_zone = 'Europe/Athens',
                                  verbose = VERBOSE)
# res_tcx
```

The following *Leaflet (Point Coordinates) Map* shows my outdoor activity during the *11th week of 2021* (the legend shows the elevation of the route),

```
#.................................
# Create the Leaflet / LeafGL Map
#.................................

res_lft = fitbitViz::leafGL_point_coords(dat_gps_tcx = res_tcx,
                                         color_points_column =
'AltitudeMeters',
                                         provider =
leaflet::providers$Esri.WorldImagery,
                                         option_viewer =
rstudioapi::viewer,
                                         CRS = 4326)

res_lft
```

3-dimensional plots of activities

Another option of this package is to plot a route in 3-dimensional space. For this purpose we'll use the rayshader package, which internally uses rgl (*OpenGL*). First, we have to extend the boundaries of our route for approximately *1.000 thousand meters* (adjust this value depending on your area of interest),

```
#...................................................
# compute the sf-object buffer and the raster-extend  (1000 meters
buffer)
#...................................................

sf_rst_ext = fitbitViz::extend_AOI_buffer(dat_gps_tcx = res_tcx,
                                          buffer_in_meters = 1000,
                                          CRS = 4326,
                                          verbose = VERBOSE)
# sf_rst_ext
```

Then for the extended area we will download Copernicus Digital Elevation Model (DEM) data.

The *Copernicus elevation data* come either in **30** or in **90** meter resolution. We will pick the *30* meter resolution product for this route. The **CopernicusDEM** is an R package, make sure that you have installed and configured the **awscli** Operating System Requirement if you intend to download and reproduce the next 3-dimensional map using the elevation data (you can find instructions in the README.md file for all 3 Operating Systems),

```
#....................................................................
# Download the Copernicus DEM 30m elevation data
# there is also the option to download the DEM 90m elevation data
# which is of lower resolution but the image size is smaller which
# means faster download
#....................................................................

dem_dir = tempdir()
# dem_dir

dem30 = CopernicusDEM::aoi_geom_save_tif_matches(sf_or_file =
sf_rst_ext$sfc_obj,
                                                 dir_save_tifs =
dem_dir,
                                                 resolution = 30,
                                                 crs_value = 4326,
                                                 threads =
parallel::detectCores(),
                                                 verbose = VERBOSE)

TIF = list.files(dem_dir, pattern = '.tif', full.names = T)
# TIF

if (length(TIF) > 1) {

  #....................................................
  # create a .VRT file if I have more than 1 .tif files
  #....................................................

  file_out = file.path(dem_dir, 'VRT_mosaic_FILE.vrt')

  vrt_dem30 = CopernicusDEM::create_VRT_from_dir(dir_tifs = dem_dir,
                                                 output_path_VRT =
file_out,
                                                 verbose = VERBOSE)
}

if (length(TIF) == 1) {

  #..................................................
  # if I have a single .tif file keep the first index
  #..................................................

  file_out = TIF[1]
```

```
}

#......................................
# crop the elevation DEM based on the
# coordinates extent of the GPS-CTX data
#......................................

raysh_rst = fitbitViz::crop_DEM(tif_or_vrt_dem_file = file_out,
                                sf_buffer_obj = sf_rst_ext$sfc_obj,
                                CRS = 4326,
                                digits = 6,
                                verbose = VERBOSE)
# sp::plot(raysh_rst)
```

The GPS route that I use is an *ascending & descending* route therefore we can convert the GPS (TCX) data to a spatial *LINESTRING* by using the maximum altitude as a *split point* of the route to visualize the ascending route in *blue* and the descending in *red* (there is also the alternative to specify the split point based on time using the **time_split_asc_desc** parameter),

```
linestring_dat = fitbitViz::gps_lat_lon_to_LINESTRING(dat_gps_tcx =
res_tcx,
                                                      CRS = 4326,

time_split_asc_desc = NULL,
                                                      verbose =
VERBOSE)
```

then we create the *'elevation_sample_points' data.table parameter* for the *3-dim* plot based on the *min.*, *middle* and *max.* altitude of the previously computed *'res_tcx'* data,

```
idx_3m = c(which.min(res_tcx$AltitudeMeters),
           as.integer(length(res_tcx$AltitudeMeters) / 2),
           which.max(res_tcx$AltitudeMeters))

cols_3m = c('latitude', 'longitude', 'AltitudeMeters')
dat_3m = res_tcx[idx_3m, ..cols_3m]
```

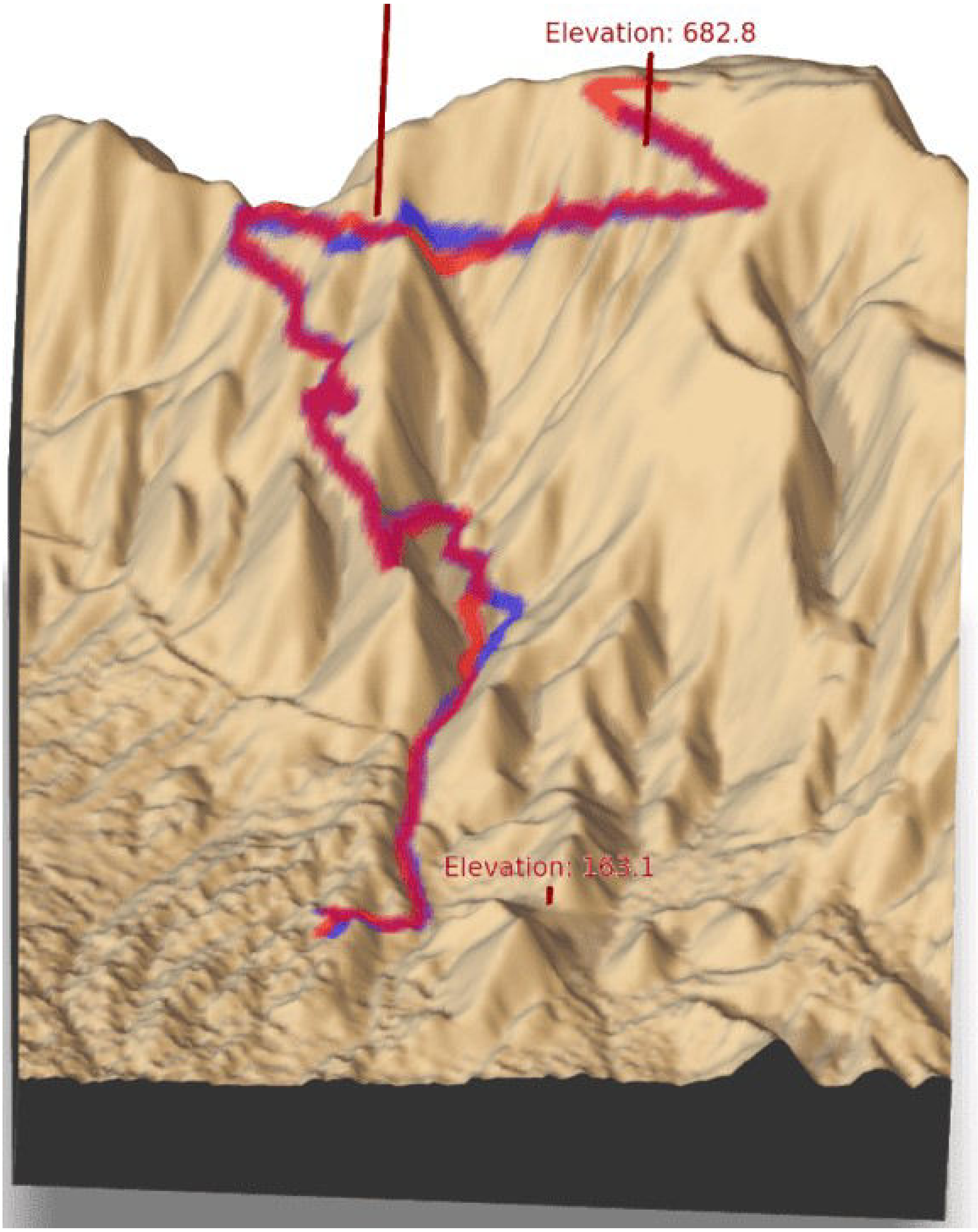
and finally we visualize the *3-dimensional Rayshader Map*,

```
snapshot_rayshader_path = file.path(tempdir(), 'rayshader_img.png')
```

```
rgl::open3d(useNULL = TRUE)                          # this removes the
second rgl-popup-window

fitbitViz::rayshader_3d_DEM(rst_buf = raysh_rst,
                            rst_ext = sf_rst_ext$raster_obj_extent,
                            rst_bbx = sf_rst_ext$buffer_bbox,
                            linestring_ASC_DESC = linestring_dat,
                            elevation_sample_points = dat_3m,
                            zoom = 0.3,
                            windowsize = c(1000, 800))

rgl::rgl.snapshot(snapshot_rayshader_path)
rgl::par3d(mouseMode = "trackball")   # options: c("trackball",
"polar", "zoom", "selecting")
rgl::rglwidget()
```



In the output map we observe

- the *3 specified elevation vertical lines* (including their *altitude values* in meters)
- in *blue* color the *ascending* route
- in *red* color the *descending* route

The attached map here is a screenshot. You can play with the map by viewing the route from a different angle in one of my personal Fitviz-blog posts

An updated version of the **fitbitViz** package can be found in my Github repository and to report bugs/issues please use the following link, https://github.com/mlampros/fitbitViz/issues.

Citation:

If you use the **fitbitViz** R package in your paper or research please cite https://cran.r-project.org/web/packages/fitbitViz/citation.html:

```
@Manual{,
  title = {fitbitViz: Fitbit Visualizations},
  author = {Lampros Mouselimis},
  year = {2021},
  note = {R package version 1.0.1},
  url = {https://CRAN.R-project.org/package=fitbitViz},
}…
```